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Investigating groundwater-stream interaction through time series analysis of head observations

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Groundwater-surface water interaction has gained considerable attention in hydrology in the last decennia owing to the realization of its importance for water management and ecology. From a quantitative point of view, knowledge of exchange fluxes between groundwater and streams can be used to estimate the base flow of the streams, the buffering capacity of the stream, or the hyporheic zone residence time. Estimation of exchange fluxes remains challenging and has been quantified so far mainly by inverse modeling of temperature profiles measured in riverbeds.
The objective of this research project is to apply time series analysis of groundwater head fluctuations measured near a stream to estimate hydrogeologic parameters, allowing in turn to estimate the average exchange fluxes.
The method is demonstrated with measurements obtained in a 70m long row of monitoring wells placed perpendicular to the river Aa in the Netherlands. Time series analysis was applied to separate the influence of precipitation excess from the influence of river stage fluctuations on groundwater head. Interpretation of the response functions of both stresses provided qualitative insights in the way river stage fluctuations propagate to adjacent aquifers and allowed for the estimation of hydrogeologic parameters controlling groundwater-surface water exchange fluxes. The method is easy to implement and can be applied to quantify exchange fluxes in the field of groundwater-surface water interaction in a way comparable to pumping tests in groundwater hydraulics.