



中國海洋大學



Strengthened Ocean-desert Process in the North Pacific over the Past Two Decades

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2020-10-28

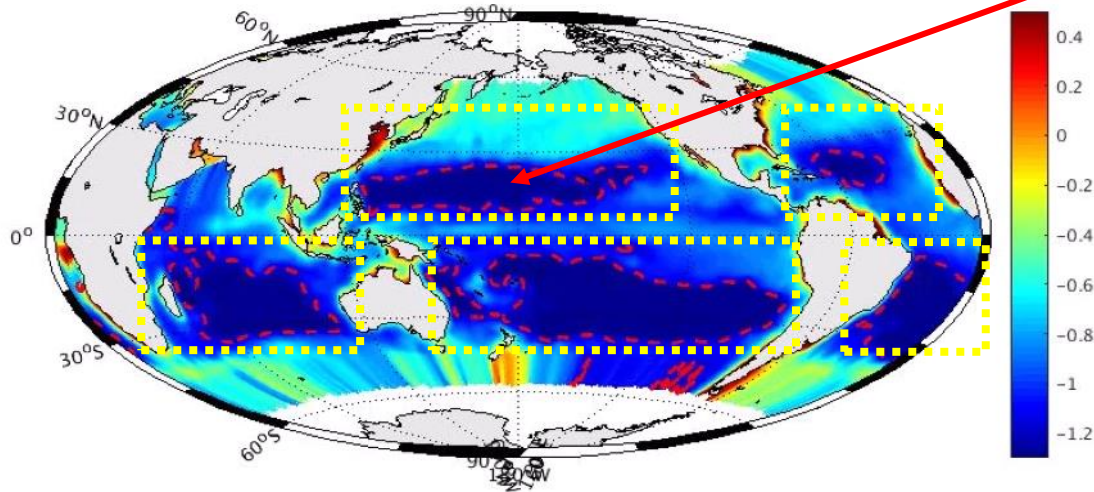
Topic-VS4



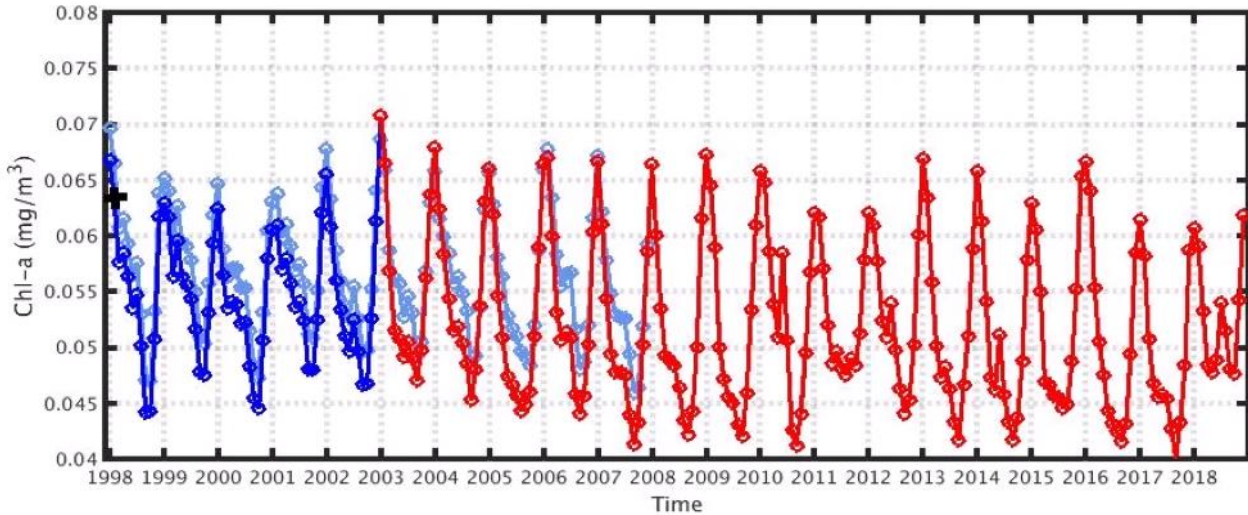


Introduction: ocean desert

North pacific ocean desert (NPOD)



marine dessert: $\text{Chl} \leq 0.07 \text{ mg/m}^3$

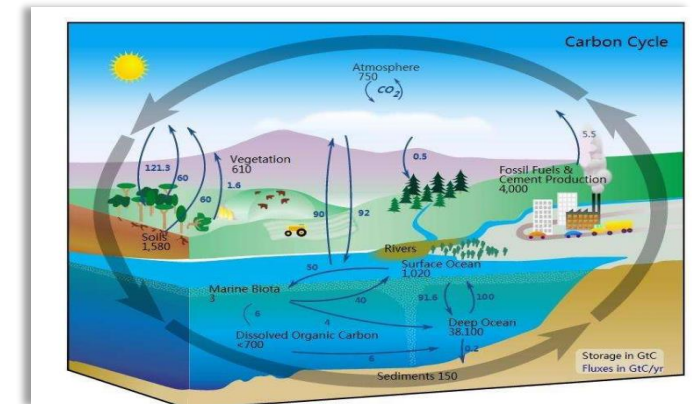


1

Their immense size
(they occupy ~40% of low-latitude ocean area)

2

The carbon exported
from the surface to the deep ocean.

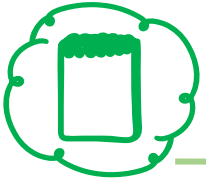


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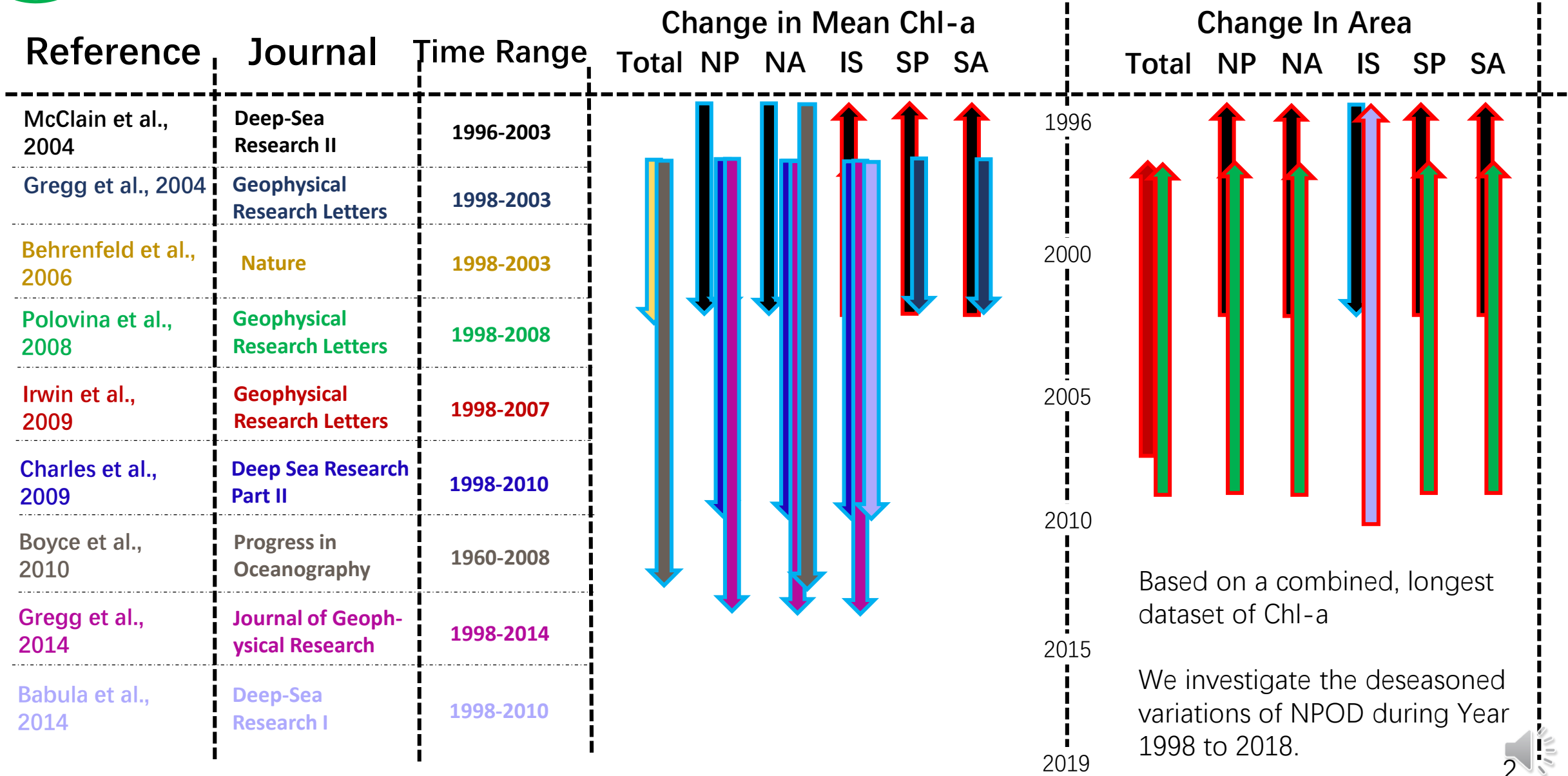
Long-term variation



