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Assessing the accuracy of $\delta^{18}O_{sw}$ estimates from corals: lessons from simple Monte Carlo simulations

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Paired measurements of δ^{18}O and Sr/Ca in coral aragonite are routinely used for deriving estimates of $\delta^{18}O_{sw}$ and, by extension, sea surface salinity variations over the past centuries. However, in practice, the accuracy (or the error) of these estimates is often difficult to assess.

Here, we use simulated proxy data and Monte-Carlo simulations to investigate the accuracy of $\delta^{18}O_{sw}$ estimates from paired coral δ^{18}O and Sr/Ca measurements. First, we estimate expected values of coral Sr/Ca and δ^{18}O from instrumental or reanalysis data of sea surface temperature (SST) and sea surface salinity (SSS). We then add the typical analytical errors onto the expected Sr/Ca (δ^{18}O) data as random numbers and compute $\delta^{18}O_{sw+error}$ from the noisy proxy data for a 1000 sample Monte Carlo. From this simple Monte Carlo simulation, the range of correlation coefficients between $\delta^{18}O_{sw+error}$ and expected $\delta^{18}O_{sw}$ is estimated. As expected, we find that this range mainly depends on the magnitude of the actual SSS variations at a given site, as well as on the slope of the $\delta^{18}O_{sw}$-SSS relationship.

A comparison with real coral-based $\delta^{18}O_{sw}$ reconstructions from multiple sites indicates that correlations between reconstructed $\delta^{18}O_{sw}$ and instrumental SSS fall within the range of correlation coefficients predicted based on our Monte-Carlo simulation.

Thus, our simple simulation exercise may help to assess the feasibility of $\delta^{18}O_{sw}$ and salinity reconstructions from corals in different climatic settings, provided that (i) some instrumental data of $\delta^{18}O_{sw}$ and/or SSS is available, and (ii) the slope of the $\delta^{18}O_{sw}$-SSS relationship is known.