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An Observational Study of Southern Hemisphere Poleward Moving Radar Auroral Forms Using 2021 SuperDARN Data

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Introduction

- Why this work matters
- Background:
  - Upper Atmosphere
  - SuperDARN
  - Indices
  - PMAFs/PMRAFs
- Methods of Detection/Results- 2 Dates
  - RTI
  - FOV
  - Convection
- Conclusions
- Future Work

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Why does it matter?- Satellites!

1. **EUV Creates Plasma**
   This occurs all the time, but during periods of high solar activity or a flare/CME, more plasma is generally generated

2. **Temperature Profile Changes Due to Introduced Energy**
   The upper atmosphere is hydrostatic, this temperature profile change causes expansion

3. **Higher Density Air Reaches LEO Altitude**
   LEO always face some drag, but drag increases as density increases

4. **Satellites Must Regain Speed**
   This requires the use of station fuel, which many LEO satellites don't have!

5. **Satellites' Lifetime in Orbit Limited**
   More space debris created, future expensive launches required, etc

$$\mathbf{a}_{drag} = -\frac{1}{2}(C_d A/m)\rho|\mathbf{v}-\mathbf{v_a}|^2 \mathbf{e}_{\mathbf{v}-\mathbf{v}_a}$$

C_d - Ballistic drag coefficient
A - Cross-sectional area
m - Satellite mass
ρ - Atmospheric density

https://www.space.com/spacex-starlink-satellite-deorbit-video

Background- Upper Atmosphere

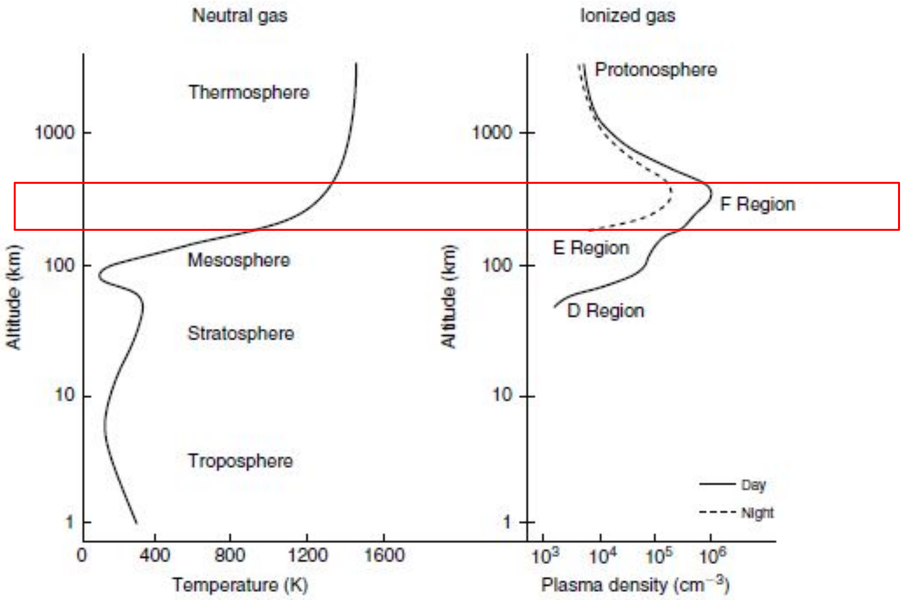

Figure 1.1 Typical profiles of neutral atmospheric temperature and ionospheric plasma density with the various layers designated.

Background- Upper Atmosphere

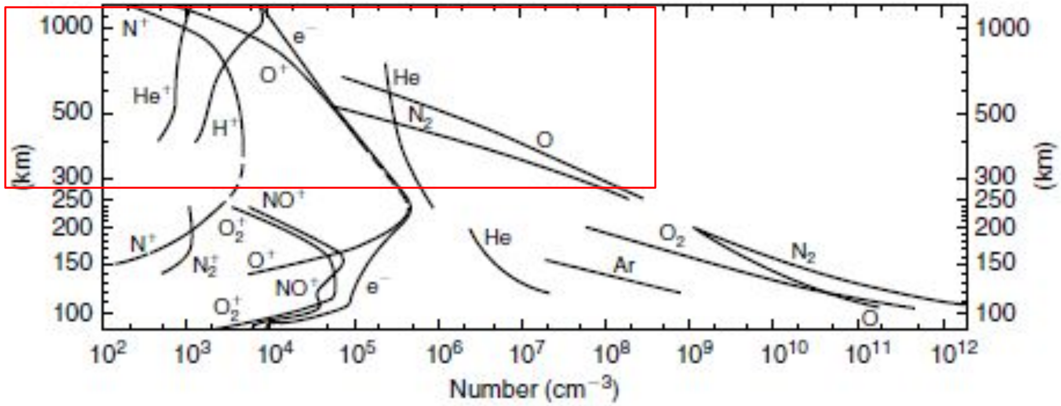

Figure 1.2 International Quiet Solar Year (IQSY) daytime atmospheric composition, based on mass spectrometer measurements above White Sands, New Mexico (32°N, 106°W). The helium distribution is from a nighttime measurement. Distributions above 250 km are from the *Elektron 11* satellite results of Istomin (1966) and *Explorer XVII* results of Reber and Nicolet (1965). [C. Y. Johnson, U.S. Naval Research Laboratory, Washington, D.C. Reprinted from Johnson (1969) by permission of the MIT Press, Cambridge, Massachusetts. Copyright 1969 by MIT.]

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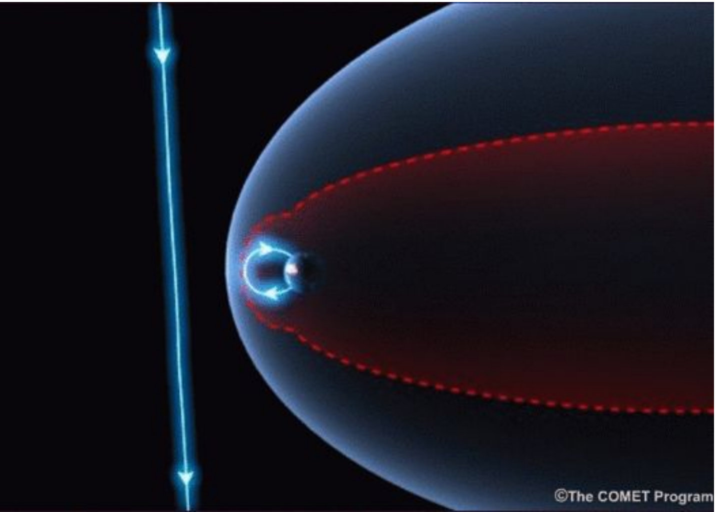
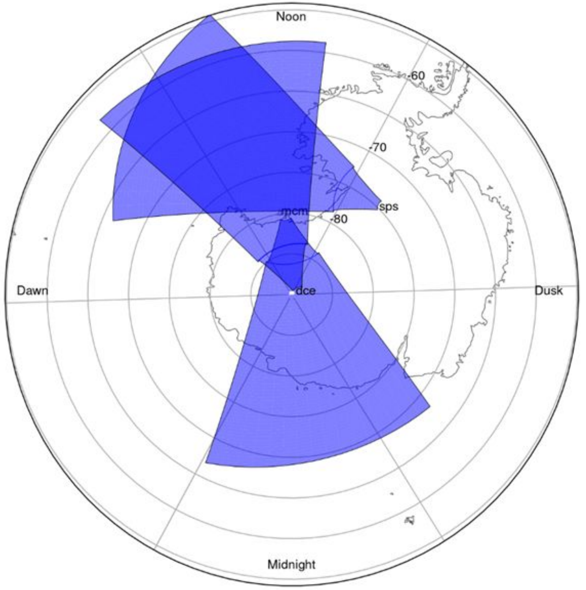
Background: SuperDARN

- SuperDARN- Super Dual Auroral Radar Network
- Measures plasma convection in the E/F regions of the ionosphere
- Uses Doppler shift to determine plasma velocity
    - Combine radars to determine direction

