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PARTICULATE MATTER IN DIFFERENT ATMOSPHERIC RESERVOIRS: COPENHAGEN; A HIGHLY POPULATED AREA VERSUS STATION NORD; A REMOTE HIGH ARCTIC SITE

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Motivation: Why study pollution in urban air?

- Urban particulate emissions in major cities are mostly linked to the increasing road traffic, domestic wood burning and industrial emissions

  ► Elevated aerosol mass concentrations lead to an **increased risk of mortality and morbidity** (epidemiology)

  ► Elevated number concentrations of ultrafine particles < 100 nm in diameter lead to **increased risk in mortality and morbidity** (epidemiology)

  ► Chemical compositions such as black carbon (“soot”), certain organics, or metals are believed to increase the **risk of diseases**.

  ► Especially, very **young**, **elderly** and people with **asthma** indication are **risk groups**

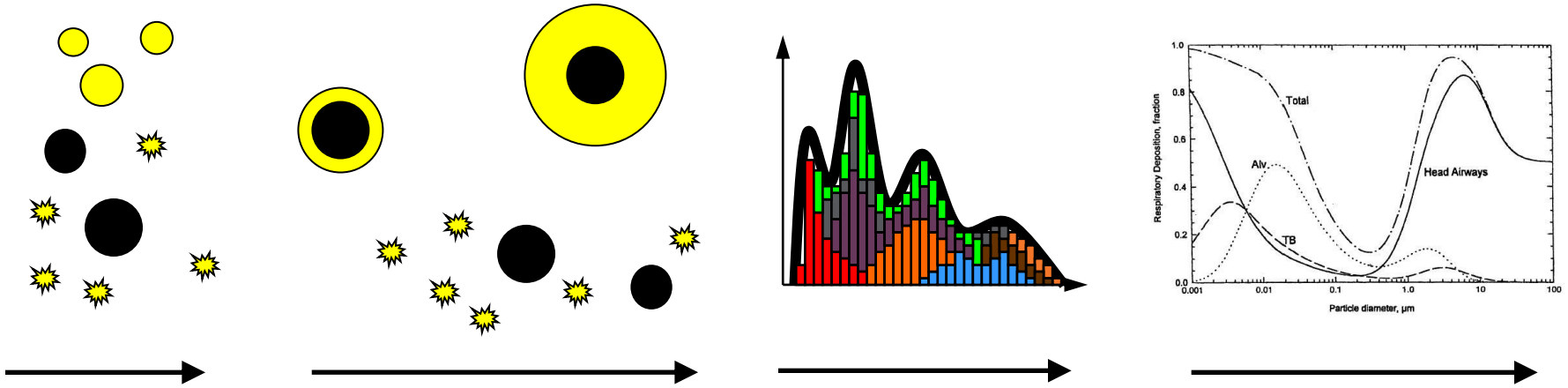
Results: Particulate exposure levels and doses

