Operational Forecasting of Marine Meteorology by Model and Observation in KMA

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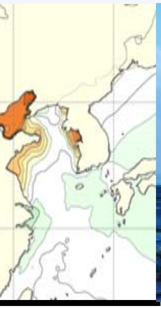
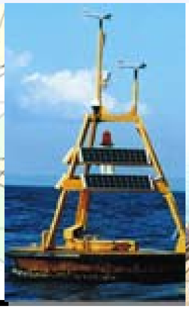
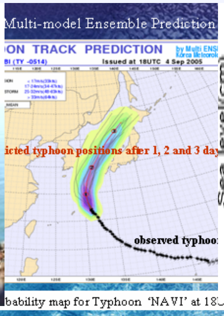
If you are marine forecaster,

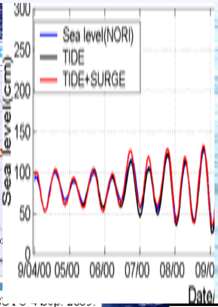
What system do you need ?

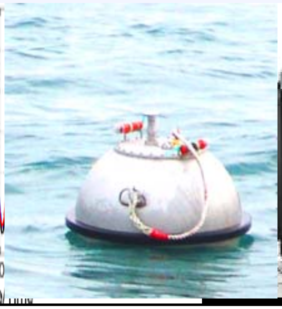
- First of all, necessity of numerical models
- In order to set up the model, need to observing system
- Consider the local features of high wave & tide, swell and inundation in the low level coast (experiences, **tide model, spectral wave model and statistical method**)
- The high resolution model needed (**super computer**)
- Demand the synthetic judgment (**monitoring system**)









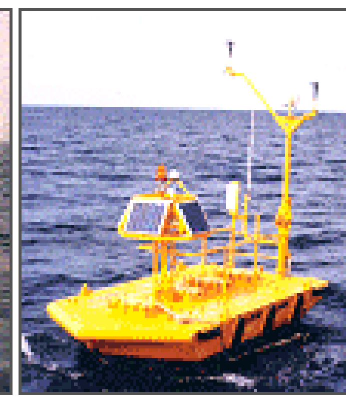


The Wave Observation Network by KMA Buoy

Buoy	Installation	Location	Local depth (m)	Parameters
Dukjok-Do	`96. 7 (05.12 replacement)	15 km west of Dukjok island 37°14' N, 126 °01' E	30	Wind direction Wind speed Gust Pressure Moisture Temperature Max. Wave height Sig. Wave height Ave. Wave height Wave period Wave direction
Chilbal-Do	`96. 7 (05.12 replacement)	2 km northwest of Chilbal island 34°48' N, 125 °47' E	33	
Geomun-Do	`97. 5 (06.09 replacement)	14 km east of Geomun island 34°00' N, 127 °30' E	79	
Geoje-Do	`98. 5 (06.10 replacement)	16 km east of Geoje island 34°46' N, 128 °54' E	84	
Donghae	`01. 5	70 km east of Donghae city 37°32' N, 130 °00' E	1520	

Dukjok

Geoje

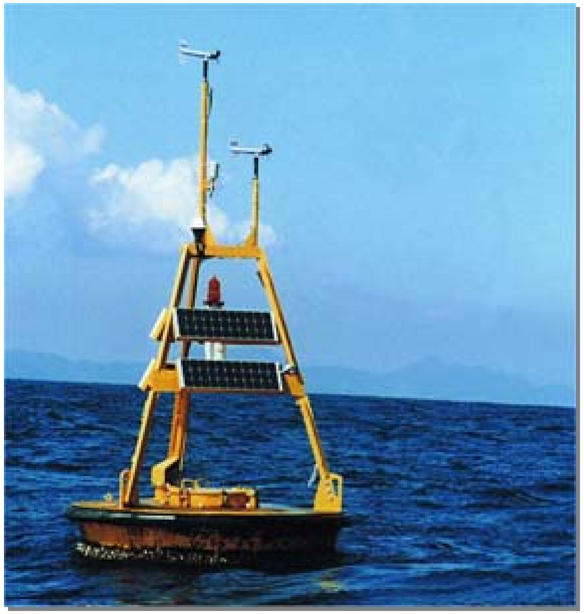


Donghae

Application of BUOY made in Korea for marine meteorology observation



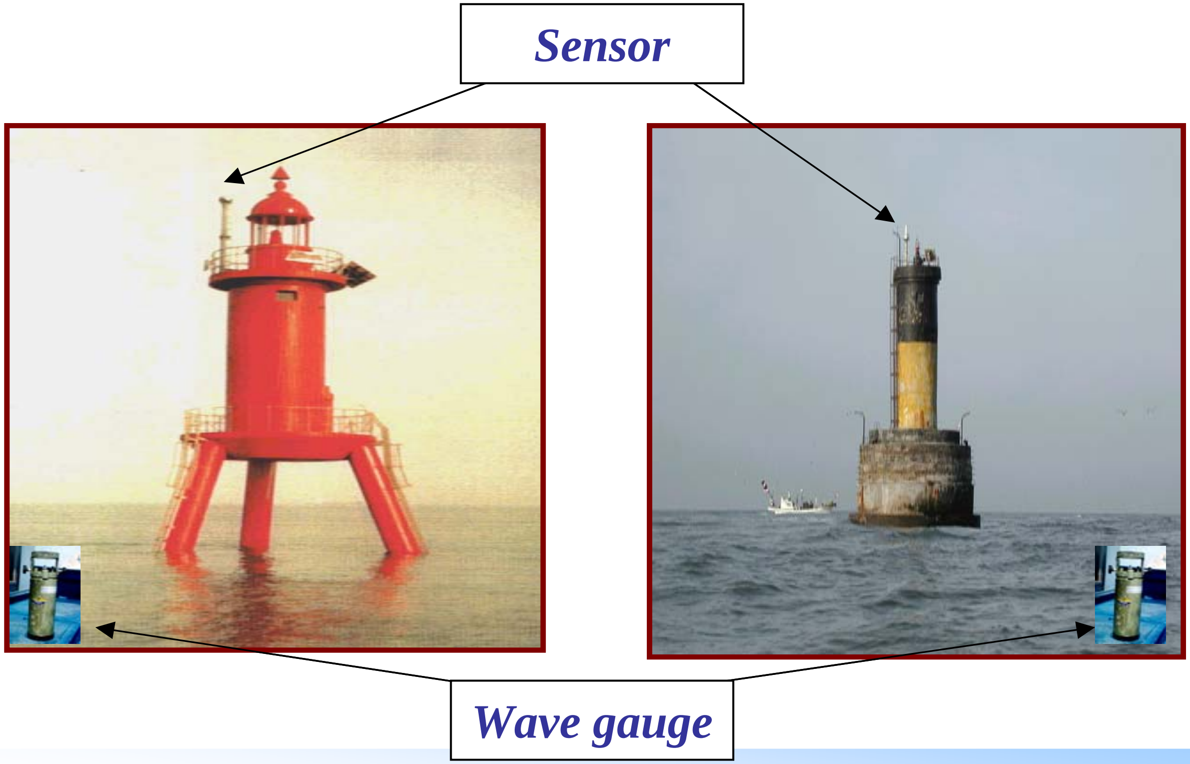




- *Until now, all BUOY in Korea were imports*
  → *Domestic production and assembling of BUOY with our technology*

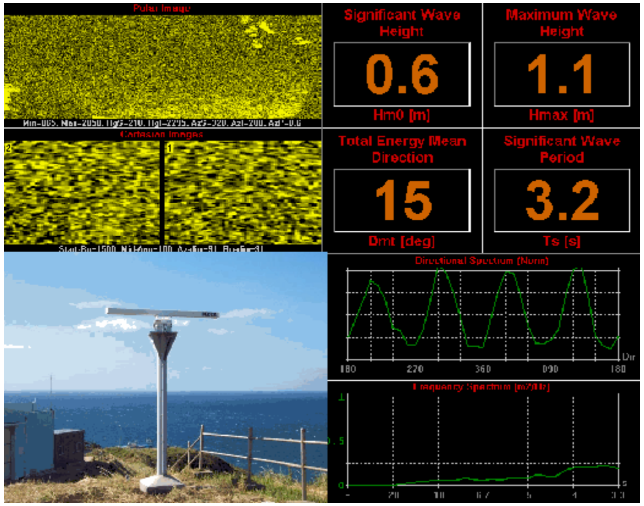
- *The validation work were performed using waverider*

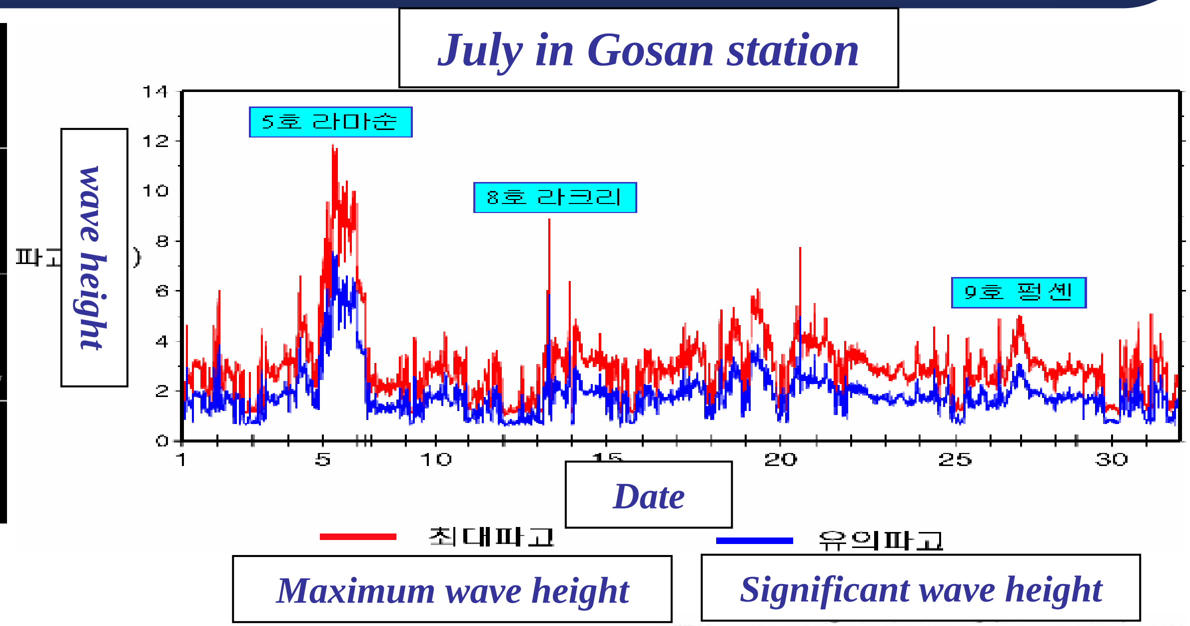
Development of wave observation methods : pressure-type wave gauge, AWS

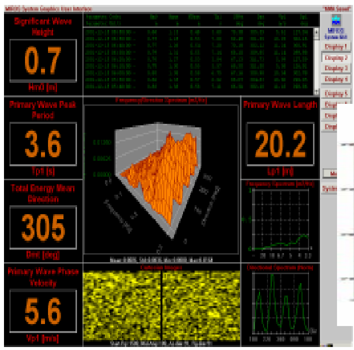


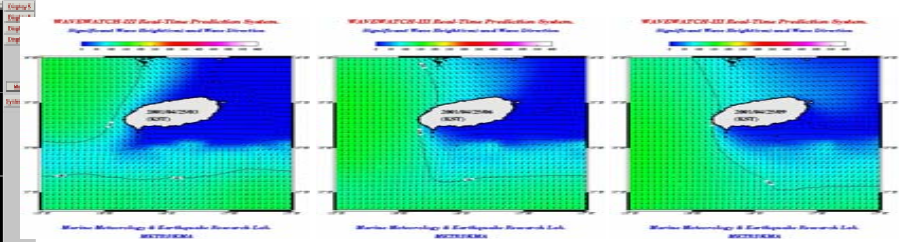
- ***Simultaneous wave/atmosphere observation system***
  - using pressure-type wave gauge and AWS
- ***Long-term wave observations and data collection offshore of Yellow Sea***
  - Real-time wave observation using wave gauge

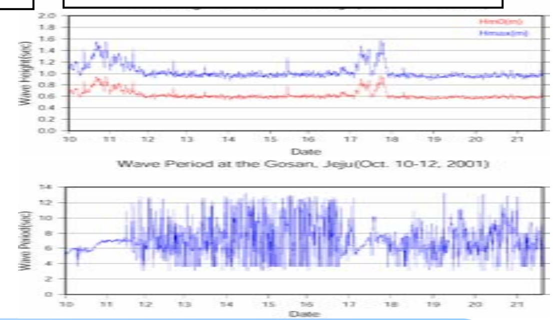
Wave observations with radar-type wave gauge







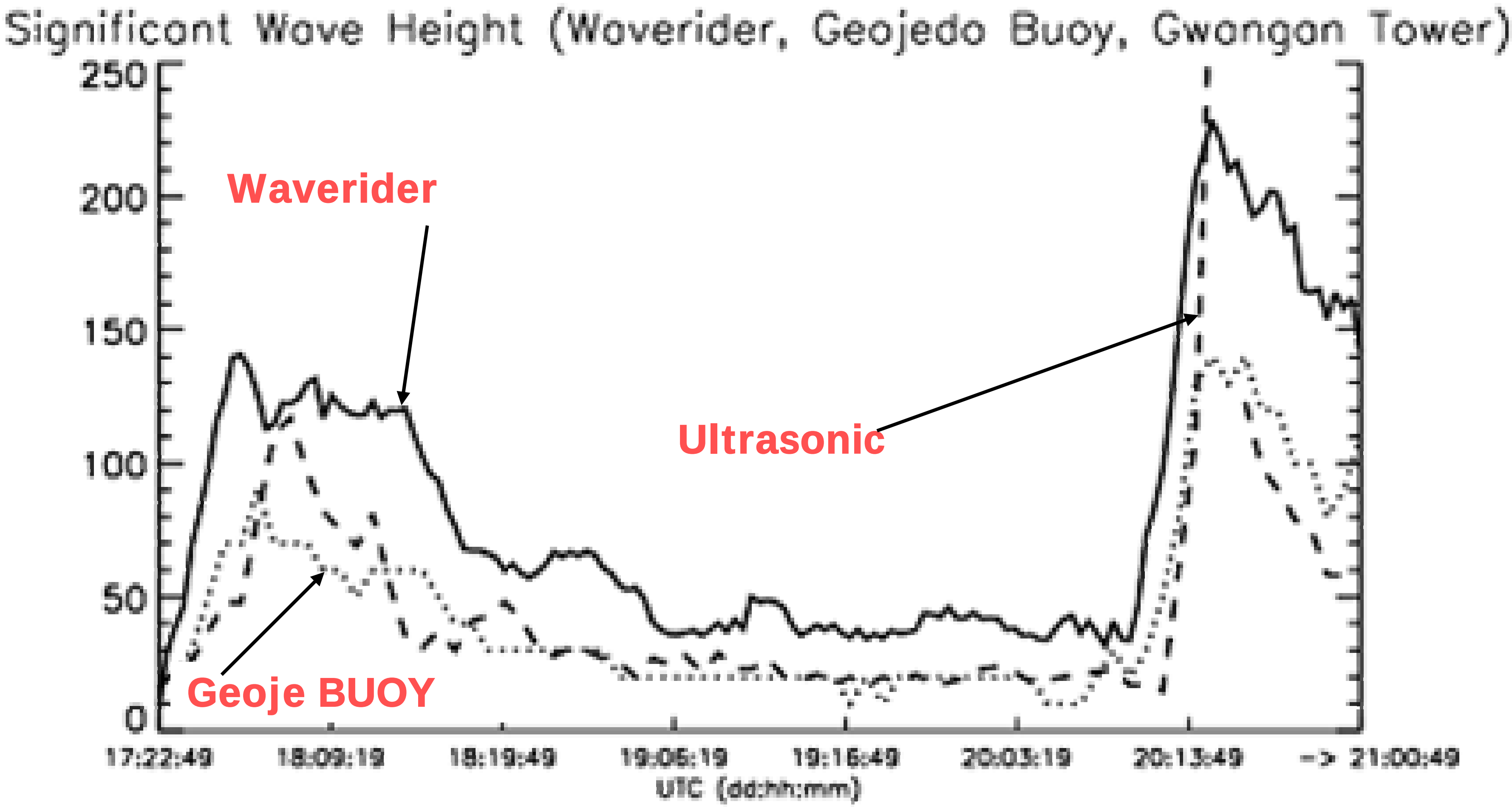




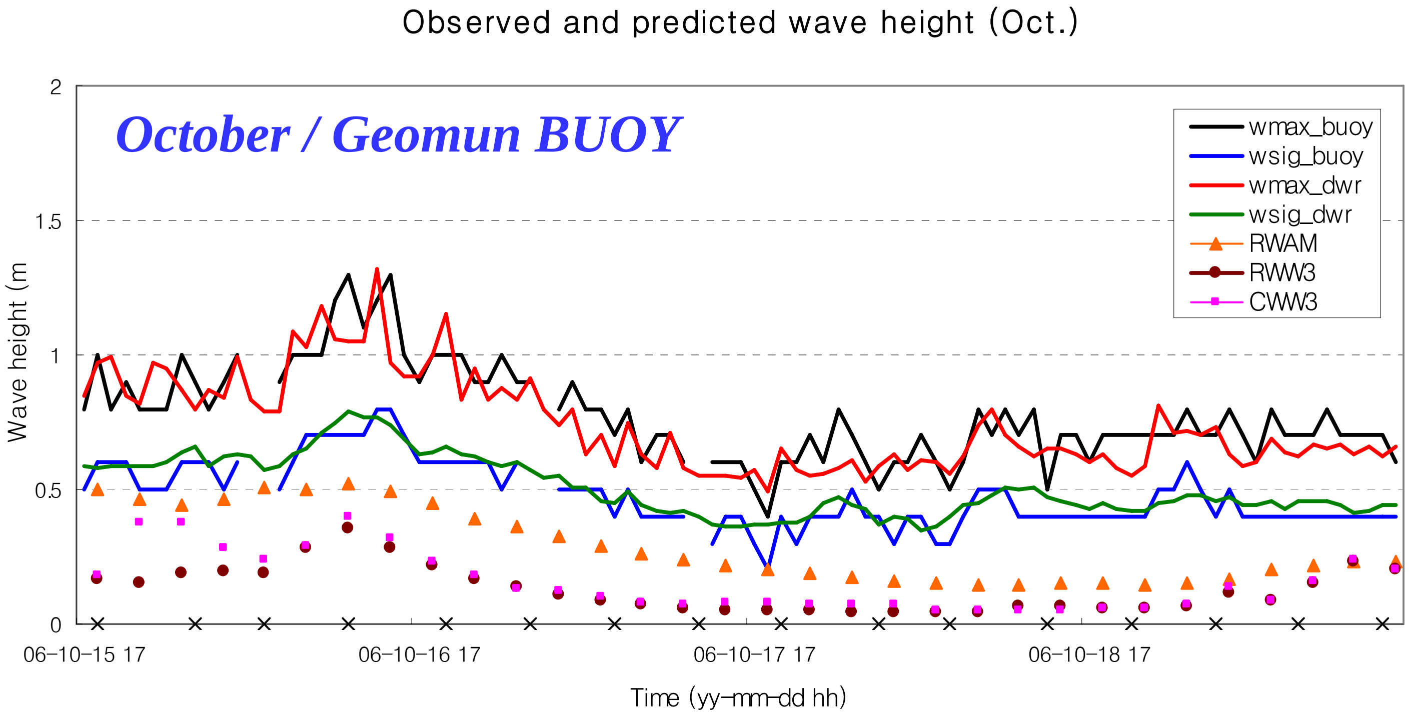
Operating wave observations with radar-type wave gauge established in Gosan observatory