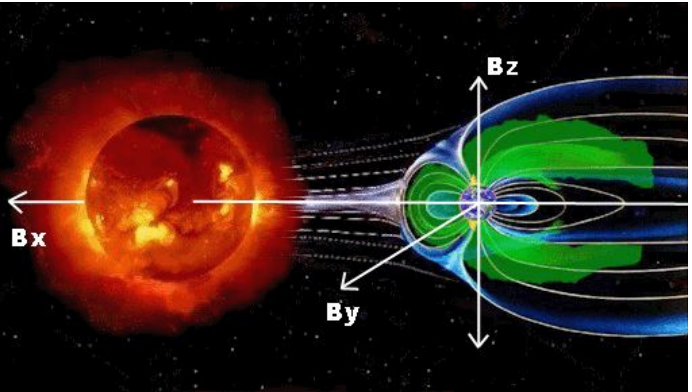


https://www.weather.gov/jetstream/ionosphere_max



Background: Parameters

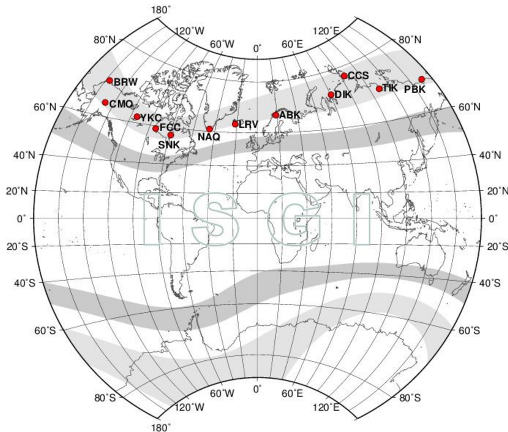
- B_x, B_y, B_z- solar wind's magnetic field components
- A_U, A_L - Magnetometer measurements of the northern hemisphere
  - A_E and A_O- Derived measurements
- Sym-H- Geomagnetic disturbances at mid-latitudes



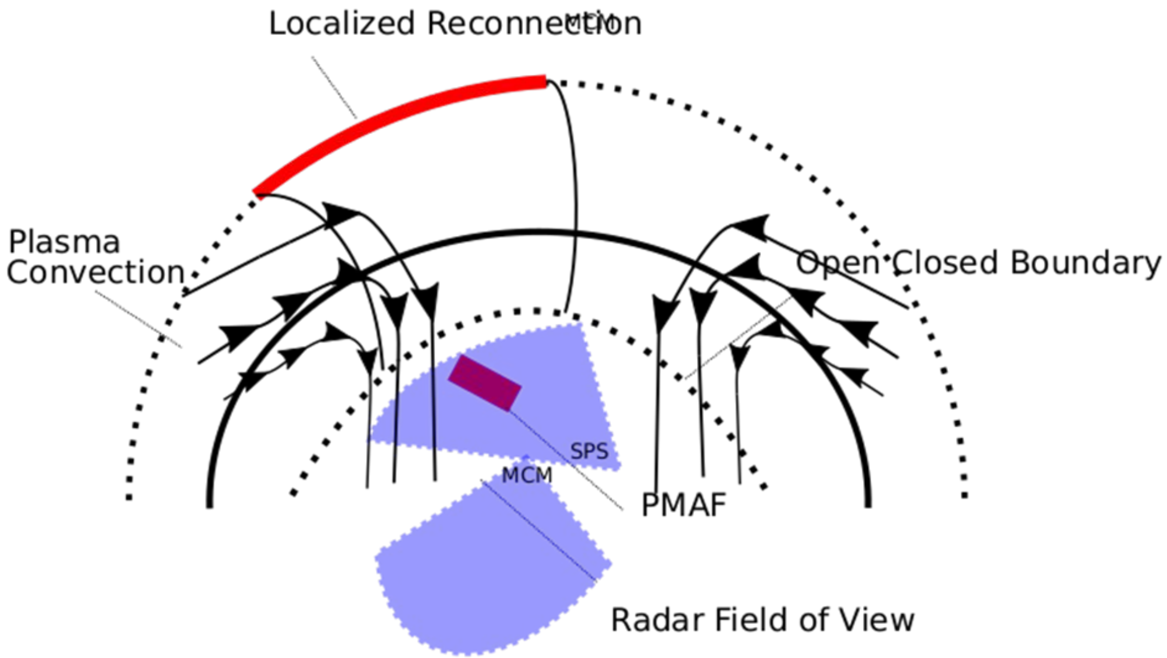
https://earthsky.org/sun/aurora-season-auroras-equinox-connection/