Figure 1 Global ocean surface mean Chl-a concentration from 1998 to 2018. The red dashed line represents the 0.07 mg/m³ contours of Chl-a, the boxes delimited by the blue dashed lines is the study area.

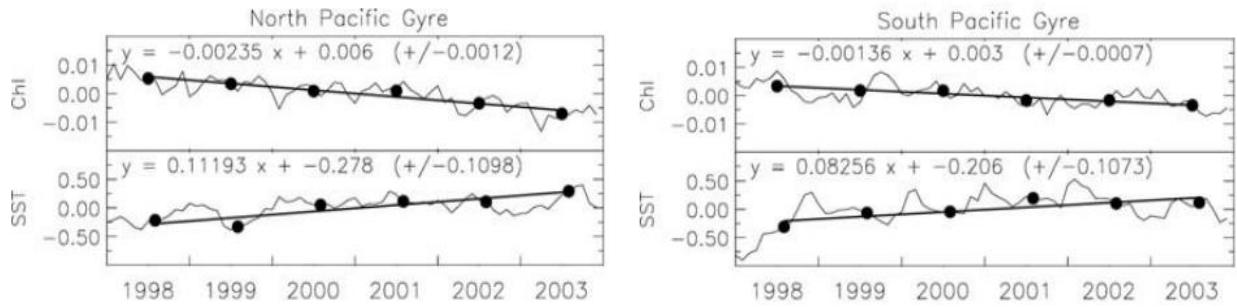


Introduction : long-term variation ocean desert

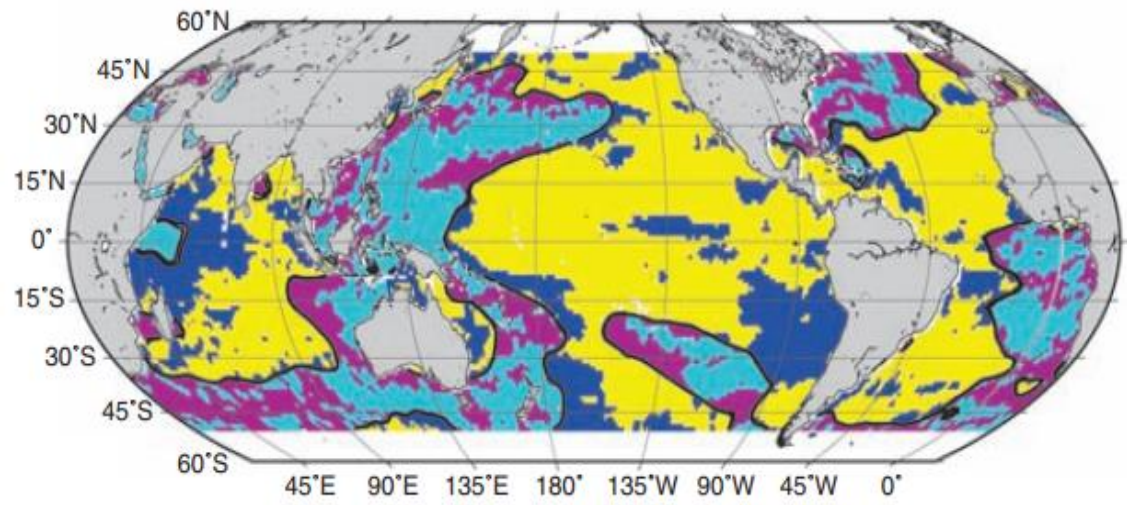
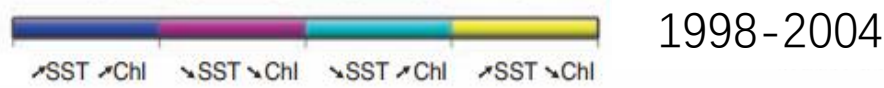




Introduction : potential factors



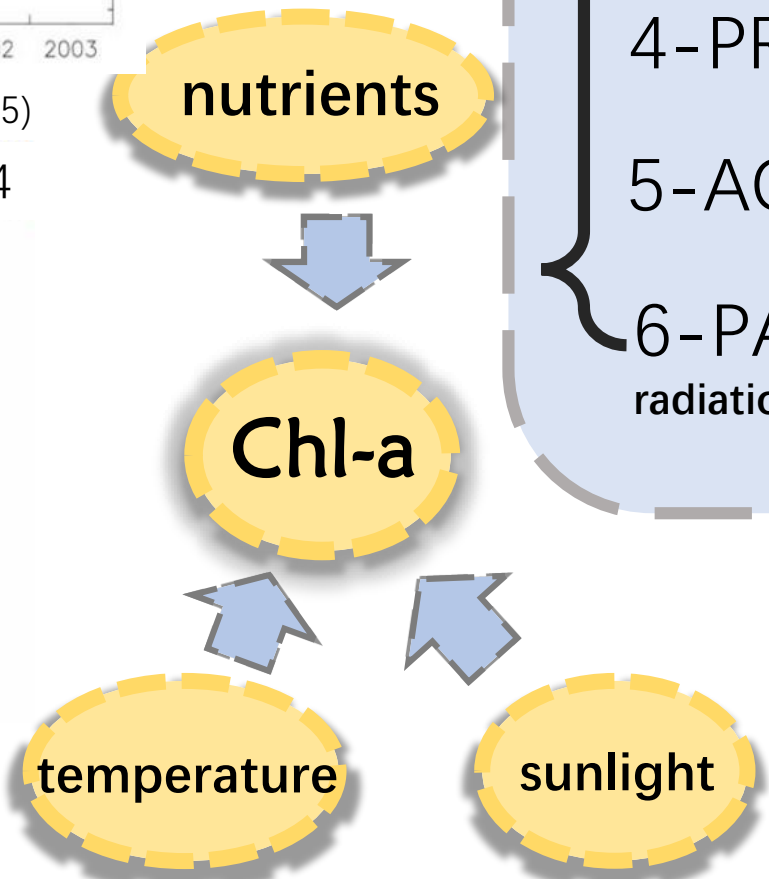
Gregg et al (2005)

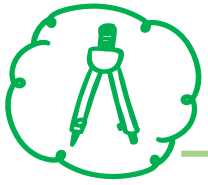


Elodie et al (2005)

Figure 2 Map of areas with concomitant parallel or opposite changes of Chl and SST, as indicated between 1999 and 2004.

