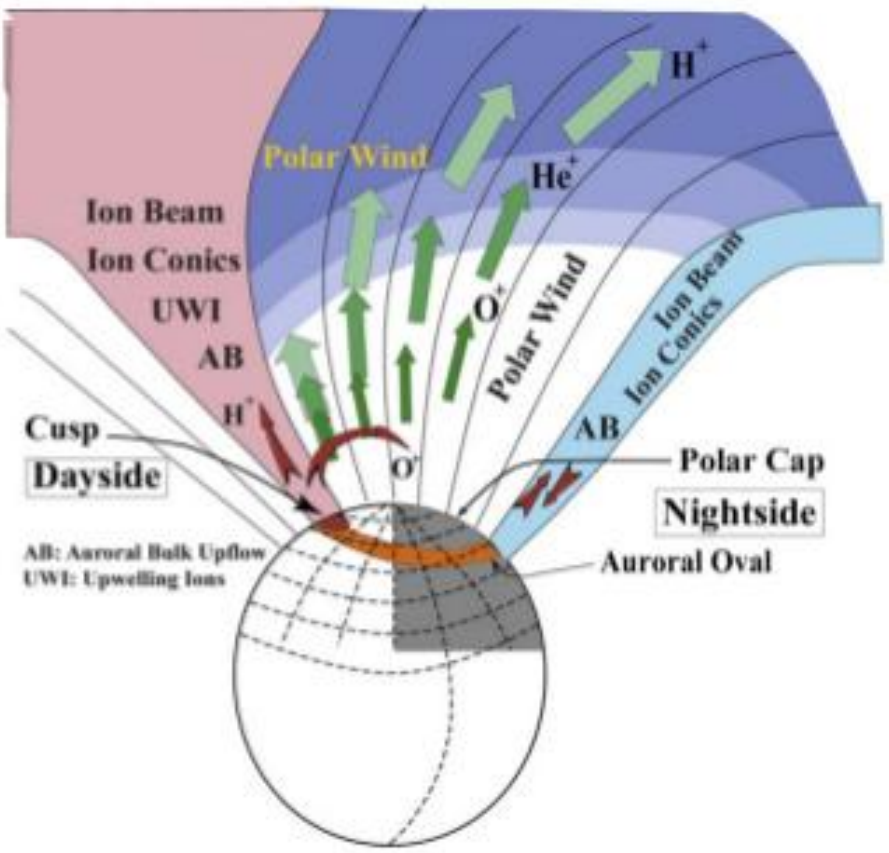
Group 4: Observations of particle precipitation and ion heating events

Zac Berkowitz[1], Philip Fernandes[2], Melessew Gereme[3], Rob Gillies[4] and Daniel Kramer[5]

International ISR Workshop
Kangerlussuaq, Greenland
July 23, 2011

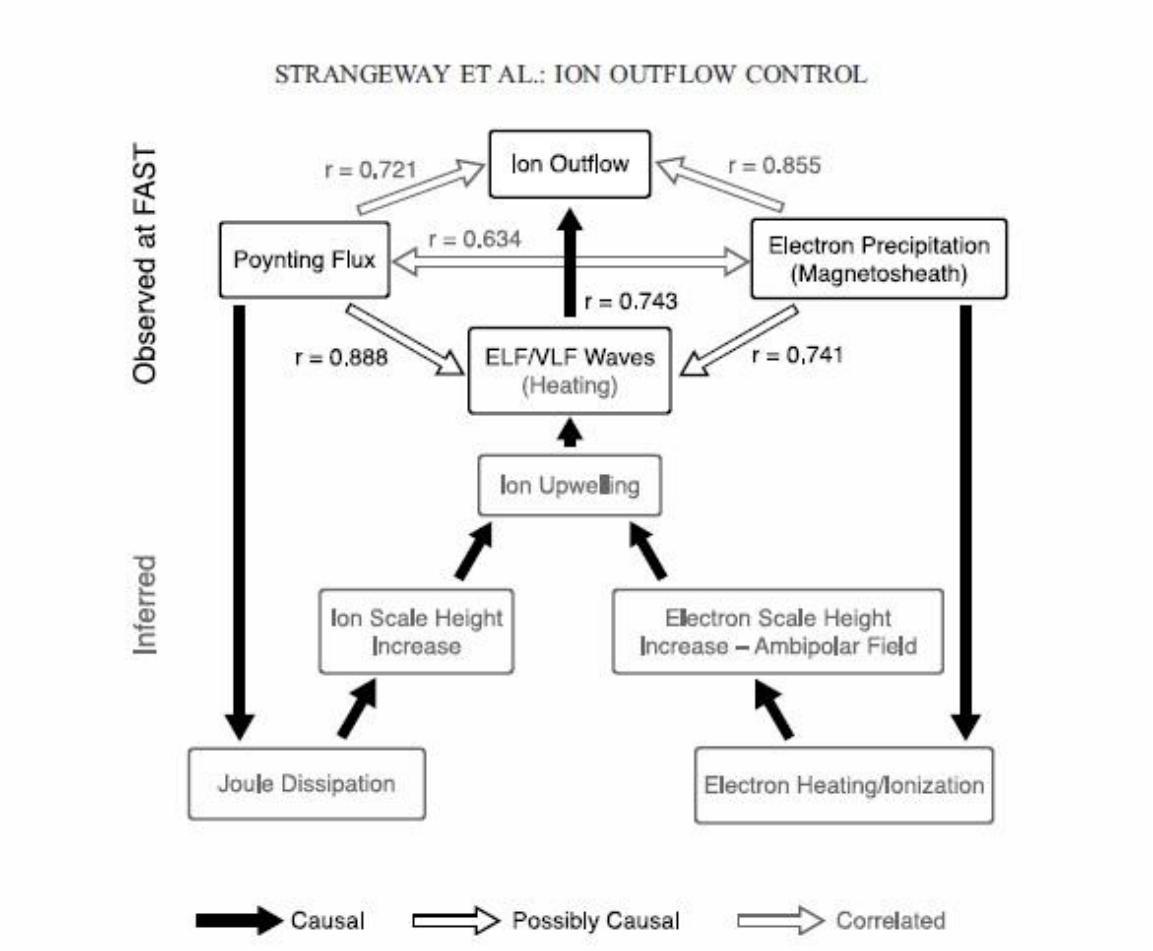
1. University of Washington, USA
2. Dartmouth College, USA
3. University of Bahir Dar, Ethiopia
4. University of Saskatchewan, Canada
5. University of Trier, Germany

