JRA-55 Forced High-Resolution Wave Climate Hindcast around Japan and its Spectral Representation

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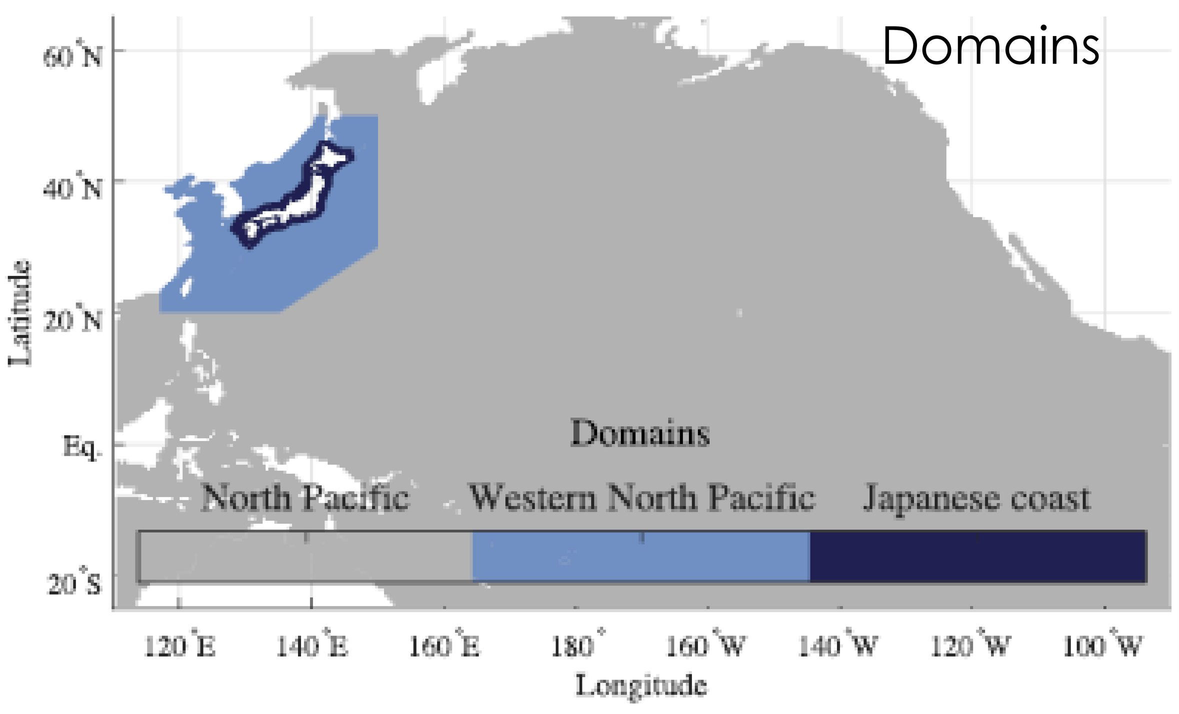
A 34-year high-resolution ocean surface wave climate hindcast around Japan is presented, and the wave climate around Japan is examined from a spectral point of view. The spectral wave climate representation provides new insight into the wave climate around Japan with clear relationships between the atmospheric conditions, the wave height, direction, and period.

JRA-55 Forced Wave Hindcast

The wave climate hindcast was conducted using the spectral wave model WAVEWATCH III. WAVEWATCH III is forced with six-hourly surface wind data and the monthly sea ice fields by JRA-55 atmospheric reanalysis data.



Period : 1979 – 2012
Domain :
- D1: 30 min
  25S-65N,110E-90W
- D2: 10 min
  20N-50N,117E-150E
- D3: 4 min
  100 km from coast

Model configurations
- Source: ST4, DIA
- Freq.:0.035–0.5047 Hz
- Dir.: 10 degree

