Paper summary and overview

This paper explores the role of atmospheric gravity waves during north-east USA winter storms in the absence of orographic influences. Networks of high precision pressure sensors have been positioned in Toronto, ON, Canada and New York, NY, USA, and pressure wave events are identified from the 3+ year timeseries of data that has been collected. Using the meteorological context provided by ERA5, Doppler radar, surface stations and radiosondes, these events are characterised and studied. Consistency with previous literature is found regarding strong upper-level flow imbalance to the south or west of the gravity wave event locations, however not many events are detected with both gravity waves and enhanced snowfall radar bands, and no conclusive relationship between the two can be established from this study.

Overall, this is a really good paper which provides a thorough exploration of non-orographic gravity wave-driven enhancements to north-east USA winter storms and their associated snowfall. The method and theory sections demonstrate that a very detailed experimental process has been followed, and the figures and text have been produced with a lot of care and attention to detail. The scientific findings are a little inconclusive in places, however, agreement with existing literature is found and the results appear to be relatively robust. I can therefore recommend publication in ACP once the following minor comments have been addressed.

General Comments

1. I feel as though the abstract doesn't tell the full story about the final conclusions of this paper. There is not much about the conclusion of a lack of a common association between reflectivity bands and gravity waves, and between Doppler velocity waves and gravity waves – which to me forms a large part of the purpose of the study. It also finishes quite abruptly, can this be rounded off in a better way?
2. Given that many of the cases are quite different in both their pressure trace morphology and synoptic context, and with the relatively small sample sizes of similar events when the radar data is taken into account, I am unsure about how concrete any conclusions about the **general** role of gravity waves in winter storms **globally** are from this study. Although much of the method and theoretical work is very good, section 3 seems to finish with a bit of a dead-end and no demonstrable link between gravity waves and snowfall bands, despite the build-up in the introduction section?
3. Some of the background on primary and multi-bands is barely mentioned later on in the results, is this because this aspect was not explored further or because the sample size of relevant events was too small to study this?
4. I wonder whether a slightly looser constraint on defining what is and isn't a gravity wave event could increase the sample size without affecting the results too much, and enable a broader study to be done, even if the uncertainty associated with each individual event is higher?
5. In spite of the above, the science that has been conducted seems to be of a high quality, and even a result which is in agreement with existing literature, or one of limited conclusiveness on the role of gravity waves in winter storm snowfall bands, is still a good scientific outcome for this paper.

Specific Comments

1. P01L00: Can the title be shortened and/or simplified to make it more attractive to read? Also, gravity waves (GWs) are not in the title and yet they are front and centre of the start of the abstract. This is intriguing!
2. P03L56: Would it be possible for excessive riming to occur such that ice particles become heavy enough to fall below this region into a warmer/drier layer, such as occurs with some cirrus streaks? I am not sure myself, but wanted to raise the question, as this would be another possible mechanism that rimed ice masses could be removed from the upward branch of a gravity wave. Perhaps the wording "will not be removed" is a little bit strong? Reading on, I can see that the final sentence in the paragraph validates the possibility for removal mechanisms other than the two given in this sentence.
3. P04L95: The range of 5 min to 2 h is quite a large one, I wonder whether there is much difference between primary bands and multibands here that would point towards a greater importance of predicting one type over the other for severe snowfall impacts? I'm assuming that primary bands typically stay over one location for a longer period of time? Is there a difference in the typical intensity of each type, or are they about the same?
4. P05L129: This statement is not true, in observations there are many other ways to definitively confirm the presence of gravity waves, from satellite data to radiosonde profiles, ground-based radar and lidar and aircraft measurements etc. Furthermore, the presence of a perturbation in pressure sensor data is not enough by itself to signify the presence of a gravity wave, as the authors correctly point out elsewhere.
5. P06L153: I wonder if there is a slightly clearer way of writing these three sentences (from "A scale-dependent threshold function…" to "…Mean wavelet power increases with wave period.")? In Allen et al. (2024d, AMT), the necessity for the scale-dependent threshold K is fully explained - with lower values leading to more waves being detected but with the possibility of artefacts, and a K value of 10 leading to only the strongest wave signals being identified. Whilst it's of course important to only summarise the details from that paper here, could this part be rephrased so that the reader has a little more context about K?
6. P10L279: This Data and Methods section is very good, and there are no additional changes that I can identify as being required. The key data sets are introduced in an appropriate order, and a good level of detail is provided about the methods used to analyse these in turn. Great!
7. P10L289: These two sentences follow on from each other a little strangely, could this be very slightly rephrased to improve the flow?
8. P11L309: How might the event extraction method lead to the correlation seen in figure 7? I'm intrigued to know why there was more residual wavelet signal extending beyond the given event duration for the synthetic events that you tested against.
9. P12L355: I wonder if it is a bit unclear to say that 13 (57%) occurred north or east of a surface low, when events 25 and 30 were also to the east? Do you mean that there are 13 that are *close-by* to the north or east (i.e. not 25 and 30 which are further away), and in only *simple* cases (i.e. not 6 or 26 which are more complex)?
10. P13L387: I did find myself getting a little bit lost in section 3.1.2 (from L354 to L372) trying to follow certain events through the text, although I can see the challenges in presenting the information clearly when so many of the cases are unique in various ways. L373 to L387 are much clearer, and the questions raised regarding the surface lows and upper-level troughs earlier on in the subsection are well answered from L380 to L387.

