

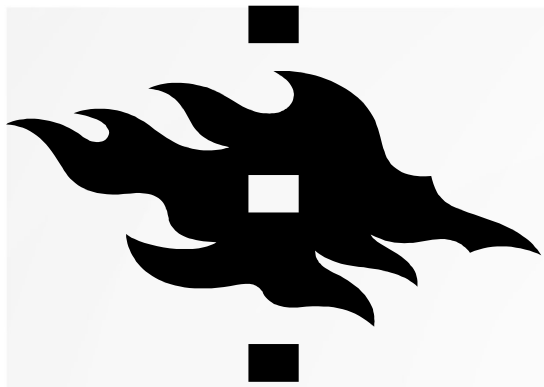
# INAR

INSTITUTE FOR ATMOSPHERIC AND  
EARTH SYSTEM RESEARCH



FOR THE  
ONLY  
PLANET  
WE HAVE

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# – Stations for Measuring Ecosystem - Atmosphere Relation

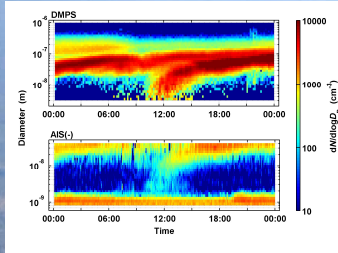
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Finland

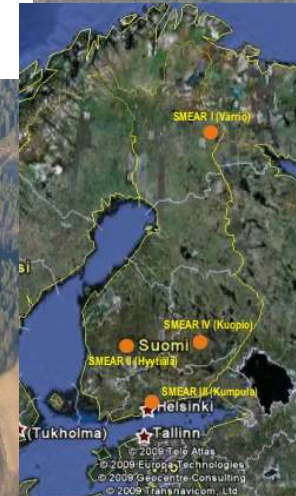




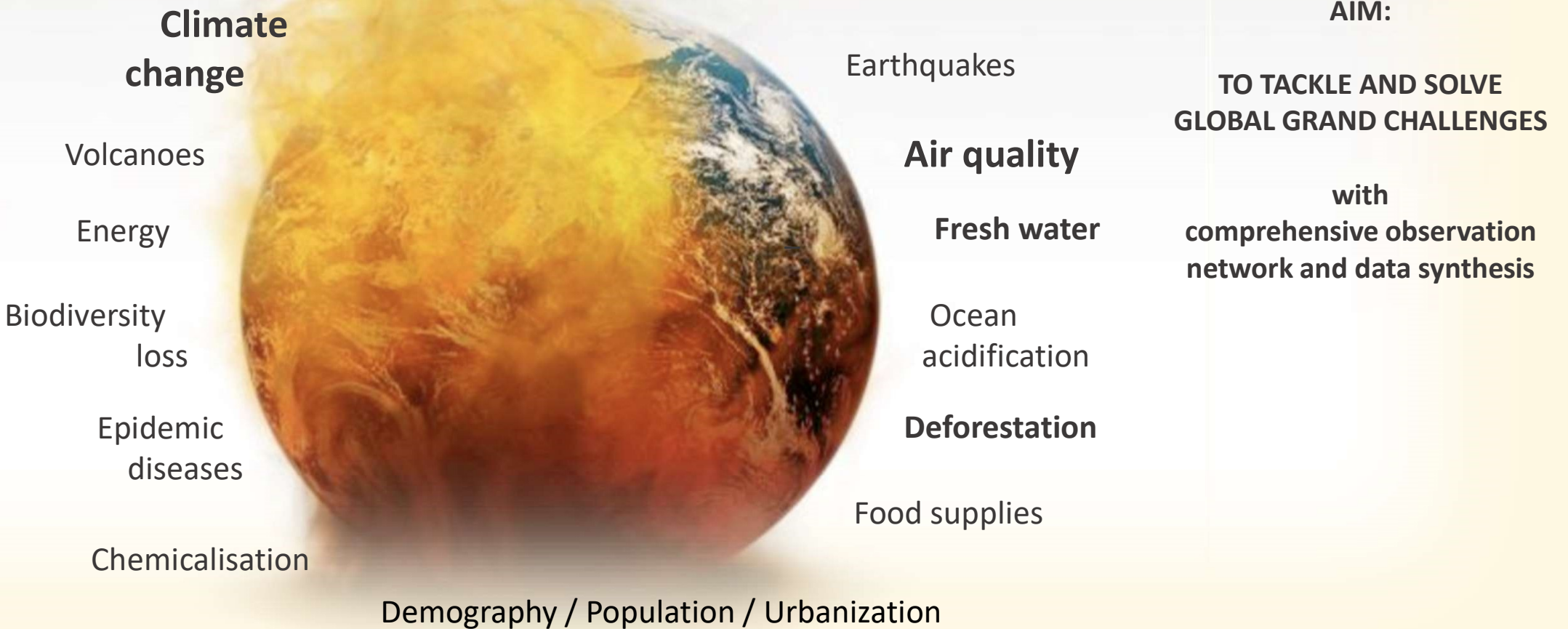
## Main message:

- 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 -

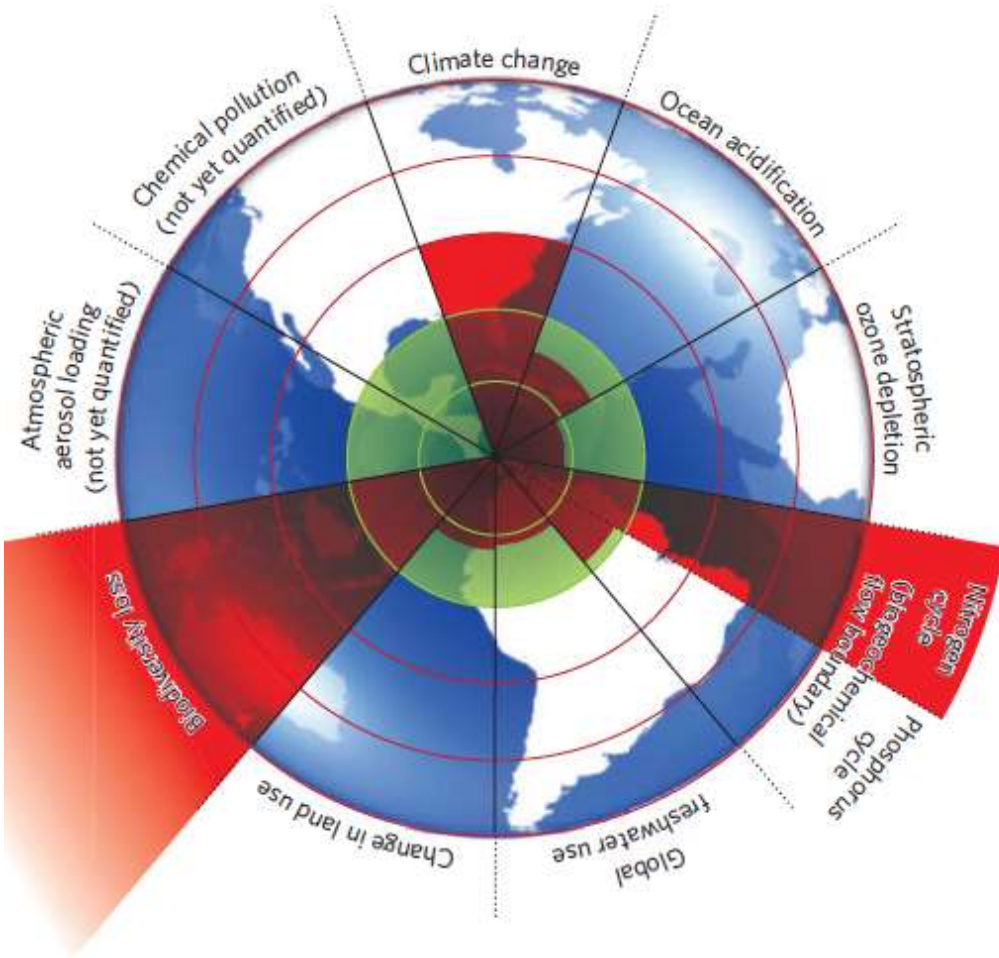


# Global grand challenges





# A safe operating space for humanity



Rockström et al. (2009) A safe operating space for humanity, Nature 461, 472-475.

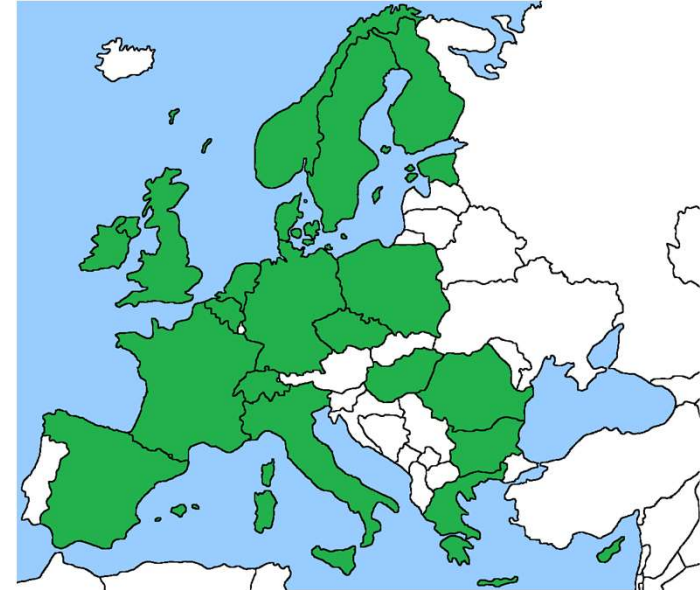
# What is needed to respond to the grand challenges?

- World-class Research Infrastructures (RIs) in a form of integrated network of RIs
  - ACTRIS; ICOS; LTER; ANAEE; ENVRI
  - Co-location, cooperation
  - Urban, agricultural and natural environments
  - Spatial representativeness: across Europe
- Excellent science – outstanding quality, critical mass and interdisciplinary research
- Education and training – knowledge exchange
- Innovations – contributing to innovation environment
- Science to society – continuous dialogue

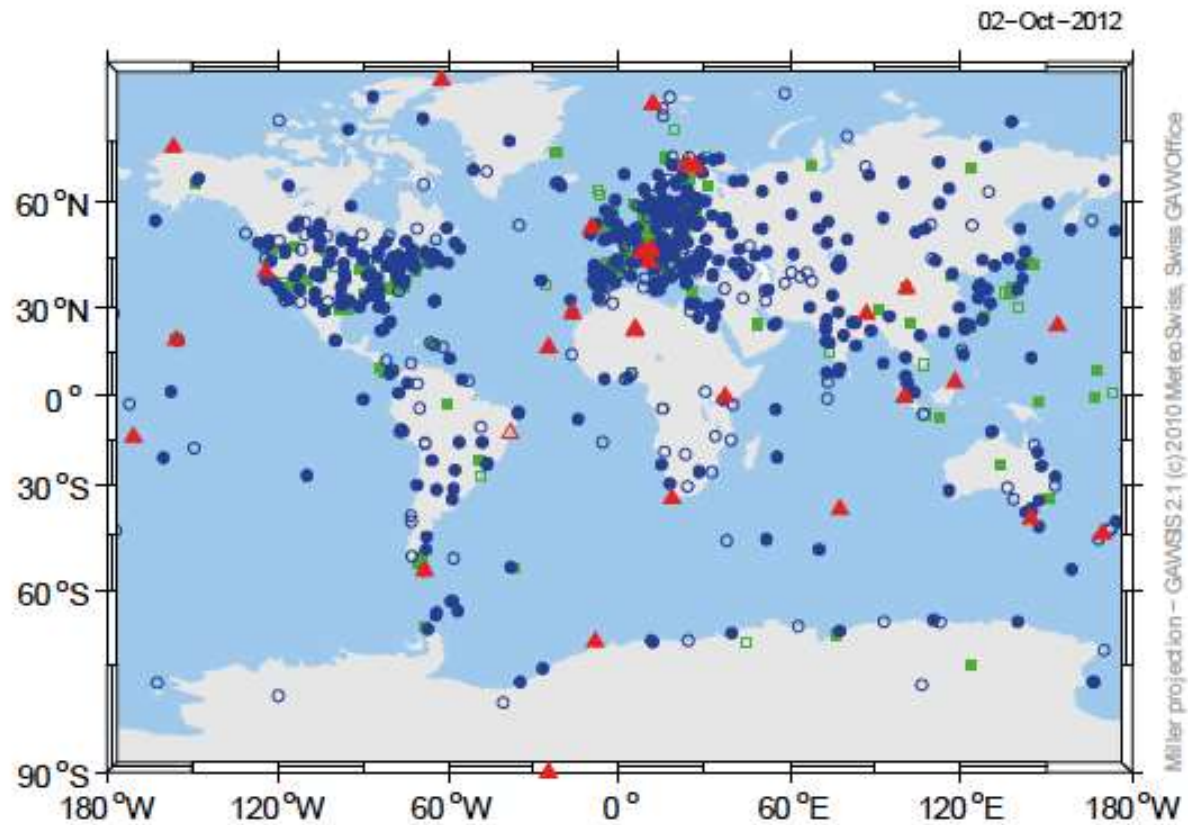


## Aerosols, Clouds, and Trace gases Research Infrastructure - European ESFRI research infrastructure

- ACTRIS provides data and research, instrument, industry, and training services for the various user groups
- ACTRIS consists of observing stations, exploratory platforms, instrument calibration centres, data centre, and Head Office
- ACTRIS implementation is led by Finland and UHEL and FMI contributes to ACTRIS Head Office, Data Centre and have several ACTRIS national stations



# The Global Atmospheric Watch (GAW) Network



▲ GAW Global Station    ● GAW Regional Station    ■ Contributing Station  
Open symbols denote closed or inactive stations.





Pan Eurasian Experiment (PEEX) analysis of existing capacity → capacity building in education, training, instruments, new stations for regional representation



WG: T. Petäjä, I. Bashmakova, A. Borisova, P. Alekseychik, H.K. Lappalainen, A. Mahura, N. Altimir, S. Chalov, P. Kontantinov, N. Zaitseva + many active stations

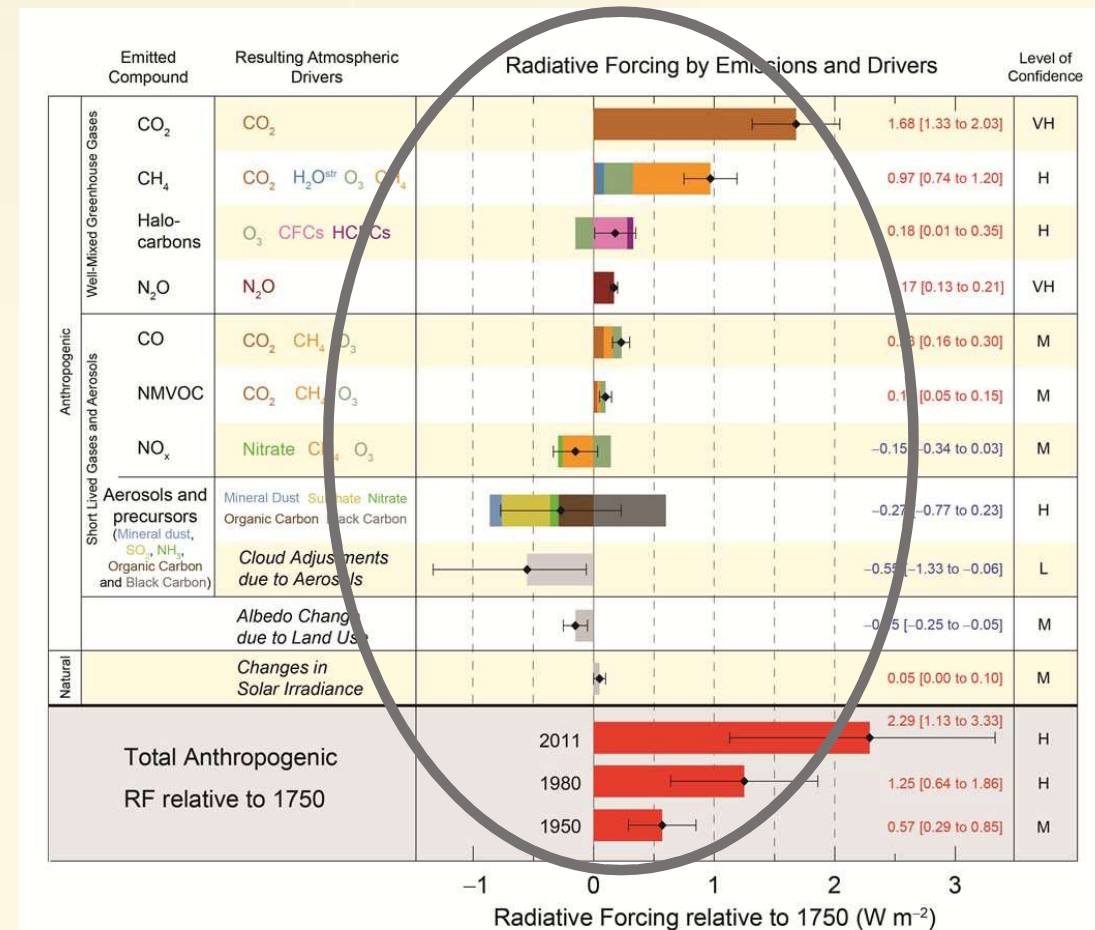
# INTEGRATED APPROACH: THE GLOBAL EARTH OBSERVATORY / GLOBAL SMEAR

Current observations (see IPCC 2013) are fragmented:

- 1) Greenhouse gases (ICOS)
- 2) Aerosols (ACTRIS)
- 3) Air quality (ACTRIS)
- 4) Ecosystems (eLTER)
- 5) Climate (ICOS, ACTRIS, eLTER)
- 6) ...

Future aspiration: **Integrated approach**

- To understand feedbacks
- To reduce uncertainties
- To mitigate and adapt effectively

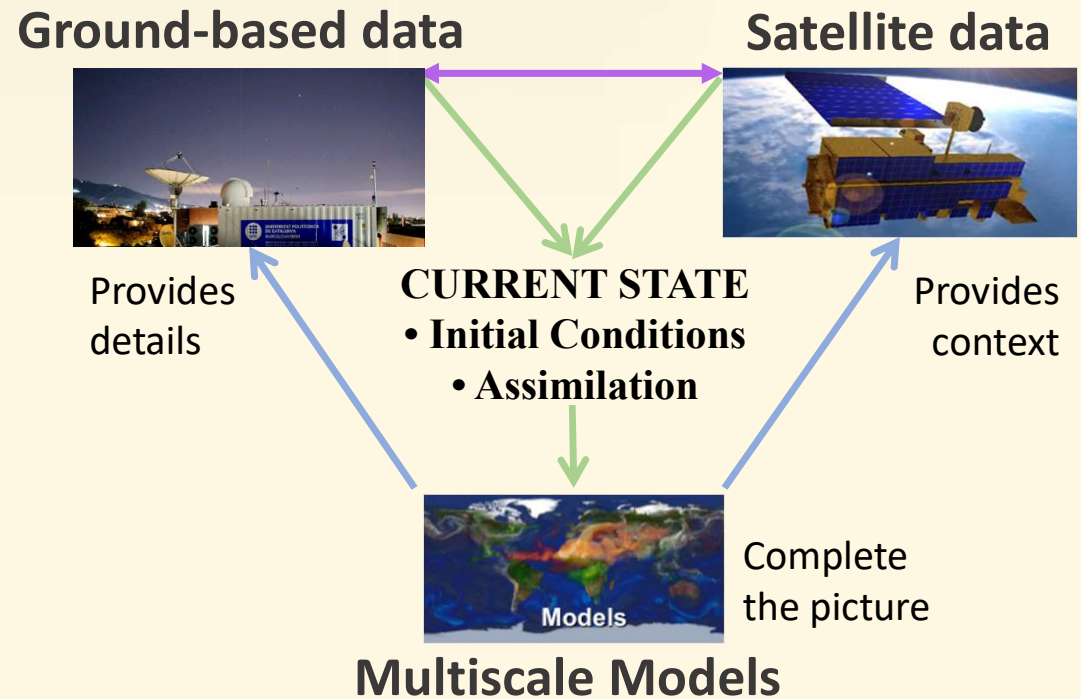


# A MULTIDIMENSIONAL, MULTIDISCIPLINARY, MULTISCALE APPROACH TO RESPOND TO THE GRAND CHALLENGES

Clear and ambitious vision / from deep understanding to practical solutions

Empirical measurements and modelling / from observations to new theories

From research to innovations / economic growth and human wellbeing







An enclosure for measuring gas exchange between plants and the atmosphere at a station in Finland.

