Biogenic Aerosols – Effects on Clouds and Climate (BAECC)

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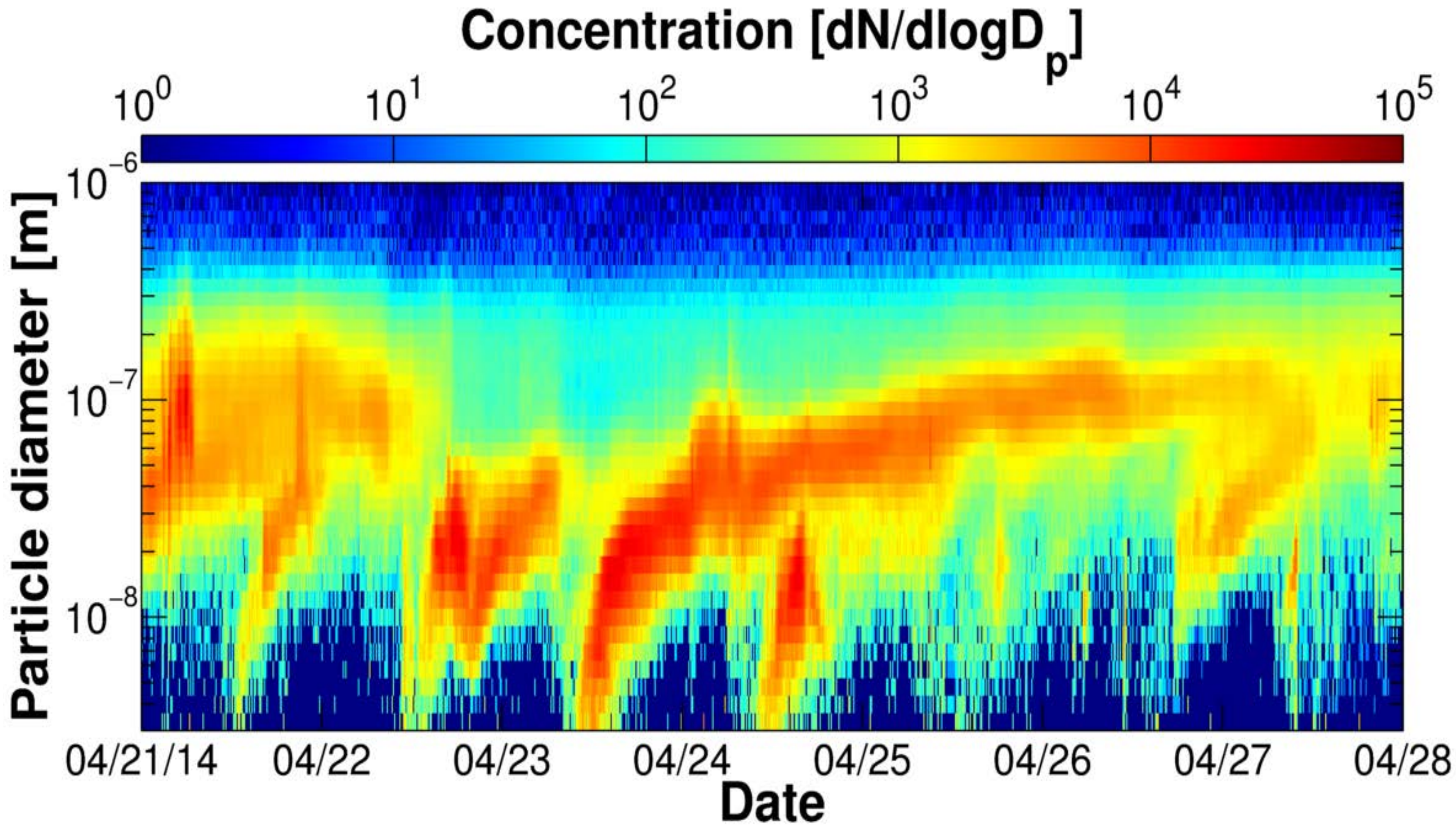
Nicki Hickmon
Mike Ritsche
And the BAECC consortium

UNIVERSITY OF HELSINKI
ATMOSPHERIC SCIENCES

ASR 2015 spring meeting
March 18, 2015

University of Helsinki, University of Reading, University of Eastern Finland, Stockholm University, University of Washington, Aerodyne Research, Argonne National Laboratory

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.

