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Sensitivity of groundwater level in the Seine River basin to changes in interannual to decadal climate variability

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Groundwater level (GWL) variations can be expressed over a wide range of timescales. As aquifers act as low-pass filters, low-frequency variability (interannual to decadal variability) originating from large-scale climate variability represents a significant part of GWL variance. Anthropogenically-driven climate change may affect, and have maybe already affected, the internal climate variability which explains the low-frequency variability of hydrological processes. Such changes in internal climate variability could therefore affect GWL variations. How GWL, including extremes, may respond to such changes and variations in climate variability however remains an open question.

To tackle this issue, we implemented an empirical numerical approach allowing to assess the sensitivity of aquifers to changes in large-scale climate variability, using the whole Seine hydrosystem (76000 km^2) as a case study. The approach consisted in: i) identifying and modifying the spectral content of precipitation, originating from large-scale climate variability, using signal processing; ii) injecting perturbed precipitation fields as input in a physically-based hydrological/hydrogeological model (the CaWaQS software) for the Seine river basin for simulating perturbed GWL; iii) comparing the spectral content, trend and extremes of perturbed GWL with the reference GWL. We used the Safran precipitation field over the period 1970-2018, which was initially used for model calibration and validation. GWL data for the Seine basin is a subset of a database of climate-sensitive time series (i.e. low anthropogenic influence) recently set up at the BRGM and University of Rouen Normandy. First, the Safran reanalysis and observed GWL time series were analyzed using continuous wavelet transform to identify the different timescales of variability: interannual (2-4yr and 5-8yr) and decadal (~15yr). Then, the different timescale of precipitation time series were extracted using maximum overlap discrete wavelet transform. For each time series of the precipitation field, the amplitude of each timescale was modified individually, by either increasing or decreasing it by 50%. This led to six scenarios of perturbed low-frequency variability of precipitation, which are subsequently used as input in the CaWaQS model

to assess the response of GWL variability and extremes.

Preliminary results indicate that perturbations of the amplitude of interannual to decadal precipitation variability result in substantial changes in the variability of GWL, affecting the same timescales, as well as timescales that were not modified in the precipitation field. Implications of these findings on potential trends and the frequency of extremes of GWL is currently being explored.