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Cloud microphysical effects of turbulent mixing and entrainment

RAYMOND SHAW, Michigan Technological University, BIPIN KUMAR, JOERG SCHUMACHER, Ilmenau University of Technology — Turbulent mixing and entrainment at the boundary of a cloud is studied by means of direct numerical simulations that couple the Eulerian description of the turbulent velocity and water vapor fields with a Lagrangian ensemble of cloud water droplets that can grow and shrink by condensation and evaporation. The focus is on detailed analysis of the relaxation process of the droplet ensemble during the entrainment of subsaturated air, in particular the dependence on turbulence time scales, droplet number density, initial droplet radius and particle inertia. We find that the droplet evolution during the entrainment process is captured best by a phase relaxation time that is based on the droplet number density with respect to the entire simulation domain and the initial droplet radius. Even under conditions favoring homogeneous mixing, the probability density function of supersaturation at droplet locations exhibits strong negative skewness, consistent with droplets near the cloud boundary being suddenly mixed into clear air, but rapidly approaches a narrower, bimodal shape. The droplet size distribution, which is initialized as perfectly monodisperse, broadens and also becomes somewhat negatively skewed. However, particle inertia and gravitational settling impose a sharp cutoff in both tails of the droplet size distribution during later stages of the mixing.

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