Gasses and Particles

Physico-chemical interaction: Aging

Ambient concentrations

Deposition in human airways



Emission level

Transformation level

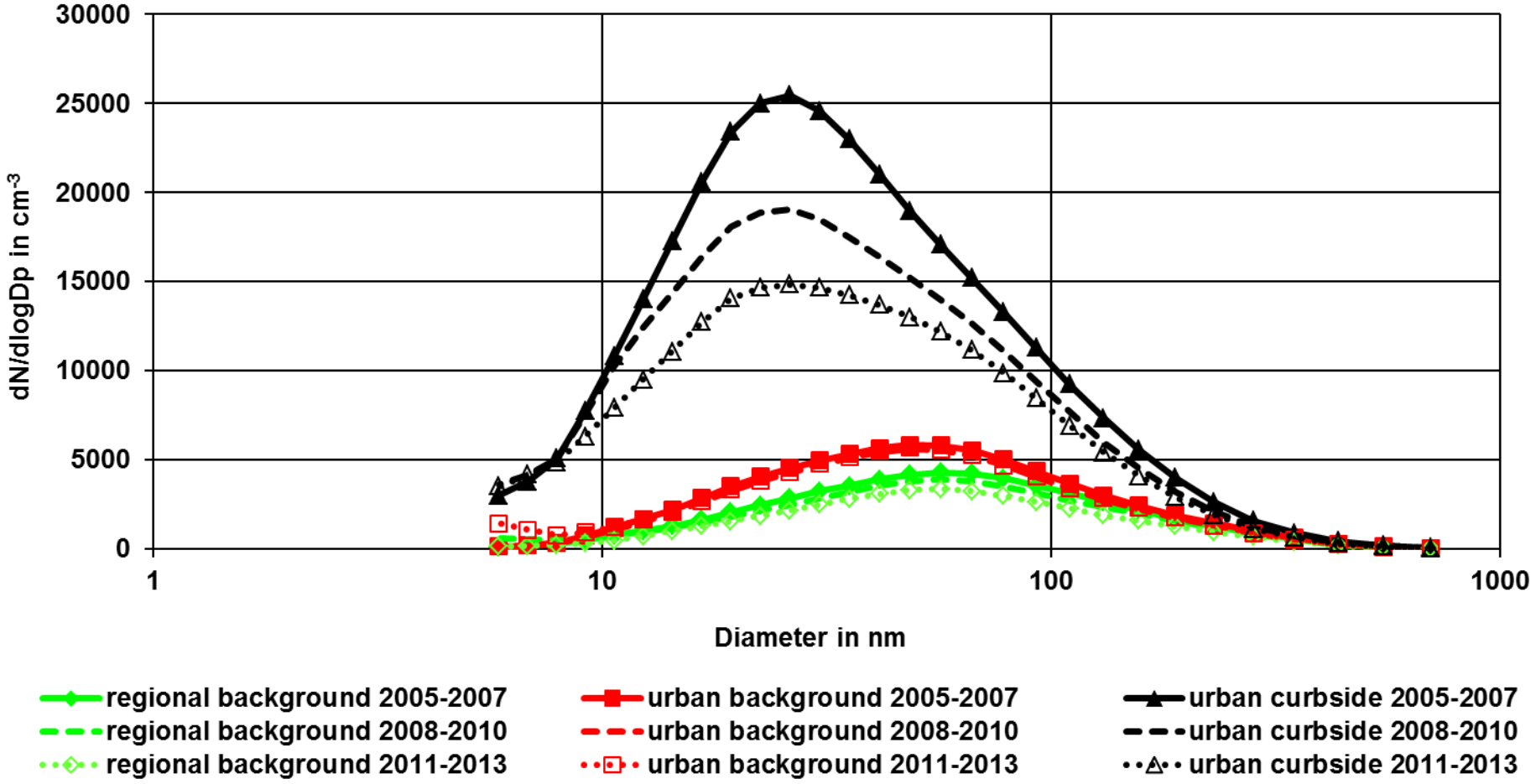
Exposure level

Dose level

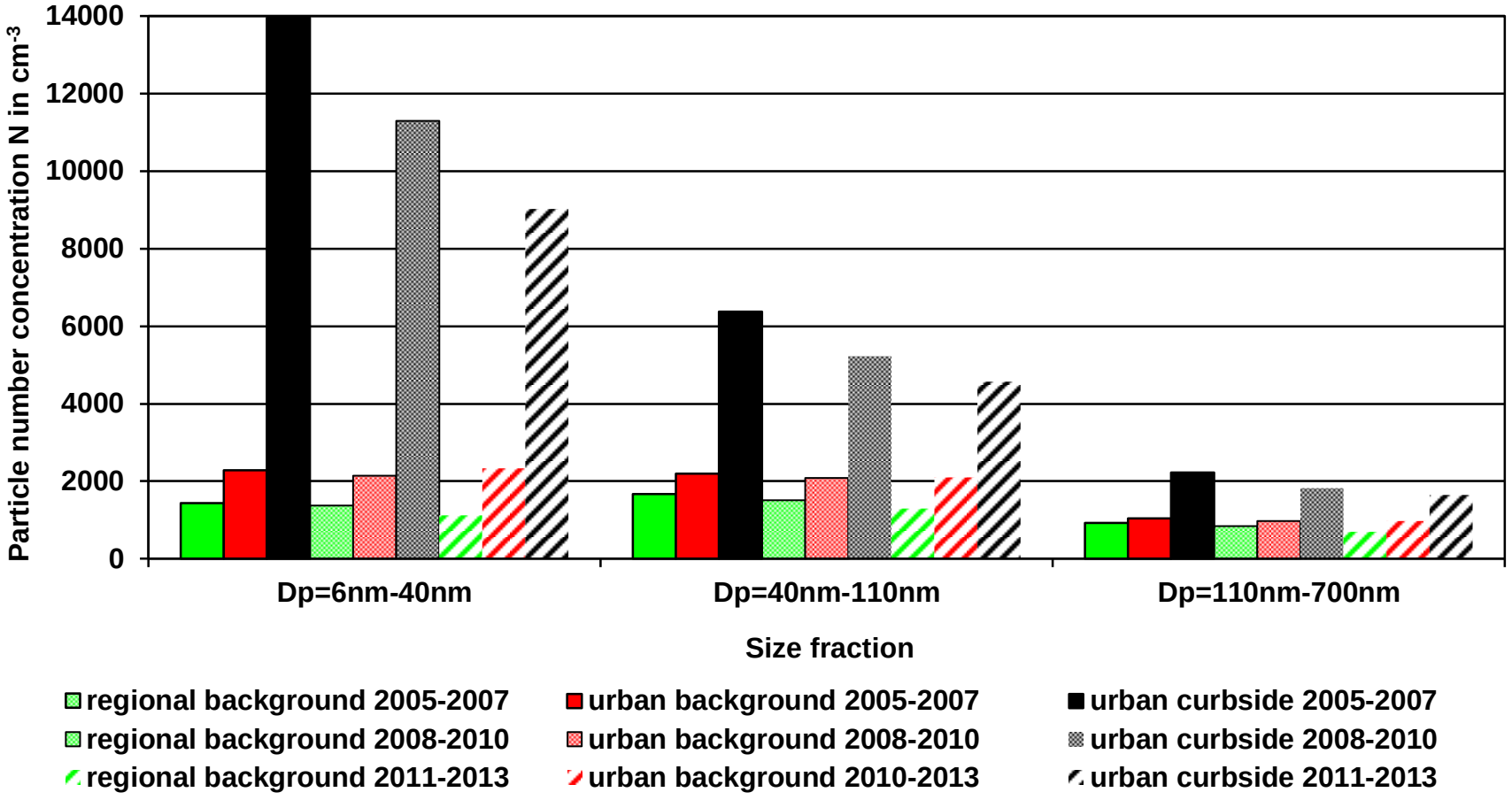
