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Late Miocene surface ocean properties in the eastern equatorial Indian Ocean: monsoon and global climate drivers

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Palaeoceanography of the equatorial Indian Ocean during the late Miocene

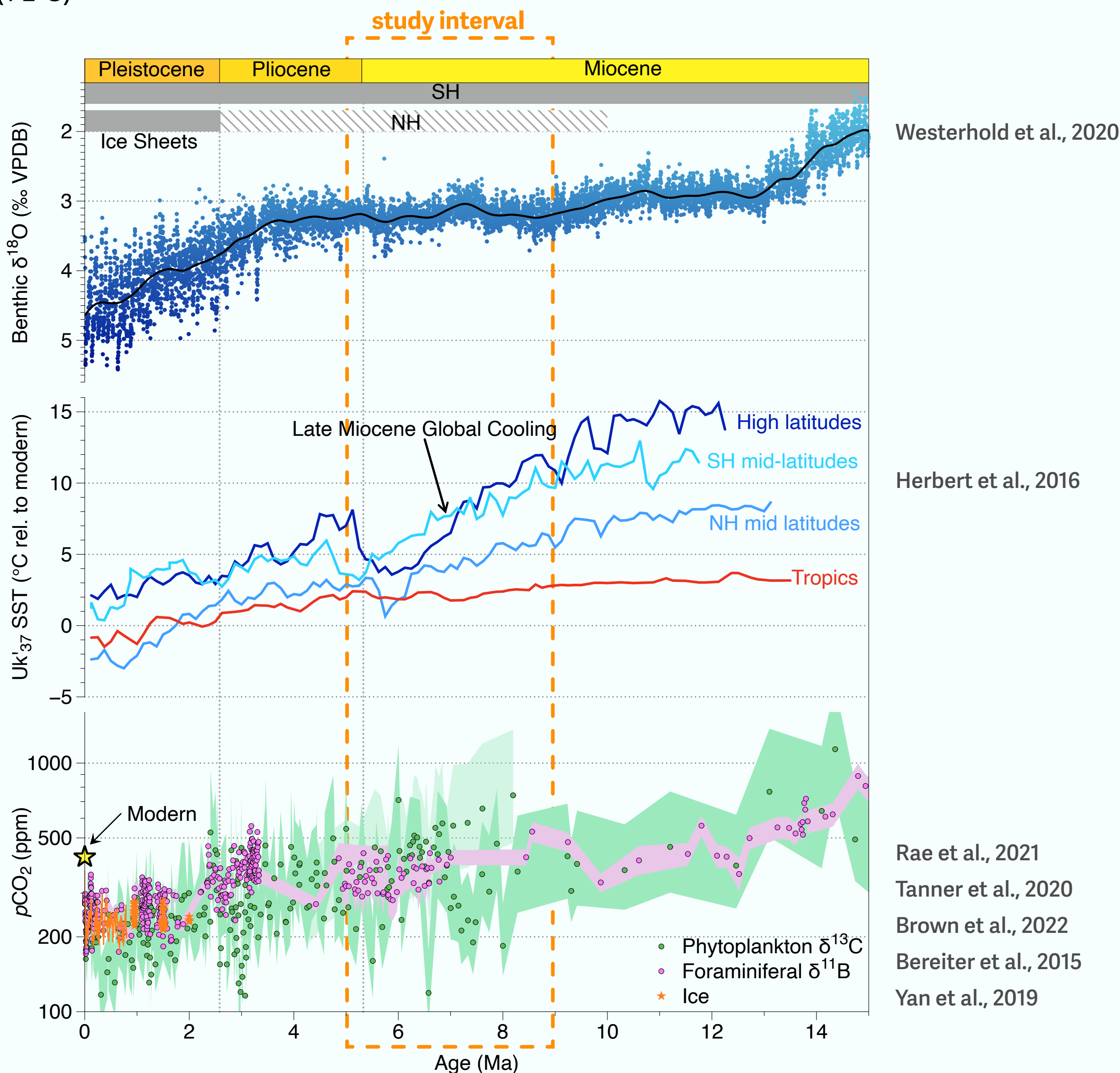


Clara T. Bolton¹ (bolton@cerege.fr), C. Martinot¹, K. Tachikawa¹, A.-C. Sarr^{1,2}, L. Vidal¹, E.J. Rohling³, K. Grant³, G. Marino⁴, Y. Donnadieu¹, C. Sonzogni¹, M. Garcia¹

