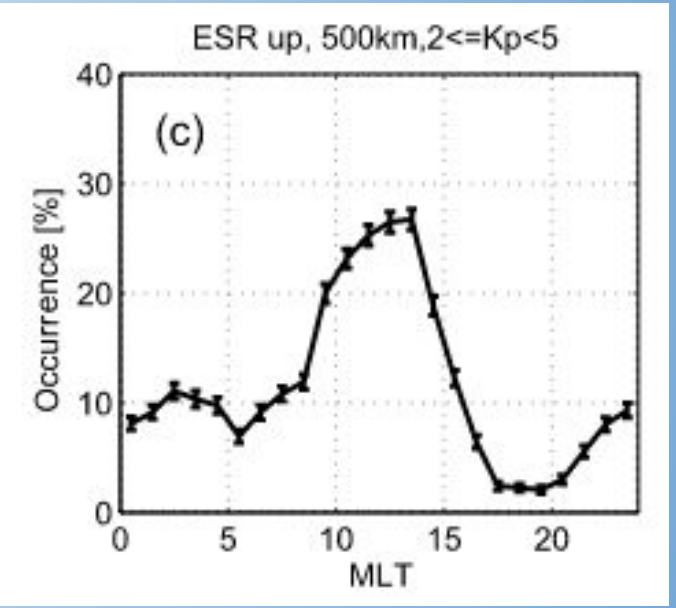
High-latitude ISR Observations of the Auroral Oval

Group 1 - Ion Upflow/Auroral Oval

(Amal, Emily, James, Kyle, Neethal, Rikard, Riley)

Objective and Motivation

- Ion upflow predominantly dayside cusp phenomenon - but field-aligned radars at ESR and Tromsø may observe nightside upflow (with 10% occurrence probability)
- If no upflow, composite Southward (ESR) and Northward (Tromsø) EISCAT ISR likely provide view of auroral oval, precipitation and heating



Ogawa et. al. 2008

Experimental Setup

ESR Svalbard Radar

- Folke Mode - Field-aligned 42m and Southward 32m at 30 degrees elevation
- Chose this mode to use both antennas
- Pointed the 32m towards where we thought the auroral oval would be

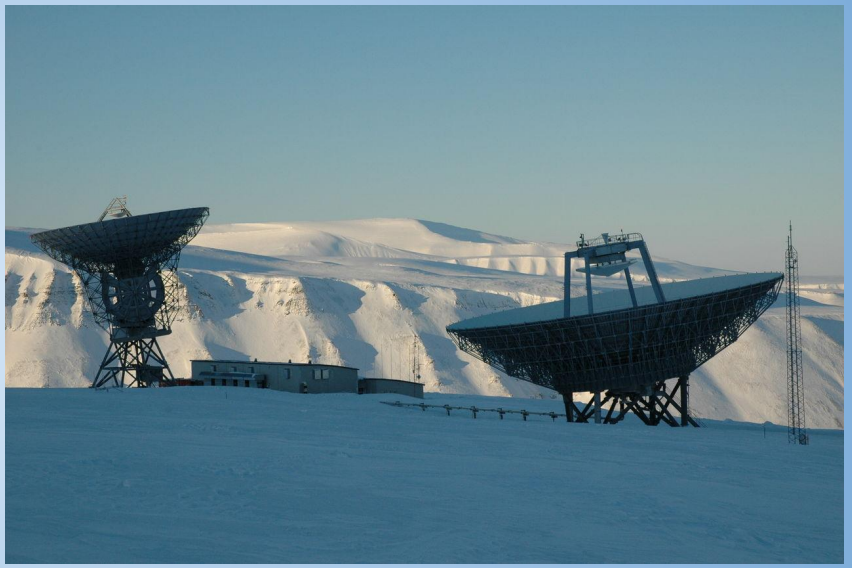


Photo by Tom Grydeland, from Wikimedia Commons.

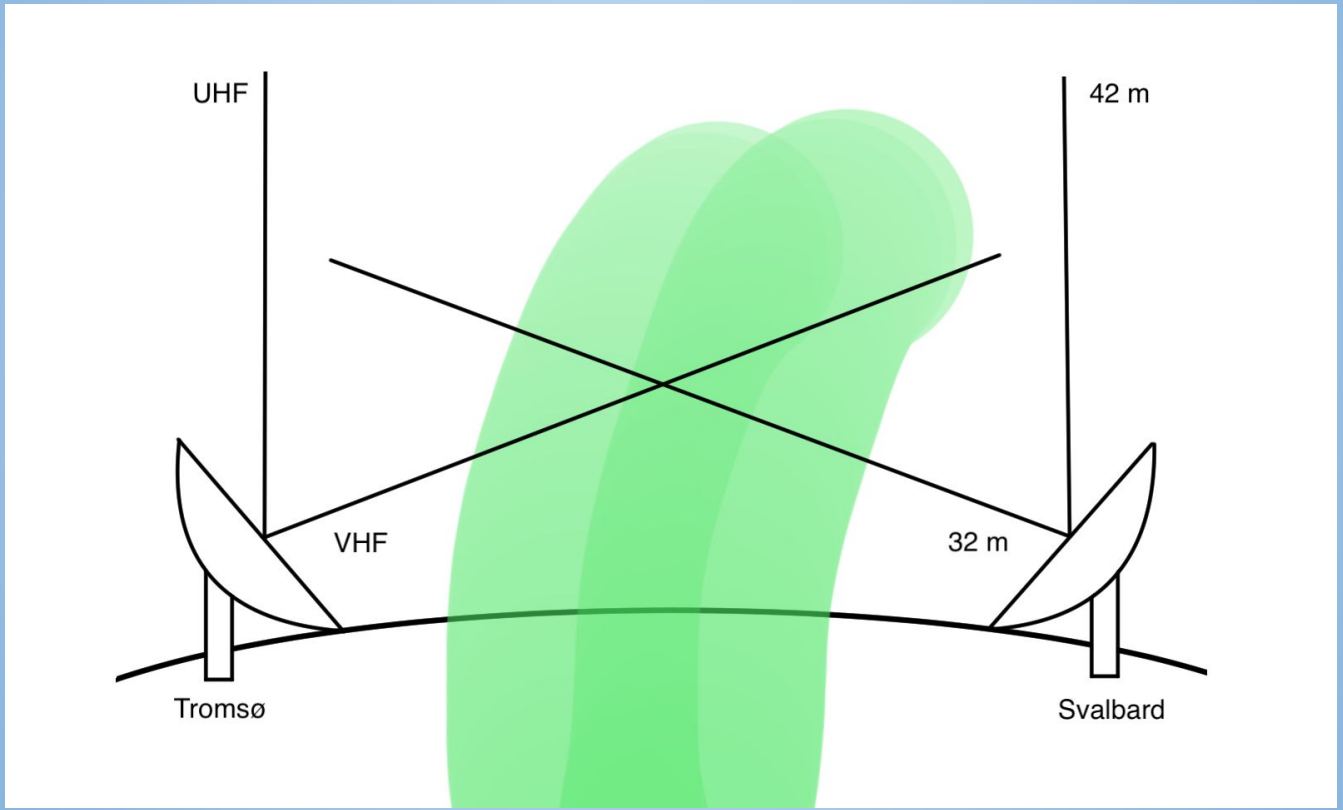
Experimental Setup

EISCAT Tromsø Radars

- UHF - Beata mode - field-aligned
- VHF - Bella mode - Northward at 30 degrees elevation
- Pointed the VHF towards where we thought the auroral oval would be

Photos of the UHF antenna (top) and VHF antenna (bottom). From the EISCAT Japan website.