Definition of mean wave spectra

The spectral wave climate is represented by temporal-mean two dimensional (direction-frequency) wave spectra. The temporal-mean two-dimensional wave spectra ($\overline{F(\theta,f)}$) are defined as follows:

$$\overline{F(\theta,f)} = 1/n \sum_{i=1}^{n} F(\theta,f)$$

where θ is the direction, f is the frequency, and n is the number of time steps. Using $\overline{F(\theta,f)}$, the temporal-mean significant wave height ($\overline{H_s^{sp}}$) is defined as follows:

$$\overline{H_s^{sp}} = 4\sqrt{\iint \overline{F(\theta,f)} d\theta df} = \sqrt{\overline{H_s^2}} = \sqrt{\overline{H_s}^2 + \sigma_{H_s}^2}$$

where $\overline{H_s^{sp}}$ equals to the root mean square of H_s and $\sigma_{H_s}^2$ is the variance of H_s. Analogously with $\overline{H_s^{sp}}$, the temporal-mean mean period ($\overline{T_m^{sp}}$) and mean direction ($\overline{D_m^{sp}}$) are defined as follows:

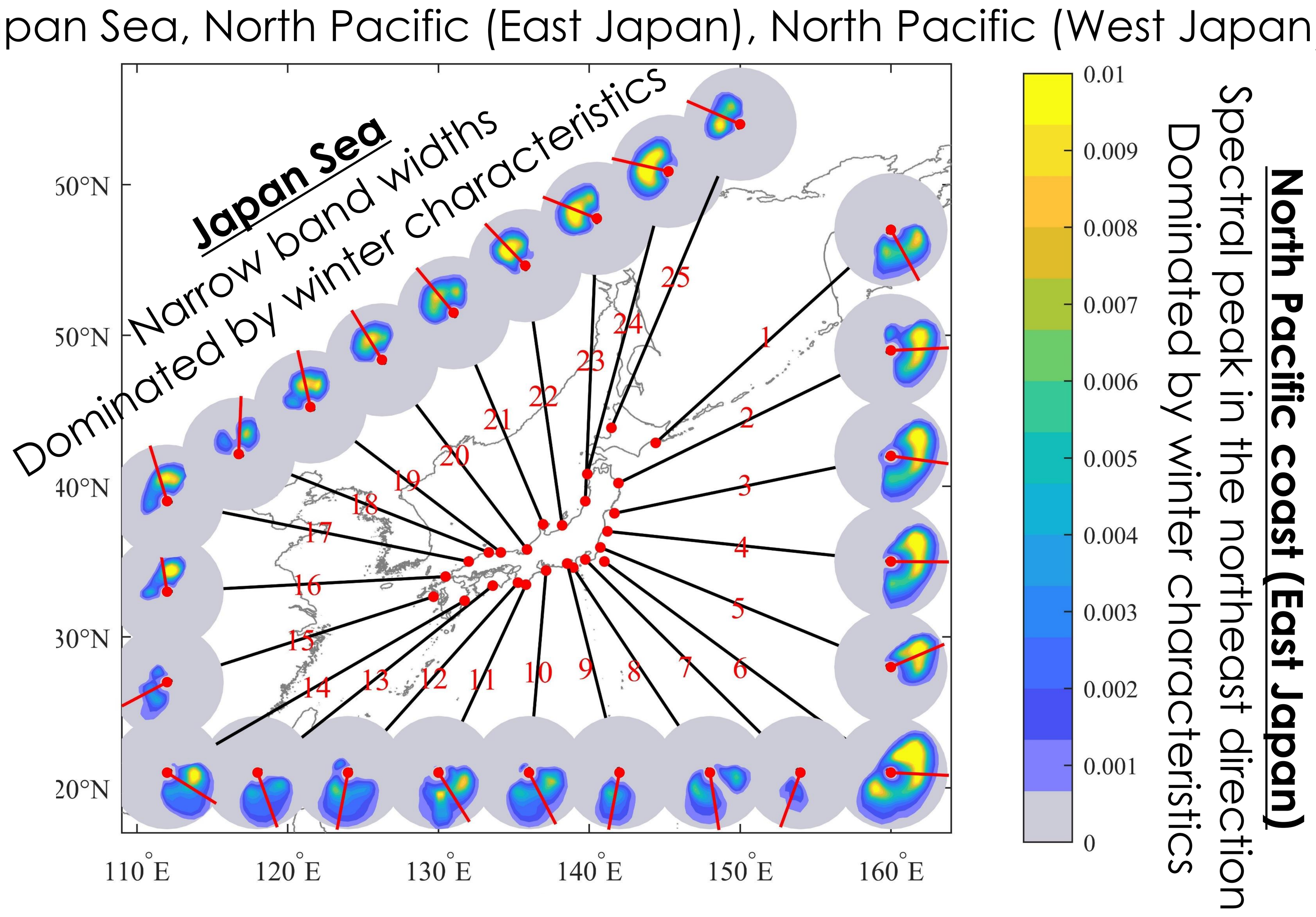
$$\overline{T_m^{sp}} = \left(\frac{\iint f\,\overline{F(\theta,f)} d\theta df}{\iint \overline{F(\theta,f)}\, d\theta df}\right)^{-1} = \left(\frac{\overline{H_s^2 f_m}}{\overline{H_s^2}}\right)^{-1}$$

