Primary productivity dynamics in the northeastern Bay of Bengal over the last 26,000 years

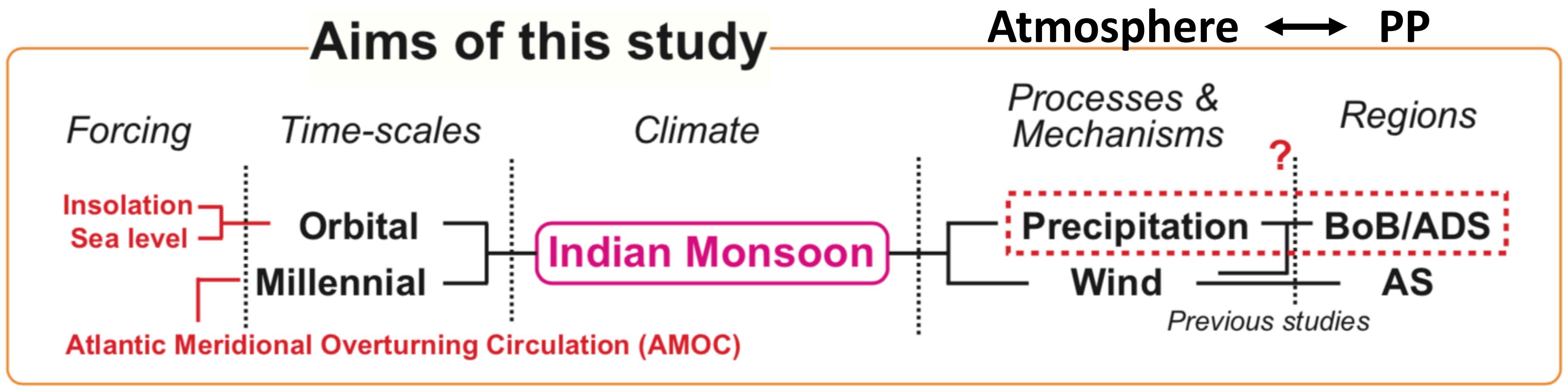
Xinquan Zhou[1]

Stéphanie Duchamp-Alphonse[1], Masa Kageyama[2], Franck Bassinot[2], Luc Beaufort[3], Christophe Colin[1]

[1]Université Paris-Saclay, Géosciences Paris Sud, UMR 8148, CNRS, Orsay, France
[2]Laboratoire des Sciences du Climat et de l'Environnement, UMR 8112, CEA/CNRS/UVSQ, Université Paris-Saclay, Centre CEA-Saclay, Gif-sur-Yvette, France
[3]Centre de Recherche et d'Enseignement de Géosciences de l'Environnement, UMR 7330, CNRS/IRD/Aix-Marseille Université, Aix-en-Provence, France

Introduction

Primary productivity (PP) dynamics in the past is not well studied in the northeastern Indian Ocean i.e. the Bay of Bengal (BoB) and the Andaman Sea (ADS), compared to the northwestern Indian Ocean i.e. the Arabian Sea (AS). The surface seawater of these two parts are both under the influence of the Indian Monsoon, but differences in local hydrologocal and ecological settings can be observerd (Fig. 1). At present, the BoB and the ADS are characterized by relatively low annual sea surface salinity (SSS) and low annual PP compared to AS becuase of much higher freshwater input. Here, we present a paleo-PP records over the last 26 kyr, from the northeastern BoB and study the mechanism driving these PP variations.



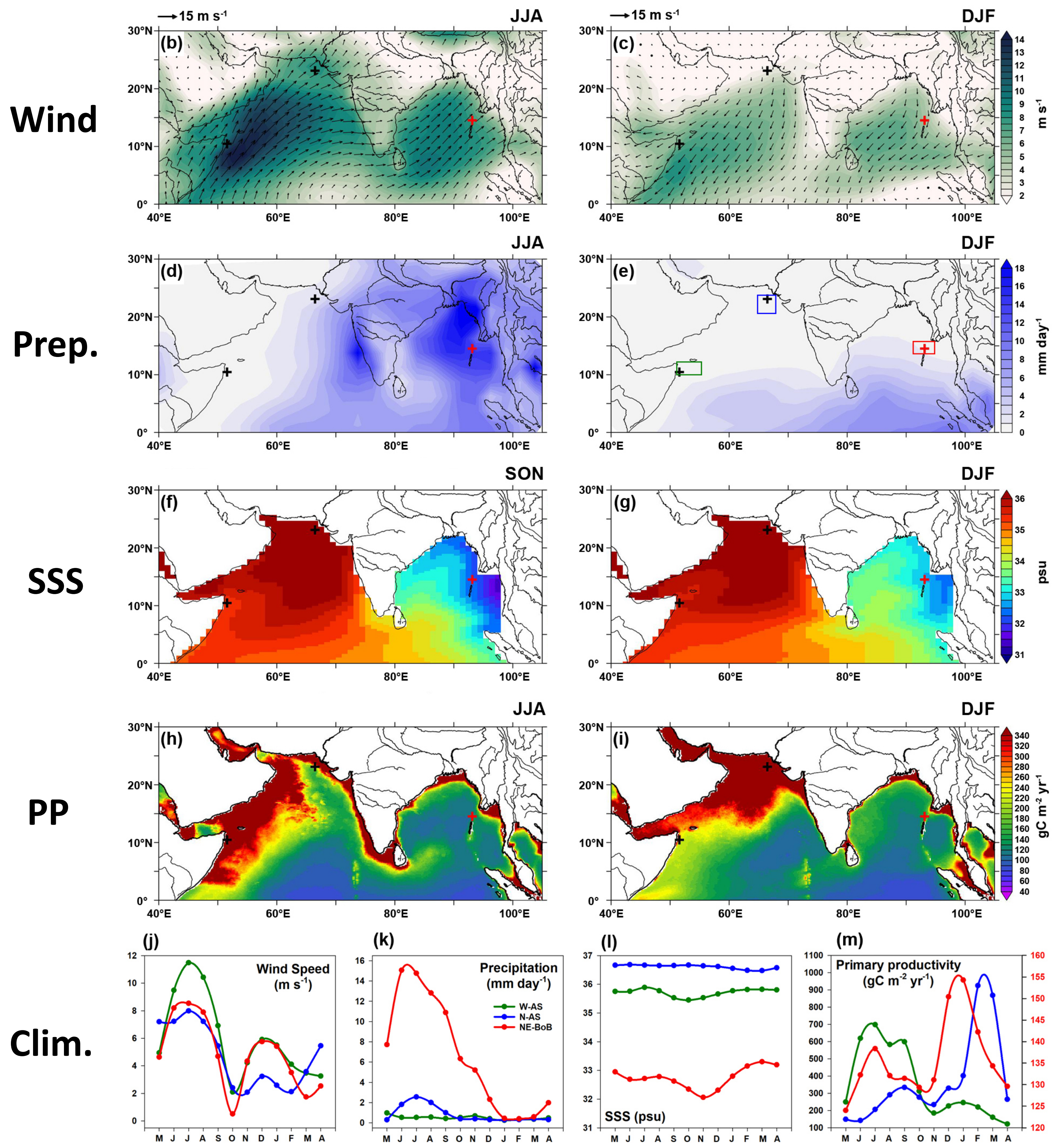
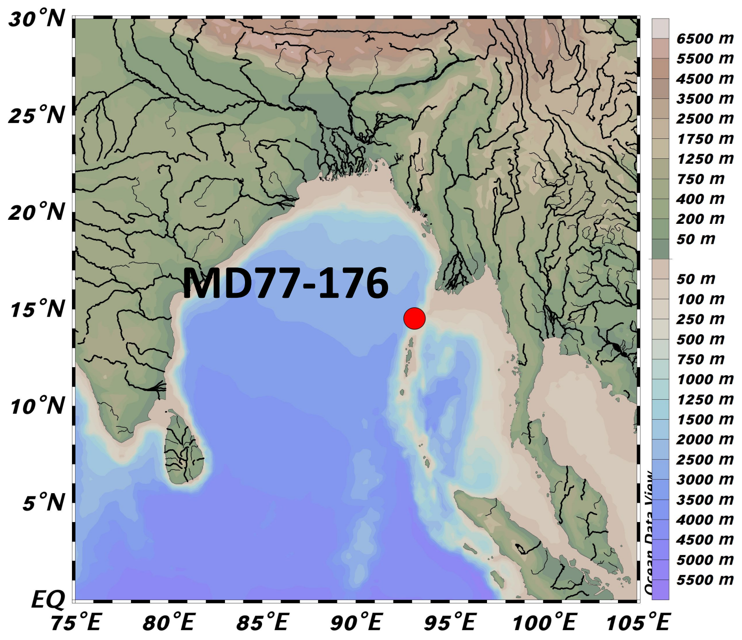


