Geophysical Research Abstracts
Vol. 20, EGU2018-19716-1, 2018
EGU General Assembly 2018

A PDRMIP multi-model study on the impacts of regional aerosol forcings on global and regional precipitation

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Atmospheric aerosols such as sulfate and black carbon (BC) generate inhomogeneous radiative forcing and can affect precipitation in distinct ways compared to greenhouse gases (GHGs). Their regional effects on the atmospheric energy budget and circulation can be important for understanding and predicting global and regional precipitation changes, which act on top of the background GHG-induced hydrological changes. Under the framework of the Precipitation Driver Response Model Inter-comparison Project (PDRMIP), multiple models were used for the first time to simulate the influence of regional (Asian and European) sulfate and BC forcing on global and regional precipitation. The results show that, as in the case of global aerosol forcing, the global fast precipitation response to regional aerosol forcing scales with global atmospheric absorption, and the slow precipitation response scales with global surface temperature response. Asian sulphate aerosols appear to be a stronger driver of global temperature and precipitation change compared to European aerosols, but when the responses are normalised by unit radiative forcing or by aerosol burden change, the picture reverses, with European aerosols being more efficient in driving global change. The global apparent hydrological sensitivities of these regional forcing experiments are again consistent with those for corresponding global aerosol forcings found in the literature. However, the regional responses and regional apparent hydrological sensitivities do not align with the corresponding global values. Through a holistic approach involving analysis of the energy budget combined with exploring changes in atmospheric dynamics, we provide a framework for explaining the global and regional precipitation responses to regional aerosol forcing.