Geophysical Research Abstracts
Vol. 16, EGU2014-12443, 2014
EGU General Assembly 2014

Towards a Lagrangian mixing scheme at the stratocumulus cloud top

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Mixing processes at the top of stratocumulus clouds are still not well understood. This causes uncertainty in weather and climate predictions of the subtropics and polar regions, where stratocumuli play an important role. Parameterizations of mixing are usually based on high resolution models, but these might be hampered by a lack of understanding of the interaction of the droplet dynamics with small scale turbulence. For example, most models assume thermodynamic equilibrium for the droplets but in reality it takes a finite time to reach this thermodynamic equilibrium. Moreover it is assumed that cloud droplets are equally distributed over the cloud domain, but the droplets have a tendency to prefer regions with lower vorticity. Both factors could be an important factor for the cloud mixing.

To investigate the microphysical droplet dynamics in a cloud, both Eulerian and Lagrangian schemes can be used. In a traditional Eulerian approach all droplets are treated as a continuum field. This approach is computationally much cheaper than the Lagrangian one, but it is known to introduce extra diffusion and to smooth out fluctuations of the droplet dynamics. In order to resolve the mixing dynamics more accurately, a Lagrange approach can be used. Here the equations of motion are solved individually for each droplet, and the droplet dynamics are coupled to the flow equations. This approach needs much more computational resources than the Eulerian approach. Therefore, simulations using a Lagrangian description are limited to small domains. Despite the more extensive numerical effort and costs, the application of this method in some idealized configurations could reduce uncertainties regarding the role of microphysical dynamics in the mixing process.

Our goal is to develop a Lagrangian scheme to work in high resolution simulations of the stratocumulus cloud top. We use Direct Numerical Simulations for the flow, which is then coupled to the Lagrangian scheme. We want to compare our Lagrangian results to fully Eulerian simulations, in order to determine the major differences of both schemes. We are particularly interested in quantifying the deviations in the mixing introduced by the Eulerian scheme. Furthermore, we want also to explore the effect of mixing on the droplet radius spectrum and to asses which model of the mixing (homogeneous or inhomogeneous) fits better for the mixing at the top of stratocumulus clouds.