Title: Observations of traveling ionospheric disturbances driven by gravity waves from sources in the upper and lower atmosphere.

Overview of Manuscript

This work investigates the sources of ionospheric disturbances due to atmospheric gravity waves due to high latitude space weather and low latitude tropospheric dynamics. They used multiple observational techniques to detect traveling ionospheric disturbances (TIDs) with large and medium scale characteristics, and atmospheric gravity waves (AGWs). Using observations and reanalysis data, they investigated the upper atmospheric dynamics that possibly excited the large and medium scale TIDs originating from the troposphere. The manuscript has the potential to contribute significantly to literature; however, there are some issues that need to be addressed.

It is concerning that no relationship between the observed wave and the source has been made in the current state of the manuscript. Instead, only what appeared to be a literature review of the previous works was done in conjunction with the results presented. Additionally, the presentation of the work from abstract to the conclusion is not in any chronological order, thus making it very difficult to comprehend the work and make the necessary relationship between any observed phenomenon and the other. For instance, the author mentioned the observed AGWs that induced MSTIDs. No comparison was made in order to prove that the AGWs indeed induced the observed MSTIDs. Also, they mentioned that the observed AGWs were excited though space weather event or tropospheric activity without arguing with evidence whether the said source is really the source or not. They provided some evidence and in some cases links to the evidence. Most of the links are not working.

Considering this lack of details, and the other comments listed below, I suggest the manuscript be subjected to a major revision. If these issues can be addressed, and the techniques more properly explained, the manuscript will contribute significantly to literature.

Major Comments

- **Abstract:**
  1. The abstract did not capture the necessary aspects of the work to give the reader a complete idea about the work. The work was not introduced, and the order of presentation makes it difficult follow. Kindly revise the abstract.

- **Introduction:**
  1. The introduction of the work is too precise and lacks a chronological presentation. There is no detailed presentation in this section. I encourage the authors to revise the introduction.

2. No in-depth and related literature review has been made.

- **Data sources and methods**

1. The data sources and methods are not detailed enough to understand the step by step process to analyze the data. They are possibly assuming the readers are familiar with the subject. They need to expand and give more information on the methodology.

2. Kindly provide a map showing the location where each data was collected. The comprehension as to the location where the authors are referring to in the manuscript is confusing, it would be better for the reader to know the locations of data collection.

3. The authors gave shallow descriptions of the methods used in retrieving the parameters. I suggest they restructure this section into subsections for each instruments and give a detail description of each instrument as well as the methodology employed in retrieving the parameters. The section can be structured as follows:

2. Data sources and methods

2.1. Advanced Modular Incoherent Scatter Radar (AMISR)

Description of the instrument and the methodology/ data analysis

2.2. Multi-point and multi-frequency continuous HF Doppler sounding system

Description of the instrument and the methodology/ data analysis

2.3. SuperDARN

Description of the instrument and the methodology/ data analysis

2.4. Global Navigation Satellite System (GNSS)

1. Description of the instrument and the methodology/ data analysis

- **Result**

The presentation of the result is quite confusing. This section also needs further revision.

- **AGWs/TIDs originating from sources in the troposphere**

This section needs total revision with more graphical evidence.

- **Discussion**

1. The discussion and conclusion are too shallow and fail to mention the main scientific contribution of the work to literature.

- **Summary and conclusions**

    1. The conclusion does not reflect the results presented and discussed. The authors intend to investigate the source of the AGWs induced MSTIDs. However, this has not been demonstrated in the current state of the manuscript.

Minor Comments

- **Abstract:**
    1. For instance, Between **Lines 21-24**: The work was not introduced properly, rather information about the instruments were given.

    3. **Line 27-29:** they mention the aim of the work, however, the preceding and succeeding sentences are not compatible, making the flow in the write-up interruptive. Kindly revise.

