Geophysical Research Abstracts
Vol. 21, EGU2019-14532, 2019
EGU General Assembly 2019

Regional aquifer parameters by spectral analysis of groundwater head fluctuations – a synthetic study

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Regional groundwater models have been used to evaluate impacts of human perturbation on natural groundwater system in terms of water quality and quantity. Moreover, insights from modelling approaches guide long-term resources management and are the basis of decision making for sustainable strategies of groundwater usage and protection.
Measurements techniques such as pumping tests reveal effective transmissivity and storativity values of the aquifer. These parameters represent a local bulk volume surrounding the measurement location and can be used for characterization and modelling of groundwater system in small catchments. Bringing these models to the regional scale is mostly constrained by data availability and the ability to regionalize local measurements. The spectral analysis of groundwater head fluctuations might be a feasible tool to bridge the scale and derive effective parameters containing information about regional segments of the aquifer. This study evaluates the information content of head measurements as time series in the frequency domain and presents implications for regionalization of hydrogeological properties. Furthermore, our investigations give advice for goal oriented measurement campaigns in the field.
Different analytical solutions to derive aquifer parameters from head fluctuations based on stochastic approaches in the frequency domain (power spectral density) have been developed and applied on field data from complex aquifers. We tested two methods in a virtual homogeneous environment and verified the functionality with different constraints. Head time series have to cover long time periods to ensure that all scales of aquifer dynamics are represented in the signal and the measurement location within the aquifer clearly determines the characterized aquifer volume, i.e. the derived aquifer parameters by the spectral analysis. This gives evidence for an optimal location to perform groundwater head measurements in the field.
Future investigations will focus on a heterogeneous model design to assess the influence of layered and distributed hydraulic properties on the head fluctuations.