Observing the polar ionosphere using incoherent scatter radar

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Overview

- Goals.
- Background
- Experiment design
  - Part 1: Triangular
  - Part 2: Azimuth and elevation scanning
- Results:
  - Electric field calculations
  - Aurora or plasma blobs?
  - Neutral winds
- Conclusion

Goals

- Calculate height profiles of the ionospheric electric field and compare to values averaged over height
- Look for phenomena like auroras or plasma blobs
- Calculate neutral winds and drifts

Experiment set-up 1

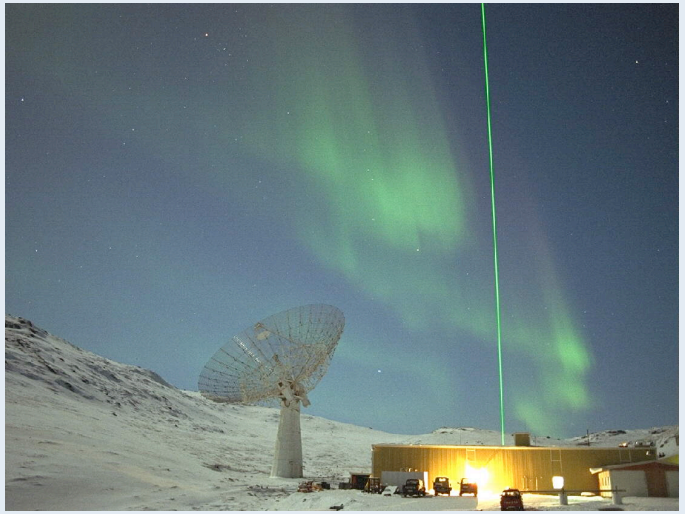
- Sondrestrom radar beam configuration:
- 3 dwells position:
- Elevation: 80°, azimuth: 141° (along magnetic field)
- Elevation: 80°, azimuth: 321° (northward direction)
- Elevation: 80°, azimuth: 70° (eastward direction)

- Scanning:
- Elevation: from 0° till 180°, azimuth: 0°
- Elevation: 45°, azimuth: from 90° till 270°

Experiment set-up 2

- EISCAT radar beam configuration:
- Scanning:
- Elevation: from 0° till 180°, azimuth: 0°
- Elevation: 45°, azimuth: from 90° till 270°

