

## PAN-EURASIAN EXPERIMENT (PEEX) PROGRAM -

### OVERVIEW AND FUTURE PROSPECTS

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### BACKGROUND

Pan-Eurasian Experiment (PEEX) Program ([www.atm.helsinki.fi/peex/](http://www.atm.helsinki.fi/peex/)) is an international, multi-disciplinary, multiscale bottom-up initiative. The precursor idea of the Eurasian Pan-Eurasian Experiment (PEEX) was introduced by Kulmala et al. (2011) addressing the importance of land-atmosphere dynamics of Siberian boreal forests for the climate system. The first idea was to organize so called Pan-Siberian experiment, a measurement program for aerosols, Greenhouse gases (GHG) and biogenic volatile organic compounds (BVOCs). Within this activity, an establishment of a coherent, coordinated observation network from Scandinavia to China, together with a science program focused on understanding processes in the land-atmosphere interface was preliminary discussed. In 2012, this idea expanded to cover the whole Northern Eurasian geographical domain and China, and evolved into the Pan-Eurasian Experiment (PEEX) (Kulmala et al. 2011, Lappalainen et al. 2014, 2015).

### STATE-OF-THE-ART AND FUTURE CHALLENGES

The promoter institutes of PEEX are: University of Helsinki and Finnish Meteorological Institute in Finland, Institute of Geography of Moscow State University, AEROCOSMOS, and Institute of Atmospheric Optics (Siberian branch) of the Russian Academy of Sciences (RAS) in Russia, Institute of Remote Sensing and Digital Earth (RADI) of the Chinese Academy of Sciences (CAS) and Institute for climate and global change research of Nanjing University in China. The program governance and the communications is coordinated by the PEEX Offices in Helsinki (PEEX Headquarters, PEEX-HQ), Moscow, Nanjing and Beijing under the

guidance of the Program Steering Committee. In 2018, the office network is expected to expand and new offices and/or local contact points will be established in Vladivostok and in Tyumen. The upcoming challenge will be education of the new PEEEX science officers working as the local contact points and establish fluent information flows within the network.

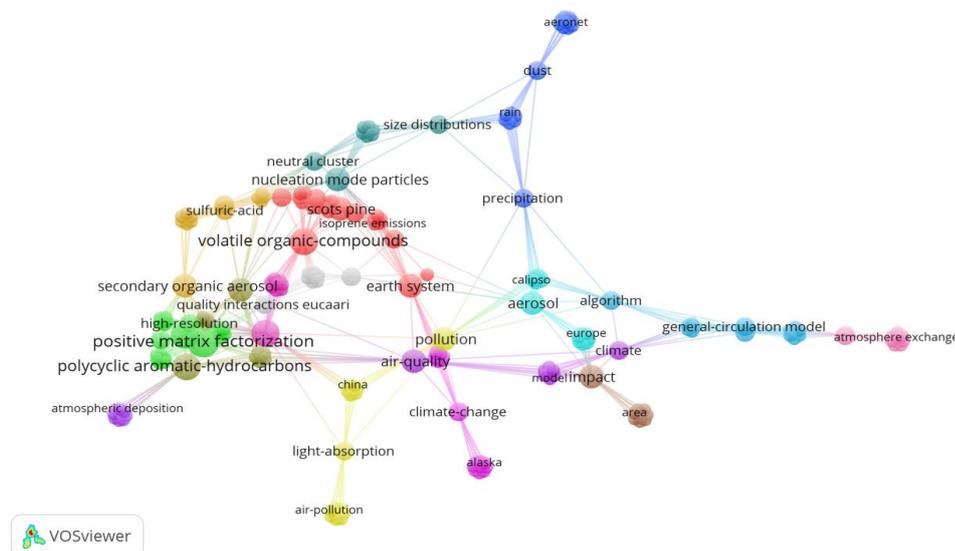
At an institutional level, the collaboration within PEEEX is typically initiated via signing a Memorandum of Understanding (MoU) with the PEEEX program. At the moment we have signed PEEEX oriented MoUs with 30 universities and research institutes in Russia and 5 in China. As a whole the PEEEX researchers' network includes approximately 4000 researchers from 20 countries from Europe, Russia and China. The PEEEX science conferences are the main forum for research community to share their scientific outcomes. In addition to organization of the conferences, the active work of the PEEEX working groups (WG) is facilitated. So far, the Modelling-Platform WG and the Infrastructure WG have been the most active and their work has been mainly focusing on the concept design of the modelling platform and on establishing the PEEEX in-situ observation network in Russia. New working groups and community based activity as bottom-up activities are foreseen on topics like "environmental change and epidemics" and "connecting social parameters to atmospheric emissions".

