UNIVERSITY OF TARTU

Emissions
~~Air pollution~~ from land sources as a driver for Earth system changes in the Baltic Sea region

Heikki Junninen

University of Tartu
Institute of Physics, Laboratory of environmental physics

University of Helsinki
Institute for Atmospheric and Earth System Research/Physics

Euroopa Liit
Euroopa Regionaalarengu Fond

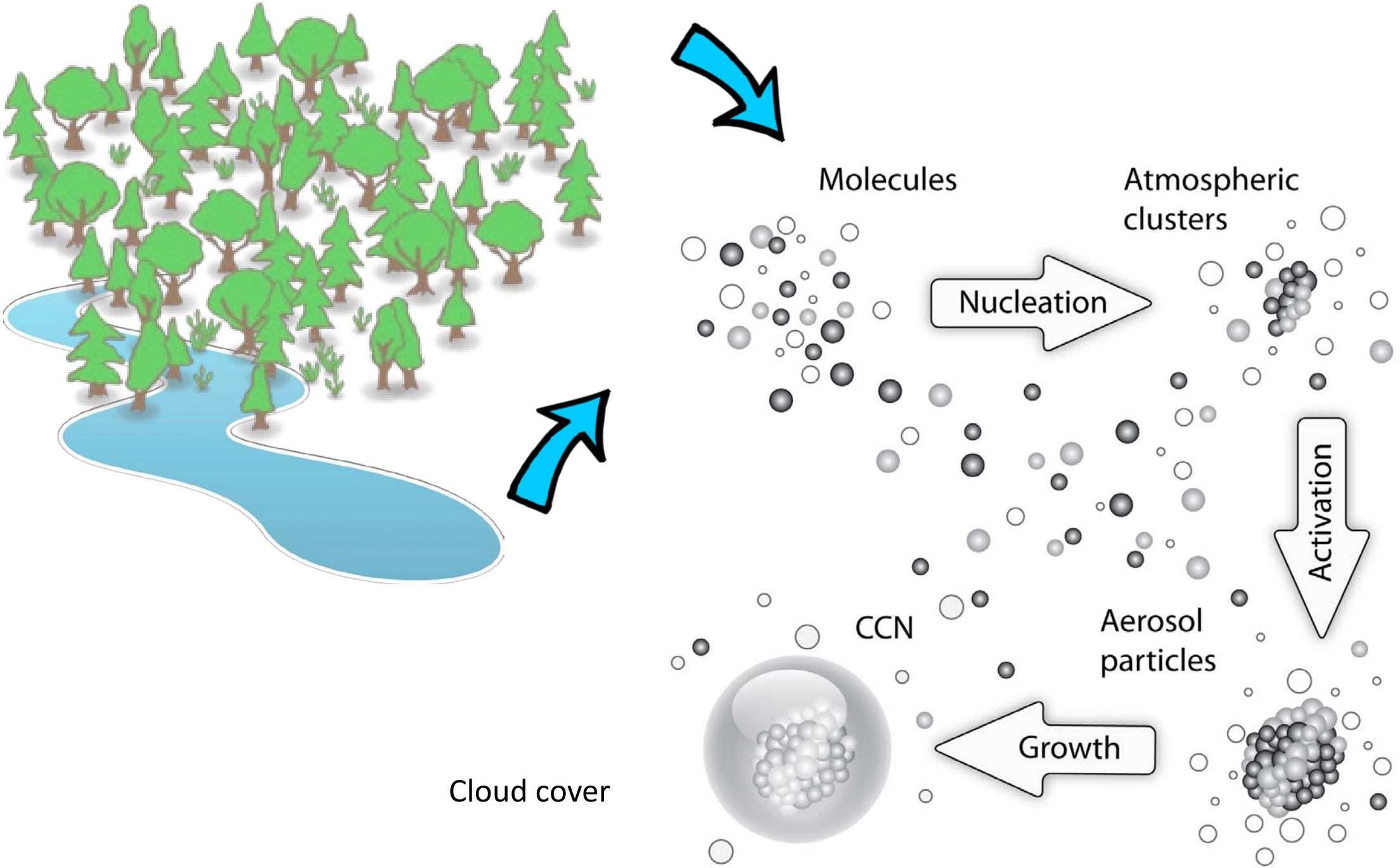
Eesti tuleviku heaks

Mobilitas+

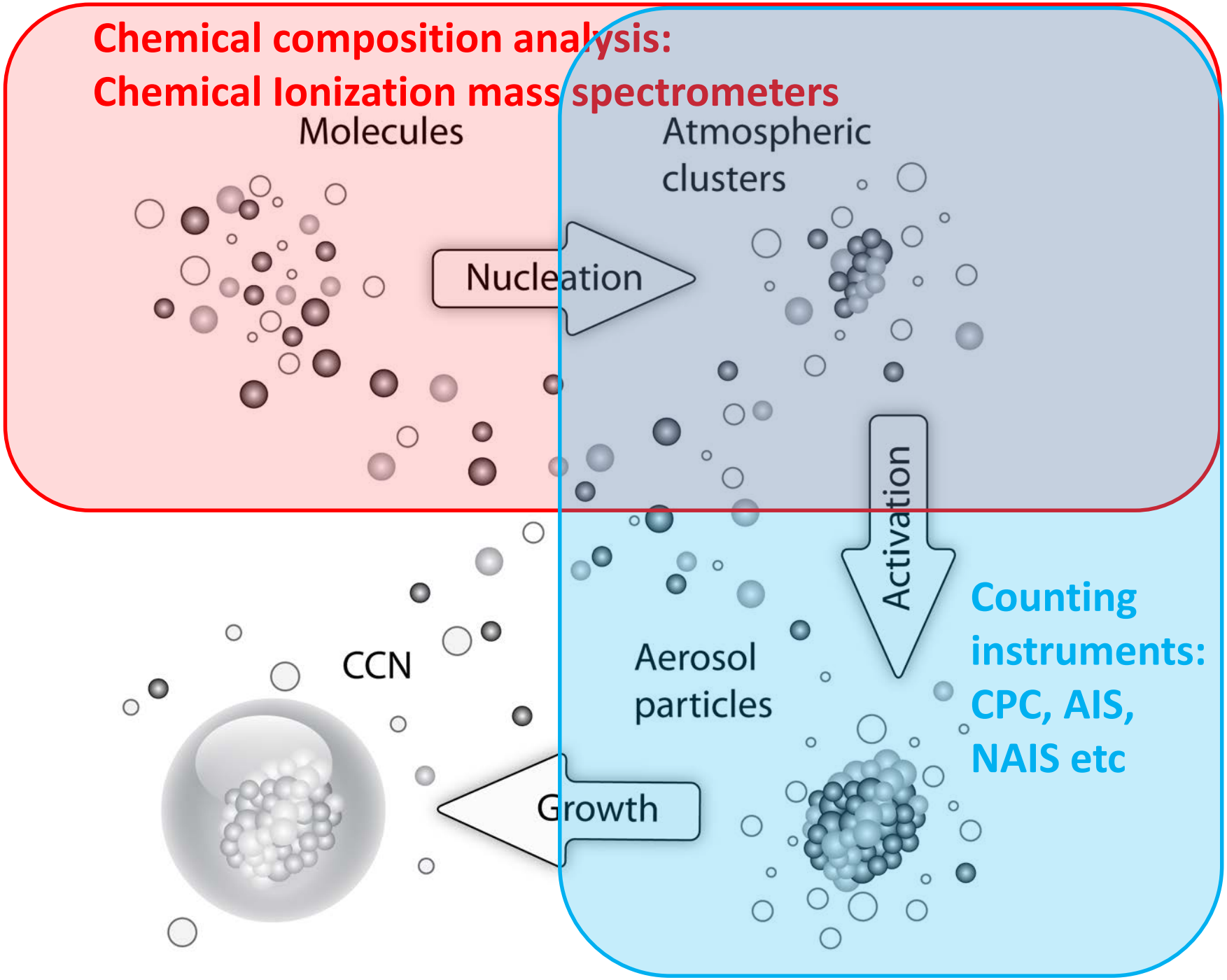
MOBTT42

Baltic Earth Workshop

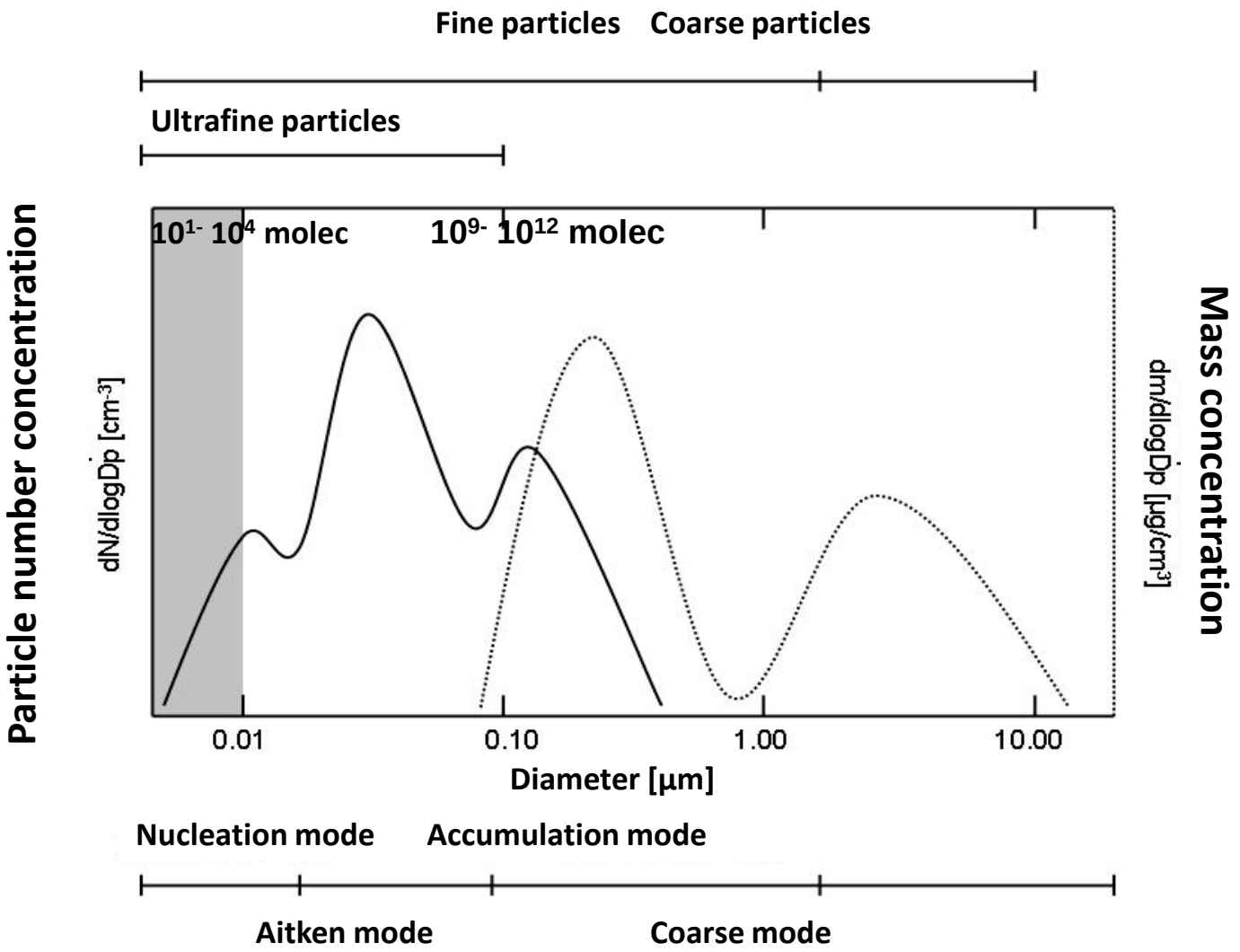
Tallinn, 2018


Molecules
Atmospheric clusters
Nucleation
Activation
CCN
Aerosol particles
Growth

Cloud cover


Chemical composition analysis:
Chemical Ionization mass spectrometers
Molecules
Atmospheric clusters
Nucleation
Activation
Aerosol particles
CCN
Growth
Counting instruments: CPC, AIS, NAIS etc