- EISCAT



Sondrestrom

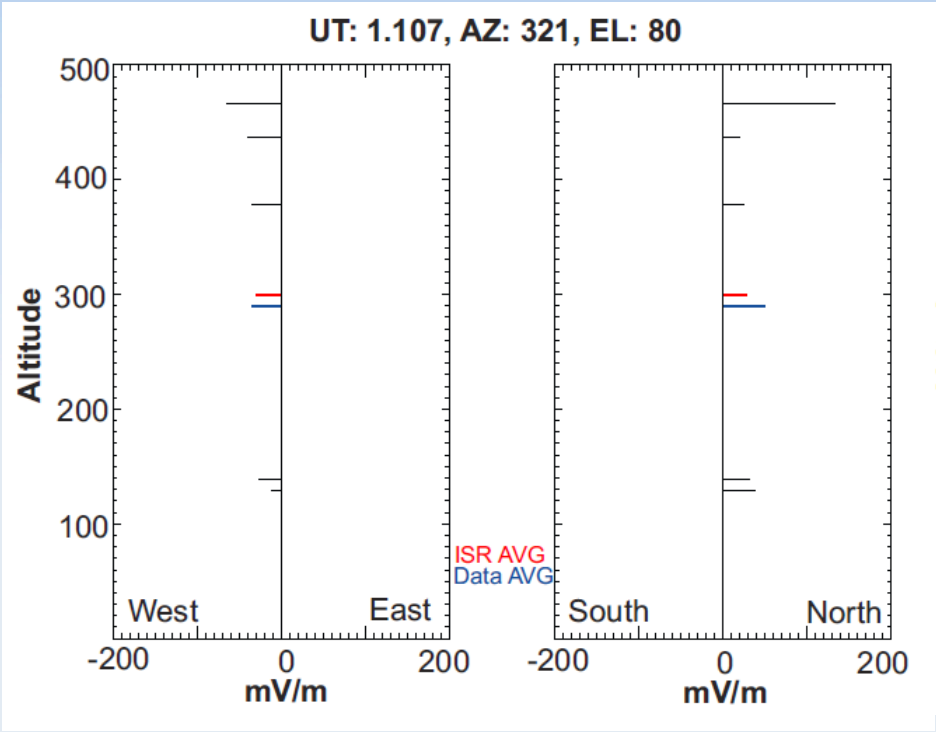
Experiment set-up cont'd

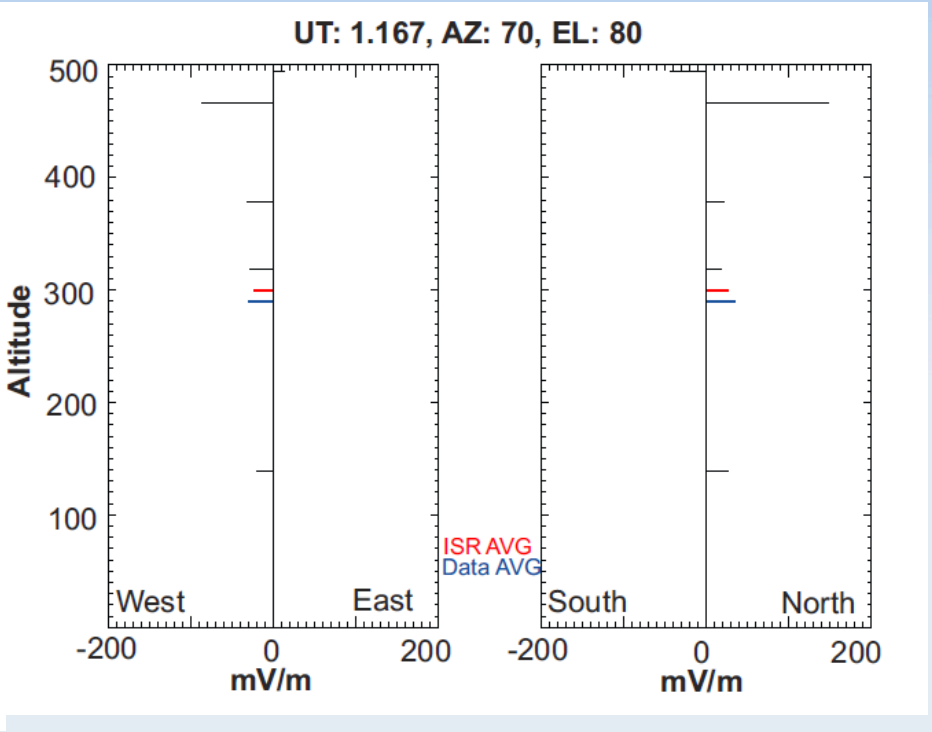
- ☺ **Alternating code**
  - **Aurora and electric fields:**
    - - Covers desired altitude (E-region)
    - - Able to obtain required parameters
- ☺ **Long pulse**
  - **Winds:**
    - - Covers F2-region altitude
    - - Te, Ti, Velocities, Ne, collision frequency

Electric Fields

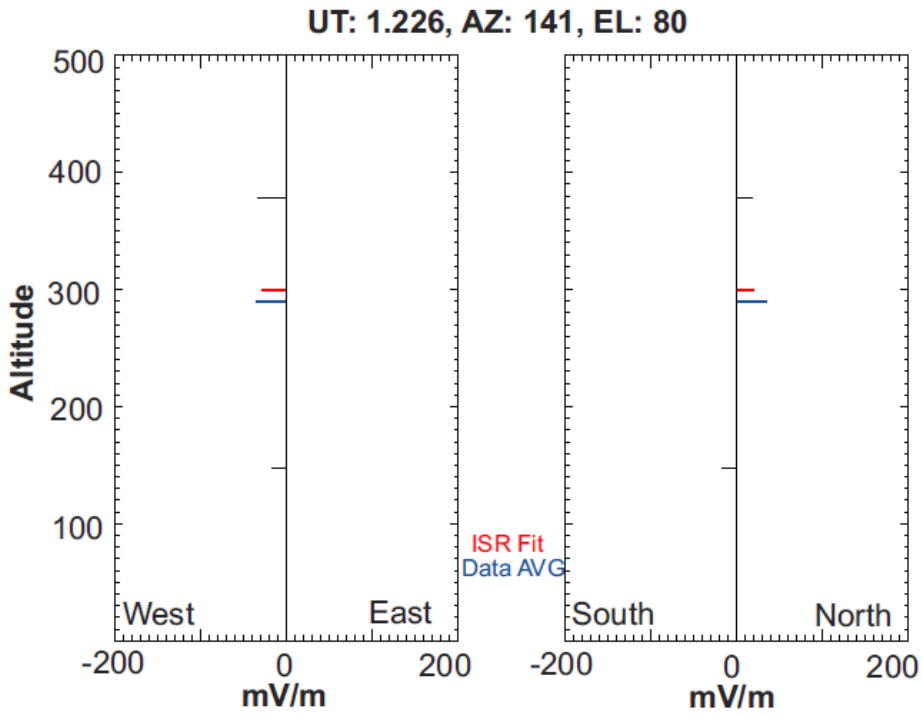
- Used 3 minute alternating pulse code data over 30 minutes
- Three locations chosen, cycled through each location
- Calculated $\mathbf{E} = -\mathbf{U}_{ion} \times \mathbf{B}$
- $\mathbf{U}_{ion}$ found was calculated from ISR and B provided by Madrigal subroutine in East-North-Up system
- $\mathbf{U}_{ion}$ data was selected based on which points had < 50% uncertainty
- Magnetic Midnight ~ 0200 UT, observations in evening/ midnight sector

