

PAN-EURASIAN EXPERIMENT (PEEX) PROGRAM ADDRESSING THE FUTURE NEEDS OF THE NORTHERN HIGH LATITUDES RESEARCH INFRASTRUCTURE

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1. INTRODUCTION

Pan-Eurasian Experiment (PEEX) Program is an international, multidisciplinary, multiscale bottom up initiative, established in 2012 (PEEX Science Plan 2015). The PEEX geographical focus is on the northern high latitudes (Arctic, boreal) and on China and the new Silk Road Economic Belt regions (Kulmala et al. 2015, Lappalainen et al. 2014, 2018, 2019). PEEX framework is driven by a research approach and high quality RI development focused on solving grand challenges, like climate change and air quality (Kulmala et al. 2015, Kulmala 2015). PEEX *in situ* observation network is based on the SMEAR (Stations Measuring the Earth Surface – Atmosphere Relations) concept and has been introduced by Hari et al. (2005, 2016) and Kulmala et al. (2016). The specific future needs for the Arctic marine environments has been discussed by Vihma et al. (2019). The PEEX RI mission is addressing the observational gap especially in the Northern Eurasian region and development of the *in situ* station network in this region (Aleksyechik et al. 2016). The PEEX RI mission finds synergy with and is contributing the international Arctic RI projects like EU Horizon-2020 iCUPE (*Integrative and Comprehensive Understanding on Polar Environments*; www.atm.helsinki.fi/icupe) coordinated by INAR (Petäjä et al., 2019 paper in preparation) and INTAROS (*Integrated Arctic Observation System*; www.nersc.no/project/intaros) coordinated by the Nansen Environmental and Remote Sensing Center (Norway).

2. FUTURE NEEDS OF NORTHERN HIGH LATITUDES RESEARCH INFRASTRUCTURE

The baseline for the future needs of the Arctic and Northern high latitudes research infrastructures and for the *in situ* observations should be connected to the global context. Kulmala (2015, 2018) has addressed that the Grand Challenges (GC) (climate change, urban air pollution, ocean acidification, food security etc.) are interlinked, but current observations are fragmented (Kulmala et al. 2015). The future research infrastructure needs to be built on an integrated approach. A new type of “Global Earth Observatory” would enable better understanding and quantification of the land – atmosphere - ocean interactions and feedbacks, to solve the urban air quality challenges in megacities and to make mitigation and adaptation plans more effectively (Kulmala 2018). Furthermore, there are a number of society relevant large scale research questions of the Northern high latitudes introduced by the PEEX science plan. To be able to answer and find solutions to

these questions a new, novel RI and multidisciplinary datasets are needed (Kulmala et al. 2015, Lappalainen et al 2017).

The University of Helsinki INAR has introduced the “Station for Measuring Earth Surface – Atmosphere Relations”, the GlobalSMEAR bottom-up initiative (Hari and Kulmala 2005, Hari et al. 2017, Kulmala 2018, www.atm.helsinki.fi/globalsmear). The GlobalSMEAR aims to establish a global in-situ station network based on the SMEAR concept. The global network would consist of the SMEAR flagship stations together the different standard, flux and advanced stations (Hari et al. 2017, Kulmala 2018). The integrated measurements of the hierarchical station network would increase our knowledge on the processes in the land-atmosphere-ocean framework. Furthermore, it would increase our understanding on the impact of anthropogenic activities on the ecosystems and urban environments. The land-based station network would consist of the existing infrastructures of standard stations including weather stations, flux (FLUXNET) stations, flagship stations and satellite receiving stations. The importance of the long-term continuation of advanced measurements of aerosols, clouds, GHGs and trace gases in the northern Eurasian area is addressed.

The concept of a hierarchical network for the Arctic ocean observations would consist of simple buoys deployed on sea ice in the open sea, sophisticated buoys, research vessels, flagship stations, manned drifting ice stations, and permanent coastal and archipelago stations introduced by Vihma et al. (2019). Vihma et al.(2019) is providing a comprehensive perspective on the marine Arctic component of PEEEX and is discussing, how to improve the marine atmospheric in situ data availability and quality to better understand the most important atmospheric processes. Also the RI needs for several aspects like sea ice related data, climatological analysis, navigation and the data needs to reduce uncertainties in the heat and freshwater budgets of the Arctic Ocean and its marginal seas are discussed. Furthermore, there are other important observational need to address topics like an increasing CO₂ partial pressure in the atmosphere and the capacity of the world oceans to uptake CO₂. In the end, it is also a question, how to improve the in situ station network to better understand the linkages between the marine Arctic and Eurasian continent and how to improve also the observational coverage needed for improved atmospheric and ocean re-analyses (Vihma et al. 2019).

There are ongoing projects going into these directions, for example, the ERAPLANET Strand-4 iCUPE - Integrative and Comprehensive Understanding on Polar Environments. We need integrated picture of polar pollution via novel proxy indicators appropriate for communication to the decision makers and to the general public and fill gaps and improve data services and data products available for polar areas. Thus iCUPE aims to establish and maintain long-term, coherent and coordinated observations and research activities on environmental quality and natural resources in polar areas (Petäjä et al. paper in preparation). iCUPE is highlighting the development of novel, integrated, quality-controlled and harmonized in-situ observations and satellite data in the polar areas, as well as data products to the end users. The iCUPE activities will be implemented based on research and at the same time aiming beyond the state-of-the-art with thematic objectives like the assessment of the impacts of anthropogenic activities on the levels of pollution via comprehensive observations, novel proxy variables in the polar environments by utilizing long-term Arctic monitoring data, historical ice core samples and data from Antarctica as a baseline.

3. CONCLUSIONS

There are concept and a wider understanding on the future needs of the land based and marine research infrastructures for the Northern high latitudes (Kulmala 2018, Vihma et al 2019, Petäjä et al. in preparation). This understanding is based on the society relevant large scale research questions, on solving the Grand Challenges like climate change and the specific role of the Arctic Ocean for the global climate system. The coordinated, comprehensive and continues in situ observation concept is addressed and direction towards integrated in situ station approach and new data products.

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