Ground-truthing silicate chemical weathering using machine learning

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Silicate weathering plays a critical role in regulating the climate and habitability of terrestrial planets. A sound framework to predict silicate chemical weathering and to explore what factors drive variations in weathering rates is essential, both to explore Earth system responses during past climate perturbations and to forecast the impact of ongoing and future anthropogenic carbon injections. However, due to the complexity of natural weathering processes, we still, arguably, lack a robust quantitative framework that can be reliably used to predict silicate weathering fluxes on regional scales, and there has been persistent debate about what factors play the strongest roles in shaping the rates of chemical weathering.

Using a machine learning technique, we show that 96% of the amount of variability inherent in silicate weathering fluxes of the watersheds in the continental United States can be explained. Soil moisture, catchment slope, precipitation, temperature, the presence of fine-grained siliciclastic rocks and plants all have a major influence on silicate chemical weathering rates. Further, our developed framework indicates that basalt (mafic rocks) do not play a significant role in controlling the silicate weathering fluxes. By multiplying the exposed land area of each rock type with their relative importance, we arrived at a conclusion that an increase in siliciclastic sediments (e.g., shales) within the weatherable shell through the Cenozoic was a key factor driving cooling over the past 66 million years.