Pan-Eurasian Experiment

Tuukka Petäjä, Veli-Matti Kerminen, Markku Kulmala, Sergej Zilitinkevich, and co-workers

Department of Physics
University of Helsinki
Finland

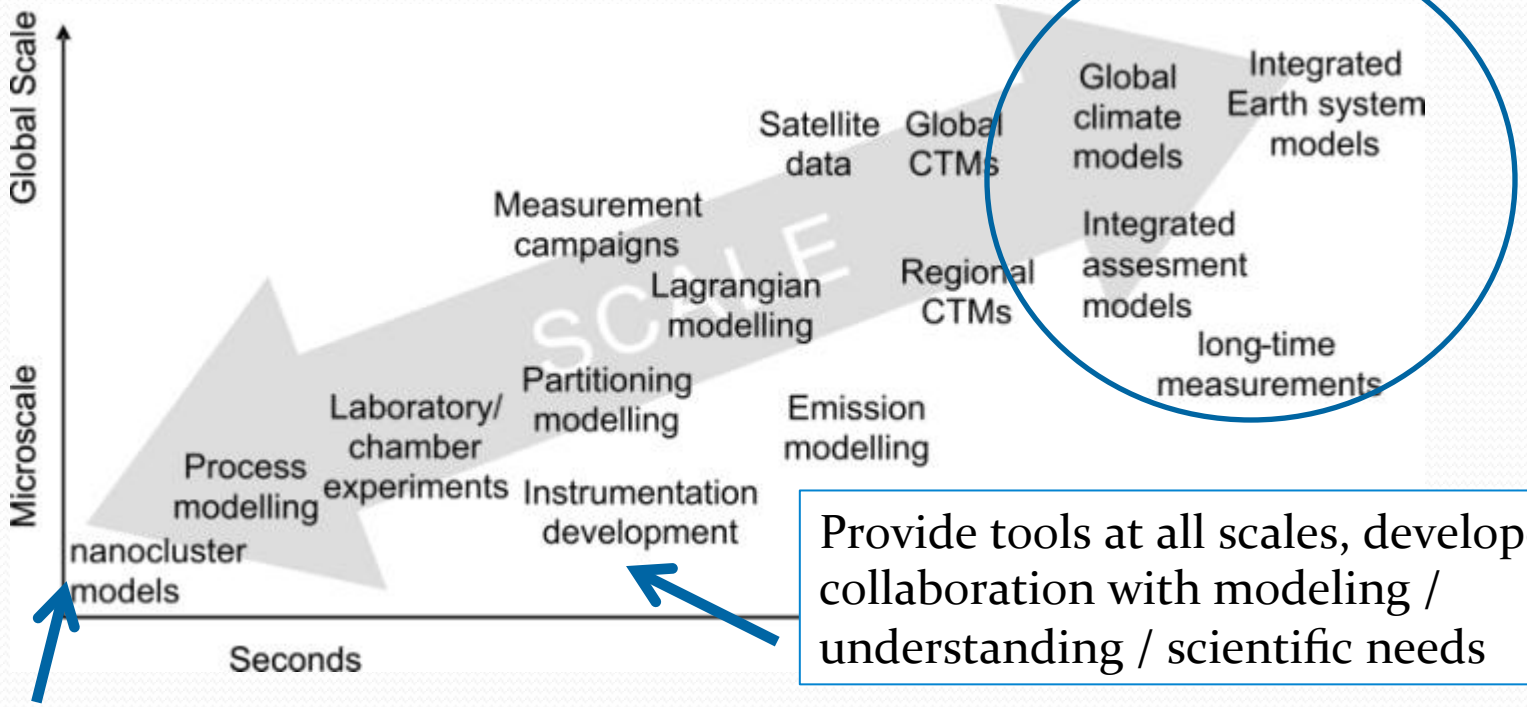
A new programme for EU-Russia-China… collaboration towards better knowledge of our environment in the conditions of global change

University of Helsinki
Atmospheric Sciences

How to meet the research and innovation needs?

- clear and ambitious vision
- empirical / experimental approach
  laboratory, field, instrument development …
- theoretical
  basic theories, simulations, model development…
- From research to innovations; new SMEs

Up-scaling to continental and global scales

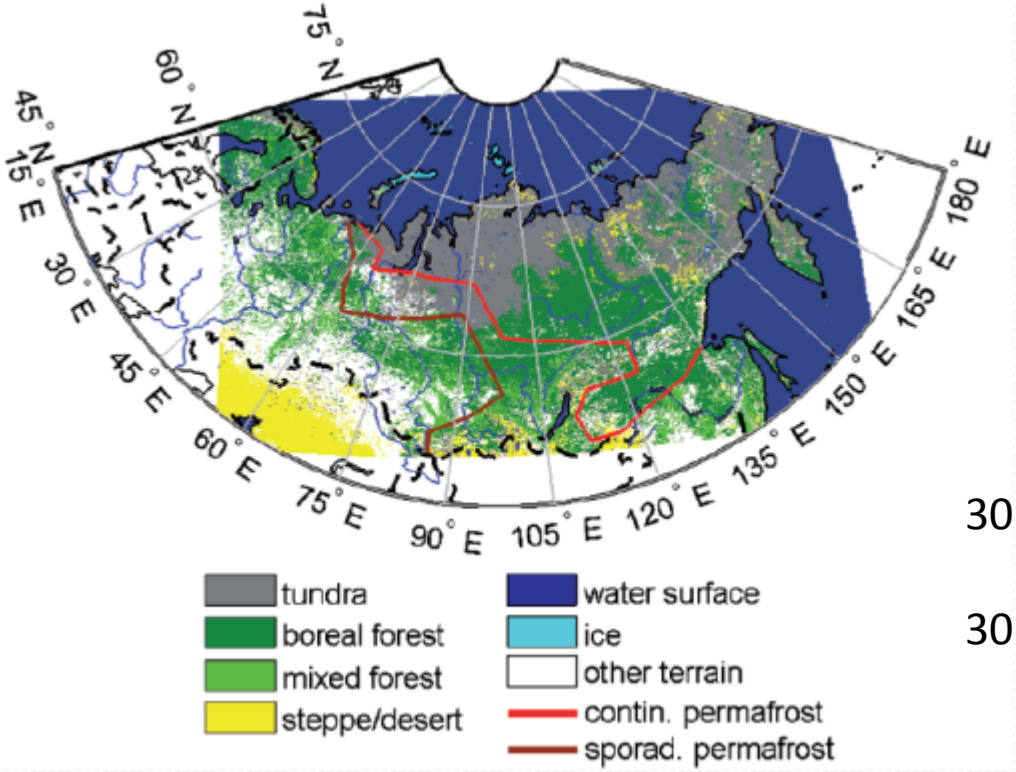


Provide tools at all scales, developed in collaboration with modeling / understanding / scientific needs

Measurements!

