Reply on RC1

We thank the reviewer for their helpful comments. For clarity we included the reviewer's comments written in black with our comments in blue to each issue listed in between.

This study describes the trajectories of surface drifters in the equatorial western Atlantic Ocean and discusses surface velocity associated with the mean current (NBC) and Yanai waves. The results are interesting and worth reporting in my evaluation, but I wonder whether the manuscript could be improved by adding one view: the Stokes drift of Yanai waves. I also suggest additional analyses of the statistical significance of correlation coefficients and those of spectra of surface velocity and winds. These points are detailed below.

We thank the reviewer for the very positive comments that acknowledges the relevance of our manuscript.

1) The authors examined the trajectories of surface drifters, which represent Lagrangian-mean horizontal velocity. Lagrangian-mean velocity is the sum of Eulerian-mean velocity and Stokes drift. Eulerian-mean velocity is the flow field averaged at a fixed point. Stokes drift is wave-induced transport. Stokes drift is a wave property and can be computed from the linear solution. (Section 10.1 in Bühler (2014) describes Stokes drift in general.) Smyth et al. (2015) computed the Stokes drift of a vertically propagating Yanai wave (their Eq. (10)). Its zonal component on the equator is (|m|/N) v0^2/2, which is always positive. (m is vertical wavenumber, N is buoyancy frequency, and v0 is a parameter of wave amplitude.) Note that N/|m| can be replaced with c, where c is the horizontal phase speed of inertial gravity waves in a shallow water system (see Section 4b in McCreary 1984). I think this is consistent with the eastward movement of an artificial drifter in the right panel of Fig. 4. The meridional component of the Stokes drift is 0 (Smyth et al. 2015). This also seems consistent with the right panel of Fig. 4, because Stokes drift represents the transport averaged over one wave cycle. This is worth mentioning.

Bühler, O., 2014: Waves and Mean Flows, Cambridge University Press.

McCreary, J. P., 1984: Equatorial beams. J. Mar. Res., 42, 395-430.

Smyth, W. D., T. S. Durland, and J. N. Moum (2015), Energy and heat fluxes due to vertically propagating Yanai waves observed in the equatorial Indian Ocean, J. Geophys. Res. Oceans, 120, 1–15, doi:10.1002/2014JC010152.

We thank the reviewer for making this point. We agree that the impact of Stokes drift should be considered. We have thus analytically calculated the Stokes drift as suggested by the reviewer. We also calculated numerically wave-induced Lagrangian velocities in a background flow field. We further introduce Stokes drift in the introduction part of the manuscript and describe the calculation in the methods. The material we added is detailed in the answers below.

2) Smyth et al. (2015) theoretically predicted that Yanai waves would be accompanied by zonal Stokes drift, but, to my knowledge, observational evidence for this has never been reported so far. Since Stokes drift contributes to material

transport, it may also have climatic significance. This point further highlights the significance of the present study.

The reference to Smyth et al. (2015) will be added in the introduction of the manuscript. We further add a paper by Li and Pacanowski (1996) that also discusses the Stoke's drift of Yanai waves.

- Li, X., P. Chang, and R. Pacanowski, A wave-induced stirring mechanism in the mid-depth equatorial ocean, J. Mar. Res.,54, 487-520,1996

3) Smyth et al. (2015) estimated the Stokes drift for a vertically propagating wave, and it is unclear whether their result applies directly to the current case. I wonder if it is feasible to analytically compute the horizontal Stokes drift from Eqs. (2) and (3) in the manuscript, and compare it with the numerical estimate in the right panel of Fig. 4. The following papers may help. Weber et al. (2014) computed the Stokes drift of equatorial Kelvin waves. Weber (2017) calculated the Stokes drift of equatorial Rossby waves. Alternatively, please look for a study that computes the Stokes drift of Yanai waves in a shallow-water system and cite it if one exists.

Weber, J. E. H., Christensen, K. H., & Broström, G. (2014). Stokes drift in internal equatorial Kelvin waves: Continuous stratification versus two-layer models. Journal of Physical Oceanography, 44(2), 591-599.

Weber, J. E. H. (2017), Equatorial Stokes drift and Rossby rip currents, J. Geophys. Res. Oceans, 122, 4819–4828, doi:10.1002/2016JC012653.

