Responses to Reviewer 1:

The better performance of the modified slab model against observations. How robust is this result? The selection of the damping coefficient is kind of arbitrary. If a larger damping coefficient were used, the original slab model might perform better while the modified slab model could under-predict the magnitude of near-inertial currents.

Thanks for your suggestions. We have addressed this point with corresponding explanations on lines 252-255 in the revised manuscript.

We agree with you that the different damping coefficients can change the results of near-inertial currents (NICs) produced by the modified and original slab models. To verify the stability of the result, we followed your suggestion and reran the model using three other larger damping coefficients (r^{-1} = 5 days, 6 days and 7 days) and also the annually average mixed layer depth. We found that the NICs patterns are not very sensitive to the different damping coefficients and the different MLDs (Figure R1). On the other hand, previous studies suggest that r is much less than f, therefore the modeled NICs can be not sensitive to the value of r (Alford, 2001).

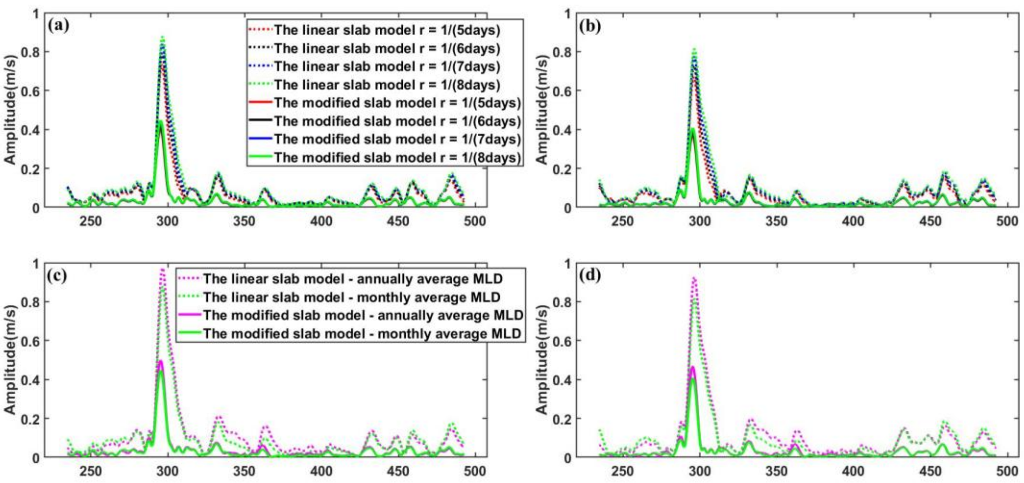

Figure R1. Speeds (m/s) of simulated NICs in the surface mixed layer at stations S2 ((a) and (c)) and S3 ((b) and (d)). Red, black, blue and green dashed lines denote results calculated using the linear slab model applied monthly average MLD, with r^{-1} = 5 days, 6 days, 7 days and 8 days) respectively. Red, black, blue and green solid lines denote results calculated using the modified slab model applied monthly average MLD, with four different values of r respectively. Purple dashed and solid lines respectively denote results calculated using the linear and modified slab model applied annually average MLD, with r^{-1} = 8 days. Yearday is the day relative to 00:00:00 (GMT) on 1 January 2016.

The difference in NIC speed between the modified and original models is attributed to energy transfer between eddies and NICs. However, this difference could also result from the difference in the generation of wind-induced NICs in cyclonic eddies and anticyclonic eddies, rather than energy transfer between eddies and NICs.

Thanks for your suggestions. We fully agree with you that the generation of wind-induced NICs in cyclonic eddies and anticyclonic eddies can be different.

The relative motion between the wind and the current can modulate the wind power input in the presence of anticyclonic and cyclonic eddies. As a result, different wind-generated NICs may be induced in anticyclonic and cyclonic eddies under the same wind conditions.

To determine the difference in the speeds of wind-induced NICs within the anticyclonic eddy and cyclonic eddy, we conducted an additional experiment as you suggested. In this experiment, the original slab model is used to simulate the NICs in the anticyclonic eddy and cyclonic eddy under the same wind conditions, and we use the relative wind speed to calculate the wind stress τ, which is defined as

$$\tau = \rho_0 c_d \left|\overrightarrow{U_{wind}} - \overrightarrow{U_{current}}\right| \left(\overrightarrow{U_{wind}} - \overrightarrow{U_{current}}\right)$$

where ρ_0 is the air density, c_d is the drag coefficient, U_{wind} is the wind speed at 10-m height and $U_{current}$ is the current speed. Other experiment settings are the same as ExpA3.