$$\overline{D_m^{sp}} = \tan^{-1}\left(\frac{\iint \sin\theta\, \overline{F(\theta,f)} d\theta df}{\iint \cos\theta\, \overline{F(\theta,f)} d\theta df}\right) = \tan^{-1}\left(\frac{\overline{H_s^2 \sin D_m}}{\overline{H_s^2 \cos D_m}}\right)$$

where $f_m = 1/f_m$. $\overline{T_m^{sp}}$ and $\overline{D_m^{sp}}$ are equal to the mean values weighted by the squared H_s.

Mean wave spectra around Japan

The characteristics of the spectral wave climate ($\overline{F}$) are investigated by classifying them into three types (Three regions).
Japan Sea, North Pacific (East Japan), North Pacific (West Japan)



North Pacific coast(West Japan) $[m^2/(s\cdot rad)]$
Bi-modal peaks
Long-period components (TC generated waves)
Dominated by summer characteristics

Red line: $\overline{D_m^{sp}}$, θ: waves coming from, radius: Period not frequency

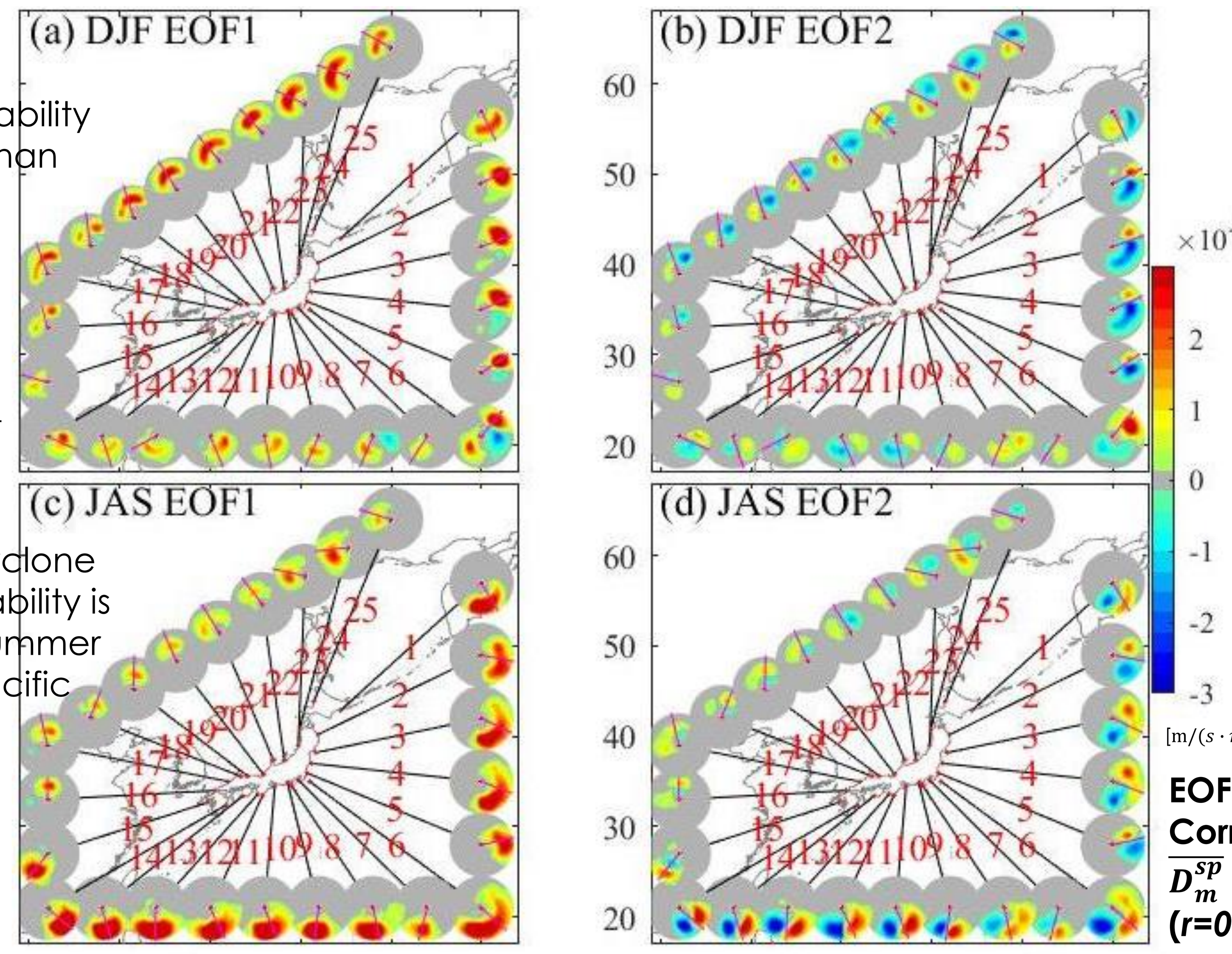
Variability of monthly mean spectra (EOF)