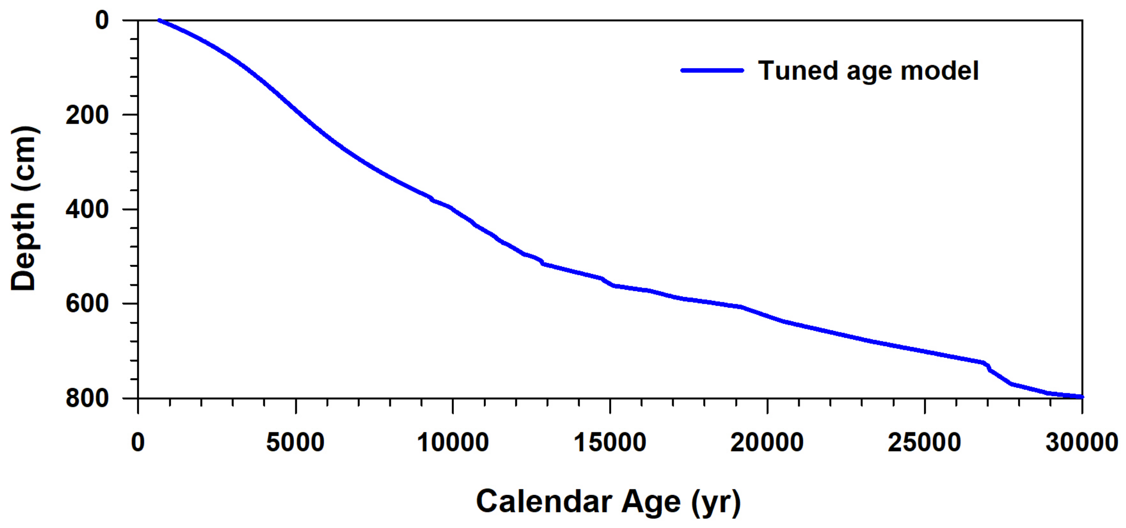
Fig. 1

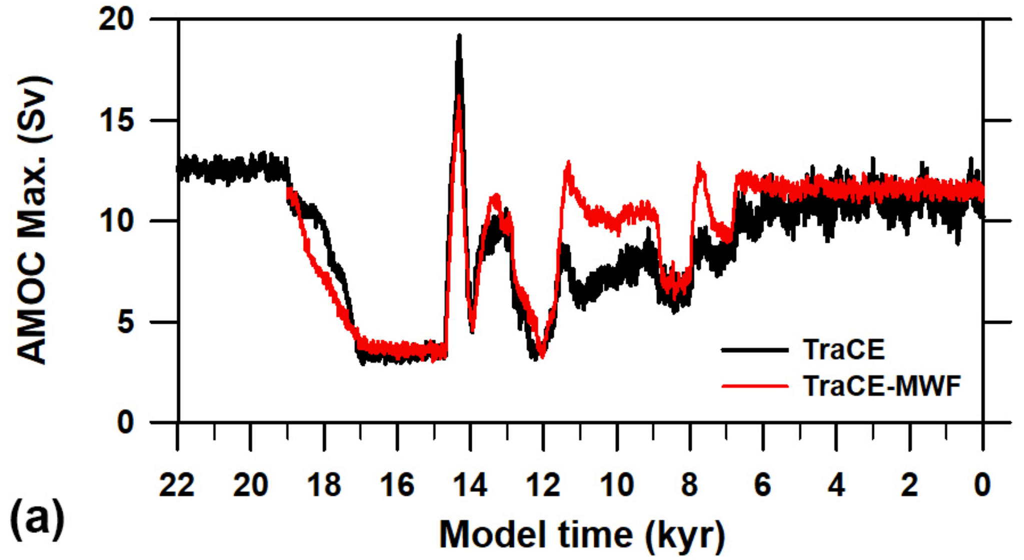
Data source:
NCEP Global Ocean Data Assimilation System (http://esrl.noaa.bov/psd/data/grided/data.godas.html
MODIS chlorophyll-a and PP calculated using the VGPM model (http://science.oregonstate.edu/ocean.productivity)
NCEP-DOE Reanalysis 2 (http://esrl.noaa.bov/psd/data/grided/data.ncep.reanalysis2.html)
CPC Merged Analysis of Precipitation (http://esrl.noaa.bov/psd/data/grided/data.ncep.camp.html)

