title = "The predominant control of hydroclimatic conditions on carbon
and weathering fluxes at the hillslope scale",
author = "Wen, Hang and Sullivan, Pamela and Billings, Sharon and Ajami,
Hoori and Cueva, Alejandro and Flores, Alejandro and Hirmas,
Daniel and Koop, Aaron and Murenbeeld, Kathryn and Zhang, Xi and
Li, Li",
abstract = "Soil biota generate CO2 that can vertically export to the atmosphere, and dissolved organic and inorganic carbon (DOC and DIC) that can laterally export to streams and accelerate weathering. These processes are regulated by external hydroclimate forcing and internal structures (permeability distribution), the relative influences of which are rarely studied. Understanding these interactions is essential a hydrological extremes intensify in the future. Here we explore the question: How and to what extent do hydrological and permeability distribution conditions regulate soil carbon transformations and chemical weathering? We address the questions using a hillslope reactive transport model constrained by data from the Fitch Forest (Kansas, United States). Numerical experiments were used to mimic hydrological extremes and variable shallow-versus-deep permeability contrasts. Results demonstrate that under dry conditions (0.08 mm/day), long water transit times led to more mineralization of organic carbon (OC) into inorganic carbon (IC) form (>98\%). Of the IC produced, ~ 75\% was emitted upward as CO2 gas and ~ 25\% was exported laterally as DIC into the stream. Wet conditions (8.0 mm/day) resulted in less mineralization (~88\%), more DOC production (~12\%), and more lateral fluxes of IC (~50\% of produced IC). Carbonate precipitated under dry conditions and dissolved under wet conditions as the fast flow rapidly droves the reaction to disequilibrium. The results depict a conceptual hillslope model that prompts four hypotheses for our community to test. H1: Droughts enhance carbon mineralization and vertical upward carbon fluxes, whereas large hydrological events such as storms and flooding enhance subsurface vertical connectivity, reduce transit times, and promote lateral export. H2: The role of weathering as a net carbon sink or source to the atmosphere depends on the interaction between hydrologic flows and lithology: transition from droughts to storms can shift carbonate from a carbon sink (mineral precipitation) to carbon source (dissolution). H3: Permeability contrasts regulate the lateral flow partitioning via shallow flow paths versus deeper groundwater though this alter reaction rates negligibly. H4: Stream chemistry reflect flow paths and can potentially quantify water transit times: solutes enriched in shallow soils have a younger water signature; solutes abundant at depth carry older water signature.",
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