Current Issues in Aerosol Science: Recent Progress and New Challenges

Urs Baltensperger
Laboratory of Atmospheric Chemistry
Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

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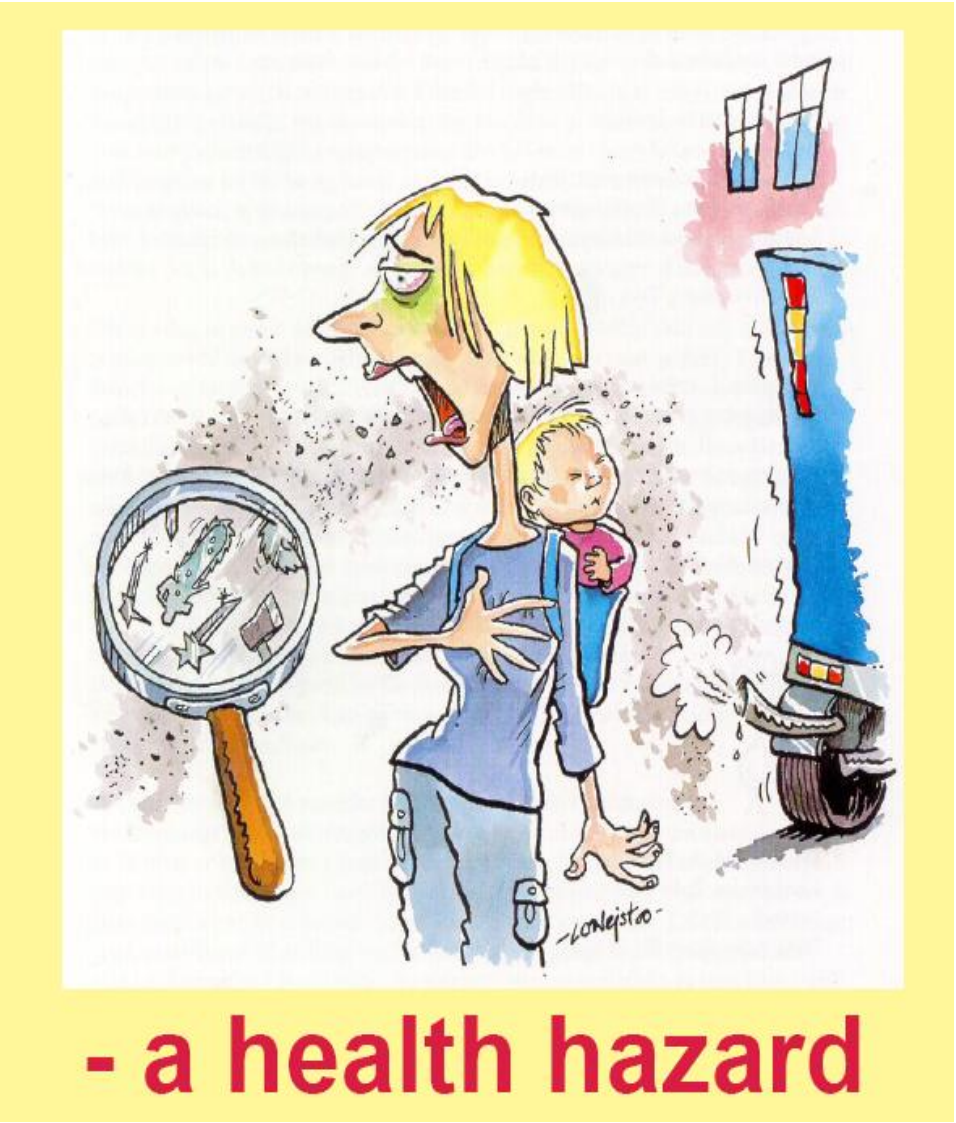
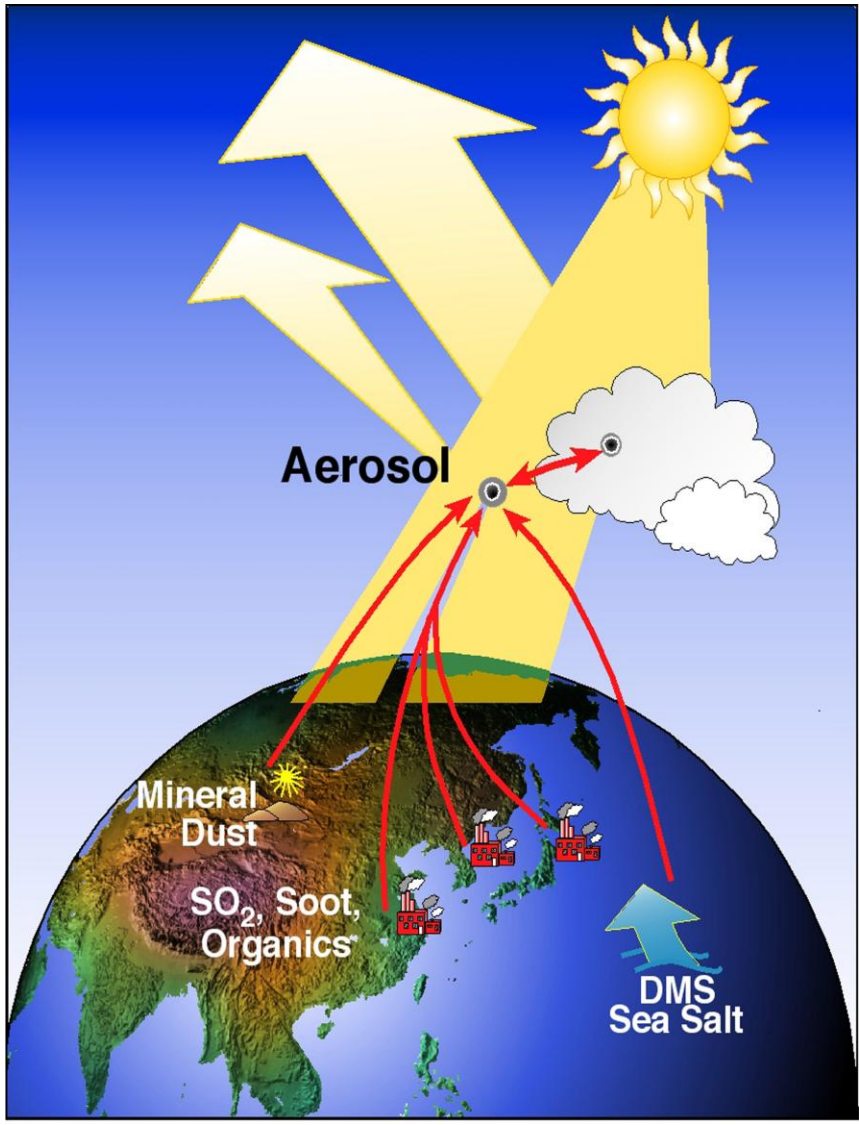
Aerosols affect our health and have an impact on climate



Source: www.ecocouncil.dk



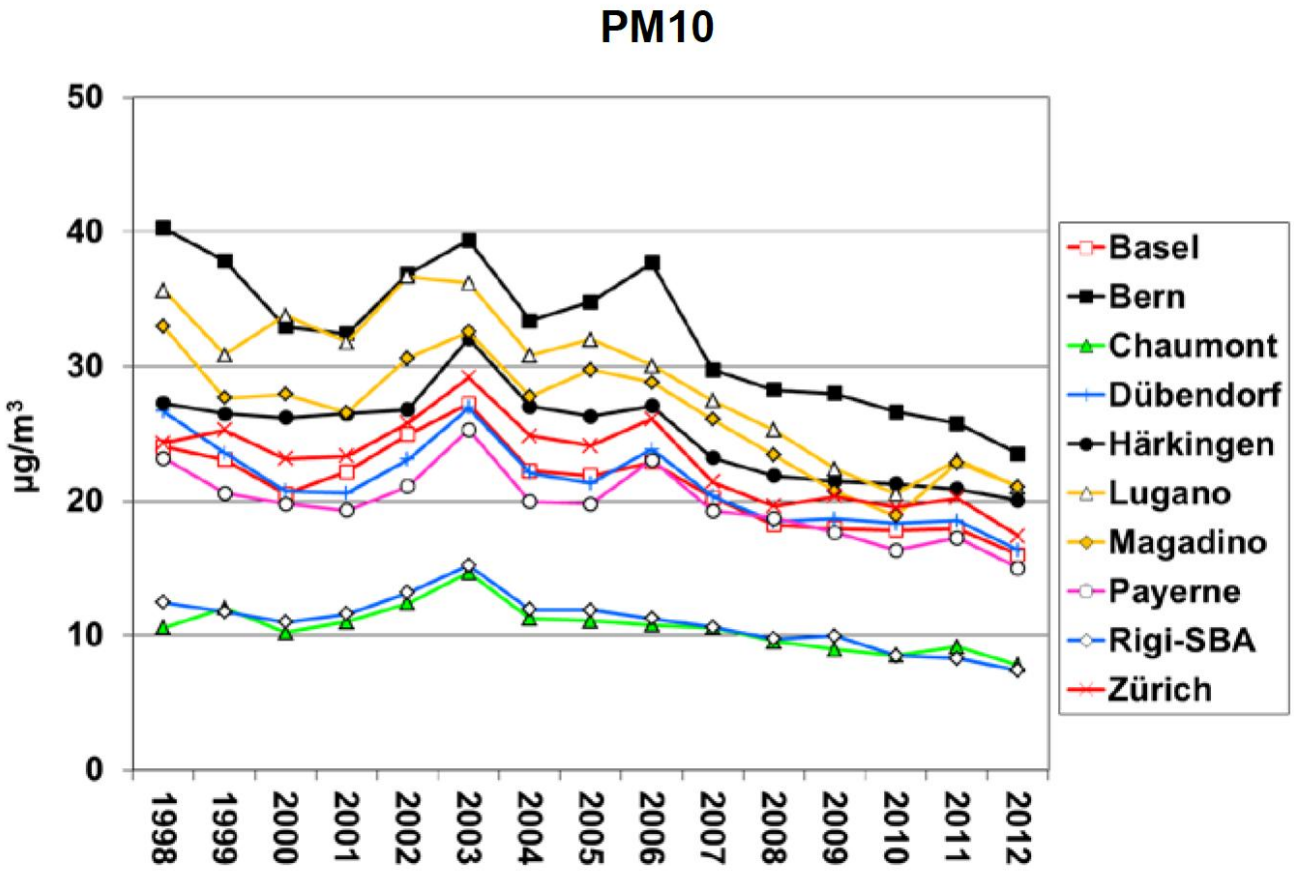
http://saga.pmel.noaa.gov/aceasia/

Research questions

- Today‘s levels and properties of PM?
- Sources of PM?
- Past and expected trends?
- Influence on health?
- Influence on climate?