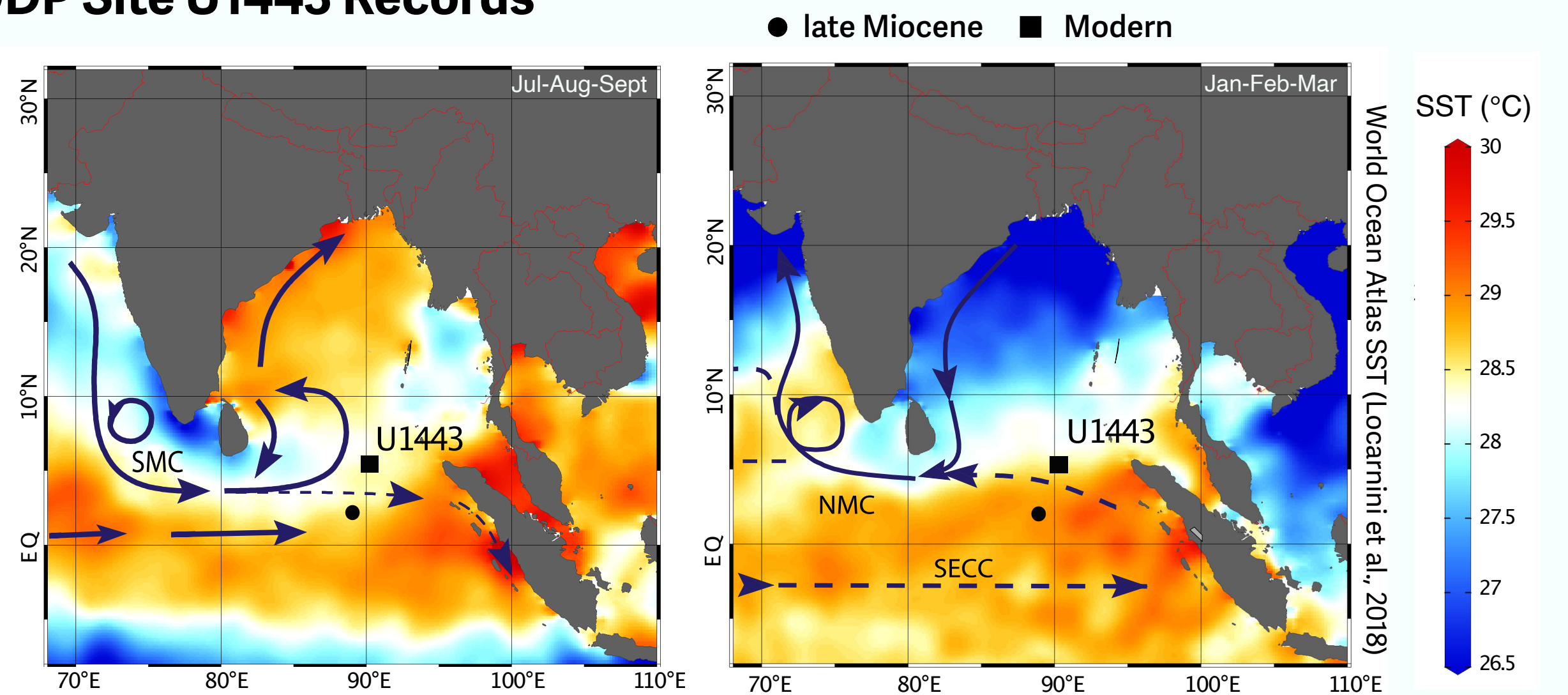
1. CEREGE, Aix-en-Provence, France
2. ISTERRE - Grenoble Alpes University, France
3. Australian National University, Canberra, Australia
4. Universidade de Vigo, Vigo, Spain