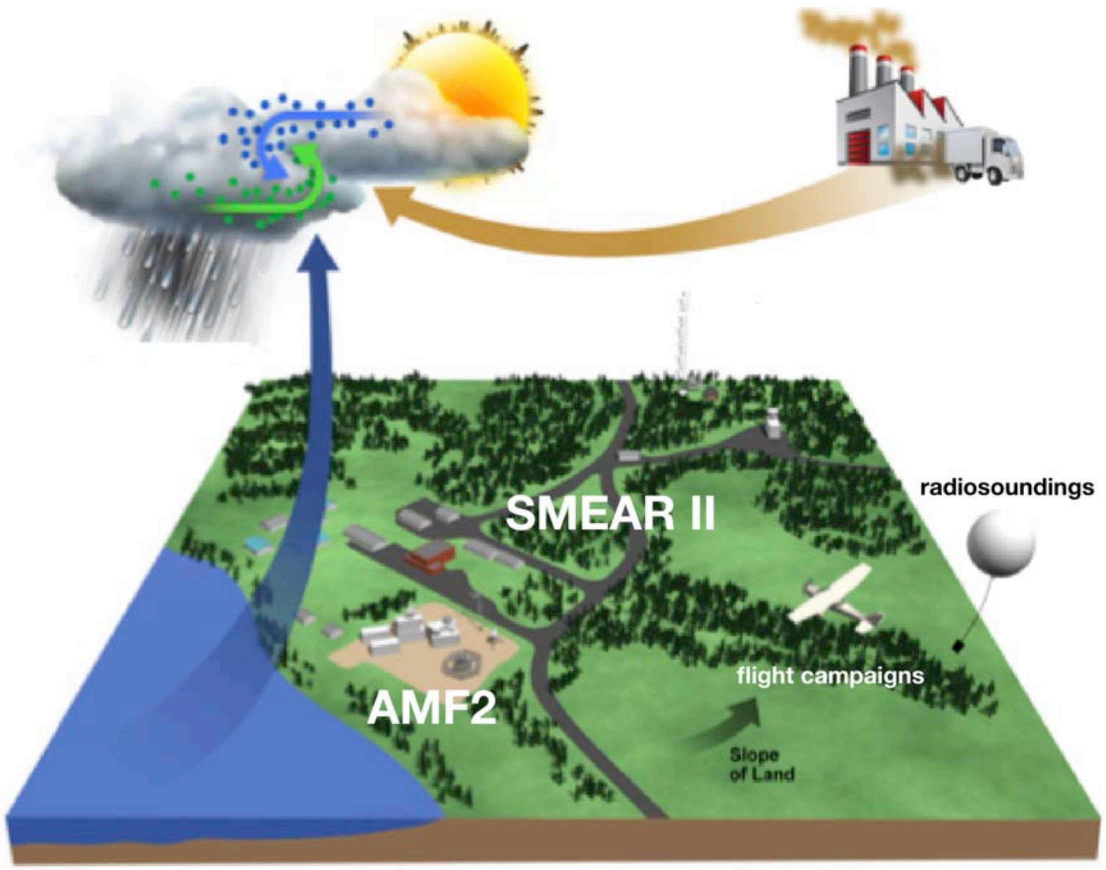
ARM CLIMATE RESEARCH FACILITY

Biogenic Aerosols – Effects on Clouds and Climate (BAECC)

Campaign took place at Hyytiälä, Finland, from 1st Feb to 14th Sep 2014 (~8 months)

University of Helsinki, Finland: Research station SMEAR II

U.S. Department of Energy, ARM program: ARM Mobile Facility 2 (AMF2)



SMEAR II
- In-situ observations
- Airborne intensive observation periods
- Atmosphere-biosphere interactions
- Boundary layer height
- Horizontal wind profile
- Cloud base height
- Intensive campaign observations

AMF2
- Cloud observations
- Vertical structure and radiation
- Atmospheric profiling
- Surface meteorology
- In-situ observations

BAECC SNEX
- Snowfall microphysics

Figure courtesy of Nicki Hickmon et al. (ARM)

Combination of different measurement techniques

Several remote sensing instruments, which obtained vertical structure of aerosols and clouds, e.g.:

Ka Zenith Radar, 8.6 mm (35 GHz)

High Spectral Resolution Lidar, 523 nm

Microwave radiometer 12.6 mm (23.8 GHz) and 9.5 mm (31.4 GHz)

PollyXT Raman lidar, 355 nm, 532 nm, 1064 nm

Marine W-band Radar, 3.2 mm (95 GHz)

Vaisala Ceilometer, 910 nm

HALO Doppler wind lidar, 1.5 µm

Aircraft measurements

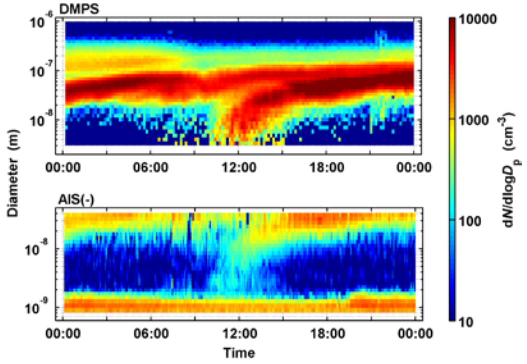
140 flight hours during total of 30 days