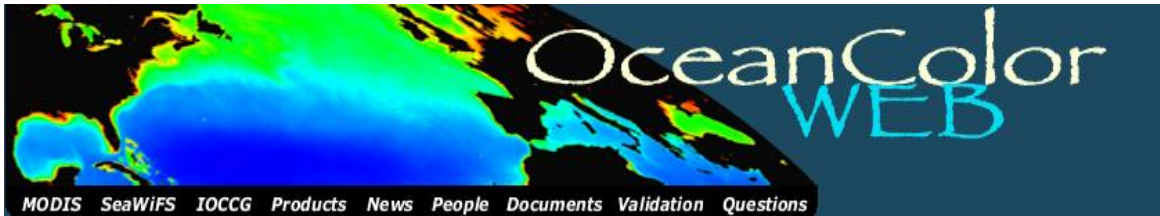
- 1 - SST (sea surface temperature)
- 2 - WS (wind speed)
- 3 - SSH (sea surface height)
- 4 - PRE (precipitation)
- 5 - AOD (Aerosol Optical Depth)
- 6 - PAR (photosynthetically active radiation)





Data

Data source



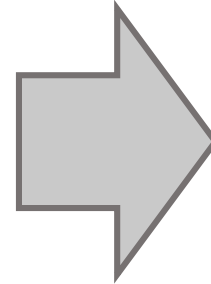
Chl-a:

Moderate-Resolution Imaging Spectroradiometer
(MODIS)

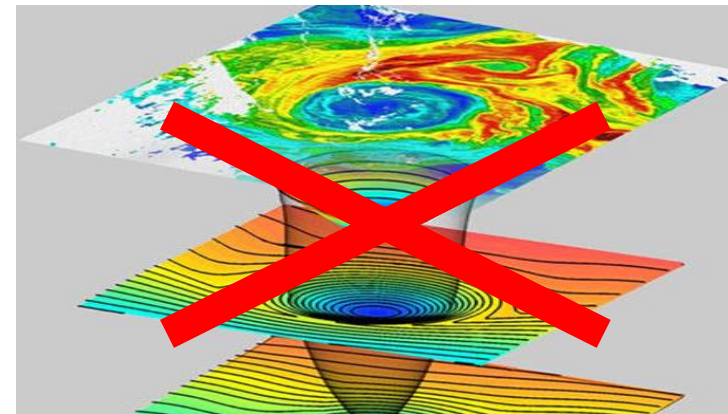
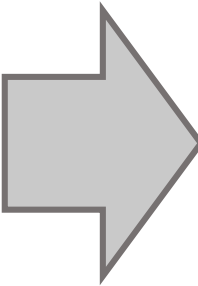
Sea-viewing Wide Field-of-view Sensor
(SeaWiFS)

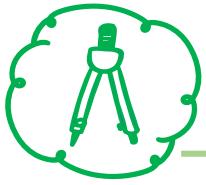
spatial resolution : $1/12^\circ$
temporal resolution: 1 day

January 1, 1998---December 31, 2018 (a total of 21 years)

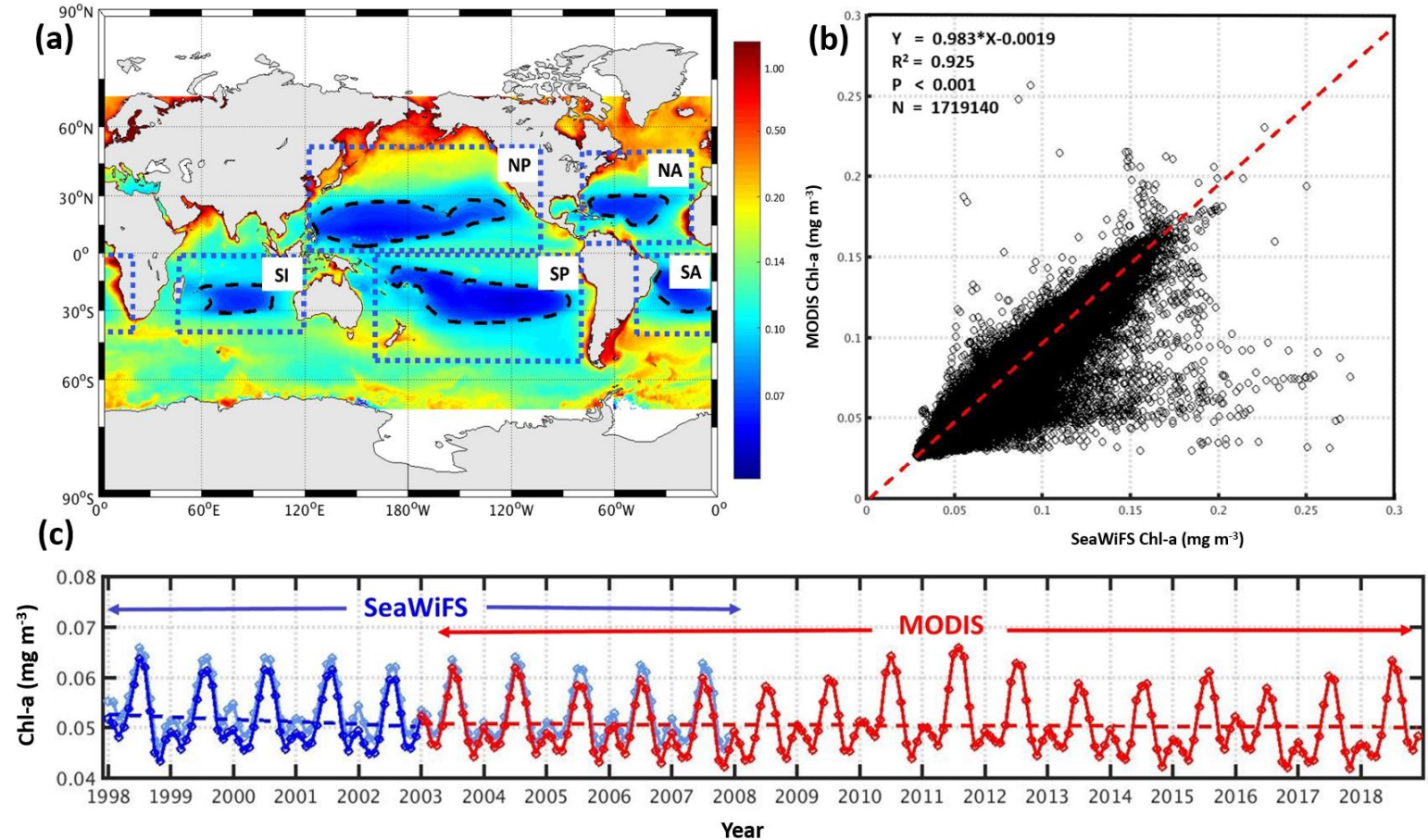


13-day running mean
100-km running mean





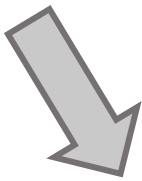
Data and method



ocean desert
variation

intensity
area
position

McClain et al (2004)
Polovina et al (2008)

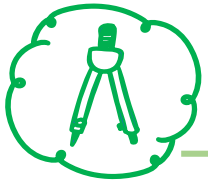


$$\alpha_{lon} = \frac{\sum_{i=1}^n C_{chl-a} l_{lon}}{\sum_{i=1}^n C_{chl-a}}$$

Hsin et al (2013)

$$\delta_{lat} = \frac{\sum_{i=1}^n C_{chl-a} l_{lat}}{\sum_{i=1}^n C_{chl-a}}$$

Figure 3 (a) NPOD geographical region (dashed black curve), and the color shadings show global ocean surface mean Chl-a concentration (b) Comparison of monthly surface Chl-a concentration retrieved by SeaWiFS and MODIS-Aqua during 2003–2007 in five ocean deserts (c) Time series of monthly Chl-a concentrations in global ocean deserts area (the black dashed line in a) retrieved by SeaWiFS (light blue curve for raw data; blue curve for merged data) and MODIS-Aqua (red curve).



