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3.12.2019
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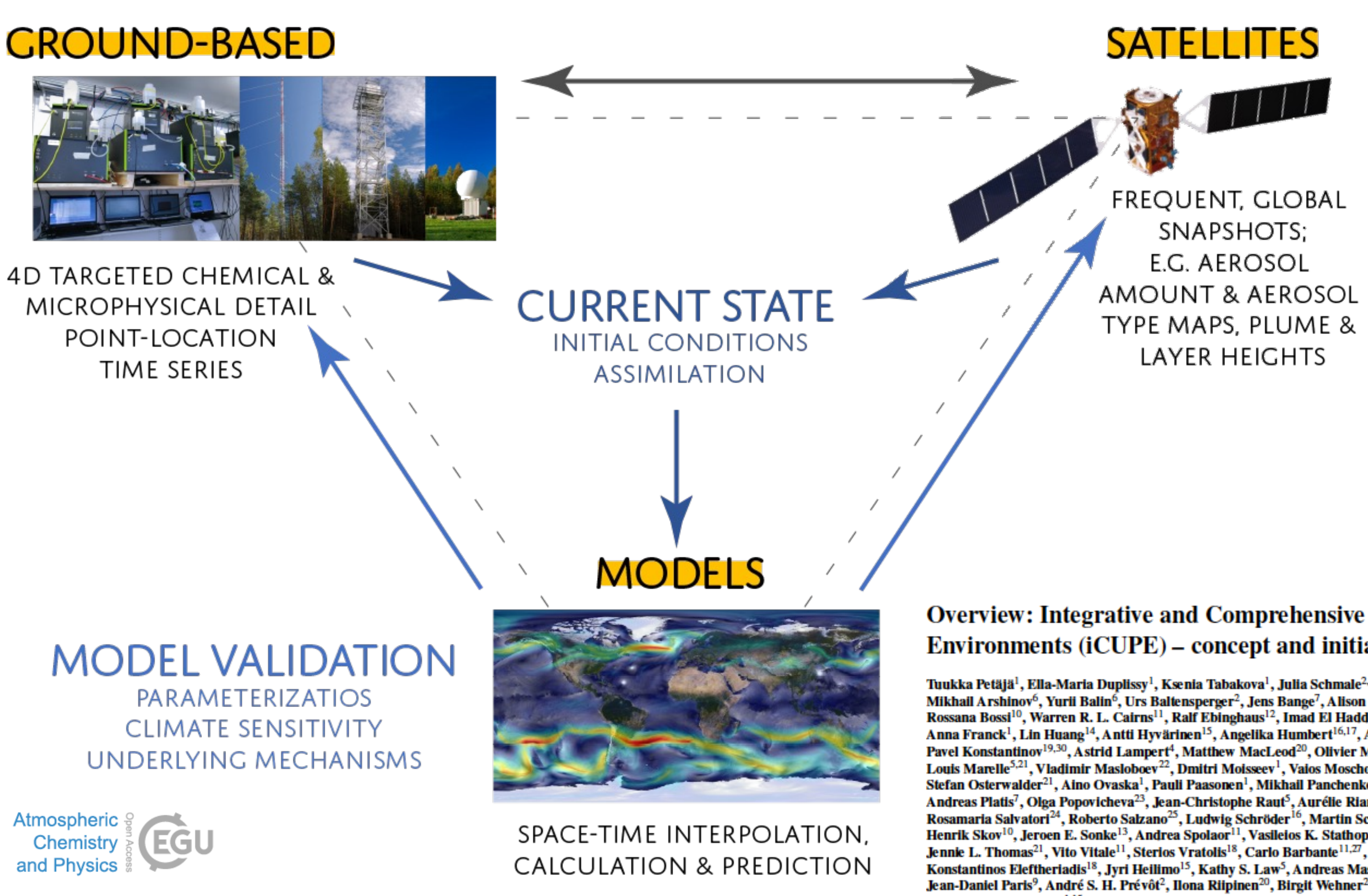
ClimEd

Pan-Eurasian Experiment
PEEX

Advanced techniques in atmospheric and Earth System Research

Tuukka Petäjä

1.10. 2024



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

Tuukka Petäjä[1], Ella-Maria Duplissy[1], Ksenia Tabakova[1], Julia Schmale[2,3], Barbara Altstädter[4], Gerard Ancellet[5], Mikhail Arshinov[6], Yurii Balin[6], Urs Baltensperger[2], Jens Bange[7], Alison Beamish[8], Boris Belan[6], Antoine Berchet[9], Rossana Bossi[10], Warren R. L. Cairns[11], Ralf Ebinghaus[12], Imad El Haddad[2], Beatriz Ferreira-Araujo[13], Anna Franck[1], Lin Huang[14], Antti Hyvärinen[15], Angelika Humbert[16,17], Athina-Cerise Kalogridis[18], Pavel Konstantinov[19,30], Astrid Lampert[4], Matthew MacLeod[20], Olivier Magand[21], Alexander Mahura[1], Louis Marelle[5,21], Vladimir Masloboev[22], Dmitri Moisseev[1], Vaios Moschos[2], Niklas Neckel[16], Tatsuo Onishi[5], Stefan Osterwalder[21], Aino Ovaska[1], Pauli Paasonen[1], Mikhail Panchenko[6], Fidel Pankratov[22], Jakob B. Pernov[10], Andreas Platis[7], Olga Popovicheva[23], Jean-Christophe Raut[5], Aurélie Riandet[9,a], Torsten Sachs[8], Rosamaria Salvatori[24], Roberto Salzano[25], Ludwig Schröder[16], Martin Schön[7], Vladimir Shevchenko[26], Henrik Skov[10], Jeroen E. Sonke[13], Andrea Spolaor[11], Vasileios K. Stathopoulos[18], Mikko Strahlendorff[15], Jennie L. Thomas[21], Vito Vitale[11], Sterios Vratolis[18], Carlo Barbante[11,27], Sabine Chabrillat[8], Aurélien Dommergue[21], Konstantinos Eleftheriadis[18], Jyri Heilimo[15], Kathy S. Law[5], Andreas Massling[10], Steffen M. Noe[28], Jean-Daniel Paris[9], André S. H. Prévôt[2], Ilona Riipinen[20], Birgit Wehner[29], Zhiyong Xie[12], and Hanna K. Lappalainen[1,15]

Comprehensive atmospheric and environmental observations with some examples

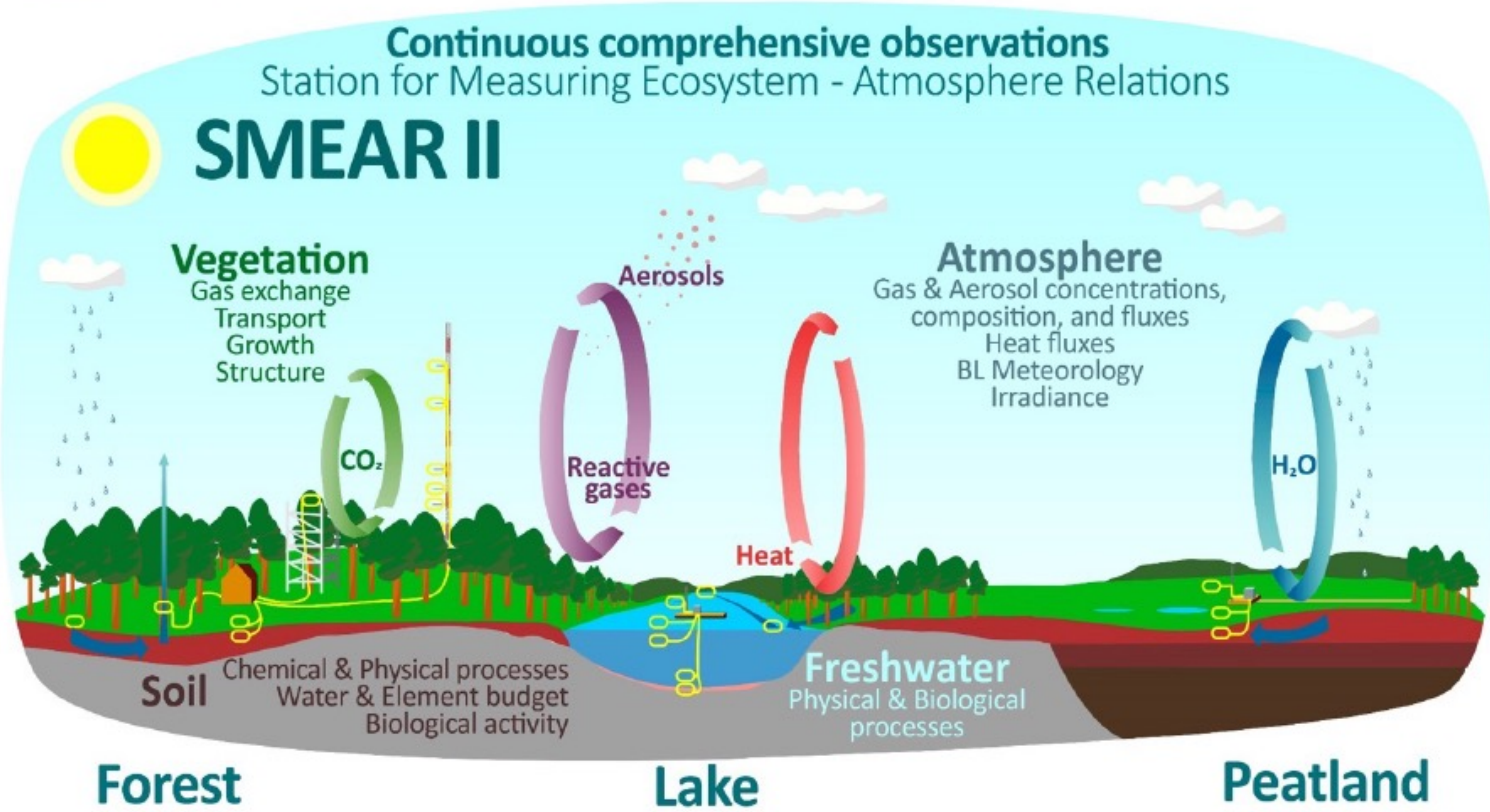
Stations for Measuring Ecosystem-Atmosphere Relation (SMEAR)

- Biosphere – aerosol – cloud – climate interactions
- Biogeochemical cycles of carbon, nitrogen, sulphur and water.
- Analysis of gaseous and particle pollutants and their role in cloud formation
- Analysis of water, carbon and nutrient budgets of soil.
- Analysis of environment and tree structure on gas exchange, water transport and growth of trees

- SMEAR I: Värriö, sub-Arctic boreal;
- SMEAR II: Hyytiälä, boreal
- SMEAR III: Kumpula, urban background
- SMEAR IV: Kuopio, Puijo, aerosol-cloud interactions
- SMEAR Estonia: Järvselja, hemiboreal

SMEAR

SMEAR II station in Hyytiälä, Finland



Over **1200** different variables

Flagship site for integration: combines all IPCC components.