spring, summer, and autumn

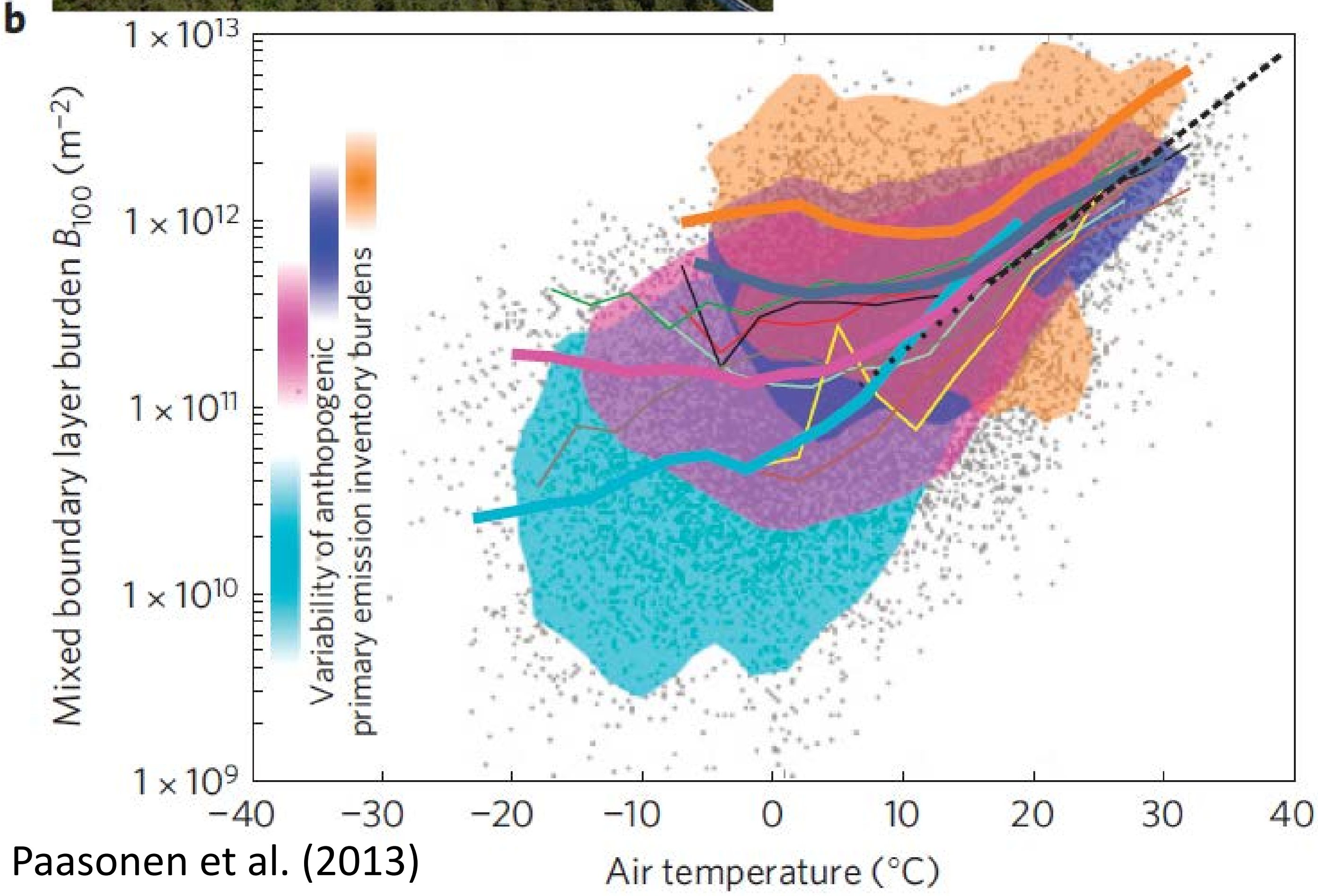
Radiosoundings

Launches 4 times per day

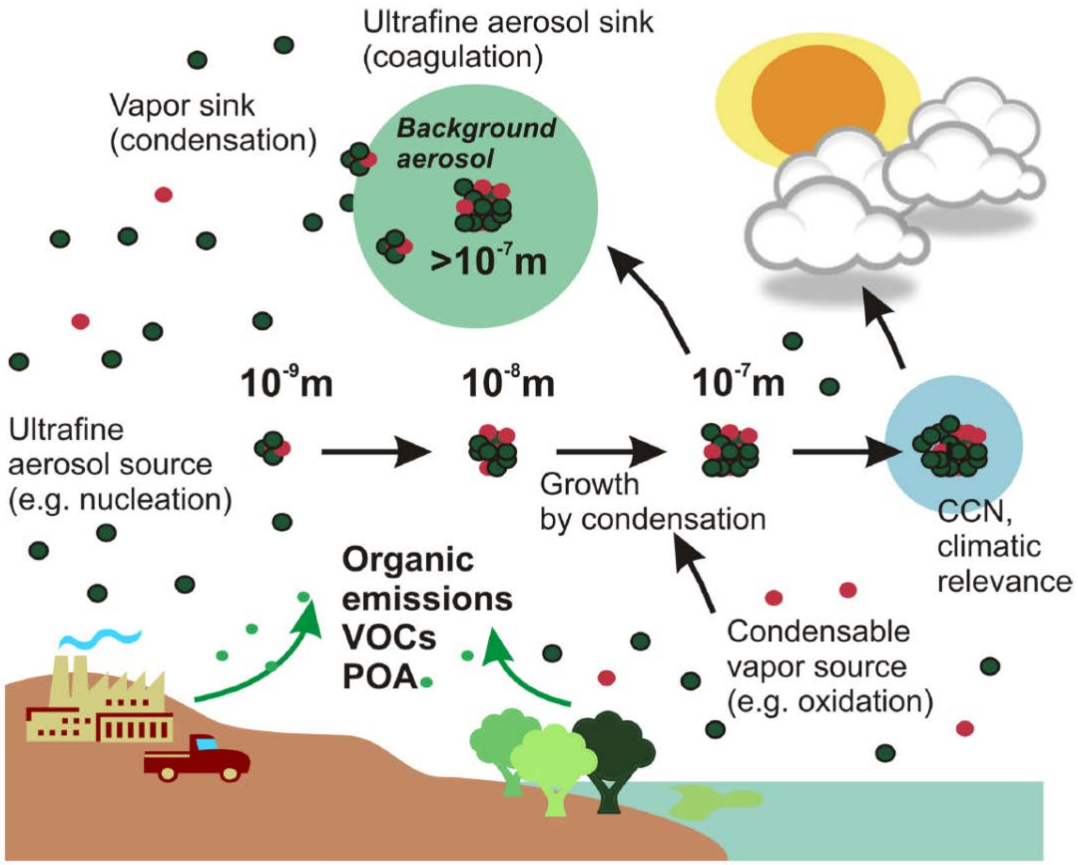
Photoes courtesy of Juho Aalto and Antti Manninen (UHEL)