Data and method

Table S1. Details of all data description

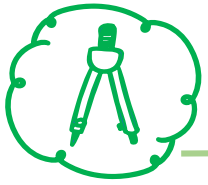
Variable	Source/Product	Unit	Temporal Resolution	Spatial Resolution
Chlorophyll-a (Chl-a) Concentration	SeaWiFS & MODIS Level-3 Standard Mapped Images	mg m ⁻³	Daily	~0.09°×0.09°
Sea Surface Temperature (SST)	NOAA Optimum Interpolation (OI) SST, V2	°C	Monthly	1°×1°
Precipitation (PRE)	European Centre for Medium-Range Weather Forecasts (ECWMF) ERA5 monthly averaged data on single levels	mm day ⁻¹	Monthly	0.25°×0.25°
Photosynthetically Active Radiation (PAR)	MODIS Level-3 Standard Mapped Images	einstein m ⁻² day ⁻¹	Monthly	~0.09°×0.09°
Sea Surface Height (SSH) Relative to Geoid, Wind Speed (WS)	National Centers for Environmental Prediction (NCEP)	m, m s ⁻¹	Monthly	0.25°×0.25°
Horizontal Velocity Components (u,v), Temperature (T), Salinity (S) and Mixed Layer Depth (MLD)	Simple Ocean Data Assimilation version 3 (SODA3)	m s ⁻¹ , °C, m	Monthly	0.5°×0.5°
Nutrients (N+P) Concentration	World Ocean Atlas 2013 (WOA 2005)	μmol L ⁻¹	Monthly	1°×1°
Aerosol Optical Depth (AOD)	MODIS Level-3 Standard Mapped Images		Monthly	~0.09°×0.09°

Nutrients (N + P) concentration

Mixed Layer Depth (MLD)

Horizontal velocity components, temperature, salinity data

A 1D K-Profile Parameterization (KPP) model



Results and discussion: intensity and area of NPOD

largest ocean desert globally
the most significant decline



North Pacific
Ocean Desert
(NPOD)

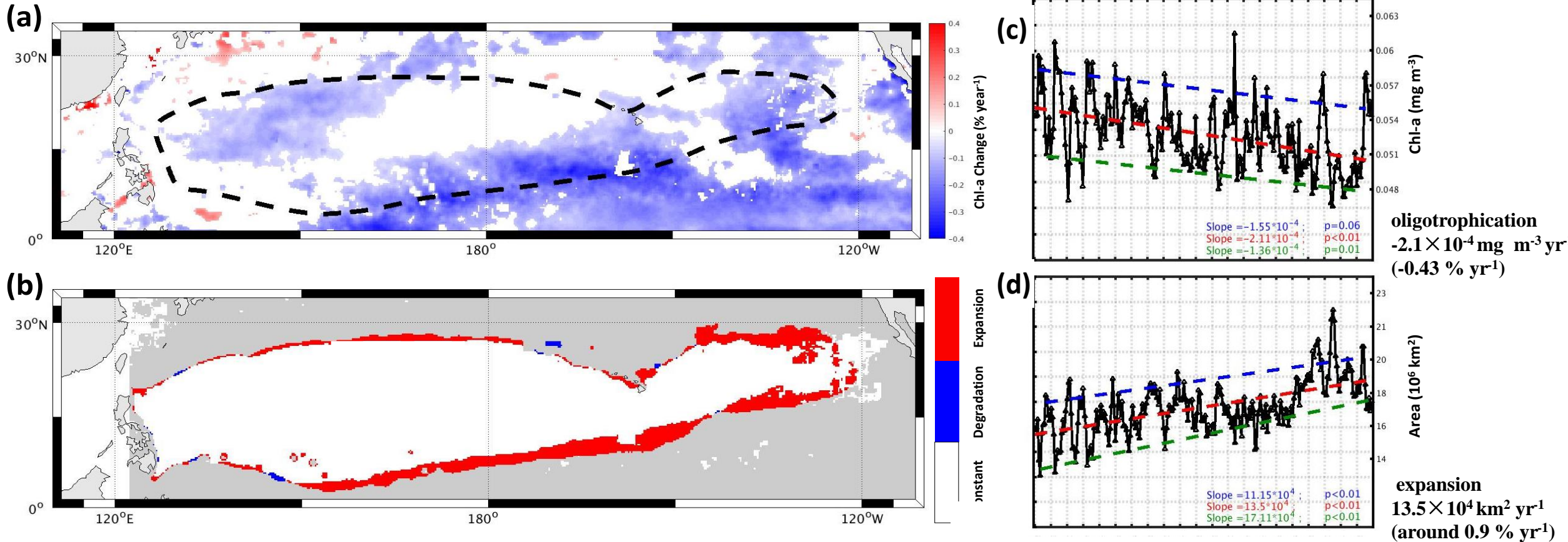
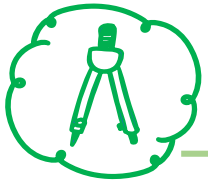


Figure 4 Trends of intensity and area of the North Pacific Ocean Desert (NPOD).



Results and discussion : intensity and area of NPOD

Trends in 10-year Sections of the NPOD Chl-a (%/year)

