Modeling unsaturated zone water stable isotope depth profiles in an evaporation dominated environment.

Marcel Gaj*, Matthias Beyer, Markus Wallner, Paul Koeniger, Josefina Hamutoko, Heike Wanke, Thomas Himmelsbach

Introduction:

Northern Namibia is a region with high population growth rate, limited water resources and a transboundary aquifer system where groundwater recharge and groundwater flow processes are not yet fully understood.

The main objective of this study is to get a better understanding of groundwater recharge processes of the shallow aquifer system in the Cuvellai-Etosha-Basin (CEB). Evaporation, transpiration and root water uptake are the main factors reducing the quantity of precipitation that contribute to recharge. These, in turn, depend on soil type and depth, climate, the distribution, density and type of vegetation, and the depth to the groundwater. Since recharge processes are affected by unsaturated zone processes stable isotopes appear as a powerful tool to improve processes understanding and modeling approaches (Sprenger at al., 2014).

The present study presents results of a field experiment conducted in northern Namibia. Isotope depth profiles are included in the calibration process of a SVAT model on a hourly time step. This improved parameter estimations and reduced model uncertainty.

References:


Results:

A plot was equipped with soil moisture sensors. Readings were performed every 3 hours. The plot was irrigated with 60mm of water. The dry out was monitored over a period of 10 days. Soil moisture temperature and isotope data was collected. An isotope enabled SWAT-model (Haverd and Cuntz, 2010) was calibrated conventionally using soil moisture data and in addition the same model was calibrated with soil moisture and isotope data. Initial parameters and their ranges were kept equal for all model runs. Constraints were derived from soil physical properties derived from laboratory and field experiments.

The model calibrated with soil moisture data does not capture the recession behavior especially of the top most layer. The lower layer is overestimated. Considering stable isotope data for the calibration process improves the representation of the recession behavior in terms of shape. The maximum infiltration depth is slightly underestimated. Both models fail to represent the soil moisture behavior of five and 10cm depth, because water repellent properties were observed in the field (Fig 8). Further the modeled temperature is better including isotope depth profiles. Both models underestimate temperatures lower 15 cm. However, parameter identifiability and process representation improved by incorporating stable isotope data, for soil moisture and temperature data. Especially, Water quantities at depth improved which is relevant for groundwater recharge estimations.

Outlook:

- Isotope data with higher temporal and spatial resolution using in situ methods are promising to improve processes understanding and modeling approaches.
- Model runs on a daily time step and the inclusion of seasonal isotope depth profiles are soon to be developed.
- Parameter transferability from hourly to daily time steps for regionalization purposes.
- Coupled run with LSM including different root water uptake routines.
- Long-term recharge predictions using climate projections as input for groundwater models will be made.