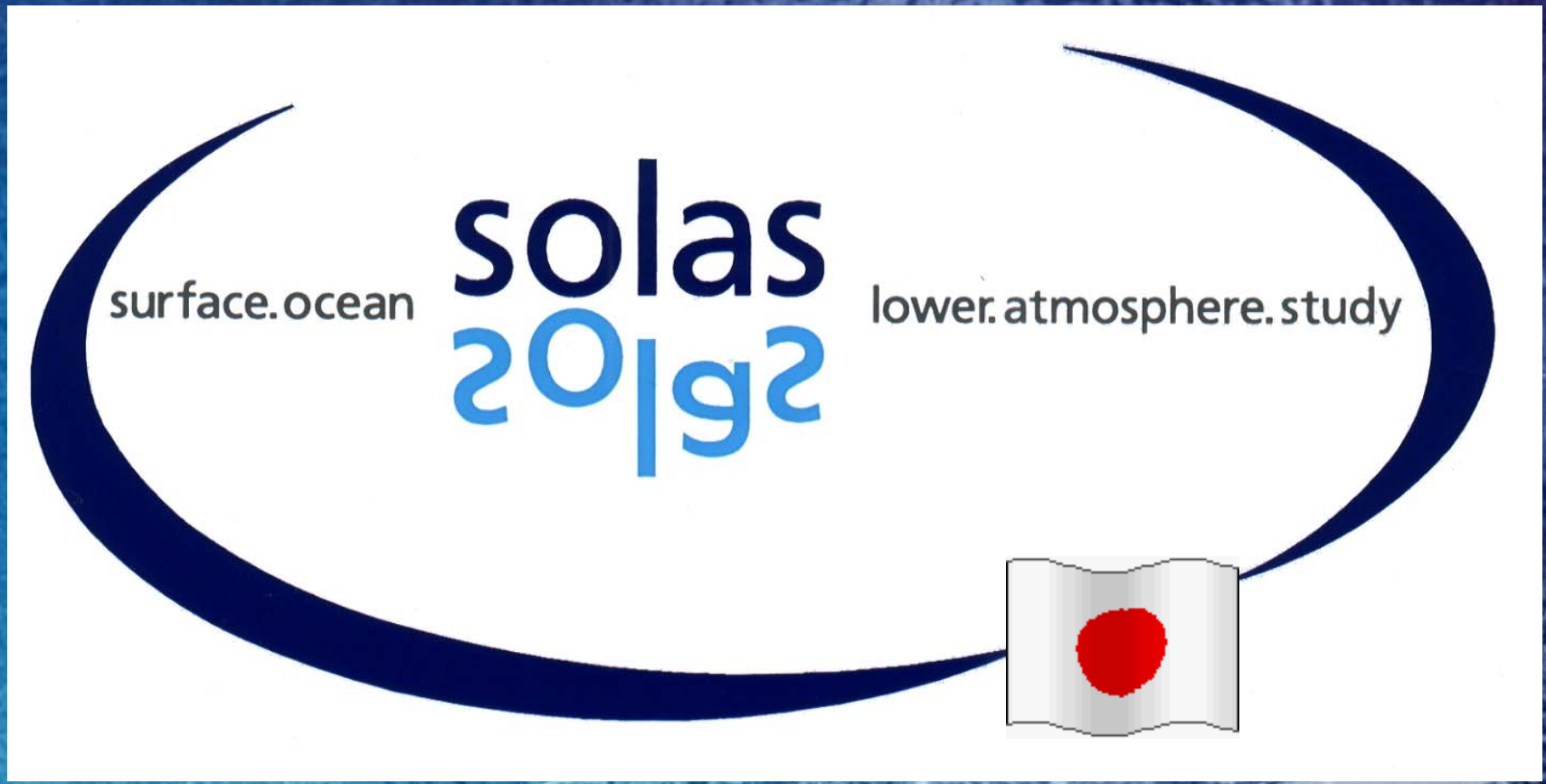
PICES MONITOR/BIO Workshop 5
October 27, 2007

# The effect of tropical cyclone on the primary production enhancement - Some results from the W-PASS (Western Pacific Air-Sea interaction Study) project

Eko Siswanto, Joji Ishizaka, Mitsuhiro Toratani, Toru Hirawake and Sei-Ichi Saitoh

**W-PASS (Western Pacific Air-Sea interaction Study) project**

# Solas-Japan Chair: Mitsuo Uematsu




**Linkages in Biogeochemical Cycles Between Surface Ocean and Lower Atmosphere**

# Background

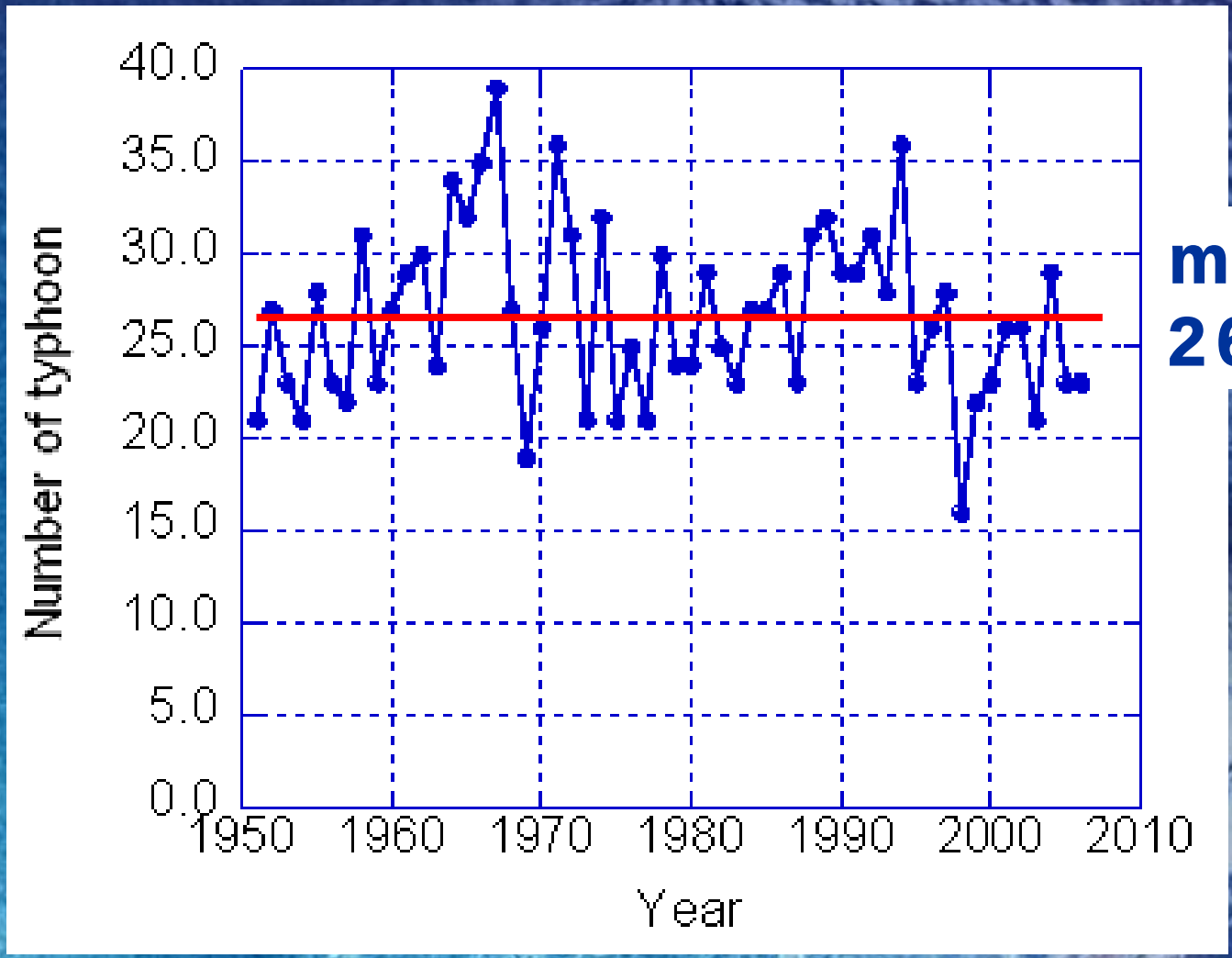
**The facts have been known:**

- Typhoon passage can enhance ocean phytoplankton chlorophyll-a and primary production,
- The northwest Pacific typhoon activities have been known to be related to El Nino/La Nina events, but

**Some information have not been documented yet, such as:**

- How El Nino/La Nina events influence ocean primary production in the East China Sea through typhoon activity,
- Complete interannual and interdecadal variations in typhoon-enhanced ocean primary production,
- Estimation of typhoon contribution to summer-fall new production in the East China Sea.