10-year sections in Chl-a concentration Change

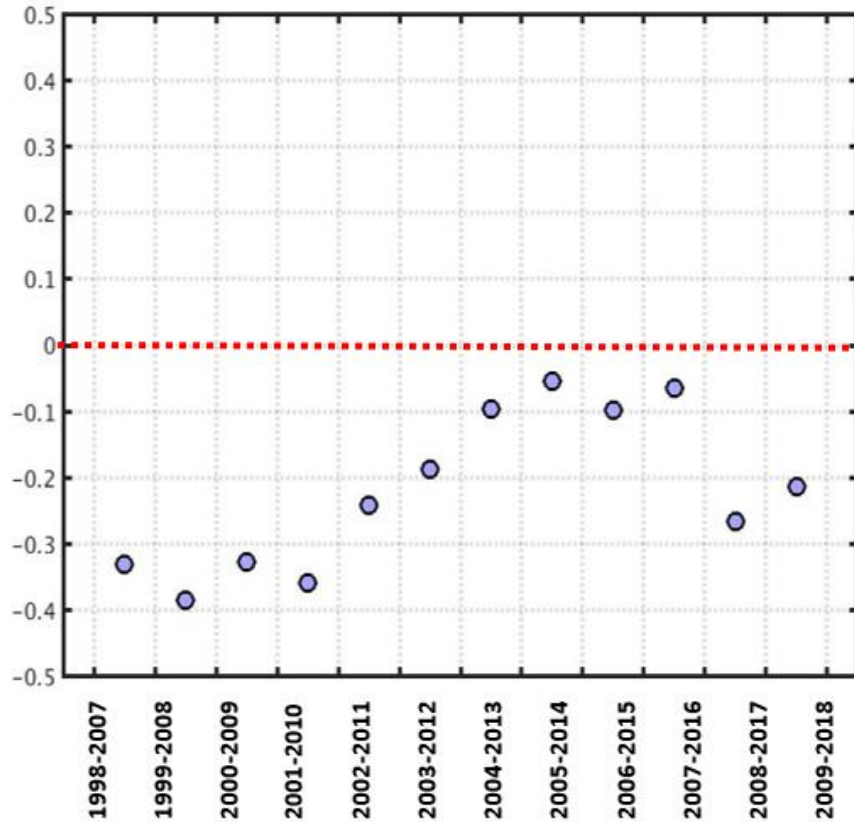


Figure 5 Rates of 10-year sections in Chl-a concentration Changes of the NPOD

sensitivity test

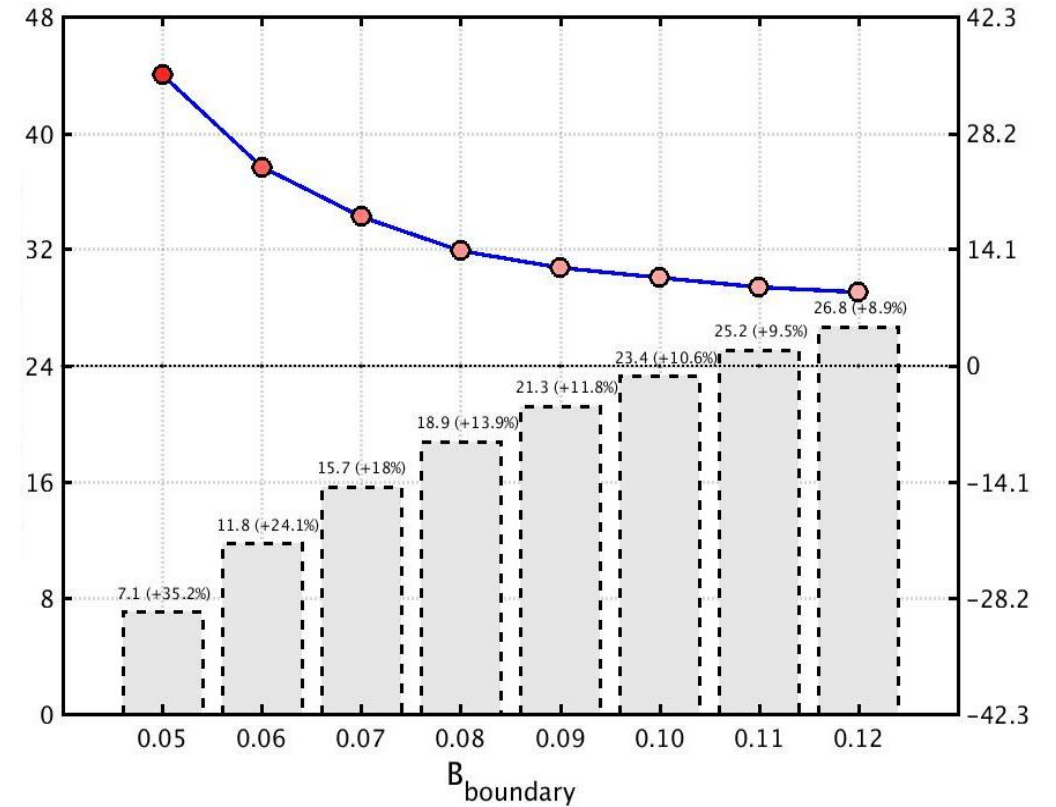
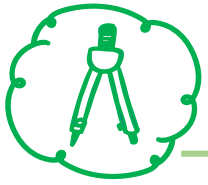


Figure 6 Climatological mean area (bar chart, left axis) and area change (line chart, right axis) with different thresholds.



Results and discussion: potential factors

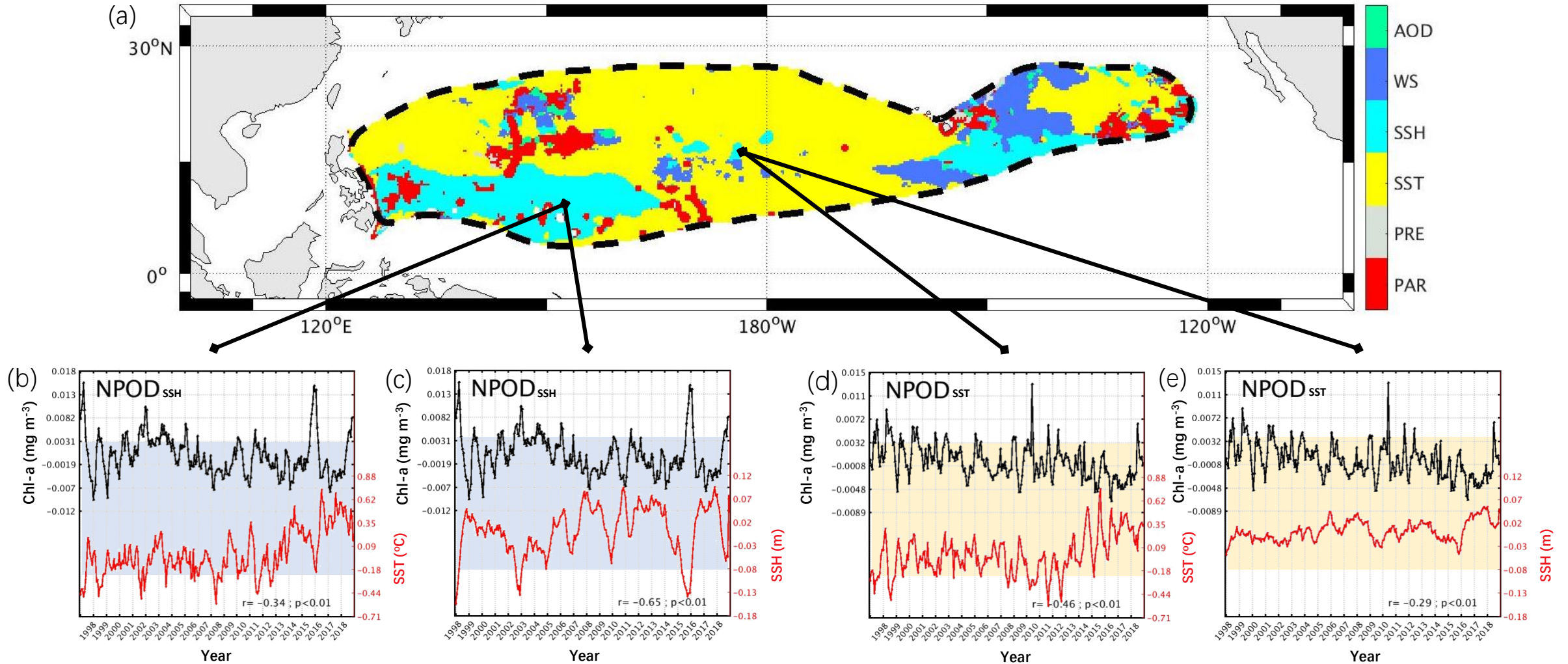
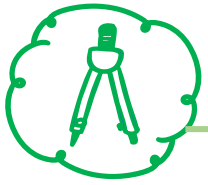
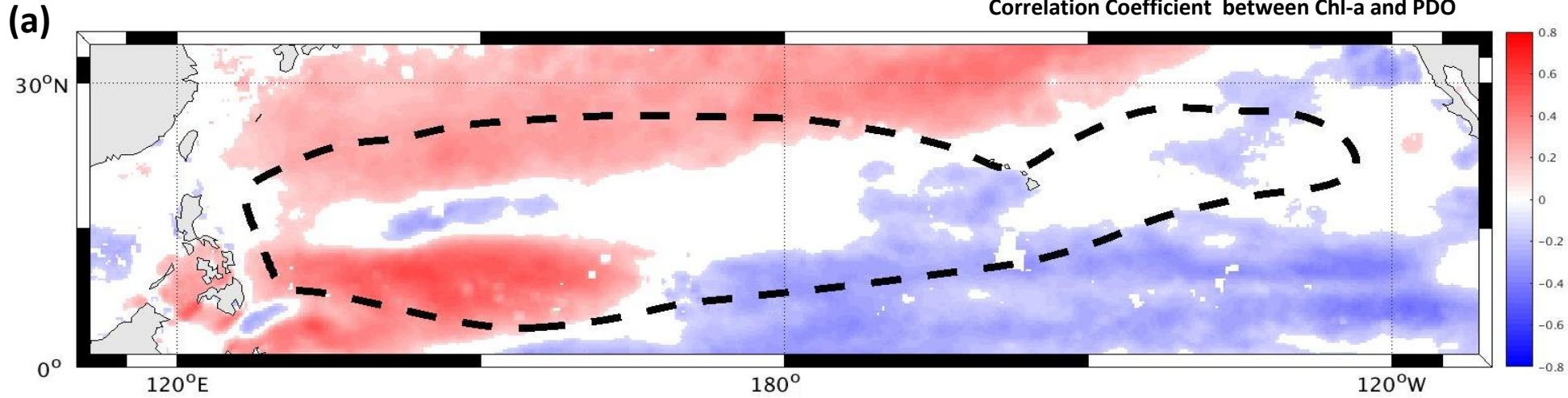


Figure 7 (a) North Pacific Ocean Desert (NPOD) geographical region (dashed black curve), and the color represents the dominating factor of Chl-a variation. (b-e) Deseasoned time series of Chl-a concentration are correlated with the deseasoned sea surface temperature and sea surface height in NPOD.