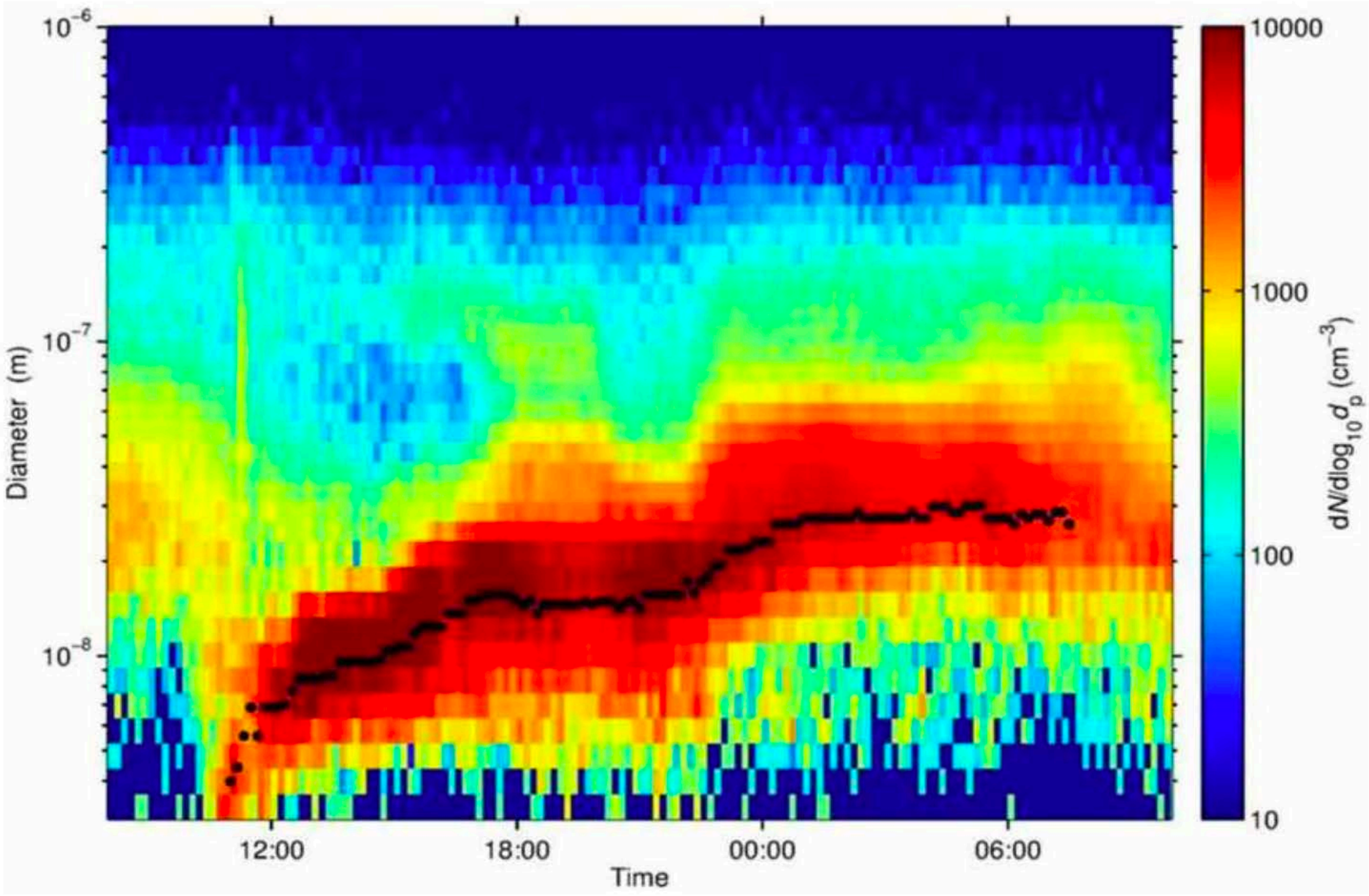
Aerosol size distribution



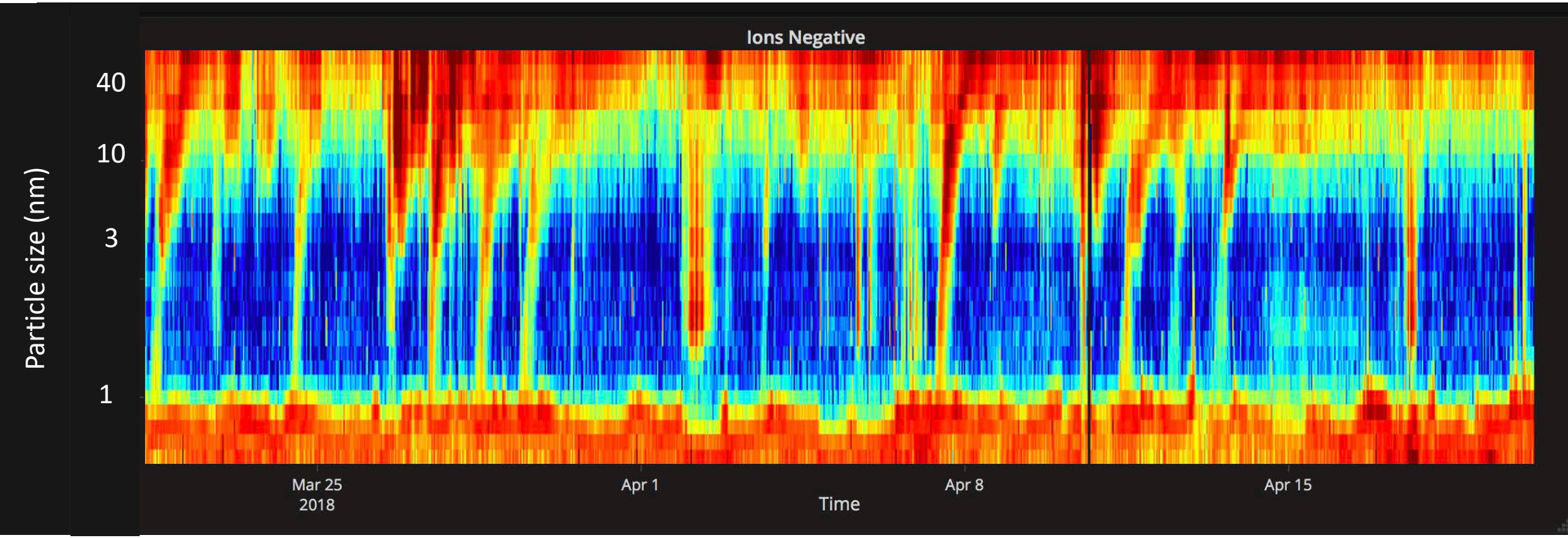
Air: 2.5e19 molecules/cm3

New particle formation events.

