Conjugated measurements of flow channels in the ionosphere using DMSP and AMISR

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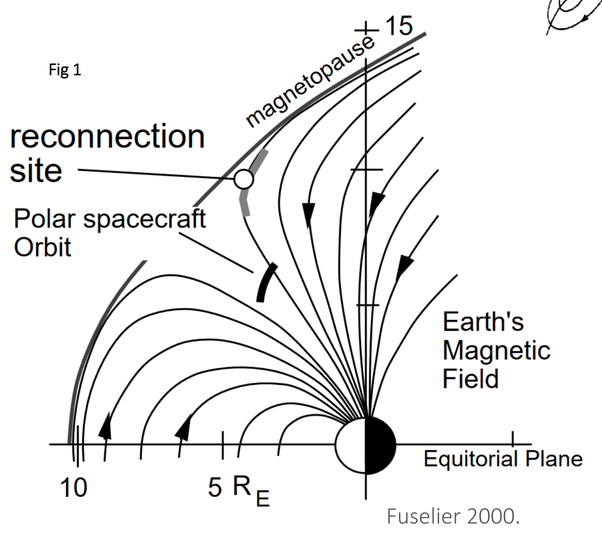
Abstract

Fast and narrow ion flow channels at high altitudes appear mainly due to magnetic reconnection and the waves that move along the field lines into the ionosphere. By using satellite data from the Defense Meteorological Satellite Program (DMSP) such events can be studied using energy flux, velocity density and temperature measurements. DMSP is ideal for spatial measurements over the polar caps given its low earth orbit. The inclusion of measurements done with Incoherent Scatter Radars (ISR) such as Poker Flat (PFISR) and Resolute Bay (RISR) can add an extra layer of understanding by looking at conjugated points with DMSP and the benefit of a better temporal resolution, which DMSP lacks. Energy measurements from DMSP help find the close/open magnetic field line boundary, regularly associated with the auroral region, as well as ionospheric flow channels generated from reconnection. F region cap patches coming down due to high latitude reconnection in the event of a northward IMF are measured using both DMSP and RISR. Perpendicular flows can be obtained using several oblique beams to estimate the flow and data products. Conjunction points are presented in order to try and confirm prior identifications of large enhancements, polar caps and large enhancements on the EXB due to reconnection, with the prospect of a full Joule heating analysis for the future.

Motivation

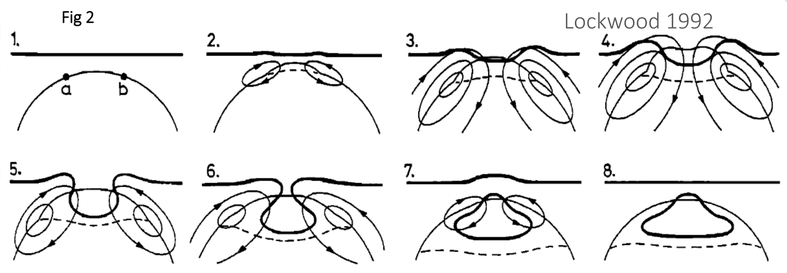
Ionospheric flow channels can be the result of several events, but thanks to the Dungey Cycle [1], it is known that reconnection drives convection in the magnetosphere due to frozen in flux assumption. Thus, drift is then on the horizontal plane, and can be measured with DMSP and studied to understand more about magnetic reconnection and convection. In the case of a northward IMF, reconnection happens over the polar caps, as opposed to closer to the equatorial region. As shown on Figure 1 [3], this means that low earth orbit satellites, such as DMSP, cam measure the results of reconnection much easier.

Fig 1



Fuselier 2000.