Results and discussion: oscillation of NPOD position



Pacific Decadal Oscillation (PDO)

'horseshoe' pattern of SST

Chl-a change at boundaries

northwest-southeast oscillation

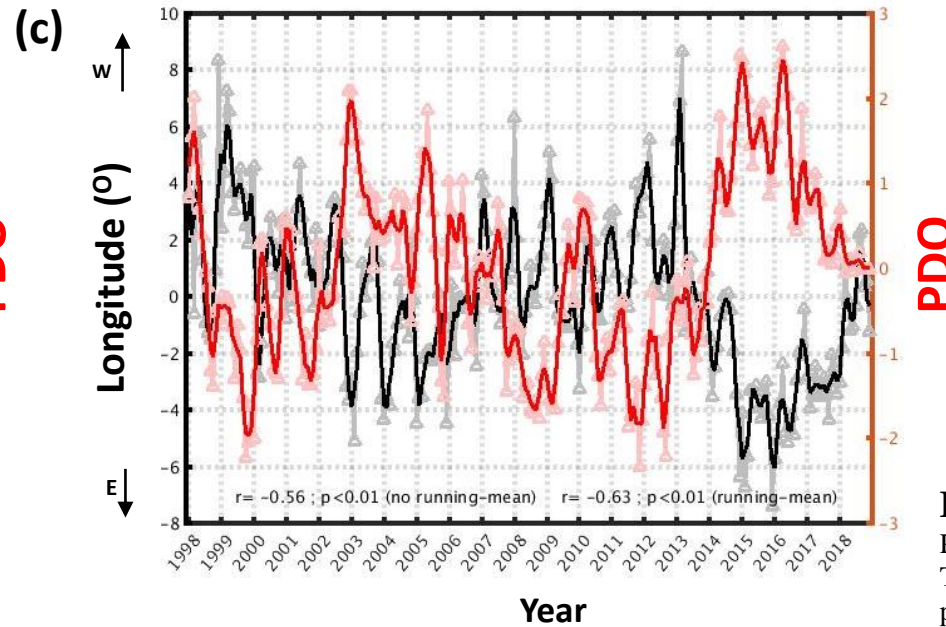
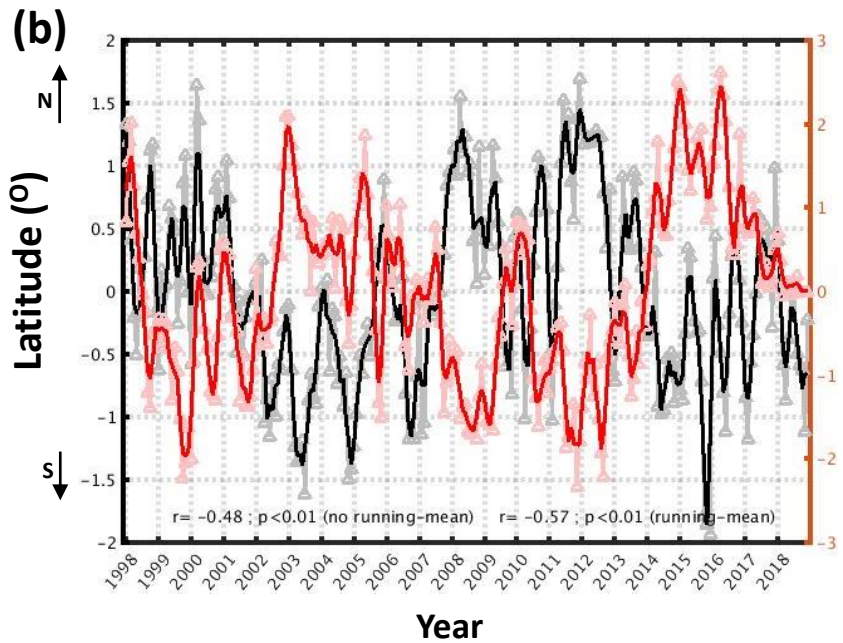
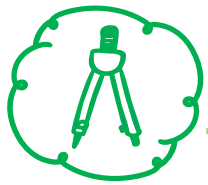


Figure 8 (a) correlation coefficient between the PDO Index and deseasoned Chl-a time series. (b,c) Time series of PDO Index and NPOD central position



Results and discussion: Linkage of NPOD to ocean physics

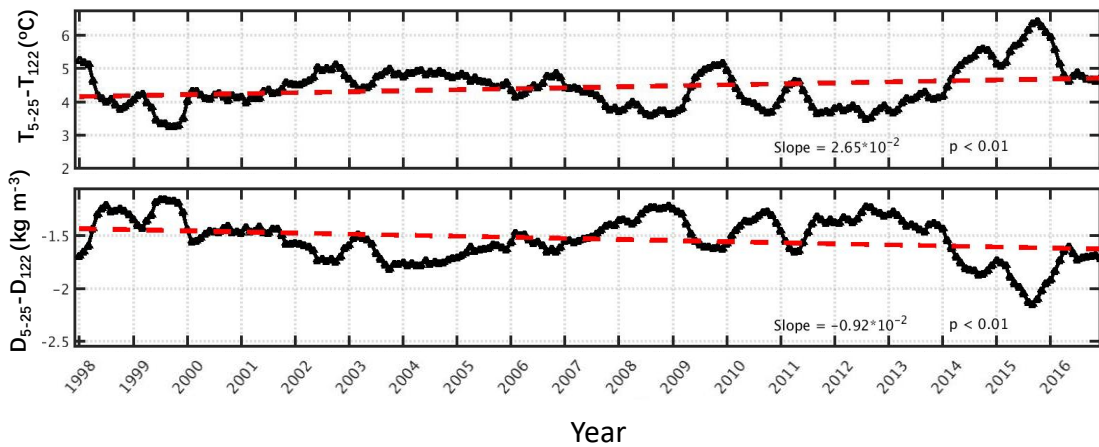
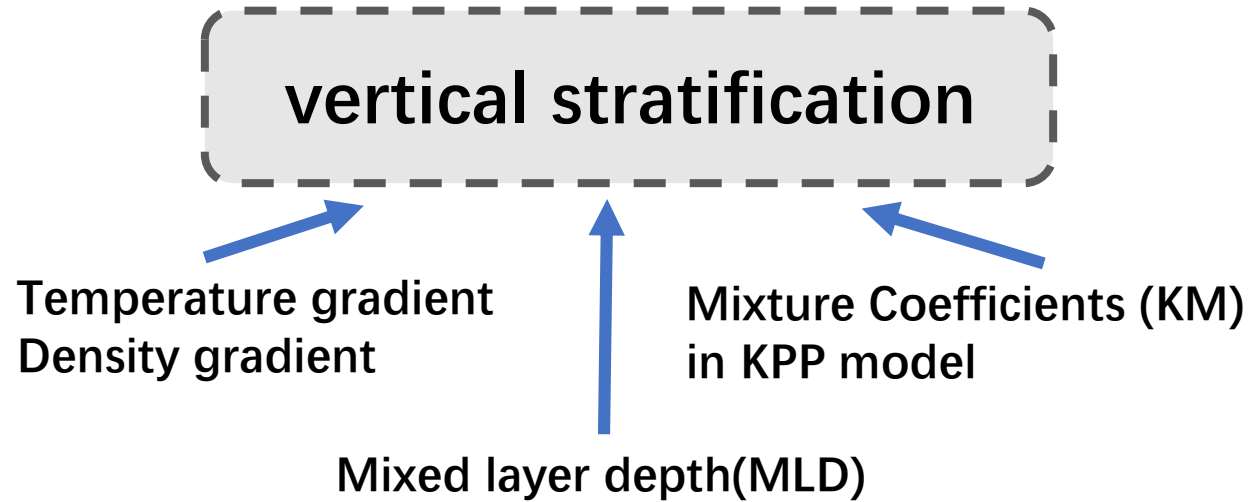


Figure 9 Temperature gradient and density gradient in NPOD.

