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3.12.2019

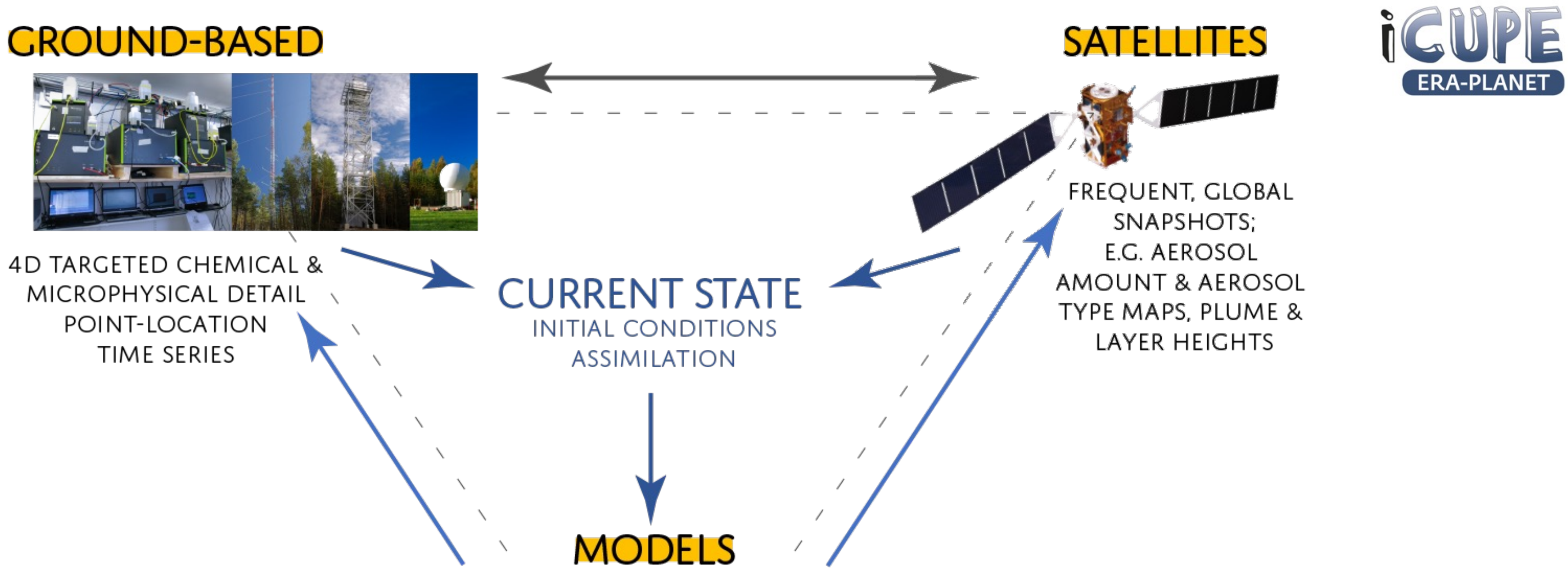
Integrative and Comprehensive Understanding on Polar Environments (iCUPE)

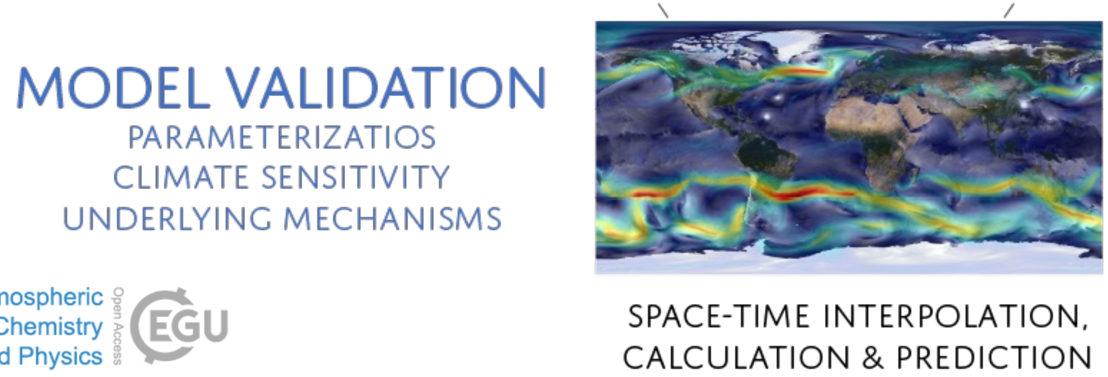
Tuukka Petäjä and the iCUPE consortium

Based on iCUPE project outcomes
2018-2021

iCUPE ERA-PLANET consortium

1) University of Helsinki (UHEL) (coord)
2) Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI)
3) Consiglio Nazionale delle Ricerche (CNR)
4) Centre National de la Recherche Scientifique (CNRS)
5) Aarhus University (AU)
6) Helmholtz Zentrum Potsdam GFZ Deutsches GeoForschungsZentrum (GFZ)
7) Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research GmbH (HZG)
8) Leibniz Institute for Tropospheric Research (TROPOS)
9) Stockholm Unversitet (SU)
10) N.C.S.R. Demokritos, Institute of Nuclear and Radiological Science & Technology, Energy & Safety (NCSR)
11) Finnish Meteorological Insitute (FMI)
12) Estonian University of Life Sciences (EULS)
13) Paul Scherrer Institut (PSI)





Atmospheric Chemistry and Physics
Open Access

Overview: Integrative and Comprehensive Understanding on Polar Environments (iCUPE) – concept and initial results

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https://www.atm.helsinki.fi/icupe/index.php/datasets/list-of-datasets-as-deliverables

DS Teasers: https://www.atm.helsinki.fi/icupe/index.php/datasets/submitted-datasets

