The Substorm Gordian Knot: Onset Patterns and Frequencies

Emily Sobel
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BACKGROUND

- Substorms begin with reconnection in the plasma sheet and convect along field lines back towards the Earth, returning magnetic flux to the dayside

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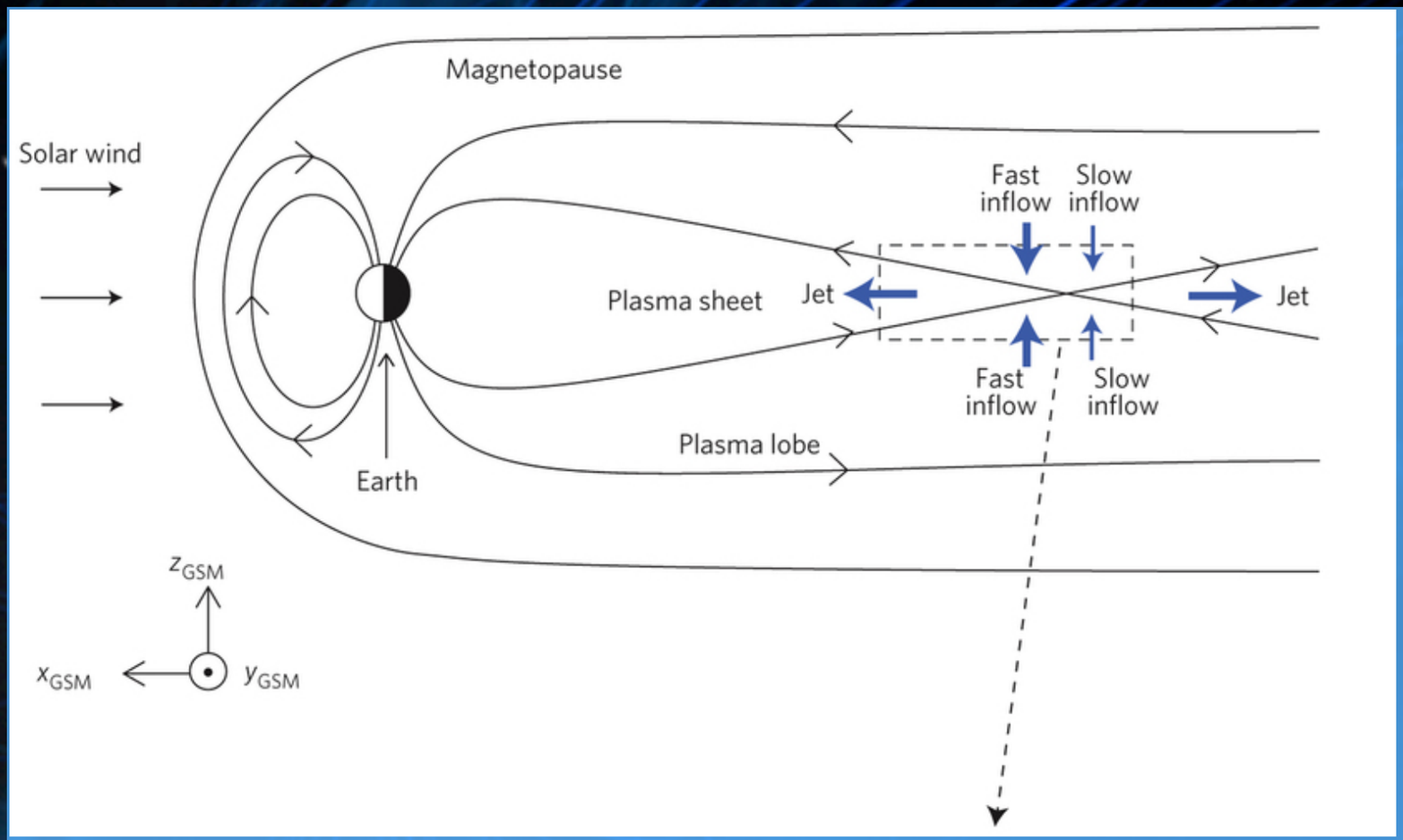

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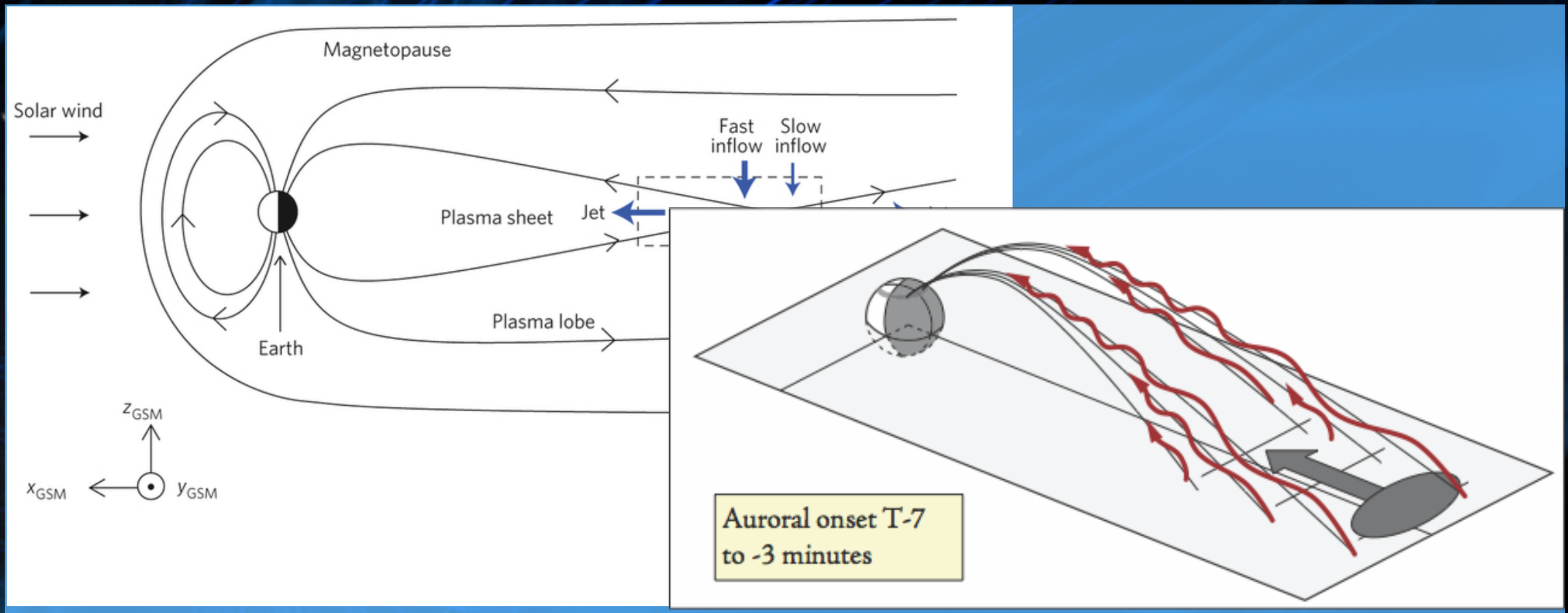

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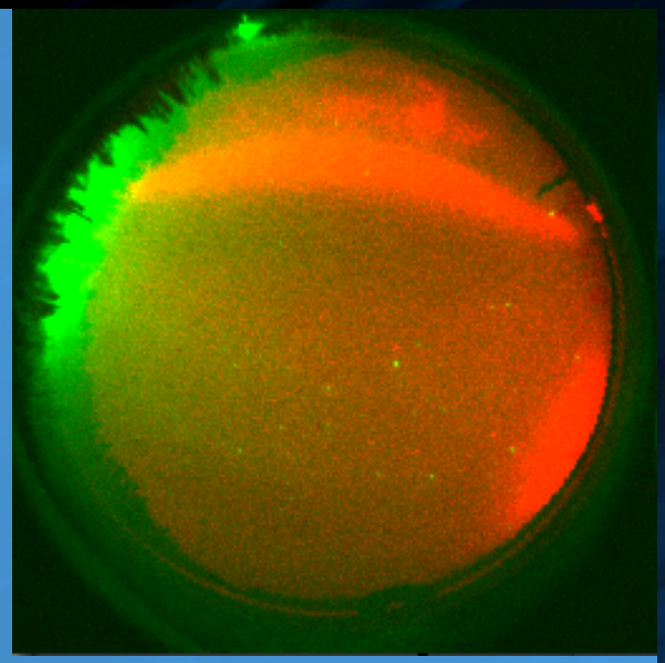

