Response to Reviewer 2 comments

The authors of this manuscript thank the reviewer for the comments. Our response to the comments are presented below.

> In this paper, the ionospheric irregulariteis are studied by using two methods: the absolute and relative changes of electron density. The distribution characteristics with local time, season and longitude of irregular structures are reproduced. The differences in the latitudinal distribution, and the correlation difference with F107 between the two methods are reported. The main problem for the reviewer is that the relative change depends on both the absolute change in electron density and the value of background electron density. The strong relative change in the equatorial region may be due to the weaker background electron density. The dependence on F107 is not strong and may also be due to changes in background electron density with F107. From this point of view, perhaps absolute changes may be more suitable for studying the ionospheric irregularities. So I don't know why the author should use the relative change as a way to study the ionospheric irregularities? I hope they can explain why. More interesting is the finding of the importance of the meridional difference in electron density in the irregular structure of the ionosphere. Could they explain more about the physical mechanism?

Response:

- We are aware of the fact that the relative change depends on both the absolute change in electron density and the value of the background electron density. We are also aware that the strong relative change in the equatorial region may be due to the weaker background electron density. We also mentioned in the manuscript in Pg. 12 L. 11-13 that, "From both local time and longitudinal perspectives, Wan et al. (2018),https://doi.org/10.1002/2017JA025072 confirmed that the depletion amplitudes of irregularities are closely linked to the background electron density intensity." From the results obtained by Wan et al. (2018),https://doi.org/10.1002/2017JA025072 it is observed that high background electron density is concentrated at the EIA belts than at the magnetic equator. We also mentioned in Pg. 12 L.9-11 that,“ 'Among other parameters, the growth rate of equatorial ionospheric irregularities is controlled by the electron density gradient. Ionospheric irregularities in the equatorial and low latitudes can cascade upwards and along the magnetic field lines to the EIA belts characterized by high background N_e and steep gradients in density (Muella et al., 2010).'
- The question asked by the reviewer i.e, why we use the relative change as a way to study the ionospheric irregularities, is one of the motivations for the current manuscript. Multiple studies have adopted the relative change to quantify ionospheric irregularities, while others have adopted the absolute perturbation (The reviewer is referred to the literature cited in Pg.3 L.19-21). Dao et. al. (2011),doi:10.1029/2011GL047046 adopted the relative perturbation to quantify irregularities. Their reason for using the relative perturbation was that the absolute perturbation is correlated with the ambient ion density, which varies due to several factors such as varying altitude. Instead, they computed the normalized depletion of ambient density, $\Delta N/N$, in an attempt to decouple any variables associated with the varying ambient density.

  However, discrepancies between the two methods in terms of identifying ionospheric irregularities have also been identified in earlier studies (This has been discussed in Pg. 3 L. 21-31). In Pg.3 L. 21-31, we also explain how comparison of the two methods is important in the meridional direction. Therefore, in this manuscript we use the relative change as a way to identify ionospheric irregularities to compare with absolute change.

  The absolute changes are most relevant to assess the effects of irregularities on radio signals and scintillations, which is for applied purposes. However, for studying the physical mechanisms causing irregularities the relative change is perhaps more important. For example, if a plasma instability is suspected to be the cause of irregularities, the observed relative change can give indications whether the disturbances can be assumed linear (small relative changes up to perhaps 10 %) or non-linearity needs to be considered (larger relative changes). Therefore we think that it makes sense to investigate the statistical occurrences of both absolute and relative changes.

– Concerning the mechanism responsible for the meridional distribution of ionospheric irregularities,

* Ionospheric irregularities are generated after sunset in the low latitude region due to the plasma instabilities and the most important parameter for their development is the equatorial evening vertical plasma drift ($\vec{E} \times \vec{B}/B^2$) (Fejer et al,1999, https://doi.org/10.1029/1999JA900271, Abdu 2005,DOI: 10.1016/j.asr.2005.03.150) known as the pre-reversal enhancement in vertical drift when the eastward electric field is intensified due to the action of the F region dynamo. At low latitudes, the ionosphere presents the EIA with high electron density observed between about $\pm 15 - \pm 20°$magnetic latitude. The EIA have their origin in the upward $\vec{E} \times \vec{B}$ plasma drift of the equatorial F layer. The zonal electric field

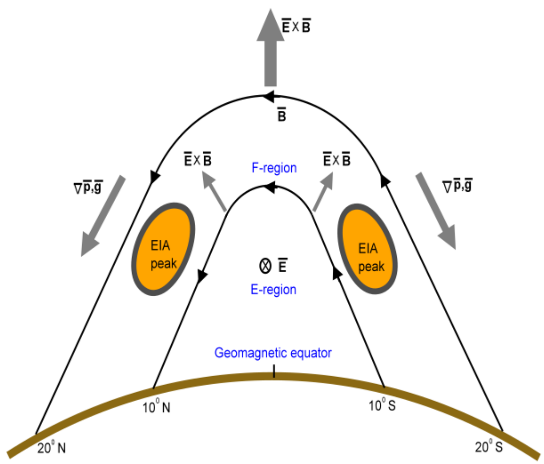

Figure 1: Appleton Anomaly Scheme

that exists in the equatorial ionosphere is directed to the east during day, creating an upward vertical $\vec{E} \times \vec{B}/B^2$ drift velocity. Soon after the sunset, this eastward electric field is intensified (pre-reversal peak) by the F region dynamo and the plasma from F region is uplifted to high altitudes. Meanwhile, the plasma from low altitudes quickly decline due decreasing of the intensity of incident solar radiation(Kelley, 2009). After lifting to high altitudes in the equatorial region, the plasma starts a descent movement along magnetic field lines. This movement happens due to the action of gravity (g) and pressure gradient (∇p) forces as illustrated in Figure 1. This phenomenon (the plasma elevation and the subsequent descent along magnetic field lines to low latitudes) is known as the fountain effect, giving origin to the EIA. The upward vertical plasma drift in the equator after sunset that gives origin to the pre-reversal peak, is the main factor responsible for the plasma irregularity generation (Fejer et al., 1999, https://doi.org/10.1029/1999JA900271). This means that around sunset at low latitudes, the enhanced eastward electric field in F region enlarges the equatorial fountain effect, causing the two crests of the EIA to get stronger and the trough above the dip equator to become deeper. We also quoted in Pg 12 L.10-11 that, " Ionospheric irregularities in the equatorial and low latitudes can cascade upwards and along the magnetic field lines to the EIA belts characterized by high background N_e and steep gradients in density (Muella et al., 2010,https://doi.org/10.1029/2009JA014788)."

* The difference in latitudinal distribution of ionospheric irregularities as observed in the meridional direction characterized by std(dN_e) and std$(dN_e)/N_e$ as discussed in the manuscript can be explained by the differences in background electron density and electron density gradients at the crests and trough. As mentioned by the reviewer, high values of std$(dN_e)/N_e$ occur at the equator because it depends on the background electron density which is low at the magnetic equator. High values of std(dN_e) occur at the crests because of high background electron density at these locations and steep electron density gradients (as presented in Figure 9).