**Response to Referee comments**

**Name of manuscript:** South Atlantic Anomaly during ascending and maximum phase of solar cycle 24

**Authors:** Khairul Afifi Nasuddin, Mardina Abdullah, Nurul Shazana Abdul Hamid

We thank Nonlinear Processes in Geophysics for an experience in improving the journal. The comment has been read and taken consideration discreetly. The following summarize the effort the author take in answering the comment.

**Comments from Referee 1:**

**1.**

**(1) Comments from Referee:** In line 42 page 2.This is completely untrue. It is caused by reversed flux patches on the core-mantle boundary.

**(2) Author’s comment:**

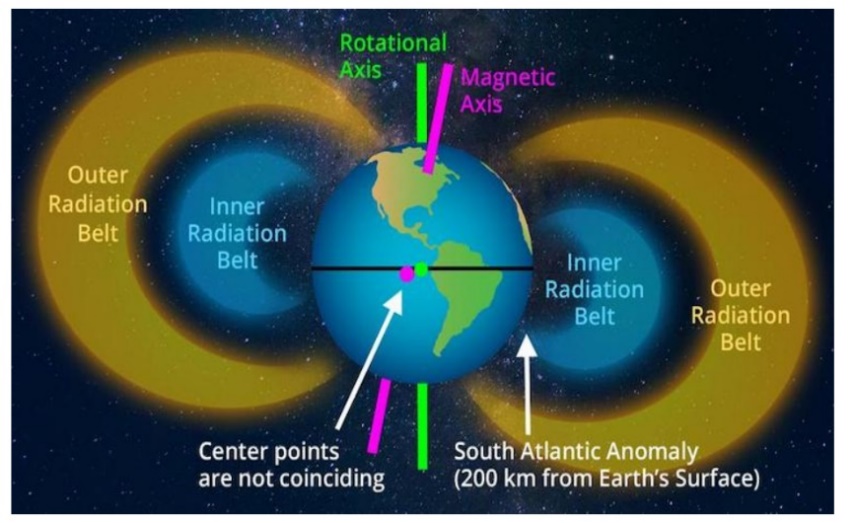
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Figure: SAA region

The author reference on the formation of SAA based on the noncoincidence of the geomagnetic dipole axis and Earth’s rotating axis is based in Zou et. al (2015).

The author would hope to be given the opportunity to explain based on research on Zou et. al (2015) on the formation of SAA. The author explain that from figure SAA region, the Van Allen radiation belts are in proportional about the Earth’s magnetic axis (magenta line) , that is tilted with respect to the Earth’s rotational axis (green line) by an angle of roughly 110. The intersection between the magnetic and the rotation axis which can be seen in figure SAA region is position not at the Earth’s centre, but some 450 km to 500 km away. Due to the asymmetry which occur, the inner Van Allen belt is closest to the Earth’s surface over the south Atlantic Ocean that it dips down to 200 km in altitude. The SAA region is a region where the Earth’s inner Van Allen radiation belt comes near to the Earth’s surface dipping down to an altitude of 200 km which the SAA region experience an increased flux of energetic particles in this area.

This is what the author try to illustrate on the SAA region.

**2.**

**(1) Comments from Referee:** In line 51 page 2**.** Again. this is untrue. The SAA and its effects are well known in the geomagnetic and aeronomy communities.

**(2) Author’s comment:**  The author would like to highlight on the damage spacecraft undergo through the SAA region. This can foster a reading interest for those learning about the SAA region.

**3.**

**(1) Comments from Referee:** In line 53 page 2.It© hard to see how you can completely avoid it on an 6-8 hour space walk.

**(2) Author’s comment:**  The author believe the astronaut will take safety precaution during the extravehicular activity.

**4.**

**(1) Comments from Referee:** In line 59 page 2.This is a repeat of the previous sentences.

**(2) Author’s comment:** The author would like to emphasize on the threat and damage of SAA region.

**5.**

**(1) Comments from Referee:** In line 64 page 3.You’©e just said previously that no one knows about the SAA outside space scientists. Which is it ?

**(2) Author’s comment:** In line 51 page 2, the author emphasize on the danger and hazard of SAA region. While in line 64 page 3, the author would like to focus on the important of SAA region.

**6.**

**(1) Comments from Referee:** In line 66 page 3.Again, this is a repeat of what you said in the past few paragraphs.

**(2) Author’s comment:** The author believe it is necessary to mention since it can develop the interest of the reader.

**7.**

**(1) Comments from Referee:** In line 68 page 3. This is exactly the same analysis as your previous article: Nasuddin, K. A., Abdullah, M., and Abdul Hamid, N. S.: Characterization of the South Atlantic Anomaly, Nonlin. Processes Geophys., 26, 25·®35, <https://doi.org/10.5194/npg-26-25-2019>, 2019.