We thank the reviewer for this suggestion. We analytically calculated the Stokes drift of linear Yanai waves of specific baroclinic modes. We also calculated the horizontal wave-induced Lagrangian velocities including a background velocity field (see Fig. R1).
Considering trajectories of drifters in a combined velocity field, we have

$$\frac{dX}{dt} = u_{Yanai}(X,Y,t) + u_{Background}(X,Y)$$

$$\frac{dY}{dt} = v_{Yanai}(X,Y,t) + v_{Background}(X,Y)$$

we then can derive a wave-induced Lagrangian velocity by

$$U_L = \frac{(X_{Yanai+Background}(\mathrm{t_T}) - X_{Yanai+Background}(t_0))}{T}$$

where T denotes one wave period of the Yanai wave. t_0 and t_T mark the time steps during the deployment or initialization and the time step after one wave period, respectively.

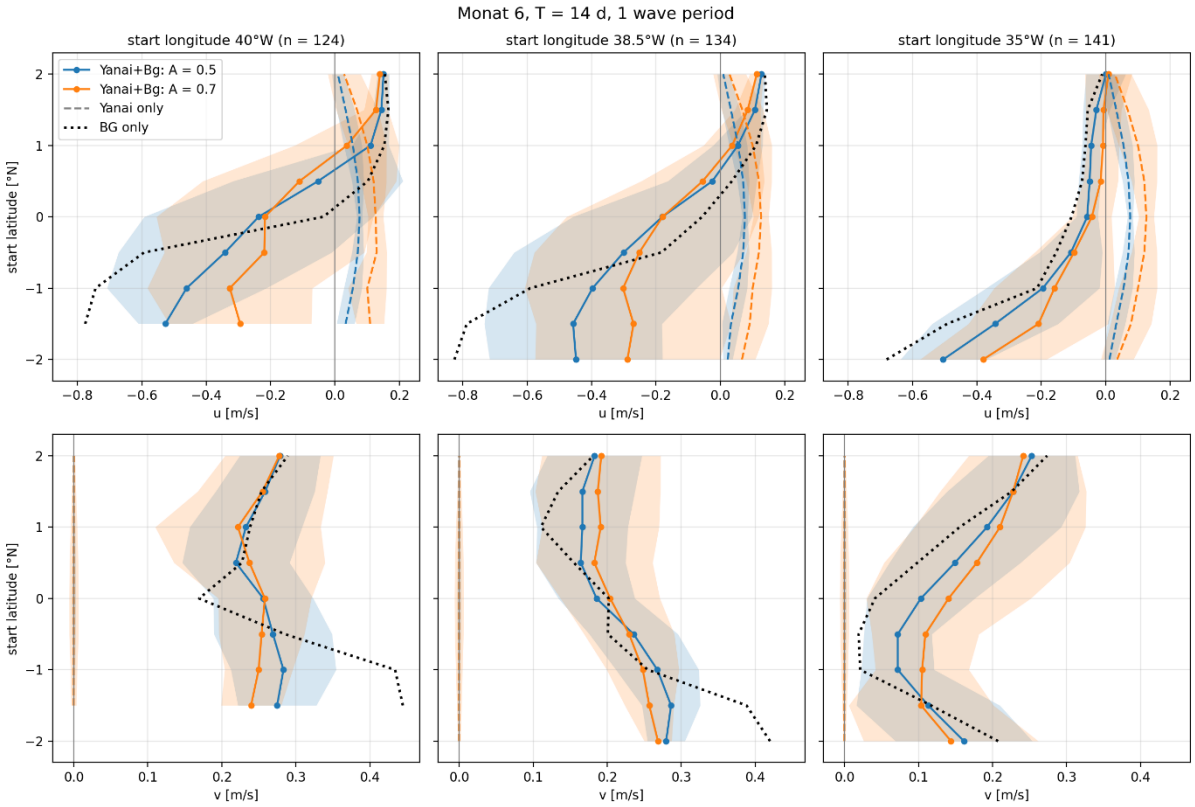


*Figure R1: The upper (lower) panels show the wave-induced Lagrangian zonal (u_L) (meridional (v_L)) velocities averaged over one wave period of a 14-day Yanai wave and plotted against the start latitude. The results are obtained by varying wave phase between 0 and 2*pi to derive a mean drift and a standard deviation. The columns show different start longitudes (40°W, 38.5°W, 35°W, from left to right). Different line styles represent different velocity fields that were used to calculate the trajectories. Black dashed lines show the case for the monthly mean climatological background flow field only (background (BG) only, for June), blue and orange dashed lines show the cases for the flow field associated with the Yanai wave only (Yanai only). The solid blue and orange lines are based on a combination of the background flow field and the Yanai-wave-associated velocities (Yanai+BG). Blue (orange) colors represent the 0.5 (0.7) m/s amplitude of the Yanai wave. The total number of considered trajectories is 124, 134, and 141 from left to right panel.*

In figure R2 we show some examples for trajectories and wave-induced Lagrangian velocities for different cases. Looping trajectories of artificial drifters can occur when the wave-induced Lagrangian velocities (u_L and v_L) are close to zero (see Fig. R2 a and b). However, larger wave-induced Lagrangian velocities, here close to 0.5 m/s, tend to prevent looping trajectories (see Fig. R2 c).

