Incoherent Scatter Radar Observation of High Latitude Ionosphere

Group 3

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Outline

1. Introduction
2. Overview Plot
3. Convection Pattern Analysis based on Line-of-sight Ion Velocity
4. E Region Perturbation
5. Comparison with TEC Data
6. Summary

Overview of Polar Cap Convection

Solar wind interacts with Earth's magnetosphere

↓

Electric fields mapped down along equipotential lines to ionosphere

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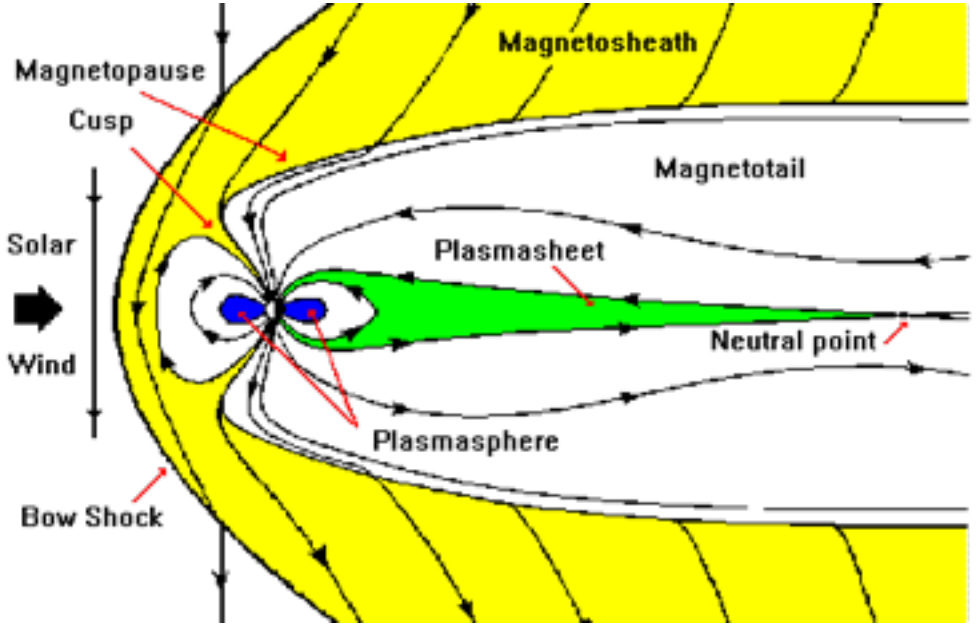
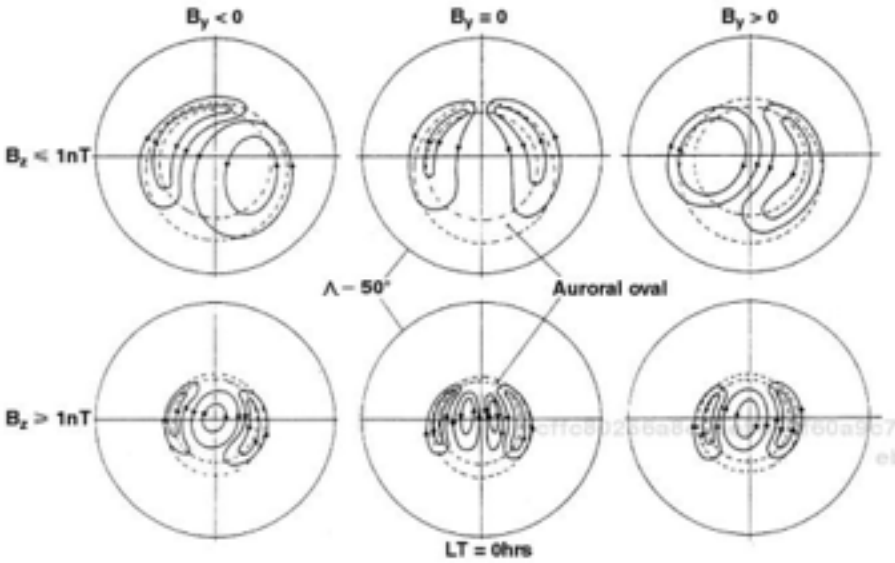
ExB drift causes plasma convection across polar cap



Credit: Internet

- High latitude ionosphere is very dynamic.
- Solar wind condition is suggested as main controlling factor.
- Energetic particles from solar wind and magnetosphere also play a role, to which high latitude ionosphere has easier access. [Hunsucker and Hargreaves [2002].]

e.g.
Multiple convection cells under northward IMF;
Atmosphere gravity waves in response to auroral activity, etc.;



Cowley and Lockwood 1992

1.2 Objectives

Observe the ionosphere F region with EISCAT Svalbard radar (ESR)

Examine geomagnetic conditions for possible geomagnetic activities

Compare with global convection data from SuperDARN

Potential phenomena related to total electron content (TEC), E region perturbation, etc.

