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Change of the ENSO-related $\delta^{18}O$–SST correlation from coral skeletons in northern South China Sea: A possible influence from the Kuroshio Current

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ABSTRACT

Chemical proxies are useful analogs for reconstructing physical properties of sea water, such as sea surface temperature (SST) and sea surface salinity (SSS). Time series of these inferred properties would allow for reconstructions of past El Niño–Southern Oscillation (ENSO) events, where no instrumental records exist. In this study, a monthly oxygen isotope record from a *Porites* coral is used to explain how past ENSO events are recorded in the coral skeletons. The sample covers a 12 year period and was collected from Nanwan Bay, Taiwan. During El Niño events the coral skeleton is shown to produce a $\delta^{18}O$–SST correlation with a slope of $-0.12 \pm 0.04‰\ °C^{-1}$. During other times, this value is significantly different, with a slope of $-0.21 \pm 0.04‰\ °C^{-1}$. Coral that grew during El Niño summers have $\delta^{18}O$ values which are enriched by ~0.2‰, relative to other times. A possible mechanism to explain this difference may be enhanced penetration of Kuroshio Current waters into the South China Sea during summer. The observed contrast in the correlation of $\delta^{18}O$–SST variability in this sample supports the influence of El Niño in eastern Asia.

1. Introduction

The El Niño–Southern-Oscillation (ENSO) phenomenon is well-known for its influence on regional climate and human livelihood, especially in the western Pacific Warm Pool (WPWP) and the west coast of South America. The effect of ENSO events on low-latitudes of the Pacific has been widely studied using coral records (Kuhnert et al., 1999; Le Bec et al., 2000; Cobb et al., 2003; Sun et al., 2005). During an El Niño episode, the WPWP shifts eastward and causes drought in the western Pacific regime (Morimoto et al., 2002; Cobb et al., 2003; Risk et al., 2003). Xu et al. (2004) examined the correlation between the Southern Oscillation Index (SOI) and precipitation records of 30 basins in Southeast Asia and the Pacific. They concluded that El Niño events significantly reduce precipitation in the region south of 20°N. In sub-tropical zones however, the climatic impact of ENSO cycles and the interaction between ENSO and the Asian Monsoon are still unclear. Taiwan lies on the northwestern fringe of the WPWP, and is variably influenced by both ENSO and the East Asian monsoon. East of Taiwan, the Kuroshio Current (KC), and North Equatorial Current (NEC) are the dominant surface currents and drive the heat engine in the western Pacific (Fig. 1a). Based on satellite observations and numerical modeling, these currents normally enter the northern South China Sea (NSCS) and East China Sea off the southern and northern coasts of Taiwan respectively. These currents are affected by ENSO events and exhibit seasonal variability (Kim et al., 2004; Nakamura et al., 2006; Gan et al., 2006; Yuan et al., 2006). The route and intensity of the KC control surface circulation in the NSCS area.

Corals are ideal for paleoclimatic research because of their wide distribution in tropical to sub-tropical oceans and potential geochemical tracers, such as stable isotopes and trace metals (e.g., Beck et al., 1992; Shen et al., 1996, 2005; Gagan et al., 1998, 2000; McCulloch et al., 1999; Alibert et al., 2003; Reuer et al., 2003; Wyndham et al., 2004; Sun et al., 2005). Paired Sr/Ca and $\delta^{18}O$ measurements on coral skeletons produce reliable proxy records for both sea SST and SSS (e.g., Urban et al., 2000; Tudhope et al., 2001; Cobb et al., 2003; Corrège, 2006; Abram et al., 2007). But in the early 1990s, $\delta^{18}O$ was considered to be dominated by SST, and suitable as a direct SST proxy in some tropical and sub-tropical regions. One reason came from the inconvenient determination of Sr/Ca ratio till the popularity of Q-ICP-MS and SF-ICP-MS in late 90s. The other was the distinct thermo-seasonality which would make the SST-induced $\delta^{18}O$ prevailed in the coral skeletons. Based on the assumption of a constant annual mean value for $\delta^{18}O_{sw}$, the first-order equation of $\delta^{18}O_{coral}$–SST relationship can be expressed as:

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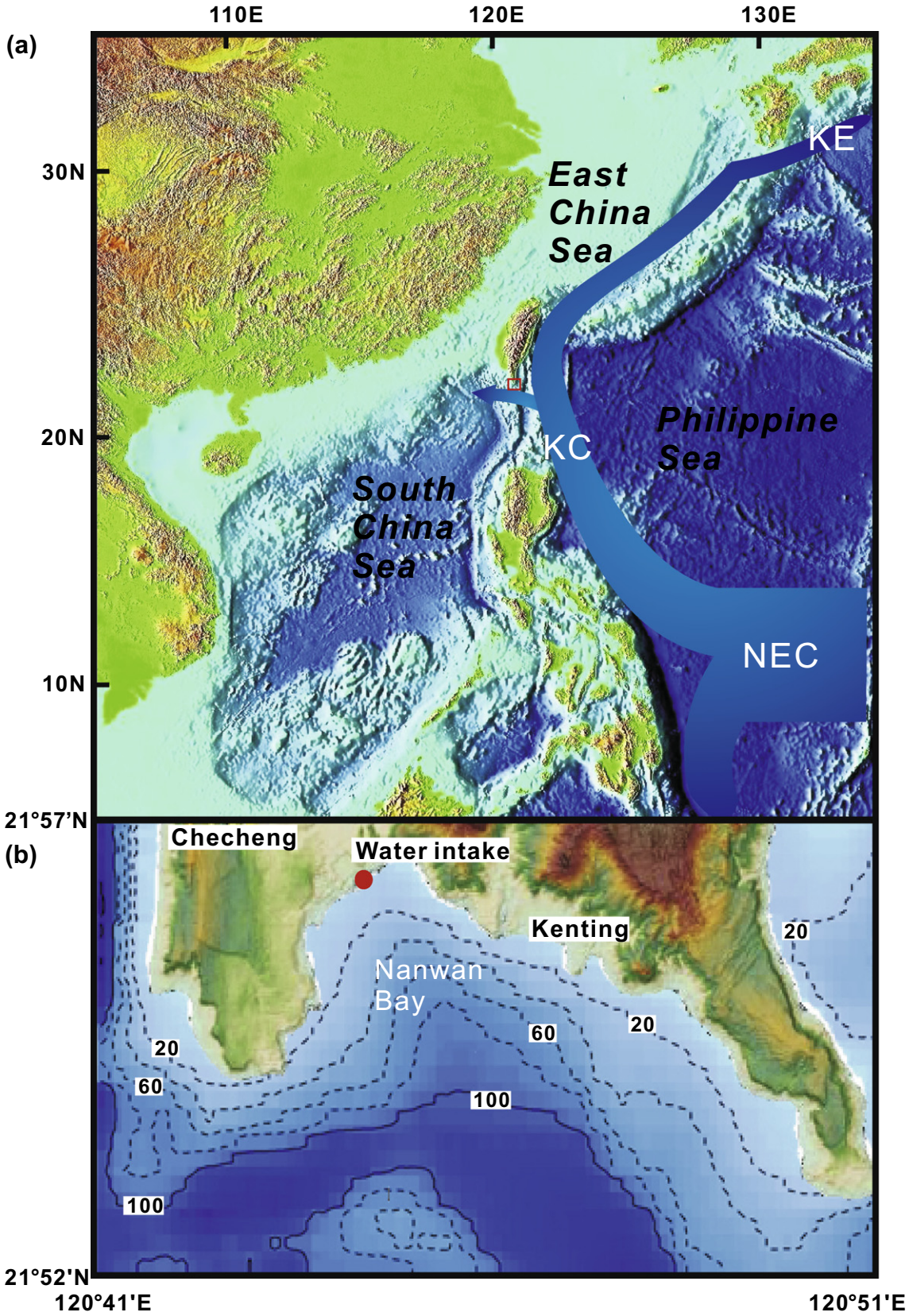

Fig. 1. (a) Geographical map of East Asia and route of the Kuroshio Current (KC, blue shadowed). The main stream of KC goes northward along east coast of Taiwan, but in the winter, a westward branch may move across the 121E longitude and penetrate into the north SCS through the Luzon Strait (Qu and Lukas, 2003; Kim et al., 2004; Qu et al., 2004). Some evidence shows the possibly ENSO-induced inter-annual pathway variations in summer season. NEC: North Equatorial Current. KE: Kuroshio Extension. (b) Geographical and bathymetrical map of southern tip of Taiwan. We collected a 12-year-old living *P. lutea* coral from the water intake pond of the Third Nuclear Power Plant at the west edge of Nanwan Bay on 1st October 2003 (shown as filled red circle). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)