The variability in the monthly mean wave spectra is examined using an empirical orthogonal function (EOF) analysis. EOF 1st and 2nd modes in winter (DJF) and summer (JAS) is analyzed.

Winter variability is greater than summer in Japan Sea

EOF1 Corr. with $\overline{H_s^{sp}}$ and $\overline{T_m^{sp}}$ (r=0.9)

Tropical cyclone wave variability is strong in summer in North Pacific (West)

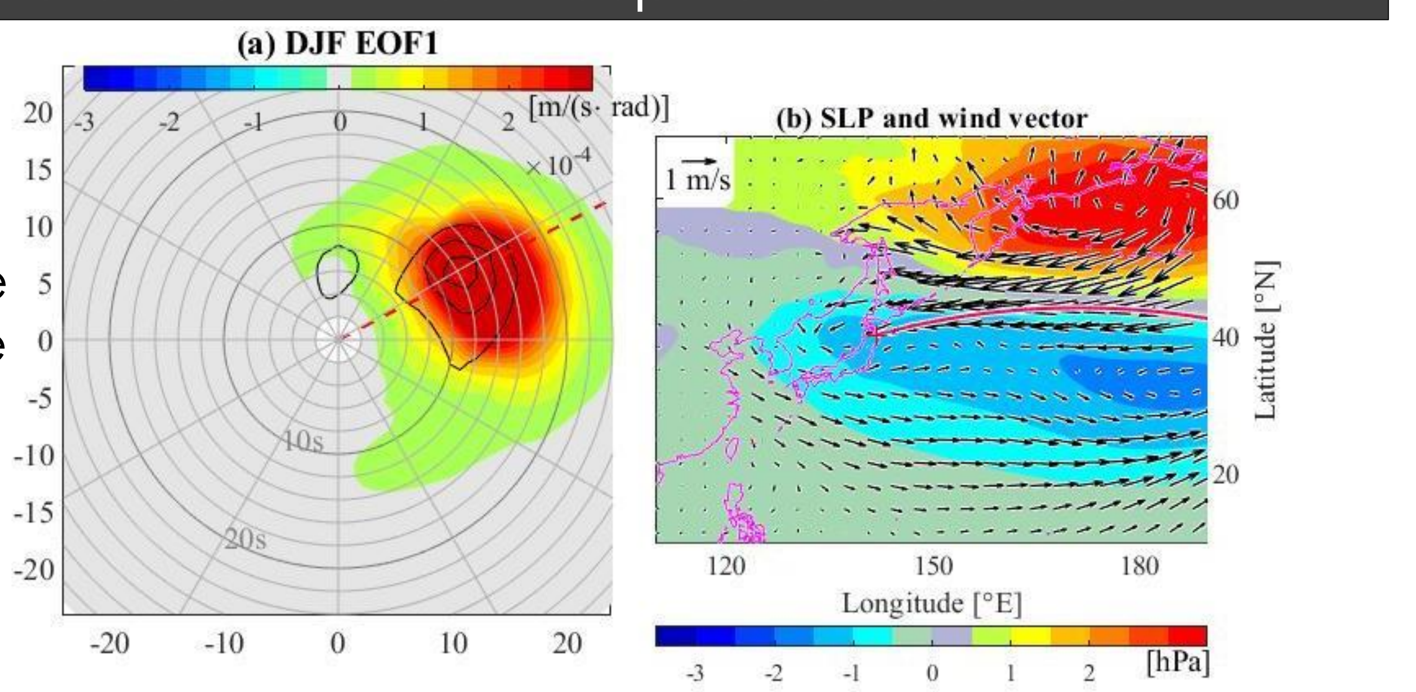


EOF2 Corr. with $\overline{D_m^{sp}}$ (r=0.5~0.9)

EOF1 and 2 have no correlation. Thus, the correlation between $\overline{H_s^{sp}}$ and $\overline{D_m^{sp}}$ is generally low.

EOFs related with atmospheric condition

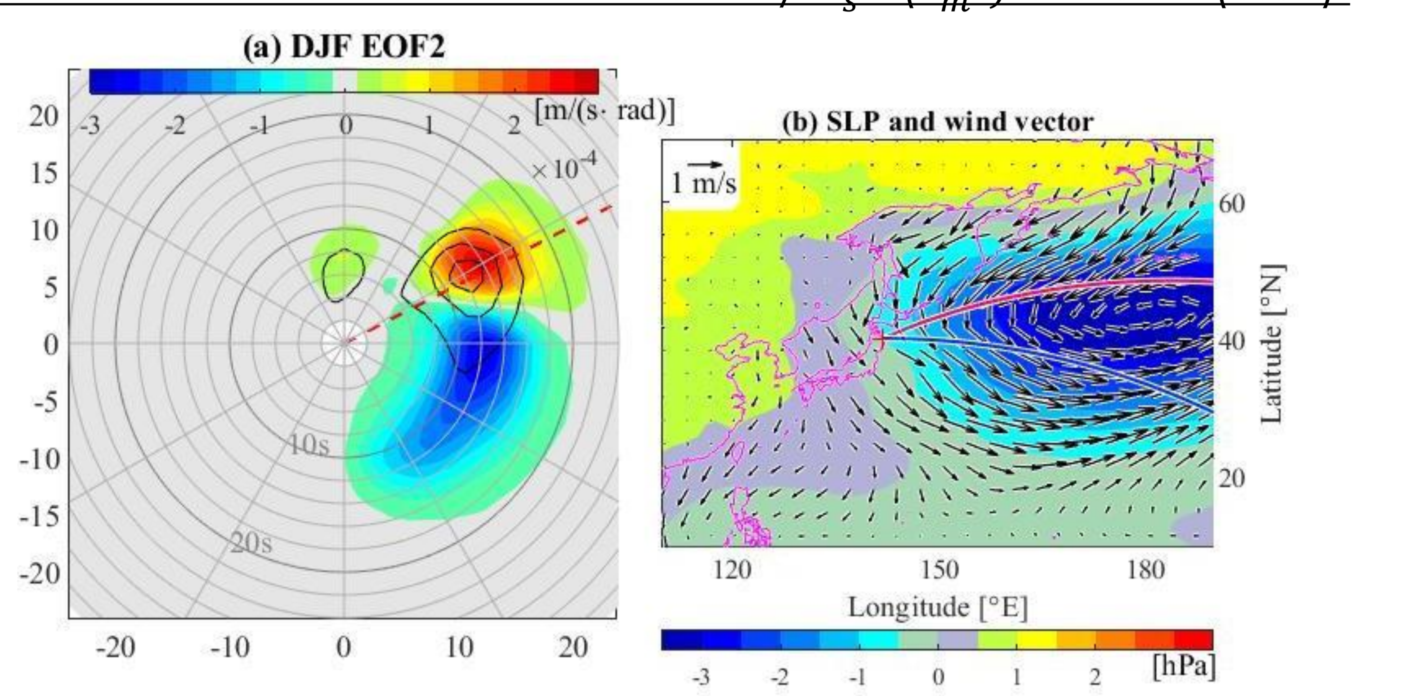
EOF1 of the representative location in the **North Pacific coast (East Japan)**



