Middle Holocene (4.6 ka) hydroclimatic variations from monthly geochemical records in a fossil coral at Ishigaki Island.

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Observing long-term variations and elucidating the mechanisms of hydroclimate in the Ryukyu regions are essential to understanding the East Asian climate and its teleconnections to other hydroclimatic systems, such as the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Although geochemical proxies in coral skeletons enable obtaining climatic components such as sea surface temperature (SST) in monthly resolution extending beyond the instrumental records, the traditional coral chronology of linear interpolation, implemented to access proxy values between summer and winter anchor points, eradicates the intra-seasonal variabilities and creates frequency modulation artifacts, which possibly leads to misinterpretation. As an alternative approach, this study uses the Dynamic Time Warping (DTW) algorithm to convert depth-sampling datasets into time series. DTW-derived outputs, processed further, could demonstrate monthly coral growth models that can be applied to obtain time series of palaeo-corals, 4.6 ka in this study, under a particular assumption of a temporally unchanged growth rate without interpolation. Analyses of modern coral data established strong, positively correlated calibration lines between Sr/Ca ($\delta^{18}O$) and SST (r = -0.97; -0.91), yet no correlation between $\delta^{18}O_{sw}$ and salinity (r = 0.13). Furthermore, compared to the modern coral data, the fossil records at 4.6 ka illustrate the positive (negative) excursions of Sr/Ca ($\Delta\delta^{18}O_{sw}$) by 0.2-0.3 mmol/mol (0.2-0.6 per mil) in all, summer, and winter. The fossil Sr/Ca and $\Delta\delta^{18}O_{sw}$ records illustrate both the stronger seasonality and larger interannual variations in summer and winter. Overall, the lower $\Delta\delta^{18}O_{sw}$ and higher Sr/Ca ratios, coupled with greater seasonal irregularity at 4.6 ka during the La Niña-like condition, indicate the consequences of synchronous weakening of the Kuroshio Current rather than atmospheric monsoon variability. This oceanographic alteration at 4.6 ka effectively reduced meridional energy transport, shifted the current axis southward and made it more sinuous, and collapsed the saline barrier and climate buffer. Our results suggest that, while the SST seasonality is often referred to the East Asian Monsoon strength, in Ishigaki Island at 4.6 ka, this relationship was obscured during periods of Kuroshio variability.

Keywords: Kuroshio current, Palaeoclimate records, East Asian climate, Marine carbonate geochemistry, Mid-Late Holocene, Temperature and Salinity

