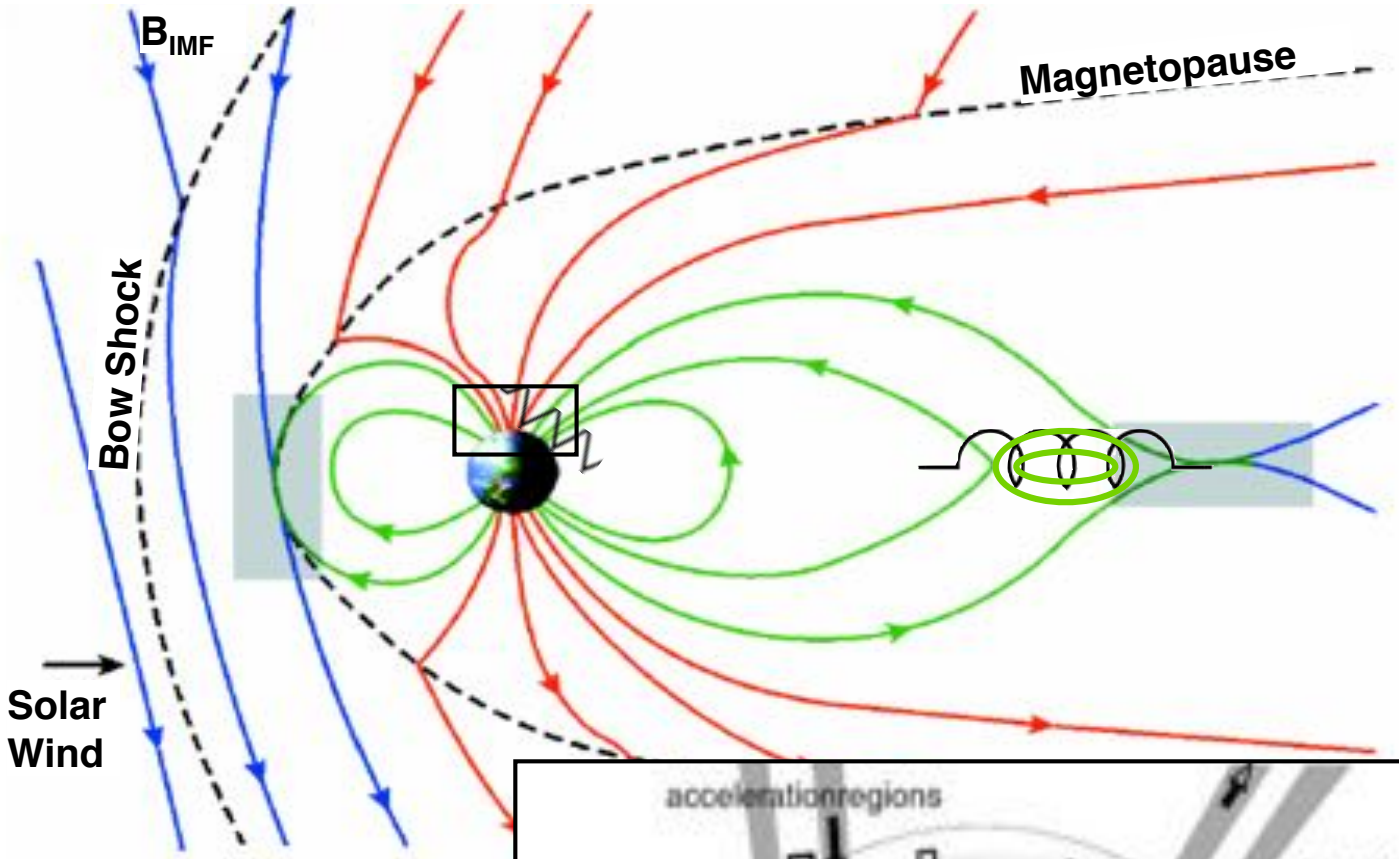
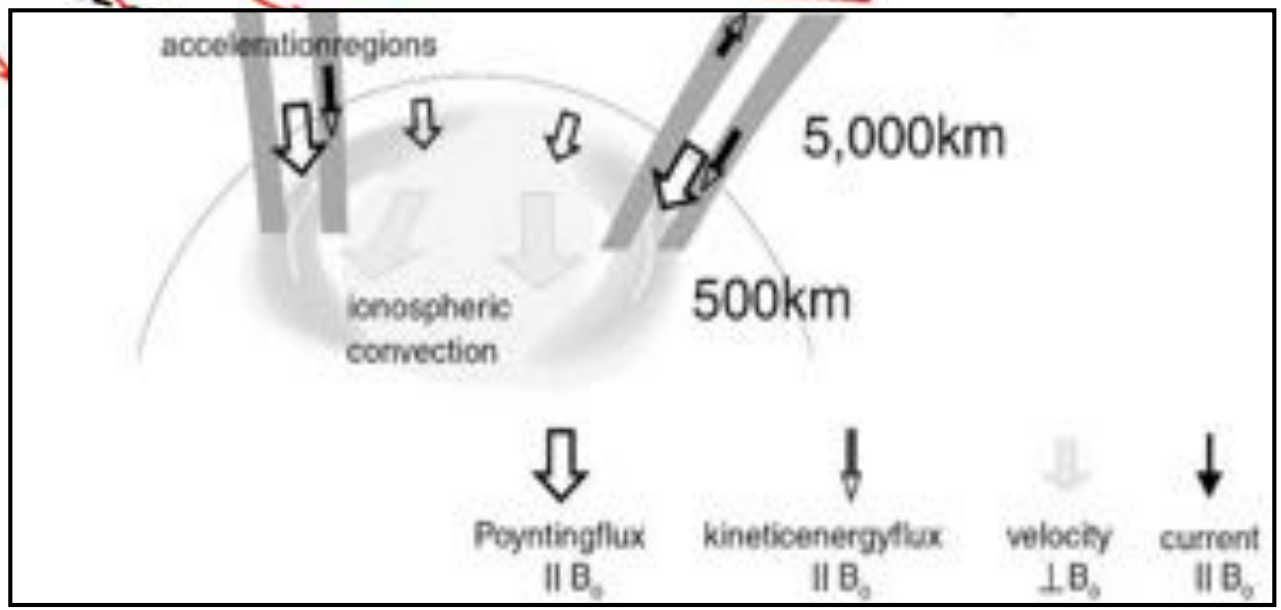
Auroral Plasma Dynamics Revealed through Radio-Optical Sensor Fusion

Joshua Semeter
Boston University Center for Space Physics

Acknowledgements: Sebastijan Mrak, Brent Parham, Nithin Sivadas, John Swoboda, Michael Hirsch, Hassan Akbari, Chhavi Goenka, Matt Zettergren, Marcos Diaz

Solar wind - Magnetosphere Coupling: Energy Storage and Release

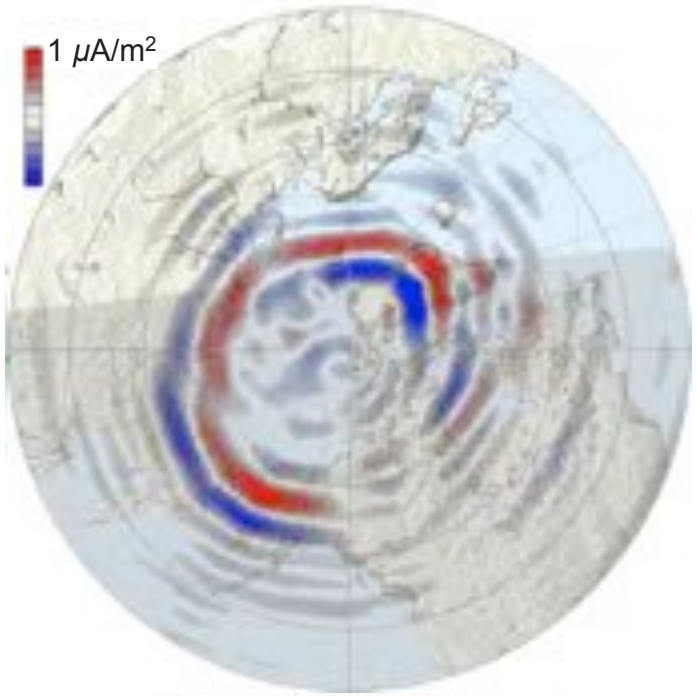


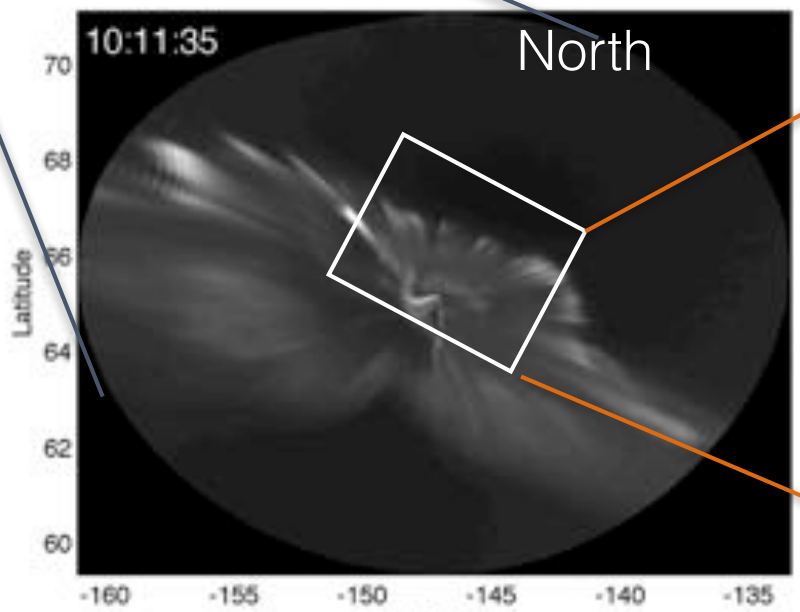


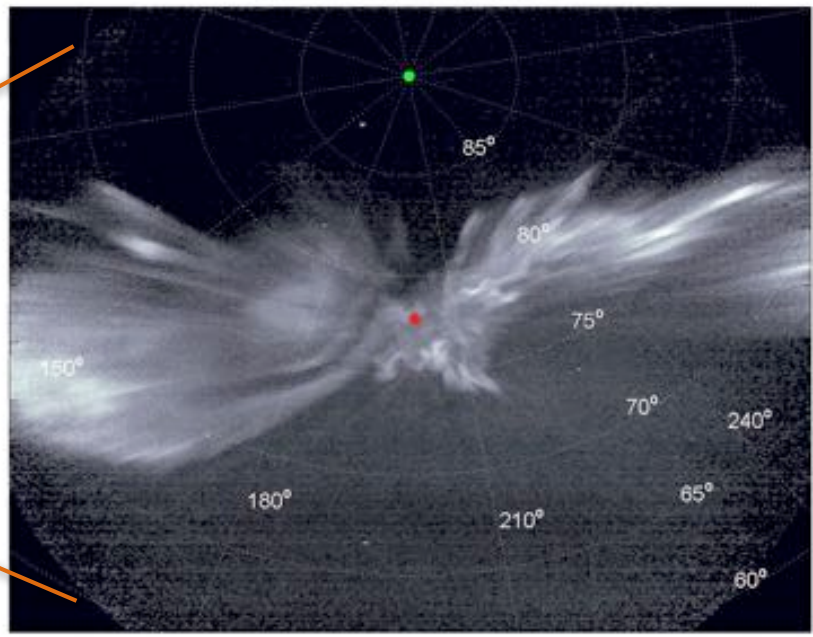
Inductive energy is accumulated in the magnetotail via interaction with the solar wind. Stored energy is released impulsively into the atmosphere as heat, ionization, radiation, and bulk acceleration of gases.