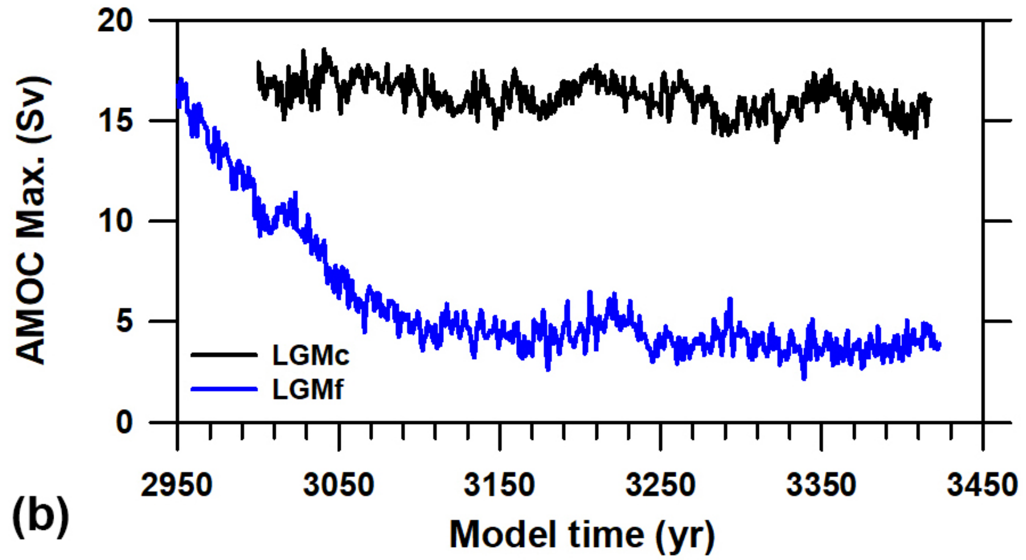
Methods

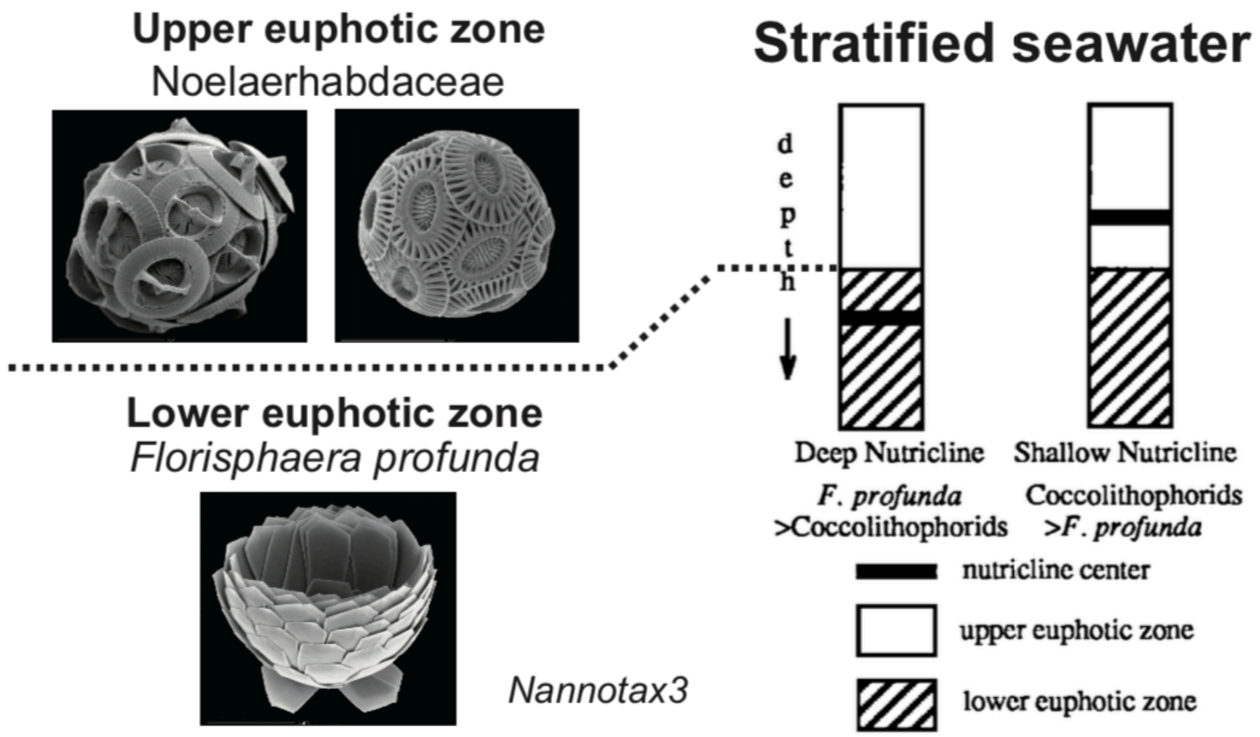
1. **PP reconstruction**
2. **Climate model**



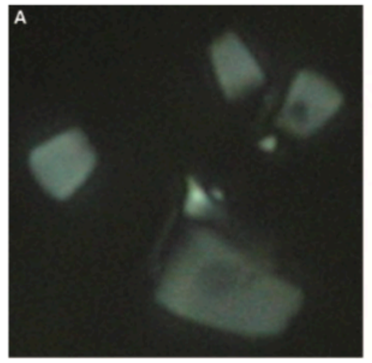








Coccolithophores



$Fp\% = N_{Fp}/N_{total} \times 100$

$PP = [10^{(3.27-0.01 \times Fp\%)}] \times 365/1000$ *Ref. 1, 2, 3, 4*

TraCE-21 transient simulation (run with CCSM3) *Ref. 5, 6*

outputs over the last 22,000 years

IPSL-CM5A-LR *Ref. 7, 8*

CMIP5 Preindustrial control (PI)

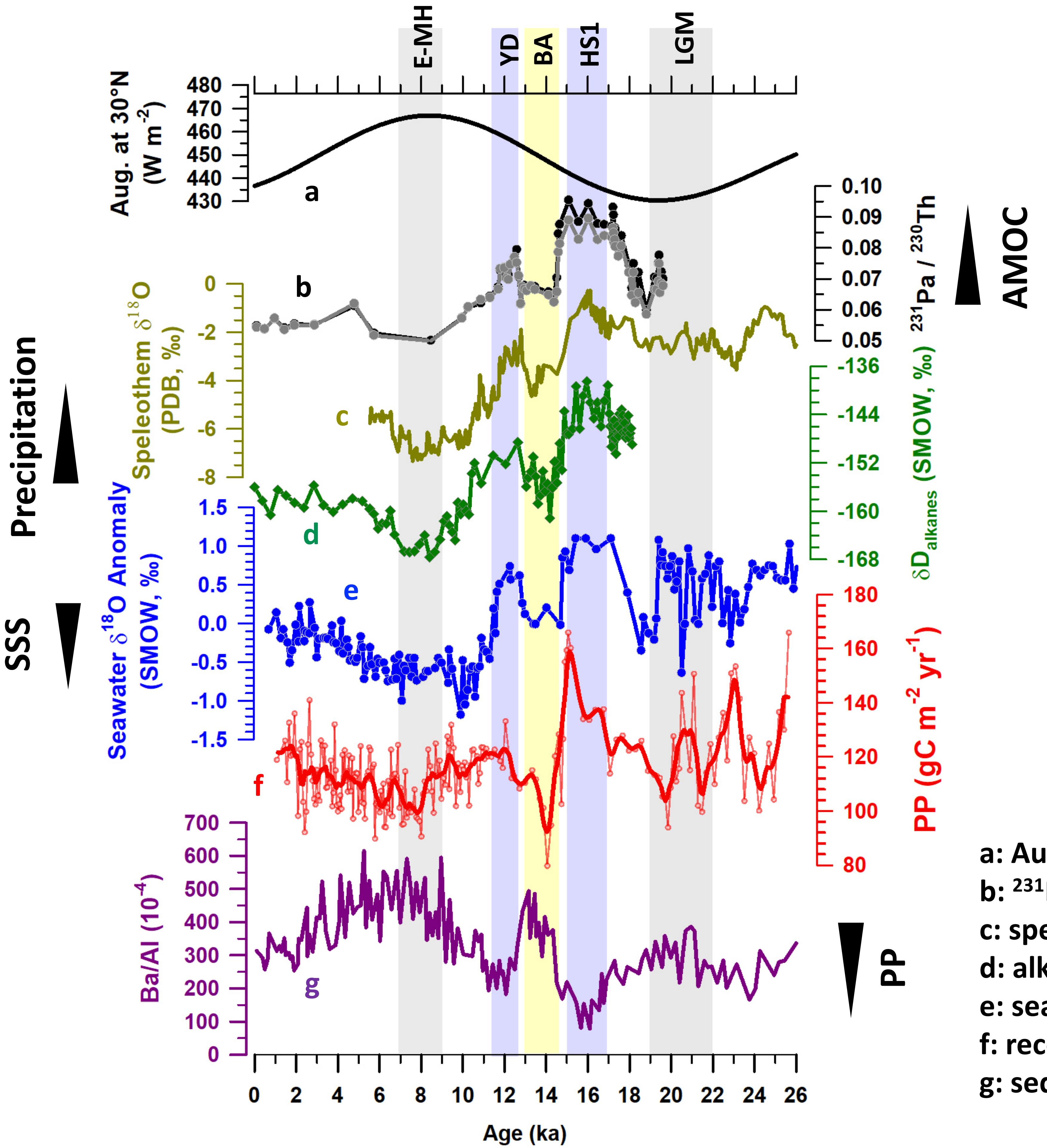
PMIP3 Mid-Holocene (MH)

