Searching for STEVE-like electron temperature spikes with Swarm

H. Panwar, New Jersey Institute of Technology
G. W. Perry, New Jersey Institute of Technology
A. Gyakobo, New Jersey Institute of Technology
L. V. Goodwin, New Jersey Institute of Technology
W. E. Archer, Canadian Space Agency

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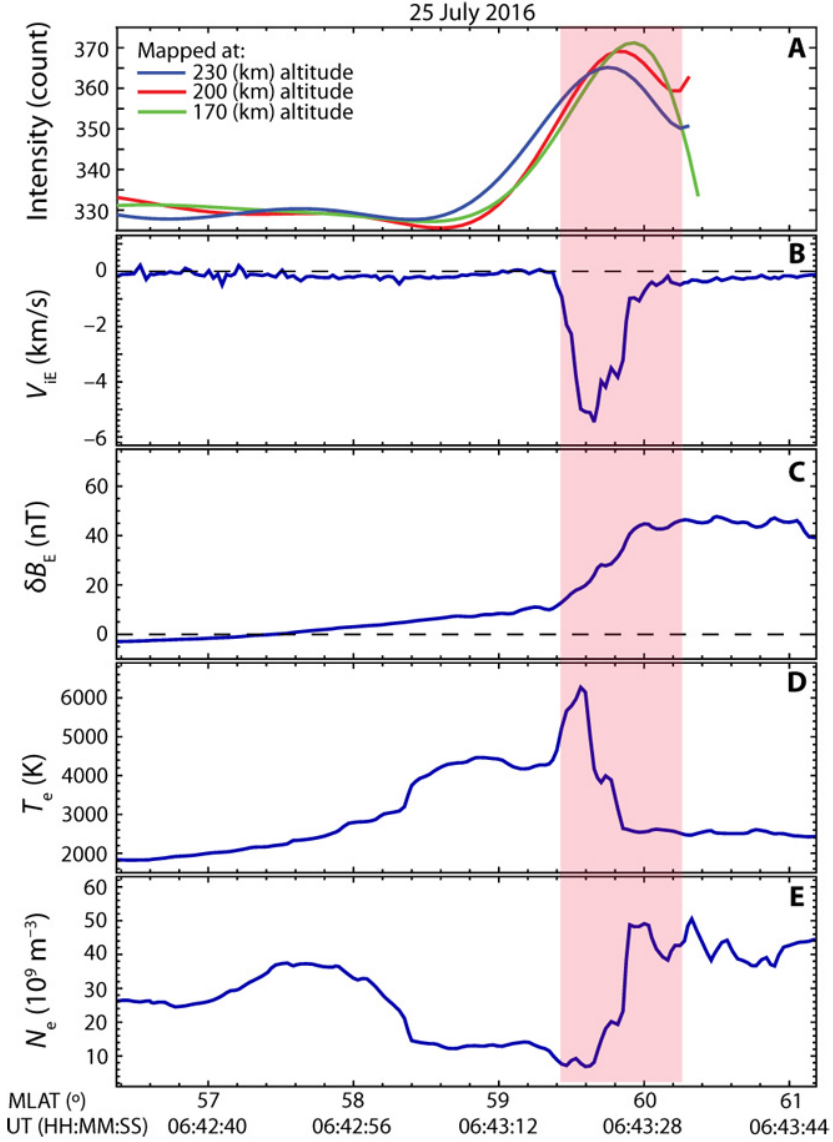
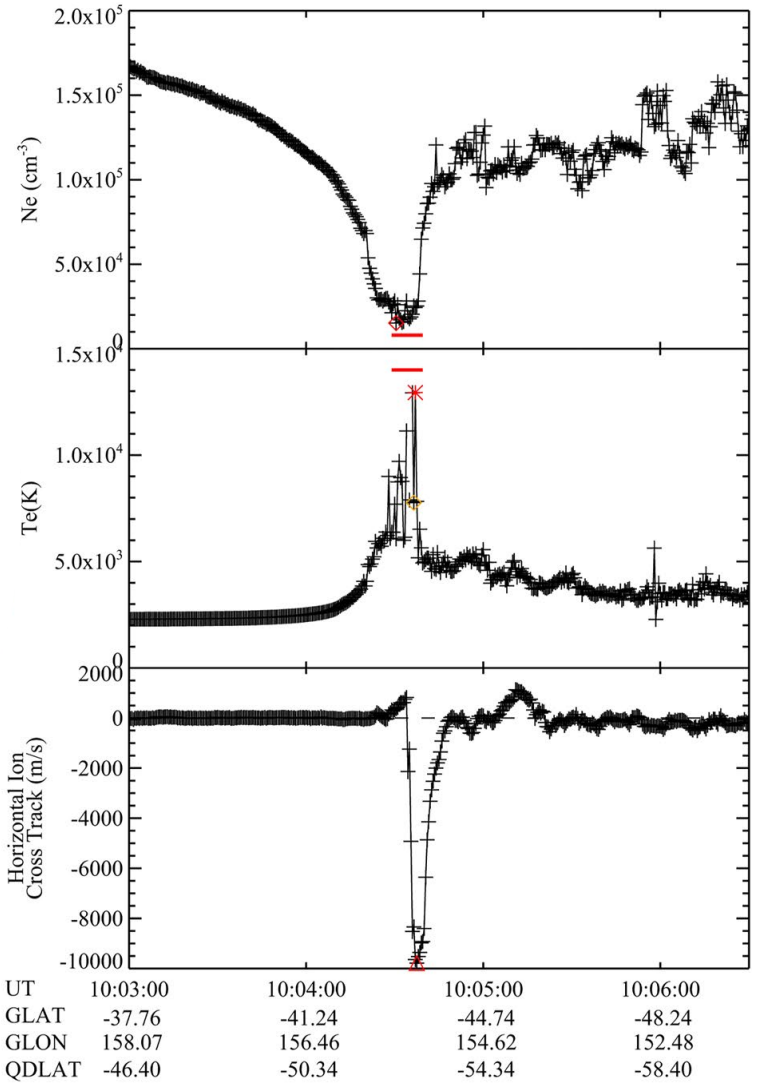
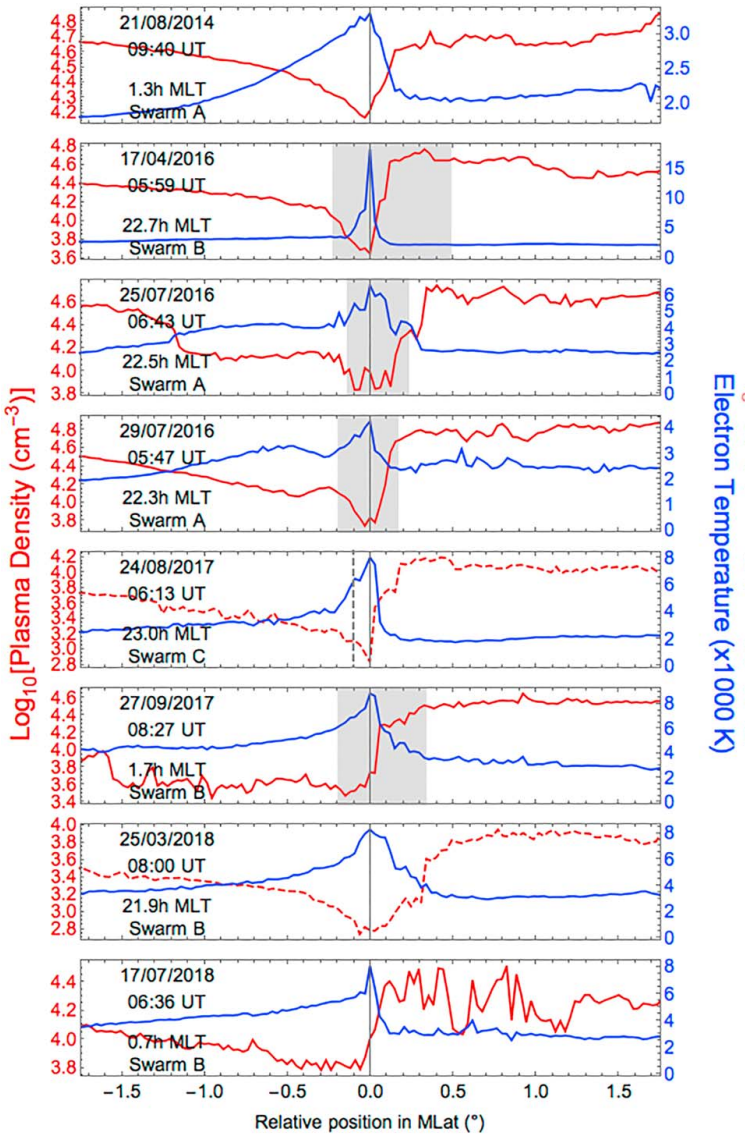