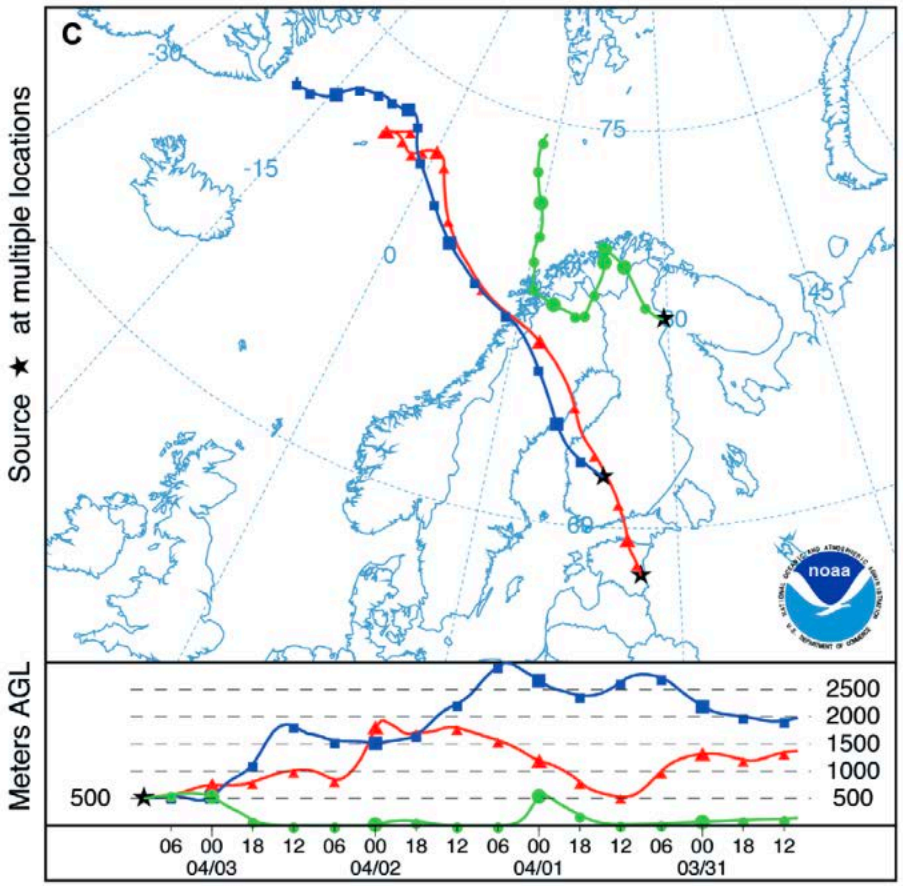
Particle growth about 3nm/h

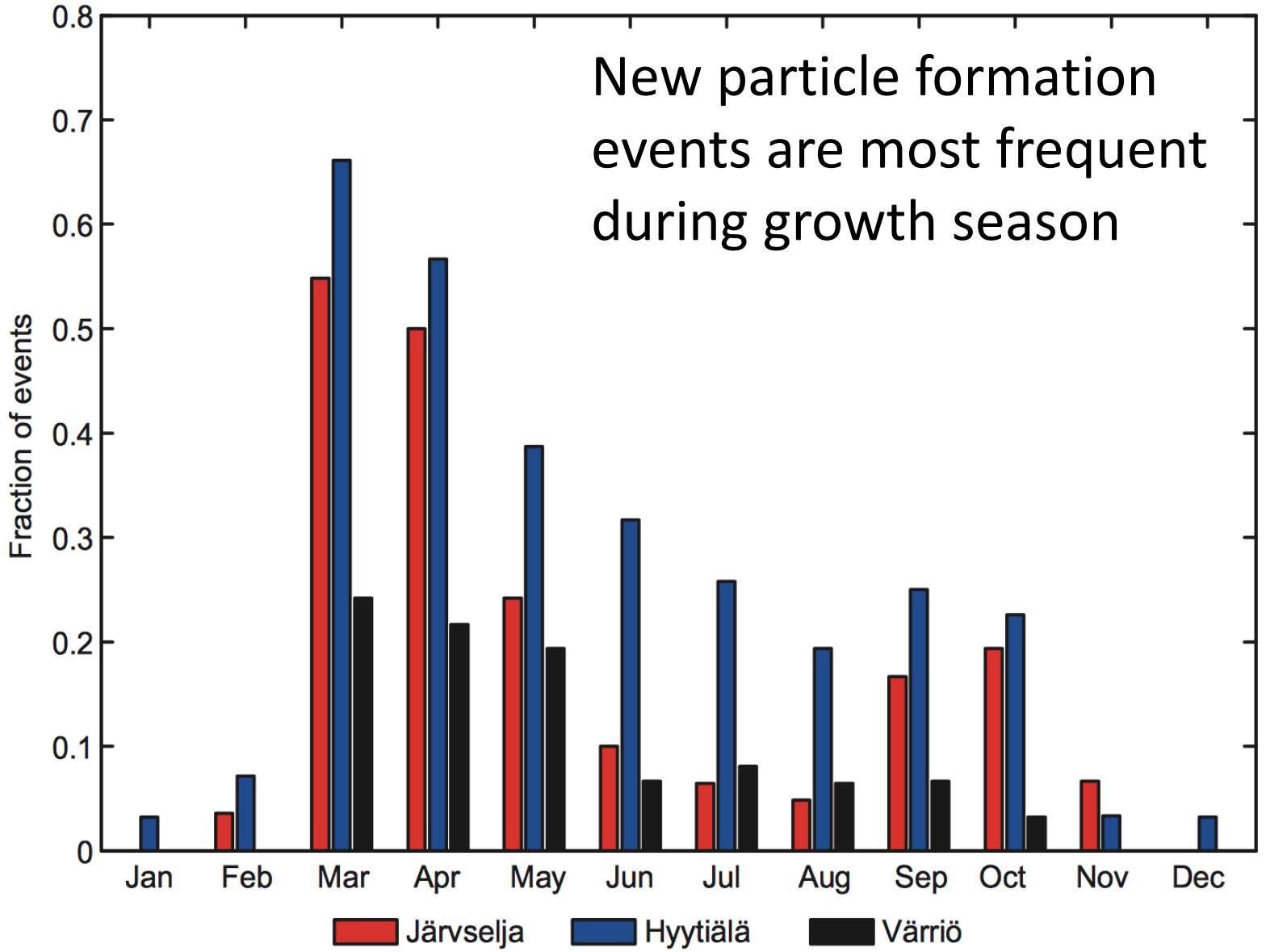


Example time series of aerosol size distributions in Järvselja SMEARestonia station



New particle formation is a large scale phenomenon





Vana et al. 2016 BER

Why/how the bursts happen?

- Atmosphere must produce low volatility components in time scale of seconds.
- Well known reaction that produces low volatility compound:

$$SO_2 + OH\bullet + H_2O \rightarrow H_2SO_4 \downarrow$$