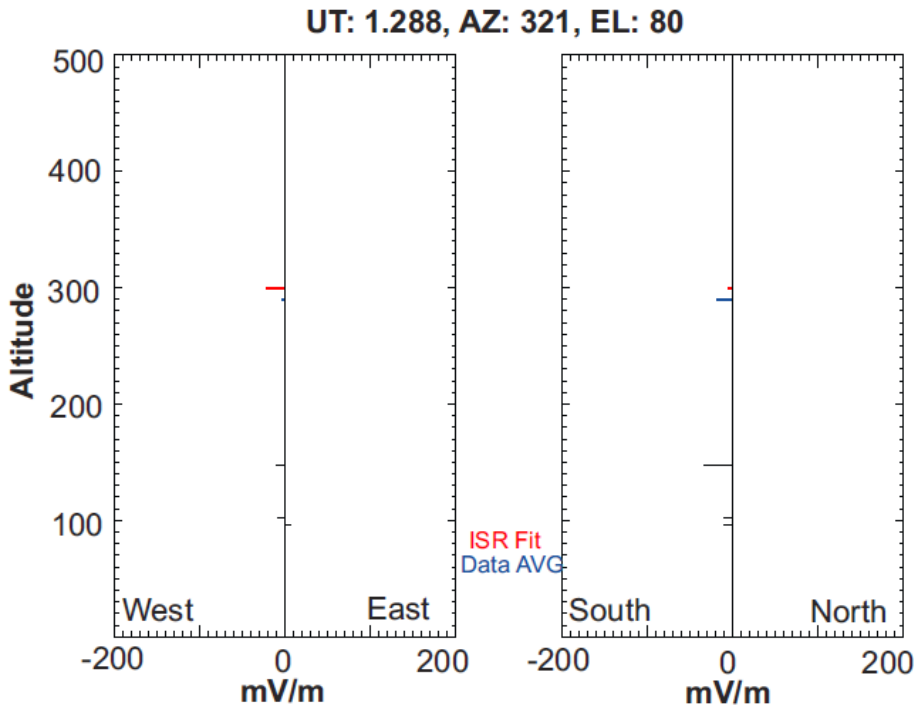
Electric Fields



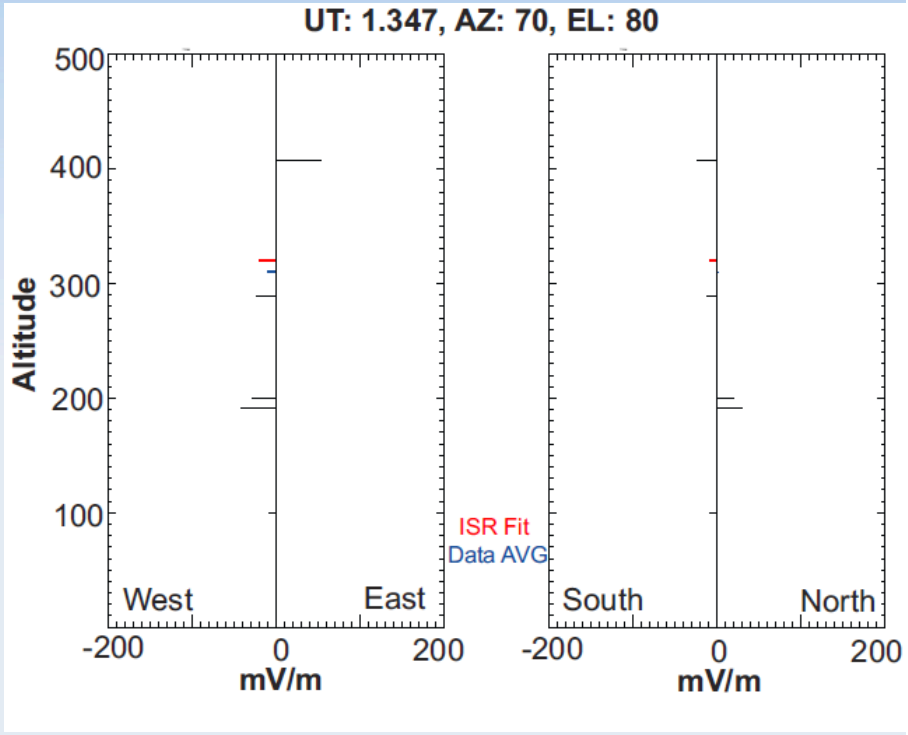


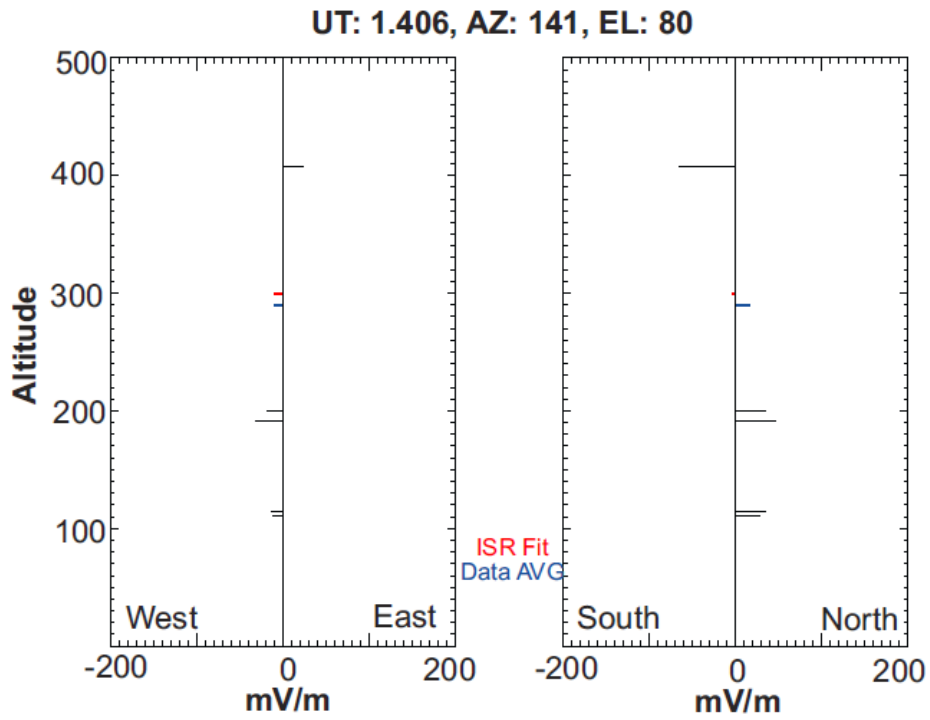
Electric Fields





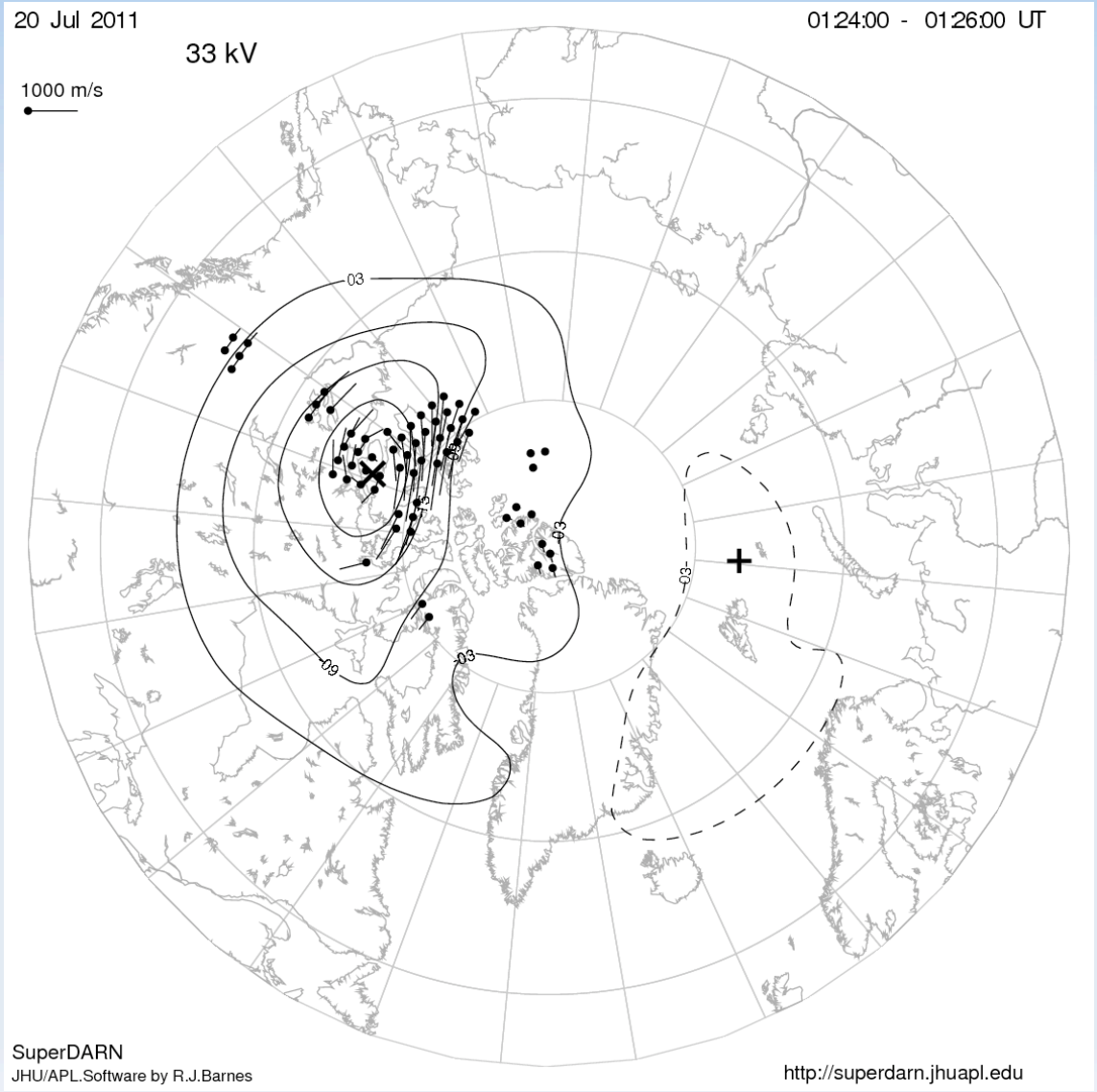
