AGU Advance

Supporting Information for

Ionospheric Dawnside Subauroral Polarization Streams: A Unique Feature of Major Geomagnetic Storms

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Introduction

This supporting information provides additional figures of dawnside and duskside SAPS observed by DMSP (Figures S1-S5), simulated by MAGE (Figures S6-S7), comparison of electric and magnetic drifts (Figure S8), energetic proton fluxes measured by the LANL satellites at the geosynchronous orbit (Figure S9), controlled MAGE simulation experiments with ten times reduced IMF (Figure S10) and zero IMF B_Y (Figure S11), and animations showing the test particle convection-drift in the magnetosphere obtained with the CHIMP test particle simulations.

Figure S1. Dawnside and duskside SAPS observed by DMSP F13 from 14:02 UT to 14:32 UT. The format is similar to that in Figure 2 of the main manuscript.

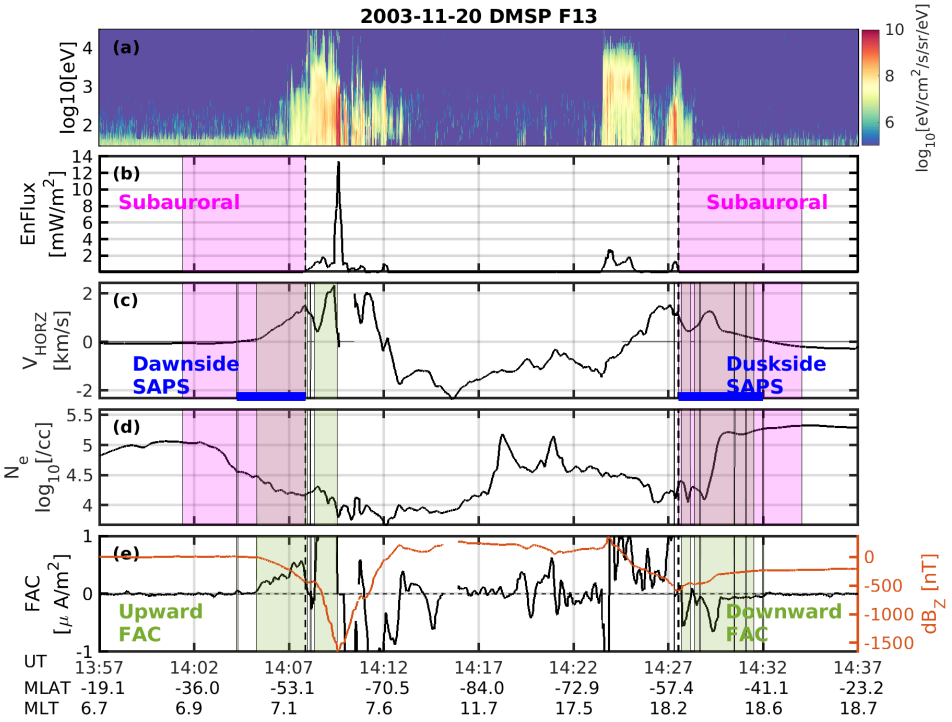


Figure S2. Dawnside and duskside SAPS observed by DMSP F14 from 14:09 UT to 14:49 UT. The format is similar to that in Figure 2 of the main manuscript.