Clustering (stabilization) with bases allows growth through NH3 or DMA addition

$$H_2SO_4 + NH_3 \rightarrow (H_2SO_4)_x(NH_3)_y$$

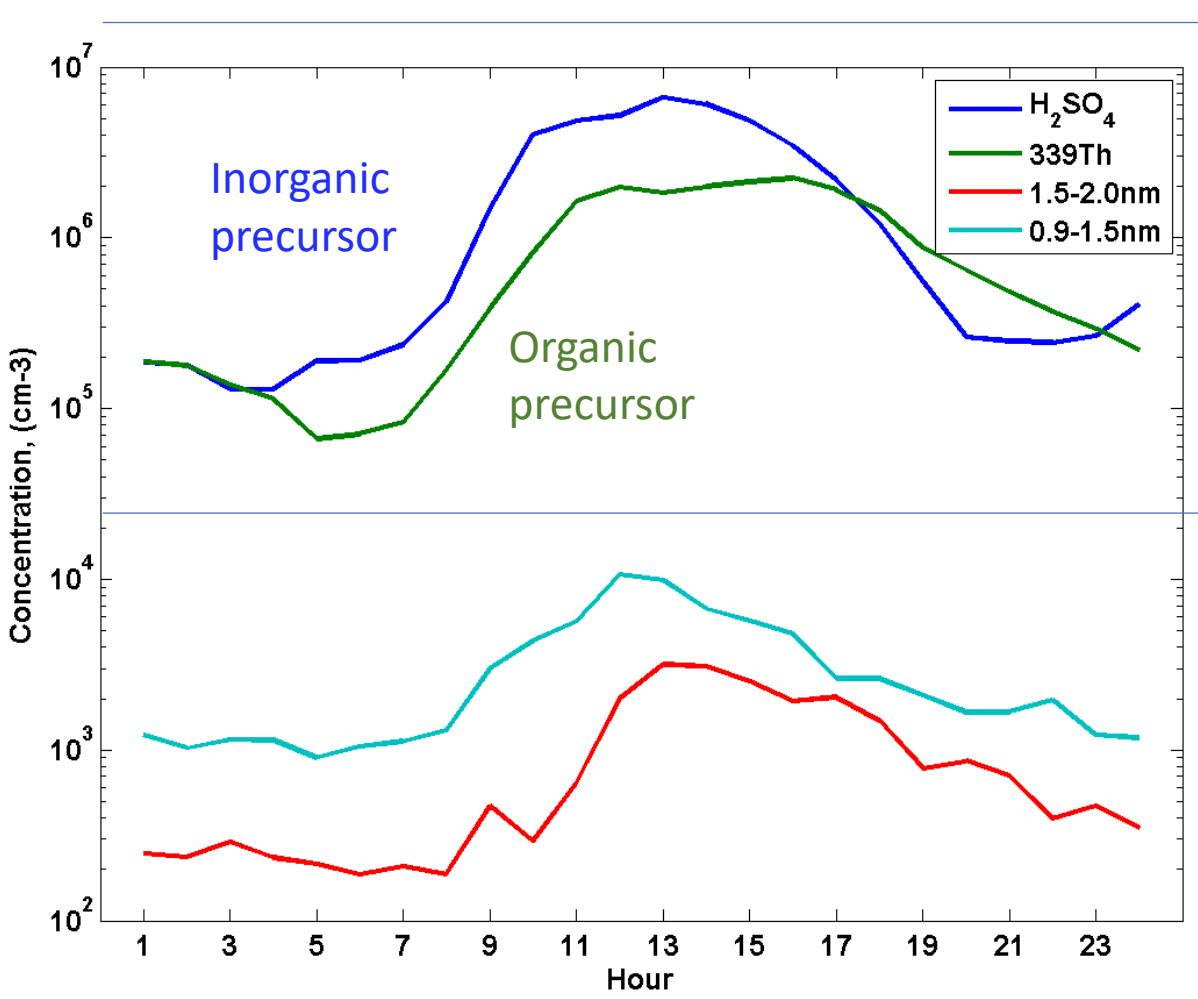
Can we detect these claimed clusters and molecules?

Concentrations of particle precursors are extremely low
Concentration of clusters still much lower!!! How to measure?

Air (1atm) contains $2.5*10^{19}$ molecules/cm^3

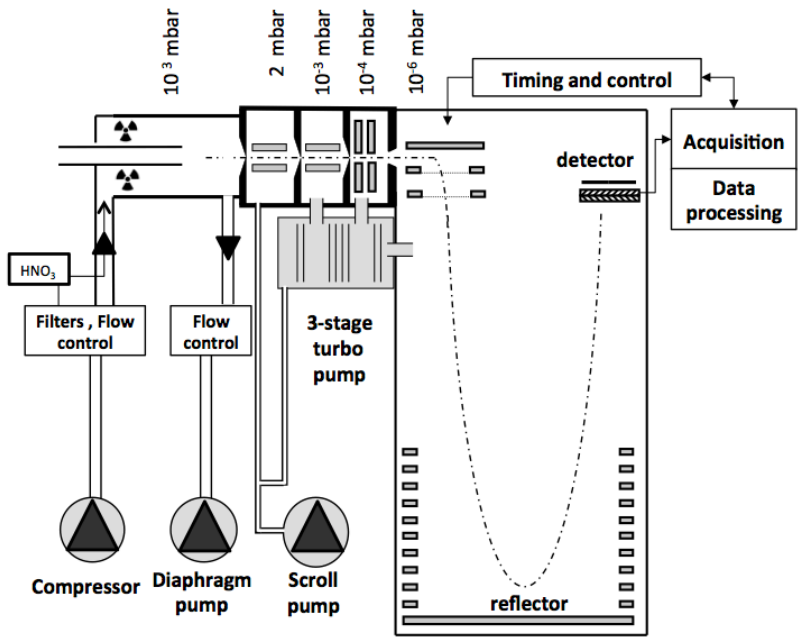
How much is a part per quadrillion (ppq) 10^{-15}?