Multiple comparisons of wave observations

Comparisons of wave observations

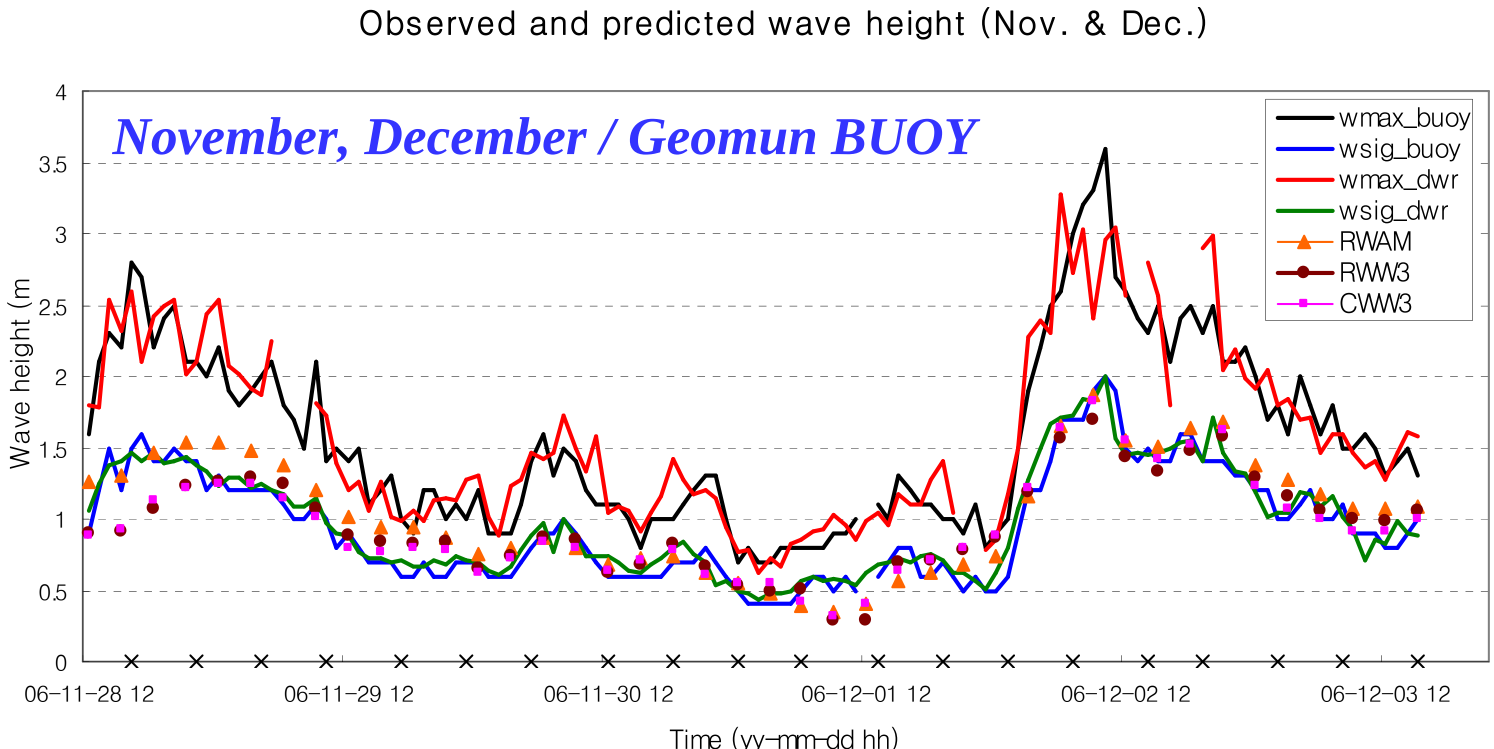


Comparisons and Validation of observations - BUOY vs DWR



	BUOY		DWR	
	BIAS	RMSE	BIAS	RMSE
RWAM	-0.199	0.048	-0.218	0.052
RWW3	-0.355	0.134	-0.379	0.148
CWW3	-0.328	0.118	-0.352	0.129

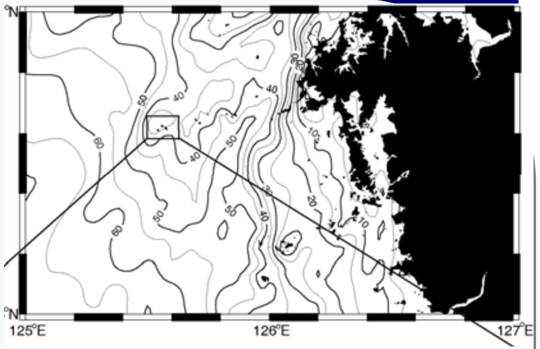
Comparisons and Validation of observations - BUOY vs DWR

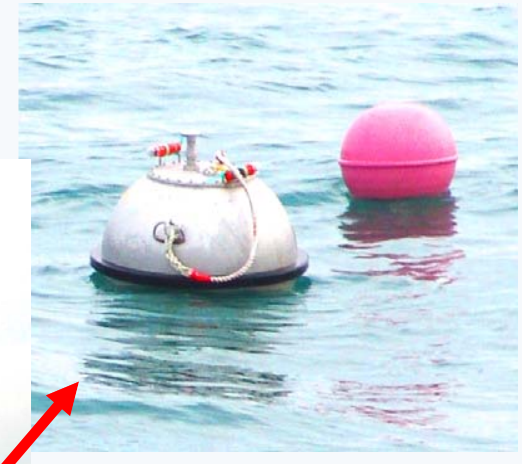


	BUOY		DWR	
	BIAS	RMSE	BIAS	RMSE
RWAM	0.105	0.032	0.059	0.024
RWW3	0.022	0.023	-0.023	0.025
CWW3	0.009	0.019	-0.033	0.020

Comparisons of wave observations - Radar-type vs waverider

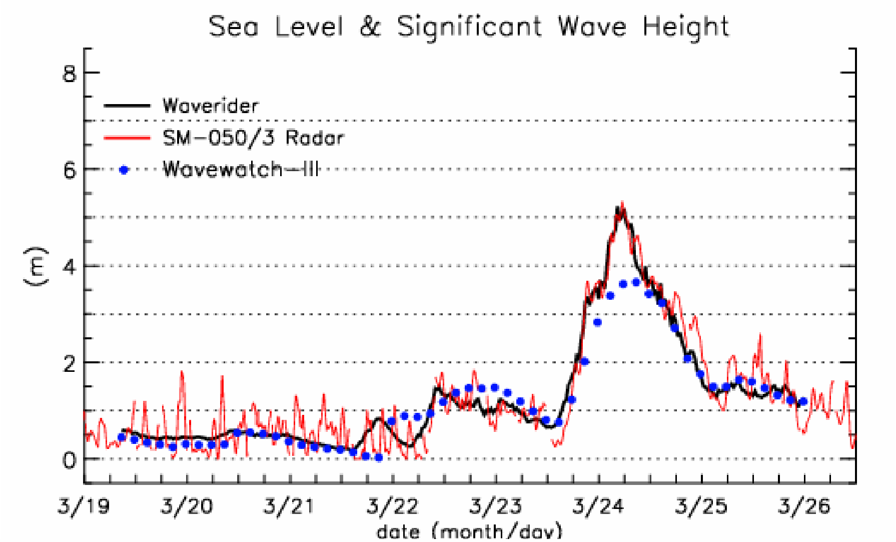
SM-050 Radar

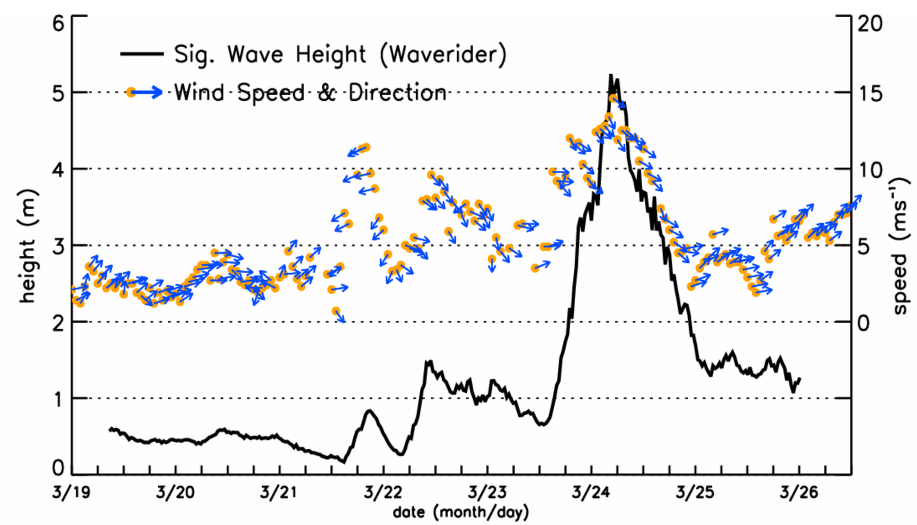


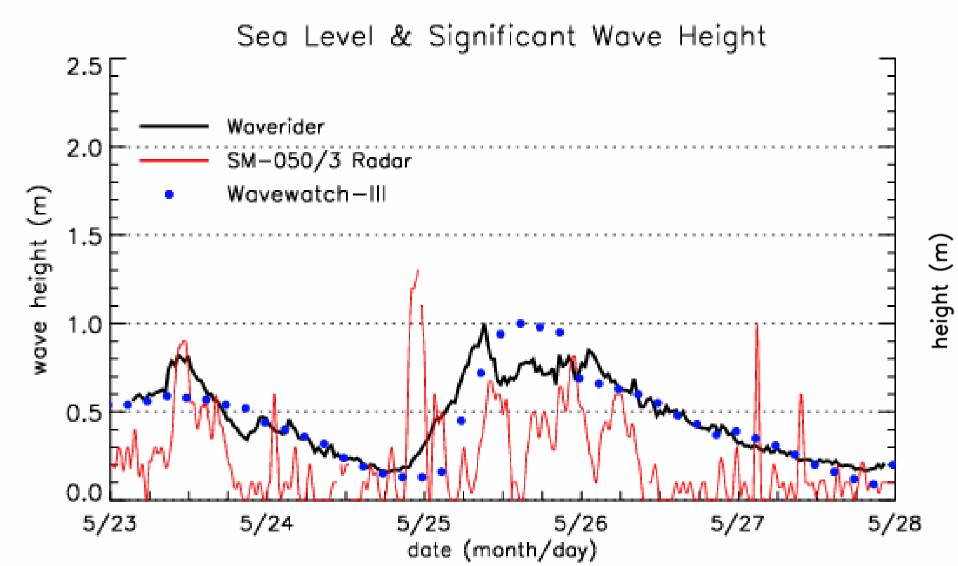


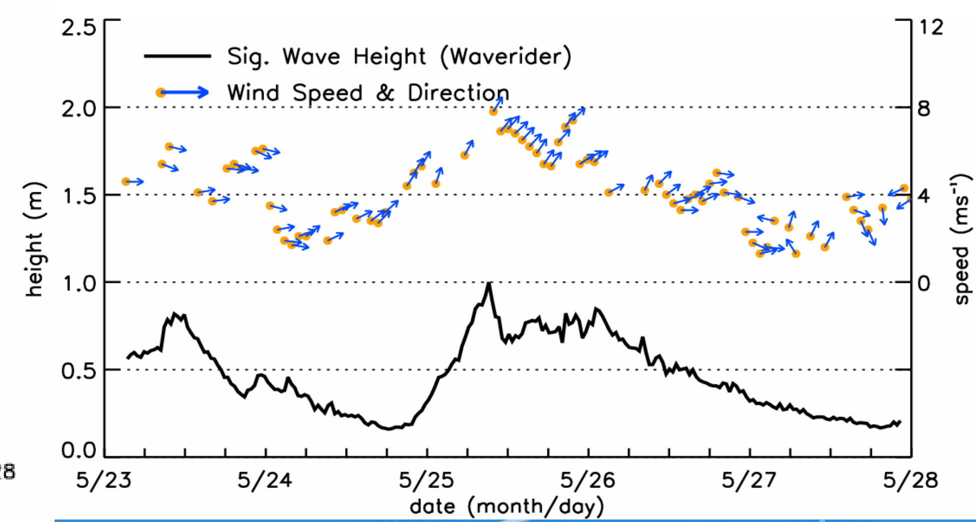
Waverider

Comparisons and Validation of observations - Radar-type vs waverider





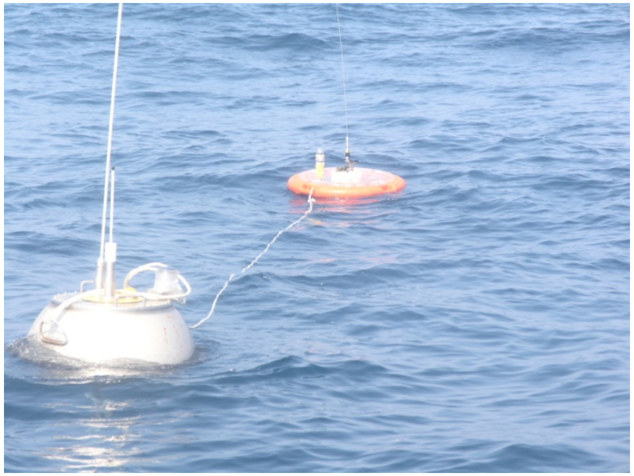




Mooring waverider & wave observations from BUOY made in Korea

BUOY made in Korea

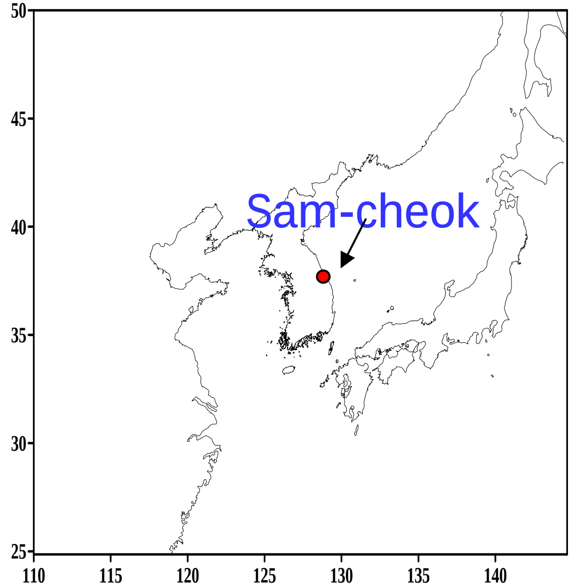
Comparison observation



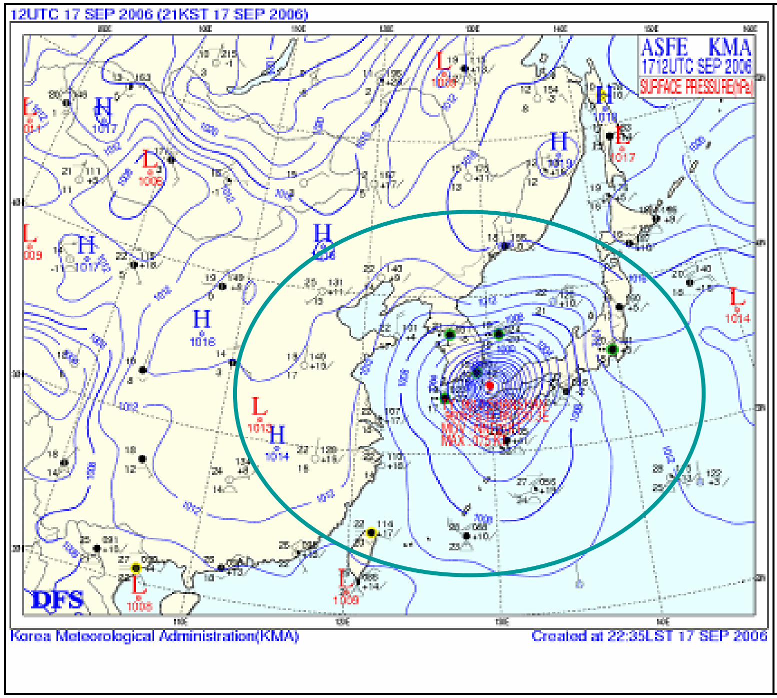
- Stability test of a model BUOY
- Comparison observations
- Transmission test
- We plan to introduce the production of BUOY in Korea

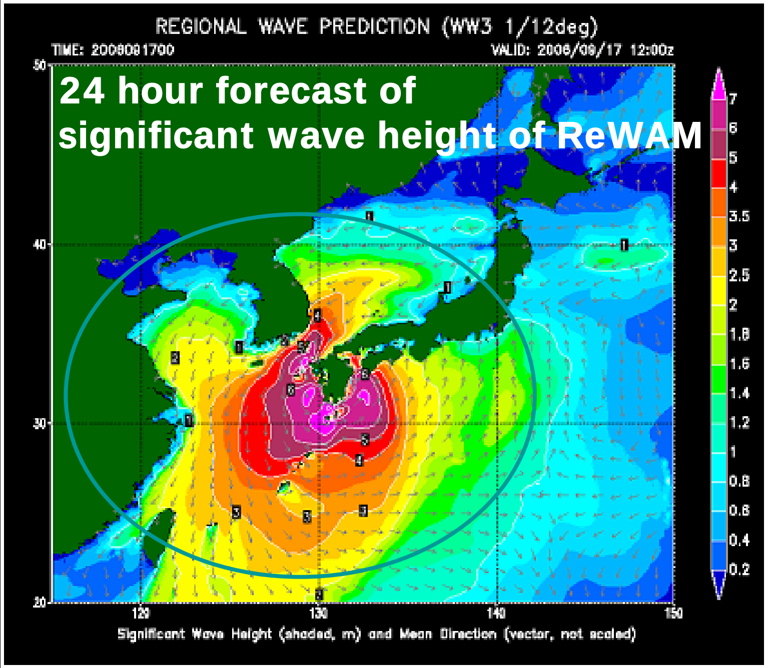
Example of damages caused by swell combined with the outgoing typhoon at Sam-cheok, Kangwon

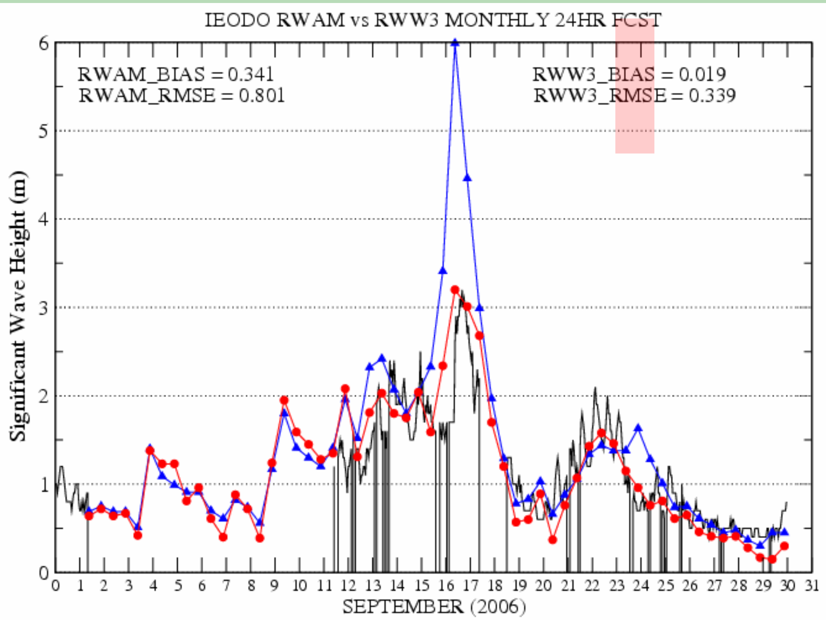
.....The typhoon 'ShanShan' passing through the east coasts caused the swell generating inundation....



........................Publics usually regard swell as storm surge.
On 19, september, 2006, typhoon ShanShan passed through the east coasts. The typhoon alert was canceled inland and no one could expect high waves. However, the inundation by huge waves had occurred at Samcheok with a lot of property damages. It is because strongly perpendicular swell in East sea when typhoon passed through was produced and caused strong winds and momentarily high waves.







2006. 9. 17. 12 UTC

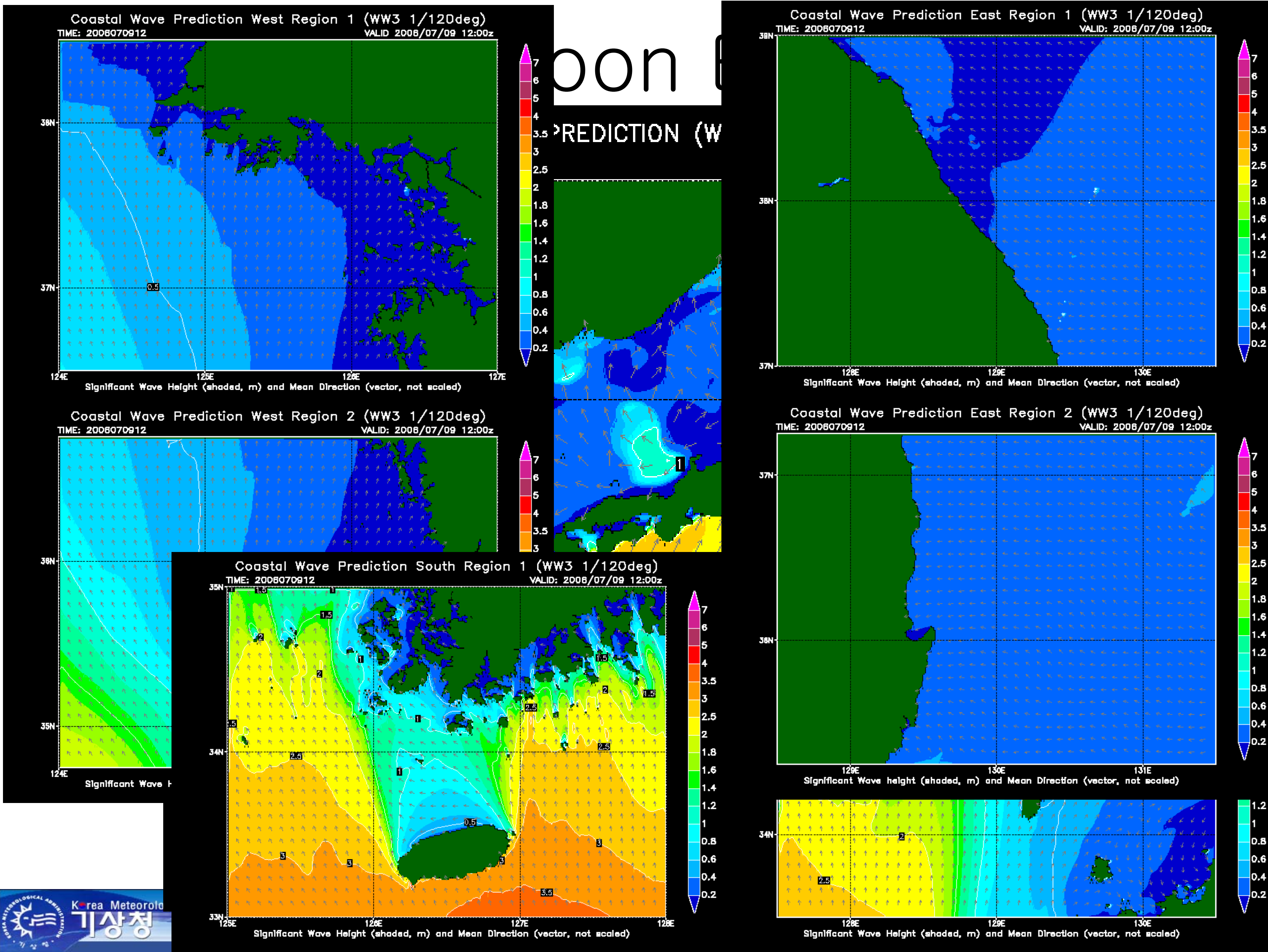
Typhoon *ShanShan*

RWAM BIAS=0.341

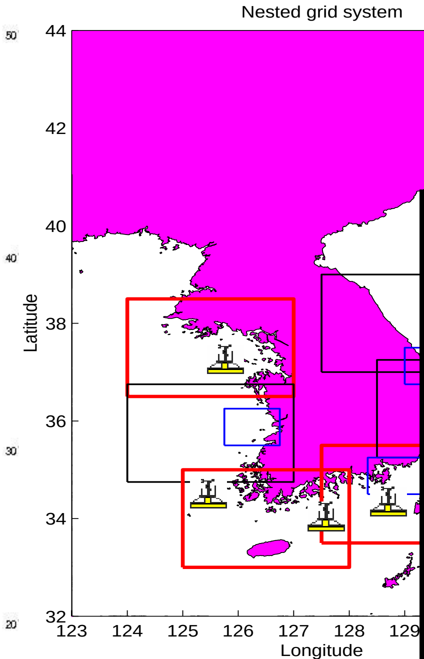
RWAM RMSE=0.801

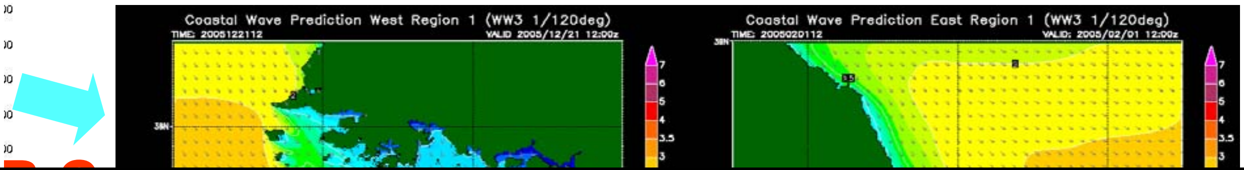
RWW3 BIAS=0.019

RWW3 RMSE=0.339

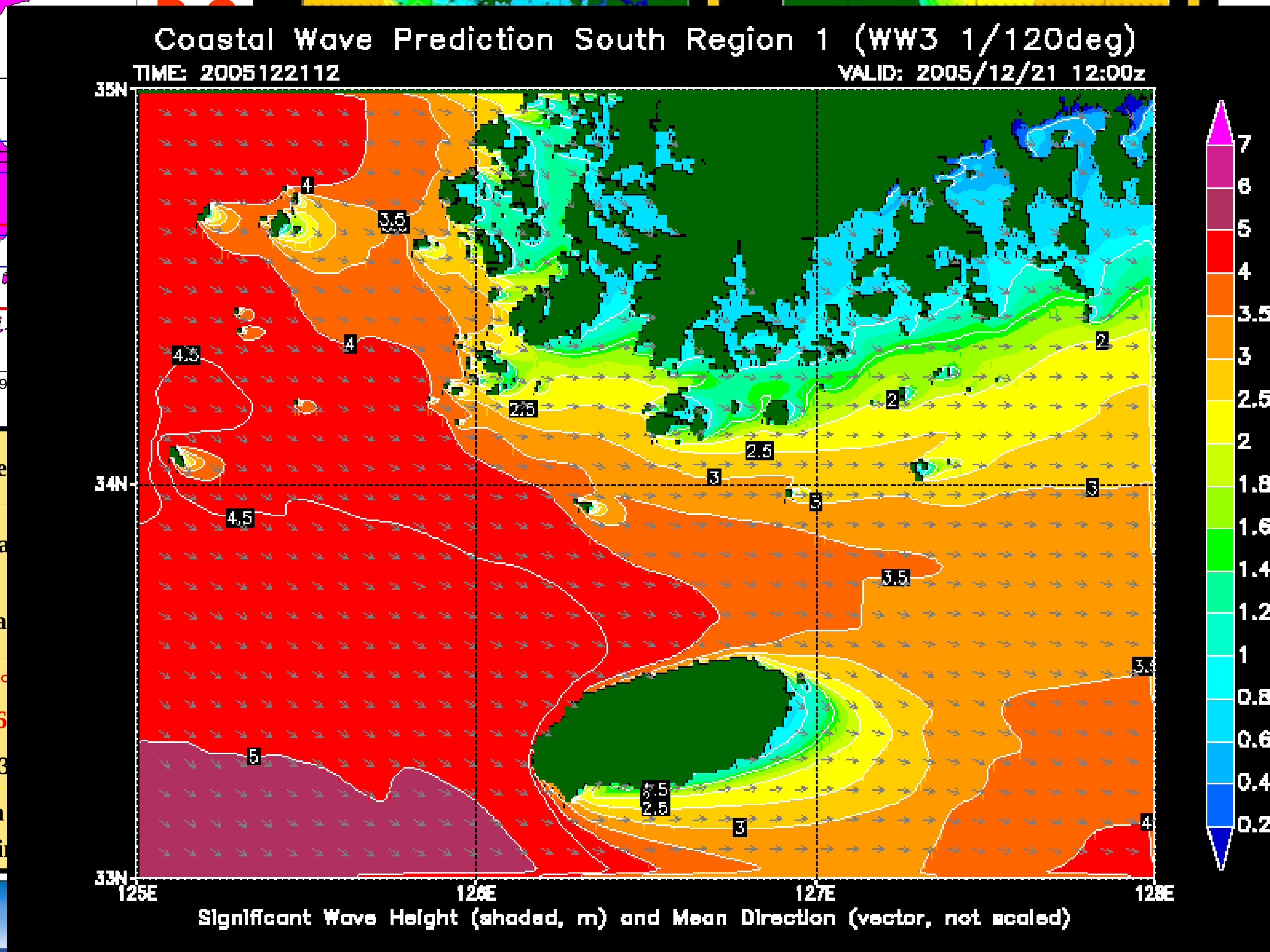

oon E
PREDICTION (W
Coastal Wave Prediction West Region 1 (WW3 1/120deg)
TIME: 2006070912
VALID 2006/07/09 12:00z
Significant Wave Height (shaded, m) and Mean Direction (vector, not scaled)
Coastal Wave Prediction West Region 2 (WW3 1/120deg)
TIME: 2006070912
VALID: 2006/07/09 12:00z
Significant Wave H
Coastal Wave Prediction East Region 1 (WW3 1/120deg)
TIME: 2006070912
VALID: 2006/07/09 12:00z
Significant Wave Height (shaded, m) and Mean Direction (vector, not scaled)
Coastal Wave Prediction East Region 2 (WW3 1/120deg)
TIME: 2006070912
VALID: 2006/07/09 12:00z
Significant Wave height (shaded, m) and Mean Direction (vector, not scaled)
Coastal Wave Prediction South Region 1 (WW3 1/120deg)
TIME: 2006070912
VALID: 2006/07/09 12:00z
Significant Wave Height (shaded, m) and Mean Direction (vector, not scaled)
Significant Wave Height (shaded, m) and Mean Direction (vector, not scaled)
Korea Meteorolo
기상청

Coastal WAVEWATCH III [1km]

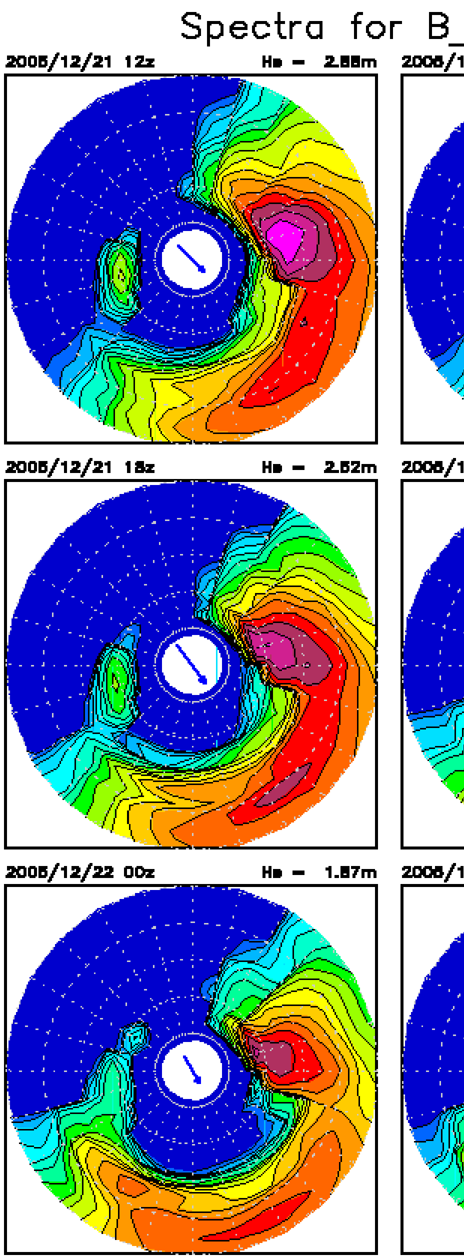




Model	Wave
Coordinate System	Spherica
Model Domains	6 coa
Horizontal Resolution	1/120 ° (36
ΔT	3
Input Data	E,U,V from RDAPS Wi