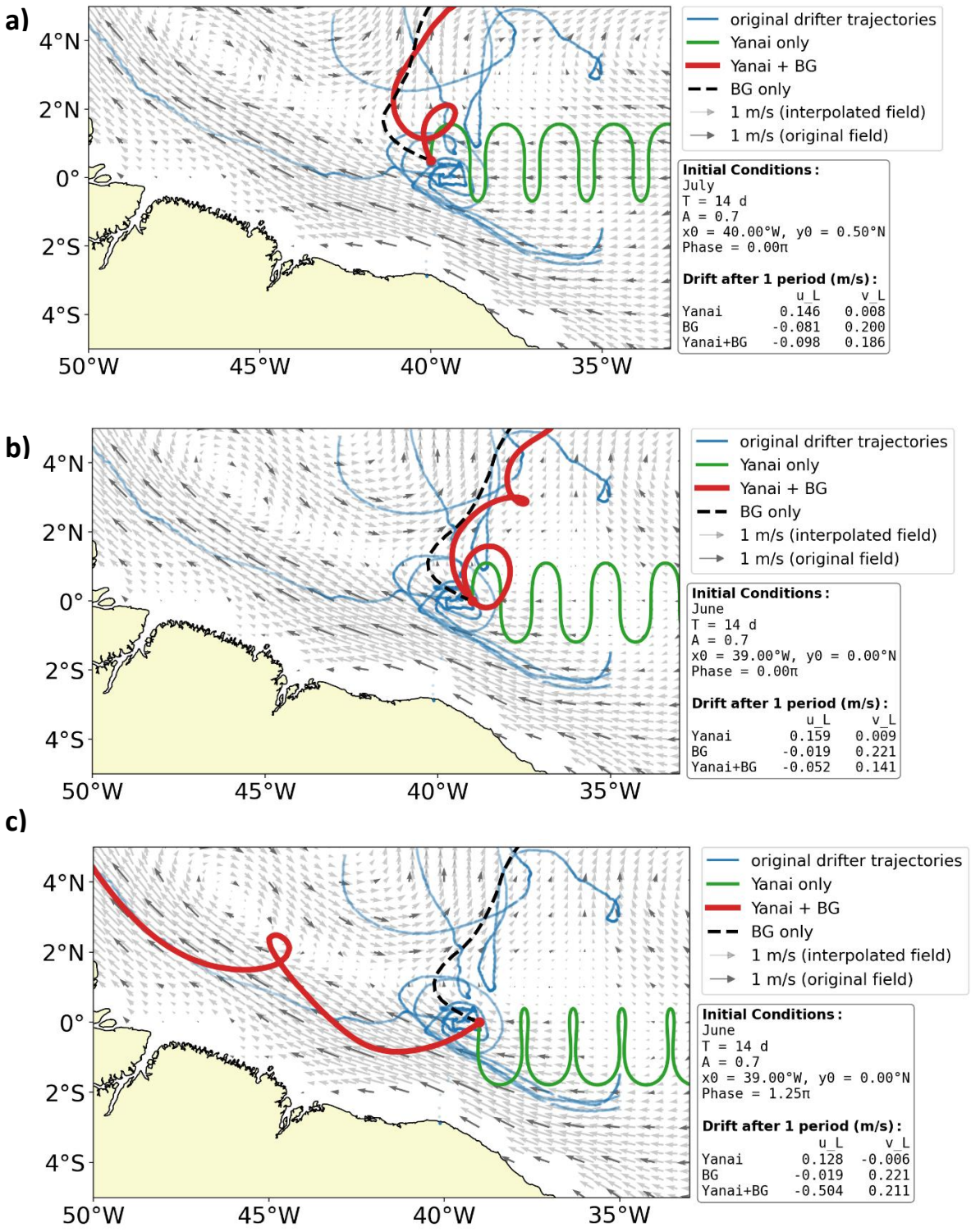
