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Neogene seawater δ7Li and 10Be/9Be indicate increasing land surface reactivity caused cooling since the middle Miocene

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The cause of late Neogene $p\mathrm{CO}_2$ decline and ensuing cooling is frequently attributed to increased erosion and attendant increases in silicate weathering. However, observations of increasing erosion are frequently attributed to temporal and spatial averaging biases; in turn, the magnitude of the weathering increase—and even its existence—remains equally controversial, with both carbon cycle models and marine ^{10}Be/^{9}Be suggestive of a minimal change in weathering. Here, we use a parsimonious carbon cycle model that tracks two, new weathering-sensitive isotopic tracers (δ^7Li and ^{10}Be/^{9}Be) to solve for the erosional and volcanic forcing required to explain cooling since the middle Miocene (16 Ma). We show that an increase in land surface reactivity—sustained by an increase in erosion—is necessary to simultaneously explain the late Cenozoic records of seawater δ^7Li, seawater ^{10}Be/^{9}Be, and atmospheric $p\mathrm{CO}_2$. Decreases in the input fluxes of carbon alone, through volcanism, are unable to match these records. An increase in erosion drives a global decline in the average intensity to which silicate rocks have been weathered even as the global silicate weathering flux remains constant. The result is a more reactive Earth surface, which produces the same weathering flux as in the middle Miocene, but at a lower atmospheric $p\mathrm{CO}_2$ and with a greater erosional flux. Thus, long-term cooling during the late Cenozoic reflects a change in how the Earth surface partitions the products of denudation into weathering and erosion.