1.3 Experimental Design

Radar Site: Svalbard 32 m antenna

Location: 78N, 16E

Rationale: Radar within polar cap

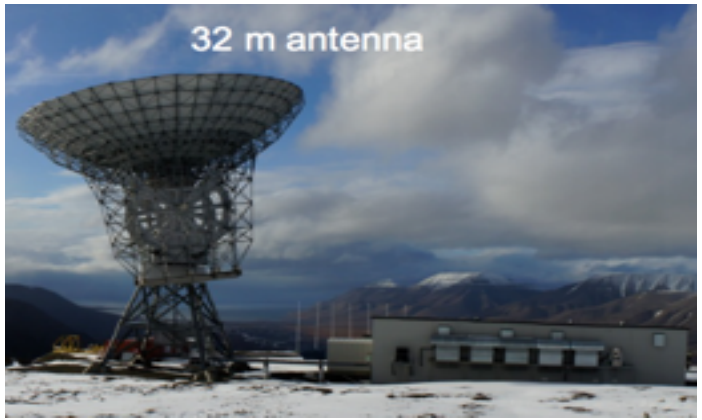
Time Slot: 16:30 to 18:30 UT

Pointing: 30 deg elevation, pointing North

Rationale: Low elevation allows for line of velocities to be derived

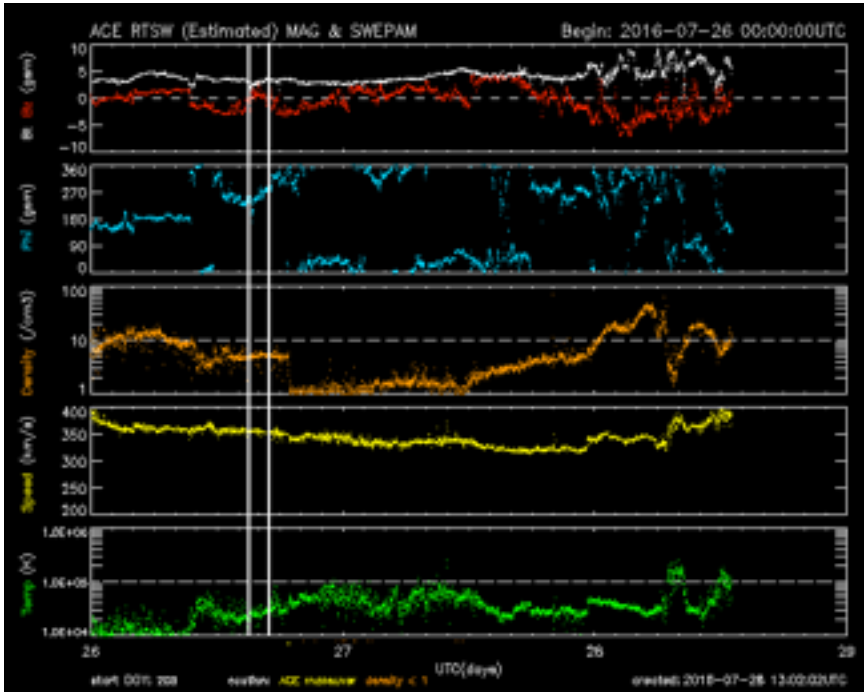
Pulse Code: Folke

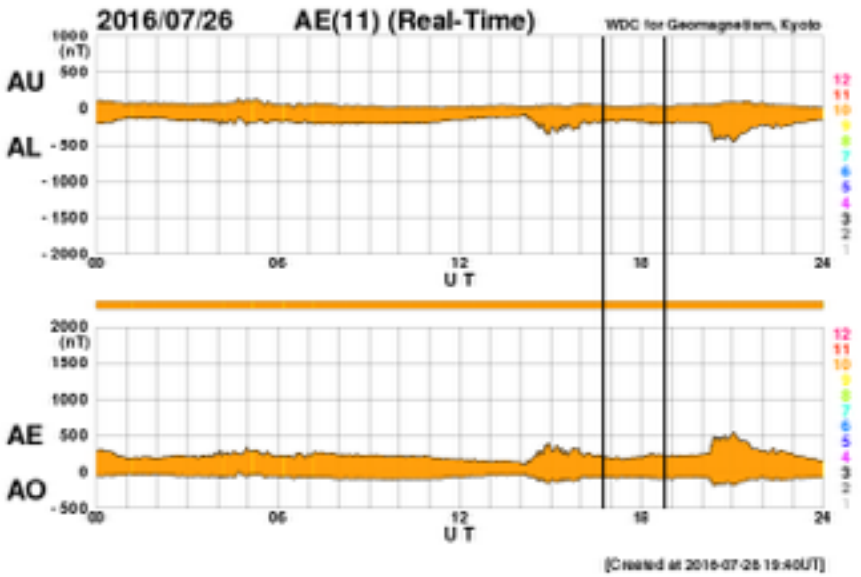
Range: 43-1014 km



1.4 Conducting the Experiment

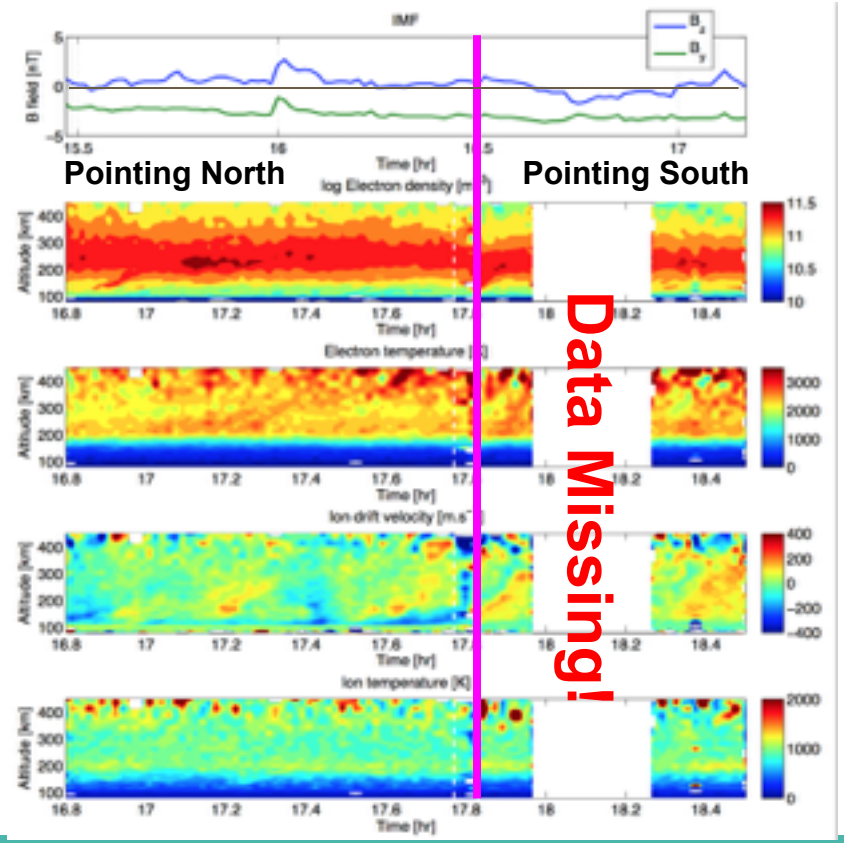
2.1 Solar wind and IMF conditions

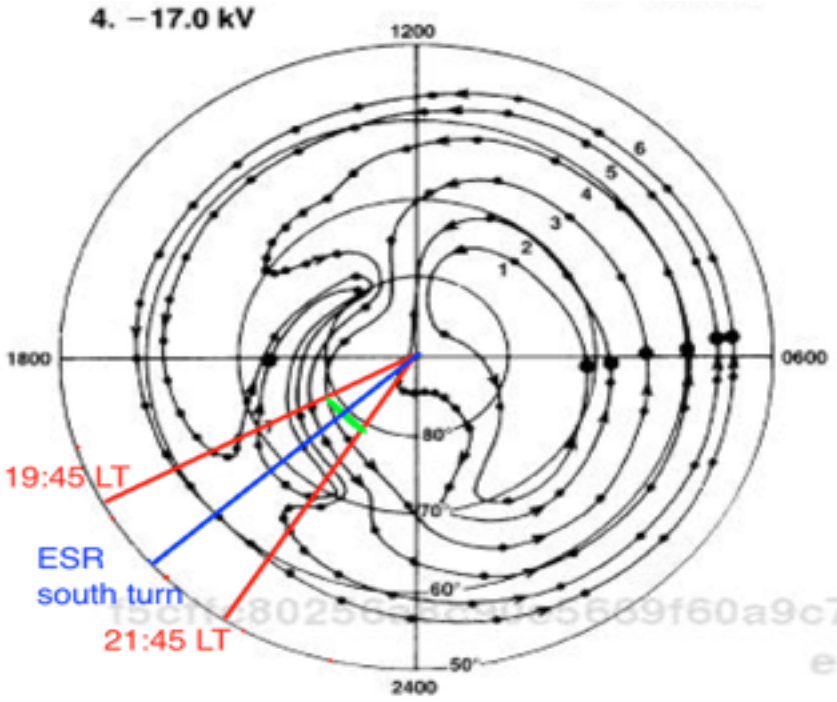