(MacDonald et al., 2018)



(Martinis et al., 2022)



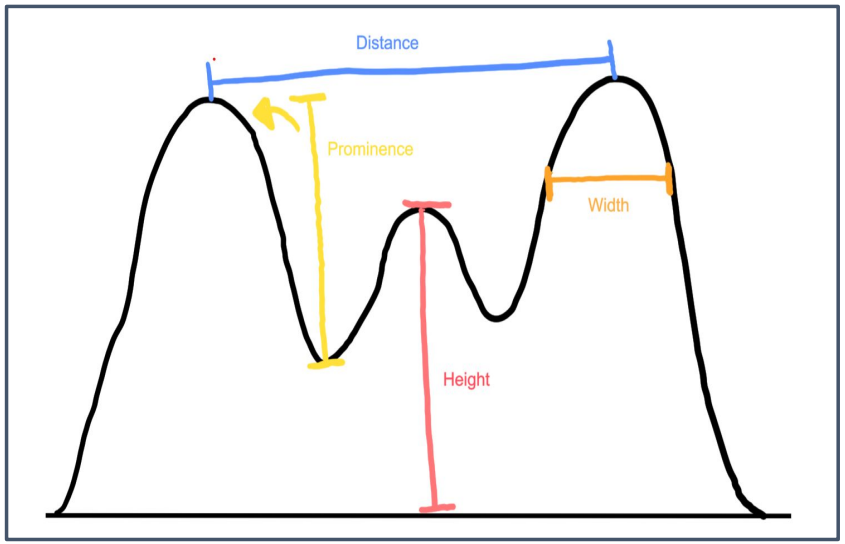
(Archer et al., 2019)

Motivation

- One of the traits of STEVE/SAID encountered by spacecraft in low Earth orbit is their prominent electron temperatures.
  - Distinct optical characteristics and plasma flows are also observed, but not our focus in this presentation.
- **How common are these electron temperature "spikes"?**

Methodology

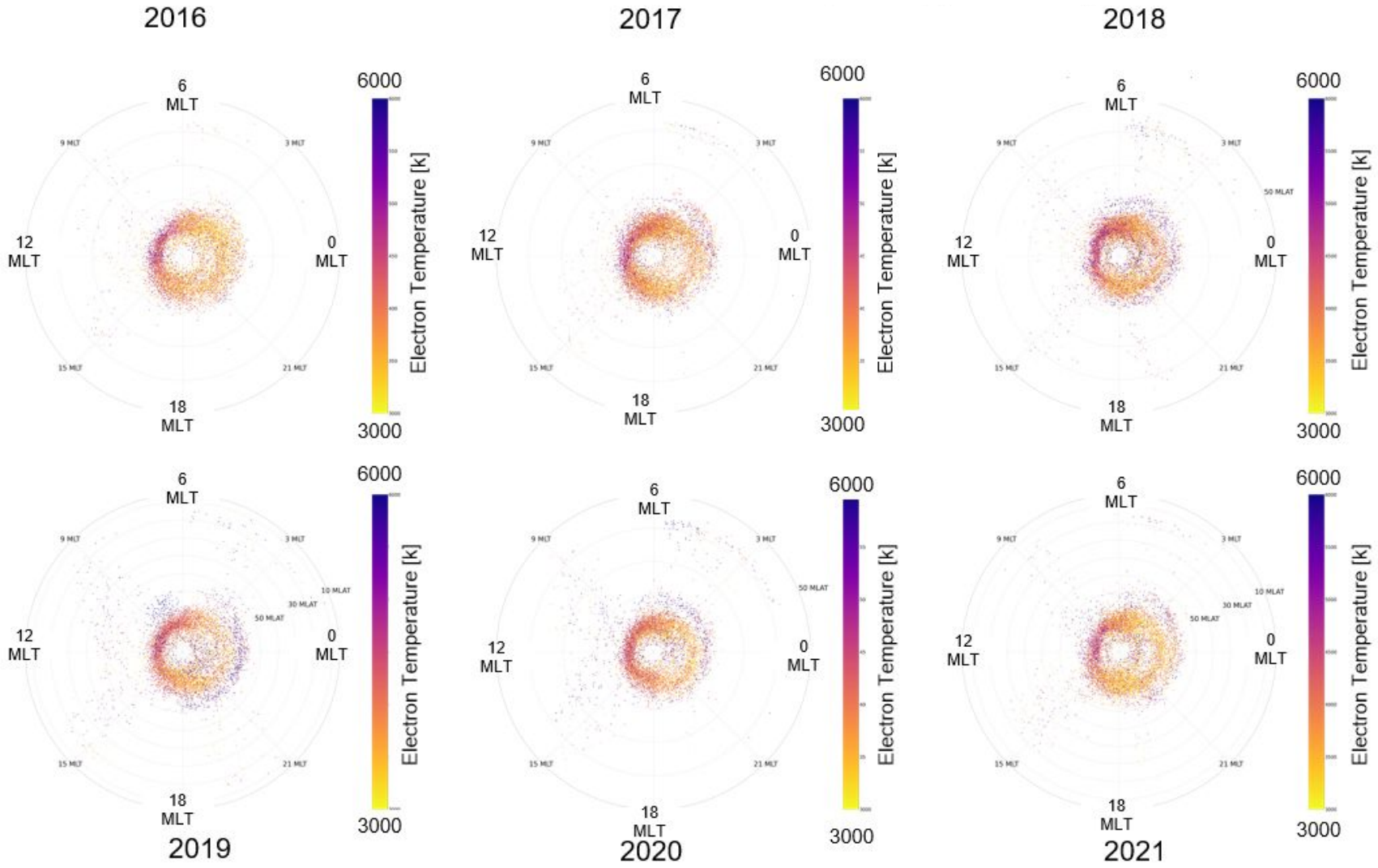
- Develop an algorithm that sifts through the Swarm electron temperature data and identifies electron temperature “spikes”.
    - Using the Swarm EFI LP data set “SW_OPER_EFIA_LP_1B”.
- Use the Archer et al. (2019) SAIDs as the archetype the spikes.
- Run the algorithm on all Swarm A, B, and C electron temperature data.



Spike conditions

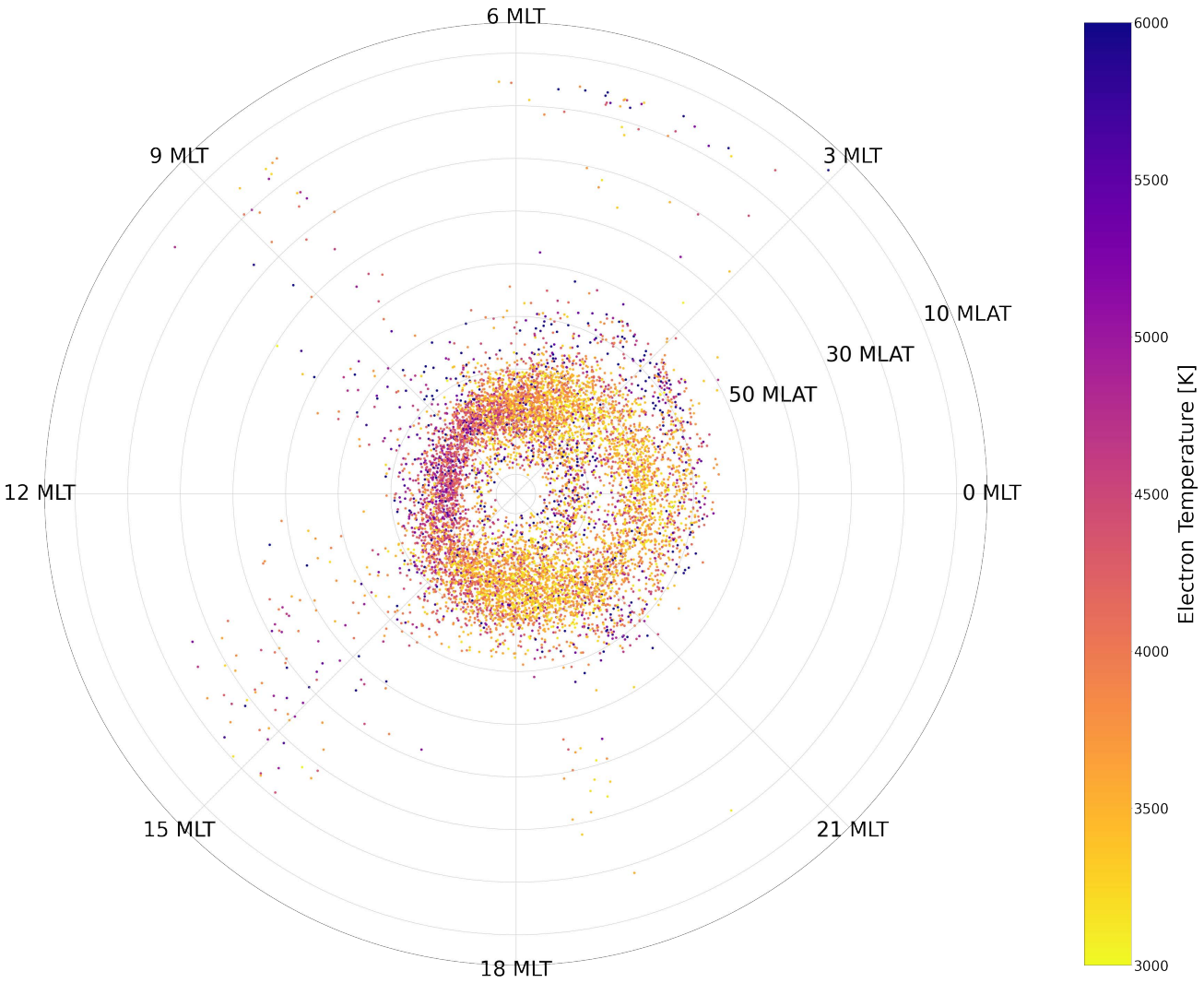
- Height: 3000 - 20,000 K.
- Distance: 100 samples (~350 km along track).
- Width: 4 - 40 samples (~15 - 150 km along track).
- Prominence: 1250 - 5000 K.

