

# ***Interactive comment on “Spread F occurrence features at different longitudinal regions during low and moderate solar activity” by Abimbola O. Afolayan et al.***

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Referee 1 First about the title “Spread F occurrence features at different longitudinal regions during low and moderate solar activity”. I think as the present manuscript describes only RSF so the title should be more specific. a)Thanks for your suggestion. This will be corrected while revising the manuscript

In the line 17-18, “at different. ....2013” the meaning is not clear here. a)This has been changed to “during 2010 and 2013 which represents the low and moderate solar activity periods respectively”

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3. In lines 24-26, “The observed features .....of occurrence”, please rephrase the sentence. a) Changed to “The longitudinal distribution of the RSF occurrence features include the observed difference in the onset time, duration and seasonal occurrence peak”.
4. Please put a space between the word “widespread” in line number 38. (a) This has been corrected
5. Line 47-48: “The pre-reversal enhancement (PRE).....in conjunction” the vertical drift velocity of what and how it is related with PRE? (a) This has been corrected
6. Line 50-52: please put some references in favour of the statement “The PRE.....instability mechanism”. (a) Relevant references have been added as suggested
7. Line 54: replace “of the” with “in”. 8. Line 57: use “conditions” instead of “condition”  
(a) Both comments (7) and (8) have been corrected as suggested
9. Line 58: whenever you are using the phrase “past studies” please include some suitable references. (a) Thank you, some relevant references have been included.
10. Lines 59-61: “The complex.....low latitude region.” Please include the references Haldoupis et al., (2003) and Miller (1997) a. Haldoupis C, Kelley MC, Hussey GC, Shalimov S. Role of unstable sporadic ÅRE layers in the generation of midlatitude spread F. Journal of Geophysical Research: Space Physics. 2003 Dec;108(A12) b. Miller, C. A, Electrodynamics of midlatitude spread F 2. A new theory of gravity wave electric fields, J. Geophys.Res., 102(A6), 11533-11538, 1997. (a) Thanks for your suggestion.
11. Line 103-104: “the different .....solar activity”, please mention which seasons you are using for your manuscript, yearly mean of SSN or F(10.7) and the longitudinal range using for this study. (a) “the different” have been changed to “equinox and solstice”, while the yearly mean of F(10.7) was included for each year. However,

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the longitudes of the considered stations have been specified under the methodology section.

12. Line 127: Please specify the longitude range. (a) The longitudes have already been listed in Table 1. However, we have reframed the sentence.

13. In Table 1, please refer to the short forms for all ionosonde stations that you used throughout the manuscript. (a) Thanks for your suggestion.

14. Line 135: please delete “echo” from the statement “the recorded.....SSF” (a) Deleted

15. In the same sentence please some references of “Bowman” e.g., a. Bowman, G. G., (1960), A relationship between “spread-F” and the height of the F2 ionospheric layer, Aust. J. Phys., 13, 69-72. b. Bowman, G. G., (1998), Short-term delays (hours) of ionospheric spread F occurrence at a range of latitudes, following geomagnetic activity, J. Geophys.Res., 103(A6), 11627-11634 a) The suggested references have been added

16. Line 139: please replace the word “height” by “altitude” and delete the words “echo” and “axis”. (a) This has been corrected as suggested.

17. Line 141: “Hereafter, we.....RSF”, if you consider both RSF and SSF as RSF then why are you mentioning SSF separately? (a) We have rewritten the highlighted comment.

18. Line 151-153: “the data are taken.....MSA period. Since ..... solar flux unit is similar,” Not clear, are you consider both 2009 and 2010 data for LSA and 2011, 2013 data for MSA? Because mixing of 2009 with 2010 data, also 2011 with 2013 data is not a scientific approach to analyze equatorial ionosphere. (a) Thanks. The data were taken during Oct, 2009 (72.14 sfu) was only used to represent the RSF occurrence at this region during the LSA period due to the low data availability during Oct, 2010 (81 sfu) at the Jicamarca station. We assumed that there will be

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negligible difference between the background ionospheric condition and subsequently the ionospheric parameters driving the spread F initiation at this region during both years. The highlighted statement will be deleted and the specific season and station where data was taken in the year 2009 will be indicated during the manuscript review.

