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Recent developments integrating connected non-lotic and ephemeral water bodies into the Pulse-Shunt Concept

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River networks have been conceptualized as “leaky pipes” for carbon loss. However, there remains considerable uncertainty regarding where, when, and how carbon loss takes place along the aquatic continuum across hydroclimatic conditions. Recent modelling efforts have been developed to (1) connect river reaches with non- or semi-lotic systems including lakes, reservoirs, floodplains and wetlands, and (2) account for river network connectivity via quantification of ephemeral streamflow. These models, which use techniques such machine learning to scale from local measurements to high-resolution river network data products, enable the quantification of relative carbon loss fluxes in lentic vs. lotic systems across stream orders (“where”) within standardized hydroclimatic scenarios representing the full continua of flows and seasonal conditions possible within a watershed (“when”). These models further quantify carbon uptake via both biomineralization and photomineralization (“how”). We frame findings into an updated conceptual model of the Pulse-Shunt Concept, which builds on the representation of river networks as leaky pipes by correlating the “leakiness” with dependence on flow and stream order. We suggest that lakes and other lentic systems should be considered as reactivity “nodes” interspersed along mostly unreactive or passive river reaches. We additionally discuss how these river network modelling approaches can continue to be improved using sensor networks.