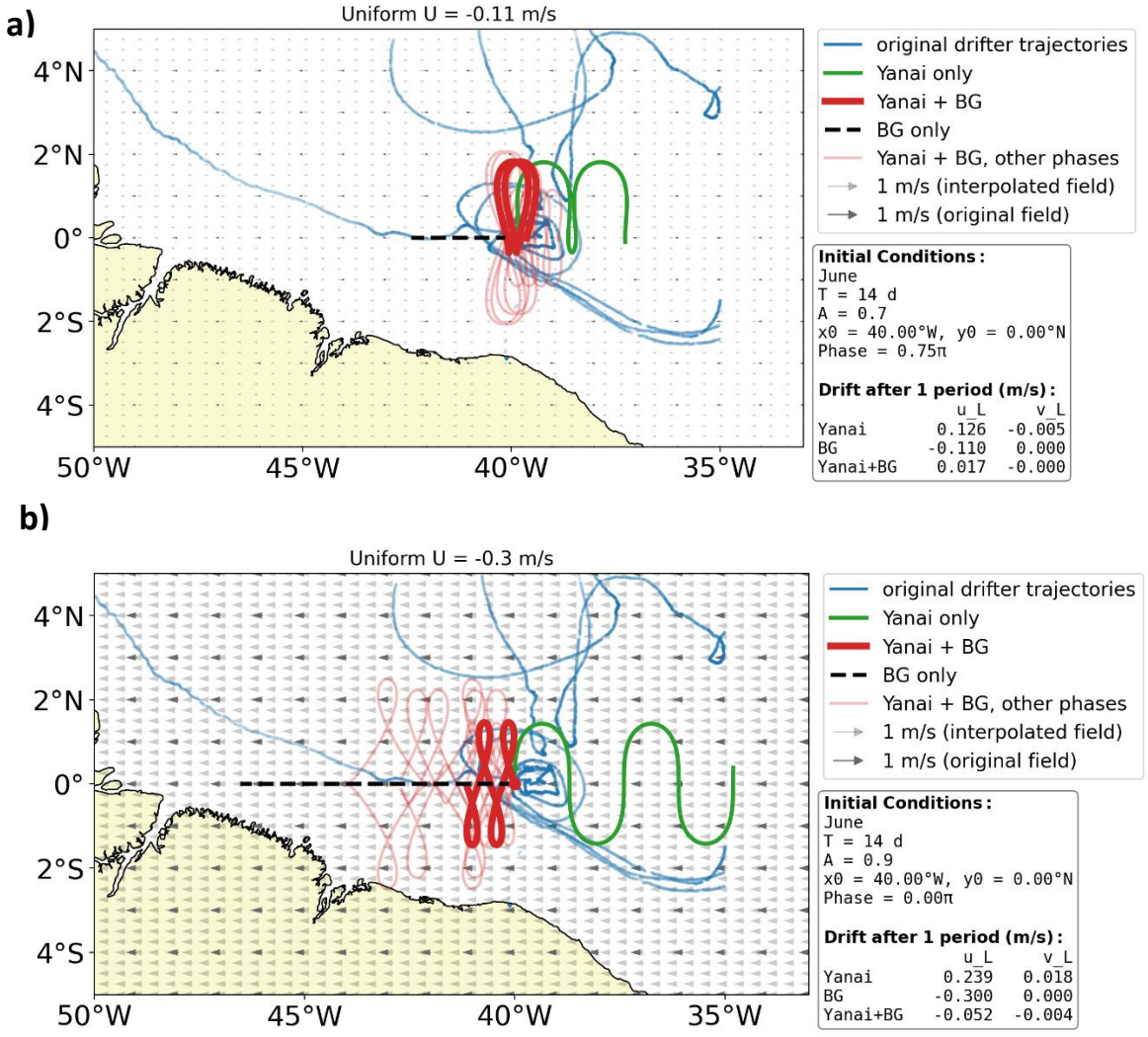