Experimental Setup



Experimental Setup

Time of experiment:

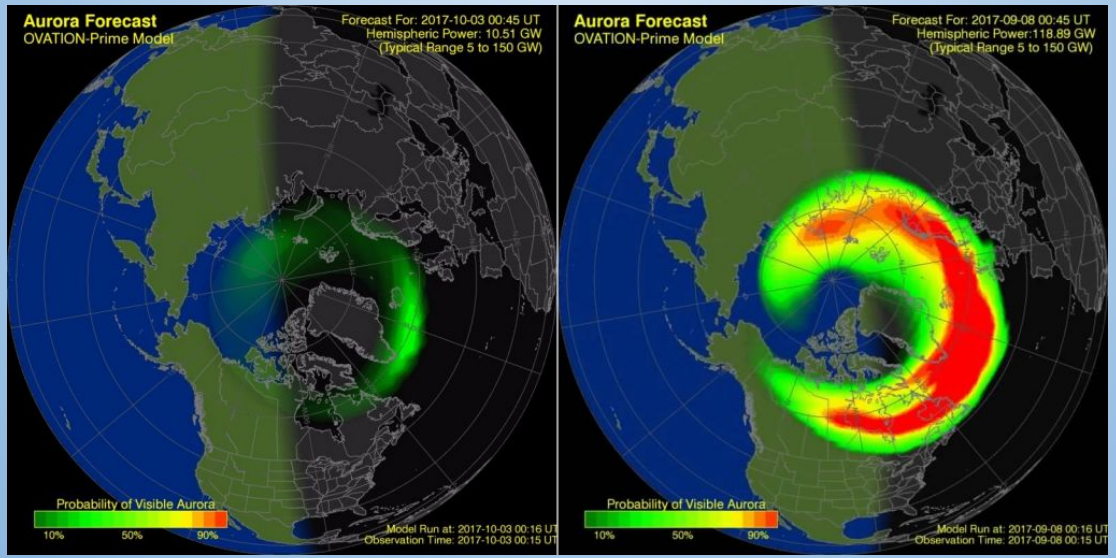
August 13, 2019, 20:00 - 22:00 UT
(22:00 - 00:00 MLT)

We chose this because it was the closest time period to the nightside aurora - ideal MLT for precipitation in oval

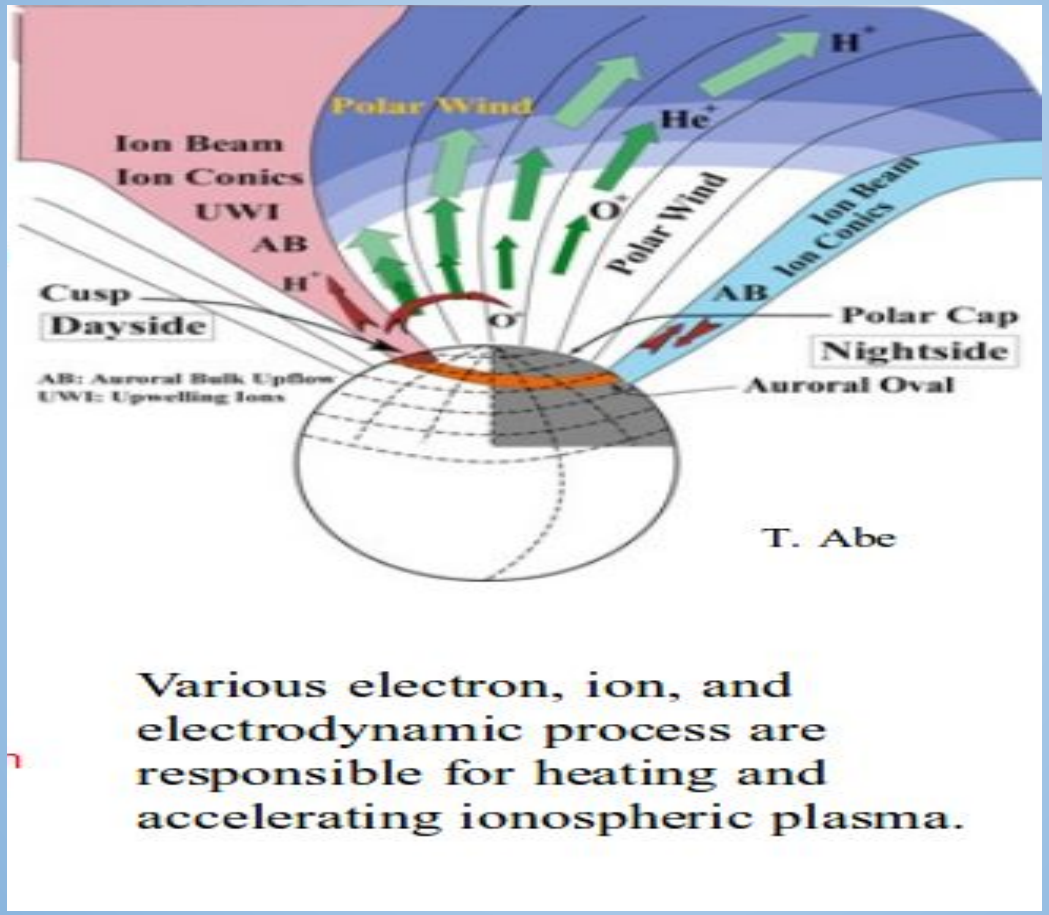
Right: Photo of the aurora by Lars Tiede, from Wikimedia Commons.

Identifying the Auroral Oval

- The auroral oval maps to the precipitation of energetic ions and electrons that originate in the magnetosphere.
- North of the auroral oval is polar cap, which is magnetically connected to solar wind
- Auroral oval is variable! It can widen and expand southward with geomagnetic activity

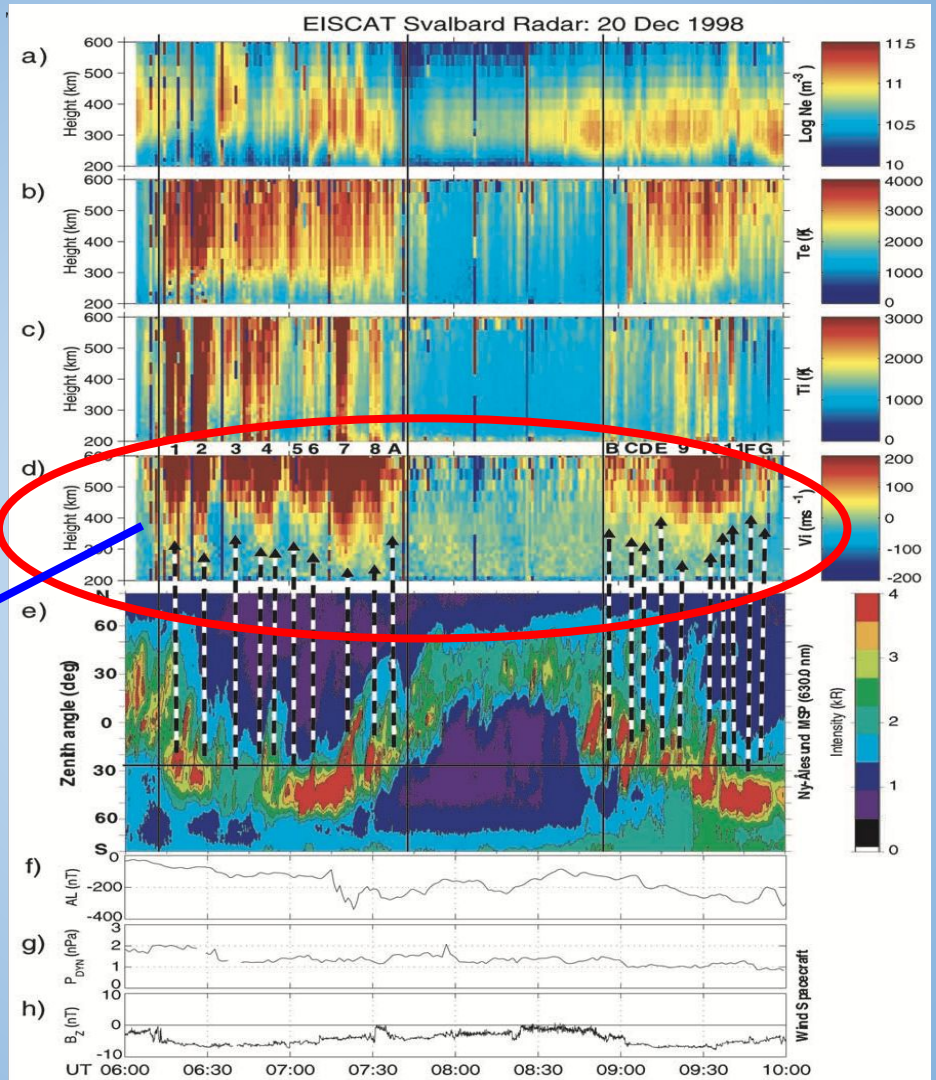


Why is ion upflow interesting?



Various electron, ion, and electrodynamic process are responsible for heating and accelerating ionospheric plasma.

Typical example of Ion Upflow event observed at Svalbard



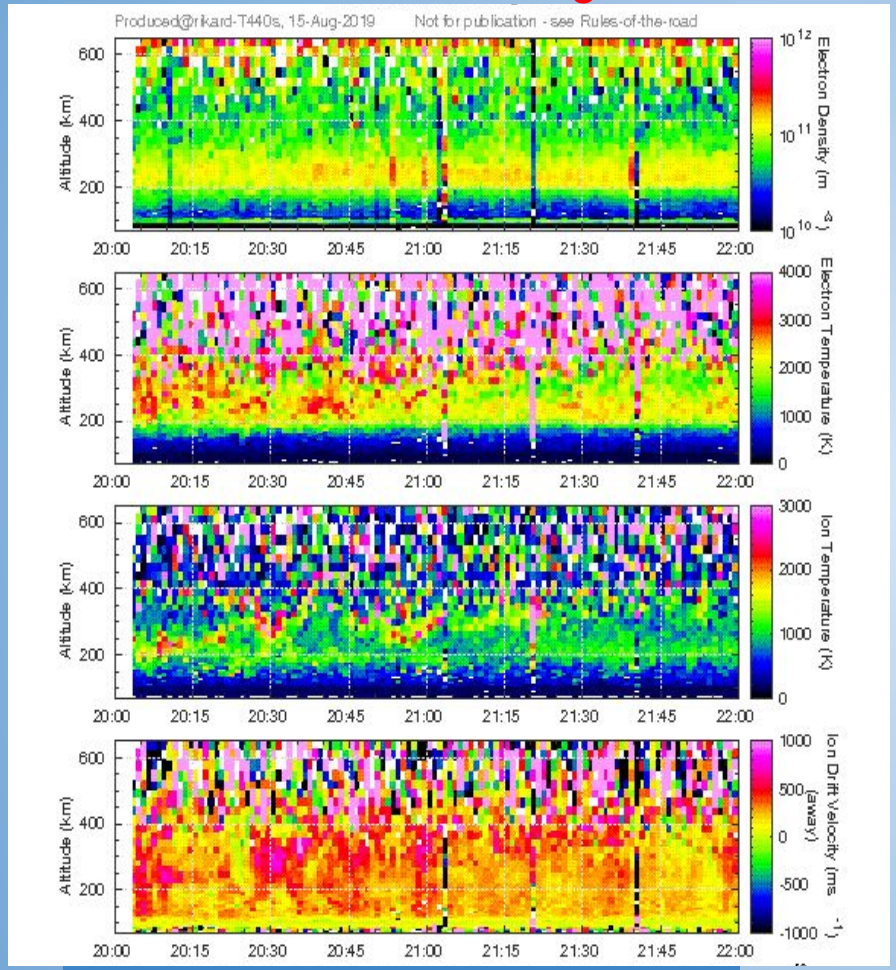
Sequence of upflow burst observed during times when auroral activity was present above Svalbard

Moen et. al, GRL 2004

Observations

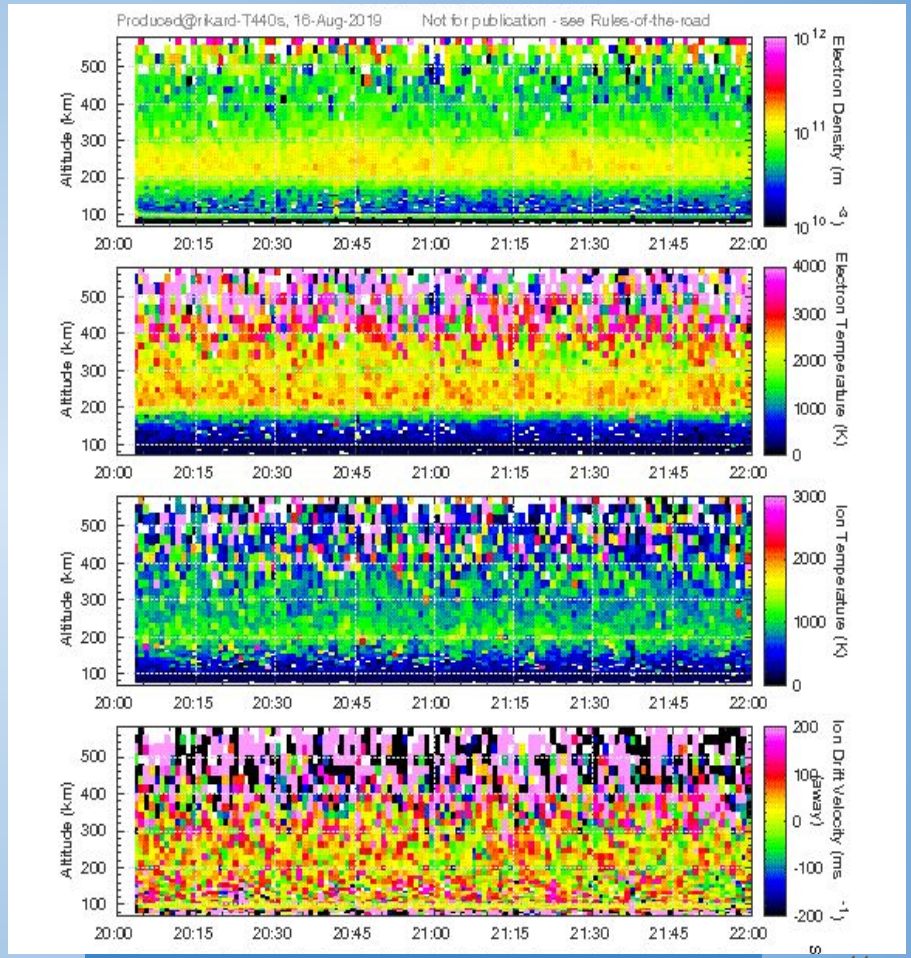
Svalbard, Tromsø, ion upflow, auroral activity, comparison with other data