Geospace multiscale mission

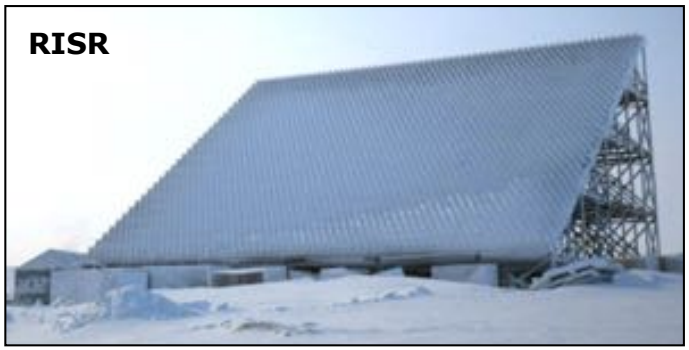
Spherical harmonic expansion

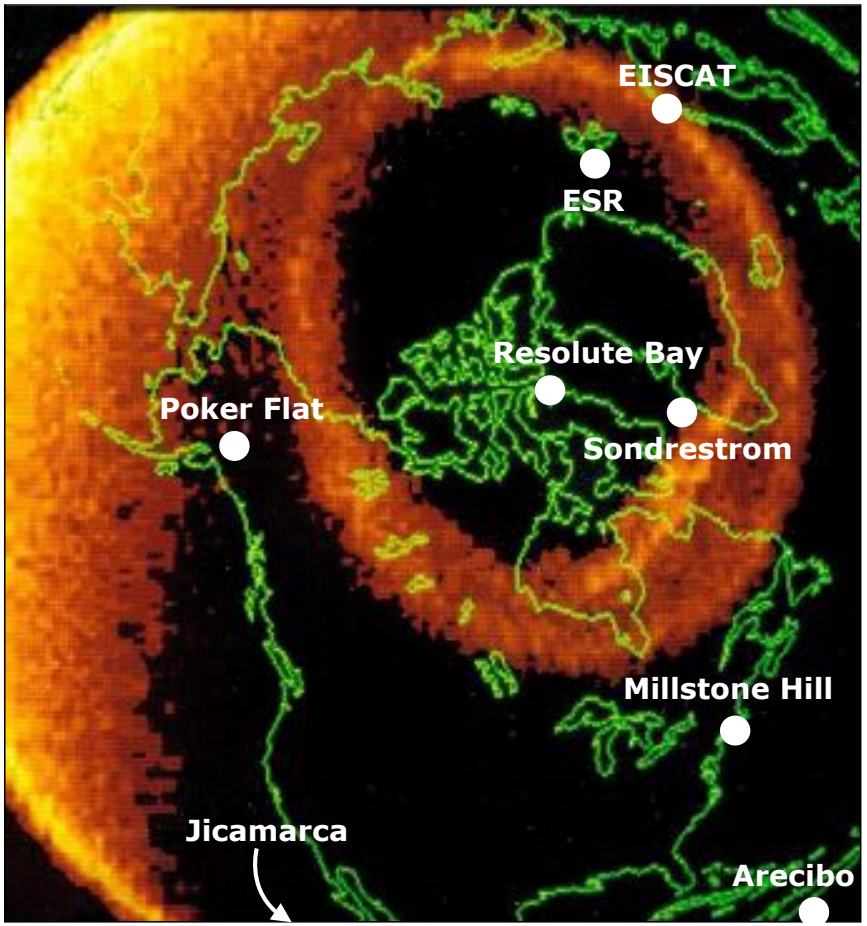


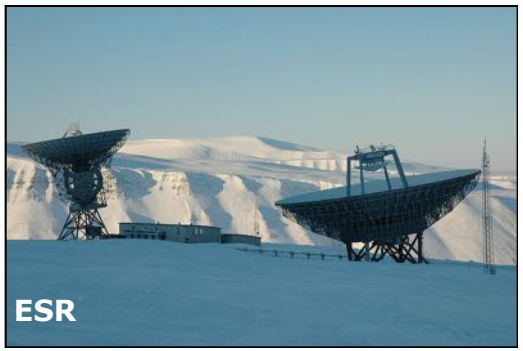


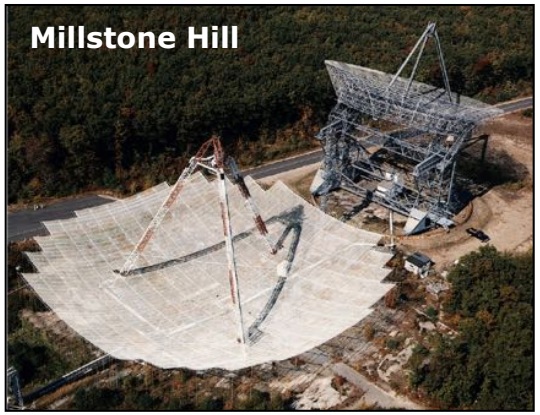


Incoherent Scatter Radar









Incoherent Scatter Radar

Ion-acoustic

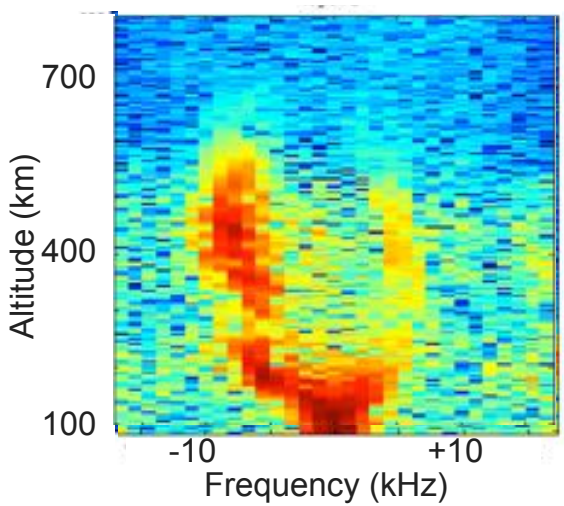
$$\omega_s = C_s k \qquad C_s = \sqrt{k_B(T_e + 3T_i)/m_i}$$

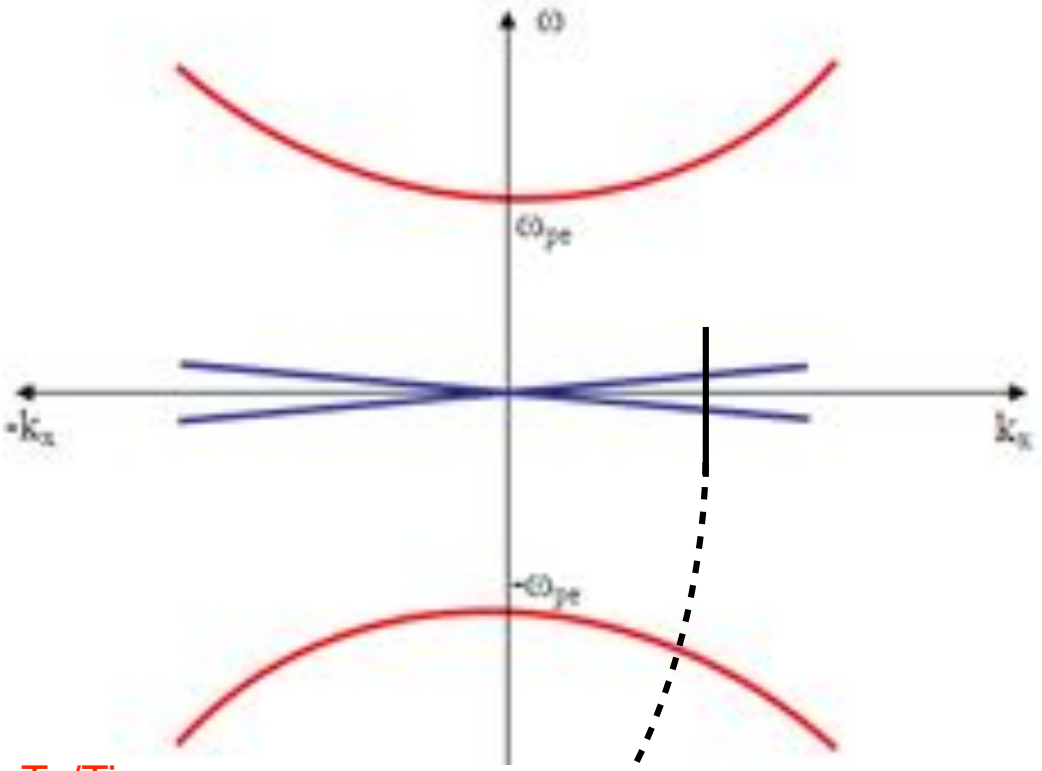
$$\omega_{si} = -\sqrt{\frac{\pi}{8}}\left[\left(\frac{m_e}{m_i}\right)^{\frac{1}{2}} + \left(\frac{T_e}{T_i}\right)^{\frac{3}{2}} \exp\left(-\frac{T_e}{2T_i} - \frac{3}{2}\right)\right]\omega_s$$

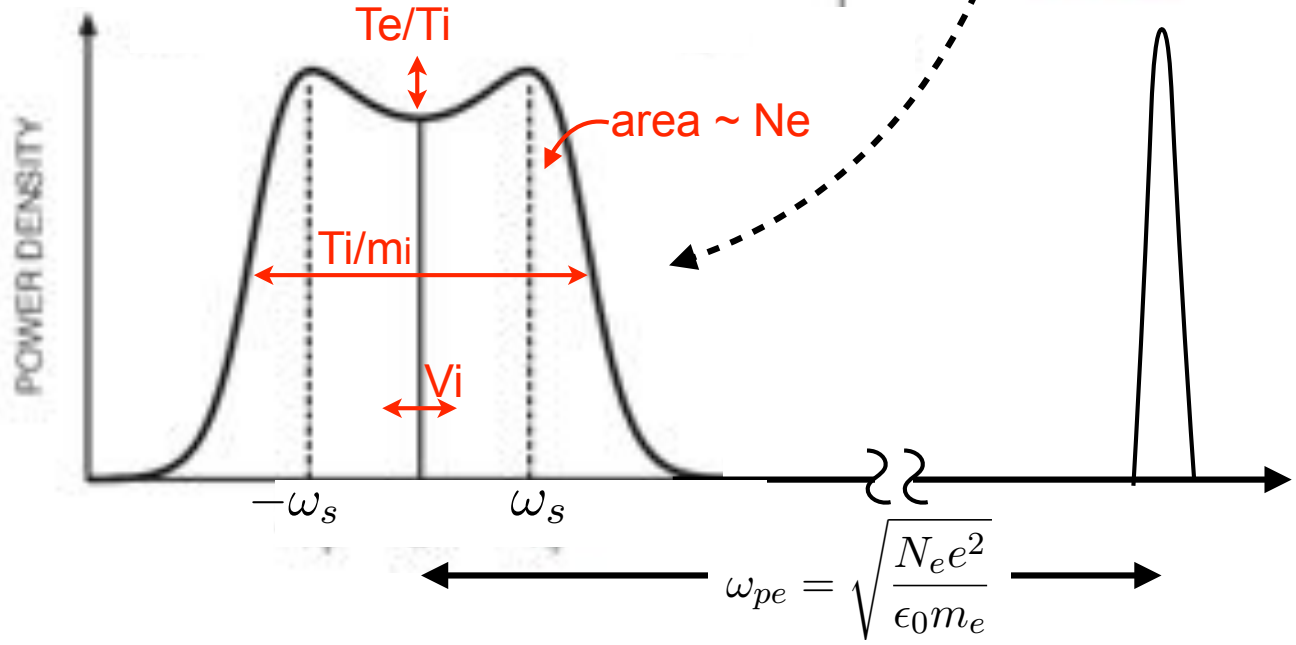
Langmuir

$$\omega_L = \sqrt{\omega_{pe}^2 + 3\,k^2\,v_{the}^2} \approx \omega_{pe} + \frac{3}{2} v_{the}\lambda_{De}k^2$$

$$\omega_{Li} \approx -\sqrt{\frac{\pi}{8}}\frac{\omega_{pe}^3}{k^3}\frac{1}{v_{the}^3} exp\left(-\frac{\omega_{pe}^2}{2k^2v_{the}^2} - \frac{3}{2}\right)\omega_L$$

