Distribution of near-inertial waves in the mixed and deep layers of the East/Japan Sea from a high-resolution wind-forced ocean model

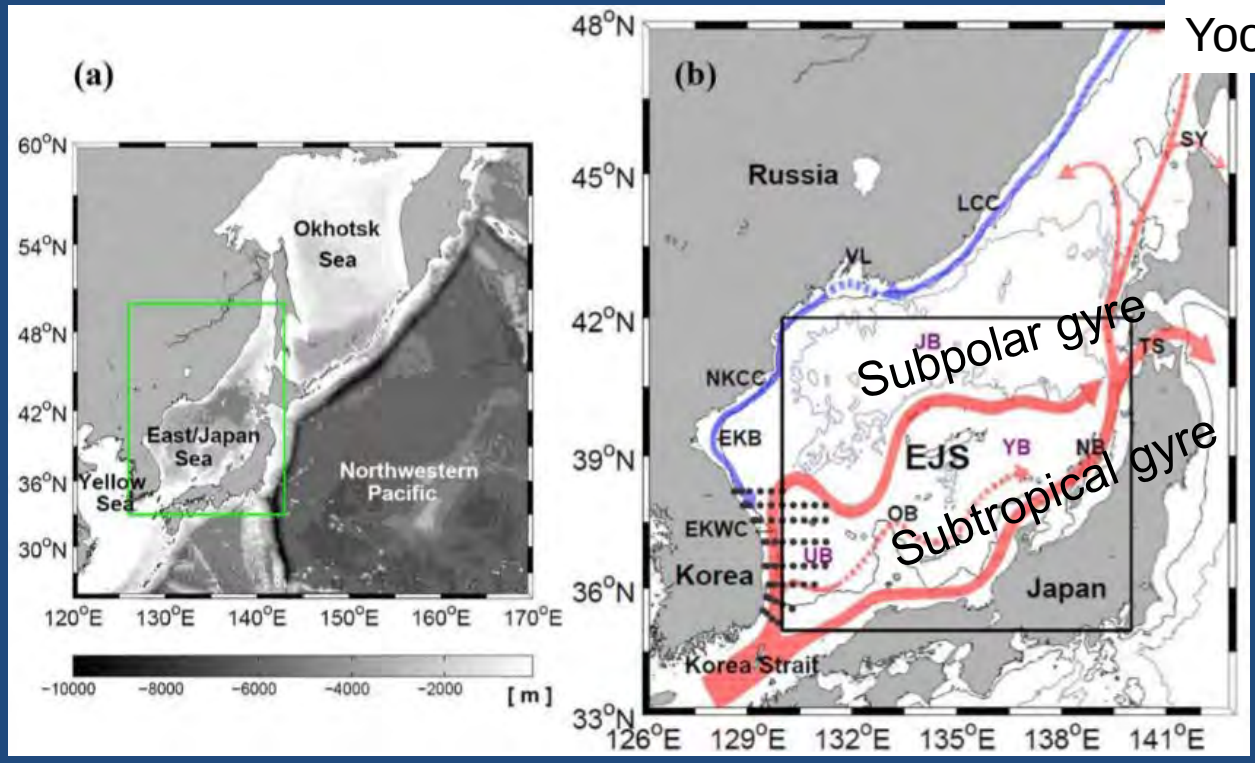
Chanhyung Jeon[1], Jae-Hun Park[1],
Young-Gyu Park[2] and Hong Sik Min[2]

[1] Inha University (IU),
[2] Korea Institute of Ocean Science and Technology (KIOST)

Near-inertial waves (NIWs)

- Inertial wave is the inertial oscillation which frequency is the local inertial frequency *f*.
- NIWs show a spectral peak around the local *f*, and they are observed almost everywhere in the global ocean.
- NIW is one of the crucial sources for ocean vertical mixing.
- Better understanding of NIWs and their impact on ocean mixing may lead us to better prediction of future climate changes.

The East/Japan Sea (EJS)

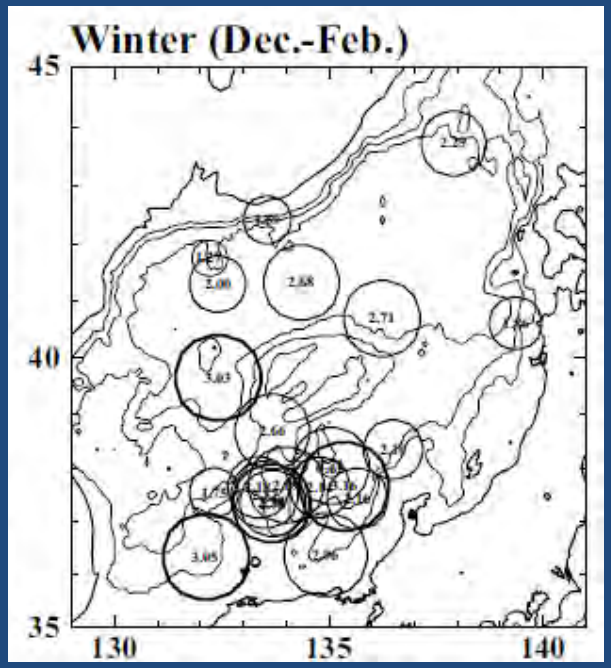


Yoon et al. 2016

- subtropical and subpolar gyres, subpolar front
- abundant mesoscale eddies
- deep convection and meridional overturning circulation

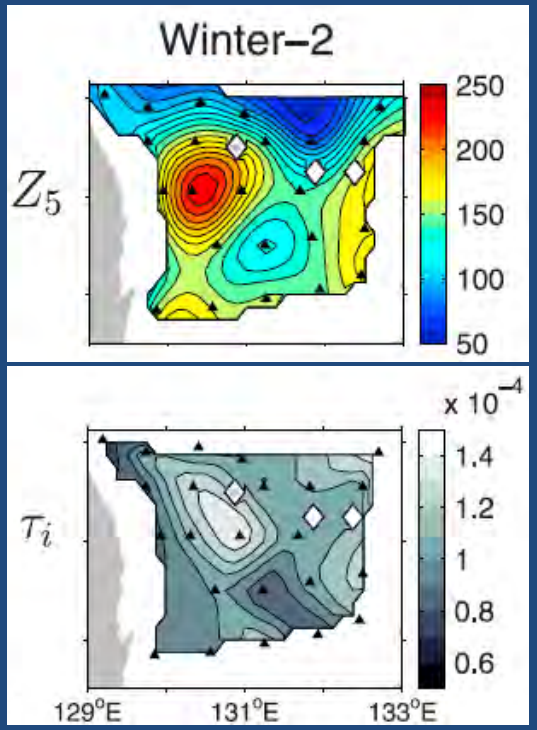
NIWs in the EJS

Mori et al. 2005



NIWs are stronger in the deep layer at the southern EJS.

Park and Watts, 2005



5°C isotherm depth

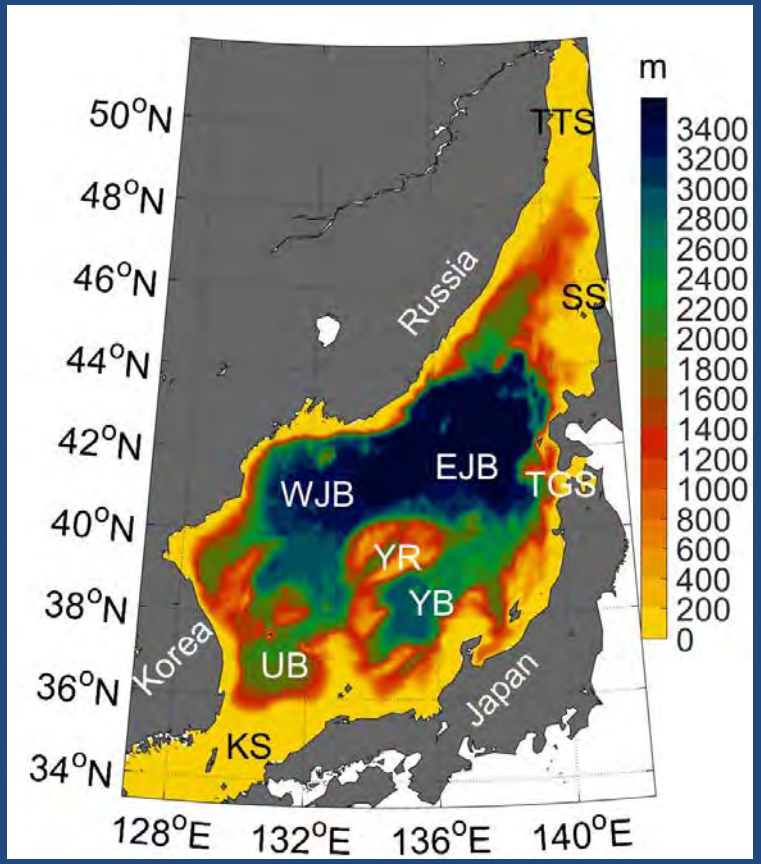
NIWs signal

Anticyclonic eddy can trap the NIWs energy their inside.

