Interactive Reply on "An investigation of the ionospheric F-region near the EIA crest in India using OI 777.4 and 630.0nm nightglow observations" [angeo-2018-3]

Referee's Comment: The analysis of ionospheric variability is always welcome, and more now that space weather is a topical issue. However, I think that the method used to obtain Nm and hmF2 to analyze variations, is not appropriate to analyze variability over a single location. In my opinion, the method detailed by Makela et al. (2001) using nightglow emissions is useful for analyzing data over a region or area. If I am wrong, I would like the authors to convince me of this. Also, to analyze variations, you could analyze directly the airglow data. I am not convinced by your analysis of the absolute data you obtain for Nm and hmF2. However, the method is really interesting and may be useful for regions where F2 region ionospheric parameters cannot be obtained in another way.

Reply: We welcome critical comments of the esteemed referee regarding our submission and sincerely thank for his valuable comments on single location measurements, analyzing directly the airglow data, calibration technique, and appreciating the methodology of deriving Nm and hmF2 and its usefulness over a wide region. We would like to present our case stating the following limitations that prompted us to adopt such analysis technique limited over zenith:

(i) During 2009, airglow observing conditions over Allahabad were not very favourable, and all-sky images suffered from light contamination in an annular region (maximum near edges and decreasing towards centre). As Nm/hmF2 measurements greatly depend upon intensity information, we restricted the analysis to a limited field of view over zenith. We totally agree with the esteemed referee to study a broad region using this technique, and have presented Nm and hmF2 maps on one occasion (09 January 2016). On this night, good quality all-sky imaging data was available (along with coincidental COSMIC electron density profile for intensity calibration).

(ii) We agree with the esteemed referee that the nocturnal behaviour discussed herein can be studied by directly analyzing the airglow data. Nocturnal variability of low latitude ionosphere inferred using OI 630.0 nm intensity over India has been reported earlier by Mukherjee et al. (2000, 2006). Observations of OI 777.4 nm emission over India has not been reported to the best of our knowledge. As simultaneous data of OI 777.4 and 630.0 nm were available, we attempted this study following concept put forward by Sahai et al. (1981) and Makela et al. (2001).

(iii) In their study, Sahai et al. (1981) utilized OI 777.4 and 630.0 nm emission intensities measured using narrow field of view (3 – 5°) photometers. A correlative study of emission intensities with simultaneous ionosonde measurements indicated good correlations between $(I_{7774})^{1/2}$ and Nm, and between the ratio $(I_{7774})^{1/2}/(I_{6300})$ and hmF2. Authors concluded "Simultaneous measurements of these two emissions would be a very useful technique for remote sensing of the ionospheric F layer dynamics." Furthermore, the electrodynamical features viz. EIA, MTM and gravity waves (0.7 – 3.0 h period)

discussed herein are large-scale processes (beyond the limited coverage of our imager's field of view of ~ 140°). Thus, we assume that the variations observed over zenith can be assumed to represent the general behaviour of ionosphere within the limited field of view of imager. Such a choice also facilitates in calibrating the intensities using COSMIC electron density profiles.

Main comments:

Referee's Comment: 1) I would like the authors to explain the usefulness of estimating Nm and hmF2 for a single station with the method they propose, despite of the disadvantage of having to estimate a calibrating factor for example.

Reply: We sincerely thank the esteemed referee for this invaluable comment which we missed to highlight in our submission. Firstly, limited reports exist in literature that features simultaneous measurements of these two emissions (Sahai et al., 1981; Makela et al., 2001; Abalde et al., 2004). Study of Sahai et al. (1981) was limited to observations of good correlations between $(I_{7774})^{1/2}$ and ionosonde derived Nm, and between the ratio $(I_{7774})^{1/2}/(I_{6300})$ and ionosonde inferred hmF2. Makela et al. (2001) outlined a technique to create ionospheric topographic maps using airglow derived Nm-hmF2, and presented two case studies; while, Abalde et al. (2004) utilized their simultaneous measurements to infer the vertical drift velocities. Potential usefulness of technique has not been explored since then, and we attempt to study the ionosphere over a low latitude station using a limited data in this work. We will incorporate these corrections in the revised version.

Referee's Comment: 2) I would expect a more robust statistical analysis adding more cases maybe, or some tests, before deciding the calibrating factor.

Reply: We were keen to determine suitable calibration term but were unable to perform an analysis suggested by the esteemed referee because of the following reason:

A crucial limitation with this study is limited data of few nights. Nightglow observations were carried out during 15 September – 15 December 2009. Nightglow observations were severely affected by the presence of clouds during September; while, the foggy weather conditions affected observations during November - December. Consequently, good quality data of 14 nights only were available for a meaningful study. Only two COSMIC coincidences were noted coinciding with our observations, and have been presented in Table 2.1. Each of them yielded different set of calibration terms; hence, two sets of derived Nm and hmF2 have been discussed in results. Around 20 days of quality data was collected in next epoch of observation during 2015 - 2016; however, only one COSMIC coincidence was observed on 09 January 2016. Observations on this night have been discussed in Section 5.5 of the report.

Referee's Comment: 3) Are there any recent papers using this method to assess Nm and hmF2 parameters for just one location?

Reply: Such an investigation has not been carried out since Makela et al. (2001).

Other comments:

Referee's Comment: 1) Page 4, lines 23-24: I do not understand what do you mean by " ... however, is limited to report by Sahai et al. (1981) and Makela et al. (2001)."

Reply: We sincerely thank the esteemed referee for pointing out this. We mean to say that "Such an investigation has not been carried out since Makela et al. (2001)".

Referee's Comment: 2) Page 8, line 22: I guess that "Hm" should be "hmF2"

Reply: We sincerely thank the esteemed referee for pointing out this. We will correct this in the revised version.

Referee's Comment: 3) Page 10, in the section of "Comparison with earlier reports", this comparison should be made under the same conditions specifying time, solar activity level, geomagnetic activity level, etc. If this is not the case, anyway you should mention these conditions.

Reply: We sincerely thank the esteemed referee for this suggestion. We will incorporate the suggestions in revised version.

Referee's Comment: 4) Page 14, in "Signatures of gravity waves in Nm and hmF2 variations". How do you estimate the periods?

Reply: We sincerely thank the esteemed referee for this comment. The wave periods were estimated using Lomb-Scargle analysis. We will add this point in revised version.

Referee's Comment: 5) Figures 8 and 9: Which Nm and hmF2 is shown? That obtained with the airglow emissions?

Reply: We sincerely thank the esteemed referee for pointing out this shortcoming in Figure caption. We are referring here to airglow derived Nm and hmF2. We will correct this in our revised version.