Results



Swarm A

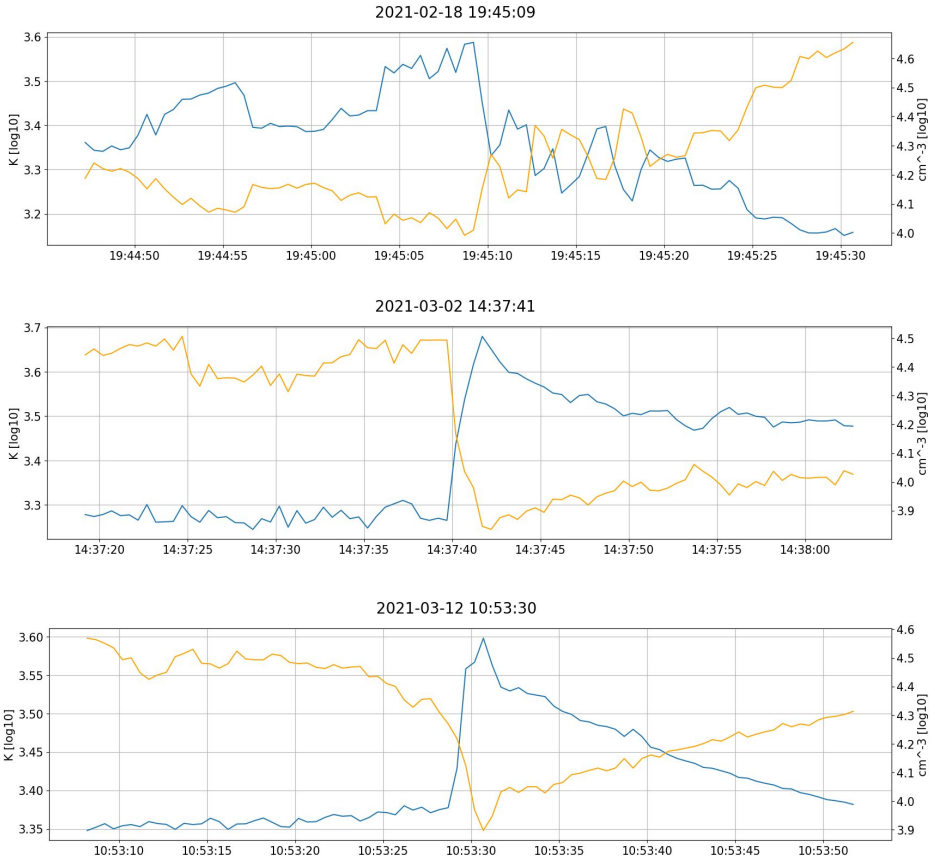
Results



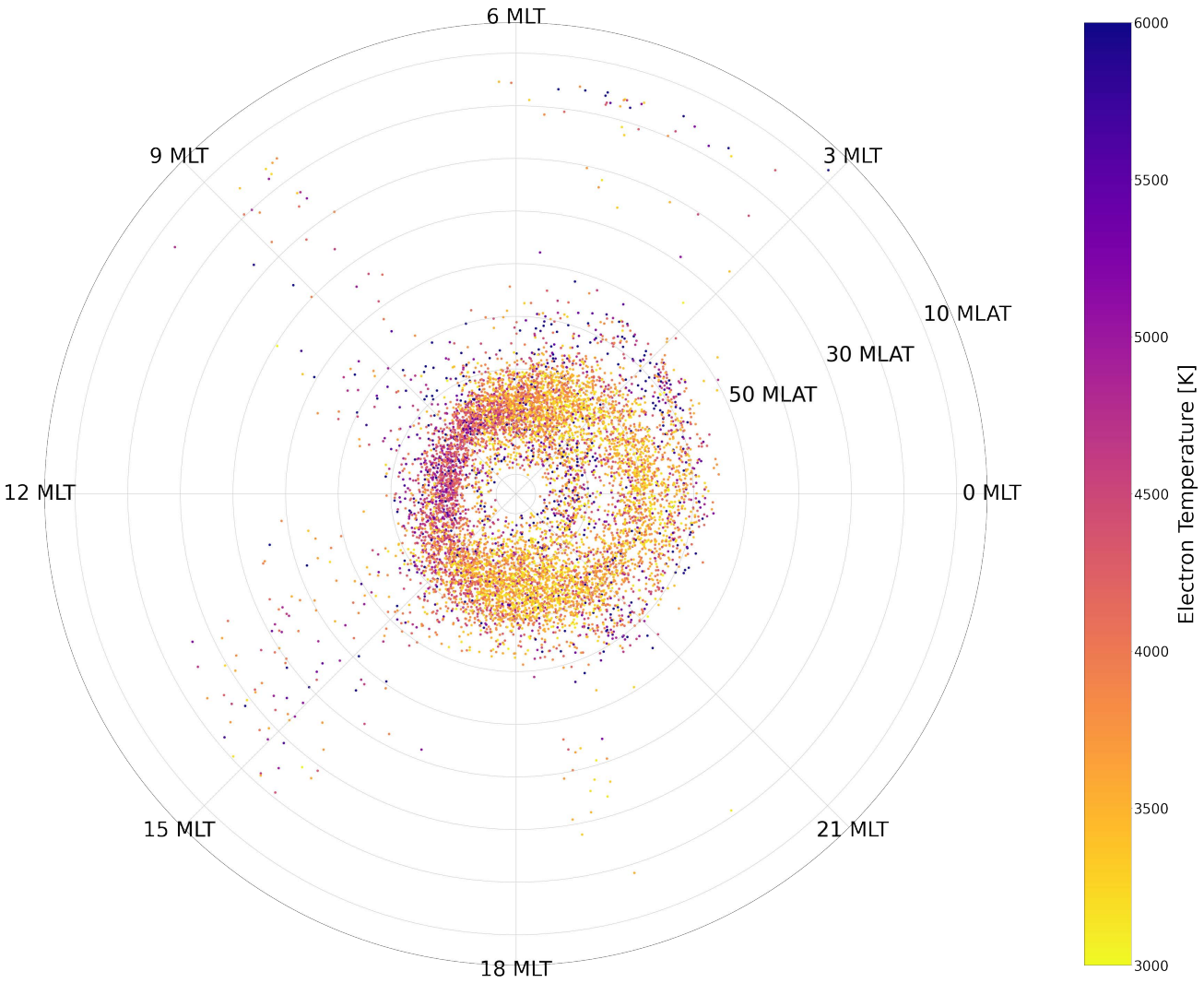
Swarm A 2021 - All spikes

Methodology (contd..)

- To further constrain our spike events, we performed a correlation analysis to identify events with a corresponding drop in plasma density.