Fig. R2: Examples of experiments with artificial drifters under different initial conditions. Blue lines indicate the trajectories of the original drifters. Red, green, and black indicate artificial drifter trajectories using different velocity fields: combined background mean flow and Yanai wave associated velocities, only Yanai wave associated velocities, only the background mean flow field, respectively. Wave-induced Lagrangian velocities (u_L and v_L) are calculated over the first wave period.

4) The authors reported that the trajectories of some of the drifters are circular in shape. I wonder whether a circular trajectory occurs when the eastward Stokes drift of Yanai waves balances the mean westward current. The lower panel of Fig. 7 shows that floats make a circular trajectory when they are deployed south of the equator along 35°W. This might be due to westward NBC south of the equator at this longitude. This point can be checked by generating an artificial flow field that includes Yanai waves and a spatially uniform westward mean current, then deploying an artificial drifter.

We thank the reviewer for the interesting comment. Indeed, circular trajectories occur when using a mean westward current. In addition to the experiments with the combined background field containing Yanai wave associated and mean flow associated velocities, we conducted experiments with simpler background fields: 1) and 2) spatially uniform field with different mean westward velocities, 3) simple westward shear flow, and 4) rotated northwestward shear flow mimicking the NBC (Fig. R3). Under certain conditions, all tested background fields produce looping trajectories. Nevertheless, the results closest to the observed behavior is achieved with a mean shear flow (Fig. R3 c,d).



