Pleistocene Seawater $\delta^{18}O$ reconstructions from the Indian and East Asian Monsoon Regions

*Steven C Clemens[1], Masanobu Yamamoto[2]

1. Brown University, 2. Hokkaido University

The study of orbital-scale climate change during the late Pleistocene is unique in that the signal-to-noise ratio is large, the external forcing (insolation) is known, and the critical internal forcings (greenhouse gases and terrestrial ice volume) are well constrained. As such, it should be possible to assess the underlying mechanisms driving climate change at this time scale, as well as the relative sensitivity to these forcing mechanisms.

We present three reconstructions of local seawater $\delta^{18}O$, including previously published records from the East China Sea (U1429)[*S. C. Clemens et al.*, 2018], the Andaman Sea (NGHP 17)[*Gebregiorgis et al.*, 2018], and our new work from the northeast Indian Margin, Bay of Bengal (U1446). Local seawater $\delta^{18}O$ is based on removal of the SST and global seawater $\delta^{18}O$ from planktonic foraminifer $\delta^{18}O$ and reflects changes in surface salinity driven by rainfall and runoff from surrounding catchment basins. This proxy offers an independent reconstruction for comparison to speleothem $\delta^{18}O$ and other proxies in order to assess driving mechanisms and the extent to which the Indian and East Asian subsystems covary with one another.

In the northern East China Sea, *G. ruber* $\delta^{18}O$ has the same precession- and millennial-scale structure as the onshore speleothem $\delta^{18}O$ record from the Yangtze River Valley[*Cheng et al.*, 2016]. However, after removing the temperature and global seawater $\delta^{18}O$ signals, the offshore seawater $\delta^{18}O$ has almost no precession-scale (23 kyr) variance)[*S. C. Clemens et al.*, 2018]. This result contrasts with the speleothem record, which is almost exclusively dominated by precession-scale variance, and argues against external insolation as the primary driver of East Asian monsoon rainfall in the Yangtze River Valley region.

The Andaman Sea record monitors direct rainfall and runoff from the Irrawaddy and Salween catchment basins. The precession-band timing of low seawater $\delta^{18}O$ (increased rainfall, low mixed-layer salinity) indicates that strong monsoonal rainfall lags maximum northern hemisphere insolation by ~9 kyrs at the precession band[*Gebregiorgis et al.*, 2018]. Our new Indian Margin record resides within the low-salinity East India Coastal Current fed by runoff from the Ganges-Brahmaputra complex, the Mahanadi Basin, and direct rainfall. The Indian Margin seawater $\delta^{18}O$ reconstruction also demonstrates this large lag. The lag in both these records agrees with that of the summer-season (southwest) monsoon wind strength records from the NW Arabian Sea[*S.C. Clemens and Prell*, 2003; *S.C. Clemens et al.*, 1991].

This precession-band timing (lagging minimum precession by 7-9 kyrs) precludes insolation as a direct forcing for Indian monsoon rainfall and wind strength, pointing instead to decreased high-latitude ice volume, increased greenhouse gasses, and latent heat export from the southern hemisphere as the primary drivers of monsoon circulation at these time scales[*S.C. Clemens and Prell*, 2003].

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