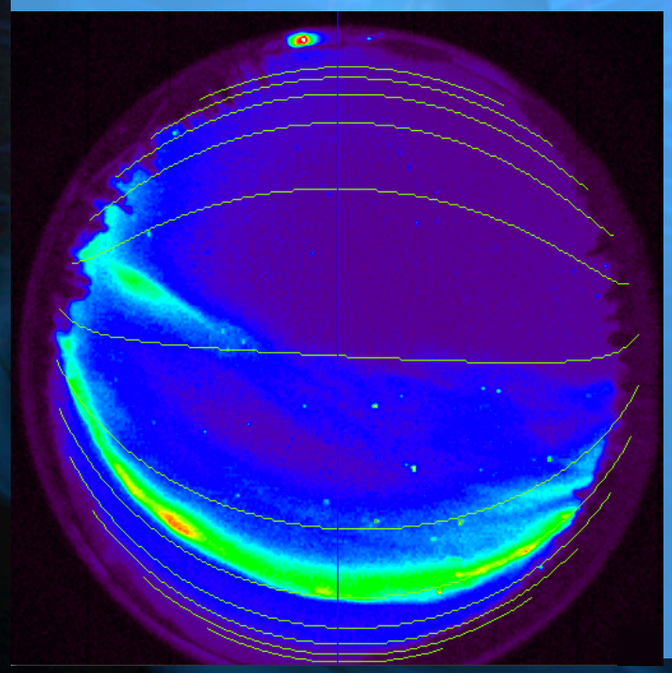

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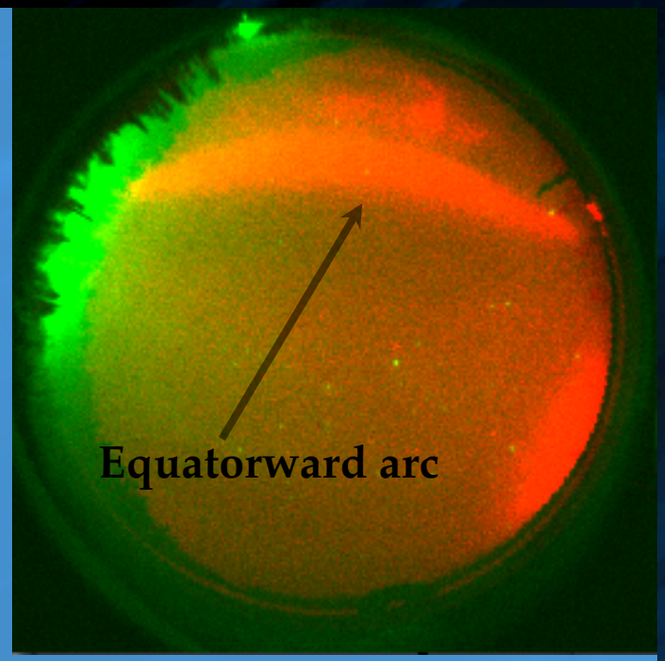

