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CCN frequency distributions and aerosol chemical composition from long-term observations at European ACTRIS supersites

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Cloud droplet number concentration is regulated by the availability of aerosol acting as cloud condensation nuclei (CCN). Predicting the air concentrations of CCN involves knowledge of all physical and chemical processes that contribute to shape the particle size distribution and determine aerosol hygroscopicity. The relevance of specific atmospheric processes (e.g., nucleation, coagulation, condensation of secondary organic and inorganic aerosol, etc.) is time- and site-dependent, therefore the availability of long-term, time-resolved aerosol observations at locations representative of diverse environments is strategic for the validation of state-of-the-art chemical transport models suited to predict CCN concentrations. We focused on long-term (year-long) datasets of CCN and of aerosol composition data including black carbon, and inorganic as well as organic compounds from the Aerosol Chemical Speciation Monitor (ACSM) at selected ACTRIS supersites (http://www.actris.eu/). We discuss here the joint frequency distribution of CCN levels and of aerosol chemical components concentrations for two stations: an alpine site (Jungfraujoch, CH) and a central European rural site (Melpitz, DE). The CCN frequency distributions at Jungfraujoch are broad and generally correlated with the distributions of the concentrations of aerosol chemical components (e.g., high CCN concentrations are most frequently found for high organic matter or black carbon concentrations, and vice versa), which can be explained as an effect of the strong seasonality in the aerosol characteristics at the mountain site. The CCN frequency distributions in Melpitz show a much weaker overlap with the distributions of BC concentrations or other chemical compounds. However, especially at high CCN concentration levels, a statistical correlation with organic matter (OM) concentration can be observed. For instance, the number of CCN (with particle diameter between 20 and 250 nm) at a supersaturation of 0.7% is 5000 cm-3 or higher when OM concentration is also high (> 3 μg m-3) while nitrate concentration can span over a wide range of concentrations (0.2 – 10 μg m-3) with no relation to CCN concentrations. These results suggest that a quantitative analysis of the phenomenology of CCN in connection to that of aerosol chemical components provides useful constraints for current models simulating the formation of CCN and the underlying physical and chemical atmospheric processes.
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