

MHD-test particles simulations of moderate CME and CIR-driven geomagnetic storms at solar minimum

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Introduction

Figure S1 shows expanded time intervals from Figure 1 for the 13-14 May 2021 CME-shock driven storm and the Aug-Sept 2021 CIR-driven storm. **Figure S2** shows the Van Allen Probes orbits during the two events studied up to the time indicated by red and blue dots for Probes A and B, respectively. The orbital period is 9 hours. **Figure S3** shows contributions of simulated trapped and injected PSD to the total PSD shown in Figure 5. **Figure S4** shows the contributions of the simulated trapped and injected PSD to the total PSD shown in Figure 6. **Figure S5** shows total PSD at 5000 MeV/G for both events studied. **Table S1** lists the Aug -Sept event substorms.

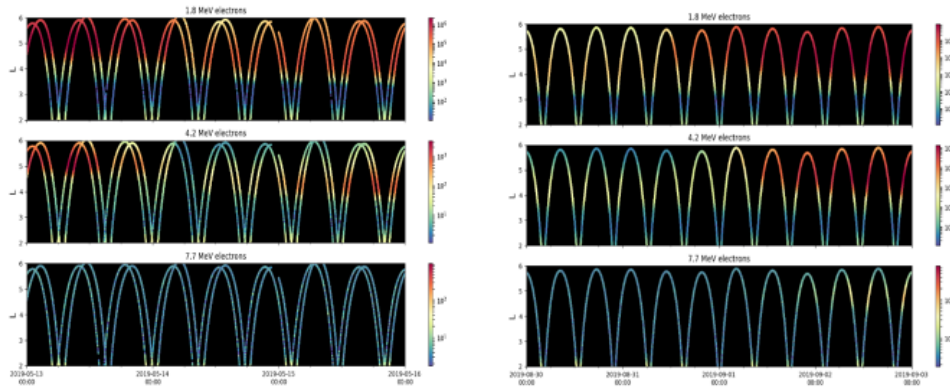
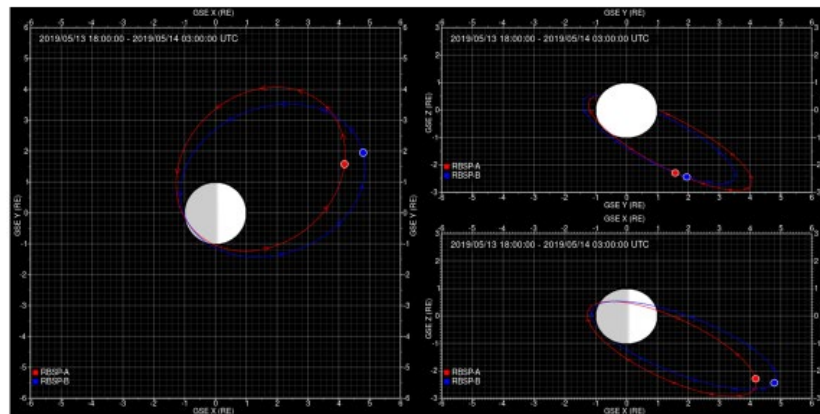


Figure S1. a) Expansion of the time interval 00 UT 13 May to 00 16 May in Figure 1, which shows a strong decrease in flux between the first outbound and inbound orbits on 14 May, and recovery beginning on the next outbound orbit. The recovery continues through the end of the GAMERA simulation at 00 UT 16 May with evidence for steady inward transport characteristic of radial diffusion (Jaynes et al. 2018). b) Same as a) for 30 Aug – 03 Sept. Note the absence of flux dropout initially for this CIR event as compared with the CME-shock event in Figure S1.