Purpose

Investigate the distribution of the NIWs energy in the mixed and deep layers of the EJS from a data-assimilated high-resolution wind-forced ocean model

High-resolution wind-forced ocean model (RIAM Ocean Model)



Domain of the model

- ✓ Developed for real-time forecast
- ✓ Horizontally 1/12^{o}
- ✓ Vertically 64 layers (z-coordinate)
- ✓ 3-D temperature and salinity, SSH, and transport through Korea Strait are assimilated.
- ✓ Model is forced using hourly interval winds and other atmospheric variables (and tides).
- ✓ Hourly inputs and outputs from Nov. 2012 to Sep.2015 (34-month) are analyzed.

Results

1) NIWs in the mixed layer

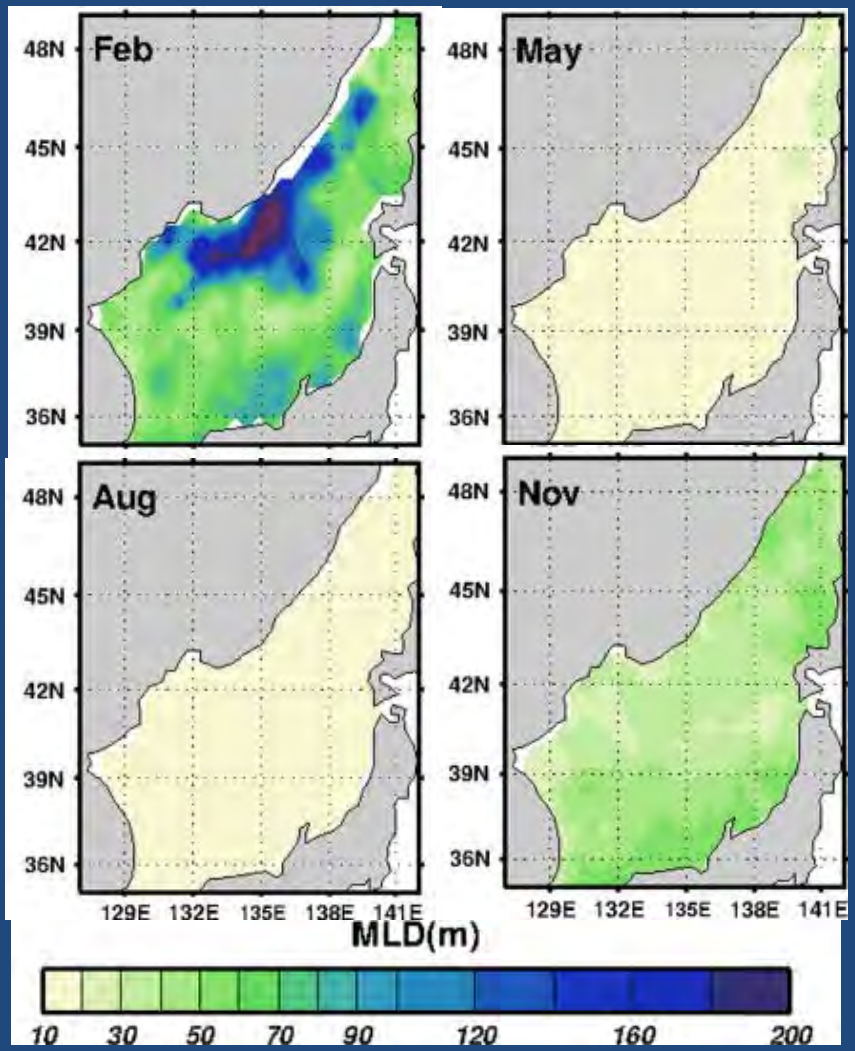
2) NIWs in the deep layer (400–1000m)

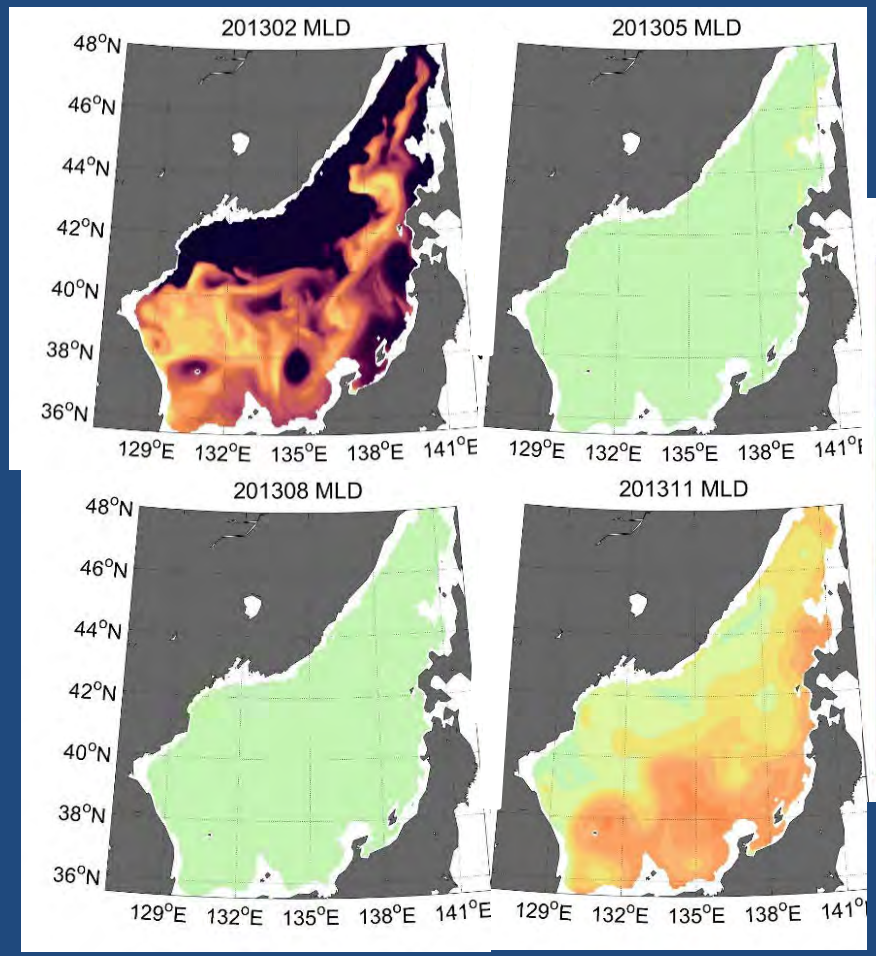
3) NIW energy flux

1) NIWs in the mixed layer
: evaluate mixed layer depth

Mixed layer depth is defined where dT > 0.2 from the surface.

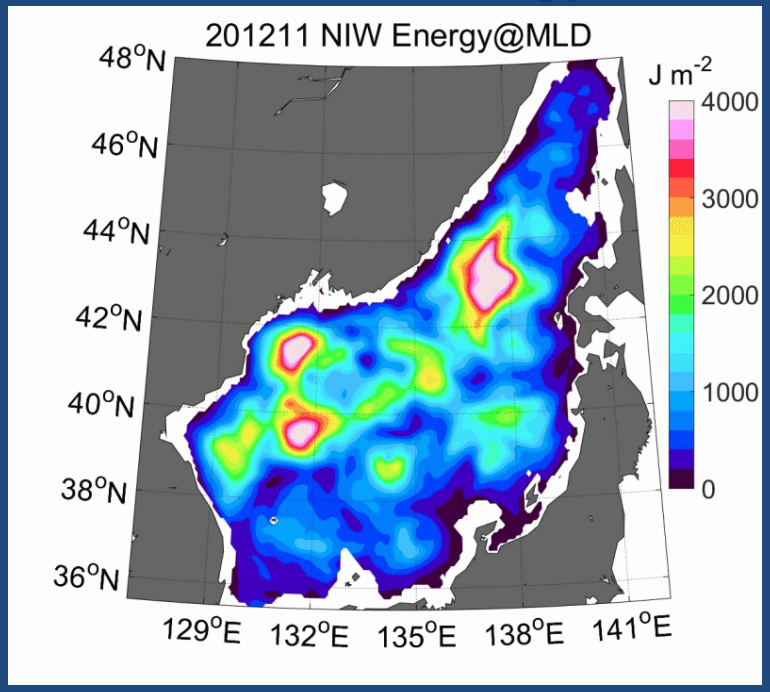
Lim et al. (2012)



