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Stable glacial–interglacial continental weathering fluxes sustained by glacial landscape weathering

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Continental weathering plays a pivotal role in regulating atmospheric CO2 levels, thereby exerting a profound influence on global climate. To gain insights into future climate change, it is crucial to identify variations in continental weathering across Quaternary glacial-interglacial cycles, which are characterized by significant CO2 fluctuations. However, the glacial-interglacial variation in the flux of continental weathering to the ocean remains poorly understood, as available marine and terrestrial data present conflicting findings. In this study, we reconstruct the continental weathering history over the past 800,000 years for High-Mountain Asia, a region crucial for understanding the weathering response to mountain glacier activity across glacial-interglacial cycles. Our results indicate that the $^{87}Sr/^{86}Sr$ ratio in lake water, which serves as an indicator of catchment chemical weathering, increased during cold intervals (such as glacials and cold episodes within interglacials) and decreased during warm stages (i.e., interglacials). Conversely, the $^{87}Sr/^{86}Sr$ ratio in the nearby Chinese Loess Plateau, a non-glaciated region where loess reflects the composition of the upper continental crust, exhibited lower values during glacials and higher values during interglacials. A straightforward upscaling simulation, based on our observations of contrasting weathering dynamics in glaciated and non-glaciated regions, suggests that the Sr flux and 87Sr/86Sr ratios of global river waters flowing into the ocean effectively balance out during glacial-interglacial cycles. Glacier landscape weathering emerges as a novel mechanism that counterbalances weathering variations within continents, potentially restricting the variability of continental weathering flux to a narrow range during these cycles.