ESR - 42m field-aligned



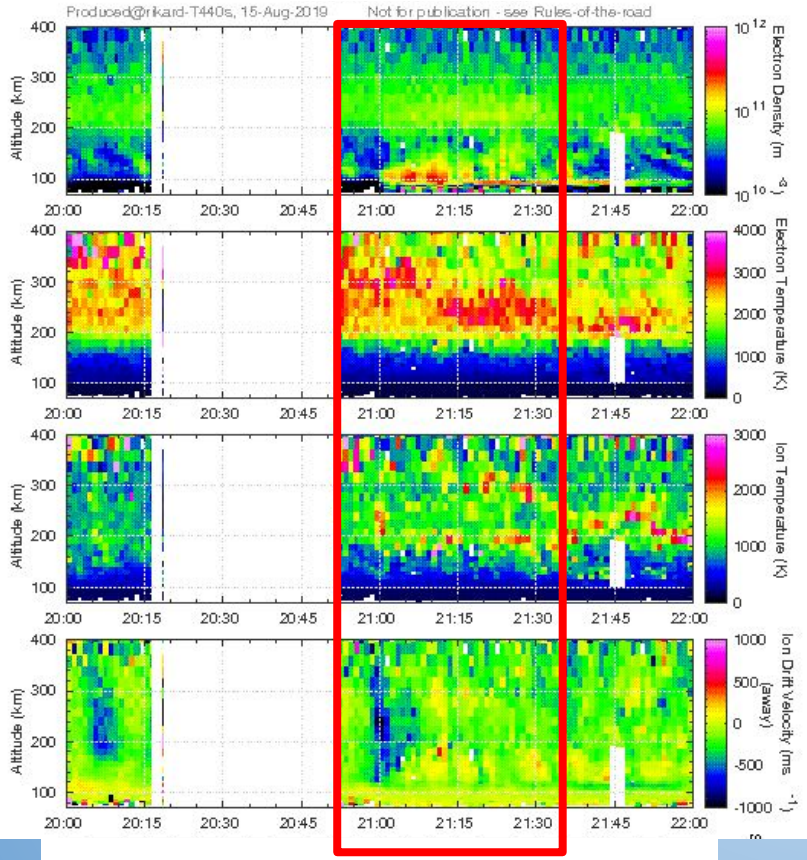
UT (hr)

ESR - 32m Southward



UT (hr)

VHF Tromsø



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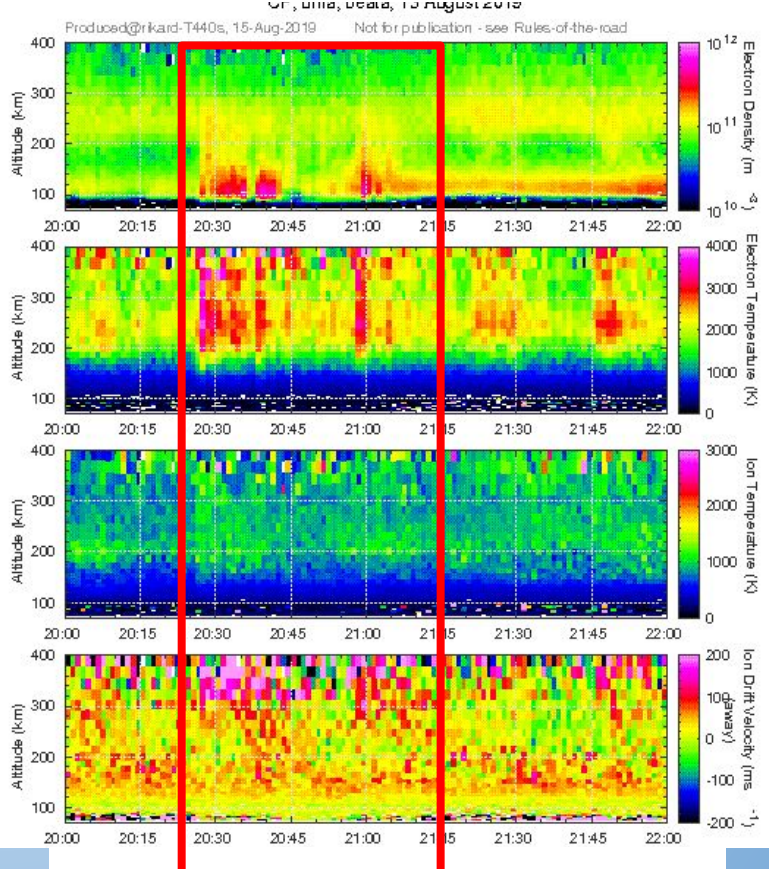
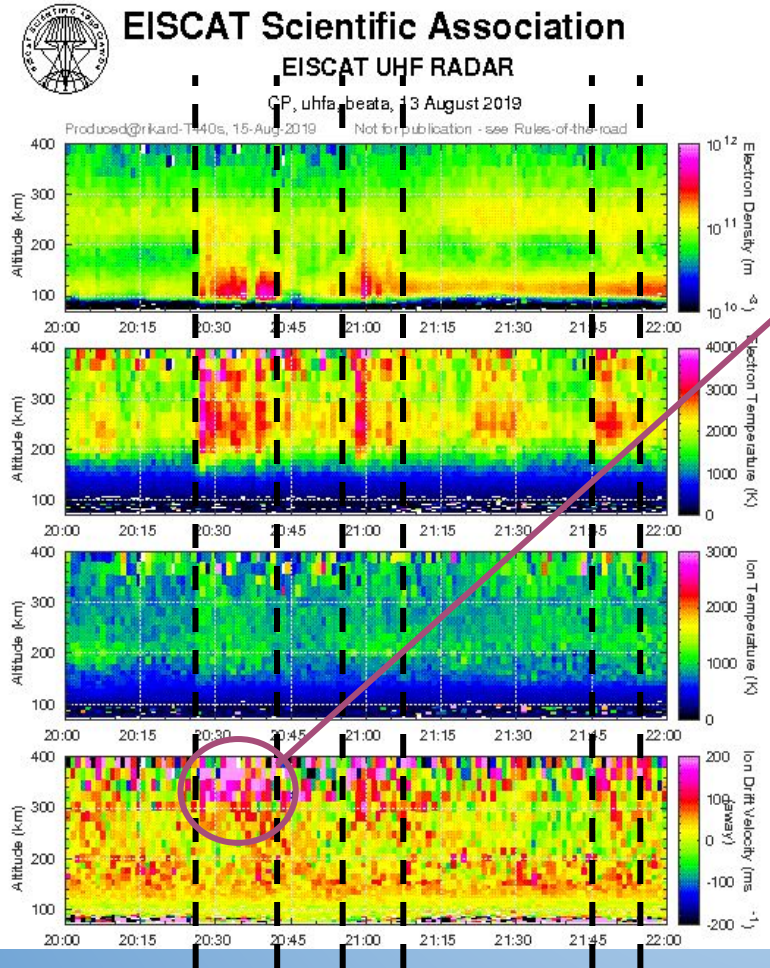
UHF Tromsø



UT (hr)

