Development and Application of the Regional Ocean Forecasting System in China

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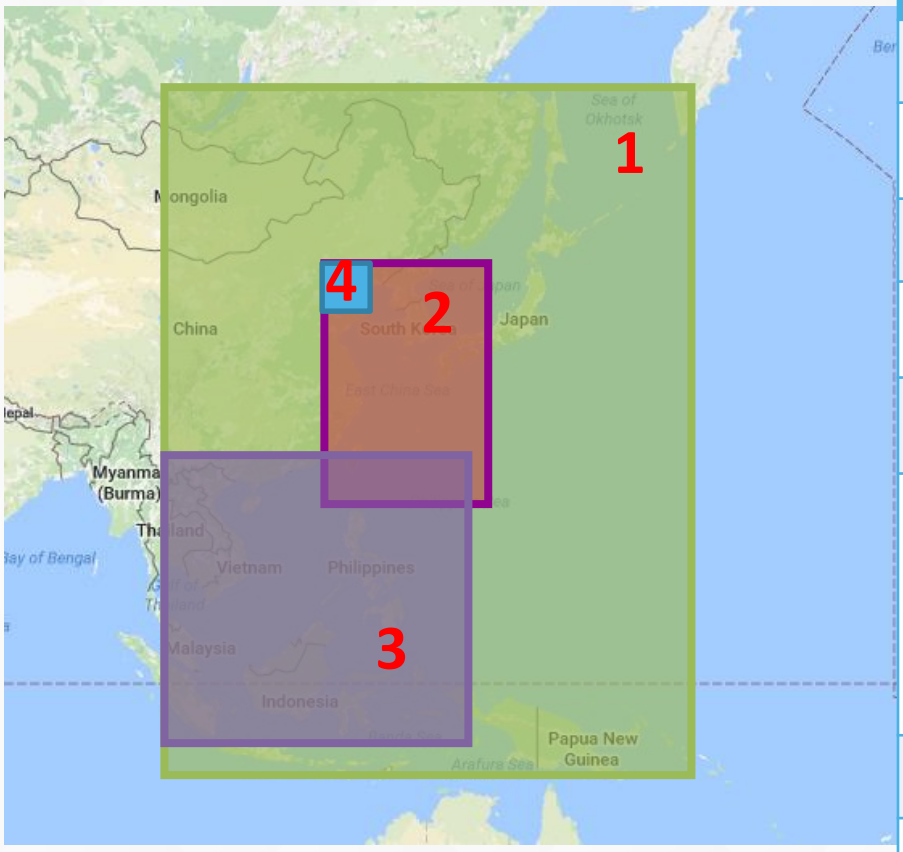
Contents

Chinese Operational Hydrological Forecasting System



		1. North-west Pacific	2. South China Sea	3. East China Sea	4. Bohai Sea
OGCM		ROMS			
Horizontal Res.		1/20°	1/30°	1/30°	1/60°
Vertical Res.		30 levels	36 levels	30 levels	30 levels
Atmosphere Forcing		GFS/CGOGS-wind/NMEFC-WRF			
Assimilation Scheme		3D-VAR	Nudging/EnOI		Nudging
OBS	SST	MGDSST			
	SSH	Jason-1 & Jason-2, Cryosat, SARAL and HY2			
	Others	In-situ temperature and salinity profiles, e.g. Argos, XBTs			
Products		Temperature, Salinity, Currents			
Forecast Range		5 days			
Update Frequency		Daily			

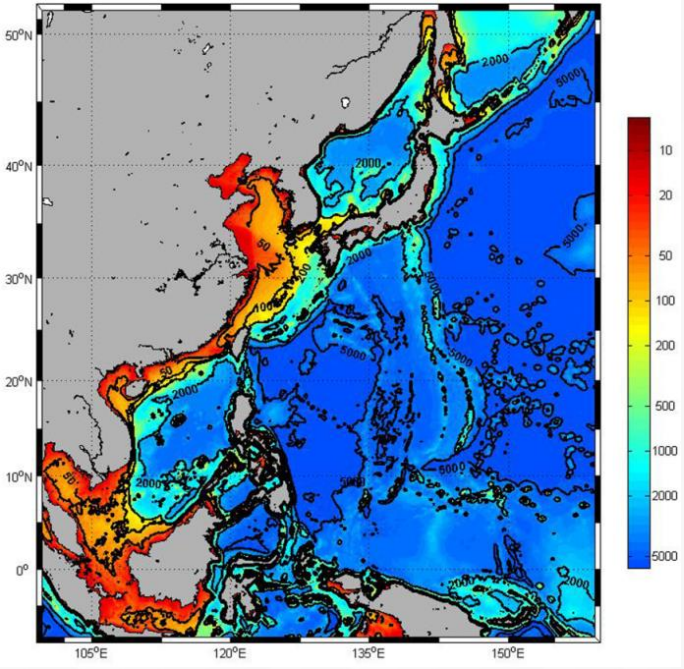
02

Operational Ocean Forecasting Systems

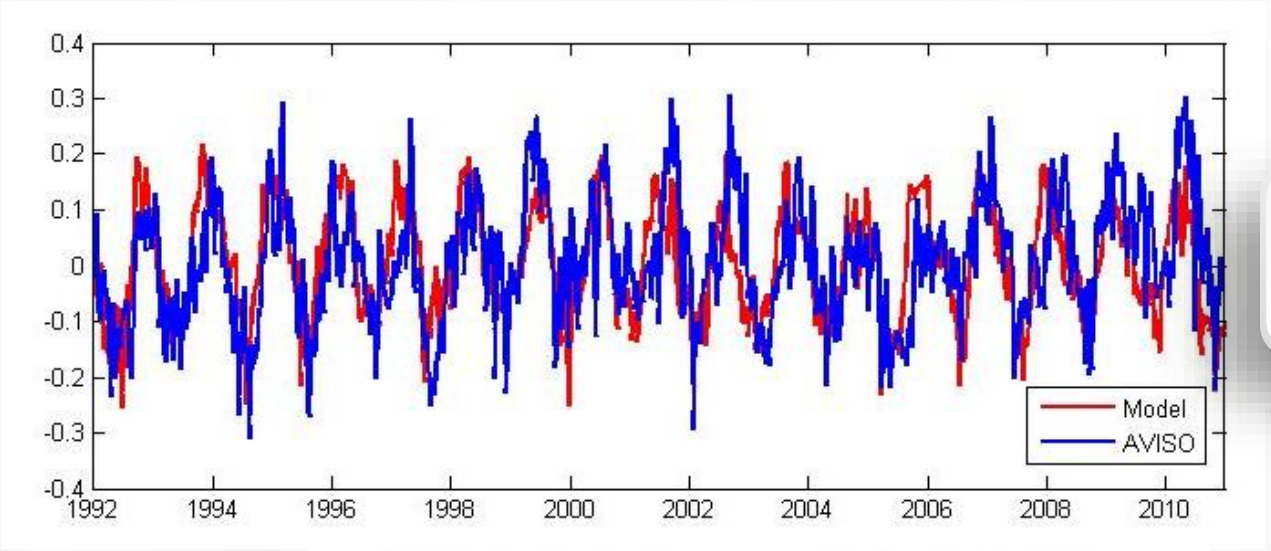
2.1 North-west Pacific Model

Configuration

Region	8°S~52°N；99°E~160°E
Resolution	1/20°×1/20°× 30 σ-Levels
Time Steps	Internal 180s；External 6s
Boundary Condition	MOM4 global ocean forecasting system
Hindcast Forcing	GFSR 4×daily data
Clim Data	SODA climatology data
Topo Data	GEBCO(0.5'×0.5'), with observation data corrected in East China Sea



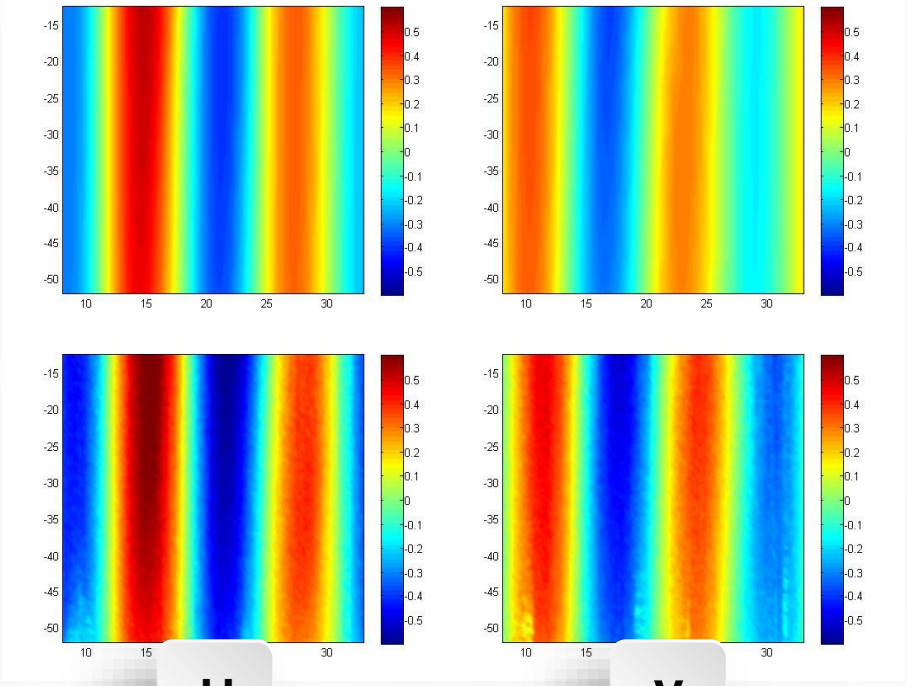
Model Validation



Sea Water Level at (120°W, 20°N) from 1992 to 2011

Modeling

Obs



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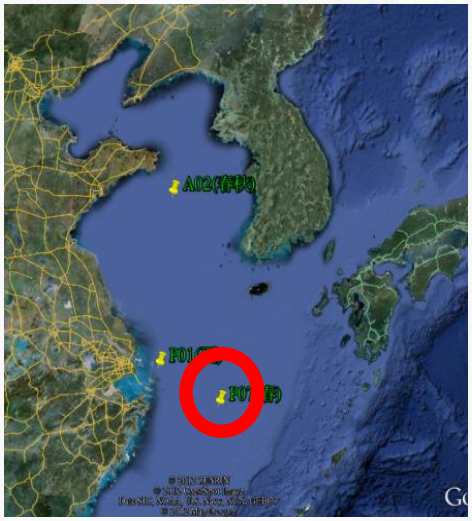
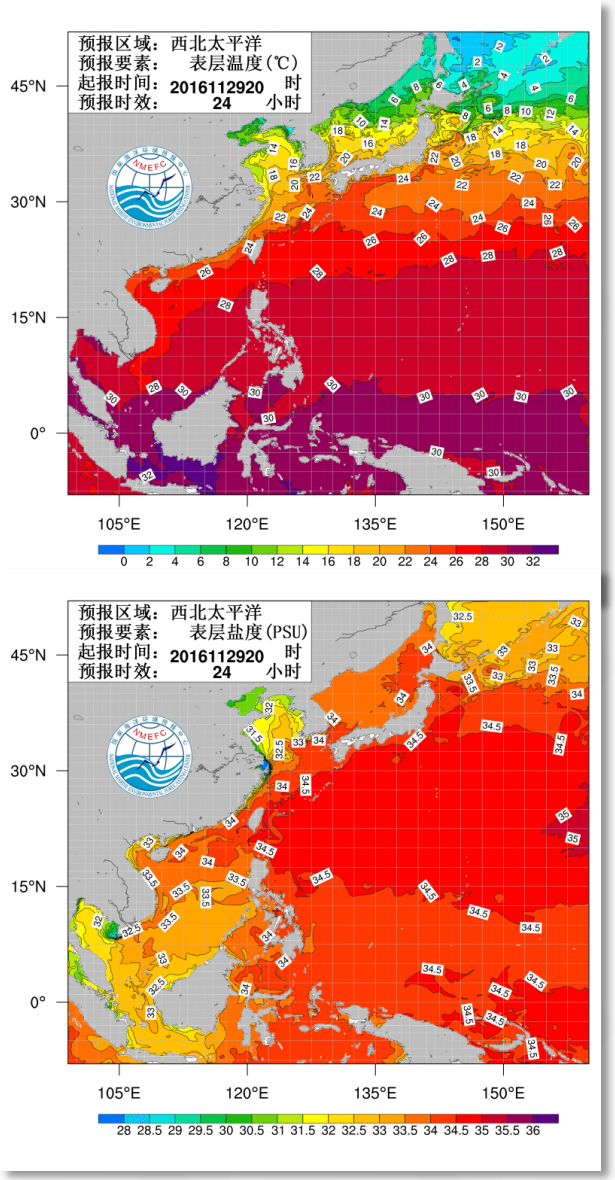
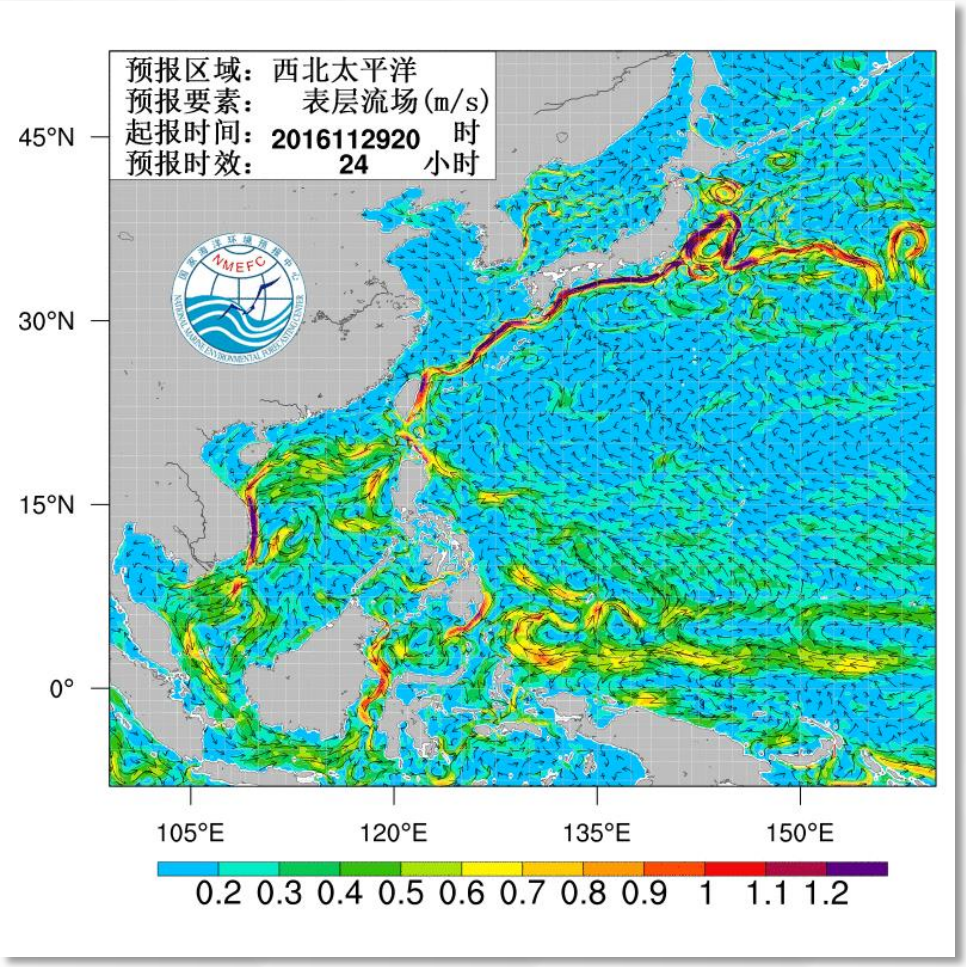


Products of NwPM

Temperature / Salinity / Current

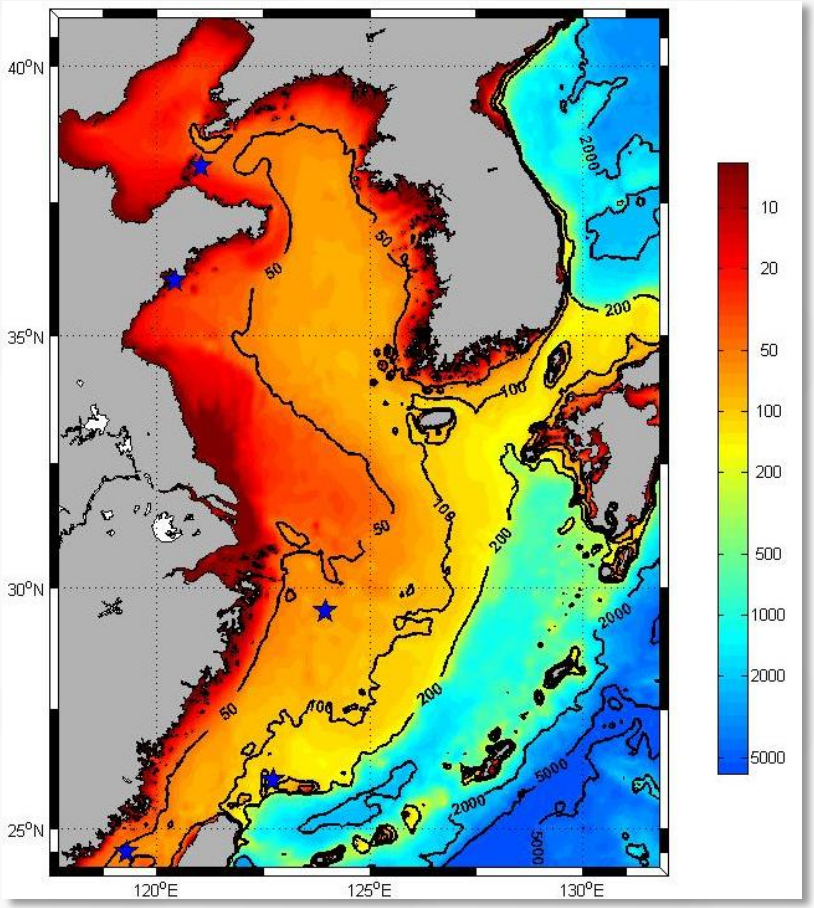




2.2 East China Sea Model

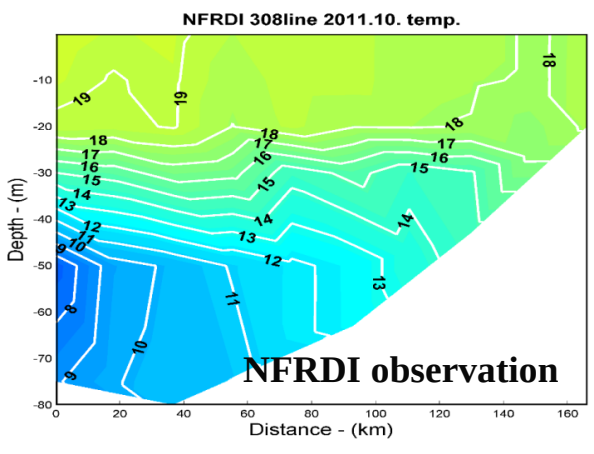
Configuration

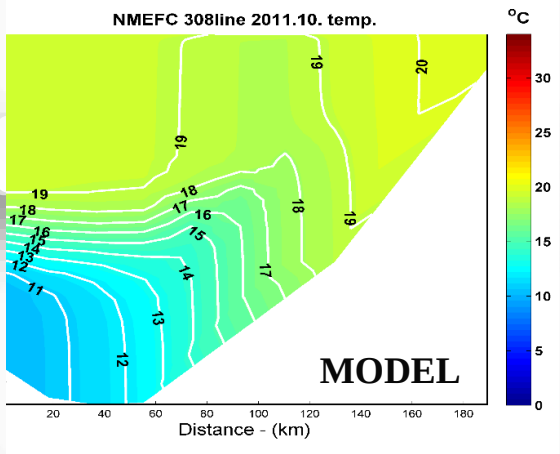
- Based on ROMS,
- Research Area:
  114°～133°E, 22°～41°N
- Model Domain:
  the BoHai, YS and the ECS
- Resolution:
  1/30°× 1/30° (3.5km) ×30 sigma levels
- Bathymetric data:
  GEBCO & China Coastal data
- Boundary Data:
  SODA & NWP
  10 tidal constituents (TPXO7)
- Forcing data:
  WRF(NMEFC)& GFS
- River Discharge: Yangtze River

