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Utilization of a precise method of calculation of supersaturation for simulation of droplet concentration and aerosol activation in highly polluted convective clouds

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It is a usual practice in cloud resolve models that use bulk parameterization or spectral microphysics schemes to perform nucleation of cloud condensational nuclei (CCN) just after dynamical time steps, when supersaturation in the updrafts attains its maximum values. Diffusional growth of droplets and ice crystal is calculated after nucleation was performed. The diffusional growth decreases supersaturation. As a result, during each model time step supersaturation experiences significant fluctuations. At the same time microphysical processes take place simultaneously, so that diffusional growth does not allow supersaturation to reach the extreme values, when only effects of updrafts are taken into account. The utilization of supersaturation after the vertical advection for droplet nucleation can lead to an unrealistically high droplet concentration, especially in clouds growing in a very dirty air, for instance, within the zones of biomass burning. Moreover, the values of supersaturation and droplet concentration turn out to be highly dependent on the model time step. To avoid these uncertainties, a new method of the supersaturation calculation has been developed. According to this method the supersaturation values with respect to water and ice are calculated analytically from equations, in which both the dynamic tendency and diffusion growth are taken into account simultaneously. The approach was used for simulation of deep continental clouds, as well as pyro-clouds observed in the Amazon region during the SMOCC experiment. Results show that the new approach eliminates fluctuations of supersaturation during one model time step and prevents artificial activation of huge amount of aerosols. As a result, the droplet concentration tends to be

in a good agreement with measured in situ, and a significant fraction of smaller CCN remains non-activated. The approach allows the utilization of larger time steps and makes calculations more stable.