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Development of JMA storm surge model

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Contents

- JMA storm surge model
- Storm Surge Watch Scheme (SSWS)
- Multi-Scenario predictions for SSWS
- Finite Element Method (FEM) model

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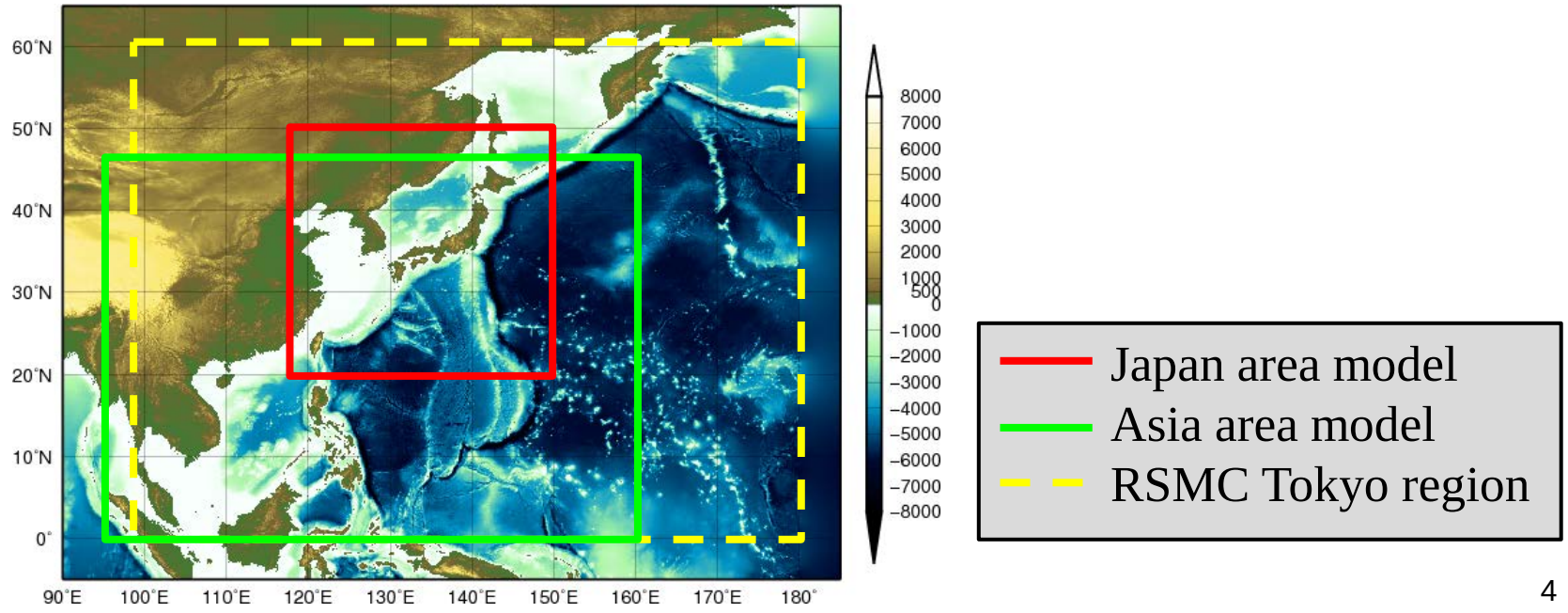
JMA storm surge model

- JMA operates two storm surge models.
  1. Japan area (to issue warning and advisory for Japan)
  2. Asia area (to provide SSWS information for Typhoon Committee members)