Datasets

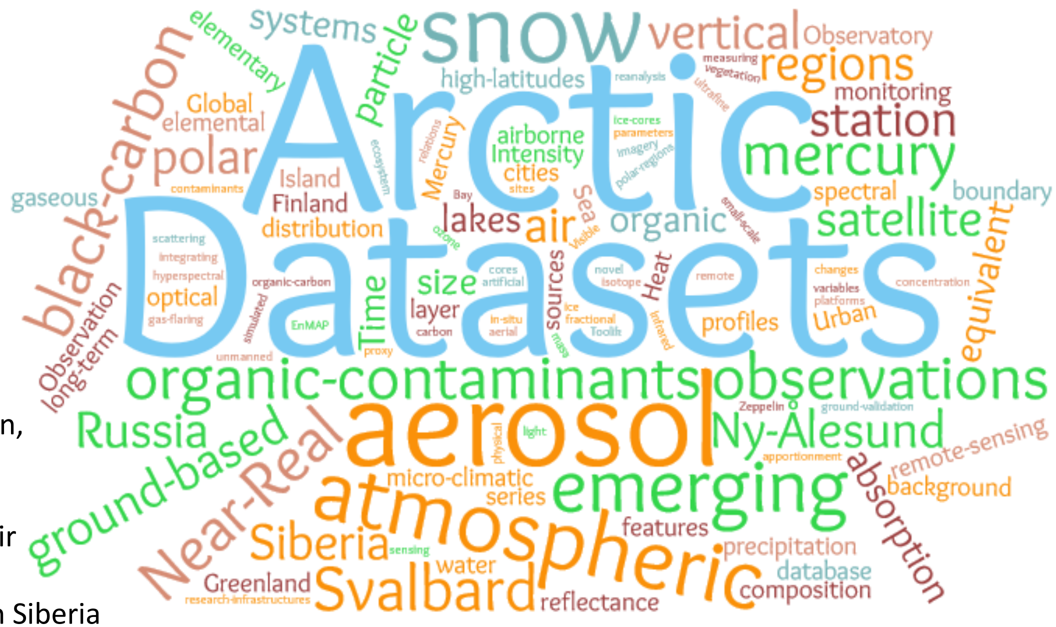


Figure: 2020©INEP-iCUPE: Author: Stephany Mazon

The iCUPE Datasets on:

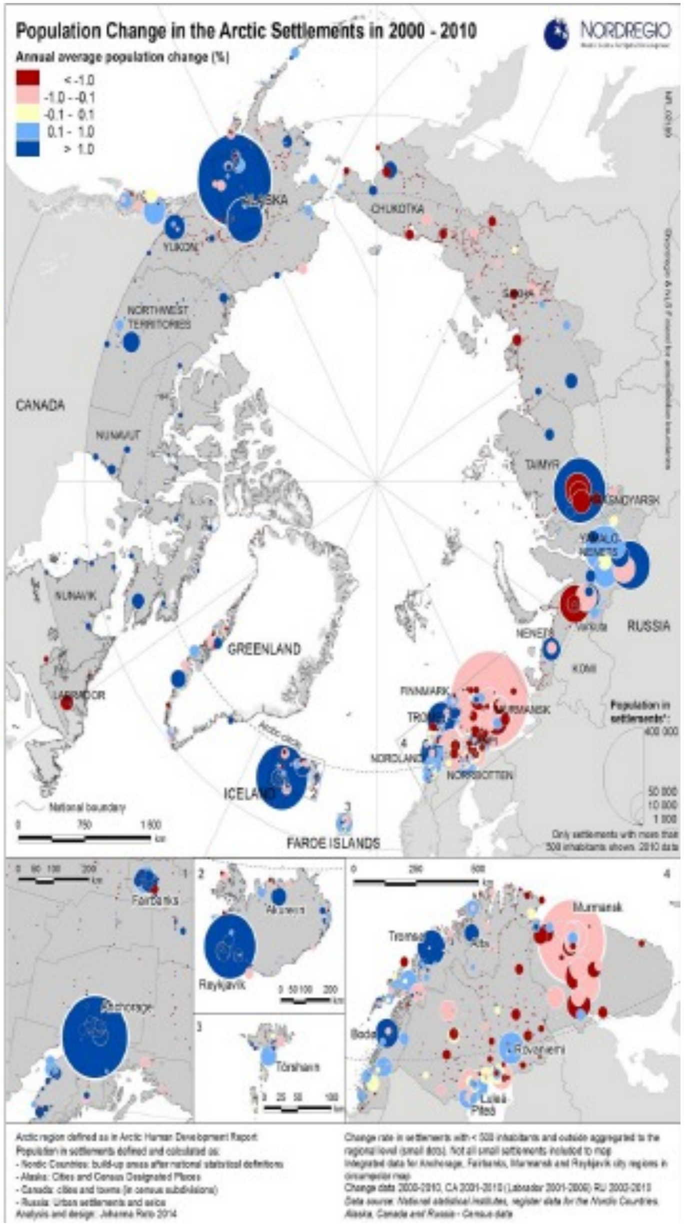
Dec 2018 - emerging organic contaminants in air from the Arctic
May 2019 - emerging organic contaminants in snow in the Arctic
Jun 2019 - anthropogenic contaminants in snow from polar regions
Jun 2019 - anthropogenic contaminants in ice cores from polar regions
Sep 2019 - emerging organic contaminants in water from the Arctic
Sep 2019 - near-real time aerosol absorption measurements from Zeppelin Station, Ny Ålesund, Svalbard
Dec 2019 - Arctic atmospheric Hg(II) observations
Jan 2020 - long-term monitoring of gaseous elementary mercury in background air at the polar station Amderma, Russian Arctic
Mar 2020 - classification of artificial light sources in the Yamal Peninsula, Western Siberia
Mar 2020 - fractional snow cover area in selected sites of Svalbard islands (Norway)
Mar 2020 - small-scale vertical and horizontal variability of atmospheric boundary layer aerosol using unmanned aerial systems
Apr 2020 - time series of lake size changes in Northeast Greenland
May 2020 - validated aerosol vertical profiles from ground-based and satellite observations above selected sites in Finland and Siberia
May 2020 - visible near infrared airborne and simulated EnMAP satellite hyperspectral imagery of Toolik Lake, Alaska
Jul 2020 - aerosol ultrafine and large particle size distribution, scattering, absorption and equivalent black carbon at Ny-Alesund, Svalbard
Jul 2020 - snow spectral reflectance measurements at Ny-Alesund, Svalbard
Jul 2020 - vertical profiles of equivalent black carbon in the Arctic boundary layer at Ny-Ålesund, Svalbard
Sep 2020 - ground-validation of precipitation measurements in high-latitudes
Oct 2020 - organic aerosols in the Arctic

