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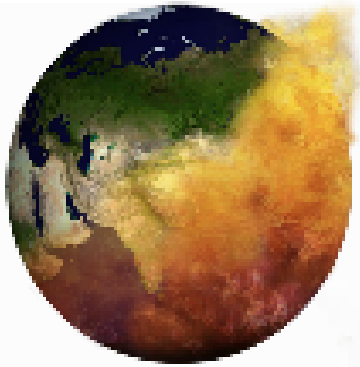

Pan-Eurasian Experiment
PEEX

PEEX Programme Science Plan and Research Collaboration

Hanna Lappalainen
University of Helsinki

Zoom on 15.Nov.2021

University of Helsinki, Institute for Atmospheric and Earth System Research (UHEL-INAR)
& Lomonosov Moscow State University

Online Young Scientist School(YSS)–MEGAPOLIS-2021
"Multi–Scales and –Processes Integrated Modelling, Observations and Assessments for Environmental Applications"

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KEY QUESTION

Why understanding of Atmosphere Earth Surface – Biosphere is important for Climate Change ?

- New feedback mechanism / interactions / processes
- More time to act: Mitigate & Adapt

TOOLS for understanding of Atmosphere – Earth Surface – Biosphere interaction, feedbacks

- Pan-Eurasian Experiment (PEEX) Program for understanding the Atmosphere – Earth Surface – Biosphere in the Arctic – boreal context / Northern Eurasia / Silk Road Region (2012 ->)
- GlobalSMEAR (Stations Measuring Earth Surface Atmosphere Relations) Initiative for Global Earth Observatory for filling the observational gap of the atmospheric – ecosystem in situ data (2015 - >

Academician Markku Kulmala

Academy Professor
Academy of Finland

Director of INAR Institute, University of Helsinki, FI

Foreign Academician
Member of CAS
Member of RAS

Citation over 40000
H-index =104
ISI No. 1 Citation in Geoscience (2011-2018)

Multidisicplinary Research / RI/ Education / Societal impact on the Arctic-boreal & China
INITIATOR OF PEEX PROGRAM

Stations for Measuring Earth Surface - Atmospheric Relations (SMEAR)
DEVELOPER AND FRONTMAN OF SMEAR CONCEPT

Pan-Eurasian Experiment
PEEX

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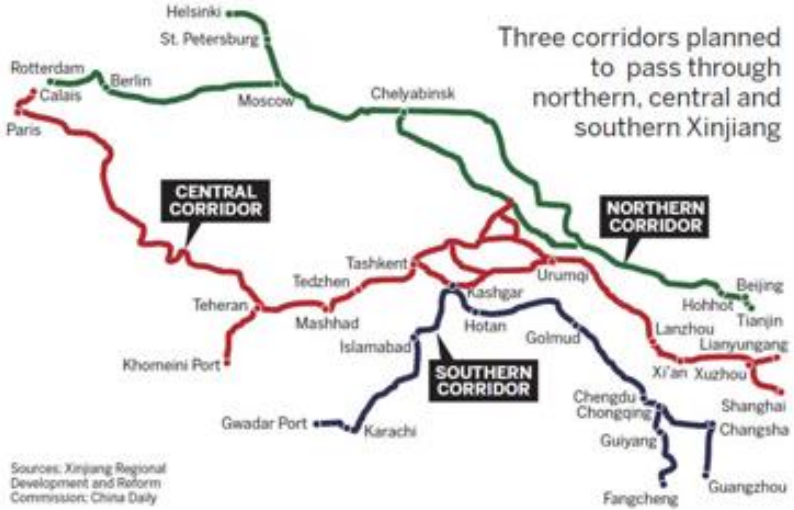
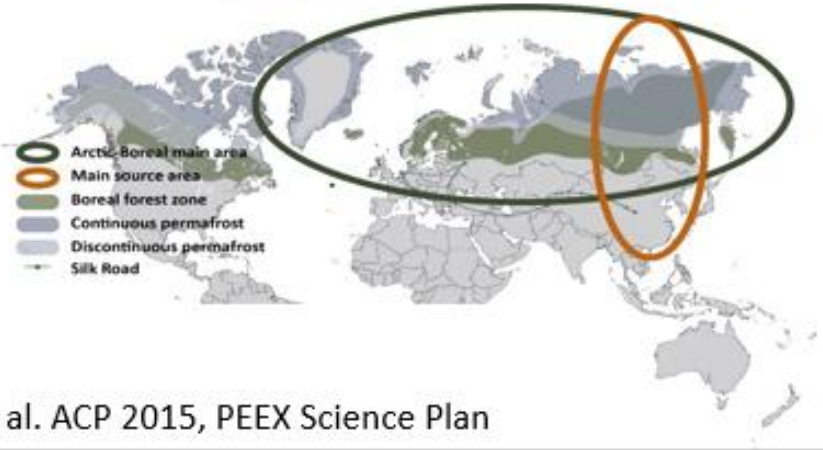
Pan-Eurasian Experiment
PEEX

SMEAR
GLOBAL CHALLENGES NEED GLOBAL MEASURES

PEEX AIMS RESOLVING GRAND CHALLENGES IN SUSTAINABLE WAY IN THE NORTHERN EURASIAN REGION AND IN CHINA

- From deep understanding to Practical solutions
- Multidisciplinary, multiscale research approach
- Coherent, coordinated research infrastructures
- Scientific information and services receiving the greatest possible impact
- Knowledge transfer - Multidisciplinary education





Refs. Kulmala et al. ACP 2016, Lappalainen et al. ACP 2016, Hari et al. ACP 2015, PEEX Science Plan

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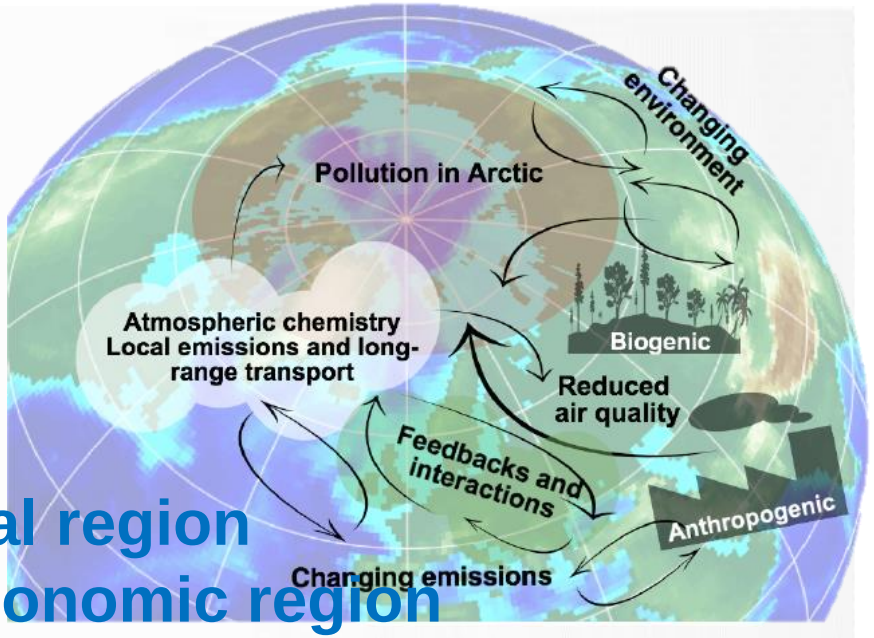
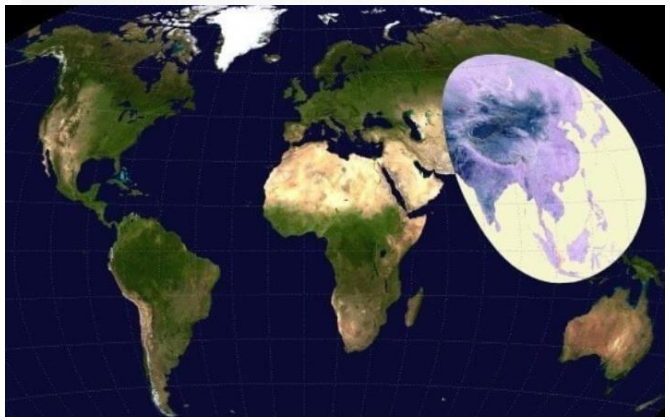
PEEX PROGRAM

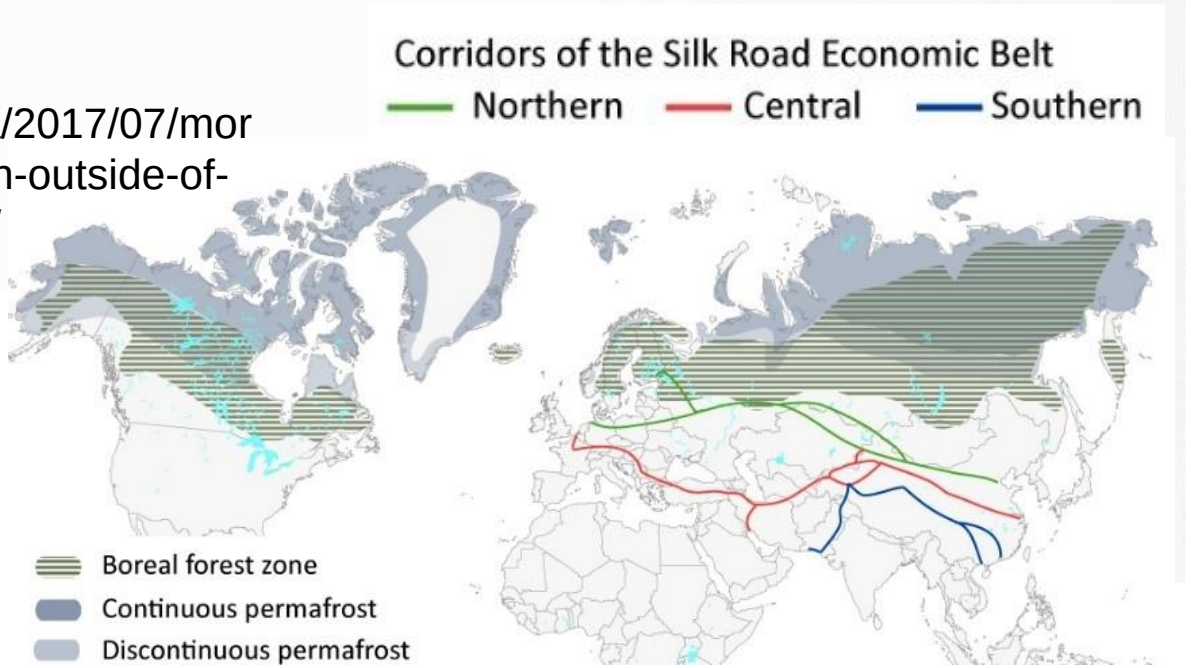
Collaboration



- **Russia: focus on arctic-boreal region**
- **China: focus on Silk Road economic region**

https://www.weforum.org/agenda/2017/07/more-people-live-inside-this-egg-than-outside-of-it-and-other-overpopulation-data/