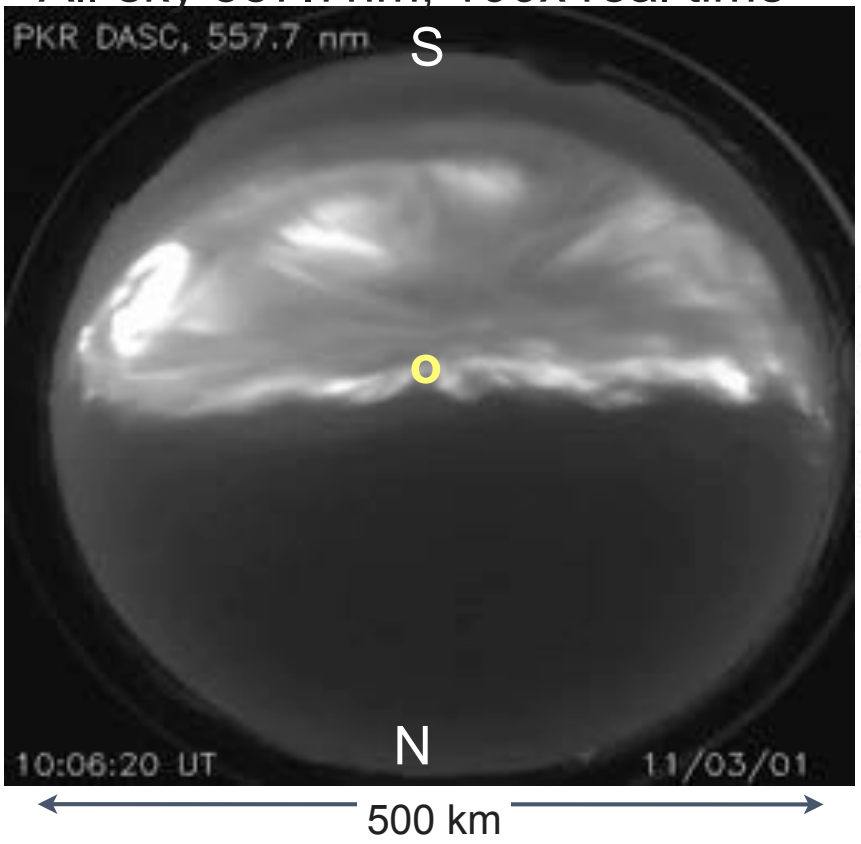




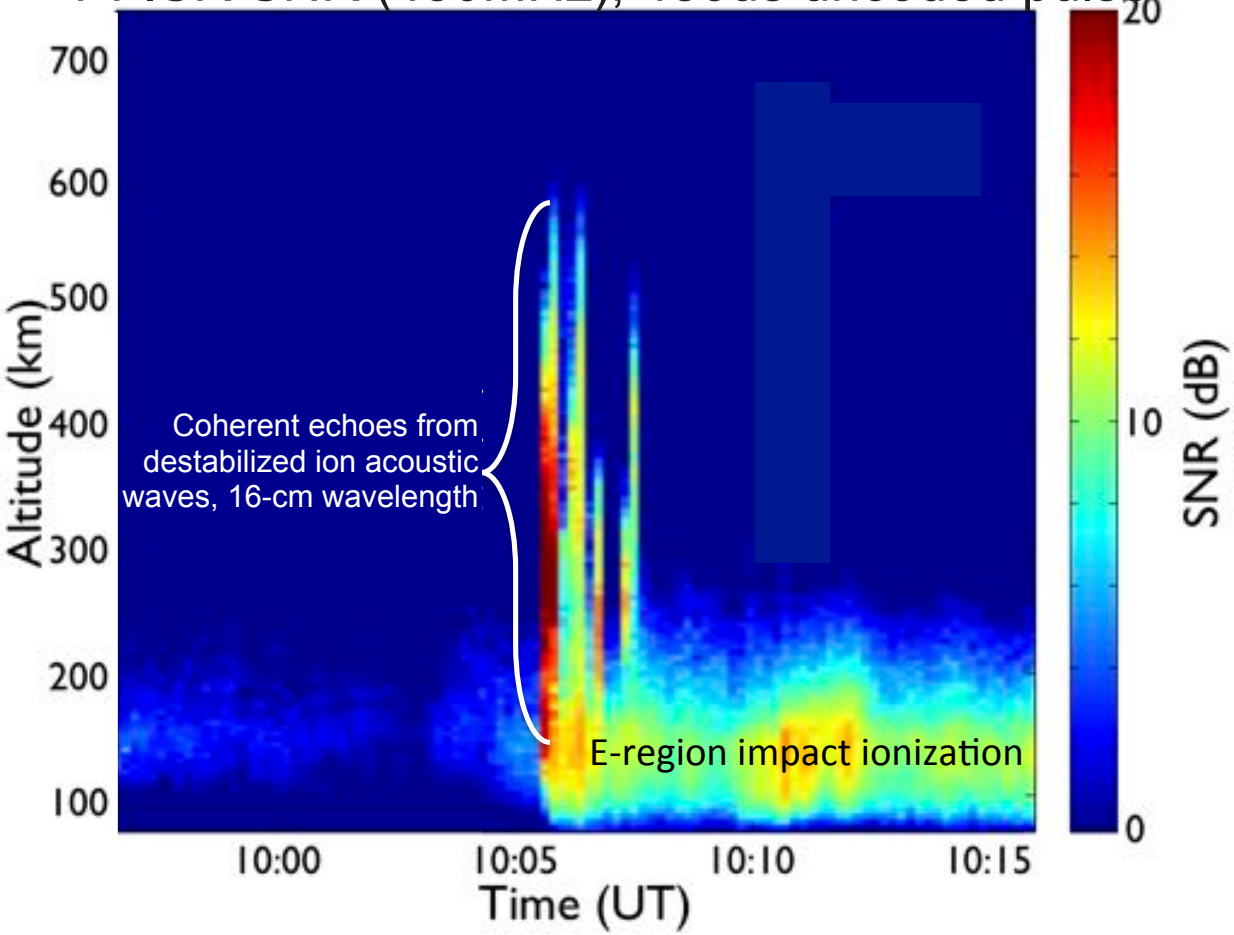


Radar perspective

All-sky 557.7nm, 100x real time

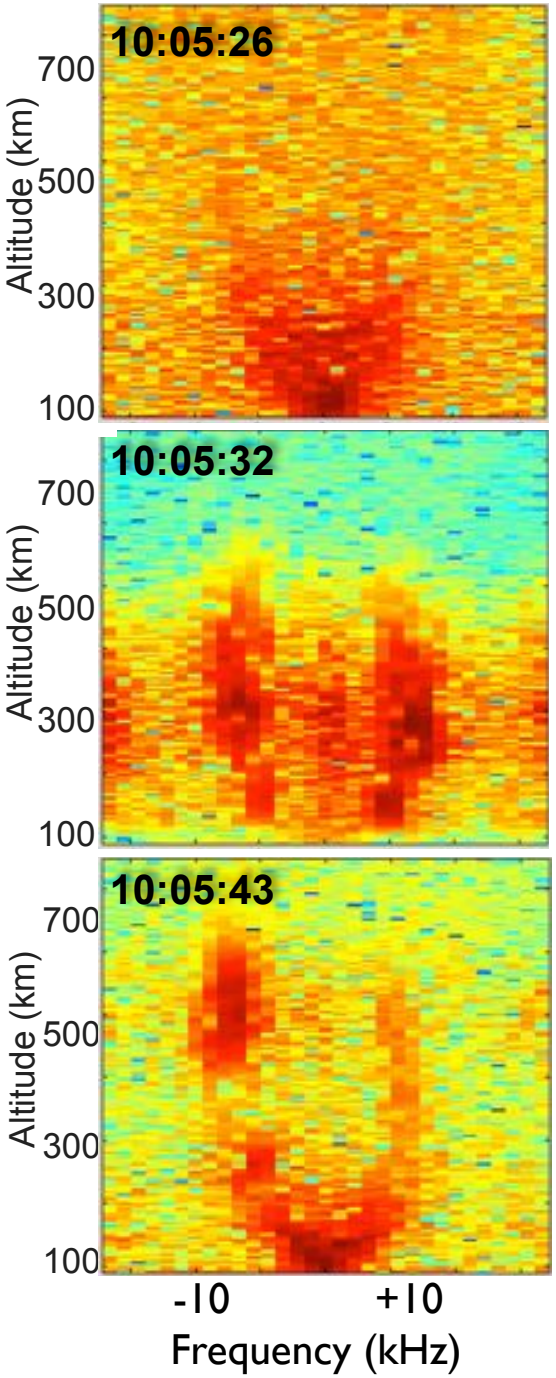


PFISR SNR (450MHz), 480us uncoded pulse

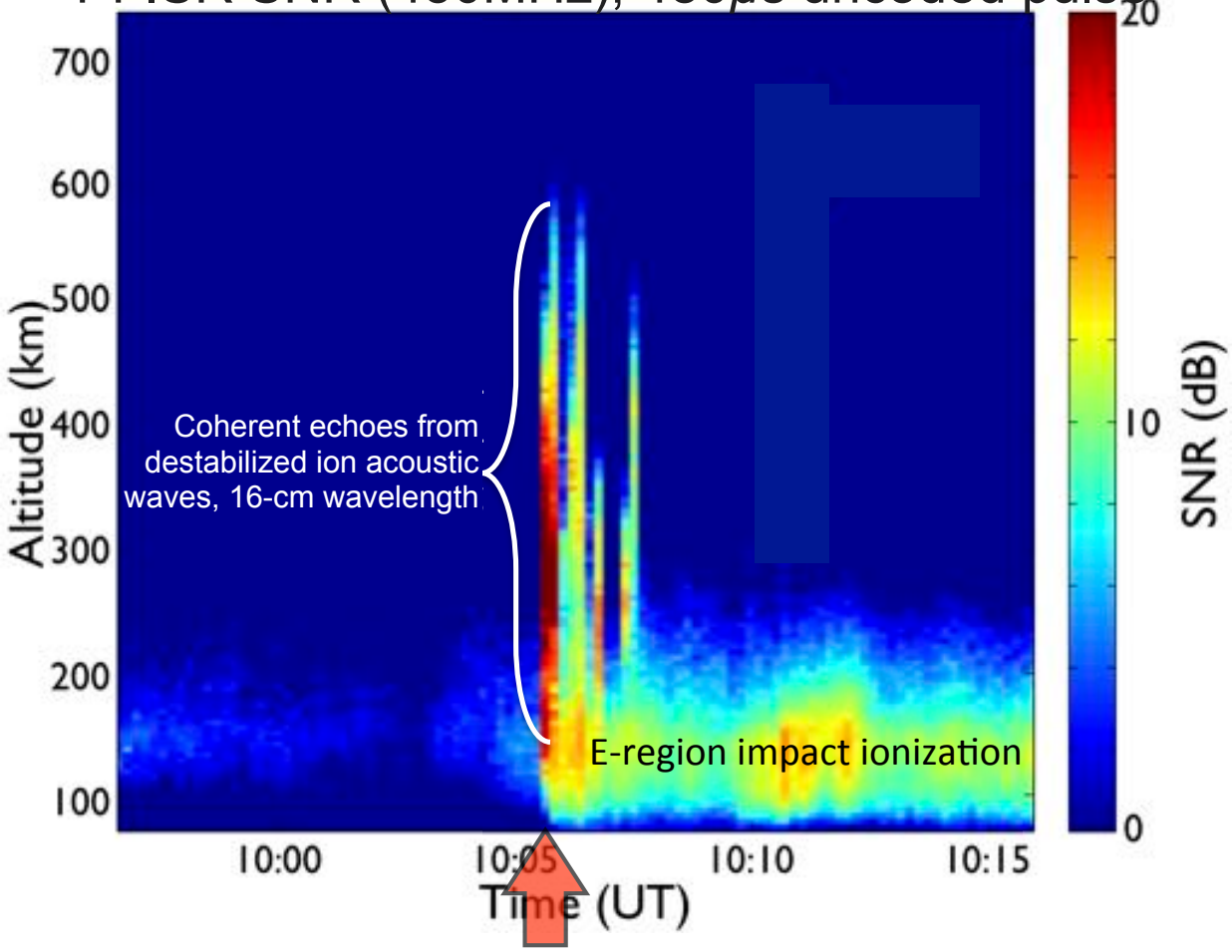


Akbari et al., 2013

Radar perspective



PFISR SNR (450MHz), 480μs uncoded pulse

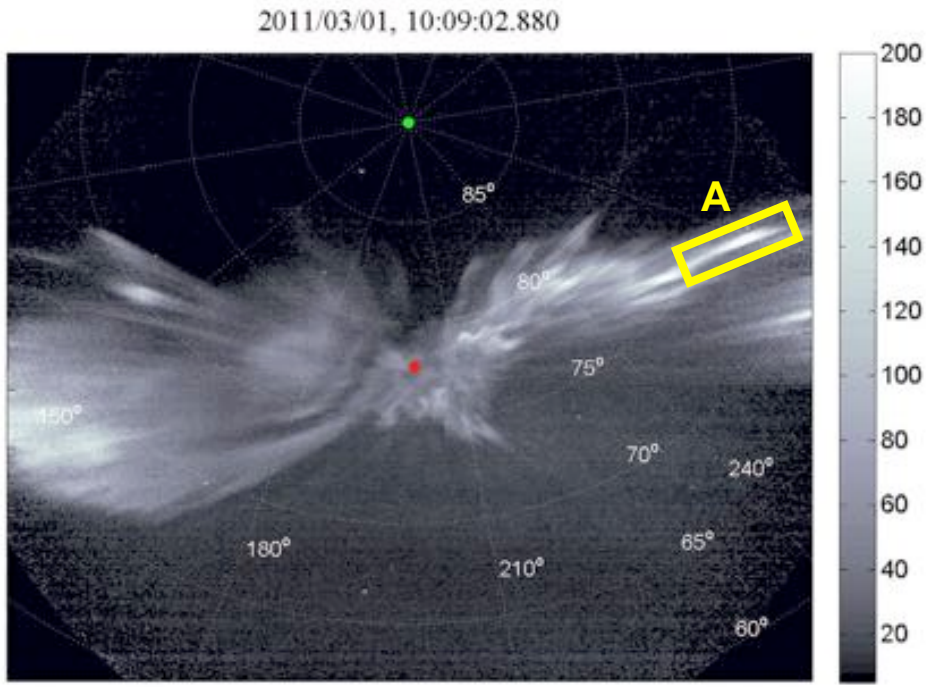


