An Operational Forecast System with the Third Generation Wave Model Used in Shanghai Meteorology Center

Shanghai Typhoon Institute/CMA

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Outline

- Motivation for this study
- Methodology and its application
- Statistical analysis of the precision
- Other operational marine forecast systems developed by Shanghai Typhoon Institute will be briefly introduced
- Summary of conclusions

Motivation

- **Shanghai Meteorology Center undertake tasks of making forecast of wind and wave over the Yellow Sea and East China Sea, but few people works on wave in the departments and institutes of CMA**

- **Most of the operational products were taken from National Marine Environment Forecast Center (NMEFC) of China or NOAA of USA, but the information obtained has disadvantages(relatively low resolution and short period of validity).**

- **Model results of the second generation wave model is smaller than observations because of relatively weak tropical cyclone forecasted by the meteorological model previously used, and it also needs to be improved in the new operational wave forecast system.**

Methodology

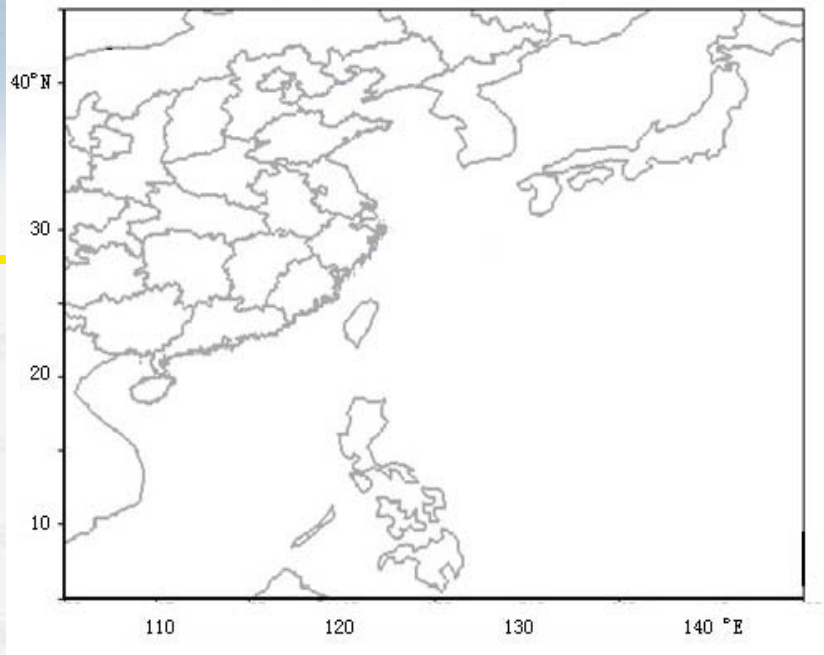
- **An operational wave forecast system is established based on the third generation wave model – WW3**
- **Warp correction for the wind speed is made if there is no typhoon.**
- **Typhoon model wind field is set up automatically to that of general circulation model if typhoon exists.**

Conclusions

- **The products include sea surface wind, significant wave height, mean wave direction, mean wave period and swell within 168 hours.**

- **The precision of strong wind forecasting can be improved with about 5% rising by using the wind field with error correction and establishing a more reliable typhoon model wind field, and furthermore the forecasting precision of the disastrous wave can be improved by 4%.**

Parameters



- Domain : 5ºN～45ºN,105ºE～145ºE
- Horizontal resolution : 0.5°×0.5°

- 25 discrete spectrum frequencies range from 0.0418 HZ to 0.41 HZ
- 24 spectrum directions with a 15°increment

- solid boundary can absorb incident waves without reflection
- no energy input at the open boundary.

The data source and process of sea surface wind

- **AVN/NCEP forecast and analysis results**

  Spatial resolution of original AVN data : 1º×1º

  Temporal resolution : 6h

  Bilinear interpolation method is used to get wind field at every integral time step of model with the resolution of 0.5º×0.5º

  Warp correction is also made before inputting into the model

- **T213 forecast and analysis results from National Meteorological Center of China**

  The T213 data processing is same to the AVN data

Setting up of typhoon model wind field (1)

Obtain the forecast information about intensity of typhoon center.

sources of typhoon intensity:

1) operational forecast of JTWC with the leading time of 120h

2) The operational products of Shanghai Typhoon Institute using objective forecast method is used as standby with the leading time of 72h.

Because the leading time of wind field of AVN and T213 are both 168h, and the present objective forecast method can't forecast the intensity of typhoon after 120h or 72h, so the ways are taken as follows:

Setting up of typhoon model wind field (2)

1) calculate the average difference of maximum wind speed surrounding the typhoon center within 120h or 72h between AVN or T213 (V1) and result of objective typhoon intensity forecast method (V2) :

$$DV = \frac{1}{n}\sum_{t=1}^{n}(V_2 - V_1)_t$$

2) Pick up the AVN or T213 maximum wind speed surrounding the typhoon center V1, regard V1+DV as the modified maximum wind speed after 120h or 72h.