Basically quiet geomagnetic environment

2.2 Data Overview

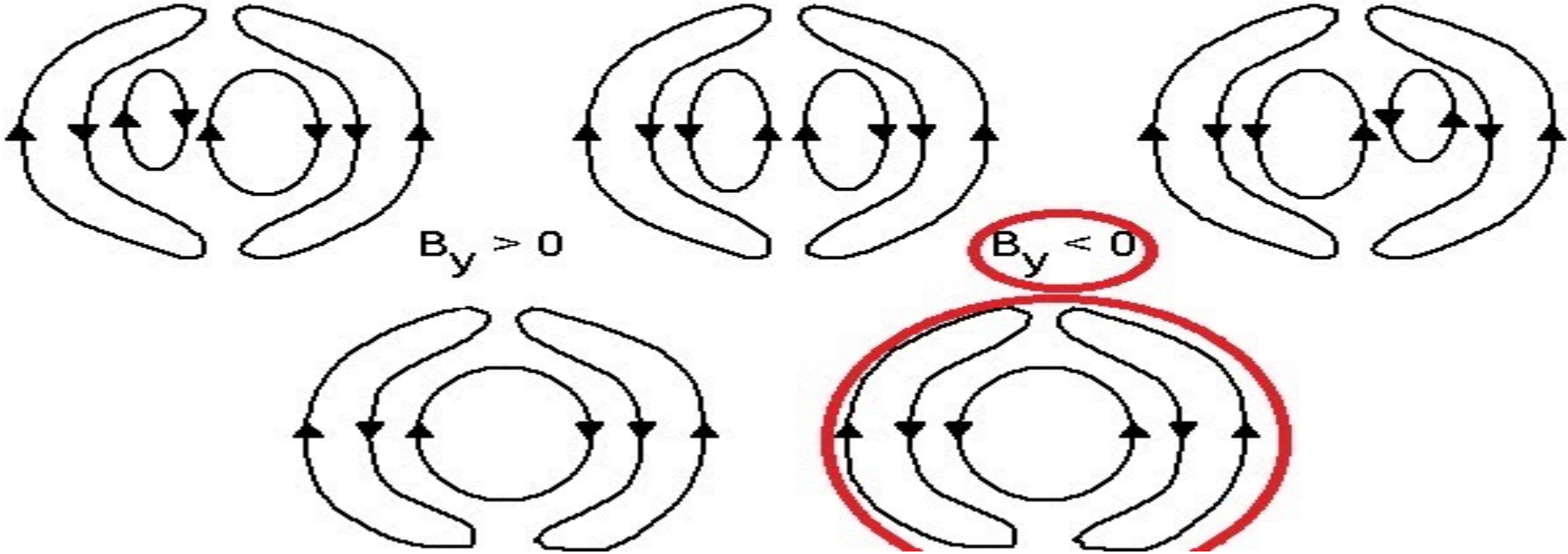




3.1 What type of convection pattern we are looking for?

B_z northward

Upper row: strongly, lower row weakly



3.2 What is SuperDARN ?

Super Dual **A**uroral **R**adar **N**etwork.

HF Radar chain around the globe, mostly located at mid-latitude (~30[deg]), high-latitude (~50[deg]) & polar-cap region (~65[deg]).

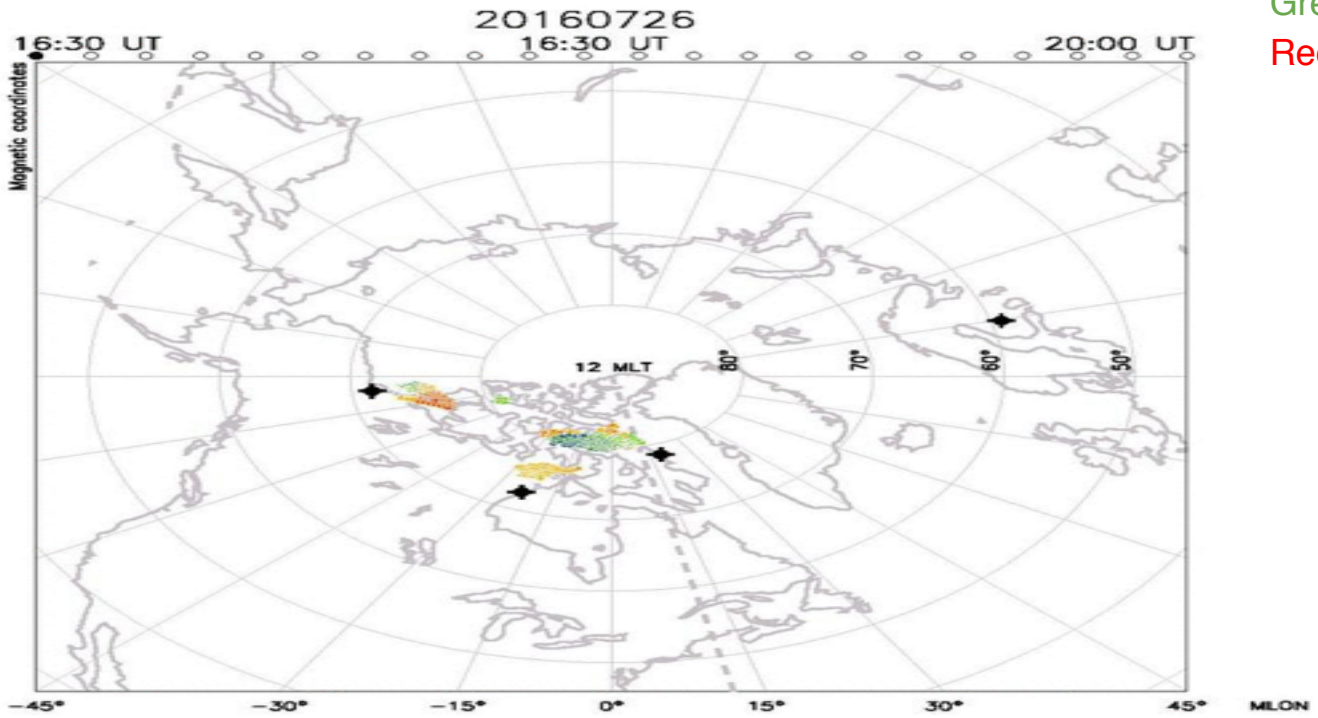
Mostly used to see & model the high-latitude & polar convection patterns.

