Response to the Reviewer #1

Anonymous Referee #1: Interactive comment on "A case study of the day-to-day occurrence of plasma irregularities in low-latitude ionosphere from multi-satellite observations" by Weihua Luo et al.

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Manuscript: ANGEO-2019-128 by Weihua Luo et al. This paper investigated plasma bubbles and blobs in low latitudes and the roles of electric field, neutral winds, and neutral composition in the creation of them using various satellite observations. Reading the text and following the figures required a painful effort. This paper was like a department store with various miscellaneous stuffs. Results were a simple display of various observational data, and discussion was full of speculation and repetition of known facts. I did not find any scientific value from results and discussion. Below are Conclusions of the paper. My response to these conclusions will be good enough.

Response: We would like to thank the reviewer for her/his constructive comments and suggestions on our study.

In this manuscript, we report the occurrence of the plasma bubbles and blobs in two successive days under quiet and disturbed conditions, respectively. The variations of Equatorial Ionization Anomaly (EIA) during the two days were similar. The interesting results can be summarized as, 1) The EIAs were strengthened during the quiet day (17 August) and the disturbed day (18 August), which means the zonal electric fields were enhanced. On the disturbed day, the enhancement of electric field can be attributed to the Prompt Penetration Electric Field (PPEF). On the quiet day, we prove that the enhancement was not associated with the PPEF, which may be related with the lower atmosphere, such as Large-Scale Wave Structure (LSWS). 2) The EIAs became asymmetric in these two days, which may be related with the meridional wind. Generally, the plasma bubble is preferable to occur when the EIA is symmetric because of the absent of the meridional wind. When the co-existence of enhanced eastward electric field and meridional wind, the competition of the two factors should be considered. On 17 and 18 August, the eastward electric fields were enhanced and lead to the occurrence of irregularities, though the EIA became asymmetric due to the existence of meridional wind. Furthermore, the enhanced eastward electric field will strengthen the EIA, and the occurrence of vertical wind in equatorial region, which are preferable to the generation of plasma bubbles. From the results, we can speculate that the effects of enhancement of eastward electric field play the first important role in the occurrence of irregularities, while meridional wind may play the secondary important role in the occurrence of irregularities. The factors leading to the enhancement of eastward electric field under quiet condition need to be further investigated, which may be the key factor for the day-to-day occurrence of plasma irregularities in equatorial and low-latitude ionosphere.

(1) On a quiet day, 17 August 2003, after local sunset, the plasma bubbles in 180_E sector were detected by GRACE, ROCSAT-1 and DMSP F15 satellites. After about 100 minutes, the plasma blobs in 170_E sector were detected by ROCSAT-1 in low latitude region due to the westward motion of plasma irregularities. On 18 August 2003, during the main phase of the storm, the plasma bubbles in 180_E sector were firstly recorded, and the plasma blobs in 170_E sector were also detected after about 100 minutes by ROCSAT-1.

(2) Observations from CHAMP and GRACE indicated that EIAs were enhanced significantly before the occurrence of plasma bubbles on the two successive days with respect to that on other days. EIA asymmetry also displayed remarkable variations.

: These two are just the description of observational data. I do not find any scientific message from these descriptions.

Response:

We summarize the observational results here. The report describes that the plasma bubbles and blobs were detected in the same region on two successive days, and EIAs were enhanced significantly and became asymmetric before the occurrence of plasma bubbles. These descriptions provide the foundation to discuss the factors leading to the occurrence of irregularities.

(3) [O/N2] ratio also showed the increase on 17 and 18 August 2003. The increase can be attributed to the downward wind, generating from the enhancement of EIA strength.

: The O/N2 ratio provided by GUVI does not purely represent thermospheric conditions. Because the radiative recombination of oxygen ions enhances the OI 135.6 nm emission, the O/N2 ratio enhancement can be caused by the enhancement of the oxygen ion density. Without any evidence, the argument of the connection of the O/N2 ratio change to vertical winds and vertical winds to the EIA strength are not a meaningful speculation.

Response:

As the reviewer pointed out, the [O/N_2] ratio enhancement can also be caused by the enhancement of the oxygen ion density. On 18 August, the O^+ inside the plasma bubbles recorded by ROCSAT-1 showed the decrease.

It is possible to say that the increase of [O/N_2] ratio was from the downward wind, generating from the enhancement of EIA.

(4) The remarkable enhancement of EIA strength under quiet condition can be attributed to the enhancement post-sunset eastward electric field, due to the factors from below, such as the gravity waves at the lower atmosphere, which need to be further studied. In result, the enhanced EIA give rise to a downward wind in equatorial region, which favor the initiation of R-T instability and occurrence of plasma bubble. The downward wind also lead to the enhancement of [O/N2] ratio. The enhancement of post-sunset eastward electric field is suggested to be the most important for the day-to-day development of plasma irregularity, which could lead to the rapid rise of F-layer, EIA enhancement, and also the generation of vertical wind in equatorial region.

: I do not know how gravity waves can produce such a strong eastward electric fields.

All the descriptions here are based on speculation which has no scientific value.

Response:

On 17 August, a quiet day, the EIA was strengthened and became asymmetric, which means the existence of enhanced eastward electric field and meridional wind. The results from the calculation of Interplanetary Electric Field (IEF) and Prompt Penetration Electric Field (PPEF) model showed that the background zonal electric field was not affected by the factors from the upper, e.g. PPEF. The factors from the lower atmosphere may also enhance the F-region electric field. Thus, we speculate that the background zonal electric field was strengthened due to the Large-Scale Wave Structure (LSWS), which may be a key factor to the day-to-day occurrence of irregularities in equatorial and low-latitude ionosphere. In fact, we also do not know how the waves can strongly affect the electric field (upward plasma drift) on 17 August, and we want to study the effects of the LSWS on the zonal electric field in F-region. Unfortunately, we cannot access any observational data or model simulation to prove this speculation.

The effects of LSWS on the F-region plasma drift or zonal electric field need to be further studied.

(5) Meridional wind plays an important role in the occurrence of the plasma blob in low latitude ionosphere. Under the effects of the meridional neutral wind, in addition to the polarization electric field from the occurrence of plasma bubbles, the plasma blobs occurred on two successive days.

: The authors do not have the measurements of meridional winds. Blobs can be produced by the mechanism that the authors mentioned here, but this statement does not provide any constructive answer to the question of the origin of blobs.

Response:

In the manuscript, we do not have the measurements of meridional winds. It is difficult to measure the meridional winds at some longitudinal regions, such as the 170°E in this study. Thus, we attempt to analyze physically the possible factors leading to the occurrence of plasma bubbles and blobs, from the variations of Equatorial Ionization Anomaly (EIA). It is well known that the major factors affecting the development, strength and asymmetry of EIA are zonal electric field and meridional wind (e.g. Balan et al., 2018; Khadka et al., 2018). Based on the observations from CHAMP and GRACE, which can be well used to study the latitudinal variations of electron density, the results showed that the EIAs on the two successive days (17 and 18 August) were strengthened and became asymmetric, which means that the co-existence of enhanced eastward electric field and meridional wind in physics.

Under the presence of meridional wind, the plasma blob may generate after the occurrence of plasma bubbles.

References

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Khadka, S.M., C.E. Valladares, R. Sheehan, A.J. Gerrard (2018), Effects of electric field and neutral wind on the asymmetry of equatorial ionization anomaly, *Radio Science*, 53,683-697