



PAN EURASIAN EXPERIMENT (PEEX)
— TOWARDS A NEW MULTINATIONAL, MULTIDISCIPLINE
CLIMATE, AIR QUALITY AND ENVIRONMENT
RESEARCH EFFORT IN ARCTIC AND BOREAL
PAN-EURASIA REGIONS



INAR

Online integrated meteorology-chemistry- aerosols regional/subregional/urban scale modelling

by Alexander Mahura

Institute for Atmospheric and Earth System Research (INAR) / Physics
Faculty of Science, University of Helsinki (UHEL), Finland

&

In linkage with multiple research projects and collaboration with many colleagues

SPBU & UHEL virtual-meeting & discussions

24 April 2020

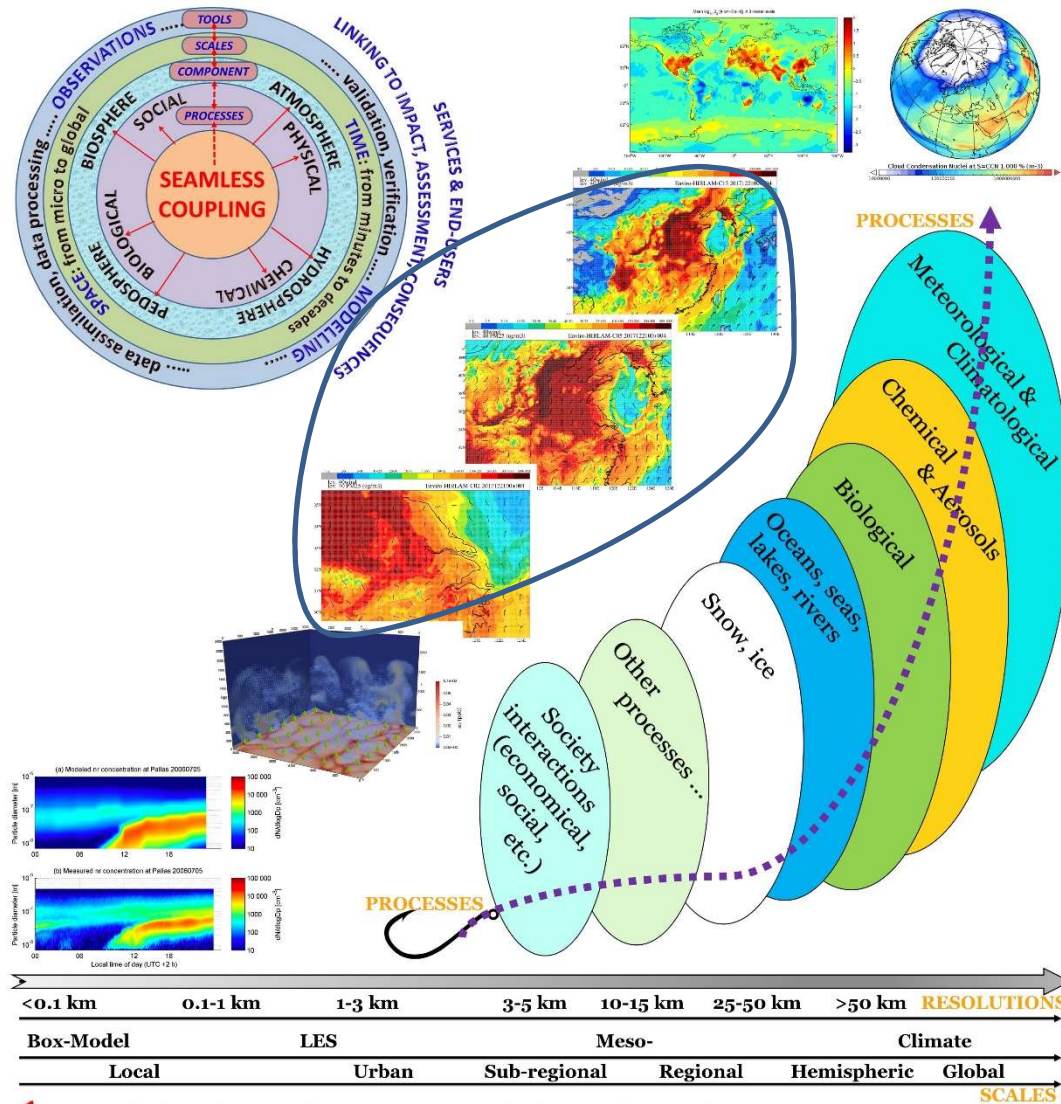
Helsinki, Finland / St. Petersburg, Russia



Multi-Scale & -Processes Modelling at INAR



PAN EURASIAN EXPERIMENT (PEEX)
 TOWARDS A NEW-GENERATIONAL, MULTI-SCALE
 CLIMATE, AIR QUALITY AND ENVIRONMENT
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 PAN-EURASIAN REGIONS



RESEACRH TOOLS & PARTNERS
 EC-Earth, Enviro-HIRLAM, ASAM, SOSAA, MALTE-box
 IT Center for Science
 (CSC, Finland; <https://www.csc.fi>)
 European Center for Medium-range Weather Forecasting
 (ECMWF, UK; <https://www.ecmwf.int>)

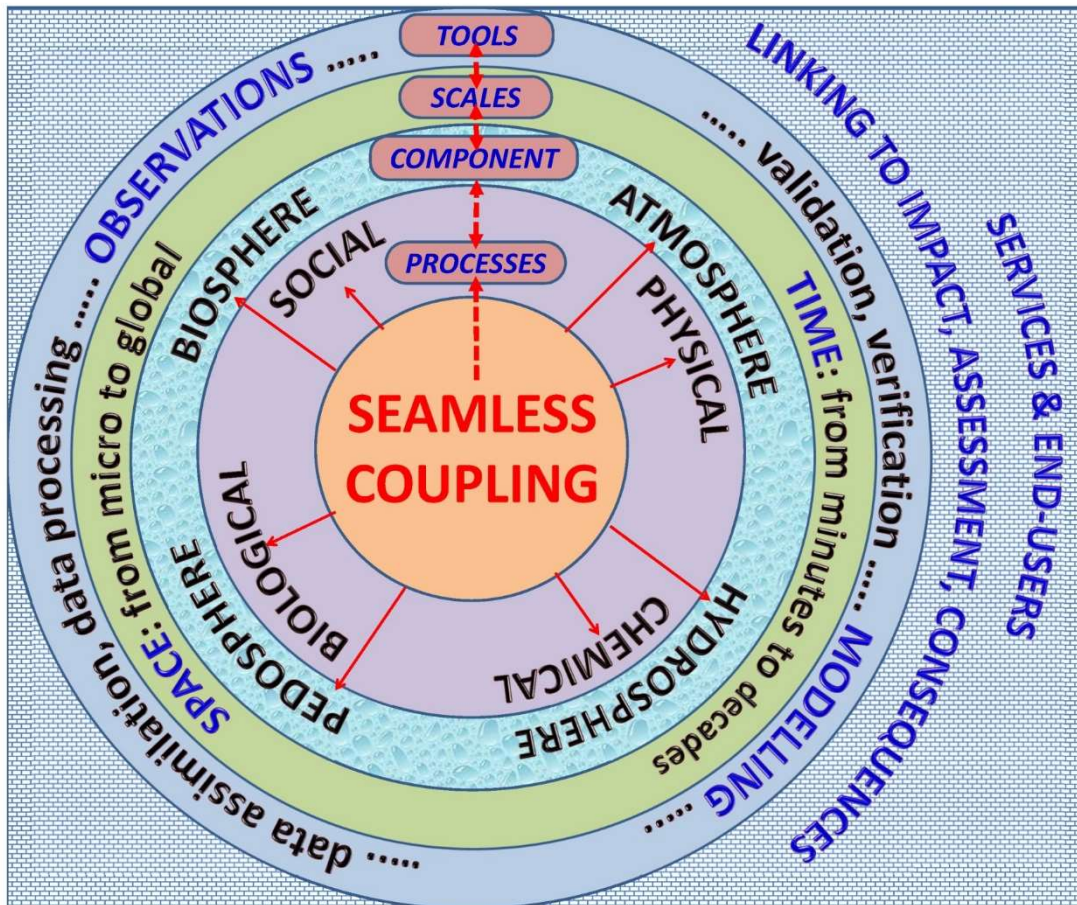


Grid-cell COMPUTATIONAL TIME
 HELSINGIN YLIOPISTO
 HELSINGFORS UNIVERSITET
 UNIVERSITY OF HELSINKI
 MATEMAATTIS-LUONNONTIETEELLINEN TIEDEKUNTA
 MATEMATISK-NATURVETENSKAPLIGA FAKULTETEN
 FACULTY OF SCIENCE

From the poster at the INAR kick-off-meeting (Helsinki, Finland), Jan 2018



Seamless approach considers several dimensions of the coupling



- i) **Time scales** (from minutes and nowcasting till decades and climate time-scale);
- ii) **Spatial scales** (from street till global scales with downscaling and upscaling methods);
- iii) **Processes**: physical, chemical, biological, and social;
- iv) **Earth system components**: atmosphere, hydrosphere, pedosphere, ecosystems/ biosphere;
- v) Different types of **observations** and **modelling tools**: data processing and data assimilation, validation and verification of modelling results; and
- vi) **User-oriented** integrated systems and **impact based forecasts and services**.

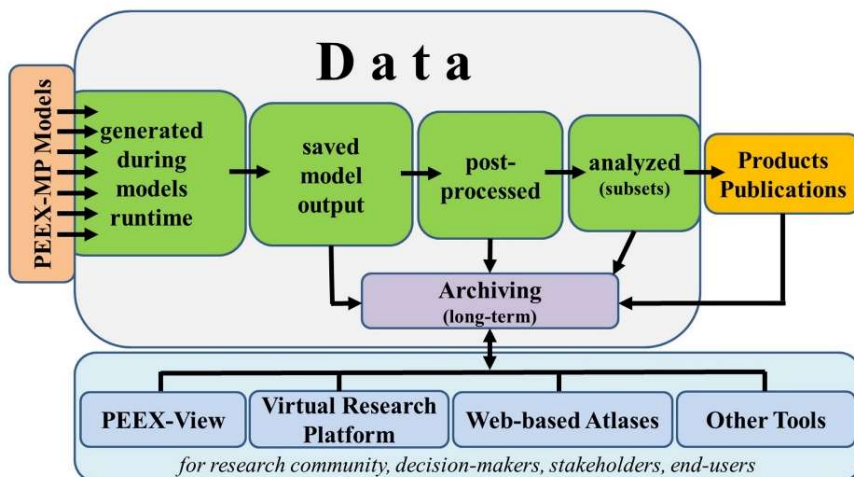
=> New generation of seamless models integrated with observations

PEEX-MP Models as Research Tools

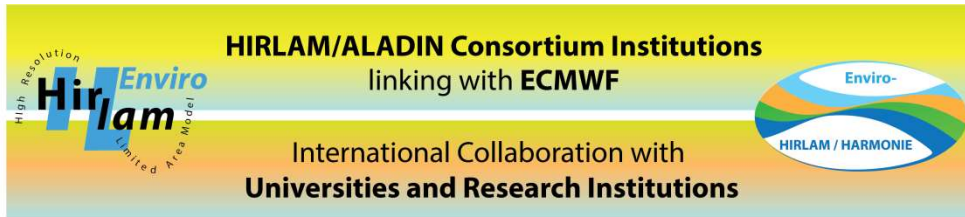


<https://www.atm.helsinki.fi/peex/index.php/modelling-platform>

- PEEX-Modelling-Platform (PEEX-MP) Overview
- Modelling Tools & Demonstration
- PEEX-MP Meetings & Sessions

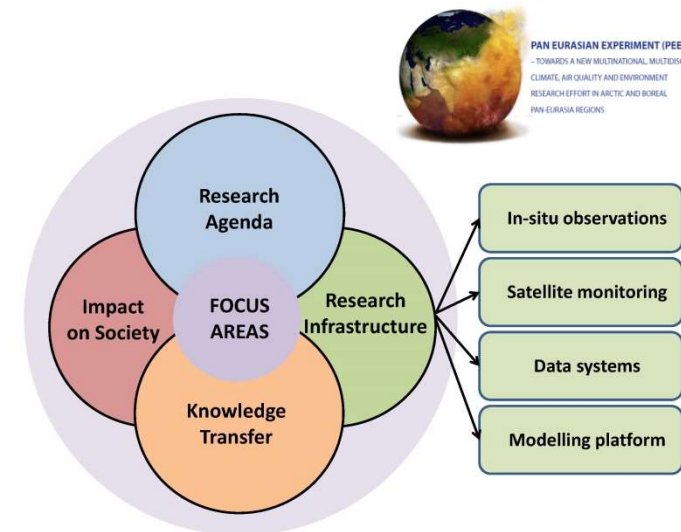


ATMOSPHERE	HYDROSPHERE	PEDOSPHERE	BIOSPHERE	PHYSICAL	CHEMICAL	BIOLOGICAL	PEEX-MP Models
XXX				XXX	XXX		HadGEM2-ES
XXX	XXX	XXX		XXX	XXX		Enviro-HIRLAM
XXX	XXX		XXX	XXX	XXX	XXX	SILAM
XXX	XXX			XXX	XXX		FLEXPART
XXX				XXX	XXX		DERMA
XXX	XXX		XXX	XXX	XXX	XXX	SOSAA
XXX	XXX			XXX			HYCOM-CICE
XXX			XXX	XXX	XXX	XXX	CH4MOD
XXX				XXX			SWAN
XXX			XXX	XXX	XXX	XXX	Argo-C
XXX	XXX			XXX			GLOBO/BOLAM/MOLOCH
XXX		XXX	XXX	XXX		XXX	AVIM2
XXX	XXX	XXX	XXX	XXX	XXX	XXX	EC-Earth
XXX				XXX	XXX		UCLALES-SALSA
XXX				XXX	XXX		CTDAS
XXX			XXX	XXX	XXX	XXX	SIM-BIM
XXX				XXX	XXX		TOMCAT-GLOMAP
XXX				XXX	XXX		CAM-Chem
XXX	XXX			XXX	XXX		MPI-ESM
XXX	XXX	XXX	XXX	XXX	XXX	XXX	CESM
XXX	XXX			XXX	XXX		PALM
XXX				XXX			LESNIC
XXX			XXX	XXX	XXX	XXX	EmpBVOC
XXX				XXX			HBM
XXX				XXX	XXX		WRF-Chem
XXX				XXX	XXX		DNDC-HONO
XXX				XXX	XXX		GEOS-Chem
XXX	XXX	XXX	XXX	XXX	XXX	XXX	CNMM-DNDC
XXX	XXX		XXX	XXX			SUEWS
XXX				XXX	XXX		ATMES
XXX				XXX			MMAD&IT
XXX				XXX	XXX		IMDAF
XXX				XXX	XXX		EurCTM



