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Development of an efficient wave model and wave reanalysis in Japanese bays

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Introduction

Wave Information

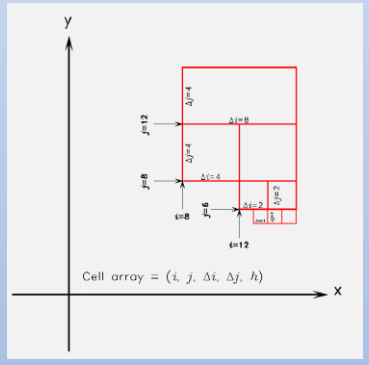
- ✓Important for safety of navigating vessels and DRR and mitigation for the coastal hazards
- ✓The long-range characteristic of ocean waves is crucial for DRR planning, ship design etc
- ✓Characteristic of long–range wave are interested in regards of climate change.

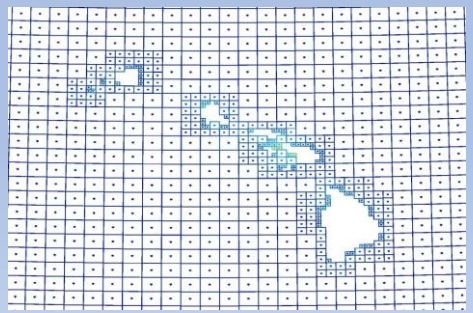
⇒

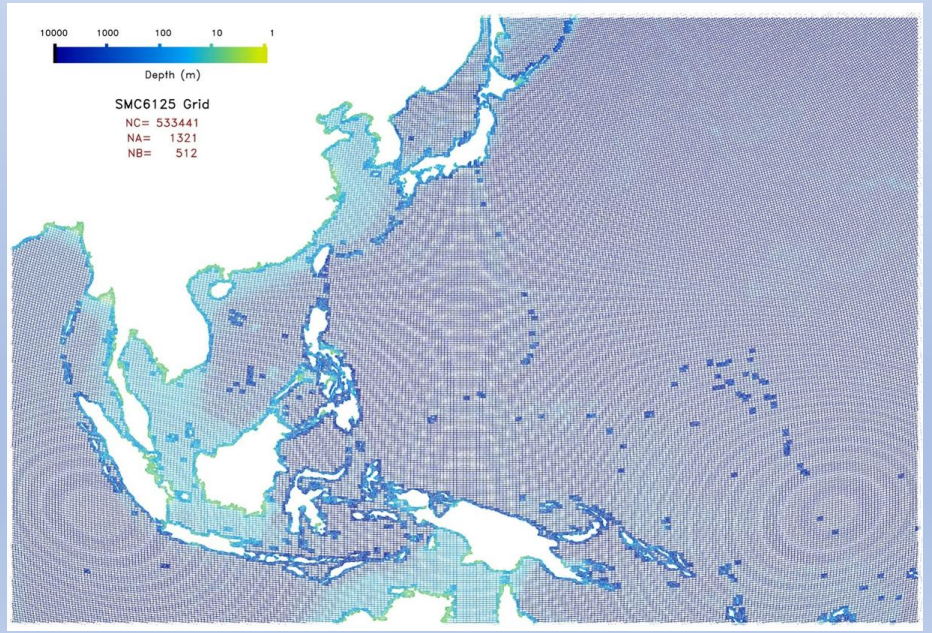
We are conducting wave reanalysis around the coast of Japan, with the wind of JRA-3Q, the latest JMA reanalysis. An efficient wave model was developed for long calculation.

SMC (Spherical Multi-Cell) grid Li (2011, 2019)

- A kind of unstructured grid models, but much efficient by using Finite Difference Method
- Reduced grid in polar region, and fine mesh adaption only around land area.
- SMC grid wave model is operationally used in UKMO

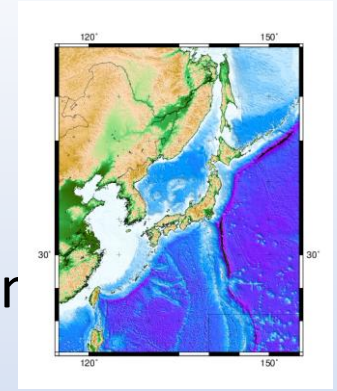






Li (2014)

