Lab-studies connecting hygroscopic growth and droplet activation

The Leipzig Aerosol Cloud Interaction Simulator (LACIS) has been used in several studies to examine the hygroscopic growth and droplet activation of different kinds of aerosol particles. LACIS allows to measure both, hygroscopic growth up to very high relative humidity (RH > 99%), and droplet activation with the same instrument. Therefore it became possible to examine the connection between hygroscopic growth and droplet activation and to test to which extent these two processes can be consistently described, e.g. using the Köhler theory. Future applications will aim at extending the examinations to low temperatures, i.e., below the melting point of ice.

The sketch shows the setup in its 1m long version, which is used for measurements of hygroscopic growth and droplet activation. A more detailed description of LACIS can be found here.

An overview over results from our investigations is given here:

- Activation of droplets was investigated by different instruments during an inter-comparison study. Besides LACIS, also a Cloud Condensation Nucleus Counter (CCNC) from DMT and two Wyoming type CCNCs were deployed. Differently coated soot particles were examined, and it was found that the instruments agreed within measurement uncertainty (Henning et al. (2010), Snider et al. (2010), Stratmann et al. (2010)).
-Particles from different sea-water samples (some devoid of organic material, some containing algal exudates) were examined. For each sample both, hygroscopic growth and activation to droplets, could be jointly described by using a single hygroscopicity parameter, which was independent of the solution concentration (Niedermeier et al. (2008), Wex et al. (2010)).
-HULIS (HUmic Like Substances) was extracted from different atmospheric filter samples. Particles were generated by dispersion of watery solutions of the extracted HULIS. Both, hygroscopic growth and activation, could jointly be represented by the Köhler-theory using a single constant value for the hygroscopicity parameter and a concentration dependence of the surface tension of the solution (Wex et al. (2007), Ziese et al. (2008)). Different samples from a suite of different sampling locations were found to have very similar hygroscopic properties. It was also shown that even small amounts of inorganic contamination in the HULIS extracts (related to the extraction protocol) may influence the results, which might explain different results obtained in past studies on HULIS hygroscopicity (Kristensen et al. (2012)).
- SOA (Secondary Organic Aerosol) particles were generated by ozonolysis of α-pinene in the laboratory. Using Koehler-theory, hygroscopic growth and activation could only be consistently described when assuming a lowering of the surface tension (down to about 55 mN/m), together with a large change of hygroscopicity (already about 5-fold in an RH range from 90% to 99.6%) with solution concentration. This suggested either changing non-ideality or slightly soluble substances being present (Wex et al. (2009), Petters et al. (2009)). These findings solved an open issue, namely that SOA particles activated to cloud droplets more easily than would be expected based on the often observed low hygroscopic growth. The mass accommodation coefficient of water vapor on liquid water was determined by studying the activation and subsequent droplet growth of NaCl particles and was found to be between 0.3 and 1 (Voigtländer et al. (2007)).
- Due to the ability of LACIS to measure hygroscopic growth very precisely up to very high relative humidities (RH < 99%), deliquescence of particles consisting of slightly soluble succinic acid could be directly measured. For 200nm particles the deliquescence point was found to be 99% RH (+/-0.2%) (Wex et al. (2007)).

Literature:


