

Response to Reviewers' Comments

Revision 2

Reviewer 1

There are few papers dealing with the relationship between meteor events and Es occurrence and the region studied in the proposed manuscript is scarcely investigated. Thus the work can provide a valuable scientific contribution. Nevertheless, I find the scientific discussion too vague and I recommend to revise significantly the paper that cannot be accepted for publication in its present form.

My major concern is about the discussion that needs to be extended, integrated and tailored to the region under investigation. I read the paper by Chandra et al. (2001) mentioned in the manuscript: the authors of that paper made an in-depth dissertation of the Es layer formation and evolution interpreting the shape of the traces in the ionograms and they provided a detailed description of the meteor event. I understand the authors consider several meteor events, nevertheless I invite them to extend their discussions.

Authors' Response

Authors would like to thank reviewer for spending his/her precious time to read and comment on the paper. All comments and recommendations from reviewer to extend discussion have been addressed and a number of references have been added with reference to the added discussion. It is expected that the extended discussion will satisfy the reviewer. The comments from the reviewer have certainly helped improve the quality of the paper. All changes made with reference to the reviewers' comments are highlighted in red in the revised manuscript.

Reviewer 1

In particular, the discussion needs to be extended when the authors claim (lines 142-143) "The abnormalities are caused by plasma instabilities due to the various electrodynamic processes in the ionosphere." What are these various processes? Are these processes locally generated or are they linked to plasma transport?

Authors' Response

To extend the discussion and incorporating the specific point raised by the reviewer, following sentences have been added in the revised manuscript:

"Cross-field plasma instabilities cause the abnormalities due to the various electrodynamic processes in the ionosphere. These instabilities are triggered by the enhancement of plasma density in a particular volume when an external force acts on that same volume. A small disturbance can then lead to the separation of charges, which produces a small electric field, which with the presence of the geomagnetic field increases the disturbance (Simon, 1963)."

Simon, A.: Instability of a Partially Ionized Plasma in Crossed Electric and Magnetic Fields. *Physics of Fluids*, 6(3), 382. doi:10.1063/1.1706743.

Reviewer 1

What do the authors mean with "unfavorable conditions" in the sentence (lines 143-145) "Meteoric activity may provide metallic ions to the ionosphere, but they may not be displayed in ionograms if the conditions are unfavorable."?

Authors' Response

To extend the discussion and incorporating the specific point raised by the reviewer, following sentences have been added in the revised manuscript:

“The aforementioned instabilities have been shown to be capable of producing the diffuse type of sporadic E (Tsuda et al., 1969). The formation of this diffuse layer may cause the ionogram to display scatter echoes that exceed the actual critical frequency of the sporadic E layer formed as a result of metallic ions deposited by meteors.”

Tsuda, T., Sato, T., and Matsushita, S.: Ionospheric irregularities and the cross-field plasma instability. *Journal of Geophysical Research*, 74(11), 2923–2932. doi:10.1029/ja074i011p02923.

Reviewer 1

Also the sentence (lines 153-155) “Es layer may be affected by differences in climatology and wind dynamics” should be extended and discussed in the context of the regional analysis presented in the manuscript.

Authors' Response

To extend the discussion and incorporating the specific point raised by the reviewer, following sentences have been added in the revised manuscript:

“For example, long-period zonal and meridional winds at the mesopause region, with periods between 2 to 18 days may be considered to be planetary wave activity. Planetary waves have been observed to have strong variability between different seasons, with periods of 2 days in the summer, 5 days in spring and even exceeding 10 days during the winter (Jacobi et al., 1998). Studies have proposed vortex flows associated with planetary waves to explain the season dependence of sporadic E layers (Shalimov et al., 1999). Vortex flows are already known to affect the development of E layers (Pancheva et al. 2003). The meteor count may also be influenced by some biases. A number of the recorded meteors may not be metallic in nature and would not deposit any metallic ions in the ionosphere, possibly explaining why a higher meteor count during winter months did not amount to a higher average foEs.”

Pancheva D., Haldoupis C., Meek C. E., Manson A. H., and Mitchell N. J.: Evidence of a role for modulated atmospheric tides in the dependence of sporadic E on planetary waves. *Journal of Geophysical Research*, 108(A5), 1176, doi:10.1029/2002JA009788.

Shalimov S., Haldoupis C., Voiculescu M., and Schlegel K.: Midlatitude E region plasma accumulation driven by planetary wave horizontal wind shears. *Journal of Geophysical Research*, 104, 28,207.