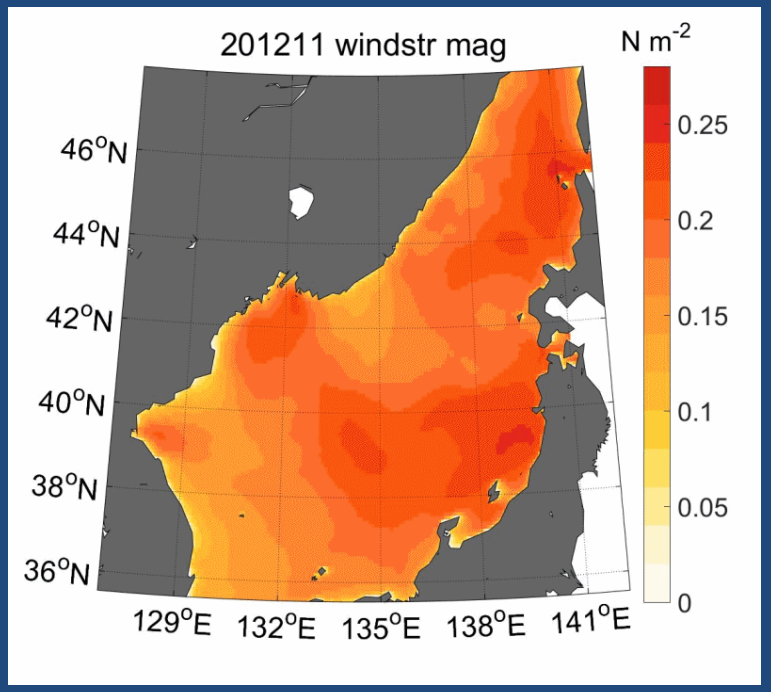


1) NIWs in the mixed layer (temporal)

NIWs energy



Wind stress

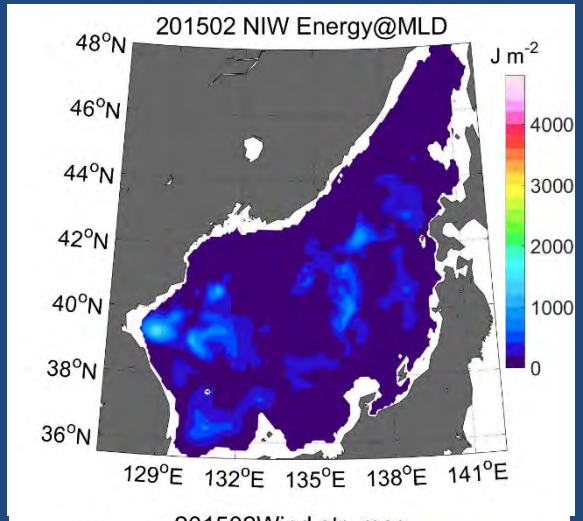


1. NIWs are stronger in winter than in summer corresponding to the strength of wind stress.

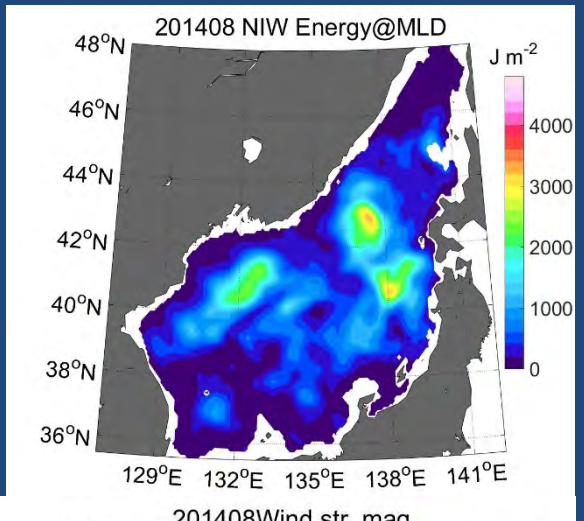
1) NIWs in the mixed layer (temporal)

2. But sometimes NIWs are weak (strong) in winter (summer) even the wind is strong (weak).

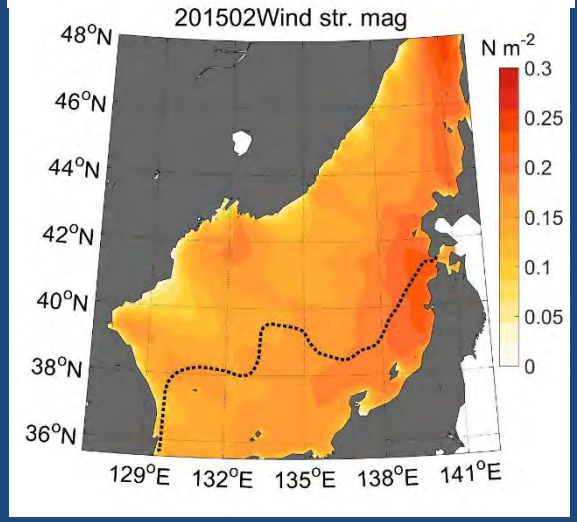
Relatively weak NIWs



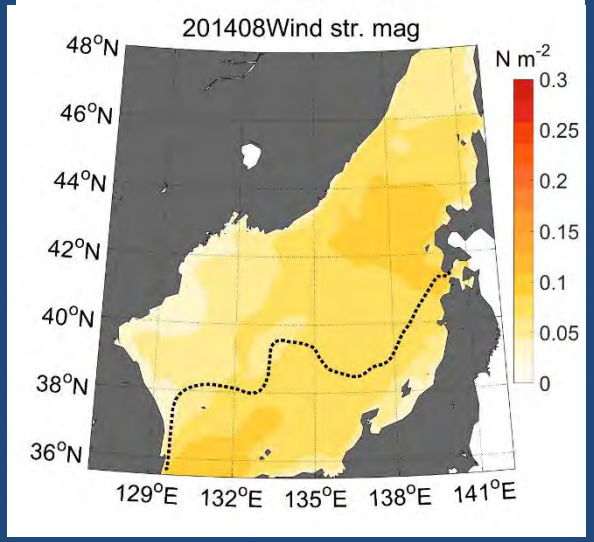
Relatively strong NIWs



strong wind (in winter)



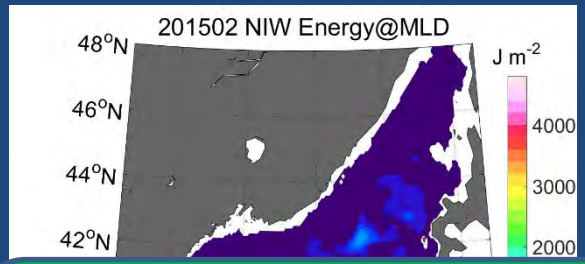
weak wind (in summer)



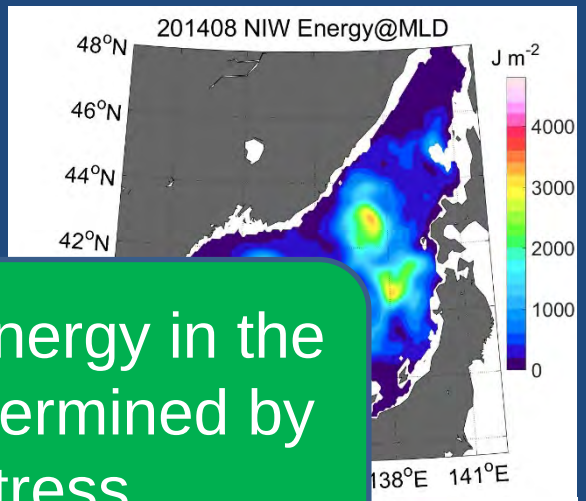
1) NIWs in the mixed layer (temporal)

