Title. Revealing basin-scale metabolism drivers via model-experiment integration

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Abstract (400 words maximum):
Inland waters contribute significant amounts of carbon dioxide (CO2) to the atmosphere. In particular, river corridors generate CO2 emissions larger than lakes and reservoirs combined. Carbon cycling in rivers has been widely studied via two key processes: carbon fixation (Gross Primary Production, GPP) and organic carbon mineralization (Ecosystem Respiration, ER), which together constitute river metabolism. These estimates are commonly derived from diel dissolved oxygen measurements, which encompass the collective aerobic organisms (including autotrophs and heterotrophs) and habitats (such as benthic, planktonic, and hyporheic zones). While river metabolism is influenced by the interaction of several biotic and abiotic factors across habitats, commonly used models like the Networks with Exchange and Subsurface Storage (NEXSS) and the River Corridor Model (RCM) assume that hydrologic exchange is the primary driver of metabolism and thus focus only on simulating riverine sediment (hyporheic) respiration rates across scales. Here we evaluate the role that physical, chemical, and biological processes have on riverine metabolism and sediment respiration via model-experiment integration (ModEx). To do this, we test a hypothesis derived from process-based model results which states that hydrologic exchange is the key driver of sediment respiration at the basin scale. We test this hypothesis by comparing RCM model predictions at the basin scale with measured sediment respiration rates across 48 sites in the Yakima River Basin (YRB). We found no qualitative or quantitative correspondence between our observed respiration rates associated with sediments and the respiration rate predictions from the physical model. One potential reason for the lack of correspondence between observed and predicted respiration rates is that respiration within the physical model is limited to the hyporheic zone. Our measurements of sediment respiration integrate processes from benthic, planktonic and hyporheic zones that are hydrologically connected to the active channel. The field measurements, therefore, include additional processes that are not represented in the physical model. Our observed-predicted comparison does not, therefore, reject the model. Instead, the lack of correspondence indicates there are important processes not represented in the model and the processes that are represented do not strongly drive spatial patterns of in situ respiration. Collectively, our results contribute to the existing conceptual understanding of river sediment respiration by addressing previously unexplored ModEx relationships across scales.