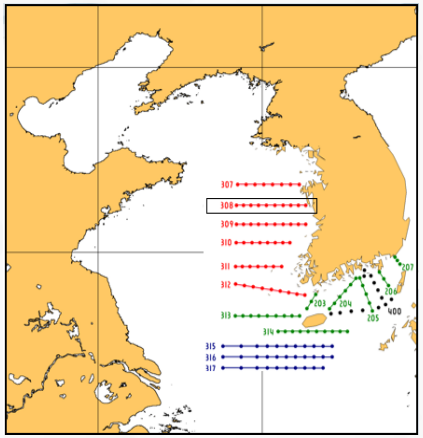


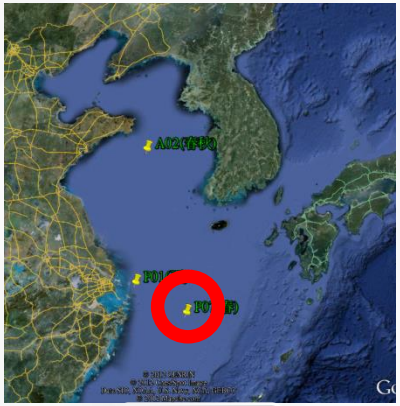
Model Validation

Temperature from Section Data









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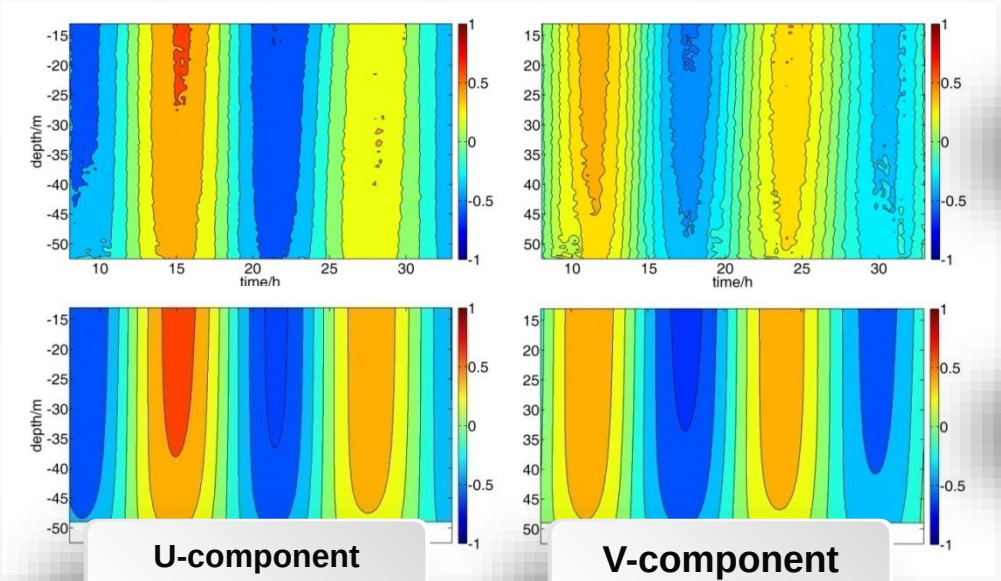
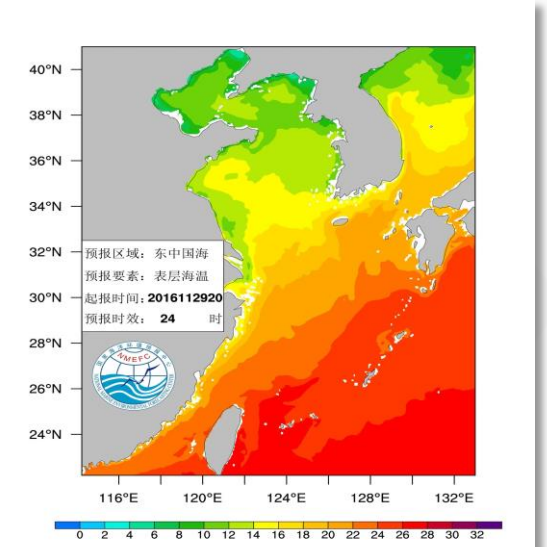
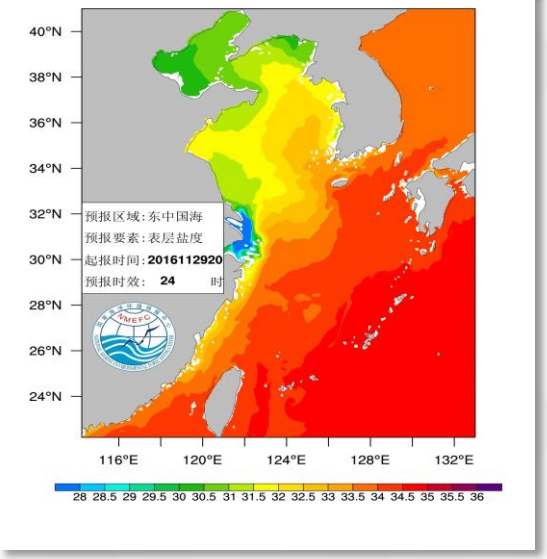
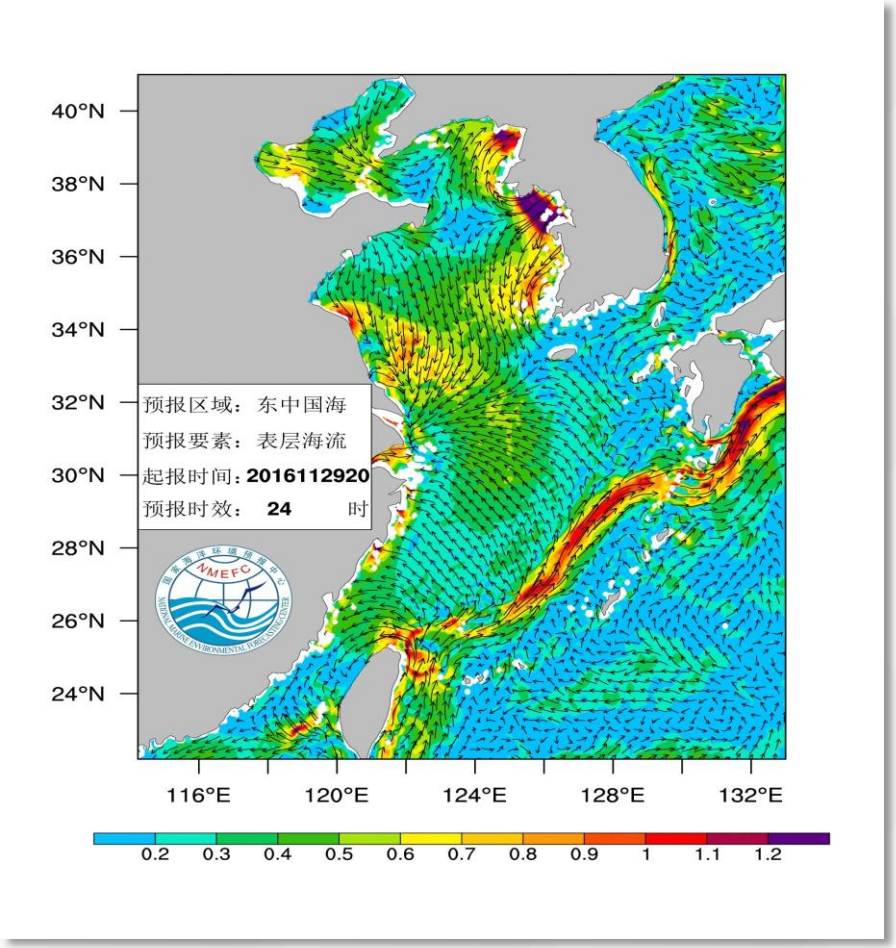


Products of ECSM

Temperature / Salinity / Current



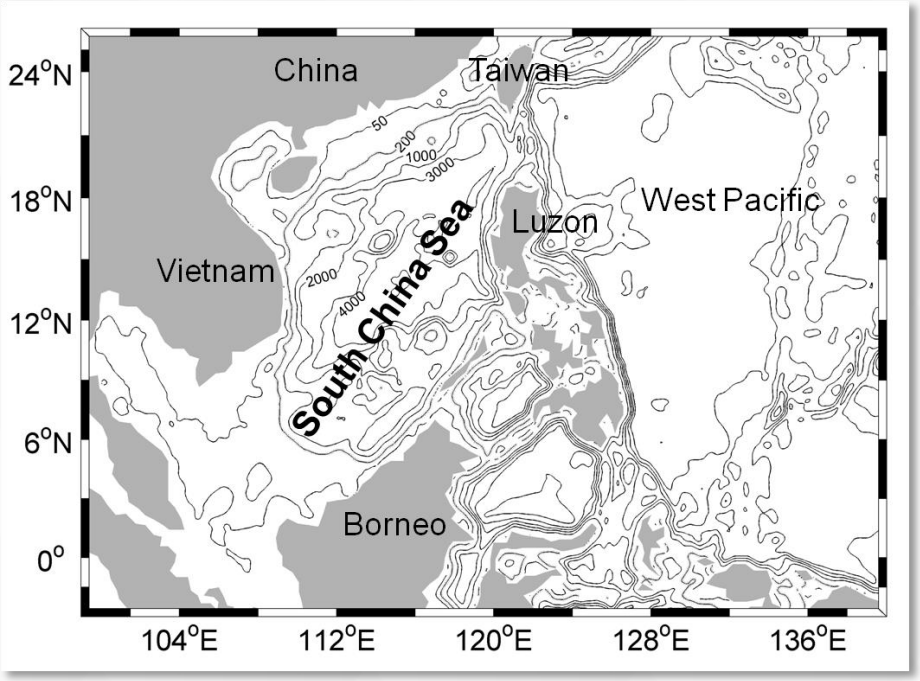




2.3 South China Sea Model

Configuration

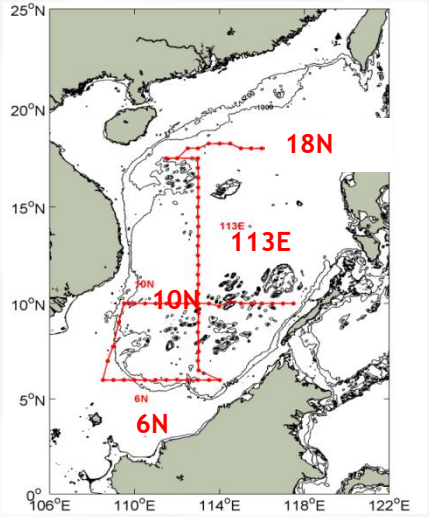
- ✓Region
  - -5°N—26°N
  - 98°E—140°E
- ✓Horizontal Resolution
  - 1/30°
- ✓Vertical Resolution
  - Max Depth 6000 m
  - Min Depth 10 m
  - 36 Layers
- ✓Topo
  - ETOPO1



Model Validation

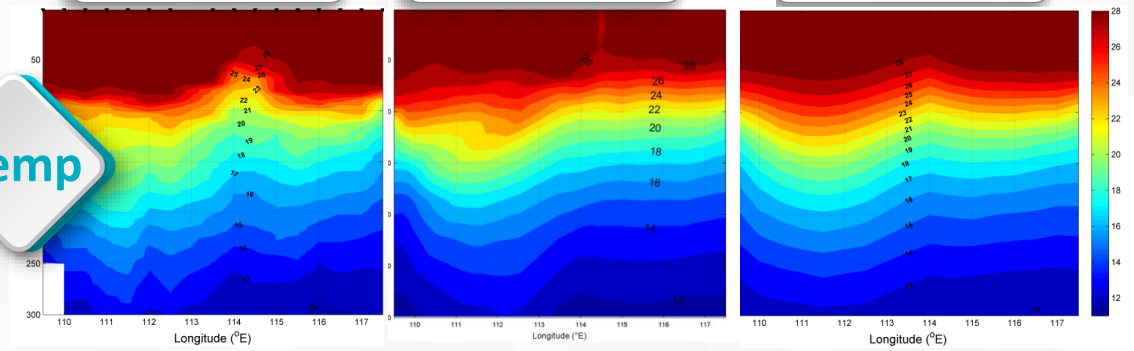
Comparison with Obs.

Aug. 9
~
Sep. 8

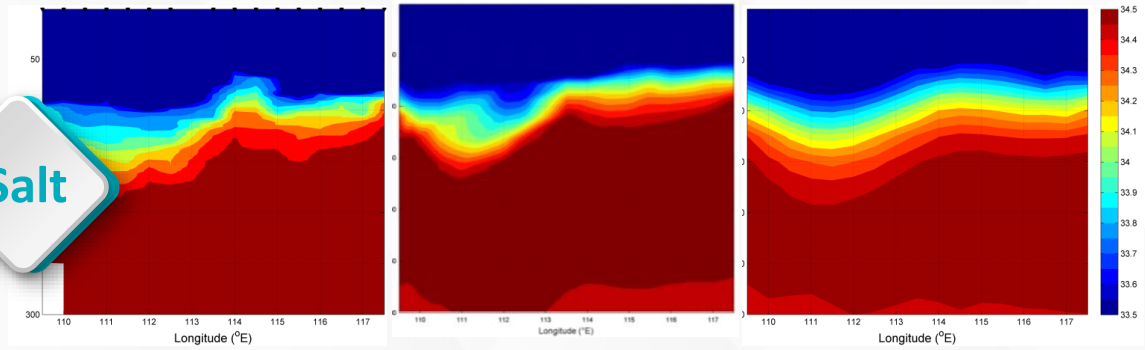


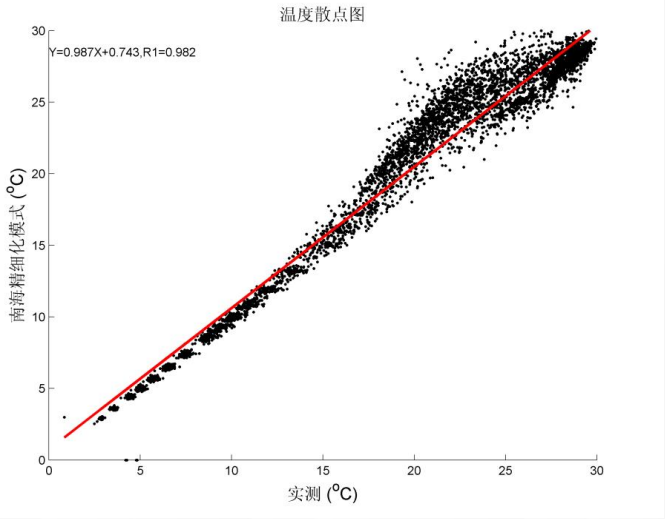
Observation | Mercator | SCSOFS

Temp



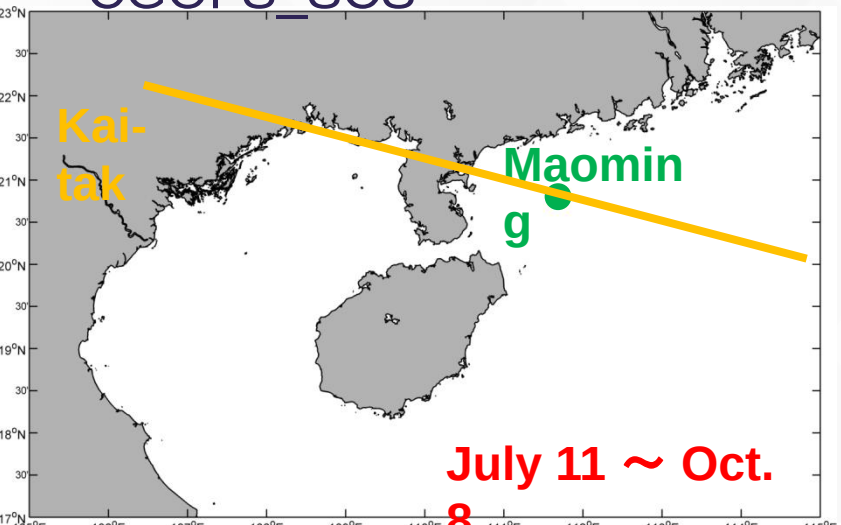
Salt

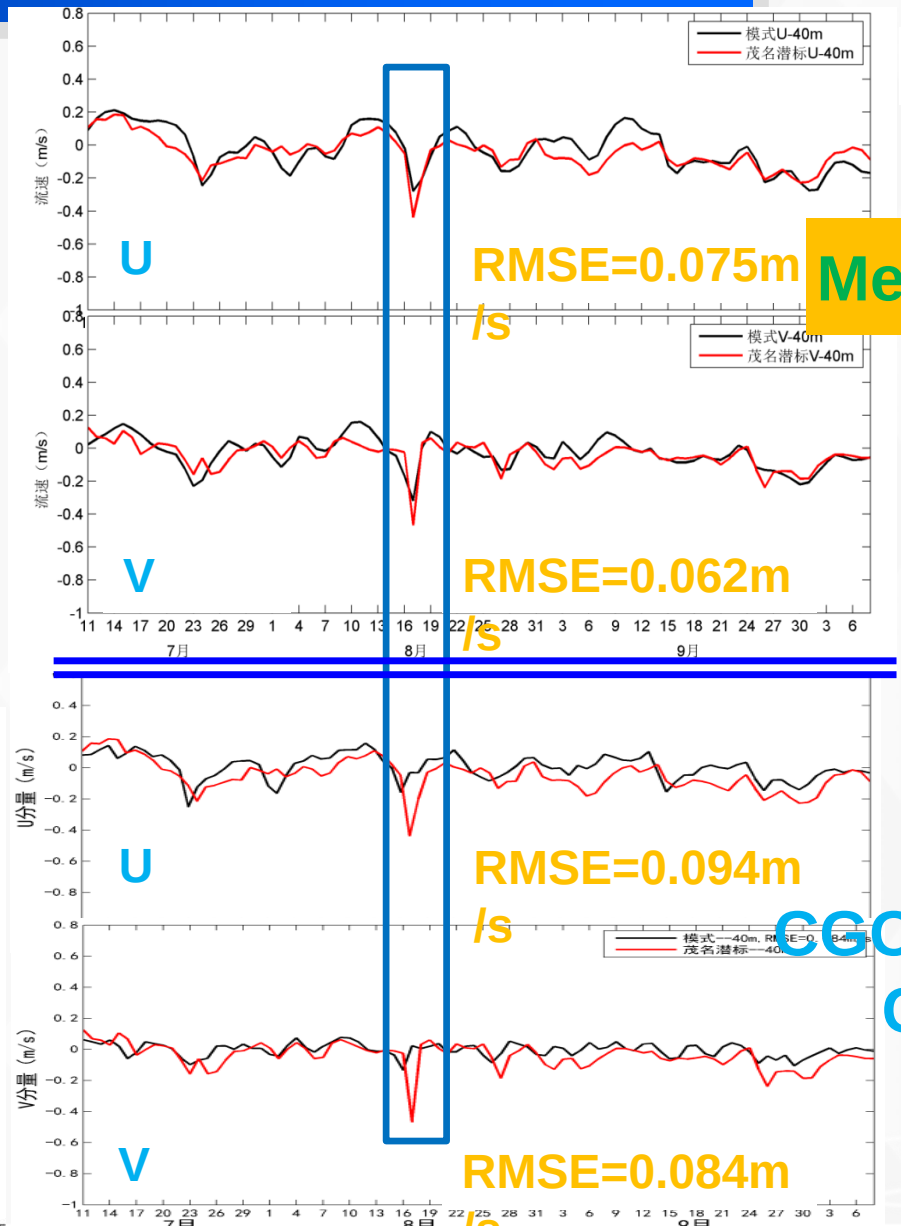




Currents Comparison with mooring Obs.

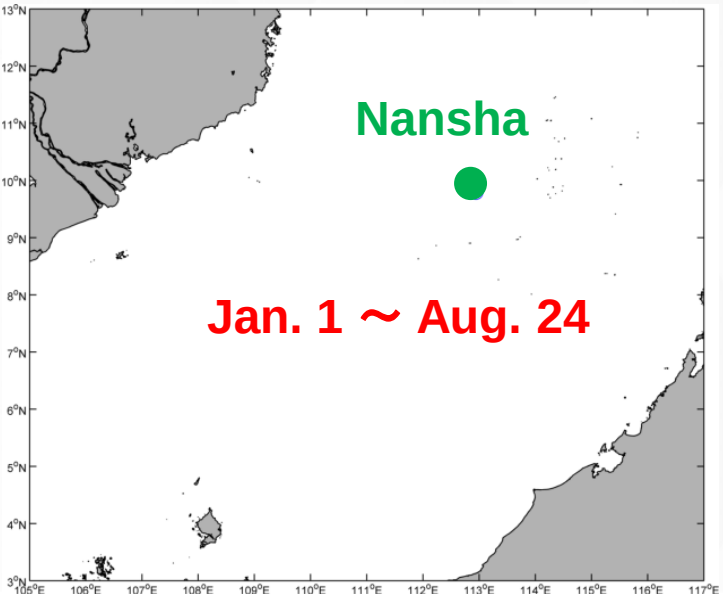
- Both systems can capture the same variation trends of the timeseries with the obs.
- Mercator catch the Typhoon Kai-tak well, but not for CGOFS_SCS
- CGOFS_SCS results lead the Obs. about 1 days in phase
- Mercator results are in better agreement with the obs. than CGOFS_SCS



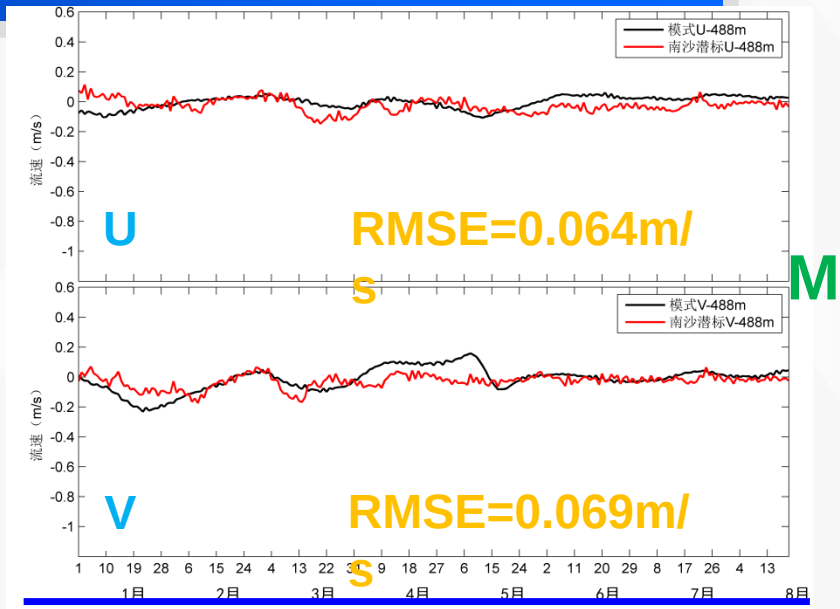


Currents Comparison with mooring Obs.

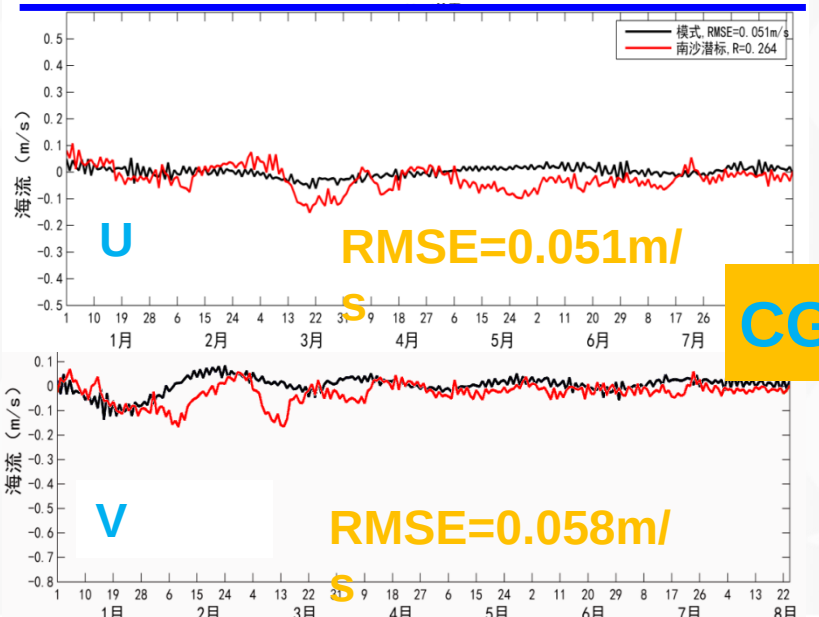
- Both systems' velocities are weaker than obs., do not show too much variability.
- CGOFS_SCS results are better agreement with obs. than Mercator.



488m



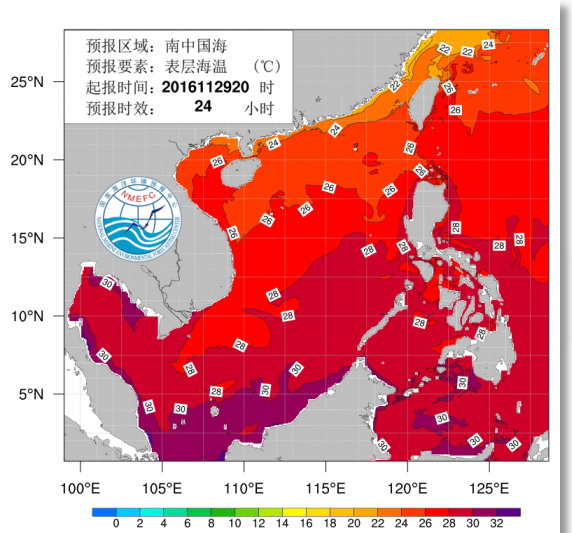
Mercator

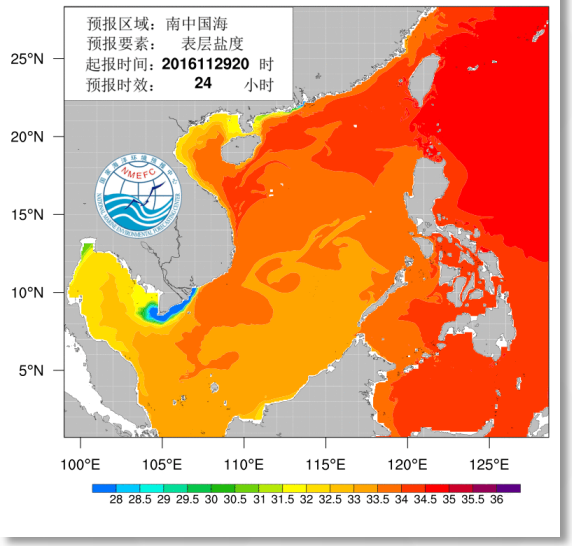


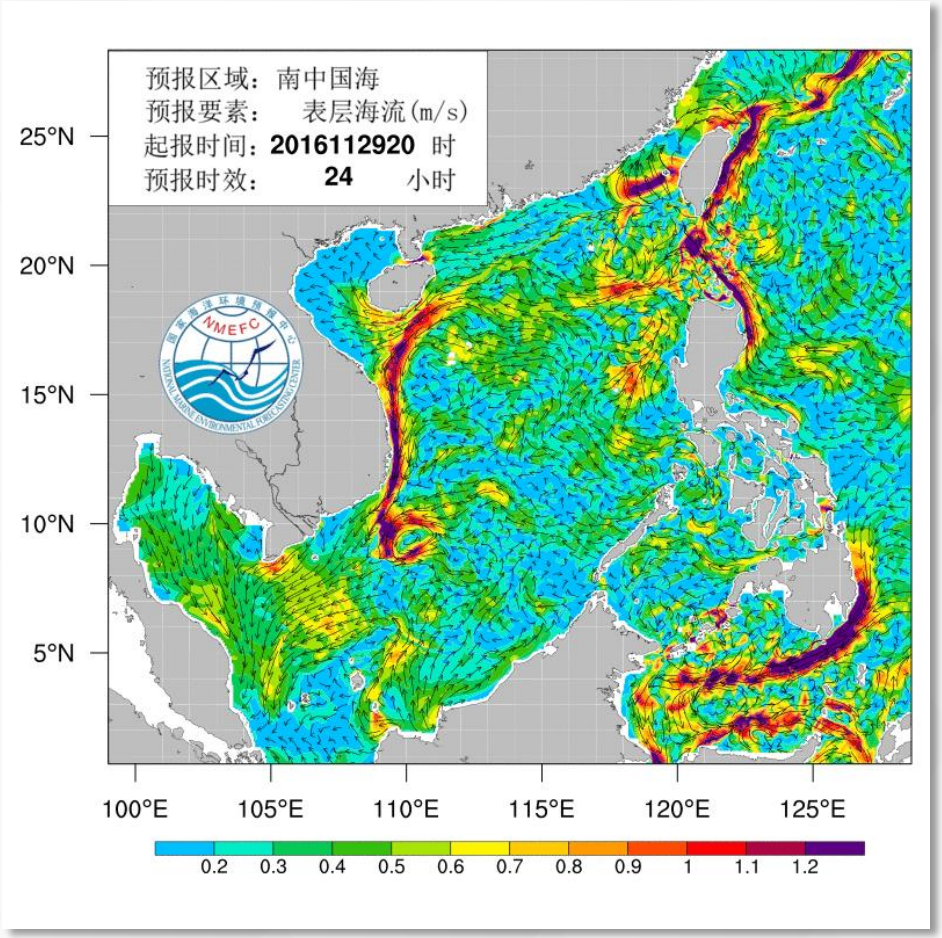
CGOFS_SCS

Products of SCSM

Temperature / Salinity / Current





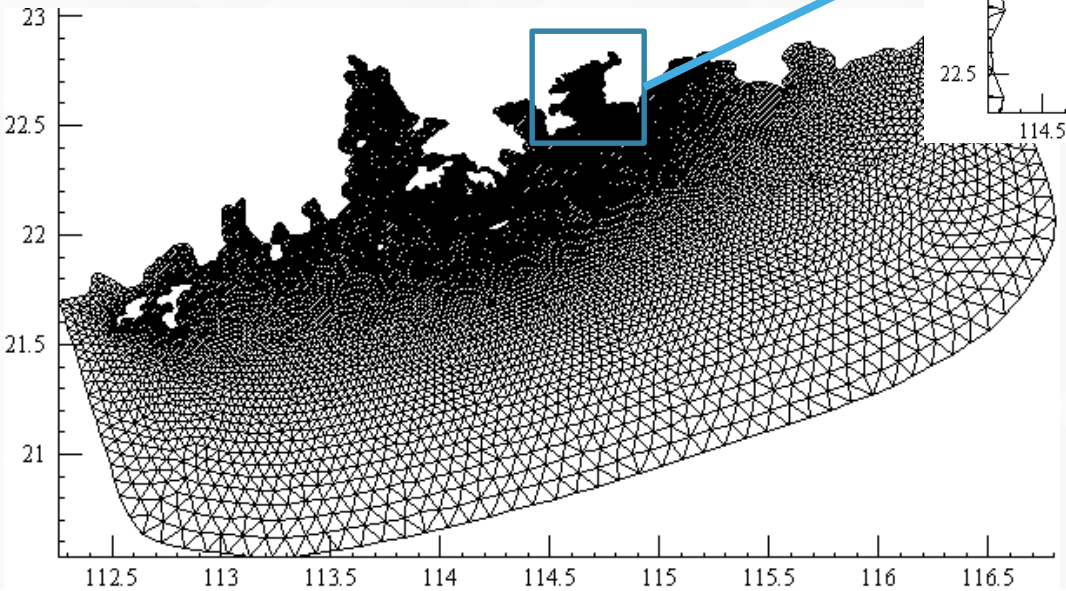


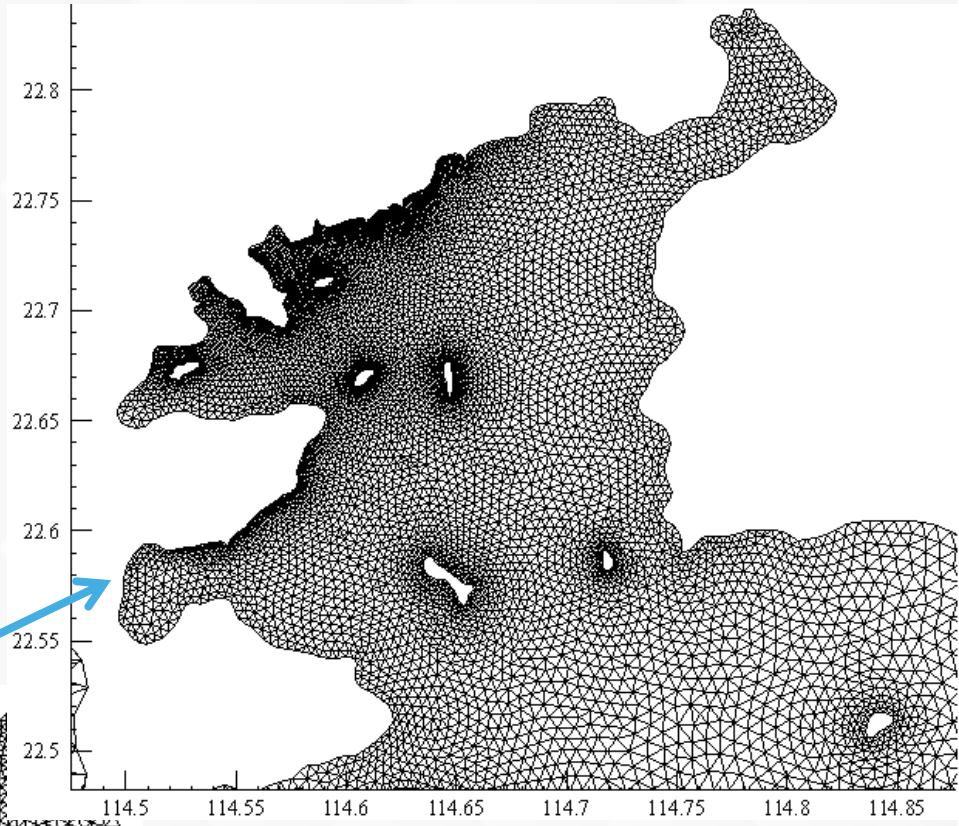
2.4 Daya Bay Coastal Model

Region: 112.3°~116.7°E、20.4°~23.0°N

Resolution: < 200m

Boundary: M_2、S_2、K_1、O_1、N_2、K_2、P_1、Q_1

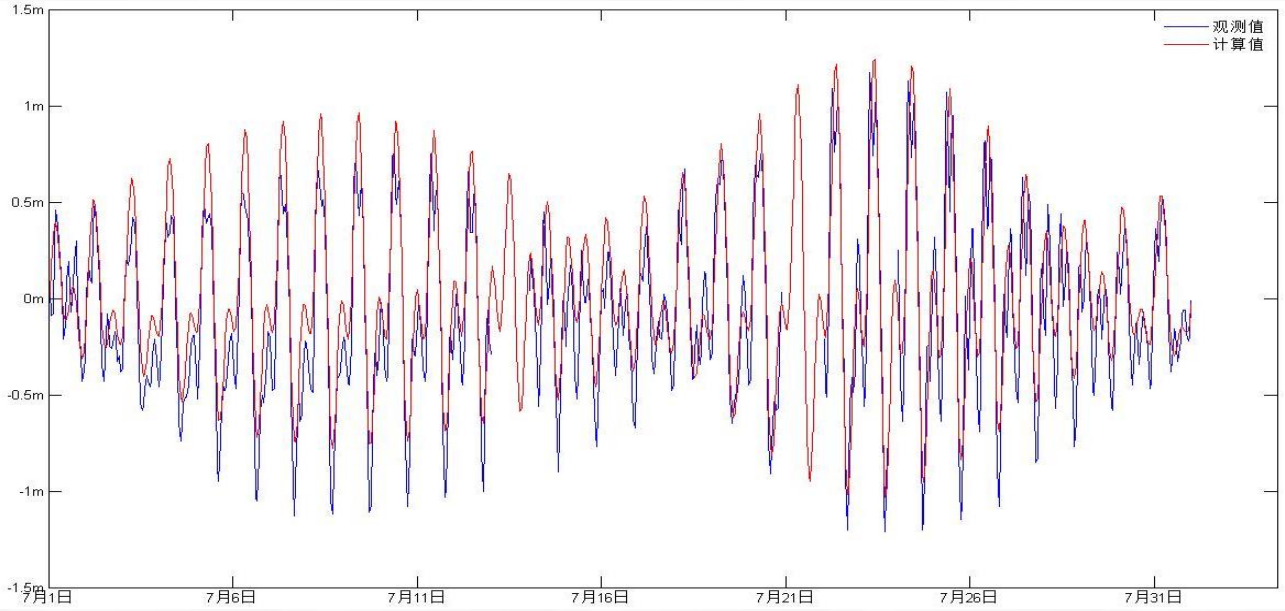




Unstructured grid of the model

Model Validation

	M2		S2		K1		O1	
	Amp	Pha	Amp	Pha	Amp	Pha	Amp	Pha
Mod.	0.363	255.76	0.155	284.54	0.355	306.55	0.283	250.56
Obs.	0.351	256.56	0.139	287.50	0.338	306.78	0.275	248.74
Bias	0.012	-0.8	0.016	-3.0	0.017	-0.24	0.008	1.82

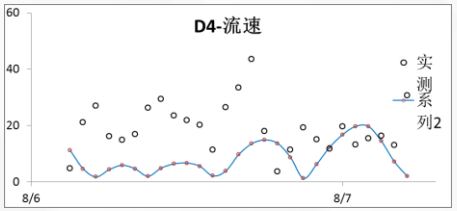


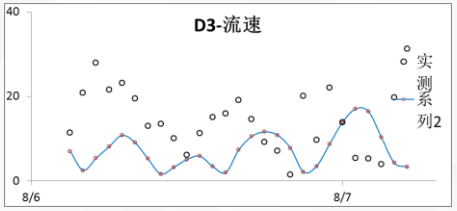
AE: 0.18
RE: 0.52
Bias: 0.05
SD: 0.19

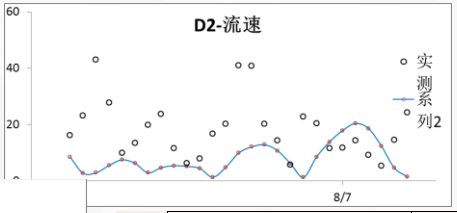
Temporal evolution of sea level at Huizhou station.
Blue line is observations, red line is simulations.

