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]

Reference: Anonymous Referee #2

We welcome critical comments and suggestions of the esteemed referee regarding our submission and sincerely thank for appreciating the technique and pointing out the shortcomings in the submission.

Referee's Comment: The atomic oxygen 777.4 nm and 630.0 nm nightglow emission intensities are important to study structural changes and dynamical processes in the thermosphere and ionosphere F2 region under various helio-geophysical conditions. In my opinion, the method of deriving NmF2 (Nm) and hmF2 parameters over Allahabad (25.5º N, 81.9º E, geomag. lat. ~ 16.30º N) using simultaneous ground-based observations of the 777.4 nm and 630.0 nm nightglow intensities, described in the manuscript, is interesting but rough.

The volume emission rates of 777.4 nm and 630.0 nm lines and corresponding behavior of ground-based observed intensities are largely determined by the ionosphere F2 region electron density height profile and its temporal changes, which are not always fully specified by Nm (NmF2) and hmF2. Using simple Chapman's layer, specified by Nm and hmF2, for estimation of 777.4 nm and 630.0 nm lines nightglow intensities is possible for some region and certain time intervals (Makela et al., JGR, 2001).

Reply: We agree with the esteemed reviewer that the technique is interesting and has not been utilized since Sahai et al. (1981) and Makela et al. (2001). 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.

In the ionosphere, ions, electrons and neutral participate in a series of complex chemical reactions which result in charge exchange, recombination, dissociative recombination, airglow emissions, quenching of excited states, etc.. Altogether these processes result in the derivation of ionospheric parameters from airglow measurements more difficult and contribute to uncertainty in derived quantities. Study of Sahai et al. (1981) indicated 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. Later on, Makela et al. (2001) modified this technique with few assumptions (for Chapman's layer, NO^+ and O_2^+ ions, ion-ion recombination in OI 777.4 nm emission, and the effects of exospheric temperatures on 630.0 nm emission) and arrived at empirical equations relating emission intensities to ionospheric parameters using numerical computations. Few assumptions have been pointed out in our study. In the revised submission, errors due of these factors will be mentioned. Makela et al. (2001) successfully utilized this technique to study ionization anomaly (one of the processes that we have presented in this report).

Main comments:

Referee's Comment: 1) In the manuscript it is noted: "Assuming the quasi-neutral ionospheric plasma to be mainly composed of O+ ions and electrons, its intensity can be seen depends on ne(h)2 where ne(h) is the electron density at height h. Now ne(h) is related with Nm through well-known Chapman's function (Tinsley et al., 1973)" (P.5, lines 23-26).

As I understand, here the importance of electron density decrease caused by ions recombination in the nighttime ionosphere F2 region electron density ne(h,t) is not considered. But these processes should be taken into account, since in this study the 6-8 hours of nighttime observational interval is used: "Mostly, the duration of continuous observation on each night was typically 6 – 8 hours" (P. 7, line 19). The tendency of decrease in the 777.4 nm and 630.0 nm lines intensities, demonstrated in Figure 2, could be coupled with the electron density nighttime decrease.

Reply: We sincerely thank the esteemed referee for pointing out limitation w. r. t. Chapman's profile and ionospheric chemistry. As stated in the previous paragraphs, we will discuss these issues in the revised version.

Referee's Comment: 2. Which nighttime intervals correspond to the COSMIC electron density profile on October 14 and 11 December 2009 (Figure 1)?

Figure 1 shows that for different nights of the considered dataset (September-December 2009) the electron density height profile and hmF2 can be sufficiently different. Actually, changes in hmF2 (also in NmF2) occur during any night of year which gives uncertainties to calibrate the 777.4 nm and 630.0 nm intensities, even for the single considered night.

Reply: We are sincerely thanking for pointing out this shortcoming in Figure 1. In the revised version, the time information will be mentioned. 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. Clear sky data of 14 nights only was available to perform this 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. Next epoch of observation was during 2015 and 2016;

however, only one COSMIC coincidence was observed on 09 January 2016. We were keen to understand these uncertainties but were unable to do so owing to few coincidences.

Referee's Comment: 3. The authors noted, that " Consequently, good quality data of 14 nights only were available for a meaningful study. " (P.7, lines 18-19). In this case the demonstrated results of the airglow derived Nm and hmF2 for all observations during September-December 2009 (Figures 3 and 4) need more clarification.

Reply: We are sincerely thankful for the esteemed review for this suggestion. We will modify the text suitably to clarify that the results are based on limited database of few nights.

Other comments:

Referee's Comment: 1. In equations (2) and (3) the dimensions of Nm parameter are different.

Reply: We sincerely thank the esteemed referee for pointing out this shortcoming. In the revised version, we will incorporate corrections in the equations so as to refer electron densities in m^{-3}.

Referee's Comment: The cited equation (7), "equation (3) and (7),..." (P. 8, line 29), "using equations (2), (3) and (7) ..." is not presented in the manuscript.

Reply: We sincerely thank the esteemed referee for pointing out this. Correct text is "….using equations (2), (3) and (6) …." and correction will be incorporated in the revised version.

Referee's Comment: 3. The written form of the values of the planetary geomagnetic indices Ap "Ap=01, Ap=02, ..." (Figures 5 an 6) is not convenient, because the cases of Ap≥100 are also possible.

Reply: We sincerely thank the esteemed referee for this suggestion. We will use Kp range in revised version.

Referee's Comment: 4. In Figure 7 a comparison of airglow derived hmF2 with ionosonde measurements is not given.

Reply: We sincerely thank the esteemed referee for this comment. Such a comparison has not been presented in Figure because large discrepancies were noted between airglow derived hmF2 and ionosonde measurements. This fact has been mentioned in text.

Referee's Comment: 5. Why was not used the ionosonde electron density height profile on 9 January 2016 to calibrate 777.4 nm and 630.0 nm? It could be more precise over Allahabad, than the COSMIC electron density profiles.

Reply: We sincerely thank the esteemed referee for this suggestion. In the revised version, we will perform such analysis to calibrate 777.4 nm intensity using ionosonde measured Nm and will discuss this in the revised version. Since large discrepancy between airglow derived and ionosonde measured hmF2 was observed on this night points out, we feel that this possible points out toward limitations on using hmF2/hpF2 towards true height of the F2 layer maximum.