Biogenic Aerosols: Effects on Clouds and Climate (BAECC) 2014

Tuukka Petäjä
Dmitri Moisseev
Ewan O’Connor
et al.

Department of Physics, University of Helsinki, Finland

Finnish Meteorological Institute, Helsinki, Finland

March 20, 2013
Potomac, Maryland
USA
Biogenic Aerosols - Effects on Clouds and Climate (BAECC)

a proposal for the ARM Mobile facility incl. (M)AOS

Lead Scientist *
Dr. Tuukka Petäjä
Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL)

For Contact: e-mail: tuukka.petaja@helsinki.fi; mobile: +358-50-41 55278

Co-Investigators
Dr. Dmitri Moisseev
Radar laboratory, Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL)

Dr. Ewan O'Connor
Finnish Meteorological Institute, Helsinki, Finland (FMI), and University of Reading, UK

Dr. Hanna Lappalainen
Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL), and Finnish Meteorological Institute (FMI)

MSc. Janne Levula
Station for Measuring Forest Ecosystem – Atmosphere Relations (SMEAR), and Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL)

Dr. Jaana Bäck
Department of Forestry, University of Helsinki, and Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL)

Dr. Michael Boy
Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL)

Dr. Mika Komppula
Finnish Meteorological Institute (FMI)

Dr. Anders Lindfors
Finnish Meteorological Institute (FMI)

Dr. Harri Kokkola
Finnish Meteorological Institute (FMI)

Dr. Hannele Korhonen
Finnish Meteorological Institute (FMI)

Dr. Heikki Lihavainen
Finnish Meteorological Institute (FMI)

Dr. Sami Romakkaniemi
University of Eastern Finland (UEF)

Prof. Veli-Matti Kerminen
Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL)

Prof. Kari Lehtinen
Finnish Meteorological Institute (FMI)

Prof. V. Chandrasekar
Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL), and Colorado State University (CSU)

Prof. Gerrit de Leeuw
Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL), and Finnish Meteorological Institute (FMI)

Prof. Ari Laaksonen
Finnish Meteorological Institute (FMI), and University of Eastern Finland (UEF)

Prof. Douglas R. Worsnop
University of Helsinki (UHEL-ATM), Finnish Meteorological Institute (FMI), and Aerodyne, USA

Prof. Markku Kulmala
Division of Atmospheric Sciences, Department of Physics, University of Helsinki (UHEL)
BAECC goals

Generally:
1) To understand the impact of biogenic aerosol formation on cloud properties and climate

Specifically:
1) To resolve the role of biogenic secondary aerosol formation in cloud processes in warm, mixed phase and ice clouds over boreal environment,
2) by utilizing AMF2 remote sensing capabilities with process-scale modeling to complete the link between our comprehensive 19-year observational record of aerosol and biosphere-atmosphere interactions to cloud processes,
3) To expand our local observations over larger spatial scales up to Earth System behavior via hierarchy of models and satellite observations
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

From nano to global

Mäkelä et al. 1997, GRL
Kulmala et al. 2001, Tellus
I Small clusters and molecules
- No direct connection to NPF
- Very slow growth

II Critical size for clustering
- Sulfuric acid and amines
- Stabilizing organic compounds
- Slowly growing (<1 nm/h)
- Determines $J_{1.5}$

III Growing clusters
- Organics start to dominate
- Rapidly growing (~2 nm/h)
- Nano-Köhler
- Determines $J_3$

Key processes:
- Gas-phase reactions, cluster formation/evaporation
- Cluster stabilization
- Activation of clusters for enhanced growth

Direct Observations of Atmospheric Aerosol Nucleation
Markku Kulmala et al.
Science 339, 943 (2013);
DOI: 10.1126/science.1227385
Aerosol formation leads to a substantial increase in CCN concentrations (based on in-situ observations).

In boreal environment the increase can be 100% (Sihto et al. 2011, ACP).
Global measurement activities

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; Merikanto et al. 2009)
Stations for Measuring Forest Ecosystem–Atmosphere Relations

SMEAR-I Värriö 67°46' N, 29°35' E
SMEAR-II Hyytiälä 61°51' N, 24°17'E
SMEAR-III Helsinki 60° 12'N, 24° 57' E
SMEAR-IV Puijo 62°54'N, 27°39'E

Pallas-GAW station 67°58'N, 24°07'E
Continuous Measurements

SMEAR II
Station for measuring Forest Ecosystem - Atmosphere Relations
University of Helsinki, Forestry Field Station, Hyytiälä

TREE
- gas exchange
- water flows
- growth & structure
- canopy light
- environment

ATMOSPHERE
- aerosols
- atmosphere chemistry
- cloud microphysics
- micrometeorology
- irradiance

SOIL
- water & nutrients
- gas concentrations
- temperature

61°51’N, 24°17’E
SMEAR stations

I Värriö
II Hyytiälä
III Kumpula
IV Kuopio, Puijo

Welgegund, South Africa
Järvselja, Estonia
Nanjing, China

Pallas-Sodankylä
GAW, Finnish Met. Institute
BAECC – Measurement Setup
Finnish Weather Radar Network
- 8 C-band weather radars
- 3 Dual-pol radars
- 5 Doppler radars

Closest radar is at about 65 km
Courtesy of E. O’Connor
Practical organization

**WP 1: Project coordination**
WP leader Tuukka Petäjä

**WP 2: From emissions to aerosol**
WP Leader Jaana Bäck

**WP 3: From Aerosol to Clouds**
WP leader Dr. Ewan O’Connor FMI

**WP 4: From Clouds to Precipitation**
WP leader Dr. Dmitri Moisseev, UHEL

**WP 5: Feedbacks and interactions, integration to existing activities**
WP leader Prof. Veli-Matti Kerminen

**Task 1.1 Scientific coordination**
Dr. Tuukka Petäjä, UHEL; Dr. Hanna Lappalainen, UHEL

**Task 1.2 Technical Management**
MSc. Janne Levula, SMEAR site operation manager
| WP/ Task                     | -3 | -2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|------------------------------|----|----|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|
| **WP 1 Management**          |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |
| T 1.1 Scientific coordination|    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |
| T 1.2 Technical coordination |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |
| **WP 2 From emissions to aerosol** |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 2.1 Precursor vapor emission rates |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 2.2 Aerosol in-situ measurements |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| **WP 3 From Aerosol to clouds** |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 3.1 Aerosol transport      |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 3.2 Cloud properties      |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| **WP 4 From Clouds to Precipitation** |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 4.1 Surface precipitation mapping |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 4.2 Vertical structure of precipitation |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| **WP 5 Feedbacks, interactions, integration** |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 5.1 Radiative transfer model & satellite products |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 5.2 Development of new parametrizations |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| T 5.3 Quantification of new feedbacks & interactions |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| Airborne IOP's                |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| Data delivery                |    |    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |