CCN ACTIVATION MODEL

The simulations are carried out using a recently developed CCN activation model (Arabas and Pawlowska, 2010). The model describes evolution of the size of an ensemble of solution droplets contained in an adiabatic air parcel being lifted and cooled beyond supersaturation.

The model utilizes the adaptive method of lines (MOL) for numerically solving the so-called dynamic equation of aerosol growth by condensation coupled with the heat budget of an adiabatic air parcel. Employment of MOL (Lagrangian representation of particle size evolution) allows accurate description of aerosol chemical composition. That is because particle properties such as mass of solute are retained throughout the computation. Particle composition is represented in the model by a single parameter $\kappa$, using the $\kappa$-Köhler parameterisation (Petters and Kreidenweis, 2007). The rate of growth of a solution droplet at a given chemical composition. That is because particle properties such as mass of solute are retained throughout the computation. Particle composition is represented in the model by a single parameter $\kappa$, using the $\kappa$-Köhler parameterisation (Petters and Kreidenweis, 2007). The rate of growth of a solution droplet at a given chemical composition.

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Particle size spectra are approximated in the model using histograms composed of bins whose position and width evolve with time. The result of the size distribution at the right part of the droplet spectrum in the region between the unactivated aerosol mode and the activated cloud-droplet mode evolves poorly represented. The adaptive size distribution spectrum allows for the accuracy of the numerical solution by adjusting only very small size bins for a smaller number of simulations and scope of the model equations being integrated. The figure to the right presents a comparison of aerosol spectra evolution as calculated in two model runs with adaptive size spectrum discretization. The time series of the model result of the day (left) shows how the shape of the cloud droplet spectrum (blue line, histogram, bottom x-axis) changes during the period of the simulations. The evolution of size of all particles (i.e. unactivated and activated) is represented in the plots to the right by plotting the number of particles in each bin (top x-axis, top y-axis) and the total droplet concentration (bottom x-axis, bottom y-axis) different model time steps (of variable length). The scale corresponds to the difference between the drop and air temperatures. The evolution of the relative humidity (RH) is plotted with the green line (bottom x-axis).

OBservational Data

Current analysis is based on the in-situ aerosol observations made on the SAFIRE ATR-42 aircraft during the EUCAARI IMPACT field campaign (see Crumeyrolle et al., 2010, for details). The aerosol size spectrum within the 10-250 nm radius range was measured using a scanning mobility particle size (SMPS) large particles of radii up to 0.65 µm were measured using an optical spectrometer (OPC). Two sets of model input parameters are derived from the aircraft observations during research flights RF49 (May 13th, flight over Cabauw) and RF51 (May 15th, flight over the North Sea). Data from these two flights were chosen, for they represent distinct aerosol characteristics of relatively polluted and pristine air masses. The red dashed lines correspond to measurements obtained with an additional pair of SMPS and OPC connected to the aerosol inlet through a heater set at 280°C. The black curves are the trimodal lognormal distributions from Whitty (1978) used in the simulations discussed above.

Figure 1 presents simulations run with the measured aerosol size spectra used as model input (spectra averaged over ca. 200 s). The initial layout of the histogram bins in the model corresponds to the layout of SMPS and OPC size classes. Aerosol is assumed to be initially in equilibrium with the measured ambient humidity, and the initial concentration of dry aerosol is found by inverting the $\kappa$-Köhler curve. Simulations were run with different values of $\kappa$ and different initial aerosol number concentrations leading to different maximal supersaturations. All simulations were run until reaching about 150 m above cloud base where the concentration of activated droplets does not change anymore. The final concentrations are plotted as a function of the maximal supersaturation reached during the air parcel ascent. Consequently, one CCN activation spectrum (i.e. cumulative number of CCN as a function of supersaturation) is plotted for each value of $\kappa$.

The ranges of CCN concentrations measured at the single supersaturation of 0.21% on the aircraft are indicated with a red dashed line. The model results are compared with measured CCN concentrations. The model is initialised with measured aerosol size spectra. Predicted droplet concentrations are compared with measured CCN concentrations.