Contributes to :

ACTRIS

ICOS Integrated Carbon Observation System

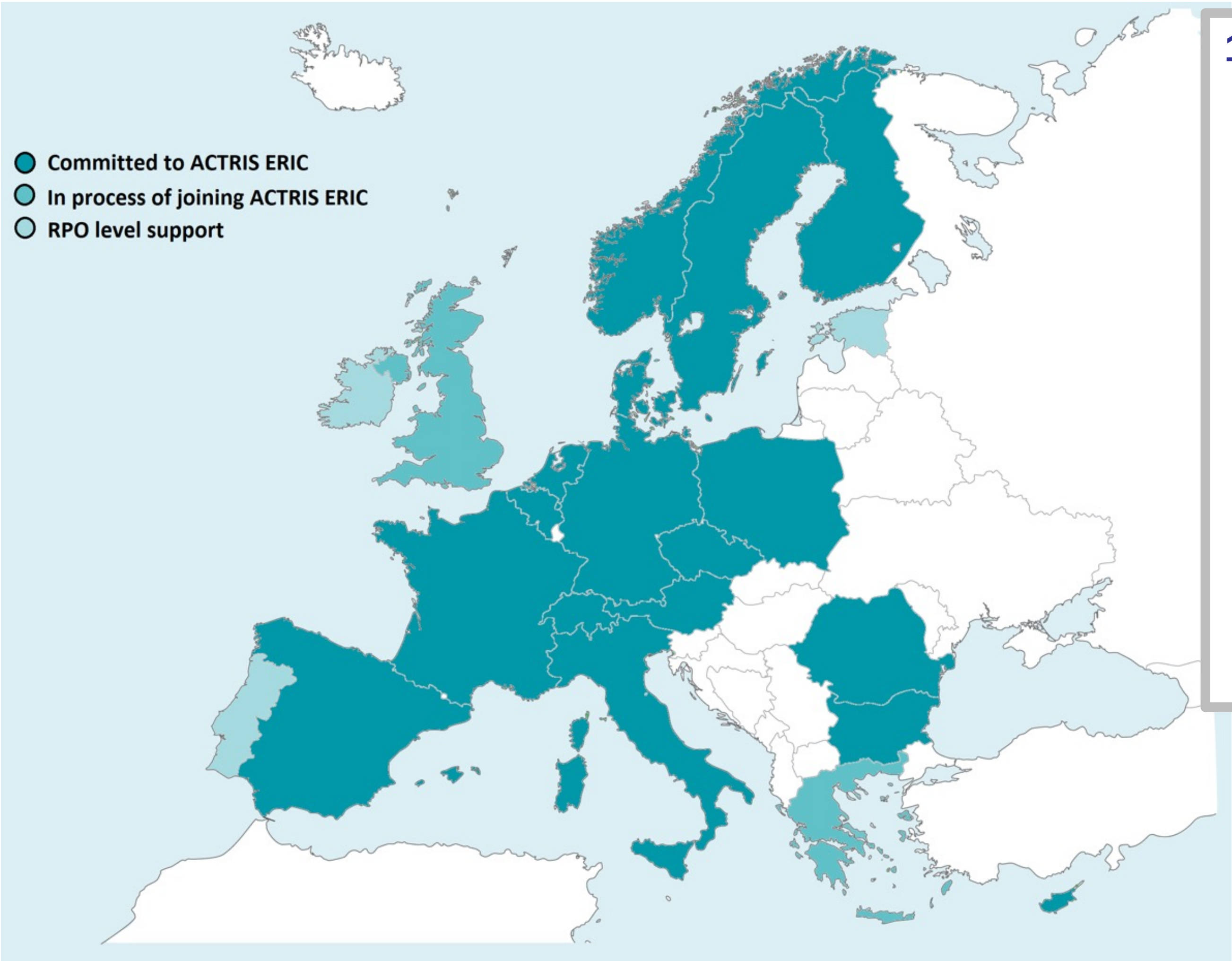
AnaEE Analysis and Experimentation on Ecosystems

LTER europe

Pan-Eurasian Experiment PEEX

World Meteorological Organisation

Aerosols, Clouds and TRace gases Research InfraStructure (ACTRIS)



17 countries in ACTRIS (with state level or RPO level support)
> 140 RPOs
> 120 National Facilites

Leading country: Finland

ACTRIS ERIC Statutory seat in Finland
(est. April 2023)
Currently 17 countries in ACTRIS ERIC

ACTRIS Financial volume

ACTRIS operations are funded by its member and observer countries. ACTRIS is a large research infrastructure with substantial financial volume.

<u>ACTRIS National Facilities</u>

- **Total investment** by the participating countries for **upgrading existing sites or building new ones: 600 M€**

<u>ACTRIS Central Facilities</u>

- **The total implementation costs of the eight Central Facilities** over 5 years (2021-2025): **100 M€**
- From 2026 onwards the estimated **annual operation costs of the Central Facilities: 16 M€.**

European level
Central Facilities

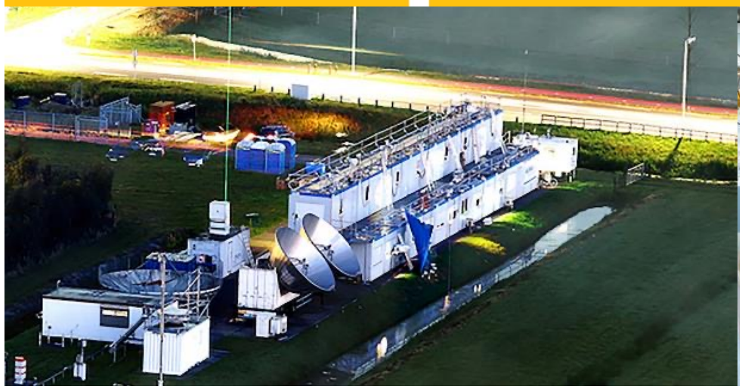
Head Office

Data Centre

Centre for Aerosol In Situ Measurements
Centre for Aerosol Remote Sensing
Centre for Cloud In Situ Measurements
Centre for Cloud Remote Sensing
Centre for Reactive Trace Gases In Situ Measurements
Centre for Reactive Trace Gases Remote Sensing

National
Facilities

Observational Platforms
Exploratory Platforms



European level:
~ **150** scientists & technicians
working in ACTRIS

National level:
~ **800** scientists and technicians

ACTRIS-Finland (ACTRIS-FI)

- ACTRIS-FI is a consortium of four organizations
  - University of Helsinki (UH)
  - Finnish Meteorological Institute (FMI)
  - University of Eastern Finland (UEF)
  - Tampere University (TAU)

- Director:
  - Tuukka Petäjä (UH)
- Coordinator and Head of UHEL Topical Centre Units:
  - Silja Häme (UH)
- ACTRIS related professorship:
  - Katrianne Lehtipalo (UH/FMI)

- ACTRIS-FI is funded by Ministry of Transport and Communications, Ministry of Education and Culture (via Academy of Finland) and the research performing organizations involved

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UNIVERSITY OF EASTERN FINLAND

FINNISH METEOROLOGICAL INSTITUTE

Tampere University

Ministry of Education and Culture, Finland

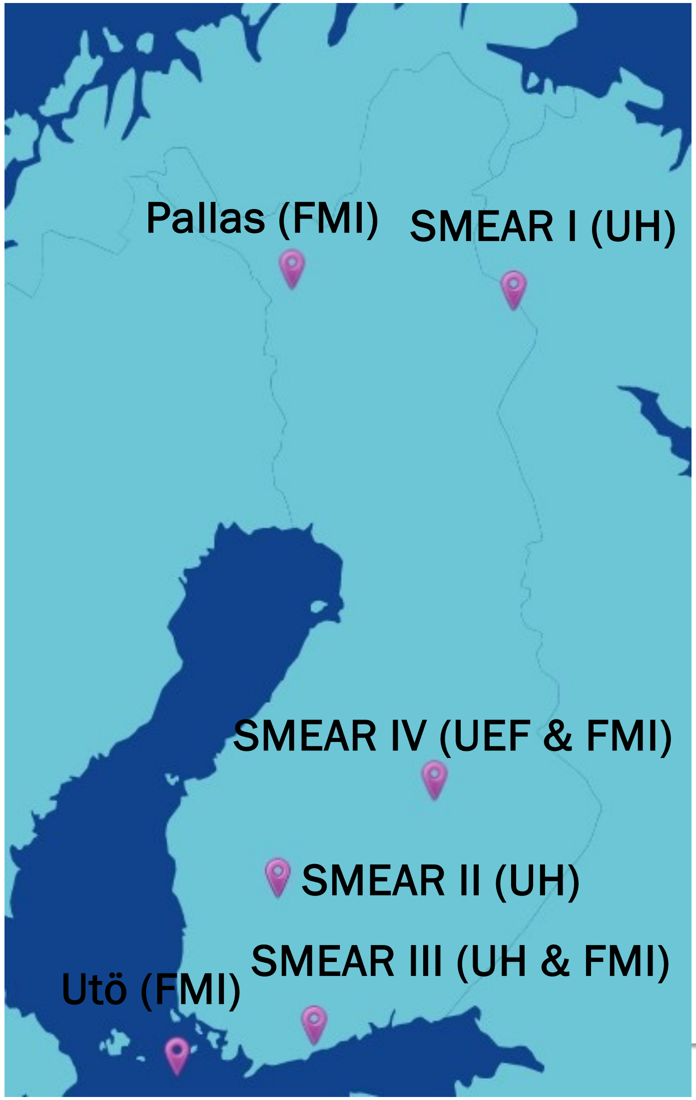
ACADEMY OF FINLAND

LVM MINISTRY OF TRANSPORT AND COMMUNICATIONS

ACTRIS

Website: https://www2.helsinki.fi/en/infrastructures/actris-finland

ACTRIS-Finland



ACTRIS-FI National Facilities (14)

- **7 Observational platforms** (6 in Finland and 1 in Antarctic Peninsula)
- **7 Exploratory platforms** (5 Mobile platforms, 1 Simulation Chamber, 1 Laboratory)

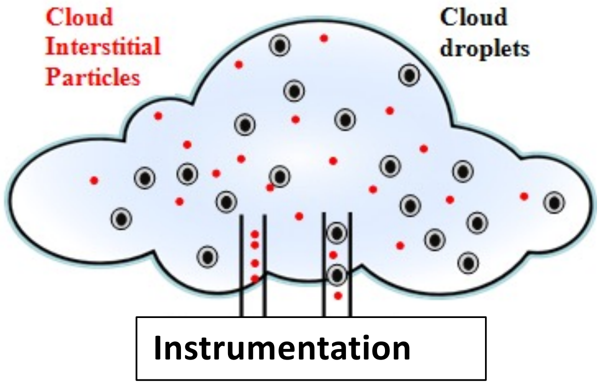
Finnish contribution to ACTRIS Central Facilities (5)

Finland contributes to 5 ACTRIS Central Facilities:

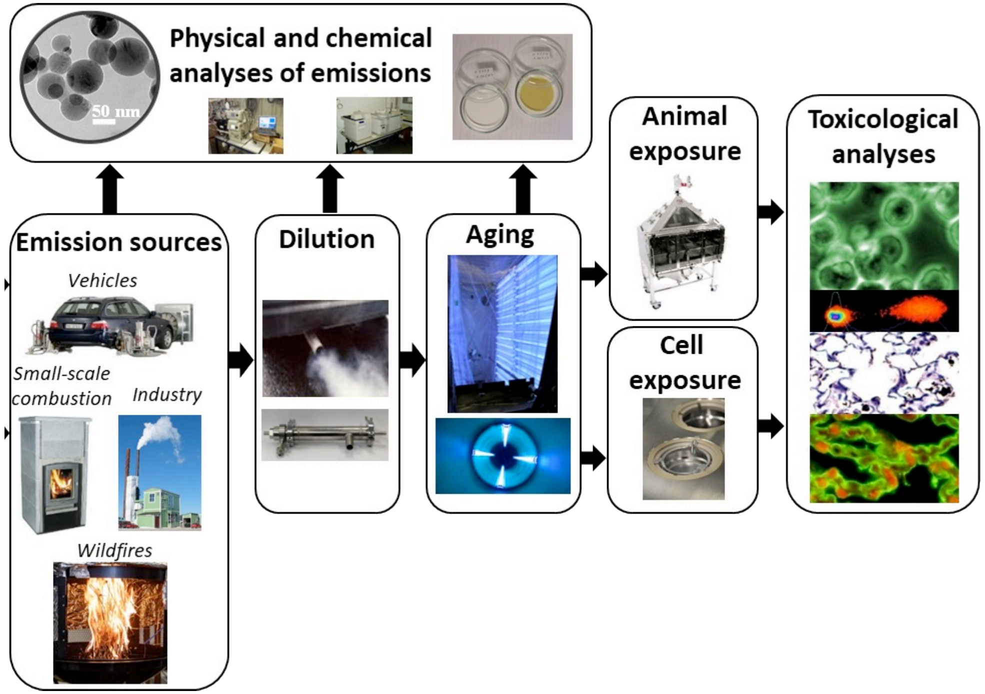
- **Head Office of ACTRIS ERIC (est. 2023)**
- **Data Centre (FMI Unit):** Unit for cloud remote sensing data.
- **Centre for Cloud Remote Sensing (FMI Unit):** Unit providing NF operation support and services for Doppler Wind Lidars.
- **Centre for Aerosol In Situ Mesurements (UH Unit):** operation support and services related to sub-10nm aerosol particle measurements.
- **Centre for Reactive Trace Gases In Situ Mesurements (UH Unit):** operation support and services related to chemical ionisation mass spectrometry of condensable vapours & aerosol precursors

SMEAR IV contributing to ACTRIS

- Puijo SMEAR IV: Aerosol & Cloud in-situ: Aerosol in-situ entered to labelling phase



- Atmospheric simulation chambers KASC EUROCHAMP & ATMO-ACCESS
- 2 simulation chambers, ILMARI for comprehensive emission studies



UNIVERSITY OF EASTERN FINLAND

Back trajectories – wildfire episode

- Fires at South-Eastern Europe (mainly grass land fires)

SMEAR IV, Finland: plume age 2-3 days (5-day back trajectories)

Zeppelin Observatory, Svalbard, Arctic: plume age 3-5 days (10-day back trajectories)