3) Set up the ideal typhoon model wind field

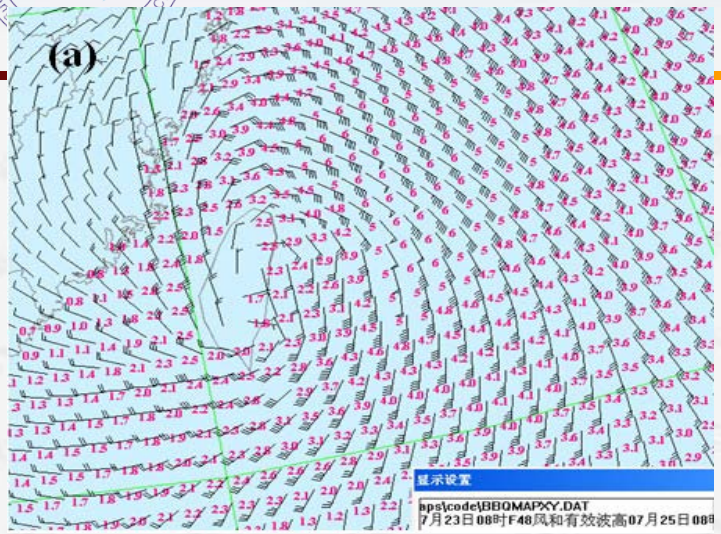
$$V(r) = W_M \frac{Rr}{R^2 - Rr + r^2}$$

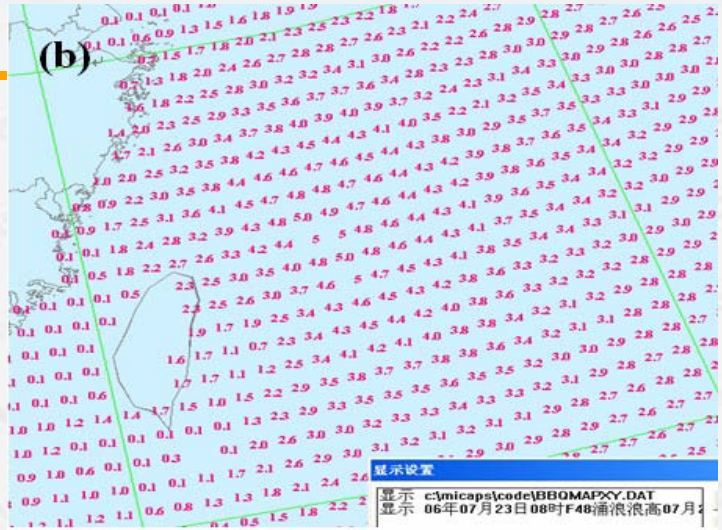
4) The typhoon model wind field Vm is defined as the combination of V(r) and the environmental wind speed Ve with different weights and the influence of typhoon moving speed Vc is also considered.

$$V^m = \frac{R-r}{R}V(r) + \frac{r}{R}V^e(r) + V_c$$

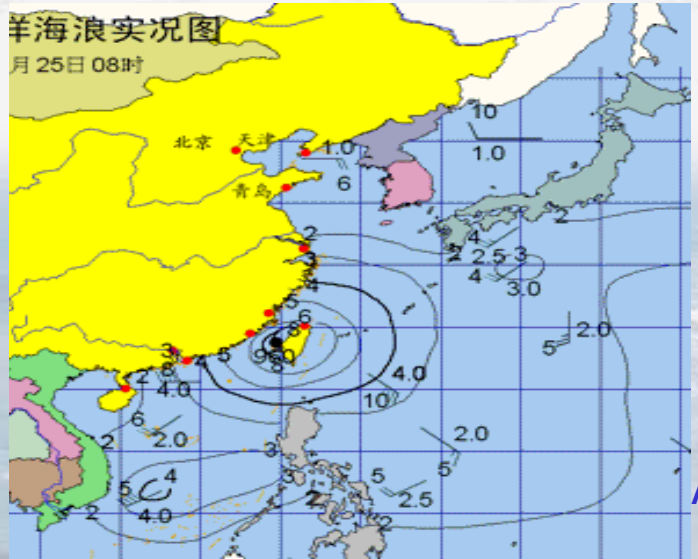
The influence of Typhoon model wind field

(Taking the No. 5 typhoon of 2006 'Kaemi' as an example)





Significant wave height and swell of the 48th hour driven by AVN wind field (the initial time is 08:00, July 23, 2006)



Maximum wind speed:

Analysis result : 35m/s

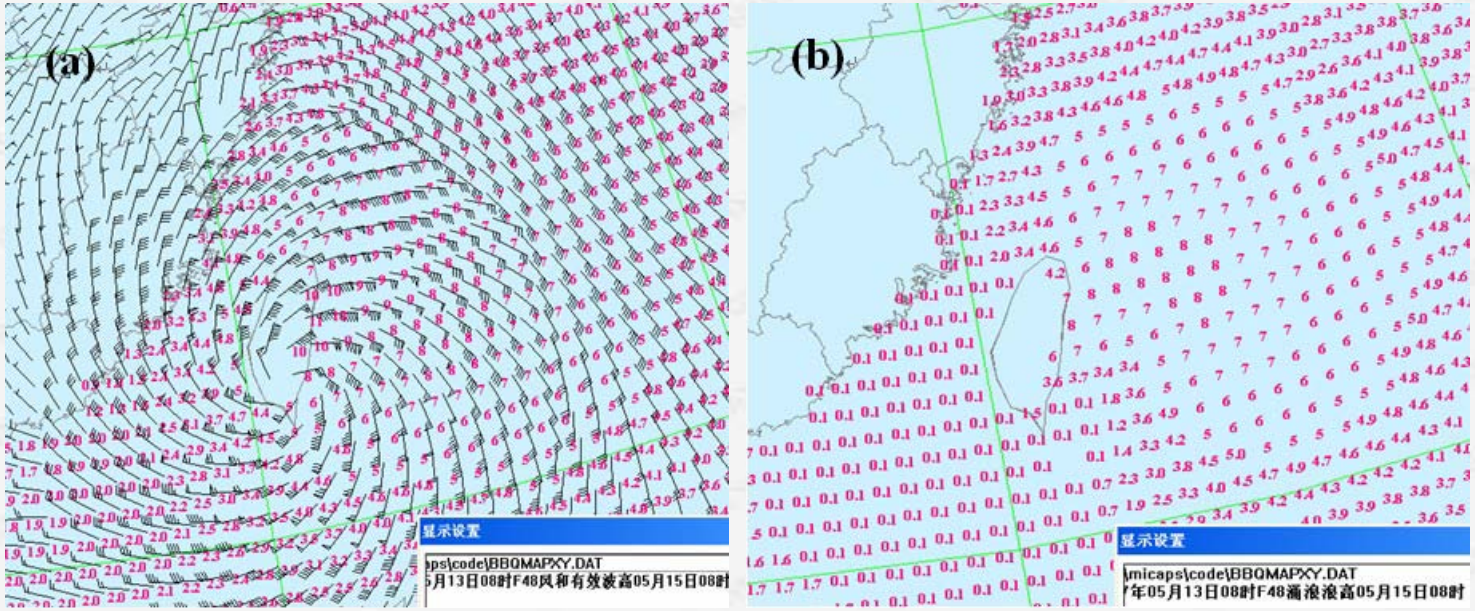
Model result: 18m/s

Maximum SWH:

Analysis result : > 10m

Model result: only 6m

Analysis of wave field supplied by NMEFC (08:00 on July 25)

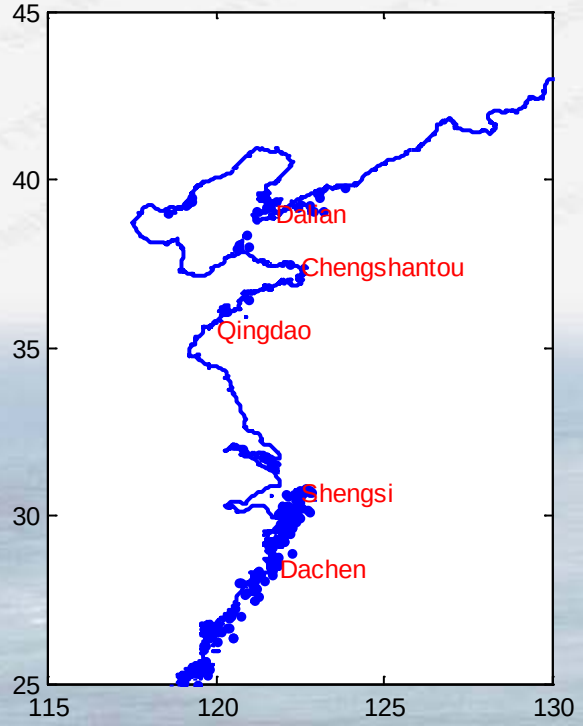


Significant wave height and swell of the 48th hour driven by AVN wind field with the typhoon model wind field embedded (The initial time is 08:00 BT, July 23, 2006)

Warp correction of strong wind

The AVN analysis wind field has systematic errors comparing to the observations, So the AVN wind field is corrected before inputting into the wave model.

