Oxygen isotopes of individual planktic foraminifers reveal Pliocene-Pleistocene change of summer surface stratification in the northern South China Sea

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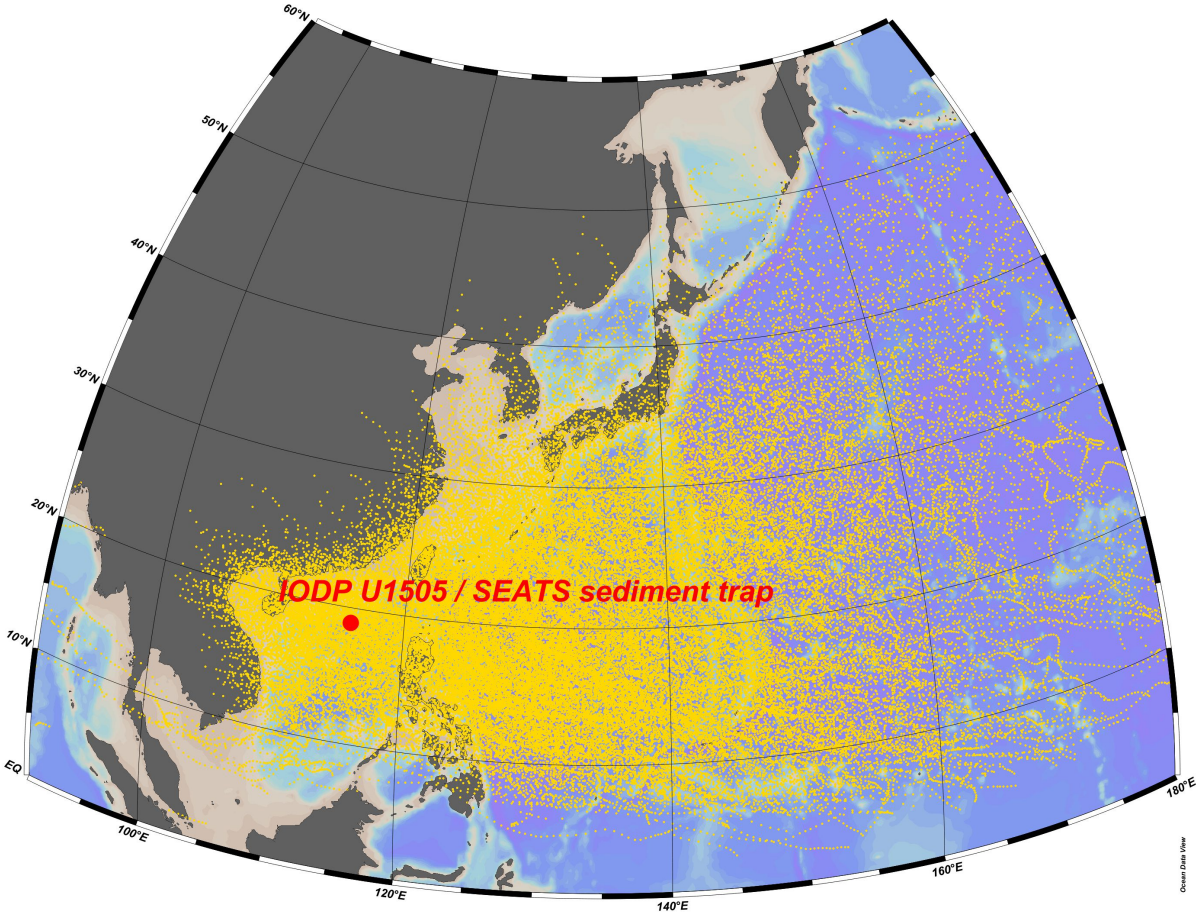
Introduction

- Most paleoceanographic studies using planktic foraminifera focus on annual means, but seasonal signals hidden within the analyses of lumped specimens could be very valuable.
- Surface ocean feedbacks on climate change may be more significant in the seasonal realm than annual mean in the northern South China Sea, a region being strongly affected by seasonal processes like typhoon.
- Here we use oxygen isotope measurements on individual specimens of planktic foraminifera to reconstruct Pliocene-Pleistocene summer surface ocean stratification in this region and infer the typhoon strength in the Pliocene.