Trends of PM10 in Switzerland

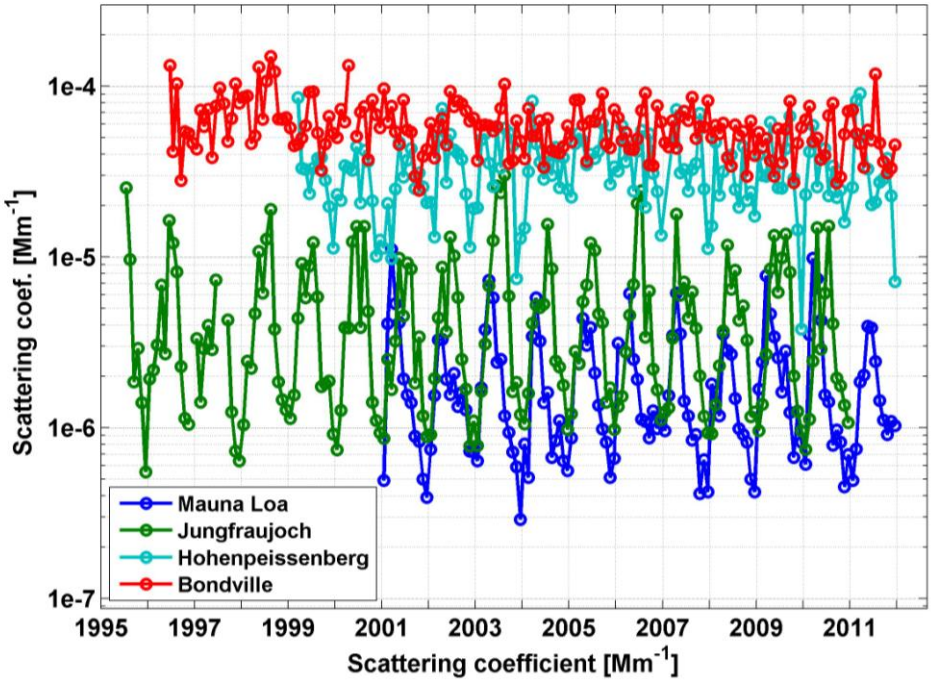
There is a substantial trend towards lower PM10 in the last 15 years in Switzerland and in Europe / United States in general, however, in countries with high technological development in this time period we see a substantial increase

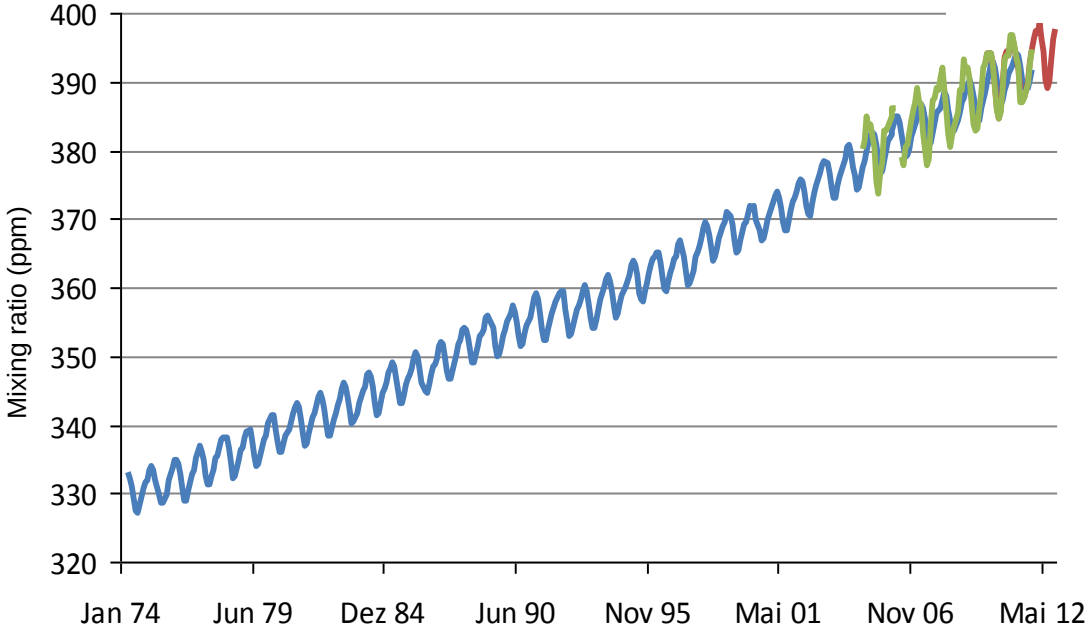


Empa-Bericht Nr. 203'056/20, 2013

Spatial variability of aerosols

➔ Concentrations and trends much more variable than e.g. CO_2

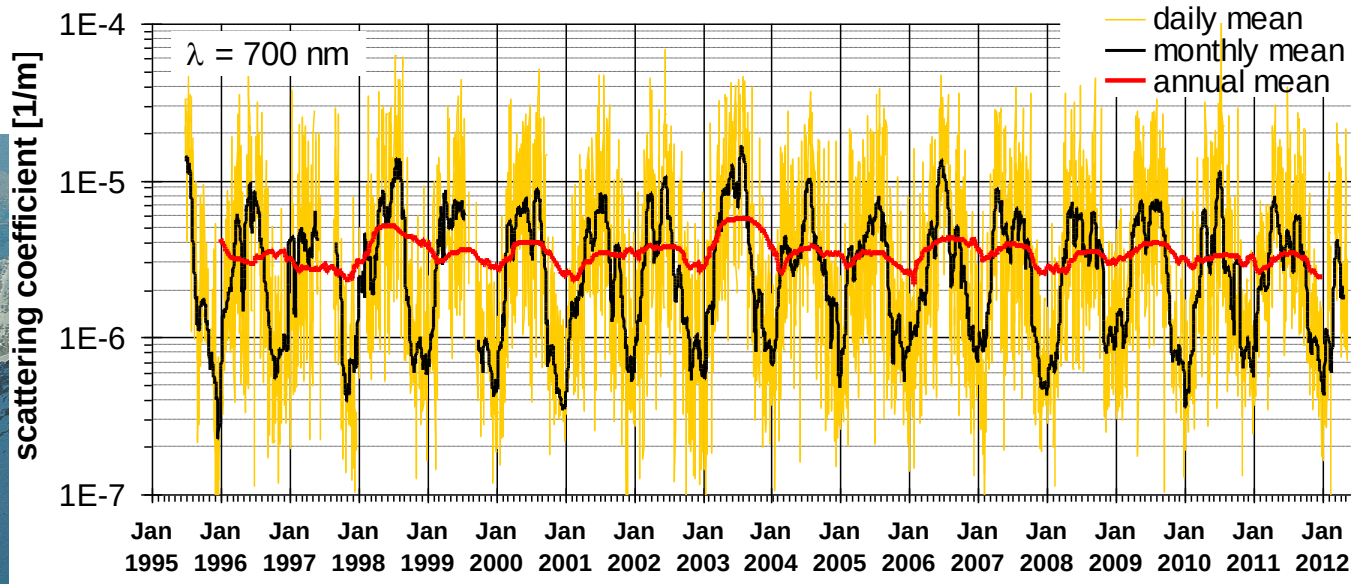


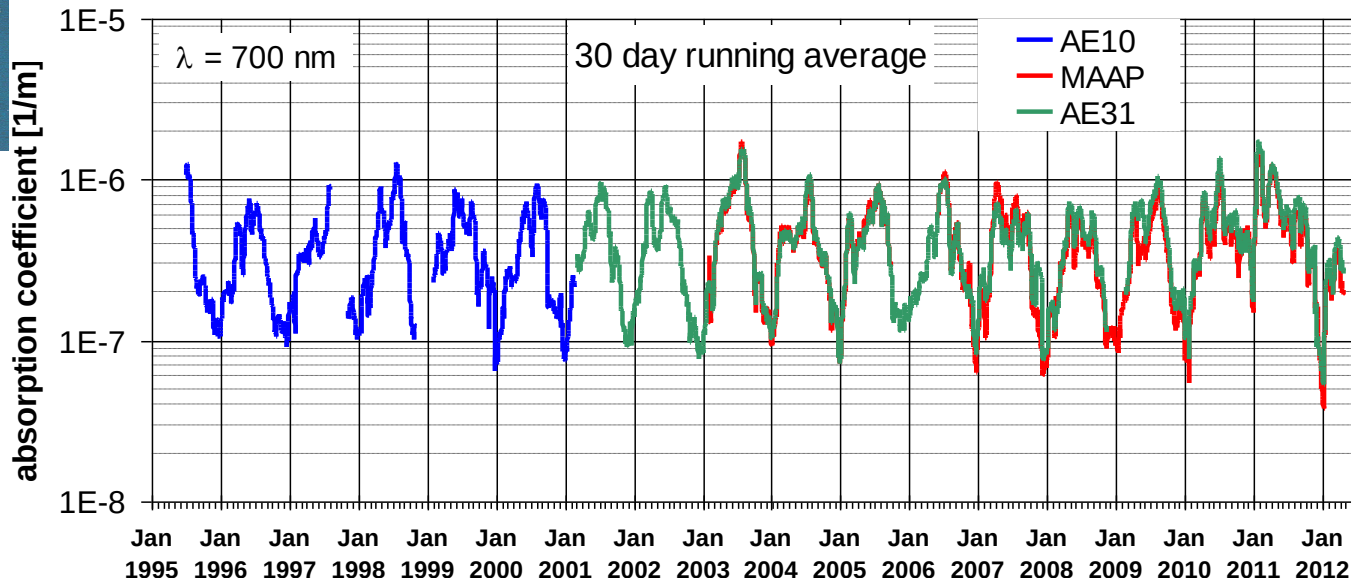


There is a wide variety of aerosol properties that are relevant to climate forcing; recommendations by the Aerosol SAG of the Global Atmosphere Watch (GAW) program of WMO

- Multiwavelength optical depth
- Mass in two size fractions
- Major chemical components in two size fractions
- Scattering and hemispheric backscattering coefficient at various wavelengths
- Absorption coefficient
- Aerosol number concentration
- Cloud condensation nuclei (at various supersaturations)
- Aerosol size distribution
- Detailed size fractionated chemical composition
- Dependence on relative humidity
- Vertical distribution of aerosol properties (e.g. LIDAR)

We have 17 years of continuous data at our site Jungfraujoch (3580 m asl)



