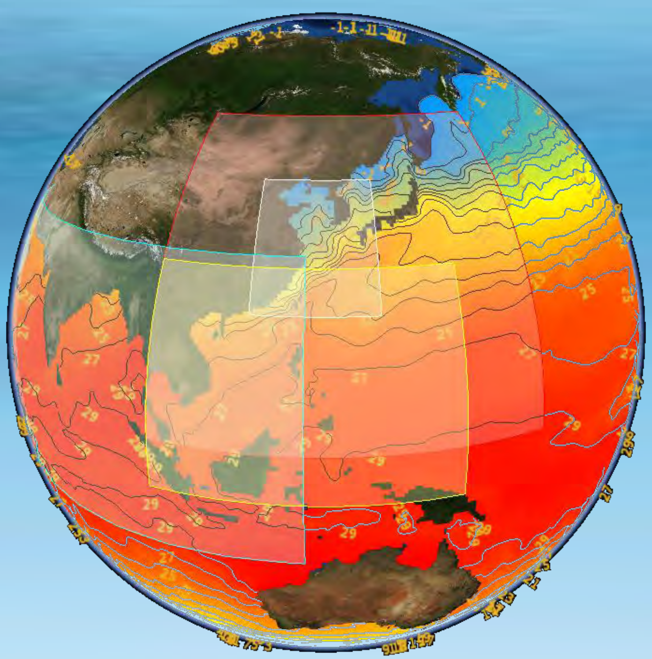
Establishment of a jellyfish model in the Northwestern Pacific



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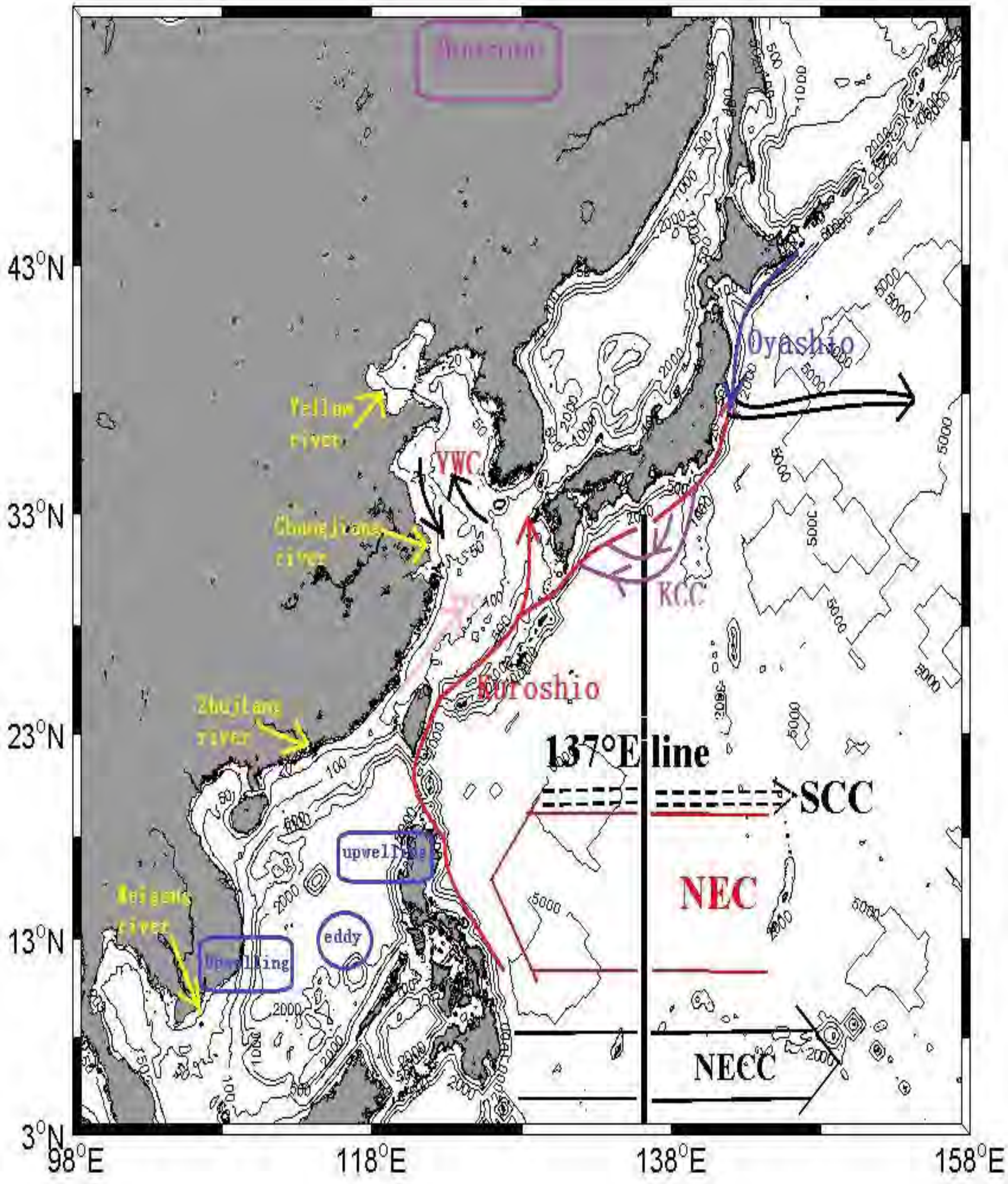
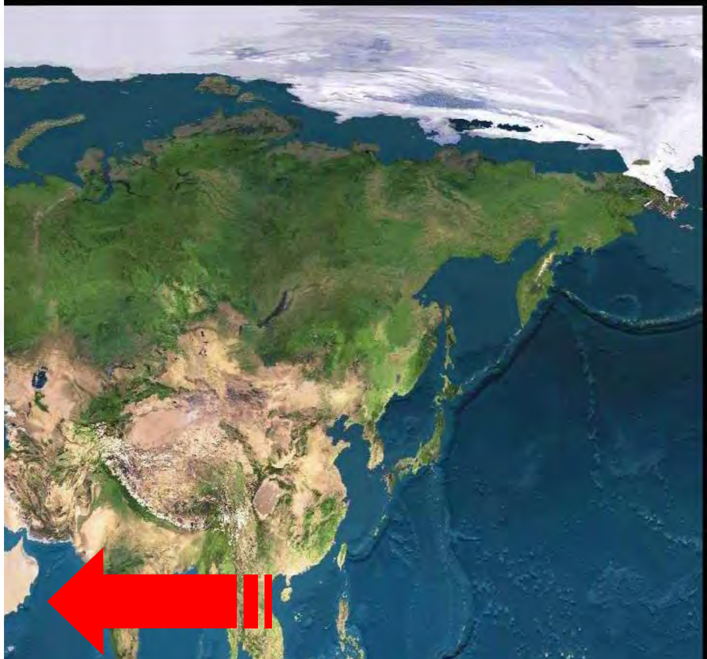
(NMEFC)

12th October, 2013

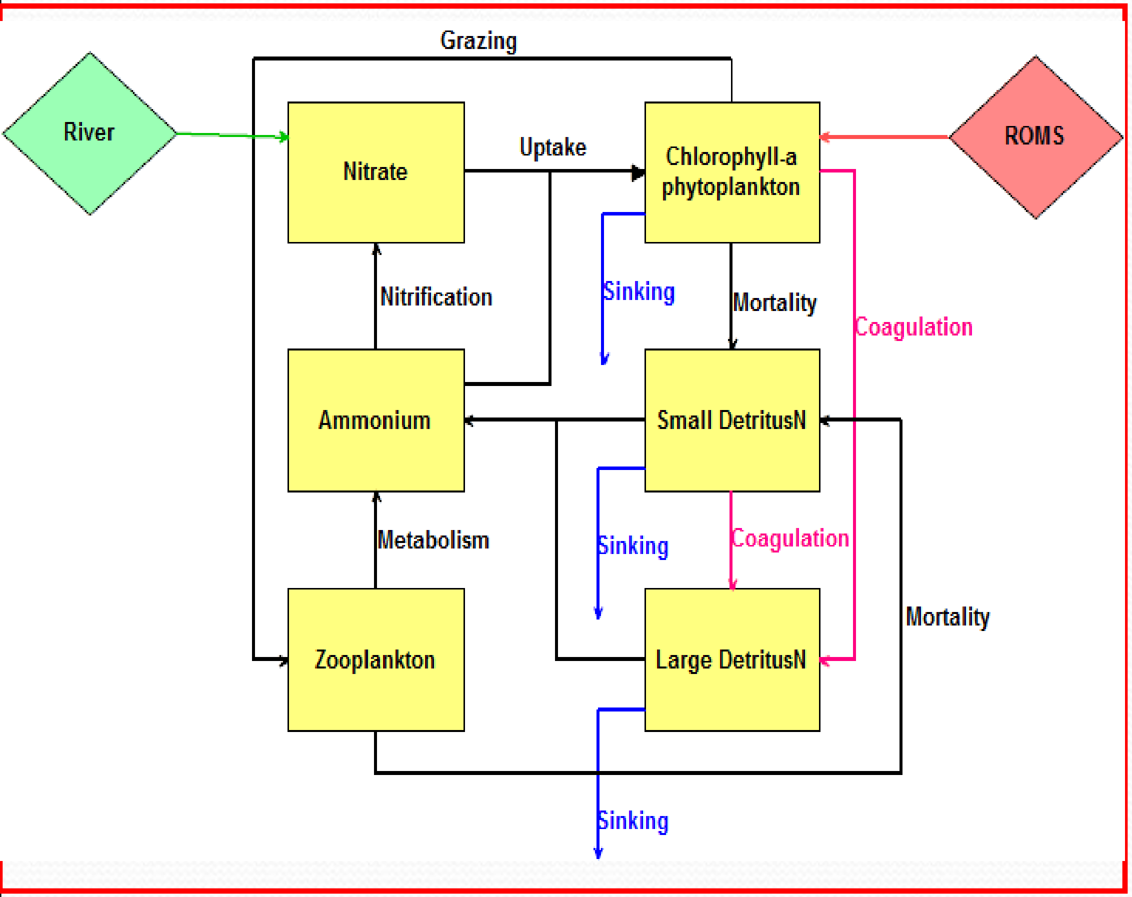
Catalogue


43°N
33°N
23°N
13°N
3°N
98°E
118°E
138°E
158°E
Oyashio
Yellow river
YWC
KCC
Kuroshio
Zhujiang river
137°E line
SCC
NEC
eddy
NECC



