Remote Sensing of Typhoons Impact and Disaster Management

- A New Ecological Index for SST Cooling Response to Typhoon

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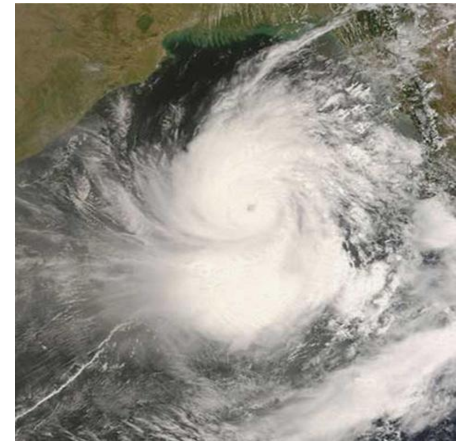
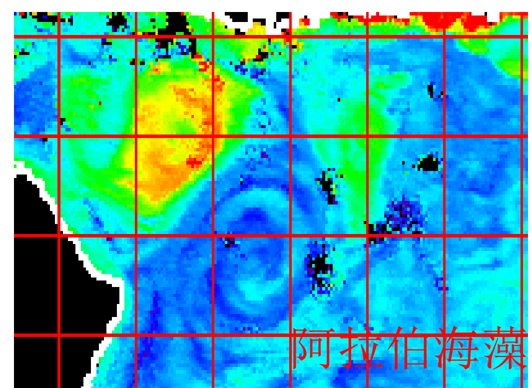
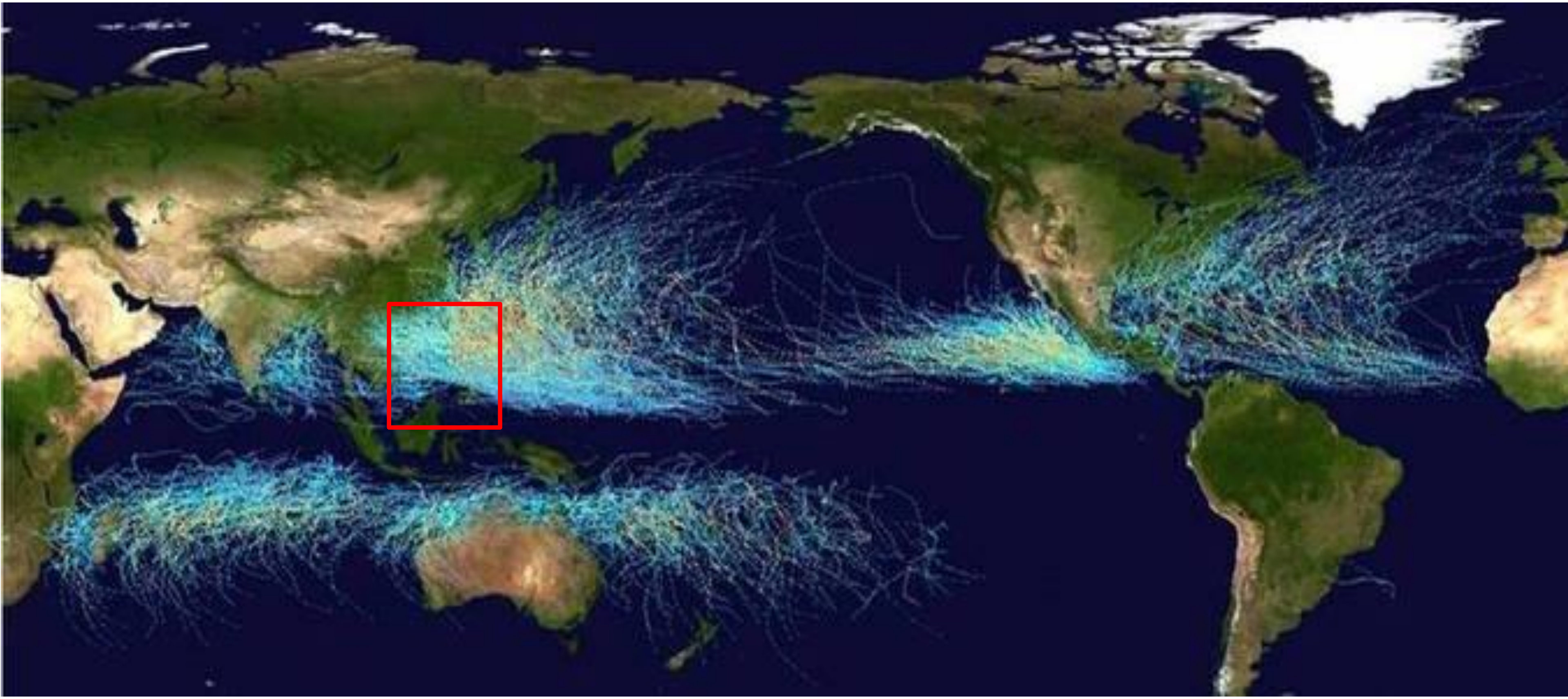
Marine Silk Road

Climate Changes /Natural Hazards

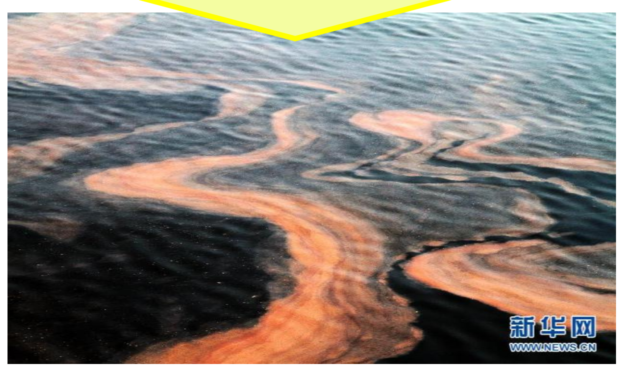






Distribution of typhoon (hurricane)

?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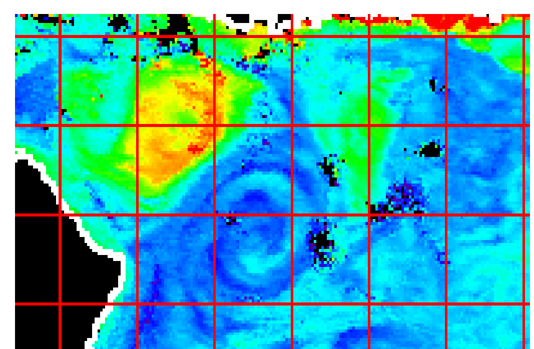


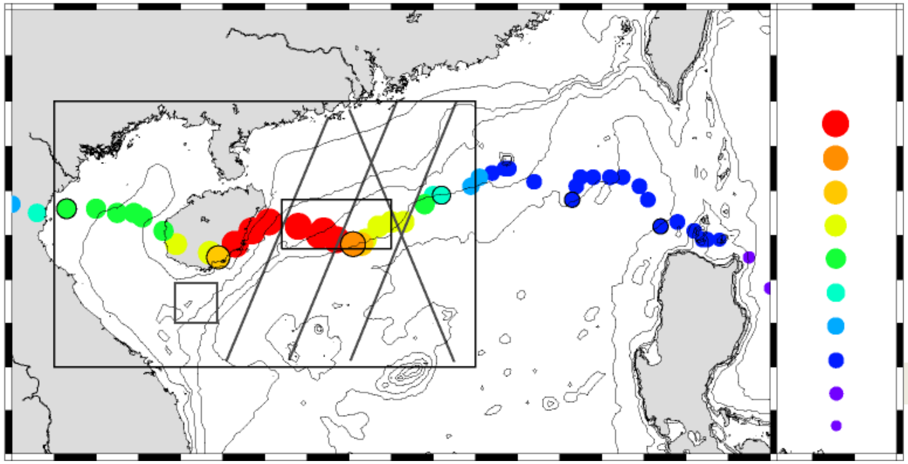
1. Typhoon impacts on marine ecosystem
2. A New Ecological Index for SST Cooling Response to Typhoon
3. Typhoon Disaster Management

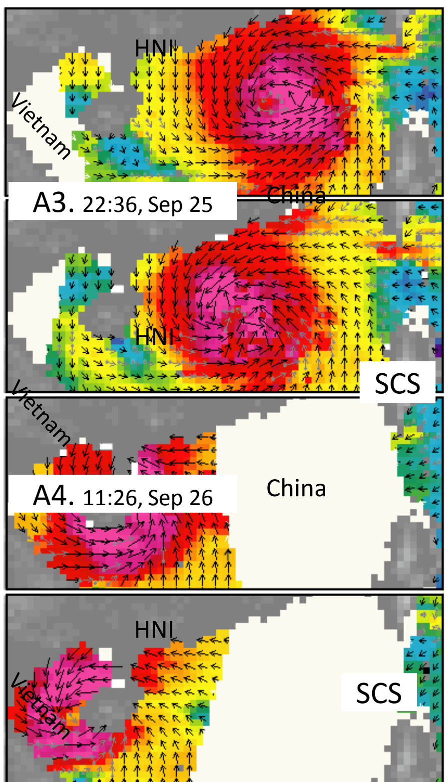
中科院南海海洋研究所 唐丹玲

1

Typhoons impact on Marine Ecosystems

DanLing TANG



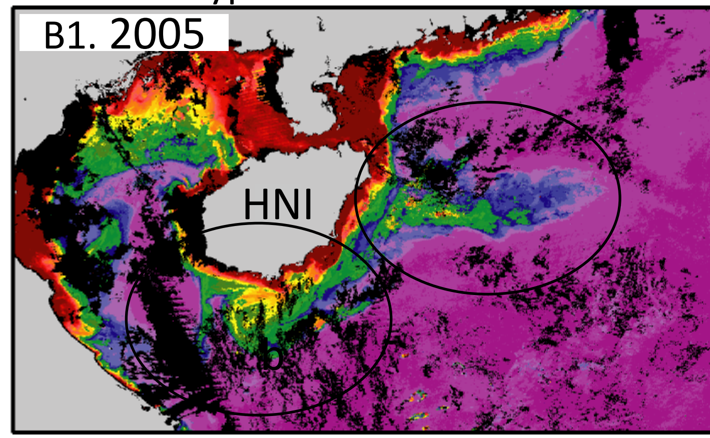


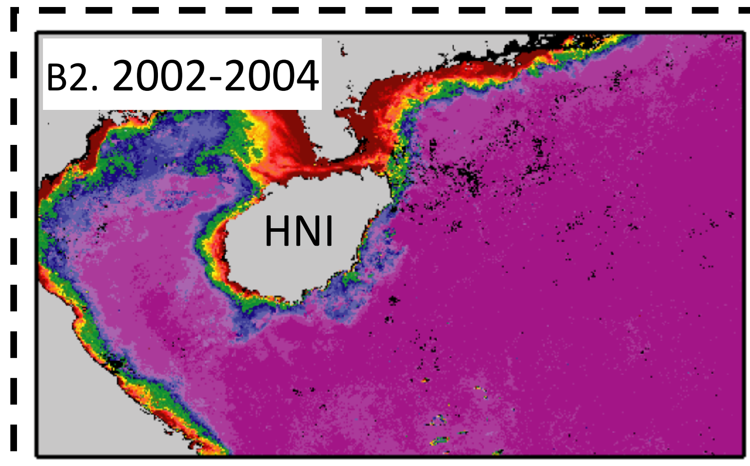
Damrey, Sep 2005

SCS

QuikScat Wind Vectors (m/s)

B. Post-typhoon Chl-a

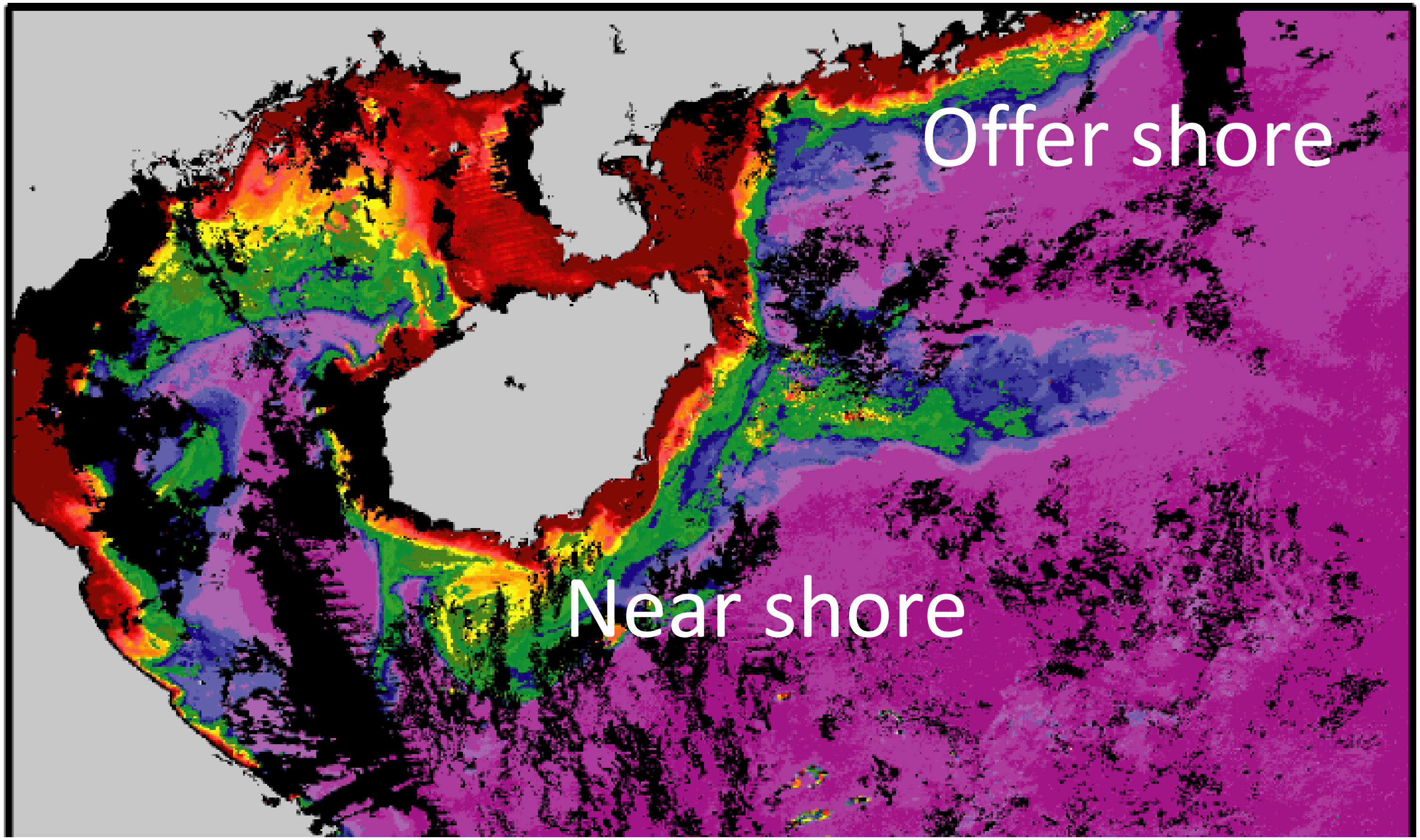




Modis Chl-a (mg m^{-3})

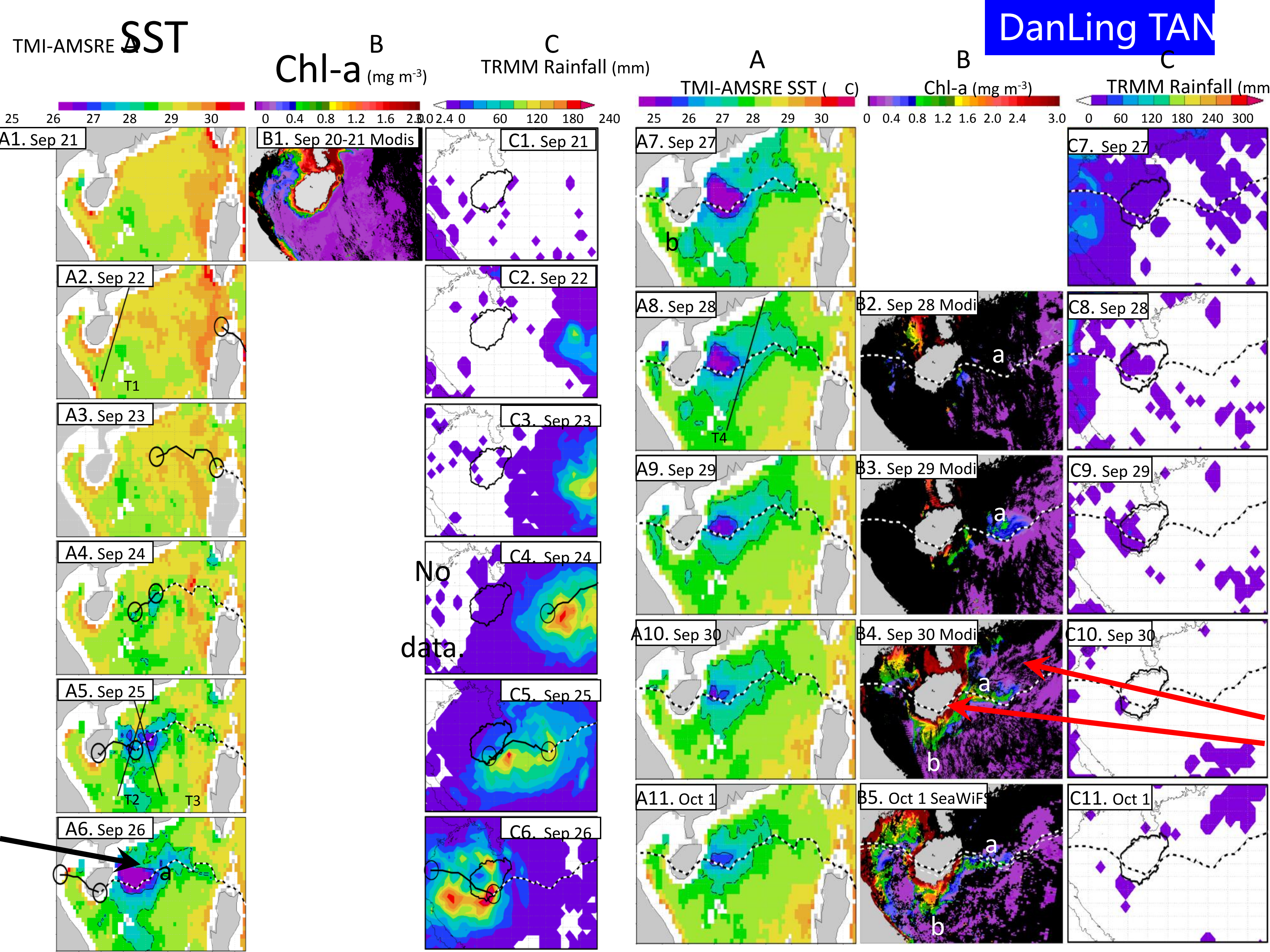
Zheng and Tang, MEPS 2007

Offshore and nearshore chlorophyll increases induced by typhoon and typhoon rain.