## Build a global Earth observatory

Markku Kulmala calls for continuous, comprehensive monitoring of interactions between the planet's surface and atmosphere.

Nature Comment (2018), Nature 553, 21–23



Many developing countries, such as Mongolia, have rural economies, so projects that can provide farmers with up-to-date agricultural information are crucial.

## Steps to the digital Silk Road

Sharing big data from satellite imagery and other Earth observations across Asia, the Middle East and east Africa is key to sustainability, urges Guo Huadong.

Nature Comment (2018), Nature 554, 25-27

## Sharing big data from satellite imagery and other Earth observations

### Global SMEAR and Digital Belt & Road - DBAR

Academician, Academy Professor **Markku Kulmala**  
University of Helsinki, Faculty of Science  
Institute for Atmospheric and Earth System Research  
markku.kulmala@helsinki.fi

Academician, Professor **Guo Huadong**  
Chair of DBAR  
The Institute of Remote Sensing and Digital Earth  
Chinese Academy of Sciences  
guohd@radi.ac.cn



# SMEAR II station in Hyytiälä, Finland

Over **1200** different variables

**Continuous comprehensive observations**  
Station for Measuring Ecosystem - Atmosphere Relations



## SMEAR II

### Vegetation

Gas exchange  
Transport  
Growth  
Structure

### Atmosphere

Gas & Aerosol concentrations,  
composition, and fluxes  
Heat fluxes  
BL Meteorology  
Irradiance

CO<sub>2</sub>

Reactive  
gases

Heat

H<sub>2</sub>O

### Soil

Chemical & Physical processes  
Water & Element budget  
Biological activity

### Freshwater

Physical & Biological  
processes

### Forest

### Lake

### Peatland

**Flagship site** for  
integration:  
combines all IPCC  
components.

**Contributes to :**





# SMEAR STATIONS



SMEAR I Värrö  
Lapland 1990-



SMEAR III urban  
Helsinki 2004-



SMEAR IV  
Puijo 2008-



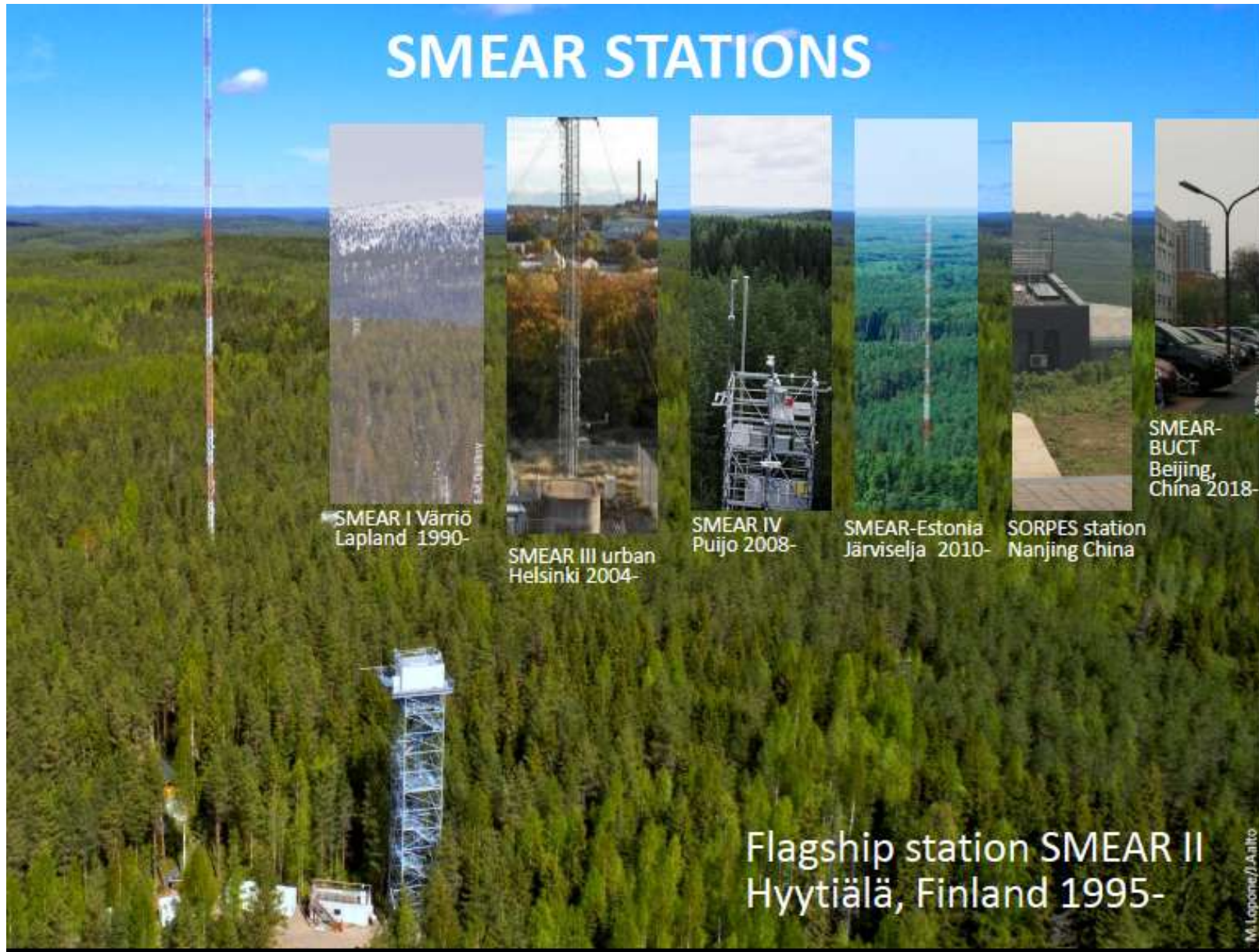
SMEAR-Estonia  
Järviselja 2010-



SORPES station  
Nanjing China



SMEAR-  
BUCT  
Beijing,  
China 2018-



Flagship station SMEAR II  
Hyytiälä, Finland 1995-

M. Lappone/J. Aalto



# Flagship station SMEAR II

N 61° 50.845', E 24° 17.686', altitude 180 m a.s.l.