Rationale

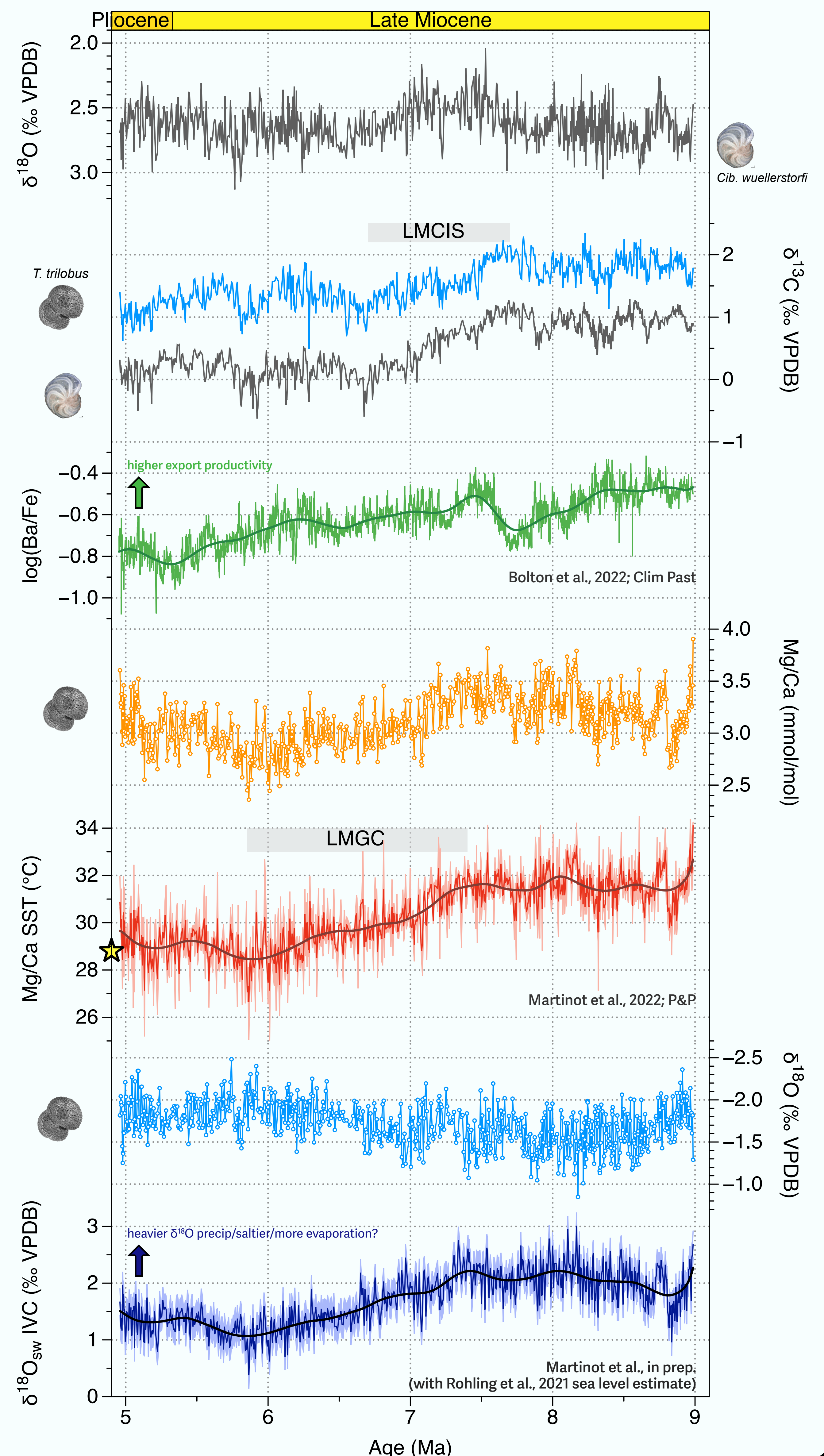
During the late Miocene (~11-5 Ma), pCO₂ may have been 1-3 x pre-industrial values, and mean global temperatures were ~3-4°C higher than today, with reduced latitudinal gradients. Major ecosystem changes during this time are consistent with decreasing temperatures and pCO₂, yet proxy evidence for these physical climate changes remains sparse because few continuous, high-resolution paleoclimate records cover this interval. Major (5-10°C) late Miocene cooling was previously revealed for the mid- and high-latitudes based on the alkenone SST proxy, however tropical SST records suggest only minor cooling (1-2°C)



