On the quantification of turbulence in cirrus clouds using MST Radar and Lidar measurements

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The small-scale turbulence in cirrus has an important influence on stratosphere-troposphere exchange processes and also controls the cloud microphysical structure and life cycle through entrainment processes. Marginally severe turbulence was reported in the anvils besides active overshooting convective cores by air craft measurements. An attempt is, therefore, made to quantify the turbulence in cirrus clouds using simultaneous observations of MST Radar and Lidar, at Gadanki, during the period 1998-2012. The statistics of physical/geometrical and optical properties of cirrus clouds are first compared with those available in the literature to check whether or not the removal of majority of the data (because of the non-availability of simultaneous MST radar observations and stringent quality control techniques adopted) has altered the statistics. The sub-set of data that satisfies above conditions clearly reproduced the known features of cirrus clouds over Gadanki: occurrence height in the range of 8-18 km with a maximum at 13-14 km; exhibiting seasonal variability in the occurrence with the maximum occurrence at a higher height during monsoon; geometrical thickness in the range of 2-4 km with a maximum value as high as 8 km during summer; and prominence of optically thin clouds (>80%).

Availability of simultaneous measurements allows clear identification of cirrus clouds (from lidar measurements) and estimation of turbulence (spectral width measurements from MST radar) in different regions of cirrus. For instance, turbulence in the core (CI) and boundaries (± 0.5 km of the cloud top, CT and cloud bottom, CB) of the cloud is quantified to better understand the entrainment processes. It is observed that the turbulence near the CB is larger than that in CI and CT. Further, the statistics showed that there is no linear dependence of turbulence on the optical depth, but the turbulence is nearly twice in thick cirrus (optical depth, $\tau \geq 0.03$) compared to that in thin cirrus clouds (optical depth, $\tau < 0.03$).