Ionospheric Upwelling and the Level of Associated Noise at Solar Minimum

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Status: open (until 03 Apr 2024)

- **RC1**: 'Comment on angeo-2023-37', Anonymous Referee #1, 26 Feb 2024 reply

  Review of "Ionospheric Upwelling and the Level of Associated Noise at Solar Minimum" by David et al.

  The authors present a statistical study into the occurrence and characteristics of noise in incoherent scatter radar observations. Noise frequently accompanies ISR altitude profiles, and, as researchers in the field well know, one must be aware of its characteristics to properly interpret ISR data. The work is a timely scrutiny of measurement noise based on a large dataset of ISR data. The authors provide a well written introduction to ISR operation and explain how noise is defined. The results are presented in a structured concise manner. I quite enjoyed reading this paper.

  I believe that publishing the paper *as is* is justifiable. Nevertheless, there are potential points of improvement that bear promise should the authors wish to pursue them. The below list is meant to provide some ideas, and I do not expect or demand that the authors pursue all of these points.

  - The authors are rather vague on the mechanisms that produce noise to begin with. Are low ionization levels alone enough to cause local winter noise to dominate in this way? Does noise always appear with the same essential characteristics or is it possible to discern certain physical traits in the noise?
  - How does the noise proportion during local winter respond to the onset of geomagnetic storms? A simple superposed epoch analysis of storm-time onsets (or the onset of other geomagnetic index-excursions) which may show when or whether the signal rises above the noise during such events.
  - The radar in question is well positioned to observe the cusp, where ion outflows are highly characteristic, as well as elevated ionization rates. This sector, as well as the midnight sector, see a dip in the noise occurrence in Figure 4. Notably, the soft electron ionization that is characteristic for the cusp provides abundant F-region ionization. A short discussion of why noise is suppressed in these sectors may be enlightening.

  Sentence 20: "(...) common high-latitude phenomena, and are frequent during local summer."

Sentence 25: should it read "(...) altitudinal increase of the ionosphere"?

Sentence 80: Perhaps the authors can offer preliminary suggestions as to whether and/or why a deep solar minimum is associated with increased levels of noise.

RESPONSE

The authors deeply appreciate the reviewer for taking time to painstakingly go through the manuscript. Although the reviewer did not make the minor corrections mandatory, the authors have made reviews as highlighted below following the valuable recommendations from the reviewer on how to improve the manuscript.

- Sentence from line 95 has the following added to it.

It is worthy to note that the dip in the noise occurrence in Figure 4 is as a result of large ion outflows and an elevated ionization rate, which are characteristics around the cusp. The contributory role to the suppression of noise in this sector, as well as the midnight sector may be attributed respectively to the soft electron precipitation, which is characteristic of the abundant F-region ionization, and the reconnection usually experienced at the night side, leading to substorm.

Thank you for suggesting ways of improving the analysis presented in this manuscript. A robust study on geomagnetic storms and noise proportion will be looked at in detail in future work.

- Sentence in line 20: has been edited as suggested by the reviewer as follows:

…common high-latitudes phenomena, and frequent during local summer.

- Sentence in line 25 has been rewritten as follows:

…occurrence frequency of upwelling ions has a direct relationship with increase in geodetic altitude

- A preliminary suggestion to Sentence 80 has been added. The literature cited would be useful for readers.

…occurrence observed here may be attributed to low signal-to-noise ratio characterizing much of the high-latitude data at deep solar minimum around the period (David et al., 2018).