Design of SMC grid



○Changed points

✓Grid resolution is defined considering the distance fror

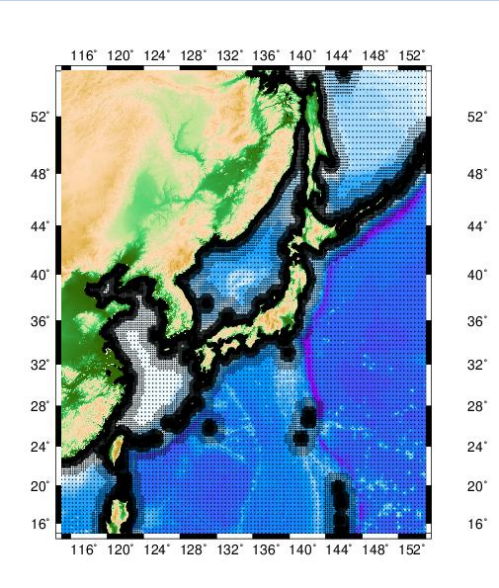
← fine mesh grids are only around land gird

✓Only square mesh is considered

← rectangle is applied

✓1st order upstream scheme

← 2nd /3rd Order UNO scheme + diffusion



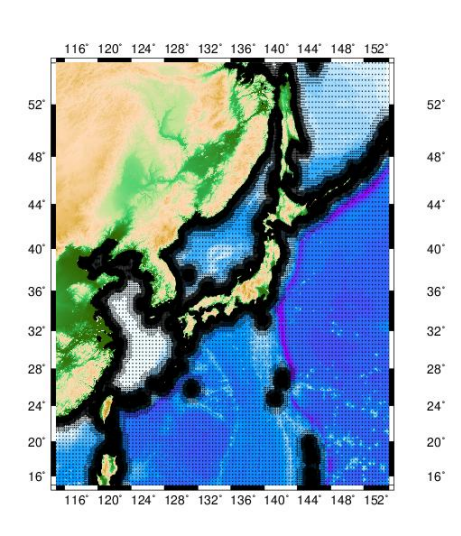
Domain: 115E - 155E, 15N – 55N
5km resolution (801 x 801 = 641,601)

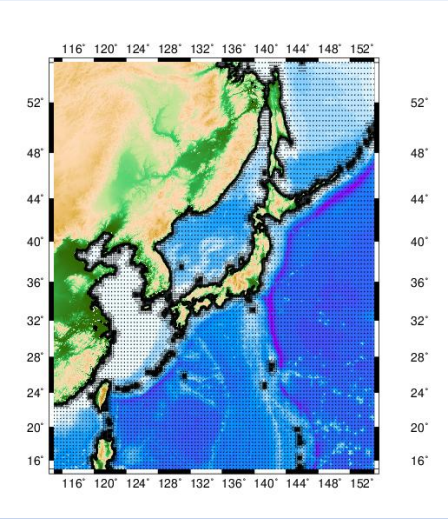
SMC 4 levels

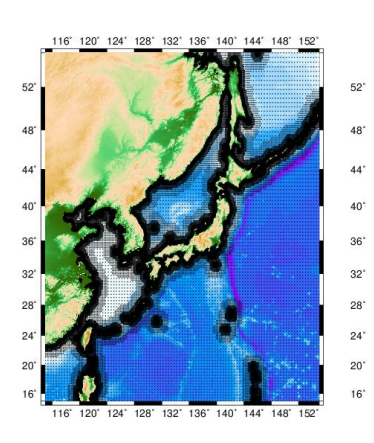
Res (km) :	5,	10,	20,	40
Dist (km) :	40,	80,	160,	
Num. Grid:	51,212,	12,301,	4,929,	4,515

Total: 72,957, (land: 196,494)

SMC grid options







SMC 4 levels

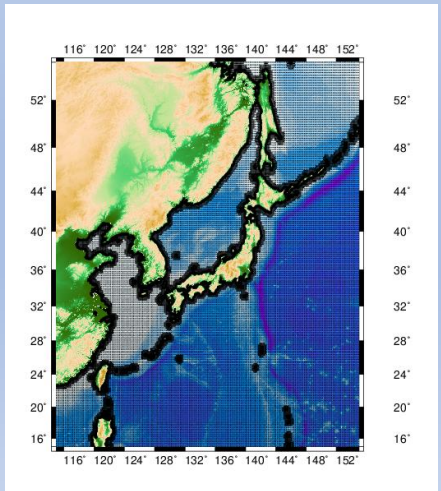
Res (km) :	5,	10,	20,	40
Dist (km) :	60,	120,	150,	
Num. Grid:	72,898,	11,535,	3,232,	4,645

