Impacts of aerosol direct effects on the South Asian climate: assessment of radiative feedback processes using model simulations and satellite/surface measurements

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Abstract

Current assessment of aerosol radiative effect is hindered by our incomplete knowledge of aerosol optical properties, especially absorption, and our current inability to quantify physical and microphysical processes. In this research, we investigate direct aerosol radiative effect over heavy aerosol loading areas (e.g., Indo-Gangetic Plains, South/East Asia) and its feedbacks on the South Asian climate during the pre-monsoon season (March–June) using the Purdue Regional Climate Model (PRCM) with prescribed aerosol data derived by the NASA Goddard Earth Observing System Model (GEOS-5). Our modeling domain covers South and East Asia (60–140E and 0–50N) with spatial resolutions of 45 km in horizontal and 28 layers in vertical. The model is integrated from 15 February to 30 June 2008 continuously without nudging (i.e., only forced by initial/boundary conditions). Two numerical experiments are conducted with and without the aerosol-radiation effects. Both simulations are successful in reproducing the synoptic patterns on seasonal-to-interannual time scales and capturing a pre-monsoon feature of the northward rainfall propagation over Indian region in early June which shown in Tropical Rainfall Measuring Mission (TRMM) observation. Preliminary result suggests aerosol-radiation interactions mainly alter surface-atmosphere energetics and further result in an adjustment of the vertical temperature distribution in lower atmosphere (below 700 hPa). The modifications of temperature and associated rainfall and circulation feedbacks on the regional climate will be discussed in the presentation.

In addition to modeling study, we will also present the most recent results on aerosol properties, regional aerosol absorption, and radiative forcing estimation based on NASA's operational satellite and ground-based remote sensing. Observational results show spatial gradients in aerosol loading and solar absorption accounting over Indo-Gangetic Plains during the pre-monsoon season. The direct radiative forcing of aerosols at surface to be -19–23 Wm^{-2} (12–15 % of the surface solar insolation) over NW India is estimated using an observational approach. A comparison of aerosol radiative forcing between numerical simulation and observational estimate will be presented. Overall, this work will demonstrate the aerosol direct effects from both modeling and observation perspectives, and further to assess the physical processes underlying the aerosol radiative feedbacks and possible impacts on the large-scale South Asian monsoon system.

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