CURRENT AND FUTURE ASSESSMENT OF THE MAIN AQUIFER UNITS CONTRIBUTION TO THE RIVER DISCHARGE OF THE LOIRE BASIN DURING LOW FLOW

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The evolution of the Loire river low flows is a key issue for various uses such as water supply, irrigation or industrial needs. Power production is a major activity in Loire basin with four nuclear power plants using Loire river water for the cooling system. To estimate the evolution of long term in-stream low flow distribution, it is necessary to have a good estimate of the contribution of a complex aquifer system to the river discharge. For this purpose, three main overlaying aquifer units are considered: Beauce Limestones (Oligocene), Chalks (Seno-Turonian) and Sands (Cenomanian). These units are part of Paris sedimentary basin and cover an area of 38000 km².
A distributed process-based hydrogeological model (Eau-Dyssée) is implemented with the coupling of five modules: surface water budget, watershed routing, river routing, unsaturated zone transfer, and groundwater flow. The model is based on a finite difference numerical scheme and the surface component covers an area of 120 000 km2 with 63 234 grid-cells.
The model is calibrated at the daily time step over a 10-yr period and validated over another 10-yr period. Then a test simulation is run over 35 years insuring that the model does not deviate for long term simulations. The model evaluation is based on discharges and piezometric time series recorded at 158 gauging stations and 197 piezometers. A hybrid fitting methodology, based on an automated inverse method and a trial-error one, has been developed for the fitting of the Beauce aquifer unit. The other units are calibrated by trial and error. The fitted model simulates properly both discharges and piezometric heads over the whole domain between 1974 and 2009, with a global RMSE between simulated and observed piezometric heads of 2.86 m, and all Nash efficiency at the Loire discharge gauging stations over 0.9.
The fitted model has then been used to quantify the hydrosystem mass balance at different time scales. The average aquifer contribution to the Loire river discharge during low flow is estimated at 15 m3.s-1 between 1975 and 2008, with a contribution of 10 m3.s-1 for severe low flow period. The spatial analysis of these contributions points out the vulnerability of the Dampierre-Orléans reach (63 km) to hydric stress, with potential water loses in 2100. First results of simulations using four different climate change projections indicate an averaged decrease of these contributions reaching 8 to 50% in 2100.