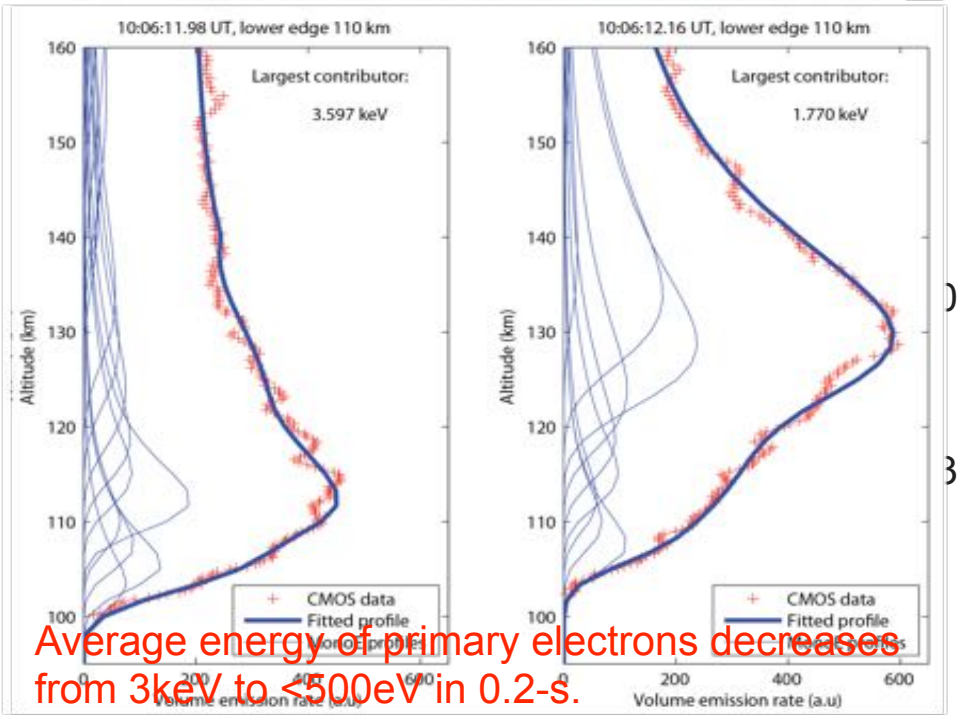
Candidate mechanisms:

1. Parametric decay of Langmuir turbulence (beam related)
2. ion-electron streaming instability (current related)

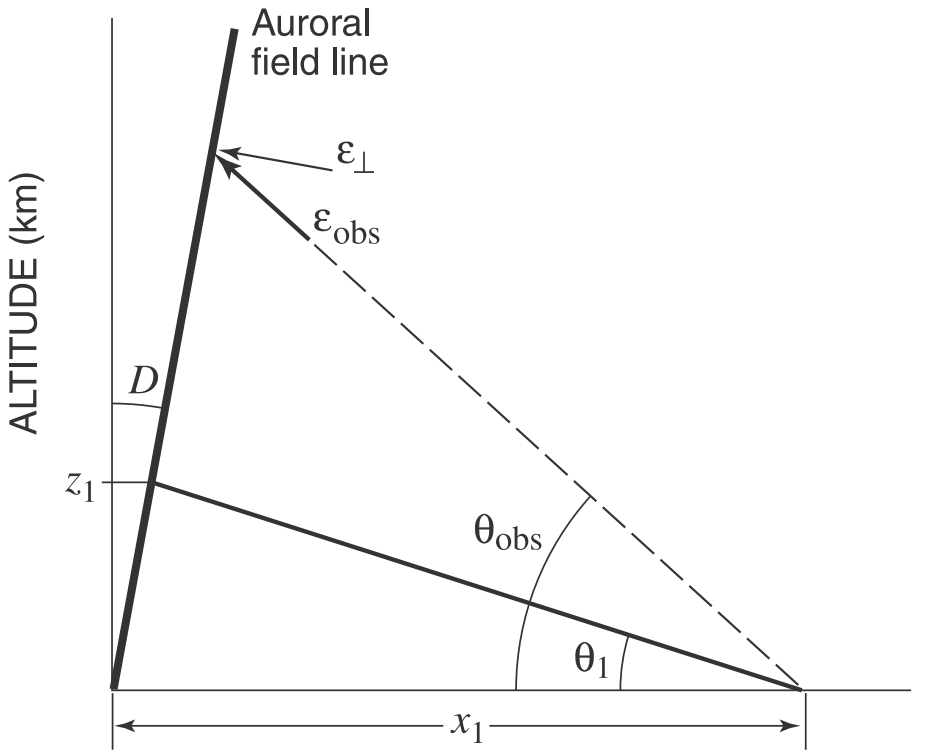
Akbari et al., 2013

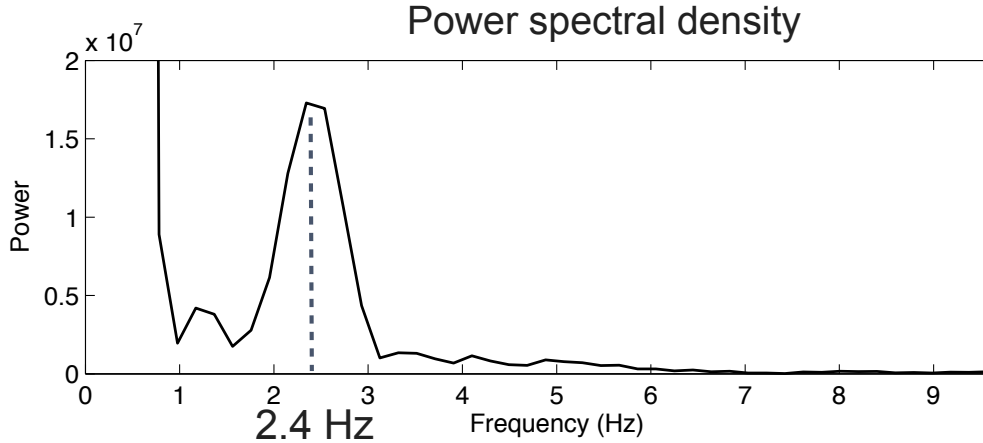
Optical manifestation of dispersive bursts





Average energy of primary electrons decreases from 3keV to <500eV in 0.2-s.