- Figures from an unpublished paper removed

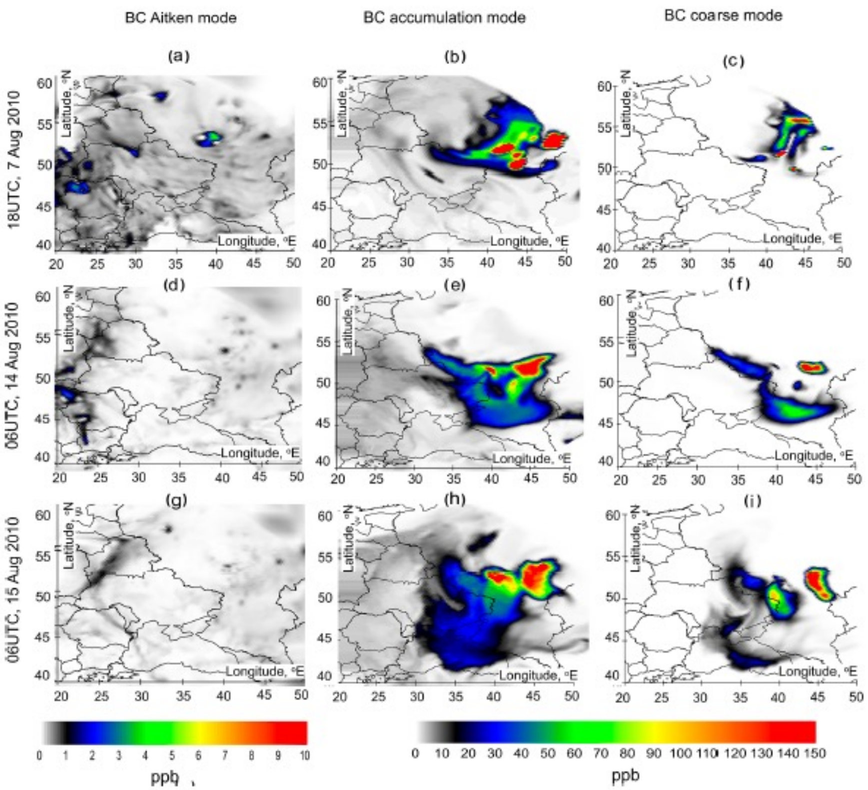
23-09-2020 to 10-10-2020

04-10-2020 to 09-10-2020

Komppula et al., GRL, in review

Enviro-HIRLAM model estimates of elevated black carbon pollution over Ukraine resulted from forest fires

Mykhailo Savenets[1], Larysa Pysarenko[1], Svitlana Krakovska[1], Alexander Mahura[2], and Tuukka Petäjä[2]



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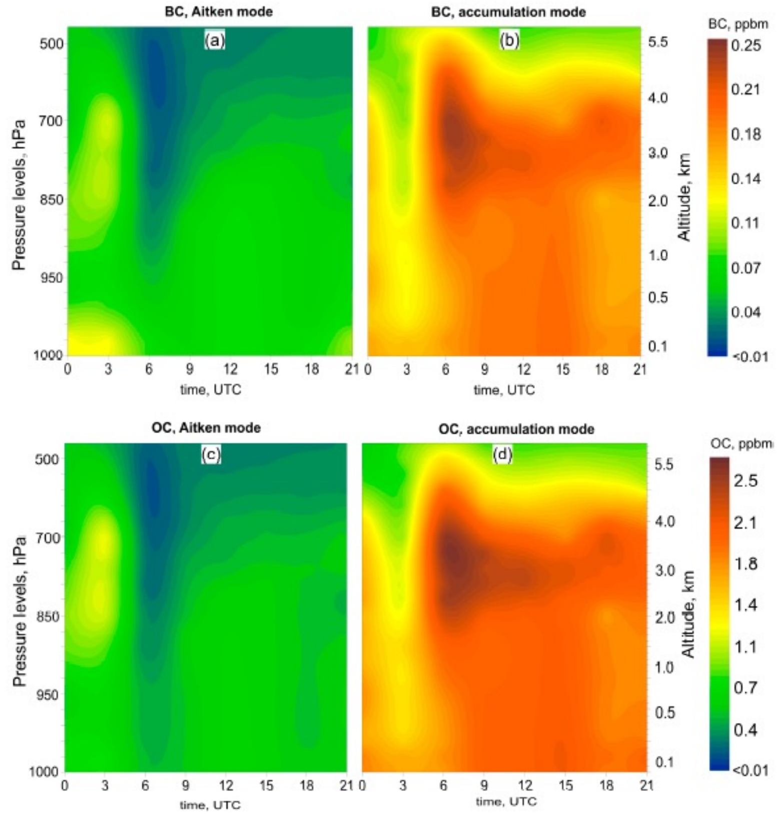
Article

Seamless Modeling of Direct and Indirect Aerosol Effects during April 2020 Wildfire Episode in Ukraine

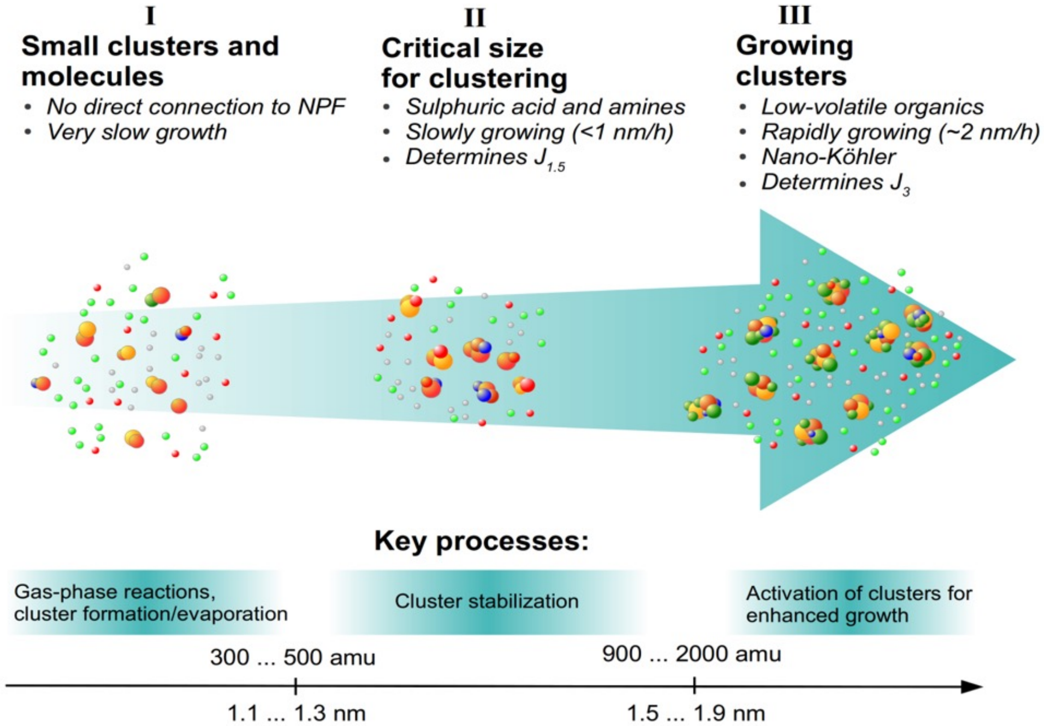
Mykhailo Savenets [1,*], Valeriia Rybchynska [1,2], Alexander Mahura [3], Roman Nuterman [4], Alexander Baklanov [4,5], Markku Kulmala [3] and Tuukka Petäjä [3,*]

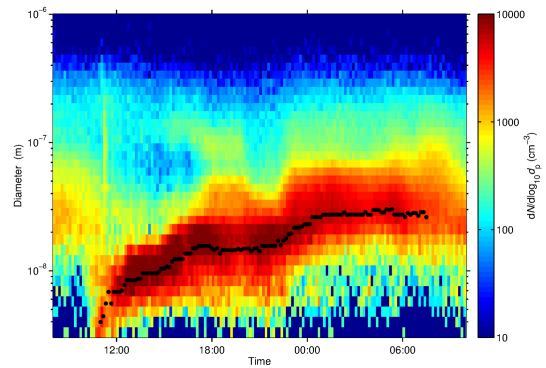


atmosphere
MDPI

Scientific insights into aerosol formation and related technology development

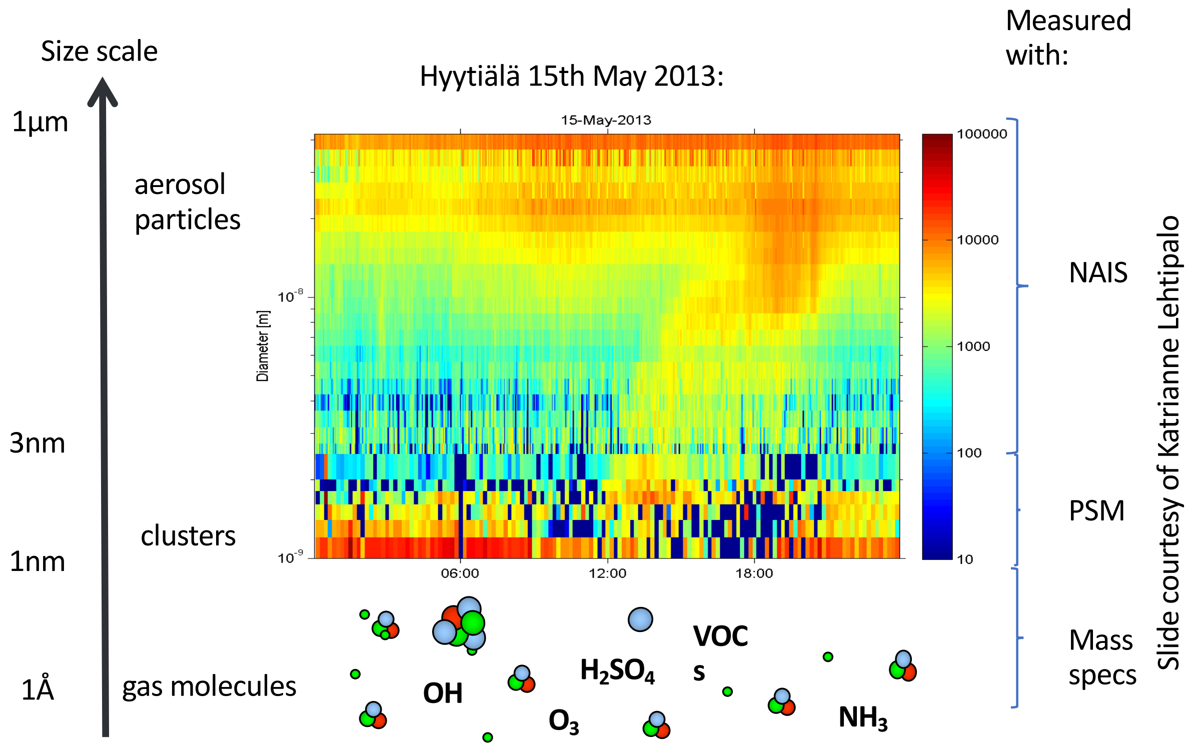
Atmospheric nucleation / clustering processes



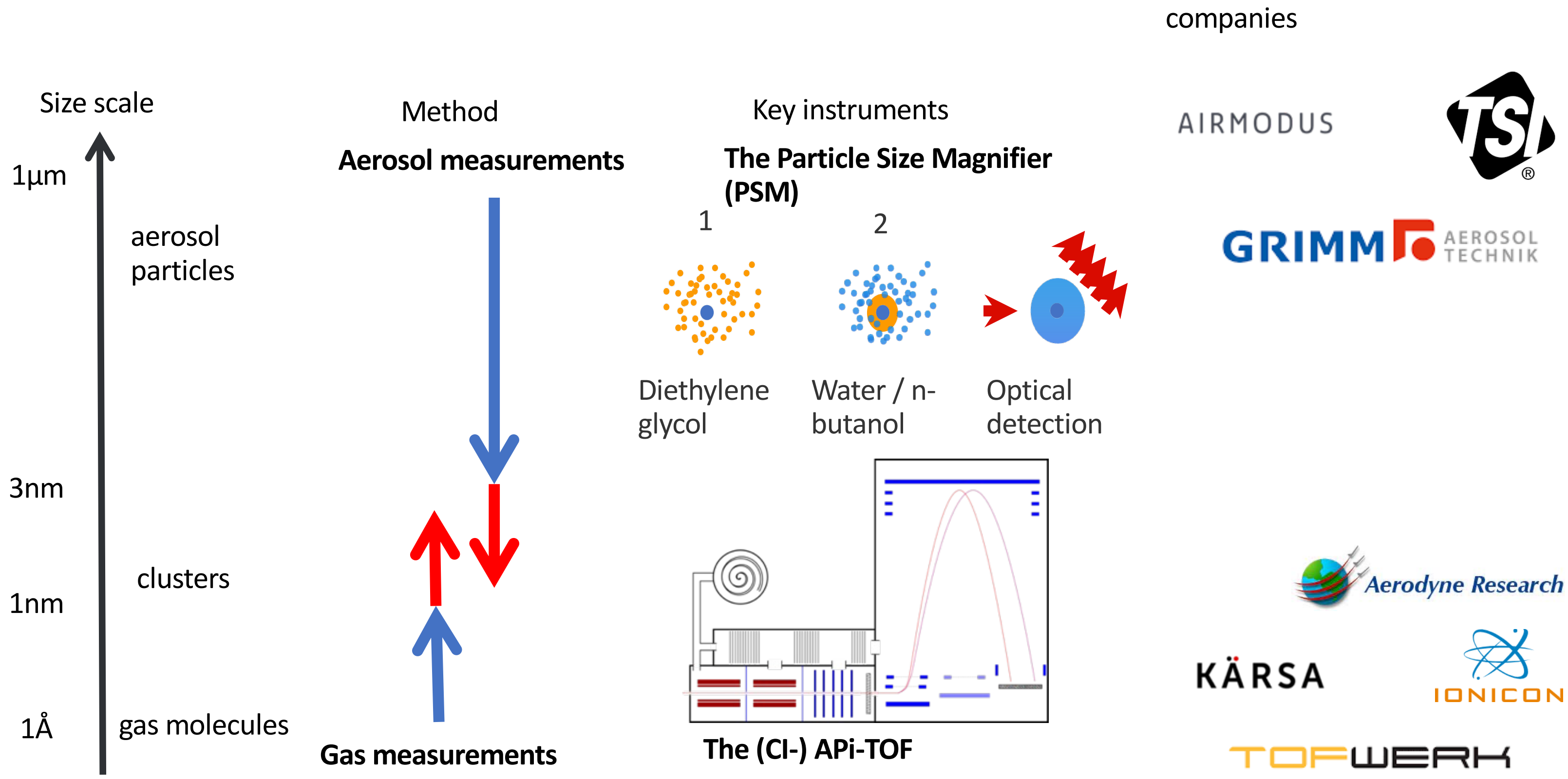


Kulmala et al., Science, 2013

In order to distinguish different processes contributing to the number concentration below 10 nm, we need complementary instrumentation



