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Robustness of global CCN simulations and implication for droplet formation: A BACCHUS and AEROCOM intercomparison

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In the frame of the BACCHUS EU program and AEROCOM project, general circulation and global chemistry-transport models are evaluated for their ability to simulate aerosol number concentrations, cloud condensation nuclei (CCN) and cloud droplets number concentration (CDNC). Model-to-model comparisons and comparisons of model results with observational data are performed. In total, fifteen global models provided detailed results for the years 2010-2015 for eight European observatory sites belonging to the ACTRIS network and one site in Japan. Model predictions for the number concentration of aerosol particles and CCN at various supersaturation ratios, along with the mass composition of PM1 particles were directly compared to long time-series of hourly-obtained observational data. The ability of the current state-of-the-art atmospheric models to predict the long-term seasonal variability as well as the short-term (< 10 days) dynamical behavior of aerosol particles and CCN has been thus evaluated. By using a cloud droplet formation parameterization, the CDNC for five of the observational sites, which provided sufficient CCN data, was computed and compared to the corresponding CDNC derived from the models results. Annual mean surface-level particle number concentrations for various sizes and CCN at 0.2 % supersaturation calculated by the models along with their corresponding chemical composition are presented and discussed.

The analysis of these results shows that in general i) the models underestimate the CCN number concentration at almost any supersaturation ratio due to the low number of particles with sizes relevant to the CCN formation that the models predict compared to the observations, ii) models predict seasonal variabilities of aerosol particles number concentrations, mass concentrations and CCN similar to observed ones, iii) short-term persistence of CCN at the ACTRIS sites is calculated to be between 2 and 10 days in agreement with observations. However, the models are not always able to capture the relative order of the winter/summer persistence times, iv) the differences between the observed and the model computed CDNC are smaller than the differences for the CCN and the number of aerosol particles.