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Estimation of groundwater recharge from time series modeling of groundwater levels in non-linear systems

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Groundwater recharge remains a notoriously difficult flux to estimate, despite ongoing scientific efforts. In recent years, time series modeling using impulse response functions has gained popularity to simulate groundwater levels and is quickly becoming a common tool for hydrogeologists. Several approaches have been developed to estimate recharge from time series models for both linear and non-linear systems (e.g., [1], [2], and [3]). In this study, we introduce a novel approach to estimate groundwater recharge from observed groundwater levels in nonlinear systems (i.e., twice the precipitation does not necessarily lead to twice the recharge). We extend a time series model using impulse response functions with a non-linear unsaturated zone module that simulates recharge. The model parameters are estimated by fitting the simulated to the observed groundwater levels, with the groundwater recharge as an intermediate model result.

The method is tested on a time series of groundwater levels observed in Southeastern Austria (Wagna), where lysimeter data of seepage to the groundwater is available for model validation. The simulated groundwater recharge suggests an event-based recharge behavior, with most recharge occurring shortly after larger precipitation events. This finding agrees with the behavior observed in the lysimeter data. The estimated recharge fluxes show a high correlation with the observed seepage on time scales from years to months or weeks, while daily recharge rates show larger errors. Advantages of the method include limited data requirements (only precipitation, potential evapotranspiration, and groundwater time series are required) and the possibility to correct for other factors causing groundwater level fluctuations (e.g., pumping, river levels). This makes it possible to apply the method in locations where little system knowledge (e.g., soil profiles) is available.

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