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Effects of turbulence and aerosols on the droplet spectrum formation in stratiform clouds

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A boundary layer (BL) model is presented in which the subcloud area and a stratiform cloud are considered as two components of a single system. Velocity fields in the BL is generated by time dependent turbulent flow using a "cheap" turbulent model obeying observed data as concerns the turbulent velocity fluctuations statistics. Several thousand air parcels are transported by this velocity field. Aerosols and droplets in each parcel are described by size distribution containing 2000 mass bins. Some fraction of aerosols in parcels crossing the condensation level is activated and gives rise to the droplet formation. The rest aerosols remain non-activated. In course of their motion, parcels experience accelerations and supersaturaion in the parcels fluctuates. In case the positive fluctuations are significant, new in-cloud nucleation gives raise the formation of new droplets and to bimodal droplet spectra. When parcels cross the cloud base from above, droplets evaporate, and aerosols in parcels return back into the environmental atmosphere. In contrast with other trajectory ensemble models, an interaction between parcels is taken into account. Fluxes of temperature, humidity and droplets between parcels are calculated, and droplet spectra in parcels change respectively. In this way, droplet sedimentation is taken into account. Collisions between droplets are described by the stochastic equation of collisions with collision kernels, which take into account effects of cloud turbulence on droplet collisions. The collision rate enhancement due to turbulence depends on the dissipation rate and Reynolds number.

Droplet size distributions in parcels, as well as spectra averaged in the horizontal direction are calculated. Effects of aerosols and cloud turbulence on droplet spectrum formation, on the spatial variability of droplet spectra and on the bimodal spectra oc-

currence are investigated. It is shown that droplet spectra in parcels located at small separation distances can be quite different. Formation of bimodal spectra was found in a significant fraction of cloud parcels.