Identification of STEVE-SAID Events in Swarm Data

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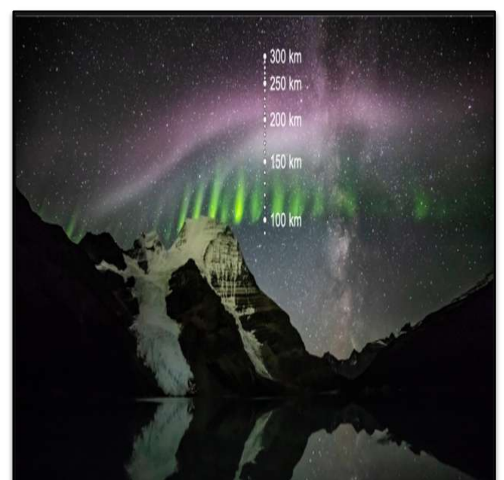
Background

- Strong Thermal Emission Velocity Enhancement (STEVE) is an optical phenomenon
- Observed as a purple band of light equatorward of auroral oval (Archer et. al 2019)

Left: Photograph by Dave Markel Photography, National Geographic Your Shot. Available at: https://www.nationalgeographic.com/science/article/odd-aurora-named-steve-revealed-to-be-two-different-sky-shows-in-one



Right: Photograph of STEVE emissions and a green picket fence taken by Robert Downie. Figure taken from Archer et. al. (2019a)

- STEVE found to be associated with intense Subauroral Ion Drift (SAID) under following conditions (Archer et. al 2019): (1) High electron temperature (2) Low plasma density (3) High peak ion velocities
- **Motivation: Develop an algorithmic approach to identify coupled STEVE and SAID events**

Methodology

- Create spike finding routine for electron temperature that matches SWARM A spikes identified in Archer et. al 2019

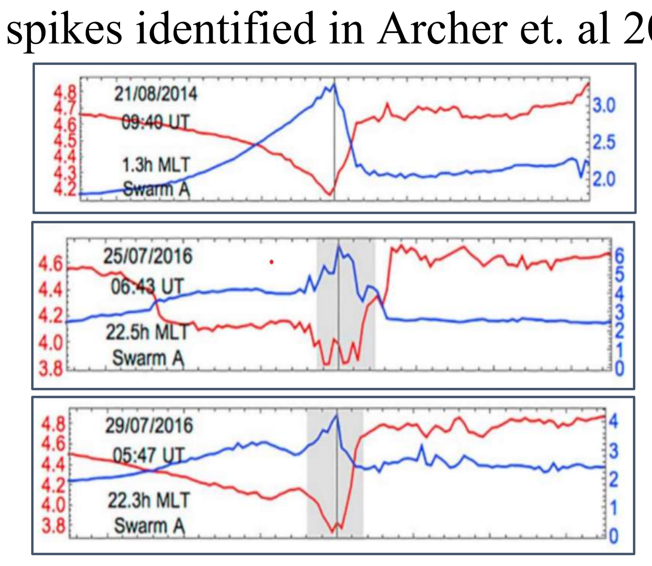


Figure 1: 3 Swarm A temperature spikes as identified in Fig. 1 from Archer et. al 2019

- Parameters: Height (3000 - 20000 K), Distance (100 samples), Width (4 – 40 samples), Prominence (1250 – 5000 K)
- Run all available data through spike finding routine
- Apply cross-correlation filtering with plasma density

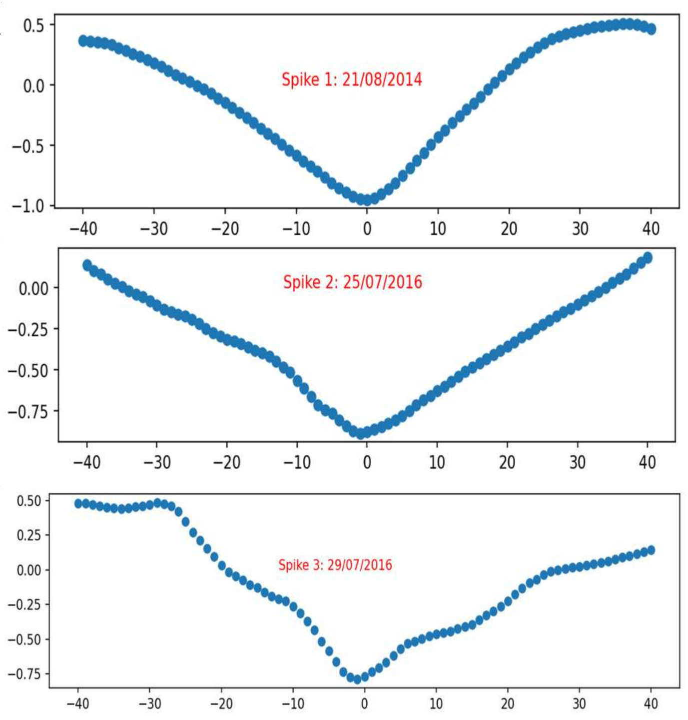


Figure 2: Electron temperature vs Plasma Density Correlation for 3 Swarm A events from Fig.1