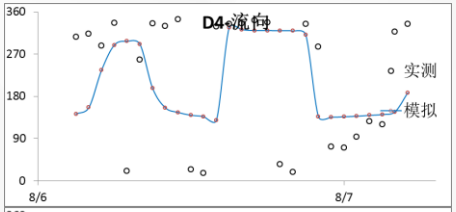
Model calibration

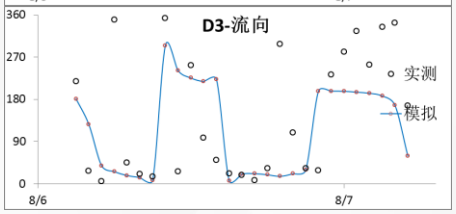
Location of observation stations

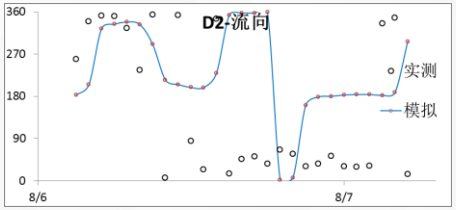


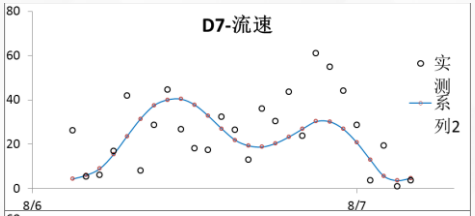


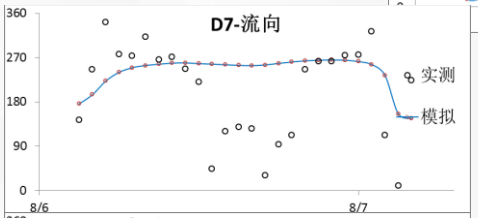


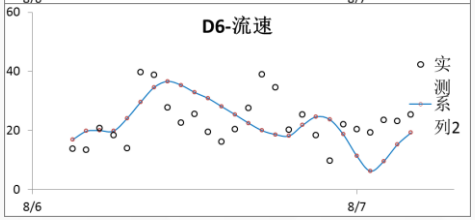


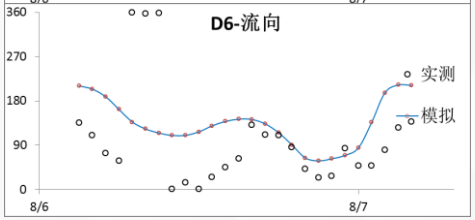


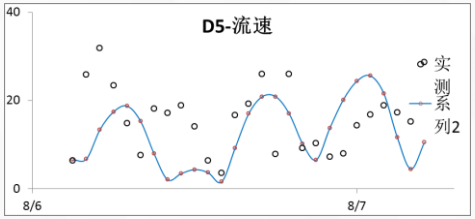


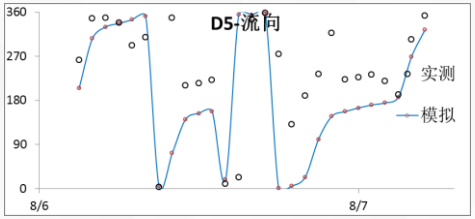








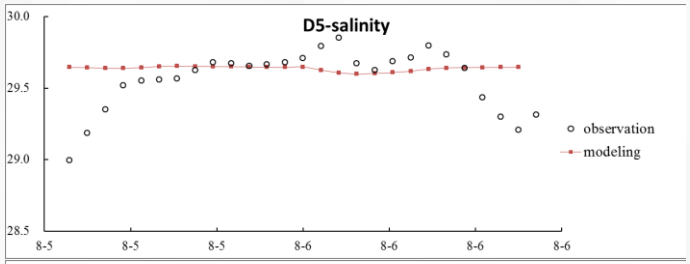


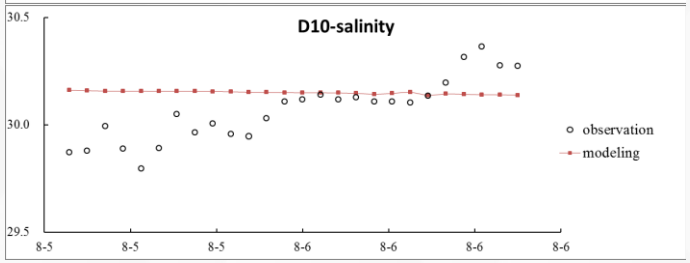


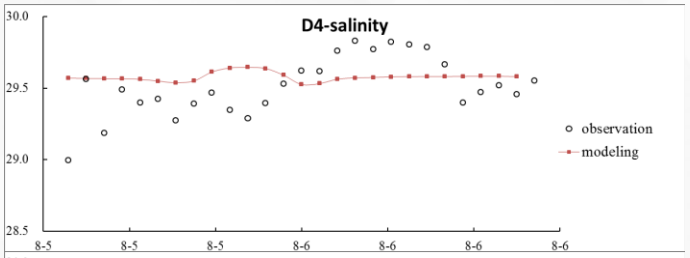
实测		模拟		相对误差	
流速	流向	流速	流向	流速	流向
33.6	114.4	32.8	101.9	3%	13°
31.4	126.8	38.0	116.0	17%	10°
55.4	111	74.8	89	22%	22°
52.4	111.9	74.1	95	17%	17°
45.8	128	61.4	107	25%	21°
49.9	98.1	58.1	78	20%	20°
41.1	86.8	47.4	77	9%	9°
32.5	71	37.9	77	6%	6°
32.2	60	31.5	77	17%	17°
34	55	35.5	77	23%	22°
34.1	63	39.8	76	14%	14°
37.1	68	42.8	75	7%	7°
42.3	74	42.6	72	2%	2°
42.5	82	40.6	68	14%	14°
40	99	34.9	75	28%	23°
40	88	24.5	63	25%	25°

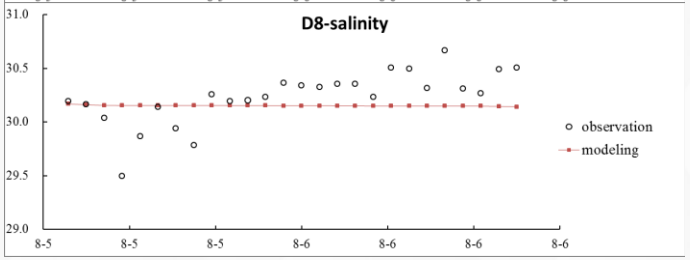
Forecast Validation

S









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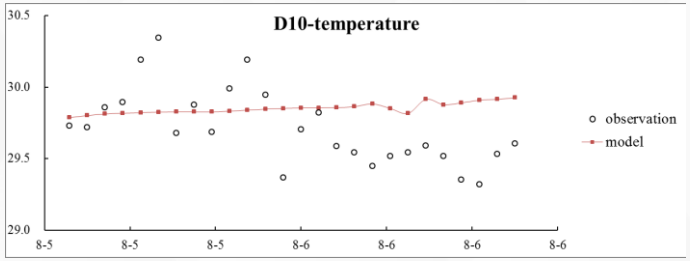
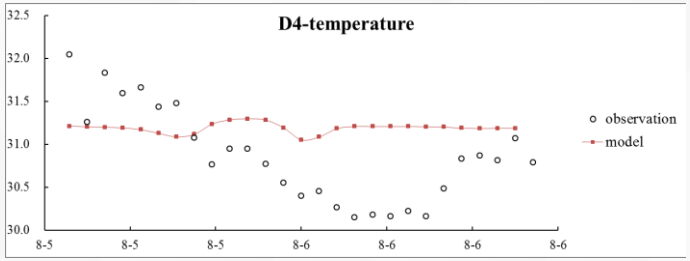
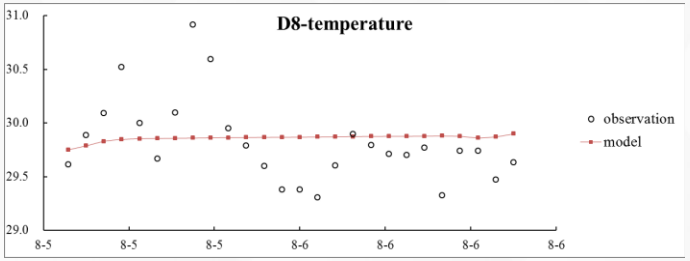
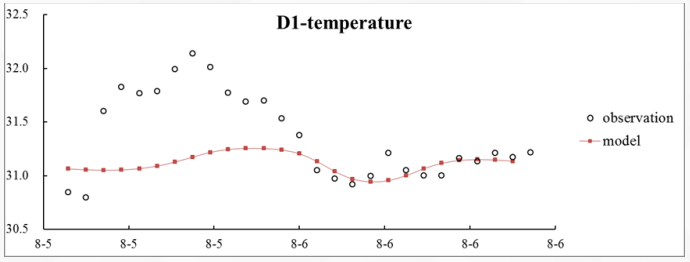






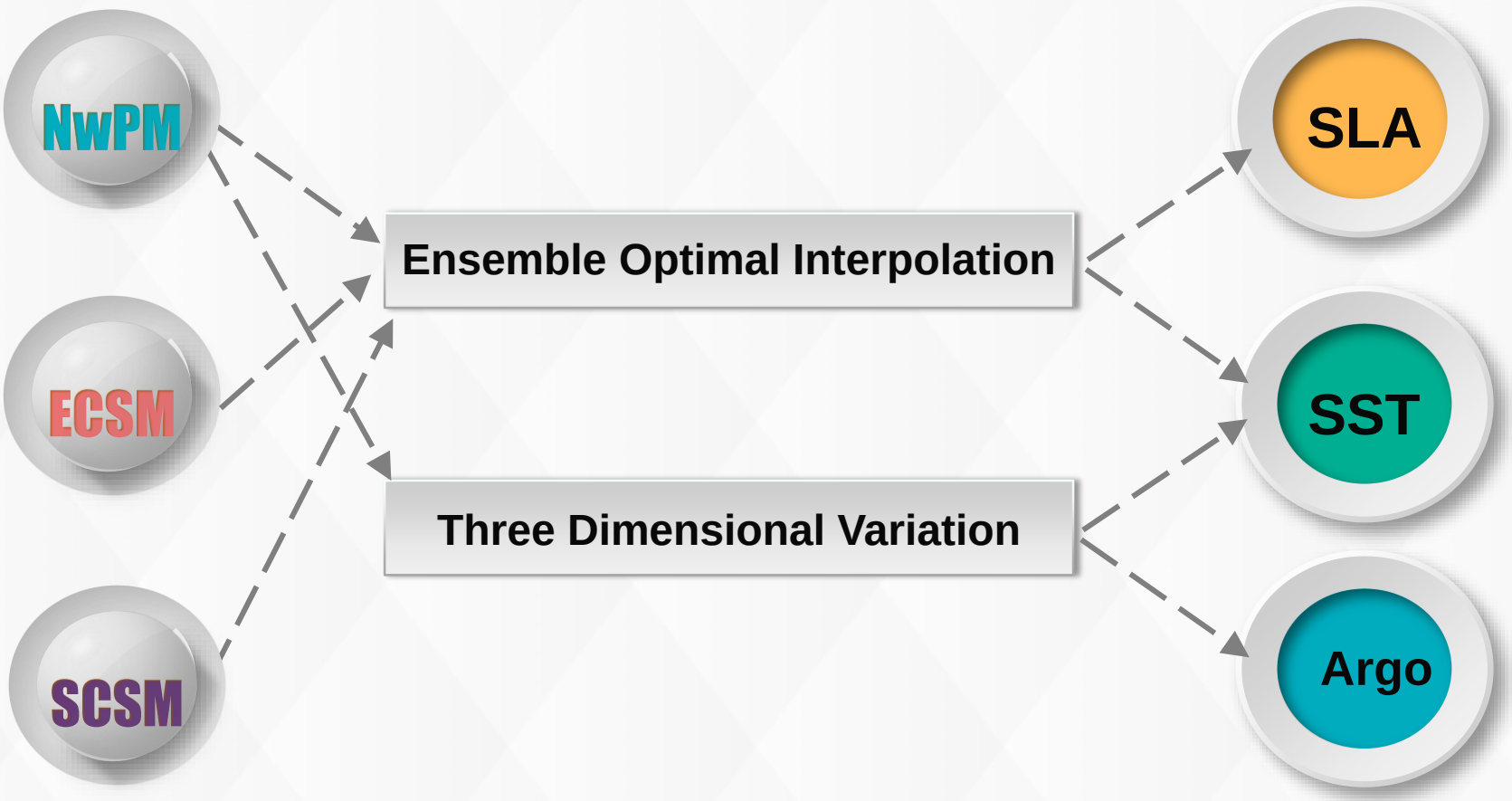


<1.0℃

03

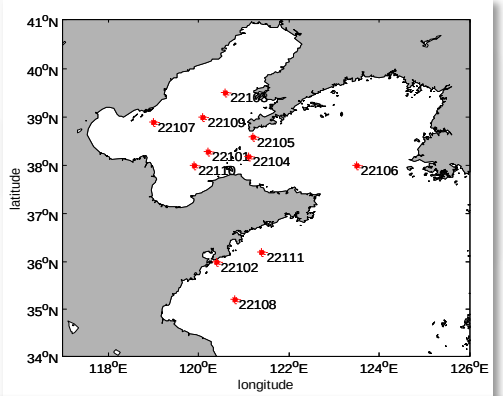
Data Assimilation Scheme

Data Assimilation Scheme

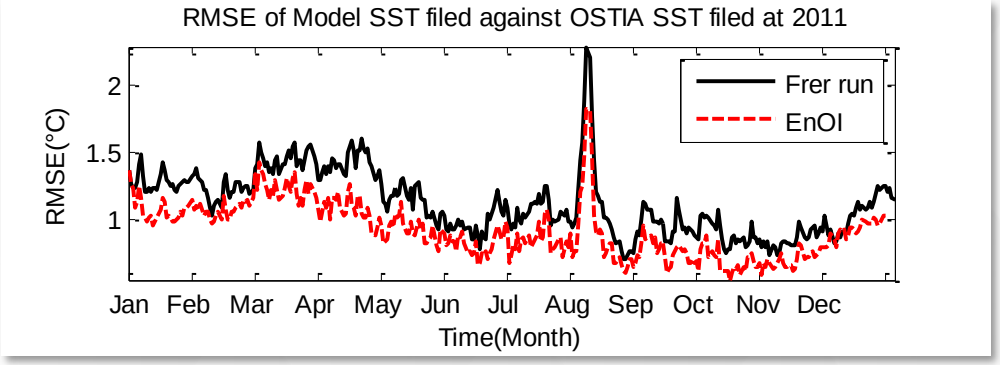


EnOI Scheme

- Assimilation Method: EnOI
- Period: 2011/01/01~2011/12/31
- Observation data for assimilation: OSTIA analysis SST product
- Assimilation cycle: 5 day (at 00:00)
- Parameter value: alpha=0.3,localization radius: R=150km



RMS error of Model SST against buoy temperature(° C)

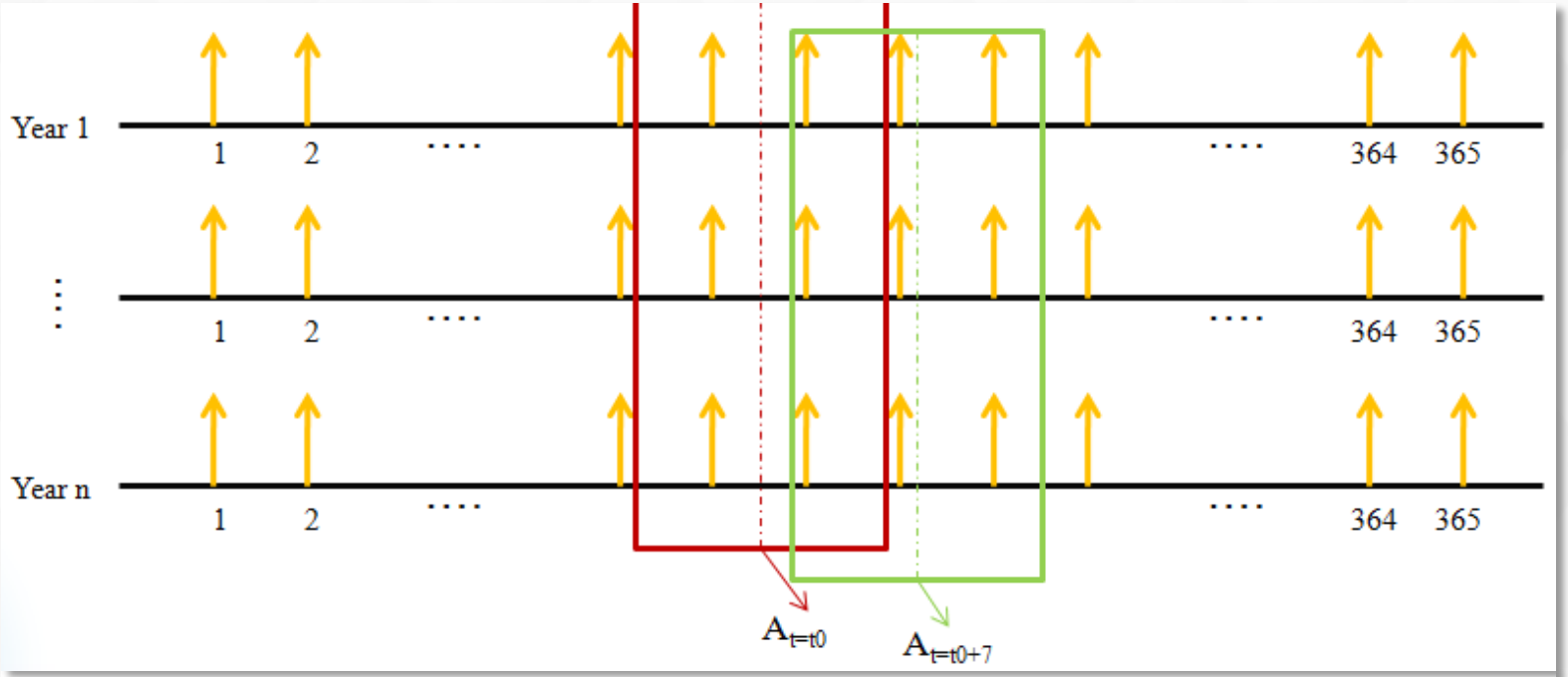


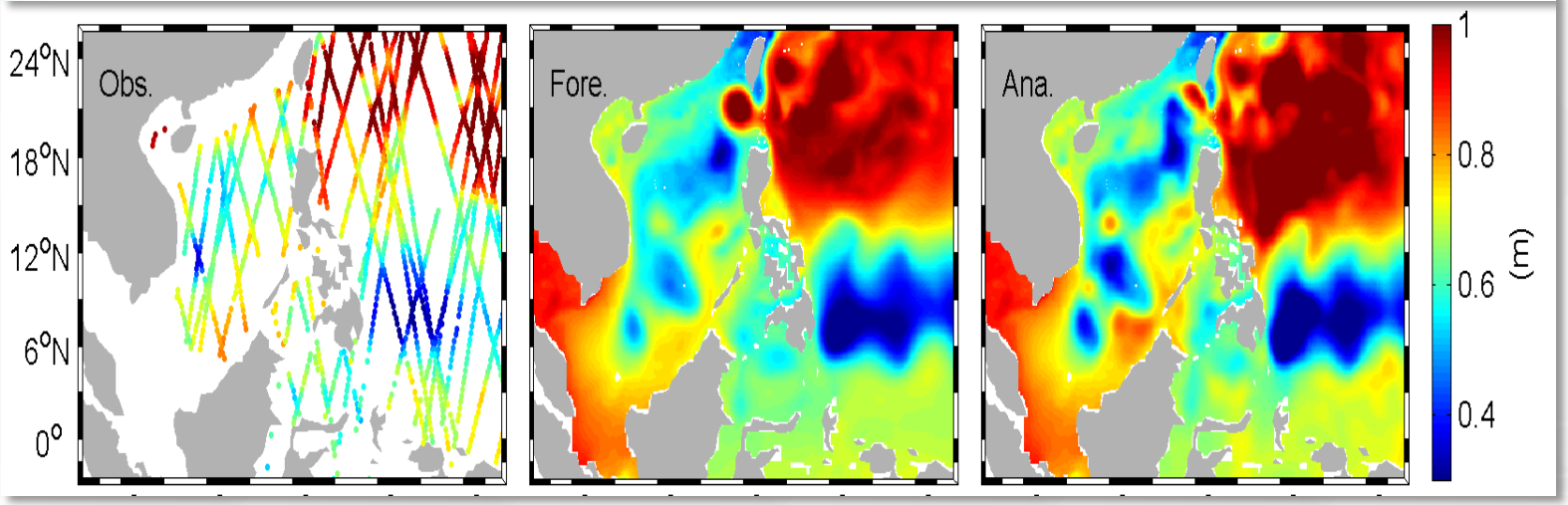
RMS error of Model SST filed against OSTIA SST filed

