JMA/WMO Workshop on
Effective Tropical Cyclone Warning in Southeast Asia
Japan Meteorological Agency, Tokyo, 11-14 / Mar / 2014

JMA's International Cooperation in Strom Surge Forecasts in Southeast Asia

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- Introduction
  - Risk of storm surges
  - Situation of storm surges in Southeast Asia
- Storm Surge Information
  - Storm surge model
  - Storm Surge Watch Scheme
- Cooperation in capacity building
- An integrated approach
  - WMO Coastal Inundation Forecast Demonstration Project (CIFDP)
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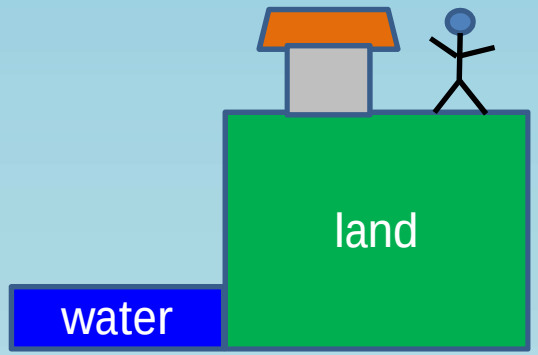
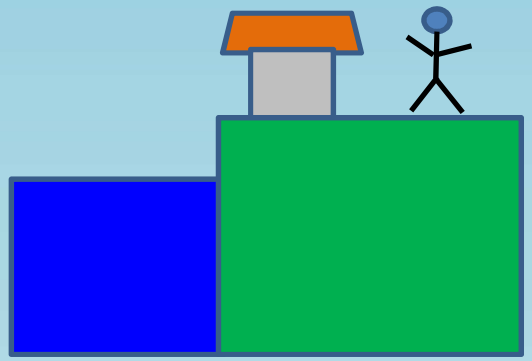
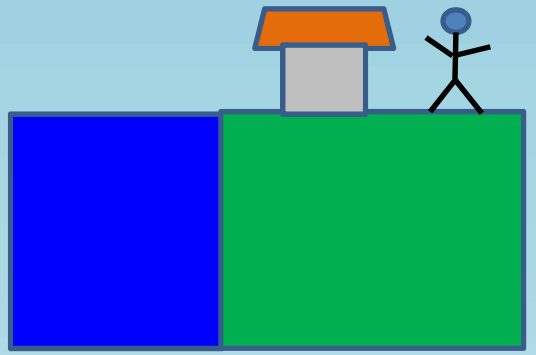
Risk of Storm Surges



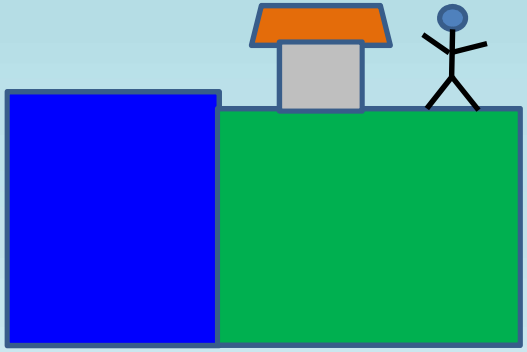
(definitely) Safe



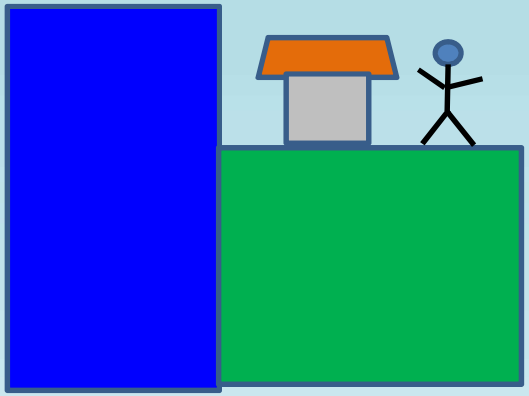
Safe



(still) Safe



danger



Very danger

Risk of storm surges is decided by the difference

Between water level and land height.

Mechanism of storm surges

1. Inverse barometer effect

1hPa pressure decrease ***1cm surge***

2. Wind setup

surge

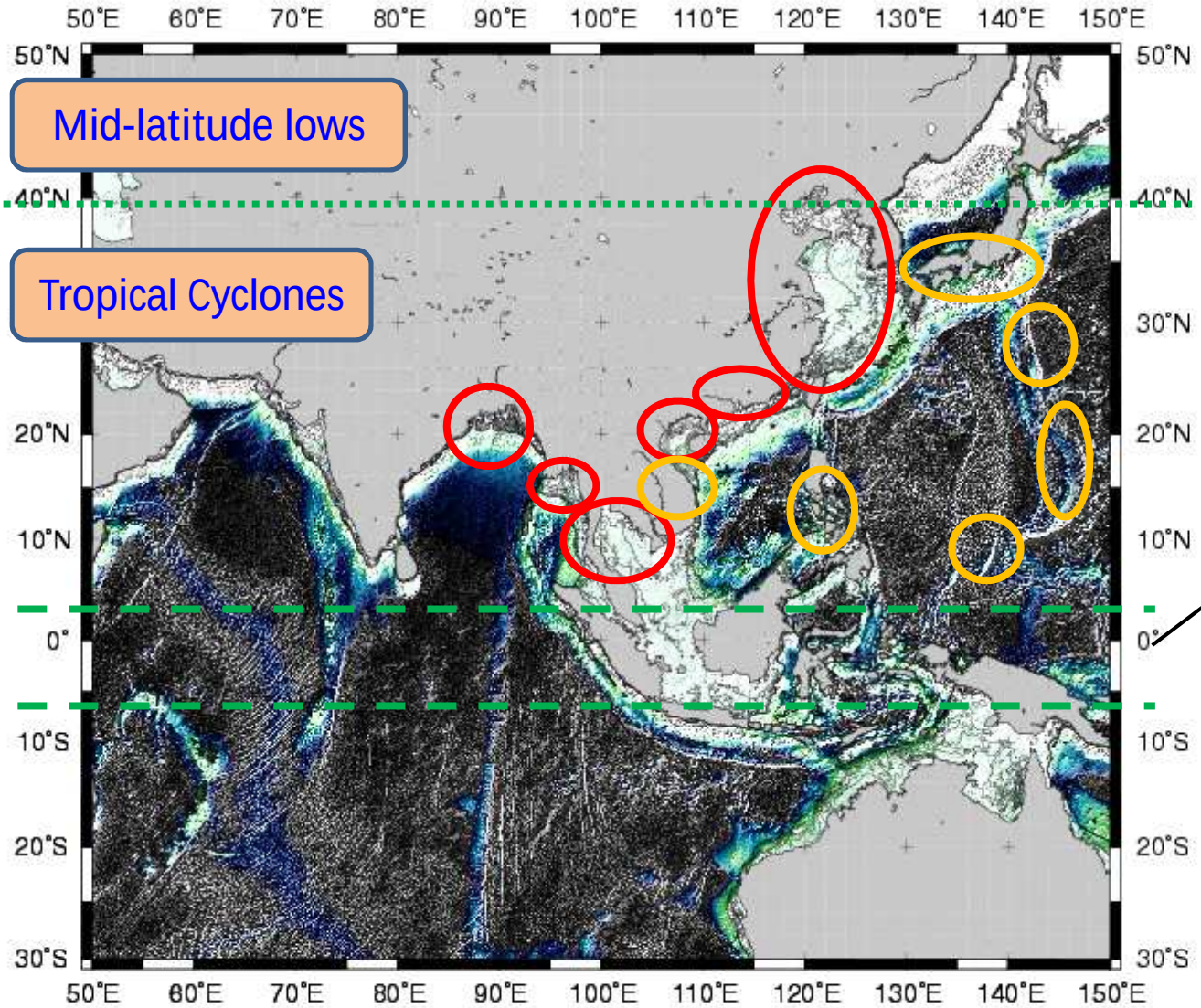
$\propto V^2$ **(*wind stress*: *square of wind speed*)**

$\propto L$ **(*horizontal scale of wind*: *fetch*)**

$\propto 1/h$ **(inverse of water depth)**

Geographic condition

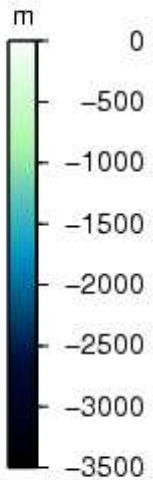
Sea Bathymetry(NGDC ETOPO2)



The area vulnerable to storm surge

large storm surge

Rare Tc



Contours are drawn in every 50m.