- Filter all identified spikes using minimum cross-correlation factor with threshold -.80
- Identify visual patterns

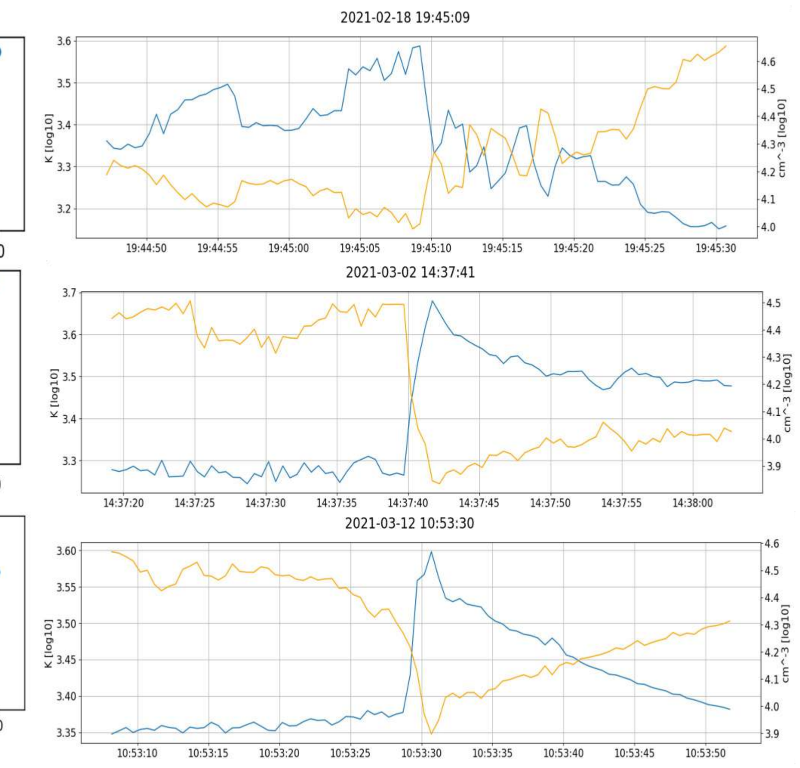


Figure 3: (Top) Only anti-correlation vs **(Middle)** Trough crossing vs **(Bottom)** Density Drop

- Find a routine to separate mere anti-correlated and Trough crossing events from true density drops