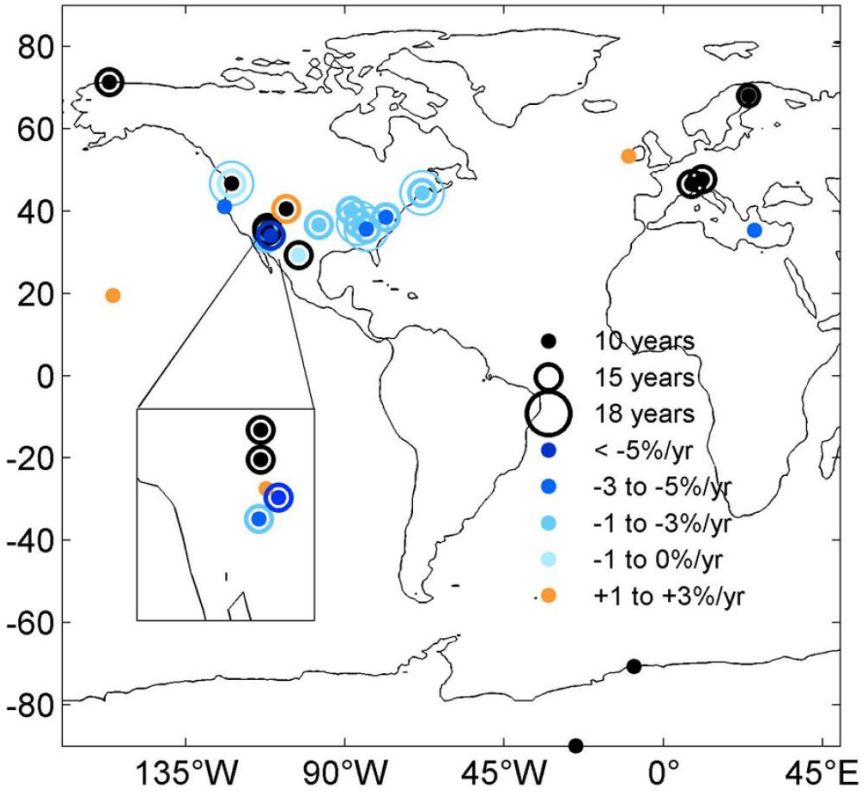


There are only very few stations with long-term measurements of climate relevant properties

➔ we need more stations with long-term vision to better assess the impact of aerosols on climate

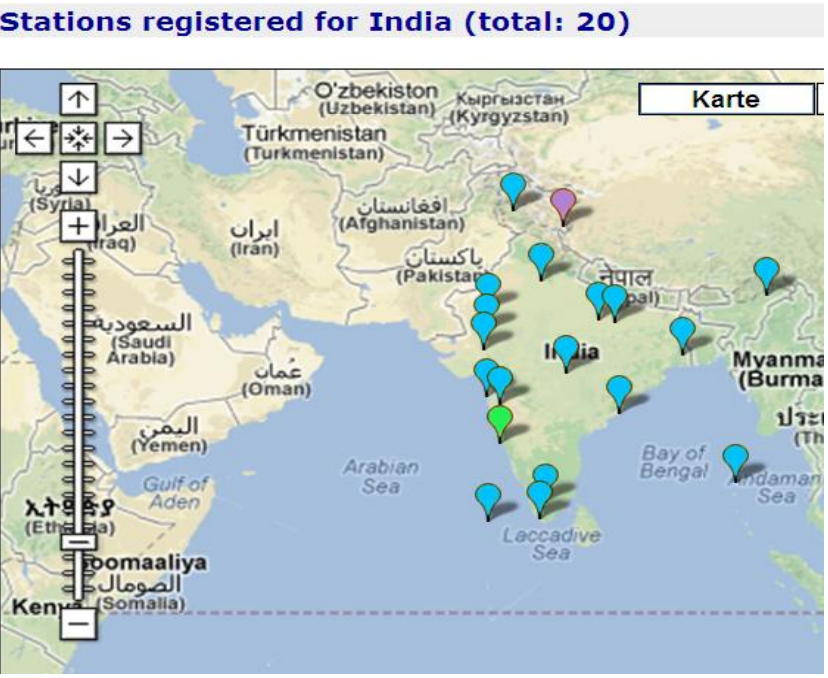
The ‚global' stations of the Global Atmosphere Watch program of the World Meteorological Organization

Trends of the aerosol light scattering coefficient



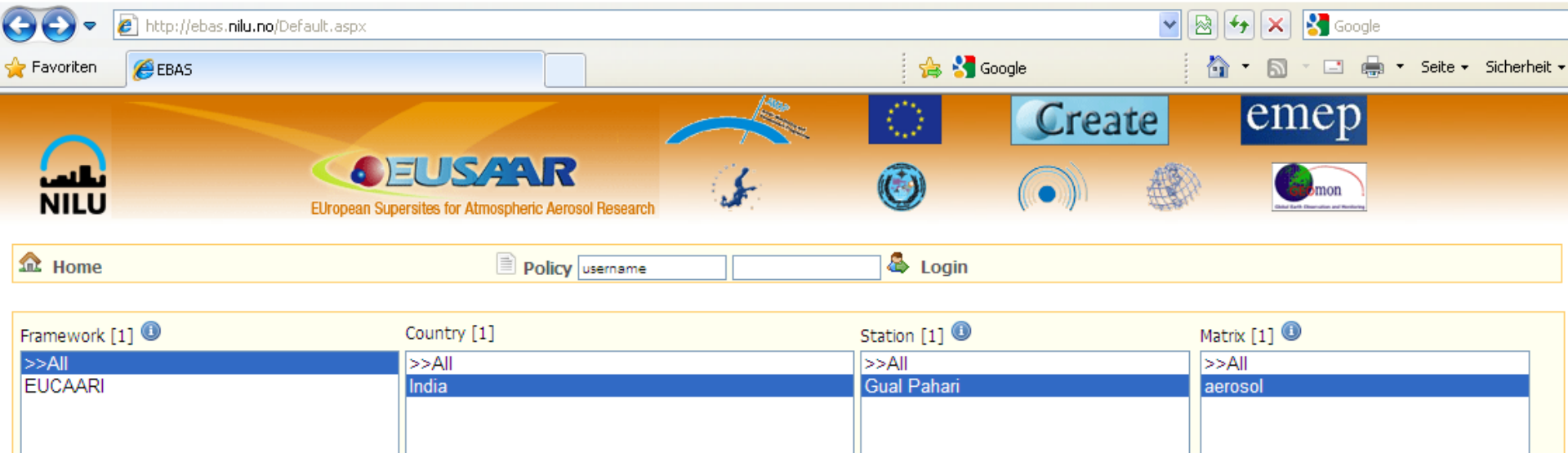
Collaud Coen et al., ACP 2013

Participation of India in the GAW program



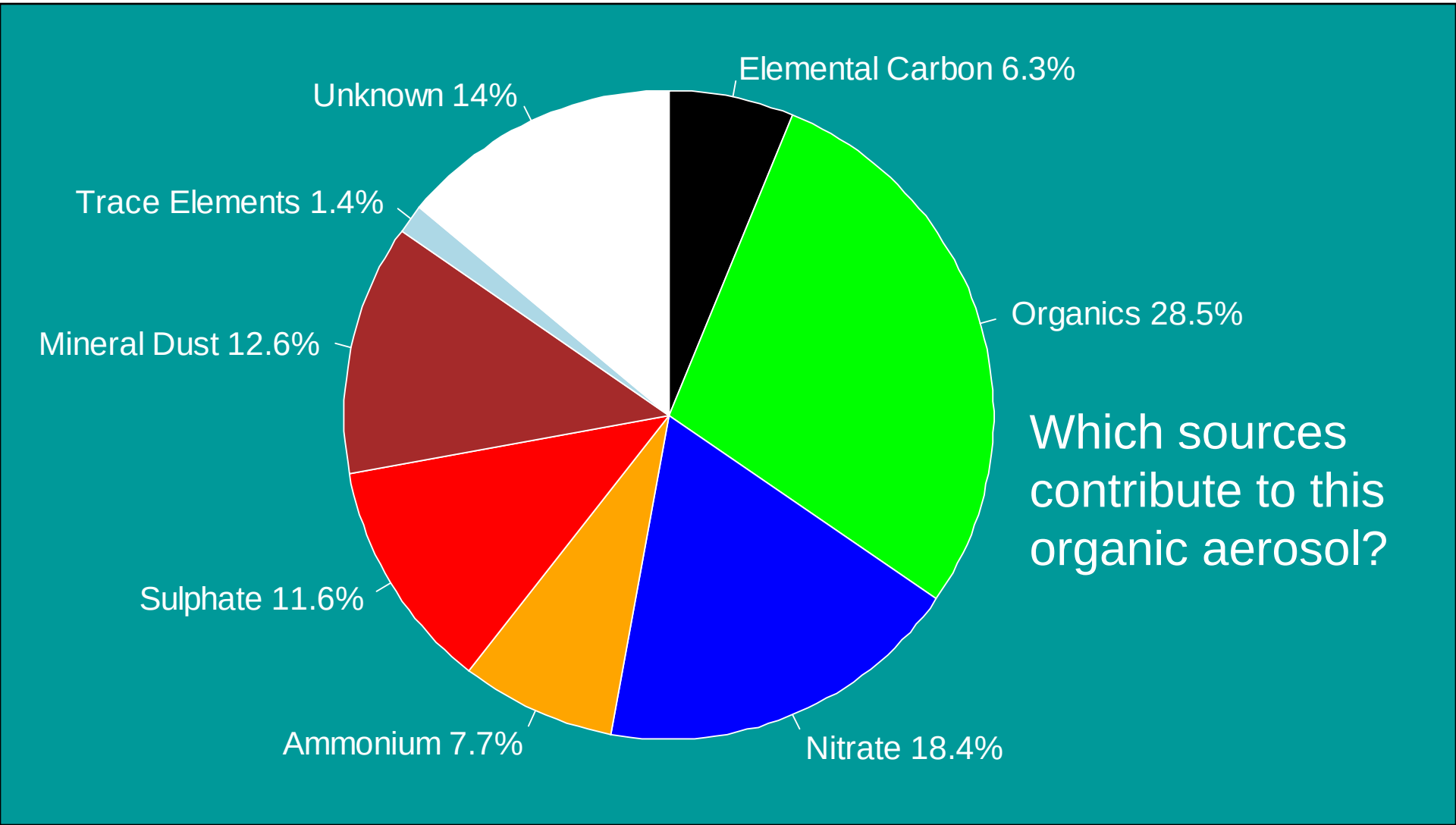
20 stations are registered as Regional GAW stations, but only Gual Pahari has delivered aerosol data, and these were stopped in January 2010, according to http://ebas.nilu.no (the World Data Center for Aerosols)

➔ any contribution to the GAW aerosol program is very welcome!



