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Searching for the right scale in catchment hydrology: the effect of soil spatial variability in simulated states and fluxes

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The advances in computer science and the availability of new detailed data-sets have led to a growing number of distributed hydrological models applied to finer and finer grid resolutions for larger and larger catchment areas. It was argued, however, that this trend does not necessarily guarantee better understanding of the hydrological processes or it is even not necessary for specific modelling applications. In the present study, this topic is further discussed in relation to the soil spatial heterogeneity and its effect on simulated hydrological state and fluxes. To this end, three methods are developed and used for the characterization of the soil heterogeneity at different spatial scales. The methods are applied at the soil map of the upper Neckar catchment (Germany), as example. The different soil realizations are assessed regarding their impact on simulated state and fluxes using the distributed hydrological model mHM. The results are analysed by aggregating the model outputs at different spatial scales based on the Representative Elementary Scale concept (RES) proposed by Refsgaard et al. (2016). The analysis is further extended in the present study by aggregating the model output also at different temporal scales. The results show that small scale soil variabilities are not relevant when the integrated hydrological responses are considered e.g., simulated streamflow or average soil moisture over sub-catchments. On the contrary, these small scale soil variabilities strongly affect locally simulated states and fluxes i.e. soil moisture and evapotranspiration simulated at the grid resolution. A clear trade-off is also detected by aggregating the model output by spatial and temporal scales. Despite the scale at which the soil variabilities are (or are not) relevant is not universal, the RES concept provides a simple and effective framework to quantify the predictive capability of distributed models and to identify the need for further model improvements e.g., finer resolution input. For this reason, the integration in this analysis of all the relevant input factors (e.g., precipitation, vegetation, geology) could provide a strong support for the definition of the right scale for each specific model application. In this context, however, the main challenge for a proper model assessment will be the correct characterization of the spatio- temporal variability of each input factor.

Refsgaard, J.C., Højberg, A.L., He, X., Hansen, A.L., Rasmussen, S.H., Stisen, S., 2016. Where are the limits of model predictive capabilities?: Representative Elementary Scale - RES. Hydrol. Process. doi:10.1002/hyp.11029