Ion upflow observed at Tromsø



Vi ~ 150 m/s
n(O+) ~ a few 10^{10} m^{-3}

Corresponding to an upflow flux of a few 10^{12} $m^{-2}s^{-1}$

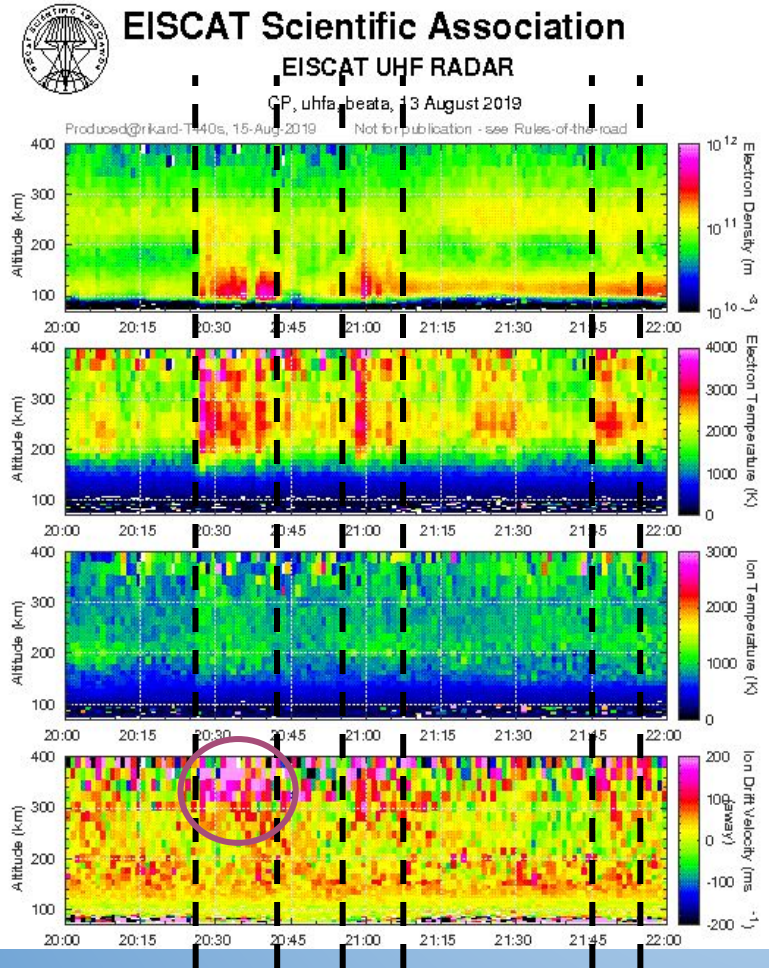
<u>Ogawa et al. 2009:</u>

cusp: ~10^{13} $m^{-2}s^{-1}$

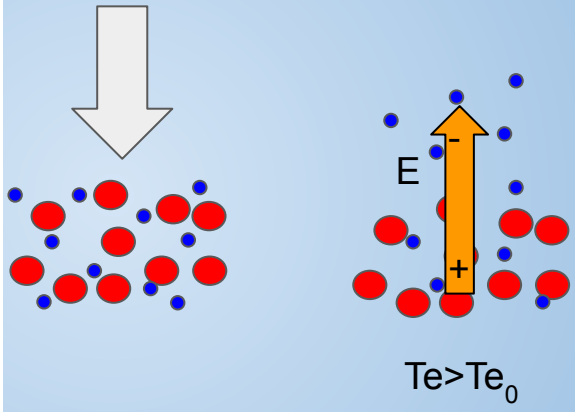
Polar cap: ~10^{12} $m^{-2}s^{-1}$

Ogawa et al., On the source of the polar wind in the polar topside ionosphere: First results from the EISCAT Svalbard radar, GRL, 36, 2009

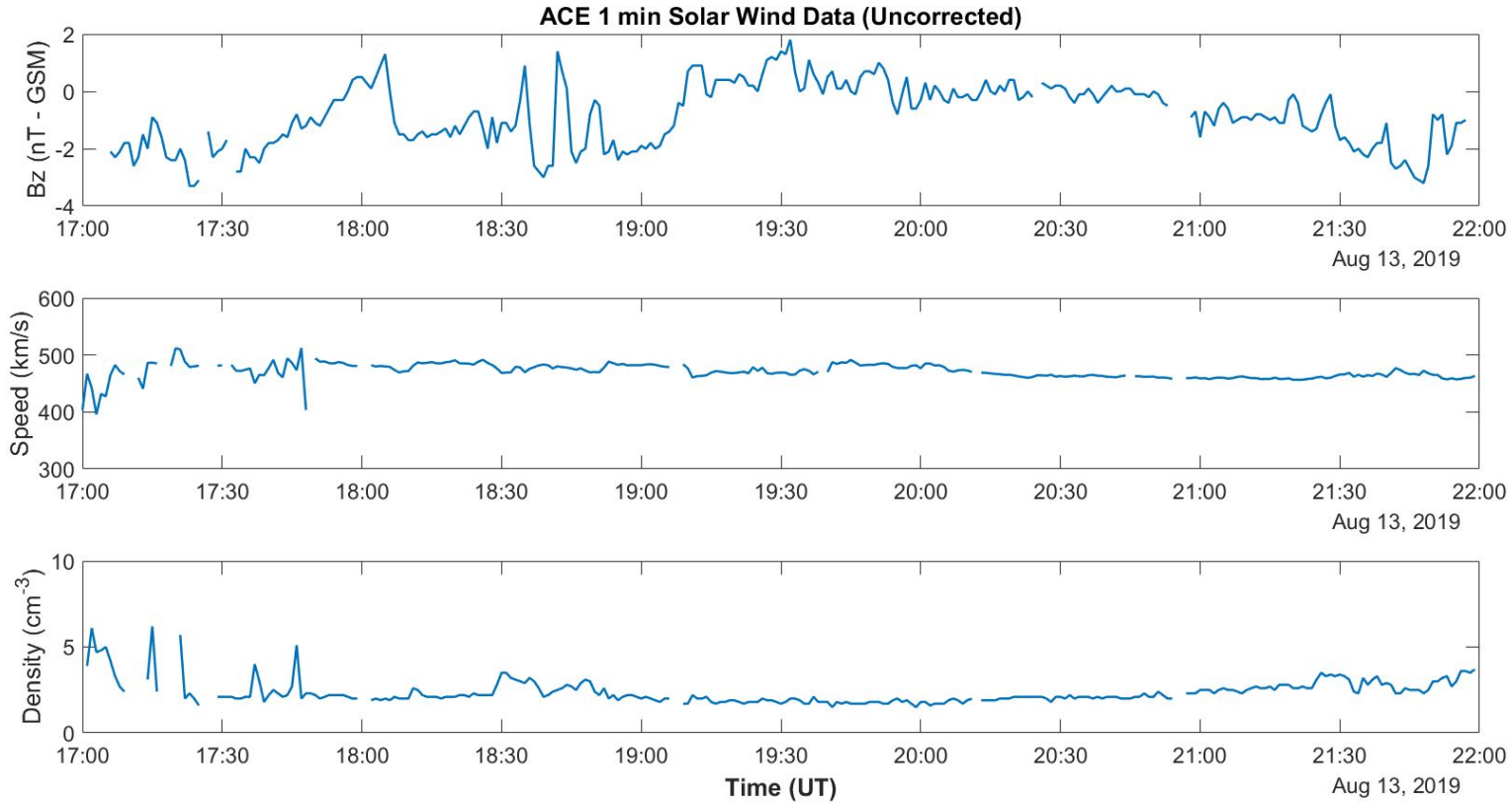
Ion upflow observed at Tromsø



The coupling between the ion upflow and electron precipitation:



Solar wind conditions during study period

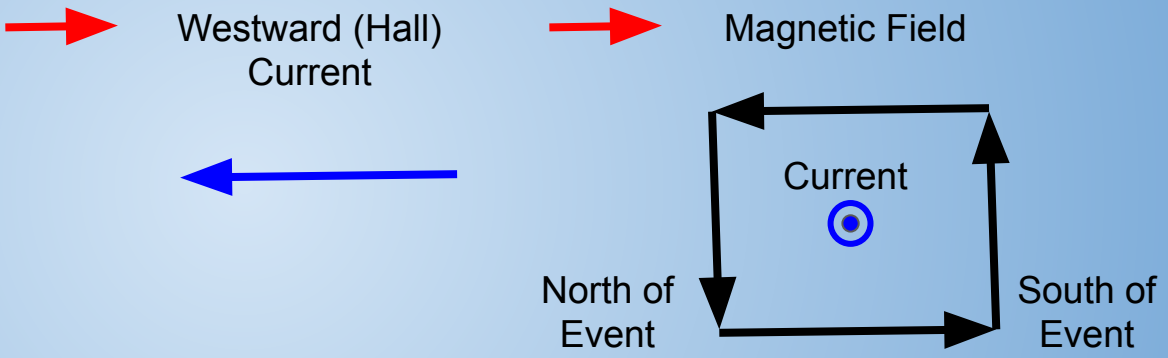


Interpretation of Space Weather Parameters

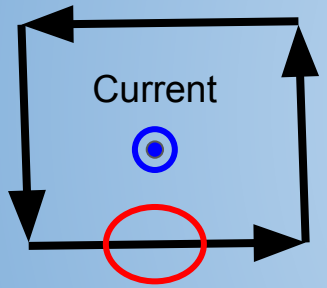
- Bz is small, negative for some time. Possible evidence of a small substorm earlier than our time period.
- Solar wind speed is slightly higher than normal.
- Density is low