**(2) Author’s comment:** The author emphasize that this study method is different because it involves 2 solar phases namely the ascending phase of solar cycle 24 and the maximum phase of solar cycle 24 and different active period and normal period with different station in the middle latitude region and high latitude region. In this research, low latitude region has been added to study its characteristic with SAA region.

**8.**

**(1) Comments from Referee:** In line 70 page 3.Why would it be different under different phases of the solar cycle. That affects the external magnetic field? The SAA is drifting slowly westward due to changes of the core field and flow, not because of the solar cycle.

**(2) Author’s comment:**  Solar cycle produce solar flare and it has an effect on the Earth’s magnetic field. Different flare have different strength. During maximum phase of solar cycle 24, it is the period when the Sun is the most active. Solar maximum occur during April 2014. The research is conduct to see the characteristic of the SAA region during solar maximum phase and the ascending phase of solar cycle 24. It is conduct to see the state of SAA region under ascending phase of solar cycle 24 and maximum phase of solar cycle 24 since during the maximum phase of solar cycle 24, sun is the most active and large numbers of sunspots appear and it may have an impact on the Earth’s global climate.

**9.**

**(1) Comments from Referee:** In line 80 page 3.How does this research get used for reference in satellite launches and increase knowledge of the field? Can you explain this further?

**(2) Author’s comment:**  We can see the characteristic of SAA region tend to be persistent. This happen in the research during the ascending phase and maximum phase. If the SAA region in the future for example, has a result such as a number of antipersistent characteristic, it might result something to occur in the SAA region. Safety precaution can be taken for satellite. Different result in SAA region could be a geomagnetic reversal would start to occur for example.

**10.**

**(1) Comments from Referee:** In line 86 page 3.What do you mean influence of SAA on the space weather? The SAA has no influence on space weather - that is caused by the Sun and the solar wind. The weak field of the SAA modulates the effect of space weather in that region.

**(2) Author’s comment:**  We can see based on observation there are cases such as instrument not properly operate when going through SAA region. Data collection stop taking when moving through the SAA region. Astronaut health is also endanger in SAA region. The author would like to explain the influence of the SAA on the space weather with this example.

**11.**

**(1) Comments from Referee:** In line 92 page 3.This doesn’t make sense as written. You seem to be saying that the Dst is less correlated with CMEs in the descending phase. However, a CME is a CME and its effect depends on how directed at the Earth it is and how strong, not what part of the cycle it comes from. Perhaps you are confusing the number of Earth-directed in each phase?

**(2) Author’s comment:**  The author meant the outcomes from the research conducted by Nigam et al (2017) is the correlation between Dst and coronal mass ejection on behalf of the ascending phase of solar cycle 24 is less in comparison to the ascending phase of solar cycle 23. The author hope to not create misunderstanding regarding the descending phase.

**12.**

**(1) Comments from Referee:** In line 97 page 4.OK – but what does that have to do with the SAA?

**(2) Author’s comment:**  It is a reference to study the SAA region during the solar cycle phase.

**13.**

**(1) Comments from Referee:** In line 107 page 4.This is incorrect. Diurnal variation is due to photoionisation of molecules in the upper atmosphere, creating an imbalance of electrons and ions which are in turn driven by the neutral winds and the earth’s main field in to a two-cell sun synchronised dynamo. It’s nothing to do with the magnetosphere in that sense.

**(2) Author’s comment:** The author would like to emphasize on the main effect of the interaction between the interplanetary magnetic field, geomagnetic field and the solar wind is that the geomagnetic field is compressed on the sunward side, giving rise to a diurnal variation at mid latitudes whereby this variation can be observed by monitoring the geomagnetic field using the global network of magnetic observatories. This is mention in by Hamid et al. (2010) in Scaling and fractal properties of the horizontal geomagnetic field at the tropical stations of Langkawi and Davao in February 2007 in AIP Conference Proceedings.

**14.**

**(1) Comments from Referee:** In line 121 page 4.This is really unclear. People have been studying this for literally centuries – what are the dominant time-scales and signals in geomagnetic data: e.g. https://link.springer.com/referencework/10.1007/978-1-4020-4423-6

**(2) Author’s comment:** The author would like to highlight the method of fractal analysis in the research which can develop to extract quantitative and qualitative information from time series, which have been applied to study a large variety of irregular signals and to detect deep dynamical features.

**15.**

**(1) Comments from Referee:** In line 126 page 4.This is not true – you are only looking at a few days of data, not the entire part of the solar cycle?

**(2) Author’s comment:**  There are several part of solar cycle such as ascending phase, maximum phase and descending phase of solar cycle. The research focus on the maximum phase and ascending phase of solar cycle 24. The maximum phase of solar cycle 24 occur only on April 2014. While the ascending phase of solar cycle 24 reveal SAA region has a tendency to be persistent. This result also appear and supported in journal “ Characterization of the South Atlantic Anomaly “ where SAA region reveal a tendency to be persistent during the ascending phase of solar cycle 24. The author indicate in line 128 page 5 that the date chosen are 6 August 2011 and 24 July 2011 representing the ascending phase of solar cycle 24 and 12 April 2014 and 14 May 2014 representing the maximum phase of solar cycle 24.