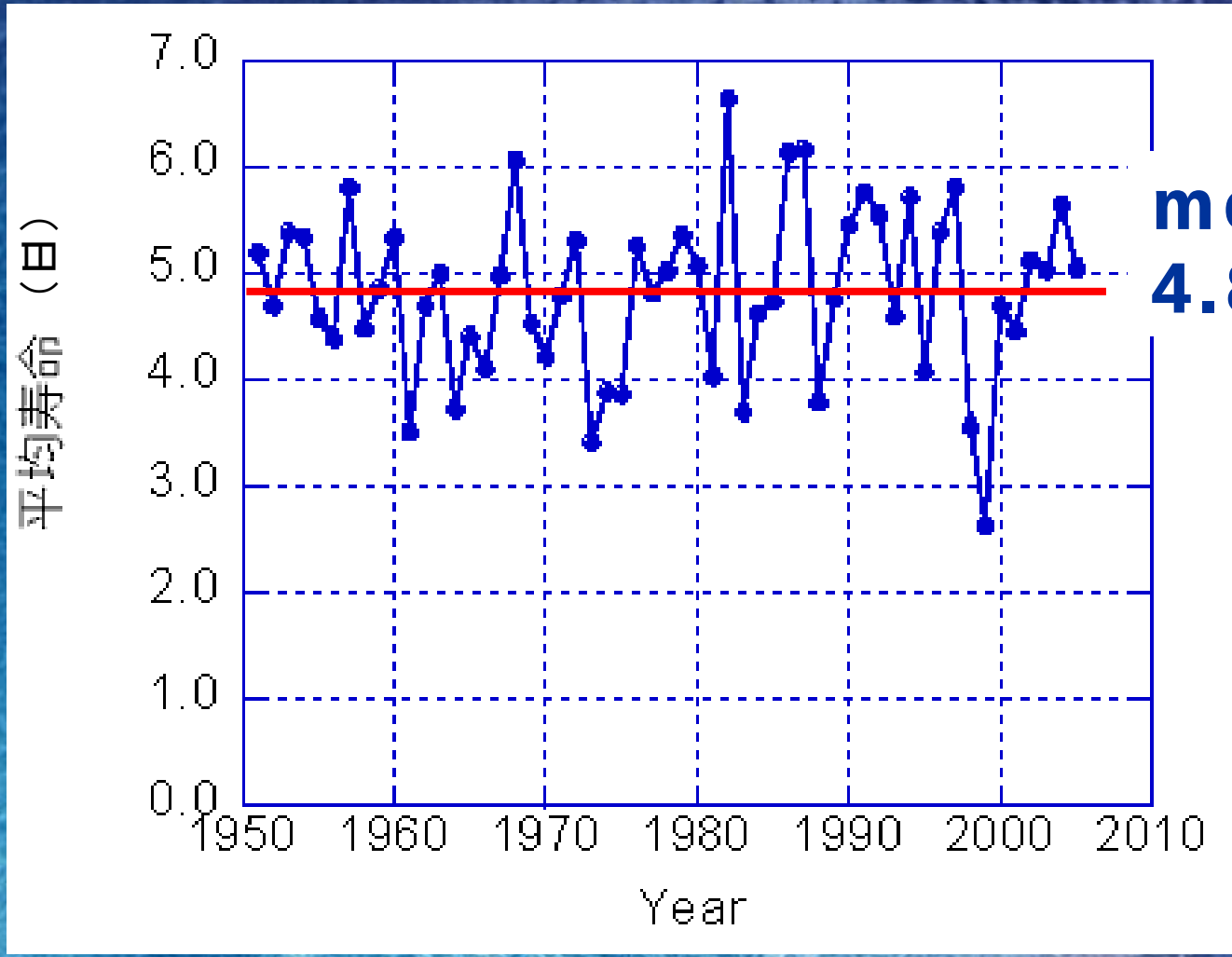
# Number of Typhoon per year




mean
26.6

台風経路データ（気象業務支援センター）より

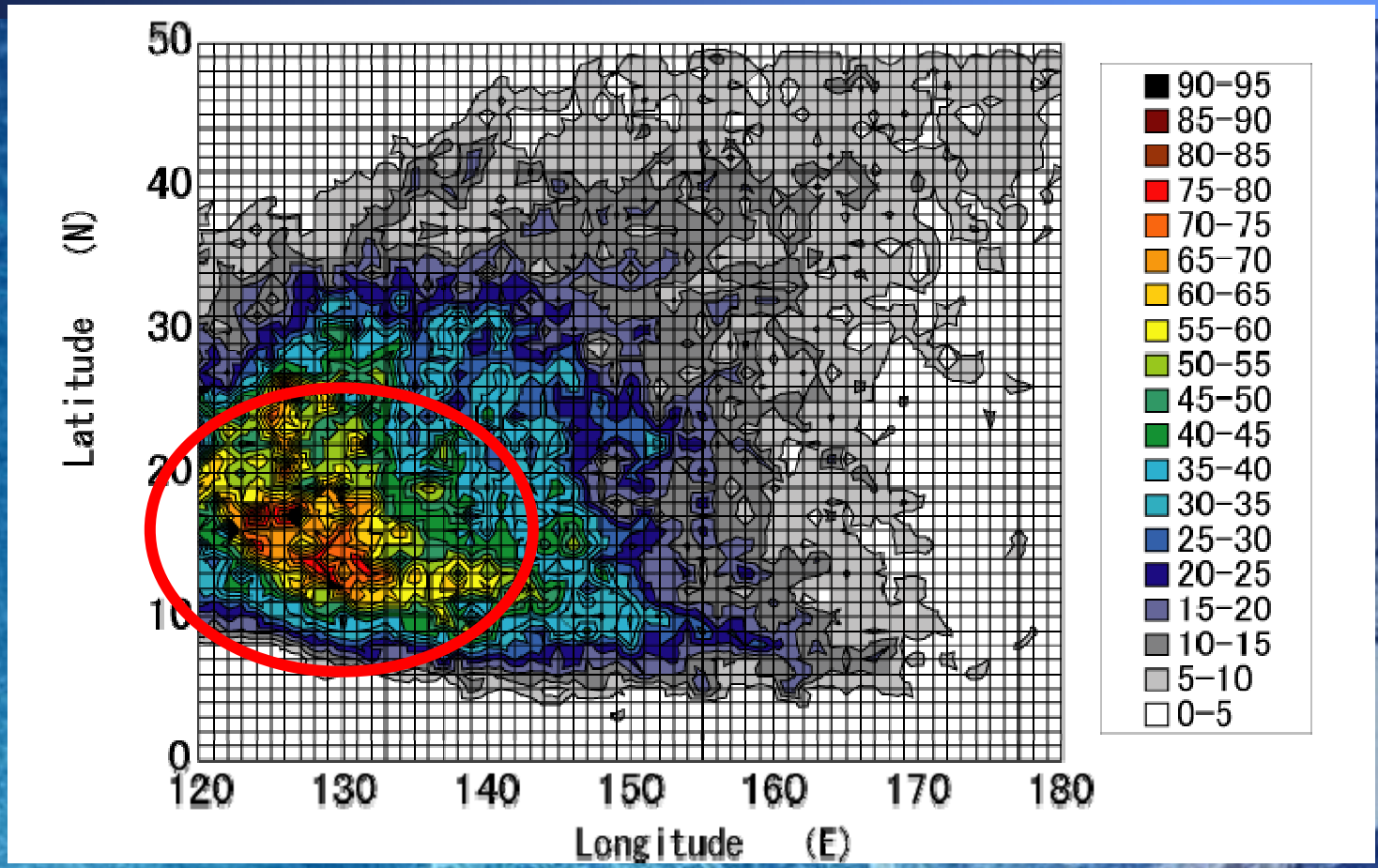
# Life Time of Typhoon




**mean 4.8 days**

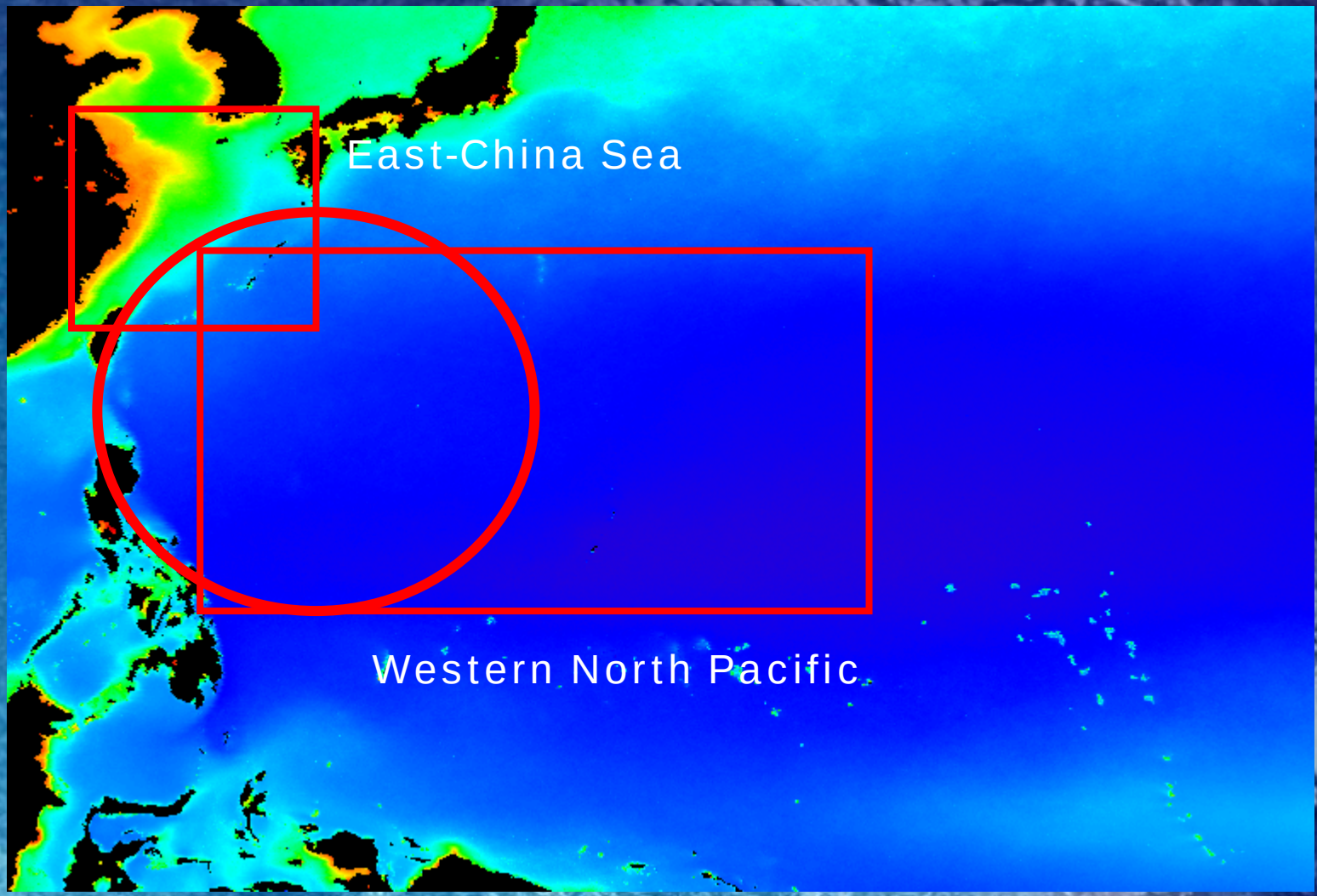
台風経路データ（気象業務支援センター）より

# Spatial Pattern of Frequency of Typhoon Passage (1951-2005)




Number of Typhoon

# Study Area



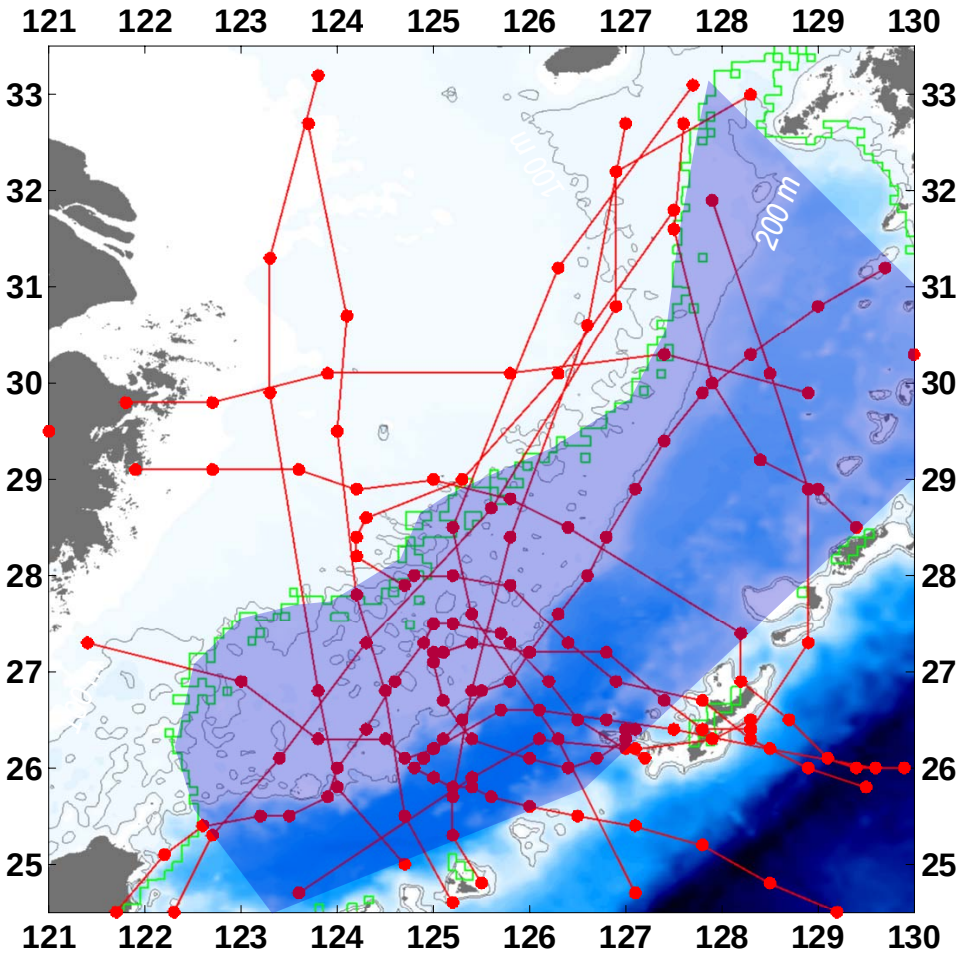
# Interannual and Interdecadal Variations of Typhoon-Induced Primary Production:

## *A Case Study for The Outer Shelf of The East China Sea*

*Siswanto, E., J. Ishizaka, K. Yokouchi, K. Tanaka, C.K.Tan*

*Geophysical Research Letter, 34 (2007)*

# Materials and Methods




**Study Area:**

- *Area delineated with blue polygonal*
- *The west border of the area (green contour) is 0.37 mg $m^{-3}$ chlorophyll-a (Chl-a) isopleth derived from summer mean SeaWiFS Chl-a*

**Study Period:**

- *Summer-fall period (June – October)*

**Satellite Data (1998 ~ 2004):**

- *SeaWiFS Chl-a*
- *SeawiFS photosynthetically available radiation (PAR)*
- *TRMM/TMI sea surface temperature (SST)*

**Typhoon Data:**

- *13 typhoons (red curves and circles) before and after which clear SeaWiFS Chl-a data are available (from Japan Meteorological Agency)*
- *Typhoon variables: typhoon transit speed (TS) and maximum sustained wind (MSW)*