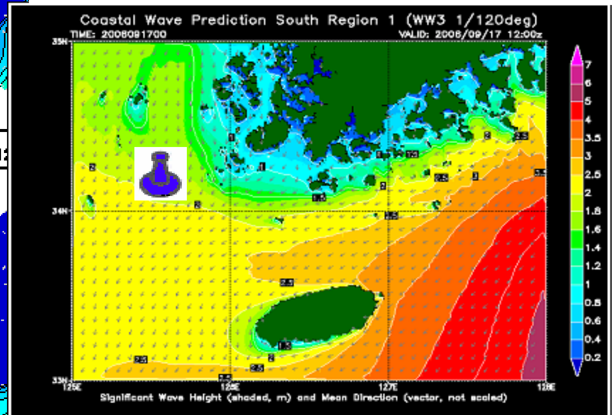


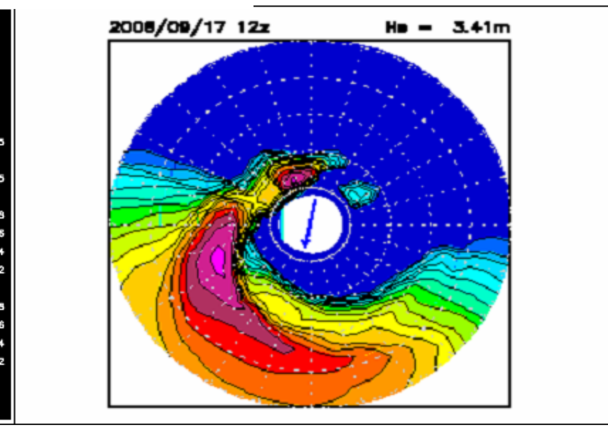
[Geomundo]



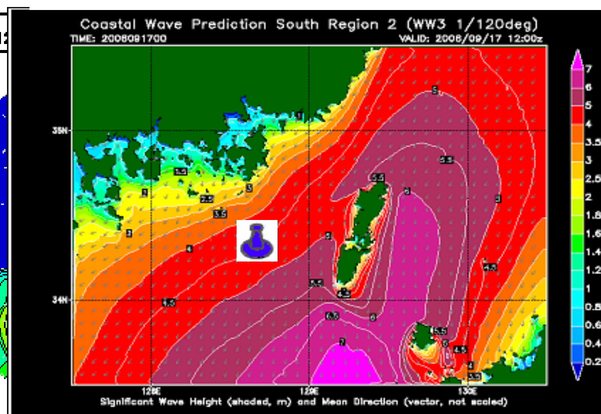
- significant wave height :
- average wave direction :
  from northwest to southeast

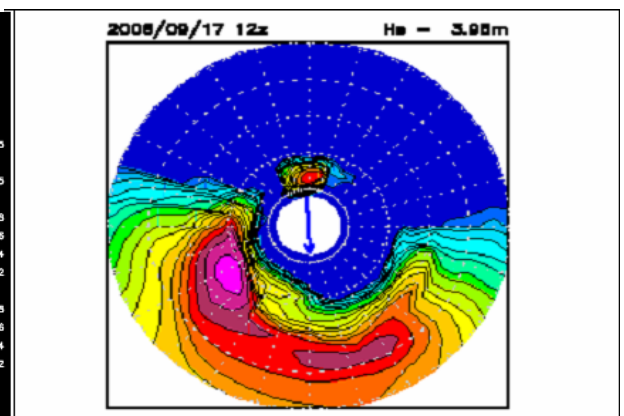
Geomundo Buoy(22103)



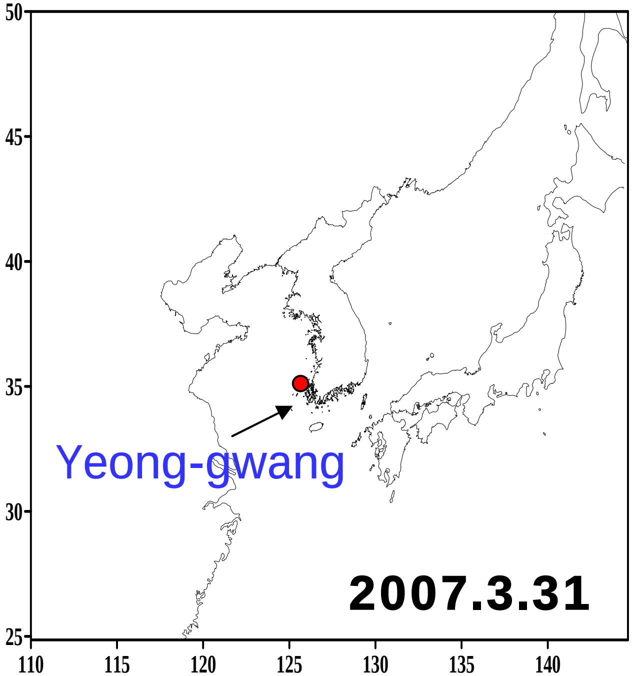


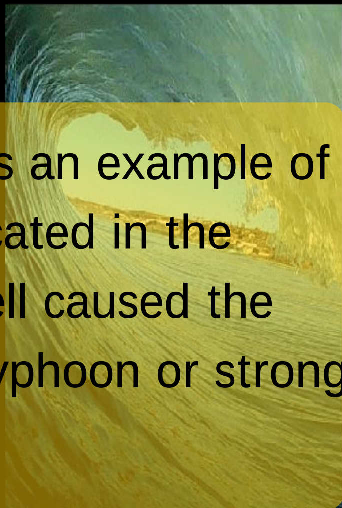
Geojaedo Buoy(22104)





Example of damages caused by swell at Yeong-gwang, Jeonnam

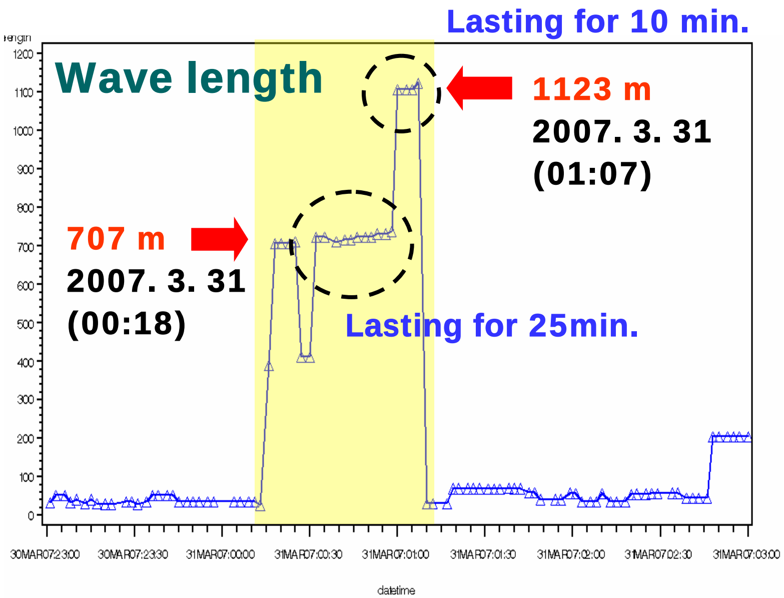


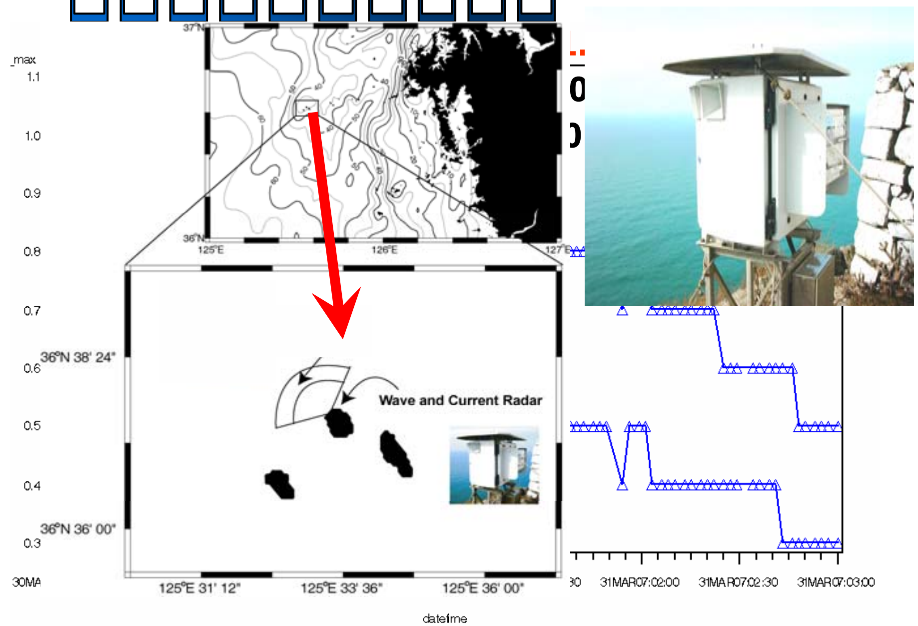


......The inundation of the southwest coastal areas caused by swell This is an example of damages caused by swell in Yeong-gwang, Jeonnam. Yeong-gwang is located in the southwest coastal areas of Korea. .... On 31, March, 2007, Huge swell caused the inundation in those areas leaving a lot of damages. It is not because of typhoon or strong winds but because of unknown long wave and topographical effects.

The Complex Oceanic Meteorological Observatory Station in Yellow Sea(COMOS)

[illegible] and [illegible] at COMOS





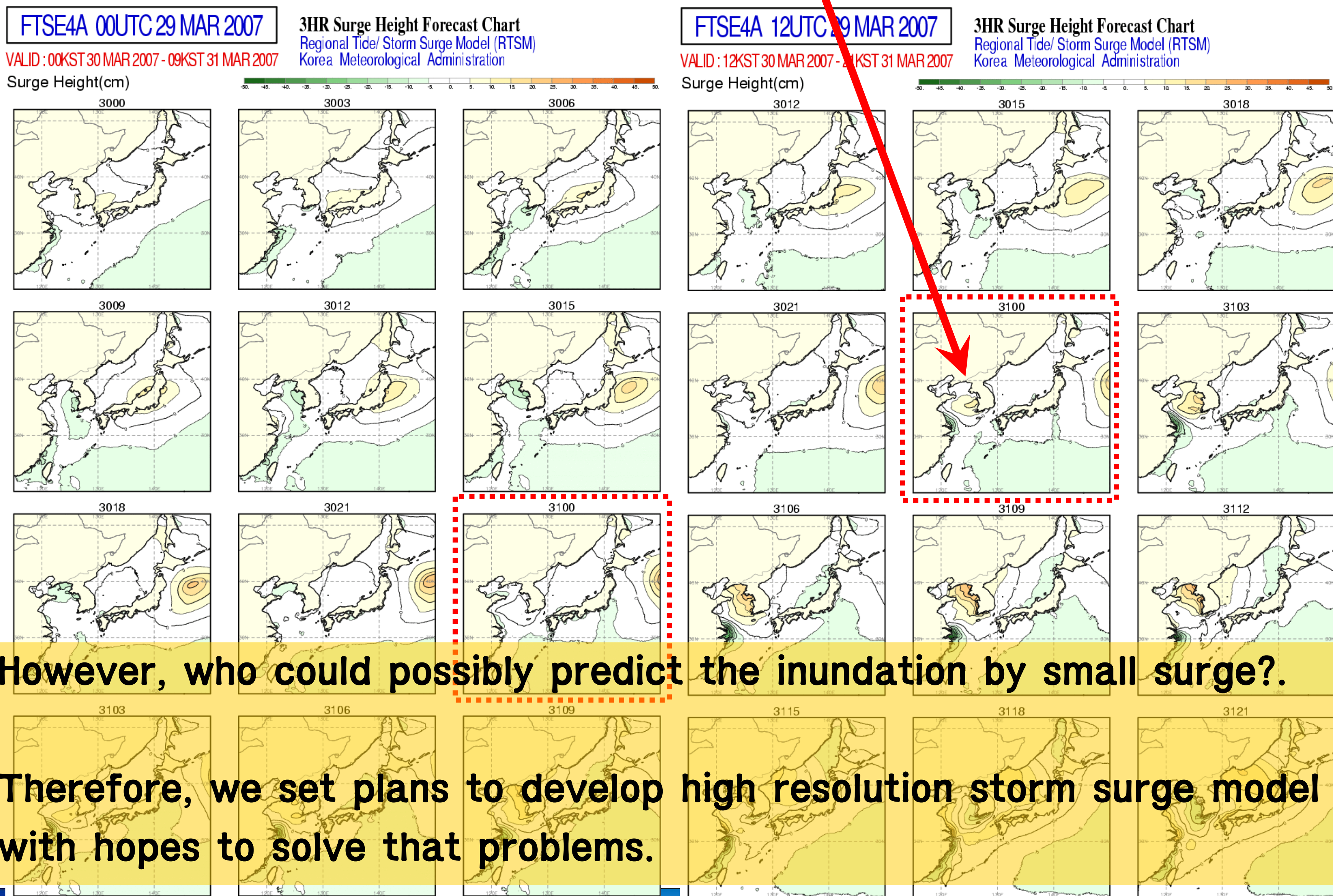
At the time that swell had occurred, we observed swell which have long period wave by Radar type wave measurement SM-50 Radar at the COMOS in Yellow Sea.

Wave length & Wave height

Significant wave at about 1 m was observed for 25 minutes in COMOS.

Long wave length of 1 km has been detected for 25 minutes by SM-Radar type Wave measurment at COMOS. Although the mechanism of this long wave is not clearly found out, but it is obvious that long wave had created and detected. The inundation in Yeong-gwang and Samangeum seemed to be produced by topographical effects combined with shallow water effects, after long wave propagated fast from Yellow Sea.

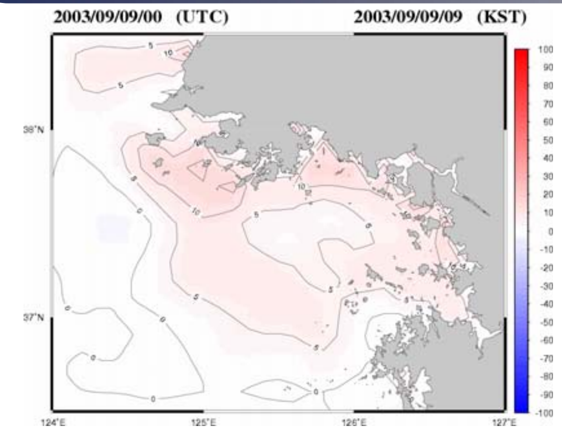
The 48 hours forecast charts of storm surge model the elevated sea level at about 15cm 24 hours ago

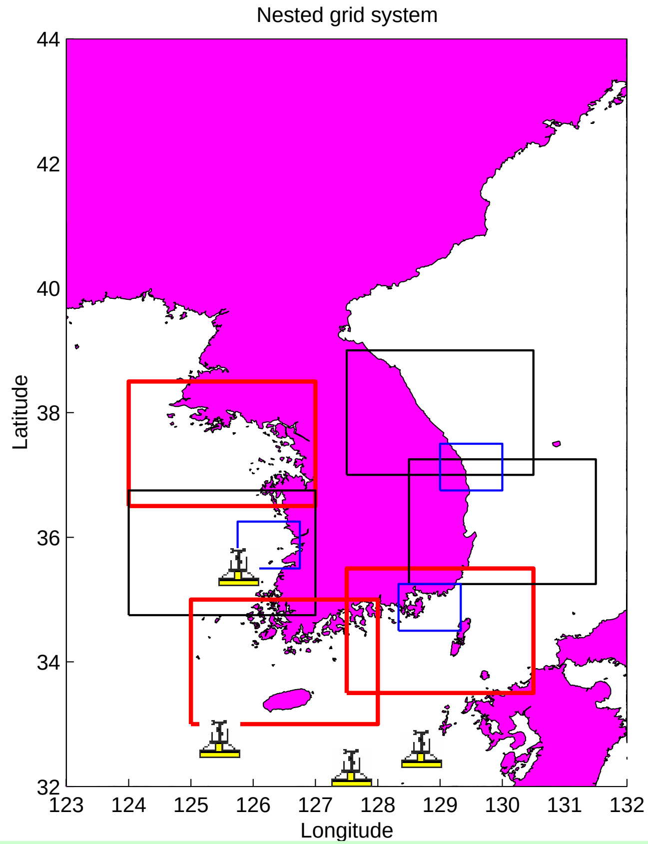


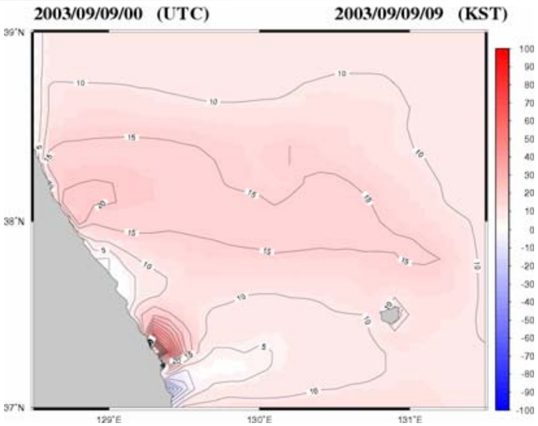
However, who could possibly predict the inundation by small surge?.