https://isgi.unistra.fr/indices_ae.php

Distribution of *AE* observatories



Method of Formation



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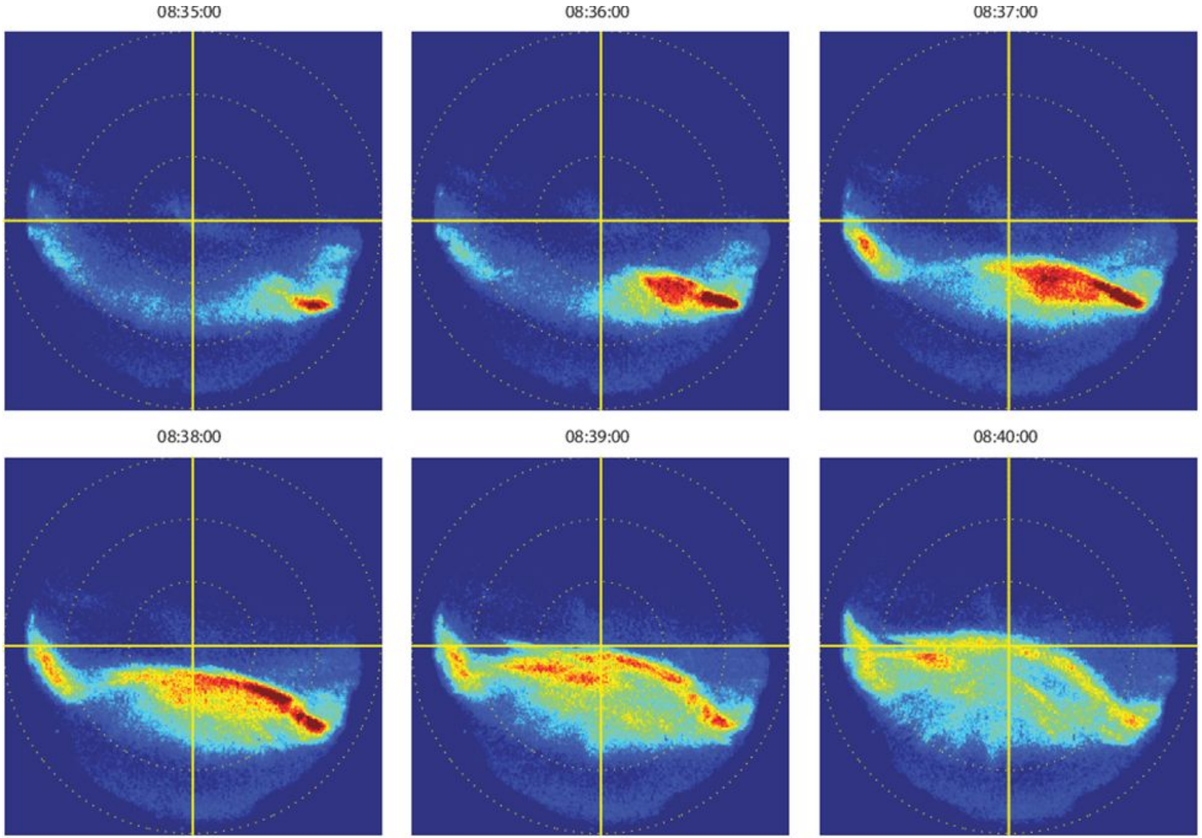
Background 2: PMAFs



From "Poleward moving auroral forms (PMAFs) revisited: responses of aurorae, plasma convection and Birkeland currents in the pre- and postnoon sectors under positive and negative IMF By conditions" by P.E. Sandholdt and C.J. Farrugia, 2007, *Annales Geophysicae,* p. 1631, PennState College of Earth and Mineral Sciences

Background 2: PMRAFs

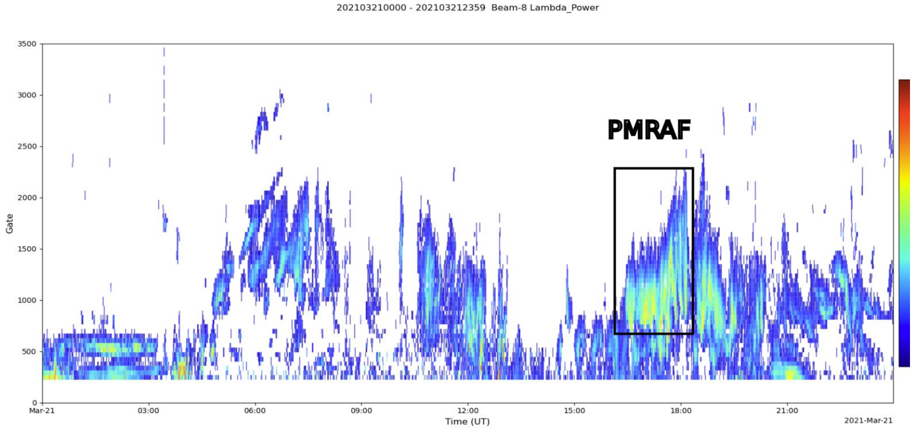
PMRAFS- Polar Moving Radar Auroral Forms

