Investigation of the Mid-Latitude Ionospheric Response to Strong Thermal Emission Velocity Enhancement (STEVE) Events

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ABSTRACT

- **Strong Thermal Emission Velocity Enhancement (STEVE):** Narrow, sub-auroral optical feature typically observed during the recovery phase of substorms
- **Key Characteristics:** Not driven by strong particle precipitation like typical aurora; co-located with intensive Sub-Auroral Ion Drifts (SAIDs) reaching several km/s
- **Objective:** Investigate ionospheric response to STEVE using SuperDARN radar (FHW) and all-sky imager (ASI) data
- **Parameters Analyzed:** Doppler velocity and radar echo counts before, during and after STEVE
- **Hypothesis:** Expect a depletion of SuperDARN echoes co-located with STEVE due to associated ionospheric density troughs that suppress radar backscatter

INTRODUCTION

What are Strong Thermal Emission Velocity Enhancements (STEVEs)?

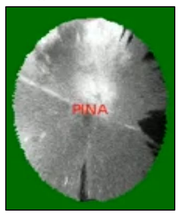
Fig 1

Source: [2]

- Long (thousands of km in lon) & narrow (tens of km in lat) mauve colored optical structure [1]
- Often (but not always) accompanied by green picket fence [1]
- Occurs mainly during recovery phase of geomagnetic substorms [2]
- Not associated with significant particle precipitation like typical aurora [1]
- Linked with intense Sub-Auroral Ion Drifts (SAIDs) reaching several km/s [2]

What observational tools are used to study STEVE and its ionospheric effects?

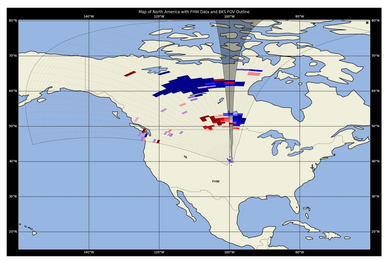
Fig 2



All-Sky Imagers

- Capture visible emissions like STEVE arcs and green picket fences
- Provide spatial and temporal context for optical auroral events

Fig 3



SuperDARN Radars

- Detect ionospheric plasma flows via HF backscatter
- Reveal flow structures and disturbances linked to STEVE

METHODOLOGY

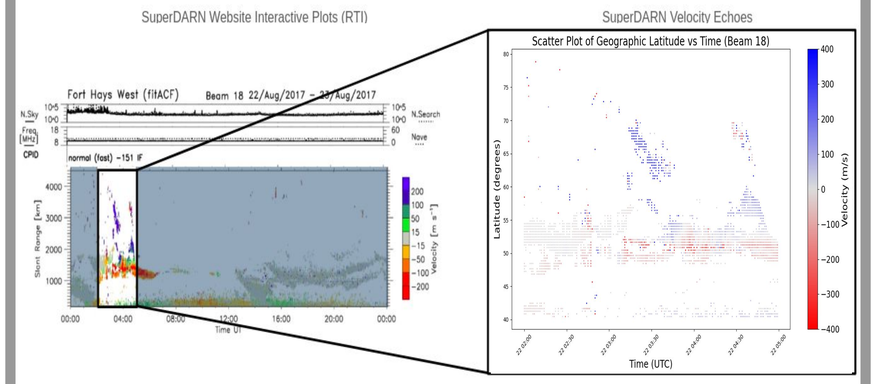


Fig 4: Comparison between a Range-Time-Intensity (RTI) plot from the SuperDARN website and a custom RTI plot generated from velocity echoes. This side-by-side comparison is used to validate the consistency and accuracy of the processed data.