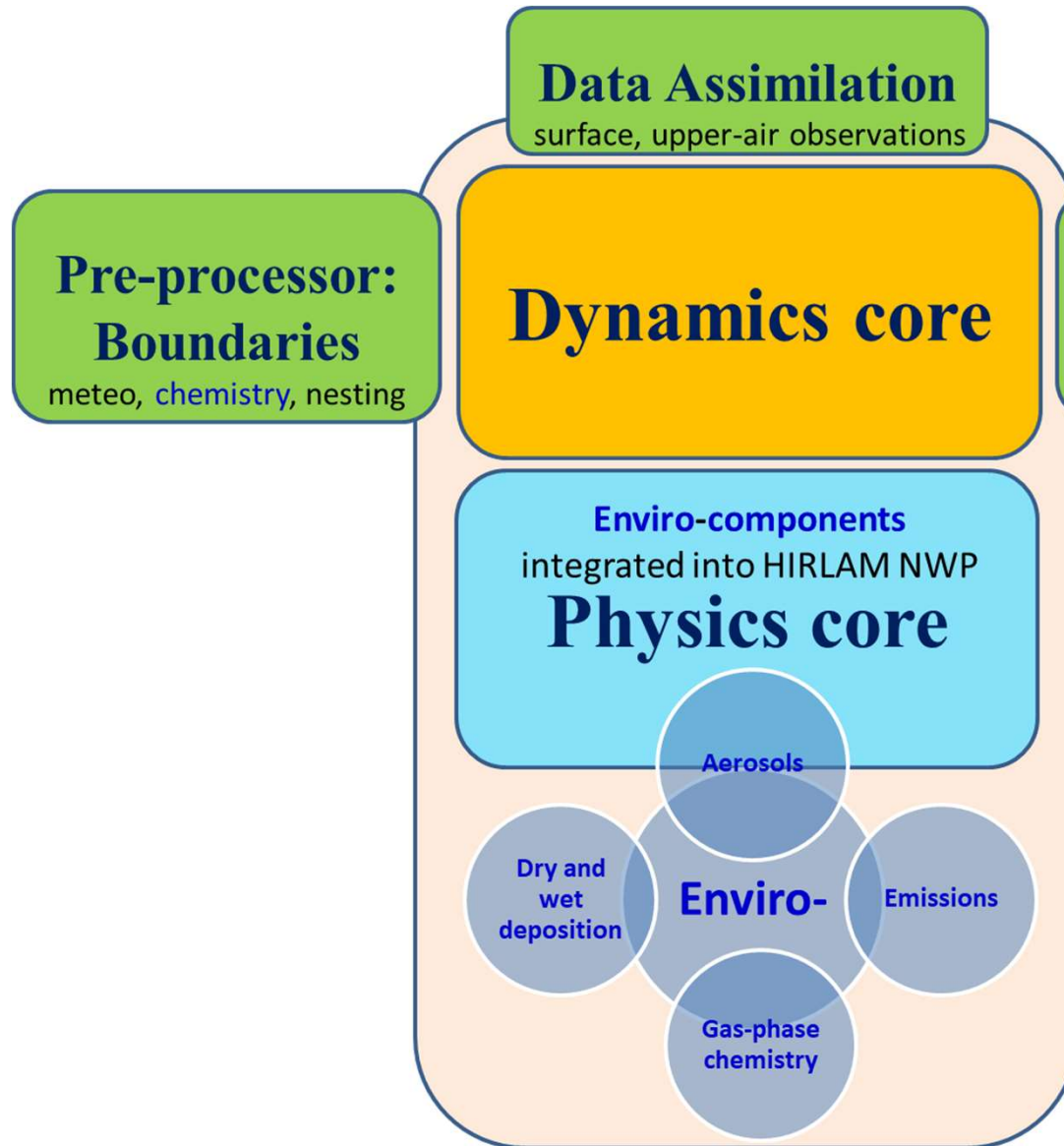
Enviro-HIRLAM/ HARMONIE (EnviroHH)

*(Collaboration, Research and
Development, Science
Education, Dissemination, New
Products and Applications)*



**Enviro-HIRLAM linkage to the PEEEX-
Modelling Platform**

Enviro-HIRLAM (Environment – High Resolution Limited Area Model)



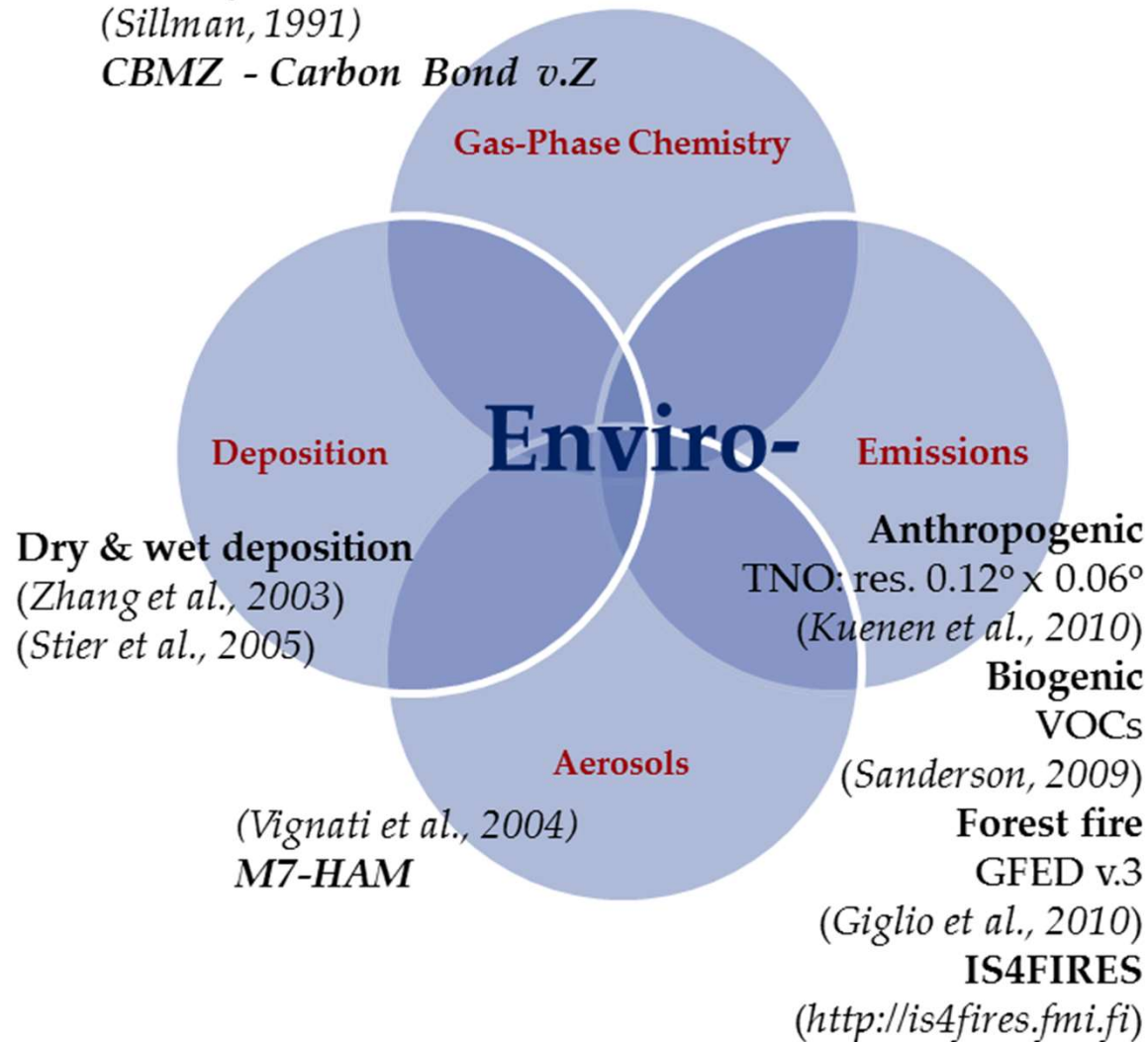
- **Seamless / online coupled integrated meteorology-chemistry-aerosols downscaling modelling system for predicting weather and atmospheric composition**

(Baklanov et al., 2017) most recent overview of the modelling system

Components of Enviro-HIRLAM

(Zaveri and Peters, 1999);
 (Shalaby et al., 2012);
 (Sillman, 1991)

CBMZ - Carbon Bond v.Z



Enviro-HIRLAM research and development team

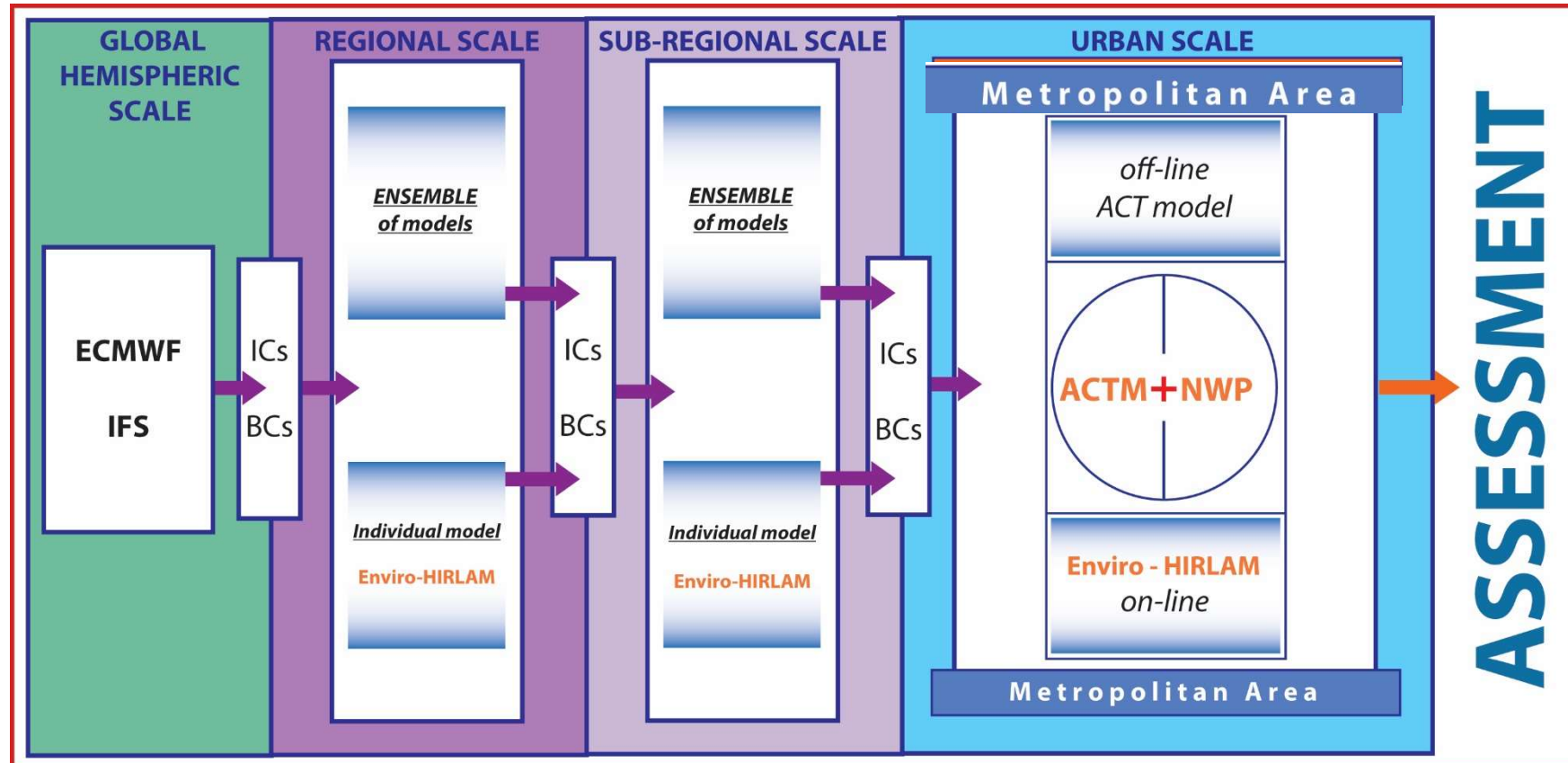
Baklanov et al., 2002-...;
Korsholm et al., 2006-2010;
Mahura et al., 2004-...;
Nuterman et al., 2007-...;

& many other colleagues through collaboration (Denmark, Russia, Ukraine, Kazakhstan, Baltic States, Spain, Turkey, etc.)

Note: emission datasets used depend on research projects:
 MEGAPOLI, TRANSPHORM, PEGASOS, MarcoPolo, EnsCLIM, CarboNord, etc.

