

# Polar cap Patches on Global Scales with SuperDARN radars and GPS TEC

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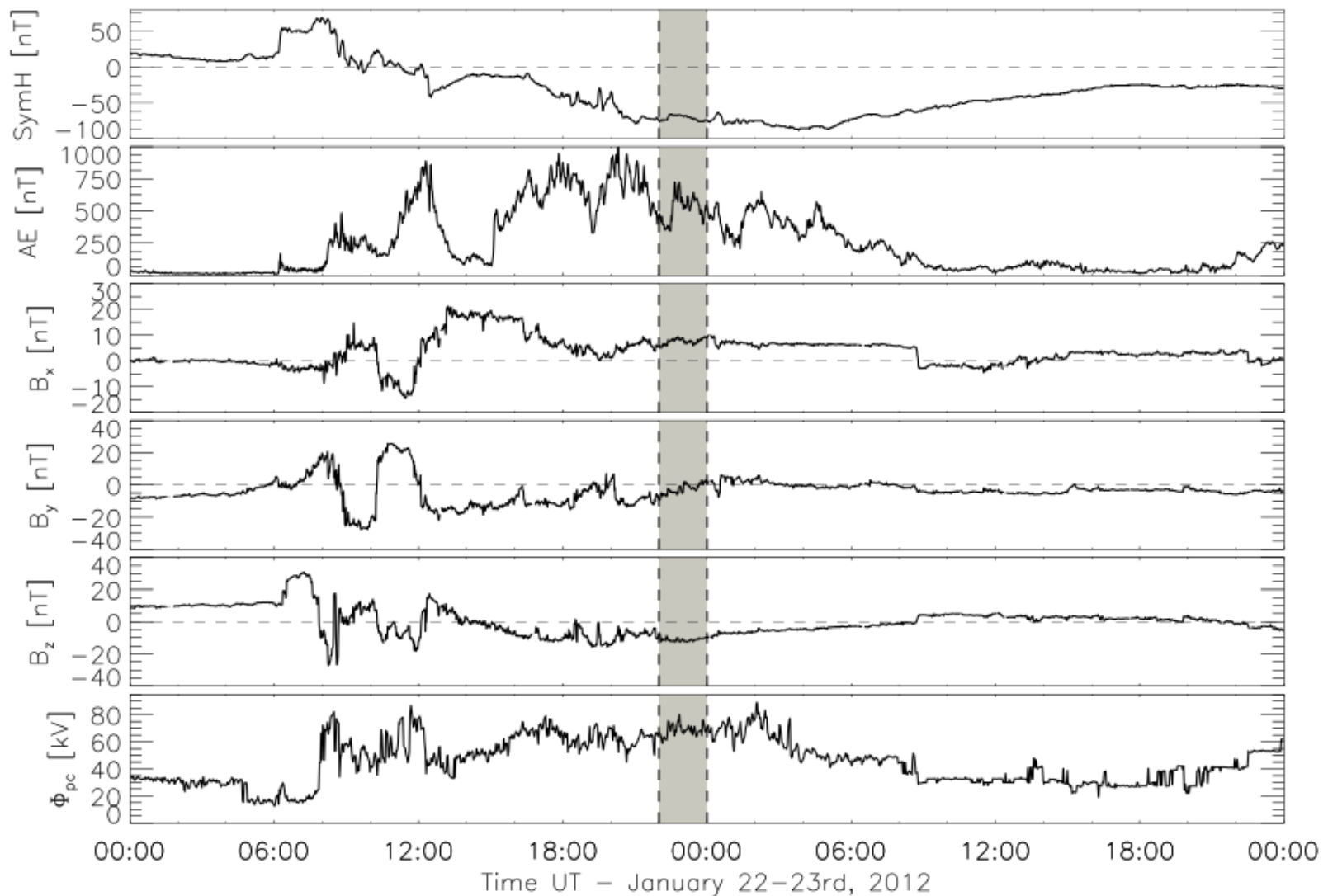
## 2014 CEDAR Workshop

# Motivation



- Previous studies have examined patches using various combinations of GPS total electron content (TEC), SuperDARN, incoherent scatter radar, optical, rocket data, etc.
- For the first time, we use a combination of GPS TEC, SuperDARN HF radars, and 630.0 nm all-sky airglow imagers (ASIs) to study the conformity of patch characteristics across all three datasets during a moderate geomagnetic storm on 22 January 2012.