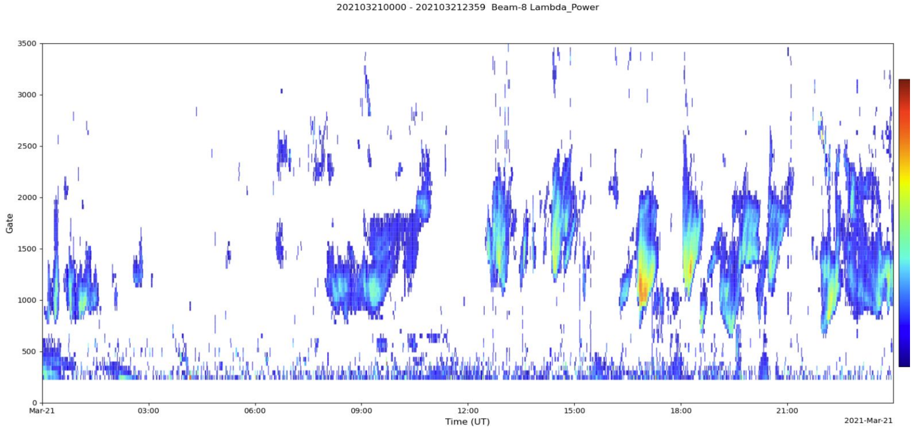
- Key Features
  - Localized (dense) plasma
  - Fast moving convection (~1000 m/s)
  - Repeated ‘waves’ with 2-10 minute gap
  - Occurs near magnetic noon
  - Linked closely with traditional PMAFs

Summary of Work

- Categorized 60 PMRAF events throughout 2021
  - Attempted automatic signature detection with Fourier analysis technique
  - Confirmed McMurdo Streaks for 21 of these events