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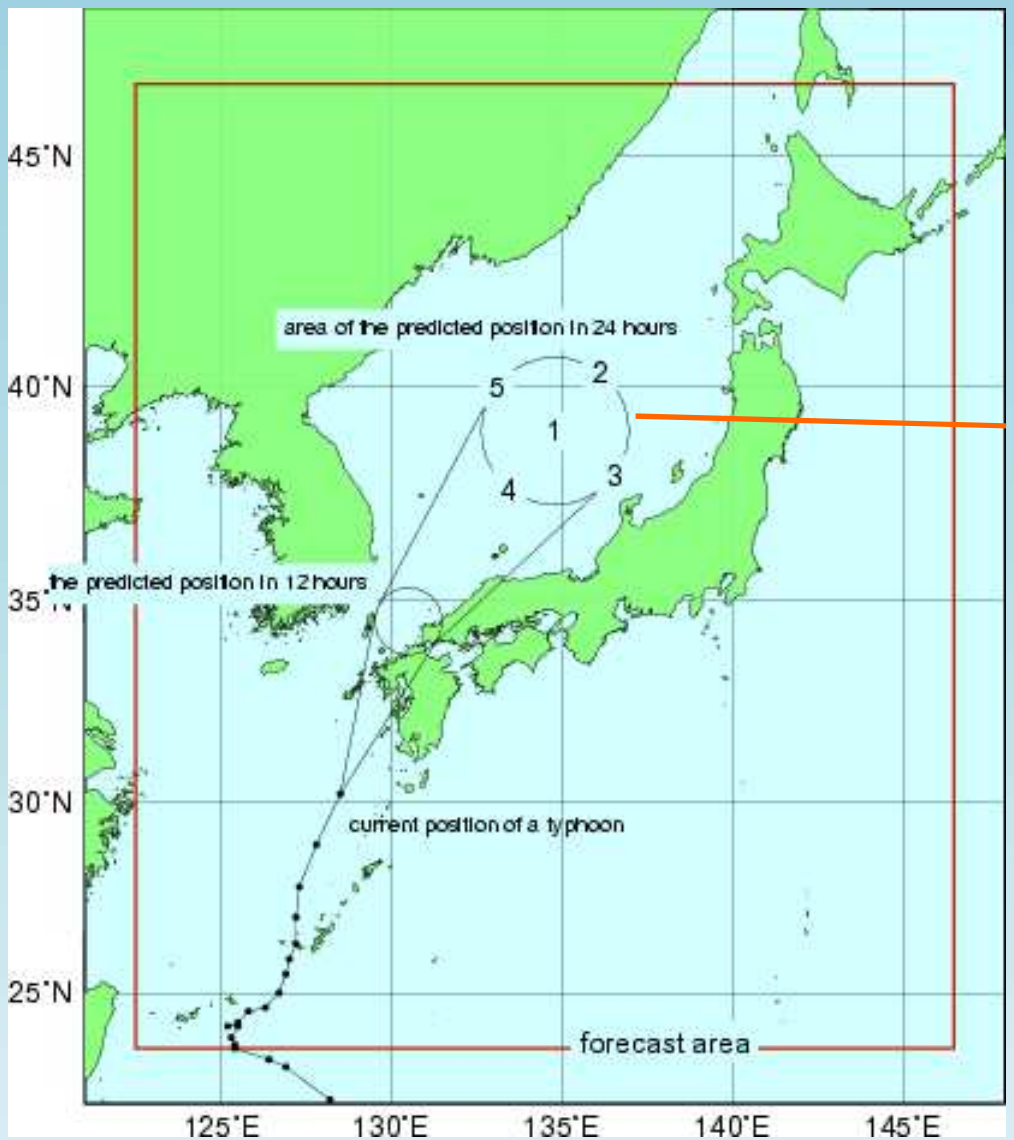
Operational Storm Surge Models at JMA

	Japan Area	**Asia Area**
Model	2 dimensional non-linear model	**2 dimensional lineralized model**
Coordinate	Lat/Lon Cartesian grid Arakawa C-Grid	**Lat/Lon Cartesian grid** **Arakawa C-Grid**
Area	20.0N~50.0N 117.4E~150.0E	**0.0~46.0N** **95.0E~160.0E**
Grid resolution	45’’×30’’～12’×8’ (1km~16km) Adaptive Mesh Refinement (AMR)	**2’×2’** **(3.7km)**
Time step	4 seconds	**8 seconds**
Forecast hours	33(30)	**72**
Calculation run	8 times / day (3 hourly)	**4 times / day** **(6 hourly)**
Initial time (UTC)	00,03,06,09,12,15,18,21	**00,06,12,18**
Number of prediction courses	In case of Typhoons: 6 courses (Center, 4 courses on the forecast circles, NWP predicted course) No typhoon: **1** course (NWP course)	**1 course** **(NWP predicted course)**
forcing	MSM GPV (5km)	**GSM GPV (20km)**
Typhoon bogus	**Pressure profile: Fujita(1952)** **Gradient wind (with inflow angle 30 deg.)** **Asymmetric component by typhoon movement**	

5 model runs for 5 possible typhoon tracks



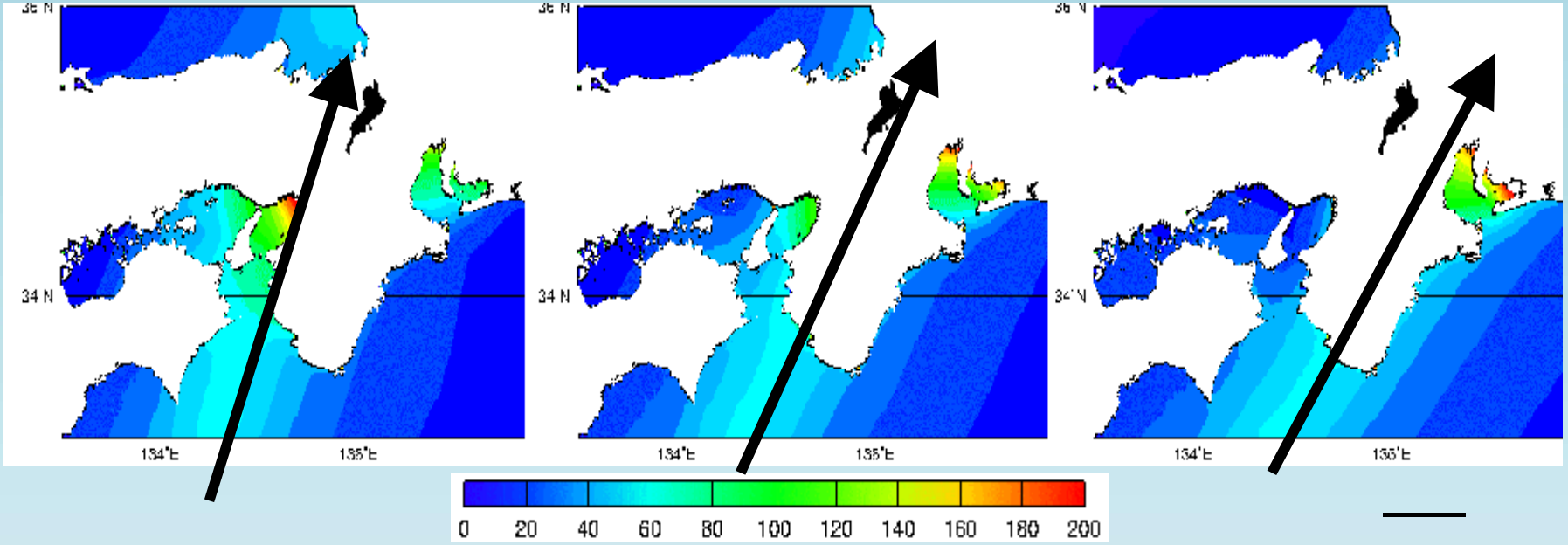
- The model runs for 5 possible tropical cyclone tracks to cover a major set of scenarios.

1. Center track with highest possibility
2. Faster track
3. Rightward biased track
4. Slower track
5. Leftward biased track

Why do we need “ensemble” Predictions?

Storm surge behaviors strongly depend on typhoon tracks.

Left Center Right



WMO Storm Surge Watch Scheme (SSWS)

Real-time storm surge information issued for TC Members by the RSMC Tokyo

- Storm surge distribution maps (2011.6 -)
- Storm surge time series charts (2012.6 -)

History

2008.6 60th WMO Executive Council (Geneva, 2008.6)
Request to WMO/SG to facilitate development of Storm Surge Watch Scheme.

2008.12 14th Regional Association II (Tashkent)

2009.1 41st Typhoon Committee (Chiang Mai)
plan for the establishment of a Regional Storm Surge Watch Scheme suitable for the TC region.

2010.1 42nd Typhoon Committee (Singapore)
request to Members of providing tidal data & bathymetric data to RSMC Tokyo.
(System development in JMA)

2011.6 RSMC Tokyo has started operation to provide storm surge distribution maps through its Numerical Typhoon Prediction (NTP) website.

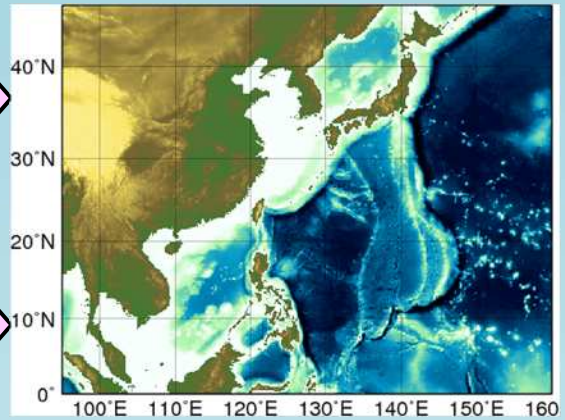
2012.6 RSMC Tokyo has started to provide storm surge time series charts at one point for each TC Member (forecasting points to be increased in due course).

2013.6 RSMC Tokyo extended forecasting region and added seven stations for time series charts.

Asia Area Storm Surge Model

Global Spectral Model (GSM)
Sea Level Pressure winds

Typhoon Information
Locations, Central pressure, wind etc



- 2 min. resolution (3.7km)
- 72 hours forecast
- 3 hourly product
- 4 times run a day (00/06/12/18 UTC)

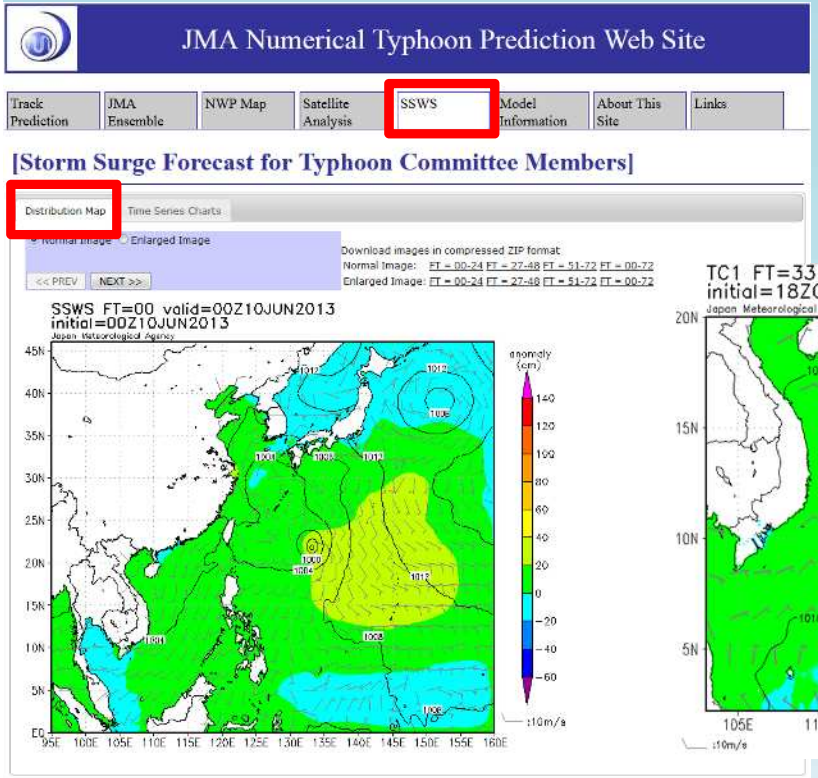
Products are provided to the Typhoon committee members via the JMA Numerical Typhoon Prediction (NTP) Website