Components of the Enviro-HIRLAM modelling system

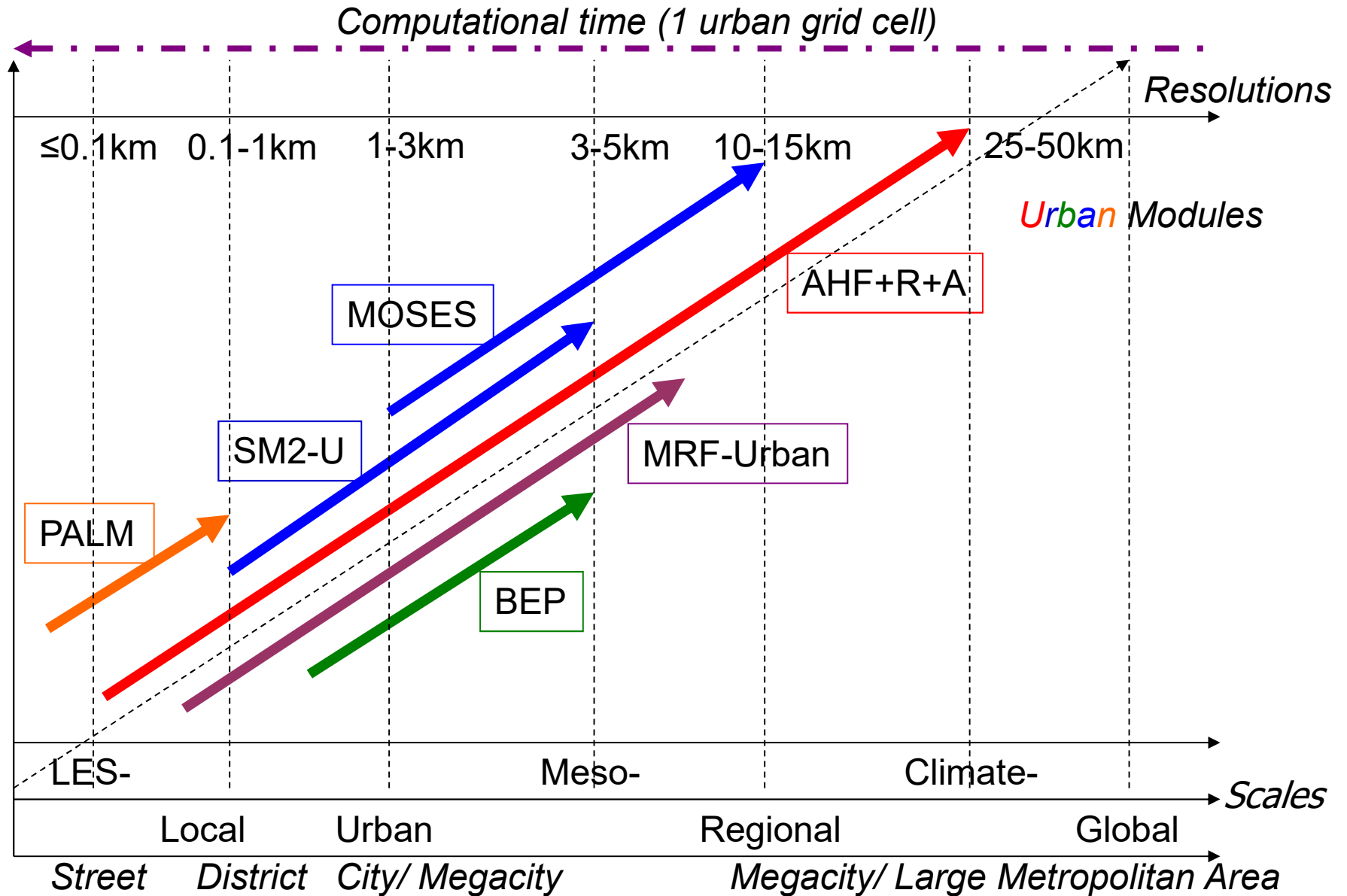
Enviro-HIRLAM Downscaling for Regional-Subregional-Urban/City/Local scales





Hierarchy of Urbanization Approaches

(Mahura & Baklanov, 2011)



Urban Districts in Metropolitan Areas: Classification & Characteristics

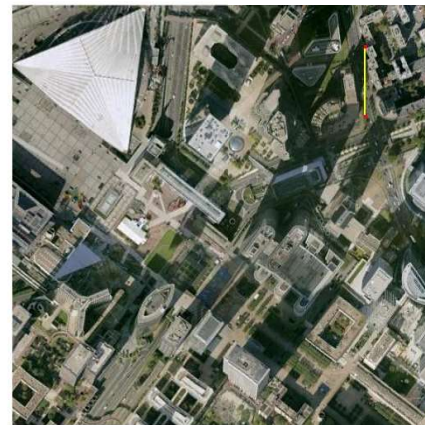
Residential (RD)



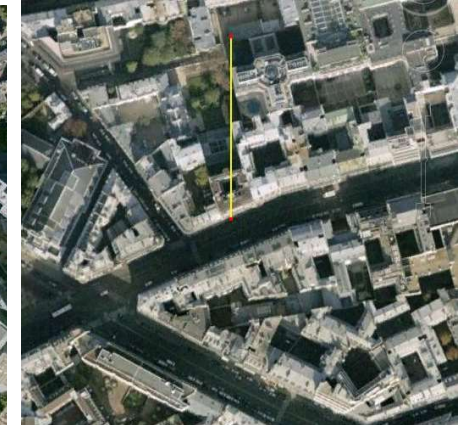
City Center/High Buildings District (CC/HBD)



City Center



High Buildings District



Industrial Commercial (ICD)



GIS - Extraction of districts related characteristics (statistics):

- *Morphology parameters* (avg. height, volume, perimeter, compactness, space between buildings)
- *Cover modes* (surface density (SD) of buildings, of vegetation, hydrography, roads, N buildings)
- *Aerodynamic parameters* (roughness length, displacement height, frontal and lateral SD)

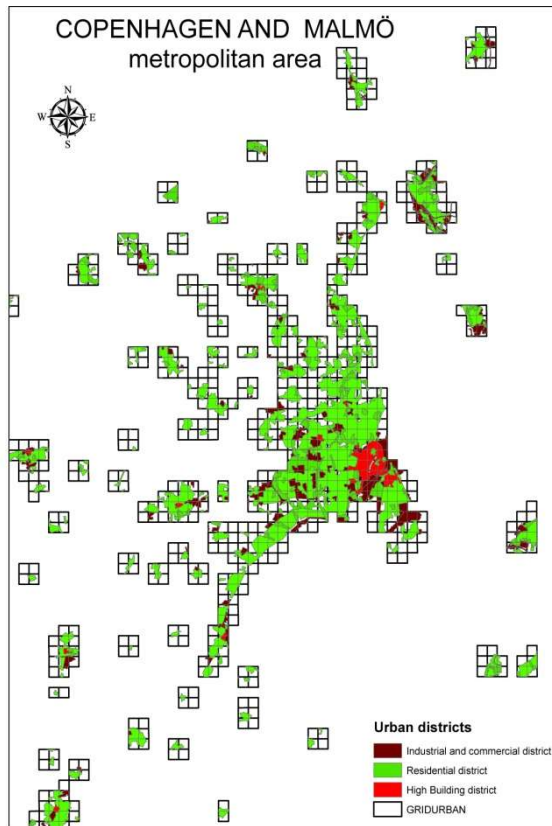


Residential District

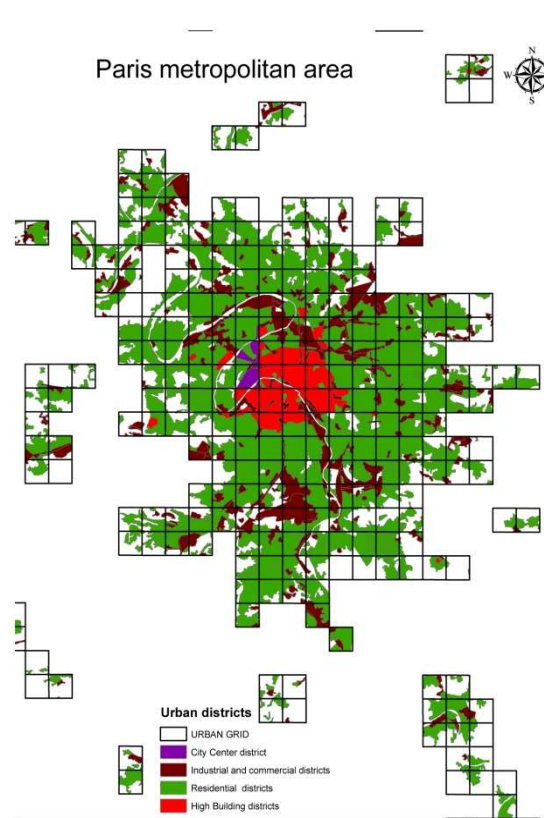


Industrial Commercial District

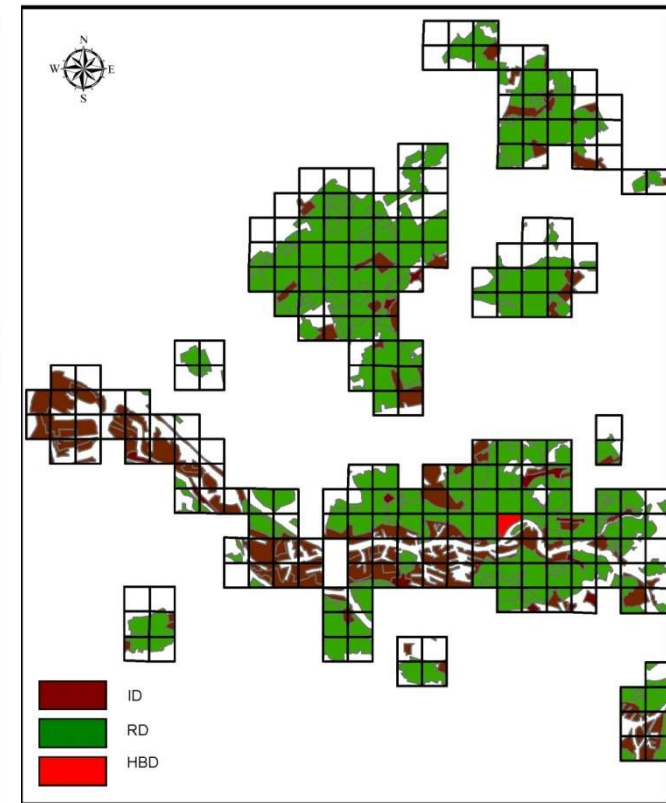
Urban Districts in Metropolitan Areas: Classification & Characteristics



Copenhagen (Denmark)



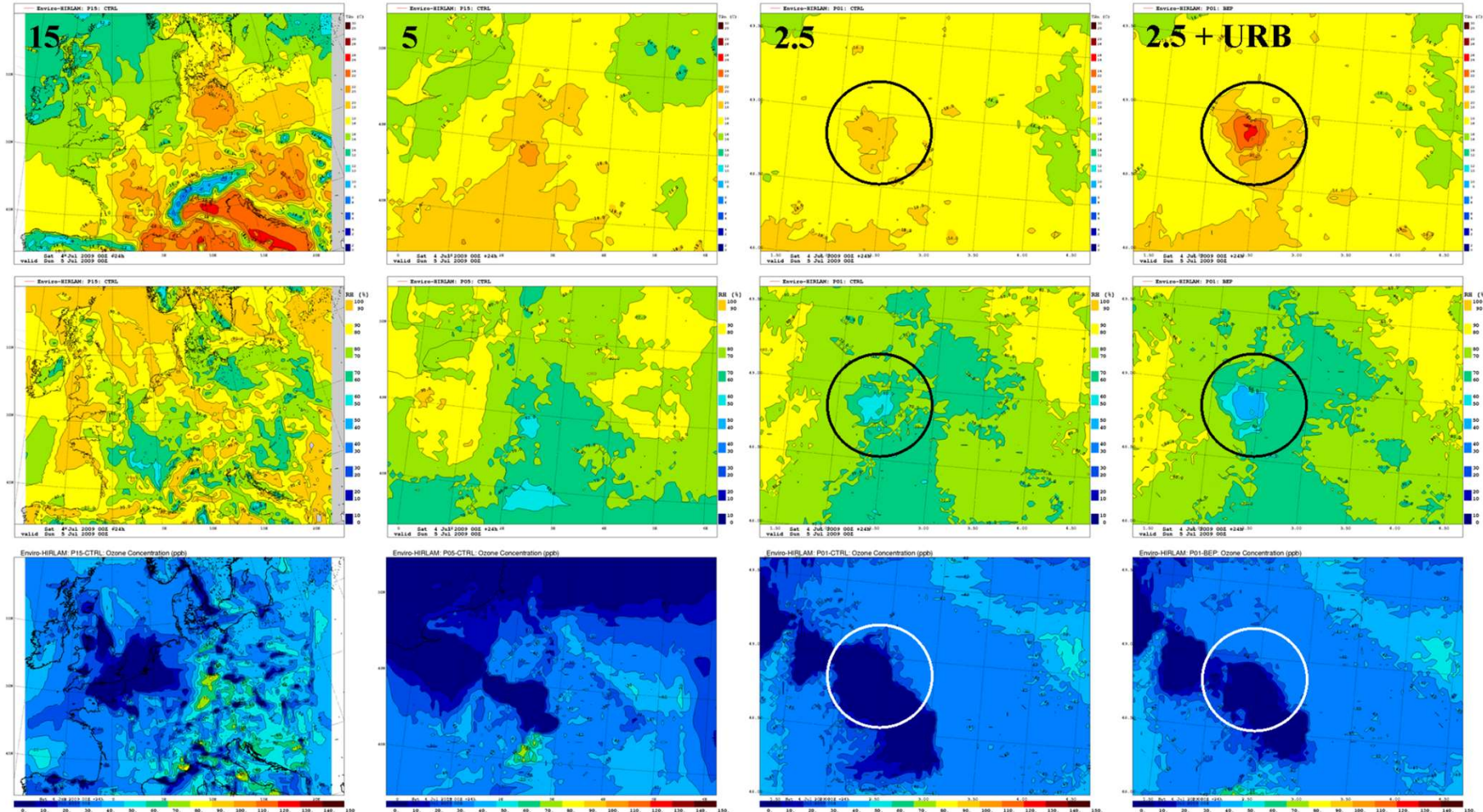
**Paris (France)
Metropolitan Areas**



Rotterdam (The Netherlands)

