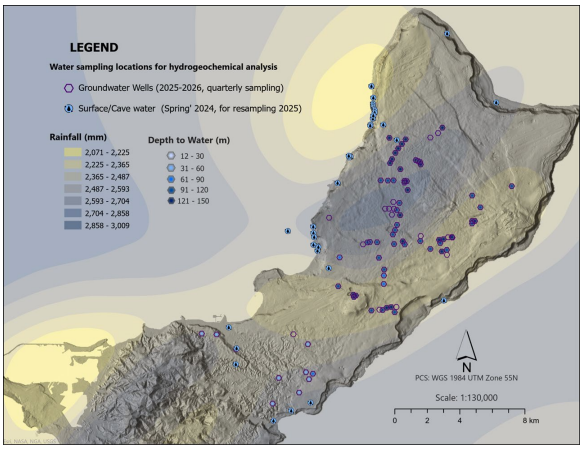
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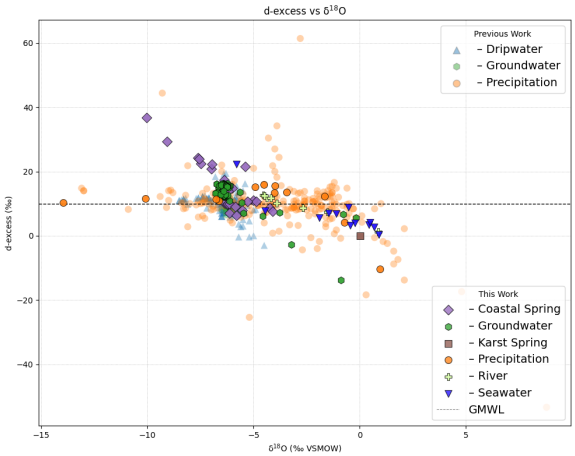
Groundwater Isoscape of the Northern Guam Karst Aquifer System

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Freshwater security in small island communities depends heavily on understanding groundwater systems. Groundwater is a critical resource especially for karst islands but often remains poorly constrained due to an inherently complex hydrology tied to their heterogeneous geology. Northern Guam is an uplifted carbonate plateau that hosts a sole-source karst aquifer supplying >80% of the island's drinking water. Precipitation (~2,160–2,540 mm/year) is the primary control of the island's hydrology. Recharge occurs by rapid infiltration with as much as 12–28% of recharge reaches the aquifer within ~1.5 hours of a rainfall event [1] to accumulate as freshwater lens atop a denser seawater or discharge as springs along the coast. We developed a groundwater isoscape from quarterly sampling of ~100 wells to understand how spatial patterns of $\delta^{18}O$ and $\delta^{2}H$ reflect sources, seasonal variability, and flow paths across Northern Guam. This effort notably expands the island's groundwater and coastal springs isotopic dataset to compliment published data that only includes precipitation, cave drips and some wells [see 2–4]. A total of 129 water samples from rivers, cave pools and coastal springs were also collected in Spring 2024 and 2025 for robust hydrogeochemistry (Fig.1). Precipitation generally exhibits strong seasonal variation, while seasonality is damped in groundwater, coastal springs and inland surface waters, which also plot near the global meteoric water line (GMWL) but with a shallower slope. Coastal springs exhibit enriched isotopic values and reduced d-excess consistent with evaporation and freshwater–seawater mixing near discharge zones (Fig.2). Mapping island-wide isotopic patterns helps in interpreting climate, surface hydrology, and subsurface karst processes that support aquifer management. We anticipate this expanded isoscape will strengthen how we translate isotopic signals in paleoclimate archives into reconstructions of past climate variability.





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