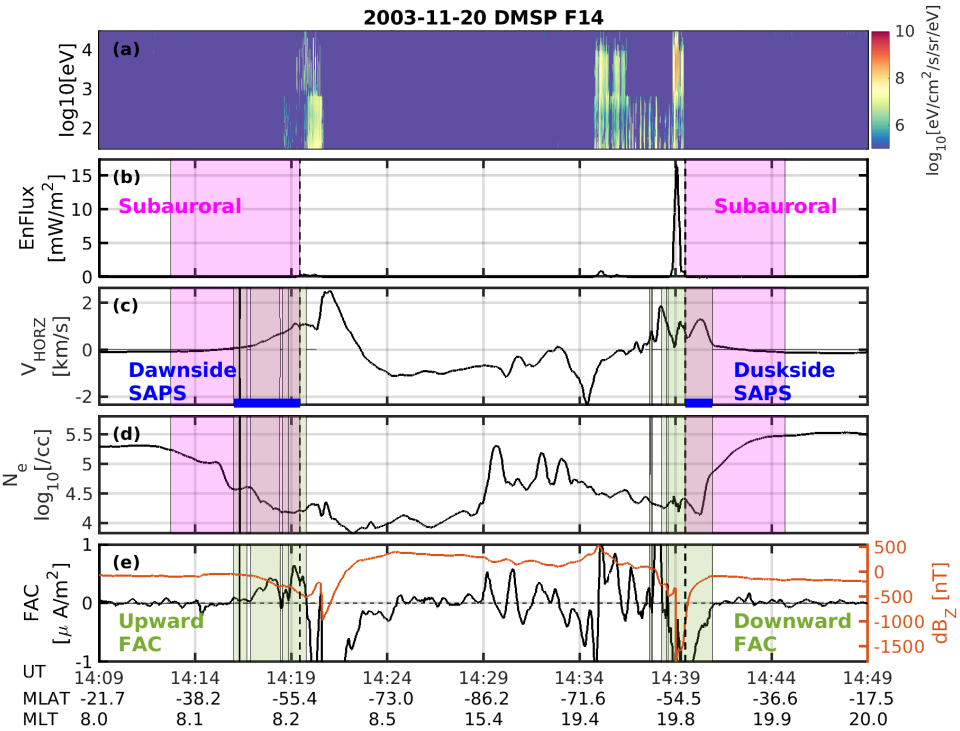


Figure S3. Duskside SAPS observed by DMSP F15 from 13:40 UT to 14:20 UT. No substantial dawnside SAPS are identified. It is probably because the auroral crossing point of 11 MLT was near the eastward end of the dawnside SAPS channel. The format is similar to that in Figure 2 of the main manuscript.

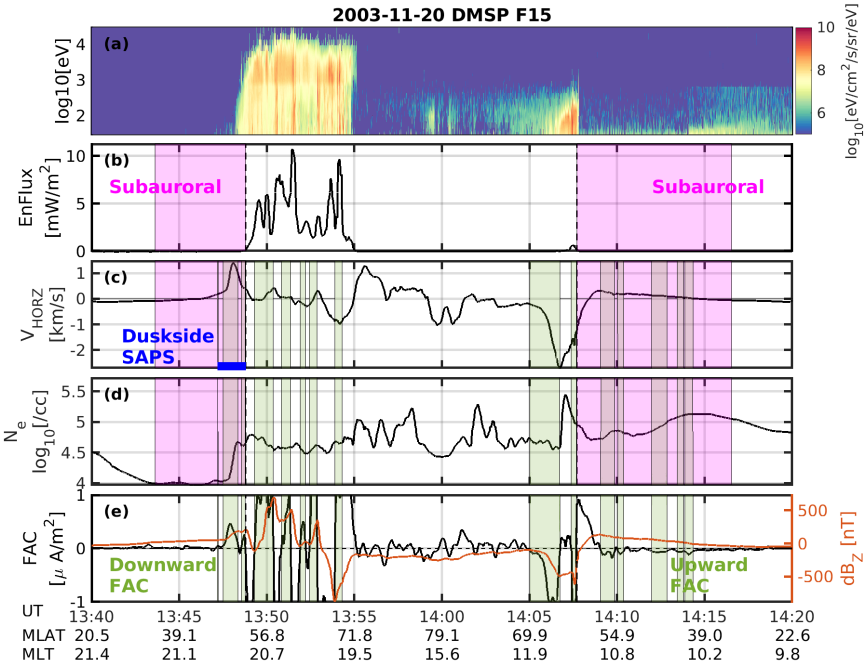


Figure S4. Duskside SAPS observed by DMSP F13 during 06:17-06:57 UT. This plot contains more detailed information than Figure 3a in the main manuscript, where only the horizontal ion drift and auroral and FAC boundaries are shown.