2 Content

NPZD-(Nutrient Phytoplankton Zooplankton Detritus Model)



phytoplankton

Source： nutrient， light intensity， temperature ；

Lost： sinking， mortality， coagulation

zooplankton

Source： grazing phy；

Lost： mortality， metabolism， excretion

Nitrate

Source： river runoff， nitrification；

Lost： uptake

Ammonium

Source： river runoff，detritus remineralization ，zoo metabolism and excretion；

Lost： uptake， nitrification

DET: Large DetritusN

Source： Coagulation；

Lost： remineralization， Sinking

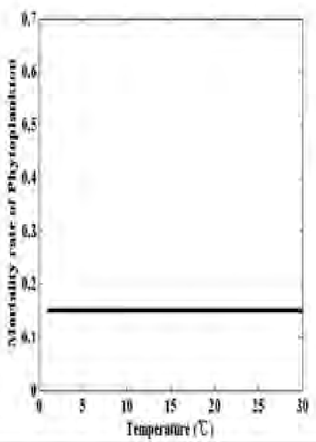
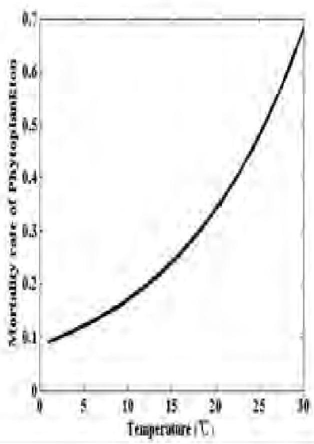
DET: Small DetritusN

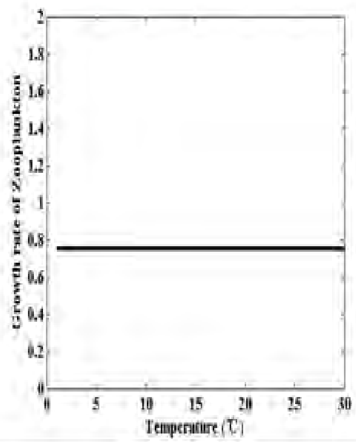
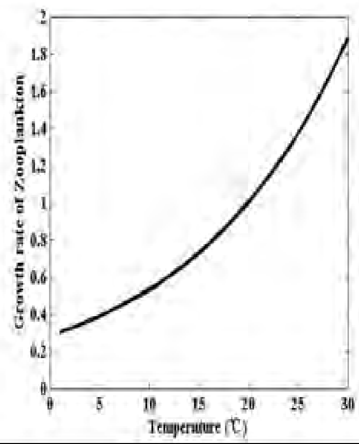
Source： Zoo and phy mortality；

Lost： Coagulation， remineralization， Singking

Formulation Modification---

Considering the biological characteristic in the China Coastal Sea, we did the modification as follows:

Mortality rate of phytoplankton	
Old Model	Modified Model
Mp=Constant	Mp=Mor*exp（Kmor*T）
Constant=0.15	Mor=0.0585;　KMor=0.0693
	

Growth rate of Zooplankton	
Old Model	Modified Model
Gmax=Constant	$Gmax=\mu_{20}*q_{10}^{(T-20)/10}$
Constant=0.75	$\mu_{20}=1$;　$q_{10}=1.8840$
	

Mor: Death Rate at 0℃;

Kmor: Phytoplankton temperature coefficient for mortality ;

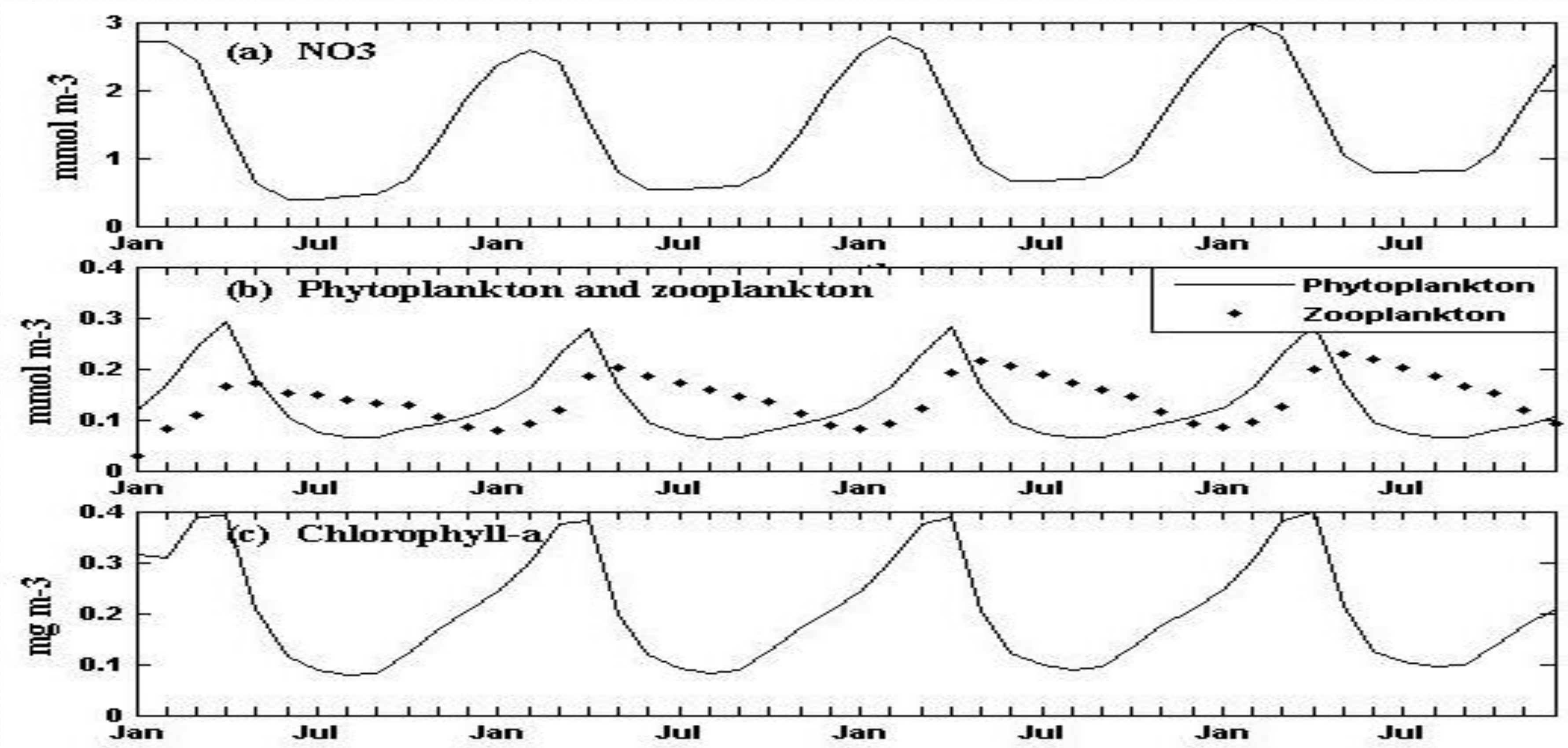
μ20: Maximum specific growth rate of zooplankton at 20°C;

q10: Temperature dependent growth rate;

2 Content

- 2-1 Setup of the Model
- 2-2 Sensitivity Analysis
- 2-3 Jellyfish Model

Conservation of biological model



Steady of the model: needs about 1 year to reach a regular annual cycle

Sensitivity Analysis:

$$S_{C,X} = \left(\frac{C_X - C_{X+\%}}{C_X}\right) / \left(\frac{X - X_{+\%}}{X}\right)$$

Freidrichs, (2001)

With $X_{+\%}$ as the value biological parameter after adding in accordance with a fixed proportion, $C_{x+\%}$ as the homologous phytoplankton concentration.

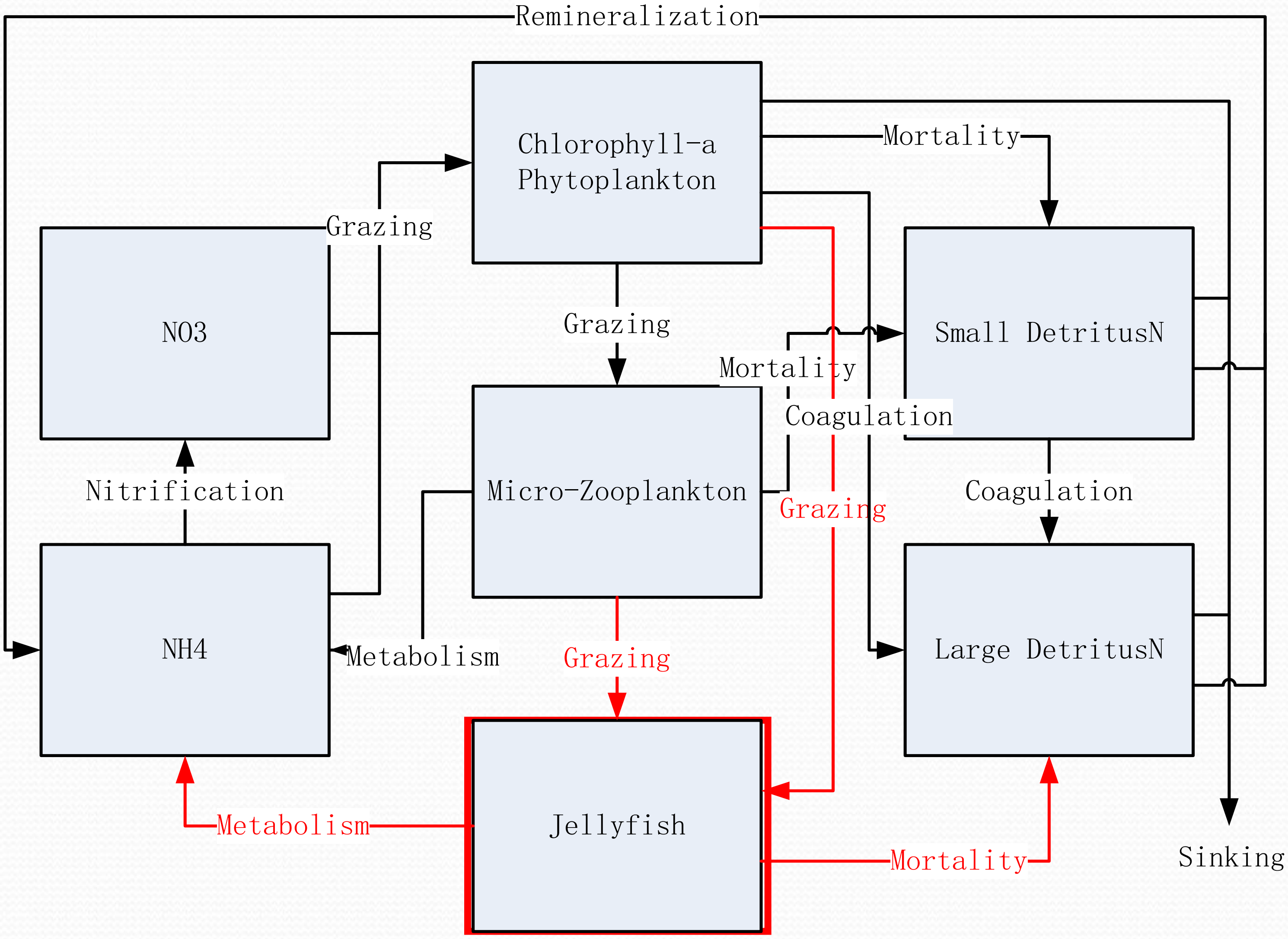
Table sensitivity values of NPZD model parameters in NWP

parameter	Explanation	Phytoplankton variation	Parameter variation	Sensitivity
Attsw	Light attenuation due to seawater	0.0691	0.5	0.1382
Attchl	Light attenuation due to chlorophyll	-0.0117	0.5	0.0234
Parfrac	Fraction of shortwave radiation that is photosynthetically active	0.039	0.5	0.078
I_thNH4	Radiation threshold for nitrification inhibition	0.0065	0.5	0.013
D_p5NH4	Half-saturation radiation for nitrification inhibition	0.0082	0.5	0.0164
K_{NO3}	Inverse half-saturation for phytoplankton NO_3 uptake	-0.0696	0.5	-0.1392
K_{NH4}	Inverse half-saturation for phytoplankton NH_4 uptake	-0.0757	0.5	-0.1514
ZooAE_N	Zooplankton Nitrogen assimilation efficiency	-0.52	0.5	**-1.04**
PhyIP	Phytoplankton, NH_4 inhibition parameter	0.0071	0.5	0.0142
PhyIS	Phytoplankton, initial slope of P-I curve	0.0376	0.5	0.0753
ZooMR	Zooplankton mortality rate	-0.107	0.5	-0.214
ZooER	Zooplankton specific excretion rate	-0.0734	0.5	-0.1468
ZooBM	Zooplankton Basal metabolism	-0.6299	0.5	**-1.2598**
LDeRRN	Large detritus remineralization rate N-fraction	-0.0472	0.5	-0.0944
SDeRRN	Small detritus remineralization rate N-fraction	-0.0614	0.5	-0.1228
CoagR	Coagulation rate: aggregation rate of SDeN + Phy ==> LDeN	-0.0612	0.5	-0.1224
NitriR	Nitrification rate: oxidation of NH_4 to NO_3	-0.059	0.5	-0.118
wPhy	Vertical sinking velocity for phytoplankton	-0.0712	0.5	-0.1424
wLDet	Vertical sinking velocity for large detritus	-0.0712	0.5	-0.1424
wSDet	Vertical sinking velocity for small detritus	-0.0757	0.5	-0.1514
μ20	Maximum specific growth rate of zooplankton at 20°C	0.5017	0.5	**1.0034**
q_{10}	Temperature dependent growth rate	-0.1027	0.5	-0.2054
Mor	Phytoplankton mortality rate at 0 Celsius	-0.0609	0.5	-0.1218
K_{mor}	Phytoplankton temperature coefficient for mortality	-0.0527	0.5	-0.1054

2 Content

- 2-1 Set up of the Model
- 2-2 Sensitivity Analysis
- 2-3 Jellyfish Model

Jellyfish Model



Based on ROMS-FENNEL

Controlling Functions

$$\frac{\partial Phy}{\partial t} = \mu Phy - gZoo - m_p Phy - \tau(SDet + Phy)Phy - \omega_p \frac{\partial Phy}{\partial z} - \underline{GraSP}$$

$$\frac{\partial Chl}{\partial t} = \rho_{Chl} \mu Chl - gZoo \frac{Chl}{Phy} - m_p Chl - \tau(SDet + Phy)Chl - \omega_p \frac{\partial Chl}{\partial z} - GraSP \frac{Chl}{Phy}$$

$$\frac{\partial Zoo}{\partial t} = g\beta Zoo - l_{BM} Zoo - l_E \frac{Phy^2}{k_p + Phy^2} \beta Zoo - m_z Zoo^2 - \underline{GraSZ}$$

$$\frac{\partial NH4}{\partial t} = -\mu_{\max} f(I) L_{NH4} Phy - nNH4 + l_{BM} Zoo + l_E \frac{Phy^2}{k_p + Phy^2} \beta Zoo + r_{SD} SDet + r_{LD} LDet + \underline{Excretion} + \underline{Egestion}$$

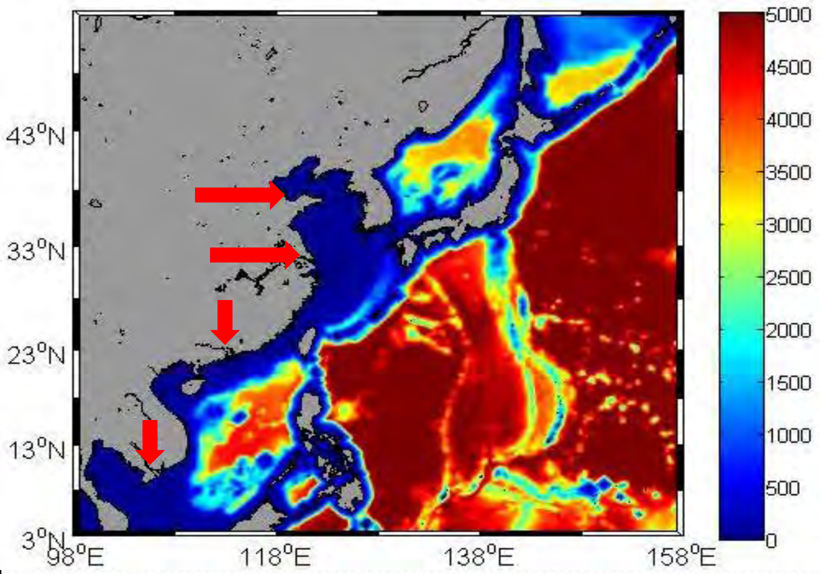
$$\frac{\partial NO3}{\partial t} = -\mu_{\max} f(I) L_{NO3} Phy + nNH4$$

$$\frac{\partial SDetN}{\partial t} = g(1-\beta)Zoo + m_z Zoo^2 + m_p Phy - \tau(SDetN + Phy)SDetN - r_{SD} SDetN - \omega_S \frac{\partial SDetN}{\partial z}$$

$$\frac{\partial LDetN}{\partial t} = \tau(SDetN + Phy)^2 - r_{LD} LDetN - \omega_L \frac{\partial LDetN}{\partial z} + \underline{Mortality}$$

$$\frac{\partial Jell}{\partial t} = GraSP + GraSZ - Excretion - Egestion - Mortality$$

Physical Model: ROMS



River / Month	Yellow Sea		Chang Jiang River		Zhu Jiang River		MeiGong River	
	Temp	discharge	Temp	discharge	Temp	discharge	Temp	discharge
1	1.1	2700	6.8	9800	19	4150	26	7040
2	2.2	2000	5.4	11626	19	4050	26	4190
3	6.9	6000	7.3	18201	20	4100	27	3020
4	13.6	3300	11.7	16638	23	6650	29	2680
5	19.3	2600	17.9	19601	25	15750	30	3690
6	23.8	2200	23.1	30382	28	16850	29	10400
7	25.9	3500	25.1	42003	29	19250	29	17300
8	26.0	5200	27.0	47603	29	16900	28	26000
9	20.8	2100	25.2	40509	28	10900	29	31000
10	15.1	2800	22.1	25902	26	8400	29	29900
11	8.9	3800	17.0	15191	23	6250	28	20500
12	1.7	2000	11.3	11201	20	4900	27	12100

- **Set Up**

  Region：98°E ~ 158°E，3°N ~ 52°N；

  Resolution： 1/12° ×1/12° ×22;

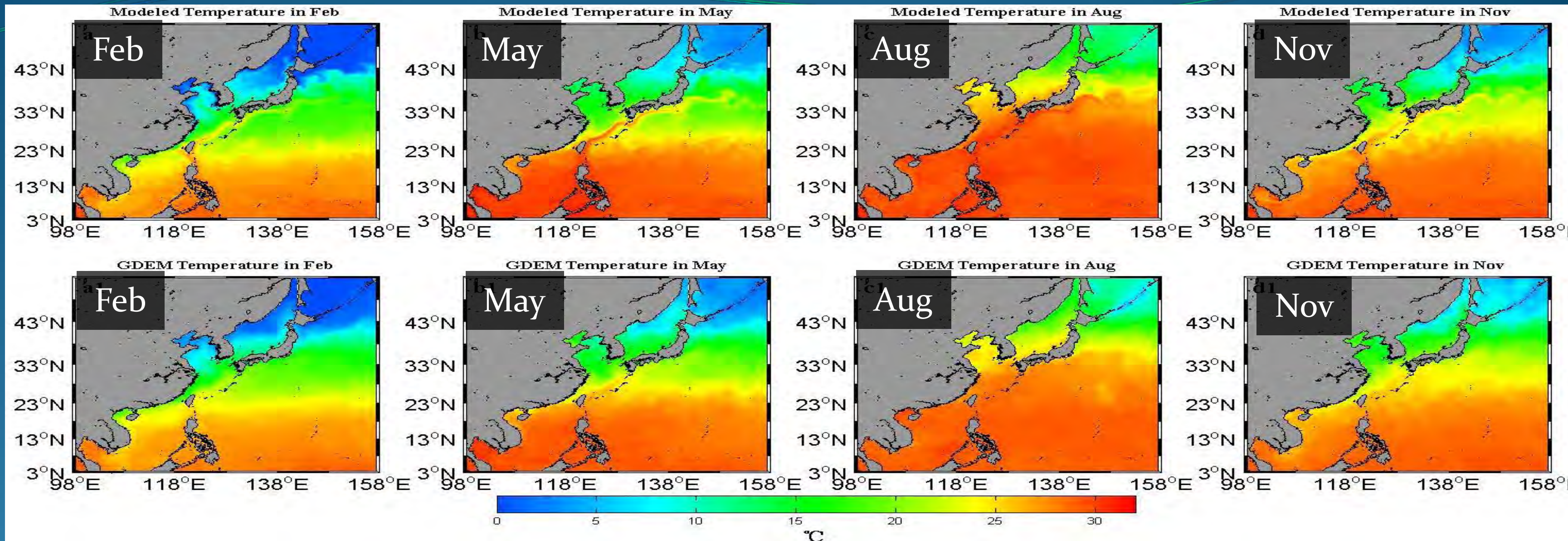
  Open Boundary：South、East、North

- **Isobaths** → GEBCO 0.5’×0.5’
- **Boundary** / **Climatological** → SODA（0.5º×0.5º×40）
- **Forcing data** → COADS（0.5º×0.5º）
- **Initial** → u、*v*、zeta :0; temp 、salt： *WOA* 09(1°×1°×24）

SST (1982-2005)

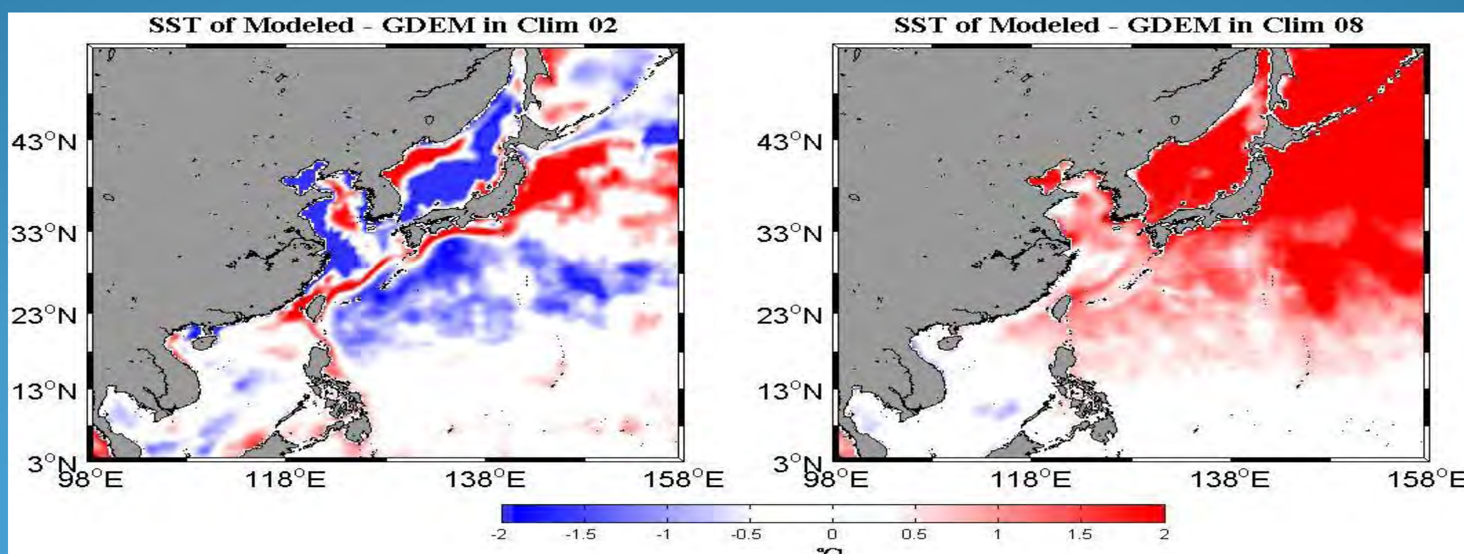
ROMS

GDEM
(Generalized Digital Environmental Model)