2. But sometimes NIWs are weak (strong) in winter (summer) even the wind is strong (weak).

Relatively weak NIWs

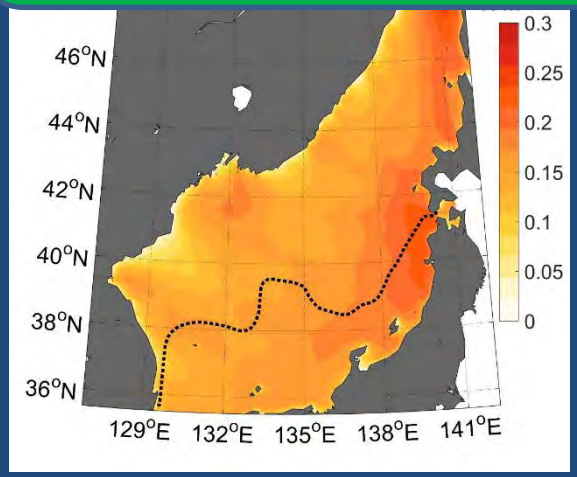


Relatively

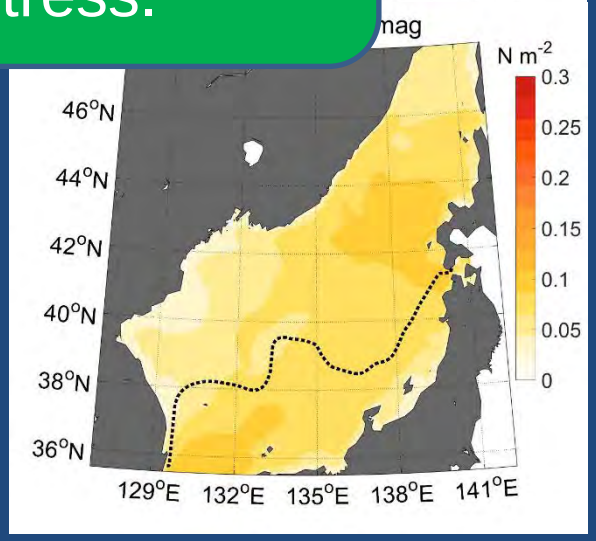


This result suggests that NIWs energy in the mixed layer of the EJS is not determined by only the strength of wind stress.

strong wind (in winter)

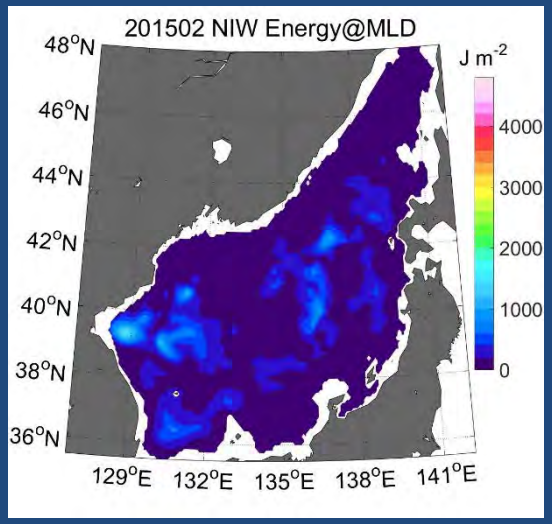


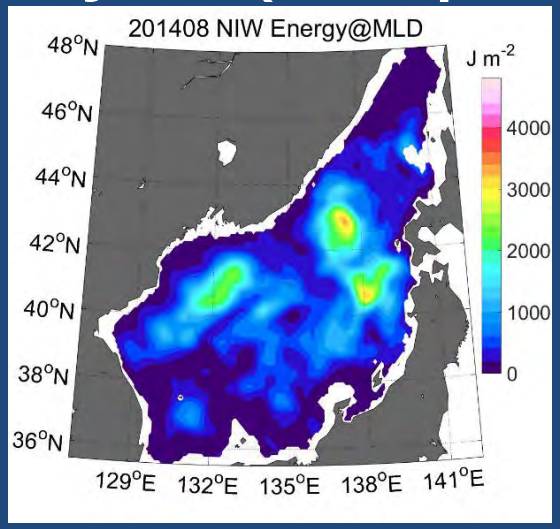
weak wind (in summer)



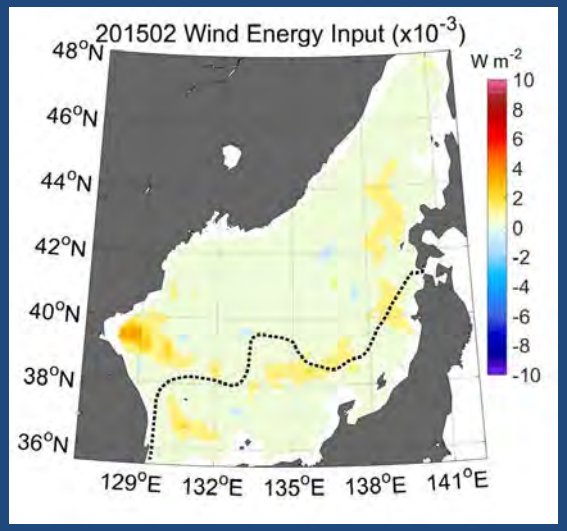
1) NIWs in the mixed layer (temporal)