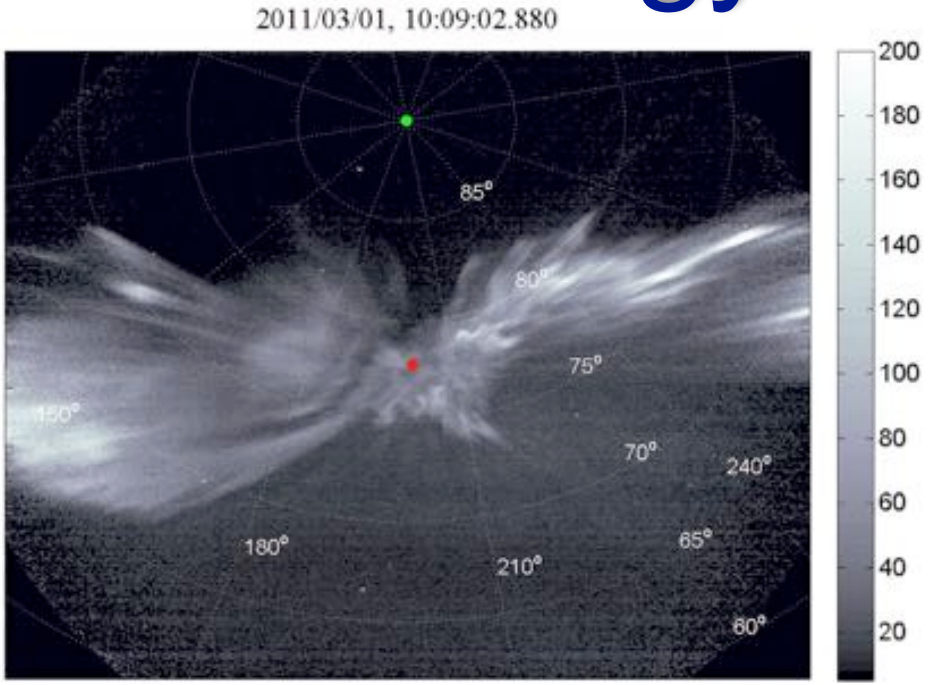


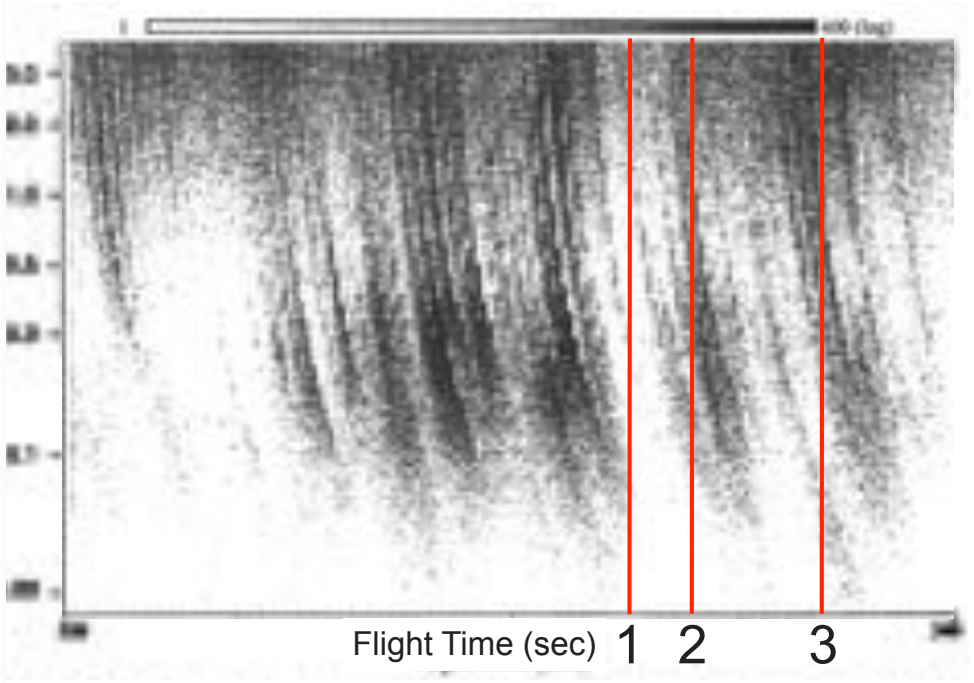


Field-aligned bursts are periodic at ~2.4Hz

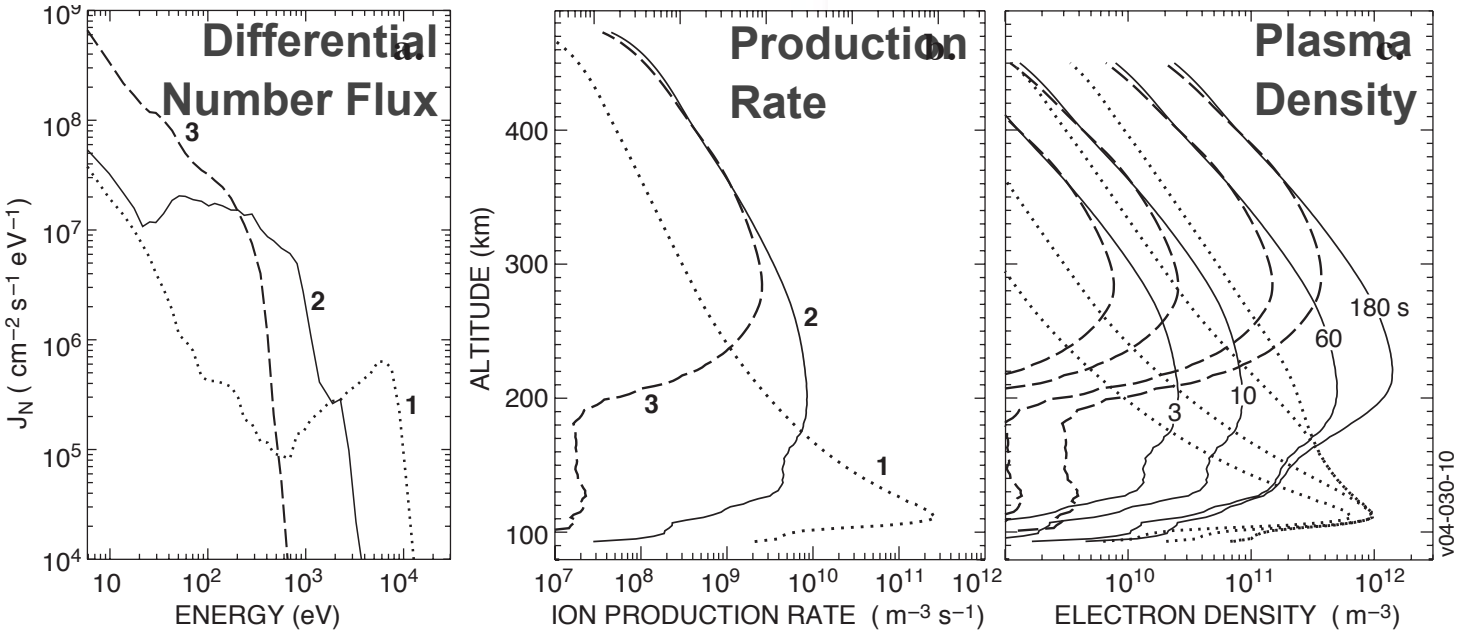
Dahlgren et al., JGRA 2013

Time-energy dispersed electron



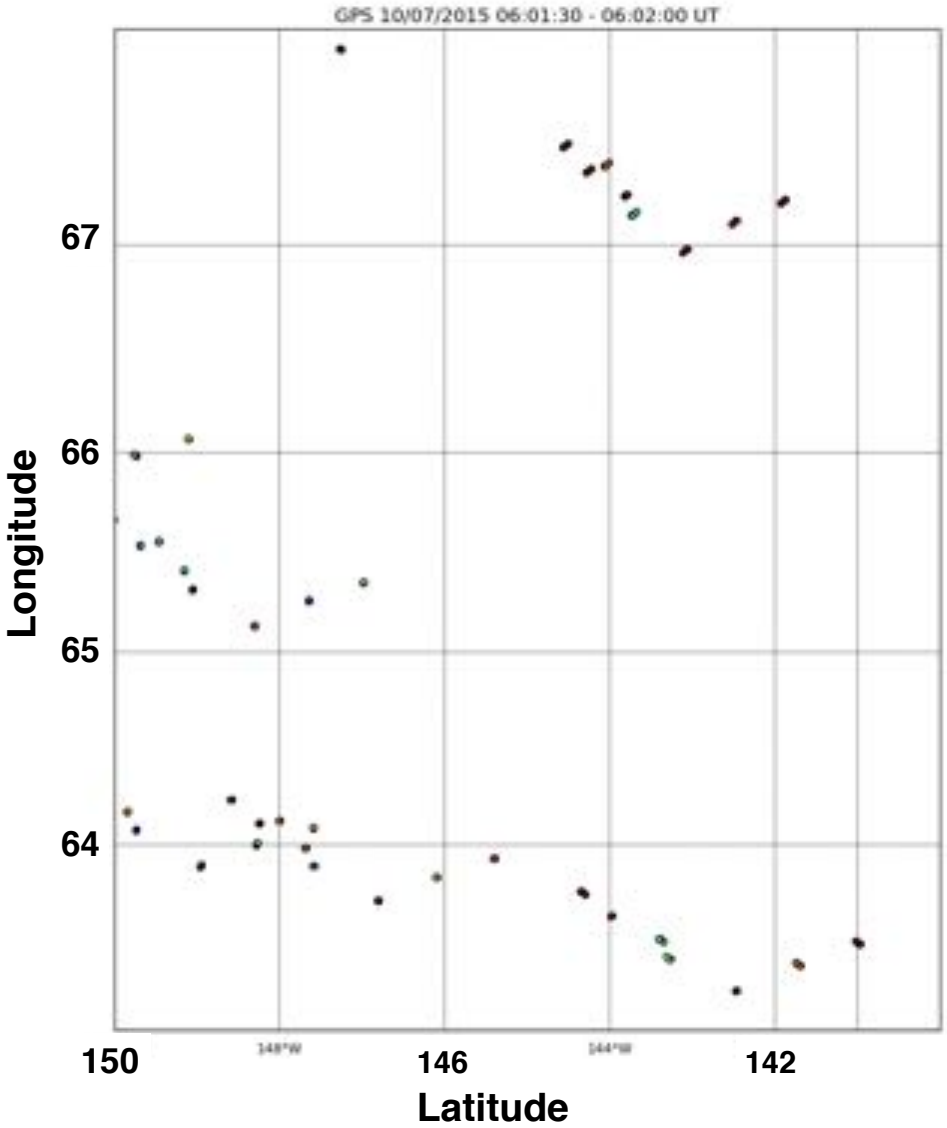


Arnoldy et al., 1999



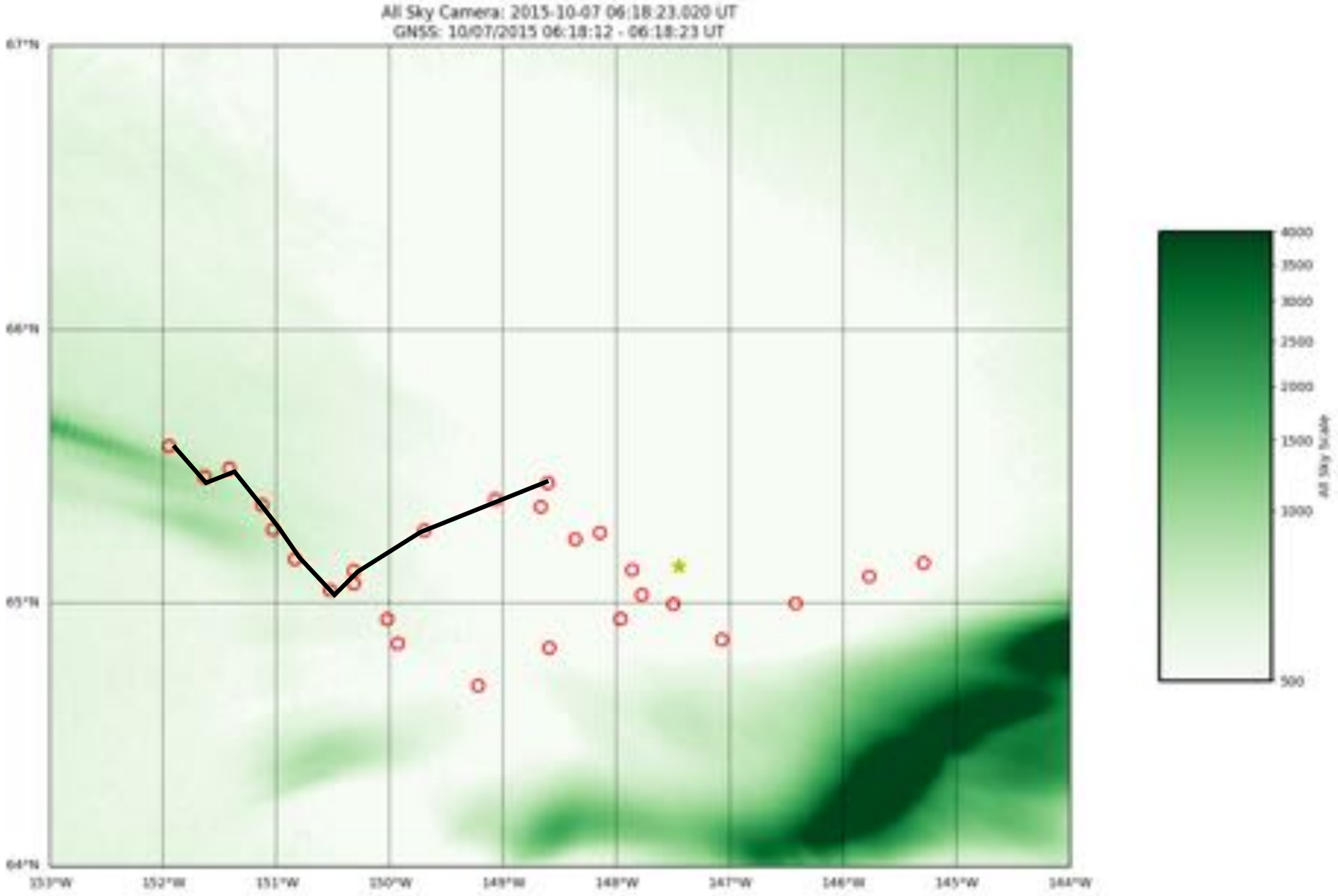
Semeter et al., 2005