Feb Aug

ROMS-GDEM

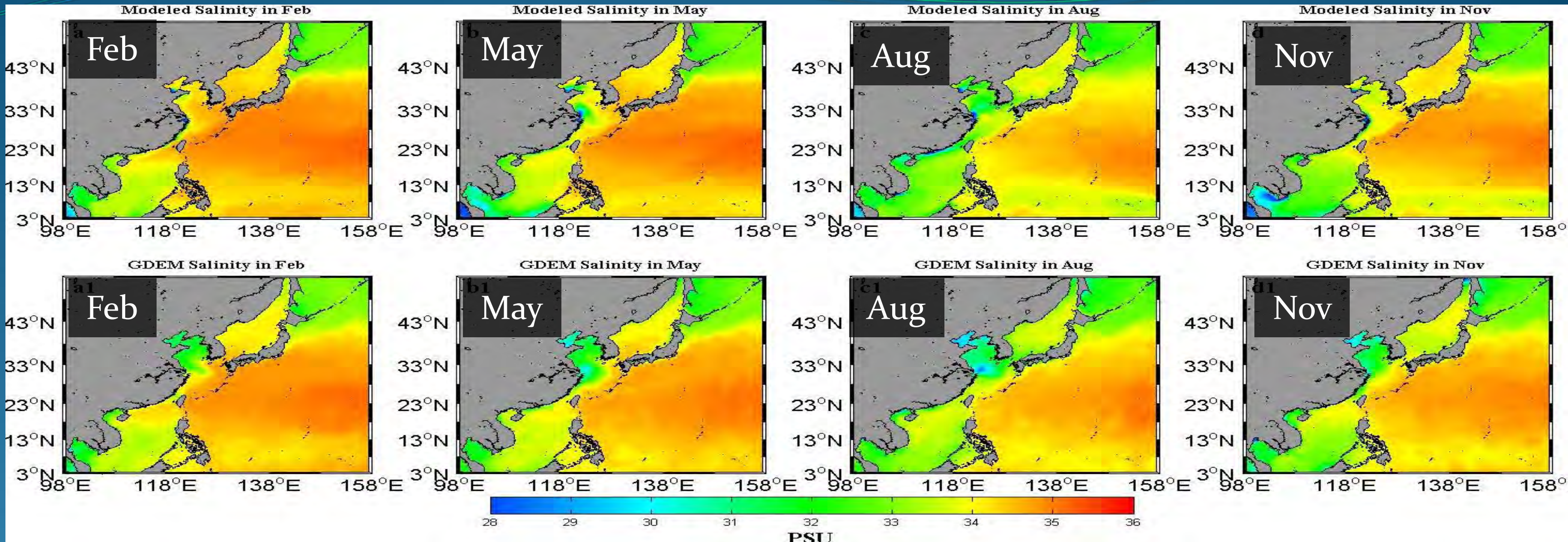


RMSE 1.36℃ 1.12℃

SSS（ 1982-2005 ）

ROMS

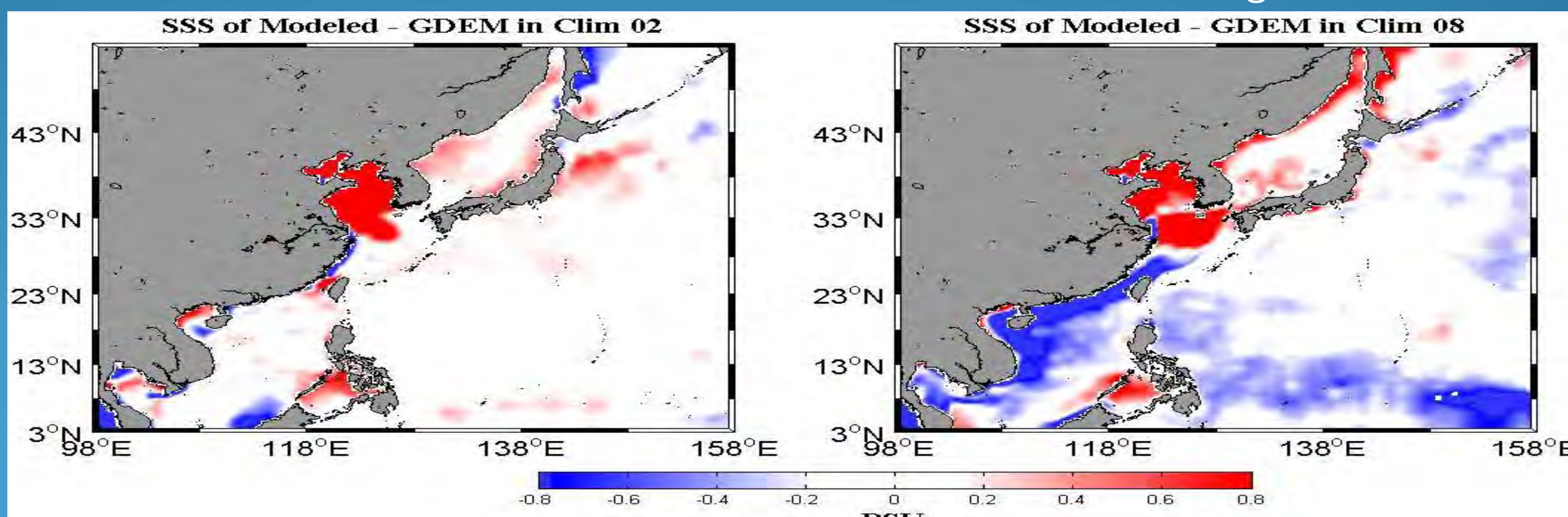
GDEM



Feb

Aug

ROMS-GDEM

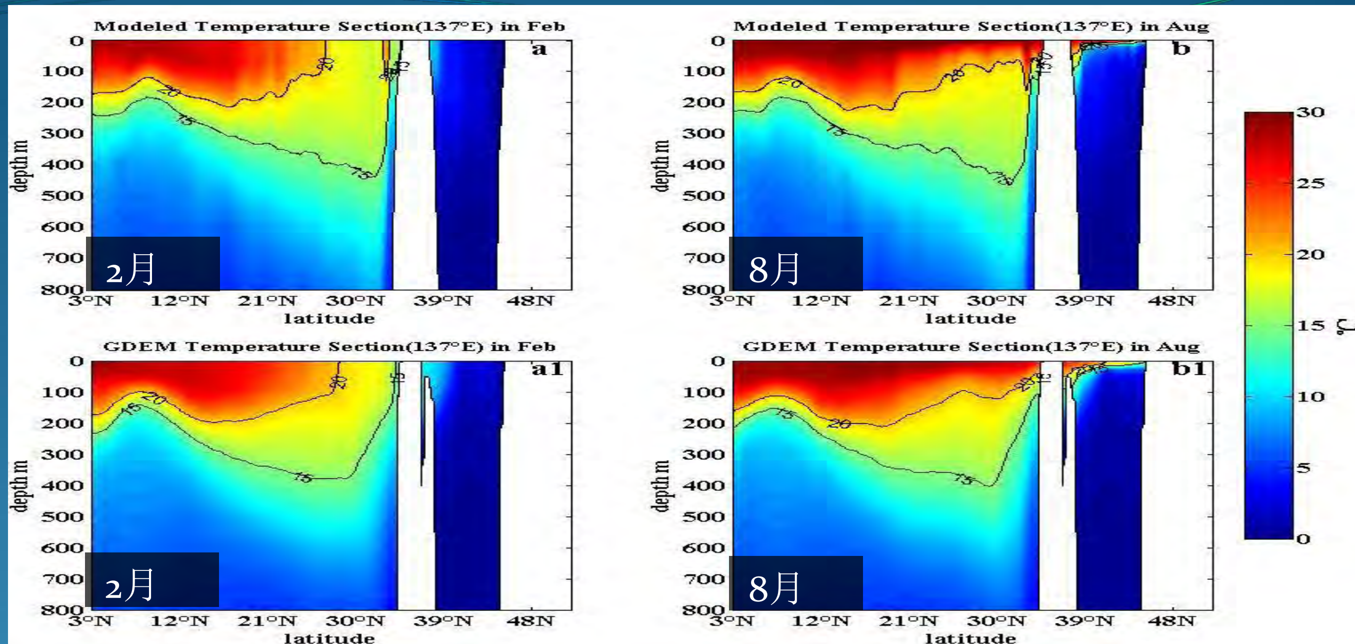


RMSE 0.59psu 0.81psu

