Study on Air-Sea Interaction under Typhoon and Its Application of Two Important Projects

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Shanghai Typhoon Institute/CMA

2018.02.26

1、National Basic Research Program of China(2009-2013), STI/CMA,…...

Unusual Variation of Landfalling Tropical Cyclone Behavior and Associated Physical Mechanism

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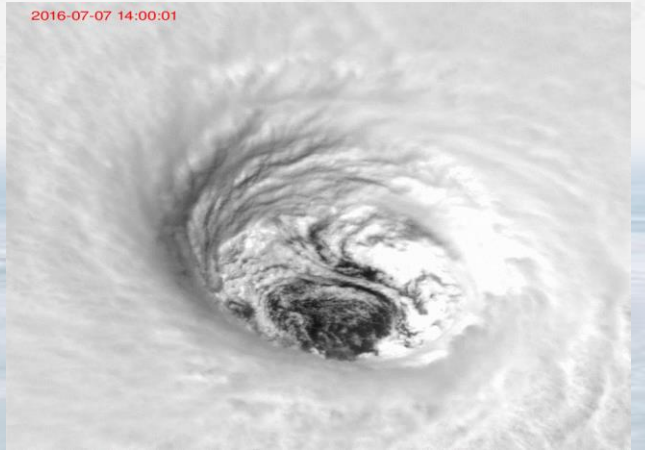
2、National Basic Research Program of China(2012-2017), SIO,STI…….

Study on Response of Upper Ocean and Mechanism of Modification to Typhoon



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- Importance of Air-sea Interaction to TC
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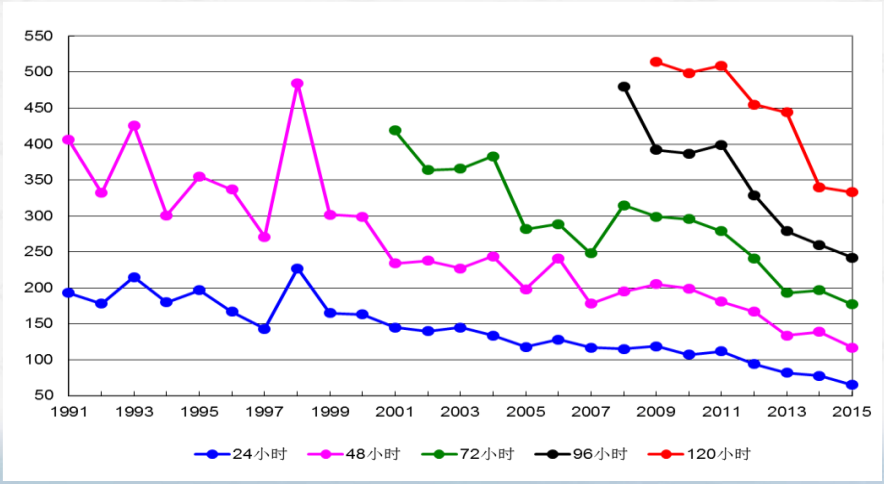
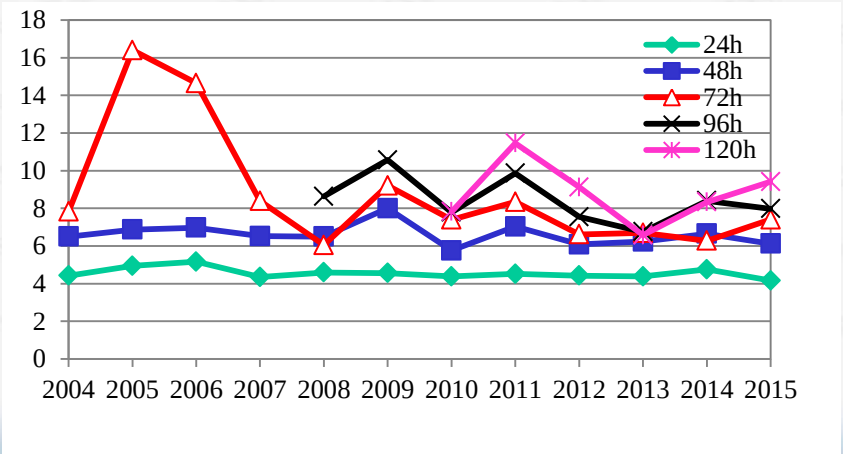
- Improvement of TC Air-sea Coupled Model
- Numerical Sea Wave and Storm Surge Forecast

Chllenge: no progress for intensity forecast of TC

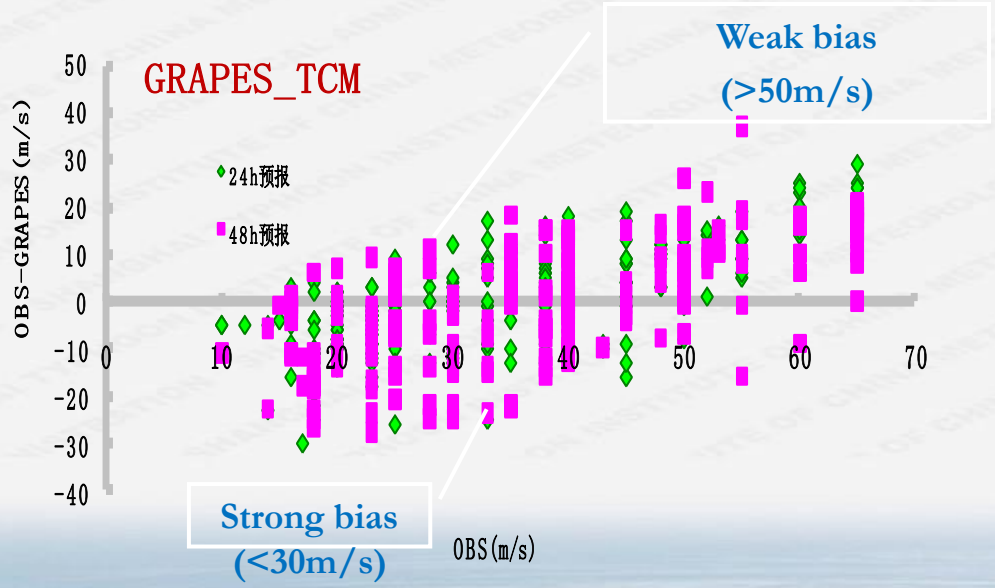


Track error of TC (CMA)

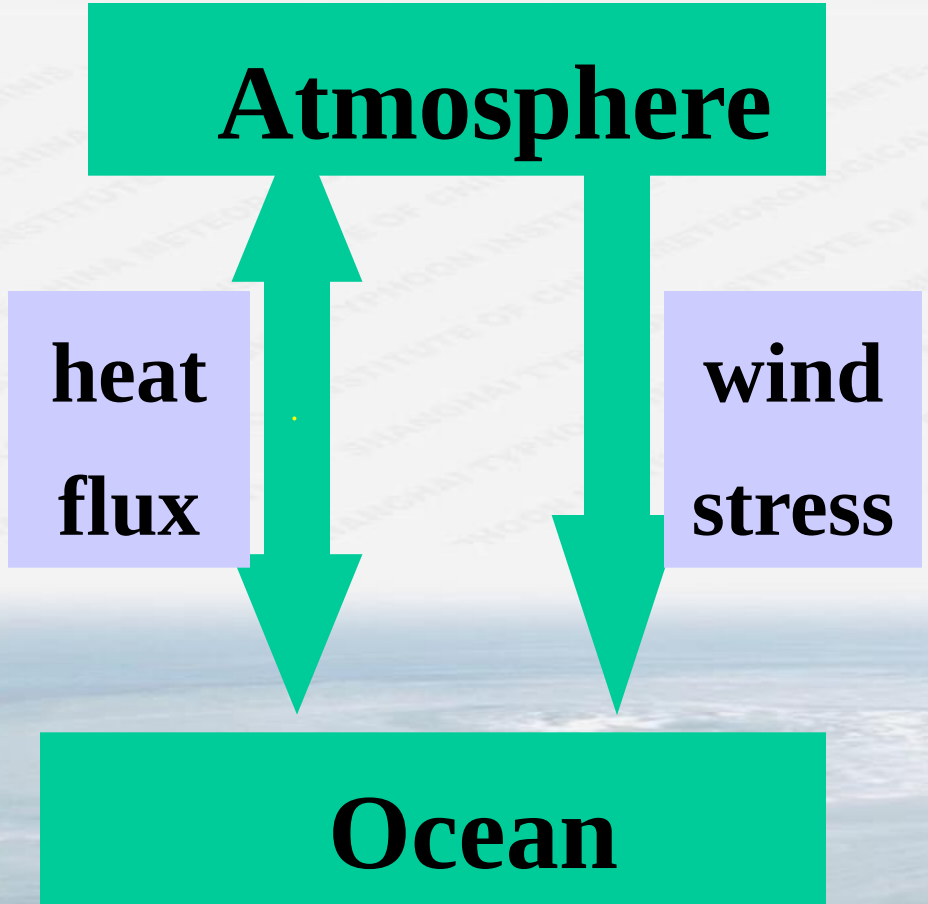


Intensity error of TC (CMA)