Product examples (1)

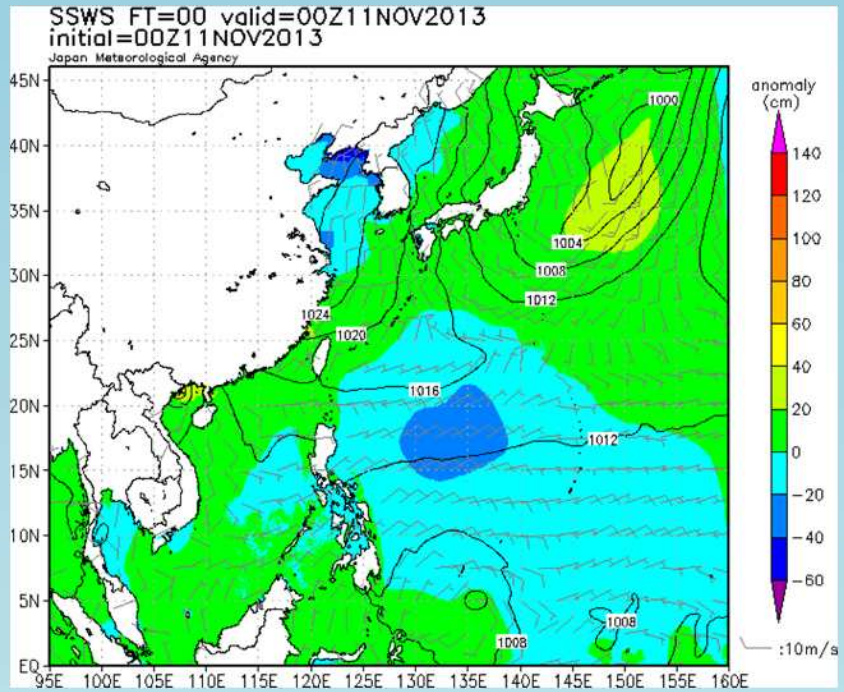
Horizontal storm surge maps

- Whole domain maps and enlarged ones around a typhoon (3hourly, up to 72 hours) are provided **(1 June, 2011 ~)**

JMA Numerical Typhoon Prediction (NTP) Website (https://tynwp-web.kishou.go.jp/)

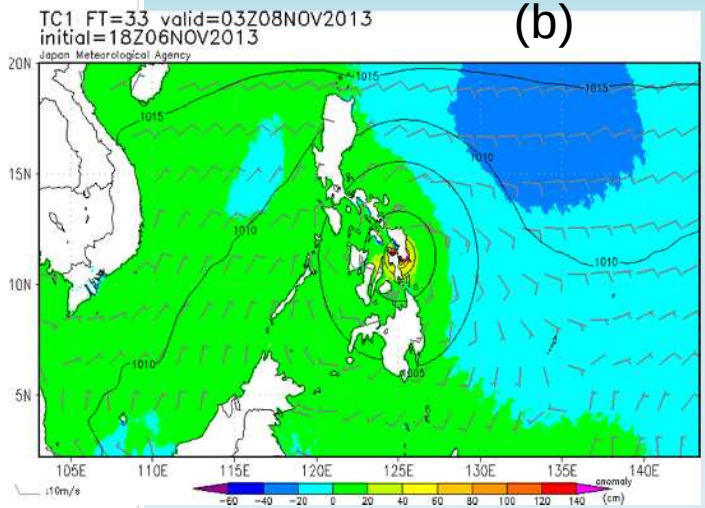


(a)



(a) storm surge map

(b)



(b) enlarged map

(The map data can be downloaded too.)

Product examples (2)

Time series charts at selected stations

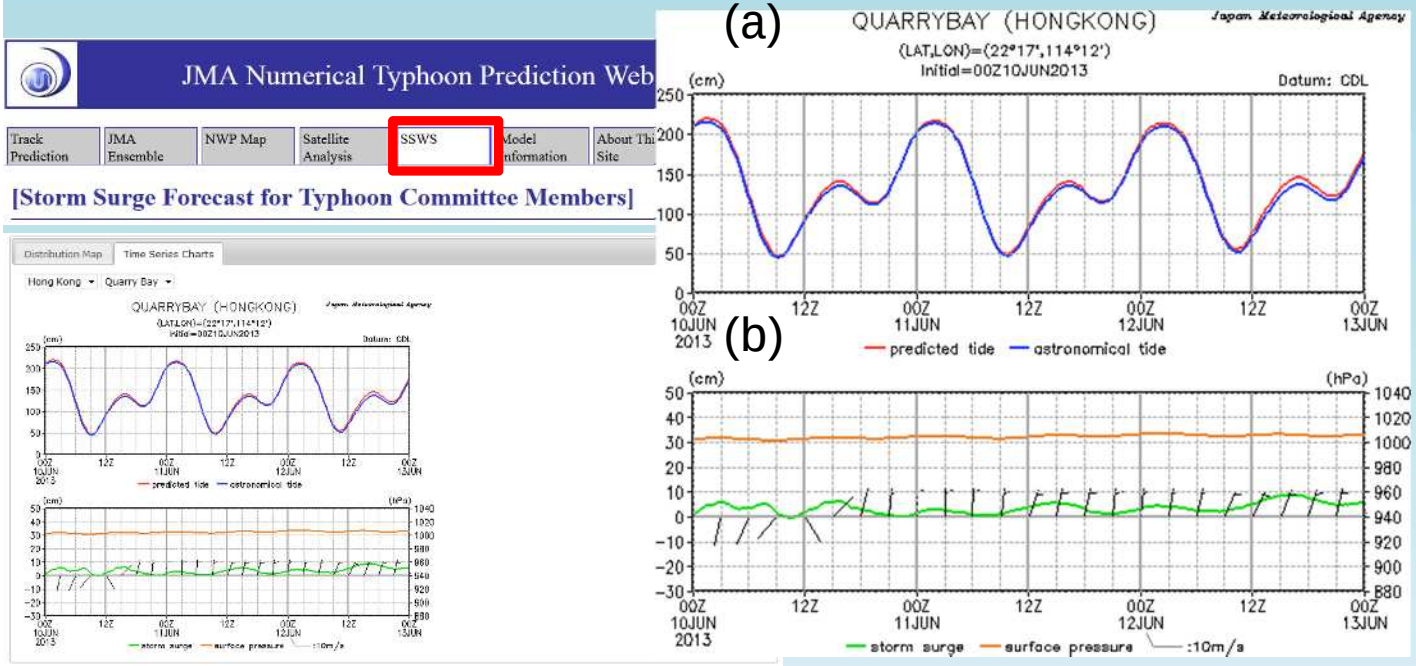
Predicted storm surges / tides, astronomical tides, sea level pressures and winds are provided

- Current: 10 stations

  Macao, Quarry Bay (Hong Kong), Hua Hin, Chum Phon (Thailand),

  Incheon, Boryeong, Mokpo, Busan, Jeju, Sokcho (Korea)

- 9 stations (Philippines), 20 stations (Vietnam), and 1 stations (Guam, US) (*in 2014*)
- stations will further increase upon request from TC Members



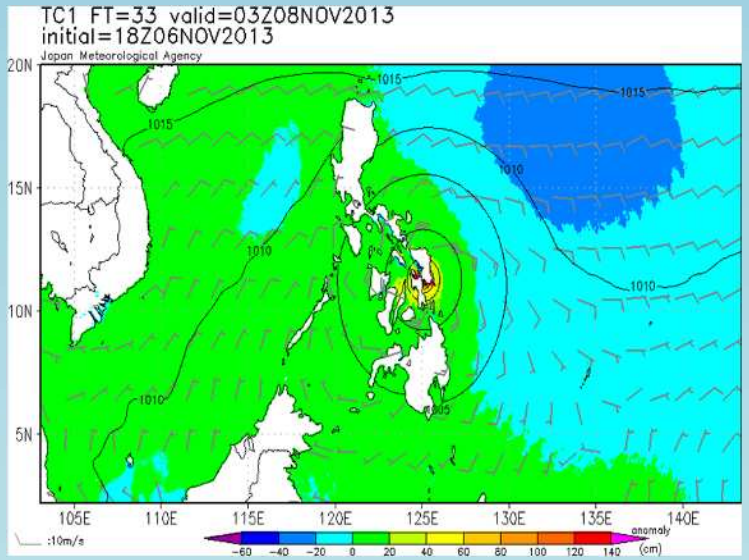
(a) Predicted (red) and astronomical (blue) tides

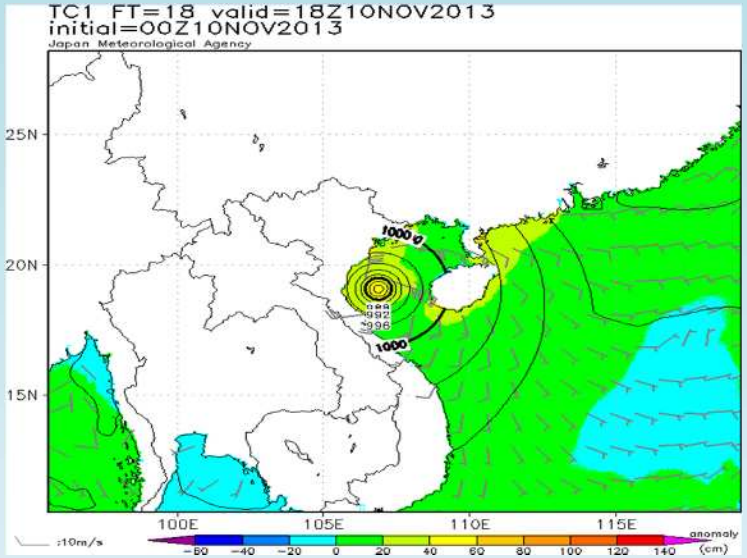
(b) Storm surges (green), surface pressure (orange) and wind barbs

