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Comparing atmosphere-land surface feedbacks from models within the tropics (CALM). Part 1: Evaluation of CMIP5 GCMs to simulate the land surface-atmosphere feedback

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Man-made transformations to the environment, and in particular the land surface, are having a large impact on the distribution (in both time and space) of rainfall, upon which all life is reliant. From global changes in the composition of the atmosphere, through the emission of greenhouse gases and aerosols, to more localised land use and land cover changes due to an expanding population with an increasing ecological footprint, human activity has a considerable impact on the processes controlling rainfall. This is of particular importance for environmentally vulnerable regions such as many of those in the tropics. Here, widespread poverty, an extensive disease burden and pockets of political instability has resulted in a low resilience and limited adaptative capacity to climate related shocks and stresses.

Recently, the 5th Climate Modelling Intercomparison Project (CMIP5) has run a number of state-of-the-art climate models using various present-day and future emission scenarios of greenhouse gases, and therefore provides an unprecedented amount of simulated model data. This paper presents the results of the first stage of a larger project, aiming to further our understanding of how the interactions between tropical rainfall and the land surface are represented in some of the latest climate model simulations. Focusing on precipitation, soil moisture and near-surface temperature, this paper compares the data from all of these models, as well as blended observational-satellite data, to see how the interactions between rainfall and the land surface differs (or agrees) between the models and reality.

Firstly, in an analysis of the processes from the "observed" data, the results suggest a strong positive relationship between precipitation and soil moisture at both daily and seasonal timescales. There is a weaker and negative relationship between precipitation and temperature, and likewise between soil moisture and temperature. For all variables, the correlations are stronger at the seasonal timescale. These results also suggest that there are "hotspots" of high linear gradients between precipitation and soil moisture, corresponding to regions experiencing heavy rainfall. Secondly, in a comparison of these relationships across all available models, preliminary results suggest that there is high variability in the ability of the models to reproduce the observed correlations between precipitation and soil moisture. All models show weaker correlations than in the observed at daily timescales. Finally, one of the models (namely HadGEM2-ES, from the UK Met Office Hadley Centre) will be focused upon as an example case study. Here, preliminary findings suggest a difference between the model and the observations in the timings of the correlations, with the model showing the highest positive correlations when precipitation leads soil moisture by one day.