Consortium Agreement
for
iCUPE project

Project title:

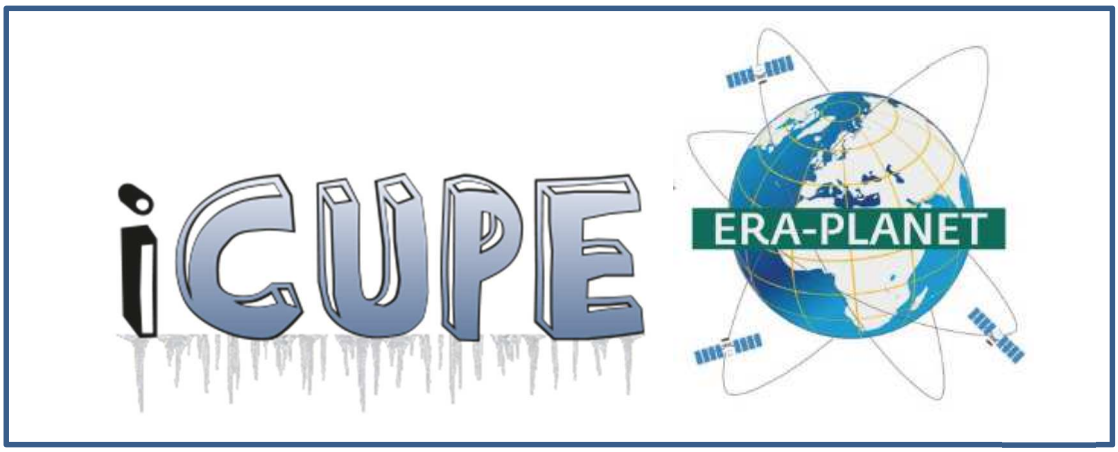
Integrative and Comprehensive Understanding on Polar Environments (iCUPE)

A project of

THE EUROPEAN NETWORK FOR OBSERVING OUR CHANGING PLANET

(ERA-PLANET)

Grant Agreement n. 689443



iCUPE is a project funded under ERA-Net Cofund Actions.

iCUPE ultimate goal is to answers to ”European network for observing our changing planet” (ERAPLANET) thematic strand 4 (Polar areas and natural resources). By combining integrated in-situ and satellite EO with a modelling platform, iCUPE will: 1) synthesize data from comprehensive long-term measurements, intensive campaigns and satellites, collected during the project or provided by on-going international initiatives 2) relate the observed parameters to impacts, and 3) deliver novel data products, metrics and indicators to the stakeholders concerning the environmental status, availability and extraction of natural resources in the polar areas. These data, metrics and indicators will be targeted to identified stakeholders. They will be useful for policy development and for improving and clearly communicating our multidisciplinary understanding of status of the polar environment and pollution dynamics in the future. The knowledge generated is relevant to the general population, policy makers and scientists.

The iCUPE concept is served by a methodology comprised of 7 Work packages described in the iCUPE Consortium Plan. The latter is attached as Attachment 4 to this Consortium Agreement.

This Project Consortium Agreement is based on the ERA-PLANET Consortium Agreement that remains the main term of reference for any dispute.

In the case of provisions not covered in this Consortium Agreement, the relevant provisions of the ERA-PLANET Consortium Agreement shall be considered.

In case the terms of this Consortium Agreement are in conflict with the terms of the ERA-PLANET Consortium Agreement, the terms and conditions of the latter shall prevail.

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This Consortium Agreement is based upon Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for the participation and dissemination in "Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020)" (hereinafter referred to as "the Rules"), and the ERA-PLANET Consortium Agreement (amended version of November 28th 2016, approved by ERA-PLANET partners), and the Grant Agreement N. 689443 for ERA-PLANET and its annexes including its amendments. This Consortium Agreement is made on 1th September 2017 hereinafter referred to as the Effective Date.

This Consortium Agreement is entered into between:

The Project Coordinator:

37 (Coordinator) Fysiikan laitos, ilmakehätieteen laitos, Helsingin yliopisto (**UHEL**) - Finland

and the following other Parties:

1. Consiglio Nazionale delle Ricerche (**CNR**) - Italy

2. Aarhus Universitet (**AU**) - Denmark

5. Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (**AWI**) - Germany

7. Centre National de la Recherche Scientifique (**CNRS**) - France

11. Estonian University of Life Sciences (**EULS**) - Estonia

14. Finnish Meteorological Insitute (**FMI**) - Finland

17. Helmholtz Zentrum Potsdam GFZ Deutsches GeoForschungsZentrum (**GFZ**) - Germany

18. Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH (**HZG**) - Germany

25. N.C.S.R. Demokritos, Institute of Nuclear Technology and Radiation Protection (**NCSR**) - Greece

27. Paul Scherrer Institut (**PSI**) - Switzerland

30. Leibniz Institute for Tropospheric Research (**TROPOS**) - Germany

36. Stockholms universitet (**SU**) - Sweden

hereinafter, jointly or individually, referred to as "Parties" or "Party" relating to the Project entitled

"Integrative and Comprehensive Understanding on Polar Environments", in short "iCUPE" hereinafter referred to as "Project"

WHEREAS:

The Parties, having considerable experience in the field concerned, have submitted a proposal for the Project within the ERA-PLANET Joint Call as part of ERA-PLANET Cofund Actions under Horizon 2020 (2014-2020). The proposal was retained for funding by independent experts as a contribution to the ERA-PLANET thematic strand 4 (Polar areas and natural resources).

The Parties wish to specify or supplement binding commitments among themselves in addition to the provisions of the ERA-PLANET Grant Agreement N. 689443 and its annexes including its amendments (hereinafter “Grant Agreement”) and the ERA-PLANET Consortium Agreement.

NOW, THEREFORE, IT IS HEREBY AGREED AS FOLLOWS:

Section 1: Definitions

1.1 Definitions

Words beginning with a capital letter shall have the meaning defined either herein or in the Horizon 2020 Rules for Participation or in the Grant Agreement including its Annexes.

1.2 Additional Definitions

Co-fund: means the Parties' direct contribution which can be in-kind and/or in cash.

Consortium Body of iCUPE is a body that is part of the organisational structure of this Consortium.

Consortium Budget of iCUPE means the global budget for implementation and execution of the Project as detailed in Section 7 of this Consortium Agreement.

EU-Top-Up is the financial contribution of the European Commission to the Trans-national Projects funded according to the ERA-PLANET Consortium Budget, as defined in the Grant Agreement and its annexes and amendments.

In-kind funding or **In-kind contribution** means a contribution of a Party that may involve external funding and/or internal resources of the Party. This contribution can include professional services or expertise (provided as costs of permanent and/or non-permanent research staff), provision of (or access to) equipment, special materials and facilities. The extent to which in-kind contribution is deemed eligible to the project is linked first of all to the provisions set by the European Commission in the ERA-PLANET Grant Agreement, but also by the National and/or institutional obligations of a Party.

Project Consortium means all of the Parties participating in the Project which are signatories to this Consortium Agreement.

Project Consortium Plan is the Description of the Project and the related agreed budget as result of the approved funded project. Updates to the Project Consortium Plan shall be proposed to the ERA-PLANET Executive Board, which shall express his decision by accepting or rejecting the changes. The Description of the Project (i.e. the initial project proposal, Part B, Technical Annex Sections 1-3), at its start, is given as Attachment 4 to this Consortium Agreement; the agreed budget is given in Section 7 of this Consortium Agreement.

Project Coordinator is the Party in charge of the overall coordination of iCUPE. The appointed Coordinator is Tuukka Petäjä – Helsingin yliopisto, established in Helsinki, Finland (Party n° 26).

Project Task Leader (PTL) means the Party that has been allocated responsibility by the Project Consortium to coordinate a specific task.

Project Work Package Leader (PWPL) means the Party that has been allocated responsibility by the Project Consortium to coordinate a Work Package composed of one or several tasks.

Needed means:
For the implementation of the Project:

Access Rights are needed if, without the grant of such Access Rights, carrying out the tasks assigned to the recipient Party would be impossible, significantly delayed, or require significant additional financial or human resources.

For exploitation of own Results:

Access Rights are needed if, without the grant of such Access Rights, the Exploitation of own Results would be technically or legally impossible.

Section 2: Purpose

This Consortium Agreement refers only to the Project iCUPE.

The purpose of this Consortium Agreement is to specify with respect to the Project the relationship among the Parties, in particular concerning the organisation of the work between the Parties, the management of the Project and the rights and obligations of the Parties concerning *inter alia* liability, Access Rights and dispute resolution, Financial Provisions and implementation of the Project.

Section 3: Entry into force, duration and termination

3.1 Entry into force

An entity becomes a Party to this Consortium Agreement upon signature of this Consortium Agreement by a duly authorised representative.

This Consortium Agreement shall have effect from the Effective Date identified at the beginning of this Consortium Agreement.

A new entity, that is already Party of ERA-PLANET Consortium, becomes a Party to this Consortium Agreement upon signature of the accession document (Attachment 2) by the new Party and the Project Coordinator. Such accession shall have effect from the date identified in the accession document.

A party which has not yet signed this Consortium Agreement shall not be entitled to vote nor to receive any EC contribution.

3.2 Duration and termination

The Project shall be performed in a period starting on the 1st of September 2017 (the Start Date of the Project) and ending on the 31st of August 2020 (the End Date of the Project).

This Consortium Agreement shall continue in full force and effect until complete fulfilment of all obligations undertaken by the Parties under the Grant Agreement and under this Consortium Agreement.

However, this Consortium Agreement or the participation of one or more Parties to it may be terminated in accordance with the terms of this Consortium Agreement.

This Consortium Agreement shall automatically terminate in respect of the affected Party/ies, subject to the provisions surviving the expiration or termination under Section 3.3 of this Consortium Agreement, if

- the Grant Agreement is terminated, or
- if a Party's participation in the Grant Agreement is terminated.

3.3 Survival of rights and obligations

The provisions relating to Access Rights, Confidentiality, for the time period mentioned therein, as well as for Liability, Applicable law and Settlement of disputes as well as financial rules agreed in 7.5 shall survive the expiration or termination of this Consortium Agreement.

Termination shall not affect any rights or obligations of a Party leaving the Consortium incurred prior to the date of termination, unless otherwise agreed between the General Assembly and the leaving Party. This includes the obligation to provide all input, deliverables and documents for the period of its participation.

Section 4: Responsibilities of Parties

4.1 General principles

Each Party undertakes to take part in the efficient implementation of the Project, and to cooperate, perform and fulfil, promptly and on time, all of its obligations under the Grant Agreement and this Consortium Agreement as may be reasonably required from it and in a manner of good faith as prescribed by Belgian law.

Each Party undertakes to ensure that its representatives are able to perform the duties required of them in the Grant Agreement and this Consortium Agreement.

Each Party undertakes to notify the Project Coordinator promptly, in accordance with the governance structure of the Project, any significant information, fact, problem or delay likely to affect the Project, following the Grant Agreement.

The Project Coordinator undertakes to notify the ERA-PLANET Coordinator promptly any significant information, fact, problem or delay likely to affect its Project.

Each Party shall promptly provide all information reasonably required by a Consortium Body or by the Coordinator to carry out its tasks and prepare the deliverables.

Each Party shall take reasonable measures to ensure the accuracy of any information or materials it supplies to the other Parties.

Each Party undertakes to ensure that the tasks described in the accepted Project Proposal are fulfilled on time together with the attached list of Deliverables (see, Attachment 4). The project proposal, Part B, Technical Annex Sections 1-3 becomes the “Description of the Project”.

Deliverables submission procedure:

- 1 month before deadline – a reminder will be sent by the Project Coordinator to the responsible WP leader of the deliverable
- 2 weeks before deadline – the responsible WP leader of the deliverable submits the full draft of an already internally reviewed deliverable to other WP leaders
- 1 week before deadline – the other WP leaders submits feedbacks to responsible WP leader
- 2 days before deadline – responsible WP leader submits final deliverable to Project Coordinator.
- 1 day before deadline – Project Coordinator submit ERA-PLANET Coordinator of final deliverable through the established web platform.

4.2 Termination

In the event that any of the Parties is terminating its participation in the Project, that Party shall promptly notify the Project Consortium and both the Project Coordinator and the ERA-PLANET Coordinator. The ERA- PLANET General Assembly shall be convened for taking a decision. The Parties of the Project shall use reasonable endeavour to reach an agreement on re-allocating the work and contribution of the Party terminating its participation in order that the aims and objectives of the Project can still be met after the withdrawal. A restructured Project Consortium Plan will be

drawn and will be first submitted to the Project General Assembly and then to the ERA-PLANET Coordinator and the European Commission.

4.3 Breach

In the event that a responsible Consortium Body identifies a breach by a Party of its obligations under this Project Consortium Agreement (e.g. improper implementation of the Project), the Project Coordinator or, if the Coordinator is in breach of its obligations, the Party appointed by the General Assembly, will give formal notice to such Party requiring that such breach will be remedied within 30 calendar days from the date of receipt of the written notice by the Party.

If such breach is substantial and is not remedied within that period or is not capable of remedy, the Project General Assembly may decide to declare the Party to be a Defaulting Party and to decide on the consequences thereof which may include termination of its participation.

4.4 Involvement of third parties

The provisions of this paragraph are identical to provisions given on the same issue in the ERA-PLANET Consortium Agreement (see paragraph 4.4 of ERA-PLANET CA).

Section 5: Liability towards each other

5.1 No warranties

In respect of any information or materials (including Background[1] and Results[2]) supplied by one Party to another under the Project, no warranty or representation of any kind is made, given or implied as to the sufficiency or fitness for purpose nor as to the absence of any infringement of any proprietary rights of third parties.

Therefore, in accordance with the ERA-PLANET Grant Agreement:

- the recipient Party shall in all cases be entirely and solely liable for the use to which it puts such information and materials, and
- no Party granting Access Rights shall be liable in case of infringement of proprietary rights of a third party resulting from any other Party (or its Affiliated Entities) exercising its Access Rights - provided such infringement was not caused by a wilful act or gross negligence.

However, each Party shall promptly inform the other Party of any claims of third parties that come to their knowledge.

5.2 Limitations of contractual liability

No Party shall be responsible to any other Party for any indirect or consequential loss or similar damage such as, but not limited to, loss of profit, loss of revenue or loss of contracts, provided such damage was not caused by a wilful act or gross negligence.

The present Consortium Agreement covers the liability for implementation costs of the project.

The Party's aggregate liability towards the other Parties, shall be limited to once the Party's share of the EU-Top-Up allocated to the Project as given in section 7 of this Consortium Agreement provided such damage was not caused by a wilful act or gross negligence.

The terms of this Consortium Agreement shall not be construed to amend or limit any Party's statutory liability.

5.3 Damage caused to third parties

The provisions of this paragraph are identical to provisions given on the same issue in the ERA-PLANET Consortium Agreement (see paragraph 5.3 of ERA-PLANET CA).

5.4 Force Majeure

The provisions of this paragraph are identical to provisions given on the same issue in the ERA-PLANET Consortium Agreement (see paragraph 5.3 of ERA-PLANET CA).

Section 6: Governance structure

6.1 General structure

The organisational structure of the Project Consortium shall comprise the following Project Consortium Bodies, which specific operational procedures are defined in Section 6.3:

- **Project General Assembly**
- **Project Executive Board**
- **Project Coordinator**
- **Project Management Support Team**

TThe organisational structure of the Project Consortium may eventually include the following additional Bodies:

- **Advisory Boards**
- **Policy Advisory Board**
- **Scientific Advisory Board**
- **Stakeholder Network**

Description and operational procedures of External Advisory Boards are defined in Section 6.4 of this Consortium Agreement.

6.2 General operational procedures for Project Consortium Bodies

6.2.1 Representation in meetings

Any Party that is a member of a Project Consortium Body (hereinafter referred to as "Member"):

- is expected to be present or represented at any meeting of such Project Consortium Body;
- may appoint an authorized substitute or a proxy to attend, take decision and vote at any meeting;
- shall participate in a cooperative manner in the meetings.

6.2.2 Preparation and organisation of meetings

Meetings of each Project Consortium Body may also be held by teleconference or other telecommunication means.

The chairperson of a Project Consortium Body shall convene meetings of that Project Consortium Body as indicated below:

	Ordinary meeting	**Extraordinary meeting**
Project General Assembly	At least once a year	At any time upon written request of the Project Executive Board or 1/3 of the Members of the Project General Assembly
Project Executive Board	At least 2 times per year	At any time upon written request of any Member of the Board or the Project coordinator

The chairperson of a Project Consortium Body shall give notice in writing of a meeting to each Member of that Project Consortium Body as soon as possible and no later than the minimum number of days preceding the meeting as indicated below:

	Ordinary meeting	**Extraordinary meeting and teleconference meetings**
Project General Assembly	14 calendar days	7 calendar days
Project Executive Board	7 calendar days	5 calendar days

The chairperson of a Project Consortium Body shall prepare and send each Member of that Project Consortium Body (here Project General Assembly), an agenda no later than 14 days preceding the meeting (7 days for extraordinary meetings).

Any agenda item requiring a decision by the Members of a Project Consortium Body must be identified as such on the agenda.

Any Member of a Consortium Body may add an item to the original agenda by written notification to all of the other Members of that Consortium Body up to 7 days preceding the meeting (2 days for extraordinary meeting for the Executive Board).

During a meeting, the Members of a Project Consortium Body present or represented can unanimously agree to add a new item to the original agenda.

Any decision may also be taken without a meeting if the Coordinator circulates to all Members of the Consortium Body a written document that is then agreed by the defined majority (see Section 6.2.3.) of all Members of the Consortium Body. Such document shall include the deadline for responses. The agreement may also take the form of an electronic vote. The Project Coordinator shall immediately inform the Members of the Project Consortium body and on the outcome of a written procedure.

The Project Coordinator shall also immediately inform the ERA-PLANET Coordinator on the outcome of any written relevant procedure.

Decisions will only be binding once the relevant part of the Minutes has been accepted according to Section 6.2.5.

6.2.3 Voting rules and quorum

Each Consortium Body shall not deliberate and decide validly unless two-thirds (2/3) of its Members are present or represented (quorum).

If the quorum is not reached, the chairperson shall convene an extraordinary meeting, which shall not deliberate and decide validly unless majority (50% plus one of its Members) are present or represented.

Each Party present or represented in the meeting of each Project Consortium Body shall have one vote.

Defaulting Parties may not vote.

Decisions shall be taken by a majority of two-thirds (2/3) of the votes cast. The number of cast votes is represented by the number of Parties present or represented at each meeting being non-defaulting Parties.

6.2.4 Veto rights

A Member which can show that its own work, time for performance, costs, liabilities, intellectual property rights or other legitimate interests would be severely affected by a decision of a Consortium Body may exercise a veto with respect to the corresponding decision or relevant part of the decision.

When the decision is foreseen on the original agenda, a Member may veto such a decision during the meeting only.

When a decision has been taken on a new item added to the agenda before or during the meeting, a Member may veto such decision during the meeting and within 15 calendar days after the draft minutes of the meeting are sent.

In case of exercise of veto, the Members of the related Project Consortium Body shall make every effort to resolve the matter, which occasioned the veto to the general satisfaction of all its Members.

A Party may not veto decisions relating to its identification as a Defaulting Party. The Defaulting Party may not veto decisions relating to its participation and termination in the consortium or the consequences of them.

A Party requesting to leave the consortium may not veto decisions relating thereto.

6.2.5 Minutes of meetings

The chairperson of a Project Consortium Body shall produce written minutes of each meeting, which shall be the formal record of all decisions taken. He/she shall send the draft minutes to all Members within 14 calendar days of the meeting.

The minutes shall be considered as accepted if, within 14 calendar days from sending, no Member has sent an objection in writing to the chairperson with respect to the accuracy of the draft of the minutes.

The chairperson shall send the accepted minutes to all the Members of the Project Consortium Body to the Project Coordinator and to ERA-PLANET Coordinator, who shall safeguard them.

If requested the Project Coordinator shall provide authenticated duplicates to Parties.

Minutes shall be posted on the reserved section of the Project website and made available to the Project Consortium, the ERA-PLANET Consortium and the EC through a specific password.

6.3 Specific operational procedures for the Project Consortium Bodies

6.3.1 Project General Assembly

In addition to the rules described in Section 6.2, the following rules apply:

6.3.1.1 Members

The Project General Assembly shall consist of one representative of each Party (hereinafter General Assembly Member) taking part to the Project.

Each Project General Assembly Member shall have a mandate of decision-making on behalf of the Party it is representing. Every Party shall only have one mandate of decision-making.

The Project Coordinator shall chair all meetings of the Project General Assembly, unless decided otherwise in a meeting of the General Assembly.

The Parties agree to abide by all decisions of the Project General Assembly. This does not prevent the Parties from choosing the veto option in accordance with Section 6.2.4 or from submitting a dispute to resolution in accordance with the provisions of Settlement of disputes in Section 13.8.

6.3.1.2 Functions and Decisions

The Project General Assembly is the decision making body and responsible for the overall direction and follow-up of the Project.

The following decisions shall be taken by the General Assembly:

- Proposals for changes to this Consortium Agreement and its Attachments
- Changes to the Project Consortium Plan after approval of ERA-PLANET General Assembly
- Any other decision related to the project

Evolution of the consortium:

- Withdrawal of a Party from the Project Consortium and the approval of the settlement on the conditions of the withdrawal
- Identification of a breach by a Party of its obligations under this Consortium Agreement
- Declaration of a Party to be a Defaulting Party
- Remedies to be performed by a Defaulting Party
- Proposal to the ERA-PLANET General Assembly for a change of the Project Coordinator
- Proposal to the ERA-PLANET General Assembly for suspension of all or part of the Project
- Proposal to the ERA-PLANET General Assembly for termination of the Project and the Consortium Agreement
- Replacements of WP leaders of Project, as needed.

6.3.2 Project Executive Board

In addition to the rules described in Section 6.2, the following rules apply:

6.3.2.1 Members

The Executive Board shall consist of the Project Coordinator, the Project Work Package Leaders and Project Task Leaders. Other members shall be allowed to participate to the Executive Board upon invitation but have not voting rights.

The Project Coordinator shall chair all meetings of the Project Executive Board, unless decided otherwise by a majority of the Executive Board.

6.3.2.2 Functions and Decisions

The Project Executive Board will propose on key issues of the project such as policy objectives, dissemination strategy and project activity.
In particular, the Project Executive Board shall:

- prepare the meetings, propose decisions and prepare the agenda of the General Assembly according to Section 6.3.1.2
- seek a consensus among the Parties
- be responsible for the proper execution and implementation of the decisions of the General Assembly
- monitor the effective and efficient implementation of the Project
- collect information on the progress of the Project at least every 6 months, collect and approve the deliverables, examine that information to assess the compliance of the Project with the Project Consortium Plan and, if necessary, propose modifications of the Consortium Plan to the General Assembly
- prepare the content and timing of press releases and joint publications by the Project Consortium,

6.3.2.3 Minutes of meetings

Minutes of the Project Executive Board meetings, once accepted, shall be sent by the Project Coordinator to the Project General Assembly Members and to the ERA-PLANET Coordinator for information.

6.3.3 Project Coordinator

6.3.3.1 Main role

The Project Coordinator is the entity acting as the intermediary between the Parties and the ERA-PLANET Consortium Bodies and shall perform all tasks assigned to it as described in the Grant Agreement and in this Consortium Agreement.

If the Coordinator fails in its coordination tasks, the Project General Assembly may propose to the ERA-PLANET General Assembly to change the Project Coordinator.

The Project Coordinator shall not be entitled to act or to make legally binding declarations on behalf of any other Party or of the Project Consortium, unless explicitly stated otherwise in the Grant Agreement or this Consortium Agreement.

The Project Coordinator shall not enlarge its role beyond the tasks specified in this Consortium Agreement and in the Grant Agreement.

6.3.3.2 Functions and Decisions

In particular, the Project Coordinator shall:

- monitor the progress of the project in collaboration with the Executive Board
- monitor compliance by the Parties with their obligations
- convene and chair Project General Assembly and Project Executive Board meetings of the project
- keep the address list of Members and other contact persons updated and available
- collect, review to verify consistency and submit reports, other deliverables (including financial statements and related certifications) and specific requested documents to the ERA PLANET coordinator
- transmit documents and information connected with the Project to any other Parties concerned and to the ERA-PLANET Coordinator
- provide, upon request, the Parties with official copies or originals of documents which are in the sole possession of the Project Coordinator when such copies or originals are necessary for the Parties to present claims.

If one or more of the Parties is late in submission of any project deliverable, the Project Coordinator may nevertheless submit the other Parties' project deliverables and all other documents required by the Grant Agreement.

6.3.4 Project Management Support Team

Supports the Project coordinator during the different phases of the project and care the relationship with the Parties.

6.3.5 Trans-national Project Work Package Leaders and Task Leaders

In addition to the rules described in Section 6.2, the following rules apply:

6.3.4.1 Functions and Decisions

A Party that is Project Work Package Leader shall, within its Project:

- manage the whole Work Package in coordination with the different Task Leaders and ensure full coverage of the Work Package activities,
- assist the Parties in performing their respective activities in the Work Package,
- coordinate the Work Package activities with the other Work Package Leaders in order to develop a coherent working methodology and to avoid overlapping of work,
- provide the Project Coordinator with regular activity reports, collecting the information from the different Task Leaders involved in the Work Package and meeting the deadlines established by the Coordinator or indicated in the Consortium Plan,
- provide upon request information on financial aspects to the Project Coordinator.

A Party that is Task Leader shall, within its Project:

- manage the task in coordination with the Work Package Leader and ensure full coverage of the task activities,
- assisting the Parties in performing their respective activities within the task,

- coordinate the task activities with the other Project Task Leaders and Project Work Package Leaders in order to develop a coherent working methodology and avoid overlapping of work,
- provide the Project Work Package Leader with regular activity reports, meeting the deadlines established by the Project Work Package Leader or indicated in the Project Consortium Plan,
- provide upon request information on financial aspects to the Project Coordinator and/or the Project Work Package Leader.

The transfer of responsibility for Work Package and task leadership may be done by mutual consent of the Party leaving the Work Package/task responsibility and the Party taking in charge the Work Package/task responsibility. Transfer of Work Package/task responsibility within the Project shall be approved by the Project General Assembly upon proposal of the Project Coordinator. The Party taking the Work Package/task responsibility must ensure to the Project Consortium its capacity to dedicate the human, financial and intellectual resources necessary to assume its new role.

Changes in the Project Work Package/task content and timeline could be necessary. Any change shall be approved by the Project General Assembly.

6.4 External Advisory Boards

6.4.1 Advisory Boards

The Project has external advisory boards (“Advisory Board”) to help the Project Consortium in particular matters. Advisory Boards and their members will be appointed and steered by the Project Executive Board. The Project Coordinator will ensure that a non-disclosure agreement is executed between all Parties and each Advisory Board member. Its terms shall be not less stringent than those stipulated in this Consortium Agreement, and it shall be concluded no later than 30 calendar days after their nomination or before any confidential information will be exchanged, whichever date is earlier. The Advisory Board members shall be allowed to participate in Project General Assembly meetings upon invitation but have not any voting rights.

6.4.1.1 Policy Advisory Board

The Policy Advisory Board will care the interaction among the policy makers and the stakeholders (private or public).

6.4.1.2 Scientific Advisory Board

The Scientific Advisory Board will care the scientific interaction with the stakeholders (private or public).

6.4.1.3 Stakeholder Network

The stakeholder network is composed by the project stakeholders that are the main targets of the project outcomes.

6.4.2 Preparation and organisation of meetings

Meetings of each External Advisory Board may also be held by teleconference or other telecommunication means.

The chairperson of a External Advisory Board shall convene meetings of that External Advisory Board as indicated below:

	Ordinary meeting	**Extraordinary meeting**
Policy Advisory Board	At least once a year	At any time upon written request of any Member of the Policy Advisory Board or the Project coordinator
Scientific Advisory Board	At least once per a year	At any time upon written request of any Member of the Board or the Project coordinator
Stakeholder Network	At least once per a year	At any time upon written request of any Member of the Network or the Project coordinator

The chairperson of a External Advisory Board shall give notice in writing of a meeting to each Member of that Board as soon as possible and no later than the minimum number of days preceding the meeting as indicated below:

	Ordinary meeting	**Extraordinary meeting and teleconference meetings**
Policy Advisory Board	14 calendar days	7 calendar days
Scientific Advisory Board	14 calendar days	7 calendar days
Stakeholder Network	14 calendar days	7 calendar days

The chairperson of a External Advisory Board shall prepare and send each Member of that External Advisory Board an agenda no later than 14 days preceding the meeting (7 days for extraordinary meetings).

Any agenda item requiring a decision by the Members of a External Advisory Board must be identified as such on the agenda.

Section 7: Financial provisions

7.1 General Principles

7.1.1 Overview

The budget amount allocated in a Project is under the sole responsibility of the Party.

The contributions to support the Project consist of the national/regional contributions as defined in the Annex 2 of the Grant Agreement and the EU funding (EU-Top-Up).

Each Party's share of the Consortium Budget consists of such Party's Co-Fund plus such Party's EU-Top-Up, see section 7.4.

7.1.2 Distribution of the EU Funding

The EU-Top-Up for each Party shall be distributed by the ERA PLANET Coordinator according to:

- the ERA-PLANET Consortium Plan (Annex 1 and 2 of the ERA-PLANET Grant Agreement)
- the approval of reports by the European Commission, and
- the provisions of payment in Sections 7.2, 7.3 and 7.4 of this Consortium Agreement.

7.1.3 Justifying costs towards the European Commission

In accordance with its own usual accounting and management principles and practices, each Party shall be solely responsible for justifying its costs with respect to the Project towards the European Commission. Neither the Coordinator nor any of the other Parties shall be in any way liable or responsible for such justification of costs towards the European Commission.

7.1.4 Financial consequences of the termination of the participation of a Party

A Party leaving the consortium shall refund all payments it has received except the amount of contribution accepted by the European Commission. Furthermore, a defaulting Party shall, within the limits specified in Section 5.2 of this Consortium Agreement, bear any reasonable and justifiable additional costs occurring to the other Parties in order to perform its and their tasks.

7.2 Payments

Payments to Parties are the exclusive tasks of the ERA-PLANET Coordinator. The ERA-PLANET Coordinator shall transfer any funds directly to the Parties involved in the Projects.

Related banking and transaction costs are borne by the receiving Party.

Payments shall reflect budget approval and payment schedule of the Project.

In particular, the ERA-PLANET Coordinator shall:

- notify the Party concerned promptly of the date and composition of the amount transferred to its bank account, giving the relevant references
- perform diligently its tasks in the proper administration of any funds and in maintaining financial accounts

With reference to Article 21.2 of the Grant Agreement, no Party shall before the end of the Project receive more than its allocated share of the maximum grant amount from which the amounts retained by the European Commission for the Guarantee Fund and for the payment of the balance have been deducted.

The payment schedule will be handled according to the provisions of this Consortium Agreement (section 7.4.3.).

The provisions under Article 7.2 do not concern Parties not eligible to receive EU funding.

7.3 Withholding of payments

The ERA-PLANET Coordinator is entitled to withhold any payments due to a Party identified by a responsible Consortium Body to be in breach of its obligations under this Consortium Agreement. The ERA-PLANET Coordinator is entitled to recover any payments already paid to a defaulting Party. The ERA-PLANET Coordinator is equally entitled to withhold payments to a Party when this is suggested by or agreed with the European Commission.

7.4 Budgeting

The budget of each Party participating to the Project is given by the sum of Direct costs (in-kind and/or cash) and the indirect costs (see Annex 2 to the Grant Agreement).

The eligible costs of each Party within iCUPE are reported in the following Budget Table:

ICUPE

No	Participant (acronym)	Country	(A) Direct personnel costs /€	(B) Other direct costs /€	(C) Direct costs of sub-contracting /€	(D) Costs of in-kind contribution not used on the beneficiary's premises /€	(E) Indirect Costs /€ (=0.25(A+B-D))	(F) Total estimated eligible costs /€ (=A+B+C+E)	(G) Reimbursement rate (%)	(H) Max. EU Contribution /€ (=F*G)	(I) Requested EU Contribution/€
37	UHEL	Finland	670.000,00	162.500,00	-	-	208.125,00	1.040.625,00	0,33	343.406,25	343.275,00
1	CNR	Italy	1.198.129,30	266.840,40	-	-	366.242,43	1.831.212,13	0,33	604.300,00	604.300,00
2	AU	Denmark	359.457,89	246.603,03	-	-	151.515,23	757.576,15	0,33	250.000,13	250.000,00
5	AWI	Germany	339.465,00	896.000,00	-	-	308.866,25	1.544.331,25	0,33	509.629,31	442.300,00
7	CNRS	France	658.748,00	-	-	-	164.687,00	823.435,00	0,33	271.733,55	265.000,00
11	EULS	Estonia	317.000,00	47.000,00	-	-	91.000,00	455.000,00	0,33	150.150,00	150.000,00
14	FMI	Finland	326.000,00	19.000,00	-	-	86.250,00	431.250,00	0,33	142.312,50	142.000,00
17	GFZ	Germany	502.149,00	79.872,00	-	-	145.505,25	727.526,25	0,33	240.083,66	240.000,00
18	HZG	Germany	171.450,00	46.732,00	-	-	54.545,50	272.727,50	0,33	90.000,08	90.000,00
25	NCSR	Greece	147.000,00	23.000,00	-	-	42.500,00	212.500,00	0,33	70.125,00	70.000,00
30	TROPOS	Germany	79.800,00	43.000,00	-	-	30.700,00	153.500,00	0,33	50.655,00	50.000,00
36	SU	Sweden	240.000,00	10.000,00	-	-	62.500,00	312.500,00	0,33	103.125,00	103.125,00
27	PSI	Switzerland	456.767,00	165.325,00	-	-	155.523,00	777.615,00	-	-	-
		Total	**5.465.966,19**	**2.005.872,43**	-	-	**1.867.959,66**	**9.339.798,28**		**2.825.520,48**	**2.750.000,00**

The Parties shall report cost categories according to the rules in the Grant Agreement.

Parties not receiving EU funding (mentioned in EU REGULATION N. 1290/2013 of the European Parliament and of the Council of 11 December 2013), like for example the Swiss Parties, are Beneficiaries as all other members of the Consortium and therefore must implement the action task

attributed to them in Grant Agreement Annex 1, including those for implementation of Trans-national Projects, whilst their estimated costs are shown in Annex 2 (though not eligible) and must comply with the obligations under the Grant Agreement. However, not all of the obligations under the Grant Agreement and this Consortium Agreement apply to such Parties receiving no EU funding. Rules and not-applicable provisions are given in the Grant Agreement, Article 9.

7.4.1 Budget Share of the Parties in the Project

A Party shall be reimbursed only for the tasks carried out in the Project.

A Party that spends more than its allocated share will be reimbursed only in respect of duly justified eligible costs up to an amount not exceeding that share. Costs are only eligible for funding if they have incurred between the Start and End Dates of the Project.

7.4.2 Payment Payment to Parties

Payments to Parties of the Project will be made in accordance with the Art. 21 of Grant Agreement and the ERA-PLANET Consortium Agreement, in the following separate instalments as agreed below:

- 81 % (80% + 1%) on receipt of the second pre-financing payment by the European Commission, based on actual requested funding following call evaluation results;
- 14 % (max) on receipt of the balance payment by the European Commission. The payment is subject to the approval of the final report by the European Commission (for each Party the reporting period is from the Start Date and the End Date of the Project). The payment of the balance reimburses the remaining part of the eligible cost incurred by the Parties for the implementation of the Project.
- 5 % on receipt of the payment by the European Commission of the Guarantee Fund.

iCUPE				I Pre-financing	II Pre-financing	TOTAL Pre-financing	GUARANTEE FUND	BALANCE
		Requested EU Contribution/€	IMPLEMENTATION COST (IC) ERA-PLANET WPL	1%	80%		5%	
37	UHEL	€ 343.275,00		€ 3.432,75	€ 274.620,00	€ 278.052,75	€ 17.163,75	€ 48.058,50
1	CNR	€ 604.300,00	€ 68.150,00		€ 415.290,00	€ 483.440,00	€ 30.215,00	€ 90.645,00
2	AU	€ 250.000,00		€ 2.500,00	€ 200.000,00	€ 202.500,00	€ 12.500,00	€ 35.000,00
5	AWI	€ 442.300,00		€ 4.423,00	€ 353.840,00	€ 358.263,00	€ 22.115,00	€ 61.922,00
7	CNRS	€ 265.000,00		€ 2.650,00	€ 212.000,00	€ 214.650,00	€ 13.250,00	€ 37.100,00
11	EULS	€ 150.000,00		€ 1.500,00	€ 120.000,00	€ 121.500,00	€ 7.500,00	€ 21.000,00
14	FMI	€ 142.000,00		€ 1.420,00	€ 113.600,00	€ 115.020,00	€ 7.100,00	€ 19.880,00
17	GFZ	€ 240.000,00		€ 2.400,00	€ 192.000,00	€ 194.400,00	€ 12.000,00	€ 33.600,00
18	HZG	€ 90.000,00		€ 900,00	€ 72.000,00	€ 72.900,00	€ 4.500,00	€ 12.600,00
25	NCSR	€ 70.000,00		€ 700,00	€ 56.000,00	€ 56.700,00	€ 3.500,00	€ 9.800,00
30	TROPOS	€ 50.000,00		€ 500,00	€ 40.000,00	€ 40.500,00	€ 2.500,00	€ 7.000,00
36	SU	€ 103.125,00		€ 1.031,25	€ 82.500,00	€ 83.531,25	€ 5.156,25	€ 14.437,50
27	PSI	€ 0,00		€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00
	TOTAL	**€ 2.750.000,00**	**€ 68.150,00**	**€ 21.457,00**	**€ 2.131.850,00**	**€ 2.221.457,00**	**€ 137.500,00**	**€ 391.043,00**

7.5 Insufficient financial contribution of the European Commission

In the unlikely case that the financial contribution of the European Commission is not sufficient to contribute to the costs of the Project in the planned way the Parties agree to use the procedure described in the paragraph 7.5.1 of the ERA-PLANET Consortium Agreement.

The provisions under Article 7.5 do not concern Parties not eligible to receive EU funding.

7.6 Return of excess payments; receipts

In any case of a Party having received excess payments, the Party has to return the relevant amount to the ERA-PLANET Coordinator without undue delay upon request by the ERA-PLANET Coordinator.

In case a Party earns any receipt that is deductible from the total funding as set out in the Consortium Plan, the deduction is only directed toward the Party earning such income. The other Parties' financial share of the budget shall not be affected by one Party's receipt. In case the relevant receipt is more than the allocated share of the Party as set out in the Consortium Plan, the Party shall reimburse the funding reduction suffered by other Parties.

Section 8: Results

8.1 Ownership of Results

8.1 Ownership of Results

For the avoidance of doubt, the term "Results" in this Consortium Agreement refers to the Results generated by the funded Projects.

Results are owned by the Party that generates them. .

Two or more Parties own Results jointly if:

(a) They have jointly generated them and

(b) It is not possible to:

(1) establish the respective contribution of each Party, or

(2) separate them for the purpose of applying for, obtaining or maintaining their protection.

Regarding the digital research data generated in the action, ownership of Results must be specified in compliance with the Data Management Plan (produced as a living document within ICUPE).

Unless otherwise agreed:

- each of the joint owners shall be entitled to use their jointly owned Results for non-commercial activities on a royalty-free basis, and without requiring the prior consent of the other joint owner(s), and
- each of the joint owners shall be entitled to otherwise exploit the jointly owned Results and to grant non-exclusive licenses to third parties (without any right to sub-license), if the other joint owners are given:
    a. at least 45 calendar days advance notice; and
    b. Fair and Reasonable compensation.

8.2 Dissemination of own Results

For the avoidance of doubt, nothing in this Section 8.2 has impact on the confidentiality obligations set out in Section 10.

During the Project and for a period of 1 year after the end of the Project, the dissemination of own Results by one or several Parties, including but not restricted to publications and presentations, shall be governed by the procedure of Article 29.1 of the Grant Agreement subject to the following provisions.

Prior notice of any planned publication shall be given to the other Parties at least 45 calendar days before the publication. Any objection to the planned publication shall be made in accordance with the Grant Agreement in writing to the Coordinator and to the Party or Parties proposing the dissemination within 30 calendar days after receipt of the notice. If no objection is made within the time limit stated above, the publication is permitted.

An objection is justified if:

a) the protection of the objecting Party's Results or Background would be adversely affected
b) the objecting Party's legitimate academic or commercial interests in relation to the Results or Background would be significantly harmed.

The objection has to include a precise request for necessary modifications.

If an objection has been raised the involved Parties shall discuss how to overcome the justified grounds for the objection on a timely basis (for example by amendment to the planned publication and/or by protecting information before publication) and the objecting Party shall not unreasonably continue the opposition if appropriate measures are taken following the discussion.

The objecting Party can request a publication delay of not more than 90 calendar days from the time it raises such an objection. After 90 calendar days, the publication is permitted, provided that Confidential Information of the objecting Party has been removed from the publication as indicated by the objecting Party.

8.3 Dissemination of another Party's unpublished Results or Background

For the avoidance of doubt, nothing in this Section 8.3 has impact on the confidentiality obligations set out in Section 10.

A Party shall not include in any dissemination activity another Party's Results or Background without obtaining the owning Party's prior written approval, unless they are already published.

8.4 Use of names, logos or trademarks

Nothing in this Consortium Agreement shall be construed as conferring rights to use in advertising, publicity or otherwise the name of the Parties or any of their logos or trademarks without their prior written approval.

Section 9: Access Rights

For the avoidance of doubt, this section refers to the Access Rights of the ICUPE Parties and does not include the background/ results of other projects.

In Attachment 3, the Parties have identified and agreed on the Background for the Project and have also, where relevant, informed each other that Access to specific Background is subject to legal restrictions or limits.

Anything not identified in Attachment 3 shall not be the object of Access Right obligations regarding Background.

Any Party may add further own Background to Attachment 3 during the Project by written notice to the other Parties. However, approval of the Project General Assembly is needed should a Party wish to modify or withdraw its Background in Attachment 3.

9.1 General Principles

Each Party shall implement its tasks in accordance with the Consortium Plan and shall bear sole responsibility for ensuring that its acts within the Project do not knowingly infringe third party property rights.

Any Access Rights granted expressly exclude any rights to sublicense unless expressly stated otherwise.

Access Rights shall be free of any administrative transfer costs.

Access Rights are granted on a non-exclusive basis.

Results and Background shall be used only for the purposes for which Access Rights to it have been granted.

All requests for Access Rights shall be made in writing.

The granting of Access Rights may be made conditional on the acceptance of specific conditions aimed at ensuring that these rights will be used only for the intended purpose and that appropriate confidentiality obligations are in place.

The requesting Party must show that the Access Rights are needed.

The Parties herewith agree that the Swiss national authority funding Swiss Beneficiaries not receiving EU funding shall not be considered a third party in the sense of Article 11 of the ERA-PLANET Grant Agreement. In particular, such Beneficiaries are allowed to communicate to their national funding agency any Confidential Information (such as but not limited to project reports) required by such national funding agency. Other Parties being in similar conditions will consider these requirements, where necessary.

9.2 Access Rights for implementation

Access Rights to Results and Background needed for the performance of the own work of a Party under the Project shall be granted on a royalty-free basis.

9.3 Access Rights for Exploitation

Access Rights to Results if needed for exploitation of a Party's own Results shall be granted on a royalty-free basis, accordingly to ERA-PLANET Consortium Agreement (art. 10).

Access Rights to Background if Needed for Exploitation of a Party's own Results, including for research on behalf of a third party, shall be granted on Fair and Reasonable conditions.

A request for Access Rights may be made up to twelve months after the end of the Project or, in the case of a non-defaulting Party leaving voluntarily and with the other Parties' consent, up to twelve months after the termination of the requesting Party's participation in the Project.

9.4 Access Rights for Parties entering or leaving the consortium

As regards Results developed before the accession of the new Party, the new Party will be granted Access Rights on the conditions applying for Access Rights to Background.

Access Rights granted to a Defaulting Party and such Party's right to request Access Rights shall cease immediately upon receipt by the Defaulting Party of the formal notice of the decision of the General Assembly to terminate its participation in the Consortium.

A non-defaulting Party leaving voluntarily and with the other Parties' consent shall have Access Rights to the Results developed until the date of the termination of its participation.

It may request Access Rights within the period of time specified in Section 10.4.

Any Party leaving the Project shall continue to grant Access Rights pursuant to the Grant Agreement and this Consortium Agreement as if it had remained a Party for the whole duration of the Project.

Section 10: Non-disclosure of information and confidentiality

10.1 Scope

All information disclosed by a Party to any other Party in connection with this Project will be considered as "*Confidential Information*" only if:

- it has been explicitly marked as "confidential" at the time of disclosure; or
- in case such information was disclosed orally, it has been identified as "confidential" at the time of disclosure, and has been confirmed and designated in writing within 15 calendar days from oral disclosure at the latest as Confidential Information by the Disclosing Party.

10.2. Approach

The Recipients hereby undertake in addition and without prejudice to any commitment of non-disclosure under the Grant Agreement, for a period of 4 years after the end of the Project:

- not to use Confidential Information otherwise than for the purpose for which it was disclosed;
- not to disclose Confidential Information to any third party without the prior written consent by the Disclosing Party;
- to ensure that internal distribution of Confidential Information by a Recipient shall take place on a strict need-to-know basis; and
- to return to the Disclosing Party on demand all Confidential Information which has been supplied to or acquired by the Recipients including all copies thereof and to delete all information stored in a machine readable form. The Recipients may keep a copy to the extent it is required to keep, archive or store such Confidential Information because of compliance with applicable laws and regulations or for the proof of on-going obligations.

10.3 Range

The Recipients shall be responsible for the fulfilment of the above obligations on the part of their employees or third parties involved in the Project and shall ensure that they remain so obliged, as far as legally possible, during and after the end of the Project and/or after the termination of the contractual relationship with the employee or third party.

10.4 Exception

The above shall not apply for disclosure or use of Confidential Information, if and as far as the Recipient can show that:

- the Confidential Information becomes publicly available by means other than a breach of the Recipient's confidentiality obligations;
- the Disclosing Party subsequently informs the Recipient that the Confidential Information is no longer confidential;
- the Confidential Information is communicated to the Recipient without any obligation of confidence by a third party who is to the best knowledge of the Recipient in lawful possession thereof and under no obligation of confidence to the Disclosing Party;

- the disclosure or communication of the Confidential Information is foreseen by provisions of the Grant Agreement;
- the Confidential Information, at any time, was developed by the Recipient completely independently of any such disclosure by the Disclosing Party;
- the Confidential Information was already known to the Recipient prior to disclosure or
- the Recipient is required to disclose the Confidential Information in order to comply with applicable laws or regulations or with a court or administrative order, subject to the provision Section 11.7 hereunder.

10.5 Handling

The Recipient shall apply the same degree of care with regard to the Confidential Information disclosed within the scope of the Project as with its own confidential and/or proprietary information, but in no case less than reasonable care.

10.6 Unauthorised disclosure

Each Party shall promptly advise the other Parties in writing of any unauthorised disclosure, misappropriation or misuse of Confidential Information after it becomes aware of such unauthorised disclosure, misappropriation or misuse.

10.7 Disclosing Confidential Information in order to comply with applicable laws or regulations

If any Party becomes aware that it will be required, or is likely to be required, to disclose Confidential Information in order to comply with applicable laws or regulations or with a court or administrative order, it shall, to the extent it is lawfully able to do so, prior to any such disclosure

- notify the Disclosing Party, and
- comply with the Disclosing Party's reasonable instructions to protect the confidentiality of the information.

The confidentiality obligations under this Consortium Agreement shall not prevent the obligations arising from the GA concerning the communication with the European Commission.

Section 11: Data Management

Appropriate and secure use of material and data of the Project will be enabled according to the application of common standards. iCUPE project has to provide its data management plan according to the "Guidelines on FAIR Data management in Horizon 2020" (version July 2016) - link: http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf, and according to ERA-PLANET Data Management Plan (Deliverable 4.5).

The collected data will be protected and secured, in order to avoid a malevolent use of it.

Section 12: Miscellaneous

12.1 Attachments, inconsistencies and severability

This Consortium Agreement consists of:

- this core text
- Attachment 1 (List of amendments)
- Attachment 2 (Accession document)
- Attachment 3 (Background included)
- Attachment 4 (Description of the Project - i.e. the initial project proposal, Part B, Technical Annexes 1-3)

In case the terms of this Consortium Agreement are in conflict with the terms of the Grant Agreement, the terms of the latter shall prevail. In case of conflicts between the attachments and the core text of this Consortium Agreement, the latter shall prevail.

Should any provision of this Consortium Agreement become invalid, illegal or unenforceable, it shall not affect the validity of the remaining provisions of this Consortium Agreement. In such a case, the Parties concerned shall be entitled to request that a valid and practicable provision be negotiated which fulfils the purpose of the original provision.

12.2 No representation, partnership or agency

Except if otherwise provided in Section 6, no Party shall be entitled to act or to make legally binding declarations on behalf of any other Party or of the Consortium. Nothing in this Consortium Agreement shall be deemed to constitute a joint venture, agency, partnership, interest grouping or any other kind of formal business grouping or entity between the Parties.

12.3 Notices and other communication

Any notice to be given under this Consortium Agreement shall be in writing to the addresses and recipients as listed in the most current address list kept by the Coordinator.

Formal notices:

> If it is required in this Consortium Agreement (e.g. Section 4.2, 13.4) that a formal notice, consent or approval shall be given, such notice shall be signed by an authorised representative of a Party and shall either be served personally or sent by mail with recorded delivery or telefax with receipt acknowledgement.

Other communication:

> Other communication between the Parties may also be effected by other means such as e-mail with acknowledgement of receipt, which fulfils the conditions of written form.

Any change of persons or contact details shall be notified immediately by the respective Party to the Coordinator. The address list shall be accessible to all concerned.

12.4 Assignment and amendments

No rights or obligations of the Parties arising from this Consortium Agreement may be assigned or transferred, in whole or in part, to any third party without the other Parties' prior formal approval.

Amendments and modifications to the text of this Consortium Agreement not explicitly listed in Section 6.3.1.2 requires a separate written agreement to be signed between all Parties.

12.5 Mandatory national law

Nothing in this Consortium Agreement shall be deemed to require a Party to breach any mandatory statutory law under which the Party is operating.

12.6 Language

This Consortium Agreement is drawn up in English, which language shall govern all documents, notices, meetings, arbitral proceedings and processes relative thereto.

12.7 Applicable law

This Consortium Agreement shall be construed in accordance with and governed by the laws of Belgium excluding its conflict of law provisions.

12.8 Settlement of disputes

The parties shall endeavour to settle their disputes amicably.

In case of a conflict of opinion, which cannot be solved within the respective Consortium Body or between the respective Consortium Bodies, the Project Coordinator shall be approached for advice. He/She may decide to seek a decision of the General Assembly in order to come to a solution. If the Project Coordinator is involved in the conflict, the members of the Executive Board not involved in the conflict should take over this role.

Should the attempts to settle the dispute within the Consortium fail to bring about a full agreement between the Parties the Consortium will try to solve it through arbitration.

All disputes arising out of or in connection with this Consortium Agreement, which cannot be solved amicably, shall be finally settled under the Rules of Arbitration of the International Chamber of Commerce by one or more arbitrators appointed in accordance with the said Rules. The place of arbitration shall be Brussels if not otherwise agreed by the conflicting Parties. The award of the arbitration will be final and binding upon the Parties. Nothing in this Consortium Agreement shall limit the Parties' right to seek injunctive relief in any applicable competent court.

Section 13: Signatures

AS WITNESS:

The Parties have caused this Consortium Agreement to be duly signed by the undersigned authorised representatives in separate signature pages the day and year first above written.

37. Helsingin yliopisto (UHEL), Finland

Project Legal Signatory

HANNU KOSKINEN

6.11.2017

Signature

Role Head of Dept. of Physics

1. Consiglio Nazionale delle Ricerche (CNR), Italy

Project Legal Signatory : NICOLA PIRRONE

Signature: Nicola Pirrone

Role: DIRECTOR OF CNR-IIA

2. Aarhus University (AU), Denmark

AARHUS UNIVERSITET

Project Legal Signatory

Signature

8 NOV. 2017

Role

Anette P. Miltoft
Head of
Corporate Relations
and Technology Transfer
Aarhus University

5. Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), Germany

Project Legal Signatory		
	Prof. Dr. Antje Boetius	Dr. Karsten Wurr
Signature		
Role		
	Director	Administative Director

7. Centre National de la Recherche Scientifique (CNRS), France

Project Legal Signatory

Pour le Président du CNRS
Par délégation
le Délégué régional Ile-de-France Ouest&Nord
L'Adjointe au Délégué régional
Ana Claudia FONSECA BREFE

Signature

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
Délégation Ile-de-France Ouest & Nord

Role

11. Estonian University of Life Sciences (EULS), Estonia

Project Legal Signatory Ille Jaakma

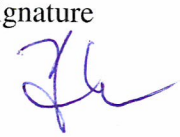
Signature

Role Vice Rector of Research

14. Finnish Meteorological Insitute (FMI), Finland

Project Legal Signatory

Signature



Role Yrjö Viisanen
Research Director

17. Helmholtz Zentrum Potsdam GFZ Deutsches GeoForschungsZentrum (GFZ), Germany

Project Legal Signatory

Signature

Role

18. Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH (HZG), Germany

Project Legal Signatory

Signature

Role

M. Ganß
Director

ppa. Dr. T. Kleber-Janke
Deputy Scientific
Director

Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung GmbH
06. NOV. 2017

25. N.C.S.R. Demokritos, Institute of Nuclear Technology and Radiation Protection (NCSR), Greece

Project Legal Signatory

Director of N.C.S.R. "Demokritos"
& Chairman of the Board
Georgios Nounesis

Signature

Role

27. Paul Scherrer Institut (PSI), Switzerland

Project Legal Signatory

A. Wokaun

U. Baltensperger

Signature

Prof. Dr. Alexander Wokaun
Division Head

Prof. Dr. Urs Baltensperger
Project Manager

Role

08-11-2017

PAUL SCHERRER INSTITUT
PSI
5232 Villigen PSI, Schweiz

30. Leibniz Institute for Tropospheric Research (TROPOS), Germany

Project Legal Signatory Prof. Dr. Andreas Macke

Signature

Role Director

Leibniz-Institut
für Troposphärenforschung e.V.
Permoserstraße 15
04318 Leipzig
Telefon: (0341) 2717 7060

36 Stockholms Universitet (SU), Sweden

Project Legal Signatory

Signature

Maryam Hansson Edalat
Head of Research Support Office
Stockholm University

Role

Stockholms universitet

Attachment 1: List of amendments

Empty page until a new Amendment will be approved.

Attachment 2: Accession document

Accession of a new Party to

iCUPE Consortium Agreement,

[OFFICIAL NAME OF THE NEW PARTY AS IDENTIFIED IN THE **Grant Agreement**]

hereby consents to become a Party to the Consortium Agreement identified above and accepts all the rights and obligations of a Party starting on [date].

hereby certifies that the Consortium has accepted in the meeting held on [date] the accession of [the name of the new Party] to the consortium starting [date].

This Accession document has been done in 2 originals to be duly signed by the undersigned authorised representatives.

[INSERT NAME OF THE NEW PARTY]

Project Legal Signatory

Signature

Role

[Date and Place]

Project Legal Signatory

Signature

Role

[Date and Place]

Attachment 3: Background included

According to the Grant Agreement (Article 24) Background is defined as "data, know-how or information (…) that is needed to implement the action or exploit the results". Because of this need, Access Rights have to be granted in principle, but Parties must identify and agree amongst them on the Background for the project. This is the purpose of this attachment.

As to STOCKHOLMS UNIVERSITET (SU), it is agreed between the Parties that, to the best of their knowledge

Option 1: The following background is hereby identified and agreed upon for the Project. Specific limitations and/or conditions, shall be as mentioned hereunder:

Describe Background	Specific limitations and/or conditions for implementation (Article 25.2 Grant Agreement)	Specific limitations and/or conditions for Exploitation (Article 25.3 Grant Agreement)
Background that has been generated by the researchers participating in the iCUPE Project on behalf of SU and which is relevant and needed for the proper implementation of the Project.	Access will only be granted as far as SU is legally entitled to do so. SU also excludes from its obligations to grant Access rights all Background which SU is not able to grant access rights due to third party rights.	Access will only be granted as far as SU is legally entitled to do so. SU also excludes from its obligations to grant Access rights all Background which SU is not able to grant access rights due to third party rights.

As to **PAUL SCHERRER INSTITUT**, no data, know-how or information of **PAUL SCHERRER INSTITUT** shall be Needed by another Party for implementation of the Project (Article 25.2 Grant Agreement) or Exploitation of that other Party's Results (Article 25.3 Grant Agreement).

FORM TO BE USED BY PROJECT PARTNERS FOR ANY EVENTUAL CHANGE:

As to INSERT NAME OF PARTNER, it is agreed between the Parties that, to the best of their knowledge (*please choose)*

Option 1: The following background is hereby identified and agreed upon for the Project. Specific limitations and/or conditions, shall be as mentioned hereunder:

Describe Background	Specific limitations and/or conditions for implementation (Article 25.2 Grant Agreement)	Specific limitations and/or conditions for Exploitation (Article 25.3 Grant Agreement)

Option 2: No data, know-how or information of [NAME OF THE PARTY] shall be Needed by another Party for implementation of the Project (Article 25.2 Grant Agreement) or Exploitation of that other Party's Results (Article 25.3 Grant Agreement).

Attachment 4: iCUPE Consortium Plan

ERAPLANET STRAND 4

Project proposal (Part B)

Final version
19 May 2017

COVER PAGE

Title of Proposal

Integrative and Comprehensive Understanding on Polar Environments (iCUPE)

Proposal Acronym | iCUPE

Title of Proposal

Integrative and Comprehensive Understanding on Polar Environments (iCUPE)

List of participants

ERA-PLANET Participant No	Participant Legal Name	Country
37 (Coordinator)	Helsingin yliopisto (UHEL) Tuukka Petäjä	Finland
1	Consiglio Nazionale delle Ricerche (CNR) Carlo Barbante	Italy
2	Aarhus University (AU) Andreas Massling	Denmark
5	Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) Angelika Humbert	Germany
7	Centre National de la Recherche Scientifique (CNRS) Aurelién Dommergue	France
11	Estonian University of Life Sciences (EULS) Steffen Noe	Estonia
14	Finnish Meteorological Insitute (FMI) Jyri Heilimö	Finland
17	Helmholtz Zentrum Potsdam GFZ Deutsches GeoForschungsZentrum (GFZ) Sabine Chabrillat	Germany
18	Helmholtz-Zentrum Geesthacht (HZG) Zhiyong Xie	Germany
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Proposal Acronym | iCUPE

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1. Excellence

The project "iCUPE - integrative and Comprehensive Understanding on Polar Environments" is motivated by the fact that the role of polar regions will increase in terms of megatrends such as globalization, new transport routes, demography and use of natural resources. These megatrends have environmental effects and will drastically affect e.g. regional and transported pollutant concentrations. Overall, land and ocean areas located in the polar latitudes are undergoing and will undergo substantial changes due to increased anthropogenic activities during the next 40 years. As a consequence, the polar areas face interconnected grand challenges (Figure 1.)

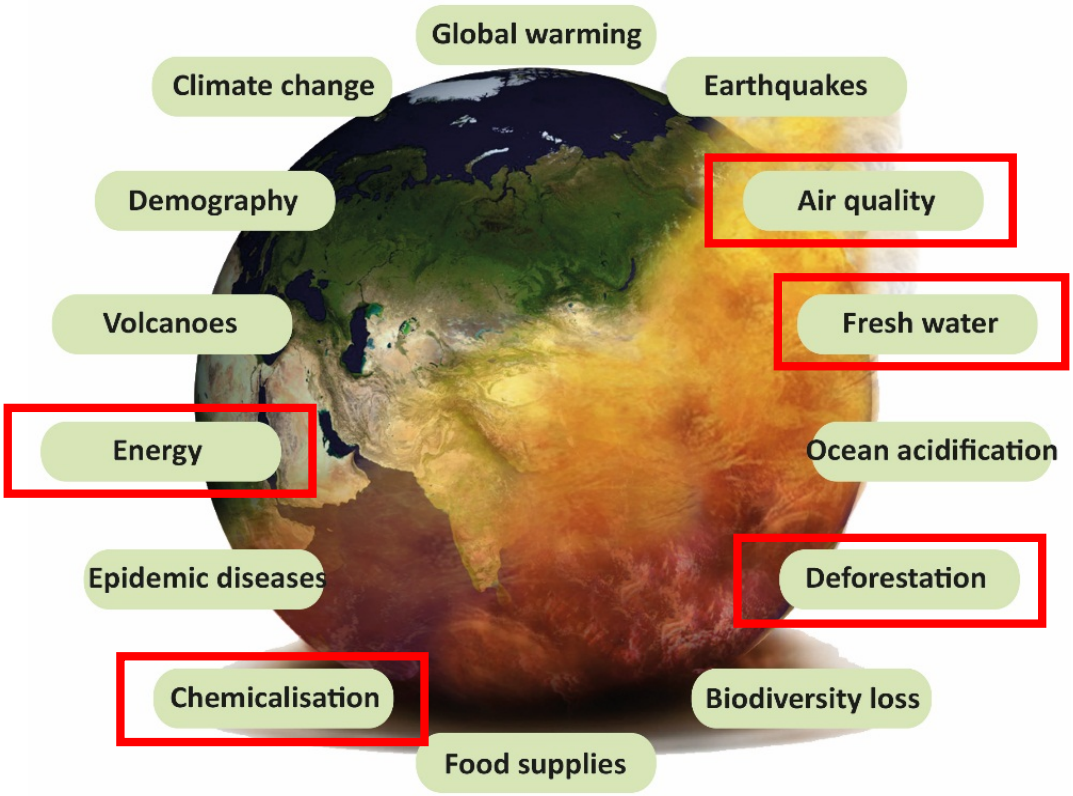

Figure 1. The interconnected grand challenges (Kulmala et al. 2015, Lappalainen et al. (2016) driven by global megatrends, such as globalization, climate change and demographics and requirements for natural resources. A particular focus on polar areas, iCUPE tackles problems arising from pollution concentrations, pollution transport, utilization of energy and consequent emissions, chemicalization and availability of natural resources with a combination of in-situ and satellite observations in combination with a set of modeling tools.

Particularly the polar areas are facing rapid changes in the coming decades (Overland et al., 2013; Ford et al., 2015). Driven by demographic development and globalization, particularly the Arctic societies, in particular, are facing several grand challenges, such as air, soil and water pollution, climate change, higher demand for resource extraction in these regions, increased anthropogenic emissions due to year-round shipping in the seas of the Arctic Ocean, and other local sources, and long-range transported pollution from Europe, Asia (Russia, China, India), and North America (e.g. Buixade Farré et al. 2014) These activities will put the fragile Arctic environment and the population living in this area in a vulnerable position. The changes will pose unpredictable consequences on food chains, biodiversity and the primary production of different plant ecosystems and ecosystem capacity to recover from the pollution exposure and environmental changes (e.g. Arnold et al. 2016).

The future warming of the Arctic will affect demographic trends by increasing urbanization and migration to northern regions, and by accelerating changes in societal issues and air quality. One major consequence of warming in the northern latitudes is related to changes in the cryosphere, including the thawing of permafrost and the Arctic Ocean becoming sea ice free part of the year (Kokeli et al., 2017; Meier et al., 2014). This will accelerate global trade activities in the Arctic region if the northern sea route is opened for shipping between the Atlantic and Asia's Far East. Northern ecosystems and Arctic regions are a source of major natural resources such as oil, natural gas and minerals. The availability and exploitation of natural resources depends also on how significantly the permafrost thaw will damage existing infrastructure.