# Geomagnetic Indices

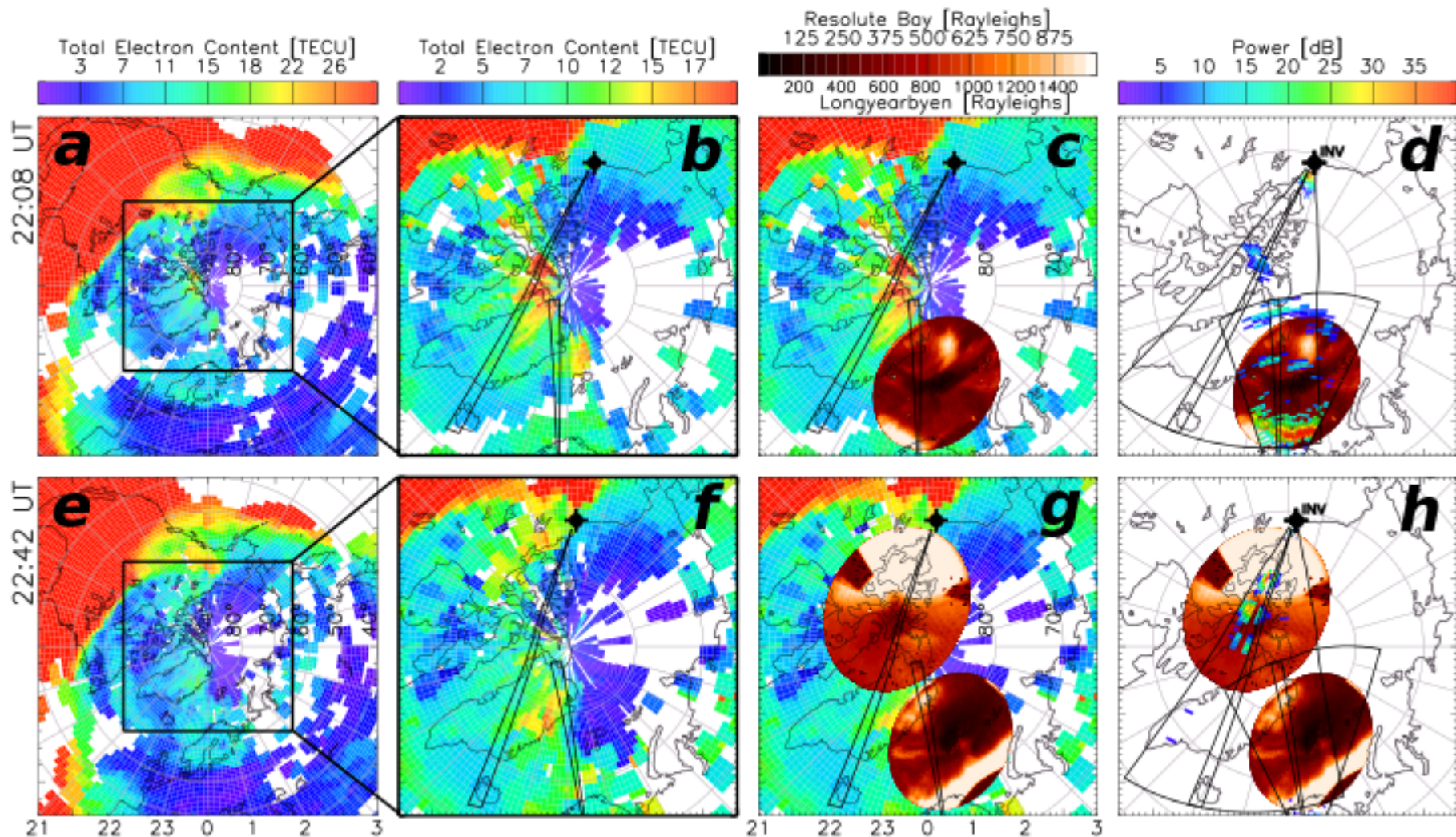


# Event Overview



- A moderate geomagnetic storm was triggered by the arrival of a coronal mass ejection (CME) at the Earth's magnetosphere at 06:15 UT on 22 January 2012, seen as an abrupt intensification and then steady decline in the Sym-H index.
- A 2 hour interval from 22:00-24:00 UT was identified during the main phase of the storm during which a train of patches was observed in the polar cap ionosphere.
- This period was characterized by recurrent substorm activity in the AE index, and elevated cross polar cap potential in the northern hemisphere as derived from SuperDARN measurements.