Chllenge: Bias of intensity forecast of TC



Coupled Atmosphere-Ocean System



Cd= f(u10)
no change for SST

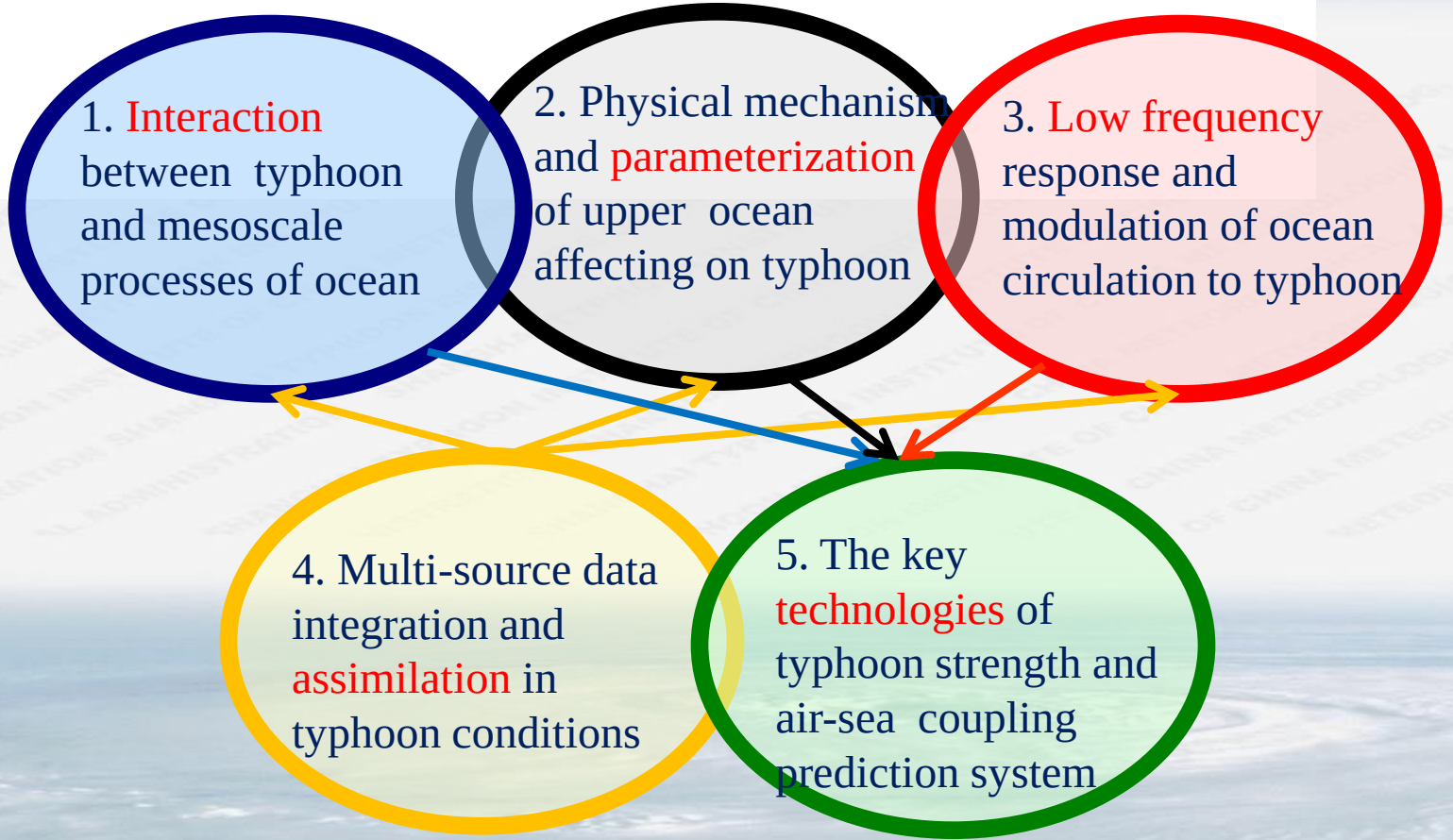
before

Key Scientific Questions

The response mechanism of multi-scale circulation in upper ocean to typhoon

The dynamic and thermal structure of upper ocean to modulate the typhoon

Sub-projects and their relationship



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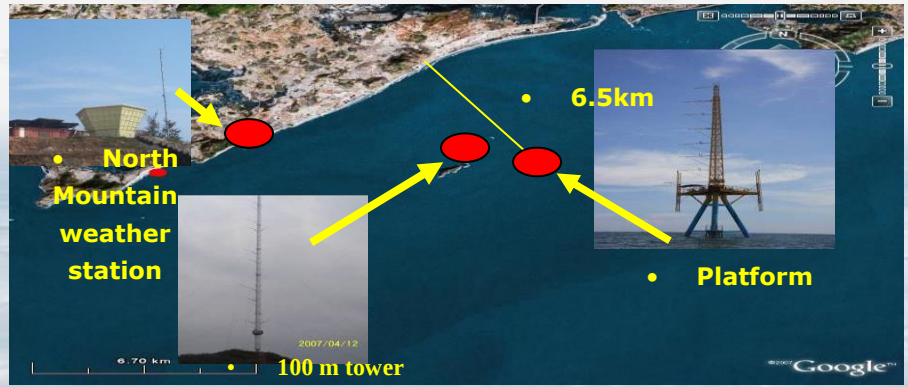
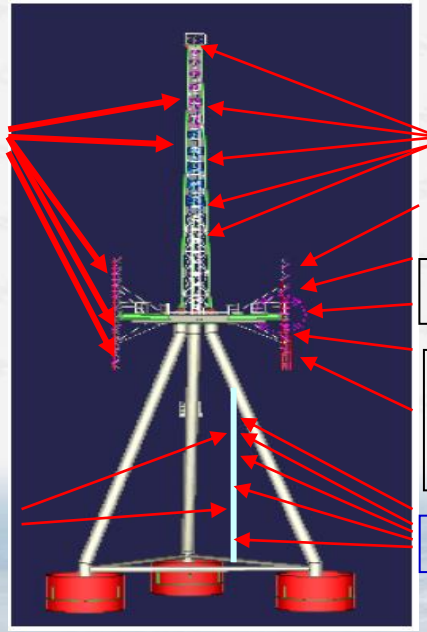
Maoming BoHe Marine meteorological science test base

- **Weather Station at North Mountain：Boundary wind profile instrument；Radiometrics ；Sea wave radar；Automatic weather station**
- **Platform on the sea： Ultrasonic wind thermometer； wind， temperature， humidity on 5 layers； Rain gauge； Infrared sea surface thermometer**
- **Blow sea surface：Sea temperature and salinity on 3 layers；ADCP**
- **Island：100 m tower wind， temperature， humidity on 5 layers；**