Motivation: Ion Upflow



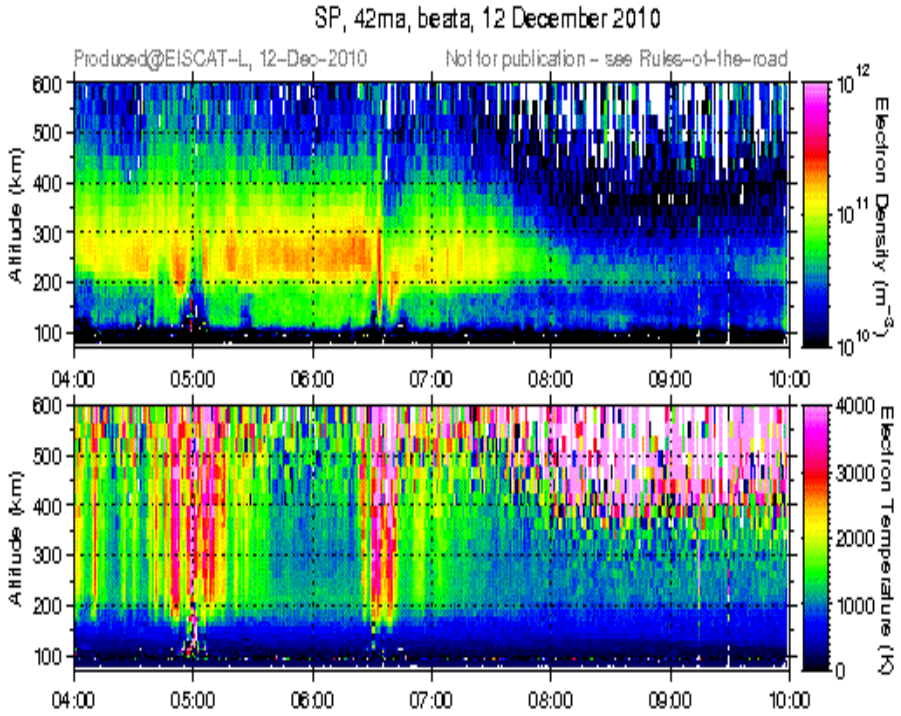
Yau et al., 2006

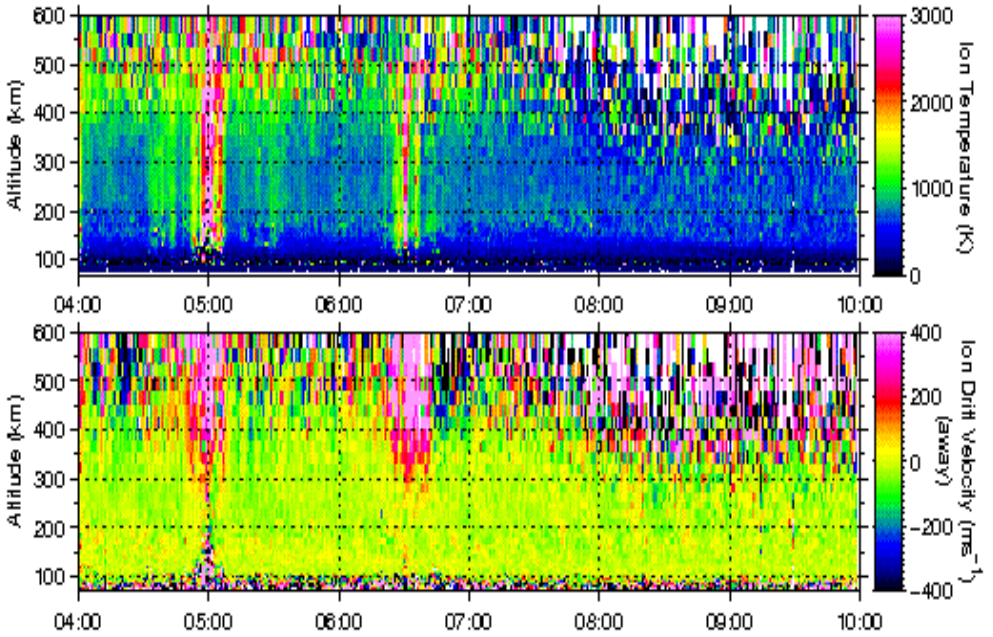
Ion Up/Outflow



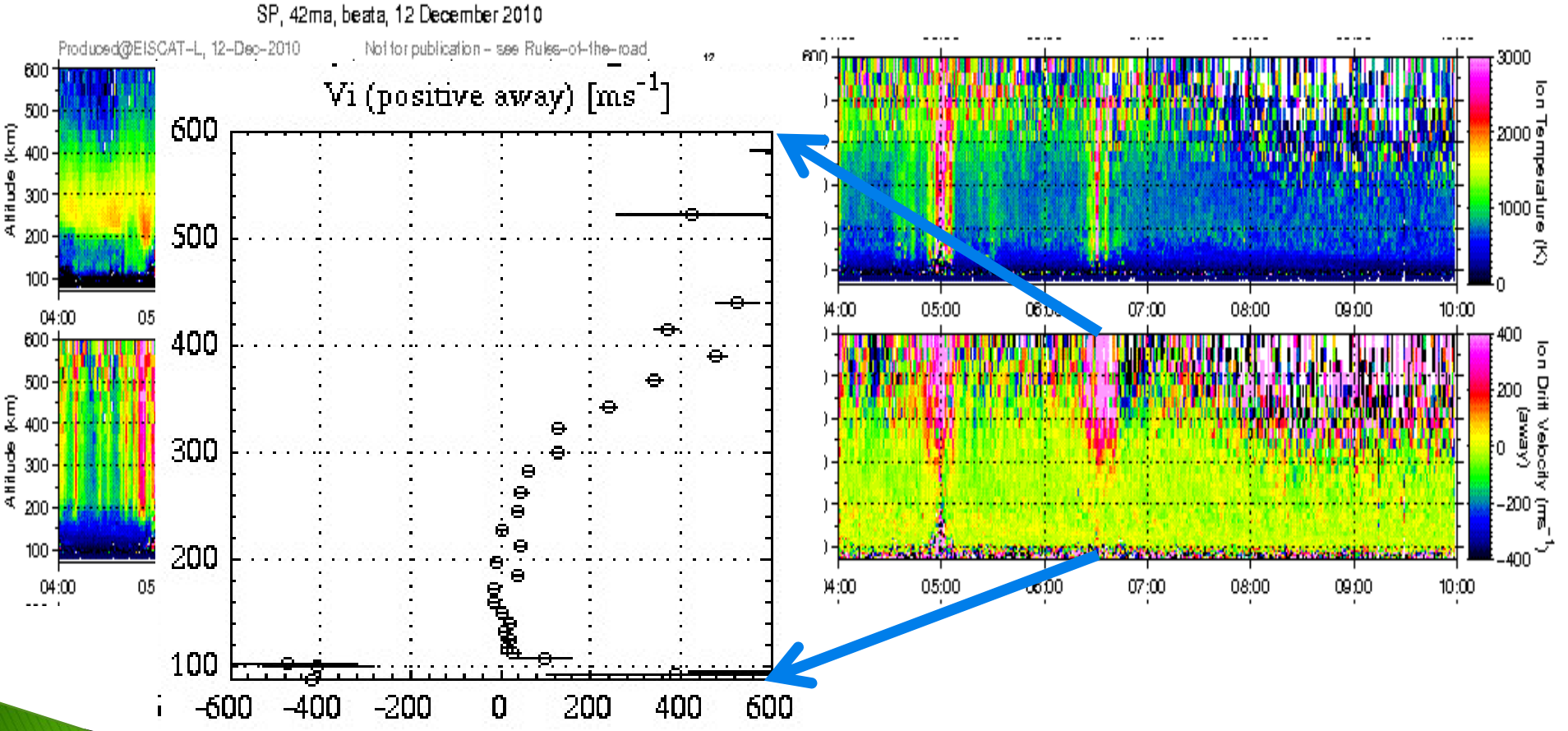
Strangeway et al., 2005

Typical ion upflow example





Typical ion upflow example



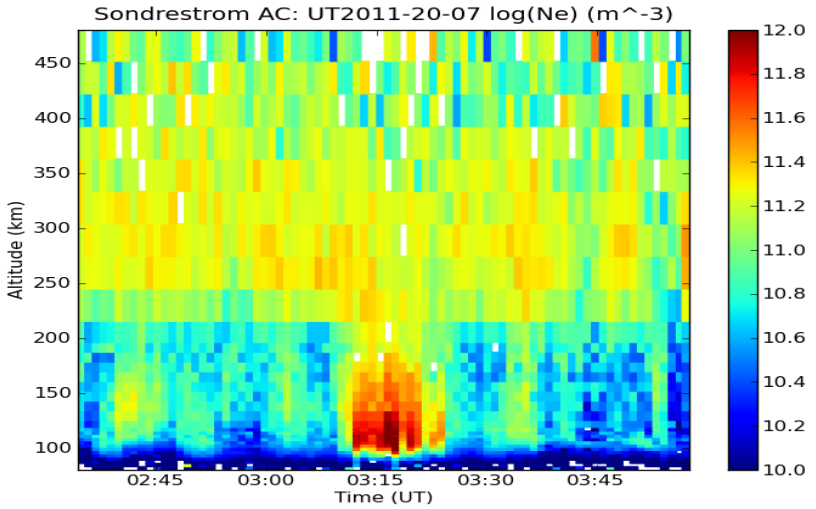
Experiment Setup

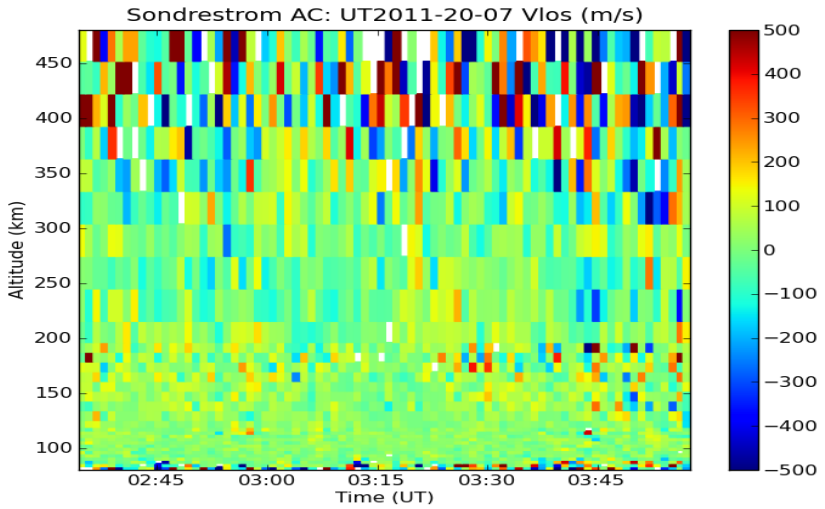
- General
  - Anti-parallel to magnetic fieldline
  - Time: 2:30 – 4:00 UT

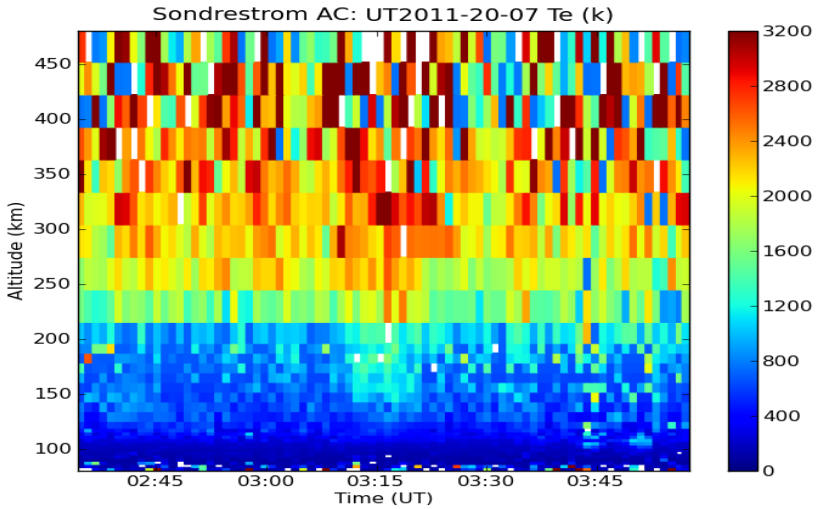
- Sondrestrom ISR:
  - Mode: Option 2 (AC/LP)
  - Output: 1min 5min

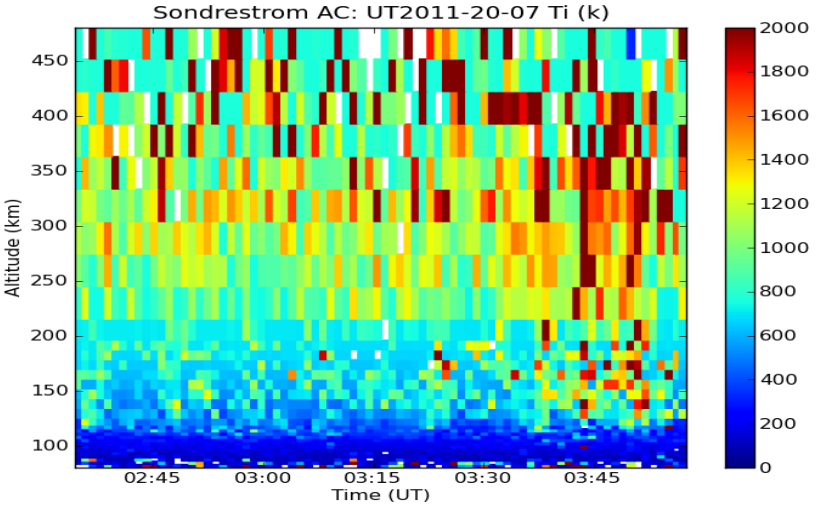
- EISCAT:
  - Mode: CP-1
  - Tristatic observations

Sondrestrom AC data:

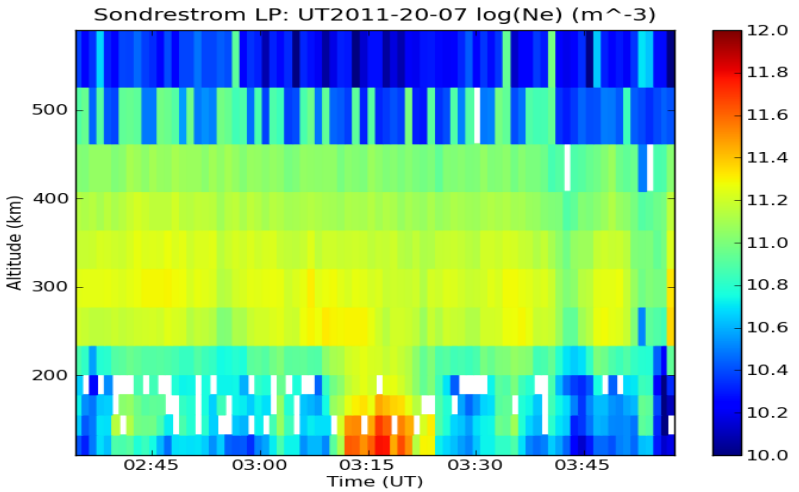


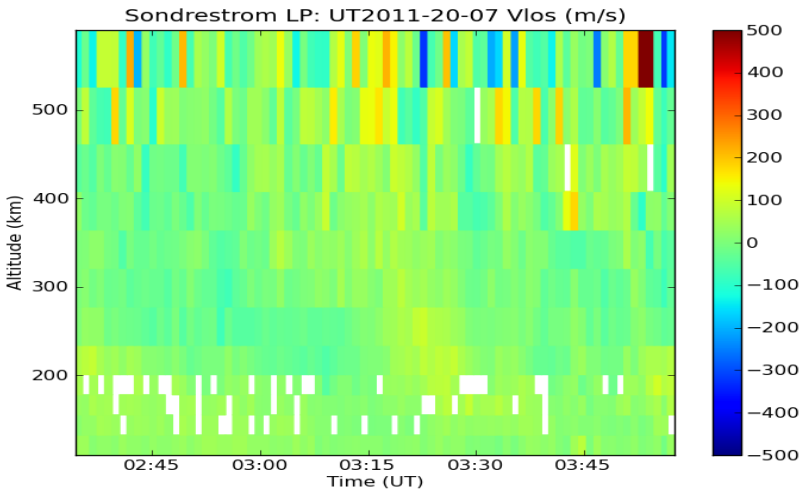


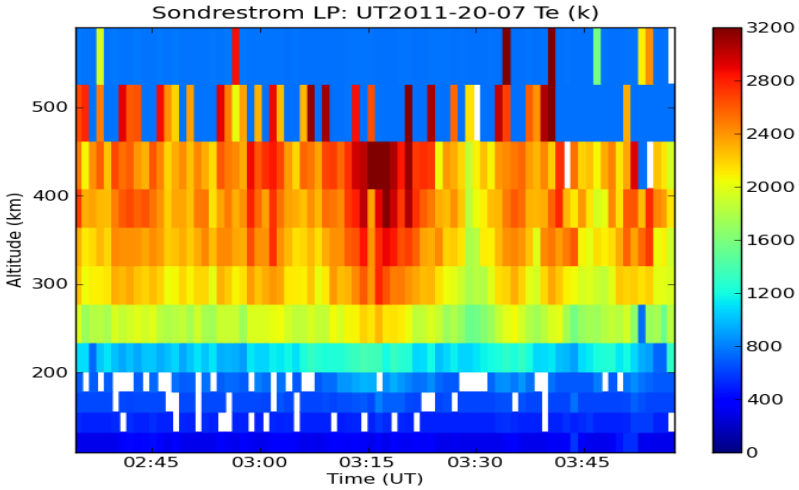


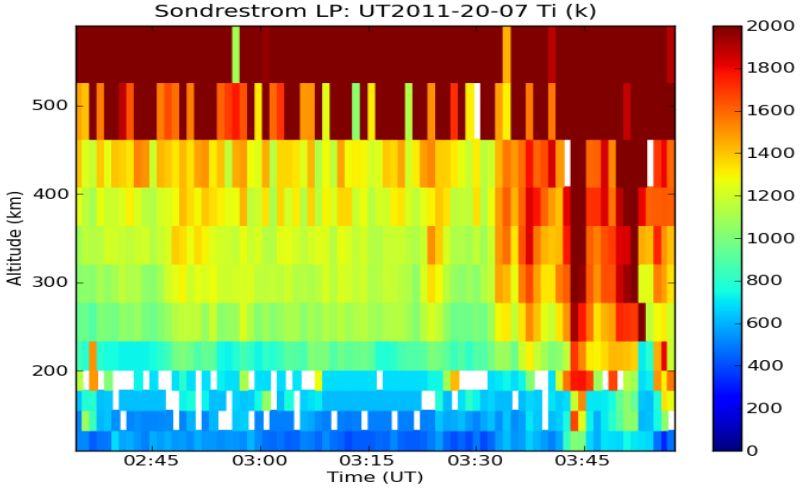


Sondrestrom LP data:

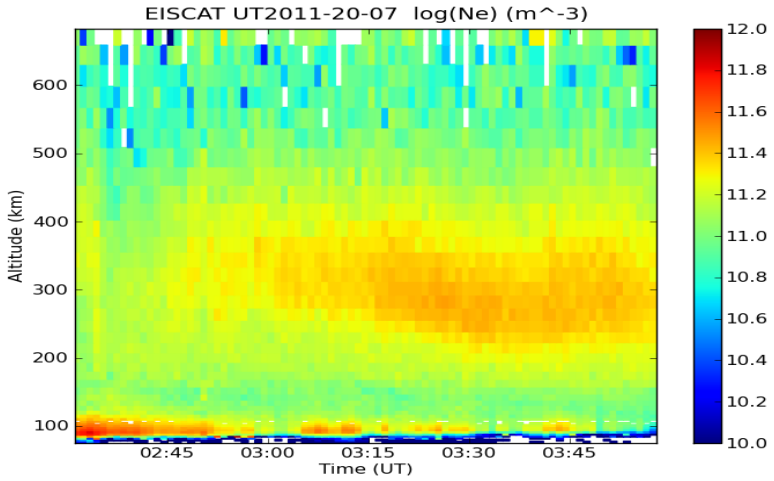


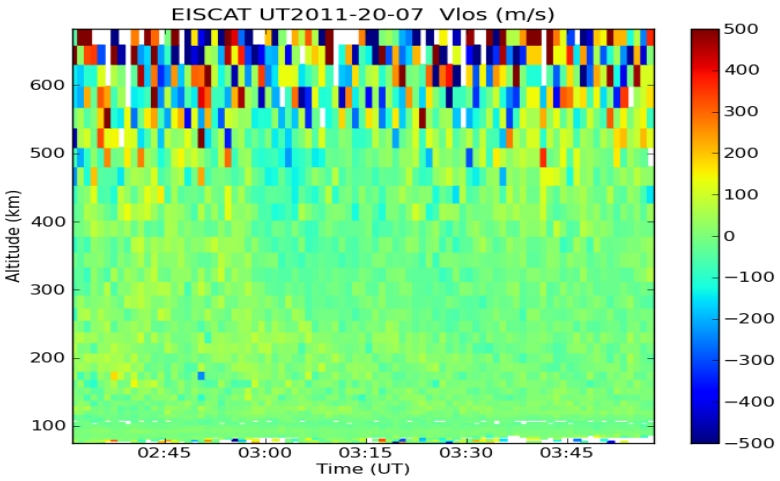


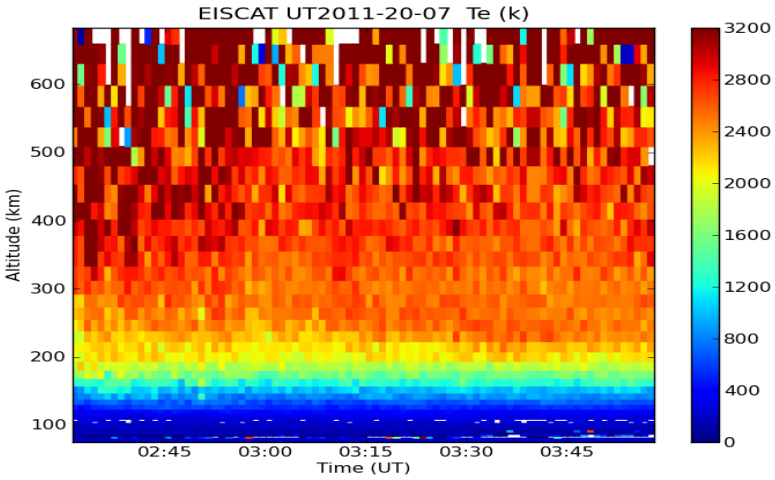


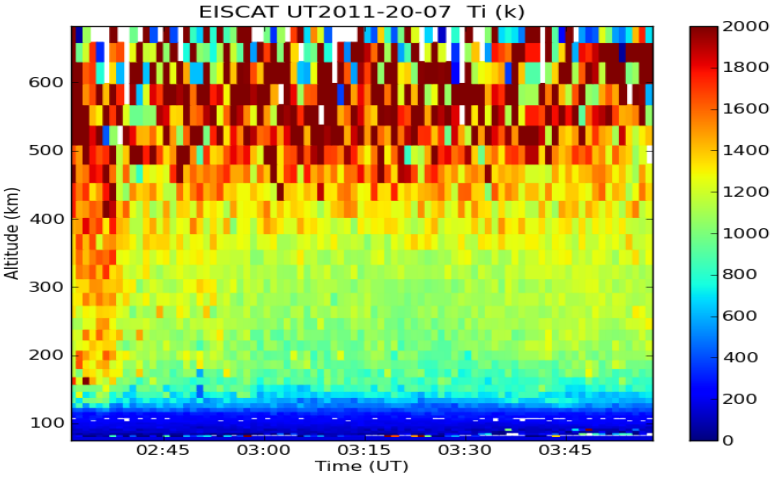


EISCAT data:

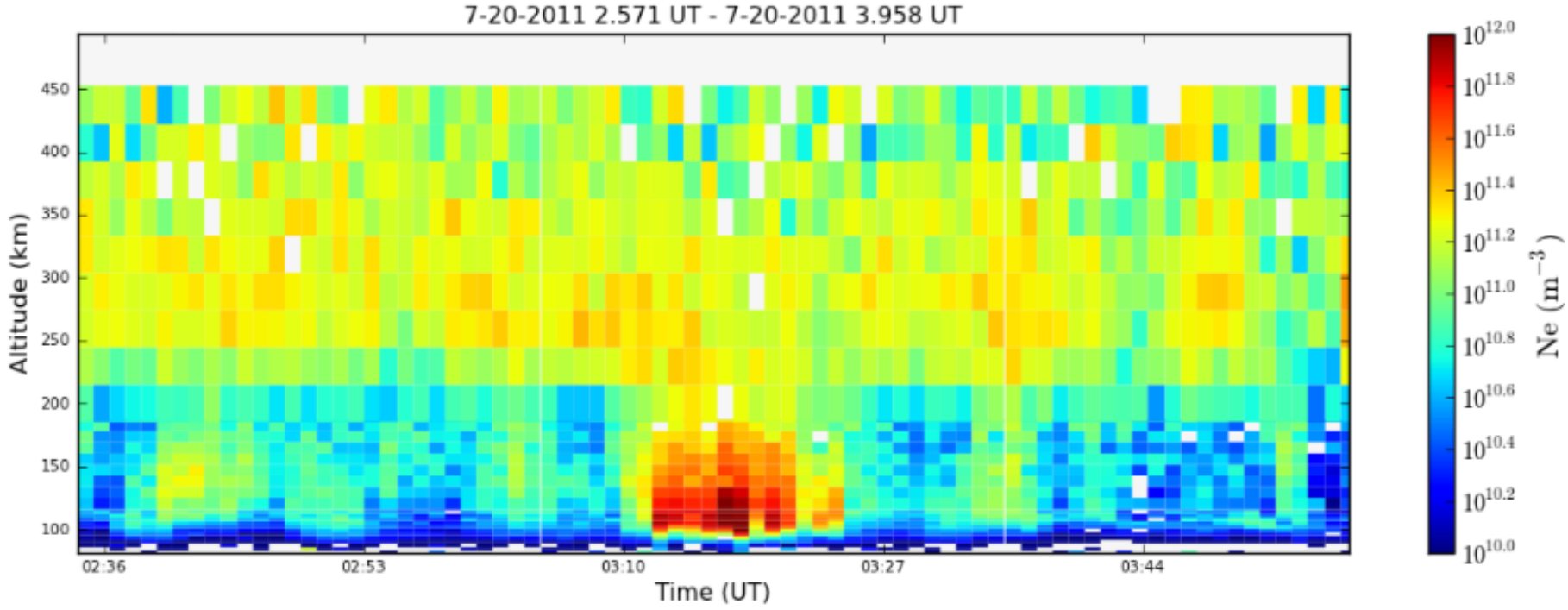

EISCAT UT2011-20-07 log(Ne) (m^-3)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
12.0
11.8
11.6
11.4
11.2
11.0
10.8
10.6
10.4
10.2
10.0


EISCAT UT2011-20-07 Vlos (m/s)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
500
400
300
200
100
0
−100
−200
−300
−400
−500

