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Impact of turbulence on CCN activation and early growth of cloud droplets

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Scaled-up DNS and implicit LES simulations are used to study turbulent cloud base CCN activation and early growth of cloud droplets. The simulation framework includes a triply periodic computational domain ~1,000 cubic meters filled with inertial-range homogeneous isotropic turbulence. The domain experiences decrease of the mean air temperature and reduction of the mean pressure, both mimicking the rise of an adiabatic air parcel through the cloud base. Results of turbulent simulations are compared to CCN activation and droplet growth within a classical nonturbulent rising parcel. The key difference is a blurriness of the separation between activated and nonactivated (haze) CCN, especially for weak mean ascent rates, when CCN activate and subsequently some deactivate instead of becoming cloud droplets above the cloud base. This leads to significantly larger spectral widths in turbulent parcel simulations compared to the adiabatic nonturbulent parcel once CCN activation is completed. Further increase of the spectral width in the turbulent parcel is similar to that for the initially-monodisperse droplets in the inertial-range homogeneous isotropic turbulence that we and others studied previously, with the standard deviation of the radius squared increasing approximately as the square root of time. This contrasts with the classical nonturbulent parcel framework for which the radius squared standard deviation above the cloud base remains constant because of the parabolic growth of cloud droplets once surface tension and dilute effects can be neglected.