Figure and Table Comments

1. General: Please could you stick to one format for labelling colorbars and figures? Sometimes you state the variable with units alongside in brackets (e.g. figure 7), sometimes it is just the units (e.g. figure 8), sometimes the units are in square brackets (e.g. figure 4). The fonts and font sizes are sometimes different as well, can these be unified where this is possible? Please also label subplot panels with letters where possible (a), (b), (c) etc. See the ACP style guide for guidance with this.
2. Figure 2: Could you please add lat/lon labels to these figures, even if it is just to 2(a)?
3. Figure 4: Is it possible to remove the blank tick from figure 4d which shows where there is no wave? Either this or explicitly write out "No Wave" or "Not a wave" perhaps.
4. Figure 5: It is currently a little tricky to distinguish between some of the points on figures 5b and 5c, as well as to match up points and error bars. Would it be possible to make these two plots slightly clearer?
5. Figure 6: Some of the text is a little small on this figure, can this be made a bit larger somehow? I'm conscious that there is limited space to do this though.
6. Figure 8: Not a necessity by any means, but if it is possible to remove the outer rectangular border for each subplot, I feel like it would improve this figure (and others). Some indication of lat/lon bounds, even if just on one subplot, or in a new one in the lower-right corner, would be helpful.
7. Figure 11: Please add lat/lon labels.
8. Figure 13: Please label panels with letters and use same headings as in figure 4.
9. Table 1: Is it possible to sort Table 1 alphabetically, chronologically (first use) or otherwise to make it easier to search for the term required? The idea of having this table is a good one though.
10. Table 2: Can the format of Table 2 be reverted to be identical to that of Table 1 for consistency? I acknowledge that this may be changed anyway during publishing, in which case there is no problem.

Technical Corrections

1. P01L26: Please either remove brackets from "(up to 67 min)", or give an indication of whether these are short, moderate or large gravity wave periods.
2. P01L28: Replace "those" with "these".
3. P02L37: Please either insert a comma after "2 to 67 min" or place the numerical values in brackets after "spatial" and "time".
4. P02L37: Replace "larger" with "upper" and "smaller" with "lower".
5. P02L43: Insert two commas to separate out the clause ", at least in part,".
6. P02L47: Please insert "also" after "There has", or make a similar change so that the paragraph flows a little better.
7. P04L109: Remove the 'a' before 'more likely'.
8. P04L117: "Section 3.1.3 puts the pressure waves into context of radar-detected features" reads a little strangely, is there a clearer way to phrase this?
9. P04L118: Please write out "Sect. 4" as "Section 4" for consistency.
10. P14L411: Add "to" between "chose" and "categorize".
11. P15L447: Remove the "a" after "suggests", and "associations" should not be plural.