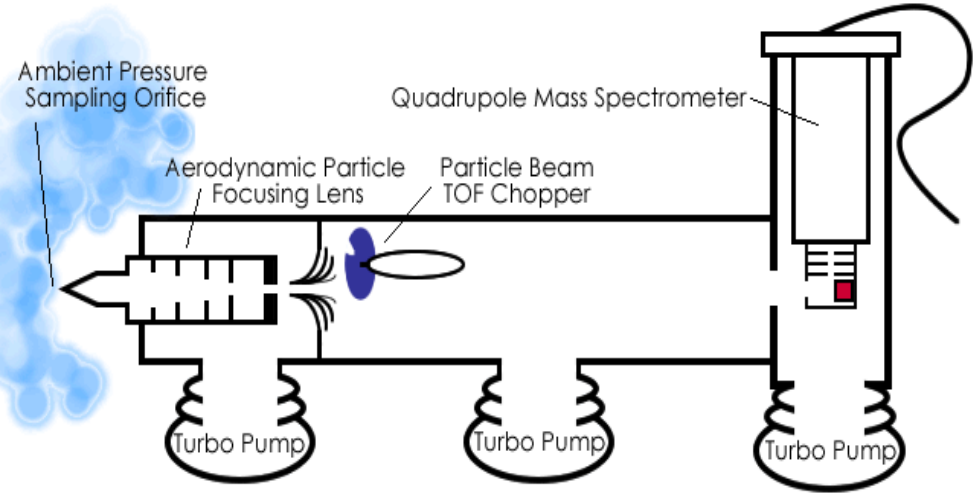
A PM reduction strategy requires the knowledge of the sources

Example: chemical composition of Zurich

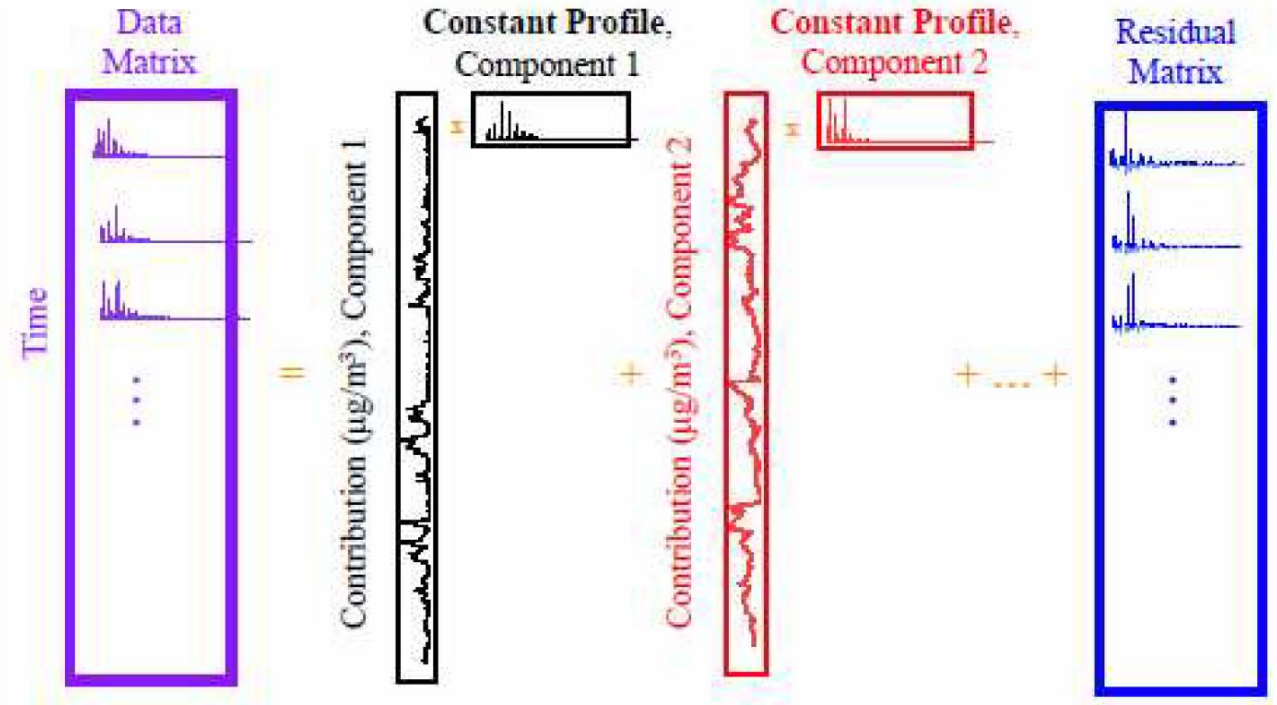


Which sources contribute to this organic aerosol?

Positive Matrix Factorization (PMF) of aerosol mass spectrometer data



➔ source apportionment



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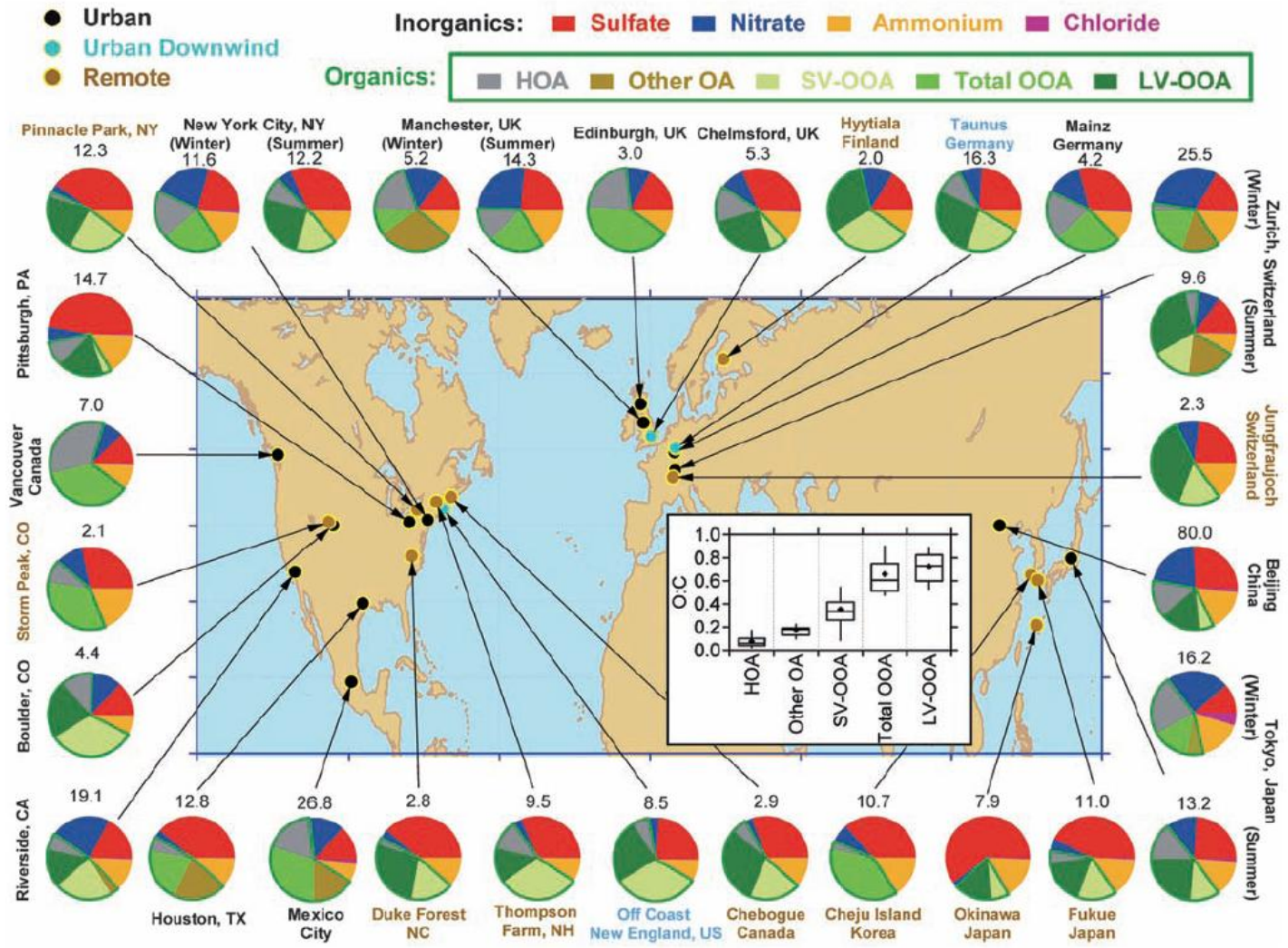
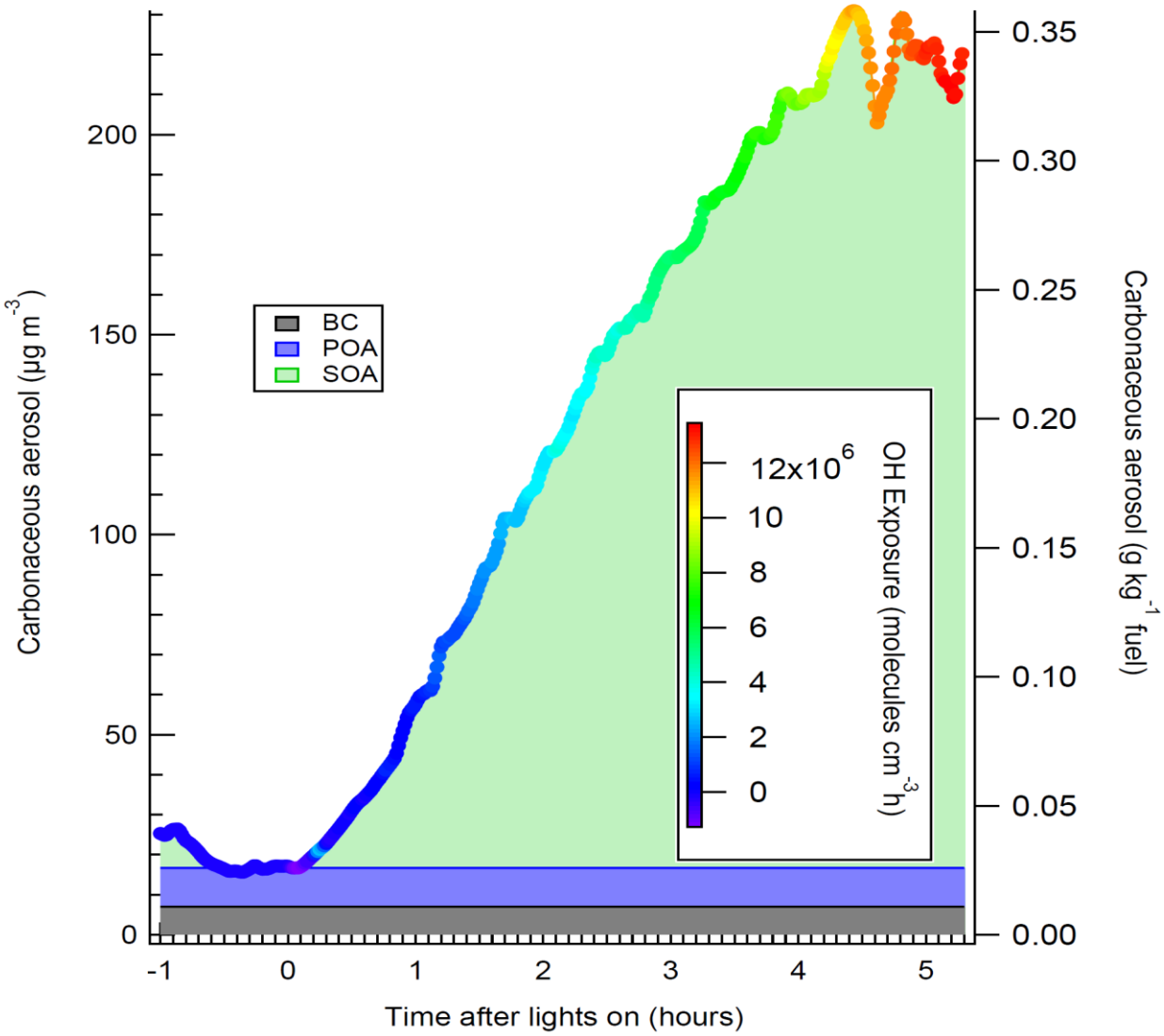
PMF allows to discriminate the organic aerosol into primary organic aerosol (traffic, wood combustion, cooking) and secondary (oxygenated) organic aerosol; the latter often splits into a semivolatile and a low-volatility fraction (SV-OOA and LV-OOA)



