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Carbon storage, transfer and outgassing driven by floodplain morphology and seasonality at the Rio Bermejo, Argentina

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To understand how climate change impacts the global carbon cycle, we need a mechanistic understanding of the natural processes driving the capture and release of CO_2 from landscapes. Through photosynthesis, vegetation removes carbon from the atmosphere and the organic carbon (OC) stored in vegetation, soils, and sediments can be eroded and subsequently transported by rivers to the oceans. During transport, OC can be stabilized and temporally stored in floodplains or oxidized and returned to the atmosphere as CO_2. The balance between storage and release controls the floodplains net carbon balance. Recent research suggests that OC storage exceeds OC emissions on floodplains of meandering rivers. However, how floodplain morphology and seasonality affect OC transfer, storage and release are not well constrained yet.

During wet and dry seasons, we measured the flux and $\delta^{13}C$ content of the CO_2 emissions from the floodplain of the Río Bermejo, Argentina, along its braided and meandering reaches. We focused on emissions from sediment deposited on the recently exposed river bed, on the active floodplain, and in paleochannels. Overall, the CO_2 flux magnitude was three times higher in the wet season versus the dry season. $\delta^{13}C$ values did not differ significantly between seasons, except for paleochannel sediments where CO_2 was more enriched in ^{13}C during the wet season (-12.7‰) than the dry season (-16.3‰). CO_2 fluxes from wet river bed sediments were the lowest, averaging 0.025 ± 0.3 $mol \cdot m^{-2} \cdot d^{-1}$, and $\delta^{13}C$ values averaged -11.4‰, suggesting rapid mixing with atmospheric CO_2 (-11.9‰), rather than OC mineralization. CO_2 emitted from active floodplain sediments showed $\delta^{13}C$ values ranging from -36.9‰ to -7.4‰ and CO_2 fluxes ranging 0.023 – 1.6 $mol \cdot m^{-2} \cdot d^{-1}$. We suggest rapid mineralization of fresh, labile OC on the active floodplain, and large-scale mineralization of older, stored OC: ^{13}C-depleted active floodplain CO_2 is fueled by decomposition of OC deposited during recent floods, predominantly at the braided reach. Whereas, ^{13}C-enriched CO_2 from paleochannels and meander reaches suggests mineralization of carbon, possibly stored over millennia. Our data provides insights on how floodplain morphology and seasonality modulate the storage and release of carbon over multiple timescales.