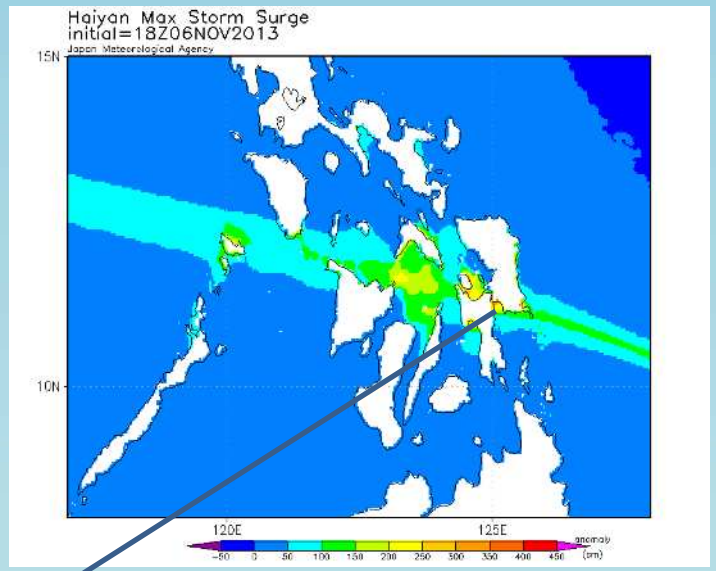
Example of a time series data at Quarry Bay (Hong Kong)

SSWS Product for Ty Haiyan

JMA issues storm surge distribution maps, but it becomes invisible when pressure contours are densely drawn.





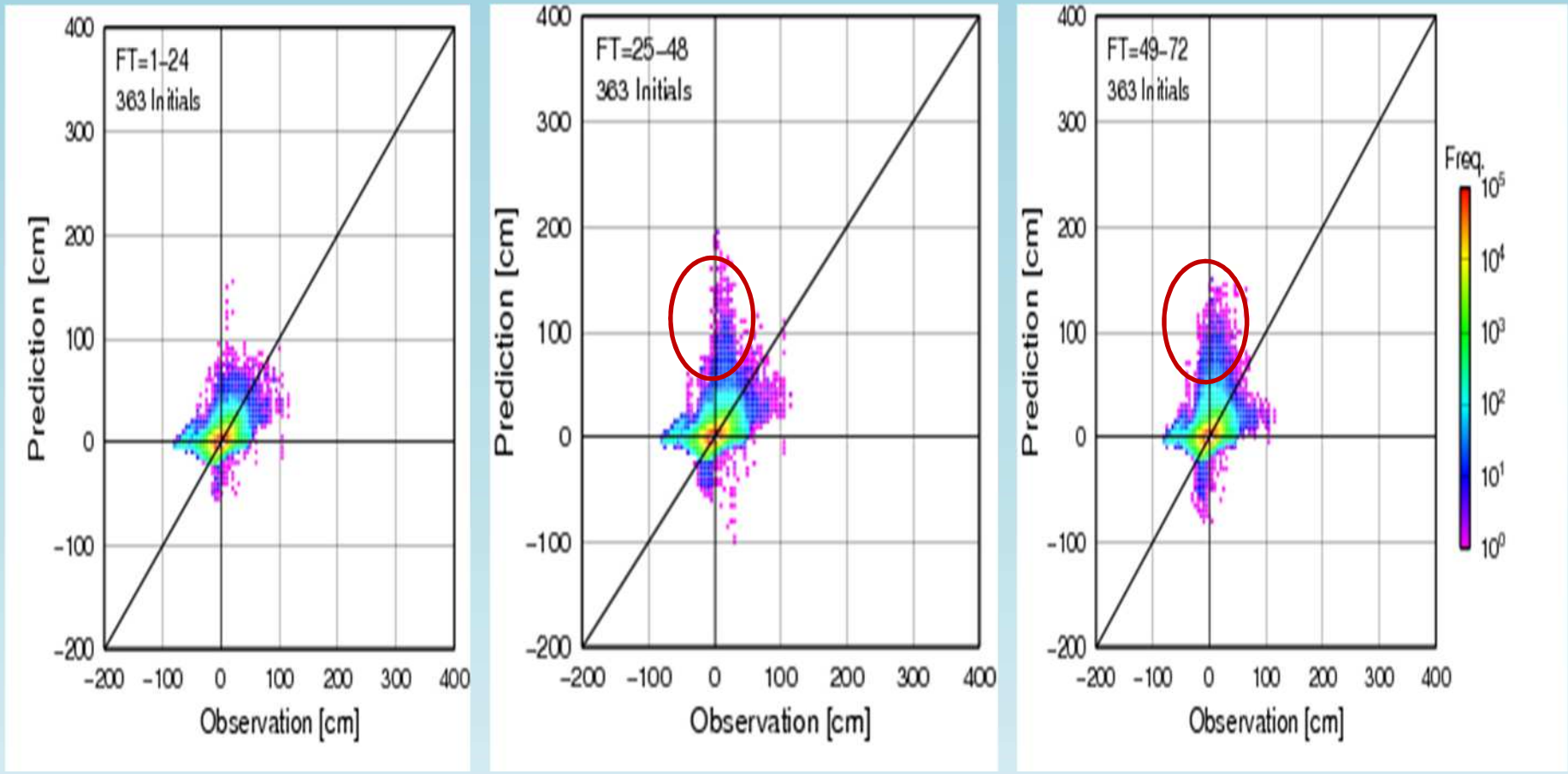


Predicted maximum storm surge: 3.7m

We are now planning to modify the map image , so that , the maximum surge height can be easily recognized.

Accuracy of Asian region storm surge model (August – November, 2013)

Comparison with tide observed data in Japan



The main cause of errors seems to be the error of typhoon position.

Improvement plan

- Modification of storm surge model products
- To add more stations for time series
- To improve storm surge model accuracy
- Enhanced information (probabilistic / inundation)

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JMA collaboration with NMHSs

JMA also trains staff of other National Met. / Hydro. Services and provides storm surge model for using their own operation.

- **ESCAP/WMO Typhoon Committee Attachment Training at the RSMC Tokyo**
- **TCP/JCOMM Technical workshop**
- **JICA training course**
- **individual visits**

(Recent one)

Training and Capacity building on Storm Surge Modeling and Risk Mapping

(24-28, June, 2013, in Bangkok)

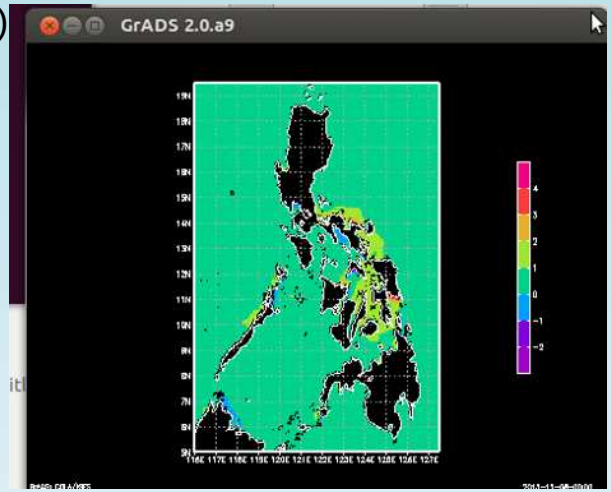
Organized by Asian Disaster Preparedness Center (ADPC),

Supported by UNESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness and the MOFA(Norway)

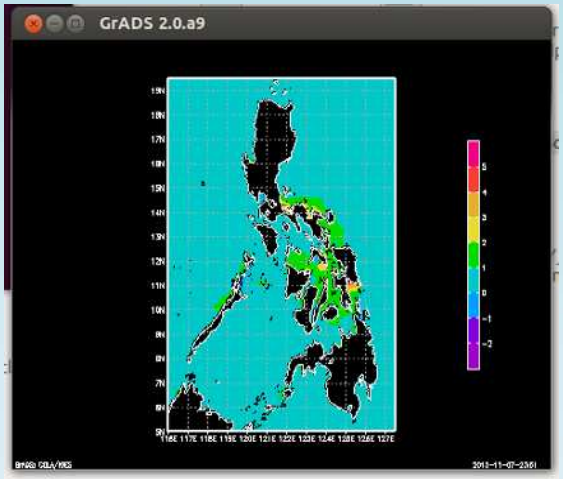
Participants: PAGASA(Philippines), DMH(Myanmar), DOM(Sri Lanka), NHMS(Vietnam), TMD(Thailand)

Example of storm surge prediction by Ty Haiyan, operationally simulated by PAGASA staff

(a)



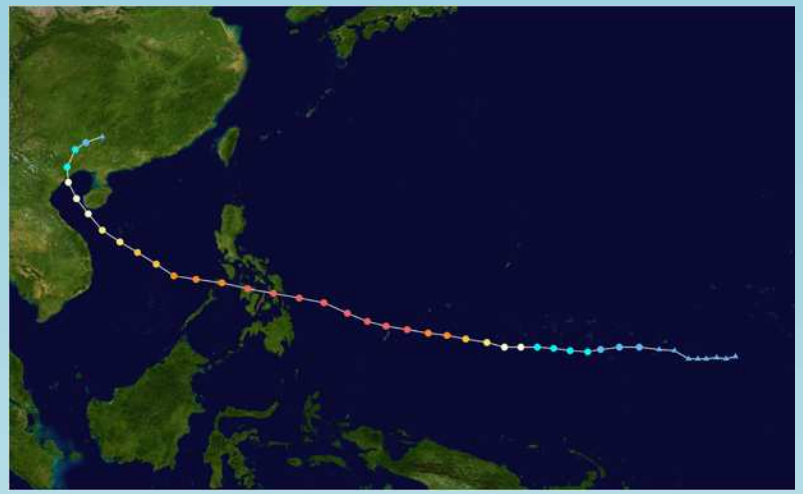
(b)

