Reanalysis of wave conditions around the coast of Japan

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○ Introduction

Wave information is important for the safety of voyaging ships in offshore and Disaster Risk Reductions (DRR) in coastal areas. The long-term characteristics of waves are required as basic data for coastal disaster mitigation planning or hull design. In particular, there is growing interest in the long-term trends as a part of climate change impact.

Japan meteorological Agency has long archive of wave analyses/predictions, but their regulation and quality have some gaps when operational systems were changed. Therefore, we have started a wave reanalysis project for creating a homogeneous wave dataset. We also focus on long-term characteristics in the coasts of Japan, especially inner bays.

○Japanese Reanalysis for Three Quarters of a Century (JRA-3Q)

Atmospheric forcing is a key factor for wave simulations and reliable wind data are crucial for reasonable wave reanalysis. JMA has been conducting the Japanese Reanalysis for Three Quarters of a Century (JRA-3Q) for these years and the products have been just available (partly opened on 9 Dec 2022 and fully opened on 10 Aug 2023). The surface wind data of JRA-3Q is going to be used for the wave reanalysis.

The JRA-3Q uses a sophisticated data assimilation system (based on the operational set-up as of December 2018) and covers the period from September 1947 onward to extend the current period, the quality of data has much improved from the previous JMA reanalysis data JRA-55 (the Japanese 55-year Reanalysis).

Table 1 Outline of JRA-3Q

	JRA-3Q	JRA-55
Version of the system	JMA operational system at Dec, 2018	• JMA operational system • at Dec, 2009
Area	Lon: 0-360, Lat: -90-90	Lon: 0-360, Lat: -90-90
Grid resolution	40km	55km
Vertical levels	100	60
Data interval	6 hourly	6 hourly
Data duration	September, 1947 -present	1958-2023

JRA-3Q gives more reliable synoptic scale disturbances and tropical cyclones, which are important factors for high waves. The first look of the performances were reported by Harada et al. (2021) and so on, but they mainly focused on upper air conditions, the performance of surface winds were checked firstly.

Figure 1 shows JRA-3Q wind speeds of the Pacific in September 2019. A few of typhoons formed in north western Pacific and developed low pressures in the southern hemisphere. Figure 2 shows verification results of the wind speeds, compared with satellite observations by JASON-3 and SARAL. The scatter plots indicate good agreement of JRA-3Q winds with observations, and correlation are over 0.9. However, extremely stormy winds were not compared, and further verification is necessary.

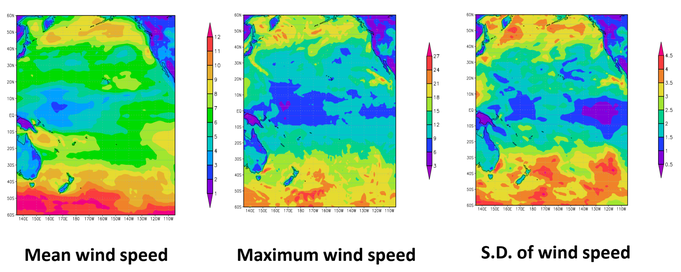

Figure 1 JRA-3Q wind speeds in September 2019. Mean values(left), maximum values (middle), And standard deviation (right).

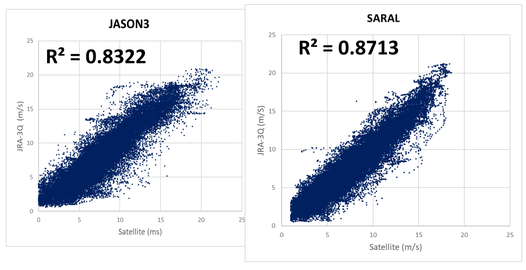

Figure 2 Comparison of wind speed of JRA-3Q and satellites in September 2019.

○Outline of Wave reanalysis

The wave models for reanalysis project was newly designed. Since the main target of reanalysis is detailed wave condition in the coast of Japan and a high resolution (~ 2km) model is required for resolving inner bays. Considering of available computer resources, we adopted variable grid system , based on the Spherical Multi-Cell (SMC) grid (Li, 2012). The grids system was set from 1 minute to 16 minutes (5 levels), and the range of those levels were determined from distances of grids from land. JMA issues coastal wave information within 20 miles, the area is covered by 1-minute resolution, but resolution becomes 16 minutes in offshore.

