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Groundwater- Surface Water Interaction at the Regional Scale

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Today, both scientists and practitioners agree that management of water resources has to be performed in an integrated way. At the same time there is an increasing need for research at the regional scale (here 10^3 to 10^6 km^2), because (i) this is the scale where interaction between environmental and human systems is fully developed through various links between supply and consumption, sources and sinks, etc. and (ii) the regional scale links global change to local impacts and action. The regional scale is the scale of management – to acknowledge this might be an important first step in finding the appropriate ways to address it. In any case, it is of utmost importance, that groundwater-surface water (GW-SW) interaction – as a central process of the hydrological cycle – is considered on the regional scale too.

The starting point for the present contribution is two regional integrated models developed by the first author and the problems encountered in the attempt to implement adequately the GW-SW interaction therein. To evaluate if solutions to these problems were available from other studies, the available knowledge and tools were reviewed to extract common findings and guidance on how to analyse, describe and finally model GW-SW on the regional scale. Here we compare the characteristics of GW-SW interaction at different scales, the particularities of the regional scale, the available knowledge on how to regionalize and/or upscale processes, properties and parameters from smaller to larger scales and the model concepts available to describe GW-SW interaction at the regional scale.

The overall conclusions are somewhat disillusioning: A large variety of research efforts has addressed the underlying problem setting and a plethora of tools were developed, yet GW-SW interaction at the regional scale is rarely explicitly addressed in a systematic way. It is evident that regional scale hydrological research on coupled surface-subsurface systems has to deal with high complexity paired with low data availability and heterogeneity of data. At the same time, GW-SW interaction at the regional scale can no longer be considered a process focused on the interface between groundwater and surface water body – processes in between and far away from river stretches increasingly outweigh local processes. To account for this, models that simultaneously describe all the related processes in groundwater, surface water and the unsaturated zone are required. Fully coupled physics-based models (for example HydroGeoSphere or ParFlow) seem to be the most appropriate for this work. However, the data availability and heterogeneity issues form an obstacle to employing such complex models at the regional scale. A way out of the dilemma might be fully coupled physics-based models that are flexible enough to allow (harsh) simplification where necessary and nested approaches. However, models that satisfy the performance criteria usually applied within the scientific community might never be feasible at regional scales. Regional scale integrated models of groundwater-surface water systems might thus have to be developed from a different perspective: Either merely driven by unique, context- and scale-specific demands of practical water resources management or by developing integrated regional models for the sole purpose to provide a regional framework for nested local solutions. The ongoing discussion of the complexity-versus-simplicity-question in hydrological modelling might not be helpful in the attempt to find the appropriate path to successful regional scale integrated modelling - if it is just led within the hydrologic modelling community alone. Participatory and transdisciplinary approaches might be more helpful in the attempt to provide meaningful regional solutions.