Total: 92,310, (land: 196,494)

SMC 4 levels

Res (km) :	5,	10,	20,	40
Dist (km) :	10,	25,	50,	
Num. Grid:	27,158,	10,683,	3,910,	5,287

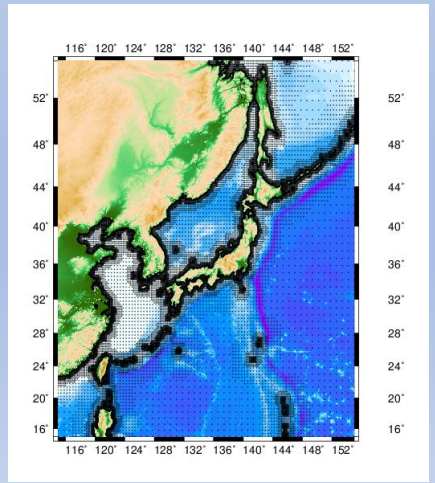
Total: 47,038, (land: 196,494)



SMC 3 levels

Res (km)	dist (km)	Num. Grid
5	20	27,158
10	50	10,683
20		24,209

Total: 62,050 (land: 196,494)



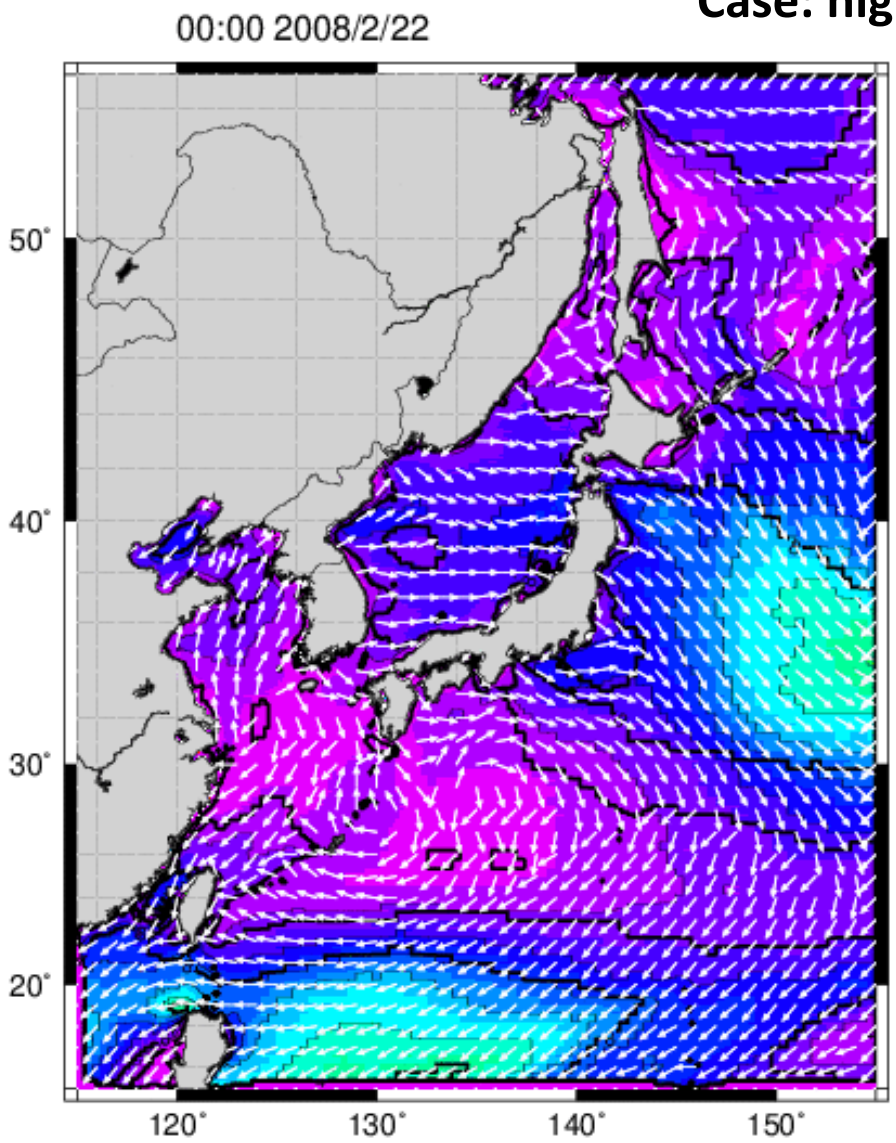
SMC 5 levels