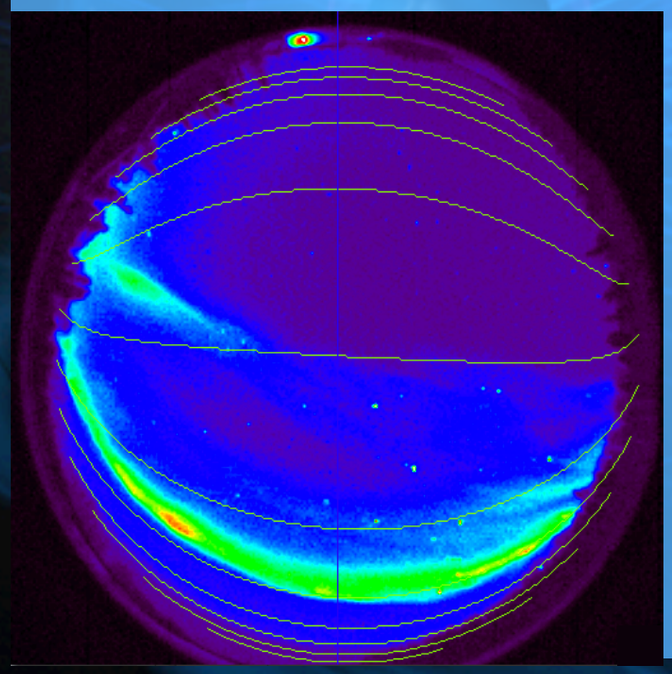

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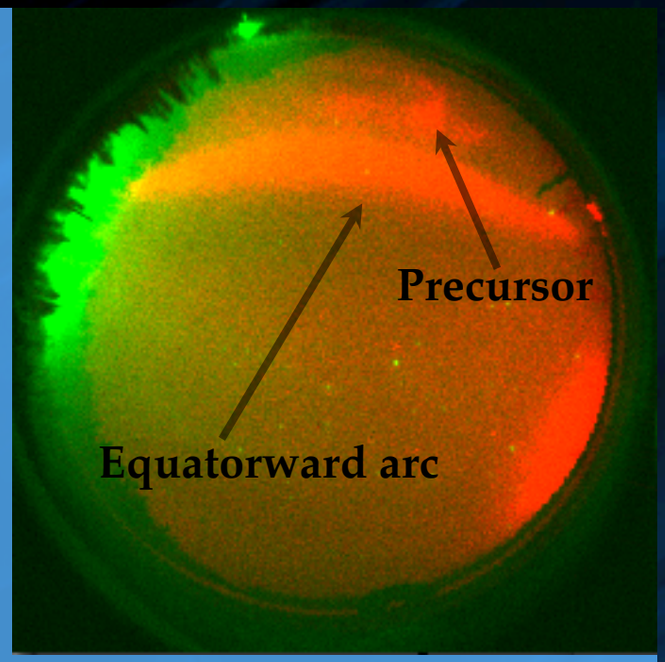

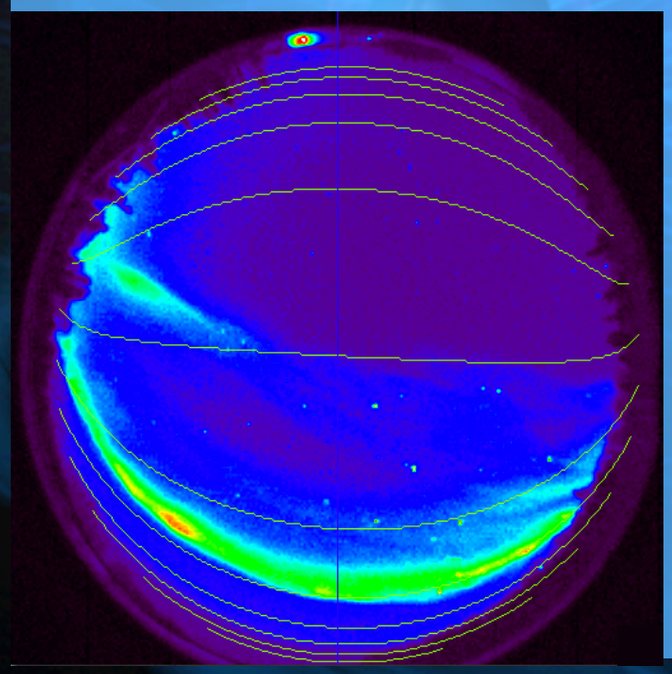

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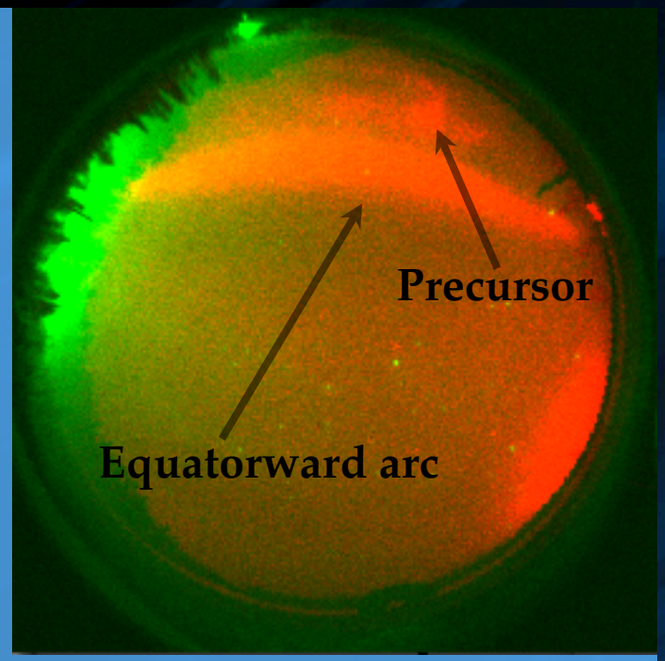