BoHe Marine meteorological observation platform

Air-sea flux observation



Eddy covariance system

Gradient observation system

Radiation

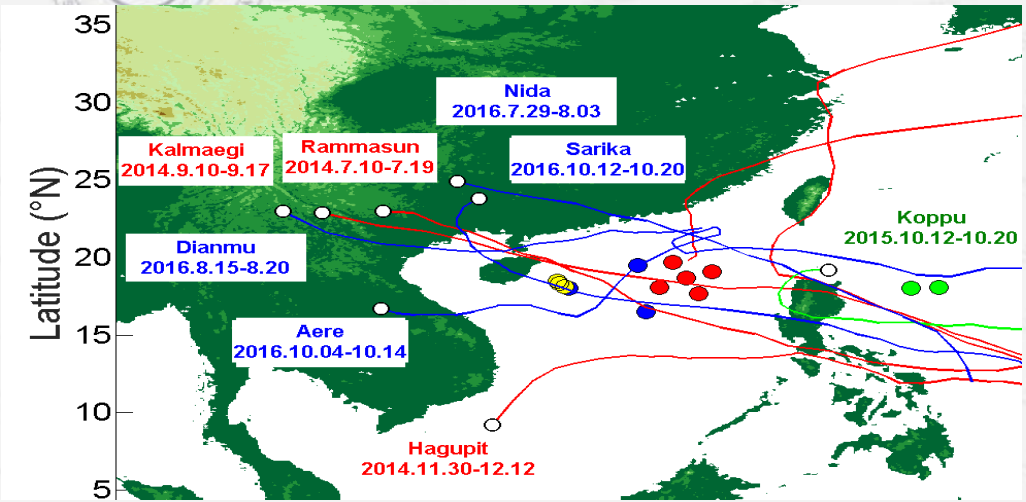
Infrared telemeter for SST

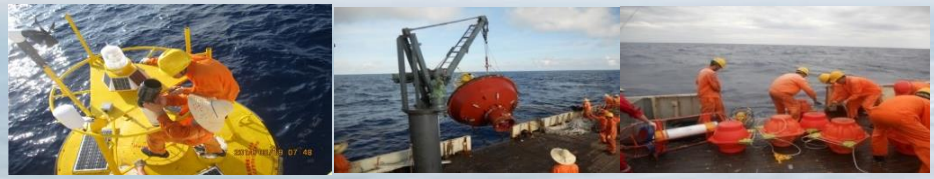
Doppler velocity

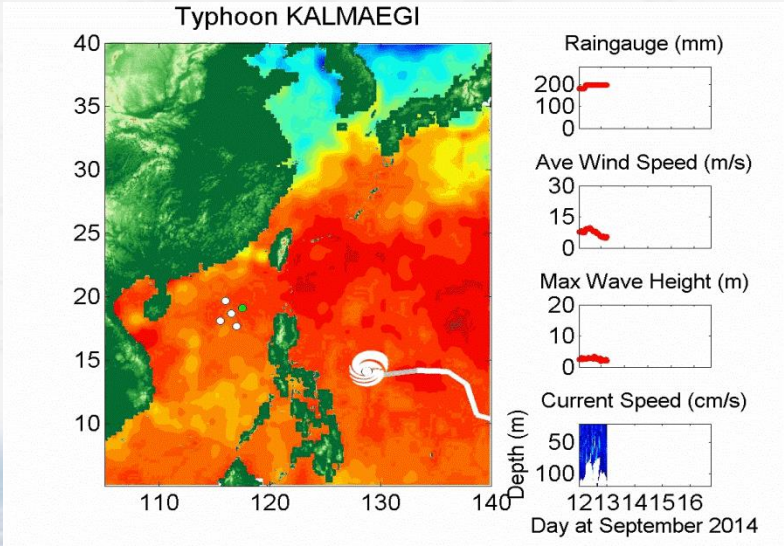
Temperature/salinity

ultrasonic instrument

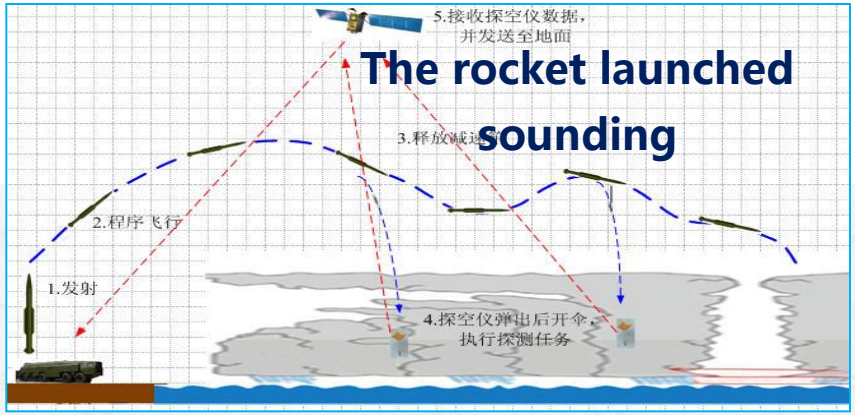
Buoy/submarine observation array



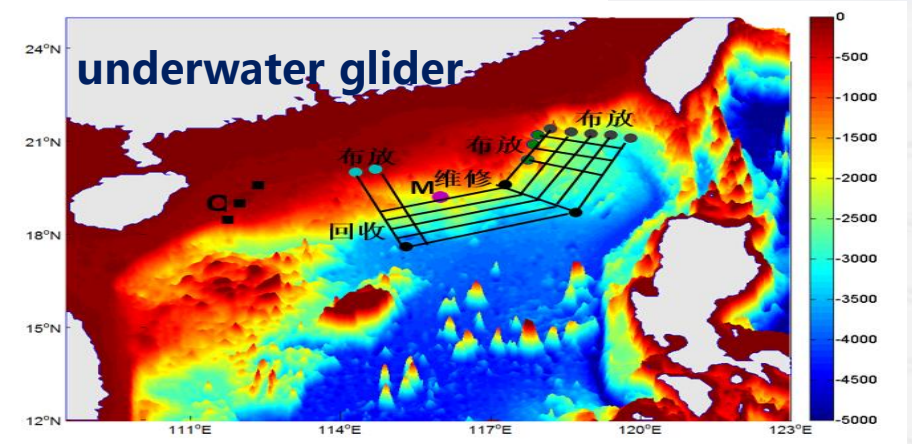


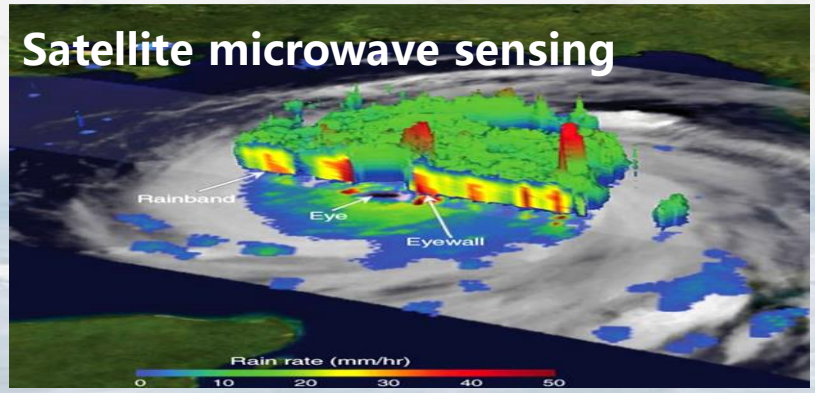


Other observations



The rocket launched sounding





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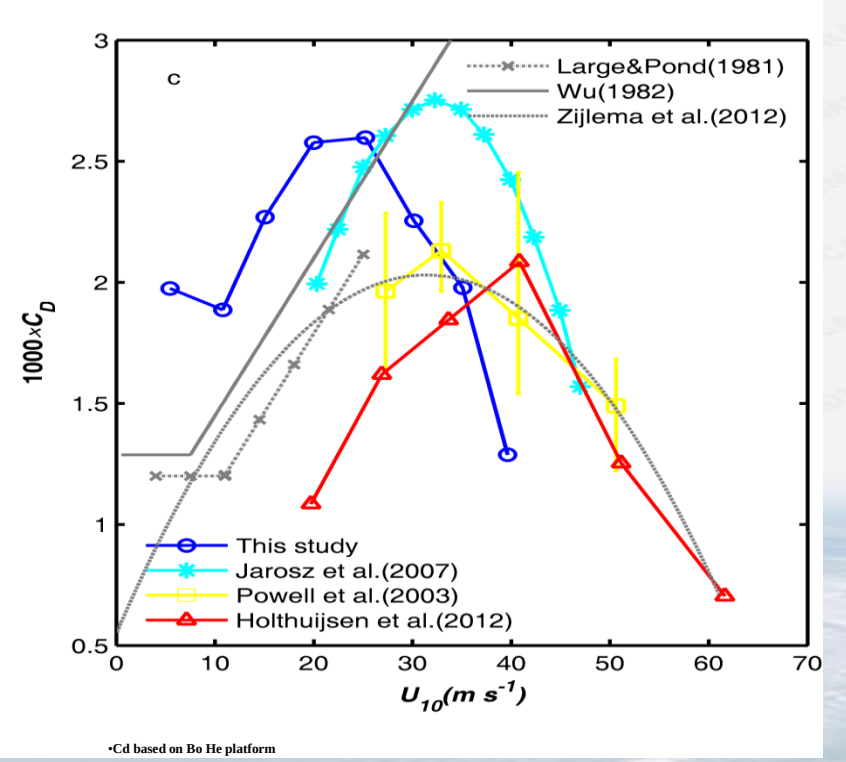
New air-sea exchange *Cd* changing with u10 under the typhoon

Theoretical mechanism：

◆waves broken by depth of water results in the curve of *Cd* moving toward low wind

◆The phase velocity inhibition results in *Cd* increase



•Cd based on Bo He platform

A new parameterization scheme, the drag coefficient is dependent on the depth of the water

Charnok：

$$z_0 = C_{z_0}\left(u_*^2/g\right) + o_{z_0}$$

$$C_d = \left(\frac{k}{ln\frac{10.0}{z_0}}\right)^2$$

Shallow water

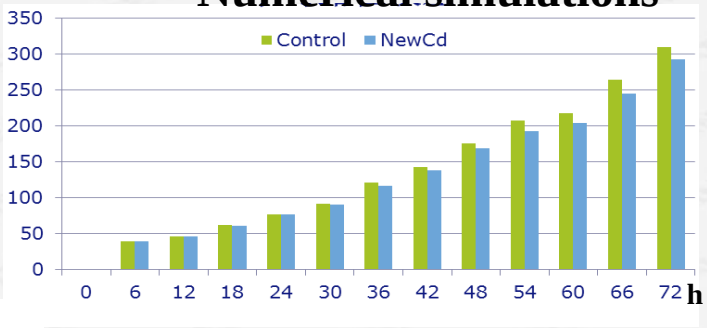
$$1000C_D = \begin{cases} 1.95, & 5.4 < U_{10} < 10.8 \\ 1.41 + 0.05U_{10}, & 10.8 < U_{10} < 25.2 \\ \frac{131}{U_{10}^2} + \frac{62}{U_{10}}, & 25.2 < U_{10} < 39.6 \end{cases}$$

deep sea

Large and Pong (1981,JPO)

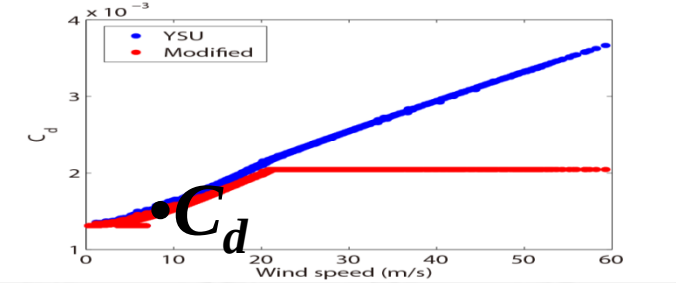
$$1000Cd = \begin{cases} 1.2, & 4 < U_{10} < 11 \\ 0.49 + 0.065 * U_{10}, & 11 < U_{10} < 35 \\ \frac{3390}{U_{10}^2}, & U_{10} > 35m/s \end{cases}$$