PEEX PROGRAM

www.atm.helsinki.fi/peex/

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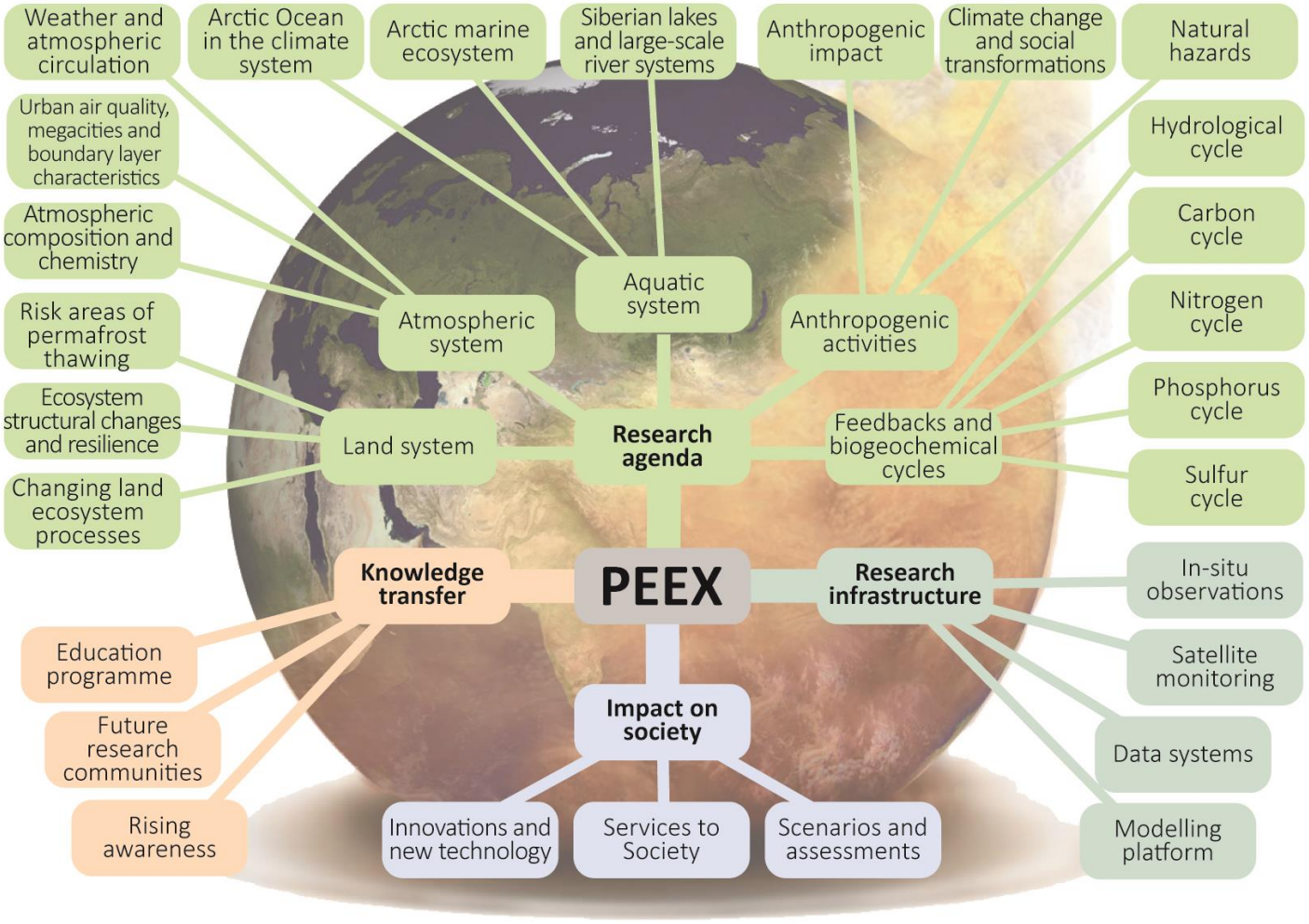

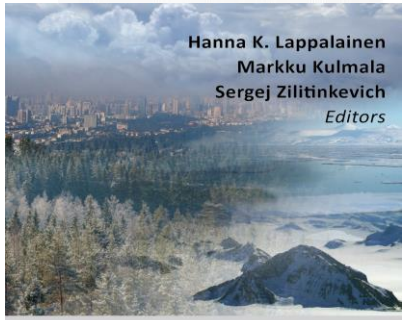

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

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PEEX BASELINE

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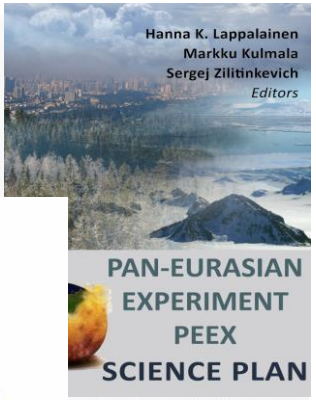

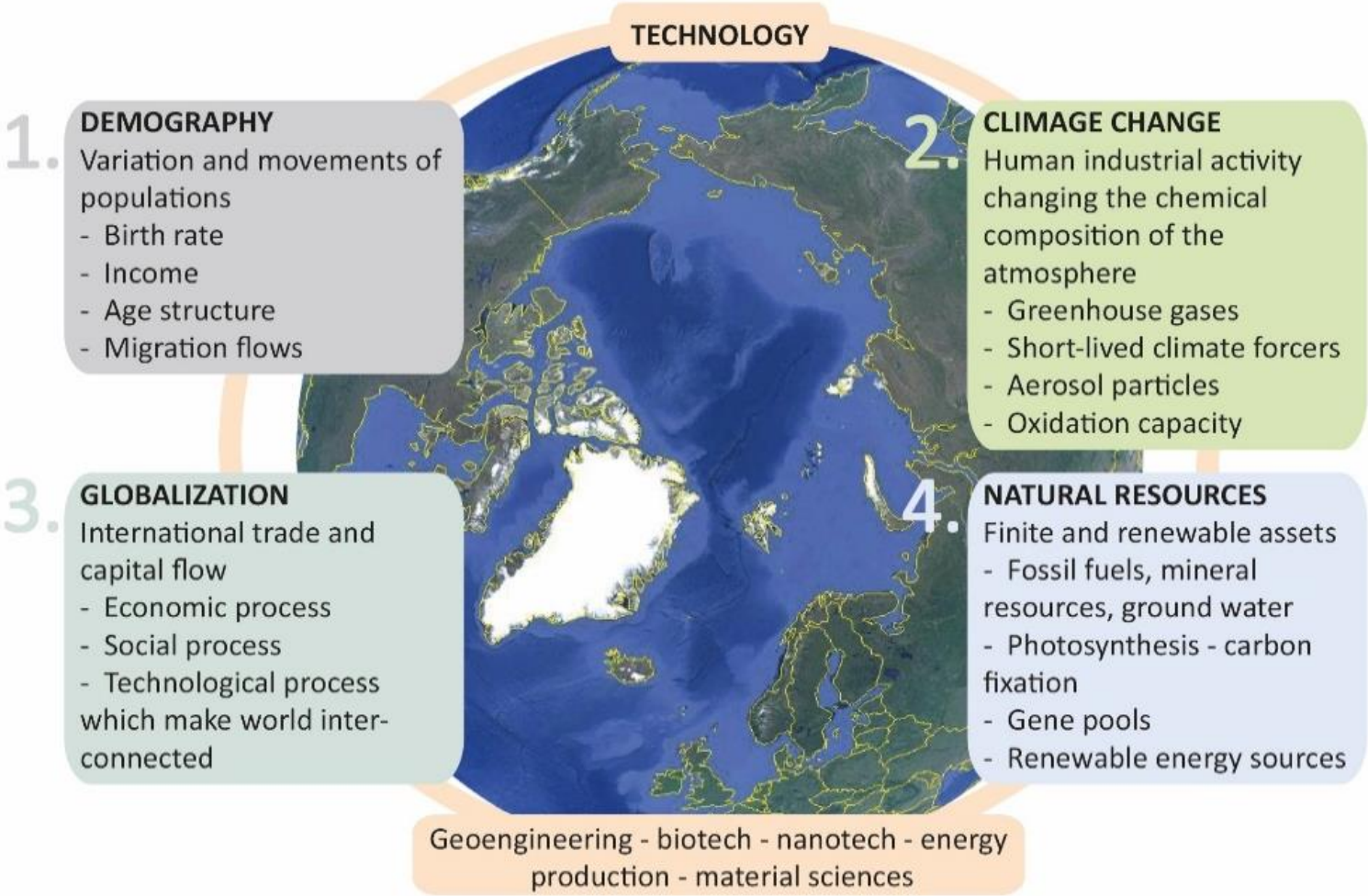

Global forces modifying the northern regions future within next 40 years (adapted from **The New North: The World in 2050 by Laurence Smith**).

