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A comparison of two integrated numerical models for simulating groundwater-atmosphere interactions

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Integrated numerical models based on a detailed representation of both groundwater and atmospheric dynamics have gained increasing attention within the scientific community over the last years. These models dynamically simulate the interaction processes and feedback mechanisms occurring within the soil-vegetation-atmosphere continuum over a range of spatial and temporal scales. As such, these models are advanced tools for addressing a range of applied (e.g., real-time flood forecasting, water resources management) and scientific (e.g., rainfall persistence, soil moisture recycling) problems in both catchment- and regional-scale hydrology.

The aim of this study is to compare two integrated terrestrial systems that have been recently developed and that explicitly resolve for state variables and exchange fluxes from the deeper subsurface to the atmosphere. One system (PF.WRF) is based on the coupling of the Weather Research and Forecasting (WRF) atmospheric model with the three-dimensional variably saturated subsurface ParFlow model. The two sub-models are internally coupled in an explicit, operator-splitting manner via the Noah land surface scheme. The second system (TerrSysMP) consists of the regional climate and weather forecast model COSMO coupled also with ParFlow but via the Community Land Model (CLM). The study is carried by looking at key hydrometeorogical processes (e.g., evolution of the planet boundary layer, repartition of land surface energy fluxes, and diurnal soil moisture changes) for a set of both idealized tests and one real case scenario. The idealized runs involve the simulation of the diurnal cycle for a flat domain with idealized initial and boundary conditions, and homogeneous land cover configurations. The real case scenario consists into a 5-days hindcast simulation over the North Rhine-Westphalia domain in Germany. In this latter case, models results, based upon equilibrium initial conditions for the subsurface and realistic atmospheric conditions at the boundaries, are also compared with states (e.g., soil moisture and soil temperature) and fluxes (e.g., latent and sensible heat) measured at different sites.