VAP Orbit 14 May 2017 Ending 3 UT



VAP Orbit 30 Aug 2019 Ending 1800 UT

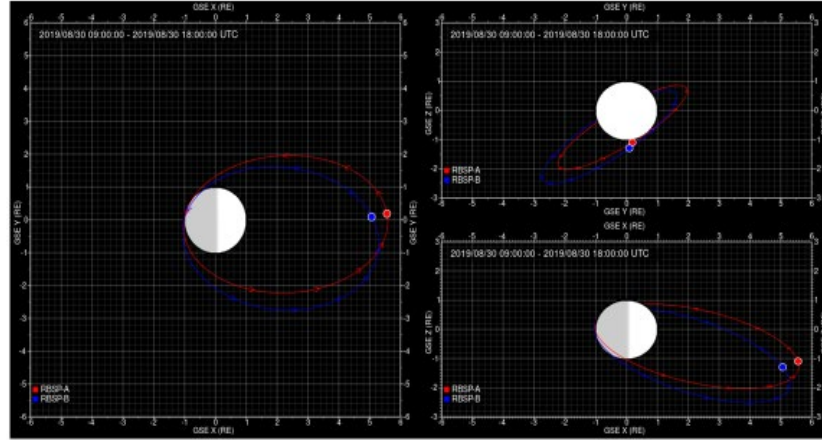


Figure S2. Van Allen Probes orbits for a) 13-14 May CME-shock event and b) Aug – Sept CIR event. Apogee is closer to noon for the second event. The left panel shows the GSM x-y plane, upper right shows y-z plane and lower right shows x-z plane.