- Diameter of hair to distance to Sun.
- Area of a shoe to area of earth.
- Concentration of climatically relevant atmospheric clusters.



Kulmala et al., 2013 Science

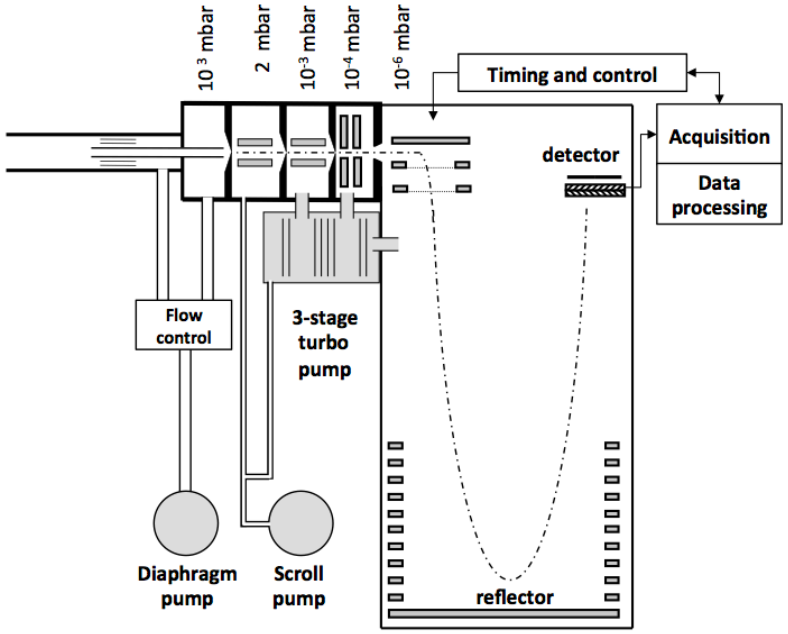
In-situ composition measurements of nano-clusters



Chemical ionization time-of-flight mass spectrometry (CI-APiTOF) with calibration unit

Jokinen et al. 2012 ACP

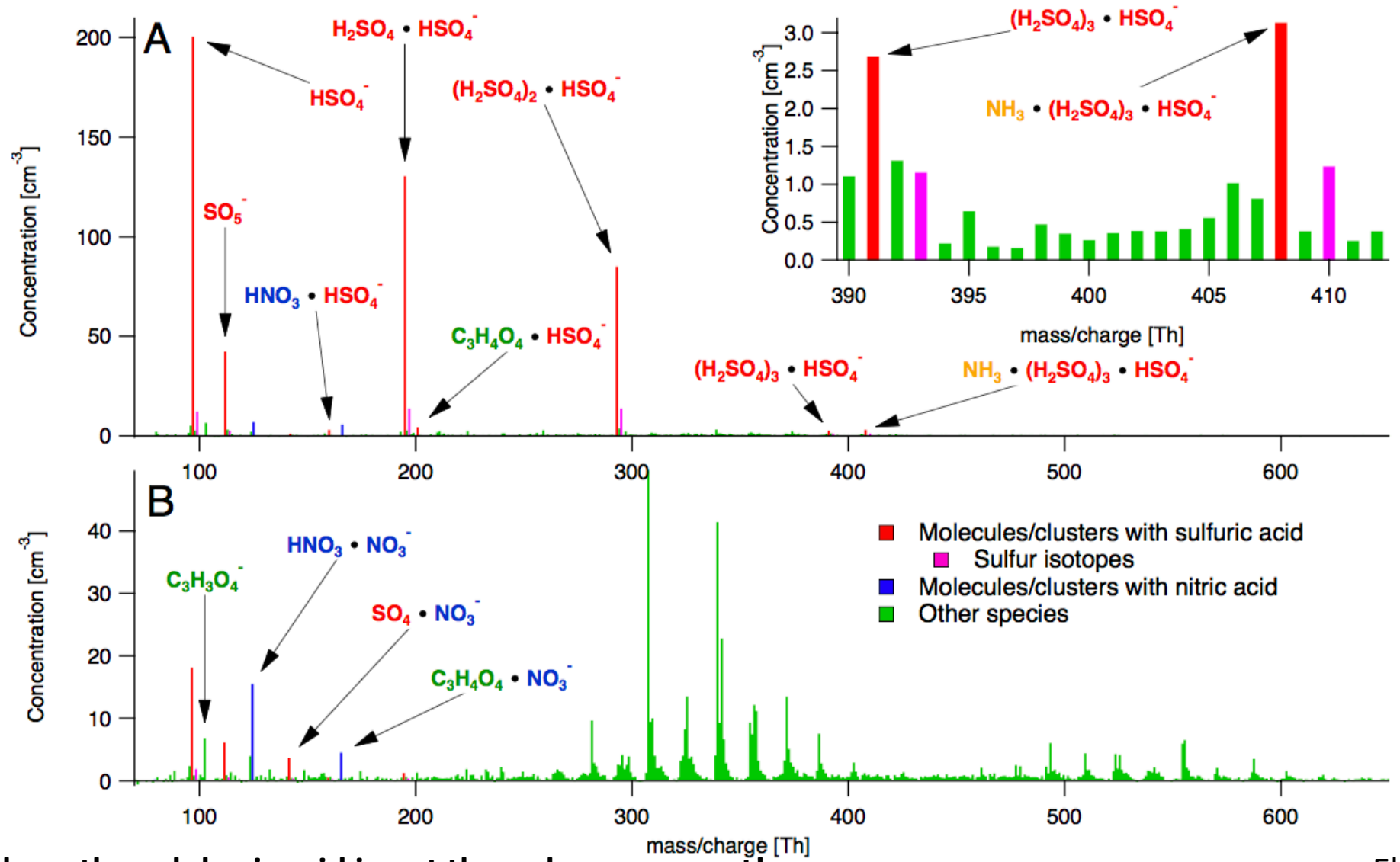
or



Atmospheric pressure interface time-of-flight mass spectrometry (APiTOF)

