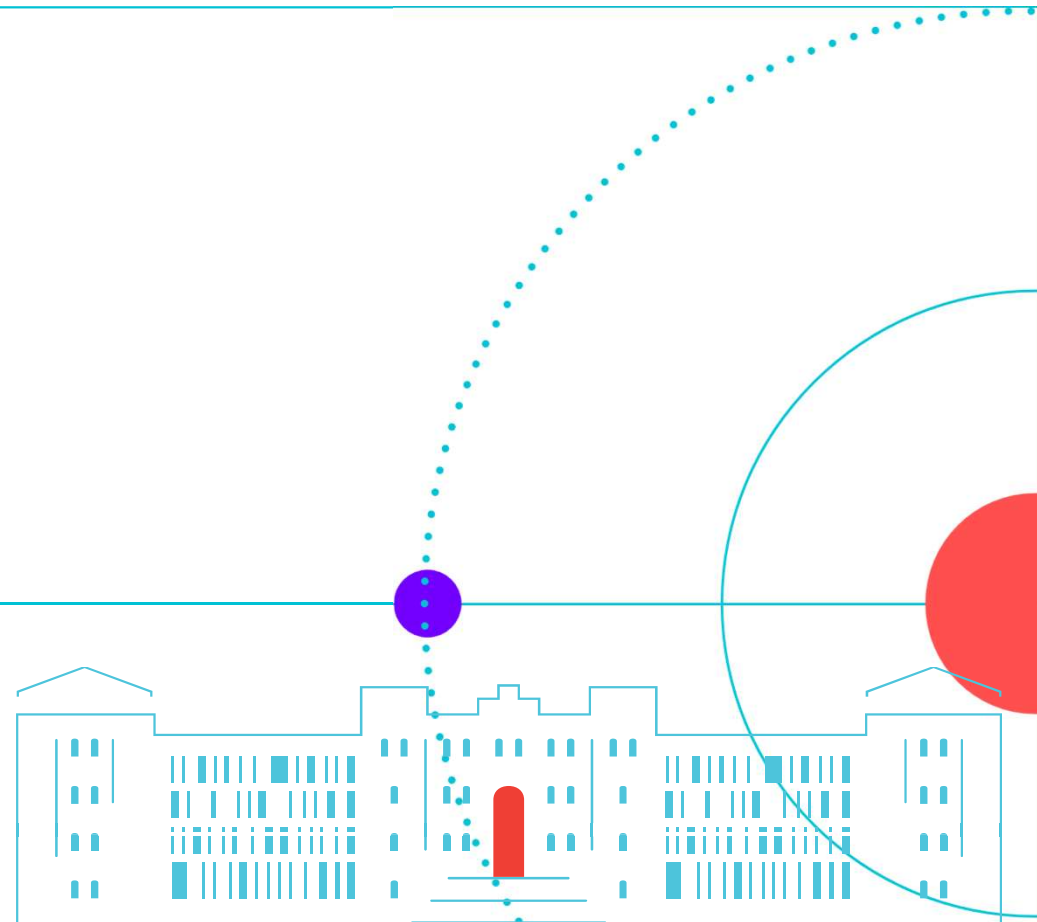


Role of Groundwater Depth on Heatwave Dynamics

TUHH
Technische
Universität
Hamburg

27.03.2025

Anastasia Vogelbacher

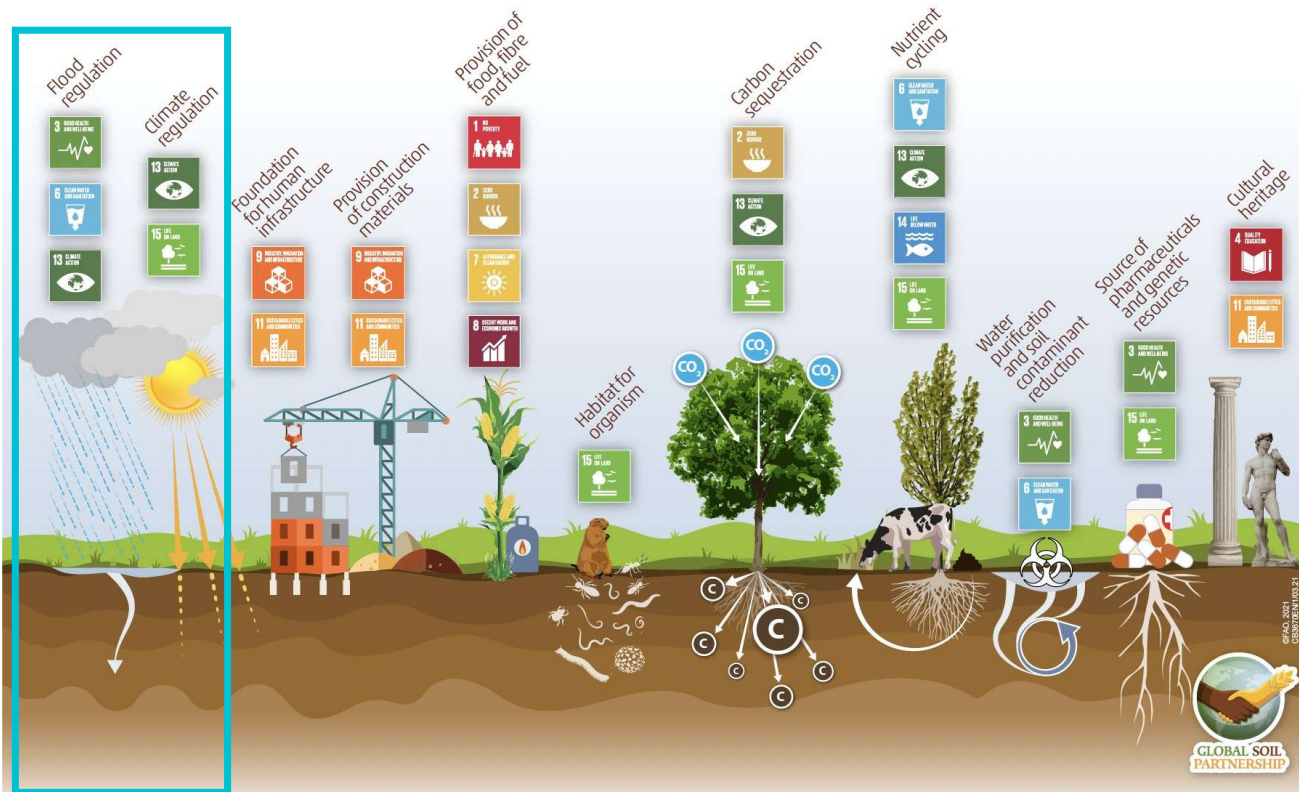


