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A theoretical approach to assess soil moisture–climate coupling across CMIP5 and GLACE-CMIP5 experiments

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Climate on land is influenced by various land–atmosphere interactions which involve diverse land surface state variables. In several regions, soil moisture plays an important role for climate through its control on the partitioning of net radiation into sensible and latent heat fluxes and, consequently, its impact on temperature and precipitation. The Global Land-Atmosphere Coupling Experiment–Climate Model Intercomparison Project phase 5 (GLACE-CMIP5) aims to quantify the impact of soil moisture on these important climate variables and to trace the individual coupling mechanisms. GLACE-CMIP5 provides experiments with different soil moisture prescriptions that can be used to isolate the effect of soil moisture on climate.

Here, we apply a theoretical approach that relies on the distinct relation of soil moisture with evaporative fraction (the ratio of latent heat flux over net radiation) and with near-surface air temperature in different soil moisture regimes to quantify the climate impact of the diverse soil moisture prescriptions in the GLACE-CMIP5 experiments. Calculating the soil moisture effect on evaporative fraction with this theoretical approach yields very similar values as directly obtained estimations from the GLACE-CMIP5 experiments (pattern correlation of 0.85). Moreover, the soil moisture effect on temperature is well captured in those regions where soil moisture exerts a strong control on latent heat fluxes. The theoretical approach is also applied to quantify the soil moisture contribution to the temperature on the hottest day of the year yielding consistent results with recent estimations of *Vogel et al.* (2017). Finally, GLACE-style soil moisture prescription is also mimicked in an extended set of CMIP5 models. The results indicate consistency between the soil moisture–climate coupling strength estimated with GLACE-CMIP5 and CMIP5 models. The presented theoretical approach constitutes thus a simple and powerful tool to quantify soil moisture–climate coupling in both GLACE-CMIP5 and CMIP5 models without the need of performing additional simulations with soil moisture prescription.

Vogel, M. M., Orth, R., Cheruy, F., Hagemann, S., Lorenz, R., Hurk, B., and Seneviratne, S. I.: Regional amplification of projected changes in extreme temperatures strongly controlled by soil moisture-temperature feedbacks, Geophysical Research Letters, 44, 1511–1519, 10.1002/2016GL071235, 2017.