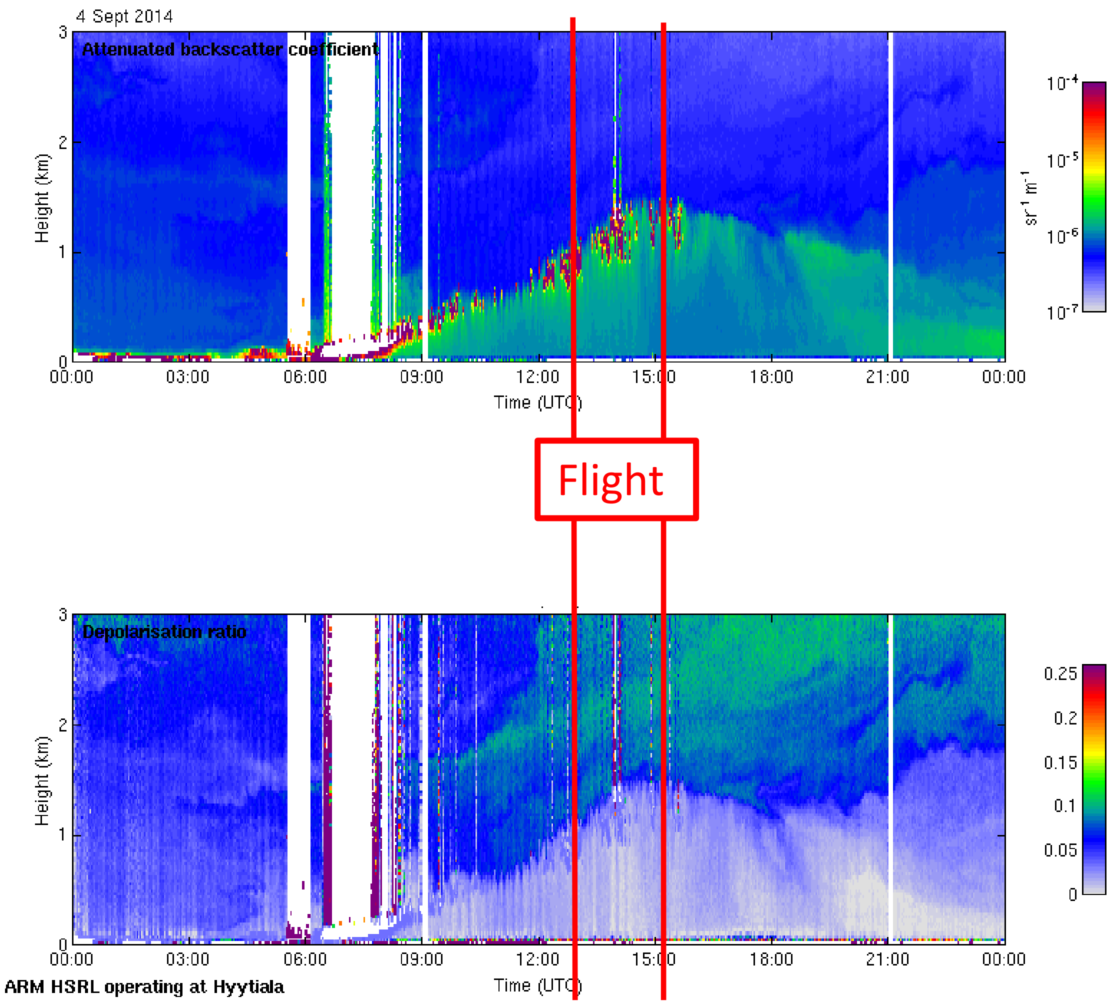
From emissions to aerosol particles

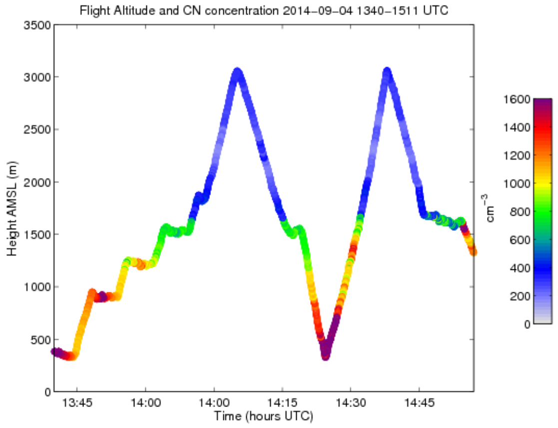


Paasonen et al. (2013)
Nature Geosci.



Aircraft evaluation of lidar-derived aerosol profiles





Aircraft:	Skyvan
DMT, TSI:	Aerosol DSD
SP2:	Black Carbon
PICARRO:	Gases
HR-AMS-SP:	Chemical Composition

