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Soil moisture - atmosphere interactions during the 2003 European summer heatwave

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The physical processes and the sequence of feedbacks contributing to the record-breaking 2003 European summer heatwave [1,2,3] involve substantial uncertainties. Here we use the regional climate model CHRM to identify key processes and feedbacks that contributed to the occurrence and persistence of this heatwave. In particular, we investigate the role of soil moisture and its interaction with the atmosphere through latent and sensible heat fluxes. Sensitivity experiments are performed by perturbing spring soil moisture in order to determine its influence on the formation of the heatwave. A multi-year regional climate simulation for 1970-2000 using the same model set-up is used as reference and validation period. The simulations are driven by lateral boundary conditions and sea-surface temperatures from the ECMWF operational analysis and reanalysis (ERA-40), thereby prescribing the large-scale circulation.

A large precipitation deficit together with early vegetation green-up [4] and strong positive radiative anomalies in the months preceding the extreme summer event contributed to an early and rapid loss of soil moisture, which exceeded the multi-year average by far. The exceptionally high temperatures, most pronounced in June and August 2003, were initiated by persistent anticyclonic circulation anomalies that enabled a dominance of the local heat balance [5]. The lack of moisture resulted in strongly reduced evapotranspiration and latent cooling [6] and thereby intensified the surface temperature anomalies.

The evaluation of the experiments with perturbed spring soil moisture shows that this quantity is an important parameter for the evolution of the European summer climate. Simulations indicate that moderate spring soil moisture anomalies may account for

more than 2°C surface temperature differences during the summer 2003. Moreover, negative soil moisture anomalies are revealed to influence the tropospheric circulation by producing a surface heat low and enhancing the positive height anomaly in the mid-troposphere, pointing towards a positive feedback mechanism between soil moisture and atmospheric circulation.

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