Healthy soil plays a crucial role in connecting groundwater and climate processes.

TUHH

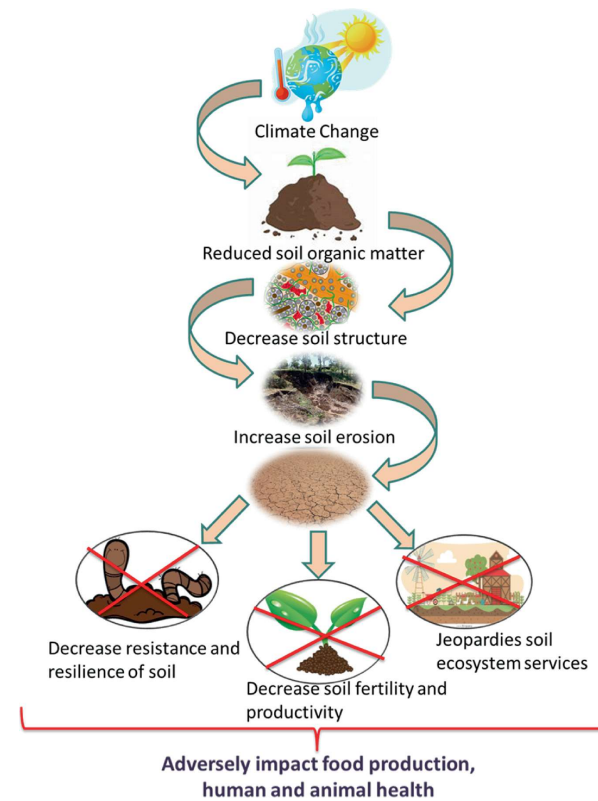
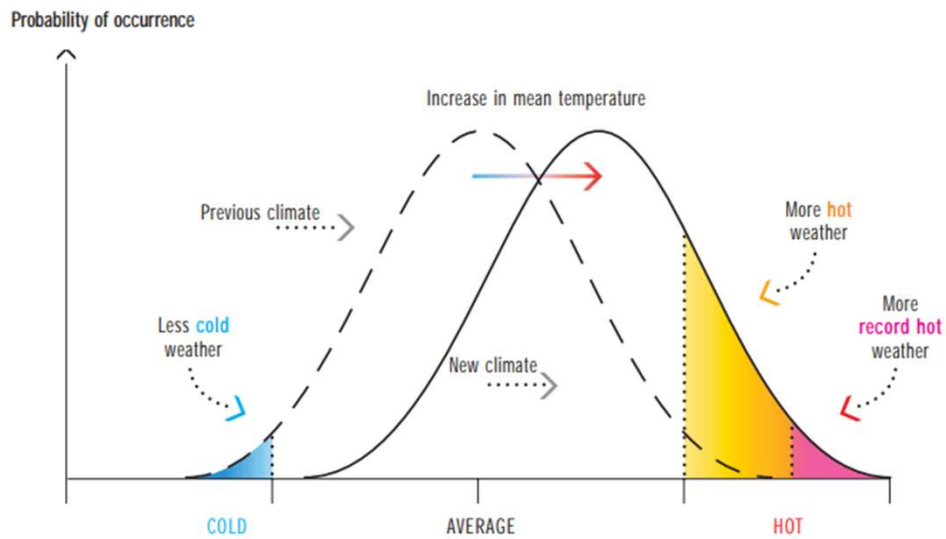


