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How shallow and deep groundwater impact environmental parameters correlated with global heatwaves

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Heatwaves present serious challenges to ecosystems, human health, and a wide range of socioeconomic activities. As the frequency and intensity of heatwaves increase, understanding the mechanisms driving their dynamics and interactions with land surface processes become more important. While extensive research has investigated the influence of various land and atmospheric parameters on heatwaves, less is known about how groundwater depth influences heatwave dynamics through their effects on soil moisture and surface evaporative fluxes (Vogelbacher et al., 2024, Sadeghi et al., 2012). To address this knowledge gap, we investigated how the groundwater depth affects the key parameters controlling heatwave dynamics on a global scale. Specifically, we developed more than 200,000 localized Artificial Intelligence (AI) models to represent the spatial distribution of heatwave frequency over the past 21 years across the world. For each model, a radius of 1.5 degrees (approximately 149 neighboring pixels) is considered in the computation to identify key parameters contributing to heatwaves in that region. We analyzed surface fluxes, as well as atmospheric, hydrological, and local environmental variables, to understand their correlation to heatwaves. Our findings suggest that geopotential height representing atmospheric drivers, is the key predictor of heatwave events in regions with deep groundwater tables (>100 m). In contrast, in areas with shallow groundwater (<10 m), surface fluxes emerge as important contributor to the onset of heatwaves. These findings highlight the less-discussed impact of groundwater depth on atmospheric processes and the important role of soil in linking groundwater and the atmosphere. Our results have important implications for water and land management, emphasizing the need for integrated approaches to understand and address the increasing risks posed by heatwaves.

References:

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