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Comparison of tools for integrated assessment and management of groundwater resources in different river basins with special regard to sustainability

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Today, sustainable management of water and land resources is widely understood as an integrative, cross-border task. Research activities such as the BMBF-GLOWA-Initiative and the European Community financed RIVERTWIN project take up this idea and link it to the investigation of the effects of Global Change on the hydrological cycle. Models are important tools that facilitate the understanding of systems and help to predict changes and to support decisions with far-ranging implications. Since groundwater is a major drinking water resource in many parts of the world, the groundwater system and its accurate representation play a major role in integrated modelling systems. Within GLOWA-Danube a large-scale three-dimensional numerical groundwater flow model has been developed for the Upper Danube Catchment, the greatest part of which lies in Germany and Austria (˜80.000 km2). The model runs within the DANUBIA framework coupled to 15 other models and produces reasonable results in most parts of the model domain. The DANUBIA groundwater model itself is of course not 'capable' of carrying out any management tasks. Management is done by people - but in case of integrated models meant designed to simulate future scenarios needs to be partly done within the integrated model itself as will be described later in this paper. In case of DANUBIA the groundwater model provides input for a water supply model, which links the physical water resources to the human side of the water cycle, the consumers. The challenging task, from the modeling

perspective, is to find the appropriate modelling concept and exchange parameters for both models. Concepts and parameters, in turn, have to be consistent with the available input data and other requirements of the DANUBIA integrated framework. Groundwater Management according to worldwide or European standards such as the European Water Framework Directive has two main objectives: to provide water in sufficient quantity and quality to different consumers and at the same time to maintain and guarantee good qualitative and quantitative status of groundwater resources. Whereas a good quality can be described relatively simply by evaluating the chemical composition of groundwater, (a good quantitative status is far more difficult to define because of the varying nature of groundwater resources of different types in different climates. In an integrated model it is, therefore, especially important and at the same time challenging to set and adjust threshold values that define the maximum amount of water that can be extracted sustainably. Such thresholds must be appropriate for the specific aquifer type and climatic conditions but also depend strongly on the spatial and temporal scales of relevance. The relevant scale, in turn, is a function of the application or, in other words the type of problems an integrated model is designed to solve. Therefore, threshold values have to be dynamic and distributed rather than fixed and generalized for a whole catchment. Even better than using threshold values is using ’flags’, signals that indicate changes in the qualitative or quantitative status of a groundwater resource. These flags - for example, ’orange’ which indicates significant depletion of a groundwater resource - can be interpreted differently depending on the relevant spatial and temporal scale, type of application, importance of the problem etc. In the DANUBIA integrated model, flags will be used to send signals to different ’Actor Models’. Actor Models represent the consumers, e.g. the domestic users represented by the ’Household Actor Model’ and the Water Suppliers (represented by the aforementioned ’Water Supply Model’). These Actor Models are comprised of a number of individual ’Actors’, objects which perform different actions depending on their individual attributes. This leads to a far more flexible treatment of the sustainability problem than the rational, usually balance-term-related, threshold definition. Parallel to the development of the integrated DANUBIA groundwater and water supply model, a second large-scale groundwater flow model is now being developed for the Neckar Catchment, Germany (15.000 km2). It will be part of the river basin management tool developed by the RIVERTWIN research cooperation, financed by the European Community. The objective of RIVERTWIN is the development of an integrated regional model MOSDEW for the strategic planning of water resources in twinned river basins under contrasting ecological, social and economic conditions. The basins under examination are the Neckar Catchment in Germany, the Oueme Basin in Benin and the Chirchik Basin in Uzbekistan. Due to the higher data density in Germany, the integrated model is being developed first for the Neckar Catchment and will afterwards be adjusted to the remaining two catchments where only sparse data is available. This paper however, focuses on the comparison of different approaches in the Danube and Neckar Catchments. Though the basins are adjacent, they are quite different with respect to their hydrogeological characteristics. It is, therefore, interesting to investigate the transferability of the concepts and the lessons learned from the Upper Danube to the Neckar Basin.