Along section of 137°E

ROMS

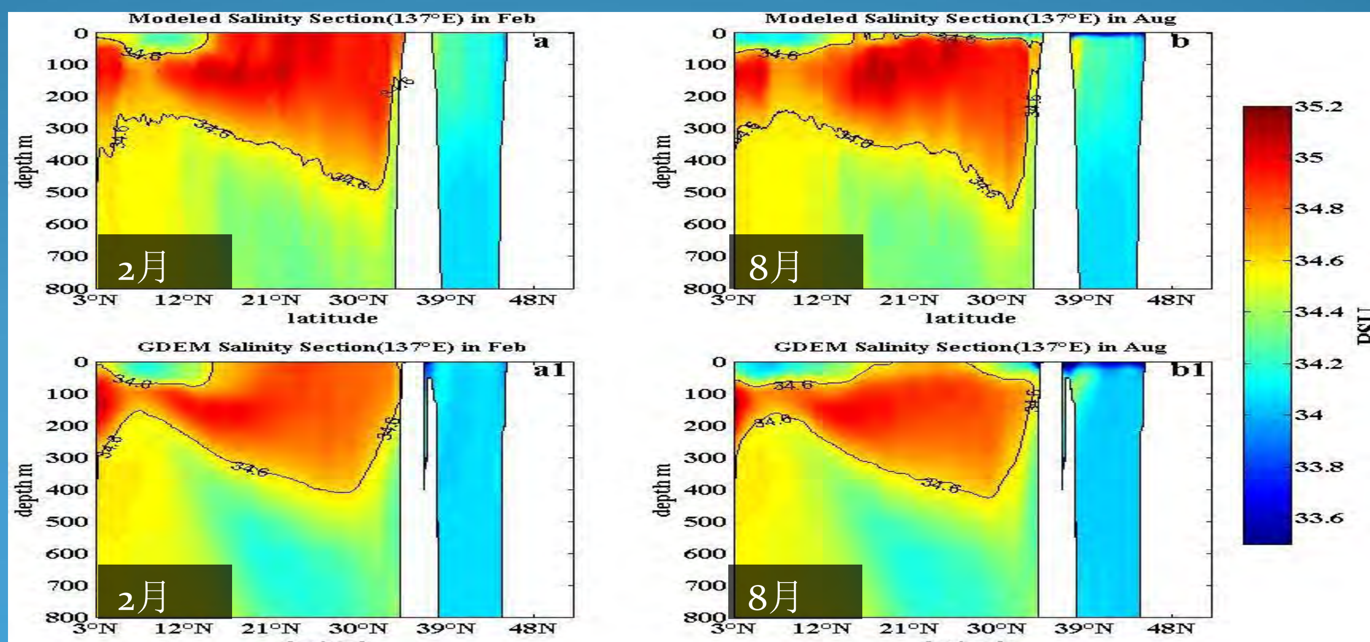
GDEM



Temp

ROMS

GDEM

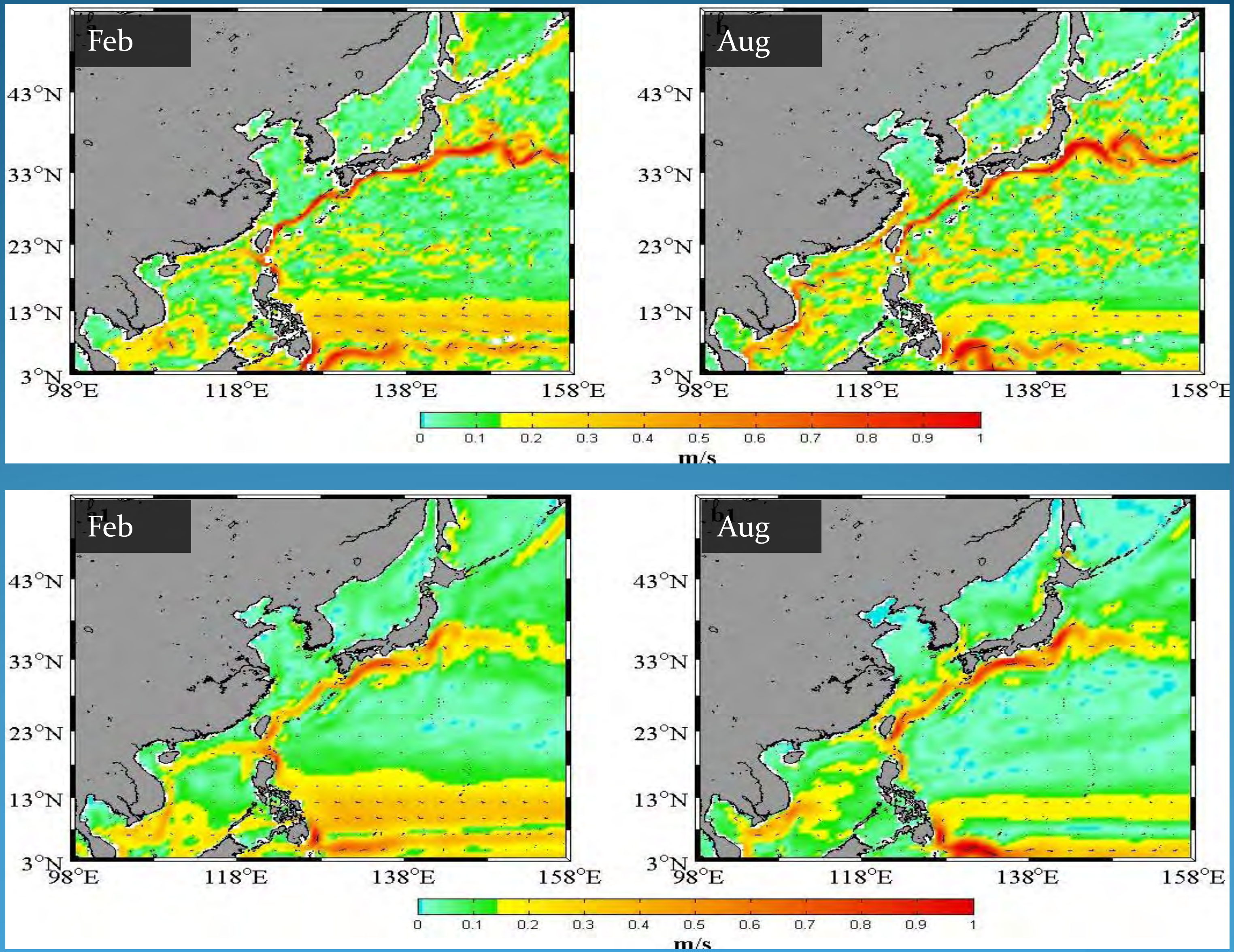


Salt

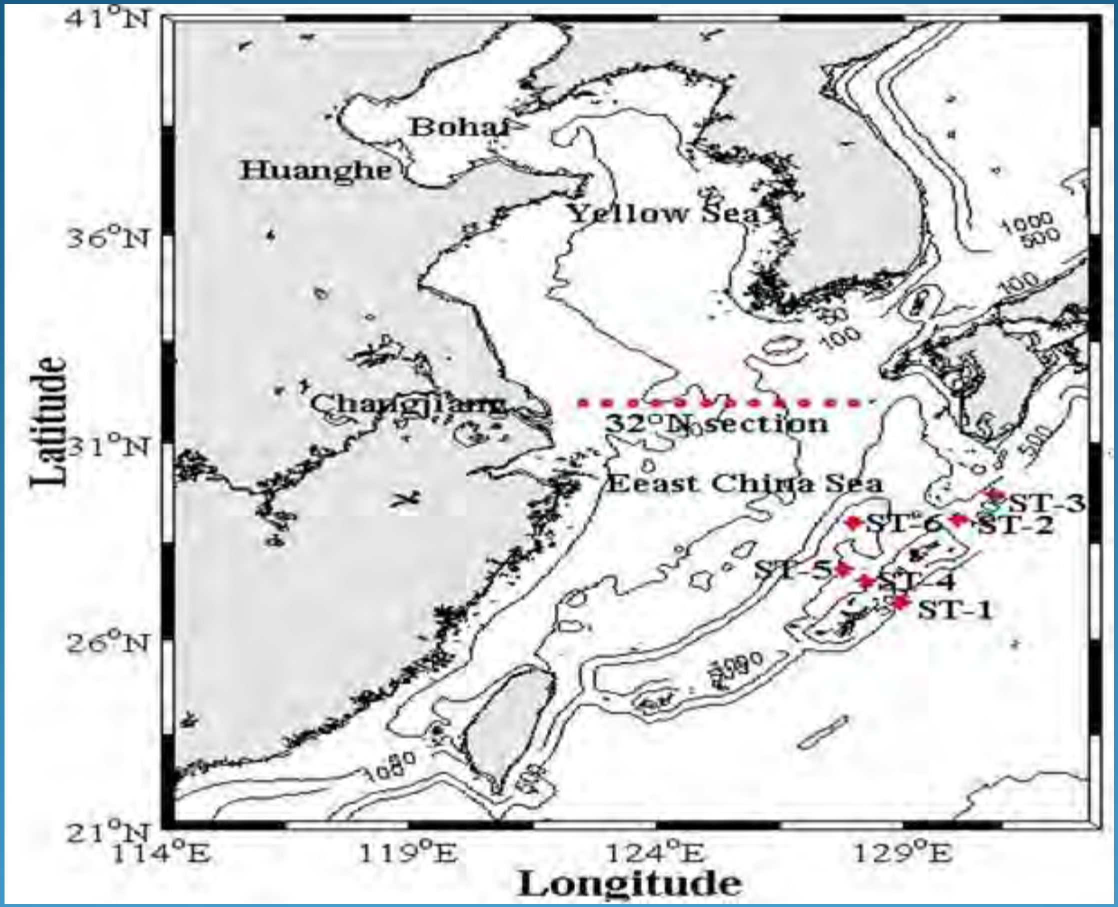
Sea surface currents (1982-2005)

