The 14th International workshop on wave forecasting and hind casting and 5th Coastal Hazards Symposium
12/Nov/2015

Recent improvement plans for JMA wave forecast information and system

Nadao Kohno

Office of Marine Prediction, Global Environment and Marine Department, Japan Meteorological Agency

1-3-4, Ote-machi, Chiyoda, Tokyo 100-8122, Japan +81-3-3212-8341 (ext. 5139)
e-mail: nkono@met.kishou.go.jp, nkohno@mri-jma.go.jp

Outline (summary)

JMA has plans to improve wave forecast information and system

- ✓ Marine Weather Forecast Distribution Map (18 MAR, 2015-)

  One day graphical forecasts for the sea around Japan.
  Six hourly forecast maps on winds, waves, visibility (fog) and ship icing up to 24 hours, are uploaded to JMA web site.

- ✓ Week range wave forecast (second quarter of 2016-)

  Wave Ensemble model system

  JMA is going to add wave and wind information to one-week forecasts. It is also planned to issue early warnings if high waves are feared in week range.

- ✓ 'Tough Navigation Area' information (early 2017-)

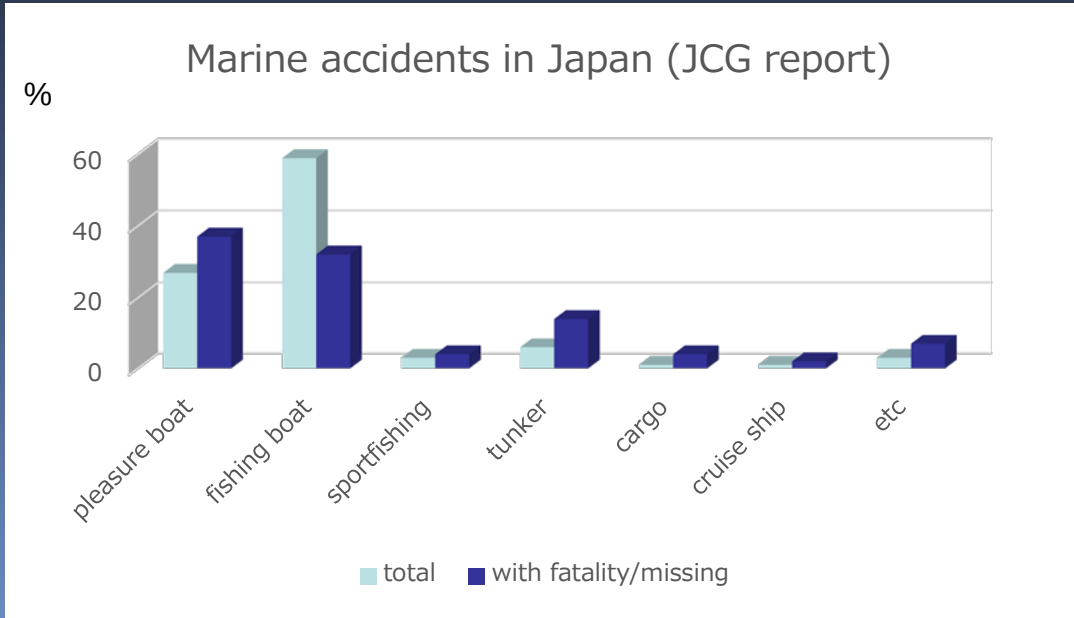
  Information on rough sea state, namely tough navigation area information will be added to JMA radio facsimile (JMH) wave charts.

Contents

- Marine Weather Forecast Distribution Map
- Week range wave forecast
  (Wave Ensemble model system)
- ‘Tough Navigation Area’ information

Motivation

- According to Japan Coast Guard report, most of Marine accidents in Japan, especially with fatality/missing, occured by small boat, such as pleasure bots or fishing boats. The 25 % of the cause of accidents are “carelessness or misunderstandings of weather condition”.
- The graphical image forecasts “Marine Weather Forecast Distribution Map” are newly introduced as local marine information so that user can understand the weather condition better than the text message.
- Pleasure boats and small fishing boats are included to target users. The maps are issued not via JMA web site but also via Marine Information and Communication System (MICS) of Japan Coast Guard (JCG), which users can get information via Broad / Narrow band internet, and mobile phones.



MICS

Marine Weather Forecast Distribution Map

Elements

Wind (speed and direction), Wave height,
horizontal visibility (fog), degree of ship icing

Products

1 degree mesh forecasts (6 hourly , up to 24 hours)

Product initial and frequency

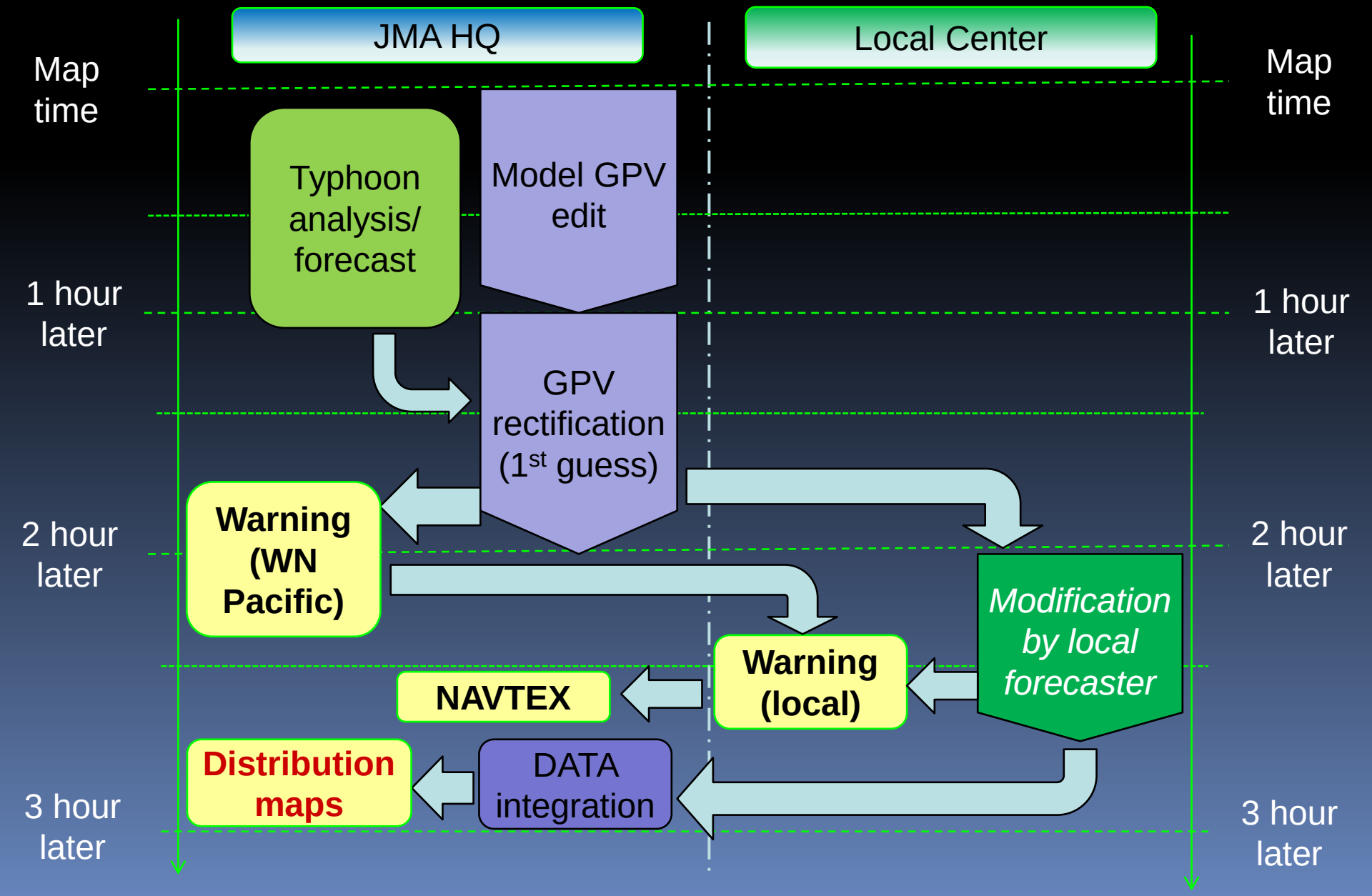
4 times / day (00, 06, 12, 18 UTC)

The products are issued around 3 hours later after the map time
(00, 06, 12, 18 UTC)

Media

- JMA web site
- Marine Information and Communication System (MICS) of Japan Coast Guard

Time line of distribution map creation

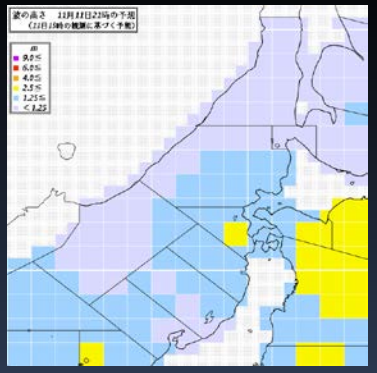


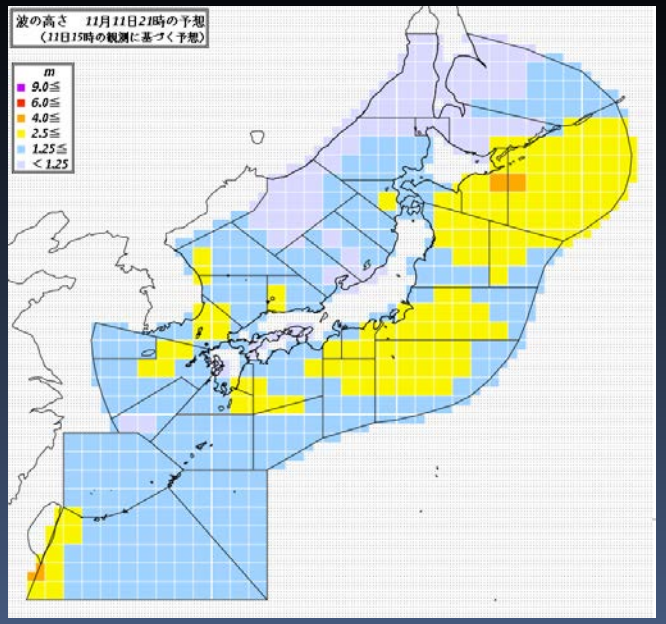
Product Maps

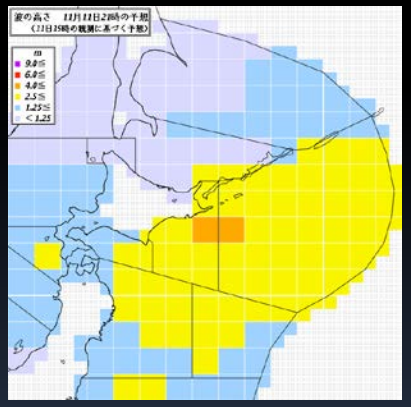
http://www.data.jma.go.jp/fcd/yoho/umimesh/fcst_umimesh.htm

Whole area and 5 reginal maps are created for users' interest.