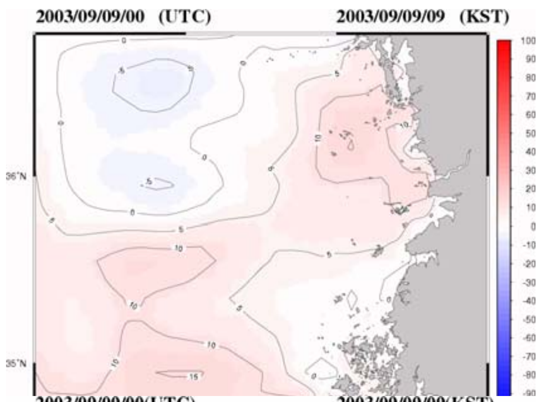
Therefore, we set plans to develop high resolution storm surge model with hopes to solve that problems.

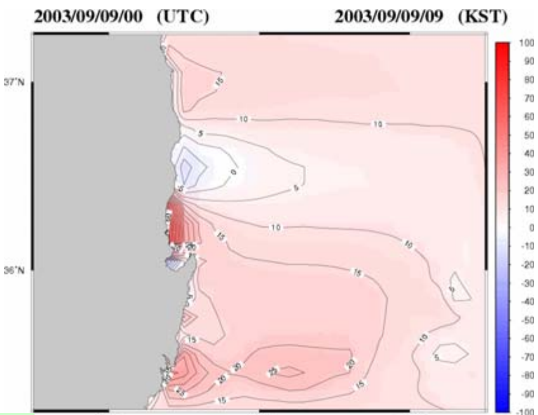
Development of Nested Storm Surge Model

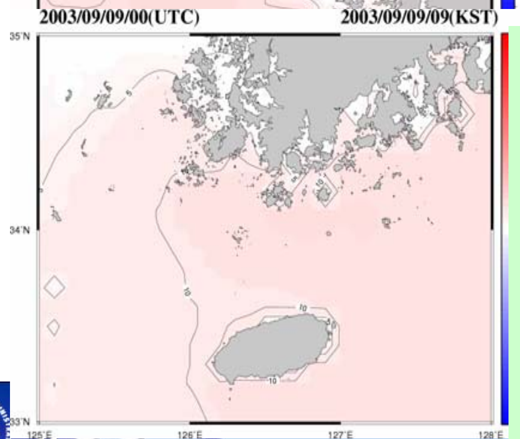




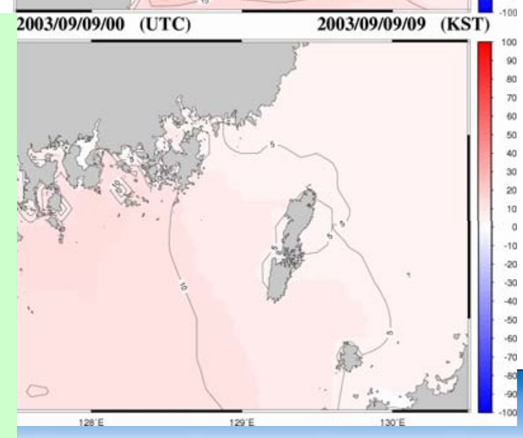






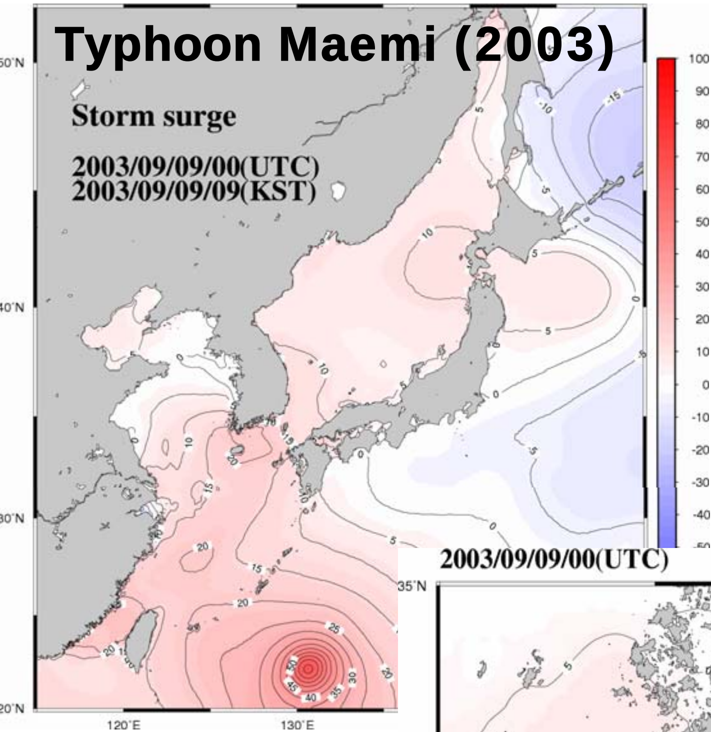


- *Using storm surge model output as an initial condition*
- *Horizontal resolution 1/120° (6 coastal regions)*
- *Same domain with Coastal wavewatch model*
- *Doing parallized work and model tuning*



Damage by Typhoon MAEMI, Sep. 2003

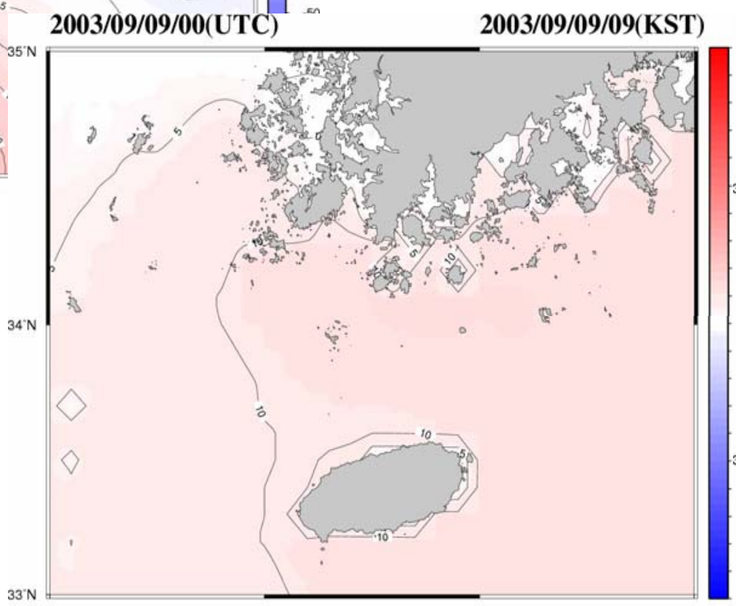
Applications of Coastal Storm surge Model

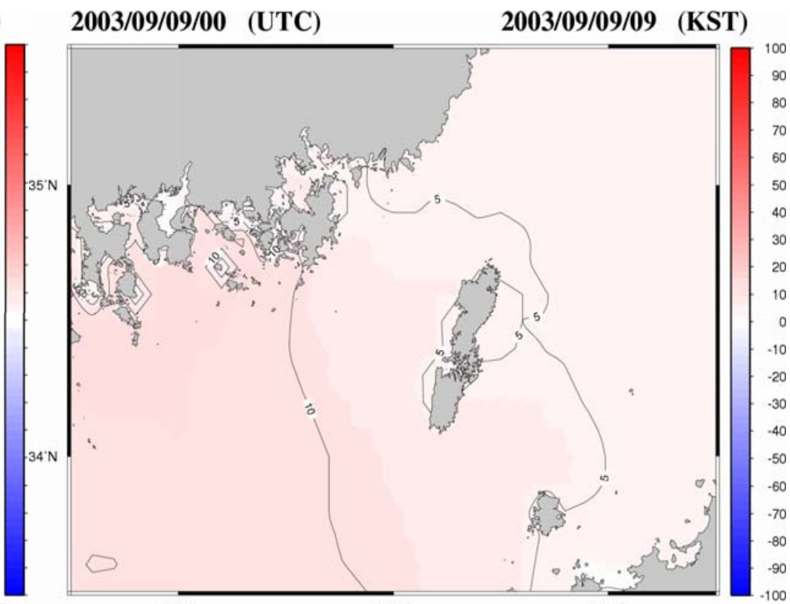


Until now, Regional model can't reproduce the highest peak of storm surges.

Especially, in Masan, maximum sea level reached 3.6 m which is the highest level as recorded.

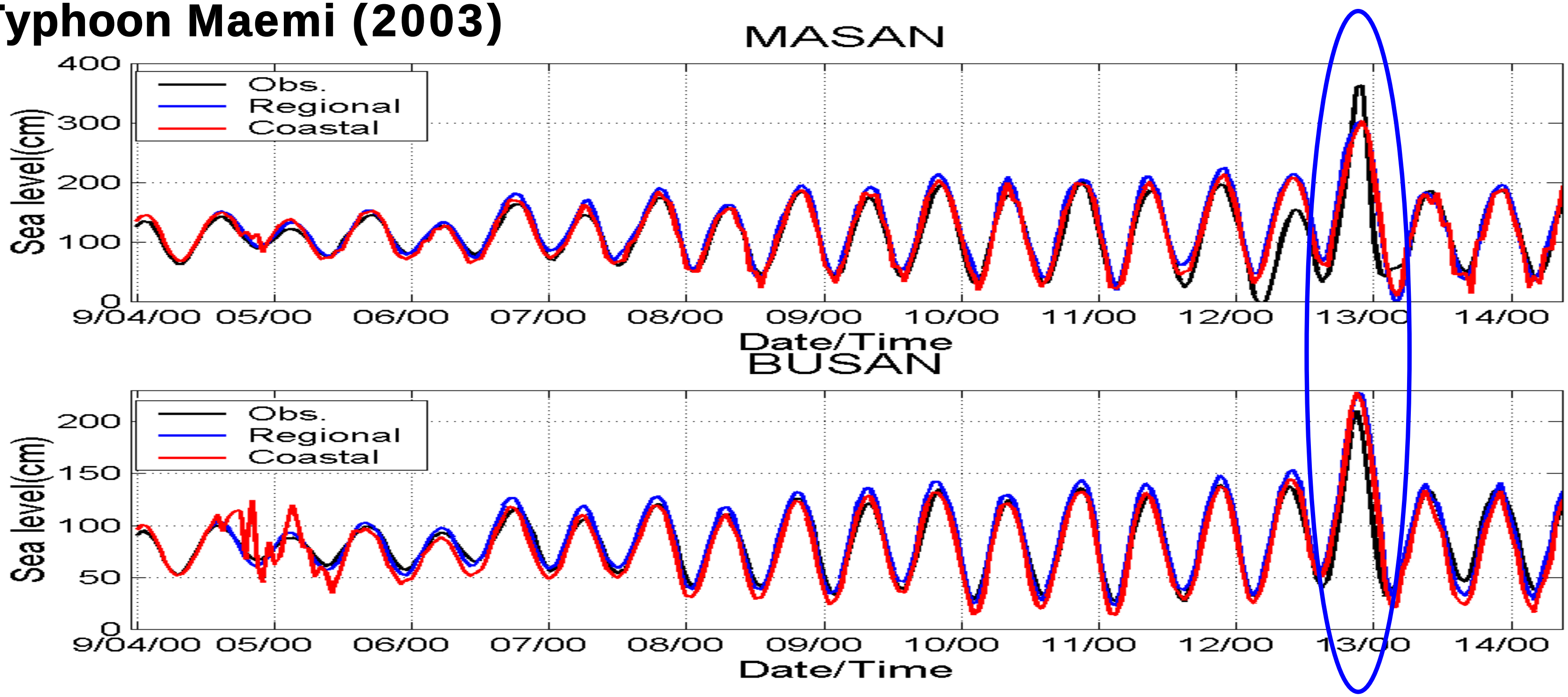
Even though the model result show the smaller value 3m than observed one, the peaks of storm surge was well represented in this model.





Applications of Coastal Storm surge Model

Typhoon Maemi (2003)



In the stations of open sea such as Jeju and Busan predicted maximum surge heights agree well with the observed ones.

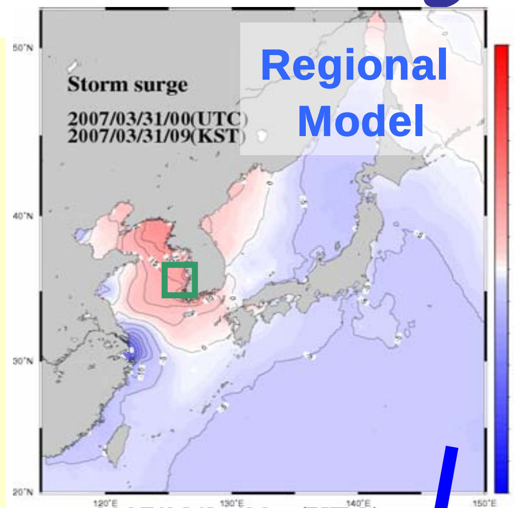
However, in the complex coastal region such as Masan, Tongyong predicted maximum surge height is much smaller than observed ones.

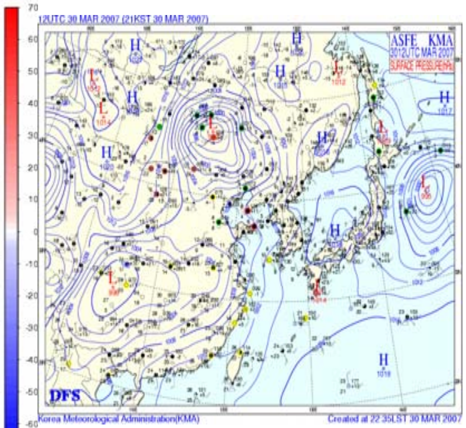
Although the model is high resolution model with 1km grid, this resolution is not enough to represent the complex southern coastline, that is the limitation of the model.

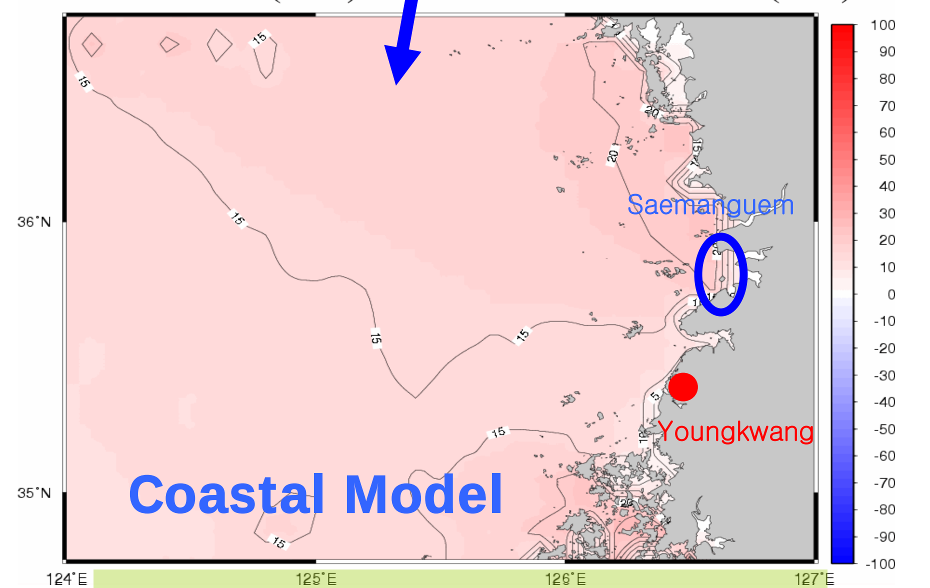
Weather Charts and Coastal & Regional Model

•Unexpected phenomena that is low pressure developed two times approached on the western coast the first day and the last day in March of this year, especially not summer season.

In this period, low pressure generated inundation and caused damages to coastal area such as Saemangeum and Young Gwang area.