Jimenez et al., Science 2009

SOA formation: Ex.: Gasoline emissions

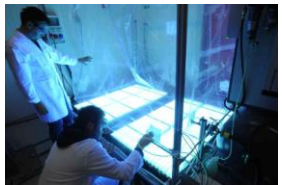


Wall loss corrected AMS + Aethalometer data

Data from smogchamber can be used for emission factor calculation

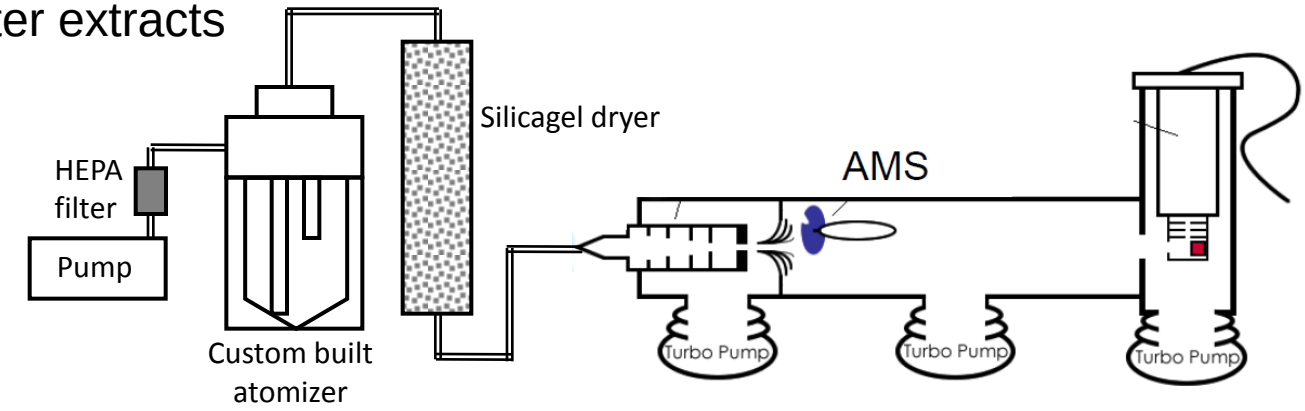
Chamber aging related to atmospheric aging via [OH] determination

C=Carbon, from CO_2, CO, Hydrocarbon (HC), primary organic aerosol (OA), WC=fuel carbon content

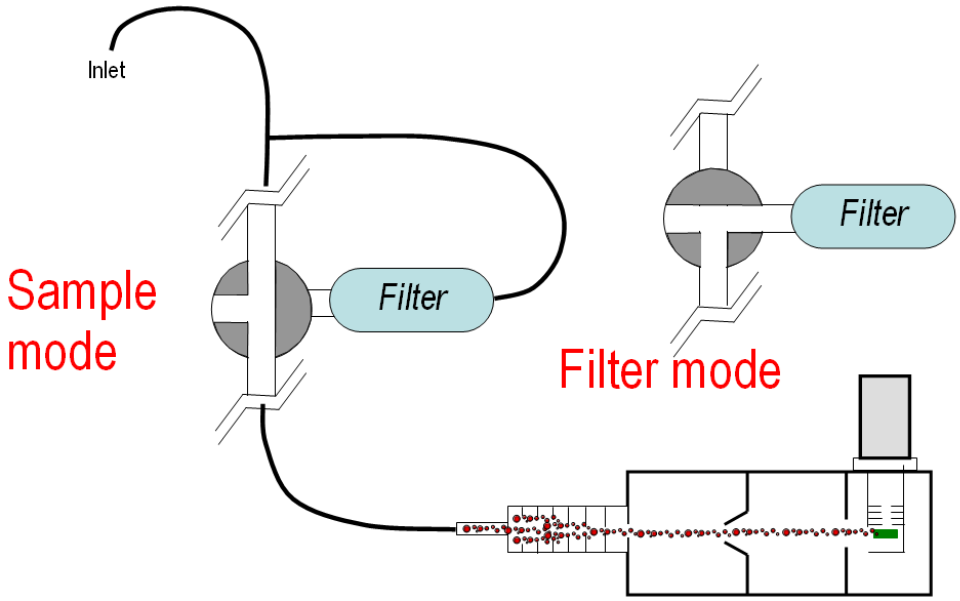


AMS measurements are expensive and are typically only done during campaigns

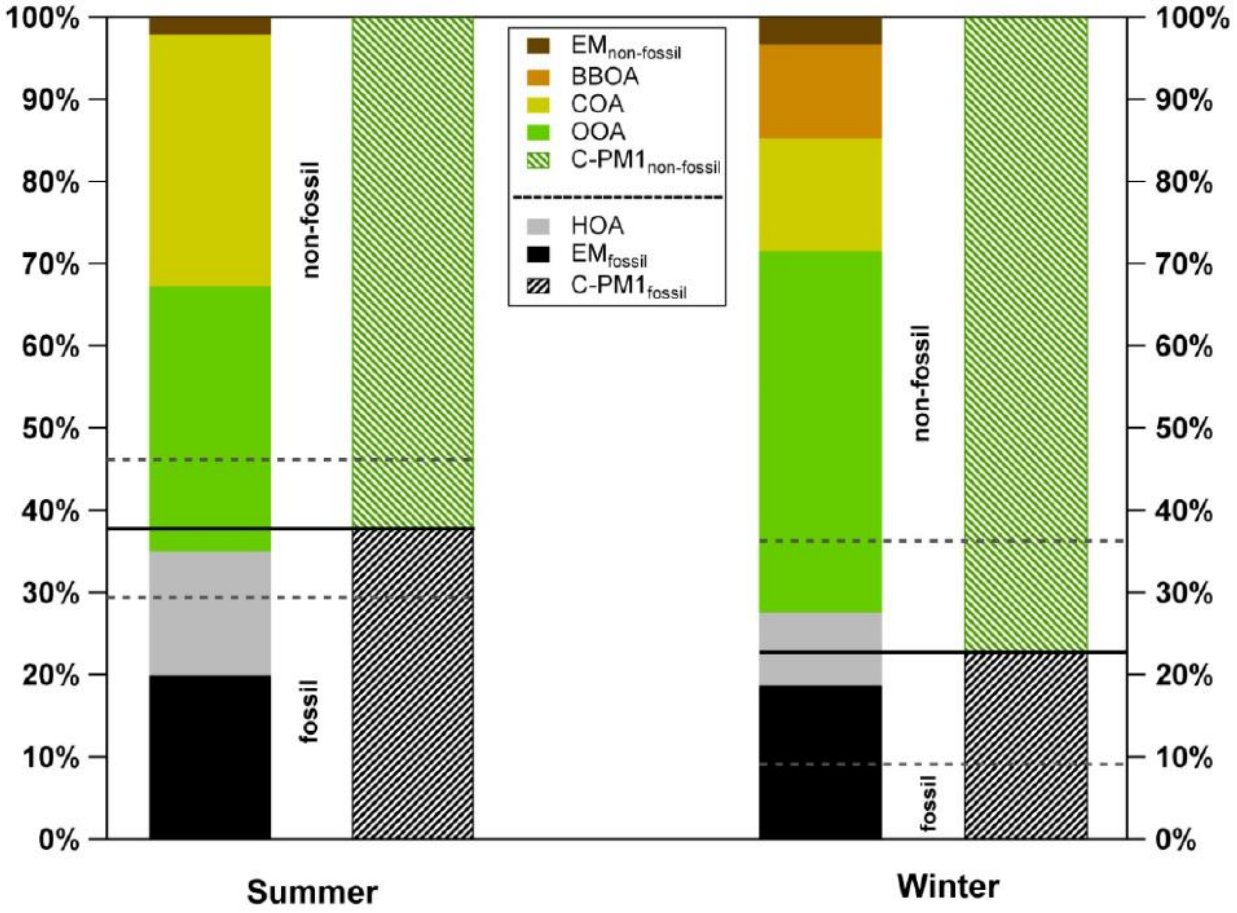
Way out: Nebulization of filter extracts



Or: use a cheaper and simpler instrument, the Aerosol Chemical Speciation monitor (ACSM)



Primary and secondary organic aerosol in Paris



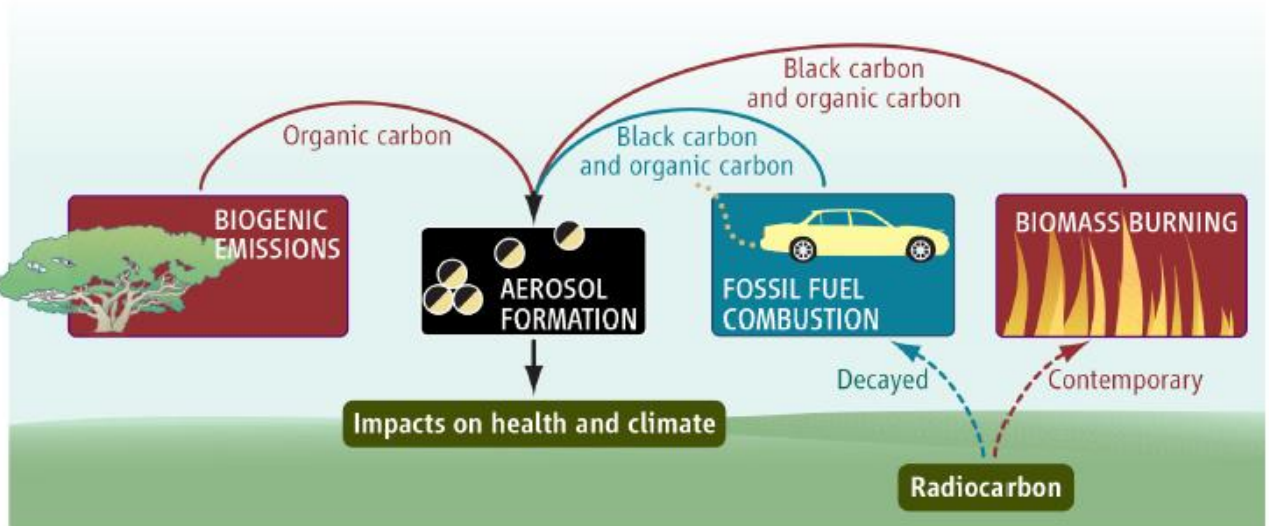
Surprise:
Primary organic aerosol from cooking can be as high as from traffic