Human activities have had a profound impact on the composition of the atmosphere and the pollution in the environment through the introduction of ever increasing quantities of heavy metals and other trace elements (Barbante et al. 2001), radioactive nuclides (Ezerinkis et al. 2014), synthesized organic compounds (Hermanson et al. 2010), aerosols such as black carbon (McConnell and Edwards, 2008), trace gases and greenhouse gases. Anthropogenic contaminants can be transported over long distances and accumulate into polar areas. Persistent Organic Pollutants (POPs, such as Polybrominated Diphenyl Ethers, PBDE, Polycyclic Aromatic Hydrocarbons, PAH, Polychlorinated Biphenyl, PCB and persistent Contaminants of Emerging Concern, CEC, Sauve and Desrosiers. 2014) are rarely produced in the Arctic, but have been found in Arctic wildlife, lake sediments, annual snow and ice (Herbert et al. 2005, Ma et al., 2011, Seki et al. 2015). Mercury and other heavy metals, such as As, Cd, and Pb, are considered toxic at any level. Their presence is generally determined by local geochemistry, but they can be emitted by human activities resulting in their increased abundance in the polar areas (Barbante et al. 2001, Zheng et al. 2015, Angot et al. 2016). Black carbon (BC), a fine component of almost pure carbon from incomplete combustion, is able to modify the snow albedo by absorbing incoming solar radiation (Jiao et al., 2014). Human activities are impacting the net abundance of these pollutants in the atmosphere, but there is a lack of data exploring the deposition patterns and the abundance of anthropogenic contaminants in polar areas. We also need an improved understanding about their redistribution into different environmental spheres including the biota of the Arctic and Antarctic and the full life cycle of these pollutants (Wöhrnschmimmer et al. 2013).

Local emissions are currently make only a small contribution to atmospheric loadings of various pollutants in polar areas, but this might change in the near future as Arctic ice-free areas will extend and more extensive Arctic shipping will become possible (Corbett et al., 2010). Nevertheless, air pollutants from other areas in the world do reach high Arctic regions and have been estimated to have significant impacts on the regional ecosystem and climate (Di Pierro et al., 2011; Breider et al., 2014). Knowledge about source contribution of atmospheric pollution is very limited and further efforts in terms of detailed source identification are urgently needed to formulate and settle mitigation strategies (e.g. Law et al. 2014). The measurements of short-lived climate pollutants, and their precursors, are necessary for evaluating the impacts of increased regional and international activities, e.g. in relation to natural resource extraction, especially in fragile Arctic environments. Correspondingly, similar activities need to be carried out in Antarctica which has a minimal amount of anthropogenic influences and can provide clean reference observations.

In relation to comprehensive in-situ observational capacity, the existing observational networks for the measurements of atmospheric concentrations of air pollutants extend to Arctic and Antarctic environments (e.g. Uttal et al. 2016). However, there are still large gaps in the current measurement networks (Lappalainen et al. 2016), and the interaction between the networks, made up of different national activities, needs to be improved. In summary, the methodology of data acquisition, data quality control and future strategies on data flows and data streams are not harmonized on either the European or global scale. Furthermore, particularly in the polar areas, measurements are not always continuous but often carried out campaign-wise due to economic, environmental or logistical challenges. Polar activities are often based on national activities and missing synergistic benefits of co-operation in the challenging environments.

Satellite remote sensing in the Arctic are based on radar and optical missions of varying spatial resolution, repeat visit times and coverage of high latitudes. Monitoring the surface variations in the Arctic region is a powerful tool to assess the impacts of changes induced into this vulnerable environment. The distribution of different type of land cover (snow, ice, vegetation, soil) can be efficiently analyzed using optical data obtained from the new satellite missions merged with data collected during field campaigns and data acquired from

cooperative observer networks. In particular, different patterns of snow cover (as well as soil and vegetation cover) exercise considerable influence on the surface energy balance, since variations in land cover change the surface albedo. While there are established methods for retrieving basic variables, changing snow and ice surfaces and ice-free areas are still challenging and the large variability of system itself is limiting the accuracy of such retrievals (Bokhorst et al. 2016). New Sentinel series of Copernicus sensors in the orbit make it possible to retrieve improved land surface variables due to increased capacities in terms of spatial, temporal and angular observations. As a consequence, new Earth Observation (EO) technics will lead to multi-mission time series needed for data assimilation into models of the Earth system compartments in the Arctic.

In summary, in order to address the current state of the environment in the polar areas and to provide fact-based decision making tools for the society in the future, comprehensive high quality observations of atmospheric concentrations of aerosols, trace gases and and related physical variables (atmosphere, ecosystem) from in-situ observations are required in concert with EO from space (Petäjä et al. 2014, Hari et al. 2016). The EO data can be used to study the interactions between different type of surface and the atmosphere. The results obtained allow us to evaluate the impact of pollutants on the equilibrium of the Arctic system and provide an important input for the evolutionary scenarios of Arctic environment. The picture needs to be harmonized and supported with complementary multi-scale modeling (e.g. Kulmala et al. 2011). The vision driving iCUPE activities is that we need to establish and maintain long-term, coherent and coordinated observations and research activities on environmental quality and natural resources in polar areas. The core idea of iCUPE is the development of novel, integrated, quality-controlled and harmonized in-situ observations and satellite data in the polar areas, as well as data products to the end users.

iCUPE is coordinated by Tuukka Petäjä from University of Helsinki (UHEL). The iCUPE consortium consists of leading European institutes and universities working in polar areas. The complementary expertise spans from comprehensive, continuous in-situ observations and campaigns in polar areas to satellite remote sensing and multi-scale modeling and impact assessments and life-cycle analysis of pollutants in the Arctic environment. The beneficiaries are UHEL, Consiglio Nazionale delle Ricerche (CNR), Aarhus University (AU), Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), Centre National de la Recherche Scientifique (CNRS), Helmholtz Zentrum Potsdam Deutsches GeoForschungsZentrum (GFZ), Helmholtz-Zentrum Geesthacht (HZG), Leibniz Institute for Tropospheric Research (TROPOS), Paul Scherrer Institut (PSI), Estonian University of Life Sciences (EULS), N.C.S.R. Demokritos, Institute of Nuclear Technology and Radiation Protection (NCSR) and Stockholm Unversitet (SU).

The consortium consists of 13 beneficiaries representing eight different countries (Finland, Italy, France, Germany, Sweden, Switzerland, Greece, Estonia) to maximize the connections to national activities and strategies in the polar areas. The complementarity of universities and research institutes facilitates provision of science-based impacts relevant to society. The expertise of the consortium provides a balanced tool-set spanning from continuous in-situ observations, satellite remote sensing and multi-scale modeling to provide novel insights into the Arctic environment both from the research point of view, from data and service provision. A more detailed description of expertise is provided in Section 4.

1.1 Objectives

The iCUPE project answers to ”European network for observing our changing planet” (ERAPLANET) thematic strand 4 (Polar areas and natural resources). By combining integrated in-situ and satellite EO with a modelling platform, iCUPE will 1) synthesize data from comprehensive long-term measurements, intensive campaigns and satellites, collected during the project or provided by on-going international initiatives 2) relate the observed parameters to impacts, and 3) deliver novel data products, metrics and indicators to the stakeholders concerning the environmental status, availability and extraction of natural resources in the polar areas. These data, metrics and indicators will be targeted to identified stakeholders. They will be useful for policy development and for improving and clearly communicating our multidisciplinary understanding of status of the polar environment and pollution dynamics in the future. The knowledge generated is relevant to the general population, policy makers and scientists.

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The work in iCUPE will integrate the ground-based and remote sensing observations in a coherent manner, improve accuracy and temporal and spatial resolution of the data and generate of novel data products suitable for decision-making and monitoring of the environmental conditions in polar regions.

The existing data and data products, as well as the data and products acquired in the future, will be curated into long-term well-documented databases and made available and ready-to-use for scientists, policy-makers and general public. With an integrated approach, the project will improve our understanding about the pollution sources and sinks, environmental and anthropogenic changes and elements of the cryosphere in polar areas by conducting high-level and high impact research by analyzing these integrated data together with the modelling frameworks.

Thematic objectives:

The iCUPE activities will be implemented based on current state-of-the-art research whilst at the same time aiming beyond the state-of-the-art with thematic aims:

- to assess the impacts of anthropogenic activities on the levels of pollution via comprehensive observations and novel proxy variables in the polar environments by utilizing long-term Arctic monitoring data, historical ice core samples and data from Antarctica as a baseline,
- to quantify the relative contributions of local and long-range transported pollution affecting the atmospheric composition, deposition and contamination cycling in the changing polar areas,
- to assess the changes in physical characteristics (e.g. snow cover, ice, permafrost, biomass, albedo) and impacts of natural resource use (gas, oil extraction, based on landscape changes and light emission) and investigating their links to ecosystems and pollution cycling in the polar areas.
- to develop a blueprint for i) retrieving new parameters, ii) new EO algorithms, iii) a concept for in-situ measurements that can be expanded to new field sites in the future,
- to develop methods for new observables and proxy variables based on current satellite missions and develop proof-of-concept strategies for future missions,
- to investigate atmospheric chemistry of halogen compounds, atmospheric oxidation capacity and their interactions with mercury life-cycle in the Arctic environment,
- to integrate existing data sources and models in order to estimate the impacts of multi-media transport of POPs, and determine their current levels in the Arctic biota and environment,
- to present an integrated picture of polar pollution via novel proxy indicators appropriate for communication to the decision makers and to the general public, and
- to fill gaps and improve data services and data products available for polar areas.

The scope of iCUPE includes both Arctic and Antarctica. Both of these areas are facing drastic environmental changes in the future. The data from Antarctica data (e.g. atmospheric in-situ and ice core data) are utilized as a background and a reference to compare with the Arctic data. This enables us to quantify anthropogenic influences and impacts of natural resource extraction in the polar areas.

Horizontal objectives:

In collaboration with the other projects in ERAPLANET, iCUPE aims:

- to facilitate European leadership and collaboration in the observation of key environmental variables,
- to foster collaboration and interoperability with relevant Joint Programming Initiatives e.g. on air pollution and health aspects,
- to improve coordination, interoperability and validation of polar in-situ and EO observations, also working in close cooperation with the existing networks and projects, and
- to optimize data streams and foster interoperability and data sharing for polar observations, in a GEOSS and Copernicus perspectives.

The proposed work and the development of integrated data products will lead to availability of integrated datasets as well as data products that various communities and stakeholders can take advantage of to develop them further e.g. with data-mining, neural network and advanced statistical techniques leaving a legacy and to assure continuity beyond iCUPE.

1.2 Relation to the work programme

iCUPE addresses the overarching objective of European Network for Observing our Changing Planet (ERA-PLANET) to simplify access to information required by decision makers and bring together and strengthen the European national and regional research and innovation programs in the EO domain. Particularly iCUPE connects to the thematic strand 4 on polar areas and natural resources by integrating national and international monitoring and assessment activities in relation to ecosystem and environment quality in Arctic and Antarctic regions.

The work in iCUPE answers to the ERAPLANET horizontal objectives and overarching goals of GEOSS and Copernicus integration by facilitating integration of the environmental pollution and sources and their transformation and impacts. The iCUPE platform takes onboard national agendas and improves co-alignment of national activities particularly in Arctic environmental observations. The iCUPE project endorses open data policies and Key Enabling Technologies (KET) via horizontal work within the ERAPLANET strands. The iCUPE work provides ground-truthing for satellites in relation to snow, precipitation and aerosol observations. Societal participation is taken into account in the iCUPE dissemination plan and via joint ERAPLANET activities. The work conducted in iCUPE leads to novel data products and services and includes impact assessments.

iCUPE has an open data policy and will implement GEOSS Data Sharing Principles with a view towards interoperability. In collaboration with other ERAPLANET projects, iCUPE will contribute to GEOSS Common Infrastructure (GCI). We will exploit Copernicus data and a wide range of EU capabilities in the EO domain. In data sharing we promote open specifications foster timely data delivery in compliance with GEOSS Data Management Principles (DMP). iCUPE will support the implementation of GEO Strategic Plan (2016-2025) (that is presented in Table 1). The project addresses several GEO tasks: Earth Data Sets, GEOSS Design and Interoperability, Oceans and Society, Impact Assessment of Human Activities and Tracking Pollutants. iCUPE will take advantage of horizontal data activities within ERAPLANET and other networks by supplying the data and will follow closely the development of sensors within other national or EU supported projects. iCUPE connects to on-going EU and national projects and networks to provide data leading to improved coordination in all steps from measurements, data processing, product development and database storage at the European level.

Table 1. Relation of iCUPE to the work programme

Goal of the GEO work programme	**iCUPE response**
To sustain the GEO initiative and development of the GEOSS system	The comprehensive approach incorporating in-situ and satellite EO contributes to the development of GEOSS system. The new data products will highlight the benefits of integrative activities and pave the way towards capacity of comprehensive environmental analysis within GEOSS.
To improve coordination and sustainability of long-term measurements with respect atmospheric pollution	Connects to national initiatives and activities and to European infrastructures performing long-term observations in the polar environments; provides new avenues for data dissemination from these activities and opens doors for coordinated design of future measurements.
To perform impact assessment in relation to increased anthropogenic activities in the Arctic	Based on the comprehensive data available via iCUPE, we are able to perform comprehensive analysis on sources of atmospheric pollution in the polar areas and explore e.g. the effects of increased natural resource extraction and other anthropogenic activities to pollution concentrations and dispersion in the Arctic environment.
To secure sustained development of the Arctic, providing more cogency information to users, stakeholders and police-makers	In collaboration with the other strand activities, iCUPE will contribute to effective data dissemination to the end users. The comprehensive approach enables self-consistency checks within the data products from different sources increasing the quality of the products.

1.3 Concept and methodology

1.3.1 Overall iCUPE concept and motivation

The motivation behind iCUPE stems from the need to answer the global grand challenges in a polar context (Figure 1). The underpinning concept of iCUPE is that trans-disciplinary research utilizing the full capacity of comprehensive in-situ observations together with state-of-the-art satellite observations is required to make advances in the understanding of atmospheric and cryospheric processes in the Arctic environment (Figure 2). Therefore, the work in iCUPE is trans-disciplinary utilizing both expertise in in-situ observations and satellite remote sensing in a close connection to modeling frameworks (Figure 3). The work is closely connected to on-going work conducted in polar areas by the consortium members and these connections enable the consortium to facilitate interactions and coordination between the national and international activities in the polar areas.

The wide spectrum of observational quantities, data products and modeled variables produced by the consortium enables the delivery of integrated data required for decisions related to the Artic pollution. The demands of the decision makers, Arctic citizens, companies involved in Arctic natural resource exploitation and local and regional authorities, in terms of the data contents and format, will be taken into account throughout the project by co-designing the project outputs in collaboration with stakeholders.

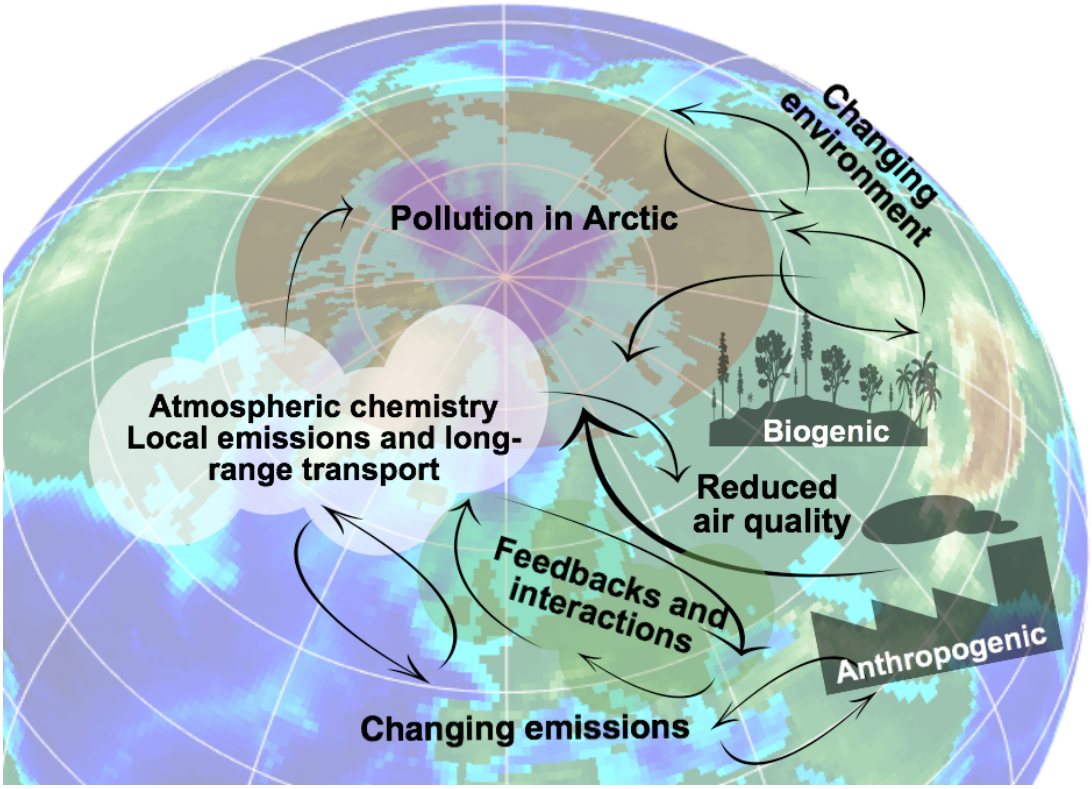

Figure 2. Atmospheric concentration of pollutants and their lifecycle in high latitudes are affected by local and regional anthropogenic activities and long-range transport from lower latitudes. Pollutant distributions and life cycles are modulated by transport patterns, changes in the biosphere, increased natural resource extraction and increased shipping in the Arctic Sea. Various feedbacks and interactions can either speed up or hinder the changes.

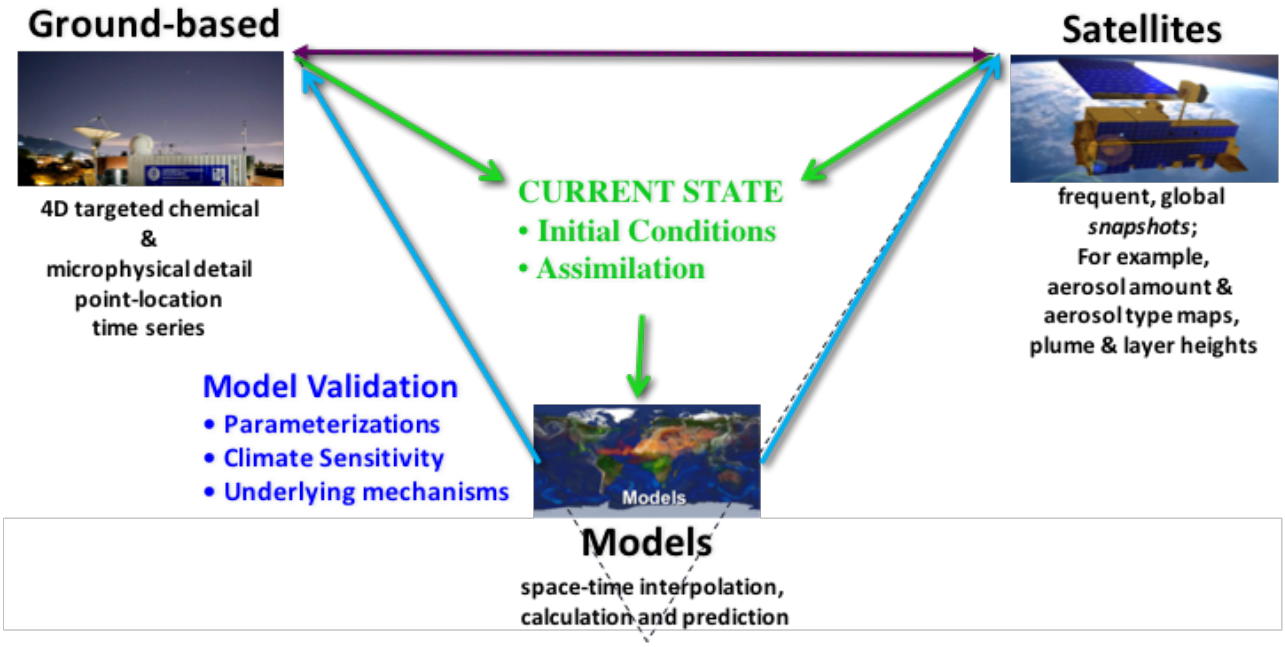

Figure 3. The integrative concept of iCUPE incorporates data and knowledge from ground-based observations, satellite remote sensing and modelling results providing a comprehensive view about the state of the environment in the polar areas.

1.3.2 Positioning iCUPE within national Arctic strategies and activities

The concept of iCUPE is to take on-board national activities and provide a platform for interactions. This facilitates synergies in a working towards a joint European Arctic actions in a cost-effective manner.

The Arctic strategy of Finland, defined in the Government Programme (2013, updated in 2016), is addressing the importance of local residents, education, research, the economy, infrastructure, the environment, stability and international cooperation in the Arctic. iCUPE strengthens the two major areas of the national Arctic strategy together with two main national instruments. (i) Stations Measuring Ecosystem Atmospheric Interactions (SMEAR) network of field stations operated in collaboration with UHEL and FMI. The stations are included in the national infrastructure roadmap and will be a significant data source for iCUPE. (ii) Pallas-Sodankylä Global Atmospheric Watch (GAW) station and National Satellite Data Centre and Finnish Copernicus Collaborative Ground station hosted by FMI. In Antarctica, UHEL and FMI conduct Antarctic research and intensive measurement campaigns in Finnish Aboa station, and in collaboration with Italy in Dome Concordia, with Germany in Neumayer III and activities are planned with United Kingdom in Halley station. The measurements in Marambio are performed in collaboration with Argentina.

Arctic strategy of Sweden, adopted in 2011, promotes economically, socially and environmentally sustainable development throughout the Arctic region. In addition, it aims to ensure that the Arctic remains a region where security policy tensions are low and addresses a strengthened role of the Arctic Council (Sweden AC chair 2011-2013, Finland 2017-2019). The iCUPE project supports these strategic aims and will deliver scientific outcomes e.g. to the Arctic Monitoring and Assessment Programme (AMAP) process. The Swedish Polar Research Secretariat gives Sweden plenty of scope to perform marine research expeditions in both the Arctic and Antarctic Oceans with the ice-breaker Oden. Within iCUPE and PEEX we are able to connect these expeditions and resulting data into European wide data providers.

The work in iCUPE contributes and supports implementation of the Danish Realm, the National Arctic Strategy and The Arctic strategy of the Ministry of Higher Education and Science. The work will strengthen Denmark's role in the Arctic climate change research and education and innovation in a field of Atmospheric and Earth System Sciences. In particular Greenland is an important stakeholder in a Danish strategy for Arctic research.

Arctic strategy of Italy released in 2015, devoted a great deal of attention to the human and environmental dimension, with an approach "*...based on the selection of actions and key instruments...including the promotion of "lessons learned" and the exchange and sharing of knowledge...".* Biodiversity protection, air pollution prevention, climate change reversal, and protection of seawaters are identified as environmental issues on which to concentrate efforts. Work in iCUPE will acquire a better knowledge on all these topics and will develop the 4D picture necessary to support sustainable politics for the Arctic. With respect to the scientific dimension of the Italian strategy, iCUPE will support the strategic aims to "*... increasing the spatial and temporal resolution of the Arctic observation system and strengthening the level of coordination among different national initiatives...*" and promote "*... the Italian participation in Arctic research as a national scientific and technological excellence...".*

The French Arctic Roadmap (2015) calls for an increased scientific cooperation in the Arctic "…in which it intends to play an active role by increasing its resources and its investment in scientific research". France calls for the implementation of more stringent environmental standards in the Arctic in order to preserve this ecologically-sensitive region which is being subject to dramatic changes and pressures.
In Germany, the strategy paper *'Rapid Climate Change in the Arctic - Polar Research as a Global Responsibility'* (2015) '*to observe the changes in the Arctic in more detail, to measure the feedback effects of polar and global processes in the Earth system and to improve prediction models*' are set as major goals. Also, it stresses the importance, from a global point of view, of protecting the Arctic environment and sees the great economic potential of Arctic resources due to sizeable oil and natural gas reserves, as well as mineral resources, along with sustainable development, biodiversity protection. Two main opportunities and risks are identified associated with economic opportunities and setting-up exemplary environmental standards. Germany engages itself in "ensuring that Arctic resources are used in a sustainable way, in the interest of the Arctic countries and of the international community, and in a way that respects the Arctic environment and indigenous peoples".

Overall, iCUPE will help us to acquire improved knowledge of the Arctic environment and promote cooperation among European countries. iCUPE will take onboard the national strategies and initiatives supporting collaborative work and facilitating the work towards a joint European vision in the polar areas.

1.3.3 Positioning iCUPE within international activities and strategies

In a global perspective, iCUPE facilitates European leadership in integration of in-situ and satellite Earth Observations and their provision to the end-users, particularly in the polar areas. The work in iCUPE benefits from a wide collaborative network available through the consortium (Table 2).

The iCUPE work will be connected to the activities within Arctic Council. The high impact of iCUPE is facilitated efficiently since the Arctic council will be chaired by Finland 2017-2018 and UHEL is an active partner in Future Earth and coordinating a thematic network on UArctic network (170 circumpolar universities). Furthermore, the iCUPE connections to national activities in the Arctic and Antactica is facilitated by e.g. European Polar Board (EPB), an independent European Organization of the major European National Polar Programmes as well as direct connections to the French Arctic Initiative, German, Swedish, Danish, Finnish and Italian activities in the polar regions.

The iCUPE project is co-aligned with Pan-Eurasian Experiment (PEEX) Program (lead by UHEL). The PEEX Program (www.atm.helsinki.fi/peex/) fosters research - research infrastructure collaboration in the fields of Atmospheric and Earth system sciences in the Northern Eurasian regions. It is a multidisciplinary, multi-scale research program aimed at resolving the major uncertainties in Earth System Science and global sustainability issues concerning the Arctic and boreal Pan-Eurasian regions and China. PEEX works towards long-term, coherent and coordinated research activities and continuous, comprehensive research and educational infrastructures across the PEEX domain.

Finland has included significant national research infrastructures, such as the SMEAR network in "Finland's Strategy and Roadmap for Research Infrastructures 2014–2020". UHEL has the leading role in Finland coordinating and developing the national components of the European environmental infrastructure networks and in improving their capacity to contribute to European infrastructure projects (ESFRI) that are all

relevant for iCUPE: Integrated Carbon Observation System (ICOS), Aerosols, Clouds and TRace gases (ACTRIS), ANAEE, LTER and SIOS, also being the most relevant infrastructures in the research tasks of iCUPE. Furthermore, iCUPE will strengthen the use of Copernicus space component (S-1, S-2, S-3, S-4, S-5/5P) and contributing to Copernicus missions (such as EnMAP, 2019) for polar areas observation. In particular, GFZ has the leading role in Germany for strategic planning and management of scientific algorithm and application development for future EO optical sensors.

According to the Danish Roadmap for Research Infrastructures a major goal is to strengthen the European collaboration through inclusion of Danish actors in European infrastructure projects (ESFRI). The iCUPE provides added values also the two new ICOS stations (and a number of associate sites) are in the process of being established in Greenland, Station Nord (Villum Research Station) and Zackenberg. These sites are also part of the European INTERACT program and will be an important part of the research infrastructure in an Arctic research and education collaboration.

The circumpolar comprehensive, long-term in-situ observation sites in Arctic include e.g. Villum research station, SIOS, Barrow, Alert, Ny-Ålesund (AWIPEV), ACTRIS observations, Tiksi, Cape Baranova, Pallas-Sodankylä GAW station, SMEAR observation network (Värriö, Hyytiälä, Helsinki, Kuopio), as well as PEEX and INTERACT2 networks and expeditions in the Arctic. In Antarctica, the observation sites are Dome Concordia, Aboa, Troll, Marambio, Mario Zucchelli, Halley, Kohnen, Neumayer III.

iCUPE is connected to Horizon 2020 projects. Particularly to INtegrated Arctic Observation System (INTAROS) and Advanced Prediction in Polar regions and beyond: modelling, observing system design and LInkages associated with a Changing Arctic climaTE (APPLICATE), which provide the required connections to the development of next generation Arctic observations and connects the work to modelling infrastructures. The connections are facilitated by the fact that several iCUPE partners are also beneficiaries in these research projects. This supports iCUPE connections to Year of Polar Prediction (YOPP) activities as well.

The Arctic field studies, such as MOSAiC on-board AWIs icebreaker “Polarstern”, and measurements on-board Swedish icebreaker “Oden” provide opportunities to observe the Arctic. iCUPE makes use of the Arctic Science Partnership coordinating field campaigns in Greenland and Canada by AU in Denmark. The connections to Atmospheric Flagship Program in Ny Ålesund and Svalbard Integrated Arctic Earth Observing System (SIOS) and INTERACT2 and PEEX station networks and German collaborative research center AC^3 on Arctic amplification increase the impacts and support integration of the activities. Furthermore, iCUPE contributes to International Arctic Science Committee (IASC), Arctic Monitoring and Assessment Programme (AMAP) and Sustainable Arctic Observation Network (SAON). There are also direct links to IGAC/IASC initiative on air Pollution in the Arctic: Climate, Environment and Societies (PACES) and to the IGAC Cryosphere and ATmospheric CHemistry (CATCH) initiative that will be also mobilized to facilitate intensive campaigns and evaluation of in-situ activities covered by iCUPE.

The work in iCUPE connects to both in-situ and satellite observations in the polar environments (Table 2). The integration will be beneficial and can lead to novel applications. Particular examples include AWIs activity “Polar regions And Coasts in the changing Earth system” (PACESII) that carries out research on the role of the cryosphere in the climate system and investigates the causes for changes of ice sheets and its effect on sea level rise. The iCUPE activities provide important EO and associated value-added to the on-going projects. iCUPE enables streamlining and optimization of complex data streams from EO and in-situ networks. National Satellite Data Centre of Finland including the Copernicus Collaborative Acquisition Station and Archiving Station providing Copernicus Sentinel satellite data will foster long-term monitoring of the cryosphere, snow extent, soil moisture, permafrost, carbon cycle, water cycle and sea ice, and enable real-time EO. To ensure link with EO satellite missions experts, iCUPE includes established current leaders in the definition of optical EO missions and derivation of new proxies and variables that can be extracted through optical EO products (Sentinel-2, EnMAP) incl. participation in GEO Community activities, GEO CA-06 EO data and mineral resources.

The work in iCUPE facilitates further integration and streamlining of the observational capacity and data products and services. It enables better coherence of long-term and campaign data and combination of detailed in-situ and more spatially representable satellite data to be provided to the end users.

Table 2. Connections between iCUPE and selected international activities in the polar areas.

iCUPE component	Organization / project	Relevance to iCUPE	Connection to iCUPE consortium
In-situ and vertical observations	Aerosols, Clouds and TRace Gases Reseach Infrastructure (ACTRIS)	Provides observational data from harmonized networks on air pollution	UHEL and FMI coordinating ACTRIS towards operational RI, several beneficiaries contribute (CNR, CNRS, EULS, TROPOS, PSI, AU)
In-situ observations	Arctic Monitoring and Assessment Program (AMAP)	Provides observational data on Arctic air pollution	AU is coordinating the Danish part of AMAP with respect to atmospheric measurements
In-situ observations	Integrated Carbon Observing system (ICOS)	Provides observational data from harmonized networks on greenhouse gases	UHEL and FMI coordinating ICOS-ERIC, CNRS hosts the Atmospheric Thematic Center.
In-situ observations	Pan Eurasian Experiment (PEEX)	Provide infrastructure access and collaborative platforms in Russia	UHEL hosts PEEX headquarters (HQ)
In-situ observations	IASOA	Provides connections and access to Arctic observation sites	FMI, AU operate infrastructures within IASOA, CNR operate infrastructures mainly in connection to flux measurements
In-situ aerosol, snow observations in Antarctica	PNRA	Provide infrastructure access and collaborative platforms in Antarctica	CNR contributes to the national research program in Antarctica (PNRA)
In-situ snow observations in the Arctic	SNOWNET	Provides better coordination of snow research activities in Svalbard	CNR is a beneficiary in SNOWNET
In-situ observations	Sustaining Arctic Observing Networks (SAON)	Facilitates research and development	FMI is preparing the value tree analysis for Arctic Observation Systems for selected variables. Several national representatives within iCUPE consortium.
Atmospheric Hg speciation, modeling	GMOS and AERIS	Provides comprehensive observational and modeling data sets	CNRS is part of GMOS and French AERIS
in situ, airborne satellite measurements, modeling	Pollution in the Arctic System (PARCS, French)	Provides the fundamental measurements for integration of in situ and satellite in Siberia and in the Arctic	CNRS is coordinating PARCS in France
In-situ, in-situ remote sensing and satellite data integration	Biogenic Aerosols – Effects on Clouds and Climate (BAECC)	Provides a comprehensive data set to develop advanced data products, calibration and validation of satellite products.	UHEL, FMI project with open data available in US Department of Energy data portal,
Data infrastructures	PEEX modeling platform	Provides tools for environmental data visualization	Part of PEEX HQ activities

Data infrastructures	smartSMEAR	Provides data storage services and data visualization for in-situ data	UHEL owned service
Data infrastructures	Italian Arctic Data Centre (IADC)	Provides data storage services and data visualization for in-situ data	CNR owned service under development
In-situ and vertical observations, satellite EO data services	Svalbard Integrated Observing System (SIOS), Data system, Knowledge Centre (SIOS-KC)	Access to infrastructures and data	CNR, UHEL, SU, NCSR contribute to SIOS activities, CNR contribute to develop SDMS, implementing Italian Arctic Data Centre (IADC).
Satellite EO	Copernicus EU EO program	Provides connection to various end-users	iCUPE beneficiaries active in scientific and political levels
Satellite EO	Group on Earth Observation (GEO) and GEOSS	Provides avenue for data and result dissemination	iCUPE beneficiaries active in research and development and working towards improved EO data infrastructures on political level.
Satellite Cal/Val	Pallas-Sodankyilä GAW station, SMEAR observation netowork	Provides ground-truth for satellite products in Arctic environment	FMI and UHEL station network
Satellite data service	National Satellite Data Centre	Provides access to Sentinel satellite products	FMI hosts in Sodankylä

1.3.4 Methodology

In order to reach the aims of iCUPE, a comprehensive suite of state-of-the-art tools are utilized and developed beyond state-of-the art during the project lifetime. The tools are listed briefly below.

Comprehensive in-situ data and observations include e.g. i) atmospheric concentrations of Persisting Organic Pollutants (POPs), Chemicals of Emerging Concern (CECs), mercury (Hg), black carbon (BC) and other short-lived climate forcers (SLCFs), greenhouse gases (GHGs) and other trace gases, ii) concentrations in the current and historical snow and ice samples, iii) meteorological variables, iv) surface properties and v) extend the in-situ data to the atmospheric column via ground-based remote sensing techniques,, vi) integrated atmospheric column measurements, such as aerosol optical depth (Table 2 and Table 4).

For **source apportionment,** we will utilize Positive Matrix Factorization (PMF), Multi-linear Engine 2 (ME-2) and Constrained Physical Receptor Model (COPREM), which is a hybrid receptor model that uses qualities from factor analytic models and chemical mass balance models. These tools provide a comprehensive data on the sources of atmospheric aerosol in the Arctic. We will use a combination of quantitative electron impact mass spectrometry and novel extractive electrospray mass spectrometry with molecular information in order to obtain information on anthropogenic contribution to the organic aerosols in polar area. This analysis will be complemented with Flexible Particle Dispersion Model (FLEXPART) to acquire sensitivity plumes (Stohl et al., 2005) for backward and forward simulations. The FLEXPART is used for the source attribution for the detected atmospheric Hg with Potential Source Contribution Function (PSCF).

Source strength methods. Aerosol sources from natural resource extraction (gas and oil fields, flaring) in the Arctic are characterized by optical remote sensing night data in collaboration with ERAPLANET Strand 2 and here applied to the Arctic environments. This data will provide a view on the availability and utilization of natural gas and oil and related light pollution coming from resources extraction expansion in the polar areas. This is complemented with GAINS inventories on aerosol/trace gas emissions.

Surface characterization. In iCUPE we utilize Sentinel2 A/B (level 1c), Landsat 8 OLI, airborne hyperspectral imagery and additional ground- based observations on vegetation phenology, pigments, and field spectroradiometric measurements and simulate upcoming satellite hyperspectral sensors (PRISMA 2018, EnMAP 2019, SHALOM 2020). This enables us to determine both the current state and the development of the vegetation conditions in the Arctic areas. This provides us a proxy for the availability of natural renewable biomass for various purposes, such as paper, pulp and manufacturing as well as for a source of bioenergy. With Sentinel 2/3 data (level 1c), Landsat 8 OLI we characterize snow/ice cover, vegetation changes and biomass characterization (vegetation status, composition, pigments), and mapping of natural resources extraction through night light observations. For glaciology, we utilize Sentinel1A and TerraSAR-X polarimetric acquisition in combination with AWI polar aircraft data with Ultra-wide band (UWB).

Organic contaminants, mercury and other heavy metals in air, snow and ice. We will have access to concentration data on the amount of anthropogenic organic compounds (PBDE, PAH, PCB and POP, CEC), Hg and other heavy metals, and black carbon (BC) in polar region from the analysis of annual snow and atmospheric measurements, as available via international networks. The work will provide novel insights into pollution life cycles, their atmospheric oxidation and transport. The snow analysis is complemented with ice core data to address the anthropogenic influences on the pollution levels over a longer time perspective. This approach will allow estimation of the background values before the industrialization thereby contributing to improved estimates of the real contribution of the human activities. Similarly, data from Antarctica will provide us a reference for a polar area that is minimally affected by the human activities and emissions in the modern times. Hg levels in the Arctic biota are among the highest globally. The exact transport pathway (atmosphere or rivers, ocean) by which mid-latitude industrial Hg emissions are transported to the Arctic is debated (Fisher et al. (2012). Similarly, the seasonal variation in atmospheric Hg in the Arctic is unique and poorly-understood with massive atmospheric mercury depletion events (AMDEs) that result in springtime Hg deposition, followed by even larger re-emission in early summer. Bromine radicals are the primary oxidant for atmospheric Hg during AMDEs, which drives Hg deposition. Major uncertainties in Hg oxidation processes in atmosphere and deposition are directly tied to uncertainties in the halogen radical lifecycle. By integrating observations and modeling, iCUPE will resolve open questions in halogen chemistry in the Arctic. The work in iCUPE will make substantial scientific advances in this topic.

Furthermore, recent research has also put into question the accuracy of automated Tekran Hg speciation analyzers, that quantify atmospheric reactive Hg(II) forms, used by Hg monitoring networks (GMOS, AMnet, CAMnet) in the Arctic (Jaffe et al., 2014). We recently inter-compared an alternative cation exchange membrane (CEM) based method with Tekran analyzers and found 40% higher levels of reactive Hg(II) with the CEM method (Marusczak et al., 2016).

Proxy development and data harmonization and assimilation, satellite cal/val activities. We develop novel proxies utilizing a combination of in-situ, ground-based remote sensing and satellite derived data observed at SMEAR II station. We utilize previously applied methodologies (Sundström et al., 2015; Kontkanen et al, 2016), and e.g. meteorological data (principally sensible heat flux) for developing proxy for mixing layer height derived from Doppler Lidar, aerosol optical depth (AOD) and satellite derived Aerosol Indices to develop a proxy for condensation sink. We also develop proxies for ecosystem gross primary production based on multi-scale (leaf-tower-drone-satellite) chlorophyll fluorescence methods (Porcar-Castell et al. 2014, 2015). The wide spectrum of SMEAR II data as well as e.g. meteorological re-analysis data will be applied in order to improve the proxies. We utilize in-situ snow and spectral radiance measurements to validate satellite data. The precipitation products are validated against in-situ observations and ground-based weather radar data. In data assimilation, we utilize Extended Kalman Filter (EKF, e.g. Viskari et al. 2012) to combine observations on in-situ aerosol number size distribution in a coherent manner. The EKF is a sequential state estimation method for tangent-linear dynamical systems. It enables us to estimate aerosol particle number size distributions from multiple simultaneous observations. University of Helsinki Multicomponent Aerosol model (UHMA) is used to propagate the size distribution in time while updating the data assimilated size distribution from observations using their time resolution.

Modeling tools. WRF-Chem (Grell at al., 2005) simulates the emission, transport, mixing, and chemical transformation of trace gases and aerosols throughout the depth of the troposphere concurrently with the meteorology. This on-line modeling approach, which combines state-of-the-art meteorological dynamics and physical parameterizations with computational efficient chemistry and aerosol parameterizations, provides an ideal platform to investigate e.g. life-cycle of atmospheric pollution, atmospheric chemistry and life-cycle of atmospheric mercury and halogen radical chemistry in the Arctic context. We apply GAINS emission scenario model (Amann et al., 2011), and ECHAM6-HAMMOZ Earth system model for estimating the impacts of regional increases in the volumes of Arctic natural resources extraction on the emissions and further on concentrations of air pollutants (e.g. BC, SO_2, NO_x). The GAINS model provides scenarios for anthropogenic activities together with fuel-, source sector- and technology-specific emission factors for air pollutants, with which the incremental emissions related to individual large scale extraction projects can be estimated.

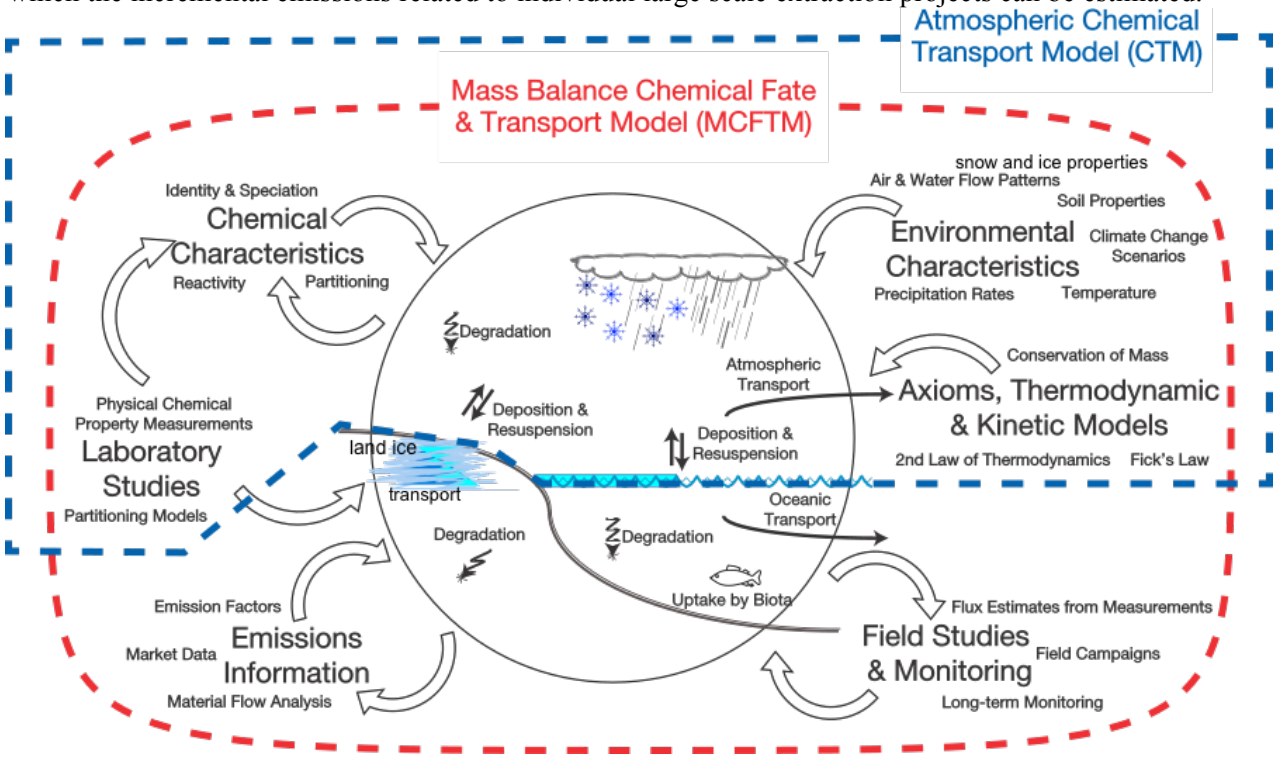

Figure 4. The iCUPE modeling framework for the life-cycle of POPs, adapted from MacLeod et al. 2010.

PMCAMx and BETR. The "integrated approach" of combining emission inventories, models and measurement data is the only way to compose a complete picture of environmental contamination by pollutants. Such an approach reveals inconsistencies in available information, and helps set priorities for further research that will support decision-making. Models are the backbone of the approach, and can be viewed as repositories of knowledge and conceptual understanding about pollutants in the environment (Figure 4). Processes and transport phenomena affecting the POP concentrations are modeled with Mass Balance Chemical Fate and transport (MCFT) models, whereas the Atmospheric Chemical Transport Models (CTM) better describe the atmospheric processing, meteorology and chemistry affecting pollutants in air. We will utilize both of these types of models, and seek synergies between them to describe the life cycle of pollutants in the Arctic. In iCUPE we use aerosol composition and concentration fields calculated with a regional air quality model PMCAMx in connection with the multimedia contaminant fate and transport model (MCFTM) BETR global model (MacLeod et al. 2010). As an example, BETR Global is one of only two POPs models that have contributed simulation results as scientific support for implementation of the Stockholm Convention and the Convention on Long-range Transboundary Air Pollution since 2011. These data will be cross validated against field data from WP 2, where high volume air samplers will be deployed to obtain concentrations for POPs in Arctic and Antarctic aerosol.

1.3.5 Organization of iCUPE work

The work is organized in Work Packages (WPs) and includes research, demonstrations and piloting. The WPs are listed below with WP leaders and responsible partners. The schematic information flow is shown in Fig. 5.

WP 0: Management (lead: Tuukka Petäjä, UHEL)

Task 0.1: Administrative, financial, legal management and quality

Task 0.2: Project meetings

Task 0.3: Internal communication and official representation

WP 1: Ground-based component for SLCFs (lead: Andreas Massling, AU)

Task 1.1: Integration of observations provided by research Infrastructures and networks (Vito Vitale, CNR)

Task 1.2: Improvement of data flow of Near-Real-Time data from in-situ measurement stations (Konstantinos Eleftheriadis, NCSR)

Task 1.3: Interactions with planned intensive observations in the polar regions (Birgit Wehner, TROPOS)

Task 1.4: Sources and sinks of atmospheric pollution in the polar areas (Andre Prévôt, PSI)

WP 2: In-situ component for organic contaminants, mercury and other heavy metals (lead: Carlo Barbante, CNR)

Task 2.1: Defining human impacts on polar regions – cryosphere monitoring and ice core archives (Carlo Barbante, CNR)

Task 2.2: Hg monitoring in Polar regions and evaluation of the atmospheric mercury lifecycle (Jeroen Sonke, CNRS)

Task 2.3: Modelling of halogen/ozone and its influence of arctic chemistry (Jennie Thomas, LATMOS-CNRS)

Task 2.4: Study of interactions between environmental spheres (atmosphere, hydrosphere, biosphere, cryosphere) (Zhiyong Xie, HZG)

WP 3: Satellite remote sensing of Arctic surfaces (lead: Angelika Humbert, AWI)

Task 3.1: Streamlining satellite remote sensing data flows for new multi-sensor, multi-dimensional products (Jyri Heilimo, FMI)

Task 3.2: Optical satellite remote sensing (Rosamaria Salvatori, CNR, Sabine Chabrillat, GFZ)

Task 3.3: Radar satellite remote sensing (Angelika Humbert, AWI)

Task 3.4: Contribution to the strategic development of comprehensive EO in the Polar Areas (Mikko Strahlendorff, FMI)

WP 4: Integrating in-situ and satellite components (lead: Jean-Daniel Paris and Kathy Law, CNRS)

Task 4.1: Novel quality assurance methods, proxies and observables related to aerosols, mixing layer and biosphere parameters (Pauli Paasonen, UHEL)

Task 4.2: Methodologies for validation of precipitation and cloud satellite products in high-latitude and Arctic regions (Dmitri Moisseev, UHEL)

Task 4.3: Sources and sinks and transport of Arctic pollution determined from an integrated analysis of in-situ and satellite data (JD Paris, CNRS-LSCE, Kathy Law, CNRS-LATMOS)

Task 4.4: Impact assessment and future exposure scenarios of pollutants in the Arctic (Matt MacLeod, SU)

WP 5: Data provision, interoperability and facilitation of data and services (Steffen Noe, EULS)

Task 5.1: iCUPE Data management plan (Alexander Mahura, UHEL)

Task 5.2: Appliance of ERA-PLANET principles and key enabling technologies for interoperability: infrastructure design and development (horizontal) (Stefano Nativi, CNR)

Task 5.3: Compliance of iCUPE to GEOSS and Copernicus data sharing principles and GCI interoperability testbeds (horizontal) (Paolo Mazzetti, CNR)

Task 5.4: Implementation of interoperability interfaces on international and community-based standards, GEOSS Data Management Principles and GEO Label (horiz.) (Paolo Mazzetti, CNR)

Task 5.5: Facilitating iCUPE data pilots, data and services towards ERA-PLANET community, GEO and Copernicus (Steffen Noe, EULS)

WP 6: Dissemination, strategic development (lead: Hanna Lappalainen, UHEL)

Task 6.1: Stakeholder engagement (Hanna Lappalainen, UHEL)

Task 6.2: Interaction within ERAPLANET strands (Tuukka Petäjä, UHEL)

Task 6.3: Research impact assessment (Ella-Maria Duplissy, UHEL)

Task. 6.4: Future strategies and contingency plans (Hilppa Gregow, FMI)

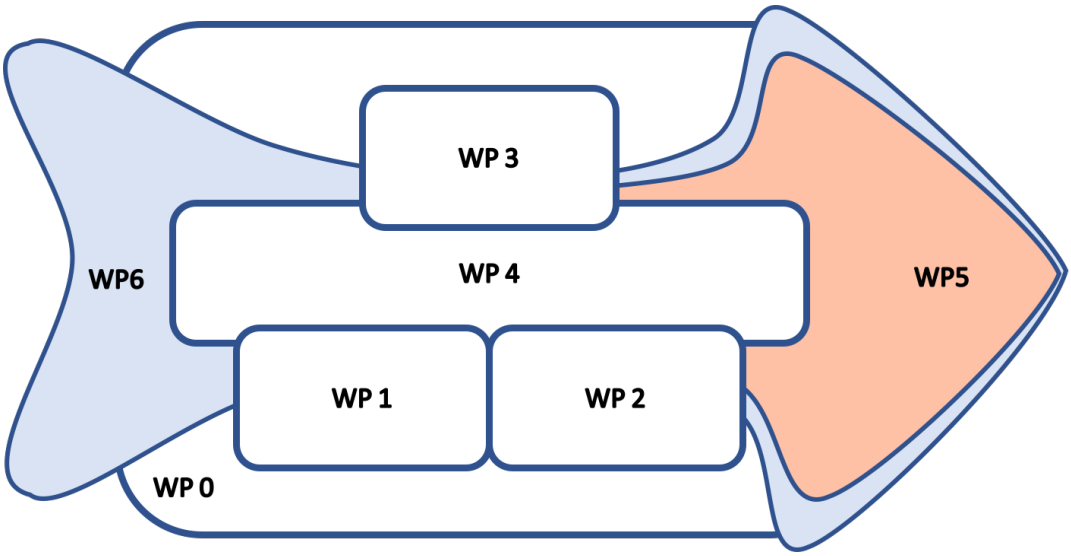

Figure 5. The schematic workflow concept of the iCUPE project: Management (WP 0) provides the basis for the work and. The proposed research and initial harmonization of the data is carried out in WP1 and WP2 (ground-based and in-situ observations) and in WP3 (satellite observations). The data and information from WPs 1-3 are integrated and assessed in WP 4 and the data products and assessments are distributed through WP5. Taking into account the work program and interactions with the stakeholders and their needs (WP6, dissemination and strategic development) will interacts with the other ERAPLANET strands and iCUPE stakeholders providing a co-design component for the data products and integration and will provide e.g. impact assessments on the pollution exposure in the Arctic.

1.3.6 Gender considerations

iCUPE follows the European Commission guidelines and principles for the gender policy. iCUPE is committed to make visible the gender awareness keeping in mind that a balance between genders improves the quality of European research environment as a whole. In practice three WPs are lead by female scientists and there are nine female task leaders.

Unfortunately, the disciplines engaged in the iCUPE are traditionally male dominated, which constitutes both a challenge and an opportunity. As an example, currently the gender balance at UHEL-ATM; the percentage of female scientists among PhD students is 43%, among post docs 41%, among senior scientists 43% and among professors 19%. This situation is changing towards a more balanced situation as the younger generation of scientists is more balanced and the organization is supporting gender balance in recruitment processes.

We will make special measures will have to be taken to improve the gender balance in all iCUPE activities and consider this feature as an opportunity as there is a great potential to make significant progress with respect to gender balance even during the lifetime of iCUPE. A special effort is made to encourage women to take leadership roles, and to provide administrative support to limit the additional bureaucratic work load. We ensure that all announcements will be written in a gender-neutral language and encourage participation in in particular from female colleagues.

1.4 Ambition

The work in iCUPE aims to provide new knowledge, data and data services on the transportation, transformation and impacts of pollutants in the polar atmosphere, cryosphere, hydrosphere and biosphere. The research will be conducted with ground-based and satellite retrieved observations and modeling, and the different data products will be harmonized, inter-compared and integrated to allow their efficient use in understanding and predicting the impacts of anthropogenic activities on the fragile polar regions.

The work in iCUPE will lead to substantial improvement in integration of in-situ and satellite EO and modeling. Table 3 shows the technical readiness level (TRL) before and after iCUPE for activities in iCUPE. The TRL levels are Technology readiness levels are specified as: TRL 1 – basic principles observed, TRL 2 – technology concept formulated, TRL 3 – experimental proof of concept, TRL 4 – technology validated in lab, TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies), TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies), TRL 7 – system prototype demonstration in operational environment, TRL 8 – system complete and qualified, TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Table 3. Technical readiness levels of selected iCUPE activities, data and services.

iCUPE activity	**TRL at the beginning**	**TRL after iCUPE**	**Reasoning**	**Means to verify / iCUPE deliverable**
Source apportionment of aerosols (WP 1)	5	7	iCUPE will make a prototype on improving source identification of air pollutants in the Arctic	D 1.4.2
In-situ Near Real Time (NRT) delivery from Arctic observation site (WP 1)	6	7	iCUPE will pilot NRT data delivery from a selected Arctic observation site	D 1.2.1
columnar aerosol polar night measurements (WP 1)	6	7	iCUPE will work to consolidate lunar photometry in polar areas	D 1.1.1c
snow/vegetation spectral albedo (WP 1)	5	7	iCUPE will work to develop robust systems/methdologis to implement continuos measurements	D 1.1.4
Anthropogenic contaminants in snow from polar regions (WP 2)	3	5	iCUPE will develop robust protocols for snow sampling and analysis.	D 2.1.1
Anthropogenic contaminants in ice cores (WP 2)	3	5	iCUPE will demonstrate feasibility and consolidate methods for ice core analysis.	D 2.1.2
Atmospheric Hg speciation (WP 2)	7	8	iCUPE will intercompare two existing Hg(II) speciation methods, thereby improving SOPs and data quality	D 2.2.2
Atmospheric Hg, halogen, ozone modelling (WP 2)	6	7	Improved iCUPE observation quality will help improve 1D and regional model parameterizations.	D 2.3.1
Vegetation condition and snow cover mapping using current and upcoming Copernicus satellites	3	6	iCUPE will demonstrate use of new EO optical sensors for improved services	D 3.2.1 D 3.2.2
Monitoring of gas flaring via artificial light (WP 3)	3	7	iCUPE will demonstrate use of the tool developed by ERA-Planet Strand 2	D 3.2.1 D 3.2.2
Time series of lake size over a key region in Northeast Greenland (WP 3)	6	7	iCUPE will develop an algorithm for lake size detection and for prototype demonstration compared to various satellite sensors.	D 3.3.1
Improved capacity for satellite cal/val of precipitation (WP 4)	6	7	iCUPE utilizes a combination of ground-based validation and ground-based remote sensing for precipitation	D 4.2.1

Integration of in situ, satellite and model for sources sinks and transport of pollution (WP4)	2	4	iCupe will bring emerging theoretical concept of data integration and use the challenging Arctic as a laboratory	D 4.3.2
Environmental assessments on Arctic pollution impact (WP 4)	6	7	iCupe will improve impact assessments based on novel integration approaches and enhanced model validation strategies	D 4.4.2

The ambition in iCUPE will make significant advances towards a better integration between existing in-situ observational networks for polar measurement data on short-lived air pollutants including both aerosols and trace gases, as well as contaminants. The focus is on the availability of long-time data series and on the facilitation of intensive campaigns as well as on piloting near real-time data. Quality control, data flows and data streams will be harmonized within iCUPE.

The work in iCUPE will improve the existing knowledge of mercury cycling in the polar areas coupling real observation from continuous atmospheric mercury monitoring and surface snow sampling with regional atmospheric chemical and transport modelling. Furthermore, iCUPE allows us to fill knowledge gaps regarding the presence of anthropogenic organic compounds and heavy metals in the polar snow and suspended in the aerosol phase, improving our understanding of their abundance in the polar areas. Furthermore, iCUPE will go beyond-state-of-the-art in the understanding of anthropogenic influences on POP and mercury levels in a historical perspective as we will be to address the effects of industrial revolution to the pollution levels based on ice-core data. The comparison between Arctic and Antarctica enables us to address the more recent changes in the heavy metal concentrations as we perform comparisons between Arctic and Antarctica data sets. These activities provide crucial data UNEP Global Partnership on Atmospheric Mercury Transport and Fate Research (UNEP F&T) and to Global Monitoring Plan (GMP) of the Stockholm Convention on Persistent Organic Pollutants (POPs) of UNEP as well as GEO-flagship on mercury. These activities support implementation of various international treaties such as the Minamata and Stockholm Conventions.

As the atmospheric pollutants and their dispersion is a transboundary problem, links will be established including European and global projects and activities. Existing data sets on atmospheric chemistry and physics as well as existing air samples will be further analyzed to enhance our knowledge on gaseous and particulate sources with natural and anthropogenic origin in the high Arctic areas. In concert with satellite observations to characterize aerosol emissions from, for example, natural gas extraction and flaring, we will improve substantially our fundamental understanding about local and regional atmospheric pollution sources in the Arctic and their transboundary transport. The outcomes from iCUPE are directly relevant to the work of the Task Force on Hemispheric Transport of Air Pollutants (TF HTAP) under the UNECE-CLRTAP convention on long-range transport of air pollutants as well as AMAP/ACAP under the Arctic Council.

The iCUPE ambition includes integration of in-situ measurements with satellite remote sensing that has its strength clearly in the spatial coverage compared to point-wise in-situ data, In particular, in the Arctic, where station-based observations are sparse, satellite remote sensing thus greatly enhances our capability of observing large areas efficiently. The in-situ point-wise data allows to calibrate and validate the remotely sensed data at the first place.

In the past decade, satellite remote sensing products have been widely used for monitoring of Earth system compartments and techniques like InSAR, offset tracking and classification schemes have been used to derive valuable products for monitoring the Arctic (e.g. Joughin et al. 2000). However, satellite data was still too sparse for retrieving time series of products in sufficient spatial resolution and coverage in high latitudes. As availability of radar and optical satellite data is increasing, the step from infrequent 2D observations to 4D observations can be made and will revolutionize our ability for monitoring change in the Arctic (Joughin et al., 2010, Nagler et al. 2015, Mouginot et al, 2017). iCUPE works towards these improvements to improve spatial resolution and multi-mission integrative data allows us to resolve seasonal evolution of essential climate variables in the Arctic and decrease measurement errors. Within iCUPE we aim for investigating the frontiers

of satellite remote sensing and find advice for future mission development in conjunction with in-situ observations. This integrative approach will highly benefit in-situ observations of atmospheric and cryospheric parameters, too, as the scope for interpretation of point wise measurements is enormously enlarged, enabling the atmospheric community to find links between the temporal evolution of cryospheric observables and atmospheric constituents. After the iCUPE integration, bio-geophysical feedbacks can potentially be quantified by synergistic satellite data analysis. Earlier studies have substantiated the special importance of satellite data to decode these feedbacks and the integrative analysis in iCUPE will provide additional tools and knowledge to make progress in this quantification.

Several ongoing satellite missions, including the Sentinels of Copernicus, are forming a large variety of products dedicated to monitor snow cover (e.g. Pulliainen et al. 2014, Nagler et al. 2016). These snow products are obtained by using different processing algorithms based on radiative modelling and/or integration with ground data sets. The integration between satellite data and automatic imaging systems can be significantly efficient for optical sensors and all the available data, properly integrated and validated, can enhance the capability to describe the evolution of the snow cover in polar areas (e.g. Bernard et al. 2013, Pope and Rees, 2014). We use this information in iCUPE. As the Arctic areas are changing rapidly, this results in remarkable vegetation biomass changes, hydrological changes, with impacts on e.g. habitats changing, surface states and carbon emissions. New current developments in the atmospheric correction and pre-processing of optical data, algorithms for data analyses, and availability of new state-of-the-art sensors (Copernicus Sentinels, hyperspectral sensors) with improved spectral coverage and regular monitoring enhance our capabilities to extract bio-/geo-physical surface variables such as vegetation status, composition, biomass, wetness, and surface water states in polar areas. This capacity is utilized and developed further in iCUPE.

Radar remote sensing is a very suitable tool for investigating snow and ice bodies without limits of cloud coverage or light. All of this data could be used to direct the in-situ measurements, melt areas are where exchanges between the cryosphere and oceans/ lakes occur. Their identification means that sampling can be intensified and targeted on areas of real concern. High resolution of the missions like e.g. TerraSAR-X allows to study processes on an adequate scale. In contrast to optical sensors, radar penetrates the frozen ice surface, opening the potential of tomography for cold surfaces (Pardini et al. 2016) and allows melt detection like supraglacial lakes or melt ponds on sea ice. Using scattering models even the retrieval of the density of snow is now getting reachable. These in-situ observations will be done as part of iCUPE as identification of the firn layer is imperative for ice core collection. Also snow pits will be dug for the analysis of POPs and heavy metals in snow, snow stratigraphic data found will be communicated rapidly to the radar remote sensing team. Tomography of the thin layer of ice sheets requires in-situ observation, which is typically performed as shallow ice cores or as long snow pits from which layering can be determined. Also, polarimetric radar imagery opens completely new possibilities (Parrella et al. 2015), as changes in surface structures can be assessed by comparison with scattering models representing different polarisation states. These are approaches, as a key part in iCUPE's satellite component, which go far beyond the classical variables like velocity of glaciers and structural quantities like rift detection etc. and are thus an enhancement and the development of a future perspective.

As a whole, the iCUPE consortium will perform comprehensive and integrative data analysis and interpretation to capture the sources of atmospheric pollution in the polar areas as well as their transport from the mid latitudes. The iCUPE work aim to robust and homogenous data streams. The increased integration with other data sets will able us to explore atmospheric processing of pollutants (deposition/oxidation) and interaction with snow/ice surfaces and study the pollutant / contaminant interactions and processes with ecosystems (microbes) in the polar areas. The work makes progress in the analysis of the natural environment through monitoring of land surface properties (snow/ice, permafrost, biomass, wetness) and analysis of resource management (emission of light due to anthropogenic activities, landscape changes) in the polar areas based on EO observations. As a whole, iCUPE will advance the sector of the Key-Enabling Technologies for EO applications and will reinforce data provision and data services from GEOSS, thus reinforcing the European role in GEOSS and contribute to the dialogue with Copernicus downstream services.