From emission to deposition

Measurement sites: Danish measurement stations (urban curbside, urban background, regional background

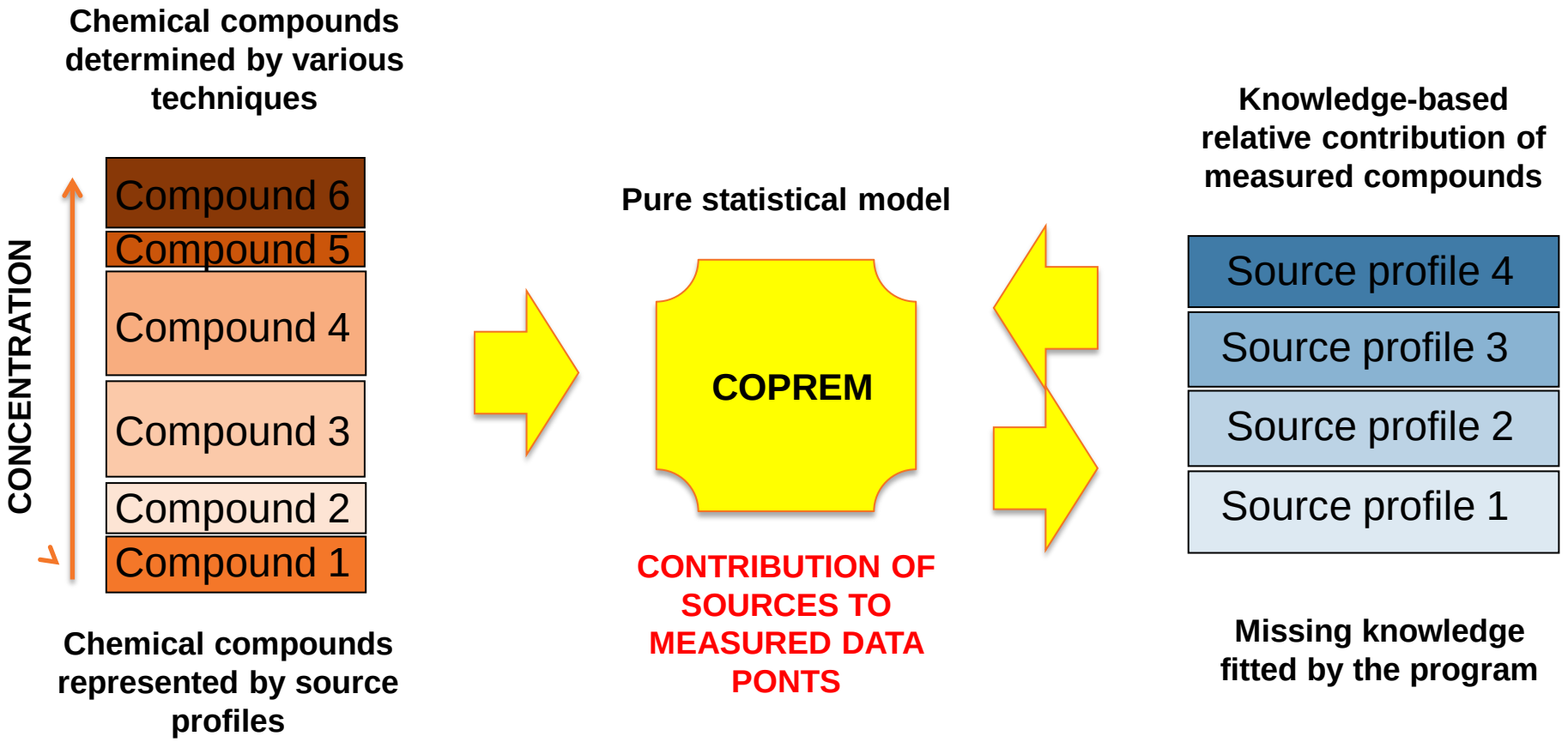
Results: Particle number size distribution at Danish stations from 2005 - 2013