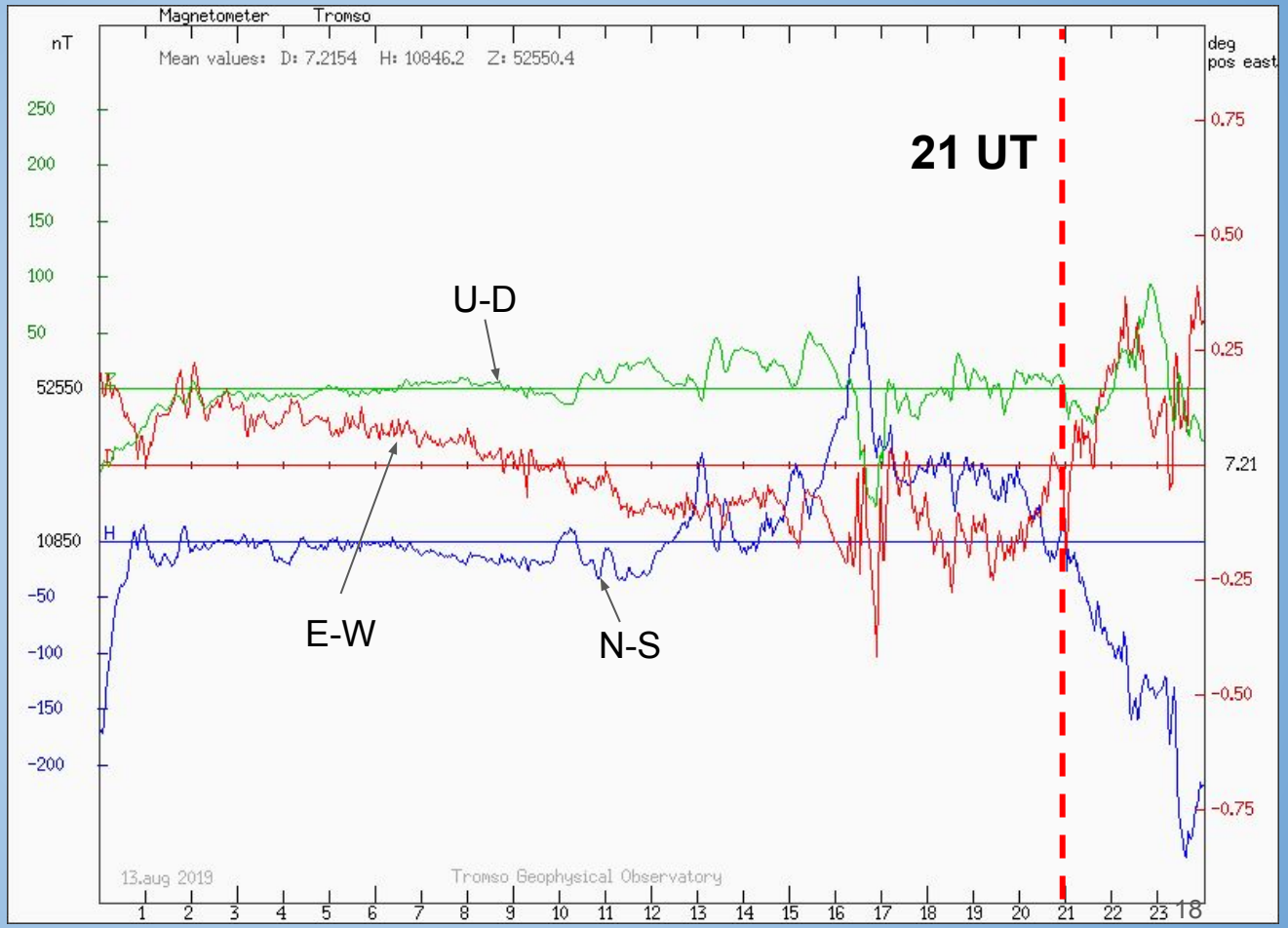
There could be some connection to space weather driving, although it’s hard to know about the timing!