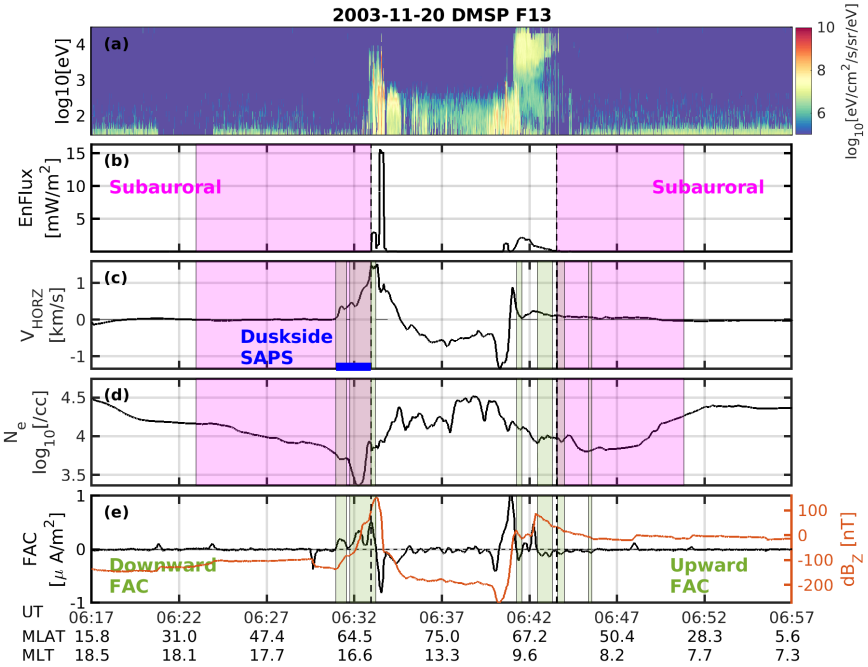


Figure S5. Duskside and dawnside SAPS observed by DMSP F13 during 18:10-18:50 UT. This plot contains more detailed information than Figure 3b in the main manuscript, where only the horizontal ion drift and auroral and FAC boundaries are shown.

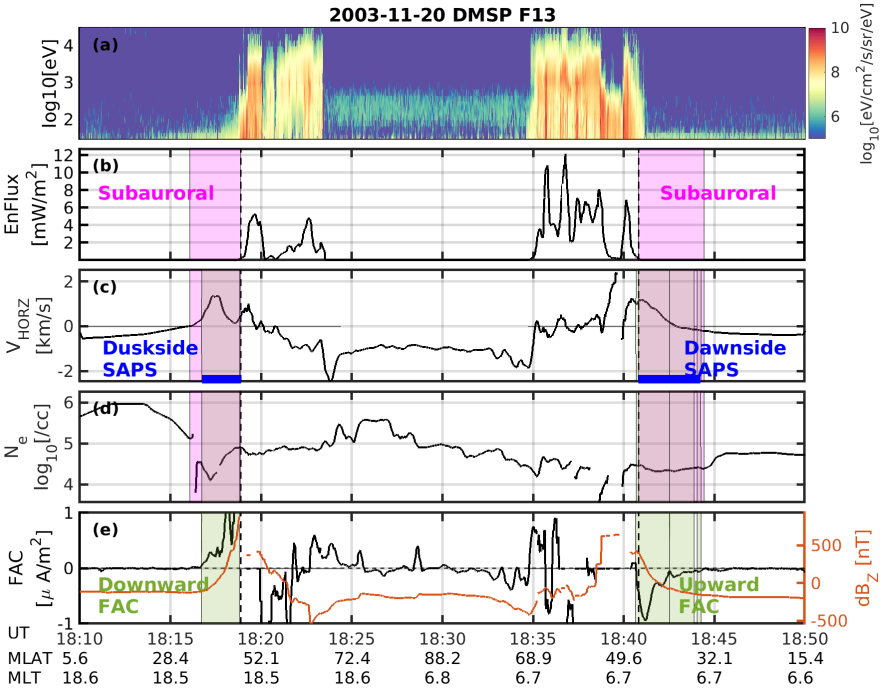


Figure S6. Duskside SAPS simulated by MAGE during 06:17-06:57 UT. This plot contains more detailed information than Figure 3c in the main manuscript, where only the horizontal ion drift and auroral and FAC boundaries are shown.