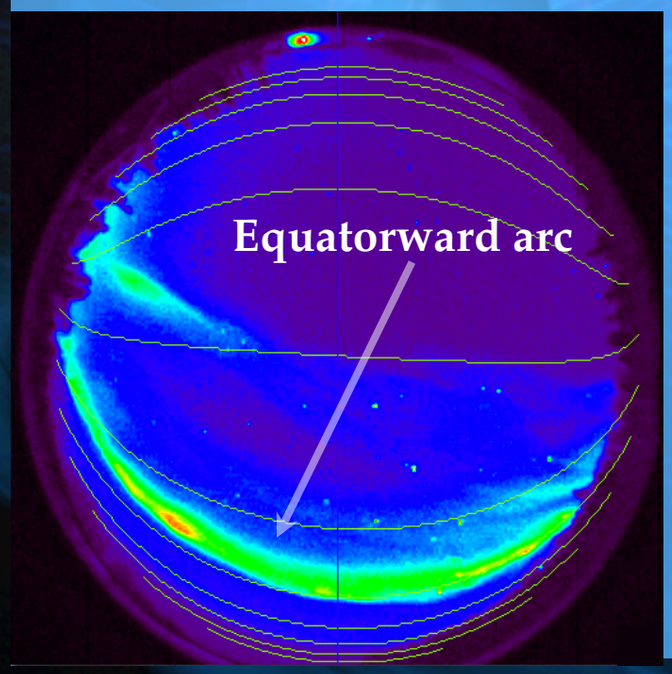

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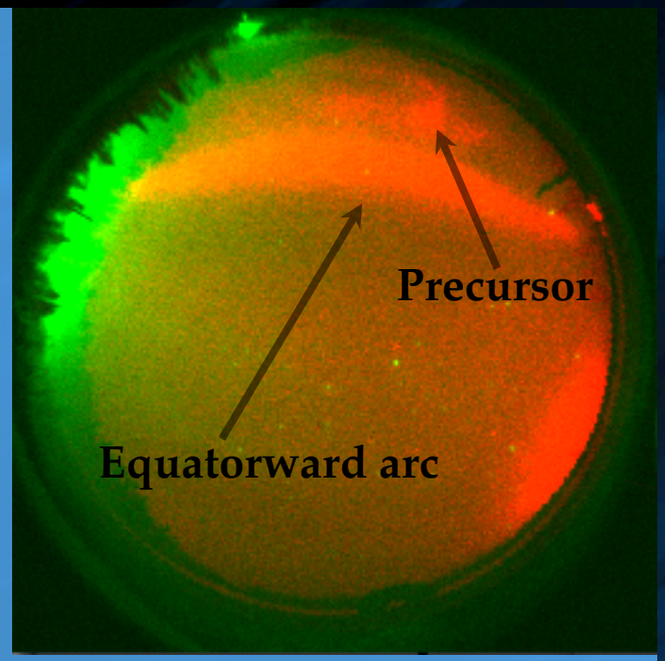