12UTC 30. March. 2007

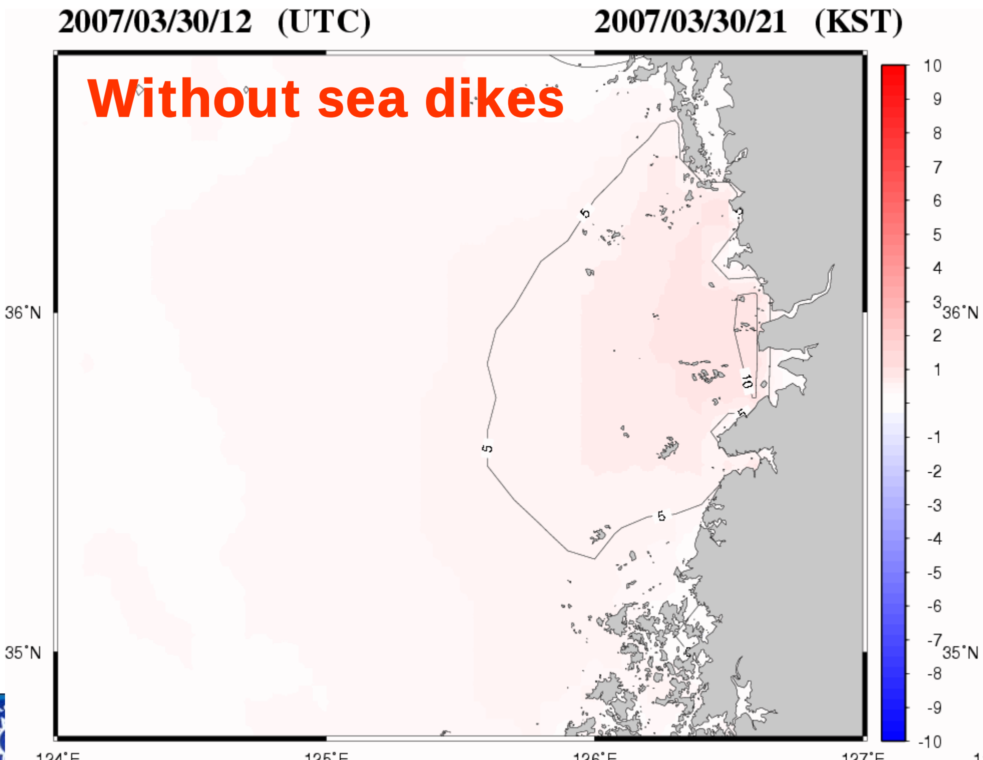
– 21 UTC 30. March. 2007

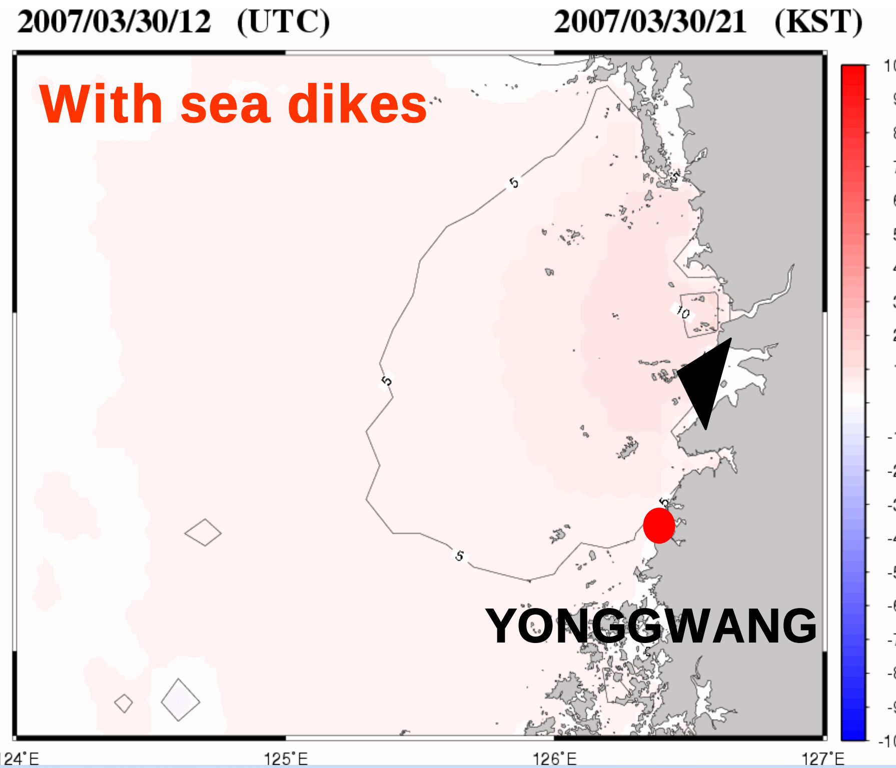
Saemangeum Project effect?

The Saemangeum Project connects Gunsan to Buan by constructing the 33 km-long sea dikes.

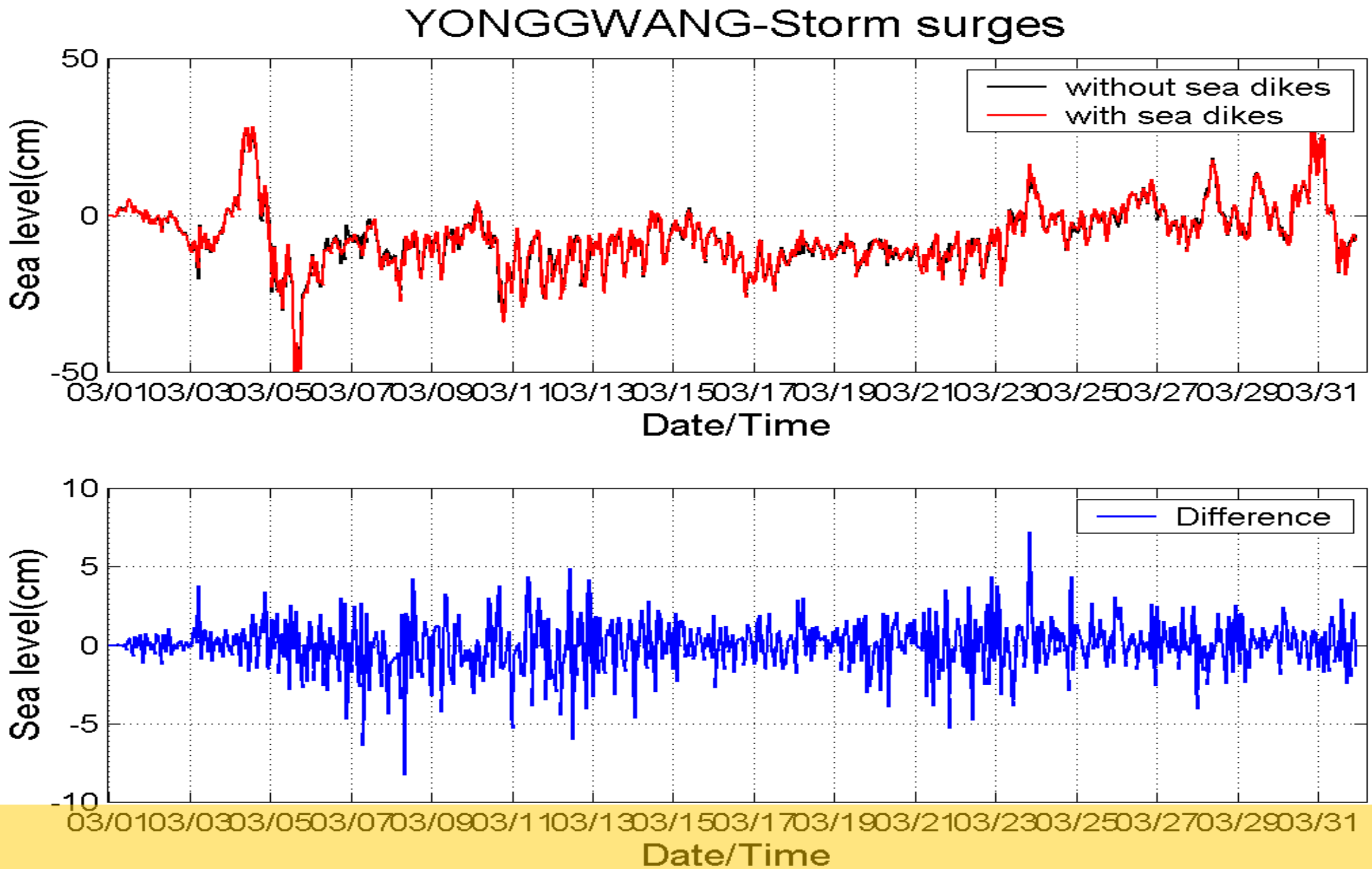
It creates 28,300 ha of land 11,800 ha of freshwater lake.

So, we simulated this effect of sea dikes by high resolution storm surge model.



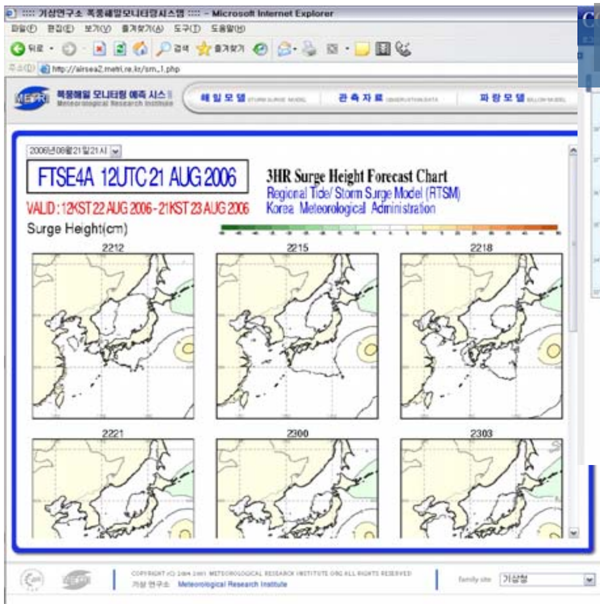


Storm surges differences

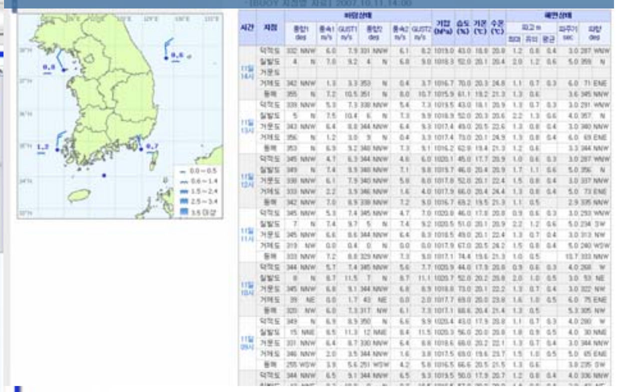


After all, the construction of sea dikes can't caused inundation in these area.

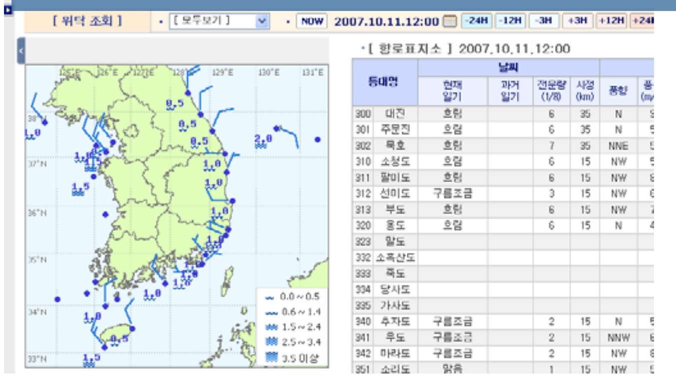
Development of comprehensive nowcasting application



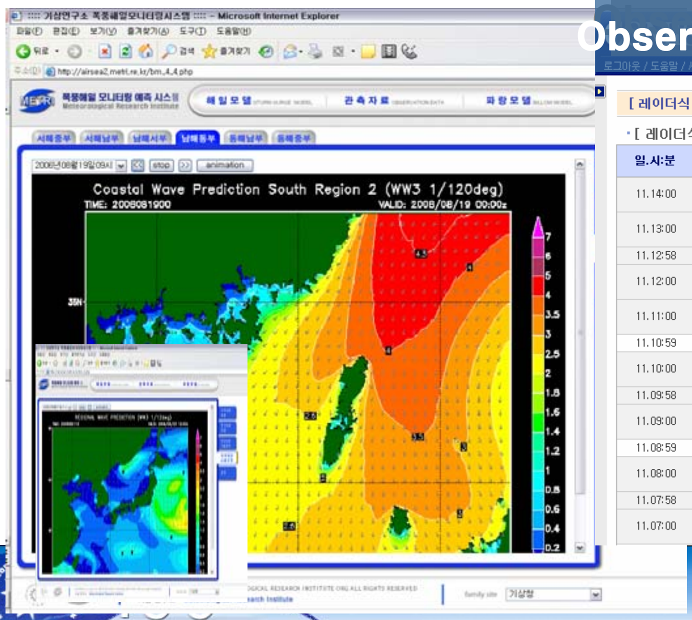
Buoy monitoring system



Observations in light house



Observations Radar-type wave gages & in Tower by KMA

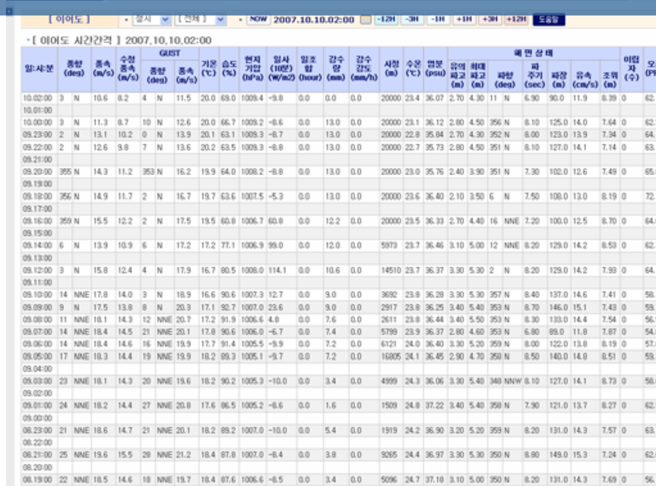


Observations in IEODO by NORI

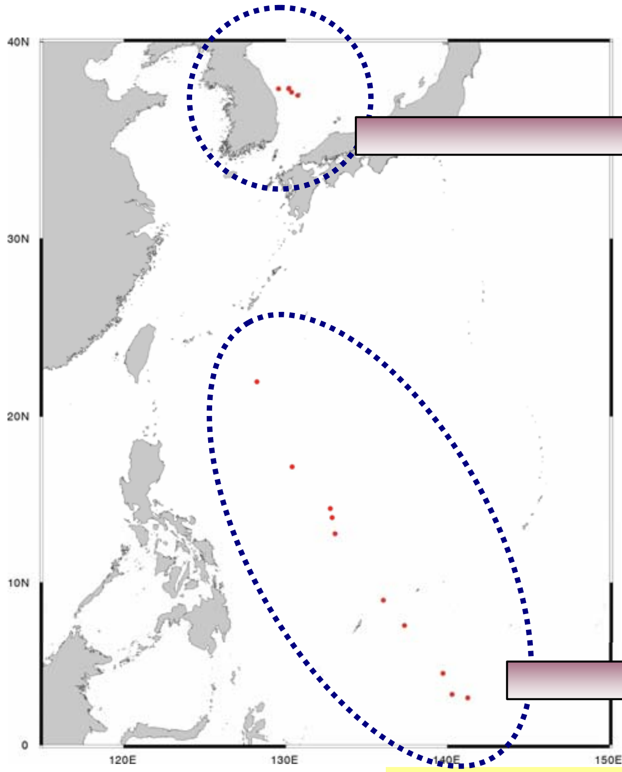
[레이더식 파고계] 문숫자 [전체] 정시 [전체] NOW 2007.10.11.14:00

[레이더식 파고계 1시간간격] 2007.10.11.14:00

일.시:분	지점명	유의파고 m	최대파고 m	파주기 sec	파향 deg		파속 m/s	파장 m
11.14:00	고산	0.98	1.61	5.51	18.42	NNE	8.50	46.27
	격렬비도	1.20	2.00	4.90	322.00	NW	8.30	44.00
11.13:00	고산	1.00	1.64	5.51	35.67	NE	8.63	47.70
	격렬비도	1.30	2.20	5.00	319.00	NW	8.00	41.00
11.12:58	격렬비도	1.30	2.10	5.00	308.00	NW	8.00	41.00
11.12:00	고산	1.01	1.65	5.58	28.80	NNE	8.60	47.41
	격렬비도	1.30	2.20	5.10	338.00	NNW	8.40	45.00
11.11:00	고산							
	격렬비도	1.40	2.30	5.20	329.00	NNW	8.50	46.00
11.10:59	격렬비도	1.40	2.30	5.20	331.00	NNW	8.50	46.00
11.10:00	고산	0.94	1.55	5.38	344.62	NNW	8.50	46.23
	격렬비도	1.50	2.50	5.20	327.00	NNW	8.30	44.00
11.09:58	격렬비도	1.50	2.60	5.20	329.00	NNW	8.30	44.00
11.09:00	고산	0.96	1.58	5.43	319.33	NW	8.52	46.46
	격렬비도	2.00	3.40	5.40	314.00	NW	9.20	54.00
11.08:59	격렬비도	2.00	3.30	5.40	322.00	NW	9.20	54.00
11.08:00	고산	1.00	1.64	5.49	296.90	WNW	8.62	47.61
	격렬비도	2.20	3.60	5.30	316.00	NW	9.50	58.00
11.07:58	격렬비도	2.30	3.70	5.30	315.00	NW	9.50	58.00
11.07:00	고산	0.94	1.55	5.39	261.23	W	8.57	47.07
	격렬비도	1.80	2.90	5.40	311.00	NW	9.50	57.00



IN-SITU Observation



[Deployment of ARGO float (Metri / KMA)]