Northern Urbanization

Baklanov et al. (2021)

Arctic and Northern region is characterized:

- Much **lower population density** and not fast growing, but **global warming can increase urban developments**
- Highly urbanized with ≈ **90%** of population living in citie
- **Small size cities** are dominating, but not less problems
- About **100** urban settlements with > 5000 inhabitants
- Much **higher vulnerability** and lower sustainability
- **Cold climate is a dominant environmental factor**
- Urban nexus includes:
  - Snow – impact on management and planning
  - Frozen soil & permafrost – infrastructure stability
  - Frozen surface water – water supply and sewage
  - Dormant vegetation – reduced ecosystem services
  - Stagnant and stably stratified atmosphere – air pollution and urban heat island
  - Low temperatures – health issues and working routines
  - **high energy consumption**
- **Migration is a dominant societal factor** in the region
  - More than 60% of urban population are 1st generation migrants
  - High skills but little sense-of-place
  - External, unsustainable development agenda



SMURBS ERA-PLANET

iCUPE ERA-PLANET

4th PACES Open Science meeting (26-28 May 2021) on its Session 2:
Integrated Urban Systems (IUS): Twin cities - GURME initiative concluded:

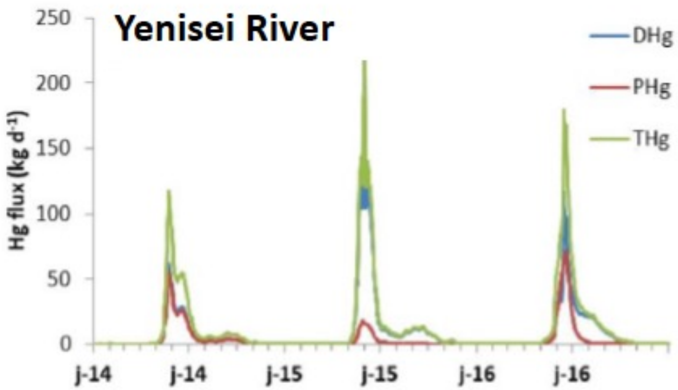
- **Complex multidisciplinary approach is needed for building climate and environmentally smart and sustainable Arctic cities;**
- **Improvements and adaptation of the novel WMO concept of the IUS for Arctic and winter cities are important and require further research;**
- **It is decided to propose a new GURME project on IUS for Northern Twin Cities. Cities in focus and some initial pairs of twin cities have been identified;**
- **Key science focus will be on very stable boundary layers of winter and Arctic cities and their interactions with urban processes, air pollution and climate change.**

- iCUPE work contributed to the definition of Northern twin city concept
- Sustainability of Arctic cities

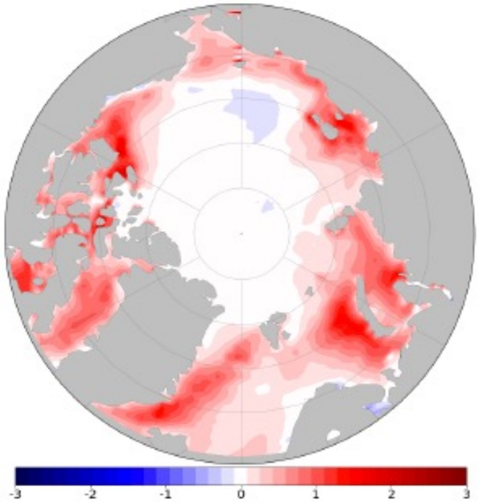
Eurasian river spring flood observations support net Arctic Ocean mercury export to the atmosphere and Atlantic Ocean

Jeroen E Sonke[1], Roman Teisserenc[2], Lars-Eric Heimbürger-Boavida[3], Mariia Petrova[3], Nicolas Marusczak[1], Theo Le Dantec[2], Artem Chupakov[4], Chuxian Li[2], Colin Thackray[5], Elsie Sunderland[6], Nikita Tananaev[4], Oleg Pokrovsky[1]

Sonke et al.

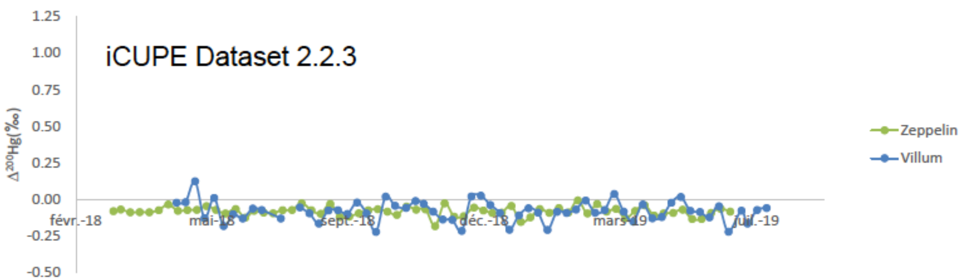


Pan-arctic rivers: 44 ± 4 Mg/y



June/July net Hg air→sea flux
…if 30% of river Hg → AO
Permafrost Hg→AO→air?