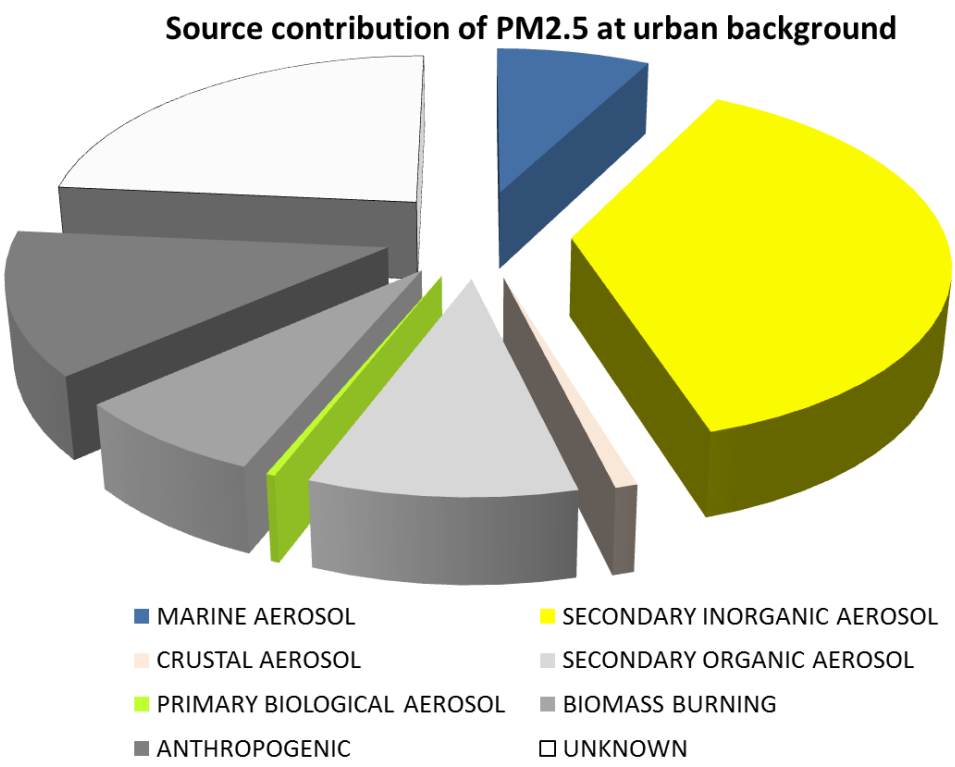
Results: Particle number concentrations in selected size regimes at Danish stations from 2005 - 2013



Results: Principle of source apportionment using COPREM (COnstrained Physical REceptor Model)



Results: Source apportionment of PM2.5 at urban background in Copenhagen



- Secondary inorganic aerosols are most abundant
- Marine sea salt particles and secondary organic aerosols are the major natural sources
- Minor natural sources include primary biological and crustal particles
- Biomass burning and coal combustion are the major anthropogenic sources
- Traffic, oil combustion and additional anthropogenic sources are also observed

Summary: Urban measurements

► Mean diameters of particle number size distributions increase with distance to major traffic sources

► Particle number concentration in all different size regimes is always highest for urban curbside > urban background > regional background.

► In general, a decreasing trend in particle number concentration is observed at all stations

► Especially for smaller particles at the urban curbside according to changes in engine technology, fuel composition and exhaust technologies

► Source receptor relationships of PM2.5 in the urban background show anthropogenic contribution in the order of 20%, natural sources have high impact

Motivation: Why study pollution in Arctic air?