Contour: Mean wave spectra ($\overline{F}$)
Color: EOF, Red dashed line: $\overline{D_m^{sp}}$
Contour: Regression map of SLP on EOF
Vector: Regression map of wind

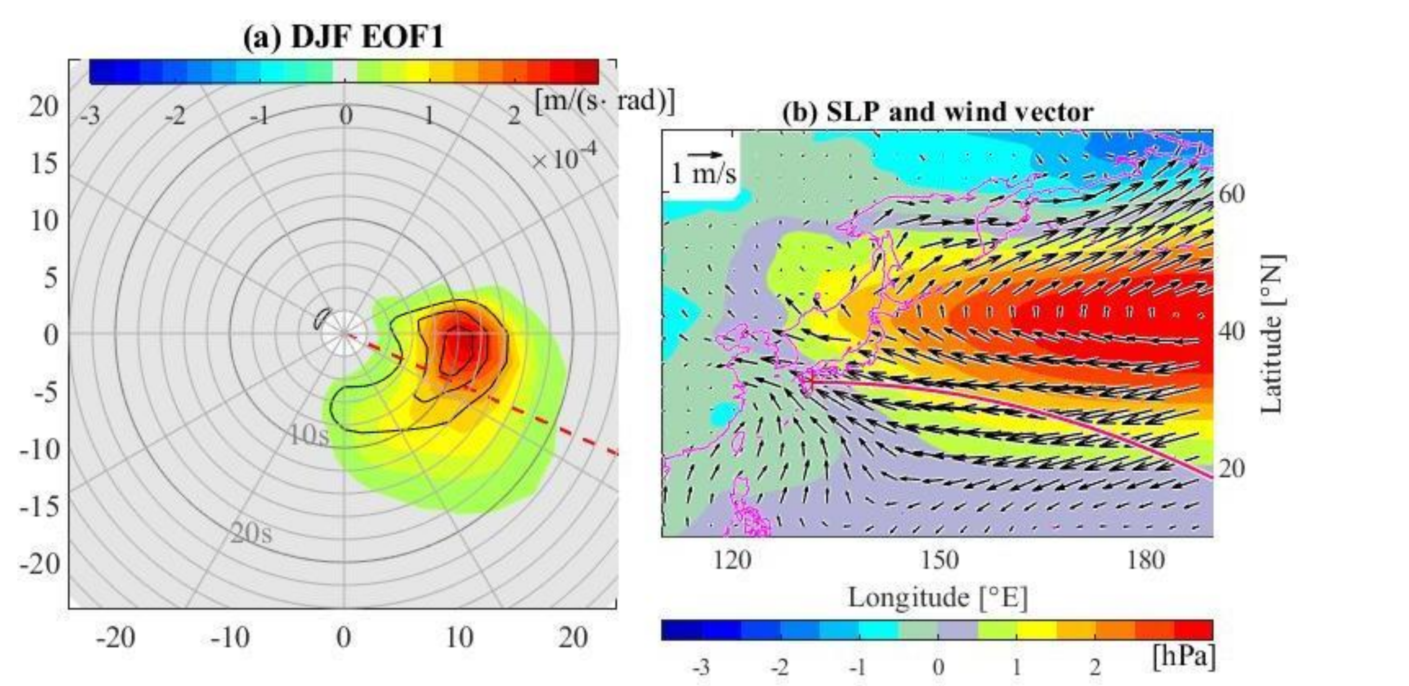
The **EOF1** represents the **variance in swell wave height** related to that in wind around Aleutian Islands. The corr. coef. with monthly $\overline{H_s^{sp}}$ ($\overline{T_m^{sp}}$) are 0.97 (0.89).

EOF2 of the representative location in the **North Pacific coast (East Japan)**



The **EOF2** represents the variance in **swell wave direction** related to that in SLP in the center of NP. The corr. coef. with monthly $\overline{D_m^{sp}}$ is 0.76.

EOF1 of representative location in the **North Pacific coast (West Japan)**



The **EOF1** represents the variance in **swell wave height** related to that in SLP in the center of NP. The corr. coef. with monthly $\overline{H_s^{sp}}$ ($\overline{T_m^{sp}}$ are 0.99 (0.88).

The wave height variability (EOF1) is related to wave direction variability (EOF2) at locations 1000 km apart via the sea level pressure variance over the North Pacific.