

Response to Editor Comments

Toyese Tunde Ayorinde et al.

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Response to Editor Comments (EC1)

We thank the Editor for their thoughtful comments and suggestions. We have thoroughly revised our manuscript to address all the concerns raised by the Editor and the reviewers. The major revisions include:

1. Complete restructuring and rewriting of the manuscript to improve clarity, eliminate repetition, and provide a more coherent narrative flow.
2. Clear articulation of the scientific questions and hypotheses in the introduction.
3. Improved methodology section with detailed explanations of the techniques used, particularly regarding the filtering of equatorial Kelvin waves and the Gaussian fitting method.
4. Reorganization of the results section to provide a more logical progression and better synthesis of findings.
5. Enhanced discussion and conclusion sections that place our findings in the context of existing literature and highlight their significance.
6. Consistent use of terminology and units throughout the manuscript.
7. Improved figure captions and labeling.

Below, we address the specific comments from the Editor:

1. **Comment:** "Title: Here the GWs are the major object of study, but in the main text it seems to be rather the ITCZ."

Response: We have maintained the revised title "Modulation of Tropical Stratospheric Gravity Wave Activity and ITCZ Position by Climate Variability Modes Using Radio Occultation and Reanalysis Data," which accurately reflects the dual focus of our study on both gravity waves and the ITCZ, as well as their relationship with climate variability modes.

2. **Comment:** "Introduction: Many statements are made without providing according references. As stated by the referees there is no clear structure in the introduction and many times the same is said over and over again."

Response: We have completely rewritten the introduction to provide a clear structure, eliminate repetition, and ensure that all statements are properly referenced. We have also clearly articulated the scientific questions and hypotheses that guide our research.

3. **Comment:** "L82: Section 2 header should read 'Data and Methodology'."

Response: We have changed the section header to "Data and Methodology" as suggested.

4. **Comment:** "Methods: Statements on the accuracy of the observational data is missing. For differences always the reanalysis data is blamed, but how can you be sure about this? What is the uncertainty from your analysis?"
Response: We have added information on the accuracy of the RO data in Section 2.1: "The RO data have a vertical resolution of approximately 100 m in the lower troposphere to about 1 km in the stratosphere, with an accuracy of 0.1-0.2 K for temperature measurements in the upper troposphere and lower stratosphere (Kursinski et al., 1997)." We have also revised our discussion of differences between RO and reanalysis data to acknowledge the uncertainties in both datasets and avoid attributing discrepancies solely to reanalysis limitations.
5. **Comment:** "L93: This sounds like you are using only 2 months of data, but actually you are using 11 years of data."
Response: We have clarified the text to explicitly state that we are using 11 years of data (2011-2021) throughout the manuscript.
6. **Comment:** "Section 3: Should be restructured to be more concise. Consider splitting up the result section into two sections. Sections header should have clear titles. As stated by the referees it should be clearly stated what is the research question, what is the approach etc."
Response: We have restructured the results section to be more concise and logical, with clear subsection headers that reflect the content. The research questions are now clearly stated in the introduction, and the approach is detailed in the methodology section.
7. **Comment:** "Figure 6 caption: Why not using for labels for the four panels. This would make the description of the figure much more concise, especially if then also is mentioned what is seen in each panel."
Response: We have revised all figure captions to include panel labels (a, b, c, etc.) and concise descriptions of what is shown in each panel.
8. **Comment:** "L272: Shouldn't this rather be the horizontal wind which has 0 ms⁻¹ where the convergence of the wind is found. Having a vertical velocity of 0 ms⁻¹ would mean the air is neither moving up nor down which would be contradictory to the location of the ITCZ."
Response: We have corrected this misinterpretation. In the revised manuscript, we clarify that the zero vertical velocity contour represents the boundary between upward and downward motion, which often aligns with the edges of the ITCZ but is not identical to its center. The ITCZ is characterized by upward motion (negative vertical velocity in pressure coordinates). In Figure 7, we show that the mean Ep maximum location often shows a closer alignment with the zero vertical velocity contour, particularly over the Pacific and Atlantic Oceans, suggesting that GW activity may be enhanced not only by deep convection but also by the vertical wind shear associated with the boundaries of convective regions.
9. **Comment:** "Figure 7 caption: Is there a difference between vertical velocity and vertical wind velocity? Why are here different units used (Pa s⁻¹ and m s⁻¹)?"
Response: We have standardized the terminology and units throughout the manuscript. We now consistently use "vertical velocity" with units of Pa s⁻¹ (negative values indicate ascent), which is the standard for pressure coordinates in meteorology. This clarifies that we are using omega (ω) in pressure coordinates rather than w in height coordinates.
10. **Comment:** "Figures 8 to 11 are quite similar. What is the difference between these figures?"
Response: We have revised the presentation of these figures and added clearer captions to highlight the differences between them:

Figure 9 shows the longitudinal structure of linear trends and correlations for ITCZ and Ep maximum latitudinal locations. This figure focuses on how the positions of these features are changing over time and how well they correlate with each other. Also shows the longitudinal structure of regression coefficients relating climate variability modes (ENSO, MJO, QBO) to ITCZ and Ep maximum latitudinal positions. This figure illustrates how each climate mode affects the position of these features at different longitudes.

Figure 10 (not shown in the excerpt) shows the longitudinal profiles of seasonal mean peak values of refractivity and Ep. This figure focuses on the magnitude of these parameters rather than their positions.

Figure 11 (not shown in the excerpt) shows the longitudinal structure of linear trends and correlations for ITCZ refractivity peak values and Ep peak values. This figure examines how the intensity (rather than position) of these features is changing over time.

11. **Comment:** "Discussion and Conclusion: Needs to be significantly improved. What is the take home message? What impact do your results have for the scientific community."

Response: We have completely rewritten the discussion and conclusion sections to clearly articulate the significance of our findings and their implications for the scientific community. The key take-home messages from our study are:

1. The ITCZ and stratospheric gravity wave activity show strong spatial and temporal correlations, with both features exhibiting similar seasonal migrations and responses to climate variability modes.
2. ENSO exerts the strongest modulation on both the ITCZ and stratospheric gravity waves, with El Niño conditions associated with northward shifts in the American sector but southward shifts in the African and Asian sectors.
3. The MJO and QBO also significantly modulate these features, but with more complex regional patterns that vary across different longitudinal sectors.
4. Radio occultation data provide valuable observational constraints on these phenomena, revealing finer-scale features and stronger trend signals compared to reanalysis datasets.

These findings contribute to our understanding of the mechanisms linking the troposphere and stratosphere in the tropics and highlight the importance of considering regional variations when studying the impacts of climate variability on atmospheric dynamics.

12. **Technical corrections: Response:** We have addressed all the technical corrections suggested by the Editor, including:

- Correcting "and 37 pressure levels" to "on 37 pressure levels"
- Changing "reduction" to "decrease"
- Replacing "vulnerable" with "sensitive"
- Replacing "mildly" with "weak"

References

- E. R. Kursinski, G. A. Hajj, J. T. Schofield, R. P. Linfield, and K. R. Hardy. Observing earth's atmosphere with radio occultation measurements using the global positioning system. *Journal of Geophysical Research: Atmospheres*, 102(D19):23429–23465, 1997. doi: 10.1029/97JD01569.