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AEROSOL INFLUENCES ON CLIMATE: RADIATIVE FORCING AND BEYOND

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ABSTRACT

Atmospheric aerosols influence shortwave (solar) irradiance at the surface and at the top of the atmosphere (TOA) by scattering and absorbing light (direct effects) and by modifying the reflectance and persistence of clouds (indirect effects). Estimation of aerosol direct radiative effects requires knowledge of aerosol optical properties (extinction coefficient, single scattering albedo, and asymmetry parameter), all of which depend on relative humidity and wavelength, as a function of three-dimensional location and time, as well as the reflective properties of the surface and the presence, nature, and height of clouds. Estimation of aerosol forcing of climate change relative to the preindustrial climate requires knowledge of the perturbation in these influences due to changes in aerosol loading, distribution, and properties. Aerosol indirect forcing results from increase, relative to the preindustrial climate, in the number concentration of cloud droplets and resultant increase in cloud reflectivity and inhibition of precipitation development, increasing cloud persistence, both of which contribute to enhanced planetary shortwave albedo, with possible increases in downwelling longwave surface irradiance as well. Despite considerable attention these aerosol effects remain highly uncertain. Moreover, although these forcings are commonly represented as changes in global annual average net TOA irradiance, this quantity does not fully capture the climate influences of aerosols, even in global mean. Other aerosol effects include modification of the hydrological cycle and the carbon cycle. Inhibition of precipitation development, while not reducing total precipitation, is expected to result in enhanced atmospheric burden of water and geographical displacement of precipitation. Decreases in surface irradiance by aerosols reduce evapotranspiration, decreasing the strength of the hydrological cycle. Alteration of the direct to diffuse irradiance by light scattering aerosols may change the amount of photosynthesis and evapotranspiration. These influences are only beginning to be recognized and metrics for their quantification identified. This talk reviews present understanding and points to needed research.
