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The soil moisture-precipitation feedback in simulations with explicit and parameterized convection

C. Hohenegger (1), P. Brockhaus (1), C.S. Bretherton (2), and C. Schaer (1)

(1) Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland (peter.brockhaus@env.ethz.ch), (2) Department of Atmospheric Sciences, University of Washington, Seattle, USA

We perform perturbed soil-moisture simulations, using various convection modeling setups over central Europe. In one set of simulations, convection is explicitly simulated at 2-km resolution, whereas in other sets of simulations, it is parameterized with the Tiedtke and the Kain-Fritsch-Bechtold schemes and varying closures at 25-km mesh size. The single-month (July 2006) simulations reveal that the feedback between initial soil-moisture and precipitation is vastly different between the setups, not only in magnitude but also in sign. We suggest that this finding has profound implications for the modeling uncertainty of extreme precipitation events, soil-moisture memory, heat wave incidence and seasonal predictability.

The explicit modeling approach yields a clear negative feedback, thus precipitation being favored by dry soil conditions. The Tiedtke scheme, on the other hand, shows a strong positive feedback, thus precipitation being favored by wet soil conditions. Finally, the Kain-Fritsch-Bechtold convection scheme results in a negative feedback sign, with a magnitude even stronger than in the simulations with explicit convection.

It is found that in both the explicit and the Kain-Fritsch-Bechtold simulation, wet initial soil conditions result in a particularly strong low-level cloudiness. The radiation shielding caused by the low-level clouds suppresses deep convection in wet soil-moisture conditions. On the other hand, dry (but not too dry) conditions not only reduce this shielding but also produce more vigorous thermals due to the higher Bowen ratio over dry soil. In contrast, with the Tiedtke scheme, dry soil-moisture conditions strongly suppress deep convection, unless the closure is replaced by a moisture-independent formulation.