cooler during the LGM, yet the $\delta^{18}O$ enrichment observed down-gradient was best explained by modern shallow groundwater leaking downward rather than by paleoclimate effects (Clark *et al* 1997). Their tracer patterns, together with hydraulic modeling, revealed that southeastern Georgia's segment of the FAS is semi-confined, with localized downward flux through discontinuities in the Hawthorn Group. However, those studies did not include direct sampling of overlying wetlands—notably the Okefenokee Swamp—or pair chemical signatures with time-series head data. As a result, the magnitude, timing, and spatial organization of swamp–aquifer exchange remain unresolved.

1.2 Broader scientific problem

Globally, recent studies reveal that recharge processes are far more heterogeneous than long-assumed: diffuse and focused fluxes can coexist across small spatial scales, and even deep aquifers thought to contain ancient water can be dynamically connected to modern surface sources (Thaw *et al* 2022, Berghuijs *et al* 2022, Cuthbert *et al* 2019, Jasechko *et al* 2017). Yet empirical tests of these processes beneath large peat wetlands remain rare. Such systems are often treated as hydrologically self-contained, dominated by precipitation and evapotranspiration, with little consideration of vertical leakage. However, evidence from other environments—arid floodplains, ephemeral basins, glaciofluvial aquifers—demonstrates that focused recharge through localized windows can transmit surface signals deep into regional aquifers. Whether the Okefenokee Swamp functions purely as an evaporative terminus or as a zone of focused downward exchange thus remains a key uncertainty with implications for both groundwater budgets and contaminant pathways.

1.3 Objectives and approach

This study provides the first direct test of hydraulic connectivity between the Okefenokee Swamp and the UFA. We combine new δ^2H–$\delta^{18}O$ measurements (2025) from swamp waters and nearby wells with the historical 1990s tracer dataset of Clark et al. (1997) and analyze multi-year records of swamp stage and groundwater heads. Together, these datasets allow us to evaluate both spatial isotopic signatures and temporal coupling between surface and subsurface systems.

Our objectives are to:

1. Quantify the isotopic evidence for swamp-derived water within the UFA;
2. Determine whether exchange is diffuse or focused and identify likely pathways; and
3. Interpret the findings within the global context of groundwater–surface water coupling and intrusion vulnerability.

Guided by the global literature on preferential recharge and semi-confined systems, our working hypothesis is that the Okefenokee Swamp and the UFA are hydraulically