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Leaky deltas: sources or sinks in the global carbon cycle?

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Deltas have global relevance as major centers of marine primary production, biogeochemical transformations, and human activity, all of which influence the global carbon cycle. However, substantial knowledge gaps remain in our understanding of the processes governing carbon cycling in deltas, their impacts on marine biogeochemistry, and their trajectories under future climate and anthropogenic pressures. Carbon burial estimates in deltas are primarily based on large-scale mass balance estimates of riverine inputs and oceanic outputs. These approaches provide valuable global-scale insights but obscure the mechanisms that control the transformation, storage, and lateral and vertical fluxes of carbon within deltaic systems. To improve predictions of carbon fate in these complex and vulnerable environments, we need to develop a mechanistic understanding of internal processes that regulate carbon cycling across the land-ocean interface, including biological production and respiration, mineral interactions, sediment transport, and ecosystem feedbacks. To highlight these challenges and constrain the current state of knowledge, we convened ~50 scientists during the Leaky Deltas workshop in March 2025 (https://www.us-ocb.org/leaky-deltas-workshop-2025/) with expertise in fluvio-deltaic and biogeochemical processes to develop a review paper on the role of deltas in the carbon cycle [1]. This effort has resulted in a new perspective on how physical and biogeochemical processes interact with organic carbon production and remineralization processes over spatial scales ranging from individual molecules and grains to the entire delta plain and coastal ocean and over temporal scales ranging from seconds to millennia. The Leaky Deltas Working Group members should be considered co-authors of this abstract. We consider both small and large-scale processes, from photochemical transformation, tidal cycles and air-water-sediment gas exchange to tectonics and global sea-level fluctuations. This work provides a novel synthesis and identifies major knowledge gaps that need to be addressed to improve our understanding of and ability to quantify the role of river deltas in the global carbon cycle.

[1] OCB Leaky Deltas Working Group: https://www.us-ocb.org/leaky-deltas-workshop-2025/