Instrument cottage



Instruments on mast (130m) and towers to measure at different heights



Eddy Covariance systems



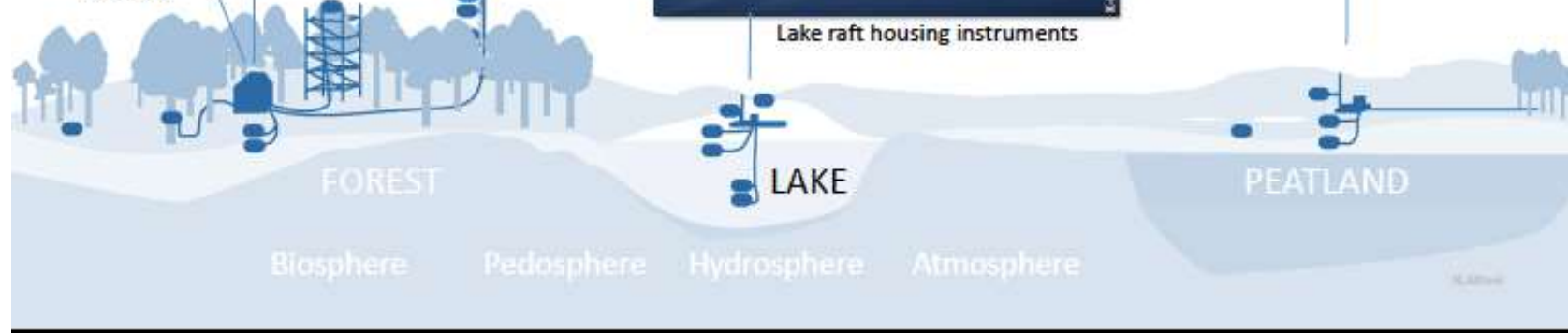
Aerosols



Shoot-level flux chamber



Lake raft housing instruments



Biosphere

Pedosphere

Hydrosphere

Atmosphere

FOREST

LAKE

PEATLAND

# Atmospheric nucleation / clustering processes

## I Small clusters and molecules

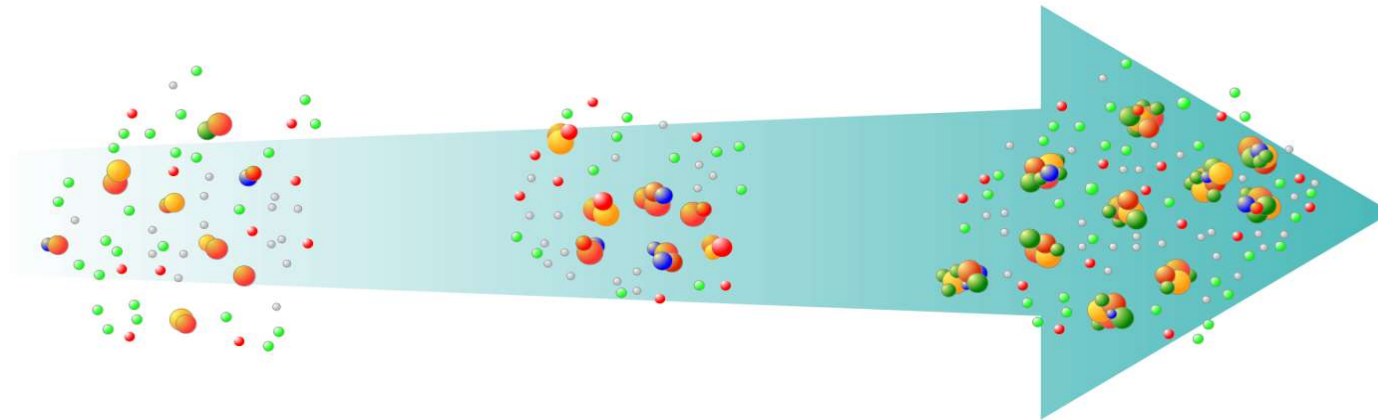
- No direct connection to NPF
- Very slow growth

## II Critical size for clustering

- Sulphuric acid and amines
- Slowly growing (<1 nm/h)
- Determines  $J_{1.5}$

## III Growing clusters

- Low-volatile organics
- Rapidly growing (~2 nm/h)
- Nano-Köhler
- Determines  $J_3$



### Key processes:

Gas-phase reactions,  
cluster formation/evaporation

Cluster stabilization

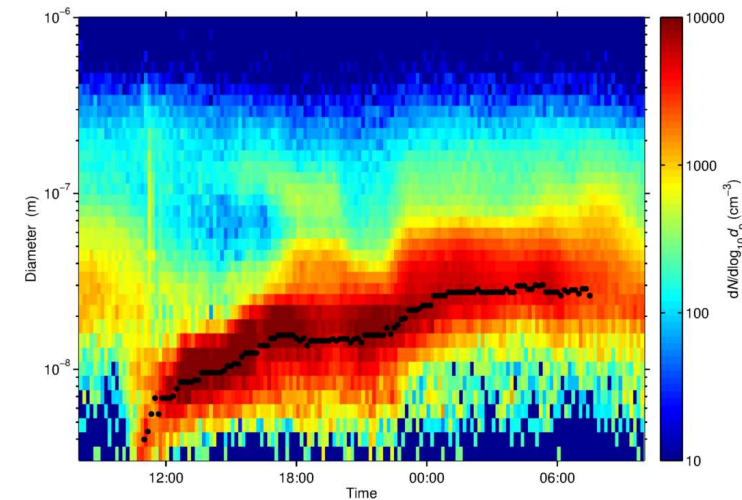
Activation of clusters for  
enhanced growth