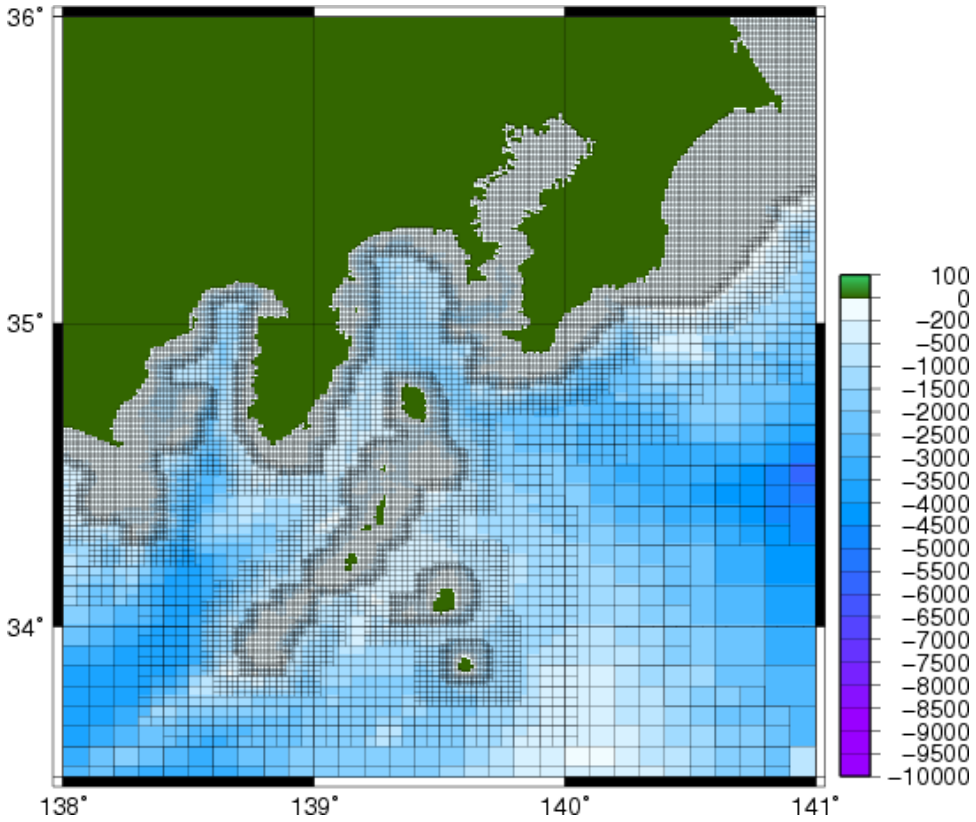
Specifications

	Japan Area	Asia Area
Model	2 dimensional non-linear model	2 dimensional linearalized model
Coordinate	Lat/Lon Cartesian grid Arakawa C-Grid	Lat/Lon Cartesian grid Arakawa C-Grid
Area	20.0N~50.0N, 117.5E~150.0E	0.0N~46.0N, 95.0E~160.0E
Resolution	45''x30''~12'x8 (1km~16km) Adaptive Mesh Refinement (AMR)	2'x2' (~3.7km)
Time step	4 seconds	8 seconds
Forecast range	39 hours	72 hours
Calculation run	8 times/day (3 hourly)	4 times/day (6 hourly)
Initial time	00,03,06,09,12,15,18,21 UTC	00,06,12,18 UTC
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 predicted course)	In case of typhoons: 1 course (Center on the forecast circles) No typhoon: 1 course (NWP predicted course)
Forcing	MSM (Meso Scale Model) GPV (5km)	GSM (Global Spectral Model) GPV (20km)
Typhoon bogus	Pressure profile: Fujita (1952) Gradient wind (with inflow angle 30 deg.) Asymmetric component by typhoon movement	