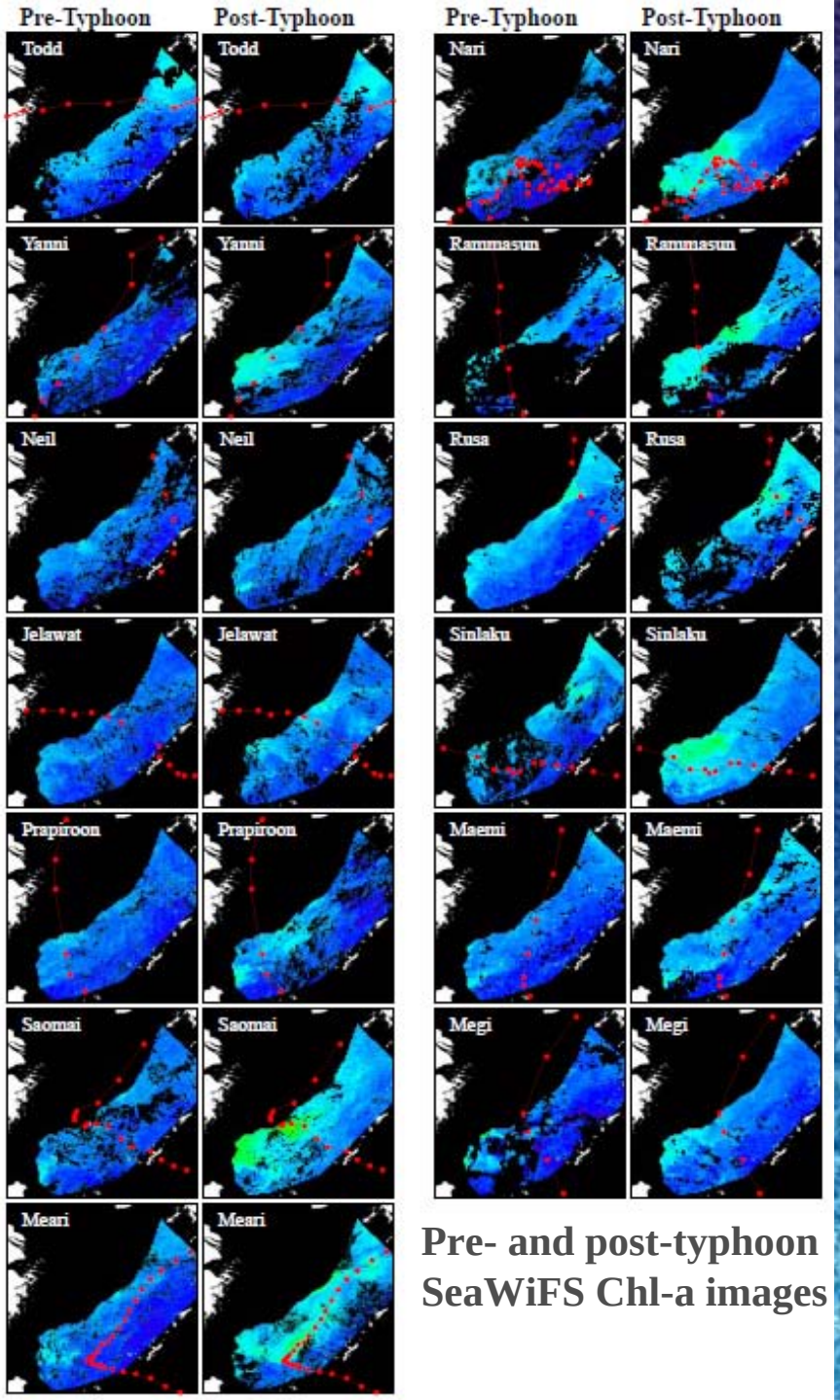
**Primary Production Model:**

- *VGPM (Behrenfeld and Falkowski, 1997)*

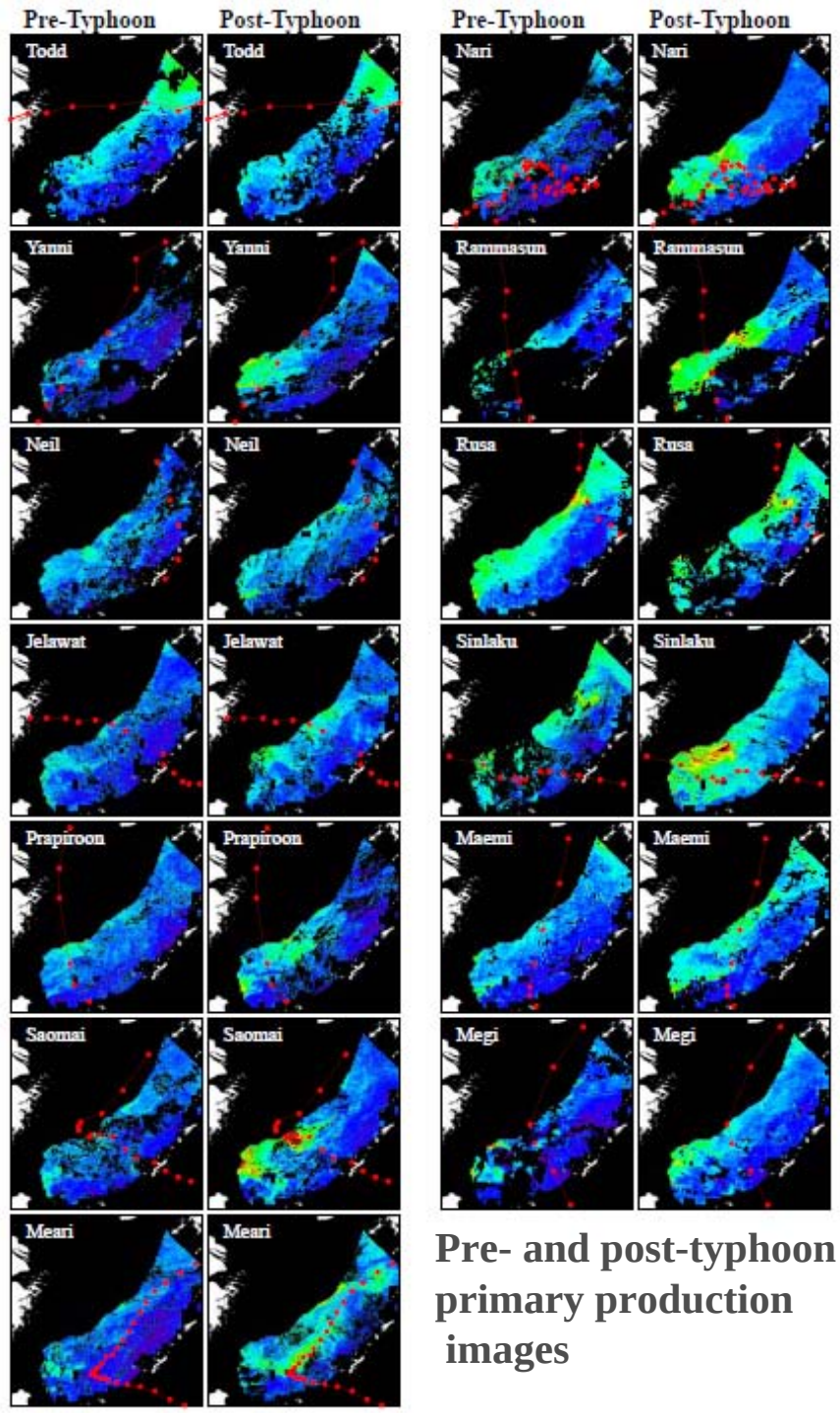
$$PP = 0.66125 \times P^{B}_{opt} \times \left[\frac{PAR}{(PAR + 4.1)}\right] \times Z_{eu} \times Chl_0 \times D_{irr}$$

