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Coupled versus uncoupled hydrometeorological modeling: the impact of surface water ponding and lateral routing on land-surface atmosphere exchange

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In the scientific community, coupled atmospheric hydrological modeling systems have been gaining popularity over the last years. The idea of representing the hydrological cycle in a multi-directional way, such that lateral flow processes on the land surface and in the subsurface are considered, generally increases the conceptual realism of coupled hydrological and meteorological model systems, with additional feedback processes potentially being taken into account. However, in this way, the realistic representation of physical processes may not always be advanced with similar strength. Especially if associated model parameters are defined in a lumped way for larger areas or if land-surface or soil properties are too much generalized, the added value of fully coupled simulations might be little.

We compare two (1x1 km) simulations for a medium-sized river catchment in southern Germany, obtained with 1) the standard Weather Research and Forecasting model (WRF) and 2) the surface ponding and surface routing enabled fully-coupled WRF-Hydro model.

We improved the soil layer representation of the current standard release of WRF-Hydro, i.e. the soil features representation of Noah-MP was changed from horizontally distributed to three dimensional and soil layer depths were related to the terrain slope. Additionally, infiltration and percolation parameters were altered from domain uniform into basin-wise distributed values.

The two simulations share an identical setup for 4 lumped land-surface and 3 conceptual hydrological model parameters that were calibrated using an observation driven WRF-Hydro configuration. Moreover, both simulations were obtained from the same binary. For the unconstrained (only lateral boundary condition updates) 6 month simulation (late spring to early fall 2016), we investigate how the inclusion of surface lateral hydrological processes alters water and energy flux budget terms at the catchment scale. Additionally, we analyze the differences for spatial patterns of soil-moisture which could potentially be sensitive for precipitation generation during local synoptic forcing.