

How does groundwater table influence heatwave occurrences globally?

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Heatwaves pose a significant threat to ecosystems, human health and a wide range of socio-economic activities. Understanding the mechanisms that drive heatwave dynamics and their interactions with land surface processes is essential as the frequency and intensity of heatwaves are projected to increase in the future. While a number of studies have focused on the role of atmospheric and land surface variables on heatwaves, less is known about how groundwater depth might influence heatwave dynamics through its effects on soil moisture and surface evaporative fluxes. To address this, we examined past heatwave occurrences over a 21-year period, focusing on areas with shallow and deep groundwater levels in different climate and land cover regions. Furthermore, we examined the relationship between heatwave events and key variables across different water table levels on a global scale. For this purpose, we developed more than 200,000 localized artificial intelligence (AI) models to represent summer heatwave frequency across the globe. For each location (pixel), we considered data within a 1.5 degree radius (approximately 149 neighboring pixels) to identify key variables that contribute to heatwave occurrence. We used the model's built-in feature-importance metrics and tailored AI techniques to determine which variables, among surface fluxes and atmospheric, hydrological and local environmental variables, primarily govern heatwave occurrence in areas with different groundwater levels. Our results indicate that geopotential height, representing atmospheric drivers, dominates heatwave estimates in regions with deep groundwater levels (>100 m). In contrast, in areas with shallow groundwater (<10 m), surface fluxes emerge as an important contributor to heatwave occurrence. These findings shed light on the less discussed impact of groundwater depth on key environmental variables associated with heatwave events, and support sustainable climate adaptation and resource management.