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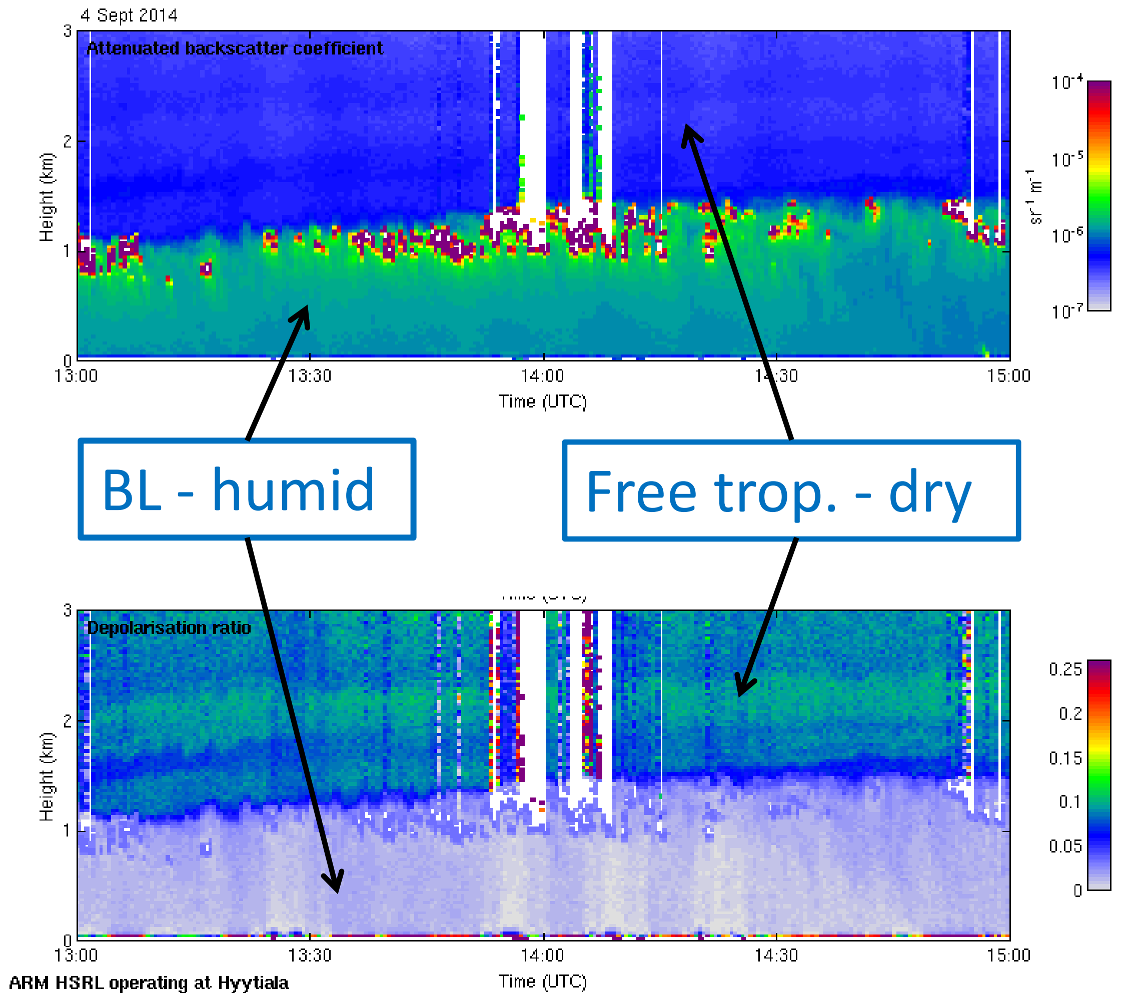

