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Hydrology and Earth System Sciences
Discussions

Interactive comment on "High-Resolution Virtual Catchment Simulations of the Subsurface-Land Surface-Atmosphere System" *by* Bernd Schalge et al.

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Dear Reviewer,

thank you for your feedback and suggestions made regarding our paper. We would like to highlight the two major motivations for this paper. The first is to provide insights into the problems we faced while constructing the VR and how to overcome them. We believe this material is valuable for scientists working on similar problems because our lessons learned are not particular to our specific problem but are of general value to the modelling and the Data Assimilation (DA) community. We agree the manuscript lacks some emphasis on this part and we will remedy this in the modified version.

Second, the VR created is designed as a basis for data assimilation (DA) experiments. Similar efforts are often criticized for insufficient proof that the synthetic observations created are comparable to real observations. We demonstrate that due to the high resolution and the number of processes involved in the coupled approach, which puts the size of the domain at the edge what is currently possible, our VR can be used for DA experiments. We show that TerrSysMP produces reasonable results in all compartments with the expected variability. We discuss insufficient results concerning passive microwave satellite observations and some aspects of river discharge, and we explain how we deal with these problems.

In the following we respond to your more specific comments.

'The modelling platform and individual components have been used previously and were also tested and compared against real data elsewhere, so there are no general new insights, except maybe that is has not yet been done explicitly for the Neckar region before.'

While the TerrSysMP model system has been evaluated to some degree before, it remains state-of-the-art and we highlight in the paper the aspects in this model which are most important for DA experiments. Amongst those are discharge comparisons with real observations of the uncalibrated model system. Our results show the model is able to produce good results without calibration, and we discuss how the simulation can be improved in the future. Houtekamper et al. (2004) state that e.g. for atmospheric DA, questionable results might ensue from using virtual observations given "poorly understood model imperfections". Coupled models such as TerrSysMP are even more complex than the models used then and thus need thorough tests before being used as a VR in DA experiments. Our results demonstrate this and are designed to be used as a benchmark for the VR concept. Existing model studies on the Neckar catchment use simpler, mostly uncoupled models, which are specifically designed to reproduce certain model outputs when calibrated, river discharge for instance (e.g., Samaniego et al. 2010). Such models, however, cannot be used for cross-compartmental DA which requires coupled simulation of all processes with potential to be sensed by monitoring systems. We acknowledge the shortcoming in the reproduction of the timing of discharge peaks by TerrSysMP, which however would be similar for all models using homogeneous grids for representing river flow, but also suggest a remedy as outlined in the paper. In a revised version, we would make this point clearer and put more focus on this point.

'The difficulties in relating microwave data to land surface soil moisture conditions is also well known and widely published.'

While extensive literature exists on satellite remote sensing of soil moisture, little has been done regarding the effect of resolution when soil moisture is used as a variable for data assimilation. Our study paves the way to evaluate such and other effects. While existing parameterizations for L-band, such as CMEM in our case, are well suited for SMOS retrievals, we find large differences in brightness temperature distributions between our VR and SMOS/SMAP observations. We hypothesize that these differences mainly originate from CMEM parametrization defaults oriented at the ECOCLIM/TESSEL land model, and are not suitable for the CLM included in TerrSysMP. In a revised version we will modify this section accordingly and present further ideas to ameliorate these problems.

'The dependency of ET to soil moisture availability and water table depth as outlined in section 4 is, in my opinion, basic soil physics material that is taught in every introductory course.'

The aim of the data assimilation tests will be to evaluate the effect in cross-compartments (e.g. the impact of assimilation of groundwater heads to the simulated evapotranspiration). For this reason, ET-water table relation is a very important hydrological process that should be reproduced in the VR. Consequently, we were quite happy that our VR exhibits the expected relation. In a revised version of the paper we will significantly shorten this section and put more weight on the inter-annual soil

moisture dynamics of the catchment and address the low inter-annual variability and wet bias including strategies to solve these problems. Nonetheless, we do see the importance of highlighting the issues which arise from using physically-based models rather than extensive calibration to achieve expected model dynamics. Additionally, we would focus more on the added value of high resolution by including comparisons of fluxes and state variables in the overlap area of the two domains.

We agree, more emphasis is needed on the 'lessons learned' part of the paper. We will point out some of the novel aspects more clearly, while the validation sections will not suffer much from significant shortening to warrant a publication as a stand-alone paper. Currently we are running the fully coupled system (atmosphere at 1.1 km, surface and subsurface at 400 m) and plan to present initial results for comparison in a revised version. This is particularly interesting regarding the comparison of fluxes in the domain overlap mentioned above.

Kind regards,

the authors

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