Buoy	Free run	EnOI	improved (%)
22101	1.29	1.01	21.9
22102	0.81	0.90	11.0
22103	2.31	2.07	10.0
22104	1.54	1.41	8.2
22105	1.21	1.09	10.3
22106	1.06	0.94	10.9
22107	1.92	1.36	29.0
22108	1.54	1.24	19.3
22109	1.38	0.90	34.5
22110	1.29	0.96	25.3
22111	1.12	1.14	1.6
average	1.41	1.18	16.5

EnOI Scheme

Schematic diagram of “running” ensemble-sampling at assimilation time t

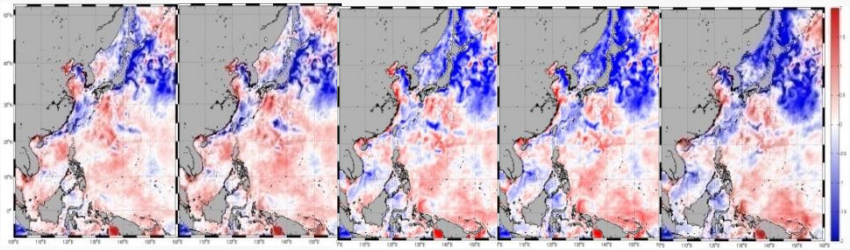




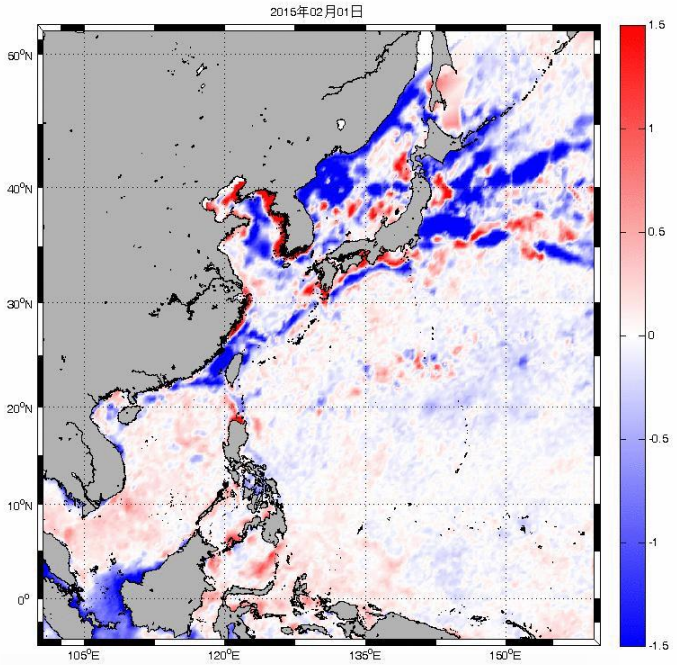
3DVAR Scheme

Data Assimilation of SST

- Method: 3D-Var
- Period: 2015/01/01 ~ now
- Observation data for assimilation: MGDSST (Merged satellite and in situ data Global Daily Sea Surface Temperatures, 1/4 ° × 1/4 °)
- Assimilation cycle: Daily (at 12:00 UTC)



1st 2nd 3rd 4th 5th



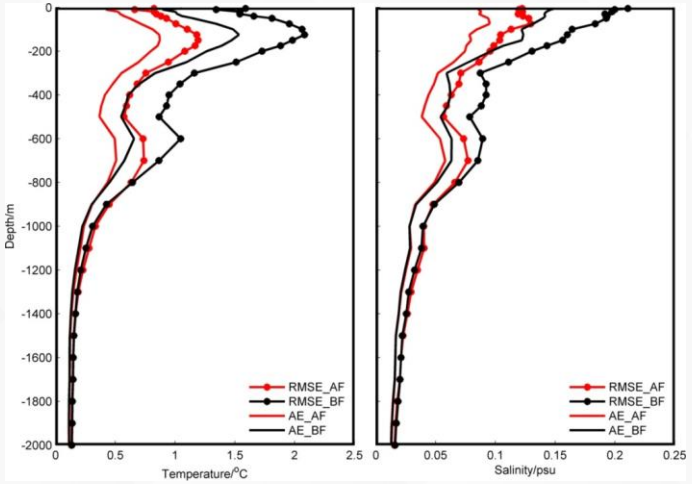
The Errors between simulations and observations

Day	ME	AE	RMSE
1st	0.09	0.51	0.76
2nd	0.13	0.56	0.79
3rd	-0.04	0.56	0.82
4th	-0.10	0.60	0.87
5th	-0.15	0.62	0.92

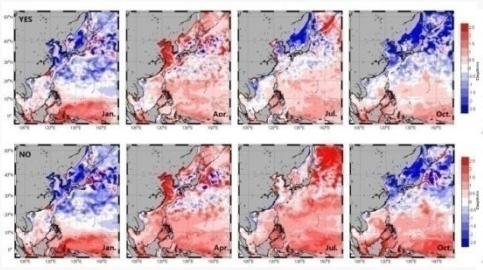
3DVAR Scheme

Data Assimilation of Argo profiles

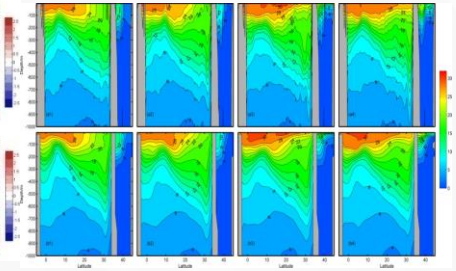
- Method: 3D-Var
- Period: TEST: 2006/01/01~2006/12/31;
  Operational Run: 2015/01/01~now.
- Observation data for assimilation: T/S Argos Profiles
- Assimilation cycle: Daily (at 00:00 UTC)

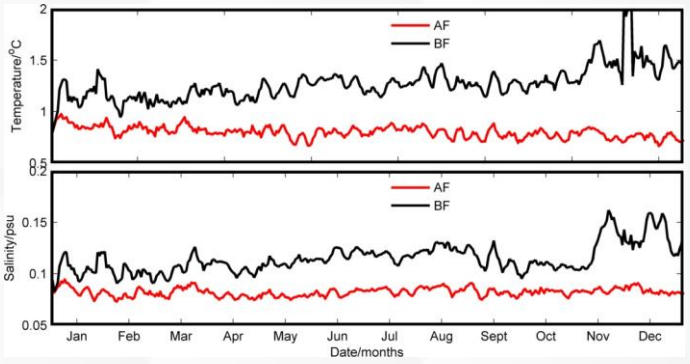


Temperature at surface

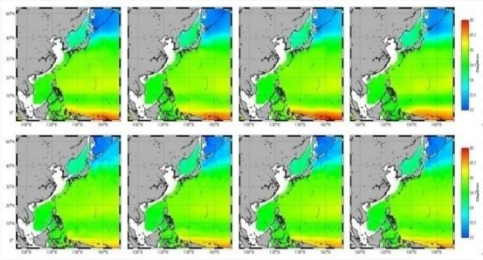


The 136°E section: Temperature

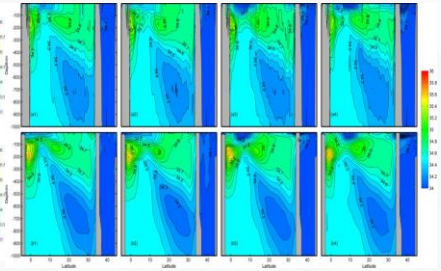




Salinity at 150m



The 136°E section: Salinity

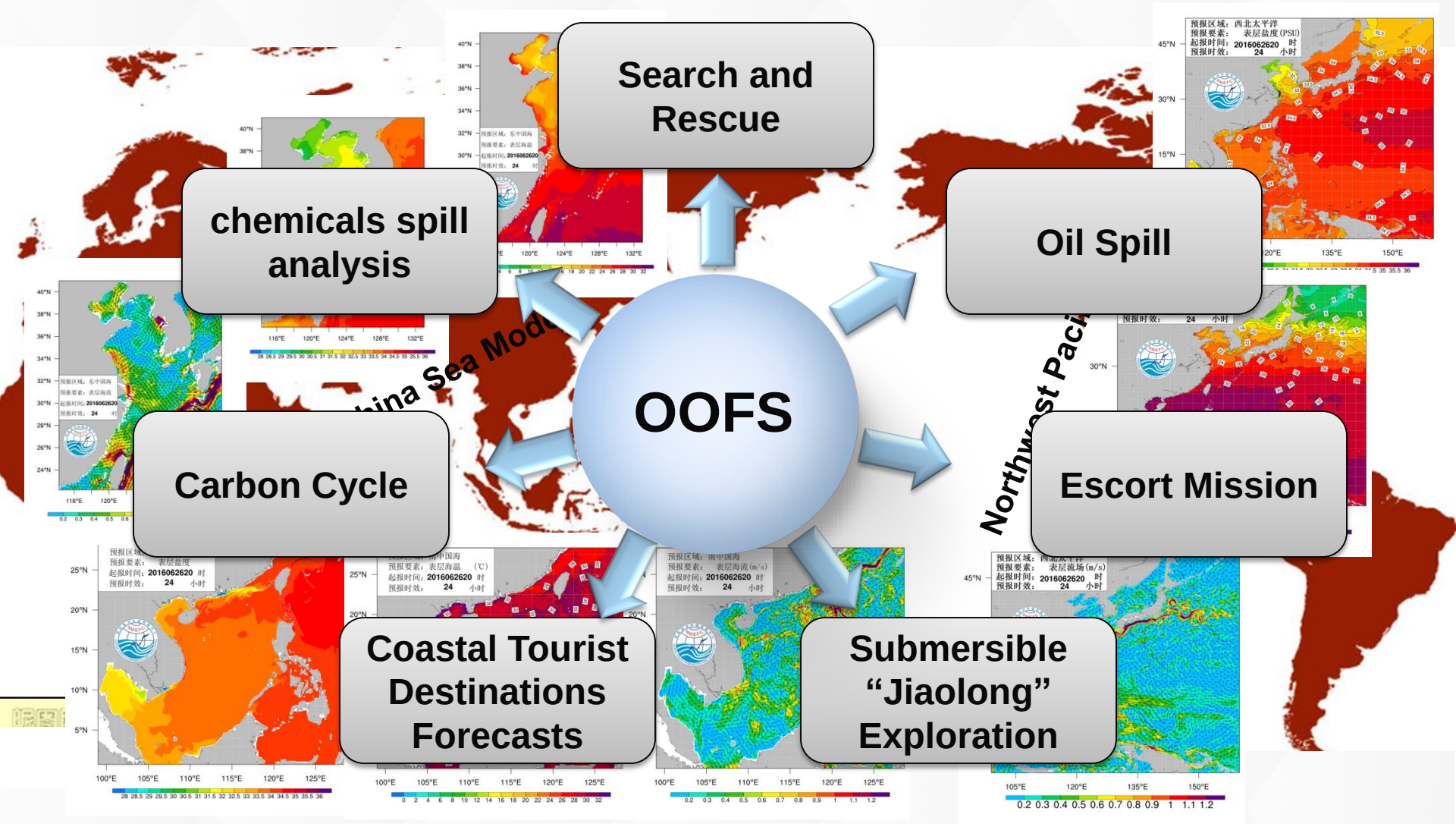


For temperature, the RMSE decreases from 0.988 °C in the SF run to 0.620 °C in the AF run, i.e. a 37.21% reduction occurs.
For salinity, the RMSE decreases from 0.098 in the SF run to 0.071 in the AF run, i.e. a 27.98% reductions.

04

Ocean Applications

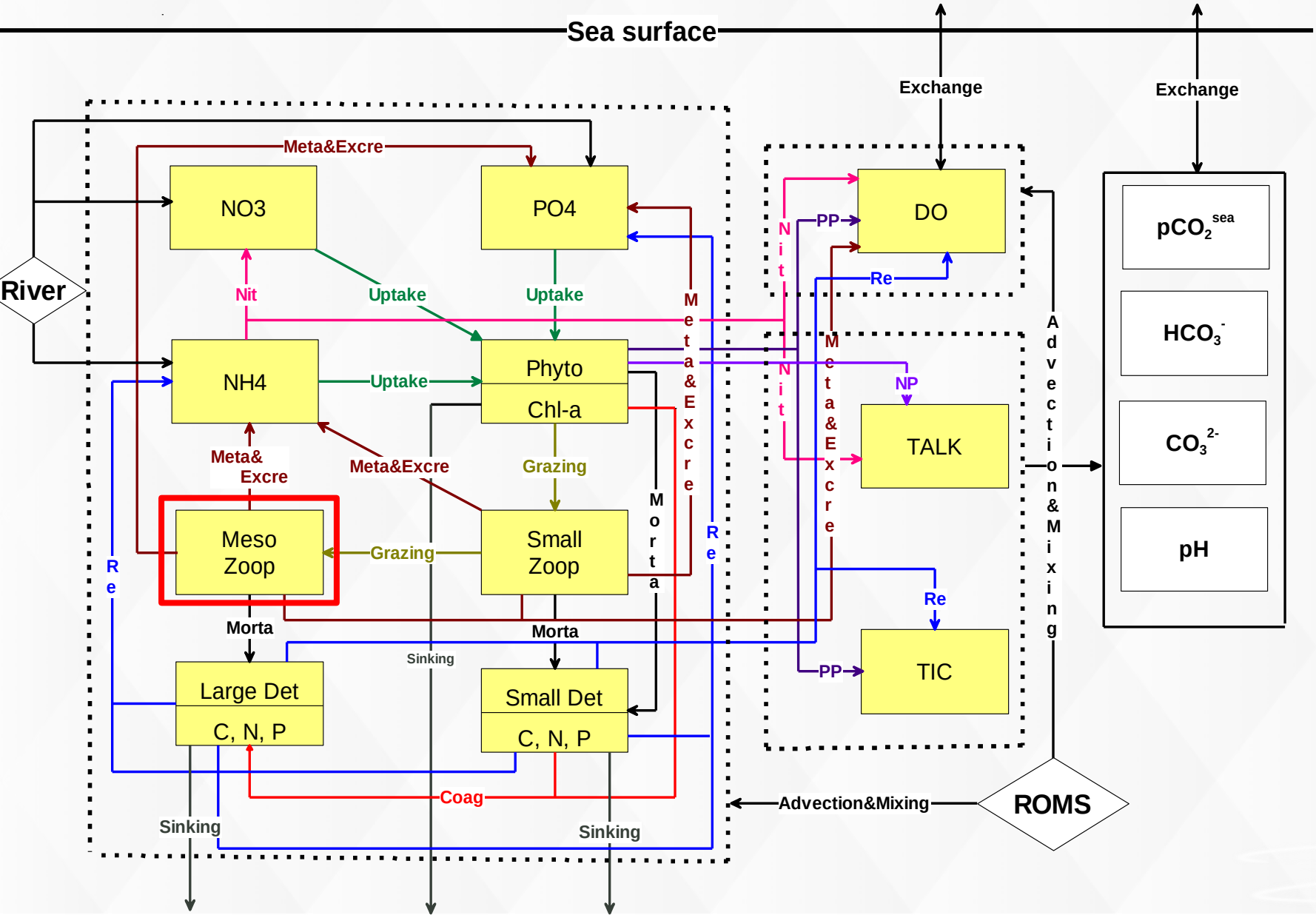
Ocean Applications



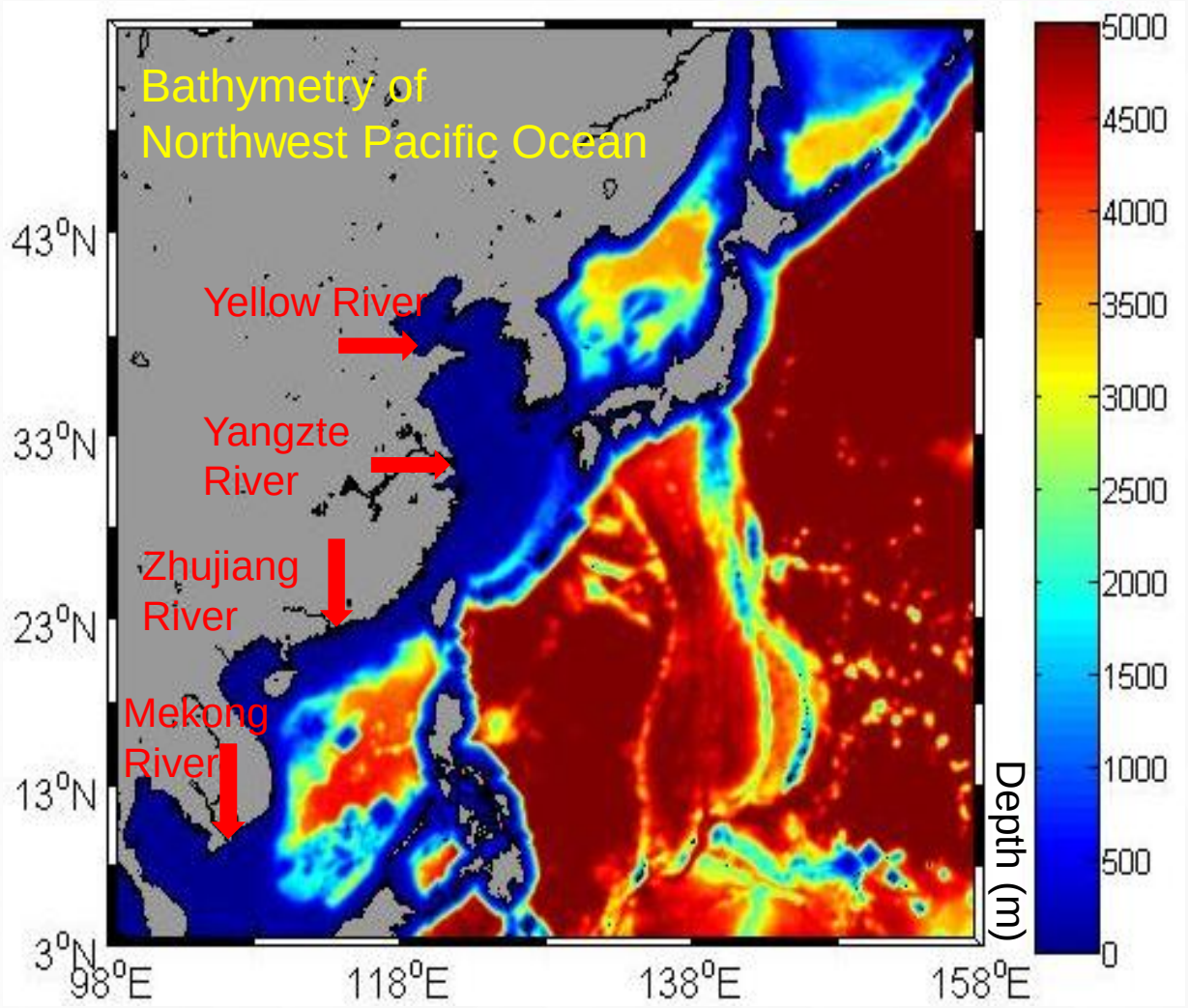
South China Sea Model

Northwestern Pacific Ocean

1) Marine Ecosystem Forecasting System



1. Physical-Biogeochemical Model Basic Sets



Initial Field

- NO3
- TIC
- DO
- TALK

→ WOA09 data 1° ×1° ×24

- Chlorophyll-a → SeaWiFS
- Phytoplankton
- Zooplankton
- Detritus

→ Chlorophyll

- NH4 → 1

• Boundary Field

south, east, north → WOA09 data nutrient 1° ×1° ×24

west → NO3, NH4: Yellow River, Yangtze River, Zhujiang River, Mekong River

• Parameters optimization

Mortality: Mp=constant

→ $Mp=Mor*\exp(Kmor*T)$

Nutrient uptake :