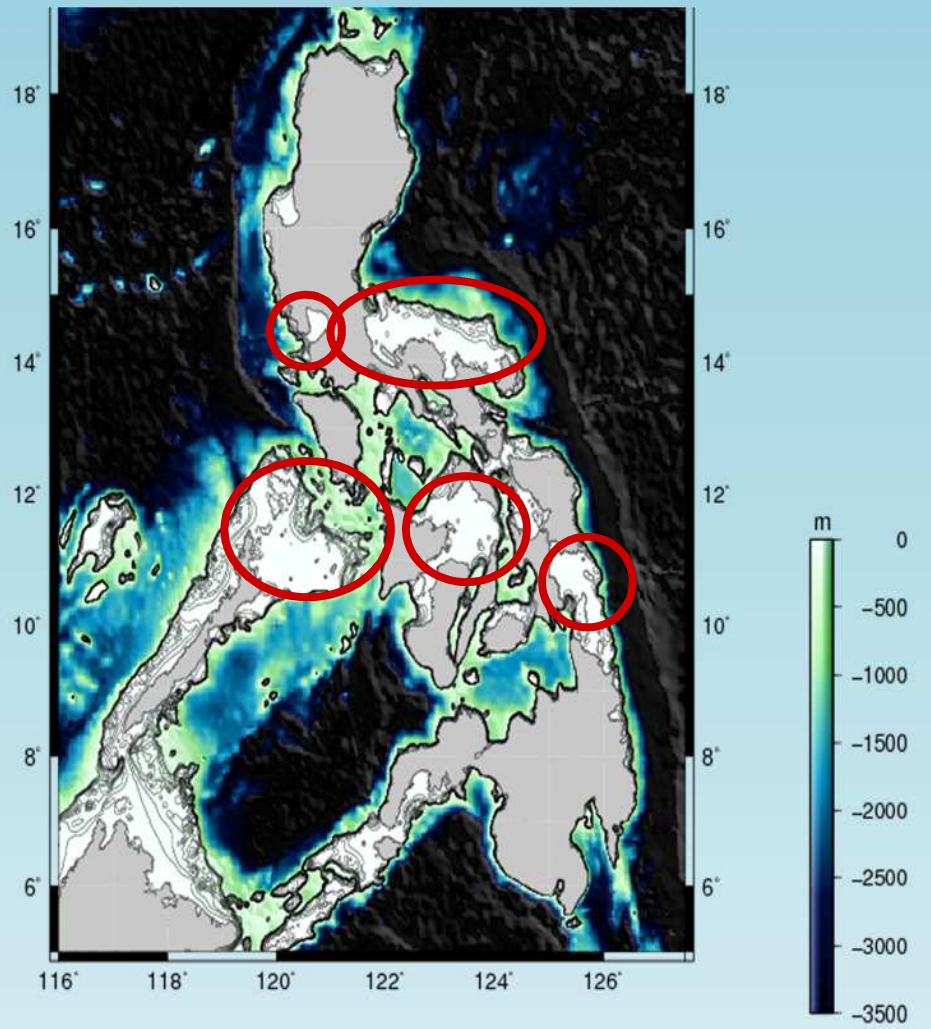


(a) 03UTC (3 hours forecast)
(b) 06UTC (6 hours forecast)

Initial: 00UTC on NOV 08

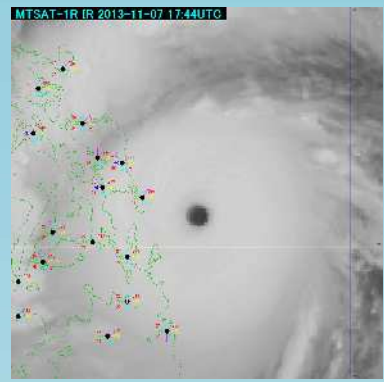
Storm surges by Typhoon Haiyan (1330)





Bathymetry of the Philippines

Operational Analysis



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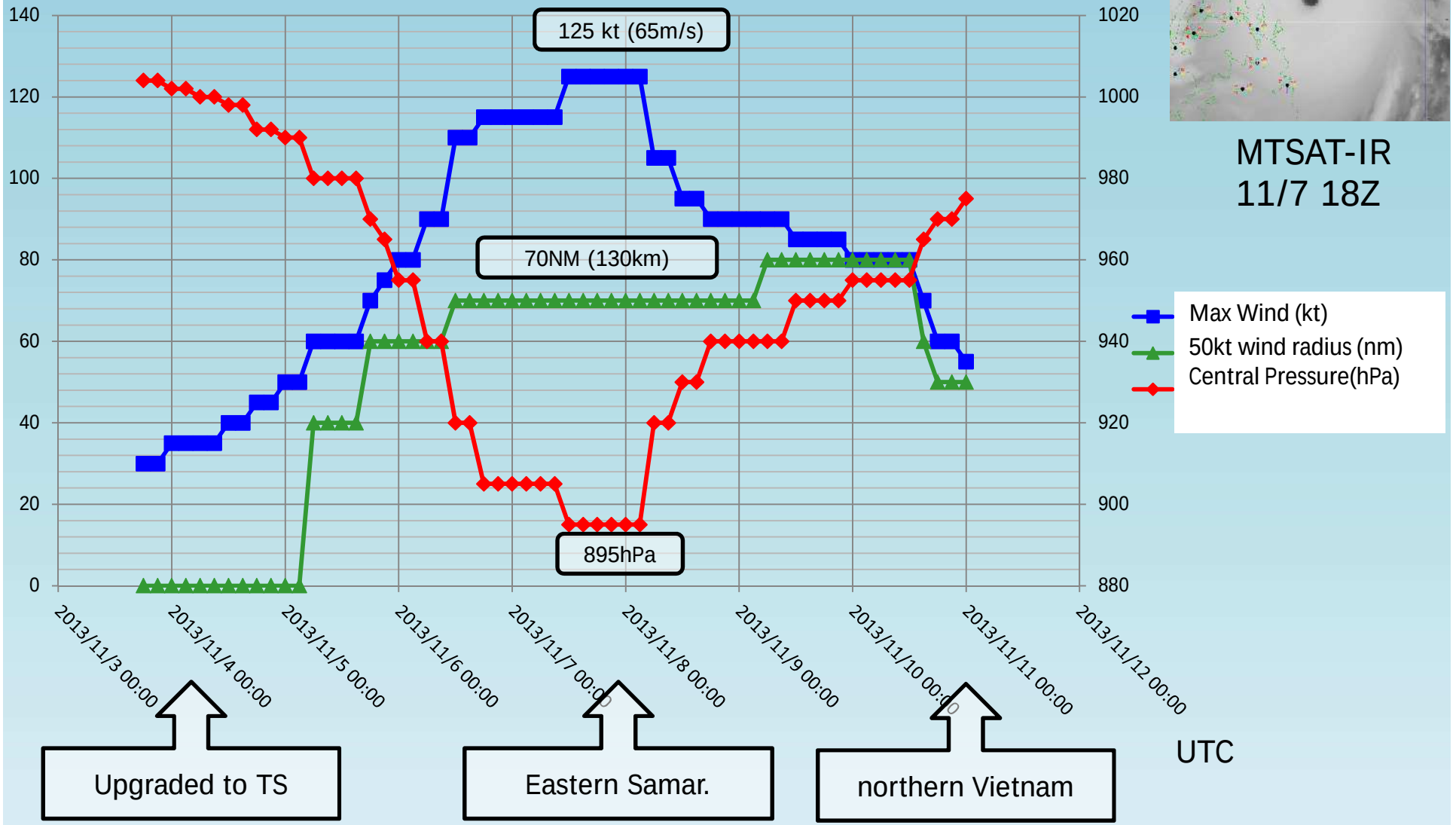
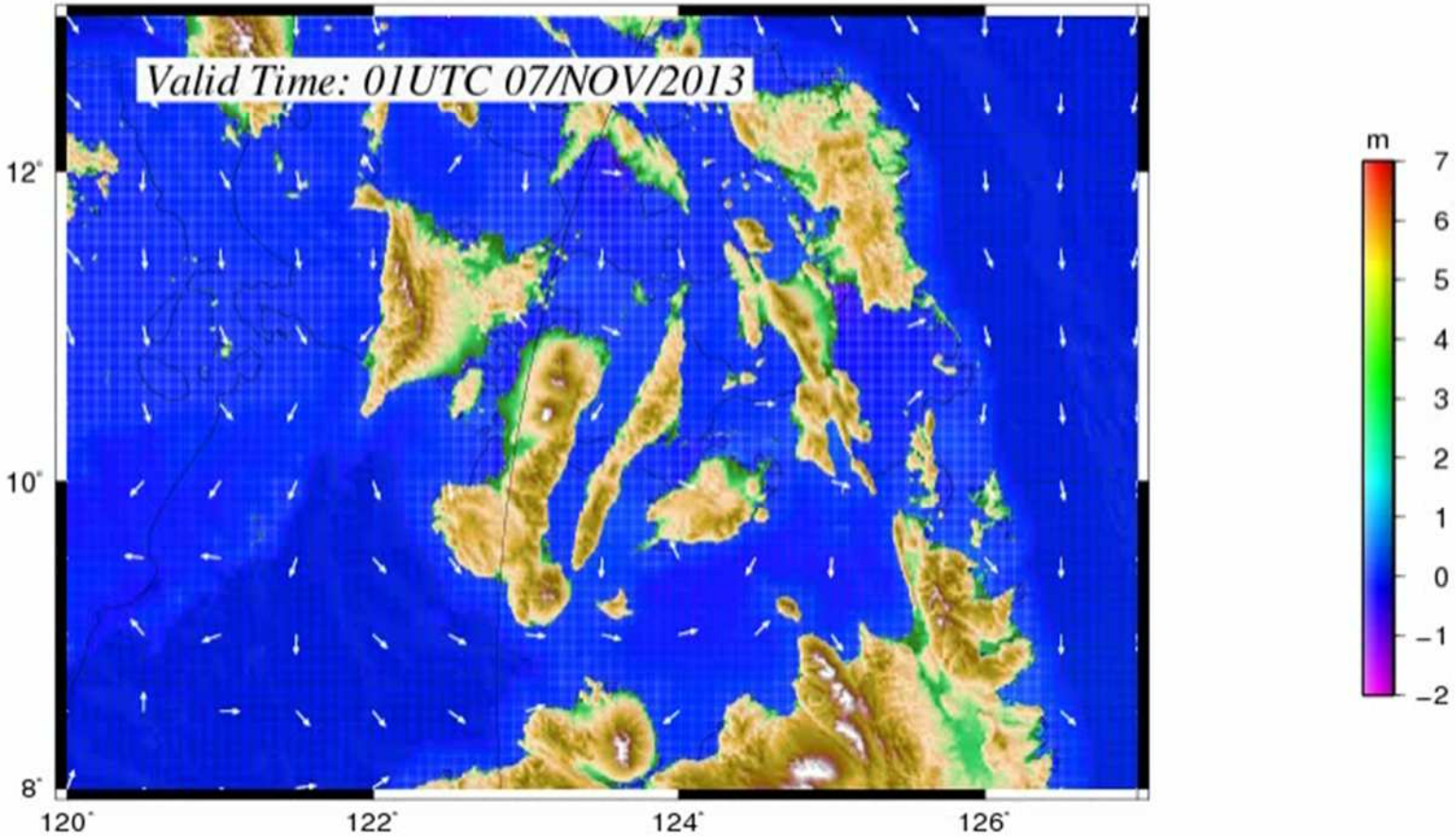
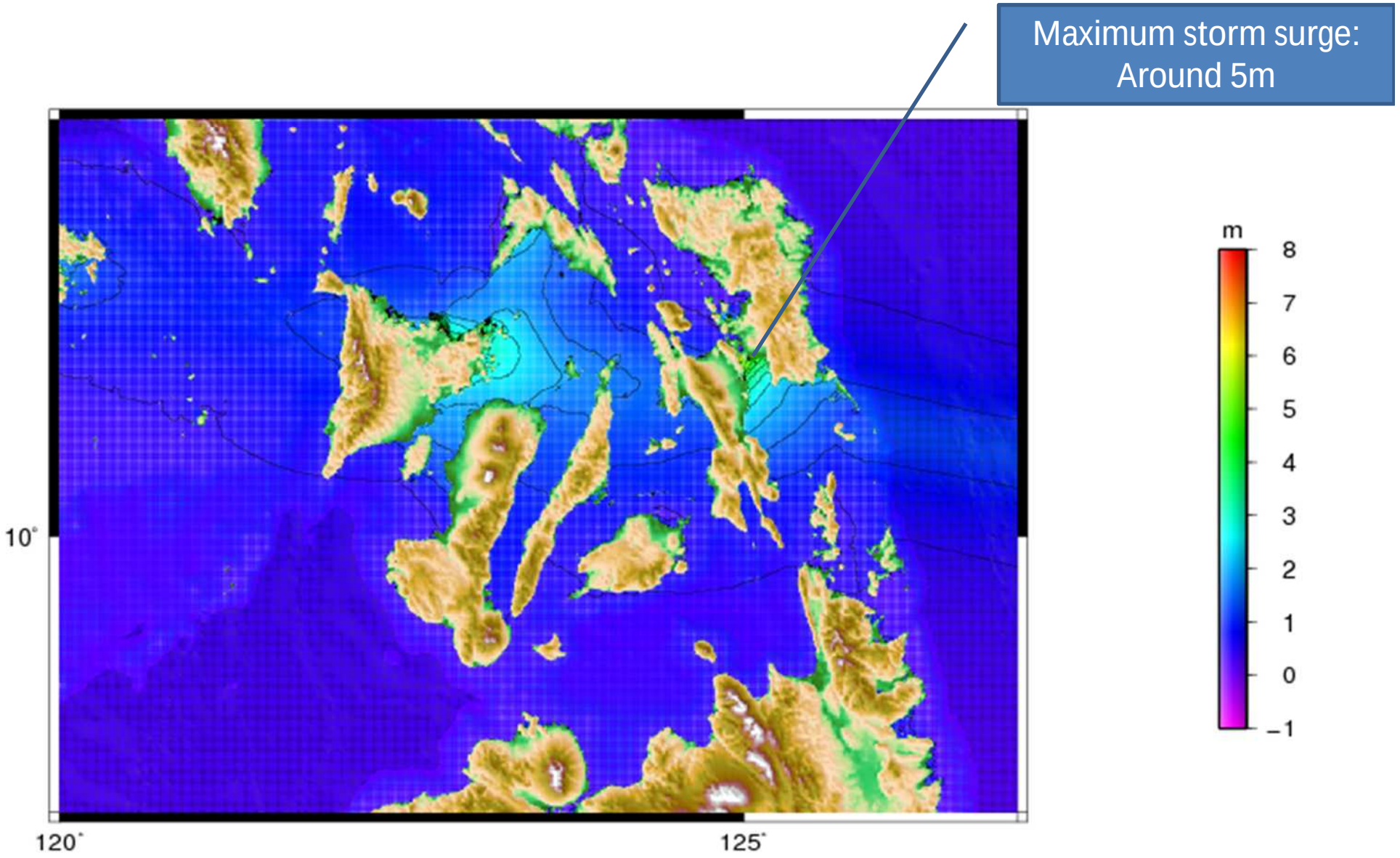
11/7 18Z