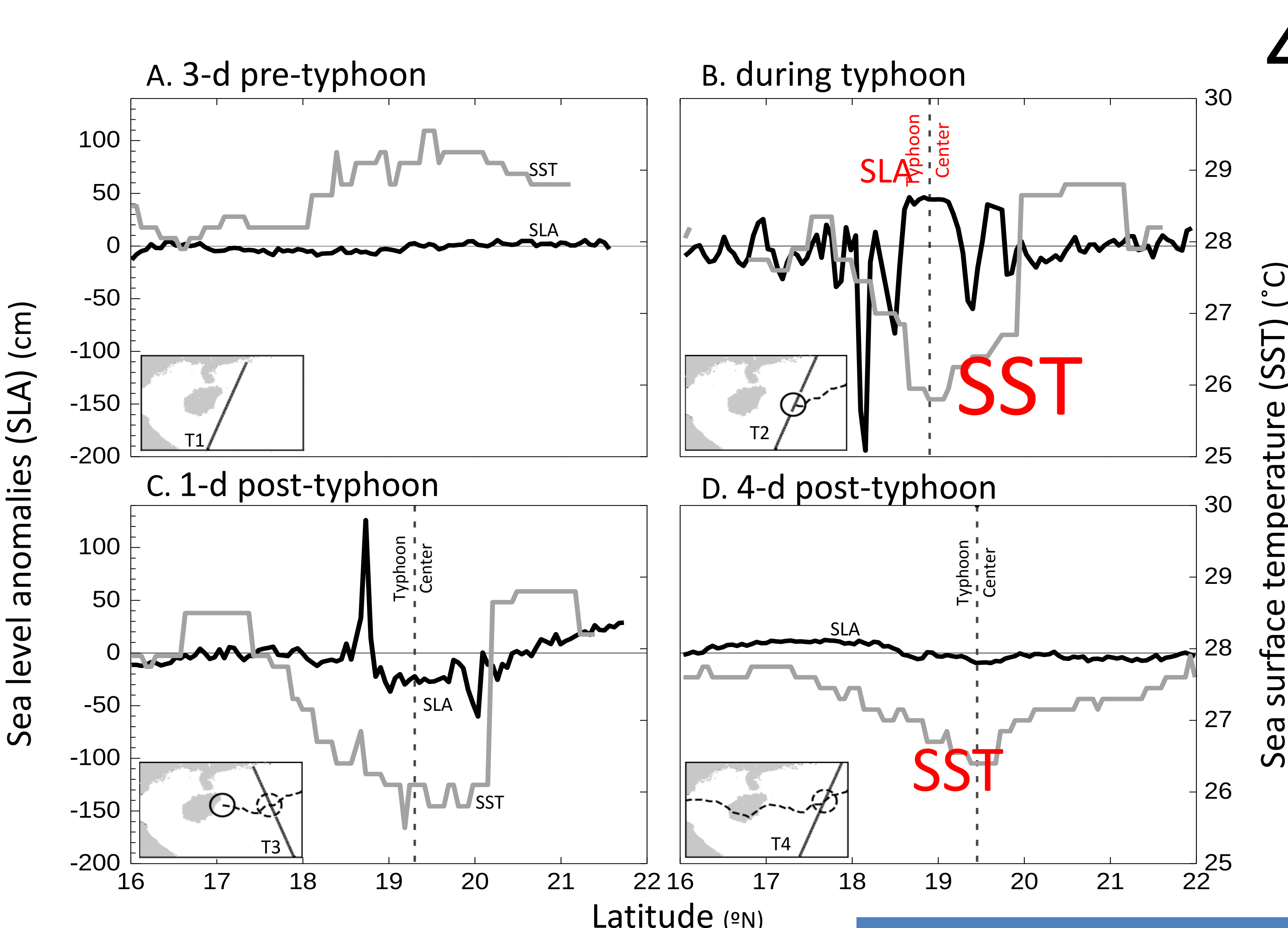


Guangming Zheng and Danling Tang, 2007,

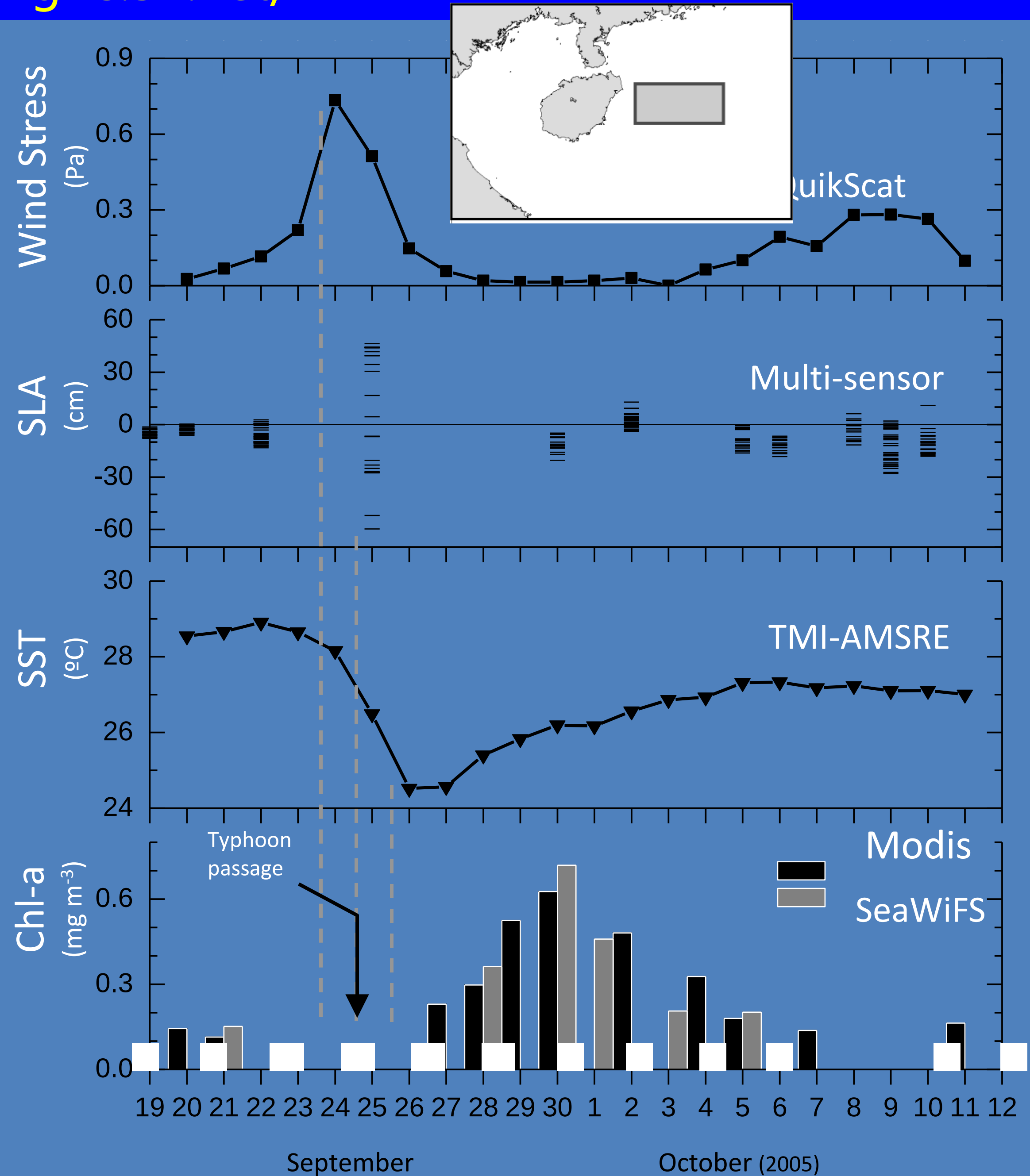
Marine Ecology Progress Series, 333：61-74，2007 (SCI)


DanLing TAN
TMI-AMSRE A SST
B
Chl-a (mg m-3)
C
TRMM Rainfall (mm)
A1. Sep 21
A2. Sep 22
T1
A3. Sep 23
A4. Sep 24
A5. Sep 25
T2
T3
A6. Sep 26
a
B1. Sep 20-21 Modis
No
data.
C1. Sep 21
C2. Sep 22
C3. Sep 23
C4. Sep 24
C5. Sep 25
C6. Sep 26
A
TMI-AMSRE SST (C)
B
Chl-a (mg m-3)
C
TRMM Rainfall (mm)
A7. Sep 27
b
A8. Sep 28
T4
A9. Sep 29
A10. Sep 30
A11. Oct 1
B2. Sep 28 Modi
B3. Sep 29 Modi
B4. Sep 30 Modi
B5. Oct 1 SeaWiF
a
b
C7. Sep 27
C8. Sep 28
C9. Sep 29
C10. Sep 30
C11. Oct 1

Sea level variation & sea surface cooling



Zheng and Tang, MEPS 2007



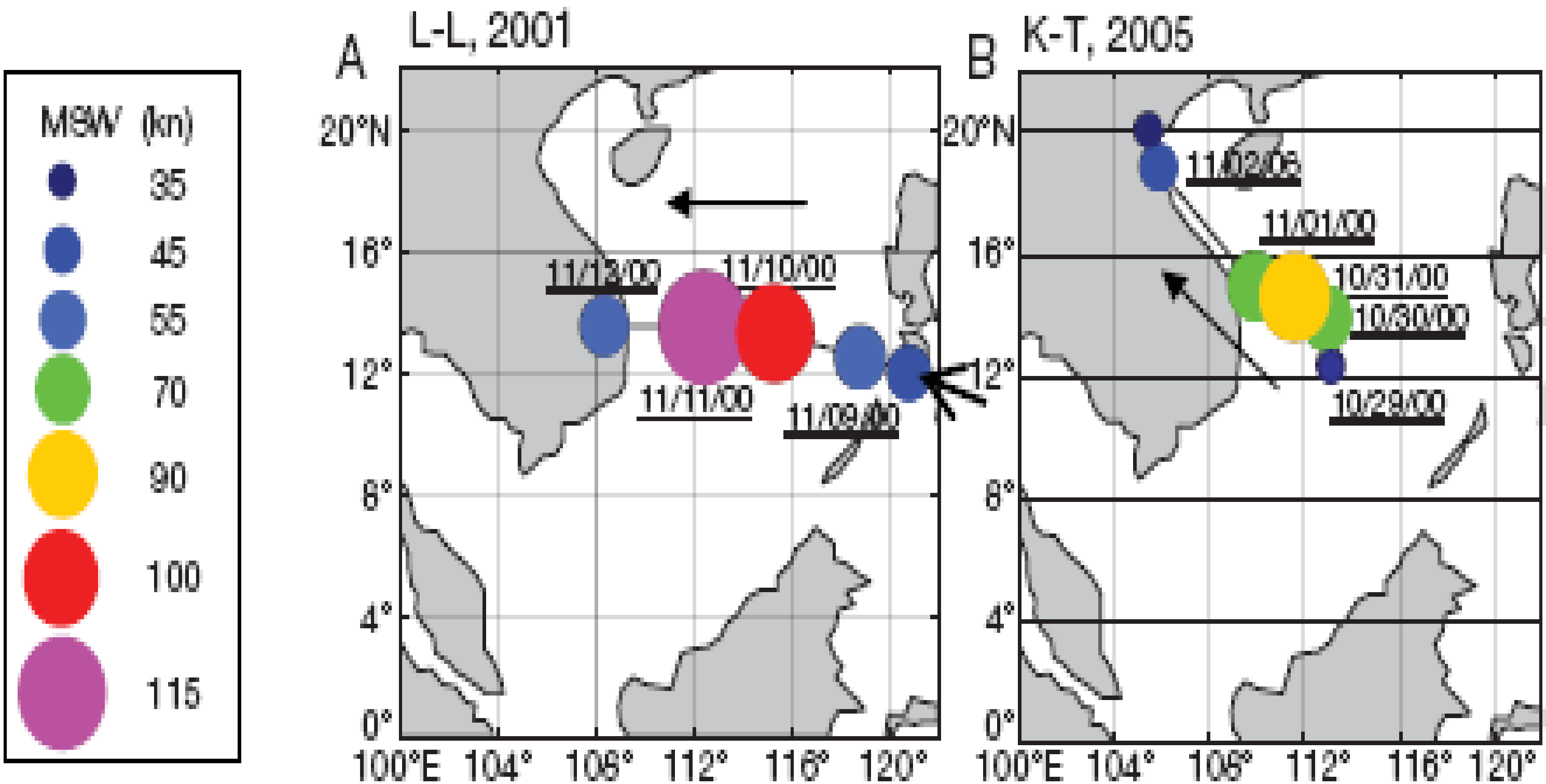
Typhoon wind

sea level variation

SST decrease

Chl-a peak

- **intensities /Wind Speed?**
- **translation speeds**



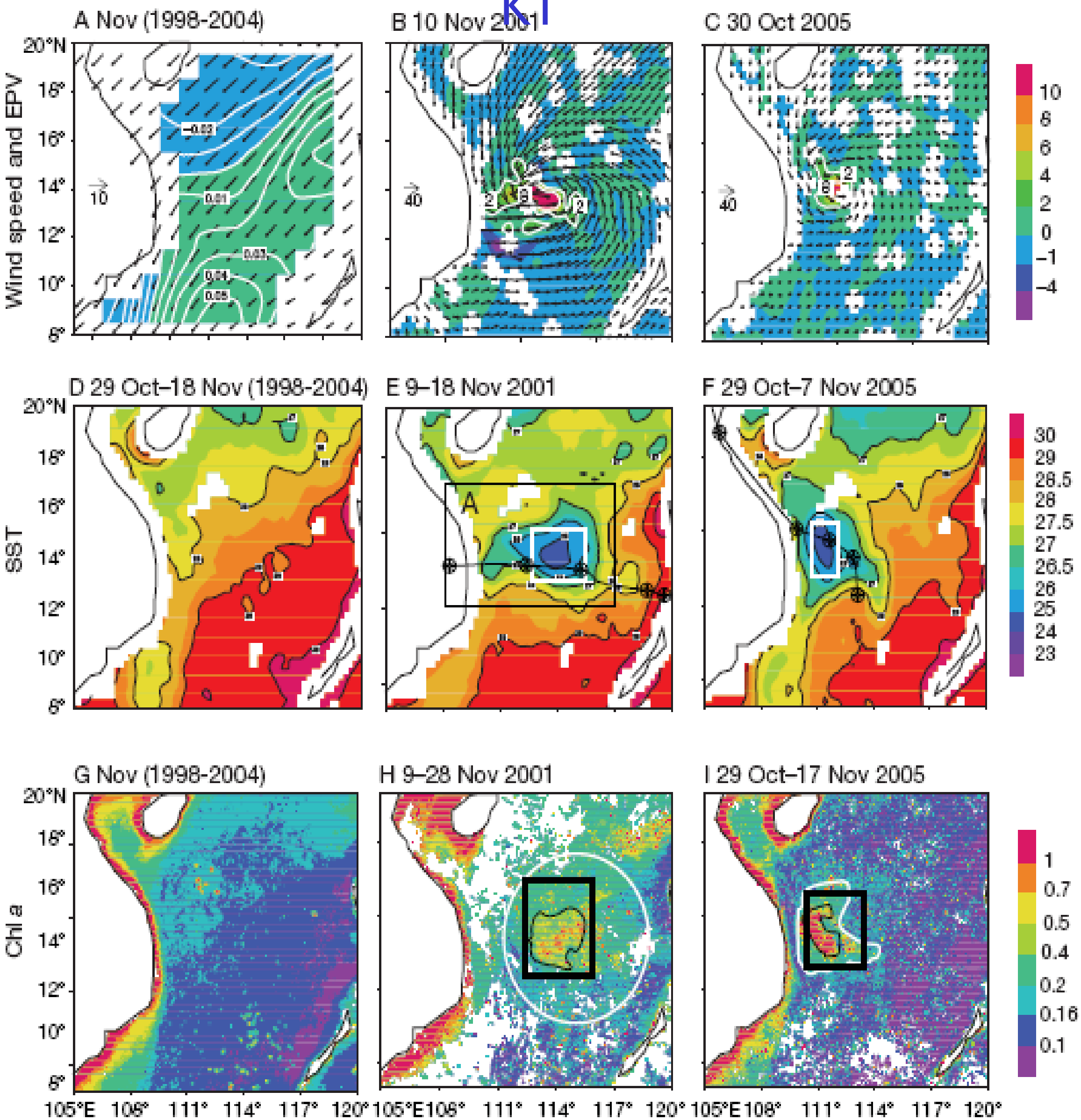
) Track and intensity of typhoons L-L (2001) and K-T (2005) in the SCS. MSW: maximum sustaine (in knots, 1 kn = 0.514 m s^{-1})

Zhao H, DanLingTang, Wang Y. 2008 MEPS

Tang DanLing 唐丹玲

Strong, fast-moving (4.4m s-1)