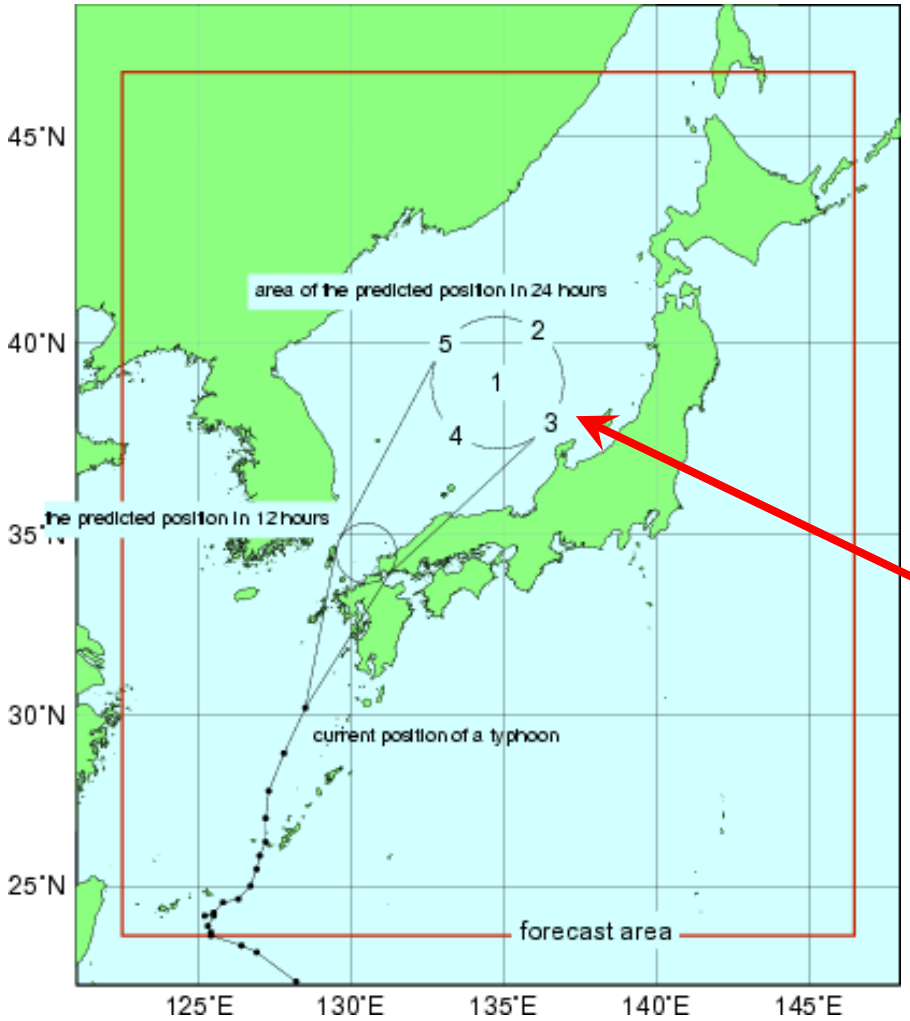
Both models don't include inundation, ocean wave and river water.

Adaptive Mesh Refinement

- We are interested in storm surges in beaches, not offshore.
  - Shallow water: fine mesh
  - Deep water: coarse mesh
- Fine mesh only in coastal area
  - Number of grid < 1/10
  - Fast calculation



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

(Ensemble prediction system for Japan area storm surge model is being developed.)

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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.

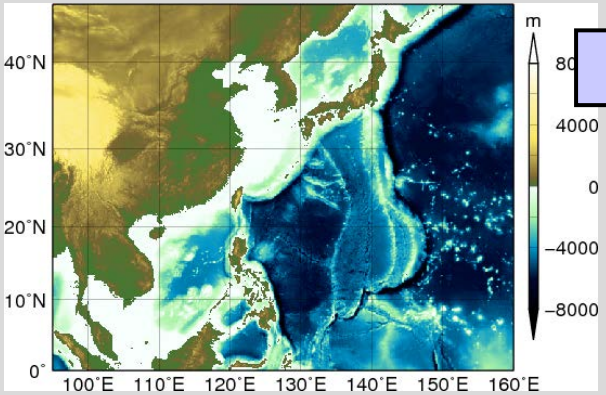
  (System development in JMA)
- 2011.6　RSMC Tokyo has started operation to provide storm surge distribution maps through its Numerical Typhoon Prediction (NTP) website.
- 2012.6　RSMC Tokyo has started to provide storm surge time series charts.

Outline of SSWS

JMA NWP routine

GSM
(Sea level pressure, wind)

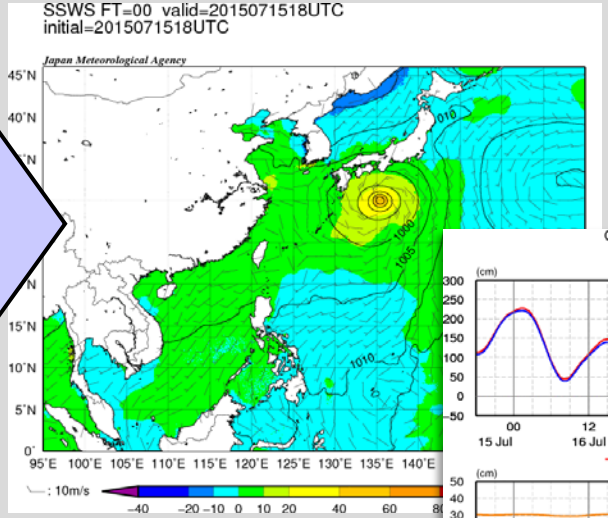
Typhoon information
(location, central pressure, wind etc.)