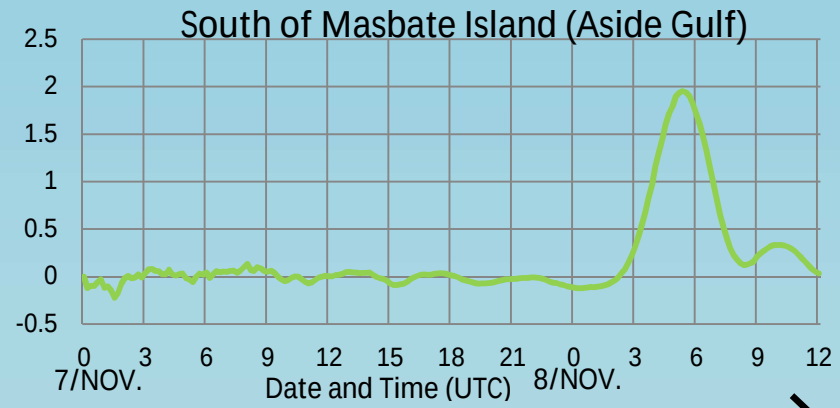
Storm Surges in Philippines by Ty Haiyan

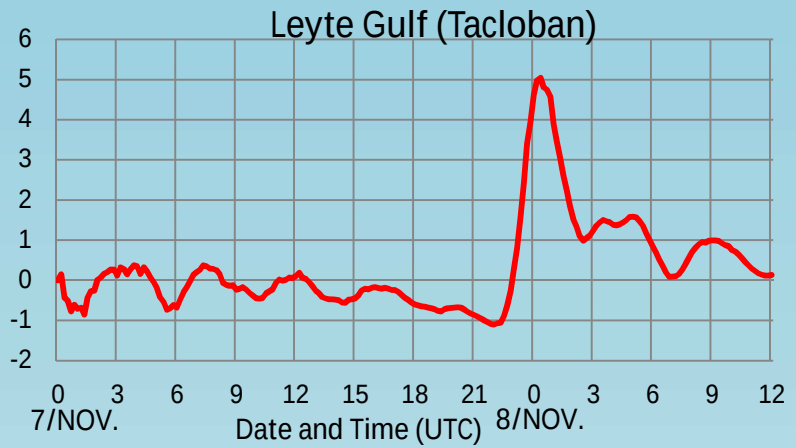


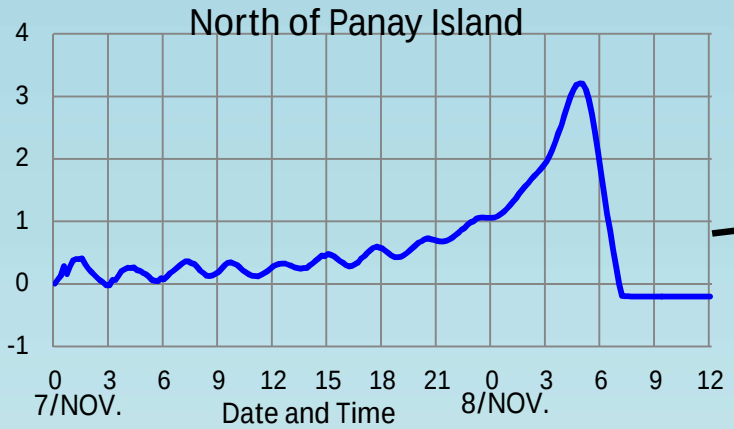
Maximum storm surge by Ty Haiyan

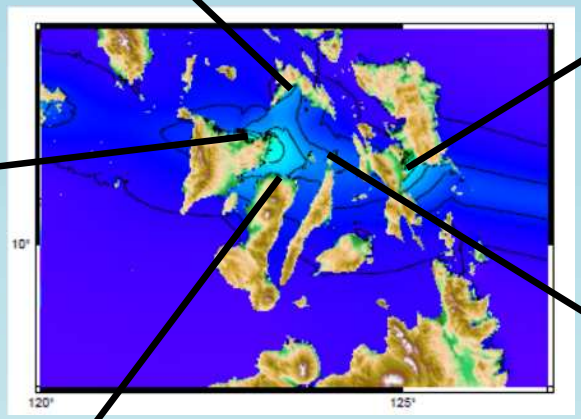


Storm surges by Ty Haiyan

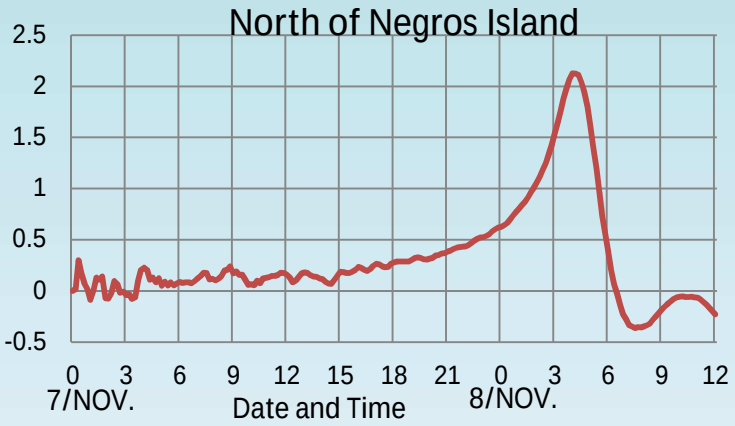


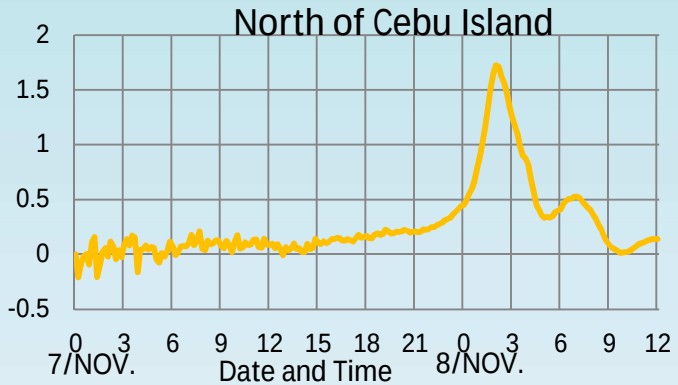






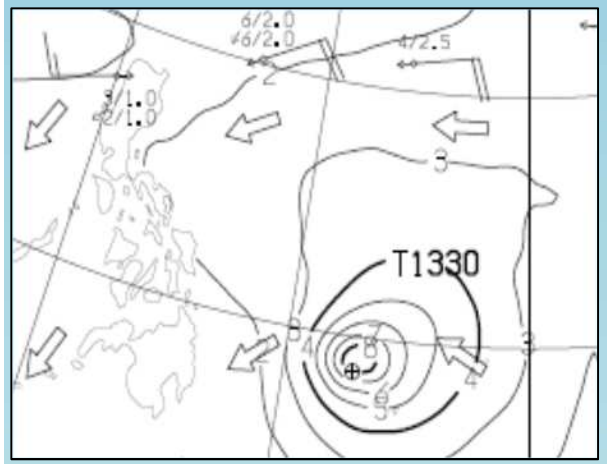
Storm surge (m)



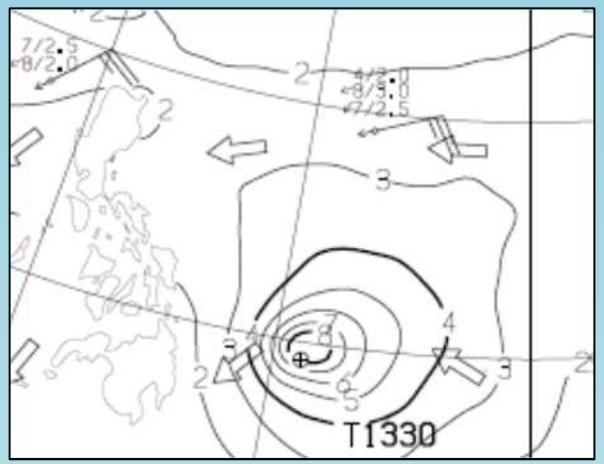


Ocean waves by Ty Haiyan

Significant wave heights (m)



00UTC 07 NOV 2013