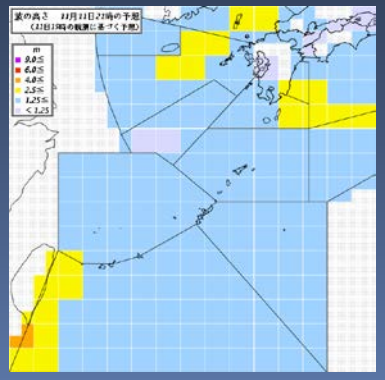
West North Japan
(Sea of Japan)



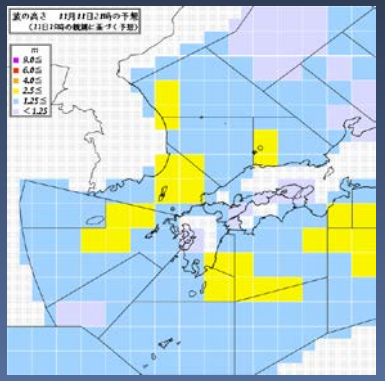




East North Japan
(Sea of Okhotsk
and Pacific Ocean)

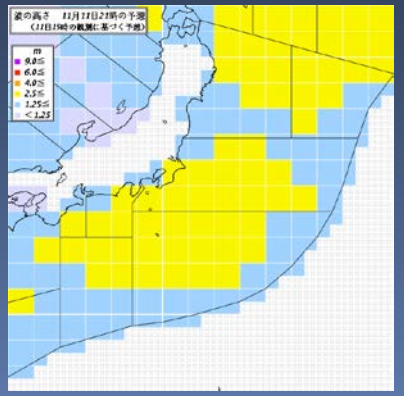


East China Sea
and Okinawa



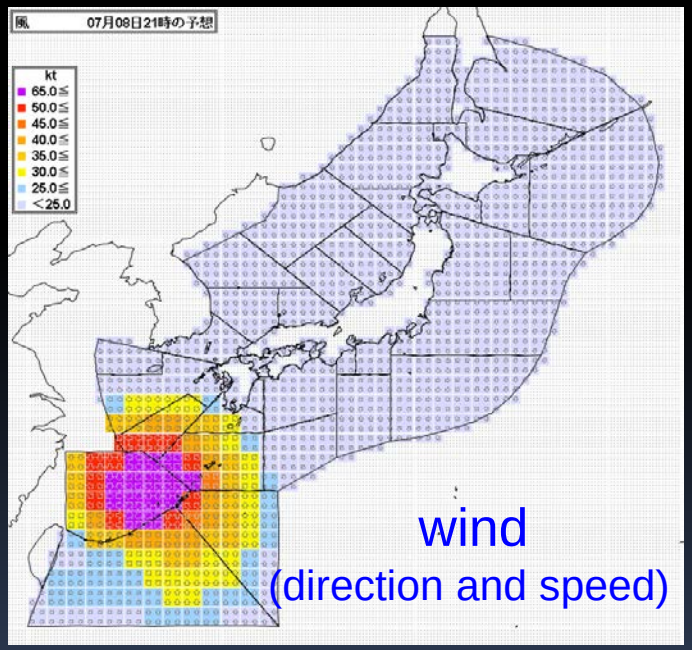
West Japan
(Sea of Japan, East China Sea
and Pacific Ocean)

Whole Japan coast

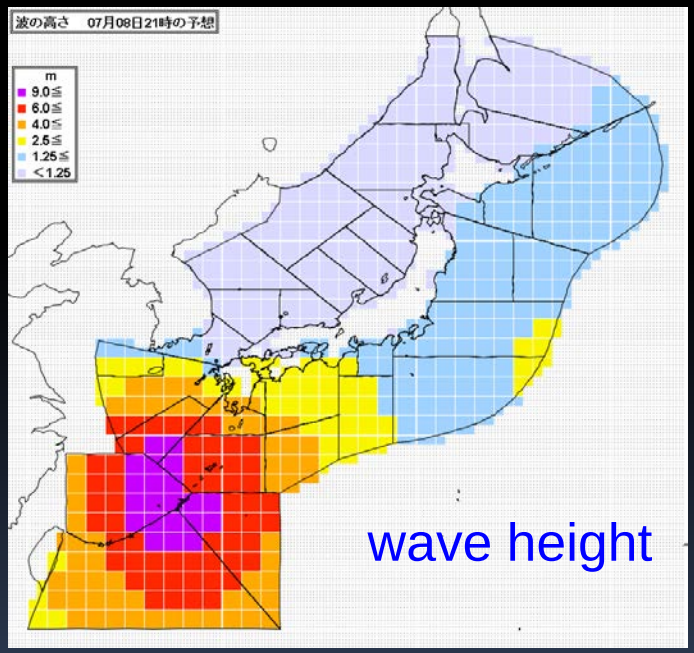


East Japan
(Pacific Ocean)

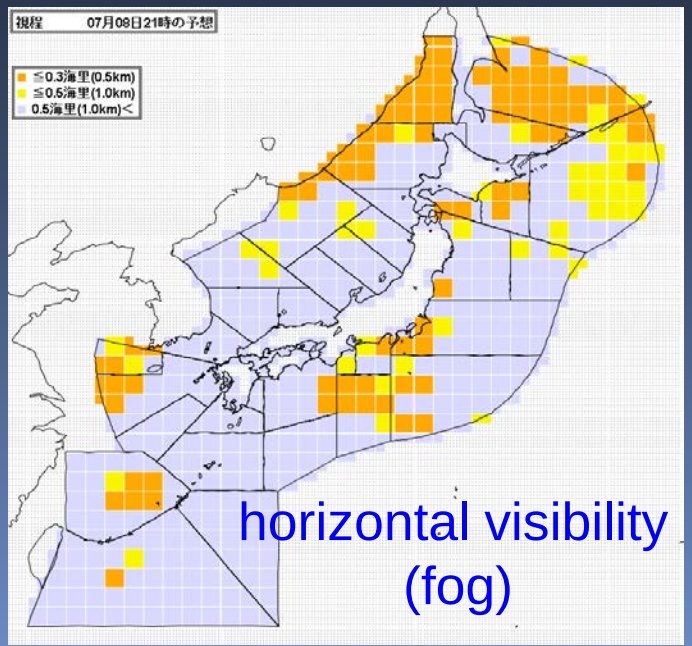
Product Elements



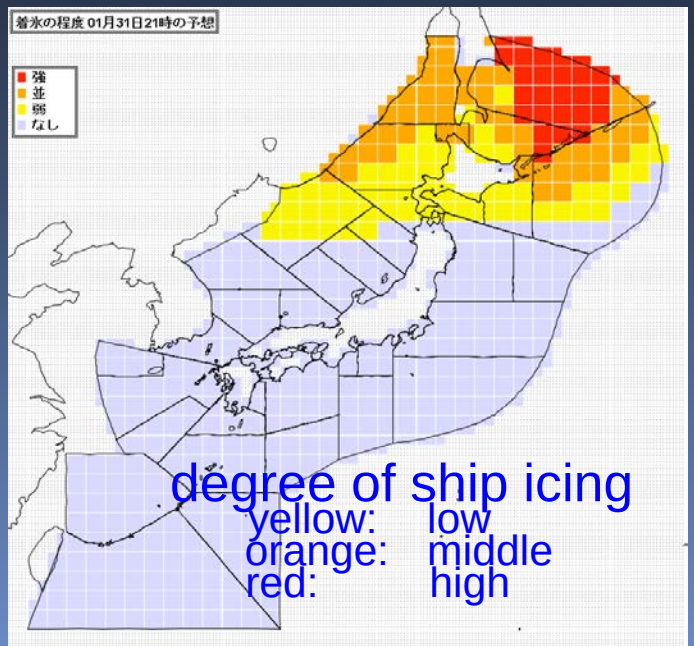
wind
(direction and speed)



wave height



horizontal visibility
(fog)



