PEEX – Pan-Eurasian EXperiment Programme Science Plan

Markku Kulmala

E-mail: markku.kulmala@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics Faculty of Science, University of Helsinki (UHEL), Finland
https://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

& Hanna K. Lappalainen, Sergej Zilitinkevich
& PEEX Research Community [1]
[1] *see pp 244-250 of the PEEX Science Plan*

The **Pan-Eurasian EXperiment** (PEEX; https://www.atm.helsinki.fi/peex) is a multidisciplinary climate change, air quality, environment and research infrastructure program focused on the Northern Eurasian domain, and in particular, on the Arctic and boreal regions. It is a bottom-up initiative by several European, Russian and Chinese research organizations and institutes in co-operation with United States and Canadian organizations and institutes.

At current moment, the PEEX network includes more than 4000 researchers worldwide. There are several PEEX Thematic Working Groups (WGs) such as the Research Infrastructure, Modelling-Platform, Satellite, and foreseen other WGs. As of now, more than 30 PEEX Memorandum of Understanding (MoU) were signed with universities and research institutes in Russia and China (https://www.atm.helsinki.fi/peex/index.php/mou).

According to the developed PEEX Science Plan (*PEEX, 2015*), 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 **PEEX vision** 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. The identified large scale research topics to be studied from a system perspective towards better system understanding of the Arctic-boreal regions are shown in Figure 1.

The vision also includes the establishment and maintenance of long-term, coherent and coordinated research and education activities and continuous, comprehensive research infrastructures in the PEEX domain. PEEX aims to contribute to the Earth system science agenda and climate policy in topics important to the Pan-Eurasian environment, and to provide adaptation and mitigation strategies for the Northern Pan-Eurasian and Chinese societies related to Grand Challenges particularly climate change and air quality.

The **PEEX mission** aim to be a next-generation natural sciences and socio-economic research initiative using excellent multi-disciplinary science with clear impacts on future environmental, socio-economic and demographic development of Arctic-boreal regions as well as of China.

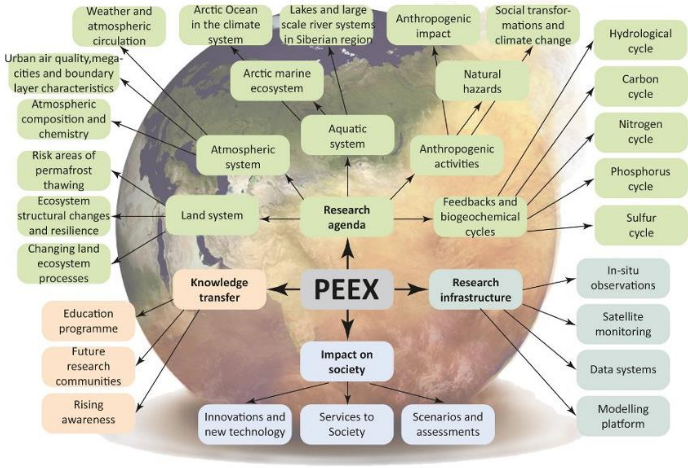

Figure 1. *Detailzation of the PEEX agenda represented by 4 main focus areas: Research agenda, Research infrastructures, Impact on society, Knowledge transfer (Fig. from PEEX, 2015).*

The **PEEX *research agenda*** defines the large-scale key topics and research questions of the land-atmosphere-aquatic-anthropogenic systems in the Arctic-boreal context as well as megacity-climate interactions and air quality issues. The ***research infrastructure*** introduces the current state of the art observation systems in the Pan-Eurasian regions and presents the future baselines for the coherent and coordinated research infrastructures in the PEEX domain. The ***impact on society*** addresses key aspects related to mitigation and adaptation strategies. It also involves planning for preparing northern societies to cope with environmental changes, developing reliable early-warning systems, and addressing the role of new technology in the implementation of these strategies and plans. The ***knowledge transfer*** is focused on educational programs at multiple levels, strengthening future research communities, and raising awareness of global changes and environmental issues.

The **PEEX scientific results** will fill the current gaps in our knowledge of the processes, feedbacks and links within and between the major components of the Earth system, and the biogeochemical cycles, in the Arctic-boreal context.

The PEEX domain covers a wide range of interactions and feedback processes between humans and natural systems, with humans acting both as the source of climate and environmental change, and the recipient of the impacts. Reliable climate information and scenarios for the coming decades are crucial for supporting the adaptation of northern societies to the impacts of climate change and cryospheric changes. Human decision-making concerning, for example, land use and fossil fuel burning are represented by agent-based and integrated assessment models, and climate scenarios, which will be utilized and further developed for the Northern Pan-Eurasian region. In urban and industrialized regions, the process understanding of biogeochemical cycles includes anthropogenic sources, such as industry and fertilizers. PEEX climate scenarios, especially estimates of the type and frequency of natural hazards in the future, will be used to improve climate prediction capacities in Europe, Russia and China.

References:

PEEX (2015): Pan-Eurasian EXperiment Science Plan. Eds. Lappalainen H.K., Kulmala M., Zilitinkevich S., ISBN 978-951-51-0587-5, 307 p, http://www.atm.helsinki.fi/peex/images/PEEX_Science_Plan.pdf

Linking TRAKT project to the PEEX networking

Hanna K. Lappalainen

E-mail: hanna.k.lappalainen@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics Faculty of Science, University of Helsinki (UHEL), Finland
https://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

& Markku Kulmala, Tuukka Petäjä, Alexander Mahura, Risto Makkonen, Sergej Zilitinkevich

