Identifying the autoconversion process in continental stratus and strato-cumulus clouds using novel ground-based remote sensing techniques

C. Acquistapace, U. Löhnert, M. Maahn, A. Hirsikko, P. Kollias

Clouds play an essential role in Earth's climate system through their interaction with solar and long-wave radiation, their contribution to the global hydrological structure and the vertical transport of energy and mass. Several microphysical processes that act at small scale contribute and control the lifetime of clouds (condensation, evaporation, autoconversion, accretion etc). Understanding how these processes work is essential for accurate predictions of weather and climate. However, because these processes take place on the sub-grid scale of numerical models, these cloud microphysical processes must be parameterized. In clouds without the frozen phase, one of these processes is the so-called autoconversion, which quantifies the collision/coalescence between clouds droplets to form small drizzle droplets, which then have a significant sedimentation velocity and can lead to rapid precipitation development via the accretion process. Autoconversion is usually parameterized in numerical models by means of a threshold in liquid water mass mixing ratio. Such thresholds are typically obtained from small-scale models with explicit representations of cloud microphysics. Observations of the autoconversion process are rare and there is need to assess the employed parameterization schemes that describe when clouds begin to precipitate.

Different ground-based remote sensing techniques are currently being exploited to be able to characterize the location in the cloud, the thermodynamic and environmental conditions and cloud drop size distribution moments (number concentration, water content) where the onset of precipitation occurs. Here, a one year data set (March 2012-March2013) of single layer liquid water clouds obtained at the Jülich ObservatorY for Cloud Evolution (JOYCE) located at the Forschungszentrum Jülich, Germany is analyzed. The Cloudnet target categorization scheme is applied continuously to the cloud radar, ceilometer and microwave radiometer measurements constrained by temperature profiles from a numerical weather prediction model. The Cloudnet scheme allows for the differentiation of precipitating and non-precipitating clouds. The two populations are analyzed with respect to variables such as total column liquid water path, cloud geometrical thickness, cloud base/top temperature etc. The derived statistical distributions are used for the evaluation of numerical models using parameterizations of cloud microphysical processes and allow concluding if precipitation initialization is taking place under the same conditions as observations suggest.

Preliminary analysis indicates that the Cloudnet scheme does not allow exactly pinpointing the moment of the onset of the autoconversion process because the scheme applies only a threshold in radar reflectivity. Thus, this contribution makes use of a novel approach based on higher Doppler spectra moments (as opposed to the "standard" moments reflectivity, Doppler velocity and Doppler width) obtained from the MIRA cloud radar at JOYCE. One of these higher moments is the skewness of the radar Doppler spectrum, with which deviations from the ideal Gaussian shape of the spectrum can be detected. Note, that cloud droplets only without any significant fall velocity but under the influence of turbulence will lead to a Gaussian

Doppler spectrum, whereas the onset of drizzle will lead to a deviation from the ideal Gaussian form (i.e. positive skewness at first). This contribution will show analyses of case studies of clouds at the onset of precipitation. Skewness values observed at cloud base, cloud top and within the cloud are derived as a function of reflectivity. Based on this, the Cloudnet scheme can also be evaluated and additionally, a more detailed insight into the validity of autoconversion parameterizations in numerical models can be obtained.