  - Pulled IMF and auroral indices from SuperMAG and OMNI for all 60
    - Ran basic statistics on indices
  - Used Model (Bristow et al. 2021) to run Convection mapping software for 21 events

3 Methods of Detection: **RTI**, FOV, Convection





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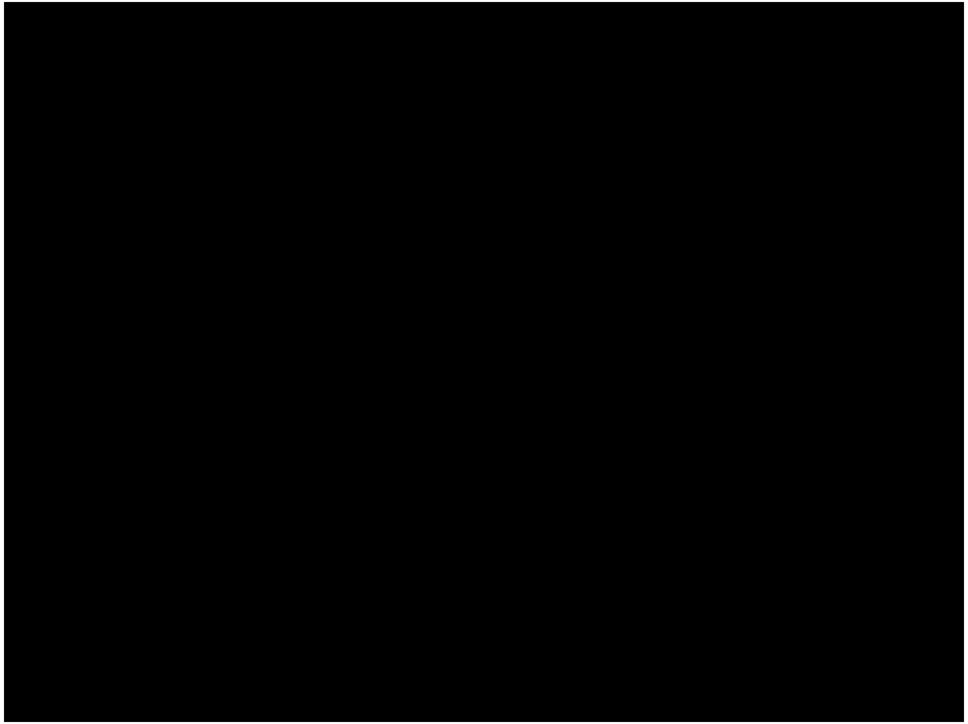
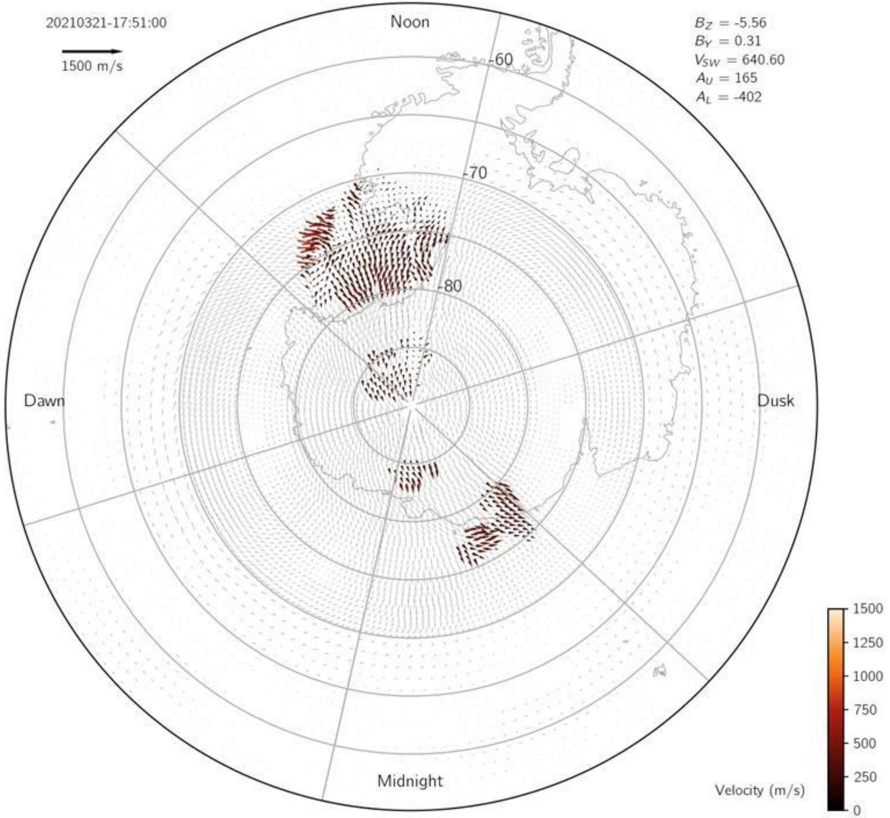