Asia area storm surge model

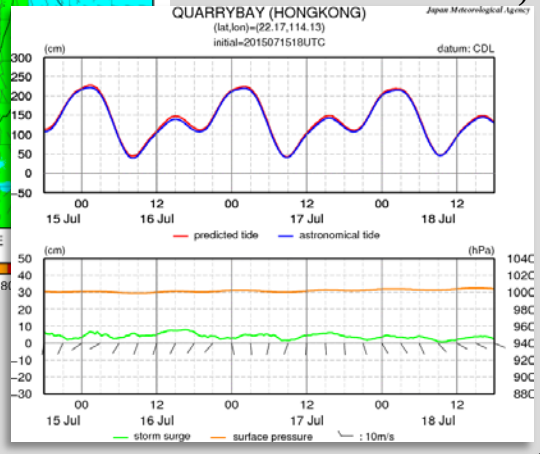
Products

Products are provided to Typhoon Committee members via JMA Numerical Typhoon Prediction (NTP) website.



Storm surge distribution map
(3 hourly, up to 72 hours)

Time series chart
(currently provided for 51 locations)



Problem

- Asia area storm surge model is based on one scenario by GSM and bogus.
- Deterministic forecast is insufficient for risk management.

- JMA plans to introduce multi-scenario predictions into the Asia area storm surge model.

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JMA Typhoon EPS

- Multi-Scenario predictions for SSWS are based on JMA Typhoon EPS (TEPS) which was upgraded in 2014.
- JMA TEPS employs a low-resolution version of GSM.

	Previous system	Current System
Ensemble size	11	25
Initial time	00,06,12,18 UTC	
Forecast range	132 hours	
Horizontal resolution	TL319 (~55 km)	TL479(~40 km)

Cluster analysis

- We are planning to select five scenarios from TEPS 25 members.
  (from restriction of computer resources…)
- Cluster analysis is adopted to determine the scenarios.

Cluster analysis

K-means method

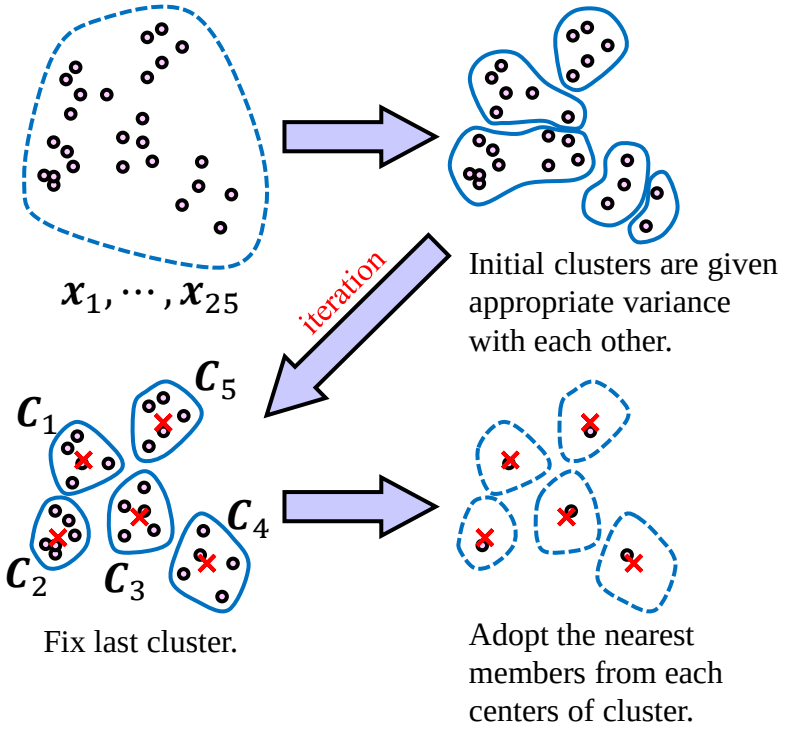
(N=25, K=5)

