Group 3 2018 ISR Workshop Experiment

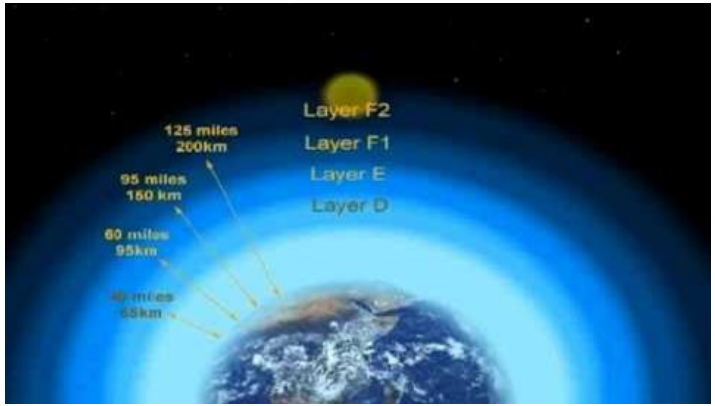
Andres Vaccariello, Han Jin,
Paul Kennedy, Yifan Huang

Outline

- Motivation
- Experiment Goals
- Experiment Design
- Results
  - Density
  - Velocity
  - Temperature
- Comparison With Other Instruments
  - Millstone Hill Ionosonde
- Conclusion

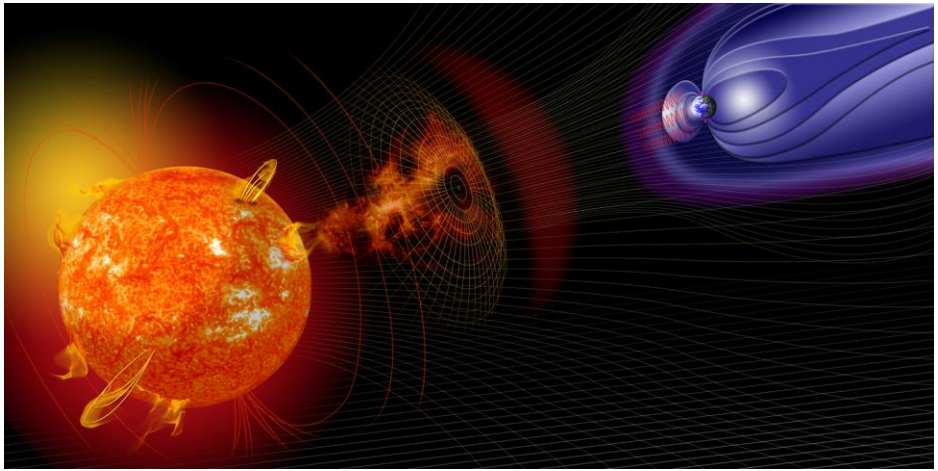
Motivation

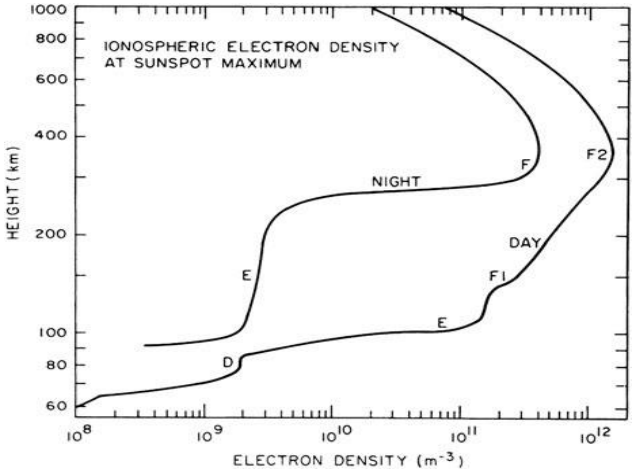
- Experience how data is collected
- Study the behavior of the ionosphere outside of text books
- Looking for patterns that may be interesting to analyze
- Understand the functionality of the radar
    - Different modes
    - How data is collected and processed



Experiment Goals

1. Observe the behavior of the Ionosphere during sunset
2. Observe possible geomagnetic storm (Predicted to occur between 8:00 PM to 2:00AM LT)
3. Use both observations to analyze possible changes in the electron density





Experiment Design

Mode: Type A

Time: 11:00 PM to 1:00 AM

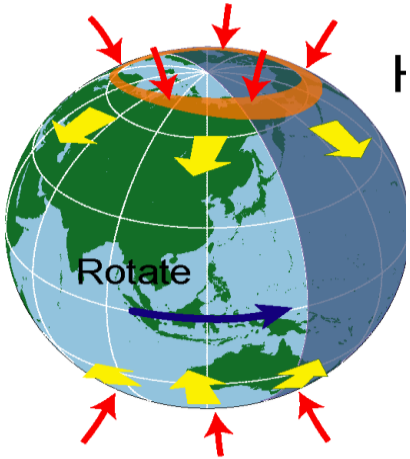
Characteristic :

- Vertical profiles [zenith]
- Regional vectors [45 deg elevation]
- Wide field scans [6 deg elevation)
- MISA fixed positions on either side of magnetic meridian
- E, F region F2 peak high accuracy Langmuir mode electron density available (daytime ionosphere)
- Experiment cycle time = ~34 minutes

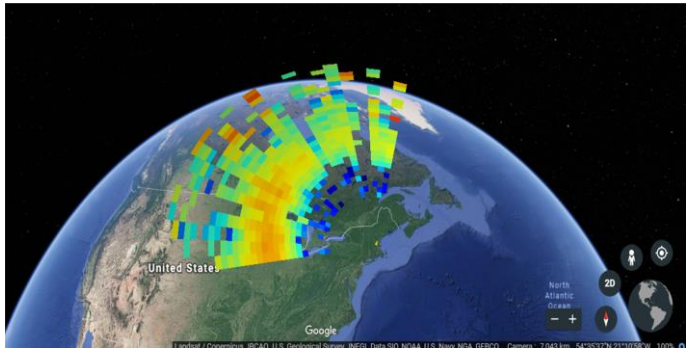
Why did we choose this mode?

Expected results of a geomagnetic storm would include a spatial variation in electron density (due to expansion of the polar cap)

Mode A scan gives the best wide view of potential spatial effects due to the a storm



Energy input to the high latitude ionosphere indirectly produces westward ion motion in the sub auroral ionosphere



Physics background

Interaction between geomagnetic storm and the ionosphere.

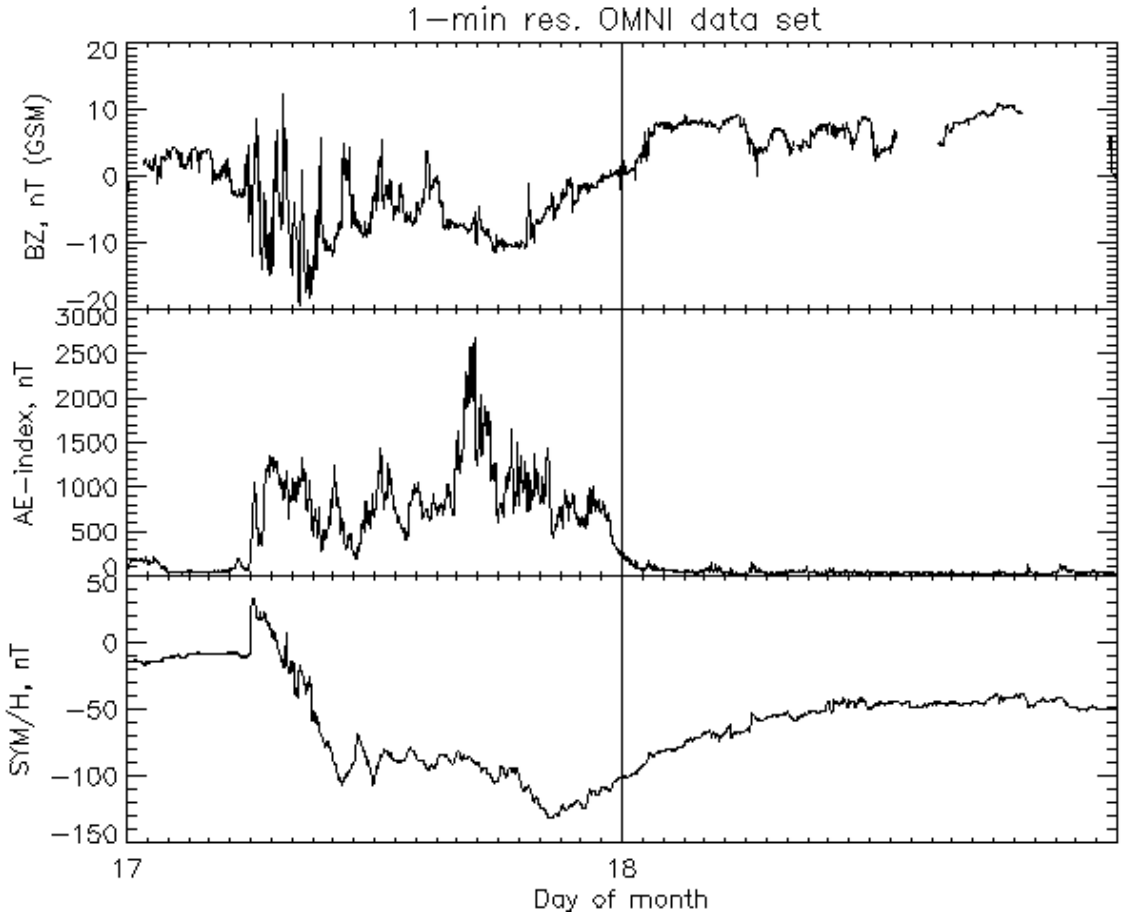
Negative effects	Positive effects
• Auroral heating produces uplift which decrease the F region. • The heating allows the expansion of the atmosphere. • This expansion push N_2 up. • Making recombination possible and decreasing the electron density.	• Auroral heating produces fast winds oriented towards the equator. • The wind pushes Ions up along the tilted B-field lines to a higher altitudes. • The lower density at higher altitudes produces les recombination process. • The ionosphere electron density increase