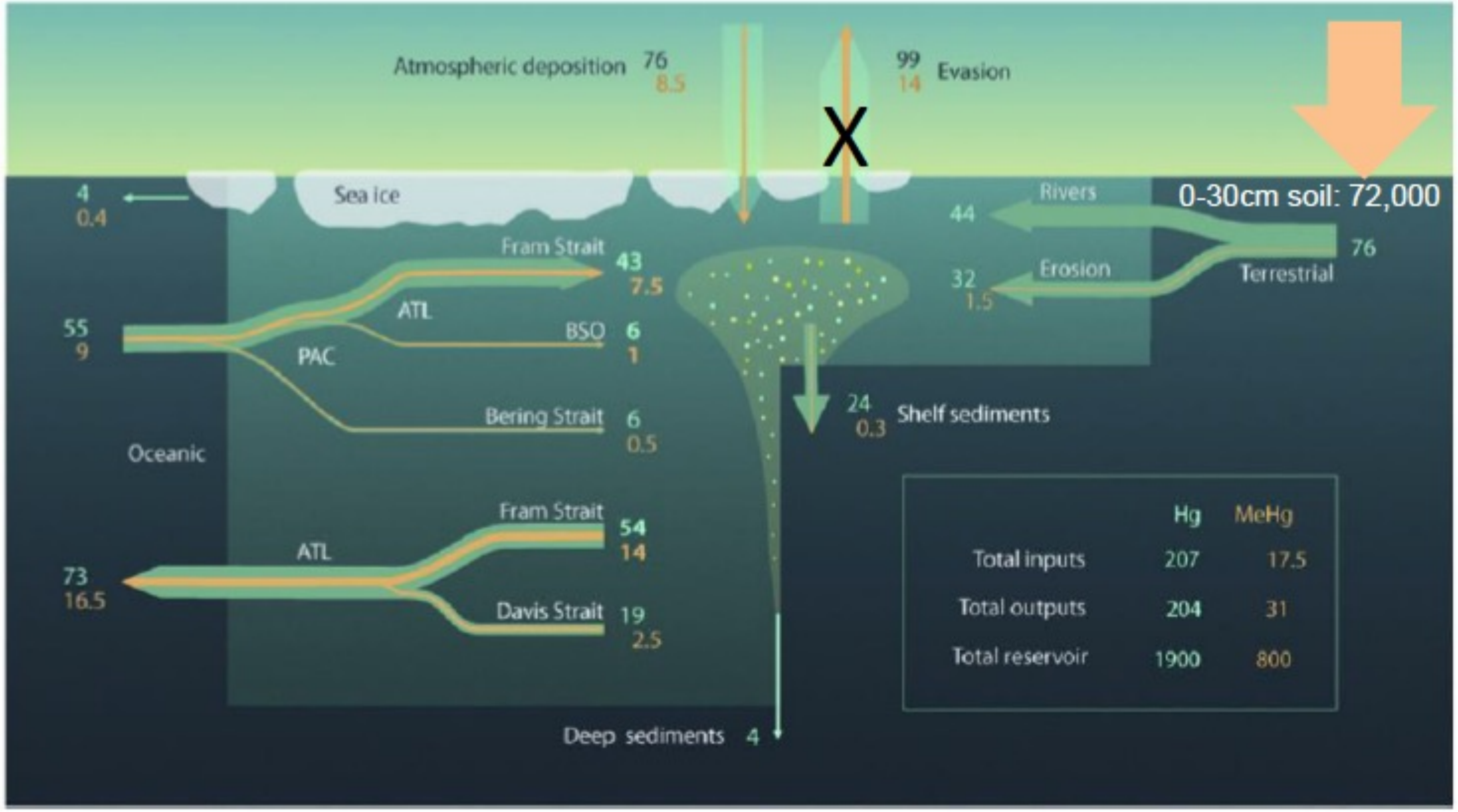
iCUPE: Sonke et al., 2018, PNAS



iCUPE: Atmospheric Hg^0 isotope fingerprints: $\Delta^{200}Hg$

Summer peak is not from terrestrial sources!

Origins: mid-latitude anthropogenic Hg emissions + natural Hg
Transport: oceans, air, rivers
Fate (of permafrost soil Hg): partial burial on shelf

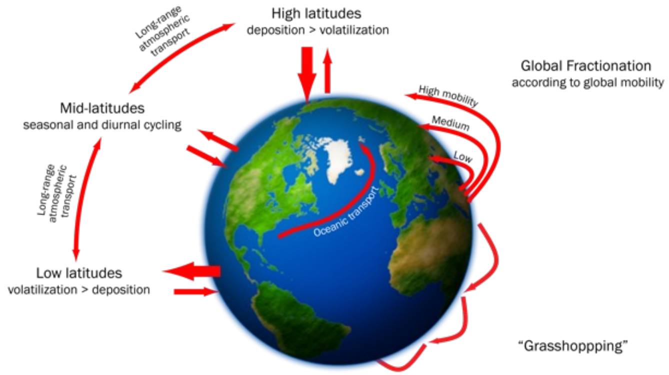


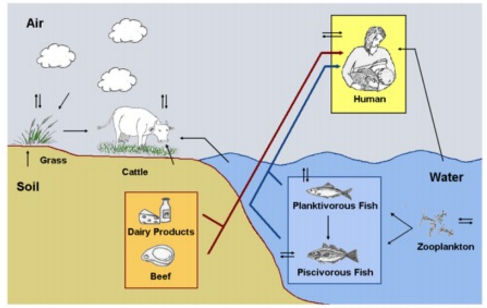
Petrova et al., 2020 Marine Chemistry; see also AMAP 2021 soon