New technologies for reaching the sizes of nucleating clusters



First ACTRIS CiGas CI-APi-ToFMS intercomparison at TROPOS ACD-C 27.02.2023 – 10.03.2023

Nina Sarnela,
Roseline Thakur, Dina Alfaouri
Silja Häme, Tuukka Petäjä
CiGas-UHEL, University of Helsinki

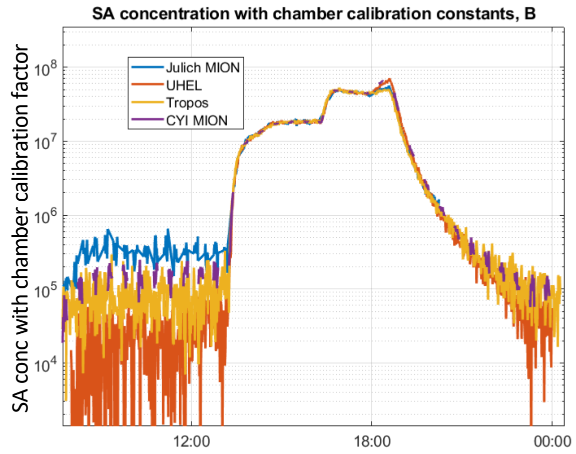
Peter Mettke, Falk Mothes, Ricarda Gräfe, Tobias Hübner, Hartmut Herrmann
Leibniz Institute for Tropospheric Research (TROPOS)
Atmospheric Chemistry Department (ACD)

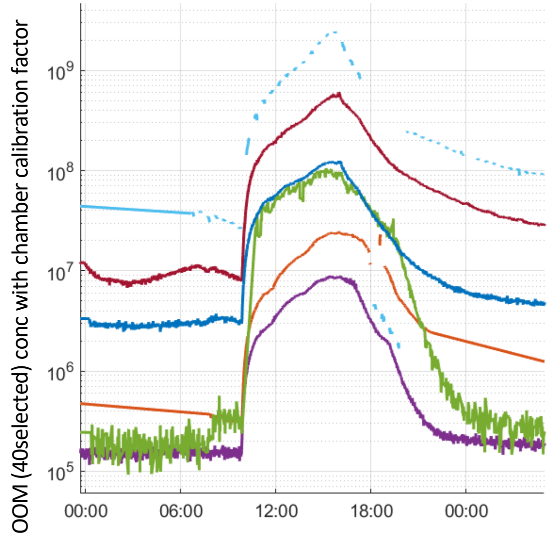
You can contact us: actris-api@helsinki.fi / nina.sarnela@helsinki.fi / silja.hame@helsinki.fi

First ACTRIS CiGas CI-APi-ToFMS intercomparison at TROPOS ACD-C 2023

- The first intercomparison workshop gathered **10 Chemical Ionization Mass Spectrometers** and **27 researchers** together for two weeks of chamber studies of **condensable vapours in March 2023**
- Focused on the detection of **sulfuric acid** and different **oxidized organic compounds** (target reactive trace gases of CiGas-UHEL)
- Workshop included also data analysis intercomparison exercise

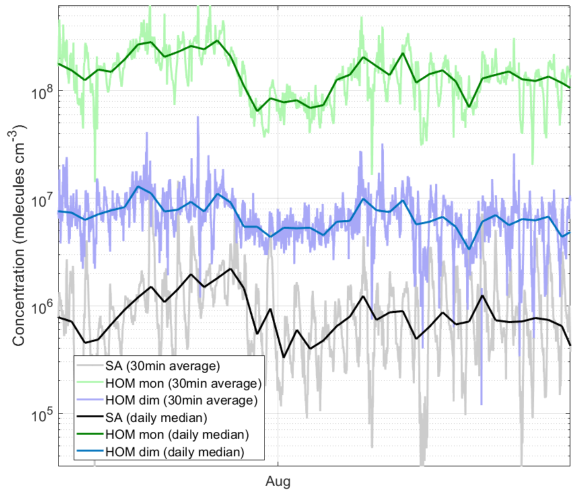
chamber	inlet	reagent ions	ionization	mass spectrometer
A	EISELE	NO_3^-	corona	L-TOF
A	aircraft CI	NO_3^-	corona	H-TOF
A	AIM	NO_3^-	VUV	L-TOF
A	EISELE	NO_3^-	X-ray	H-TOF
A	EISELE	NO_3^-	X-ray	H-TOF
B	MION	NO_3^-/Br^-	X-ray	L-TOF
B	MION	NO_3^-/Br^-	X-ray	L-TOF
B	EISELE	NO_3^-	X-ray	L-TOF
B	EISELE	NO_3^-	Am241	C-TOF
B	FIGAERO	I^-	Po210	H-TOF





Field intercomparison 2024

- We'll offer a possibility to bring your CIMS-instrument to SMEAR II station (Hyytiälä, Finland) to measure side-by-side NF's own instruments and other participant's instruments 29.7-11.8.2024
- SMEAR II NF has "Eisele-type"-NO_3-CIMS and MION-(Br/NO_3/ambient ion)-CIMS instruments
- Summertime measurements will provide possibility to compare the sensitivities towards oxygenated organic compounds + inorganic acids
- More details can be decided with
- the participants



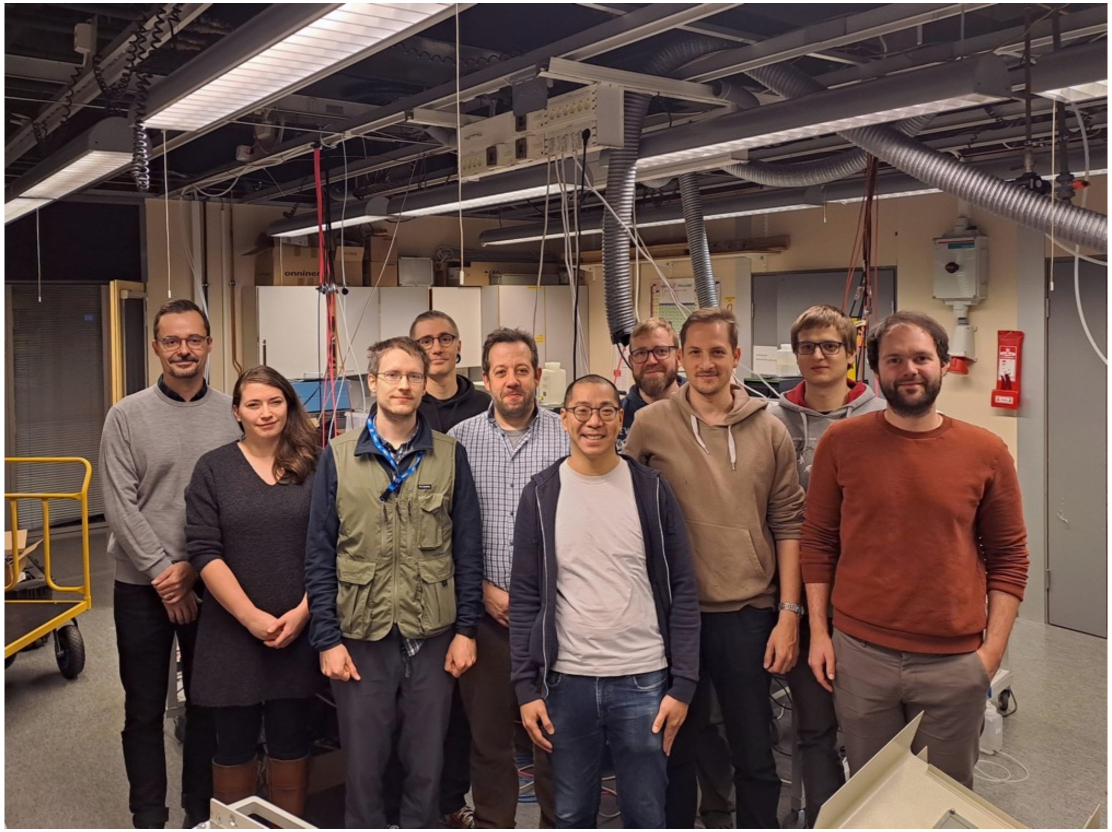
You can contact us: actris-api@helsinki.fi / nina.sarnela@helsinki.fi / silja.hame@helsinki.fi

First ACTRIS nanoparticle workshop in Helsinki 6.11.2023 – 17.11.2023

- Participants from Airmodus, TSI and Grimm

- University of Helsinki, Cyprus Institute, Czech Academy of Sciences, University of Frankfurt

- Main organizer: Janne Lampilahti, UHEL



Results from SMEAR II in Hyytiälä, Finland

Environmental Research Letters

Environ. Res. Lett. 13 (2018) 103003

TOPICAL REVIEW

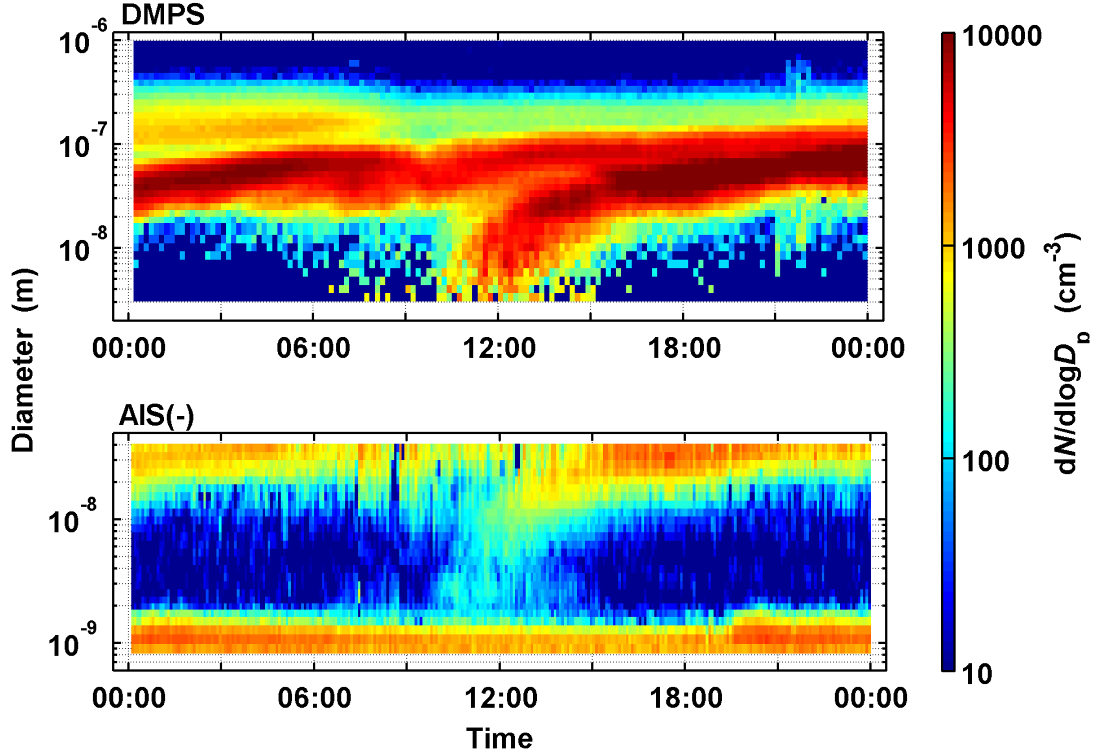
Atmospheric new particle formation and growth: review of field observations