Fig 2

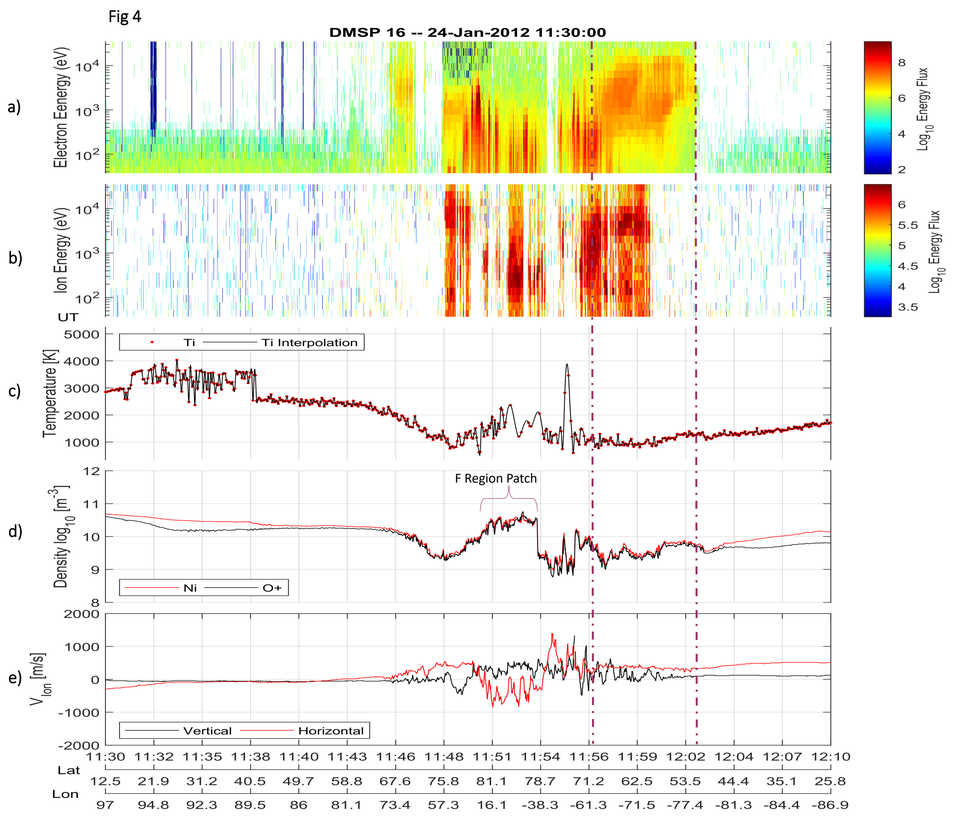


The result of reconnection at the polar caps is the existence of F region patches (or polar cap patches) [2], which are areas of cold dense plasma that is pushed equatorward due to reconnection as shown on Figure 2 from Lockwood et al. Solid line represent high plasma density contours while dashed one correspond to the low latitude magnetopause. As such, the motivation for using DMSP and radar conjunctions to study this phenome arises from the complexity and different movements that occur.

Findings

DMSP and RISR measurements: F Region Patches

Fig 4



Methodology and Setting

The main objective is to find conjunctions between DMSP satellites and AMISR measurements. The known storm of January 2012 was selected as a starting point due to the existence of a 42 beam configuration at RISR. Even though only LOS velocities are computed for radar beams, more advanced data products such as 3D velocity vectors [6] can be resolved for AMISR and are available. Density profiles are already available by using the techniques presented by Semeter and Butler et al [4][5]. This date is also characterized for having a northward IMF, thus securing magnetic reconnection event happening over the polar cap and the possibility of F region patches coming down. As shown on Figure 3, the different DMSP satellites (from DMSP15 to 18) as they orbit over the polar region go close to RISR at the times of interest, showing here the horizontal ion velocity is shown along the direction (sunward/anti-sunward) and magnitude.