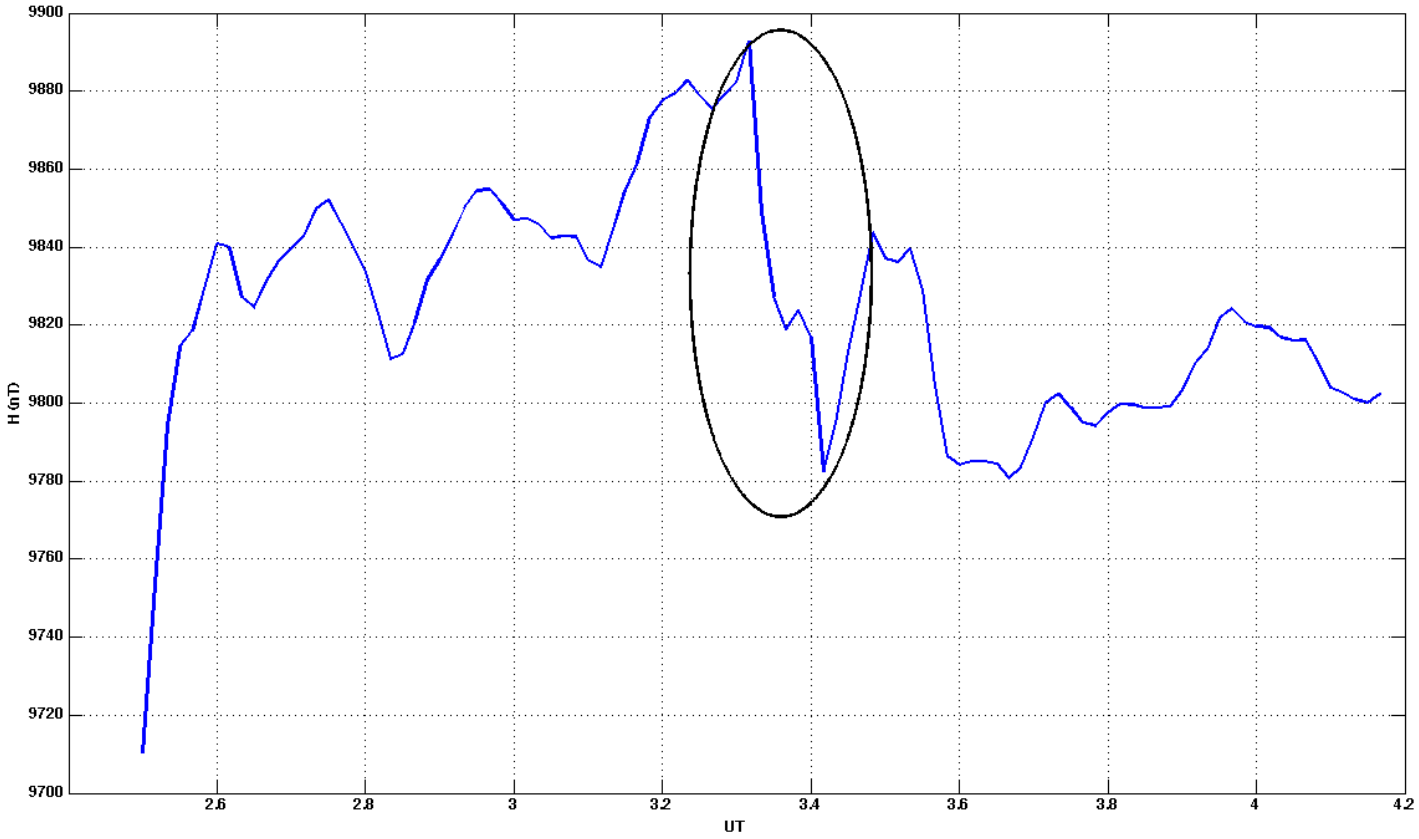

EISCAT UT2011-20-07 Te (k)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
3200
2800
2400
2000
1600
1200
800
400
0


EISCAT UT2011-20-07 Ti (k)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
2000
1800
1600
1400
1200
1000
800
600
400
200
0