At current moment the Pan-Eurasian EXperiment programme (PEEX) network includes more than 4000 researchers worldwide. The existing PEEX dissemination platform and communication tools will be used for presenting and promoting the TRAKT-2018 project (*TRAnsferable Knowledge and Technologies for high-resolution environmental impact assessment and management*) for the PEEX community.
The information is distributed through the PEEX official website (https://www.atm.helsinki.fi/peex - in English, Russian and Chinese), e-news, instagram, twitter (https://twitter.com/PEEX_News), e-mailing list (https://www.atm.helsinki.fi/peex/index.php/peex-e-mailing-list), newsletters (https://www.atm.helsinki.fi/peex/index.php/newsletter).
So far the PEEX programme signed more than 30 PEEX Memorandum of Understanding (MoU) with universities and research institutes in Russia and China (https://www.atm.helsinki.fi/peex/index.php/mou).
As part of the TRAKT project, during the official kick-off-meeting (22-24 Jan 2018, St. Petersburg, Russia; Fig. 1) such MoUs were signed also with 3 Russian partners involved into the project – the Nansen International Environmental and Remote Sensing Center (NIERSC; http://www.niersc.spb.ru; St. Petersburg), the Scientific Research Center for Ecological Safety (SRCES; http://ecosafety-spb.ru; St. Petersburg) and the Kola Science Center of the Russian Academy of Sciences (KSC RAS; http://www.kolasc.net.ru/english/index.html; Apatity, Murmansk region).

***Figure 1.** TRAKT-2018 project kick-off-meeting (Jan 2018) – participants working moments, and brainstorming on steps of the project realisation (led by the project coordinator Dr. Igor Ezau).*

Moreover, basic information about the TRAKT project is linked to the PEEX official website and available at: https://www.atm.helsinki.fi/peex/index.php/trakt-2018. The TRAKT activities are well linked with two PEEX focus areas (Fig. 2) such as the "*Knowledge Transfer*" and "*Impact on Society*".

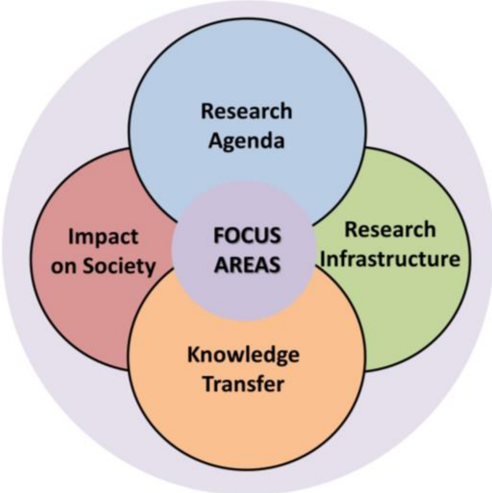

***Figure 2.** PEEX is represented by 4 main focus areas: Research Agenda, Research Infrastructures, Impact on Society, Knowledge Transfer.*

The "Knowledge Transfer" focus area directs towards educational programs at multiple levels, strengthening future research communities, and raising awareness of global changes and environmental issues. And in particular: (i) to educate the next generation of multidisciplinary experts and scientists capable of finding tools for solving grand challenges; (ii) to increase public awareness of climate change impacts in the Pan-Eurasian region; (iii) to distribute the new knowledge and data products to scientific communities and the public sector; and (iv) to deliver tools, scenarios and assessments for climate policy makers and authorities.
The "Impact on Society" focus area addresses key aspects related to mitigation and adaptation strategies. It also involves planning for preparing northern societies to cope with environmental changes, developing reliable early-warning systems, and addressing the role of new technology in the implementation of these strategies and plans.
As part of the PEEX Working Groups meeting (scheduled for 1-2 November 2018, Helsinki, Finland), the TRAKT partners were invited to present the achieved results to a wider PEEX community. TRAKT is also invited to contribute to the 4th PEEX Science Conference (2019, Helsinki). Materials and results of the project are expected to be included into lecture courses at Universities. In addition, the INAR-UHEL team is also agreeing to provide the Enviro-HIRLAM model through signing agreement on the model code transfer and use for research, development and educational purposes for the project partners. A closer involvement and project contribution are also expected as part of the PEEX climate policy making and to international forums, decision-makers and national authorities (see more information in the PEEX Science Plan, sections 5.2 & 6.1).

References:

PEEX (2015). Pan-Eurasian EXperiment Science Plan. Eds. Lappalainen H.K., Kulmala M., Zilitinkevich S., ISBN 978-951-51-0587-5, 307 p, http://www.atm.helsinki.fi/peex/images/PEEX_Science_Plan.pdf

SMEAR – Station for Measuring Ecosystem-Atmosphere Relations

Tuukka Petäjä

E-mail: tuukka.petaja@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics Faculty of Science, University of Helsinki (UHEL), Finland
https://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

& Markku Kulmala, Timo Vesala, Jaana Bäck, Hanna K. Lappalainen & SMEAR stations researchers [1]

1 https://www.atm.helsinki.fi/SMEAR/index.php/people

The SMEAR research stations are developed and used to perform comprehensive and continuous observations (https://www.atm.helsinki.fi/SMEAR/index.php[2]) for the relationship of atmosphere – Earth's surface/ biosphere in boreal climate zone (Fig. 1). The main aims of research are: (i) biosphere - aerosol - cloud - climate interactions; (ii) biogeochemical cycles of carbon, nitrogen, sulphur and water; (iii) analysis of gaseous and particle pollutants and their role in cloud formation; (iv) analysis of water, carbon and nutrient budgets of soil; (v) analysis of environment and tree structure on gas exchange, water transport and growth of trees.