# Patch Observations



# Instrumentation



- The two ASIs are located in Resolute Bay, Canada (RSB) and Longyearbyen, Norway (LYR) and monitor the intensity of atomic oxygen red line emissions at 630.0 nm wavelength, which are known to be closely related to the  $F$  region peak electron density [*Weber et al.*, 1984; *Perry et al.*, 2013].
- We focus on observations from the PolarDARN Inuvik radar (INV) and CUTLASS Finland radar in Hankasalmi (HAN) which share common fields of view with the RSB and LYR imagers, respectively.
- Global maps of GPS TEC binned into  $1^\circ \times 1^\circ$  cells at 5 min cadence are obtained from the online Madrigal database at MIT Haystack Observatory [*Rideout and Coster*, 2006].

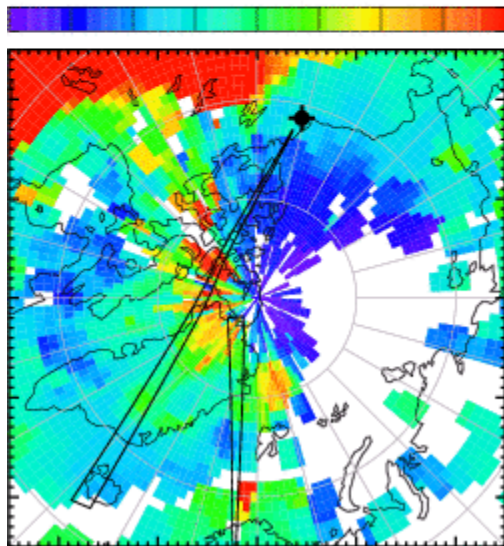
# Patch Observations

TEC/ASI/SuperDARN  
Observations of Polar Cap Patches

22/Jan/2012 22:00:17.0

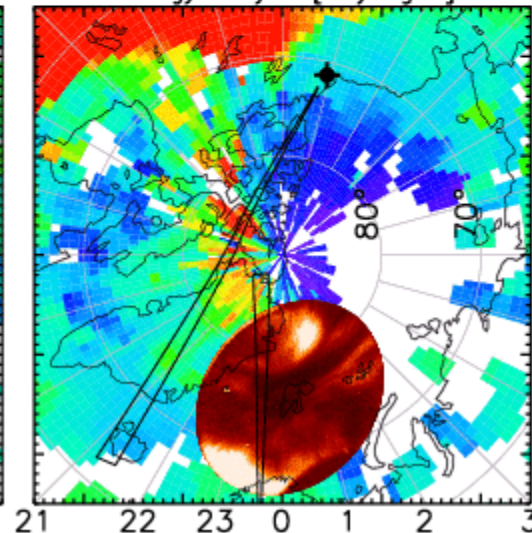


Total Electron Content [TECU]  
2 5 7 10 12 15 17

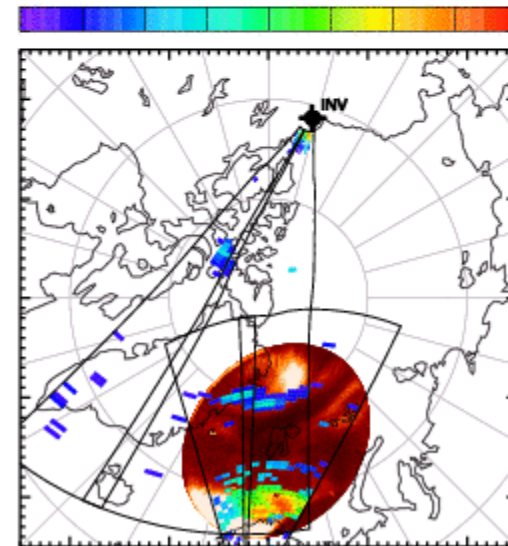


Resolute Bay [Rayleighs]  
125 250 375 500 625 750 875

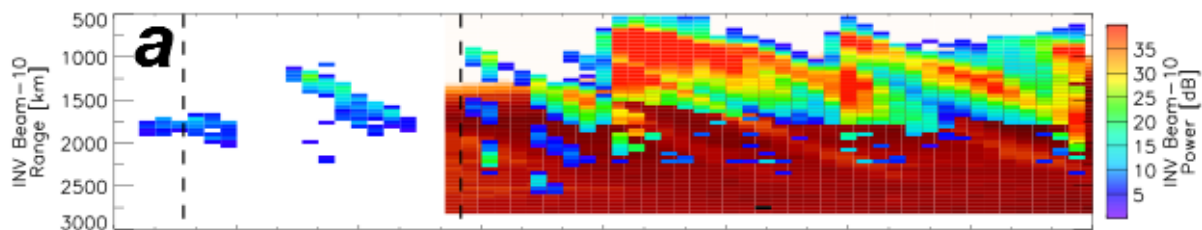
200 400 600 800 1000 1200 1400  
Longyearbyen [Rayleighs]



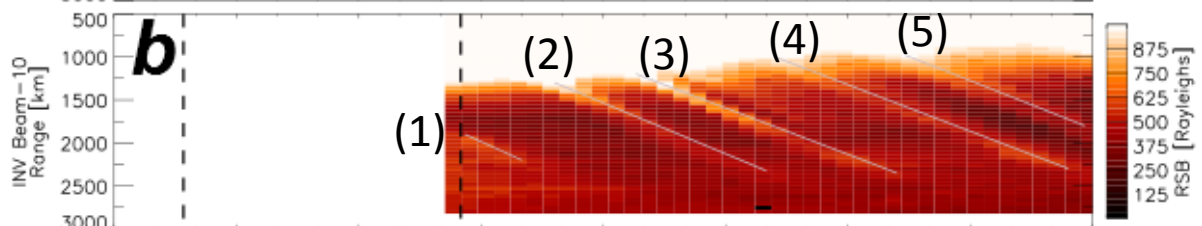
Power [dB]  
5 10 15 20 25 30 35



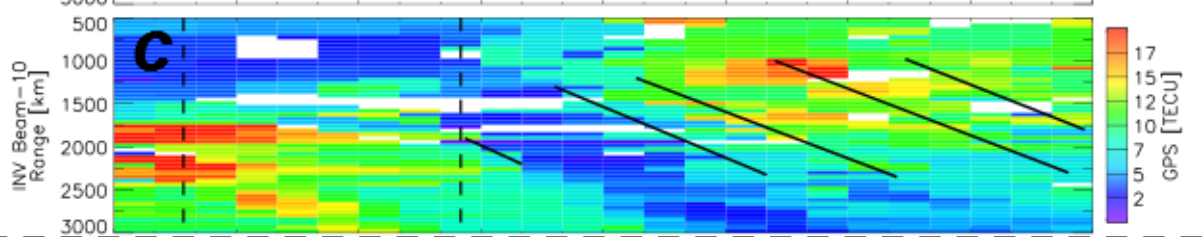
RSB + INV  
(Beam 10)



