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Boundary Layer Clouds in the polluted environment during CAIPEEX and the role of moisture

Thara Prabha
(prabha.thara@gmail.com)

Prabha T. V. , G. Pandithurai, S. Dipu,
B. N. Goswami, R. S. Maheshkumar, and J. R. Kulkarni
Indian Institute of Tropical Meteorology, Pune, India

A major Cloud Aerosol Interaction and Precipitation Enhancement EXperiment (CAIPEEX; http://www.tropmet.res.in/∼caipeex/) was conducted by the Indian Institute of Tropical Meteorology in India. First phase of the experiment during the pre-monsoon and monsoon season of 2009 included aerosol, cloud condensation nuclei, cloud droplet concentration and other environmental measurements over different geographical locations over the Indian subcontinent. Cloud and aerosol measurements onboard the research aircraft was carried out over varying degrees of polluted/dry/wet environments depending on the progression of monsoon. We used CAIPEEX observations and cloud resolving model simulations at high resolution to investigate the role of pollution in changing the cloud properties, boundary layer dynamics and precipitation. These simulations are carried out by incorporating CAIPEEX observations over selected clean and polluted environments with a distinct difference in the environmental moisture content. Motivation for this study comes from several earlier studies over different places, emphasizing that aerosol effects on precipitation depends strongly on the environmental conditions and the type of cloud.

Three intensive CAIPEEX field campaign periods are considered namely, (a) during pre-monsoon dry conditions dominated by boundary layer clouds (b) during the progression of the monsoon with both boundary layer clouds and mid level clouds and (c) for the active monsoon over the peninsular India, also including high level clouds. Three cases are used to investigate the impact of pollution under dry to moist environments on the rainfall distributions and on the PBL dynamics. Relative humidity varied between 20-80 % inside the boundary layer and 50-70 % above the BL cloud free regions, in the cases considered. It is shown that simulated rainfall decreased significantly in a relatively dry, polluted environment dominated by Boundary Layer Clouds, which can be explained by an increase in the cloud droplet concentrations. Although precipitation associated with Boundary Layer Clouds is less significant, it changes the radiative impact by influencing the boundary layer convection and cloud formation. The evaporative cooling lead to destabilization of the boundary layer, that has influenced the boundary layer wind shear, further enhancing convection.