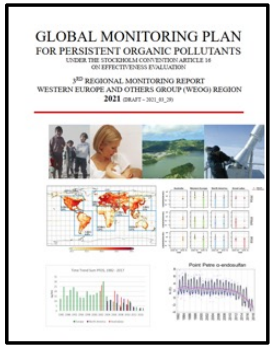
iGOSP ERA-PLANET
iCUPE ERA-PLANET

Improved modeling of impact assessment of pollutants in the Arctic

- We can model source-to-human pathways of persistent organic pollutants to support impact assessments
  - In iCUPE, for effectiveness evaluation of the Stockholm Convention in the 2020 WEOG and Global reports (1)
- For a well-characterized POP, PCB153, we captured 58% of variance in log(c) in breastmilk, with RMSE of a factor of 4.5 (2)
- Pollutants with properties outside the range of “traditional POPs” present new challenges for models
  - Low volatility
    - Partly addressed in iCUPE with a new non-equilibrium distribution model (3)
  - High water solubility
  - Bioaccumulation due to protein binding





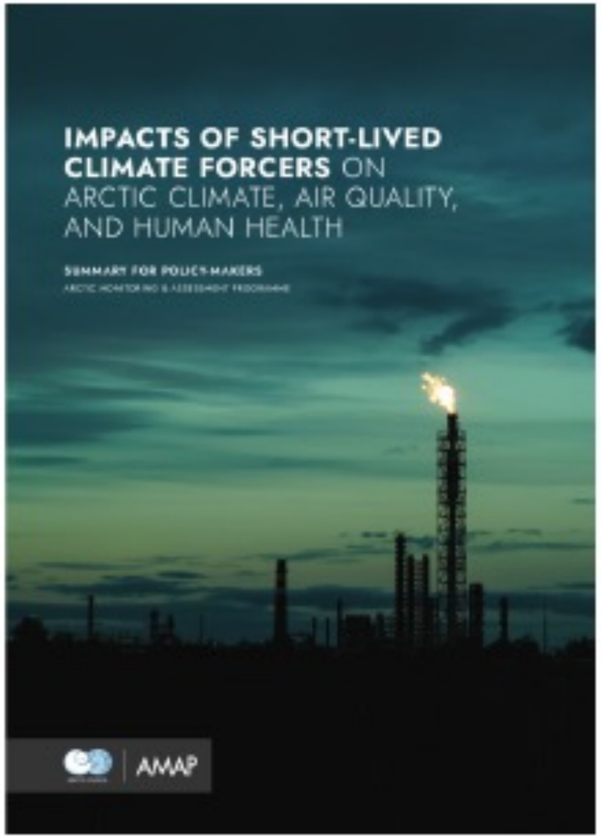


(1) http://www.pops.int/Implementation/GlobalMonitoringPlan/MonitoringReports/tabid/525/Default.aspx
(2) MacLeod et al. Environmental Science: Processes & Impacts, 20, 747-756, 2018
(3) Zhao et al. Environmental Science & Technology, 55, 14, 9425–9433, 2021

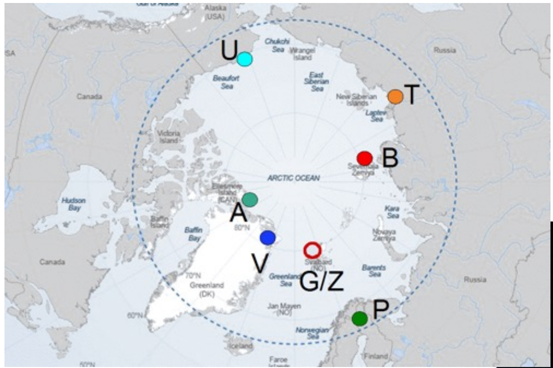
Evaluation of local pollution sources in the Eurasian Arctic based on integrated data analysis and modelling - conclusions

Law et al.

