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Land-climate feedbacks and climate extremes in the regional climate model COSMO-CLM^2

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Land-climate feedbacks play a significant role for summer temperature variability and extreme events, in particular in the context of climate change in Europe (e.g. Seneviratne et al. 2010). These processes are to a large extent associated with soil moisture dynamics, but also with vegetation processes, since plants' transpiration is the largest contributor to evapotranspiration in many regions.

We investigate here the role of land-climate feedbacks for regional climate in Europe using the newly developed coupled biosphere-atmosphere regional climate model COSMO-CLM^2 (Davin et al. 2011). The model can be used either coupled to the Community Land Model (CLM), an advanced land surface scheme (LSM), or to TERRA-ML, the native land surface scheme in COSMO-CLM. We perform control runs and extreme soil moisture experiments with both LSMs to investigate the influence of the LSM on the simulation of land-climate feedbacks.

Overall, the results for the soil moisture experiments are consistent with the two LSMs. However, using the more sophisticated LSM CLM reduces the sensitivity to the extreme soil moisture experiments. This is in-line with a decreased temperature variability that reduces the overestimation of temperature variability in the model. In addition, high temperatures are better represented with the more sophisticated LSM. The influence of the land surface is constrained to southern Europe with CLM. With TERRA-ML, regions of strong land-climate coupling are more extended.

We also investigate the connection between heat waves and droughts in the simulations. In regions where land-climate coupling is strong, both models underestimate the relationship whereas they overestimate it in regions with weak land-climate feedbacks. In transitional zones from strong to weak coupling this relationship is overestimated when using TERRA-ML but well captured with CLM. Furthermore, we analyse simulated energy balance anomalies over grassland and forests during heat waves and droughts and evaluate them with observations.

These results highlight the importance of the correct representation of vegetation processes and soil hydrology for the simulation of land-climate feedbacks in a regional climate model. Biases in climate variability and extremes can be reduced with the use of a more sophisticated land surface scheme and results in a more realistic representation of land-climate feedbacks. The new COSMO-CLM^2 is found to be a valuable tool to investigate vegetation-climate interactions on the regional scale, although further improvement could still be achieved.

References:

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