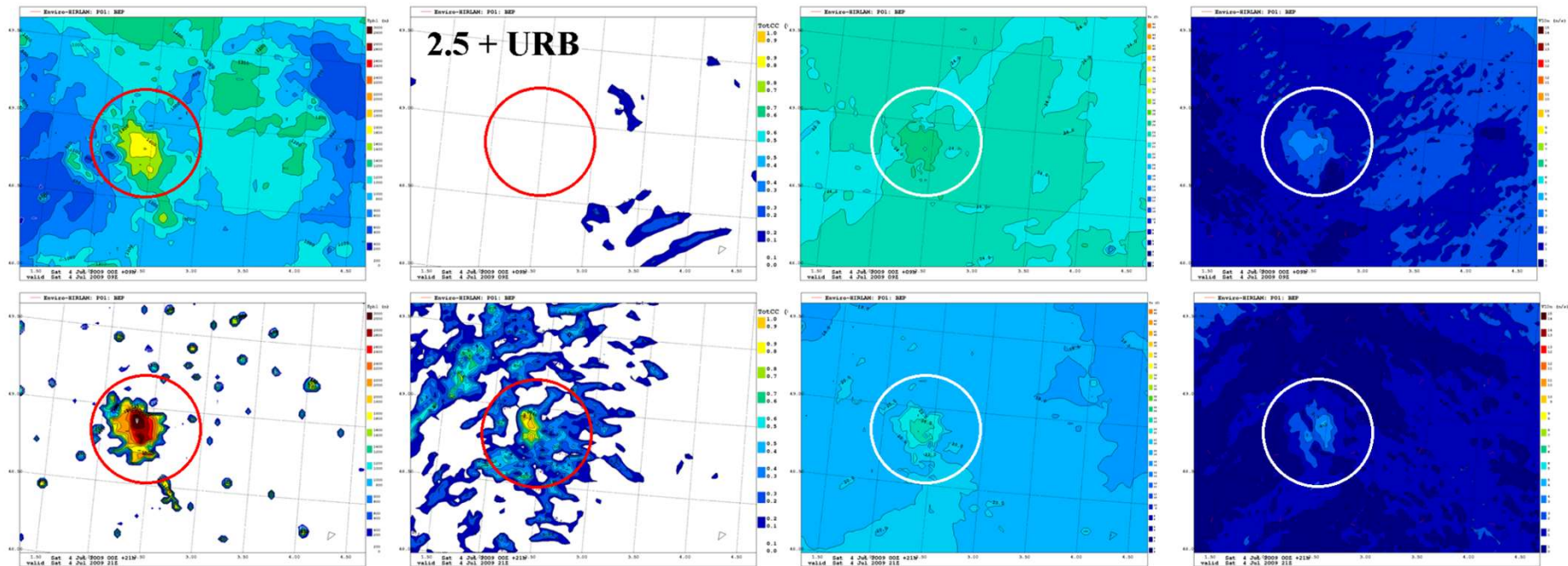


Downscaling for Paris Metropolitan Area (meteorology & chemistry)

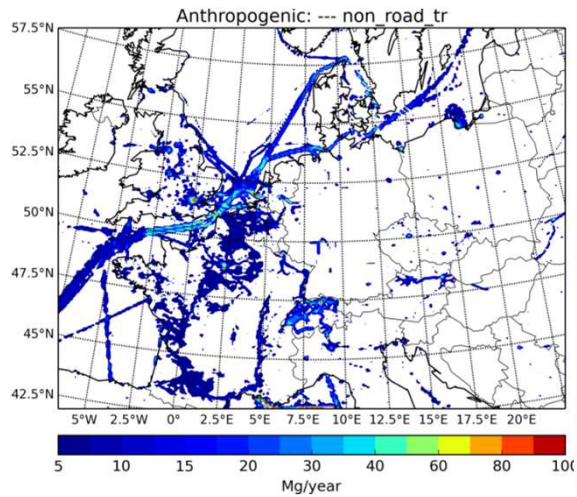


Enviro-HIRLAM downscaling (from left to right: CTRL 15—5—2.5 km & 2.5+URB) meteorological (top—air temperature, middle—humidity) and chemical (bottom—ozone) fields on 4 Jul 2009, 00+24 UTC.

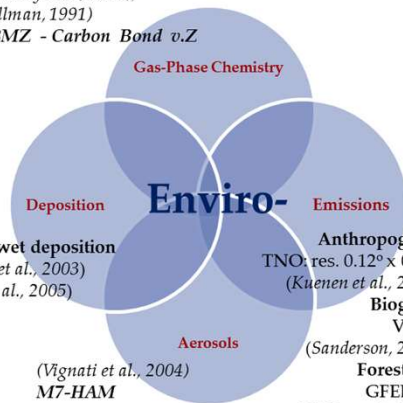
Paris Metropolitan Area: Temporal Variability of Meteo.Parameters



Variability of (from left-to-right) boundary layer height, total cloud cover, surface temperature, wind speed on 4 Jul 2009 at (top) 09 UTC and (bottom) 21 UTC based on Enviro-HIRLAM model run at 2.5 km resolution with URB=BEP+AHF included.

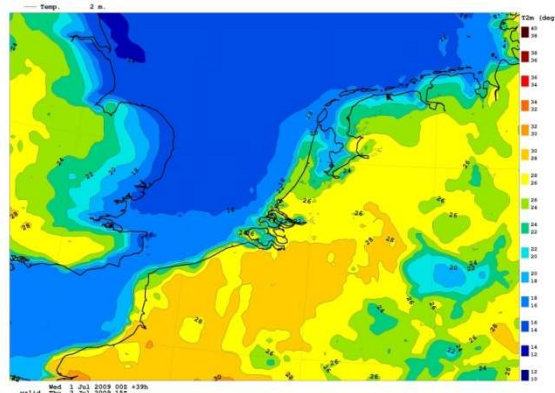
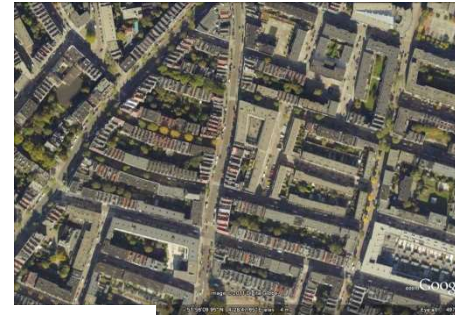


(Zaveri and Peters, 1999);
(Shalaby et al., 2012);
(Sillman, 1991)
CBMZ - Carbon Bond v.Z



Dry & wet deposition
(Zhang et al., 2003)
(Stier et al., 2005)

Anthropogenic
TNO: res. 0.12° x 0.06°
(Kuenen et al., 2010)
Biogenic
VOCs
(Sanderson, 2009)
Forest fire
GFED v.3
(Giglio et al., 2010)
IS4FIRES
(<http://is4fires.fmi.fi>)



Regional-Scale run (Enviro-HIRLAM-R15 – 15 km)

R15 (NWP+Enviro)

154 x 148 grids, 40 vert.l., 240 sec, rotated coord.; BCs - ECMWF

Meso-Scale run (Enviro-HIRLAM-R05 – 5 km)

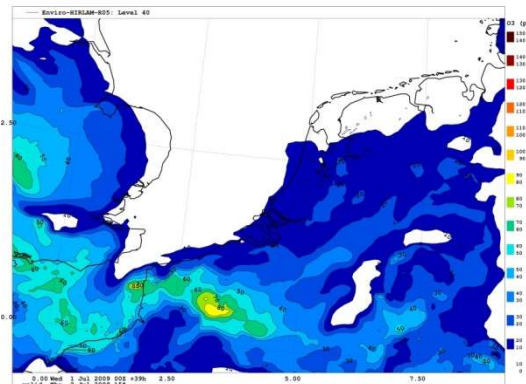
R05 (NWP+Enviro)

172 x 142 grids, 40 vert.l., 120 sec, rotated coord., BCs – R15

Urban-Scale run (Enviro-HIRLAM-R02 – 1.5 km)

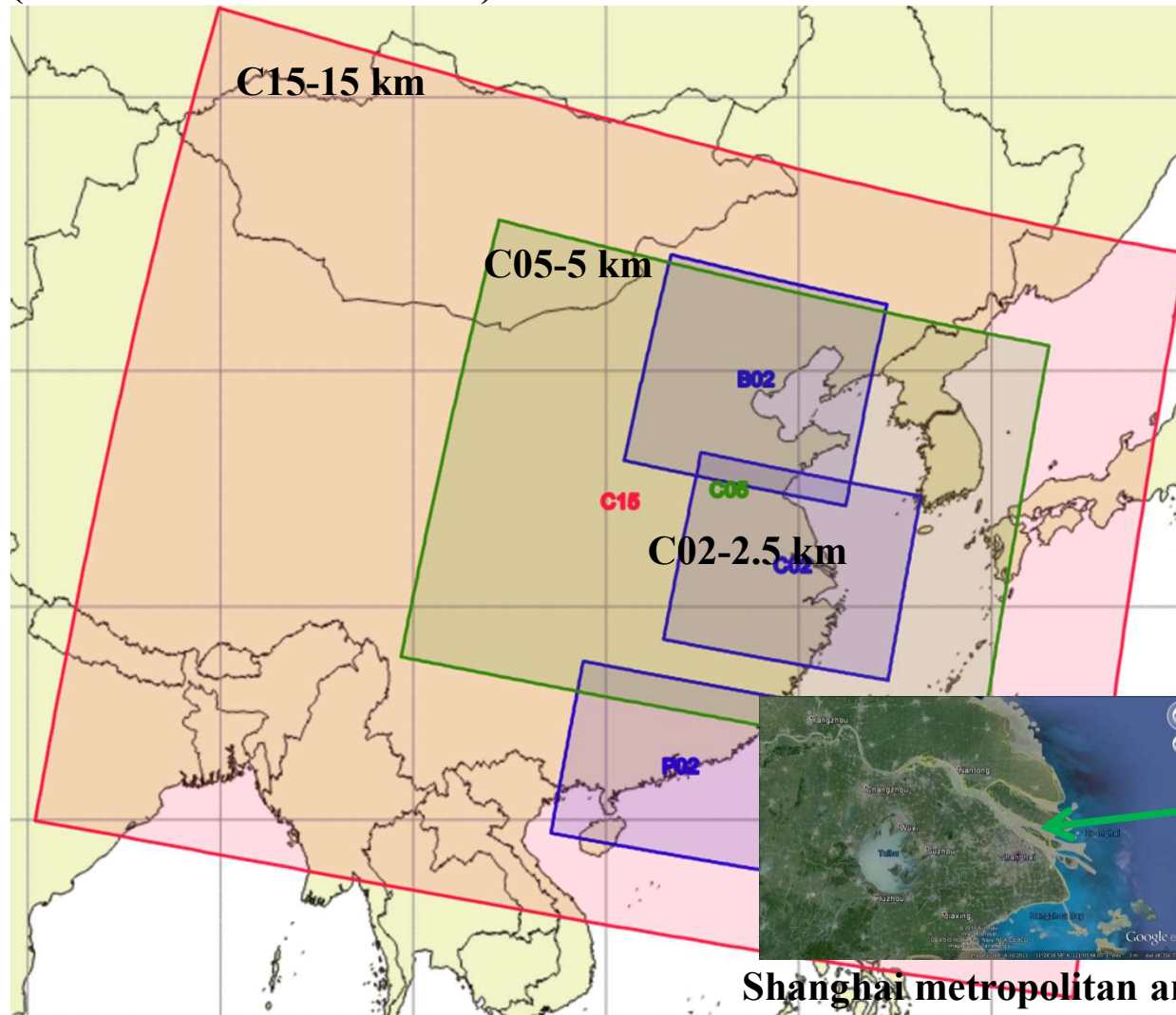
R02 (NWP+Enviro ± BEP)

172 x 158 grids, 40 vert.l., 60 sec, rotated coord., BCs – R05

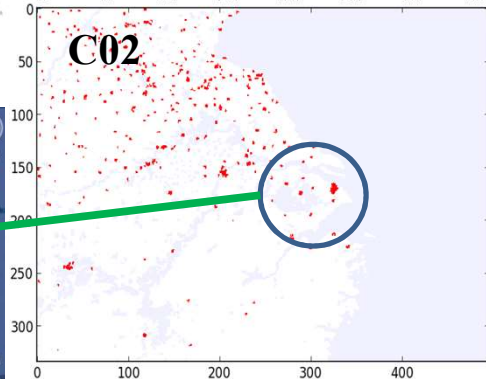
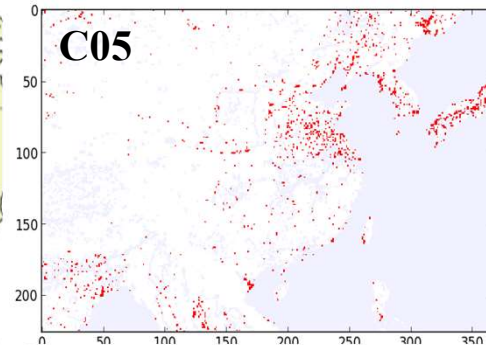
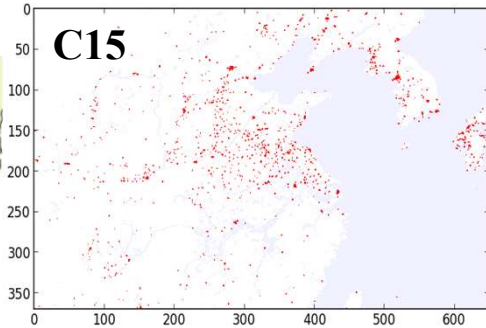