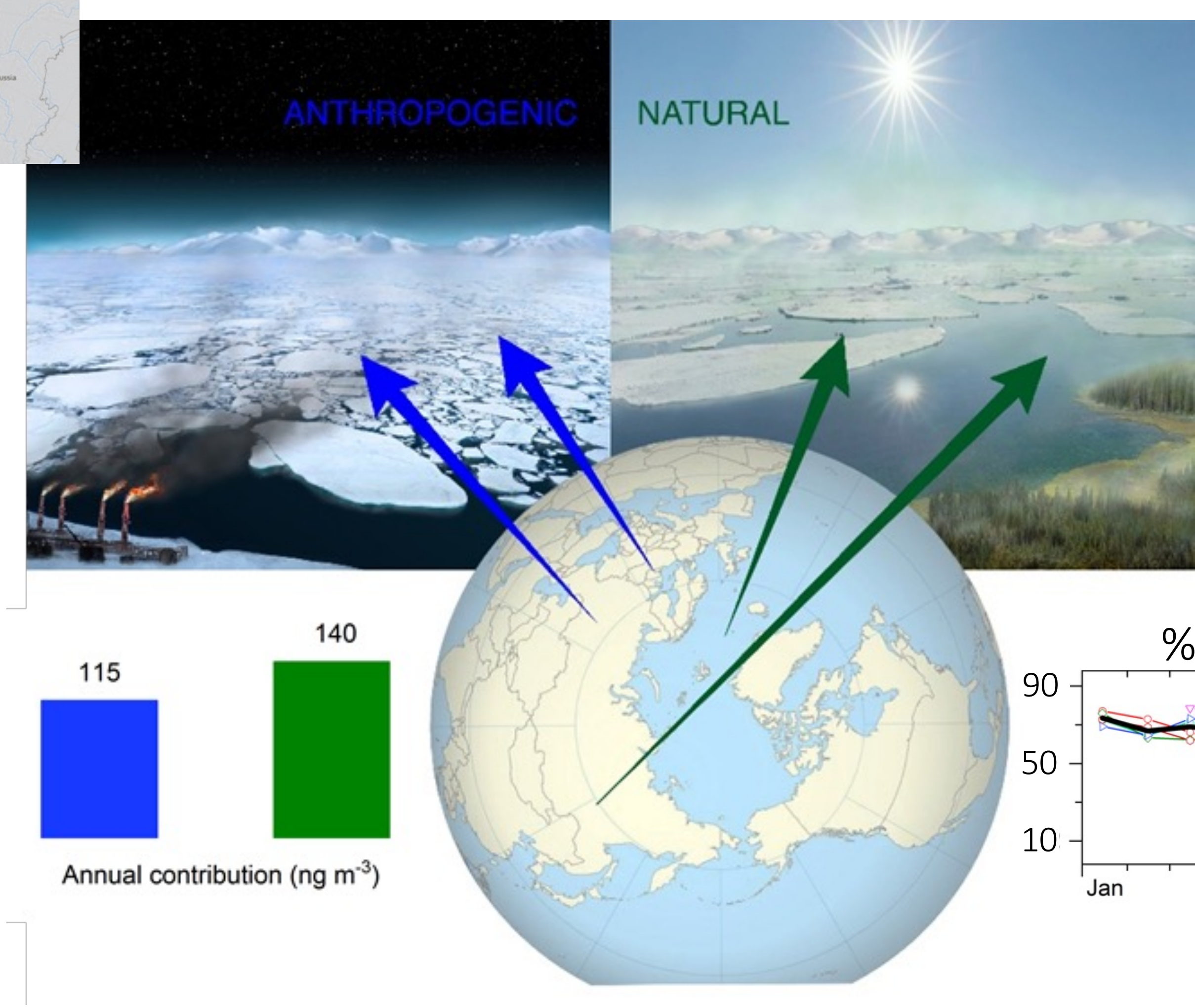
- Combined analysis using airborne, satellite data & modelling to identify deficiencies in current inventories
- Daily variability important for gas flaring
- Contributed to Arctic Council AMAP SLCF climate assessment 2021

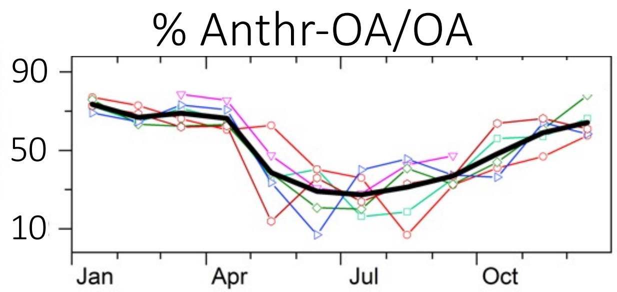


# Equal contributions of natural and anthropogenic emissions to Arctic OA



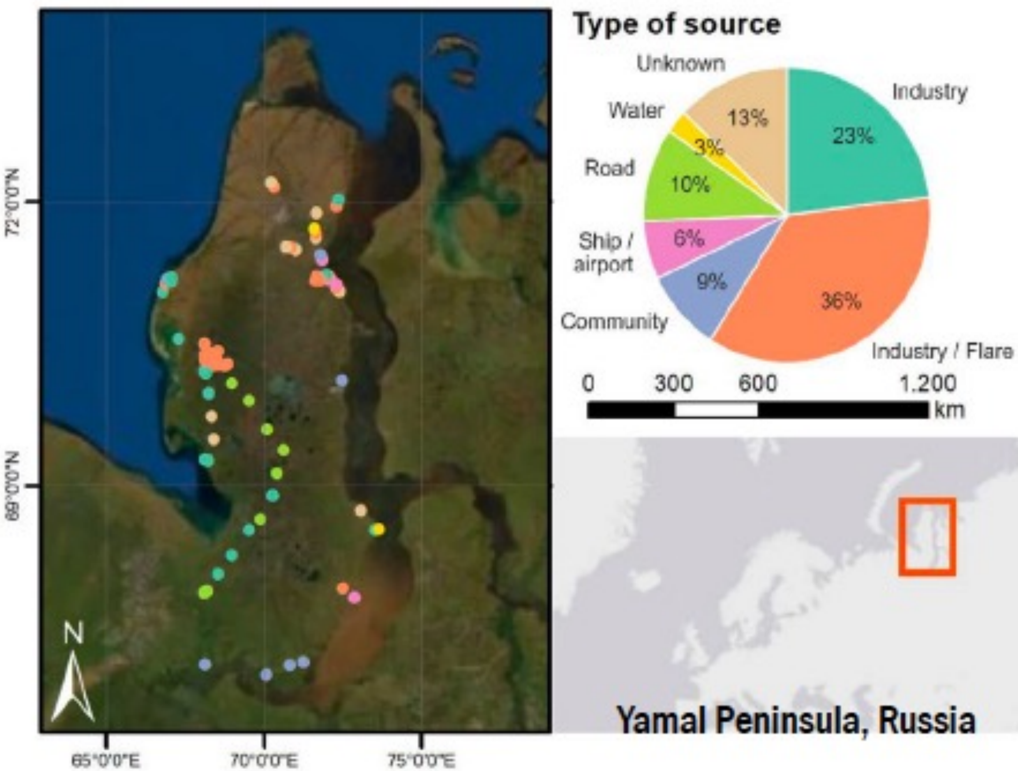
El Haddad et al.



