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Interactive comment on "From the Sun to the Earth: August 25, 2018 geomagnetic storm effects" *by* Mirko Piersanti et al.

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We thank the Reviewer who appears to agree with the significance of our results and comments our work as suitable for publication after minor revisions. In the revised version all her/his suggestions have been considered, namely: General comments

1. The paper can be signiïňĄcantly improved if the authors look more carefully into the driver effects. For example, the authors mention the CME observed on 20 August was a very slow, and consequently weak, CME. Therefore, this kind of CME would drive a very weak IP shock in its leading edge, if any, while traveling in the heliosphere. However, given the IMF and solar wind data detected atâĹijL1 presented by the authors in Figure 2, I can't tell there is a fast forward interplanetary shock there. There is no

clear positive jumps in solar wind parameters (T, Np, V) and IMF (B). A positive sudden impulse is clearly and usually seen in ground magnetometer data in response to an IP shock impact. However, I could not see a clear SI event when I plotted SYM-H here on my side, neither can I see a clear SI signature in SYM-H data shown in the left column of ïňĄgure 9. Please clarify this: where is the shock around L1? If there is one, does it clearly satisfy the Rankine-Hugoniot conditions? This is very important because this would impact your discussion of inward magnetopause motion (from 10 to 7 Re, approximately). As it is I think it was because of magnetopause erosion caused by the gradual depletion of IMF Bz, which is not shown in the manuscript. We thank the reviewer for his/her useful comments and we completely agree you. There is no clear evidence of an IP shock preceding the magnetic cloud, despite the presence of a positive SI at midlatitude ground stations. This is probably due to the impact of the front boundary of the magnetic cloud coupled with a southward switching of the Bz,IMF. Thus, we change accordingly the discussion about GOES and L1 satellite data.

2. Now, still looking at Figure 2, there is something I think ins't clear: What do the edges of the light red highlighted area indicate? The IP shock onset or the front boundary of the magnetic cloud? As a matter of fact, according to the CME list provided by Ian Richardson (http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm#(a)), the CME of 25 August 2018 detected at L1 did not have a magnetic cloud associated with it. Can you clearly say why your CME had a magnetic cloud, even though it was a weak CME and most likely did not drive a shock in its front edge at 1 AU? The red area of Figure 2 indicates the front boundary of the magnetic cloud. In our opinion the CME of August 25, 2018 has a magnetic cloud. In fact, following Burlaga et al. (1981), we clearly found at L1 point a region of enhanced magnetic field strength, smooth rotation of the magnetic field vector, and low proton temperature. Since the ICME under analysis was very slow and weak, it is not characterized by its typical structure (i.e. a fast-mode shock wave followed by a dense (and hot) sheath of plasma (the downstream region of the shock) and a magnetic cloud), but it contains only the magnetic cloud. In addition,

as stated by Lepping, R. P. et al. (1990) “a magnetic cloud presents a typical speed of 450 km/s and magnetic field strength of 20 nT”, which are consistent with our satellites observations.

3. According to Figure 2 and Figure 3, there was a CIR/HSS right after the CME. If the geomagnetic storm of 25-26 August 2018 occurred as a result of the impacts of a CME and a CIR back-to-back, why possible effects of these combined rivers are not discussed in the text? By looking at the SYM-H plot (Figure 9), one can speculate that the magnetosphere was starting to recover from the CME when the CIR arrived. Does this have any impacts on the subsequent geomagnetic activity? Do you think SYM-H effects were ampliïňĄed with the CIR arrival? This might explain why the GIC effects in 2018 storm were stronger than the effects in the 2015 storm. However, it is very common to see a clear SI signature preceding a strong geomagnetic storm, which did not occur on 25 August 2018. In other words, does the CIR play any roles in increasing the storm effects discussed in the manuscript? Thank you very much for your observations. Looking at the “quicklook” of temporal trend of the AE indices (wdc.kugi.kyoto-u.ac.jp/aedir/), we have noticed that during the recovery phase, the AL index is characterized by strong decreases caused by sudden variations of the Bz,IMF carried by the CIR (“back-to-back” to the ICME), which correspond to an increase of the westward auroral electrojet current. Such effect is clearly visible in the decrease of the magnetic field recorded on the ground (Figure 9 of the manuscript) in the down side. We discussed this point in the manuscript. Anyway, in our opinion, this effect cannot be visible in the GIC plot, because it was evaluated at the time corresponding to the minimum Sym-H value, when the CIR have not yet impact onto the magnetosphere.

