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Mapping the spatio-temporal dynamics of groundwater-dependent ecosystems (GDEs) with a global groundwater model.

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Groundwater-dependent ecosystems (GDEs) are ecosystems that rely on subsurface or surface expressions of groundwater. These ecosystems host a wide array of unique flora and fauna and provide **important** ecosystem services. However, GDEs are threatened by the unsustainable extraction of groundwater as well as climate change. Mapping the spatio-temporal dynamics of GDEs and **potential** changes therein under climate change and socio-economic developments is an essential step towards their conservation. To this end, **we have** developed a methodological framework for mapping groundwater-dependent ecosystems using the global groundwater model GLOBGM [1], run at 30 arc sec (~1 km) resolution. The advantage of a physically-based groundwater model over statistical or machine learning methods is that it allows for the reconstruction and projection of impacts of changes in climate, land use, and human water use on GDEs.

We distinguish three categories of GDEs: aquatic (rivers and lakes), (inland) wetland, and terrestrial (phreatophyte) GDEs. For each GDE category, we defined a set of criteria for identifying their distribution and degree of groundwater dependence based on groundwater levels, groundwater discharge, and land surface parameters (e.g., saturated area fraction). After calibrating the groundwater model with groundwater heads, we ran the model in both steady and transient states, applying the set of criteria to the model outputs to map the different types of GDEs, their degree of groundwater dependency, and their spatio-temporal dynamics.

We validated the model in two ways. First, we compared our simulated groundwater depths against observed groundwater depths. Our model was able to represent observed conditions for about 75% of the groundwater depth locations. Second, we validated the simulated occurrence of GDEs based on the steady-state model runs against the GDE atlas available for Australia [2], where we found a hit rate above 80%. For Australia, our transient runs revealed an overall decline in groundwater dependency between the periods 1979-1998 and 1999-2019, as measured by the average number of months that GDEs are fed by groundwater. This is corroborated by an increase in groundwater depth at the observation wells, indicating that Australian GDEs have become

increasingly threatened over the past decades.

For the next step, we envision upscaling our approach to the entire globe and projecting the fate of GDEs under different global change scenarios. This, in turn, is a key step towards identifying sustainable groundwater management strategies that contribute to the conservation of GDEs and their unique biodiversity.

References

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