Healthy soils, a prerequisite to achieve the SDGs



FAO (2021)

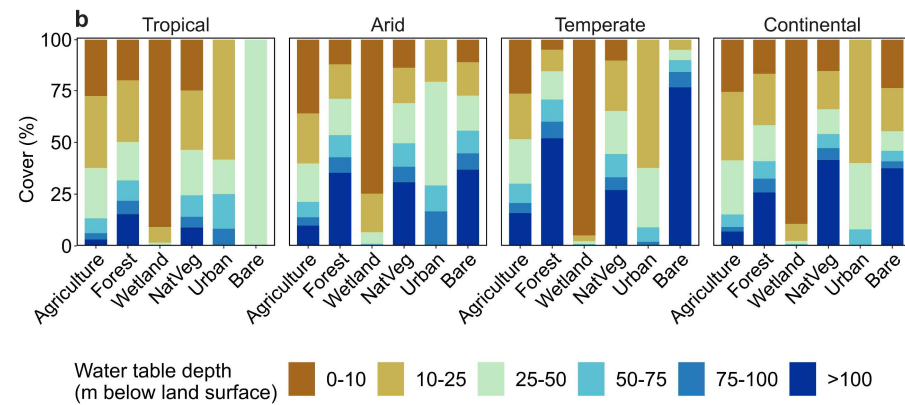
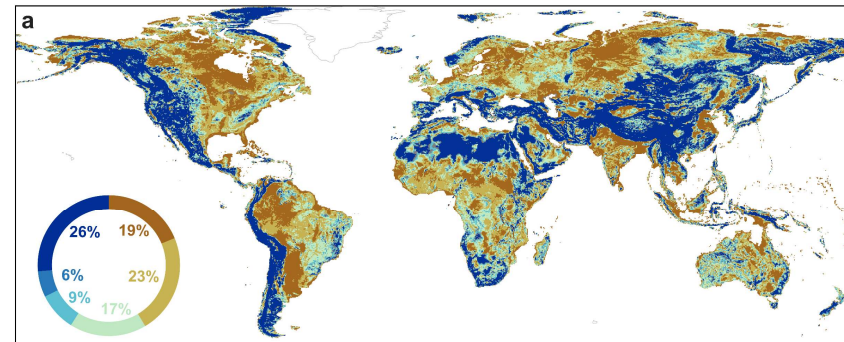
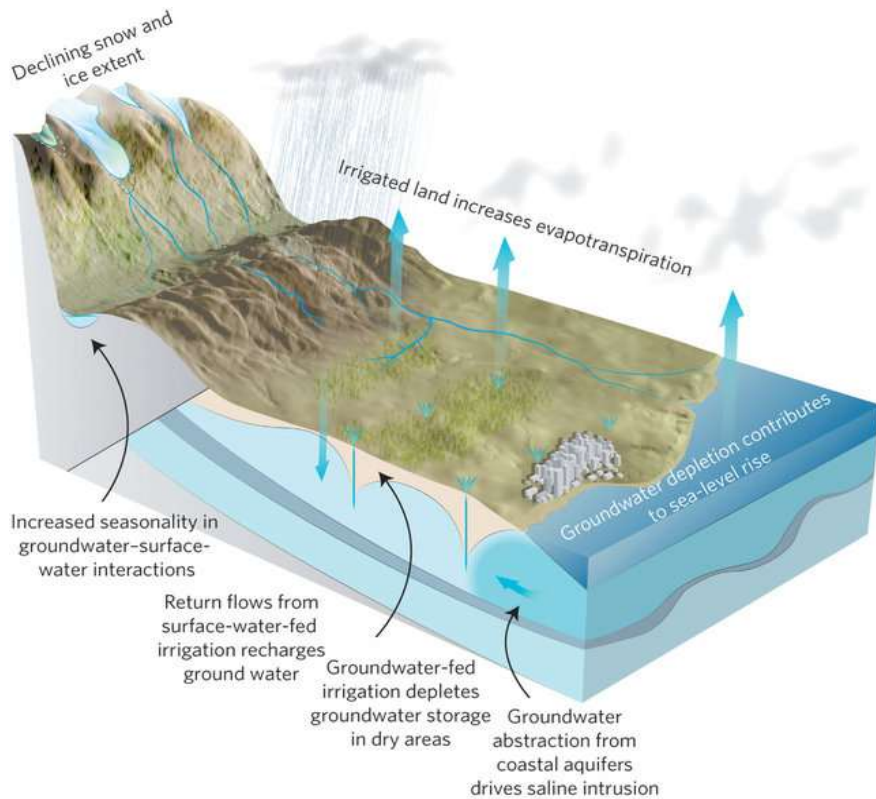
Increasing temperatures affect soil health