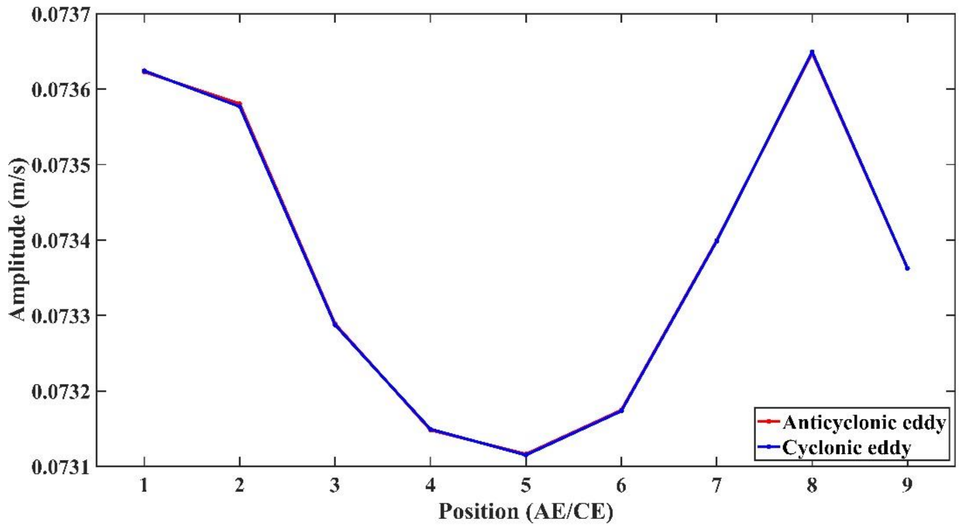

Figure R2. Averaged speeds of wind-induced NICs in the anticyclonic eddy and cyclonic eddy. Numbers on the horizontal axis denote nine fixed locations P1 to P9. The wind rotates cyclonically at the inertial frequency.

We demonstrate that the amplitude of the NICs generated in the cyclonic and anticyclonic eddy is almost the same under the same wind conditions (Figure R2). Therefore, the difference in NIC speed between the modified and original models is induced by the energy conversion between mesoscale eddies and NICs.

The direction of energy transfer between eddies and NICs appears to depend on the wind rotation frequency. Please explain why, for some rotation frequencies, the energy transfer occurs from eddies to NICs, while for others, it shifts from NICs to eddies.

Thanks for your suggestions. We have made some modifications accordingly in Section 5.3 in the revised manuscript.

The energy transfer between mesoscale eddies and NICs is bidirectional, but overall, it is dominated by the positive energy transfer (i.e., energy is transferred from mesoscale eddies to NIWs). When the winds rotate anticyclonically within the frequency range of -1.15f to -0.75f, the energy transfer between NICs and mesoscale eddies is negative and relatively strong. These frequencies are close to the inertial frequency of -f, which can induce the resonance and generate significant NICs. Therefore, the large NICs provide a strong energy source for reverse energy conversion, and the near-inertial kinetic energy can be reabsorbed into the background mesoscale eddies to help reconstruct the geostrophic balance.

Can you explain why alpha has a maximum value at the eddy translational speed of 11 cm/s? What is special about this translational speed?

Thanks for your valuable comments. We have added some explanations on lines 490-500 and 516-521 in the revised manuscript.

For an anticyclonic eddy with $|SLA_c|$=0.64 m, the sum of average speeds of the transferred NICs at the nine locations ($\sum$ NICs_U$_{AE}$) increases linearly from about 0.133 m/s to 0.148 m/s as the translational speed increases from 4 cm/s to 11 cm/s. The increase of the translational speed enhances the total kinetic energy of mesoscale eddies, which can provide a larger energy source and be more beneficial for the conversion of NICs. It should be noted that the change in the eddy kinetic energy caused by the different translational speeds is relatively small in comparison with the total eddy energy determined by the mesoscale eddy strength. Therefore, the change in the amplitude of the transferred NICs is relatively small. After the translational speeds reach 11 cm/s, the values of $\sum$NICs_U$_{AE}$ are almost the same with that at the translational speed of 11 cm/s.