More specifications -

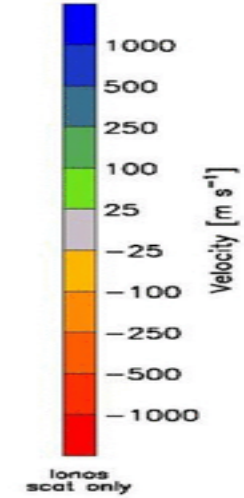
- Low elevation angle ~ 30[deg].
- Satisfy orthogonality condition - able to see the E X B drift.

Can also be used to read low altitude irregularities of ionosphere.

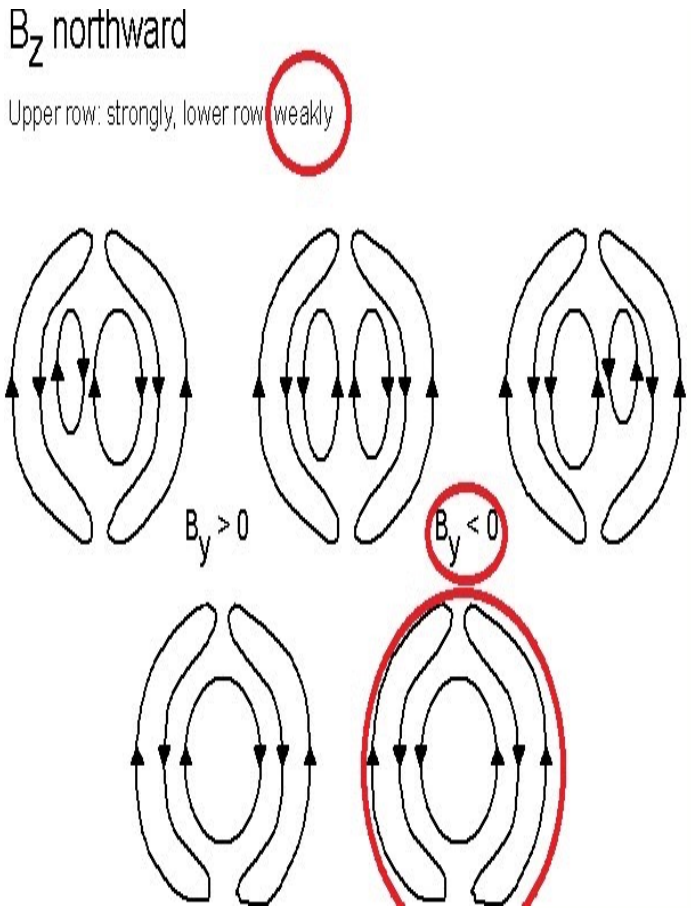
3.3 Plasma Flow in SuperDARN Data (L-o-S velocity)

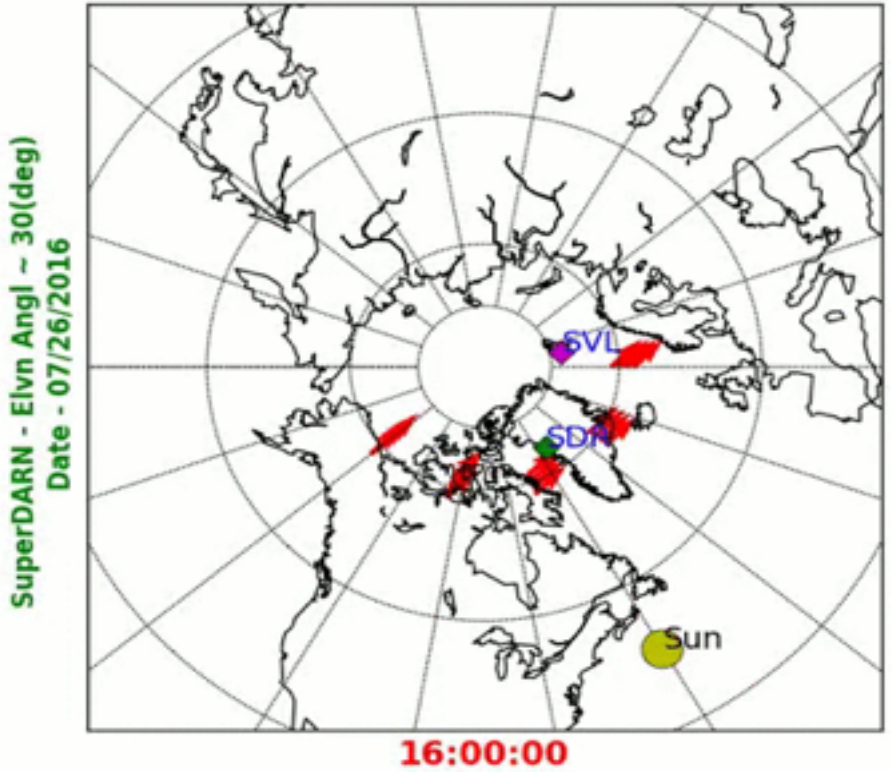


Green/Blue - Towards.
Red/Yellow - Away.