Electric Fields





Generally northward and westward directed electric fields

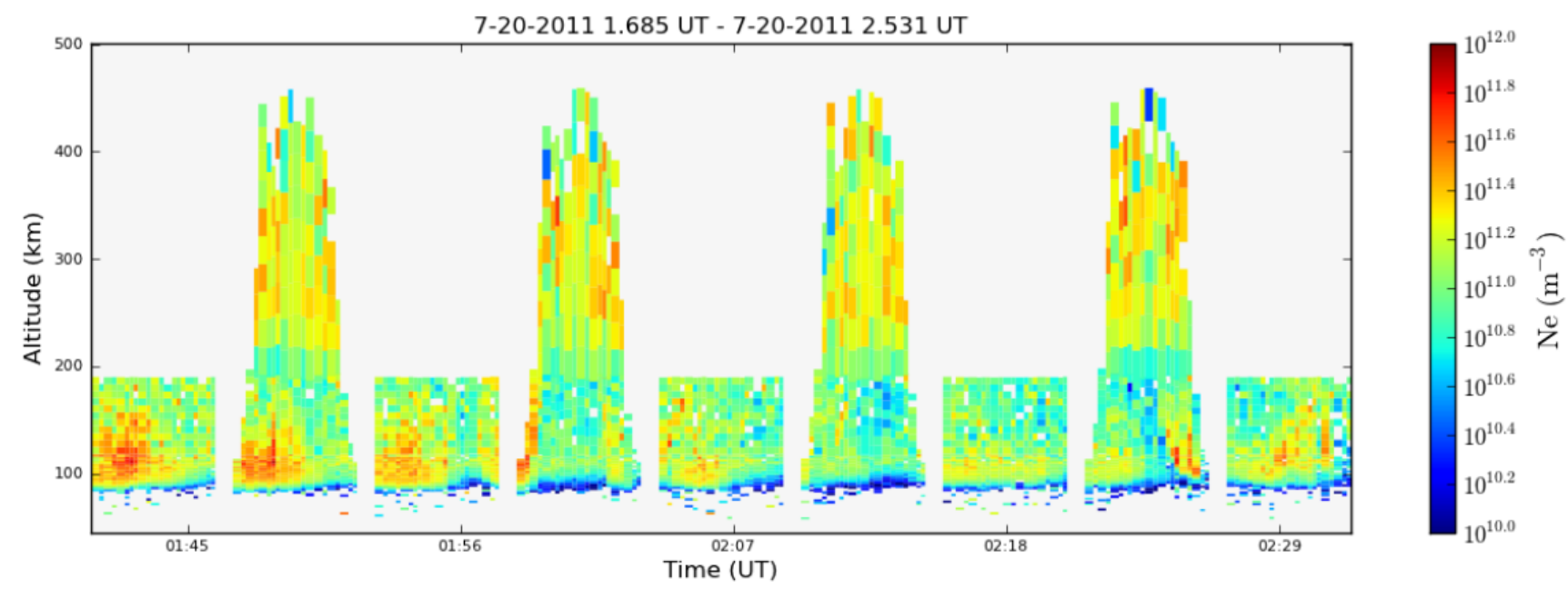
Electric Fields

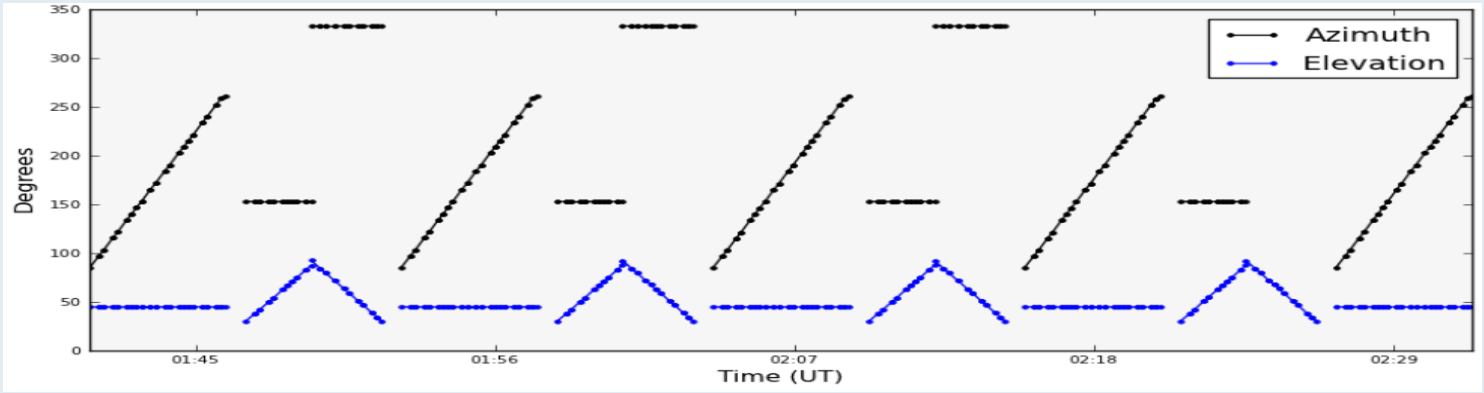