Samples : Observations two times a day from 2000 to 2006 at Dalian, Chengshantou, Qingdao, Shengsi and Dachen stations.

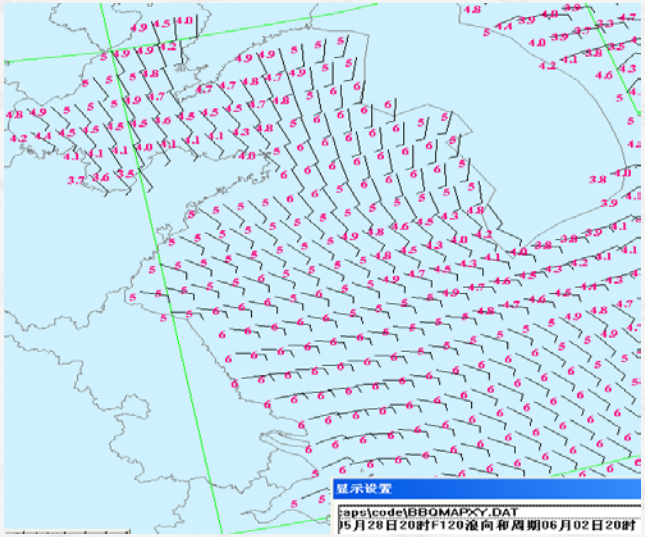


wind scale	systematic errors
6~7(10m/s~15 m/s)	7.7%
7~8 (15m/s~20 m/s)	8.4%
8~9and above(>20m/s)	10.1%

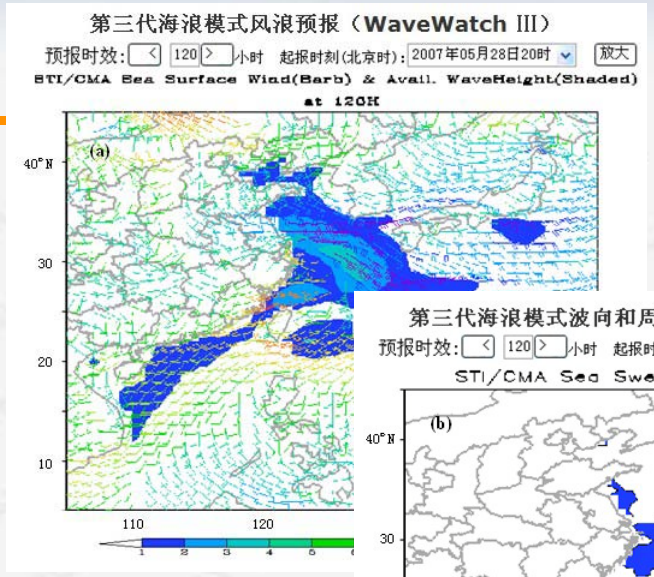
Running of the operational system

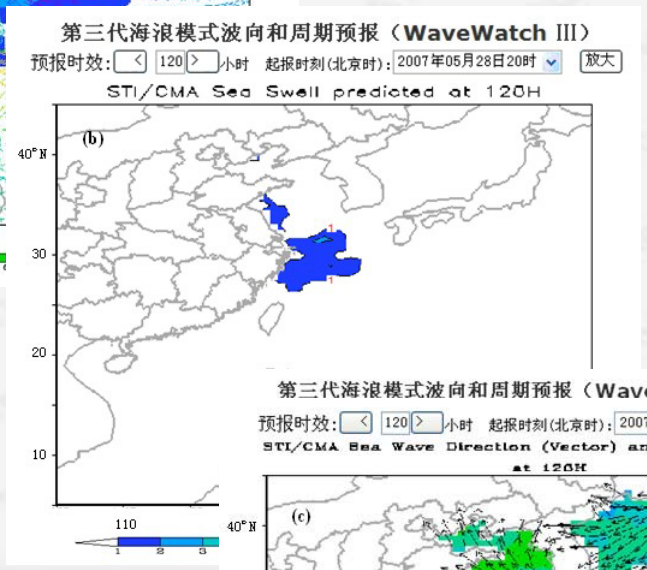
- **Forecast products are provided to Shanghai Meteorological Center initialize at 08:00 and 20:00 everyday, the products are stored on PC-cluster and forecasters can access on MICAPS platform.**
- **The operation initialized at 08:00 starts at 12:30 everyday and operation initialized at 20:00 starts at 2:50 the next morning.**
- **The operational time is about 1h and 20min on PC-CLUSTER, and 95% of the running jobs are normal.**