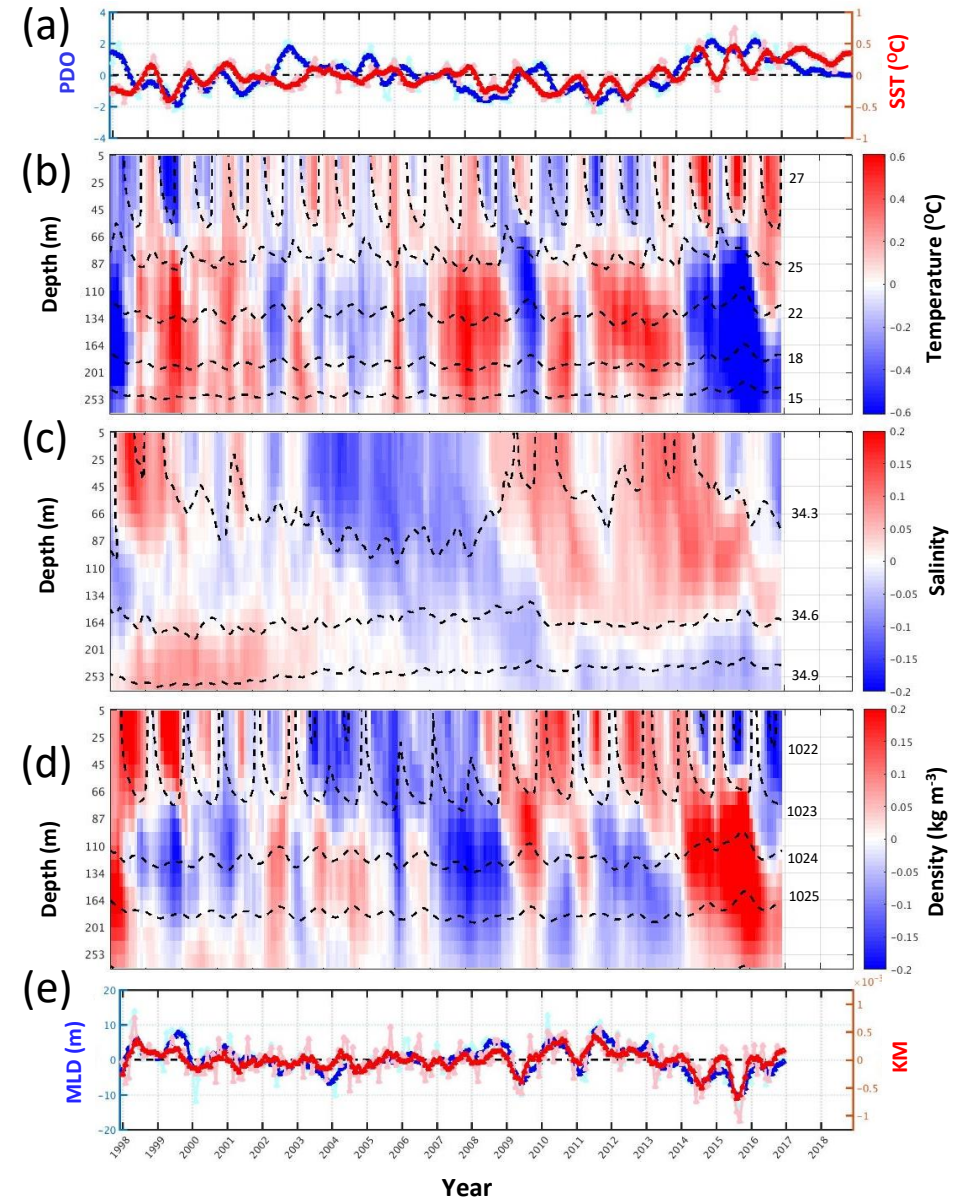
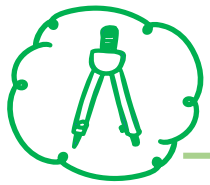


Figure 10 Impact of sea surface temperature (SST) variation on the NPOD oligotrophication





Conclusion

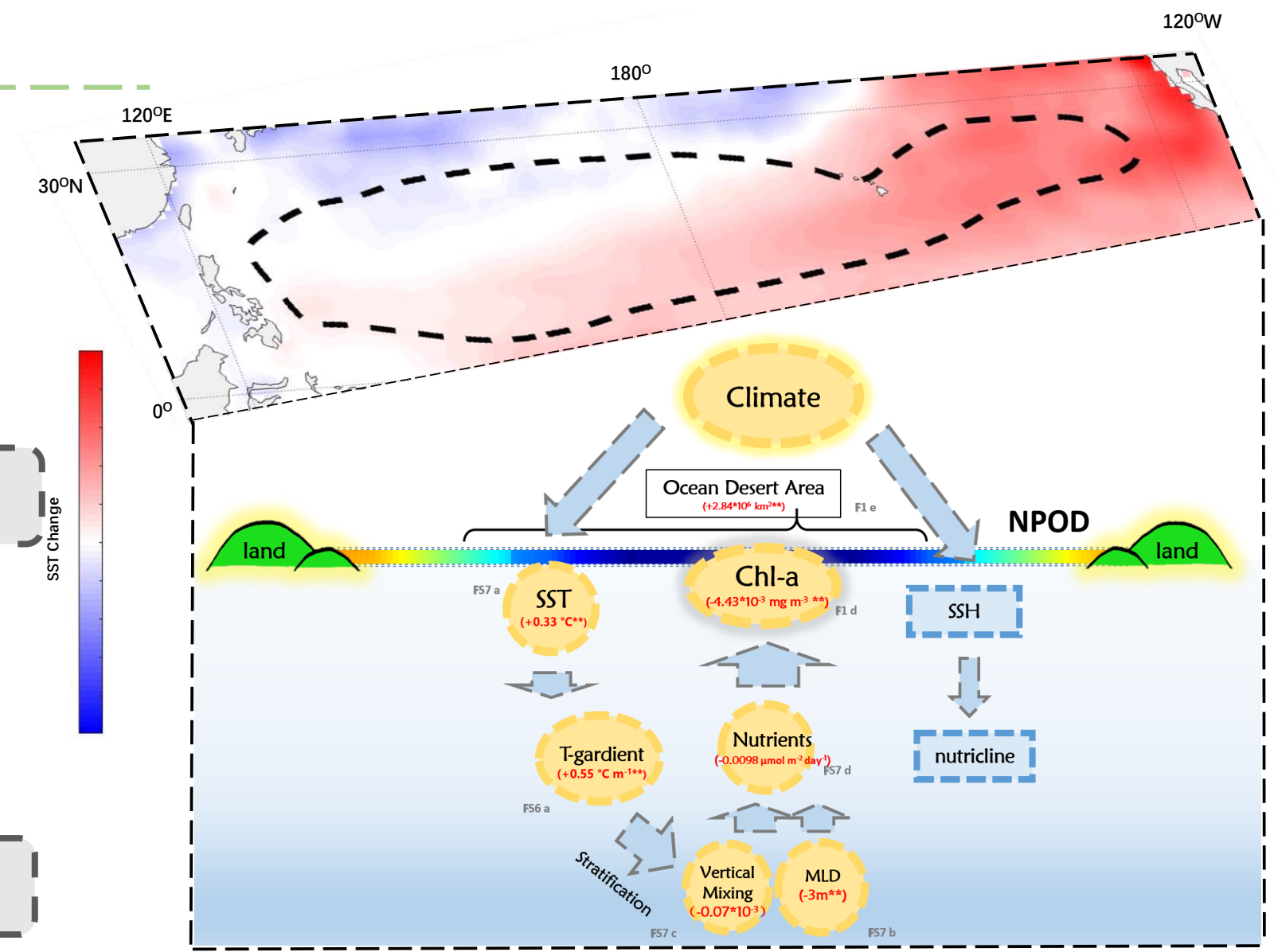
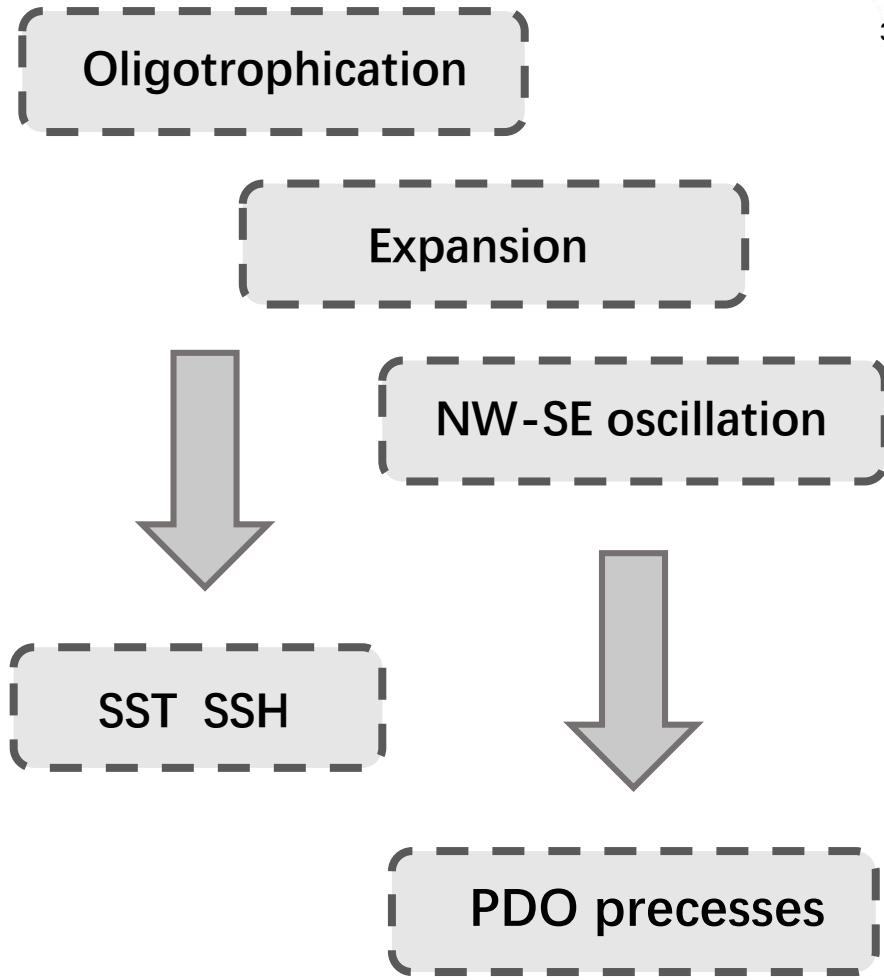
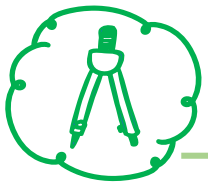