The discovery, visualization and access to data will be implemented in line with the other ERAPLANET thematic projects. Specific tools for quality checking and pre-processing of data is developed in synergy with analogous activities in the other ERAPLANET projects, SIOS and GEO via the GEOSS GCI. iCUPE provides capacity building, interoperability, service characterization, visualization, performance and data quality assessment and enables pathways toward near real time data to better contribute to Copernicus downstream services.

2. Impact

2.1 Expected impacts

iCUPE is a science driven ERA-PLANET strand proposal, which science approach provides the necessary basis for developing the different data products. The overall aim of the iCUPE is to evaluate and present a holistic understanding of the impacts of various increasing human activities on the polar areas, and especially in the Arctic. The main **scientific impact** of the iCUPE is related to improved understanding and new knowledge about local and remote sources of Arctic air pollutants, including Short-Lived Climate Forcers (SLCFs) and their precursors, and their sinks, and improved quantification of the life cycle of mercury, heavy metals, black carbon and persistent organic pollutants. In addition, iCUPE examines changes in the Arctic snow and ice surfaces, vegetation, biomass characteristics, maps out the development of natural resources extraction and delivers the new first impact assessments of the future exposure scenarios of pollutants in the Arctic.

As a crucial part of this work, iCUPE will deliver new data products and develop novel observables, methods and algorithms (WP 4). The new iCUPE data products will fill current observational gaps in key variables of Persisting Organic Pollutants (POPs), Chemicals of Emerging Concern (CECs), SLCFs, and trace gases in the polar context. New data (products) are foreseen on ice sheet and glacier surface structures, on vegetation biochemical characterization and on night light mapping, on atmospheric mercury, on persistent chemicals of Emerging Global Concern in the Arctic and on POPs at the global scale. iCUPE will allow us to merge satellite images with ground truth data that are already collected by different Arctic Observatories, thus creating a new interdisciplinary network of continuous monitoring of the Arctic environment. These new data products will make an important contribution to the development of sustainable and interoperable observational and prediction systems of the polar areas and enhance the European leadership in the Arctic monitoring and provision of data-related services to key stakeholders. The remote sensing efforts within iCUPE will extend current capabilities of monitoring of snow and ice surfaces significantly. In addition, iCUPE will provide a blueprint on the capabilities of planned and future satellite missions for EO observations of polar regions and introduce a concept for in-situ measurements, which is capable of complementing the satellite based observations of the polar regions.

iCUPE will use specific deliverables as a primary source for the “quantified indicators and targets”. The “technical readiness levels” of selected iCUPE activities, data and services, introduced in 3.2.3, are the main tool for estimating the impact during the project.

2.1.1 iCUPE impacts in relation to the Work Programme

(i) European leadership in GEO and European participation to COPERNICUS. The iCUPE contributes to integration of the on-going observations and filling observational gaps in ground-based and remote sensing observations of the polar/ Artic regions. This project will bring the added value to the EU-Blue Growth project “Arctic observation system” (INTAROS), which main focus is on operational atmospheric in-situ data and GHGs. iCUPE recognizes, the same challenge as addressed already by INTAROS, that the passive sensors of polar orbiting satellites have problems during the polar night and hence making the retrieval of atmospheric information very difficult with large uncertainties. The project will analyze the exiting data pools and provide new data products, which will improve the accuracy, temporal and spatial resolution of the SLCFs and other EO data in the polar regions**.**

The current and upcoming satellite missions will greatly enhance our capability of Earth observation even though very sparse in-situ station network give is limiting the comprehensive and correct EO analysis across the Arctic area. iCUPE provides new information out of EO observations by using generic big data statistical methods on EO data (WP3). iCUPE will also advance beyond recent retrieval of satellite remote sensing data and develop novel approaches and provide guidance for a strategic development of satellite remote sensing (Polar EO needs & opportunities, WP 3). As an outcome of this work iCUPE will describe the common in-situ data interface with the Polar EO data, the capabilities and limitations of advanced optical satellite missions for snow / vegetation /gas flaring mapping applications in Artic areas. Novel analysis enables also the estimations of the supraglacial lake volumes in a key region in Northeast of the Arctic and analysis ice sheet and glacier surface structures.

(i) impact measured:

- Baseline: iCUPE partners are coordinating and active participants in EO mission definition, while enables direct contacts and impacts of iCUPE with GEOSS and Copernicus.
- Preliminary indicator: a completion of Task 3.4 on contribution to strategic development of comprehensive EO in the polar areas, Deliverables 3.4.1 (M12), 3.4.2 (M24) on Polar EO needs and opportunities.

(ii) Contribution to the development of sustainable and interoperable observational, modelling, data assimilation and prediction systems

The horizontal tasks within ERAPLANET facilitate data provision keeping in mind interoperability (WP 5). Within iCUPE, the data interoperability is carried out by the evaluating the interoperability interfaces and tests with GEOSS Common Infrastructure (GCI), TEPs and Copernicus Data Integration and Analysis System (DIAS) in collaboration with the ERA-PLANET Strands 1-3. This work contributes to the GEOSS and utilizes the GEOSS GCI and the "GEO Discovery and Access Broker - Application Program Interface" (DAB APIs) (Task 5.2).

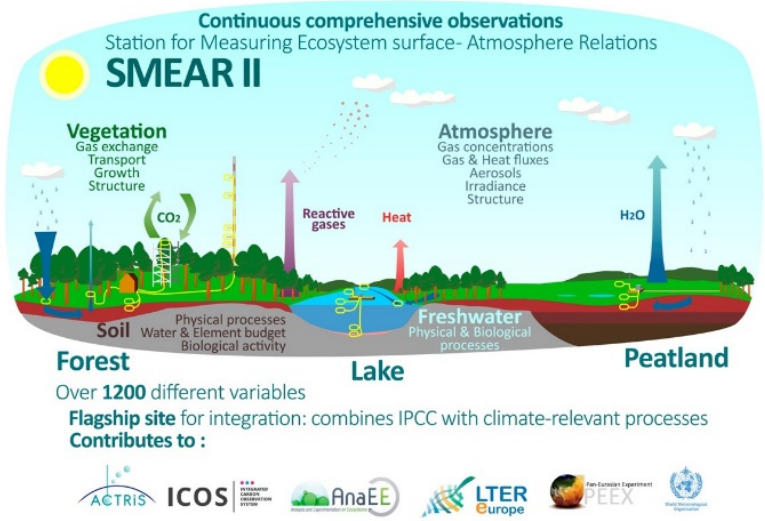

Figure 6. A schematic of a comprehensive observation site that offers data to various European environmental RIs and can act as a platform for satellite cal/val activities, novel data production and benchmarking instrumentation. SMEAR II site in Hyytiälä is the most prominent site for these activities and will provide the starting point for the development.

The work in iCUPE explores ways to deliver open data in near real time seamlessly to different end-users, such as Earth System modeling community (WP 1). The new data products will be stored and made available in the integrated iCUPE virtual platform (Task 5.2). In addition, iCUPE will provide recommendations for future research strategy for the next 30 years including the assessment of the quality of the current methods and data and suggesting improvements for both observations and analysis of the SLCFs, POPs, heavy metals and CECs.

As a part of the strategy work iCUPE introduces a concept for flagship stations (Figure 6) for the coherent, coordinated, comprehensive in-situ measurements in the polar areas and for future satellite mission planning (Task 3.4). In this task iCUPE will focus on two different approaches. First of all, iCUPE is introduces

"Stations Measuring the Earth surface – Atmosphere Relationships" (SMEAR) concept and will explore its interoperability with GEOSS and Copernicus structures. This concept is based on integrated observation of the land-atmosphere interface describing different energy flows. The concept has been developed at the SMEAR-II station in Hyytiälä, Finland since 1995. Today it represents the most advanced in-situ ecosystem-atmospheric station in the world measuring over 1200 variables in a continuous basis, 24/7. Furthermore, it is contributing several European ESFRIs (ACTRIS, ICOS, LTER, ANAEE). In GEO flagship activities, the SMEAR concept is relevant for Global Observation System for Mercury (GOS4M), Geo Carbon and GHG Initiative and GEO Cold Regions Initiative (GEO CRI).

The modelling toolbox of iCUPE covers different data analysis tools such ME-2, COREM, FLEXPART, PSCF (WP1,4), 3D atmospheric chemical-aerosol transport models PMCAMx, WRF-Chem and Multimedia contaminant fate & transport model MCFTM - BETR Global, which is a geographically-explicit global-scale multimedia contaminant fate model (WP4), and emission scenario model (GAINS) together with the Earth System Model (ESM) ECHAM6-HAMMOZ (WP4). During the project lifetime iCUPE will develop integrative modeling tools and test the interoperability of modeling and observational data. For example, the aerosol composition and concentration fields calculated with PMCAMx will be used for improving the multimedia contaminant fate and transport model (MCFTM) BETR Global, which currently includes only one generic aerosol type (Task 4.3).

(ii) Impact measured:

- Baseline: the beneficiaries have earlier experience on different aspects of in-situ observation interoperability, EO mission planning and have contributed to the determination of the EO data products
- Preliminary indicator: a successful work in Task 3.4, Tasks 5.1-5.5 (on data provision, interoperability and facilitation of data and services) and the related deliverables and milestones.

(iii) Improvement and selection of effective environmental indicators for end-users. In order to enable science-based decision-making both locally and regionally, the comprehensive and harmonized data produced within iCUPE will be applied for improving the modeling capacity for future exposure and impact scenarios in the Arctic. Within the project, first such scenarios representing alternative possible resource development paths will be developed for scientific and policy use**.** The project will use the BETR Global model, which is has been earlier supported the implementation of the Stockholm Convention and the Convention on Long-Range Transboundary Air Pollution (CLRTAP). The model has also been applied for scenario analysis and impact assessment of POP emissions. iCUPE will also apply emission scenario model (GAINS) together with the ESM ECHAM6-HAMMOZ and documented national plans on extracting natural resources in polar areas (e.g. Yamal MegaProject in Russia), for generating specific scenarios on changes in polar emissions and their impacts on pollutant concentrations (e.g. BC, OC, SO_2, CH_4). The scenarios will provide insights to the extensive multi- and inter-disciplinary assessments on the alternative future scenarios for the Arctic environment (Task 4.4).

As part of the work, iCUPE will provide a discussion platform to exchange best practices in the ground sites and to foster collaboration between the consortium partners and the end-users (Task 6.2). The project will also involve representatives from EMEP, WMO-GAW, Arctic Council AMAP, SAON, INTAROS, POLARNET, IASC and the Russian and Chinese research communities via PEEX.

(iii)Impact measured:

- Baseline: iCUPE uses state of the art models verified for the policy making
- Preliminary indicator: successful work of the Task 4.4 on impact assessment and future exposure scenarios of pollutants in the Arctic, Task 6.2 on interactions within ERAPLANET strands; and related deliverables and milestones.

(iv) Contribution to accurate, comprehensive information to policy and decision-makers. iCUPE will provide multidisciplinary information and novel data on the current status of the polar environment (WP 1-5). It will deliver quantified data on the relative contributions of local and long-range transported pollutants affecting the atmospheric composition in the Arctic, on emission and deposition of pollution affecting the properties of snow and ice, on the effects of changes in atmospheric composition and surface properties that are essential required for science-based decision-making.

As we perform and report data on long range transported pollutants, their deposition and accumulation in the snow cap and release dynamics during the Arctic spring, we can follows POPs, heavy metals, mercury and emerging pollutants from deposition to their entry into the hydrosphere and eventually into the food chain. In connection to the iCUPE modeling framework, we are able to identify their sources and provide insights into the decision-making processes.

iCUPE provides novel insights into POP transport and processing (Task 4.4) in the cold climates and integrates the multidisciplinary information to an impact assessment of pollution in terms of POPs and CECs. This assessment is suitable to address openly environmental issues at local and regional scales for a science-based decision making and support. The main policy making stakeholders of iCUPE are the Arctic Council and United Nations' Environment Programme (UNEP) and United Nations' Economic Commission for Europe (UNECE). iCUPE provides an update of the POPs list of the Stockholm Convention and delivers evidence of transboundary transport, sources and sinks of SLCFs, POPs, CECs and mercury in the Arctic in synergy with CLRTAP convention (Task 2.2). iCUPE supports Minamata Convention by providing data on a quality controlled and consistent GMOS atmospheric Hg data set and improving Hg exposure estimates (Task 2.2, 2.4). Scenarios on specific changes in polar emissions and their impacts on pollutant concentrations (e.g. BC, OC, SO_2, CH_4) will be made available for the policy and decision making (Task 4.4).

(iv)Impact measured:

- Baseline: Impact assessment of POP exposure is based on single aerosol type, not size resolved sampling for POP concentrations.
- Preliminary indicator: a completion of Task 2.2 on mercury monitoring and evaluation of its lifecycle; Task 4.4 on impact assessment and future exposure scenarios of pollutants in the Arctic; and associated deliverables and milestones.

(v) Exploitation and use of EO derived data for the benefit of citizens' daily life. The increased level of understanding on the pollution transport and source in the Arctic as well as POP exposure assessments (WP 4) provide data that is valuable and relevant for the general public. Snow coverage (WP3) cycle and its changes affect life of Arctic communities considerably. Avenues to exploit this data in a way that it benefits and affects the daily life of the selected local communities in the Arctic are considered in collaboration with the stakeholder engagement as a part of dissemination activities (WP 6). One potential connection point could be to join INTAROS case studies in two selected communities in Greenland (Denmark) and Svalbard (Norway) by providing information on the sources, sinks and transport of SLCFs, POPs, metals, CECs and mercury. This would enable the local communities to take advantage of the integrated iCUPE data products in tackling local and regional challenges associated with air pollution dispersion.

Impact measured:

- Baseline: The iCUPE outcomes will be connected and distributed to the ongoing project, which have local contacts and specific activities involving Arctic citizens
- Preliminary indicator: completion of Task 6.1 and associated deliverables and milestones.

(vi) Reinforcement of the interface with user communities in GEOSS framework. iCUPE will collaborate with existing European ESFRI infrastructures and national facilities as well as INTAROS, APPLICATE (coordinator AWI, also an iCUPE beneficiary) by filling the observational and data gaps of POPs, CECs and SLCFs in the polar areas with the special focus on utilization and integration of observational data with iCUPE modeling tools. The project will assess the parameter variability (WP 1,4) based in well identified supersites (Svalbard, Värriö & Hyytiälä (SMEAR-I & II), Pallas-Sodankylä, Ny-Ålesund, Villum measurements, Antarctic: Mario Zucchelli, Dumont Durville, Dome C research bases) along quasi-longitudinal transects from east to west at high latitudes. iCUPE will provide a spatial expansion of the dataset that is quality controlled around the ground-based sites needed for the validation of the satellite datasets.

Impact measured:

- Baseline: The partners are well connected to the main Arctic in situ observation stations and research infrastructures, but synergies between national activities are not optimized.
- Preliminary indicator: Successful provision of data from WP 1-4 through iCUPE virtual platform and associated deliverables and milestones.

2.1.2 Other impacts

(i) iCUPE impact on innovation capacity

In collaboration with the active and innovative beneficiaries, the iCUPE project forms an innovative and inspiring framework for joint work. There is potential for innovation related to in-situ instrument (WP 1, WP 2, particularly reactive mercury) and satellite techniques utilized in the project. Other expected innovation will be in laboratory analysis methods for POPs, CECs and heavy metals, to push the instruments to lower detection limits for these analytes in water, snow and ice. This in turn will benefit the community as the methods can be formalized and transferred to laboratories that carry out controls under European water frame work directive. The beneficiaries have a proven track-record for innovation. For example, the challenges in aerosol in-situ characterization in low concentration areas, such as Arctic, has pushed the development of aerosol instrumentation towards more sensitive instruments. These techniques were commercialized by Airmodus Ltd (www.airmodus.com) and applied also outside the field of atmospheric sciences (engine emission characterization). In addition, part-per-quadrillion detection techniques developed for observing atmospheric trace gases and clusters (WP 1) with high-resolution mass spectrometry has developed into cross-domain innovation. At the moment, the atmospheric instruments are developed in in several other domains such as MTTD-ONE concept designed for transportation and logistics security with the special focus on automated luggage and parcel screening for explosives detection (karsa.fi). In terms of satellite remote sensing, a lot of new innovative opportunities are also foreseen in a New Space era, which is based on increased capacity of novel sensors and also on nano-satellite solutions. Both hyper spectral imaging and full polarimetric interferometric SAR sensors are in development with many small compared to one big mission observation system solutions that have not been used yet (see WP3).

(ii) iCUPE impact on scientific outcomes from the polar regions

Scientific outcomes are expected to contribute to improved understanding about the drivers and consequences of Arctic and boreal climate change, and fundamental mechanisms associated with cryosphere-atmosphere-biosphere interactions in particular related to pollutants and contaminants in polar regions.

We will use novel ground-based techniques to monitor arctic atmospheric Hg speciation and dynamics, along with PBDE, PAH, PCB, Persistent Chemicals of Emerging Global Concern, heavy metals (Cr, Pb, Cd), and black carbon (BC) in the snow, air and ice. This will lead to an improved integrated understanding of the lifecycles of these persistent pollutants in the Polar regions.

The comprehensive source apportionment based on detailed in-situ characterization and novel approaches with a combination of modeling, remote sensing and advanced analysis tools will provide novel insights into the sources of atmospheric pollution in the Arctic.

The EO activities that will be carried out within iCUPE will help to understand and predict snow-cover changes and their multiple consequences in the polar environment. The scientific outcomes are fostered by open data availability and interoperability enforced by iCUPE. Generally, this facilitates higher visibility and reusability of scientific outcomes. Especially iCUPE scientific outcomes contribute to data and services of GEOSS and Copernicus but also the ERA-PLANET community as a whole will increase awareness of the environmental impacts and status in the fragile polar regions of the public audience.

2.1.3 Quantified indicators and targets

In addition to the “preliminary indicators” and “successful outcome of the relevant deliverables”, iCUPE utilizes the concept of “technical readiness” as quantified indicators for the impact. The technical readiness levels (TRL) of iCUPE activities, data and services is provided in Table 3 and what are the impact of iCUPE to the TRL during the project life-time. The TRL levels are utilized as quantified indicators for the iCUPE activities.

2.1.4 Foreseen barriers, obstacles

There are no foreseen barriers and obstacles such as such as regulation, standards, public acceptance, workforce considerations, financing of follow-up steps, cooperation of other links in the value chain, which would hinder the successful progress of the iCUPE project.

2.2 Measures to maximize impact

In order to maximize the impact on GEO/Copernicus European leadership, contribution to the sustainable and interoperable new polar data products, enhancing the overall exploitation of Arctic EO data for the use of different stakeholder holders iCUPE is introducing the preliminary dissemination & exploitation plan in the sections below. The preliminary plan introduces the aspects of data and other scientific results exploitation and pays a special attention to the identification of different stakeholders and their engagement.

2.2.1 Plan for the dissemination and exploitation of the iCUPE results

2.2.1.1 Baseline

iCUPE data and stakeholder dissemination activities will be made under the ERAPLANET umbrella in close collaboration with projects active in Strands 1-3. All the Strands are having many common international stakeholders (ESFRIs, ESA, EEA, JRC, GEO Working Groups; Copernicus, European Commission and/or national authorities). Contacts and face-to-face meetings with various stakeholders will mainly take place during the joint ERAPLANET annual meetings, while targeted stakeholders are contacted more regularly. The project will have specific tasks on data and metadata interoperability (WP5) and standards with the specific objectives to ensure long-term preservation and access to the wealth of GEO data in Europe. The main dissemination tool for the iCUPE will be an interactive iCUPE virtual platform.

2.2.1.2 iCUPE data

iCUPE data utilize satellite data (natural resources, biosphere, aerosol concentration, utilization of gas fields, flaring, surface characteristics, glaciers and snow surfaces, calibration and validation activities), in-situ data (aerosol physical, optical and chemical characterization, source apportionment, trace gas concentrations from long-term sites and intensive campaigns), comprehensive campaigns and data on Hg, POPs concentrations, snow characteristics, life cycle of contaminants) and modelled data, See Table 4 for a concise overview. Furthermore, Table 2 lists the relevant networks, infrastructures and services and Section 4 describes the capacities of the beneficiaries to perform the comprehensive EO proposed in iCUPE. Table 3 for the envisioned Technical Readiness Levels that we envision for the iCUPE data products. Figure 7 presents the schematic connection of iCUPE data flows and interfaces.

Table 4. Sources of data utilized in the iCUPE work.

WP	data
1	• EBAS; AERONET, WDCGG databases, ACTRIS datasets: aerosols: Aerosol optical depth, aerosol particle size distribution, number concentration, black carbon, organic carbon, SO_2, NOx, CO_2, CH_4, organic aerosol source apportionment data
2	• Analyses of surface snow, ice core data: atmospheric aerosol and glacial melt water for POP, CEC, aerosol BC, data on transfer rates between atmosphere and cryosphere). Data on Hg and its isotopes and CEM, other heavy metals, Cr, Pb, Cd
3	• Lit DB, in situ data, Carb-Arch in situ data • Sentinel 2/3 data (level-1), Landsat 8 OLI (WP3), Copernicus optical missions + relevant in situ data on surface characterization • Light intensity data to map out flaring emissions • Sentinel 1A, TerraSAR-X, TanDEM-X satellite data • Ultra-wide band (UWB) radar data from AWI polar aircraft activities (glacier tomography)
4	• VIIRS satellite data, YAK airborne data • CALIOP, AMD satellite data • BAECC campaign Hyytiälä; in-situ aerosol, ground-based remote sensing, precipitation from in-situ and weather radar data; • Continuous and comprehensive long-term in-situ meteorological, aerosol and trace gas data from Hyytiälä and Värriö for producing proxies • cloud and precipitation properties in Hyytiälä, Pallas-Sodankylä stations: C, Ka- and W- band precipitation and cloud radars, Doppler lidar, humidity and temperature profiling microwave radiometer, a comprehensive suite of ground-based precipitation sensors • data on clouds and precipitation properties verifying precipitation products of NASA GPM, Eumetsat METOP satellites and cloud / precipitation products of NASA Cloudsat and the upcoming ESA EarthCare missions

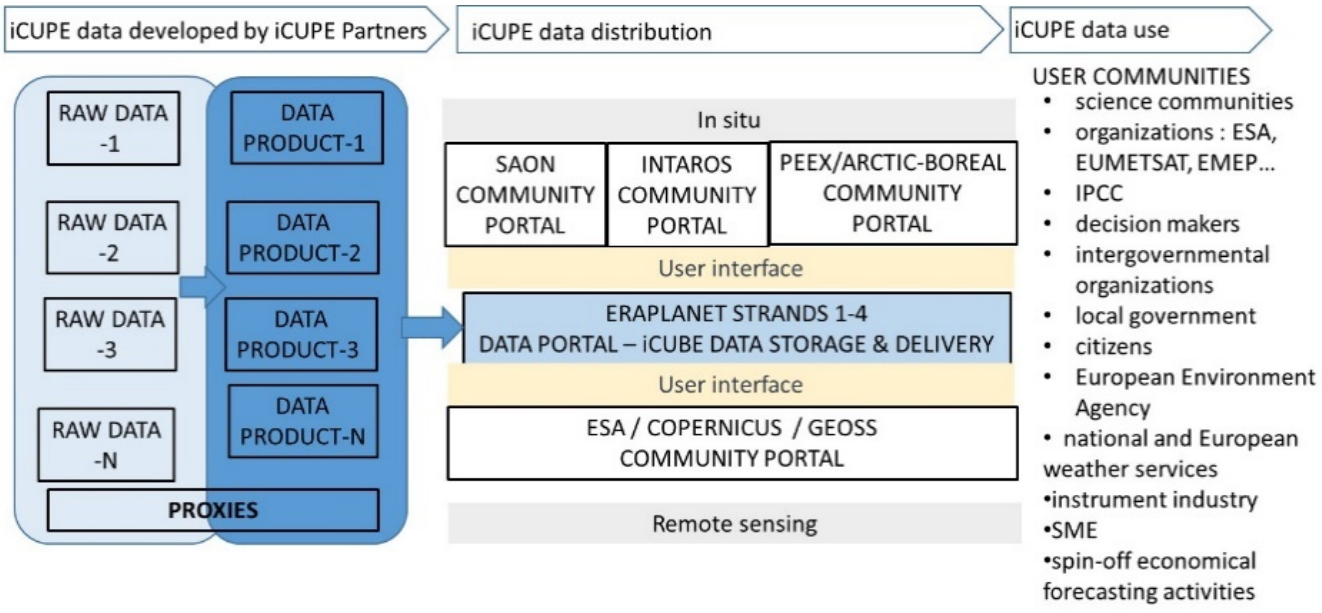

Figure 7. The schematic figure of iCUPE data flow from raw data via iCUPE facilitation towards the end-users.

2.2.1.3 Data archiving and sharing principles

Archiving

The quality checked new datasets including the metadata descriptions together with the harmonized database of long time series produced in the iCUPE will be curated by the data producing beneficiary, and saved and archived by national activities. The data will be accessible via iCUPE virtual platform (WP 5). The long-term storage of iCUPE data and legacy will be planned in more detail during the project. Several options are considered, such as topical data storages, EBAS database (ebas.nilu.no), smartSMEAR (www.atm.helsinki.fi/smartSMEAR), GEOSS portal (www.geoportal.org), World Data Centre of Aerosols (http://www.gaw-wdca.org/), for mercury observations we could connect to GEO flagship Global Observation System for Mercury (GOS4M). The aerosol and trace gas observations will be continued in collaboration of ACTRIS Research infrastructure and its data services. In the future, PEEX offers continuation in the Arctic observations and integration of in-situ and satellite data in the Arctic context. For applicable data, another option could also be Copernicus Climate Change Service (C3S) that offers a possibility for operational and quality controlled information sharing. These aspects are developed in Task 5.1 (Data management plan), which is evolving during the project. The legacy and continuation of iCUPE work is planned in WP 6.

Delivery & distribution

iCUPE will provide a virtual platform that will distribute all final data products and proxies, such as advanced aerosol data products based on the joint operation of in-situ observations and satellite-derived products or different proxies for gaseous precursors and oxidants (Task 4.4). This will be developed within ERAPLANET strand projects to keep in mind interoperability and data sharing principles endorsed by GEOSS. We explore possibilities to maximize the use of new data products and advertising these to larger communities, such as in several community portals such as SAON Arctic Observation System and Arctic Portal and PEEX Program- the Arctic-Boreal Hub Portal. The SAON portal expands the visibility of the iCUPE data to US and Canadian and PEEX to Russian and Chinese research and other end-user communities. For selected topical data sets, some will be included in the University of Helsinki smart-SMEAR platform and disseminated via metadata catalogs to a wider audience. The data curation, metadata addition and data description are under the responsibility of the WP leaders and necessary resources for this are included in the project plan. The work in iCUPE will utilize the KETs endorsed within ERAPLANET. This is facilitated with horizontal data tasks in WP 5.

iCUPE will be participating to the Open Research Data in Horizon 2020. It's data policy follows the general guidelines of "Science Europe Principles on Open Access to Research Publications and implements also the GEO Data Sharing Principles (DSP). This will pave the way towards interoperability between the systems and digital infrastructures. E.g. subsequent work with the iCUPE data will enable e.g. analysis of a longitudinal transect, where coordinated observations will be implemented for columnar aerosol and snow spectral characteristics. The open access to new non-protected iCUPE data will be provided free of charge to all end-users.

The detailes of the iCUPE data management and principles of the open access to the publications are determined in the iCUPE Data Management Plan. The data manegement plan will be based on the "Horizon 2020 FAIR DMP" and it will be used as a management plan template. Data Management plan will also discuss principles of joint publications, new data, models and software. iCUPE partners will also sign a consortium agreement to manage ownership and access to key knowledge (IPR, research data, etc.). The conditions for pursuing the market opportunities arising from the project's results will be included in the consortium agreement. The grant agreement will be formulated following Development of a Simplified Consortium Agreement, DESCA suitable for H2020 projects.

2.2.1.4 Essential variables & cross-thematic interoperability

The data is harmonized within ERA-PLANET in virtual platform. This enables interoperability between Strands. Testbeds, pilots and data facilitation of iCUPE data towards Copernicus and GEOSS systems are performed using key enabling technologies.

To achieve ERA-PLANET overarching objectives, iCUPE will pursue cross-thematic interoperability and contribute effectively to GEOSS approach. iCUPE is integrating in-situ and satellite remote sensing data and contributes together with end-users to the definition of key and society-relevant indicators. This promotes the use of EO Essential Variables and their generation for monitoring processes related to the environment monitoring (Task 6.1). Furthermore, iCUPE will implement the set of interoperability principles and Key Enabling Technologies promoted by ERAPLANET as part of the Work Package tasks such as GCI brokering approach and its principles (GEOSS Data Management and Data Sharing Principles; GEO Discovery and Access Broker -technology, assure shared data/service quality, include re(use) metadata for shared data/services and will contribute produces data/services to GEOSS via the Common Infrastructure.

Together with the other ERA-PLANET projects, YOPP, APPLICATE and INTAROS iCUPE implements a set of best practices. It will also give recommendations to improve interoperability among the existing and emerging data infrastructures in order to contribute to GEOSS via the GCI. iCUPE will address several GEO tasks, such as IN-02: Earth Data Sets, IN-05: GEOSS Design and Interoperability, SB-01: Oceans and Society, SB-05: Impact Assessment of Human Activities, HE-02: Tracking Pollutants.

2.2.1.5 Open access publishing of the iCUPE results

Key results targeted for the science community will be published in high-impact journals, such as Nature and Nature family journals, Science, PNAS, The Cryosphere, Global Change Biology or Atmospheric Chemistry and Physics e.g. in PEEX Special Issue. The scientific results will contribute to the 1st PEEX Scientific Assessment (drafted in 2018). iCUPE will be actively introduced in annual conference proceedings, such as at EGU, AGU.

The research results will be categorized by the iCUPE Steering Group as either to be (i) openly disseminated or (ii) protected. The disseminated materials can be publications, software or research data. For the scientific publications, the “gold model” open access is preferred and the article is immediately provided in open access mode as published. The details of the publication and result categorization procedures will be determined in Consortium Agreement (CA), which includes listing of foreground and background information by the partners.

2.2.1.6 Communication and stakeholder engagement activities

An open and interactive communication and stakeholder engagements is required to maximize the effect of iCUPE research and data service development. The communication is divided into three categories: (i) internal within the project, (ii) horizontal communication between ERAPLANET Strand activities, and (iii) external interactions with other activities within GEO and Copernicus, European environmental research infrastructures, end-users of the data products and general public.

Internal communication between project partners

The internal dissemination aims are:

- to monitor the successful progress of the project and the delivery of the project outcomes as scheduled
- to ensure information flows and contributions between work packages

The internal dissemination of knowledge within iCUPE will be boosted via internal project meetings (face-to-face meetings, teleconferences, connect-pro/ WebEx/Skype), web-pages and iCUPE mailing list. The project delivery reports and meeting minutes will be available from the project intranet. The project partners will promote and disseminate project results on appropriate platforms under their normal process. The iCUPE consortium will organize annual project reviews in a connection of the workshops and ERAPLANET annual meetings throughout the project three year period. A large part of intra-project communication and during-the-project dissemination will be handled by website and mailing lists, which will be managed by the iCUPE Project Office.

Horizontal communication within ERAPLANET strands

The horizontal dissemination aims are:

- to ensure information flows and contributions between ERA-Planet strands with the special focus on the data interoperability

- to increase the visibility of the iCUPE data products and research outcome in the ERA-PLANET community
- to enhance the stakeholder engagement of the ERA-Planet mission level stakeholders

The horizontal dissemination within ERA-PLANET is performed in close collaboration with other Strand projects and their Project Offices under the guidance of ERA-PLANET coordination office. This ensures a quick mobilization of novel and innovative service development and internal expertise sharing between the Strands. The horizontal work enables harmonization of ERA-PLANET work and outcomes. It facilitates a common voice for the ERA-PLANET to maximize the impacts within European research and development landscape via planning of joint dissemination work to the external audiences.

External dissemination and stakeholder engagement

External dissemination aims are:

- to improve the way scientific knowledge can stimulate the research communities and general public interested and concerned in the polar regions
- to increase the usage of the in situ and satellite based data of the polar regions
- to increase the access to polar field stations and their data usage
- to prove science based new information guiding the policy making of the global challenges and related development of polar regions.

iCUPE recognizes that in order to maximize the impact of the research, it is crucial to understand the views of the stakeholders. During the annual face-to-face meetings with the stakeholders, their needs for the contents and formats of the produced data, data products and impact metrics will be discussed. The gathered information will be utilized in preparation of the data.

Stakeholders

iCUPE relevant stakeholders consists of several groups ERA-PLANET stakeholders and specific iCUPE stakeholders interested in polar /Arctic regions. iCUPE stakeholder consists of research projects (INTAROS, APPLICATE, PACES), existing coordination actions (Arctic Council AMAP/SAON, GEOSS; Copernicus, PEEX Russian Arctic-Boreal Regions), German Earth system knowledge platform ESKP, existing research infrastructures (ICOS, ACTRIS, GAW, BSRN, MPLN), existing networks (SIOS, INTERACTS2, PEEX - Russia in-situ, IASOA-Arctic experimental observations, GMOS, AMnet, CAM (Hg monitoring networks) and Arctic research communities (Arctic-boreal Hub). In addition to these groups iCUPE will invite national decision makers, company representatives and Arctic citizens to the iCUPE Stakeholder Group.

Methods & tools for dissemination

The iCUPE will use traditional methods of communication and modern tools like social media. The traditional methods include scientific papers, science based assessments, e-News, press releases, articles in popular science magazines and in domestic and international newspapers. A special attention will be paid to the distribution of information about the iCUPE activities to the broader society in an understandable way. Furthermore, the dissemination of results will also take place via press-releases, brochures, peer-reviewed publications, presentations in international conferences like GEO workshops, EGU, EAC, AGU, iLEAPS, SOLAS and IGAC. The Advisory Board of iCUPE will ensure that the most urgent knowledge is immediately transferred to relevant users, regardless of whether they are end-users like policy makers or the public in general.

Dissemination of integrated results and data products will be optimized via a iCUPE network website / infra. The website will be constructed at the beginning of the project and it will be continuously updated and maintained during the project. The iCUPE site / infrastructure will also serve as a public information source for the iCUPE, where iCUPE stakeholders can share materials and ultimately serve as an archive of the activities and impact of the iCUPE for reporting. The iCUPE site will provide summarized information on the latest results and access to scientific publications including archives of research results (papers and other documents including scientific animations).

iCUPE will collaborate with the ERAPLANET Project Office and Arctic-boreal hub / PEEX-HQ coordinated by UHEL. iCUPE will deliver information to Arctic-Boreal Hub/ PEEX e-News. Via PEEX e-news to information is distribute also the Russian and Chinese research communities at a large scale. iCUPE

will find synergy with the social media tools of the Arctic-Boreal Hub / PEEX and may, for example, visualize the iCUPE science and infrastructures. Through a Arctic-Boreal Hub map, the collaborating iCUPE infrastructures (e.g. stations, institutes) can be mapped and documented (e.g. what type of instruments/research is carried out where).

2.2.1.7 Sustainability of iCUPE activities beyond the project period

The iCUPE active period is scheduled from 2017-2020. However, the research approach should be considered as a long-term activity, which would be having a continuation after the funding period. The work in iCUPE include a vision for the sustainability and continuity of the work. This will be elaborated in terms of generated novel data, products and services within data management plan, which will be also updated during the lifetime of the project. In terms of legacy and continuation of the work, iCUPE contain long-term preparative work in strategic development of EO, both in-situ and space-borne. This work is performed in connection with national and European strategies in EO and Arctic sustainable development.

As an example, to sustain the iCUPE activities and concepts, the iCUPE project is connected to EU-PolarNet, which provides connections to international partners that constitute the world´s largest consortium in expertise and infrastructures for the polar research. The actions together with Sustaining Arctic Observation Networks (SAON), Pan Eurasian Experiment (PEEX), International Network for Terrestrial Research and Monitoring in the Arctic (INTERACT2) and GEO Cold Region Initiative (GEO CRI) provides a long-term strategy for both polar areas, integrating cutting-edge science and top quality infrastructures, which will exert an impact at a global scale for a sustainable future.

3. Implementation

3.1 Work plan — Work packages, deliverables

The work performed within iCUPE is described in Table 3.1a. The work is organized in Work packages listed in Table 3.1b. The deliverables are listed in Table 3.1c and Milestones in Table 3.2a.
The work in iCUPE consists of research activities that lead to novel understanding on the environmental conditions, surface characteristics, atmospheric concentrations and pollution transport data sets.

Table 3.1a: Work package descriptions

WP 0: Management (lead: Tuukka Petäjä, UHEL)

Work package number	0	**Lead beneficiary**			UHEL
Work package title	**Management**				
Participant number	37	1	2	5	7
Short name of participant	UHEL	CNR	AU	AWI	CNRS
PM per participant:	25	2	2	2	2
Participant number	11	14	17	18	25
Short name of participant	EULS	FMI	GFZ	HZG	NCSR
PM per participant:	1	1	2	1	1
Participant number	27	30	36		
Short name of participant	PSI	TROPOS	SU		
PM per participant:	2	1	1		
Start month	1			**End month**	34

Objectives

The aim is to provide overall project coordination and management by:

- ensuring efficient financial and administrative management of iCUPE, coordinating project reporting, and implementing appropriate quality control measures for monitoring the progress of the project

activities (including milestones, deliverables and risk minimization organization).
- optimizing the information flow between the partners, scientific community, end-users and stakeholders through regular project meetings and implementing efficient internal communication

Description of work

This work package will ensure the success of the project through timely delivery of quality assured and quality controlled outputs. It will ensure adequate coordination and management of the iCUPE WPs in all scientific, technical, administrative, financial, and legal matters, including day-to-day management activities and liaison with its consortium partners. It is also responsible for managing risks and adequately responding to external stimuli, which may have the potential to impact upon the work schedule. The Coordinator and the project office will guarantee high-quality management of the project through the following key tasks:

Task 0.1: Administrative, financial, legal management and quality control (lead: UHEL, contributing: all)

This task will take care of financial and administrative project management including preparation and finalization of iCUPE consortium agreement, periodic review and consistency of the overall financial and human resources, and monitoring of the activities in accordance with the contract and the decisions taken by the consortium. The EC financial contribution and distribution to the beneficiaries is managed by ERA-PLANET Coordinator. The iCUPE management will implement appropriate quality control tools to monitor the work progress including deliverables, milestones, risks and contingency solutions, prepare and coordinate the periodic project reports with the partners, and ensure timely delivery to ERA-PLANET. It will moderate potential internal conflicts, propose resolutions and corrective actions. It will be in charge of the day-to-day execution of the management tasks and provide the necessary administrative and secretarial support to the project organization bodies.

Task 0.2: Project meetings (lead: UHEL, contributing: all)

A kick-off meeting and regular official project meetings (one Project Meeting per year, two Executive Board meetings per year, regular teleconferences) will be organized in order to review the work progress, measure the project results against the set objectives, and foster constructive work. The project management includes efficient interaction among all organizational bodies, including international Advisory Board, and is responsible for the follow-up of the General Assembly and Coordinator decisions. The project management will assist in preparing the meeting agendas and drafting the minutes. Besides regular teleconferences of the ExB and annual partner meetings, dedicated workshops for the networking and joint research activities will be organized. The annual partner meetings will be held side by side with a AB meeting.

Task 0.3: Internal communication and official representation (lead: UHEL, contributing: all)

An internal communication structure will be built using efficient communication tools such as the intranet site, email lists, and teleconference facilities. This task will take care of creating, implementing and maintaining the restricted-to-partners part of the website to host project internal information, and will be the central platform for information exchange among partners and associated partners. The Project Management Team is also responsible for external official representation of the consortium to parent infrastructure meetings, to stakeholder meetings, and to the EC. This especially includes work towards the sustainable integration of iCUPE into a joint ERAPLANET activities.

Deliverables

D 0.1.1: iCUPE consortium agreement (M3)
D 0.2.1: Minutes of the iCUPE Kick-off meeting (M3)
D 0.2.2: Annual report and minutes of the first iCUPE meeting (M12)
D 0.2.3: Annual report and minutes of the second iCUPE meeting (M24)
D 0.2.4: Annual report and minutes of the third iCUPE meeting (M32)
D 0.3.1: iCUPE communication tools and interfaces (website, e-mail-lists,brochure and other printed materials) (M5)

Milestones

M 0.1.1: iCUPE consortium agreement (M4)
M 0.3.1: Internal website implemented (M1)
M 0.3.2: Definition of terms of reference for the independent project bodies (M3)

Proposal Acronym | iCUPE

WP 1: Ground-based component for SLCFs (lead: Andreas Massling, AU)

Work package number	1	**Lead beneficiary**			AU
Work package title	**Ground-based component for SLCFs**				
Participant number	2	1	7	11	17
Short name of participant	AU	CNR	CNRS	EULS	GFZ
PM per participant:	24	28	4	12	17
Participant number	25	27	30	36	37
Short name of participant	NCSR	PSI	TROPOS	SU	UHEL
PM per participant:	22	39	7	1	15
Start month	1			**End month**	34

Objectives

- to develop a comprehensive data set on in-situ concentration of SLCF, column integrated parameters and particularly black carbon impacts on snow optical characteristics,
- to plan future field study activities in Arctic areas and promote synergetic effects so that their interactions will be most sufficient to create and transfer new knowledge
- to pilot near-real time delivery (NRT) from Arctic observation site,
- to facilitate integration and harmonization of existing data sets and data streams,
- to address observational gaps, in particular in relation to polar night measurements and effects of pollution on surface albedo and on radiative budget,
- to perform comprehensive aerosol source apportionment particularly for the organic aerosols.

Description of work

Task 1.1: Integration of observations provided by research Infrastructures and networks (lead: Vito Vitale, CNR, contributing: AU, UHEL, SU, TROPOS, CNRS, SU, EULS)

This task will aim to promote and facilitate interoperability and ease of access to Arctic and Antarctic aerosol and gas phase data from long-term observations, developing specific actions and realizing and implementing procedures and tools suitable towards this aim. We update the in-situ network inventory at the European level (www.eneon.net/graph). The task recognizes a common mechanism for participating in the GEOSS in-situ foundational tasks and other in-situ coordination European and international efforts and ensuring that all networks contribute to cross-domain valuable resources to GEOSS and to the achievement of the Sustainable Development Goals (SDG). This work supports the implementation of the GEO Strategic Plan (2016-2025) and the related GEO Work Programmes as this task supports a better coordination of the national contributions, and set linkages with existing related Joint Programming Initiatives and to ENEON. The work will lead to a report discussing availability and constraints for Arctic data sets and data streams presenting protocols and procedures to harmonize and integrate data for an operational use in GEO and COPERNICUS including discussion on long-term sustainability implications and needs (D 1.1.1) and specified datasets (D 1.1.2) in standardized format.

Task 1.1a: Integration of ground-based in-situ observations. We will collect data and integrate data streams provided by research infrastructures, networks, and programs devoted to the Arctic, as e.g. IASOA, SIOS, INTERACT2, PEEX, AMAP (See Table 2 and Section 4). We will devote attention also to other on-going environmental research infrastructures and networks that operate up to sub-arctic latitudes (e.g. ACTRIS, GAW, BSRN, ICOS). In relation to SLCFs, particular relevance will be provided to particle number (PN), black carbon (BC) mass and ozone and methane concentrations. IASOA promotes cooperation and harmonization of selected Arctic sites retrieving at the same time a large set of experimental SLCF observations. This network provides highly relevant data to develop a circum-Arctic perspective. With existing Antarctic observations and relevant literature, we define a baseline of the natural background for atmospheric composition in the Polar areas, which will allow to quantify the "anthropogenic offset" observed in the Arctic regions. Relevant data collected will be delivered to WP5.

Task 1.1b: Integration of regular columnar observations. Here columnar observations and vertical profiles of aerosol and trace gases carried out on a regular basis with ground-based remote sensing techniques will be

integrated in order to obtain a 4D picture of SLCFs in the Arctic, quantify the impact of intense long-range transport episodes, provide information necessary to validate satellite products and test accuracy of retrieval algorithms. Particular relevance will be provided to sun-photometric networks (AERONET, SKYNET), multipulsar lidars (MPLN) and data collected inside the NDACC network. We will develop new techniques on the basis of their potentiality to fill relevant gaps, such as the PANDONIA network for trace gases or lunar photometry technique for Aerosol Optical Thickness (AOT). The development of actions to increase columnar observations during polar night will be a specific target of this task, being this a very important gap limiting the development of a strong aerosol climatology in the Arctic. Activities in this sub-task will be strongly linked with those coordinated in Task 1.3, also in order to maximize the support of routine observations to intensive field campaigns. Retrieved data will be harmonized and delivered to WP 5.

Task 1.1c: Integration of observations on surface properties. The analysis of surface properties (e.g. snow optical characteristics, spectral reflectance) will be connected to satellite derived surface observations and build one base for satellite data validation. We will collect aerosol and snow samples at e.g. Ny-Alesund or Villum Research Station for off-line analyses to measure BC and bacteria concentrations. The work will improve satellite products with respect to snow coverage and snow characteristics.

Task 1.2: Improvement of data flow of Near-Real-Time data from in-situ measurement stations (lead: Konstantinos Eleftheriadis, NCSR; contributing: CNR, CNRS, AU, UHEL)

This task will be devoted to determine the actual status in the Arctic observing system of NRT measurements as well as to explore potentiality for a rapid improvement. For certain parameters (i.e. aerosol particle number concentration, BC, O_3) at a maturity level for Near-Real-Time (NRT) reporting, including partly-quality controlled NRT data will become available as working examples for full accessibility. This data will exclusively originate from in-situ measurement stations. This is a challenging task as Arctic stations are not always online or only expensive internet connections are provided. Dedicated methodology and specific actions/software tools will be developed to reduce these limitations. Experiences will be taken from the NEXTGEOSS and CAMS 84 project, which will serve as a knowledge base for this task. NRT data will allow a comparison with modelling experiments to improve modelling platforms for forecasting purposes. The output of this task will highly contribute to WP 4 where satellite and in-situ components will be integrated.

Task 1.3: Interactions with planned intensive observations in the polar regions (lead: Birgit Wehner, TROPOS, contrib. all)

Here we facilitate coordination on planned Arctic field campaigns on a global scale. This is done in collaboration with INTAROS, APPLICATE, SAON and PEEX. We will use e.g. the Arctic Science Partnership (ASP), which coordinates field campaigns in Greenland and Canada with support by the Arctic Research Centre (ARC) at AU. Also, AU is a partner in the Atmospheric Flagship Program in Ny Ålesund where atmospheric observations in Svalbard are coordinated. Joint activities will be carried out by the organizations participating in this task. iCUPE will be coordinated with IGAC/IASC and PACES activities aiming to collect new data on local sources of Arctic pollution (e.g. in Siberia) and assess pollution transported to the Arctic from important mid-latitude emission regions such as Asia. iCUPE activities are strongly linked and coordinated with PACES and PEEX activities. In particular, iCUPE will benefit from past and future airborne activities in Russia, for example via GFZ-AWI airborne trace gas measurements in the Lena river delta region and YAK-AEROSIB, linked to the French PARCS (Pollution in the Arctic System) project, making aircraft measurements of aerosols and trace gases in the Siberian Arctic (CNRS). The synergies, cooperation with specific on-going projects and programmes will be explored in detail and co-operations will be improved. The integration of the German collaborative research centre AC3 investigating Arctic amplification will further pursue the overall aims of this task and so does the planned interactions within Year of Polar Prediction (YOPP) intensive period and MOSAiC (2019-2020) and Cryosphere and ATmospheric CHemistry project CATCH. These campaigns offer e.g. tethered balloon measurements and UAV measurements in the low troposphere (up to 2 km) and aircraft measurements will be integrated in order to better understand how aerosols and trace gases typically distribute in the Arctic stable boundary layer and along the low troposphere and to further quantify the impact of long-range transported pollution in Arctic areas. In relation to this latter aspect, intensive campaigns will be carried out to increase knowledge on interaction with ABL dynamics and on microphysical characteristics of aerosol

stratification. All these aspects are very relevant to increase the accuracy of satellite products and better connect surface and satellite observations.

Task 1.4: Sources and sinks of atmospheric pollution in the polar areas (lead: Andre Prévôt, PSI, contrib. CNR, UHEL, CNRS, AU, NCSR)

The analysis of atmospheric pollution sources outside the Arctic areas and transported to these areas will be supported by utilizing available data via Task 1.1 and Task 1.2. In addition to physical characterization of aerosols, chemical on-line mass spectrometer data as well as off-line filter sampling will be used. Tools for investigation will include e.g. PMF, ME-2 and COPREM. A re-analysis of filters across sites/seasons/years with a focus on the characterization of organic aerosols (combination of quantitative electron impact mass spectrometry and novel extractive electrospray mass spectrometry with molecular information) will be carried out. The task will be restricted to statistical analyses. The Flexible Particle Dispersion Model (FLEXPART) will be applied to acquire sensitivity plumes (Stohl et al., 1999) for backward and forward simulations. PSCF analysis will be applied on the sensitivity plumes in order to acquire sources, sinks and transport pathways of pollution in the Arctic (Eleftheriadis et al. 2009). Additionally, FLEXPART will be used to estimate the actual contribution of each source area to the pollutant mass measured at each measurement site or measured by a satellite. The output of this exercise will be related to long-term observation data series. The modelling work on improved characterization of sources and sinks of ozone, and in particular the role of mercury (WP2, Task 2.2) and aerosols (WP4, Task 4.3), will contribute to this task by providing simulations with WRF-Chem.

Deliverables with relevant task, delivery time and responsible beneficiary and type (R=Report, O=Data/Other, P=Public)

D 1.1.1: Report on discussing availability and constraints for Arctic data sets and data streams presenting protocols and procedures to harmonize and integrate data for an operational use in GEO and COPERNICUS including discussion on long-term sustainability implications and needs (Task 1.1a/ CNR/ O/ P/ M30)

D 1.1.2: Data set on selected species (ground-based measurements) as e.g. particle number, black carbon mass and ozone concentration in standardized format (Task 1.1b/ CNR/ O/ P/ M20)

D 1.1.3: A collection of harmonized measurements and data of the snow spectral reflectance delivered to WP5 (Task 1.1c/ CNR/ O/ P/ M24)

D 1.2.1: A pilot data set on selected parameters of available NRT data of Arctic Research Infrastructures. (Task 1.2/ NCSR/ O/ P/ M22)

D 1.3.1: Web-page as communication platform for upcoming polar activities to increase extensive co-operations within the polar community assuring the highest synergy between the objectives of the forthcoming studies (Task 1.3/ TROPOS/ O/ P/ M18)

D 1.3.2: Integrated data collection of Arctic parameters received via ground-based remote sensing and airborne platforms for submission to WP5 (Task 1.3/ TROPOS / O/ P/ M21)

D 1.4.1: Guidelines for off-line and on-line source apportionment procedures using aerosol mass spectrometry including a protocol how to report such data in EBAS (Task 1.4/ PSI/ R/ P/ M20)

D 1.4.2: A report and a data set on source apportionment of aerosols with a focus on organic aerosols in the arctic including the source regions (Task 1.4/ PSI/ O/ P/ M33)

Milestones

M 1.1.1: Compilation of existing research infrastructures, networks, monitoring programs and corresponding relevant data sets and data streams on Arctic SLCFs for iCUPE targeted to data and data stream harmonization (M14)

M 1.1.2: Compilation of existing observations on surface properties in polar areas including remote sensing techniques and surface snow sampling. (M18)

M 1.2.1: Overview of the current status of Arctic NRT measurements, including NEXTGEOSS and CAMS 84 projects (M14)

M 1.3.1: Plan on future data flow of campaign-vise selected Arctic data sets, their sustainable storage, data harmonization and integration in existing data policies. (M12)

M 1.4.1: Aerosol source apportionment using off-line and on-line measurements finalized (M29).

Proposal Acronym | iCUPE

WP 2: In-situ component for organic contaminants, mercury and other heavy metals (lead: Carlo Barbante, CNR)

Work package number	2	**Lead beneficiary**			CNR
Work package title	**In-situ component for organic contaminants, mercury and other heavy metals**				
Participant number	1	2	7	18	
Short name of participant	CNR	AU	CNRS	HZG	
Person months per participant:	145	16	39	23	
Start month	1			**End month**	34

Objectives

- to quantify the presence, and present day lifecycle of anthropogenic contaminants ((PBDE, PAH, PCB and Persistent Chemicals of Emerging Global Concern), mercury and heavy metals (Cr, Pb, Cd), along with black carbon (BC)), through annual snow and aerosol sampling. This will be obtained from dedicated ice core samples for comparison.
- to continue atmospheric Hg monitoring in polar regions and perform an in-depth evaluation of the mercury cycle,
- to perform modelling of halogens/ozone and analyze their influence on arctic chemistry and contaminant cycles, including Hg.
- to study the exchanges and interactions of persistent contaminants between different polar environmental compartments.

Description of work

WP2 will improve our knowledge of the presence and the environmental cycling of persistent contaminants, mercury and other heavy metals in the Arctic environment during the present and over the last century. WP2 will then evaluate the exchanges of these contaminants between the atmosphere, cryosphere and biota in the Arctic by combining in situ measurements and modelling. The results obtained from modern samples will be compared with data from dedicated ice cores to obtain a long scale vision of these processes.

Task 2.1: Defining human impacts on polar regions – cryosphere monitoring and ice core archives (lead: Carlo Barbante, Andrea Spolaor, Warren R.L. Cairns, CNR-IDPA)

Here we quantify organic and inorganic anthropogenic contaminants and BC, in both the Arctic (Ny-Alesund \ Villum stations) and Antarctic (Mario Zucchelli, Dumont Durville, Dome C stations) in annual and pluriannual snow. Dedicated ice cores will be taken to study the presence of these contaminants over the last 200 years to improve our definition of the beginning of the Anthropocene epoch. Antarctic observations will be used to set the base-line for the composition of anthropogenic pollutants in the atmosphere. The data from this task will be combined with task 2.4, to connect snow measurements with on-going aerosol measurements (Ny-Alesund, Villum, EBAS on-line data archive and data from WP 1) & integrated in WP 4.

Task 2.2: Hg monitoring in Polar regions and evaluation of the atmospheric mercury lifecycle (Lead: Jeroen Sonke, CNRS-GET; participants Aurélien Dommergue, CNRS-IGE; and Jennie Thomas, CNRS-LATMOS, contrib. AU)

Mercury is a significant pollutant in Arctic biota and its lifecycle is not fully known. Particularly Hg oxidation via bromine radical chemistry is poorly known. It is crucial to re-assess the quality of atmospheric Hg data and perform required consistency checks. We will reassess atmospheric Hg(II) speciation and dynamics at two key Arctic monitoring sites: Villum (AU) and Ny-Ålesund (in collaboration with K. Aspmo). We will inter-compare Tekran analyzers with CEMs on diurnal to weekly time scales during all seasons and investigate the origin of summertime Hg emissions by monitoring the Hg isotope signatures of atmospheric Hg on a weekly basis. Hg stable isotopes have the capacity to distinguish Hg from riverine (terrestrial), marine and atmospheric origin. We will integrate our new CEM and Hg isotope observations into box models and coupled 3D Hg chemistry and transport models to improve the parameterization of atmospheric Hg oxidation mechanisms and dynamics. We will focus in particular on the role of reactive halogens on arctic Hg dynamics. We utilize the existing long-term and focused halogen measurements to interpret Hg measurements performed and complement the measurement data with FLEXPART for source

attribution for the detected atmospheric Hg.
The outcome of this work is a quality controlled and consistent GMOS atmospheric Hg data set for the Arctic.

Task 2.3: Modelling of halogen/ozone and its influence of arctic chemistry (Jennie Thomas, LATMOS-CNRS; participants: Jean-Christophe Raut, LATMOS- CNRS, Jacques Pelon, LATMOS-CNRS, Aurélien Dommergue, CNRS-IGE, contrib. Jeroen Sonke, CNRS-GET, Carlo Barbante, Andrea Spolaor, Warren R.L. Cairns, CNR-IDPA)

The main process that results in mercury deposition in the Arctic is reactions with reactive halogens in the atmosphere. During Arctic spring, reactive halogen species in the atmosphere oxidize elemental mercury (a priority pollutant) to form species that are readily deposited in the Polar regions. In addition, halogens react with ozone in the ABL and deplete ozone to near zero levels during Arctic spring. In order to interpret the new and existing long time series of both ozone and Hg, it is essential that we improve our understanding of the Arctic halogen cycle.
Here, we incorporate the findings from other work packages and tasks (WP1, WP2) into a state of the art reactive chemical transport model to improve our understanding of the Arctic halogen budget, with a focus on Hg and ozone. This will help better predict future scenarios of how the Arctic will change under the influence of environmental change by increasing our knowledge of the processes that determine the budgets of a key greenhouse gas (ozone) and key pollutant (Hg). Both process modelling and the regional Model WRF-Chem will be used including a description of halogen (bromine) chemistry on snow/ice/aerosols in the Arctic to assess how halogens influence Hg and ozone on the regional scale. Work will be closely coordinated with and take advantage of a new IGAC/SOLAS sponsored activity on atmospheric chemistry in cold regions (CATCH).

Task 2.4: Study of interactions between environmental spheres (atmosphere, hydrosphere, biosphere, cryosphere) (Zhiyong Xie, Ralf Ebinghaus, HZG, Warren Cairns, Andrea Spolaor, IDPA-CNR)

We evaluate the transfer rates between the atmosphere and the other environmental spheres. Anthropogenic contaminants are mainly transported to the Arctic by long range atmospheric transport, except for specific site where contamination is produced in situ by local activities. In this task, we utilize high volume air sampling and snow sampling in winter and spring at Ny-Alesund available since 2012 to investigate POPs and CECs). The data produced in iCUPE will improve models to predict the environmental processes and assess the effect of variability in the long-range transport and the fate of these man-made chemicals in the Arctic ecosystem. The task will deliver a data set on the persistent chemicals of emerging global concern in the Arctic by monitoring the atmosphere and its aerosol composition through the entire year, by sampling and analyzing 1) the annual snow before melting, 2) glacial melt water, 3) sea water before, during and after the melting season and 4) soil samples (where soil is present and accessible).

Deliverables with relevant task, delivery time and responsible beneficiary and type (R=Report, O=Data/Other, P=Public)

D 2.1.1: Data set of anthropogenic contaminants in snow from polar regions (Task 2.1/ CNR / O/ P/ M16)
D 2.1.2: Data set for anthropogenic contaminants in ice cores (Task 2.1/ CNR / O/ P/ M22)
D 2.1.3: Report on definition of the Anthropocene (Task 2.1/ CNR / R/ P/ M28)
D 2.2.1: GMOS observations: Improved GMOS SOPs for atmospheric Hg(II) measurements in the Arctic & updated GMOS database for Arctic atmospheric Hg(II) observations (Task 2.2/CNRS/ O/ P/ M16)
D 2.2.2: GMOS modeling: Revised reaction mechanisms and rates of atmospheric Hg(II) formation in the Arctic (Task 2.2/ CNRS/ R/ P/ M28)
D 2.2.3: GMOS observations: New Arctic atmospheric Hg isotope monitoring data set (Task 2.2/ CNRS/ O/ P/ M22)
D 2.3.1: Model evaluation of the role of halogens in Hg and ozone depletion events in the Arctic (Task 2.3/ CNRS/ R/ P/ M30)
D 2.4.1: Determination of anthropogenic contaminants in air, seawater, soil and biota in the Arctic (Task 2.4/ HZG/ R/ P/ M24)
D 2.4.2: Evaluation of the cycling and re-cycling of persistent contaminants between the atmosphere, cryosphere and ground water with their seasonal fluxes (Task 2.4/ CNR/ R/ P/ M30)

Milestones
M 2.1.1: Completed collection of surface snow (M12)
M 2.1.2: Completed collection of ice cores (M18)
M 2.1.3: Completed comparison between Arctic and Antarctic deposition rates and exchanges to obtain natural background rates. (M24)
M 2.2.1: Completed collection of atmospheric Hg(II) speciation and Hg(0) isotopic composition (M12)
M 2.3.1: Completed model coding to quantify the coupled ozone-halogen-mercury cycle (M24)
M 2.4.1: Completed collection of air, seawater, soil and biota in the Arctic (M20)
M 2.4.2: Complete 3-D atmospheric transport model coding for persistent contaminants and application to analysis date sets for the Arctic and Antarctic (M28)

WP 3: Satellite remote sensing of Arctic surfaces (lead: Angelika Humbert, AWI)

Work package number	3	**Lead beneficiary**			AWI
Work package title	**Satellite component**				
Participant number	5	1	2	14	17
Short name of participant	AWI	CNR	AU	FMI	GFZ
PM per participant:	54	54	2	49	35
Participant number	37				
Short name of participant	UHEL				
PM per participant:	3				
Start month	1			**End month**	34

Objectives
- to streamline satellite remote sensing data flows, incl. cal/val and develop novel products
- to develop analysis methods for snow surfaces, biomass and extraction of natural resources
- to characterize glacier tomography with synergistic operation of satellites and aircraft remote sensing
- to contribute to strategic development of comprehensive EO needs and opportunities in the polar areas

Description of work
The current and upcoming satellite missions will greatly enhance our capability of Earth observation, which in polar areas with a very sparse in-situ station network will give us spatial coverage to monitor the large area.

Task 3.1: Streamlining satellite remote sensing data flows for new multi-sensor, multi-dimensional products (Jyri Heilimo, FMI)
The paradigm of environmental monitoring is changing as massive data sets from emerging EO satellite constellations are becoming available. Multi-mission data sets from radars, microwave radiometers and optical sensors need to be analyzed together with similar statistical methods. To ease this process an interface to different missions and in-situ data enabling re-gridding to a common data structure is needed. This task will leverage on national projects in Finland connecting in this task international efforts to the same interface. We will streamline the availability of FMI cryospheric in-situ measurement data, measured in Northern Finland for scientific research and satellite CAL/VAL from 1) Lit-DB data (http://litdb.fmi.fi), 2) Pallas-Sodankylä GAW supersite data, 3) Carb-ARC project data.
We prepare interfaces for availability of FMI cryospheric products for ERA-PLANET. These products include satellite data derived Northern Hemisphere snow cover, satellite data derived Northern hemisphere ground freeze/thaw data, pan-european super high resolution snow water equivalent data products and develop re-gridding computations for massive parallel processing systems at FMI National Satellite Data Centre and Finnish Copernicus Collaborative Ground station.

Task 3.2: Optical satellite remote sensing (Rosa-Maria Salvatori, CNR, Sabine Chabrillat, GFZ)
Here we focus on the capabilities and limitations of current and upcoming optical remote sensing sensors for the derivation of key surface variables in Arctic areas affected by climate and anthropogenic changes. New

approaches will be developed and applied to snow/ice cover and characterization, vegetation changes and biomass characterization (vegetation status, composition, pigments), and mapping of natural resources extraction through night light observations. In the snow observations we will integrate remotely sensed data and ground-based observations (WP1). This enhances the capability of optical remote sensing to characterize snow/ice surfaces and to estimate the fraction of snow cover. The methodology will be developed on Svalbard with Sentinel 2/3 data (level 1c), Landsat 8 OLI and additional ground-based observations. The images obtained by the censored webcams available in the study site will be processed in order to be merged with the other data in the repositories considered in the project. The web images will be processed using state-of-the-art algorithms in order to estimate the fraction of snow cover in different locations. Spectroradiometric surveys will be performed in-situ to enrich the spectral library already available for ground-truthing. Similar analysis will be done to extract useful information about the vegetation cover for spring-summer time.

