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The Application and Performance of Two Soil-Vegetation-Atmosphere Modelling Platforms to a Real Hydrologic Catchment

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Land surface models are important in providing lower boundary fluxes and moisture for atmospheric models. Despite the increase in complexity and detailed representation of vegetation and root zone, LSMs remain for the most part one-dimensional column models which ignore lateral water flow at the land surface and within the top soil layers. In order to include processes effecting soil moisture variations such as shallow groundwater, runoff, overland flow, and subsurface lateral flow, a number of simulation platforms with varying complexity which couple groundwater, land surface, and atmospheric models have emerged. In this study, we compare two different integrated soil-vegetation-atmosphere modelling platforms: the ParFlow-CLM-COSMO model, developed within the Transregional Collaborative Research Centre (TR32), and the HIRHAM-MIKE SHE model, developed within the HOBE Centre for Hydrology and the HYdrological Modelling for Assessing Climate Change Impacts at differeNT Scales (HYACINTS) project. Both modelling platforms contain distributed, physically based, state-of-the-art components. ParFlow-CLM-COSMO consists of the variably saturated groundwater model ParFlow, the Community Land Model (CLM), and the regional climate and weather forecast model COSMO (German Weather Service, DWD). The HIRHAM-MIKE SHE model consists of the HIRHAM regional climate model (Danish Meteorological Institute), the SWET (Shuttleworth and Wallace Evapotranspiration) land-surface model, and the integrated hydrological model MIKE SHE (DHI). There are differences however between the two platforms in the handling of specific processes within the model components as well as differences in the coupling approach used.

During the first part of the comparison study, we focus on the coupled subsurface-landsurface components offline from the atmosphere. One of the main differences in the handling of the subsurface component in both models is the inclusion of lateral flow in the unsaturated zone. In the MIKE SHE model, the 3D Richards' equation is used for the saturated subsurface region, while the 1D Richards' equation is used to simulate water flow in the unsaturated zone using simulated dynamic groundwater levels from its saturated zone module. ParFlow, on the other hand, includes both lateral and vertical flow by using the 3D Richards' equation for the subsurface to calculate the pressure field. This allows for lateral flows in the unsaturated zone. One of the main questions to be investigated by this comparison study is whether such a dynamic approach for the subsurface is needed within a real watershed, and if so, at which locations and times. The simulations for both platforms are established for the HOBE hydrologic observatory catchment in Denmark, the Skjern catchment. During the second part of this study, the comparison is extended to include the atmospheric components, which differ in the exchange of atmospheric forcing variables and surface moisture and energy fluxes, in fully coupled simulations. While ParFlow-CLM-COSMO utilizes an external coupler, HIRHAM-MIKE SHE implements a new OpenMI technology approach. The comparison study will highlight the effects and experiences of using different coupled model approaches on the simulated subsurface-land surface-atmosphere interactions within a real hydrologic catchment.