Figure 11 Schematic of the interactive mechanism between the North Pacific Ocean Desert (NPOD) and multiple climate factors.



Future Plan

Seasonality of ocean deserts

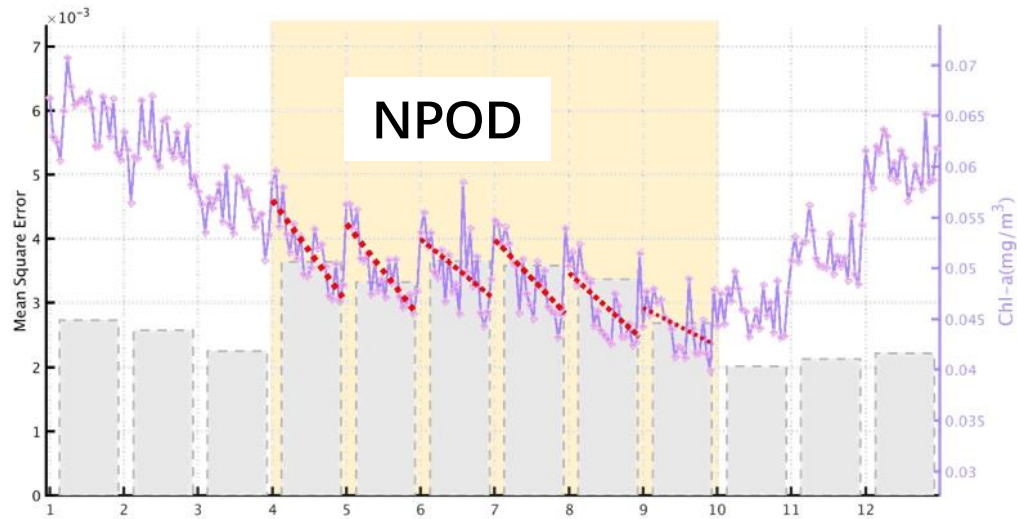


Figure 12 Oligotrophication posesesses in different month.

Other four ocean deserts

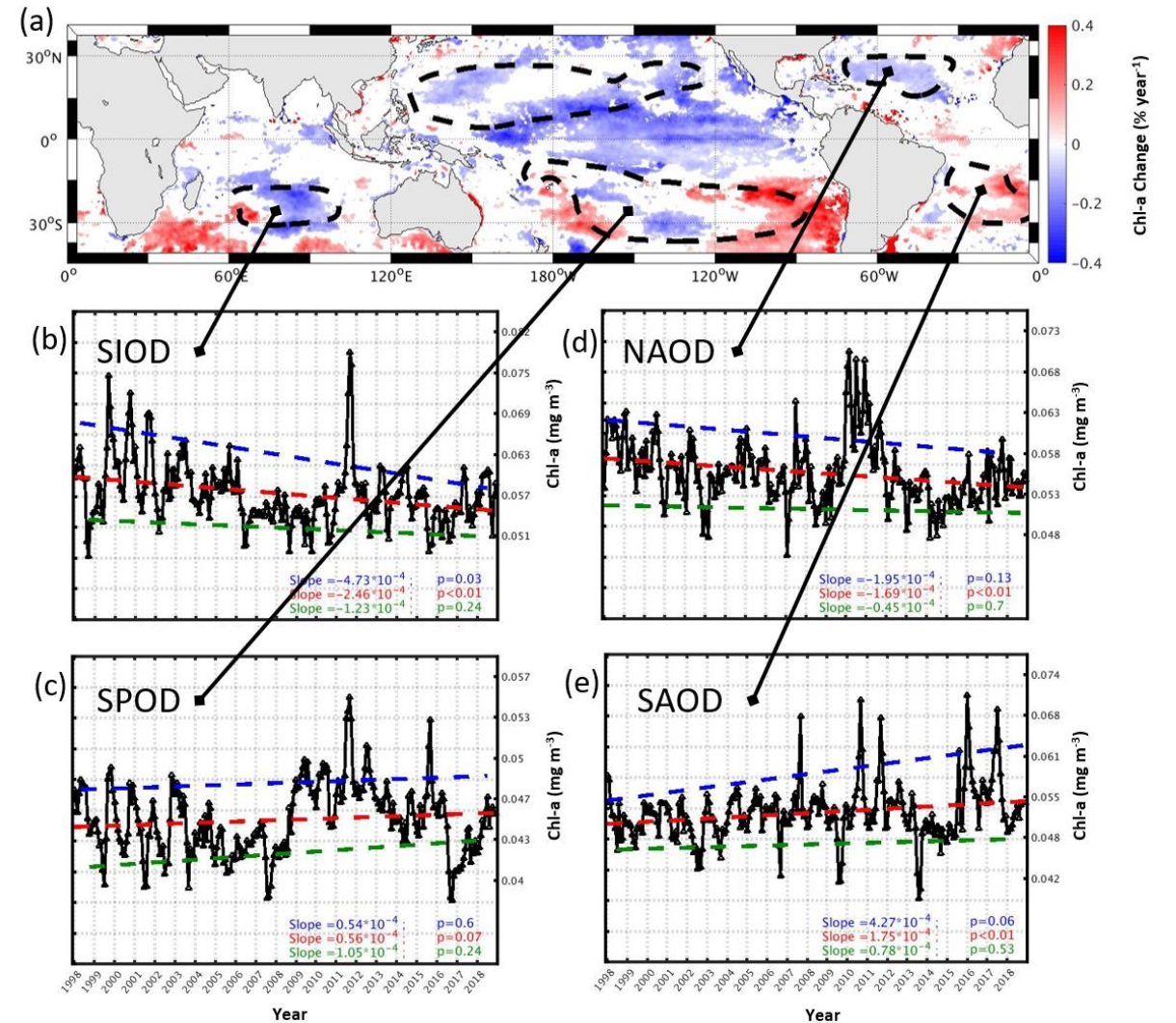


Figure 13 Spatial (a) and temporal (b-e) changes of the SIOD, SPOD, NAOD and SAOD intensity



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Thanks for your attention

2020-10-28

Topic-VS4

