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Observations of cirrus clouds in the lowermost stratosphere: common feature, rare incident, or observational artefact?

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Ground based observations by lidar instruments show evidential occurrence of optically and vertically thin cirrus clouds in the lowermost stratosphere (LMS). The knowledge about the potential formation processes of these clouds, their occurrence and distribution, and their radiative impact is very limited. Global observations of LMS cirrus clouds by satellites would be very helpful to better characterise these clouds. However, this is a difficult task because the optical thickness of LMS cirrus is usually at the edge of the detection limit (for space borne limb-sounders) or even below (for infra red nadir sounders).In addition, instrument characteristics can make it difficult to judge if a cloud observation is inside the LMS of just at or below the tropopause. Consequently it is not really proven if LMS cirrus clouds are a rare occasion or a globally common feature.

We will give a brief overview of the history of LMS cirrus observations from ground and space borne sensors and are highlighting the sometimes controversial discussion on the observation of clouds in the LMS. Then we will focus on results from measurements of the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) satellite instrument. CRISTA made a number of snapshot measurements of the UT/LS during its two Space Shuttle missions in 1994 and 1997. The measurements demonstrate the potential of the IR limb viewing technique to provide information on several trace constituents and optically thin cirrus clouds with comparably high spatial resolution. The CRISTA data are still unique for IR limb sounders in the sense of vertical (1.5 km) and horizontal (300-500 km) resolution as well as daily global coverage by using three telescopes for three different viewing directions simultaneously. The detection sensitivity for optically thin cirrus clouds is extremely high. Depending on the vertical and horizontal extent of a cirrus cloud, the detection of an ice water content $> 10^{-5} g/m^3$ is achievable. This detection limit is even better than for the CALIPSO lidar, the most sensitive instrument currently in space.

An overview of CRISTA-2 water vapour and cirrus observations in August 1997 will be given, and compared with corresponding ECMWF reanalyses and simulations by the Chemical Lagrangian Model of the Stratosphere (CLaMS). The observations indicate a considerable flux of moisture from the upper tropical troposphere into the extra-tropical lowermost stratosphere, accompanied by high cirrus cloud occurrence frequencies even at rather high northern latitudes (65N) and at altitudes above the tropopause (around 350 K potential temperature). The observations are compared with CLaMS simulations, which include a simple parameterisation for cirrus cloud formation and sedimentation of ice particles. The results suggest a connection between isentropic, quasi-horizontal transport of water vapour from the sub-tropics and the occurrence of optically thin cirrus clouds in the lowermost stratosphere well above the tropopause.