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Drought-induced calcite precipitation promotes CO_2 efflux from rivers

JINYU WANG[1], MATTHEW WINNICK[2], JULIEN BOUCHEZ[3], ALLISON E GOODWELL[4], PRAVEEN KUMAR[4,5] AND JENNIFER L DRUHAN[3,5]

[1]University of Illinois Urbana-Champaign
[2]University of Massachusetts Amherst
[3]Université Paris Cité, IPGP, CNRS
[4]Prairie Research Institute at University of Illinois at Urbana-Champaign
[5]University of Illinois at Urbana-Champaign

Presenting Author: jinyuw3@illinois.edu

Here, we utilize a novel river chemistry monitoring technique referred to as a 'RiverLab' to evaluate the extent to which hydrological drought might impede lateral carbon transport through the terrestrial environment in areas where rivers are already poised near carbonate saturation. The capacity to which drought can push the reversible stoichiometric reaction Ca^{2+} + $2HCO_3^-$ ⇌ $CaCO_3$ + CO_2 + H_2O towards carbonate formation also implies a capacity to exacerbate terrestrial carbon emissions from inland waters. We show evidence for significant carbonate precipitation across the Upper Sangamon River (Illinois, USA) during a hydrological drought spanning ~6 months in the Summer and Fall of 2022. This behavior is evidenced by a notable decrease in Ca concentration, whereas Na, K, Cl, and SO_4 concentration increased. The unique behavior of Ca is a result of the river saturation state with respect to calcite, which indicates substantial calcite precipitation, and in turn a mole-for-mole production of CO_2. We use the same concept to estimate (1) the amount of CO_2 efflux from this watershed during a much more severe drought in 2012 and, (2) upscale these observations to the production of CO_2 from U.S. and Europe streams and rivers associated with calcite precipitation during hydrological drought spanning the years 1980 to 2022, based on available water quality monitoring databases. The application of high temporal-resolution solute chemistry enables a new more comprehensive depiction of a drought period and the associated fluctuations in solute concentrations, which holds implications for our understanding of the carbon cycle alteration caused by climate change.