Furthermore, the potential of current and upcoming Copernicus optical missions for vegetation mapping in permafrost snow-free areas during the summer months will be studied and improved methodologies will be developed for a more accurate mapping and monitoring of vegetation stages applied to Arctic environments. For this, data from Sentinel2 A/B (level 1c), Landsat 8 OLI, airborne hyperspectral imagery and additional ground- based observations on vegetation phenology, pigments, and field spectroradiometric measurements will be used. Upcoming satellite hyperspectral sensors (PRISMA 2018, EnMAP 2019, SHALOM 2020) data will be simulated, and this will help us to determine both the current state and the development of the amount of natural biomass in the Arctic areas, with demonstration in selected sites (Toolik, Canada). Such maps can be utilized as a proxy for the availability of natural renewable biomass for various purposes, such as paper, pulp and manufacturing as well as for a source of bioenergy.

Also, optical remote sensing night data will be used to provide new insights on amount of areas affected by natural resources extraction (gas and oil fields) in the Arctic. A web-based tool using light night data from the US satellite Suomi NPP will be developed in ERAPLANET Strand 2 related to the observation and monitoring of artificial light sources. This tool will be applied in iCUPE to map and demonstrate growing infrastructure developments of gas and oil fields in the Artic on the land and on the continental shelves showing trends over time for selected sites. While anthropogenic light is itself a pollutant in areas that normally experience several months of darkness, this data will provide a view on the availability of natural gas and oil and subsequent light pollution coming from resources extraction expansion in polar areas.

Task 3.3: Radar satellite remote sensing (Angelika Humbert, AWI)

Surface processes will play an increasing role in the evolution of the Greenland ice sheet, as climate change will lead to increasing surface melt and with that increasing appearance of supraglacial lakes potentially lubricating the base of the ice sheet affecting ice discharge. Within this task, we will produce time series of lake area based on radar sensors (Sentinel1A & TerraSAR-X) and compare the effect of different resolution and polarization on the estimates. We will estimate lake volume based on TanDEM-X data and compare that to estimates based on optical imagery in order to assess the limitations and accuracy. This feeds into Task 3.4 and enable us to develop a strategy for observation of lake evolution in the future.

We will exploit the polarimetric radar remote sensing to understand ice sheet structures, and we will analyze Sentinel1A and TerraSAR-X polarimetric acquisitions in the two key areas 79°N Glacier and at NEGIS. Polarimetric radar remote sensing is a cutting-edge technique which is not yet fully adapted in the field of glaciology and has the potential to enable the community to retrieve further important variables. Here, we will also compare C- and X-band polarimetric data to estimate different performance for the retrieval of surface properties. However, the methodology has to be assessed by comparing with airborne and in-situ data, which we propose to carry out for the proposed locations. This will be completed by assembling recommendations for in-situ observations required for validation experiments for future polarimetric missions.

AWI is going to carry out airborne campaigns that will retrieve different types of radar and laser scanner data at two different locations in Greenland with different characteristics: the melt dominated area of 79°N glacier and the onset of NEGIS in the vicinity of the EGRIP locations, where also in-situ data of snow and surface properties will become available in coming years. We will use the data from the airborne campaigns to assess the retrieved properties from the radar remote sensing for both supraglacial lakes and surface structures.

Furthermore, an airborne-supported campaign will collect polarimetric radar echo sounding data allowing to estimate the anisotropy of the ice sheet at selected location down to a few hundred meters depth, and hence exactly the depth a L-band satellite mission could sound. This feeds into Task 3.4 with respect to retrieving vertically resolved upper ice sheet structure from space.

Task 3.4: Contribution to the strategic development of comprehensive EO in the Polar Areas (Mikko Strahlendorff, FMI, contrib. AWI, CNR, UHEL, GFZ)

While some variables retrieved by satellite remote sensing are very well established, the upcoming missions will open new possibilities for challenging variables. Techniques for detecting and monitoring air composition and environmental states are increasing in capability and efficiency. This task will develop a strategy for in-situ observation grids based on scientific and other user needs combined with adequate satellite remote sensing observations. We will perform an internet user needs consultation and a review of current and proposed future capabilities of satellite and in-situ observation systems found from internet sources. A lot of new innovative opportunities need to be reviewed as the New Space era brings with nano-satellite solutions (both hyper spectral imaging and SAR solutions are in development!) with the many small compared to one big mission observation system solutions that have not been used yet. Drones and autonomous stations for in-situ add another new opportunity. Above all combining everything in smart big data systems for maximum exploitation can help to guide both satellite and in-situ observation system developments. This shall act as guidance for upcoming satellite missions and connecting them with comprehensive in-situ monitoring networks.

Deliverables with relevant task, delivery time and responsible beneficiary and type (R=Report, O=Data/Other, P=Public)

D 3.1.1: Technical report on common satellite data interface description document to describe how satellite derived cryospheric measurement data can be accessed and utilized (Task 3.1/ FMI/ R/ P/ M22)

D 3.1.2: Technical report on common in-situ data interface description document to describe how FMI measured in-situ data can be accessed and utilized (Task 3.1/ FMI/ R/ P/ M24)

D 3.2.1: A technical report on the assessment of the capabilities and limitations of advanced optical satellite missions for snow, vegetation, and gas flaring mapping applications in Artic areas (Task 3.2/ CNR, GFZ/ R/ P/ M27)

D 3.2.2: A dataset on novel optical remote sensing products on snow, vegetation, and gas flaring mapping in selected sites (Task 3.2/ CNR, GFZ/ O/ P/ M30)

D3.3.1 Technical report on the assessment of the capabilities and limitations of polarimetric SAR for glaciological applications for wet-crevassed and dry surfaces of the Greenland ice sheet (Task 3.3, AWI / R / M30)

D3.3.2 Time series of lake size over a key region in Northeast Greenland (Task 3.3, AWI/O/M32)

D 3.4.1: Polar EO needs (Task 3.4/ FMI/ R/ P/ M12)

D 3.4.2: Polar EO opportunities (Task 3.4/ FMI/ R/ P/ M24)

Milestones

M 3.1.1: Overview of the available ground-based data resources useful for the integration with the Earth Observation snow products (M3)

M 3.2.1: Completed acquisition of field data and satellite imagery for snow, vegetation, and improved mapping of gas flaring based on optical remote sensing (M20)

M 3.3.1: Completed acquisition of X-band polarimetric SAR data (VV, HV, VH) over 79°N Glacier, EGRIP and ExNGT locations in summer and winter (M12)

M 3.3.2: Completed acquisition of time series of X-band data (HH) over 79°N Glacier (M20)

M 3.4.1: User needs internet survey produced and online (open for 3 months) (M6)

Proposal Acronym | iCUPE

WP 4: Integrating in-situ, satellite and model components for improved environmental assessment (lead: Jean-Daniel Paris and Kathy Law, CNRS)

Work package number	4	**Lead beneficiary**			CNRS
Work package title	**Integrating in-situ and satellite components**				
Participant number	7	1	2	17	25
Short name of participant	CNRS	CNR	AU	GFZ	NCSR
PM per participant:	45	10	6	3	15
Participant number	27	36	37		
Short name of participant	PSI	SU	UHEL		
PM per participant:	9.8	40	40		
Start month	1			**End month**	34

Objectives:

- to address measurement challenges by developing new proxies and quality assurance approaches for atmospheric aerosols,
- to support Arctic applications of atmospheric transport models by reinforcing meteorological data through the enhanced capability of satellite validation using new methodologies at the convergence of in situ satellite and models, and adapted to the Arctic,
- to establish integrated in-situ - satellite - model approaches to estimate pollution and short-lived climate forcers sources in the Arctic, using a combination of campaign and long term measurements and atmospheric chemical transport models,
- to develop new impact assessment methodologies for pollutants in Polar regions that exploit combined streams of enhanced information and to explore exposure and impact of pollutants under alternative resource exploitation scenarios.

Description of work

In order to improve our understanding of Arctic pollution and its impacts, and to enhance availability of timely information to the public and to policy makers through GEO and Copernicus, integrated methodologies adapted to the specificities of the Arctic challenges are required that can operate a smart convergence of data streams of in situ and satellite measurements. Such approaches will require enhance data processing and analysis capability, satellite validation capability for the Arctic, as well as robust Earth system models and assimilation approaches. WP4 aims to develop methodologies for the integration of in situ measurements, satellite data and models for improved environmental assessment of Arctic pollutants.

Task 4.1: Novel quality assurance methods, proxies and observables related to aerosols, mixing layer and biosphere parameters (Pauli Paasonen, UHEL; contrib.: EULS, CNR, AU, GFZ, NCSR)

In this task, we develop advanced data products based on the joint operation of in-situ observations and satellite-derived products. We will produce proxies relying on satellite measurements by parameterizing with satellite retrievals the variables from intensive campaigns or from long-term measurement data sets. Campaign-based proxies will be validated with long-term measurement data sets, and vice-versa. We will use satellite data to derive proxies e.g. for mixing layer height measured with Doppler lidar, for condensation sink (CS), and gross primary production of the biosphere. These proxies are crucial for quantifying feedback mechanisms in the Arctic environment, particularly over Siberia, and estimating pollution transport to and concentration levels over polar areas.

We will use data assimilation methodologies to generate homogenous time series of past in situ measurements. This enables effective quality control and better information extraction of historical continuous measurements applying theories and approaches of today. This will also help us to prepare for future needs in data processing and archiving as well as experimental design. We will apply our implementation of the Extended Kalman Filter to estimate aerosol size distributions based on historical aerosol number size distribution and aerosol optical data. This implementation applies a size-segregating model of aerosol microphysics to evolve the aerosol system state from one observation time to the next. Each measurement has its instrument-specific forward model. This setup enables us to generate “re-analyses” of

historical aerosol measurements. The emphasis will be initially on the accomplishment of the aerosol re-analyses for a single station in situ data (SMEAR-II), and will be shifted later to ground based remote sensing data in connection with AOD data available from WP 1. The produced proxies and observables will be made to fit directly the data formats required by GEOSS and Copernicus and delivered to WP5. The reliability of the products is tested in different locations.

Task 4.2: Methodologies for validation of precipitation and cloud satellite products in high-latitude and Arctic regions (Dmitri Moisseev, UHEL)

Given the lack of observations in the Arctic there is a need for comprehensive validation of the current and upcoming satellite products. We use direct validation and use calibrated ground observations of cloud and precipitation properties using research grade remote sensing instruments to directly verify satellite products. On the other side, we use physical validation, which verify assumptions and parameterizations used in satellite retrievals. The validation activities will be based on comprehensive measurements of cloud and precipitation properties in Hyytiälä and Pallas-Sodankylä research stations. The observation setup includes C, Ka- and W- band precipitation and cloud radars, Doppler lidar, humidity and temperature profiling microwave radiometer and a comprehensive suite of ground-based precipitation sensors. These observations collected at the research stations that provide a very detailed look into vertical structure of cloud and precipitation systems will be expanded, to yield a greater spatial coverage, by combining them with FMI C-band weather radar network observations.

The measurements of clouds and precipitation properties will be used to verify precipitation products of NASA GPM, Eumetsat METOP satellites and cloud / precipitation products of NASA Cloudsat and the upcoming ESA EarthCare missions. The emphasis of these studies is on how well high-latitude cloud and precipitation systems are captured by these missions and how good is the representation of the ice microphysics in their retrieval algorithms.

Task 4.3: Sources and sinks and transport of Arctic pollution determined from an integrated analysis of in-situ and satellite data (JD Paris, CNRS-LSCE, CNRS-LATMOS (Law), contrib. UHEL, SU, GFZ)

In this task, poorly known sources and sinks of key atmospheric species will be investigated via the combined analysis of satellite and in situ data, together with regional modeling. We will focus on improved quantification of sources and origins of pollution in the Eurasian Arctic, and in particular Siberia, where sources of trace gases and aerosols are very poorly known.

Surface and High Spectral Resolution Lidar (HSRL) collected in southern Finland at Hyytiälä during BAECC campaigns will be used for analyzing aerosol types in different layers using lidar ratio, depolarization and color ratios. Aircraft aerosol measurements with 140 flight hours around the measurement site during 30 days representing spring, summer and autumn conditions (Petäjä et al. 2016b) will also be analyzed to distinguish aerosol origins. This aerosol typing with active remote sensing from the ground will be compared with the in-situ aerosol source apportionment results from Task 1.4 and with satellite derived aerosol measurements. Data from Hyytiälä will be compared with data available from Tomsk (central Siberia, Russia) via collaboration between IOA-SB RAS, CNRS and UHEL.

An integrated analysis of existing and new in-situ (surface, lidar), airborne (e.g. YAK) and satellite data (e.g. CALIOP, ADM) will be performed based on case studies in the Eurasian Arctic, to improve understanding about local sources of anthropogenic pollution such as black carbon, ozone and its precursors (e.g. methane). Tools such as FLEXPART will be used to analyze air mass origins, including pollution plumes, during specific campaign periods as well as the importance of processing such as scavenging by clouds.

Combined analysis of airborne and satellite data will be used to improve assessment emissions such as those related to resource extraction or domestic combustion in Russia. For example, VIIRS night-light data, combined with analysis YAK data, will provide new information on black carbon emissions from flaring associated with oil/gas production, estimated to be one of the principal sources of BC in the Arctic. Anthropogenic methane source estimation in the Russian Arctic will also benefit from this analysis. Regional model simulations using WRF-Chem combined with analysis of satellite data (e.g. CALIOP, IASI) will be used to assess the importance of different sources and to examine pollutant processing. This work will benefit from the model developments on trace gas/aerosol recycling/sources at atmosphere-snow-ice interfaces (Task 2.2). Regional modeling will also be used to quantify the contributions of local pollution relative to remote sources in the Eurasian Arctic. This work will also contribute to the planning for new field campaigns, such

as PACES field campaigns investigating pollutant transport from Asia to the Arctic. It will lay the foundation for new integrated observational strategy in the detection of changes in emissions of climate forcers and air pollutants.

The PMCAMx and BETR Global models will be used to quantitatively link concentrations of atmospheric pollutants to emissions and impacts. The models will quantitatively link the concentrations of atmospheric constituents to emissions estimates. We will 1) provide an enhanced modeling platform using the PMCAMx model, including, for example, improved coupling of semi-volatile POPs treatments with (organic) aerosols, which are important for determining pollutant deposition in the gas or particle phase deposition; 2) Aerosol composition and concentration fields calculated with PMCAMx will be used to improve aerosol descriptions in BETR Global, which currently includes only one generic aerosol type. In addition, the gas-particle partitioning algorithms in BETR Global will be updated to explicitly consider partitioning of semi- and low-volatile POPs to different aerosol components, and to describe non-equilibrium partitioning of lowlatile pollutants between the gas and aerosol phases. The improved versions of PMCAMx and BETR Global will be applied to model concentrations of selected POPs, exploiting in-situ and satellite observation data collected in other WPs (WP1, WP2), and long-term monitoring data that is publically accessible in the EBAS and Stockholm Convention GMP data warehouse databases.

Task 4.4: Impact assessment and future exposure scenarios of pollutants in the Arctic (Lead SU Matthew MacLeod, UHEL, CNRS-LSCE, CNRS-LATMOS)

The integrated observational analyses, improved models and new knowledge about emission, transport, processing and fate of Arctic pollutants (Tasks 4.1, 4.2, 4.3) will be combined to provide impact assessment indicators and metrics for scientific and policy use. The nature of the impact assessment will depend on the pollutant. For example, impacts of black carbon and ozone will be linked to work in the AMAP framework on short-lived climate forcers. Results from the improved contaminant/aerosol models (PMCAMx, BETR) will be compared with existing quasi-hemispheric or higher resolution case studies with WRF-Chem aerosol simulations, which has been used in previous AMAP assessments. For POPs, BETR Global is one of only two models that have contributed simulation results as scientific support for implementation of the Stockholm Convention and the Convention on Long-range Transboundary Air Pollution since 2011. Impact assessment metrics for POPs will include source-receptor analysis and depositional flux into Polar ecosystems.

The new data and modeling tools will be further exploited to support policy analysis by providing exposure scenarios for the Arctic that represent alternative possible resource development paths. The feasibility of scenario analysis using BETR Global for has already been demonstrated in generic assessments of POP emissions (Wöhrnschimmel et al. 2013). Scenarios illustrating alternative emission reduction paths for selected POPs will be developed using the improved emissions inventories from Task 4.3 and experience with legacy POPs as a starting point.

We will further apply emission scenarios from GAINS together in the Earth system model ECHAM-HAM combined with national plans for extracting natural resources in polar areas, to generate specific scenarios for future changes in polar emissions and their impacts on pollutant concentrations (e.g. BC, OC, SO_2, CH_4). Model scenarios developed in this task will provide a multidisciplinary view of the current status of atmospheric composition in the Arctic, and explore alternative future scenarios for the Arctic environment. Alternative scenarios will be useful for outreach to the general public, and provide policy makers and scientists with forecasts based on a synthesis of models with the full scale of in-situ measurements and Earth Observations (EO) from space.

Deliverables with relevant task, delivery time and responsible beneficiary and type (R=Report, O=Data/Other, P=Public)

D 4.1.1: A blueprint for novel proxy variables integrating in-situ and satellite remote sensing data with a exemplary dataset (Task 4.1/ UHEL/R+O/ P/ M29)

D 4.1.2: Pilot aerosol re-analysis data sets for SMEAR II (Task 4.1/ UHEL/ O/ P/ M32)

D 4.2.1: A validated dataset on precipitation in the Arctic (Task 4.2/ UHEL/ O/ P/ M30)

D 4.3.1: A dataset of validated aerosol vertical profiles from ground-based and satellite observations above selected sites in Finland and Siberia (Task 4.3/ CNRS & UHEL/ O/ P/ M24)

D 4.3.2: Report on evaluation of local pollution sources in the Eurasian Arctic based on integrated data analysis and modeling (Task 4.3/ CNRS/ R/ P/ M32)

D 4.4.1: Report on enhanced POP modeling capacities with BETR & PMCAMx (Task 4.4/ SU/ R/ P/ M12)
D 4.4.2: Report on advances in integrated assessment of Arctic environmental pollution (Task 4.4/ SU/ R/ P/ M32)

Milestones
M 4.1.1: Identification of relevant in-situ and satellite data for proxy development (M6)
M 4.1.2: Identification of suitable case studies for combined source apportionment (M8)
M 4.4.1: Enhanced PMCAMx and BETR Global ready (M26)

WP 5: Data provision, interoperability and facilitation of data and services

Work package number	5	**Lead beneficiary**			EULS
Work package title	**Data provision, interoperability and facilitation of data and services**				
Participant number	11	1	2	5	7
Short name of participant	EULS	CNR	AU	AWI	CNRS
PM per participant:	37	15	8	10	2
Participant number	14	17	18	25	27
Short name of participant	FMI	GFZ	HZG	NCSR	PSI
PM per participant:	10	12	5	10	5
Participant number	30	36	37		
Short name of participant	TROPOS	SU	UHEL		
PM per participant:	5	5	30		
Start month	1			**End month**	34

Objectives

- to contribute to development of a common ERA-PLANET virtual platform,
- to ensure interoperability between the datasets and products developed in iCUPE and other ERA-PLANET strand projects
- to facilitate development of data products and datasets from WPs 1-4 to the ERA-PLANET, GEOSS and Copernicus services.

Description of work

This WP facilitates the data provision and services from iCUPE to the end-users, decision-makers, and stakeholders. Data information from WPs 1-3 is integrated and assessed in WP4, and the data products and assessments are distributed through WP5. The harmonized ground-based in-situ, regular column observations, etc. and assessed through developed novel methods, proxies and observables, are delivered to WP5 through interoperability tools and services and put at disposal of iCUPE partners and any other end-users/ decision-makers/ stakeholders (in agreement with existing data policies and open source principles).

Task 5.1: iCUPE Data management plan (lead: Alexander Mahura, UHEL; contrib.: all)

To achieve ERA-PLANET (European network for observing our changing planet) overarching objectives, and to pursue cross-thematic interoperability and contribute effectively to GEOSS, iCUPE will to implement best practices and recommended approaches of ERA-PLANET. This will allow iCUPE to contribute to GEOSS (Global Earth Observation System of Systems) via the GCI (GEOSS Common Infrastructure) and to utilize relevant Copernicus data and Core Services and EU capabilities in the EO domain. iCUPE will promote and implement the use of open specifications (i.e. international standards, Community specifications) for data sharing and will foster technological development to deliver more timely and high quality data and information, in compliance with the GEOSS DMP (Data Management Principles). Furthermore, the iCUPE data management plan will assure the coordination and interoperability between the ERA-PLANET projects and with other activities carried out as part of GEO Strategic Plan (2017-2019) (i.e., GEO Initiatives, Flagships, Foundational tasks). The above aspects are refined in the iCUPE data management plan following the "Guidelines on FAIR Data management in Horizon 2020" (version July

2016).

Task 5.2: Appliance of ERA-PLANET principles and key enabling technologies for interoperability: infrastructure design and development (horizontal) (lead: Stefano Nativi, CNR, contrib. all)

This task aims to design and implement a web-based infrastructure (i.e. the iCUPE infrastructure) to manage and share data and information. It contributes to the common (virtual) ERA-PLANET platform by implementing a set of interoperability services. For achieving that, a set of common key enabling technologies (KETs) and principles will be applied (see the ERA-PLANET KET guidelines). In particular, the iCUPE infrastructure will apply the GCI brokering approach and its principles and the GEO DAB (Discovery and Access Broker) technology.

The developed infrastructure builds on the data and services worked out by WPs 1-4. The infrastructure includes a set of interoperability APIs, as recommended by the ERA-PLANET interoperability guidelines. This facilitates effective communication and interoperability with the other ERA-PLANET strands.

Task 5.3: Compliance of iCUPE to GEOSS and Copernicus data sharing principles and GCI interoperability testbeds (horizontal) (lead: Paolo Mazzetti, CNR, contrib. EULS, all)

This task aims to ensure the compliance of iCUPE information and data products with GEOSS and Copernicus data management and data sharing principles. The compliance includes provision of metadata and data quality (Quality Assurance and Quality Control, Quality of Service, QA/QC, QoS) as well as GEO Label implementation.

This activity aims to implement a common quality level of ERA-PLANET products (see the ERA-PLANET interoperability guidelines). The activity will be realised in a close collaboration with WPs 1-4 developing iCUPE products. It is also conducted in a close co-operation with T5.1 (Data management plan).

Interacting with WPs 1-4, the development of novel data products and services is provided here. This ensure the compliance of these new developed data products and services with GEOSS and Copernicus data sharing principles and interoperability. This a key component in iCUPE as a whole. The GCI brokering approach will be applied and its principles will endorse GEOSS Data Management and Data Sharing Principles and GEO DAB (Discovery and Access Broker) technology.

Task 5.4: Implementation of interoperability interfaces on international and community-based standards, GEOSS Data Management Principles and GEO Label (horiz.) (lead: Paolo Mazzetti, CNR, contrib. all)

This task aims to access shared data and products produced in the framework of EU and international programs, and in particular: GCI/, ESA TEPs and Copernicus DIAS. Implementation of metadata and data quality (Quality Assurance and Quality Control, Quality of Service, QA/QC, QoS) strategies are utilized to ensure development of interoperability interfaces. We will utilize Data Management Principles (DMP) set by QA4EO (www.qa4eo.org) and implement fit-for-purpose indicators with GeoViQua models (www.geoviqua.org) and QualityML that enable annotations and geospatial user feedback capability.

The activity will include a set of interoperability tests between the iCUPE infrastructure (developed in T5.2) and the GCI to ensure effective interoperability of iCUPE with GEOSS. Interoperability with the infrastructures developed by the other strands will be tested, as well.

The iCUPE data will contain Persistent Identifier (PID) and follows recommendations of Research Data Alliance (RDA) on data citation. We aim to implement data versioning, timestamping and identification on iCUPE data allowing multistage data retrieval. The iCUPE data will include metadata (what is measured, where and how) describing the content of the data encompassing the end-user to properly utilize both data and services. Advantage will be taken of available tools, such as metadata editor / validator, data visualization and curation tools to ensure provenance, data identification, data curation and preservation of data and services.

Task 5.5: Facilitating iCUPE data pilots, data and services towards ERA-PLANET community, GEO and Copernicus (lead: Steffen Noe, EULS, contrib.: all)

This task facilitates development of iCUPE data pilots, links to existing data pilots and develops dissemination strategies of data sets and services. We aim to contribute data and services to GEOSS via the GEOSS Common Infrastructure (GCI) using the DAB APIs.WP1 provides a pilot on in-situ near-real time data from arctic observation stations and campaign like field expeditions. The data to be piloted include a selection from aerosol parameters, BC, methane, ozone and aerosols and can be also physical parameters

such as radiation, albedo and snow spectral reflectance. WP2 provides data on anthropogenic pollution traceable in the arctic regions, these include heavy metals (Hg, Pb, Cd) and anthropogenic organic pollutants (PBDE, PAH, PCB). Samples from snow, ice cores, seawater, soil and biota will be delivered. WP3 delivers remote sensing data accompanied by in-situ and airborne data of ice sheet structure and dynamics. Data sets of supraglacial lake formation (area, volume) and occurrence frequency and data on glacier discharge are provided. Remote sensing data on land use change (mining, oil/gas production, agriculture/forestry) and natural biomass production are delivered. WP4 provides proxies for physical parameters like height of the atmospheric mixing layer or atmospheric chemistry proxies like condensation sink using data provided from WP1-3. WP4 provides data harmonization and proxy variables linking remote sensed and in-situ ground based measurements and provides data on identification of source and sink regions and atmospheric transport of pollutants. Furthermore, WP4 delivers impact assessments and future scenario of pollutants in the arctic.
The task includes interfacing the flow of data bi-directional between iCUPE, ERA-PLANET, GEO and Copernicus communities.

Deliverables with relevant task, delivery time and responsible beneficiary and type (R=Report, O=Data/ Other, P=Public)
D 5.1.1: iCUPE data management plan (ver 1) (Task 5.1/ UHEL/ R/ P/ M03)
D 5.1.2: iCUPE data management plan (ver 2) (Task 5.1/ UHEL/ R/ P/ M15)
D 5.1.2: iCUPE data management plan (ver 3) (Task 5.1/ UHEL/ R/ P/ M27)
D 5.2.1: iCUPE infrastructure (ver 1) (Task 5.2/ CNR/ R/ P/ M24)
D 5.2.2: iCUPE infrastructure (ver 2) (Task 5.2/ CNR/ R/ P/ M34)
D 5.3.1: iCUPE data management principles (ver 1) (Task 5.3/ CNR/ R/ P/ M06)
D 5.3.2: iCUPE data management principles (ver 2) (Task 5.3/ CNR/ R/ P/ M18)
D 5.3.3: iCUPE data management principles (ver 3) (Task 5.3/ CNR/ R/ P/ M34)
D 5.4.1: iCUPE tests plan and interoperability interfaces with GCI, TEPs, DIAS and with other strands (ver 1) (Task 5.4/ CNR/ O/ P/ M12)
D 5.4.2: iCUPE tests plan and interoperability interfaces with GCI, TEPs, DIAS and with other strands (ver 2) (Task 5.4/ CNR/ O/ P/ M30)
D 5.5.1: iCUPE data pilots, data and services (ver 1) (Task 5.5/ EULS/ O/ P/ M24)
D 5.5.2: iCUPE data pilots, data and services (ver 2) (Task 5.5/ EULS/ O/ P/ M34)

Milestones
M 5.1.1: iCUPE data management plan as a living document (lead: UHEL; M4)
M 5.2.1: iCUPE data infrastructures and interoperability interfaces (lead: CNR; M21)
M 5.5.1: iCUPE data pilots, data and services for end-users (lead: EULS; M25)

Proposal Acronym | iCUPE

WP 6: Dissemination and strategic development (lead: Hanna Lappalainen, UHEL)

Work package number	6	**Lead beneficiary**			UHEL
Work package title	**Dissemination and strategical development**				
Participant number	37	1	2	5	7
Short name of participant	UHEL	CNR	AU	AWI	CNRS
PM per participant:	21	8	2	2	2
Participant number	11	14	17	18	25
Short name of participant	EULS	FMI	GFZ	HZG	NCSR
PM per participant:	1	5.2	2	1	1
Participant number	27	30	36		
Short name of participant	PSI	TROPOS	SU		
PM per participant:	2	1	1		
Start month	1			**End month**	34

Objectives

- to carry out the stakeholder engagement during the project life time
- to interact with other ERAPLANET strands and their activities
- to assess the impacts of iCUPE research and iCUPE data
- to deliver the strategy for the continuity of iCUPE in the future

Description of work

This WP will disseminate iCUPE results and data and facilitates interaction with the stakeholders in a two-way interaction. The WP provides a platform for interaction within the ERAPLANET strands and plans for the legacy and continuity of iCUPE beyond the project period.

Task. 6.1 Stakeholder engagement (lead: Hanna Lappalainen, UHEL, contrib.: all)
Stakeholder engagement plan will guide the stakeholder engagement process. The plan identifies the roles of each of the stakeholders and their role to different stages of the project lifetime and after the project. In addition, the plan introduces the methods for the engagement and the methods for monitoring and evaluation of the engagement. The main avenue for stakeholder engagement is through joint ERAPLANET (annual) meetings organized as a horizontal activity. This task ensures and facilitates the collaboration and synergy with the major European research and innovation programs on EO in the polar regions: INTAROS, APPLICATE; INTERRACT2 projects, YOPP and MOSAiC expeditions in the Arctic, WMO-GAW, SAON, Arctic Council, AMAP EG, IGAC/IASC, IGAC/PACES and IGAC/CATCH, and Russian research communities via PEEX, circumpolar research communities via U-Arctic Arctic-boreal Hub.

Furthermore, we strength involvement of decision-makers on national and international levels, and include also connections to local levels, such as city and regional administration. Feedback of these people including the public will assist in better designing, elaboration and development of the data and data services envisioned in iCUPE. This task also provides the avenue to disseminate and interact with end-users from different levels in regards to pollution impact assessments developed in WP 4. This activity will lead to a report summarizing iCUPE briefings, results from face-to-face meetings, presentations and interactions with the stakeholders.

Task 6.2: Interactions within ERAPLANET strands (lead: Tuukka Petäjä, UHEL, contrib.: all)
This task ensures interaction within the ERAPLANET strands and facilitates collaboration between the institute consortium beneficiaries.
In iCUPE we can interact with Strand 1 (Smart cities and resilient societies) by providing an arctic perspective to urban environment and air quality. The data products on aerosol source apportionment and emissions from flaring are a good example of a data set that can be utilized in Strand 1.
The satellite products on biomass availability can benefit the Strand 2 (Resource efficiency and

environmental management) activities. Our work on aerosol source apportionment benefits from Strand 2 activity developing a proxy based on satellite derived light intensity to assess the aerosol source strengths from natural gas extraction via flaring. We will utilize this in iCUPE particularly concentrating on the Arctic environment. With Strand 3 (Global change and environmental treaties) will benefit from iCUPE work on mercury and heavy metal measurements and pollution life-cycle analysis as well as the impact assessment studies performed within iCUPE.

Task 6.3: Research impact assessment (lead: Ella-Maria Duplissy, UHEL, contrib: all)
Here we perform the analysis of the impact of iCUPE research and data products and services. In the evaluation, we take into i) research outcomes (publications) ii) dissemination activities (appearances and presentations in conferences, public presentations), iii) data provision (e.g. data downloads, use by end-users).

Task. 6.4: Future strategies and contingency plans (lead: Hilppa Gregow, FMI, contrib: all)
This task interacts with task 5.1 (data management plan) and task 5.5 (data provision) in order to assure the legacy of iCUPE and prepare for the continuation of iCUPE work after the end of the project.

Overall, in the continuation there are topical options for the contingency, e.g. for mercury observations we could connect to GEO flagship on mercury, Global Observation System for Mercury (GOS4M). The thematic information on Arctic environments could be develop with further with GEO CRI. The aerosol and trace gas observations will be continued in collaboration of ACTRIS Research infrastructure. Throughout the project, PEEX activities support iCUPE and offers continuation in the Arctic observations and integration of in-situ and satellite data in the Arctic context. The data and information structures as well as calibration procedures are being formulated during the project lifetime. Another option that we consider is that the Copernicus Climate Change Service (C3S) offers a possibility for operational and quality controlled information sharing. Here we set up a framework and demonstrations / prototypes for the alternatives to integrate the new environmental information provided by iCUPE to the climate data store (CDS) of C3S is designed. Task 6.4 supports is interlinked with WP0 and uses input from WP5.

As an option, during the whole project life-cycle, linkages to the C3S projects will be mapped and synergies with ERA-Planet communicated between the projects. For instance participation in the C3S GA:s, EGU, Polar Board and within ECRA is considered for exchange of ideas. Furthermore, the proposed work links COST CA15211 "Atmospheric Electricity Network: coupling with the Earth System, climate and biological systems" especially in supporting the development of early career scientists. Furthermore, by utilizing expertise gathered in national project, we will design a demonstrator for the iCUPE operational environmental service prototype. In an operational phase, the environmental information flow would especially support those working with Arctic re-analyses and those working with short and extended range forecasts and environmental indicators.

Deliverables

Deliverables with relevant task, delivery time and responsible beneficiary and type (R=Report, O=Data/ Other, P=Public)
D 6.1.1: Stakeholder engagement plan (Task 6.1 / UHEL/R/M4)
D 6.1.2: Report on stakeholder engagement activities (Task 6.1/ UHEL/ R/ P/ M32)
D 6.2.1: Report on horizontal ERAPLANET collaboration (Task 6.2/ UHEL/ R/ P/ M33)
D 6.3.1: Report on iCUPE impacts (Task 6.3/ UHEL/ R/ P/ M34)
D 6.4.1: Demonstration on iCUPE data and service contingency (Task 6.4/ FMI/ R/ P/ M24)
D 6.4.2: Report on future plans for iCUPE (Task 6.5/ FMI/ R/ P/ M34)

Milestones

M 6.1.1: Stakeholder interactions started (M3)

M 6.2.1: Interactions with ERAPLANET strands started (M2)

M 6.4.1: Start of iCUPE contingency demo (M12)

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Table 3.1b: List of work packages with titles, beneficiary information, sum of available PM and timing.

WP	WP title	No	Leader	PM	Start Month	End month
0	Management	37	UHEL	43	1	34
1	Ground-based component for SLCFs	2	AU	169	1	34
2	In-situ component for organic contaminants, mercury and other heavy metals	1	CNR	223	1	34
3	Satellite remote sensing of Arctic surfaces	5	AWI	197	1	34
4	Integrating in-situ, satellite and model components for improved environmental assessment	7	CNRS	185,8	1	34
5	Data provision, interoperability and facilitation of data and services	11	EULS	154	1	34
6	Dissemination and strategic development	37	UHEL	49,2	1	34
				Total of 1021 PM		

Table 3.1c: List of Deliverables

*Note for Table: **R** – Report; **SR** – Short Report; **O** – Other: Dataset/ Interface/ Software/ Website/ etc.; **P** – Public; **I** – Internal*

The delivered data sets listed as deliverable type O always include relevant metadata information (what is measured, where and how).

Deliverable number	Deliverable name	WP	Lead participant	Type	Dissemination level	Delivery (M)
D 0.1.1	iCUPE Consortium Agreement	0	UHEL	O	P	3
D 0.2.1	Minutes of iCUPE Kick-off meeting	0	UHEL	R	P	3
D 0.2.2	Annual report and minutes of the first iCUPE meeting	0	UHEL	R	P	12
D 0.2.3	Annual report and minutes of the second iCUPE meeting	0	UHEL	R	P	24
D 0.2.4	Annual report and minutes of the third iCUPE meeting	0	UHEL	R	P	32
D 0.3.1	iCUPE communication tools and interfaces (website, e-mail-lists, brochure and other printed materials)	0	UHEL	R	P	5

D 1.1.1	Report on discussing availability and constraints for Arctic data sets and data streams presenting protocols and procedures to harmonize and integrate data for an operational use in GEO and COPERNICUS including discussion on long-term sustainability implications and needs	1	CNR	O	P	30
D 1.1.2	Data set on selected species (ground-based measurements) as e.g. particle number, black carbon mass and ozone concentration in standardized format	1	CNR	O	P	20
D 1.1.3	A collection of harmonized measurements and data of the snow spectral reflectance delivered to WP5	1	CNR	O	P	24
D 1.2.1	A pilot data set on selected parameters of available NRT data of Arctic Research Infrastructures	1	NCSR	O	P	22
D 1.3.1	Web-page as communication platform for upcoming polar activities to increase extensive co-operations within the polar community assuring the highest synergy between the objectives of the forthcoming studies	1	TROPOS	O	P	18
D 1.3.2	Integrated data collection of Arctic parameters received via ground-based remote sensing and airborne platforms for submission to WP5	1	TROPOS	O	P	21
D 1.4.1	Guidelines for off-line and on-line source apportionment procedures using aerosol mass spectrometry including a protocol how to report such data in EBAS	1	PSI	R	P	20
D 1.4.2	A report and a data set on source apportionment of aerosols with a focus on organic aerosols in the arctic including the source regions	1	PSI	O	P	33
D 2.1.1	Data set of anthropogenic contaminants in snow from polar regions	2	CNR	O	P	16
D 2.1.2	Data set for anthropogenic contaminants in ice cores	2	CNR	O	P	22
D 2.1.3	Report on definition of the Anthropocene	2	CNR	R	P	28
D 2.2.1	GMOS observations: Improved GMOS SOPs for atmospheric Hg(II) measurements in the Arctic & updated GMOS database for Arctic atmospheric Hg(II) observations	2	CNRS	O	P	16
D 2.2.2	GMOS modeling: Revised reaction mechanisms and rates of atmospheric Hg(II) formation in the Arctic	2	CNRS	R	P	28
D 2.2.3	GMOS observations: New Arctic atmospheric Hg isotope monitoring data set	2	CNRS	O	P	22
D 2.3.1	Model evaluation of the role of halogens in Hg and ozone depletion events in the Arctic	2	CNRS	R	P	30
D 2.4.1	Determination of anthropogenic contaminants in air, seawater, soil and biota in the Arctic	2	HZG	R	P	24
D 2.4.2	Evaluation of the cycling and re-cycling of persistent contaminants between the atmosphere, cryosphere and ground water with their seasonal fluxes	2	CNR	R	P	30
D 3.1.1	Technical report on common satellite data interface description document to describe how satellite derived cryospheric measurement data can be accessed and utilized	3	FMI	R	P	22
D 3.1.2	Technical report on common in-situ data interface description document to describe how FMI measured in-situ data can be accessed and	3	FMI	R	P	24

D 3.2.1	A technical report on the assessment of the capabilities and limitations of advanced optical satellite missions for snow, vegetation, and gas flaring mapping applications in Artic areas	3	CNR / GFZ	R	P	27
D 3.2.2	Demonstration pilot of novel optical remote sensing products on snow, vegetation, and gas flaring mapping in selected sites	3	CNR / GFZ	O	P	30
D 3.3.1	Technical report on the assessment of the capabilities and limitations of polarimetric SAR for glaciological applications for wet-crevassed and dry surfaces of the Greenland ice sheet	3	AWI	R	P	30
D 3.3.2	Time series of lake size over a key region in Northeast Greenland	3	AWI	O	P	32
D 3.4.1	Polar EO needs	3	FMI	R	P	12
D 3.4.2	Polar EO opportunities	3	FMI	R	P	24
D 4.1.1	A blueprint for novel proxy variables integrating in-situ and satellite remote sensing data with an exemplary dataset	4	UHEL	R+O	P	29
D 4.1.2	Pilot aerosol re-analysis data sets for SMEAR II	4	UHEL	O	P	32
D 4.2.1	A validated dataset on precipitation in the Arctic	4	UHEL	O	P	30
D 4.3.1	A dataset of validated aerosol vertical profiles from ground-based and satellite observations above selected sites in Finland and Siberia	4	CNRS/ UHEL	O	P	24
D 4.3.2	Report on evaluation of local pollution sources in the Eurasian Arctic based on integrated data analysis and modeling	4	CNRS	R	P	32
D 4.4.1	Report on enhanced POP modeling capacities with BETR and PMCAMx	4	SU	R	P	12
D 4.4.2	Report on advances in integrated assessment of Arctic environmental pollution	4	SU	R	P	32
D 5.1.1	iCUPE data management plan (ver 1)	5	UHEL	R	P	3
D 5.1.2	iCUPE data management plan (ver 2)	5	UHEL	R	P	15
D 5.1.3	iCUPE data management plan (ver 3)	5	UHEL	R	P	27
D 5.2.1	iCUPE infrastructure (ver 1)	5	CNR	R	P	24
D 5.2.2	iCUPE infrastructure (ver 2)	5	CNR	R	P	34
D 5.3.1	iCUPE data management principles (ver 1)	5	CNR	R	P	6
D 5.3.2	iCUPE data management principles (ver 2)	5	CNR	R	P	18
D 5.3.3	iCUPE data management principles (ver 3)	5	CNR	R	P	34
D 5.4.1	iCUPE tests plan and interoperability interfaces with GCI, TEPs, DIAS and with other strands (ver 1)	5	CNR	O	P	12
D 5.4.2	iCUPE tests plan and interoperability interfaces with GCI, TEPs, DIAS and with other strands (ver 2)	5	CNR	O	P	30
D 5.5.1	iCUPE data pilots, data and services (ver 1)	5	EULS	O	P	24
D 5.5.2	iCUPE data pilots, data and services (ver 2)	5	EULS	O	P	34
D 6.1.1	Stakeholder engagement plan	6	UHEL	R	P	4
D 6.1.2	Report on stakeholder engagement activities	6	UHEL	R	P	32
D 6.2.1	Report on horizontal ERAPLANET collaboration	6	UHEL	R	P	33
D 6.3.1	Report on iCUPE impacts	6	UHEL	R	P	34
D 6.4.1	Demonstration on iCUPE data and service contingency	6	FMI	R	P	24
D 6.4.2	Report on future plans for iCUPE	6	FMI	R	P	34

3.2 Management structure, milestones and procedures

3.2.1 Organizational structure and the decision-making

The organizational structure of iCUPE is based on the recommended "Governance Structure for Medium and Large projects" contained in the DESCA 2020 Model Consortium Agreement. The consortium bodies with well-defined roles and responsibilities, which are described in this section. The organization structure is described in Figure 8.

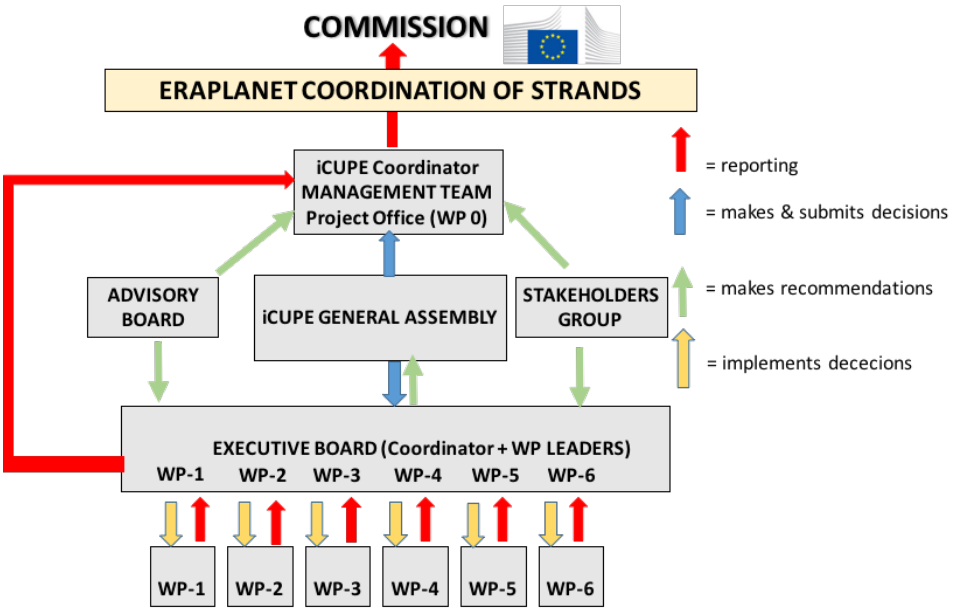

Figure 8. The organizational structure of iCUPE consists of the following bodies: WPs, Executive board, Advisory Board, Stakeholders Group and Project Office. The project interface to the Commission is coordinated by the ERAPLANET.

The project organization consists of five bodies. The project management team coordinates the overall progress within iCUPE and communicates with ERAPLANET coordination. The work within the project is distributed in to work packages lead by WP leaders . The work package leaders form an Executive board, which discuss and monitor the WP interactions and information flows. General Assembly is the main decision body and represents all the iCUPE partners. Advisory Board consists of invited experts in the area of polar observation systems and science. Stakeholder Group members represent the main stakeholder groups relevant to iCUPE work. The meetings (face-to-face / virtual) take place:

- Project Management team: As often as needed and at least once a month
- General Assembly: once per year or in case required
- Executive Board: every 6 months, can be organized remotely
- Advisory Board: once per year or in case required / can be organized remotely
- Stakeholder Group: once per year or in case required / can be organized remotely

3.2.2 Project bodies:

(i) Project Office / Project Management Team (PMT):

The objectives and responsibilities of the project management are:

- ensure compliance with EC rules and guidelines set within ERAPLANET
- achieve the specific objectives of the project within the agreed budget and timeframe
- coordinate and integrate project activities

- facilitate effective internal, horizontal, external communications
- monitor the scientific and technical progress and control the quality of the work performed
- identify risks or conflict situations and resolve them
- set up an efficient organization to support the above objectives.

The PMT is composed of the Project Office and the Coordinator. University of Helsinki will carry out the project coordination and will represent the consortium in all communications with the ERAPLANET and manage all legal and financial aspects of the project. The main tasks of the project office is to implement the efficient day-to-day management of all administrative, legal, financial and scientific matters, organize project meetings and general assembly, ensure good communication between the different project bodies, between the consortium partners and ERAPLANET bodies. Project office will also monitor compliance by the partners with respect to their obligations and collect, review and submit reports and other official deliverables requested by ERAPLANET / Commission and administrate the EC financial contribution and declare the costs, and monitor execution of decisions made by the General Assembly

The iCUPE Coordinator, Prof Tuukka Petäjä (UHEL), will be supported by the Project Office. UHEL will hire a Project Manager to oversee the day-to-day administration of iCUPE. The Project Manager will head the PMT in practical matters under guidance of the Coordinator. The tasks of the project office and the coordinator are supported by the the administrative and financial services of the Research Funding Services of the University of Helsinki. The unit was established in 1994 with an aim at providing centralized research administration and management services for the researchers of the university. The unit is part of the Research Sector, which operates under the central administration of the university. The unit has gained valuable experience from providing support services to over 600 projects during the previous EU's Framework Programmes. In the Seventh Framework Programme (2007-2013) UHEL participated in over 190 projects this far. UHEL has been a partner or a coordinator of 70 MC- and MSC-projects (7 FP and H2020).

(ii) Executive Board (ExB)

The objectives and responsibilities of the Executive Board are:

- to manage implementation of the project orientations provided by the GA, iCUPE Technical Annex and ERAPLANET
- to monitor progress of the various WP activities and collect all related information
- to refer any necessary modifications of the work plan to the GA
- to support the Coordinator in preparing meetings within ERAPLANET and related deliverables
- to support the Coordinator in preparing all dissemination and communication deliverables
- to develop a contingency plan and implement continuous risk monitoring
- to perform any other tasks specified in the consortium agreement or required by the GA.

The ExB comprises the project Coordinator and all WP Leaders (WPL): WP1: Andreas Massling, AU, WP2: Carlo Barbante, CNR, WP3: Angelika Humbert, AWI, WP4: Aurelién Dommergue, CNRS, WP5: Steffen Noe, EULS The WP leaders will organize the activities and monitor the progress in their respective work packages and will solve conflicts arising at the work-package level. They report on the compliance of the participants with the milestones and deliverables agreed with the ERAPLANET. They are responsible for maintaining good communications inside their work package and for contacting the PMT for specific assistance, if needed.

(iii) General Assembly (GA)

The objectives and responsibilities of the General Assembly are:

- to make decisions on the political and strategic orientation of the project
- to make decisions on the plans for work, dissemination and data management
- to make decisions on the structure and possible restructuring of work packages
- to make decisions on any alterations to the Consortium Agreement
- to make decisions on budget-related matters and intellectual property rights
- to make decisions on changes in consortium membership

The GA is the ultimate decision-making and arbitration body of iCUPE. It consists of one authorized representative of each partner (UHEL, CNR, AU, AWI, CNRS, EULS, FMI, GFZ, HZG, NCSR, PSI, TROPOS and SU), empowered to make decisions on behalf of his/her organization regarding its participation

in the project. GA meetings will be held once a year as a part of annual project /ERAPLANET meetings. The GAs will be chaired by the Coordinator. Details of the meeting preparation, agenda and minutes will be described in the Consortium Agreement. The first GA meeting will take place during the project kick-off meeting.

(iv) The Advisory Board (AB)

The objectives and responsibilities of the Advisory Board are:

- to advise the consortium on ways to assess the progress, performance, and achievements of the scientific work
- to advise the consortium on ways to respond to research needs related to SLCF and global change
- to advise the consortium on ways to maximize the impact of the project and infrastructure as a whole.
- to assist the consortium by promoting open dialogue between the iCUPE partners and stakeholders.

The final composition of the AB (3-5 members) will be decided during the first meeting of the General Assembly. It will comprise international experts in appropriate scientific fields, relevant industry and public authorities also representing different stakeholders relevant to WP-6 (Dissemination). The invited AB members are Stein Sandven, INTAROS Coordinator, Alexander Baklanov, WMO-GAW program coordinator, Yubao Qiu GEO High Mountain and Cold Regions coordinator. This ensures iCUPE connections to on-going research, development, data provision and integration activities world-wide.

(v) Stakeholder Group

The objectives and responsibilities of the Stakeholder Group are:

- to comment the iCUPE research outcomes, data products and their interoperability
- to enhance the visibility and usage of the iCUPE data products.

The member of the stakeholder group will be nominated by the ExB and invited by the Coordinator. A regular interaction between the iCUPE activities and the Stakeholder Group is facilitated by the Project Office and horizontal activities across ERAPLANET strands.

3.2.3 Decision-making procedures and formal meetings

The ultimate decision making entity of iCUPE is the General Assembly, but decisions are also to be made at different levels:

- **General Assembly:** The decision-making procedure within the GA is based on the principle that each partner of the iCUPE consortium has one vote. Decisions will be taken upon a majority of 75% of the votes of the partners present or represented.
- **Executive Board:** Each member of the ExB has one vote and decisions shall be taken upon a majority of 75% of the votes of the partners present or represented.
- **Work Package:** Any conflict internal to a WP will be resolved by consensus within the WP under the guidance of the WP leader. In order to ensure efficient project management, regular and formal meetings are planned within each body of the iCUPE project, as shown in Table 3. Special meetings will be held when urgent problem solving is necessary.

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Table 3.2a: List of milestones, their due date in months and means of verification

Milestone number	Milestone	WP	Due (M)	Means of verification
M 0.1.1	iCUPE consortium agreement	0	4	Consortium agreement signed
M 0.3.1	Internal website implemented	0	1	Website accessible
M 0.3.2	Definition of terms of reference for the independent project bodies	0	3	Terms of references defined and Consortium Agreement signed
M 1.1.1	Compilation of existing research infrastructures, networks, monitoring programs and corresponding relevant data sets and data streams on Arctic SLCFs for iCUPE targeted to data and data stream harmonization	1	14	Information available in iCUPE internal web page
M 1.1.2	Compilation of existing observations on surface properties in polar areas including remote sensing techniques and surface snow sampling	1	18	Information available in iCUPE internal web page
M 1.2.1	Overview of the current status of Arctic NRT measurements, including NEXTGEOSS and CAMS 84 projects	1	14	Information available in iCUPE internal web page
M 1.3.1	Plan on future data flow of campaign-vise selected Arctic data sets, their sustainable storage, data harmonization and integration in existing data policies	1	12	Information available in iCUPE internal web page
M 1.4.1	Aerosol source apportionment using off-line and on-line measurements finalized	1	29	Confirmation by responsible beneficiary
M 2.1.1	Complete collection of surface snow	2	12	Confirmation by responsible beneficiary
M 2.1.2	Complete collection of ice cores	2	18	Confirmation by responsible beneficiary
M 2.1.3	Completed comparison between Arctic and Antarctic deposition rates and exchanges to obtain natural background rates.	2	24	Confirmation by responsible beneficiary
M 2.2.1	Completed collection of atmospheric Hg(II) speciation and Hg(0) isotopic composition	2	12	Confirmation by responsible beneficiary
M 2.3.1	Completed model coding to quantify the coupled ozone-halogen-mercury cycle	2	24	Confirmation by responsible beneficiary
M 2.4.1	Completed collection of air, seawater, soil and biota in the Arctic	2	20	Confirmation by responsible beneficiary
M 2.4.2	Complete 3-D atmospheric transport model coding for persistent	2	28	Confirmation by responsible beneficiary

	contaminants and application to analysis date sets for the Arctic and Antarctic			
M 3.1.1	Overview of the available ground-based data resources useful for the integration with the Earth Observation snow products	3	3	Information available in iCUPE internal web page
M 3.2.1	Completed acquisition of field data and satellite imagery for snow, vegetation, and improved mapping of gas flaring based on optical remote sensing	3	20	Confirmation by responsible beneficiary
M 3.3.1	Completed acquisition of time series of X-band data (HH) over 79°N Glacier	3	20	Confirmation by responsible beneficiary
M 3.3.2	Completed acquisition of X-band polarimetric SAR data (VV, HV,VH) over 79°N Glacier, EGRIP and ExNGT locations in summer and winter	3	12	Confirmation by responsible beneficiary
M 3.4.1	User needs internet survey produced and online (open for 3 months)	3	6	Survey available online
M 4.1.1	Identification of relevant in-situ and satellite data for proxy development	4	6	Confirmation by responsible beneficiary
M 4.1.2	Identification of suitable case studies for combined source apportionment	4	8	Confirmation by responsible beneficiary
M 4.4.1	Enhanced PMCAMx and BETR Global ready	4	26	Confirmation by responsible beneficiary
M 5.1.1	iCUPE data management plan as a living document	5	4	Available in iCUPE internal web pages
M 5.2.1	iCUPE data infrastructures and interoperability interfaces	5	21	First versions of iCUPE infrastructure (D5.2.1) and interoperability interfaces (D5.4.1) available in iCUPE internal web page
M 5.5.1	iCUPE data pilots, data and services for end-users	5	25	Pilot iCUPE data (D5.5.1) available
M 6.1.1	Stakeholder interactions started	6	3	iCUPE presented for stakeholders
M 6.2.1	Interactions with ERAPLANET strands started	6	2	Joint meeting organized
M 6.4.1	Start of iCUPE contingency demo	6	12	Confirmation by responsible beneficiary

3.2.3 Critical risks and proposed mitigation measures

The risks associated with iCUPE are identified in Table 3.2b with appropriate mitigation measures.

Table 3.2b: Critical risks for implementation

Description of risk and likelihood	WPs involved	Proposed risk-mitigation measures
Communication challenges within a project group (low)	all WPs	Most of the project group members have previously worked together in various projects with excellent results, so the risk of communication challenges is very low. When challenges and problems arise, the project leadership will see that they are dealt with.
Organizational changes (low)	all WPs	With the ongoing transformation of the university field and reorganization taking place in civil services, it is possible that the project organizations can go through structural changes during the project period. In such a case, based on experience from previous projects, research groups and persons involved should be able to continue the project under a new organizational framework, possibly with some minor delays. As the organizations of most of the partners have been modified only recently, the probability of this event is low.
Challenges in obtaining adequate data (medium)	WP 1-4	The following challenges in obtaining data have been identified, as well as the measures to overcome them. Basically, the open accesses existing European RIs and the data owned by the project partners provides baseline for carrying out the project. Collection of some new data will depend on stakeholder participation and steps will be taken to ensure participation through meaningful process that delivers relevant results to the participants.
In-situ observations are not possible at a certain location in the Arctic / Antarctica (low)	WP 1,2	The network offers other possibilities for accessing Arctic / Antarctic observation sites to collect aerosol, snow and POP data.
The data from WP 1 required for WP 4 does not arrive in time (low/high)	WP 1,4	The data for WP comes from multiple sources. The low-risk components are associated with observations performed within ACTRIS. Complementary data is available via the network. The high-risk component is associated with work in Russia. This relies on direct contacts with the beneficiaries and the local research communities with a long track record of successful work. There are appropriate contracts. These features mitigate the risk, but the availability of the data for further analysis is still considered high-risk.
Aircraft campaign to characterize snow and glacier tomography is cancelled (medium)	WP 3	Technical difficulties and challenges are always a part of state-of-the-art campaigns in challenging environments. AWI has extended experience in organizing the field work. Furthermore, if a certain campaign, the observations are not cancelled but delayed to the next deployment. The work is complimented with satellite remote sensing.
Data products and iCUPE work does not match the expectations of the stakeholders (medium)	All WPs	The risk will be managed by applying participatory approaches from early on in the project in order to share the project's goals and to form a better sense of responsibility among the involved parties (WP7). In the case this risk nevertheless materializes, the stakeholders will nevertheless benefit greatly from participating in the process itself.
The development of PCAMx BETR Global is delayed (high)	WP 4	The improvements in the modeling framework suggested in iCUPE in terms of tools to assess the impacts of pollution are challenging. The team developing the tools is very competent. If there are delays related to this development, we can still assess the impacts with the existing tool-set.

3.2.4 Dissemination, exploitation of results, IPR and innovation management

In the project start (M1) the Consortium will make sure that questions and procedures concerning the publishing and protecting the knowledge, confidentiality, and other innovation-related activities are defined in detail and agreed in the Consortium Agreement. The conditions of the responsibilities, joint ownerships, decision-making, membership, reporting and rules for dealing with Intellectual Property will be agreed in a Consortium Agreement, which will be signed before the beginning of the project. Activities carried out in the project will be in line with the EC policy on Responsible Research and Innovation Policy for the H2020 work programme.

Concerning intellectual property rights, the Consortium will agree that all background knowledge owned by a partner or a beneficiary shall remain the property of that partner. Project results shall be the property of the partner carrying out the work leading to those results. Where two or more partners have jointly carried out work generating results and where their respective share of the work cannot be ascertained, they shall have joint ownership of such results. The confidentiality of any document, information or other material which could harm or interfere or otherwise limit the effective protection of the collaborators intellectual rights will be maintained during the project period.

The knowledge and innovations created during the project will initially be evaluated by the partner organisation owing the knowledge and innovations. The Coordinator may organise a further evaluation of the research results e.g. with the aid of the Advisory Panels with expertise in IPR, market analyses, commercialisation etc. The Advisory Panels may consist of internal (Technology Transfer Offices, TTOs, of the contracting parties) and external experts. The Coordinator will be supported in IPR matters by the legal services of the University of Helsinki and Helsinki Innovation Services (HIS) Ltd., a company owned by the University. HIS Ltd. actively monitors the new business and product ideas invented within UHEL.

3.3 Consortium as a whole

The iCUPE consortium is composed of 12 individual beneficiaries: Helsingin yliopisto (UHEL) Finland, Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), Germany, Consiglio Nazionale delle Ricerche (CNR) Italy, Centre National de la Recherche Scientifique (CNRS) France, Aarhus University (AU) Denmark, Helmholtz Zentrum Potsdam GFZ Deutsches GeoForschungsZentrum (GFZ) Germany, Leibniz Institute for Tropospheric Research (TROPOS) Germany, Stockholm Unversitet (SU) Sweden, N.C.S.R. Demokritos, Institute of Nuclear Technology and Radiation Protection (NCSR) Greece, Finnish Meteorological Insitute (FMI) Finland, Estonian University of Life Sciences (EULS) Estonia, Paul Scherrer Institut (PSI) Switzerland, and Helmholtz-Zentrum Geesthacht (HZG) Germany.

3.3.1 Complementary institute expertise

Helsingin yliopisto (UHEL) has an extensive expertise in co-designing, conducting, integrating and disseminating the results of continuous and comprehensive ground-based long-term observations, short-term in-situ campaigns and multi-scale modeling particularly in sub-Arctic and Arctic areas, with strong emphasis on aerosols, meteorology and biogenic greenhouse gas and hydrocarbon fluxes. The UHEL contributors have also solid experience in generating parameterizations and proxies for atmospheric variables.

Consiglio Nazionale delle Ricerche (CNR) contributes to iCUPE with four institutes. They have a long experience in Polar research, with focuses on anthropogenic effects on the environment, chemical contamination and processes in snow, ice, soil and waters, Air-Quality legislation and Earth Observation data. CNR manages Polar research programme and a comprehensive measurement station in Svalbard.

Aarhus University (AU) operates monitoring stations with continuous and comprehensive long-term measurements as well as conducts short-term campaigns with highly dedicated equipment in Arctic areas. They have strong experience in leading research projects and disseminating air pollution and climate related science to decision makers.

Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) has strong

expertise in leading satellite and remote sensing based initiatives and missions related to glaciers, sea ice and permafrost, as well as in combining their results with ground-based and modeling data.

The four institutes contributing to iCUPE from **Centre National de la Recherche Scientifique (CNRS)** have strong expertise in continuous and campaign-wise observations in the Arctic and Antarctica, including airborne measurements. Their research areas are in water cycle, cryosphere, Arctic pollution and atmospheric chemistry, with a dedicated mercury research platform.

Estonian University of Life Sciences (EULS) has expertise in comprehensive lon-term measurement sites for atmospheric observations and combining remote sensing, in-situ and re-analysis data for development of proxy variables. They have also developed automated data acquisition and near real-time data analysis and visualization tools.

Finnish Meteorological Insitute (FMI) has strong expertise in development of operational satellite data processing systems and open data distribution, operating satellite reference instrumentation and conducting in-situ measurements in campaigns and continuous observations.

Helmholtz Zentrum Potsdam GFZ Deutsches GeoForschungsZentrum (GFZ) has expertise in lead and definition of satellite missions and in hyperspectral imagery data processing, analyses and products and their calibration/validation.

Helmholtz-Zentrum Geesthacht (HZG) have strong experience in analysis of organic contaminant in marine and polar environments, development of ultra-sensitive analytical methods for contaminants required in polar areas, as well as in dispersion modeling.

N.C.S.R. Demokritos, Institute of Nuclear Technology and Radiation Protection (NCSR) has extensive experience on the analysis of long-term observational data particularly on Arctic air pollution and develops provision of the data to the end-users with a particular interest on near-real time (NRT) data.

Paul Scherrer Institut (PSI) has strong experience in analysis of long-term data and mass spectrometry based on-line and off-line measruements, as well as in applying source apportionment methods. They have also expertise in testing new instrumentation in controlled environment with wide range of atmospheric conditions.

Leibniz Institute for Tropospheric Research (TROPOS) has a strong expertise and capacity in performing and coordinating experiments, data collection and harmonized analysis in Arctic ground-based and airborne atmospheric measurements, as well as in calibration and quality check of aerosol instruments.

Stockholm Unversitet (SU) has strong experience in multi-scale modeling, with emphasis e.g. on persistent organic pollutants, aerosols, and interlinkages between air pollution and the Arctic climate, as well as in integrating modeling and measurements.

The contributions and expertise from the beneficiaries are described in more detail in section 4.1.

3.3.2 The combined expertise within iCUPE

As a whole, iCUPE has a strong combination of expertise, which is required for the completion of the research proposed here. The beneficiaries cover the full suite of expertise covering the in-situ observations of atmospheric pollution, aerosols, mercury, persistent organic pollutants and their concentrations in the snow, vertical profiling of aerosols from ground level, satellite remote sensing of natural resources and surface characteristics, comprehensive modeling of pollution transport, life cycle and impact assessment of pollution exposure.