degree of ship icing
yellow: low
orange: middle
red: high

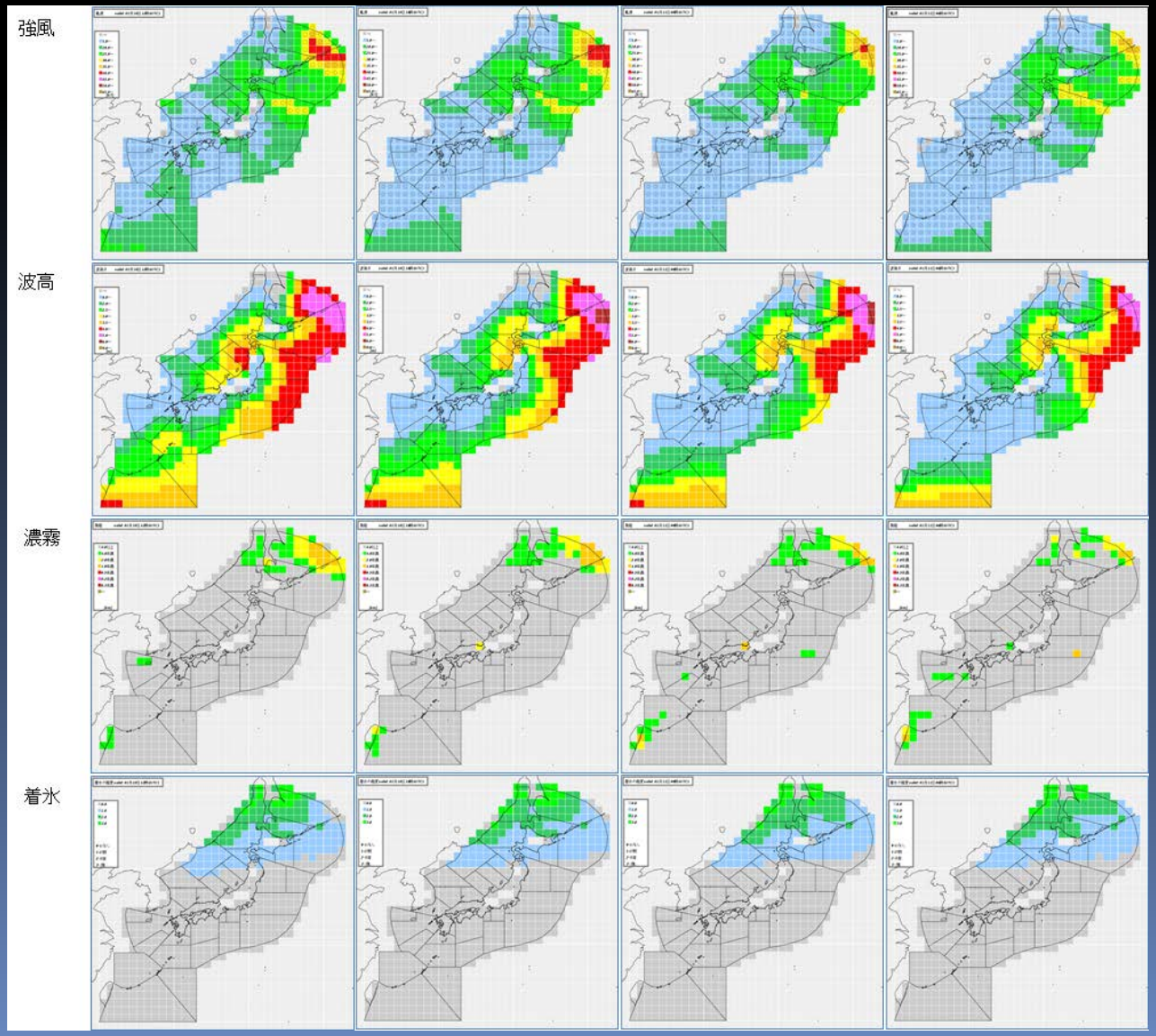
Forecast hours → 6hrs 12hrs 18hrs 24hrs

wind

wave

Visibility (fog)

Degree of Ship icing



Contents

- Marine Weather Forecast Distribution Map
- Week range wave forecast
  (Wave Ensemble model system)
- ‘Tough Navigation Area’ information

Operational wave models at JMA

	Global Wave Model (GWM)	Coastal Wave Model (CWM)	Global Wave EPS
model type	**MRI-III** (Third generation wave model)		
calculation area	global area 75° S～75° N 0° ～359.5° (cyclic)	sea around japan 20° N～50° N 120° E～150° E	**global area** **75° S～75° N** **0° ～358.75°** **(cyclic)**
grids	720 × 301	601 × 601	**289 × 113**
grid interval	0.5° × 0.5°	0.05° × 0.05°	**1.25 ° × 1.25 °**
wave spectrum components	900 components (25 in frequency × 36 in direction) frequency：0.0375～0.3Hz；logarithmically divided direction：10 degree interval		
forcing	Global Spectral Model GSM (20km grid) winds within typhoons are modified by ideal gradient winds (～ 72 hours)		**GSM EPS** **(27 members, 6 hourly)**
forecast time (12UTC) (00/06/18UTC)	264 hours 84 hours	84 hours 84 hours	**264 hours**

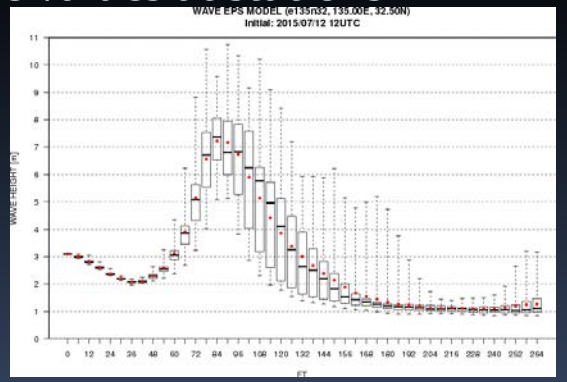
Guidance for one-week forecast

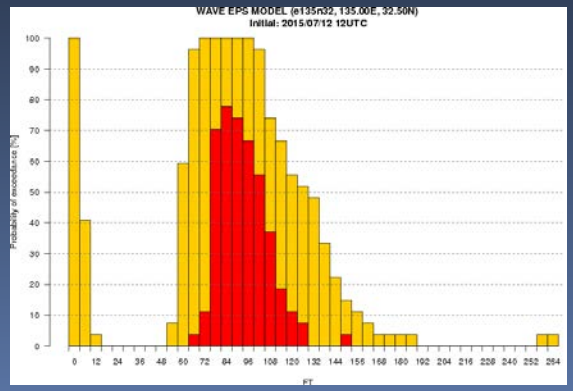
Base on discussions with operational forecasters, the guidance for one-week forecast is fixed.

Ensemble mean/ max, the third quantile, spread, probability (2 to 6m)

Stochastic values at stations are provided too.

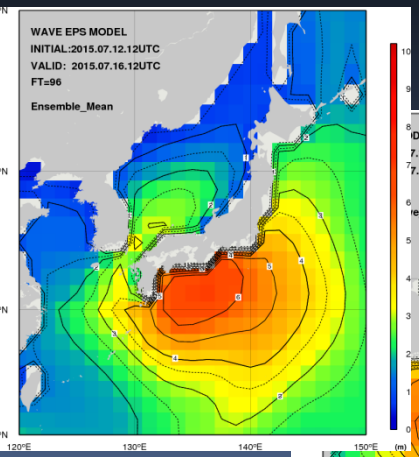
Stochastic values at stations



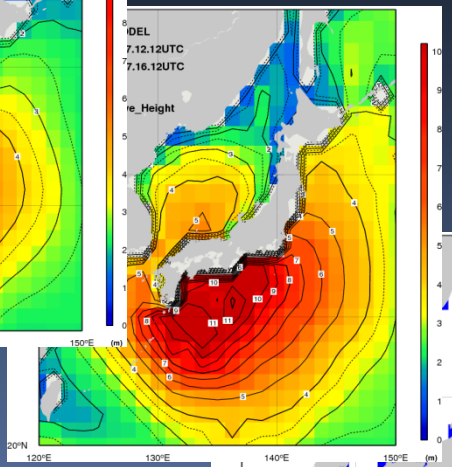


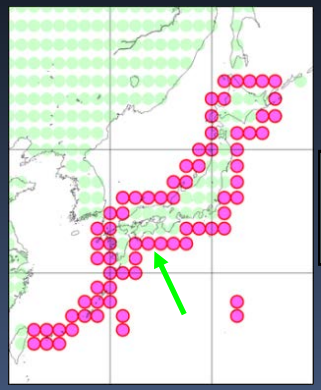
Probability
Yellow: Hw > 3m
Red: Hw > 6m