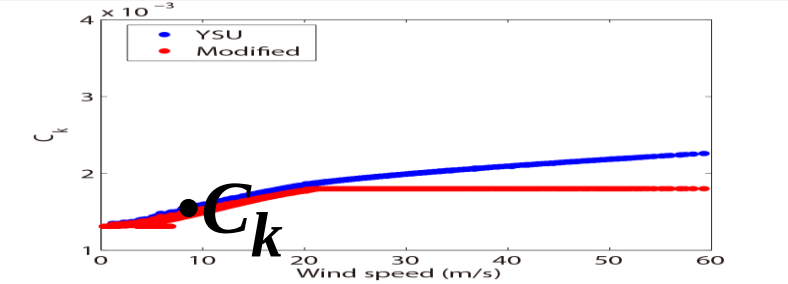
Numerical simulations



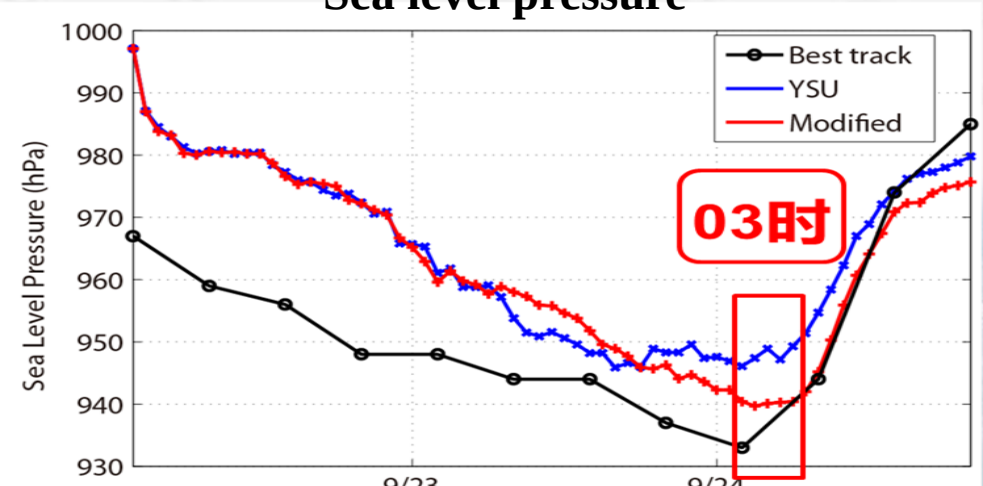
Track error of 22 TC cases in 2010－2012

Improvement of air-sea exchange coefficient algorithm

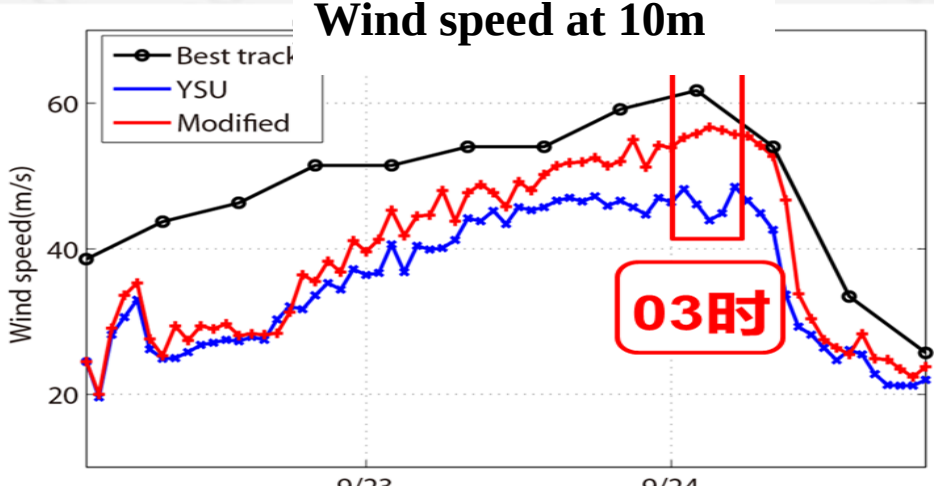




Sea level pressure

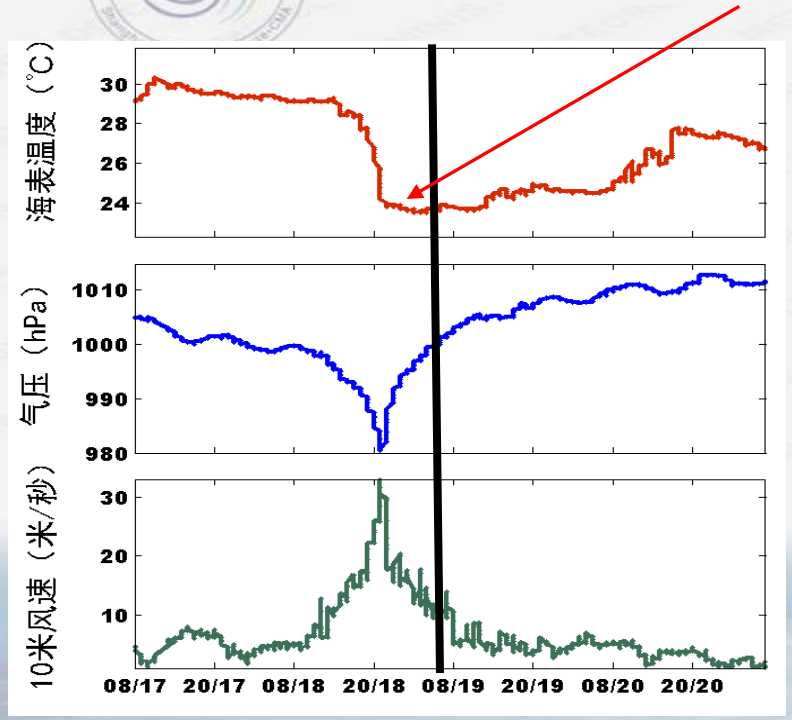


Wind speed at 10m



under the influence of the typhoon near shore sea surface temperature fell sharply

6 ℃ cooling at 63 km distance from typhoon center

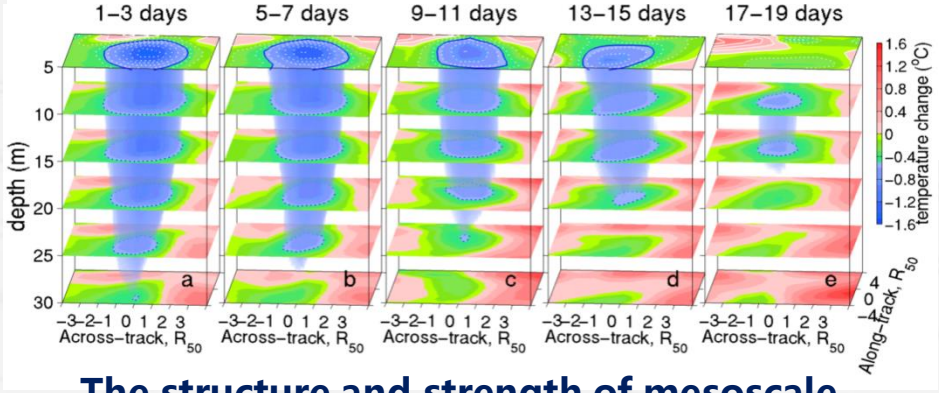


Wind speed, pressure and sea surface temperature by 0906TC

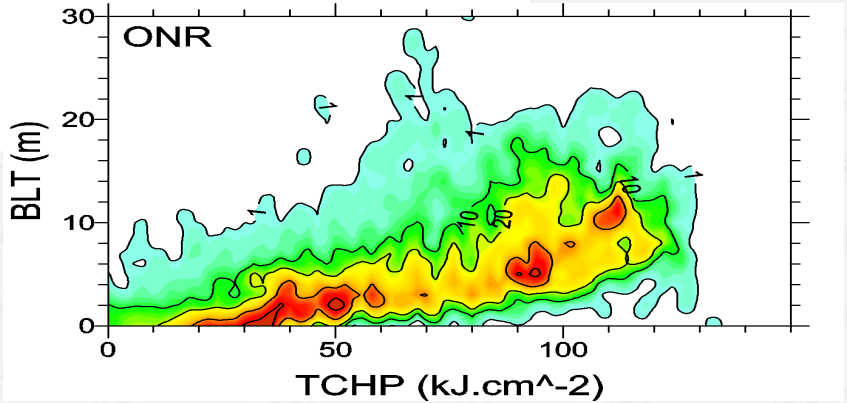
July，2009

The ocean responds and feedback to typhoons

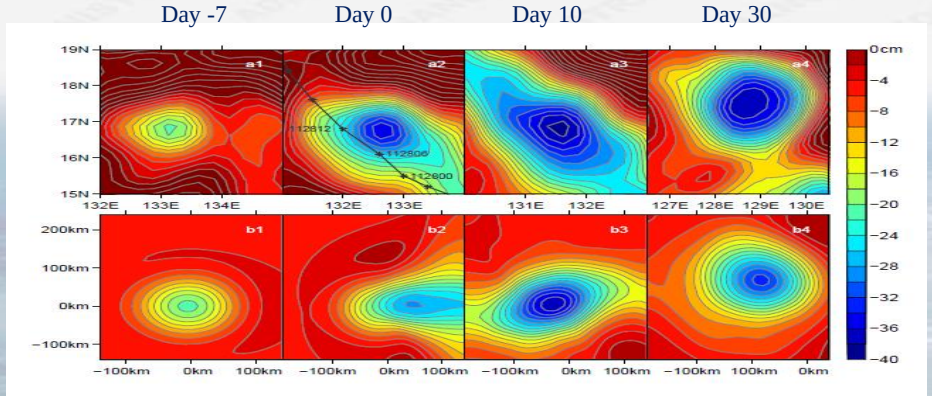
The upper ocean cooling by the typhoon



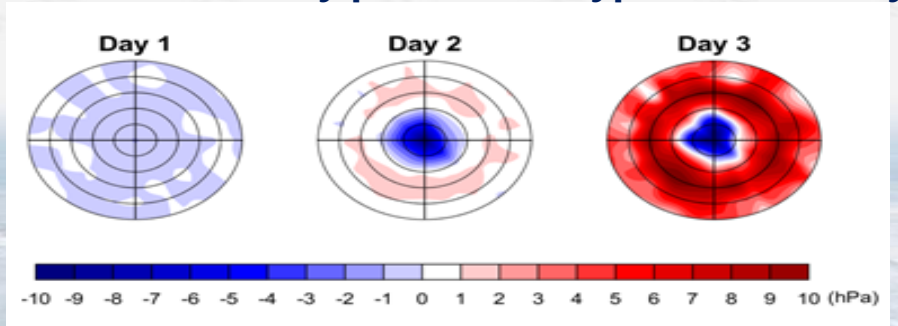
The effect of BL depth on typhoon intensity



The structure and strength of mesoscale vortex under a typhoon (SSHA)



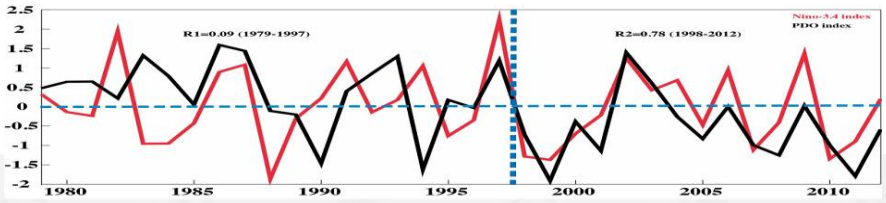
The effect of eddy position on typhoon intensity

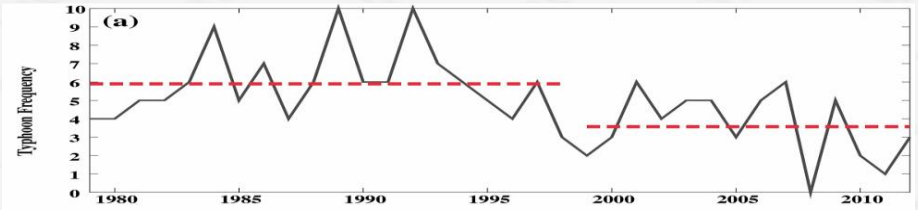


MSLP decrease if +SSTA at center and <R, outside not

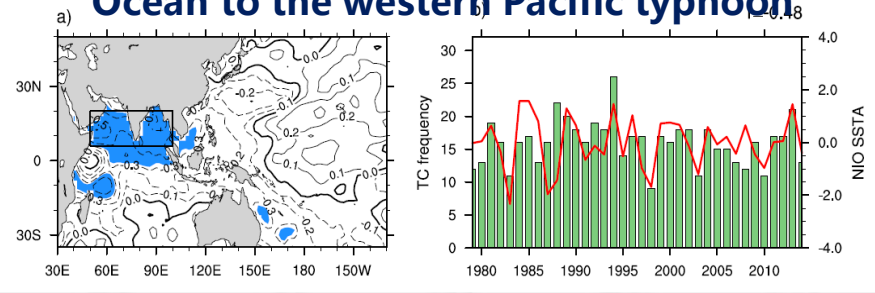
Interaction between typhoons and ocean on large scale

