Reply on RC2

This paper interprets trajectories from 8 surface drifters deployed in the equatorial Atlantic near 35W. Some of the drifter trajectories made circular loops, which are interpreted as being due to Yanai waves with a period of about 14 days, superimposed on a background current. The paper is clearly written, and the analysis generally is sound. However, the paper is close to being a "least publishable unit". There is some information here that may be useful and interesting to other researchers, so I think the paper has (barely) enough new science to be publishable. It is a straightforward interpretation of some limited new observations. The main insight is that linear Yanai waves can produce looping trajectories, something that I think many people know (e.g., see Figure 6b of the original paper on equatorial waves, Matsuno, 1966), but that may not be widely appreciated and may not have been demonstrated with data. I am ambivalent about whether the paper is worth publishing.

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

Major points:

1. I think the main result is that linear Yanai waves can produce looping trajectories. I cannot think of a paper that has made this point very explicitly, but the vortical nature of Yanai wave flow has come up in some papers (Neduhal et al., 2024, JGR Atmospheres, Fig. 11, showing that atmospheric Yanai waves have more vorticity than divergence; discussion of Dutrieux et al., 2008, JPO, noting that linear equatorial waves can have vortex-like velocity fields). However, it seems clear from the velocity field of linear Yanai waves (Figure 6b of Matsuno, 1966) that they could drive circular drifter trajectories. (Other equatorial waves can have vortex-like velocity fields, like in Matsuno, 1966, Figs. 4b, 4c, 5c. Linear surface gravity waves also drive looping Lagrangian trajectories, of course.)

We have added the suggested references to the introduction, where we discuss previous work on the vortical nature of equatorial wave flows. In response to this comment, we have revised parts of the introduction to state the contribution of our study more clearly, namely to provide observational evidence from surface drifters of looping trajectories caused by equatorial waves.

2. The interpretation that the looping drifter trajectories are due to a linear superposition of a linear mixed Rossby-gravity wave (or Yanai wave) and a background current derived from a monthly climatology requires the unstated assumption that there is no nonlinear interaction between the Yanai wave and the mean flow. This should be discussed and justified. I don't think it is very hard to justify because the Yanai waves propagate very fast compared to the mean flow speeds. This is discussed in Farrar and Durland (2012) and McPhaden and Taft (1979).

We thank the reviewer for this important remark. In our manuscript, nonlinear interactions are neglected due to the nature of the linear shallow water equations we used to derive Yanai waves. In addition, we used a mean flow field that is only

varying in space but not in time. We add a discussion about this in the manuscript and acknowledge the additional literature.

3. I fail to understand the point of the histograms in Figures 6 and 7 and all of the associated text (Lines 205-245). This strikes me as something that could make sense to an LLM agent. I think maps of trajectories might be more informative. Or, you might consider not including that at all and instead discussing Major Point 1 above.

We thank the reviewer for this comment. If we understand the suggestion correctly, the referee proposes using an AI-based approach, such as a neural network, to classify the trajectories instead of classifying them manually. We agree that this could be a valuable method for future studies. However, the classification is not the main focus of the manuscript but it is a secondary analysis intended to help understand the conditions under which looping trajectories occur. Since we do not expect a different classification method to change the main conclusions of this study, we prefer to leave this for future work. We believe that the histograms add some visual guidance and thus decided to keep them in the manuscript. Should we have misunderstood the referee's suggestion, we would be grateful for further clarification.

4. There is an apparent major discrepancy between the linear model and the observed trajectories in Figure 5: the observed trajectory appears to have "looped" several times, but the simulated trajectories looped at most once. Could the drifter have been caught in an eddy?

As mesoscale eddies rely on the geostrophic balance that breaks down at the Equator as the Coriolis force approaches zero, we do not believe that the drifters got caught in an eddy. This is indeed the reason why we turned to equatorial wave dynamics to explain the behavior of the drifters. We now state this more clearly in the introduction of the manuscript. Whether other eddy-like processes (e.g. Tropical Instability Waves) could have caused the looping trajectories of the drifters remains unclear and an in-depth investigation would exceed the scope of this paper.