PEEX-HQ is coordinating the PEEEX network at different levels (researchers, institutes and organizations) and the governance activities together with other offices in Russia and in China. This work is facilitated by different tools such as a website ([www.atm.helsinki.fi/peex/](http://www.atm.helsinki.fi/peex/)), e-news, e-mailing lists, organization of conferences, conference sessions, meetings and forums (e.g. 1<sup>st</sup> Sofia Earth Forum in Helsinki 2016). In 2012-2017, we have organized altogether 7 meetings and 3 science conferences (Helsinki 2015, Beijing 2016, Moscow 2017). Starting from January 2017, PEEEX has joined the U-Arctic community of 170 Arctic universities and PEEEX acts as a "Arctic-Boreal Hub", which is one of the U-Arctic Thematic networks ([www.uarctic.org/organization/thematic-networks/arctic-boreal-hub/](http://www.uarctic.org/organization/thematic-networks/arctic-boreal-hub/)). The Arctic-Boreal Hub –network expands the PEEEX approach into a circumpolar context and opens up connection points with the US and Canadian research communities. One practical example of this activity was the ARCTIC Fluxes – CRAICC/CRUCIAL (Critical steps in understanding land surface – atmosphere interactions: from improved knowledge to socioeconomic solutions) workshop with 71 participants from Canada, USA, Europe and Russia, organized in February 2017 in Hyytiälä, Finland. As a whole, the PEEEX network is open for new researchers and organizations representing different scientific disciplines to join in and is especially interested in strengthening the role of social and socio-economic sciences within this community.

The main scientific mission of PEEEX program is to understand large-scale feedbacks and interactions between the land-atmosphere-ocean continuum in the changing climate of the Northern high latitude and in China (Kulmala et al. 2016, Lappalainen et al. 2016). The PEEEX Science Plan (Lappalainen et al. 2015) addresses the scientific aims and large-scale research questions of the program. The focal points in the PEEEX research are e.g. on the net effects of various feedback mechanisms connecting the biosphere, atmosphere and human activities. Such feedbacks stem from higher temperature and increased concentration of greenhouse gases (GHG) in the future. The climate change and associated feedbacks lead to further consequences, such as permafrost thawing, land cover changes, increased dissolved organic carbon content in freshwaters, acidification of the Arctic Ocean, increased photosynthetic activity, elevated GHG uptake by terrestrial ecosystems, increased Biogenic Volatile Organic Compound (BVOC) emissions, secondary aerosol, changes in cloud processes and alterations in the radiation budget. These feedbacks can either hinder or speed up the climate change.

The backbone of the research approach has been the scientific contribution of the Finnish Center of Excellence in Atmospheric Science - From Molecular and Biological processes to The Global Climate (FCoE-ATM), which delivers ca 150-200 peer reviewed papers annually. In addition to FCoE –ATM, a new 5 year European Research Council's Advanced Grant project on "Atmospheric Gas-to-Particle Conversion" and the Academy professorship "Air quality - climate interactions and feedbacks" lead by Academician M. Kulmala will continue the scientific work relevant to the PEEEX research agenda. Starting from 2015 PEEEX is also gathering research results on the Arctic-boreal environments via the PEEEX Special Issue in Atmospheric Chemistry and Physics (ACP) scientific journal ([www.atmos-chem-phys.net/special\\_issue395.html](http://www.atmos-chem-phys.net/special_issue395.html)). Altogether 28 papers in a final form and 10 papers under revision have been published by August 2018. Based on the keywords listed

in the papers, the foci of the results has been on the role of boreal forest and their BVOC emissions and subsequent aerosol formation processes (Fig.1). The future challenge is to expand the scientific coverage of the published results relevant to PEEEX research agenda and, in practice, initiate the research collaboration with socio-economic research communities.



**Figure 1.** The coverage of the PEEEX research fields is based in the articles in the PEEEX special issue in ACP that are already published by August 2018. There are 28 published. The 10 papers under revision are not included here. In the following networks, the size of the circle refers to the amount of papers, the position of the circles indicates the degree of relation while the colors indicate clusters of more related circles. (Analysis and visualization by Nuria Altimir, University of Helsinki).