Weak, slow moving (2.87 m s-1) KT



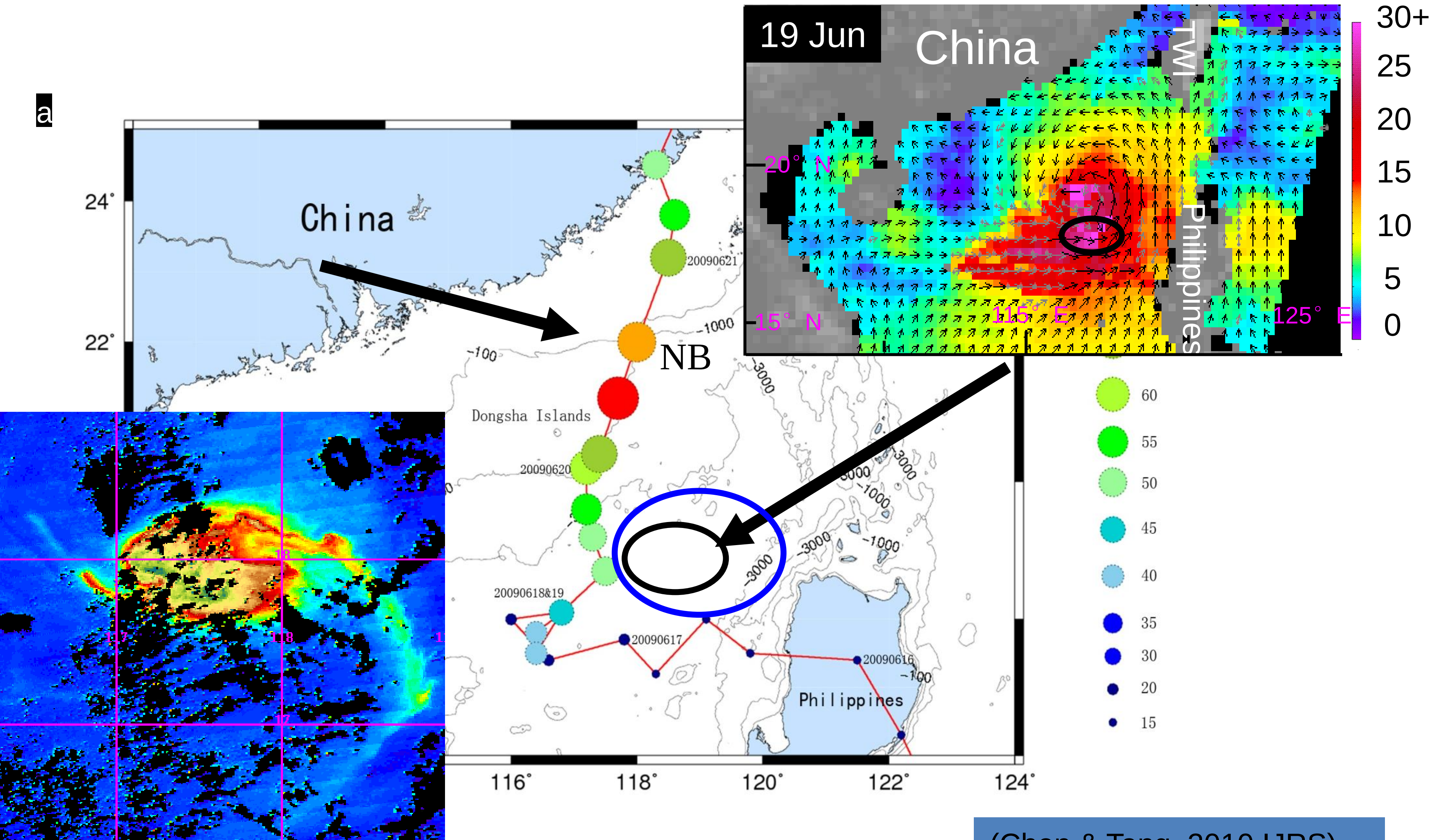
Wind

SST

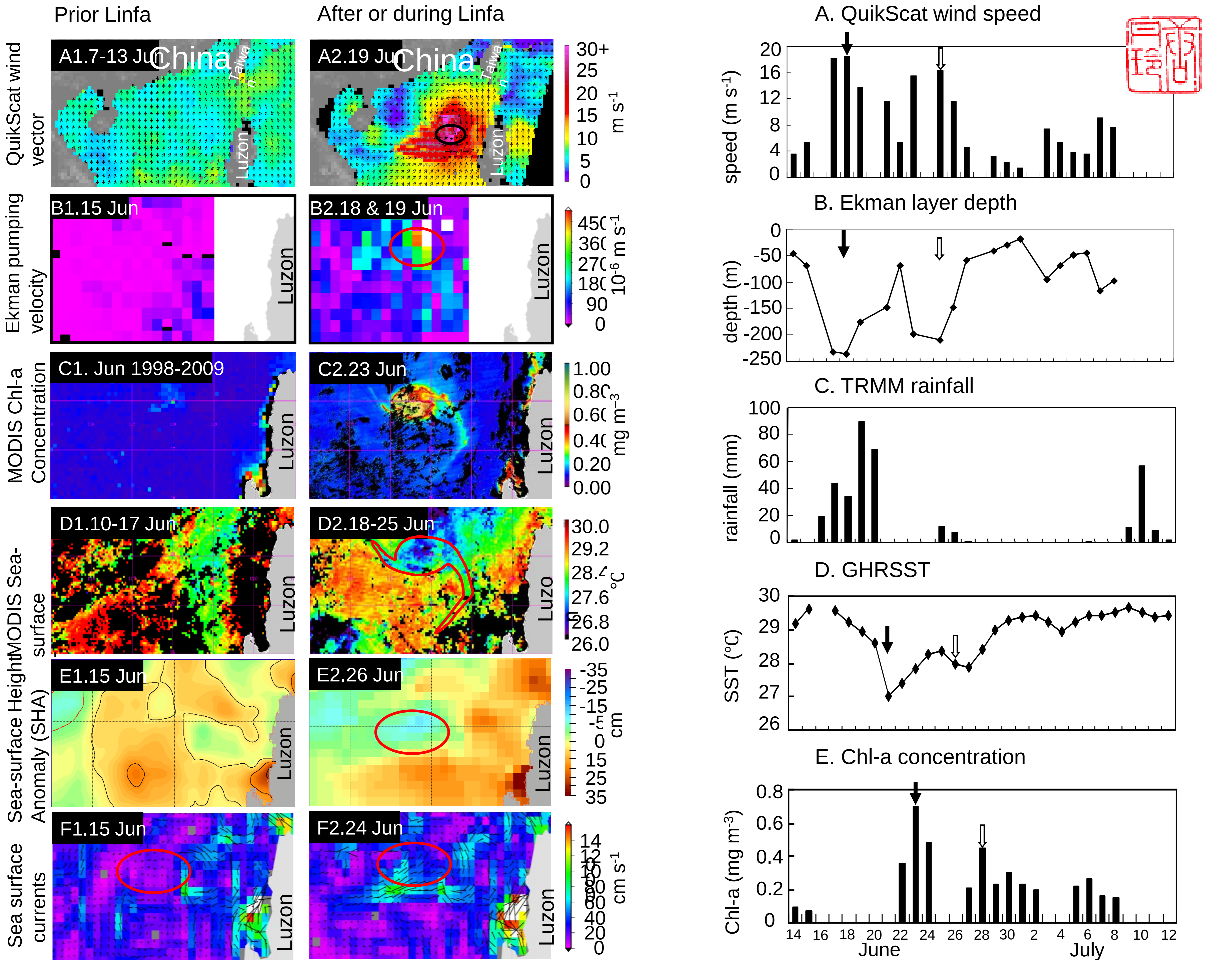
Chl a

MEPS 2008

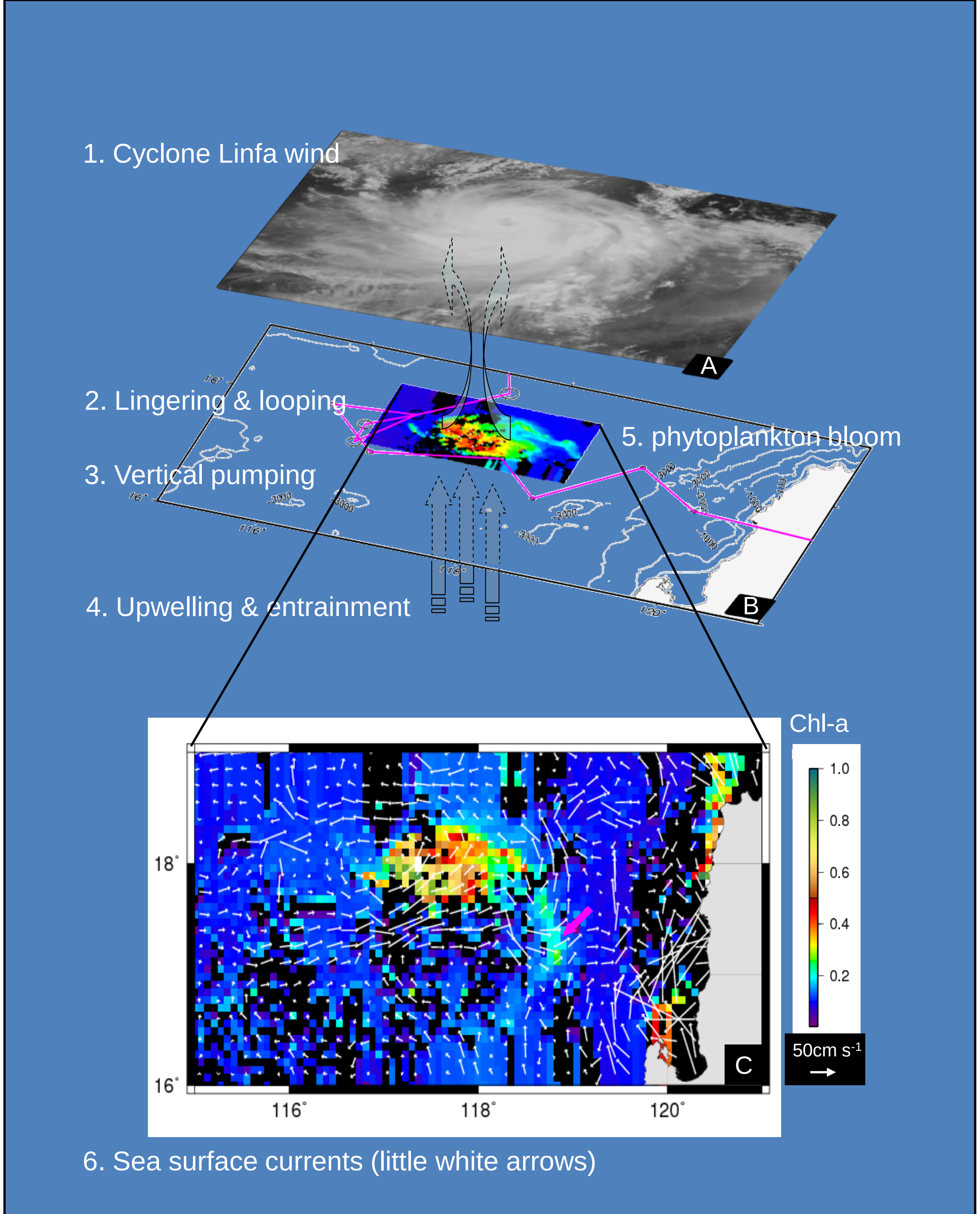
Eddy-feature phytoplankton bloom induced by tropical cyclone in the South China Sea,



(Chen & Tang, 2010,IJRS)



Prior Linfa
After or during Linfa
QuikScat wind vector
A1.7-13 Jun
A2.19 Jun
China
Taiwan
Luzon
m s-1
Ekman pumping velocity
B1.15 Jun
B2.18 & 19 Jun
10-6 m s-1
MODIS Chl-a Concentration
C1. Jun 1998-2009
C2.23 Jun
mg m-3
MODIS Sea-surface
D1.10-17 Jun
D2.18-25 Jun
°C
Sea-surface Height Anomaly (SHA)
E1.15 Jun
E2.26 Jun
cm
Sea surface currents
F1.15 Jun
F2.24 Jun
cm s-1
A. QuikScat wind speed
speed (m s-1)
B. Ekman layer depth
depth (m)
C. TRMM rainfall
rainfall (mm)
D. GHRSST
SST (°C)
E. Chl-a concentration
Chl-a (mg m-3)
June
July



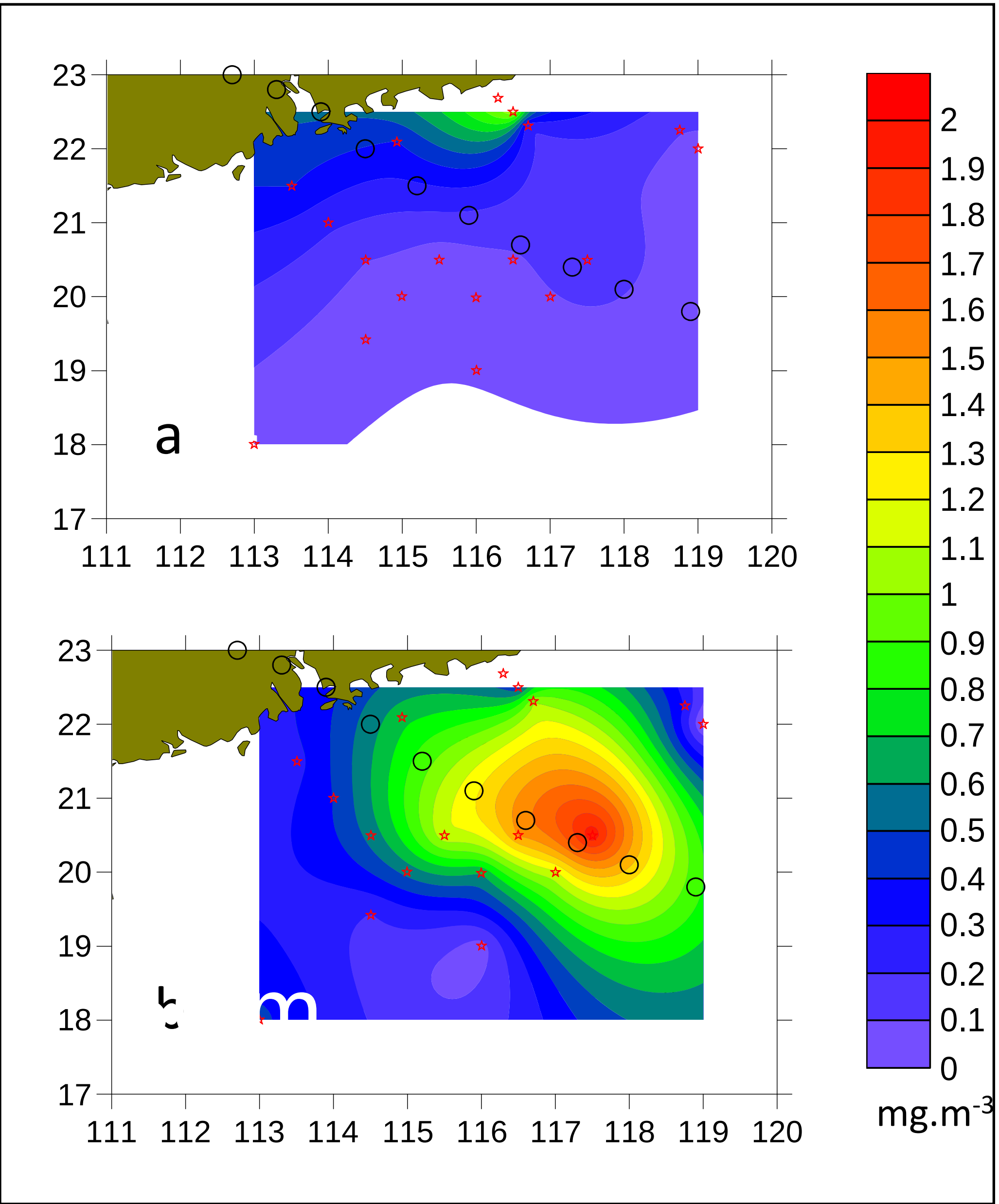
Yongqiang CHEN, DANLING TANG, 2012,

Eddy-feature phytoplankton bloom induced by tropical cyclone in the South China Sea,

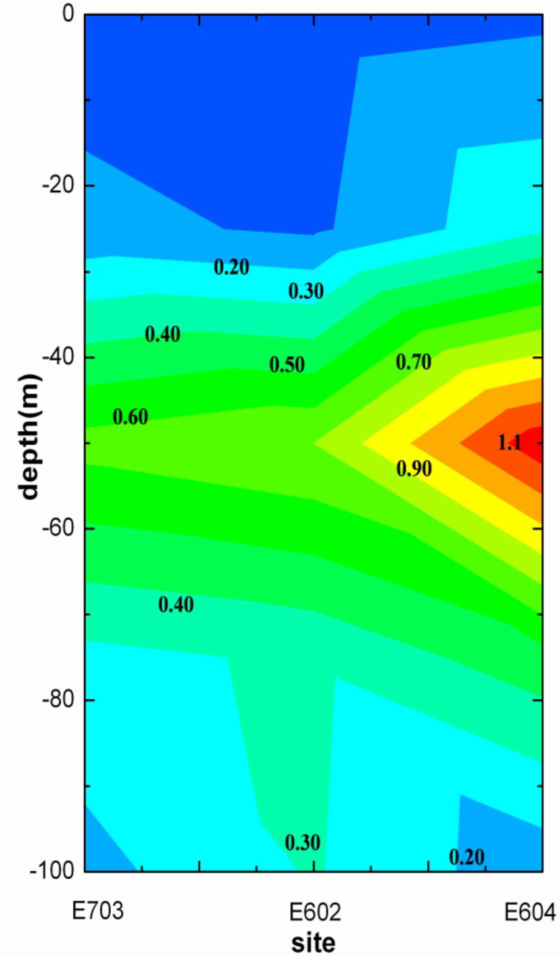
International Journal of Remote Sensing. Vol. 33, No. 23, 10 December 2012, 7444–7457.（SCI）

Chen, Tang , 2011, IJRS

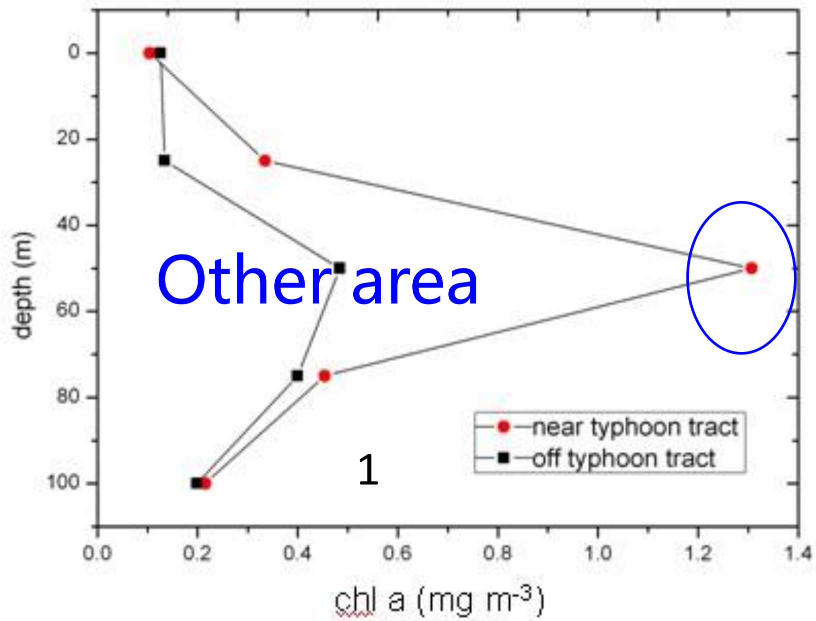
Chlorophyll on surface and subsurface

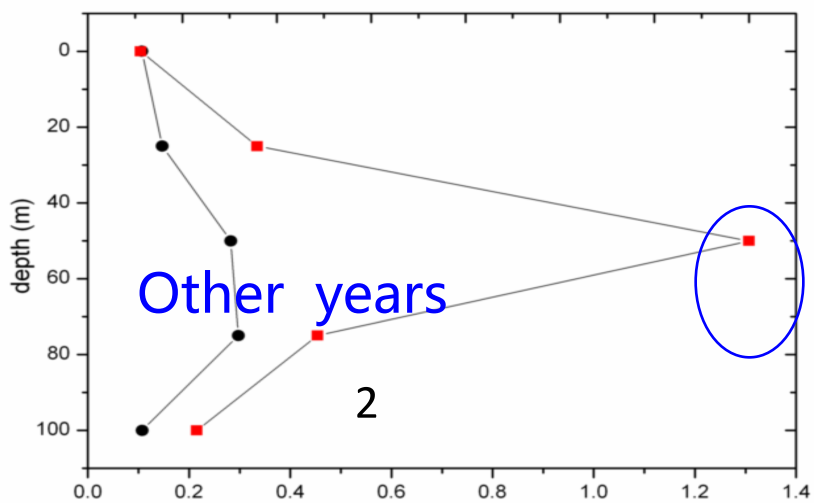


After typhoon

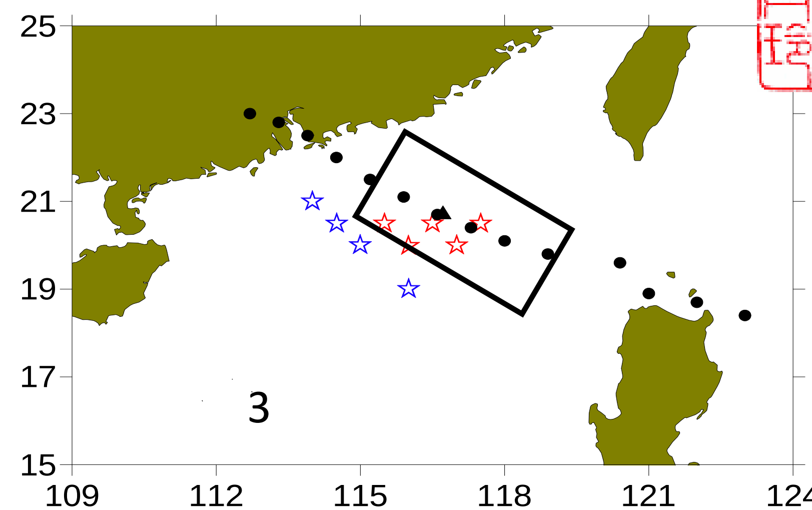


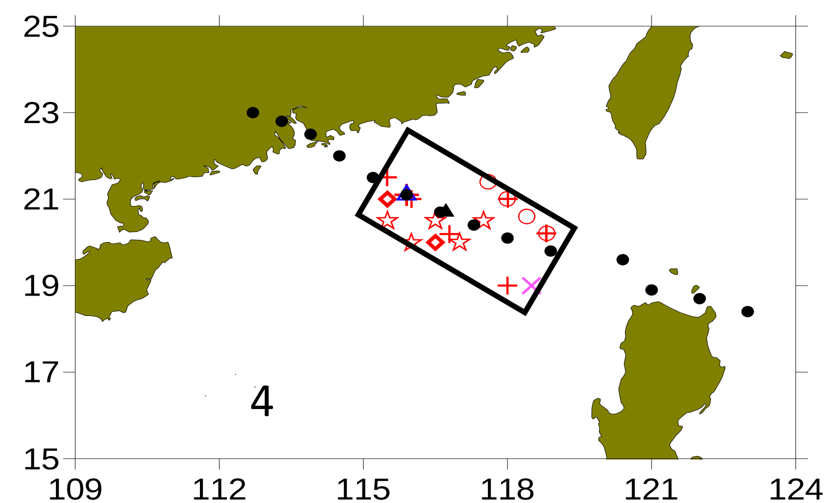
Ye and Tang, 2013, JMS





chl a (mg m-3)





HaiJun. Ye, Yi. Sui, Danling. Tang, Y. D. Afanasyev， 2013, A Subsurface Chlorophyll a Bloom Induced by Typhoon in the South China Sea. Journal of Marine Systems （SCI）.