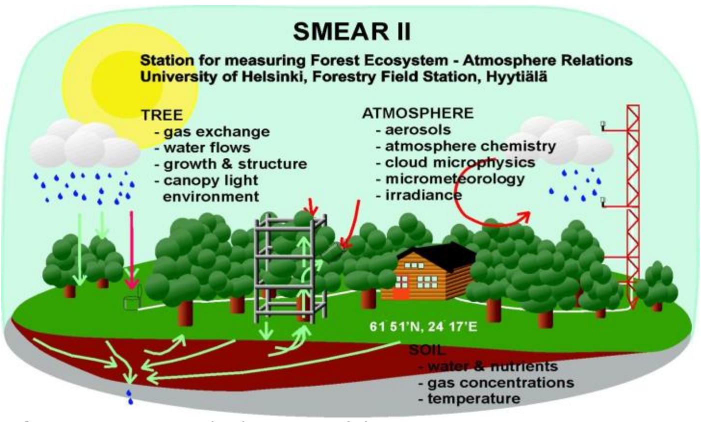

Figure 1. *Conceptual schematics of the SMEAR stations measurements.*

At SMEAR stations, in total more than 1200 different variables can be measured in urban, forest, lake, peatland, and other areas. The SMEAR concept allows to study feedbacks with different surfaces such as land, water, urban, biosphere, cryosphere, etc. It relies on open data, open access, and open data flow. There are several SMEAR stations in Finland (Fig. 3; with the most advanced SMEAR-II station in Hyytiälä, where frequently the training and educational courses are carried out, Fig. 2), also in Estonia, China as well as planned in Russia.

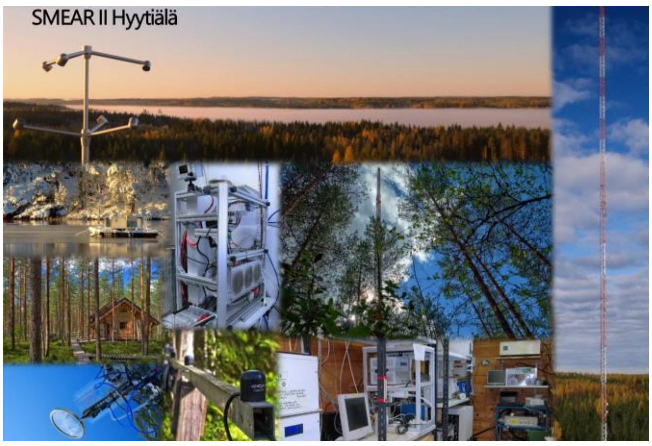

Figure 2. *SMEAR-II station in Hyytiälä, Finland.*

The closest SMEAR station to the Russian North is called the SMEAR-I station (Fig. 3-left & 4-left). It was placed into operation in 1991 in order to measure pollution levels (at first, with focus on SO_2 and then later on other chemical species) in the Eastern Lapland of Finland from various industrial sources of the Kola Peninsula (Murmansk region, Russia). It is hosted by the Värriö Subarctic Research Station, which is placed in the Värriö Strict Nature Reserve (www.helsinki.fi/forestsciences/varrio/index.html).

Figure 3. *Geographical locations of the SMEAR stations in Finland & 4 seasons at SMEAR-II station (see more illustrations at [2]).*

At SMEAR-I, during 1990s the measuring activity has increased to cover photosynthesis, weather, gas and particle measurements in addition to the measurements of air pollutants. In particular, the weather station measures wind speed and direction, air temperature and relative humidity on 5 levels (up to 15 m), and radiation (PAR, global, reflected and net radiation) is measured at the top level. Gas and particle measurements includes sampling on 4 levels (from 1 to 8 m). Concentrations of CO_2, SO_2, O_3 and NO, NOx are recorded as well as submicron particle number concentrations.The online available SMEAR-I measurements include: aerosol particle count and size distribution, atmospheric pressure, air temperature, relative humidity, precipitation, wind speed and direction, radiation components, soil temperature, carbon dioxide exchange of 4 pine shoots, and selected trace gas concentrations. Selected observations in a graphical format are web-online available (https://www.atm.helsinki.fi/SMEAR/index.php/online-observations) as well as data can be downloaded (https://avaa.tdata.fi/web/smart/smear/download).
In addition to the state-of-the-art SMEAR stations, the PEEX has also very close collaboration with many Russian partners on measurements (at different level of complexity) in the Arctic region. In particular, work is in progress on building the catalogue (Fig. 4-right) of the collaborating atmospheric-ecosystem in-situ stations in Russia. Information on these stations and their metadata is available from the developed database at https://peexdata.atm.helsinki.fi (*under request*).

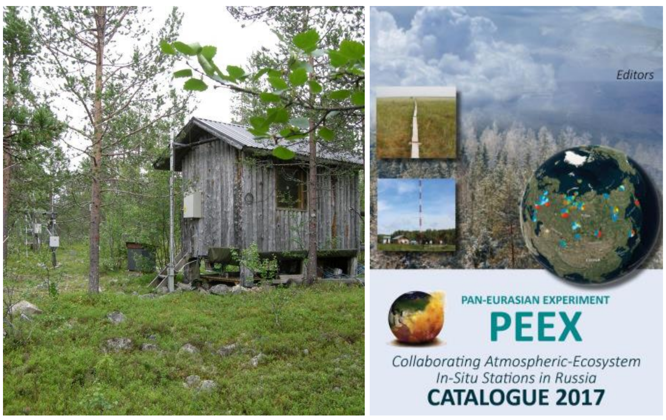

Figure 4. *SMEAR-I station in Värriö, Finland & Catalogue.*

Multi-Scales and Multi–Processes Modelling at INAR

Alexander Mahura

E-mail: alexander.mahura@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics Faculty of Science, University of Helsinki (UHEL), Finland
https://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

Risto Makkonen, Michael Boy, Zhou Putian, Tuukka Petäjä, Markku Kulmala, Sergej Zilitinkevich & "Enviro-PEEX on ECMWF" Modelling Team

According to the Pan-Eurasian EXperiment Science Plan (*PEEX, 2015*), the PEEX Modelling Platform (PEEX-MP) presents a strategy for best use of current generation modeling tools to improve process understanding and predictability on different scales in the PEEX domain (see https://www.atm.helsinki.fi/peex/index.php/modelling-platform). More than 100 members from European, Russian, and Chinese institutions have joined the PEEX-MP. The key issues considered by the MP include the following topics: anthropogenic emissions, permafrost effects, methane and carbon dioxide, ecosystem carbon cycle, short lived pollutants and climate forcers, biogenic VOC emissions, forest fires and their effects, aerosol formation in Arctic and Siberia, aerosol radiative forcing, air pollution – ecosystem feedbacks, dynamics of ocean and sea-ice, high impact events.