Results

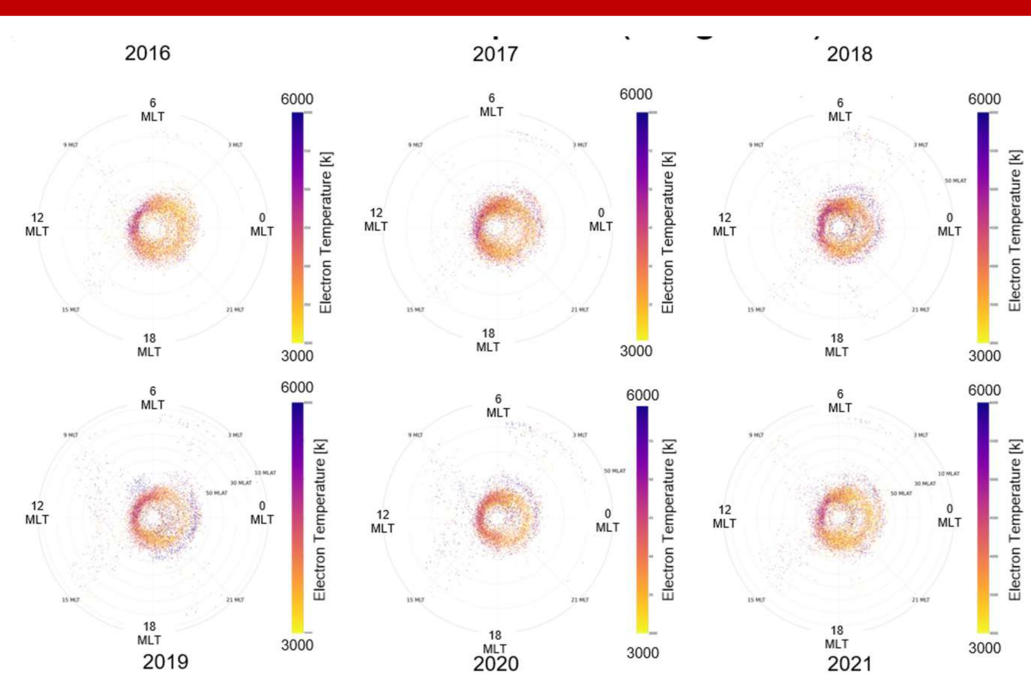


Figure 4: Progression of identified electron temperature spikes using Swarm A data from 2016 to 2021 within Northern Hemisphere

- Hotter temperature spikes generally toward magnetic noon
- Bands of hot spikes visible towards magnetic midnight
- Three-band structure seperates towards midnight

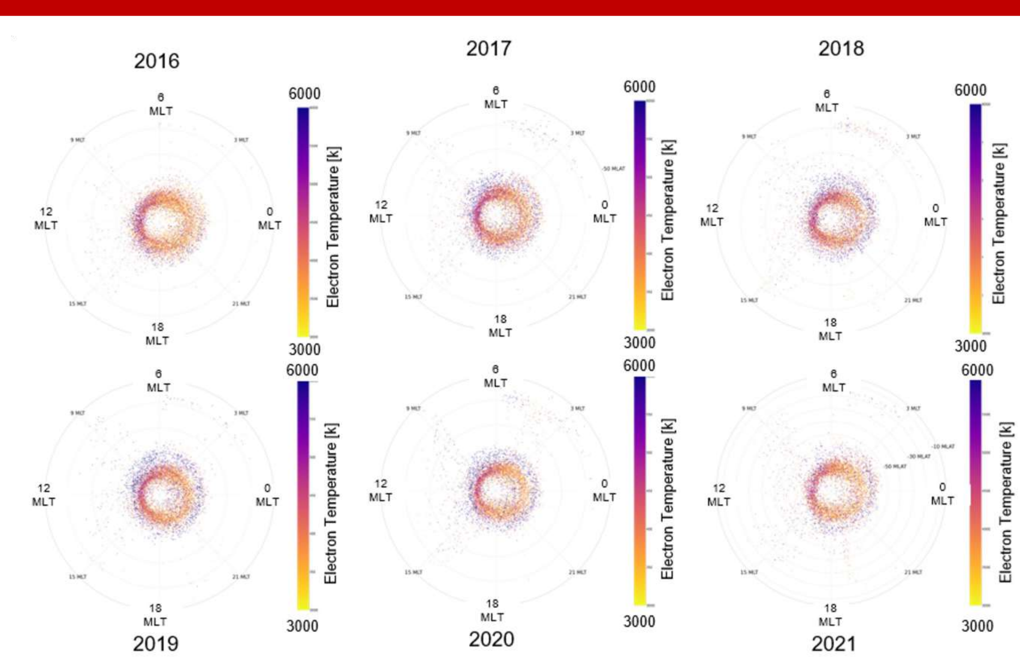


Figure 5: Progression of identified electron temperature spikes using Swarm A data from 2016 to 2021 within Southern Hemisphere

- Similar concentration of hot spikes seen in Southern Hemisphere
- Singular band of hot spikes occurring towards magnetic midnight
- Separation in subauroral zone