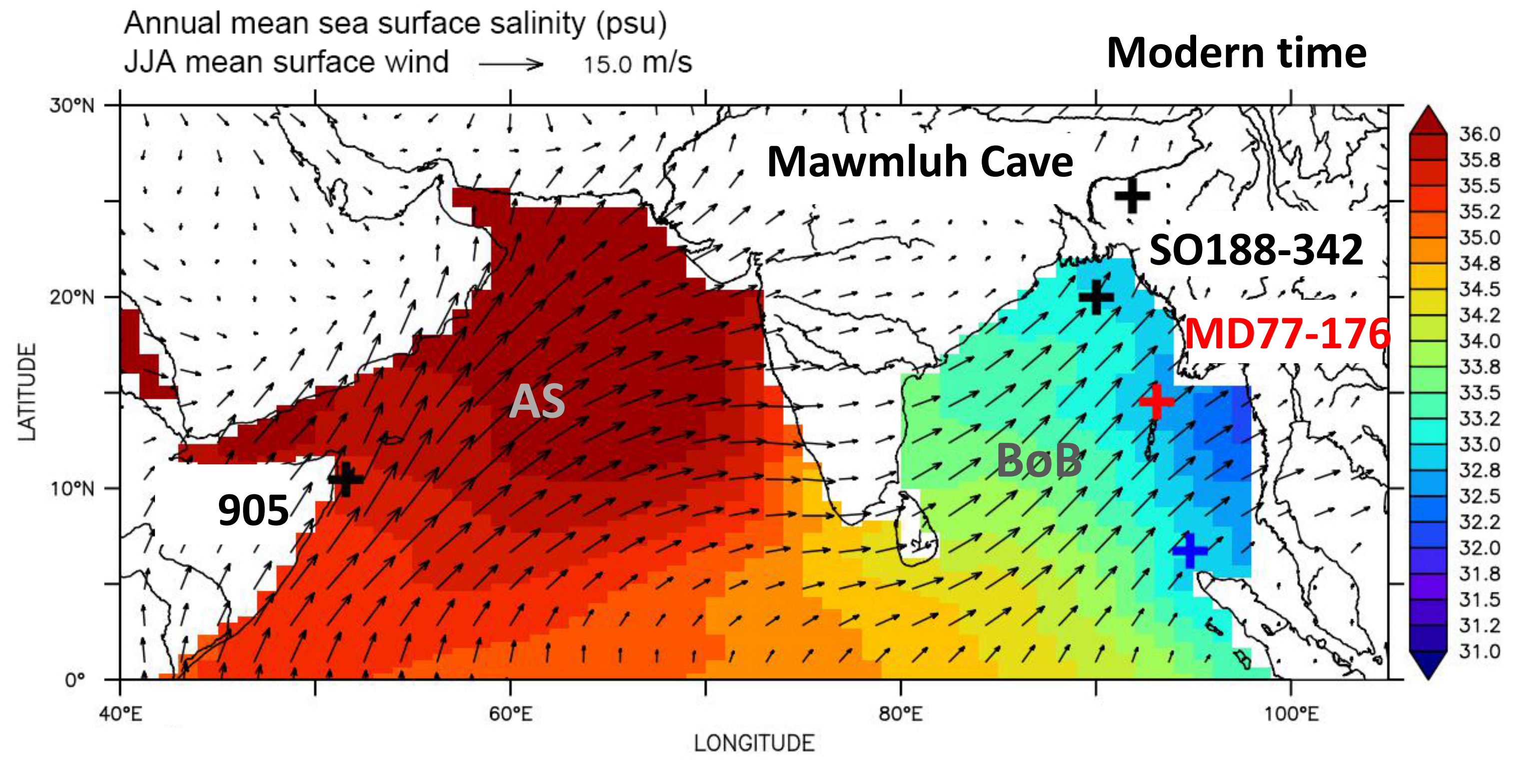
PMIP3 Last Grlacial Maximum control (LGMc)

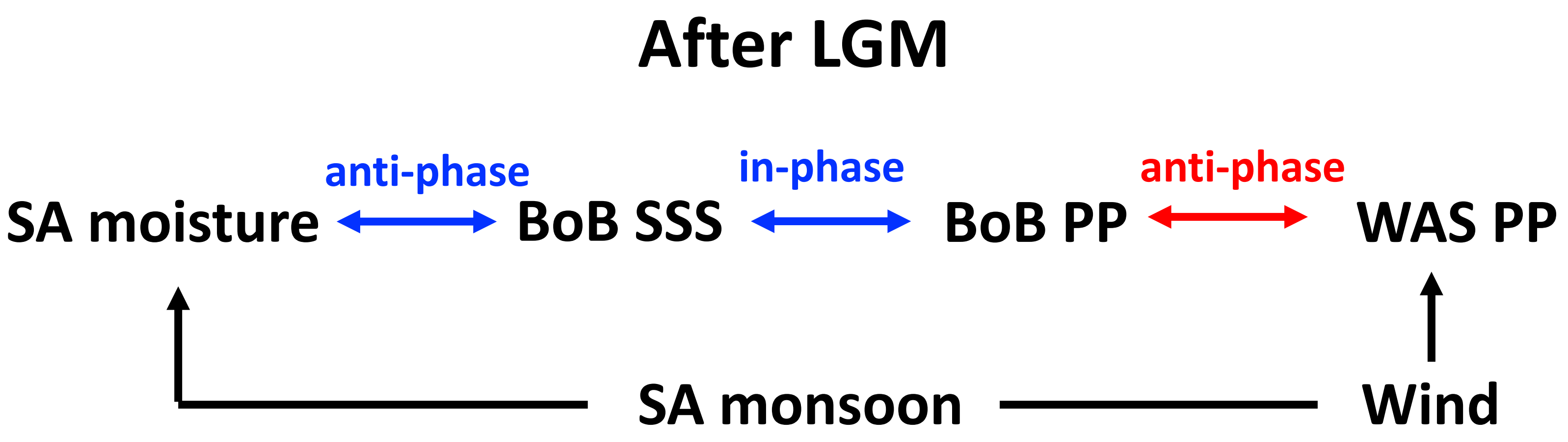
Last Grlacial Maximum fresh water hosing (LGMf)