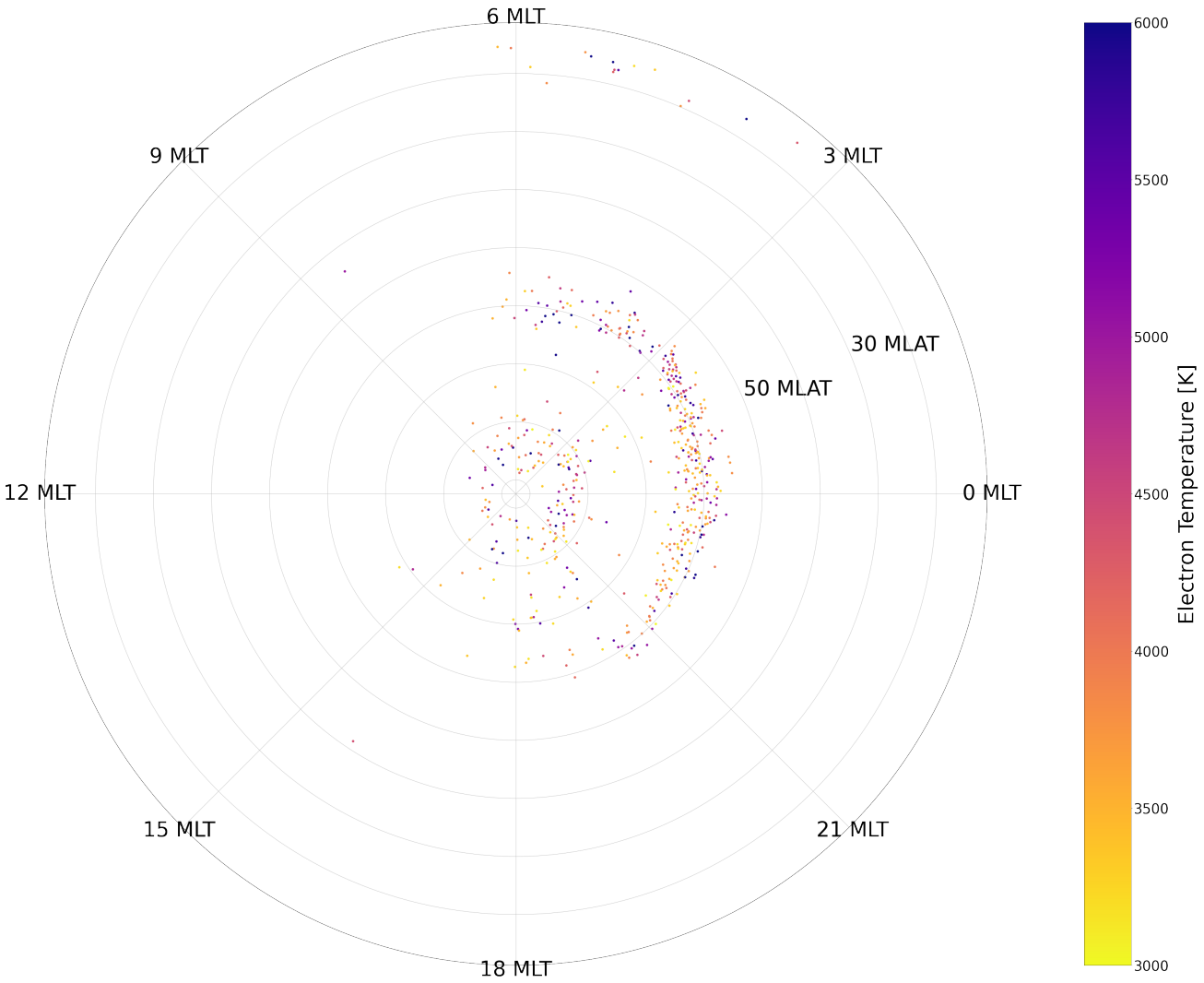


Results



Swarm A 2021 - All spikes

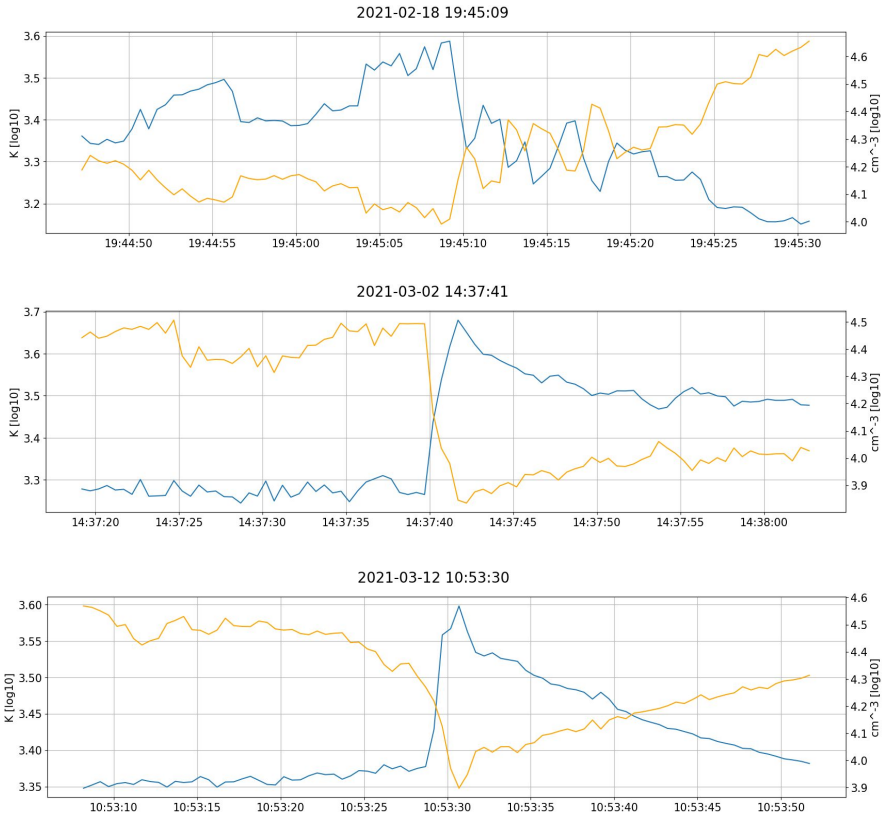
Results



Swarm A 2021 - Filtered by Plasma Density Correlation

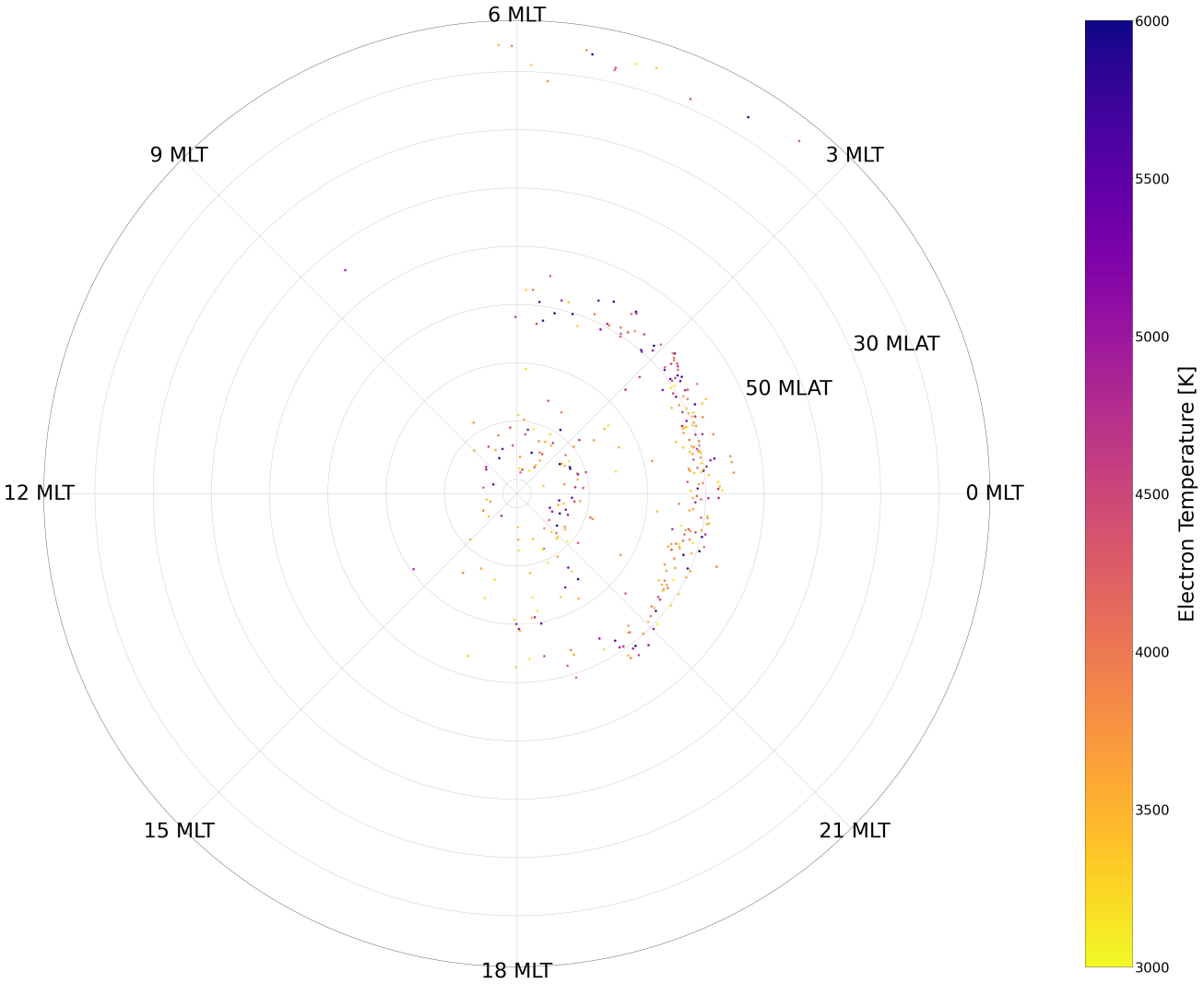
Methodology (contd..)

- After closer inspection, we realized that some of our identified events were false-positives — plasma trough crossings were being identified, so we modified the algorithm to pick out “notches” in the plasma density.