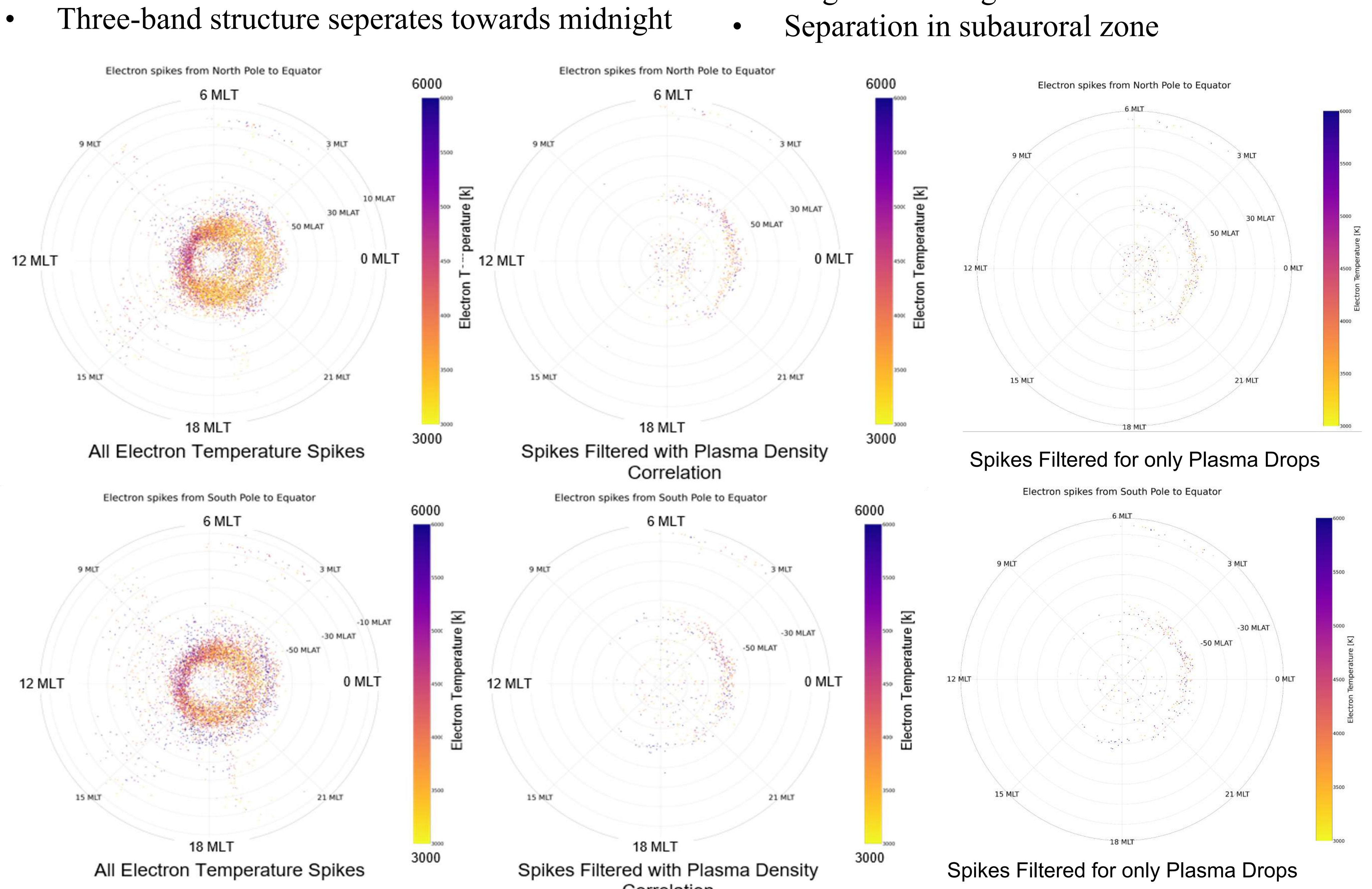


Figure 6: Electron temperature spikes in Northern Hemisphere (Top) and Southern Hemisphere (Bottom) after filtering for those with cross-correlation factor less than -.8 and all events vs drops

- Filtered temperature spikes + plasma drops occur in polar and subauroral zone
- Subauroral zone spikes occurring toward magnetic night
- Tighter spread present in Northern Hemisphere in comparison to Southern Hemisphere
- Filtering spikes with preliminary density drop detection algorithm shows a tightened cusp region