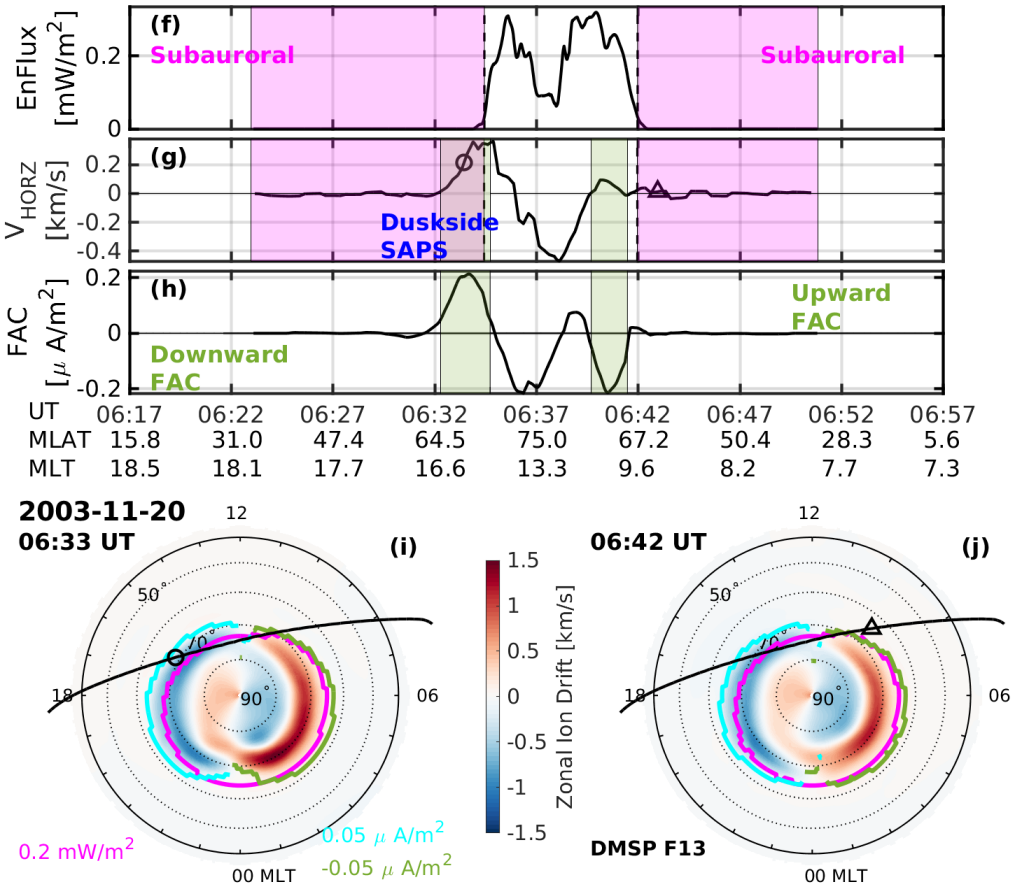


Figure S7. Duskside and dawnside SAPS simulated by MAGE during 18:10-18:50 UT. This plot contains more detailed information than Figure 3d in the main manuscript, where only the horizontal ion drift and auroral and FAC boundaries are shown.