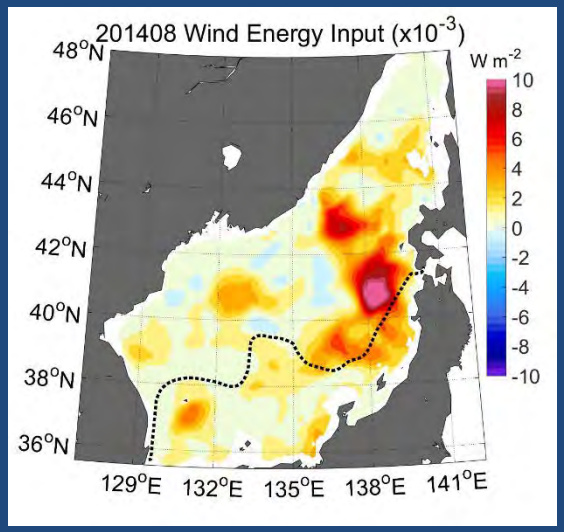
NIWs energy





$$W_I = \tau_I \cdot u_{surf}$$

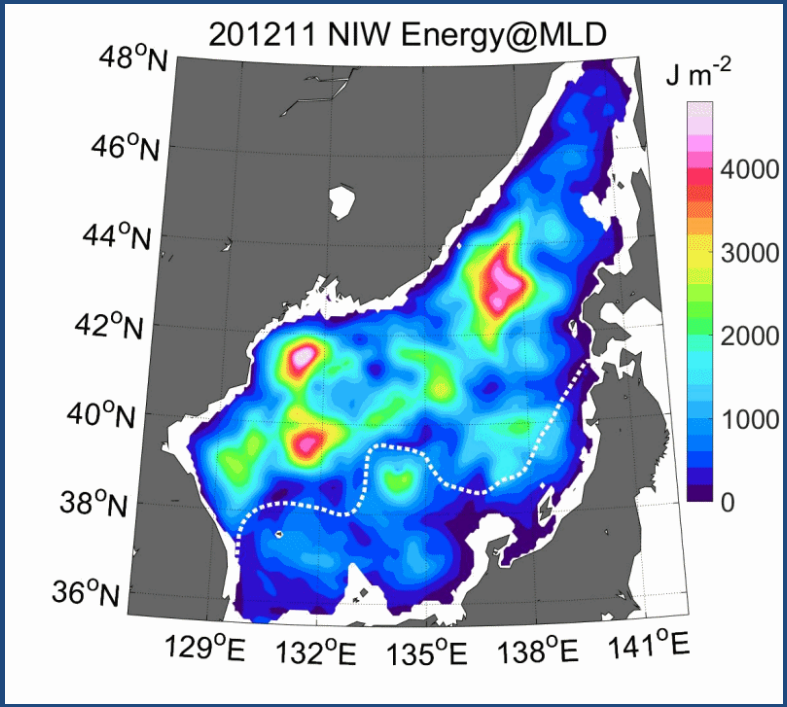


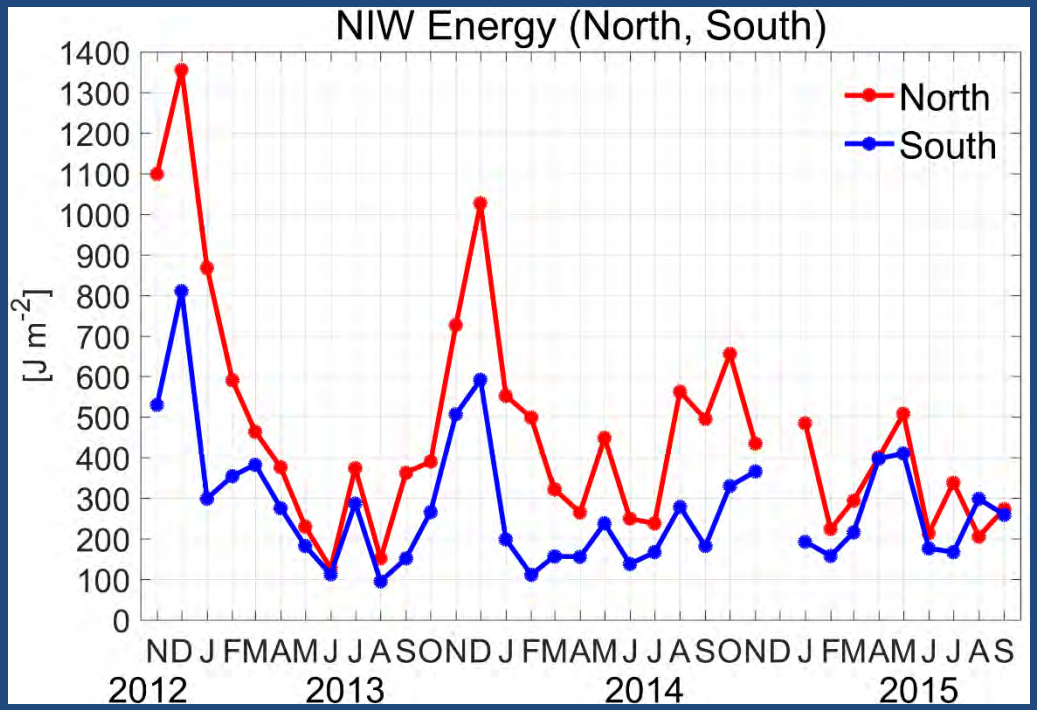


2. Strong wind-current resonance induces strong NIWs in summer even the wind is weak.

1) NIWs in the mixed layer (spatial)

NIWs

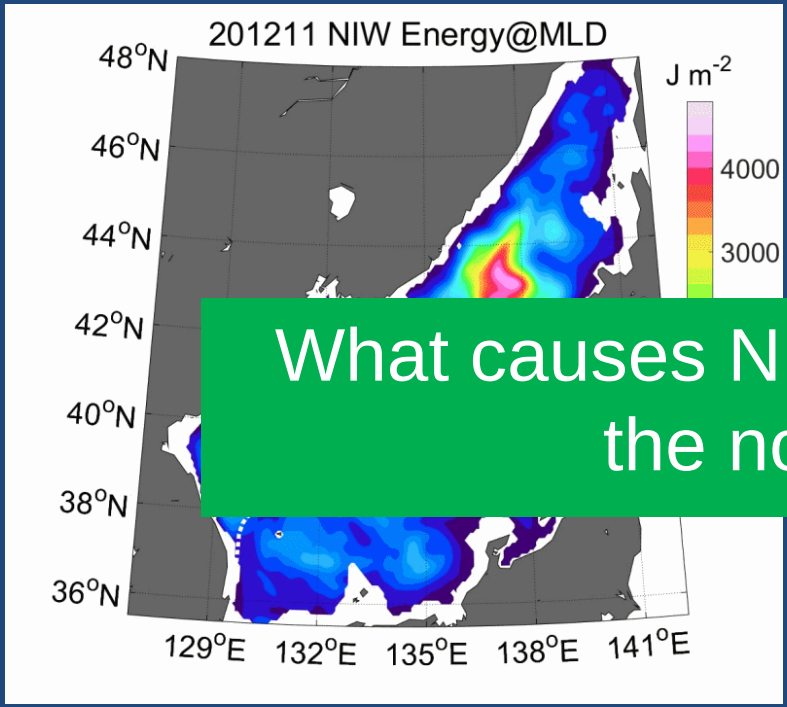


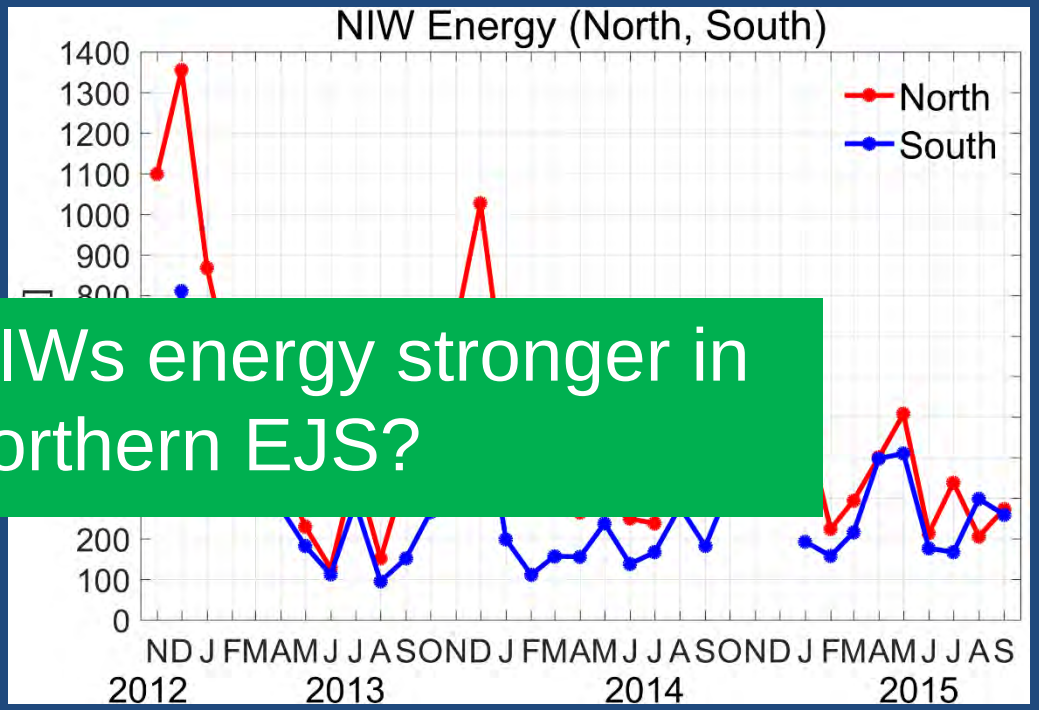


2. NIWs are stronger in the northern EJS than in the southern part.

1) NIWs in the mixed layer (spatial)

NIWs



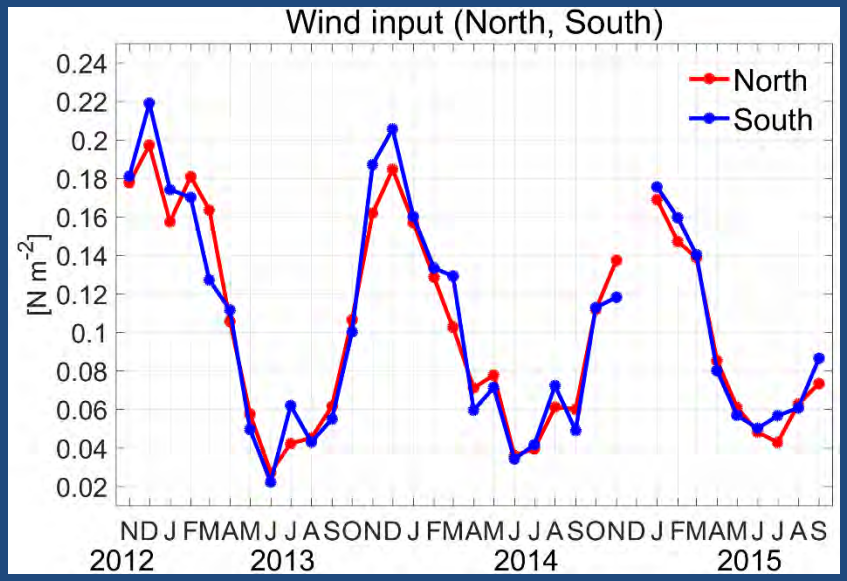


What causes NIWs energy stronger in the northern EJS?

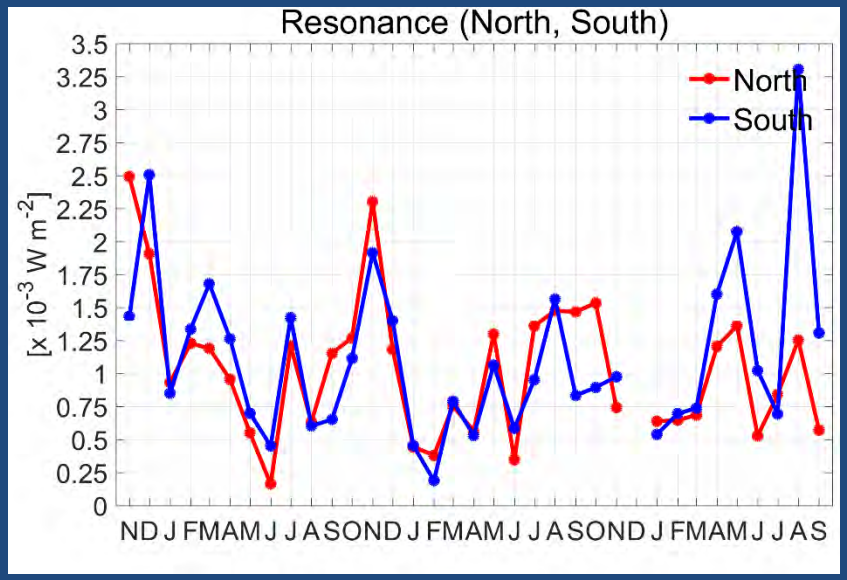
2. NIWs are stronger in the northern EJS than in the southern part.