Res (km)	dist (km)	Num. Grid
5	10	32,234
10	40	13,027
20	100	11,399
40	300	4,637
80		2,379

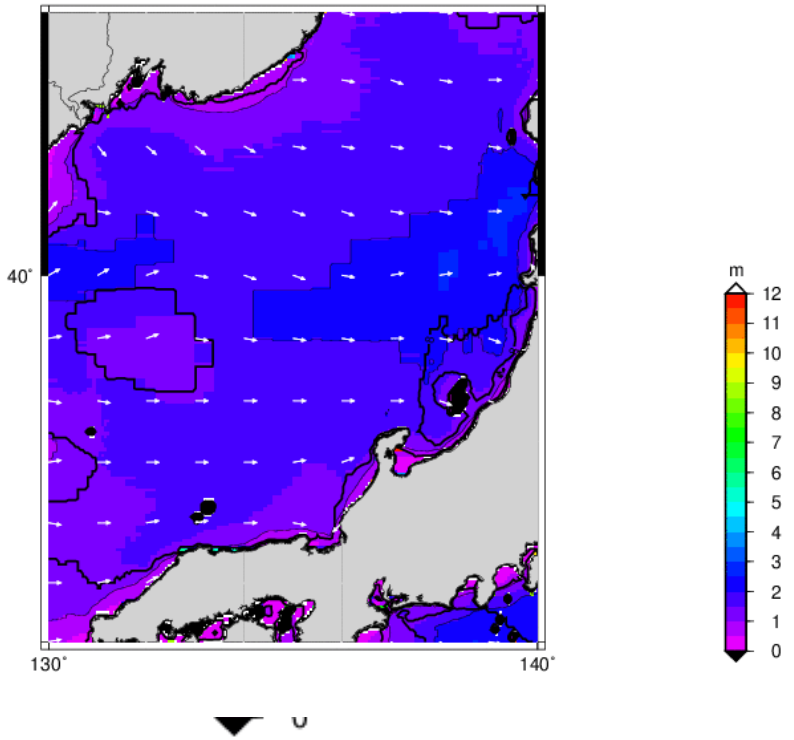
Total: 32,234 (land: 196,494)

Wave in sea around Japan (SMC grid)

Case: high waves in the Sea of Japan in Feb. 2008

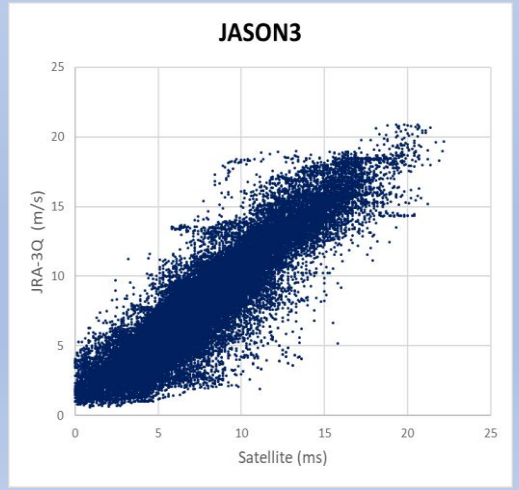


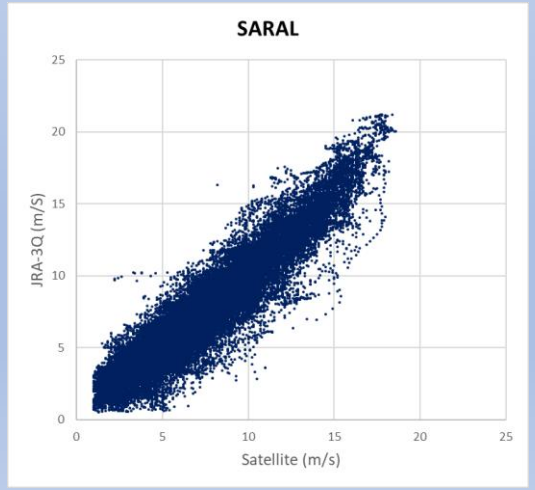
Resolution:
5 – 10 - 20 - 40 km (4levels)