Mahali Experiment



https://mahali.mit.edu

Pankratius et al., IEEE Comm. Mag., 2016, Semeter et al., GRL 2017, Mrak et al JGRA 2017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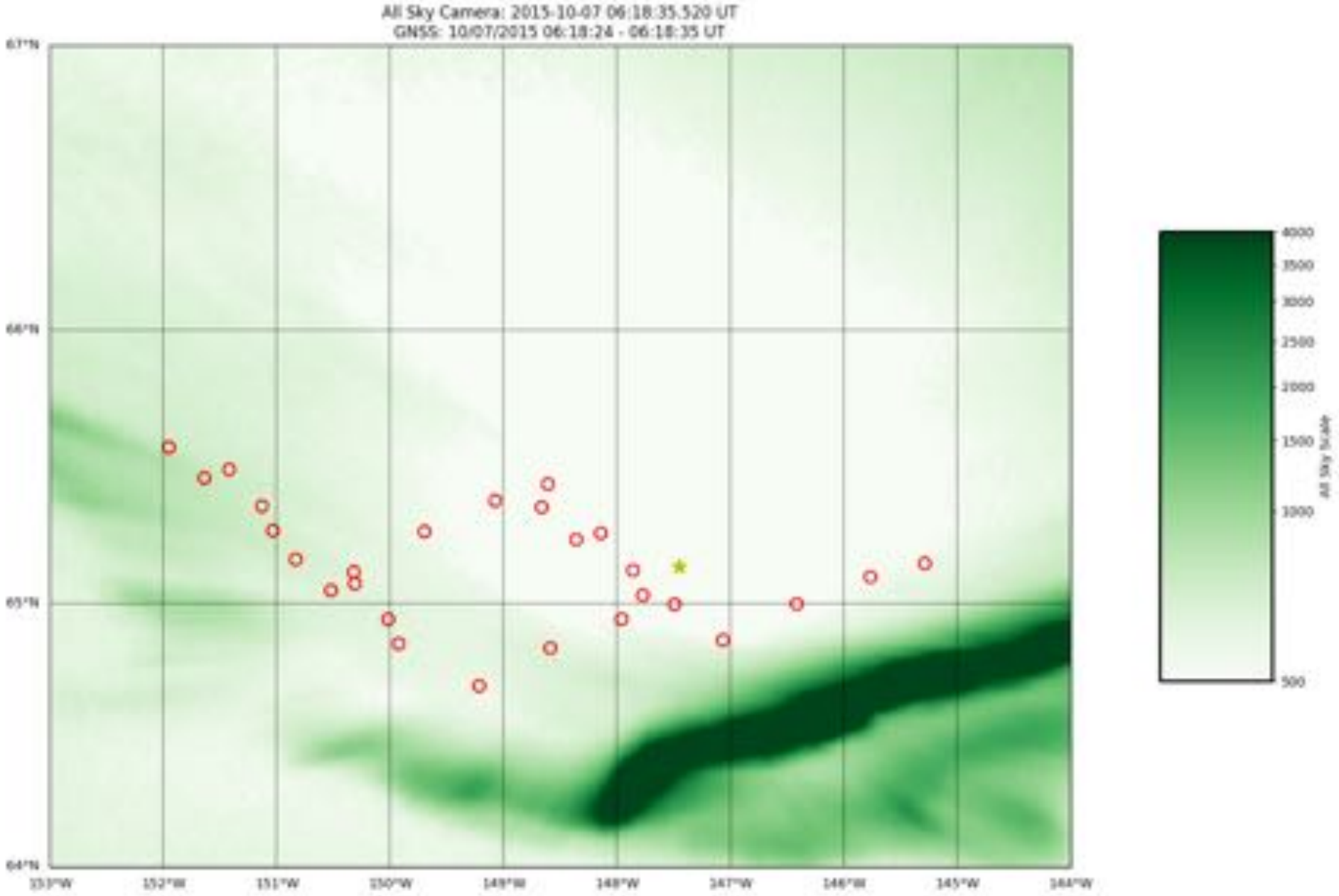
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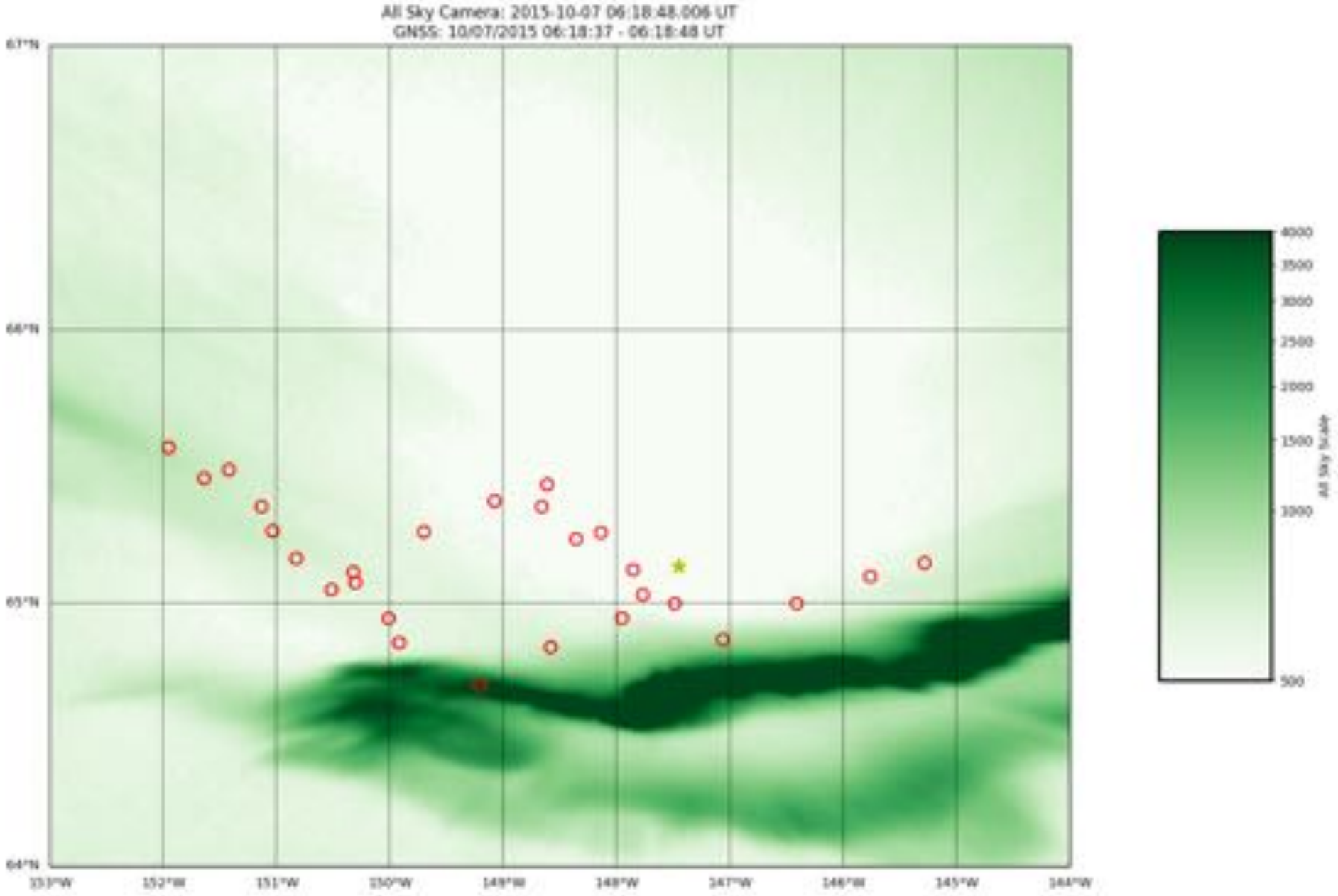
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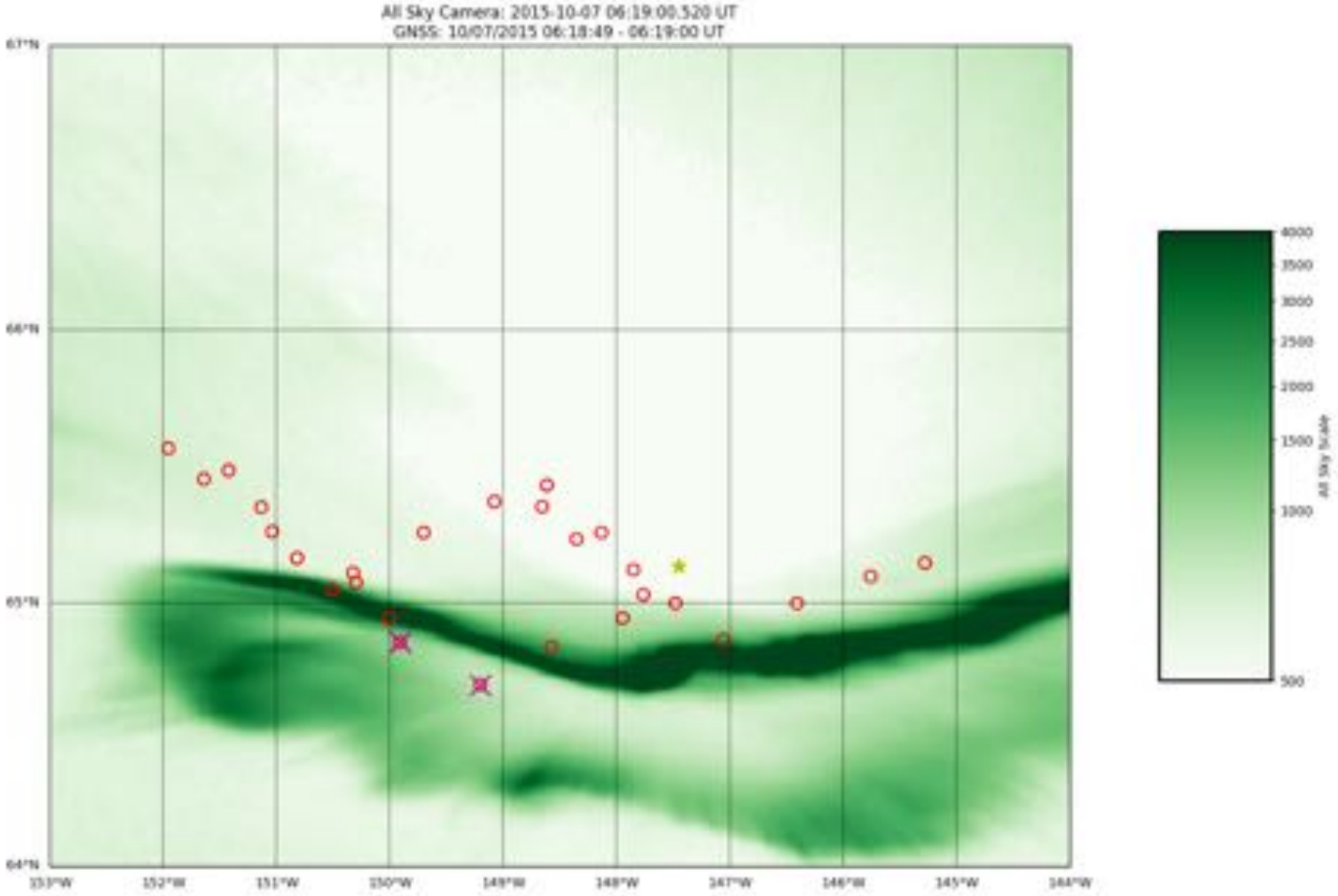
