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Efficient and uniform mobilization of solutes during high-discharge events

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In rapidly eroding mountain landscapes, storms and intense rainfall events (IREs) can generate high solute fluxes over short timescales. Most of these solutes are mobilized from the solid Earth through chemical weathering reactions, thereby influencing global carbon and nutrient cycles. However, because riverine weathering and carbon budgets are typically derived from monthly or annual discharge records, the role of storms and IREs in controlling the balance of weathering reactions that act as either sources or sinks of CO_2 remains uncertain.

Here, we investigate solute fluxes from the Choushui and Chenyoulan Rivers in Western Taiwan during two high-magnitude discharge events: a 2004 storm and a 2017 IRE. Based on an inverse model, paired discharge and geochemical datasets are used to capture transient export of solutes from different weathering reactions and their associated CO_2 fluxes. During both events and for both rivers, we find that all major cations (except for K) exhibit a very similar weak dilution or chemostatic behavior, implying that solute fluxes are governed by discharge and that high-discharge conditions contribute disproportionally to solute fluxes. Hysteresis and history effects slightly modulate this first-order pattern, but overall, the highest discharges (1500 – 2000 m^3/s) were 30–60 times more effective than baseflow (<50 m^3/s) at exporting weathering solutes, highlighting the importance of capturing transient events for accurate carbon budget estimates.

Importantly, chemostasis is almost uniform across solutes derived from silicate-, carbonate-, and sulfate weathering, with only slightly stronger dilutional behavior for solutes from silicate minerals. These observations imply that intense storms and IREs in the steep mountain catchments of Taiwan mobilize a groundwater reservoir of largely uniform composition, strongly buffering water chemistry—even in one of the wettest regions on the planet.