Junninen et al. 2010 AMT

In-situ atmospheric measurements for chemical composition of atmospheric ions



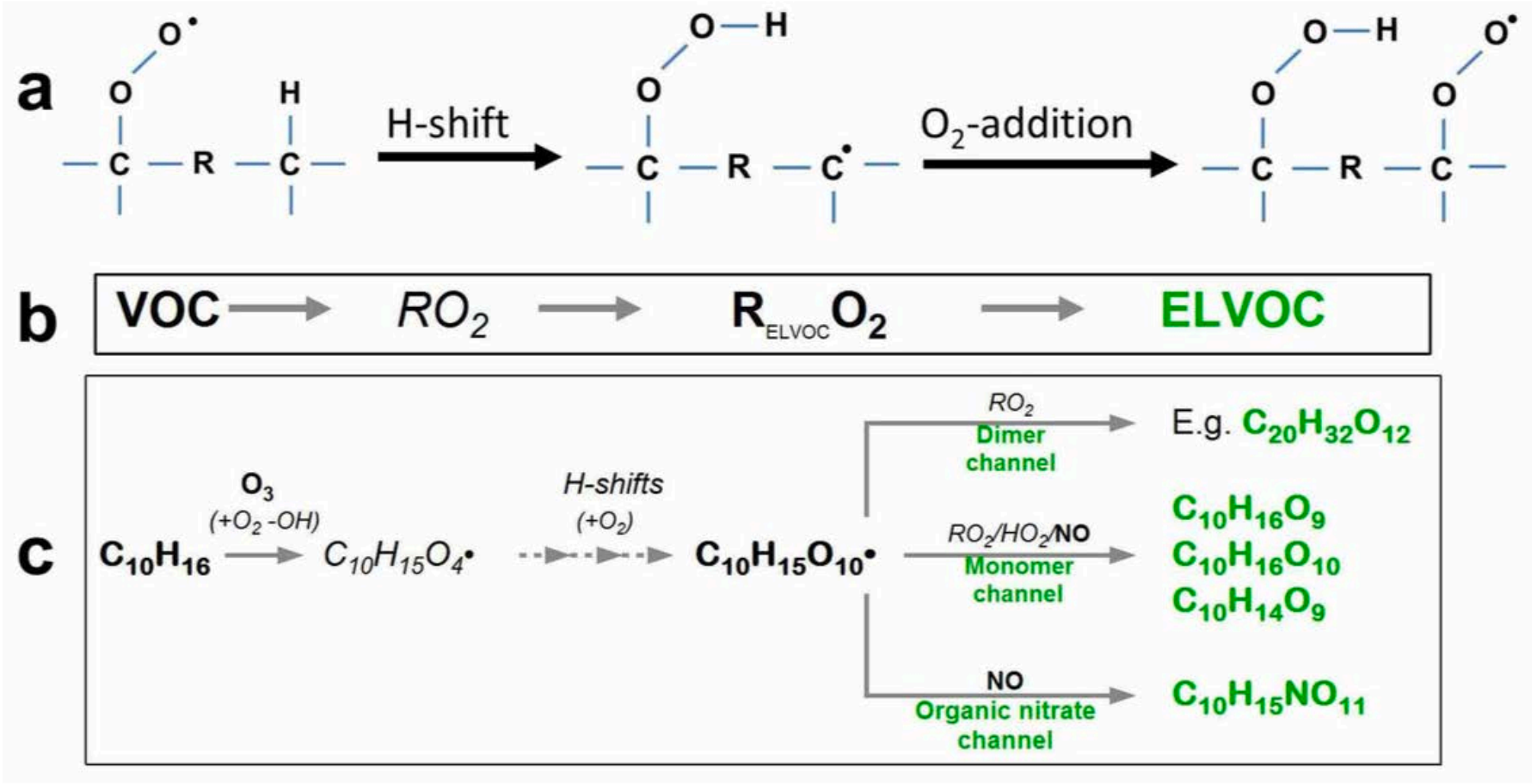
Sunny conditions

Not-sunny conditions

In atmosphere the sulphuric acid is not the only component!

Ehn et al 2010 ACP

Highly oxidized organic molecules (HOM)
Extremely Low volatility organic compounds (ELVOC)