Modulation of PDO and ENSO to typhoon

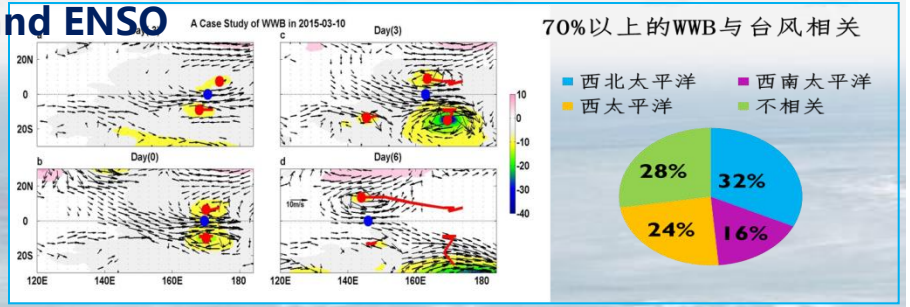




Modulation of the northern Indian Ocean to the western Pacific typhoon

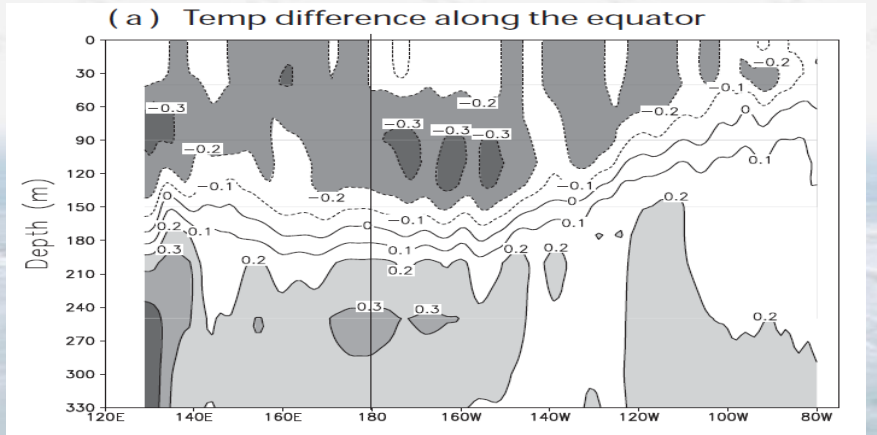


Impact of typhoon on west wind outbreak and ENSO



Chen D K

Effects of typhoons on tropical circulation and thermal structure of ocean



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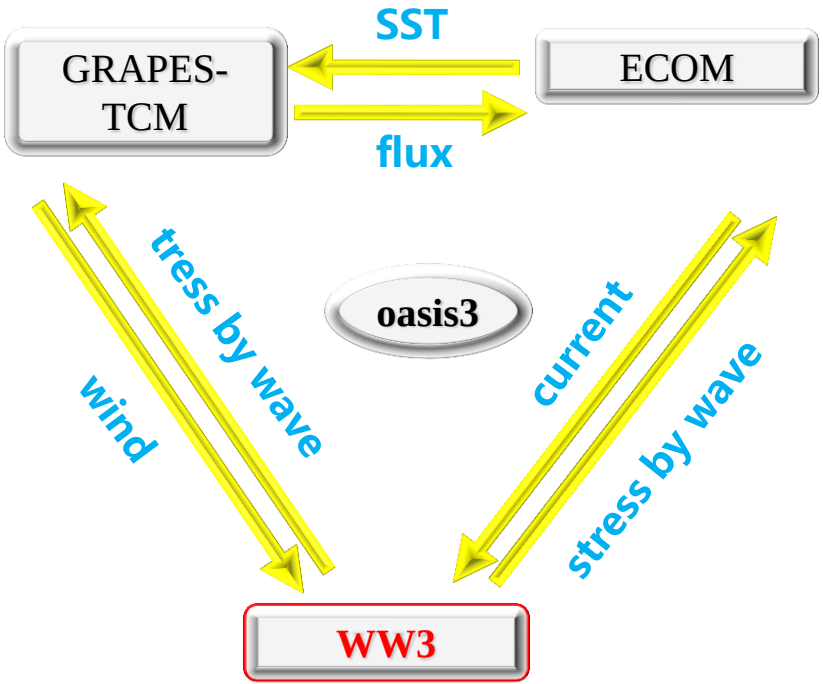
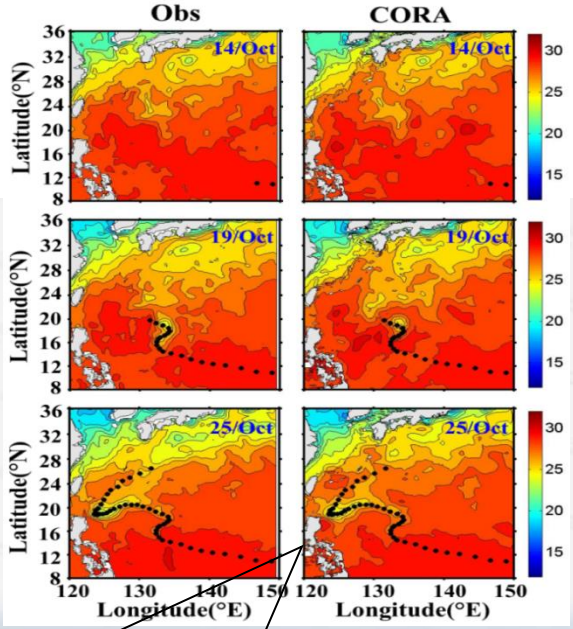
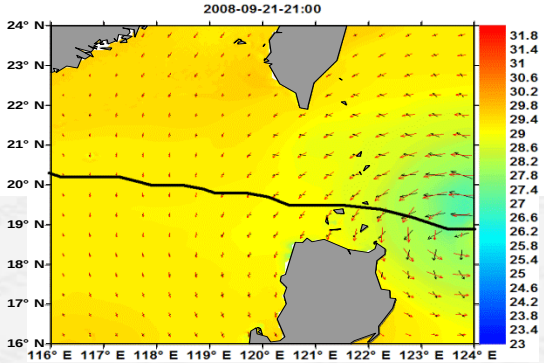
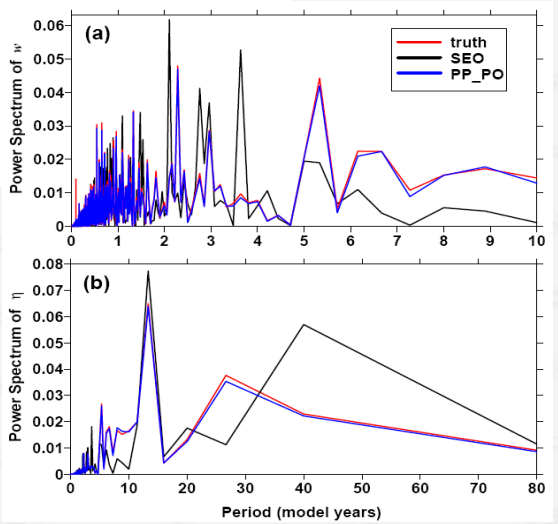
Development and application of typhoon air-sea coupled model



Data assimilation and parameter estimation of ocean under TC

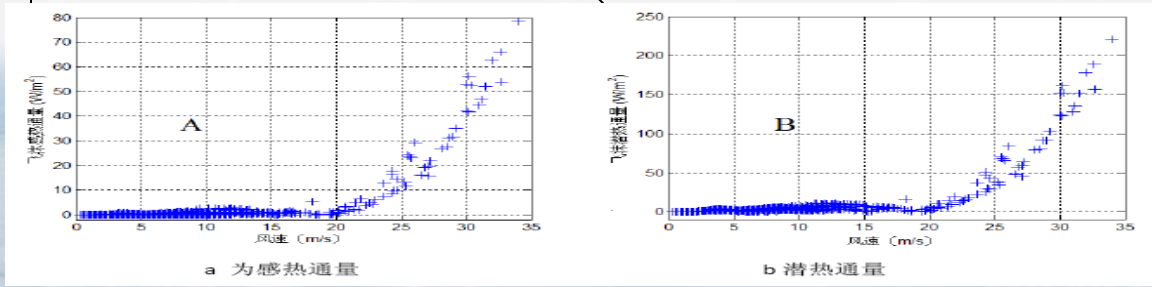






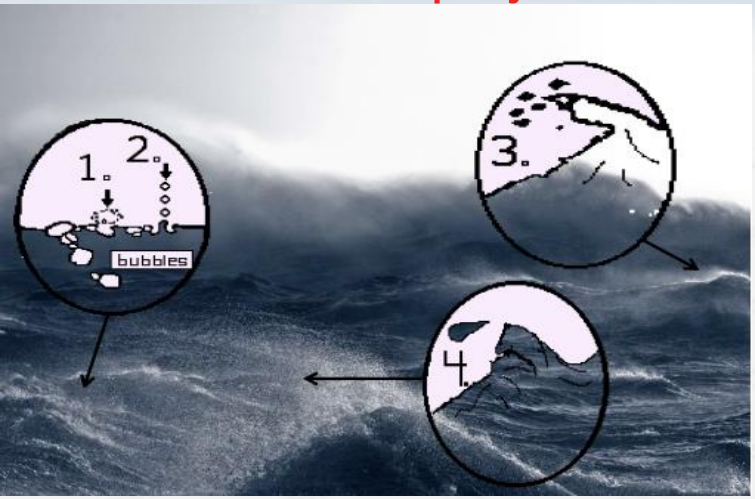
Ocean assimilation system with high resolution for typhoon processes and a reanalysis dataset CORA

The optimal parameter estimation method based on EnKF and 4D-VAR



Han G J

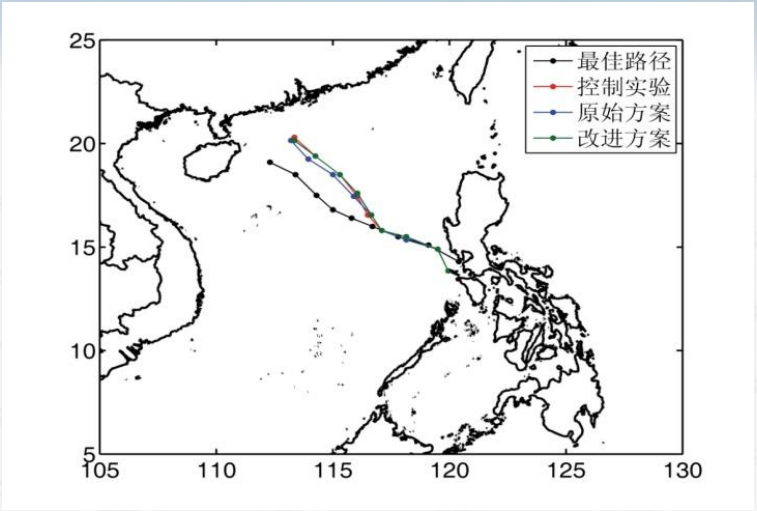
Improvement of generating function of sea spray