For a cyclonic eddy with $|SLA_c|$=0.64 m, the sum of average speeds of the transferred NICs at the nine locations ($\sum$NICs_U$_{CE}$) are all about 0.066 m/s as the translational speed increases from 4 cm/s to 11 cm/s. However, after the translational speeds reach 11 cm/s, the values of $\sum$NICs_U$_{CE}$ are larger with faster translational speeds.

Therefore, the alpha has a maximum value at the eddy translational speed of 11 cm/s. This indicates that the anticyclonic eddy transfers much more near-inertial energy than the cyclonic eddy does, particular at the translational speed of 11 cm/s.

You talked quite a bit about the importance of strain and OW parameter, but your theoretical analysis seems to say that only the relative vorticity matters?

Thanks for your valuable suggestions. We have added some explanations on lines 611-614.

Jing et al. (2017) demonstrated that the strain is responsible for the permanent energy transfer from mesoscale eddies to wind-forced NICs, because the energy transfer efficiency is always zero in absence of the strain. However, in the presence of the strain, the relative vorticity can have an influence on the energy transfer by modifying the effective Coriolis frequency. It means that both strain and relative vorticity have an impact on the energy transfer between the mesoscale eddies and NICs. The strain determines whether the energy transfer occurs, and the relative vorticity changes the magnitude of energy transfer efficiency.

In our numerical experiments, the strain of the ideal mesoscale eddy is nonzero, which means the energy transfer between NICs and mesoscale eddies occurs. Our research aims to explore the sensitivity of the energy transfer between NICs and mesoscale eddies to the wind speed, the translation speed of the mesoscale eddy, the strength of the mesoscale eddy, the wind rotation frequency and the relative vorticity in the presence of the strain. Meanwhile, we also try to better understanding of the role of the relative vorticity in the background flow for anticyclonic eddies to be significantly more efficient than the cyclonic eddies in transferring their kinetic energy to NICs. Therefore, in the theoretical analysis, we mainly explore the influence of relative vorticity on the energy conversion to verify with the numerical experiments.

It feels that your theoretical analysis is not really on energy transfer between eddies and NICs, but on the impact of relative vorticity on the generation of NICs.

Thanks for your suggestions. We have added some explanations on lines 618-621 in the revised manuscript.

It is correct that theoretical analysis is mainly about the impact of relative vorticity on the generation of NICs under steady winds, but this generation of NICs is induced by energy transfer between eddies and NICs instead of changing winds.

Without any background mesoscale eddy, the modified slab model is the same as the original slab model. The simulated NICs by the original slab model represent the near-inertial energy generated directly by the wind forcing. Since the same wind forcing is used in both the original and modified slab models, the differences in the results produced by the modified and original slab model represent the amplitudes of NICs transferred by interactions between mesoscale eddies and NICs in the mesoscale eddies after removing the generation of wind-induced NICs (i.e., the NICs produced by the original slab model).

Under the steady winds, the NICs produced by the original slab model is 0, therefore the NICs produced by the modified slab model directly represent the energy converted between mesoscale eddies and NICs.

Some minor comments:

Any validation of ERA5 winds at mooring locations?

Thanks for your suggestions. We have made some additions on lines 103-105 in the revised manuscript. The wind speed data obtained from ERA5 is widely used in the previous researches on near-inertial motions in the Northwestern Pacific (Yuan et al., 2024; Chen et al., 2023; Chen et al., 2024), which indicates that it has good applicability. Therefore, the validation of ERA5 is not conducted in this study.

Line 166. Why is smoothing required?

Thanks for your comments. The smoothing (running window) is designed to more clearly illustrate the characteristics of the near-inertia period of the currents, especially by eliminating some high-frequency noise signals.

Line 209-211. I don't see two separate weak cyclonic eddies to the east and south in the SLA map.

Accepted and revised.

Section 5.1. The eddy vertical structure is irrelevant here, since only the eddy surface geostrophic velocity is used in the numerical experiments.

Thanks for your suggestions. We fully agree with you that the eddy vertical structure is irrelevant here. Considering that $H(z)$ needs to be used to verify the rationality of the structure of the idealized mesoscale eddy, the vertical structure function was presented here.

Line 590. "Consider steady wind forcing..." There is still wind forcing with frequency omega on RHS of (27).

Thanks for your valuable comments. The omega is generated by the Fourier transform of the time-varying velocity components (u, v). Meanwhile, as the wind forcing is steady, Dirac Delta function is used here.

References

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