Minor points:

a. Line 8 and many other places (e.g., line 261): the term "surface trajectories" is used in reference to waves, and this does not seem like the right phrase. The "trajectory of a wave" is not the same thing as the trajectory of a drifter in a wave field.

We thank the reviewer for pointing this out. We changed all corresponding terms throughout the manuscript to improve readability and prevent misunderstandings.

b. Line 26: First of all, it is a trivial statement to say that Yanai waves exhibit westward phase propagation at negative wavenumbers -- that is what it means to have negative wavenumbers. Second, Yanai waves do not resemble Kelvin waves, even at positive wavenumbers. The classical statement, which does not need to be

repeated here, is that mixed Rossby-gravity waves resemble Rossby waves at large negative wavenumbers and gravity waves at large positive wavenumbers.

We thank the reviewer for pointing out this issue. As suggested we remove the classical statements about Yanai waves from the introduction.

c. I find it preferable to call these waves mixed Rossby-gravity waves, which tells us something about their dynamics, instead of Yanai waves, but fine. (I think it is generally clearer and better for scientific terms to describe the phenomena they label rather than to be named after someone.)

We see the point of the reviewer but decided to stick to the term “Yanai waves” that has been used in many previous publications. We highlight that it can be used interchangeable with the alternative term “mixed Rossby-gravity waves” in the introduction of the manuscript.

d. Section 2.2.3: It would be clearer to first describe the spectrum and then describe the filtering in another paragraph.

We thank the reviewer for this suggestion. We included the following two figures with the spectra of the meridional wind speed (see Fig. R1) and the meridional current velocity (see Fig. R2) in the method section of the manuscript before describing the filtering approach.

