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Vertical and horizontal distribution of sub-micron aerosol chemical composition and physical properties across Northern India, during the pre-monsoon and monsoon seasons

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The Indian subcontinent is one of the most polluted regions in the world. At the moment, the nature and magnitude of the aerosol impacts are poorly understood and constrained. Uncertainties lie in the vertical distribution, spatial distribution of various different aerosols and the relative contribution from different sources (Chakraborty et al, 2016).

The South West Asian Aerosol-Monsoon Interactions (SWAAMI) project, which occurred from June to July 2016, sought to address these uncertainties by carrying out an airborne experiment. Such experiment was on-board the UK Facility for Airborne Atmospheric Measurements (FAAM) BAe-146 research aircraft (pictured above). The field campaign conducted 22 flights in advance of the summer monsoon, and during the onset phase. The vertical and spatial extent of aerosols were studied across both Northern India (based out of Lucknow, in the Indo-Gangetic Plain (IGP)) and in Southern India (based out of Bangalore). Two aerosol instruments were operated by the University of Manchester on-board the aircraft; an Aerodyne Aerosol Mass Spectrometer (AMS) and a DMT Single Particle Soot Photometer (SP2).

In the IGP, organic aerosol (OA) dominates the aerosol burden, whereas outside the IGP, sulphate dominates. BC mass concentrations indicate greater values inside the IGP. The main inorganic components show different spatial patterns; sulphate is regional in nature, especially in the pre-monsoon season. Nitrate appears to be determined by thermodynamic processes, with increased nitrate mass concentration in conditions of lower temperature and higher relative humidity. The total aerosol mass concentrations display decreases as monsoon rainfall arrives over the study regions. However, the decrease is less significant over the IGP, possibly indicative of the strength of emissions sources over this region. Inside the IGP the aerosol species are more absorbing in nature, whereas in NW India aerosol present is larger in size.

The aerosol mass concentration also displays variations in the vertical profiles. Inside the IGP, profiles undergo changes with monsoon progression. During the pre-monsoon, OA and absorbing aerosol species dominate in the lower atmosphere (<1.5km) with sulphate and scattering aerosol species dominating in an elevated aerosol layer (EAL) above (>1.5km). As the monsoon progresses into the IGP region, this EAL structure diminishes, with the profile decreasing in vertical extent, mass concentration and a switch to being dominated by OA. Outside the IGP, the profiles display sulphate aerosol dominating throughout, with no change in chemical composition with monsoon progression (only decrease in vertical extent and mass concentration throughout). Dust is present in the atmospheric column, with large concentrations in NW India and the IGP. The dust concentrations decrease significantly in the IGP due to removal by the monsoon rainfall. These results will serve as useful model input for the SE Asia region.

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Reference: Chakraborty, A., Gupta, T. and Tripathi, S. N. (2016) Atmospheric Environment 136 144-155.