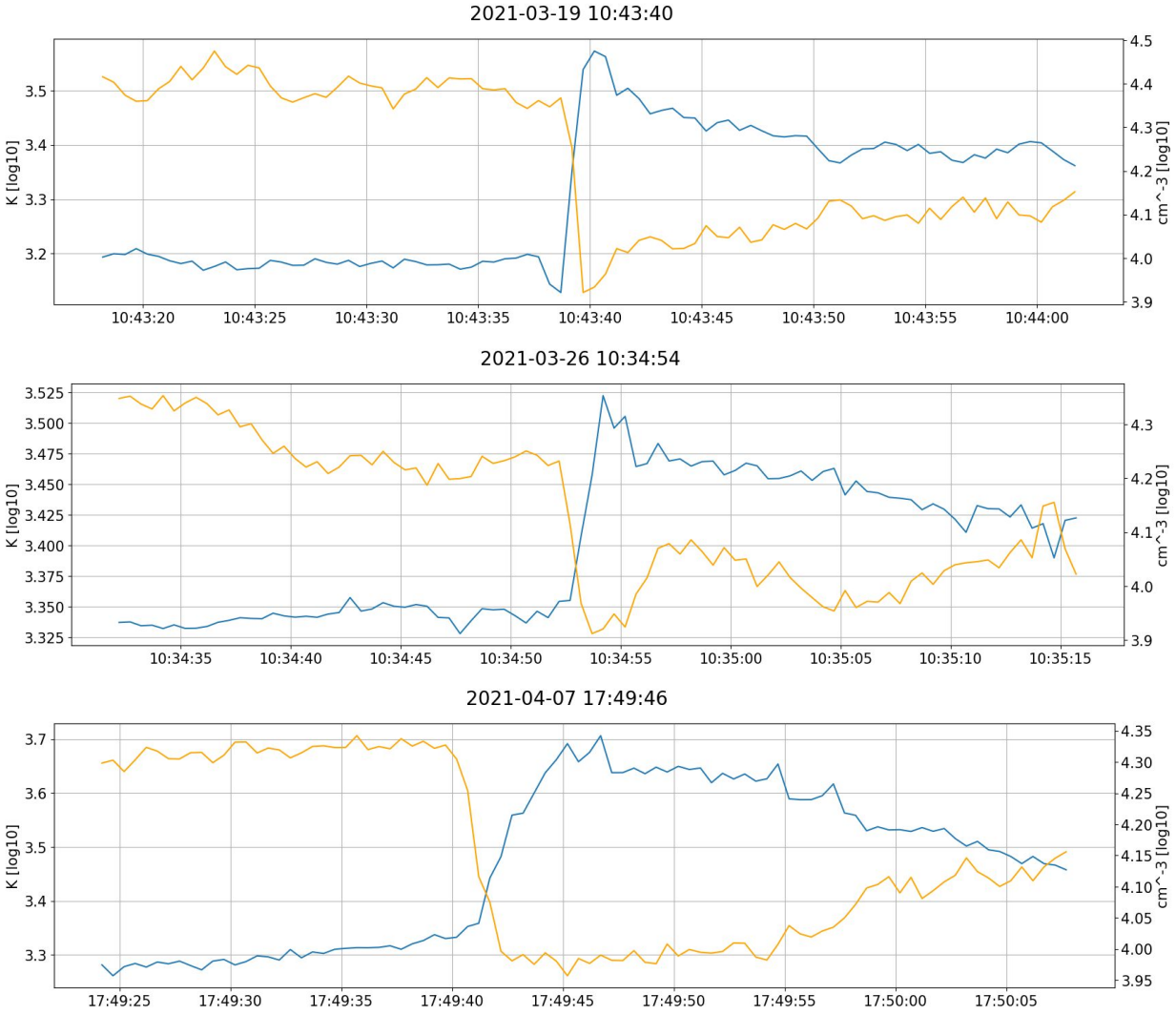
Results

Electron spikes from North Pole to Equator



Swarm A 2021 - Filtered by Plasma Density Correlation with “Drops”

Results (contd..)



Summary and Future Work

- Our motivation in this work is the determine the prevalence of STEVE-like electron temperature spikes using the Swarm data set.
    - An algorithm to perform this task was developed and implemented.
- Results show that each spacecraft observed thousands of spikes per year.
    - The spikes are organized into geomagnetic regions consistent with the auroral zone, cusp, and sub-auroral region.
- Additional analysis reveals that a subset of the spikes are associated with a plasma “trough” or “notch” decrease, and that these spikes appear to the contained to the polar-cap and sub-auroral regions.
    - It is difficult to distinguish some “trough” or “notch” plasma features from plasma trough transits.
- In future work Swarm cross-track plasma flows will be considered.

References

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

MacDonald, E. A., Donovan, E., Nishimura, Y., Case, N. A., Gillies, D. M., Gallardo-Lacourt, B., ... & Schofield, I. (2018). New science in plain sight: Citizen scientists lead to the discovery of optical structure in the upper atmosphere. Science advances, 4(3), eaaq0030

Martinis, C., Griffin, I., Gallardo- Lacourt, B., Wroten, J., Nishimura, Y., Baumgardner, J., & Knudsen, D. J. (2022). Rainbow of the night: First direct observation of a SAR arc evolving into STEVE. Geophysical Research Letters, 49, e2022GL098511. https://doi. org/10.1029/2022GL098511

Extra Slides

STEVE in ISR measurements?

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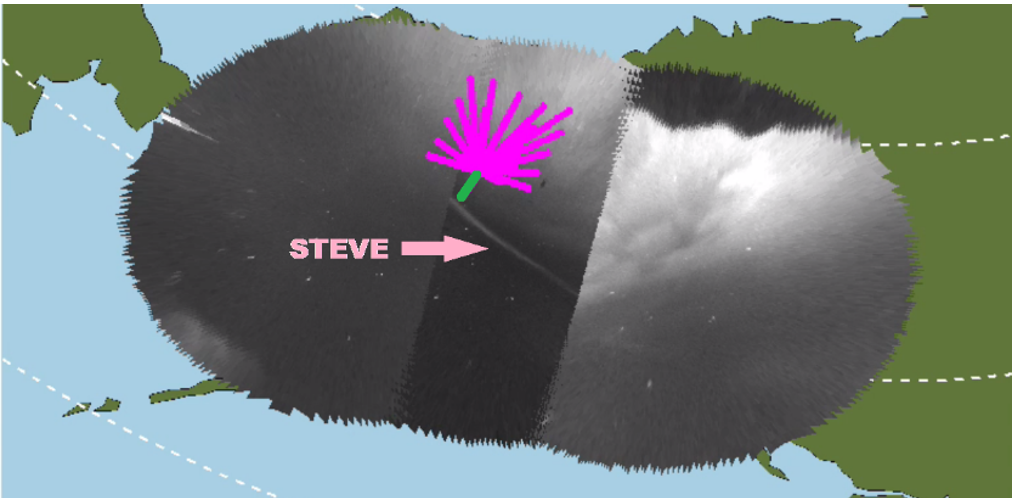