Kulmala et al., 2009, EUCAARI, ACP

Importance of Siberia



30 % of land surface = forests

30 % of forests = boreal forests

On measurements of aerosol particles and greenhouse gases in Siberia and future research needs

Markku Kulmala[1)], Pavel Alekseychik[1)], Mikhail Paramonov[1)], Tuomas Laurila[2)], Eija Asmi[2)], Almut Arneth[3)4)], Sergej Zilitinkevich[1)2)] and Veli-Matti Kerminen[2)]

Pan-Eurasian Experiment

- Continuous, comprehensive long-term measurements

  Aerosol particles, green house gases, air quality, biosphere-atmosphere exchange

- Linking ground based measurements with airborne and satellite observations

- Modeling from process level to continental scale integrating ground based and remote sensing data

Pan-Eurasian Experiment

Science questions

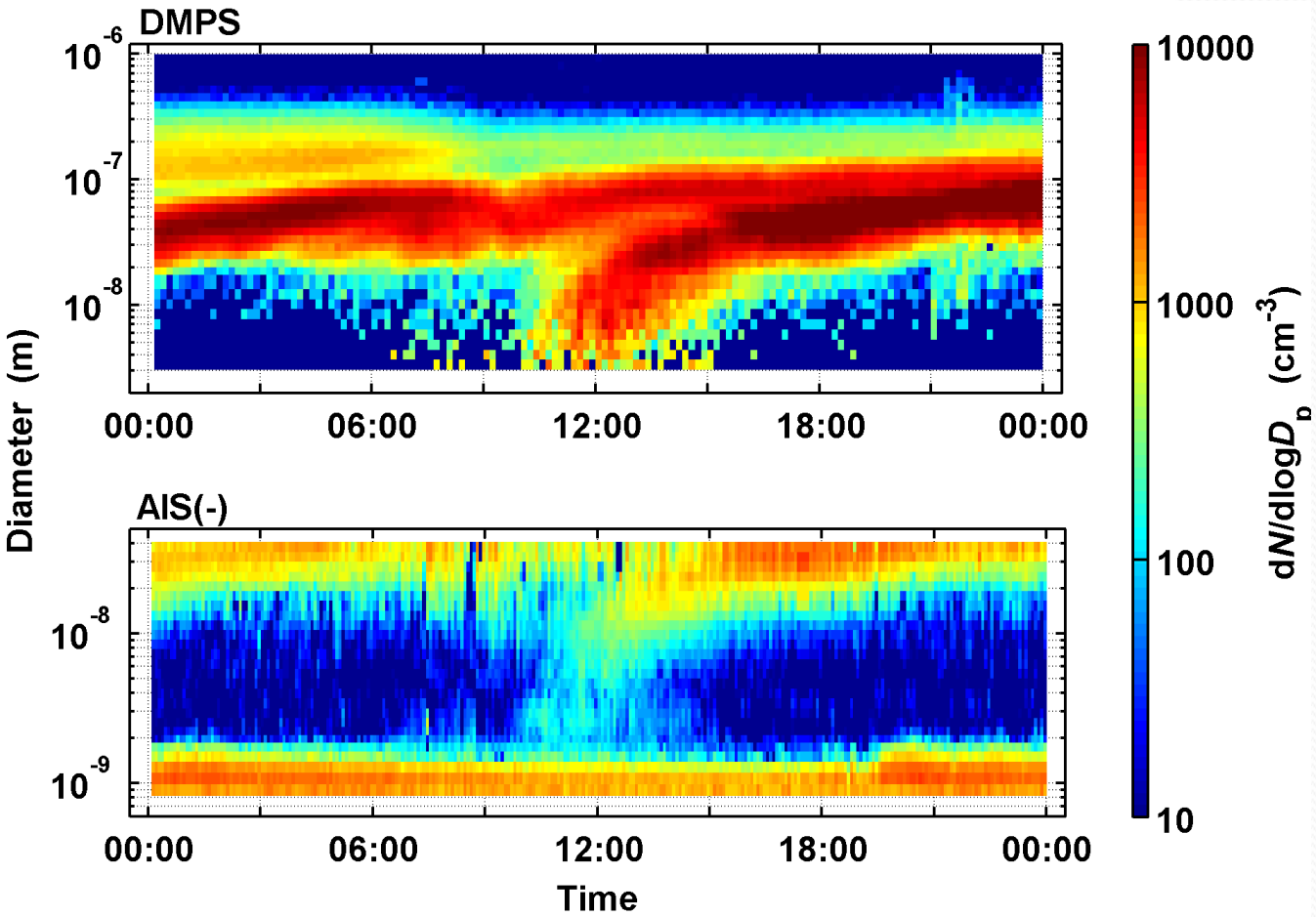
- How fast will the permafrost thaw proceed?
- How will the thawing permafrost affect hydrology, carbon fluxes and methane emissions?
- How rapidly will the permafrost melt? How will the melting permafrost affect methane emissions, and net CO_2 uptake?
- How will the cryosphere change over the next decades?
- What are the foreseen land use changes in Siberia and other Euro-Asian boreal forest areas, and how would that affect exchanges of greenhouse gases and aerosol precursors?
- What are the present biogenic volatile-organic-compound emissions and how will they change during the next 10 and 30 years over Siberia and other Euro-Asian boreal areas?
- What are the connections between ecosystem carbon cycle, the chemistry of biogenic volatile organic compounds, ozone chemistry and the formation and growth of aerosol particles?
- What are regional and global climate and air quality effects of biomass burning, in particular, in in Siberia; how do burning regimes change in response to the land-use and climate changes?
- How to identify areas especially sensitive to climate change, in particular, in Siberia?
- How do the above processes and problems relate to spatial and temporal distribution of basic features of atmospheric planetary boundary layer (first of all, its height) over Siberia and other northern Euro-Asian areas?

Bridging the gap: An example

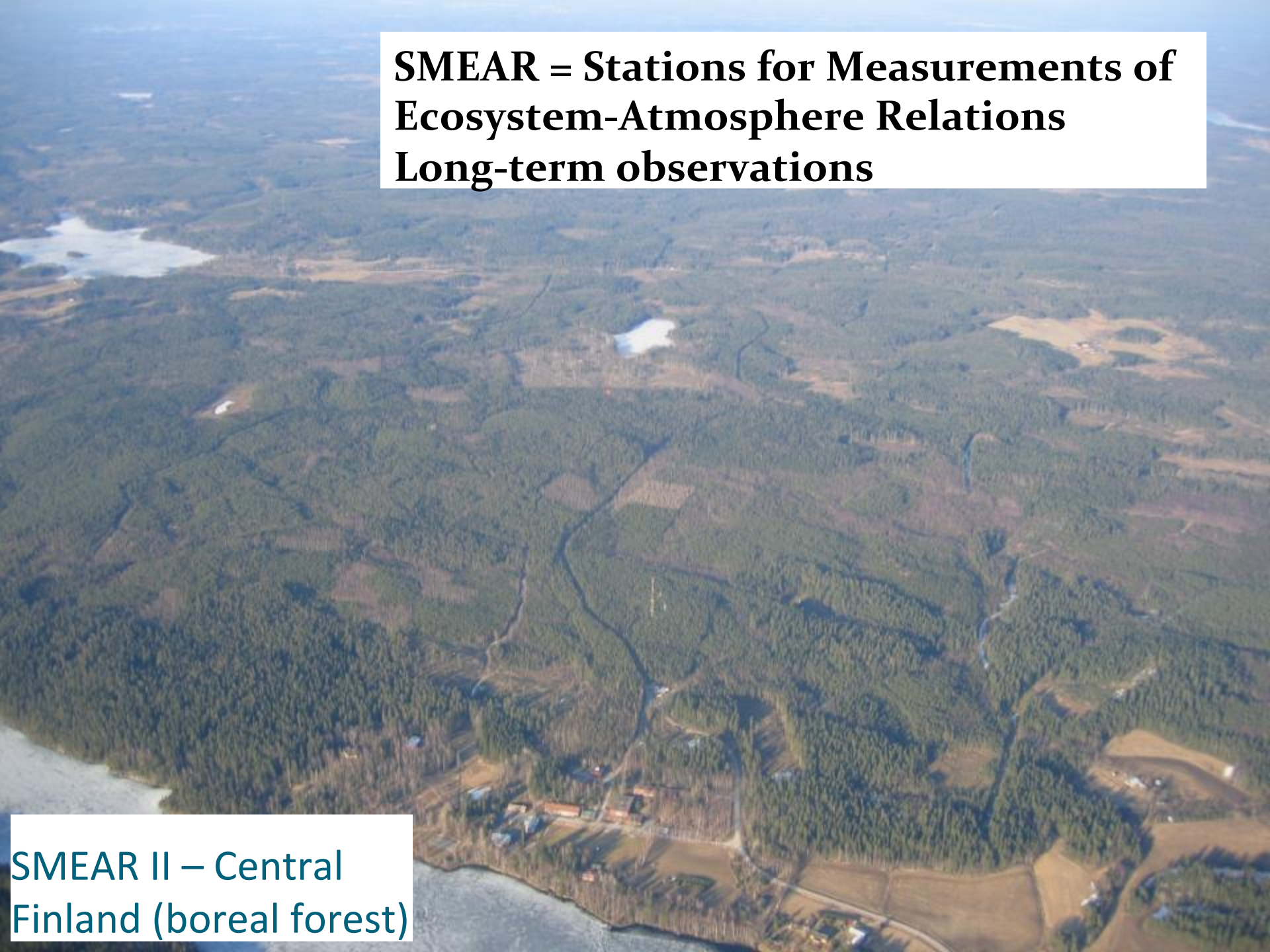
Atmospheric new particle formation and growth events