Houghton JT et al., eds. (2001). In *Climate change 2001: the scientific basis*, IPCC

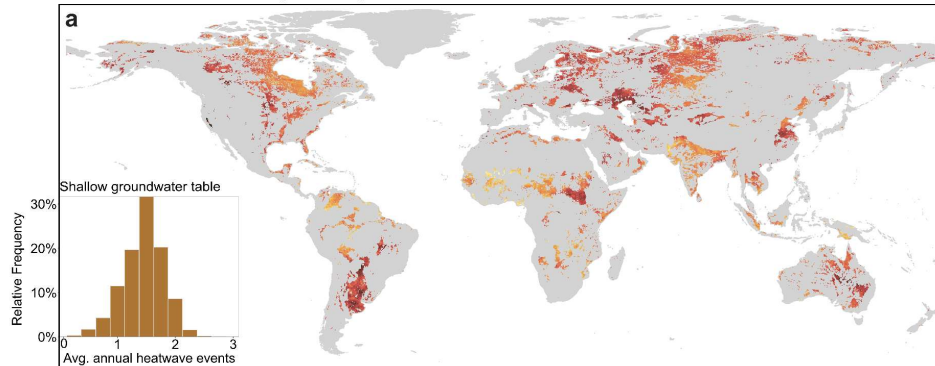
Purakayastha, T. et al., (2024) in *Soil health and climate change p.107 ff., Springer*

Soil as a Key Mediator in Groundwater–Climate Interactions

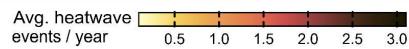
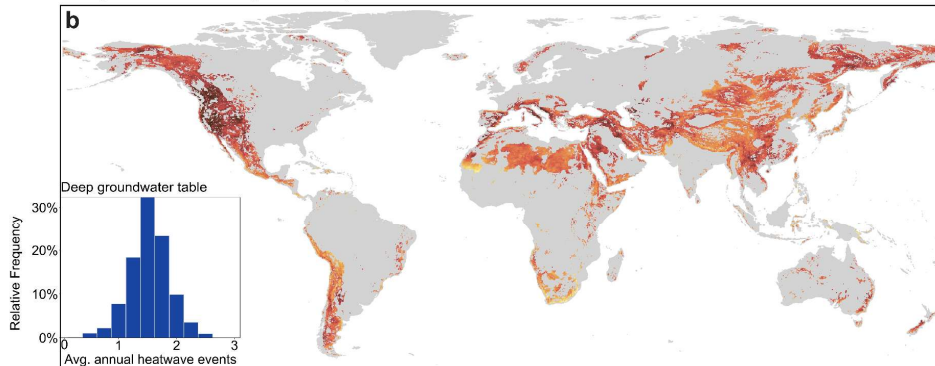