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PEEX MOTIVATION

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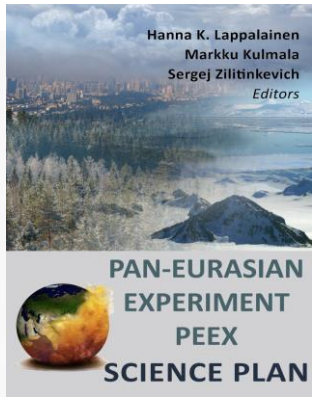
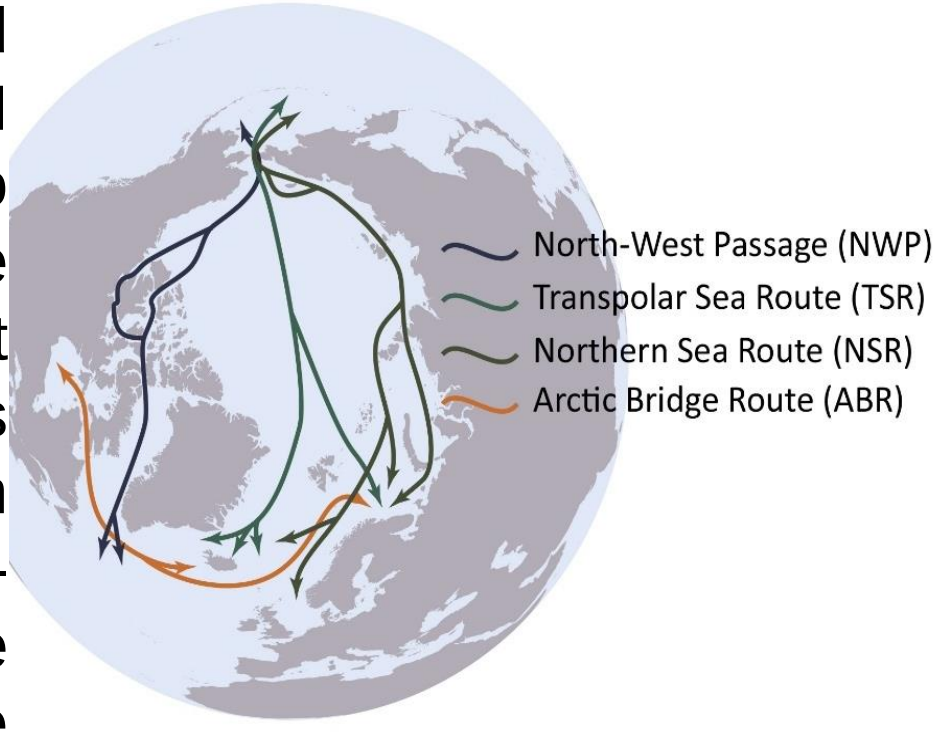
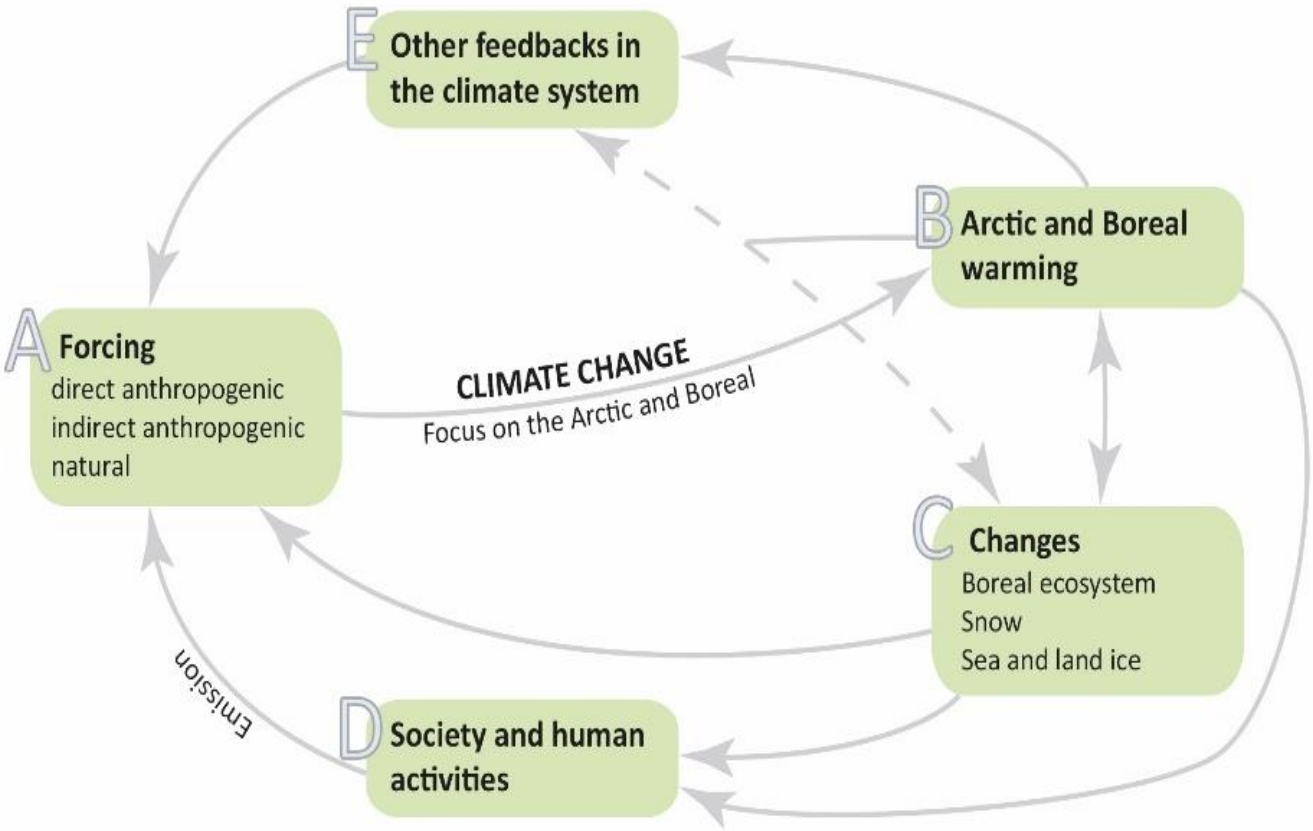


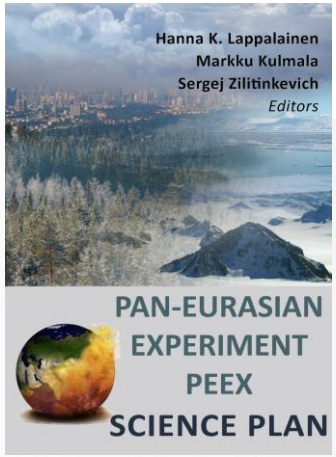
> motivated by the fact that the Northern regions – land and ocean areas located at 45° N latitude or higher – will undergo substantial changes during the next 40 years. Even the most moderate climate scenarios predict that the northern high latitudes will warm by 1.5 ° C - 2.5° C by the middle of the century, and by 3.5 ° C by the end of the century. This is more than twice the global average warming (IPCC, 2013).



Expected shipping routes in the Arctic (figure adapted from the Arctic Institute).

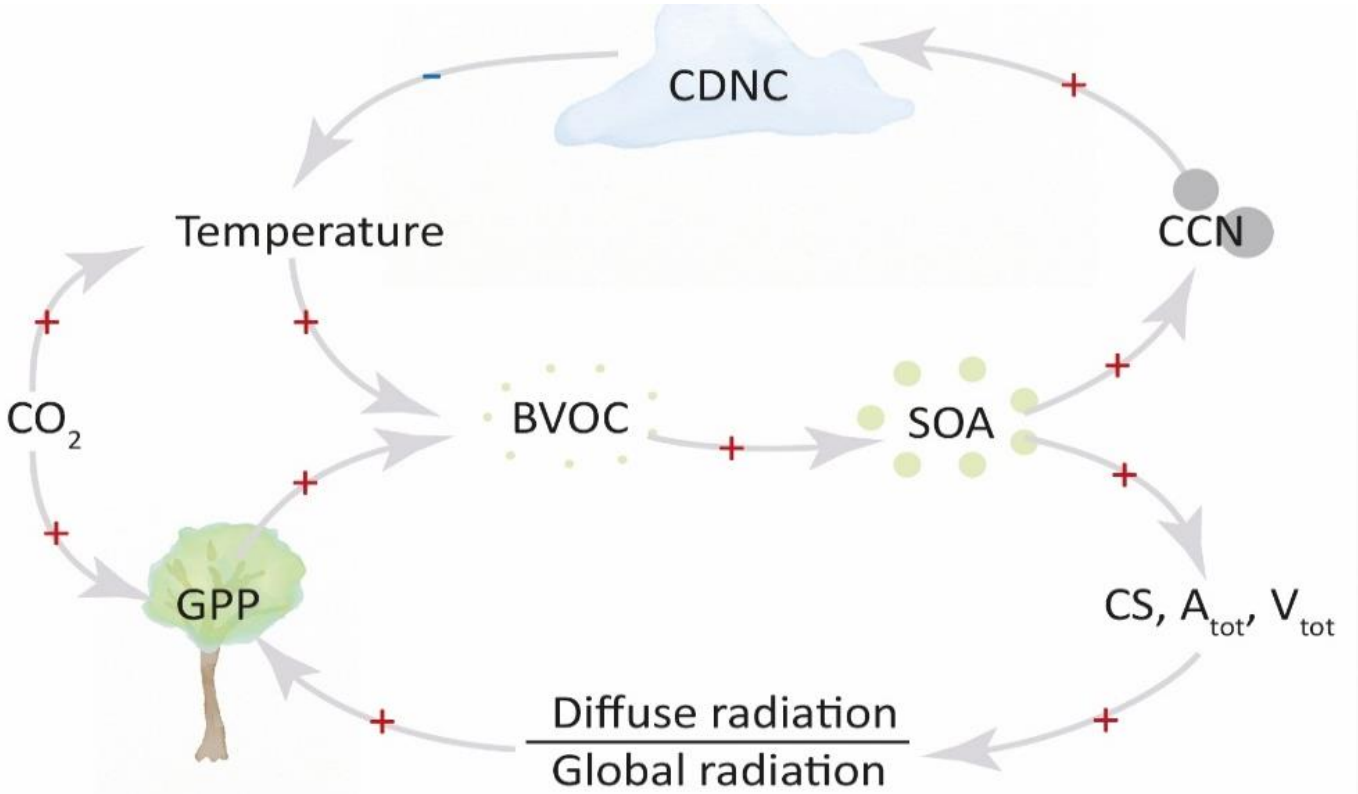
PEEX LARGE-SCALE RESEARCH SCHEMATICS

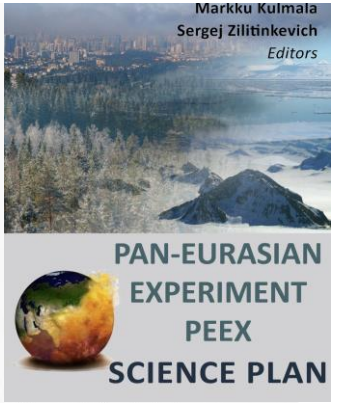




PEEX research agenda is focused on understanding the complex interlinked land-atmosphere-ocean-society system in the Arctic, boreal and Chinese context. PEEX will study the changes and processes driven by interlinked forces: (i) radiative forcing, (ii) Arctic warming, (iii) changes and feedbacks in the cryosphere, (iv) changes in society and human activities, (v) feedbacks in the climate system, (vi) feedbacks in the biosphere system (Figure 17). This holistic research approach has been adopted from the currently ongoing Nordic Center of Excellence (NCoE) on Cryosphere-Atmosphere Interactions in a Changing Arctic Climate (CRAICC), but has been expanded to cover both Arctic and boreal warming.