Downscaling for Enviro-HIRLAM: Modelling Domains vs. Metropolitan Areas

Enviro-HIRLAM model downscaling domains
(15 – 5 – 2.5 km resolutions)



Urban areas in domains

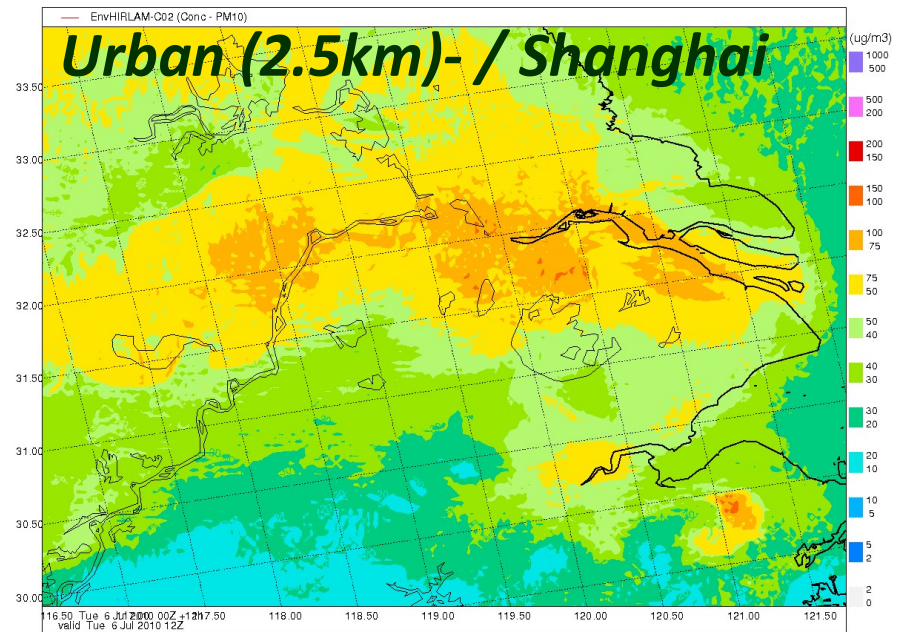
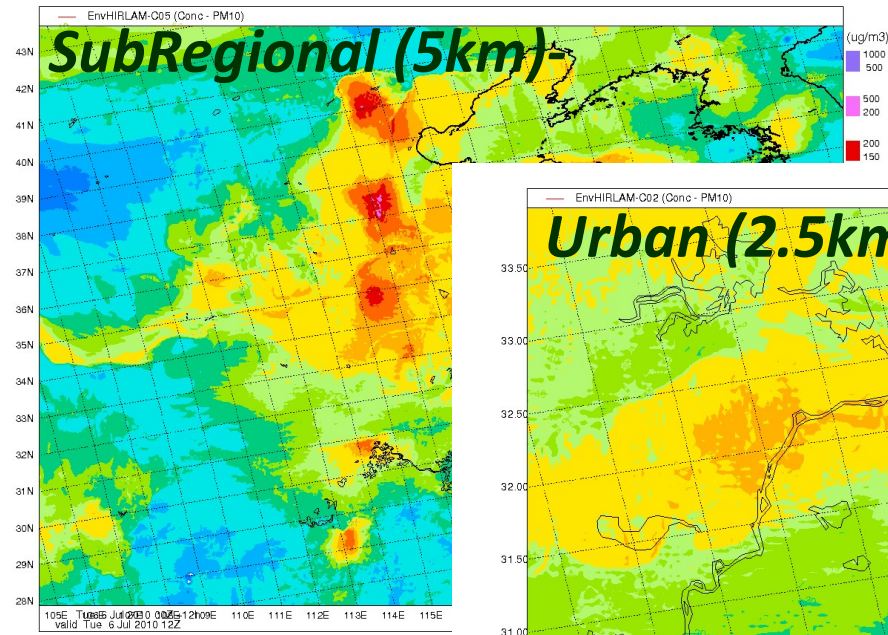
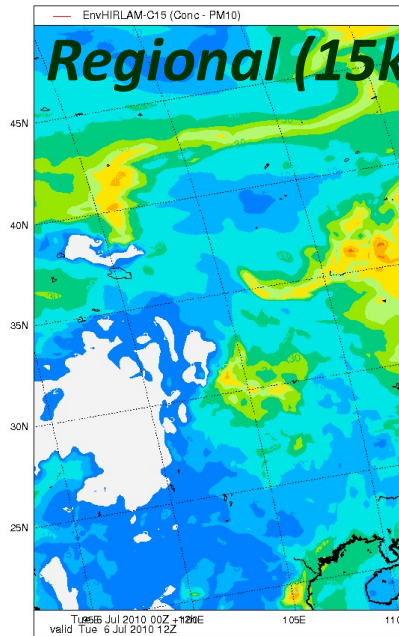




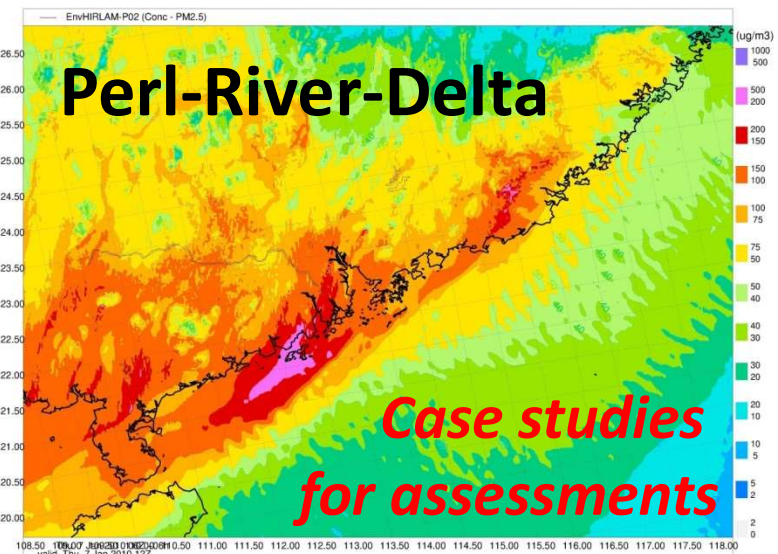
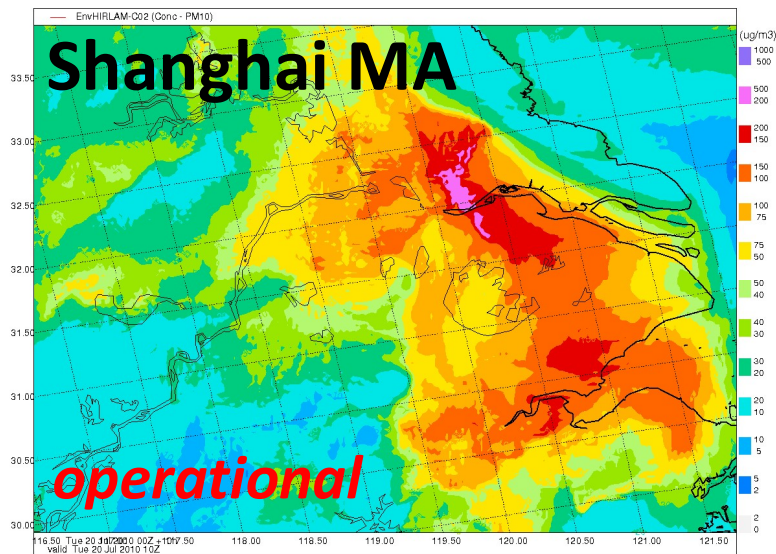
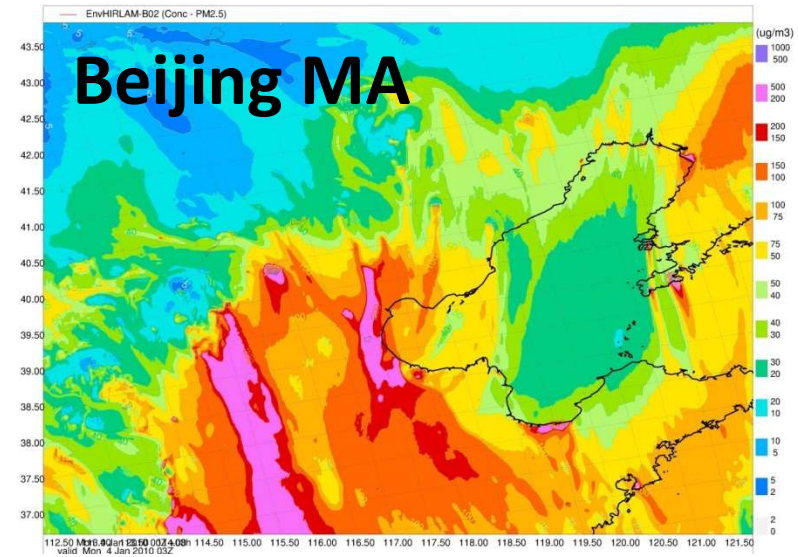
Enviro-HIRLAM Downscaling: Aerosols



PM10 (ug/m3)



Downscaling to Metropolitan Areas (MA)

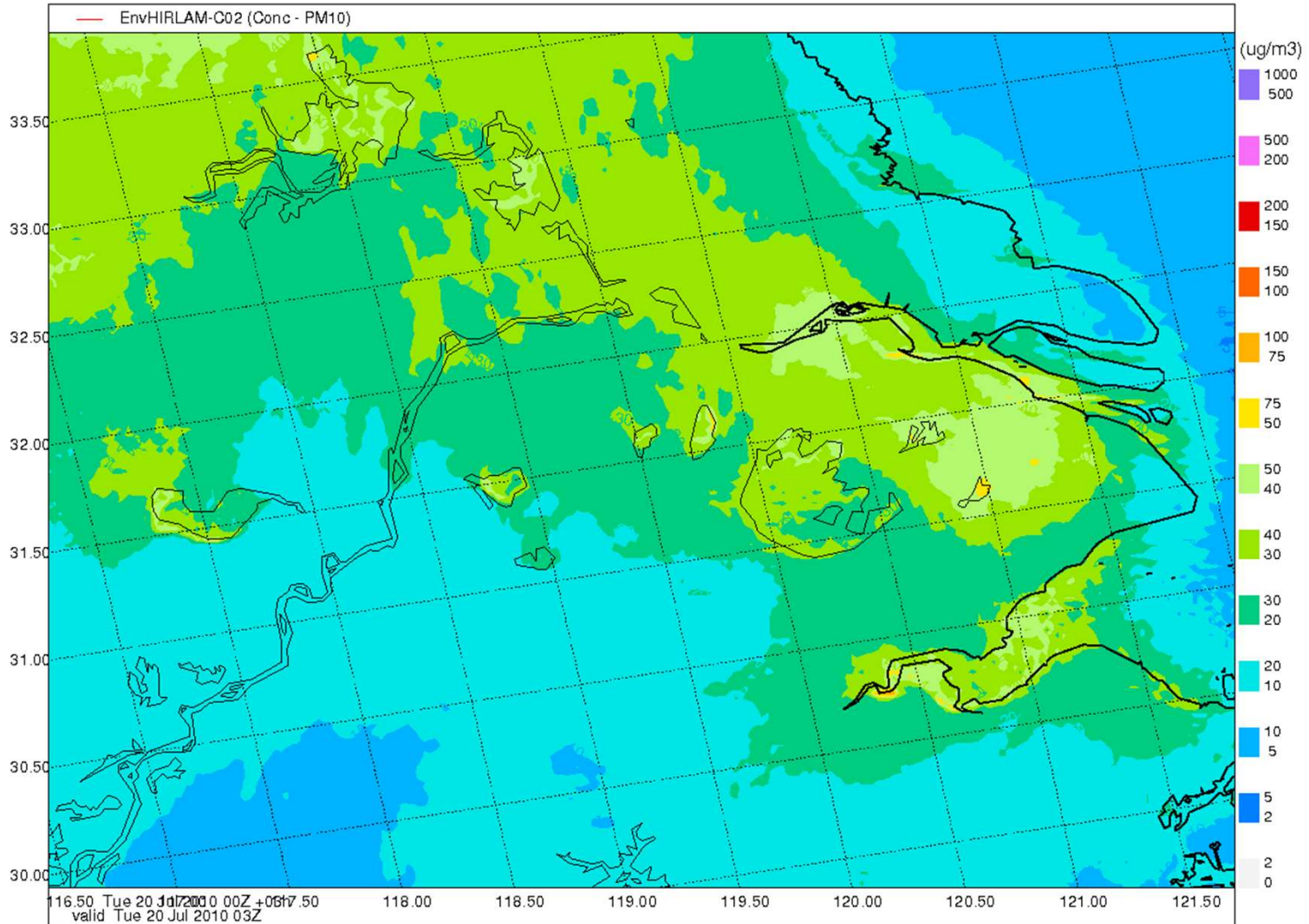




2.5km: Shanghai MA: PM10



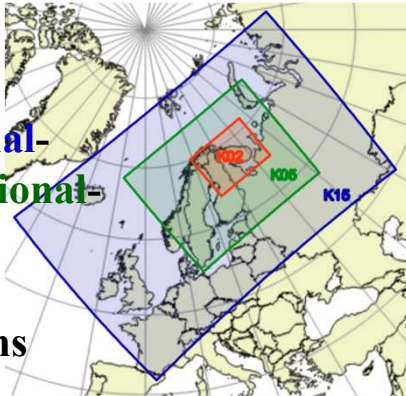
Diurnal cycle: 20 Jul 2010



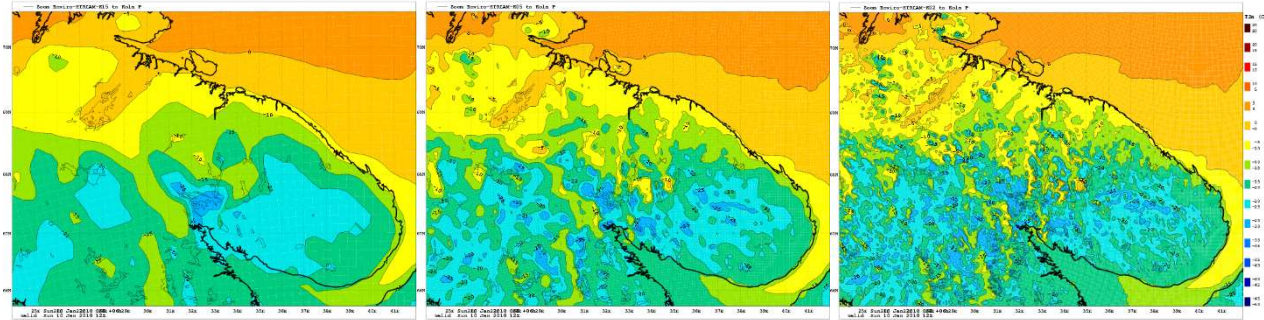
Seamless/ On-line Integrated Modelling

TRAKT - TRANSferable Knowledge & Technologies for high-resolution environmental impact assessment & management (www.atm.helsinki.fi/peex/index.php/trakt-2018)