$g=g_{max}(Phy^2/(Kp+Phy^2))$

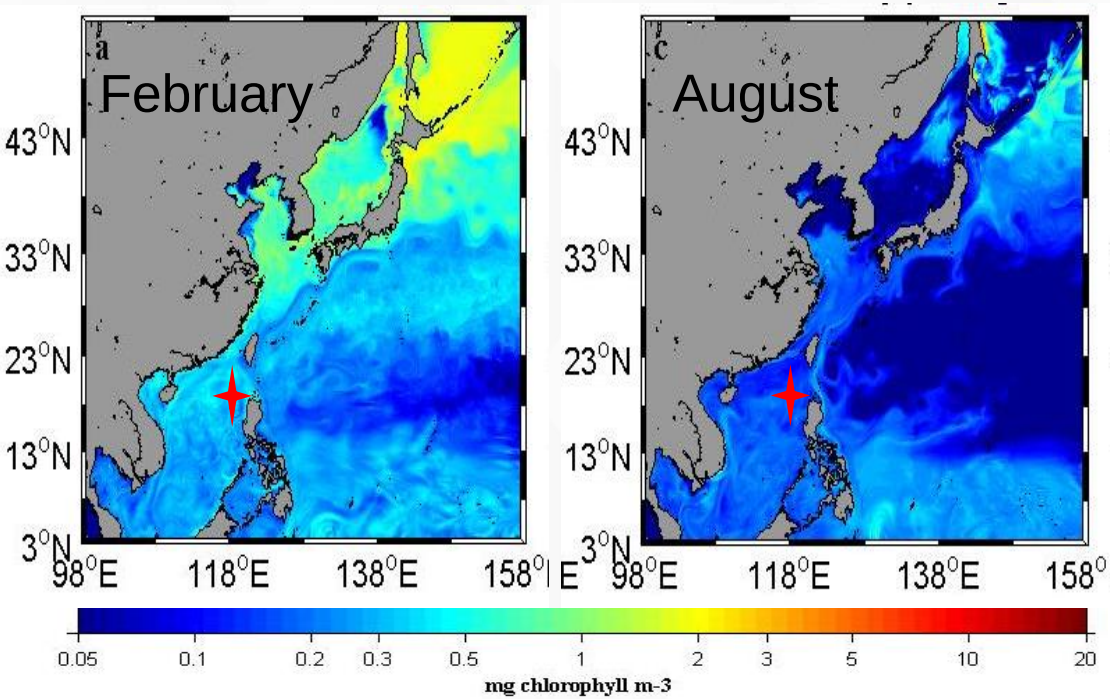
→ $g=\mu_z*[1-\exp(-\lambda*Phy)]$

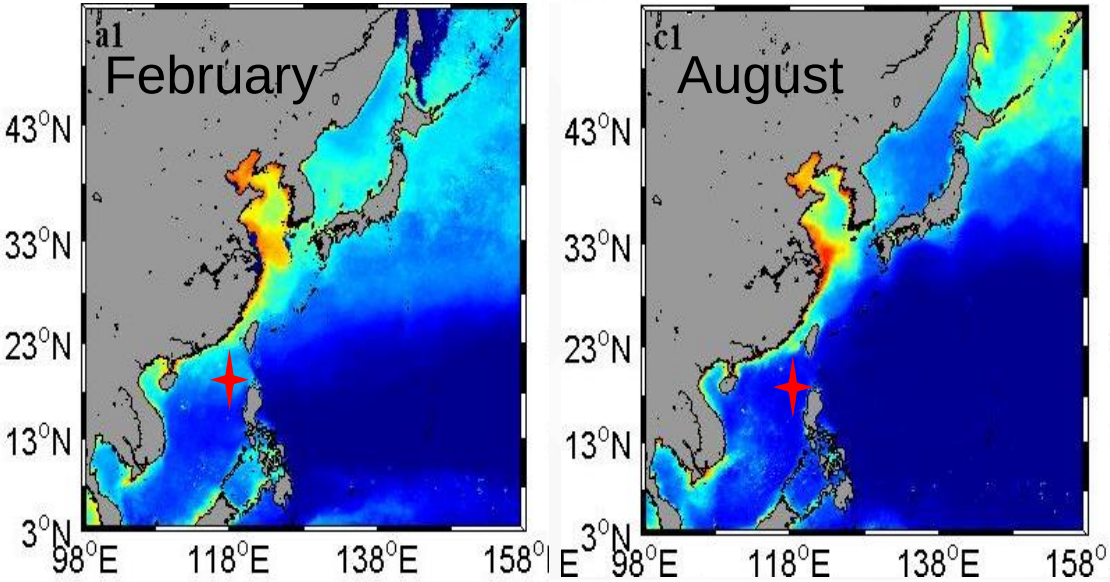
Bio_Fennel (Fennel et al., 2006; 2008)
Liu_NPZD (Liu et al., 2002)、NEMURO(Kishi et al., 2007)

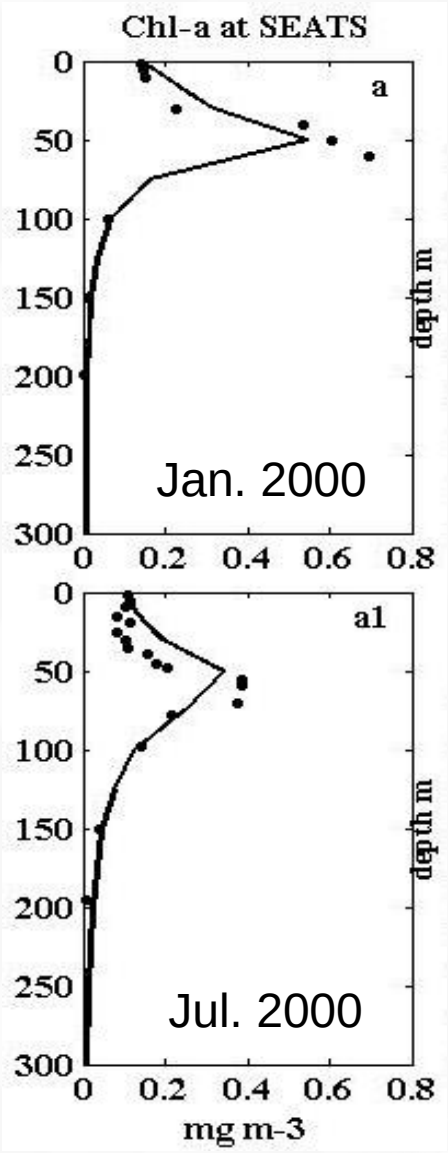
2. Model Validation : Biological Variables

MODEL

SeaWiFS

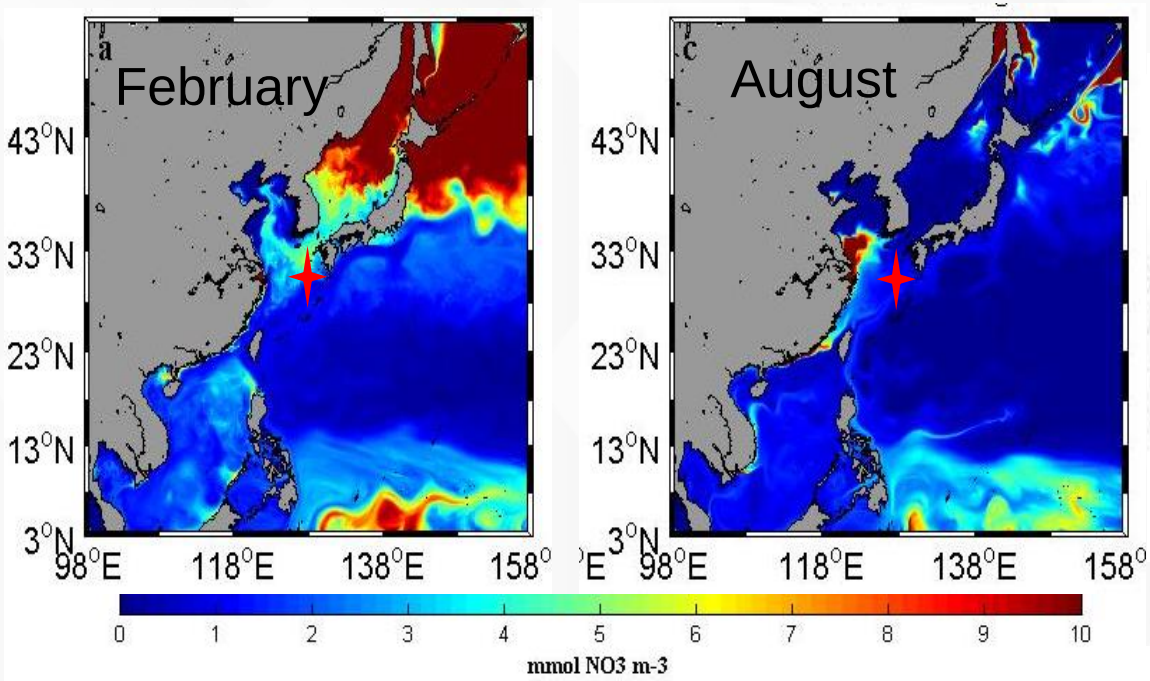


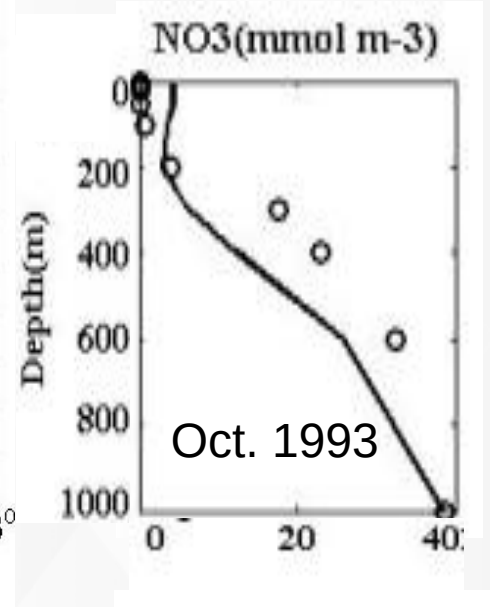




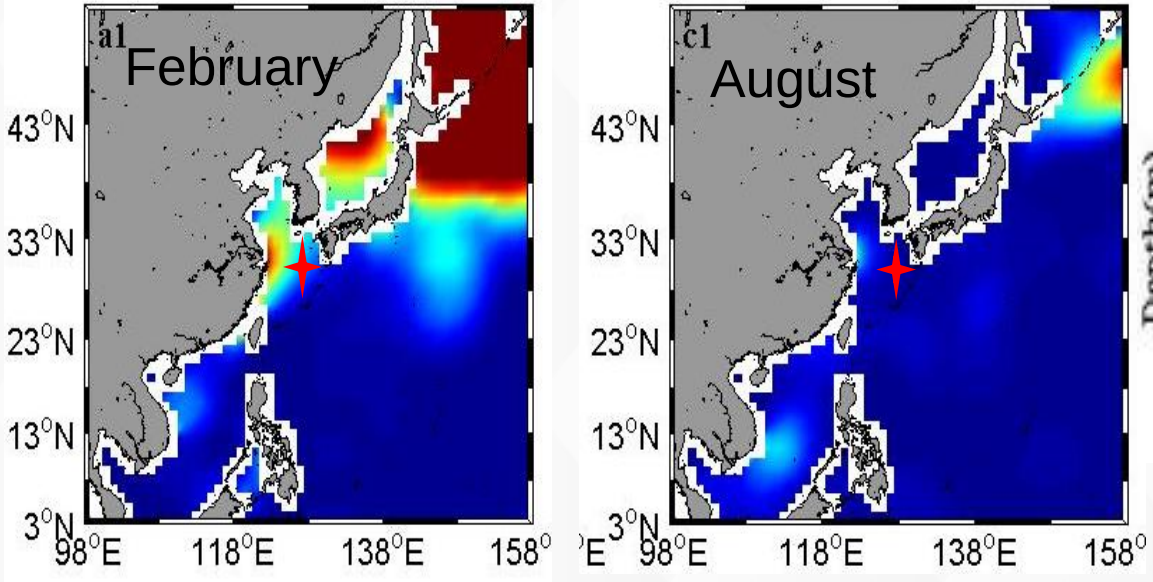
2. Model Validation : Biological Variables