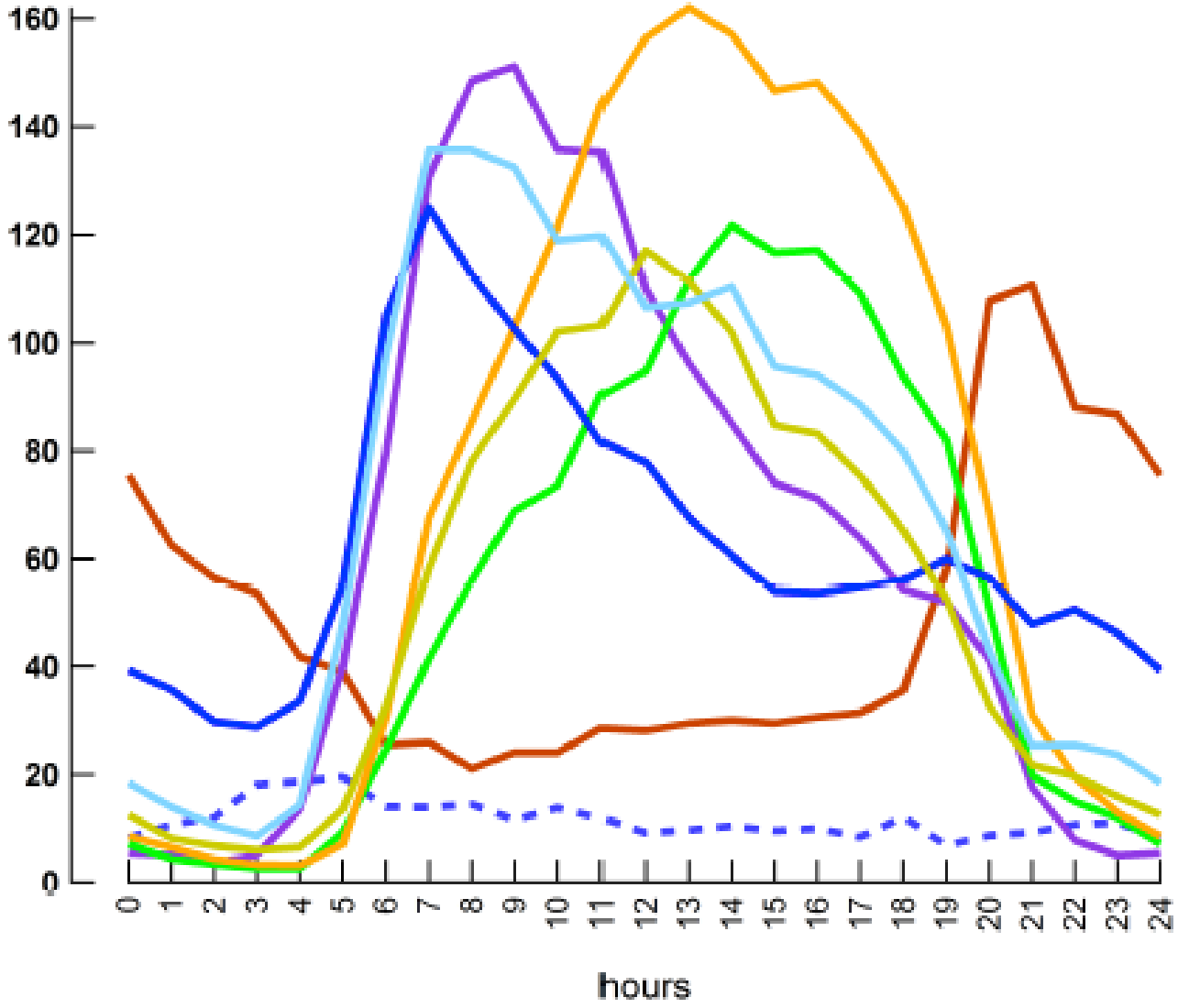


Ehn et al. 2014 Nature

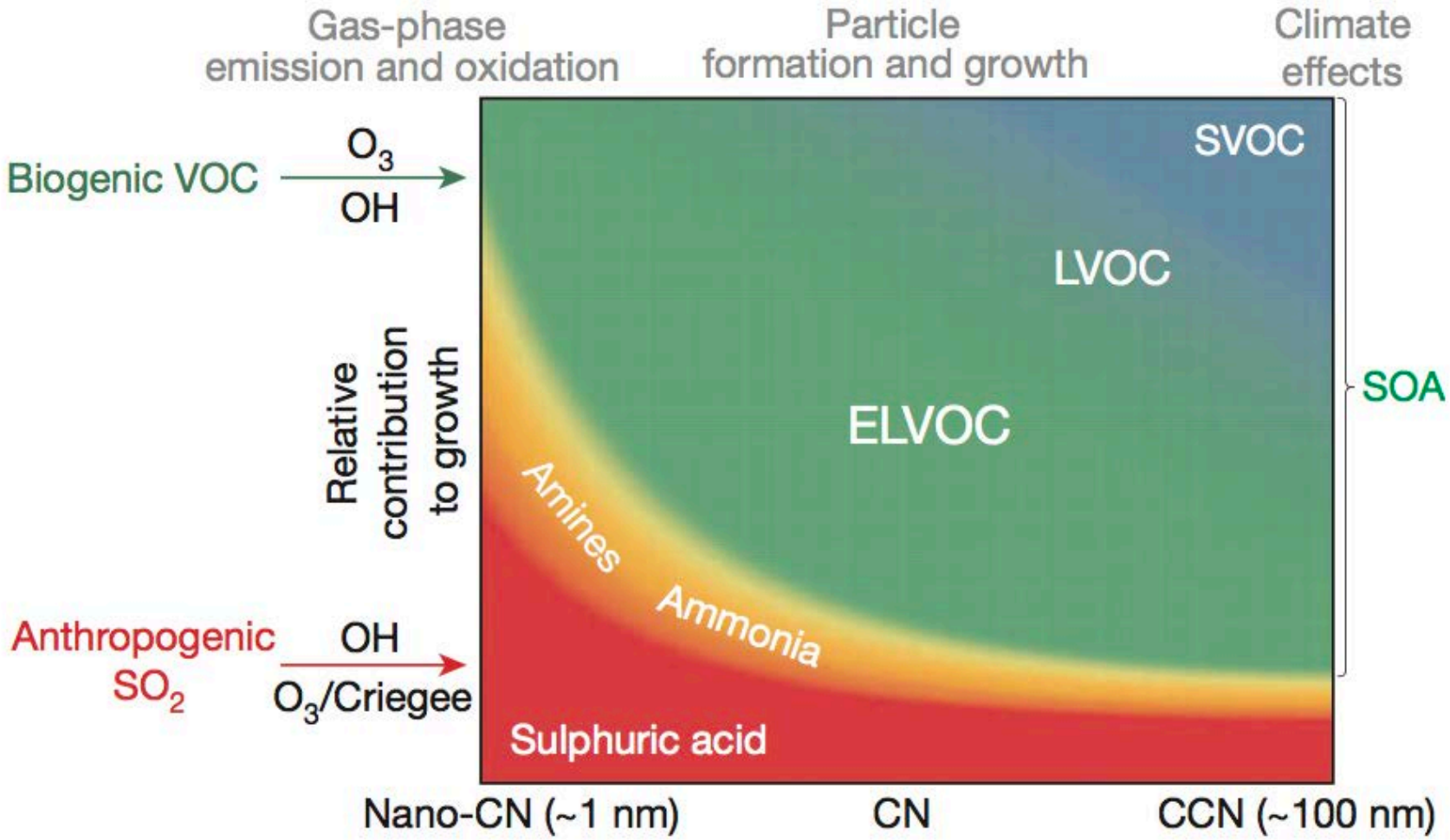
Factor analysis of mass spectrometer spectra.

Diurnal patterns of chemical components of atmospheric gases and clusters

Great variability along the day.



Importance of organic compounds on particle formation and growth

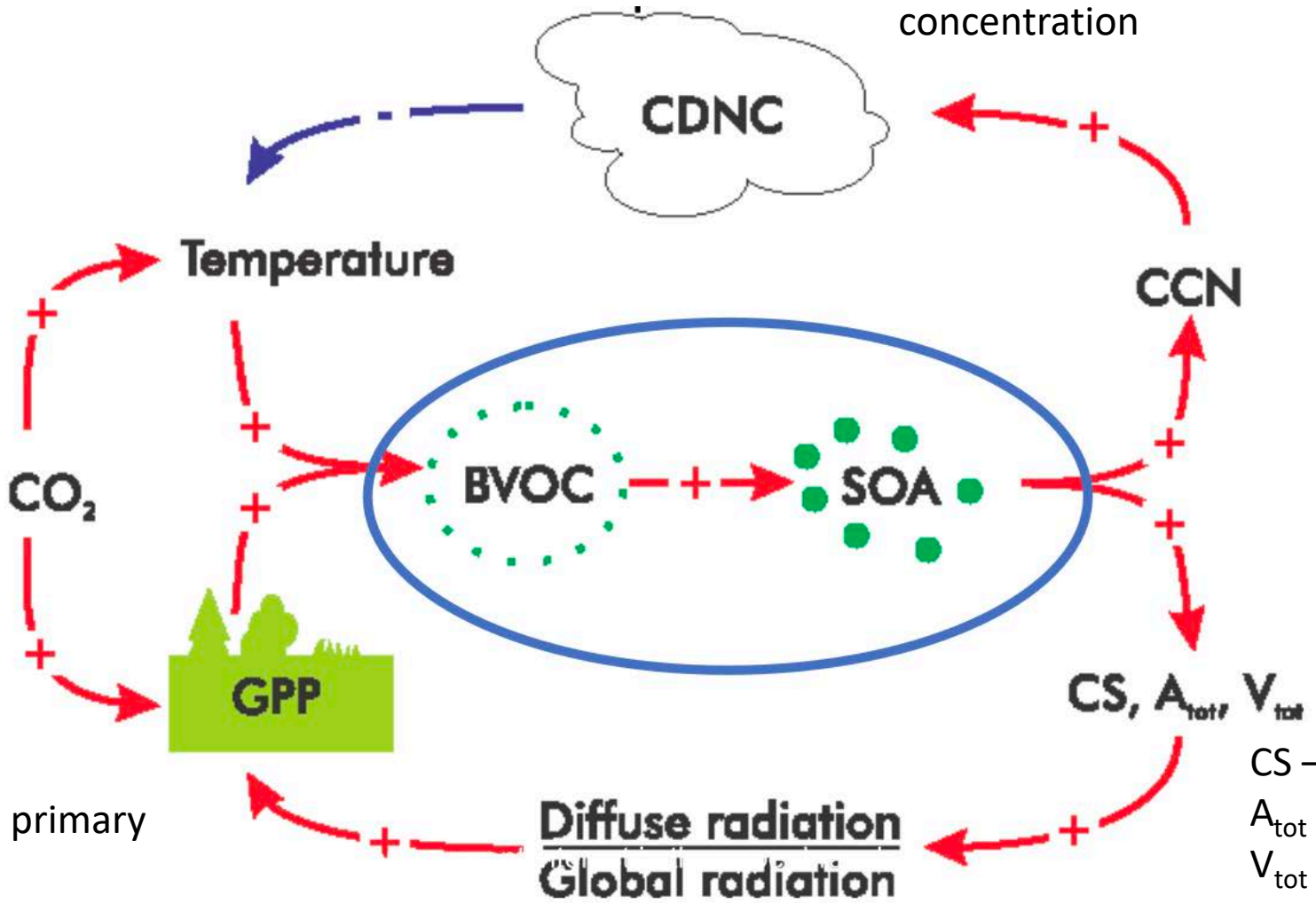


Sulphuric acid alone is not enough!