*Combined with specific $P^{B}_{opt}$ model for the ECS (Siswanto et al., 2006)*

$$P^{B}_{opt} = 9.06\ e^{0.08\,SST}$$

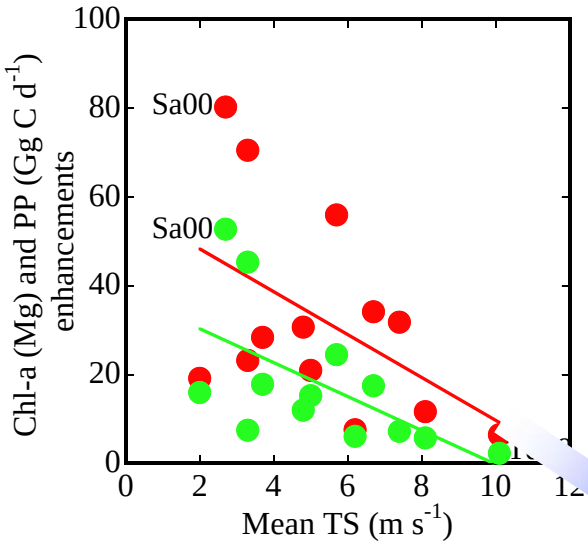


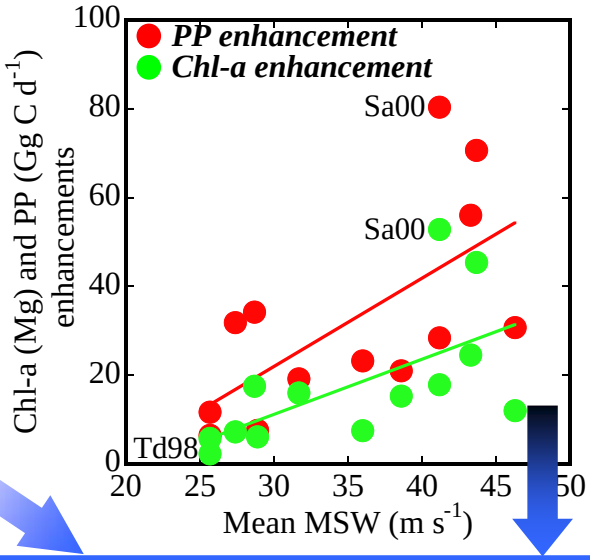

**Pre- and post-typhoon SeaWiFS Chl-a images**

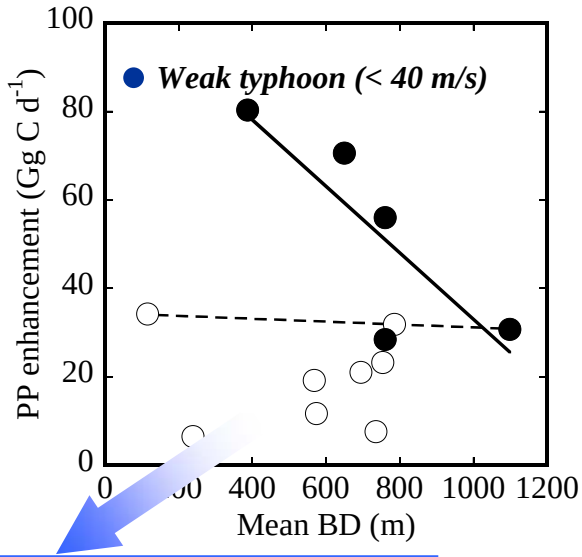



**Pre- and post-typhoon primary production images**

# Chl-a, PP Enhancements Vs. Typhoon Variables, Bottom Depth (BD)

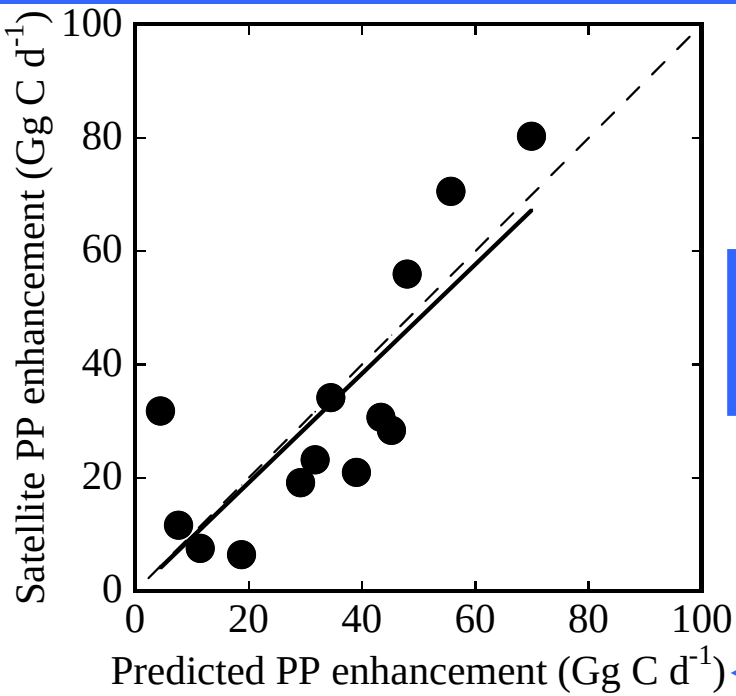


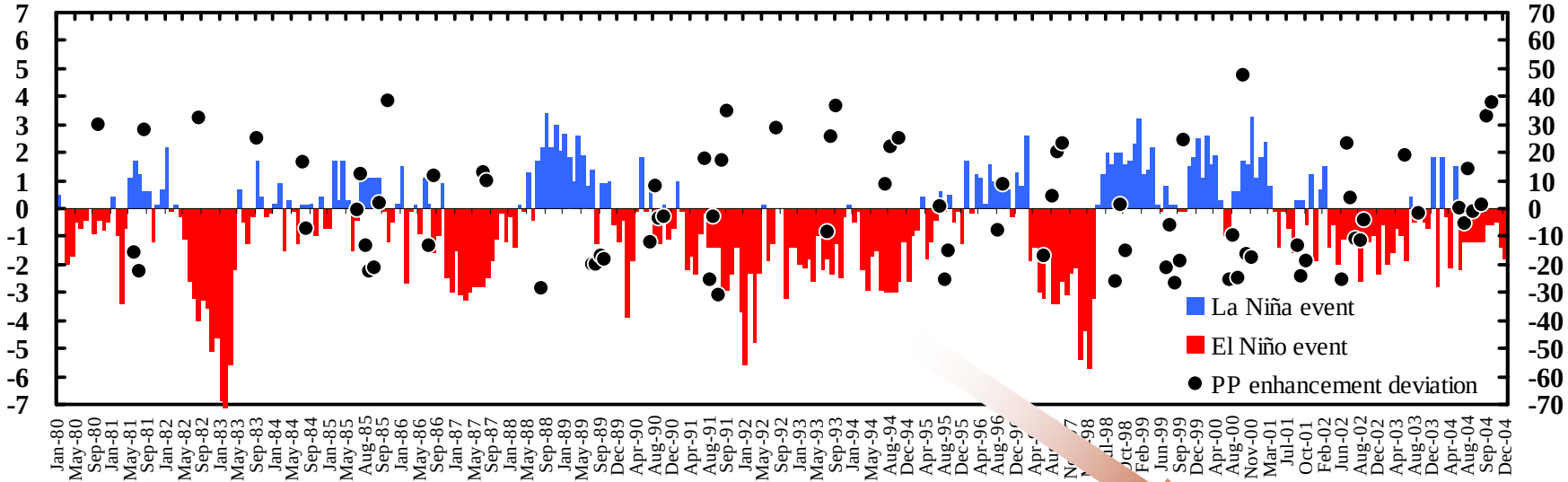

**PP enhancement = -28.14 + 2.57 Mean MSW – 0.98 Mean TS – 0.04 Mean BD**

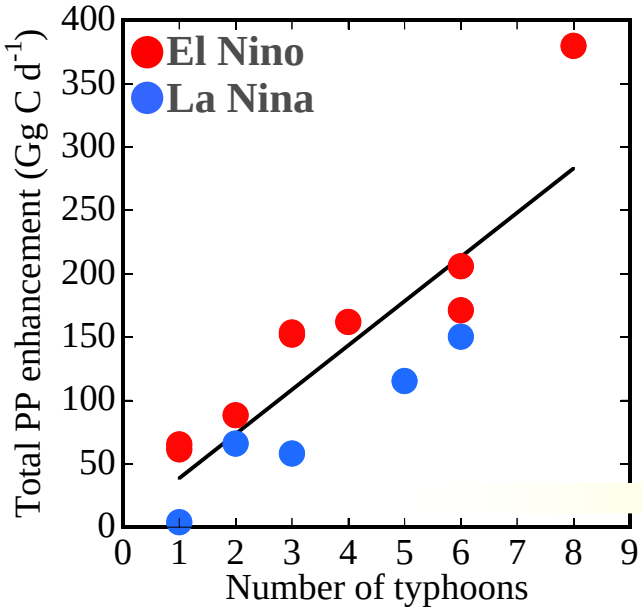
**TS: Transit Speed**
**MSW: Maximum Sustained Wind**
**BD: Bottom Depth**