East Sea 5 floats in every year
using the KMA R/V ship - Gisang2000

NW Pacific 10 floats in every year
using a commercial ship - Hanjin

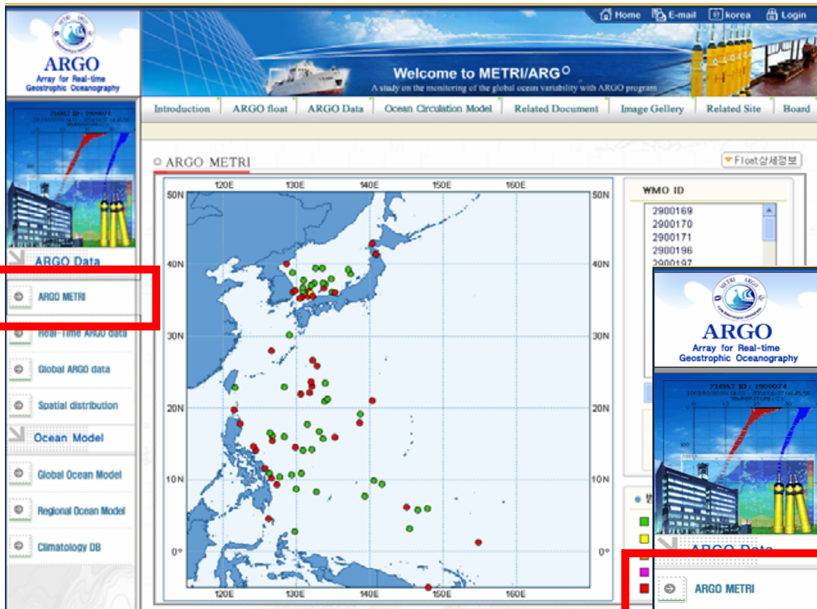
Deployment Package

Resetting

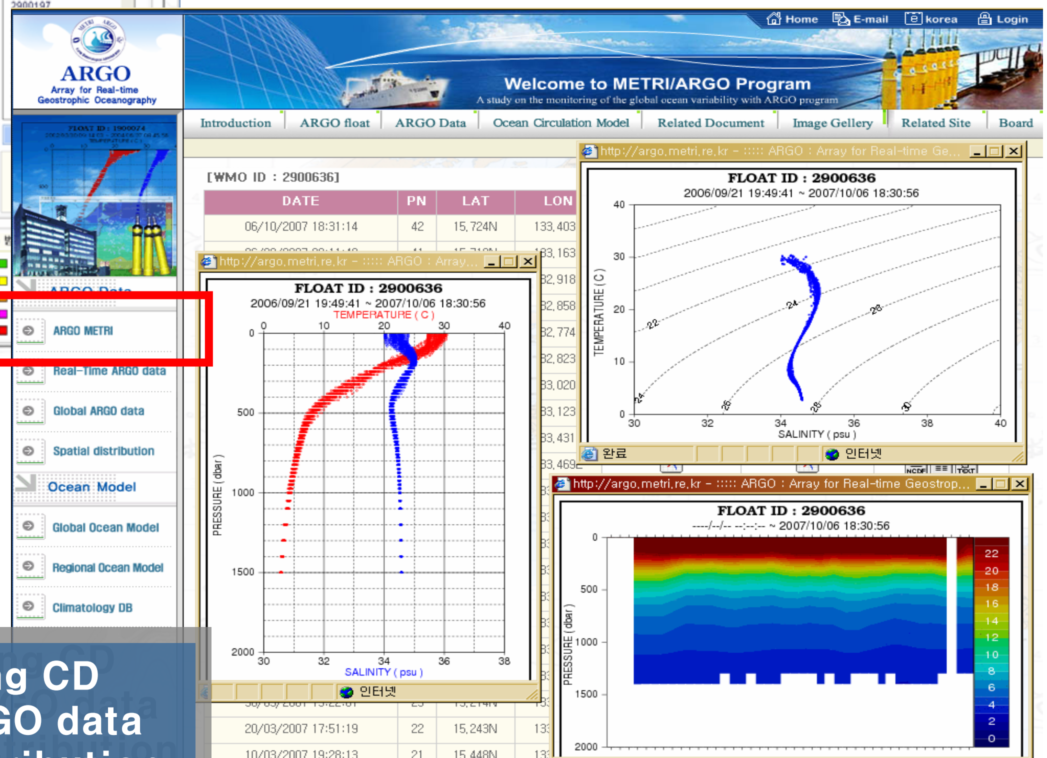
Quick Release Hook

Deployment

Data Distribution System (Metri / KMA)



Homepage for ARGO METRI/KMA



Making CD for ARGO data and Distribution

http://argo.metri.re.kr

Regionally Adapted Real Time Quality Control

Regionally adapted RTQC procedure is to apply several error data tests in temperature by which we can identify erroneous value based on background data.

- Target Profile Data List (Argo_prof.lst)
- #1 Read Argo profile data
- #2 Define flag variables (TQC, POSIT_QC)
- #3 Read ETOPO5 data
- #4 Standardization of profile data
- # 5 Global Range Test
- # 6 Read WOA05 data
- # 7 Min/Max Pressure Test
- # 8 Profile length Test
- # 9 Profile location Test
- # 10 Stuck value Test
- # 11 Regionally adapted range test
- # 12 Duplicated sampling test
- # 13 Parking depth gradient test
- # 14 Spike Test
- # 15 Profile length test
- # 16 Temperature Jump test
- # 17 Data output : QC_RES
- # 18 Data output: QC_ALL

Algorithm for R-RTQC

Background Data

World Ocean Database 2005 (WOD05)

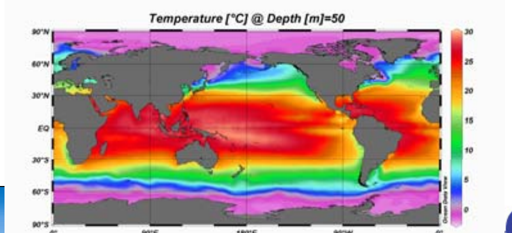
For temperature inversion, spike, and jump test : (CTD) data only

World Ocean Atlas 2005 (WOA05)

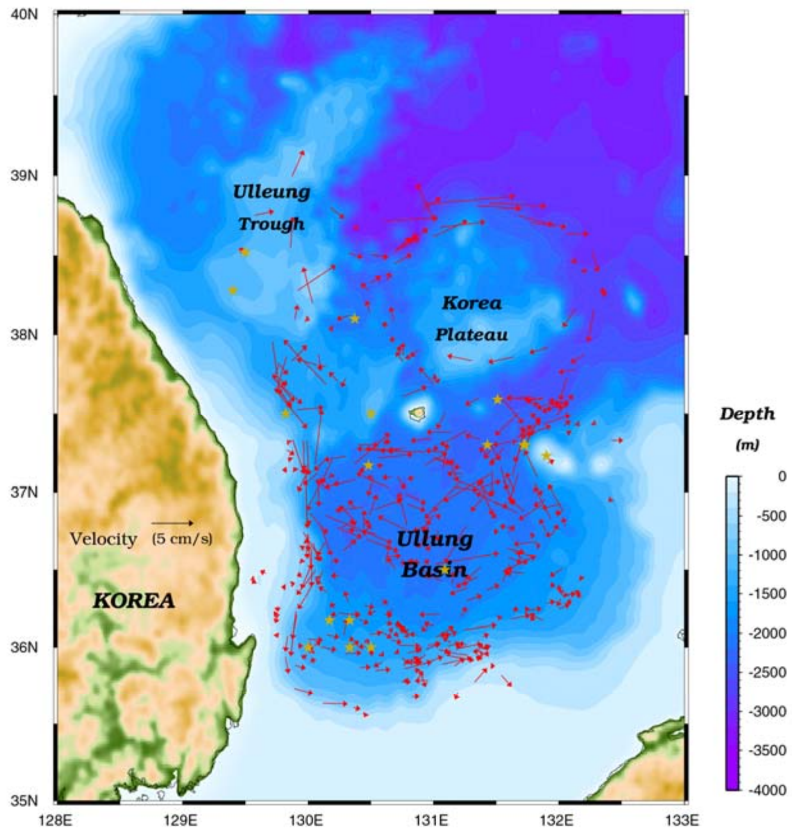
For regionally adapted range test : Mean Temperature and standard deviation

ETOPO 5

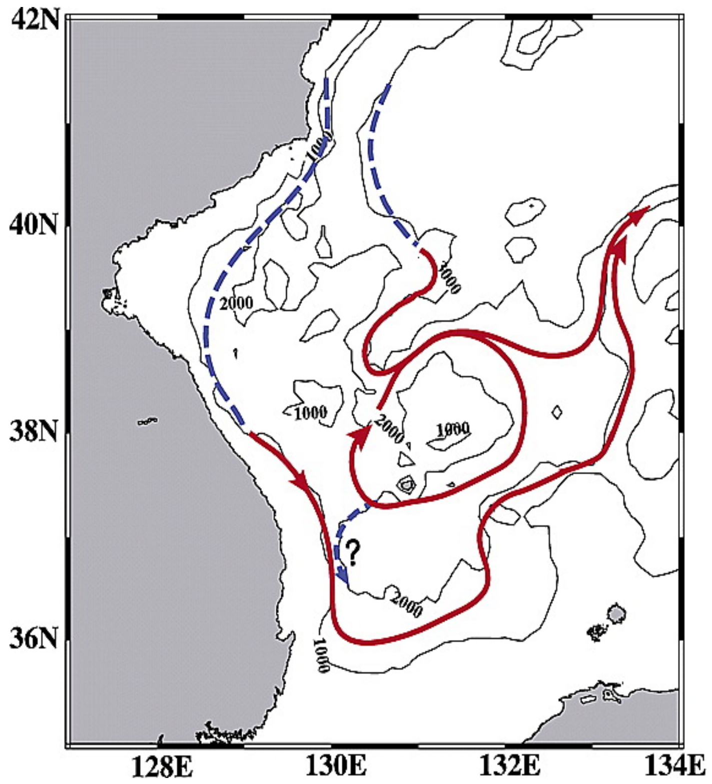
For float location test : Bathymetry



Data Application [Intermediate level circulation in the East Sea]



Current field calculated by ARGO data at the intermediate level (around 800 m)

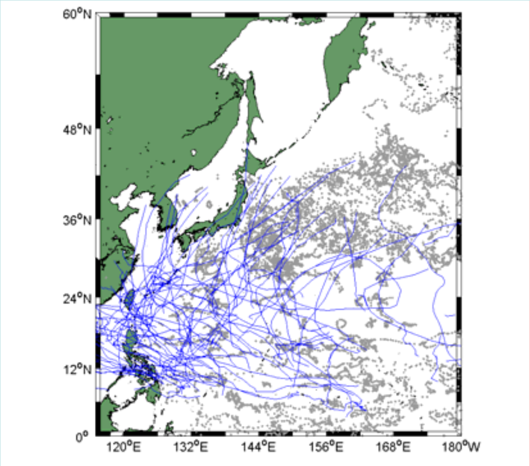


A schematic of intermediate level circulation pattern inferred from the float data over the southwestern part of the East/Japan Sea

- Cyclonic boundary current along the Korean and Japanese coast.
- Anti-cyclonic current on the Korea Plateau.
- High variability in the Ulleung basin.

Data Application [Water Mass Exchange during Typhoon event]