Center of typhoon:

$$\boldsymbol{x}_i = (lat_i, lon_i), (i = 1, \cdots, N)$$

Center of cluster:

$$\boldsymbol{C}_k = \frac{1}{N_k} \sum \boldsymbol{x}_i \,, (k = 1, \cdots, K)$$



Outline of multi-scenario predictions

JMA NWP routine

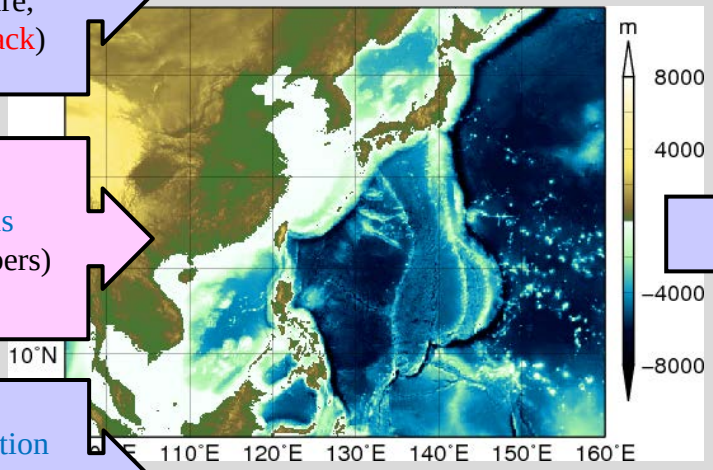
TEPS
(25 members)
(sea level pressure,
wind, typhoon track)

GPV

Cluster analysis
(select five members)

Typhoon information
(central pressure,
wind etc.)

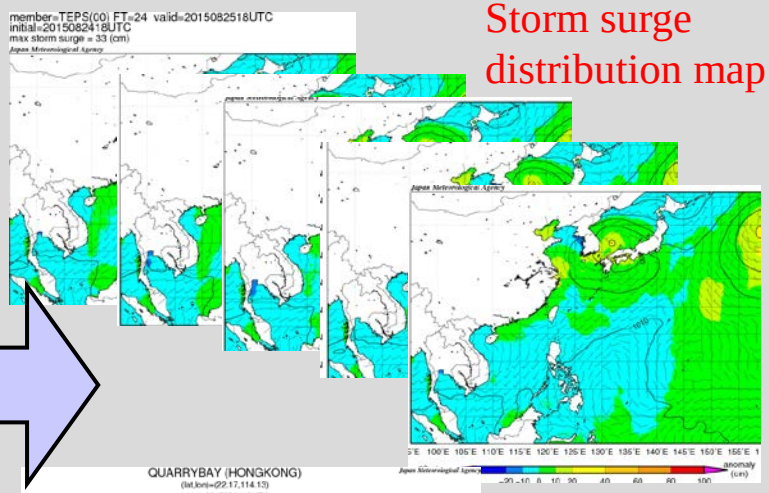
Asia area storm surge model

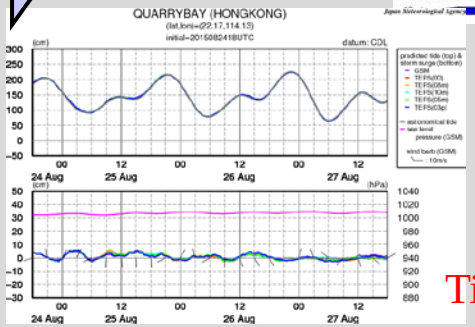


If two or more typhoons exist in model region, typhoon out of Japan region has priority for cluster analysis.