IODP Site U1443 Records



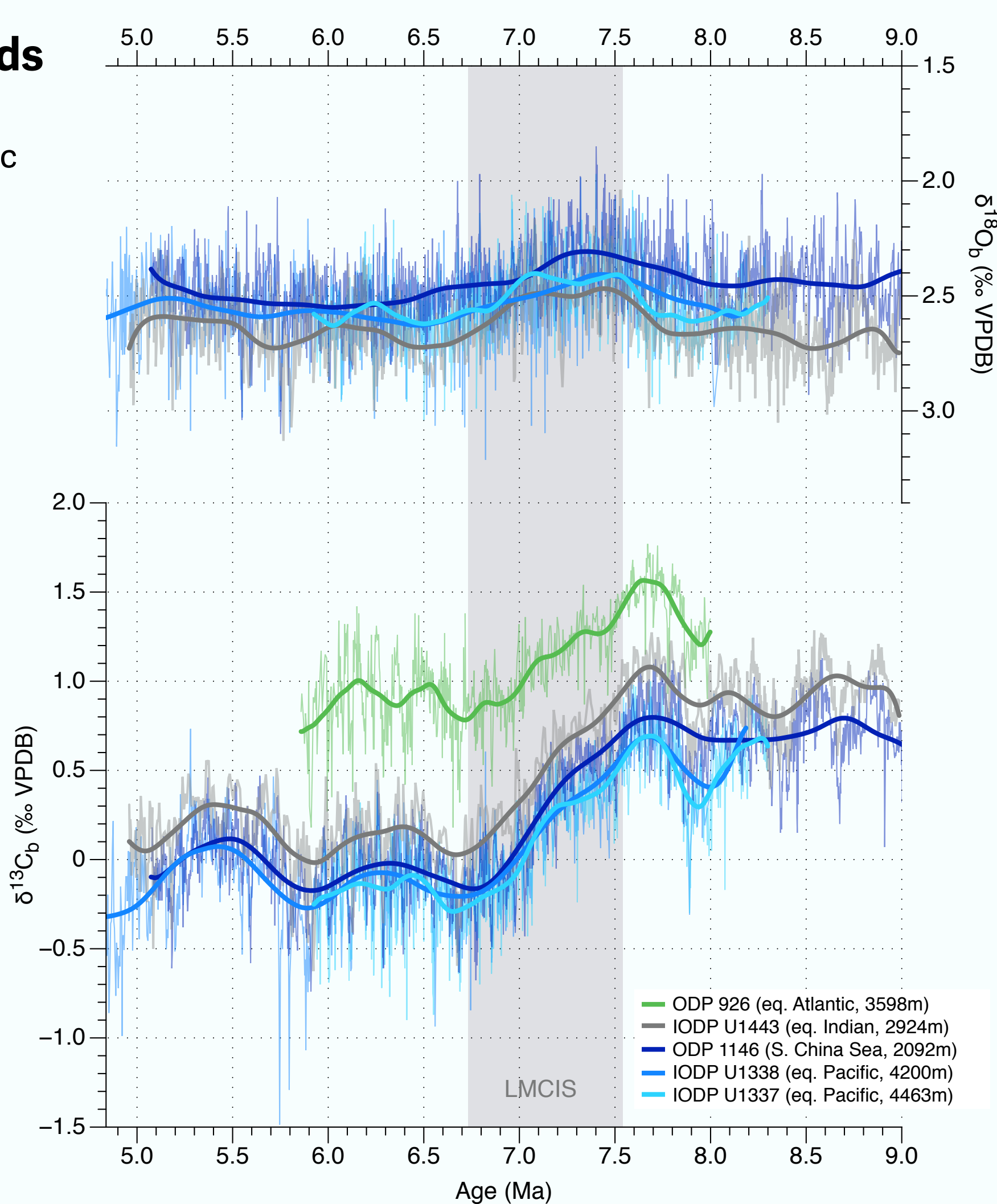
Here, we present new records of surface ocean variability based on planktic foraminiferal geochemistry (Mg/Ca and δ¹⁸O) and X-ray fluorescence (XRF) core-scanning from IODP Site U1443, spanning 9 to 5 Ma. These records, underpinned by a new orbitally tuned chronology, reveal secular and orbital-scale trends in SST, δ¹⁸O_{sw}, and export productivity that are influenced by global climate trends and the South Asian monsoon.



Benthic Isotope Records

- First orbital-resolution benthic isotope record from the deep Indian Ocean
- Independent astronomically-tuned records show good agreement
- Constant offset in δ¹⁸O and δ¹³C between deep Indian Ocean and Pacific Ocean records

Drury et al., 2016, 2018 (U1338)
 Drury et al., 2017 (U1337, 926)
 Shackleton & Hall, 1997 (926)
 Zeeden et al., 2013 (926)
 Holbourn et al., 2018 (1146)
 Bolton et al., 2022; Clim Past (U1443)