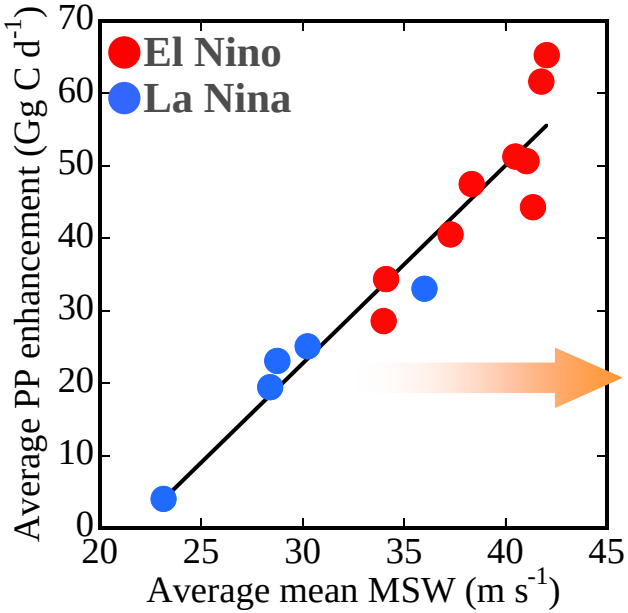



**Empirical relationship**

# Relation to El Nino/La Nina events



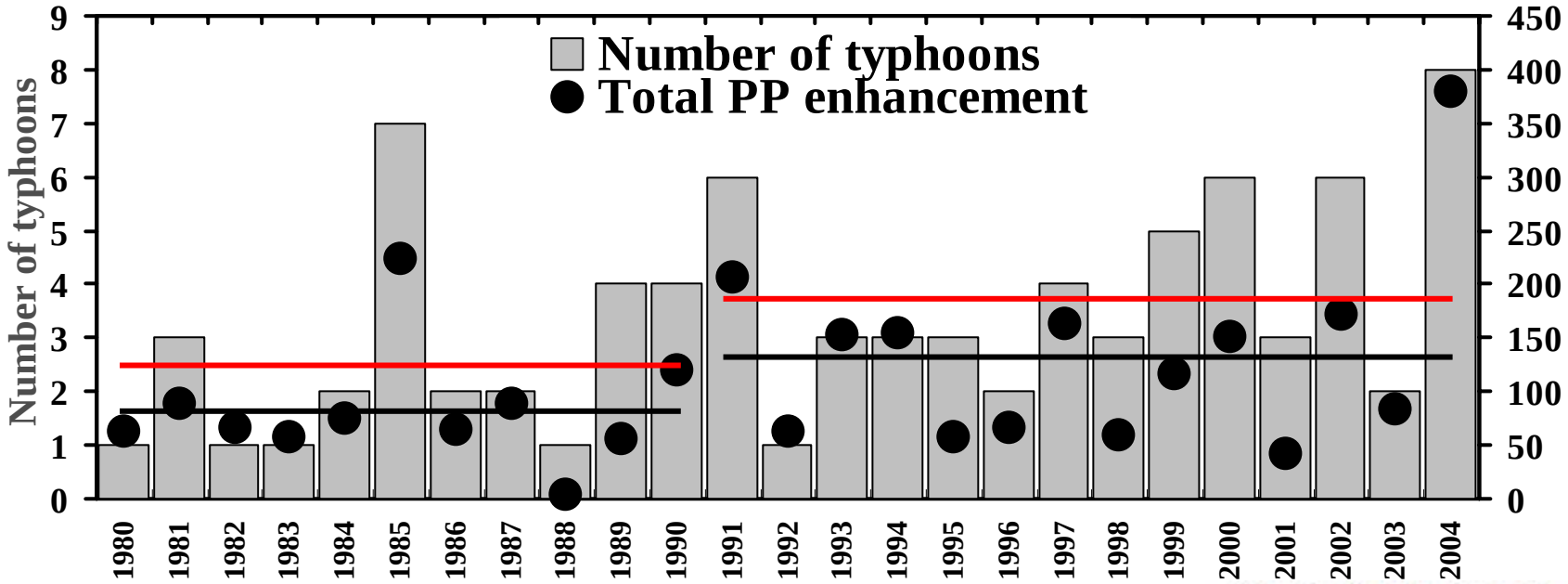




***In general, PP enhancements inversely oscillated with SOI***

***PP enhancements were higher during El Nino years associated with higher MSW***

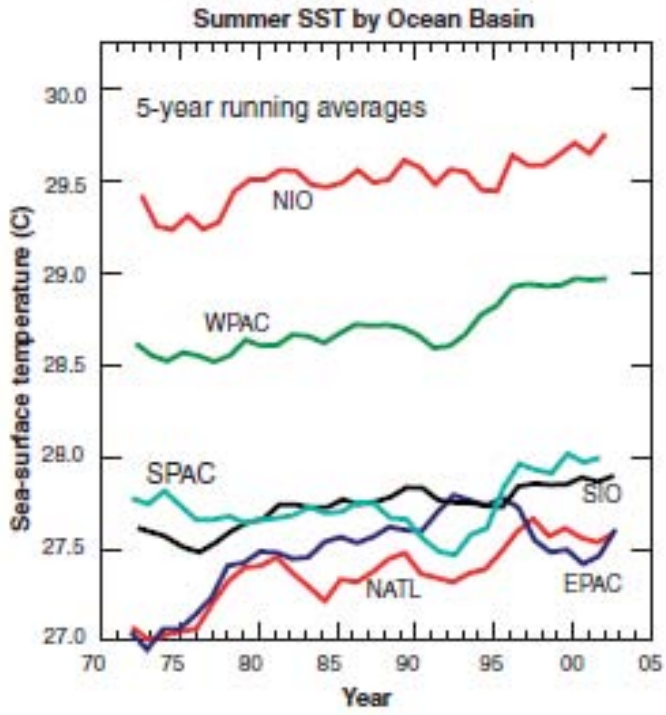
***Total PP enhancements were not related to number of typhoons***

# Trend During the Past 25 Years




**Trend Observed:**

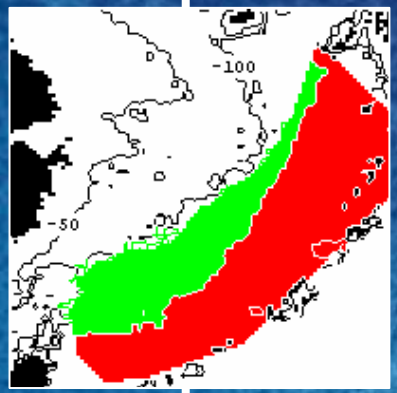
- ***During the past 25 years, the number of typhoons has tended to increase (R = 0.48, p < 0.05),***
- ***The mean number of typhoons (red lines) during 1991-2004 period (mean ~3.9 typhoon yr$^{-1}$) > during 1980-1990 period (mean ~ 2.5 typhoons yr$^{-1}$),***
- ***As a consequence, mean total PP enhancement (black lines) during 1991-2004 period (133 Gg C d$^{-1}$) > during 1980-1990 period (82 Gg C d$^{-1}$).***



# Estimates of typhoon contribution on the summer-fall new production in the study region

## Estimates of summer-fall new production

Mean summer-fall primary production (1998 – 2004)



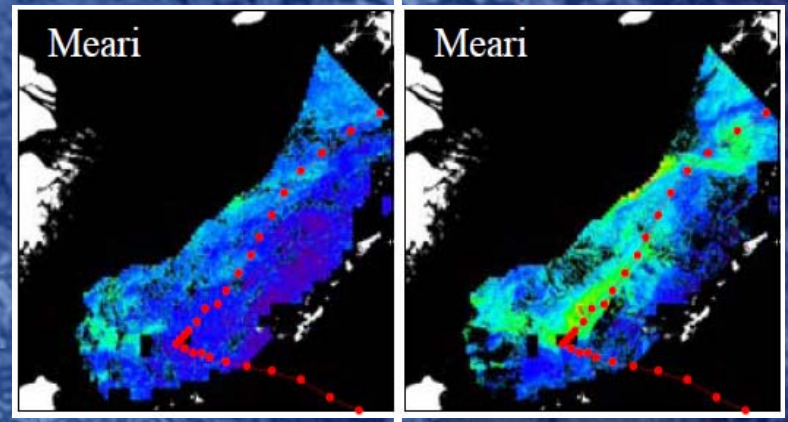

NP/PP ratio

f-ratio = 0.15 (Chen et al., 2003)
f-ratio = 0.1 (Eppley, 1989)

Mean summer-fall new production (1998 – 2004)

