Overview of the current status of Arctic NRT measurements, including NEXTGEOSS and CAMS 84 projects, M1.2.1

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

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

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

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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, O3) 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.

Geo Cold Regions Initiative (GEOCRI)

The activities conducted in GEOCRI are grouped into six thematically overarching Tasks: 1) Infrastructures, 2) **Monitoring Network and Data, 3) In-situ and Remote Sensing Integration**, 4) User Engagement and Communication, 5) Capacity Building and Knowledge Transfer, and 6) Management and Monitoring.

1.1. **NEXT GEOSS COLD REGIONS pilot action.**

This pilot has a focus on showcasing examples of products for selected areas in Cold Regions, combining remote sensing data, in situ data and model products from relevant European infrastructures and international frameworks. The products are made available through the NextGEOSS Data Hub, for users and stakeholders in the GEO community, polar research and education.

- An initial list of products includes:

1. Sea ice type and drift maps for the Fram Strait, based on Sentinel-1 SAR data
2. Sea ice concentration for the Arctic, based on satellite altimeter and passive microwave data
3. CMEMS product Arctic Ocean physics analysis and forecast product

4. Near-surface atmospheric aerosol properties (near-real-time) at Zeppelin station, Svalbard (All electrical and data infrastructure is new and upgrade with Near-Real-Time measurements at Svalbard)

5. Near-surface atmospheric aerosol properties (near-real-time) at Troll station, Queen Maud Land, Antarctica

6.C AMS aerosol optical depth forecast product. Additional products are defined in dialogue with stakeholders during the course of the project, in close collaboration and dialogue with users and stakeholders in the GEO community

- **Selected areas in Cold Regions: the Arctic/Svalbard region,**Antarctica,The Himalayan glaciers

- Data:

Atmosphere products from observation networks such as WMO Global Atmosphere Watch (GAW) and Global Cryosphere Watch (GGW).
Atmosphere products, including model forecasts, from Copernicus Atmosphere Monitoring Service (CAMS)

- Context:

GEO Cold Regions coordinates global efforts to provide Earth Observation (EO) products and services to science, decision- and policy-makers with a vested interest in the cryosphere (in particular) and the environment (in general) of polar regions and mountain areas around the world. The NextGEOSS Cold Regions Pilot focuses on three areas: (1) the Arctic/Svalbard region, (2) Antarctica, and (3) the Himalayan glaciers, and addresses the existing shortage in accessing in situ data in GEOSS. The pilot liaise with ongoing initiatives such as SIOS, GEO-CRI, WMO GCW, as well as national programs in Antarctica

- CONSORTIUM PARTNERS: NERSC, NILU, BLB
- EXPECTED OUTCOME:

The products resulting from this pilot can be used to develop Information Services for the Cold Regions Initiative, using the NextGEOSS system and making use of existing interoperability standards. The focus of the pilot is on linking together satellite and in situ data from the targeted regions, including the atmospheric, marine, and terrestrial domains, and make them available in the NextGEOSS Data Hub and the Global Cold Regions Community Portal

CAMS

The Copernicus Atmosphere Monitoring Service (http://atmosphere.copernicus.eu, CAMS) is a component of the European Earth Observation programme Copernicus. The CAMS global near-**real time (NRT) service provides daily analyses and forecasts** of reactive trace gases, greenhouse gases and aerosol concentrations

Key CAMS NRT products and their users are:

- Boundary conditions for regional air quality models (e.g. AQMEII, air quality models not participating in CAMS);
- Long range transport of air pollution(e.g. LRTAP)
- Stratospheric ozone column and UV (e.g. WMO, DWD)
- 3D ozone fields (e.g. SPARC).

Service themes are: air quality & atmospheric composition, climate forcing, ozone layer and UV.

We focus on the 'o-suite' composition fields, which are the daily analyses and forecasts produced by the IFS (Integrated Forecast System) modelling system at ECMWF, using the available meteorological and atmospheric composition observations which are ingested in the ECMWF 4D-Var assimilation system.'o-suite' composition fields: We furthermore assess the impact of the composition observations by comparing the validation results from the 'o-suite' to a 'control' configuration without assimilation. Also, the pre-operational high-resolution forecasts of CO2 and CH4 are assessed in this report. The o-suite data delivery for the period March - May 2018 (MAM 2018) was good, with an availability of 98.9% at 10 and 22 utc (two forecasts per day).

