"STATION FOR MEASURING EARTH SURFACE – ATMOSPHERE RELATIONS" CONCEPT GlobalSMEAR INITIATIVE

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1. INTRODUCTION

The Grand Challenges (GC), like climate change, urban air pollution, clean water and food security, are interlinked, but current observations are fragmented (Kulmala 2015, Kulmala et al. 2015, Kulmala 2018). For the future aspiration we need an integrated approach together with the comprehensive, continuous and coordinated observation system "a Global Earth Observatory to better understand the land - atmosphere interaction and feedbacks lined to GC, to reduce uncertainties, to improve urban air quality and to mitigate and adapt effectively (Kulmala 2018). The "Station for Measuring Earth Surface – Atmosphere Relations", the GlobalSMEAR, is a bottom-up initiative by the Institute for Atmospheric and Earth System Research (INAR), University of Helsinki (Hari and Kulmala 2005, Hari et al. 2017, Kulmala 2018, *www.atm.helsinki.fi/globalsmear*). The aim of the GlobalSMEAR is 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 at al. 2017, Kulmala 2018). The GlobalSMEAR technical model is built on a state-of-the-art in-situ observation methods, instrument technology, data system, comprehensive data analysis methods, a development and design carried out at the Stations Measuring Ecosystem Atmospheric relations (SMEAR II) station in Hyytiälä, Finland starting from 1995. The SMEAR II serves as a prototype for the GlobalSMEAR flagship station and represents the most advanced and comprehensive in-situ station worldwide. Currently the SMEAR II is carrying out standardized observations over 1200 parameters (including concentrations and fluxes) 24/7 on different ecosystems: boreal forest, wetland and lakes and is contributing to several European ESFRIs (ICOS, ACTRIS, AnaEE, eLTER) and Earth Observation systems and networks such as WMO GAW and GEO-GEOSS. Recently we have been focused on the further development of different elements (station network concept, customer journey line, building up new stations, networking and identification of new services and end users) needed for the GlobalSMEAR implementation (Kulmala 2018).

2. CURRENT APPROACH

Architecture of the hierarchic station network and data systems structure

We have formulated an architecture for the hierarchic, integrated in situ station network. As a whole, the global observation network would be based on a hierarchy of research stations, where the flagship stations would operate in a seamless collaboration with the flux stations and standard stations to achieve global and regional coverage (Hari et al. 2017). A station network of 1000 or more well-equipped ground-based stations around the world would be able to track the changes in the environmental conditions in various ecosystems and to continuously provide observational evidence to understand the factors affecting the grand challenges. The proposed approach would complete coverage from ground stations to observations of Earth's conditions and complete the satellite based information by resolving processes or fluxes, or trace the hundreds more

compounds of interest (Kulmala 2018). In addition, we have just introduced specific observation concept and roadmap, how to improve the marine atmospheric in situ data availability to better understand the most important atm. processes, how to improve the in situ station network to better understand the linkages between the marine Arctic and Eurasian continent and how to improve the observational coverage needed for improved atmospheric and ocean re-analyses (Vihma et al. 2019).

In an operational phase the GlobalSMEAR station network would deliver big data. At the moment the data coming from the University of Helsinki hosted SMEAR stations is collected and filed at the CSC – IT Center For Science Ltd. systems (*www.csc.fi/csc*) and the open data access is provided by a web interface (*avaa.tdata.fi/web/smart*). The components contributing to European research infrastructures and to WMO GAW rely on their respective data services. In the future we need to find technical and juridical (IPR, data ownership) solutions on the data collection, filing and on the open data access for the new GlobalSMEAR data. This is work in progress and is part of the ongoing INAR Beijing Haze project.

Service Concept for upgrading of an existing in situ stations and establishing a new station

In 2018 we carried out a Climate-KIC "GlobalSMEAR" project aimed at the GlobalSMEAR upscaling and for the service concept design. In this project we discussed the GlobalSMEAR service concept, markets and marketing, competition advantages and barriers in the international RI landscape and how the well-structured processes would enable us to give a support to the customer / end-user during the process starting from planning and construction until the operation phases of a new station. We introduced a modular service concept for the upgrading of instruments and measurements of an existing station or building a new station. The modules and services are flexible and can be tailored for local requirements, environments (forest, peatland, lake, agriculture land, tundra, maritime coastal line, urban) and for different purposes (climate change monitoring, air quality monitoring, different early warning systems such as fence-line observations for of hazardous volatile pollutants or dispersion of epidemic compounds). The training of the technical experts and education on the data analysis methods were included as fundamental part of the SMEAR service concept.