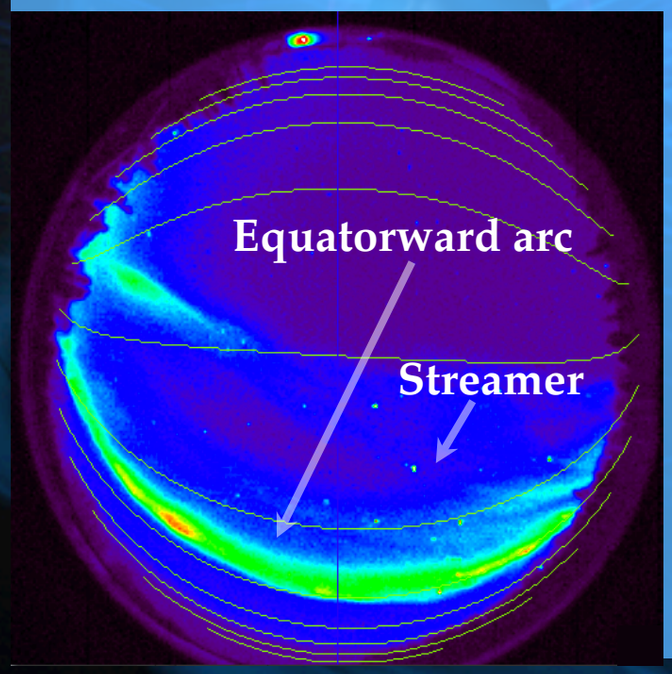

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Question and Methods

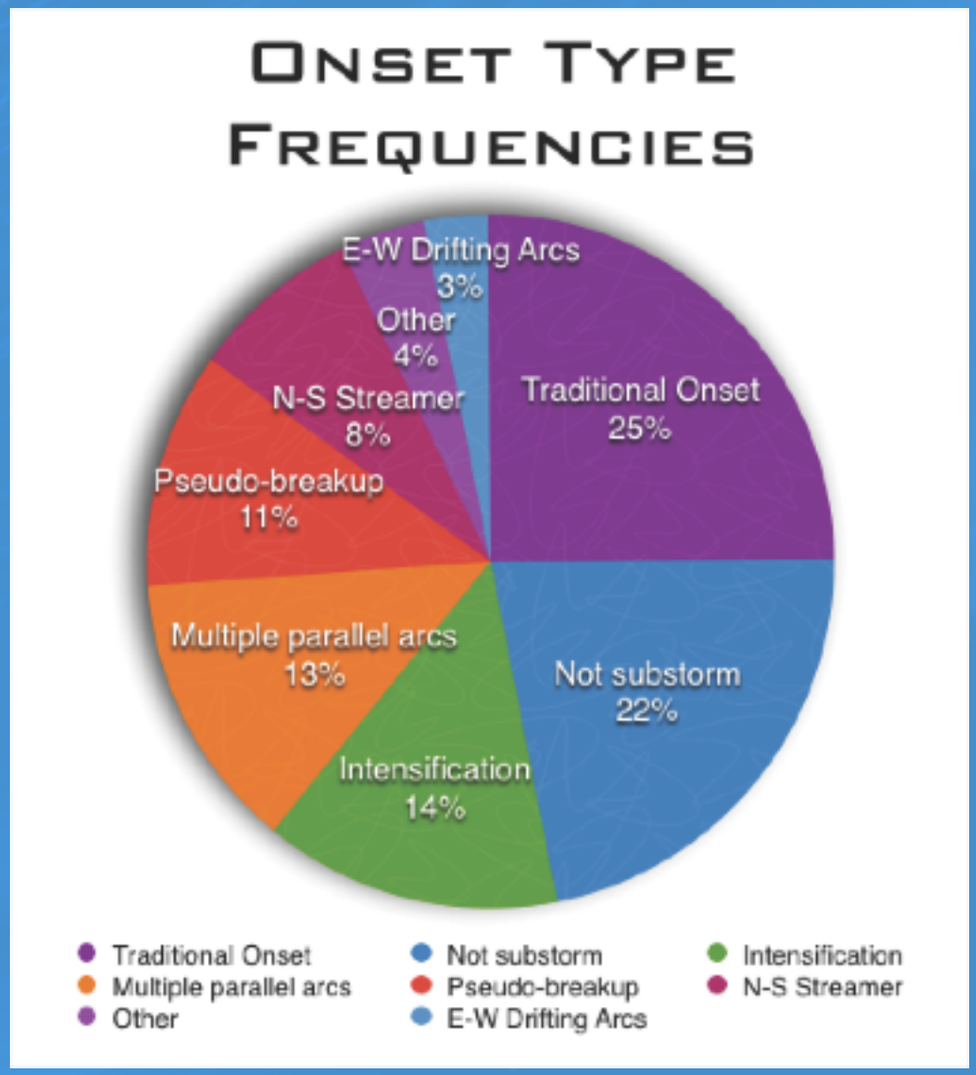
Only a handful of the Nishimura events have been published with analysis, and those analyses only used visual summary methods. We obtained their full database of events and narrowed the original list of 455 to the 202 that occurred at mid-latitude stations (Fort Smith, Fort Simpson, and Gillam). Our goal was to test the streamer hypothesis with multiple data types:

- White light all-sky imager (ASI) observations
- Red light ASI observations
- Ground-based magnetometer readings
- THEMIS bulk plasma velocity readings
- THEMIS magnetic field readings
- Auroral Electrojet (AL) index readings

RESULTS

Initial problem: most events did not actually have streamers, necessary to subdivide into various types of onsets:

- Traditional
- North-South Streamers
- East-West Drifting Arcs
- Multiple Parallel Arcs
- Intensifications
- Pseudo-breakups
- Non-Substorms
- Other