As outlined in the MACC-II Atmospheric Service Validation Protocol (2013) and MACC O-INT document (2011), relevant user requirements are quick looks of validation scores, and quality flags and uncertainty information along with the actual data. This is further stimulated by QA4EO (Quality Assurance Framework for Earth Observation, http://www.qa4eo.org) who write that “all earthobservation data and derived products is associated with it a documented and fully traceable quality indicator (QI)”. It is our long-term aim to provide such background information. The user is seen

as the driver for any specific quality requirements and should assess if any supplied information, as characterised by its associated QI, are "fit for purpose" (QA4EO task team, 2010). CAMS data are made available to users as data products (grib or netcdf files) and graphical products from ECMWF, accessible through the catalogue on http://atmosphere.copernicus.eu/.

Table 1.1: Overview of the trace gas species and aerosol aspects discussed in this CAMS near-real time validation report. Shown are the datasets assimilated in the CAMS analysis (second column) and the datasets used for validation, as shown in this report (third column). Green colors indicate that substantial data is available to either constrain the species in the analysis, or substantial data is available to assess the quality of the analysis. Yellow boxes indicate that measurements are available, but that the impact on the analysis is not very strong or indirect (second column), or that only certain aspects are validated (third column).

Species, vertical range	Assimilation	Validation
Aerosol, optical properties	MODIS Aqua/Terra AOD PMAp AOD	AOD, Ångström: AERONET, GAW, Skynet, MISR, OMI, lidar, ceilometer
Aerosol mass (PM10, PM2.5)	MODIS Aqua/Terra	European AirBase stations
O_3, stratosphere	MLS, GOME-2A, GOME-2B, OMI, SBUV-2, OMPS	Sonde, lidar, MWR, FTIR, OMPS, ACE-FTS, OSIRIS, BASCOE and MSR analyses
O_3, UT/LS	MLS	IAGOS, ozone sonde
O_3, free troposphere	Indirectly constrained by limb and nadir sounders	IAGOS, ozone sonde
O_3, PBL / surface		Surface ozone: WMO/GAW, NOAA/ESRL-GMD, AIRBASE
CO, UT/LS	IASI, MOPITT	IAGOS
CO, free troposphere	IASI, MOPITT	IAGOS, MOPITT, IASI, TCCON
CO, PBL / surface	IASI, MOPITT	Surface CO: WMO/GAW, NOAA/ESRL
NO_2, troposphere	OMI, partially constrained due to short lifetime	SCIAMACHY, GOME-2, MAX-DOAS
HCHO		GOME-2, MAX-DOAS
SO_2	GOME-2A, GOME-2B (Volcanic eruptions)	
Stratosphere, other than O_3		NO_2 column only: SCIAMACHY, GOME-2
CO_2, surface, PBL		ICOS
CO_2, column	GOSAT	TCCON
CH_4, surface, PBL		ICOS
CH_4, column	GOSAT, IASI	TCCON

System performance in the Arctic The CAMS model runs are validated using surface ozone measurements from the ESRL-GMD and the IASOA networks (7 sites) and ozone concentrations in the

free troposphere and the stratosphere are evaluated using balloon sonde measurement data. Both runs strongly overestimates surface ozone values at most of the Arctic stations with relative biases up to +60% to +80% in March - May. This large positive model offset is related to the chemistry scheme in the CAMS global system, which does not contain the halogen reactions to capture the ozone depletion events (ODE) that occur in spring. An exception from this pattern is the results from Svalbard, where due to the position of the station on a mountaintop ODE are only rarely recorded, and Summit, at the enter of the Greenland ice sheet, where ODE does not occur. In other seasons, the CAMS ozone simulations are generally in good agreement with the observations. Copernicus Atmosphere Monitoring Service CAMS84_2015SC3_D84.1.1.12_2018MAM_v1 - CAMS global validation report Page 9 of 134 Ozone concentrations in the free troposphere are in excellent agreement with observations with very low relative bias, whereas the control run underestimate concentrations up to -20%. In the stratosphere, the o-suite has a low positive bias of 3-9% for the Arctic sites, whereas the bias for the control run is 8-15%. Comparison with FTIR observations from the NDACC network shows that the CO tropospheric columns are underestimated at the arctic sites with up to 10%, while the assimilation has a positive effect on the correlation coefficient. Comparison MOPITT versions 7 shows that modeled CO total columns are in good agreement with the satellite retrievals with low bias in the Arctic (±10%).