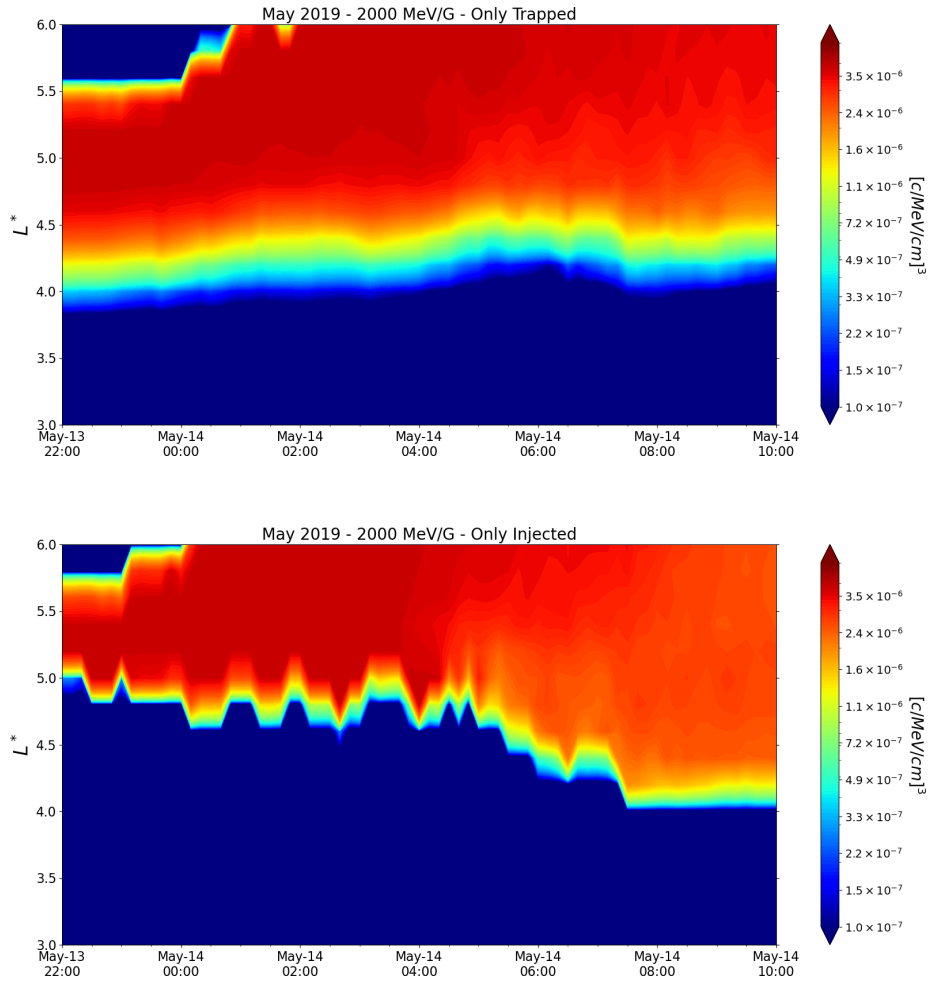


Figure S3. a) Initially trapped and b) injected PSD populations plotted separately which combine to produce total PSD plotted in Fig. 5 for 13 - 14 May CME-shock driven storm. The injected population makes a larger contribution at lower L values than the initial trapped population by the end of the simulation. The blue patch of low PSD in the upper left corner is due to mapping from L to L* since test particles are initialized inside L = 6 Re, see Figure 3b, which is inside L* = 6 Re using the TS04D magnetic field model for mapping. The ~ 9 hour orbital period with both spacecraft in close proximity at apogee (Figure A2) accounts for the step changes evident at the inner boundary of the injected population which is no longer visible by 08:00 UT when Dst reaches its minimum value of – 65 nT and the injected flux reaches its minimum L* value.

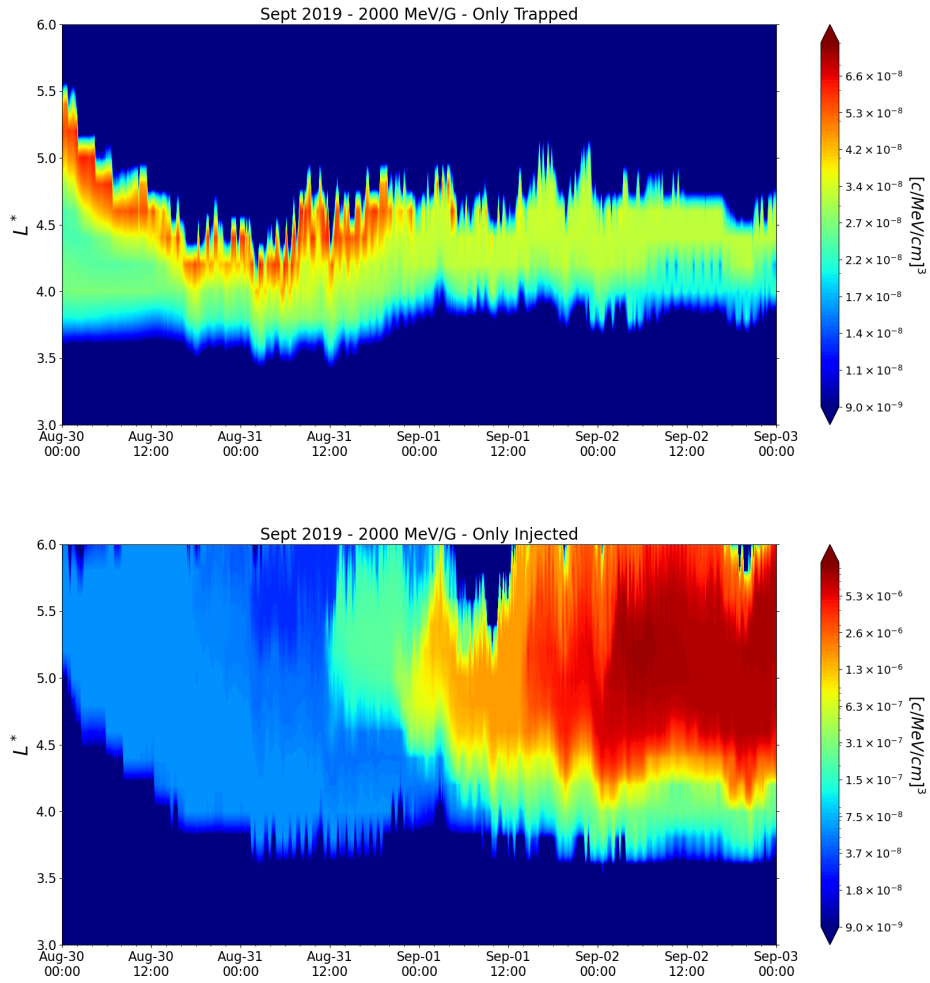


Figure S4. a) Initially trapped and b) injected populations plotted separately which combine to produce total PSD plotted in Fig. 6 for Aug – Sept CIR driven storm. Injected electrons dominate the initial trapped population (note different color scale used) which has PSD two orders of magnitude lower than initial value for the 13 – 14 May CME-shock driven storm, see comparison in Figure 4.