Groundwater depth influences heatwave occurrence

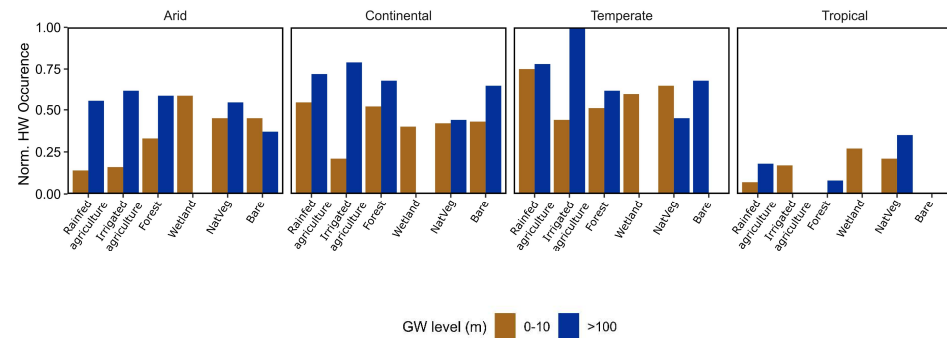
Shallow water table (<10 m)



Deep water table (>100 m)

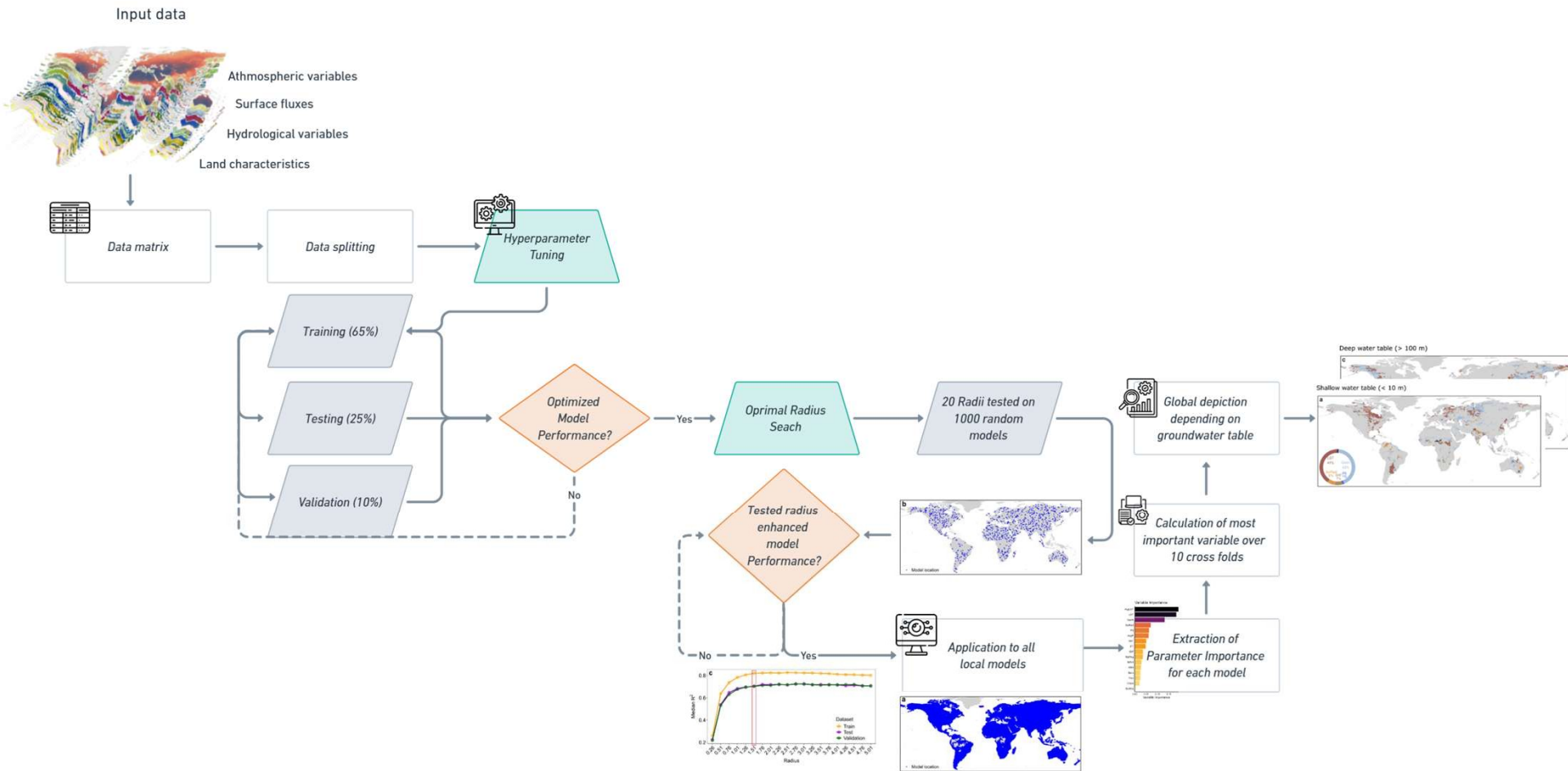


- Fewer hotspots and lower heatwave frequencies are observed over shallow water tables.