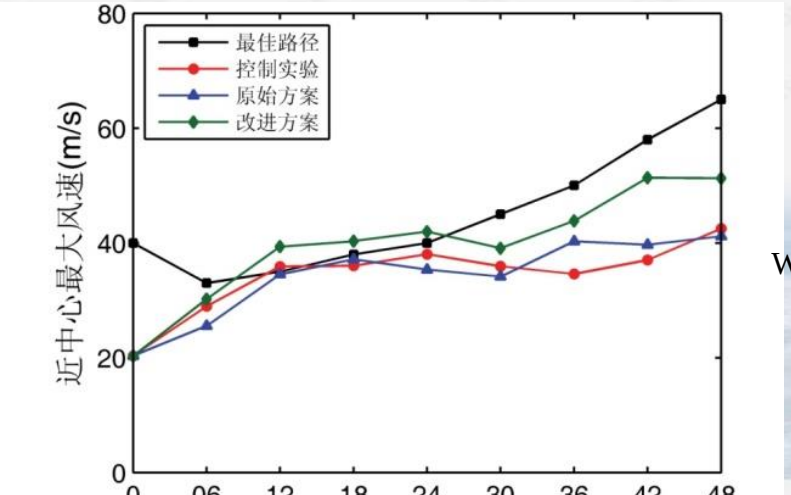


$$\frac{dF_s}{dr_{80}} = \begin{cases} T_w \left[235 \cdot U_{10}^{3.5} \exp\left(-0.55 \left[\ln\left(\frac{r_{80}}{0.1} \right) \right]^2 \right) + 0.2 \cdot U_{10}^{3.5} \exp\left(-1.5 \left[\ln\left(\frac{r_{80}}{3} \right) \right]^2 \right) \right. \\ \left. +6.8 \cdot U_{10}^{3} \exp\left(-1 \left[\ln\left(\frac{r_{80}}{30} \right) \right]^2 \right) \right], & r_{80} \le 10 \\ C_1(U_{10}) r_{80}^{-1}, & 10 \le r_{80} \le 37.5 \\ C_2(U_{10}) r_{80}^{-2.8}, & 37.5 \le r_{80} \le 100 \\ C_3(U_{10}) r_{80}^{-8}, & 100 \le r_{80} \le 250 \end{cases}$$

Drop let （< 10 μm）： Grythe et al., 2014
> 10 μm）： Andreas, 1998

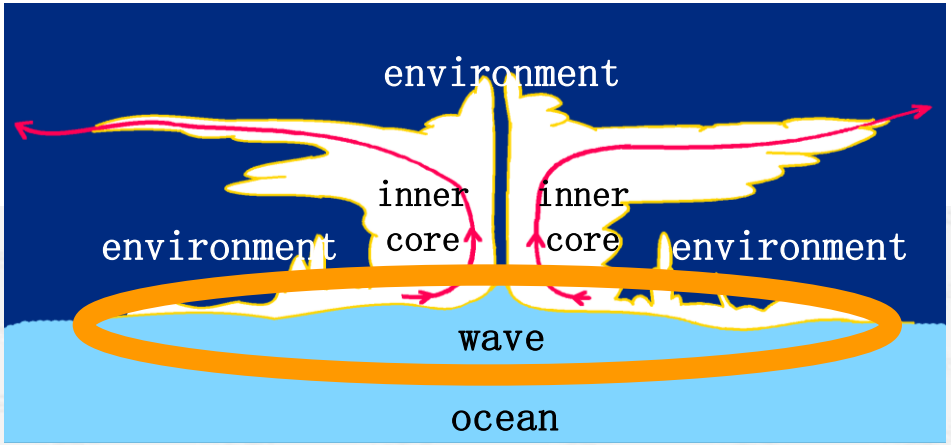
Track of Rammasun (2014)



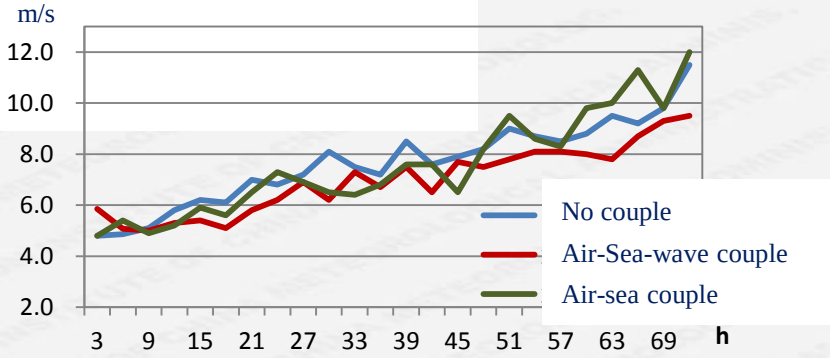


Wind speed

Development and application of typhoon air-sea coupled model

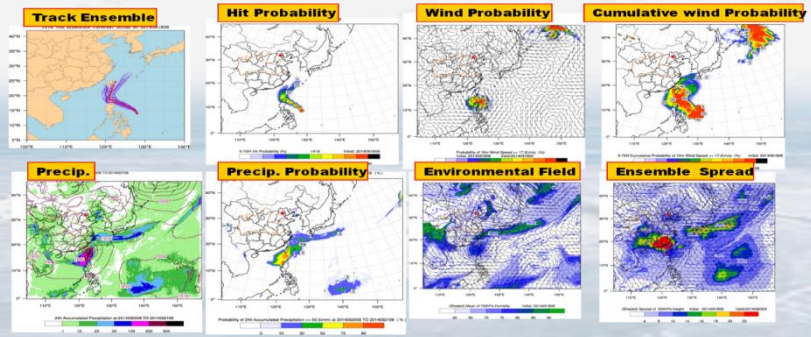


Forecast error of typhoon strength in northwest Pacific in 2016-2017



Platform of application

Products



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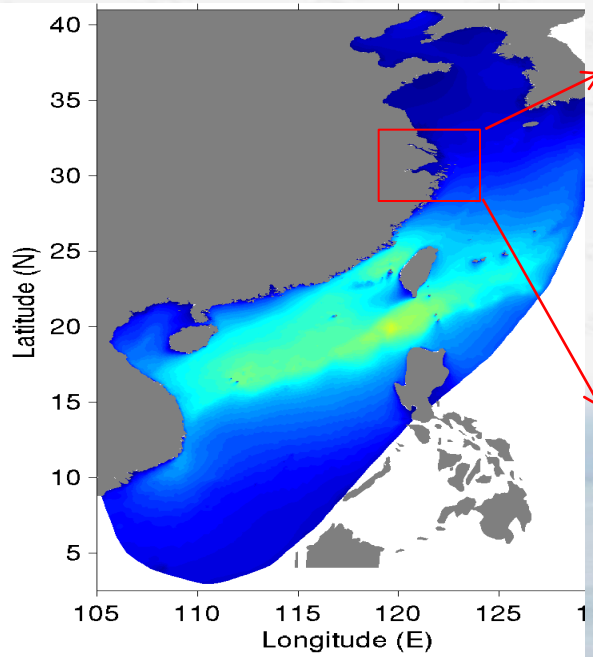
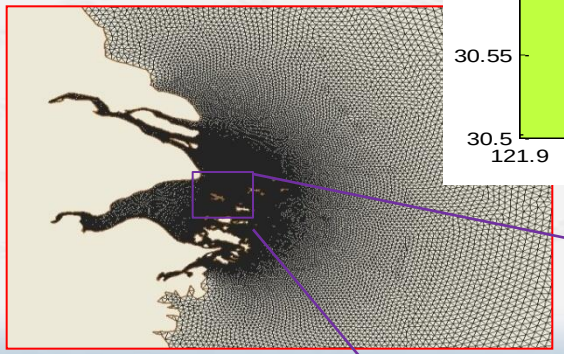
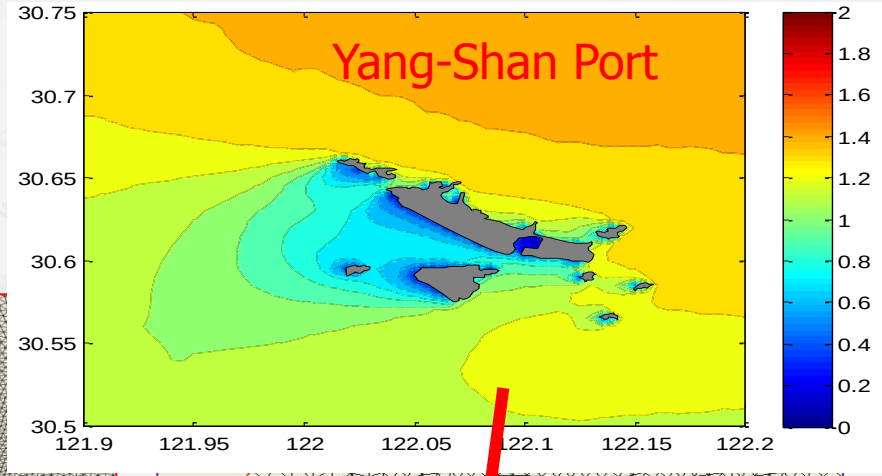
Wave Model with Fine Resolution