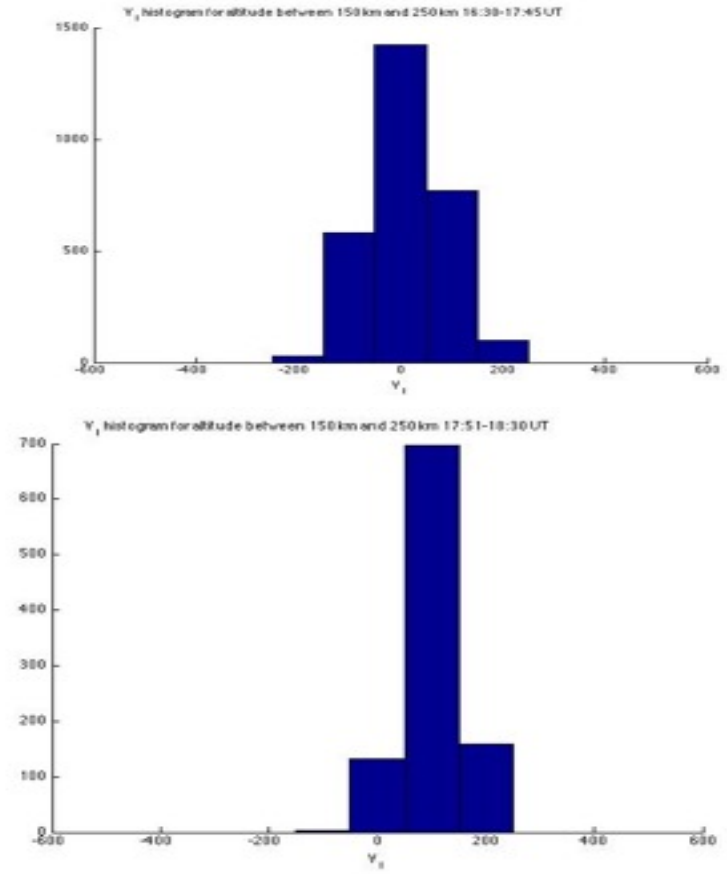


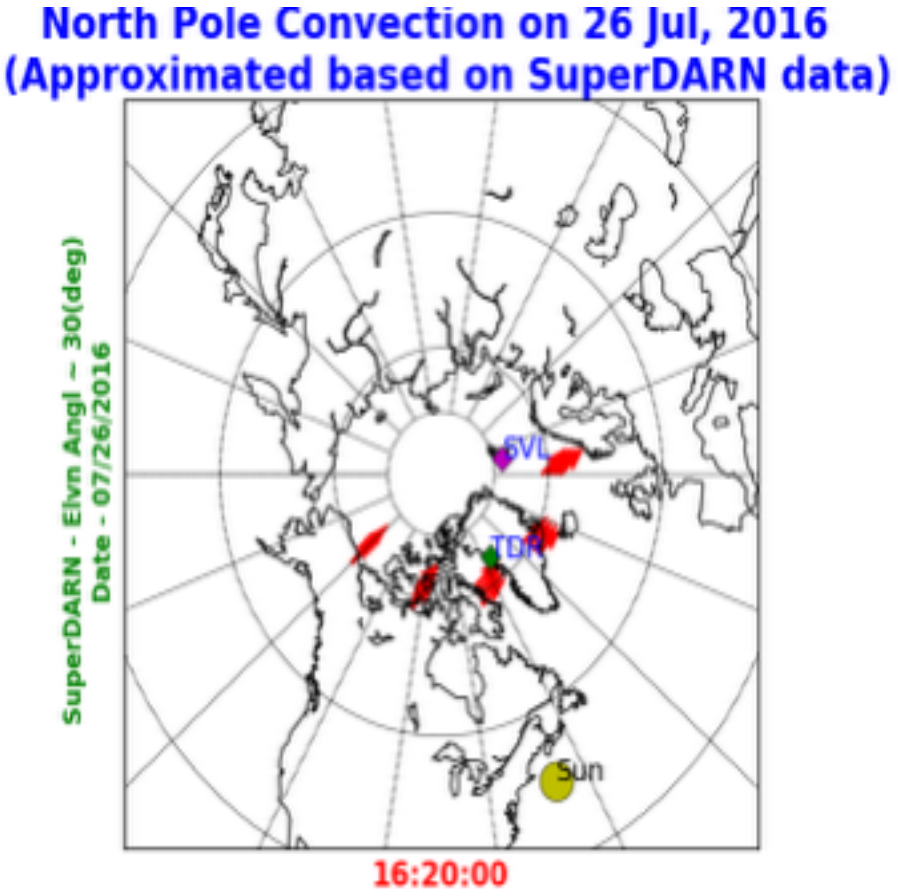
3.4 Global Convection Flow in SuperDARN Resolved Velocity (L-o-S)





3.5 Comparing ISR with SuperDARN





3.6 Takeaway Points

ISR sees a local convection of plasma.

SuperDARN used to show a global convection pattern.

- Too many approximations in global convection pattern analysis.
- Vector angle calculations.

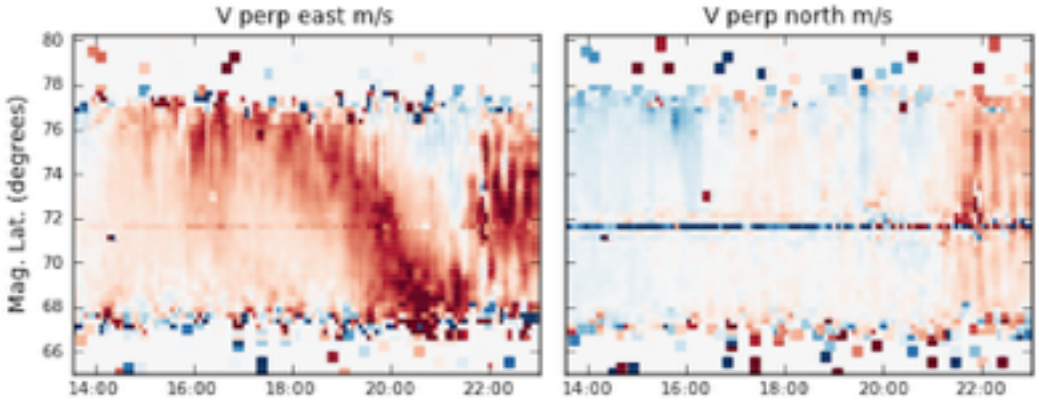
Very simplified version of convection analysis, but it matches with expected pattern.