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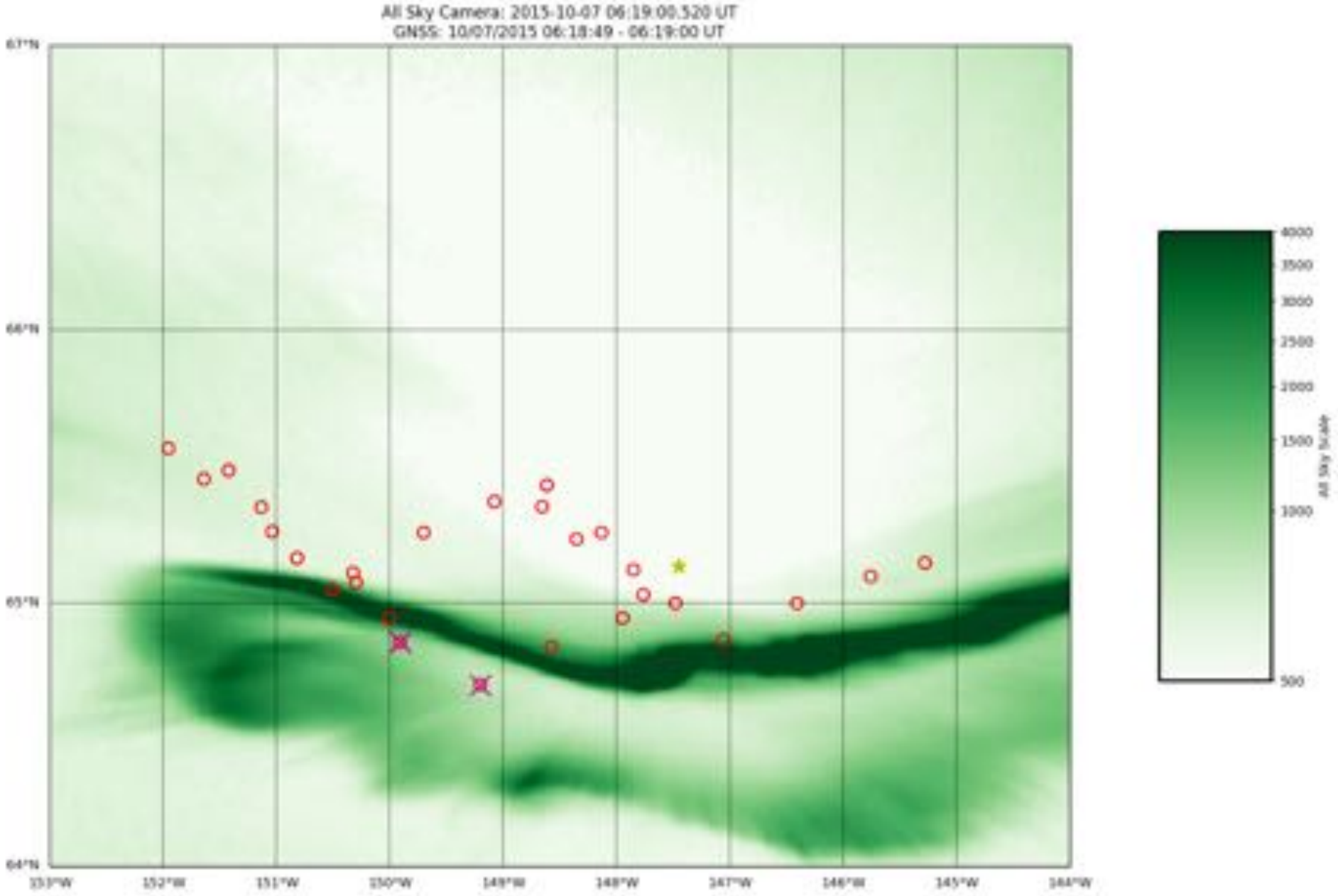
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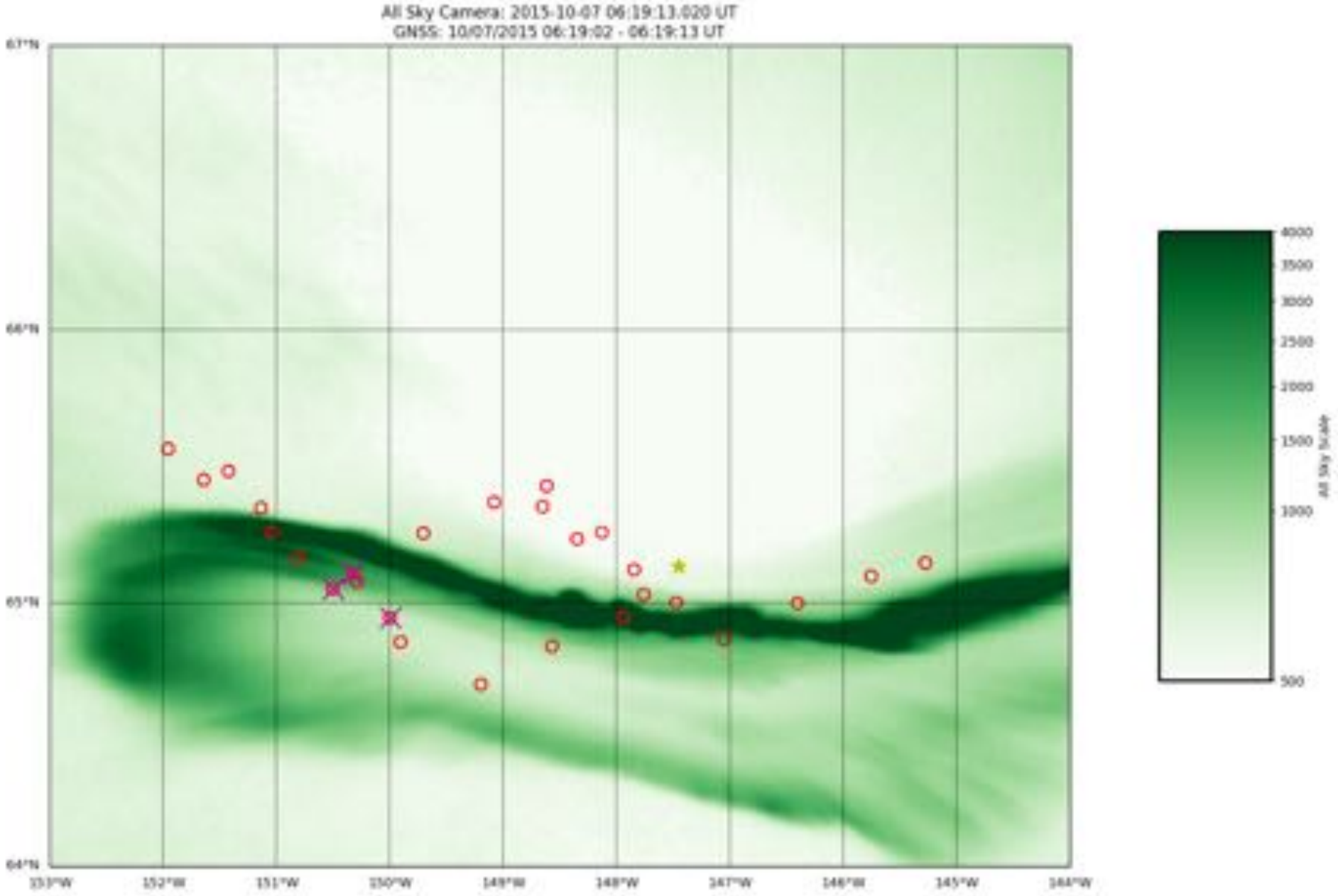
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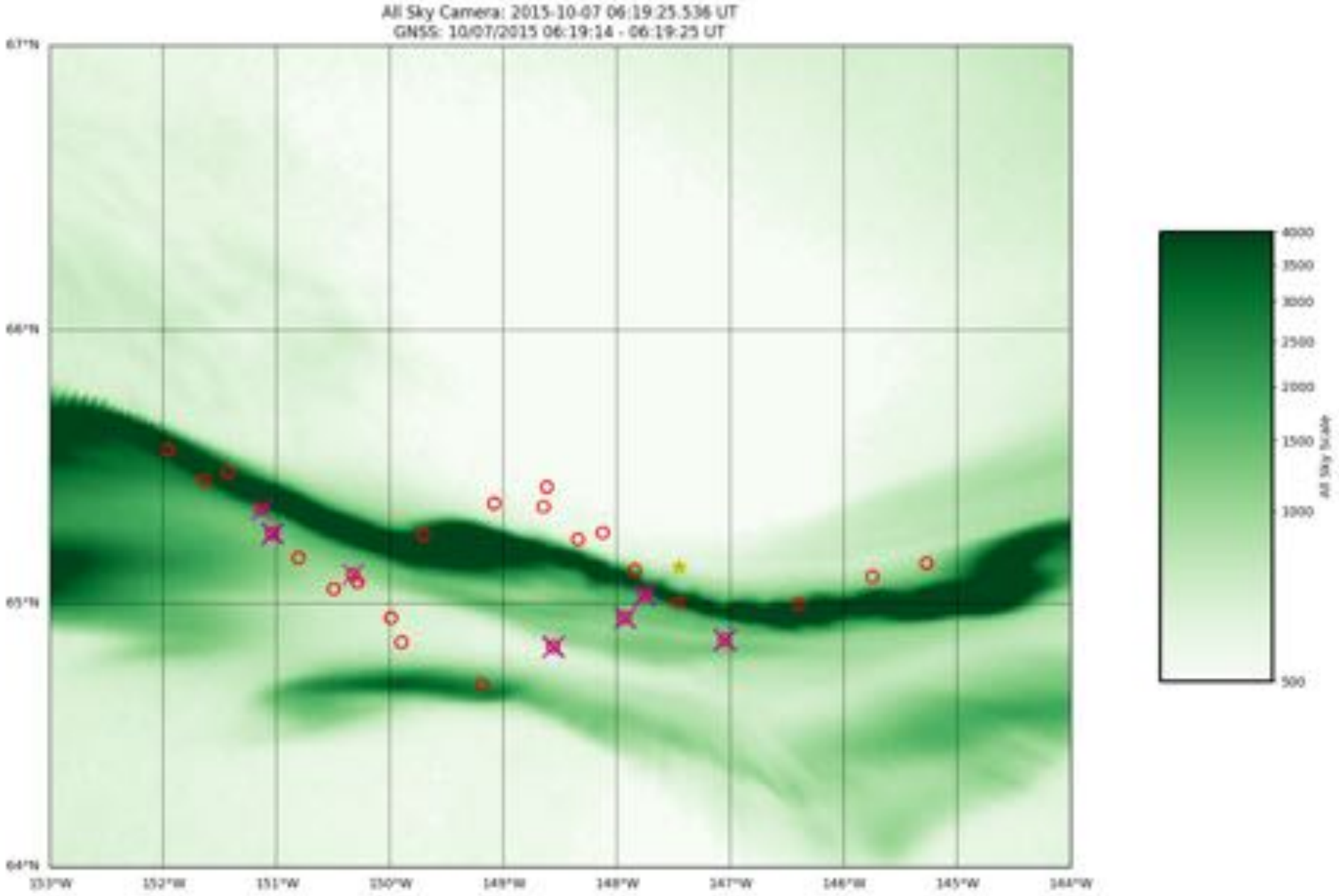
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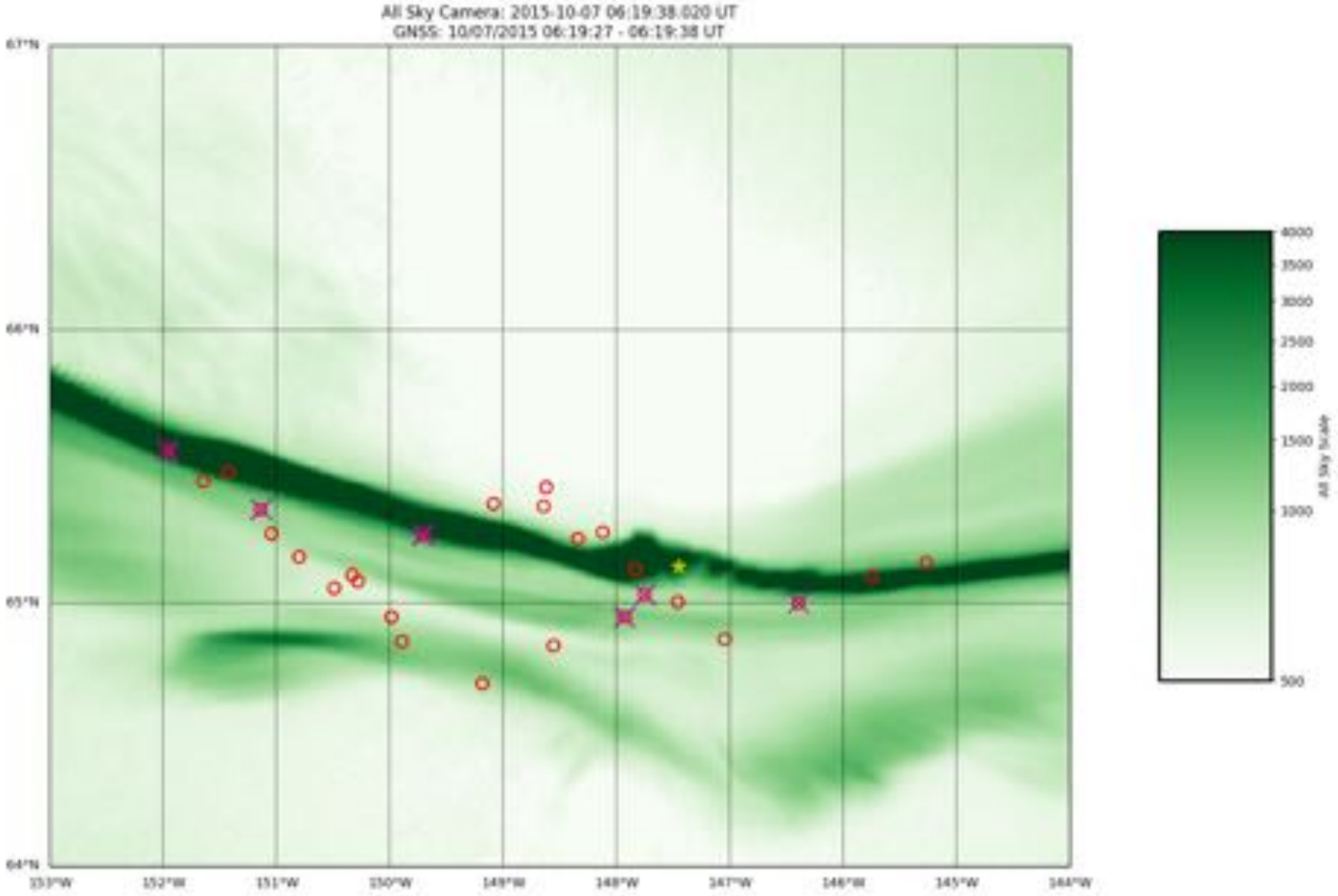