SpeciïňĄc comments

1. Line 12. Please explicitly state that this is the 2015 St. Patrick’s Day storm. Done

2. Lines 17-18. The way this sentence is written, one can wrongly understand that geomagnetic storms are only caused by CMEs. Please re-write this sentence to eliminate

this inaccurate statement. Done

3. Line 18: The reference Piersanti et al. (2017b) doesn’t appear in the reference list. I didn’t check all references; please do so. Checked

4. Line 27. Change "the Sun" to "solar". Done

5. Lines 27-28. Sun energy directly deposited in the polar ionosphere. Do you mean EUV radiation? If so, EUV radiation is directly deposited by the Sun in all dayside latitudes. I think what you mean is that solar radiation increases dayside conductivity which in turn facilitates the ïňĆow of electric current in the ionosphere? Please clarify this. It looks awkward to read. We agree with the reviewer on the importance of EUV radiation in increasing the conductivity of the ionosphere, but we wanted to describe a differenent process due to plasma and not to radiation. For this reason we modified the sentence and clarified this point.

6. Line 37. Hapgood (2019) discusses GIC effects of the May 1921 superstorm that were associated with ïňĄres in New York City. Therefore, space weather related effects can be dangerous to human life. If the authors are interested, here is the reference: Hapgood, M. (2019), The Great Storm of May 1921: An Exemplar of a Dangerous Space Weather Event, Space Weather, 17(7), 950–975, doi:10.1029/2019SW002195. Reference added

7. Line 41. Please state what deïňĄnes a G3 geomagnetic storm. We added the definition of a G3 storm using the Kp-index.

8. Line 63. Please give a number for the reader to have an idea of how fast a slow CME goes. We added a sentence clarifying this point.

9. Line 89. Add "dynamic" before "pressure". Done

10. Line 114. Change "overtook" to "overtaken". Same in line 360. Done

11. Figure 3. It is hard to see Venus as represented by the green triangle. The colour

of the fast solar wind stream has been changed to grey to solve both problems and increase the readability of the image.

12. Line 126. "Possibly" reads better than ""probably. Done

13. Line 156. Should "IP2" be "IPS"? Yes, we change it

14. Line 215. Please explicitly state of loss of lock on GPS satellites means. Add a reference if appropriate.

According to the remark made by the reviewer the following text has been added in the Introduction: “To characterize ionospheric irregularities and fluctuations, we used the Rate Of change of electron Density Index (RODI; specifications about the calculation of this index can be found in the Appendix A) estimated from the electron density measured by CSES. To understand how the presence of such irregularities could have affected navigational systems, we have also considered total electron content (TEC) values from Swarm to highlight possible loss of lock, condition under which a Global Positioning System (GPS) receiver no longer tracks the signal sent by the satellite with a consequent degradation of the positioning accuracy (Jin and Oksavik, 2018; Xiong et al., 2018).”

Jin, Y. and K. Oksavik, (2018), GPS scintillations and losses of signal lock at high latitudes during the 2015 St. Patrick’s Day storm, J. 565 Geophys. Res., 123, https://doi.org/10.1029/2018JA025933. Xiong C., C. Stolle, and J. Park, (2018), Climatology of GPS signal loss observed by Swarm satellites, Annales Geophysicae 36, 679, https://doi.org/10.5194/angeo-36-679-2018.

15. Line 219. Please state that storm intensity is represented by Dst/SYM-H data. We agree with the reviewer. We added the Dst minimum value of the 2015 Saint Patrick Storm.

16. Line 246: Remove a "the" (end of line). Done

17. Line 254. The traditional reference for the SYM-H index is Iyemori (1990),

Iyemori, T. (1990), Storm-time magnetospheric currents inferred from mid–latitude geomagneticïňĄeldvariations,JournalofGeomagnetismandGeoelectricity,42(11),1249–1265, doi:10.5636/jgg.42.1249. We agree with the reviewer. We added the reference about Sym-H.

18. Line260. Do you mean you are removing the background magnetic ïňĄeld computed by the IGRF model? Please clarify. We agree with the reviewer. We added a sentence about the baseline removal process we used for our analysis. Namely, for each ground station, we used the CHAOS-6 model to remove both the internal and crustal origin field from the magnetic data. So, we are confident that the residual magnetic field is of external origin (ionosphere + magnetosphere).

19. Line 274. "on August" should be "On August". Done

20. Line 297. "on turn" should be "in turn". Done

21. Line 312. Please include a table with the stations’ names and abbreviations and refer to it instead of referring to the IAGA website. According to Referee’s suggestion we have prepared a table (Table 1 in the revised version of the manuscript) with the names and IAGA codes of the observatories of the two latitudinal chains. The table also provides their geomagnetic latitudes, longitudes and the difference in hour from the MLT of the 0° geomagnetic meridian at 0 UT.

22. Line 346. Change "has been" too "was". No continuity here. Done

23. Line 413. Change "leaded" to "led". Done

24. Line 431. Change "comprehending" to "understanding". Done

25. My apologies, but I read in a few places mentions to "polar electrojets". Do you mean auroral electrojets? Usually, these electric currents have their effects expressed by the AU, AL, and AE indices. If so, please clarify and change it accordingly. Additionally, it would be interesting to plot these indices in another column in Figure 9. We have changed “polar electrojets” in “auroral electrojects”. Of course, it would be very

interesting to visualized the temporal trend of auroral electroject indices during the selected period. The problem is that, at the moment, these indices are not available for our period. Provisional data are available until March 2018.

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