Groundwater warming up in sync

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Cisterns are commonly used in areas where water is scarce, either because it is rare or because it has been depleted due to heavy use . Credit: Chris Zielecki / flickr

Global warming stops at nothing—not even the groundwater, as a new study by researchers from ETH Zurich and KIT reveals: the groundwater's temperature profiles echo those of the atmosphere, albeit damped and delayed.

For their study, the researchers were able to fall back on uninterrupted long-term temperature measurements of groundwater flows around the cities of Cologne and Karlsruhe, where the operators of the local waterworks have been measuring the temperature of the groundwater, which is largely uninfluenced by humans, for forty years. This is unique

and a rare commodity for the researchers. "For us, the data was a godsend," stresses Peter Bayer, a senior assistant at ETH Zurich's Geological Institute. Even with some intensive research, they would not have been able to find a comparable series of measurements. Evidently, it is less interesting or too costly for waterworks to measure groundwater temperatures systematically for a lengthy period of time. "Or the data isn't digitalised and only archived on paper," suspects the hydrogeologist.

Damped image of atmospheric warming

Based on the readings, the researchers were able to demonstrate that the groundwater is not just warming up; the warming stages observed in the atmosphere are also echoed. "Global warming is reflected directly in the groundwater, albeit damped and with a certain time lag," says Bayer, summarising the main results that the project has yielded. The researchers published their study in the journal *Hydrology and Earth System Sciences*.

The data also reveals that the groundwater close to the surface down to a depth of around sixty metres has warmed up statistically significantly in the course of global warming over the last forty years. This water heating follows the warming pattern of the local and regional climate, which in turn mirrors that of global warming.

The groundwater reveals how the atmosphere has made several temperature leaps at irregular intervals. These "regime shifts" can also be observed in the global climate, as the researchers write in their study. Bayer was surprised at how quickly the groundwater responded to climate change.

Heat exchange with the subsoil

The earth's atmosphere has warmed up by an average of 0.13 degrees Celsius per decade in the last fifty years. And this warming doesn't stop at the subsoil, either, as other climate scientists have demonstrated in the last two decades with drillings all over the world. However, the researchers only tended to consider soils that did not contain any water or where there were no groundwater flows.

While the fact that the groundwater has not escaped climate change was revealed by researchers from Eawag and ETH Zurich in a study published three years ago, it only concerned "artificial" groundwater. In order to enhance it, river water is trickled off in certain areas. The temperature profile of the groundwater generated as a result thus matches that of the river water.

The new study, however, examines groundwater that has barely been influenced by humans. According to Bayer, it is plausible that the natural groundwater flow is also warming up in the course of climate change. "The difference in temperature between the atmosphere and the subsoil balances out naturally." The energy transfer takes place via thermal conduction and the groundwater flow, much like a heat exchanger, which enables the heat transported to spread in the subsoil and level out.

The consequences of these findings, however, are difficult to gauge. The warmer temperatures might influence subterranean ecosystems on the one hand and groundwater-dependent biospheres on the other, which include cold areas in flowing waters where the groundwater discharges. For cryophilic organisms such as certain fish, groundwater warming could have negative consequences.

Consequences difficult to gauge

Higher groundwater temperatures also influence the water's chemical composition, especially the chemical equilibria of nitrate or carbonate.

After all, chemical reactions usually take place more quickly at higher temperatures. Bacterial activity might also increase at rising water temperatures. If the groundwater becomes warmer, undesirable bacteria such as gastro-intestinal disease pathogens might multiply more effectively. However, the scientists can also imagine positive effects. "The groundwater's excess heat could be used geothermally for instance," adds Kathrin Menberg, the first author of the study.

More information: Menberg K, Blum P, Kurylyk BL, Bayer P: Observed groundwater temperature response to recent climate change. *Hydrology and Earth System Sciences* 2014, 18: 4453-4466, DOI: 10.5194/hess-18-4453-2014

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