Magnetic Perturbation from Auroral Substorm



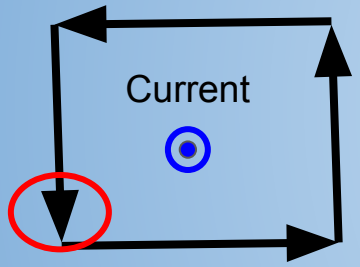
Tromsø Magnetometer

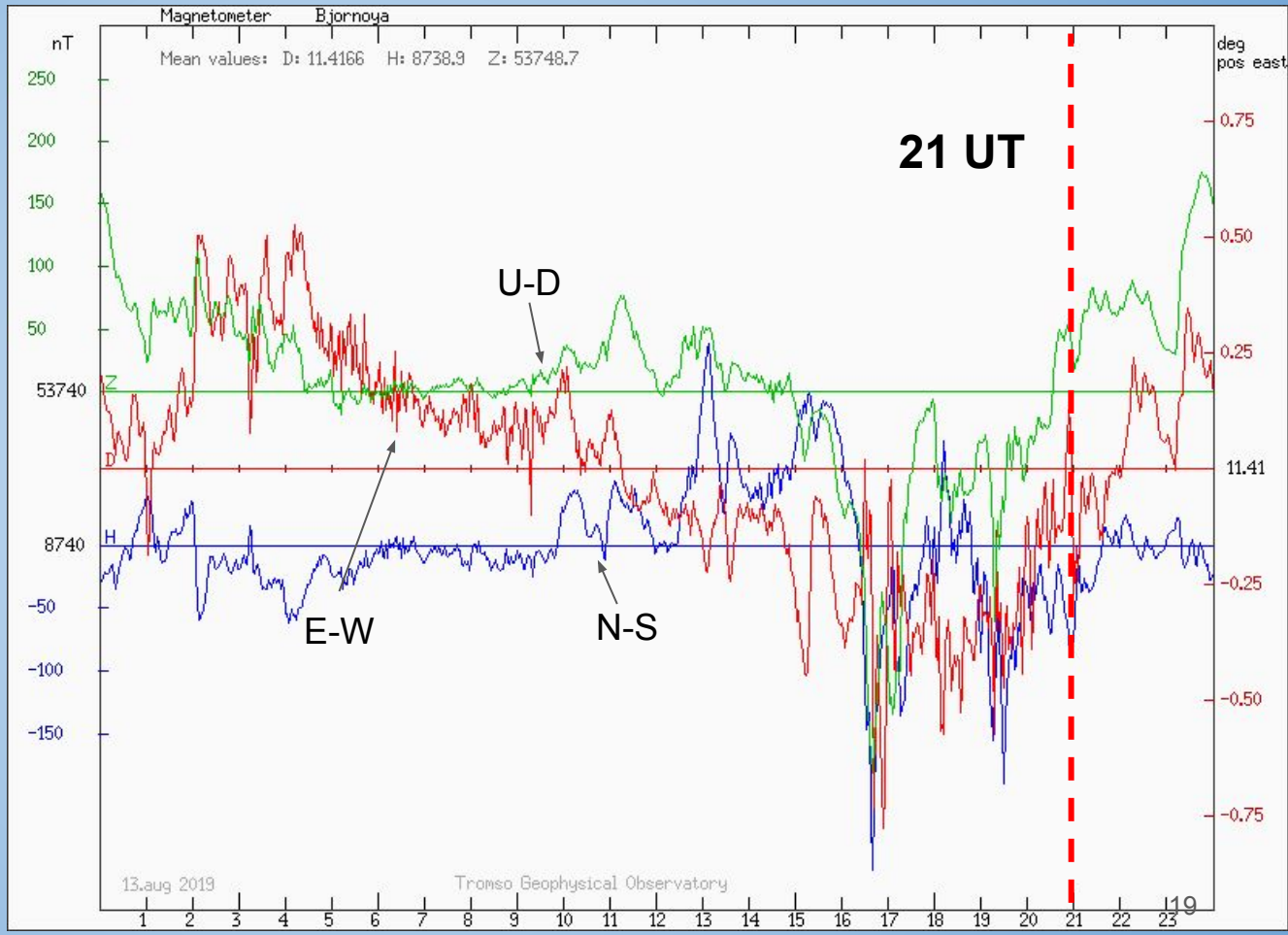




Source: Tromsø Geophysical Observatory

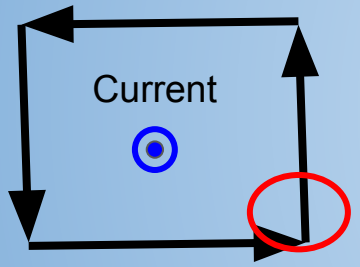
Bear Island (north) Magnetometer

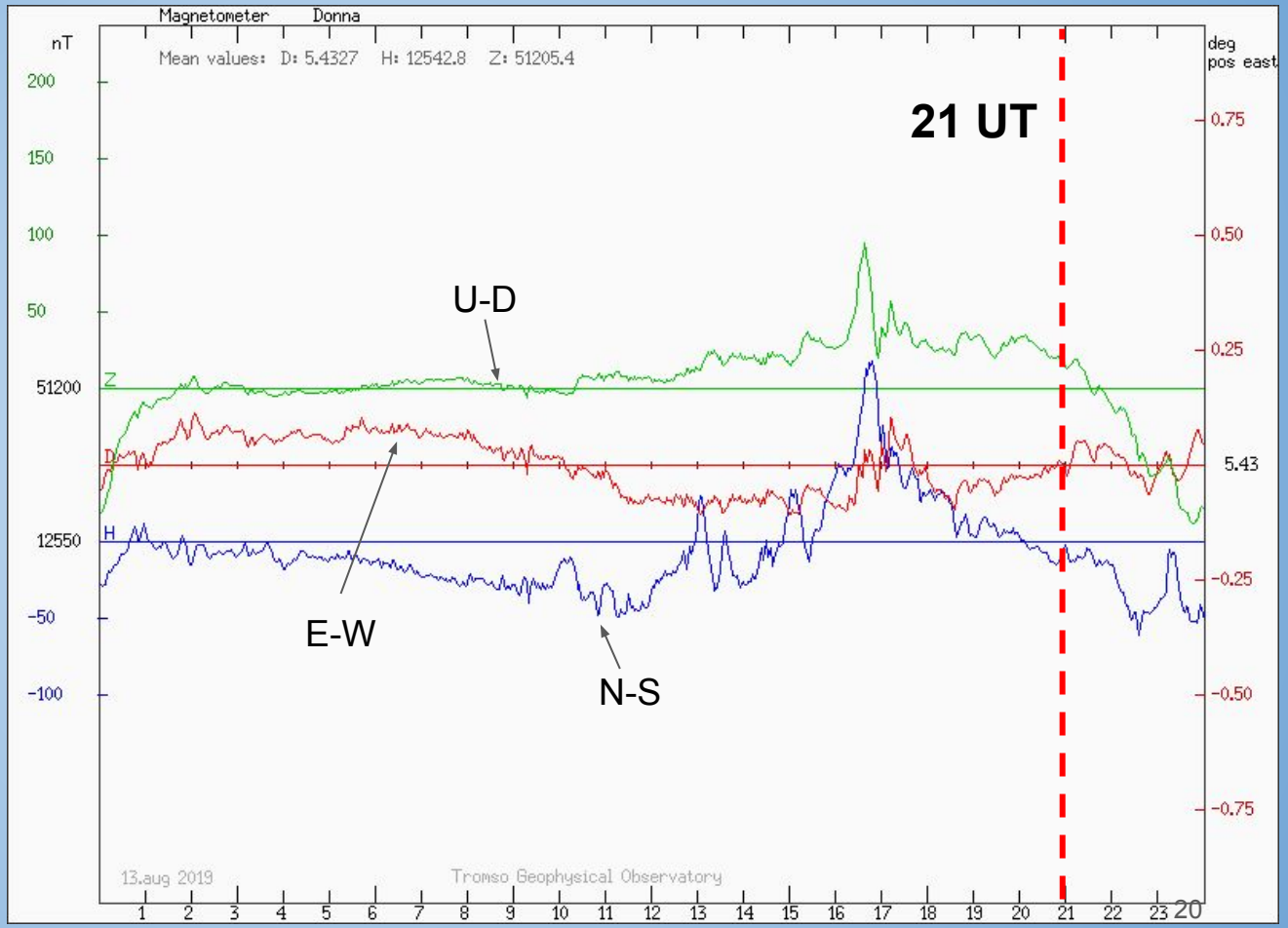




Source: Tromsø Geophysical Observatory

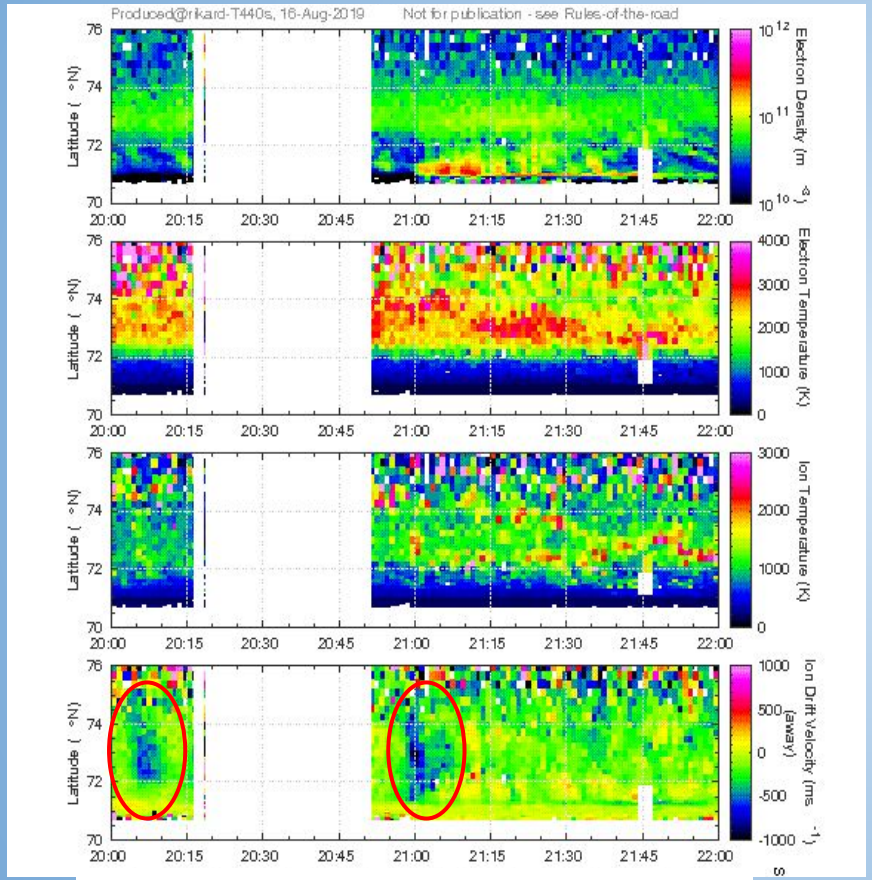
Donna (south) Magnetometer



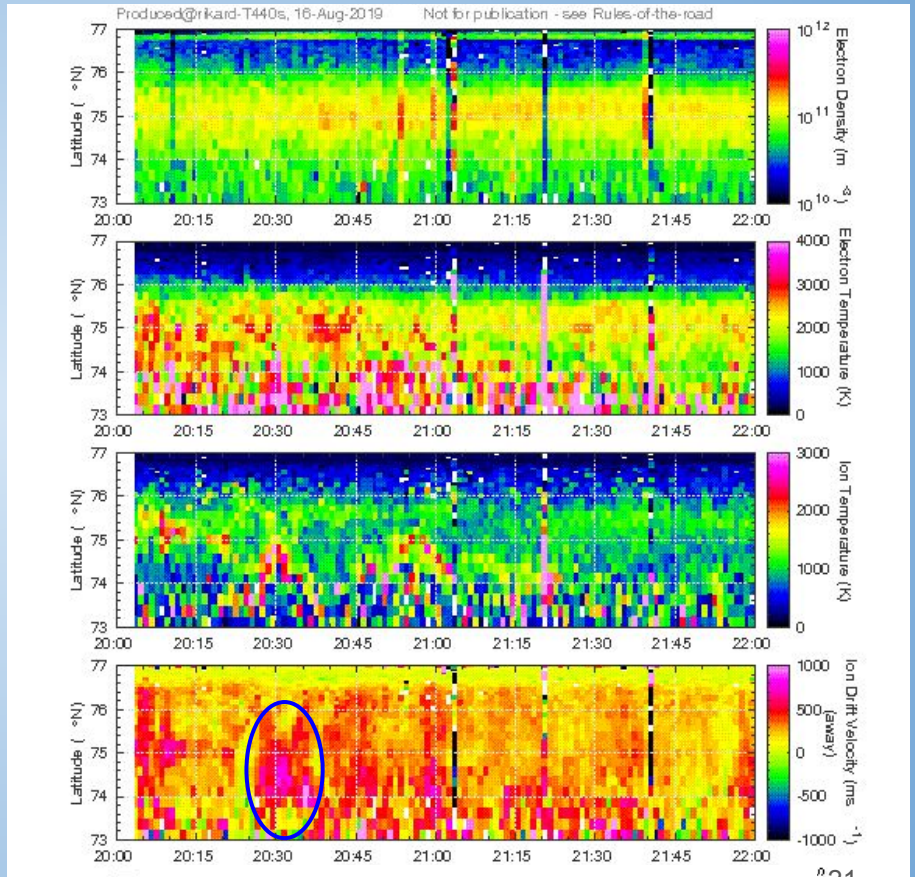


Source: Tromsø Geophysical Observatory

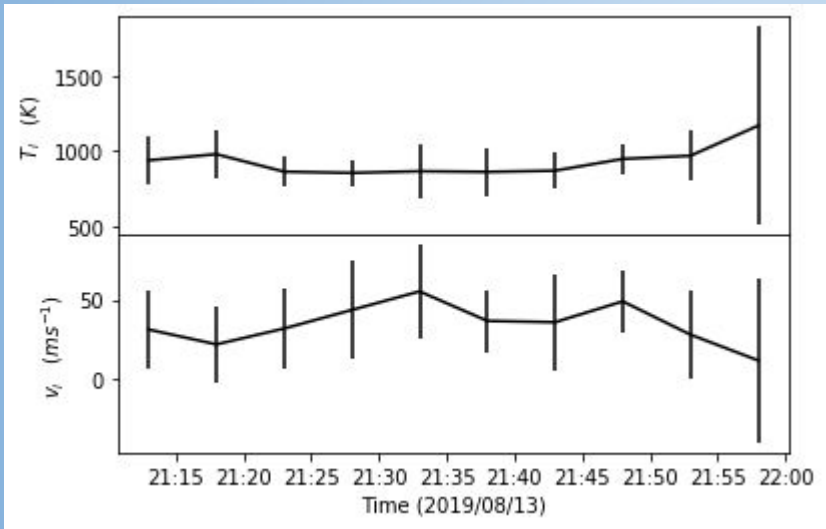
VHF Tromsø (Northward - 30°) and 32m Svalbard (Southward - 30°)



UT (hr)

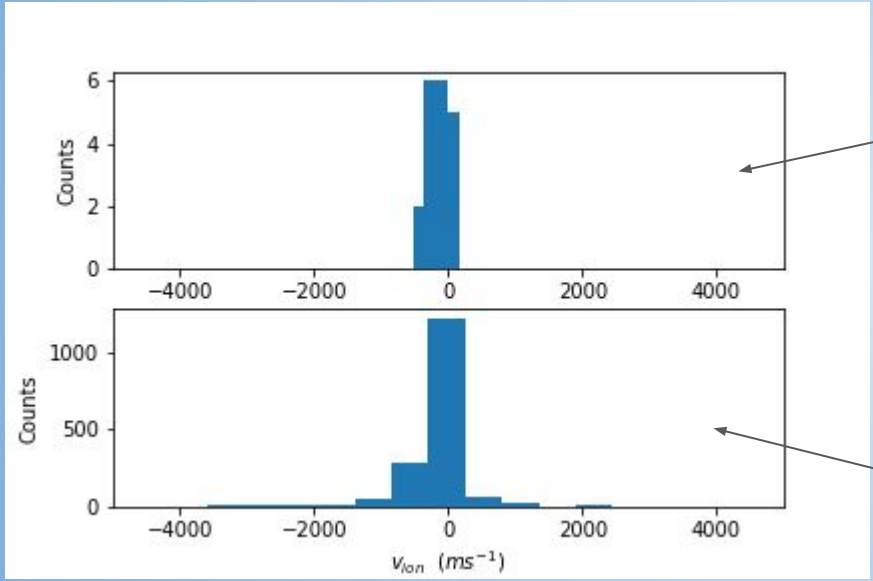


UT (hr)


1500
1000
500
T_i (K)
50
0
v_i (ms^{-1})
21:15 21:20 21:25 21:30 21:35 21:40 21:45 21:50 21:55 22:00
Time (2019/08/13)

Conclusions and Summary

- No clear ion upflow events observed at Svalbard
- Ion upflow observed in relation to electron precipitation above Tromsø
- Small geomagnetic disturbances observed with magnetometer
- Electron precipitation caused electron heating
  - Leads to aurora!
- Additional work: strong southward ion flow seen in Tromsø VHF at two different times



Vi corresponding to Ti > 1800K from 21:13 - 22:00 UT, altitude range 100-200km

All Vi measurements from 21:13 - 22:00 UT, altitude range 100-200km

Citations

EISCAT Japan http://eiscat.nipr.ac.jp/en/gi/

Ogawa, Y. et. al. (2009), Characteristics of ion upflow and downflow observed with the European Incoherent Scatter Svalbard radar, J. Geophys. Res., 114, A05305, doi:10.1029/2008JA013817