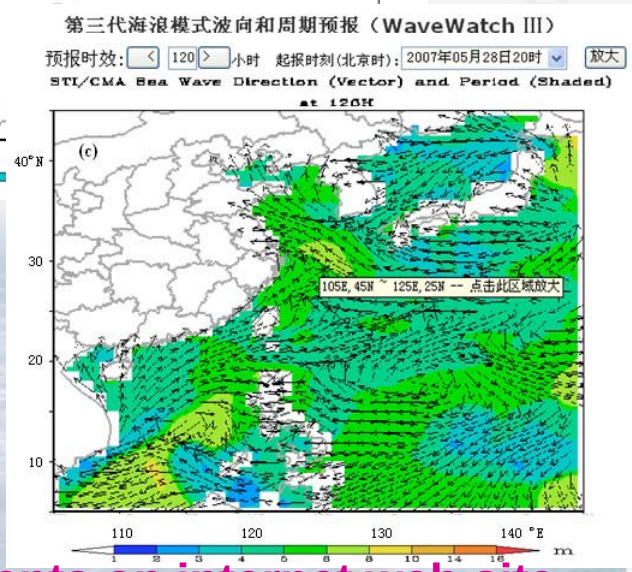
Display of the products



MICAPS platform







Display of wave elements on internet web site

Statistical analysis of the precision

Samples : Observations two times a day from 2000 to 2006 at Dalian, Chengshantou, Qingdao, Shengsi and Dachen stations.

absolute errors of the sea surface wind (unit: m/s)

wind scale	sample number	24h	48h	72h
6~7	423	2.2	2.4	3.3
7~8	110	5.6	6.5	7.0
8~9and above	23	7.7	8.4	9.0
Precision		74%	69%	63%

absolute errors of the wave direction (unit: °)

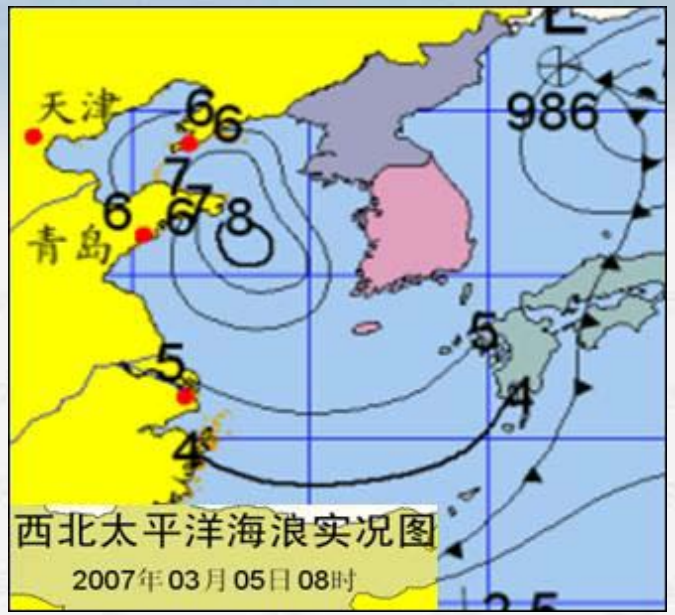
Wave scale	sample number	24 h	48 h	72 h
Slight waves (0.6~1.5 m)	321	35	40	45
Moderate waves (1.5~2.5 m)	76	34	38	44
Rough waves (2.5~4.0 m)	34	31	33	39

absolute errors of the wave period (s)

Wave scale	sample number	24 h	48 h	72 h
Slight waves (0.6~1.5 m)	92	1.5	1.6	1.7
Moderate waves (1.5~2.5 m)	46	1.7	1.7	1.8
Rough waves (2.5~4.0 m)	24	1.8	1.9	1.9

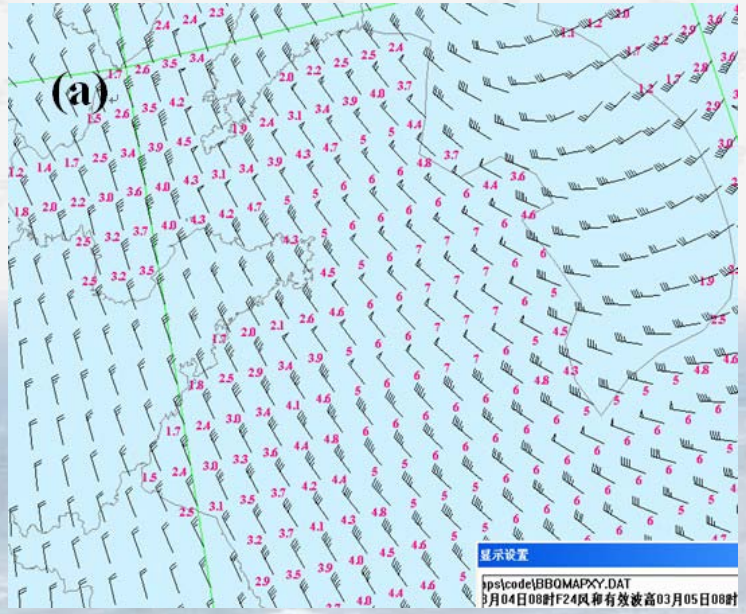
absolute errors of the significant wave height (unit: m)