The consortium has compatible and complementary expertise on data provision and data production based on the comprehensive observations and modeling. This enables us to integrate and harmonize existing data sources and models in order to estimate the impacts of current and future societal changes and scenarios on the polar regions. The iCUPE consortium shows very wide expertise in in-situ measurements in the polar regions both in terms of continuous ground-based long-term observations and ground-based and airborne

short-term campaigns. These international and national facilities and capacity is brought together within iCUPE that facilitate joint and harmonized operations in close collaboration with European research infrastructures for atmospheric composition (ACTRIS, ICOS) and ecosystem observations (LTER). The data products are distributed contribute to the development of a common ERA-Planet virtual platform to ensure interoperability between the data sets and products developed in iCUPE and other ERA-Planet strand projects while facilitating development of data products and data sets to the ERA-Planet, GEOSS and Copernicus services.

The combined expertise within iCUPE enables us to assess the impacts of anthropogenic activities on the levels of pollution, to quantify the relative contributions of local and long-range transported pollution affecting the atmospheric composition, deposition and contamination cycling in the polar areas, to assess the changes in the dynamics and characteristics (e.g. snow cover, ice, permafrost, biomass, albedo) and impacts of natural resource use (gas, oil extraction, based on landscape changes and light emission) and investigating their links to ecosystems and pollution cycling in the polar areas.

The close connections to European level and national policy makers and organizations will be applied for co-designing the relevant data products and observables. The iCUPE consortium has solid expertise for processing, analyzing and validating satellite-based data. The involved institutes have also long experience in development of satellite data processing systems. This enables us to develop a blueprint for i) retrieving new quantities, ii) new algorithms in EO iii) the concept for in-situ measurements that can be expanded to new field sites in the future. Together with the strong expertise of the iCUPE partners in coordinating and managing large-scale projects will enable the harmonization and integration of data sets with very different features and to develop methods for new observables and proxy variables for remote sensing of current satellite missions and pave the way towards their effective development and utilization in the future. The work is conducted in close collaboration with the end-users following co-design and participatory work facilitated by the iCUPE and ERAPLANET project structures.

The experience of the iCUPE consortium in multi-scale modeling (in terms atmospheric processes and atmosphere-surface interactions, transport, and anthropogenic and biogenic emissions) together with the strong expertise in generating parameterizations and emission vectors suitable for models, form a solid basis for conducting impact assessment based on the observations. The experience impact assessment closely connects to the expertise in co-design and dissemination of the results.

3.4 Resources to be committed

The budget of iCUPE is presented in Part A for each beneficiary. The work in iCUPE relies on a strong in-kind effort of the consortium. The iCUPE beneficiaries already work in polar environments, operate continuous and comprehensive observation stations in the Arctic and Antarctica performing analysis on atmospheric pollution transport, monitoring the condition of the environment and natural resources from satellites and integrate these tools towards comprehensive modeling framework and impact assessments of pollution exposure. The envisioned staff efforts for the iCUPE work is presented in Table 3.4a divided into WP workloads. A total of 1021 PM is provided in iCUPE. The workflow is presented in Gantt-chart in Table 3.4c

The in-kind contributions in the cost category “other” that contain the costs regarding travel, equipment, other goods and services and large research infrastructure is presented in Table 3.4b in the situation when the value is over 15% of the direct costs. The justifications for these costs are listed in Table 3.4b.

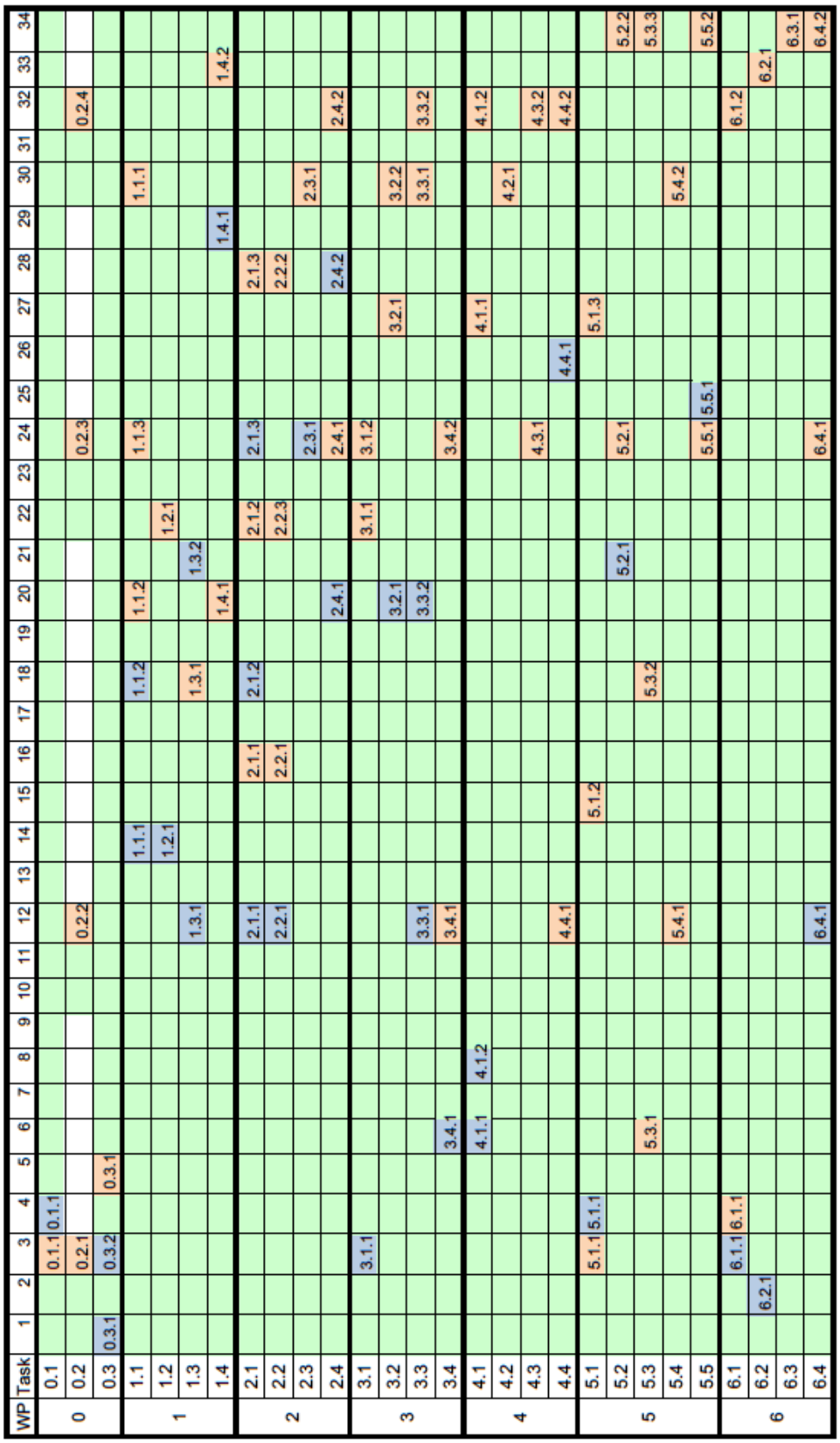
Proposal Acronym | iCUPE

Table 3.4a: A summary of staff effort in iCUPE in person months as divided into WPs assigned to the beneficiaries. The leading beneficiary for each WP is indicated in bold.

	WP0	**WP1**	**WP2**	**WP3**	**WP4**	**WP5**	**WP6**	**Total PM per Participant**
37 / UHEL	**25**	15	0	3	40	30	**21**	134
1 / CNR	2	28	**145**	54	10	15	8	262
2 / AU	2	**24**	16	2	6	8	2	60
5 / AWI	2	0	0	**54**	0	10	2	68
7 / CNRS	2	4	39	0	**45**	2	2	94
11 / EULS	1	12	0	0	12	**37**	6	63
14 / FMI	1	0	0	49	0	10	5,2	65,2
17 / GFZ	2	17	0	35	8	12	2	76
18 / HZG	1	0	23	0	0	5	1	30
25 / NCSR	1	22	0	0	15	10	2	49
27 / PSI	2	39	0	0	9,8	5	2	57,8
30 / TROPOS	1	7	0	0	0	5	1	14
36 / SU	1	1	0	0	40	5	1	48
Total Person Months per WP	43	169	223	197	185,8	154	49,2	1021

Proposal Acronym | iCUPE

Table 3.4c. The iCUPE workflow presented in a GANTT chart depicting the milestones and deliverables for all WPs and tasks during the project lifetime.



Proposal Acronym | iCUPE

Table 3.4b: 'Other direct cost' items (travel, equipment, other goods and services, large research infrastructures)

37 / UHEL	Cost (€)	**Justification**
Travel	20 000	The costs related to international travel to iCUPE, ERAPLANET and other relevant meetings and conferences for the coordination team of iCUPE. Travel costs for WP work and meetings.
Equipment	0	
Other goods and services	142 500	The cost is for operation of comprehensive SMEAR observation network in Finland to collect in-situ aerosol, trace gas and ecosystem data, ground based remote sensing of vertical profiles of aerosol particles and aerosol chemical composition for source apportionment and source identification. The unit cost (research working day) based on real costs for SMEAR I (Värriö) and SMEAR II (Hyytiälä) are performed in connection with LTER and ACTRIS infrastructure projects.
Total	**162 500**	

1/CNR	**Cost (€)**	**Justification**
Travel	157.130,40	Participation in meetings, networking and conferences, also to establish and develop connections with owner of data, programmes and other initiatives Field campaigns in Svalbard and other study areas to collect samples, maintain/improve observations, realize new implement to fill specific gaps.
Equipment		
Other goods and services	109 710,00	Consumables, supplies for field campaigns, maintenance of field equipment, dissemination costs
Total	266 840,40	

2/AU	**Cost (€)**	**Justification**
Travel	22 291	Travel to meetings and infrastructures
Equipment		
Other goods and services	224 312	The cost is for operation and handling of the Villum Research Station in North Greenland. Activities include the measurement of physical and chemical properties of short-lived climate forcers as aerosols and black carbon based on in-situ observations. Activities also include the measurement of trace gasses, POPs and Hg and a set of meteorological and climatological parameters. Some of these activities are related to the Arctic Monitoring and Assessment Program.
Total	246 603,03	

Proposal Acronym | iCUPE

5 / AWI	Cost (€)	Justification
Travel	20.000	Costs for international travels to ERA Planet meetings and international conferences (EGU, IGARSS, Fringe) for two persons.
Equipment	0	
Other goods and services	876 000	For Task 3.3. three airborne campaigns will deliver substantial input for in-situ data. Here, we perfom two airborne radar campaigns with AWIs new ultrawide band radar that allows a high resolution of internal ice structure in multichannel mode, thus allowing SAR processing as well as a snow radar surveying the snow pack on top of the firn at the same time. Together with the laser scanner data and optical camera operating in parallel, we will retrieve datasets to be used for combination with the radar satellite datasets. Furthermore, a third airborne-supported campaign will retrieve shallow firn cores at locations across north Greenland (former North-Greenland-Traverse drill locations) at which we will perform during drilling polarimetric radar echo sounding, such that he retrieve beside firn properties (depth of the X-band signal) also the anisotropy down to a depth of a potential L-band mission would sense. Approval of campaigns and budget is attached as separate letter.
Total	896 000	

11 / EULS	Cost (€)	Justification
Travel	10 000	Travel to iCUPE meetings and associated conferences
Equipment		
Other goods and services	37 000	Observations in SMEAR Estonia and other stations on aerosols, trace gas concentrations and ecosystem parameters to support proxy variable development and verification.
Total	47 000	

14 / FMI	Cost (€)	Justification
Travel	19 000	10 domestic travels from FMI HQ (Helsinki) to FMI NSDC (Sodankylä), 6 international travels to European locations to Strand 4 project / ERA-Planet and iCUPE consortium meetings
Equipment		
Other goods and services		
Total	19 000	

Proposal Acronym | iCUPE

17 / GFZ	Cost (€)	Justification
Travel	11 700	Costs for international travels to ERA Planet meetings and international conferences (EGU, EARSeL) for two persons.
Equipment	68 172	Equipment costs and infrastructure costs for use of GFZ instrumentation (Eddy-covariance sensor at the surface-atmosphere flux tower along with the relevant meteorological and soil climatological sensor networks at the Russian-German Research Station Samoylov Island in the Siberian Lena River Delta), use of IT (computing, data management and data storage), use of satellite simulation tool and algorithms provided by GFZ. A more detailed description is provided in section 4.1.
Other goods and services	0	
Total	79 872	

18 / HZG	Cost (€)	Justification
Travel	32 232	6 travels to Svalbard for measurement team including subsistence during measurement periods
Equipment	0	
Other goods and services	14,500	Transport of materials 7,500 €, conference and publication fees 7,000 €
Total	46 732	

25 / NCSR	Cost (€)	Justification
Travel	10 000	The costs related to international travel to iCUPE, ERAPLANET and other relevant meetings and conferences for WP fieldwork in Svalbard, dissemination activities and meetings.
Equipment	6000	In Situ aerosol classifier
Other goods and services	7000	Transport costs of equipment for field experiments, consumable materials, filters, sensors, calibration services.
Large research infrastructure		
Total	**23000**	

27 / PSI	Cost (€)	Justification
Travel	10 000	4 trips for 2 persons for iCUPE associated meetings and conferences.
Equipment	155325	New LTOF APiTOF instrument for chemical analysis required for source apportionment is purchased. This will be 50% of the time available for iCUPE activities. 30% of the depreciation costs are accounted for this project.
Other goods and		

services		
Total	165 325	

30 / TROPOS	**Cost (€)**	**Justification**
Travel	20 000	Travel and accommodation costs during intensive campaigns in the Arctic (e.g. to Ny Alesund and Villum research stations)
Equipment	0	
Other goods and services	23 000	Instrument shipping and operational costs during intensive campaigns in the Arctic.
Total	43 000	

36 / SU	**Cost (€)**	**Justification**
Travel	10 000	Travel and accommodation costs during iCUPE and ERA-PLANET meetings and associated meetings.
Equipment	0	
Other goods and services	0	
Total	10 000	

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4 Members of the consortium

4.1. Participants

4.1.1 University of Helsinki (UHEL)

4.1.1.1 Organisation Profile

Organisation Description
Helsingin yliopisto (University of Helsinki, UHEL) is a European research university with over 34,000 students and 8,000 employees. UHEL is the largest and most versatile university in Finland and ranks among the top 100 universities worldwide. It is a research university with many Academy of Finland designated National Centres of Excellence (10 for 2012-2017, 11 for 2014-2019). Division of Atmospheric Sciences, Department of Physics at UHEL has over 30-year tradition in atmospheric research and research coordination, including coordination of several Framework Programme projects. 150 scientists and doctoral students are currently engaged in this area. The main research subjects are aerosol dynamics, atmospheric chemistry, climate change, dynamic and radar meteorology, forest-atmosphere interactions, aerosol-cloud-climate interactions, and urban air quality. With the multidisciplinary team structure and comprehensive measurement and modeling tools, ATM is one of the few groups in the World capable of efficiently combining the climate change, greenhouse gases, trace gases, aerosol processes and vegetation processes. To solve these interdisciplinary problems, the unit has created a research program including continuous long-term atmospheric observations, global modelling and deep theoretical and experimental understanding of atmospheric cluster and aerosol dynamics. The work is pioneering, wide-perspective research from the nano/molecular scale to the global scale. UHEL is a world leader in atmospheric aerosol science and one of the founders of “terrestrial ecosystem meteorology”. The core facilities related to proposed research are the SMEAR field stations. SMEAR station in Hyytiälä and in Värriö, Finnish Lapland, and urban observations in Helsinki, are compatible with ACTRIS, ICOS and LTER providing aerosol, trace gas, flux data, aerosol vertical profiling as well as cloud observations, greenhouse gas concentrations and ecosystem observations. In addition, the stations provide extended instrumentation and instrument development for aerosol particle and atmospheric ion measurements including high-resolution mass spectrometry and extensive remote sensing capacity for continuous, comprehensive observations, ground-validation of satellite products and development of novel observables. As part of ACTRIS RI, UHEL will host the ACTRIS Head Office in Helsinki. Finnish part of the Centre performs field observations in the Arctic and Antarctic regions, instrument and methodology development for reactive trace gases, atmospheric oxidants and cluster measurements, as well as promotes education and outreach activities for the scientific community and general public. In the Arctic framework, UHEL is coordinating the Pan-Eurasian EXperiment (PEEX, www.atm.helsinki.fi/peex), which is a multidisciplinary, multi-scale program focused on solving Grand Challenges in northern Eurasia and China. It is a bottom-up initiative including ca 100 European, Russian and Chinese research organizations. The PEEX approach emphasizes that solving challenges (global warming, climate change, air quality, demography development, deforestation, ocean acidification, energy, epidemic diseases, fresh water, cryospheric change) requires large-scale coordinated co-operation of the international research communities. Division of Atmospheric Sciences had fostered the establishment of RI headquarters of ACTRIS (since 2016), ICOS ERIC (since 2015) and PEEX (since 2012) in Helsinki. In addition, the Division is strongly connected to many other major European and international research and research infrastructure initiatives, such as ANAEE, RDA, EUDAT, LTER and SIOS. UHEL is strongly involved in stakeholder interactions via PEEX and Future Earth Suomi. Together with the stakeholders we are able to facilitate research planning and implementation that fulfills the requirements of the envisioned end-users, such as decision makers (EU, national, regional, local), data provider (Copernicus, GEOSS), researchers and general public.

Proposal Acronym | iCUPE

Role in ICUPE
UHEL will lead: • Coordination of iCUPE • WP0 on Management (All Tasks) and WP6 on Dissemination and strategic development • Task 4.1 on Novel quality assurance methods, proxies and observables related to aerosol sources, sinks and mixing layer height • Task 4.2 on Methodologies for validation of precipitation and cloud satellite products in high-latitude and Arctic regions • Task 5.1 on iCUPE Data management plan • Task 6.1 on Stakeholder engagement • Task 6.2 on Interaction within ERAPLANET strands • Task 6.3 on Research impact assessment UHEL will also contribute to**:** • WP1 on Ground-based component for SLCFs (with in-situ observations, data analysis) • WP3 on Satellite remote sensing of Arctic surfaces (with validation of satellite products) • WP4 on Integrating in-situ, satellite and model components for improved environmental assessment (with development of novel proxy variables) • WP5 on Data provision, interoperability and facilitation of data and services (with data management plan and facilitating data pilots, data and services towards ERA-PLANET community, GEO and Copernicus) •
On the capabilities matching iCUPE tasks
The UHEL group has experience in • Leading international research and monitoring infrastructures (SMEAR, PEEX, ICOS, ACTRIS, global SMEAR) with a capacity to perform continuous and comprehensive long-term measurement sites for atmospheric observations. • Co-designing research with the stakeholders to address needs and gaps required for maximizing the research impacts and research applicability. • Participation in campaign and continuous observations of the atmospheric composition in the Arctic areas, including Nordic countries, Svalbard, Greenland, Russian Arctic and Antarctica. • Development of novel proxy variables e.g. from the combination of satellite remote sensing data, in-situ measurements and re-analysis model data. • Development of data visualization tools (smartSMEAR and PEEXview) for the ground-based observations and distributing via an open platform (www.atm.helsinki.fi/smartSMEAR). • Providing ground-truth data to NASA satellite mission (GPM) from in-situ and ground based remote sensing data. • Expertise and capacity to perform Earth System Modeling and particularly look at black carbon emissions from flaring in the Arctic areas, and their effects on the environment. • UHEL as an organization has experience of participating 236 FP7 projects, where 15 coordinated at UHEL. In H2020, UHEL participates in 117 projects, and coordinates 6 projects. In addition, 14 EU-FP7-INT projects, holds 22 individual grants and participated in 5 IAPP and 4 IRSES projects. Research Funding Services of UHEL, established in 1994, is part of the Research Sector which operates under the central administration of the university. The unit has gained valuable experience from providing support services to over 600 projects during the previous EU's FPs.

4.1.1.2 Staff Profile and their roles in iCUPE

Prof. Tuukka Petäjä (Male) UHEL	**Coordinator (CR), WP0 leader on management tasks** • Scientific expertise: over 15 years of research experience related to atmospheric sciences. He leads the experimental aerosol group (size of 60 people) at UHEL of consisting of 3 sub-groups; 10-15 PhD students and 2-5 post-doc level members per group; educated 16 PhDs and currently supervising 10 students. has published 281 peer reviewed articles (8 in Science, 8 in Nature), with total cit. of 9817 and h-factor of 48. He is highly cited scientist (2014-, Thompson Reuters). He obtained the FAAR Award in excellent aerosol science and Vaisala Award 2013 for his work on combining state-of-the-art science and instrument development. • PI of Biogenic Aerosols – Effects on Clouds and Climate (BAECC), multiplatform research campaign to elucidate the role of secondary aerosols to clouds, supported by US Department of Energy. • Science director of Pan Eurasian Experiment (PEEX), national delegate to SAON board, board member of PACES initiative, academician in International Eurasian Academy of Sciences (IEAS). • Managerial expertise: head of technical staff of Kumpula science campus, head of Värriö sub-arctic research station in Lapland. He has participated practical organization of 11 EU projects, UHEL PI in ACTRIS2 H2020 infrastructure project, which is constructing European-wide harmonized observations on atmospheric trace gases, aerosol particles and clouds. Petäjä is a team leader in Finnish Center of Excellence of Academy of Finland on atmospheric sciences responsible for long-term, comprehensive observations in Finland and developing observational capacity in Russia and China.
Acad. Markku Kulmala (Male) UHEL	**Contributions to data analysis and proxy development and interactions with the stakeholders** • Director of the Division of Atmospheric Sciences at the Department of Physics, and professor at the University of Helsinki since 1996. Kulmala also acts as coordinator for the Centre of Excellence, appointed by the Academy of Finland first time in 2002 and for Nordic Center of Excellence, appointed by Nordforsk ("Cryosphere-atmosphere interactions in a changing Arctic climate" (CRAICC)), which is the largest joint Nordic research and innovation initiative to date, aiming to strengthen research and innovation regarding climate change issues in the Nordic and high-latitude Regions. Prof. Kulmala together with Prof. Pertti Hari is the primary inventor of the SMEAR (Stations Measuring Ecosystem Atmospheric Relations) concept. • According to the ISI Web of Knowledge, M. Kulmala is in the first place in the Citation Rankings in Geosciences (since 1.5.2011). His H-factor is 92. Prof. Kulmala has received several international awards such as the Smoluchovski Award (1997), the International Aerosol Fellow Award (2004), the Wilhelm Bjerkenes medals (2007), Fuchs Memorial Award (2010) and Litke Medal (2015). In 2015 he was acknowledged by a membership of the CASAD, Chinese Academy of Sciences, (CAS). Kulmala together with the Prof. Sergej Zilitinkevich is the initiator of the large scale multi - disciplinary Pan-Eurasian Experiment (PEEX) Program. • Academician in Finland, China (CAS) and Russia (IAES).

Prof. Veli-Matti Kerminen (Male) UHEL	**Contributes to integration of satellite and in-situ data with a particular interest on feedbacks and interactions (WP4)** • has been working in the field of atmospheric sciences since 1990, with the main areas of expertise being the formation and transformation of atmospheric aerosols and aerosol-cloud interactions; has published 253 peer-reviewed research articles with >11 000 citations and H-factor of 56. He has participated in 6 EU projects and lead 8 nationally-funded research projects. He received the "Marian Smoluchowski Award for Aerosol Research" in 2007 and acted as a "Lead Author" in the Working Group I of the IPCC Assessment Report 5 (2013). He has supervised 16 PhD theses, reviewed 22 doctoral thesis, acted 11 times as an opponent in a PhD defense, and reviewed >290 papers in 31 different journals. Here is currently editor in "Atmospheric Chemistry and Physics" and "Boreal Environment Research".
Ass. Prof. Dmitri Moiseev (Male) UHEL	**Contributes to validation of satellite observations (WP3)** • has an ample experience in utilizing ground-based precipitation and remote sensing observations for retrievals of cloud and precipitation microphysical properties; acted as PI of Light Precipitation Validation Experiment (2010, NASA GPM and CloudSat ground validation experiment) and co-PI of BAECC; member of NASA Precipitation Measurement Missions science team and manages the GPM ground-validation component in Finland
Prof. Olaf Kruger (Male) UHEL	**Contributes to development of novel satellite data products (WP4)** • has more than 20 years of experience with radiation, aerosols, clouds and air pollution. He has a strong record in teaching diverse aspects of general meteorology including satellite remote sensing of the atmosphere and the ocean (University of Hamburg, Ludwig Maximilian University of Munich, Tartu University). His research with satellite data contributed significantly to the understanding of aerosol cloud-mediated processes - aerosol indirect effects. Among the findings are the effects of anthropogenic emissions on cloud albedo in Europe and China. In 2011 he detected one branch of the so-called CLAW hypothesis, the plankton driven change of cloud albedo and precipitation in the Southern Hemisphere.
Dr. Hanna Lappalainen (Female) UHEL	**WP6 leader on dissemination and strategic development tasks** • Pan-Eurasian Experiment (PEEX) Secretary General, works currently at PEEX Headquarters, at the University of Helsinki (Division of Atmospheric Sciences, Department of Physics). She has a long-term experience of coordinating large-scale research projects and funding applications and has been working as a research coordinator and a science coordinator in the projects such as "European Integrated Project on Aerosol Could Climate and Air Quality Interaction" EU-FP7-EUCAARI (2007-2010) and "Finnish Center of Excellence in Physics, Chemistry, Biology and Meteorology of Atmospheric Composition and Climate Change" (2012-2013). Lappalainen has received NASA Goddar Team Award EOS-AURA satellite OMI-Team in 2005 and an International Eurasian Academy of Sciences (IEAS) Silver medal in 2015. Since 2014 Lappalainen has been a representative of Finland in the Sustainable Arctic Observing Network (SAON) Data working group and a Future Earth - iLEAPS Steering Group Member. She obtained her PhD from the

	Department of Biological and Environmental Sciences, University of Helsinki, Finland and has been engaged in analysis of the atmospheric concentration of the Biogenic Volatile Organic Compounds (BVOCs) and plant phenological time series and modelling.
Dr. Pauli Paasonen (Male) UHEL	**Task leader responsible for proxy development and parameterizations.** • UHEL university researcher; data analysis and parameterisations of biogenic formation and anthropogenic emissions of aerosols, and their transport and impacts in the Arctic area; work experience at UHEL, IIASA (International Institute for Applied Systems Analysis, Austria) and SYKE (Finnish Environment Institute, Finland) on pollution transport and emission modelling; group leader (Aerosol-Cloud-Climate-Interactions – group) and Coordinator of the Doctoral Programme in Atmospheric Sciences; 37 published peer reviewed articles with >1600 citations, h-index 21
Dr. Alexander Mahura (Male) UHEL	**Task leader responsible for data management plan** • UHEL university researcher; has more than 25 years of research experience in modelling of atmospheric processes and transport of pollutants (including radionuclides and pollen) on local-meso-regional-hemispheric scales, on-line integrated meteorology-chemistry-aerosols modelling at regional-urban scales, impact of urban areas on meteorology and atmospheric composition, atmospheric chemistry, atmospheric boundary layer processes, environmental impact and risk assessment, fine-scale numerical and road weather prediction, statistics; worked in Russia, USA, Austria, France, Denmark in research institutions and Universities; co-author of over 300 sci.-tech. publications, incl. 5 books and about 50 peer-reviewed papers; since 2000 has been involved in many international projects such as AR-NARP, FARECS, INTAS, FP5 FUMAPEX, FP6 Enviro-RISKS, FP7 (MEGAPOLI, TRANSPHORM, MACC, MarcoPolo), Horizon2020 (ESCAPE), NordForsk, and TEMPUS funded projects, EU COST Actions (-728, -EUPOL, -ENCWF, -EuMetChem), HIRLAM, HARMONIE, EnviroChemistry & EnviroAerosols on ECMWF HPC.
Dr. Ella-Maria Duplissy (female) UHEL	**Task leader responsible for research impact assessment** • PhD in atmospheric sciences (2014), has been doing research on Arctic and Antarctic aerosols and their interaction with clouds and climate. With a background in meteorology, has a wide understanding on the atmospheric processes in the Arctic. She has also experience in participating campaign measurements in the polar regions.
Dr. Albert Porcar-Castell (Male) UHEL	**Contributes to development of the proxy for gross primary production based on satellite derived fluorescence data** • Academy Research Fellow, leader of the Optics of Photosynthesis Laboratory at department of Forest Sciences (UHEL). With >15 years experience in plant ecophysiology, photosynthesis and interpretation of chlorophyll fluorescence signals of vegetation, has coordinated pioneering studies and large field campaigns. He is the main author of the highly cited Darwin Review on the Remote Sensing of Chlorophyll Fluorescence and its connection to photosynthesis; 28 published peer reviewed articles (65% of them as first or last author), 650 citations, h-index 14.

Dr. Risto Makkonen (Male) UHEL	**Contributes to analysis of Arctic emissions and their impacts, particularly from flaring and natural gas extraction** • Main scientific interests include secondary aerosol formation, aerosol nucleation, as well as natural and anthropogenic aerosol-climate effects through global simulations. Expertise in several climate models (ECHAM-HAM, NorESM, EC-Earth). Group leader (Earth System Modeling guidance group) at UHEL. Work experience from UHEL and University of Oslo. Work package co-leader in EU FP7 project BACCHUS and Nordforsk Center of Excellence eSTICC. Received the Finnish Association for Aerosol Research (FAAR) award for "pioneering work in global aerosol modeling" in 2015. Board member of Nordic Society For Aerosol Research.
M.Sc. Nina Sarnela (Female) UHEL	**Contributes to field data analysis from the Arctic campaigns (Greenland, Svalbard, Värriö)**
M.Sc. Xuemeng Chen (Female) UHEL	**Contributes to field data analysis from Antarctica**
M.Sc. Lauri Ahonen (Male) UHEL	**Contributes to field observations in the Arctic areas during intensive campaigns**
M.Sc. Anna Nikandrova (Female) UHEL	**Contributes to data analysis on integrating ground-based remote sensing, flight measurements and ground-based in-situ data.**
M.Sc. Ksenia Tabakova (Female) UHEL	**Contributes to data analysis on integrating ground-based remote sensing, satellite data and ground-based in-situ data.**
Finnish Center of Excellence on Atmospheric Sciences (FCoE-ATM)	UHEL work in iCUPE closely connects to multidisciplinary research team of FCoE that includes 235 scientists working in the fields of physics, chemistry, biology and meteorology at the Universities of Helsinki and Eastern Finland (Kuopio), and at the Finnish Meteorological Institute. Our work is based on a network of field stations producing extensive long-term data on atmospheric properties and ecological mass fluxes in different types of environments and regions, including Arctic, boreal and tropical ecosystems, and on focused experiments and modeling aimed at understanding the observed patterns. We have been awarded with the Academy of Finland CoE status three times since 2002 and the Nordic CoE status in 2003 and 2010. The objective is to quantify the feedbacks between the atmospheric processes and changing functioning of biosphere in changing climate. In order to do this, we will 1) find out and quantify the main climatic feedbacks and forcing mechanisms related to aerosols, clouds, precipitation, biosphere-atmosphere and cryosphere-atmosphere interactions, 2) develop, refine and utilize the newest measurement techniques and modeling tools scaling from quantum chemistry to global Earth System Observations and Models, 3) create a deep and quantitative understanding on the role of atmospheric clusters and aerosol particles in local and global biogeochemical cycles of water, carbon, sulfur and nitrogen and their linkages to the atmospheric chemistry, and 4) integrate the results in the context of regional and global scale Earth system understanding.

4.1.1.3 Relevant Projects

ACTRIS-2 IA European Research Infrastructure for the observation of Aerosol, Clouds, and Trace gases, H2020, Project GA number: 654109

ACTRIS Preparatory Phase Project is a EU Horizon 2020 Coordination and Support Action (grant agreement No 739530).

Client	Volume	Period
	0.365 M€ for UHEL (ACTRIS2) 0.800 M€ for UHEL (ACTRIS PPP)	2015-2019 2017-2019

Relevance to iCUPE

- Innovation in instrumentation as one of the fundamental building blocks of ACTRIS-2. Associated partnership with SMEs stimulates development of joint-ventures addressing new technologies for use in atmospheric observations.
- Improvement of systematic and timely collection, processing and distribution of data and results for use in modelling, in particular towards implementation of atmospheric and climate services. ACTRIS-2 invests substantial efforts to ensure long-term sustainability beyond the term of the project by positioning the project in both the GEO and the on-going ESFRI contexts, and by developing synergies with national initiatives.
- To further develop and disseminate integration tools to fully exploit the use of multiple atmospheric techniques at ground-based stations, in particular for the calibration/validation/integration of satellite sensors and for the improvement of the parameterizations used in global and regional-scale climate and air-quality models

Description

Context & objectives

The **ACTRIS-2** Integrating Activities (IA) addresses the scope of integrating state-of-the-art European ground-based stations for long-term observations of aerosols, clouds and short lived gases. It consolidates and improves services offered within FP7 funded Integrated Infrastructures Initiative ACTRIS (2011-2015). ACTRIS-2 takes up the overarching objectives of ACTRIS to further integrate the European ground-based stations and to construct a user-oriented RI, unique in the EU-RI landscape, for aerosols, clouds, and short-lived gas-phase species.
Target user-groups in ACTRIS-2 comprise a wide range of communities worldwide. End-users are institutions involved in climate and air quality research, space agencies, industries, air quality agencies. ACTRIS-2 represents a fundamental step towards the establishment of the atmospheric component of the Integrated European Observing System and a clear upgrade in services offered to users.

Results

- To maintain and increase availability of long-term observational data relevant to climate and air quality research on the regional scale produced with standardized or comparable procedures throughout the ACTRIS network of stations;
- To further develop and disseminate integration tools to fully exploit the use of multiple atmospheric techniques at ground-based stations, in particular for the calibration/validation/integration of satellite sensors and for the improvement of the parameterizations used in global and regional-scale climate and air-quality models;
- To open calibration facilities and advanced observing platforms to Trans-National Access to the

benefit of a large user community, including SMEs, and to further facilitate virtual access to high quality information, tools and services enhancing the ACTRIS Data Centre;
- To maintain and enhance capacity of training in the field of atmospheric observations particularly directed to new users including those from non-EU developing countries;
- To increase the Technology Readiness Level of technologies for atmospheric observation of aerosols, clouds, and trace gases in close partnership with EU SMEs associated to the project.
- To develop a sustainable strategy for maintaining ACTRIS-services in the long-term, improving synergies with all relevant research infrastructures in the field of environmental sciences and coordination with national strategies in the EU.

EU H2020 project ENVRIPLUS (Environmental Research Infrastructures Providing Shared Solutions for Science and Society). Grant agreement n. 654182 (2015-2019).

Client	Volume	Period
	0.450 M€ for UHEL	2015-2019

Relevance to ICUPE

ENVRIplus
- is Horizon 2020 project bringing together Environmental and Earth System Research Infrastructures, projects and networks together with technical specialist partners to create a more coherent, interdisciplinary and interoperable cluster of Environmental Research Infrastructures across Europe.
- provides an ideal ecosystem for iCUPE for result dissemination and integration with the European landscape in environmental infrastructures.
- Connection to ENVRIplus facilitates collaboration beyond traditional research communities and stakeholders.

Description

Context & objectives

ENVRIplus objective is to provide common solutions to shared challenges for European Environmental and Earth System Research Infrastructures in their efforts to deliver new services for science and society. To reach this overall goal, ENVRIplus brings together Environmental and Earth System Research Infrastructures, projects and networks together with technical specialist partners to build common synergic solutions for pressing issues in Research Infrastructure construction and implementation.
ENVRIPLUS is driven by 3 overarching goals: 1) favouring cross-fertilization between Research Infrastructures, 2) implementing innovative concepts and devices across Infrastructures, and 3) facilitating research and innovation in the field of environment to an increasing number of users outside the Research Infrastructures.

Results

- Theme 1 “Technical Innovation” is to improve the Research Infrastructures’ abilities to observe the Earth System, particularly in developing and testing new sensor technologies, harmonizing observation methodologies and developing methods to overcome common problems associated with distributed remote observation networks.
- Theme 2 “Data for Science” aims at generating common solutions for shared information technology and data related challenges of the environmental Research Infrastructures in data and service discovery and use, workflow documentation, data citations methodologies, service virtualization, and

user characterization and interaction.

- Theme 3 "Access to Research Infrastructures" aims to develop harmonized policies for access (physical and virtual) for the environmental Research Infrastructures, including access services for the multidisciplinary users is the ultimate goal.
- Theme 4 focusing on "Societal Relevance and Understanding" will investigate the interactions between Research Infrastructures and society. The team will find common approaches and methodologies how to assess the Research Infrastructures' ability to answer the economical and societal challenges, develop ethics guidelines for Research Infrastructures and investigate the possibility to enhance the use Citizen Science approaches in Research Infrastructure products and services.
- Theme 5 "Knowledge Transfer" will ensure the cross-fertilisation and knowledge transfer of new technologies, best practices, approaches and policies of the Research Infrastructures by generating training material for Research Infrastructure personnel to use the new observational, technological and computational tools and facilitate inter-Research Infrastructure knowledge transfer via a staff exchange program.
- Theme 6 "Communication and Dissemination" will create Research Infrastructure communication and cooperation framework to coordinate activities of the environmental Research Infrastructures towards common strategic development, improved user interaction and interdisciplinary cross-Research Infrastructure products and services.

Academy of Finland project Centre of Excellence in Atmospheric Science – From Molecular and Biological processes to The Global Climate (FCoE ATM).

Client	Volume	Period
ACADEMY OF FINLAND	For 2017-2019: 3.4125 M€ for UHEL	From 2002 on Current grant 2014-2019

Relevance to ICUPE

FCoE ATM combines

- process-level understanding with comprehensive, long-term field measurements in investigating the complicated couplings between the biosphere and atmosphere,
- field data, satellite observations and model simulations and produces complementary approaches between these methods

Description

Context & objectives

The main scientific objective of ATM is to quantify the COBACC (COntinental Biosphere-Aerosol-Cloud-Climate) feedbacks in changing climate. The main objective is divided to four sub-objectives:

- find out and quantify the main climatic feedbacks and forcing mechanisms related to aerosols, clouds, precipitation, biosphere-atmosphere and cryosphere-atmosphere interactions,
- develop, refine and utilize the newest measurement techniques and modeling tools scaling from quantum chemistry to global Earth System Observations and Models,
- create a deep and quantitative understanding on the role of atmospheric clusters and aerosol particles in local and global biogeochemical cycles of water, carbon, sulfur and nitrogen and their linkages to the atmospheric chemistry, and
- integrate the results in the context of regional and global scale Earth system understanding.

Proposal Acronym | iCUPE

Results

FCoE ATM research highlights from years 2014-2016 cover topics from atmospheric new particle formation, gas-to-particle conversion and cloud formation processes, to ecosystem processes, air quality, global climate, and development of new research methods.
The atmospheric new particle formation and gas-to-particle conversion results include e.g.

- discovery of extremely low volatile organic compounds from monoterpene oxidation forming a large source of secondary organic aerosols (SOA)
- discovery of pure biogenic nucleation without sulphuric acid
- analysing long aerosol and non-methane hydrocarbon (NMHC) data series from Arctic stations
- modelling work showing that approximate continuum models for cluster and particle growth can lead to distortions of cluster concentrations
- development of chemistry-aerosol-dynamic models to include a multi-layer deposition module for all gaseous molecules
- development of new methods and knowledge on particle counter operation, cluster generation and heterogeneous nucleation
- observations of aerosol formation and concentrations at various sites around the world

In atmospheric chemistry, FCoE ATM has e.g.

- developed small scale on-line and off-line mass spectrometry based method to study chemical reactions in gas phase
- a novel method based on comprehensive two-dimensional gas chromatography coupled to time-of-flight mass spectrometry to determine vapor pressures of atmospheric aerosols.

In the ecosystem processes results, we have studied e.g.

- the effect of weather and needle ontogenesis on monoterpene synthase activity, storage and emission in Scots pine
- monoterpene fluxes from forest floor
- the effect of wind and water convection on the surface exchange of carbon dioxide in lakes
- how mature Scots pine trees consistently emit N_2O and CH_4
- wetland is a marked sink of CO_2 at subarctic Pallas supersite while spruce forest and alpine tundra has an annual balance close to zero
- 137Cs has remained rather mobile in the forest soil for decades after Chernobyl and Fukushima accidents, but the 137Cs in the structure of the trees remains.

We have gained understanding on the feedback between atmospheric aerosol particles and the stability of the boundary layer that limits the subsequent anthropogenic emissions to a shallower layer leading to intensified poor air quality conditions in urban environments, particularly in China.
Ground and space based remote sensing instruments have been used to e.g.

- dramatically improve snow observations
- improve boundary layer analysis
- produce frost/thaw mapping from satellite data for the northern hemisphere using L-band satellite radiometers that is a totally new source of spatially reliable information
- show that air with high aerosol content is associated with increased upper tropospheric humidity due to microphysical effects of aerosols.

Our Earth System Modelling approach has

- formed future scenarios for global anthropogenic size-segregated particle number emissions,
- developed aerosol formation modules for global models ECHAM-HAM and EC-Earth,
- investigated formation of extremely low volatile organic compounds and further cloud condensation nuclei from biogenic emissions,
- developed methods for quantification of global dew collection potential on artificial surfaces,

- developed CarbonTracker Europe-CH4 to estimate global methane emission.

Joint activities with the various research groups within the CoE ATM enable us to study the chains of chemical reactions and physical processes that secondary pollutants, such as ozone and organic aerosols, undergo in China's polluted urban air, and enable us to study atmospheric vapor, cluster and nanoparticle concentrations, dynamics, and their connection to atmospheric nucleation.

Pan Eurasian Experiment (PEEX)

Client	Volume	Period
	For coordination: ~0.4 M€/year for UHEL	2012-

Relevance to ICUPE

- **PEEX** coordinates major research infrastructure projects in Siberia and China, and integrates satellite and ground-based observations with multi-scale modelling. PEEX offers for iCUPE a direct contact to Russian and Chinese researchers and decision makers related to Arctic environment and use of natural resources.

Description

Context & objectives

PEEX is an umbrella organisation under which all large scale projects of Division of Atmospheric Sciences at UHEL are organized (including e.g. ATM Center of Excellence, see above; Acad. Kulmala ERC funding)
PEEX is a multidisciplinary, multi-scale research initiative aiming at resolving the major uncertainties in Earth System and Global Sustainability Science concerning the Arctic and boreal Pan-Eurasian regions including the impact and influence of China. The vision of PEEX is to solve interlinked global grand challenges influencing human well-being and societies in northern Eurasia and China in an integrative way, recognizing the significant role of boreal and Arctic regions in the context of global change. The list of grand challenges cover subjects such as climate change, air quality, biodiversity loss, chemicalization, food supply, energy production and fresh water supply.
Solving any of the Grand Challenges (climate change, air quality, ocean acidification, fresh water, food supplies) requires a multi-scale-multidisciplinary research program linked with fast track policy making. The Pan-Eurasian Experiment (PEEX) contributes to solving global scale grand challenges in the northern Pan-Eurasian context. The PEEX approach emphasizes the converging understanding of physical and socio-economic processes within the Earth system, particularly in the changing pristine and urban environments of the northern (45°N or higher) latitudes and Arctic regions. The PEEX aims to be a next-generation natural sciences and socio-economic research initiative having a major impact on the future environmental, socio-economic and demographic development of the Arctic and boreal regions. PEEX also aims to be a science community building novel infrastructures in the Northern Pan-Eurasian region.

Proposal Acronym | iCUPE

Biogenic Aerosols – Effects on Clouds and Climate (BAECC)		
Client	**Volume**	**Period**
	0.7 M€ for UHEL	2013-2015

Relevance to ICUPE

Provides comprehensive data on atmospheric composition (aerosols etc) with a suite of in-situ and ground based remote sensing instruments. Data available for iCUPE work.

Description

Context & objectives

In the Biogenic Aerosols - Effects on Clouds and Climate (BAECC) experiment the hypothesis was that the boreal forest is a source of aerosol particles that form and grow to a size where they activate to become cloud droplets, altering the radiation balance of the Earth and, therefore, providing a direct link between the atmosphere and the biosphere.

The main objective of BAECC was to verify the effects of secondary aerosol formation on cloud properties with a combination of in situ observations and active remote sensing instruments provided by AMF2, and place these observations within a larger context through modeling efforts.

In particular, the aims was to provide insights into:

- the uncertainties of indirect effects on climate of the aerosol particles in the boreal environment, and, in particular, the role of secondary aerosol particles in CCN and IN concentrations and their effects on cloud microphysics;
- the magnitude of the feedback mechanisms associated with aerosol-cloud-climate-air quality interactions using both in situ and active remote sensing data.

Results

A vast data set was collected during BAECC, which will be contrasted against the 18-year data set already available from SMEAR-II. As a technical example, we validated co-located AMF2 aerosol measurements against SMEAR-II instrumentation. Furthermore, additional aerosol measurements operated approximately 300 m apart enabled us to study spatial variability of aerosol number concentration and number size distribution in small scale. Analysis of the BAECC dataset will continue for many years.

4.1.1.4 Relevant Publications

1.	Petäjä, T., O'Connor, E.J., Moisseev, D., Sinclair, V.A., Manninen, A.J., Väänänen, R., von Lerber, A., Thornton, J.A., Nicoll, K., Petersen, W., Chandrasekar, V., Smith, J.N., Winkler, P.M., Krüger, O., Hakola, H., Timonen, H., Brus, D., Laurila, T., Asmi, E., Riekkola, M.-L., Mona, L., Massoli, P., Engelmann, R., Komppula, M., Wang, J., Kuang, C., Bäck, J., Virtanen, A., Levula, J., Ritsche, M. and Hickmon, N. (2016) BAECC, A field campaign to elucidate the impact of Biogenic Aerosols on Clouds and Climate, Bull. Am. Met. Soc., DOI: http://dx.doi.org/10.1175/BAMS-D-14-00199.1
2.	Zieger, P., Aalto, P.P., Aaltonen, V., Äijälä, M., Backman, J., Hong, J., Komppula, M., Krejci, R., Laborde, M., de Leeuw, G., Pfüller, A., Rosati, B., Tesche, M., Tunved, P., Väänänen, R. and Petäjä, T. (2015) Low hygroscopic scattering enhancement of boreal aerosol and the implications for a columnar optical closure study, Atmos. Chem. Phys. 15, 7247–7267.
3.	Kulmala, M., Arola, A., Nieminen, T., Riuttanen, L., Sogacheva, L., de Leeuw, G., Kerminen, V.-M. and Lehtinen, K.E.J. (2011) The first estimates of global nucleation mode aerosol concentrations based on satellite measurements, Atmos. Chem. Phys. 11, 10791-10801.
4.	Sporre, M.K., O'Connor, E.J., Håkansson, N., Thoss, A., Swietlicki, E. and Petäjä, T. (2016)

	Comparison of MODIS and VIIRS cloud properties with ARM ground-based observations over Finland, Atmos. Meas. Technol. 9, 3193-3203.
5.	Kulmala, M., Lappalainen, H.K., Petäjä, T., Kurtén, T., Kerminen, V.-M., Viisanen, Y., Hari, P., Sorvari, S., Bäck, J., Bondur, V., Kasimov, N., Kotlyakov, V., Matvienko, G., Baklanov, A., Guo H.D., Ding, A., Hansson H.-C., Zilitinkevich S. (2015) Introduction: The Pan-Eurasian Experiment (PEEX) – multidisciplinary, multiscale and multicomponent research and capacity-building initiative, AtmChem&Phys., 15, 13085-13096.

4.1.1.5 Relevant Infrastructures

UHEL operates three extensive multidisciplinary SMEAR (Stations for Measuring Earth surface and Atmosphere Relations) observation sites in Finland. They cover regions from subarctic regions of Lapland to Baltic Sea region in Southern Finland. These observation sites are part of ACTRIS-Finland, and connected to ICOS, ANAEE, LTER, GAW and other international infrastructures and initiatives. In addition to the SMEAR stations, ACTRIS-Finland facilities include a state-of-the-art aerosol, cluster and trace gas laboratory.

UHEL will host the ACTRIS Head Office in Helsinki. UHEL is coordinating Pan Eurasian Experiment (PEEX, www.atm.helsinki.fi/peex/), which is a multidisciplinary, multi-scale program focused on solving Grand Challenges in northern Eurasia and China. It is a bottom-up initiative including ca 100 European, Russian and Chinese research organizations. UHEL is strongly connected to many other major European and international research and research infrastructure initiatives, such as ICOS, ANAEE, LTER, RDA, EUDAT and SIOS.

The **SMEAR I** (Station for Measuring Earth surface and Atmosphere Relations) station at Värriö Strict Nature Reserve (67°46'N, 29°35'E, 400 m a.s.l.) is situated in Lapland, in a rural area far removed from any settlements. It is surrounded by a Scots pine (Pinus sylvestris l.) forest, which is over 40 years old in the station's immediate vicinity. The measurements are performed on a hill top. There are no pollution sources nearby, but emissions from industrial activities (e.g., smelters) from the Kola Peninsula area may be carried to the station. The initial measurements focused on sulphur dioxide but during the 90s the scope of measurements were significantly augmented. Today, among other things, the SMEAR station measures the weather, aerosols, inorganic gases in the atmosphere, the gas circulation and its relationship to the growth of forests. http://www.helsinki.fi/forestsciences/varrio/research/smear.html

The **SMEAR II** station at Hyytiälä (61°51'N, 24°17'E, 180 m above sea level, a.s.l.) has extensive facilities for measuring forest-atmosphere relations and has been active since 1996. This site is the flagship of the SMEAR network providing, for example, the longest continuous time series of sub-micron aerosol number size distribution measurements. The main research fields are: analysis of gas and particle concentrations and fluxes and their role in aerosol and cloud formation; analysis of water, carbon and nutrient budgets of the forested catchment, and analysis of environment and tree structure on gas exchange, water transport and growth of trees. http://www.atm.helsinki.fi/SMEAR/index.php/smear-ii

The Research Infrastructure **(RI) ACTRIS** – Aerosols, Clouds and Trace Gases - is the pan-European RI that consolidates activities amongst European partners for observations of aerosols, clouds, and trace gases and for understanding of the related atmospheric processes, to provide RI services to wide user groups. ACTRIS is composed of 8 connected elements: distributed National Facilities (observation platforms and exploratory platforms) both in Europe and globally, and 7 Central Facilities (Head Office, Data Centre and 5 Calibration Centres). ACTRIS provides access to its facilities, open-access data, research support, instrument calibration and development, and training to various user groups. By providing data and access ACTRIS enhances science, but it also generates and disseminates knowledge, boosts technological development, and creates human capital and jobs for the benefit of the society. ACTRIS will positively impact on e.g. human health, climate resilience, and protection from environmental hazards and reduction of air pollution. ACTRIS has been selected to the ESFRI roadmap in 2016 as mature enough to be implemented within the next ten years. ACTRIS Preparatory Phase Project (PPP) will have a significant role in enabling the transition from a project based network of research facilities to a centrally coordinated integrated pan-European RI. ACTRIS PPP brings together a wide community of research performing organizations, research funding organizations and ministries needed to take the decisions and actions to

move forward in the implementation of the ACTRIS. The main objectives of ACTRIS PPP are to develop the organizational, operational and strategic frameworks of the RI. The work includes legal, governance, financial, technical, strategic, and administrative aspects carried out in 9 work packages. The main outcomes of PPP are signature-ready documents for establishment of a legal entity with well-defined operations and a sound business plan.
PEEX - The Pan-Eurasian Experiment (PEEX) is a multidisciplinary, multi-scale program focused on solving grand challenges in northern Eurasia and China focusing in Arctic and boreal regions. PEEX will also help to develop service, adaptation and mitigation plans for societies to cope with global change. It is a bottom-up initiative by several European, Russian and Chinese research organizations and institutes with co-operation of US and Canadian organizations and Institutes. The PEEX approach emphasizes that solving challenges related to climate change, air quality and cryospheric change requires large-scale coordinated co-operation of the international research communities. Strong involvement and international collaboration between European, Russian and Chinese partners is needed to answer the climate policy challenge: how will northern societies cope with environmental changes? The promoter institutes of this initiative are UHEL and in Finland; the Institute of Geography of Moscow State University, AEROCOSMOS, and the Institute of Atmospheric Optics (Siberian branch) of the Russian Academy of Sciences (RAS) in Russia; the Institute of Remote Sensing and Digital Earth (RADI) of the Chinese Academy of Sciences (CAS) and the institute for climate and global change research of Nanjing University in China. PEEX is built on collaboration by EU, Russian and Chinese parties, involving scientists from various disciplines, experimentalists and modelers, and international research projects funded by European, Russian and Chinese funding programs. The first active PEEX period is 2013–2033, though PEEX will continue until 2100. PEEX is open for other institutes to join.
ICOS is the the European Research Infrastructure for on-line, in-situ monitoring of greenhouse gases (GHG) to understand their present-state and future sinks and sources. The ICOS Head Office is located in Helsinki since 2013. The national ICOS network consists of 14 atmospheric and ecosystem stations. The partners of ICOS- Finland are University of Helsinki, University of Eastern Finland and Finnish Meteorological Institute. ICOS RI provides effective access to coherent and precise data and assessments of GHG inventories with high temporal and spatial resolution. ICOS also provides profound information for research and understanding of regional budgets of greenhouse gas sources and sinks, their human and natural drivers, and the controlling mechanisms. ICOS permits to detect changes in regional greenhouse gas fluxes, early warning of negative developments and the response of natural fluxes to extreme climate events, to reduce uncertainties in Earth System models.
ECHAM-HAM is a global aerosol-climate model developed originally in Hamburg. Currently ECHAM-HAM development is divided between several institutions, e.g. ETH Zürich, MPI Hamburg, UHEL and FMI. The atmospheric part of the model is based on the ECMWF model. The aerosol module includes aerosol components sulphate, black carbon, organic carbon, sea salt and dust. The size distribution can be described either with seven log-normal modes (M7) or sectional approach (SALSA). The aerosols are interactively coupled to cloud droplet activation, allowing studies of aerosol indirect effects. The atmospheric model can be coupled with several other ESM components, such as ocean model MPIOM, land-surface model JSBACH and ocean biogeochemistry model HAMOCC.
GAINS (Greenhouse Gas – Air Pollution Interactions and Synergies) is an integrated assessment model developed and maintained by IIASA (International Institute for Applied Systems Analysis, Austria). It brings together information on the sources and impacts of air pollutant and greenhouse gas emissions and their interactions by combining data e.g. on economic development and the structure, control potential and costs of emission sources. GAINS assess all the main air pollutants and greenhouse gases (SO_2, NO_x, PM, NMVOC, NH_3, CO_2, CH_4, N_2O, F-gases) with more than 1000 measures to control the emissions to the atmosphere for each of its nearly 170 regions. Pauli Paasonen has been a a IIASA guest scholar working with GAINS Advanced mode. He is able to calculate the expected emissions from specified large-scale projects and combine them with the existing scenarios.

4.1.1.6 Third parties involved in the project (including use of third party resources)

No third parties involved

4.1.2 Consiglio Nazionale delle Ricerche (CNR)

4.1.2.1 Organisation Profile

Organisation Description

The National Research Council (Consiglio Nazionale delle Ricerche - **CNR**) of Italy is one of the most important public research performing organization in Italy, reporting directly to the Ministry of the Education, University and Research. Its duty is to carry out, promote, spread, transfer and improve research activities in the main sectors of knowledge growth and of its applications for the scientific, technological, economic and social development. It is organized in 7 Departments coordinating the activities of more than 100 Institutes in the main fields of knowledge, from life sciences to engineering, from earth system science to humanities, and managing the research infrastructures.
The CNR Department of Earth System Science and Environmental Technologies (CNR-DTA, www.dta.cnr.it) in one of them. Its mission is to support and coordinate the research activities carried out by its 13 associated Institutes dealing with environmental sciences, including climate change, and the development of innovative monitoring technologies. The activities of the Department of Earth System Science and Environmental Technologies (DTA) are carried out by a staff of approximately 1100 people supported by approximately other 800 collaborators in the research area.

The following institutes from the CNR DTA are taking part in iCUPE:

The Institute for the Dynamics of Environmental Processes (**CNR-IDPA**) is dedicated to advancing the understanding of the processes of the Earth system and their interactions with the humankind. It pursues this goal through basic and applied research and education, by focussing on monitoring and management of anthropogenic effects. It develops approaches to support problem-solving in earth-sciences and decision-making for sustainable development, and communicates its results to promote understanding and awareness, to the benefit of the wider society.
The main research activities of the CNR-IDPA involve the study of chemical contamination on a global level, the mechanisms of transport and transfer of pollutants between different environmental compartments, the processes and cycles of transformation of chemicals in the environment, and the development of chemical analytical methodologies for the specific study of pollutants in snow, ice, soil and waters. IDPA has a large experience in the research on past climate change and in the study of the contamination level from local to global scales, especially in remote and mountainous areas. The Institute's activities take also place in highly populated areas to assess the impact of human activities on the environment, to understand the mechanisms of spread of contamination and to propose the best actions for environmental recovery.
The Institute of Atmospheric Sciences and Climate (**CNR-ISAC**) employs over 200 staff members to conduct pure and applied research on atmospheric sciences and the climate system. The ISAC is organized into four divisions: Dynamic Meteorology, Climate Change, Observations, Atmospheric Processes and a technical service structure: Field Facilities and Instrumentation. The ISAC mission is to improve the knowledge of the atmospheric and climate processes of the planet Earth and at the same time to produce results directly transferable to the society also beyond the national borders.
The Institute for Atmospheric Pollution Research (**CNR-IIA**) employs over 100 persons involved in research activities concerning different thematic areas: Atmospheric Pollution in Urban and Industrial Areas; Emerging Air Contaminants in Environmental Emissions; Pollutant Cycles Across Different Spatial Scales and in Polar Areas; Global and Regional Atmospheric Modelling; Developing EO (Earth Observation) Devices and Methods; Geospatial Information and Environmental Knowledge-Sharing; Transfer of Technical and Scientific Knowledge for the Production and Implementation of Air-Quality Legislation; and High-performance sensors and sensing systems for monitoring air quality and environment. As part of the CNR-IIA Institute, two research groups will contribute: the Developing Earth Observation Devices and Methods thematic group focuses its research to integrate multi-platform and multi-sensor EO data to monitor and improve the overall quality of the EO system, its data, and its

products. The Florence Division of IIA and in particular the Earth and Space Science Informatics laboratory (ESSI-lab) will be in charge of the interoperability and data management task applying the horizontal enabling technologies of ERA-Planet.

Role in ICUPE

CNR teams will lead:

- WP2 on In-situ component for organic contaminants, mercury and other heavy metals
- Task 1.1 on Integration of observations provided by research Infrastructures and networks
- Task 2.1 on Defining human impacts on polar regions – cryosphere monitoring and ice core archives
- Task 3.2 on Optical satellite remote sensing
- Task 5.2 on Appliance of ERA-PLANET principles and key enabling technologies for interoperability: infrastructure design and development (horizontal)
- Task 5.3 on Compliance of iCUPE to GEOSS and Copernicus data sharing principles and GCI interoperability testbeds (horizontal)
- Task 5.4 on Implementation of interoperability interfaces on international and community-based standards, GEOSS Data Management Principles and GEO Label (horizontal)

CNR teams will also contribute to:

- WP0 on Management
- WP1 on Ground-based component for SLCFs
- WP3 on Satellite remote sensing of Arctic surfaces
- WP4 on Integrating in-situ, satellite and model components for improved environmental assessment
- WP5 on Data provision, interoperability and facilitation of data and services
- WP6 on Dissemination and strategic development

On the capabilities matching iCUPE tasks

- CNR-DTA is engaged with significant scientific activities in the Arctic Region, by managing the Dirigibile Italia Station at Ny-Alesund, Svalbard, cooperating in several international Polar initiatives, and manages the Italian Programme of Antarctic Research (PNRA).
- In this framework, CNR is continuously engaged in promoting and actively contributing with skill and expertise to international cooperation programmes and RIs development at national and European level from Mediterranean to polar regions.
- Participating Institutes and research groups have been involved for more than 20-30 years in research in polar regions, developing extensive expertise in their specific fields of activity. For the IDPA we can report for example its continuous operation as part of the PNRA at Mario Zucchelli station and Dome C as well as in the Arctic on the Svalbard Islands and Greenland. This activity was supported by national and the following ERC projects; Early Human Impact, GMOS, P4F; ALPINE-SPACE and EPICA. For ISAC we can report as example the CCT-Integrated project (www.isac.cnr.it/~radiclim/CCTower), the management of BSRN station in Concordia and related activities on BRDF reflectance above Antarctic Plateau (PNRA STRRAP-b project STudy of the Radiative Regimes over the Antarctic Plateau and beyond) and the strong involvement in SIOS ESFRI project; for IIA we can highlight the activities concerning the development of an integrated platform for snow observations (combining spectral albedometry and snow cameras, continuously operating in Dome-CAntarctica, Ny-Ålesund / Svalbard islands and Italian Alps), the development of an automated image-processing software (SnowNoSnow) focused on the estimation of the fraction of snow cover, and the participation to national (ARCA, different PNRA expeditions) and international projects (CICCI) aimed to characterize the atmosphere / snow cover interface.
- The Florence division of CNR-IIA has been leading the interoperability architecture and brokering technologies implemented by GEOSS. In particular, the ESSI-lab of CNR-IIA is in charge of the GEO DAB (Discovery and Access Broker).