300 ... 500 amu

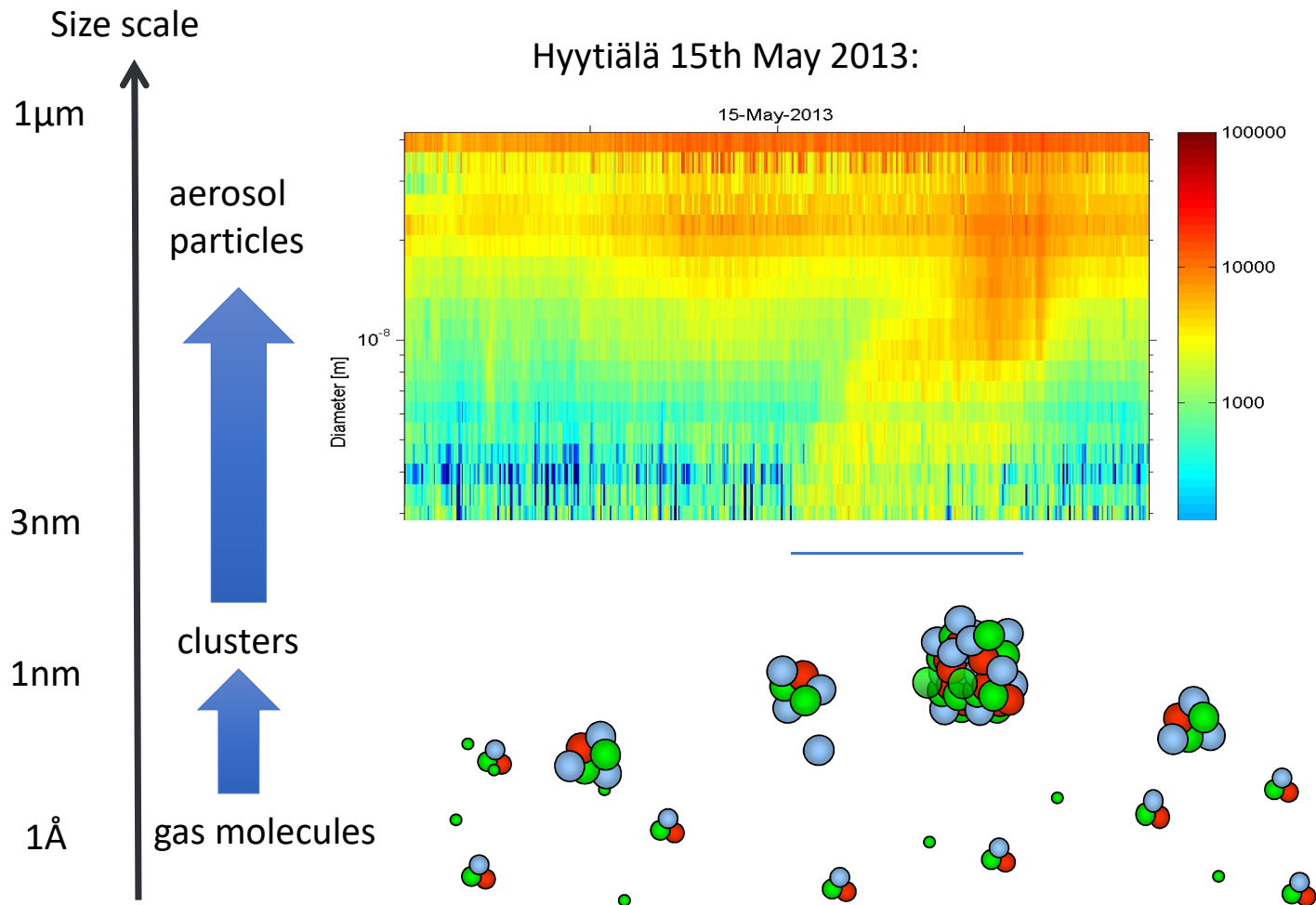
900 ... 2000 amu

1.1 ... 1.3 nm

1.5 ... 1.9 nm

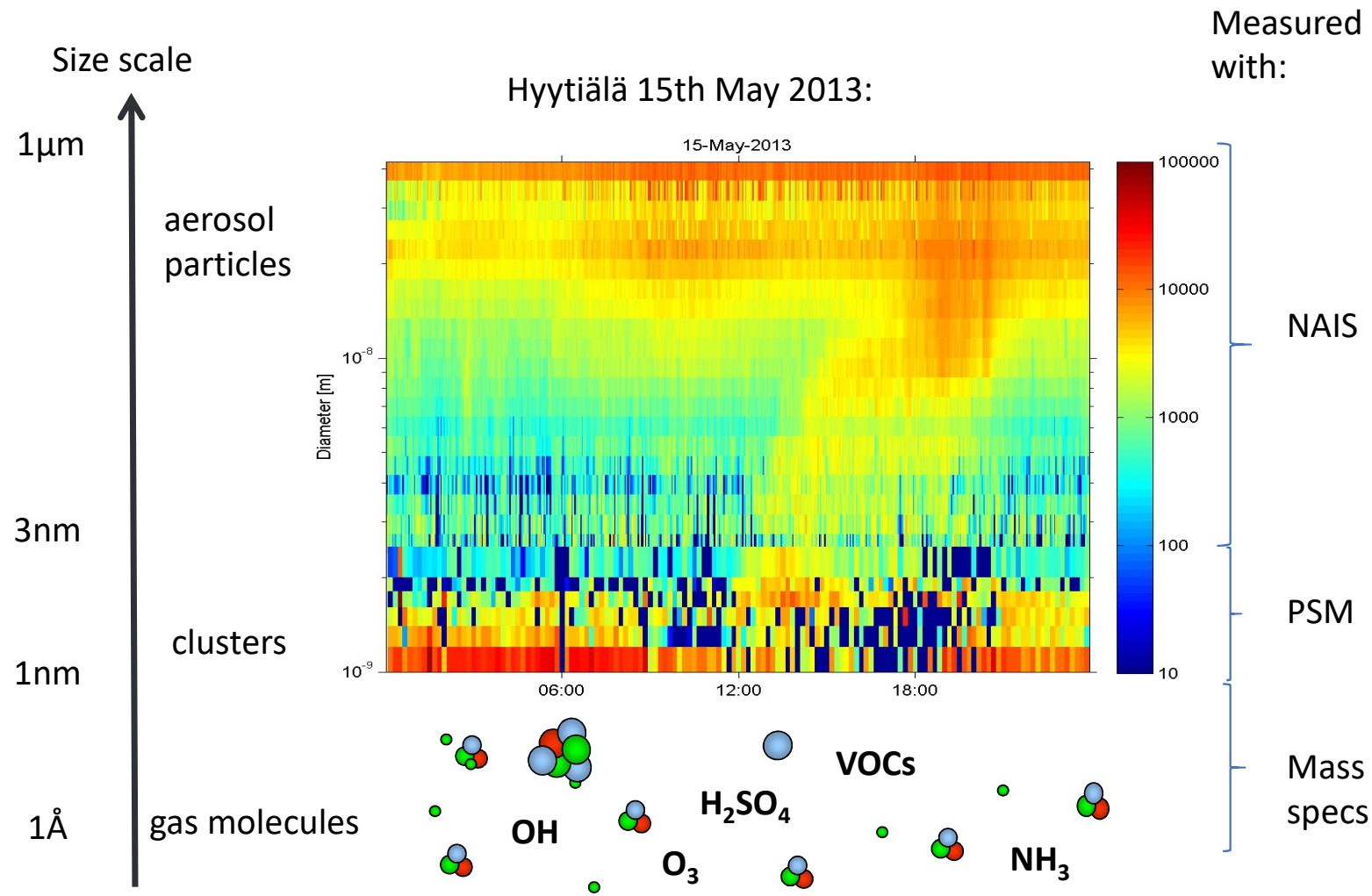


# Problem: how to measure new particle formation?



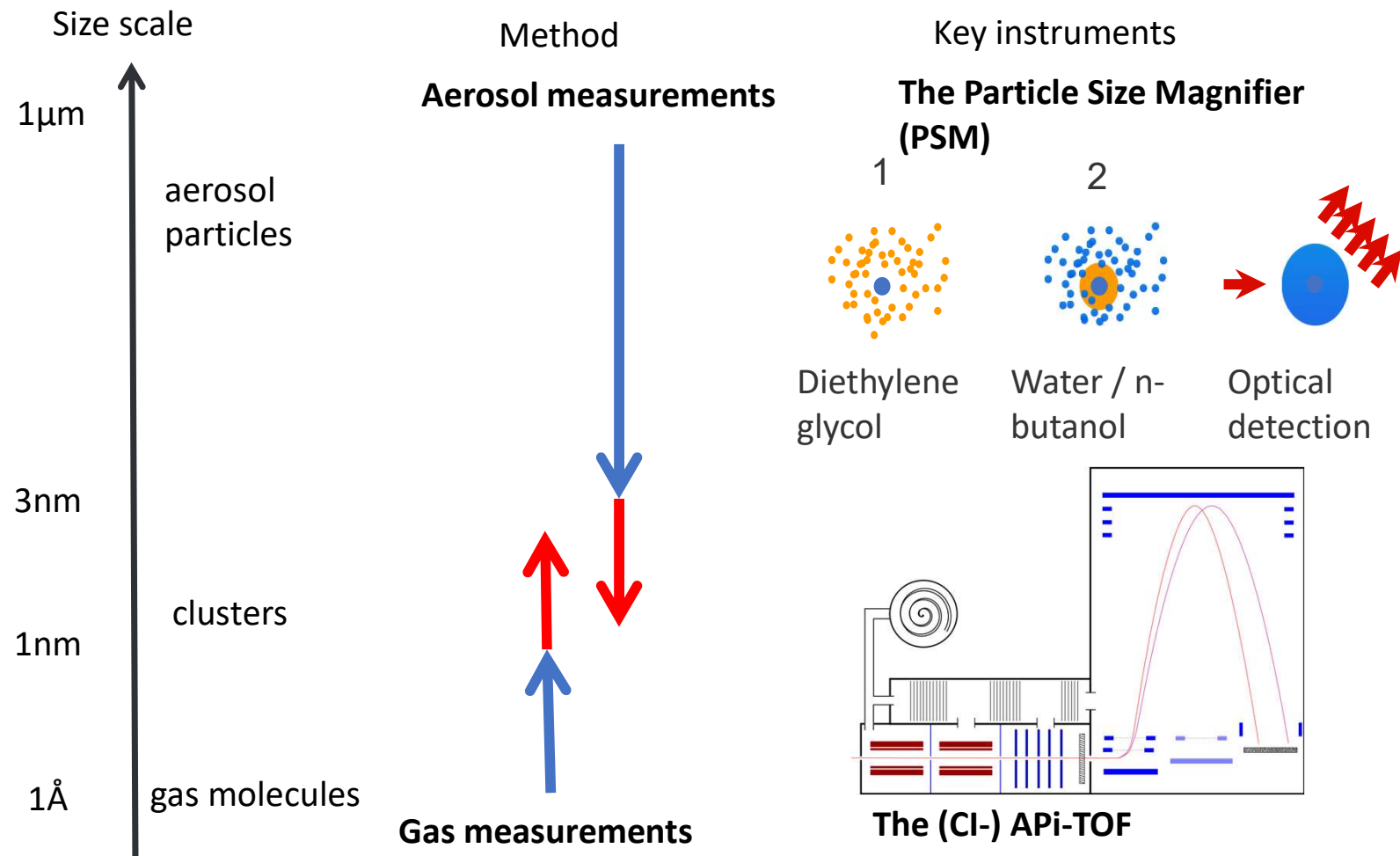


# Discovering the world below 3 nm



# New technologies for reaching the sizes of nucleating clusters

Slide courtesy of Katrianne Lehtipalo