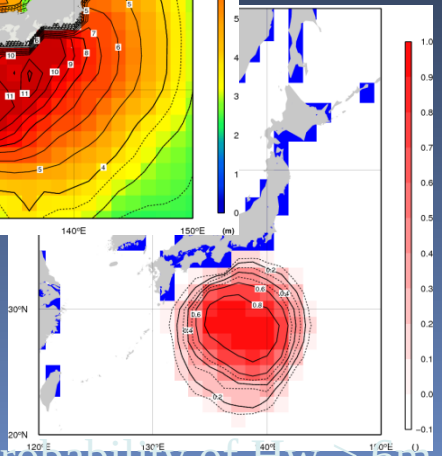
Ensemble mean



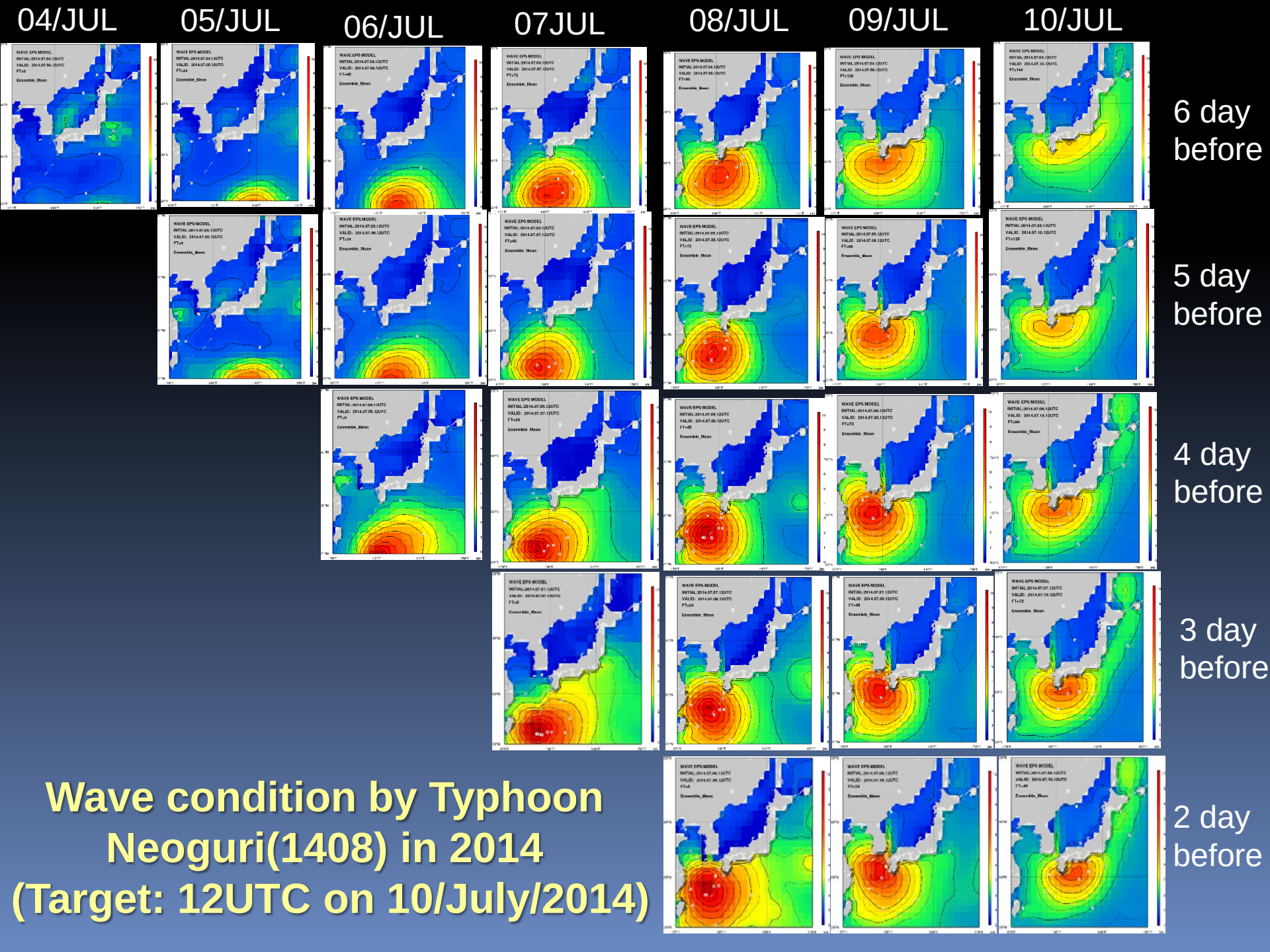
Max Hw of members





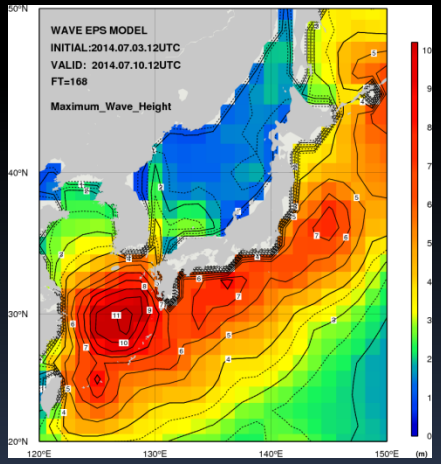


Probability of Hw > 6m

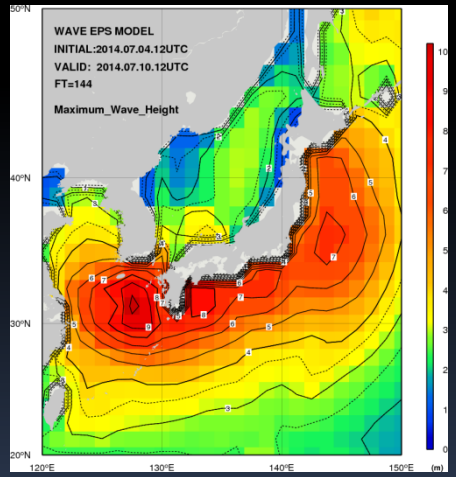

04/JUL
05/JUL
06/JUL
07JUL
08/JUL
09/JUL
10/JUL
6 day before
5 day before
4 day before
3 day before
2 day before
Wave condition by Typhoon Neoguri(1408) in 2014
(Target: 12UTC on 10/July/2014)