Results: Aurora or ...?

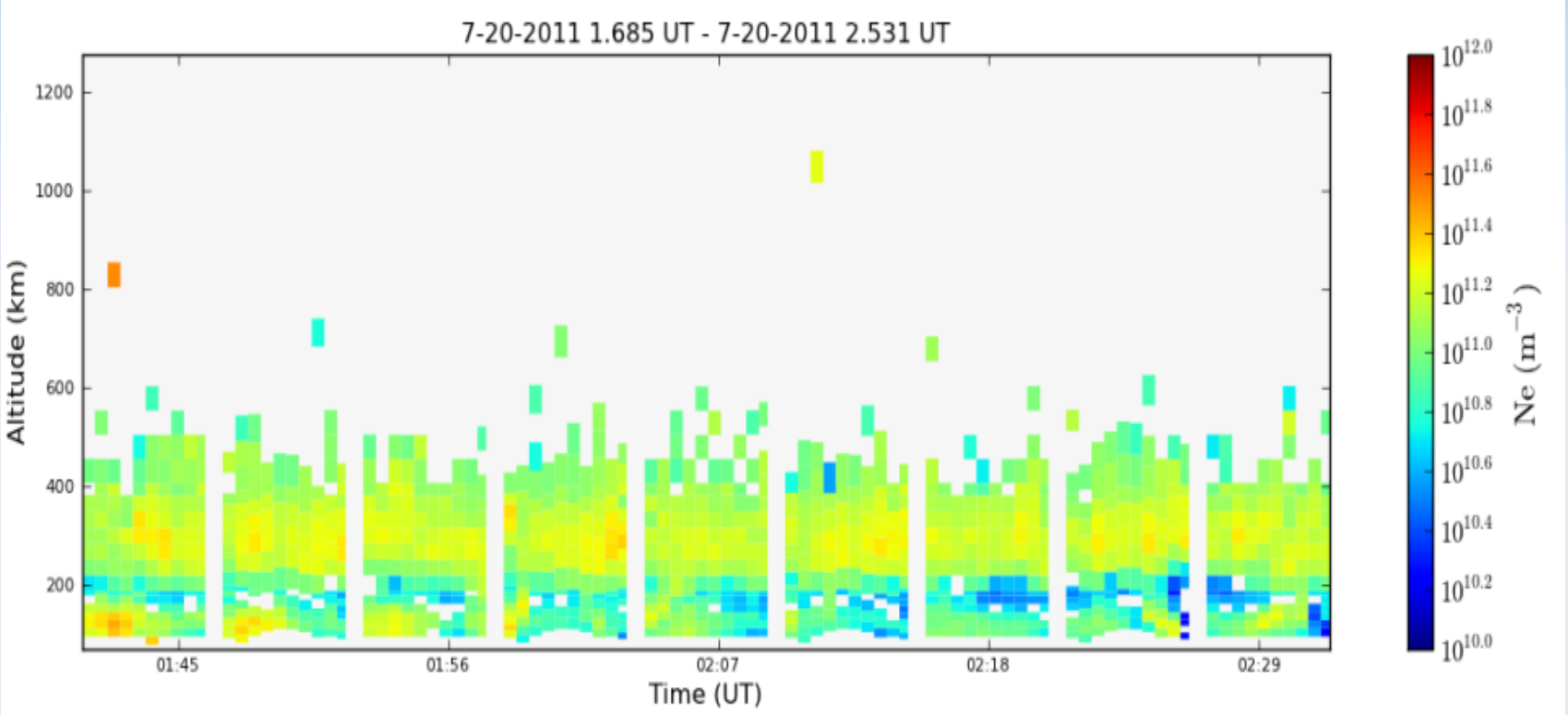
- In summer, visible detection of aurora is difficult
- Incoherent scatter radar can be used as a method of detection