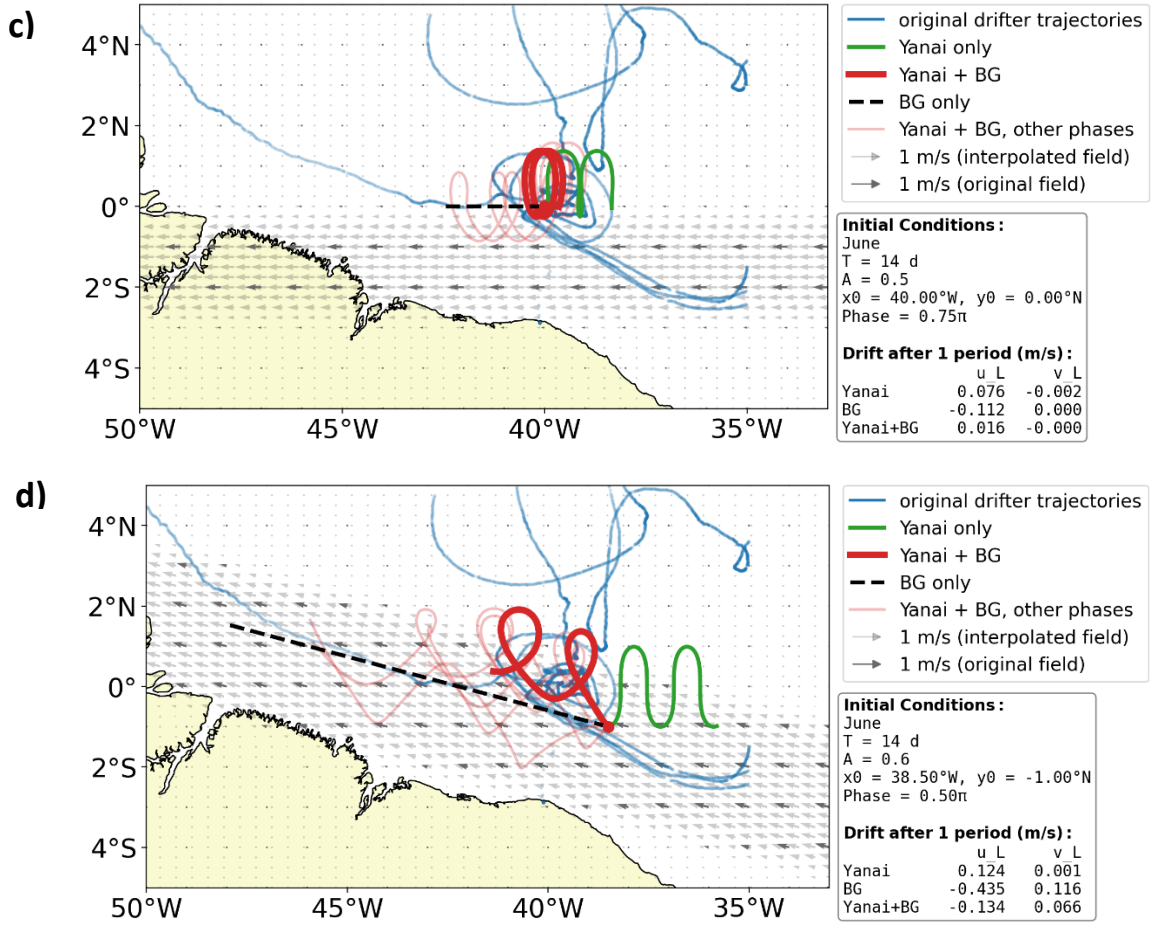


Fig. R3: Examples of experiments with artificial drifter trajectories and different background fields: a) and b) with a uniform mean background flow field with 0.11 m/s and 0.3 m/s, respectively. c) and d) with a mean sheared background current orientated westward (c) and rotated along the coast (d) mimicking the NBC, respectively. Red lines show the trajectories for the combined velocity field of Yanai wave and background field for the different phases of the Yanai wave. The green line shows the trajectory for a Yanai wave only field corresponding to the thick red line for the combined field, and the dashed black line indicates the trajectory for a background only flow field. Blue lines represent the trajectories of the original drifters.

5) Line 156 and Figure 1. Please discuss the statistical significance of the correlation coefficients. It can be computed following Section 3.14.1 in Thomson and Emery (2014). The effective degree of freedom can be computed following Section 3.15 in Thomson and Emery (2014) or the appendix in Metz (1991).

Metz, W. (1991). Optimal relationship of large-scale flow patterns and the barotropic feedback due to high-frequency eddies. Journal of Atmospheric Sciences, 48(9), 1141-1159.

Thomson, R.E., and W.J. Emery, 2014: Data Analysis Methods in Physical Oceanography. Elsevier.

We thank the reviewer for pointing out this issue. We now conducted a Student t significance test on the correlation coefficient confirming the significance on a 95% level of our results and adding this to the method section of the manuscript.

6) The authors show meridional winds and oceanic current velocity band-passed for the periods from 11 to 20 days in Figure 3. I suggest showing the spectrum of these variables to justify focusing on these specific periods.

We thank the reviewer for this suggestion. We included the following two figures with the spectra of the meridional wind speed (see Fig. R4) and the meridional surface velocity (see Fig. R5) in the method section of the manuscript.