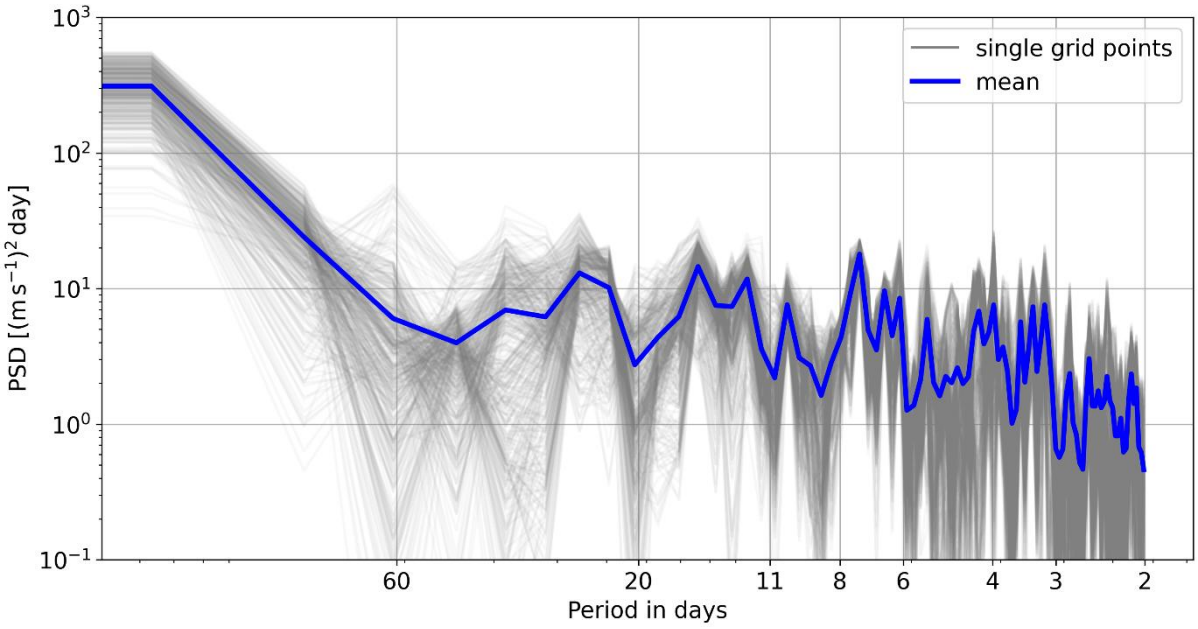


Figure R1: Power spectral density (PSD, in $(ms^{-1})^2 day$) of the meridional wind speed component (10 m) for 45°W to 35°W and within ± 1.5° latitude of the equator from March to August 2023 on a double logarithmic scale. Grey lines represent PSD for individual grid points, blue line shows the corresponding mean.

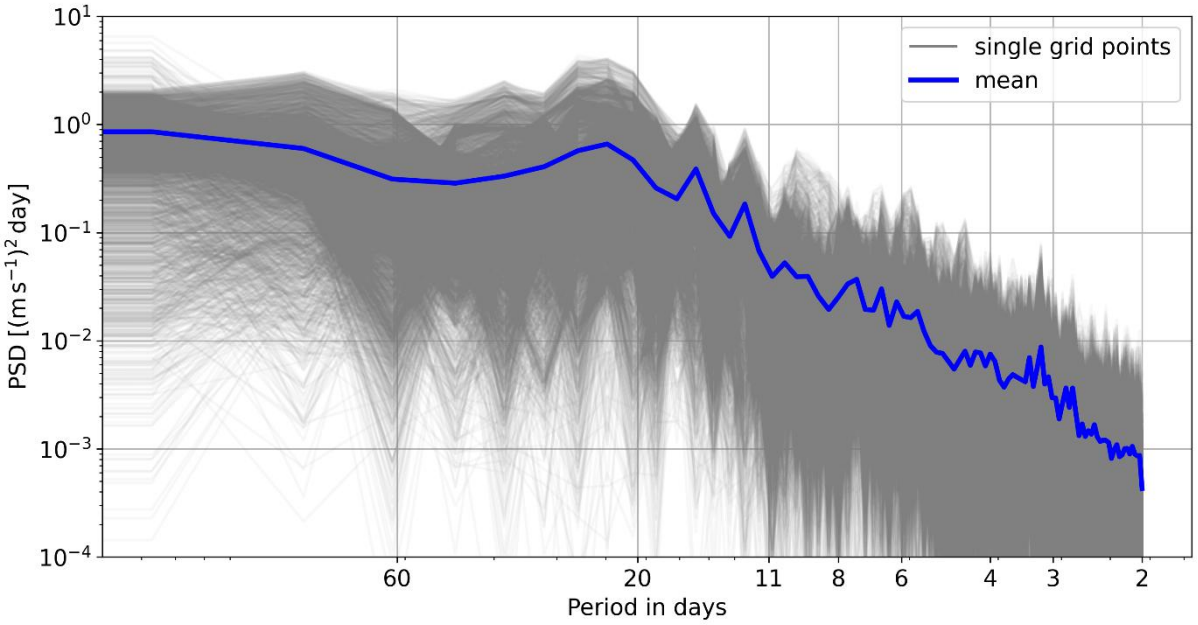


Figure R2: Same as R1 but for the meridional GLORYS velocities averaged over the upper 15m depth.

e. Section 2.2.4: It would be clearer to first explain why you need this and then describe it. Moreover, there is not a clear statement of what reanalysis you are talking about. GLORYS is mentioned in the fourth sentence.

We are rewriting the paragraph to improve readability and the story line.

f. Section 2.2.4: The validation of GLORYS velocities against PIRATA velocities is weak for the following reasons: (i) correlation does not tell us what time scales are well represented (the spectral coherence would do that), (ii) it appears (from the caption of Figure 1) that a 10-day running mean was applied to the velocities before calculating the correlation -- that seems like a poor choice, since a 10-day average is not sufficient to look at a 14-day signal.

