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Investigation of midlatitude high clouds characteristics and processes by combining lidar and balloon-borne measurements

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Observations of persistent high supersaturations with respect to ice inside and around cirrus clouds as well as subsaturation within midlatitude cirrus clouds challenge our understanding of how ice clouds form and evolve in time. Improving this understanding is essential for a better assessment of the microphysical properties and of the radiative budget of tropospheric aerosols and ice clouds, as highlighted in the latest IPCC report.

We combine remote Raman lidar measurements of water vapor and particle backscatter with in situ frost point hygrometer and backscatter sonde measurements to derive midlatitude ice cloud properties including the in-cloud humidity. The general goal is a better understanding of microphysical and radiative processes of tropospheric aerosol and cloud particles, in particular concerning the conditions leading to supersaturation with respect to ice and impeded dehydration of the upper troposphere.

We constrain processes in ice clouds by tracking the evolution of cloud backscatter and humidity by obtaining “cloud matches”, i.e. measuring the same cloud-filled air parcel twice. Match points are some 10 to 40 minutes apart and with a match error of less than 2 km. Statistical analysis of previous balloon flights over Payerne (Switzerland) and Lindenberg (Germany) show clear differences in the balloon-borne measurements of upper tropospheric and lower stratospheric humidities, which are not due to geographic differences but reveal the superiority of cryogenically cooled hygrometers over single-stage Peltier cooled hygrometers. We present case studies of the balloon-lidar match measurements, supplemented with modeling results from the Zurich Optical and Microphysical box Model (ZOMM), and discuss these with respect to microphysical processes and instrumental uncertainties.