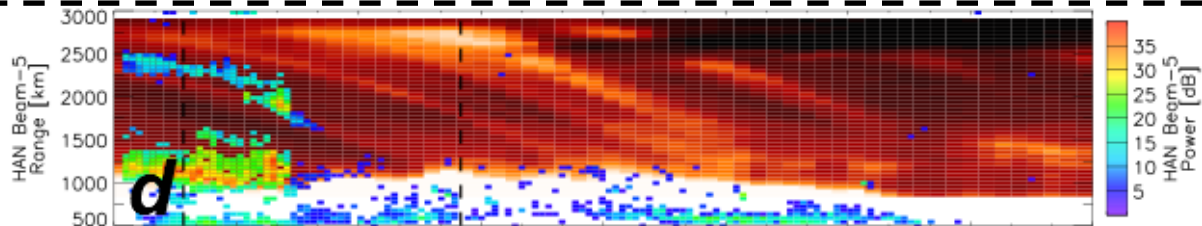
RSB



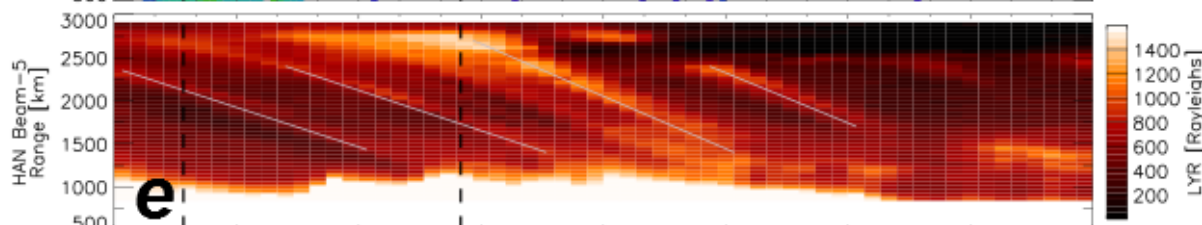
GPS TEC



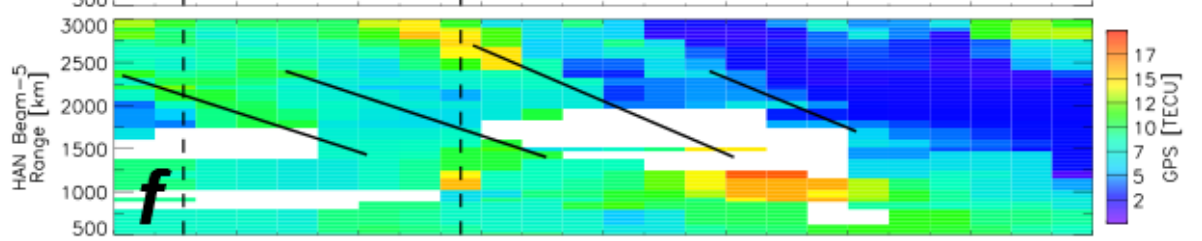
LYR +  
HAN  
(Beam 5)



LYR



GPS TEC



Anti-sunward

Time UT - January 22nd, 2012



# Discussion

- We generally find good spatial agreement between the GPS TEC and 630.0 nm airglow, which are both often treated as proxies for  $F$  region electron densities.
- The GPS TEC is averaged over  $\sim 100$  km spatial scales and cannot resolve the fine-scale structure of patches visible at  $\sim 2$  km and  $\sim 4$  km resolution with the ASIs.
- The HF backscatter patches observed by SuperDARN also correlate with the airglow patches, reveal structure on tens-of-km scales, and extend the capability for monitoring patch activities into daylight conditions

# Web-based Tools



- An interactive plotting tool has been developed for the VT SuperDARN website to overlay maps of GPS TEC and SD backscatter power onto single plots or animated movies as seen here