At INAR, a number of application areas of new integrated modelling developments is expected as a part of the research project "Enviro-PEEX on ECMWF" (2018-2020; https://www.atm.helsinki.fi/peex/index.php/enviro). The focus is to analyse importance of the meteorology-chemistry-aerosols interactions and feedbacks and to provide a way for development of efficient techniques for on-line coupling of numerical weather prediction (NWP) and atmospheric chemical transport via process-oriented parameterizations and feedback algorithms, and hence, to improve NWP, climate and atmospheric composition forecasting.

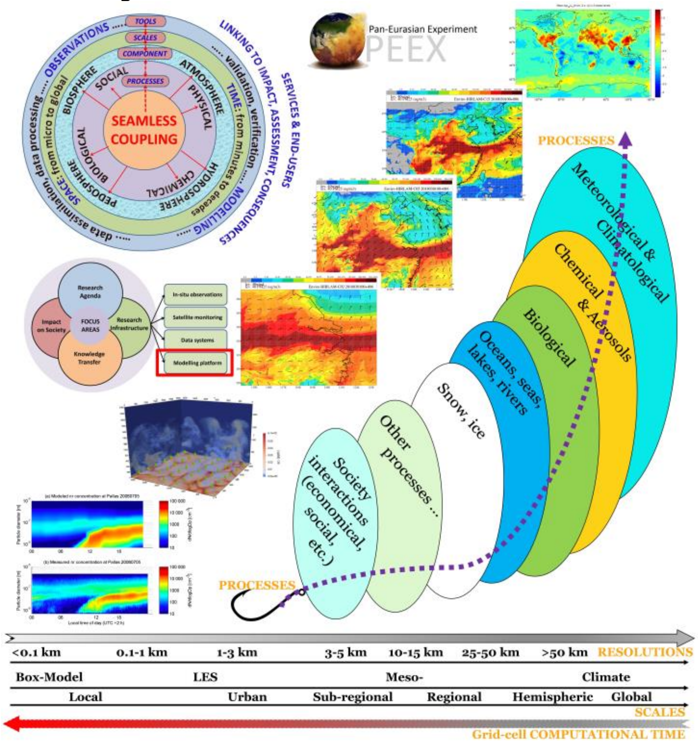

Figure 1. *Multi-scales & -processes modelling at INAR (NOSA-FAAR Conference, Mar 2018; poster by Mahura et al.).*

The seamless/ on-line integrated coupling includes different processes, components, scales and tools (see Fig. 1). At INAR, several research tools are used: the EC-Earth (*Hazeleger et al., 2010*), Enviro-HIRLAM (*Baklanov et al., 2017*), ASAM (*Jähn et al., 2015*), SOSAA (*Boy et al., 2011*), MALTE-box (*Huang et al., 2016*), and others.

The scales to be considered cover scales from micro- to local, urban, sub-regional, regional, hemispheric, global; and from box-model to large eddy simulations, meso- and climate scales. The horizontal resolutions for models runs are ranging from a few meters to more than a degree in the latitudinal-longitudinal domain. The processes, at the current moment studied at different degree of understanding and to be considered include meteorological and climatological, chemical and aerosols, biological, hydrological, and others as well as taking into account society interactions (see Fig. 1).

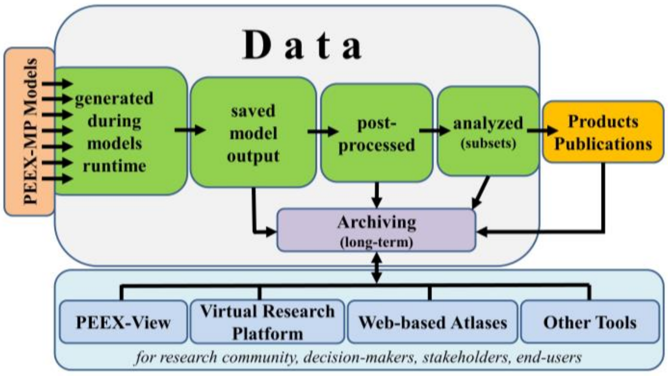

Figure 2. *PEEX Modelling Platform data flow from model runs to products and publications with long-term archiving and delivering for potential customers.*

Available observations for atmosphere and ecosystems (in particular, from the SMEAR stations and PEEX metadatabase stations) will be used for data assimilation and data processing as well as for the models validation and verification studies.

The IT Center for Science (CSC, Finland; https://www.csc.fi) and European Center for Medium-range Weather Forecasting (ECMWF, UK; https://www.ecmwf.int) are in active collaboration with INAR, where CRAY's supercomputing facilities, mass storage systems, meteorological and atmospheric composition data archives are used extensively.

The large dataset during PEEX-MP models runtimes will be generated, post-processed, analysed, and also saved for long-term storage (see Fig. 2). These data can be visualised and analysed using different tools such as the PEEX View, Web-based Atlases, Virtual Research Platform by the members of the research community, decision-makers, stakeholder, end-users.

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Earth System Modelling with EC-Earth

Risto Makkonen

E-mail: risto.makkonen@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics Faculty of Science, University of Helsinki (UHEL), Finland
https://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

TRAKT project assesses the performance of global Earth System Model EC-Earth in the study domain. EC-Earth is developed and applied jointly by over 30 European research institutes (*Hazeleger et al., 2010, 2012*). The Coupled Model Intercomparison Project 5 (CMIP5) was the first CMIP for EC-Earth, and now the model is participating CMIP phase 6 (CMIP6).