Space Weather Prediction Center NOAA https://www.swpc.noaa.gov/

Tromsø Geophysical Observatory http://geo.phys.uit.no

Wikimedia Commons

Outline

1. Introduction - James
2. Objective motivation - ion upflow, maybe it could be on nightside, keep it short - James
3. Experiment overview - Emily
4. Previous study of ion upflow - Amal
5. What we observed for ion upflow in Svalbard (no upflow) - Amal
6. Auroral Oval background - Neethal
7. Interesting features: Tromsø Precipitation - Neethal
8. Interesting features: Tromsø Electron Heating - Rikard
9. Interesting features: Tromsø upflow - Rikard
10. Interesting features: Tromsø ion drifts - Kyle
11. Space weather parameters - Kyle
12. Magnetometer data - Riley
13. Conclusions/physical interpretation - James

Important points

- Significant Electron precipitation is observed above Tromsø around 20:30 to 20:45 UT and 21:00 UT.
- Svalbard UHF at higher latitude did not observe any significant precipitation.
- At Tromsø precipitation is observed as clear enhancement in electron density and temperature.
- The ion velocities are also found to be enhanced during precipitation intervals, with higher negative values indicating particle motion towards Tromsø location.
- The VHF observations from Tromsø indicate the poleward edge of the precipitation to be with in 70 degree latitude.
- Magnetometer data at Bear Island, Tromsø, and Donna stations indicate a westward current and thus aurora above Tromsø starting around 21:00 UT.