Fig 3

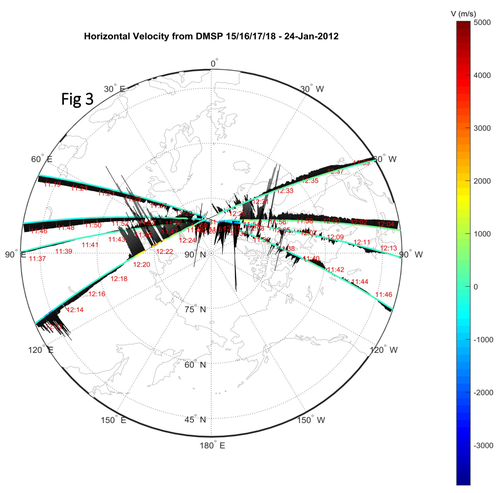
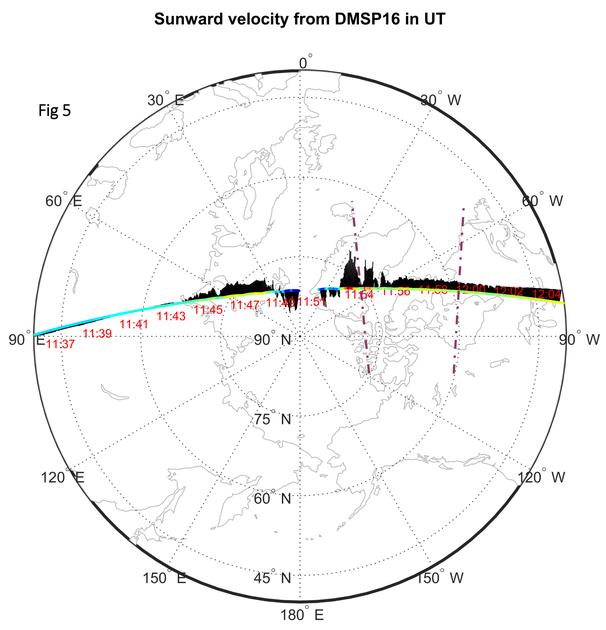


Fig 5



- DMSP is capable of identifying F region patches using the density measurements, and at the same time RISR is able to single out a patch coming down. This suggest the location for the boundary of close/open magnetic field lines.
- From both Figure 4 and Figure 5 we see how this boundary coincides with the auroral zone.
- Figure 6, where cuts of RISR density profile data have been plotted in 3D (by J Semeter), shows that at lower altitudes we have ionization. This two separated measurements then confirm that the aurora is a good discriminator for the boundary.
- Figure 6 shows an F Region patch. Density measurements done by DMSP on Figure 4d also show an F Region Patch in the enhanced density marked between ~11:50 UT and ~11:54 UT.
- Snapshots of RISR data in time as shown on Figure 7 (by J Semeter), region patch is seen moving across the radar.
- There are large velocities towards the radar, which suggest a velocity component towards the boundary. This motion is not resolved or when by DMSP.
- Both DMSP and RISR time snapshots show the existence of flips in velocity, which can be attributed to unresolved convection cells.
- Finally, Figure 8 shows low density that appears at lower altitudes, just as Figure 6, further confirming the assumption of auroral ionization at lower altitudes.

