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Land surface modeling in convection permitting simulations

Chiel van Heerwaarden and Imme Benedict
Wageningen University, Meteorology and Air Quality, Wageningen, Netherlands (chiel.vanheerwaarden@wur.nl)

The next generation of weather and climate models permits convection, albeit at a grid spacing that is not sufficient to resolve all details of the clouds. Whereas much attention is being devoted to the correct simulation of convective clouds and associated precipitation, the role of the land surface has received far less interest. In our view, convective permitting simulations pose a set of problems that need to be solved before accurate weather and climate prediction is possible.

The heart of the problem lies at the direct runoff and at the nonlinearity of the surface stress as a function of soil moisture. In coarse resolution simulations, where convection is not permitted, precipitation that reaches the land surface is uniformly distributed over the grid cell. Subsequently, a fraction of this precipitation is intercepted by vegetation or leaves the grid cell via direct runoff, whereas the remainder infiltrates into the soil.

As soon as we move to convection permitting simulations, this precipitation falls often locally in large amounts. If the same land-surface model is used as in simulations with parameterized convection, this leads to an increase in direct runoff. Furthermore, spatially non-uniform infiltration leads to a very different surface stress, when scaled up to the course resolution of simulations without convection.

Based on large-eddy simulation of realistic convection events at a large domain, this study presents a quantification of the errors made at the land surface in convection permitting simulation. It compares the magnitude of the errors to those made in the convection itself due to the coarse resolution of the simulation. We find that, convection permitting simulations have less evaporation than simulations with parameterized convection, resulting in a non-realistic drying of the atmosphere. We present solutions to resolve this problem.