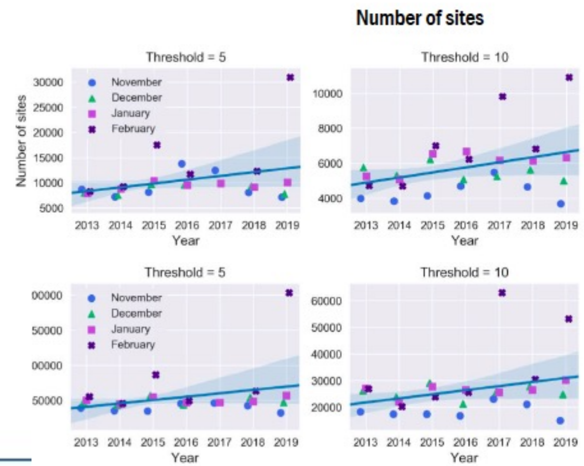


Artificial light in the Arctic: Light source classification on Yamal Peninsula

- Bright light sources in the Arctic can also be classified together with the use of high resolution optical remote sensing data
- The majority of light emissions come from industry and gas flaring



Coesfeld and Kyba (2019)



remote sensing

MDPI

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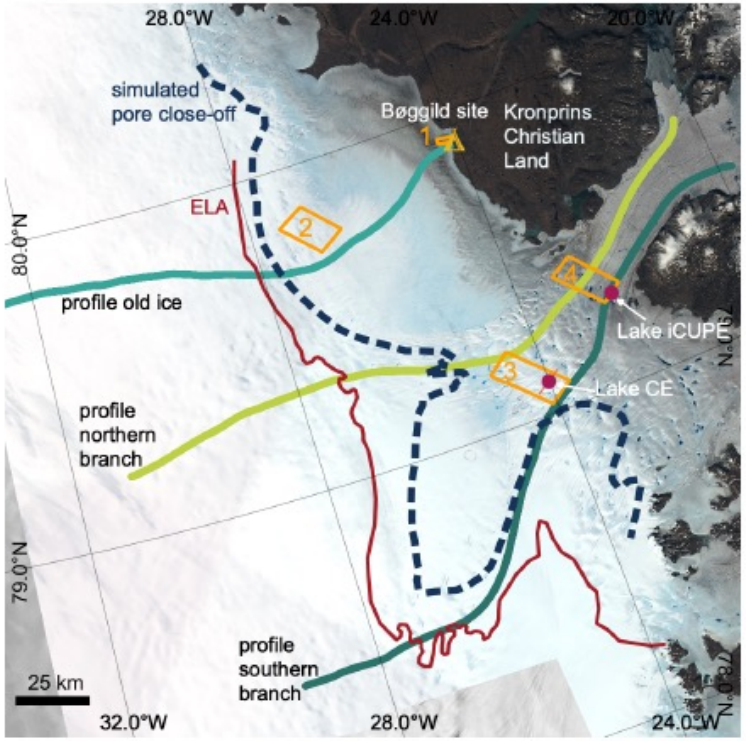
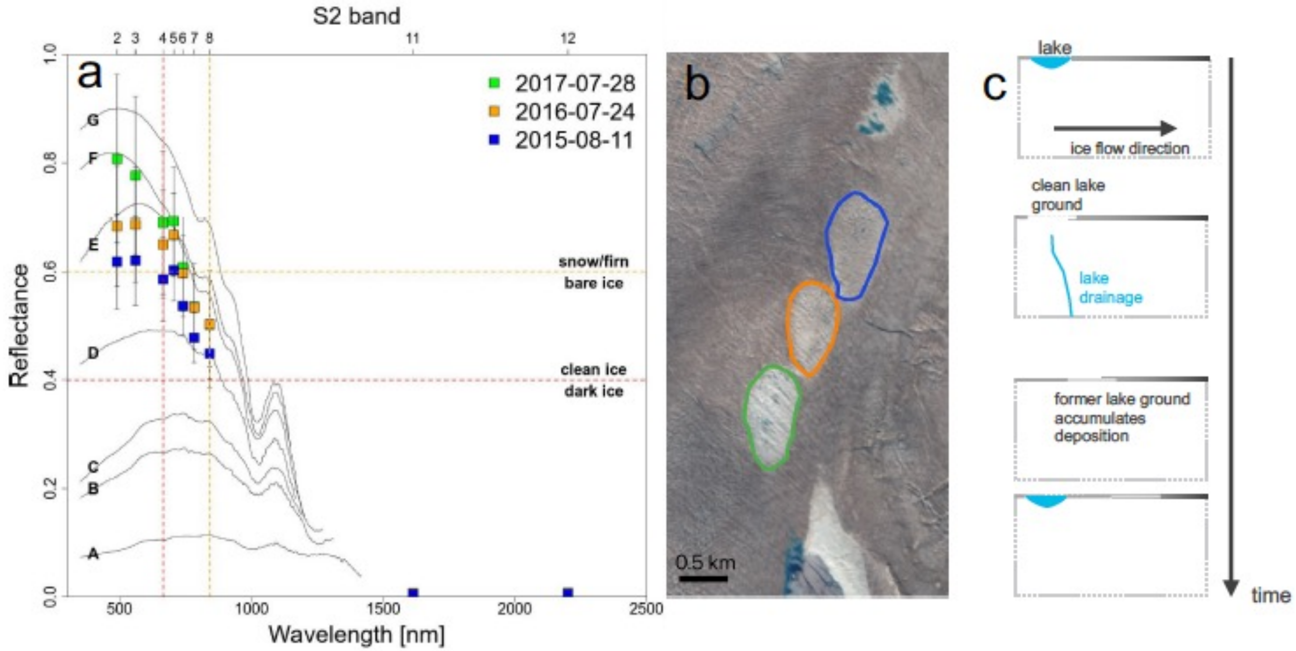
Article