Ehn et al. 2014 Nature

COBACC (COntinental Biosphere-Aerosol-Cloud-Climate) feedback loop

CDNC – cloud droplet number concentration



CCN – cloud condensation nuclei

SOA – secondary organic aerosol

BVOC – biogenic volatile organic compounds

GPP – gross primary product

CS – Condensation sink
A_{tot} – total aerosol area
V_{tot} – total aerosol volume

Kulmala et al. 2014 BER

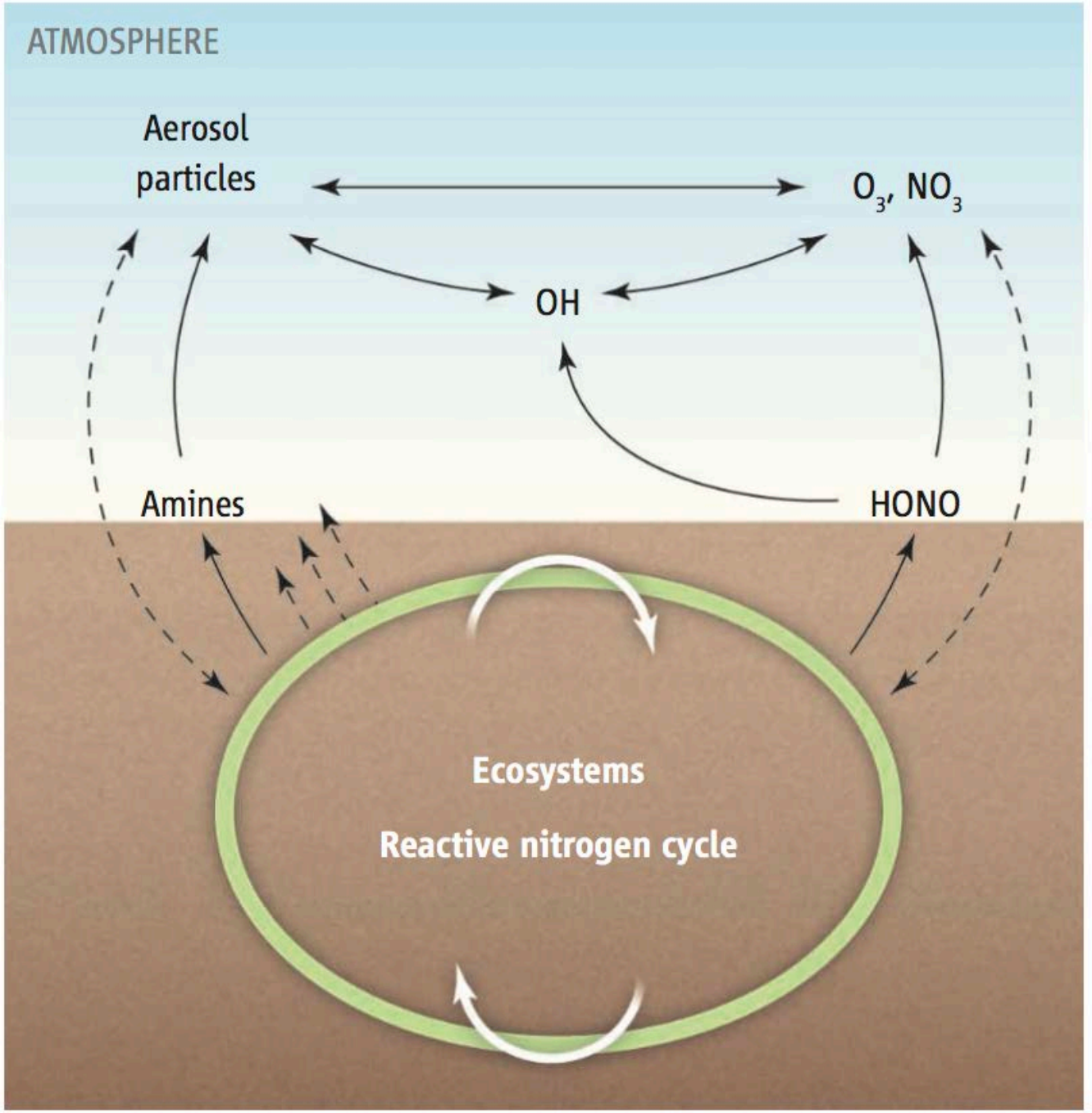
Emission of nitrous compounds from soil.

Effect is two fold:

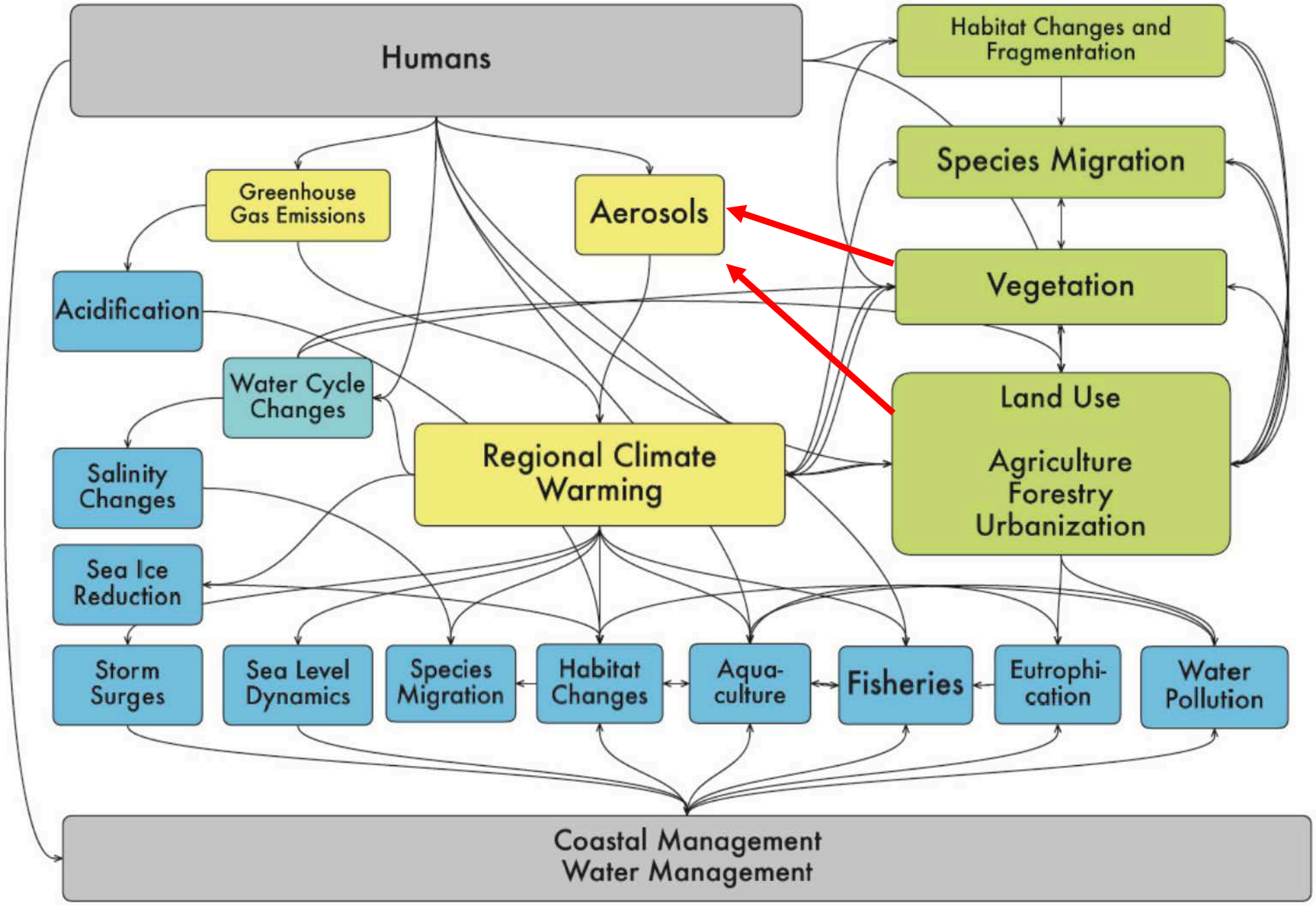
1) Source of stabilizing agent (Amines, Ammonia)
2) Source of oxidizing agent

HONO-> OH

What is the effect on climate when:
Global use of of fertilizers increases?
Global temperature increases?



Kulmala et al. 2011 Science


Humans
Habitat Changes and Fragmentation
Species Migration
Greenhouse Gas Emissions
Aerosols
Vegetation
Acidification
Water Cycle Changes
Land Use
Agriculture
Forestry
Urbanization
Regional Climate Warming
Salinity Changes
Sea Ice Reduction
Storm Surges
Sea Level Dynamics
Species Migration
Habitat Changes
Aqua-culture
Fisheries
Eutrophi-cation
Water Pollution
Coastal Management
Water Management