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The role of soil moisture in land surface-atmosphere coupling: climate model sensitivity experiments over India

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It is generally acknowledged that anthropogenic land use changes, such as a shift from forested land into irrigated agriculture, may have an impact on regional climate and, in particular, rainfall patterns in both time and space. India provides an excellent example of a country in which widespread land use change has occurred during the last century, as the country tries to meet its growing demand for food. Of primary concern for agriculture is the Indian summer monsoon (ISM), which displays considerable seasonal and subseasonal variability. Although it is evident that changing rainfall variability will have a direct impact on land surface processes (such as soil moisture variability), the reverse impact is less well understood.

However, the role of soil moisture in the coupling between the land surface and atmosphere needs to be properly explored before any potential impact of changing soil moisture variability on ISM rainfall can be understood. This paper attempts to address this issue, by conducting a number of sensitivity experiments using a state-of-the-art climate model from the UK Meteorological Office Hadley Centre: HadGEM2. Several experiments are undertaken, with the only difference between them being the extent to which soil moisture is coupled to the atmosphere. Firstly, the land surface is fully coupled to the atmosphere, globally (as in standard model configurations); secondly, the land surface is entirely uncoupled from the atmosphere, again globally, with soil moisture values being prescribed on a daily basis; thirdly, the land surface is uncoupled from the atmosphere over India but fully coupled elsewhere; and lastly, vice versa (i.e. the land surface is coupled to the atmosphere over India but uncoupled elsewhere).

Early results from this study suggest certain 'hotspot' regions where the impact of soil moisture coupling/uncoupling may be important, and many of these regions coincide with previous studies. Focusing on the third experiment, i.e. uncoupled over India and coupled elsewhere, preliminary results suggest an increase in rainfall, surface temperature and pressure over northern India and the Himalayas, as well as a decrease in rainfall over the Bay of Bengal and the Maritime Continent. Other metrics, such as the northward propagation of intraseasonal rainfall variability and sensible and latent heat fluxes, are also discussed.