Composition & concentration of:

- precursor gases
- initial clusters
- gases responsible for the subsequent growth



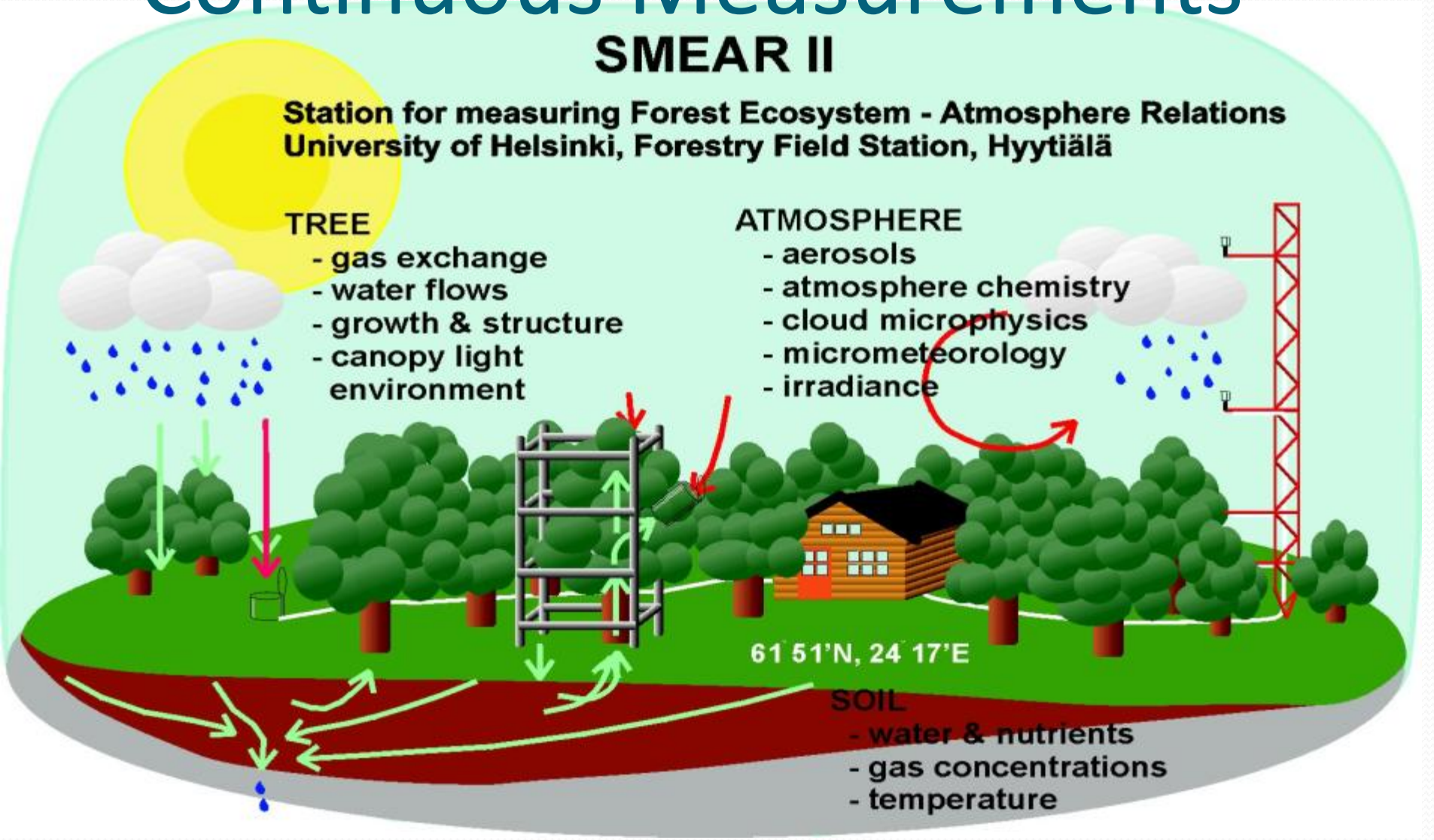
Mäkelä et al. 1997, GRL
Kulmala et al. 2001, Tellus



SMEAR = Stations for Measurements of Ecosystem-Atmosphere Relations
Long-term observations

SMEAR II – Central Finland (boreal forest)

Continuous Measurements



SMEAR II Hyytiälä

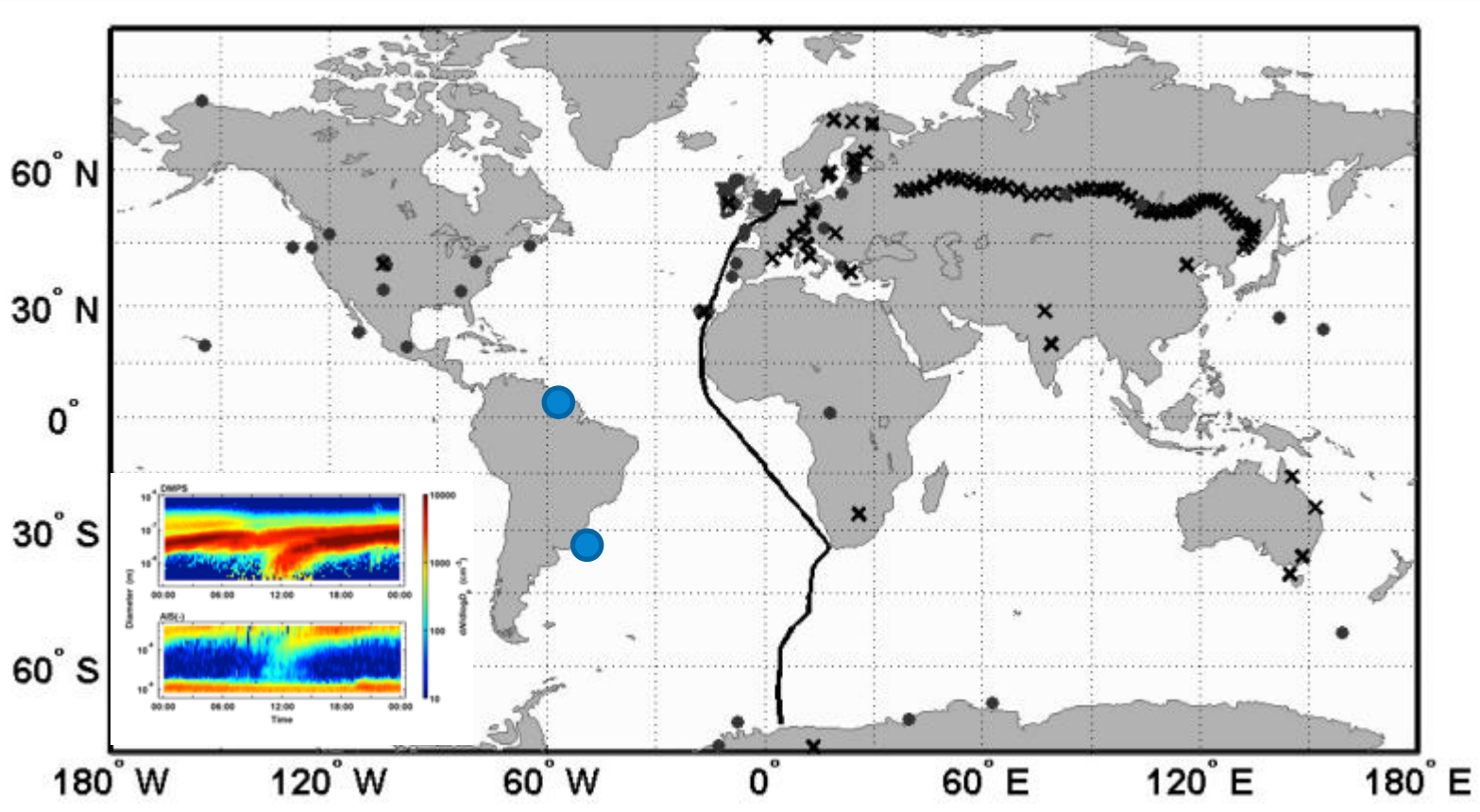
Hierarchical station network

From Hari, Andreae, Kabat, Kulmala
Boreal Environment Research, 14, 442, 2009

1. **Basic stations**
   - weather stations
2. **Flux stations**
   - Fluxnet stations
3. **Flag ship stations**
   - comprehensive stations
     + sources and sinks for greenhouse gases, trace gases, aerosols
   - different environments

