Investigating Similarities and Differences of Radial Diffusion within the Van Allen Belts During Geomagnetic Storm Times

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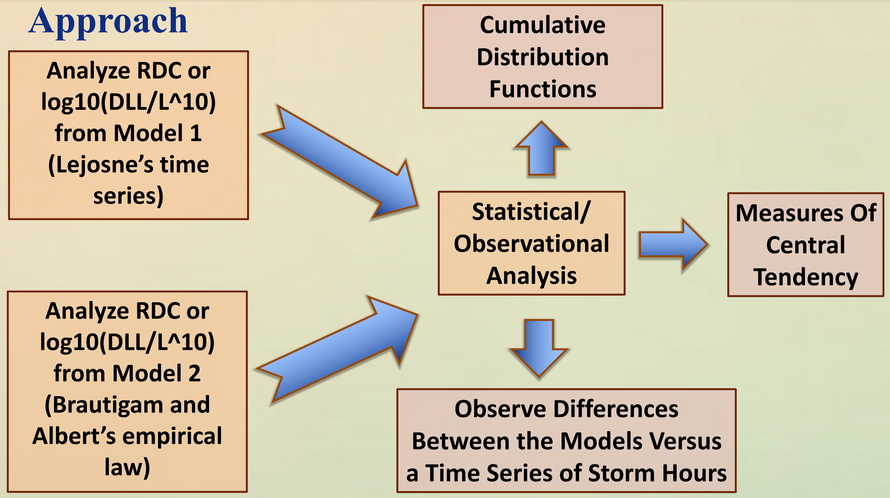
Abstract

This study tries to quantify the differences and similarities within two models that quantify the radial diffusion coefficient (log10(DLL/L^10)) during geomagnetic storm times: Lejosne (2020) and Brautigam & Albert (2000) . The first model is a time series of electromagnetic radial diffusion coefficients over the years 1995–2019 (Lejosne) and the second is an established empirical law that has tried to quantify the RDC using Kp geomagnetic activity indices (Brautigam and Albert). We have primarily observed the behavior of electron fluxes within the solar wind data which we see as a variable that affects the RDC. Both models are similar in nature in that they are quantified using the Kp index which helps us reduce major variability within the two models when conducting analysis. We have, as of now, done analysis on 6 different geo-storms and are beginning to see that different storm phases and intensities of the storm could play a major role in quantifying the RDC. To conclusively say they do, we will have to do more analysis on different storms. By pinpointing the times of major differences between models, we can start to determine the geomagnetic conditions during which the radial diffusion framework needs to be reassessed the most.

Approach



Methods

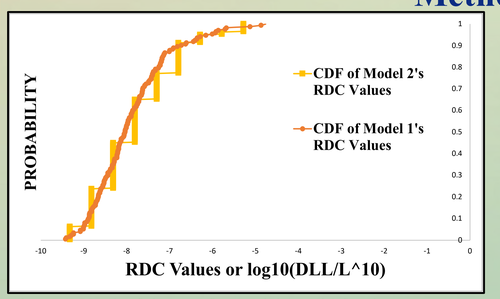


Figure 1 : CDF's of the RDC for Model 1 and 2 for the geomagnetic storm between 20150313 to 20150322

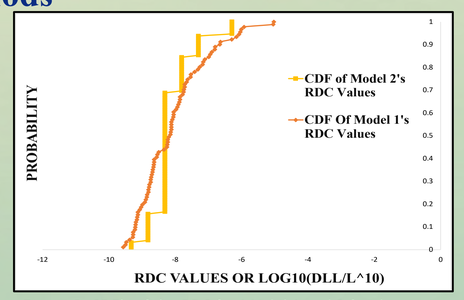


Figure 2: CDF's of the RDC for Model 1 and 2 for the geomagnetic storm between 20150622 to 20150629

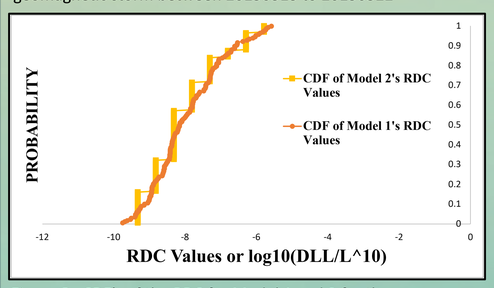


Figure 3 : CDF's of the RDC for Model 1 and 2 for the geomagnetic storm between 20151217 to 20151223

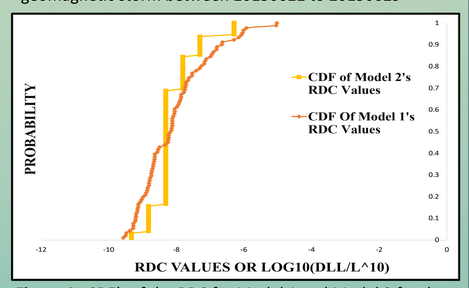


Figure 4 : CDF's of the RDC for Model 1 and Model 2 for the geomagnetic storm between 20150107 to 20150110