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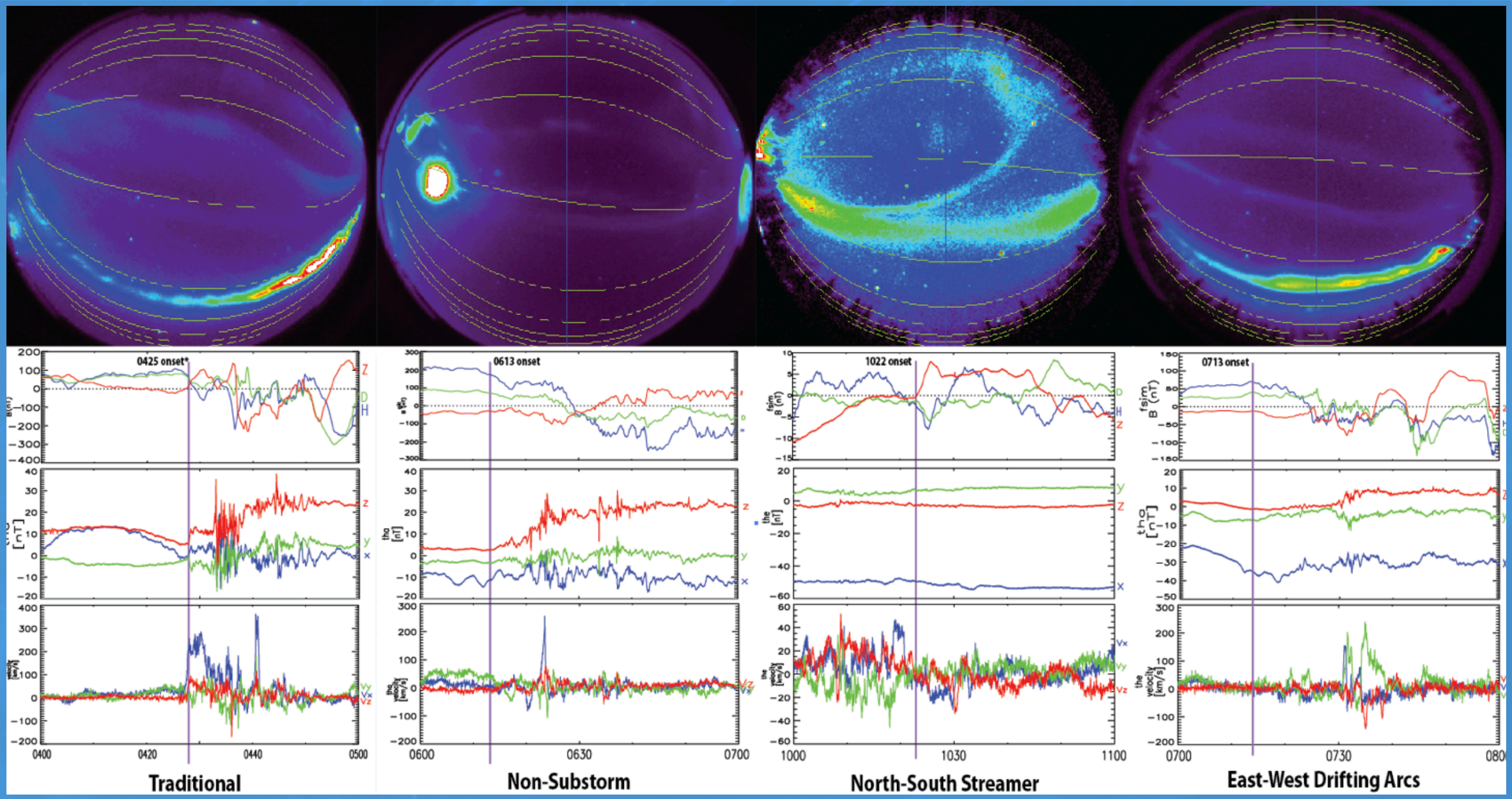


Plots are (top to bottom): white light ASI, ground magnetometer readings, THEMIS magnetic field strength, and THEMIS bulk plasma velocity readings for example events of 4 main subcategories. Each type has distinct characteristics, suggesting different causes for the visual phenomena pictured.

