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Observations of Aerosol and Cloud Microphysics at Mt. Lulin and its implication to aerosol indirect effect

Abstract

Aerosol can modify cloud microphysics as known as the aerosol indirect effect (AIE). However, observational evidence for AIE is limited due to the scarcity of mountainous stations capable of providing aerosol and cloud measurements. In spring, Taiwan is often influenced by long-range transport of biomass burning emissions originating from the Southeast Asian Peninsula via westerly winds in the low-level free troposphere. Abundant aerosols may accompany cloud systems moving into Taiwan under favorable synoptic weather conditions. To gain a better understanding of the characteristics of aerosol-laden cloud systems, a field experiment was conducted at the Lulin Atmospheric Background Station (LABS) from March 1st to 12th, 2024. In addition to LABS's observations, a suite of aerosol-cloud microphysics instruments, including Cloud Droplet Probes (CDP) and 11-D optical particle counters, was deployed to measure size distribution, number concentration, effective diameter, and liquid water content (LWC).

The results indicate that cloud number concentration (N_d) does not exhibit a monotonic increase as aerosol number concentration ($PM_{2.5}$) increases. Similarly, cloud effective diameter (ED) does not exhibit a monotonic decrease either. The relationship between $PM_{2.5}$ and liquid water content (LWC) within clouds is further analyzed. Aerosol indirect effect on cloud droplets is significant only when the ratio of LWC to $PM_{2.5}$ falls within a certain range ($\log(LWC/PM_{2.5}) > -1.5$). Within this range, higher aerosol concentrations are associated with an increase in the number of smaller cloud droplets. This study improves to our understanding of the impact of biomass burning aerosols on cloud droplets. It demonstrates that, with an increase in aerosol concentrations, cloud droplets tend to dissipate rather than form or maintain themselves in the environment, which aligns with the Aerosol Indirect Effect (AIE).

Keyword

Aerosol Indirect Effect (AIE), Cloud Microphysics