The EC-Earth comprises of atmosphere model IFS (Integrated Forecasting System), ocean model NEMO (Nucleus for European Modelling of the Ocean; *Madec et al., 2008*) and vegetation model LPJ-GUESS (Lund-Potsdam-Jena General Ecosystem Simulator), coupled with OASIS (Ocean Atmosphere Sea Ice Soil; *Redler et al., 2010*) coupler (Figure 1). Aerosols and chemistry are included through the global chemistry-transport model TM5 (Transport Model 5). The atmospheric model IFS might be changing to OpenIFS, which would also increase the potential user groups of EC-Earth model and link more to meteorological training. The full ESM version of EC-Earth is currently being implemented in computing infrastructures around Europe.

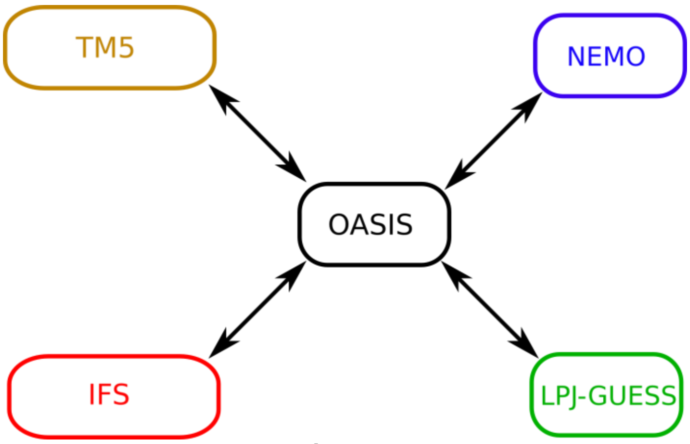

Figure 1.
EC-Earth model components: TM5 (aerosols and chemistry), NEMO (ocean), IFS (atmosphere), LPJ-GUESS (vegetation).

The IFS is the atmospheric model developed at European Centre for Medium-Range Weather Forecast (ECMWF, UK). The proposed assessment in TRAKT is using IFS with 62 vertical levels and a horizontal spectral resolution of T255 corresponding to roughly 0.54ºx0.54º, which is rather high resolution for ESM applications. The IFS is coupled to the ocean model NEMO, which is run with 1º horizontal resolution and 42 vertical levels. The ice model LIM (The Louvain-la-Neuve Sea Ice Model; *Vancoppenolle et al., 2009; Rousset et al., 2015*) is coupled directly to the ocean model.

The TM5 (*van Noije et al., 2014*) describes aerosols using a 7-mode size distribution (*Vignati et al., 2004*), with 4 soluble and 3 insoluble modes. TM5 includes most abundant aerosol species: sulfate, black carbon, organic carbon, sea salt and mineral dust. TM5 uses a grid of 3ºx2º for aerosols and chemistry.

For the current CMIP6 version of EC-Earth ESM, several relevant modifications are included: 1) TM5 aerosol fields are communicated via OASIS to IFS for aerosol indirect (cloud) effect, 2) interactive dust emissions and 3) secondary organic aerosol (SOA) scheme are implemented. The University of Helsinki has actively participated in the CMIP6-development of TM5, namely aerosol nucleation, aerosol growth and SOA module development.

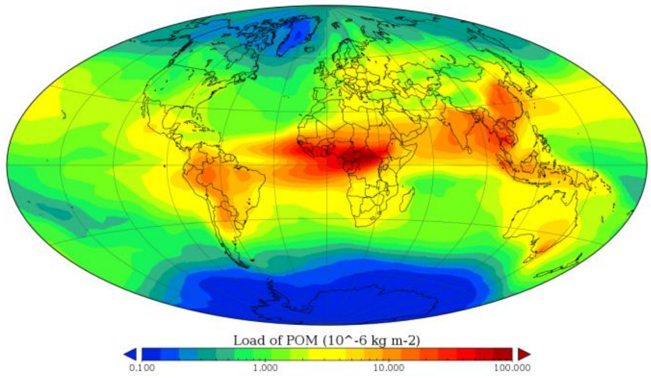

Figure 2.
Monthly average load of particulate organic matter for January (kg m-2), as simulated by TM5 aerosol-chemistry model in EC-Earth. Primary visible sources of POM in the model include wildfires, anthropogenic sources, and biogenic precursors.

The LPJ-GUESS (*Smith et al., 2001*) is the terrestrial vegetation components of EC-Earth. It is a dynamic process-based ecosystem model which can predict structural and compositional ecosystem properties. In EC-Earth, the atmospheric model IFS communicates temperature, radiation, precipitation and soil state to LPJ-GUESS. Concurrently, LPJ-GUESS updates simulated low and high vegetation fraction as well as leaf area index to IFS land surface module. In addition to land surface processes, gas-phase transport of CO2, aerosols and precursors is communicated between TM5 and LPJ-GUESS. The CMIP6-version of EC-Earth includes version 4 of LPJ-GUESS, together with e.g. a new land albedo parameterization and fire module. For the benefit of the proposed project, LPJ-GUESS is now being updated with speciated monoterpene emissions for detailed SOA formation in the atmosphere.