Connections to
- remote sensing and airborne measurements
- intensive measurement campaigns with new instrumentation

Particle formation and growth is a global phenomenon (Kulmala et al., JAS 2004)

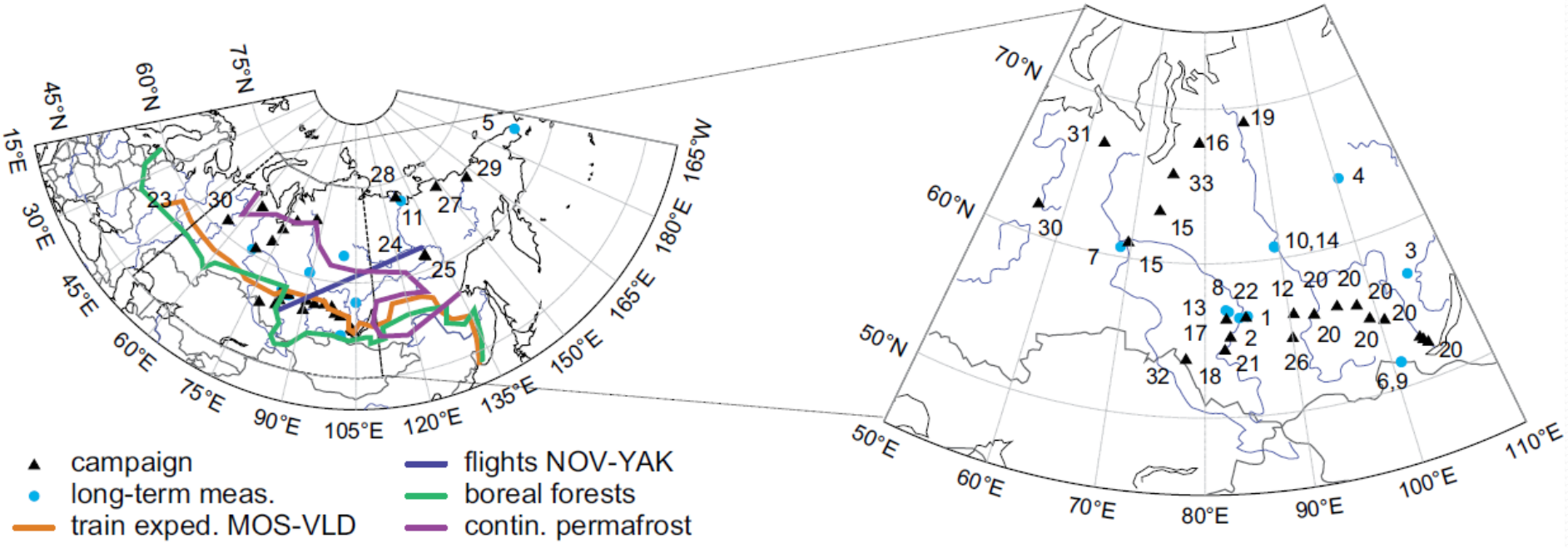


- Contributes significantly to global particle and CCN numbers (Spracklen et al., 2006; 2008; Carslaw, ICNAA 2009)

Examples

- Review of past activities
- Current measurement activities
  - Tiksi
  - satellite observations
  - Biomass burning assessment

Review of past activities



On measurements of aerosol particles and greenhouse gases in Siberia and future research needs

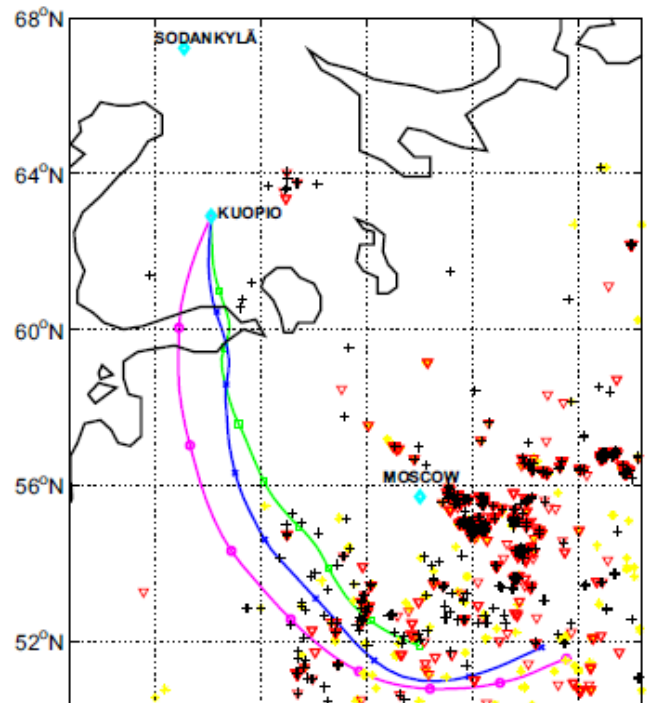
Markku Kulmala[1)], Pavel Alekseychik[1)], Mikhail Paramonov[1)], Tuomas Laurila[2)], Eija Asmi[2)], Almut Arneth[3)4)], Sergej Zilitinkevich[1)2)] and Veli-Matti Kerminen[2)]

Current activities

Biomass burning

Helsinki 21.8. 2006

Moscow summer 2010



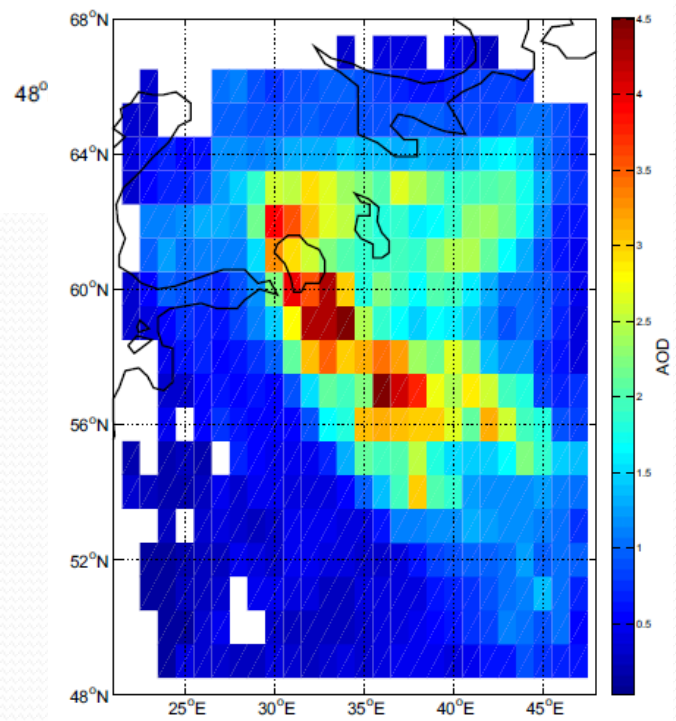
Biomass burning aerosols observed in Eastern Finland during the Russian wildfires in summer 2010 – Part 2: Remote sensing