Regional-
subregional-
urban
scale
domains



Enviro-HIRLAM Downscaling (with zooming) over the Kola Peninsula area)



15 km

5 km

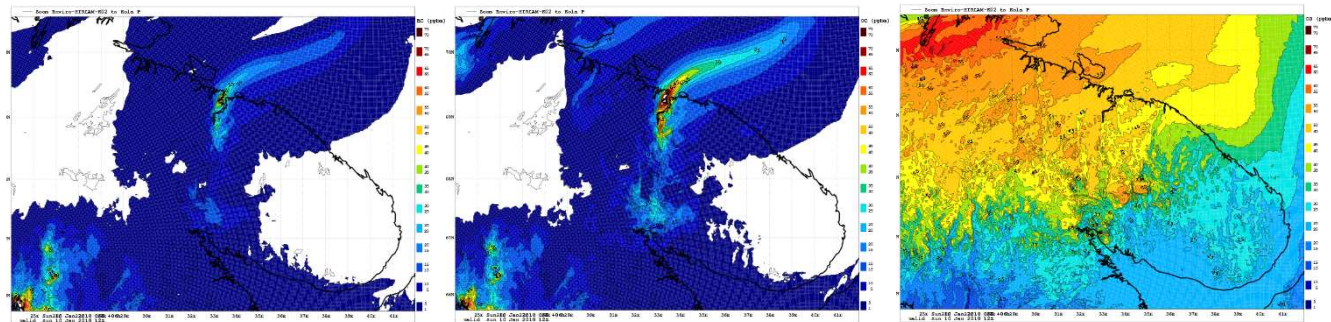
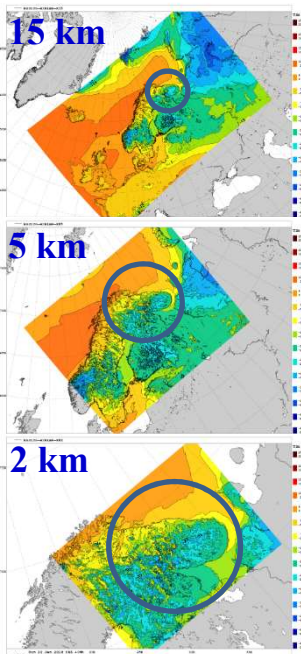
2 km

Meteorology: Air temperature at 2m (T2m)

Seamless /
online
integrated

meteorolog-
-chemistry-
aerosols
modelling

at multi-
scales



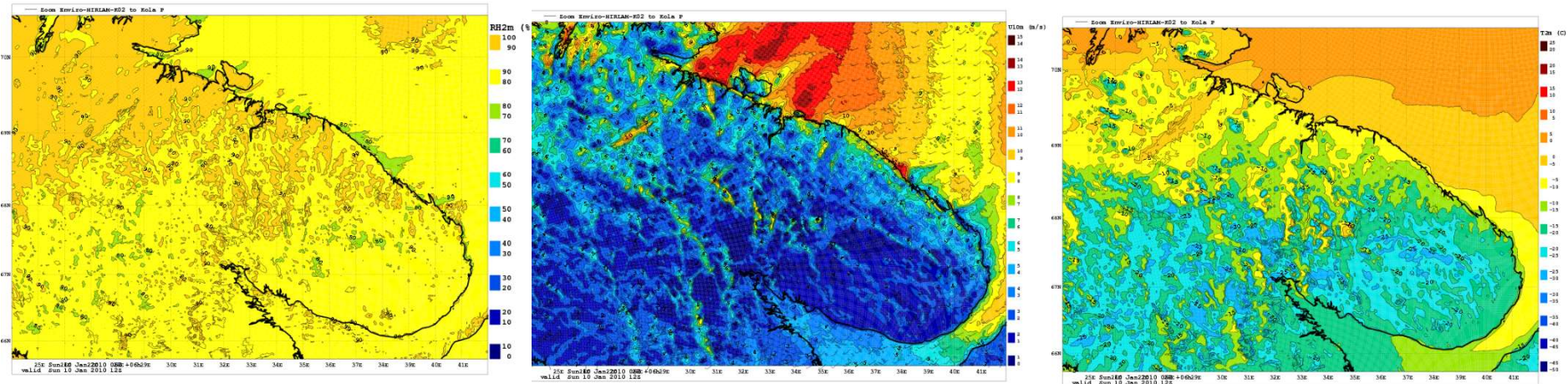
Black carbon (BC)

Organic Carbon (OC)

Ozone (O₃)

Atmospheric composition: at 2 km horizontal resolution

High resolution (at 2 km) for meteorology



Meteorology:

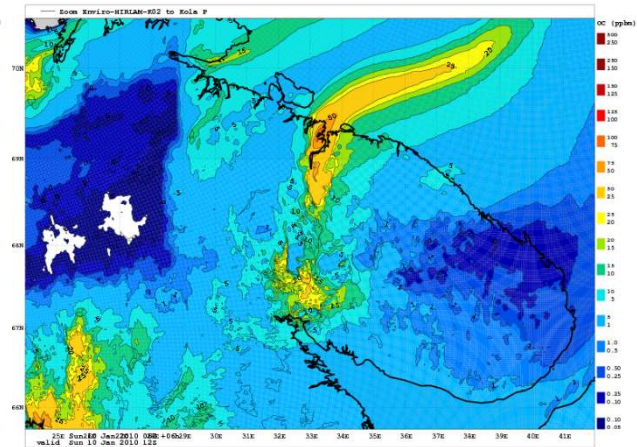
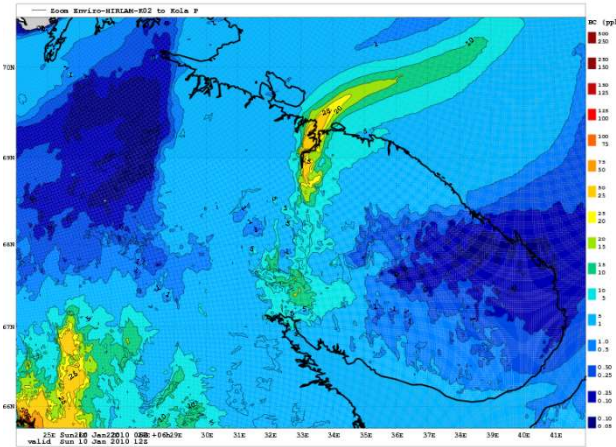
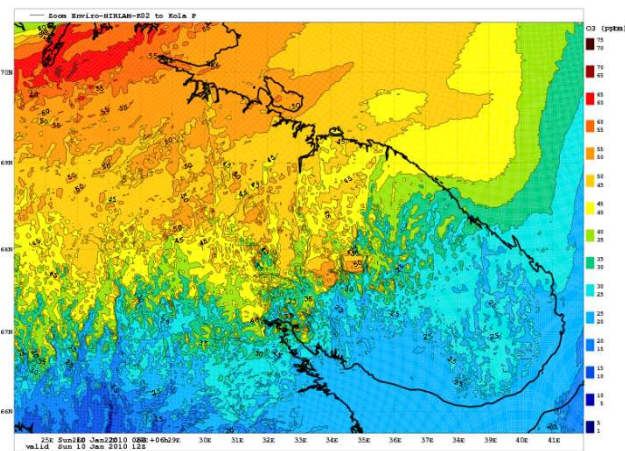
Relative Humidity (RH2m),

Wind Speed at 10m (U10m) ,

Air temperature at 2m (T2m)

An example of the Enviro-HIRLAM model high resolution output
over the Kola Peninsula area

High resolution (at 2 km) for atmospheric composition



Atmospheric Composition:
Ozone (O₃)

Black Carbon (BC),

Organic Carbon (OC),

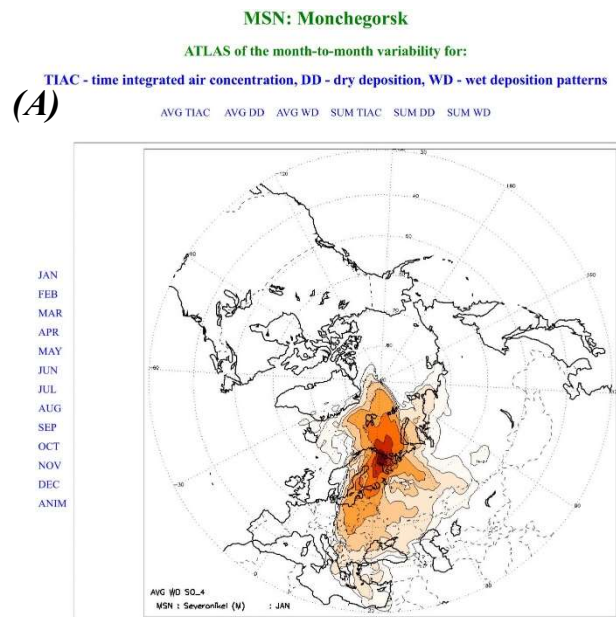
An example of the Enviro-HIRLAM model high resolution output
over the Kola Peninsula area



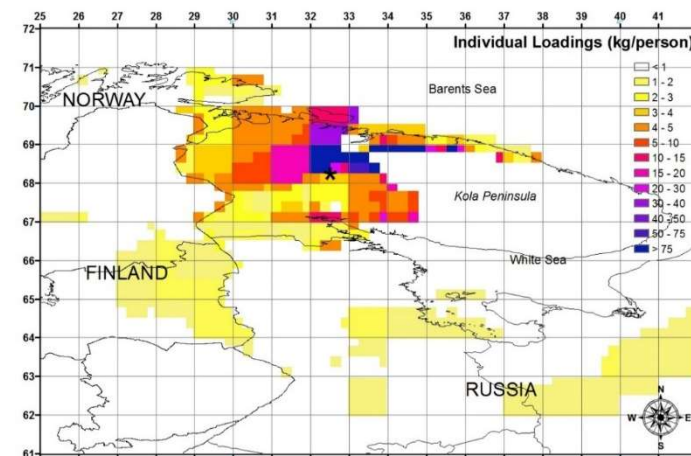
Web-Atlas for Transboundary Pollution & Loadings for Population



<http://www.atm.helsinki.fi/peex/webatlas/WEBATLAS.html>



(B)



(A) Month-to-month variability of average (AVG) and summary (SUM) time integrated air concentration (TIAC), dry (DD) and wet (WD) deposition patterns of sulphates from smelters of the Mochevorsk Enterprise (Kola Peninsula, Mirmansk region, Russia);

&

(B) Individual yearly loadings for population (in kg/person) from deposited sulfates resulted from the Severonickel smelters continuous emissions (mild scenario, appx 32 thou. tonnes of SO_2).