Veli-Matti Kerminen[1], Xuemeng Chen[1], Ville Vakkari[2], Tuukka Petäjä[1], Markku Kulmala[1,3,4] and Federico Bianchi[1,3]

Atmospheric new particle formation in China

Biwu Chu[1], Veli-Matti Kerminen[1], Federico Bianchi[1,2], Chao Yan[1], Tuukka Petäjä[1,3], and Markku Kulmala[1,2]

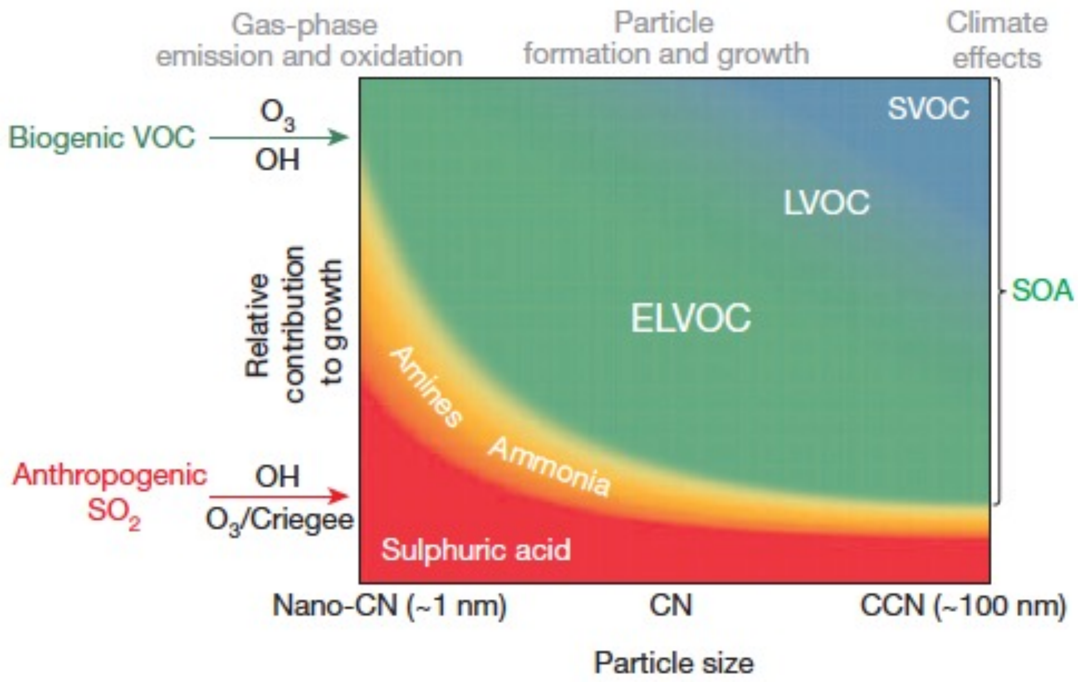
Atmos. Chem. Phys., 19, 115–138, 2019

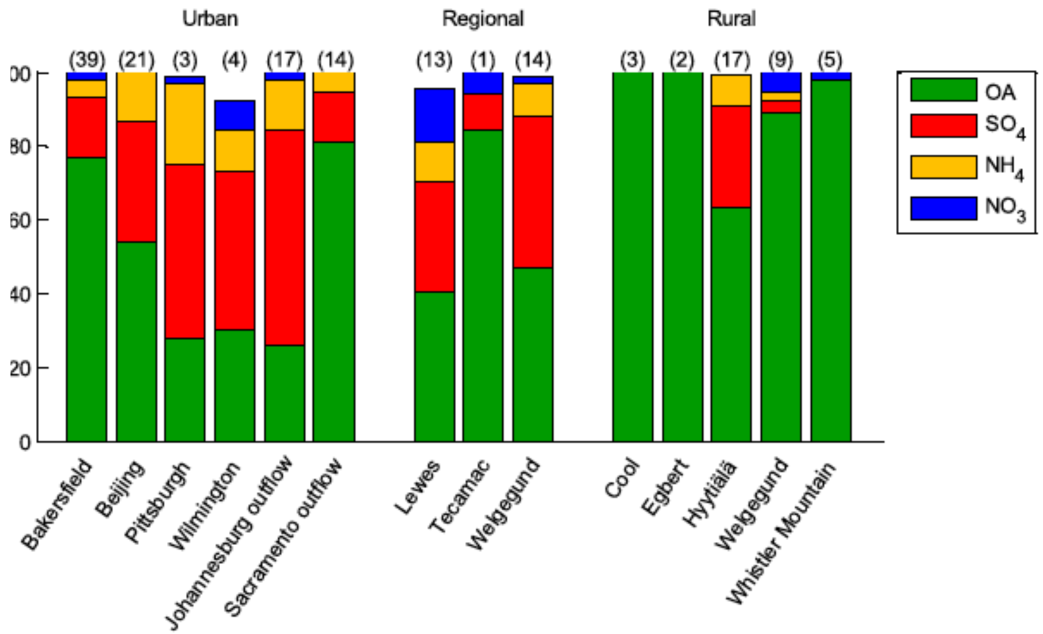


Key compounds for initial clustering

Sulfuric acid
Ammonia
Amines
Oxidized organics
Iodic acid (marine, Arctic)

Key compounds for the growth
Oxidized organics
MSA (marine)
+ other vapors above
Considerable variability from one location to another





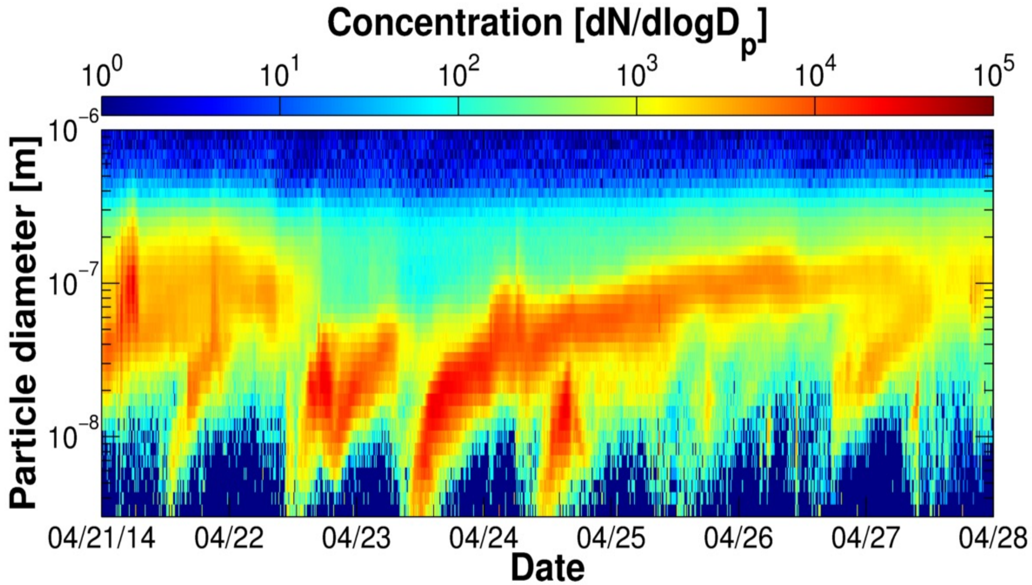
Different vapors responsible for growth as a function of size.

Different vapors responsible for the growth in different environments.

Ehn et al. (2014) Nature

Kerminen et al. (2018) Environ. Res. Lett.

Science Plan - Biogenic Aerosols- Effects on Clouds and Climate (BAECC)



1. From Emissions to Aerosols
2. From Aerosols to Clouds
3. From Clouds to Precipitation
4. Feedbacks and Interactions

- What is the role of newly formed particles in the cloud activation *in-situ*?
- Do they alter the cloud properties / precipitation?

Petäjä, T. (2013) Science Plan Biogenic Aerosols – Effects on Clouds and Climate (BAECC), US Department of Energy, Office of Science, DOE/SC-ARM-13-024.

ARM CLIMATE RESEARCH FACILITY

The **Atmospheric Radiation Measurement (ARM) Climate Research Facility** is a U.S. Department of Energy scientific user facility, providing data from strategically located in situ and remote sensing observatories around the world.

ARM Mobile Facility 2 in Hyytiälä, Finland, February 2014 – September 2014

Goal: To understand the impact of biogenic aerosol formation on cloud properties and climate

Tools: Aerosol Observing system (AOS), Balloon-borne sounding system, laser distrometer, micropulse lidar, microwave radiometer, high spectral resolution lidar, Scanning W-band and Ka-band cloud radars (SWACR, M-WACKR, Ka-band zenith radar (KAZR)

Principal investigator: Tuukka Petäjä, UHEL

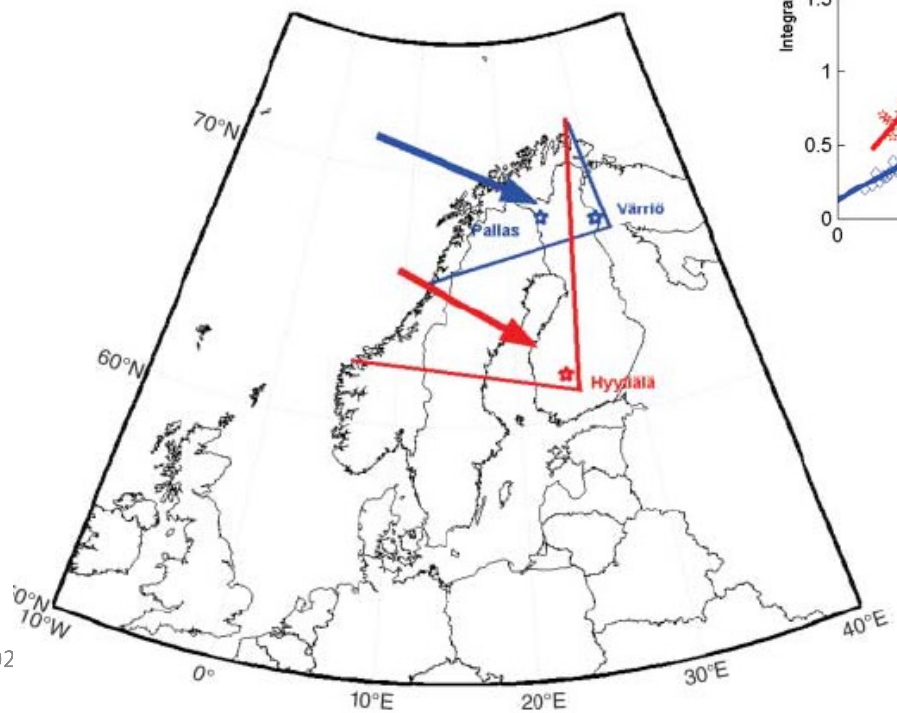
BAECC

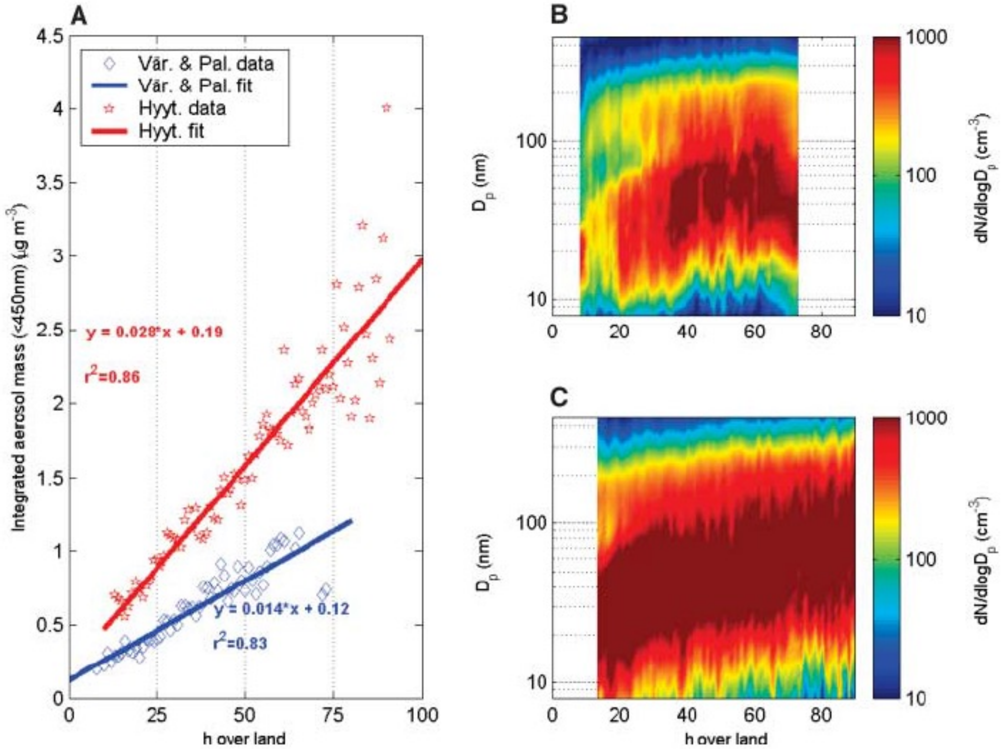
A FIELD CAMPAIGN TO ELUCIDATE THE IMPACT OF BIOGENIC AEROSOLS ON CLOUDS AND CLIMATE