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Seamless Integrated Meteorology-Chemistry-Aerosols Enviro-HIRLAM Modelling

Alexander Mahura

E-mail: alexander.mahura@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics Faculty of Science, University of Helsinki (UHEL), Finland
https://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

& the Enviro-HIRLAM Research and Development Team

The development seamless/ on-line integrated meteorology-chemistry-aerosols modelling system such as the **Enviro-HIRLAM** (***Environment – HIgh Resolution Limited Area Model***) is expected to be able to handle and study some of major existing processes and interactions, which is difficult to investigate using the off-line modelling approach. Following *Jacobson et al. (2007) and Zhang (2008),* among these processes and interactions there are the following. At first, the direct effect - radiative effect of chemical species in the atmosphere via absorption and scattering. At second, the semi-direct effect - effect of aerosols and clouds on photolysis rates via modifying actinic fluxes and temperature. At third, the semi-direct effect - effect of aerosols on boundary layer meteorology via changing meteorological variables and atmospheric stability. At fourth, the 1st and 2nd indirect effects - effect of aerosols on cloud formation and reflectance via aerosol activation, droplet and ice core nucleation, autoconversion, and collection. And, at firth, the indirect effects - effect of aerosols on precipitation by affecting clouds and water vapour. These processes and interactions are important in studies for weather, climate, air quality, ecosystems, etc. Aerosols, being an integral part of the atmosphere, play important role in the environmental conditions behaviour. Depending on origin, chemical composition, lifetime, size, shape, optical properties, etc. aerosols can cause multiple complex effects in the atmosphere at various temporal and spatial scales *(Kulmala et al., 2009; Calvoa et al., 2012).*

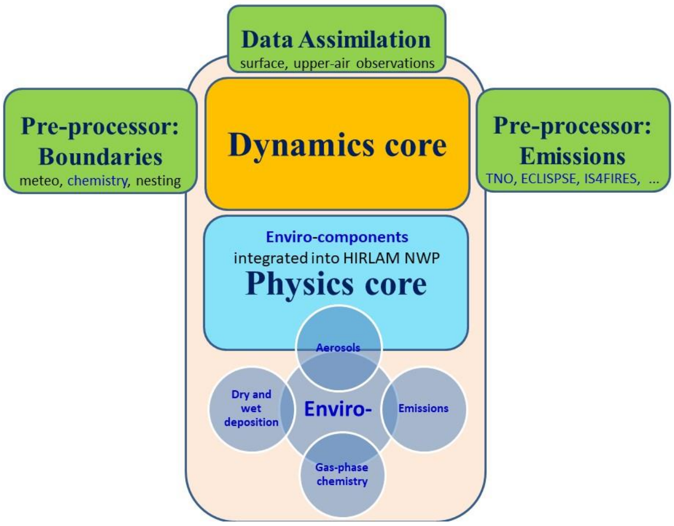

Figure 1. *General schematics of the Enviro-HIRLAM modelling system.*

The Enviro-HIRLAM model is developed as a fully online integrated numerical weather prediction (NWP) and atmospheric chemical transport (ACT) model for research and forecasting of joint meteorological, chemical and biological weather at multi-scales (*Baklanov et al., 2017*).

The NWP part developed by HIRLAM consortium is used for operational weather forecasting. The Enviro-components were developed in collaboration with the Universities from different countries. The Enviro-consists (*see all references in Baklanov et al., 2017*) modules for gas-phase chemistry CBMZ and aerosol microphysics M7 (includes sulphate, mineral dust, sea-salt, black and organic carbon). There are also modules of urbanization (anthropogenic heat flux and roughness, building effect parameterisation, others) for land surface scheme, natural and anthropogenic emissions, nucleation, coagulation, condensation, dry and wet deposition, sedimentation of aerosols. The improved Savijarvi radiation scheme takes into account explicitly for aerosol radiation interactions for 10 aerosol subtypes. The aerosol activation scheme was implemented in STRACO condensation-convection scheme. The nucleation is dependent on aerosol properties, ice-phase processes are reformulated in terms of classical nucleation theory. The schematics is shown in Fig 1.

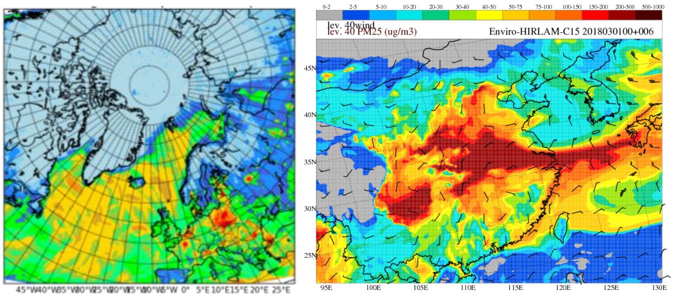

Figure 2. *Enviro-HIRLAM model simulation examples: (left) averaged spatial distribution of the maximum PM2.5 concentration field at 12 UTC for the month of Jan 2010; & (right) operational forecast for the China on 1 Mar 2018 (00+06 h forecast length).*

Enviro-HIRLAM runs in a downscaling chain, for the outer model domain (run at low resolution) the initial and boundary conditions for meteorology and atmospheric conditions are taken from ECMWF. The vertical levels vary between 40-60. The finest horizontal resolution is about 1.5 km. The model can be run in both research and operational modes. Emissions include anthropogenic, biogenic, and natural; and these are pre-processed. Different parts of the model were evaluated vs. ETEX-1 experiment, Chernobyl accident, Paris summer/winter campaigns, etc. The model was tested in FPs FUMAPEX, MEGAPOLI, TRANSPHORM, PEGASOS, MACC, MarcoPolo projects as well currently is used within frameworks of the Pan-Eurasian EXperiment programme (PEEX; https://www.atm.helsinki.fi/peex) tasks. Examples of the model simulations are shown in Fig 2.

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Process-Based Modelling for the Meteorology-Chemistry-Aerosol System

Michael Boy

E-mail: michael.boy@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics, Faculty of Science, University of Helsinki (UHEL), Finland
https://wiki.helsinki.fi/display/AMG

& the Atmospheric Modelling Group (AMG)

The main focus of the process-based modelling in the PEEX-MP is to increase our understanding of hydrological, physical, meteorological and chemical mechanisms in the lower part of the troposphere. This includes the emissions of biogenic volatile organic compounds (BVOC) from different ecosystems with a special focus on boreal region, their vertical and horizontal distribution and their chemical reaction paths. Further to investigate the formation and growth of secondary organic aerosols (SOA) inside the planetary boundary layer (PBL) and to improve our understanding of in- and below cloud formation and activation mechanisms, which is still far away from complete. We aim at finding process parameterizations that can be subsequently applied in climate predictions and reduce significant uncertainties therein (see Figure 1).