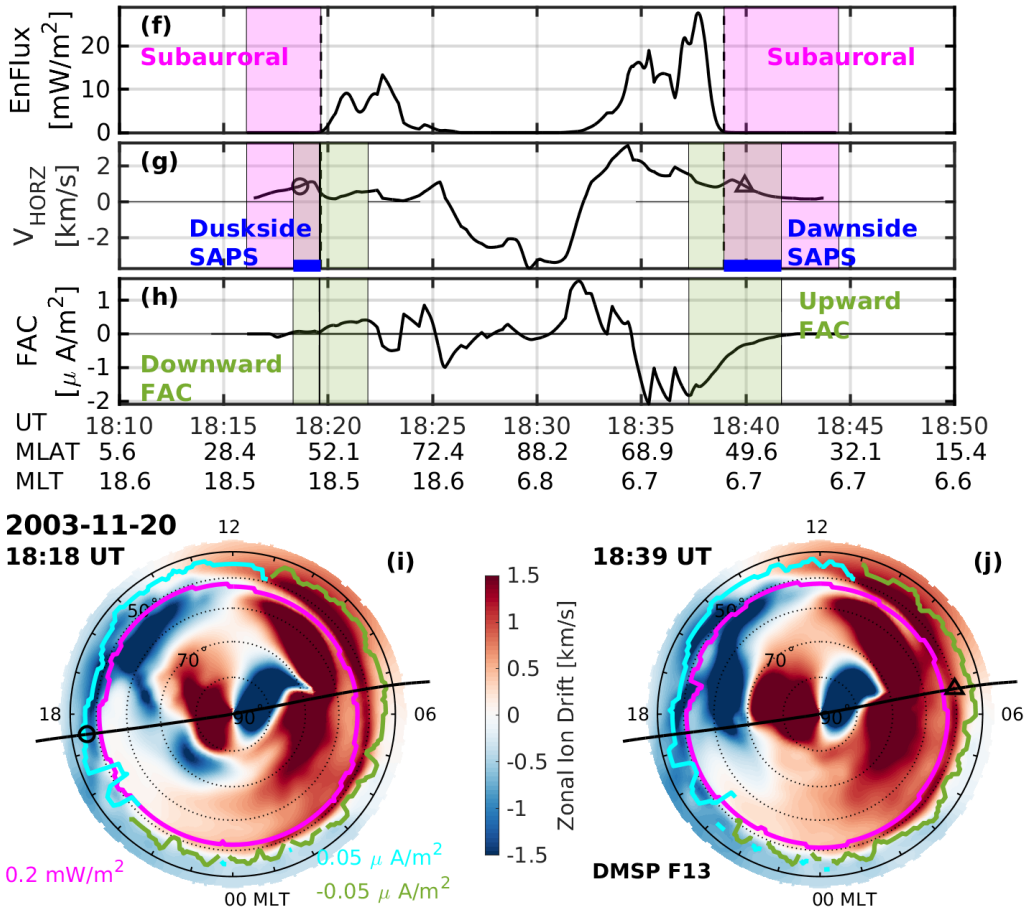
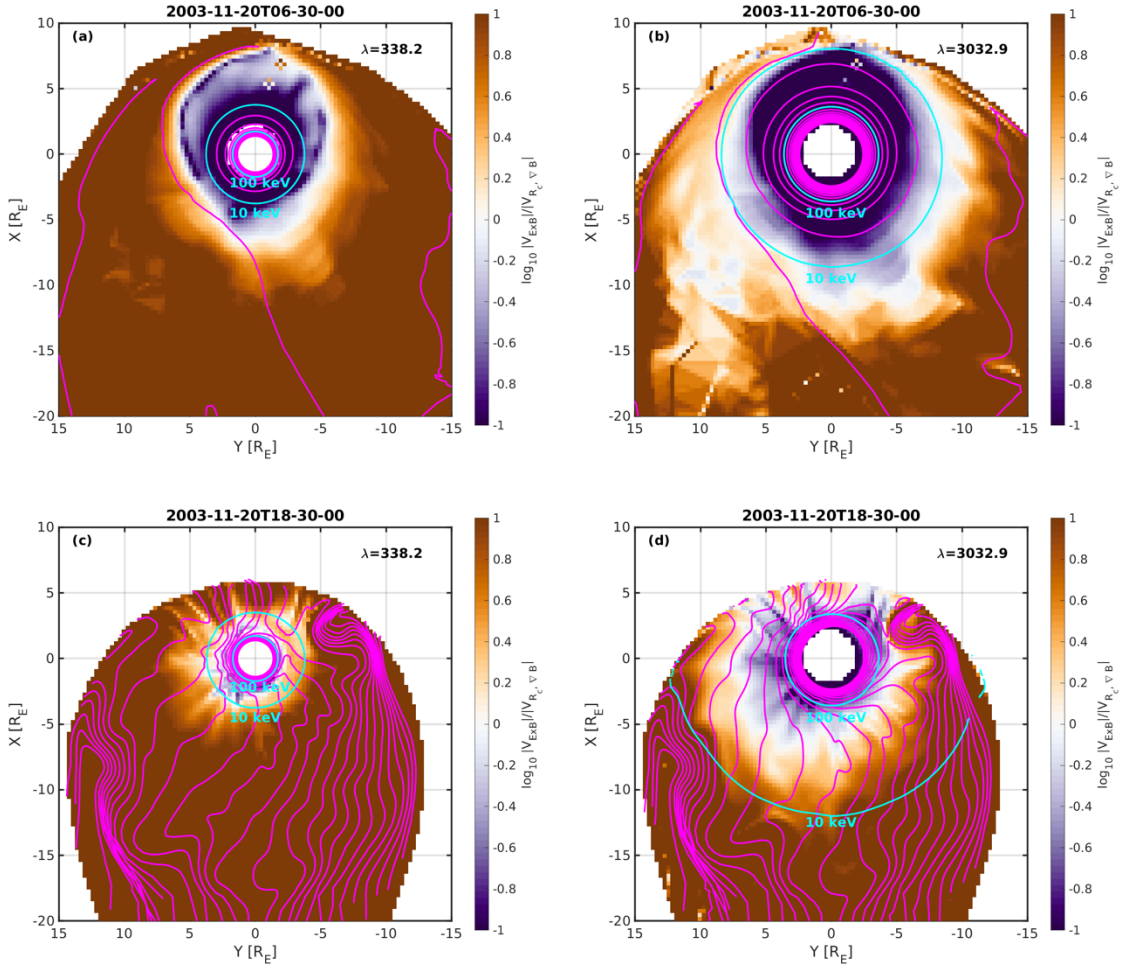


Figure S8. Ratio between electric and magnetic drifts for additional two energy invariants at 06:30 UT and 18:30 UT. Similar to the comparison shown in Figures 4c-4d based on lambda=1139.0, the ions with lambda=338.2 and lambda=3032.9 are also dominated by magnetic drifts at 06:30 UT and by electric drifts at 18:30 UT when they are energized to 10-100 keV during the adiabatic inward transport.