Dissolved oxygen (DO)

?

typhoon / tropical cyclone

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Advances in Space Research 53 (2014) 1081–1091

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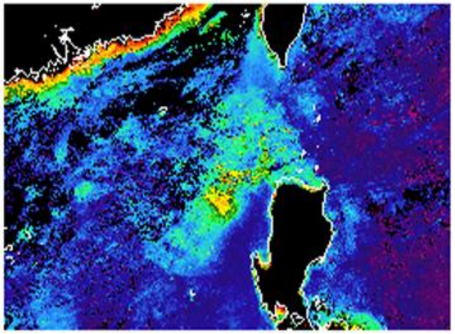
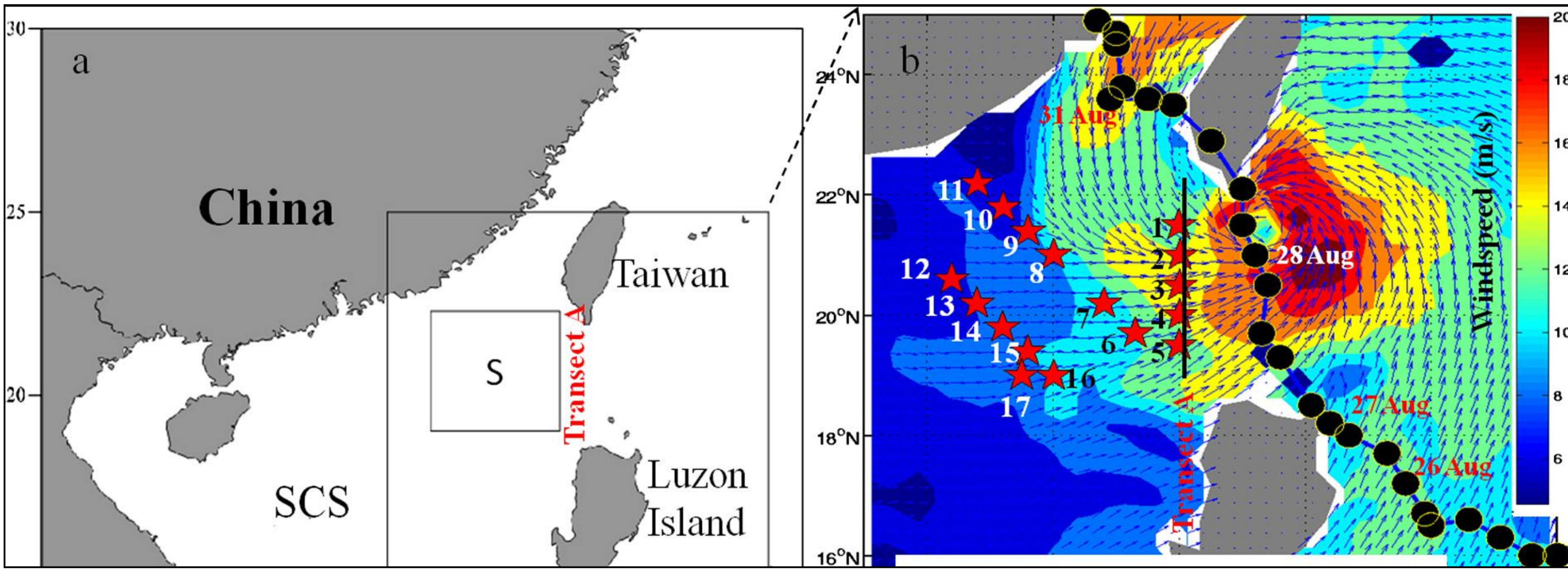
Response of dissolved oxygen and related marine ecological parameters to a tropical cyclone in the South China Sea

Jingrou Lin [a,b,c], Danling Tang [a,b,*], Werner Alpers [d], Sufen Wang [a]





the super-typhoon Nanmadol between 22 and 30 August 2011,

Horizontal distribution

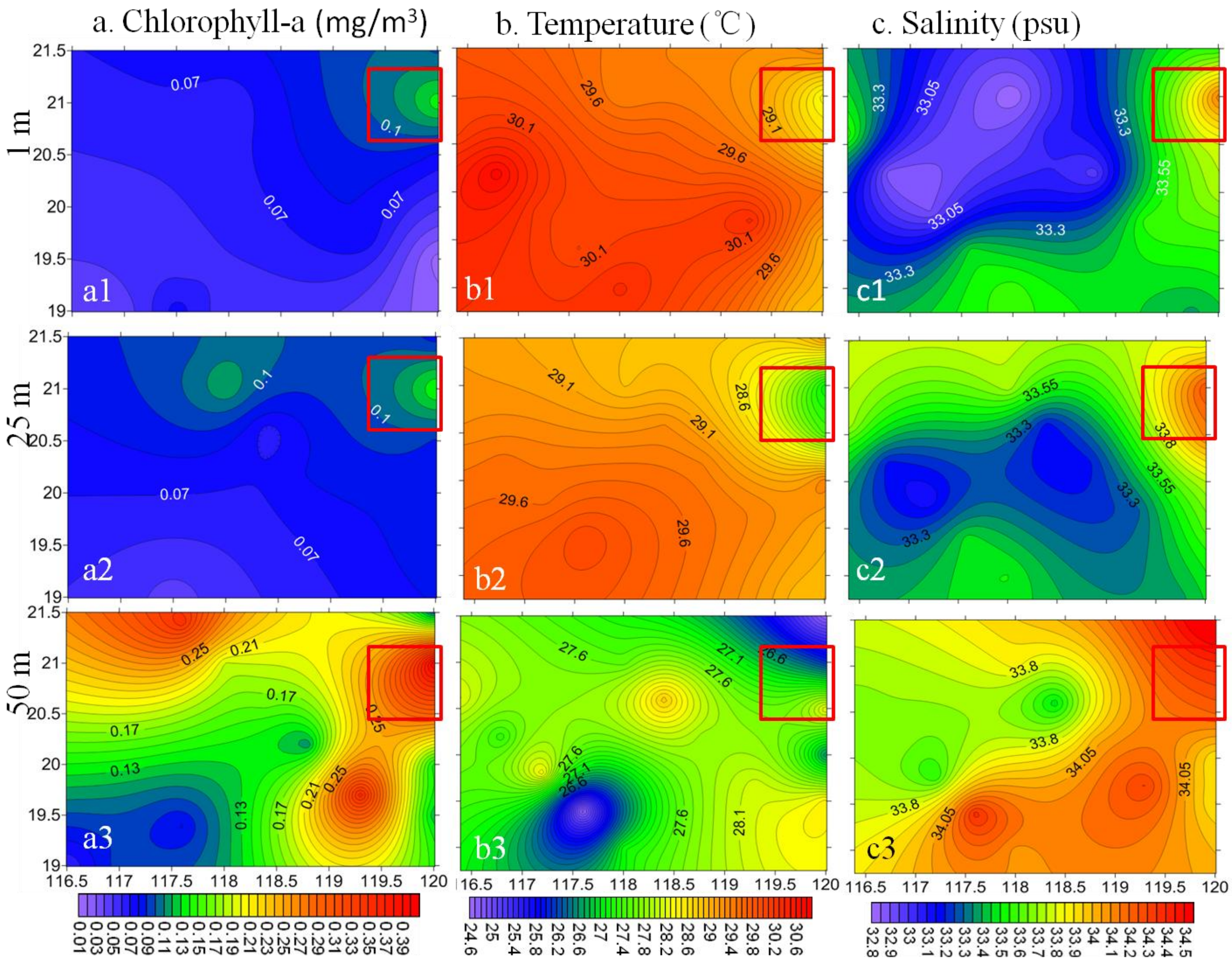
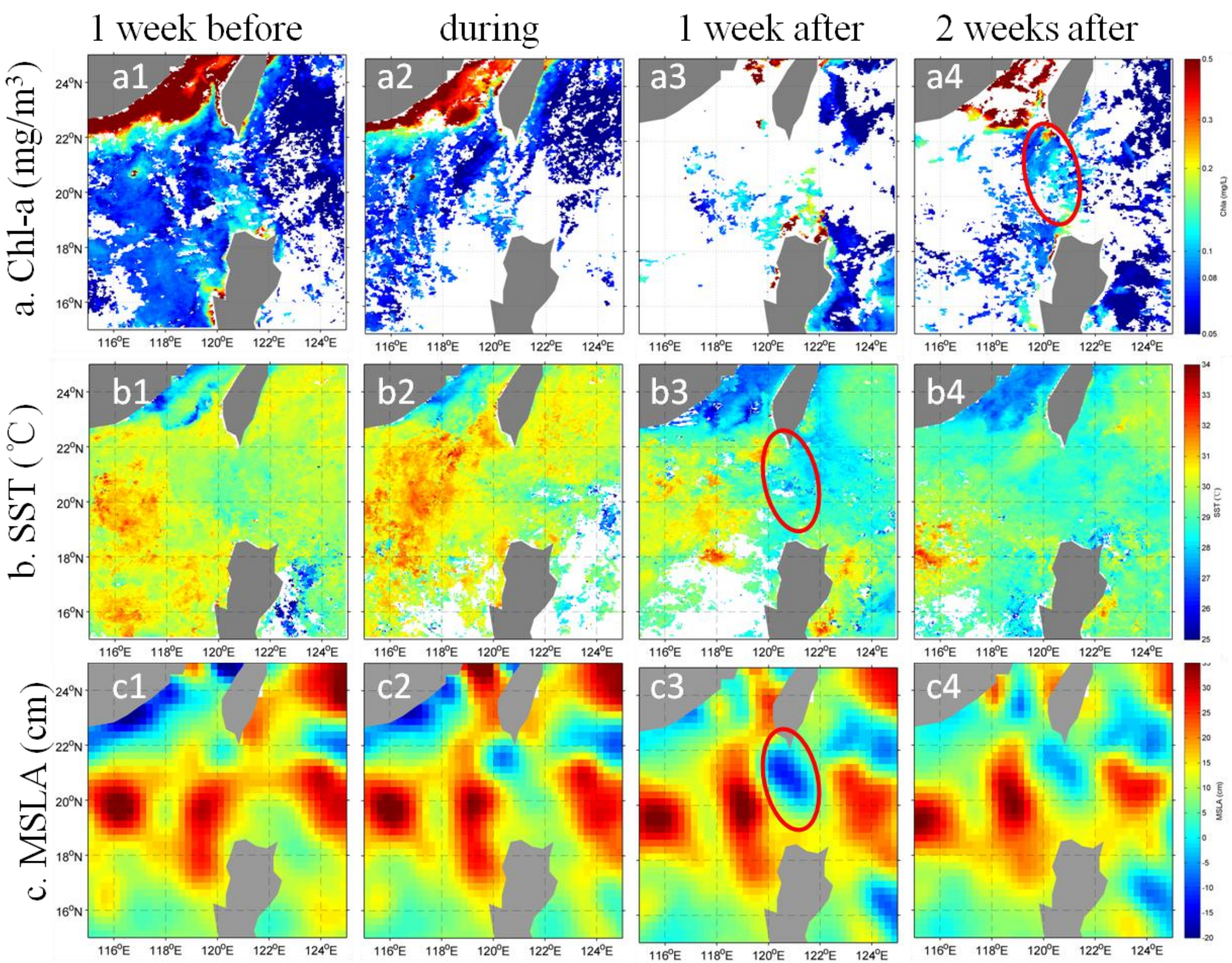


Fig.3

Horizontal distribution

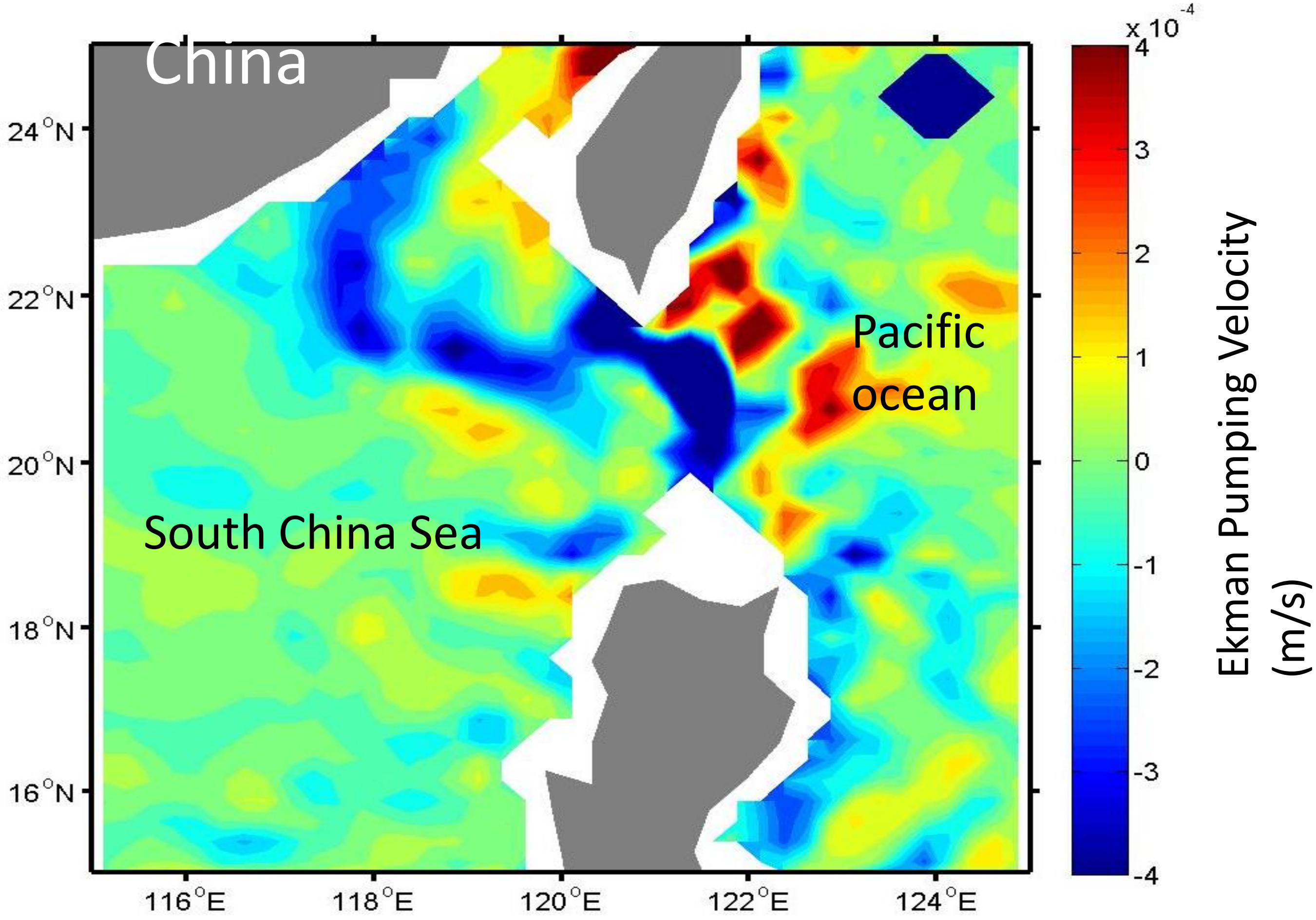


The Chl-a (mg m3) and SST (C) maps are 8-day composites retrieved from MODIS data

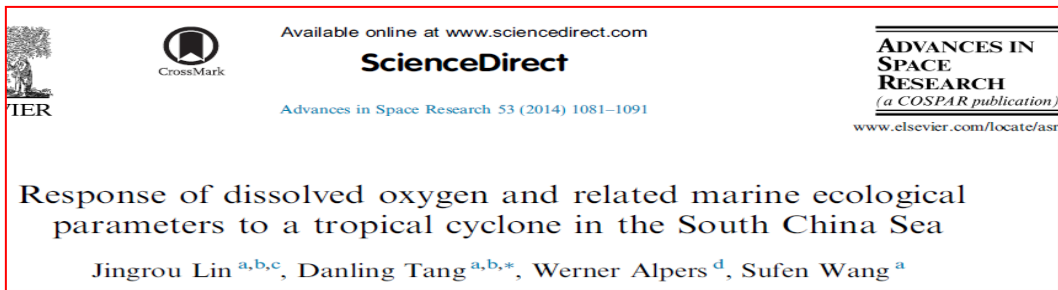
the SLA (cm) maps are weekly composites retrieved from altimeter data of several satellites

Fig.6

Daily averaged Ekman pumping velocity (m s1)



28 Aug 2011.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Sea surface current (m s1), the passage of the typhoon in Luzon Strait.