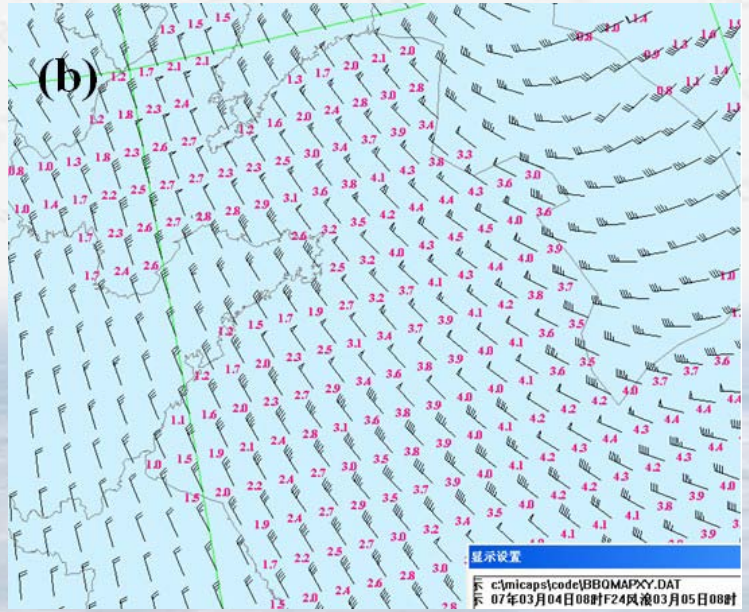
Wave scale	sample number	24h	48h	72h
Slight waves (0.6~1.5 m)	321	0.3	0.4	0.5
Moderate waves (1.5~2.5 m)	76	0.5	0.7	0.8
Rough waves (2.5~4.0 m)	34	0.8	1.0	1.3



Analysis result of the wave height at 08:00, March 5

cold air in the beginning of March 2007

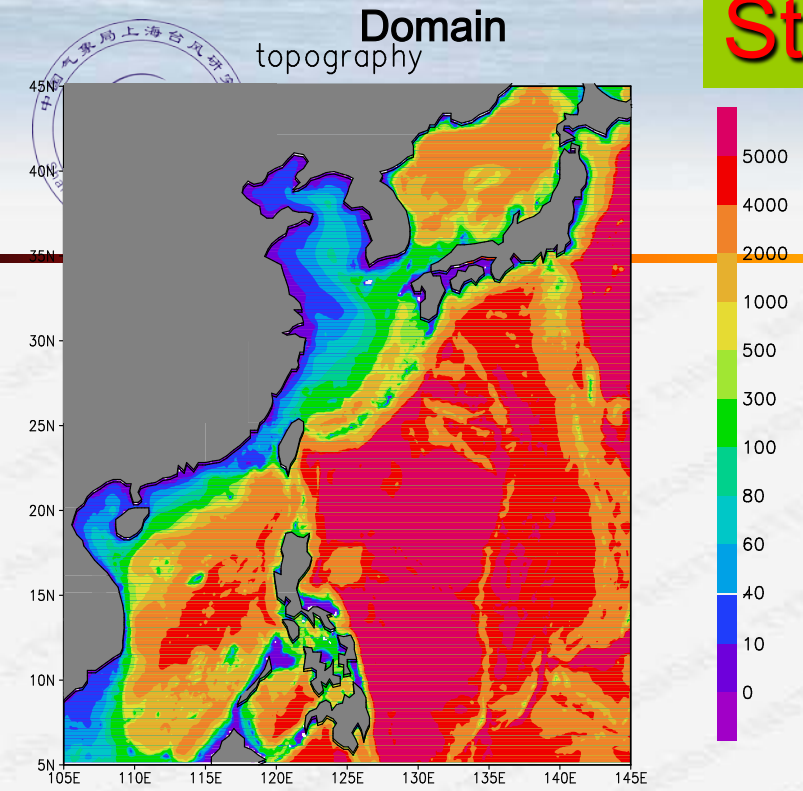




Significant wave height forecasted by WW3 (a) and the second generation wave model (b)