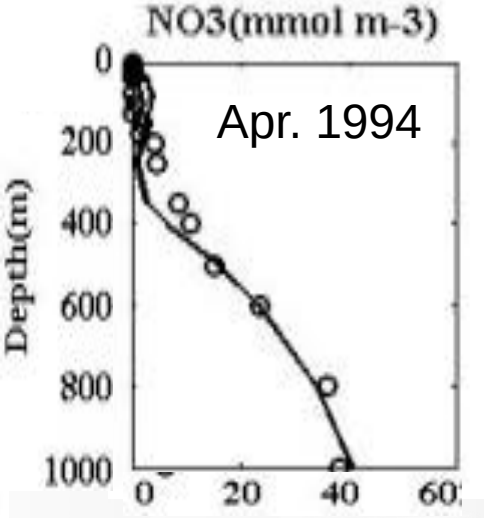
MODEL





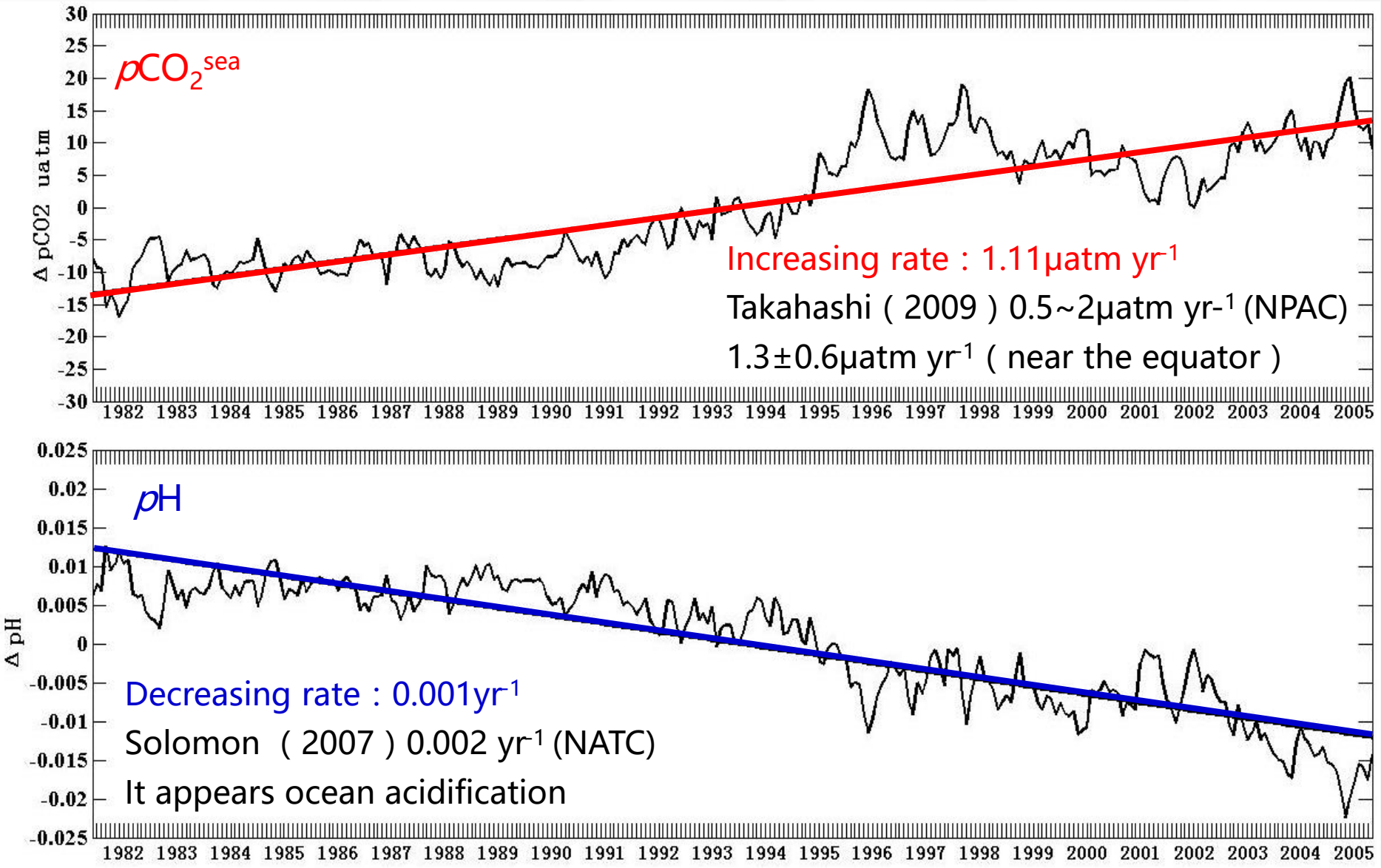
WOA09





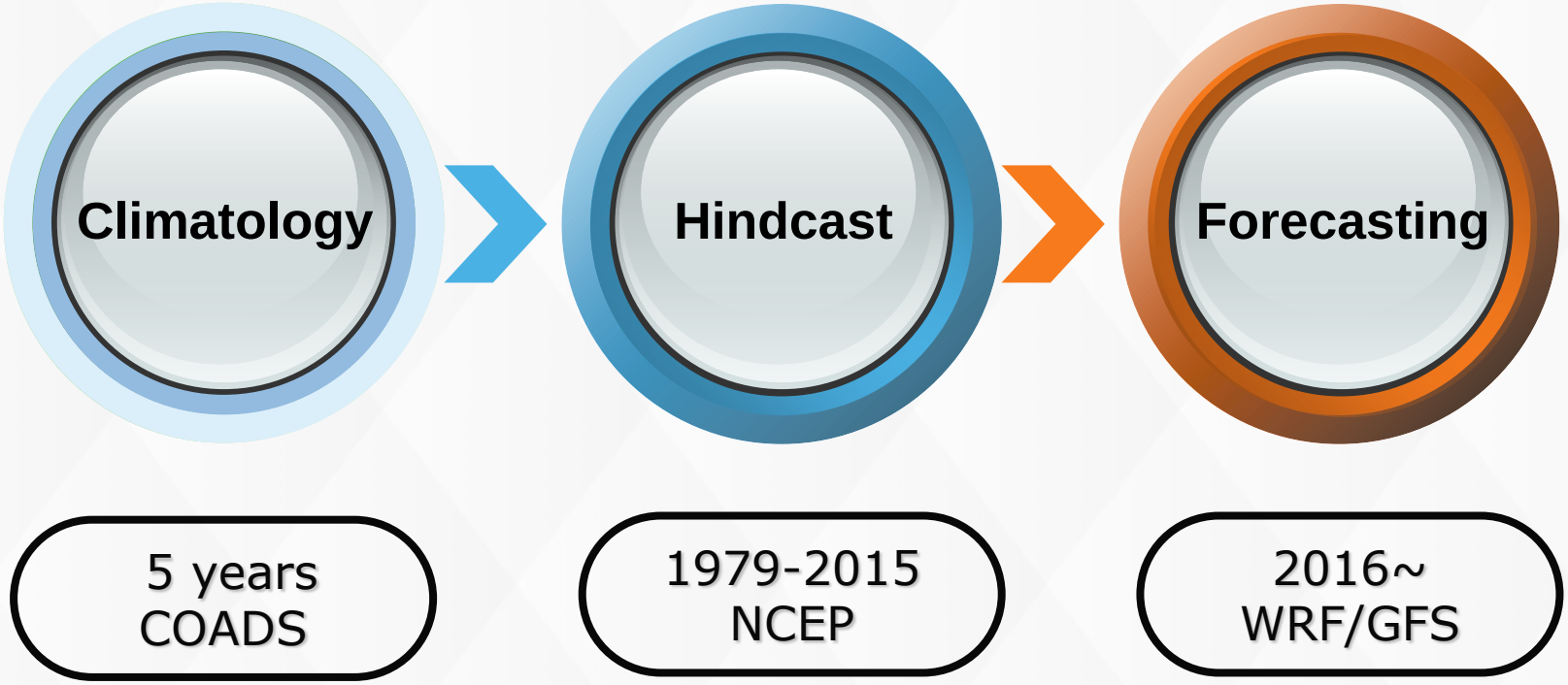
Northwestern Pacific Ocean

3. Application : Acidification

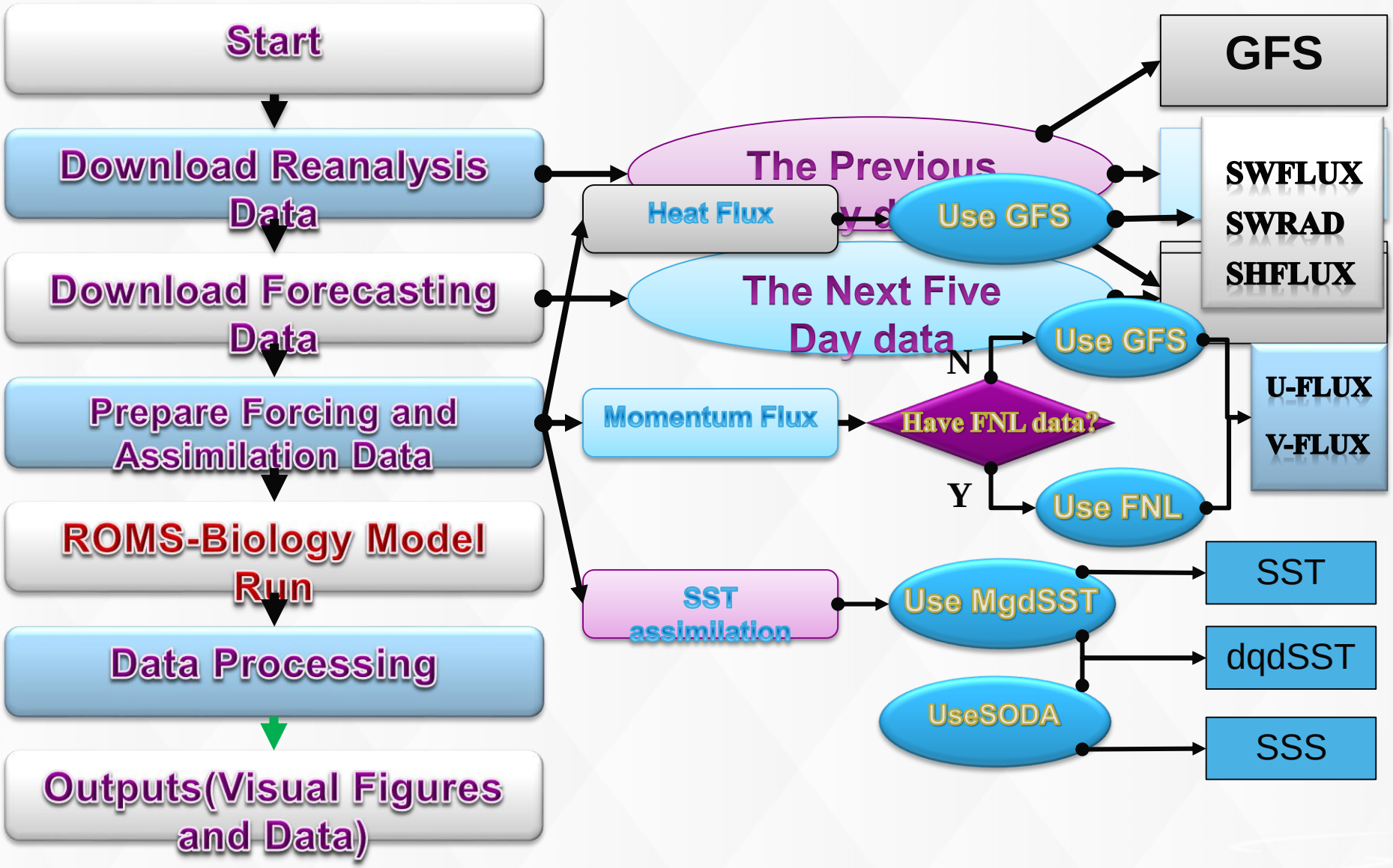


4. Operational System：Forecasting Flow Chart

System Frame

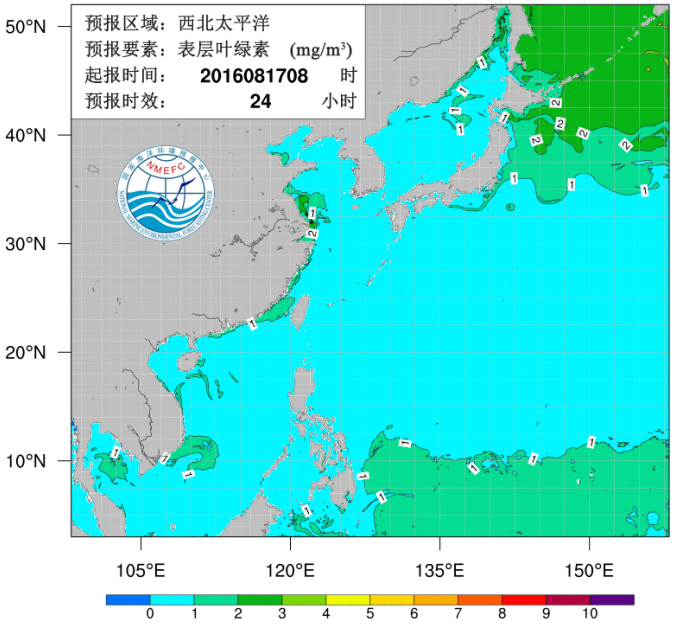


4. Operational System：Forecasting Flow Chart

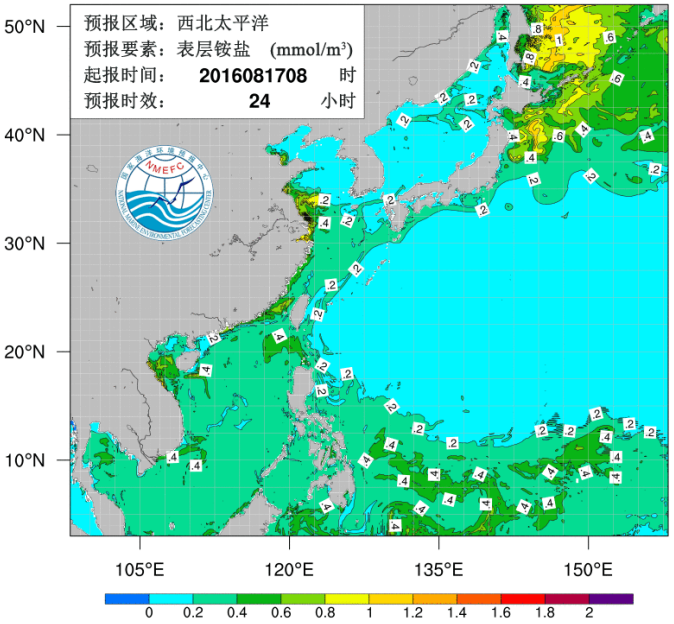


4. Operational System：Products

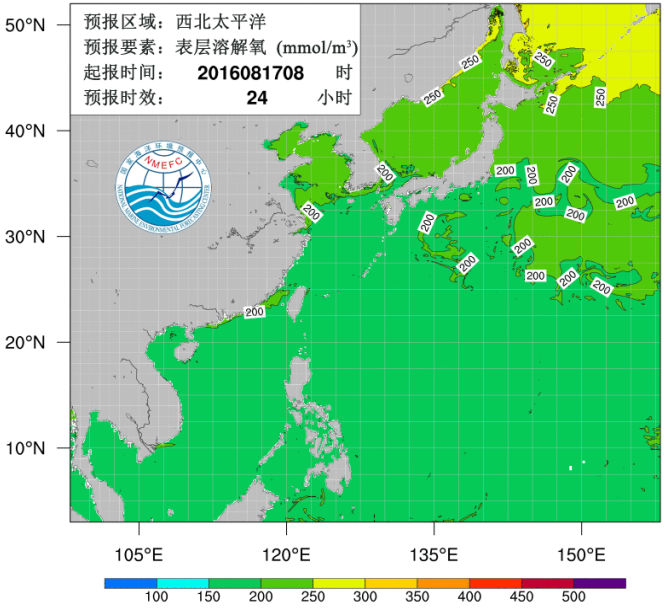
Chl-a



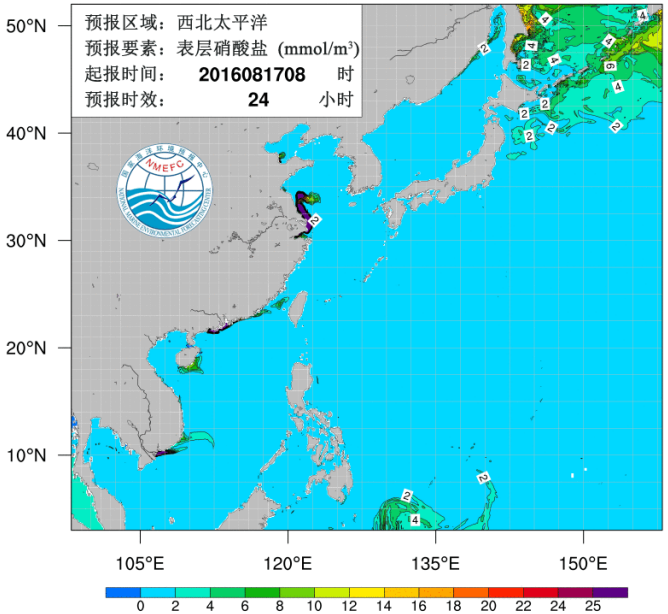
NH4



DO

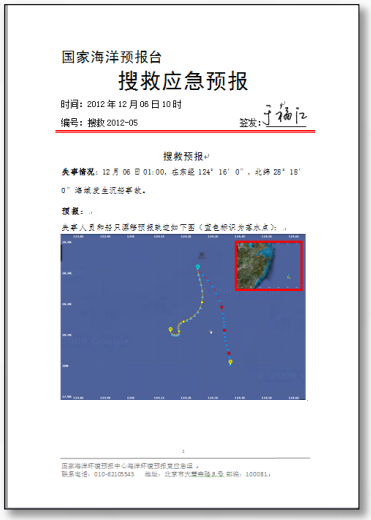


NO3



2) Search and Rescue

Forecasts for trajectory of vessels lost motion and drowning person


国家海洋预报台

搜救应急预报

时间：2012 年 12 月 08 日 10 时

编号：搜救 2012-05

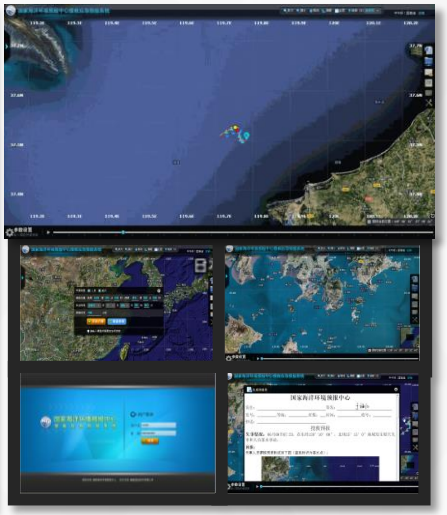
签发：

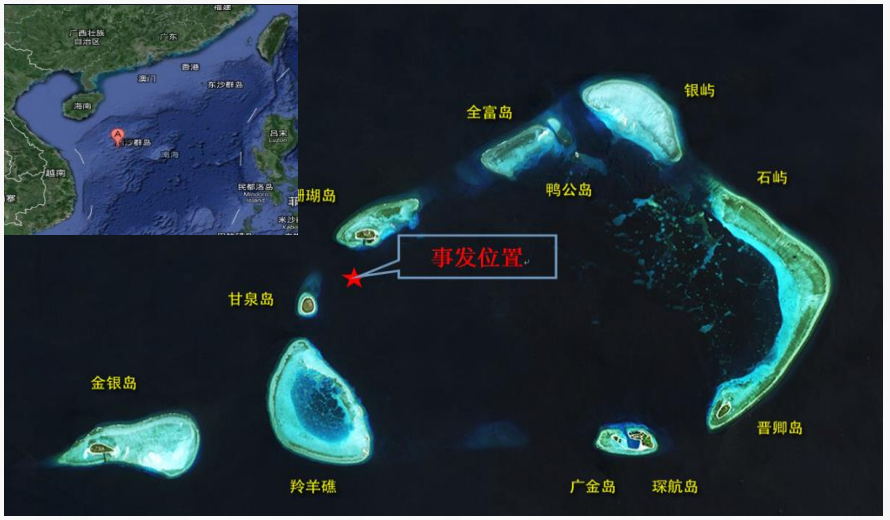
搜救预报

失事情况：12 月 06 日 01:00，位于约 124° 16′ 0″，北纬 28° 18′ 0″ 海域发生沉船事故。

预报：

失事人员和船只漂移预报结果如下图（蓝色标识为落水点）：





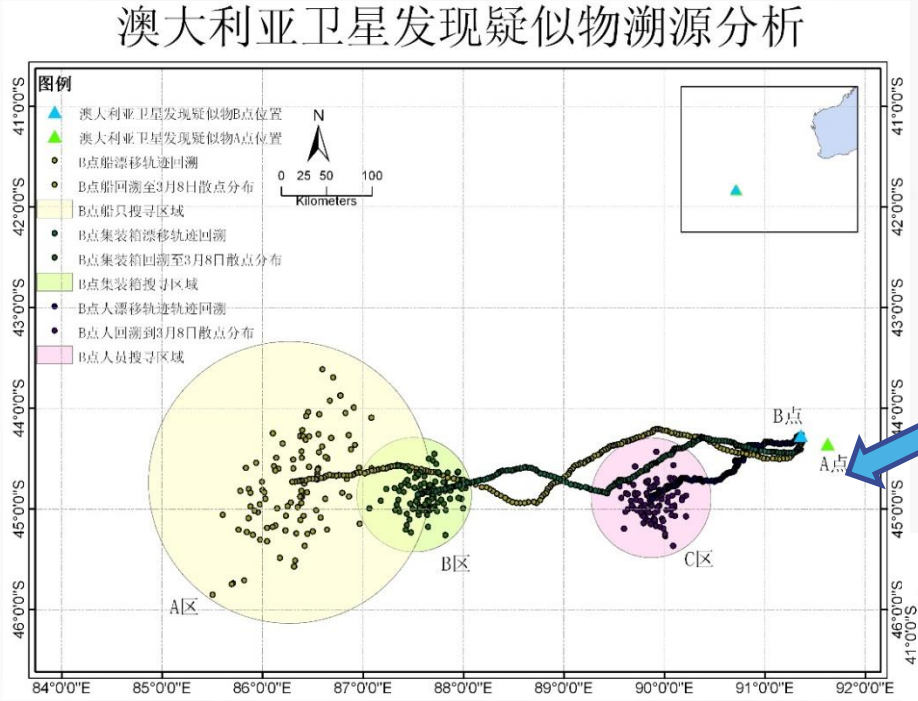
Emergency forecasting of search and rescue in Xisha islands sea area (On September 29, 2013, "Butterfly Typh")

Missing Malaysian flight MH370 emergency forecasting (On March 8, 2014)

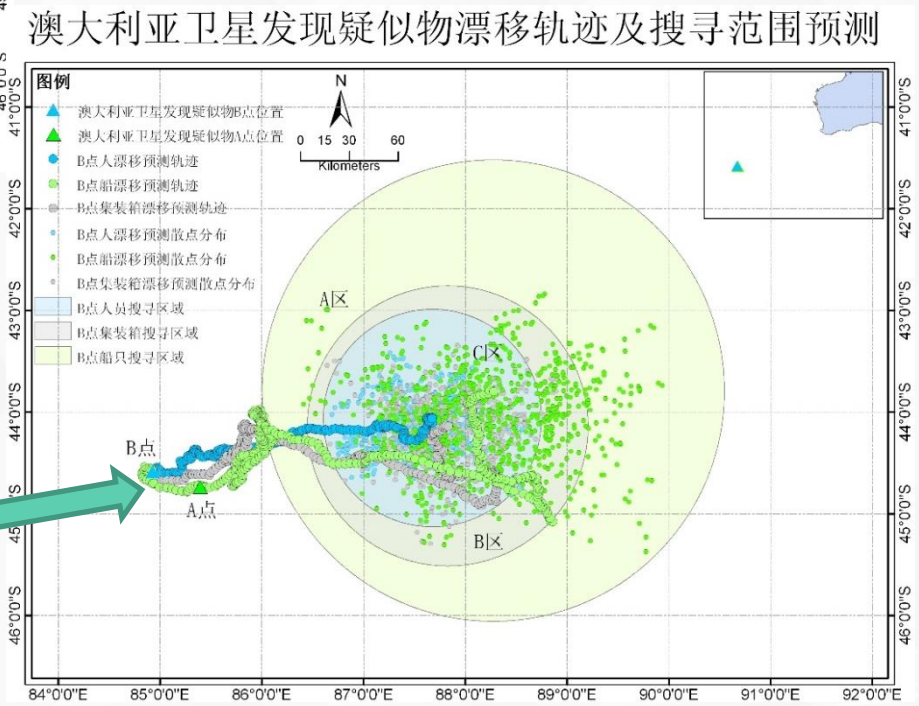
Missing Malaysian flight MH370 emergency forecasting (On March 8, 2014)

March 8th 01:20 am, Malaysia flight MH370 lost contact at 06 °55'15 "N, 103°34'43" E, which draw the world's attention. NMEFC launched the emergency response immediately.

- Until April 20th, NMEFC have organized 10 emergency consultations, and distributed 77 search and rescue emergency forecasting bulletins to all levels of management sectors (Office of the State Oceanic Administration , Chinese Arctic and Antarctic Administration , Office for Ocean, China Coast Guard Command Center , China maritime Search and Rescue Center , Operational command center of Navy Command Headquarters , Civil Aviation Meteorological Center, China Ocean Shipping Company, Navy hydrometeorological Center , Xue Long Ship (CHINARE), Meteorological and Hydrological Space Weather Station of the Headquarters of the General Staff , China rescue and Salvage of Ministry of Transport).
- The bulletins covers the following: drift forecasting of the missing person and life rafts, backtracking of the suspicious debris and oil slick observed by satellite, drift forecasting and suggested search area of the suspicious sea target discovered in Malacca, 72-hour marine environmental forecasting (weather, wave, current, sea temperature) of search and rescue regions and routes of China's search force.



Forecasts for trajectories of suspected content to source derived from Australian satellite.



Forecasts for drifting trajectories of suspected content derived from Australian satellite, and probable scanning zone.