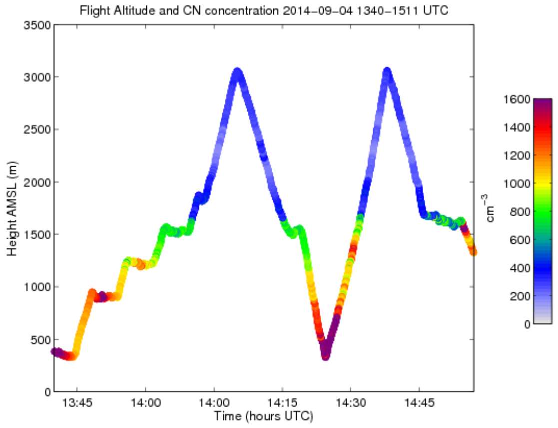

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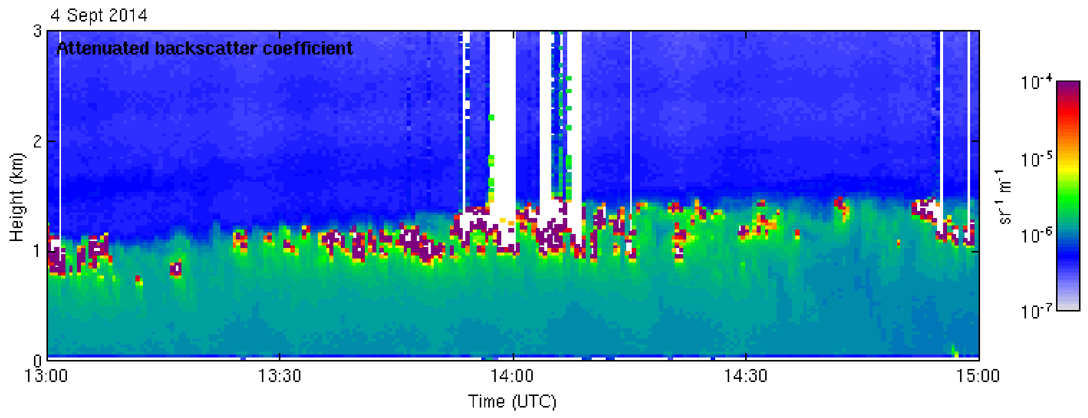
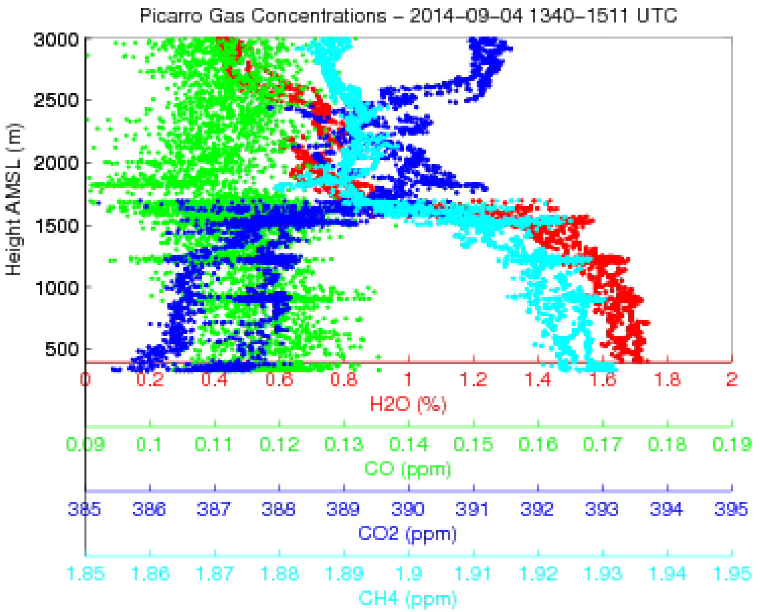
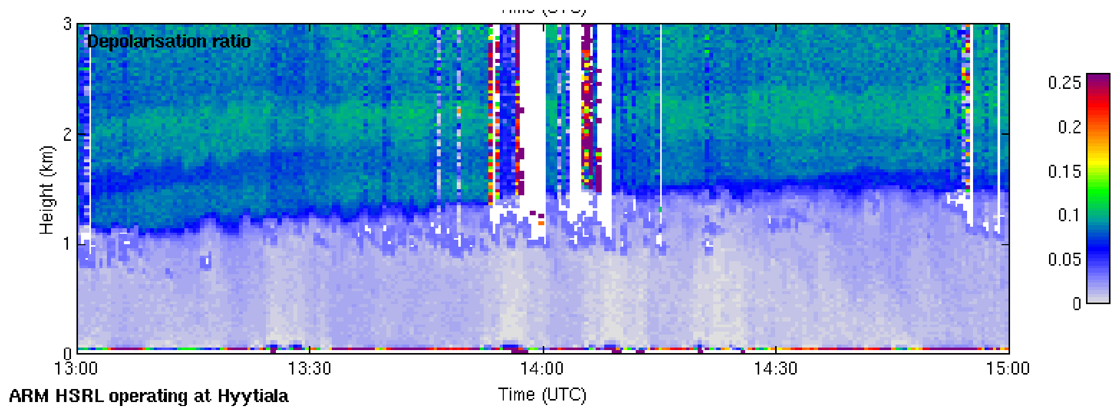
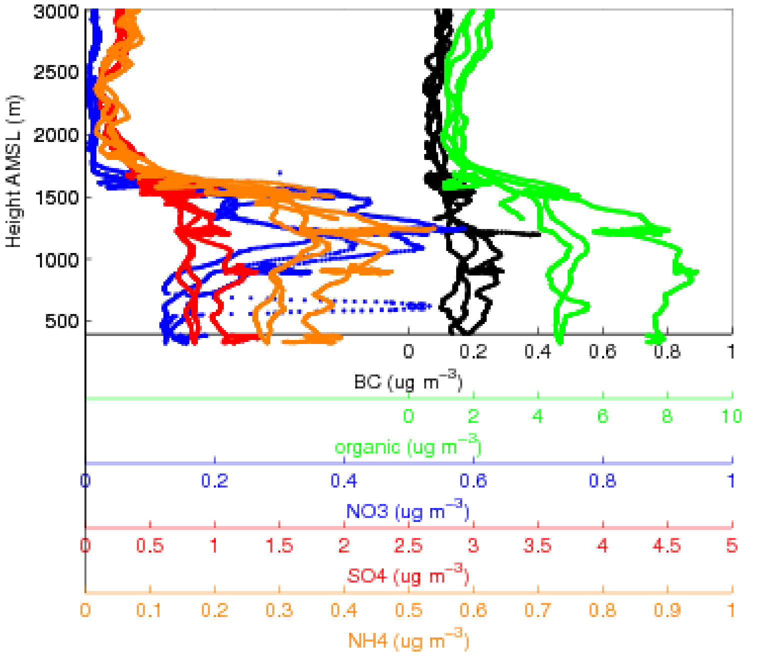








Link surface -> vertical profile -> cloud

Investigate mixing with long range transport

Also, as a part of or linked to BAECC, several surface based measurements were carried out

BAECC SNEX

Snowfall microphysics: precipitation rate, type, phase, and particle size distribution.

Analysis of fall velocity–dimensional relations.

Derivation of bulk density and mass-dimensional relations.

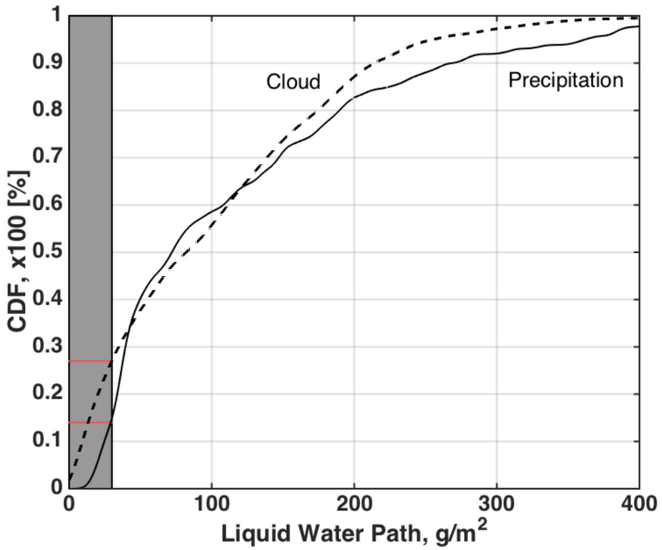
Intensive observation periods during spring 2014 at SMEAR II

Aerosol size distribution:
vertical and horizontal variability

Aerosol chemical composition measurements
HR-AMS, FIGAERO-CIMS, ACSM

Photoes courtesy of Matti Leskinen, Juho Aalto, and Dmitri Moisseev (UHEL)

Observations of cloud-to-precipitation processes during BAECC



- > 70 % of observed cold clouds are mixed phase
- > 80 % of snow originates from mixed phase clouds