Analysis

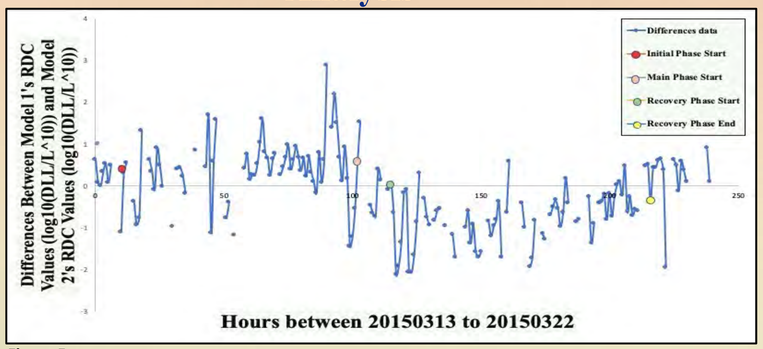


Figure 5

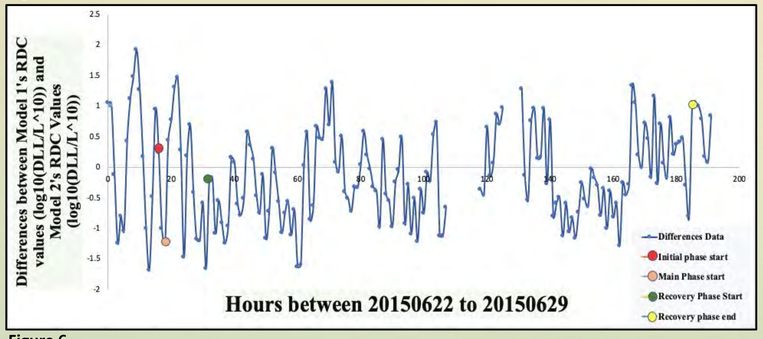


Figure 6

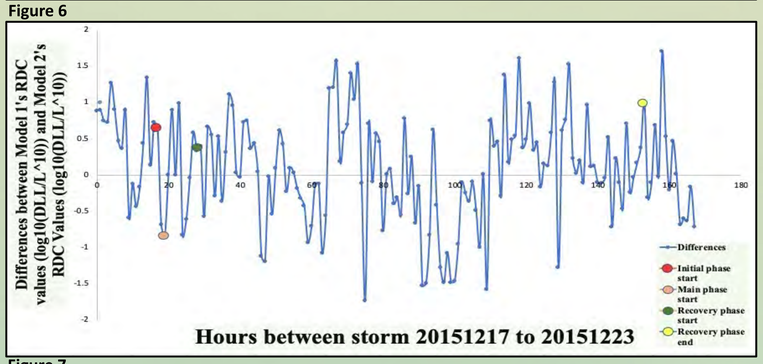


Figure 7

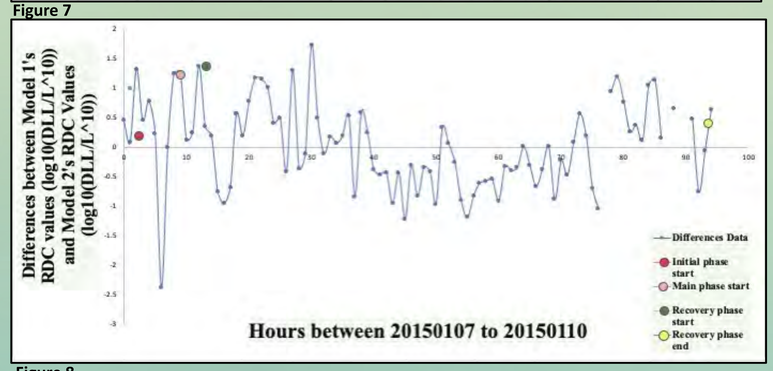


Figure 8

Figures 5-8 above represent the differences between the RDC Values of Model 1(Lejosne) and Model 2 (Brautigam and Albert) versus a time series of a geomagnetic storms with four different phases of the storm labeled within the graph.

Conclusions

- Measures of Central Tendency
  - The Standard Deviation for the differences between the models for each storm seemed to be relatively small and less spread out indicating that there are potential similarities between both models quantification of the RDC. To be able to statistically verify this we ran a Coefficient of Variation test for each storms RDC differences between the models.

$$CV = \frac{\sigma}{\mu}$$

  - The Coefficient of Variation for each storm was less than 1 which indicates that the differences were spread relatively close to the means. Observing how the mean for the differences data for each Storm was close to 0, (approximately to the hundredths and tenths place for each mean difference for each storm) we can assume that the Models RDC Values are statistically similar.
- Storm Phases Observations
  - Storm Phases characterize the time period of the storm and as observed might play a major role in understanding log10(DLL/L^10) values.
  - We observed that 5/6 storms mean minimum values wee observed in the Recovery Phase Start to Recovery Phase End.
  - 4/6 Storms have the mean minimum values occur during the Main Phase

Future Work

- Observe a lot more storms to see what similarities and differences we continue to see within the time series vs differences graphs.
  - Continue to observe the similarities between the phases of the storms and where we see a mean max difference and a mean minimum difference.
- Continue to do statistical tests on data for both Model 1, Model 2 and their respective differences
  - T test- A test that can help us measure if the differences between two groups is statistically significant or o=if it happened by chance

References

[1]Lejosne, S. (2020). Electromagnetic radial diffusion in the Earth's radiation belts as determined by the solar wind immediate time history and a toy model for the electromagnetic fields. *Journal of Geophysical Research: Space Physics*, 125, e2020JA027893. https://doi.org/10.1029/2020JA027893

[2]Brautigam, D. H., and Albert, J. M. (2000), Radial diffusion analysis of outer radiation belt electrons during the October 9, 1990, magnetic storm, J. Geophys. Res., 105(A1), 291–309, doi:10.1029/1999JA900344.

[3]NASA/GSFC's Space Physics Data Facility's OMNIWeb (https://omniweb.gsfc.nasa.gov/)

[4](https://doi.org/10.5281/zenodo.3731708)

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