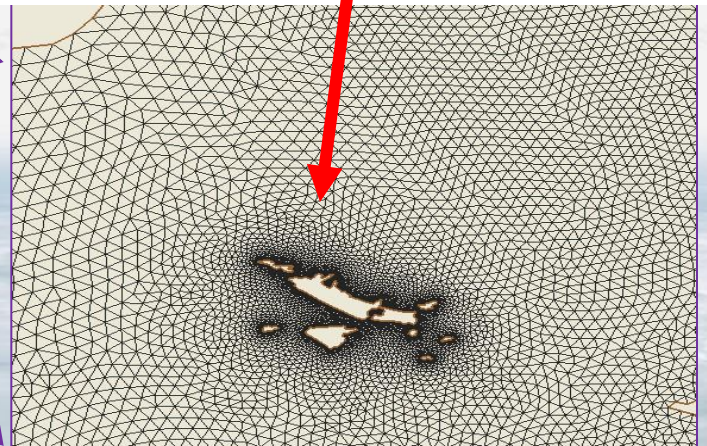
Model: SWAN **Highest Reso. :** 20 m

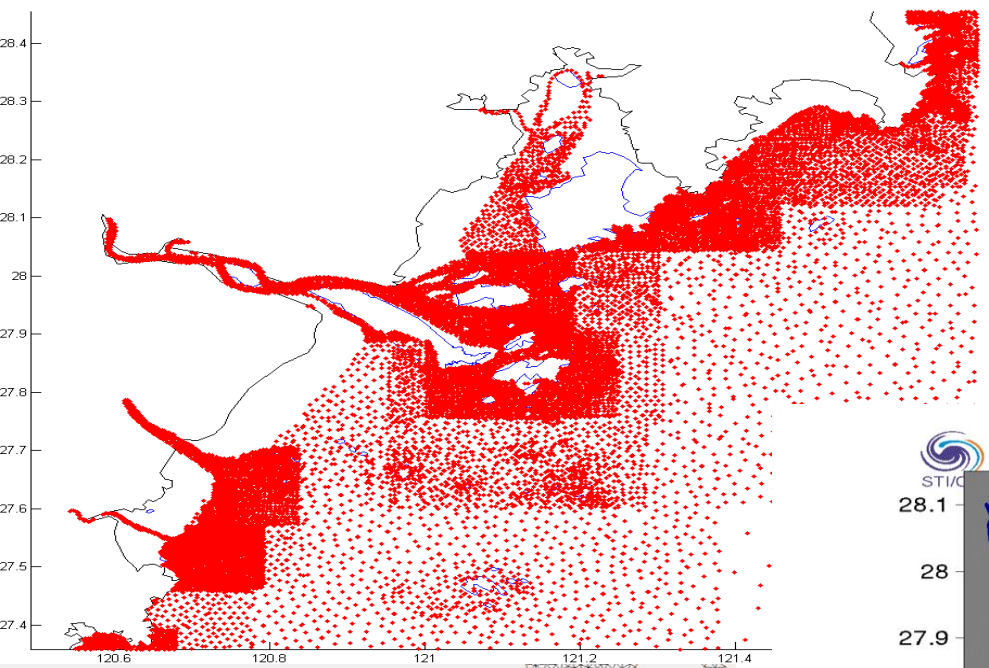
Valid time: 72h



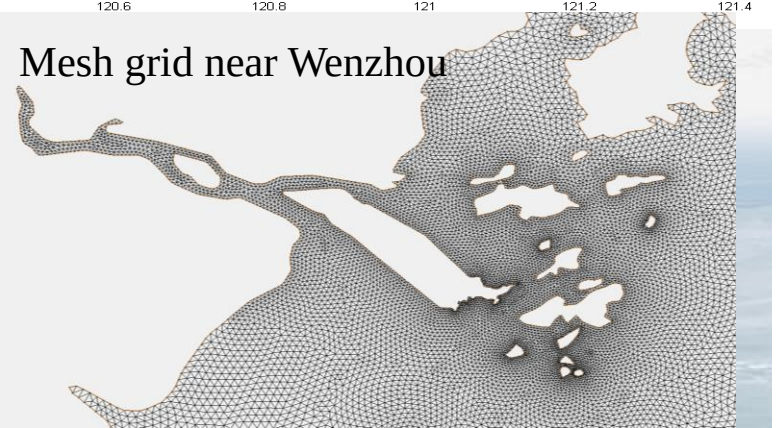






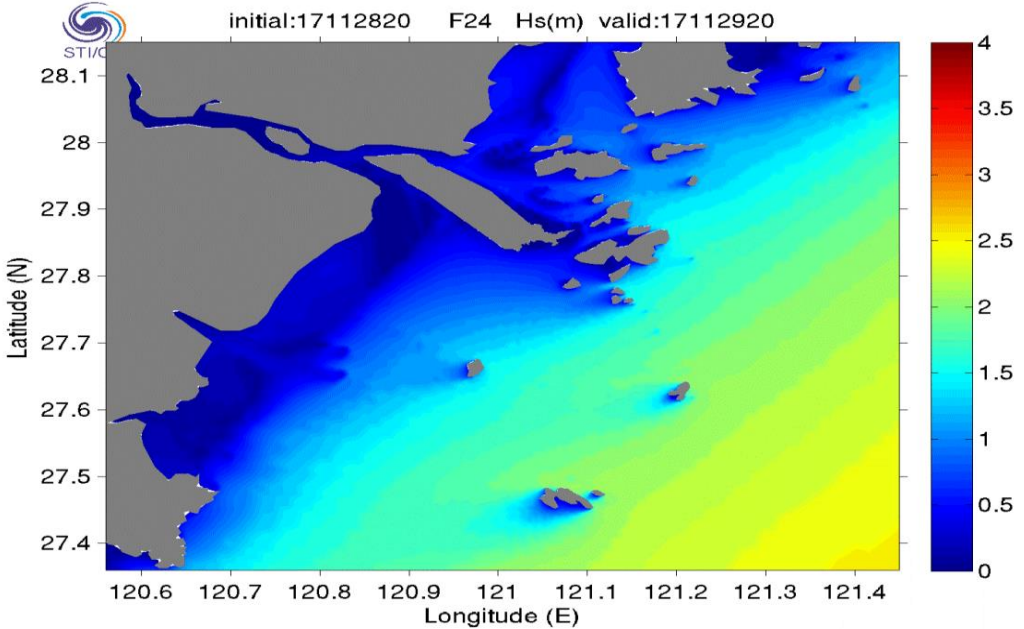


The topography data near Wenzhou



Mesh grid near Wenzhou

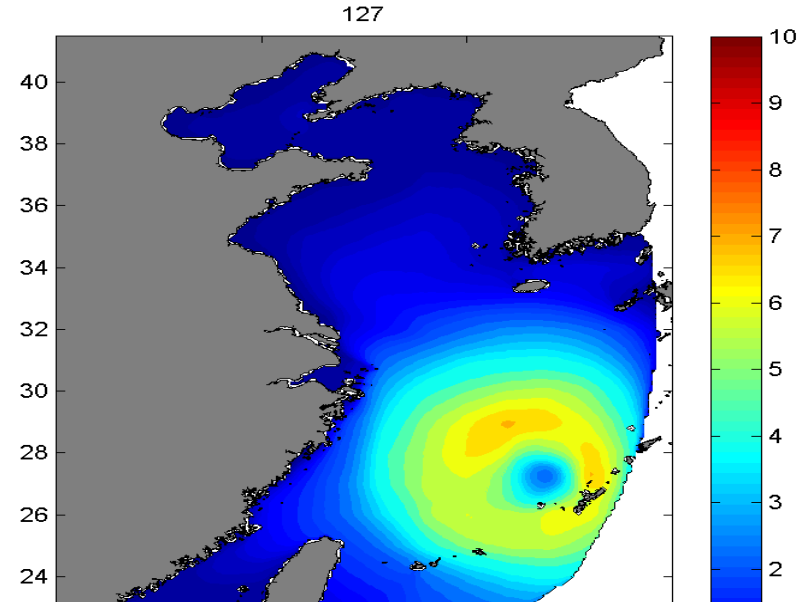
Hs forecast



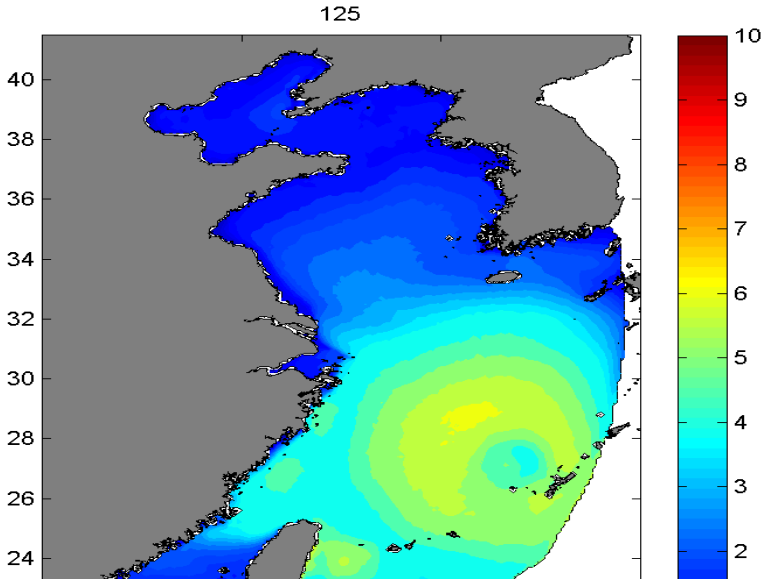
TC1211 “ HaiKui”