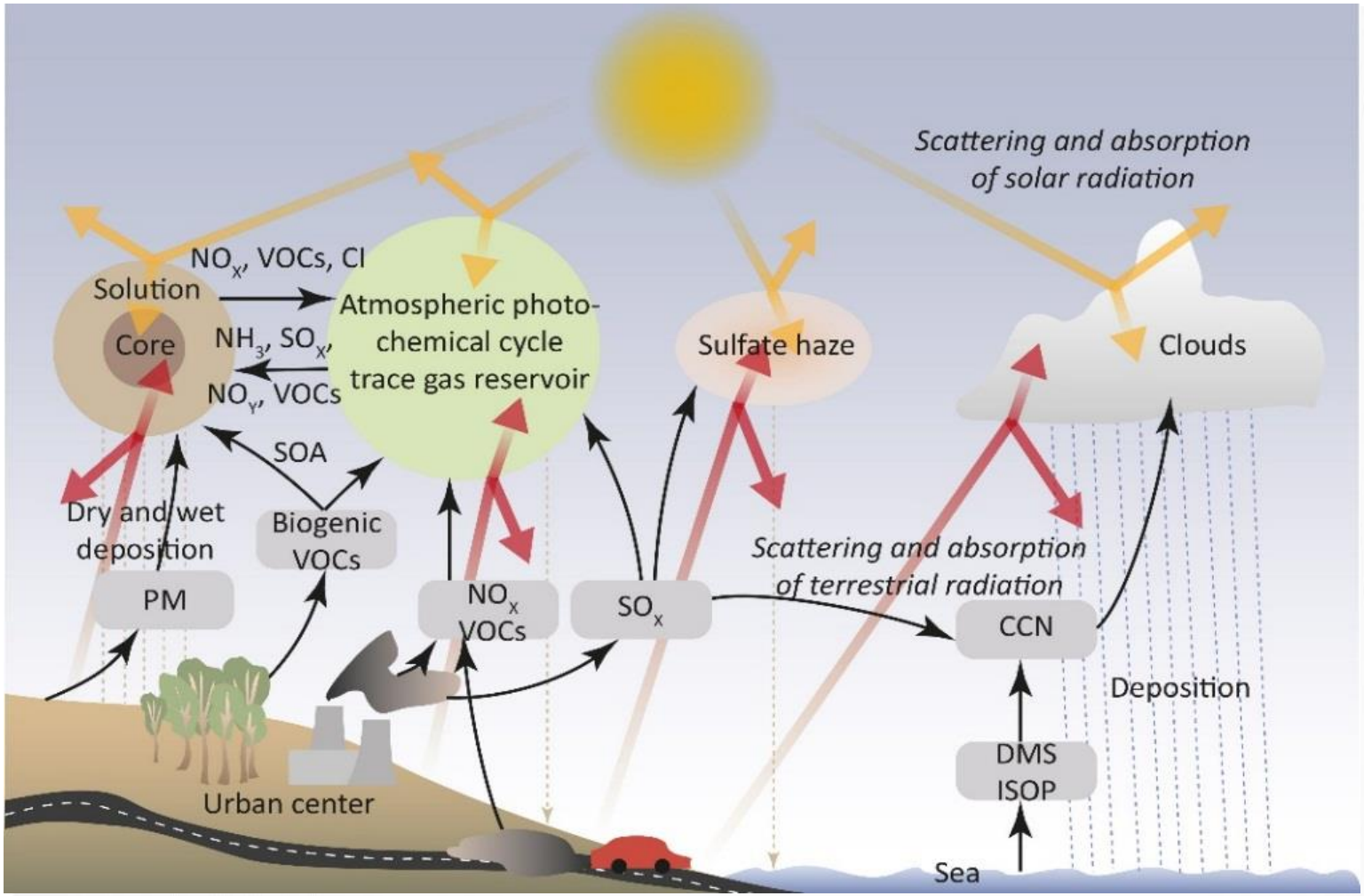
PEEX:**3.7 FEEDBACKS, INTERACTIONS AND BIOGEOCEMICAL CYCLES**





The two loops associated with the continental biosphere-aerosol-cloud-climate (COBACC) feedback. BVOC=biogenic volatile organic compounds, SOA=secondary organic aerosol, CS=the condensation sink (a measure of the aerosol particle population's ability to remove vapors from the air by condensation), A_{tot}=total aerosol surface area, V_{tot}=total aerosol volume, CCN=cloud condensation nuclei, CDNC=cloud droplet number concentration, and GPP=gross primary

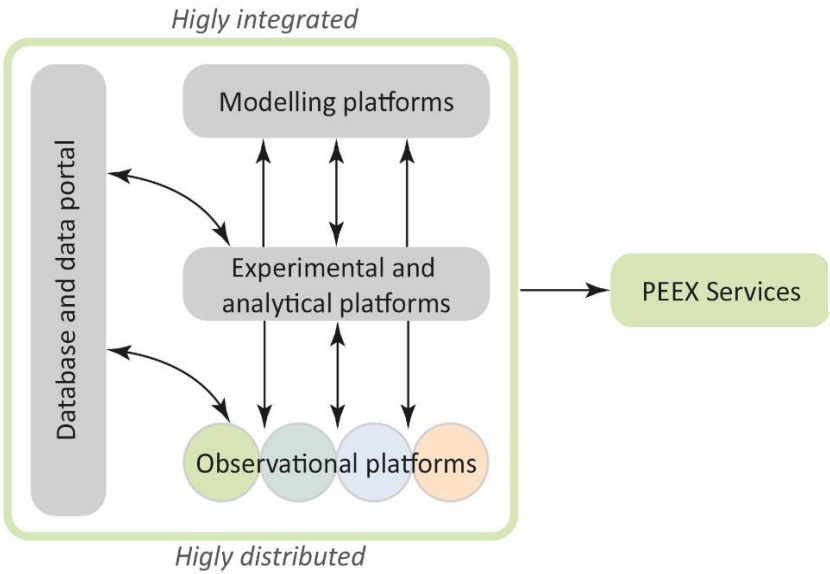
PEEX 3.4.1 Atmospheric composition and chemistry



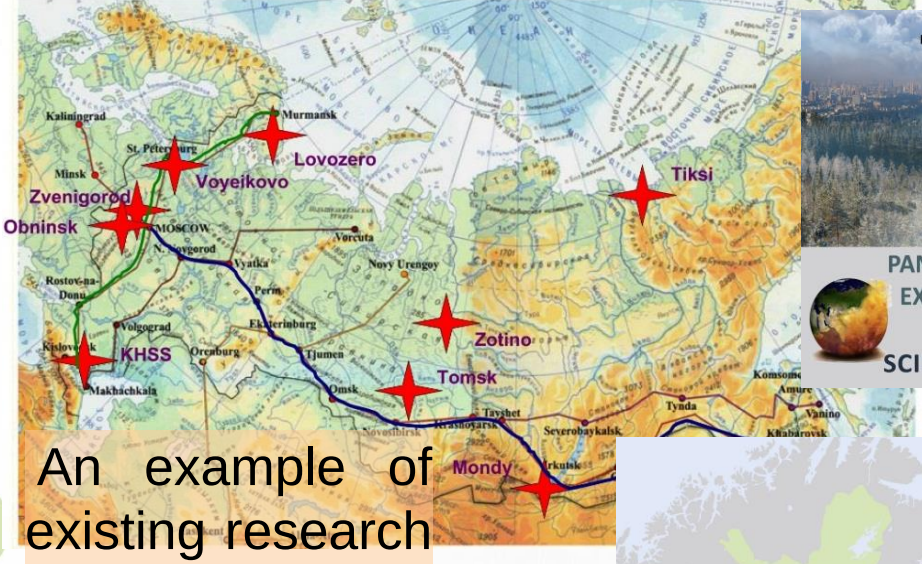
Presentations
- Skorokhod
- Popovicheva
- Chubarova

Figure 20 Atmospheric system -interactions. Figure adapted from Zhang (1994) and Zhang (2007).

4. PEEX RESEARCH INFRASTRCTURE (F2)



The conceptual design of the PEEX infrastructure is based on the service-oriented approach (Lappalainen et al., 2014) connecting and integrating data from highly distributed observational and modeling networks as well as from various experimental platforms. See also section 5.3.



An example of existing research infrastructures andactivities: the Obukhov Institute of Atmospheric Physics Measurements (Elansky, 2012).

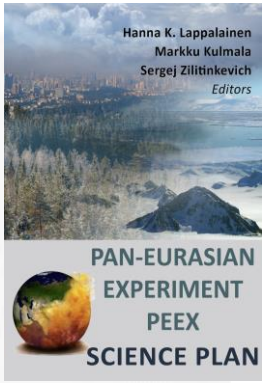
Figure 50 The SMEAR (Station for Measuring Ecosystem-Atmosphere Relations) atmospheric observation network.