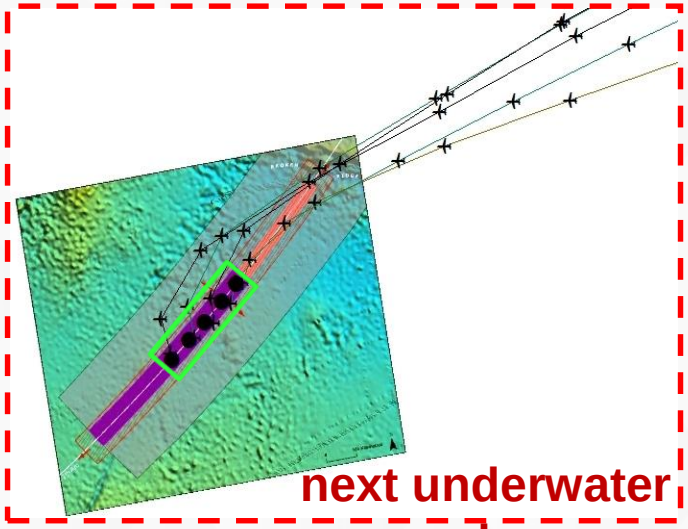
1. To simulate the drift trajectories of debris

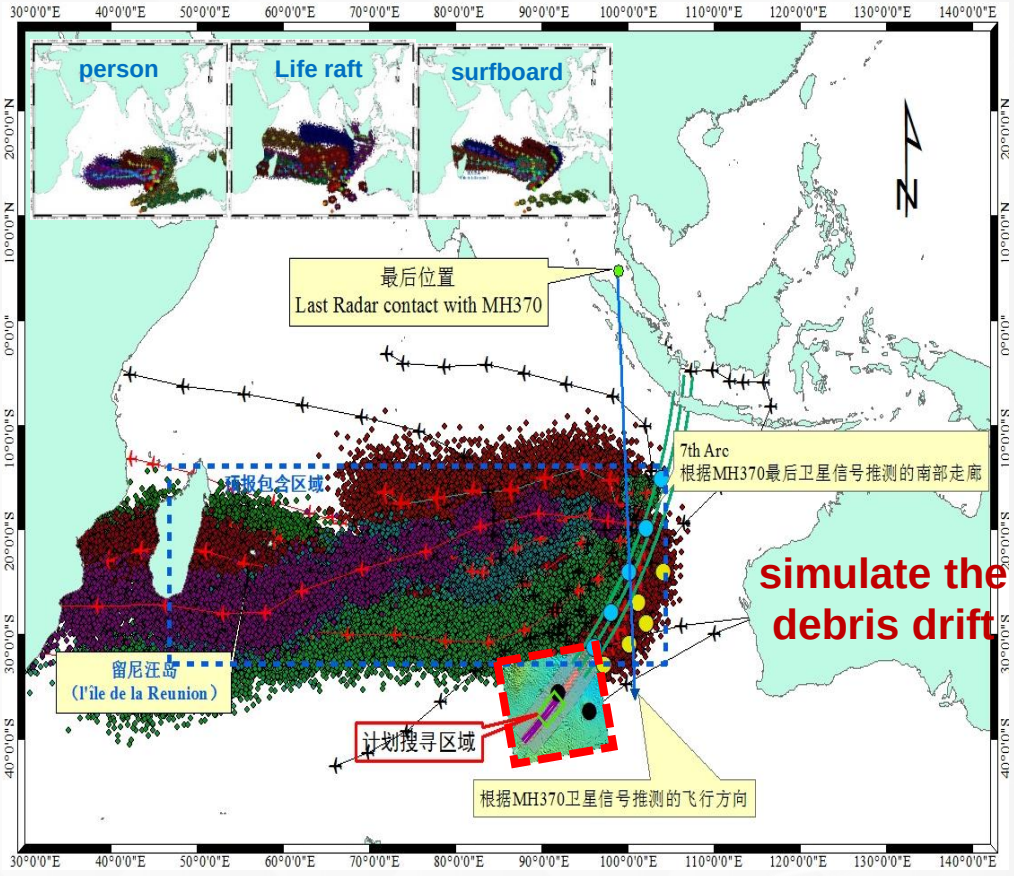
- The NMEFC drift modelling indicated that the net drift of most debris in the sixteen months from March 2014 to July 2015 is likely to have been northward and then westward or directly westward away from the north accident site.
- But the drift from the south accident site is likely to eastward to the western Australia.

2.To access the next underwater search area

(in the red dashed area) published in Aug. 11st

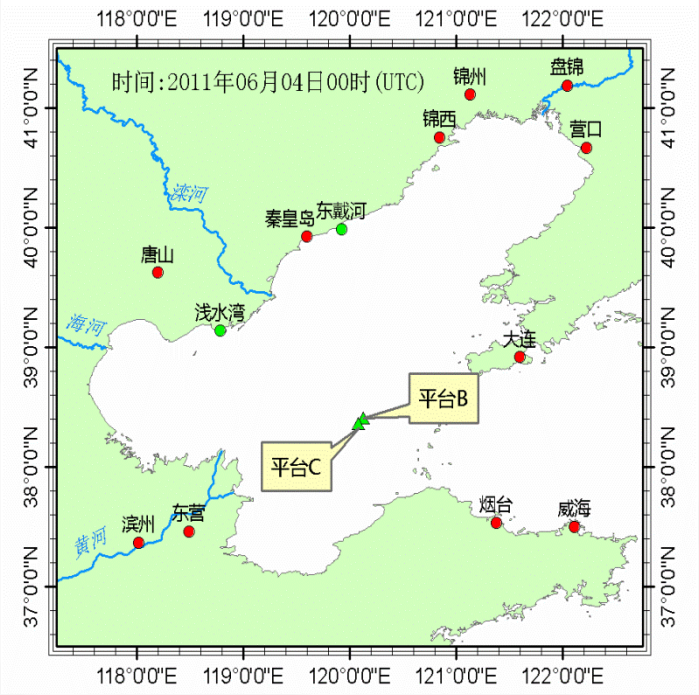
- The opportunity of the drift from the area to La Réunion Island is very small.



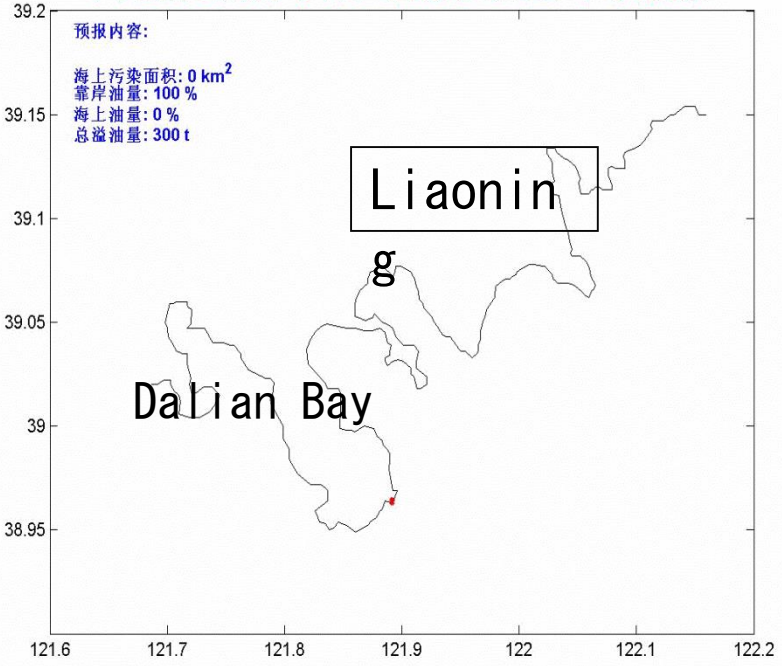


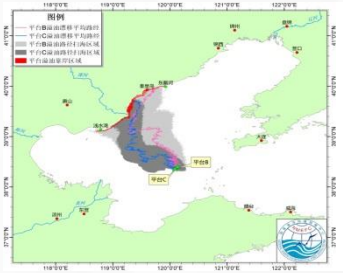
3) Emergency cases — Oil Spill

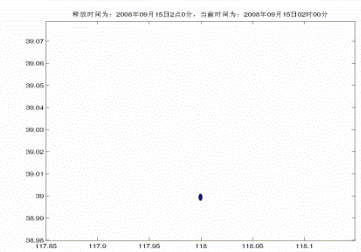
June 2011, Oil Spill in Bohai Bay

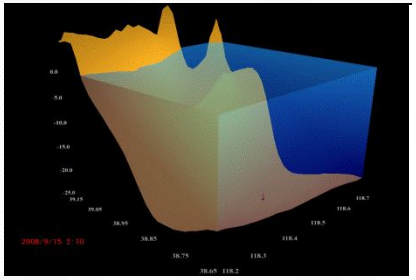


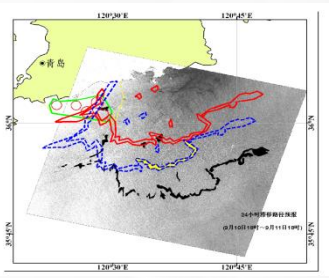
July 2010, Explosion in Dalian Xingang Factory explosion











4) Marine hazardous materials transport

8·12 Tianjin Port hazardous materials transport analysis

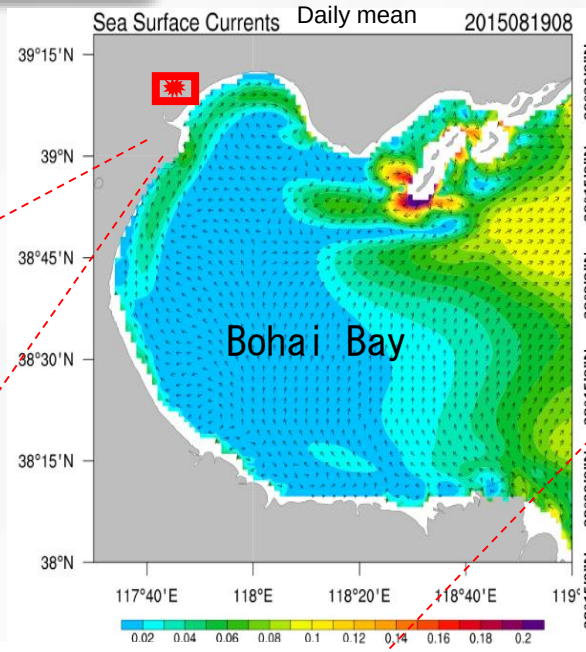
1. To simulate the surface current

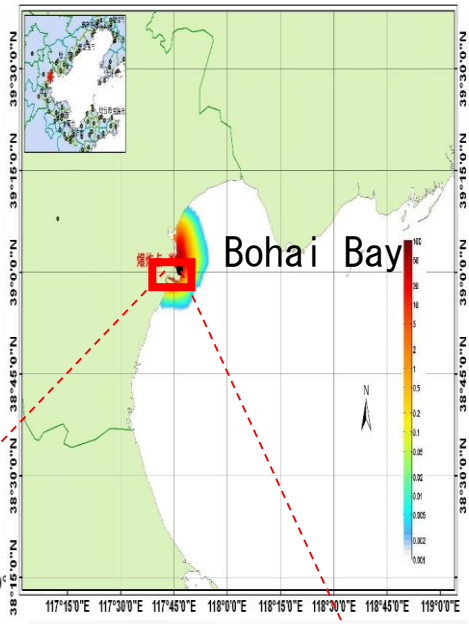
➢Irregular semi-diurnal tides in **Bohai bay**;

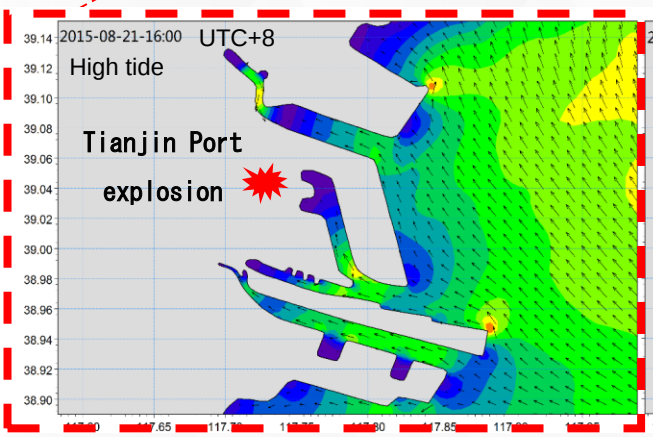
➢Westward at high tide and eastward at low tide in **Tianjin Port** coastal area.

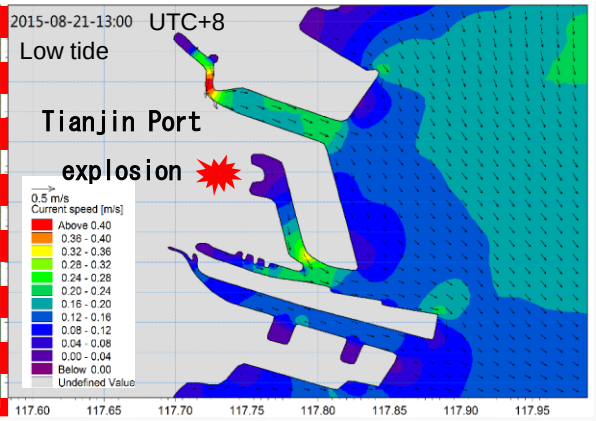
2. Supposing the chemicals spilled from Sewage outlet to the sea, To forecast the marine area of influence in 72hours.

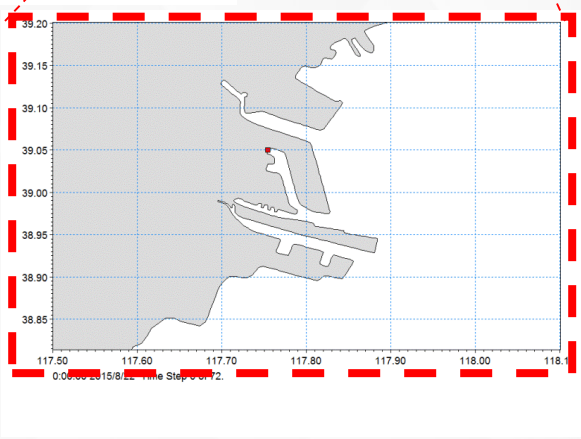
➢The concentration diffusion process was simulated on high resolution current.







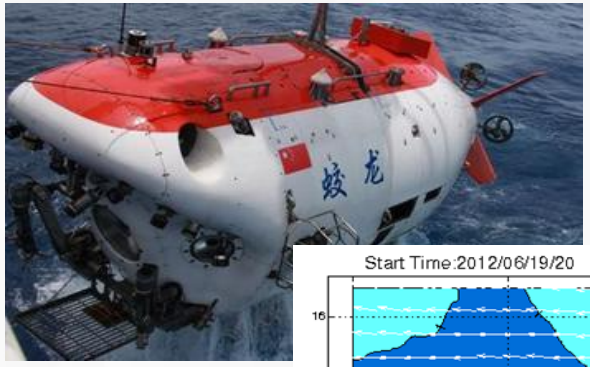




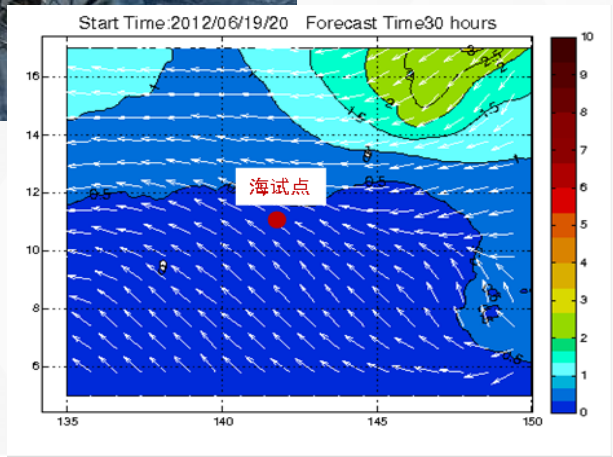
5) Environmental Forecasts

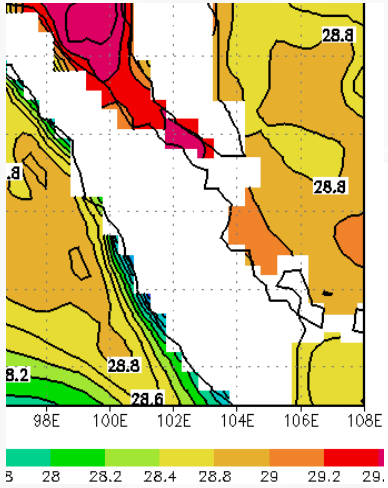
Forecasts for Travel Channel (20130521)

City	Wave	Temperature	City	Wave	Temperature
Da Lian	Slight	10.7	Maldives	Moderate	29.0
Vladivostok	Slight	5.9	Cape Town	Moderate	16.2
Jeju	Slight	17.7	Rio de Janeiro	Moderate	24.2
Tokyo	Slight	18.4	Lisbon	Moderate	17.9
Shanghai	Slight	19.1	Barcelona	Slight	16.6
Keelung	Slight	24.9	Bergen	Rough	8.3
San Ya	Slight	28.8	Hamburger	Very Rough	11.2
Hong Kong	Slight	25.8	San Francisco	Rough	11.6
Bangkok	Slight	31.0	New York	Slight	13.0
Singapore	Slight	30.9	Sydney	Slight	22.4
Dubai	Slight	27.7	Hawaii	Moderate	25.8

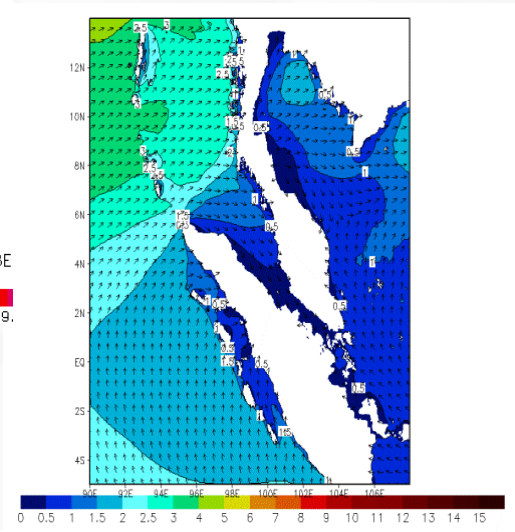


Submersible “Jiaolong” Exploration



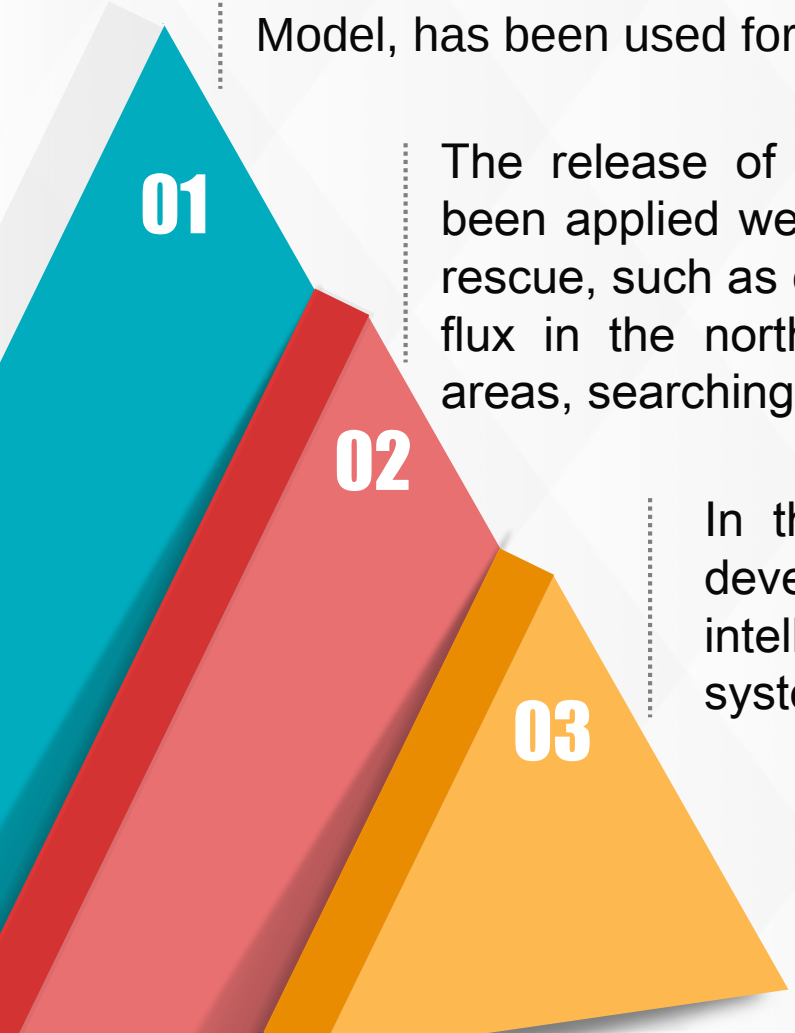


Escort Mission in the Strait of Malacca



05 Summary

Summary



01 The Operational Ocean Forecasting System of China Sea, which include Northwest Pacific Model, East China Sea Model and South China Sea Model, has been used for operational forecasting everyday.

02 The release of Operational Ocean Forecasting System have been applied well to ecological, oil spill forecasting, search and rescue, such as chlorophyll-a, nutrients in the north Pacific, CO_2 flux in the northwest Pacific Ocean, oil explosion in coastal areas, searching for MH370 , and so on.

03 In the further work, extension of forecast range, development of forecast system with independent intellectual property, construction of observation system will be considered more and more.

Thank You !

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