Results: Periodic plasma density structures in ionosphere



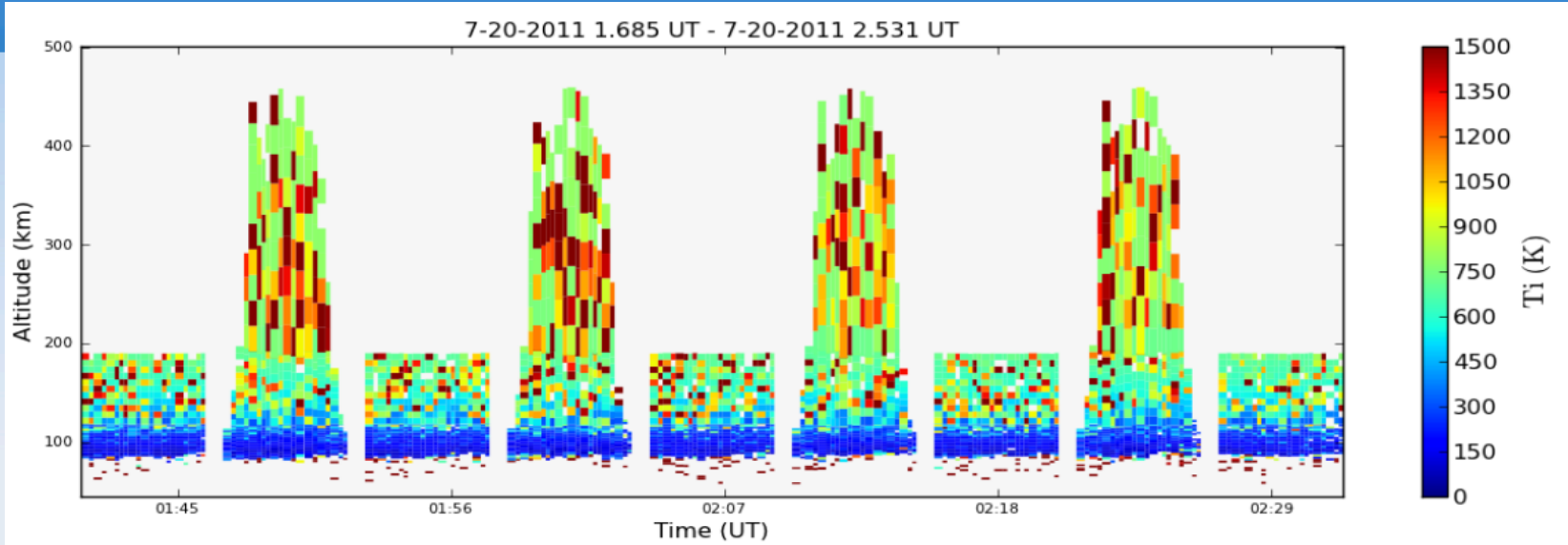


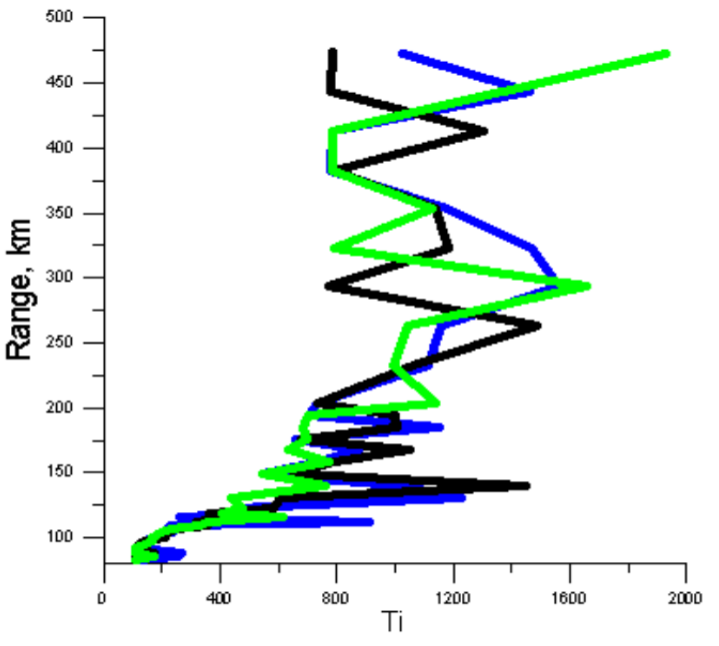
Larger pulse & Longer integration

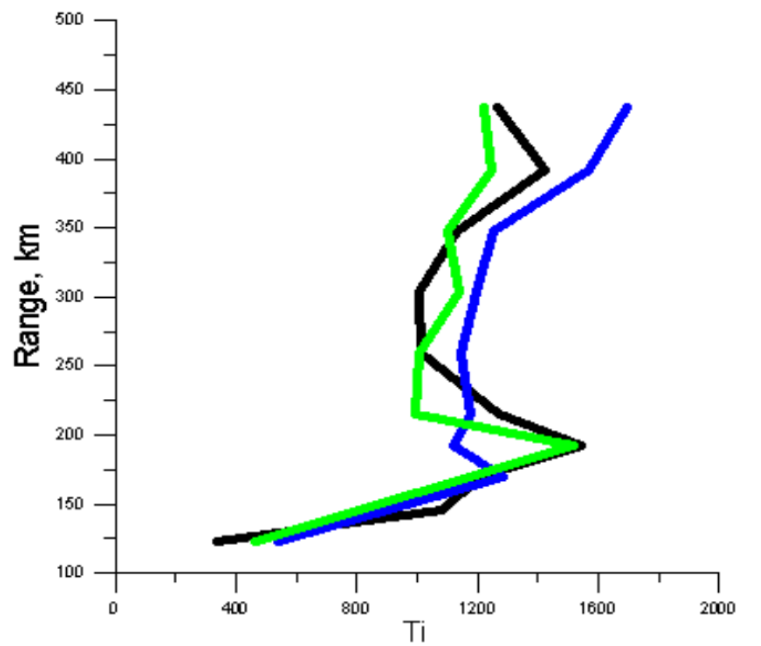


Are these measurements reliable ?

