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Impact of river stage prediction methods on stream-aquifer exchanges in a hydro(geo)logical model at the regional scale

F. Saleh, N. Flipo, and C. de Fouquet
MINES ParisTech, Geosciences Department, 77305 Fontainebleau, France (firas.saleh@mines-paristech.fr)

The main objective of this study is to provide a realistic simulation of river stage in regional river networks in order to improve the quantification of stream-aquifer exchanges and better assess the associated aquifer responses that are often impacted by the magnitude and the frequency of the river stage fluctuations.

The study focuses on the Oise basin (17 000 km2, part of the 65 000 km2 Seine basin in Northern France) where stream-aquifer exchanges cannot be assessed directly by experimental methods. Nowadays numerical methods are the most appropriate approaches for assessing stream-aquifer exchanges at this scale.

A regional distributed process-based hydro(geo)logical model, Eau-Dyssée, is used, which aims at the integrated modeling of the hydrosystem to manage the various elements involved in the quantitative and qualitative aspects of water resources. Eau-Dyssée simulates pseudo 3D flow in aquifer systems solving the diffusivity equation with a finite difference numerical scheme. River flow is simulated with a Muskingum model. In addition to the in-stream discharge, a river stage estimate is needed to calculate the water exchange at the stream-aquifer interface using the Darcy law.

Three methods for assessing in-stream river stages are explored to determine the most appropriate representation at regional scale over 25 years (1980-2005).

The first method consists in defining rating curves for each cell of a 1D Saint-Venant hydraulic model. The second method consists in interpolating observed rating curves (at gauging stations) onto the river cells of the hydro(geo)logical model. The interpolation technique is based on geostatistics. The last method assesses river stage using Manning equation with a simplified rectangular cross-section (water depth equals the hydraulic radius).

Compared to observations, the geostatistical and the Manning methodologies lead to slightly less accurate (but still acceptable) results offering a low computational cost opportunity for taking into account river stage fluctuations in regional distributed process-based hydro(geo)logical models. It is an efficient way to improve the physics of the stream-aquifer interactions and better assess soil water content at the regional scale when high resolution morphological data is not available.

This study offers several perspectives such as simulating the hydrodynamic behavior of alluvial wetlands and assessing the pollutants removal or release by biogeochemical processes at regional scale such as nitrate contamination.

Keywords: Stream-aquifer interactions, Regional scale, Quantitative Hydrology, Hydrogeology, River stage simulations, Hydrosystem modeling