$$\gamma + O \rightarrow O^+ + e^-$$

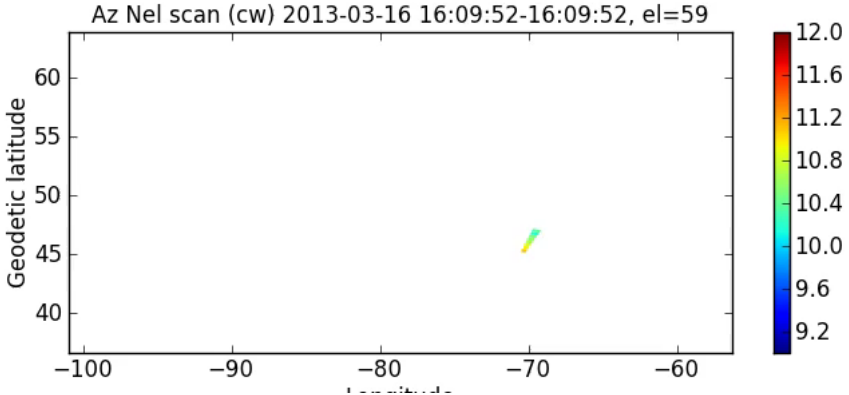
$$N_2 + O^+ \rightarrow NO^+ + N$$

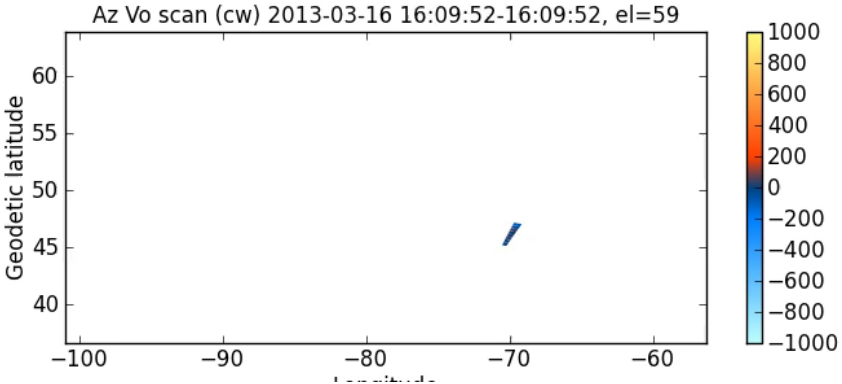
$$NO^+ + e^- \rightarrow NO$$

Magnetic Conditions of 2013 St. Patrick's Day Storm

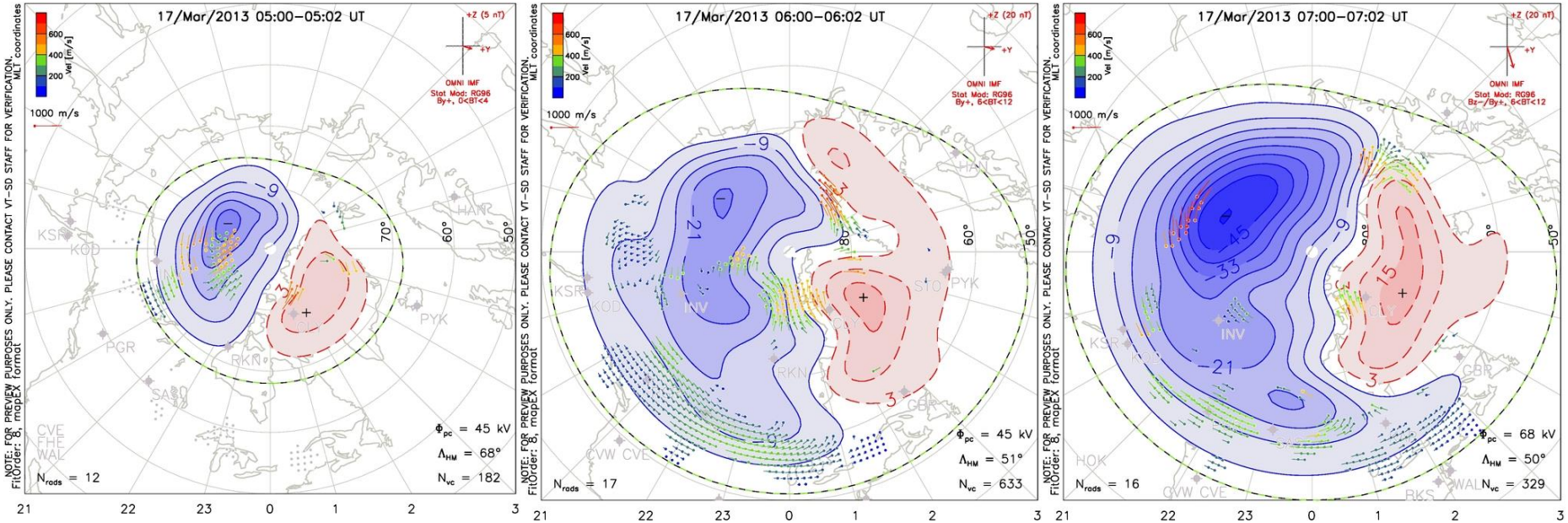


Observations of the 2013 St. Patrick's Day Storm

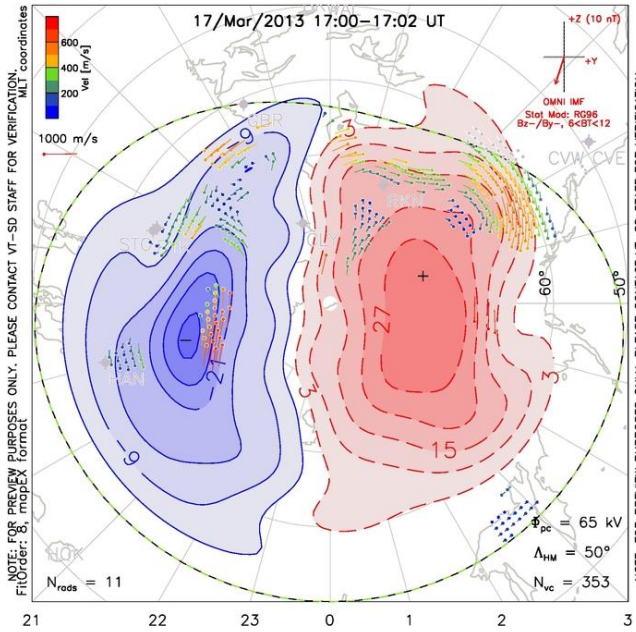


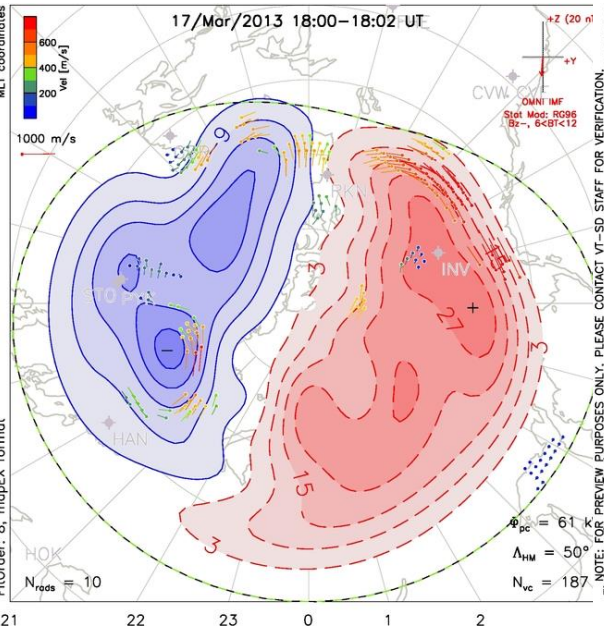


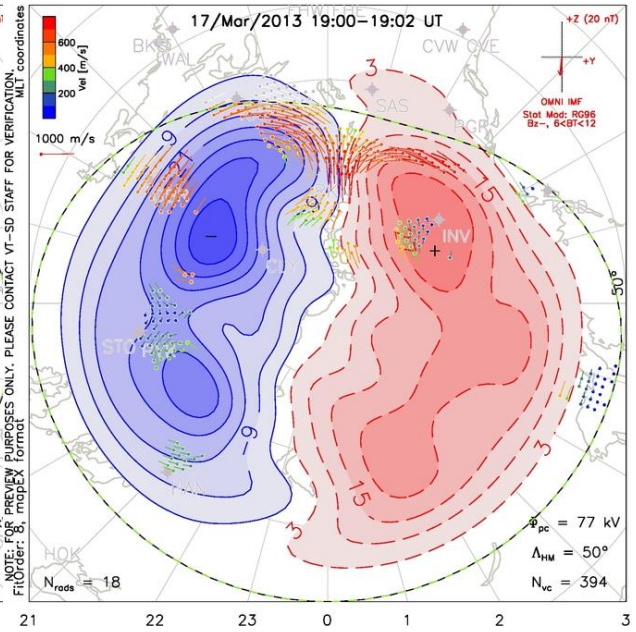
St. Patrick's Storm Convection Maps: Onset