4.1.2.2 Staff Profile and their roles in iCUPE:

Prof. Carlo Barbante **CNR-IDPA** **(Male)**	**Lead WP2** • Director of the IDPA-CNR, Male • *Education* M.Sc. in Chemistry, University Padova, Italy, 1988 • Full Professor for Analytical Chemistry, 2006 • *Experience relating to the project* Scientist with a very high international profile. In the last fifteen years, he has made substantial contributions to the Environmental and Climate Sciences in Polar Regions. He is national delegate to the International Arctic Scientific Committee (IASC) and to the Scientific Committee on Antarctic Research (SCAR). He is member of the Italian Antarctic National Scientific Commission and participated in several scientific expeditions to the poles. Carlo Barbante has a long-standing experience in handling EU projects related to climate and environment. He is an ERC Advanced Grant awardee and Italian National Delegate to Horizon 2020 for the Societal Challenge "Climate Action, Environment, Resource Efficiency and Raw Materials".
Dr. Vito Vitale **CNR-ISAC** **(Male)**	**Contributes to WP1 (also leading Task 1.1), WP4 (Task 4.5), WP6** • *Role in the Institution:* Senior scientist • *Main expertise:* radiative transfer processes in the atmosphere • *Education:* M.SC degree in Physics • *Experience relating to the project:* Expert of radiative transfer processes into the atmosphere, with a research focus on radiation balance and role that aerosols, clouds, traces gases, surface characteristics play in modulating SW and LW components at surface as along the atmosphere. Involved in polar research since 1988, has acquired a lot of experience in field activities and optimisation of instruments for this hard environment, also developing original instrumentation for radiometry and passive ground-based remote sensing. At present in the Arctic coordinate the Climate Change Tower Integrated Project (CCT-IP, www.isac.cnr.it/~radiclim/CCTower). He coordinates CNR participation to the Svalbard Integrated Earth Environment Observational System (SIOS) initiative and to the SIOS-PP EU project. Is vice-president of the CNR Polar Research Committee, and CNR representative to the Ny-Ålesund Science Managers Committee (NySMAC). He is national delegate to the International Arctic Science Committee Atmospheric Working Group (IASC-AWG) and represents Italy in the Sustaining Arctic Observing Network (SAON) Steering Board.
Dr. Rosamaria Salvatori **CNR-IIA** **(Female)**	**Contributes to WP3 (also leading Task 3.2)** • *Role in the Institution:* Senior scientist • *Main expertise:* Remote Sensing/pectroradiometry • *Education:* Ph.D in Earth Sciences • *Experience relating to the project:* Involved, as senior researcher, in environmental studies in Polar and Mediterranean areas using remote sensed images with different spatial and spectral resolutions. Her research activity is focused on the study of the spectroradiometric properties of different natural and handmade surfaces, in the 350-2500nm spectral range, in order to recognize their pattern and features from remote sensed data. In particular, since 1997 she carried out, as principal investigator, field surveys in Polar Regions (Antarctica and Arctic) to study the spectroradiometric properties of snow and ice, and the

	interactions at the snow/air interface. She participated to the development of a system to monitor continuously the snow surface in remote sites with the aim to follow the snow metamorphic process. She is coordinator of the CNR-IIA thematic area "Developing Earth Observation Devices and Methods" and she is Adjunct Professor in Remote Sensing and GIS at the Department of EcoBiology of the University of Rome – Sapienza, since 2011.
Dr. Roberto Salzano **CNR-IIA** **(Male)**	**Contributes to WP3** • *Role in the Institution:* Scientist • *Main expertise:* spectroradiometry / Geochemist • *Education:* Ph. D in Earth Sciences • *Experience relating to the project:* Expert of snow-cover characterization using visible and infra-red techniques. His interest is the monitoring of the snow-cover evolution during the different seasons in terms of areal extension and spectral albedo for different purposes (hydrological, remote sensing and chemical exchanges). The recent activity has been devoted to develop automated tools aimed to estimate the fraction of snow cover from cameras and the spectral albedo in the Vis-NIR wavelength range from custom albedometers. He is supporting the availability of this kind of information in different remote areas from automated stations located in Ny-Ålesund, Dome-C and Italian Alps. He is actually involved in the COST action ES1404, in the framework of the harmonisation task between different approaches aimed to estimate spectral albedo. He has collaboration with the Finnish Meteorological Institute aimed to develop a common platform for the study of snow cover from cameras.
Dr. Sabina Di Franco **CNR-IIA** **(Female)**	**Contributes to WP3 and WP5** • *Role in the Institution:* Scientist • *Main expertise:* knowledge organisation/geomorphology, • *Education:* M.SC degree in Earth Sciences • *Experience relating to the project:* She has key qualifications within knowledge organisation, including remote sensing and GIS. As semantic expert, she was involved in an ESA/ESRIN Project "Prod-trees" focused on developing an advanced platform that allows searching for Earth Observation products in two ways: a semantically enabled search and a multi-criteria search. Her field of action comprises also environmental assessment activities, with estimation and evaluation of short and long-term effects of a program or project on the quality of its location's environment. Her expertise includes using remotely sensed imagery in geomorphology and natural and anthropic risk studies.
Dr. Stefano Nativi **CNR-IIA** **(Male)**	**Leads Tasks 5.2 and 5.3** • *Role in the Institution:* Senior Scientist • *Experience relating to the project:* Has significantly contributed during the last 10 years to the design and development of international digital infrastructures for Earth Sciences, including: INSPIRE, GEOSS, Copernicus, and US NSF Earth Cube. His research activity deals with multidisciplinary interoperability, mediation and brokering technologies, Open and Big Data. He is national delegate to the Infrastructure Implementation Board of the Group on Earth Observation (GEO) for the Global Earth Observation System of Systems (GEOSS). He is a member of the Steering Committee of the "e-Infrastructure and Data

	Management" Collaborative Research Action (CRA) of the Belmont Forum. He is the Italian delegate for the SCAR (Scientific Committee on Antarctic Research) SC-ADM (Standing Committee on Antarctic Data Management). He scientifically coordinates the CNR working group for the Data Management of the National Antarctic Research Program (PNRA). He is in charge of the e-infrastructure design for the Italian Arctic Data Centre.
Dr. Paolo Mazzetti **CNR-IIA** **(Male)**	**Leads Task 5.4** • Role in the Institution: Senior Scientist • Main expertise: Research Infrastructure, Web services • Education: M.SC degree in Electronic Engineering • Experience relating to the project: Taught "Telematics" at the University of Florence at Prato for the degree in Information Engineering for seven years. He has more than fifteen years of experience in design and development of infrastructures and services for geo-spatial data sharing in the context of national, European (FP7, CIP, H2020) and global initiatives. He has been member of the GEO Institutions Development Implementation Board (IDIB). He participated in the E-Infrastructures and Data Management Collaborative Research Action of Belmont Forum. He is the Italian national representative in the Arctic Data Committee (ADC).
Dr. Warren RL Cairns **CNR-IDPA** **(Male)**	**Contributes to WP2** • *Role in the Institution:* researcher • *Main expertise*: Environmental Analytical Chemistry • *Education:* Ph.D Analytical Chemistry • *Experience relating to the project:* Chemist mainly involved in analysis of air, snow and other precipitation in the environment. His research activity also concerns analytical method development to determine trace elements and organic compounds in snow and ice samples using mass spectrometry techniques (ICP-MS, HPLC-MS/MS, GC-MS). He has participated in a scientific campaign in Antarctica and has been PI for one project and WP leader for another. He is also responsible for mercury in air analysis in the Alps (Dolomites) as part of GMOS.
Dr. Andrea Spolaor **CNR-IDPA** **(Male)**	**Contributes to WP2** • *Role in the Institution:* Researcher • *Main expertise:* Analytical chemistry and Glaciology • *Education:* Ph.D Polar Sciences • *Experience relating to the project:* Chemist and a glaciologist, he is mainly involved in the reconstruction of past climatic and environmental conditions based on the analysis of polar and Alpine ice cores. His research activity also concerns analytical method development to determine trace elements and organic compounds in snow and ice samples using mass spectrometry techniques (ICP-MS, HPLC-MS/MS, GC-MS). He has participated in several scientific campaigns in the polar regions (Antarctica and the Svalbard Islands) and the Alps (Monte Rosa, Monte Bianco and Dolomites).
M.Sc Clara Turetta **CNR-IDPA** **(Female)**	**Contributes to WP2** • *Role in the Institution:* Researcher • *Main expertise:* Geology, Analytical chemistry and Oceanography • *Education:* M.Sc Geology • *Experience relating to the project:*

	Geologist mainly involved in analysis of marine waters, snow and ice in the environment. Her research activity also concerns analytical method development to determine trace elements in snow and ice samples using mass spectrometry techniques (ICP-MS). She has participated in scientific campaigns in the Arctic and Antarctica and has been PI for projects in both environments.
Dr. Roberta Zangrando CNR-IDPA (Female)	**Contributes to WP2** • *Role in the Institution:* researcher • *Main expertise*: Environmental Analytical Chemistry • *Education:* Ph.D Analytical Chemistry • *Experience relating to the project:* A chemist mainly involved in analysis of air, snow and aerosol in the environment. Her research activity also concerns analytical method development to determine trace organic compounds in snow and ice samples using mass spectrometry techniques (HPLC-MS/MS, GC-MS). She has participated in a scientific campaign in Antarctica and in the Arctic and has been a component of many projects on polar areas.
Dr. Giulio Cozzi CNR-IDPA (Male)	**Contributes to sample analysis and data management WP2**
Dr. Fabiana Corami CNR-IDPA (Female)	**Contributes to sample analysis and data management WP2**
Massimiliano Vardé CNR-IDPA (Male)	**Contributes to sample analysis and data management WP2**
Dr. Angelo Lupi CNR-ISAC (Male)	**Contribute to WP 1 and WP4** • *Role in the Institution*: Researcher • *Main expertise:* radiative transfer processes and aerosol interaction with solar radiation • *Education:* PhD. In Polar Science • *Experience relating to the project:* His activities are focused on the study of the optical properties of the atmosphere, the interactions between ultraviolet radiation, visible and infrared with atmospheric constituents: his research interest have turned to the impact that aerosol, trace gases and cloud exert on the radiation balance of the Earth-Atmosphere system , focusing in particular on I) the assessment of the direct radiative effects produced by the aerosol and ii) the assessment of the radiation balance in polar areas. His scientific activity has been divided among experimental research (solar photometry, in situ aerosol optical measurements, radiation fluxes) and modelling using radiative transport codes for the evaluation of the radiative fluxes in the atmosphere. Over the past years he has participated at five Antarctic campaigns gaining experience in instrumentation and data analysis At present has Scientific Responsibility of the Baseline Surface Radiation Network (BSRN) site at the Italian-French Station Concordia.
Dr. Angelo Viola CNR-ISAC (Male)	**Contributes to WP1, WP5, WP6** • Role in the Institution: Senior Researcher • Main expertise: Atmospheric boundary layer • Education: M. SC degree in Physics • Experience relating to the project:

	Experienced acoustic remote sensing techniques (SODAR) to study of the thermodynamic processes in the atmospheric boundary layer; contributed to implement the SODAR to increase the vertical resolution and observe the fine turbulent structure of the atmospheric surface layer. The system has been used in several field campaigns in Antarctica. Since 2009 he is the scientific coordinator of the Amundsen - Nobile Climate Change Tower installed in Ny-Alesund (Svalbard). Since 2014 he is deputy coordinator of the Working Group of the arctic established within CNR-DTA to manage the Arctic station "Dirigibile Italia" and its scientific infrastructures. He coordinates the implementation of the digital infrastructure IADC (Italian Arctic Data Center) for Arctic data management. Since 2015 he is responsible of measurement and the instrumentation owned by KOPRI to measure concentrations and temporal variations of greenhouse gases (methane, water vapor and carbon dioxide) at the CCT. At the present time he is also the national representative in AMAP.

4.1.2.3 Relevant Projects

EuPolarNet

Client	Volume	Period
	0.17 M€ for CNR	1/3/2015-1/3/2020

Relevance to ICUPE

- **EU PolarNet** is a project to improve cooperation and planning of Polar research in the EU and so is directly relevant to iCUPE.

Description

Context & objectives

- **EU-PolarNet** will develop and deliver a strategic framework and mechanisms to prioritise science, optimise the use of polar infrastructure, and broker new partnerships that will lead to the co-design of polar research projects that deliver tangible benefits for society.
- Expected results are the development of integrated polar science programmes.
- Improvement of existing networks to coordinate data and infrastructure sharing between partner organisations.

SIOS PP

Client	Volume	Period
	0.36 M€ for CNR	2010-10-01 to 2014-09-30

Relevance to ICUPE

- **SIOS PP** project was to set up a multi-disciplinary research infrastructure covering all important elements of the coupled Earth System in the Arctic. The resulting "Svalbard Integrated Arctic Earth Observing System" (SIOS) Large infrastructure (currently included in the ESFRI roadmap) will be extensively used by iCUPE partners.

Description

Context & objectives

Environmental change and climate change in particular, are expected to be most pronounced in the polar regions. For this reason, a multi-disciplinary research infrastructure covering all important elements of the coupled Earth System in the Arctic is a very valuable tool to quantify the ongoing global change and to verify the capability of Earth System models to predict future changes. The proposed EFRI project ""Svalbard Integrated Arctic Earth Observing System"" (SIOS) is intended to take this role.

Results

- Move step forward establishment of a regional observational system for long-term measurements in and around Svalbard, addressing Earth system science questions related to global change. Identify weaknesses and a development plan for the observing system to adequate it to this scope.
- Develop the legal and governance structure, financial strategy, implementation plans for services and a data management system, scientific integration framework of the SIOS infrastructure. Services and central node for data system will be hosted in the Knowledge Center (KC) facilitity. KC will become pivotal (but not unique) also for networking and to formulate strategies for larger projects.
- The consortium also developed a preliminary SIOS data policy related to data management and utilisation. Contacts with satellite operators were established with the aim of integrating the satellite remote sensing sector into the SIOS Earth observation strategy.

STRRAP-b

Client	Volume	Period
PNRA	0.195 M€ for CNR	2013-2016

Relevance to ICUPE

- **STRRAP-b** project aimed to investigate spectral surface radiance in polar regions, develop relatively low-cost system for spectral measurements able to operate in the field in harsh environments, provide data set for improvement of satellite retrievals, directly providing methodologies and instruments/techniques to WP1 (task 1.1c) and WP3 (task 3.2) of iCUPE.

Description

Context & objectives

The project aims to deepen the knowledge of the Antarctic Plateau radiative regime and its regulating processes, through in situ radiometric measurements coupled with remote sensing techniques, using broadband and hyperspectral instrumentation. Information provided by the BSRN station and new instrument implementations were exploited to (i) calibrate/validate satellite retrieval products related to the surface reflectivity; (ii) define the configuration of parameterization of the SW and LW fluxes in clear sky conditions; (iii) extend spectral knowledge of the components of solar radiation and to verify the compatibility of spectral and satellite (MODIS, Landsat) broadband albedo derived by hyper- or multi-spectral ground measurements in the 350-1600 nm region.

Results

- evaluation of the effects of cloud cover, ozone and water vapor, and surface reflectance properties on the radiative balance over the East Antarctic Plateau, and DW and UW fluxes characterization for

different conditions of cloud coverage.
- validated measurements of the components of solar and infrared irradiance incident and reflected by the surface.
- surface albedo behaviour above the Antarctic Plateau during spring and summer months.
- A sledge equipped with a series of instruments to measure (during MODIS overpass): (1) Spectral Bi directional reflectance along both principal and perpendicular plane of reflection; (2) Broadband incoming and reflected irradiances (SW and LW); (3) Diffuse-ratio; (4) Albedo in 3 spectral bands (Vis, 1240nm, 1640nm); (5) Pan-Tilt (5 Hz); (6) Surface temperature anisotropy; (7) Surface roughness

PNRA16_00295 (2017-2019) "Bromine and mercury, cycles and transport processes on the Antarctic plateau"

Client	Volume	Period
PNRA	0.13 M€ for CNR	2017-2019

Relevance to ICUPE

- A project to investigate mercury cycles and halides transport at Concordia Station in Antarctica, an activity directly related to WP2 in iCUPE

Description

Context & objectives

The objectives are to build on the results of the previous project to investigate the role of halides in the mercury cycle on the Antarctic Plateau and their use as markers for sea ice extent.

Results

- Expected results will be:
- a transect of Hg, Br and I concentrations carried out during a re-supply traverse from the coast to the Antarctic inland.
- High temporal resolution analysis of snow pit and surface snow samples from Dome C station.
- Atmospheric mercury measurements at Dome C station synchronous with snow surface sampling

4.1.2.4 Relevant Publications

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2. Barbante C., Barnola J.-M., Becagli S., Beer J., Bigler M., et al. (EPICA Comm. Members). One-to-one coupling of glacial climate variability in Greenland and Antarctica. Nature, 444 (2006) 195-197. Jitaru P., Gabrielli P., Marteel A., Plane J.M.C., Planchon F., Gauchard P.-A., Ferrari C., Boutron C., Adams F., Hong S., Cescon P., Barbante C. Atmospheric depletion of mercury over Antarctica during glacial periods. Nature Geoscience, 3 (2009) 505-508.
3. Mazzola, M., Tampieri, F., Viola, A.P., Lanconelli, C. and Choi, T. (2016), Stable boundary layer vertical scales in the Arctic: observations and analyses at Ny-Ålesund, Svalbard. Q.J.R. Meteorol. Soc., 142, 1250-1258. doi:10.1002/qj.2727
4. Salzano R. Lanconelli C., Salvatori R., Esposito G., Vitale V. (2017) Continuous monitoring of spectral reflectance of snowed surfaces in Ny-Ålesund. Rendiconti Lincei, 27(1):137–146.
5. M. Mazzola, R.S. Stone, A. Herber, C. Tomasi, A. Lupi, V. Vitale, C.Lanconelli, C. Toledano, V.E. Cachorro, N.T. O'Neill, M. Shiobara, V. Aaltonen, K. Stebel, T. Zielinski, T. Petelski, J.P. Ortiz de Galisteo, B. Torres, A. Berjon, P. Goloub, Z. Li, L. Blarel, I. Abboud, E. Cuevas, M. Stock, K.-H. Schulz, A. Virkkula, (2012) Evaluation of sun photometer capabilities for retrievals of aerosol optical depth at high latitudes: The POLAR-AOD intercomparison campaigns, Atmospheric Environment, 52, June, pp.4-17, ISSN 1352-2310, http://doi.org/10.1016/j.atmosenv.2011.07.042.

4.1.2.5 Relevant Infrastructure

CNR maintain a research station in Ny-Ålesund, where research projects and continuous monitoring activities take place all over the year. "Dirigibile Italia", whose name recalls the 1928 expedition by Umberto Nobile, was open in 1997 as a multidisciplinary research station. Out of a surface of 330 square meters, 170 are office and labs space. The base is open all the year round, though it manned only while research activities are taking place. It can host up to seven researchers, working on: Atmospheric Chemistry & Physics; Marine Biology; Physics of the High Atmosphere; technological research, Geology and Geophysics; Glaciology, Nivology and permafrost; Paleoclimate; Oceanography/limnology; terrestrial Ecosystems; Environmental studies; Humane Biology and Medicine. Starting in 2009, three important multidisciplinary observation platforms have been added to the station: the Amundsen-Nobile Climate Change Tower (CCT), the aerosol and Gruvebadet interface processes lab (GVB) and a mooring (MD1) on the inside of the Kongsfjiorden.

4.1.2.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.3 Aarhus University (AU)

4.1.3.1 Organisation profile

Organisation Description
Aarhus University (AU) Aarhus University (AU) ranges among the top ten universities founded within the past 100 years and is currently number 73 on the shanghai ranking list. It educates 44,500 students and about 450 PhD students annually with 11,550 permanent staff. In 2015, the university posted a turnover of more than 830 million Euros. The university realized a profit of more than 23 million Euros. **Department of Environmental Science (ENVS)** Department of Environmental Science (ENVS) is under Faculty of Science and Technology at Aarhus University (AU). The Department of Environmental Science serves as independent scientific institution with a high research profile but additionally serving as national monitoring and otherwise fact finding institution. ENVS-AU is located in Roskilde, Denmark, and has an annual turnover of about 14 million Euros. ENVS-AU has a staff of about 130 people, of which about 60 work within atmospheric research, monitoring and advisory. **Advisory work (measurements)** ENVS-AU is the sole operator of the DK national air quality monitoring network, and responsible for managing the national air quality databases. ENVS-AU is accredited according to ISO 17025 for sampling & analysis of air pollution by DANAK. ENVS-AU is the national reference laboratory for air quality for the Danish Environmental Protection Agency (EPA), and national focal point for the European Environment Agency (EEA). ENVS-AU has extensive experience in organizing & running field experiments. ENVS-AU has been advisor for the Danish EPA with respect to air quality aspects and climate aspects for many years. **Advisory work (modelling)** In addition, AU-ENVS does develop and apply atmospheric chemistry-transport models, from hemispheric down to street scale, for hind-, now- & forecasting of air pollution. A unique expertise at ENVS-AU is the modelling of transport of air pollutants over the northern hemisphere with special focus on the Arctic area. The modelling is performed within the DEHM (Danish Hemispheric Eulerian Model) for assessment of air pollutant impacts on the environment. ENVS-AU is a partner of the Partnership for European Environmental Research (PEER), which has a strong background in policy oriented environmental and climate change research. ENVS-AU has been advisor for the EU Commission and the European Environment Agency (EEA) on various advisory projects. **ARC (Arctic Research Centre)** Many researchers within AU-ENVS are affiliated with the Arctic Research Centre (ARC) at Aarhus University. ARC is an interdisciplinary research centre that connects scientist within the Aarhus University and promotes interdisciplinary research. ARC bridges scientific objectives between the communities that carry out Arctic research across the continents as being a part of the Arctic Science Partnership (ASP). In addition to research, ARC does promote teaching on master and PHD level within areas that promote specific Arctic questions.
Role in ICUPE
AU will lead: • WP1 on Ground-based component for SLCFs AU will also contribute to**:** • WP0 on Management • WP2 on In-situ component of organic contaminants, mercury and other heavy metals • WP3 on Satellite remote sensing of Arctic surfaces • WP4 on Integrating in-situ, satellite and model components for improved environmental assessment

- WP5 on Data provision, interoperability and facilitation of data and services
- WP6 on Dissemination and strategic development

On the capabilities matching iCUPE tasks

The AU-ENVS group has experience in

- Leading research projects on national, Scandinavian, European and international level.
- Operating monitoring stations with a capacity to perform continuous and comprehensive long-term measurements for atmospheric observations even at extremely remote sites.
- Carrying out short-term observations within campaigns for observations of the atmospheric composition using highly dedicated equipment even in extremely remote (e.g. Arctic) areas.
- Performing hemispheric modeling and particularly on atmospheric air pollutants as BC, aerosols and gaseous short-lived climate pollutants.
- Advising the Danish and European ministry in questions related to air pollution and climate change.

4.1.3.2 Staff Profile and their roles in iCUPE

Prof. Andreas Massling (Male) AU	**(WP 1 leader) Contributes to field observations in the Arctic areas during intensive campaigns and for long time series on short-lived climate pollutants.** • Senior scientist; internationally recognized expert in aerosol physics with strong focus on atmospheric processes. The objectives of his studies comprise climate change topics and in recent years his studies were mostly related to the Arctic environment; his key expertises - investigation of physico-chemical aerosol properties, the understanding of haze and cloud processes and the role of atmospheric black carbon in the Arctic atmosphere; has been supervisor/co-supervisor of several PhDs, opponent for 2 PhD. theses, reviewer and co-editor for several scientific journals and member on different scientific boards; has published 62 peer-reviewed articles in Web of Science with about 1841 citations (1751 without self-citations) by 1278 citing articles (1245 without self-citations) and 29.69 citations per item resulting in an h-index of 27 by 2 Jan 2017; Management expertise: head of physics at Villum Research Station (VRS).
Prof. Henrik Skov (Male) AU	**(Head of Villum Research Station) Contributes to data analysis on overall particle and gas phase chemistry and interacts with the stakeholders.** • has lead several research projects within arctic atmospheric chemistry and he is leading the Danish monitoring in the Arctic atmosphere as the Danish contribution to AMAP; published a total of 91 (79 registered in Scopus) peer-reviewed articles with 2428 citations resulting in an h-index of 30; has been supervisor/co-supervisor and opponent of several Ph.D. students. He is reviewer and co-editor for several scientific journals and is a head or member on different scientific boards; Management expertise: head of Villum Research Station (VRS).
Dr. Jacob Klenø Nøjgaard (Male) AU	**Contributes to field data analysis from the Arctic campaigns and long-term monitoring data with respect to particle chemistry and source**

	apportionment. • senior scientist; atmospheric chemist with focus on atmospheric aerosols and their formation, transformation and sources; ambient, including Arctic processes, studies and source apportionment by application of mass spectrometry techniques and data analysis, including receptor modeling; supervisor for 2 PhD and 7 MSc students; opponent on 2 PhD theses, several bachelor/ master theses, appointed censor at the University of Copenhagen; has 34 peer-reviewed publications, 671 citations and H index 15; board member of the VRS in the high Arctic, and responsible for organic chemical analyses in the Air National Air Quality Monitoring Program in Denmark.
Dr. Jesper Christensen (Male) AU	**Contributes to hemispheric modelling of climate air pollutants with special focus on Arctic areas.** • senior scientist; key qualifications are atmospheric modelling, especially in development of chemical atmospheric transport models and weather forecast models and the application of models for air quality assessment; his research includes long range transport modelling of air pollution especially for the Arctic areas, intercontinental transport of pollution and weather and air pollution forecast modelling on local and regional scales. He has developed the air pollution model system, Danish Eulerian Hemispheric Model (DEHM), which is central in the international AMAP (Arctic Monitoring and Assessment Program) programme and in many of the atmospheric model activities at ENVS/AU; has been supervisor for 5 PhD, 6 MSc and 1 BSc students; has more than 100 international peer-reviewed publications on these and related topics; have been cited 3041 times per 21/4-2017 in Web of Science (>300 cit. in 2016); H-index is 33.
Dr. Rossana Bossi (Female) AU	**Contributes to field data analysis from the Arctic campaigns and long-term monitoring data with respect to gaseous pollutants (POPs, etc).** • Senior scientist; has more than 20 years of experience in analysis of organic compounds in environmental samples at trace levels; has been working with sampling and analysis of atmospheric samples from the Arctic in the past 10 years; has 72 peer-reviewed articles with an H-Index of 21 (Web of Science); Management expertise: member of daily management board of VRS.

4.1.3.3 Relevant Projects

METAPOL		
Client	**Volume**	**Period**
	35 k€ for AU-ENVS /year	2016- 2018
Relevance to iCUPE		
METAPOL "Meteorological and pollutant observations in the high Arctic (METAPOL)" project outcome		

will be first estimates on overall absorbing and scattering potential of observed aerosol population at Villum Research Station (VRS) which is highly influenced by anthropogenic contributions during the Arctic haze period in the high Arctic. The results will significantly contribute to the understanding of the dynamics and thus identify the controls on the temperature profiles in air. Specifically, we will determine the surface energy budget and assess its various forcing components such as aerosols, clouds and surface properties. Data will be put into context with other Arctic stations (Zackenberg, Alert, Ny Ålesund) to get an advanced understanding of the spatial distribution of these climate-relevant parameters. Aerosols are short-lived climate pollutants and their impacts are thus of major interest within iCUPE.

Description

METAPOL project aims at receiving a dataset that is needed to make estimates on the direct aerosol effect of Arctic aerosols on regional climate. Collected data (short-wave and long-wave, UV radiation) from the meteorological tower at Villum Research Station will be evaluated together with a dataset of aerosol population and aerosol optics. The data will be linked allowing estimates of the direct aerosol effect.

CLIF

Client	Volume	Period
	90 k€ / year for AU-ENVS	2014-2017

Relevance to ICUPE

CLIF "Climate Forcers in the high Arctic (CLIF)" project provides time series of concentrations of selected species as pollutants in air and in snow based on existing measurements and through the continuation of these measurements at Villum Research station (VRS). The existing results will be interpreted using e.g. computer simulations based on a hemispheric chemistry transport model (DEHM) that covers the Northern Hemisphere. This will provide insight into mechanisms and feedbacks of transport and surface fluxes as well as on the interaction between species in the high Arctic under changing conditions due to the accelerating climate change which is of high relevance to iCUPE. In this way unique knowledge will be obtained that can be used in the prediction of future climate and how climate will affect the Arctic environment. In addition - besides measurements in the atmosphere - samples of surface snow will be analysed for the content of Elemental Carbon and Organic carbon (EC and OC) as EC and OC in snow have important climate properties as well.

Description

CLIF project aims to obtain information about the concentrations, lifetimes, fate and dynamics of a series of species in the Arctic atmosphere that have direct or indirect climate forcing properties and where Arctic processes are central for the global climate. Concentrations of the most important greenhouse species as methane, carbon dioxide, ozone, BC and particles are measured. These compounds are central for understanding present and future climate forcing and feedbacks.

Proposal Acronym | iCUPE

AMAP

Client	Volume	Period
	300 k€ / year for AU-ENVS	2017-2018

Relevance to ICUPE

AU is responsible for the Danish contribution to the part of the "Arctic Monitoring and Assessment Program (**AMAP**)" dealing with contaminants in the atmosphere. Attention towards the effect of international pollutant regulations has high priority, as well as the identification of emerging pollutant issues in the Arctic. Focus is also on short-lived climate forcers as aerosols and black carbon which is highly synergetic with the iCUPE objectives.

Description

AMAP project aims to continue the monitoring of contaminants in the atmosphere in Greenland to detect temporal and geographical changes and to understand the mechanisms behind them especially those related to climate and to changes in sources and source regions.

EVAM-SLCF (continuation of CLIFF: project proposal under review)

Client	Volume	Period
	90 k€ / year for AU-ENVS	2017-2020

Relevance to ICUPE

EVAM-SLCF "Evaluation of existing measurements in 2015 and 2016 and new measurements of short-lived greenhouse forcers in 2017 and 2018 (EVAM-SLCF)" project is a continuation of the CLIF project. Basically, obtained data in the CLIF project will be further processed and analyzed with respect to air as well as to snow sampling. Additionally, data on the vertical profile of particles and halogen species in the atmosphere and other key substances using drones and remote sensors will be obtained which is in line with iCUPE objectives. Measurements determining particle size distribution, absorption and scattering coefficients of the ambient aerosol population will be continued for further improvement of chemical transport models like DEHM and subsequently ESM models to estimate the climate forcing in the Arctic.

Description

EVAM-SLCF project objectives are in line with previous CLIF project as measurements are continued and new information is gained on short-lived climate pollutants with respect to their direct and indirect effects on the Arctic climate. Also, vertical information on some climate-relevant parameters will be obtained.

4.1.3.4 Relevant Publications

1.	Nguyen, Q. T., Glasius, M., Sørensen, L. L., Jensen, B., Skov,' H., Birmili, W., Wiedensohler, A., Kristensson, A., Nøjgaard, J. K., Massling, A. (2016) Seasonal variation of atmospheric particle number concentrations, new particle formation and atmospheric oxidation capacity at the high Arctic site Villum Research Station, Station, Atmos. Chem. and Phys., 16, 11319 -11336.
2.	Uttal, T., Starkweather, S., Drummond, J., Vihma, T., Cox, C. J., Dlugokencky, E., Ogren, J., McArthur, B., Schmeisser, L., Walden, V., Laurila, T., Darby, L., Makshtas, A. P., Intrieri, J., Burkhart, J., Haiden, T., Goodison, B., Maturilli, M., Shupe, M., de Boer, G., Stone, R., Saha, A., Grachev, A., Bruhwiler, L., Persson, O., Lesins, G., Crepinsek, S., Long, C., Sharma, S., Massling, A., Turner, D. D., Stanitski, D., Asmi, E., Aurela, M., Skov, H., Eleftheriadis, K., Virkkula, A., Platt, A., Forland, E., Verlinde, J., Yoshihiroo, I., Nielsen, I. E., Bergin, M., Candlish, L., Zimov, N., Zimov, S., O'Neil, N., Fogal, P., Kivi, R., Konopleva, E., Kustov, V., Vasel, B., Viisanen, Y., Ivakhov, V. (2016) International Arctic Systems for Observing the Atmosphere (IASOA): An International Polar Year Legacy Consortium, Bulletin of the American Meteorological Society, 97 (6), 1033-1056.
3.	Eckhardt, S., Quennehen, B., Olivie, D., Berntsen, T., Cherian, R., Collins, W., Christensen, J. H., Daskalakis , N., Flanner, M., Herber, A., Heyes, C., Hodnebrog, Ø., Jiao, C., Kanakidou, M., Klimont, Z., Langer, J., Law, K., Massling, A., Myhre, G., Myriokefalitakis, S., Quaas, J., Quinn, P., Raut, J.-C., Rumbold, S., Sharma, S., Samset, B., Schulz, M., Skeie, R., Tunved, P., von Salzen, K., Stohl, A. (2015) Large improvements in model capabilities to simulate black carbon and sulfate concentrations in the Arctic atmosphere: a multi-model evaluation using a comprehensive measurement data set, Atmos. Chem. and Phys., 15 (16), 9413-9433.
4.	Massling, A., Nielsen, I. E., Kristensen, D., Christensen, J. H., Sørensen, L. L., Jensen, B., Nguyen, Q. T., Nøjgaard, J. K., Glasius, M., Skov, H., (2014) Atmospheric black carbon and sulfate concentrations in Northeast Greenland, Atmos. Chem. and Phys., 15 (16), 9681-9692.
5.	Nguyen, Q., Kristensen, T. B., Hansen, A. M. K., Skov, H., Bossi, R., Massling, A., Sørensen, L.-L., Bilde, M., Glasius, M., Nøjgaard, J. K. (2014) Characterization of humic-like substances in Arctic aerosols, J. of Geophys. Res., 119 (8), 5011-5027.
6.	Fenger, M., Sørensen, L. L., Kristensen, K., Jensen, J., Nquyen, Q., Nøjgaard, J. K., Massling, A., Skov, H., Glasius, M. (2013) Sources of anions in aerosols in northeast Greenland during late winter, Atmos. Chem. and Phys. 13 (3), 1569-1578.

4.1.3.5 Relevant Infrastructure

Villum Research Station (VRS)

The Department of Environmental Science at Aarhus University is operating the newly established high Arctic Villum Research Station (VRS) at Station Nord (SN) in North Greenland (81o 36' N, 16o 40' W at 6 m ASL). The station has recently been renewed via a project grant of about 9.5 million € including new facilities and instruments. The instruments applied in this project are financed within this grant. The given infrastructure is a key parameter in this project as the harsh climatic conditions in the high Arctic impose large difficulties for successful field studies. VRS is the second-most northern, year-round manned atmospheric observatory in the world. The station is base for multidisciplinary research including all aspects of natural sciences and hosts scientists from all over the world since 2013. At VRS AU-ENVS is the sole operator of the basic measurements for atmospheric research including the chemical and physical state of aerosols and gasses and the analysis of meteorological parameters in the high Arctic. The station has an annual turnover of about 400 k€ for handling logistics.

4.1.3.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

Proposal Acronym | iCUPE

4.1.4 Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI)

4.1.4.1 Organisation Profile

Organisation Description

The Alfred-Wegener-Institute Helmholtz-Centre for Polar and Marine Research (AWI) is one of the internationally leading institutions for research in polar regions and oceans of temperate and high latitudes. The institute works bipolar and fosters interdisciplinary research in three divisions (Climate Science, Geoscience and Bioscience). It coordinates and provides infrastructure for polar research for all German scientists and international cooperation. The institute is based in Bremerhaven, Potsdam, Helgoland and Sylt, and operates polar stations in Antarctica and Spitsbergen. AWI is a Foundation of Public Law.

The main focus of research is to understand the changes and driving forces of the Arctic and Antarctic system with particular emphasis on climate change issues. It considers the impact of a warming world on the polar regions and feedbacks to the global climate. In the North Sea climatic and anthropogenic impacts are studied as driving force for ecosystem change.

Strength of AWI is the excellent infrastructure for observing the ocean and the polar regions including stations, ships and airplanes. Advanced laboratory equipment is available for high precision analysis of ice cores, sediment cores and biological samples Long term observations are maintained at the polar stations on Spitsbergen (AWIPEV base with atmospheric, permafrost and underwater observatories), in the Fram Strait (oceanography and biology) and in Antarctica (Neumayer station III with meteorological, geophysical and air chemistry observatories) as well as in the Weddell Sea (oceanography).

AWI has a leading role in large national and international research projects, e.g. as the coordinator of EPICA (European Polar Ice Coring in Antarctica), a joint European Science Foundation and European Commission (EC) scientific programme, funded by the EC and by national contributions from 10 countries. Overall, the AWI is involved in international projects since more than 25 years and participated in numerous European FP5, FP6 and FP7 projects and other international collaborations.

Role in ICUPE

AWI will lead:

- WP3 on Satellite remote sensing of Arctic surfaces
- Task 3.3 on Radar satellite remote sensing

AWI will also contribute to:

- WP0 on Management; Ground-based component for SLCFs
- WP3 on Task 3.4 on the strategic development of comprehensive EO in the Polar Areas
- WP5 on Data provision, interoperability and facilitation of data and services
- WP6 on Dissemination and strategic development

On the capabilities matching iCUPE tasks

The AWI group has experience in

- Leading the Topic Cryosphere (glaciology, sea ice and permafrost) in the Helmholtz Alliance Remote Sensing and Earth System Dynamics, a national radar remote sensing initiative
- Leading international cal/val activities for satellite missions (CryoVex)
- Conducting and leading field expeditions and airborne campaigns investigating the dynamics of ice sheets, glaciers and ice shelves in Greenland and Antarctica for retrieving in-situ data for validating satellite observations, for obtaining key glaciological variables for quantifying changes in polar ice sheets and to understand the driving mechanisms
- Development of entire processing chains for satellite remote sensing data, e.g. CryoSat-2 ice volume changes from the level of waveform tracking to the final product of mass loss of Greenland
- Combining satellite remote sensing radar data with ground penetrating radar and modeling to

identify origins of surface structures retrieved in satellites
- participating in the core team national satellite mission application for Tandem-L, a full polarimetric L-band SAR mission in high resolution including products and representing the cryosphere part of this application
- expertise in ice modeling and using satellite remote sensing data products for data assimilation in ice sheet models

4.1.4.2 Staff Profile and their roles in iCUPE:

Prof. Angelika Humbert (Female) AWI	**WP3 leader** • Scientific expertise: over 15 years of research experience in glaciology, in particular ice modeling and remote sensing: radar remote sensing of ice shelf break-up events, calving, crevasse and crack evolution, structural glaciology using radar remote sensing and ground penetrating radar, supraglacial lake development and meltchannel evolution, mass balance of ice sheets using altimetry; modeling of ice shelves, ice sheets and large outlet glaciers using multi-scale hybrid-physics approach in finite elements, subglacial hydrology modeling , fracture mechanical modeling and modeling of calving processes • PI of HGF-EDA Cryosphere (radar remote sensing), BMBF SR1.5 EP-GrIS (projections Greenland), BMBF GROCE-DAVE (modeling grounding line dynamics), DFG SPP1158 Calving of ice shelves, FISP (Filchner Ice Shelf Project), iGRIFF (79°N Glacier project) and LSAR79NG, LSAR-RECISL two airborne campaigns (DLR's L-band SAR system onboard AWI's aircraft 79°N Glacier and Recovery Glacier) • Professor for ice modeling University of Bremen • Managerial expertise: head of glaciology section, head of ice modeling group, head of glaciology remote sensing group
Dr. Veit Helm (Male) AWI	**Contributions to data analysis** • Scientific expertise: altimetry of ice sheets including all satellite borne altimeters (ERS, ENVISAT, ICESat, CryoSat-2), laser scanner analysis, airborne radar data analysis (snow radar, ground penetrating radar and ultrawideband radat), SAR processing of satellite and airborne radar data over ice sheets, interferometry of ice sheets using TerraSAR-X, Sentinel1A • PI of several data proposals TanDEM-X • Member of esa CryoSat quality group; since 2004 member of the CryoSat Validation Retrieval Team (CVRT). CVRT was initiated by ESA for the purpose of the calibration and validation of CryoSat using ground truthing. Selected validation sites in the Arctic and Antarctica were visited by scientists of the CVRT doing coordinated airborne surveys and glaciological fieldwork on ground. Veit Helm conducted several CryoVEx-campaigns in both Hemispheres during the last couple years. He was and still is responsible for the processing of the ASIRAS data acquired during the CryoVEx campaigns. ASIRAS (Airborne SAR Interferometric Altimeter System) is the airborne counterpart of the SIRAL instrument on-board of CryoSat-2. To validate the ESA ASIRAS SAR processor Veit Helm developed an independent SAR processor that improved the quality and reliability of the CryoVEx data sets used for the purpose of CryoSat validation. • Managerial expertise: expedition leader of various airborne campaigns

Dr. Niklas Neckel (Male) AWI	**Contributions to data analysis** • Scientific expertise: SAR remote sensing of ice sheets, ice shelves and glaciers, ICESat altimetry of mountain glaciers, geospatial analysis • PI of ongoing TanDEM-X data proposals ATI_GLAC7208 and DEM_GLAC1608 • Reviewer of several scientific journals including Remote Sensing of Environment, Journal of Glaciology, Remote Sensing, ISPRS Journal of Photogrammetry and Remote Sensing

4.1.4.3 Relevant Projects

HGF-EDA Remote Sensing and Earth System Dynamics

Client	Volume	Period
	20M€, 830k€ for AWI	2012-2017

Relevance to iCUPE

• Radar remote sensing cutting edge topics ranging from snow density profiles, over polarimetry to structural glaciology, investigating ice surface structures is a valuable input to WP3.

Description

Context & objectives

The HGF Alliance "Remote Sensing and Earth System Dynamics" (EDA) aims at the development and evaluation of novel bio/geo-physical information products derived from data acquired by a new generation of remote sensing satellites; and their integration in Earth system models for improving understanding and modelling ability of global environmental processes and ecosystem change. The Earth system comprises a multitude of processes that are intimately meshed through complex interactions. In times of accelerated global change, the understanding and quantification of these processes is of primary importance.

The key objective of the proposed Alliance is to prepare the HGF centers and the national/international science community for the utilisation and integration of bio/geo-physical products provided by the next generation radar remote sensing missions (e.g. Tandem-L) into the study of natural and anthropogenic impact on Earth's ecosystems by:

- developing new bio/geo-physical information products from remote sensing data;
- integrating the new products into Earth system models;
- improving the understanding and modelling of dynamic processes;
- providing a unique forum for the education of a new generation of scientists.

This is a unique opportunity to exploit and widen the expertise of all participating centres and to maximise their role and contribution in the international environmental change science. The Alliance has the potential to change the way ecosystem change is addressed today and this is the reason why it becomes essential and indispensable.

4.1.4.4 Relevant Publications

1. V. Helm, A. Humbert, and H. Miller. 'Elevation and elevation change of Greenland and Antarctica derived from CryoSat-2' The Cryosphere, 8, 1539–1559, 2014, doi:10.5194/tc-8-1539-2014
2. Neckel, N., Loibl, D., Rankl, M.. Recent slowdown and thinning of debris-covered glaciers in south-eastern Tibet, Earth and Planetary Science Letters, Vol 464, 2017, 10.1016/j.epsl.2017.02.008.
3. Overly T. B. , Hawley, R. L. , Helm V. , Morris, E. M. and Chaudhary, R. N. (2016): Greenland annual accumulation along the EGIG line, 1959-2004, from ASIRAS airborne radar and neutron-probe density measurements , The Cryosphere, 10 (4), pp. 1679-1694; doi: 10.5194/tc-10-1679-2016.
4. Rankl, M., Fürst, J. J., Humbert, A., and Braun, M. H.: Dynamic changes on the Wilkins Ice Shelf during the 2006–2009 retreat derived from satellite observations, The Cryosphere, 11, 1199-1211, doi:10.5194/tc-11-1199-2017, 2017.
5. Wouters, B. , Martin-Español, A. , Helm, V. , Flament, T. , van Wessem, J. M. , Ligtenberg, S. R. M. , van den Broeke, M. R. and Bamber, J. L. (2015): Dynamic thinning of glaciers on the Southern Antarctic Peninsula , Science, 348 (6237), pp. 899-903 . doi: 10.1126/science.aaa5727

4.1.4.5 Relevant Infrastructure

AWI operates two polar aircrafts with a wide field of instruments in the Arctic and Antarctic. Among the instruments are several radars, mainly ground penetrating radars, laser scanners, hyperspectral cameras and EM-birds. Recently AWI got new ultra-wide band radar (UWB) a multi-channel radar that allows to resolve the structures within ice sheets down to the base in high resolution. For radar remote sensing approaches also the snow radar with a high resolution in the upper few metres of the ice sheets is relevant. Of particular relevance for this iCUPE are also two airborne campaign applications, in which DLR's L-band SAR system will be installed on AWI's aircraft and for the first time used to study the L-band retrieval similar to the future Tandem-L mission over two glaciers with various very specific structures (surface melt ponds, crevasse fields, subglacial water – warm & wet and cold & dry glacier types), while having for the exactly same locations also high resolution ground penetrating radar with AWI's UWB, allowing to compare the internal structure obtained using SAR tomography as the future Tandem-L mission with the high-resolution multichannel SAR.

The AWI-ICE-CT facility is operating a large-scale X-ray microfocus-computer tomograph especially designed for snow and ice core applications. It provides the ice core research community with spatially high-resolved density profiles of firn cores and allows for a detailed description of the three-dimensional microstructure of firn and snow. The CT measurements are non-destructive and can be performed on various spatial resolution of 15-100 µm over whole ice core segments and core lengths. In combination with new snow sampling techniques using carbon-fiber tubes it gives the opportunity to capture the geometrical status of near-surface snow and their evolution with time.

AWI operates jointly together with the French Polar Institute the Arctic Research Base AWIPEV in Ny-Ålesund on Spitsbergen. AWIPEV Base has a long record of ground truthing observations for satellite CAL/VAL exercises, building on the observatories installed there. They include a WMO / GAW Baseline Surface Radiation Network (BSRN) Station, an observatory for the Network for the Detection of Atmospheric Composition Change (NDACC), as well as a permafrost observatory, which also has been used for interpreting earth observing systems. The comprehensive and state-of-the-art instrument suite of co-located remote sensing and in-situ instruments at this base in Ny-Ålesund, Svalbard, possesses a unique potential for deriving a whole suite of essential Arctic climate variables. This allows characterizing the properties and physical processes within the atmospheric column and into the soil in a comprehensive way. The measurements reach from below the surface, through the boundary layer, troposphere into the stratosphere and lower mesosphere, including basic meteorology, temperature, humidity, aerosols, clouds and trace gases, as well as soil temperature and moisture and their fluxes between soil and atmosphere.

AWI also operates the research icebreaker 'Polarstern', which allows year-round operation in the ice-covered waters. The AWI department of Climate System involved here investigates the interaction of polar atmosphere, ice and ocean to obtain a better understanding of the relevance of Polar Regions for climate. Both extensive field and modelling work is carried out. During 25 years, scientists and technicians

of the section Observational Oceanography have established a world leading role in observational polar oceanography and have implemented key observing systems in the Arctic and the Antarctic oceans. AWI has excellent facilities and a long experience in operating moored observatories both in the Arctic and Antarctic as well as in the application of various autonomous platforms including floats, gliders and ice tethered observatories. Since 1997 AWI has been operating the moored array in Fram Strait and since 2008 gliders have been included in the Fram Strait Observatory.
AWI is leading the MOSAiC project, which will be a Multidisciplinary drifting Observatory for the Study of Arctic Climate will be the first year-round expedition into the central Arctic exploring the Arctic climate system. The project with a total budget exceeding 60 Million € has been designed by an international consortium of leading polar research institutions, under the umbrella of the International Arctic Science Committee (IASC), led by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), Arctic and Antarctic Research Institute (AARI) and the University of Colorado, Cooperative Institute for Research in Environmental Sciences (CIRES).

4.1.4.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.5 Centre National de la Recherche Scientifique (CNRS)

4.1.5.1 Organisation Profile

Organisation Description

The Centre National de la Recherche Scientifique (**CNRS**) is a government- funded research organization, under the administrative authority of France's Ministry of Research. With more than 32.000 employees (researchers, engineers, technicians and administrative staff), a budget of 3 billion euros, the CNRS is active in all fields of knowledge, drawing on more than 1200 research joint units.
CNRS will participate with four institutes: **CNRS-IGE** (Institut des Géosciences de l'Environnement in Grenoble), **CNRS-LATMOS** (Laboratoire Atmosphères, Milieux, Observations Spatiales), **CNRS-LSCE** (Laboratoire des Sciences du Climat et de l'Environnement) and **CNRS-GET** (Géosciences Environnement Toulouse).
CNRS-IGE (240 persons, joint research unit Univ Grenoble Alpes/IRD/G-INP) conducts research on climate, the water cycle, cryosphere and natural and anthropized environments. This research aims to better understand the processes that govern the various geophysical compartments (ocean, atmosphere physics and chemistry, cryosphere, watersheds, critical zone), their interactions and responses to human pressures, and the processes of adaptation and resilience of societies. Their research is developed within the framework of international scientific programs (CLIVAR, CLIC, CORDEX, GEWEX, Future Earth) and contribute to the expertise needed for IPCC reporting activities (several IGE members regularly contribute to IPCC reports). IGE is directly involved in several large-scale European or international initiatives (LTER / LTSER, ACTRIS, ENVRI +) aimed at networking observation data. An important strength of IGE is its ability to collect data in extreme environments (in Polar Regions for instance).
CNRS- LATMOS (https://www.latmos.ipsl.fr/) is a leading European research institution involved in field measurements, instrument development, satellite observations, and modeling (150 permanent researchers, 230 people total). LATMOS has expertise in Arctic Pollution and atmospheric chemistry including coordinating large international projects, including IPY POLARCAT. Members of LATMOS specialize in developing/using models to describe trace gas and aerosols in the Arctic. CNRS-LATMOS is part of past/ongoing EU projects including ACCESS and ICE-ARC and leads French Arctic projects including PARCS (Pollution in the Arctic System). Work contributes to ongoing Arctic assessments lead by AMAP and research contributes directly to Future Earth through IGAC (PACES and CATCH) and IASC (PACES).
CNRS-GET (http://www.get.obs-mip.fr/) is one of the top European research and training centers, with 110 faculty members and over 100 PHD and post-doctoral researchers in fields ranging from experimental biogeochemistry, isotope geochemistry to geodynamics and nanomaterials. CNRS-GET hosts a dedicated Hg research platform that has over 20 years of experience in Hg analysis of atmospheric, aquatic, geological and biological specimens. CNRS-GET has provided unique observations of atmospheric Hg speciation to GMOS, from the Pic du Midi Observatory, a high altitude (2877m) atmospheric chemistry facility dedicated to monitoring and R&D on trace gases and aerosols. CNRS-GET has also coordinated recent ERC StG and PoC on atmospheric Hg cycling, and H2020 MSCN, and French ANR projects on polar Hg science, including contributions to the GEOTRACES programme.
CNRS-LSCE (Laboratoire des Sciences du Climat et de l'Environnement, Climate and environmental science laboratory) is a joint research unit of CEA (French Atomic Energy Commissiopn), CNRS, and UVSQ (Université de Versailles St Quentin). LSCE brings expertise in atmospheric composition monitoring, development and operation of sensor systems at locations worldwide related databases. LSCE has actively participated in a large number of EU funded projects including GHG-EUROPE-IP, MACC, MACC-II, -III and InGOS. It coordinated ICOS-PP, the Preparatory Phase of the ICOS European research infrastructure for carbon observation, with a coordination role in legal and governance affairs, as well as in defining the standard atmospheric measurements protocols jointly with the community. LSCE has been in charge of maintaining a near real time data collection system across Europe with sustained adhesion of the scientific community, enabling downstream operational usage within Copernicus. LSCE coordinated ICOS-INWIRE, supporting the development of new solutions for robust, cost-effective sensor systems

enabling seamless data provision for Copernicus atmospheric and land services. LSCE is currently a leading component of the ICOS European Research Infrastructure, operating the Atmospheric Thematic Center, and a key contractor in the Copernicus Atmospheric Monitoring Services for greenhouse gases (CAMS-84, CAMS-47, CAMS-73) led by ECMWF.

Role in ICUPE

CNRS will lead:

- WP4 on Integrating in-situ, satellite and model components for improved environmental assessment

CNRS will also contribute to**:**

- WP0 on Management
- WP1 on Ground-based component for SLCFs (through interactions with planned intensive observations: YAK and contributions to discussions on plans for international field activities focusing on improved knowledge about natural cycles (CATCH) and anthropogenic pollution (PACES))
- WP2 on In-situ component for organic contaminants, mercury and other heavy metals (mercury monitoring and evaluation of the Hg life cycle, regional modeling of ozone/halogen and its influence on arctic chemistry)
- WP5 Data provision, interoperability and facilitation of data and services (data and product provision to horizontal ERAPLANET activities)
- WP6 on Dissemination and strategic development (through synergy with EU programs and international initiatives (PACES, CATCH), dissemination)

On the capabilities matching iCUPE tasks

The CNRS group has experience in

- Participation in field campaigns and continuous observations of the atmospheric composition in the Arctic, including airborne campaigns Svalbard, Greenland, Russian Arctic and Antarctica.
- Developing and testing new observations of contaminants
- Regional modeling of atmospheric chemistry and aerosols
- Management of monitoring infrastructures
- Analysis of satellite, aircraft and ground-based data
- Coordination of European programs and international initiatives on polar regions
- Expertise on atmospheric chemistry, transport of pollutant, pollutant processing in polar regions

4.1.5.2 Staff Profile and their roles in iCUPE:

Dr. Kathy Law (Female) CNRS-LATMOS	**Contributing to WP4 (co-lead) on joint analysis of aircraft and satellite data combined with regional chemical-aerosol modeling (WP4) and liaison to PACES activities (WP1, 6).** CNRS director of research at LATMOS; was co-chair of the POLARCAT-IPY project and is currently co-chair on PACES - international Arctic air pollution initiative (IASC/IGAC) [2015-]; was co-President of the *Chantier Arctique* Scientific Committee and French member of the Arctic Council AMAP Expert Group on Black Carbon and Ozone; was vice-chair of the IASC Atmosphere WG (IASC) [2011-16]; coordinates the French CNRS project PARCS (Pollution in the Arctic System) and PI on current EU project ICE-ARC (Ice, Climate, Economics – Arctic Research on Change) and recent EU projects ACCESS and ECLIPSE; has more than 100 publications.

Dr. Jean-Christophe Raut (Male) CNRS-ATMOS	**Contributes to WP2** joined LATMOS (Laboratoire Atmosphères, Milieux, Observations Spatiales) as assistant professor at UPMC in 2009; participated to the validation of the space-borne CALIOP lidar on CALIPSO satellite. His current research focuses on the understanding of key processes related to aerosols in the Arctic region (transport and processing, ageing, deposition processes, interaction with clouds, radiative impacts) through a synergy between modeling (WRF-Chem mesoscale online transport chemistry model) and observations (ANR-CLIMSLIP, EU-ACCESS, EU-ECLIPSE, EU-ICE-ARC, PARCS).
Dr. Jacques Pelon (Male) CNRS-ATMOS	**Contributes to WP2** Director of Research at CNRS working at LATMOS; works on cloud and aerosol radiative properties and interactions in the Arctic with a focus on aerosol sources and transport. He is developing new data products from the CALIPSO mission (satellite measurements of aerosols and clouds) in the Arctic region. He is also the co-coordinator of the IAOOS-EQUIPEX project and responsible for the development of the atmospheric portion of the IAOOS Arctic observation system.
Dr. Gérard Ancellet (Male) CNRS-ATMOS	**Contributes to WP4** on analysis of aircraft data from the YAK project and aerosol satellite data, in particular from CALIOP using, for example, air mass origin tools such as FLEXPART**.** He is a CNRS Director of Research working at LATMOS; has more than 30 year experience in atmospheric science working on lidar remote sensing, airborne data analysis, campaigns related to Stratosphere/Troposphere Exchange, urban pollution and long-range transport (e.g. co-lead of French projects POLARCAT and CLIMSLIP) and is author of more than 100 peer-reviewed scientific papers.
Tatuso Onishi (Male) CNRS-ATMOS	**Contributes to WP2** received Ph.D. in 2002 from the Department of Aeronautics and Astronautics of Massachusetts Institute of Technology, he worked as a post-doctoral fellow in the Department of Applied Aerodynamics of ONERA (Office National d'Etudes et de Recherches Aérospatiales) from 2003 to 2005. Since 2005, he has been a research engineer at LATMOS; provides research and technical support for the regional modelling at LATMOS.
Eng. Ariane Bazereau (Female) CNRS-ATMOS	**Contributes to WP4** on analysis of satellite data, in particular retrievals of aerosol profiles and cloud information from the CALIOP instrument; research engineer at LATMOS
Jean-Daniel Paris (Male) CNRS	**WP4 co-leader, contributes to WP1** He received his PhD from UVSQ in 2008 on greenhouse gases observations. His research interests are focusing on the carbon cycle and atmospheric composition; co-author of 28 peer-reviewed publications (h=11); participated to the GEO CL-02 Carbon task and is a contributing author to the GEO Carbon Strategy Report 2010. He leads a team of 18 scientists and engineers dedicated to greenhouse gas research. He has been from 2007 to 2015 the coordinator of the French-Russian YAK-AEROSIB atmospheric research program, and has been chief field scientist for 4 multi-instrumented large aircraft campaigns. With the ICOS research infrastructure (Integrated Carbon Observing System) he has been in charge among other, of liaison to GEO and Copernicus during the ICOS Preparatory Phase (FP7, 2008-2012). He coordinated the EU FP7 project ICOS-INWIRE (2012-2016, 9 partners, 2M€), researching solutions for

	robust data streams from sensors on the field to databases to Copernicus and GEOSS users for ICOS. He leads the Technology theme (4 WPs) of ENVRIplus (2015-2019), dedicated to the development of new, common approaches in the operations of research infrastructures and maximizing joint science applications. Dr Paris is an invited expert to the Belmont Forum e-infrastructures and data management initiative, and a CEA representative in the national operational structure for Earth observation data management (French 'interpoles'). He is involved in CAMS-84, supporting the validation of operational atmospheric CO2 and CH4 forecast validation from in situ measurements for Copernicus. He teaches a carbon cycle lecture at the International Arctic Master programme of UVSQ.
Dr. Jennie Thomas (Female) CNRS	**Contributes to WP1, WP2 and WP6** CNRS researcher. Her research focuses on studying Arctic tropospheric chemistry, including natural cycles and anthropogenic pollution. She has experience developing and using models (0D, 1D, and 3D) to study Arctic tropospheric chemistry including processes occurring on snow and ice. Recent studies included quantifying ozone import into the Arctic troposphere during POLARCAT (IPY) using the regional model WRF-Chem. She participated actively in ACCESS aircraft campaign, aimed at quantifying local pollution sources in the Arctic (northern Norway) during summer 2012. She works on Arctic regional modeling as part of EU-ICE-ARC project. Most recently, she participated in the NETCARE aircraft campaign (Resolute Bay, Canada/July 2014); leading a new international initiative on chemical processes in cold regions, including the Arctic (CATCH).
Ass. Prof. Aurélien Dommergue (Male) CNRS-IGE	**Contributes to WP2** leads the group of atmospheric research at the University of Grenoble Alps; developed research on atmospheric mercury exploring the most remote places on Earth for atmospheric monitoring (polar regions, high altitude sites) and he has published 50 papers on this topic. He led multiple projects at the national and international level and contributed to UNEP and AMAP reports.
Dr. Jeroen Sonke (Male) CNRS-GET	**Contributes to WP2** Research Director at CNRS-GET and the University of Toulouse, where he leads the stable isotope geochemistry group. He recently coordinated four polar mercury science studies, including the ERC Starting Grant "Mercury Isotopes"; his group regularly leads high profile studies on mercury science.
Eng. Laure Laffont (Female) CNRS-GET	**Contributes to WP2** Engineer at CNRS-GET and the University of Toulouse, where she supervises the Mercury Laboratories. She will coordinate laboratory management, maintenance, training and use for all mercury concentration analyses.

4.1.5.3 Relevant Projects

- **StG: FP7: ERC StG MERCURY ISOTOPES, 258537, Exploring the isotopic dimension of the global Hg cycle, 2010-2015, coord. J Sonke.**
- **PoC: ERC PoC MIMO, 665482, Development of a mercury isotope monitoring tool. 2015-2016.coord. J Sonke.**
- **MSCA: HORIZON 2020: MSCA IF MEROXRE 657195, Understanding the fate of Arctic atmospheric mercury (Hg) deposition, 2015-2017, coord J. Sonke**
- **PARCS (Pollution in the Arctic System) funded by CNRS, French Arctic Initiative) (2015-2017), coord. K. Law, WP leads (A. Dommergue, J. Thomas, J.-D. Paris, J.-C. Raut), participant (J. Sonke, G. Ancellet)**
- **GMOS, FP7,2011-2015, Global Mercury Observation System, participant A. Dommergue**
- **PACES (air Pollution in the Arctic: Climate, Environment and Societies), co-chair (K. Law), SC member (J. Thomas), international initiative co-sponsored by IGAC/IASC.**

Client	Volume	Period
	1.179 M€ for CNRS (StG) 0.15 M€ for CNRS (PoC) 0.17 M€ for CNRS (MSCA) 0.740 M€ for CNRS (PARCS) 7M€, 0.32 M€ for CNRS (GMOS)	2010-2015 2015-2016 2015-2017 2015-2017 2011-2015

Relevance to iCUPE

- The ERC StG project developed Hg stable isotope signatures as source and process tracers at the global scale. Arctic research focused on Hg isotopes in marine biomonitor tissues (Point et al. 2011, NGEO), and in terrestrial atmospheric deposition. The project also developed cation exchange membranes (CEMs) for atmospheric oxidized Hg sampling, and highlighted inaccuracies in currently used instrumentation by GMOS/AMNet, and proposed new SOPs that will be further tested in iCUPE.
- The ERC PoC MIMO project developed a commercial atmospheric Hg isotope monitoring tool (MIMO), which prepares the next generation of automated Hg isotope monitoring, fully compatible with GMOS instrumentation. iCUPE will make use of the MIMO tool.
- MSCA MEROXRE project examines the mechanisms of terrestrial atmospheric Hg deposition to arctic tundra ecosystems, making use of and further refining the MIMO tool.
- PARCS contributes to many objectives relevant to iCUPE including work on mercury cycle, collection of new data on Arctic aerosols and interactions with clouds, trace gas and aerosol distributions in Siberia (YAK campaign), modeling of Arctic trace gases and aerosol sources and impacts.
- PACES is an international initiative on Arctic air pollution. Plans for new measurements campaigns on long-range transport of pollution to the Arctic and local Arctic pollution, together with model comparison activities are being discussed.

Proposal Acronym | iCUPE

EU H2020 project ENVRIPLUS (Environmental Research Infrastructures Providing Shared Solutions for Science and Society). Grant agreement n. 654182 (2015-2019).		
Client	**Volume**	**Period**
	1.536 M€ for CNRS	2015-2019

4.1.5.4 Relevant Publications

1. Dommergue, A., Sprovieri, F., Pirrone, N., Ebinghaus, R., Brooks, S., Courteaud, J. and Ferrari, C. P.: Overview of mercury measurements in the Antarctic troposphere, Atmos. Chem. Phys., 10(7), 2010.
2. Point, D., Sonke, J.E, Day, R.D., Rosenau, D.G., Hobson, K.A., Vanderpol, S.S., Moors, A.J., Pugh, R.S., Donard, O. F. X., and Becker, P. B., (2011). Methylmercury photodegradation influenced by sea ice cover in Arctic marine ecosystems. Nature Geoscience, v4, p188-194.
3. Law, K.S., A. Stohl, P.K. Quinn, C. Brock, J. Burkhart, J.-D. Paris, G. Ancellet, H.B. Singh, A. Roiger, H. Schlager, J. Dibb, D.J. Jacob, S.R. Arnold, J. Pelon, J.L. Thomas, Arctic Air Pollution: New Insights from POLARCAT-IPY, *Bull. Amer. Met. Soc.*, doi: http://dx.doi.org/10.1175/BAMS-D-13-00017.1, 2014.
4. Paris, J.-D., A. Stohl, P. Ciais, P. Nedelec, B. Belan, M. Arshinov, and M. Ramonet, Source-receptor relationships for airborne measurements of CO2, CO and O3 in the troposphere above Siberia: a cluster-based approach, Atmos. Chem. Phys. 10, 1671-1687, 2010.
5. Thomas, J. L., Stutz, J., Lefer, B., Huey, L. G., Toyota, K., Dibb, J. E., and von Glasow, R.: Modeling chemistry in and above snow at Summit, Greenland – Part 1: Model description and results, Atmos. Chem. Phys., 11, 4899-4914, doi:10.5194/acp-11-4899-2011, 2011.

