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Multimodel assessment of renewable groundwater resources across Europe at 1.5, 2, and 3 degrees global warming

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Groundwater is the primary source of water supply for sustaining the lives of billion of people and surrounding ecosystems around the Globe. Climate change and variability threaten the sustainable use of renewable groundwater resources in many regions across the World. Yet the assessment on the effects of global warming on projected estimates of renewable groundwater resources and uncertainties surrounding those estimates at a locally relevant scale is lacking. Here, we provide a comprehensive, continental-scale assessment of past, present, and future changes in renewable groundwater resources (as a form of groundwater recharge after being suitably aggregated to longer time scales) across Europe at an unprecedented spatial resolution of (5 X 5) km^2 and local groundwater bodies as per the European Water Framework Directive (WFD). Specifically our aim here is to understand the response of Europe-wide groundwater resources to different global warming levels in accordance to 2015 IPCC Paris agreement. Our analyses are based on multi-model ensemble simulations from the EDgE[1] and HOKLIM[2] projects (funded by ECMWF and BMBF-Germany) which comprises of four hydrologic and land-surface models (HMs: mHM, Noah-MP, PCR-GLOBWB, and VIC) driven by a suitably downscaled, observation based E-OBS forcing data for the historical records (1950-2015) and five bias corrected CMIP5 GCMs datasets for the near-past to future climate conditions (1970-2100) under three representative concentration pathways (RCPs: 2.6, 6.0, and 8.5). A time-sampling approach is applied to identify 30-year periods with distinct warming levels corresponding to global surface air temperature increase of 1.5, 2.0, and 3.0 K compared to the pre-industrial levels. We contrast the changes in the multi-model ensemble recharge between the periods of distinct warming levels and to the contemporary conditions (1971-2000). Our analyses show a clear North-South gradient of changes in mean annual recharge across Europe with declining trends being observed in the Mediterranean region, and increased availability of groundwater resources in the North Scandinavian region with increased warming (at end of the Century). The continental part of the Europe shows relatively lower changes in the mean renewable groundwater resources. A greater sensitivity/amplifications in changes are noticed in the Mediterranean region to the response of increased warming levels. Though limited, but our ensemble simulations allow disentangling the different sources of uncertainties (HMs vs. GCMs) – which generally pointed out a larger chunk of uncertainty in modeling results arises due to differences among GCMs (forcings); but there are clearly areas where the uncertainty due to (different process representation of) HMs is substantial, and can not be neglected. Overall, our study underscores the need for multi-model ensembles for the assessment of future changes in renewable groundwater resources across Europe, and discuss about related impacts avoided in higher warming worlds.

1. www.edge.climate.copernicus.eu

2. www.ufz.de/hoklim