- In winter and early spring pollution does reach the Arctic via long-range transported air masses originated from other continents

  ► **Direct Effect:** aerosol particles scatter (e.g. sulfate) and absorb (e.g. black carbon) the incoming solar radiation which can lead to cooling or warming of the atmosphere)

  NOTE: Particles grown by water vapor condensation (haze) may also absorb terrestrial radiation and warm the surface

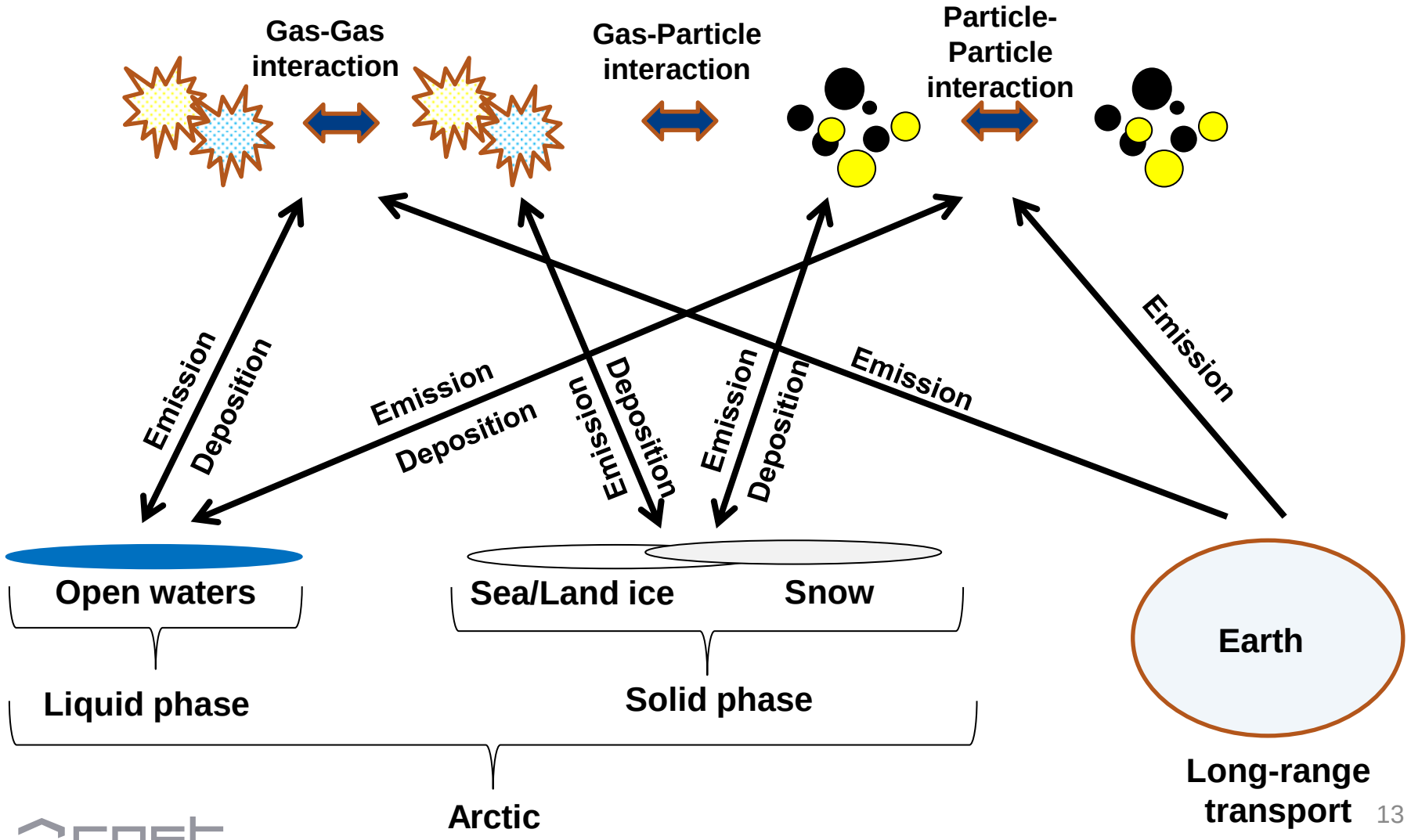
  ► **Indirect Effect:** aerosol particles serve as cloud condensation nuclei and ice nuclei for the formation of clouds and fog which reflect solar radiation (Twomey effect) and cool the atmosphere