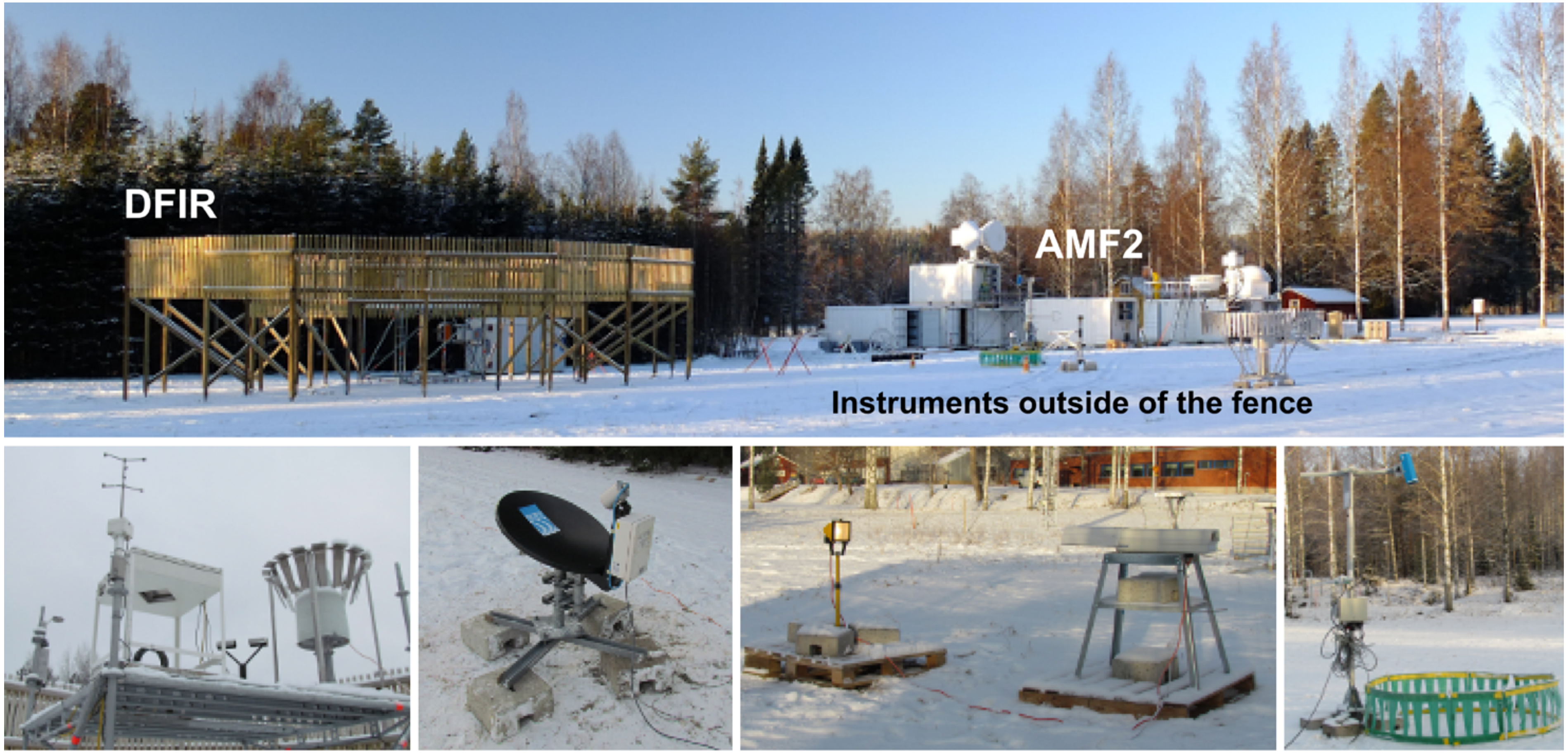
Ground-based observations of snow give us a glimpse into processes that take place above

Quantitative estimation of snowfall microphysics (PSD, density, m-D, v-D, mass flux) to

- connect to multi-frequency and dual-pol radar observations
- give a detailed view of snow growth processes, by combining with multi-instrumental remote sensing

Quality of observations and retrievals is insured by consistency of retrieved PSD, density, v-D and m-D between instruments, methods and each other