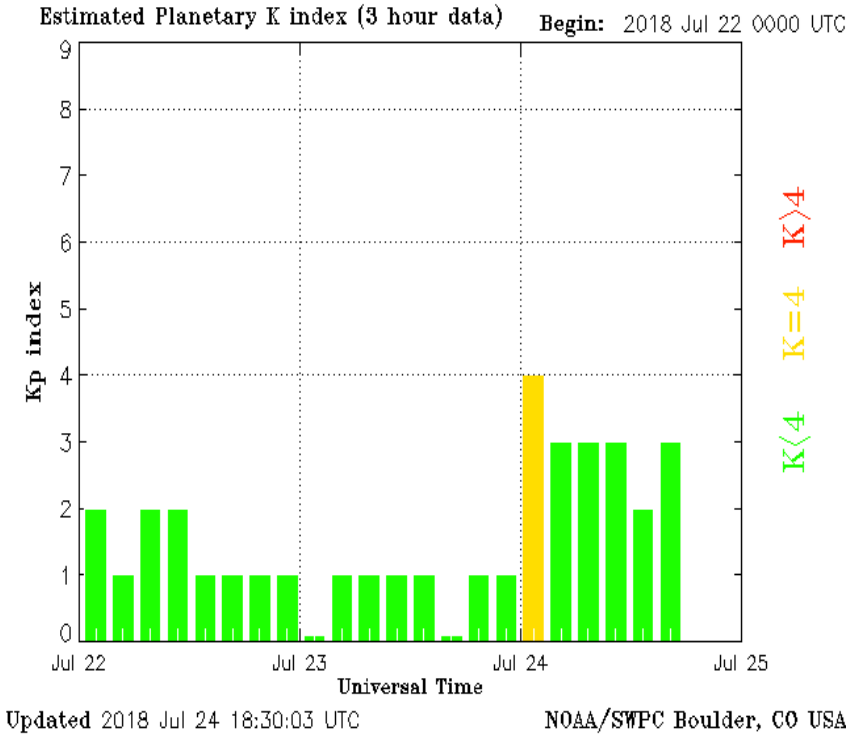
St. Patrick's Storm Convection Maps



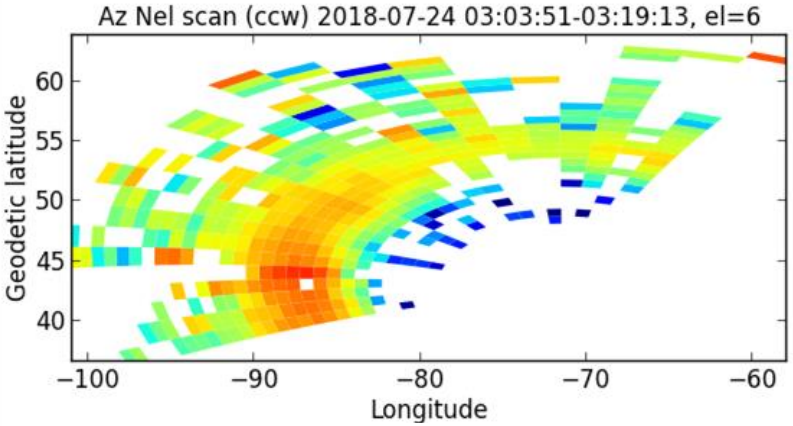


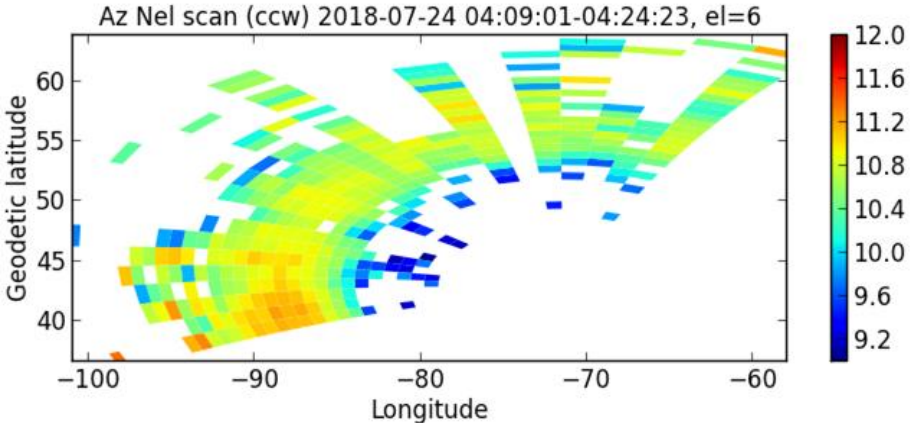


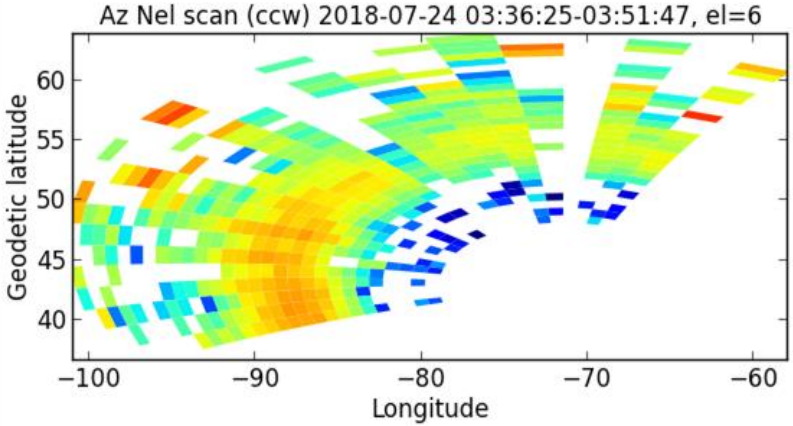
Heighted Magnetic Activity Prior to Our Experiment