Results

PP variations







a: August insolation at 30° N

b: $^{231}Pa/^{230}Th$ record of North Atlantic core OCE326-GGC5 *Ref. 9*

c: speleothem $\delta^{18}O$, Mawmluh Cave *Ref. 10*

d: alkane hydrogen isotope, SO188-342KL *Ref. 11*

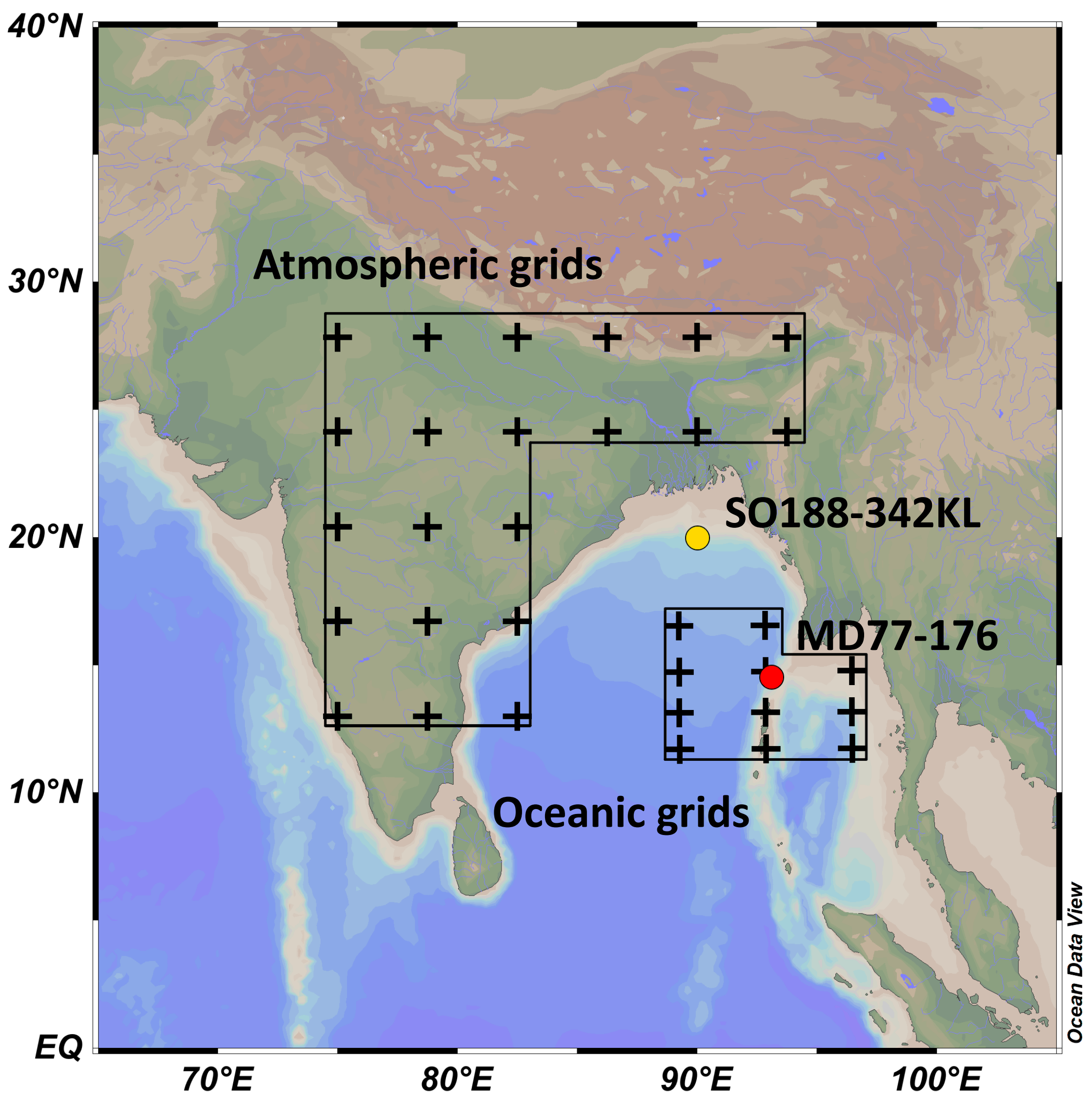
e: seawater $\delta^{18}O$ anomaly, MD77-176 *Ref. 12*

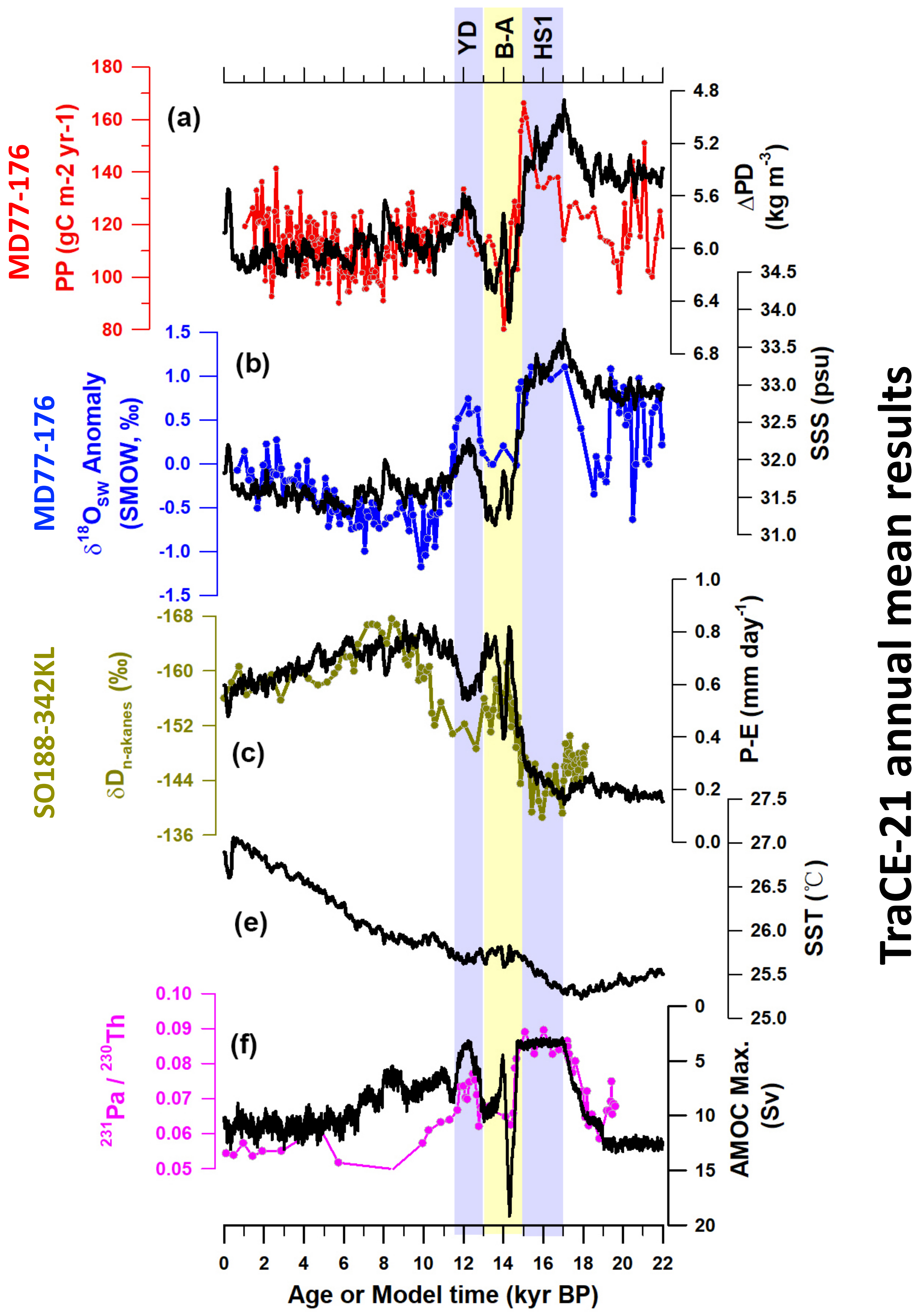
f: reconstructed PP, MD77-176, this study