Spatiotemporal analysis of heatwave events (2001–2022) across regions with shallow and deep groundwater tables.

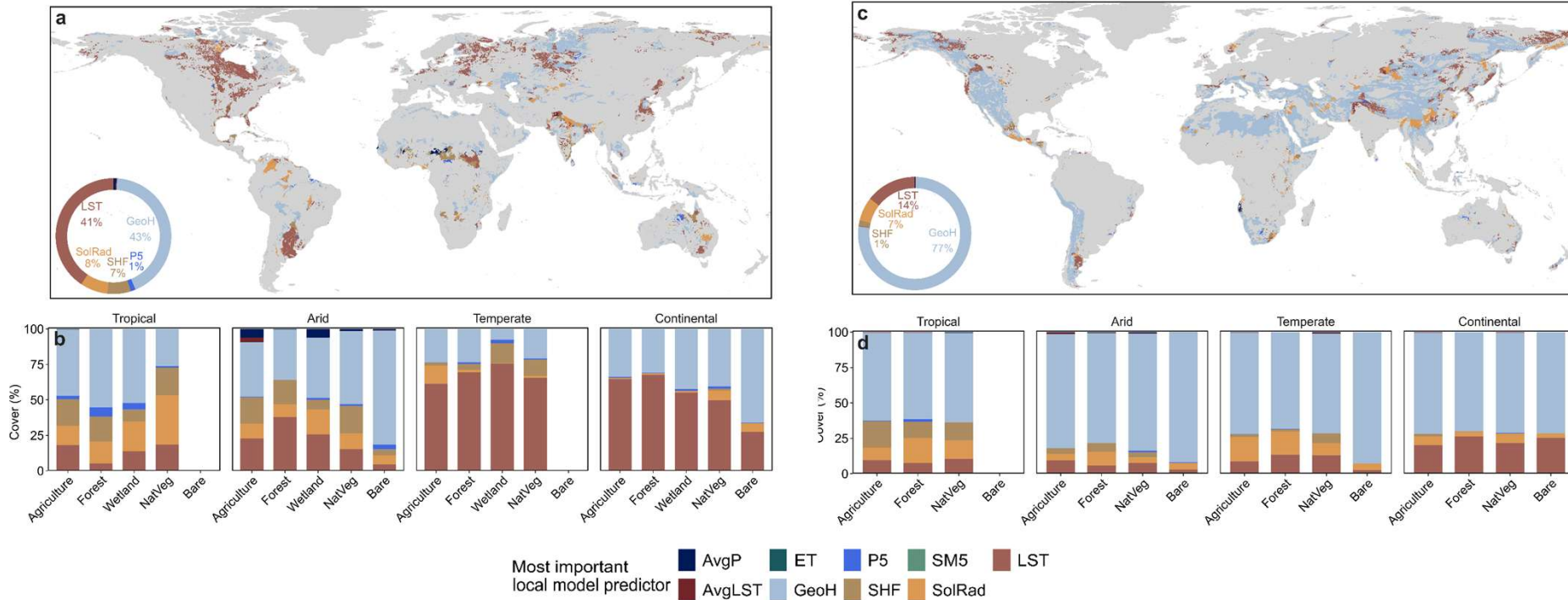
Application of localized AI models to estimate groundwater's role on environmental variables



