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The impact of our warming climate on global groundwater temperatures

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Groundwater, the largest reservoir of unfrozen freshwater on Earth, plays a crucial role in supporting life and ecosystems. Its thermal regimes influence various environmental processes, impacting groundwater-dependent ecosystems, geothermal potential, and groundwater quality. Despite its significance, little is known about how groundwater responds to surface warming across spatial and temporal scales. Here we present a comprehensive analysis of global groundwater temperature patterns, utilizing the latest CMIP6 scenarios.

In this study we developed the first global model of groundwater temperature patterns, combining analytical solutions to conductive heat transport with high-resolution maps of ground thermal diffusivity and geothermal gradient. This model, validated with over 8,000 groundwater temperature measurements, allows users to estimate present and future temperature depth profiles globally. Past trends show a median global groundwater temperature increase of 0.3 °C over the last two decades. When simulating projected groundwater temperatures globally, our model reveals an average warming of 2.2°C (SSP 245) to 3.8°C (SSP 585) between 2000 and 2100 at the depth of the water table. Regional variations are substantial due to climate change and water table depth variability, with mountainous regions exhibiting the lowest warming rates. These distinct regional variations emphasize important thermal controls and the need for localized analysis.

Our work sheds light on the importance of understanding groundwater warming patterns, identifying 'hot spots' that may pose risks to both ecosystems and human well-being. In this study we also offer a specific focus on Europe, providing averages to enhance regional relevance and address emerging challenges in groundwater quality and habitat preservation.