Maximum wave heights

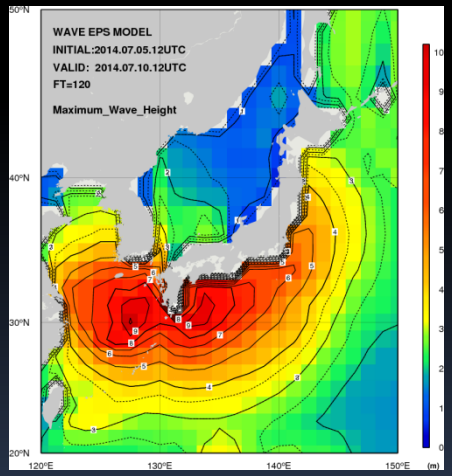
03/JUL FT=168



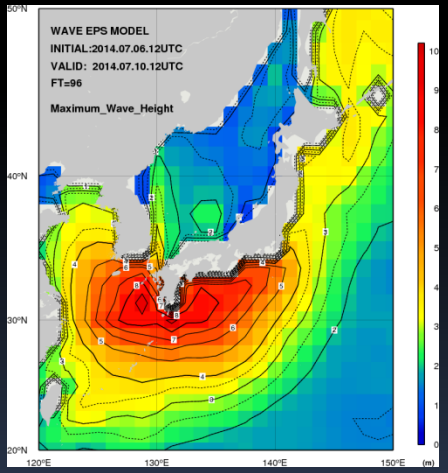
04/JUL FT=144



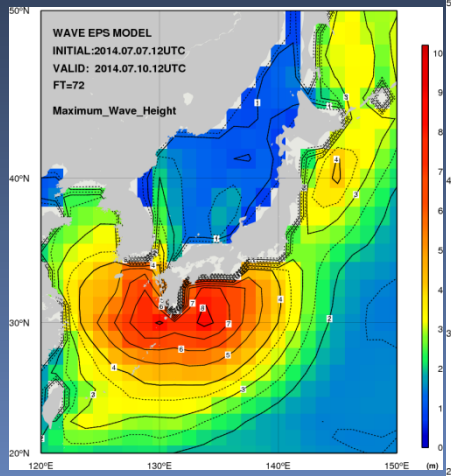
05/JUL FT=120



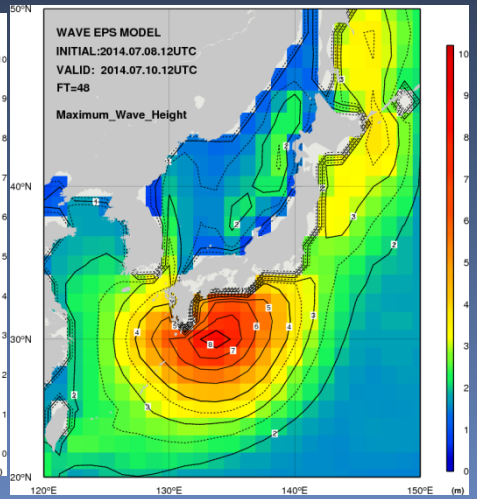
06/JUL FT=96



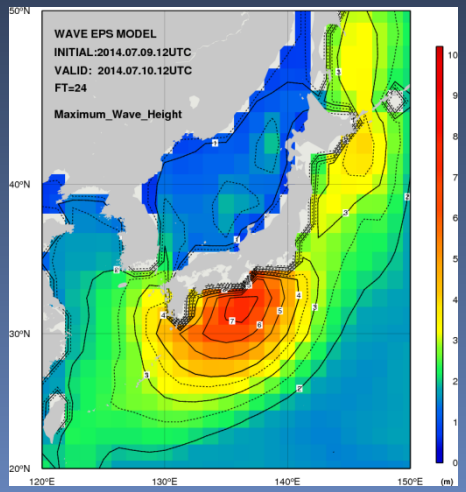
07/JUL FT=72



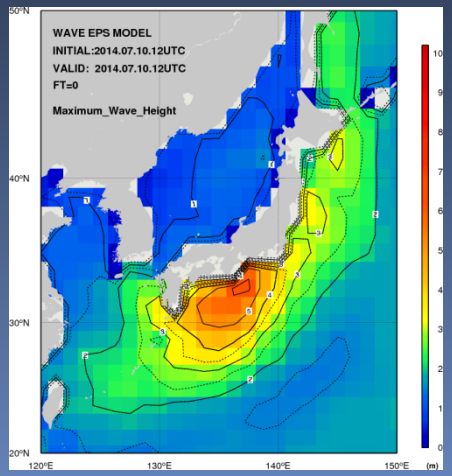
08/JUL FT=48



09/JUL FT=24

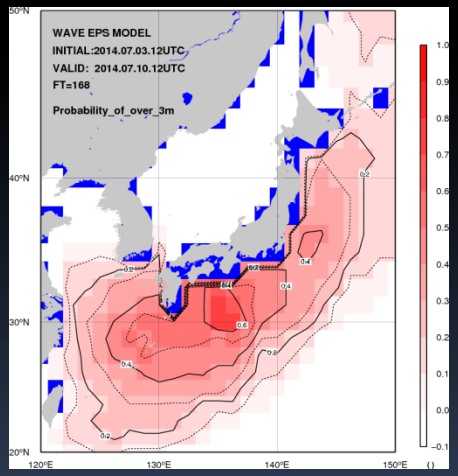


10/JUL FT=00

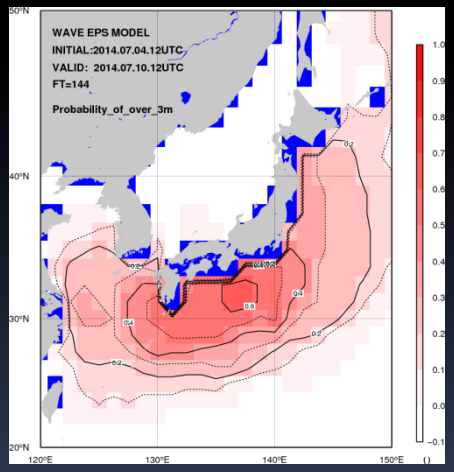


Probability of Hw_sig > 3m

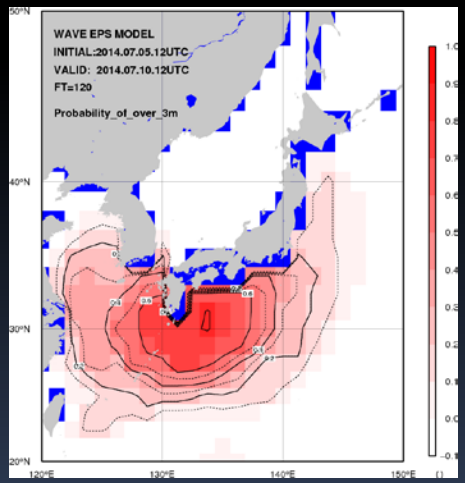
03/JUL FT=168



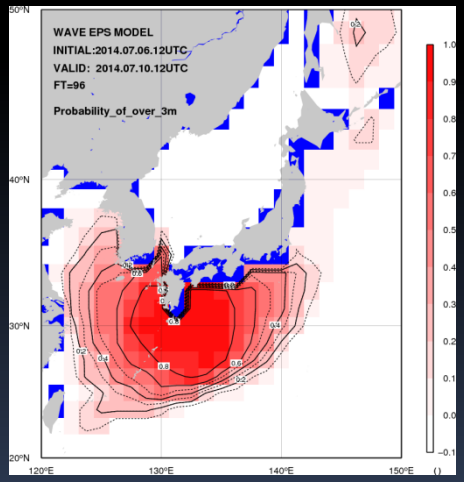
04/JUL FT=144



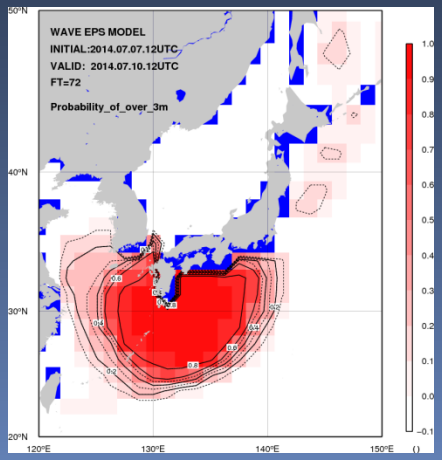
05/JUL FT=120



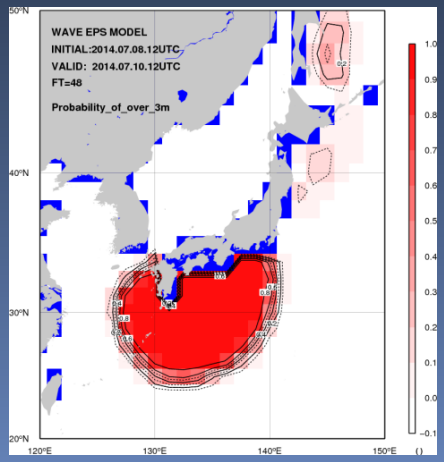
06/JUL FT=96



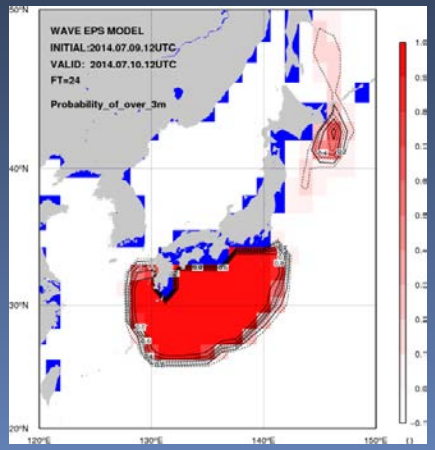
07/JUL FT=72



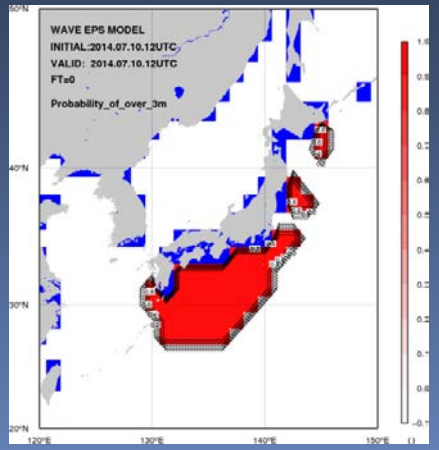
08/JUL FT=48



09/JUL FT=24

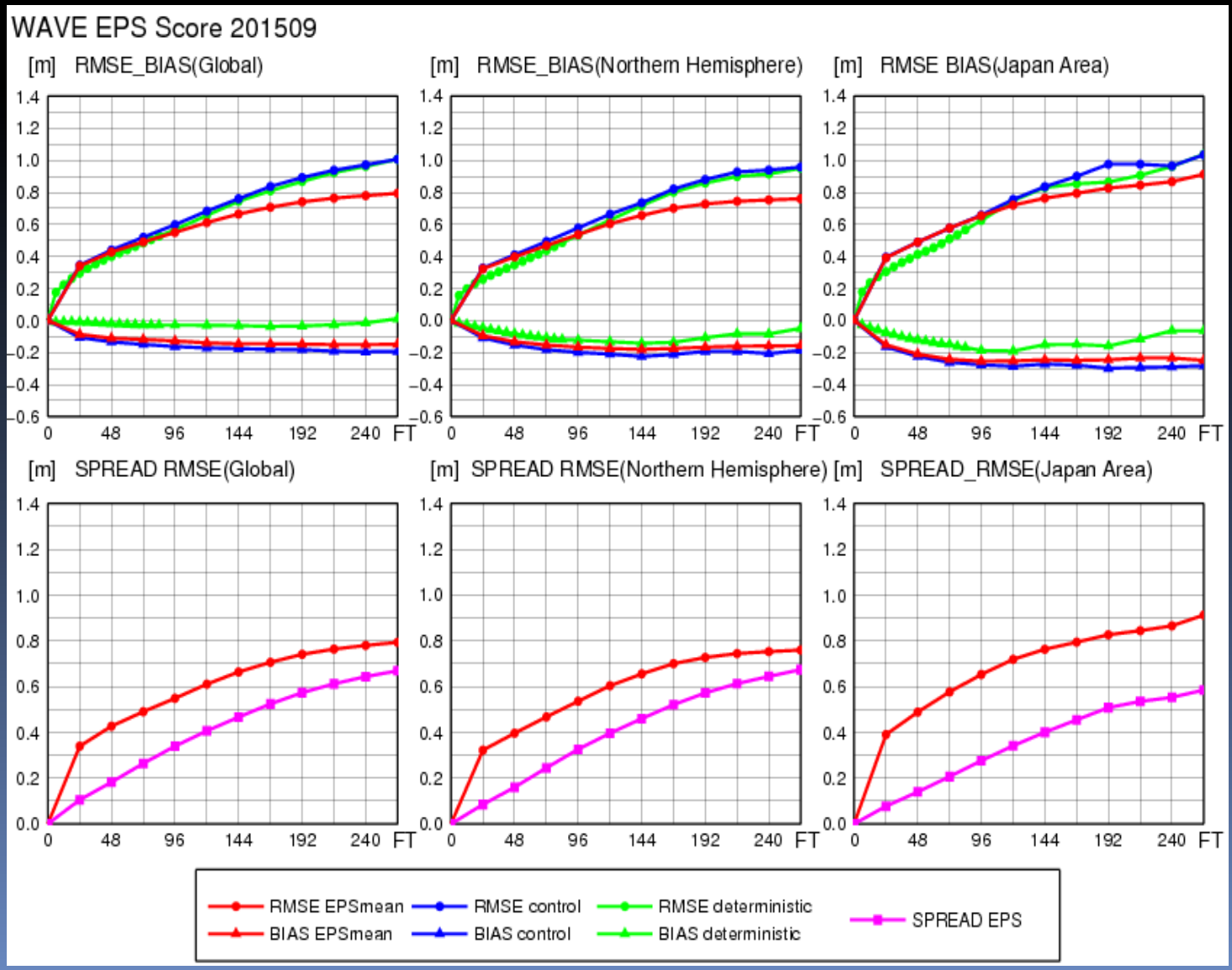


10/JUL FT=00



Performance of the Ensemble forecast

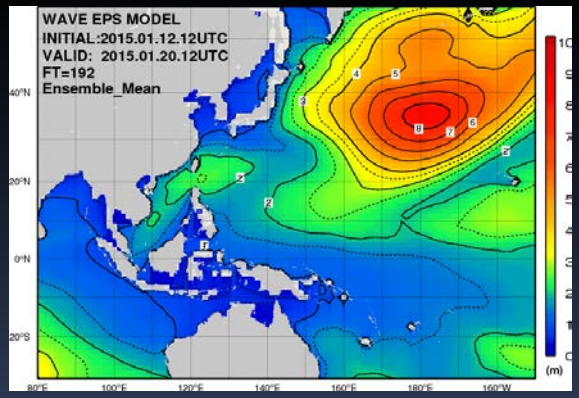
RMSE of ensemble mean (Aug/2015)

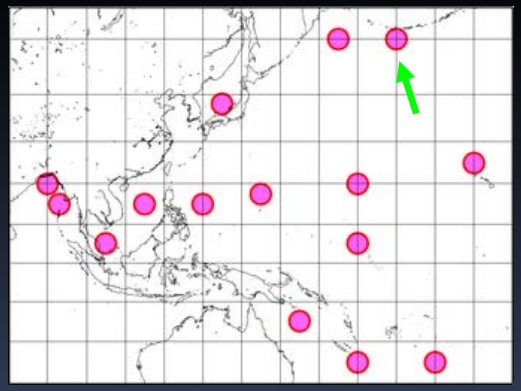


One-week ocean wave prediction

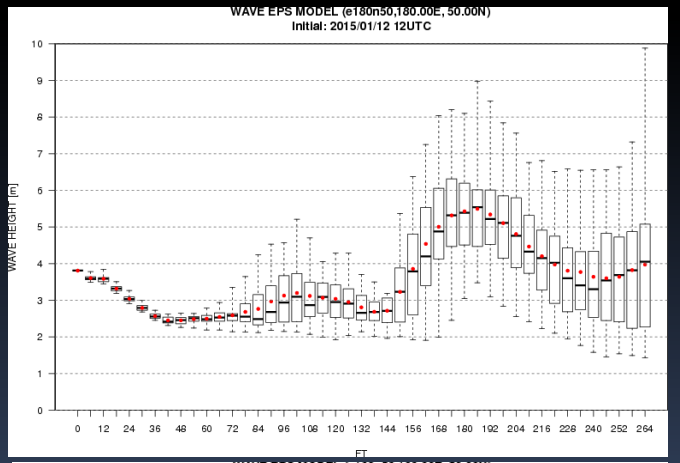
The products will be available to Typhoon Committee members for the aid of early-warning.

Product Images

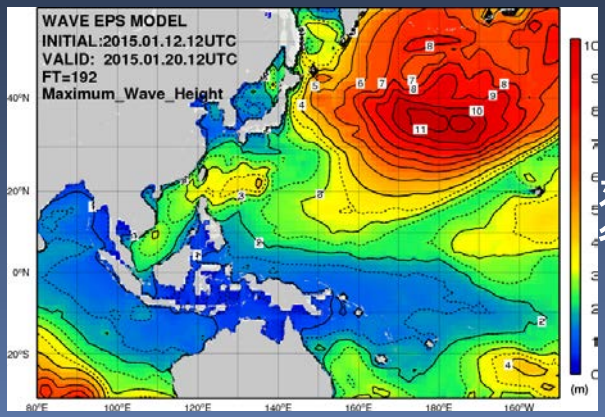


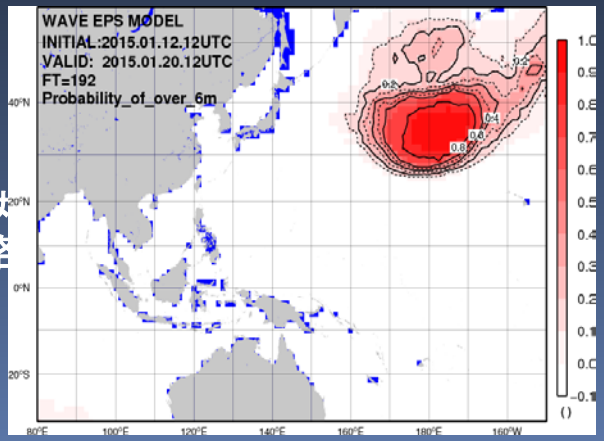


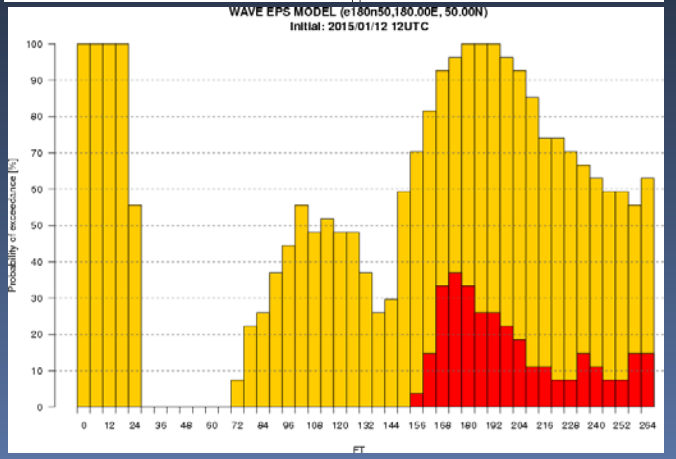
Stochastic values at stations



Mean wave height







Maximum wave height

Probability of Hw_sig > 6m

(Results of 192 hours forecast)