We thank the reviewer for pointing out this issue.

Re (i): We believe that a high and significant correlation of the two timeseries, which shows that GLORYS represents the equatorial flow field reasonably well, is sufficient for our study, even though information about the representation of single time scales are missing. The use of the GLORYS output in our study (to confirm the biweekly signal in the surface velocities) is strengthening our theory but is not used in the main framework. Therefore, we think that a further analysis like spectral coherence would be indeed interesting but outside of the scope of this study.
Re (ii): Instead of applying a 10-day running mean to the data before calculating the correlation, we now use unfiltered daily data (Fig. R3). We calculated the correlation also for a 2 day and 5 day running mean to analyze the effect. In addition, we tested the significance of all correlations using a Students t test. The correlation coefficients only differ by about 0.01 and all cases are significant at a 95% level. The correlation coefficient is not sensitive to choosing daily values with no running mean applied or

daily values with a 2-day, 5-day or 10 day- running mean applied.
For a 95% significance level:

u-component		
Running mean	Pearson correlation coefficient *r*	p-value
No running mean, daily values	0.7683	8.9e-12
2 days	0.7737	1.69e-09
5 days	0.7842	5.153e-06
10 days	0.7872	0.00142
v-component		
No running mean, daily values	0.777	2.399e-27
2 days	0.7849	5.013e-21
5 days	0.793	1.583e-13
10 days	0.7767	1.711e-08

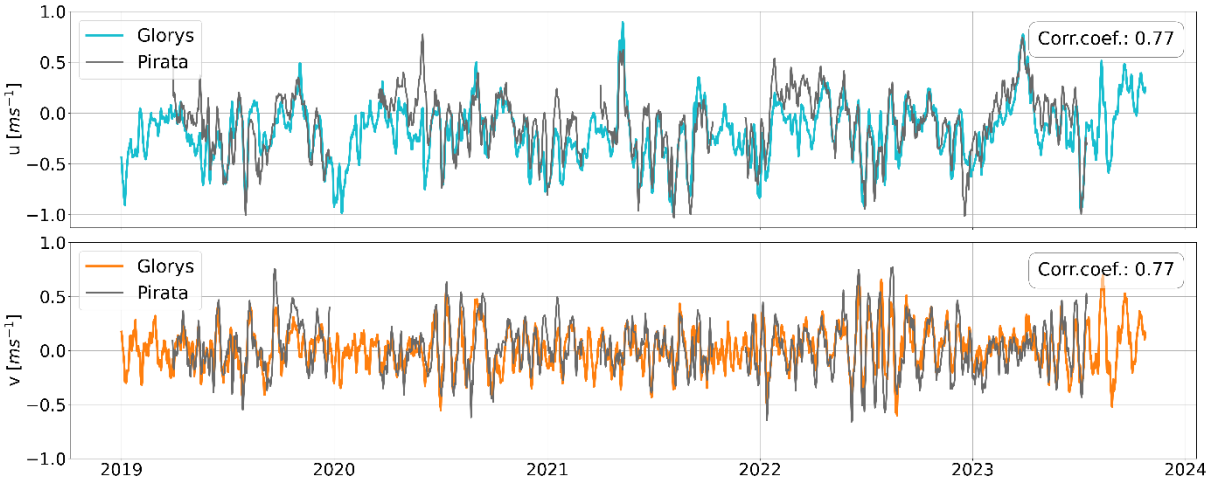


Figure R3: Comparison of upper 15 m zonal (upper panel) and meridional (lower panel) velocities for GLORYS (cyan/orange) and PIRATA (black) at the equator and 23 °W for 2019-2024. The Pearson correlation coefficient is calculated for each panel (unitless). Velocities are daily mean values and given in meters per second.

g. Lines 195-205: The wording in these two paragraphs needs work.

We are revising the paragraphs.

f. Line 232: "reality-close" is not an adjective I am familiar with.

We are changing and editing all the corresponding sentences.