Localized AI models capture the role of groundwater on heatwave dynamics

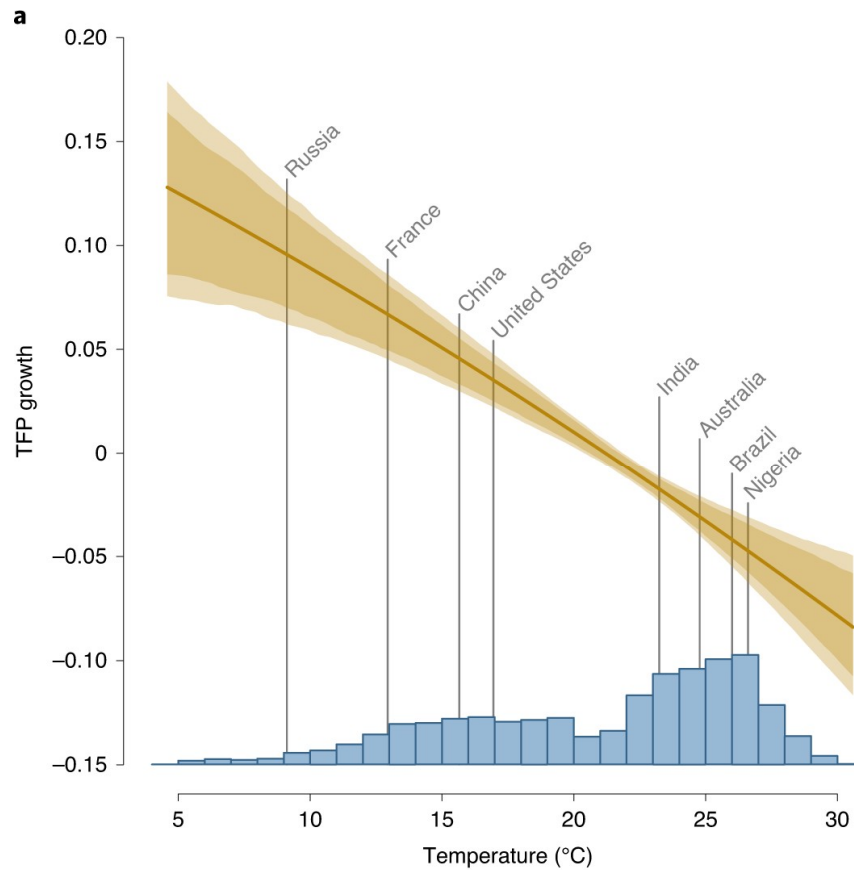
Shallow water table (< 10 m)

Deep water table (> 100 m)

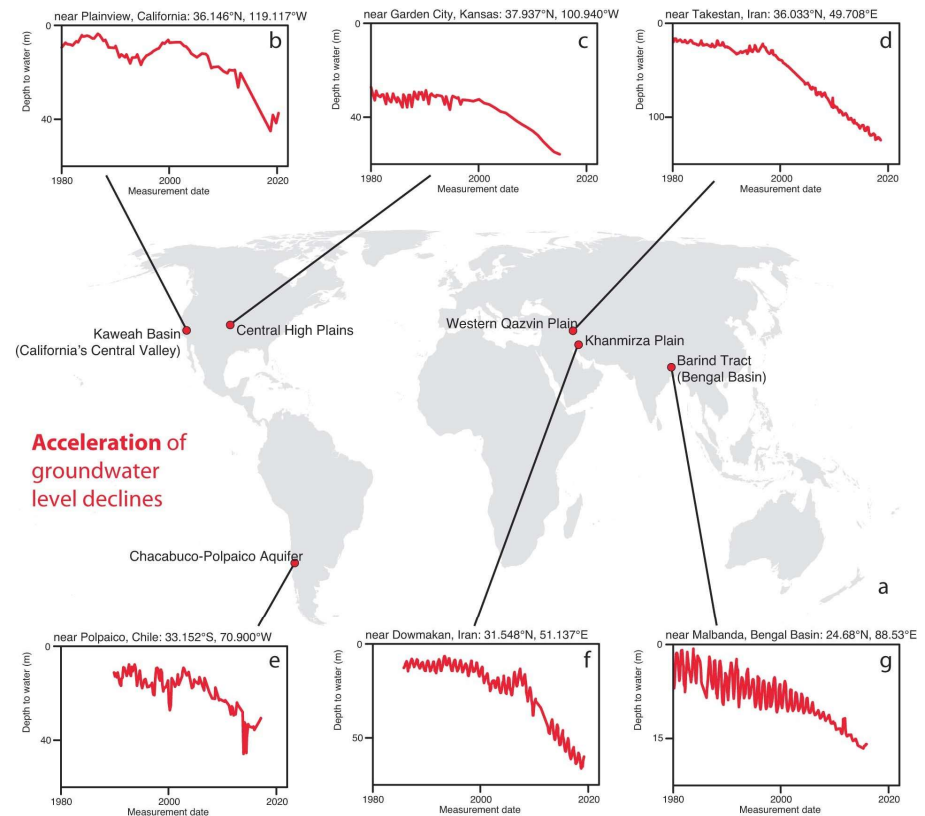


- Surface fluxes play a stronger role over shallow water tables, while atmospheric variables dominate over deep water tables in estimated HW events.