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



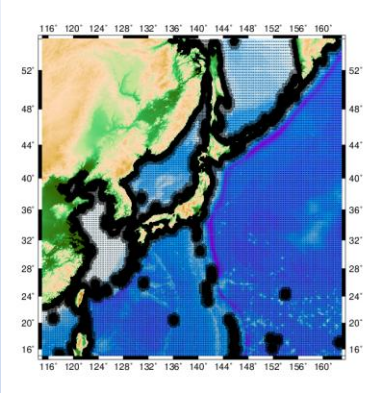


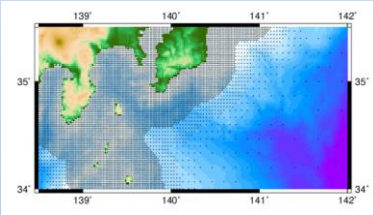
Several extreme events occurred by 6 typhoons and developed lows.

JRA-3Q surface winds can be fairly compared with satellite observations.

Wave Reanalysis

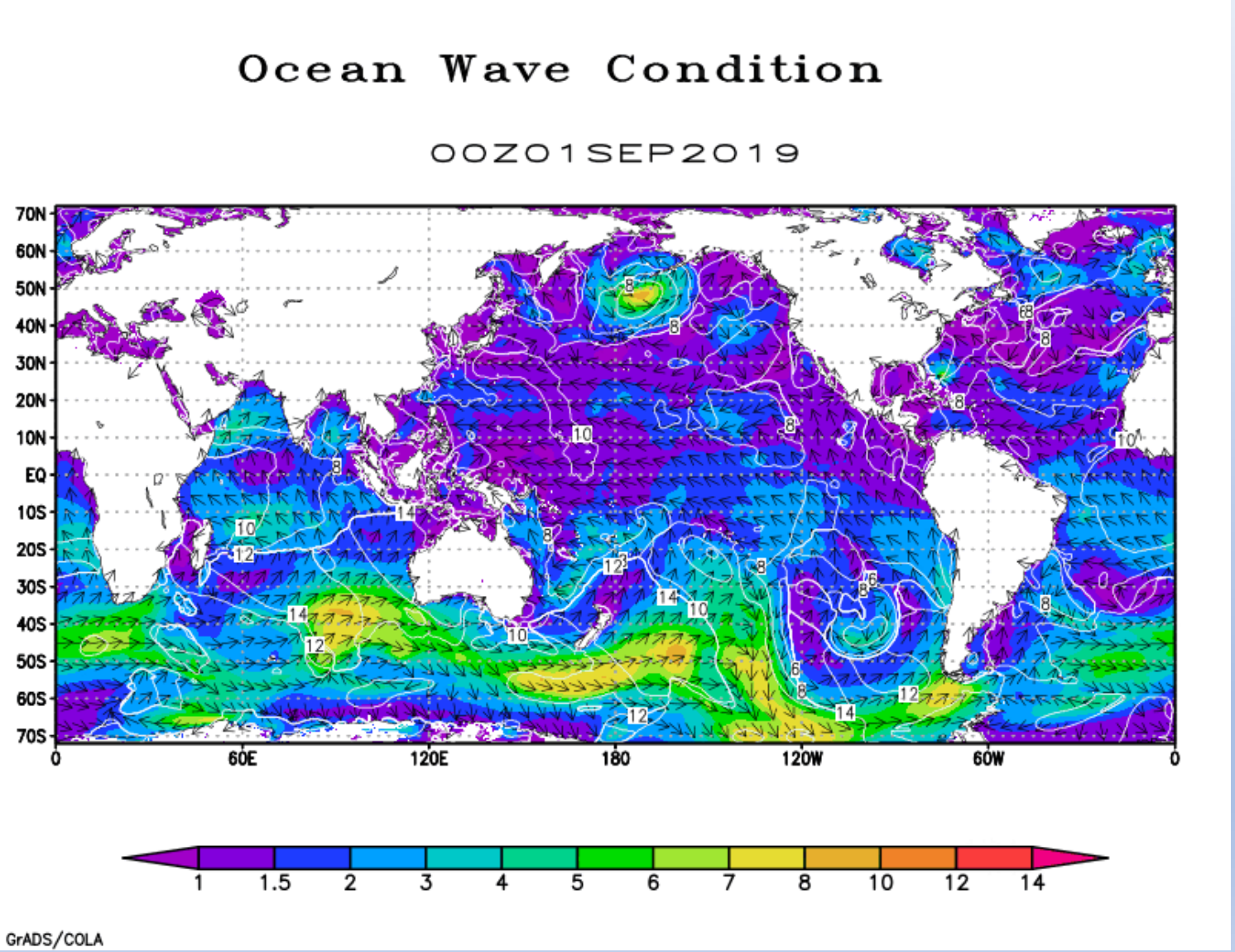
model	JMA wave model MRI-III	
Area	Lon: 0 - 360, Lat: -72 – 72	Lon: 115-155, Lat: 15 - 55
Resolution	16 分 (regular grid)	1 ~ 16 min (SMC grid) Range of resolution: distance from land (NM) 1 min: 0 – 20, 2 min: 20 – 30, 4 min: 30 – 40, 8 min: 40 – 60, 16 min: 60 -
Wave spectrum	900 components (freq: 25 x dir: 36） Period: 0.0375～0.3Hz, dir: 10 deg.	
forcing	JRA-3Q	
product	Significant waves: 3 hourly Wave components (windsea, swell ×2): 3 hourly Wave spectrum (selected points): 6hourly	Significant waves: hourly Wave components (windsea, swell ×2): hourly Wave spectrum (selected points): 3 hourly
Analysis period	1970 – 2020	