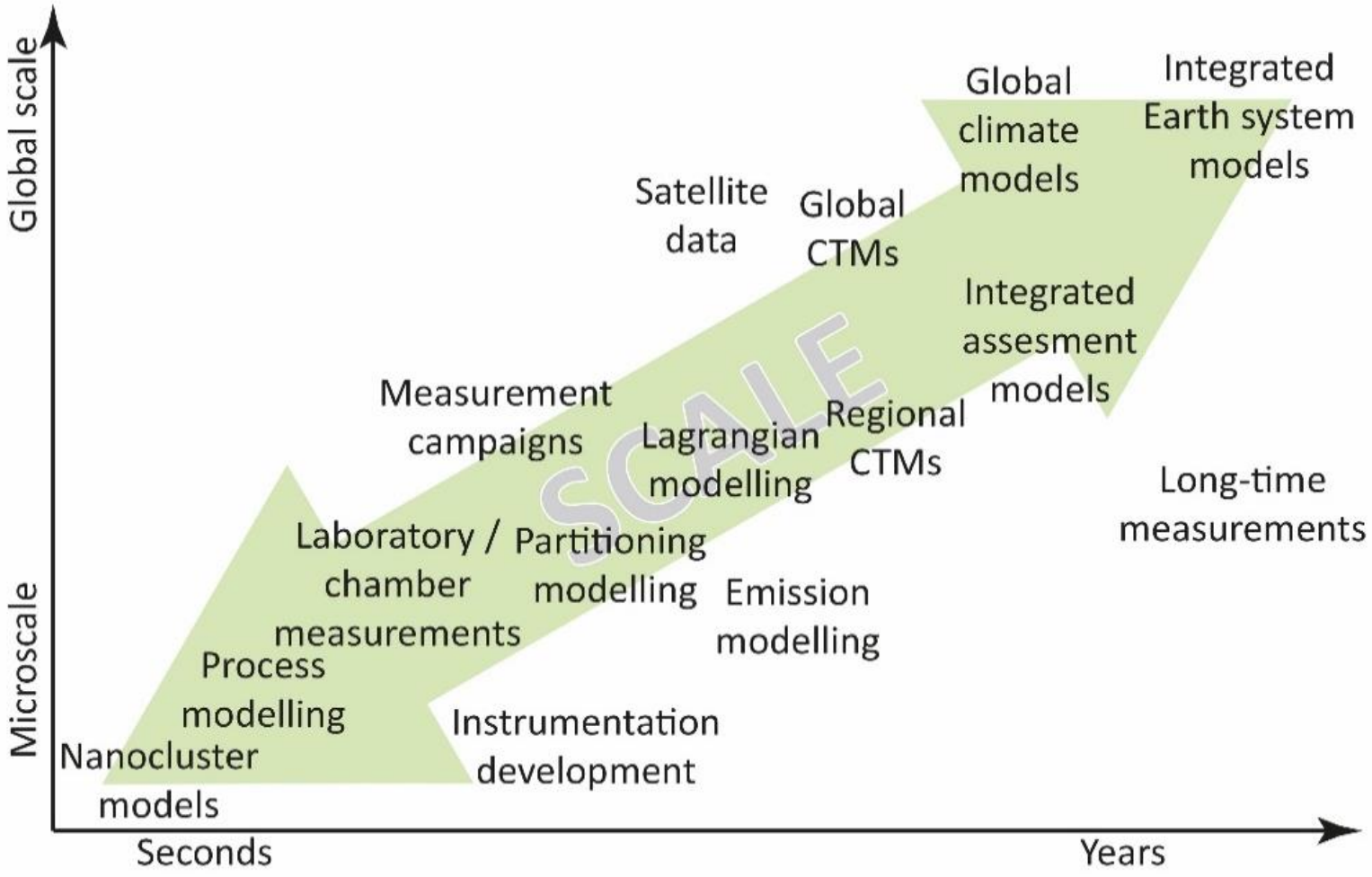
Presentations:

- Sogacheva, Petäjä, Bäck, Chalov, Konstantinov ..

4. PEEX RESEARCH INFRASTRCTURE (F2)

Modeling and analysis infrastructures



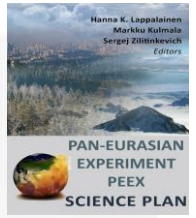


Presentations Mon 15.Nov:

- Makkonen
- Chalov
- Eresmaa
- Baklanov

Figure 65 The temporal and spatial scales of modeling and observations within the PEEX domain.

5.1 CLIMATE: MITIGATION AND ADAPTATION



- Presenations on environmental health

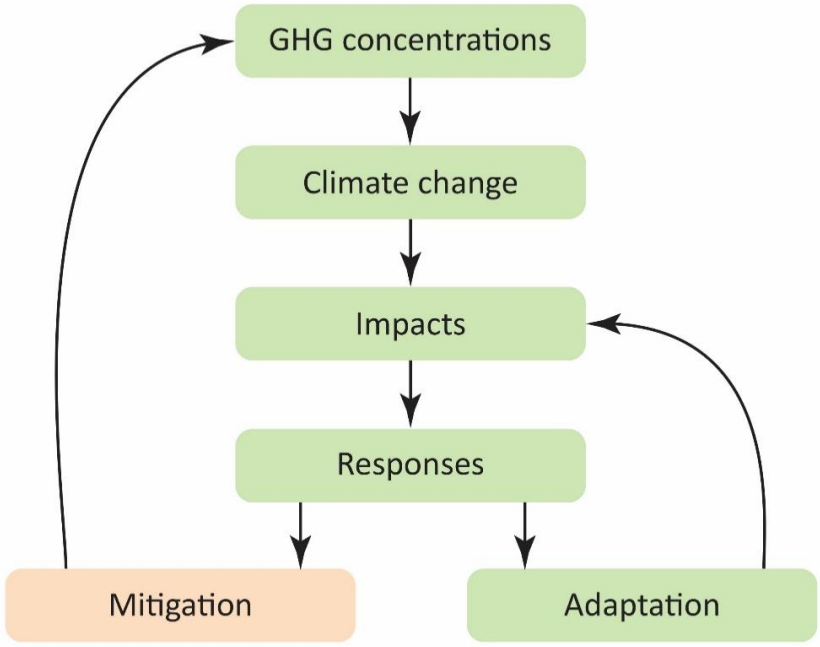


Figure 69 Mitigation is understood as activities to protect nature from society (Stehr et al., 2005).

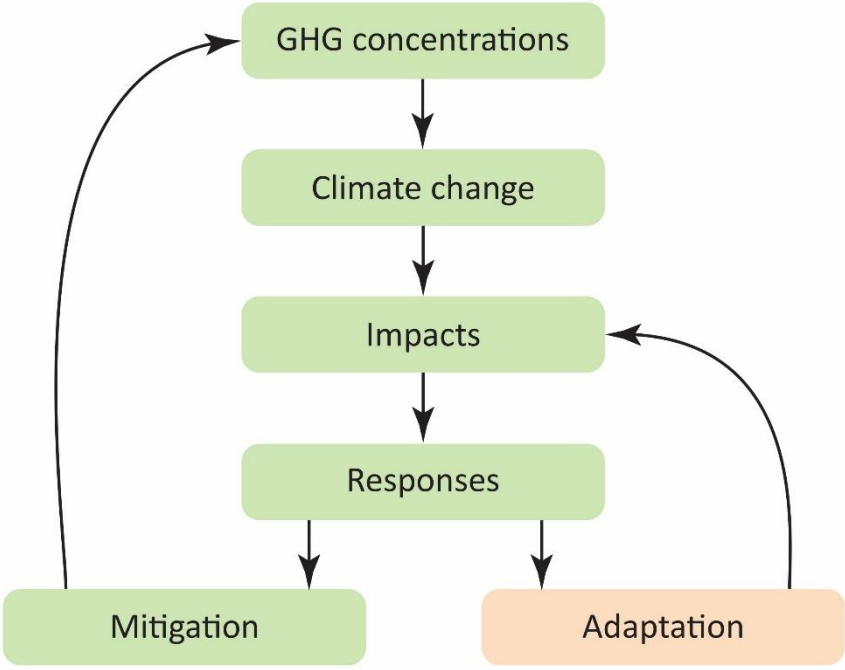


Figure 70 Adaptation represents activities understood as protecting society from nature (Stehr et al., 2005).

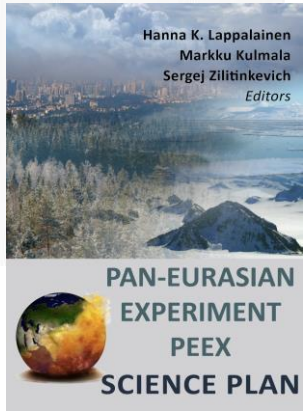
PEEX Research - Infrastructure - Society dimension

↓

PEEX-F4 Knowledge Transfer

Audience	Aim	Methods / Tools
Scientifc community	Scientific breaktroughs outside PEEX domain	Data exploitation - PEEX labelled data
Students	Capacity building in PEEX domain Next generation experts	PEEX Education Programme
Decision makers & international forums	Climate policy making regional - global	PEEX scenarios & mitigation plans
Private sector	Innovations Geoengineering	Instrument development / scientific results
General public	General awareness	Brochures, websites, social media

Figure 75 Undergraduate and graduate students participating to an intensive field course in Hyytiälä, Finland. Photo by Ella-Maria Kyrö



PEEX PROGRAM

Organization

PROJECT OFFICES

- Moscow State University, Moscow, Russia
- AEROCOSMOS, Moscow, Russia
- Earth Cryosphere Institute – Federal Research Centre Tyumen Scientific Centre of SAB RAS, Tyumen, Russia
- Pacific Geographical Institute of Geography FEB RAS, Vladivostok, Russia
- Institute of Remote Sensing and Digital Earth, CAS (RADI), Beijing, China
- University of Nanjing, Nanjing, China

PEEX PROGRAM Collaboration

- 38 PEEX MoUs with the universities and research organization in Russia (status Nov.2021)
- 7 PEEX MoUs with Chinase organizations, key collaborators

Digital Belt and Road (DBAR) Program

PEEX RESEARCH

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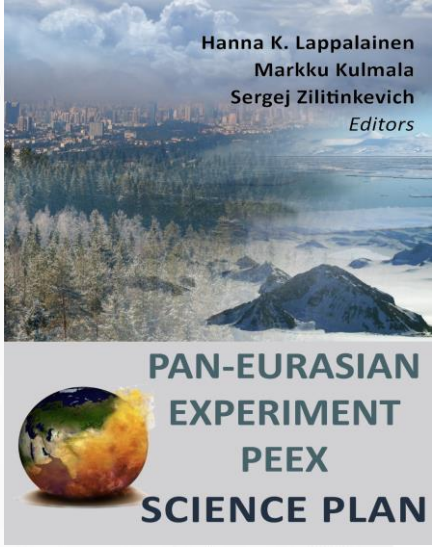

