Multiscale and Multicriterial Hydrological Validation of the Eco-hydrological Model SWIM

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Abstract: The hydrological validation described in this paper follows a bottom-up approach, when at first 12 mesoscale subbasins, covering the main subregions of the basin, are validated, and then the information gained from the mesoscale is used to validate the hydrological processes of the whole basin. Special attention was paid to the use of spatial information (maps of water table depth) in addition to usual point data (water discharge at gauge stations) to validate the model. While the primary purpose of distributed hydrological models is to reproduce both water fluxes in subbasins and hydrotopes along with river discharge, they are often validated using only observed river discharge. The paper describes a method to reproduce and validate also local hydrological processes such as water table dynamics inside subbasins, using contour maps of the water table and observed groundwater level data as additional input for the validation. The investigation was carried out with the ecohydrological model SWIM (**S**oil and **W**ater **I**ntegrated **M**odel), which integrates hydrology, vegetation, erosion and nutrient dynamics at the watershed scale. It was developed to investigate the impacts of climate and land use changes on the hydrological processes and water quality at the meso- to macroscale. The study area is the German part of the Elbe basin (80,256 km^2). It is representative of humid / semi-humid landscapes in Europe, where water availability during the summer season is the limiting factor for plant growth and crop yields.

Keywords: macroscale hydrological validation; ecohydrological model; groundwater dynamics; sensitivity; uncertainty

1. INTRODUCTION

The paper focuses on validating the hydrological module of the ecohydrological model SWIM (**S**oil and **W**ater **I**ntegrated **M**odel, Krysanova *et al*., 1998). The water cycle is of special importance, because all other ecological processes are related to or dependent on water, its flows and state. Model results for 12 subbasins of the Elbe with a size of 280 to 23,690 km^2, from different regions of the basin and for the whole basin (80,258 km^2) are presented and discussed. It is demonstrated how basin integrated information like water discharge in rivers can be used in combination with maps of the groundwater table as spatial information to calibrate and validate the model.

Hydrological modeling at the meso- to macroscale implies various uncertainties (Bergström & Graham, 1998). One reason is that the data are normally available at a rough resolution (maps of soils and land use data), or have to be interpolated (climate data, groundwater data). In addition, process-based models normally combine physically-based mathematical descriptions and conceptual formulations. Therefore, hydrological models at the macroscale have to be calibrated and need to be validated with historical time series.

Nested investigations in different subbasins from the main subareas (in our case the mountains, the loess area and the lowlands) help to understand the overall pattern of the hydrological processes. Multicriterial validation using a combination of point data like water discharge at the basin outlet (as an integrated characteristic for the whole basin), and spatially distributed data, like contour maps of the water table, will improve the reliability of results, e.g. of the simulated flow components (Arnold, 1993; Refsgaard & Knudsen, 1996; Andersen, 2001).

Another important issue is to determine model sensitivity to the input parameters and uncertainty of the simulated hydrological processes, so that the robustness of model results can be estimated.

2. MATERIAL AND METHODS

2.1 The model

The watershed model SWIM integrates hydrology, vegetation, erosion and nutrient dynamics. A three level scheme of spatial disaggregation from basin to subbasin and to hydrotopes is used in SWIM. A