Chapter 3: Isolated-Wetland Contribute Relatively Little to Stream Carbon but Foster External Lateral Export: Mapping the Carbon Cycle in “Wetlandscapes”.

* Landscape hydrology predicates that hydrologic and biogeochemical changes in one region of a watershed have the potential to cascade across the entire basin.
* Through the lens of landscape hydrology, the watershed is viewed as a singular, relatively closed system, encompassing micro-ecosystems that collectively contribute to the basin’s distinct biogeochemical and hydrologic fingerprint.
* However, the relevance of "landscape hydrology" is watershed specific, dependent on the basin's connectedness or how water flows and is stored between inland waters.
* This landscape "connectedness" is largely dependent on wetland area, namely geographically isolated wetlands (GIWs).
* GIWs disrupt the flow of watershed runoff. Instead of water flowing down elevation and exported to streams, water is instead stored within the catchment, fated to either efflux to the atmosphere, remain stored in the wetland basin, or exchange with the surficial aquifer.
* Through wetland-aquifer exchange, GIWs modulate the surficial aquifer by sourcing and receiving groundwater, buffering flow extremes, and dictating downstream baseflow, while also facilitating transport between inland waters, even without overland connectivity.
* In low-relief catchments, the biogeochemical signature of each inland water is dependent on the upland hydrology, as well as the water table elevation.
* The chemical fingerprint of low-relief stream water results from the "wetlandscape," the biogeochemical reactions within GIWs, the surficial aquifer, and the river corridor.
* In contrast, dry, unconfined watersheds with less exchange between inland waters feature aquatic environments that are more independent, with stream biogeochemical signatures more like terrestrial inputs.
* GIWs are global hot spots; the anaerobic conditions, long residence times, and extended hydroperiods of GIWs encourage the re-mineralization and storage of carbon while simultaneously exporting processed waters downstream through groundwater or overland flow ("spill-and-fill").
* In the literature, direct observations estimate GIWs' contributions to stream carbon is small.
* Only 20% of total stream carbon is sourced by GIWs, with the remainder assumed to come from the riparian zone.
* These studies, though useful for finite carbon budgeting, undermine GIWs' role in global carbon cycling by (1) sampling from overland, intermittent flow paths while excluding subsurface export, and (2) failing to interrogate GIWs' influence on watershed-level carbon export.
* Despite model estimates, current research has not directly explored the cumulative impacts of landscape hydrology on carbon export, particularly concerning carbon cycling.
* GIWs are known to modulate the surficial aquifer, providing a buffer against flow extremes, increasing watershed inundation and residence times, and fostering watershed connectivity.
* These ecological functions of GIWs are integral to the broader energy and water dynamics within the “wetlandscape.”
* Energy exchange through the wetlandscape operates as a chain reaction: water and its contents runoff into GIWs, where it then diffuses into the surficial aquifer, which subsequently exports water to riparian wetlands and streams as baseflow.
* The surficial aquifer is the wetlandscape transport-network while GIWs serve as the “capacitors”.
* These interactions dictate downstream baseflow, surface-groundwater exchange, watershed inundation, and carbon export.
* Even as soils dry, GIWs can sustain the surficial aquifer and its streams into the early seasons of drought.
* The longer the watershed remains inundated, the greater the carbon storage (in wetlands) and export potential (to streams).
* For the third chapter of my dissertation, I will estimate both direct and indirect carbon contributions from GIWs to streams by longitudinally sampling for DIC, DOC, and POC from three BEF streams within basins of various wetland densities. Thus far in my PhD, I will have explored stream carbon temporal dynamics and RC fluxes in fluctuating hydrologic settings. By coupling my longitudinal sampling results with the findings from Chapters 1 and 2, I can isolate the influence of isolated wetlands. Assuming RC fluxes and stream productivity responses to fluctuating discharge are homogeneous throughout the reach, I can investigate how nearby GIWs influence stream carbon as water accumulates downstream. Studies have directly explored GIW carbon contributions, and none have included observed RC fluxes along with stream metabolism models.
* (1) I hypothesize that each stream will gain carbon, increasing in DIC, DOC, and POC as water flows downstream. Although I expect depressional wetlands to contribute to the stream carbon, (2) I hypothesize the RC will remain the dominant carbon source. However, during flooded conditions, (3) I anticipate the wetland contribution will be greatest due to a shallower surficial aquifer and overland flow. Additionally, (4) I expect streams in watersheds with greater wetland areas to have higher total carbon (TC) concentrations across wetland, RC, and stream boundaries.
* Using the results from my entire dissertation, I aim to holistically map stream carbon sources and fluxes, allowing me to draw detailed inferences on low-relief, “wetlandscape” carbon budgets. By testing these hypotheses and developing a carbon budget, I aspire for this chapter to offer both an improved understanding of low-relief carbon cycling and practical applications. Specifically, my objective for Chapter 3 is to inform management decisions on how to optimize landscape hydrology for carbon storage.