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Improvement to the global silicate weathering model through improved surface erosion calculation

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Silicate weathering is an important sink for the atmospheric CO_2 but there is still large uncertainty in both the observations and numerical modeling of global silicate weaterhing. Silicate weathering is affected by many factors such as climate, tectonic, and biology, making it complex to study. Although the observations provide some local interrelationships between silicate weathering rate and these factors, most of the two-dimensional weathering models perform poorly. Previously, Zuo et al. [1] showed that a popular model [2] substantially overestimated the silicate weathering rate over tropical regions. They postulated that the overestimate in weathering rate was due to the overestimate of surface erosion, based on the observation that these regions were largely coincident with areas where highly leached soils existed. The distribution of such soils were also coincident with that of the dense vegetation, denoted by large leaf area indices. They thus proposed to improve the silicate weathering model by simply reducing the surface erosion where leaf area index is large. An arbitrary expoential relationship between surface erosion and leaf area index was chosen and optimized, and the silicate weathering rates calcuated were significant improved. Here we test the influence of a new surface erosion model on the global silicate weathering model in [1]. This surface erosion model is based on a machine learning method, which predicts erosion from many environmental factors such as surface slope, precipitation, temperature, tectonic activity, vegetation etc., thus removing the arbitray assumption of [1] that dense vegetation would weaken the tropical erosion substantially. The silicate weathering rates calculated based on this new erosion model also show a significant improvement in comparison with river basin observations. This new silicate weathering model should thus be preferred because its surface erosion is calculated in a more comprehensive way.

[1] Zuo et al (2024), A revised model for silicate weathering considering the influence of vegetation cover on erosion rate, Geoscientific Model Development, 17

[2] Park et al (2020), Emergence of the Southeast Asian islands as a driver for Neogene cooling, PNAS, 117.