Round 3: Review on
"Mesospheric gravity wave activity estimated via airglow imagery, multistatic meteor radar, and SABER data taken during the SIMONe–2018 campaign"
by Fabio Vargas et al.

Editor Decision: Publish subject to minor revisions (review by editor) (18 Jun 2021) by William Ward

Comments to the Author:

I have carefully examined the author's response to the latest comments from the reviewers. For the analysis of the larger scale waves and minor comments, their response is fine but they have not adequately addressed some of the issues associated with the analysis of the shorter scale waves. Unfortunately, these relate to the basic analysis approach that the authors use to determine these small scale gravity wave parameters and hence also impact the interpretation of their observations. These issues are outlined below.

1) Reviewer 1 commented on the lack of waves with intrinsic periods less than 20 minutes. The authors are correct that by shifting the images by the background wind prior to the analysis puts their analysis into a zero background wind framework. However, because their sampling time is 10 minutes, there will be aliasing of waves with periods less than 20 minutes into their analysis which have not been accounted for. This is because the technique used doesn't distinguish the propagation direction correctly and waves with periods that are harmonics of 10 minutes (i.e 10 minutes, 5 minutes) will not be seen since they will be observed as stationary waves. The fact that the exposure time is 2 minutes is not relevant to this aliasing issue.

The authors acknowledge that there is an ambiguity in the wave direction which cannot be directly resolved with the phase of the cross correlation but claim (Appendix B) that this can be resolved by choosing delta theta < 0 as this represents time progressing forward (ll 460 - 461). However, the sign of this angle depends on the propagation direction so this ambiguity remains. Note that Tang et al., [2005] whose analysis technique the authors follow, (page 105, first paragraph after Figure 2), also acknowledge the presence of this ambiguity but are able to resolve it since the period between images is two minutes. This time is short enough that it is unlikely that the gravity waves are able to travel more than half a wavelength between images. With the 10 minute sampling time associated with the data that authors are discussing this argument is no longer true. This issue would explain the issue that this reviewer noted. Other authors have observed numerous gravity waves with periods less than 20 minutes (Taylor et al., JGR, 1997; Li et al., 2018) and it is unlikely that this would not be the case for the location where the authors are making their measurements. This issue is likely the reason for the discrepancy between the observations of Li et al., 2011 and the author's observations which the authors comment on (lines 277 to 305).

Resolution of this issue in the context of this paper is difficult as it is fundamental to the author's calculation of the momentum flux and characterization of the waves during the observation period. Possibly acknowledging the observational filter and stating that the results are restricted to a subset of gravity waves would be the best way to proceed.

The filtering effect pointed by the editor is factual and can be verified in Fig. 11. However, figure 11 also shows that waves of 40 min will have finite amplitude. Observe in Fig. 11 that the amplitude decays fast for waves with a period <20 min and becomes zero for a period equal to 10 min. Of course, having a higher time resolution between sequential airglow images is better, as one can verify on Li et al. (2011) for a time resolution of 2 minutes when they could detect waves in the Brunt-Vaisala period range and above. Ideally, a better airglow experiment would rely on having all-sky imagers dedicated to each emission. This difficulty manifests here as the autodetection method's inability to capture waves of periods shorter than the integration time. Therefore, we have followed the editor's suggestion and added this discussion to lines 485-490.

2) Reviewer 1 also comments on the author's claim that the wave only lasts a short time. In response the authors use values of the vertical phase velocity to argue that a wave will pass through an airglow layer in less than 30 minutes. This argument is incorrect. The vertical phase velocity is not the appropriate parameter to determine the residence time of a particular wave in the field of view of the imager.

Typically several bands or wavefronts are seen in airglow images (as is shown in Figure 3 of this paper) and the 2D Fourier analysis identifies these bands as a wave with particular kx and ky. The airglow image provides a horizontal cut across a wave packet that is travelling with a group velocity perpendicular to and with a velocity magnitude different from that of the phase velocity. Hence the corrugated feature identified as a wave will remain in the image until the wave packet travels through the airglow layer. The actual residence time of a wave in the image requires knowledge of the group velocity and the scale of the wave package. The authors have not used this information (and are probably not able to) to determine the residence time of the wave.

This impacts the interpretation of the authors results and requires that the paragraph starting on line 184 needs to be rewritten. They can state that their convention is to count each set of three images where a wave is identified as a wave but need to acknowledge that they are likely multiply counting a particular wave packet with this convention.

We have followed the editor suggestion and rewrote the paragraph. In lines 185-190 one can read now: “It is possible that the observed wave events represent waves independent from one another because the observed waves have relatively long vertical wavelength and propagate vertically fast under weak horizontal winds. However, we recognize that this is not always the case and, as the oscillations slow down as they propagate vertically, their residence time within a given airglow layer could be long. Therefore, some of the detected waves could have been counted twice while evaluating the average momentum flux and other wave statistics.”.

3) Reviewer 2 questions the amplitude determination of the small scale waves. The authors have responded appropriately to these comments. Never-the-less it would improve the paper if a few sentences were devoted to this in the main body of the text.

We have followed the editor suggestion and added the following to lines 175-180: “The auto-detection method relies on three sequential airglow frames to obtain two time-difference images used in the cross-spectral analysis to obtain gravity wave parameters. The calculation of time-difference images leads to a change in the amplitude of the waves (in the TD images compared to the original ones). The amplitude influences the Fourier analysis and therefore also the result of the cross-correlation. However, this issue is properly taken care of by restoring the amplitude of the waves as seen in the original images. Further details about this correction and the auto-detection method is found in Appendix B.”.