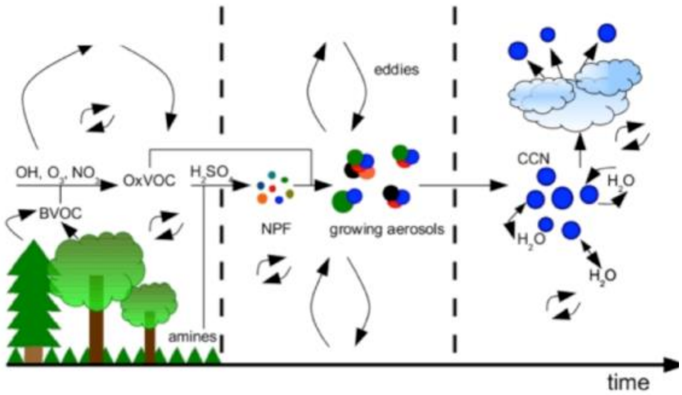

Figure 1: *General schematics on the scientific objectives.*

To achieve these goals we apply a seamless process-based modelling system including a set of different models: starting from the zero-dimensional models MALTE-BOX and ADCHAM, the one-dimensional model SOSAA, the two-dimensional model ADCHEM and the three-dimensional high-resolution regional model SILAM. In addition to understand the impact of turbulence on the different processes we operate the large-eddy-simulation model (LES) ASAM and the direct numerical simulation model (DNS) PENCIL-CLOUD. The advantage by applying this seamless-process-based model system is in the use of several modules like the ecosystem emission module MEGAN (Model of Emissions of Gases and Aerosols from Nature) or the aerosol module UHMA (University of Helsinki Multicomponent Aerosol Model) in several models, which provides improvements in one process to other models at the same time. A schematic spatial-temporal distribution for all models applied is provided in Figure 2.

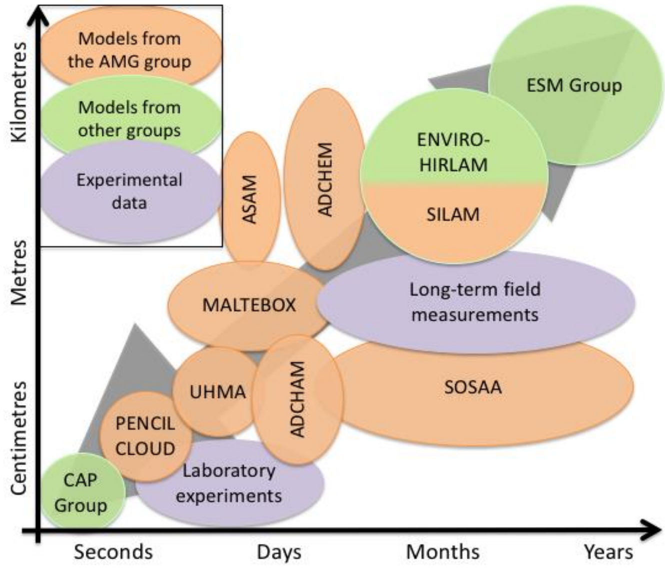

Figure 2: *Schematic time-space picture of the models applied in the Atmospheric Modelling Group, the connection to other groups (models) and the used experimental data (size of circles and ovals represent approximately the spatial and temporal area covered by the model or experimental data; CAP = Computational Aerosol Physics Group, ESM = Earth System Modelling Group).*

Detailed information for the individual models are available at the AMG website: https://wiki.helsinki.fi/display/AMG/Atmospheric+Models
One of the main objectives of the group is to gain a comprehensive understanding of the precursors, formation, growth, and transformation of SOA and to quantify the associated climate impacts with a focus on anthropogenic versus biogenic effects. Recently we have developed the most comprehensive Peroxy Radical Autoxidation Mechanism (PRAM), which explicitly simulates the formation of HOM from monoterpenes (*Roldin et al., 2018*). We use PRAM together with detailed molecular cluster dynamics and aerosol dynamics models to constrain the contribution of highly oxygenated organic molecules (HOM) to the formation and growth of new particles to the climatically important cloud condensation nuclei (CCN) size range. Based on our process-based model results we will evaluate and suggest how to improve the new particle formation (NPF) and SOA formation parameterization used by regional and earth system models (see figure 3).

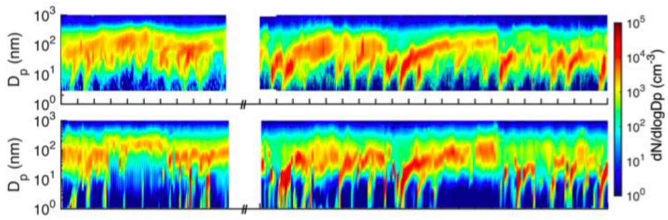

Figure 3: *Measured (upper plot) and modelled (lower plot) particle size distributions for the periods 15^{t} -25^{th} of May 2013 and 15^{th} of April to 4^{th} of May 2014 at SMEAR II, Hyytiälä, Finland. ADCHEM was used for these model runs and the NPF was simulated with ACDC assuming that the clusters were formed from NH_3 and H_2SO_4.*

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Monthly Concentration & Deposition Patterns from Smelters of the Russian North: Atlas

Alexander Mahura

E-mail: alexander.mahura@helsinki.fi

Institute for Atmospheric and Earth System Research (INAR) / Physics Faculty of Science, University of Helsinki (UHEL), Finland
https://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

Alexander Baklanov[2], Jens. H. Sørensen[3]

[2] World Meteorological Organisation, Geneva, Switzerland
[3] Danish Meteorological Institute, Copenhagen, Denmark

There are several locations in the northern Russian Arctic associated with large amounts of sulphur dioxide (SO_2) emission into the atmosphere. They are known as smelters, and they could have the largest environmental and health impacts. These are the Russian enterprises located in the cities of Norilsk (Krasnoyarsk Krai), Mochegorsk and Nikel-Zapolyarny (Murmansk region). Information about environmental and pollution situation in these regions of Russia is provided through annual state reports. A series of studies was performed as a part of the Russian state scientific-research programmes, Kola Science Center and Siberian Branch of the Russian Academy of Sciences projects, Arctic Monitoring and Assessment Programme activities, and others.

