Uncertainty assessment and sampling strategies for global silicate weathering rates

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Chemical weathering of silicate rocks plays an important role in global geochemical cycles by providing nutrients to terrestrial and marine ecosystems and regulating the level of atmospheric CO_2 over geologic timescales. To model the global carbon cycle in the Earth' past, we need to first quantify the current global silicate weathering rate and their uncertainties. Historically, the chemical fluxes are calculated as the product of discharge and concentrations of major elements measured from limited samples. However, recent studies with times-series datasets showed that the use of limited samples with asynchronous discharge could introduce a large uncertainty into the estimates of silicate weathering rates.

In this study, we examined how sampling protocols in individual catchments and incomplete sampling of global rivers could impact the estimates of catchment- and global- scale silicate weathering rates. We analyzed sources of uncertainties in catchment and global silicate weathering rates using globally compiled data that consist of multiple river chemical data and synchronous discharge from GEMS/Water and HYBAM.

Our results showed that uncertainties in catchment-scale silicate weathering rates were due mostly to the variations in discharge and cation fractions from silicate substrates. To calculate unbiased silicate weathering rates, we suggest that at least 10 and preferably ~ 40 temporal chemical data points with synchronous discharge from each river are necessary. For global silicate weathering rate, we found that the main uncertainty came from the extrapolation to the global flux and the model configurations of source differentiation methods. To reduce the uncertainties in the global silicate weathering rates, coverage of synchronous datasets of river chemistry and discharge to rivers from tectonically active regions and volcanic provinces must be extended, and catchment-specific silicate end-members for those rivers must be characterized.