A modeling study of differing impacts of black carbon and sulfate aerosols on global precipitation

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Besides greenhouse gases, aerosols are also important forcing agents on climate change, which receive great expectations for potential short-term mitigations of global warming through their emission controls. Black carbon (BC) and sulfate (SF) are two kinds of aerosols with quite different optic properties and therefore interacting with the climate in different ways. This study explores the climatic effects of BC and SF on global precipitation with simulations using MIROC5 (5^{th} version of the Model for Interdisciplinary Research on Climate). Results show that BC causes a decrease in global annual mean precipitation, consisting of a large negative component of fast precipitation response (ΔP_{fast}) scaled with atmospheric absorption and a small positive component of slow precipitation response (ΔP_{slow}) scaled with the BC-caused global warming. SF also causes a decrease in global annual mean precipitation, which is dominated by ΔP_{slow}, corresponding to the surface cooling caused by SF. BC causes a northward shift of ITCZ (Intertropical Convergence Zone) mainly through ΔP_{fast}, whereas SF causes an obvious southward shift of ITCZ through ΔP_{slow}. The displacement of ITCZ caused by BC and SF is found to linearly correlate with the corresponding change in cross-equatorial heat transport in the atmosphere, implying that the ITCZ shift occurs as a manifestation of the atmospheric heat transport in response to the BC and SF forcings. Comparing the ITCZ response caused by BC and SF between CGCM (atmosphere-ocean fully coupled model) and SOM (atmosphere-slab ocean coupled model), it is found that SOM exaggerates the cross-equatorial heat transport in the atmosphere and the ITCZ shift both for BC and SF. This underscores the importance of fully coupled ocean in modeling study of regional climate response.

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