Site location

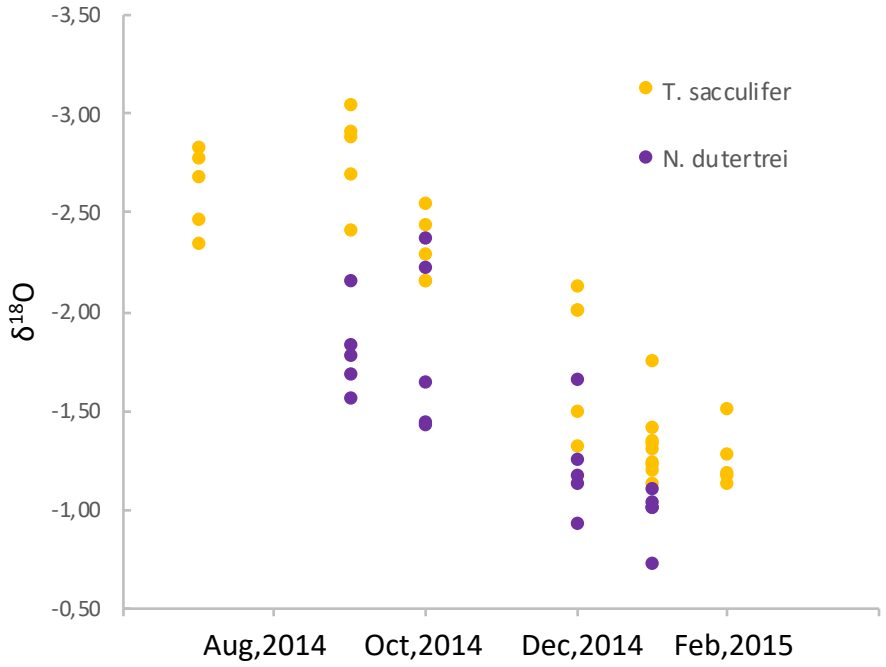


Yellow dots represent the tracks of typhoons and tropical storms from 1945 to 2010 (each dot representing the center location of a typhoon or tropical storm every three hour). Data from Knapp et al. (2010).

