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Not so Isolated: Isotopic and Hydraulic Evidence of Vertical Connectivity Between the Okefenokee Swamp and Floridan Aquifer

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Abstract

The Okefenokee Swamp has long been assumed to be hydraulically isolated from the Upper Floridan Aquifer (UFA) due to the intervening Hawthorne Formation, a Miocene-age confining unit. Here we test that assumption using stable water isotopes and multiyear time series of swamp and aquifer water levels. Isotope mixing model using $\delta^{18}O$ indicates that 27–95% of groundwater beneath the swamp is swamp-derived, with the remainder resembling regional UFA water. Coherence analysis and impulse-response modeling show that water level fluctuations propagate across the Hawthorne layer with a lag of ~30 days, yielding a vertical hydraulic diffusivity of ~291 m^2/d. These independent lines of evidence confirm that the swamp and aquifer are hydraulically connected through a semi-confining system. Vertical leakage from the swamp may represent 5–15% of annual rainfall and contributes to the isotopic enrichment of UFA waters downgradient. This overturns prevailing hydrogeologic conceptual models and suggests that wetland–aquifer interactions are more dynamic and consequential than previously recognized.

1. Introduction

Groundwater–surface water exchanges govern both water quantity and quality across climates, yet their spatial modes—whether diffuse or focused—remain difficult to quantify. Recharge occurs along a continuum between diffuse infiltration through soils and focused leakage via streams, depressions, or karst features. Climatic aridity and local hydrogeology largely determine where a system lies on that continuum. Observations across sub-Saharan Africa show that humid regions sustain diffuse, seasonally consistent recharge, whereas semi-arid areas experience threshold-controlled, episodic recharge through focused infiltration from ephemeral flows (Cuthbert *et al* 2019). Globally, field syntheses confirm that recharge fractions scale nonlinearly with aridity and that preferential flowpaths strengthen the connection between aquifers and surface fluxes beyond what global models typically resolve (Berghuijs *et al* 2022).