ROMS

SODA



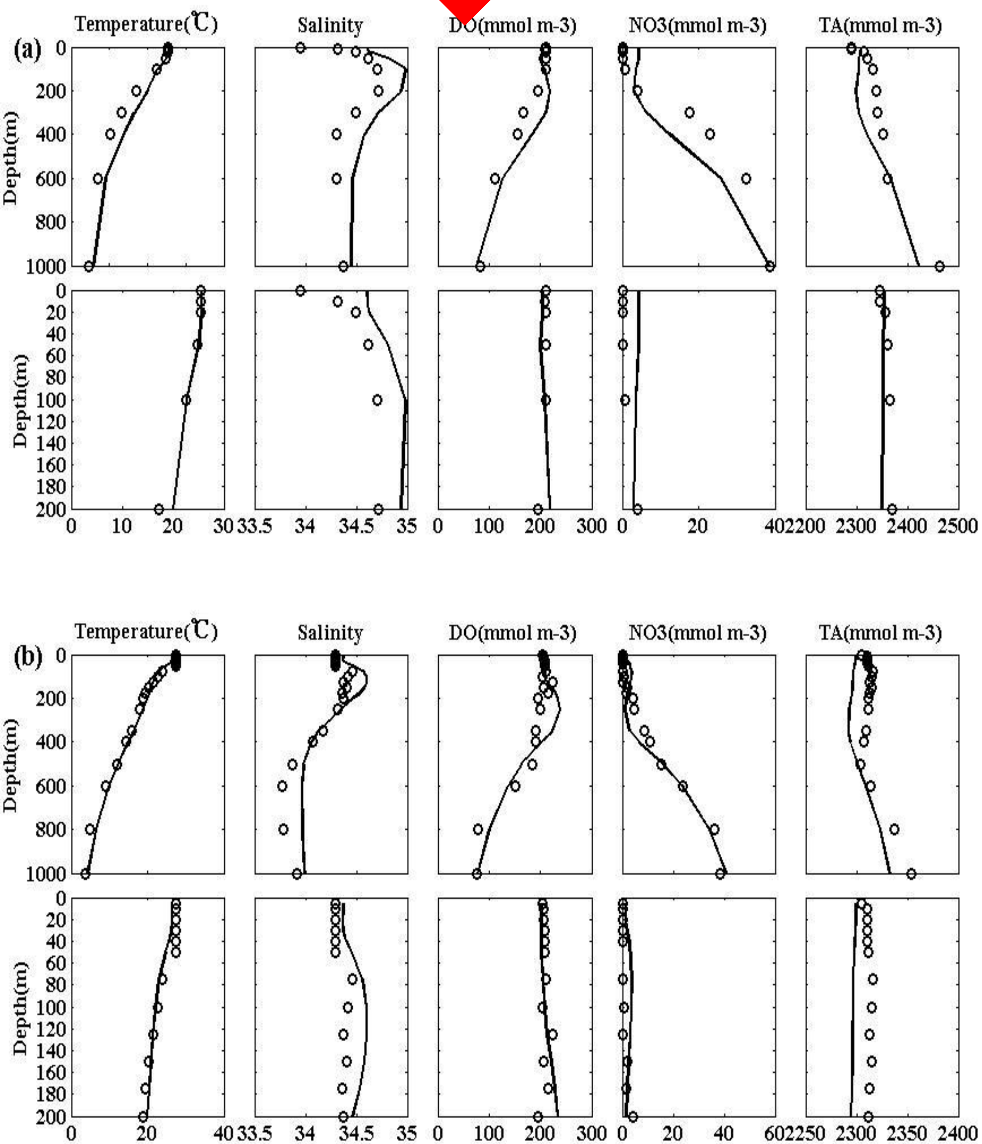
Model validation

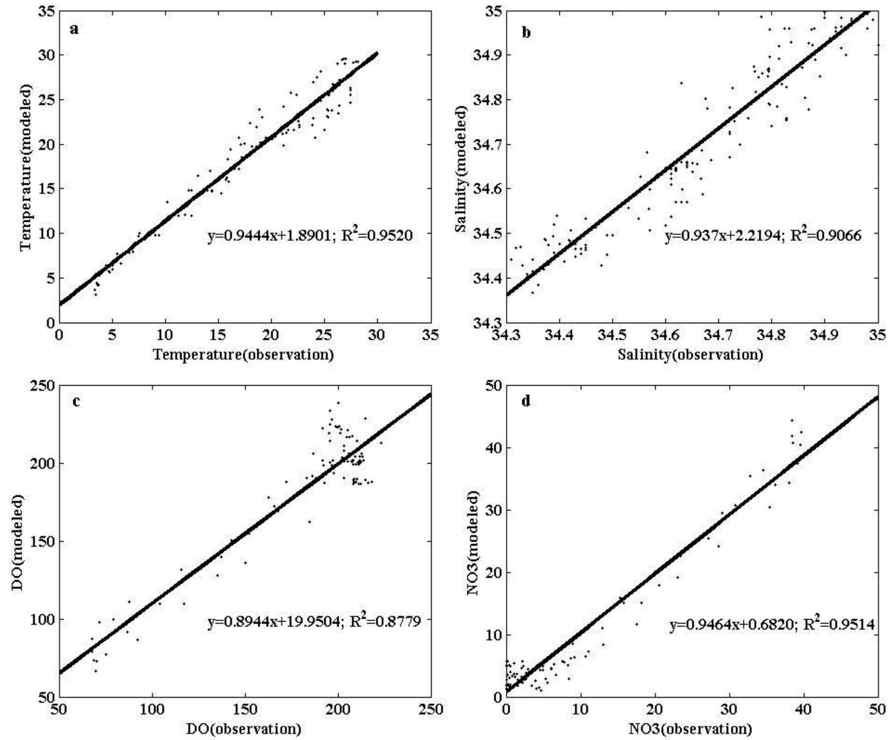


(1)The data along 32ºN section and at station site 6(ST-6) is derived from the survey cruises through the Joint Global Ocean Flux Study(JGOFS) in April 1994(Qiao et al. 2005).
(2)The other station data at station site 1, 2, 3, 4, 5(ST-1, ST-2, ST-3, ST-4, ST-5) is from the survey cruises by Japan from September to October in 1993.

(a): Compare the modeled results(solid line) with observed results(open circle) in October 1993 (ST-4)

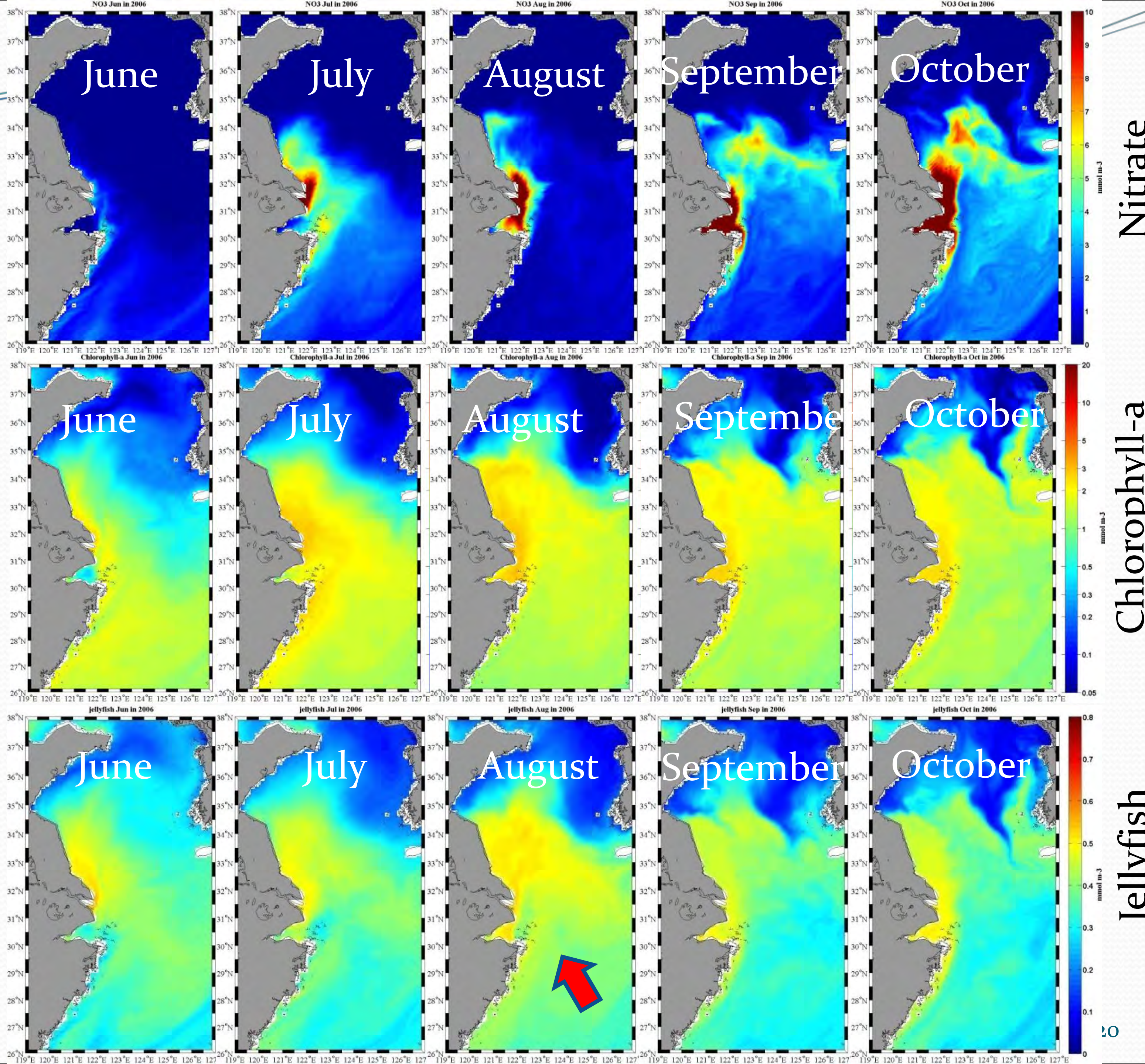
(b): Compare the modeled results(solid line) with observed results(open circle) in April 1994 (ST-5)