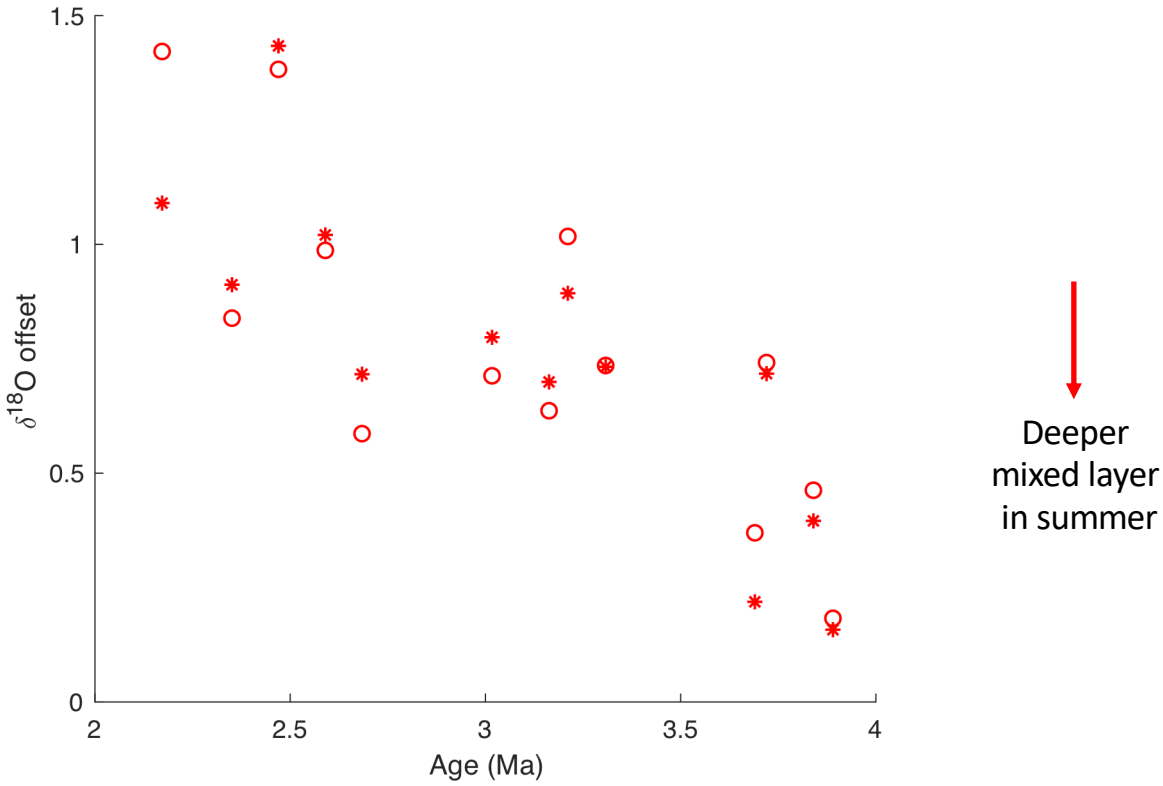
Sediment trap data

- The minimum $\delta^{18}O$ of individual mixed layer-dwelling forams from a sediment sample records the mixed layer signal in the warm season (while the meaning of the maximum $\delta^{18}O$ can be equivocal due to deeper calcification; Billups and Spero, 1996).
- Sediment trap data from the SEATS station suggest that the seasonal signal dominates the data in the northern South China Sea. The minimum $\delta^{18}O$ of *Trilobatus sacculifer* and *Neogloboquadrina dutertrei* represent the mixed layer and the upper DCM (deep chlorophyll maximum zone), respectively, in summer-early autumn (typhoon season).

Individual foram data from sediment traps at the SEATS Station (more data to come)