4.1.5.5 Relevant Infrastructure

As one of the 10 thematic institutes of CNRS, INSU, the National Institute for Earth Sciences and Astronomy (INSU) elaborates, develops and coordinates research programs in Earth Observation. Within its field, INSU undertakes and coordinates research performed at national and international level by CNRS and other public French research bodies. The institute is also operating various facilities: observatories, platforms, observation services and e-infrastructures (databases, community models, centres for satellite data analysis). CNRS is involved in many European projects dealing with Earth sciences and infrastructures like EUPolarNet, EPOS, ENVRI, ATLANTOS, CAMS, My Ocean, ACTRIS, JERICO, ICOS, IAGOS, GMOS, INTAROS, AWIPEV.
CNRS co-coordinate **ACTRIS-2 IA.** The Research Infrastructure (RI) ACTRIS – Aerosols, Clouds and Trace Gases - is the pan-European RI that consolidates activities amongst European partners for observations of aerosols, clouds, and trace gases and for understanding of the related atmospheric processes, to provide RI services to wide user groups. ACTRIS is composed of 8 connected elements: distributed National Facilities (observation platforms and exploratory platforms) both in Europe and globally, and 7 Central Facilities (Head Office, Data Centre and 5 Calibration Centres). ACTRIS provides access to its facilities, open-access data, research support, instrument calibration and development, and training to various user groups. By providing data and access ACTRIS enhances science, but it also generates and disseminates knowledge, boosts technological development, and creates human capital and jobs for the benefit of the society. ACTRIS will positively impact on e.g. human health, climate resilience, and protection from environmental hazards and reduction of air pollution. ACTRIS has been selected to the ESFRI roadmap in 2016 as mature enough to be implemented within the next ten years. ACTRIS Preparatory Phase Project (PPP) will have a significant role in enabling the transition from a project based network of research facilities to a centrally coordinated integrated pan-European RI. ACTRIS PPP brings

together a wide community of research performing organizations, research funding organizations and ministries needed to take the decisions and actions to move forward in the implementation of the ACTRIS. The main objectives of ACTRIS PPP are to develop the organizational, operational and strategic frameworks of the RI. The work includes legal, governance, financial, technical, strategic, and administrative aspects carried out in 9 work packages. The main outcomes of PPP are signature-ready documents for establishment of a legal entity with well-defined operations and a sound business plan.
PACES is endorsed as a full activity under the auspices of International Global Atmospheric Chemistry (IGAC) project (under Future Earth), and under the International Arctic Science Committee Atmosphere WG. PACES aims to reduce uncertainties related to our understanding of sources, processing, fate and impacts of remote and local Arctic air pollution on climate, ecosystems and societies (discussed in Arnold et al., 2016). The overarching aim is to create new collaborative efforts between observational and modelling groups, social science researchers and local Arctic communities to address these issues. PACES aims to provide international community leadership in coordination of large international collaborative efforts, such as coordinated field experiments, model comparison and evaluation exercises. **CATCH** is an emerging international initiative sponsored by IGAC (www.igacproject.org) that aims to facilitate development of a cross-disciplinary research community and establish linkages within neighbouring disciplines including atmosphere, ocean, ice, snow, biology, clouds, dynamics, and fundamental chemistry. It also aimed to foster future collaborative work by highlighting cross-disciplinary research questions and identifying future research needs/opportunities. CATCH held a first community science workshop in Apr 2017 and will build activities through interactions with projects including iCUPE. **PARCS** addresses issues related to local and remote sources and impacts of Arctic air pollution including aerosol-cloud interactions, interactions between natural cycles and anthropogenic pollution, study of natural cycles in the atmosphere, sea-ice, marine environments including the mercury cycle, ozone-halogens; includes the collection of new observations and modeling (funded via the French Arctic initiative by CNRS since 2015).
The ICOS Atmospheric thematic Center is located at LSCE. It includes the ICOS central atmospheric data processing unit and the Metrology Labotory dedicated to metrology and calibration as well as test and validation of sensors. Its tasks are technological watch on emerging sensors as well as validation of standard sensors prior to their field deployments across Europe. It will be mobilized in WP1.
FP7 GMOS project as a unique global observing system providing comparable monitoring data on mercury levels in air and marine ecosystems in the Southern and Northern Hemispheres (S&NH) aiming to support the Minamata Convention (MC, Arts. 19 & 22). Its Modeling Task Force involves the worldwide mercury modeling community and is aimed to assess the effectiveness of policy measures that will be undertaken by Nations for the MC. GMOS provides observations from over 35 ground-based monitoring stations located in the S&NH, ad-hoc cruise campaigns over oceans and seas, and from tropospheric studies. Long-term and high precision observations and analysis of the mercury cycle in the different domains of the Earth System (atmosphere, ocean, land), are required to understand the role of anthropogenic activities, to better quantify Hg sources and sinks, and to determine Hg impact on ecosystem and human health.
WRF-Chem - Weather Research and Forecasting model coupled to Chemistry (ruc.noaa.gov/wrf/wrf-chem) is a regional chemical transport model based on the weather forecasting model WRF. The model is used for studying regional atmospheric chemistry, aerosols, and meteorology in the Arctic; includes emissions, transport, mixing, chemical transformations, and fate (deposition) of trace gases and aerosols.

4.1.5.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.6 Estonian University of Life Sciences (EULS)

4.1.6.1 Organisation Profile

Organisation Description
Eesti Maaülikool (Estonian University of Life Sciences, EULS) is a public University, organized in 5 institutes and the only University in Estonia whose priorities in academic and research activities are centered on sustainable development of natural resources. The academic structure is composed of research and development institutes or institutions, research centers and other structural units. The University hosts the Estonian Centre of Excellence in reseach: "EcolChange – Ecology of Global Change: Natural and Managed Ecosystems" which is a cooperation between two Estonian Universities, EULS and the University of Tartu. EULS is associated Partner in ACTRIS2 and partner in ACTRIS PPP as well as partner in RINGO (Readiness of ICOS for Necessities of Integrated Global Observations). The Estonian University of Life Sciences coordinates and leads the activities at the Station for Measuring Ecosystem Atmosphere Relations (SMEAR Estonia). The research and development at the SMEAR Estonia station is maintained by cooperation between EULS, the University of Tartu and the Tartu Observatory. At EULS, the Institutes of Agricultural and Environmental Sciences and of Forestry and Rural Engineering are involved in the activities at the SMEAR Estonia station. The SMEAR Estonian station (in Järvselja, southeast Estonia) - newest and southernmost point in the European SMEAR stations network. Since 2008, the Department of Plant Physiology and the Department of Forest Management are involved in interdisciplinary research and teaching and created a research program on climate adaption, biosphere-atmosphere interactions, and science based resource management.
Role in ICUPE
EULS will lead: • WP5 on Data provision, interoperability and facilitation of data and services • Task 5.5 on Facilitating iCUPE data pilots, data and services towards ERA-PLANET community, GEO and Copernicus EULS will also contribute to**:** • WP0 on Management • WP1 on Ground-based component for SLCFs • WP4 on Integrating in-situ, satellite and model components for improved environmental assessment • WP6 on Dissemination and strategic development
On the capabilities matching iCUPE tasks
The EULS group has experience in • Leading international research and monitoring infrastructures (SMEAR Estonia) with a capacity to perform continuous and comprehensive long-term measurement sites for atmospheric observations. • Participation in campaign and continuous observations of the atmospheric composition in the Arctic areas, including Nordic countries, Greenland, and Russian Arctic. • Development of novel in-situ variables related to changes in ecosystem processes, stress ecophysiology, combination of satellite remote sensing data and in-situ measurements, and mathematical model development. • Development of automated data acquisition, near real-time data analysis and visualization tools for the ground-based observations. • Providing ground-truth data to NASA satellite mission (GPM) from in-situ and ground based remote sensing data.

4.1.6.2 Staff Profile and their roles in iCUPE

Dr.rer.nat Steffen M. Noe (Male) EULS	**Leading the SMEAR Estonia station, Coordinating the ERA-Planet activities in Estonia** • Scientific expertise: more than 15 years of research experience related to mathematical modeling, plant and forest ecology, and atmospheric sciences. He leads the SMEAR Estonia measurement station (size of 25 people, 10 at EULS, 10 at the University of Tartu, and 5 at the Tartu Observatory); currently 5 PhD students and about 7 Msc students are linked to the research activities. He has educated 1 PhD, 3 Msc and is currently supervising 4 students. He has published 29 peer-reviewed articles with total citations of 357 and h-factor of 11. • PI of the project Biosphere-atmosphere interaction and climate research applying the SMEAR Estonia research infrastructure. • Managerial expertise: Leader of the SMEAR Estonia station. He has participated practical organization of 2 EU projects, acts as ACTRIS and ICOS focal point in Estonia, is member in the Finnish-Estonian SMEAR Advisory board.
Ass.Prof. Ahto Kangur (Male) EULS	**Contributions to field data analysis and near real-time data delivery** • at the Department of Forest Management and experienced in teaching and training from bachelors to PhD level. He has published 10 peer-reviewed articles with total citations of 118 and h-factor of 4. • Managerial expertise: He is member of the leading council of the Järvselja Experimental Forestry Station.
M.Sc. Alisa Krasnova (Female) EULS	**Contributes to field data analysis and near real-time data delivery**
M.Sc. Dmitrii Krasnov (Male) EULS	**Contributes to field data analysis and near real-time data delivery**
M.Sc. Sandra Metslaid (Female) EULS	**Contributes to field data analysis and near real-time data delivery**

4.1.6.3 Relevant Projects

ACTRIS Preparatory Phase Project is a EU Horizon 2020 Coordination and Support Action (grant agreement No 739530).

Client	Volume	Period
	0.04 M€ for EULS	2017-2019

Proposal Acronym | iCUPE

Estonian Environmental Observatory

Client	Volume	Period
	1.6 M€ for EULS	2010 ->

Relevance to ICUPE

- The scientific infrastructure network covers the SMEAR Estonia in-situ measurement station contributing to ICUPE, access to different field stations and data facilities.

Description

Context & objectives

The Estonian ESFRI roadmap project that implements a comprehensive measurement network in Estonia. It focuses on a holistic ecosystem scale research infrastructures that cover terrestrial and marine ecosystems.

The Centre of Excellence EcolChange

Client	Volume	Period
	1 M€ for EULS	2016 - 2023

Relevance to ICUPE

- The Centre of Excellence "Ecology of Global Change: natural and managed ecosystems" provides knowledge on adaption of ecological systems facing environmental changes.

Description

Context & objectives

The objective is to integrate studies of ecosystem function, biodiversity and adaptability. Create symbiosis between macroecological big-data, genetic and experimental approaches. Incorporate ecological knowledge into principles of adaptation to global change through sustainable ecosystem management. Enhance ecologically sustainable economic growth via smart regional planning in forestry and agriculture: functionally diverse forests, cultivars for future climates, novel crops and sustainable nutrient cycles.

4.1.6.4 Relevant Publications

1. Noe S.M., Krasnov D., Krasnova A., Cordey H.P.E. & Niinemets Ü. 2016: Seasonal variation and characterisation of reactive trace gas mixing ratios over a hemi-boreal mixed forest site in Estonia. Boreal Env. Res. 21: 332–344.
2. Kulmala M., Hõrrak U., Manninen H.E., Mirme S., Noppel M., Lehtipalo K., Junninen H., Vehkamäki H., Kerminen V.-M., Noe S.M. & Tammet H. 2016: The legacy of Finnish–Estonian air ion and aerosol workshops. Boreal Env. Res. 21: 181–206.
3. Lappalainen, H. K., Kerminen, V.-M., Petäjä, T., Kurten, T., Baklanov, A., Shvidenko, A., Bäck, J., Vihma, T., ... Noe, S.M., ..., 2016. Pan-Eurasian Experiment (PEEX): Towards holistic understanding of the feedbacks and interactions in the land–atmosphere–ocean–society continuum in the Northern Eurasian region. In Atmos. Chem. Phys., 16,14421-14461.
4. Noe, S.M., Niinemets, Ü., Krasnova, A., Krasnov, D., Motallebi, A., Kängsepp, V., Jõgiste, K., Hõrrak, U., Komsaare, K., Mirme, S., Vana, M., Tammet, H., Bäck, J., Vesala, T., Kulmala, M., Petäjä, T., Kangur, A. 2015. SMEAR Estonia: Perspectives of a large-scale forest ecosystem – atmosphere research infrastructure. – Forestry Studies 63, 56–84.
5. Ülo Niinemets, Paolo Ciccioli, Steffen M. Noe, and Markus Reichstein (2013), Scaling BVOC Emissions from Leaf to Canopy and Landscape: How Different Are Predictions Based on Contrasting Emission Algorithms?, in Biology, Controls and Models of Tree Volatile Organic Compound Emissions, Ü. Niinemets and R.K. Monson (eds.), 357-390, Tree Physiology 5, Springer Science + Business Media Dordrecht 2013.

4.1.6.5 Relevant Infrastructure

The SMEAR Estonia station is maintained by the Institute of Agricultural and Environmental Sciences together with the Institute of Forestry and Rural Engineering of EULS. The measurement station has been built to serve as in-situ monitoring platform of the atmosphere-biosphere interactions and to participate in ACTRIS and other relevant research infrastructures such as ICOS and ANAEE. The set of atmospheric measurements and equipment that is already existing covers measurements of atmospheric trace gases and aerosol precursors, air ion and aerosol number concentrations and fluxes.
The SMEAR Estonia station is part of the Estonian Environmental Observatory (EEOBS), which is listed on the Estonian national research infrastructure roadmap. SMEAR Estonia is a comprehensive large-scale research infrastructure to assess atmospheric and ecosystem parameters in-situ. The major objectives are multidisciplinary research and developments to increase understanding of air quality, health and environmental management in current and future climate conditions and to provide decision frameworks to policy makers on environmental and economical sustainability. Contributing national partners are the Institute of Physics of the University of Tartu (UT) and the Estonian Environmental Research Center (EERC) acting as an approved laboratory and monitoring facility of Estonia. The national partners add further measurement locations in Estonia (rural areas and cities) and calibration services.

4.1.6.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.7 Finnish Meteorological Institute (FMI)

4.1.7.1 Organization Profile

Organisation Description
Earth Observation research, development and operational activities of Ilmatieteen laitos (Finnish Meteorological Institute or FMI for short) include activities ranging from instrument design, application research and development to operational satellite data receiving, processing and utilization. The activities related to remote sensing of snow cover and boreal/arctic soil-vegetation processes are mainly carried out by the Arctic research program (FMI/ARC). It forms and executes one of the 8 core research programs of the Research Division of FMI. FMI/ARC is also responsible for the operations of National Satellite Data Centre (NSDC) in its Sodankylä premises. FMI/ARC has modern facilities including super computing capabilities for the analyses of massive data sets, such as long time-series of global Earth Observation satellite data. Advanced mathematical and image processing and data archiving/delivery software are applied for both research and operational purposes. The Earth Observation research group of FMI/ARC is one of the world leading teams in the remote sensing of the Earth's cryosphere. FMI/ARC coordinated the multi-national ESA GlobSnow initiative focusing on global monitoring of snow with EO instruments developing long-term CDRs for climate research. These activities are continuing with various ESA and EU-funded projects that include the development of satellite-based indicators for environmental monitoring and operational situational awareness systems. Relevant ESA-projects also include the development of global soil frost and soil moisture monitoring. These activities are further developed in the CARB-ARC project of the Academy of Finland's Arctic program for the needs of carbon monitoring by combining remote sensing of the surface and the atmosphere, which is related to the European research infrastructure ICOS (Integrated Carbon Observation System). Specific development of Sentinel-1/2/3 processing lines is currently ongoing in FP-7 Sen3App project. R&D activities are also related to the development of ice monitoring and weather services to the Arctic. FMI/ARC coordinates NSDC and several international initiatives focusing on the monitoring of the cryosphere, including the development of long-term data records for climate research (e.g. ESA DUE-GlobSnow and Copernicus Global Land Service). The activities also include EU-funded projects concerning the development of satellite-based indicators for environmental monitoring and operational situational awareness systems. Relevant ESA-projects also include the development of global soil frost/moisture monitoring. In CARB-ARC project of the Academy of Finland's Arctic program carbon processes monitoring is investigated combining remote sensing of the surface and the atmosphere related to the European research infrastructure ICOS (Integrated Carbon Observation System).
Role in ICUPE
FMI will lead: • Task 3.1 on Streamlining satellite remote sensing data flows for new multi-sensor, multi-dimensional products • Task 3.4 on Contribution to the strategic development of comprehensive EO in the Polar Areas • Task. 6.4 on Future strategies and contingency plans FMI will also contribute to**:** • WP0 on Management • WP3 on Satellite remote sensing of Arctic surfaces • WP5 on Data provision, interoperability and facilitation of data and services WP6 on Dissemination and strategic development
On the capabilities matching iCUPE tasks
The FMI group has experience in • Development of operational satellite data processing systems for scientific and commercial operational use and data distributing via an open platform.

- Providing in-situ measurements and operating satellite reference instrumentation for calibration and validation of European Space Agency's (ESA) spacecraft.
- Participation in campaign and continuous observations of the atmospheric composition in the Arctic areas, including Nordic countries, Svalbard, and Russian Arctic.
- Development of meaningful variables combining satellite remote sensing data, in-situ measurements and re-analysis model data.
- Expertise and capacity to perform Earth System Modelling and particularly look at black carbon emissions from flaring in the Arctic areas, and their effects on the environment.

4.1.7.2 Staff Profile and their roles in iCUPE:

M.Sc. Jyri Heilimo (Male) FMI	**Task 3.1 leader on Streamlining satellite remote sensing data flows for new multi-sensor, multi-dimensional products** Head of R&D of Satellite based services at FMI Arctic Research Centre. Mr Heilimo is responsible on leading the development of new operational services and development new products for the National Satellite Data Centre (NSDC) located in in Sodankylä Northern Finland. Before joining FMI 9 years ago, he worked over 15 years in systems engineering, business development and business management in private sector (spacecraft data satellite data processing software development sector); has well over 25 years of experience in various positions in space domain.
Mr. Mikko Strahlendorff (Male) FMI	**Task 3.4 leader on Contribution to the strategic development of comprehensive EO in the Polar Areas** Finnish delegate for the EU Copernicus Committee and a member of the GEO Executive Committee. He has worked over 15 years in product and service development for weather and related environmental information services as well as for organizing European research and operational infrastructures like the Copernicus EO program, ICOS, EuroARGO etc. He is also trying to be a PhD student working on the topic of Observation System adequacy for climate adaptation challenges
Prof. Jouni Pulliainen (Male) FMI	**Contributes to development of novel satellite data products (WP4)** has an extensive experience in conducting EO research and in research management. He is currently a research professor at FMI and head of the Arctic Research Unit. It currently employs over 50 researchers and technical staff members. A major activity of the unit is the experimental research related to satellite calibration/validation and algorithm development. The unit of Arctic Research is also responsible for the Earth Observation satellite ground segment operations at Sodankylä, northern Finland, that encompass the Finnish national ground segment activities as a co-operation of different research institutes and authorities. Prof. Pulliainen's research interests include forward modeling and inversion algorithms in remote sensing, and additionally, remote sensing data assimilation and application development for the needs of climate change studies, hydrology and weather prediction. Recently, his work has focused on the remote sensing of environmental processes of the cryosphere and boreal forest zone applying space-borne microwave and optical data (from regional to global scale). Prof. Pulliainen has been a principal investigator or project manager for several nationally funded and international research projects, including several ESA and EC contracts. He has authored over 280 scientific papers. Memberships in international and national scientific committees and organizations include: ESA Advisory Committee on Education (2001-2007); ESA CoreH2O MAG (2007-2013); ESF European Space Sciences

	Committee (ESSC, 2008 onwards), National Committee of COSPAR (2010 14 onwards), delegate of Finland to SAON board (2011 onwards), member of ESA Earth Science Advisory Committee (ESAC, 2013-2017), delegate of Finland to Earth Observation Program Board (PB-EO) of ESA (2017 onwards). Academician in Finland, China (CAS) and Russia (IAES).
Dr. Kari Luojus (Male) FMI	**Contributes to streamlining of cryospheric and soil freeze/thaw products availablity** received the M.Sc., Lic.Sc. (Tech.) and D.Sc. (Tech.) degrees from the Helsinki University of Technology (TKK), Espoo, Finland, in 2004, 2007 and 2009 respectively. Since 2008 he has been a Research Scientist and Senior Research Scientist with the Arctic Research department of the Finnish Meteorological Institute (FMI), Helsinki, Finland. He worked as the project manager for the ESA DUE GlobSnow project between 2008 and 2012 which focused on constructing long term essential climate variables concerning terrestrial snow cover. Dr. Luojus acts as a steering group member for the WMO Global Cryosphere Watch (GCW) and as the co-leader for the WMO GCW Snow Watch Group. His research interests include the development of active and passive microwave remote sensing techniques for cryosphere and hydrological applications. He is the author and co-author of more than 50 sci. publications and technical reports on microwave remote sensing.
Dr. Hilppa Gregow (female) FMI	**Leads task 6.4** Head of Unit, Climate Service Centre has more than 15 years of experience in the field of meteorology and climate. She is currently a leader of projects C3S DECM(Data Evaluation of Climate Models) and SA CLIPS(CLImate services supporting Public activities and Safety) and she is a KMB-member of ERA4CS. She participates in ECRA and supports EEA through participation in the Monitoring group of Adaptation (coordinated by Ministry of Forestry and Agriculture in Finland).
M.Sc. Matias Takala (Male) FMI	**Contributes to Streamlining satellite remote sensing data flows for new multi-sensor, multi-dimensional products** Expertise: Monitoring of snow melt status and SWE from space-borne data, information system development; received the M.Sc. in Technology degree from Helsinki University of Technology (TKK), Faculty of Electrical Engineering in 2001. From 2001-2006 he was research scientist at TKK and has been research scientist at the Finnish Meteorological Institute since 2007. His research interest includes microwave remote sensing of snow cover and developing remote sensing applications.
M.Sc. Mwaba Hiltunen (Female) FMI	**Contributes to contributes to development of new multi-sensor, multi-dimensional products** received a M.Sc. degree in Information Technology from Lappeenranta University of Technology, in 2010 and a B.Sc degree in Computer Science and Statistics from the University of Namibia in 2006. Since 2008, she has been working at the Finnish Meteorological institute as a programmer and research scientist. She has experience in handling large satellite datasets, data archiving and dissemination, application programming interfaces.
M.Sc. Kimmo Rautiainen (Male) FMI	**Contributes to streamlining of cryospheric and soil freeze/thaw products availablity** received M. Sc. (Tech.) degree in 1996 from Helsinki University of Technology, Laboratory of Space Technology, Espoo, Finland. He has over twenty years of work experience in the field of Earth Observation. His

	background includes microwave radiometer engineering and system design, and passive remote sensing applications. He has been with the Finnish Meteorological Institute (FMI) since 2010, specializing in development of retrieval algorithms for passive microwave remote sensing, with focus on cryosphere applications. At FMI, he has acted as technical project manager for SMOS related frost detection algorithm development studies. His current research interests include the development of cryosphere applications, especially the detection of soil freezing and thawing, L-band satellite missions. Currently he has 22 peer reviewed publications.

4.1.7.3 Relevant Projects

EU FP7 project SEN3APP (Processing Lines And Operational Services Combining Sentinel And In-Situ Data For Terrestrial Cryosphere And Boreal Forest Zone. Grant agreement n. 607052 (2014-2016).

Client	Volume	Period
	0.741 M€ for FMI	2014-2016

Relevance to iCUPE

- SEN3APP project has adapted several cryospheric automated satellite data processing lines to use of Copernicus Sentinels' data. Thus, leveraging sustainable and long-term stability of Northern hemisphere and pan-European snow and cryospheric monitoring.
- Improvement of systematic and timely satellite data processing and distribution of data and results for use in modelling, in particular towards implementation of cryospheric services.
- To further develop and disseminate integration tools to fully exploit the use of multiple cryospheric satellite processing systems.

Description

Context & objectives

The SEN3APP project addresses the topic of continuous and accurate monitoring of snow, glaciers, lake ice, soil (frost) and land cover/forest changes in the Earth's cryosphere, and in the boreal forest zone. Changes in cryosphere and boreal forests have a major influence to water resources and the cycling of water and carbon. Thus, the topic represents a theme of high socio-economic relevance to the European citizens. Smart, sustainable and innovative products and services shall be developed in order to support European Space Policies, especially related to the Global Monitoring for Environment and Security (GMES). SEN3APP will be able to demonstrate services with a future as commercial services or as public services justified by societal benefits with economic value. Key commercial customers will be attracted in hydro power and forest industries and the public services have great value for eco hazard forecasts.

Results

SEN3APP is concerned with the development, implementation, operationalization and validation of Sentinel data processing lines for cryospheric (terrestrial) and land cover/phenology applications. Both global and regional applications are included, focusing to high latitudes of the Earth and other parts of the cryosphere:

- Global and regional snow cover: snow extent, snow melt line, fractional snow cover (FSCA), wet (melting) snow area
- Glaciers: extent, perculation zone, glacier displacement maps
- Water bodies including the mapping of extent of (seasonally varying) water areas and lake/river ice processes

- Soil freezing and thawing processes (tundra, boreal forests, wetlands and alpine regions) and concurrent changes in forest vegetation
- Permafrost subsidence
- Intra-annual monitoring of ecosystem functioning, based on time-series of vegetation indices relevant in northern boreal zone
- Monitoring of inter-annual changes in land cover
- Intermediate products such as cloud-screened surface reflectance.

Carb-ARC (Carbon Balance under Changing Processes of Arctic and Subarctic Cryosphere project for Finnish Academy).

Client	Volume	Period
SUOMEN AKATEMIA	0.947 M€ for FMI	2015-2018

Relevance to iCUPE

- Improvement of systematic and timely collection, processing and distribution of data and results for use in modelling, in particular towards implementation of atmospheric and climate services. CARB-ARC invests substantial efforts to ensure long-term sustainability beyond the term of the project by positioning the project in both the GEO and the on-going ESFRI contexts, and by developing synergies with national initiatives.
- To further develop and disseminate integration tools to fully exploit the use of multiple atmospheric techniques at ground-based stations, in particular for the calibration/validation/integration of satellite sensors and for the improvement of the parameterizations used in global and regional-scale climate and air-quality models

Description

Context & objectives

The higher northern latitudes are especially sensitive to climate change, indicated by above-average rising temperatures (IPCC 2013). A considerable positive feedback on global warming is likely once additional carbon is liberated from thawing ground (e.g. Stokstad 2004). However, the prediction of the overall response of the system is uncertain. Thus, the quantification and monitoring of physical processes of the circumpolar terrestrial cryosphere are highly important for the understanding of climate system feedbacks, especially concerning linkages between the atmosphere and soil/biosphere. Space-borne derived global long-term datasets of high temporal resolution are the only means to obtain information on some of the relevant processes, especially given the hindered accessibility of these hostile environments. Currently, such proper data sets are available for the spatial distribution of polar sea ice, whereas in the case of land areas information on snow and soil freezing characteristics is limited or inadequate. For example, spatially and temporally continuous monitoring information on soil freezing depth is lacking, both for the regions of seasonal frost and permafrost (with an overlying active layer). On the other hand, investigations performed by applying detailed on-site measurement data have shown that changes in the seasonal cycle of soil-snow-vegetation processes have a major impact on the annual carbon balance (Piao et al. 2008, Vesala et al. 2010, Melaas et al. 2013, Xu et al. 2013). The goal of the proposed research and development activity is to specifically tackle this problem at high latitudes with the aid of novel Earth Observation (EO) data sources. Thus, the scope is to develop and demonstrate continental-scale mapping of CO2 and CH4 sources and sinks in the boreal forest and subarctic zones based on novel EO products.

Results

- Synergistically retrieval of information on the seasonal cycle of the high-latitude land surface carbon exchange processes
- Improvement of thematic and spatial accuracy of EO data products measuring key surface variables such as soil moisture, soil freeze/thaw state, vegetation water content and snow cover (Pulliainen 2006, Takala *et al*. 2011, Rautiainen *et al*. 2013, 2014).
- Focusing on the development of methodologies applicable to the mapping of the annual carbon balance (related to CH4 and CO2 sinks and sources).
- Use of EO data products as proxy indicators of selected key variables that are directly linked to greenhouse gas (GHG) exchange, gross primary production (GPP) or photosynthesis
- Improve the state-of-the-art of EO products concerning soil state and snow cover characteristics.
- Define computational solutions for challenging assimilation systems.
- Establish novel monitoring capabilities for GHG exchange at the Arctic and boreal environments including the upscaling of localized GHG measurements.
- Improve the representation of the carbon budget and associated processes in land surface models through data assimilation with the novel EO products.
- The impact also includes contribution to the scientific and operational goals of ESA, ICOS and the Finnish space strategy (see above section Project justification).

ENVIBASE

Client	Volume	Period
VALTIOVARAINMINISTERIÖ	0.833 M€ for FMI	2015-2018

Relevance to ICUPE

- The National Satellite Data Centre (NSDC) receives, processes, archives and distributes satellite data. The main goal of the center is to provide easily accessed satellite data and products to users from a single point. NSDC is a Copernicus Collaborative Ground Segment and responsible for delivering Sentinel data to Finnish and neighboring area users.
- Besides freely available Sentinel data, NSDC provides optical and SAR satellite data and value-added products from other satellites.
- The NSDC provides a processing environment for users next to a data source.

Description

Context & objectives

The Envibase project is a significant national investment in boosting the technical infrastructure behind the collection, management, sharing and utilization of environmental data in Finland. Envibase concentrates on the development of information systems and processes used in the collection and utilization of multi-source environmental data. The project emphasizes the principles of free and open data as well as iterative development according to the feedback from the users of services developed.

The main work in Envibase is conducted on five specific entities:

- The enhanced use of GIS- and remote sensing infrastructure for environmental applications
- The development of the National Satellite Data Centre (NSDC)
- The development of the Finnish Biodiversity Information Facility (FinBIF)
- The redesigned utilization of citizen observations in environmental monitoring
- Enhanced management and sharing of research datasets

Results

- ENVIBASE project has supported further development of FMI's National Satellite Data Centre, allowing further development of Copernicus Collaborative Ground Station activities
- Setting up and initialization of massive parallel processing environment for Sentinel's data processing and support Collaborative Ground Segment activities
- Establish data dissemination framework for Earth Observation data and scientific data products dissemination to data users and partners.
- The Centre's capabilities can be utilized in context of ERA-PLANET project

4.1.7.4 Relevant publications

1. Jari Ala-Ilomäki, Juval Cohen, Jyri Heilimo, Eija Hyvönen, Pekka Hänninen, Jaakko Ikonen, Maarit Middleton, Paavo Nevalainen, Tapio Pahikkala, Jonne Pohjankukka, Jouni Pulliainen, Henri Riihimäki, R. Sutinen, Sakari Tuominen, jari Varjo, New Computational methods for efficient utilisation of public data, report, Geologian Tutkimuskeskus 217(217):1-55 · March 2015
2. Kari Luojus, Jouni Pullianen, Juval Cohen, Jaakko Ikonen, Matias Takala, Juha Lemmetyinen, Tuomo Smolander, Chris Derksen, Thomas Nagler, Bojan Bojkov, Assessing global satellite-based snow water equivalent datasets in ESA SnowPEx project, 10.1109/IGARSS.2016.7730376, Conference: IGARSS 2016
3. Kari Luojus, Jouni Pulliainen, Matias Takala, Juha Lemmetyinen, Tuomo Smolander, Jaakko Ikonen, Juval Cohen, and Chris Derksen, Hemispherical Snow Water Equivalent Records of Satellite-Based Data and CMIP5 Climate Model Simulations*, Geophysical Research Abstracts, Vol.15, EGU2013-7289, 2013*
4. Mikko Strahlendorff, Sebastien Duyck, Johan Gille, Anastasia Leonenko, Timo Koivurova, Marie-There von Schickfus, Adam Stepien, Jennie Thomas, Climat Change in the Arctic Chapter, In book: The Changing Arctic and the European Union, Brill, Editors: Adam Stepien, Timo Koivurova, Paula Kankaanpää, 2015
5. Matias Takala, Jaakko Ikonen, Kari Luojus, Juha Lemmetyinen, Sari Metsämäki, Juval Cohen, Ali Nadir Arslan, Jouni Pulliainen, New Snow Water Equivalent Processing System With Improved Resolution Over Europe and its Applications in Hydrology, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing · January 2016
6. Jaakko Ikonen, Juho Vehviläinen, Kimmo Rautiainen, Tuomo Smolander, Juha Lemmetyinen, Simone Bircher, Jouni Pulliainen, The Sodankylä in situ soil moisture observation network: An example application of ESA CCI soil moisture product evaluation, Geosci. Instrum. Method. Data Syst., 5, 95–108, 2016

4.1.7.5 Relevant Infrastructures

Finnish Meteorological operates the atmospheric monitoring systems of Finland including operational weather stations, ground-based weather radars, sounding stations, air quality monitoring stations as well as numerous scientific measurement systems observing the atmosphere and atmosphere-surface interaction. The computing facilities of FMI include a super computer applied for operational numerical weather predictions and for research use. The Arctic Research Centre in Sodankylä is the largest research station of FMI equipped with a large ensemble research and operational instruments that monitor various atmospheric characteristics and atmosphere-soil-vegetation interaction (including sow cover). The instrumentation also includes reference systems for space-borne remote sensing instruments (e.g. multi-channel microwave radiometers/radars, hyper-spectral UV-, VIS- and IR-spectrometers).
FMI-Arctic Research Centre also operates a National Satellite Data Centre applied to acquire data from NASA's EOS satellites, NPP-Suomi, FY-3a/b/c, CosMo-SKYMED SAR and Sentinel-1 SAR (Sentinel Collaborative Ground Segment). Operational satellite data processing lines are used for these and other sensors to provide products for atmospheric variables (e.g total ozone column) and for terrestrial parameters (global and European snow cover, product on soil frost of northern hemisphere, based on

spaceborne instrumentation). A part of NSDC's activities is the Finnish Copernicus Collaborative Ground station that archives Copernicus Sentinels' data from Arctic region and disseminates the products to users via FINHUB portal and processes various data products operationally; products to support Baltic winter navigation, Northern hemisphere cover and snow water equivalent, Northern hemisphere soil freeze/thaw products. NSDC satellite data downlink, data archive and high-power computing capabilities can be utilised in context of ERA-PLANET project.
The Pan-Eurasian Experiment (PEEX) is a multidisciplinary, multi-scale program focused on solving grand challenges in northern Eurasia and China focusing in Arctic and boreal regions. PEEX will also help to develop service, adaptation and mitigation plans for societies to cope with global change. It is a bottom-up initiative by several European, Russian and Chinese research organizations and institutes with co-operation of US and Canadian organizations and Institutes. The PEEX approach emphasizes that solving challenges related to climate change, air quality and cryospheric change requires large-scale coordinated co-operation of the international research communities. Strong involvement and international collaboration between European, Russian and Chinese partners is needed to answer the climate policy challenge: how will northern societies cope with environmental changes? The promoter institutes of this initiative are the University of Helsinki and the FMI in Finland; the Institute of Geography of Moscow State University, AEROCOSMOS, and the Institute of Atmospheric Optics (Siberian branch) of the Russian Academy of Sciences (RAS) in Russia; the Institute of Remote Sensing and Digital Earth (RADI) of the Chinese Academy of Sciences (CAS) and the institute for climate and global change research of Nanjing University in China. PEEX is built on collaboration by EU, Russian and Chinese parties, involving scientists from various disciplines, experimentalists and modelers, and international research projects funded by European, Russian and Chinese funding programs. The first active PEEX period is 2013–2033, though PEEX will continue until 2100. The first PEEX meeting was held in Helsinki in October 2012. PEEX is open for other institutes to join.
ICOS is the European Research Infrastructure for on-line, in-situ monitoring of greenhouse gases (GHG) to understand their present-state and future sinks and sources. The ICOS Head Office is located in Helsinki since 2013. The national ICOS network consists of 14 atmospheric and ecosystem stations. The partners of ICOS- Finland are University of Helsinki, University of Eastern Finland and FMI. ICOS RI provides effective access to coherent and precise data and assessments of GHG inventories with high temporal and spatial resolution. ICOS also provides profound information for research and understanding of regional budgets of greenhouse gas sources and sinks, their human and natural drivers, and the controlling mechanisms. ICOS permits to detect changes in regional greenhouse gas fluxes, early warning of negative developments and the response of natural fluxes to extreme climate events, to reduce uncertainties in Earth System models.

4.1.7.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.8 Helmholtz-Zentrum Potsdam DeutschesGeoForschungsZentrum (GFZ)

4.1.8.1 Organisation Profile

Organisation Description

The Helmholtz-Zentrum Potsdam DeutschesGeoForschungsZentrum (GFZ) is the German National Research Centre for Earth sciences and a member of the German Helmholtz Association (HGF). Research at the GFZ focuses on the geosphere within the highly complex System Earth with its further subsystems, its interacting subcycles, and its wide network of cause-and-effect chains. This is done in a close interdisciplinary collaboration with the related scientific disciplines physics, mathematics, chemistry, and biology as well as with the engineering sciences disciplines of rock mechanics, engineering hydrology and seismology. The GFZ methodical core competences are in application and development of satellite technologies and space-based measuring methods, operation of geodetic-geophysical monitoring networks, application of geophysical deep-sounding techniques for the tomography of the solid Earth, execution of scientific drilling, laboratory and in experimental techniques, and modelling of geoprocesses, thereby contributing to the mission of the Helmholtz Association and its Research Fields Earth and Environment and Energy to solve some of the most pressing questions of society.
Remote sensing deals with the monitoring of Earth surface variables and processes from a range of spatial and temporal scales using in-situ, airborne and spaceborne instruments. The GFZ Remote Sensing section focuses on the development and use of remote sensing techniques for the monitoring of land surfaces. In particular, research lines comprise (i) methodological developments for remote sensing data analysis and definition of future satellite missions, and (ii) application-oriented research for the monitoring of bio- and geophysical parameters of interest to a wide range of scientific disciplines, including land degradation studies, natural resources, global vegetation functioning, and land-atmosphere interactions. In particular, the remote sensing section is renowned for its expertise in hyperspectral remote sensing and is the scientific leader of the EnMAP hyperspectral satellite sensor to be launched in 2019. The section infrastructure consists of one of the most equipped spectral laboratories in the world for calibration/validation of hyperspectral imagery with two HySpex hyperspectral cameras (VNIR-SWIR) and associated instrumentation, and a high number of state-of-the-art laboratory and field spectroradiometers covering from the visible to the thermal wavelengths (ASDs, GERs, Lambda950 and GX FTIR), and EnMAP simulation and algorithms development tools for the delivery of EnMAP products from the upcoming EnMAP satellite.

Role in ICUPE

GFZ will contribute to:

- WP0 on Management
- WP1 on Ground-based component for SLCFs
- WP3 on Satellite remote sensing of Arctic surfaces
- WP4 on Integrating in-situ, satellite and model components for improved environmental assessment
- WP5 on Data provision, interoperability and facilitation of data and services
- WP6 on Dissemination and strategic development

On the capabilities matching iCUPE tasks

The GFZ group has experience in

- Definition and lead of future satellite missions (science P.I. of the EnMAP satellite "the Environmental Mapping and Analysis Program" mission, BMWi/Germany, launch 2019). Definition of next generation satellite missions for Earth observation in optical and thermal wavelengths (EnMAP-Follow on, ESA Earth Explorer Missions TMAX, Hypex-2, ESA hyperspectral imaging mission concept HyperNext), and for atmosphere observations (MERLIN

"Methane Remote Sensing LIDAR" Mission).

- Operation of eddy covariance flux tower (contributing to FLUXNET and the German TERENO long term observatory) and airborne eddy covariance.
- Coordination and acquisition of airborne remote sensing data and ground-truth campaigns for field acquisitions of surface parameters for calibration/validation of hyperspectral imagery data and data products.
- Development of novel approaches for hyperspectral imagery data processing and analyses e.g. development of spectral indices (NSMI Normalised Soil Moisture Index) for an improved derivation of key geophysical variables based on advanced remote sensing data, in-situ measurements and process understanding.
- Development of novel applications, algorithms and toolboxes (Eetes EnMAP End-to-End Simulation Tool, HYSOMA Hyperspectral Soil MAPper: www.gfz-potsdam.de/hysoma, EnSoMAP EnMAP Soil Mapper: www.enmap.org/enmapbox, My Sky at night: www.myskyatnight.com) for hyperspectral imagery pre-processing and analyses, and for night light emissions to quantify skyglow. Distribution via an open platforms.
- Large experience in coordinating research under EU-programs as contributors to EU FP6DeSurvey, FP6 HYRESSA, leader in FP7 EUFAR and FP7 EUFAR2 of soil algorithms from hyperspectral imagery, H2020 INTAROS.

4.1.8.2 Staff Profile and their roles in iCUPE:

Dr. Sabine Chabrillat (Female) GFZ	**Leader of GFZ participation, co- Task leader responsible for mapping and monitoring of vegetation and of natural resources extraction** Sabine Chabrillat is senior scientist at the GFZ Potsdam remote sensing section, Head of the working group of hyperspectral remote-sensing application with a research focus on new algorithms for extraction of bio/geochemical variables from imaging spectroscopy data. Physicist with a PhD in new approaches for the analyses of hyperspectral imagery from the university of Toulouse, France, she worked at the Center for the Study of Earth from Space / CIRES, Boulder, Colorado, USA, at the University of Toulouse, France and is at the GFZ Potsdam, Germany since 2001. Dr. Chabrillat is Co-chair ISPRS Commission VII - WG3 "information extraction from hyperspectral data", Leader in EnMAP program of the soil applications (DE), Member of the satellite programs TMAX (ESA EE9), Hypex2 (ESA EE9), HyperNext (ESA concept future missions), EnMAP-Follow On (DE), Review Panel Member EUFAR Transnational Access User Group, and holder of a publication record of >120 publications. • Scientific expertise: over 15 years of research experience related to imaging spectroscopy analyses and interpretation; leads the working group "hyperspectral remote sensing applications" (size of 12 people) at the GFZ Remote Sensing section including senior scientists, post-doc scientists, and several PhD students; has educated 7 PhDs and currently supervising 4 students; published 30 peer reviewed articles in remote sensing journals with total cit. of 1209 & h-factor of 15. • PI and Co-PI of research projects in national and international programs (EU, Germany, Belgium, Spain) related to the potential of hyperspectral imagery for soil, vegetation and soil degradation mapping in arid and agricultural lands (PROSOIL, UAVSOIL, ENMAP-SOIL, MASOMED). • Contribution and advisor of several projects related to the potential of hyperspectral imagery for polar areas characterization.

	• Board member of EUFAR transnational access selection panel, science team member of satellite projects (Germany EnMAP; France HYPXIM; ESA TMAX, Hypex2; ESA HyperNext). • Managerial expertise: head of section 1.4 spectral laboratory, head of section 1.4 research working group, participation in many research and management committees, lead field and airborne hyperspectral campaigns since many years; has participated in practical organization of 5 EU projects, and 2 infrastructure projects (EnMAP, MOSES).
Prof. Torsten Sachs (Male) GFZ	**Contributions to Ground-based component for SLCFs (WP1)** • head of the Earth-Atmosphere Interactions Group within the GFZ Section Remote Sensing. His research focusses on the land-atmosphere exchange of heat, water vapor, and greenhouse gases (CO2, CH4) on spatial scales ranging from experimental plots (1 m²) to regions (>10.000 km²) using continuously measuring flux towers and airborne eddy covariance in both temperate and high latitudes. In recent years he has conducted eight extensive aircraft and helicopter-based campaigns in the US, Canadian, and Siberian Arctic as well as northern Scandinavia. Among other projects, he is involved in INTAROS and 2 NASA-JPL led projects within the Arctic-Boreal Vulnerability Experiment (ABoVE) as well as in the Science Advisory Group of the German-French Methane Remote Sensing LIDAR (MERLIN) Mission.
Dr. Christopher Kyba (Male) GFZ	**Contributes to development of novel satellite products: Mapping and monitoring of Arctic emissions, particularly from flaring and natural gas extraction (WP3)** • has been studying artificial light in the nighttime environment since 2009; uses a variety of methods, including satellite observations (VIIRS DNB), astronaut photographs from the International Space Station, aerial photography, ground based imaging, ground based radiometric time series, and citizen science observations; developed three citizen science apps related to the topic: “Loss of the Night” app, “My Sky at Night”, “My Simulated Sky at Night”; chair of the International Steering Committee for “Artificial Light at Night” conference series.
Prof. Luis Guanter (Male) GFZ	**Contributes to development of novel satellite products (WP 3)** • head of the section 1.4: Remote sensing, coordinator of research activities (~50 employes); PI of German EnMAP hyperspectral mission and scientific. responsible for the the DLR Study “Next Generation Hyperspectral Payload” Phase 0; Head of the GlobFluo working group on the remote sensing of chlorophyll fluorescence (DFG Emmy Noether Junior Group); Responsibilities include: Scientific Principal Investigator of the EnMAP mission and Head of the EnMAP Science Advisory Group, Member of the Sentinel-2 Mission Advisory Group
Dr. Karl Segl (Male) GFZ	**Contributes to development of novel satellite products: Satellite simulation tool, satellite imagery pre-processing and analyses (WP 3)** • senior researcher at the GFZ remote sensing section, Head of working group – EO mission development and data preprocessing; co-investigator and science team member of many national and international projects (e.g. EnMAP-satellite, HiTeSEM, GeoMultiSens, MOMS-2/2P Mission, ESA-Sentinel-2), funded by various governmental and industrial institutions; present research is focusing on

	the development of optical sensor end-to-end simulation systems including data recording, data pre-processing and sensor calibration, sensor validation and processing and evaluation of hyperspectral lab-field- and airborne data; external lecturer at Potsdam University
Dr. Andreas Kueppers (Male) GFZ	**Contributes to interoperability of data and services, dissemination and strategic development**
Mr. Christian Wille (Male) GFZ	**Contributes to in-situ and remote sensing data acquisition and analyses: Greenhouses gases emission measurements in arctic areas (WP1)**
Mss. Sylvia Magnussen (Female) GFZ	**Contributes to in-situ and remote sensing data analyses: Data management, IT expertise and data storage (WP1 and WP3)**

4.1.8.3 Relevant Projects

Preparation for the scientific use of the hyperspectral mission EnMAP, BMWi/Germany

Client	Volume	Period
Federal Ministry for Economic Affairs and Energy	2,2 Mio (subtopic Geology/soils and Simulation - 1,1Mio)	Long-term project >10 years Current funding phase: 2016-2018

Relevance to iCUPE

- Innovations in optical remote sensing sensor techniques and in hyperspectral remote sensing data processing are ones of the fundamental building blocks of EnMAP scientific preparation program.
- Improvement of data pre-processing and analyses tools, acquisition of calibration/validation ground-truth data in parallel with airborne acquisitions, towards implementation of future Copernicus hyperspectral missions' products and services with the development of generic tools and softwares. The EnMAP scientific preparation program support the integration of the project in GEO groups and synergies with end-users.
- To further develop and disseminate algorithms tools to fully exploit the use of upcoming hyperspectral mission EnMAP, in particular for the development of novel data products, and for calibration/validation of satellite data and data products and for improvement of the determination of surface and atmospheric bio/geochemical variables for carbon cycle global modeling.
- Development of improved services and products as a support to Copernicus program (EnMAP is a Copernicus contributing mission) and GEO's missions and groups (GFZ participates in GEO CA-06: EO data for mineral resources).

Description

Context & objectives

The Environmental Mapping and Analysis Program (EnMAP) is a German hyperspectral mission, scheduled for launch in 2019. The primary goal of EnMAP is to offer accurate, diagnostic information on the state and evolution of terrestrial ecosystems on a timely and frequent basis, and to allow for a detailed analysis of surface parameters with regard to the characterization of vegetation canopies, rock/soil targets and coastal waters on a global scale. EnMAP is designed to record bio-physical, bio-chemical and geo-chemical variables to increase our understanding of biospheric /geospheric processes and to ensure the sustainability of our resources. The EnMAP scientific preparation program addresses the scope of integrating state-of-the-art National German research institutions to pave the way to prepare the scientific

and end-users community of EnMAP data products for an improved potential of the EnMAP mission through new softwares for data processing and analyses and easy accessibility data products from non-expert users. It consolidates and improves upcoming services to be expected from the EnMAP mission.

Results

- To deliver high quality calibrated radiance and geocoded reflectance over the whole Earth.
- To maintain and enhance capacity of national and international institutions for the accurate characterization of Earth surface status and changes;
- To increase the Technology Readiness Level of technologies for data pre-processing including geometric correction and atmospheric modeling for the retrieval of surface reflectance.
- To increase the TRL of technologies for extraction of surface information and development of a new series of products and services in form of novel data products.

4.1.8.4 Relevant Publications

1.	Franz, D.; Koebsch, F.; Larmanou, E.; Augustin, J.; and Sachs, T. (2016). High net CO2 and CH4 release at a eutrophic shallow lake on a formerly drained fen. Biogeosciences, 13(10), 3051–3070.
2.	Steinberg, A., Chabrillat, S., Stevens, A., Segl, K. and Foerster, S. (2016), Prediction of common surface soil properties based on Vis-NIR airborne and simulated EnMAP imaging spectroscopy data: Prediction accuracy and influence of spatial resolution, Remote Sensing, 8(7), 613.
3.	Kyba, C., Tong, K. P., Bennie, J., Birriel, I., Birriel, J. J., Cool, A., Danielsen, A., Davies, T. W., Outer, P. N. d., Edwards, W., et al. (2015), Worldwide variations in artificial skyglow, Scientific Reports, 5.
4.	Gerilowski, K.; Krings, T; Hartmann, J.; Buchwitz, M.; Sachs, T.; Erzinger, J.; Burrows, J.P.; and Bovensmann, H. (2015). Atmospheric remote sensing constraints on direct sea-air methane flux from the 22/4b North Sea massive blowout bubble plume, Marine and Petroleum Geology, 68, Part B, 824–835.
5.	Guanter, L., Kaufmann, H., Segl, K., Foerster, S., Rogass, C., Chabrillat, S., et al. (2015), The EnMAP Spaceborne Imaging Spectroscopy Mission for Earth Observation, Remote Sensing, 7 (7), 8830-8857.

4.1.8.5 Relevant Infrastructure

The GFZ remote sensing section operates from its spectral laboratory a high number of spectroradiometers for acquisition of remote sensing data from airborne platforms and for acquisition of field measurements for calibration/validation of airborne campaigns and as a support for the development of novel approaches and novel remote sensing data products.
The EnMAP end-to-end simulation tool (Eetes) and the EnMAP soil mapper (EnSoMAP) are softwares developed by GFZ in the frame of the EnMAP scientific preparation program and available from the GFZ remote sensing section. Eetes allow to simulate upcoming hyperspectral data and allow to test and develop new data products based on sensor simulation, airborne hyperspectral data, and field surfaces observations for calibration/validation of novel approaches. EnSOMAP and similar softwares in EnMAP-Box allow determining vegetation cover based on vegetation indices and different methods.
In collaboration with the Alfred Wegener Institute – Helmholtz Centre for Polar and Marine Research (AWI) and the University of Hamburg, GFZ operates a surface-atmosphere flux tower along with the relevant meteorological and soil climatological sensor networks at the Russian-German Research Station Samoylov Island in the Siberian Lena River Delta. Airborne measurements also include surface-atmosphere fluxes, boundary layer meteorology, as well as hyperspectral and LiDAR data acquisition in support of numerous collaborative projects related to vegetation development, permafrost thaw subsidence, and Arctic coastal erosion.

4.1.8.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.9 Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung (HZG)

4.1.9.1 Organization Profile

Organisation Description

The Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH (HZG) is one of 18 members of the Helmholtz Association of German Research Centres, Germany's largest science organisation. HZG is located in Geesthacht near Hamburg with branches in Teltow near Berlin and in Hamburg, with a total staff of approximately 950 employees, including about more than 650 scientists, engineers and technicians. HZG comprises four research institutes and the Climate Service Centre Germany (GERICS), the latter being a development centre which offers products, advisory services and decision-relevant knowledge based on sound scientific evidence in order to support government, administration and business in their efforts to adapt to climate change. HZG is one share-holder of the German Climate Computing Centre (DKRZ), one of the leading computing centres worldwide exclusively dedicated to climate modelling. The DKRZ data bank is one node of the climate simulations of the Intergovernmental Panel on Climate Change (IPCC).

HZG is committed to the principles of the European Research Area by providing excellent science to support both solving Europe's societal challenges and further developing Europe's innovation potential. The research portfolio is defined along the economic value chain in areas covered by HZG's research activities, and it spans much of the innovation chains from basic to applied research including the production of laboratory prototypes. HZG engages in projects to support research and innovation at national and international levels. HZG holds more than 650 patents in areas such as advanced engineering materials and regenerative medicine. HZG maintains its own technology transfer department which provides services to HZG researchers covering e.g. protection of intellectual property, licensing, and support to spin-off.

HZG's organisational structure is based on project management principles which promote networking of HZG's activities internally and in particular with external partners. The latter include research institutes, universities, communities, private and public companies at both the national and international levels. HZG maintains central administrative, financial, technology-transfer, legal and project management departments providing its researchers with full support in all related issues. HZG has gained experience for years and has cultivated a successful tradition in both the co-ordination of and participation in different types of EU projects. Since the year 2000, researchers at HZG have coordinated some 45, and have participated in more than 150 EU projects co-financed by the European Commission, mainly through FP5, FP6, FP7 and Horizon 2020 framework programmes.

HZG's Institute of Coastal Research is conducting research on coastal regions -both coastal sea and the inhabited land. Its research specifically aims to improve the understanding of the natural coastal dynamics and its resilience to global climate change and regional drivers in order to establish a rational scientific basis for management of coastal zones. As such, the work deals with determination, understanding and assessment of change while embedding perspectives in a societal context.
The Department for Environmental Chemistry (KBC) at the Institute of Coastal Research focuses on the investigation of the occurrence, sources, transport, fate and trends of persistent anthropogenic pollutants in the coastal and marine environment. Based on extensive facilities for chemical analysis and systematic sampling strategies, the research of KBC aims to discovery bioaccumulation and geochemical cycling of emerging contaminants such as halogenated flame retardants, current-use pesticides, and personal care and pharmaceuticals in the coastal, marine and polar environment.

Proposal Acronym | iCUPE

Role in ICUPE
HZG will lead: • Task 2.4 on Study of interactions between environmental spheres (atmosphere, hydrosphere, biosphere, cryosphere) HZG will also contribute to**:** • WP0 on Management • WP5 on Data provision, interoperability and facilitation of data and services • WP6 on Dissemination and strategic development
On the capabilities matching iCUPE tasks
The HZG group has experience in • Leading international research on analysis of emerging organic contaminants in the coastal, marine and polar environment. • Participation in expedition in the Atlantic and Arctic and performing long-term atmospheric sampling at Arctic research station in Svalbard. • Development and validation for novel and sensitive analytical methods for the determination of ultra-trace levels of emerging organic contaminants in remote areas, e.g. in the Arctic and Antarctic. • Expertise and capacity to perform three-dimensional dispersion model - the Canadian Model for Environmental Transport of Organochlorine Pesticides (CanMETOP) to examine atmospheric transport and exchange fluxes between different phases.

4.1.9.2 Staff Profile and their roles in iCUPE:

Dr. Zhiyong Xie **(Male)** **HZG**	**Task leader for Study of interactions between environmental spheres (WP2)** • Has been working in the field of environment science and analytical chemistry since 2002; research interests are focused on investigating legacy and emerging organic contaminants in different environmental matrices; with novel sampling and modern instrumental strategies, he is discovering the transport pathways for legacy and emerging organic contaminants in global ocean and polar regions. • published the relevant papers for non-PBDE BFRs in the Atlantic Ocean, and for phthalate esters and synthetic polycyclic musk fragrances in the Arctic. Since 2011, he has been managing the long-term atmospheric sampling station at German-France Arctic Research Base for monitoring emerging organic contaminants at Ny-Ålesund in the Arctic. • (co)-author of 74 peer-reviewed publications, H-index of 30.
Prof. Ralf Ebinghaus **(Male)** **HZG**	**Contributions to data analysis and interactions with the stakeholders** • Head of the Department for Environmental Chemistry of the Institute of Coastal Research at Helmholtz-Zentrum Geesthacht, near Hamburg. He is also Professor (h.c.) at the Faculty of Sustainability Sciences at Leuphana University of Lüneburg. • His research fields include transport, deposition and air/sea-gas exchange of atmospheric trace constituents, such as mercury and persistent organic pollutants (POPs) with special emphasis on substances of emerging concern for the coastal, marine, and polar environment. He has crossed the traditional border between inorganic

	and organic environmental chemistry. He concentrates on the crucial question of evaluating the persistence and long-range transport potential of environmental chemical compounds. • He has co-edited three books and is editor of the CSIRO Journal "Environmental Chemistry", co-editor of the EGU Open Access Journal "Atmospheric Chemistry and Physics" and associate editor of "Chemosphere". • He has published more than 190 articles in peer reviewed journals (h-Index = 45) and several book chapters. (for detailed list see http://www.hzg.de/ebinghaus).

4.1.9.3 Relevant Projects

Helmholtz Research Programme "Polar Regions and Coasts in Changing Earth System": PACES II

Client	Volume	Period
HELMHOLTZ ASSOCIATION	0.25 M€ for HZG	2014-2018

Relevance to ICUPE

- Long-term atmospheric and snow sampling at AWIPEV station in Ny Ålesund and expedition cruises with German ice breaker *R/V Polarstern*
- Modeling biogeochemical cycling of emerging organic contaminants driven by human impacts and climate changes in the Arctic ecosystem

Description

Context & objectives

Atmospheric long-range transport is a significant route for organic contaminants to reach ecologically sensitive Arctic environment. Organic pollutants are subject to a variety of processes in the Arctic environment such as degradation, bioaccumulation and interaction between the atmosphere, snow, water and soil. Additionally, climate change may significantly influence the transport and environment fate of organic pollutants in the Arctic. This project is focused on studies of long-term trends and atmospheric transport of emerging persistent organic pollutants in the Arctic. Data and feedback from this project may improve models to predict the environmental progression and assess the effect of climate change on the long-range transport and the fate of the emerging organic contaminants in the Arctic ecosystem.

Results

We have reported the air-snow exchange fluxes of neutral poly/per-fluoroalkyl substances (PFASs) in the Arctic (Xie et al., 2015).
Occurrences and temporal trends of organophosphate flame retardants and plasticizers, brominated flame retardants, current-use pesticides and endocrine disrupting chemicals in air and snow have been determined in the Arctic.

4.1.9.4 Relevant Publications

1. Xie, Z., Wang, Z., Mi, W., Möller, A., Wolschke, H., Ebinghaus, R. (2015) Neutral Poly-/perfluoroalkyl Substances in Air and Snow from the Arctic. Scientific Reports, srep08912
2. Wang, Z. Xie, Z., Mi, W., Möller, A., Wolschke, H., Ebinghaus, R. (2015) Neutral Poly/Per-Fluoroalkyl Substances in Air from the Atlantic to the Southern Ocean and in Antarctic Snow. Environ. Sci. Technol. 49(13)., 7770-7775.
3. Zhong, G., Xie, Z., Cai, M., Möller, A., Sturm, R., Tang, J., Zhang, G., He, J., Ebinghaus, R. (2011) Distribution and Air-Sea Exchange of Current-Use Pesticides (CUPs) from East Asia to the High Arctic Ocean. Environ. Sci. Technol., 46, 259-267.
4. Xie, Z., Möller, A., Ahrens, L., Sturm, R., Ebinghaus, R. (2011) Brominated Flame Retardants in Seawater and Atmosphere of the Atlantic and the Southern Ocean. Environ. Sci. Technol. 45, 1820-1826.
5. Xie, Z., Koch, B.P., Möller, A., Sturm, R., Ebinghaus, R. (2011) Transport and fate of hexachlorocyclohexanes in the oceanic air and surface seawater. Biogeosciences 8(9), 2621-2633.

4.1.9.5 Relevant Infrastructure

HZG has about 15 years' experience in sampling and analysis of organic contaminants in the atmosphere, seawater, sediment, arctic snow and biota. State of the art sampling techniques for high-volume sampling of air and seawater in the coastal environment have been developed, validated and applied to sample for various classes of organic contaminants. Analytical methodologies have been developed and validated for a number of legacy and emerging organic contaminants, e.g. alternative brominated flame-retardants (BFRs), poly/per-Fluoroalkyl Substances (PFASs) and current-use pesticides (CUPs).

The HZG group is equipped with following preparatory and analytical techniques:

- Clean room for organic trace analysis
- Liquid/liquid- and liquid/solid-extraction techniques, e.g. solid phase extraction (SPE) or accelerated solvent extraction (ASE, Dionex ASE 350)
- Cleanup- & automated concentration techniques & preparative HPLC (Agilent Technologies, 1260 infinity)
- Gas Chromatography and Mass Spectrometry (GC-MS) (EI, CI), Agilent Technologies 5975
- Gas Chromatography-Triple Quadrupole Mass Spectrometry (GC-MS/MS) (EI, CI), Agilent Technologies 7010
- LC-MS/MS (ESI, APCI), Applied Biosystems API 4000, HPLC Agilent Technologies 1100
- LC-MS/MS (ESI, APCI), Agilent Technologies 6490, (U)HPLC Agilent Technologies 1290

An advanced three-dimensional model system, e.g. the Canadian Model for Environmental Transport of Organochlorine Pesticides (CanMETOP) has been applied to examine atmospheric transport and exchange fluxes of organic contaminants between different phases.

4.1.9.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.10 National Centre for Scientific Research "Demokritos" (NCSR)

4.1.10.1 Organisation Profile

Organisation Description
The National Center for Scientific Research "Demokritos" (NCSR "Demokritos") is the largest multidisciplinary research center in Greece, with critical mass in expertise and infrastructure in the fields of Energy & Environment, Nanotechnology, Biosciences, Particle and Nuclear Science, Informatics and Telecommunications. The NCSR "Demokritos" conducts excellent basic and applied research, for advancing scientific knowledge and promoting technological development in selected areas of national socio-economic interest. The Center also plays a pivotal role in graduate education and professional training, while its unique infrastructure is also providing high-technology services to the Industry and the Society. Current research activities of The Environmental Radioactivity Laboratory (ERL) in the Institute of Nuclear & Radiological Sciences & Technology, Energy & Safety (INRASTES) is strongly focused on the study of physicochemical properties of atmospheric aerosol urban, regional and indoor air quality, radiation protection and exposure to aerosol contaminants with radiological and toxicological interest, impacts on human health, climate change and development of new instrumentation and methodology for aerosol studies. ERL has participated in a number of projects funded by European and national programs. In addition, since 2007 it operates the Demokritos Regional Research Aerosol station, member of the Global Atmosphere Watch (GAW) and ACTRIS networks and since 2016 the Helmos Mt Free Troposphere Aerosol and Climate Change station in Western Greece. Since 2001 it operates instrumentation for measurements and data analysis at the IASOA, GAW and ACTRIS Zeppelin station, Ny Aalesund Svalbard in the European High Arctic for monitoring Black Carbon and Aerosol absorption. It has participated in important campaigns for Black Carbon and aerosol characterization in Svalbard. It also collaborates with FMI and Moscow state University at the Tiksi, Siberia Arctic station and is involved in several campaigns and in situ aerosol data analysis. It reports data within the ACTRIS and ICOS communities and contributes to the Pan Eurasian Experiment (PEEX, www.atm.helsinki.fi/peex/), a multidisciplinary, multi-scale program focused on solving Grand Challenges in northern Eurasia and China. The laboratory is accredited under EN ISO/IEC 17025: 2005 Standard for: i) The sampling and determination of the PM10 fraction of suspended particulate matter and ii) Determination of equivalence of the PM10 samplers for the field-test procedure to demonstrate reference equivalence of measurement methods. iii) the measurement of Pb, Cd, As, and Ni in the PM10 fraction of suspended particulate matter EN14902. Its members contribute to the TC264 WG15 and WG35 committees and to theRegional Programme by IAEA in the application of Nuclear techniques to source apportionment of air pollutants.
Role in ICUPE
NCSR will lead: • Task 1.2 on Improvement of data flow of Near-Real-Time data from in-situ measurement stations NCSR will also contribute to: • WP0 on Management • WP1 on Ground-based component for SLCFs • WP4 on Integrating in-situ, satellite and model components for improved environmental assessment • WP5 on Data provision, interoperability and facilitation of data and services • WP6 on Dissemination and strategic development
On the capabilities matching iCUPE tasks
The NCSR group has experience in • Leading international research and monitoring infrastructures (GAW, ACTRIS, ICOS) with a capacity to perform continuous and comprehensive long-term measurements at critical sites for

atmospheric observations.