Petäjä et al. (2016) Bull. Am. Met. Soc. 97, 1909-1928, https://doi.org/10.1175/BAMS-D-14-00199.1

High Natural Aerosol Loading over Boreal Forests

P. Tunved,[1*] H.-C. Hansson,[1] V.-M. Kerminen,[2] J. Ström,[1] M. Dal Maso,[3] H. Lihavainen,[2] Y. Viisanen,[2] P. P. Aalto,[3] M. Komppula,[2] M. Kulmala[3]





Tunved et al. (2006) Science

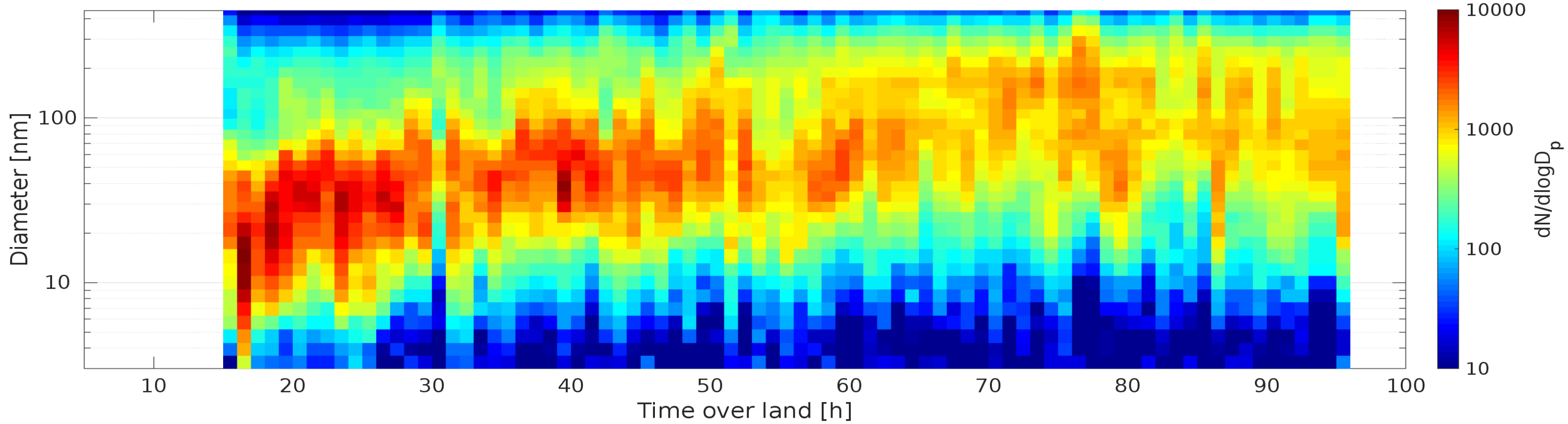
ARTICLES
https://doi.org/10.1038/s41561-021-00876-0

nature geoscience

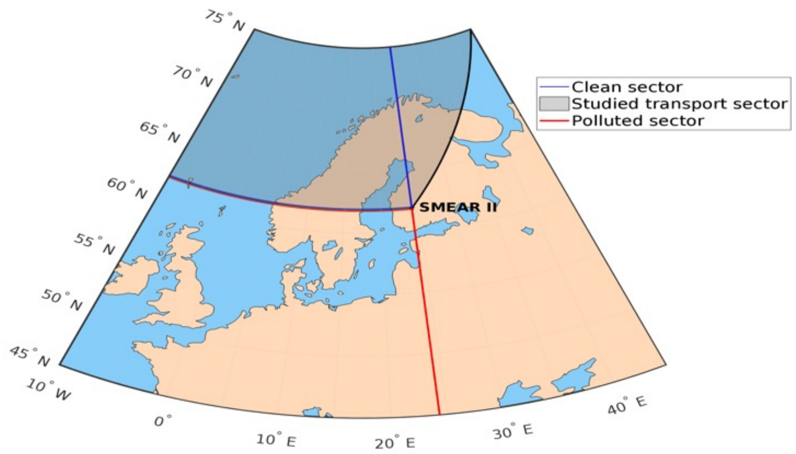
Check for updates

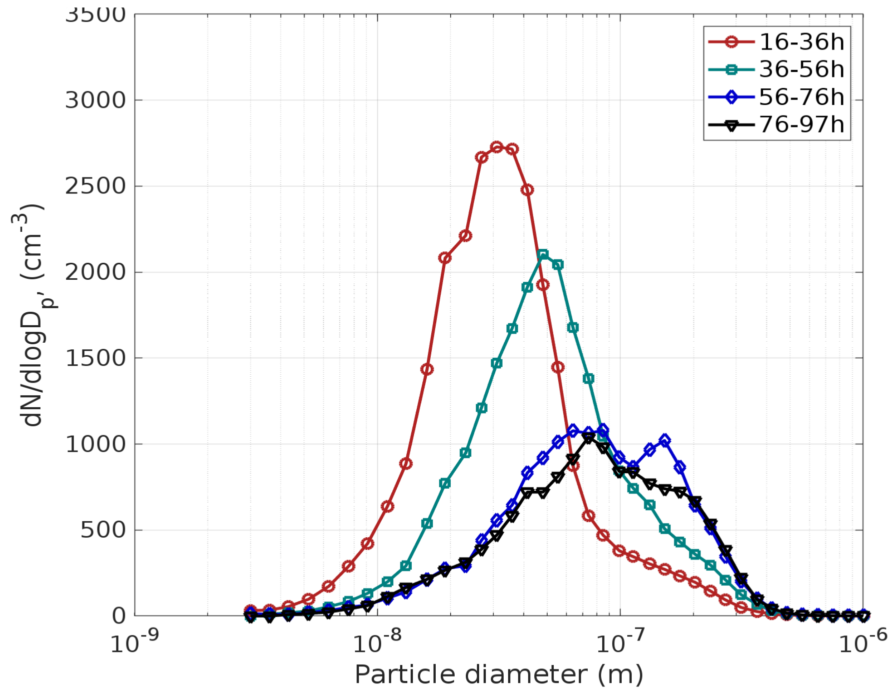
Influence of biogenic emissions from boreal forests on aerosol–cloud interactions

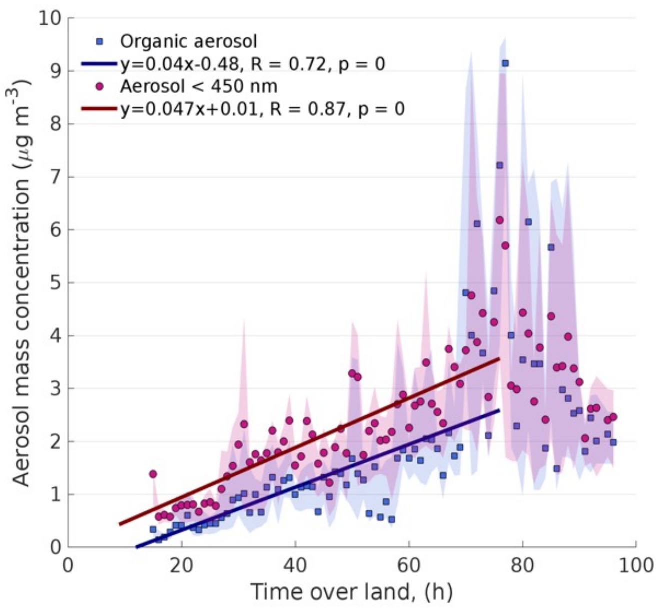
T. Petäjä[1,2], K. Tabakova[1], A. Manninen[1,3], E. Ezhova[1], E. O'Connor[3,4], D. Moisseev[1,3], V. A. Sinclair[1], J. Backman[1,3], J. Levula[1], K. Luoma[1], A. Virkkula[1,2,3], M. Paramonov[1,3], M. Räty[1], M. Äijälä[1], L. Heikkinen[1], M. Ehn[1], M. Sipilä[1], T. Yli-Juuti[5], A. Virtanen[5], M. Ritsche[6], N. Hickmon[6], G. Pulik[7], D. Rosenfeld[7], D. R. Worsnop[1,8], J. Bäck[9], M. Kulmala[1,2,10,11] and V.-M. Kerminen[1]

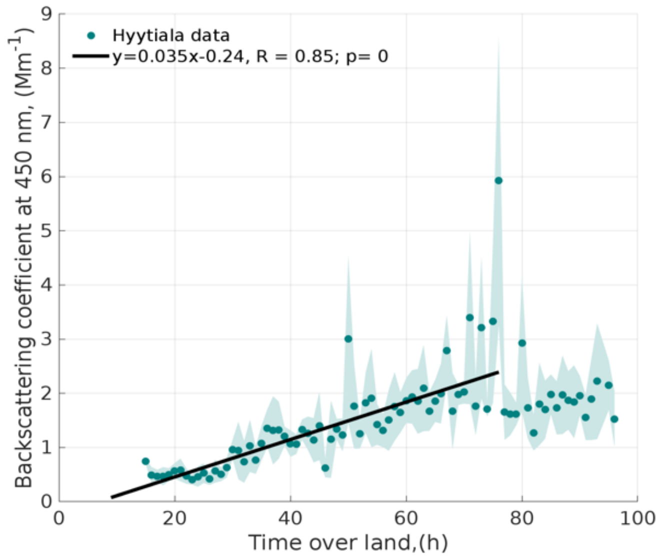


Aerosol size distribution as a function of time over land in the clean sector







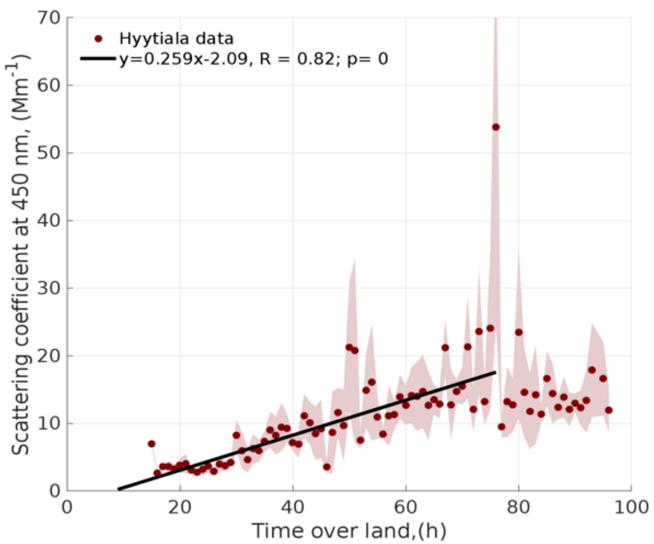


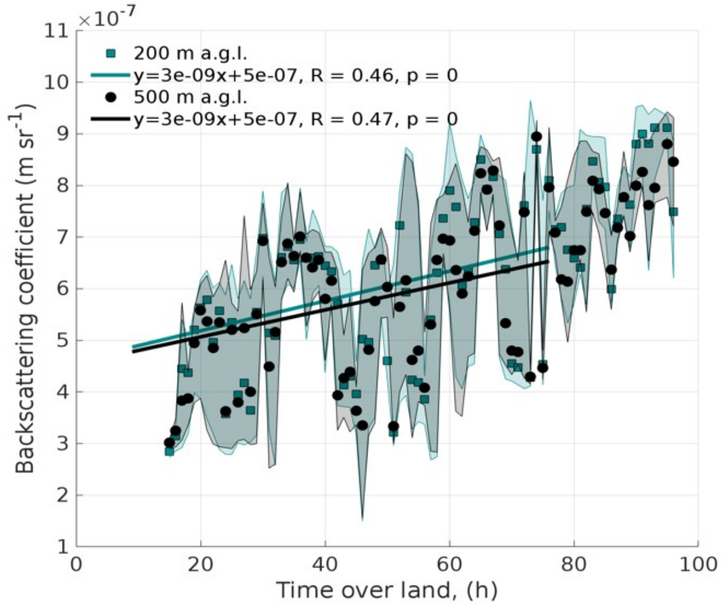
Aerosol mass is dominated by organics.

