Balloon-borne aerosol–cloud interaction studies (BACIS): field campaigns to understand and quantify aerosol effects on clouds

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A better understanding of aerosol-cloud interaction processes is important to quantify the role of clouds and aerosols on the climate system. There have been significant efforts to explain the ways aerosols modulate cloud properties. However, from the observational point of view, it is indeed challenging to observe and/or verify some of these processes because no single instrument or platform is proven sufficient. With this motivation, a set of observational field campaigns named Balloon-borne Aerosol Cloud Interaction Studies (BACIS) is proposed and conducted using balloon-borne in-situ measurements in addition to the ground-based (Lidars, MST radar, LAWP, MWR, Ceilometer) and space-borne (CALIPSO) remote sensing instruments from Gadanki (13.45° N, 79.2° E), India. So far, 15 campaigns have been conducted as a part of BACIS campaigns from 2017 to 2020. This paper presents the concept of the observational approach, lists the major objectives of the campaigns, describes the instruments deployed and discusses results from selected campaigns. Balloon-borne measurements of aerosol/cloud backscatter ratio and cloud particle count are qualitatively assessed using the range of corrected data from simultaneous observations of ground-based, space-borne lidars. Aerosol/cloud vertical profiles obtained in multi-instrumental observations are found reasonably agreeing. Apart from this, balloon-borne profiling is found to provide information on clouds missed by ground-based and/or space-borne lidars. A combination of the Compact Optical Backscatter AerosoL Detector (COBALD) and Cloud Particle Sensor (CPS) sonde is employed for the first time in this study to discriminate cloud and aerosol in an in-situ profile. A threshold value of COBALD colour index (CI) for ice clouds is found to be between 18 and 20 and CI values for coarse mode aerosol particles range between 11 and 15. Using the data from balloon measurements, the relationship between cloud and aerosol is quantified for the liquid clouds. As shown in Figure 1, a statistically significant slope (aerosol-cloud interaction index) of 0.77 found between aerosol backscatter and cloud particle count reveals the role of aerosol in the cloud activation process. In a nutshell, the results presented here demonstrate the observational approach proposed.

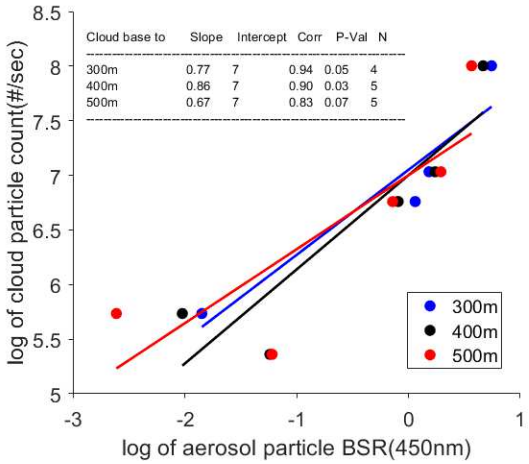

Figure 1. Scatter between logarithm values of COBALD median aerosol blue backscatter from 300, 400 and 500 meters below the cloud base and the corresponding CPS median cloud particle count. The table inside shows detailed statistics.