<http://vt.superdarn.org/>

Data Plotting Tools

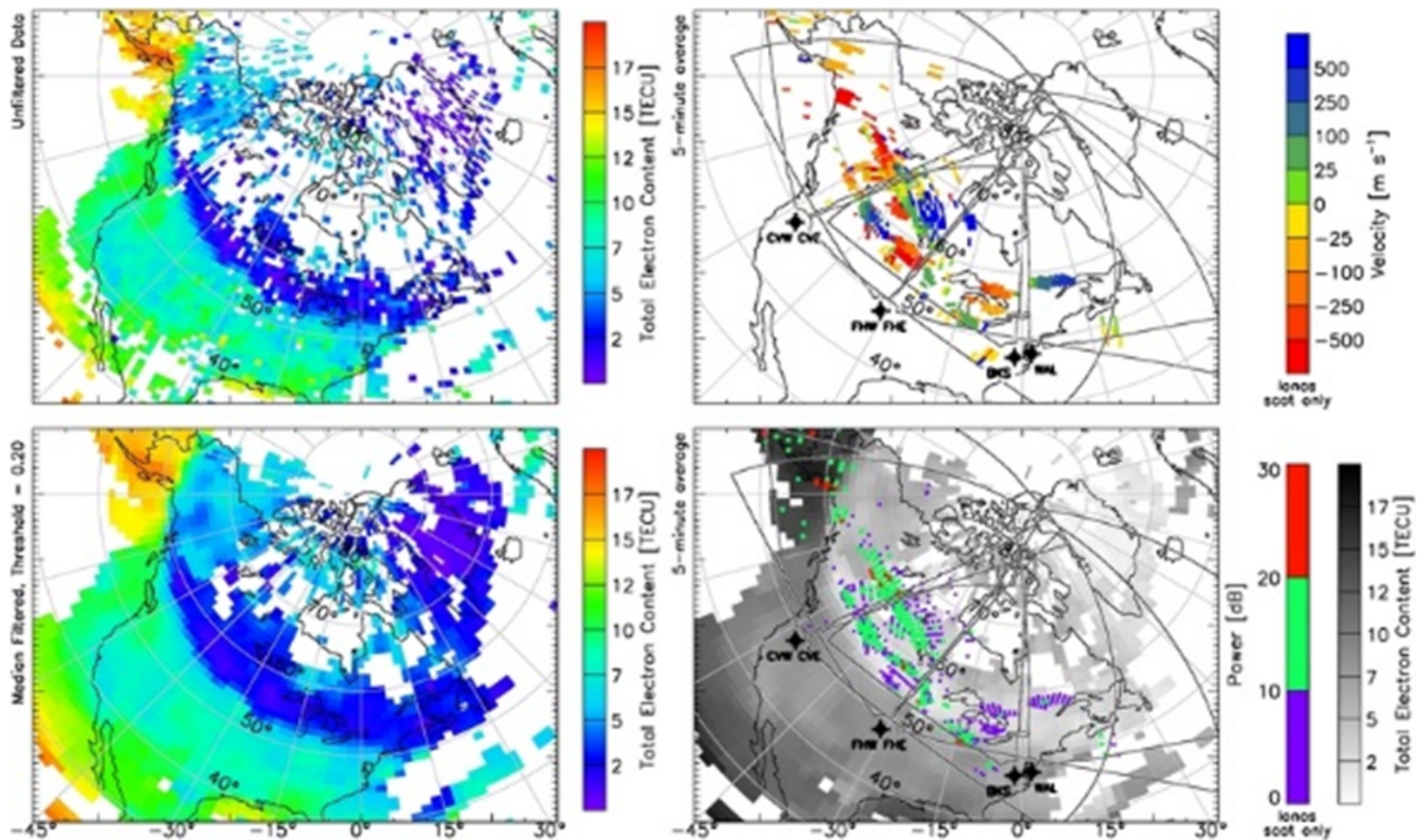
GPS/TEC Plot

- The plotting capability includes Resolute Bay 