Discussion

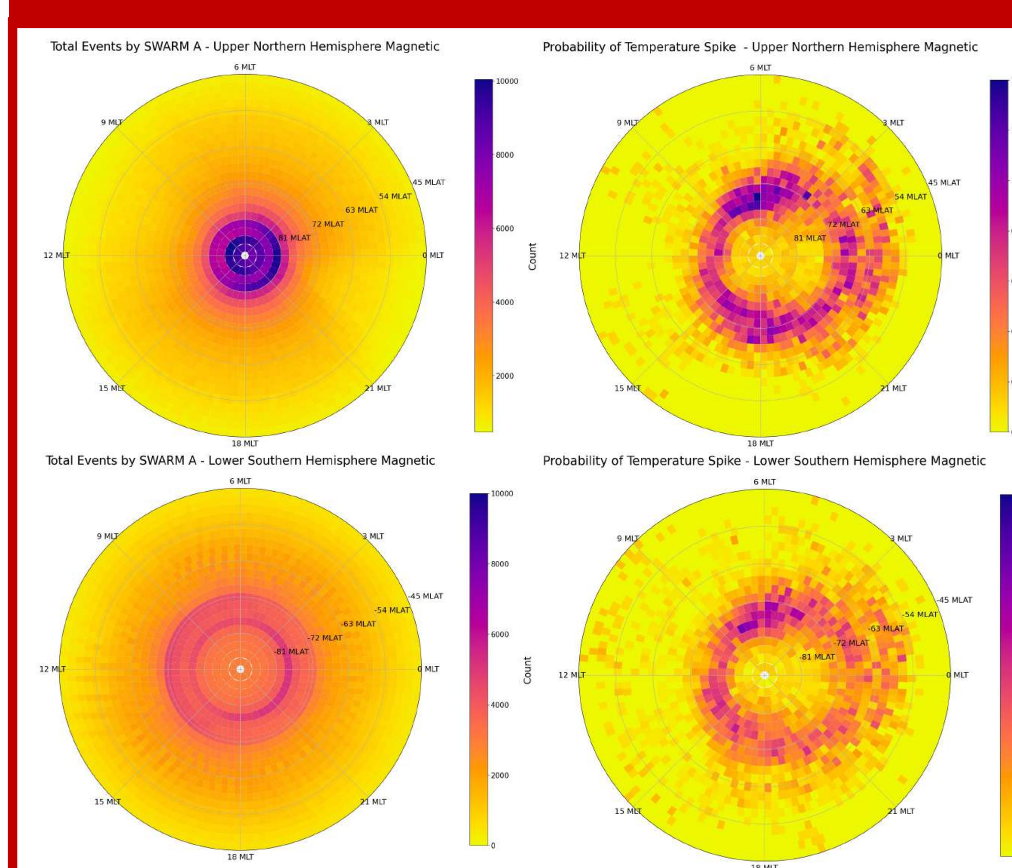


Figure 7: Statistical analysis of temperature spikes through binning - 2025 Bins

- Probability distribution of spikes accounting for SWARM events
- As high as ~1.4% chance of identifying a temperature spike
- Fairly even distribution post and pre-midnight

- Temperature spike detection algorithm followed by anti-correlation analysis are the right first steps
- Visual representation through magnetic polar plots is insightful
- Separating density drops from all inclusive list of anti-correlated events (i.e. trough crossing and general anti-correlation events) presents to be a big challenge
  - Preliminary analysis has been conducted to develop an algorithm to automate this
  - Tested using varied prominence parameter on normalized density signatures — 30%, 35%, 40%, 45%