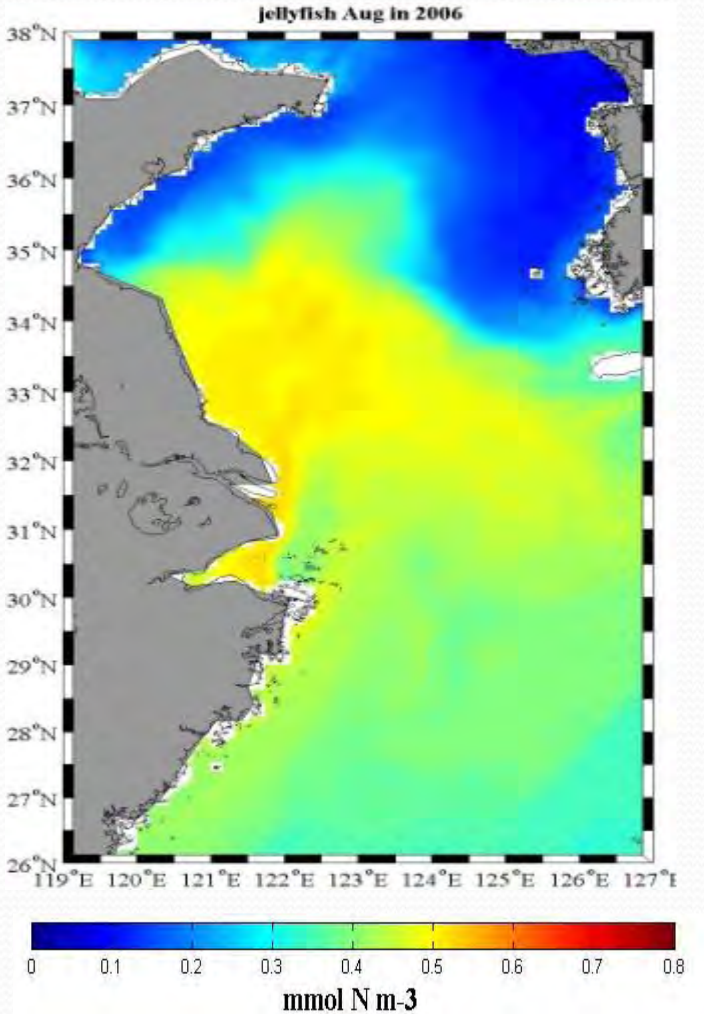


Modeled temperature(a), salinity(b), DO(c) and NO_3(d) vs observation data from 32° N section, ST-1, ST-2, ST-3, ST-4, ST-5, ST-6

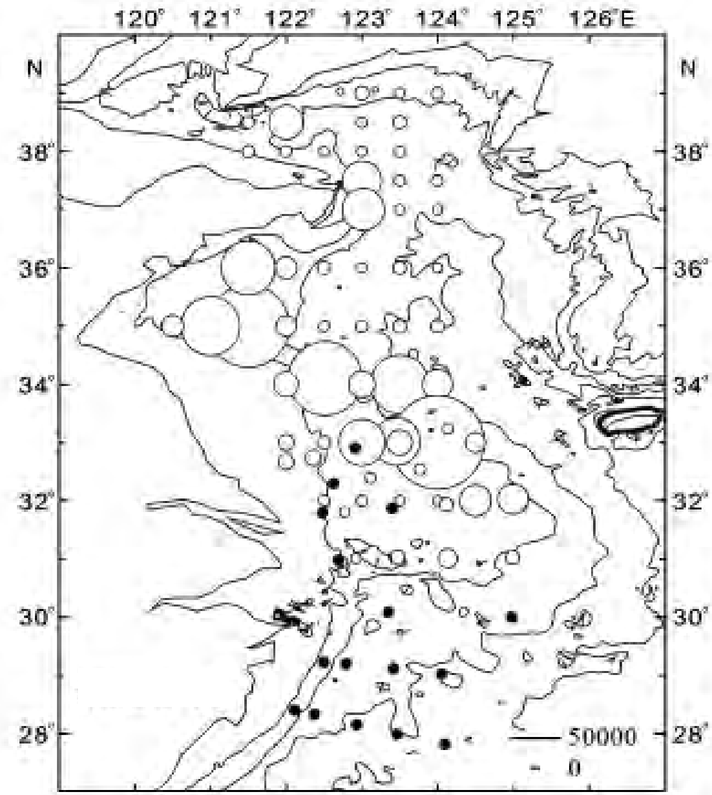
Monthly distribution of modeled results



Jellyfish distribution in the East China Sea

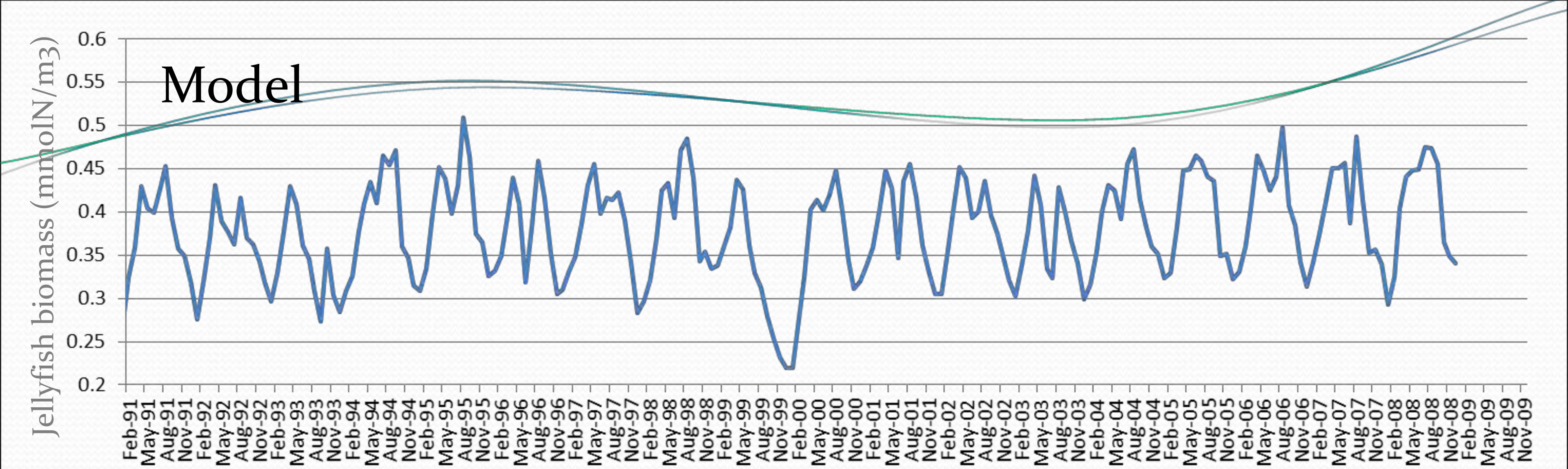


August-September, 2006



Distributions(kg/km²) of *N. nomurai* in the Yellow Sea and East China Sea

Sun et al. 2012. PROGRESS IN THE JELLYFISH BLOOM RESEARCH IN THE YELLOW SEA AND EAST CHINA SEA. OCEANOLOGIA ET LIMNOLOGIA SINICA， 43（3）



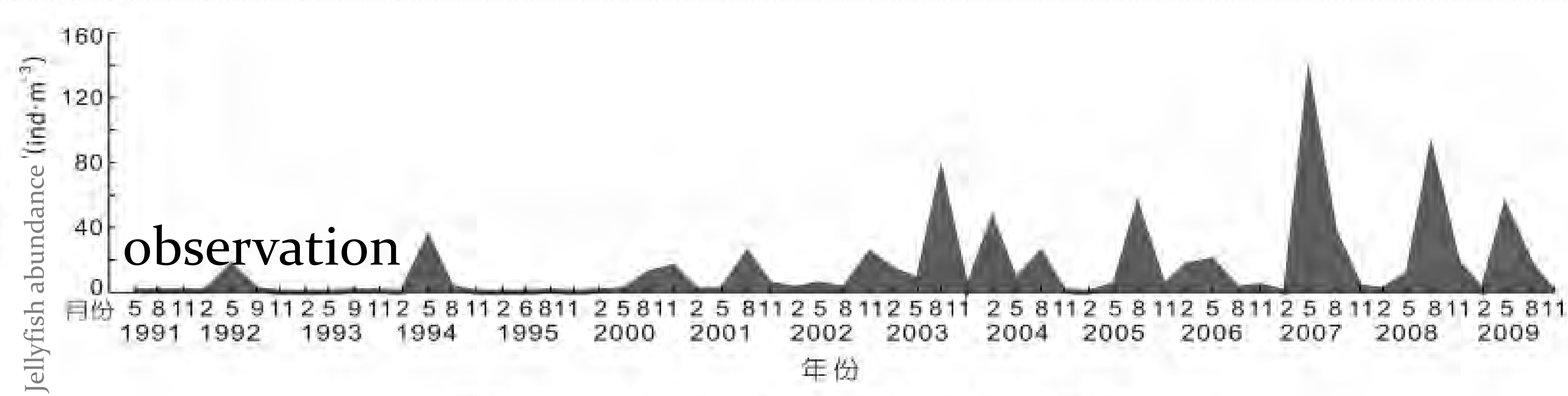


Fig.3 Variation in the abundance of small jellyfish in Jiaozhou Bay (Sun *et al*, 2012)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Yangzte River	Nitrate	40.7	39.2	40	42.1	40.7	42.9	40	36.4	35	37.9	39.2	42.1
	Ammonium	10	12.9	11.4	6.4	4.3	4.32	6.4	5	7.1	3.6	3.6	6.4

3 Conclusion

- The results shows some agreement with the observation.
- There's no increasing trend of jellyfish (model setup vs. in situ data?)
- For jellyfish model, there are more work to do ……

Thank you！

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