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Influence of soil moisture-climate and vegetation-climate interactions on European summer climate in regional climate model simulations

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Processes acting at the interface between the land surface and the atmosphere have a strong impact on the European summer climate, particularly on extreme events. These processes are to a large extent associated with soil moisture, but also with vegetation processes, since plants' transpiration is assumed to be the largest contributor to evapotranspiration in many regions. This study investigates the role of soil moisture-atmosphere as well as vegetation-atmosphere coupling for the European summer climate using regional climate model (RCM) simulations.

On the one hand we use the model COSMO-CLM driven with ECMWF reanalysis and operational analysis data to perform different RCM simulations. The set of experiments includes a control run (CTL) with interactive soil moisture, and different sensitivity experiments with prescribed soil moisture: a dry and a wet run to determine the impact of extreme values of soil moisture, as well as experiments with lowpass-filtered soil moisture from CTL to quantify the impact of temporal variability of soil moisture. Soil moisture-climate interactions are found to have significant effects on temperature extremes in the experiments and impacts on precipitation extremes are also identified. Case studies of selected major summer heat waves reveal that intraseasonal and interannual variability of soil moisture account for 5–30% and 10–40% of the simulated heat wave anomaly, respectively.

On the other hand we perform simulations with COSMO-CLM^2 to study the role of vegetation-atmosphere coupling in particular for droughts and resulting feedbacks to the regional climate. COSMO-CLM^2 stands for a new version of the COSMO-CLM coupled to NCAR's Community land model. COSMO-CLM^2 allows a detailed representation of vegetation-climate interactions at the regional scale thanks to the possibility of turning on and off different modules such as the carbon cycle (meaning that with carbon cycle photosynthesis is calculated interactively and is prescribed in the later case). We perform several experiments with and without soil moisture feedbacks and including different land surface modules to investigate the resulting vegetation-climate interactions with a focus on drought-climate feedbacks. In addition, by comparing the results obtained with COSMO-CLM vs COSMO-CLM^2 we highlight the impact of the representation of detailed vegetation processes for land-atmosphere feedbacks.