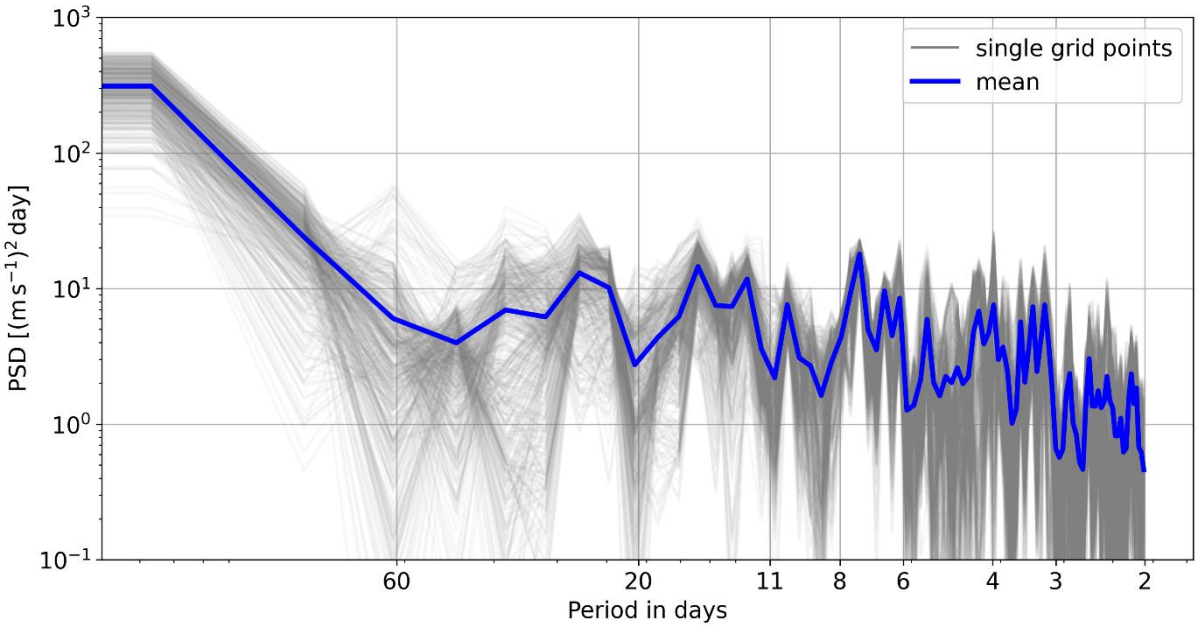


Figure R4: Power spectral density (PSD, in $(ms^{-1})^2 day$) of the meridional wind speed component (10 m) for 45°W to 35°W and within ± 1.5° latitude of the equator from March to August 2023 on a double logarithmic scale. Grey lines represent PSD for individual grid points, blue line shows the corresponding mean.

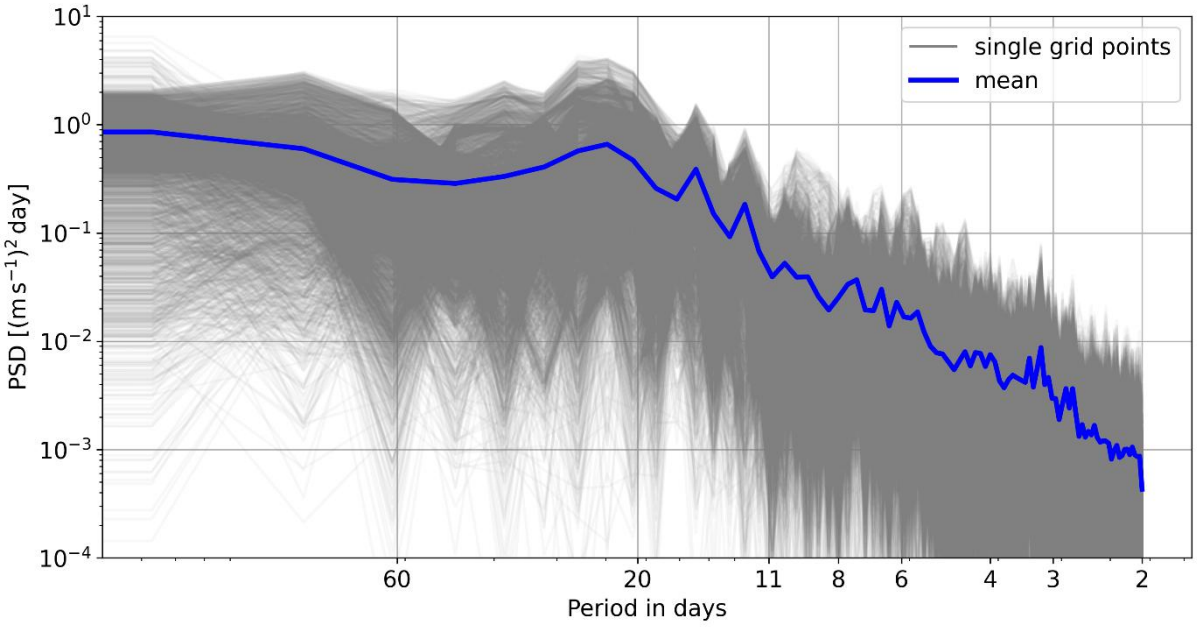


Figure R5: Same as R4 but for the meridional GLORYS velocities averaged over the upper 15m depth.

7) Line 26: It is more straightforward to say "they resemble eastward-propagating inertia gravity waves.", because it is the "gravity" part of mixed Rossby gravity waves.

We thank the reviewer for this suggestion. We changed the corresponding sentence in the manuscript.