Simultaneous Measurements of direct, semi-direct and indirect aerosol forcing with Stacked Autonomous UAVs: A New Observing Platform

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We report here first time demonstration with three autonomously flying Unmanned Aerial Vehicles (UAVs) of cloudy sky albedo, transmission atmospheric solar absorption, aerosol and cloud droplet concentrations and number densities. From these direct measurements we derive the direct, semi-direct and the first indirect aerosol forcing. The observing system consisted of 3 light weight UAVs, instrumented with miniaturized instruments (Roberts et al, 2006; Ramana et al, 2006; Corrigan et al 2006) for measuring aerosol concentrations and size distribution, cloud microphysical properties, black carbon concentration and broad band and narrow band solar fluxes. The airborne measurements were validated and augmented by the Atmospheric Brown Clouds Maldives Climate Observatory (ABC_MCO) in the island of Hanimaadhoo in the N. Indian Ocean (Corrigan et al, 2006; Ramana and Ramanathan 2006). The campaign was conducted during March and early April of 2006 when this region is subject to long range transport of pollution from S. Asia. In the stacked 3_UAV configuration, one flew in the boundary layer below clouds to characterize the aerosols feeding the clouds and the transmission of solar radiation by the absorbing aerosol layer and clouds above; the second inside the trade cumulus clouds to directly observe the fully nucleated cloud drop size and concentrations and total liquid water content; and the third above the cloud to determine the incoming solar and the reflected solar radiation. The 3-UAVs were programmed to sample the same region(or clouds) within seconds of each other, thus providing unique insights into how aerosols and boundary layer dynamics modulate the cloud microphysics and thus the albedo and solar absorption of cloudy skies in the planet. The period of observations also included a major dust-soot event which revealed a large increase in atmospheric solar absorption. We will present results on how 3-dimensional clouds with absorbing aerosols modulate atmospheric solar absorption, cloud microphysical properties, cloudy sky surface and TOA forcing and surface solar forcing.