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Hemispheric Rainfall Shifts Driven by Aerosol-Cloud Interactions

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The contrasting rainfall between the wet tropics and the dry subtropics largely determines the climate of the tropical zones. A southward shift of these rain belts has been observed throughout the latter half of the twentieth century, with profound societal consequences. Although such large-scale shifts in rainfall have been linked to interhemispheric temperature gradients from anthropogenic aerosols, a complete understanding of this mechanism has been hindered by the lack of explicit information on aerosol radiative effects. We show that the hemispheric precipitation shift does not result from aerosols directly through their absorption and scattering of radiation, but rather indirectly through their modification of cloud radiative properties. In addition to altering cloud microphysical properties, aerosol-driven changes in the atmospheric circulation also induce non-local changes in clouds. Thus, the total aerosol-mediated cloud response consists of both local microphysical changes and non-local dynamical changes. The dynamical cloud changes are comparable in magnitude to the microphysical cloud changes and act to further amplify the inter-hemispheric asymmetry of the total cloud response to aerosol forcing. Models with larger cloud responses to aerosol forcing better reproduce the observed interhemispheric temperature changes and tropical rain belt shifts over the twentieth century, suggesting that aerosol–cloud interactions will play a key role in determining future interhemispheric shifts in climate.