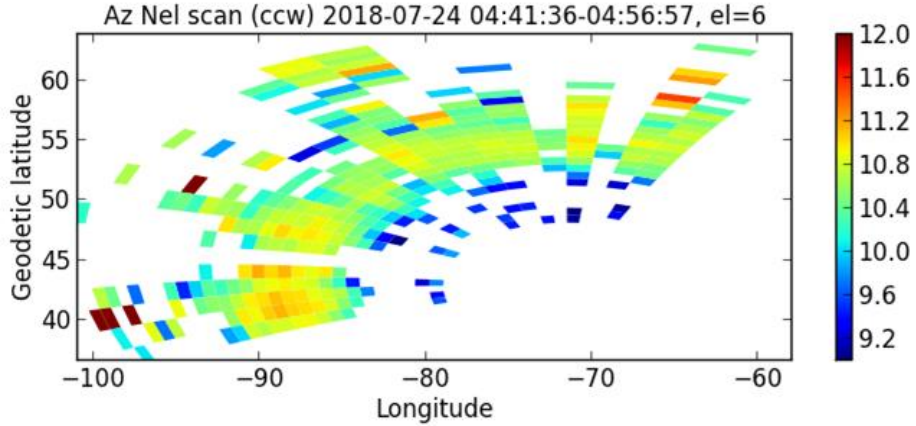


Electron Density 07-24-2018

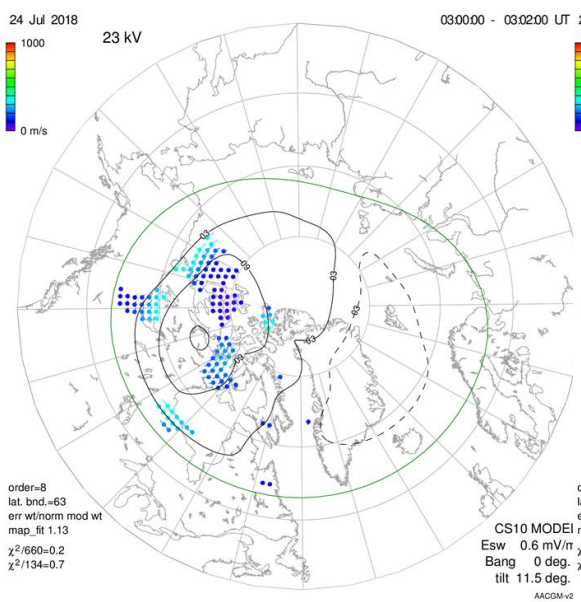




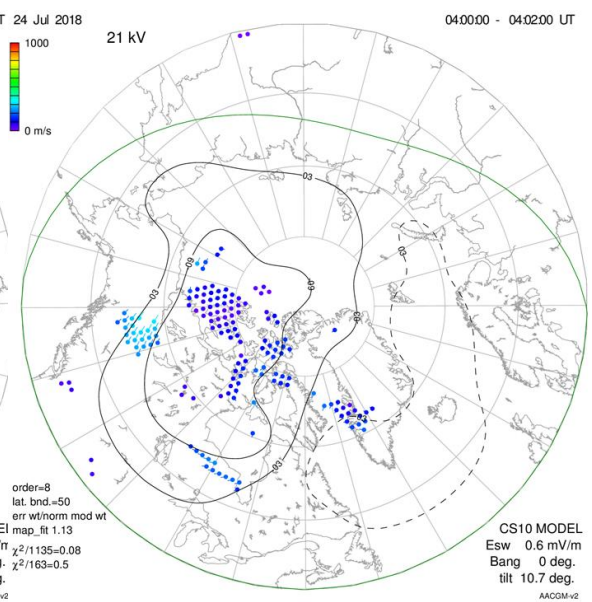




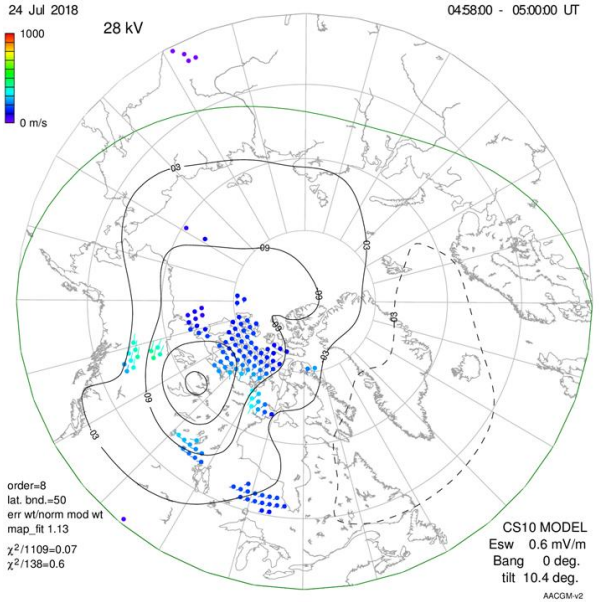
July 24 SuperDARN Convection Maps



0300 UT

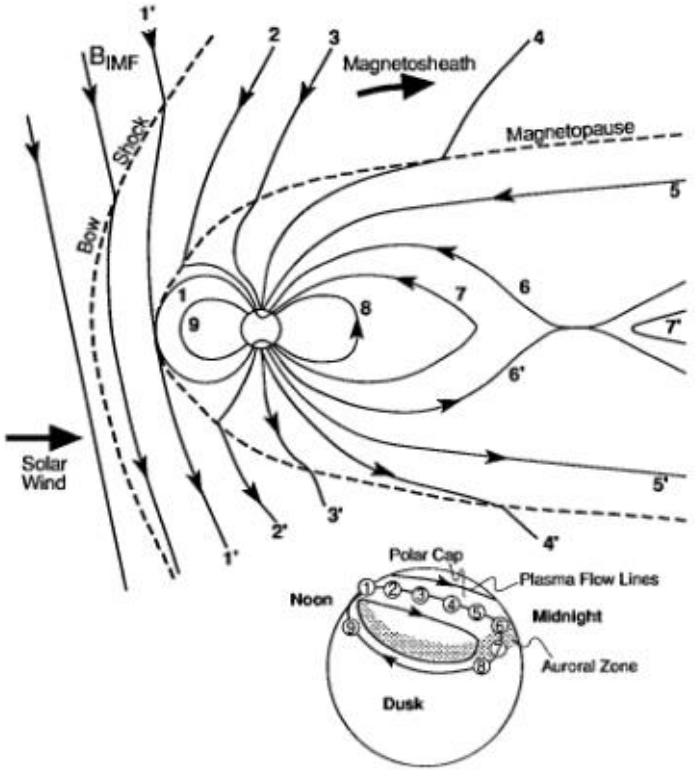


0400 UT

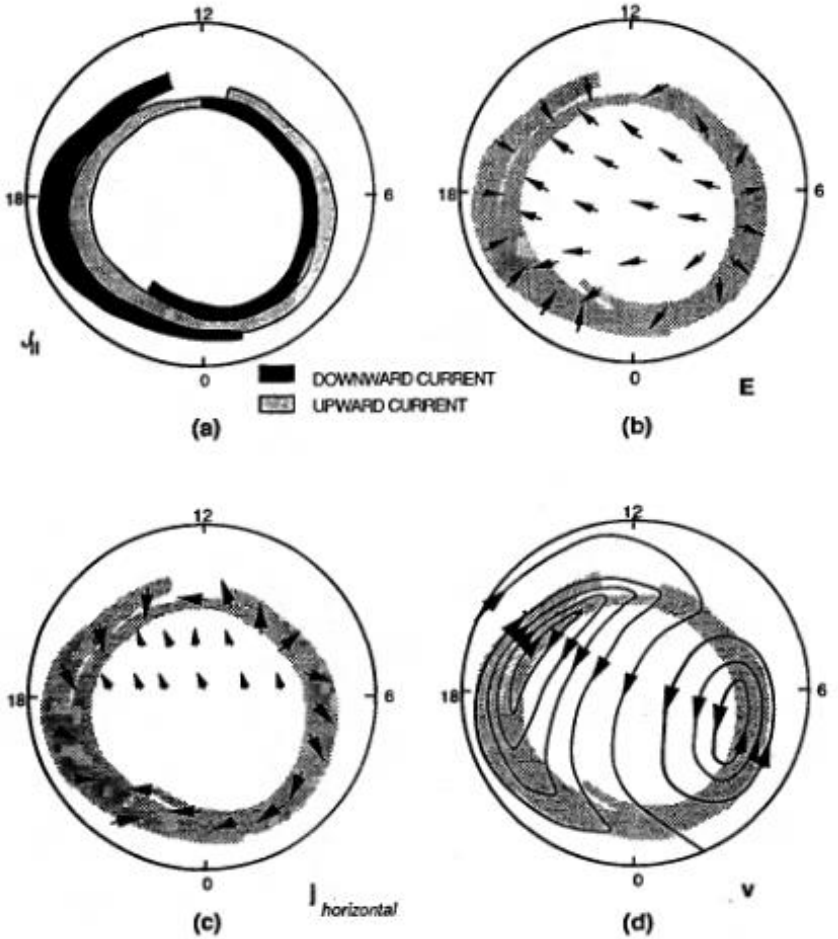


0500 UT

Physics Pictures

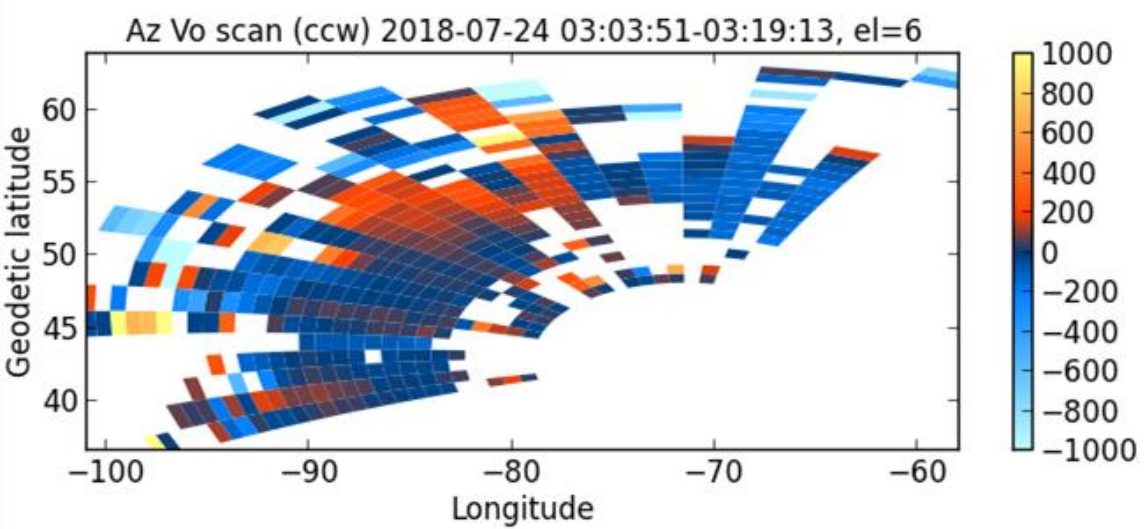


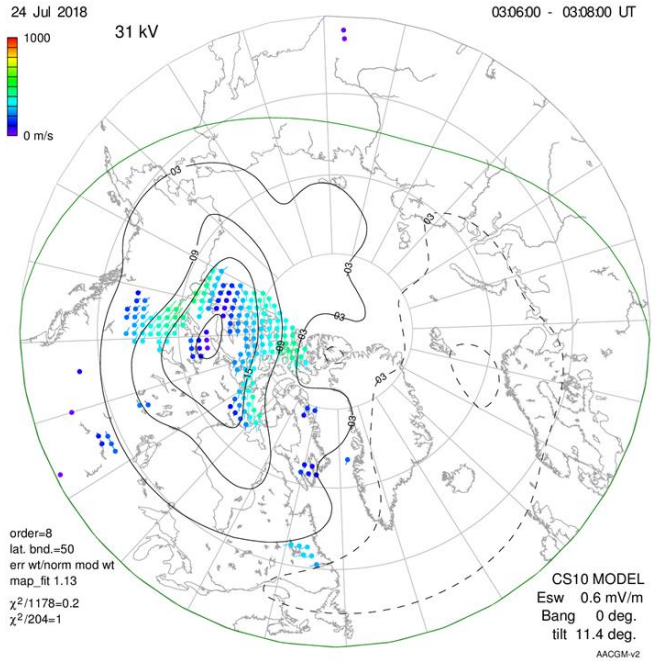
Kivelson and Russell, 1995



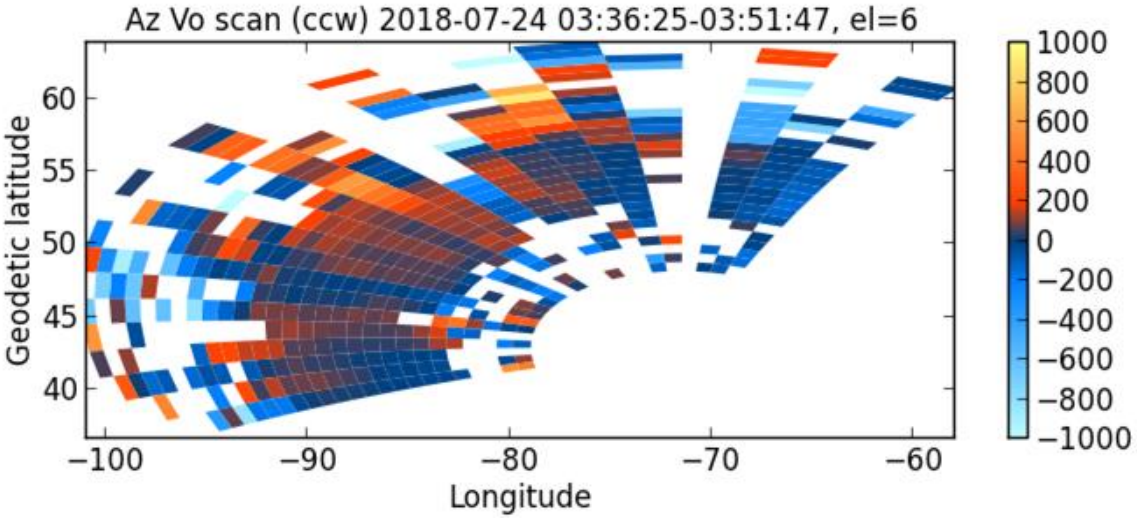
Lijima and Potemra, 1978

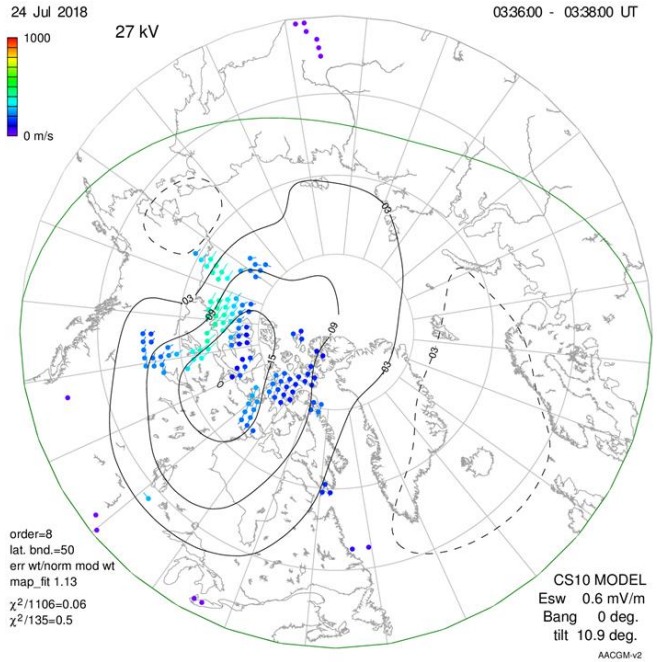
Ion Velocity, 2018-07-24 03:03:51-03:19:13, el=6