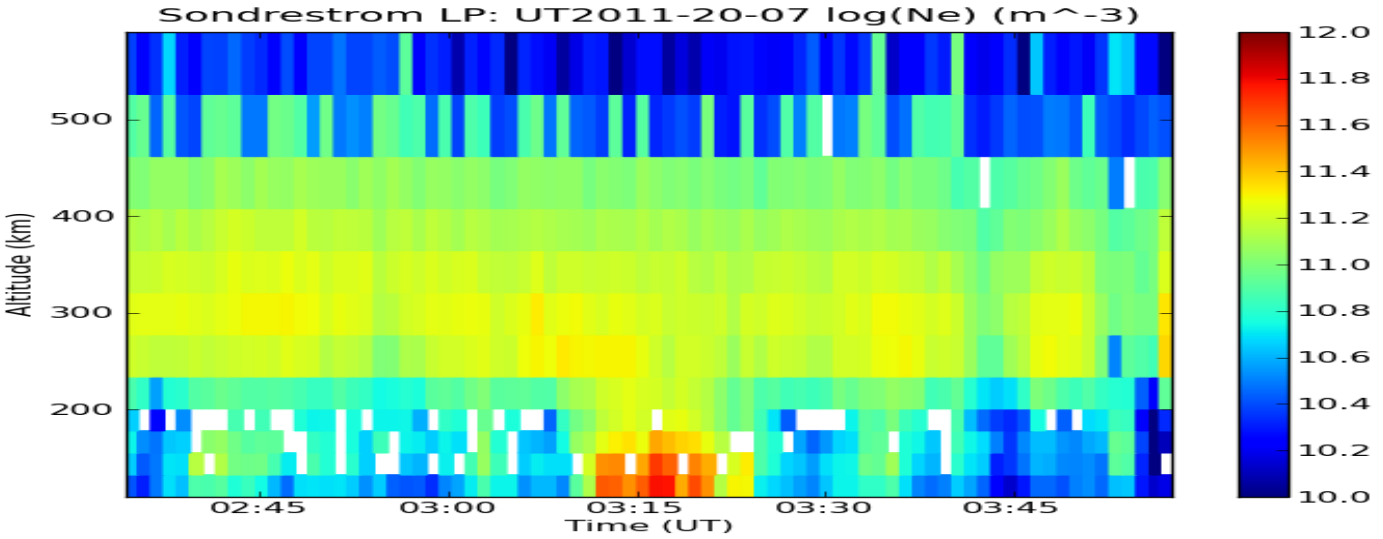
Particle precipitation event

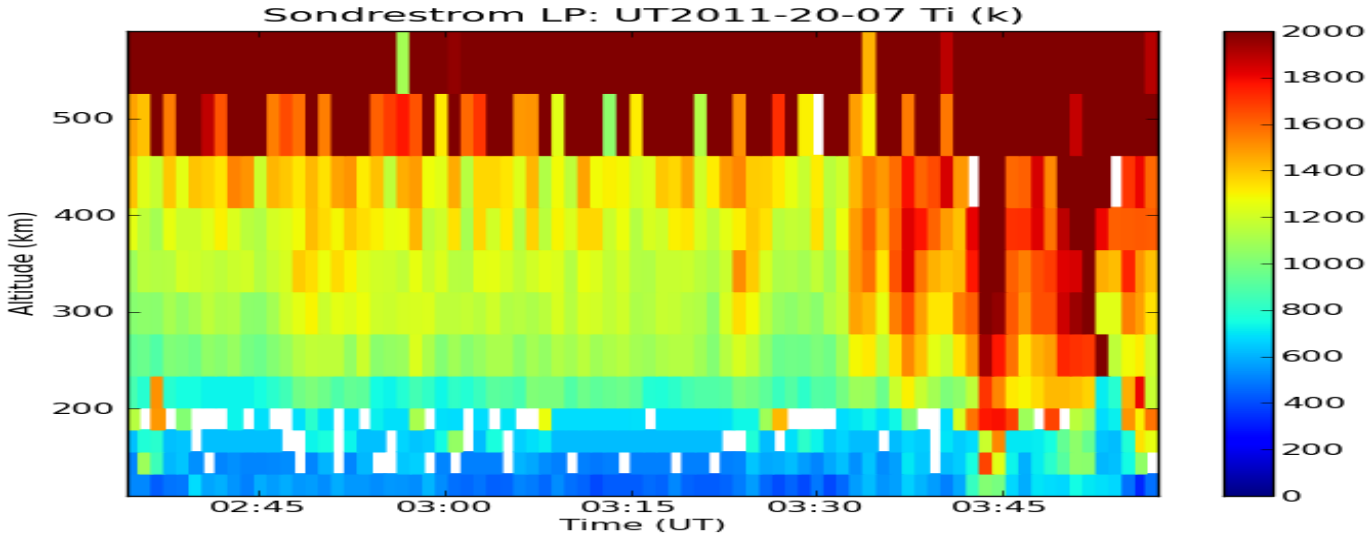


Sondrestrom magnetometer



F-region ion heating event



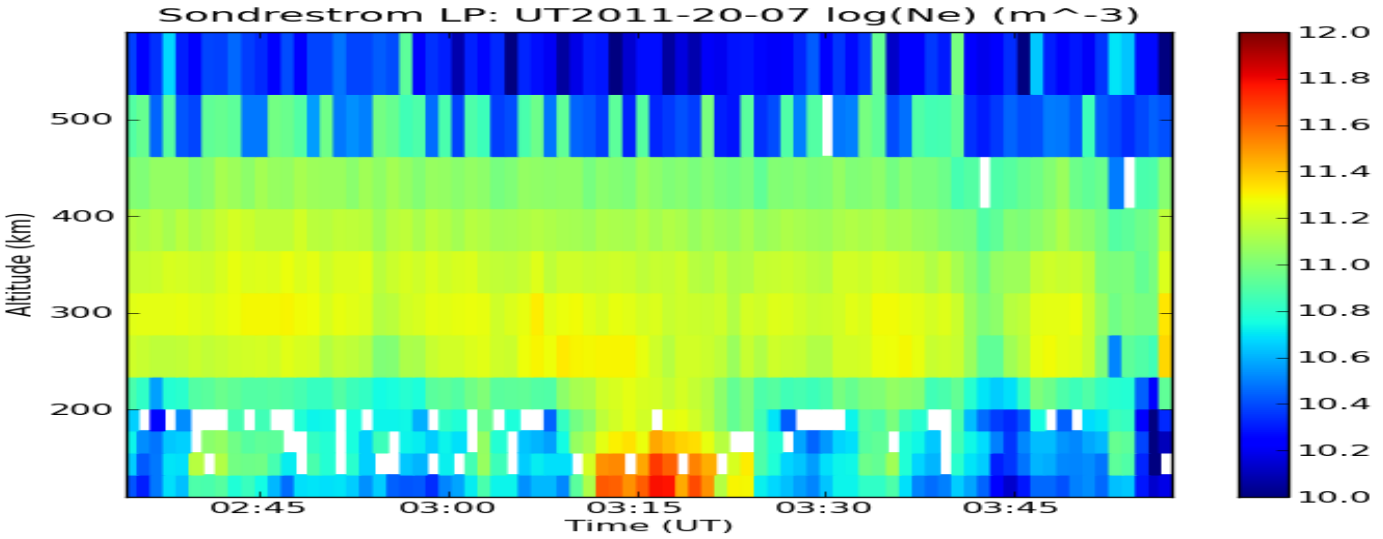


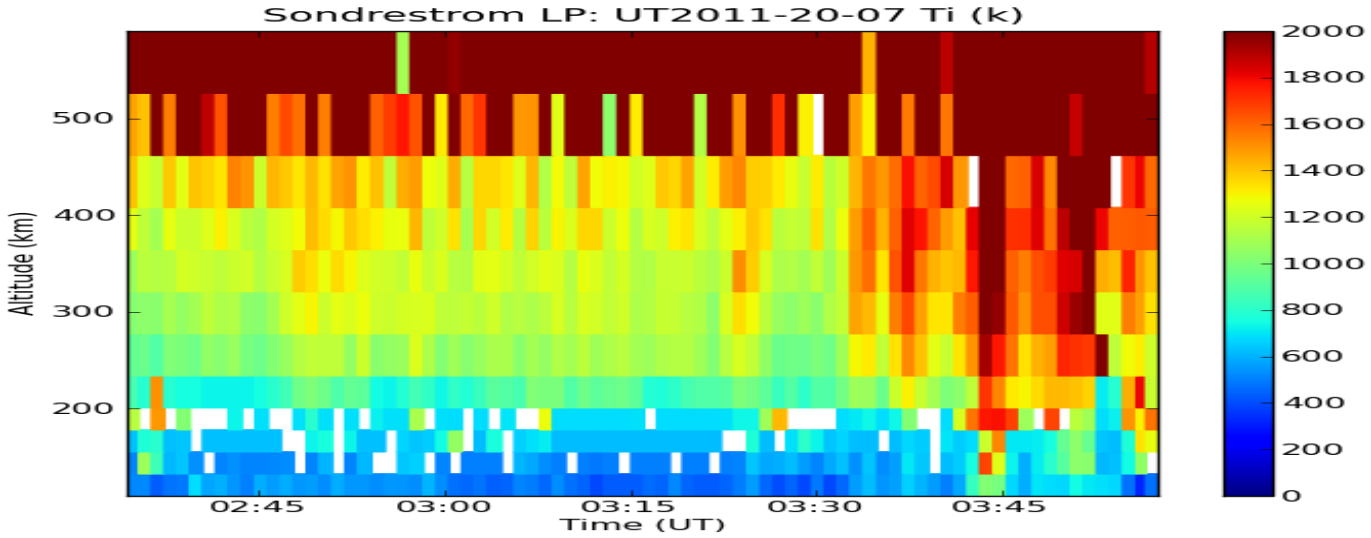
Joule / Frictional Heating

- Due to ion-neutral velocity difference
- Ion temp. increases due to collisions w/ neutrals
- Neutral gas upwells, raising concentration of N2 in F region
- Electron density measured by ISR may show depletion region due to:
  - Disturbed chemical composition altitude profile
  - Raised recombination rate due to ion heating and perturbed neutral density