**16.**

**(1) Comments from Referee:** In line 147 page 6.Mislabelled

**(2) Author’s comment:**  The author have check it. It is not mislabelled. The station name is Lviv and the IAGA Code for station Lviv is LVV.

**17.**

**(1) Comments from Referee:** In line 166 page 7.Why have you used FCC – it is not in your list and you haven’t told us where it is (though I know if is in Canada).

**(2) Author’s comment:**  The figure have been change and a suitable station relating to the research conduct have been apply.

**18.**

**(1) Comments from Referee:** In line 166 page 7.What are the X and Y units? What is the period e.g minute or Hz? What are the units of power?

**(2) Author’s comment:**  Periodogram in figure 2 can be defined as power spectral density, P(*f*) plotted with frequency, *f* in log-log scaling. The power spectral density, P(*f*) unit is watts per hertz (W/Hz) and the frequency, *f* is in Hertz (Hz). In designing the periodogram, the log-log scaling is apply which in the figure is represent as Log P(*f*) in the Y-axis and Log*f* in the X-axis.

**19.**

**(1) Comments from Referee:** In line 170 page 7.How long is the time series you used? What dates were used? What algorithm or package did you use? This is really basic information. How can I recreate this graph without this information

**(2) Author’s comment:**  The time series apply is in 24 hour. The dates for active period is 6 August 2011 and for normal period on 24 July 2011. The algorithm apply is fourier transform from MATLAB software. This information has been added in the journal.

**20.**

**(1) Comments from Referee:** In line 179 page 8.Ah, 10 October 2011 – is this for the red or the blue line in Figure 2?

**(2) Author’s comment:** This concern on figure 3. Figure 3 has been replaced and it represent the active period, 6 August 2011 for station UPS.

**21.**

**(1) Comments from Referee:** In line 199 page 9.Reads a lot like the Wikipedia page: https://en.wikipedia.org/wiki/Hurst\_exponent

**(2) Author’s comment:**  The content of it has been made reference based on journal “ Characterization of the South Atlantic Anomaly “.

**22.**

**(1) Comments from Referee:** In line 252 page 12.All you are saying here is that values of the magnetic field are correlated - this is not new or undocumented. Geomagnetic storm effects at low latitude are weak – HBK has a variation of around 100 nT in Fig 6. That is not a large variation. The change is driven primarily by the ring current in the magnetosphere which has a long recovery time and has a reasonable slow response time.

**(2) Author’s comment:** The author have further elaborate it in the line 281 till line 288 page 13.

**23.**

**(1) Comments from Referee:** In line 252 page 12.Where did you get the field strength from? Is it the average of the observatory at quiet time or a model value? Is it for the dates in question?

**(2) Author’s comment:**  The field strength is obtain from data INTERMAGNET at <https://www.intermagnet.org/>. The mean of the Earth’s magnetic field strength represent the station and it’s dates.

**24.**

**(1) Comments from Referee:** In line 264 page 12.The total strength of the field is not really relevant as the H component of the field is weak compared to the Z component at low latitude.

**(2) Author’s comment:**  SAA is known for its low Earth’s magnetic field strength. The author feel it is important to mention the total field strength as a comparison with other region.

**25.**

**(1) Comments from Referee:** In line 300 page 14.AAE sits under the equatorial electrojet this is a much more vigorous magnetic source that does change more rapidly – hence the anti-correlation over a longer period of time. The same applies to TAM as well I would suppose.

**(2) Author’s comment:**  The explanation of the EEJ as well as station AAE and station TAM has been elaborate in line 315 till line 319 page 14 and page 15.

**26.**

**(1) Comments from Referee:** In line 302 page 14.What happened to AAE?

**(2) Author’s comment:**  The data for the station in the research is obtain through INTERMAGNET. In doing the research, there are situation where the data availability is not available.

**27.**

**(1) Comments from Referee:** In line 314 page 14.The behavior of TMA and AAE have nothing to do with the strength of the field but with their proximity to the auroral electrojet. I would also question the use of AAE as it is strongly contaminated by interference from a local train line. I don’t know if the data you used have this problem?

**(2) Author’s comment:** The author has made an explanation on the EEJ and station AAE and station TAM in line 315 till line 319 page 14 and page 15. The author conduct the research based on available data.

**28.**

**(1) Comments from Referee:** In line 441 page 19.Not correct. The persistence arises from being at low latitude where the ring current is the prime source for magnetic field variation and hence long correlation times. Field strength is not the reason.

**(2) Author’s response:** Explanation has been made regarding the ring current in the Result and Discussion section, and in the Conclusion section, the author summarize it.