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Land-surface feedbacks on temperature and precipitation in CMIP6-LS3MIP projections

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The Land Surface, Snow and Soil Moisture Model Intercomparison Project (LS3MIP) aims at diagnosing systematic biases in the land models of CMIP6 Earth System Models and assessing the role of land-atmosphere feedbacks on climate change. Two components of experiments have been designed: the first is devoted to the assessment of the systematic land biases in offline mode (LMIP) while the second component is dedicated to the analysis of the land feedbacks in coupled mode (LFMIP). Here we focus on the LFMIP experiments. In the LFMIP protocol (van den Hurk et al. 2016), which builds upon the GLACE-CMIP configuration, two sets of climate-sensitivity projections have been carried out in amip mode: in the first set (amip-lfmip-pdLC) the land feedbacks to climate change have been disabled by prescribing the soil-moisture states from a climatology derived from “present climate conditions” (1980-2014) while in the second set (amip-lfmip-rmLC) 30-year running mean of land-surface state from the corresponding ScenarioMIP experiment (O’Neill et al., 2016) is prescribed. The two sensitivity simulations span the period 1980-2100 with sea surface temperature and sea-ice conditions prescribed from the first member of historical and ScenarioMIP experiments. Two different scenarios are considered: SSP1-2.6 (f1) and SSP5-8.5 (f2).

In this analysis, we focus on the differences between amip-lfmip-rmLC and amip-lfmip-pdLC at the end of the 21st Century (2071–2100) in order to isolate the impact of the soil moisture changes on surface climate change. The (2071-2100) minus (1985-2014) temperature change is positive everywhere over land and the climate change signal of precipitation displays a clear intensification of the hydrological cycle in the Northern Hemisphere. Warming and hydrological cycle intensification are larger in SSP5-8.5 scenario. Results show large differences in the feedbacks between wet, transition and semi-arid climates. In particular, over the regions with negative soil moisture change, the 2m-temperature increases significantly while the cooling signal is not significant over all the regions getting wetter. In agreement with Catalano et al. (2016), the larger effects on precipitation due to soil moisture forcing occur mostly over transition zones between dry and wet climates, where evaporation is highly sensitive to soil moisture. The sensitivity of both 2m-temperature and precipitation to soil moisture change is much stronger in the SSP5-8.5 scenario.