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

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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 hydrological and ecological settings can be observed (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 because 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.

Aims of this study

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

PP = \[10^{(3.27 - 0.01 \times Fp\%)}\] × 365/1000

Fp% = \(\frac{N_{Fp}}{N_{total}} \times 100\)

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 Glacial Maximum control (LGMc)
Last Glacial Maximum fresh water hosing (LGMf)
Results

PP variations

- **a**: August insolation at 30° N
- **b**: $^{231}$Pa/$^{30}$Th record of North Atlantic core OCE326-GGC5 Ref. 9
- **c**: speleothem δ$^{18}$O, Mawmluh Cave Ref. 10
- **d**: alkane hydrogen isotope, SO188-342KL Ref. 11
- **e**: seawater δ$^{18}$O anomaly, MD77-176 Ref. 12
- **f**: reconstructed PP, MD77-176, this study
- **g**: sediment Ba/Al ratio, 905 Ref. 13

After LGM

SA moisture ↔ BoB SSS ↔ BoB PP ↔ WAS PP

SA monsoon → Wind

Modern time

BoB PP

SA SSS

WAS PP

AMOC

Mawmluh Cave

SO188-342

MD77-176
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

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.

References

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Thank you!