



Cloud and aerosol occurrences in the UTLS region across Pakistan during summer monsoon seasons using CALIPSO and CloudSat observations

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As part of the A-train NASA constellation, Cloudsat and CALIPSO provide an unprecedented vertical observation of clouds and aerosols. Using observational data from both of these satellites, we conduct a multi-year analysis from 2006-2014, of the UTLS (Upper Troposphere and the Lower Stratosphere) region. We map out cloud and aerosol occurrences in this region across Pakistan, specifically around the summer monsoon season. Over the past five years, Pakistan has faced tremendous challenges due to massive flooding as well as earlier brief monsoon seasons of low precipitation and short drought periods. Hence, this motivates the present study towards understanding the deep convective and related dynamics in this season which can possibly influence cloud and aerosol transport in the region. Further, while global studies are conducted, the goal of this study is to conduct a detailed study of cloud, aerosols and their interplay, across Pakistan. Due to a dearth of ground observations, this study provides a dedicated focus on the UTLS domain. Vertical profiling satellites in this region are deemed important as there are no ground observations being done. This is important as both the properties and dynamics of clouds and aerosols have to be studied in a wider context in order to better understand the monsoon season and its onset in this region.

With the CALIPSO Vertical Feature Mask (VFM), Total Attenuated Backscatter (TAB) and Depolarization Ratio (DR) as well as the combined CloudSat's 2B-GEOPROF-LIDAR (Radar-Lidar Cloud Geometrical Profile) and 2B-CLDCLASS-LIDAR (Radar-Lidar Cloud Classification) products, we find the presence of thin cirrus clouds in the UTLS region in the periods of June-September from the 2006-2014 period. There are marked differences in day observations as compared to night in both of these satellite retrievals, with the latter period finding more occurrences of clouds in the UTLS region. Dedicated CloudSat products 2B-CLDCLASS (cloud classification) and 2C-TAU (Cloud Optical Depth) further confirm the presence of sub-visual and thin cirrus clouds in the UTLS region, during the summer monsoon season. From CALIPSO observations, there is significant presence of aerosol layers before the onset of precipitation in the troposphere. This thickness ranges from 1-4 km, with increasing thickness observed the 2009-2014 period. Implications of these findings are detailed in this presentation.