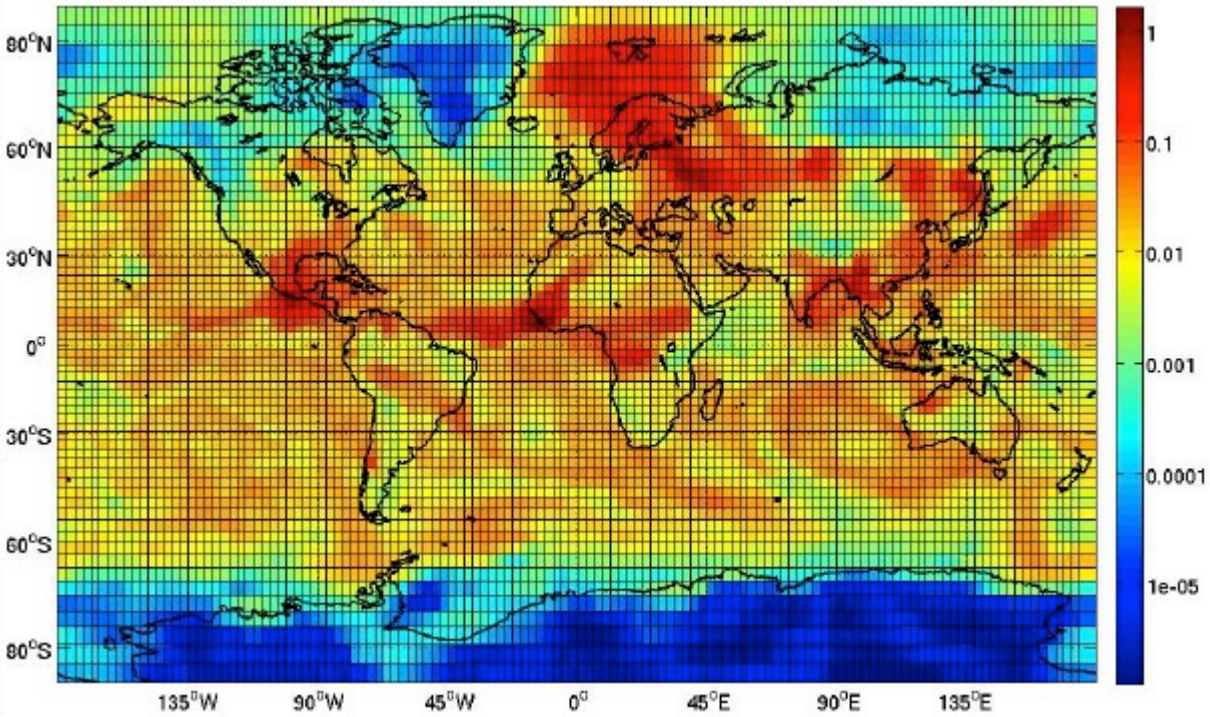
T. Mielonen [a,*], H. Portin [a,b], M. Komppula [a], A. Leskinen [a], J. Tamminen [c], I. Ialongo [c], J. Hakkarainen [c], K.E.J. Lehtinen [a,b], A. Arola [a]

On the use of satellites to obtain information on the occurrence of natural and anthropogenic aerosols over the boreal eurasian forest

G. de Leeuw[1,2], A. Arola[3], L. Sogacheva[2], N. Kivekäs[2], V.-M. Kerminen[2], A. Arneth[4,5], T. Christensen[4], H. Korhonen[3], A.-I. Partanen[3], H. Lappalainen[2], P. Kolmonen[2], T. Mielonen[3], M. Sofiev[2], M. Kulmala[1], and S. Pinnock[6]

Biogeosciences Discuss., 8, 8451–8483, 2011



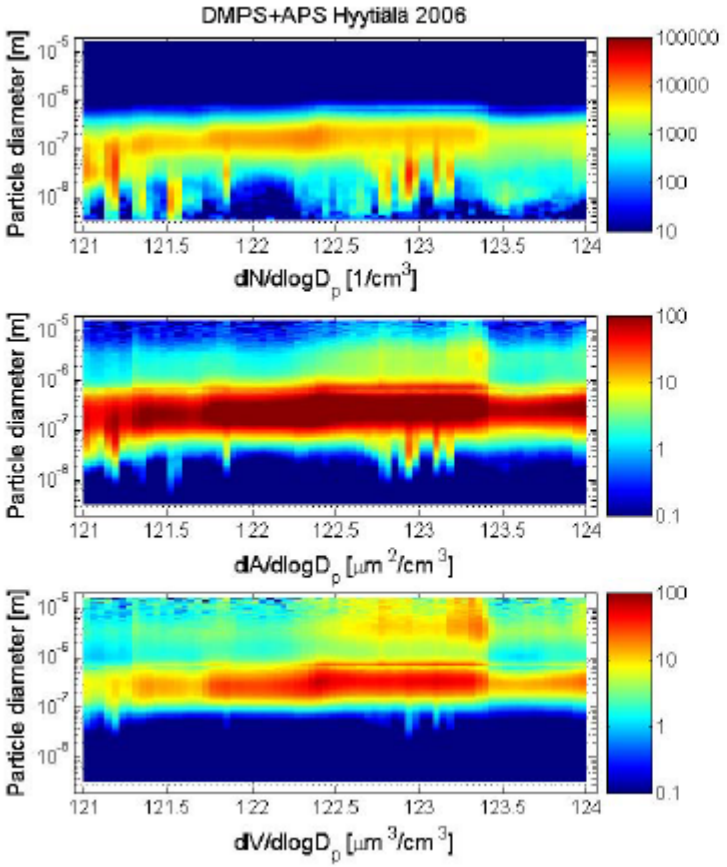


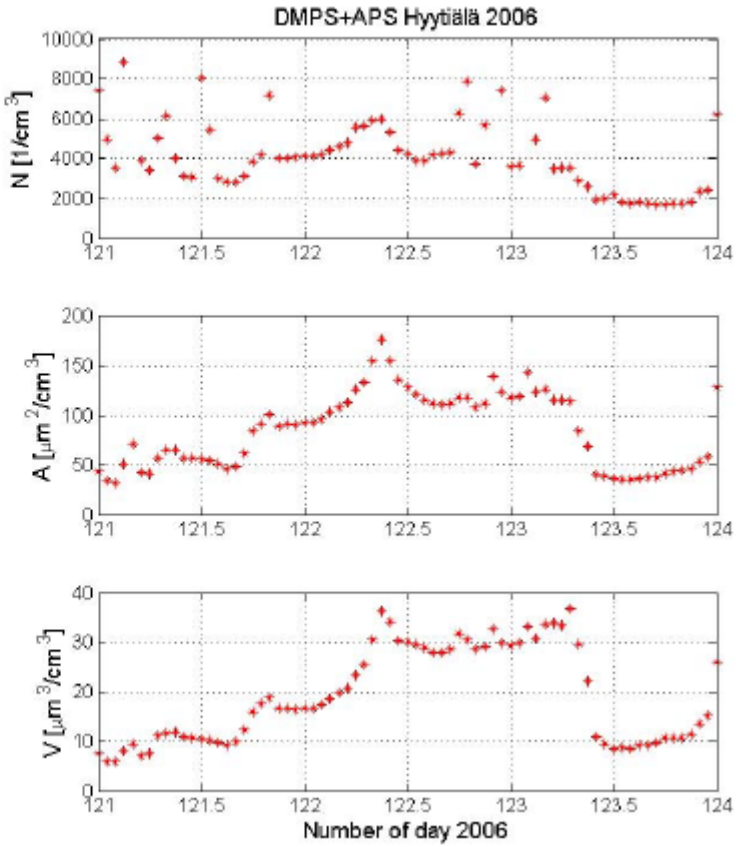
Modeled: GLOMAP + SILAM Fire emission scheme

Biomass burning aerosols observed in Eastern Finland during the Russian wildfires in summer 2010 – Part 2: Remote sensing

T. Mielonen [a,*], H. Portin [a,b], M. Komppula [a], A. Leskinen [a], J. Tamminen [c], I. Ialongo [c], J. Hakkarainen [c], K.E.J. Lehtinen [a,b], A. Arola [a]