The main strategic challenge of the program is to initiate a comprehensive and coordinated research infrastructure in collaboration with the main partners in Russia and in China. There is an urgent need for comprehensive, coordinated in-situ observations over the Arctic and Northern Eurasian region detecting different processes, energy flows, emissions and concentrations between different Earth surfaces (forest, peatlands, lakes, urban) and atmosphere. One of the most important relevant PEEEX activity is just started within ERAPLANET (The European network for observing our changing planet) project (the strand-4) called “Integrative and Comprehensive Understanding on Polar Environments (iCUPE) lead by University of Helsinki. 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, including also data products to the end users.

The PEEEX land-ecosystem in-situ network will be built upon complementary approaches. The coordination and upgrading of the existing station activities and establishing new SMEAR (Stations for Measuring Earth surface - Atmosphere Relations) -typed stations will be based a SMEAR concept (Hari et al. 2016). The principles of the PEEEX in-situ observation network, also as a part of the global observatory, are being introduced in Hari et al., 2005, 2009, 2016 and Kulmala et al. 2016., Kulmala et al 2016 (manuscript in preparation). In reference to the “coordination and upgrading of the existing stations” in Russia, the collection of the preliminary information of the existing station activities started in 2012. The first inventory on over 200 in-situ stations operating in the Arctic and Subarctic Eurasian regions was conducted by the Russian Academy of Sciences (RAS) and Moscow State University together with the University of Helsinki (Alekeychik et al. 2016). Based on the first inventory we currently collect more detailed information, here termed as “station metadata”. The station metadata, the detailed descriptions of measured variables and the observation site, enables categorize the stations in a systematic manner and will provide tools to connect them to international observation networks, such as WMO-Global Atmospheric Watch Program, China Ecosystem Network (CERN) and global SMEAR network, and to carry out standardization work towards common data formats. Based on this work, PEEEX will also publish a station e-catalog, which will give information on the on-going measurements and contact points and initiates research collaboration between the research groups.

The marine observations from the Arctic Ocean, sea ice and atmosphere, are needed to obtain a better understanding on the state and change of the marine Arctic climate system. The PEEEX marine infrastructure activity addresses the Arctic Ocean and adjacent seas. Similarly to PEEEX/SMEAR, the PEEEX marine component will be based on a hierarchical concept of station network, but affected by the practical challenges in making long-term observations in and over the sea. The processes to be studied include the sea ice thermodynamics and dynamics, ocean heat and freshwater budgets, ocean circulation, waves and tides, ocean chemistry and ecosystems, atmospheric heat and moisture budgets, synoptic-scale cyclones and Polar lows, troposphere-stratosphere coupling, atmospheric boundary-layer processes, as well as aerosols and clouds (Vihma et al., 2014; Vihma et al. manuscript in preparation).

The concept design of the PEEEX modelling platform (MP) is also in process and is planned to be published in 2018 (*Baklanov et al. manuscript under preparation*). The MP will be based a seamless modelling framework from nano-scale modelling to Earth system models. It will also introduce community-based services for data mining and for demonstrating air pollution events at regional scales. The large-scale component of PEEEX-MP will consist of ESM EC-Earth ([portal.enes.org/models/earthsystem-models/ec-earth-1/ec-earth](http://portal.enes.org/models/earthsystem-models/ec-earth-1/ec-earth)), which combines all relevant elements of the PEEEX domain in a global scale.

As a whole PEEEX is an active contributor and a collaborator in the international research and research infrastructure landscape. The main international partners and collaborators are Future Earth (PEEX - FE Partnering Program), Arctic Council (contributing the AMAP and SAON WGs), GEO – GEOSS Cold regions (PEEX - the in situ observations activity), IIASA (Arctic Initiative), iLEAPS and WMO GAW program. PEEEX is also closely connected to International Eurasian Academy – European Center and the DBAR (Digital Belt and Road) Initiative, which are interested in to provide a big data platform on earth observation from China and countries along the new Silk Road - Belt and Road area.

## CONCLUSIONS

The PEEEX has released the program agenda and is currently finalizing the conceptual design of the PEEEX relevant research infrastructures. The program is currently calling for financial support from European Union, Russian and Chinese basic funding organizations to implement the program at the large scale. The implementation of the PEEEX program would make significant impact on the sustainable development of the Northern societies and China.

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