Air quality and atmospheric composition

Tropospheric ozone (O3)

Tropospheric Nitrogen dioxide (NO2)

Tropospheric Carbon Monoxide (CO)

Formaldehyde

Aerosol

Near-Real-Time Data Reporting on EBAS

The near-real-time (NRT) scheme aims at collecting, processing, and disseminating data of selected instrument types latest within 3 hours, while the target turnover time is 1 h. This future-oriented service is targeted towards validation of weather forecast models that include atmospheric aerosol, as well as expected forecast products on air quality and health effects. Current users of the service include the European Centre for Medium-Range Weather Forecast (ECMWF).

The NRT scheme collects, processes, screens, and disseminates data automatically without regular human intervention. It is therefore expected and accepted that NRT data has a higher uncertainty than manually quality assured regularly reported data. NRT data are protected by their own data policy. Instruments currently supported include:

- Integrating nephelometer, measuring the aerosol particle scattering coefficient (TSI 3563, ECOTECH).
- Filter absorption photometer, measuring the aerosol particle absorption coefficient (Magee AE31 & AE33, Thermo 5012, various PSAP types).

- Electrical mobility size spectrometers, measuring the aerosol particle number size distribution.

NRT data are submitted in level 0 format, where they are processed to level 1.5 and published (for terminology, see page on data levels). To participate in the NRT scheme, please undertake the following steps:

- Set up an automatic routine generating hourly level 0 data files for your instrument. These should have the same time resolution as normal level 0 files, but should start and end at the turn of an hour.
- Send example of file to ebas@nilu.no for iterating out errors
- Provide information about instrument design if necessary.
- Receive FTP upload account for your station.
- Set up and activate an automatic hourly FTP upload to the account.
- For a few instrument types, data acquisition software is provided that can be used at the station to collect the data from the instrument, display them, write them to storage, and upload them automatically to the NRT service. Please refer to the Software Tools For questions, e.g. on how to generate the level 0 files automatically, please contact ebas@nilu.no, or download a presentation.

Focus on real-time correction algorithm for improved near-real time data of aerosol black carbon

For an accurate estimation of radiative forcing, a rigorous quantification of the atmospheric BC load is therefore a prerequisite, but remains a challenging task, especially in the Arctic region where concentrations can easily be below or close to the detection limits. A widely used technique to measure light absorption of aerosol particles is the use of filter-based absorption instruments such as the Aethalometer. However, the estimations from filter-based techniques have substantial uncertainties due to multiple scattering of light in the filter fibers, as well as aerosol loading effects.

•The multiple- cattering effects caused by the scattering by the filter fibers and by aerosol particles on the filter

•shadowing effect, called filter loading: reduces the optical path length in the filter an depends on the amount and optical properties of the deposited particles (negative bias)

In that context, differences in the loading and scattering artefacts on the filter-based measurements of aerosol absorption for different types of aerosols are investigated from measurements at The Zeppelin Observatory at Svalbard in the untouched Arctic Environment.

Objective : real-time correction algorithm for improved near-real time data of aerosol black carbon

- Near-real time loading compensation: using The “dual-spot” Aethalometer: (Drinovec et al., 2015)

- Investigation of appropriate C_0 value to be used for real-time correction of the shadowing effect in the arctic environment. (C_0 calculated by using MAAP absorption coefficients as reference λ=637nm).Harmonizes attenuation coeff. With light absorption coeff.as measured by co-located light absorption photometers (MAAP) (A-C. Kalogridis, M. Fiebig, G. Močnik, T. Muller, R. Krejci, M. Gini, K. Eleftheriadis, 2019; Backman et al., 2017)

- Investigation of mass absorption coefficient (MAC) is also required to infer the equivalent black carbon (eBC) mass concentration from measurements of the light absorption coefficient.

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