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The contributions of soil-moisture interactions to climate change in the tropics in CMIP5 projections from the GLACE-CMIP5 experiment

Wilhelm May (1,2), Markku Rummukainen (2), and Arndt Meier (2)

(1) Research and Development, Danish Meteorological Institute, Copenhagen, Denmark, (2) Centre for Environmental and Climate Research, Lund University, Lund, Sweden

The contributions of the projected changes in soil moisture to the overall climate change in the tropics at the end of the 21st century are quantified using the simulations from the GLACE-CMIP5 experiment. This is done by directly comparing the overall projected future changes in climate, which are partly related to changes in soil moisture, to the changes in climate that are not affected by any changes in soil moisture. As the five different climate models contributing to the experiment, i.e., CESM, EC-EARTH, GDFL, IPSL and MPI-ESM show quite different geographical distributions of the future changes in soil moisture in the tropics as well as different magnitudes, we do not consider ensemble mean values based on the corresponding simulations with these models but rather analyse the simulations from the different models separately. This allows for quantifying the contributions of the projected changes in soil moisture to climate change in the tropics for each climate model despite the different characteristics of the soil moisture changes themselves. We focus on two aspects of the interactions of the soil moisture with climate, i.e., the soil moisture-temperature coupling and the soil moisture-precipitation coupling/feedback.

The simulations show marked future changes in soil moisture content in the tropics, with a general tendency of increases in the central parts of the tropics and decreases in the subtropics. These changes are associated with corresponding changes in precipitation, with an overall tendency of a 5% change in soil moisture in response to a precipitation change of 1 mm/d. The changes in soil moisture content are found to give major contributions to the overall climate change in the tropics. This is particularly the case for the latent and sensible heat fluxes as well as near-surface temperature, where more than 80% of the overall future changes are related to soil moisture changes. For precipitation, on the other hand, 30-40% of the overall future changes are induced by the changes in soil moisture. The simulations confirm the conceptual models of the soil moisture-temperature coupling and the soil moisture-precipitation coupling/ feedback introduced by Seneviratne and colleagues. As for the soil moisture-temperature coupling, decreases (increases) in soil moisture lead to increasing (decreasing) sensible heat fluxes and near-surface temperatures. As for the soil moisture-precipitation feedback, increases (decreases) in precipitation cause increases (decreases) in soil moisture content, which, in turn, lead to increasing (decreasing) latent heat fluxes and precipitation.