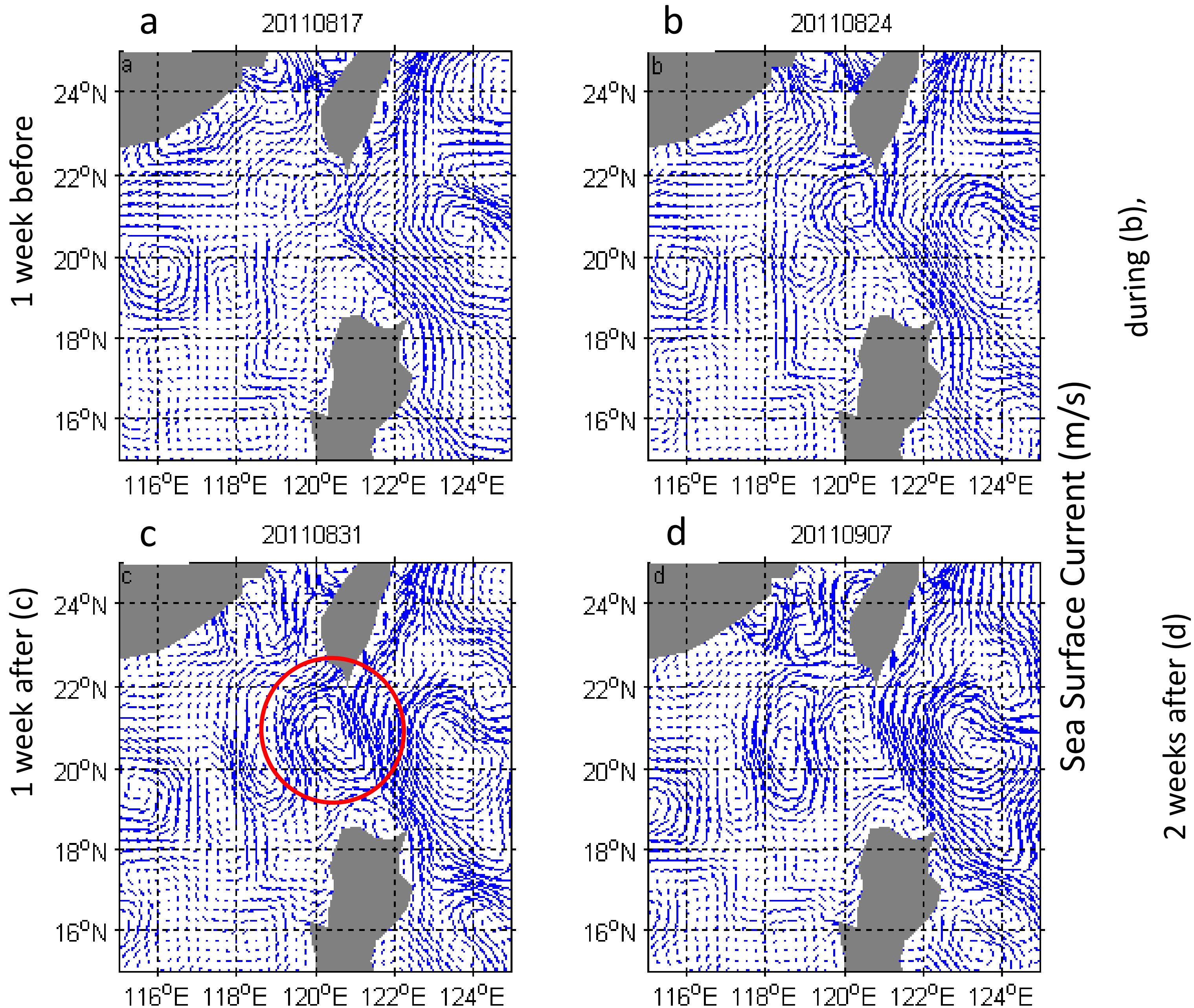


Fig.8

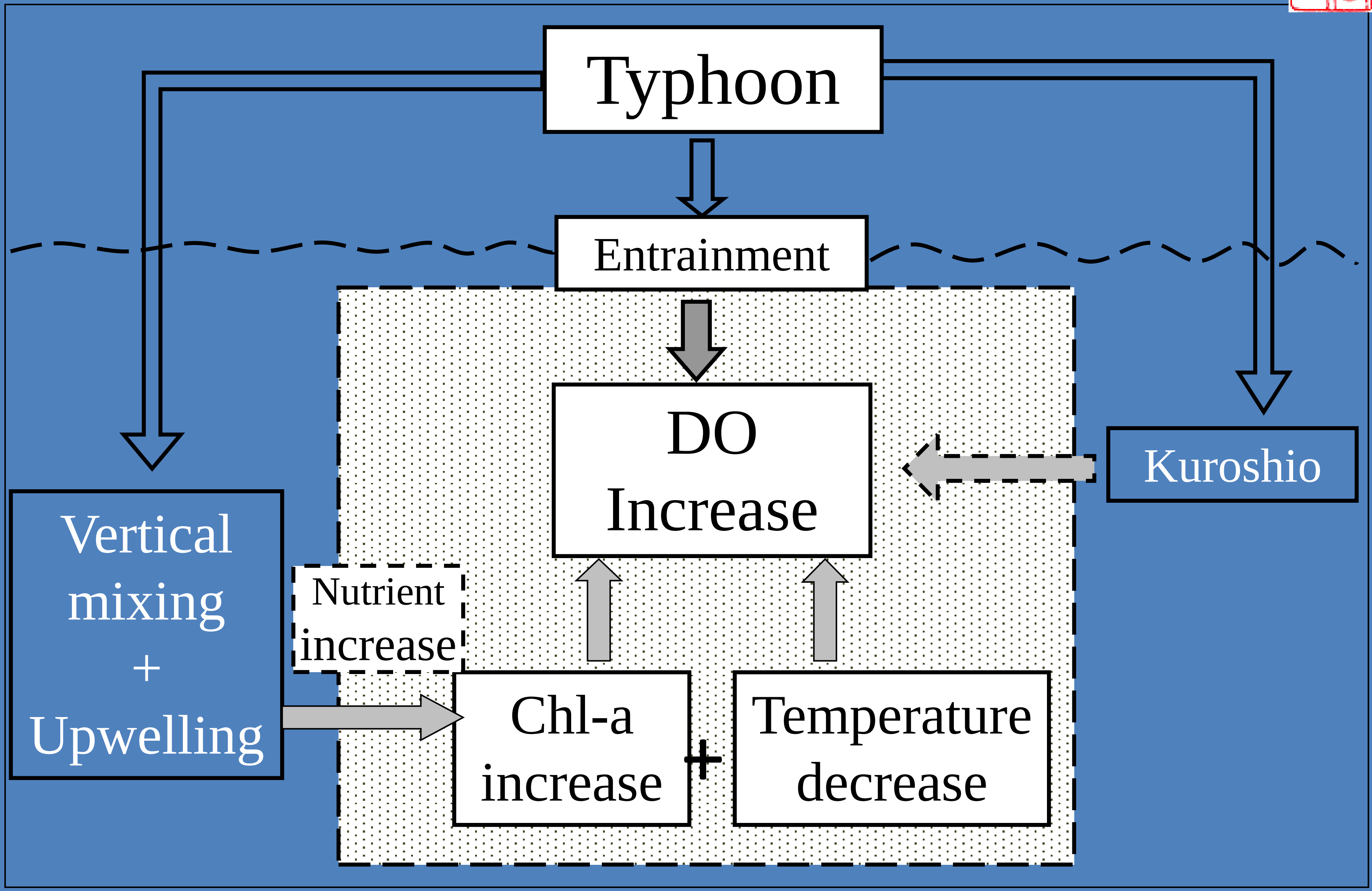
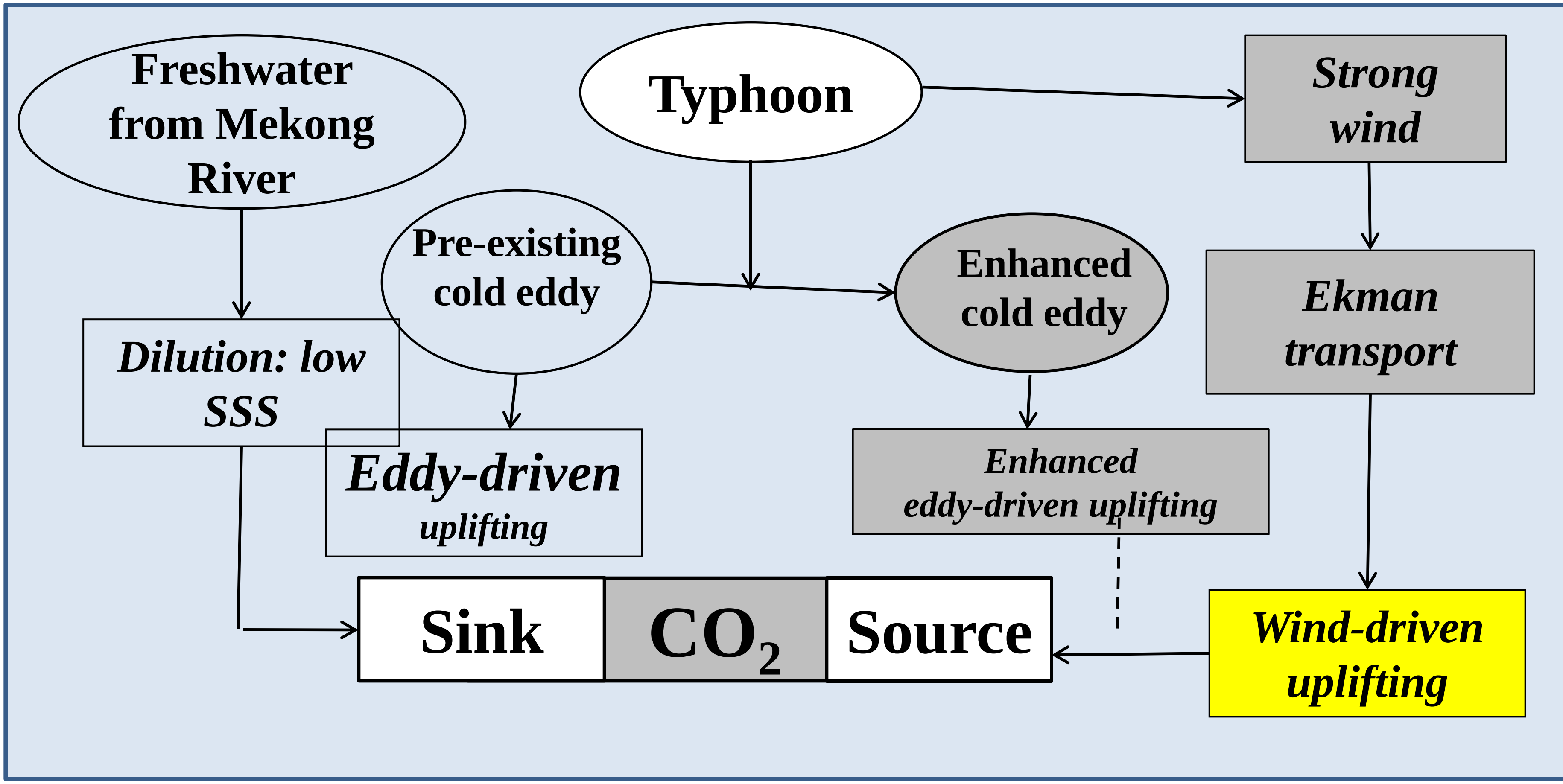

Typhoon
Entrainment
DO
Increase
Kuroshio
Vertical
mixing
+
Upwelling
Nutrient
increase
Chl-a
increase
+
Temperature
decrease

Fig.9

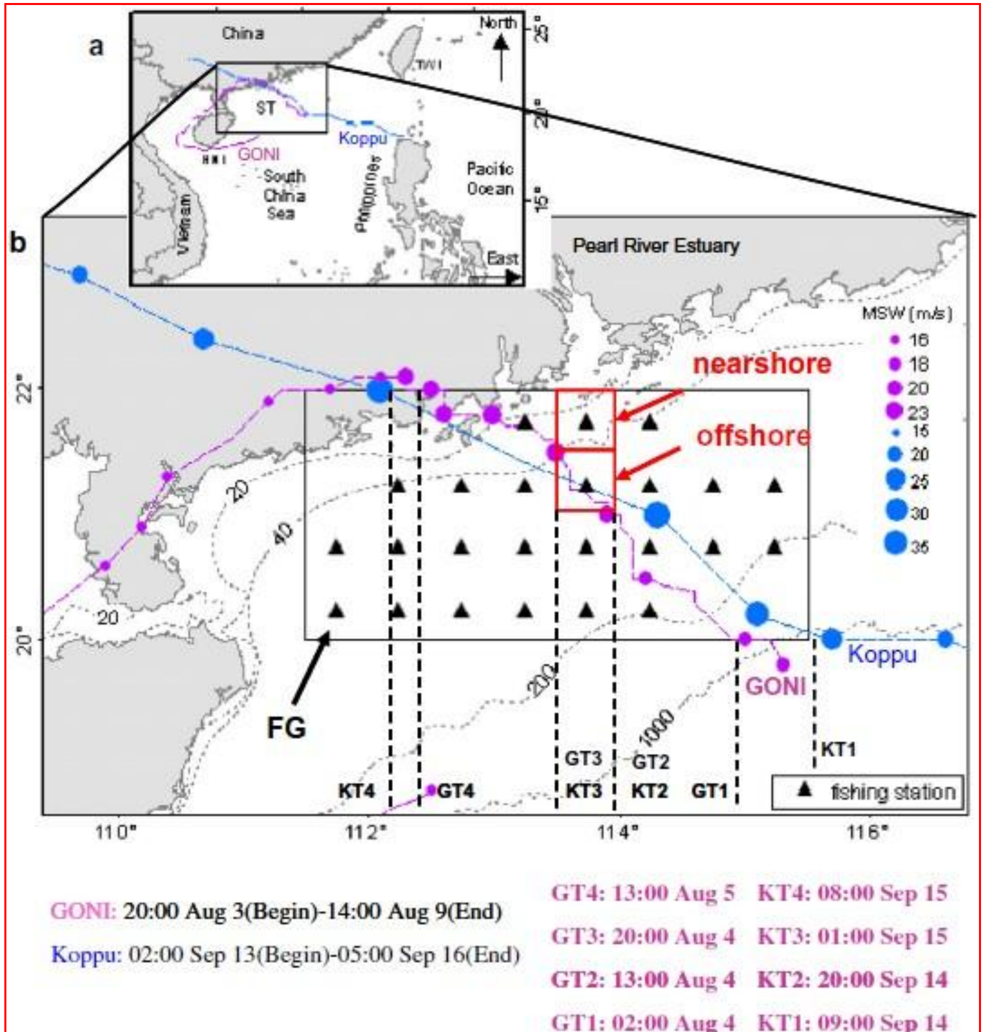
1. Surface water diluted by heavy rain, with low $pCO_{2,sw}$

2. TD uplifting eddy-driven high $pCO_{2,sw}$



change to a source temporarily

(1) Increase in **fish abundance** during two typhoons in the South China Sea

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Increase in fish abundance during two typhoons in the South China Sea

Jie Yu[a,b,c], Danling Tang[a,c,*], Yongzhen Li[b], Zirong Huang[b], Guobao Chen[b]

Yu & Tang,
2013, ASR

②species number

No	1	2	3	4 to 8	9	10	11	12	13	14	15	16	17	18	19	20
e7		√									√					
s3		√						√								
s4		√						√							√	√
s5		√						√	√	√	√	√	√	√	√	√
s7		√						√	√	√	√	√	√	√	√	√
s8		√						√	√	√	√	√	√	√	√	√
s10		√						√							√	
s11		√		G				√	√						√	√
s12		√		O				√			√					
s13		√		N				√	√	√	√	√	√	√	√	
s14		√		I				√	√	√	√	√	√		√	√
s15		√						√				√	√		√	√
s16		√						√			√		√		√	√
s21		√						√				√			√	√
s22		√						√		√		√	√	√	√	
o1		√						√	√	√	√	√	√	√	√	
o4		√						√							√	
o5		√						√	√	√	√	√	√	√	√	√
s9		√														
e1								√								
e2								√								
e6								√							√	√
s6			Increased					√	√				√	√		√
s17			records					√		√					√	√
s18								√							√	√
s19								√								√
s20								√			√				√	√
o3								√				√	√		√	√

New records

Yu & Tang, 2013, ASR

No	1	2	3	4	5	6	7	8	9	14 to 15	16	17	18	19	20	25	26
s5	√		√						√		√	√	√	√	√	√	√
s8	√								√		√	√	√	√	√		√
s11	√		√						√		√	√	√	√	√		√
s13	√		√						√	K		√	√	√			
s14	√		√						√	o	√	√	√	√	√		
s16	√		√						√		√	√	√				√
s17	√		√							p		√	√				
s21	√									p	√	√	√	√	√		√
o1			√						√	u	√	√	√				
o5	√		√						√		√	√	√	√	√		√
e2												√					
e3													√				
e5												√	√				√
e6												√	√	√	√		
e7											√	√	√	√	√		√
s2											√						
s3											√	√	√	√			
s4											√	√	√	√		√	
s6												√	√				
s7									Increased		√	√	√	√			
s10									records		√	√	√	√			
s12												√	√	√	√		
s15												√	√	√			
s18											√	√	√				
s19												√	√				
s20												√	√	√			
s22											√	√	√	√	√		
o3											√	√	√	√	√		
o4												√	√	√	√		

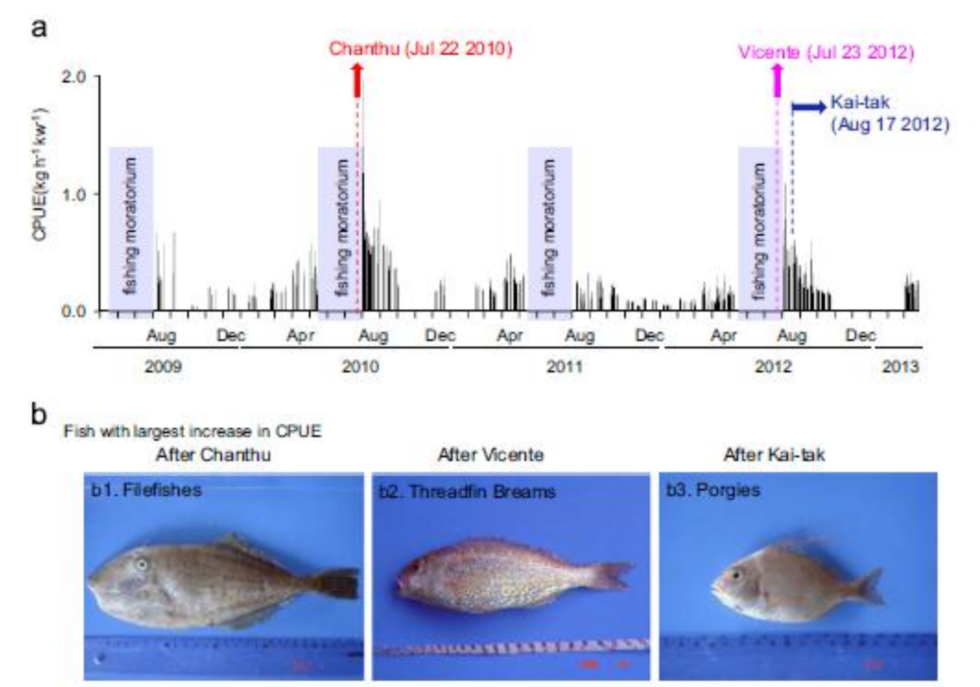


Table 1
Information of 30 main fishes sampled in the area.