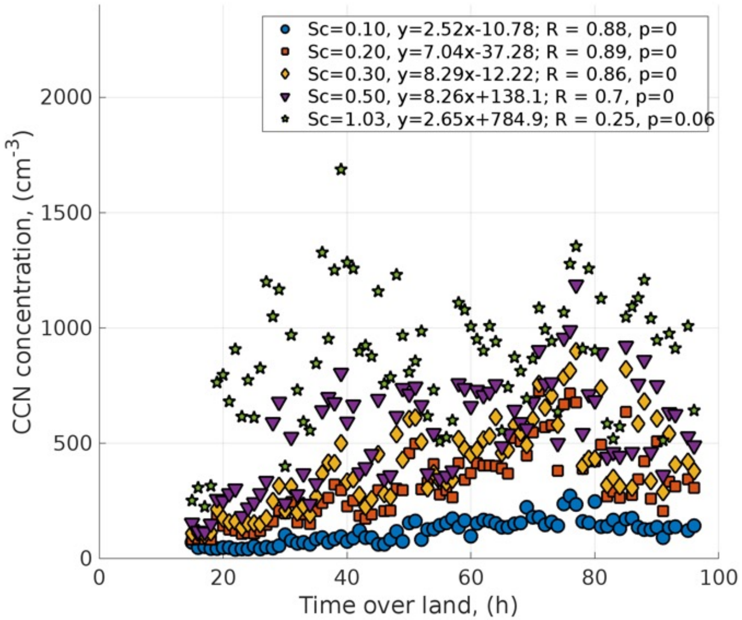
Mass accumulating as a function of time over land.

Scattering is enhanced (larger aerosol).

Both in-situ and in the boundarly layer as a whole.

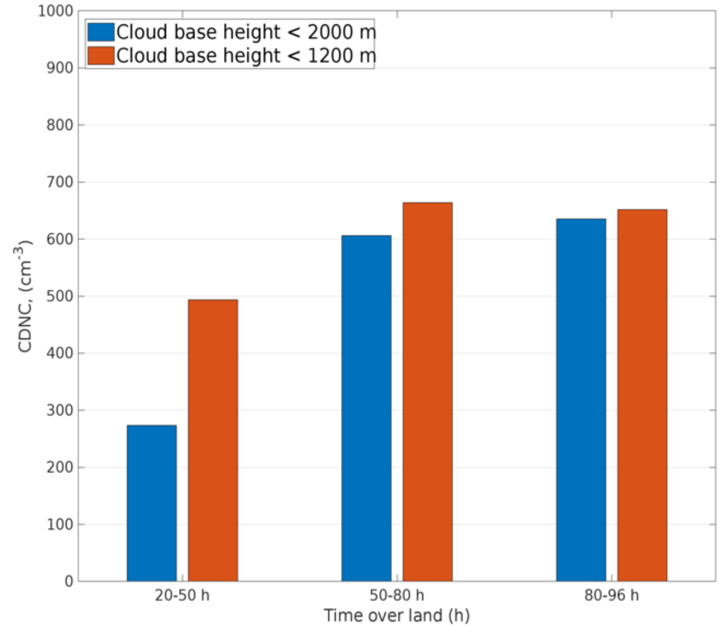


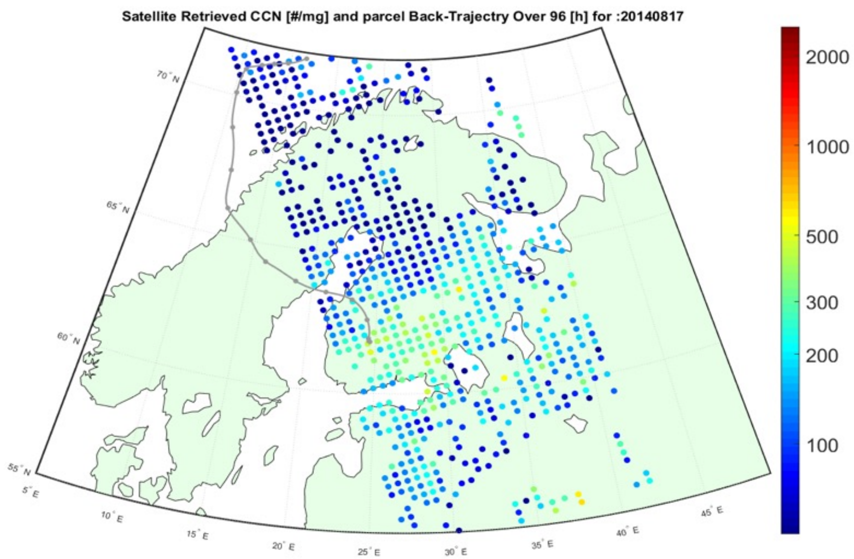




More CCN active aerosol particles as a function of time over land.

Higher Cloud Droplet Number concentration in non-precipitating clouds





Higher CCN concentration from the satellite along the trajectory.

ARTICLES
https://doi.org/10.1038/s41561-021-00876-0
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Influence of biogenic emissions from boreal forests on aerosol–cloud interactions

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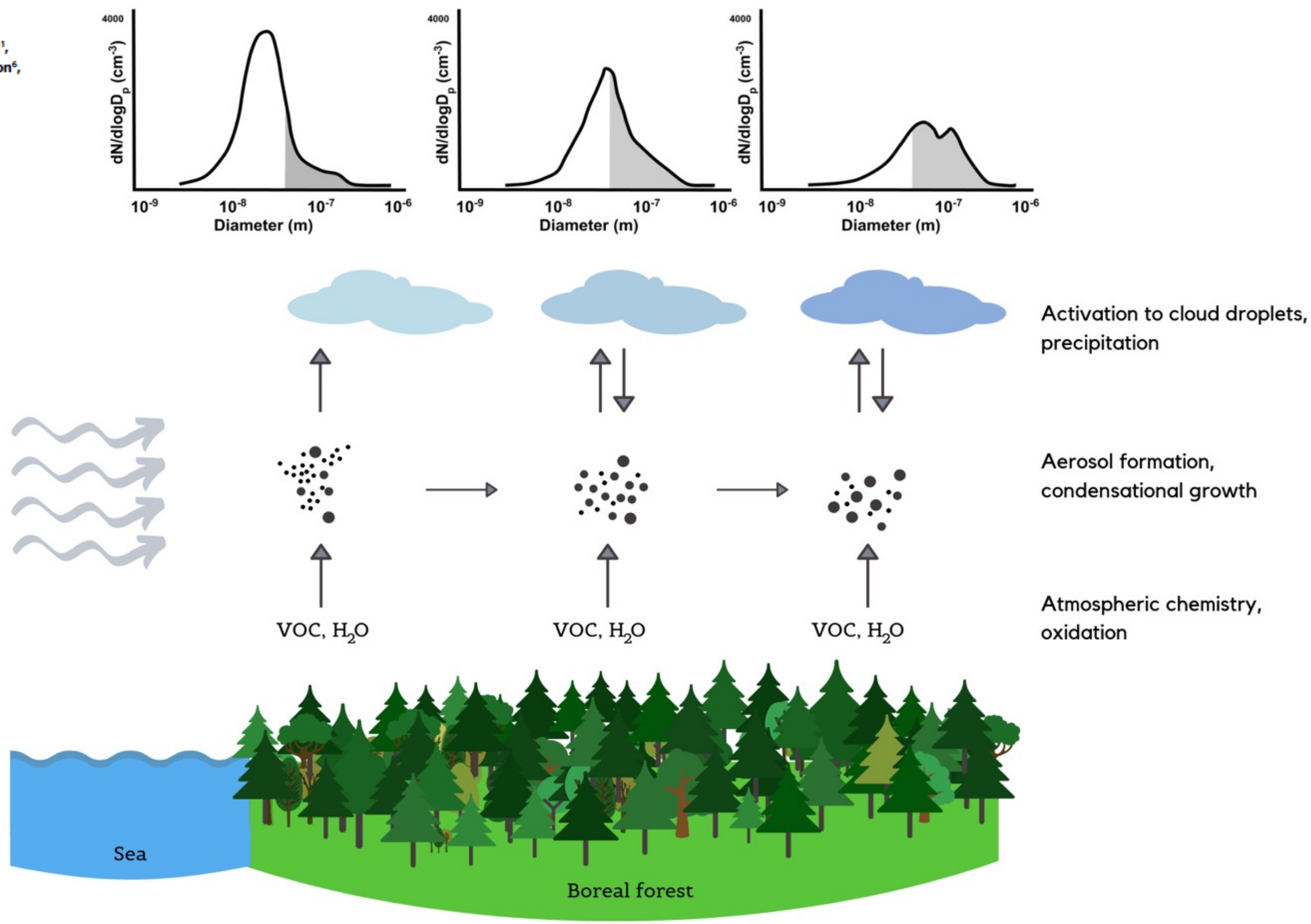

Main findings

- Aerosol physical, optical and chemical character changes as a function of time-over-land.
- At ground level and in the boundary layer
- Cloud droplet number concentrations in the clouds increases by a factor of two
  - In-situ CCN counter
  - Ground-based remote sensing
  - Satellite remote sensing
- Biogenic emissions influence the properties of clouds

Is the BAECC campaign a representative sample?

What happens in different environments?

Atmospheric Chemistry and Physics Discussions

Dynamics of aerosol, humidity, and clouds in air masses travelling over Fennoscandian boreal forests

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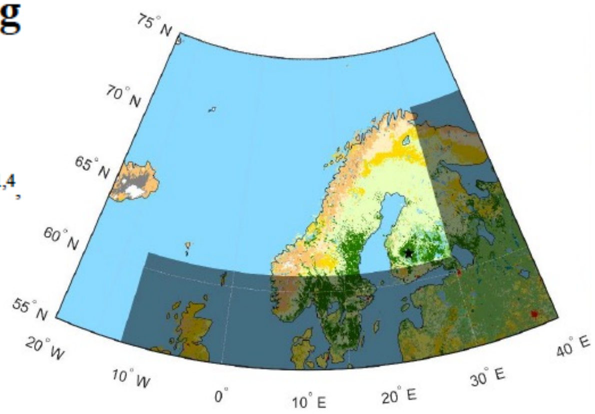

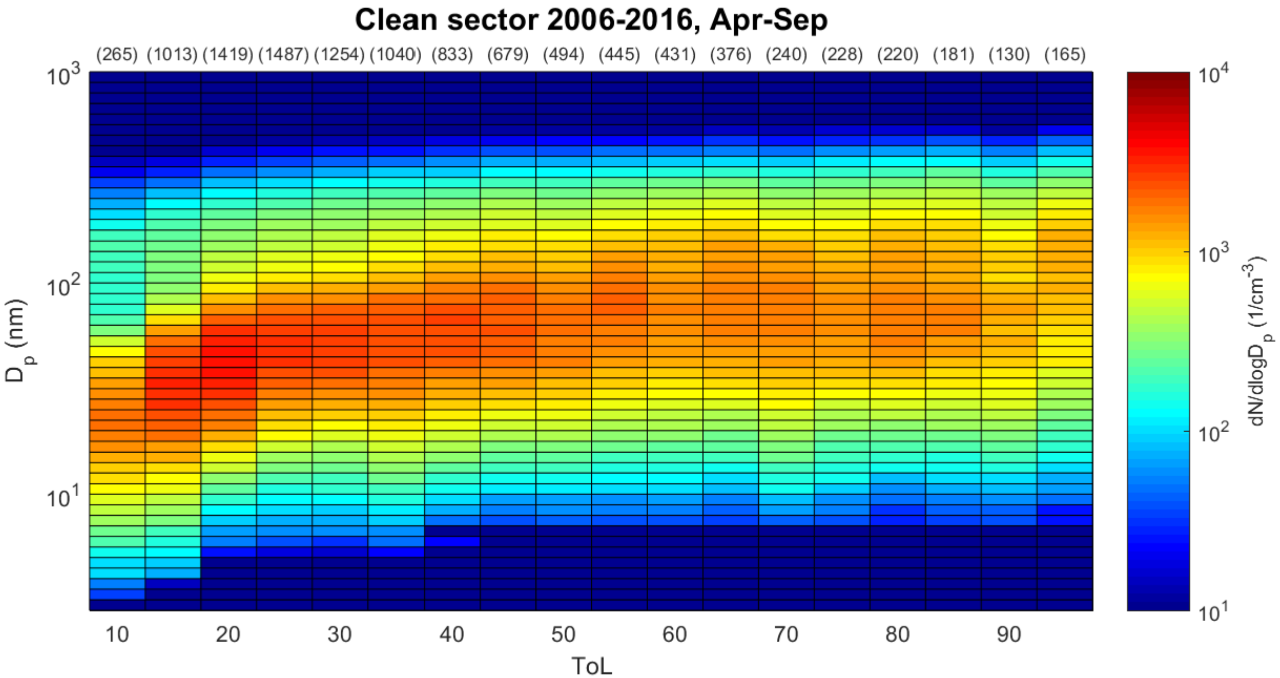

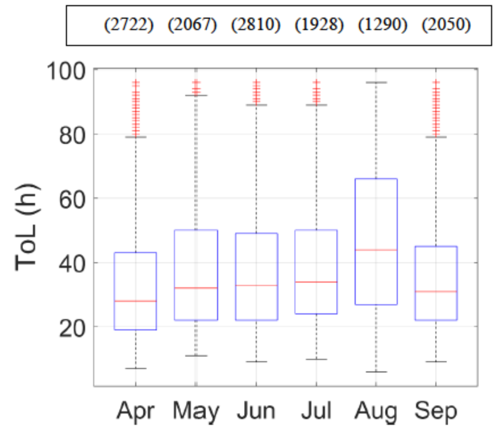

Data from Hyytiälä
2006 – 2016
Growing season

“Time over land” in different environment

Observed coupling between air mass history, secondary growth of nucleation mode particles and aerosol pollution levels in Beijing†