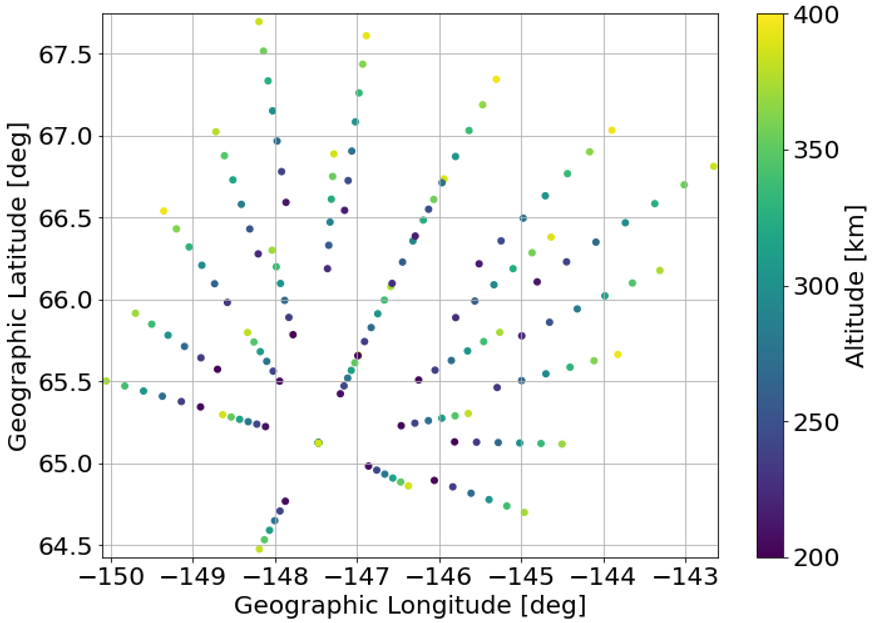

Figure courtesy of L. V. Goodwin

STEVE in ISR measurements?

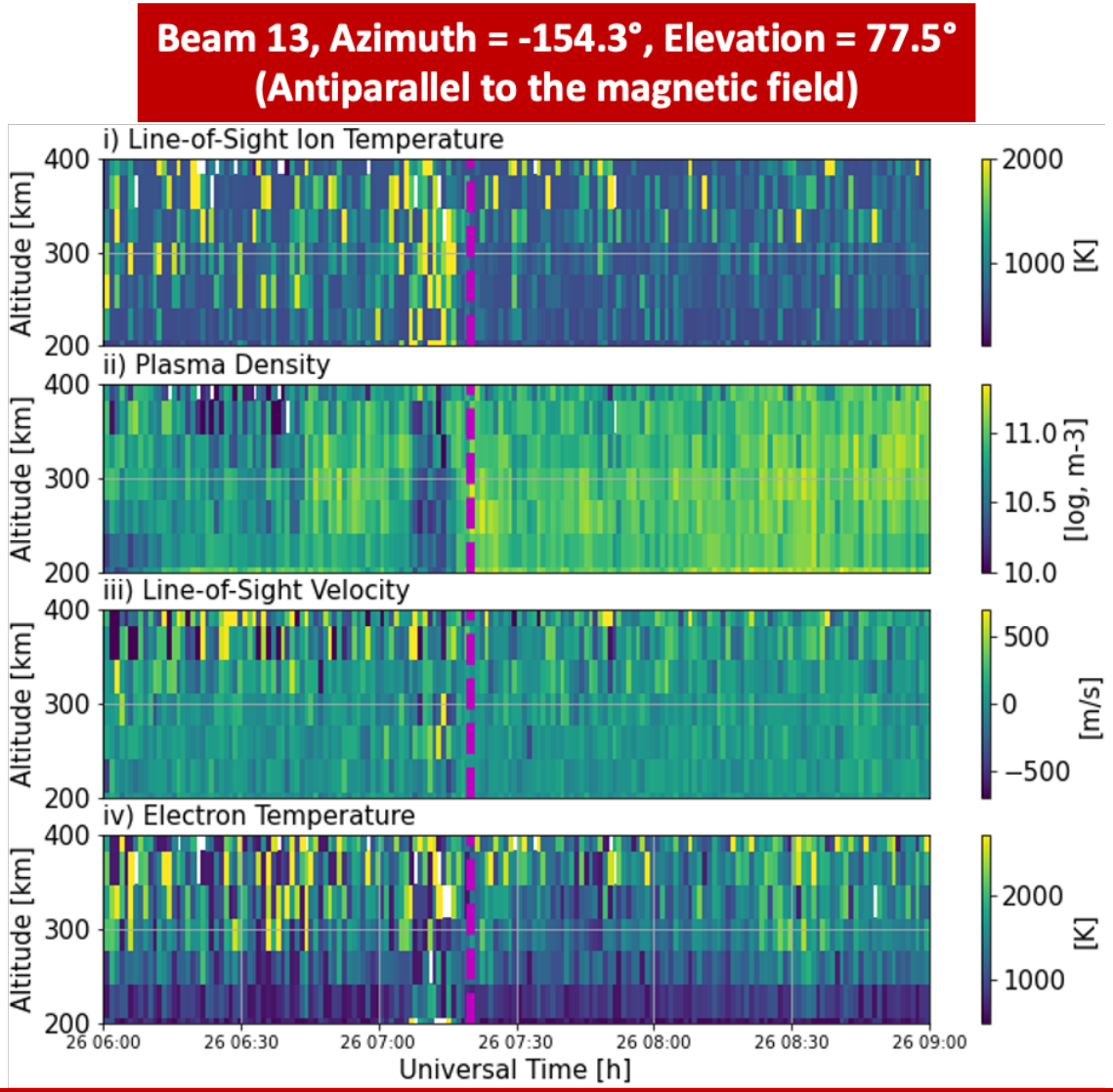

Figure courtesy of L. V. Goodwin