Typically, SOA dominates the organic aerosol, sources are still largely unknown

Insight into fossil and non-fossil carbon via carbon-14 analysis

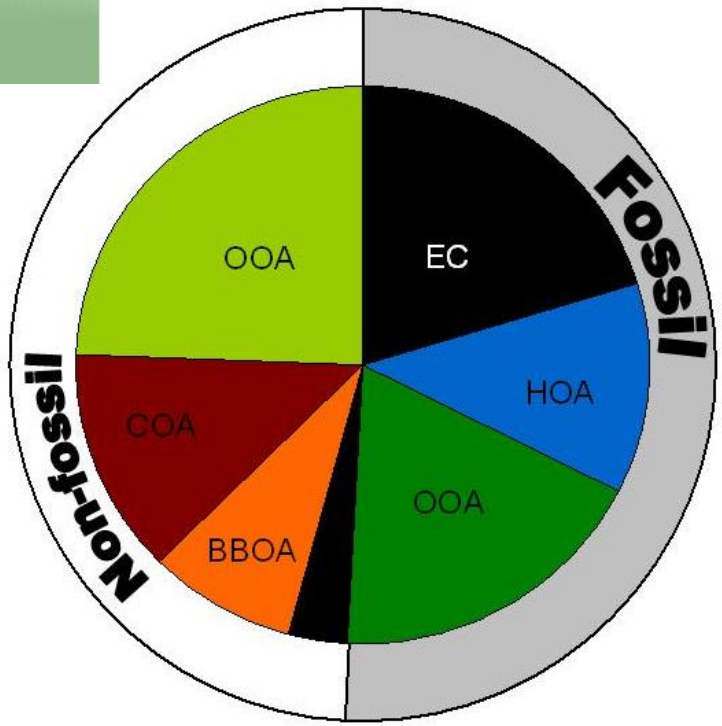
Beekmann et al., submitted

Fossil and non-fossil carbonaceous aerosol by carbon-14 measurements



See Szidat et al., 2004 ff

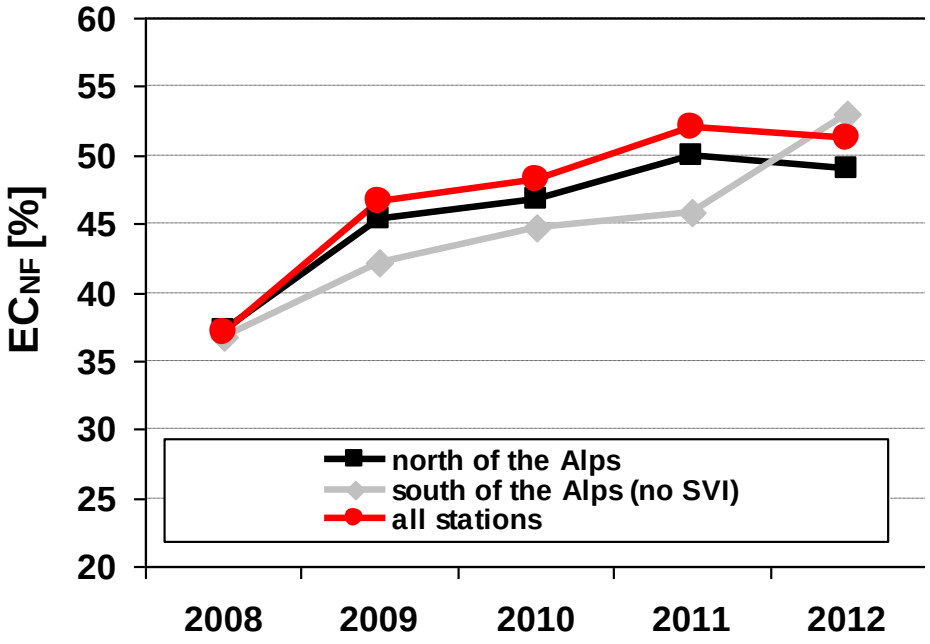
Other possible method:
wavelength dependent light absorption by the particles as measured by an aethalometer (Sandradewi et al., 2008)



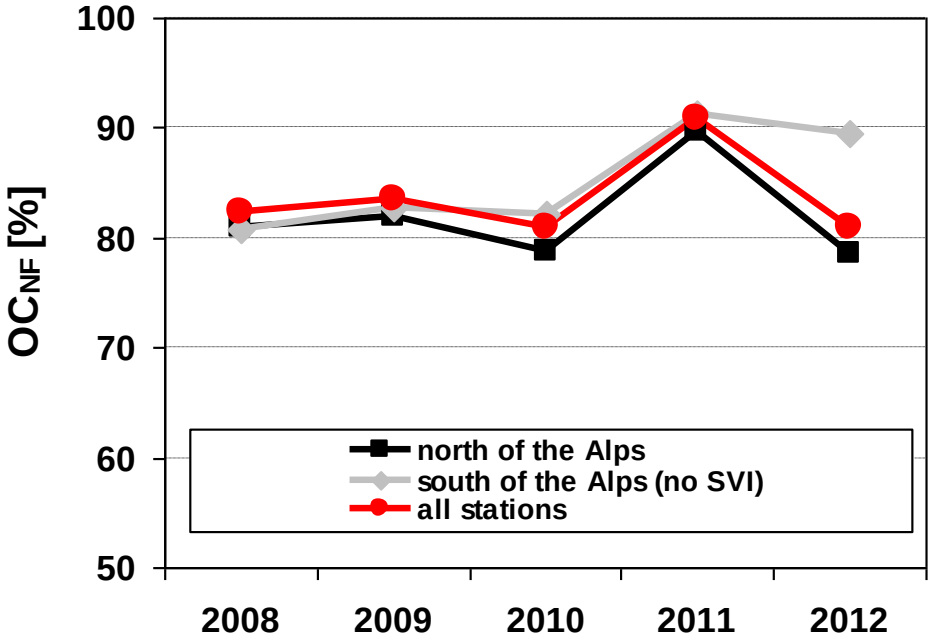
Fossil and non-fossil carbonaceous aerosol by carbon-14 measurements

Trends in the last 5 years in Switzerland:

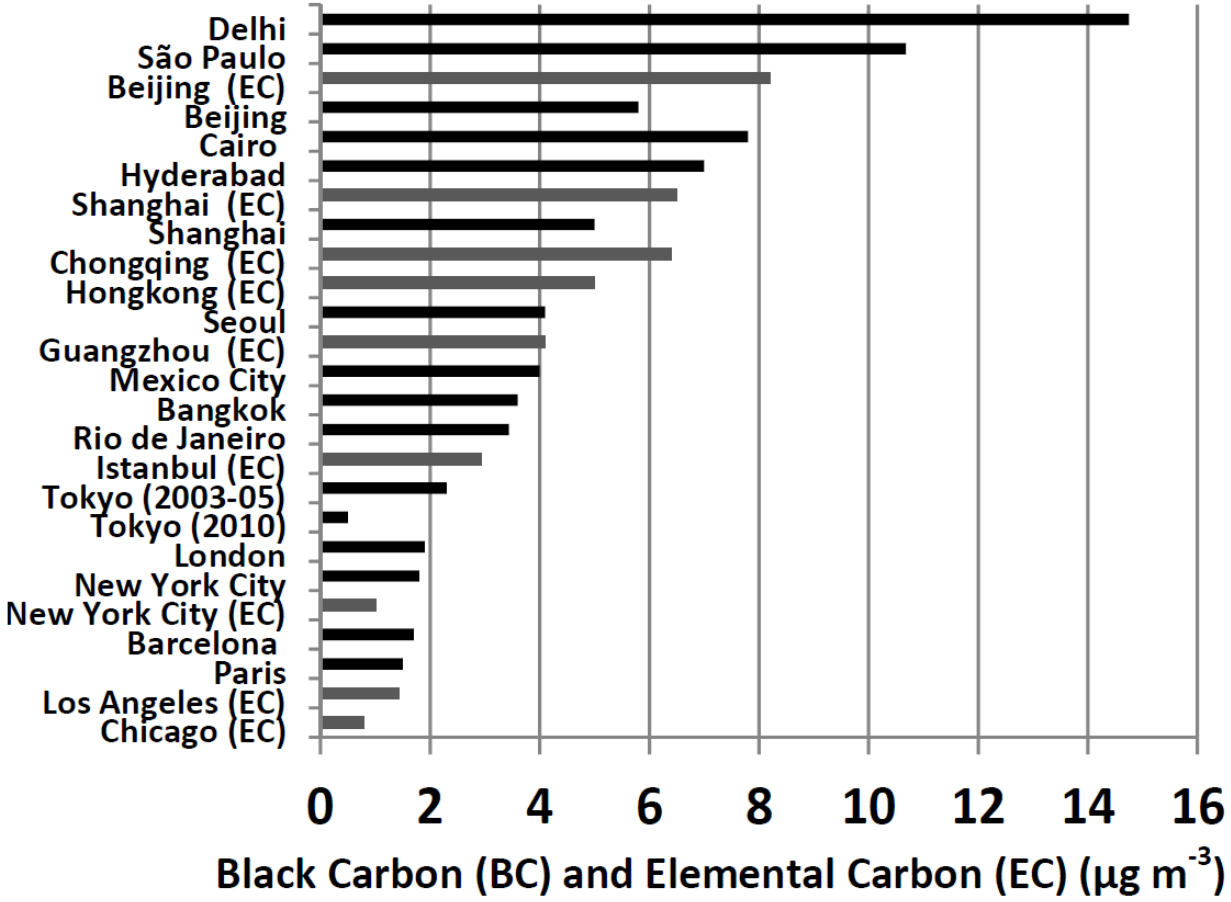
EC: more non-fossil



OC: no significant trend

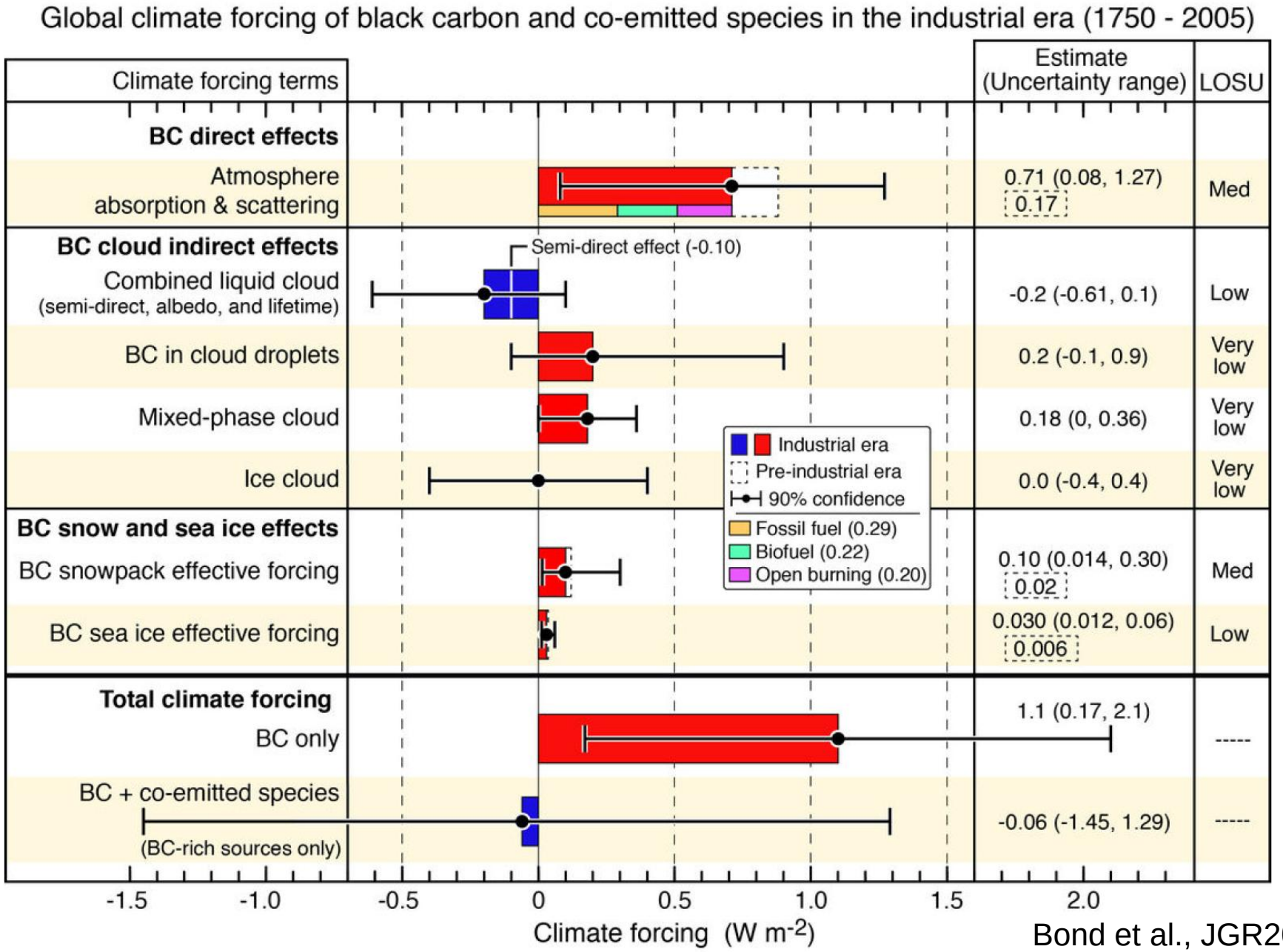


Large differences in BC concentrations



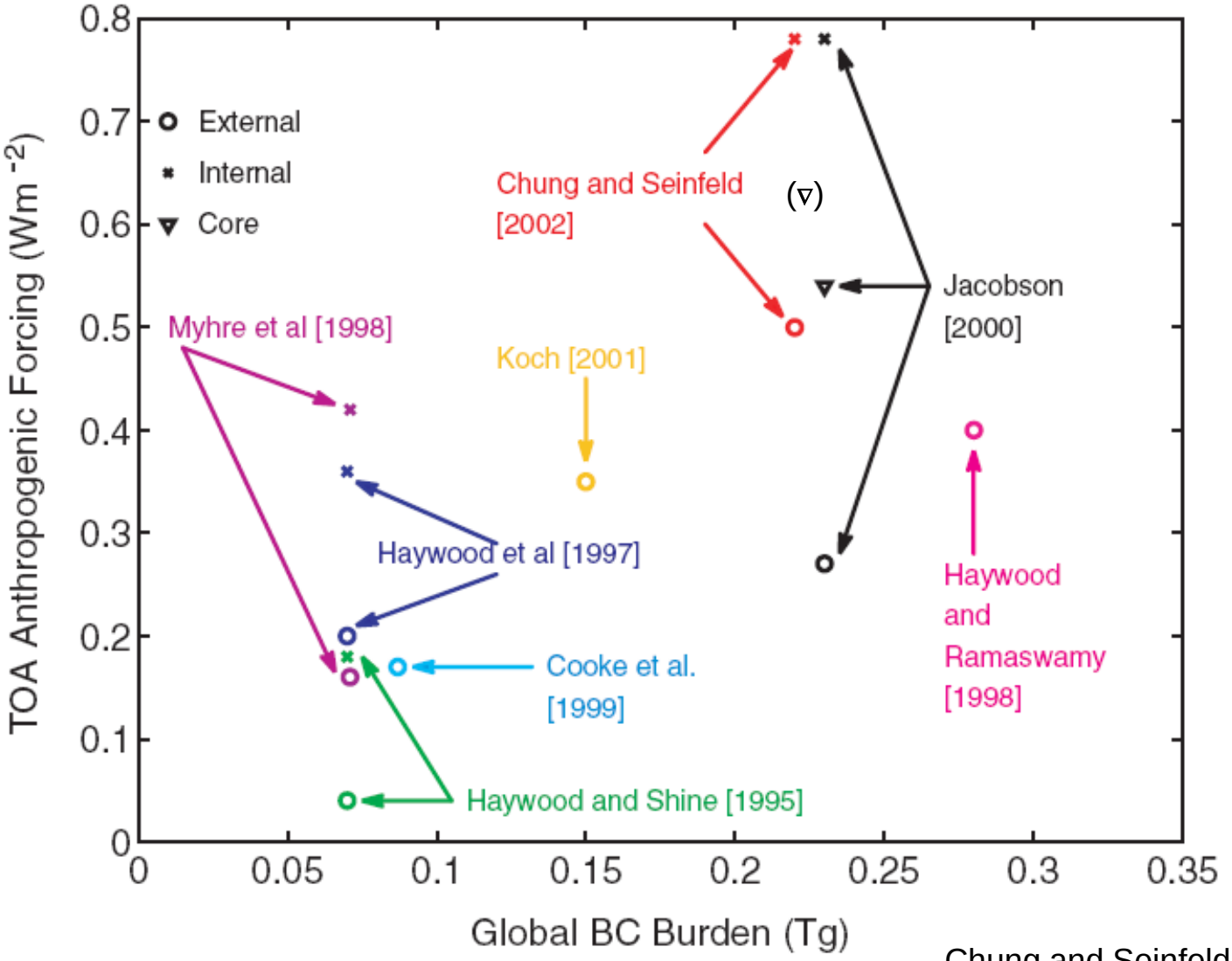
Beekmann et al., submitted

Climate forcing of black carbon



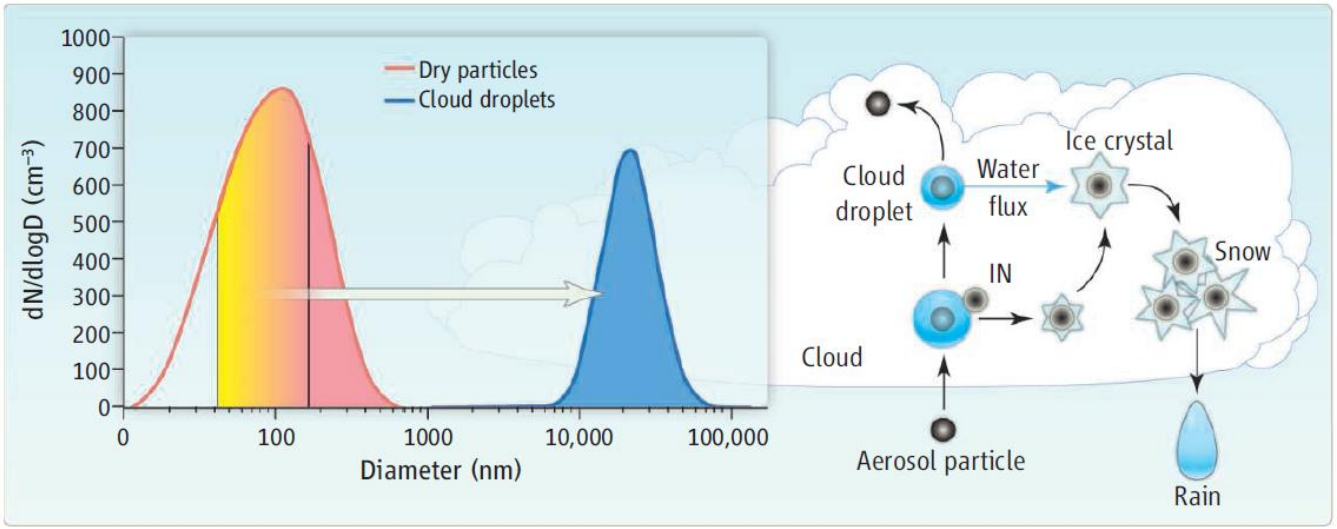
Bond et al., JGR2013

Large uncertainty in the radiative forcing of black carbon, reasons: emissions, morphology (internal versus external mixing), role in ice clouds, etc.



Chung and Seinfeld (JGR 2002)

Do BC particles act as ice nuclei?



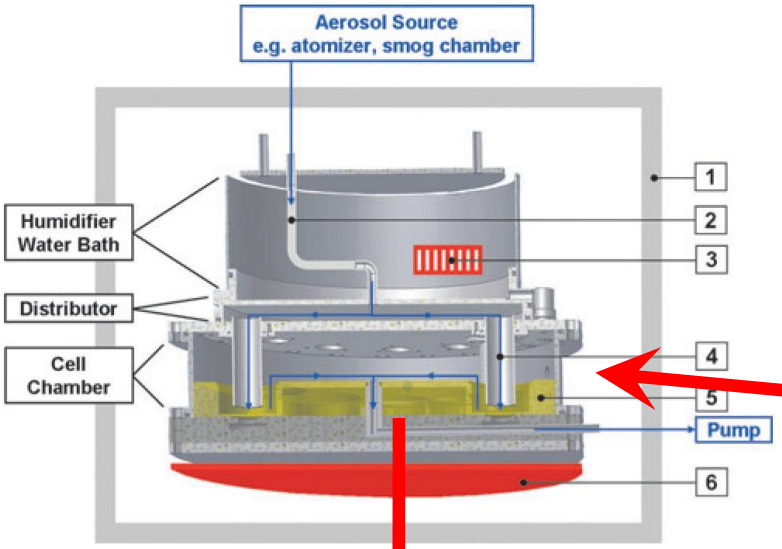
Baltensperger, Science 2010

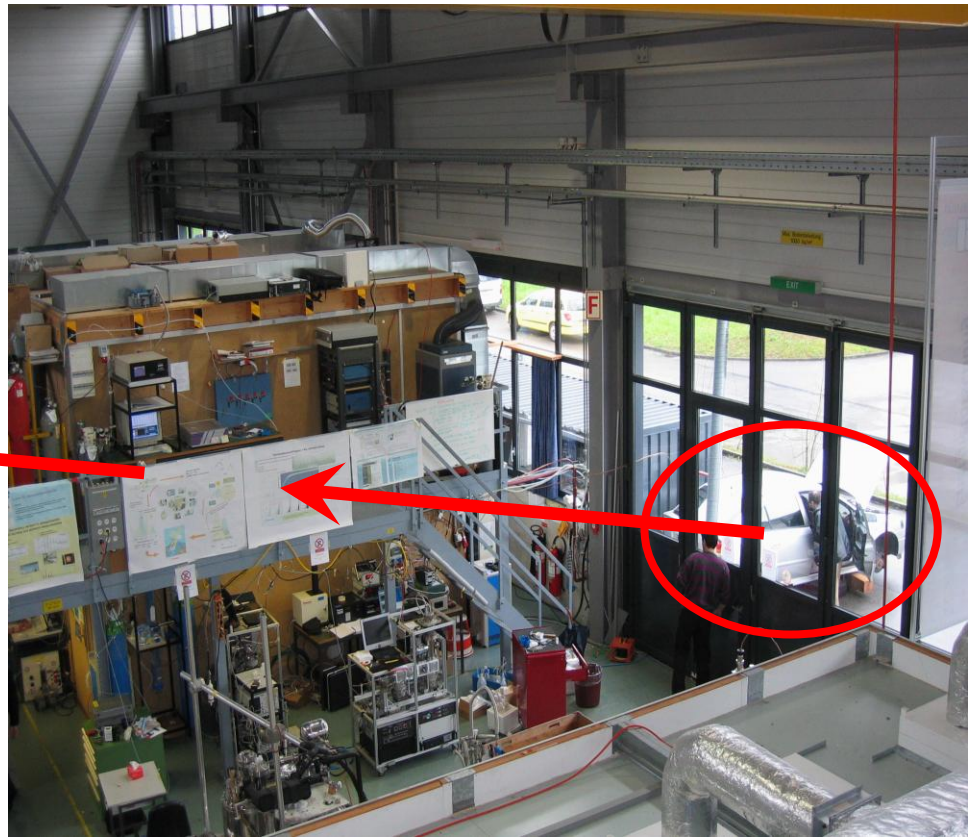
In an ice cloud, cloud droplets evaporate while few, but large ice crystals grow on ice nuclei, changing cloud radiative properties and enhancing precipitation.

