EGU23-2565, updated on 23 Apr 2024
https://doi.org/10.5194/egusphere-egu23-2565
EGU General Assembly 2023

Why do our models underestimate regional groundwater trends?

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In the course of climate change serious effects on groundwater resources are expected. Future groundwater recharge is usually assessed via hydrological models. Various studies have shown that most models fail in depicting pronounced trends observed in groundwater monitoring data at regional scales. Likewise, global hydrological models seem to systematically underestimate the low-frequency dynamics of regional water storages in the GRACE mission data (Scanlon et al. 2018) or long-lasting memory effects in terms of discharge (Fowler et al. 2022). Thus groundwater recharge modelling appears to have some fundamental problems that go far beyond the usual model uncertainties in each individual case.

This was systematically investigated. The empirical basis was given by the analysis of groundwater data of the authorities' monitoring networks in Northeast Germany, covering an area of more than 50,000 km^2. About 240 long-term time series of groundwater head and lake water level were studied. It could be shown that at weekly or monthly time scales lake water level dynamics very closely mimicked that of the adjacent groundwater body.

A very close correlation between the direction and strength of the trends and the degree of damping of the signal of groundwater recharge was found. The probability of long-term trends systematically increased with the thickness of the vadose zone. This indicates the crucial role of long-term accumulation of soil moisture deficits in the deeper unsaturated zone.

In contrast, models of groundwater recharge generally consider only the uppermost soil layers. In addition, modellers usually assume initial steady-state equilibrium conditions and thus ignore long-term memory effects in the subsurface. Simulations with different models clearly showed that this resulted in a systematic underestimation of long-term trends. Finally, it was found that model parameterizations which had been optimized with respect to discharge or topsoil moisture dynamics were not necessarily optimal for the simulation of groundwater recharge. Based on these findings clear recommendations for monitoring and model-based assessment of groundwater recharge will be given.

References:

Scanlon et al. (2018), PNAS, http://ww.pnas.org/cgi/doi/10.1073/pnas.1704665115

Fowler et al. (2022), WRR, https://doi.org/10.1029/2021WR031210

Lischeid et al. (2021), JHyd, https://doi.org/10.1016/j.jhydrol.2021.126096