

Manuscript number: egusphere-2026-4680

Title: “Impact of Super Typhoon Yagi on Earth’s Atmosphere: from Troposphere to Thermosphere/Ionosphere”

General comments:

The authors present a study of the upper-atmospheric response to Super Typhoon Yagi via vertical atmospheric coupling driven by GWs. They have used data from the Qinzhou MST radar/CLAIR, ERA5 temperatures, and ionospheric VTEC observations from two BeiDou receivers. The simultaneous observation of tropospheric and MLT winds, together with GNSS observations during Typhoon Yagi, is valuable and a main strength of the manuscript. The authors reported enhancements of short-period disturbances in the tropospheric winds, the presence of concentric structures in ERA5 temperatures, and approximately 2-h oscillations in the MLT winds and TEC variations.

However, in its present form, I have significant concerns regarding the strength of the causal interpretation. The observations clearly demonstrate upper-atmospheric and ionospheric disturbances during the Yagi event, but they do not yet convincingly establish that the approximately 2-h oscillation observed in the MLT region and ionosphere represents the same GW packet propagating upward induced by the Yagi.

The manuscript currently relies on temporal coincidence and similar spectral periods to conclude vertical coupling due to the Yagi-induced gravity wave.

The manuscript provides qualitative evidence of the vertical propagation of GWs but lacks quantitative propagation analysis to assess GW characteristics, i.e., period, vertical phase speed, time to propagate from the troposphere to the ionosphere, and horizontal/vertical wavelengths.

The manuscript is well written and comprehensible. Studies of this topic are underrepresented in the available literature, making it a worthwhile endeavour. At present, I consider the paper promising but requiring “**major**” scientific revision before it can be considered for publication.

Specific comments

1. The principal conclusion is that the ~ 2 -h oscillation detected in the MLT region and ionospheric TEC represents the portion of Yagi-generated gravity waves that survived wind filtering and propagated upward. The author's interpretation is mainly based on wavelet analyses of the simultaneous period band and the temporal coincidence on 7 September, 2024.

However, in my view, such periods alone are insufficient to demonstrate the vertical propagation of GWs. To show that any oscillation is due to vertically propagating GWs, one

needs to establish phase differences among oscillations observed in tropospheric, stratospheric, MLT, and ionospheric parameters. The author may focus on a single 2-h period rather than a band of periods spanning the troposphere to the ionosphere and attempt to derive GW parameters. The observed 2-h oscillation may arise independently in different atmospheric regions through GWs generated by other sources, atmospheric instabilities, or ionospheric electrodynamic processes.

If GW characteristics cannot be determined from the available dataset, the wording should be weakened from "propagation" or "vertical coupling" to "consistent with a possible vertical coupling".

2. For the MLT analysis, only 00:00–09:30 UT winds are retained each day, after which linear interpolation is used to fill the remaining time interval and missing observations. The manuscript explicitly acknowledges that up to 14.5 h of interpolation per day may be introduced before applying the 0.6–5 h band-pass filter and wavelet analysis. This is a substantial fraction of every 24-h record. The data presented is very useful, considering operating an MST radar in such adverse atmospheric conditions. The assertion that the 0.6–5 h filter is sufficient to eliminate the influence of this interpolation is not demonstrated. Interpolation across long gaps can generate, suppress, or modify periodic spectral structures.

I suggest that authors perform wavelet analysis using only the actual observations, without filling the long gaps (nighttime), as 2-h periods can be obtained from almost continuous observations during 00:00–09:30 UT, and the small data gaps can be filled using interpolation. Lomb-Scargle periodogram analyses will also be helpful for obtaining periods from unequally spaced time series.

3. "Significant waves" are identified as regions within the wavelet spectra as typhoon-induced, but no statistical significance test is described. The COI is shown, but it addresses only edge effects; it does not establish statistical significance. The authors should provide significance contours and also explain whether the identified 2-h feature exceeds the chosen significance threshold.

Without significance contours, statements such as "significant waves" should be replaced by more descriptive wording such as "enhanced wave power."

4. The two nearby GNSS stations provide an important independent observation of ~ 2 -h periodicity occurring at both stations, which is interesting. However, the manuscript concludes that the synchrony "strongly suggests" a common typhoon source. If it can be quantified rather than making statements based on coherent waves, it will strengthen the conclusion.