3 Methods of Detection: RTI, FOV, **Convection**



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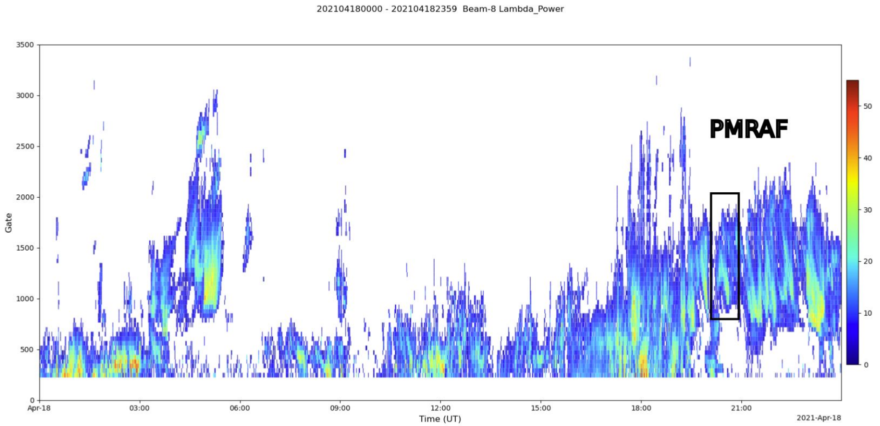
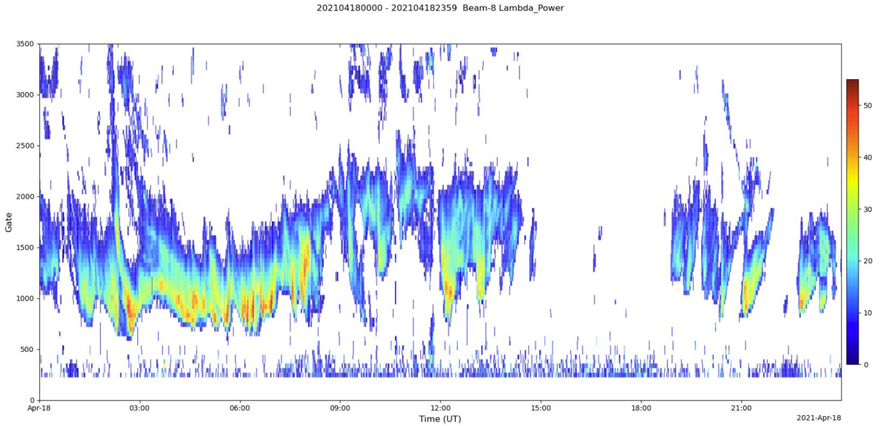
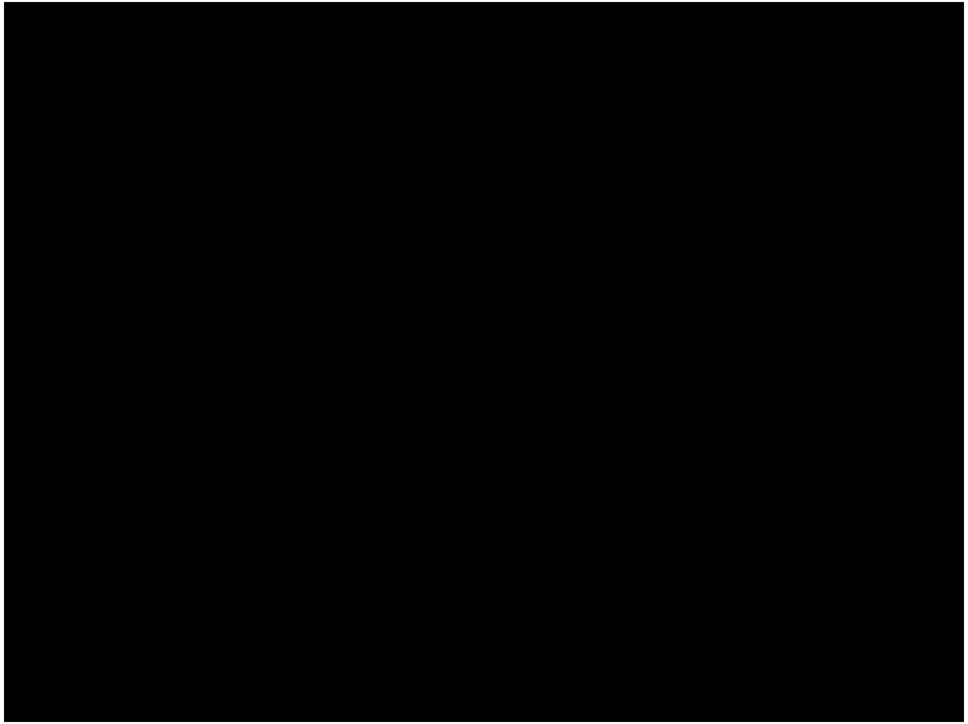
3 Methods of Detection: **RTI**, FOV, Convection





