Characterization of river/groundwater interactions by signal processing of electrical conductivity time series

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In the framework of climate change that leads to increased frequence of extreme events and to more frequent floodings, river restoration has become a fundamental nature-based solution to reduce the likelihood of flooding events and mitigate their damage on human structures and population.
Canton Ticino, southern Switzerland, currently hosts very important river restoration projects such as the one designed for river Vedeggio, which final part crosses the Vedeggio aquifer before flowing into lake Lugano. Vedeggio aquifer also hosts the two largest drinking water wells of the Canton in terms of pumping rate, Manno and Bioggio, which can provide up to 60 m^3/min of drinking water to the city of Lugano and are strategical to the Cantonal water supply framework. Due to their proximity to the river, it can be assumed that a significant fraction of water pumped by wells is exfiltrated river water.
Both the effectiveness of river restoration and the amount of river water exfiltrating in the aquifer can be studied in detail by designing and operating a high-frequency surface water/groundwater monitoring network.

This work proposes a time-series analysis of electrical conductivity signals, a natural tracer that is already present in the water, propagates fast and is subject to less smoothing than temperature, in order to better understand the correlations between surface water and groundwater. Electrical conductivity signals were treated (detrended, outliers removal) and different signal analysis techniques were applied (simple cross-correlation, optimized cross-correlation and non-parametric deconvolution). The methods converged in the estimate of the lag times between river and groundwater signals, allowing to understand the mutual interactions between surface water and groundwater and estimating the amount of river water flowing into the different piezometers and wells.
This has a double value: from one hand to assess the modifications induced by river restoration projects and from the other hand to improve the management of drinking water wells, understanding their connections to the river channel. The proposed method can be useful for similar cases where river exfiltrates into the aquifer and there is the need to assess how river restoration modifies the interactions between surface and groundwater.

REFERENCES

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