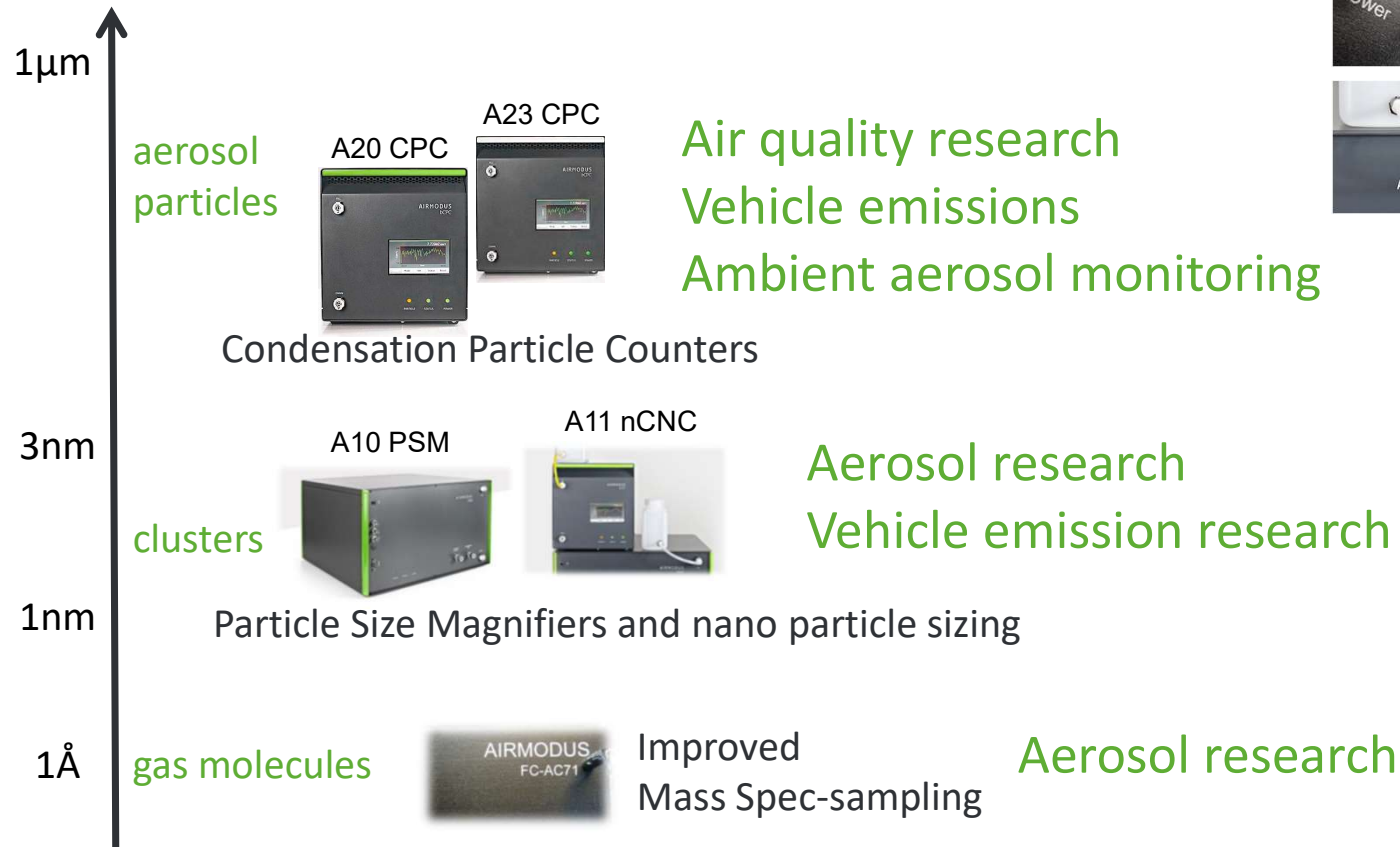


Spin-off companies

AIRMODUS

KÄRSA

# Airmodus products





KÄRSA

# Innovation in Molecular Explosives Detection

# KÄRSA



Molecular Analysis of  
Explosives with Tarkka TOF



Reduce queues and enhance  
security with K1000



# BUCT / HAZE supersite: Lab construction and facilities



- May 2017, the lab was a chemistry lab for education;