Probability
Yellow: Hw > 3m
Red: Hw > 6m

Contents

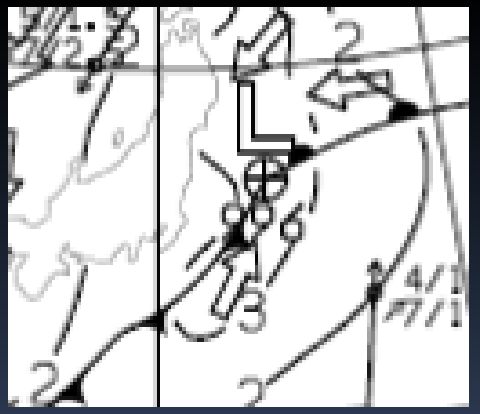
- Marine Weather Forecast Distribution Map
- Week range wave forecast
  (Wave Ensemble model system)
- ‘Tough Navigation Area’ information

Motivation

Sea state gives strong influence to voyaging vessels. In usual, wave heights are commonly used to express sea state. However, complicated sea state is quite dangerous and tough for voyaging vessels and fishing activities.

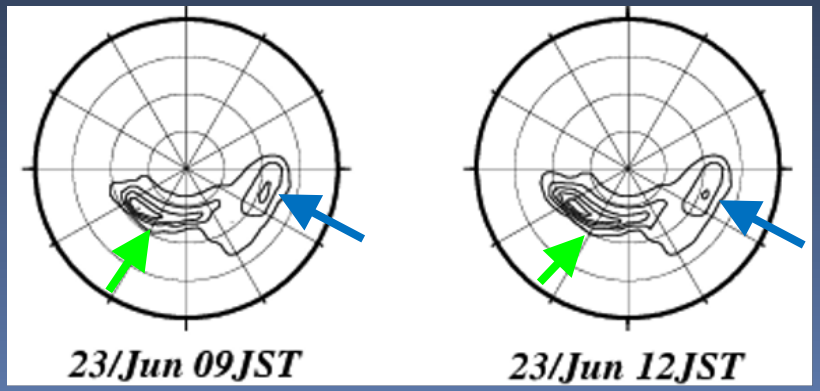
A fishing boat accident
(23 June 2008)
A fishing boat of 135 gross tonnage overturned.
4 dead, 13 missing

Location of the accident



Wave analysis chart (AWPN)
(00UTC on 23 June, 2008)

- A low pressure system moved eastward and was located in the sea off Inubo-saki at 09JST on 23.
- Wave heights of 2 to 3 m were analyzed in the south of the low pressure center., although the wave height of **3m is not so dangerous** for fishing boats of 100 gross tonnages.
- By referring the wave spectra at the accident point, spectra indicate that there were several wave components. It is supposed that this could be the main reason of overturn, although it is circumstantial.



Wave spectra

→ JMA is now developing some practical information on “tough navigation area”.

“tough navigation area”

- **Two situation are considered:**
  1. Multiple wave simultaneously exist
  2. Waves are influenced by against currents.

- The areas are marked in wave charts (JMH)
  - ✓ Simple and practical information
  - ✓ Understandable even if noise is included

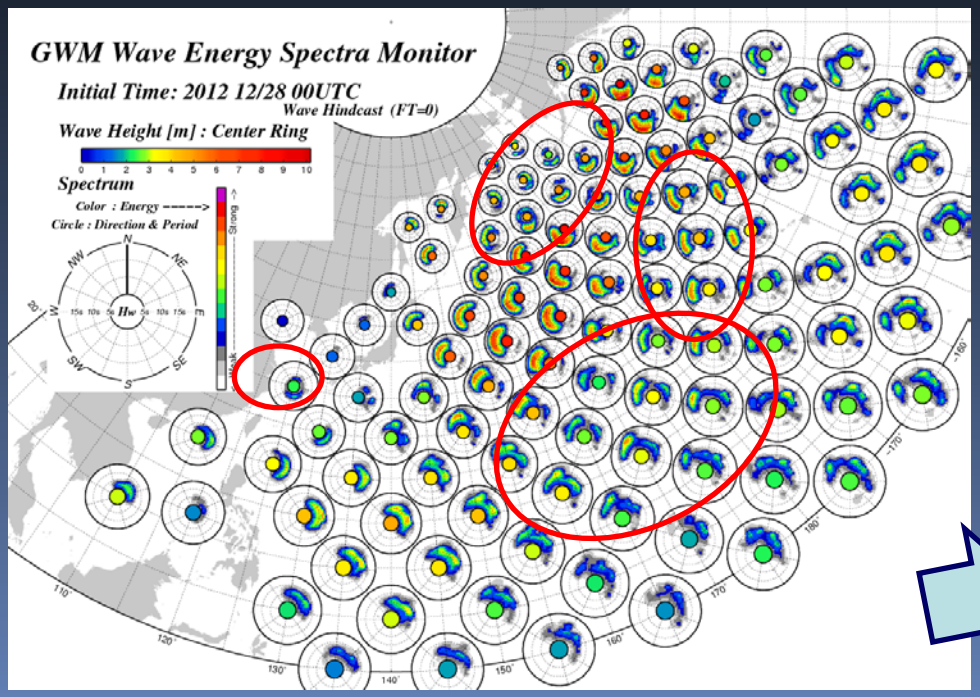
- Considering of scale of area,
  - ✓ **multiple-wave area: wave charts for NW Pacific (AWPN, FWPN)**
  - ✓ **Current-influenced area: wave charts for seas around Japan (AWJP, FWJP)**

multiple wave area

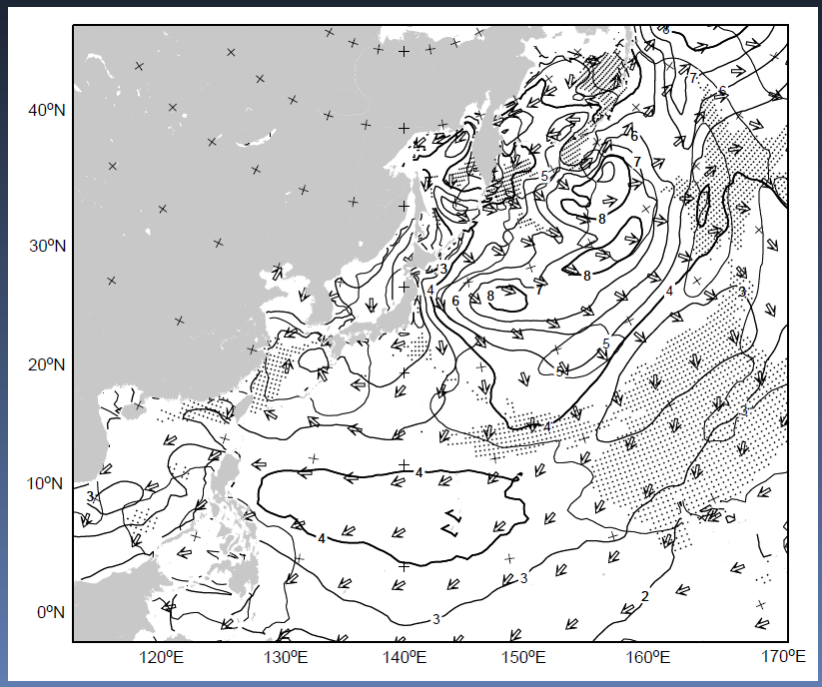
Definition (old)

1. Significant wave height $H_w > 1.2$m
2. Several waves exist: H_{w_i}, $i = 1, 2, \cdots$
   (derived from wave partitioning)
3. Some wave components have comparable wave height (energy):
   $H_{w\_i} / H_{w\_1} > 0.6$ $i = 2, 3, \cdots$

※ exclude the component direction angle is within 30 degree



Wave spectra (components)



The area is marked in wave chart

New threshold

Definition (old)

1. Significant wave height $H_w > 1.2$m
2. Several waves exist: H_{w_i}, $i = 1, 2, \cdots$ (derived from wave partitioning)
3. Some wave components have comparable wave height (energy): $H_{w\_i} / H_{w\_1} > 0.6$ $i = 2, 3, \cdots$

※ exclude the component direction angle is within 30 de

Sometimes almost whole region is marked.
⇒ threshold of minimum wave height was revised

Definition (new)

1. Significant wave height $H_w > 1.8$m
2. Several waves exist: H_{w_i}, $i = 1, 2, \cdots$ (derived from wave partitioning)
3. Some wave components have comparable wave
   - ① $H_{w\_2} / H_{w\_1} > 0.6$
   - ② $H_{w\_3} / H_{w\_1} > 0.45$
   - ③ $H_{w\_4} > 0.75$

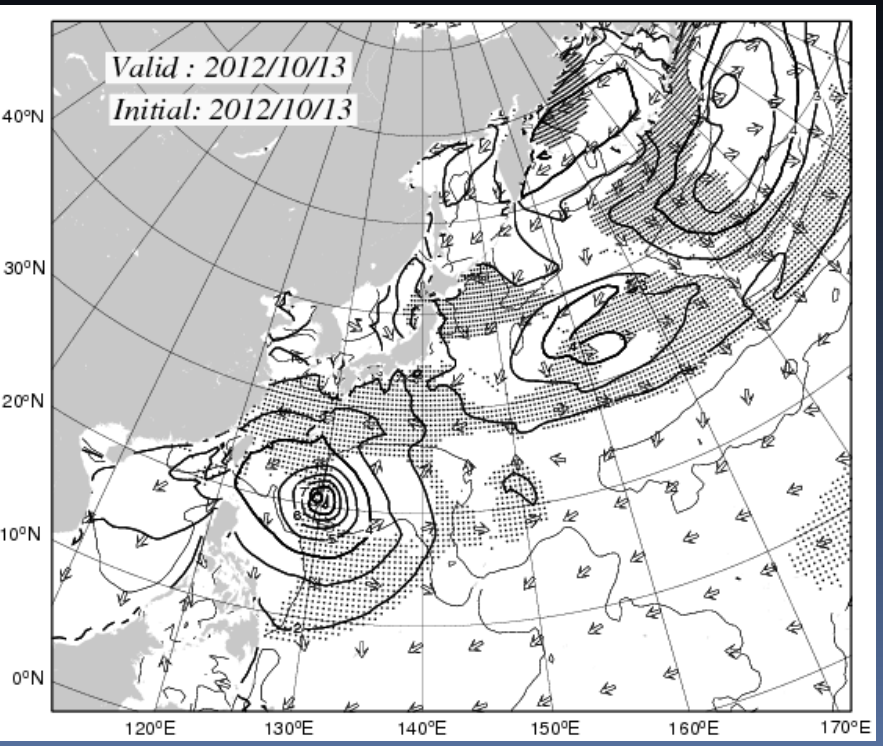
If the third largest wave has comparable wave height, the sea become more complex than two-wave condition.
The threshold was changed to smaller value.