630.0 nm airglow (when available)

# GPS/TEC Plotting Tool

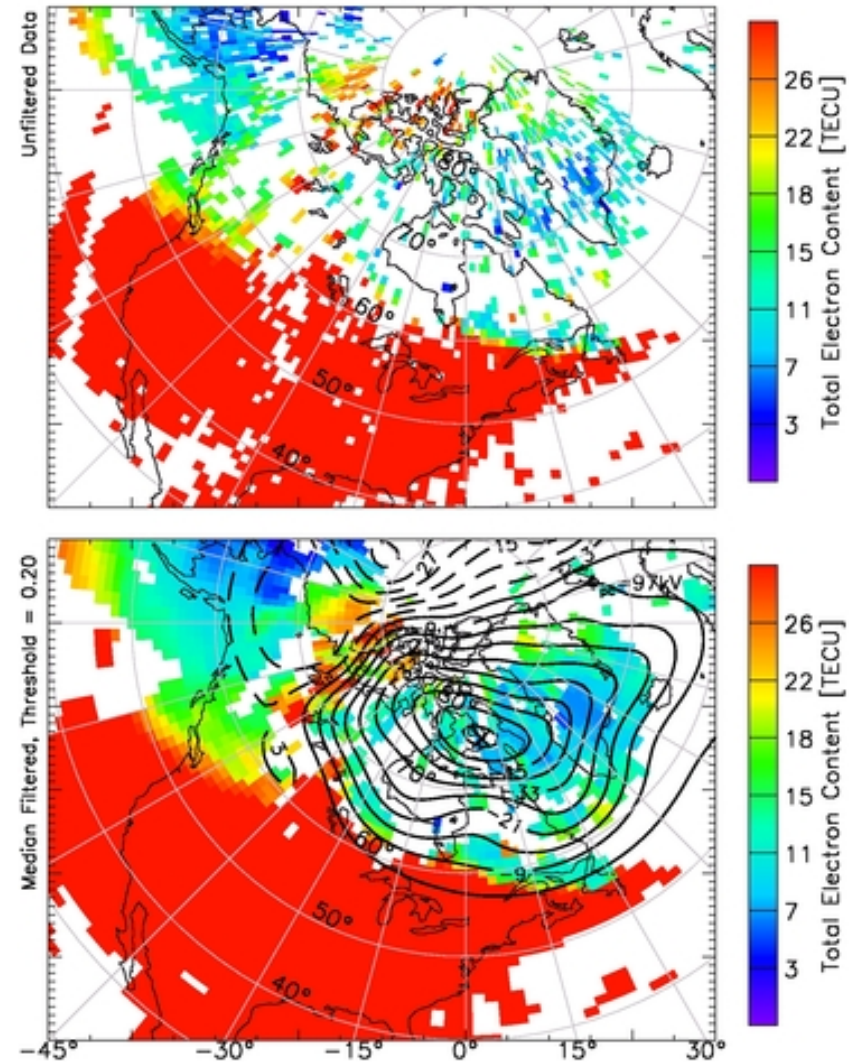
TEC Four Plot  
GPS Receiver Network (Millstone Hill)

