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A mid-latitude cirrus lidar climatology with thin cirrus clouds in the lowermost stratosphere

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Lidar observations (light detection and ranging) of cirrus clouds over Jülich, Western Germany, are performed and analyzed focusing on obtaining a representative cirrus climatology in terms of cirrus thickness, top and base heights, mid temperature, optical thickness and ice water content (IWC). The lidar instrument measures optical properties (i.e. backscatter signals, extinction coefficient and depolarization) of ice particles at a wavelength of 355 nm from the ground. The observed cirrus clouds are evaluated with a temporal averaged extinction profile and corrected for multiple scattering. The optical depth is used to classify radiative properties. Mean and median values of cirrus optical depth are found to be 0.28 and 0.12 (range: 0.002 – 3), respectively. 143 cirrus observations are analyzed together with additional meteorological data under macrophysical, radiative, and microphysical aspects. By comparing these cirrus properties to three other mid-latitude lidar climatologies (Sassen and Comstock, 2001; Immler and Schrems, 2002; Goldfarb et al., 2001), a rather good agreement is found and the Jülich lidar climatology is assessed to be representative.

Most observed cirrus base heights are around 6 to 10.5 km and top heights around 12 km, implying a frequent cirrus generation due to synoptic weather pattern (e.g. frontal systems). Thus, the cirrus clouds are relatively thick with a vertical extent of about 2.25 km and occur mostly directly around the thermal tropopause. However, around 4 % of the cirrus clouds in the lidar climatology occurred above the tropopause. This indicates cirrus cloud occurrence in the lowermost stratosphere (LMS). The gradient in water vapor at the transition between troposphere and the LMS is strongly negative. Even small contributions of moist tropospheric air masses from the tropics due to quasi-horizontal transport into the LMS can increase the water vapor concentration significantly. This enhanced water vapor values could initiate the formation of thin cirrus clouds in the LMS up to polar latitudes. Further investigations could improve the understanding of mixing processes in the UT/LS. ECMWF data will be used to show the origin of the air masses which contain cirrus clouds above the tropopause as implied by the lidar observations. This will be done by using the static stability as marker for stratospheric and tropospheric air masses.