No	Common name	Description	Habitat depth	Tropical level
1	Pelagic scad	*Decapterus* spp. dominated by *D. maruadsi*	Pelagic	Low class carnivorous fish
2	Ponyfish	*Leiognathus* spp. dominated by *L. bindus* and *L. elongatus*	Pelagic	Low class carnivorous fish
3	Pomfret	*Pampus* spp. dominated by *P. argenteus* and *P. chinensis*, and *Parastromateus niger*	Pelagic	Low class carnivorous fish
4	Chub mackerel	A single species of *Scomber japonicus*	Pelagic	Low class carnivorous fish
5	Spanish mackerel	*Scomberomorus* spp. dominated by *S.guttatus* and *S.commerson*	Pelagic	High class carnivorous fish
6	Spinyhead croaker	*Collichthys* spp. dominated by a *Collichthys lucidus*	Meso demersal	Low class carnivorous fish
7	Jewfish	*Johnius* spp. dominated by *J. dussumieri* and *J. belangerii*	Meso demersal	Low class carnivorous fish
8	Yellow drum	a single species of *Nibea albiflora*	Meso demersal	Low class carnivorous fish
9	Silver croaker	*Pennahia argentatus*	Meso demersal	Low class carnivorous fish
10	Grouper	*Epinephelus* spp. dominated by *E. akaara* and *E. awoara*	Meso demersal	Middle class carnivorous fish
11	Red barracuda	a single species of *Sphyraena pinguis*	Meso demersal	High class carnivorous fish
12	Hairtail	*Trichiurus* spp. dominated by *T. lepturus*	Meso demersal	High class carnivorous fish
13	Pacific rudderfish	a single species of *Psenopsis anomala*	Demersal	Low class carnivorous fish
14	Threadfin bream	*Nemipterus* spp. dominated by *N. virgatus*	Demersal	Low class carnivorous fish
15	Porgies	a single species of *Parargyrops edita*	Demersal	Low class carnivorous fish
16	Bigeye	*Priacanthus* spp. dominated by *P. tayenus* and *P. macracanthus*	Demersal	Low class carnivorous fish
17	Filefish	Thamnaconus spp. dominated by *T. hypargyreus*	Demersal	Low class carnivorous fish
18	Goatfish	Upeneus spp. dominated by *U. moluccensis* and *U. sulphureus*	Demersal	Low class carnivorous fish
19	Tonguesole	*Cynoglossus* spp.	Demersal	Low class carnivorous fish
20	Sillago	*Sillago sihama* and *S. japonica*	Demersal	Low class carnivorous fish
21	Monkfish	*Lophius* spp. dominated by *Lophius litulon*	Demersal	Middle class carnivorous fish
22	Snakefish	a single species of *Trachinocephalus myops*	Demersal	Middle class carnivorous fish
23	Conger pike	*Muraenesox cinereus*	Demersal	High class carnivorous fish
24	Lizardfish	*Saurida* spp. dominated by *S. tumbil* and *S. undosquamis*	Demersal	High class carnivorous fish
25	White-spotted spinefoot	*Siganus* spp. dominated by *Siganus oramin*	Reef	Omnivorous fish
26	Octopus	*Octopus* spp.	Cephalopoda	Low class carnivorous fish
27	Squid	*Loligo* spp.	Cephalopoda	Low class carnivorous fish
28	Cuttlefish	*Sepia* spp.	Cephalopoda	Low class carnivorous fish
29	Crab	*Portunus* spp. and *Charybdis* spp.	Crab	Low class carnivorous fish
30	Shrimp	*Penaeidae*	Shrimp	Low class carnivorous fish

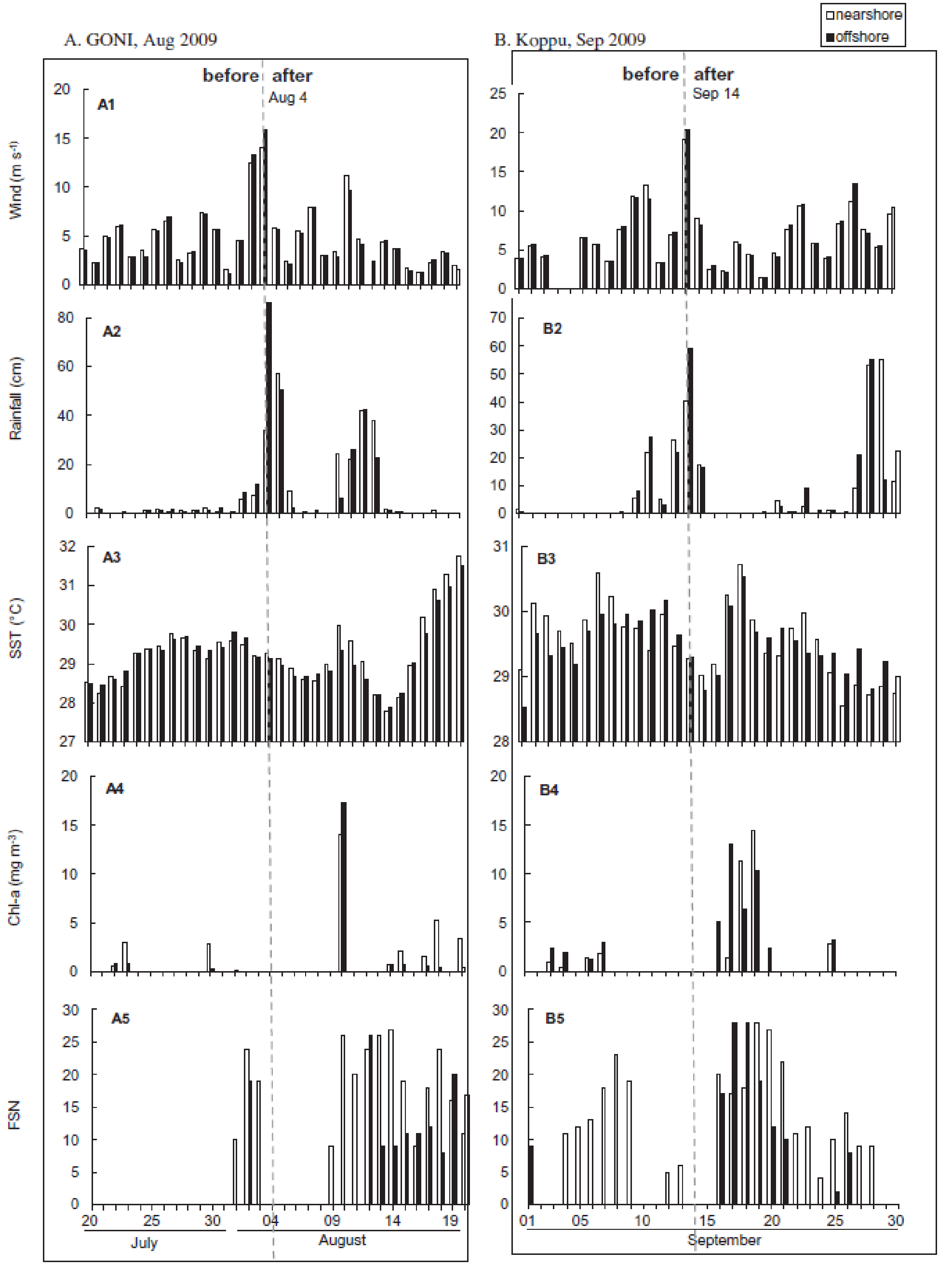


Fig. 6. Time series of wind (m s^{-1}), rainfall (cm), SST (°C), Chl-a (mg m^{-3}) and FSN. A: During typhoon GONI from July 20 to August 20th (A
A3, A4 and A5); B: During typhoon Koppu from September 1st to 30th (B1, B2, B3, B4 and B5). Blank bar represents the nearshore changes; Bla
denotes the offshore distribution; gray dashed lines indicate the occurrence of typhoons.

• **Fish**

Primary production

food

phytoplankton

nutrient

fall down

discharges

deep water

oceanic environment

upwelling …….

SST

• wind

Typhoon

1. one of the most frequent and serious natural hazards ,causing enormous economic losses.

2. significant negative impacts on coastal environments

3. positive impacts on marine ecosystems

2

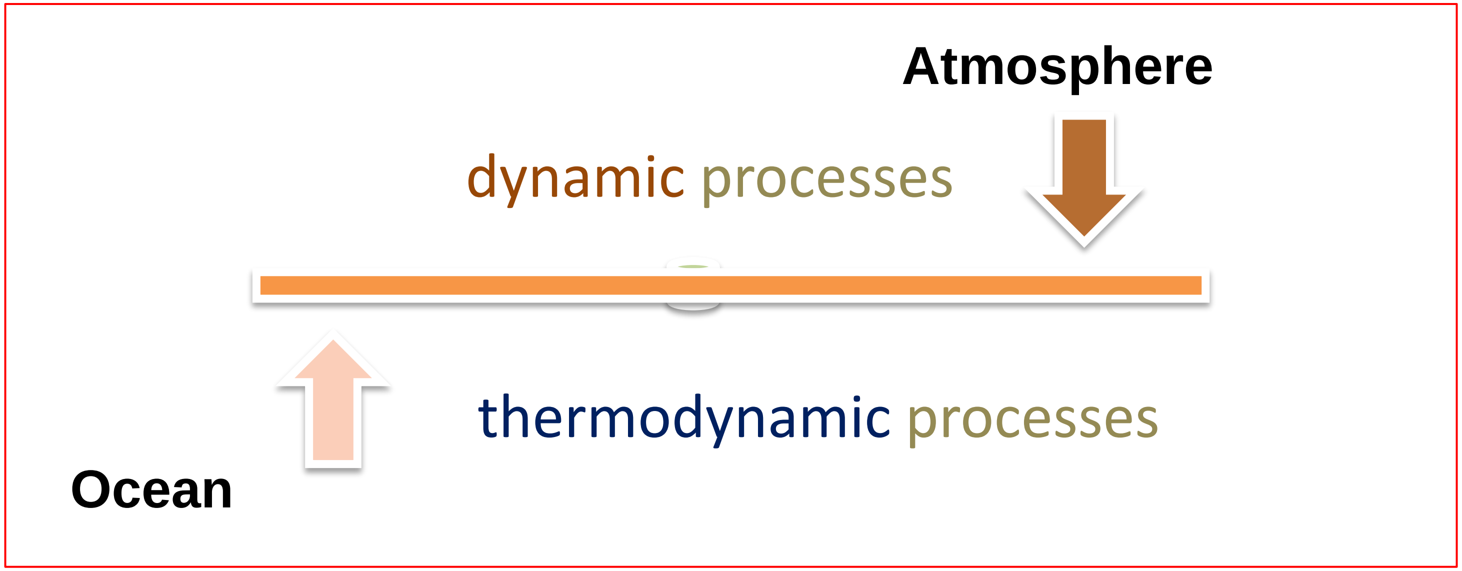
A New Ecological Index

for SST Cooling Response to Typhoons

SST -- indicator or ecological factor of marine ecosystem environment conditions typhoons propagate over the ocean surface,

- affect both the atmosphere and the ocean:

- cause great changes in the upper ocean:



Typhoon Indices from different aspects

- Saffir-Simpson Hurricane Intensity Scale

Type	Category	Pressure (mb)	Winds (knots)	Winds (mph)
Depression	td	-----	< 34	< 39
Tropical Storm	TS	-----	34-63	39-73
Hurricane	1	> 980	64-82	74-95
Hurricane	2	965-980	83-95	96-110
Hurricane	3	945-965	96-112	111-130
Hurricane	4	920-945	113-135	131-155
Hurricane	5	< 920	>135	>155

- Maximum Potential Intensity (MPI) [Emanuel, 1987]

  Using thermodynamic MPI model, Henderson-Sellers et al. (1998) predicted more intense tropical cyclones as the tropical SST warm.

- Hurricane Destruction Potential (HDP) [Gary et al., 1992]

  Taking into account the number of hurricane days and intensity, reflected its potential energy for destruction of wind and storm-surge.

- Accumulate Cyclone Energy (ACE)

  Modified from HDP, [Bell et al., 2000]; And positively correlated with ENSO indices. [Camargo et al., 2005]

- Power Dissipation Index (PDI) [Emanuel, 2005]

$$\mathrm{PDI}=\int_0^{\tau} V_{max}^3 dt$$

Based on the total dissipation of power, described the potential destructiveness of hurricanes.

- storm activity index (SAI) [Wu et al., 2008]

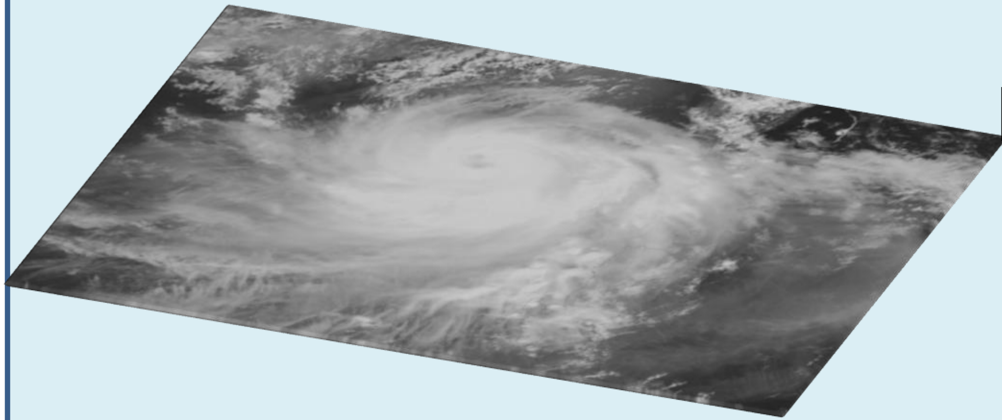
$$\mathrm{SAI}=\sum_0^N \sum_0^{\tau} V_{\max}^n$$

A function of the intensity, lifetime and annual frequency of tropical cyclones; considering SST, showed where tropical cyclones were likely to be generated.

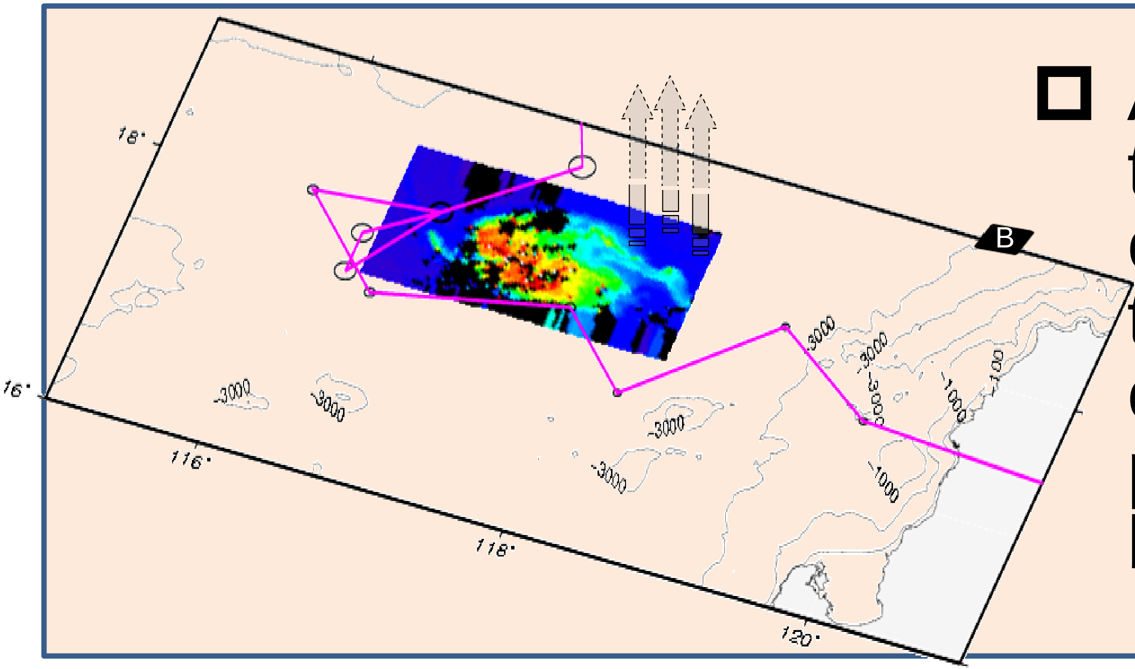
- ocean coupling/cooling potential intensity (OC_PI) index [Lin et al., 2013]

$$V_{OC\_PI}^2=\frac{\overline{T}-T_0}{T_0}\frac{C_k}{C_D}(k^*-k)$$

To predict tropical cyclones maximum intensity and describe the effect of ocean cooling.



- How much do typhoons impact on marine environments by affecting SST?



- A index to describe the effects of SST cooling in response to a typhoon that can combine its physical and biological effects

TCT (SST Cooling response to Typhoon)
$\mathrm{TCT_d}$

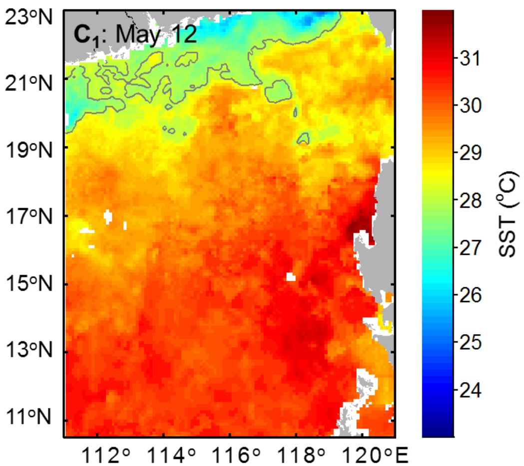
$$TCT = \sum_{i=1}^{m} S_i \times \Delta T_i \times 10^4 \qquad (1)$$

$$TCT_d = \frac{1}{d} \sum_{j=1}^{n} \sum_{i=1}^{m} S_i \times \Delta T_i \times 10^4 \qquad (2)$$

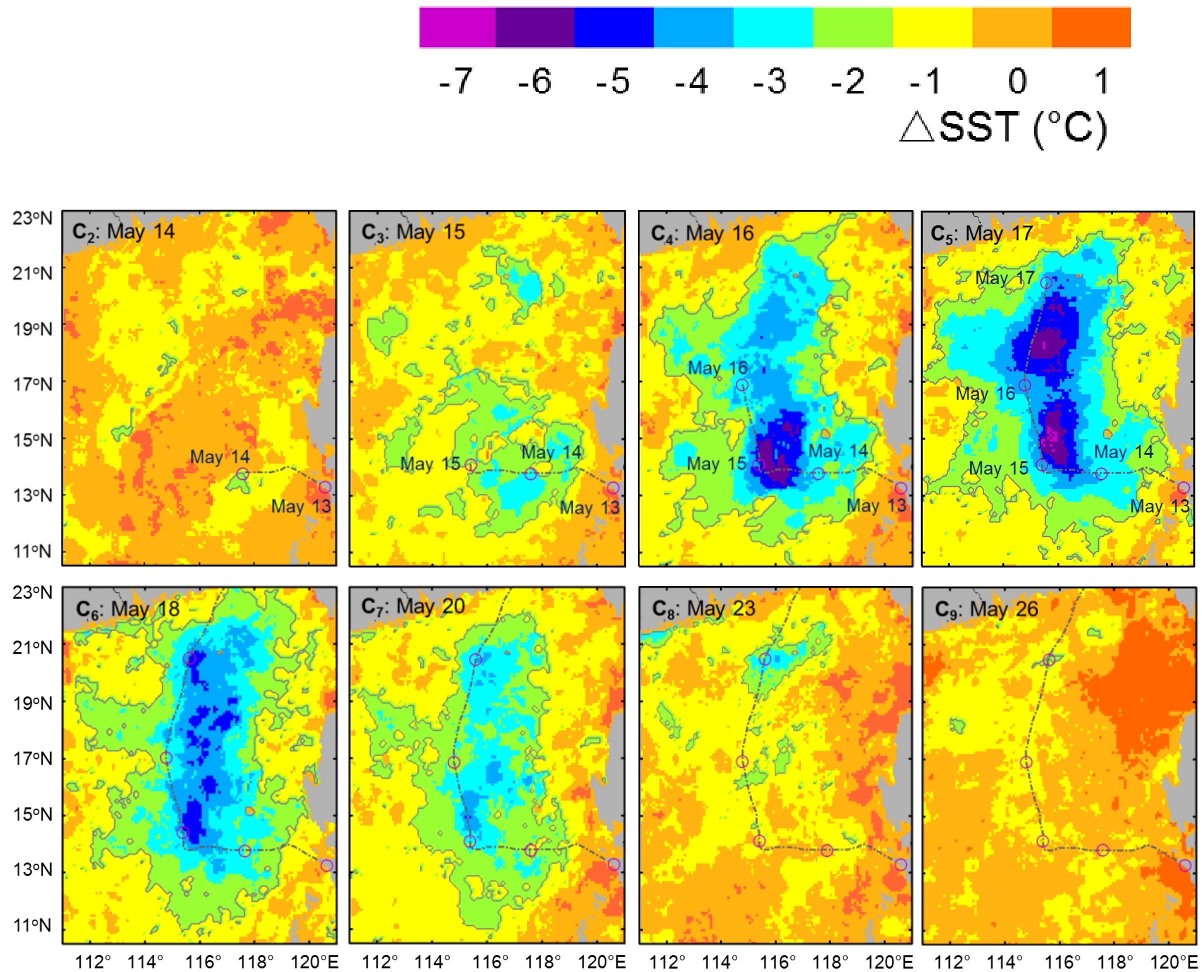
ΔT_i (°C)	magnitude of SST cooling
S_i (km^2)	area of SST cooling corresponding to ΔTi for a duration of 24 hrs.
d (days)	duration of △SST <-2°C
m, i	number of SST drops above 2 degrees in intervals of 1 degree (see text) , i=2, 3, …
n, j	the entire time (in days) of the process of SST cooling, j=1, 2, 3, …

ΔT_i : when -3< $\Delta SST \leq$ -2 °C, $\Delta \mathbf{T_1}$= 2, -4 < $\Delta SST \leq$ -3 °C, $\Delta \mathbf{T_2}$ = 3, -5< ΔSST $\leq$ -4 °C, $\Delta \mathbf{T_3}$= 4, and so on.