19. Line 162-164: "The seasonal variation of RSF. .... MSA period". Please mention the Figure numbers where you have shown the histogram patterns. a) This sentence has been deleted and the preceding sentence rewritten as "Figures 4 and 5 present the hourly distribution of the RSF occurrence percentage across the different longitude sectors during the LSA period and the MSA period, which was averaged over each month based on the available data at these stations."

20. Line 165-167: "while. .... months" please replace "start" by "starting". a) This and other related words have been corrected.

21. In the same sentence please mention that the statement you have made is that true for all longitude sectors? a) This is true and clearly shown in Figure 4 for all longitudes, except the significantly delayed starting time observed at the KWJ station during the June solstice.

22. Line 172-175: "Li et al., (2011). .... LSA year." Where is the highlighted result you have mentioned? The irregularity development at the equatorial region normally initiated around the post-sunset period over the magnetic equator and thereby transported along the magnetic field lines to Eastward directions. The post-midnight irregularities are not always the trail of post-sunset irregularities but some fresh irregularity bubbles may develop during late evening hours depending on the nighttime ionospheric effects. So please discuss the statement properly. a) This statement was based on their Figure 4 and their description of the observed EFI occurrence in the African sector during LSA (page 5, section 3.2). The following was included as you have suggested; "The maximum RSF occurrence percentage was mostly observed before the midnight period (around 21:00 LT) during most seasons at each longitude.

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However, there are months which have a significantly larger RSF occurrence percentage near midnight than at 21:00 LT. This could be attributed to either the irregularity onset delayed till pre-midnight period as a result of the ionospheric condition or multiple days with irregularities originating from distant location drifting into the ionogram's field of view (Balan et al., 2018; Narayanan et al., 2014)."

23. Line 176-178: "Furthermore, the. ....sunset time." Where is the supporting information against this statement? It can't be concluded just from the histogram plots. a) Su et al (2009) described the relationship between the delayed zonal drift reversal, peak vertical plasma drift, the instability growth rate and the irregularity onset time at positive magnetic declination longitudes. Their analysis supports our observation at the KWJ station during the June solstice. The field-aligned Pedersen conductivity term in the zonal drift velocity equation is considered a major factor influencing the seasonal difference in the zonal drift reversal. Furthermore, we made a comparison between the average altitudinal variation of the field-aligned Pedersen conductivity during the March equinox and October equinox using the TIEGCM model (figure was not included in the manuscript).

24. Figure 4: Please mention in the x axis that the time is taken in Local Time (LT). Also mention the years of observations in the caption. a) That will be corrected

25. Line 185-186: "ILR station. ....recorded" 100% of what? a) This has been changed to "all the stations except at the ILR station, where the RSF occurrence rate was already ~100 % during the LSA."

26. Line 195-196: "irregularity onset. ....onset time," where is the supporting information regarding this statement? a) Though supporting information was provided initially in the discussion section but we have included more information as suggested and edited the initial discussion. Su et al., (2009) analyzed the zonal drift reversal control of the vertical plasma drift, instability growth rate and irregularity onset in the 1500 - 1700 longitude range. The relatively small RSF occurrence percentage as observed at

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this region during the J-solstice of the LSA could be attributed to the zonal drift reversal effect and the weak background ionospheric condition in the region. The zonal drift reversal delay was described as being strongly influenced and indirectly proportional to the field-aligned Pedersen conductivity. Hence, an expectedly larger density and a corresponding increase in the field-aligned Pedersen conductivity during the MSA will cause an earlier zonal drift reversal and larger occurrence rate as shown in Figure 5.

27. Line 198-200: “The largest STBA. ....period”, where is the supporting information against this statement? a) We having rewritten this part and added supporting information as suggested.