## Estimates of typhoon-induced new production

Typhoon-enhanced primary production

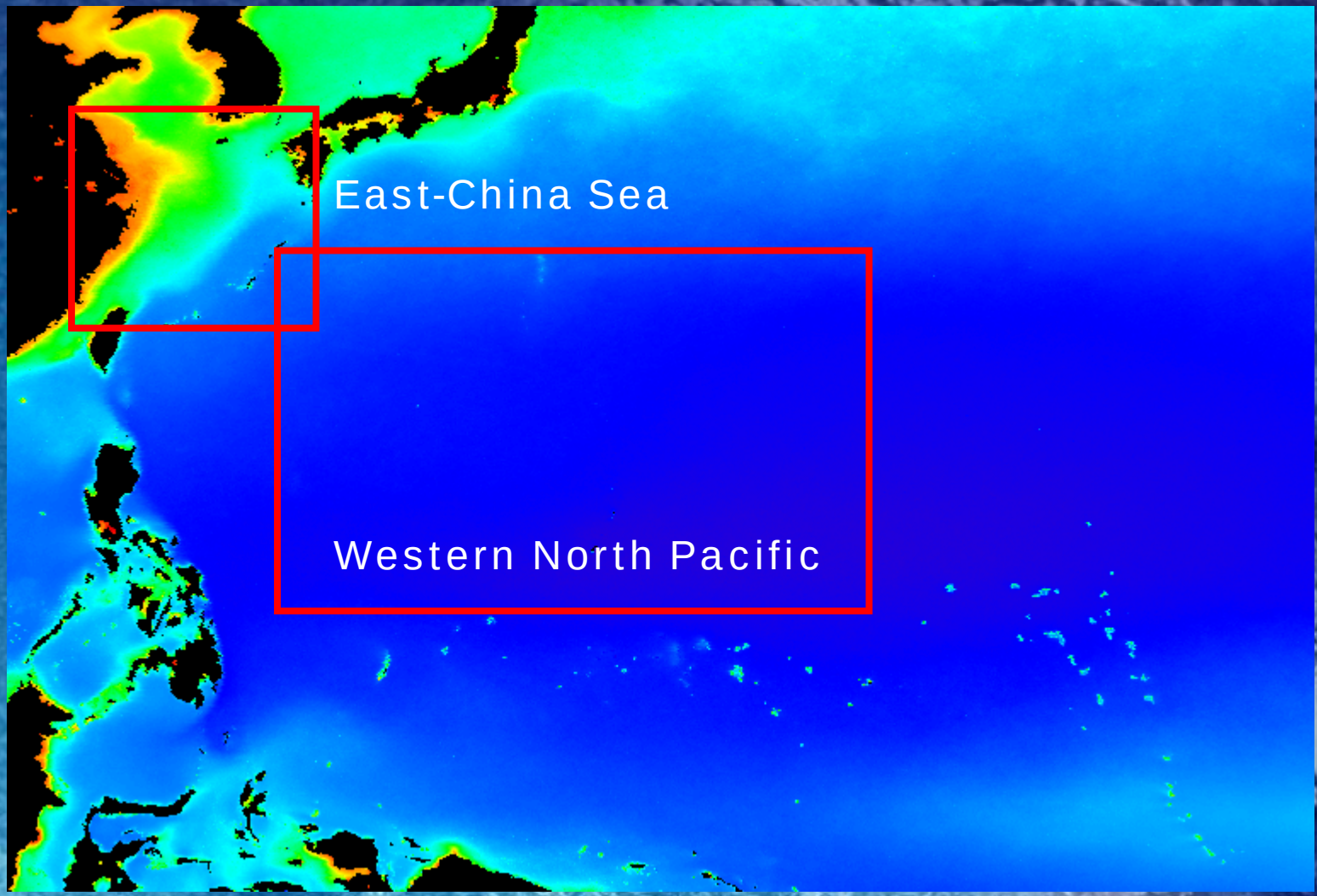



f-ratio = 0.6

Typhoon-induced new production

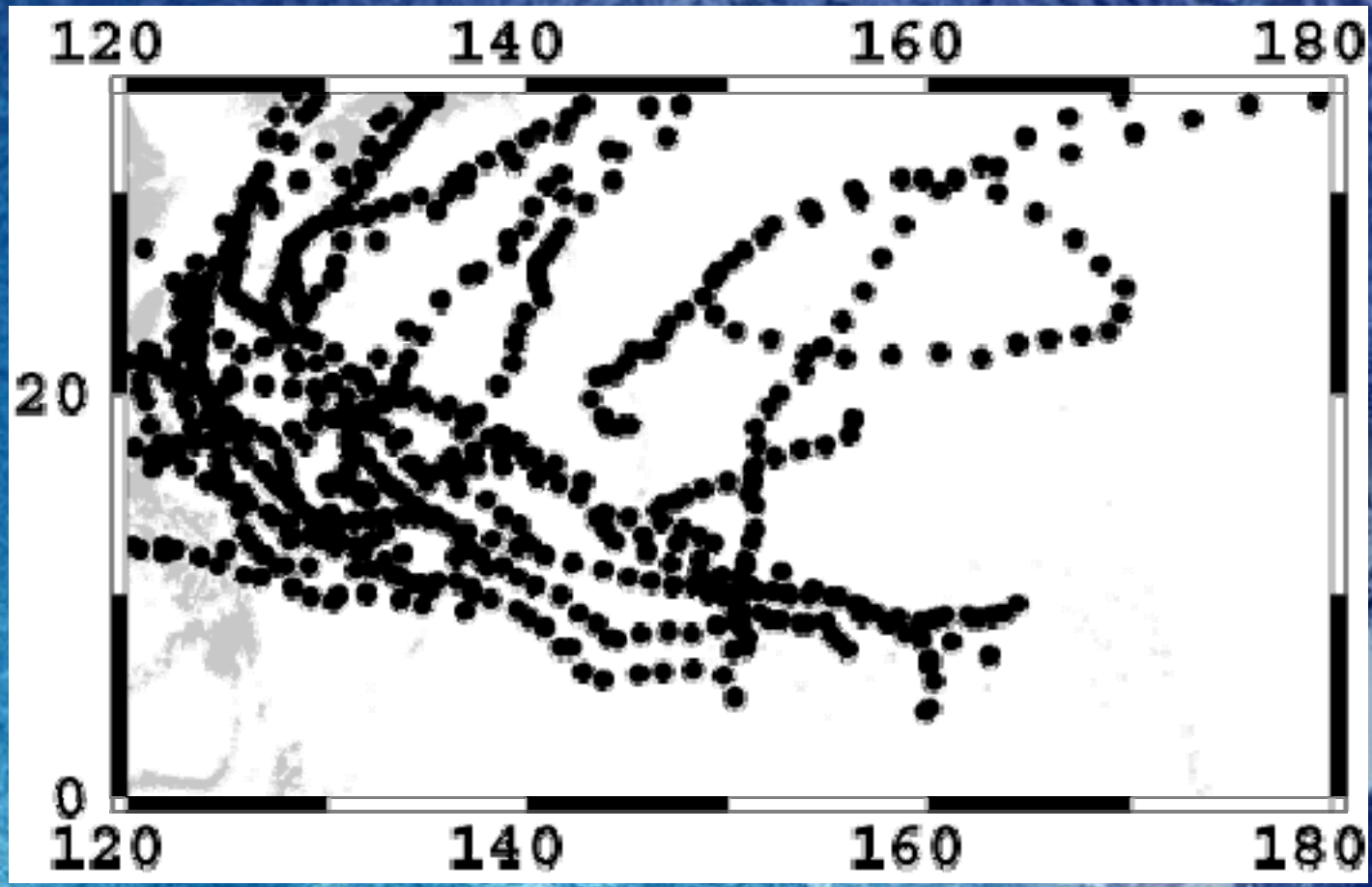
- ***Typhoon contribution to summer-fall new production was lowest in 1988 (0.4%) and highest in 2004 (39.7%) (mean 13.7%),***
- ***Typhoon contribution to summer-fall new production was also higher during El Nino years (16.7%) than during La Nina years (7.2%).***