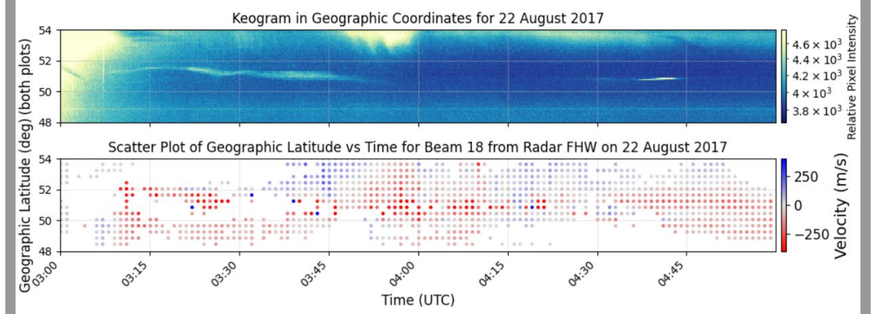


Fig 5: (Top) Keogram from the Pinawa (PINA) ASI; brighter yellow indicates stronger optical emissions. There is a clear STEVE feature ranging from 3 to 4 UT . (Bottom) SuperDARN FHW radar velocity echos at the same time and location, showing ionospheric flow patterns.

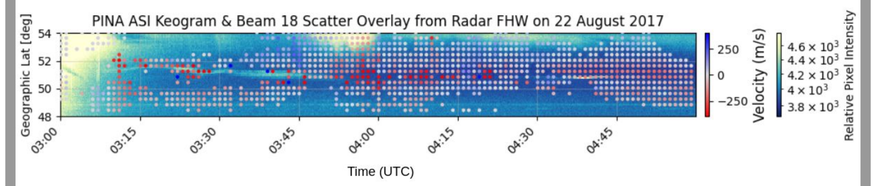


Fig 6: Overlaid ASI keogram and superDARN echoes from Fig 5. A clear gap in radar echoes aligns with the STEVE feature, followed by a narrow band or red ecoes- indicating strong westward plasma flows.

RESULTS & CONCLUSIONS

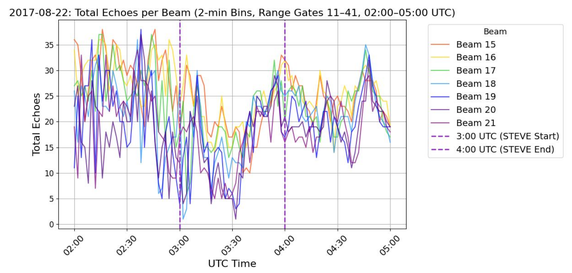
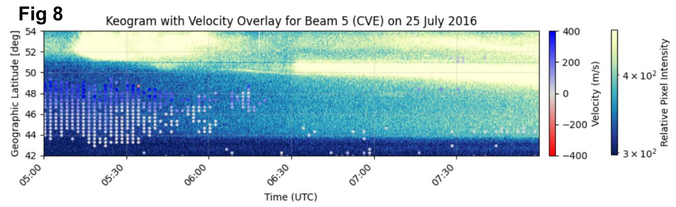


Fig. 7: Total FHW echo count for beams and range gates overlapping the PINA ASI FOV. Vertical lines mark STEVE onset and end. A sharp drop in echoes follows onset, requiring further investigation.

FUTURE WORK

The next steps include identifying multiple STEVE events that occur on the same day as overlapping SuperDARN data is available. Fig 8 (below) illustrates an example of one such day. A superposed epoch analysis will then be conducted to identify consistent patterns in electrodynamic behavior surrounding STEVE onset. This will improve understanding of mid-latitude ionospheric responses and aid in characterizing STEVE as a distinct subauroral phenomenon.

Fig 8



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[2] Nishimura, Yukitoshi, Alan Dyer, et al. “Unsolved Problems in Strong Thermal Emission Velocity Enhancement (Steve) and the Picket Fence.” Frontiers, Frontiers, 17 Jan. 2023

ACKNOWLEDGEMENTS

This work was supported by NSF under award AGS-1935110. CGS is supported by NASA under award 80NSSC22M0163. The authors acknowledge the use of SuperDARN data. SuperDARN is a collection of radars funded by national scientific funding agencies of Australia, Canada, China, France, Italy, Japan, Norway, South Africa, United Kingdom, and the United States of America. Data from the Pinawa All-Sky Imager was provided by the University of Calgary's Space Physics Group. We acknowledge the support of the Canadian Space Agency's Geospace Observatory (GO Canada) program.

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