EGU22-8212, updated on 19 Aug 2022
https://doi.org/10.5194/egusphere-egu22-8212
EGU General Assembly 2022

Closure study of aerosol-stratocumulus interactions with UCLALES-SALSA

Silvia M. Calderón[1], Juha Tonttila[1], Angela Buchholz[2], Jorma Joutsensaari[2], Mika Komppula[1], Ari Leskinen[1,2], Hao Liqing[2], Dmitri Moisseev[1,3], Petri Tiitta[1], Annele Virtanen[2], Harri Kokkola[1], and Sami Romakkaniemi[1]
[1]Finnish Meteorological Institute, Finland (silvia.calderon@fmi.fi)
[2]Department of Applied Physics, University of Eastern Finland, Finland
[3]Institute for Atmospheric and Earth System Research/Physics, Faculty of Science, University of Helsinki, Finland

We carried out a closure study of aerosol-cloud interactions during stratocumulus formation using a large eddy simulation model UCLALES-SALSA and in situ observations from the 2020 sampling campaign at the Puijo SMEAR IV station in Kuopio, Finland. UCLALES-SALSA uses spectral bin microphysics for aerosols and hydrometeors and incorporates a full description of their interactions into the turbulent-convective radiation-dynamical model of stratocumulus. Typical closure studies use observations to assess agreement between aerosol properties and cloud droplet number concentration (CDNC) in updrafts. Here, the unique observational setup allowed a closer look into the aerosol size-composition dependence of droplet activation and droplet growth in turbulent boundary layer driven by surface forcing and radiative cooling. The model successfully described probability distribution of updraft velocities and aerosol activation efficiency curves, and nicely recreated the size distributions shapes for aerosol and cloud droplets. This is the first time such a detailed closure is achieved not only accounting for activation of cloud droplets in different updrafts, but also accounting for processes evaporating droplets and drizzle production through coagulation-coalescence.
We studied two cases of cloud formation, one diurnal (24/09/2020) and one nocturnal (31/10/2020), with high and low aerosol loadings, respectively. Aerosol number concentrations differ more than an order of magnitude between cases and therefore, lead to CDNC of less than 100 cm^{-3} up to 1000 cm^{-3}. Different aerosol loadings affected the supersaturation at the cloud base, and thus the minimum size of aerosol particles producing cloud droplets. Also, as the mean size of cloud droplets in the diurnal-high aerosol case was lower, the droplet evaporation process was found to be decreasing the observed CDNC more than in the low aerosol case. In addition, in the low aerosol case, the presence of large aerosol particles played a significant role on the droplet spectrum evolution as it promoted the drizzle formation through coalescence and collision processes enhanced by cyclic turbulence fluctuations. Also, during the event, the ice particle formation was observed due to subzero temperature at the cloud top.
The studied cases are presented in detail and can be further used by the cloud modellers to test and validate their models in a well characterized modelling setup. We also provide recommendations on how increasing amount of information on aerosol properties could improve

the understanding of processes affecting cloud droplet number and liquid water content in stratified clouds.