Total storm track in the North Pacific



Match up point : Argo profile pairs and Typhoon track

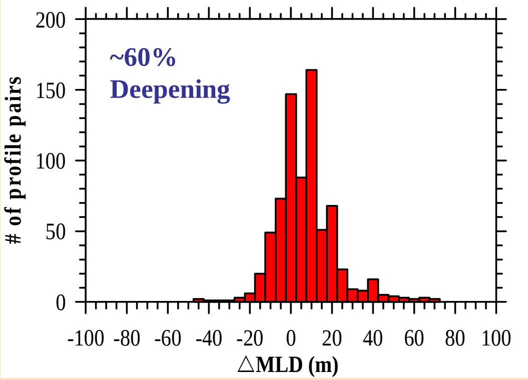
Temporal window : ± 10 days

Spatial window : ± 200 km from Typhoon track

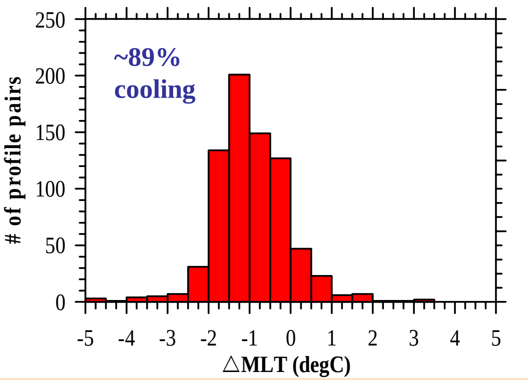
MLD definition : $T_{surface}$ - 0.3°C

Remove profiles which have salinity bias or measurement error in the mixed layer

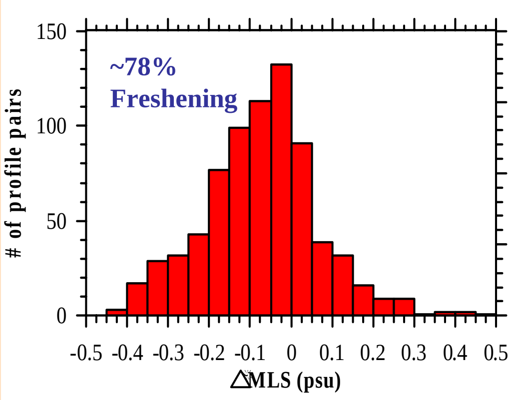
Results



$$\Delta MLD = MLD_{post} - MLD_{pre}$$



$$\Delta MLT = MLT_{post} - MLT_{pre}$$



$$\Delta MLS = MLS_{post} - MLS_{pre}$$

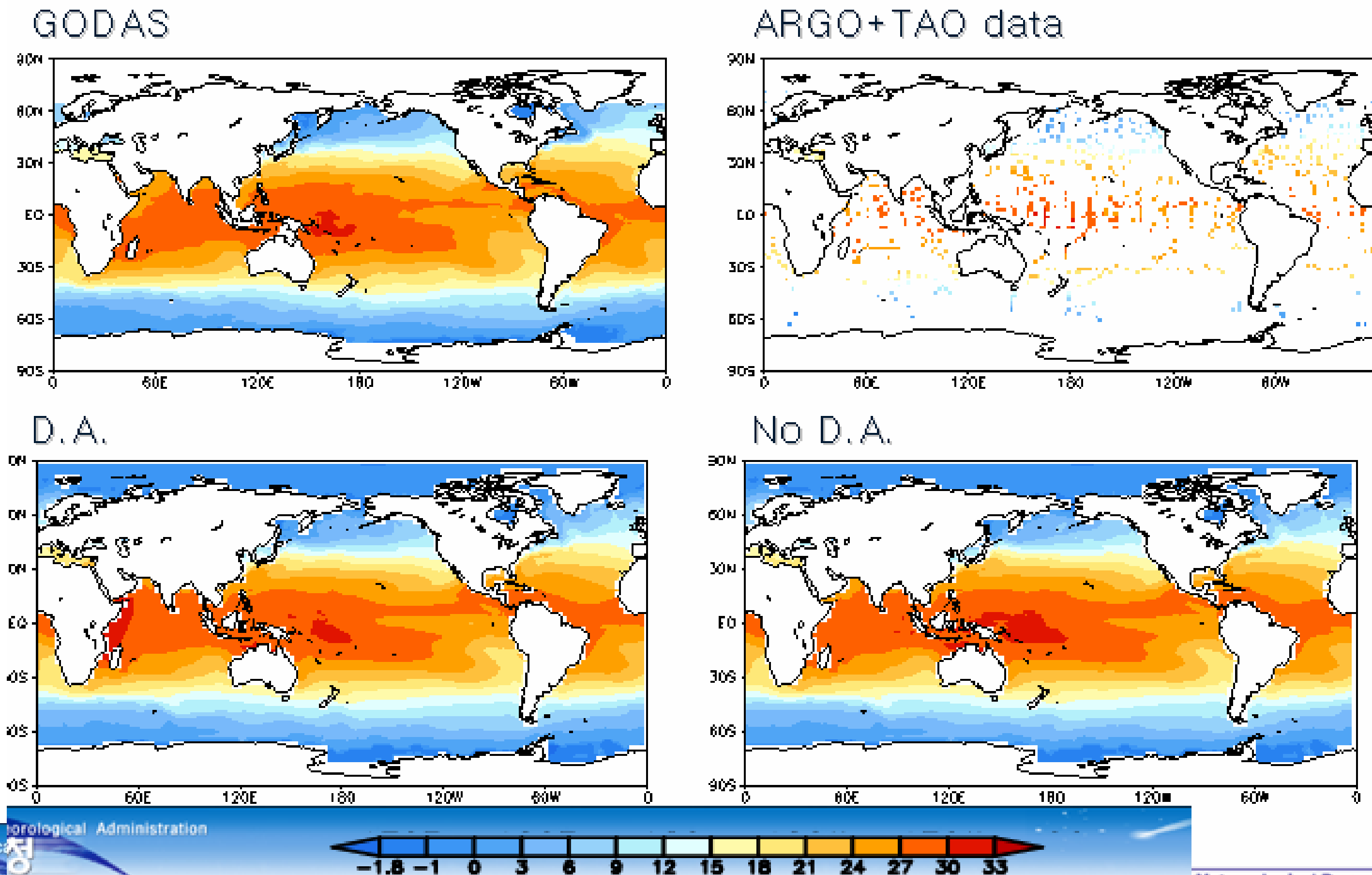
Coupled General Circulation Model

The improvement of fluctuation in the Equator using variational methods

VAN (Variational Analysis with no inversion of B) -> make the climate fields

Comparison between initial sea temperature fields and GODAS fields

2004-01-01 initial field (sea temperature) – 10m



Coupled General Circulation Model

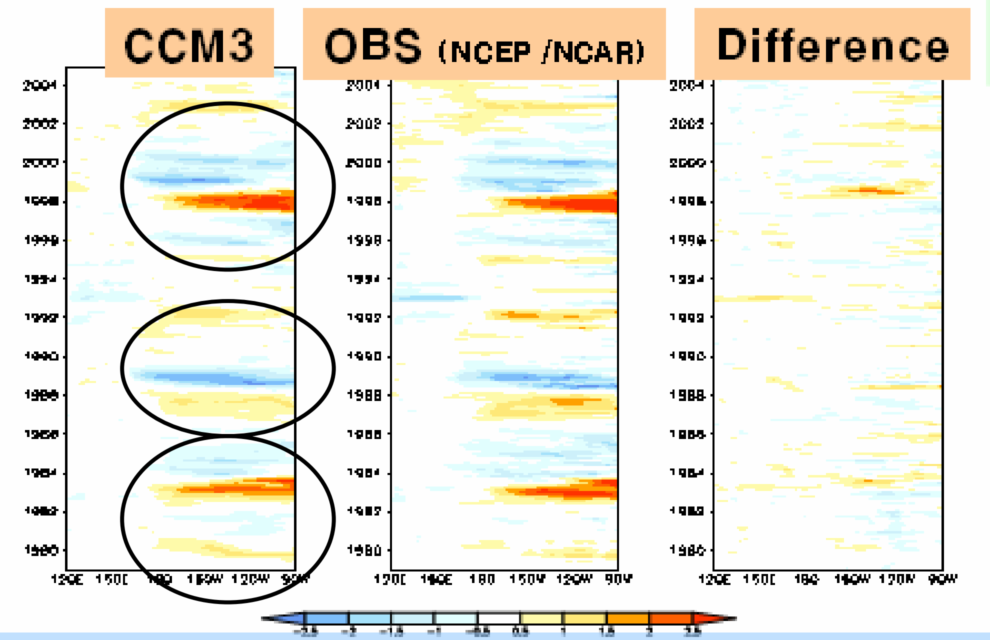
Seasonal prediction system

CME = CCM3(Atmosphere)+MOM3(Ocean)+EVP sea ice model

CGCM = (Coupled General Circulation Model)

Improvement of production method for initial fields

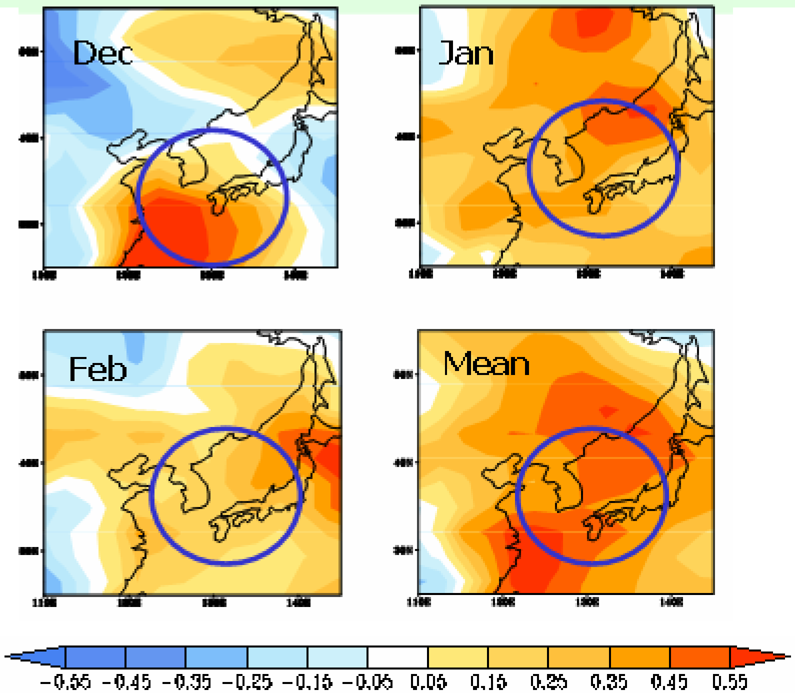
Air temperture (CCM3)



El Nino, La Nina cycle: 2-7year
(Boundary condition of CCM3 : MOM3)

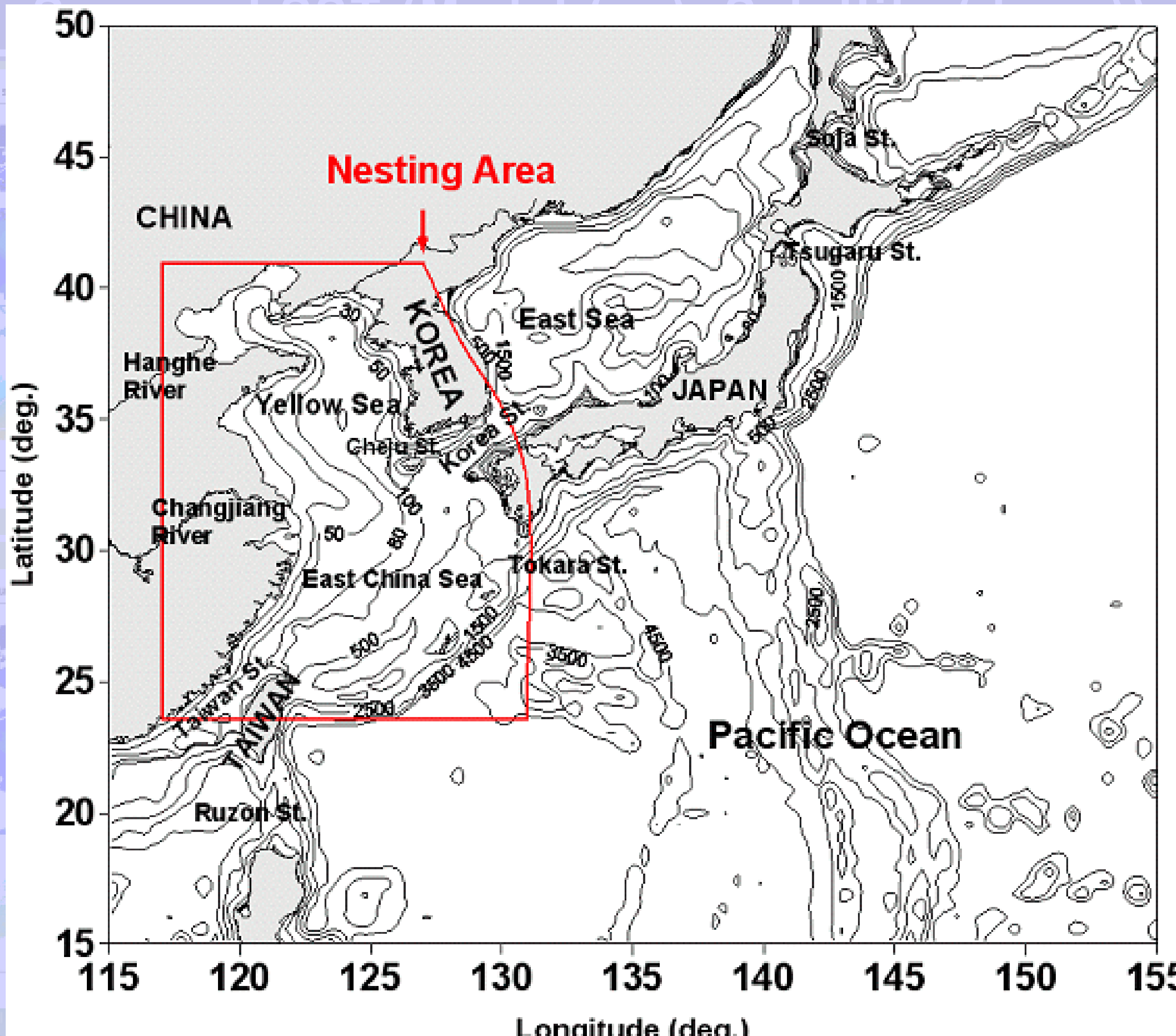
Model result : correlation (air temperature)

Simulation start : October
High correlation (positive)



Regional Ocean Circulation Model

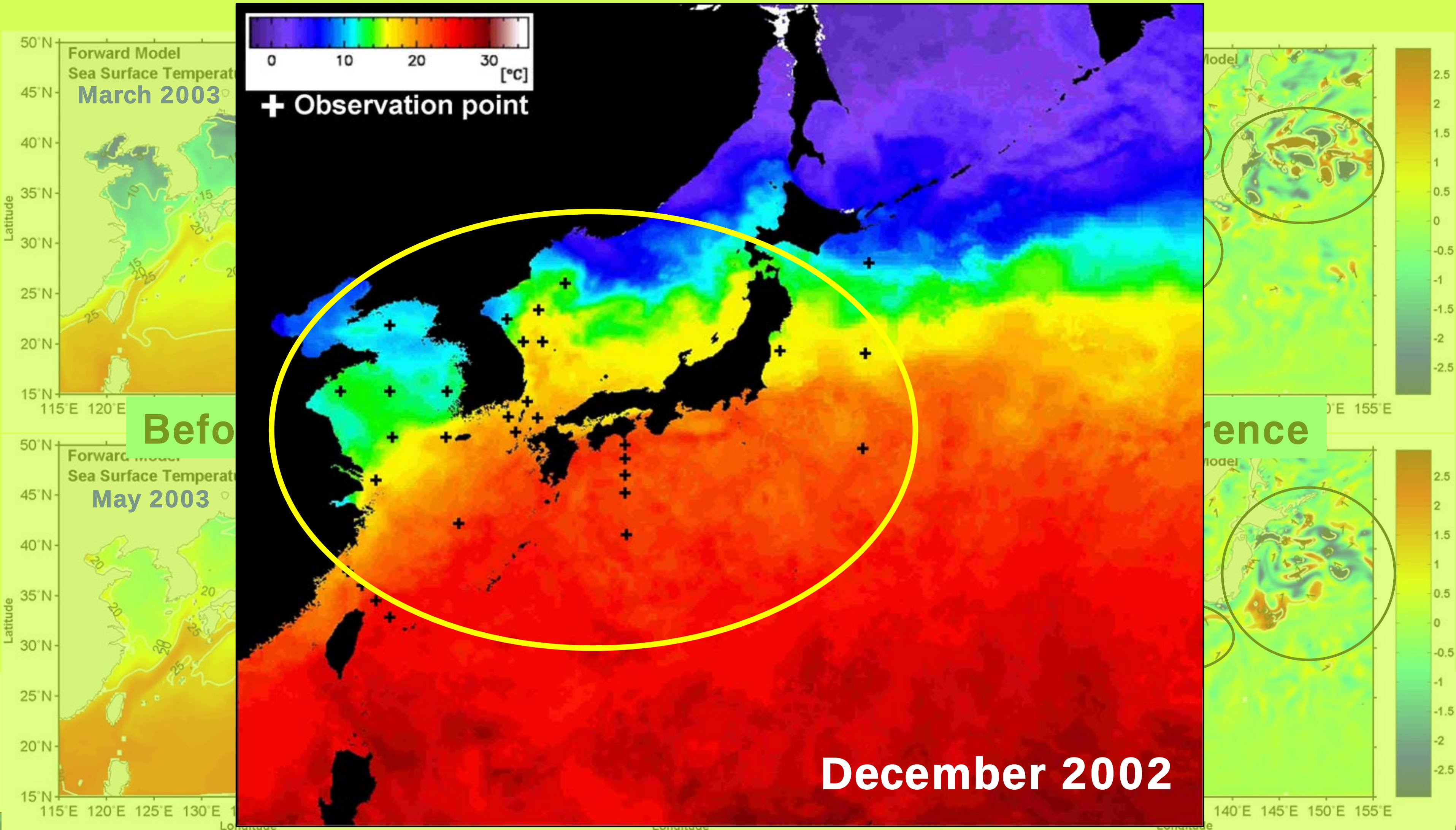
High resolution model in the Yellow Sea



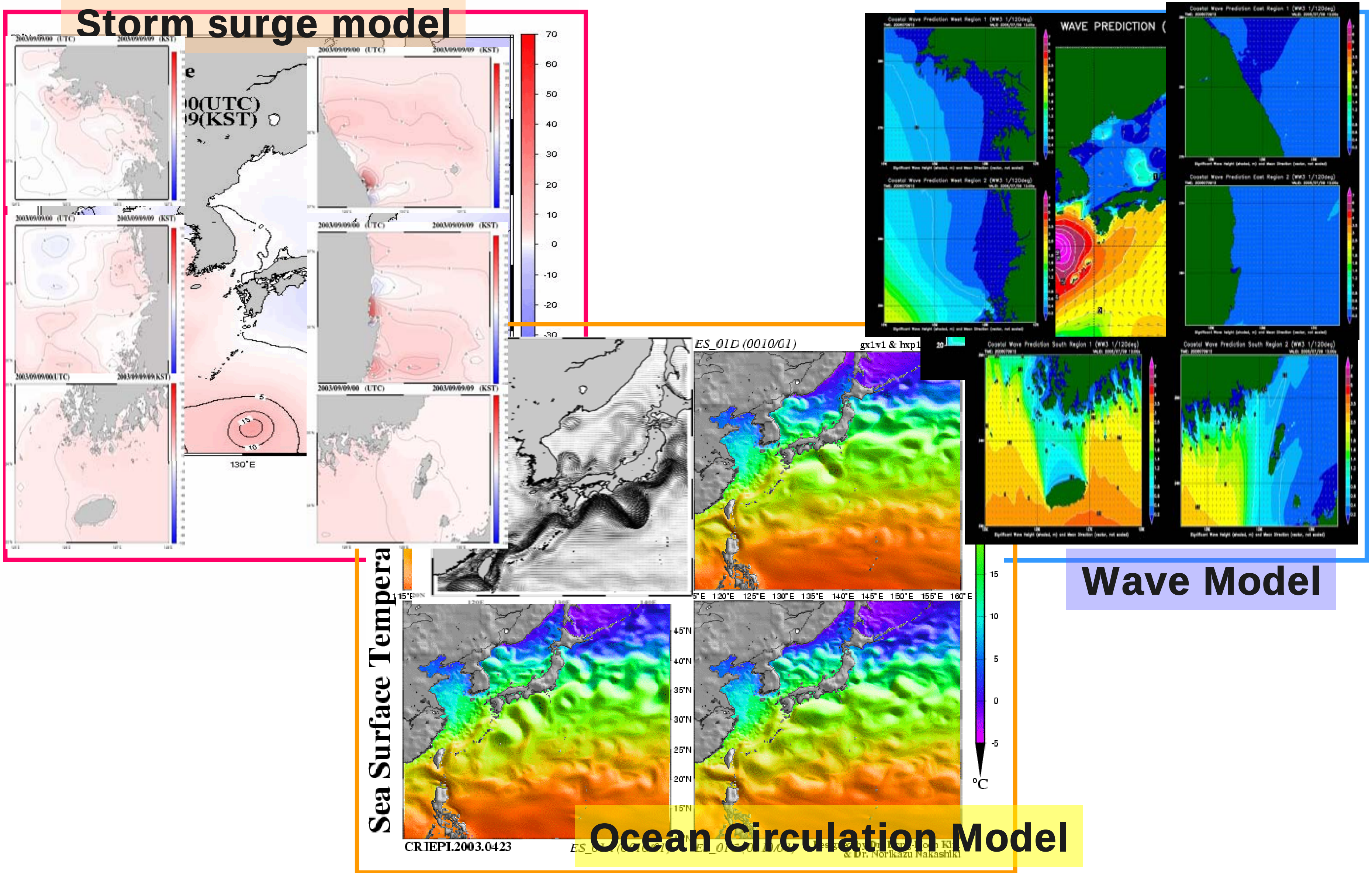
Regional Ocean Circulation Model

Data Assimilation

Ensemble Kalman filter



Coupled Ocean Monitoring System



Necessity of numerical models

The operational storm surge model and wave model are researched and developed in KMA.

The operational models include regional scale models with 30 km, 8 km grid spacing and models with fine domains of coastal areas at 1 km grid spacing.

The Observing system

The real-time data from KMA and NORI were utilized to the real-time verification system.

Consideration of typhoon and tropical cyclone

The accurate prediction of the path and the intensity of typhoon is important to improve the performances of storm surge models.

Additionally, the accurate sea surface winds prediction is needed to the advanced oceanic model results.

Consideration of the local features *of high tide, swell and inundation*

The prediction of storm surge height depends on the strength, path, moving speed of Typhoon, topography and the difference between the rise and fall of the tide and waves.

Storm surge phenomena occur also in fall, winter, spring, not only in summer.

➡ ***In order to represent the above features, the high resolution numerical model, which is able to contain local topographical characteristics, is needed to the advanced model proficiency.***

Demanding the synthetic judgment

Meteorologists in charge of forecasting should utilize monitoring system as well as the numerical model results in determining the conclusion.


DBCP-XXIII
23rd Session of the Data Buoy Cooperation Panel