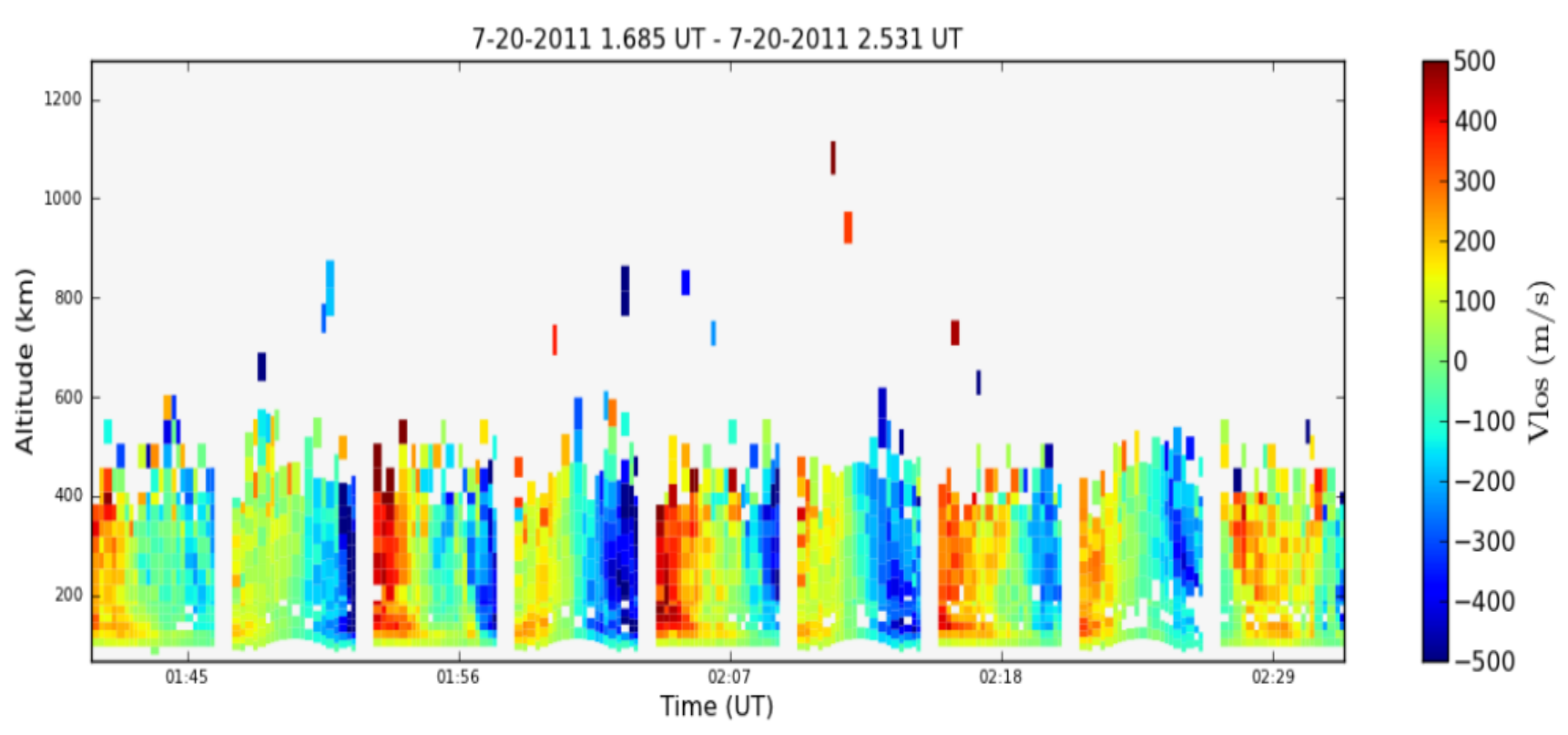
Ion temperature







Have a look at Doppler



Plasma flow is westward and northward

Horizontal gradients in field aligned current may be the cause of discrete structures in electron density

Results: Drifts/Neutral winds

Ionospheric movements:

- Winds:
  - Pressures
  - Temperatures
- Drifts::
  - Diffusion
  - Electric field
  - Winds

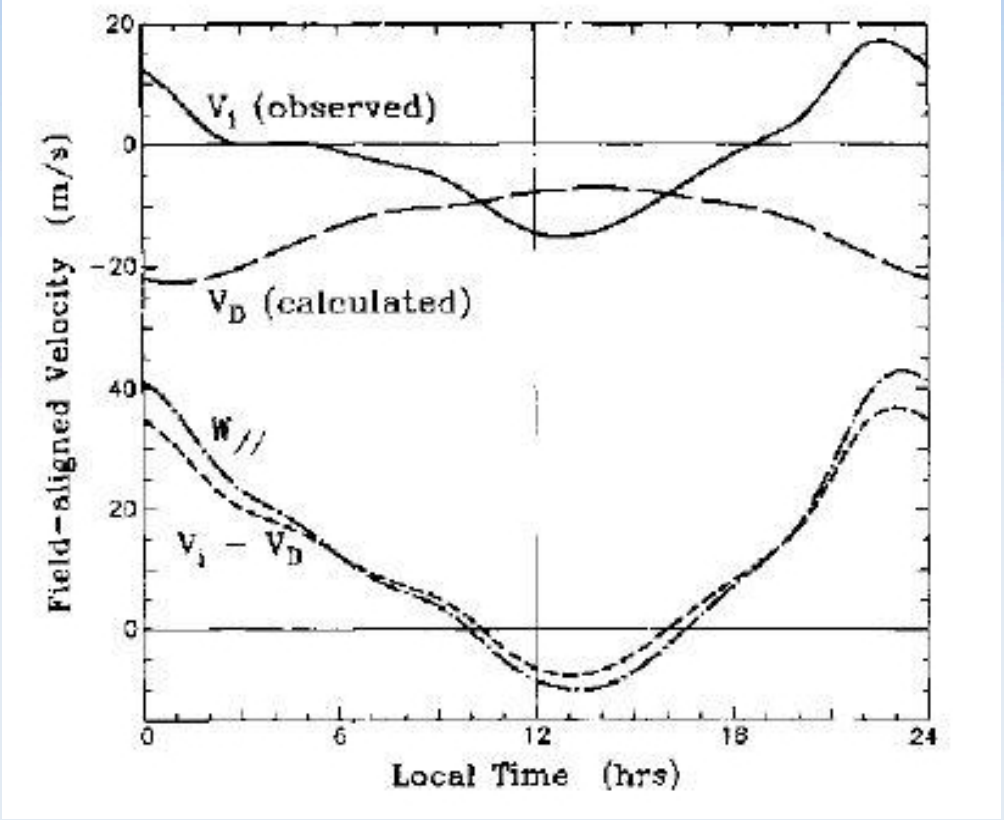
So?

LOS velocity =

wind + diffusion + electric fields

Results: Drifts/Neutral winds

- CP1: EISCAT measures ion velocity parallel to the B-field.
- Diffusion velocity: calculated from the height variations of Ne, Ti and Te.
- Vi-Vd gives us winds in the neutral atmosphere.



$$V_d = -\sin I \cdot D\left[\frac{\partial n_e}{\partial h}\cdot\frac{1}{n_e} + \left(\frac{1}{T_p}\frac{\partial T_p}{\partial h} + \frac{1}{H_p}\right)\right]$$

$$D = \frac{kT_p}{m^+\nu_{in}} \qquad H_p = \frac{kT_p}{m^+ g_{\|}}$$

$$V_m = (V_{los}\cdot\cos Y - V_d)/\cos I$$

- J.F. Titheridge «Mean meridional winds in the ionosphere at 70°N» Planet.Space Sci. vol.39 No. 5. pp.657-669, 1991

Results: Drifts/Neutral winds

	Ion Velocity, m/s	Diffusion, m/s	Wind, m/s
Dwell 1	-19	-21.2	40
Dwell 2	42	-21.3	392
Dwell 3	48	-21.3	426
Dwell 4	51	-21.3	442
Dwell 5	-11	-21.4	85
Dwell 6	-15	-21.4	63

Conclusions:

The results are in good agreement with the results obtained by Titheridge.

I guess

Conclusions

We got better in ionospheric studies....

We done our best...

We ate chocolate, listened to music and argued...

...went on group therapy hikes....

...and we didn’t even agree with eachother in the end....

.....but....


We had an assume time trying!

References

- J.F. Titheridge «Mean meridional winds in the ionosphere at 70°N» Planet.Space Sci. vol.39 No. 5. pp.657-669, 1991