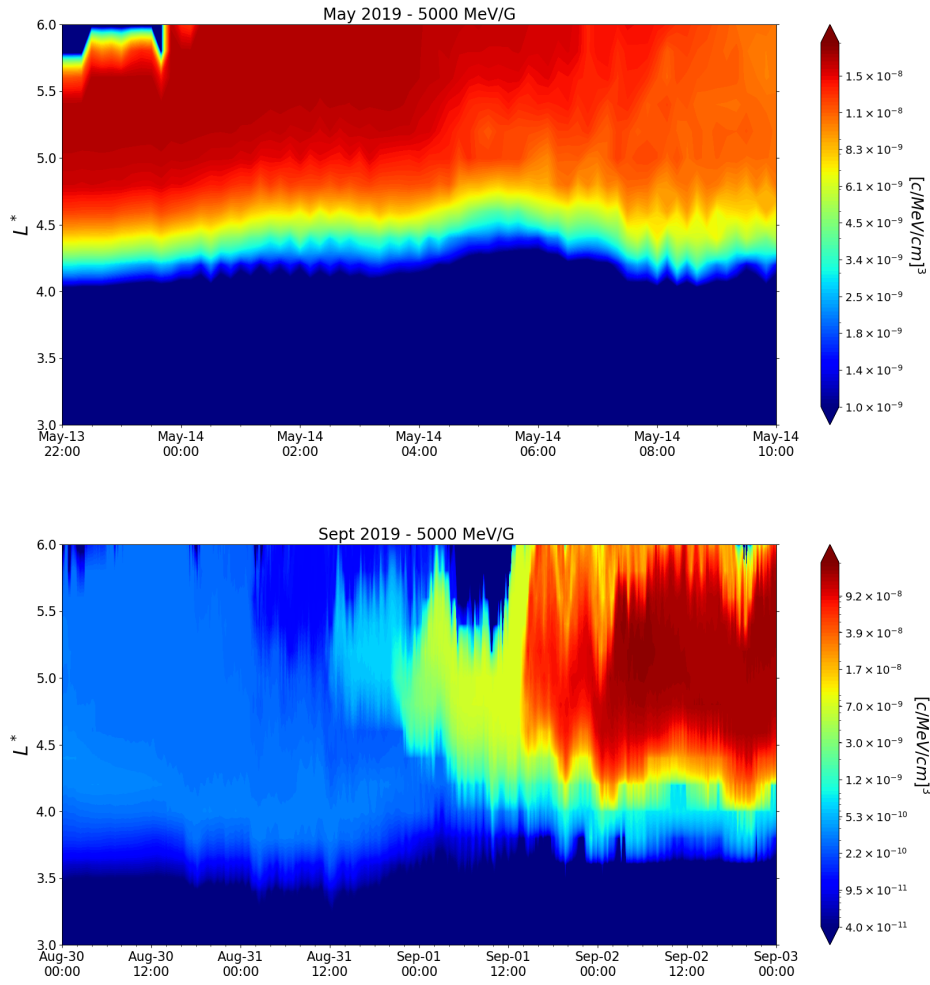


Figure S5. Total PSD (injected plus trapped) at 5000 MeV/G for a) 13 – 14 May CME-shock event and b) Aug-Sept CIR event. Note PSD enhancement for Sept event over days (vs. loss for CME shock event over hours).

Data Revision:0005

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| 2019 | 08 | 30 | 12 | 35 |
| 2019 | 08 | 30 | 16 | 08 |
| 2019 | 08 | 30 | 21 | 52 |
| 2019 | 08 | 31 | 09 | 00 |
| 2019 | 09 | 01 | 17 | 09 |
| 2019 | 09 | 02 | 08 | 32 |
| 2019 | 09 | 02 | 11 | 48 |
| 2019 | 09 | 02 | 16 | 47 |
| 2019 | 09 | 03 | 01 | 52 |
| 2019 | 09 | 03 | 05 | 13 |
| 2019 | 09 | 03 | 12 | 13 |