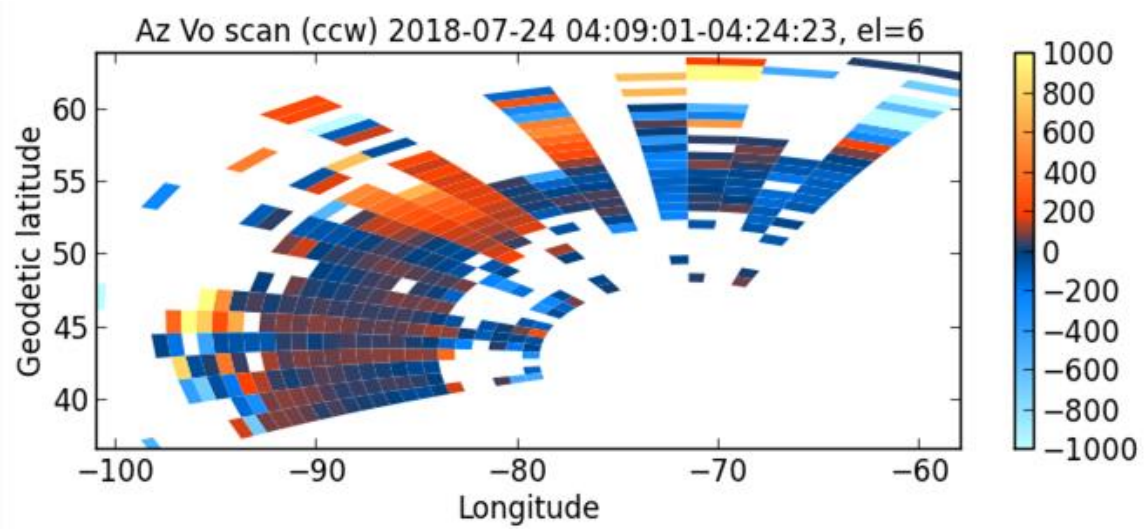


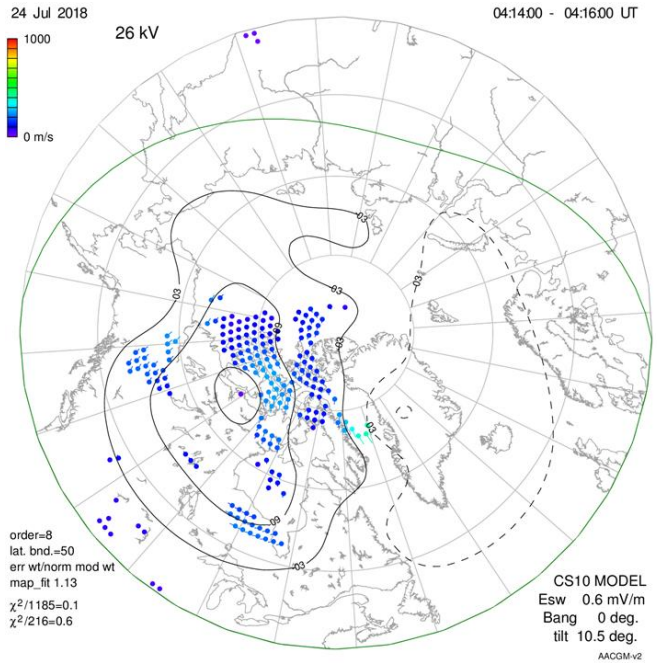
Ion Velocity, 2018-07-24 03:36:25-03:51:47, el=6



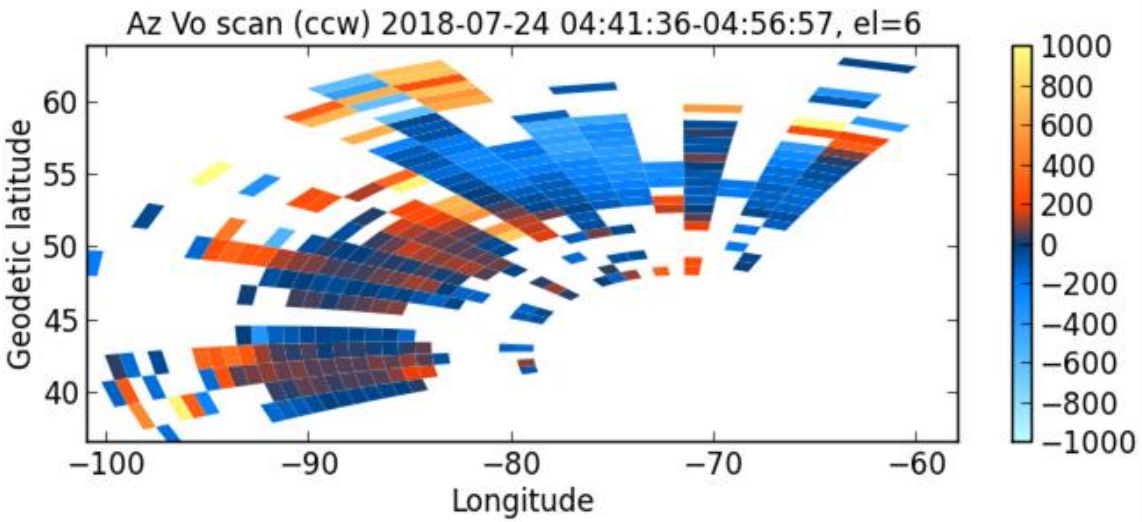


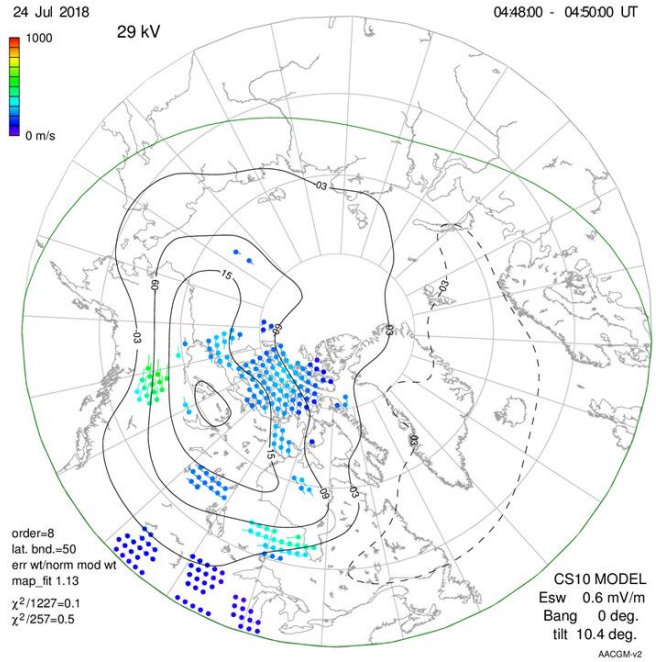
Ion Velocity, 2018-07-24 04:09:01-04:24:23, el=6



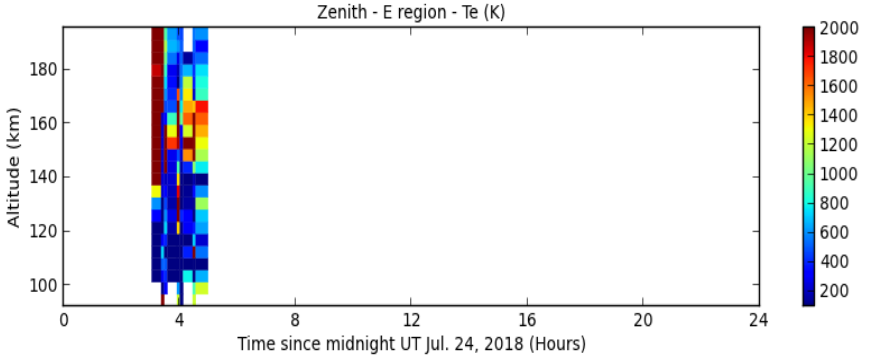


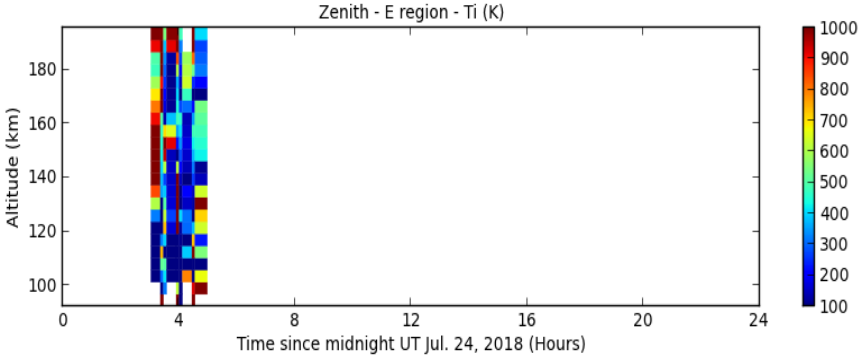
Ion Velocity, 2018-07-24 04:41:36-04:56:57, el=6