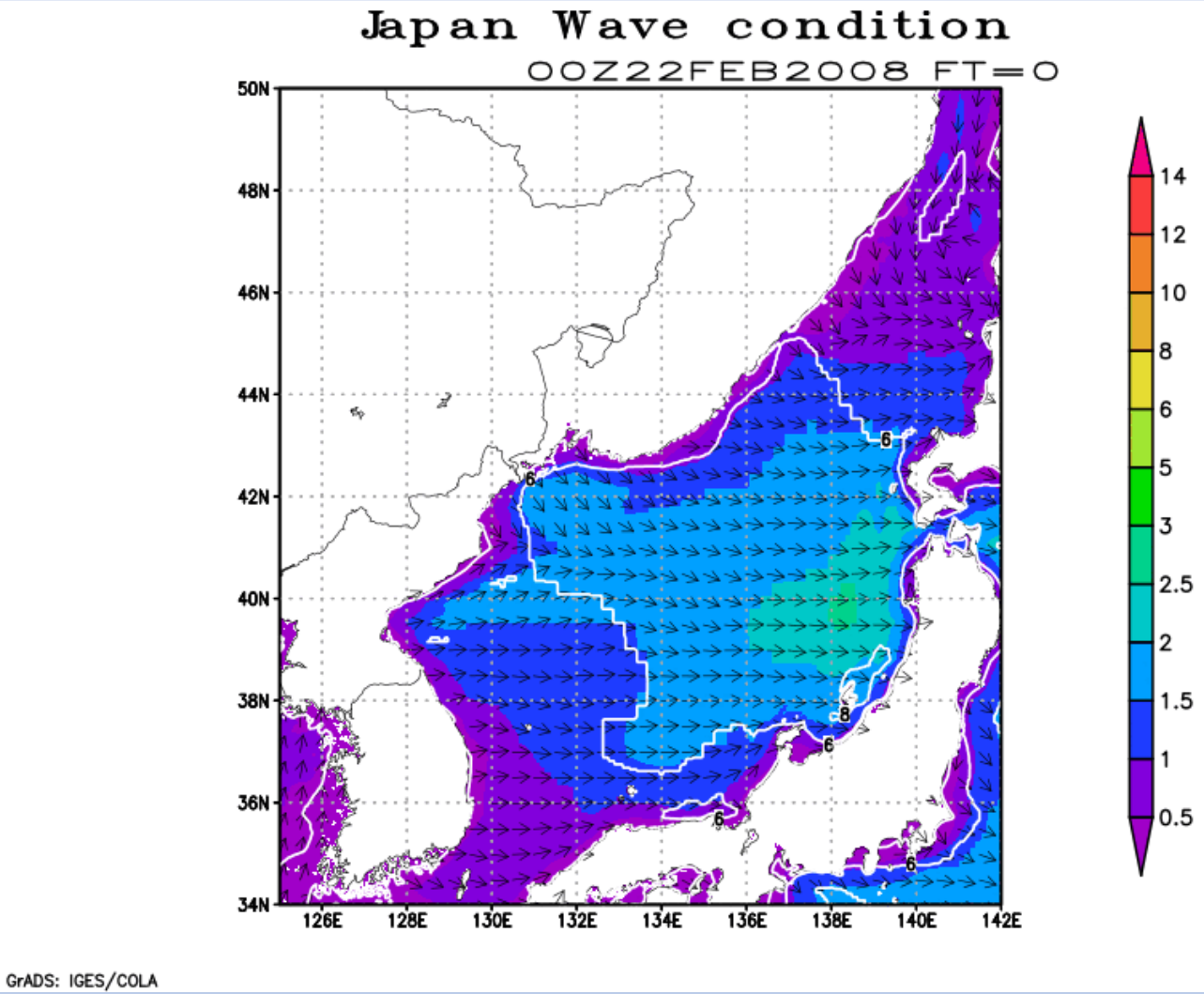
Global calculation (regular grid)