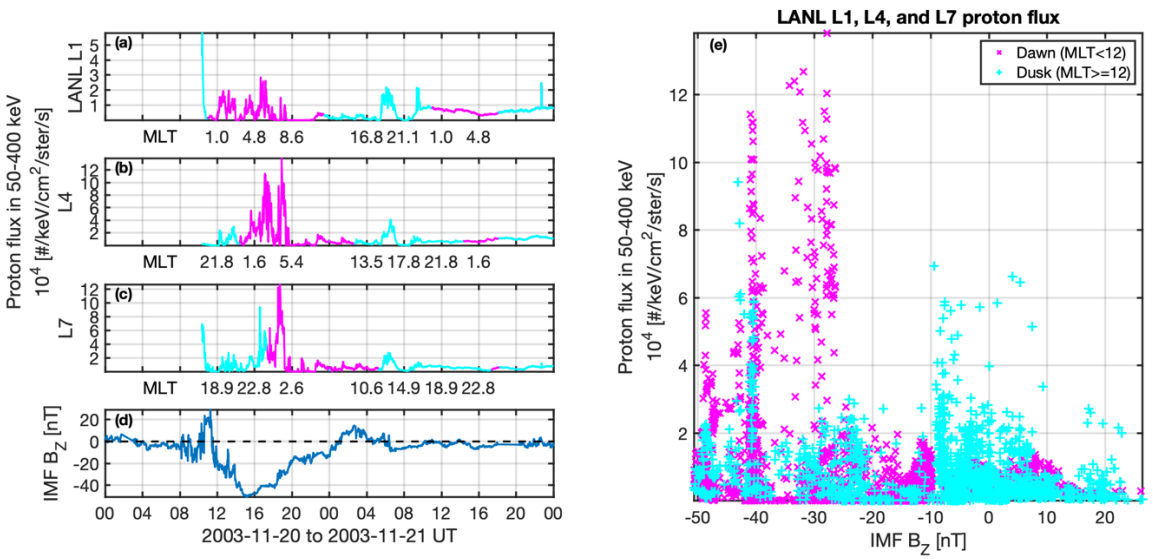


Figure S9. (a-c) Energetic proton fluxes in the energy range of 50-400 keV measured by the LANL L1, L4, and L7 satellites during 20-21 November 2003. The LANL satellites were in a geosynchronous orbit at different MLTs. The magenta curves indicate when each satellite was in the dawn sector, i.e., MLT<12. The cyan curves indicate when the satellites were in the dusk sector, i.e., MLT>=12. (d) IMF B_Z. (e) Energetic proton flux distribution with IMF B_Z when the satellites were in dawn (magenta crosses) and in the dusk (cyan pluses).