- **Introduction:**

    1. **Line 47-48:** *TIDs generated by AGWs originating in the lower atmosphere come from a variety of sources…* .
        a. The authors need to be mindful of the choice of words. AGWs capable of propagating to the ionosphere and modulating TEC are considered TIDs or perturbation generated in the ionosphere. It will be better to say TIDs are GWs modulated TEC or better still to say TIDs are driven by GWs. This is the case when considering TIDs mostly originating from the lower atmosphere.
        b. This sentence is too long. I suggest you break it into two parts:
            i. sources at the lower latitude and equatorial regions.
            ii. sources at high latitude.

2. **Line 59-62:** *The Joule heating due to the ionospheric currents of in the lower thermosphere is a source of equatorward propagating AGWs … .*
    a. It should rather be "*The Joule heating due to the ionospheric currents in the lower thermosphere is a source of equatorward propagating AGWs …. .* [remove the "**of**"]

- **Data sources and methods**

1. **Line 83-84:** *To retrieve TIDs, background densities are removed by applying Savitzky-Golay filter (Press and Teukolsky, 1990).*

    a. How was the data preprocessed before the application of the Savitzky-Golay filter? Why is this filtering method chosen over the other methods?

2. **Line 86-98:** The authors just cited the works done by others and possibly assumed the readers are familiar with the method. It is important to state and discuss the specific methods used, even if the readers are familiar.

3. **Lines 100-114:** a brief but yet no detailed description of the SuperDARN is given. However, similar to the other instruments, basically no information on the methodology used to first preprocess the data, followed by the data analyzing to retrieve the necessary background information or wave parameters. Kindly provide this information.

4. **Line 116:** What is SECS inversion technique? Why have you chosen this approach over the others? Details are needed to enhance the understanding of the reader.

5. **Line 123-136:** Similar to other comments on the previous instruments.

6. **Line 134-135:** The authors need to give enough details on this procedure instead of citing reference.

7. **Line 138-142:** This section is not supposed to be here. It should be in the acknowledgement.

- **Result**

    - **AGWs/TIDs originating from lower thermosphere at high latitudes**

1. **Line 146-167:** This section needs to be in the introduction.

- **Event of January 8/9, 2013**

The presentation of this section:

2. the presentation is not arrange such that the reader can easily understand.

3. the presentation of the corresponding Figures is not in sequential order. For instance, in some part of the text, results presented in Figure 9 are presented before Figure 8.

4. some undefined abbreviations are found within this section.

- **Events of November 1 and 4-5, 2014**

5. What are the parameters of the observed waves? How do you know they are large-scale characteristics? This section needs to be revised. Either a table or a plot needs to be provided with the wave parameters. Putting some of them in the texts is not enough.

1. **Line 301-302:** *Atlantic are sources of the GWs, which supports previously published results referenced above and points to winter jet stream as a likely source of GWs*.

    a. Please cite some references.

- **Events of November 1-8, 2014**

2. **Line 376-378: …** *were likely sources of MSTIDs propagating eastward to southeastward, as observed in the detrended vTEC maps (indicated by arrows in Figs. 13a,b) on November 1 and 8, 2014.*

    a. It has been mentioned that the propagation of the MSTIDs are indicated by arrows in Figure 13a.b. However, no arrows have been plotted. Only ">>" were used. Kindly use real arrows.

3. **Line 388-390:** *As described in more detail by Chum and Podolská (2018) and Chum et al. (2021), the use of well correlated signals at two or three different frequencies makes it possible to determine a 3-D phase velocity vector.*

a. How will the reader know the details in Chum and Podolská (2018) and Chum et al. (2021) with respect to the obtained result? Kindly mention here the exact point of these references.

- **Physical mechanism of GW generation in the troposphere**

4. **Line 439:** *Using the ERA5 reanalysis, similar to Figs. 15e,f, north-eastward propagating GWs in the ….*

   a. This is a bit confusing. There is no Figs. 15e,f. Kindly check and correct.

- **Discussion**

1. **Line 454-455:** "*In Section 3.1, we have shown evidence that even during a geomagnetically very quiet period the TIDs that were observed by PFISR in Alaska can be attributed to sources at high latitudes*".

   a. This aspect of the manuscript in Section 3.1, appear more of literature review and presentation of result. I would like to encourage the authors to really show (with diagrams) other evidence that the high latitude sources were really the possible sources of the detected TIDs.