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Comment on acp-2021-952

Anonymous Referee #1

Referee comment on "How do gravity waves triggered by a typhoon propagate from the troposphere to the upper atmosphere?" by Qinzeng Li et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-952-RC1, 2022

Review of "How do the gravity waves triggered by typhoon propagate from the troposphere to upper atmosphere?" by Li et al.

This paper uses multilayer observations (troposphere, mesosphere, and thermosphere) along with reanalysis data to characterize deep propagation of gravity waves generated above Super Typoon Chaba. The authors use wavelet analysis to examine the scales across the different layers and suggests that waves seen in the thermosphere could be secondary waves generated by wave dissipation in the mesosphere. This is determined by ray-tracing analysis and by examining the decay of wave amplitude in the OH layer. This paper is of interest to the community and can be published with just some relatively minor revisions. However, it could benefit significantly from some clarification and additions to the sections regarding ray-tracing, the link between the OH and 630 nm waves, and the explanations of wave dissipation and secondary wave generation processes. Comments are given below:

Line 23: Suggest removing 'the' from capture the concentric waves.

Line 28: replace ray-tracing revealed that' with 'ray-tracing suggests that'

Line 30: What is meant by 'resembling the relay in the context'??

Line 45: Are a unique type of GWs. Note: concentric waves have also been generated from primary wave breaking, volcanoes, explosions, rockets (e.g. see works by Vadas and Becker ; Lund et al. (2020), Kogure et al (2020)).

Line 45: 'convective activity'

Line 65: Suggest re-writing as: This paper presents a case study examining GCWs excited by Super Typhoon Chaba (2016).

Line 81: Just "mainland China"

Line 89: "With a central wavelength"

Line 116: add a space between October and 2016

Lines 142-143: resolution is used twice in this sentence.

Line 147: Suggest "We use a ray tracing method to estimate the source location of the thermospheric secondary CGWs.

Line 176: add space to ERA-5reanalysis data.

Line 177: Why different times?

Figure 4: Axis labels.

Line 184: replaced "embraced" with "were present over a large area"

Line 208: How similar are the reanalysis datasets and the OH data? This seems a strange scientific decision. How do you justify this?

Line 208: also, I'm not sure single wavelength is correct, more a single wavepacket, or a single dominant wavelength.

Line 211: Due to resolution of the reanalysis?

Line 213: You are talking about in the reanalysis dataset here?

Line 214: When the CGWs from ERA-5 at the altitudes….

Line 214: Can you confirm that the waves in the ERA-5 at 20, 40, and 60km are the same wave? Perhaps using a meridional-vertical slice through the ERA-5 dataset to show continuity of wave phases with altitude.

Line 217: Usually waves generated from convective sources are part of a continuous spectrum of waves rather than discrete.

Lines 221, 224, and 225: Change 'observation period' to 'observed period'.

Line 222, Line 226: change "horizontal wavelength of the atmosphere" to 'dominant horizontal wavelength of the CGWs in the ERA-5 reanalysis'

Line 224: I think a better sentence structure would be "The wave packet observed in the OI 630 nm airglow was quasi-monochromatic"

Figure 6: I am curious why you do not perform a wavelet analysis on the 630 nm data as you did with the OH and ERA-5 data? This may be beneficial for comparison

Line 254: Maybe I am confused here? But the wavelet analysis in 5d, e, and f all show spectral power between 100-150km horizontal wavelength. The blue lines in Figure 7c also appear to match up with dark phases in the intensity of the OH image? The waves seen in the 630 nm will have relatively smaller amplitudes at OH heights and you wouldn't necessarily expect them to dominate there. The waves in the 630 nm data also have much faster phases speeds, shorter periods and thus a more vertical trajectory. This means that they will not travel as far horizontally as the waves noted as dominant in the OH layer so

the radius of the concentric pattern would be expected to be smaller.

Line 257: remove the word “moreover”

Line 270: How sensitive is the result to the starting altitude and the phase of the 630 nm wave where the starting point for the reverse ray-trace is chosen?

Line 275: Just because the wave would have been reflected at 95 km there doesn’t necessary mean it was generated there. It just suggests that the wave could not have comes from below this altitude according to linear theory. However, the wave could have been generated at any altitude between 95 km and the altitude of observation.

Line 315: I think the images in Figure 8 show clear signs of nonlinearity, instability, and smaller scale wave generation via wave-wave interaction and/or wave breaking.

Line 316: I’d suggest rewriting as: “However, it is noted that wavepacket amplitude fluctuations can also result from the transient nature of the wavepacket.”

Line 317: I’m not sure I understand the statement: “the observed CGW dissipation is real, unless it propagates horizontally”

Line 328: Why does this imply that the CGW may be dissipated? I think the Figure 8 with its evidence of small-scale structure and nonlinearity is evidence enough. What wave parameters were used for the m2 analysis in Figure 10?

Lines 330-332: While this statement is true, this is a huge simplification of the problem. Secondary waves can be generation via many mechanisms that are both non-dissipative and dissipative. Momentum does not need to be deposited in the mean flow to generate secondary waves but can be transferred nonlinearly from the primary wave mode to harmonics or subharmonics, the wave can also induce local mean flow accelerations just because of the transience of the wave packet which can lead to wave breaking. Local momentum flux divergence associated with wave breaking, vortex generation, and wave interactions can also generate secondary acoustic and gravity waves. For some references see: Franke and Robinson (1999), Fritts et al (2006), Zhou et al (2002), Chun and Kim (2008), Lund and Fritts (2012), Fritts et al (2015), Dong et al. (2020), Fritts et al (2020), Heale et al (2020; 2021), Bolini et al (2016), Vadas et al (2003), Vadas and Becker (2019), Scinocca and Ford 2000, Snively 2017. I’d recommend sections 2.2 and 4 from Fritts et al. (2006): Mean and variable forcing of the middle atmosphere by gravity waves.