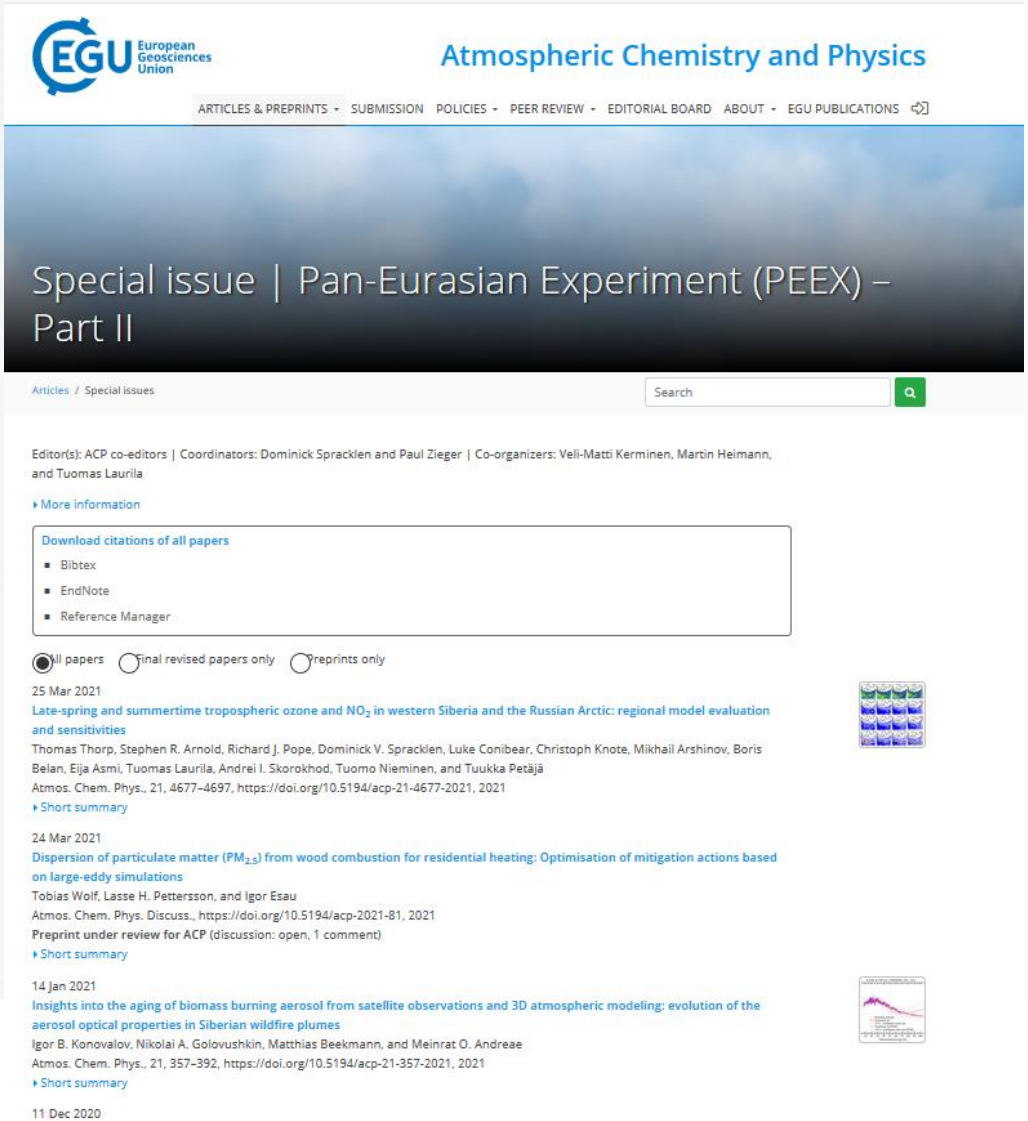

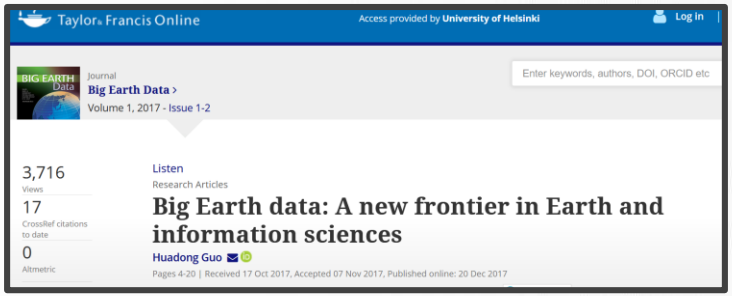

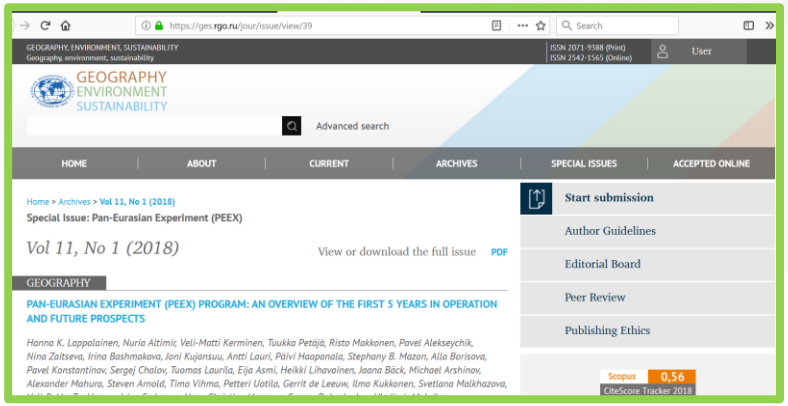

PEEX RESEARCH

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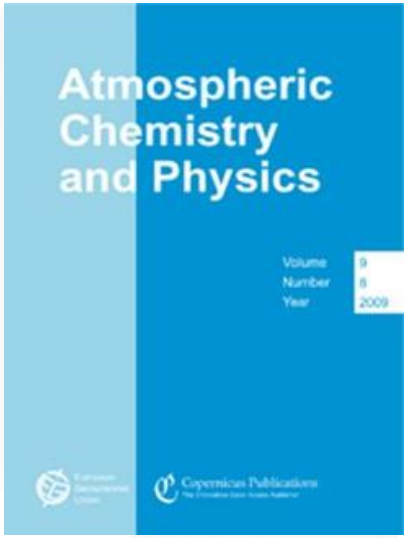
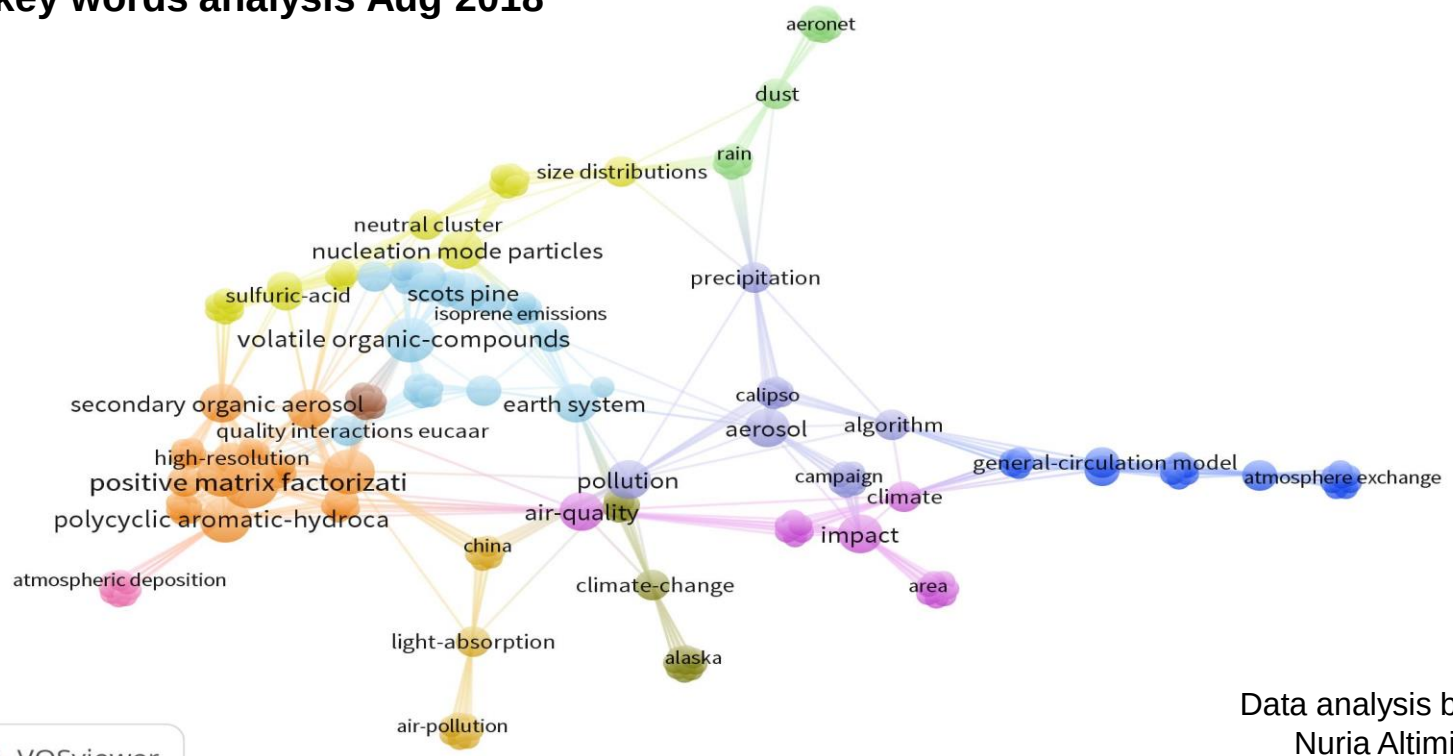


- foci of the results has been on the role of boreal forest and their BVOC emissions and subsequent aerosol formation processes.

key words analysis Aug 2018



Data analysis by
Nuria Altimir,
Univ.Helsinki

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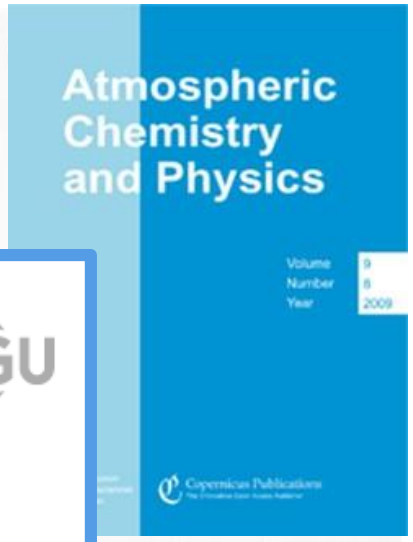

https://doi.org/10.5194/acp-2021-341
Preprint. Discussion started: 19 May 2021

Atmospheric Chemistry and Physics Discussions
Open Access
EGU

Overview: Recent advances on the understanding of the Northern Eurasian environments and of the urban air quality in China - Pan Eurasian Experiment (PEEX) program perspective