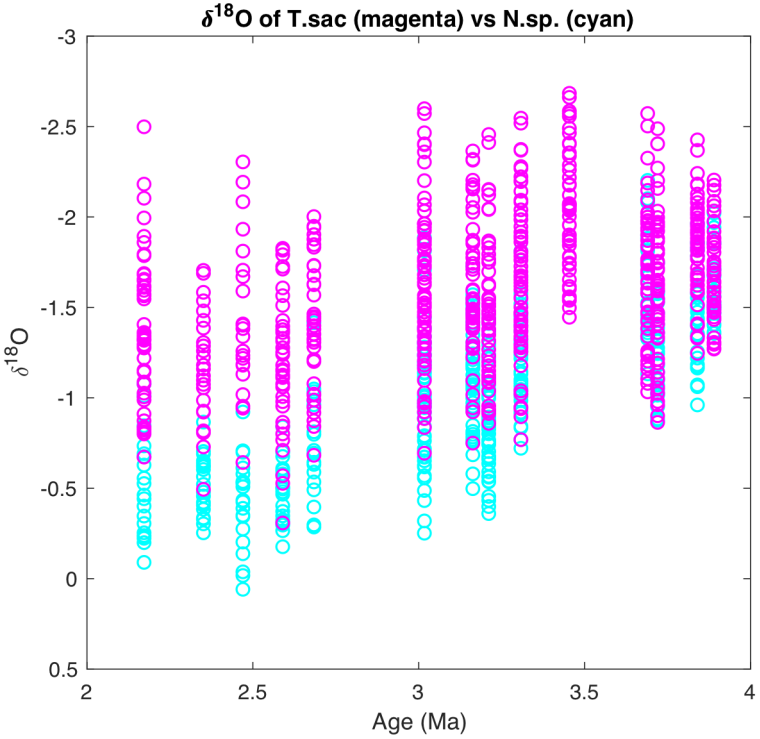
Sediment core data

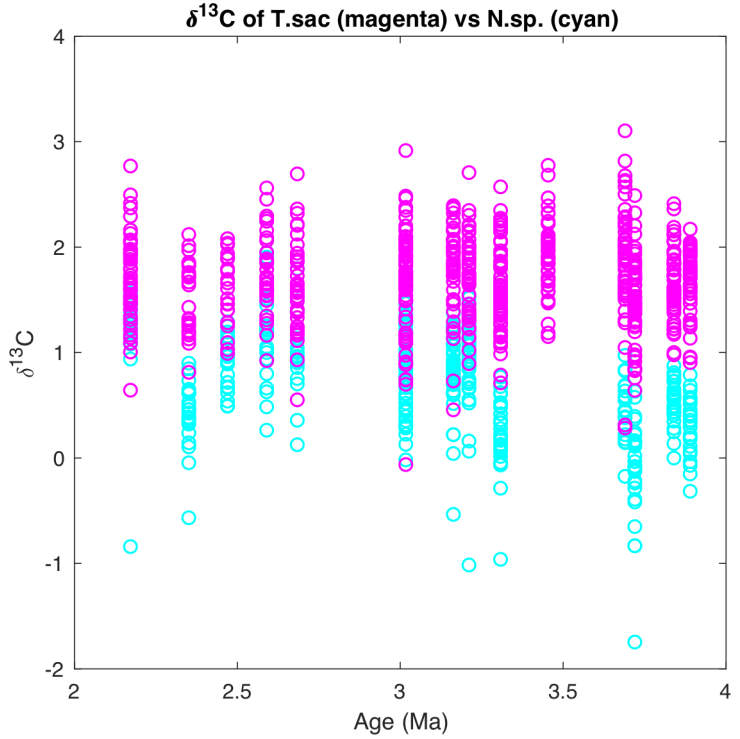


Offset between *Neogloboquadrina sp.* (*N. dutertrei/N. humerosa*, no species offset; Cannariato and Ravelo, 1997) and *T. sacculifer* $\delta^{18}O$ minimum (*N. sp* minus *T.sac;* Outliers already excluded using the 1.5 interquartile range criterion to minimize the influences of extreme cases, bioturbation, etc.).
Circles: calculated with the strict $\delta^{18}O$ min; Stars: calculated with the mean of the lightest 10% $\delta^{18}O$.

Sediment core data

The smaller $\delta^{18}O$_min offset was not caused by the vertical approaching of their habitat depths in the Pliocene, as suggested by ^{13}C data.

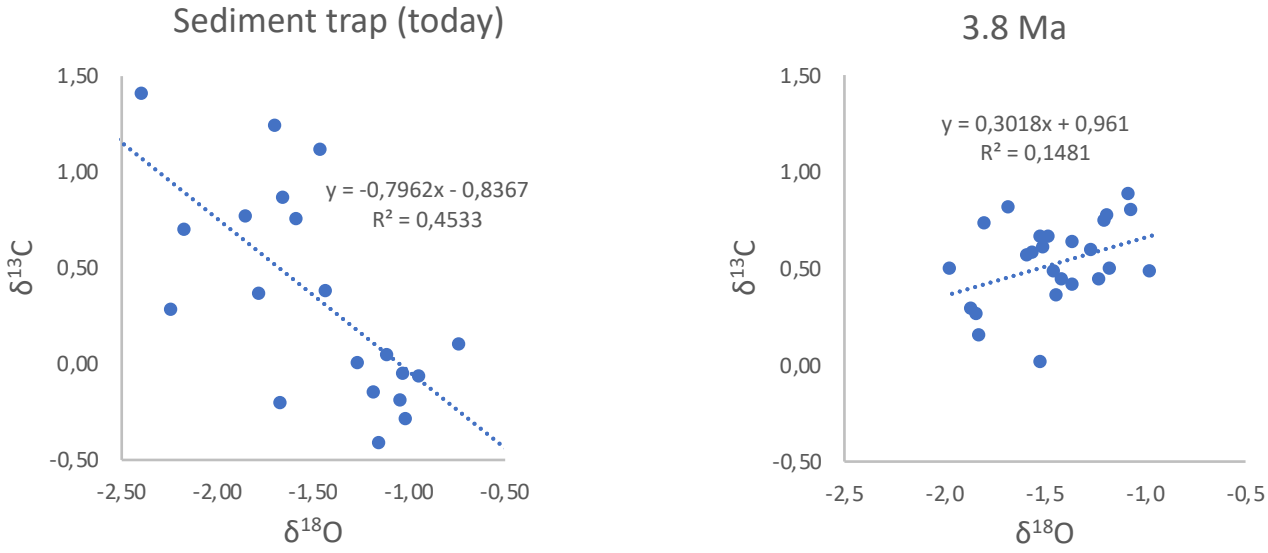




Data of individual foram specimens from U1505

Paleoclimatic implications

While permanent thermocline is set by climate mean states such as the meridional SST gradient, summer thermocline and mixed layer depths at our site are dominated by seasonal processes. The most plausible cause for the deeper summer mixed layer in the Pliocene is stronger mixing by tropical cyclones, consistent with some modeling studies (e.g., Korty et al., 2008; Fedorov et al., 2010). The enhanced mixing also agrees with the change of *Neogloboquadrina* ^{13}C-^{18}O relationship which suggests that seasonality was weaker and productivity was higher in summer during the Pliocene, as opposed to winter today (consistent with a weaker Pliocene winter monsoon; e.g., Li et al., 2004).



Data of individual *N. dutertrei/humerosa* specimens

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