Abstract

A tongue of ionization (TOI) is a channel of high-density $F$ region plasma transported from the dayside mid-latitude ionosphere through the cusp and into the polar cap by enhanced convection electric fields. Previously, mid-latitude plumes of ionization, known as storm enhanced density (SED), carried sunward and poleward by the low-latitude edge of the sub-auroral polarization stream have been suggested as the dayside source of polar TOI. However, SED plumes have also been observed over North America without any evidence of the formation of a TOI. To better understand the mechanisms which cause the formation of a polar TOI from an SED plume, we present simultaneous total electron content (TEC) observations from ground-based GPS receivers and ionospheric backscatter recorded by SuperDARN radars during a geomagnetic storm driven by a coronal mass ejection (CME) on 26-27 Sep. 2011.

Introduction

- Beginning with the construction of a new radar at Wallops Island, VA in 2005, a program has been underway to expand the SuperDARN area of coverage to middle latitudes for further ionospheric studies during periods of enhanced geomagnetic activity (Baker et al., 2007).
- Vertical TEC represents the combined contribution of the ionosphere and overlying plasmasphere. Researchers at MIT Haystack offer globally gridded GPS TEC data as zenith values binned into $1^\circ$ by $1^\circ$ cells at 5 minute resolution via the online Madrigal database, given in units of $10^{16}$ electrons/m$^2$ (Rideout and Coster, 2006).

Observations

- During an hours-long period of dynamic geomagnetic activity on 26 Sep. 2011 (Figure 1), a channel of high-density $F$ region plasma is seen to be transported through the dayside cusp and across the polar cap at velocities in excess of 1400 m/s by enhanced convection electric fields extending to middle latitudes ($\Lambda = 60^\circ$).
- Figure 2 shows that the TOI over North America from 18:00-20:00 UT. A channel of enhanced TEC is seen beginning to move poleward from midlatitudes at 18:30 UT, coinciding with a period of sustained positive IMF By and southward IMF Bz, until a northward turning at 19:15 UT.
- A plume of enhanced TEC is observed several hours after the formation of the TOI (Figure 3) and elongates in magnetic local time over North America until about 00:30 UT on 27 Sep. 2011.

Observations (cont.)

- The characteristics of the TOI observed from 18:30-19:40 UT are similar to those previously described by Foster et al., 2005 and Hosokawa et al., 2010, although for the first time simultaneous measurements at mid-latitudes have been available to confirm the equatorward expansion of the high latitude convection electric fields into the dense source region.

Discussion

- Figure 2: GPS TEC maps with SuperDARN convection patterns overlaid (left) and LOS velocity measurements from ionospheric scatter for selected radars (right) during TOI interval. All panels are plotted in magnetic local time with solar noon at the top.
- High antisunward velocities are observed by the polar Inuvik (INV) radar from 18:30-19:40 UT within the region of enhanced TEC as it passes through the radar FOV (Figure 4), corresponding to the TOI.
- No sign of the later SED feature is observed in either the radar or TEC polar cap measurements, indicating that the high-TEC plume was no longer being convected to high latitudes.

Conclusions

- Observations from the CME-driven geomagnetic storm on 26-27 September 2011 have been presented for two cases of potential TOI formation from an SED.
- During an hours-long period of dynamic geomagnetic activity, enhanced convection electric fields transported a channel of high-density $F$ region plasma from an SED region in the dayside mid-latitude ionosphere into the polar cap.
- After the solar wind IMF conditions quieted and the dayside convection electric fields retreated to higher latitudes, an SED plume was observed extending to, but not entering, the polar cap region.
- For this fossil feature, the source mechanism (enhanced electric fields) previously drawing plasma from mid-latitudes and into the polar cap was no longer locally active and no HF backscatter was observed within the region of enhanced TEC.

References

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