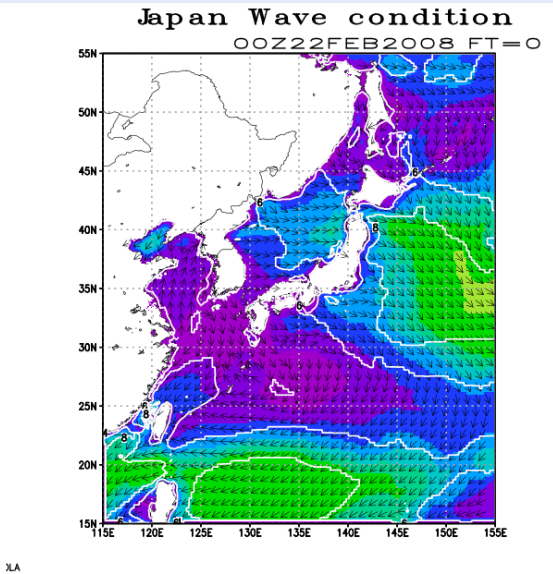
September 2019



Wave in sea around Japan (SMC grid)

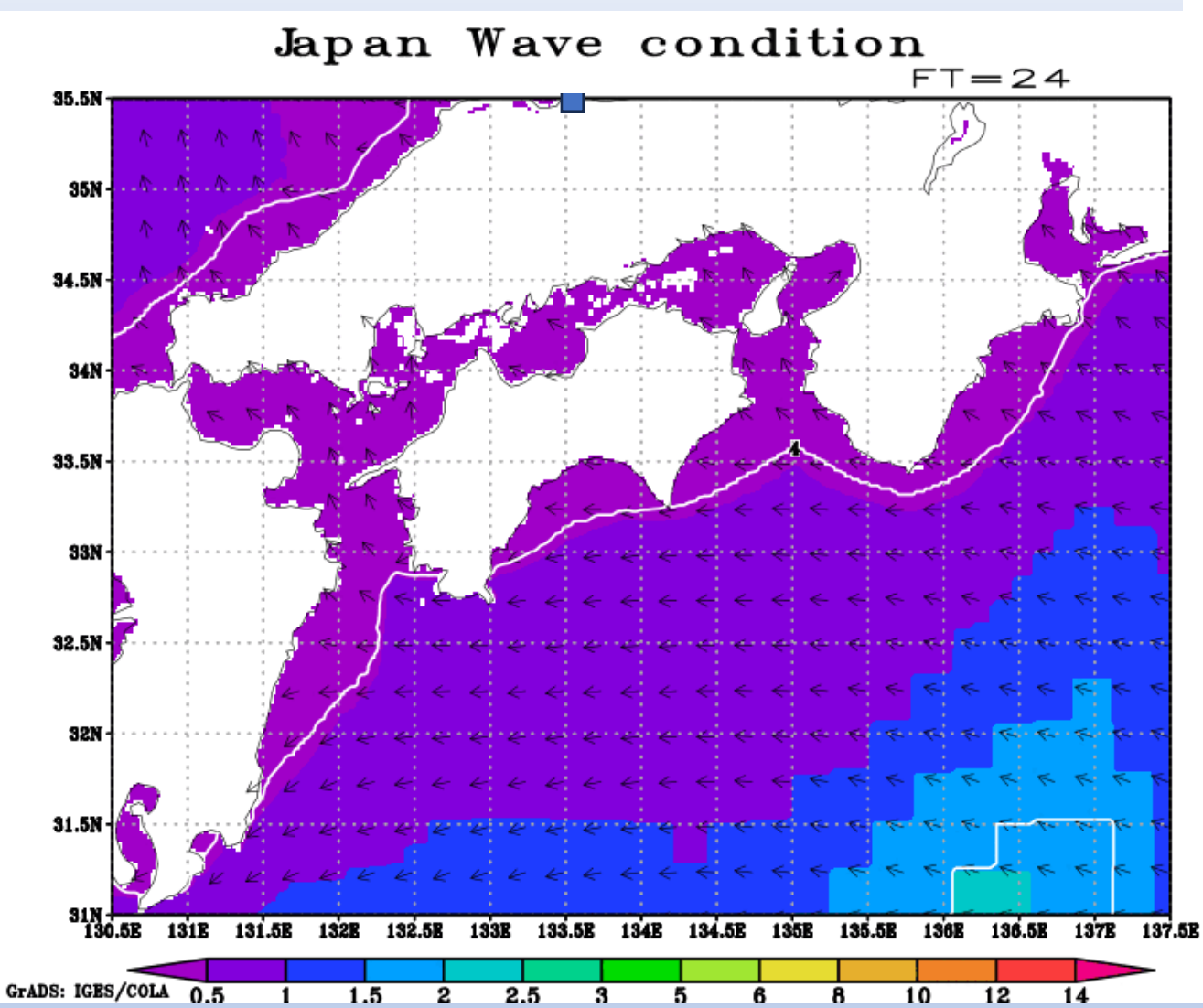
Case：High waves in the Sea of Japan in February 2008

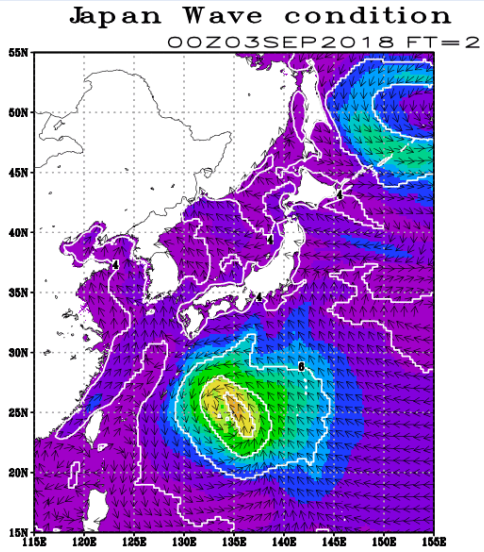




Wave in sea around Japan (SMC grid)

Case: High waves by Typhoon Jebi in September 2018





Summary

- An efficient wave model with SMC（Spherical Multi-Cell）grid was developed.
- The model resolves coastal areas with fine grids and becomes coarse in offshore n offshore, same as unstructured model. However, it is efficient because of direct calculation with since finite difference method.
- We also modified some coefficients to optimize JRA-3Q wind, and the model gives good accuracy in general.
- Using the model, we are conducting wave reanalysis around Japan, with wind data of JRA-3Q the latest JMA reanalysis.
- The reanalysis is carried out in global (regular grid model) and sea around Japan (SMC grid model).

Thank You for attention!

The JMA Mascot “*Harerun*”
(The word “hare” means fine weather in Japanese.)

※A part of this work was supported by *JSPS* KAKENHI *Grant* Number *JP21K21353.*