SST cooling response to typhoon Chanchu



(C$_1$). SST before typhoon Chanchu, color scale: SST (°C), gray solid line is the 28°C isotherm.

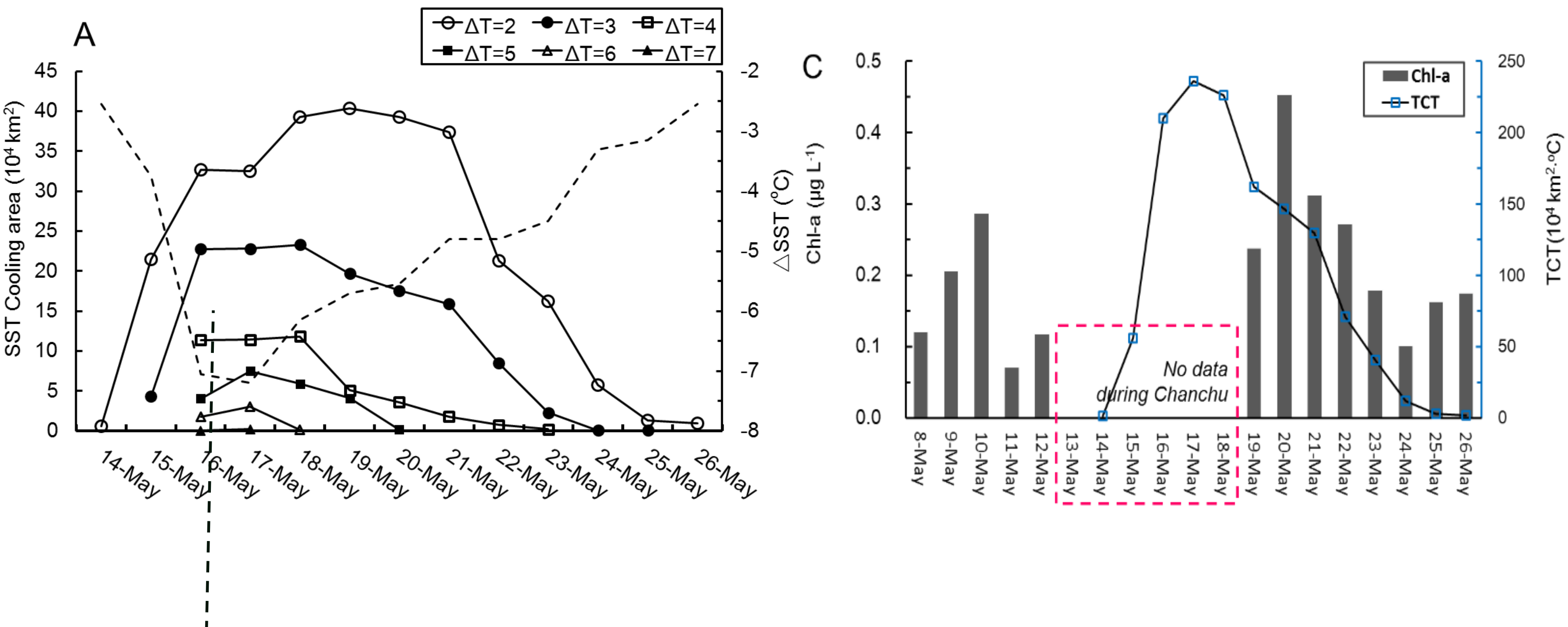


(C$_2$~C$_9$). Changes of ΔSST during and after typhoon Chanchu passing, color scale: ΔSST (°C), gray solid line is the -2°C isotherm.

TCT depended essentially on:

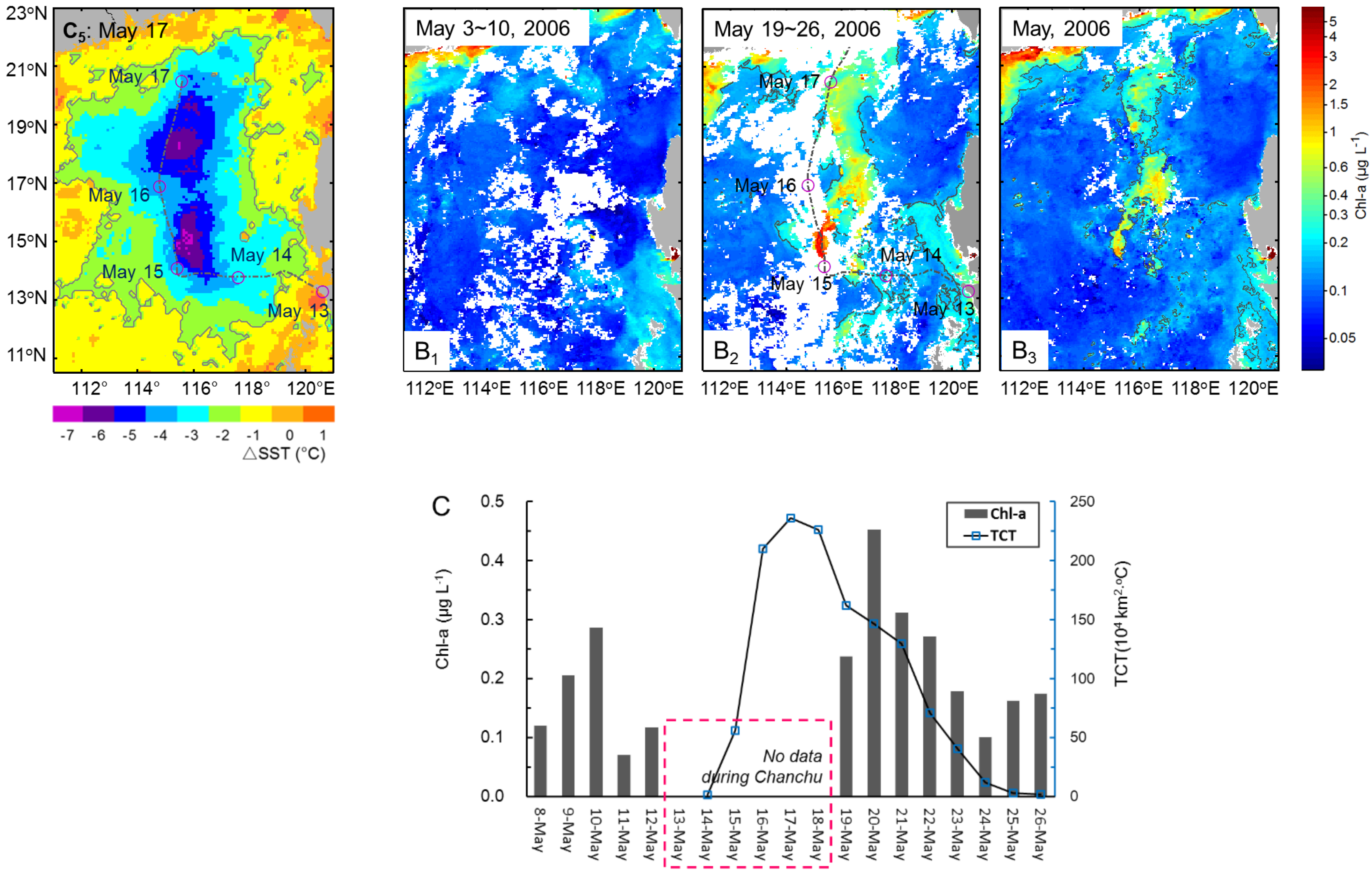
the extent of SST cooling;
cold pool area;
and the duration of the cold wake.

TCT_d was determined by the duration of SST cooling.

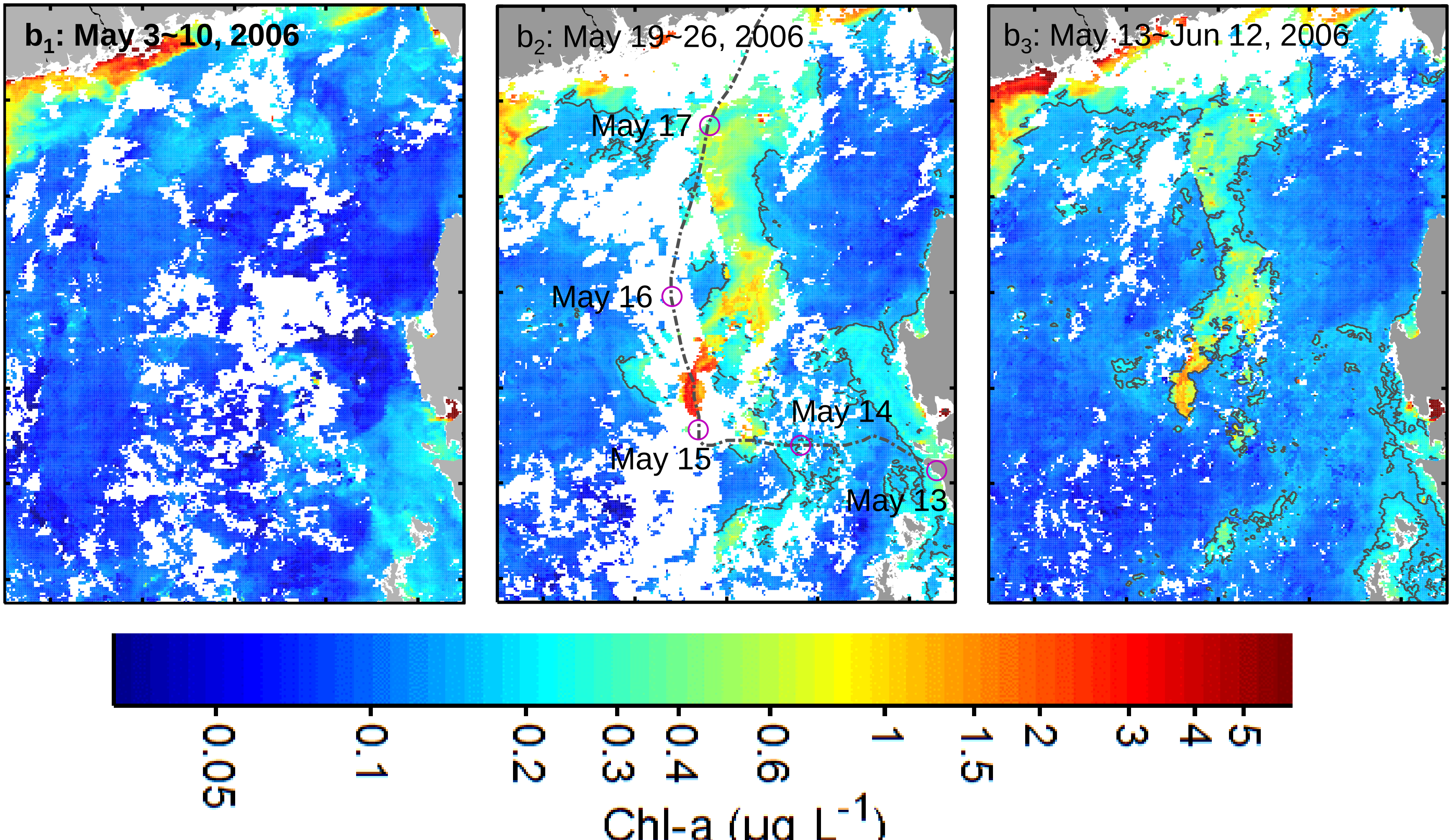


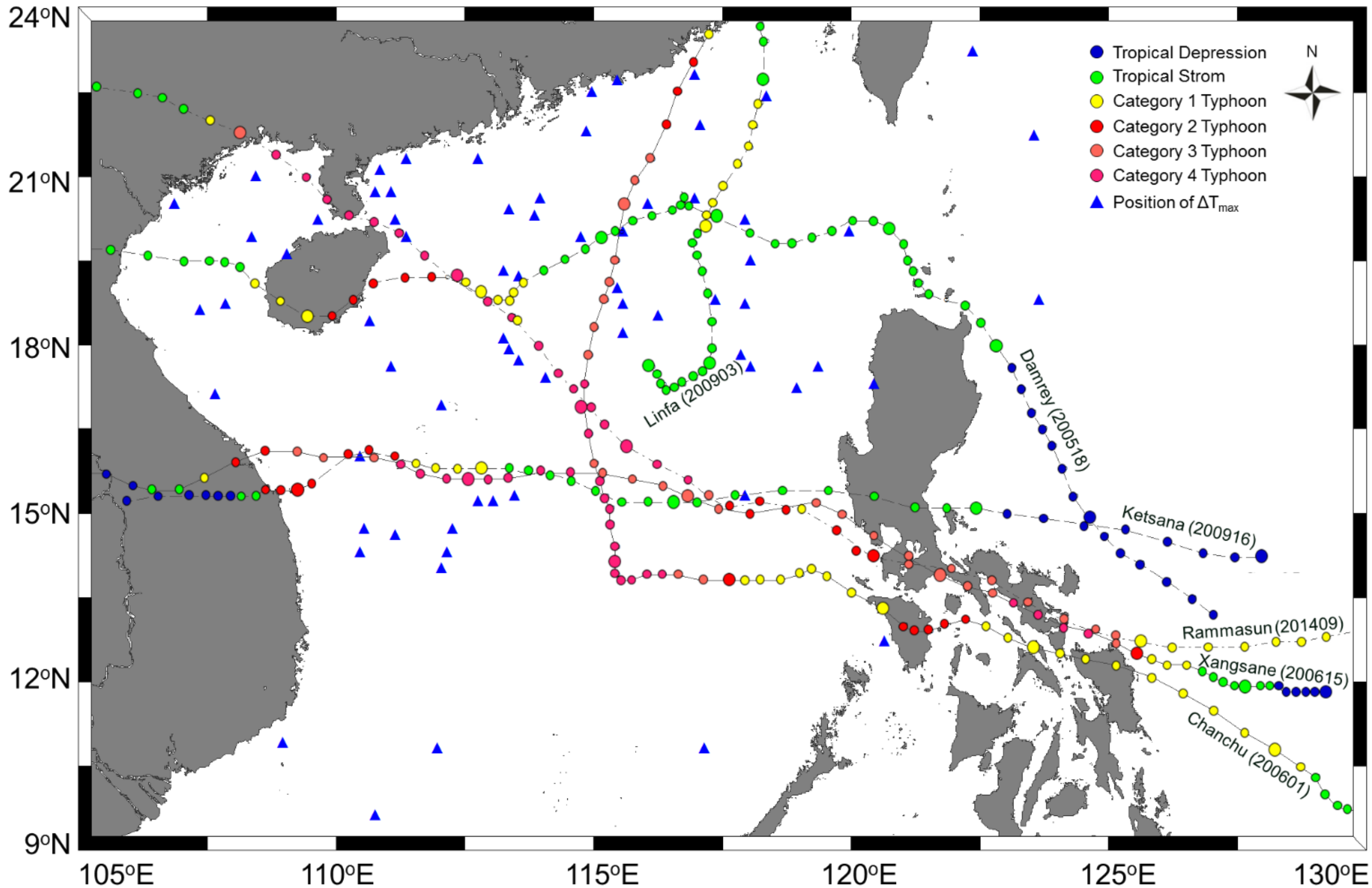
Time series of SST cooling area variation
accompanied with typhoon Ke moving

Variation of sea surface Chl-a during and after typhoon Chanchu



B: Variation of sea surface Chl-a during and after typhoon Chanchu

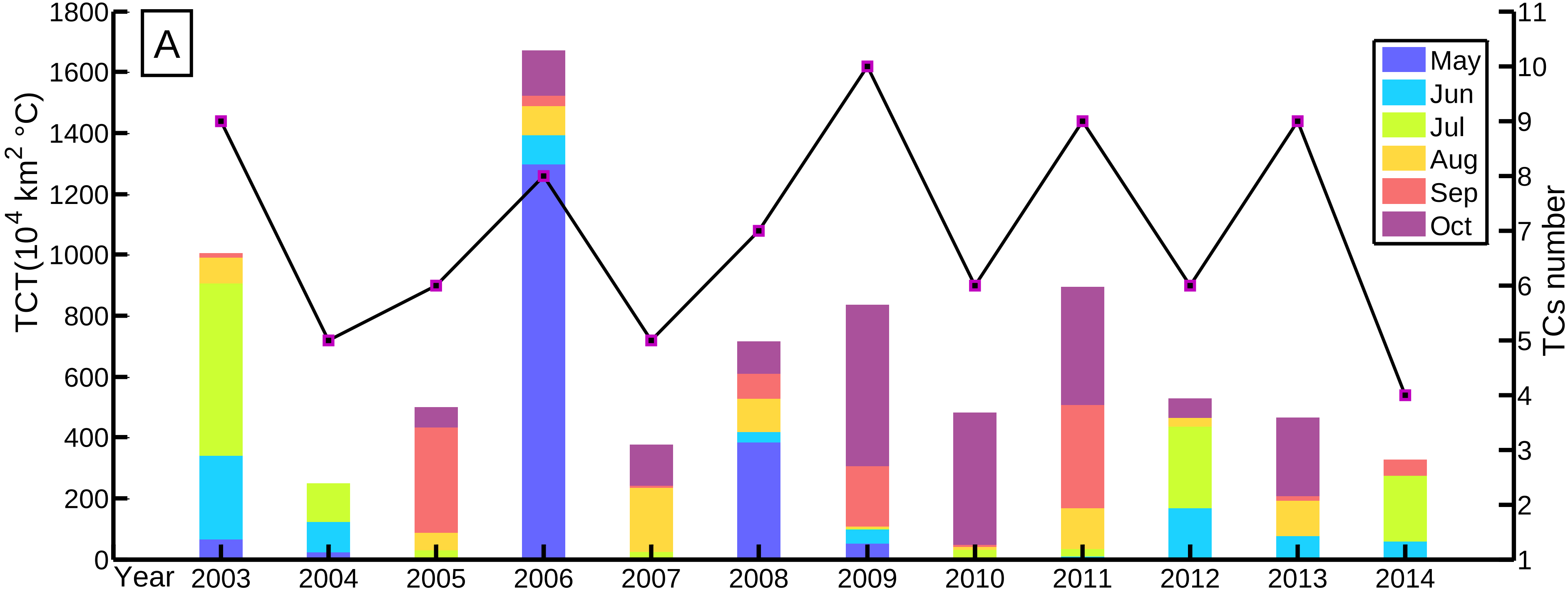




24ºN
21ºN
18ºN
15ºN
12ºN
9ºN
105ºE
110ºE
115ºE
120ºE
125ºE
130ºE
N
Tropical Depression
Tropical Strom
Category 1 Typhoon
Category 2 Typhoon
Category 3 Typhoon
Category 4 Typhoon
Position of ΔT_{max}
Linfa (200903)
Damrey (200518)
Ketsana (200916)
Rammasun (201409)
Xangsane (200615)
Chanchu (200601)