# Lab construction and facilities



- May 2017, the lab was a chemistry lab for education;
- Nov 2017, the lab was renovated



# Lab construction and facilities



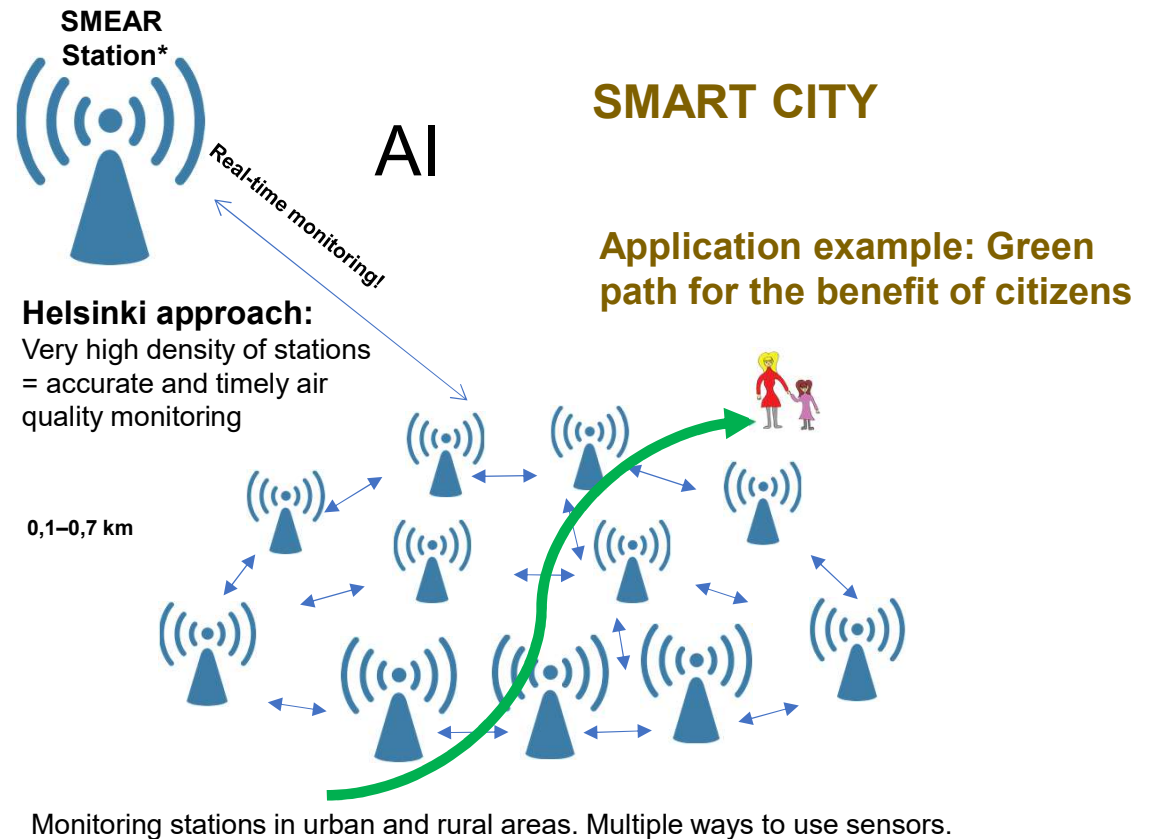
- May 2017, the lab was a chemistry lab for education;
- Nov 2017, the lab was renovated
- Feb 2018, the lab is well equipped with start-of-the-art instruments

# HIGH DENSITY OF MEASUREMENT STATIONS & AUTOMATICALLY CALIBRATED SENSORS PROVIDING REAL-TIME MEASUREMENT DATA

- Low cost mini- & micro-sensors and base stations across the environment supported by 4G NB-IOT network leading to a viable 5G service
- Field calibration by highly accurate atmospheric science SMEAR Station

## Enables multiple applications:

- City planning, health and wellbeing, wearable and fitness devices, vehicular technology, mobile apps, HD-maps
- High quality maps and calibration technique that takes into account correlations across environments.



SMEAR\* = Station for Measuring Earth Surface-Atmosphere Relations (SMEAR)  
<https://www.atm.helsinki.fi/SMEAR/>

# UIA HOPE (2018-2021)

- **Partners:** City of Helsinki, University of Helsinki (INAR, Computer and Geo Sciences), Forum Virium Helsinki, Vaisala, HSY, Useless and FMI.
- **HOPE (Healthy Outdoor Premises for Everyone)** is a project funded by European Union Urban Innovative Actions (UIA) programme.
- In HOPE, low-cost sensors will be distributed in Vallila-Kumpula, Jätkäsaari and Pakila areas in Helsinki and their data will be managed with 5G networks and FMI-ENFUSER model.

## Current activities:

- 100 portable University of Helsinki sensors in three different locations
  - First air quality monitoring period May-June and 30 users from Jätkäsaari; clip-on sensors with Mobile APP
  - #ilmanlaatuajokot -people to be found by FV
- MegaSense platform connected to FMI ENFUSER **including 15 new Vaisala site**
- INAR led AQ2.0



SMEAR tower in Kumpula



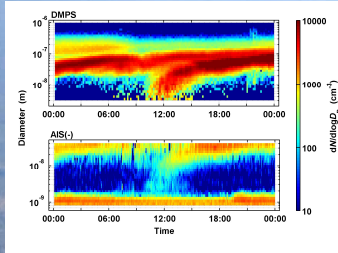
University of Helsinki, portable sensors for HOPE



# HOPE-crowd sourcing air quality data

- Aerosol particles (PM<sub>2.5</sub>, PM<sub>10</sub>)
  - Ozone, carbon monoxide, nitrogen dioxide
  - Temperature, pressure, relative humidity
  - Location, movement and light intensity
- 
- 100 sensors deployed in Jätkäsaari neighborhood
  - "Air quality troops", ilmanlaatujoukot





## Main message:

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SMEAR II station  
(boreal) 1995 -



Towards  
coordinated  
continuous  
comprehensive  
Global Earth Observatory



**Vipuvoimaa**  
**EU:lta**  
2014–2020



**Euroopan unioni**  
Euroopan aluekehitysrahasto

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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.



## Prof. Tuukka Petäjä

- Full Professor of experimental atmospheric sciences
- Vice director of INAR institute
- Head of Aerosol laboratory, Head of Värriö sub-arctic research station and SMEAR research infrastructure
- Pan Eurasian Experiment (PEEX) Science director
- over 350 peer reviewed publications, 17 in Nature or Science
- H-factor 60, total number of citations over 15000
- Vaisala award for development of scientific instrumentation for nanoparticles and trace gases
- Thompson Reuters Highly cited scientist since 2014
- Academician, International Eurasian Academy of Sciences