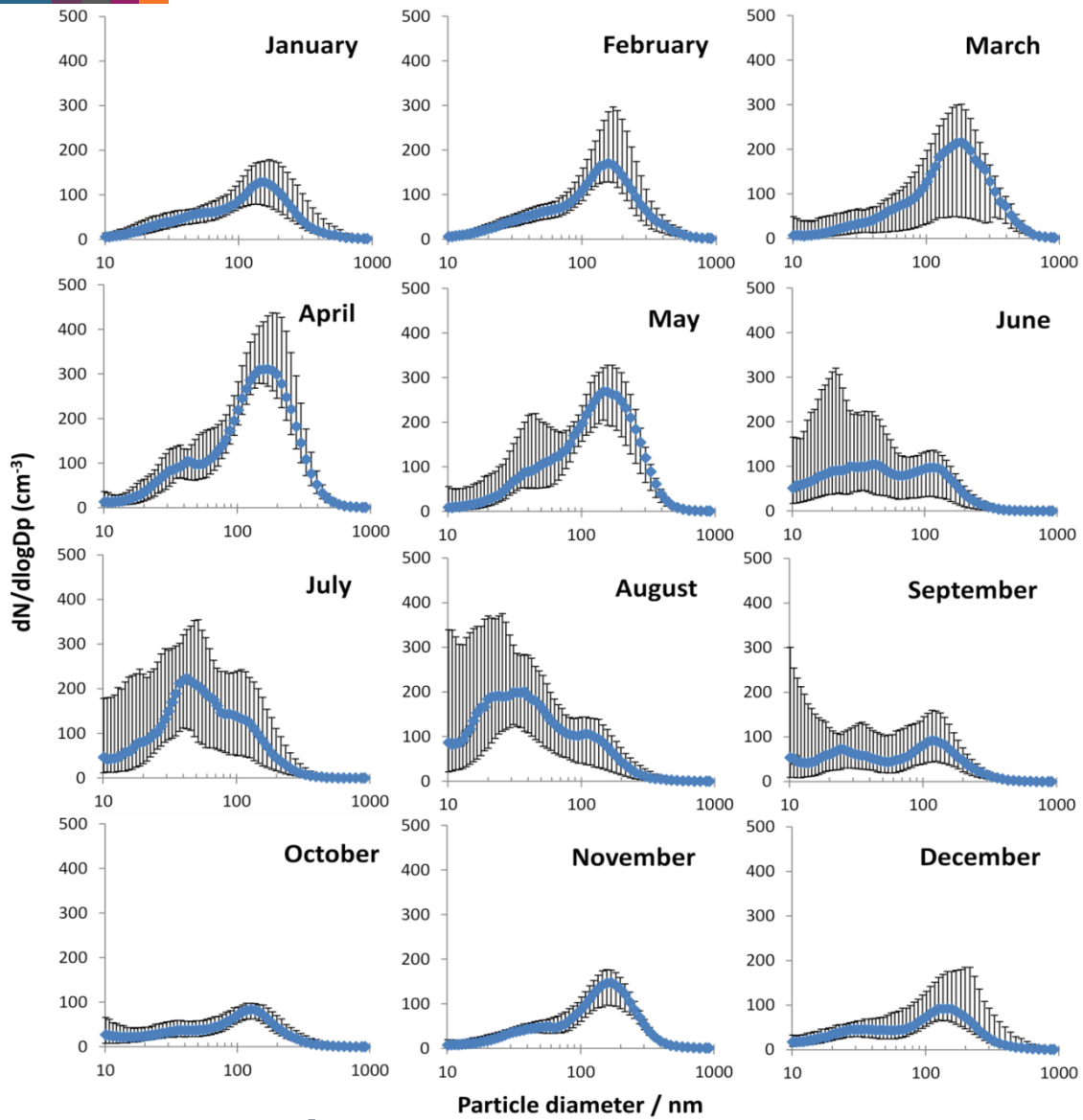
  NOTE: Clouds may also absorb terrestrial radiation and warm the surface

  ► **Semi-indirect Effect:** Deposition of BC on snow- and ice-covered surfaces leads to a warming of the near-surface area and acceleration of ice-melt

Measurement sites: Villum Research Station (VRS) in the high Arctic (Greenland)

Emissions and interactions of gasses and particles in the Arctic?

