SOIL MOISTURE – ATMOSPHERE INTERACTIONS DURING THE 2003 EUROPEAN SUMMER HEATWAVE

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A record-breaking heatwave affected the European continent in summer 2003, causing between 22,000 and 35,000 deaths and large financial losses due to crop shortfall and forest fires [1,2,3]. The physical processes and the sequence of feedbacks during the formation of heatwaves 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 the synoptic-scale circulation and soil hydrology and their interaction and feedback processes. Sensitivity experiments are performed by perturbing spring soil water 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.

The exceptionally high temperatures in summer 2003 were initiated by anticyclonic atmospheric circulations that enabled a dominance of the local heat balance over Europe [4]. Strong positive radiative anomalies and a large precipitation deficit in the months preceding the extreme summer event contributed to a rapid loss of soil water, which exceeded the multi-year average by far. The lack of moisture resulted in strongly reduced evapotranspiration and latent cooling during the 2003 heatwave. The evaluation of the experiments with perturbed spring soil water shows that this quantity is an important parameter for the evolution of the European summer climate. Simulations indicate that moderate spring soil water anomalies may account for more than 2°C surface temperature differences during summer 2003. Moreover, negative soil water anomalies are revealed to influence the tropospheric circulation by forcing a surface heat low and strengthening the positive height anomaly in the mid-troposphere, pointing towards a positive feedback mechanism between surface conditions and atmospheric circulation.

References

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