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Comment on acp-2021-737

Anonymous Referee #1

Referee comment on "Exceptional middle latitude electron precipitation detected by balloon observations: implications for atmospheric composition" by Irina Mironova et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-737-RC1, 2021

Review of "Exceptional middle latitude electron precipitation detected by balloon observations: implications for atmospheric composition" by Mironova, Sinnhuber, Bazilevskaya, Clilverd, Funke, Makhmutov, Rozanov, Santee and Sukhodolov

The electron precipitation event is quite intriguing and should be published. However contrary to what has been stated in the paper, the interplanetary and geomagnetic conditions are quite ordinary and are not an obvious cause. I will comment in more detail about that. I would say that the event is more of a mystery than one that can be explained. I think the authors will agree with this point of view?

Main Comments

Please provide a blow up of the solar wind parameters and the geomagnetic activity before and after your event. A better geomagnetic index now commonly used is the SME index. It involves many more ground stations and is a better index than AE. The SYM-H index is essentially a one minute average of Dst and therefore with better time resolution is superior to Dst. I recommend that you use this index as well.

I have made such a plot to see what was going on in interplanetary space and on the ground for your event. I agree that I have found nothing exceptional for your exceptional electron precipitation event. A ~200 nT substorm is very common and is a weak event. If you look at JGR, 95, A3, 2241-2252, 1990 in their Figure 2, 200 nT is quite weak in comparison to a general distribution. If you look at a distribution of SME values you will find the same results. The same goes for the interplanetary Bz component. A value of ~-5 nT is quite common. Look at the above paper's Figure 1.

Your comment that there is not a magnetic storm is correct. But I take exception to your ascribing your event to a 200 nT substorm. I think this should be toned down since the substorm is so weak.

Abstract, line 5. "This event was likely caused…". Perhaps "possibly" rather than "likely"? Soften things a bit. I will later point out that this is a double substorm event. This may possibly be the cause?

The readership should know that your event is one of precipitation of relativistic electrons that are already trapped in the magnetosphere and were accelerated by other mechanisms. The precipitation event does not have anything to do with the acceleration of the electrons to such high energies. This is not clear in the present version of the text. Please correct the text so that the readership will not be misled. Acceleration mechanisms are described in Nature, 437, 227, doi:10.1038/nature03939; JGR, 115, A00F01, 2010. doi:10.1029/2010JA015870; ApJ, 799:39, 2015, doi:10.1088/0004-637X/799/1/39. You may wish to add a short discussion of this for the readership?

Minor Comments

Line 17. A good reference to add here is JGRSP, 121, 2016. doi:10.1002/2016JA022499.

Line 117. "AE index larger than 200 nT". In my plot I find two substorms, one with an SME of ~500 nT and a second with ~400 nT. It would be best if you quote exact numbers. And of course show the plot in high resolution.

Same line. A Dst of -12 nT is not thought of as a magnetic storm. I suggest that you state this here. A good reference for this is JGR, 99, A4, 5771-5792, 1994. They quote a Dst level which they consider a threshold for a magnetic storm. Most space weather people use this value.

Lines 120-122. I suggest that you reword this. I see two dips in the IMF Bz. These cause the two substorms as mentioned above. You should refer to this when you show your blow up of the solar wind parameters and geomagnetic activity. It is possible that the TWO substorms may have caused your unusual event. Concerning a good reference for IMF bz and substorms, see JGR, 77, 16, 2964-2970, 1972. The event in Figure 3 has some similarities to your event.

Lines 245-6. New results show that plasmaspheric hiss is most intense near the slot region, not near the plasmapause boundary. The new results show that plasmaspheric hiss is quasi-coherent leading to orders of magnitude faster pitch angle scattering. This paper hypothesizes that the slot is formed much faster than previously believed. See JGRSP, 124, 10063-10084. 2019. https://doi.org/10.1029/2019JA027102 and references therein.

Lines 263-264. It might be possible that it is not substorm intensity that led to your event, but the double substorm. For example here is a scenario. The first southward IMF Bz led to the first substorm through magnetic reconnection (reference Phys. Rev. Lett, 6, 2, 47-48, 1961). This led to the injection of ~10-100 keV electrons in the midnight sector (reference JGR 76, 16, 3587-3611, 1971). The electrons gradient drift to the noon sector (taking ~ 1 hr see JGR82, 32, 5112-5128, 1977) and there create electromagnetic outer zone chorus through the temperature anisotropy instability (reference JGR, 71, 1, 1-28, 1966). The chorus propagates into the plasmasphere (reference Nature, 452, 2008. Doi:10.1038/nature06741). Now a second southward IMF creates a second substorm and the injected 10 to 100 keV electrons drift from the midnight sector to the noon sector. When these electrons get there they enhance the preexisting hiss in the slot region leading to the parasitic loss of relativistic electrons.