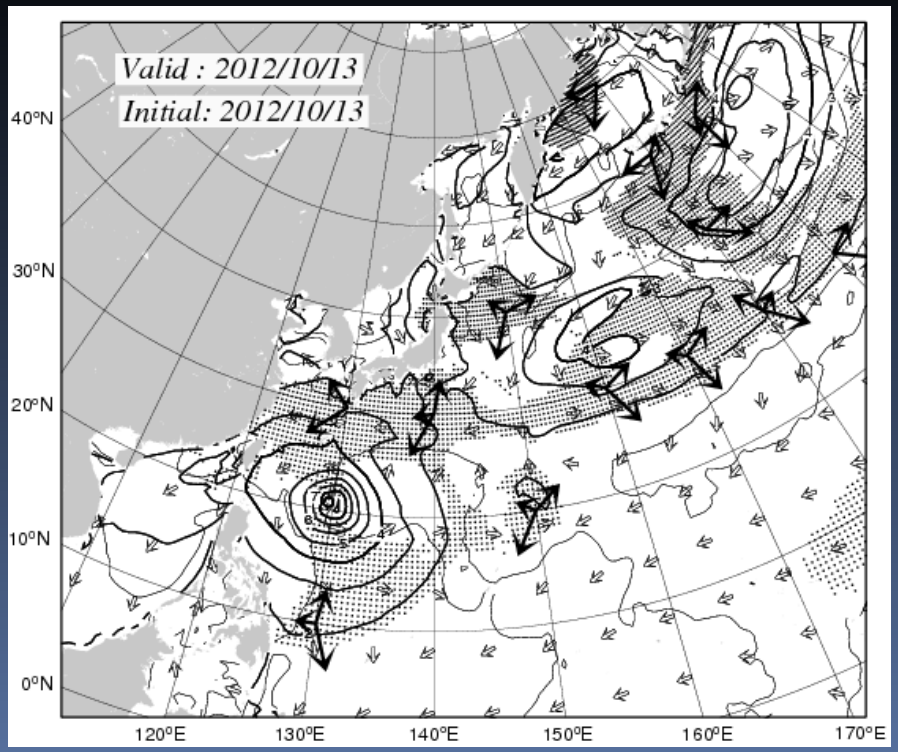
※ exclude the component direction angle is within 30 degree

Product Image

Comment: "*It is difficult to understand the concrete image of the area.*"

⇒ Direction of each components is plotted in marled area.

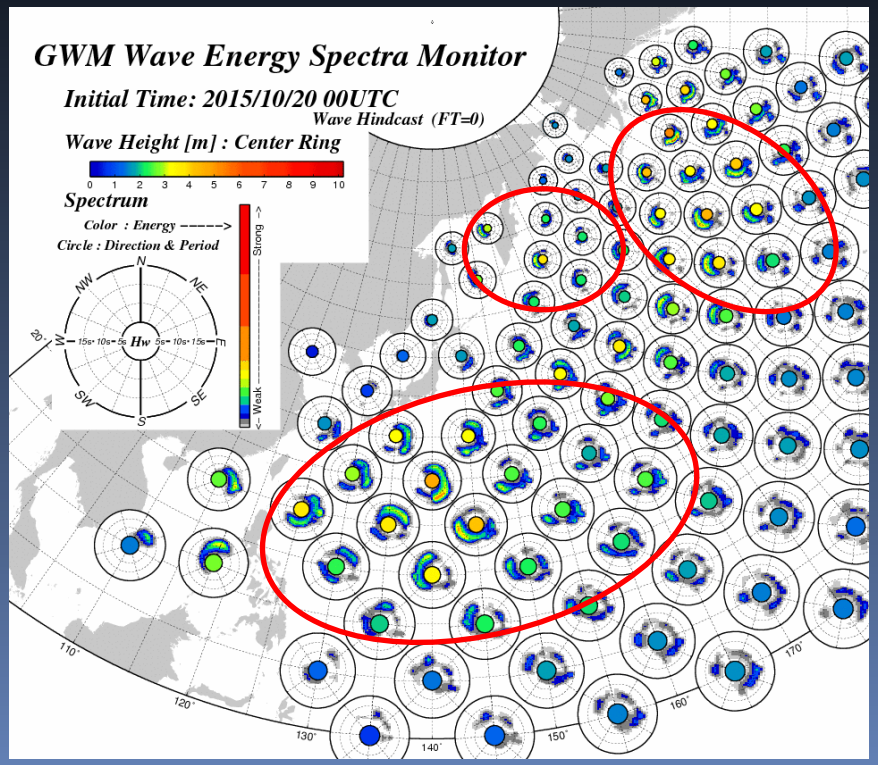




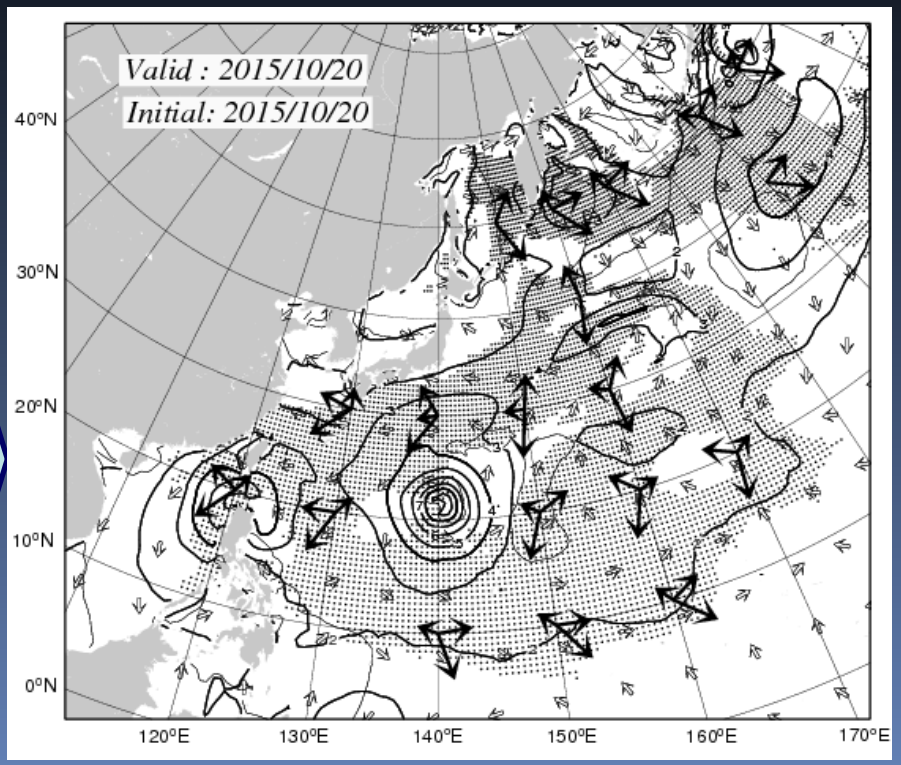
Threshold Definition (current)

1. Significant wave height $H_w > 1.8$m
2. Several waves exist: H_{w_i}, $i = 1, 2, \cdots$ (derived from wave partitioning and sorted)
3. Some wave component has comparable wave height (energy):
   - **1) $H_{w\_2} / H_{w\_1} > 0.6$**
   - **2) $H_{w\_3} / H_{w\_1} > 0.45$**
   - **3) $H_{w\_4} > 0.75$**

※ exclude the component direction angle is within 30 degree



Wave spectra (components)

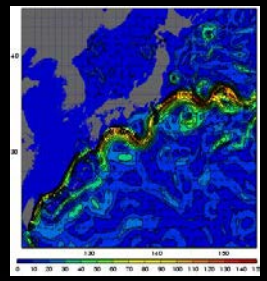


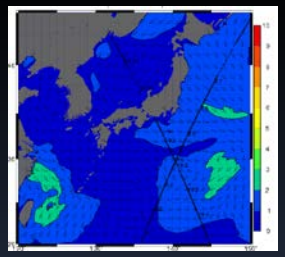
The image of JMH wave chart

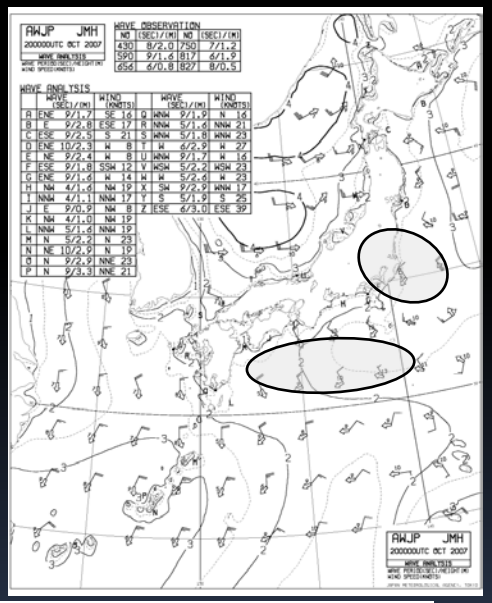
Current effect on waves

1) Refer current data and wave data
2) Calculate relative current speed to wave
3) Estimate wave height modification

The area wave height becomes higher than the original value will be marked.