Environmental Science: Atmospheres

ROYAL SOCIETY OF CHEMISTRY

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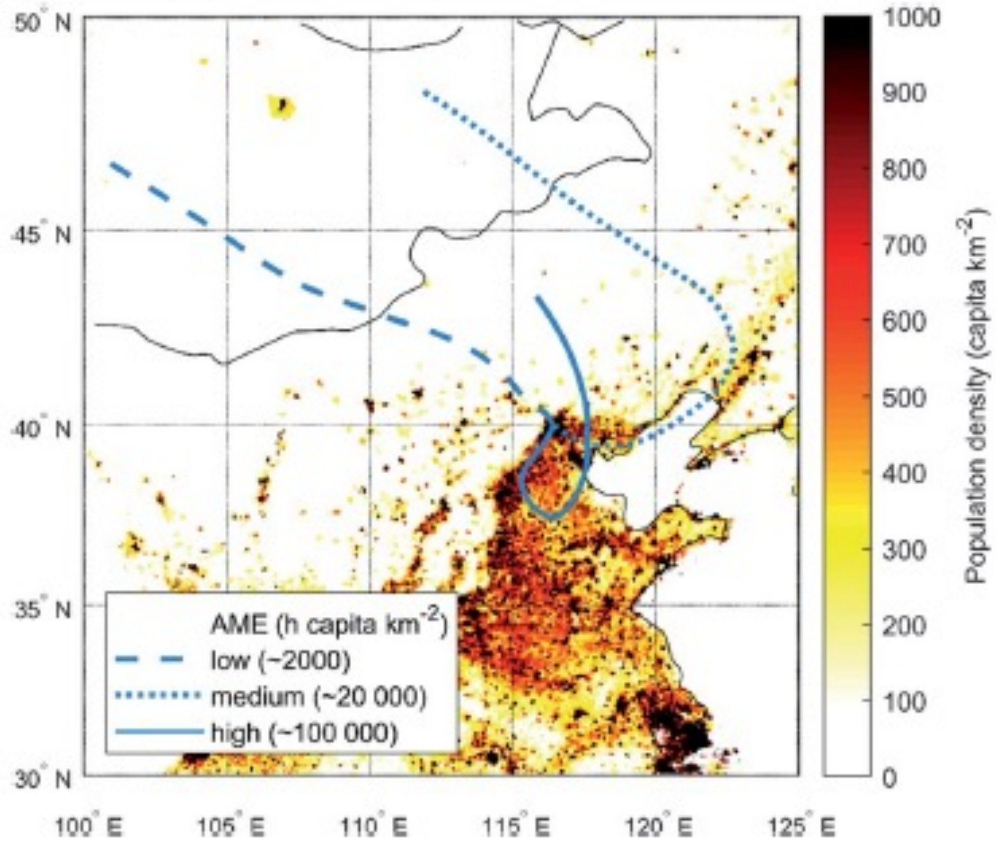


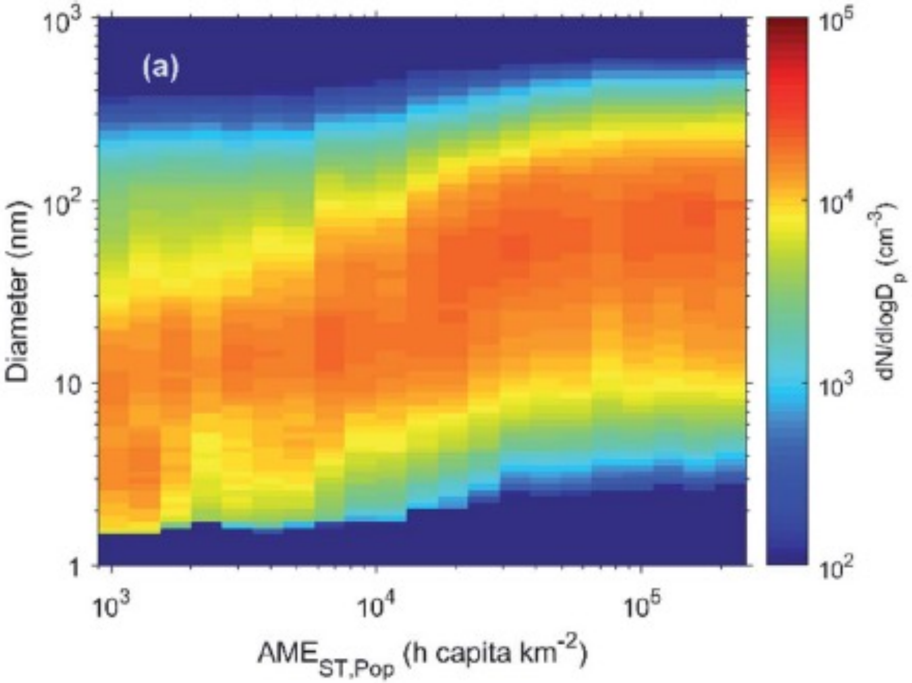
Air mass exposure to anthropogenic emissions (AME)

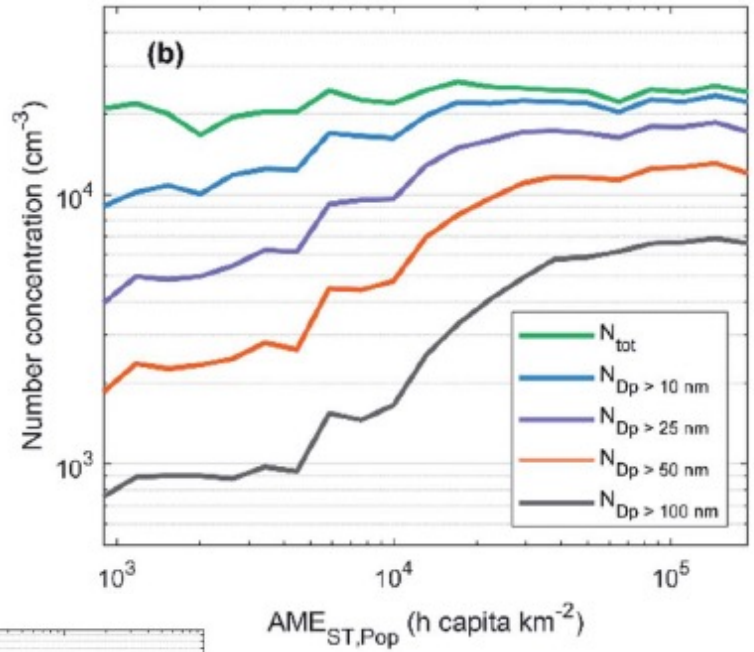
$$\mathrm{AME}_{\mathrm{ST},x,H}(t) = \sum_{t_b=1\ \mathrm{h}}^{72\ \mathrm{h}} A_x[\mathrm{lat}(t,t_b),\mathrm{lon}(t,t_b)] \times 1\ \mathrm{h}$$

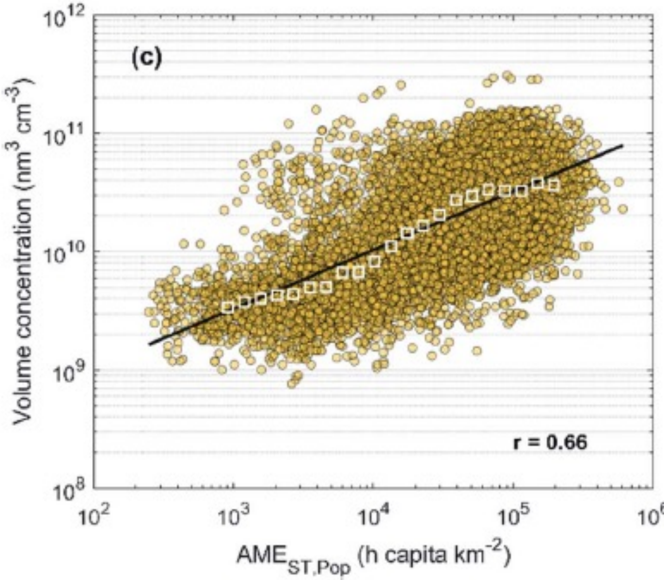
$$|\ \text{trajectory height} \leq H$$

A describes the anthropogenic emissions in the certain grid.

Can be population, can be SO2 emissions, NOx emissions or column NO2 concentration

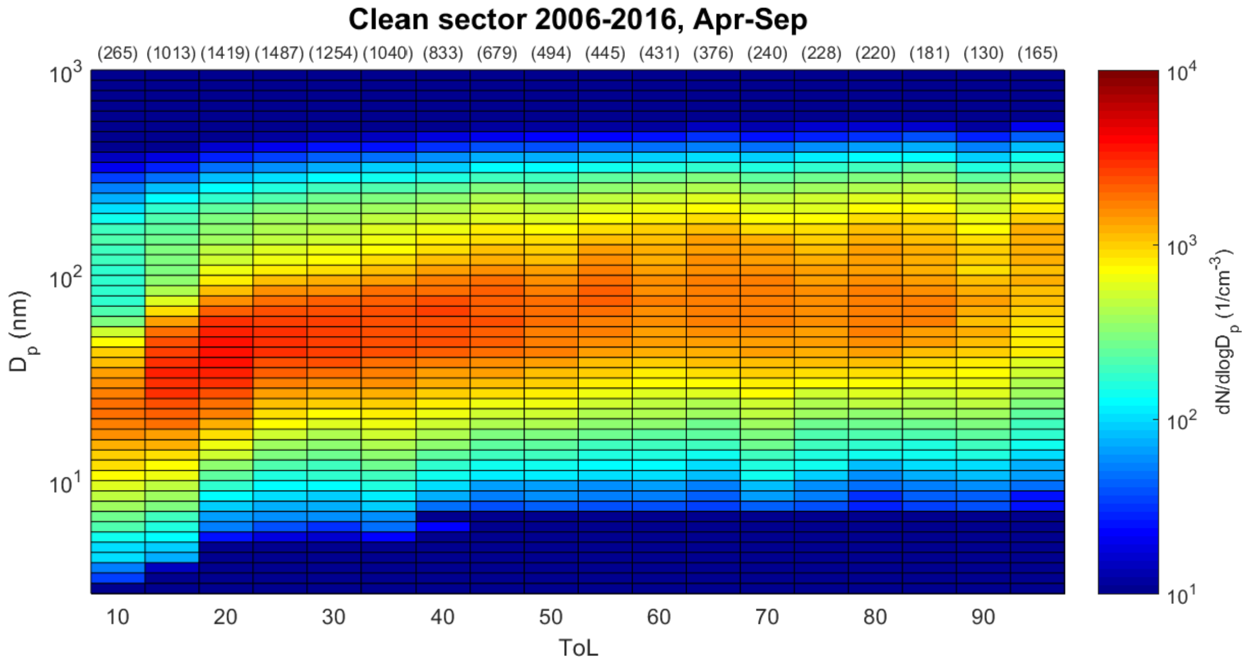






Aerosol size distribution is influenced by accumulated anthropogenic influence

To follow up:



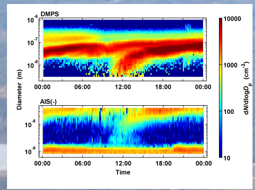
Räty et al. (2022) The effect of boreal forest on clouds and precipitation based on comprehensive atmospheric observations (ACP)

We need to collect a set of long-term sites and make similar analysis:

- Europe (Montseny, Puy de Dome, Melpitz)
- USA (Southern Great Plains, Utqiavik)
- *China (time over cities), Nanjing, Beijing (done)*

Methodology is generic.

Study different processes (with different interaction time)



Main message:

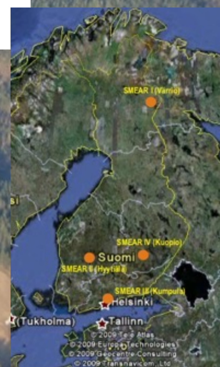
1) Commitment to comprehensive and continuous environmental observations

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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