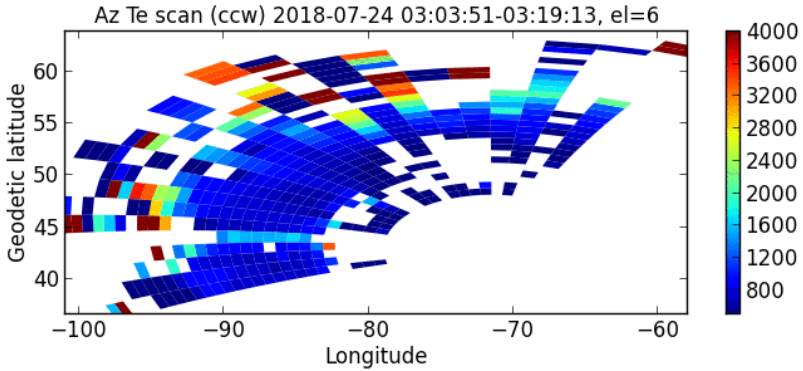


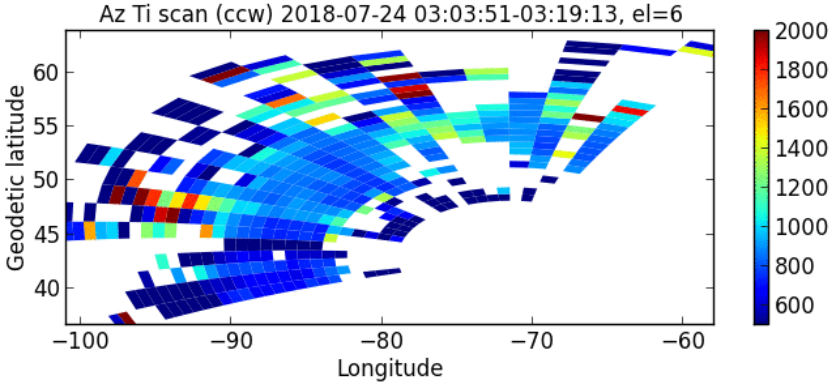


Electron and Ion Temperature

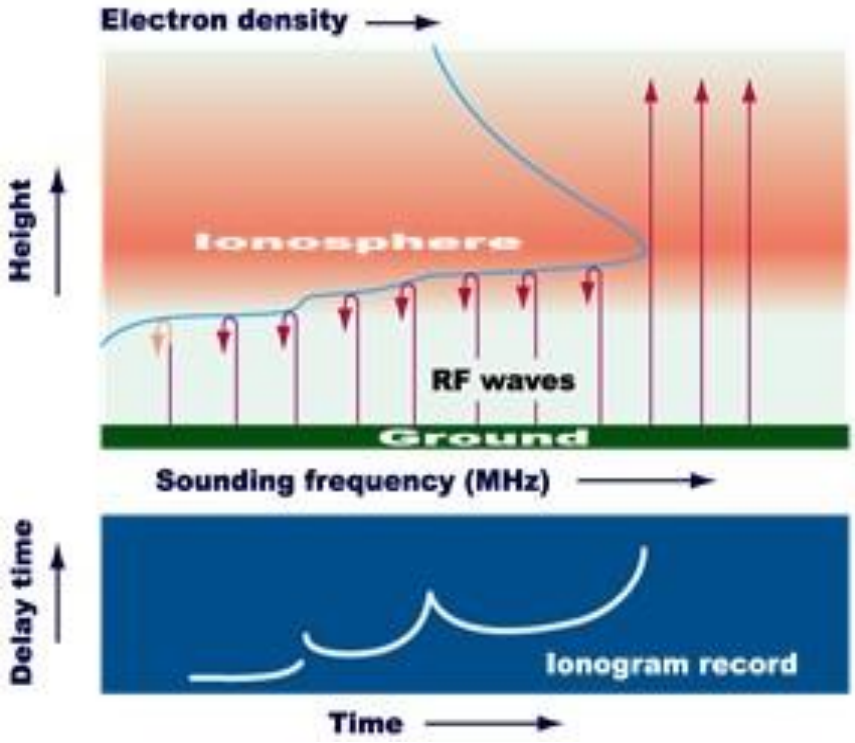








Millstone Hill Ionosonde Observations



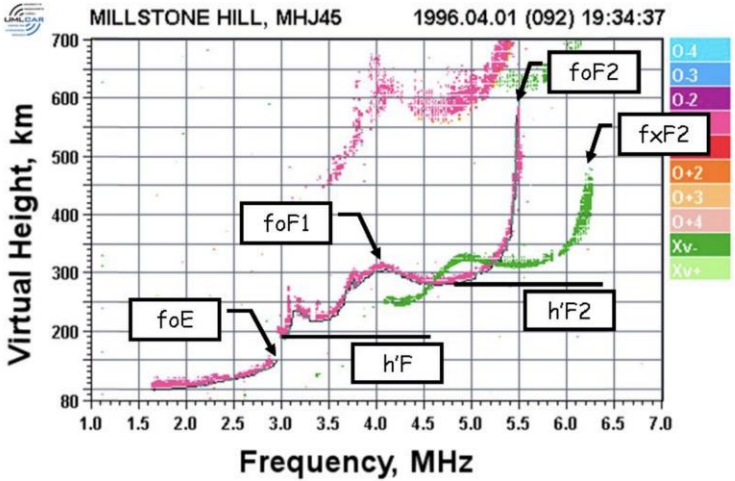
★ The radio wave in the range 2-30 MHz is transmitted from the FM/CW ionosonde to the ionosphere by the ionosphere sounding antenna

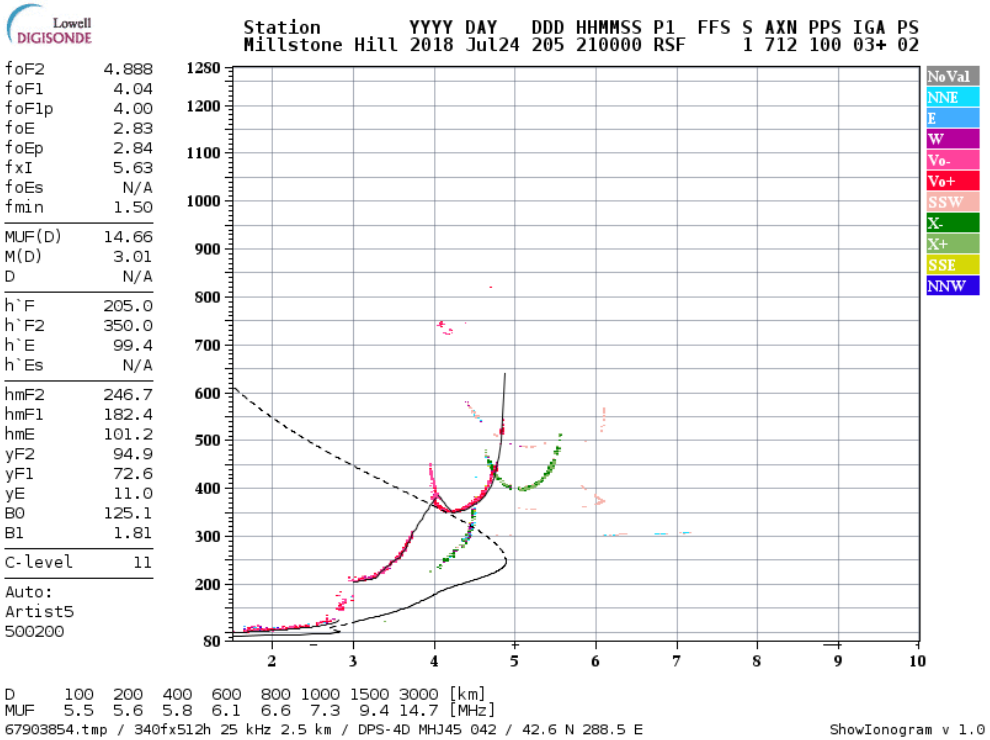
★ The reflected pulse is received and its delay time is recorded as a trace on the ionogram.

Millstone Hill Ionosonde Observations

❖ Ionograms (2-min time resolution)

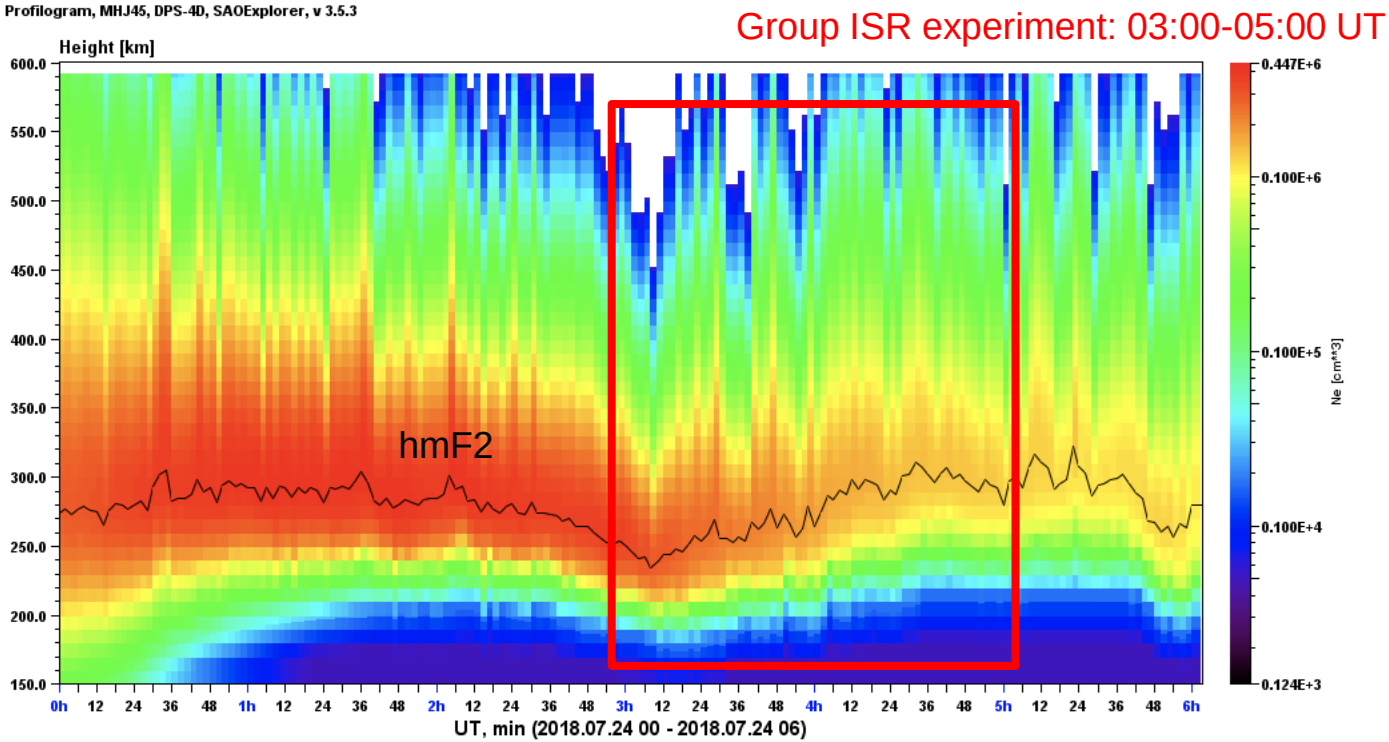
- Time series of scaled data
  - Ionospheric characteristics
    - foF1, foF2, h'F, hmF2…..
  - Plasma density profilograms