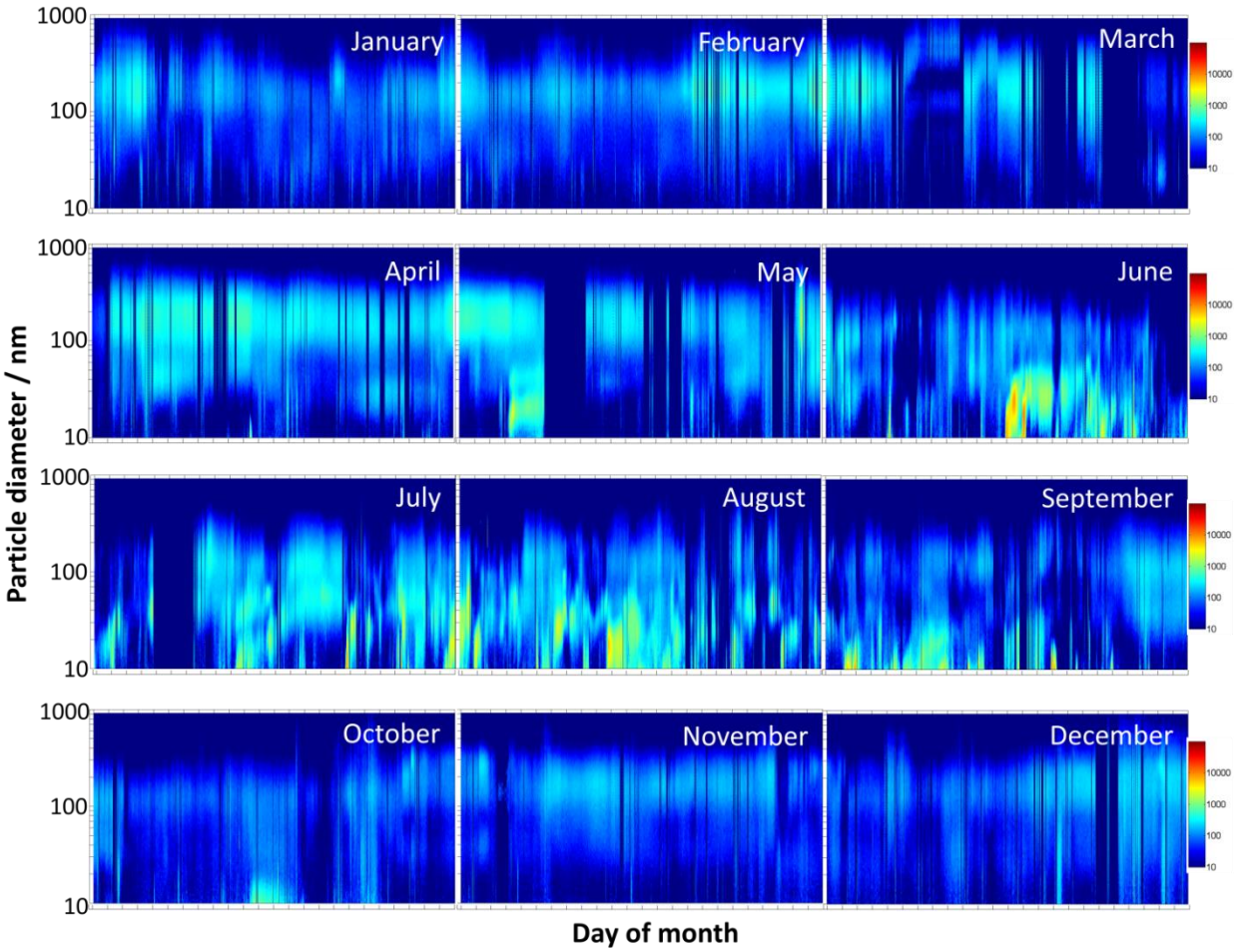




Particle number size distribution at Station Nord during 2012

- **Pronounced accumulation mode during Arctic haze**
- **Pronounced nucleation mode during Arctic summer**
- **Concentration range only a few hundred particles per ccm**

3-dimensional plot of particle number size distribution at Station Nord during 2012