1) NIWs in the mixed layer (spatial)

Wind stress



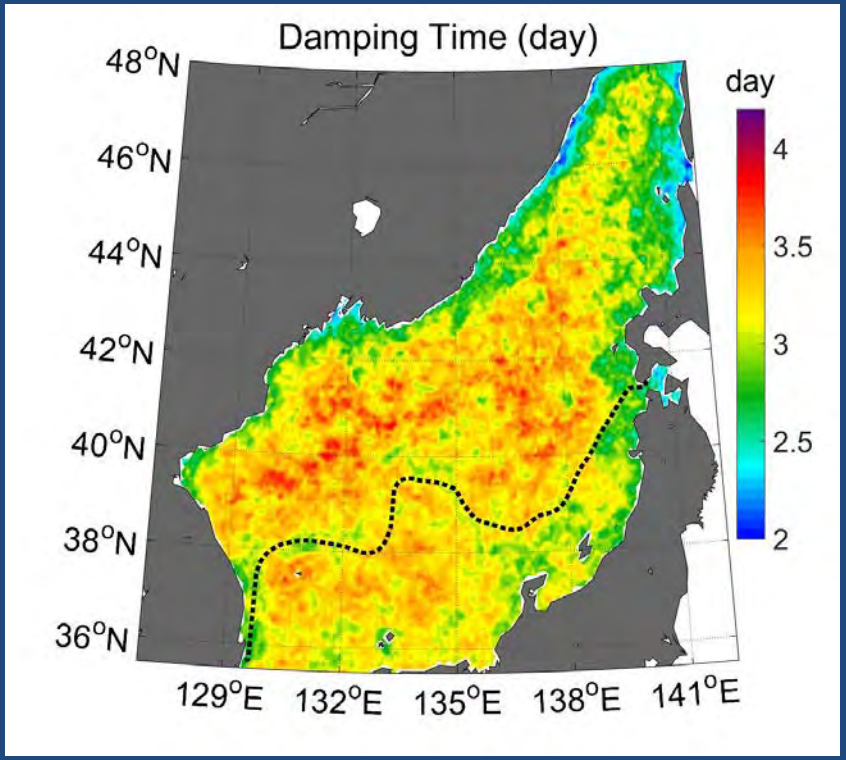
Wind-current resonance



2. Strengths of wind stress and resonance are not the factors resulting in stronger NIWs energy at the northern part of the EJS.

1) NIWs in the mixed layer (spatial)
Different damping timescale btw. north & south

Averaged over the total period



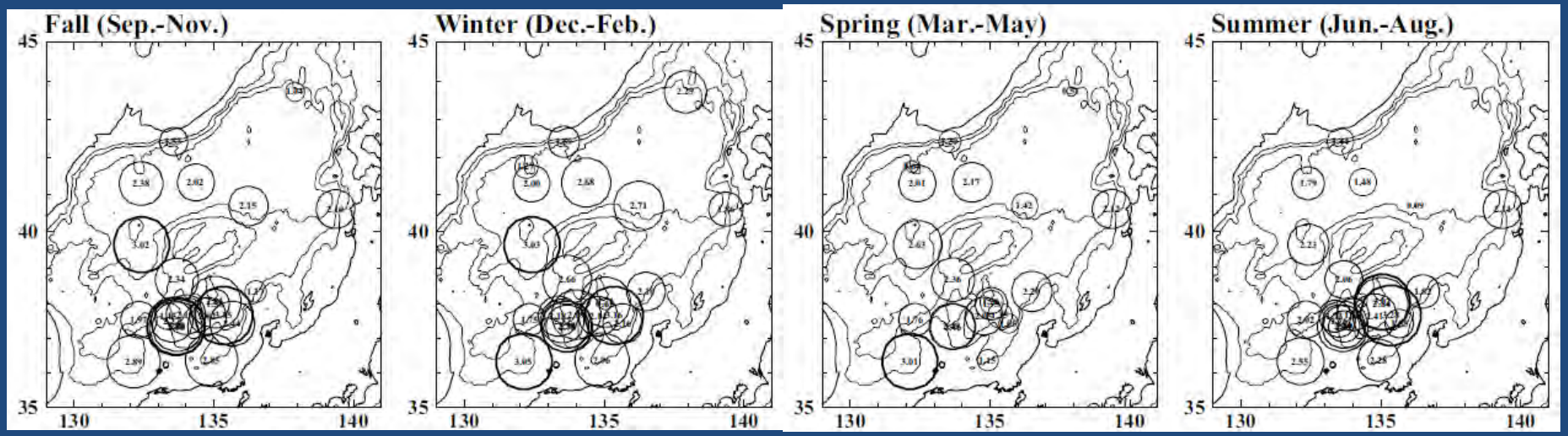
Damped timescale is determined when the NIW oscillating radius is reduced to its e-folding scale from the maximum within 5-day segments.

2. Longer damping timescale in the northern EJS.
→ NIWs are sustained longer in the northern EJS.
Therefore NIWs energy are stronger in the northern EJS.

Previous study

2) NIWs in the deep layer

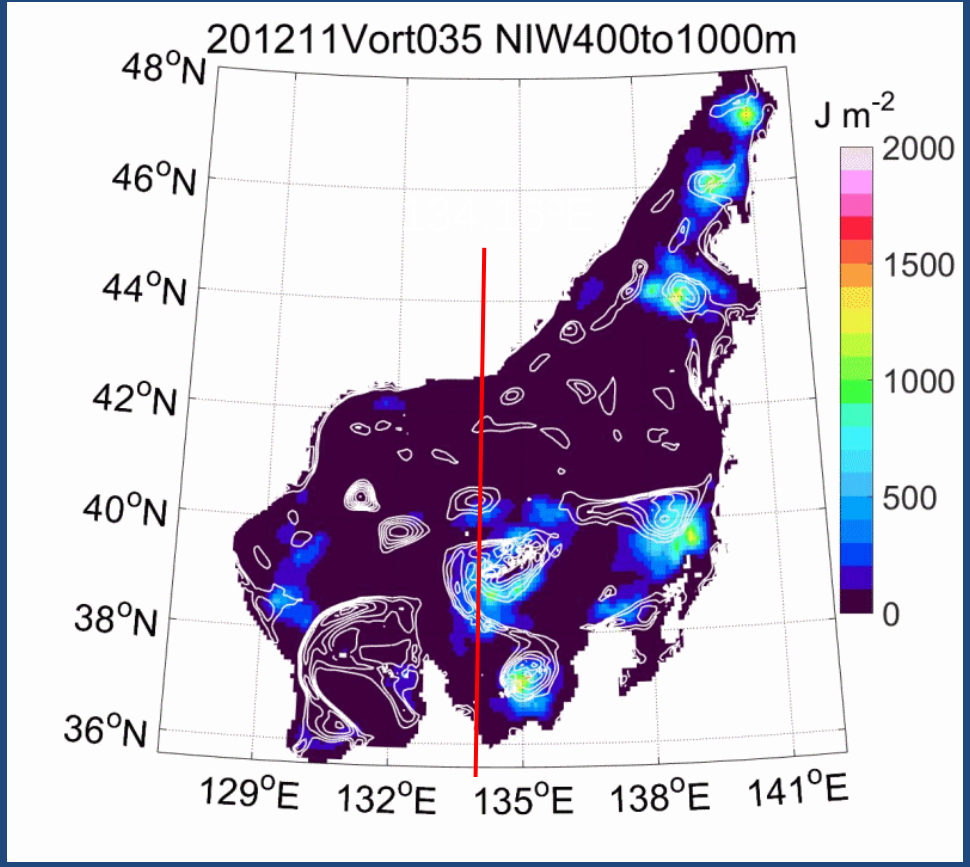
Log-scale size circle is the intensity of near-inertial current