Hanna K. Lappalainen[1,2], Tuukka Petäjä[1,2], Timo Vihma[3], Jouni Räisänen[1], Alexander Baklanov[4], Sergey Chalov[5], Igor Esau[6], Ekaterina Ezhova[1], Matti Leppäranta[1], Dmitry Pozdnyakov[7], Jukka Pumpanen[8], Meinrat O. Andreae[9,42,43], Mikhail Arshinov[10], Eija Asmi[3], Jianhui Bai[11], Igor Bashmachnikov[7], Boris Belan[10], Federico Bianchi[1], Boris Biskaborn[12], Michael Boy[1], Jaana Bäck[13], Bin Cheng[3], Natalia Ye Chubarova[5], Jonathan Duplissy[1], Egor Dyukarev[14], Konstantinos Eleftheriadis[15], Martin Forsius[16], Martin Heimann[17], Sirkku Juhola[20], Vladimir Konovalov[18], Igor Konovalov[19], Pavel Konstantinov[5,33], Kajar Koster[13], Elena Lapsina[21], Anna Lintunen[1,13], Alexander Mahura[1], Risto Makkonen[3], Svetlana Malkhazova[5], Ivan Mammarella[1], Stefano Mammola[22,23], Stephany Mazon[1], Outi Meinander[3], Eugene Mikhailov[24, 25], Victoria Miles[6], Stanislav Myslenko[5], Dmitry Orlov[5], Jean-Daniel Paris[26], Roberta Pirazzini[3], Olga Popovicheva[27], Jouni Pulliainen[3], Kimmo Rautiainen[3], Torsten Sachs[28], Vladimir Shevchenko[29], Andrey Skorokhod[30], Andreas Stohl[31], Elli Suhonen[1], Erik S. Thomson[32], Marina Tsidilina[39], Veli-Pekka Tynkkynen[34], Petteri Uotila[1], Aki Virkkula[3], Nadezhda Voropay[35], Tobias Wolf[6], Sayaka Yasunaka[36], Jiahua Zhang[37], Yubao Qiu[37], Aijun Ding[38], Huadong Guo[37], Valery Bondur[39], Nikolay Kasimov[5], Sergej Zilitinkevich (†)[1,2,3], Veli-Matti Kerminen[1] and Markku Kulmala[1,2,39,40,41]

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PEEX RESEARCH

Lappalainen et al. 2021 ACP

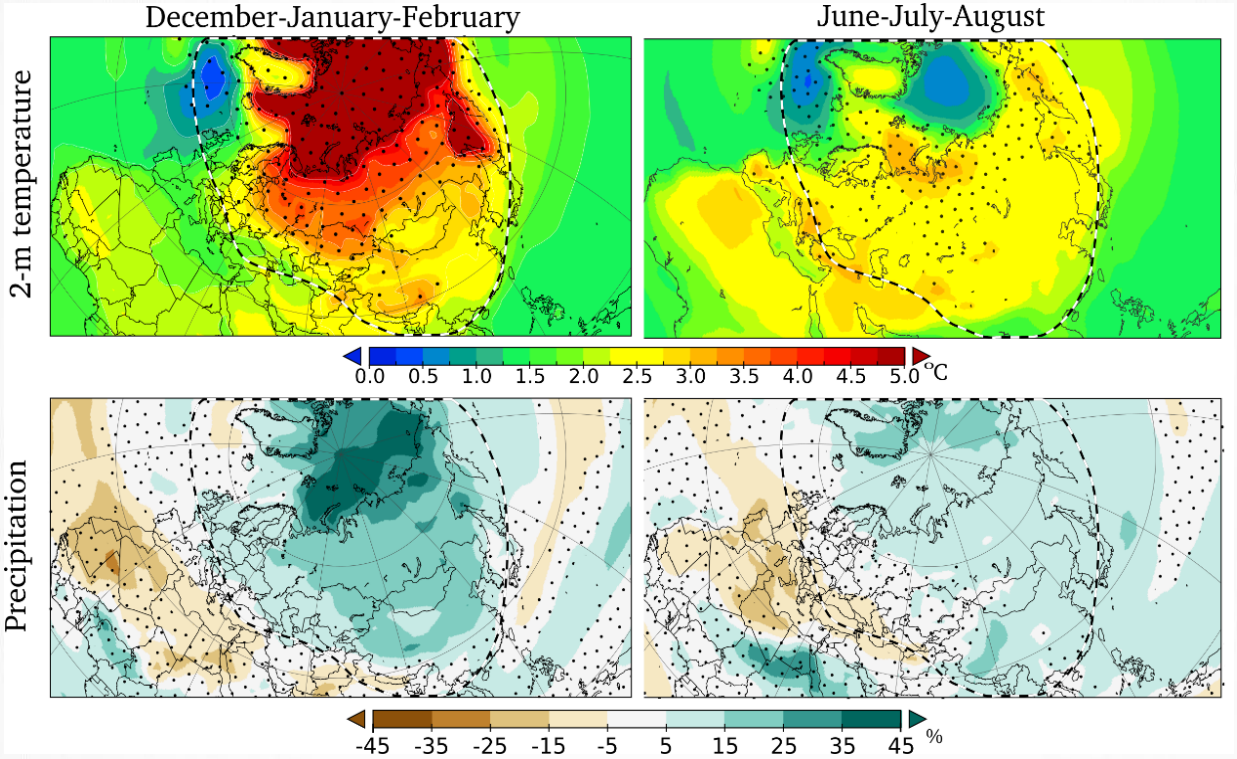

Figure 9. Changes in 2-meter temperature (ºC, upper panels) and precipitation (%, lower panels) during the 21st century. Present-day climatology is averaged over years 1981-2010 and end-of-century climatology over 2070-2099. Winter (left) and summer (right) are shown separately. Dotted areas indicate high variability in model ensemble (for temperature: standard deviation of 21st century change exceeds 1ºC; for precipitation: standard deviation of 21st century change exceeds 100% or present-day precipitation). The model results are from IPCC AR5, based on 42 individual models in CMIP5 experiments under the RCP4.5 scenario.

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RESEARCH HIGH LIGHTS RUSSIA

- Medical-geographical analysis of distribution of natural focal diseases in Yamalo-Nenets Autonomous Okrug accounting for climate change with *Prof. Svetlana Malkhazova group, Moscow State University*
- Permaforst analysis & Mechanisms, pathways and patchiness of the Arctic ecosystem responses and adaptation to changing climate (CLIMECO) in collaboration with *Academician Vladimir Melnikov group, University of Tyumen*
- Land – atmosphere feedback loops over Northern Eurasia in collaboration with *Prof. Boris Belan and Dr. Michael Arshinov V.E. Zuev Institute of Atmospheric Optics*
- GHG fluxes at the Mukhrino Field Station West Siberia, Profs. Elena Lapshina, Yugra State University (West Siberia)

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Ezhova et al. EcoHealth 18, 217–228, 2021
https://doi.org/10.1007/s10393-021-01549-5

ECOHEALTH

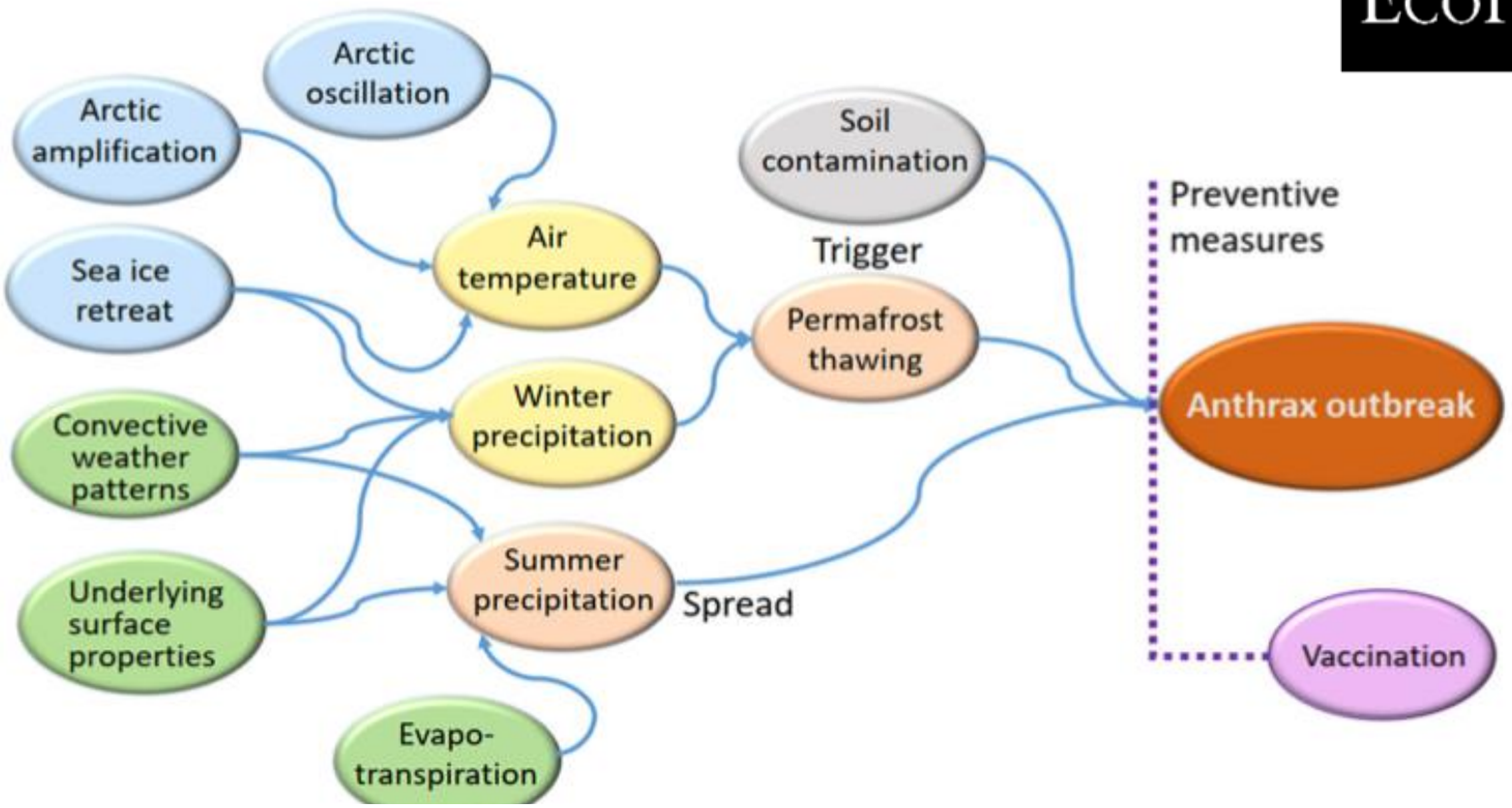


Figure 6. Outline of the connections between climatic factors and anthrax outbreak in the Arctic. Arctic amplification, Arctic oscillation and sea ice retreat determine temperature dynamics in the Arctic on annual scale. Sea ice retreat introduces an increasing trend into the winter precipitation dynamics, whereas local weather patterns and extreme events contribute to its variability. Summer precipitation is determined by the local underlying surface properties, evapotranspiration and convective patterns. Warming climate and winter precipitation dynamics influence active layer deepening which can trigger anthrax outbreak via revival of old bacteria. Dry summer boosts spread of the disease and intensifies the outbreak. Vaccination is a preventive measure to control the spread of disease.