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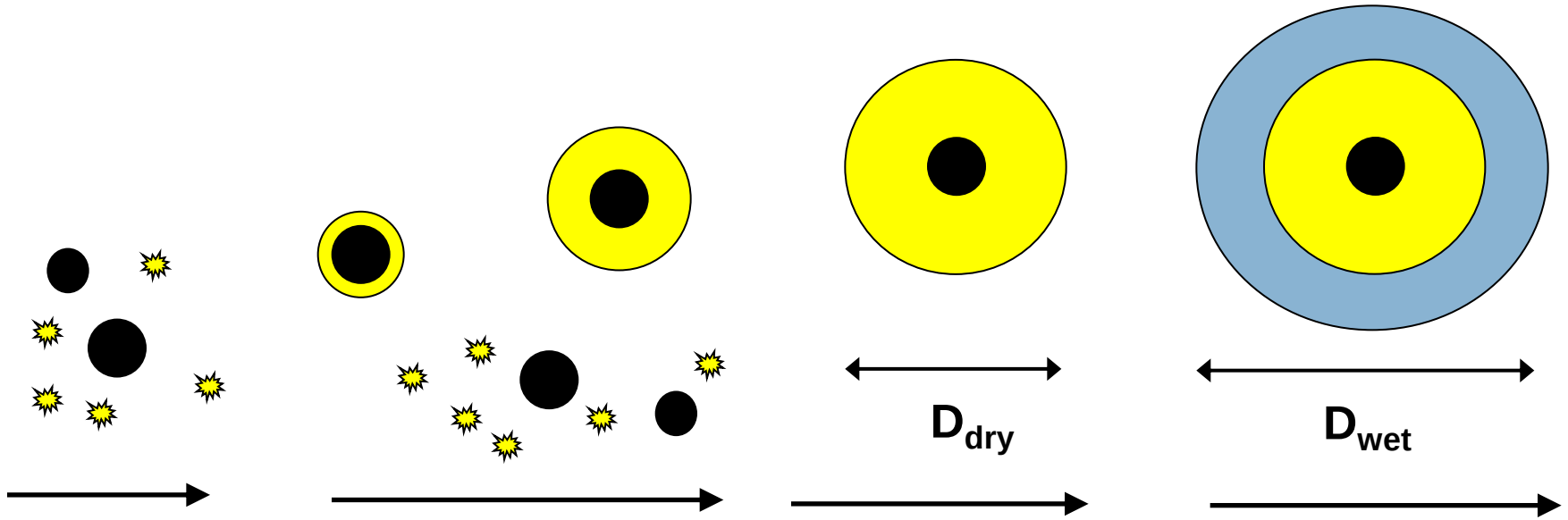
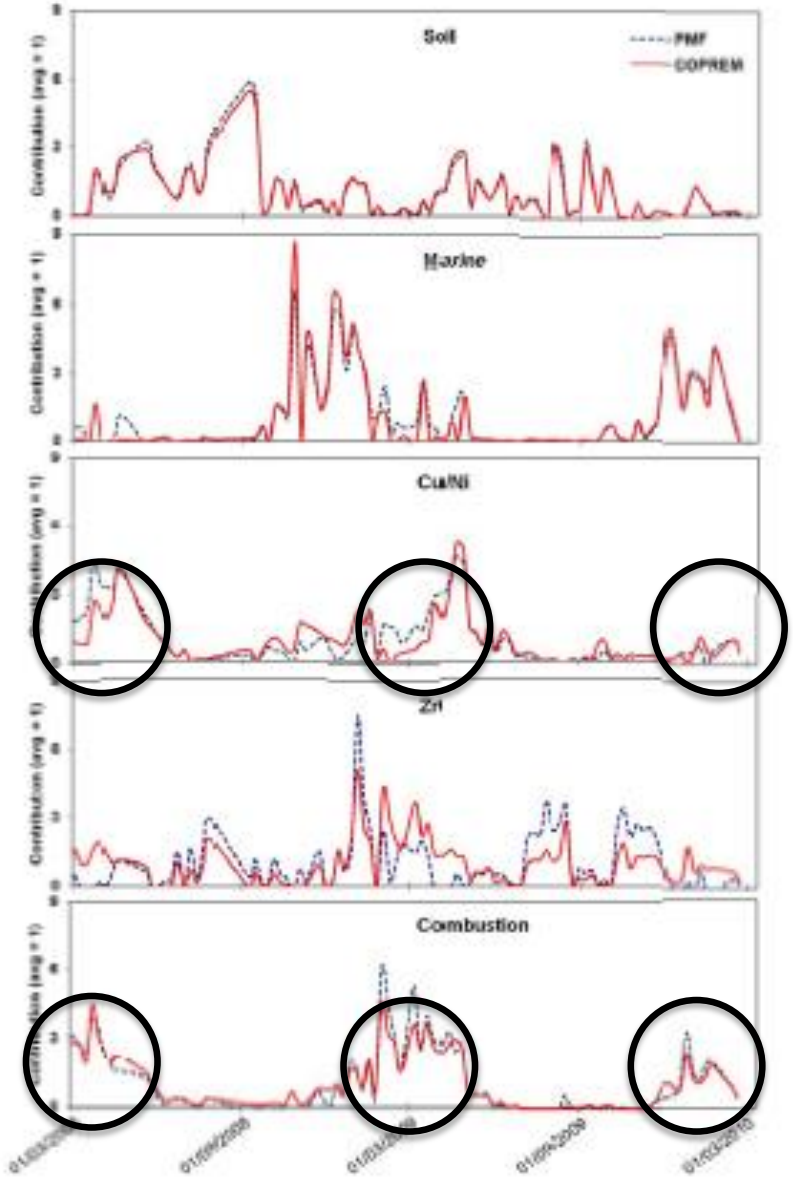
What happens during long-range transport to the Arctic?



Arctic transport over several days



Results: Source apportionment of TSP at Villum Research Station (VRS) in the high Arctic (Greenland)

- In late winter/early spring air masses originated in other continents reach the high Arctic (Arctic haze)
- Natural sources include a marine and a crustal source
- Cu/Ni source represents mining emissions from Siberia
- Combustion source represents anthropogenic activities from Europe / Asia / North America

Summary: Arctic measurements

► Particle number concentrations range up to a few hundred particles cm^{-3} over the year

► Accumulation mode particle number increases during the Arctic haze period

► In the summer nucleation of particles is observed in the high Arctic assuming local sources emitting the precursors for these events

► Source apportionment confirms transport of particles from mining activities (Siberia) and other anthropogenic sources (mainly combustion sources) to the Arctic

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Thank you for your attention after such a long day!