# Study Area

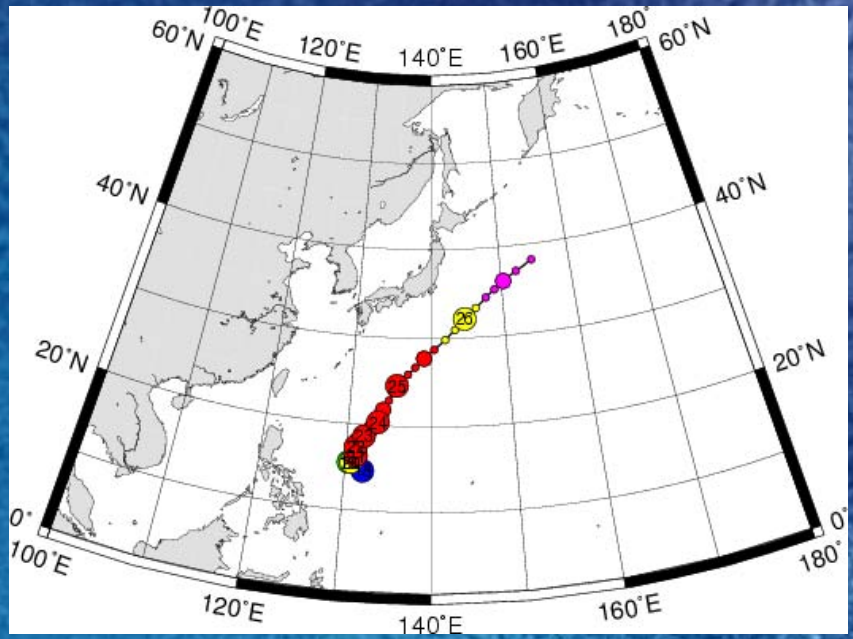


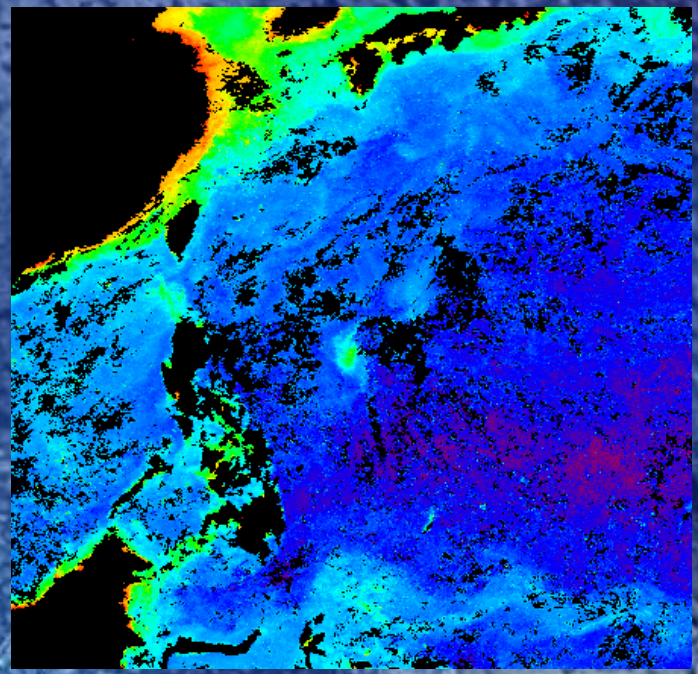
# Number of Typhoon in 2003 = 21

- Trajectory of Typhoon in 2003



# Typhoon No.0317 (2003)



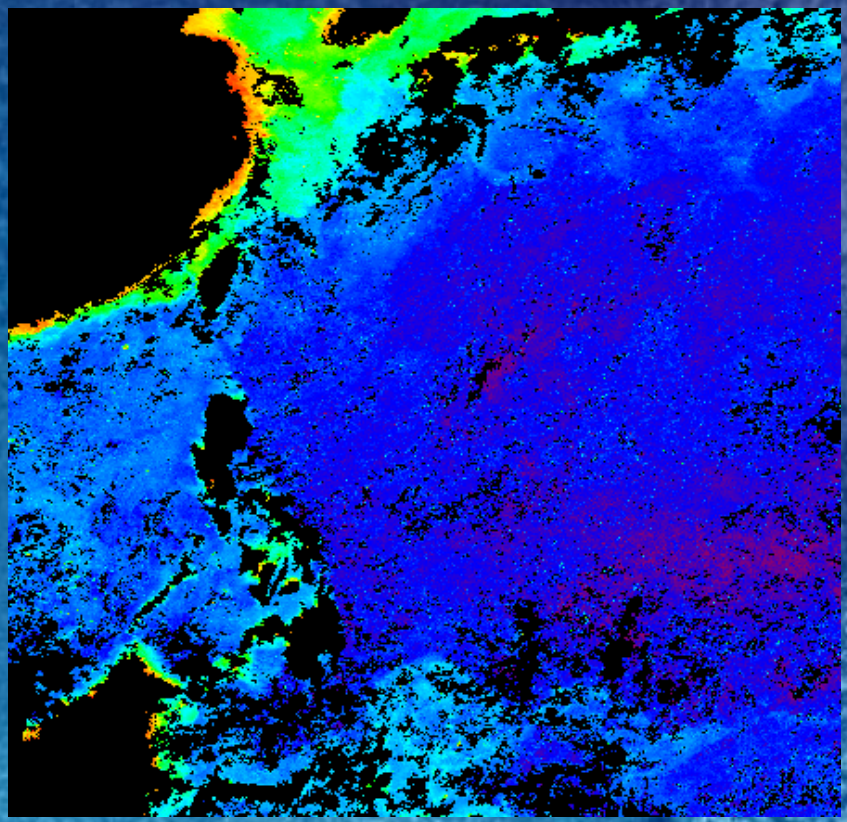



デジタル台風　北本 朝展 @ 国立情報学研究所 (NII)
http://agora.ex.nii.ac.jp/digital-typhoon/summary/wnp/s/200317.html.ja

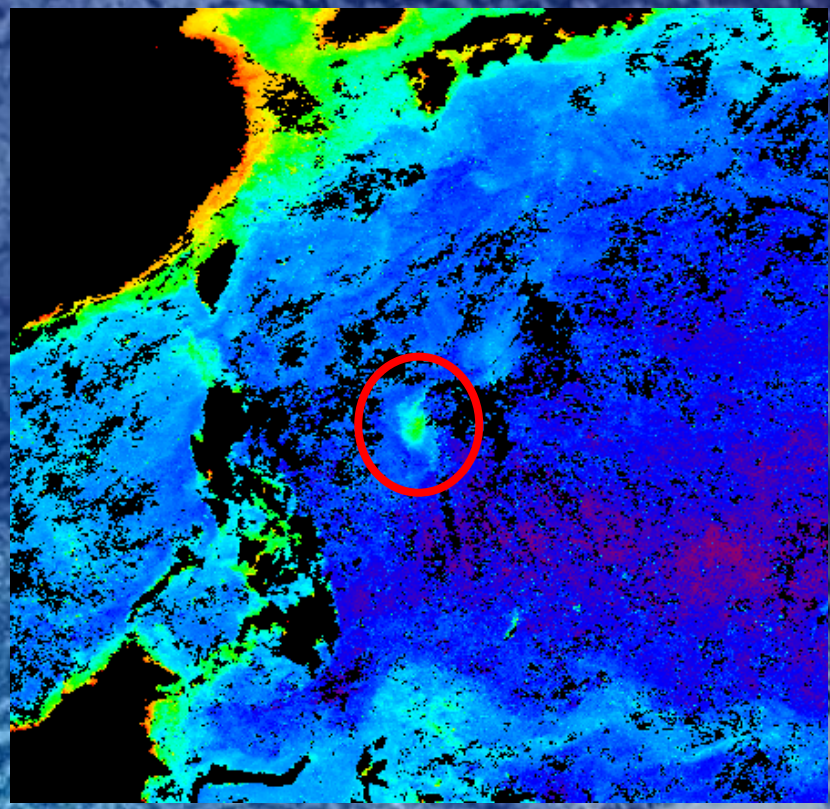
2003-10-19 ～2003-10-26
Minimum Pressure　940hPa
Maximum Wind Speed　46.3m/s
Mean Speed　4.67m/s

- **SeaWiFS 8days Mean Chl-a**
- **October 24-31, 2003**

# Before and After Chl-*a* iamges



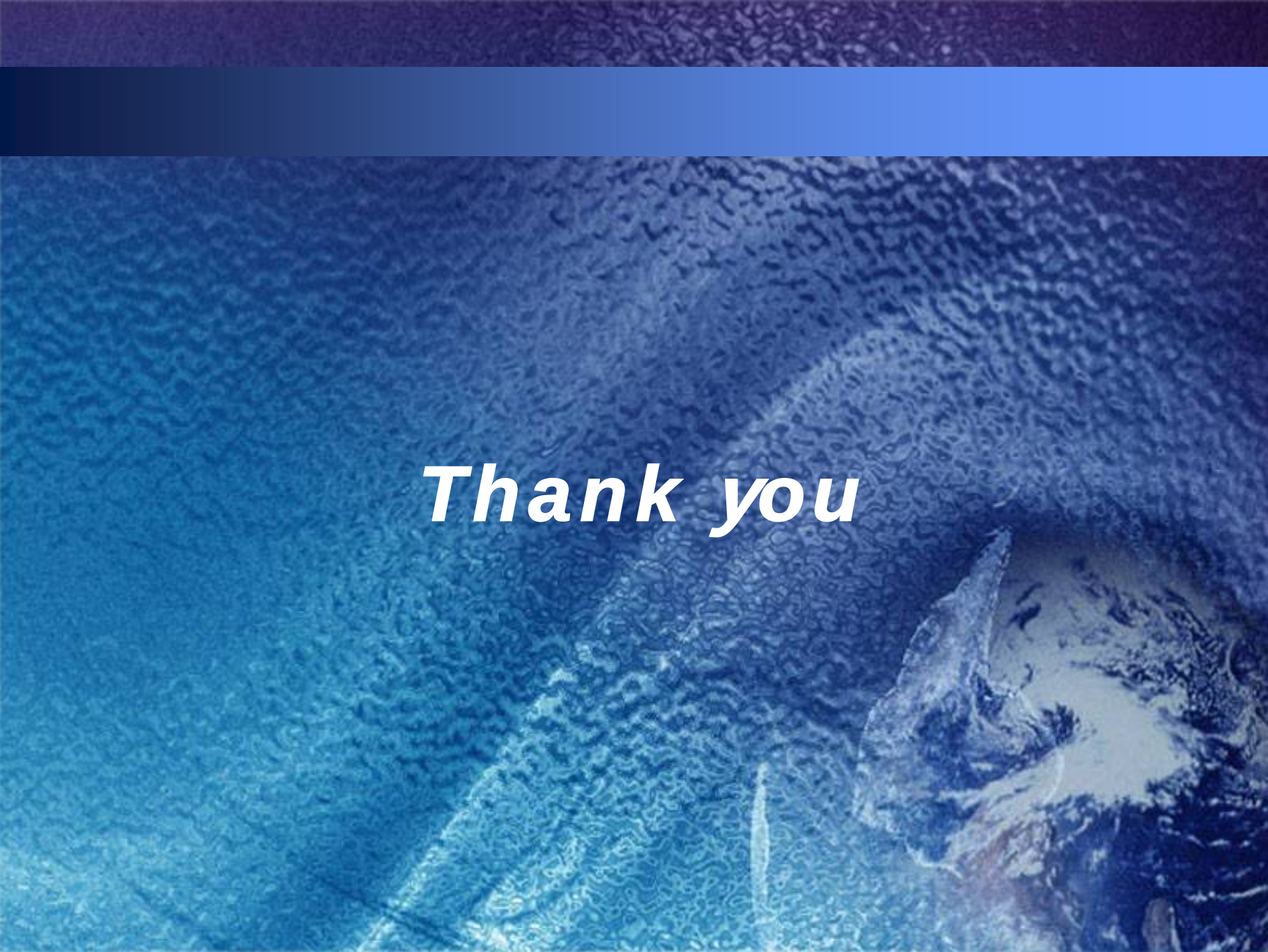
- October 8-15, 2003



- October 24-31, 2003

# Summary

- Using typhoon variables and bottom depth, PP enhancements due to typhoon passage are possible to be estimated even without satellite ocean color data,
- In general, because typhoons tended to be more (less) intense during El Nino (La Nina) years, typhoon-enhanced PP was also higher (lower) during El Nino (La Nina) years,
- Typhoon-enhanced PP has also shown a tendency to be higher during 1991-2004 period than that during 1980-1990 period,
- Typhoon crossing the ECS might contribute within 0.4% - 39.7% of the summer-fall new production in the study region of ECS.


Thank you