BAECC-SNEX setup



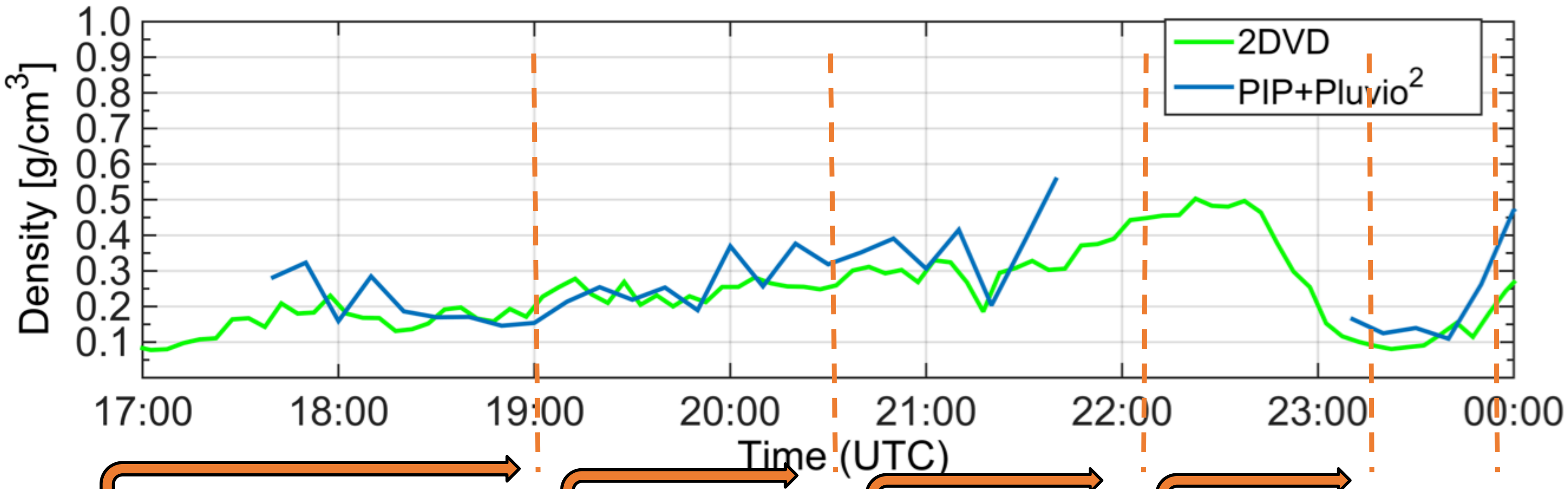
Instruments inside of the fence

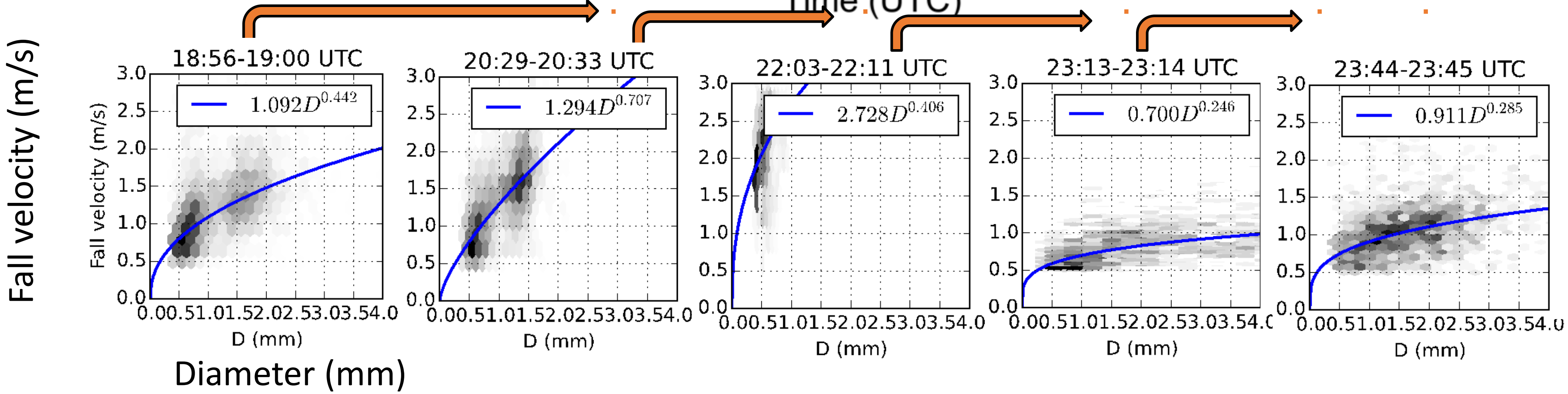
Micro Rain Radar

NASA Particle Image Package

Snow depth sensor and 3D anemometer

Bulk density consistency check - velocity Feb 21, 2014





- Density retrievals are also consistent with v(D) observations

BAECC SNEX findings

- Excellent dataset of 20 snow events (combining wet and dry snow events)
- Quantitative estimation of snowfall microphysics is possible
- Quality of observations and retrievals can be verified through consistency between retrievals and observations from different instruments
- Now we need to use this data to
  - connect multi-frequency and dual-pol radar observations to snow microphysics and snow growth processes

Next steps in BAECC:

Determine the relative importance of natural and anthropogenic aerosol and aerosol which has undergone long-range transport to the formation of CCN, and their interaction with clouds and precipitation.

1. Aerosol transport from surface to the clouds?
2. In-situ CCN vs satellite derived CCN concentrations?
3. Aerosol aging during transport and CCN activity of the aerosol
4. Comprehensive aerosol and trace gas source apportionment and connection to aerosol typing with Lidars and aircraft data
5. Sensitivity of cloud-precipitation processes to the CCN concentrations (Doppler spectra and dual polarization observations from multi-frequency radars in synergy with Lidar measurements)
6. Aerosol removal processes as a function of particle size and precipitation type

Thank you for your attention

PI talks:
Wornsop, Petäjä and Kalesse

Posters: Petäjä, Moisseev

Breakout Session on Thursday 10:30 – 12:30 in meeting room Potomac

Supported by Academy of Finland and

US Department of Energy

BAECC breakout session, Chair Petäjä
Thursday 10:30 – 12:30
Room Potomac

1. Tuukka Petäjä – BAECC introduction 5 min
2. Antti Manninen – AMF2 / SMEAR 2 intercomparison 5 min
3. Celia Faiola – Aerosol chemical composition 10 min
4. Joel Thonton – FIGAERO-CIMS, Spring intensive 10 min
5. Daniel Rosenfeld – CCN concentrations from satellites and in situ 10 min
6. Paul Zieger – Aerosol optical closure 10 min
7. Ewan O'Connor – lidar and aircraft observations of aerosol vertical profiles 10 min
8. Victoria Sinclair – WRF model comparison with BAECC data 10 min
9. Dmitri Moisseev – BAECC snowfall experiment 10 min
10. V. Chandrasekar – Cloud and precipitation separation from Doppler spectra 10 min

SHORT SC-7 Skyvan, unpressurized aircraft (Short Brothers and Harland Ltd, Northern Ireland, UK), owned by Aalto University

Instrumentation:
outside:
- DMT CAPS probe: CAS-DPOL, CIP-Greyscale, LWC
- BMI Isokinetic Inlet

on board:
<u>aerosol</u>
- Aerodyne HR-AMS–SP
- Aerodyne CAPS – PM_x
- DMT CCNc-100
- TSI CPC 3010
- DMT SP2
- MicroAeth AE51

<u>gases</u>
-Picarro

4 operators + 2 pilots