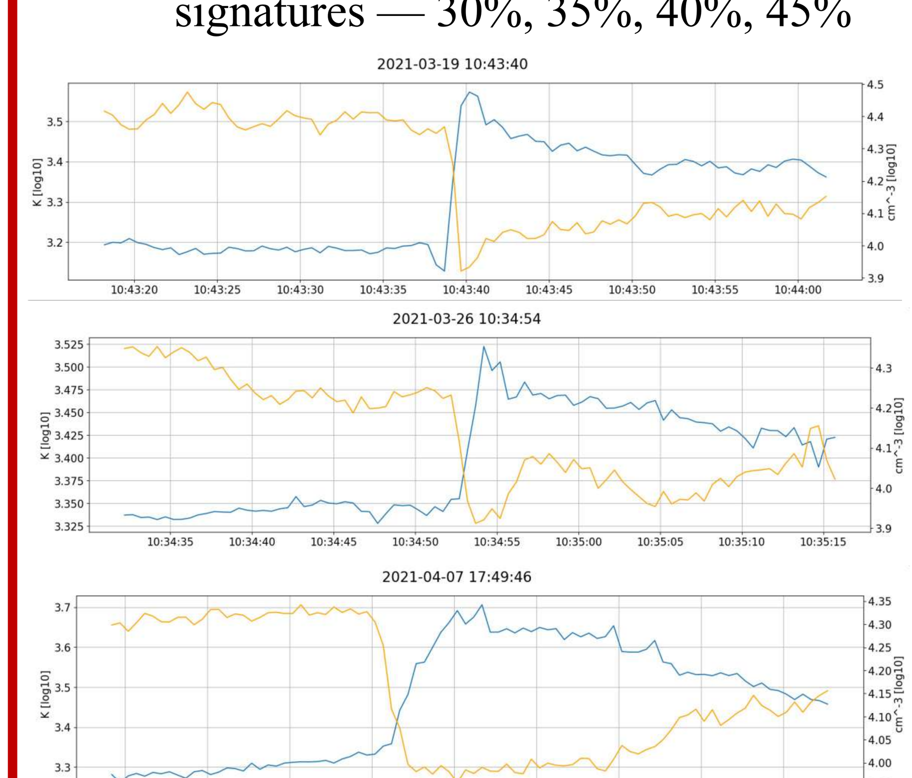


Figure 8: Anti-correlated events with ambiguous characterization

- Less than ideal success rate, i.e. 25% false negative rate
- Degree of subjectivity distinguishing drops from troughs contributes to low success rate
- Need for well defined characteristics to separate drops from troughs and other event

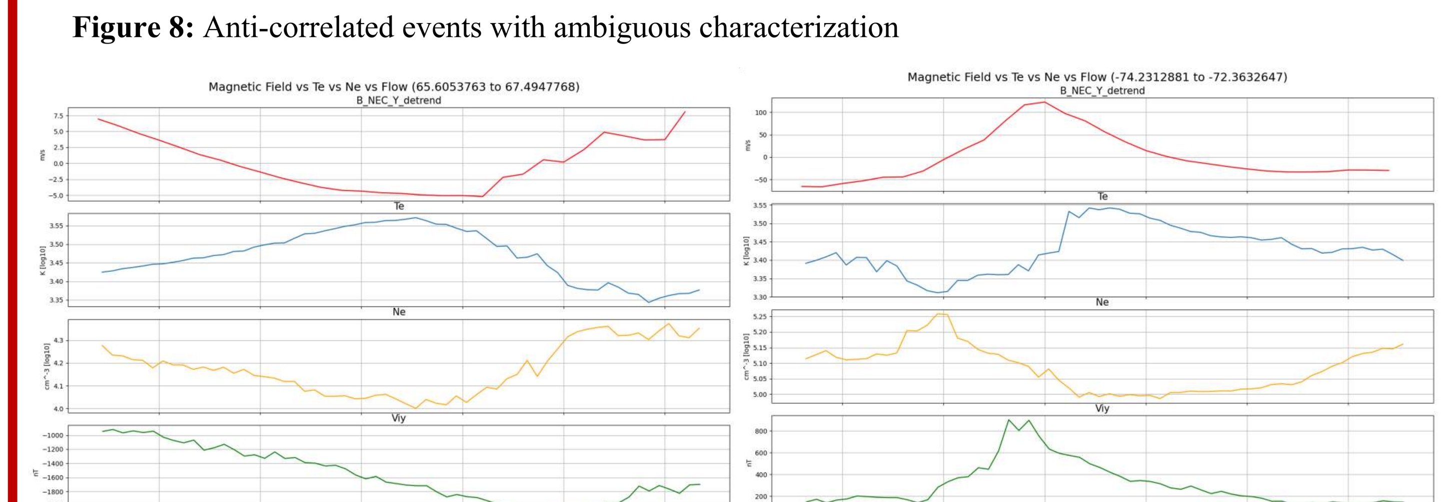


Figure 9: Sample flow and magnetic data for 2 Te spike/Ne drop events

- We observe good spike in Te and good drop in Ne but no obvious similarity in the magnetic signatures nor the velocity signature in the two events
- Further analysis is required

Summary

- Algorithm to identify STEVE-SAID coupled events exist under 3 conditions: (1) High electron temperature (2) Low plasma density (3) High peak ion velocities
- Incorporating electron temperatures and plasma density, results show events in polar and subauroral zone
- Need a deterministic way to differentiate all anti-correlated events from those with density drops

- **Future work:**
  - Develop specific characterization of drops
  - Further analysis with magnetic and flow data
  - Superposed epoch analysis

Bibliography:

Archer, W. E., Gallardo-Lacourt, B., Perry, G. W., St.-Maurice, J.-P., Buchert, S. C., & Donovan, E. F. (2019). Steve: The optical signature of intense subauroral ion drifts. Geophysical Research Letters, 46, 6279–6286. https://doi.org/10.1029/2019GL082687

Gringorten, Irving & Yepez, Penelope. (1992) AD-A257 770 THE DIVISION OF A CIRCLE OR SPHERICAL SURFACE INTO EQUAL-AREA CELLS OR PIXELS. https://apps.dtic.mil/sti/pdfs/ADA257770.pdf