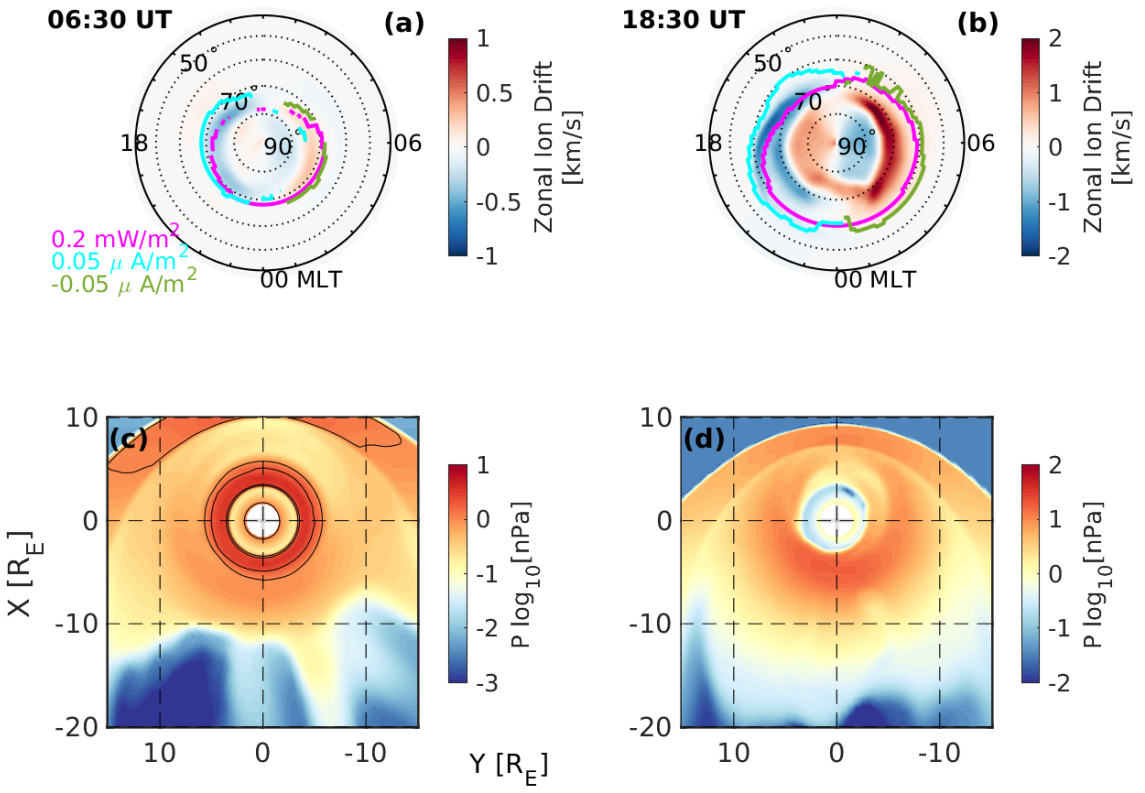


Figure S10. Controlled simulation results with ten times reduced IMF. (a-b) Zonal ion drifts in the northern hemisphere ionosphere with a similar format to Figures 3e-3f. (c-d) Plasma pressure in the magnetospheric equatorial plane with a similar format to Figures 3g-3h. Both before the storm commencement at 06:30 UT and during the main phase at 18:30 UT, duskside SAPS are formed in the gap between the equatorward boundary of electron precipitation (magenta curves around 18 MLT) and the equatorward boundary of downward Region-2 FACs (cyan curves around 18 MLT). But there are no obvious dawnside SAPS even during the main phase when the IMF is reduced by ten times. The sawtooth like upward FAC boundary in the prenoon sector at 18:30 UT in panel (b) is due to small scale FAC structures at ~50 deg MLAT.