Statistics of history typhoons swept over SCS in summer (2007~2014)

Year	TCs	Typhoon parameters					Calculation parameters			Environment impact parameters		
		Duration (hrs)	Min Pres. (hPa)	Max Wind (knots)	Ave Speed (m/s)	Cat.	d	m	n	SST cooling ^{O}C	TCT $10^4 km^2 \bullet {}^oC$	TCT_d $10^4 km^2 \bullet {}^oC$
2014	HAGIBIS (201407)	84	996	45	5.81	TS	8	2	8	3.75	10	7.22
	RAMMASUN (201409)	180	935	135	6.86	4	12	3	12	4.95	40	19.94
	KALMAEGI (201415)	126	960	75	7.36	1	9	2	9	3	7	2.72
2013	BEBINCA (201305)	84	990	40	4.39	TS	7	2	7	3.6	23	8.31
	RUMBIA (201306)	96	985	65	7.75	1	6	1	6	2.55	1	0.24
	JEBI (201309)	84	985	60	5.17	TS	7	2	7	3.45	4	2.87
	UTOR (201311)	138	925	130	5.5	4	9	3	9	4.05	16	8.23
	USAGI (201319)	156	910	140	4.33	5	9	2	9	3	7	1.69
	WUTIP (201321)	90	965	90	5.08	2	12	2	12	3.75	15	6.29
2012	TALIM (201205)	84	985	50	4.39	TS	13	2	13	3.9	34	13.03
	VICENTE (201208)	78	950	115	4.47	4	11	3	11	4.5	38	18.69
	KAI-TAK (201213)	126	970	70	6.08	1	7	2	7	3.15	6	2.01
	TEMBIN (201214)	270	950	115	4.08	4	4	3	4	3.9	8	4.52
	GAEMI (201220)	120	990	55	3.58	TS	7	2	7	3.3	7	3.96

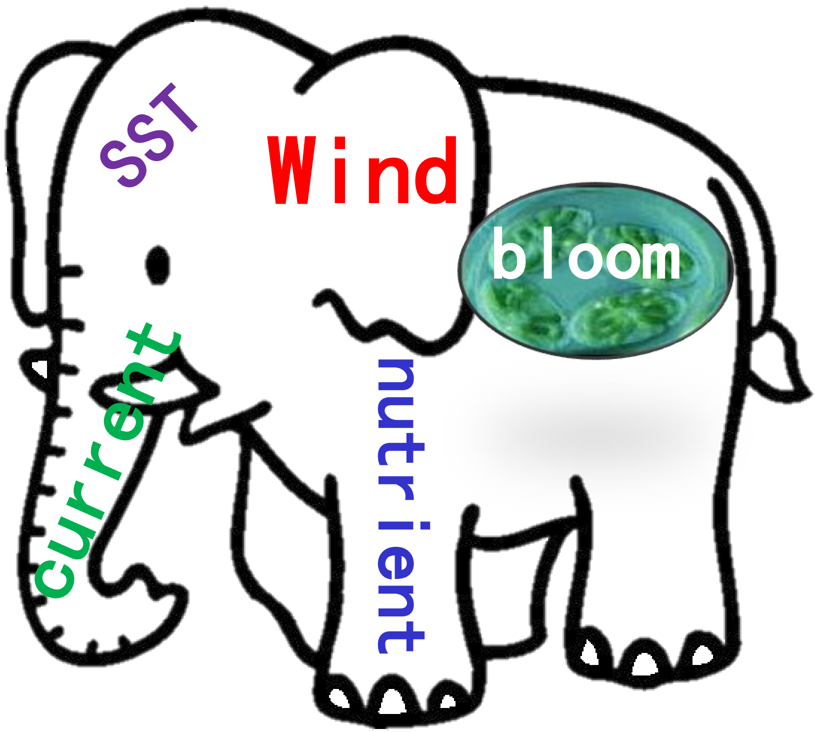


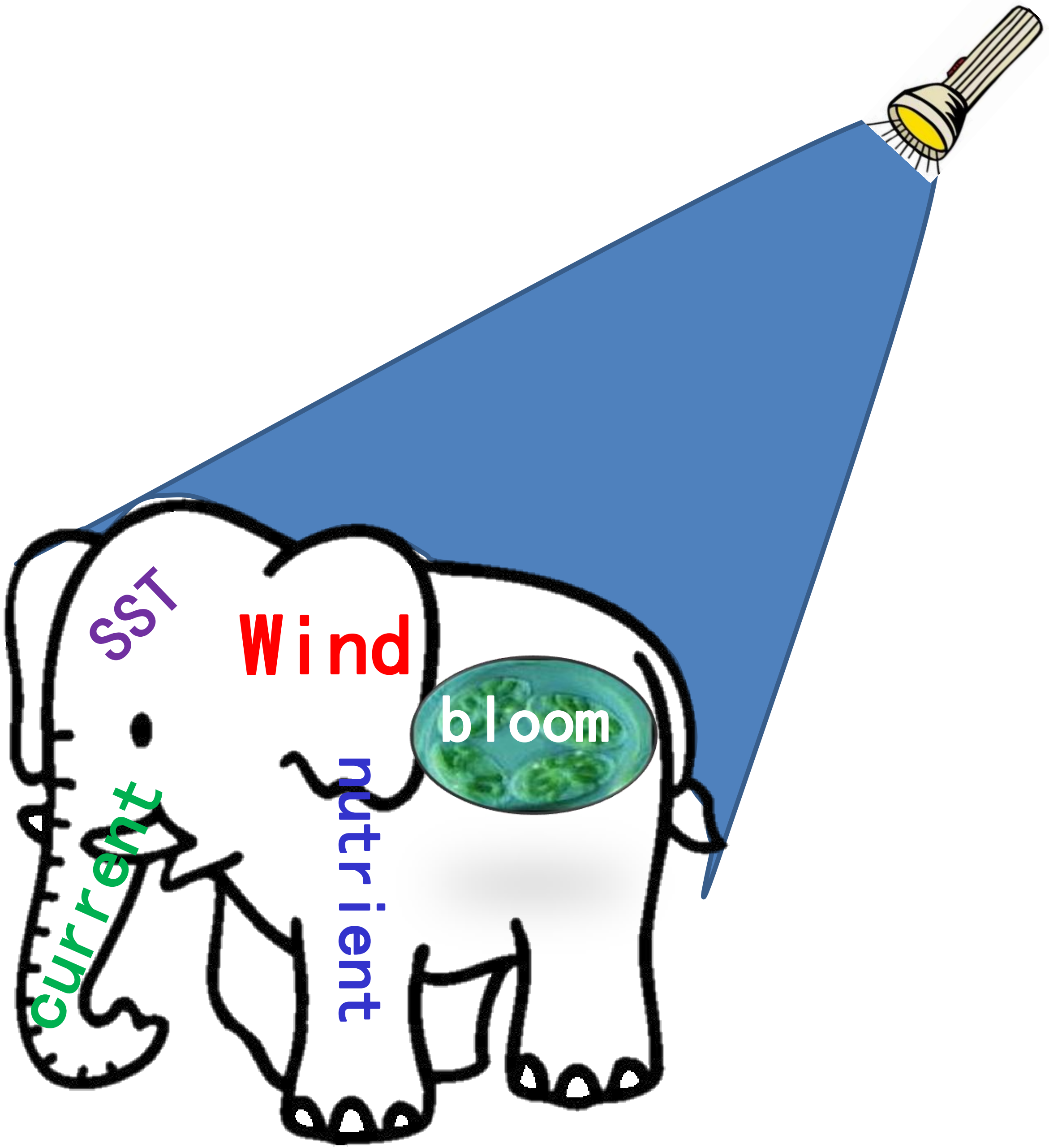
A
TCT(10^4 km^2 °C)
TCs number
Year
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
0
200
400
600
800
1000
1200
1400
1600
1800
1
2
3
4
5
6
7
8
9
10
11
May
Jun
Jul
Aug
Sep
Oct

3

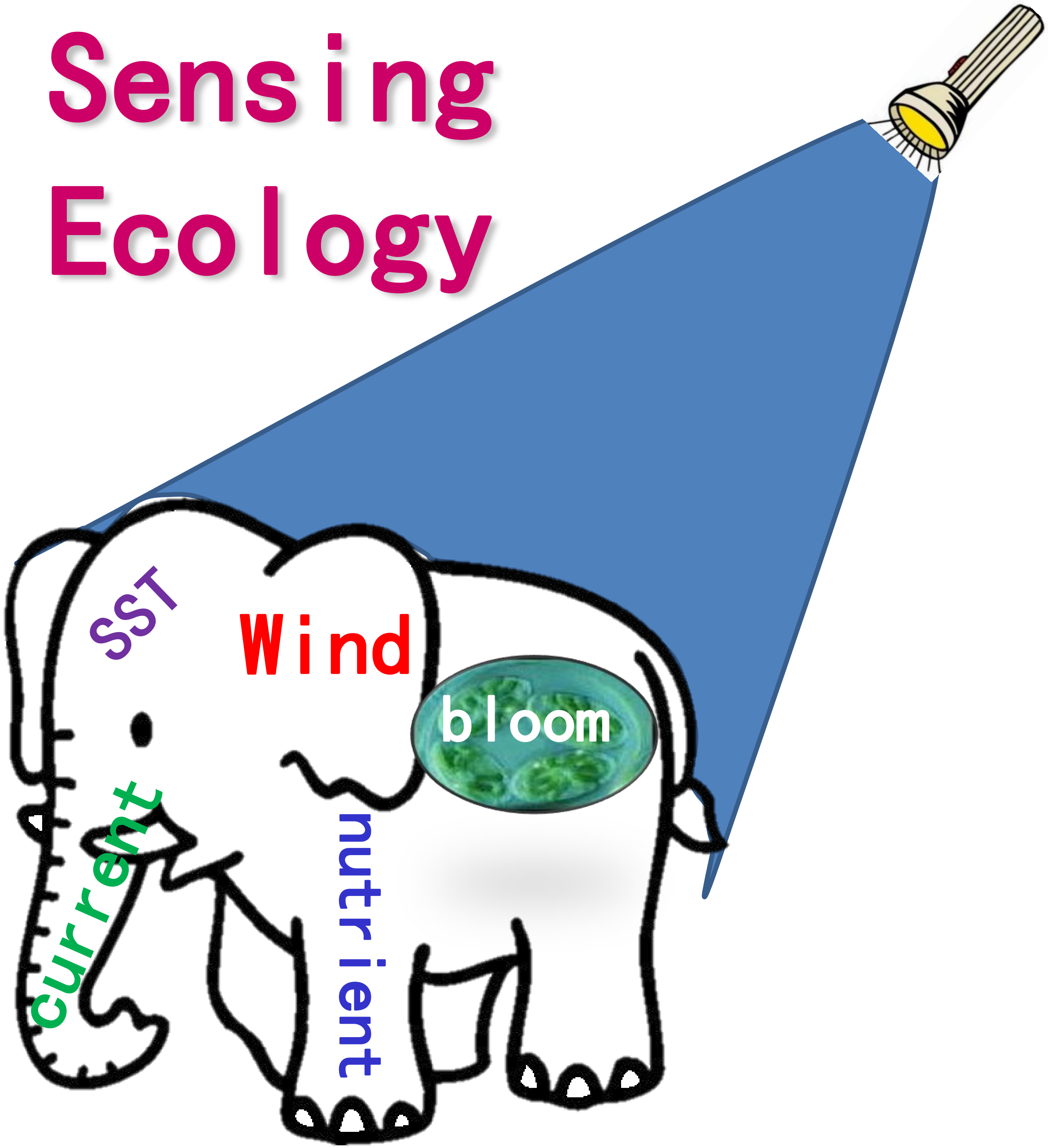
Typhoon disaster management

- Typhoon Disaster Loss valuation System based on satellite data and Multi-Models

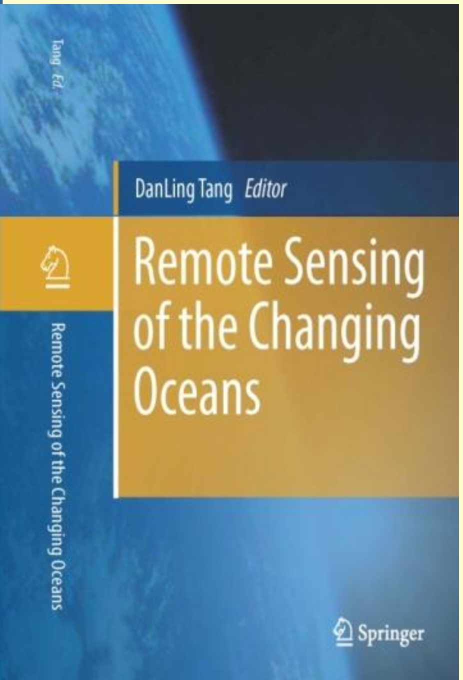

SST
Wind
bloom
current
nutrient

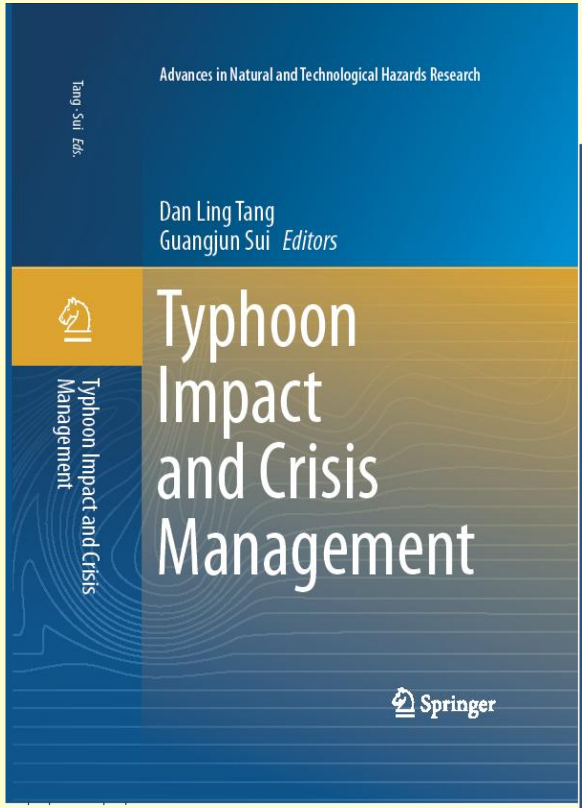

SST
Wind
bloom
nutrient
current

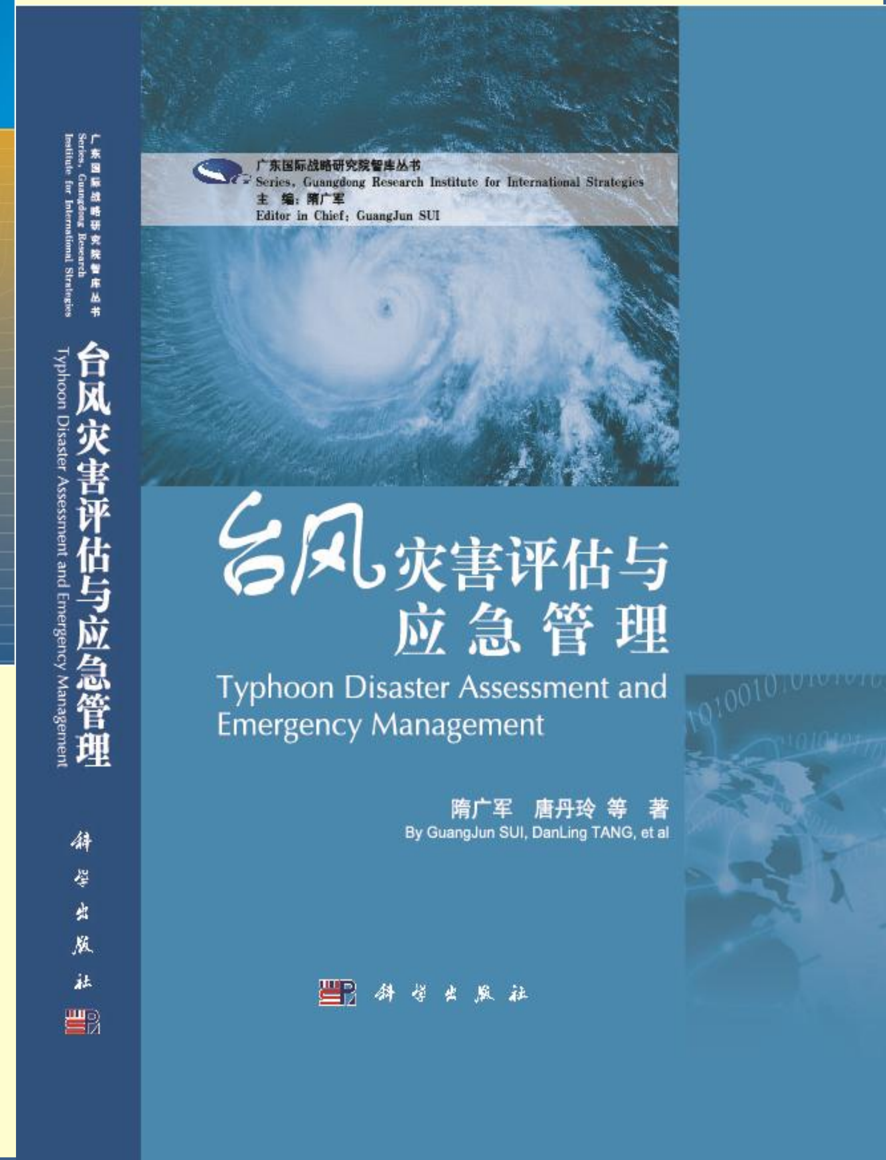
Remote Sensing
Marine Ecology



Springer
the language of science







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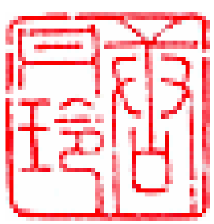
DanLing TANG (lingzis)

Thank You!

South China Sea Institute of Oceanology
Chinese Academy of Sciences



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