Products

Storm surge distribution map



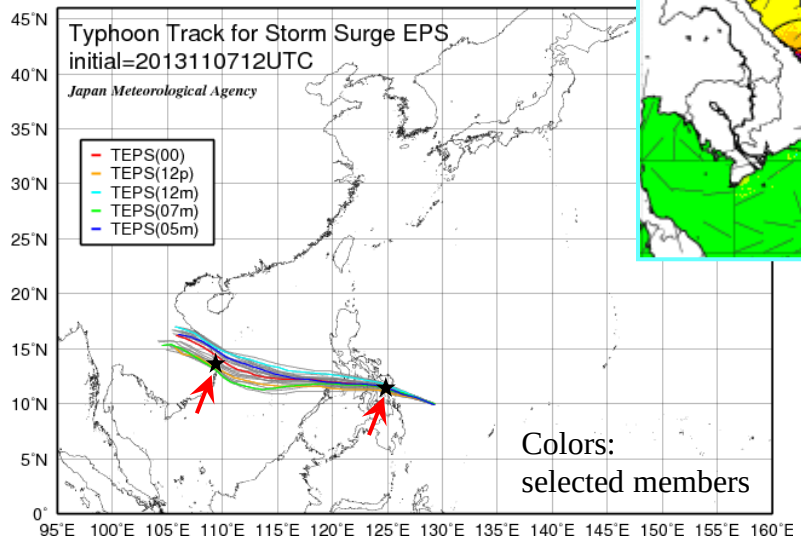


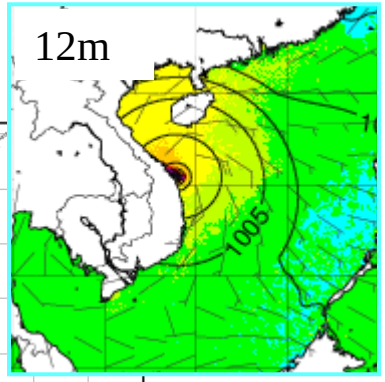
Time series chart

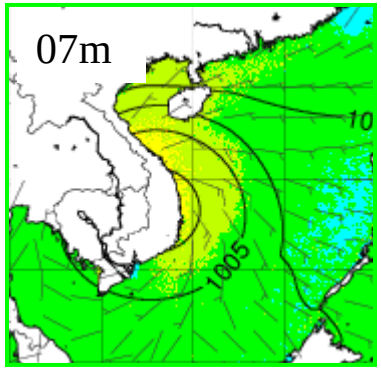
Example

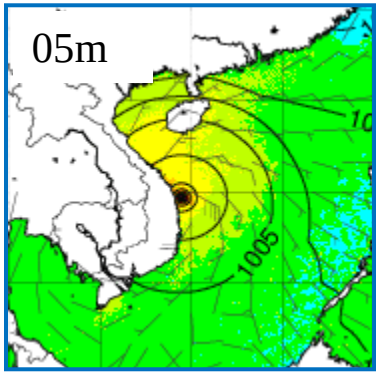
T1330 (Haiyan)