Mori et al.(2005)

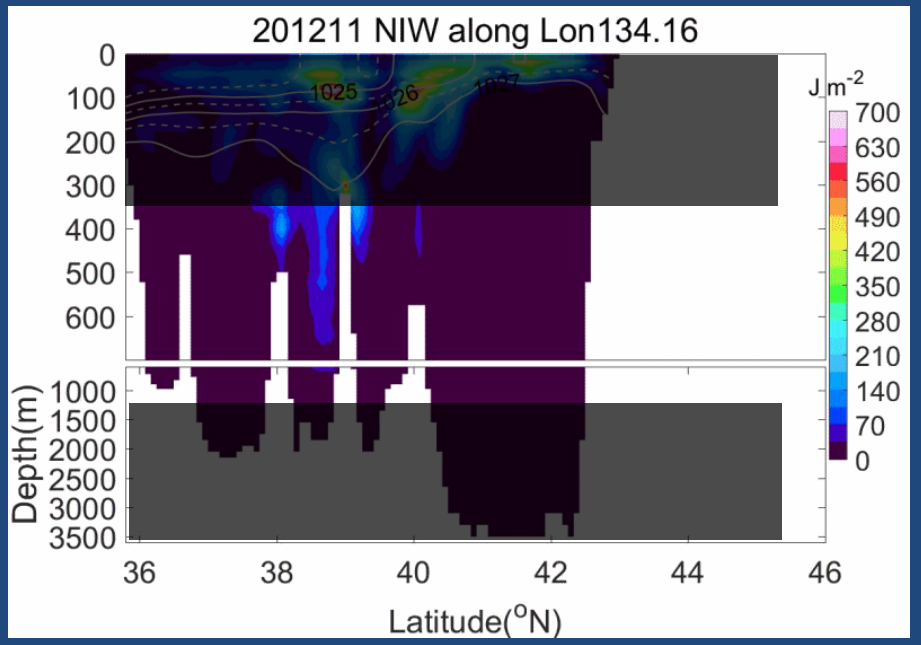
1. NIWs are stronger in the southern EJS than in the northern part.
2. Seasonal variation of NIWs is weak in the deep layer.

2) NIWs in the deep layer (400–1000 m)



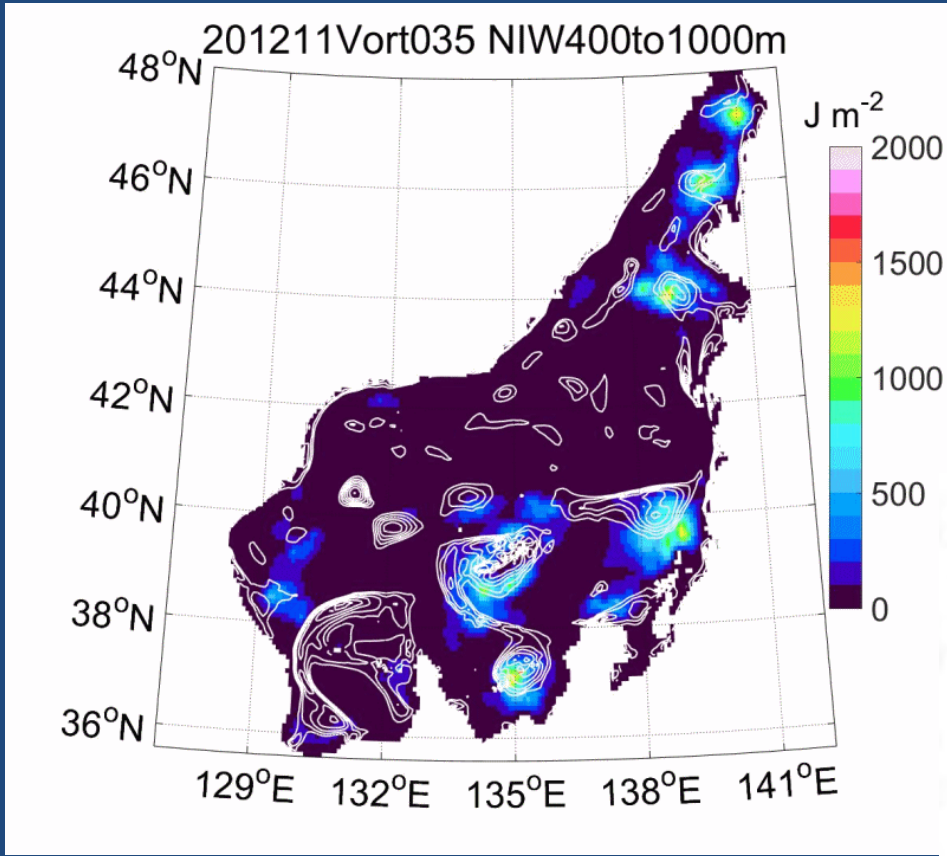
Color: NIWs integrated 400-1000 m
Contour: negative vorticity at 35 m

Meridional Section along 134.16°E



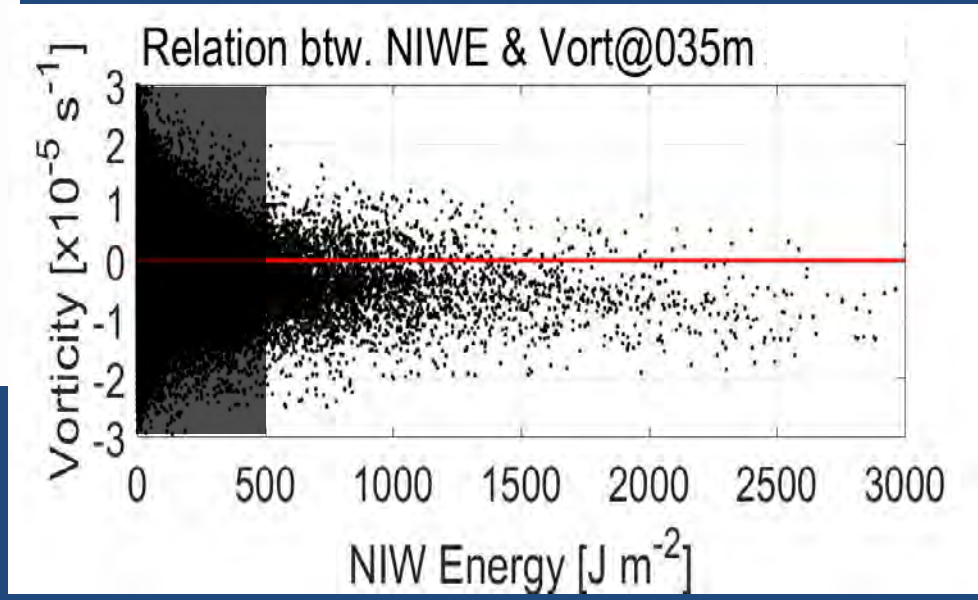
Color: NIWs
Contour: density

2) NIWs in the deep layer (400–1000 m)

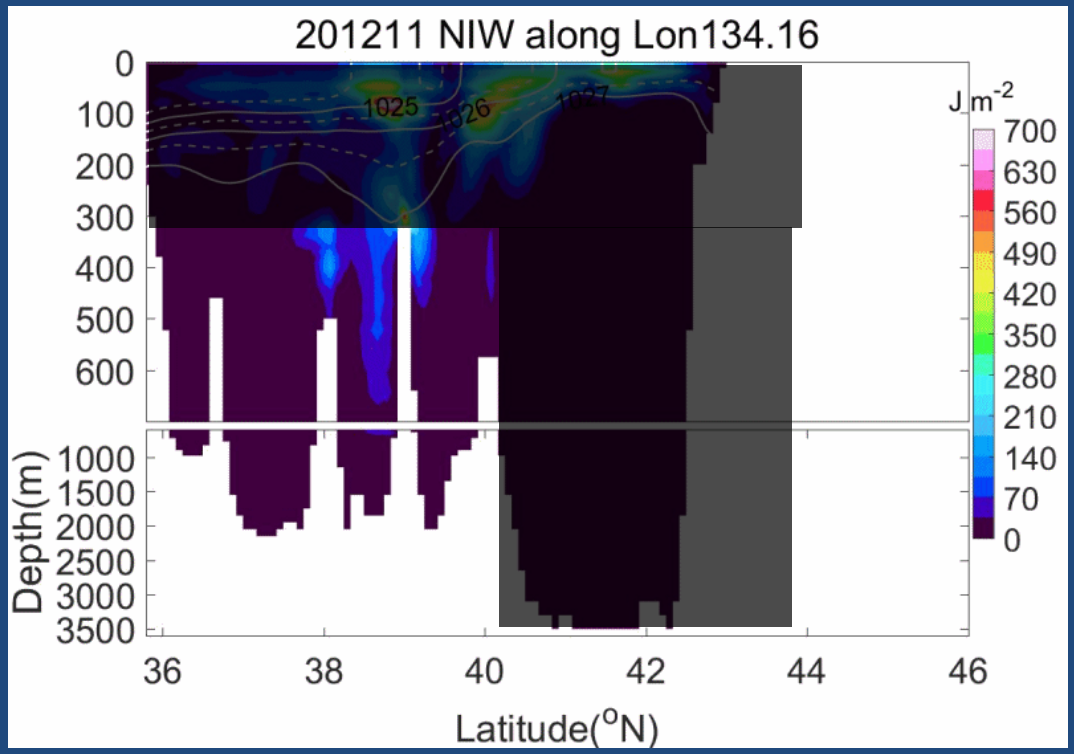


Color: NIWs integrated 400-1000 m
Contour: negative vorticity at 35 m

Strong NIWs are found at negative vorticity area (clockwise)