Wave height modifications by currents

For deep water wave

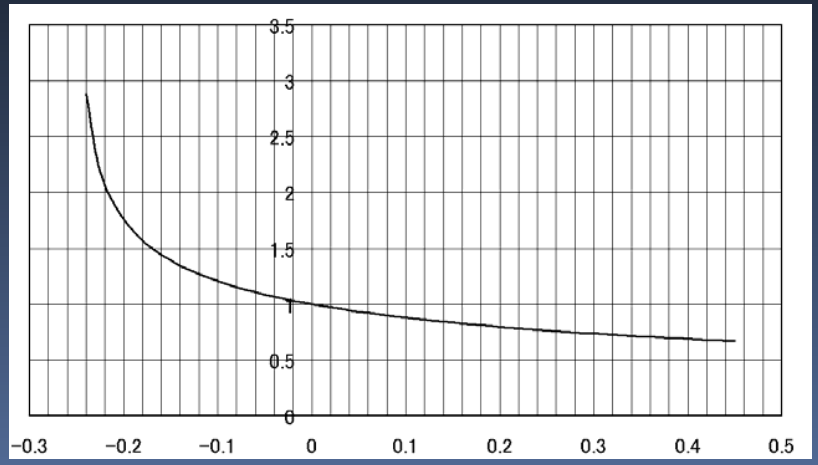
$$\frac{h}{h_0} = \sqrt{\frac{2}{1+\frac{4U}{c_0}+\sqrt{1+\frac{4U}{c_0}}}}$$

h: modulated wave height,

h_0 : original wave height

U: relative current speed (to wave),

$c_{0:}$: phase speed of wave



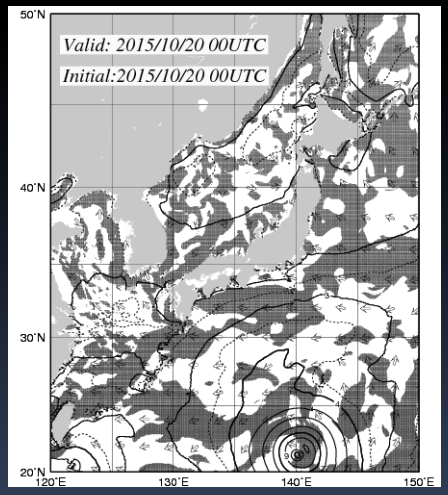
Wave heights become larger when

a. against current speed is large

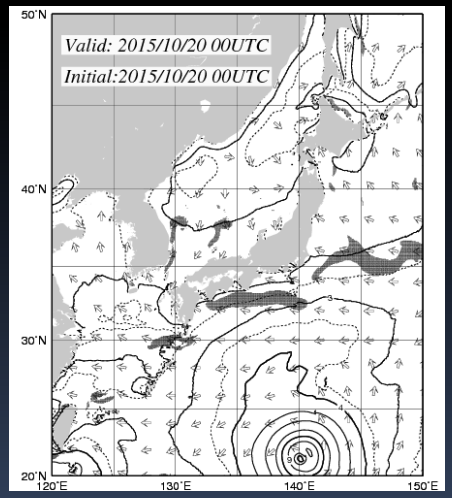
b. small phase speed (short waves)

Impact of enhancement rate

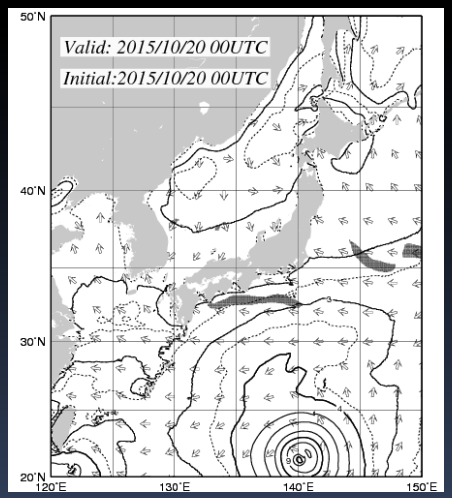
$$H_w \geq \alpha H_{w0}$$



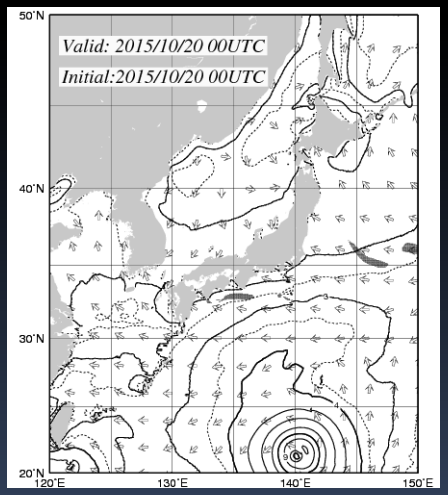
$\alpha > 0$



$\alpha > 0.05$ (5%)



$\alpha > 0.10$ (10%)



$\alpha > 0.15$ (15%)

Considering of comments by
Researchers / Crews of JMA R/V Ryofu-Maru,
The threshold was changed to the following definition:

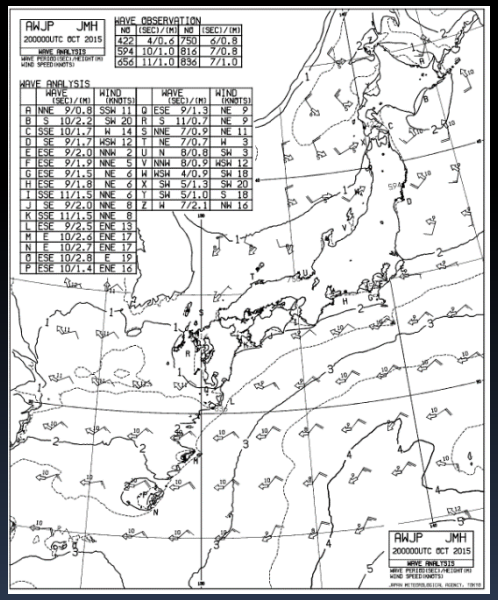
- Wave height > 0.5m
- Enhancement rate > 5% (← 10%)

JMA R/V Ryofu-maru
(1400t)

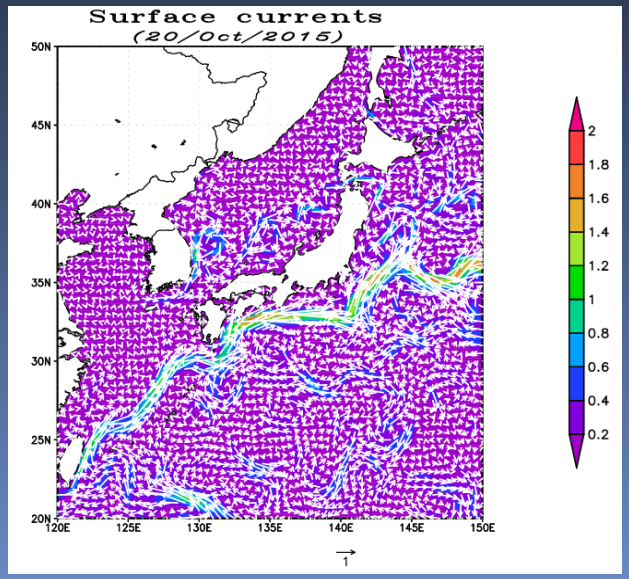
Current area

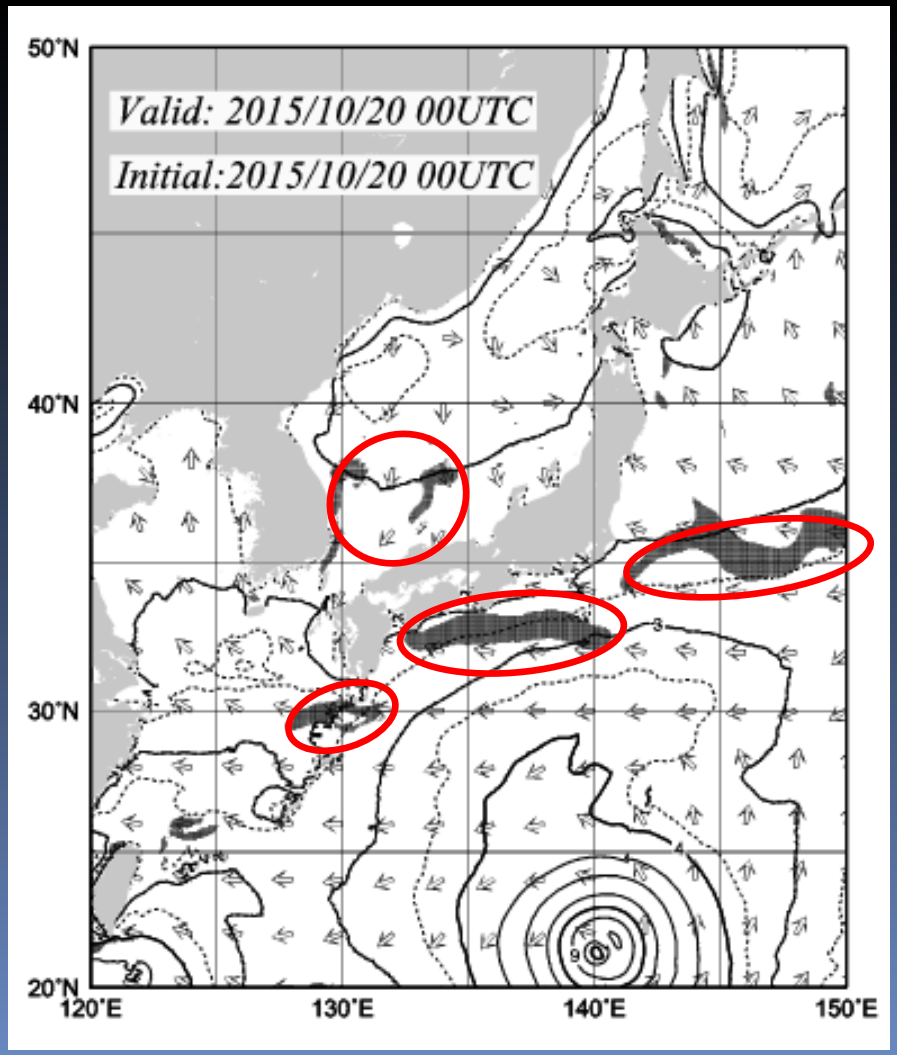
AWJP

(20/OCT/2015)



Surface currents of MOVE-WNP





Further work

- Multiple wave region
  - Threshold revision is still necessary
  - Classification of threshold, considering of ship size
  - Modification of product image
- Current effected region
  - Evaluation with wave components
- Trial monitor
  - JMA Research Vessels
  - Some Marchant ships (NYK etc)

We are going to start issuing the information in early 2017.

Summary

JMA is going to improve wave forecast information and system

- ✓ Marine Weather Forecast Distribution Map (18 MAR, 2015-)

  One day graphical forecasts for the sea around Japan.
  Six hourly forecast maps on winds, waves, visibility (fog) and ship icing up to 24 hours, are uploaded to JMA web site.

- ✓ Week range wave forecast (second quarter of 2016-)

  Wave Ensemble model system

  JMA is going to add wave and wind information to one-week forecasts. It is also planned to issue early warnings if high waves are feared in week range.

- ✓ 'Tough Navigation Area' information (early 2017-)

  Information on rough sea state, namely tough navigation area information will be added to JMA radio facsimile (JMH) wave charts.

Thank you for attention!