Jacobi C., Achminder R., and Kürschhner D.: Planetary wave activity obtained from long-period (2– 18 days) variations of mesopause region winds over central Europe (52N, 15E). *Journal of Atmospheric and Solar Terrestrial Physics*, 60, 81.

Reviewer 1

Minor comments:

Caption Figure 3: Simultaneous monitoring of meteors and Es layer over Arabian Peninsula from May 2019– April 2020. (a) Es occurrence frequency as function of local time, (b) **Hourly average of foEs recorded using ionosonde**, (b) Hourly meteor count.

Figure3b Y-axis label: **foEs average (MHz)**

Line 116: **Fig 4 is a comparison between the daily and monthly meteor counts with daily and monthly averages of foEs layer occurrences.**

Caption Figure 4: Daily and monthly averages of **foEs** and meteor count over Sharjah. (a) Including all observations (24 hours), (b) Nighttime observations only

Figure 4 Y-axis label: **foEs average (MHz)** Caption Figure 5: Relationship between **foEs** layer monthly averages and monthly meteor count observed at Sharjah.

Figure 5 X-axis label: **foEs monthly average (MHz)**

Authors' Response

All the minor changes suggested by the reviewer have been incorporated in the revised manuscript (highlighted in red).

Reviewer 2

This article had a significant improvement, and the results are significant. In this version, there are just too many small English mistakes. Some examples are listed below. However, I suggest that the authors revise these little mistakes in all the text.

Authors' Response

Authors would like to thank reviewer for reviewing their article. The comments from the reviewer have certainly helped improve the quality of the paper.

Reviewer 2

The article "the" is missing in a lot of parts. I cited here some examples, but I suggest the authors review the entire manuscript.

Line 10: Include the article "the" before Es layer.

Line 15-17: Please, divide the last sentence into two parts to avoid confusion to the reader. Also, include the article "the" before the Es layer.

Line 21: Include the article "the" before the word visible.

Line 22: Remove the comma after the word shower. And revise the comma in all the text.

Line 23: There are instead of there is.

Line 26: Include the article "the" before the word geographical.

Line 30: Include the article "the" before the word lower.

Line 31: Include the article "the" before the word radio.

Line 32: Replace this phrase with: "Detection using visual cameras can only be performed during the night compared to radio-based observations that can be performed throughout the day and suitable for estimating total meteor activity."

Line 36: Remove comma after Kopp.

Line 41: Include the word as after the as well.

Line 41/Line 42/Line 44/Line 46: Include the article "the" before Es layer.

Line 44: Include the article "the" before Arabian.

Line 49: Include the comma after the word paper. And the article "the" before Es layer in all the paragraphs.

Line 55-57: Rewrite the phrases.

Line 59: Replace for: "The meteor counts have been obtained".

Line 61: "To do so" is so informal. Please, replace it.

Line 62: Include the word with after the along.

Line 67: Replace for “Thus, the STK simulation illustrates how much each tower covers the UAE sky, which adds up to 70% coverage of the sky.”

Line 73: Replace for “...to detect movements from the sudden changes easily in pixel values.”

Line 95: “All the data used in this study are...” instead of “All the data used in this study is”

Line 105: Include the article “the” before Es layer.

Line 108: It is “a 1-year”.

Line 109: It is “an average”.

Line 109-110: Replace for “It is expected that the Es layer observations would be more substantial as the solar cycle gets stronger in the coming years.”

Line 116: Replace for: “Fig 4 compares”.

Line 117: Include the comma before the word “and” and remove it after the word nighttime.

Line 119: Replace for: “...the monthly meteor count shows an opposite trend with a larger number of meteors...”

Line 121: It is “a very similar...”

Line 122: It is “The meteor count is the same...”

Line 127: Include the comma after the Younger et al. (2009), and after Ascension Island (8oS).

Line 129: Include the article the before the word maximum.

Line 136: Replace for “Baggaley and Steel (1984) were unable to find any correlation between meteor activity and Es layers' occurrence.”

Line 143: Replace for “Plasma instabilities cause the abnormalities due to the various electrodynamic processes in the ionosphere.”

Line 146: Replace for “It is shown in Fig 5 that the annual variation of both observations, on average, does not correlate monthly, having linear correlation coefficients less than -0.35 (negative 0.35) for both full-day and nighttime observations.”

Line 156-157: Replace for “unknown”, include the article the before the word transportation, and remove the word also.

Line 174: Replace for “Es layer may not be observed if the meteoric activity period does not provide long-lived metallic ions in the background plasma density.”

Line 176: Replace for “..., leading...”

Line 180: Replace for “of the role...”

Authors' Response

All changes suggested by the review have been incorporated in the revised manuscript and highlighted in red.