Impacts of Air Pollution Aerosols on Clouds in India

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The interaction between aerosols and clouds is probably the biggest uncertainty of all climate forcing/feedback processes. Clouds have significant effect on Earth's radiative balance. Low clouds reflect incoming sunlight back to space, acting to cool the planet, whereas high clouds can trap outgoing terrestrial radiation and act to warm the planet. Changes in cloud cover, in cloud vertical development, and cloud optical properties will have strong radiative and therefore, climatic impacts. Furthermore, factors that change cloud development will also change precipitation processes. These changes may alter amounts, locations and intensities of local and regional rain, creating droughts, floods and severe weather. Cloud droplets form on a subset of aerosol particles called cloud condensation nuclei (CCN). In general, an increase in aerosol leads to an increase in CCN and an increase in cloud droplet concentration. Thus, for the same amount of liquid water in a cloud, more available CCN will result in a greater number but smaller size of droplets. A cloud with smaller but more numerous droplets will be brighter and reflect more sunlight to space, thus exerting a cooling effect. This is the first aerosol indirect effect or "cloud albedo effect". The effectiveness of a particle as a CCN depends on its size and composition so that the degree to which clouds become brighter for a given aerosol perturbation, and therefore the extent of cooling, depends on the aerosol size distributions and its size-dependent composition. In addition, aerosol perturbations to cloud microphysics may involve feedbacks; for example, smaller drops are less likely to collide and coalesce; this will inhibit growth, suppressing precipitation, and possibly increasing cloud lifetime. In this case clouds may exert an even stronger cooling effect.

Some aerosol particles, particularly black carbon and dust, also act as ice nuclei (IN) and in so doing, modify the microphysical properties of mixed-phase and ice-clouds. An increase in IN will generate more ice crystals, which grow at the expense of water droplets due to the difference in vapor pressure over ice and water surfaces. The efficient growth of ice particles may increase the precipitation efficiency. In deep convective, polluted clouds there is a delay in the onset of freezing because droplets are smaller. These clouds may eventually precipitate, but only after higher altitudes are reached that result in taller cloud tops, more lightning

and greater chance of severe weather. Recently, Indian Institute of Tropical Meteorology (IITM) conducted a four-month long field campaign namely Cloud Aerosol Interactions and Precipitation Enhancement Experiment (CAIPEEX) over continental India. Using these measurements, observational effect of pollution aerosols on cloud microphysics and warm rain initiation will be presented.