28. Figure 5: Please mention in the x axis that the time is taken in Local Time (LT). Also mention the years of observations in the caption. a) Thanks, it will be corrected. 29. Line 210-215: “The observed pattern ..... D-solstice period.” How can you conclude that ESF occurrence is independent of solar activity whereas solar activity is one of the major controlling agents of equatorial ionosphere? a) Thanks for your observation. That was actually a wrong attempt towards highlighting the probable contribution of other factors to the solar flux dependence of RSF occurrence in the region during the S-equinox. However, the statement has been deleted and the preceding statements edited in order to achieve a better illustration of our observation.

30. Line 215: what do you mean by non-occurrence of RSF? a) This has been changed to “absence of RSF occurrence”

31. Line 218: Please rephrase “anti-solar activity” with “inverse solar activity” throughout the overall manuscript. a) Thanks. This has been changed

32. Line 219: Please mention the location from where Su et al., (2007) have been described the inverse solar activity effects of RSF events during the solstice seasons. a) This has been changed to “The inverse correlation between the solar flux intensity and the RSF occurrence have been observed at the low ESF longitudes from 2300 to 100 and 900 to 2600 during the J-solstice and D-solstice respectively (Su et al., 2007)”

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33. Line 226: occurrence percentage of what? a) Thanks. Corrected to “RSF occurrence percentage”

34. Line 227-229: “The typical .....ESF events.” Please provide some references in support of your statement. a) We have added (Dao et al., 2017; Otsuka, 2018).

35. Figure 6: Please mention in the x axis that the time is taken in Local Time (LT). a) This has been added

36. Line 243: PRE in the equatorial ionosphere normally occurs during sunset or before but not at evening. So please correct the statement in line 243. a) This has been corrected

37. Line 246-247: “In case of ..... MSA period.” Please mention the proper Figure number in the statement. a) The statement refers to Figure 7(a and b) and that has been included.

38. Line 252-255: “Such zonal .....sectors”, Please put some references. a) Thanks for your suggestion, (Abdu, 2016; Vichare and Richmond, 2005) have been included.

39. Figure 7 (a and b): Please mention in the x axis that the time is taken in Local Time (LT). a) That has been corrected

40. Line 285-288: This section is I think not necessary for the manuscript. a) This section has been deleted as suggested

41. Line 314-316: “The equinox ..... entirely.” Please provide some reference. a) (Manju and Madhav Haridas, 2015; Tsunoda, 2010b) have been added to the sentence.

42. Line 327-329: “They associated ..... On the defined h'FC.” Please rephrase the sentence. a) This sentence has been changed to “Manju and Madhav Haridas, (2015) explored the probable relationship between the observed equinox asymmetry in the threshold height ( $h'$  F<sub>c</sub>), the ESF occurrence percentage and the O/N<sub>2</sub> ratio.”

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43. Line 348-351: "We assume ..... during both epoch." The meaning of the statement is not clear. a) Thanks for your suggestion, this section has been changed to; "This observation is likely due to the complementary role of the major factors influencing the plasma instability growth and their variability with the solar flux intensity. The observed large RSF occurrence percentage during the S-equinox of the LSA at this longitudes have been earlier related to the effect of the contracted ionospheric density. However, the increase in the bottom-side density scale length during the MSA (Lee, 2010) and this will cause an increase in the threshold PRE the irregularity occurrence (Smith et al., 2016)."

44. Line 359: Please replace "longitudes" by "ionosonde stations". a) This has been corrected.

45. Figure 8: Please put it in result section instead of discussion. a) This has been moved to the result section as suggested

46. Line 380-401: In my opinion, this paragraph is more suitable to demonstrate Figure 8 in the result than discussion section. a) Thanks for your suggestion, this has been moved to the result section

47. Line 405-412: "The relationship .....as expressed as V ...." This portion is also not necessary in the discussion section of the present manuscript. a) This has been removed as suggested

48. Line 413-415: Please make sure the letter front size should be same throughout the whole body of manuscript. a) This has been corrected

49. Line 417: What is the significance of the dust particles with this study? If you want to keep the statement described in line 417-418, please provide some reference and relate your study with the dust particles. a) Thanks for your suggestion, this has been removed



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