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Towards scale-independent land-surface flux estimates in Noah-MP

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Land-surface models use a variety of process representations to calculate terrestrial energy, water and biogeochemical fluxes. These process descriptions are usually derived from point measurements which are, in turn, scaled to much larger resolutions ranging from 1 km in catchment hydrology to 100 km in climate modelling. Both, hydrologic and climate models are nowadays run on different spatial resolutions, using the exactly same land surface representations.

A fundamental criterion for the physical consistency of land-surface simulations across scales is that a flux estimated over a given area is independent of the spatial model resolution (i.e. the flux-matching criterion). The Noah-MP land surface model considers only one soil and land cover type per model grid cell without any representation of their subgrid variability, implying a weak flux-matching. A fractional approach simulates the subgrid variability but it requires a higher computational demand than using effective parameters and it is used only for land cover in current land surface schemes. A promising approach to derive scale-independent parameters is the Multiscale Parameter Regionalization (MPR) technique, which consists of two steps: first, it applies transfer functions directly to high-resolution data (such as 100 m soil maps) to derive high-resolution model parameter fields, acknowledging the full subgrid variability. Second, it upscales these high-resolution parameter fields to the model resolution by using appropriate upscaling operators. MPR has shown to improve substantially the scalability of the mesoscale Hydrologic Models mHM (Samaniego et al., 2010 WRR).

Here, we apply the MPR technique to the Noah-MP land-surface model for a large sample of basins distributed across the contiguous USA. Specifically, we evaluate the flux-matching criterion for several hydrologic fluxes such as evapotranspiration and drainage at scales ranging from 3 km to 48 km. We investigate the impact of different upscaling operators such as arithmetic, geometric and harmonic mean. This allows us to compare the identified upscaling operators between Noah-MP and the mesoscale Hydrologic Model mHM, which enables us to understand better how upscaling operators are related to model structure. Using MPR for Noah-MP provides a considerable improvement of the physical consistency that we expect to be achievable also in other land-surface schemes.