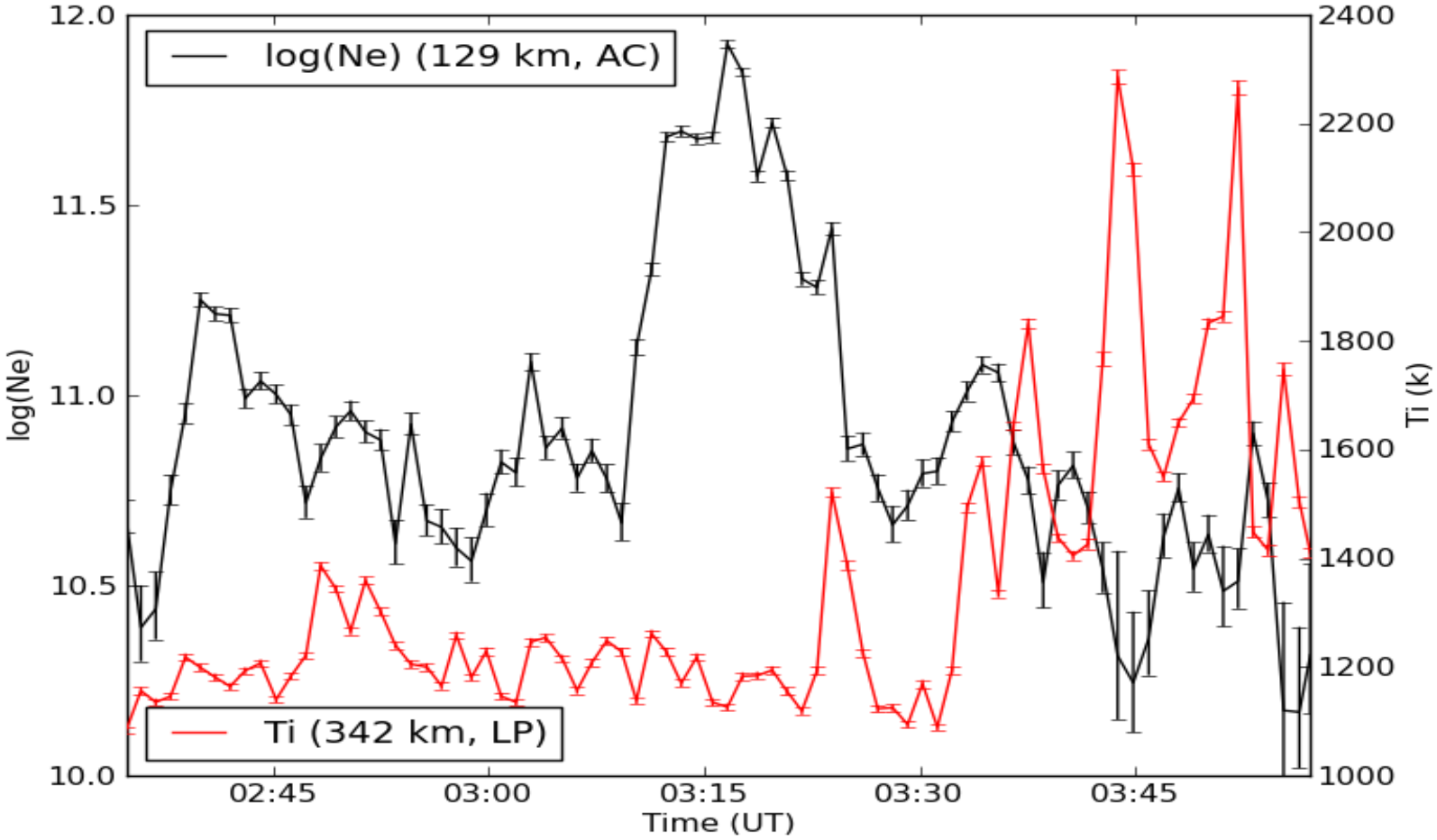
Killeen et al., 1984

F-region ion heating event

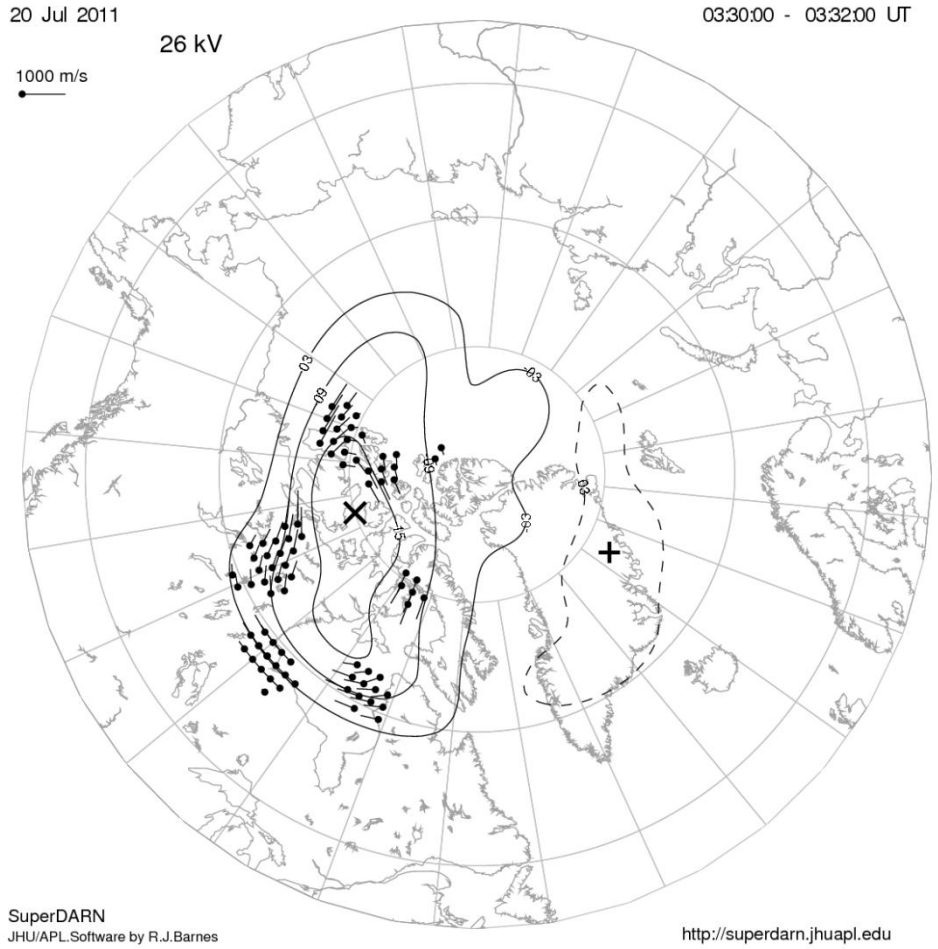




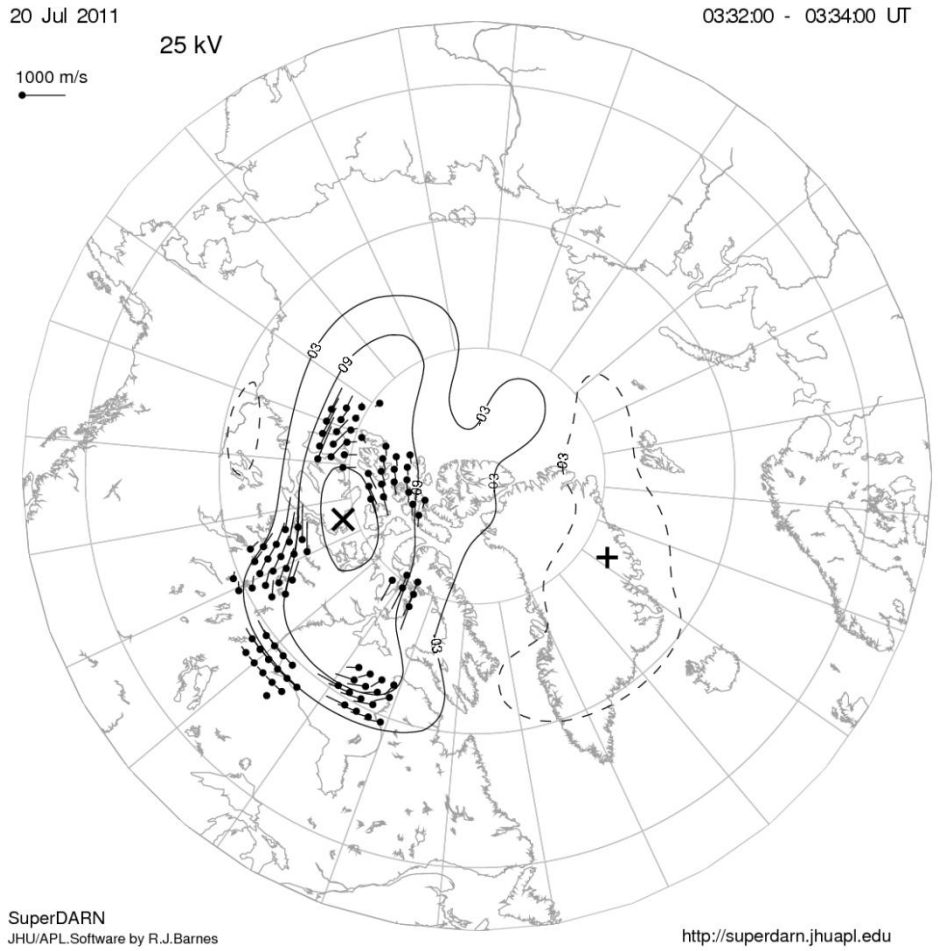
Ion temperature and density



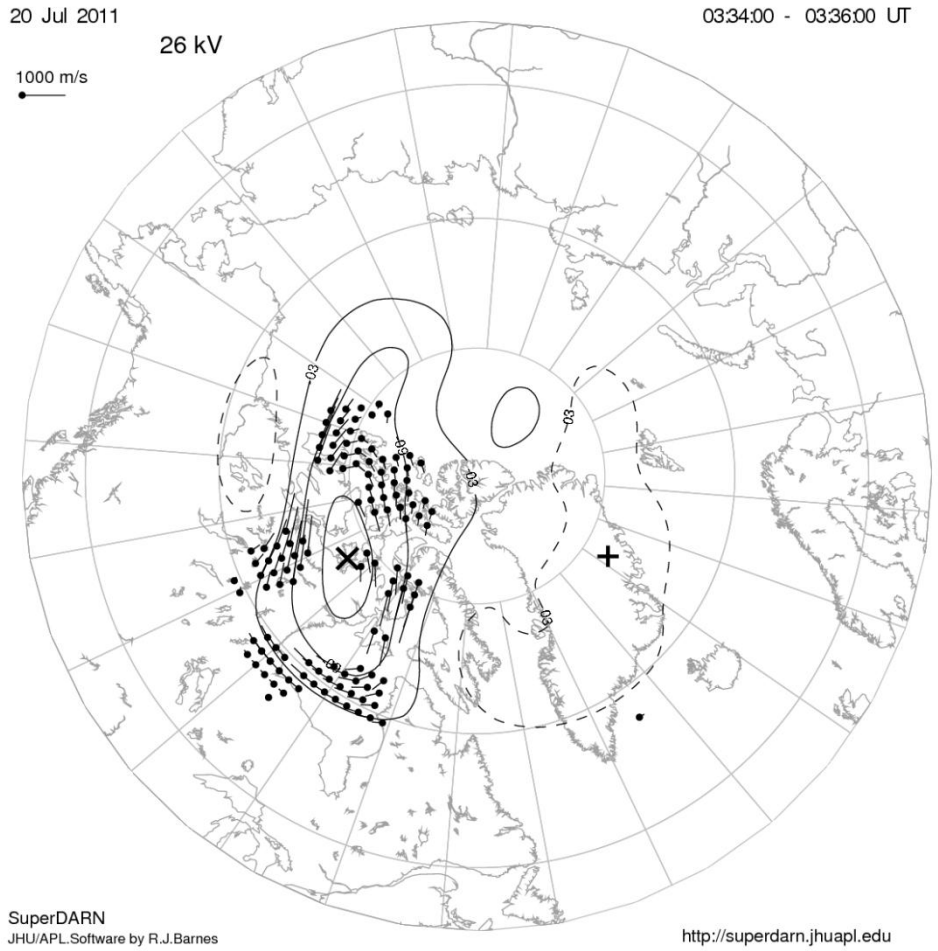
SuperDARN convection maps



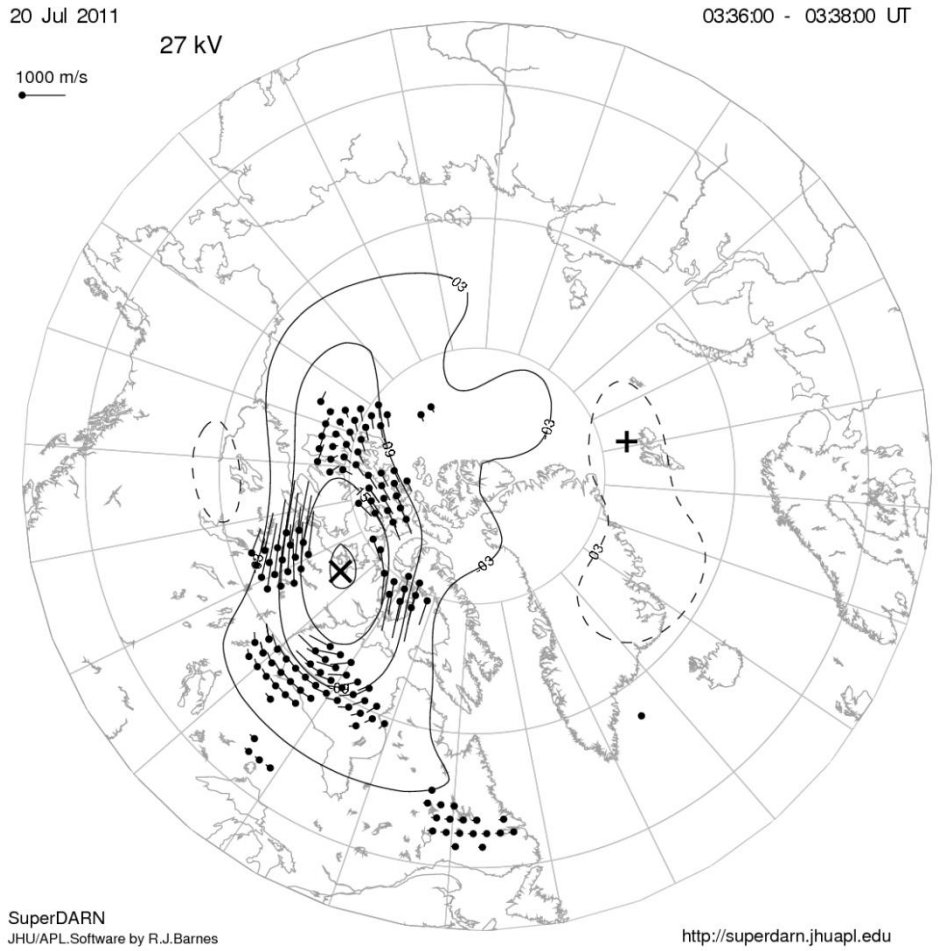
SuperDARN convection maps



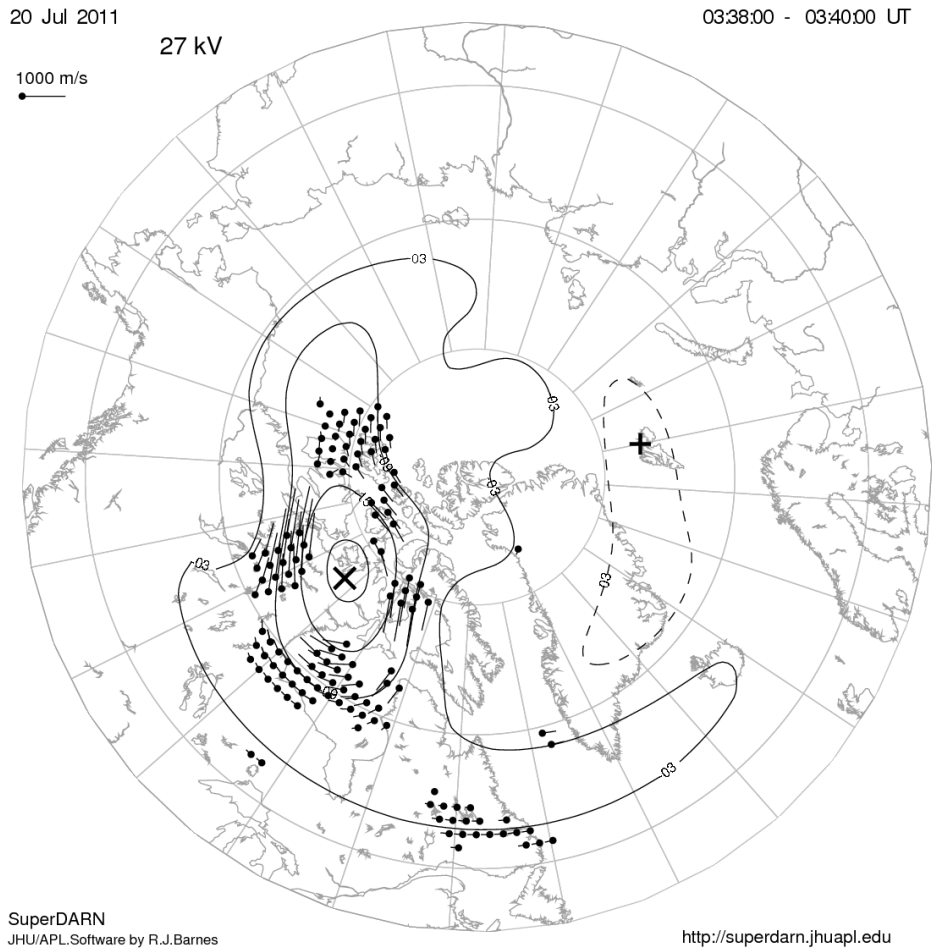
SuperDARN convection maps



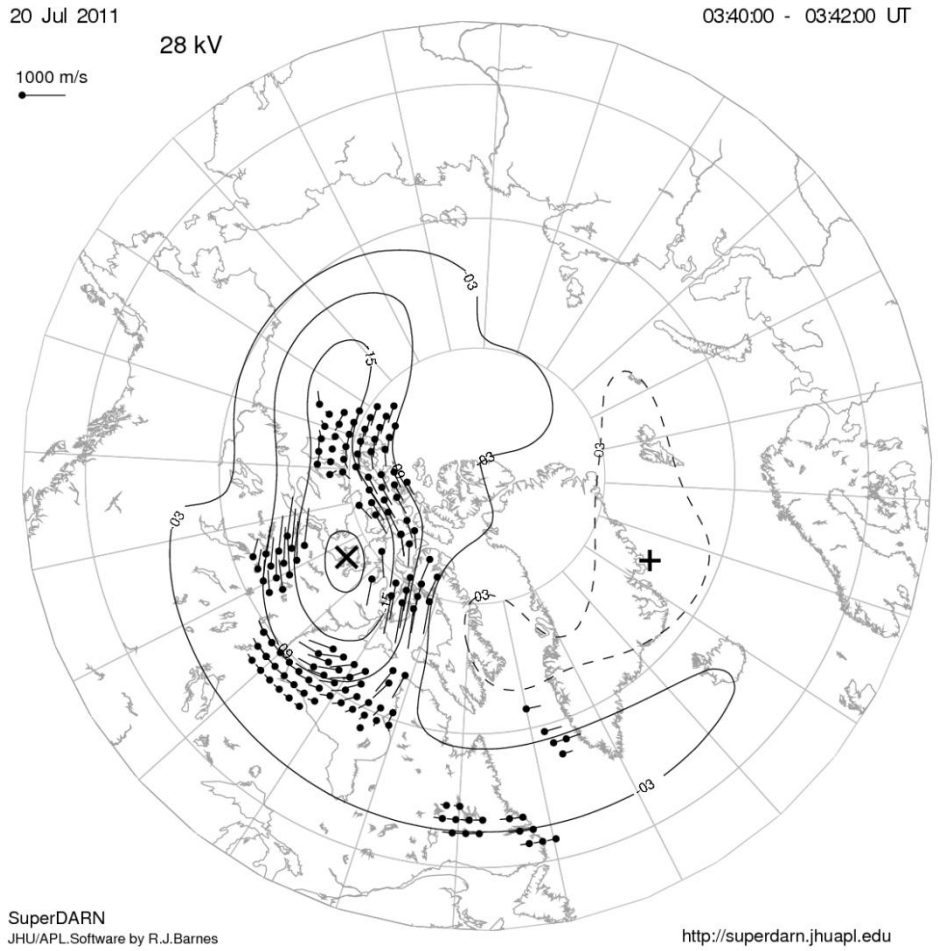
SuperDARN convection maps



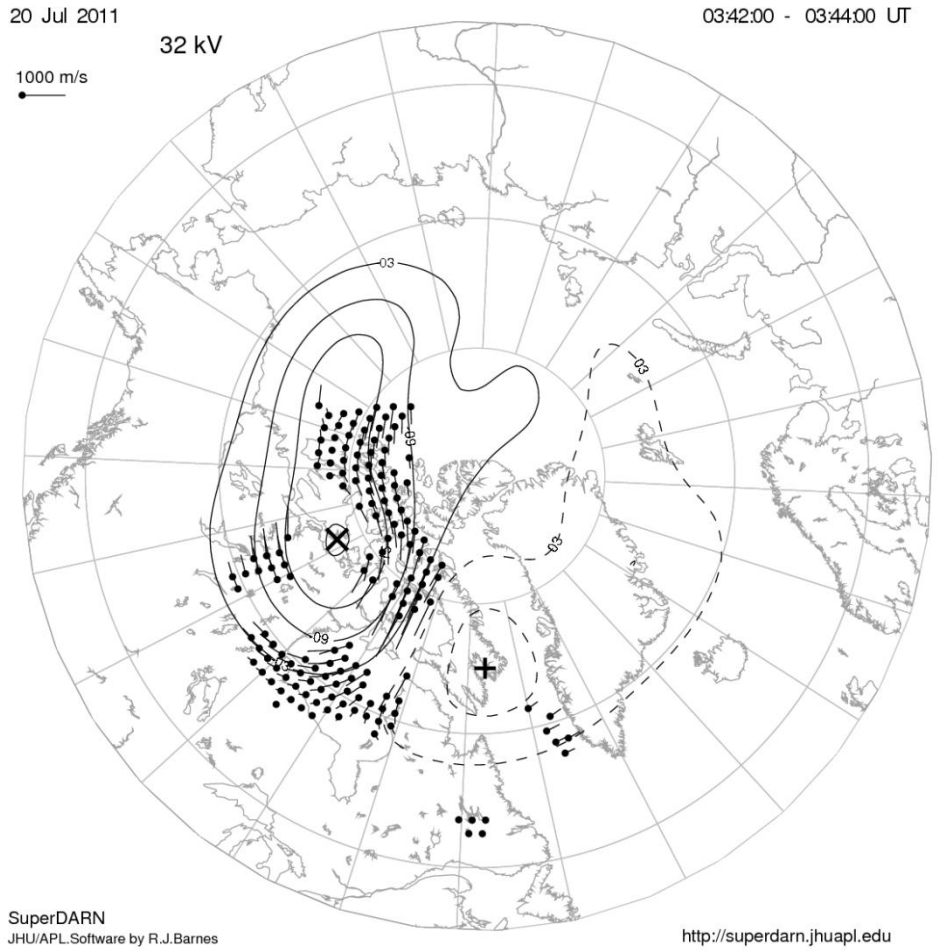
SuperDARN convection maps



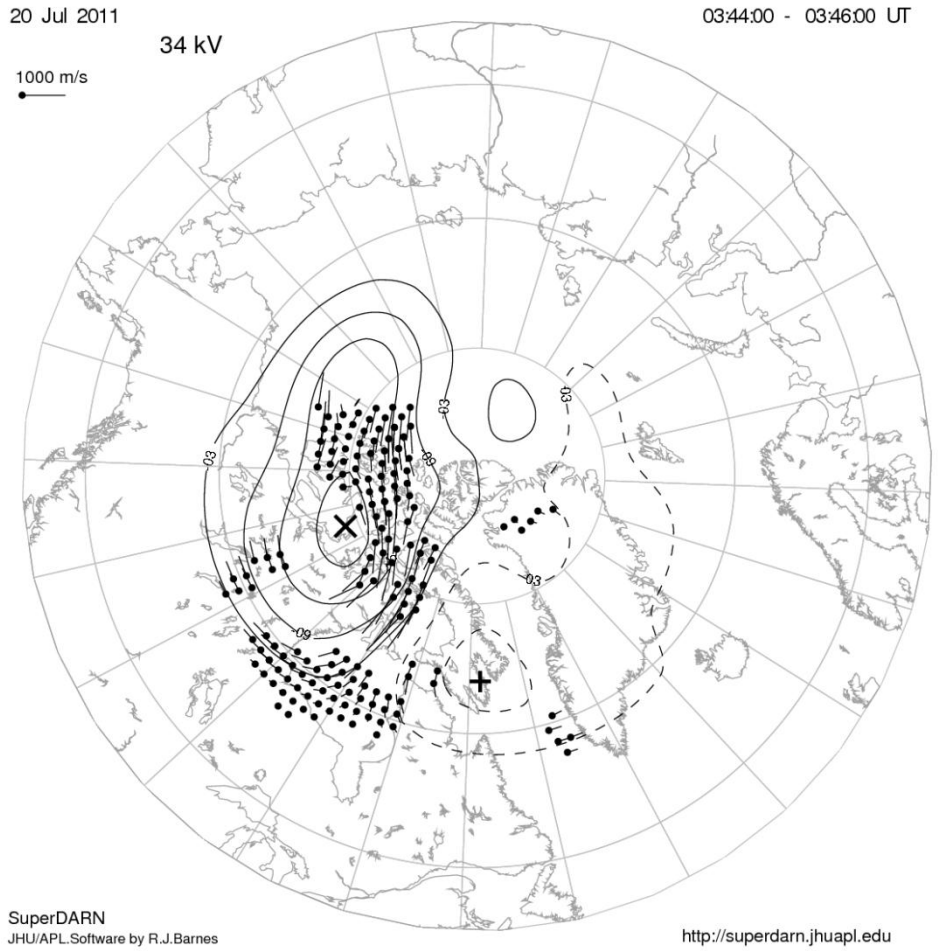
SuperDARN convection maps



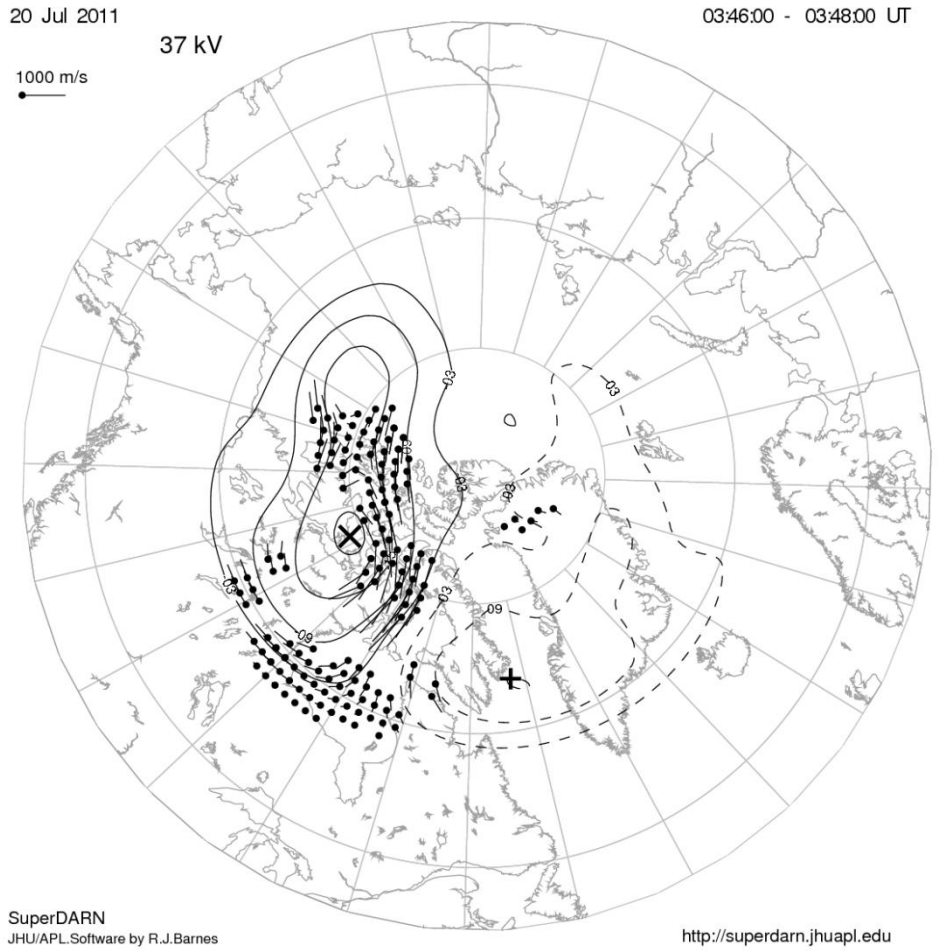
SuperDARN convection maps



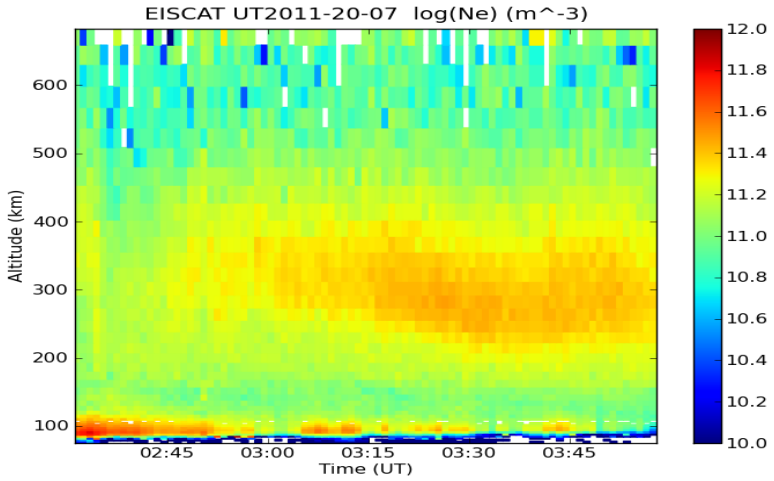
SuperDARN convection maps

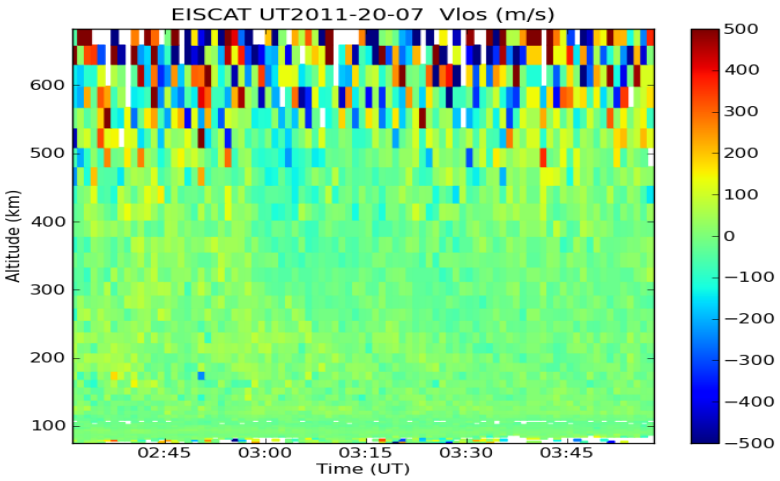


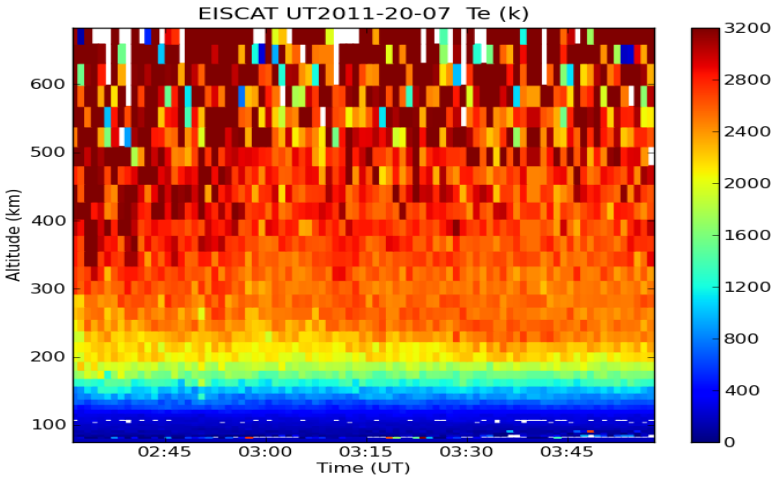
SuperDARN convection maps

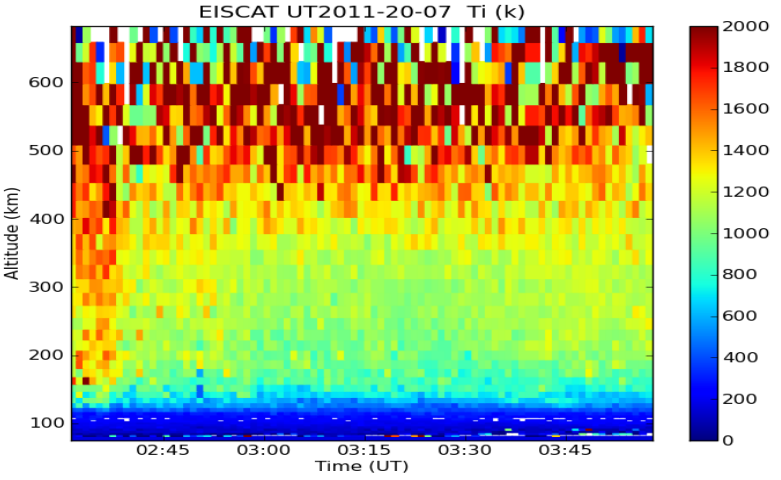


EISCAT data:

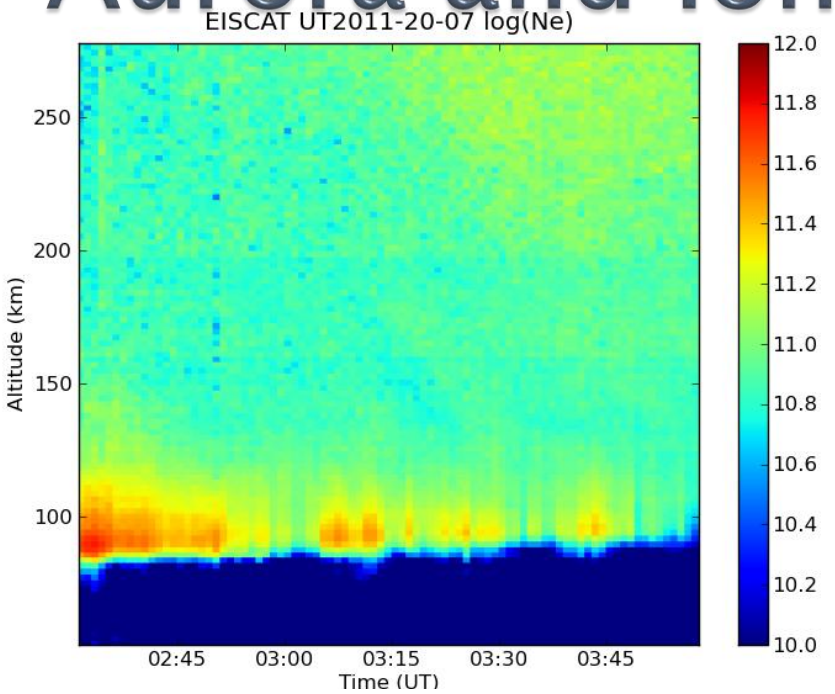

EISCAT UT2011-20-07 log(Ne) (m^-3)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
12.0
11.8