Web-based Atlas

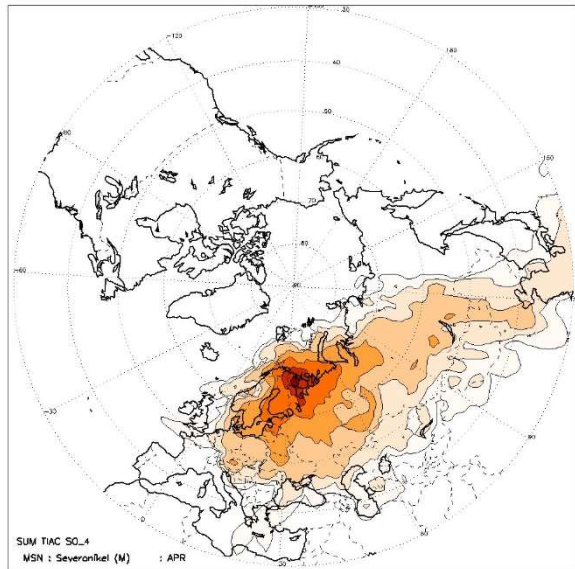
<http://www.atm.helsinki.fi/peex/webatlas/WEBATLAS.html>

MSN: Monchegorsk

ATLAS of the month-to-month variability for:

TIAC - time integrated air concentration, DD - dry deposition, WD - wet deposition patterns

AVG TIAC AVG DD AVG WD SUM TIAC SUM DD SUM WD

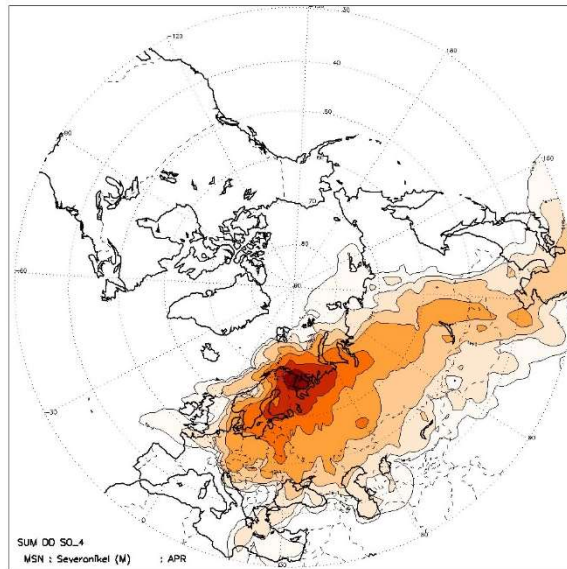


MSN: Monchegorsk

ATLAS of the month-to-month variability for:

egrated air concentration, DD - dry deposition, WD - wet deposition patterns

AVG TIAC AVG DD AVG WD SUM TIAC SUM DD SUM WD

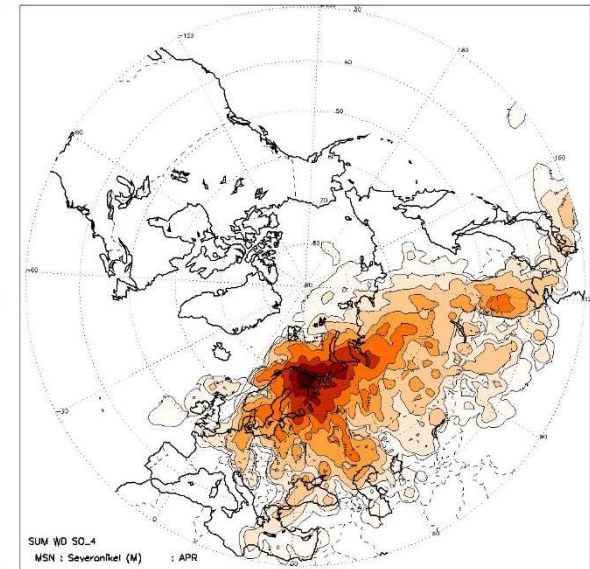


MSN: Monchegorsk

ATLAS of the month-to-month variability for:

egrated air concentration, DD - dry deposition, WD - wet deposition patterns

AVG TIAC AVG DD AVG WD SUM TIAC SUM DD SUM WD



JAN
 FEB
 MAR
 APR
 MAY
 JUN
 JUL
 AUG
 SEP
 OCT
 NOV
 DEC
 ANIM

Example of a month-to-month variability of summary (SUM) time integrated air concentration (TIAC), dry (DD) and wet (WD) deposition patterns of sulphates from smelters of the Mochegorsk Enterprize (Kola Peninsula, Mirmansk region, Russia)

<http://www.atm.helsinki.fi/peex/webatlas/WEBATLAS.html>

NNN: Norilsk

ATLAS of the month-to-month variability for:

TIAC - time integrated air concentration, DD - dry deposition, WD - wet deposition patterns

AVG TIAC AVG DD AVG WD SUM TIAC SUM DD SUM WD

NNN: Norilsk

ATLAS of the month-to-month variability for:

grated air concentration, DD - dry deposition, WD - wet deposition patterns

AVG TIAC AVG DD AVG WD SUM TIAC SUM DD SUM WD

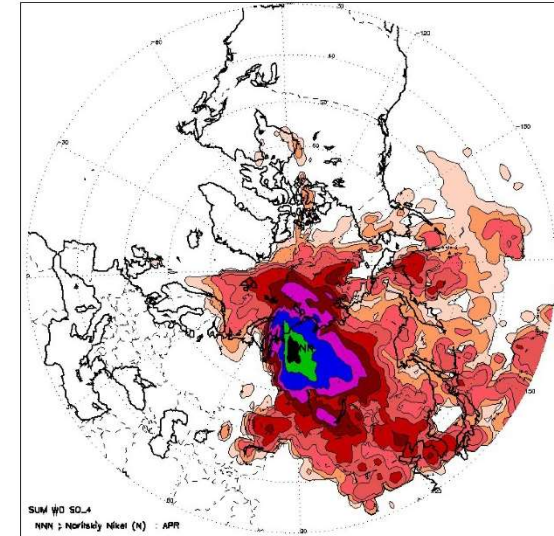
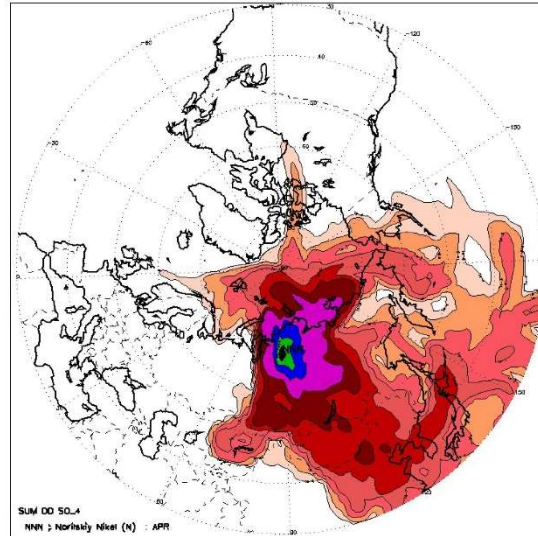
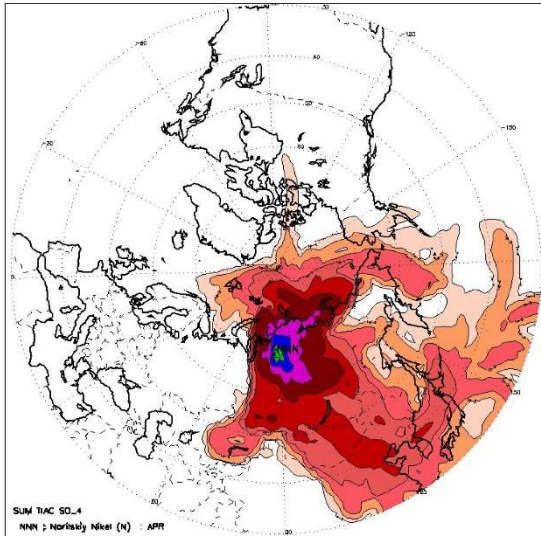
NNN: Norilsk

ATLAS of the month-to-month variability for:

grated air concentration, DD - dry deposition, WD - wet deposition patterns

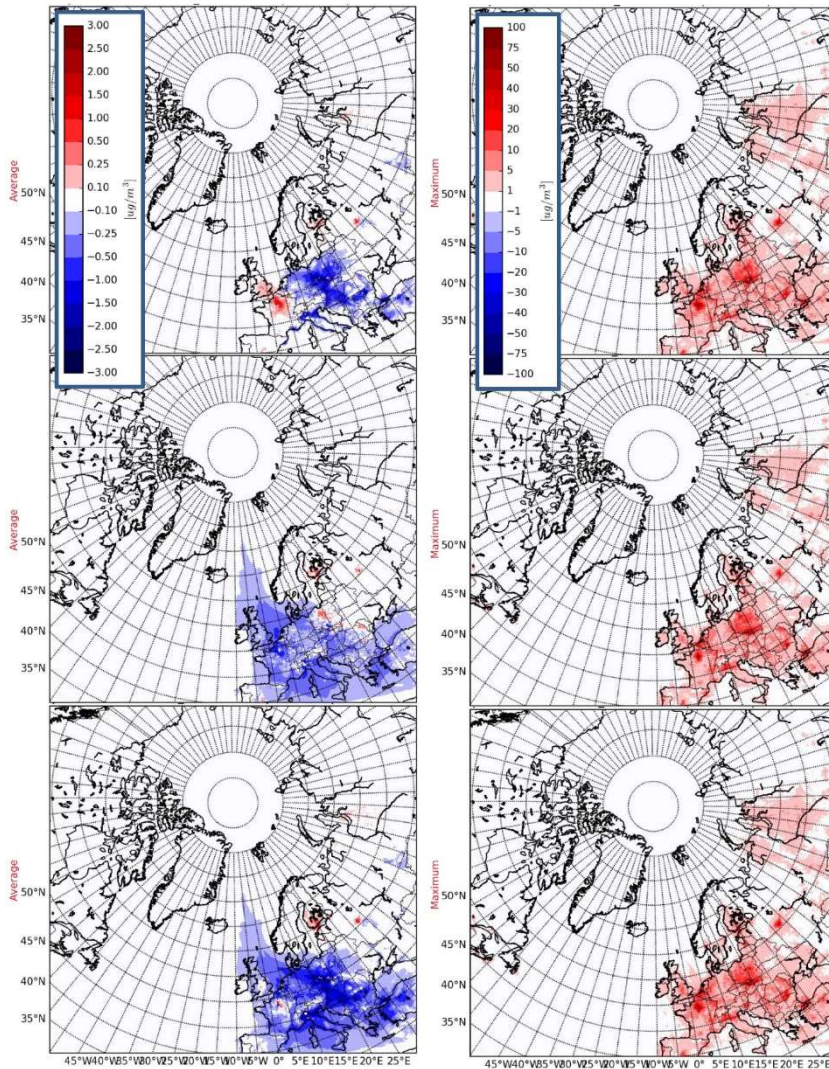
AVG TIAC AVG DD AVG WD SUM TIAC SUM DD SUM WD

JAN
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 ANIM



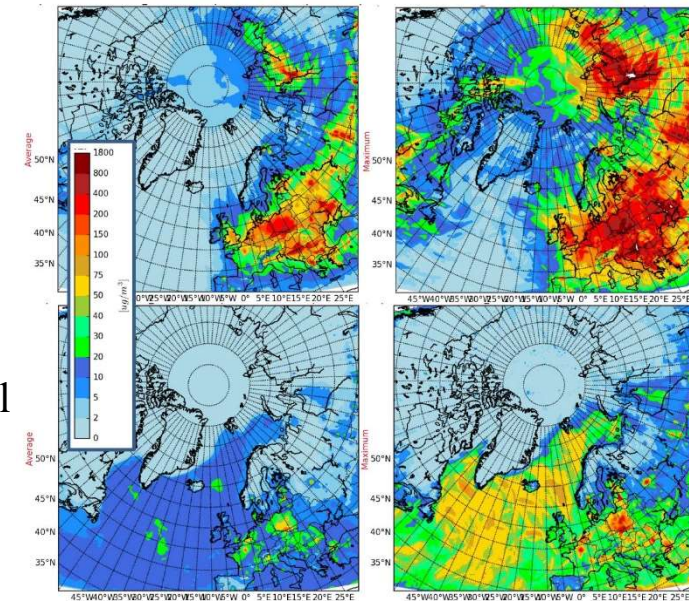
Example of a month-to-month variability of summary (SUM) time integrated air concentration (TIAC), dry (DD) and wet (WD) deposition patterns of sulphates from smelters of the Norilsk Nickel Enterprise (Krasnoyarsk Krai, Russia)

Influence of Direct & Indirect Aerosols Effects



◀ Difference fields between CTRL&DAE (top), CTRL&IDAE (middle), CTRL&DAE+IDEA (bottom) runs with the Enviro-HIRLAM model for monthly (January) averaged (left) and maximum (right) concentration of **black carbon**, BC (in $\mu\text{g}/\text{m}^3$).

CTRL –
reference run
DAE –
Direct Aerosol
Effect
IDAE –
Indirect Aerosol
Effect



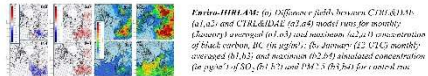
January (12 UTC) monthly averaged (left) and ▲ maximum (right) simulated concentration (in $\mu\text{g}/\text{m}^3$) of SO_2 (top) and $\text{PM}_{2.5}$ (bottom) based on the Enviro-HIRLAM control run simulations.

Collaboration with PEEEX Russian Partners



INTEGRATED MULTI-SCALE MODELLING FOR METEOROLOGY-CHEMISTRY-AEROSOLS INTERACTIONS

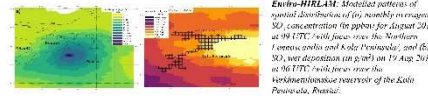
Aerosols Feedbacks & Interactions in Arctic-Boreal



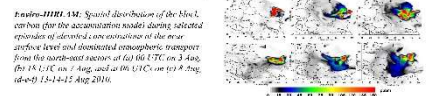
Aerosols on Regional Scale & Zooming to Urban Areas



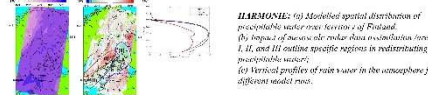
Transboundary Pollution over Kola vs. Fennoscandia



Elevated Black Carbon Episodes vs. Forest Fires



Mesoscale Resolution Radar Data Assimilation



RESEARCH TOOLS & PARTNERS	RESEARCH INSTITUTIONS	ACKNOWLEDGEMENTS
<ul style="list-style-type: none"> Enviro-HIRLAM v2.0.0 (2016-2017) Enviro-HIRLAM v2.0.0 (2018-2019) Enviro-HIRLAM v2.0.0 (2020-2021) Enviro-HIRLAM v2.0.0 (2022-2023) Enviro-HIRLAM v2.0.0 (2024-2025) 	<ol style="list-style-type: none"> 1 Institute for Atmospheric and Oceanic Research (IOAR), Faculty of Biology, Petrozavodsk University (Petrozavodsk, Karelia, Russia) 2 Institute for Atmospheric and Oceanic Research (IOAR), Faculty of Biology, Petrozavodsk University (Petrozavodsk, Karelia, Russia) 3 Institute for Atmospheric and Oceanic Research (IOAR), Faculty of Biology, Petrozavodsk University (Petrozavodsk, Karelia, Russia) 4 Institute for Atmospheric and Oceanic Research (IOAR), Faculty of Biology, Petrozavodsk University (Petrozavodsk, Karelia, Russia) 5 Institute for Atmospheric and Oceanic Research (IOAR), Faculty of Biology, Petrozavodsk University (Petrozavodsk, Karelia, Russia) 6 Institute for Atmospheric and Oceanic Research (IOAR), Faculty of Biology, Petrozavodsk University (Petrozavodsk, Karelia, Russia) 7 The Center for Global Change Science (CGCS), Dartmouth College, Hanover, NH, USA 8 The Center for Global Change Science (CGCS), Dartmouth College, Hanover, NH, USA 9 The Center for Global Change Science (CGCS), Dartmouth College, Hanover, NH, USA 	<p>Thanks to the Center for Scientific Computing (CSC) and the Center for Global Change Science (CGCS) for providing the HPC resources and support.</p> <p>The CSC and CGCS are supported by the National Science Foundation (NSF) and the Office of Naval Research (ONR).</p> <p>The CSC and CGCS are supported by the National Science Foundation (NSF) and the Office of Naval Research (ONR).</p>

“PEEX-MP research and development for online coupled integrated meteorology-chemistry-aerosols feedbacks & interactions in weather, climate & atmospheric composition multi-scale modelling”

(2018-2020)

www.atm.helsinki.fi/peex/index.php/enviro

+ MSU, RSHU, ICMMG, NIERSC


Objectives:

- to analyze importance of meteorology-chemistry-aerosols interactions & feedbacks;
- to provide a way for development of efficient techniques for on-line coupling of NWP and ACT via process-oriented parameterizations and feedback algorithms.