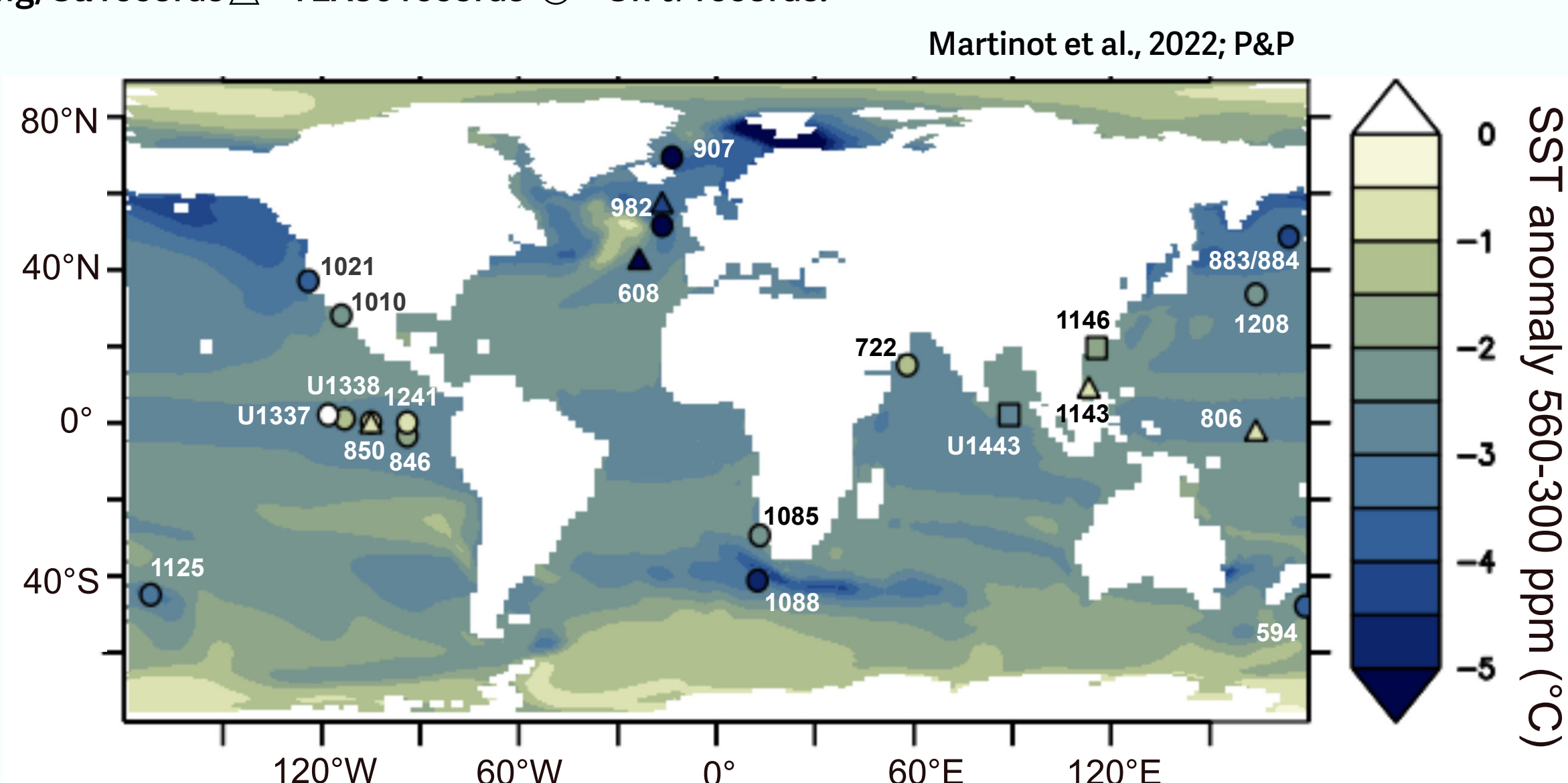


Amplitude of late Miocene Global Cooling

Colour scale shows SST anomaly from late Miocene 560ppm simulation minus late Miocene 300 ppm simulation in IPSL-CM5A2 (amplitude of modeled late Miocene cooling that best fits with proxy-derived SSTs).

Amplitude of SST cooling based on site-specific proxy records (colour within symbols), calculated from averaged recalculated SSTs at 8 ± 0.5 Ma minus 6 ± 0.5 Ma.

□ = Mg/Ca records △ = TEX86 records ○ = UK'37 records.



- Tropical late Miocene cooling at Site U1443 >3°C
- New model simulations suggest a pCO₂ decrease from 560 to 300 ppm could account for most of this cooling
- No late Miocene intensification of South Asian monsoon winds in the equatorial sector of the Indian Ocean
- Strong eccentricity-modulated precession-band productivity variations throughout
- SST variations become more sensitive to obliquity after the onset of cooling
- Local δ¹⁸O_{sw} strongly coupled to SST on long and orbital timescales