Tectonic controls on the long-term carbon isotope mass balance

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The long-term, steady-state marine carbon isotope record reflects changes to the proportional burial rate of organic carbon relative to total carbon on a global scale. For this reason, times of high $\delta^{13}C$ are conventionally interpreted to be oxygenation events caused by excess organic burial. Here we show that the carbon isotope mass balance is also significantly affected by tectonic uplift and erosion via changes to the inorganic carbon cycle that are independent of changes to the isotopic composition of carbon input. This view is supported by inverse covariance between $\delta^{13}C$ and a range of uplift proxies, including seawater $^{87}Sr/^{86}Sr$, which demonstrates how erosional forcing of carbonate weathering outweighs that of organic burial on geological timescales. A model of the long-term carbon cycle shows that increases in $\delta^{13}C$ need not be associated with increased organic burial and that alternative tectonic drivers (erosion, outgassing) provide testable and plausible explanations for sustained deviations from the long-term $\delta^{13}C$ mean. Our approach emphasizes the commonly overlooked difference between how net and gross carbon fluxes affect the long-term carbon isotope mass balance, and may lead to reassessment of the role that the $\delta^{13}C$ record plays in reconstructing the oxygenation of earth's surface environment.