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Impacts of soil-moisture feedbacks on tropical precipitation in CMIP5 projections obtained from the GLACE-CMIP5 experiment

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The impact of the projected changes in the soil moisture conditions in a CMIP5 climate scenario on precipitation in the tropics is investigated on the basis of three simulations covering the period 1950-2100 with the atmospheric component of the EC-Earth coupled climate model, in accordance with the GLACE-CMIP5 experiment. In the reference experiment (ExpR) the conditions of both the sea surface and the land surface, i.e., the soil moisture content, are prescribed on a daily basis originating from a CMIP5 simulation with the fully coupled version of EC-Earth. In one sensitivity experiment (ExpA), the mean seasonal cycle of soil moisture has been prescribed as the climatology over the period 1971-2000 obtained from ExpR. In the other sensitivity experiment (ExpB) the seasonal cycle of soil moisture is prescribed as a transient climatology from ExpR, i.e., 30-year running mean values. In all three simulations the concentrations of the well-mixed greenhouse gases and atmospheric aerosols have been prescribed according to observations for the period 1950-2005 and according to the RCP8.5-scenario for 2006-2100. The direct comparison between ExpB and ExpA for future climate conditions allows for assessing the contribution of the projected changes in soil moisture to the overall changes in climate simulated in ExpR. The projected changes at the end of the 21st century (2071-2100) with respect to 1971-2000 are considered here.

ExpR gives pronounced changes in the soil moisture content in the tropics at the end of the 21st century, mainly driven by corresponding changes in precipitation. In general, there are increases in the soil moisture in regions, where soil moisture is already high, and decreases in regions, where the soil moisture is already low. With the strong seasonal variation of precipitation in response to the seasonal shift in the location of the Inter-Tropical Convergence Zone, the projected changes in precipitation and, hence, in soil moisture undergo seasonal variation. As a consequence, the impact of soil-moisture feedbacks in the tropics also strongly varies by season. This affects turbulent energy fluxes, in particular the latent heat flux, as well as various aspects of regional-scale precipitation in different ways. In the subtropics, for instance, where soil moisture is the limiting factor for convective activity in the dry season, the projected future decrease in soil moisture strongly contributes to the projected decrease in precipitation. In the central tropics with abundant soil moisture, on the other hand, the projected soil moisture increase plays a less important role.