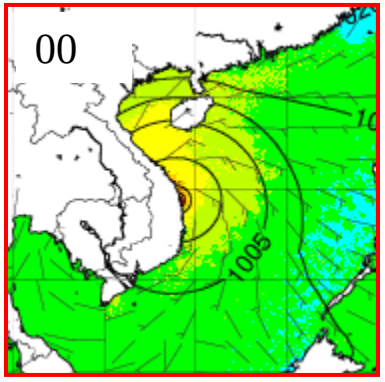
7.Nov 12UTC initial

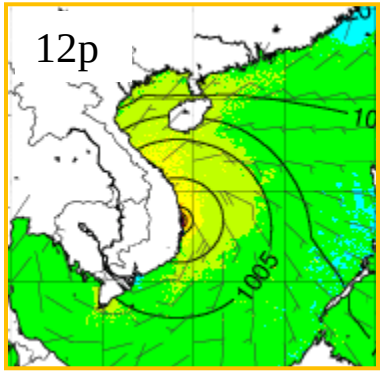


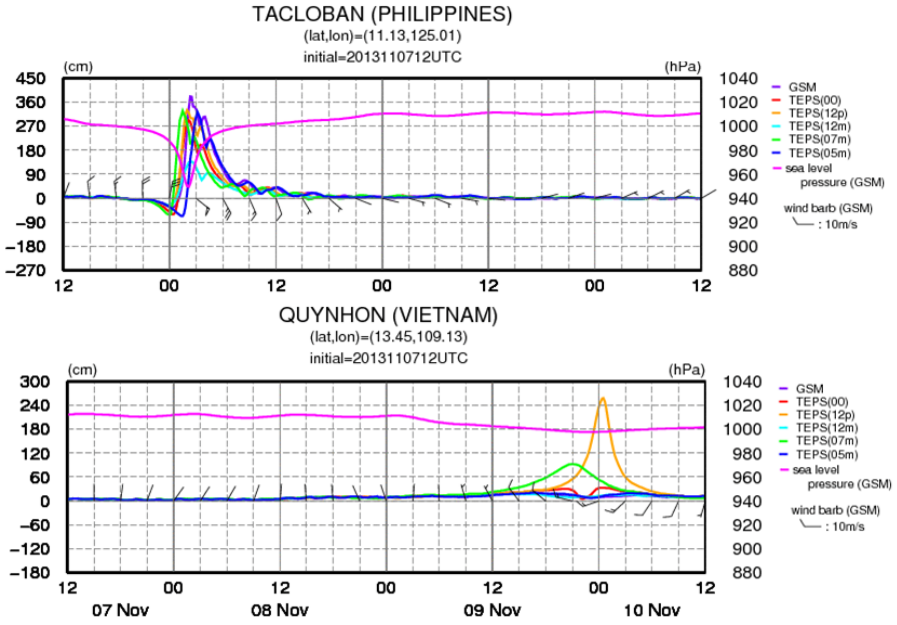












Plans

- Multi-Scenario system and its products are going to be started and issued in 2016.
- In the next JMA super computer system (2018?~), some members going to be added for Probabilistic forecast.

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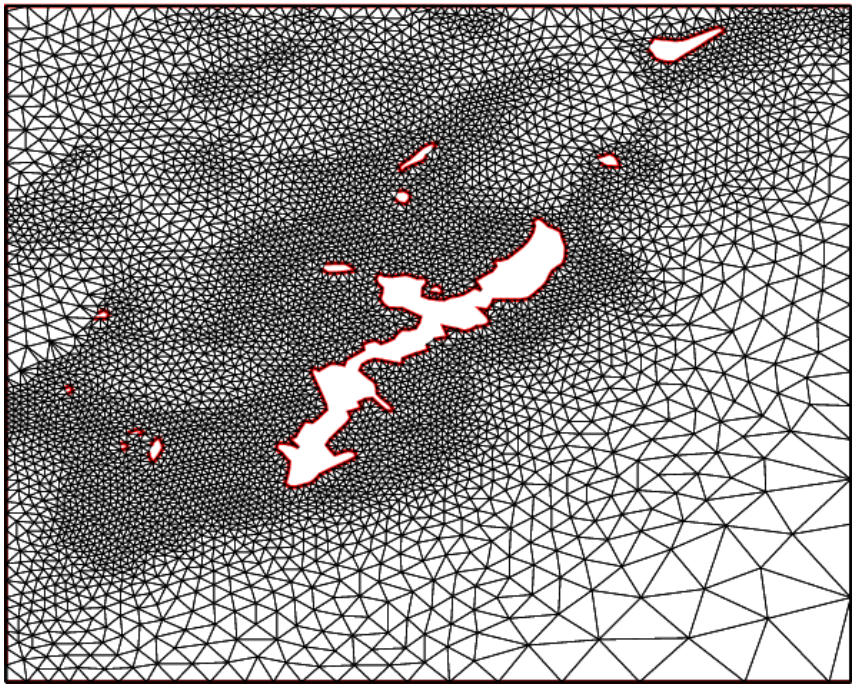
Finite Element Method (FEM)

- In FEM, Model region is divided to finite elements. Any forms of element are valid (unstructured grid).
- FEM is suitable for storm surge calculation.
- JMA is developing FEM storm surge model aiming for practical use in the next JMA super computer system.

Generating unstructured grid

- Delaunay triangulation
- Coastal data:
  GSHHG (NOAA)
- Topography data:
  ETOPO (NOAA)
- Coastal data is modified to target resolution.
- For extremely large area, Delaunay triangulation is adopted for divided small areas, they are combined to one later.



Ex.) Okinawa area
Max resolution is 1 minute.

Summary

- JMA operates two storm surge models (Japan area, Asia area).
- In framework of SSWS, products of Asia area model is provided for typhoon committee members.
- Multi-scenario predictions are going to be introduced to Asia area model in 2016.
- JMA is developing also FEM model for next super computer system.