Including groundwater depth in heatwave analysis provides new insights into variables driving heatwaves



Response of agricultural productivity to weather (Ortiz-Bobea et al., 2021, *Nature Climate Change*)



Declining groundwater levels in selected monitoring wells (Jasechko et al., 2024, *Nature Climate Change*)

References

Houghton JT et al., eds. (2001). *Climate change 2001: the scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, Cambridge University Press.

Ortiz-Bobea, A., Ault, T.R., Carrillo, C.M. et al. Anthropogenic climate change has slowed global agricultural productivity growth. *Nat. Clim. Chang.* **11**, 306–312 (2021). <https://doi.org/10.1038/s41558-021-01000-1>

Purakayastha, T.J., Trivedi, A., Biswas, S., Kumar, D. (2024). Soil Health and Climate Change. In: Pathak, H., Chatterjee, D., Saha, S., Das, B. (eds) *Climate Change Impacts on Soil-Plant-Atmosphere Continuum. Advances in Global Change Research*, vol 78. Springer, Singapore. https://doi.org/10.1007/978-981-99-7935-6_4

Shokri, N., Aminzadeh, M., Flury, M. et al. Sustainability Nexus AID: soil health. *SNF* **33**, 3 (2025). <https://doi.org/10.1007/s00550-025-00560-6>

Taylor, R. G., Scanlon, B., Döll, P., Rodell, M., Van Beek, R., Wada, Y., Longuevergne, L., Leblanc, M., Famiglietti, J. S., Edmunds, M., Konikow, L., Green, T. R., Chen, J., Taniguchi, M., Bierkens, M. F. P., MacDonald, A., Fan, Y., Maxwell, R. M., Yechieli, Y., ... Treidel, H. (2013). Ground water and climate change. *Nature Climate Change*, 3(4), 322–329. <https://doi.org/10.1038/nclimate1744>

UN Water (Hrsg.). (2022). *Groundwater making the invisible visible*. UNESCO. ISBN: 978-92-3-100507-7

United Nations Office for the Coordination of Humanitarian Affairs. (2022). *Extreme Heat: Preparing for the Heatwaves of the Future*. Retrieved from <https://www.unocha.org/publications/report/world/extreme-heat-preparing-heatwaves-future>

Vogelbacher, A., Aminzadeh, M., Madani, K., & Shokri, N. (2024). An Analytical Framework to Investigate Groundwater-Atmosphere Interactions Influenced by Soil Properties. *Water Resources Research*, 60. <https://doi.org/10.1029/2023WR036643>

Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. (2021). *Climate Change 2021 The Physical Science Basis Summary for Policymakers*. IPCC. www.ipcc.ch/report/ar6/wg1/

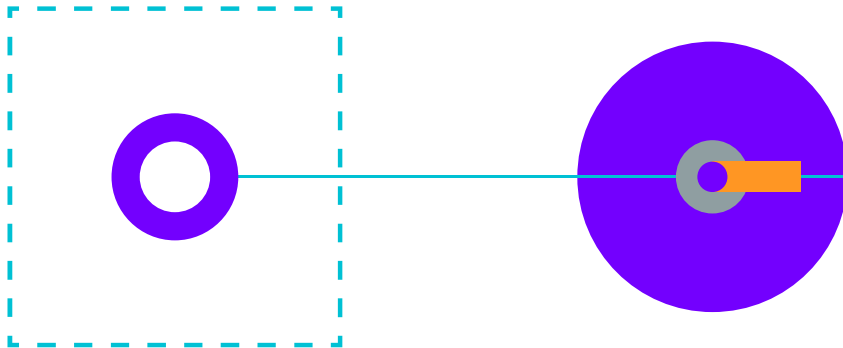
Vogelbacher, A., Afshar, M.H., Aminzadeh, M., Madani, K., AghaKouchak, A., Shokri, N. (2025). Role of Groundwater Depth on Heatwave Dynamics (in review)

Thank you for your attention!

Any questions ?



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