RESULTS

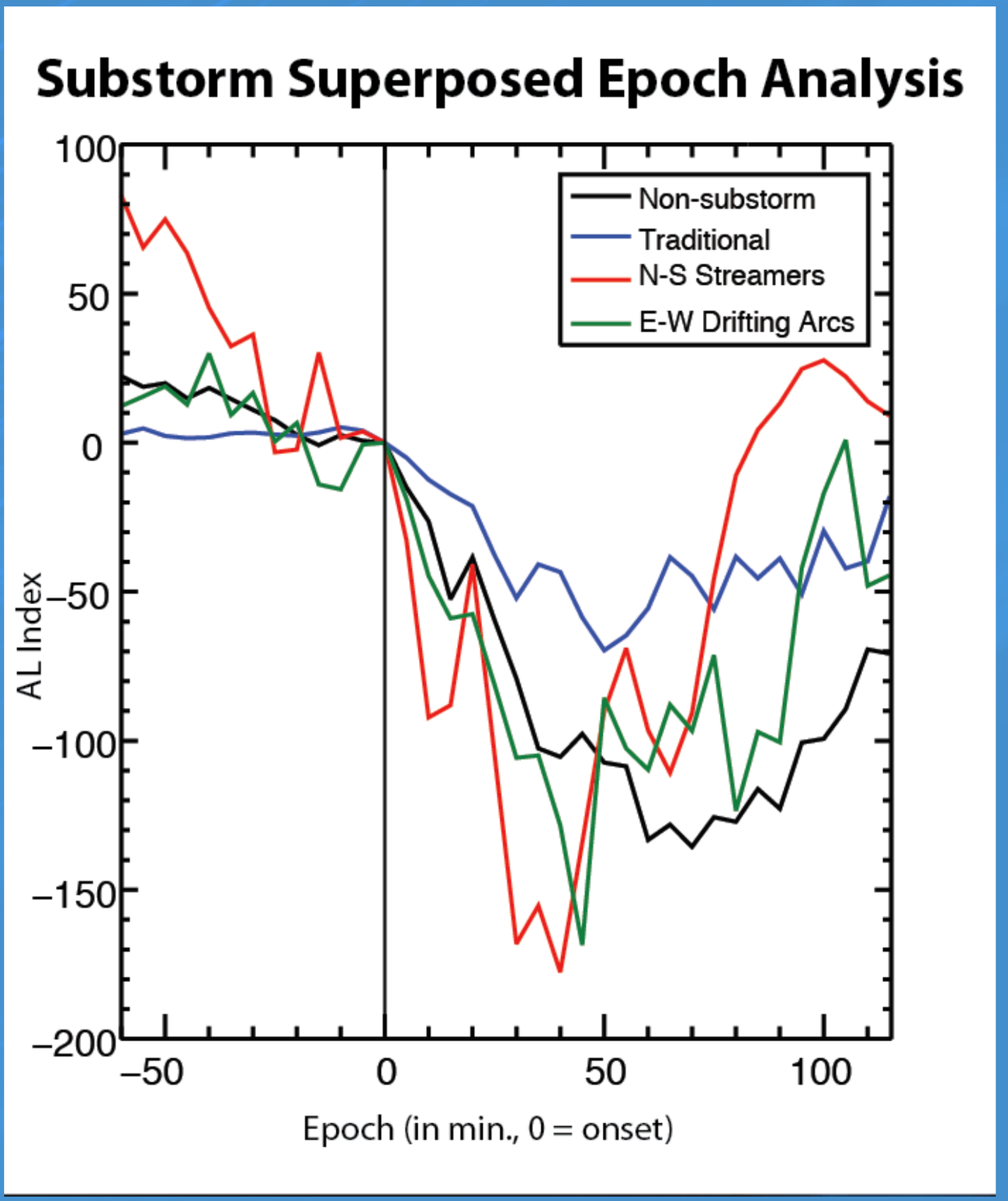
Superposed epoch analysis was used to determine how an "average" substorm of each type would behave.

✦Traditional: fairly steady value pre-onset,followed by sharp decrease once storm commences

✦N-S Streamer: erratic decrease, no visible change around onset

✦E-W Drifting Arcs: slightly more ordered than streamers, but still erratic

✦Non-substorms: closest in overall form to traditional category, although with some irregularities and a longer timeframe



CONCLUSIONS

- Traditional onsets (25% of the total events): the overall shape of the averaged AL index value vs. time graph was consistent with the onset of an isolated substorm. However, the absolute minimum of the graph was significantly lower than expected, compared to the other types of onsets.

- Non-substorms (22%): organized visually as “quiet” periods, but often had identifiable activity in the other data analyses, and appear similar to the traditional substorms in the epoch analysis. Further investigation showed that at least 32% of these events were onsets, but were outside the field of view (FOV) for the station in question.

- East-west drifting arcs (3%): showed low activity in velocity and magnetic field readings from THEMIS and erratic AL levels before and during onset, leading to the conclusion that these are likely remnants of older substorm activity.

- **Streamers** (8%): rarely came within 1° of magnetic latitude of an equatorward arc prior to onset, and THEMIS velocity and magnetic field readings often showed negligible activity during these events. **The vast majority of database onsets occurring within the FOV of a given station do not have streamer-triggered onsets, and evidence suggests the streamers are probably related to substorm activity already underway in other locations.**

ACKNOWLEDGEMENTS/WORKS CITED

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