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Understanding the silicate weathering feedback at the catchment scale

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The quantitative relationship between chemical weathering fluxes and climatic variables like temperature and rainfall underlies models of Earth's biogeochemical cycles, planetary habitability, as well as the fate of anthropogenic carbon emissions and associated mitigation efforts. Measuring this relationship, however, has proved challenging because of the myriad non-climatic controls on weathering, difficulties with upscaling theory and laboratory experiments, as well as the limited timescale of modern observations. Here, we address these issues for two test cases: the role of catchment hydrology in setting the influence of rainfall on weathering fluxes and the role of glaciers in modulating weathering fluxes at low temperatures.

The Luquillo Critical Zone Observatory offers a unique opportunity to test the role of hydrology in chemical weathering. Much of the region is thought to operate in the "supply-limited" weathering regime where increases in rainfall are not expected to substantially increase weathering fluxes. With this constraint, we tested different coupled hydrologic and reactive transport models to see what factors are necessary to maintain constant fluxes while increasing rainfall rates. We found that changes in the routing of water through the shallowest portions of the Critical Zone can act as an effective "speed limit" on silicate weathering and help enforce supply limitation.

Iceland's coastal and interior portions had different glacial histories over the last 10,000 years due to the competing effects of local and global climate change. We took advantage of this dichotomy by analyzing lake sediments from two catchments that simultaneously lost and gained glaciers, respectively. Using a new multi-proxy approach to estimate absolute weathering fluxes in the past at the catchment scale, we found a positive correlation between silicate weathering fluxes and the extent of glaciation.