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Anthropogenic Aerosols and Tropical Precipitation

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Anthropogenic aerosols can affect the radiative balance of the Earth-atmosphere system and precipitation by acting as cloud condensation nuclei (CCN) or ice nuclei (IN) and thus modifying the optical and microphysical properties as well as lifetimes of clouds. Recent studies have also suggested that the direct radiative effect of anthropogenic aerosols, particularly absorbing aerosols, can perturb the large-scale circulation and cause a significant change in both quantity and distribution of critical tropical precipitation systems ranging from Pacific and Indian to Atlantic Oceans. This effect of aerosols on precipitation often appears in places away from aerosol-concentrated regions and current results suggest that the precipitation changes caused by it could be much more substantial than that by the microphysics-based aerosol effect. To understand the detailed mechanisms and strengths of such a "remote impact" and the climate response/feedback to anthropogenic aerosols in general, an interactive aerosol-climate model has been developed based on the Community Climate System Model (CCSM) of NCAR. Its aerosol module describes size, chemical composition, and mixing states of various sulfate and carbonaceous aerosols. Several model processes are derived based on 3D cloud-resolving model simulations. We have conducted a set of long integrations using the model driven by radiative effects of different combinations of various carbonaceous and sulfate aerosols and their mixtures. The responses of tropical precipitation systems to the forcing of these aerosols are analyzed using both model and observational data. Detailed analyses on the aerosol-precipitation causal relations of two systems: i.e., the Indian summer monsoon and Pacific ITCZ will be specifically presented.