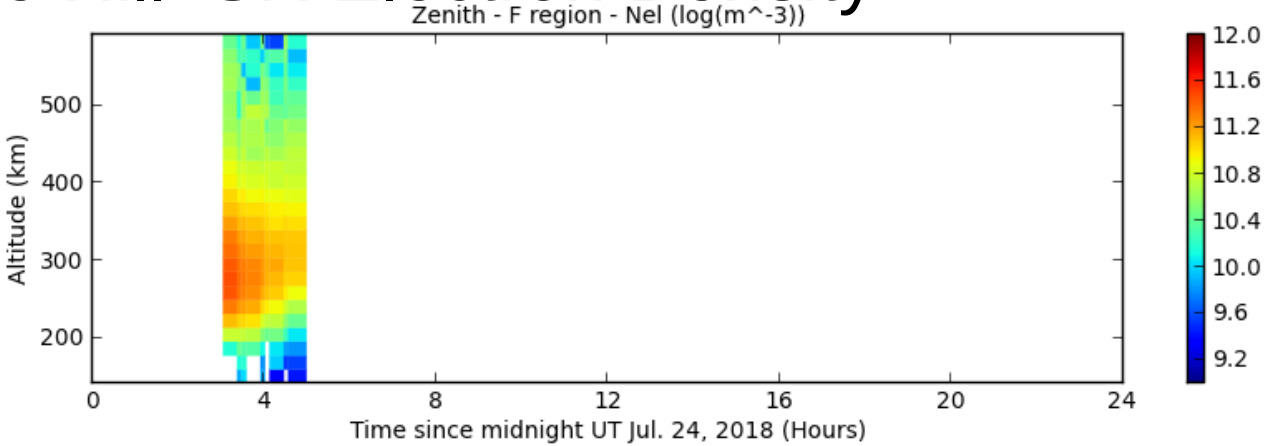


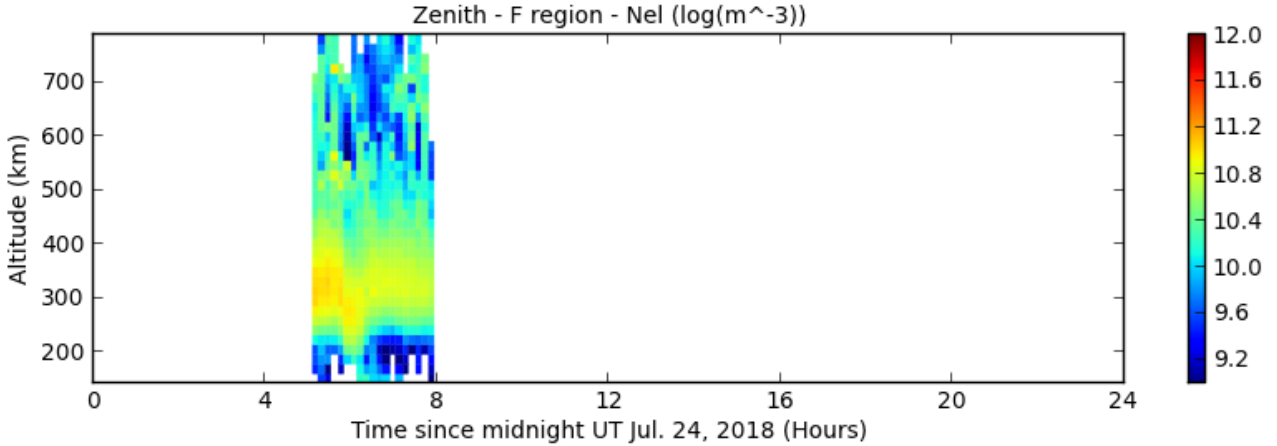
Millstone Hill Ionosonde Observations

- Profilogram (auto-scaled by SAO-explorer software)



Millstone Hill ISR Electron Density



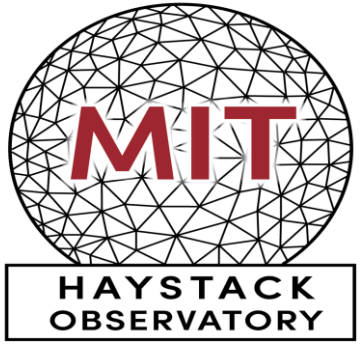


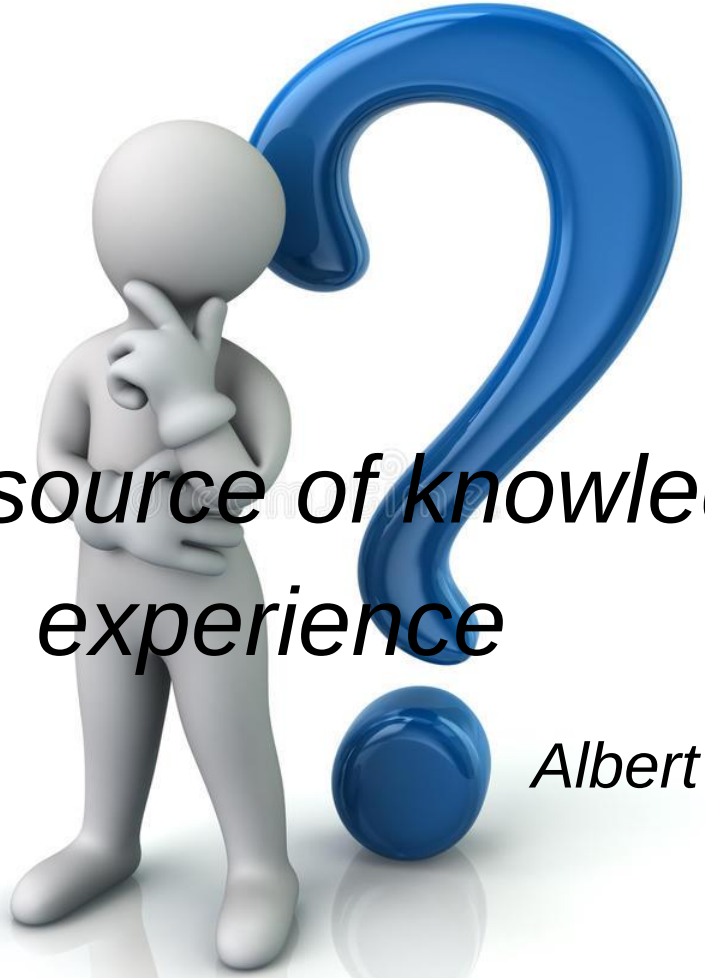
Conclusions

- Gained experience designing and using data from an ISR experiment
- Used available data from several instruments to form a more complete picture of the ionosphere activity
- Observed polar cap expansion into mid-latitudes due to increased magnetic activity

Acknowledgements

- All the instructors
- Millstone Hill operators
- PFISR, Jicamarca, Arecibo, SuperDARN
- National Science Foundation