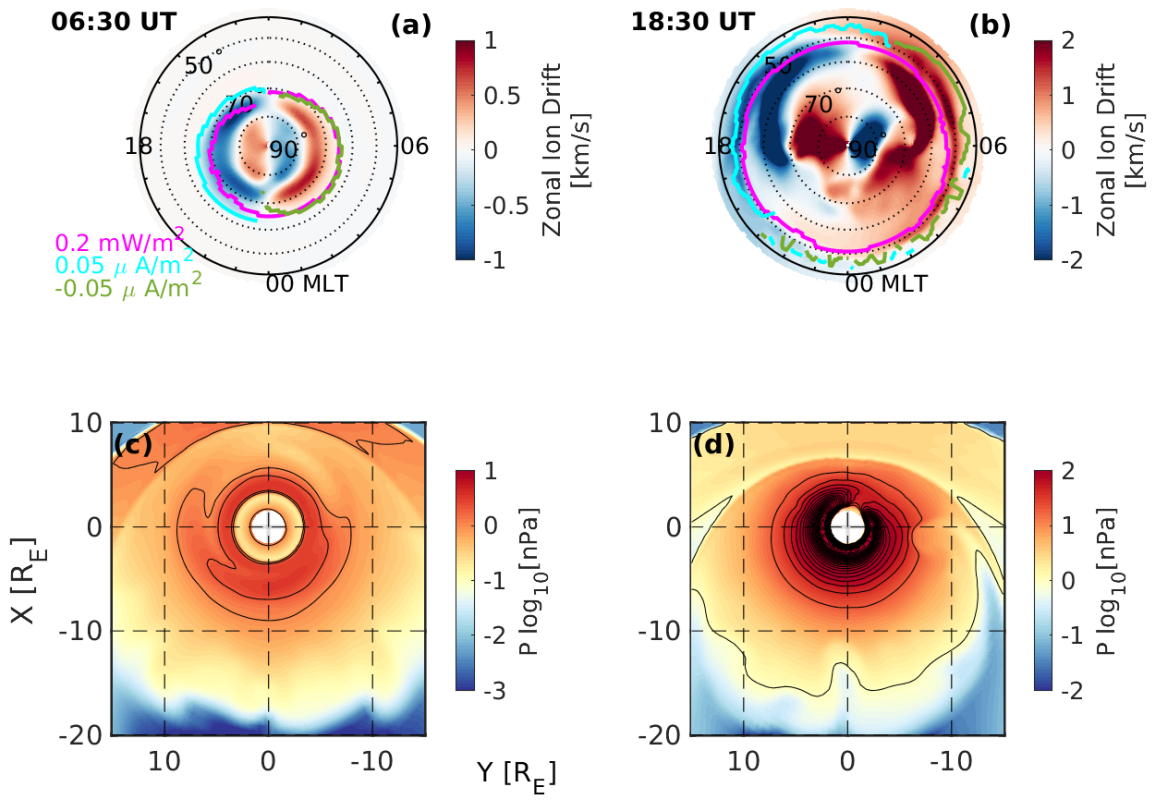
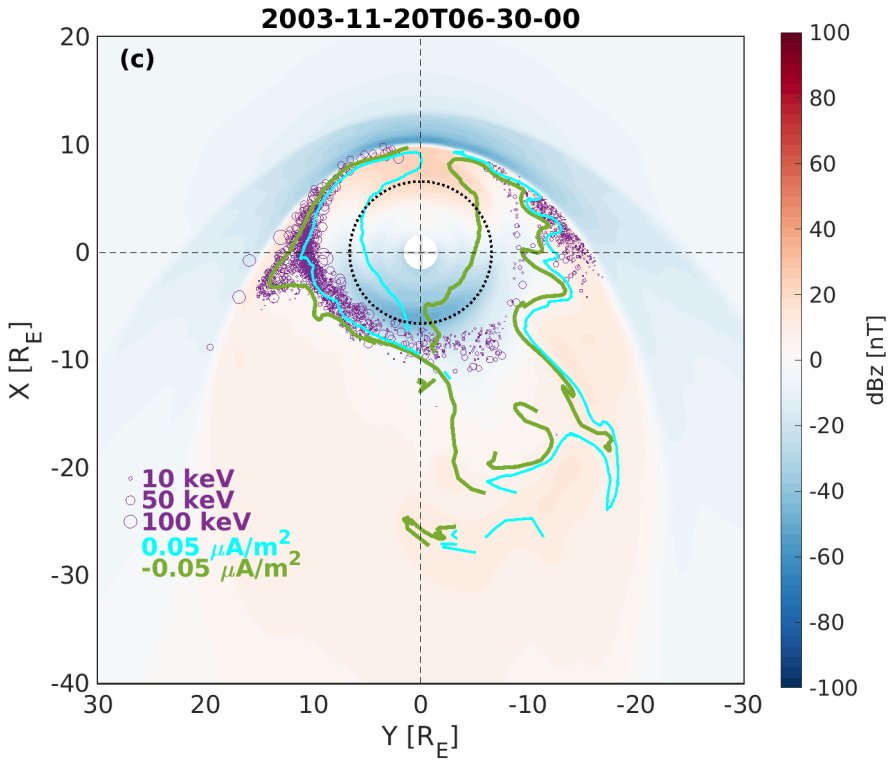


Figure S11. Controlled simulation results with IMF B_Y=0. (a-b) Zonal ion drifts in the northern hemisphere ionosphere with a similar format to Figures 3e-3f. (c-d) Plasma pressure in the magnetospheric equatorial plane with a similar format to Figures 3g-3h. Both before the storm commencement at 06:30 UT and during the main phase at 18:30 UT, duskside SAPS are formed in the gap between the equatorward boundary of electron precipitation (magenta curves around 18 MLT) and the equatorward boundary of downward Region-2 FACs (cyan curves around 18 MLT). Substantial dawnside SAPS are still formed during the main phase despite zero IMF B_Y.

Movie S1. A movie showing the evolution of test particles released from the nightside plasma sheet at 06 UT. The format is similar to that in Figure 4c and 4d in the main manuscript. The purple circles indicate the energy of the protons. The background is the residual magnetic field, i.e., Bz subtracted by the dipole magnetic field. The green and cyan curves are upward and downward ionospheric FAC boundaries defined with a threshold of 0.05 microA/m^2 and mapped from the northern hemisphere ionosphere along geomagnetic field lines to the equatorial plane. Plots of similar format are combined in Movie S1. The mapping of FAC boundaries is shown every ten minutes.



Movie S2. Similar format to Movie S1. The particles are released from 18UT.