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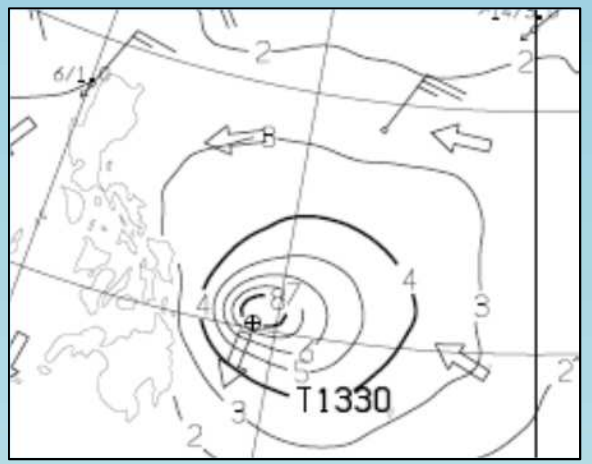

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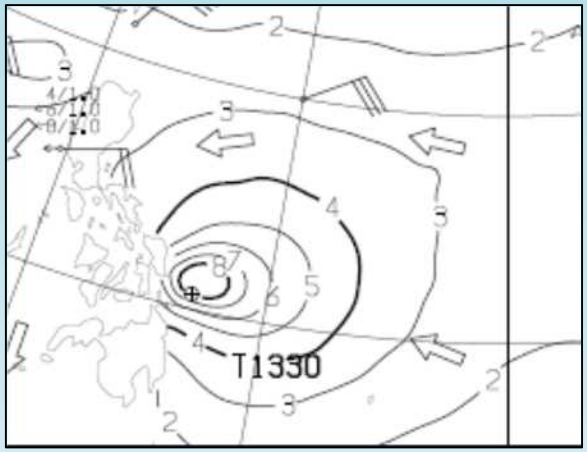
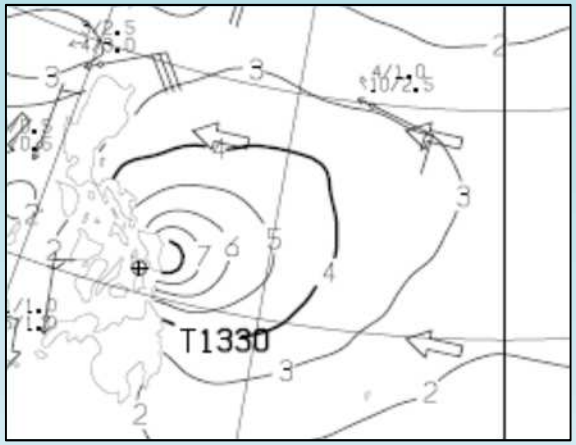


18UTC 07 NOV 2013



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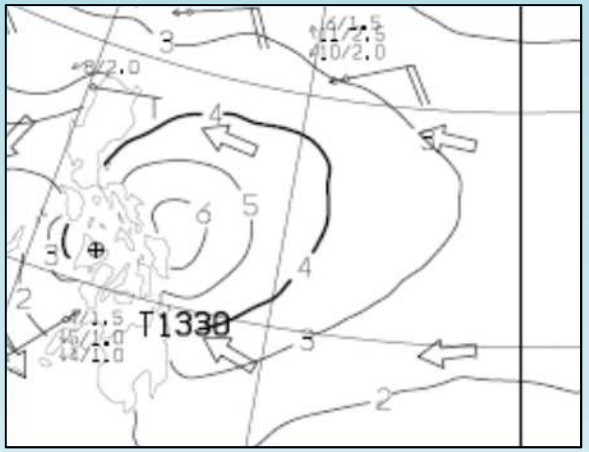

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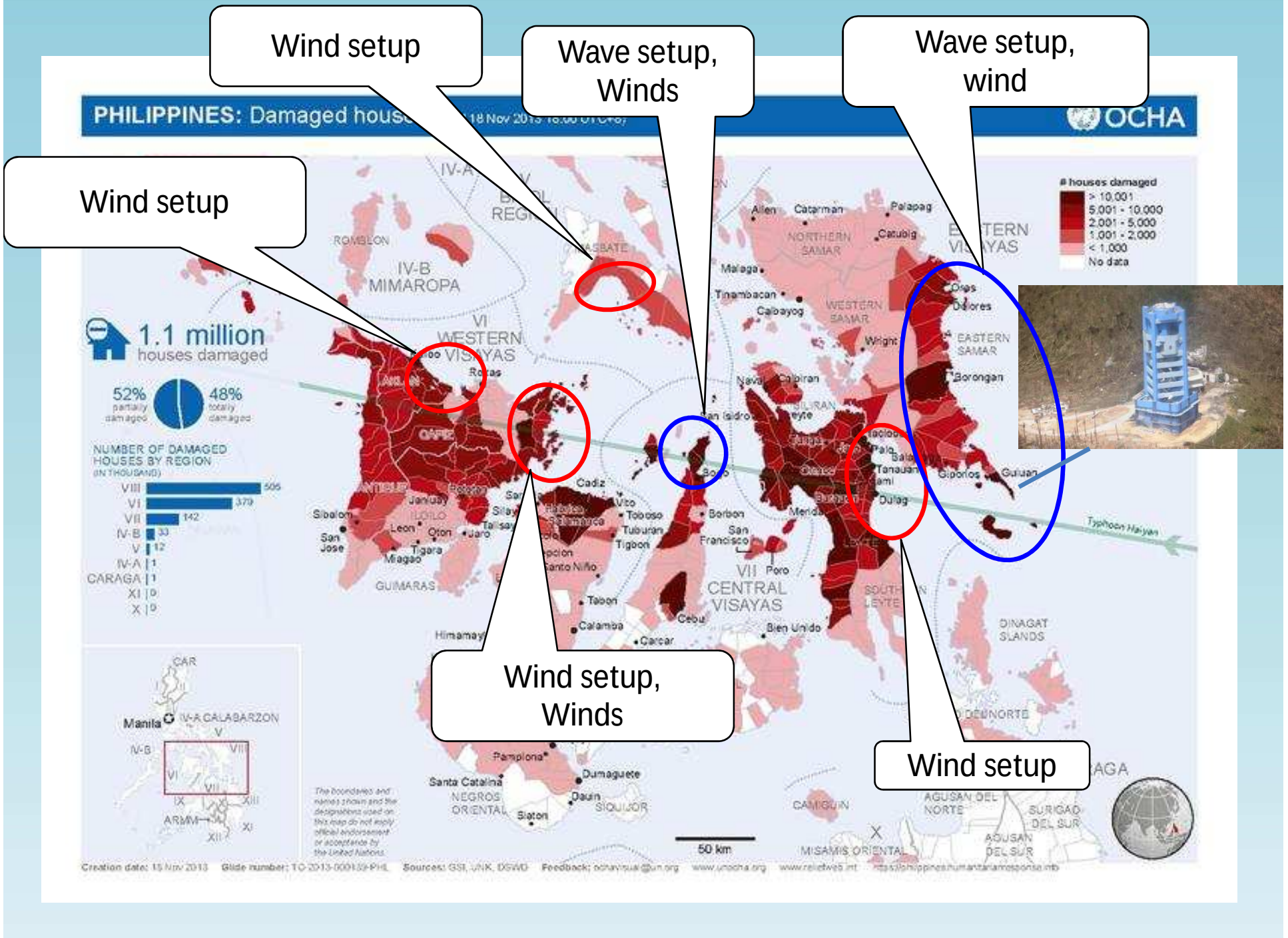
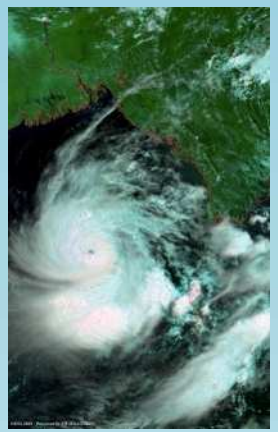
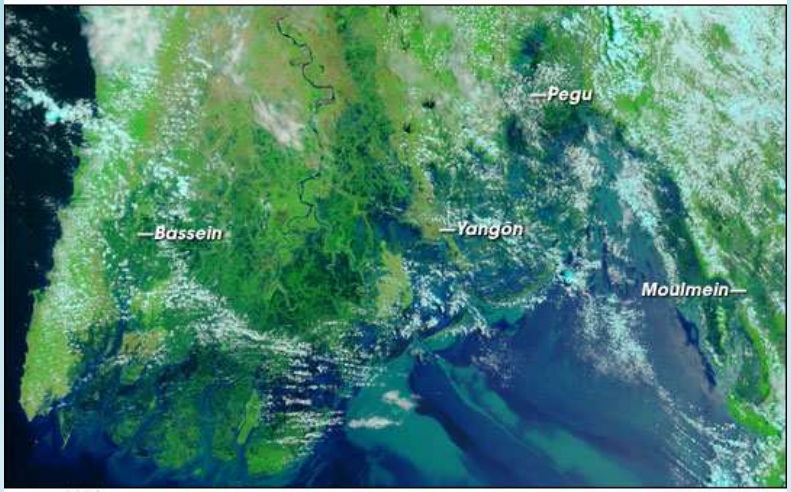

