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Sulfur isotope variability of sulfate within the modern ocean

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While the S isotope composition of seawater sulfate is generally considered to be homogenous due to the relatively long residence time of sulfate compared to S turnover during global oceanic mixing, minor variations in isotopic values of seawater sulfate have been reported that suggest systematic differences, particularly related to latitude, freshwater input, oxygen flux, and redox conditions. To further investigate these trends, we determined the triple S isotope compositions (i.e., ratios of $^{34}S/^{32}S$ and $^{33}S/^{32}S$) of seawater samples spanning different water masses across the South Pacific Ocean. Contextualized within pre-existing isotopic measurements of seawater sulfate, our results indicate that seawater S isotope compositions can display minor, but nevertheless consistent and statistically significant, variances from the conventionally upheld norm based not only on previously suggested latitude and O_2 concentration, but also on water mass, hydrothermal influence, and ice-melt influence. Integrating our data within a global framework, we report an overall seawater sulfate S isotope $\delta^{34}S$ range from 18.8‰ to 22.4‰, while $\Delta^{33}S$ values range from 0.011‰ to 0.057‰. Assimilated, while our data are consistent with previously accepted S isotope composition averages of seawater sulfate, minor deviations apparent in our dataset, coupled with those apparent within the literature, imply global isotopic variability that occurs on shorter timescales than global oceanic mixing. Moving forward, we suggest that non-ubiquitous natural deviations in modern and ancient seawater S isotope ratios should be considered when constructing S isotope models designed to elucidate the operation of the modern oceanic S cycle as well as its ancient counterpart.