YES!!!, we can see a correlation among the ion velocity measured in ISR

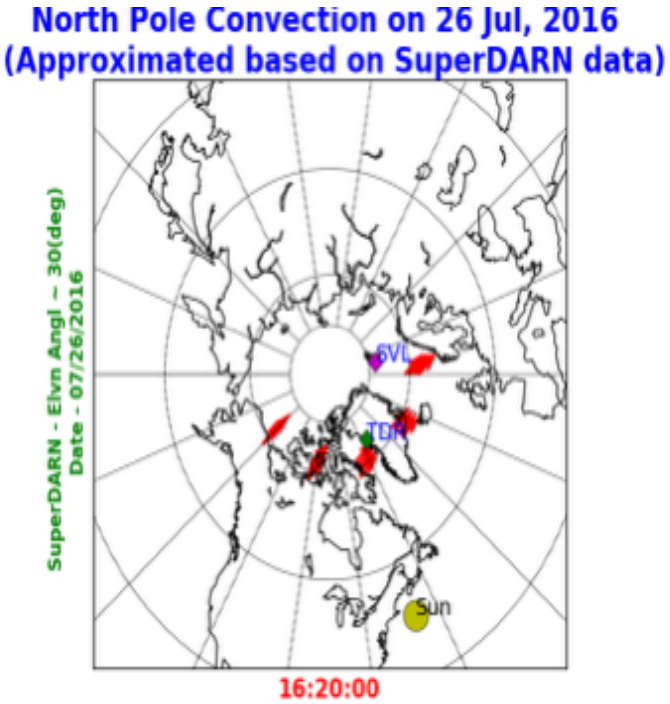
Other Interesting Features

Comparison to ISR Sondrestrom

Derived Velocities at Sondrestrom (Blue is positive, Red is negative)

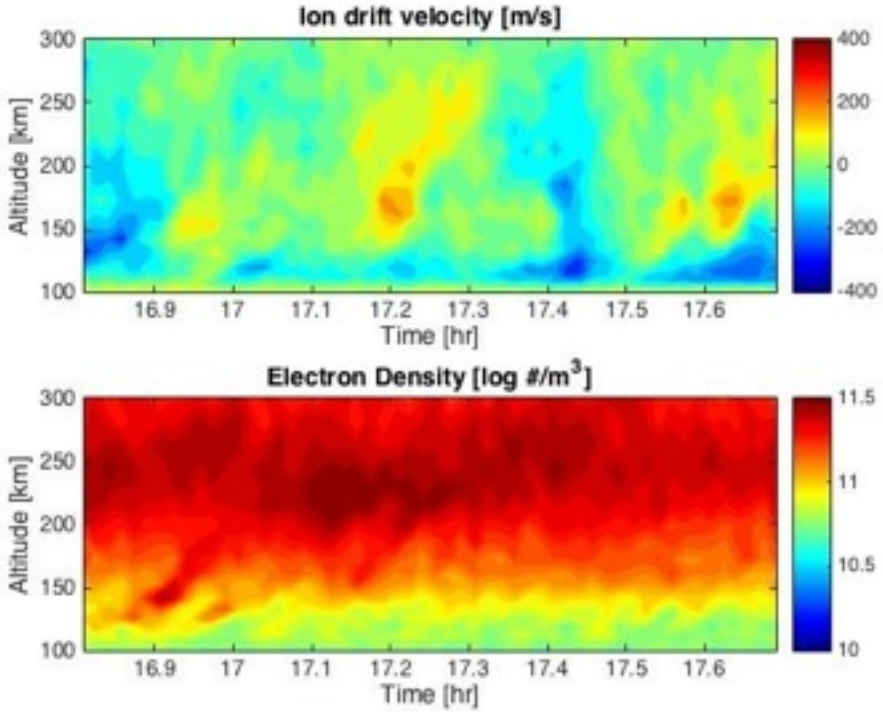


Westward flow at Sondrestrom and comparison to SuperDARN seems to imply latitudinal shear at location



E-region perturbations

Northward looking Period

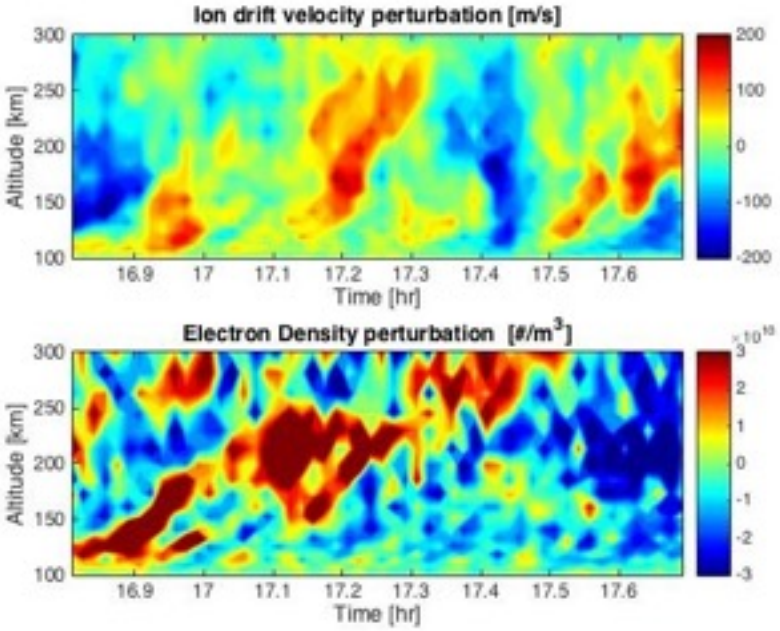


Lack of strong plasma convection allows for clear perturbations to be seen.