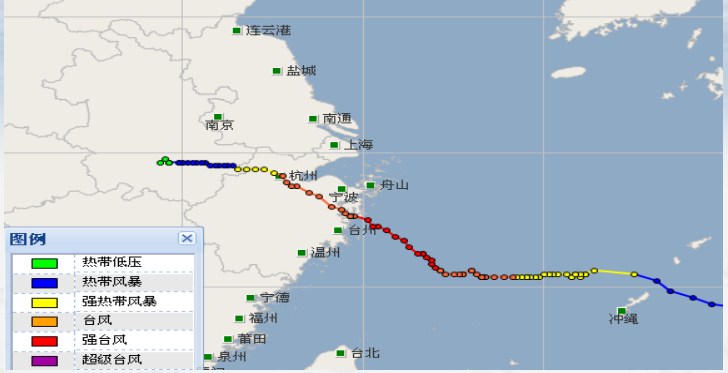
Simulation of Wave

HS



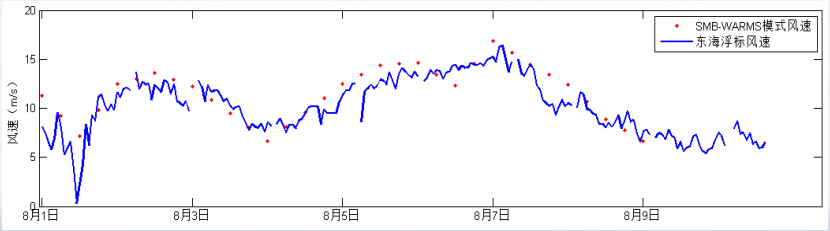
Wave Period

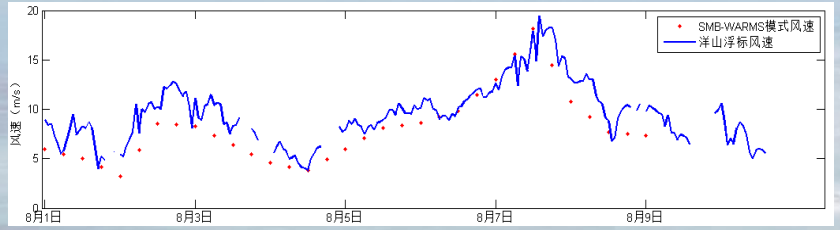




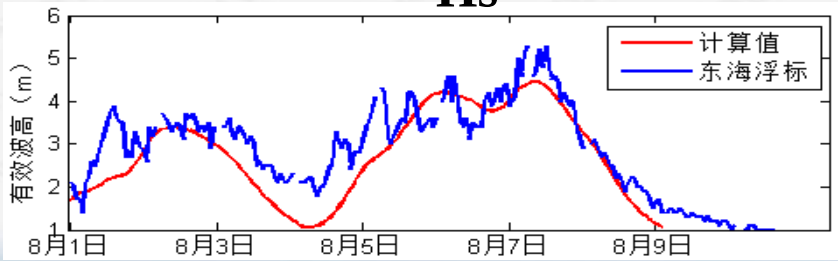
Track and Strength of TC1211 “ HaiKui”

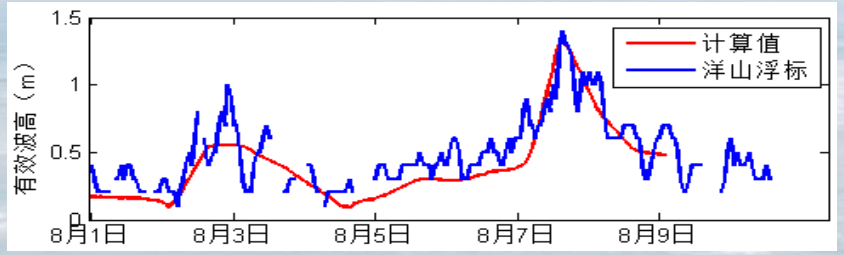
Wind





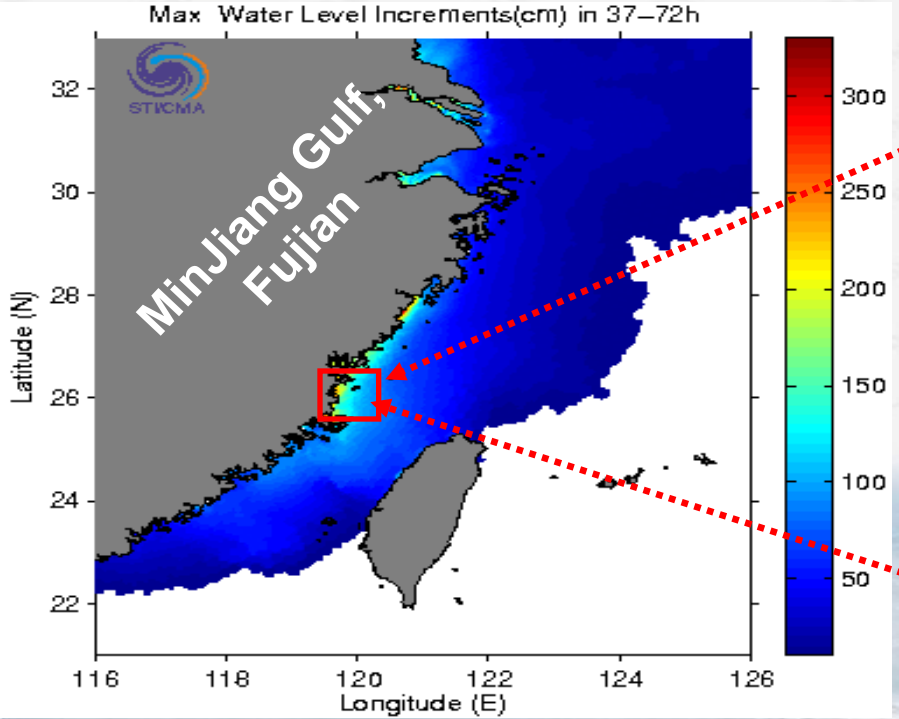
Hs

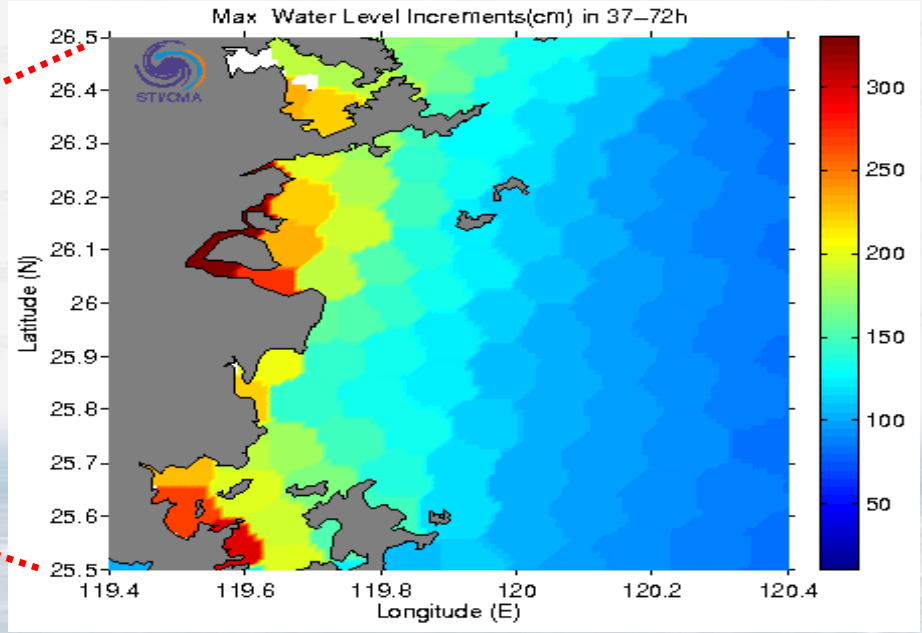




Storm Surge Model FVCOM

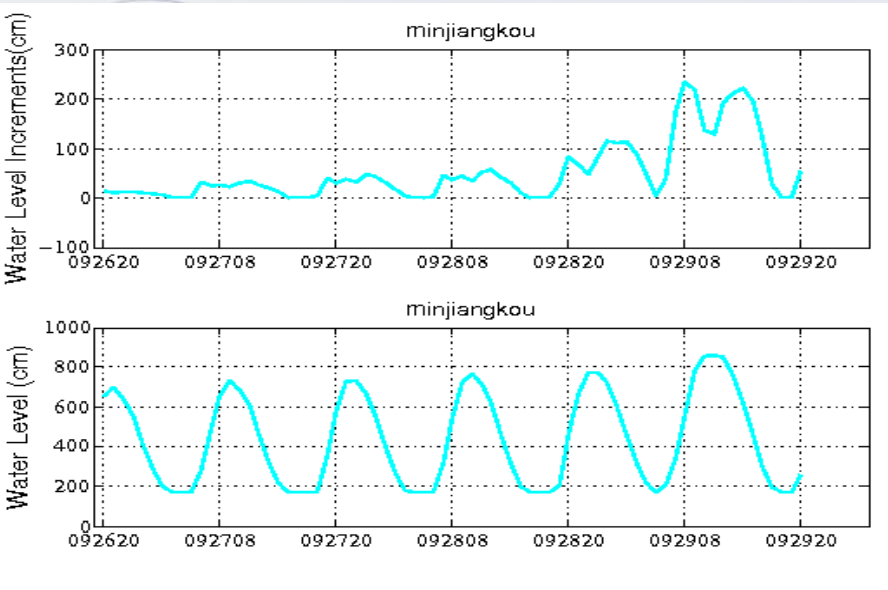
Sea Level Increment forecast



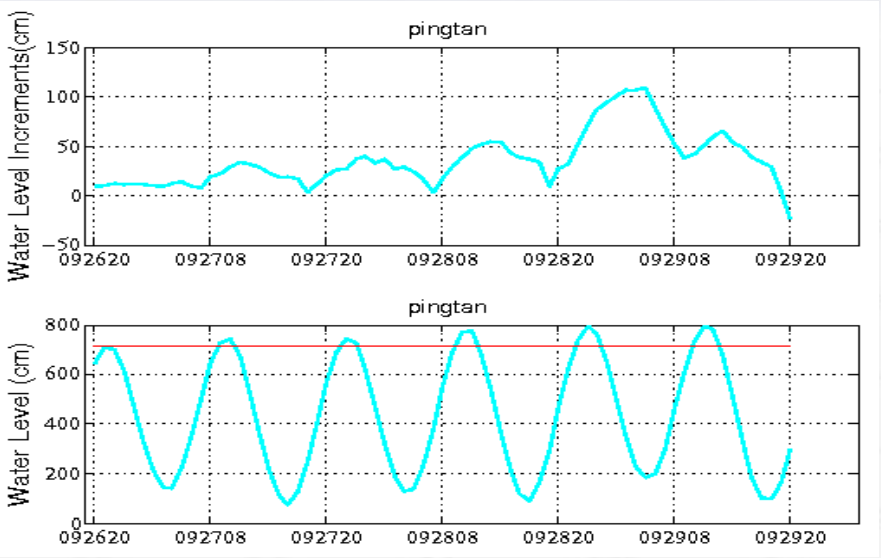


From 08:00, Sep. 28 to 20:00 Sep. 29,2015

Storm Surge Model Based on FVCOM



Sea Level (below) and its Increment (upper) forecast at Mingjiang Gauge Station



Sea Level (below) and its Increment (upper) forecast at Pinggtan Gauge Station

Valid time : 20:00, Sep. 26 -----20:00 Sep. 29,2015

Conclusion: 1.2-2.3 m increment from north Fujian to south Zhejiang, over warning level over most of coast, up to 3.0 m locally.

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