- Co-designing research with the stakeholders to address needs and gaps required for maximizing the research impacts and research applicability.
- Participation in campaign and continuous observations of the atmospheric composition in the Arctic areas, including Svalbard, Greenland and Russian Arctic.
- Development of data processing harmonization and provision of interoperable NRT data for Copernicus and GEO applications
- Expertise and capacity to perform Earth System Modeling and particularly combine Atmospheric Models like FLEXPART with respect to back tracking Arctic black carbon to Northern Latitude emissions from flaring in the Arctic areas and lower continental emissions
- NCSR as an organization has experience of participating in several FP7 projects and has gained valuable experience from providing support services to European Research and National stakeholders

4.1.10.2 Staff Profile and their roles in iCUPE

Dr. Konstantinos Eleftheriadis (Male) NCSR (GR)	**Task 1.2 leader, NCSR PI at iCUPE Campaigns** • Research director, aerosol physicist; scientific expertise: over 25 years of research experience related to atmospheric sciences. He leads the experimental aerosol group (size of 12 people) on aerosol physicochemical characterization and development of novel sampling and measurement techniques. He has established and is responsible for the Demokritos Regional Research Aerosol station, member of the Global Atmosphere Watch network (GAW-DEM), operating since 2007. He has been actively involved in European initiatives for the development of standardized methods, through EUSAAR (European Supersites for Atmospheric Aerosol Research) and ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure network) activities. He has also served as an Expert in missions for the Regional IAEA/AFRA project RAF4019 - Developing Air Pollution Monitoring in Urban Zones, where the IAEA has been assisting participating Member States to develop capacity for urban air pollution control. Dr. Eleftheriadis is the QA Manager of ERL according to accreditation certificate No. 447-3 for EN ISO/IEC 17025: 2005 Standard. He has been the PI for Demokritos in several EU FP and National programs, as well as the National Counterpart for Greece in Regional IAEA programs. He has more than 110 publications in peer reviewed journals regarding atmospheric aerosol science, measurement methodology and applications in air pollution and climate impact of atmospheric aerosol. • He has coordinated and participated in a number of projects funded by European and national programs. Among these, he has coordinated the ENTEC Infrastructure REGPOT FP7 programme for Capacity Building the NCSR Demokritos atmospheric science and technology Infrastructure, led the DG-ENV LIFE+ ACEPT-AIR programme and was PI for NCSR in the AIRUSE and LIFE-INDEX programmes. • Since 1998 he has gained access to Large Scale Arctic facilities and run several campaigns at the IASOA, GAW and ACTRIS Zeppelin station, Ny Aalesund Svalbard in the European High Arctic for monitoring Black Carbon and Aerosol absorption. • He collaborates with FMI and Moscow state University at the Tiksi, Siberian Arctic station and is involved in several campaigns and in situ aerosol data analysis including activities of PEEX, • President of the Hellenic Association for Aerosol Research

	• Member of the Pan Eurasian Academy of Sciences
Dr. Evangelia Diapouli (Female) NCSR (GR)	**Contributes to source apportionment and carbonaceous aerosols, QA/QC in data reporting for EC/OC** • Ass. researcher; chemical engineer; has more than 10 years experience in the study of atmospheric aerosol. She is member of the ERL team responsible for the operation of GAW-DEM station and has been participating in ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure network) activities regarding the integration of European aerosol stations; • She has been actively involved in European initiatives on the adoption of standardized methodology for the measurement of carbonaceous aerosol. She has participated in EC-OC measurement inter-comparisons, studies on carbonate carbon determination and interference with EC-OC measurements and development of black carbon reference material. • She is the author or co-author of 36 articles in peer review journals and has presented more than 60 papers in national and international conferences. She has also participated in six EU funded and a number of national funded projects.
Eng. Stergios Vratolis (Male) NCSR (GR)	**Contributes to integration of modelling results and in-situ data with a particular interest on feedbacks and interactions** • Chemical engineer; has research experience in design and operation of experimental measurement systems for the size distribution and physical properties of aerosols, data reporting to ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network) database, combining chemical and physical properties of aerosols in order to estimate their impact on climate and humans. • uses atmospheric transport models (trajectory model HYSPLIT and the lagrangian particle dispersion model FLEXPART) in order to establish source-receptor relationships for the measured quantities at the Athens GAW/ACTRIS Demokritos station and the Mt. Helmos Free troposphere Aerosol and GHG station. • has applied the aforementioned models in order to locate the geographic origin of pollutants in the Danube Region in the framework of the European Commission – Joint Research Center "Danube Air Nexus" project. • co-author of 10 peer reviewed journals regarding aerosol science and applications in atmospheric research.
Dr. Athina-Cerise Kalogridi (Female) NCSR (GR)	**Contributes to in-situ observations, data analysis and reporting** • PhD in Chemical Engineering; post-doctoral scientist with a Master degree in Chemical Engineering from the National Institute of Applied Sciences (INSA) of Rouen in France, and a PhD degree in Geosciences awarded in November 2014 from the the Center of Atomic Energy (CEA) and University Paris XI, France. • She focused her research activity on the quantification of fluxes of volatile organic compounds (VOC) emitted from the biosphere and the understanding of their impact on atmospheric chemistry and ozone production. • Since February 2015, a post-doctoral fellow at NCSR Demokritos, in the framework of research programs funded by the European Commission. Her work is currently related to the study of green house gases and aerosols in urban and remote environments. This includes the continuous monitoring of

	atmospheric pollutants using real-time analytical tools, data processing, and scientific analysis related to environmental assessment. In the framework of the LIFE "INDEX-AIR" project, she is actively participating in the development of an innovative and versatile policy tool that will establish a relation between population exposure to air pollutants and emission sources
Dr. Prodromos Fetfatzis (Male) NCSR (GR)	**Contributes to in-situ observations, data analysis and reporting** • Ass. Researcher, PhD Physics-Optics; physicist from the Univ. of Patras and holds MSc. and PhD from NTUA in experimental physics. He has involved in research topics such as experimental development, simulations, photovoltaic , cosmic ray experiments, instrumentation of optical spectroscopy, interferometry and characterizations using Fabry-Perot, the development of High Spectral Resolution Lidar, atmospheric aerosol measurements, development of statistical algorithms for aerosol data processing, aerosol experiments and calibrations. • He has worked as a Laboratory Associate-Fellow at TEI of Piraeus for 11 years, at the TEI of Athens for 2 years and at the National Technical University of Athens for 6 years, while he has taught at 2 schools. He has participated in 8 research projects, 7 contracts with NCSR "Demokritos", 6 contracts with the NTUA and 1 contract with the Academy of Athens and TEI of Piraeus. He has more than 30 publications in conferences and scientific journals.

4.1.10.3 Relevant Projects

ENTEC: Enhancing the Capacity for Climate Change Research in Southeast Europe (2013-2016) FP7-REGPOT-2011-1. GA No 316173

Client	Volume	Period
	2.8 M€ for NCSR	2013-2016

Relevance to iCUPE

- implementation of the NCSR Action Plan, directly aiming at strengthening the research capacity for advancing its participation in environmental/climate related research activities at European, National and Regional level. Major objectives were:
- Upgrade of the existing research infrastructure, including the recruitment of high level scientific personnel, modernization of existing unique facilities and acquisition of new equipment for two GAW high profile supersites
- Strategic partnership and collaboration between NCSR and renowned research entities in the field of atmospheric and climate research in the ERA. The present action also links cross-cutting research with national policy makers and end users;
- Outreaching of the NCSR scientific achievements and research capacities as a means of increasing visibility of the work and expanding R&D collaborations;
- Pursuit of long-term self-sustainability based on the establishment of appropriate, effective mechanisms that will ensure financial support for the whole spectrum of the proposed R&D activities, also after EnTec.

Proposal Acronym | iCUPE

Description
Context & objectives The emphasis on 'excellent people' is a long-term policy option of INRaSTES, with the provision to support further upgrading their scientific value. At least 22 highly qualified scientists will be recruited and integrated in the R&D activities of INRaSTES. They provided support to current activities and projects but also to advance existing capabilities in high priority research areas. In summary these are: Field sites and laboratory infrastructure establishment and operation; Size-resolved aerosol measurements; Data acquisition, transfer and processing; Chemical analysis and measurements of gaseous pollutants and aerosols; Development and Application of Global / Regional Circulation Models; Downscaling of GCM for regional air pollution simulations and compilation of high resolution emission inventories; Source apportionment and statistical modelling; Climate change and critical infrastructures protection; Multi-risk methodologies for disaster reduction of climatic change; Cyberinfrastructure development and operation. **Results** The improvement of INRaSTES R&D potential was achieved with the acquisition of high quality scientific equipment as a means to support theoretical and modelling activities and also provide external services. Existing and proposed equipment can be used to provide the scientific community, the Local, Regional and National Authorities with high quality data on climatic gases and their properties. Under EnTeC two unique facilities in Greece and South East Europe were introduced: one to measure vertical atmospheric composition in the boundary layer in the suburban region of Attica and one in a free troposphere background. The facilities cover a structural "gray zone" in South-eastern Europe with respect to data collection, analysis, and climate models. **Contribution to regional capacity building** The installation of a unique field monitoring station in the suburban area of Attica in addition to an integrated risk assessment approach from natural hazards. EnTeC will contribute to the development of demand and supply for climatic related R&D services in the region of Attica with obvious benefits to the sector and particularly to SMEs offering or needing such services. In the same context, EnTeC is expected to give rise to the establishment of spin-offs in Attica (and Greece) dealing with this type of activities. **Promotion of Regional R&D activities** The successful EnTeC completion should further enhance the R&D expertise of INRaSTES, to be fully integrated and also to have the ability to lead regional driven activities for the promotion of research in the area of environment and sustainable development. In order to develop, industries and SMEs as competitive business operations in an international operating environment, they need to exploit the R&D capacity and services of highly specialised entities such as INRaSTES. This would allow regional actors to gain an in-depth understanding of the climatic know-how, products and services provided by INRaSTES, in order to promote their strategic development and provided services. and coordination with national strategies in the EU.

Proposal Acronym | iCUPE

ARCFAC: European Centre for Arctic Environmental Research in Ny-Ålesund (ARCFAC V), 2008 EC contract no. 026129 GA:ARCFAC-026129-2008-14

Client	Volume	Period
	12 k€ for NCSR	2008-2010

Relevance to iCUPE

- The aim of the project is to combine physical and chemical measurements of key arctic aerosol parameters, in order to:
- Contribute a well characterised aerosol parameter dataset targeting the state of mixing of fine and ultrafine aerosol particles
- Provide simultaneous observation of the ultrafine aerosol number concentration across the nucleation Aitken and accumulation modes and a limited chemical characterisation of these modes derived from their volatility.
- Perform a closure study on the derived refractory volume distributions and the independent observations of refractory mass calculated from available chemical composition data.
- To explore the existence of non-volatile particle cores or particles in the 5-25 nm range.

Description

Project title: Investigation of Arctic Aerosol Properties with emphasis on the formation and mixing state of cloud condensation nuclei.

Context & objectives

A higher scope for aerosol characterisation was foreseen for the project, when the results are combined with the ongoing measurement programmes already established at Zepellin: Namely the dry aerosol characterisation measurements by the Stockholm University, ITM and the CCN counter operated by the Korean Polar Research Institute. The combined effort is also compatible with the databases organised by NILU and the Research programmes of the Norwegian Polar Institute towards understanding the mechanisms of Climate change in the Arctic. Following discussions with ITM we organised the campaign to commence by the beginning of May so that after an introductory test period, normal operation was scheduled for the whole of June when nucleation events are more frequent (Ström et al., 2003). The volatility tandem DMA system was set-up in the lab at NCSR "Demokritos" and experimental testing included programming of a NI (Labview) module to run the cycle of temperatures for the volatility tube as well as running the first DMA and monitoring Relative Humidity and temperature within the system. Test (NH4)2SO4 polydisperse particles were also generated by a TOPAS ATM220 particle generator and were processed by the Volatility Thermodenuder system. At concentrations close to ambient (N~105 cm-3) we observed elimination of the particle count at 230 0C at a level of 95%, while unchanged size distributions were observed at 30 and 120 0C respectively. This confirms the volatility of (NH4)2SO4 at temperatures in the range of 230 0C. The system was then packed for transport to Svalbard.

Results

In summary, the case-study measurements reported here support the hypothesis that the growth of 12-nm nanoparticles in the summertime high Arctic is driven by mechanisms involving sulfuric acid and ammonia. These particles can account for ~85% of the population during NPF events, six of which were studied here in detail and lasted from 10 – 13 hours each. The remainder is attributed to refractory particles, probably consisting mostly of BC which play a negligible role during the events, but can account for up to 100% of the population during non-event days. Our observations further suggest that the majority

of the sub-40 nm particle population during NPF events does not exist in the form of sulfuric acid but rather as partly or fully neutralized ammoniated sulfates. The fraction of these particles decreases to <15% as particle diameter increases to 200 nm. Considering the observed spatial and temporal extent of NPF events in the summertime high Arctic our observations suggest that ammoniated sulfate nanoparticles may be more ubiquitous in this region than previously thought.

4.1.10.4 Relevant Publications

1. Breider, T.J., Mickley, L.J., Jacob, D.J., Ge, C., Wang, J., Payer Sulprizio, M., Croft, B., Ridley, D.A., Mcconnell, J.R., Sharma, S., Husain, L., Dutkiewicz, V.A., Eleftheriadis, K., Skov, H., Hopke, P.K. Multidecadal trends in aerosol radiative forcing over the Arctic: Contribution of changes in anthropogenic aerosol to Arctic warming since 1980, (2017) Journal of Geophysical Research: Atmospheres, . DOI: 10.1002/2016JD025321
2. Giamarelou, M., K. Eleftheriadis, S. Nyeki, P. Tunved, K. Torseth, and G. Biskos. 2016. "Indirect Evidence of the Composition of Nucleation Mode Atmospheric Particles in the High Arctic." Journal of Geophysical Research: Atmospheres 121 (2): 965-975. doi:10.1002/2015JD023646. www.scopus.com.
3. Uttal, T., Starkweather, S., Drummond, J.R., Vihma, T., Makshtas, A.P., Darby, L.S., Burkhart, J.F., Cox, C.J., Schmeisser, L.N., Haiden, T., Maturilli, M., Shupe, M.D., De Boer, G., Saha, A., Grachev, A.A., Crepinsek, S.M., Bruhwiler, L., Goodison, B., McArthur, B., Walden, V.P., Dlugokencky, E.J., Persson, P.O.G., Lesins, G., Laurila, T., Ogren, J.A., Stone, R., Long, C.N., Sharma, S., Massling, A., Turner, D.D., Stanitski, D.M., Asmi, E., Aurela, M., Skov, H., Eleftheriadis, K., Virkkula, A., Platt, A., Førland, E.J., Iijima, Y., Nielsen, I.E., Bergin, M.H., Candlish, L., Zimov, N.S., Zimov, S.A., O'Neill, N.T., Fogal, P.F., Kivi, R., Konopleva-Akish, E.A., Verlinde, J., Kustov, V.Y., Vasel, B., Ivakhov, V.M., Viisanen, Y., Intrieri, J.M. 2016. "International Arctic Systems for Observing the Atmosphere: An International Polar Year Legacy Consortium." Bulletin of the American Meteorological Society 97 (6): 1033-1056. doi:10.1175/BAMS-D-14-00145.1
4. Eleftheriadis, K., S. Vratolis, and S. Nyeki. 2009. "Aerosol Black Carbon in the European Arctic: Measurements at Zeppelin Station, Ny-Ålesund, Svalbard from 1998-2007." Geophysical Research Letters 36 (2). doi:10.1029/2008GL035741
5. Lappalainen, H.K., Kerminen, V.-M., Petäjä, T., Kurten, T., Baklanov, A., Shvidenko, A., Bäck, J., Vihma, T., Alekseychik, P., Andreae, M.O., Arnold, S.R., Arshinov, M., Asmi, E., Belan, B., Bobylev, L., Chalov, S., Cheng, Y., Chubarova, N., De Leeuw, G., Ding, A., Dobrolyubov, S., Dubtsov, S., Dyukarev, E., Elansky, N., **Eleftheriadis, K.**, Esau, I., Filatov, N., Flint, M., Fu, C., Glezer, O., Gliko, A., Heimann, M., Holtslag, A.A.M., Hõrrak, U., Janhunen, J., Juhola, S., Järvi, L., Järvinen, H., Kanukhina, A., Konstantinov, P., Kotlyakov, V., Kieloaho, A.-J., Komarov, A.S., Kujansuu, J., Kukkonen, I., Duplissy, E.-M., Laaksonen, A., Laurila, T., Lihavainen, H., Lisitzin, A., Mahura, A., Makshtas, A., Mareev, E., Mazon, S., Matishov, D., Melnikov, V., Mikhailov, E., Moisseev, D., Nigmatulin, R., Noe, S.M., Ojala, A., Pihlatie, M., Popovicheva, O., Pumpanen, J., Regerand, T., Repina, I., Shcherbinin, A., Shevchenko, V., Sipilä, M., Skorokhod, A., Spracklen, D.V., Su, H., Subetto, D.A., Sun, J., Terzhevik, A.Y., Timofeyev, Y., Troitskaya, Y., Tynkkynen, V.-P., Kharuk, V.I., Zaytseva, N., Zhang, J., Viisanen, Y., Vesala, T., Hari, P., Christen Hansson, H., Matvienko, G.G., Kasimov, N.S., Guo, H., Bondur, V., Zilitinkevich, S., Kulmala, M. Pan-Eurasian Experiment (PEEX): Towards a holistic understanding of the feedbacks and interactions in the land-Atmosphere-ocean-society continuum in the northern Eurasian region (2016) Atmospheric Chemistry and Physics, 16 (22), pp. 14421-14461. DOI: 10.5194/acp-16-14421-2016

4.1.10.5 Relevant Infrastructures

NCSR manages in collaboration with NILU, Norway the eBC/absorption measurements at the GAW/ACTRIS Zeppelin Mt. Observatory.The observatory is located in the Arctic on Zeppelin Mountain, close to Ny-Ålesund, in the island archipelago of Svalbard. At 79° N, the station is located in an undisturbed arctic environment, away from major pollution sources. Influence from local pollution

sources, such as from the nearby community of Ny-Ålesund is also limited by the observatory's location at 474 metres a.s.l, which means that most of the time it is above the local inversion layer. The unique location of the observatory makes it an ideal platform for the monitoring of global atmospheric change and long-range pollution transport.
NCSR manages its own GAW stations in Greece with full aerosol observation facilities and lab infrastructure included in ACTRIS following the same standard operational procedures and protocls for sampling and data analysis.
NCSR has a MoU with Moscow State University and undertakes analysis of aerosol samples for carbonaceous aerosols and trace metal species at Siberian station Tiksi. Tiksi is located in the Sakha Republic of northern Siberia. It is on the coast of the Arctic Ocean and housed a weather station dating from 1932. In 2005, the Russian Federation's Roshydromet, the U.S. National Oceanic and Atmospheric Administration, the U.S. National Science Foundation and the Finnish Meteorological Institute formed a partnership to establish a new International Hydrometeorological Observatory at Tiksi in support of the International Polar Year (IPY). It continues to operate as a partnership between these entities. The facility's focus is on atmosphere-surface exchanges, radiation, aerosols, and climate-grade meteorological measurements.
The Pan-Eurasian Experiment (PEEX) is a multidisciplinary, multi-scale program focused on solving grand challenges in northern Eurasia and China focusing in Arctic and boreal regions. PEEX will also help to develop service, adaptation and mitigation plans for societies to cope with global change. It is a bottom-up initiative by several European, Russian and Chinese research organizations and institutes with co-operation of US and Canadian organizations and Institutes. The PEEX approach emphasizes that solving challenges related to climate change, air quality and cryospheric change requires large-scale coordinated co-operation of the international research communities. Strong involvement and international collaboration between European, Russian and Chinese partners is needed to answer the climate policy challenge: how will northern societies cope with environmental changes? The promoter institutes of this initiative are the University of Helsinki and the Finnish Meteorological Institute in Finland; the Institute of Geography of Moscow State University, AEROCOSMOS, and the Institute of Atmospheric Optics (Siberian branch) of the Russian Academy of Sciences (RAS) in Russia; the Institute of Remote Sensing and Digital Earth (RADI) of the Chinese Academy of Sciences (CAS) and the institute for climate and global change research of Nanjing University in China. PEEX is built on collaboration by EU, Russian and Chinese parties, involving scientists from various disciplines, experimentalists and modelers, and international research projects funded by European, Russian and Chinese funding programs. The first active PEEX period is 2013–2033, though PEEX will continue until 2100. The first PEEX meeting was held in Helsinki in October 2012. PEEX is open for other institutes to join.

4.1.10.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.11 Paul Scherrer Institute (PSI)

4.1.11.1 Organisation Profile

Organisation Description
The Paul Scherrer Institut (PSI) in Switzerland is a centre for multi-disciplinary research and one of the world's leading user laboratories. With its 1200 employees it belongs as an autonomous institution to the Swiss ETH domain and concentrates its activities on solid-state research and material sciences, energy and environmental research as well as on biology and medicine. The Laboratory of Atmospheric Chemistry (LAC) at PSI consists of about 50 researchers. It has in-depth experience with the design of experiments to characterize physical and chemical properties of aerosols including source apportionment and has a strong interest in the impact of aerosols on climate. The laboratory operates a smog chamber facility for atmospheric chemistry simulation, as well as continuous aerosol measurements at the high Alpine research station Jungfraujoch (3580 m asl) which have been performed within the Global Atmosphere Watch (GAW) program of the World Meteorological Organization (WMO) since 1995. In this capacity, PSI is a partner in the European infrastructure projects ACTRIS2, ACTRIS PPP as well as EUROCHAMP 2020.
Role in ICUPE
PSI will lead: • Task 1.4 on Sources and sinks of atmospheric pollution in the polar areas PSI will also contribute to**:** • WP0 on Management • WP1 on Ground-based component for SLCFs • WP4 on Integrating in-situ, satellite and model components for improved environmental assessment • WP5 on Data provision, interoperability and facilitation of data and services • WP6 on Dissemination and strategic development
On the capabilities matching iCUPE tasks
PSI has experience in • Analyzing long-term data • Mass spectrometry based on-line measurements • Mass spectrometry based off-line analyses of particulate matter on collected filters • Measurements in remote areas including Jungfraujoch and Svalbard • Adapting and applying source apportionment methods

4.1.11.2 Staff Profile and their roles in iCUPE:

Dr. Andre S. H. Prevot (Male) PSI	**Lead of Task 1.4, Contributor to WP1,** • Scientific expertise: over 20 years of research experience related to atmospheric sciences. He leads the gasphase and aerosol chemistry group (around 20 people) with the foci of ambient measurements including mass spectrometric methods source apportionment, aging studies using smog chambers, photochemical transport modelling. • He was involved in guiding 51 PhD student as supervisor or external referee and supervised 18 Postdocs. • He has published more than 270 peer reviewed articles, with total citations of more than 13'000 and h-factor of 55. He is a highly cited researcher (Thomson Reuters) in 2014, 2015, and 2016 (http://highlycited.com/. He is the corresponding author of one Nature, one Science, and one Nature Communication paper.

	• He is teaching in the Masters program of the Environmental Science Department since 10 years. • He was involved in more than 10 EU projects and led more than 20 national projects.
Prof. Urs Baltensperger (Male) PSI	**Contributor to WP1** • Scientific expertise: over 35 years of research experience related to research on atmospheric aerosols. Head of the Laboratory of Atmospheric Chemistry at the Paul Scherrer Institute. He coordinated an FP6 EU project and has been in the steering group of numerous EU projects. He is a member of the presiding Board of the Swiss national Science Foundation. • Professor at ETH Zurich. He has supervised more than 50 PhD theses and is currently supervising 15 on-going PhD theses. • He has published more than 400 peer reviewed articles, including 13 in Nature and Science, with more than 21'000 total citations and an h-factor of 72. He is a highly cited researcher (Thomson Reuters) in 2014, 2015, and 2016 (http://highlycited.com/. • He obtained a number of awards, including the Fellow of the American Geophysical Union (2012), the Vilhelm Bjerknes Award of the European Geosciences Union (2014), the Fuchs Memorial Award of the International Aerosol research Assembly (2014), and the Spears Memorial Award of the Royal Chemical Society (2016).
Dr. Martin Gysel (Male) PSI	**Contributor to WP1** • Scientific expertise: over 10 years of research experience related to atmospheric aerosols. He leads the Aerosol Physics Group (around 10 people) with foci on physical and optical properties of atmospheric aerosols and aerosol-cloud interactions. He was and is involved in guiding 10 PhD students as supervisor or external committee member and supervised 5 postdocs. He has published 84 peer reviewed articles with 4220 citations and H-factor of 36. He is teaching in Masters program of the Environmental Science and Physics Department of ETH Zurich since 3 years. He currently holds an ERC consolidator grant, was/is involved in 8 EU/international projects & led 3 national projects.
Dr. Markus Furger (Male) PSI	**Contributor to WP1** Scientific expertise: More than 20 years of practical experience in atmospheric sciences, especially in field campaigns. Over 10 years experience in XRF measurements of aerosols with synchrotrons. Experience in Soure apportionment. He is and was project leader in three projects dealing with the determination of aerosol trace element composition in various geographical settings (megacities, rural locations, etc.). He is author and co-author of 72 peer reviewed articles with 1282 citations and has an H-factor of 22.
Dr. Nicolas Bukowiecki (Male) PSI	**Contributor to WP1** • Scientific expertise: More than 10 years of practical experience in aerosol science and analytical chemistry. He is responsible for the routine operation, data management and quality assurance of the aerosol data collected at the global GAW / ACTRIS station Jungfraujoch. He is responsible for the technical and scientific twinning with GAW stations in Kenya, Chile, Indonesia and Vietnam. He has 48 peer reviewed articles with 1300 citations and an h-factor of 20.

Mr. Günther Wehrle (Male) PSI	**Contributor to WP1** • Technician in the Laboratory of Atmospheric Chemistry since more than ten years. He is maintaining the instruments and adapts the measurement setups including controls and data acquisition.
PhD student	**Contributes to off-line analyses, source apportionment and writing publications**

4.1.11.3 Relevant Projects

ACTRIS-2 IA European Research Infrastructure for the observation of Aerosol, Clouds, and Trace gases, H2020, Project GA number: 654109

ACTRIS Preparatory Phase Project is a EU Horizon 2020 Coordination and Support Action (grant agreement No 739530).

Client	Volume	Period
	306 k€ for PSI (ACTRIS2) 52 k€ for PSI (ACTRIS PPP)	2015-2019 2017-2019

Swiss Global Atmosphere Watch Programme

Client	Volume	Period
	722 k€ for PSI Proposal for continuation (2018-2021) at similar level in preparation)	2014-2017 2018-2021

Relevance to iCUPE

- Location of long-term measurements in a high-alpine environment where the air pollution characteristics are similar to the Arctic environment
- Provision of high-quality data sets
- Easy testing and quality assessment of newly developed instrumentation

Description

Context & objectives
To provide long-term high quality data on aerosol characteristics at a pristine site
To contribute data towards a better quantification of the impact of aerosols on climate
Results

- More than 20 years of continuous data at a high-elevation site
- First long-term source apportionment of the organic aerosol at such a pristine site world-wide

Proposal Acronym | iCUPE

EUROCHAMP 2020

Client	Volume	Period
	792 k€ for PSI	2016-2020

Relevance to iCUPE

- Testing capacity of new instrumentation in a controlled environment in a wide range of atmospheric conditions.

Description

Context & objectives

Atmospheric simulation chambers are the most advanced tools for elucidating processes that occur in the atmosphere. They lay the foundations for air quality and climate models and also aid interpretation of field measurements. EUROCHAMP-2020 will further integrate the most advanced European atmospheric simulation chambers into a world-class infrastructure for research and innovation. A co-ordinated set of networking activities will deliver improved chamber operability across the infrastructure, as well as standard protocols for data generation and analysis. Outreach and training activities will foster a strong culture of cooperation with all stakeholders and users. Collaborative links will be established with other environmental research infrastructures to promote integration and sustainability within the European Research Area. Cooperation with private sector companies will be actively promoted to exploit the innovation potential of the infrastructure by supporting development of scientific instruments, sensor technologies and de-polluting materials. Trans-national access will be extended to sixteen different chambers and four calibration centres. A new, upgraded data centre will provide virtual access to a huge database of experimental chamber data and advanced analytical resources. Joint research activities will enhance the capability of the infrastructure to provide improved services for users. Measurement techniques and experimental protocols will be further developed to facilitate new investigations on climate change drivers, impacts of air quality on health and cultural heritage, while also stimulating trans-disciplinary research. Advanced process models will be developed for interpretation of chamber experiments and wider use in atmospheric modelling. Overall, EUROCHAMP-2020 will significantly enhance the capacity for exploring atmospheric processes and ensure that Europe retains its place as the world-leader in atmospheric simulation chamber research.

Results

- Provision of reference spectra for specific source profiles, to be used in source apportionment activities in a so far unprecedented way, especially for clean locations.

Proposal Acronym | iCUPE

China Haze Swiss National Science Foundation (SNSF) project in collaboration with the National Natural Science Foundation of China (NSFC)

Client	Volume	Period
	300k€ for PSI	Foreseen: 30.6.2017 – 31.5.2021

Relevance to iCUPE

- Application of similar methods (mass spectrometry on off-line filters) but on filters collected in China
- Development and application of source apportionment methods for such filters

Description

Context & objectives

Measurements at a number of major cities show that the daily average mass concentrations of fine particulate matter (PM2.5) are approximately 1-2 orders of magnitude higher than those observed in urban areas in the US and Europe. To mitigate haze pollution the central and many local governments have released new legislations and set ambitious goals. However, the factors governing particle concentrations in many Chinese cities are poorly constrained, significantly hindering such efforts.

This project is a joint effort between the Laboratory of Atmospheric Chemistry at the Paul Scherrer Institute (PSI), Switzerland and the Key Laboratory of Aerosol Chemistry and Physics at the Institute of Earth Environment, Chinese Academy of Sciences (IEECAS). We will concentrate among other on the following studies:

- Simultaneous offline filter (4 seasons) measurements at six large cities including Beijing, Shijiazhuang, Taiyuan, Zhengzhou, Hefei, and Wuhan. This will provide spatial and detailed characterization of the chemical composition and sources of PM and OA. Results of spatial variations will help to better understand the sources and evolution of PM and provide useful datasets for these cities to take effective control strategies.
- One-year online measurements at Beijing and Xi'an (including one-month intensive measurements) with a set of sophisticated instruments (e.g., time-of-flight aerosol chemical speciation monitoring, ToF-ACSM). This will provide diurnal/seasonal characterization of chemical nature (e.g., oxidation state) and sources of OA, with a particular focus on the constraint of the source of SOA.

This joint research project is expected to significantly advance our knowledge of the sources and atmospheric evolution of PM in China. In particular, the spatial and temporal characterization of the PM sources and physicochemical properties will provide unprecedented datasets for improved model simulation of the impact of PM and SOA on haze formation, air quality, climate, and human health. The project will also foster the existing collaboration between the two partners. Publications (>10 papers) of the results in peer-reviewed and high-profile journals are expected. The obtained knowledge will also promote the public's awareness of environmental protection and be useful for policy makers to examine the current strategies for air pollution control.

Results This joint research project is expected to significantly advance our knowledge of the sources and atmospheric evolution of PM in China. In particular, the spatial and temporal characterization of the PM sources and physicochemical properties will provide unprecedented datasets for improved model simulation of the impact of PM and SOA on haze formation, air quality, climate, and human health. The project will also foster the existing collaboration between the two partners. Publications (>10 papers) of the results in peer-reviewed and high-profile journals are expected. The obtained knowledge will also promote the public's awareness of environmental protection and be useful for policy makers to examine the current strategies for air pollution control.

4.1.11.4 Relevant Publications

1. Huang, R. J., Y. L. Zhang, C. Bozzetti, K. F. Ho, J. J. Cao, Y. M. Han, K. R. Daellenbach, J. G. Slowik, S. M. Platt, F. Canonaco, P. Zotter, R. Wolf, S. M. Pieber, E. A. Bruns, M. Crippa, G. Ciarelli, A. Piazzalunga, M. Schwikowski, G. Abbaszade, J. Schnelle-Kreis, R. Zimmermann, Z. S. An, S. Szidat, U. Baltensperger, I. El Haddad, and A. S. H. Prevot (2014) High secondary aerosol contribution to particulate pollution during haze events in China, Nature, 514(7521), 218-222.
2. Bukowiecki, N., E. Weingartner, M. Gysel, M. C. Coen, P. Zieger, E. Herrmann, M. Steinbacher, H. W. Gaggeler, and U. Baltensperger (2016) A review of more than 20 years of aerosol observation at the High Altitude Research Station Jungfraujoch, Switzerland (3580 m asl), Aerosol and Air Quality Research, 16(3), 764-788.
3. Daellenbach, K. R., C. Bozzetti, A. Křepelová, F. Canonaco, R. Wolf, P. Zotter, P. Fermo, M. Crippa, J. G. Slowik, Y. Sosedova, Y. Zhang, R. J. Huang, L. Poulain, S. Szidat, U. Baltensperger, I. El Haddad, and A. S. H. Prévôt (2016) Characterization and source apportionment of organic aerosol using offline aerosol mass spectrometry, Atmos. Meas. Tech., 9(1), 23-39.
4. Canonaco, F., M. Crippa, J. G. Slowik, U. Baltensperger, and A. S. H. Prevot (2013) SoFi, an IGOR-based interface for the efficient use of the generalized multilinear engine (ME-2) for the source apportionment: ME-2 application to aerosol mass spectrometer data, Atmospheric Measurement Techniques, 6(12), 3649-3661.
5. Bozzetti, C., Y. Sosedova, M. Xiao, K. R. Daellenbach, V. Ulevicius, V. Dudoitis, G. Mordas, S. Bycenkiene, S. Bycenkiene, K. Plauskaite, A. Vlachou, B. Golly, B. Chazeau, J. L. Besombes, U. Baltensperger, J. L. Jaffrezo, J. G. Slowik, I. El Haddad, and A. S. H. Prevot (2017) Argon offline-AMS source apportionment of organic aerosol over yearly cycles for an urban, rural, and marine site in northern Europe, Atmospheric Chemistry and Physics, 17(1), 117-141.

4.1.11.5 Relevant Infrastructure

In this project the most relevant infrastructure consists of an Aerodyne aerosol mass spectrometer using electron ionization and the off-line setup described in Daellenbach et al. (2016). In addition we will acquire a new Long time-of-flight atmospheric pressure inlet mass spectrometer which will allow for the detection of organic molecules with less fragmentation due to soft ioniziation with e.g. Na^+. This was recently successfully tested with normal time-of-flight instrument. New instrument will be 50% available during the time of the project. 30% depreciation of the instrumental costs will be charged to the project.

For initial testing of the method we will compare on-line and off-line measurements for measurements at the Jungfraujoch with similarly low levels as in the Arctic. This will also aid the initial development and optimization of the soft ionization offline analysis method. For this purpose we will use the facilities at the Jungfraujoch where PSI has been operating instrumentation (mostly related to aerosol measurements) continuously since 1995 within the Global Atmosphere Watch programme, or EU projects like SINGADS (FP4), CREATE (FP5), EUSAAR (FP6), ACTRIS (FP7), and ACTRIS-2 (Horizon-2020), among others.

4.1.11.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.12 Leibniz Institute for Tropospheric Research (TROPOS)

4.1.12.1 Organisation profile

Organisation Description
The Leibniz Institute for Tropospheric Research (TROPOS, www.tropos.de) is an independent research institution with about 150 employees and is member of the Leibniz Association, one of the German non-university research organizations. The institute has a well-defined research profile with focus on aerosol and clouds. The expertise ranges from physical and chemical laboratory studies, large field experiments in which in-situ and remote-sensing techniques from ground and on aircraft are applied, to numerical modelling of cloud processes and aerosol transport. TROPOS has been an active or leading partner in many international projects related to atmospheric clouds and aerosols in the research fields of air pollution and climate. The TROPOS research station Melpitz is jointly operated by the Departments of Atmospheric Chemistry, Experimental Aerosol and Cloud Microphysics, and Remote Sensing of Atmospheric Processes, which all contribute to ACTRIS. The Leibniz Institute for Tropospheric Research (TROPOS) investigates the physical and chemical properties of natural and anthropogenic aerosols and their interaction with clouds. The research of TROPOS aims at fundamental process understanding concerning the life cycle of atmospheric aerosol particles, their physical and chemical processing, as well as their role in cloud and ice formation, under natural and laboratory conditions. Thereto, highly sophisticated experimental techniques in both field and laboratory together with complex high-resolution modelling are applied. In a broader perspective, TROPOS aims at understanding and quantifying the importance of atmospheric aerosols in general and in relation to dynamical effects in particular, as well as identifying and quantifying aerosol-related environmental risks. In other words, TROPOS elucidates the role of aerosols in the tropospheric and climate system. The department for Experimental Aerosol and Cloud Microphysics of TROPOS is a world-leading center for aerosol and cloud in-situ observations. Over the past two decades, it has contributed to the field with new and innovative technologies and methodologies, e.g. for in-situ measurements of particle size distribution, humidity-dependent and absorption properties, and mixing state of aerosols. The institute has been involved in a large number of international field studies and performs continuous observations at stations worldwide. Beside the ACTRIS site Melpitz, microphysical in-situ aerosol characterizations are conducted at GAW stations such as Cape Verde Observatory, Point Barrow and Danum Valley and within the German Ultrafine Aerosol Network (GUAN), which all deliver data to the World Data Center for Aerosols at NILU, Norway. Furthermore, TROPOS hosts the WMO-GAW World Calibration Center for Aerosol Physics (WCCAP), which is responsible for the quality assurance of microphysical aerosol parameters in the networks GAW, ACTRIS and GUAN. TROPOS is involved in all ACTRIS-2 activities related to aerosol and trace-gas in-situ measurements and vertical profiling of aerosol and clouds. TROPOS contributes significantly to the central facilities of ACTRIS with its WMO-GAW World Calibration Center for Aerosol Physics (WCCAP) as part of the European Center for Aerosol Calibration (ECAC), which is also led by TROPOS. WCCAP hosts approximately 80-100 national, European and international users per year. In addition, Melpitz is also one of the core observational sites for ACTRIS-2, where in-situ and remote-sensing studies on absorption are perfomed. TROPOS is one of the three founding members of CARIBIC (Civil Aircraft for the Regular Investigation of the atmosphere Based on an Instrument Container), which developed over the years into one of the two columns of the ESFRI landmark IAGOS (In-Service Aircraft for a Global Observing System, www.iagos.org). In IAGOS, passenger aircraft are used as platform for regular observation of the free troposphere and the tropopause region. In the Arctic framework, TROPOS is one main partner in the German Research Iniative 'Arctic Amplification' (AC^3, http://www.ac3-tr.de) which has been established to identify, investigate, and evaluate the key processes contributing to Arctic Amplification, improve our understanding of the major

feedback mechanisms, and quantify their relative importance for Arctic Amplification. In Phase I the research will focus on atmospheric and surface processes, because the ongoing rapid changes in the Arctic climate imply that mechanisms involve important atmospheric influences. In the Phases II and III the interactions between oceanic and atmospheric components in Arctic Amplification and related global aspects will be addressed in more detail. The combination of observational and modelling studies aims to improve future projections of Arctic climate development.

Role in ICUPE

TROPOS will lead:

- Task 1.3 on Interactions with planned intensive observations in the polar regions

TROPOS will also contribute to**:**

- WP0 on Management
- WP1 on Ground-based component for SLCFs
- WP5 on Data provision, interoperability and facilitation of data and services
- WP6 on Dissemination and strategic development

On the capabilities matching iCUPE tasks

The TROPOS group has experience in

- Participation in international research and monitoring infrastructures (ACTRIS, GAW, IAGOS-CARIBIC) with a capacity to perform continuous and comprehensive long-term measurement sites for atmospheric observations.
- Harmonization of large data sets and standardization of measurement procedures
- Participation in campaigns of the atmospheric composition in the Arctic areas, including Nordic countries.
- Development and modification of new instruments for airborne and mobile applications
- Expertise and capacity to perform to perform and coordinate experiments, data collection and harmonized analysis
- Calibration and quality check of aerosol measuring instruments from Research infrastructures ACTRIS and ACTRIS 2 using the World Calibration Center for Aerosol Physics (WCCAP, WMO-GAW)

4.1.12.2 Staff Profile and their roles in iCUPE:

Dr. Birgit Wehner (Female) TROPOS	**Task 1.3 leader** • Senior scientist in the Department of Experimental Aerosol and Cloud Microphysics at TROPOS and holds a PhD in Atmospheric physics (2000) about physical aerosol measurements in the urban atmosphere. • Worked as guest scientist at Peking University in Beijing, China and at NCAR, Boulder, USA, the latter one with an ASP-fellowship. • The field of expertise covers the formation of aerosol particles, their physical properties, such as mixing state and optical properties, the development and modification of aerosol measurement technique as well as the interaction between aerosol particles and clouds. • She is an expert for airborne measurements of aerosol particles, the development and characterization of instruments and the organization of measurement campaigns. Over the last 15 years she was involved in field campaigns in China, Netherlands, Barbados, Greece, USA and more. She is actively involved in the European Infrastructure ACTRIS, in German network activities as well as in the World Calibration Center for Aerosol Physics (WCCAP) of WMO-GAW hosted at TROPOS.

	• She is author or co-author of 90 peer reviewed publications with 3875 citations (H-index 36). She was leading several national research projects and participated in a number of international campaigns and projects. She was supervising 4 PhD students and approximately 15 master students until now. • Birgit Wehner is member of the board of GAeF (Gesellscchaft für Aerosolforschung), chair of the working gropup 'Atmospheric Aerosols' with the EAA (European Aerosol Association) and speaker of all working groups within EAA.
Prof. Alfred Wiedensohler (Male) TROPOS	**Contributions to data analysis, quality assurance and harmonization of aerosol data** • (PhD Electrical Engeneering in 1983) is head of the Department of Experimental Aerosol and Cloud Microphysics. He has gained >30 years of experience in aerosol in-situ technology, atmospheric process studies and long-term observations. • head of the World Calibration Centre for Aerosol Physics of WMO-GAW and the European Center for Aerosol Calibration in ACTRIS-2. • Within the ACTRIS research infrastructure he has been responsible for in-situ chemical, physical and optical properties of aerosols and leads the European Center for Aerosol Calibration. • published >350 articles (h-factor 64) with more than 14000 citations and is highly cited scientist (Thompson Reuters). • member of the WMO-GAW Scientific Advisory Group and served in the Scientific Steering Committees of ACCENT, EUSAAR, EUCAARI, and ACTRIS.
Dr. Markus Hermann (Male) TROPOS	**Contributes to the development of new measurement technique for vertical aerosol measurement to be applied in the Arctic** • has been working in the field of atmospheric sciences since 1994. Currently - deputy group leader of aerosol group in the Department of Experimental Aerosol and Cloud Microphysics at TROPOS. • expert for airborne aerosol instrumentation and has developed small and light particle instruments for that purpose. His scientific focus are in situ particle measurements in the free troposphere, where he has more than 20 years of experience. • more than two decades, he is the PI for the particle number and size distribution measurements in IAGOS-CARIBIC European Research Infrastructure. • scientific steering committees for the German research aircraft HALO and for SSiRC (SPARC activiy) and chairs the TROPOS scientific council.

4.1.12.3 Relevant Projects

ACTRIS-2 IA European Research Infrastructure for the observation of Aerosol, Clouds, and Trace gases, H2020, Project GA number: 654109 **ACTRIS Preparatory Phase Project is a EU Horizon 2020 Coordination and Support Action (grant agreement No 739530).**		
Client	**Volume**	**Period**
	0.789 M€ for TROPOS (ACTRIS2) 0.313 M€ for TROPOS (ACTRIS PPP)	2015-2019 2017-2019

Investigating the Small-Scale Vertical and Horizontal Variability of the Atmospheric Boundary Layer Aerosol using Unmanned Aerial Vehicles		
Client	**Volume**	**Period**
German Science Foundation	113 k€ for TROPOS	2017 - 2020
Relevance to ICUPE		
Vertical measurements of aerosol parameters are required and still rare. Data will be distributed via ERA PLANET and can be used for validation of remote sensing and satellite measurements.		
Description		
Context & objectives In the sope of this projectements vertical aerosol measurements will be performed in the Arctic environment 2017 – 2020. Here, unmanned aerial vehicles (UAV) are equipped with aerosol measurement technique which suitable for operation at low temperatures. A field campaign will be performed in 2018 in Ny Alesund to investigate the horizontal and vertical variation of the concentration of aerosol particles and new particle formation.		

Arctic Amplification: Climate relevant atmospheric and surface processes and feedback mechanisms		
Client	**Volume**	**Period**
German Science Foundation	~1 M€ for TROPOS	2017 -
Relevance to ICUPE		
Provides a very comprehensive data set covering nearly all aspects of atmospheric measurements. Intensive ship-based and air-borne measurements will provide new insides into the sensitive Arctic climate system. Data will be available for ERA Planet and will be complemented by additional measurements and studies. Big German initiative on Arctic measurements providing the option to combine it with other European activities.		
Description		
Context & objectives The Transregional Collaborative Research Centre TR 172 (www.ac3-tr.de/) funded by German Science foundation (DFG) provides a unique research environment to study the increase of Arctic near-surface		

temperature during the last decades, which is commonly referred to as Arctic Amplification, from complementary viewpoints, bridging various observations and modelling approaches. University of Leipzig, as the coordinating University has applied together with the University of Bremen, University of Cologne and the Alfred-Wegener Institute for Polar and Marine Research, and the Leibniz Institute for Tropospheric Research for support of this research project. The overarching scientific objective of TR 172 is to identify, investigate, and evaluate the key processes contributing to Arctic Amplification, improve our understanding of the major feedback mechanisms, and quantify their relative importance for Arctic Amplification.

4.1.12.4 Relevant Publications

1. Altstädter, B., Platis, A., Wehner, B., Scholtz, A., Wildmann, N., Hermann, M., Käthner, R., Baars, H., Bange, J., and Lampert, A.: ALADINA – an unmanned research aircraft for observing vertical and horizontal distributions of ultrafine particles within the atmospheric boundary layer, Atmos. Meas. Tech., 8, 1627–1639, 2015. Zieger, P., Aalto, P.P., Aaltonen, V., Äijälä, M., Backman, J., Hong, J., Komppula, M., Krejci, R., Laborde, M., de Leeuw, G., Pfüller, A., Rosati, B., Tesche, M., Tunved, P., Väänänen, R. and Petäjä, T. (2015) Low hygroscopic scattering enhancement of boreal aerosol and the implications for a columnar optical closure study, Atmos. Chem. Phys. 15, 7247–7267.
2. Wiedensohler, A., W. Birmili, A. Nowak, A. Sonntag, K. Weinhold, M. Merkel, B. Wehner, T. Tuch, S. Pfeifer, M. Fiebig, A. M. Fjaraa, E. Asmi, K. Sellegri, R. Depuy, H. Venzac, P. Villani, P. Laj, P. Aalto, J. A. Ogren, E. Swietlicki, P. Williams, P. Roldin, P. Quincey, C. Huglin, R. Fierz-Schmidhauser, M. Gysel, E. Weingartner, F. Riccobono, S. Santos, C. Gruning, K. Faloon, D. Beddows, R. M. Harrison, C. Monahan, S. G. Jennings, C. D. O'Dowd, A. Marinoni, H. G. Horn, L. Keck, J. Jiang, J. Scheckman, P. H. McMurry, Z. Deng, C. S. Zhao, M. Moerman, B. Henzing, G. de Leeuw, G. Loschau, and S. Bastian (2012), Mobility particle size spectrometers: harmonization of technical standards and data structure to facilitate high quality long-term observations of atmospheric particle number size distributions, Atmospheric Measurement Techniques, 5(3), 657-685.
3. Wehner, B., F. Werner, F. Ditas, R. A. Shaw, M. Kulmala and H. Siebert, Observations of new particle formation in enhanced UV irradiance zones near cumulus clouds, Atmos. Chem. Phys., 15(20), 11701-11711, 2015.
4. Hermann, M. , C. A. M. Brenninkmeijer, F. Slemr, J. Heintzenberg, B. G. Martinsson, H. Schlager, P. J. van Velthoven, A. Wiedensohler, A. Zahn, H. Ziereis (2008). Submicrometer aerosol particle distributions in the upper troposphere over the mid-latitude North Atlantic - Results from the third route of "CARIBIC". Tellus, 60B(1), 106-117.

4.1.12.5 Relevant Infrastructure

TROPOS hosts the WMO-GAW World Calibration Center for Aerosol Physics (WCCAP), which is responsible for the quality assurance of microphysical aerosol parameters in the networks GAE, ACTRIS and GUAN.

TROPOS owns a tethered balloon, which will be launched in the Arctic in 2017 for the first. The balloon is capable to lift approximately 8 kg to a maximum height of 1.5 km and can be equipped with different payloads. More applications within the framework of ERA-Planet are possible and planned.

4.1.12.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

4.1.13 Stockholm University (SU)

4.1.13.1 Organisation profile

Organisation Description
Stockholm University (**SU**) is a leading European university and one of the world's top 100 institutions of higher education and research. SU has more than 60,000 students and 5,000 staff. Stockholm University College was founded in 1878 as a bold project, a modern university in the spirit of enlightenment, with the aim of serving society. SU continues to build on this foundation as an open, innovative, and dynamic university, maintaining fundamental academic values and protecting academic freedom. In a changing and globalised world, SU contributes to a sustainable democratic society with a long-term vision, based on a solid scientific foundation that evolves constantly through the search for new knowledge. SU has identified "Climate, seas and environment" as one of its strategic leading research areas. Climate, seas and environment are all part of the Earth's natural system. Understanding how they work and areaffected by humans requires a systematic approach and interdisciplinary working methods. Reflecting the high standards for its environmental research, SU was ranked fifth in the world by the Shanghai Academic Ranking of World Universities in the subject area "Environmental Science and Engineering" in 2016. The research environment at Stockholm University is also in an internationally leading position when it comes to the Arctic region. The Department of Environmental Science and Analytical Chemistry (ACES) is a multidisciplinary department that gathers scientists from diverse fields in the natural sciences to study environmental phenomena. An additional focus on analytical chemistry allows ACES to incorporate state-of-the-art instruments and methods into our education and research. With some 215 faculty, researchers, doctoral students and support staff from over 30 countries, ACES thrives in an open research environment that fosters in-house collaboration and provides a stimulating milieu for staff and students. In addition to the core responsibilities in research, education and outreach, ACES is strongly engaged in supporting government agencies, such as the Swedish Environmental Protection Agency, the Swedish Chemicals Agency and the Swedish Agency for Marine and Water Management among others. The research at ACES spans across five major areas: chemical contaminants, atmospheric research, biogeochemical cycles of carbon and nutrients, ecotoxicology, and analytical chemistry. Extensive facilities for chemical analysis, characterization of atmospheric composition and aquaria experimentation as well as several modelling platforms and research stations spanning from the tropics to the Arctic are key to research at ACES. ACES is also a key partner in the multidisciplinary Bert Bolin Centre for Climate Research.
Role in ICUPE
SU will lead: • Task 4.4 on Impact assessment and future exposure scenarios of pollutants in the Arctic SU will also contribute to: • WP0 on Management • WP1 on Ground-based component for SLCFs • WP4 on Integrating in-situ, satellite and model components for improved environmental assessment • WP5 on Data provision, interoperability and facilitation of data and services • WP6 on Dissemination and strategic development
On the capabilities matching iCUPE tasks
The SU team has experience in: • Modeling the global fate and transport of persistent organic pollutants under climate change scenarios as a contribution to the ARCRISK EU-FP7 project. • Leading the integration of modeling and measurement data as co-lead authors of the chapter on

POPs prepared for the 2010 Assessment Report of the Task Force on Hemispheric Transport of Air Pollutants (TF-HTAP) under the Convention on Long-Range Transboundary Air Pollution.

- Integrating modeling and measurements to assess long-range transport of POPs as lead authors of the long-range transtport chapters of the 2016 reports on effectiveness evaluation of the Stockholm Convention that were submitted on behalf of the Western Europe and Other Groups (WEOG) region, and as co-lead authors of the global synthesis report that was submitted to the Stockholm Convention Secretariat in 2017.
- Experience in process modeling of atmospheric phase transitions involving the uptake and transport of pollutants by atmospheric particulate matter.
- Long-term observations of e.g. atmospheric composition, meteorological conditions and cloud properties in the Arctic at the Zeppelin station in Ny Ålesund.
- Earth System Modeling studies on the interlinkages between air pollution (in the mid-latitudes and within the Arctic) and the Arctic climate.
- Extensive experimental and modeling activities investigating the mechanisms and feedbacks governing Arctic amplification and sea ice extent through the ACAS project funded by Knut and Alice Wallenberg foundation (2017-2022).
- Development of a modeling platform for realistic description of deposition mechanisms of atmospheric organic pollutants through the AtmoRemove project funded by Knut and Alice Wallenberg foundation (2016-2021).

4.1.13.2 Staff Profile and their roles in iCUPE

Prof. Hans-Christen Hansson (Male) SU	Hans-Christen Hansson is professor in Air pollution at the department of Environmental Science and Analytical Chemistry, Stockholm University with a 30 year long career in science. His research is mostly within larger projects directed towards investigations of the life cycle of the atmospheric particles, later especially how atmospheric particles influence the radiation budget. Influence on health is also a concern, which drives his involvement connecting urban research with the regional focused research. In this he as been acting as advisor to the Swedish EPA and participated in expert groups e.g. within EMEP/CLRTAP. HC Hansson has an extensive international network through his participation in more than 15 major international projects and is co-chair of ILEAPS (Integrated Land-Ecosystem-Atmosphere Process Study) a core project within Future Earth. He is also a member of the Swedish Royal Academy of Science National committee on Global Environmental Change and editor in chief for the open access peer-review international journal TELLUS B.
Prof. Matthew MacLeod (Male) SU	Matthew MacLeod is Professor of Environmental Chemistry at the Department of Environmental Science and Analytical Chemistry at Stockholm University. He is the lead developer of the Berkeley-Trent (BETR) multimedia modeling framework that is the basis for the BETR Global contaminant fate and transport model. BETR Global is one of only two global scale models that have contributed scientific results in support of the POPs protocol of the CLRTAP convention and the Stockholm Convention since 2010. He has participated in the work of the Task Force on Hemispheric Transport of Air Pollutants (TF HTAP) and on the drafting teams that compiled the 2nd Effectiveness Evaluation Reports of the Stockholm Convention for Western Europe and Other Groups (WEOG) and at the global level.
Prof. Ilona Riipinen (Female) SU	Ilona Riipinen is a professor in atmospheric research and the head of the atmospheric science unit of ACES. Her research interests include atmospheric phase transition processes, aerosol-cloud interactions, air

	quality and global climate. The methods used in her research range from molecular scale simulations to global climate models. She has published nearly 120 research articles in international peer-reviewed journals, and was nominated as one of the Thomson Reuters Highly Cited Researchers in 2016. She has received several awards for her work on atmospheric organic aerosol, such as the Sheldon K. Friedlander award, Schmoluchovski award and the IUGG early career scientist award. She has served in the boards of American Association for Aerosol Research (AAAR), Nordic Society for Aerosol Research (NOSA), SITES ecosystem measurement infrastructure and the board of the University of Helsinki.

4.1.13.3 Relevant Projects

Air quality influence of past and future climate change, Swedish Research Council Formas

Client	Volume	Period
formas The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning	Total volume of approximately 0.3 M€ for SU	2017-2019

Relevance to iCUPE

Earth system model studies on the links between past and future air quality measures and climate, with a focus on the Arctic climate

Description

The overarching goal is to entangle how anthropogenic emissions of Short Lived Climate Pollutants (SLCP), i.e. aerosols (including sulfates, black carbon and organic carbon), methane, ozone and other climate forcing air pollutants from different regions of the world (Europe, North America, North and South East Asia) affect the global climate and the different regions, specifically the Arctic.
The purpose is twofold; firstly to further investigate the key processes behind the Arctic amplification (i.e. that the Arctic is currently warming two to three times faster than the rest of the globe) and secondly to investigate how anthropogenic SLCP emission reductions in different regions of the world more generally affect past and future warming trends in different regions.
The Arctic amplification is still not well understood (see below in the survey of the research area). And thus the present models cannot be expected to give a fully reliable projection on the influence of SLCP on the Arctic climate. This project will in close cooperation with The Norwegian Meteorological Institute participate in the development of the new version of the Norwegian Earth System Model (NorESM) and by model experiment and evaluation with observations of climate relevant atmospheric data reveal and investigate the driving processes behind the Arctic amplification.
NorESM, will be used to evaluate how past emissions of the different regions of the Northern Hemisphere have affected the climate, especially in the Arctic. Air Quality regulations have forced strongly decreased emissions of sulfate, black carbon, ozone precursors and other air pollutants in Europe and North America while in other parts the emissions have increased especially in strongly developing economies. It is of importance for the future work within CLRTAP and other organizations focused on air quality regulation to protect environment and humans, but especially for organizations as AMAP and CCAC concerned with regulation of SLCPs to reduce climate change in especially endangered areas as the Arctic. NorESM will also be used for climate projections using different applicable emission scenarios for the different regions.

AtmoRemove, Knut and Alice Wallenberg Foundation		
Client	**Volume**	**Period**
Knut and Alice Wallenberg Foundation	Total volume of approximately 0.8 M€ for SU	2016-2021
Relevance to iCUPE		
Development of new approaches for describing the wet scavenging and removal of atmospheric pollutants by clouds		
Description		
The air we breathe is a natural resource whose composition is critical for human and ecosystem health. Atmospheric particulate matter is an important driver for both air quality and global climate, as well as a vehicle for the spreading of contaminants in the environment. While significant effort has been put into understanding the sources and atmospheric processing of these aerosol particles, the processes through which they are removed from the atmosphere are much more poorly understood. The proposed research program addresses this currently overlooked topic in an innovative way, with a focus on atmospheric organic compounds. We will constrain the removal of organic particulate pollutants and their precursors by clouds, precipitation and wet surfaces, using a combination of molecular scale simulations and modeling of the dynamic cloud-formation processes. We will develop novel computational approaches to simplify these non-linear processes and better represent them in state-of-the-art air quality and climate models with reasonable computational cost, leading to improved estimates of the amount and properties of atmospheric particulate matter and its effects on air quality, pollutant deposition and climate. These improvements are necessary for evaluating the consequences of different political choices regarding e.g. emission standards, energy policies, land-use and urban planning.		

4.1.13.4 Relevant Publications

1. Acosta Navarro, J., Varma, V., Riipinen, I., Seland, Ø., Kirkevåg, A., Struthers, H., Iversen, T., Hansson, H.-C., and Ekman, A. M. L., 2016. Amplification of Arctic warming by past air pollution reductions in Europe, *Nature Geosci.*, 9, 277–281.
2. MacLeod, M.; Riley, W. J.; McKone, T. E., Assessing the influence of climate variability on atmospheric concentrations of polychlorinated biphenyls using a global-scale mass balance model (BETR Global). *Environmental Science & Technology* 2005, 39 (17), 6749-6756.
3. MacLeod, M.; Chapter 5.3: Long range transport. In: Global Monitoring Plan for Persistent Organic Pollutants Under the Stockholm Convention Article 16 on Effectiveness Evaluation. 2nd Regional Monitoring Report of the Western Europe and Others Group (WEOG) Region. 2015. http://doi.org/10.13140/RG.2.1.3627.4726. (Last accessed April 6 2017).
4. Riipinen, I., Yli-Juuti, T., Pierce, J. R., Petäjä, T., Worsnop, D. R., Kulmala M., Donahue, N. M. 2012. The contribution of organics to atmospheric nanoparticle growth. *Nature Geosci.*, 5, 453.
5. Wöhrnschimmel, H.; MacLeod, M.; Hungerbuehler, K., Emissions, fate and transport of persistent organic pollutants to the Arctic in a changing global climate. *Environmental Science & Technology* 2013 47 (5) 2323–2330.

4.1.13.5 Relevant Infrastructure

ACES hosts a wide range of facilities relevant for iCUPE. The experimental facilities include laboratory facilities with state-of-the-art mass spectrometric techniques (including e.g. FIGAERO-CIMS for simultaneous analysis of the gas and particle phases in atmospheric air), two Orbitrap mass spectrometers as well as extensive gas and liquid chromatography laboratories. ACES also hosts several field sites relevant for iCUPE such as the Norunda site in Southern Sweden, and the Zeppelin Arctic observatory in

Ny Ålesund. The modeling infrastructure relevant for iCUPE include e.g. the chemical transport and Earth System models developed and used at the atmospheric science unit (PMCAMx and NorESM) as wel as the BETR model developed by Prof. MacLeod. For extensive model calculations, ACES hosts a local cluster Fafner but collaborates also closely with the Swedish National Supercomputing Centre NSC and the Swedish National Infrastructure for Computing SNIC. Publication and dissemination of data is facilitated e.g. through the Bolin Centre database.

4.1.13.6 Third parties involved in the project (including use of third party resources)

No third parties involved.

5 Ethics and Security

5.1 Ethics

The scientific focus of the proposal is to provide novel insights and observational data on global grand challenges with a polar focus, a topic, which has economic, ecological, political, or ethical perspectives. The project is examining the environmental questions also having high ethical impact for the sustainable development of the Polar regions. The project partners are in bringing forward knowledge about climate variability, climate change and adaptation to climate change. The research approach of the project will follow the European standards of ethical principles in its tasks and outcomes ensuring equality, quality and integrity in all conductions.

The iCUPE utilizes an integrated approach combining in-situ observations, satellite remote sensing and multi-scale modeling. As an important part of the work, we conduct atmospheric observations in Russia and use data available from Tomsk, central Siberia, Russia via collaboration between IOA-SB RAS, CNRS and UHEL. The acquirement, storage and openness of the iCUPE data are based on the requirements and guidelines of the participating partner institutions. The partners are addressing the important to adhere to ethical norms in research related to aspects of knowledge, truth, avoidance of error, falsifying, misrepresenting research data promote the truth and minimize error. The collaboration with Russian partners is based on well-established contacts by the beneficiaries through bi-lateral projects and contacts.

We have performed a brief analysis of these issues and present it in the Ethical Annex below.

<u>Ethical Annex for iCUPE:</u>

The proposed project targets to provide novel insights and observational data on global grand challenges with a polar focus. Project “iCUPE - integrative and Comprehensive Understanding on Polar Environments” is motivated by the fact that the role of polar regions will increase in terms of megatrends such as globalization, new transport routes, demography and use of natural resources consequent effects of regional and transported pollutant concentrations. The iCUPE utilizes an integrated approach combining in-situ observations, satellite remote sensing and multi-scale modeling.

This annex provides information on the ethical considerations applicable to all research projects involving work conducted in third (non-EU) countries. As an important part of the work, we propose to conduct atmospheric observations in Russia, as presented in the “integrative and Comprehensive Understanding on Polar Environments” project proposal WP1 and WP4. Data from Hyytiälä will be compared with data available from Tomsk (central Siberia, Russia) via collaboration between IOA-SB RAS, CNRS and UHEL. In the WP4 the aim is to develop methodologies for the integration of in situ measurements, satellite data and models for improved environmental assessment of Arctic pollutants.

Needs of the country and benefits of the research where part of the research is carried out

Activities, such as pollution and climate change will put the fragile Arctic environment and the population living in this area into a vulnerable position. The Russian Siberia is experiencing these rapid changes as well.

Proposal Acronym | iCUPE

In the Siberia, the sources of trace gases and aerosols are very poorly known so researching and improving pollution source estimation will also benefit the polar areas of Russia.

1) the project is scientifically sound

The project is projecting research beyond-the-state-of-the-art in terms of integrating in-situ observations, satellite remote sensing and multi-scale modelling. The proposed project is scientifically sound and feasible.

2) compliance with EU/national legislature

The scientific work by the PI and his team is conducted according to EU and national legislations and internationally accepted guidance documents.

Other relevant ethical issues?

Based on our analysis, there are no other relevant ethical issues to consider.

5.2 Security

The project iCUPE does not involve any issues raising security issues as indicated in the table below.

Please indicate if your project will involve:

Activities or results raising security issues:	**N**
'EU-classified information' as background or results:	**N**