g: sediment Ba/Al ratio, 905 *Ref. 13*

Results

TraCE-21 outputs





Deglaciation

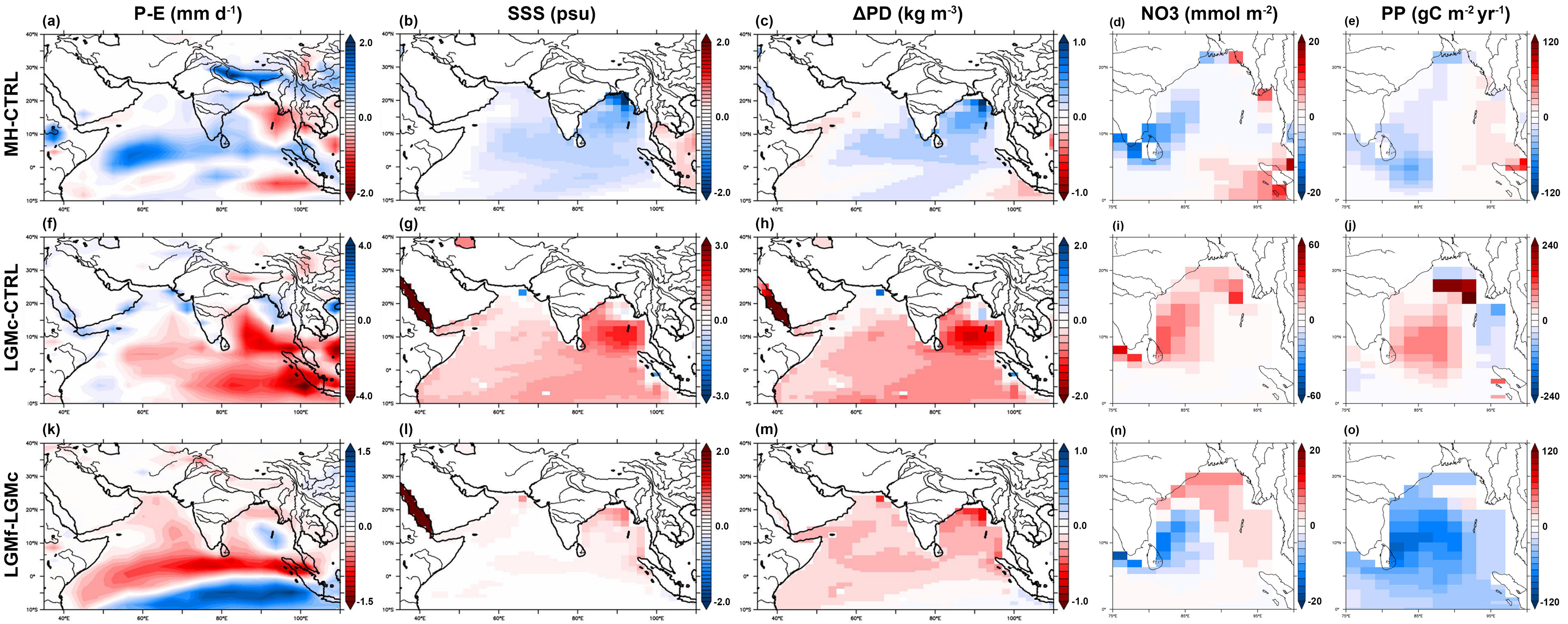
SSS changes drives upper seater stratification changes

ΔPD = Potential density difference between 200 and 5 m
SSS = Sea surface salinity
SST = sea surface temperature
P-E = Net precipitation (Total precipitation minus evaporation)

Results

Past climate and ocean

IPSL-CM5A-LR
annual mean

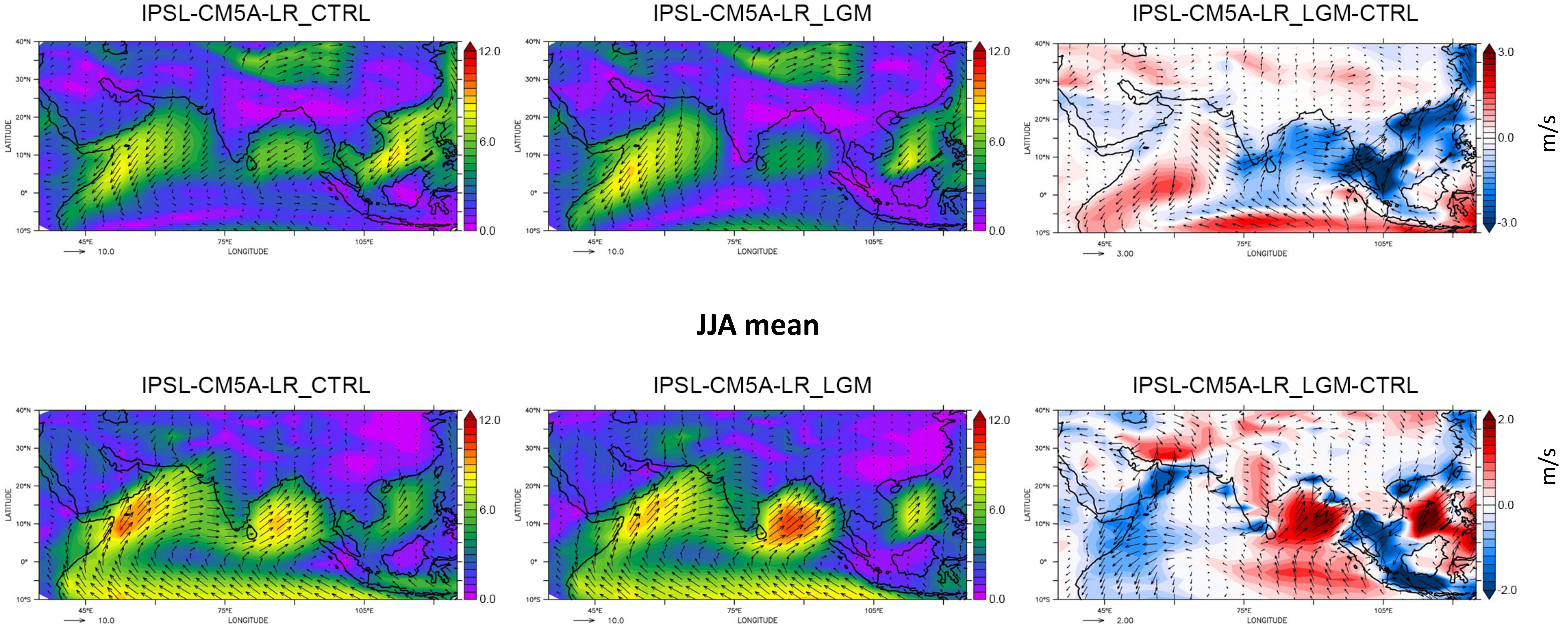


Wetter Mid-Holocene, drier LGM, and much drier LGM under weaker AMOC

Results

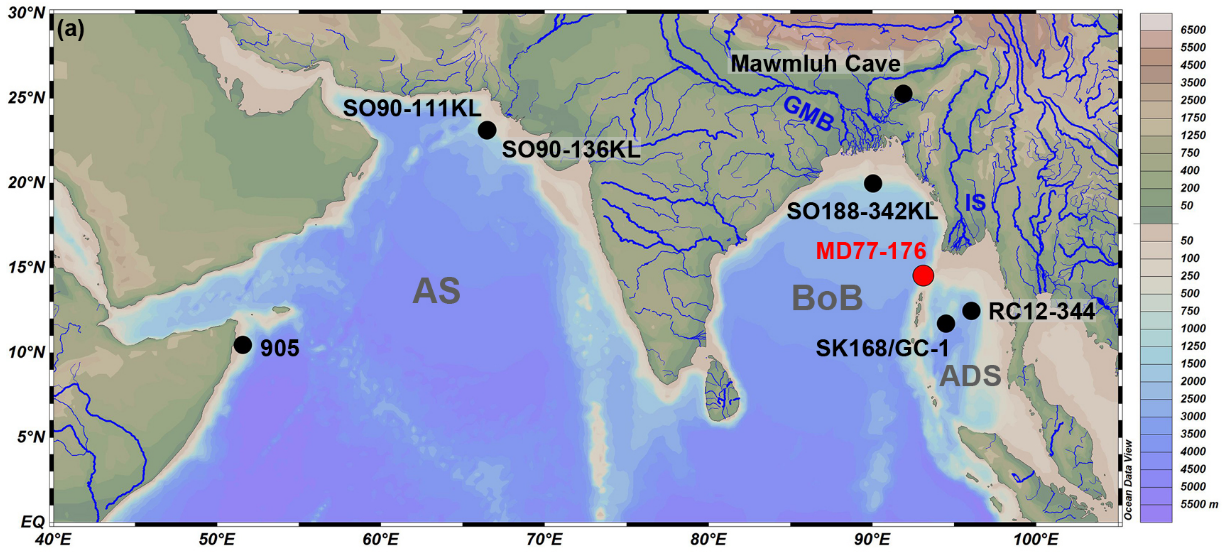
Past climate and ocean

Near surface wind
DJF mean



LGM
Westerly anomalies prevail over BoB during both summer and winter.
Stronger summer wind over saltier ocean is found in BoB.