5. The authors set all filtered TEC values with absolute amplitudes greater than 1 TECU to zero because typical gravity-wave-induced TEC disturbances are stated to be below 1 TECU. This procedure deserves considerably more justification. A hard threshold of ± 1 TECU can alter the time series nonlinearly and potentially introduce artificial spectral structures.
6. The Nanning and Dongfang IPPs are separated substantially in latitude, while both appear to show a similar period. This is useful, but the authors should exploit this spatial separation. E.g., authors could determine whether the phase of the ~ 2 -h oscillation differs between the two stations. Even a small systematic phase difference could provide information about horizontal propagation speed. This would provide considerably stronger evidence for a common GW source than simply comparing dominant periods.
7. Figure 2(b): The directions shown by red arrows are not clear. You may show the direction in the figure. I am not sure if the top is north and the right is east. What does the length of the arrows show?
8. Line 114: What is ST mode and M mode of CLAIR A? What is the difference in operating in the stratospheric-tropospheric mode and the mesospheric mode? A few lines of description may be helpful for readers.
9. Line 117: The sentence was referred to (Chinese Meridian Project, 2023); it should be mentioned in the references section. I could not find it.
10. Lines 131-132: Define JPSS $\rightarrow$ Joint Polar Satellite System-1, it was renamed after launch, If I remember it correctly.
11. Line 135: Which conventional visible-light sensors are referred to here? Provide a suitable reference.
12. Line 160: How sliding-window denoising algorithm work? A few lines of explanation may be useful to readers.
13. Line 163: Why did Typhoon strengthen the westward winds in its northern part only, and how?
14. Figure 3c: Explain why, during 6-8 September 2024, vertical wind becomes downward?
15. Figure 7: If the waves shown in ERA5 temperatures are concentric gravity waves, why do they appear only eastward?

16. Figure 8/9: Have you filled the daytime data with linear interpolation before performing the wavelet? Or you have carried out a wavelet transform for each of the 6 days individually and compiled the results in Figure 9. I think you used the first method, in which you interpolated ~13.5 or 14.5 hrs of data (000-0930 UT data is available), then applied a 0.6-5 h bandpass filter. Don't you think that such a large data gap will create artefacts in the derived periods using the wavelet transform?

Why have you taken wind disturbances averaged over the 75-100 km height range to show GWs in the MLT region? A wavelet shows a band of periods within a time window in a time series.

As shown in Figure 8, there are 3 altitudinal bands in the zonal and meridional winds, indicating three distinct ranges of wind velocities. If you take three different altitude ranges, say 75-85 km, 85-90 km, and 95-105 km and perform Lomb-Scargle on the raw data before interpolation, you may be able to identify the period present at three different altitude bands and if it is coherent and shows downward phase propagation you can confirm it is due to upward propagating GWs from lower to upper altitudes in the MLT region. This way, you may obtain characteristics of the primary upward-propagating wave. This is another way to analyse the data. I would prefer to see such analyses if the authors agree. Please do not say this is beyond the scope of the current study.

17. Lines 265-269: ST winds show 0.6-4 hr period, M winds show ~2 hr period. Can you show that this ~2 hr coherent period generated by typhoon propagated from the troposphere into the MLT region? As merely observing a coherent period is not sufficient to prove vertical propagation of the GWs from the troposphere to the MLT region.
18. Figure 10 and related discussion in the manuscript: The time period spectra of VTEC variations recorded by the GNSS receivers in Nanning and Dongfang are quite interesting. It shows the presence of a ~2-hour wave in the ionosphere, in simultaneous agreement with CLAIR-measured ST and M winds. However, to prove that simultaneous oscillation is a vertically propagating typhoon-induced GW, it will be very interesting if vertical propagation can be shown from CLAIR ST and M winds.
19. The coherent wave periods observed in the MLT region and ionosphere are centered around 2 h. In the troposphere and lower stratosphere, a 0.6-4.5 h period range is observed. Therefore, not all Yagi-induced GWs have the potential to travel to MLT-to-Ionospheric heights; this depends on the propagation environment (primarily critical-level wind filtering). Can you take a single ~2 hr period and show that it has propagated from the troposphere to MLT to the ionosphere?

20. The discussion section is more suited to a conclusions section. This section mostly summarises the conclusions obtained in the results section. The “Results and Analysis” section may be “Results and Discussions” by including the current discussion section.

Technical corrections

1. Abstract: "Great wind disturbances" should be replaced by "large wind disturbances"
2. Line 21 “In mesosphere and lower thermosphere” should be “In the mesosphere and lower thermosphere” here and throughout the manuscript.
3. Line 37 “typhoon induced GWs” → “typhoon-induced GWs” to be consistent.
4. Line 44: Once “gravity wave” is defined as GW, it should be used throughout the manuscript.
5. Lines 98-99: The KP index should be mentioned to two decimal places while using the decimal notation.
6. Line 127: investigated → investigate
7. Lines 168-170: Grammatically correct this sentence.
8. Line 217: Do you mean “The spectral period in the stratosphere” or “The period spectrum in the stratosphere”
9. Line 218: there are many wave components appearing → "many wave components appear"
10. Lines 226-227: correct “radar usually can't effectively receive anything echoes”
11. Lines 241-242: correct “local nighttime periods and some invalid data with large deviations have been pre-removed”.
12. Line 245: “there was no much disturbances emerged” → "few disturbances emerged”.
13. Line 268: The range of the wave period → The range of the wave periods
14. Line 274: “The gray dashed box are used” → “The gray dashed boxes are used”
15. Qinhzou to be Qinzhou, be consistent.
16. Line 115: five direction → five directions