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Simultaneous measurements of dust and pollution to observe aerosol-cloud interactions

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The Maldives Air Campaign (MAC) demonstrated a novel application of stacked autonomous unmanned aerial vehicles (AUAVs) for atmospheric science research (Ramanathan et al., 2006; http://www-abc-asia.ucsd.edu/). The observing system consisted of three AUAVs outfitted with miniaturized instruments for measuring aerosols, clouds, and radiometric fluxes. The stacked, formation flight was programmed to sample the same vertical region below, in, and above the clouds to study how the boundary layer aerosols feeding the trade wind cumuli modify cloud microphysical properties and albedo. Ground-based measurements of cloud condensation nuclei (CCN) also quantify the cloud-nucleating ability of the marine boundary layer (MBL) aerosols.

The experiment was conducted in March 2006 to observe long-range transport of dust and pollution from the Arabian Peninsula and South Asia and detected changes in cloud properties. A decrease in cloud fraction was observed and coincided with the arrival of an aerosol layer above the MBL. These layers, embedded with absorbing aerosols, burnt off clouds making the semi-direct effect an important aerosol-cloud interaction over the Indian Ocean. Observations and simulations show that shortwave cloud radiative forcing of the semi-direct effect is larger than that of the indirect effect.

To accomplish this campaign, aerosol, cloud, radiometric instruments, and an integrated data acquisition system have been miniaturized with a total payload weight and power less than 5 kg and 50 W, respectively. The AUAV payloads are mission-specific and outfitted to perform a defined set of measurements depending on the scientific goals. The below-cloud platform measured aerosol concentrations and size distributions within the boundary layer to assess the extent of vertical mixing and number of cloud-forming aerosol. The in-cloud platform determined cloud droplet number and size and horizontal extent - an onboard camera was used for cloud targeting. The

above-cloud platform measured aerosol concentrations in the free troposphere and the albedo of the cloud systems below. The Maldives Climate Observatory on Hanimaadhoo Island (MCOH), which serves as a supersite for the Atmospheric Brown Cloud (ABC) project (Corrigan et al, 2006; Ramana and Ramanathan 2006), complimented and validated the airborne measurements.