Seen on the ground level





The first estimates of global nucleation mode aerosol concentrations based on satellite measurements

M. Kulmala[1], A. Arola[2], T. Nieminen[1], L. Riuttanen[1], L. Sogacheva[3], G. de Leeuw[1,3], V.-M. Kerminen[1,3], and K. E. J. Lehtinen[2,4]

Atmos. Chem. Phys., 11, 10791–10801, 2011

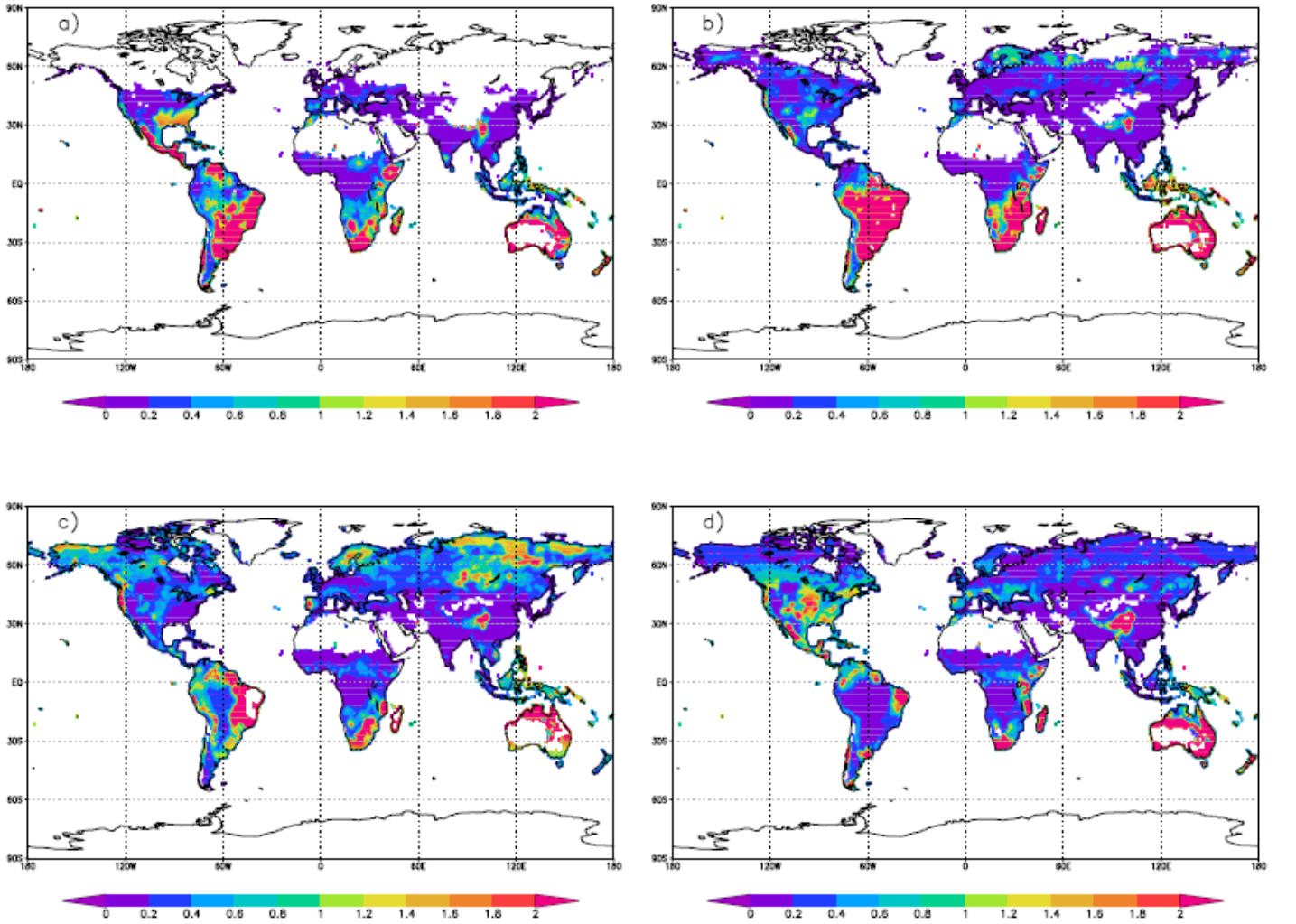
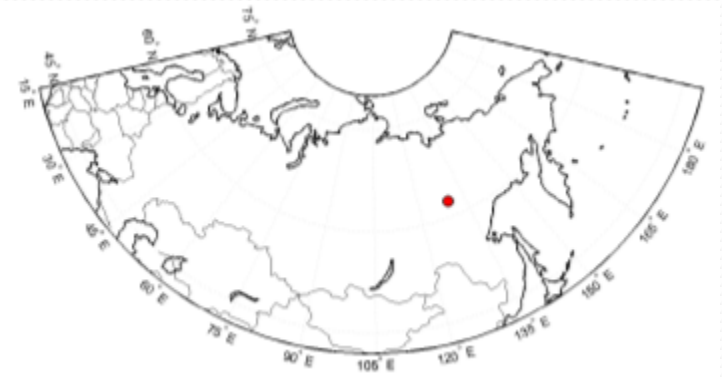


Fig. 4. The global distribution of the proxy given by Eq. (9), after replacing CS with AOD and assuming SO_2 concentration to be constant, for the different seasons of the year 2006: DJF (**a**), MAM (**b**), JJA (**c**), and SON (**d**). The unit of UV is mW m^{-2} nm^{-1}, AOD is unitless. Moreover, UV/AOD^2 is normalized by a factor of 10 000 and the color scale is restricted to between 0 and 2, in order to better show the geographical patterns.

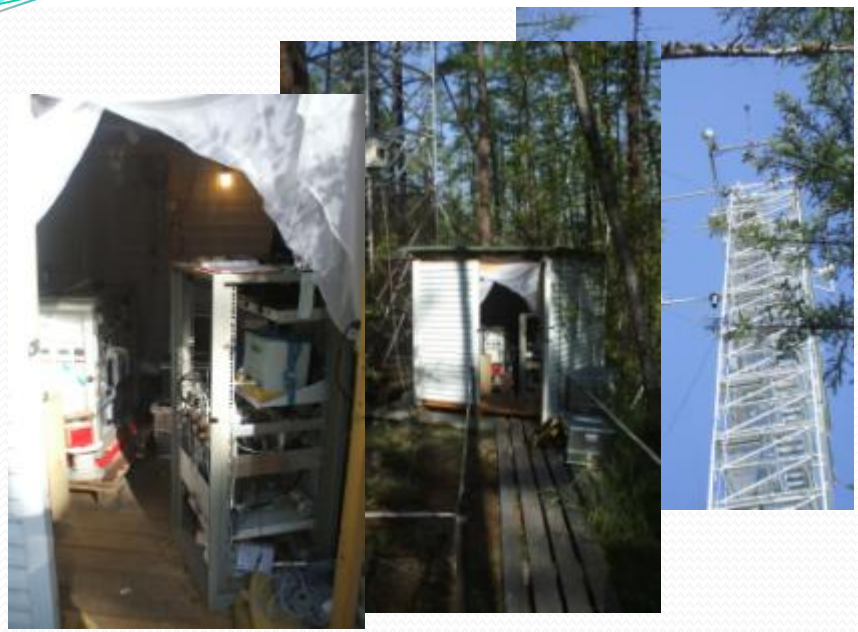
Emissions of Volatile Organic Compounds from Siberian Larch Forest

- VOC emissions of *Larix cajanderi*
- So far no reported VOC emission studies of larch in Siberia
- The aim of was to characterize the emissions of one of the major tree species of Siberian taiga



- Measurements at the Spasskaja Pad measurement site (62°15'18.4"N, 129°37'07.9"E)
- Three campaigns in the summer of 2009: 3.-24. June, 8.-26. July and 14.-30. August.

