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A Long-term Analysis of Cloud-height and Rainfall using ERA5 Reanalysis, Satellite and Ground Measurements

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Clouds and precipitation are the two critical components of the hydrological cycle that directly and indirectly affects life on the Earth. Clouds play a vital role in accomplishing the water need on the Earth as they transport water from oceans to land through precipitation. The cloud and rainfall climatology over a western-Indian semi-arid urban region has been studied using ERA5 reanalysis datasets, IMD gauge adjusted GSMaP rainfall data, and ground-based instruments, viz. lidar and disdrometer. The ceilometer lidar collocated with the disdrometer at Physical Research Laboratory, Ahmedabad provides the cloud base height up to three layers with high temporal resolution. These ground-based cloud observations are crucial for weather and climate study, as they provide better quality ground truth observations. In this study, the in-depth investigation and statistical analysis has been done using twenty-two-year (2000-2021) atmospheric cloud base height (CBH) and precipitation data over Ahmedabad (23.02°N, 72.57°E, 55m a.m.s.l.), Gujarat, India. The monthly and yearly variation of the CBH and associated rainfall has been investigated to better understand the correlation between the two over the years. It is observed that the maximum CBH occurs during winter and summer months, and minimum during monsoon. The monthly average precipitation reveals that Ahmedabad receives about 788 mm of rainfall in June, July, August, and September, which is nearly 96 % of total yearly precipitation (820mm). Record-breaking monthly precipitation in the observed period occurred in July 2017 (1052 mm) and July 2006 (818 mm). In this study, the clouds have been classified according to their base height as Low-Level Clouds (LLC), Mid-Level Clouds (MLC), and High-Level Clouds (HLC). For all the years, the average occurrence of LLC is more than 50 %, and the remaining are MLC and HLC. On the other hand, MLC and LLC are less than 40 % and 20 %, respectively, in all years. The LLC mainly contributes to the precipitation, with MLC and HLC have minimal contributions.

The cloud base height and cloud fraction play an important role in precipitation and cloud radiative forcing. Hence, the climatology of a region is influenced by the changes in the cloud properties and rainfall patterns. Therefore, a long-term analysis of clouds and precipitation is essential for model inputs and predicting future climate over a region.