& new HPC proposal for ECMWF is in preparation in May-Jun 2020




Enviro-HIRLAM: science education and training



HIRLAM/ALADIN Consortium Institutions
linking with **ECMWF**

International Collaboration with
Universities and Research Institutions




Enviro-HIRLAM/ HARMONIE

(EnviroHH)
*(Collaboration,
Research & Development,
Science Education,
Dissemination,
New Products &
Applications)*



PAN EUROPEAN EXPERIMENT (PEE)
— COOPERATION IN AIR QUALITY, CLIMATE, OZONE, AND ENVIRONMENT RESEARCH IN ARCTIC AND BOREAL HIGH-LATITUDE REGIONS



Science Education: Small-Scale Research Projects (SSRPs)

- 1) Student workbooks on SSRPs
- 2) Supplementary materials
- 3) Introduction Into Exercises (lecture by teacher)



Student - First Name, Surname


URBAN EXERCISE

The Dynamical and Thermal Effects of Metropolitan Areas on Meteorology

Teacher: Alexander Mahura (DMI)
Model: Enviro-HIRLAM

Nuffield School and Workshop on "Integrated Modelling of Meteorological and Chemical Transport Processes Impact on Chemical Hazards in Metropolitan Areas and Climate Modelling"







Student - First Name, Surname

URBAN EXERCISE

The Influence of Metropolitan Areas on Meteorology

Teacher: Alexander Mahura (Denmark)
Teacher Assistants: Adomas Mazeikis (Lithuania), Iratxe Gonzalez-Aparicio (Spain)
Model: Enviro-HIRLAM







Student - First Name, Surname

COASTAL URBAN EXERCISE

The Influence of Coastal Metropolitan Areas on Meteorology

Teachers: Alexander Mahura (Denmark), Sergey Ivanov (Ukraine)
Teacher Assistants: Julia Palamarchoik (Ukraine), Iratxe Gonzalez-Aparicio (Spain)
Model: Enviro-HIRLAM







Student - First Name, Surname

AEROSOL EXERCISE

The Impact of Atmospheric Aerosols on Meteorology

Teacher: Roman Naterman (Denmark)
Model: Enviro-HIRLAM






ATLAS METEOROLOGICAL SITUATION


Supplementary material for the URBAN exercise

Case:
3-4 July 2009

Introduction to Enviro-HIRLAM Exercises

YSSS-2014
University of Aveiro, Portugal
6-11 Jul 2014






Student - First Name, Surname

URBAN EXERCISE

The Influence of Metropolitan Areas on Meteorology

Teacher: Alexander Mahura (Denmark)
Model: Enviro-HIRLAM





PAN EURASIAN EXPERIMENT (PEEX)
 - FOUNDED A NEW INTERDISCIPLINARY, MULTISCALE
 CLIMATE AIR QUALITY AND ENVIRONMENT
 RESEARCH EFFORT IN ARCTIC AND BOREAL
 PAN EURASIA REGIONS



INAR

The recent Enviro-HIRLAM research trainings:

Enviro-HIRLAM Research Training Week: Jun 2019 (UTMN, Tyumen, Russia)

<https://www.atm.helsinki.fi/peex/index.php/education/16-courses/188-june-2019-research-training-course-seamless-online-integrated-meteorology-chemistry-aerosols-multi-scale-and-processes-modelling>



During 24-29 June 2019, the Academy of Finland ClimEco project ("Mechanisms, pathways and patchiness of the Arctic ecosystem responses and adaptation to changing climate"; www.atm.helsinki.fi/peex/index.php/climeco) research training course on "Seamless / Online Integrated Meteorology-Chemistry-Aerosols Multi-Scale and -Processes Modelling" took place in the city of Tyumen (Russia) situated on banks of the beautiful Tura River. The event was organized jointly by the University of Helsinki (UH), the Institute for Atmospheric and Earth System Research (INAR), the Finnish Meteorological Institute (FMI), and the University of Tyumen (UTMN); and arranged in premises of the Institute of the Earth Sciences. The training was organized in order to strengthen the collaboration between Finnish and Russian key investigators and corresponding institutes in the frameworks of the ClimEco project and PEEX (Pan-Eurasian EXperiment; www.atm.helsinki.fi/peex) programme; to make a detailed design enabling a longer-term, a top-level research activities in PEEX; and to build direct links and to establish student training and short-term exchange between the institutes. One of the PEEX-Modelling-Platform (PEEX-MP; www.atm.helsinki.fi/peex/index.php/modelling-tools-demonstration) models, the Enviro-HIRLAM (Environment - High Resolution Limited Area Model) modelling system was demonstrated and used.



The training included: lecturing with respect to theoretical and practical aspects of the Enviro-HIRLAM modelling system (with focus on research and development). The theoretical aspects included: weather modelling in European community; advantages/ shortcomings of on-line vs. off-line approaches; model structure, downscaling, components, schematics; specific features of urban areas and modules/ parameterizations for urbanization; land-cover and land-use class

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Tyumen, Russia AoF ClimEco Research Training Course - Finals

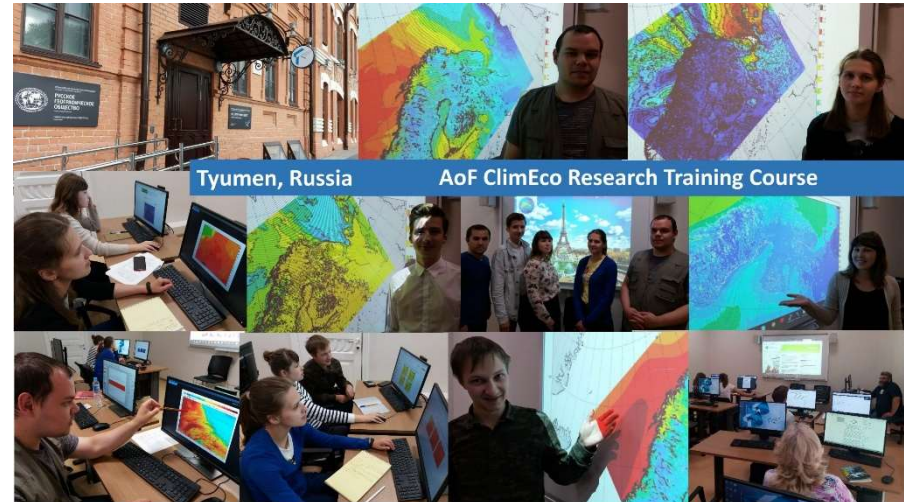


UH/PEE... and others. Respectfully: Dmiriti Gabyshev, UTMN and Alexander Mahura, UHEL-INAR.



AoF ClimEco Research Training Course

Tyumen, Russia



Tyumen, Russia AoF ClimEco Research Training Course



Planned 2020 research trainings as PEEEX-AC intensive courses & YSSSSs

vs. COVID-19

PEEX-Academic Challenge – FIRST+ Intensive Course



“Multi-Scales and -Processes Modelling and Assessment for Environmental Applications”

Location/ Host: Russian State Hydrometeorological University (RSHU, St.Petersburg, Russia)

Timeline: 20-25 April 2020

(arrivals: Sunday, 19 Apr 2020 & Course starts from Monday, 20 Apr until Saturday, 25 Apr & departures: Sat/Sun, 25-26 Apr)

	Day 1 - 20 Apr Monday	Day 2 – 21 Apr Tuesday	Day 3 - 22 Apr Wednesday	Day 4 – 23 Apr Thursday	Day 5 – 24 Apr Friday	Day 6 – 25 Apr Saturday
08:30 – 09:15	Registration, welcome & useful info	L4. Multi-model ensembles of climate change simulations (Jouni Räisänen, UH)	L8. Physiographical data for multi-scale modelling (Alexander Mahura & Risto Makkonen, UH)	L12. Atmospheric gas-phase chemistry (Sergey Smyshlayev, RSHU)	L16. Aerosol - cloud - radiation interactions (Tuukka Petäjä, Risto Makkonen, Alexander Mahura, UH)	Exercises
09:20 – 10:05	L1. Introduction to PEEEX program (Markku Kulmala, Hanna Lappalainen, UH, with focus on science education component)	L5. Numerical schemes (Maxim Motsakov, RSHU)	L9. Process-based modelling for meteorology-chemistry-aerosol System (Michael Boy, UH)	L13. Atmospheric liquid-phase chemistry (Sergey Smyshlayev, RSHU)	L17. Chemical (& meteorological) data assimilation (Palina Blakitnaya, RSHU & Michel Boy, UH)	Students oral presentations
10:05 – 10:25	Coffee/ Tea Br.	Coffee/ Tea Br.	Coffee/ Tea Br.	Coffee/ Tea Br.	Coffee/ Tea Br.	Coffee/ Tea Br.
10:25 – 11:10	L2. Numerical weather prediction and specific challenges (Sergey Smyshlayev, RSHU)	L6. Atmospheric chemical transport modelling & emissions (Sergey Smyshlayev, RSHU)	L10. Atmospheric boundary layer and dispersion processes (Sergey Zilitinkevich, UH)	L14. Aerosol particles properties (Tuukka Petäjä, UH)	L18. Evaluation of models and verification (Part 1 - meteorology) (Sergey Smyshlayev, RSHU & Risto Makkonen, Alexander Mahura, UH)	Students oral presentations
11:15 – 12:00	L3. Earth system modelling and and specific challenges (Risto Makkonen, UH)	L7. Seamless/ online integrated modelling (Alexander Mahura, UH)	L11. Atmospheric boundary layer and removal processes (Sergey Zilitinkevich, UH)	L15. Aerosol chemistry and microphysics (Tuukka Petäjä, UH)	L19. Evaluation of models and verification (Part 2 – atmospheric composition) (Sergey Smyshlayev, RSHU & Risto Makkonen, Alexander Mahura, UH)	Students oral presentations
12:00 – 13:30	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
13:30 – 14:15	Exercises	Exercises	Exercises	Exercises	Exercises	Awarding diplomas ceremony & Official closure of the Intensive Course
14:20 – 15:05	Exercises	Exercises	Exercises	Exercises	Exercises	
15:10 – 15:55	Exercises	Exercises	Exercises	Exercises	Exercises	
15:55 – 16:15	Coffee/ Tea Br.	Coffee/ Tea Br.	Coffee/ Tea Br.	Coffee/ Tea Br.	Coffee/ Tea Br.	
16:20 – 17:05	Exercises	Exercises	Exercises	Exercises	Exercises	
17:10 – 17:55	Exercises	Exercises	Exercises	Exercises	Exercises	Free Time / CitySightseeing
18:00 – 18:45	Exercises	Exercises	Exercises	Exercises	Exercises	
19:00 –	Ice Breaking Party	St.Petersburg city Excursion	Official Dinner	RSHU Excursion (after lunch)	Free Time / CitySightseeing	

COVID19 /cancelled/ --- PEEEX-AC research training intensive course (host - RSHU, St.Petersburg, Russia, 20-25 April 2020)

<https://www.atm.helsinki.fi/peex/index.php/education/16-courses/184-april-2020-peex-ac-research-training-intensive-course>

COVID19 /cancelled/ --- AoF ClimEco & RSF MegaCity Young Scientist Summer School (host - MSU, Moscow, Russia, 27 Jul – 7 Aug 2020)

<https://www.atm.helsinki.fi/peex/index.php/education/16-courses/185-jul-aug-2020-young-scientist-summer-school-on-multi-scales-and-processes-integrated-modelling-observations-and-assessment-for-environmental-applications>

	<p>Practical exercises: as Small-Scale Research Projects (SSRP) on seamless/ online integrated meteorology-chemistry-aerosols multi-scale and – multi-processes Enviro-HIRLAM, EC-Earth, MALTE-Box modelling for environmental applications (4-5 students per project) led by teachers (whom designed and realized the exercise – Michael Boy, Alexander Mahura, Risto Makkonen, Univ Helsinki) from 1st day till official oral presentation/ defence of SSRP outcomes)</p>
	<p>Socializing events: for participants - 1) Ice-Breaking Party, 2) Official Dinner, 3) Excursion to the City of St.Petersburg, 4) Excursion to RSHU University (will be organized after the lunch (for approx. 1-2 h period) and then exercises will be continued), and 5) Free Time / City Sightseeing</p>
	<p>Lectures covering aspects of: Fundamentals of atmospheric processes and modelling, surface and atmospheric boundary layer processes, atmospheric chemical transport modelling, aerosol physics and chemistry and modelling, evaluation and application</p>
	<p>Finals: Oral presentations & defence of SSRP – with awarding diplomas (3 ETCS) ceremony for students successfully presented and defended their projects, and official closure of the intensive training</p>

Thank you!