- **Other forecast systems**

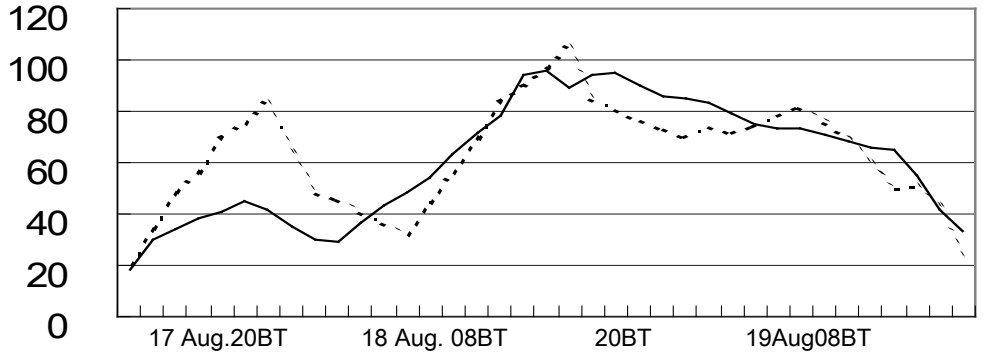
Storm Surge Forecast System

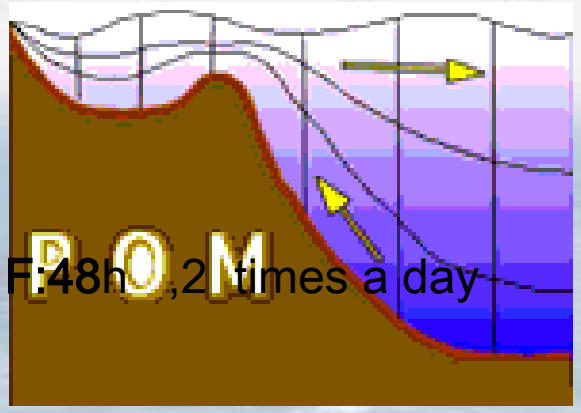


Typhoon Sepat in 2007

Time series of sea level rising of PingTan Station

solid line: Obs. dot line: forecast





F:48h,2 times a day

Shanghai Regional Storm Surge Forecast System

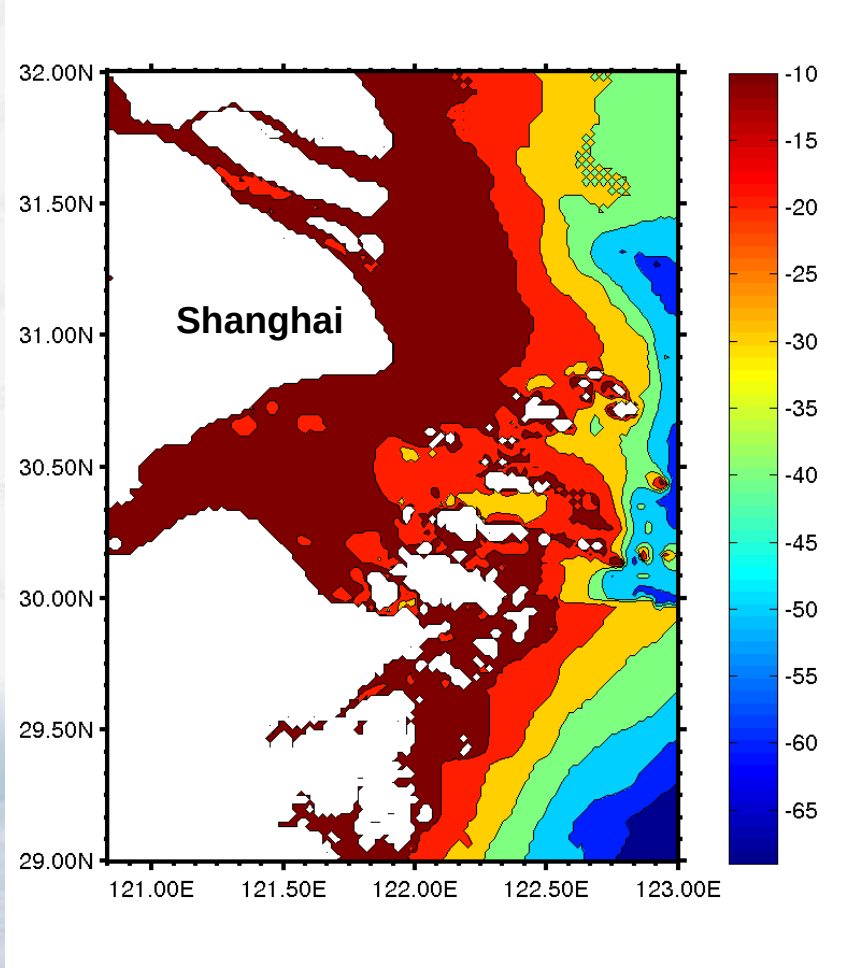
Domain:

29N-32N

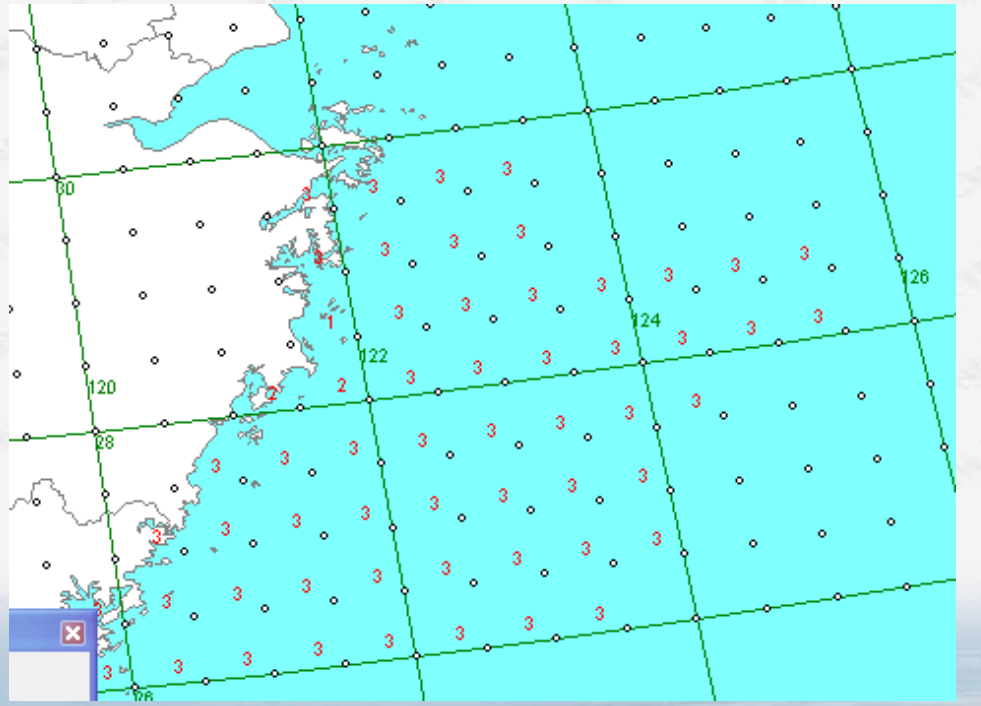
120E-123E

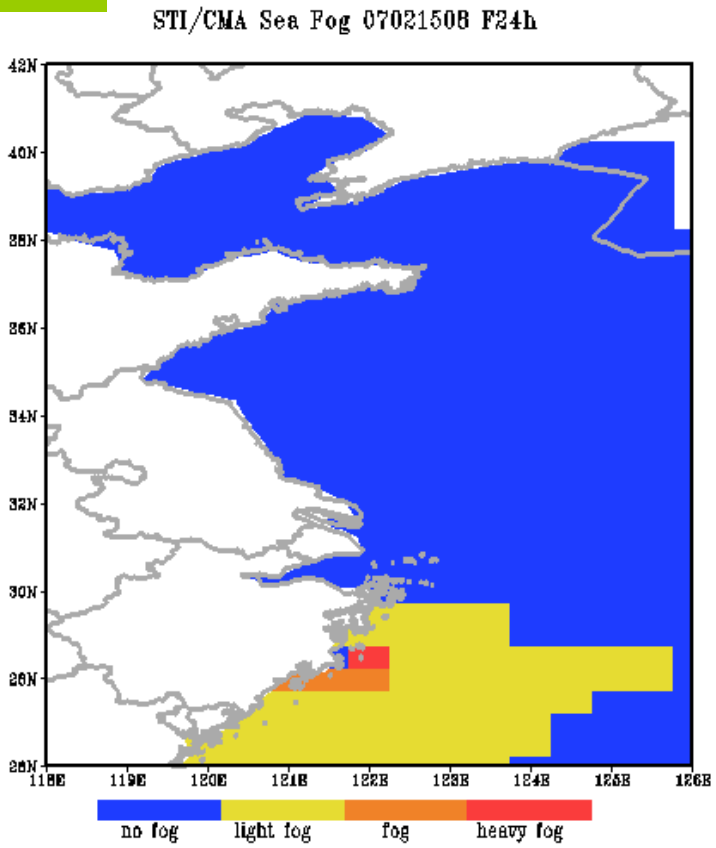
Resolution:

1km× 1km



Objective Fog forecast system





Display on web site

Display on MICAPS (1 : heavy fog; 2:fog; 3:light fog)

Conclusions

- **The products include sea surface wind, significant wave height, mean wave direction, mean wave period and swell within 168 hours.**

- **The precision of strong wind forecasting can be improved with about 5% rising by using the wind field with error correction and establishing a more reliable typhoon model wind field, and furthermore the forecasting precision of the disastrous wave can be improved by 4%.**

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Thank you for your attention!