Recent improvement plans for JMA wave forecast information and system

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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, occurred 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.

![Marine accidents in Japan (JCG report)](image_url)
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

JMA HQ

Local Center

Map time

Map time

1 hour later

1 hour later

2 hour later

2 hour later

3 hour later

3 hour later

Typhoon analysis/forecast

Model GPV edit

GPV rectification (1st guess)

Warning (WN Pacific)

NAVTEX

DATA integration

Modification by local forecaster

Warning (local)

Distribution maps
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)

Whole Japan coast

East China Sea and Okinawa

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

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

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## Operational wave models at JMA

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

Ensemble mean

Max Hw of members

Probability of Hw > 6m

Probability
Yellow: Hw > 3m
Red: Hw > 6m
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 $H_w_{\text{sig}} > 3\text{m}$

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

Mean wave height

Maximum wave height

Probability of Hw_sig > 6m

(Results of 192 hours forecast)
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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

- 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.

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

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

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

3. 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)
Definition (old)

1. Significant wave height $H_w > 1.2\text{m}$
2. Several waves exist: $H_{w,i}$, $i = 1, 2, \ldots$ (derived from wave partitioning)
3. Some wave components have comparable wave height (energy): $H_{w_i} / H_{w_1} > 0.6$ $i = 2, 3, \ldots$

※ exclude the component direction angle is within 30 degree

Wave spectra (components)

The area is marked in wave chart
**Definition (old)**
1. Significant wave height $H_w > 1.2m$
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

**Definition (new)**
1. Significant wave height $H_w > 1.8m$
2. Several waves exist: $H_{w_i}$, $i = 1, 2, \cdots$
   (derived from wave partitioning)
3. Some wave components have 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

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

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.
Comment: “It is difficult to understand the concrete image of the area.”

⇒ Direction of each components is plotted in marled area.
1. Significant wave height \( H_w > 1.8 \text{m} \)
2. Several waves exist: \( H_{w_i}, \ i = 1, 2, \ldots \) (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
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 speed (short waves)
Impact of enhancement rate

\[ H_w \geq \alpha H_{w0} \]

Considering 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%)
Current area
(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

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Thank you for attention!