Fig 6

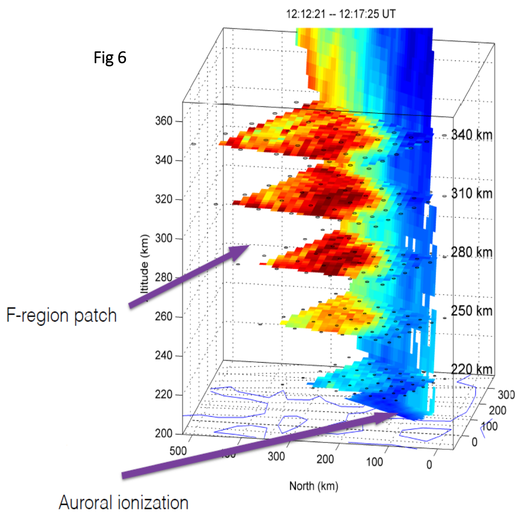


Fig 7 Plasma Density at 340km

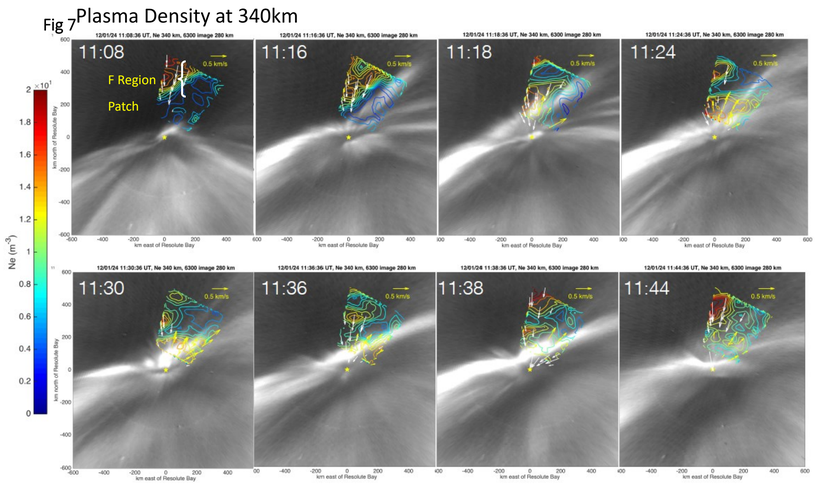
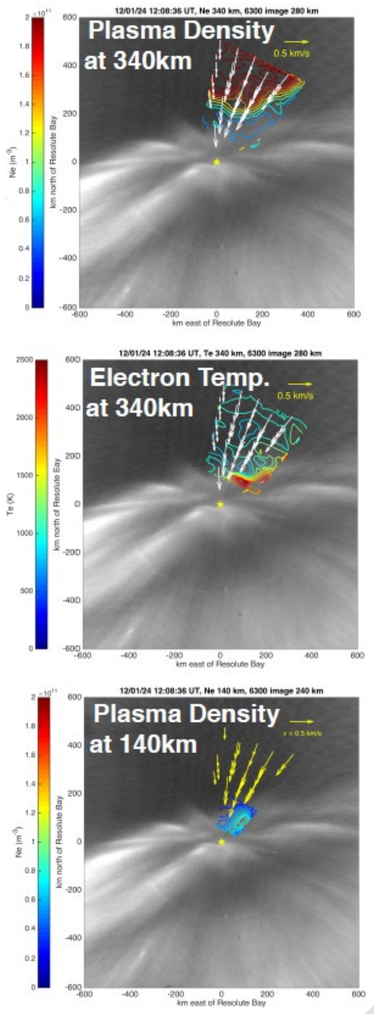


Fig 8



Conclusion

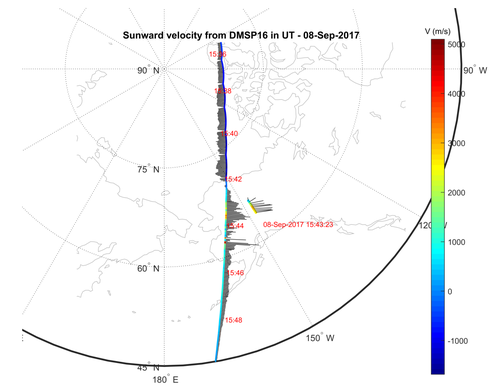
Key Findings

- DMSP is capable of identifying F region patches using the density measurements, and at the same time RISR is able to single out a patch coming down.
- In the same way, DMSP is able to approximate the location of the open/close boundary , also confirmed by E region ionization using RISR.
- The perpendicular movement resolved by RISR shows that the patch is moving into the boundary, evidence of an electric field tangential.
- DMSP is not able to resolve this transport like RISR.

Future Work

- Integrate measurements from DMSP and RISR one level further by including conductivity products, to follow into Joule Heating.
- Go over several past events, such as the one shown on figure 9 for the September 2017 storm.

Fig 9



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