Fourth International Conference on Earth System Modelling
4ICESM-151, 2017

Saharan dust reduction drives changes in the global monsoon system

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Monsoon systems represent the dominant feature of tropical climate with profound local, regional, and global impacts. Monsoon rainfall is the life-blood of more than half of the world's population, for whom agriculture is the main source of subsistence. The dependency of the agricultural sector on monsoon rains - particularly in countries with poor infrastructure and increased urbanisation – results in societies that are highly vulnerable to changes in monsoon characteristics, such as its onset and withdrawal, and total rainfall amounts. Understanding drivers and mechanisms of monsoon variability is thus of paramount importance, yet not void of major uncertainties. Here we investigate how the global monsoon system as well as its regional components, especially the extensive Asian-Australian monsoon, were modulated by increased boreal summer insolation, vegetated Sahara, and reduced dust concentrations during the mid-Holocene (6,000 yr BP). Accounting for changes in Saharan dust has recently been shown to be pivotal for reproducing the latitudinal extent of the West African monsoon during the period. Based on a set of sensitivity experiments in which all the three drivers are varied in turn as well as in combination, we show that Saharan dust forcing has significant remote effects across the tropical monsoon region, especially over South Asia and the western Pacific. Reduced dust leads to a weaker South Asian monsoon precipitation and to a southward displacement of the Meiyu-Baiu front over eastern Asia, mediated by changes in the large-scale atmospheric circulation. In general, the effect of reduced dust partially offset that due to increased Saharan vegetation alone, while in some cases, such as over western India, the two forcings interact in a non-linear way. Changes in the surface energy budget, via altered evaporation and net surface radiation, result is large temperature anomalies, particularly over the Middle East and East Asia. Overall, this study highlights the importance of Saharan dust forcing for monsoon-wide climate, which has potential important implications for the future as dust emissions might vary under a warmer climate.