11/Mar/2011 02:55:00.0  
to  
11/Mar/2011 03:00:00.0



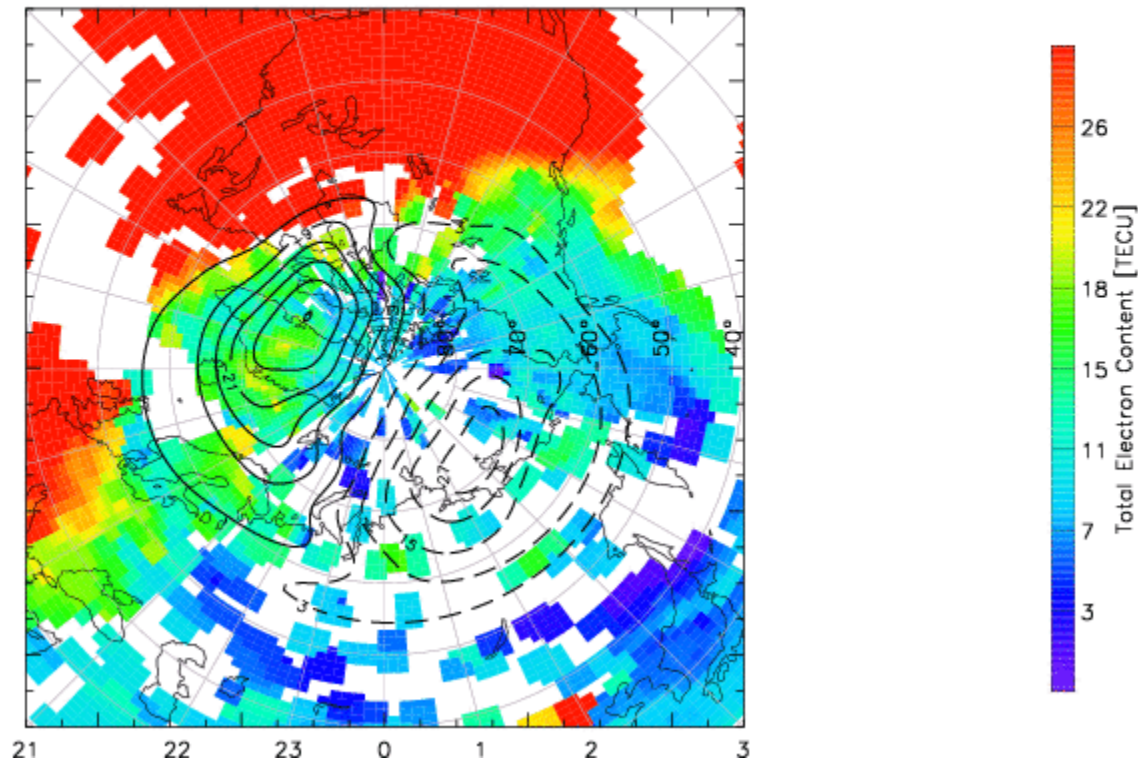
# GPS TEC & SuperDARN

- GPS TEC data has been downloaded from the Madrigal website at Millstone Hill for all processed days from Jan. 1<sup>st</sup>, 2006 to present.
- This TEC data is available for plotting with overlays of radar measurements in a variety of formats (e.g. contours of electrostatic potential).
- **Figure:** Example of potential contours overlaid on TEC map for Sep. 26<sup>th</sup>, 2011 storm.



# TEC SED/TOI/Patches

TOTAL ELECTRON CONTENT 26/Sep/2011 18:00:00.0  
Median Filtered, Threshold = 0.01 to  
26/Sep/2011 18:05:00.0



**Figure:** Evolution of tongue of ionization and fossil plume of storm enhanced density for geomagnetic storm on September 26<sup>th</sup>, 2011.