TROPOS
Leibniz Institute for Tropospheric Research

Process studies of direct and indirect radiative forcing

The dynamic behaviour of the atmospheric aerosol particle size distribution

The atmospheric **particle number size distribution** is highly variable in time and space. Meanwhile, it is one of the most important parameters to assess the aerosols's optical and cloud-forming properties.

Our research group is involved in **worldwide** activities to capture the spatial and temporal changes in the atmospheric particle number size distributions, which are closely related to the distribution and activity patterns of the associated sources and processes. Our field measurements take place in a range of ecosystems, from the globe's **clean air** regions to **polluted urban atmospheres**.

The major tools for size distribution characterisation include various **size spectrometers** based on the principles of electromobility, light scattering, and particle inertia. With our equipment, we are usually able to cover a size range between 2 nm and 10 µm.

New particle formation and growth

New aerosol particles can be formed in the atmosphere by **homogeneous nucleation** of low-volatile precursor gases. **Sulfuric acid** is the best-known precursor gas for nucleation. By further condensation of condensable vapours and coagulation, the newly formed particles may grow into diameters where particles become active light scatterers and absorbers, and can act as cloud condensation nuclei (CCN).

Our field measurements since 1996 have demonstrated that new particle formation is a regional phenomenon in the continental boundary layer, covering 100 km and more horizontally (Field measurements of new particle formation). Solar radiation seems to be an essential requirement on the way to photochemical particle formation.

One of the newer instruments to detect new particle formation is the Neutral Cluster Air Ion Spectrometer (NAIS), which is operated jointly with the University of Helsinki.

Hygroscopic growth and mixing state

Hygroscopic growth and **mixing state** are essential properties in determining the optical properties of aerosol particles in the atmosphere. We study these properties in detail using costom-made *in situ* instrumentation.

Hygroscopic growth leads to an increase in aerosol particle diameters at high ambient relative humidities, resulting in meteorological conditions characterised as "haze" or "fog". The hygroscopic properties enhance, above all, the particles' light scattering properties and their ability to form clouds.

The **mixing state** , particularly in conjunction with carbonaceous particles, influences atmospheric light absorption.

We determine the hygroscopic properties of aerosol particles under laboratory and field conditions using **hygroscopicity analysers** (H-TDMA and HH-TDMA), the particle mixing state using tandem mobility analysers (H-TDMA und V-TDMA).

Light absorption by particles - sensitivity on wavelength and mixing state

Light **absorption** by atmospheric particles is a key area of our research efforts.

Particle light absorption depends on the mixing state of the absorbing particulate material. Internally mixed black carbon (e.g. soot particles coated by a shell of light-scattering material such as sulfate) absorbs more light than externally mixed black carbon.

In the atmosphere there are three main kinds of absorbing aerosols: **black carbon**, **organic carbon**, and **mineral dust** involving iron oxides. All these materials exhibit a different behaviour regarding the wavelength dependent absorption.

Properties of non-spherical particles

Many considerations and calculations for aerosol particles assume a **spherical shape** of the particles. As can be seen, for example, from electron micrographs, this is only a crude approximation for many real-world particles. Some prominent aerosol types, particularly **mineral dust** and **biological particles** (pollen) can strongly diverge from the spherical shape.

Particle shape has an influence on **particle sizing** in some particle size spectrometers. Depending on the measurement principle, shape-dependent correction factors can be developed. Furthermore, **light scattering** depends on particle shape, with non-sperical shapes potentially causing a misestimation of the light scattering intensity by a factor of up to two.

Our research group simulates particle sizing and light scattering for scientific instruments in the laboratory as well as under atmospheric conditions as a function of various particle shapes. These simulations are performed by various radiative transfer models. A particular focus has been the analysis of non-spherical dust particles.

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