LGM PP in NE-BoB

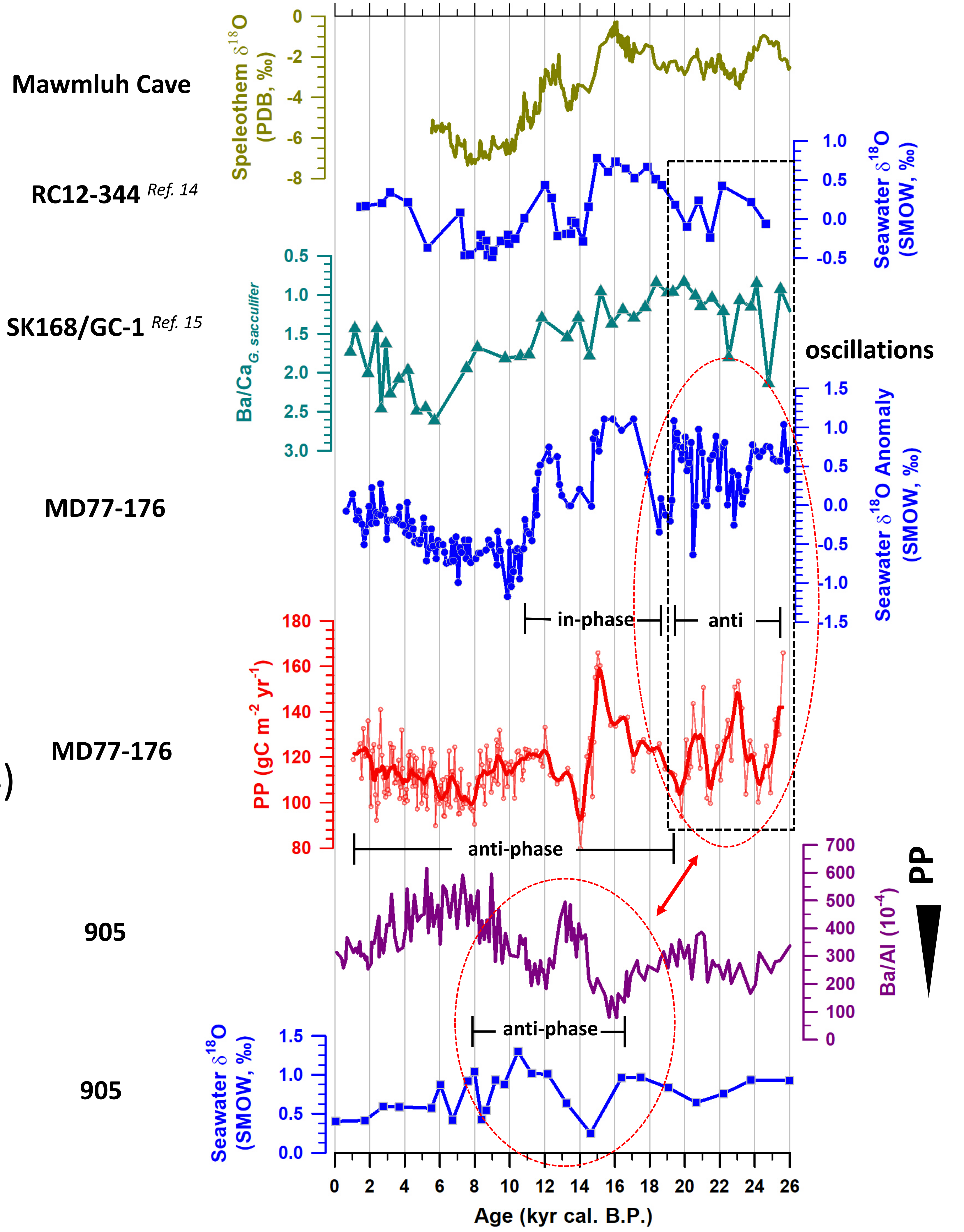


LGM

1. Stronger summer wind over saltier ocean in BoB.
   (Similar to Arabian sea)
2. PP oscillates instead of general increasing.
   (Relationships of PP vs SSS are similar in LGM BoB and deglaciation AS)

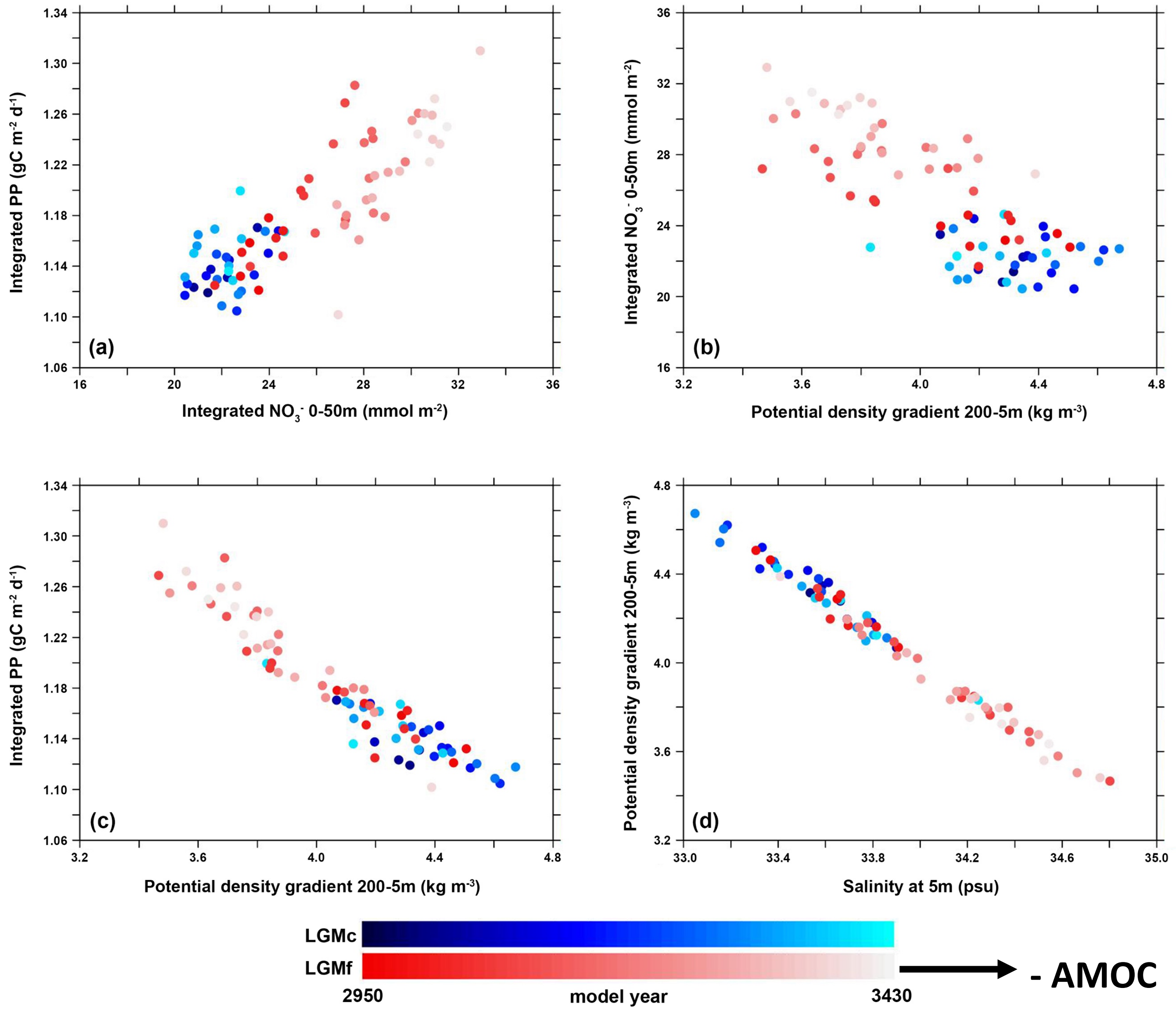
Two possibilities may work for the BoB PP oscillations:

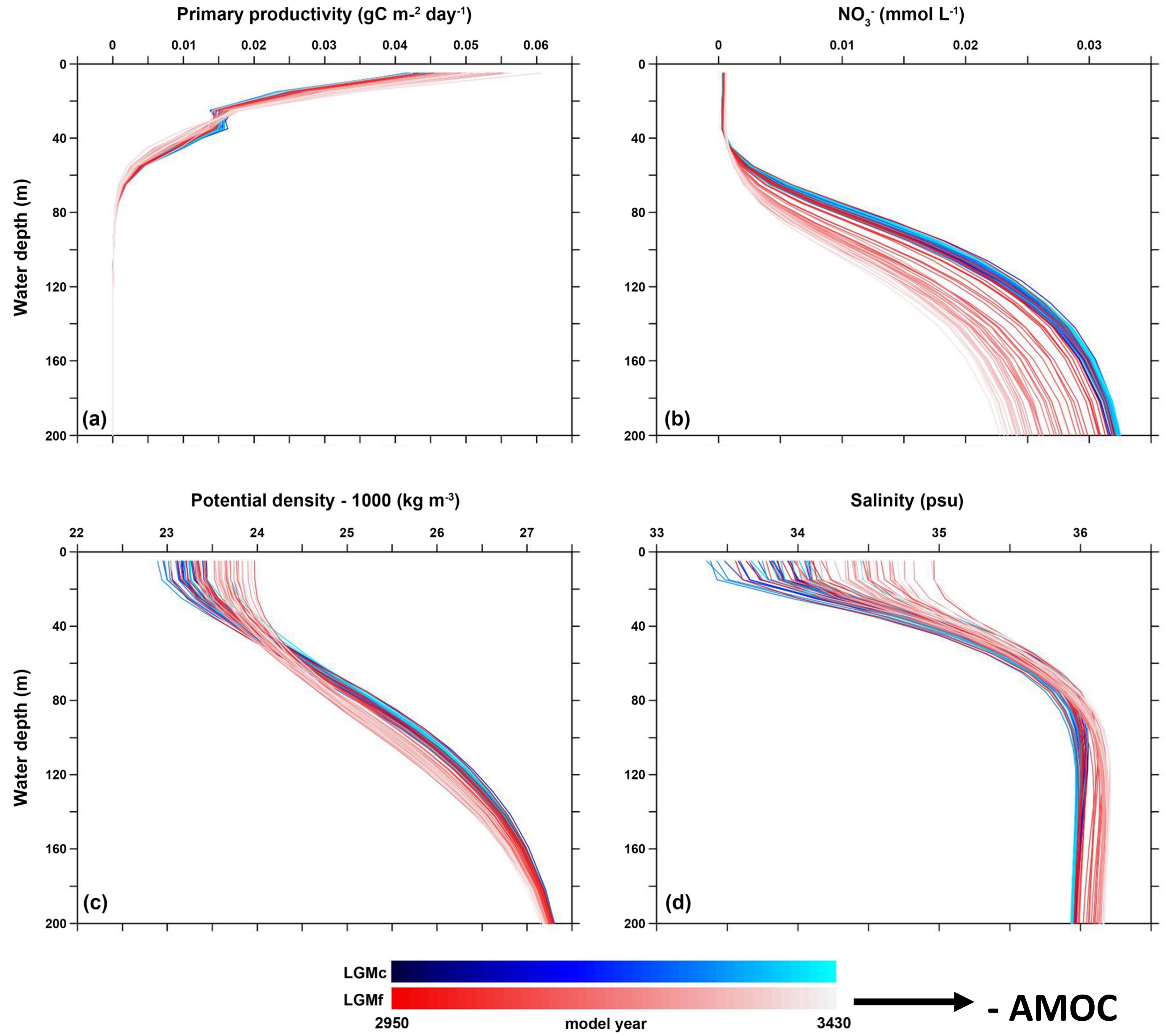
1) summer wind orientation changes abruptly during the LGM which have different outcomes of Ekman pumping;
2) river input pulses during low sea-level period bring continental nutrients, which is regional marine geological features of the NE-BoB and N-ADS.

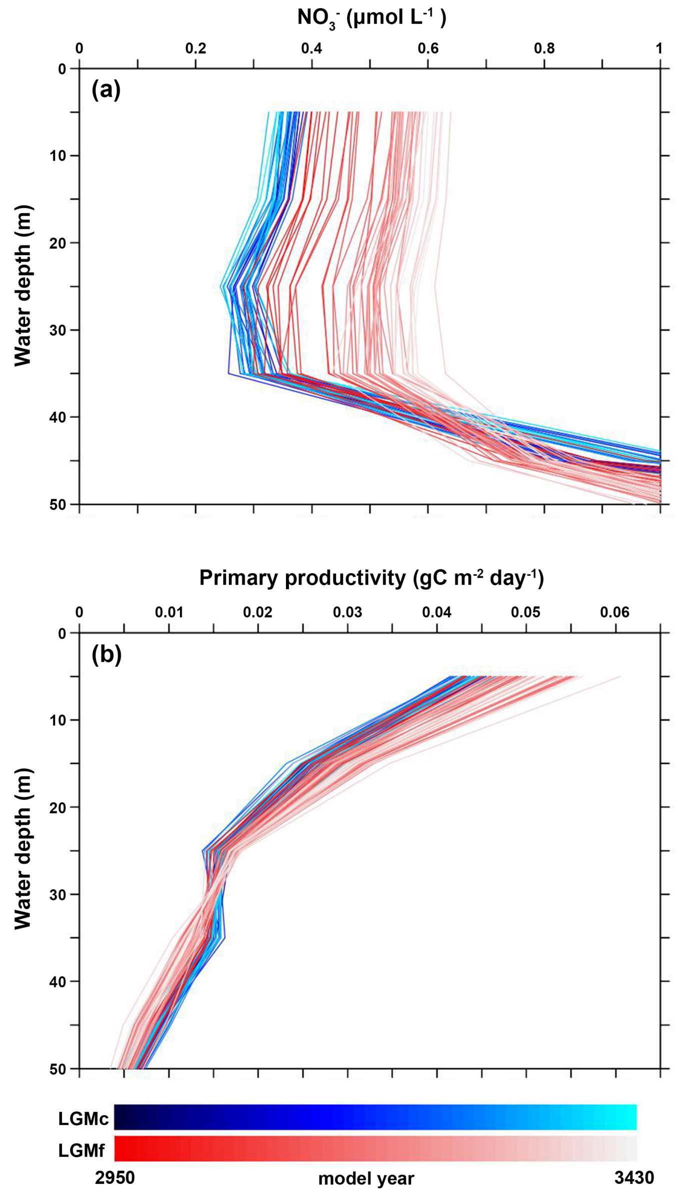


Results

PP responses to hydrological changes during the deglaciation







- AMOC → + SSS → - Stratification → + Upper nutrients → + PP

Conclusions

1. **PP record in the NE-BoB shows no general increasing in the LGM compared to the late Holocene, but PP shows oscillations with some peaks.**
2. **After the LGM, PP in the NE-BoB is controlled by salinity stratification related to monsoon precipitation.**
3. **Millennial-scale variations during the deglaciation are forced by the changes of AMOC strength.**

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Thank you!