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Using ERS spaceborne microwave based soil moisture products to predict groundwater heads in space and time.

The objective of this study is to investigate whether the time series of a remote sensing based soil moisture product called the European Remote Sensing Soil Water Index (ERS SWI) correlates to in-situ observations of groundwater head; and can thus be used for groundwater head prediction. As a test-bed we used the Rhine-Meuse basin, where we have collected more than four thousand groundwater head time series. Here we performed a correlation analysis between the time series of groundwater heads and ERS SWI spatio-temporal maps of profile soil moisture content. Results show that there is a significant correlation between ERS SWI and groundwater head time series. Correlation is strongest in shallow groundwater areas. Moreover, for areas with deep groundwater, the correlation becomes apparent if we account for the lag time (i.e. the response time of water from the upper unsaturated soil moisture zone to the saturated deeper groundwater bodies) by adding a time delay to the correlation analysis.

We further investigated the possibility of using ERS SWI to predict groundwater heads. The ERS SWI time series were used as the input of a transfer function- noise (TFN) model. We performed two modeling exercises. The first was focused on temporal forecasting of groundwater head dynamics, while the second one was to make spatio-temporal prediction of groundwater head. For the first exercise, the parameters of the TFN model were calibrated based on head time series in the period 1995-2000 by embedding the model in a Kalman filter algorithm. TFN models were calibrated separately at all locations where head measurement time series are available. Once calibrated, the TFN forecasts were validated for the period 2004-2007 in order to assess their forecasting skill. For the second exercise, we selected calibrated TFN model parameters — derived in the first exercise — from a subset of locations and used them to fit regression models with a digital elevation map as input. With these regression models, TFN model parameters were spatially predicted. Subsequently, using these estimated parameters, spatio-temporal prediction of groundwater head was performed (also with the TFN model and ERS SWI time series as the model input) and evaluated against all available observations.

Results of both exercises were promising. The TFN models can reproduce the observed groundwater head dynamics reasonably well, especially in shallow groundwater areas where soil moisture dynamics are tightly connected to groundwater head fluctuations. Our results show that ERS SWI time series should be considered as an important source of information for the assessment of large scale groundwater dynamics.