11.6
11.4
11.2
11.0
10.8
10.6
10.4
10.2
10.0

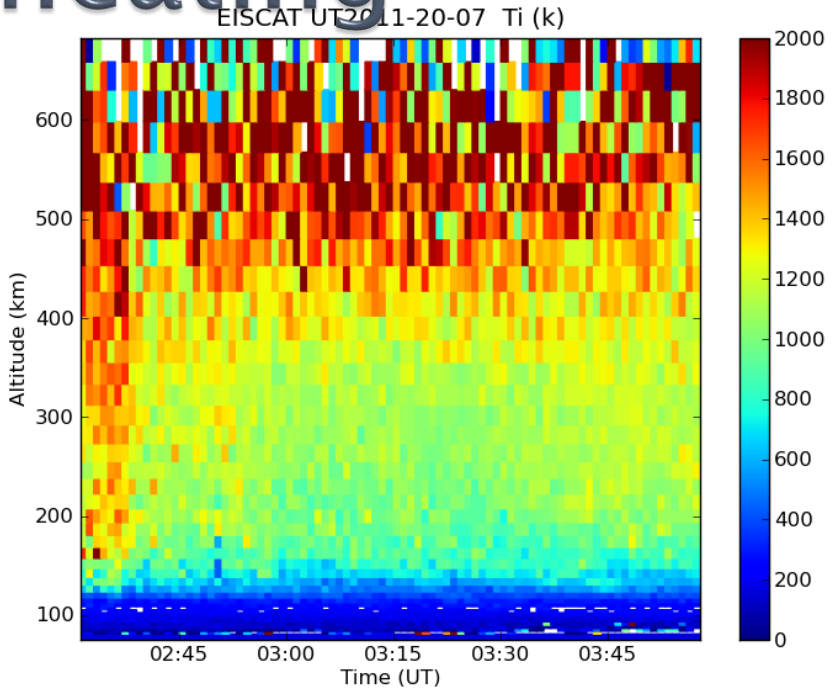

EISCAT UT2011-20-07 Vlos (m/s)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
500
400
300
200
100
0
−100
−200
−300
−400
−500

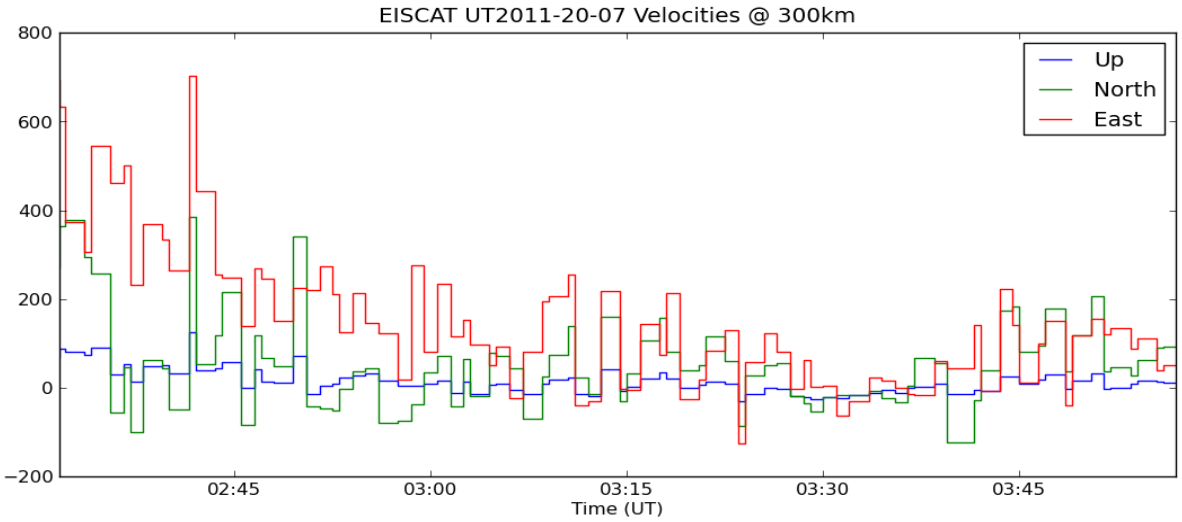

EISCAT UT2011-20-07 Te (k)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
3200
2800
2400
2000
1600
1200
800
400
0


EISCAT UT2011-20-07 Ti (k)
Altitude (km)
100
200
300
400
500
600
02:45
03:00
03:15
03:30
03:45
Time (UT)
2000
1800
1600
1400
1200
1000
800
600
400
200
0

Aurora and Ion heating







Summary

- Sondrestrom and EISCAT used to study ion upflow events
  - No ion upflow events observed
- We did observe:
  - An electron precipitation event in the Sondrestrom data
  - Two interesting ion heating events (one in the EISCAT data and one in the Sondrestrom data)
    - Sondrestrom heating event observed in conjunction with electron density depletion
    - EISCAT heating event observed in conjunction with electron precipitation event

References

- Killeen, T. L., P. B. Hays, G.R. Carignan, R. A. Heelis, W. B. Hanson, N. W. Spencer, L. H. Brace, Ion-Neutral Coupling in the High-Latitude F Region: Evaluation of Ion Heating Terms from Dynamics Explorer 2, *J. Geophys. Res*., 89, 1984.
- Strangeway, R. J., R. E. Ergun, Y.-J. Su, C. W. Carlson, R. C. Elphic, Factors controlling ionospheric outflows as observed at intermediate altitudes, *J. Geophys. Res.*, 110, 2005.
- Yau, A. W., H. G. James, and W. Lui, The Canadian enhanced Polar Outflow Probe (ePOP) mission in ILWS, *Adv. Space Res*., 38, 1870-1877, 2006.

Motivation: Ion Upflow

- Measurements of ionospheric O+ ions have been made in the magnetosphere
- These ions reach the magnetosphere through ion outflow in the polar regions
- These heavier ions in the magnetosphere will lower the Alfven speed and slow the response of the magnetosphere to external drivers
- The specific mechanism for triggering ionospheric outflow is a topic of debate:
  - Heating of the ions directly through energy injected in the cusp
  - Heating of electrons which then drag ions upwards through field aligned electric fields