VOC Emissions From Larch Forest

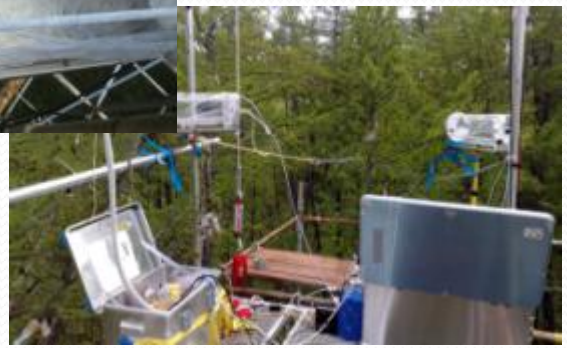


Ecosystem scale :

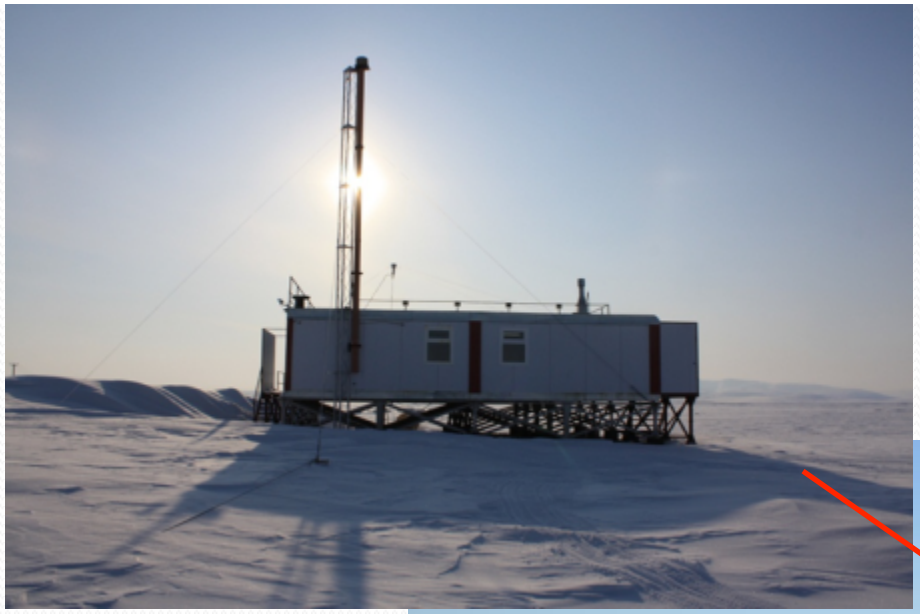
- VOC fluxes with Proton Transfer Reaction Mass Spectrometer (PTR-MS) from 32 m high tower

Shoot scale:

- One shoot enclosed to a Teflon chamber
- Adsorbent samples from the chamber
- Samples analyzed afterwards with Gas Chromatograph Mass Spectrometry (GC-MS)



Tiksi measurement station is in Arctic Russia, on the coast of the Arctic Ocean in the delta of Lena river



Aerosol measurements started in July 2010

Aerosol Particle Sizer (APS)
- Size distribution 0.5 – 10 µm

Twin- Differential Mobility Analyser (DMPS)
- Size distribution 7 – 500 nm

Aethalometer (NOAA)
- Aerosol absorption (BC mass)

Research questions and subjects of studies

1) **Detailed air mass source analysis**
   → **separating the impacts of biogenic emissions, marine sea salt, and forest and agricultural fires (with BC data)**

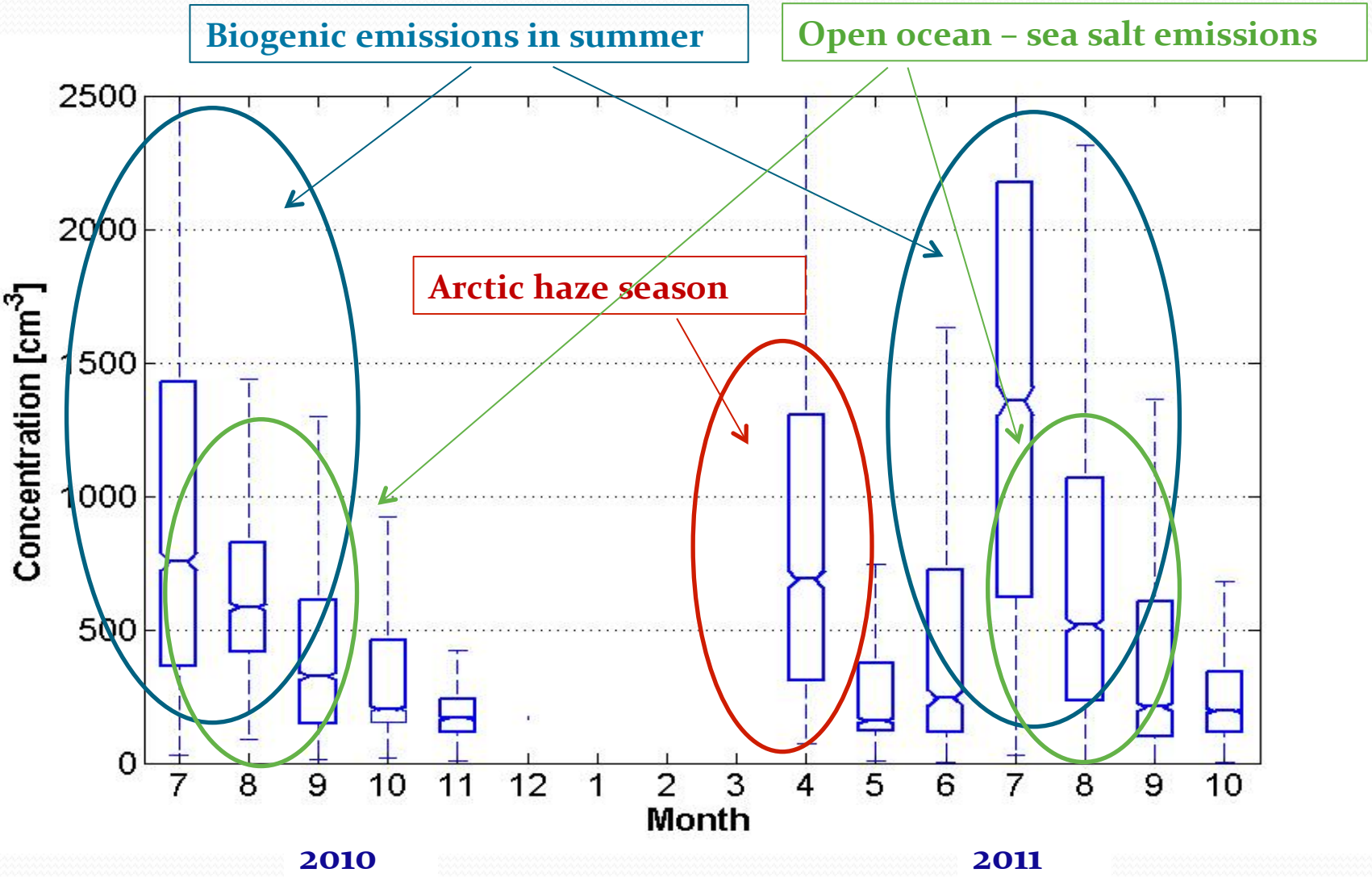
2) **Arctic Haze season – local meteorology vs aerosol sources**

3) **Secondary particle formation in the Arctic**

4) **Links to other Arctic measurements (e.g. Pallas, Värriö in Finnish Lapland)**

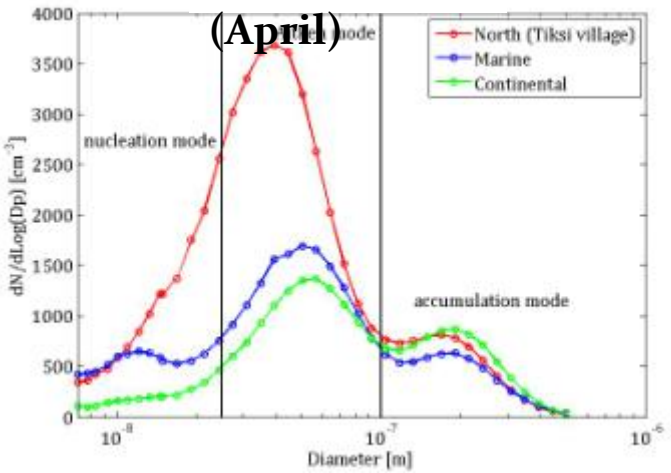
5) **Satellite and global model comparisons**