3 Methods of Detection: RTI, **FOV**, Convection



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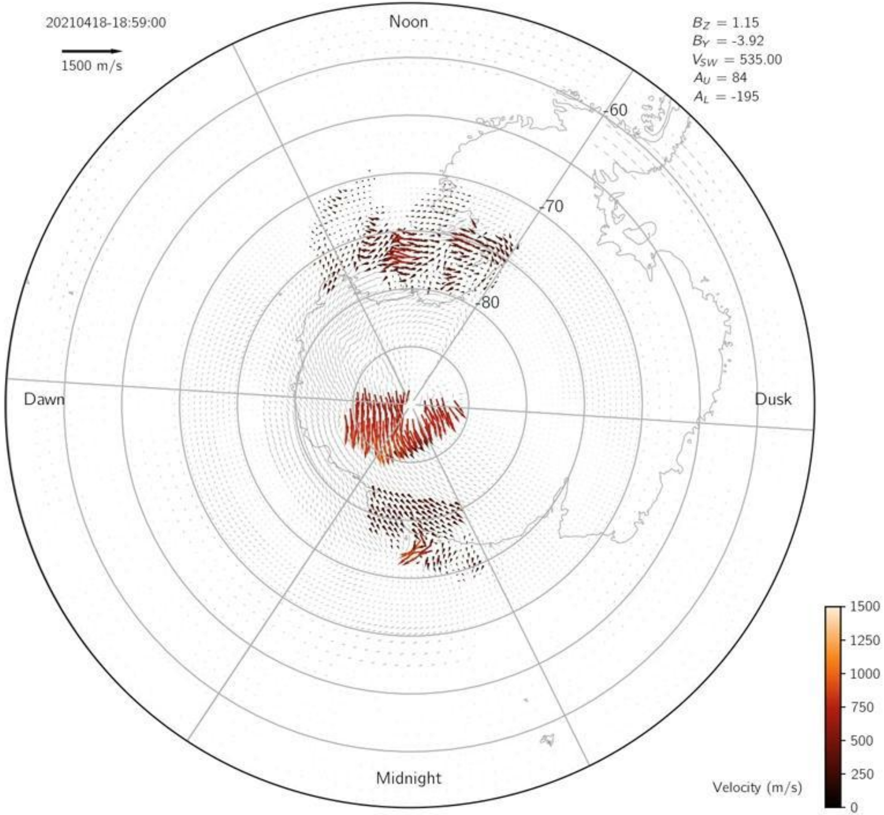
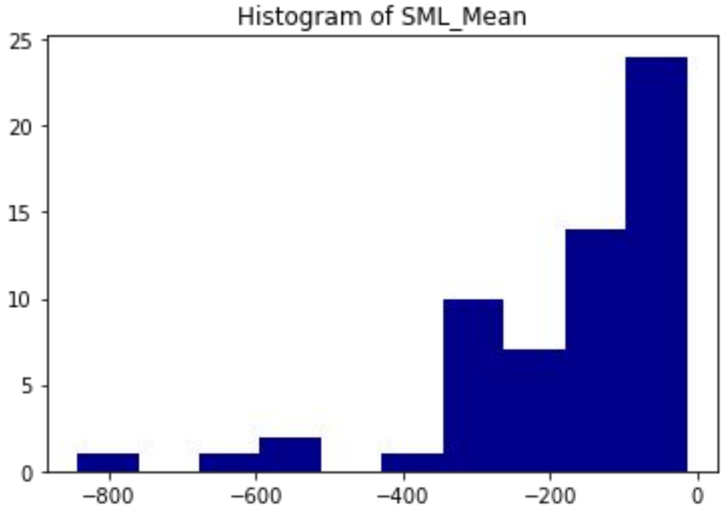
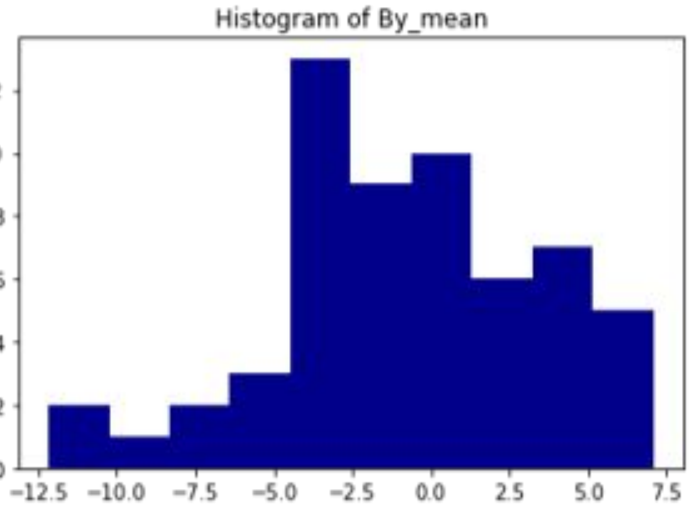


Conclusions: Correlation with IMF Parameters

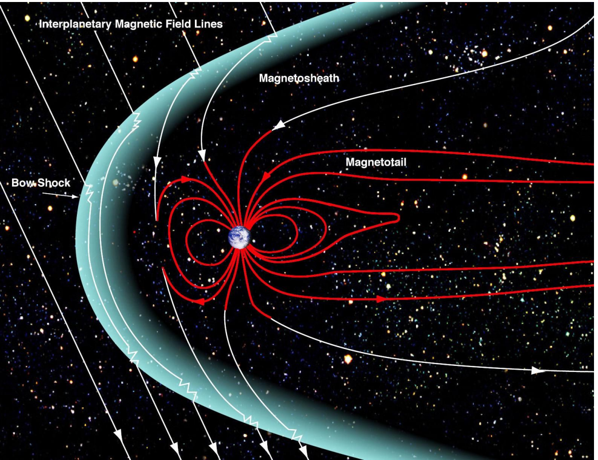
- Checked IMF, Auroral indices, and SYM_H for correlation with the onset of PMRAFs
  - B_y and A_L show weak correlation with the onset of PMRAFs
  - Other indices show no correlation
- Check for non-zero mean, standard deviation, Pearson R test





Potential Future Projects

- Create an automated method for detecting PMRAFs
- Cross reference PMRAFs with other instruments
    - Confirms occurrences
- Temperature → Density of Upper Atmosphere
- Check concurrence with Northern Hemisphere events
    - This will help confirm correlation between PMAF and PMRAF



https://www.nasa.gov/mission_pages/sunearth/multimedia/magnetosphere.html

Questions?