The modeling of atmospheric transport, dispersion and deposition of different pollutants is essential input for estimation of possible consequences on different scales ranging from hemispheric to urban/ local scales. Estimates of transboundary transport between selected countries is especially important for a decision making process. Generated model output is crucial for multi-level assessment of risk, vulnerability, impact, short- and long-term consequences for environment and population, which is living near-by or remotely from the sources of possible accidental releases and continuous emissions.

The long-term modeling of the atmospheric transport, dispersion and deposition of pollution resulted from continuous emissions from the Russian smelters was performed employing the Lagrangian-type Danish Emergency Response Model of the Atmosphere (DERMA; *Sørensen, 1998; Baklanov et al., 2008*).

The probabilistic approach, sensitivity of the model to meteorology and diffusion parameters, deposition processes, and other parameterizations are also described in more details by *Baklanov and Mahura (2004), Sørensen (1998)*, and others. The European Centre for Medium-Range Weather Forecast (ECMWF) data archives were used as input 3D meteorological fields for the year 2000. These meteorological data are given at 1°x1° resolution with 6 hour time intervals and covering the Northern Hemisphere, north of 10°N.

For each run, the pollution plume originated near the source was dispersed through the atmosphere (as well as deposited due to dry and wet deposition processes) during following 10 days. It should be noted that in general, levels of pollution can vary significantly depending on dominating meteorological conditions both within the boundary layer as well as the free troposphere, and the highest levels of pollution are generally observed in vicinity of the sources.

The generated model output included: the air concentration, the time integrated air concentration (TIAC), dry (DD) and wet deposition (WD) (see Fig. 1).

Note that such output - if it is summed over a long period of time (for example: month, season, year) or if it is averaged over a short period of time (for example: day, period of accidental release) - can represent possible short- and long-term effects and probabilistic characteristics of industrial pollution. In general, based on such available output, the geographical boundaries of potential influence due to continuous (or accidental) atmospheric releases of pollutants from different sources can be identified and possible impacts can be evaluated. An example of simulated summary and average TIAC, DD and WD patterns during 10 days of the atmospheric transport, dispersion and deposition for the month of November are shown in Fig. 1.

The Web-based Atlas, which is displaying a month-to-month (shown both as separate figures for each month as well as animation on a yearly basis) variability of these patterns is available and can be analysed at: http://www.atm.helsinki.fi/peex/webatlas/WEBATLAS.html

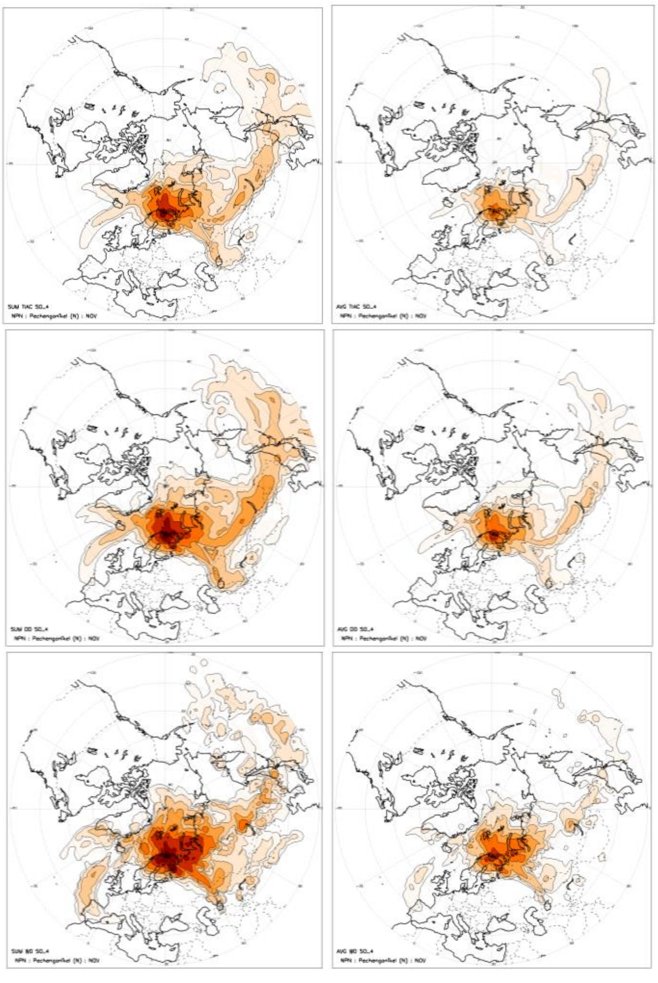

Figure 1. *Spatial patterns of the (left) summary and (right) average - (top) time integrated air concentration (TIAC), (middle) dry (DD) and (bottom) wet (WD) deposition - patterns during November due to continuous emissions of sulphates from the Nikel smelters (deposition and concentration isolines are shown starting from the lowest 1e-2 μg/m² and 1e-2 μg/m³, respectively; ΔNPN – location of the plant on the Kola Peninsula)*

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