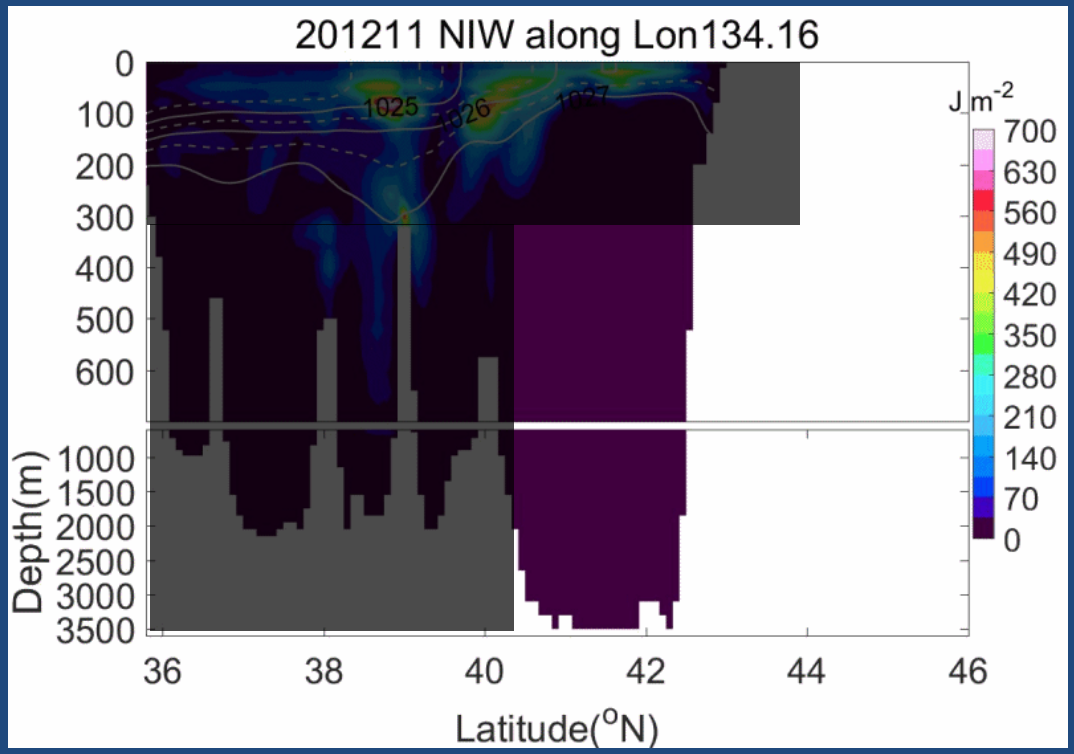


2) NIWs in the deep layer - strong in the south



- Strong negative vorticity accelerates the vertical transmission of NIW energy (chimney effect, Lee and Niller,1998)
- Energy coming from the north to south can enhance the NIW energy in the south

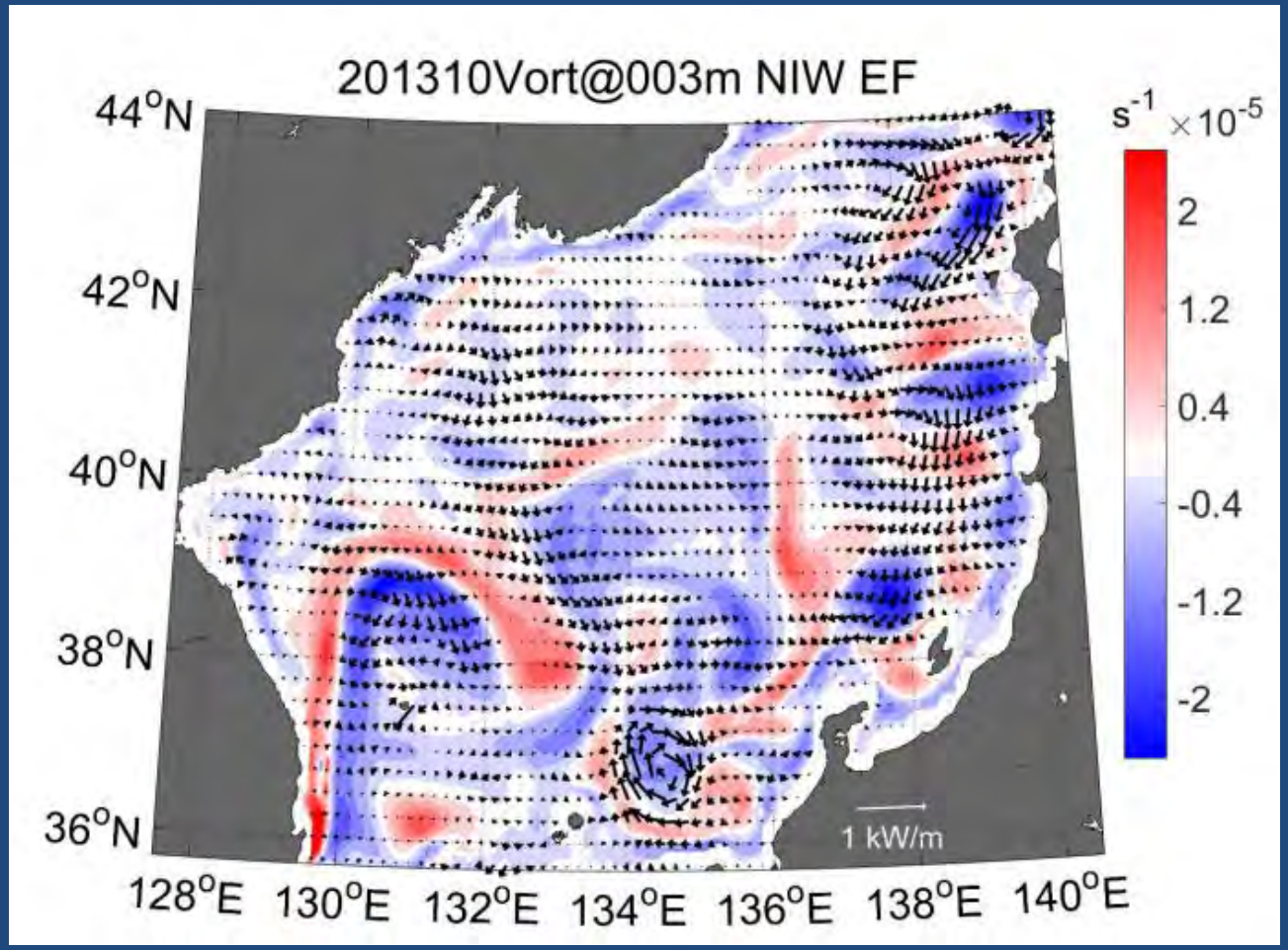
2) NIWs in the deep layer - weak in the north



- Background current has no effects on vertical transmission of NIW energy.
- No energy coming from the further north to the northern EJS

3) NIW energy flux

Depth-integrated NIWs energy flux [W/m]



Conclusion (1/2)

- NIWs in the mixed layer are generally stronger in winter than in summer because of the strong wind stress. But, when the wind-current resonance is large, strong NIWs can be generated even in weak wind.
- NIWs are stronger at the northern EJS than the southern part due to longer damping timescale.

Conclusion (2/2)

- NIWs in the deep layer are stronger at the southern part of the EJS because of strong clockwise circulation (negative vorticity) and energy propagation from the north.
- NIWs energy propagates overall southward.
- It is confirmed that anticyclonic (clockwise) eddies can trap NIWs in the EJS.

Thank you for your attention!