As a continuation of the Climate-KIC - GlobalSMEAR upscaling project, INAR has submitted a proposal called "Detailed Monitoring to Verify the Future Healthy - Clean Cities and Carbon Neutrality in Urban Environment" with University of Tartu, Estonian University of Life Sciences and Cyprus Institute to ClimateKIC Call on the innovation and demonstration projects focused on healthy, clean cities in Europe. The aim of our proposal is to co-design a SMEAR-European model (C40 cities, carbon neutrality frameworks) and to improve the customer process towards a new operational SMEAR station by using lessons-learnt from the current operational SMEAR (benchmarked) stations in Finland, Estonia, Cyprus and in China.

New SMEAR stations and the GlobalSMEAR member network

At the moment we have five SMEAR stations out of which SMEAR I-IV stations operate in Finland and SMEAR-Estonia in Järvselja, Estonia. We also have a SMEAR accredited SORPES (Station for Observing Regional Process of Earth System) station in Nanjing, China. It has been operational since 2010. However, the number of the new and accredited SMEAR stations is increasing. In May 2017 an investment of a value of 10 MEUR was granted to INAR to establish a new station at the Beijing University of Chemical Technology (BUCT; Beijing, China). In collaboration with BUCT we constructed the SMEAR concept station instrumentation and a data system in Beijing. This new "Beijing Haze" station has been operational since January 2018. In Europe, INAR is a partner in an EU Horizon2020 EMME-CARE Teaming project together with the Cyprus Institute (CyI), Max Planck Institute for Chemistry (MPIC) and Commissariat à l'Energie Atomique (CEA). In the frame of the EMME-CARE project we are in progress setting up a new observation site at Peya site in Cyprus following the SMEAR concept. These new and other SMEAR accredited stations are addressing a need for a coordinated GlobalSMEAR member network. In 2019 we have received the first applications applying the GlobalSMEAR membership. The membership offers collaborative research that aims towards joint publications, annual data workshops and meetings, the development of services and exploring of the business opportunities based on the SMEAR data.

Promoting the SMEAR concept and further networking

Starting from 2012, we have promoted GlobalSMEAR in different international conferences (EGU, ISAR, IASC etc.) and forums (Arctic Circle) and established an extensive contact network, especially, in China and Russia (see also Kujansuu et al. of this proceedings). Our current China contact network covers ca 30 universities and city administrations. The main interest in China market is on urban air quality monitoring including indoor air quality. The Chinese Ecosystem Research Network (CERN) station network for the ecosystem monitoring is part of global eLTER network. CERN / eLTER provides a standardized station network that could up upgraded to the towards SMEAR network by including an atmospheric component to the measurement setups. Our contacts and network in China are also actively involved with the Silk Road Economic Belt Initiative. Silk Road Economic Belt has interest for establishing new environmental observation systems along the Silk Road transport corridors and cities and opens opportunities for the new GlobalSMEAR stations (Lappalainen et al. 2018). The Russia contact network, covering over 30 universities and research organizations, is being built upon the Pan-Eurasian Experiment (PEEX) Programme coordinated by INAR (see also Lappalainen et al. of this proceedings). For example, recently established collaboration with Roshydromet provides potential for upgrading their meteorological station network.

3. FUTURE PRPOSPECTS

The GlobalSMEAR is mainly based on academic franchising and have different upscaling plans, end-users and end-user interests in Europe, in Eurasia, in Asia, in the Eastern Mediterranean and the Middle East (EMME) region, in Africa and in the Arctic regions. In Europe the main interest is to use advanced monitoring systems and RI on verifying the carbon neutrality and urban air quality, in Asia on the urban air and environmental pollution and in the Artic context on climate change and teleconnections. In addition the upscaling the GlobalSMEAR in these frameworks, the new openings for the SMEAR station concept are foreseen on mobile phone apps and the use of machine learning techniques. The MegaSense programme by the Univ.Helsinki, started in 2017, is aimed at these directions and gathers and fuses spatially variable gas and particulate measurements from the atmospheric instruments, commercial air quality transmitters, dense low-cost sensor arrays, and consumer wearables utilizing 4G and 5G technologies. The machine learning techniques are used for the calibration of a high number of low-quality and low-cost sensors with a small number of highly accurate SMEAR stations. The credibility of MegaSense concept and potential is huge and is currently emerged through City of Helsinki Air Quality projects Urban Sense, and EU Healthy Outdoor Premises for Everyone UIA HOPE, and through International pilots. The European potential and end users and EU-wide clean and smart cities strategies, are at the moment, indicated by the SMart URBan Solutions for air quality, disasters and city growth (SMURBS, 2018-2021, UHEL as a partner).

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