Decreasing tendency in number concentration towards winter, maxima in summer: possible sources

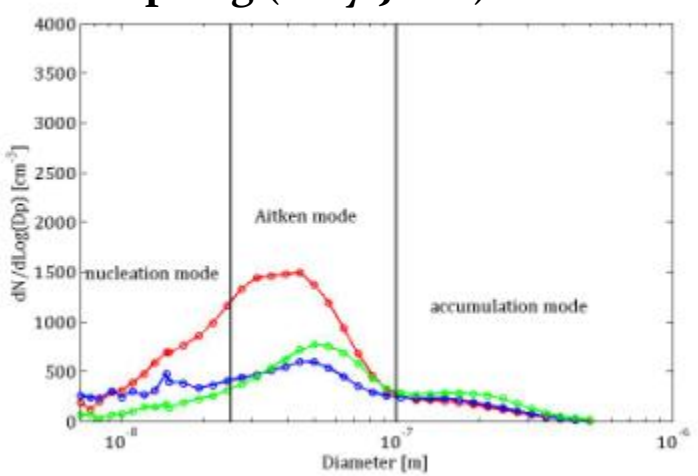


Average distributions vs wind direction: changes both by local meteorology (seasons) and sources

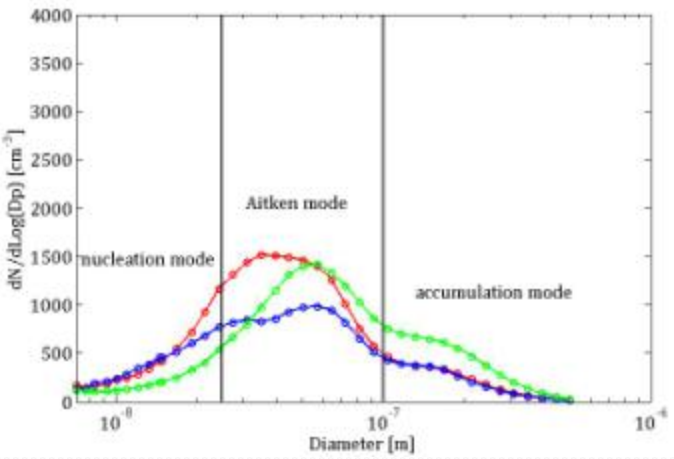
Winter (April)



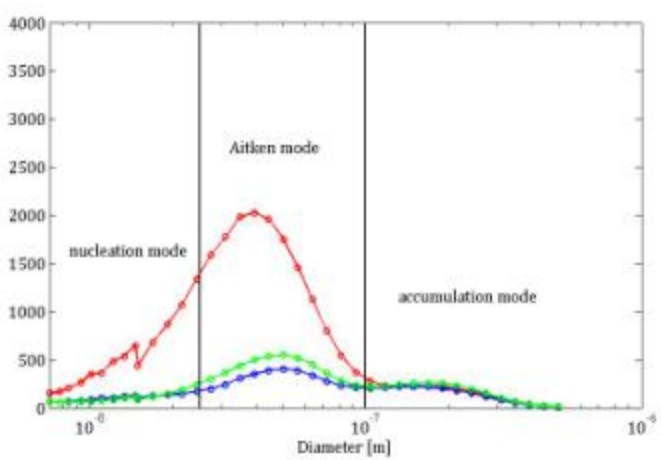
Spring (May-June)



Summer (July-August)

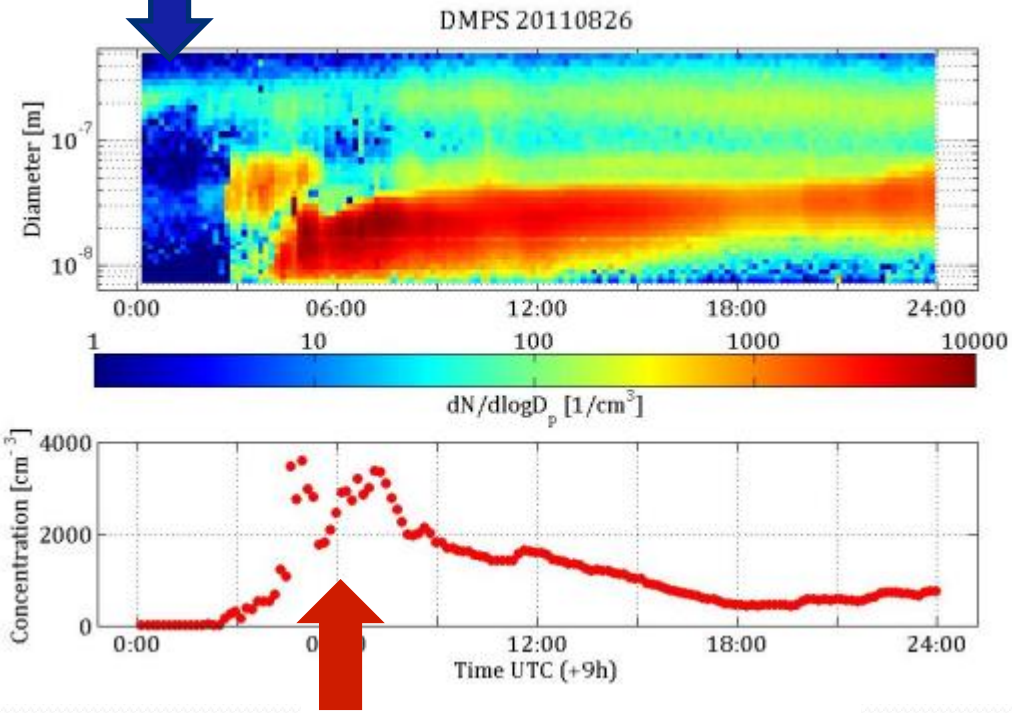


Autumn (September-November)



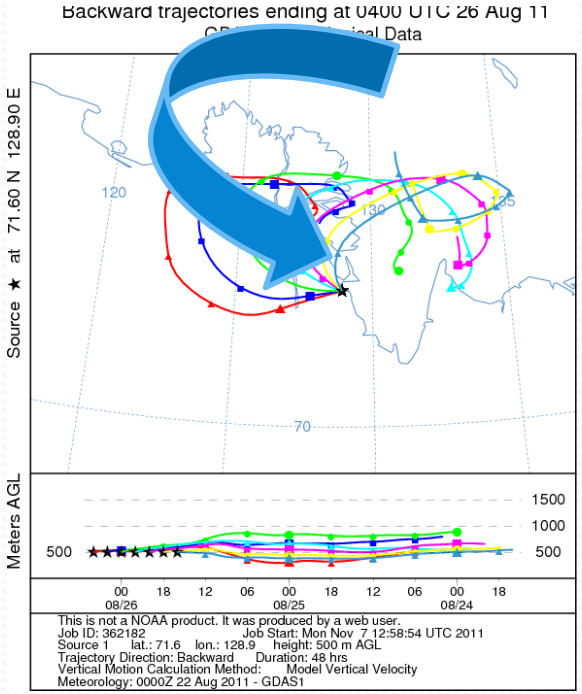
Secondary particle formation in Arctic air masses – example from autumn 2011

Very clean air mass



Dramatic increase in number concentration

Marine air mass circulating the coast



Pan-Eurasian Experiment

- Continuous, comprehensive long-term measurements

  Aerosol particles, green house gases, air quality, biosphere-atmosphere exchange

- Linking ground-based measurements with airborne and satellite observations

- Modeling from process level to continental scale integrating ground based and remote sensing data