Wind setup
Wave setup, Winds
Wave setup, wind
Wind setup
Wind setup, Winds
Wind setup
PHILIPPINES: Damaged house
OCHA
houses damaged
> 10,001
5,001 - 10,000
2,001 - 5,000
1,001 - 2,000
< 1,000
No data
1.1 million
houses damaged
52% partially damaged
48% totally damaged
NUMBER OF DAMAGED HOUSES BY REGION
(IN THOUSAND)
VIII 506
VI 379
VII 142
IV-B 33
V 12
IV-A 1
CARAGA 1
XI 0
X 0
IV-B MIMARODA
VI WESTERN VISAYAS
VII CENTRAL VISAYAS
NORTHERN SAMAR
WESTERN SAMAR
EASTERN SAMAR
DINAGAT ISLANDS
Typhoon Haiyan
Manila
IV-A CALABARZON
50 km
Creation date: 15 Nov 2013

Storm Surge by Cyclone Nargis in 2008



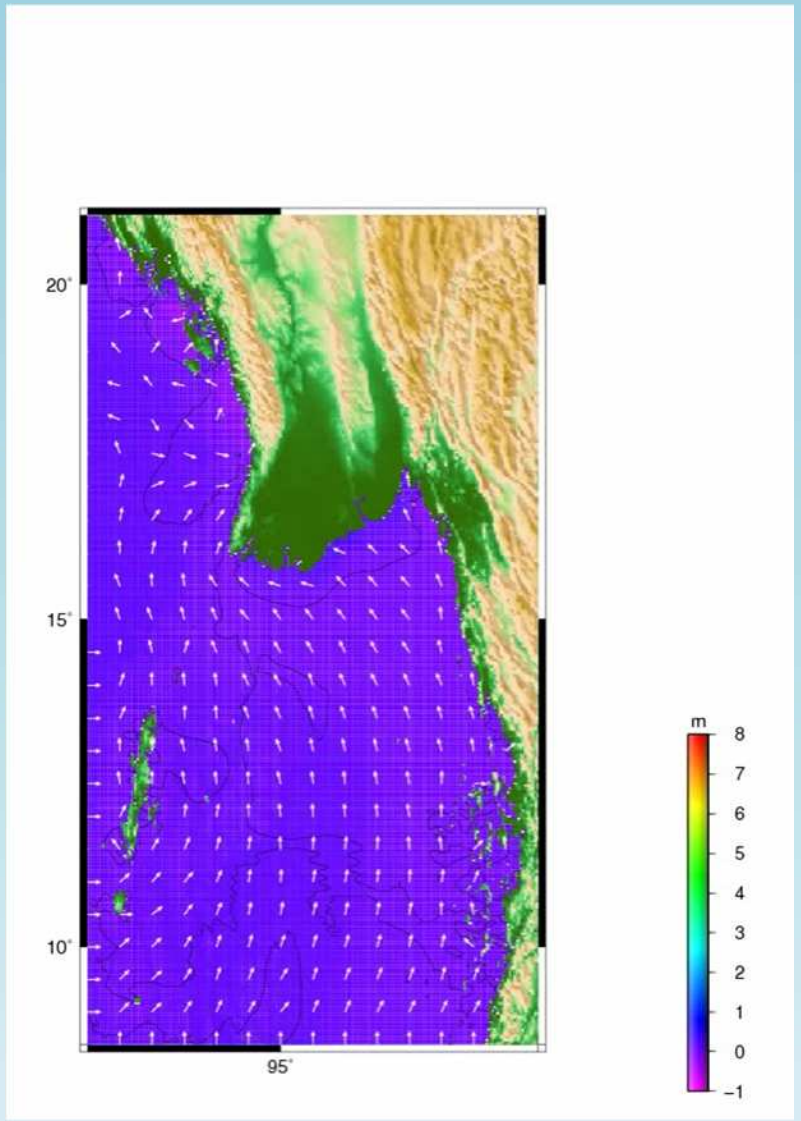
Track and intensity of Nargis

April 15, 2008

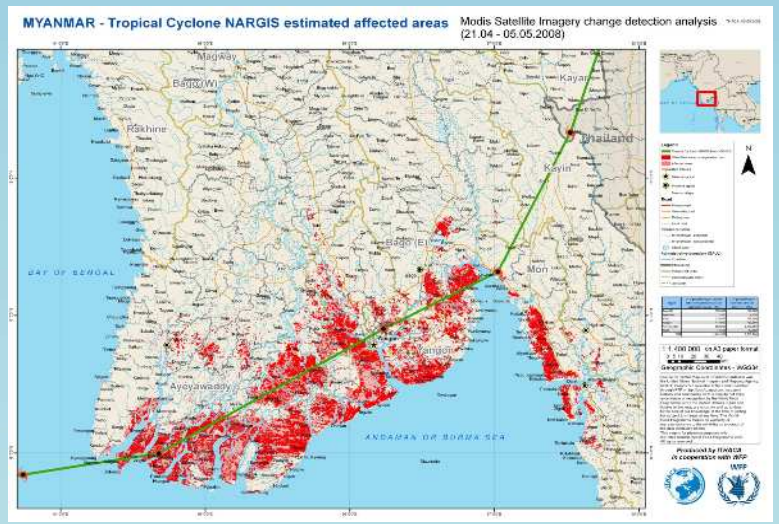


May 5, 2008

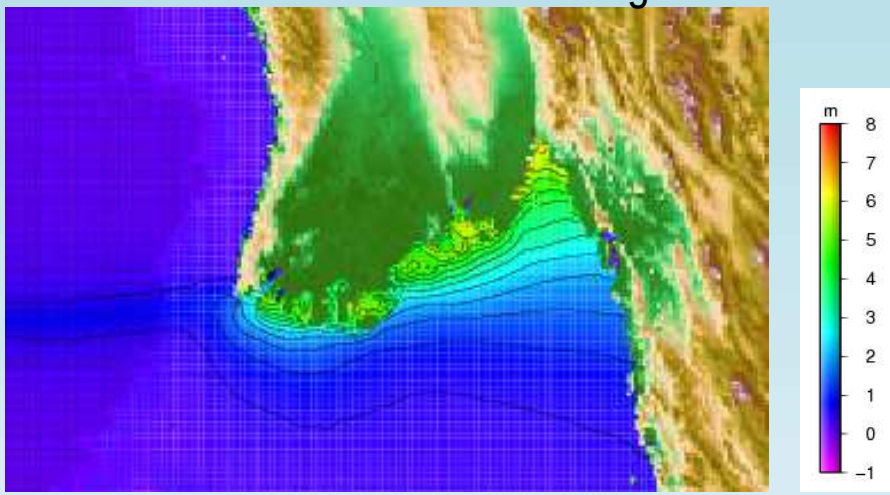
Storm Surge by Cyclone Nargis in 2008



Inundation area



Simulated maximum surge



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Summary

- Storm surges sometimes lead to severe disasters
- Inundation incidents, accompanied by storm surges, are very dangerous.
- Disasters do not occur so frequently, people tend to ignore / forget the risks

- Storm surge information is important
  - Recent information by storm surge model is satisfactory
- For further improvement, integrated information will be effective
  - (surge, tide, wave, river flow, rain, etc...) : CIFDP

- What is necessary for effective Disaster Risk Reduction?
  - reliable and easily understandable predictions
  - adequate and timely countermeasures
  - well understanding on phenomena
  - proactive action (early evacuation and so on)

Provider
Met/Hydro Services,
Governmental staff

User
citizen

Thank you !