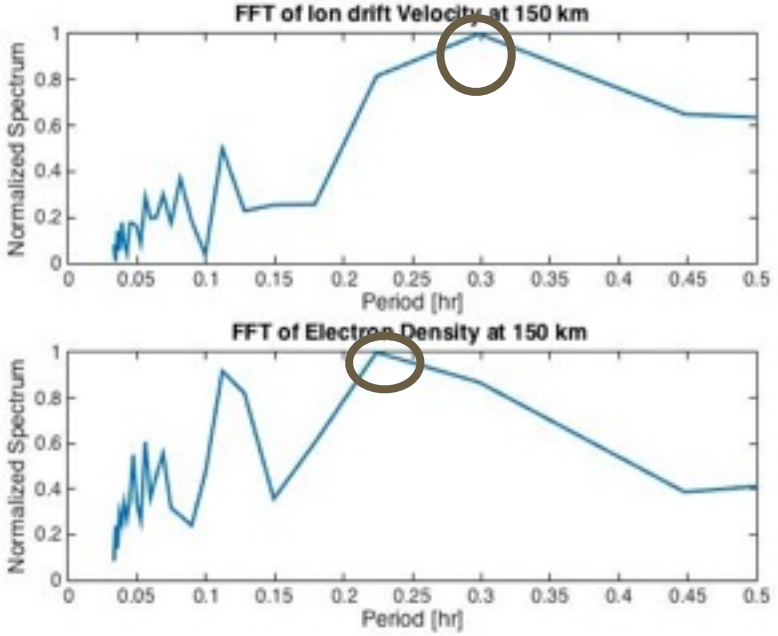
Gravity wave-driven travelling wave disturbances (TID)?

E-region perturbations

Mean at each altitude removed



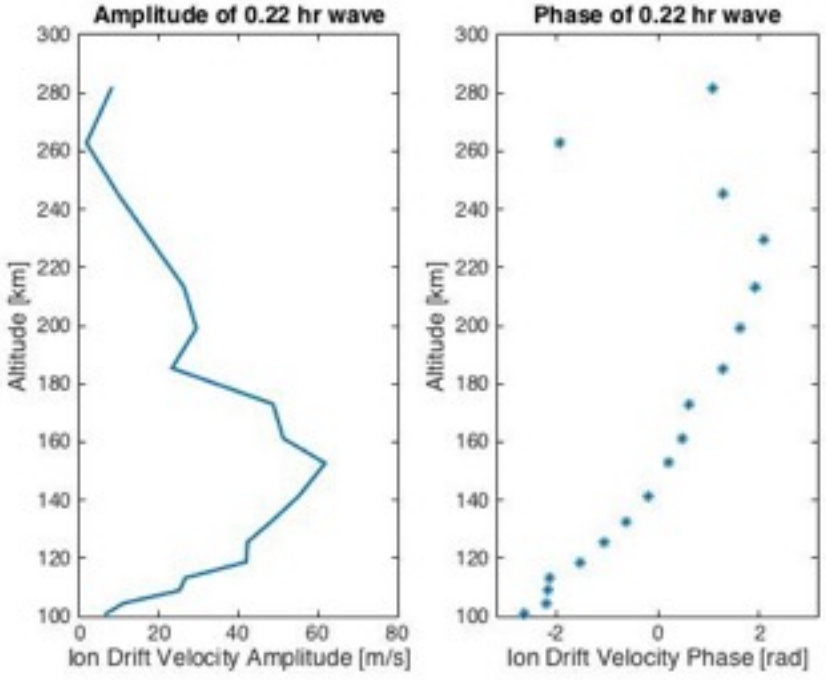
Perform FFT at constant altitude



E-region perturbations

Procedure

- Perturbations are fit to sinusoid with 0.22 hr period, consistent with the typical Brunt-Vaisala value of 13 minutes.
- Amplitude and phase extracted at each altitude



Amplitude of 0.22 hr wave peaks in E-region

Phase tilt implies that the phase velocity is moving away from the radar

Could be gravity wave driven disturbance, horizontally or vertically propagating

Phase Speed = $\frac{\text{Wavelength}}{\text{Period}}$

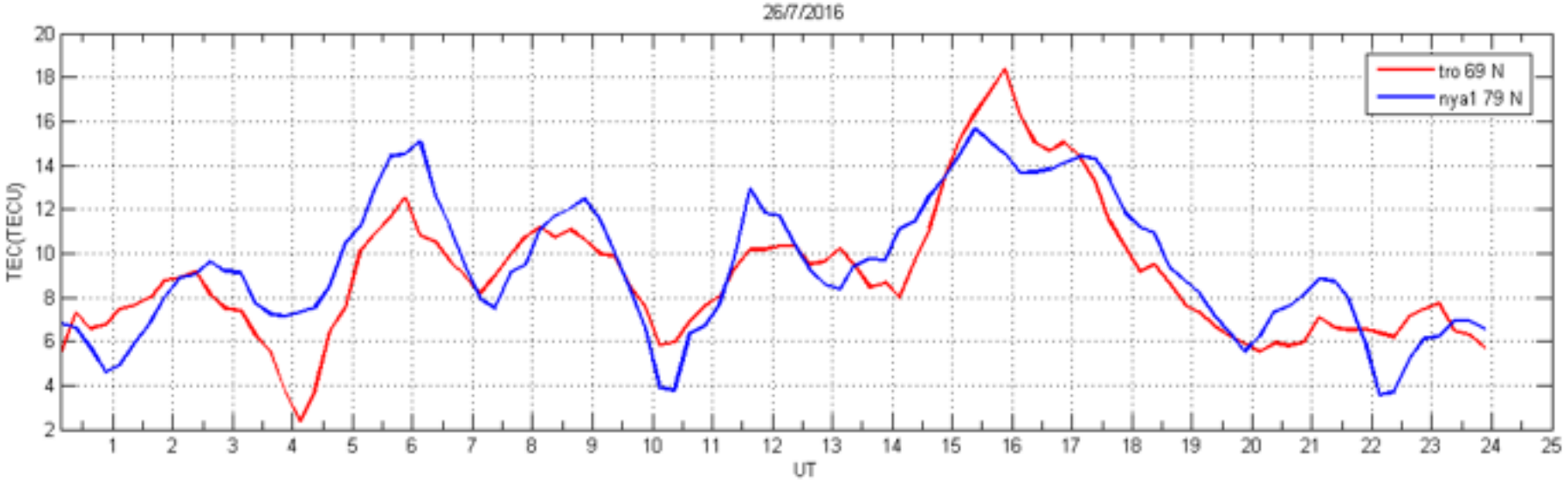
= 303 m/s

Total Electron Content (TEC) From IGS stations

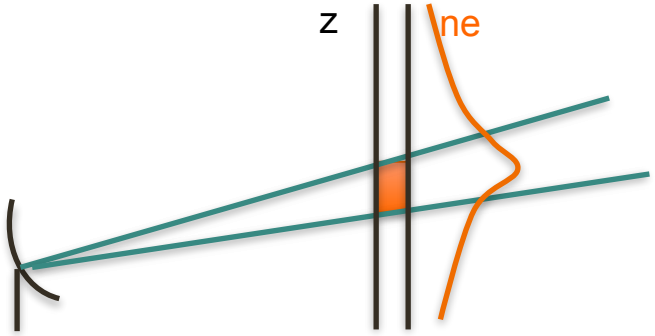
Station coordinates:

Nya1: 11.87 E, 78 N

Tro1: 18.93 E, 69 N



Comparison to GPS TEC



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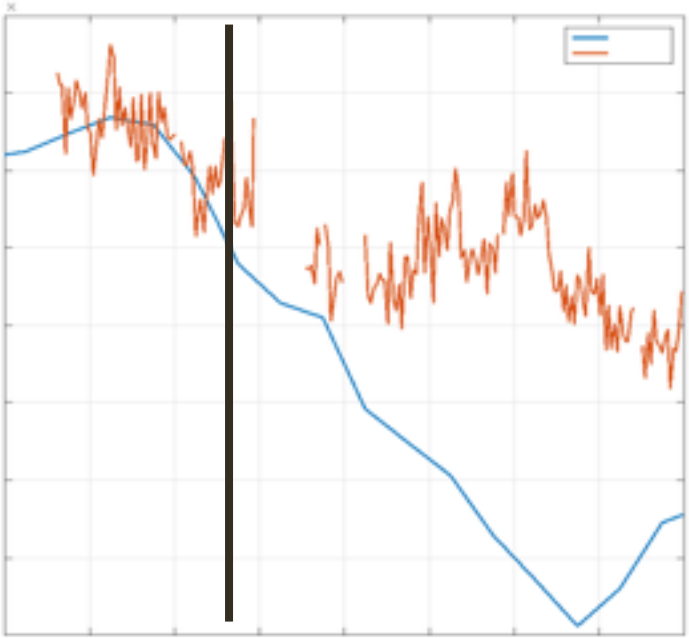
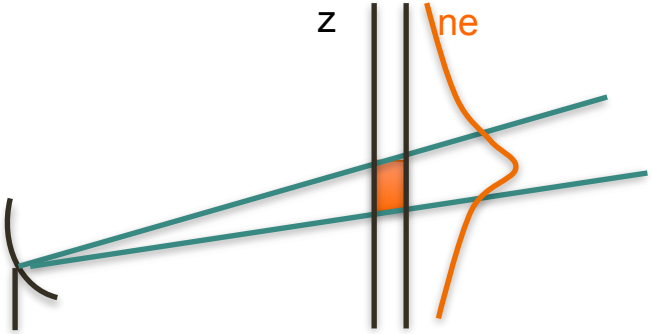




Whilst looking northwards:

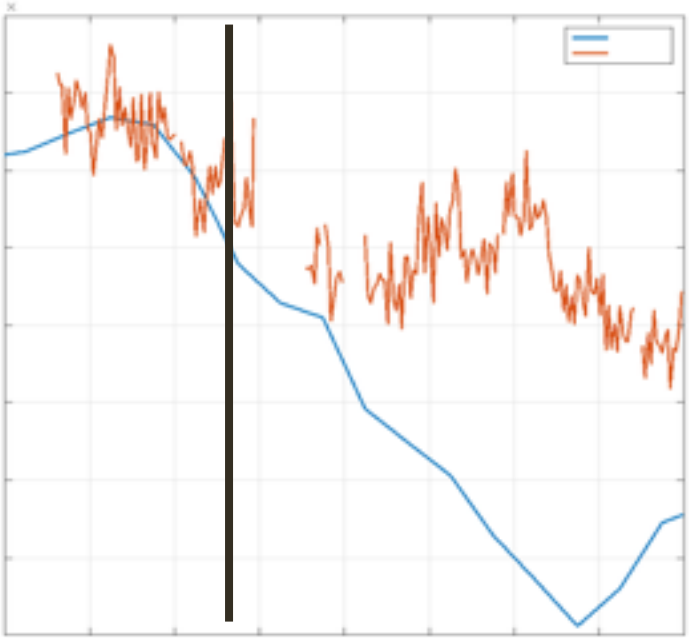
- ISR TEC appears to closely follow that measured on Svalbard

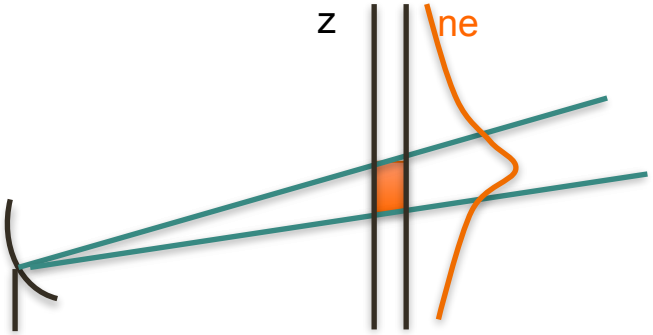
Whilst looking southwards:

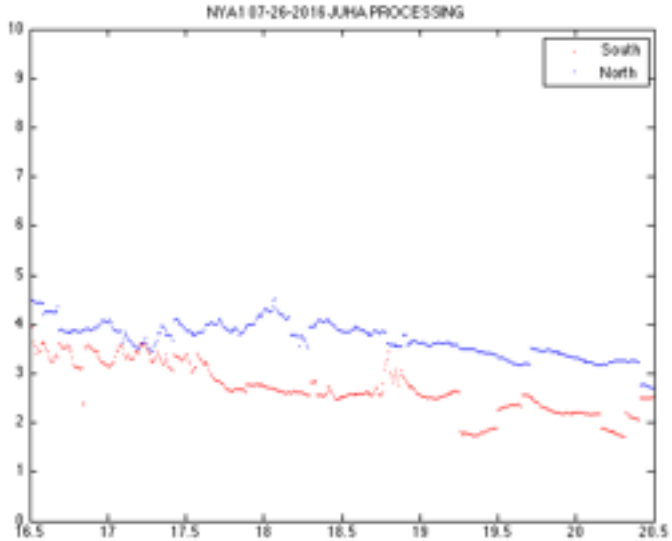
- Very different trends

➢ Different ionospheric conditions to the south of Svalbard

Comparison to GPS TEC







6. Summary

Experience of operating an ISR to observe high latitude ionosphere, fundamental plasma data obtained

Weak geomagnetic activity resulted in small polar cap convection, especially while looking northward

Line of sight velocities were consistent with SuperDARN observations

E-region oscillations may suggest presence of TIDs

Questions???

Comments!!!!!

THANK YOU!