Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23948

Using riverine time series to evaluate enhanced weathering signal lag in the Mississippi watershed

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Enhanced weathering (EW) involves spreading crushed rocks on agricultural fields to increase the speed at which natural rock weathering processes remove CO_2 from the atmosphere. Although models[1] and soil-based quantification approaches[2] suggest EW may be efficient at removing CO_2, many field[3] and mesocosm experiments[4] are lacking a clear signal in the effluent water. The most likely explanation is that dissolved ions interact with the exchangeable pool[5]. However, the exact lag time imposed by such processes is currently not clear[5], and there is also significant uncertainty surrounding the fraction of released cations that is retained in soils in secondary phases or on soil cation exchange sites.

Here, we build on records of lime application and riverine fluxes in the Mississippi River catchment[6] to assess the lag time between lime addition to fields and corresponding changes in time-series river chemistry data. We develop a detailed charge balance framework that considers lime dissolution, addition of strong acids from multiple sources, and cation exchange processes. Preliminary results suggest that it takes ~10-15 years for the ions released during liming to show up in riverine solute data for the Mississippi watershed. Furthermore, depending on assumptions about the interaction between protons from strong acids and cations in the soil exchangeable pool, we estimate that ~60-90 % of the released cations are ultimately transported out of the soil column after 10-15 years. Our analysis also suggests that agricultural liming may act as a CO_2 sink in the Mississippi catchment, in contrast to standard IPCC guidelines for agricultural greenhouse gas emissions. These findings highlight the importance of post-weathering processes for the quantification of carbon dioxide removal from EW and indicate that carbonate-based feedstocks should also be considered for EW deployment.

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