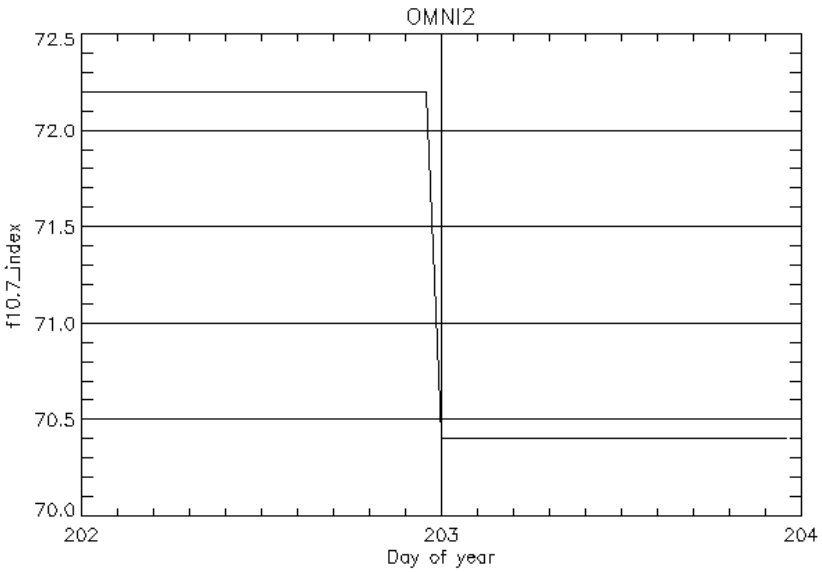


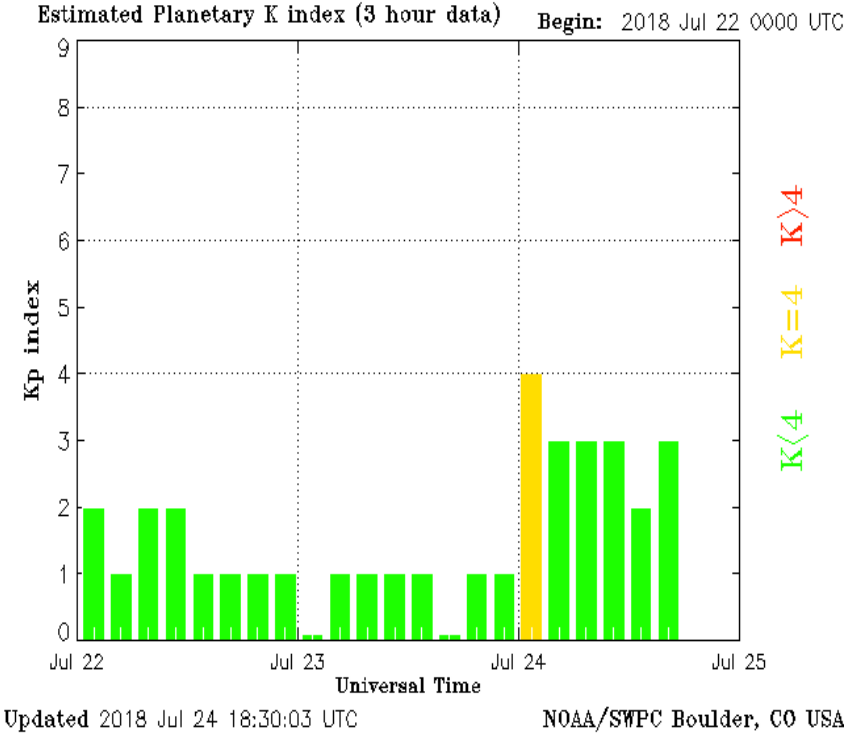


The only source of knowledge is experience

Albert Einstein

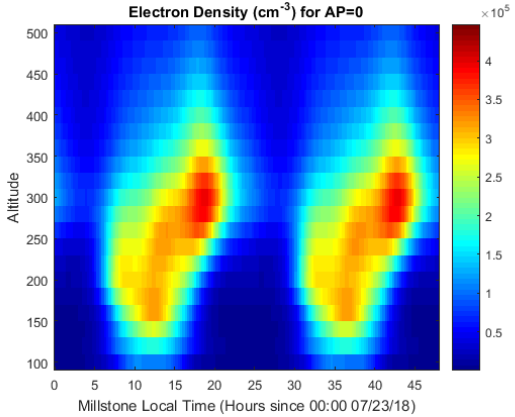
Magnetic Activity During The Experiment

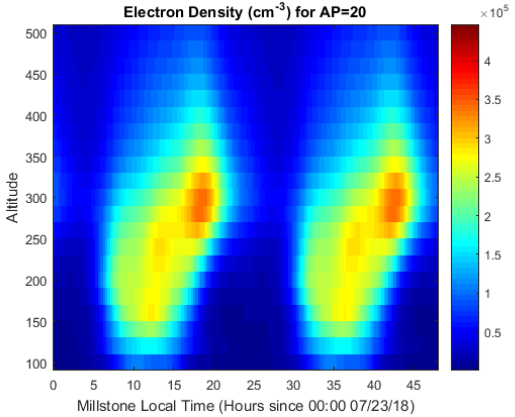


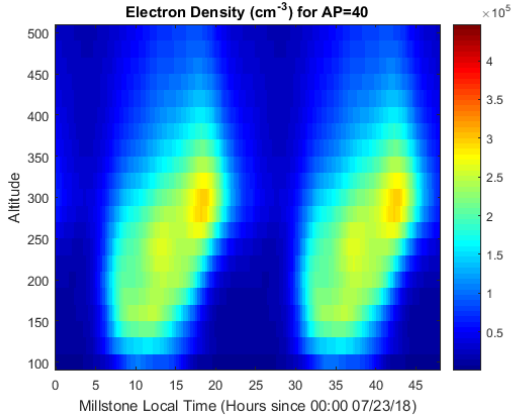


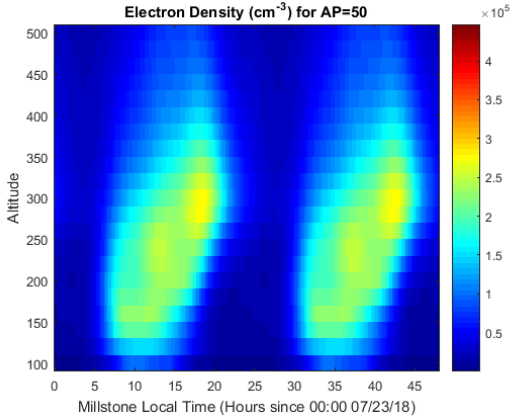
Omni-Web Data from 7/22 (Most Recent Date Available)

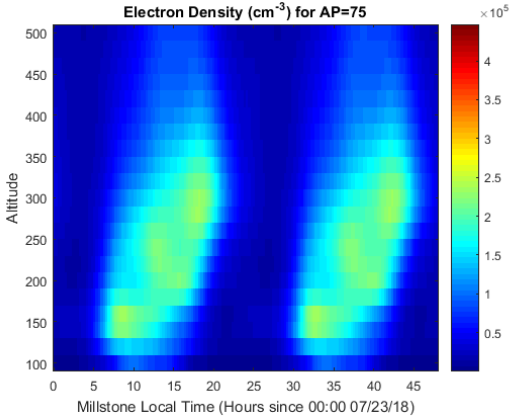
ISRIM: Incoherent Scatter Radar Ionospheric Model

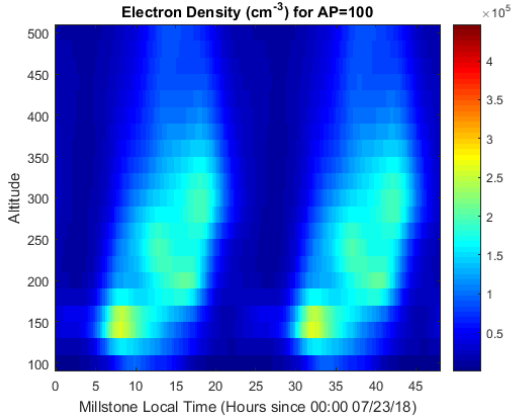




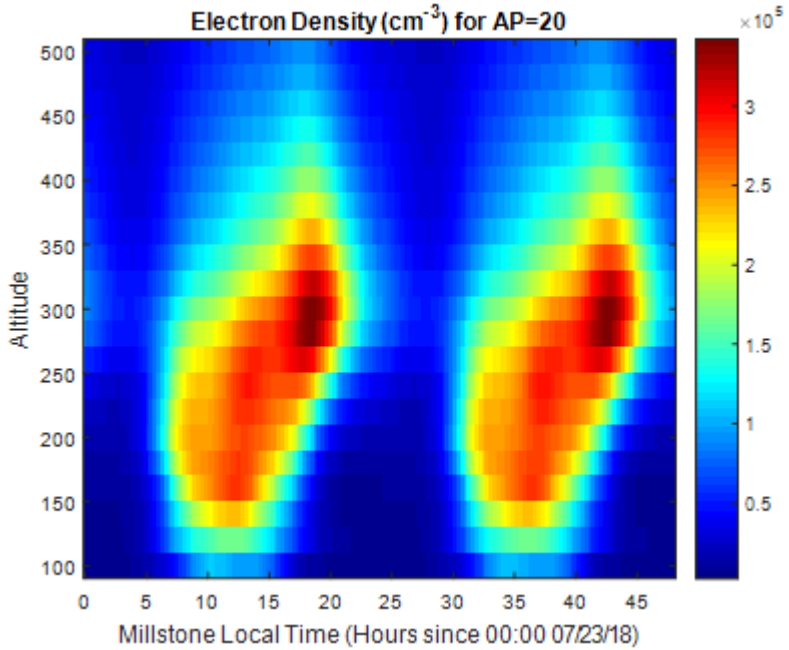


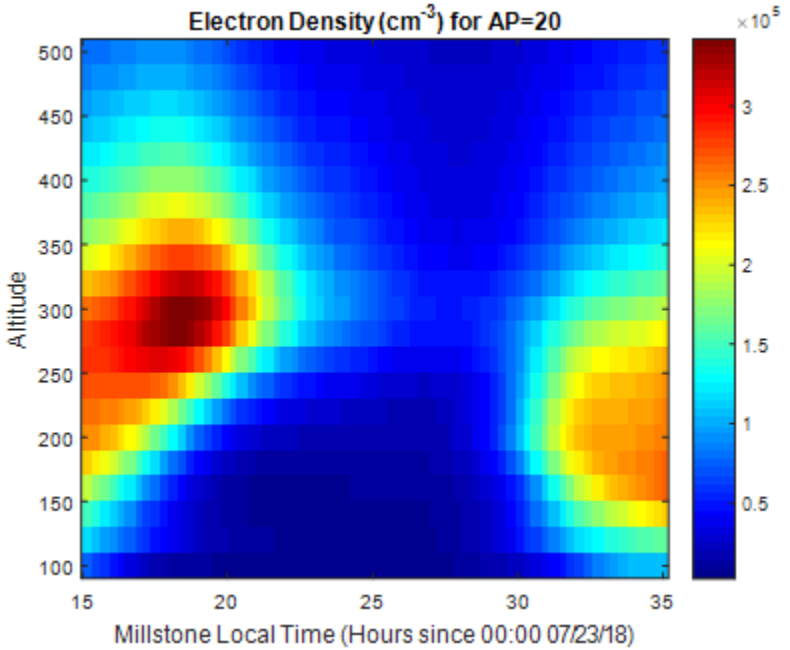






ISRIM: Incoherent Scatter Radar Ionospheric Model





http://madrigal.haystack.mit.edu/models/