Vision: Global observation network

THERE IS A NEED FOR ADVANCED IN SITU STATIONS IN THE NORTHEN EURASIA / PEEX REGION

M. Kulmala: Nature Comment, Nature 553, 21–23 4 Jan 2018)

The answer is a global Earth observatory — 1,000 or more well-equipped ground stations around the world that track environments and key ecosystems fully and continuously

- Researchers could find new mechanisms and feedback loops in this coherent data set
- Policymakers could test policies and their impacts
- Companies could develop environmental services

An enclosure for measuring gas exchange between plants and the atmosphere at a station in Finland.

Build a global Earth observatory

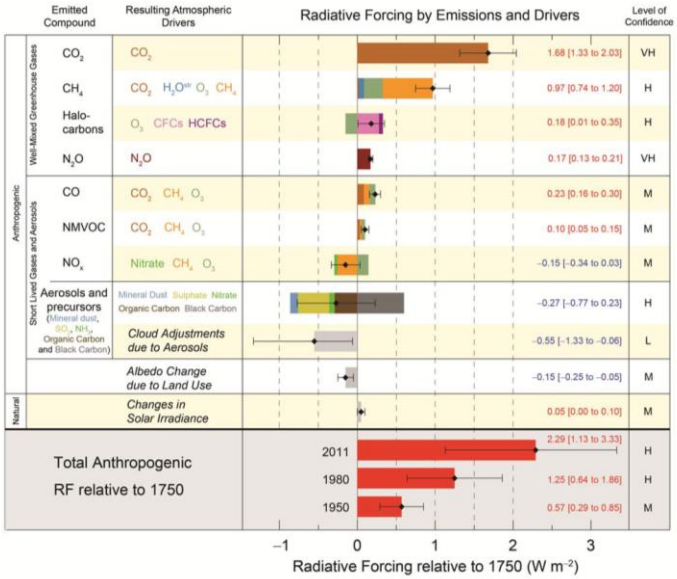
Markku Kulmala calls for continuous, comprehensive monitoring of interactions between the planet's surface and atmosphere.

FRAMEWORKS

- **UN 17 Sustainable Development Goals SDGs (2015 -)** SDGs 11, 12, 13: 'urgent action to combat climate change and its impacts'(13) , 'ensure sustainable consumption and production patterns' (NN), 'make cities and human settlements inclusive, safe, resilient and sustainable' (NN).
- **UN IPPC Report 2021 – Policymaker Summary** "*C.2 With further global warming, every region is projected to increasingly experience concurrent and multiple changes in climatic impact-drivers. Changes in several climatic impact-drivers would be more widespread at 2° C compared to 1.5° C global warming and even more widespread and/or pronounced for higher warming levels*."
- **26th UN Climate Change Conf. of the Parties (COP26), Glasgow, 31 Oct – 12 Nov 2021**

Current observations are fragmented:

- **GHGs**
- **Aerosols**
- **Air quality**
- **Ecosystem**
- **Climate**
- **…**



Kulmala 2018 Nature

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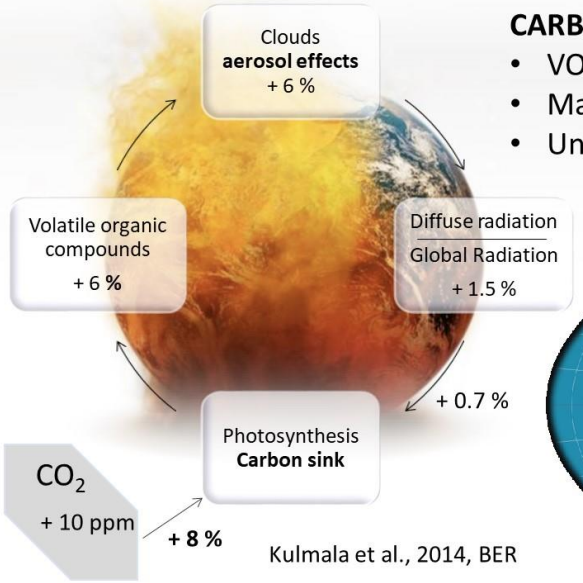
INSTITUTE FOR ATMOSPHERIC AND EARTH SYSTEM RESEARCH

Atmospheric and ecosystem big data providing key contributions in reaching United Nations' Sustainable Development Goals

Markku Kulmala [a,b,c,d,e,f], Anna Lintunen[a,g], Ilona Ylivinkka[a], Janne Mukkala[a], Rosa Rantanen[a], Joni Kujansuu[a,b,c,f], Tuukka Petäjä [a,b,c,e], and Hanna K. Lappalainen[a,e,h]

BIG EARTH DATA
2021, VOL. 5, NO. 3, 277-305
https://doi.org/10.1080/20964471.2021.1936943

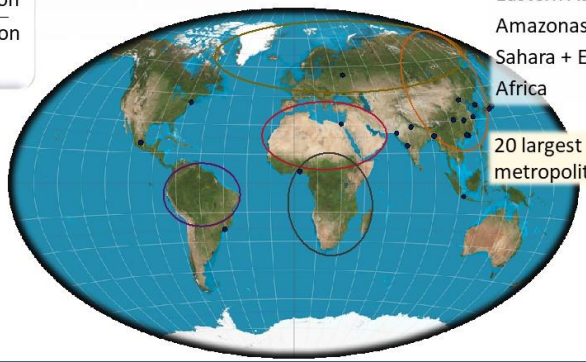
THE POTENTIAL OF SMEAR CONCEPT: GLOBAL COMPREHENSIVE FEEDBACK ANALYSIS



Kulmala et al., 2014, BER

CARBON SINK PLUS

- VOCs, Aerosols, clouds, precipitation
- Max 1.8 x carbon sink (Hyytiälä / SMEAR II results)
- Uncertainties
  => observations / models



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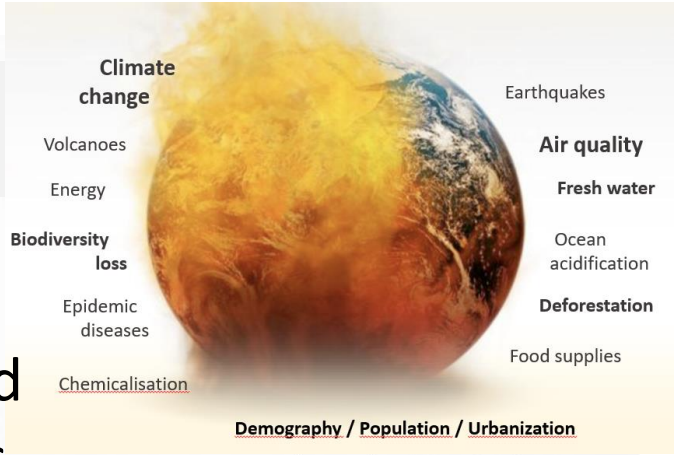
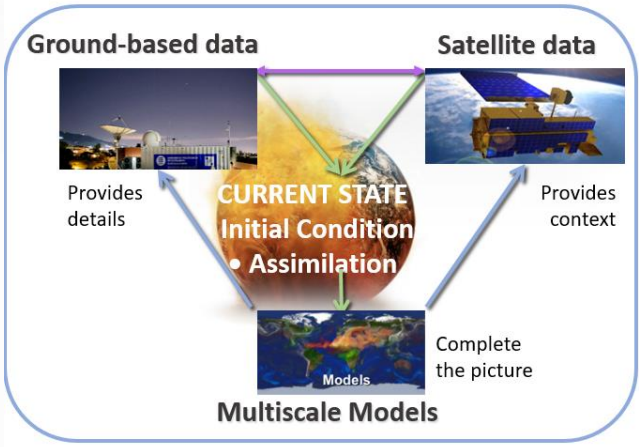
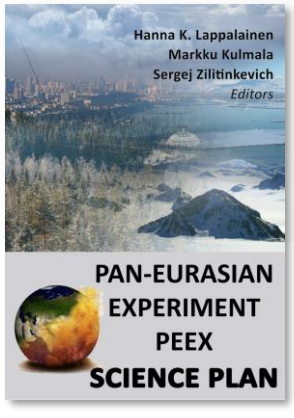
SYMMARY



- PEEX addresses high level research and research infrastructure in the topical areas, which are needed to find practical solutions to ensure the sustainable development of the Northern Eurasian and B&R environment, society and economy
- new understanding of the land-atmosphere interactions together with the coordinated, comprehensive observation system in these domains has significant societal and economic impact at regional and global scales
- these plans are needed for attracting government and private sector investments.





ACCC
CLEAN AIR. SAFE CLIMATE.

Tue 7.Dec	**Excellent science connecting research & stakeholder communities** Sergej Zilitinkevich memorial seminar in Atmospheric and Earth System Sciences	
Wed 8.Dec	**Climate change – Air Quality Forum:** from deep understanding to practical solutions, Sofia Earth Forum	
Thu 9.Dec	**Arena for Arctic Science Collaborations (AASCO)** Sponsored by Prince Albert Foundation	
Fri 10.Dec	**Climate change, Air quality challenges & Civil engagement** Sofia Earth Forum	

- www.acccflagship.fi/index.php/accc-impact-week-2021/
- **Registration for the on-line participation:**
- https://elomake.helsinki.fi/lomakkeet/112892/lomake.html
- **PEEX / Global Observatory Zoom meeting on Wed 8.Nov**