Table 2 Outline of planned wave reanalysis

model	JMA operational wave model MRI-III (JMA, 2022)
Area	Lon: 0-360, Lat: -72-72
Grid resolution	1 ~ 16 minutes (15-55N, 115-163E,north western Pacific), 16 minutes (other) [range of each resolution: NM from a land point] 1 min. : 0 – 20, 2 min.: 20 – 30, 4 min.: 30 – 40, 8 min. : 40 – 60, 16 min. : 60 -
Wave spectrum	900 components (25 in frequency x 36 in direction) frequency: 0.0375～0.3Hz, direction: 10 degree interval
forcing	JRA-3Q, winds around tropical cyclones may be modified (planned)
product	Significant waves Wave components (wind sea, and 2 swells) Wave spectra (selected points)
Data duration	1970-2020

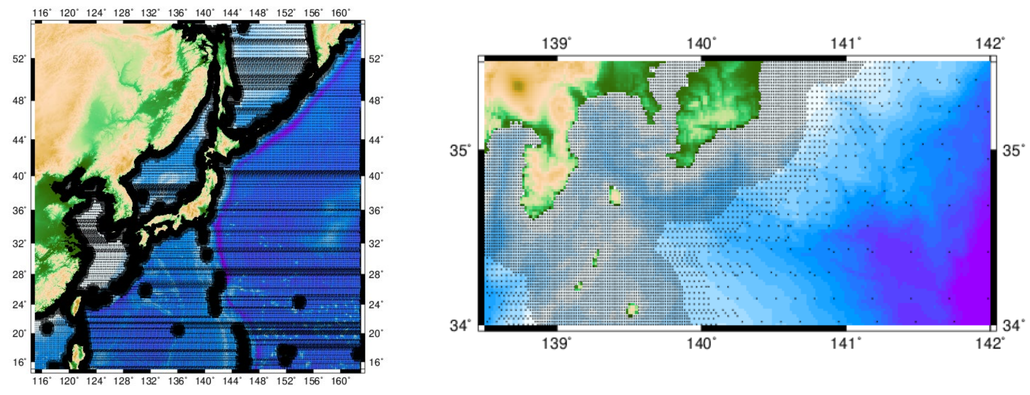

**Figure 3 Grid system image.
SMC area (left) and close up map around Kanto (right)**

Since JRA-3Q was delayed, we are checking the accuracy of surface winds. The main calculation has not yet started, and we conducted several test calculations for checking simulation ability of waves with JRA-3Q. Figure 4 and 5 shows wave simulation results of September 2019. Simulated wave conditions looks reasonable and temporal high waves by Typhoon Faxai and developed low pressure systems were fairly simulated.

It seems that JRA-3Q can be directly used to calculate high waves by tropical cyclones, but we need to check the validity more.

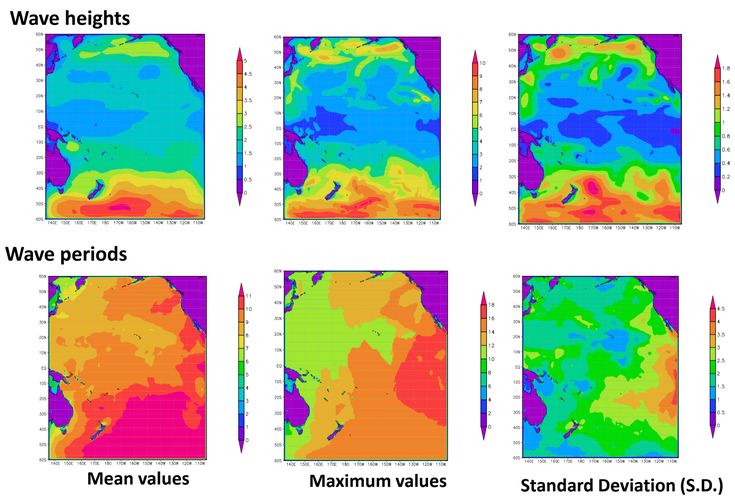

Figure 4 Simulated wave heights (upper) and period (lower) in September 2019. Mean values (left), maximum values (middle), and standard deviation (right).

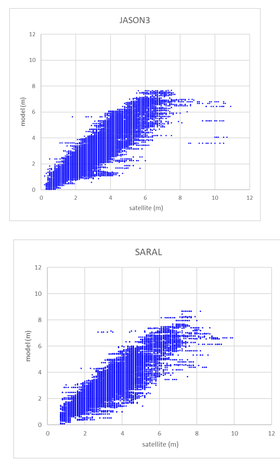

Figure 5 Comparison of wave heights with satellite observations.

○ Summary

- ✓ We have started conducting long-term wave reanalysis project , with the atmospheric reanalysis data JRA-3Q recently created by JMA.
- ✓ In the reanalysis, detailed long-term wave conditions near the coast of Japan, especially inner bays is focused.
- ✓ To conduct wave reanalysis, we designed a special wave model whose grid resolution is 1 minute around the Japanese coast. To save computational resources, we introduced variable grid system in western north Pacific, based on the SMC grid(Li, 2012).
- ✓ Due to delay of JRA-3Q, The main calculation has not yet started, and the accuracy of JRA-3Q winds was verified.
- ✓ We also have a plan to develop a new wave assimilation system, based on 3D VAR for the reanalysis, for creating accurate wave conditions.

References

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