Dark Glacier Surface of Greenland's Largest Floating Tongue Governed by High Local Deposition of Dust

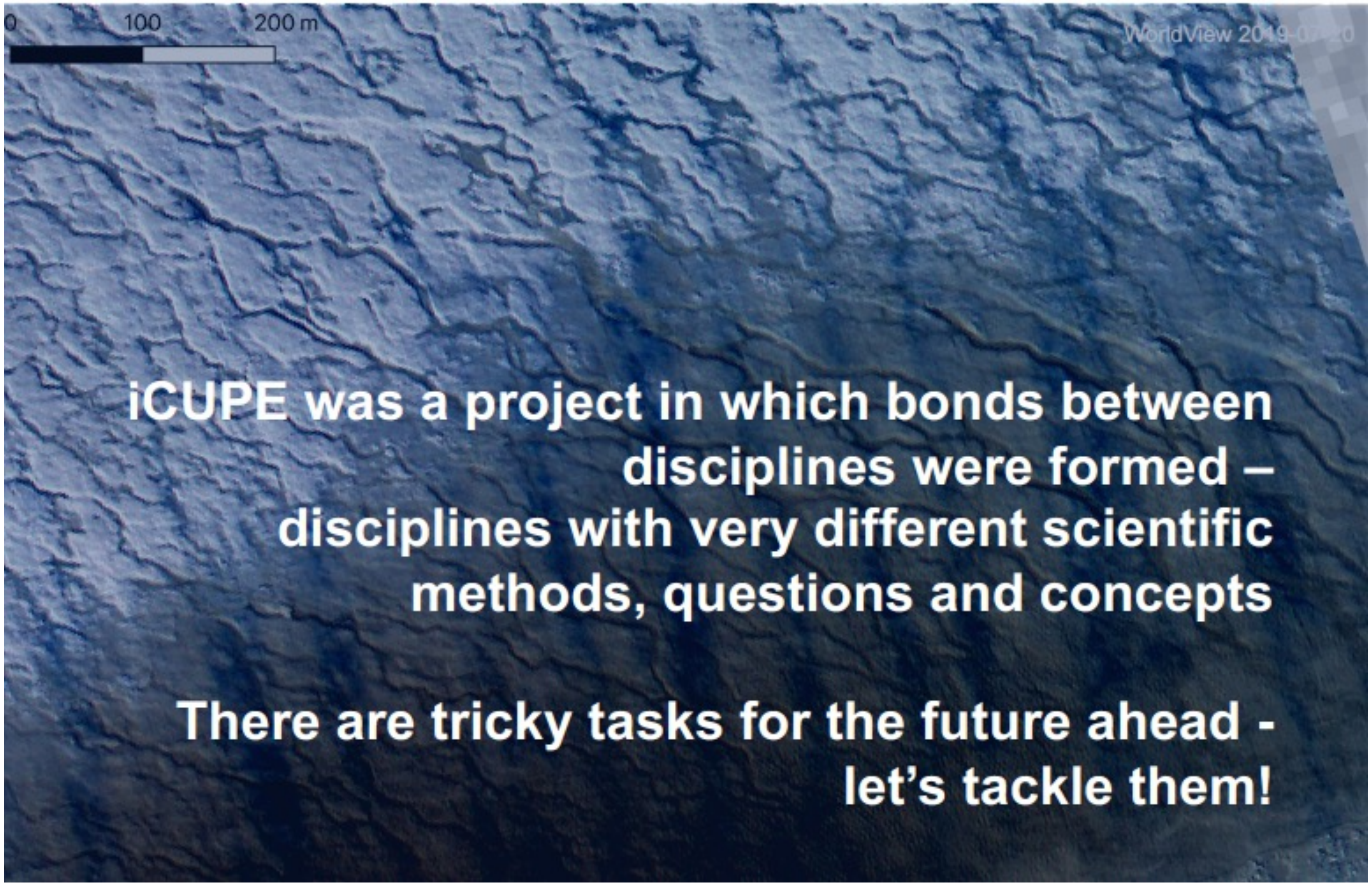
Angelika Humbert [1,2,*], Ludwig Schröder [1], Timm Schultz [3], Ralf Müller [3], Niklas Neckel [1], Veit Helm [1], Robin Zindler [1,2], Konstantinos Eleftheriadis [4], Roberto Salzano [5] and Rosamaria Salvatori [6]



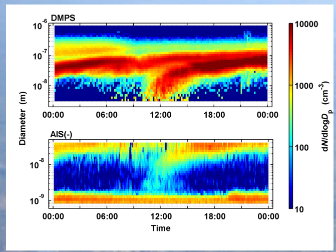


Humbert et al.

Conclusions



Humbert et al.



Main message:

1) **Commitment to comprehensive and continuous environmental observations**

2) **Continuous method development (instrumentation, models)**

3) **Active and open collaboration across various boundaries**

4) **Willingness to tackle and solve grand challenges together**

SMEAR II station
(boreal) 1995 -

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Support from Academy of Finland, European Commission, Regional Council of Lapland, Helsinki-Uusimaa Regional Council, and Business Finland are gratefully acknowledged.