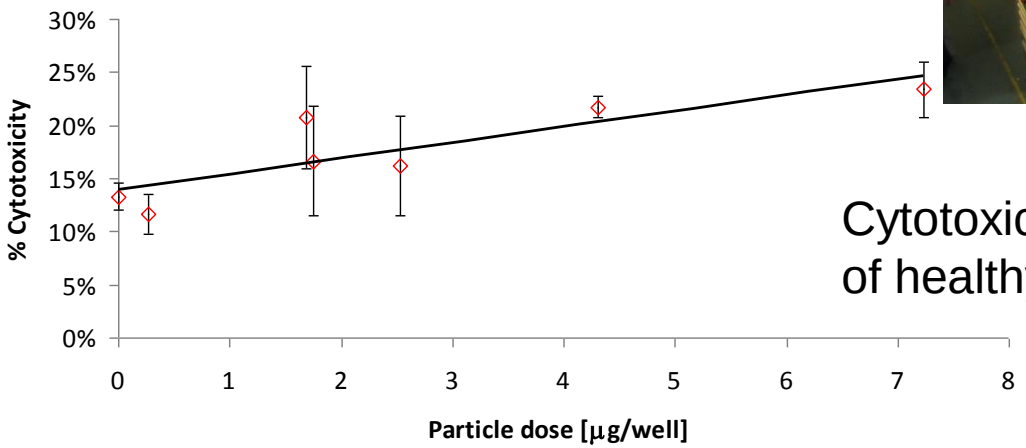
Therefore it is important which particles can act as ice nuclei.

Installation of the new ice selective inlet at the Jungfraujoch

Health effects of aerosols: Secondary aerosol is toxic as well







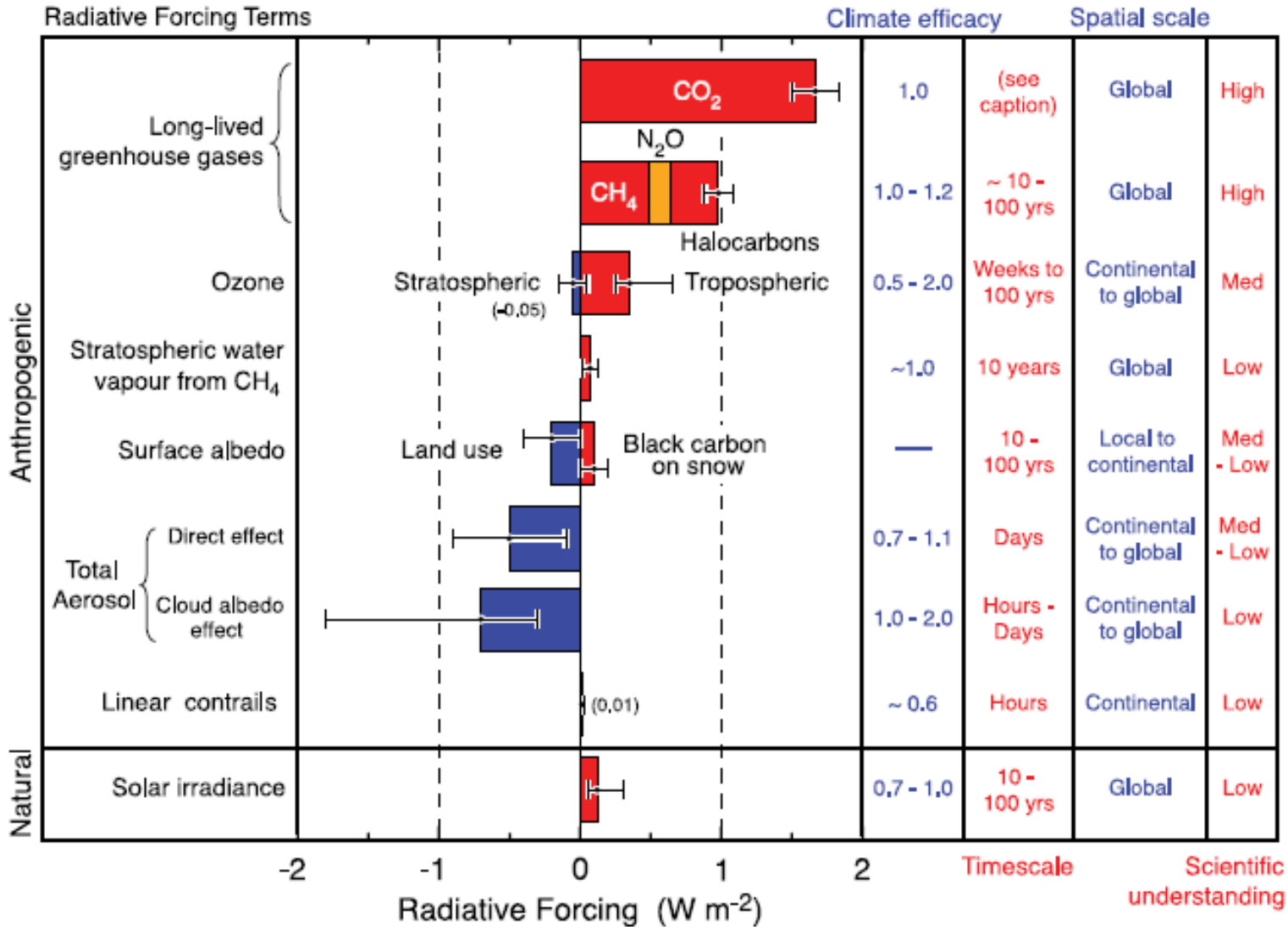
Cytotoxicity in lung material of healthy individual

Conclusions

- A large number of aerosol properties needs to be determined for a full characterization
- Aerosol particles have a wide variety of primary and secondary sources
- Recent instrument developments have brought along huge progress about the sources of aerosols
- We now need measurements at many additional sites
- Secondary organic aerosol apportionment is still a subject of intense research
- Climate impacts do not only relate to direct an indirect forcing, and many aspects (such as the IN ability of BC) are still widely unknown
- Health effects need considerable efforts in order to better assess the toxicity of different aerosol components


Thank you for your attention

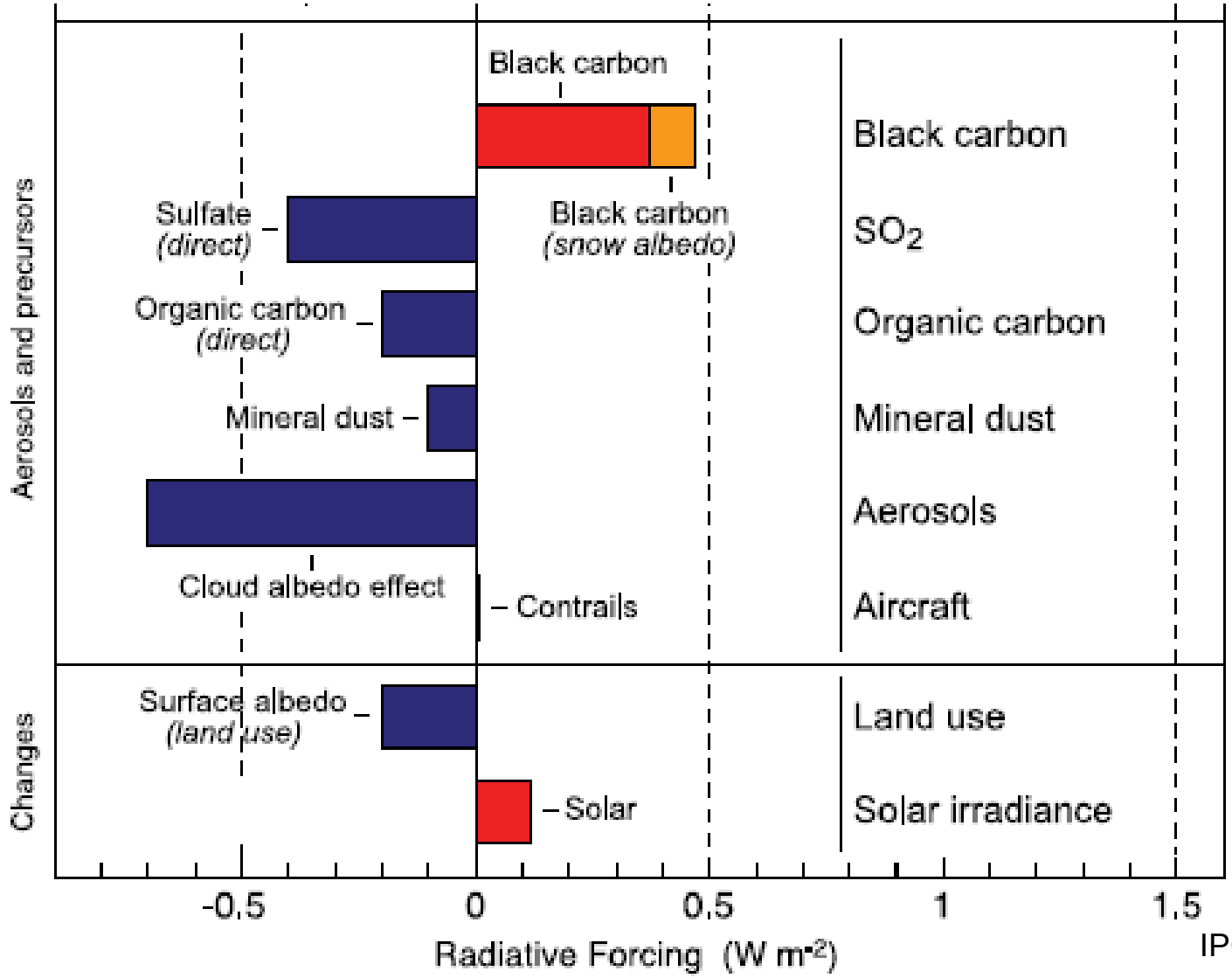
Radiative forcing of climate between 1750 and 2005



IPCC (2007)

No CO_2 time scale is given,as its removal from the atmosphere involves a range of processes that can span long time scales

Radiative forcing of climate between 1750 and 2005 for different aerosol components



IPCC (2007)