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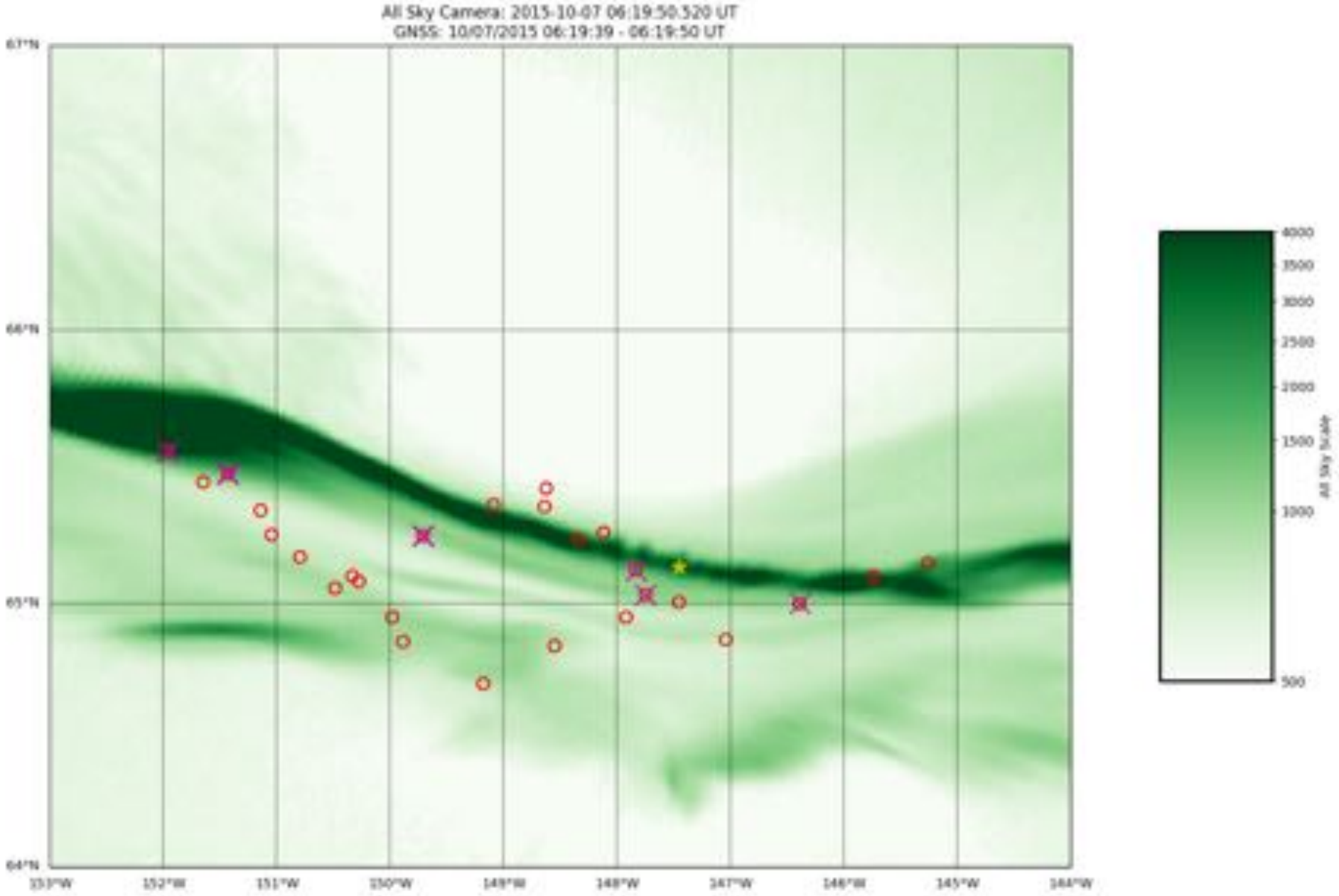
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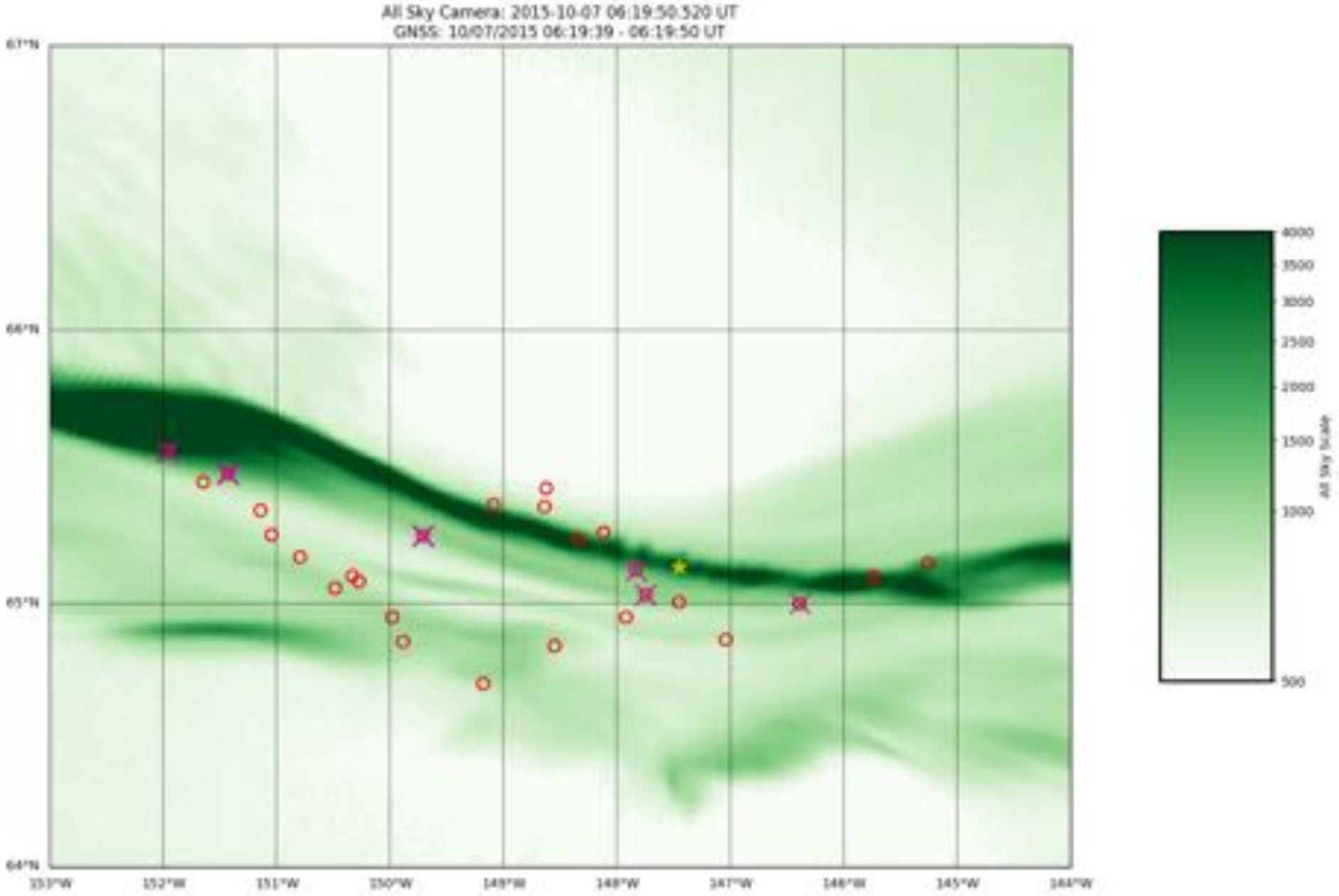
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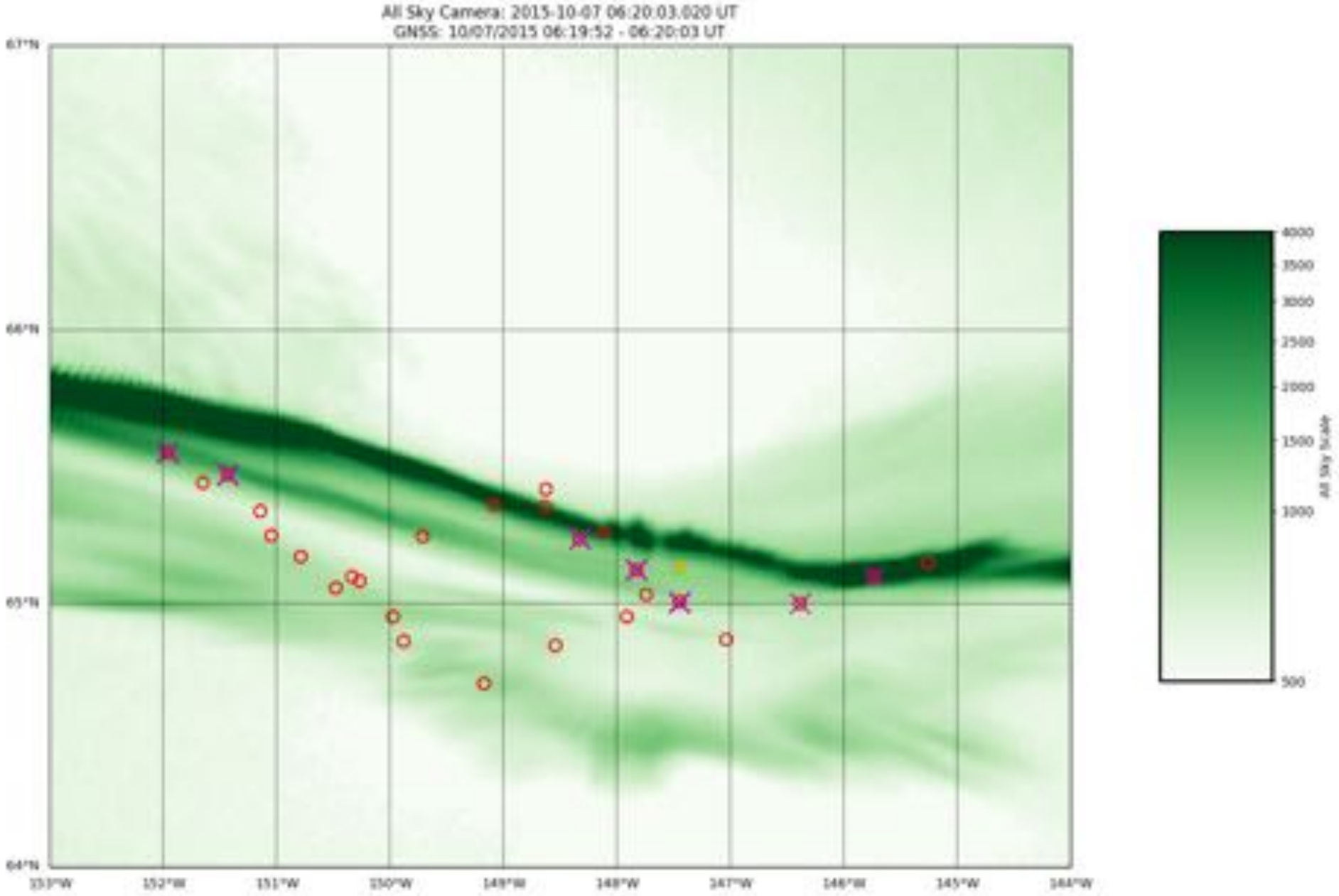
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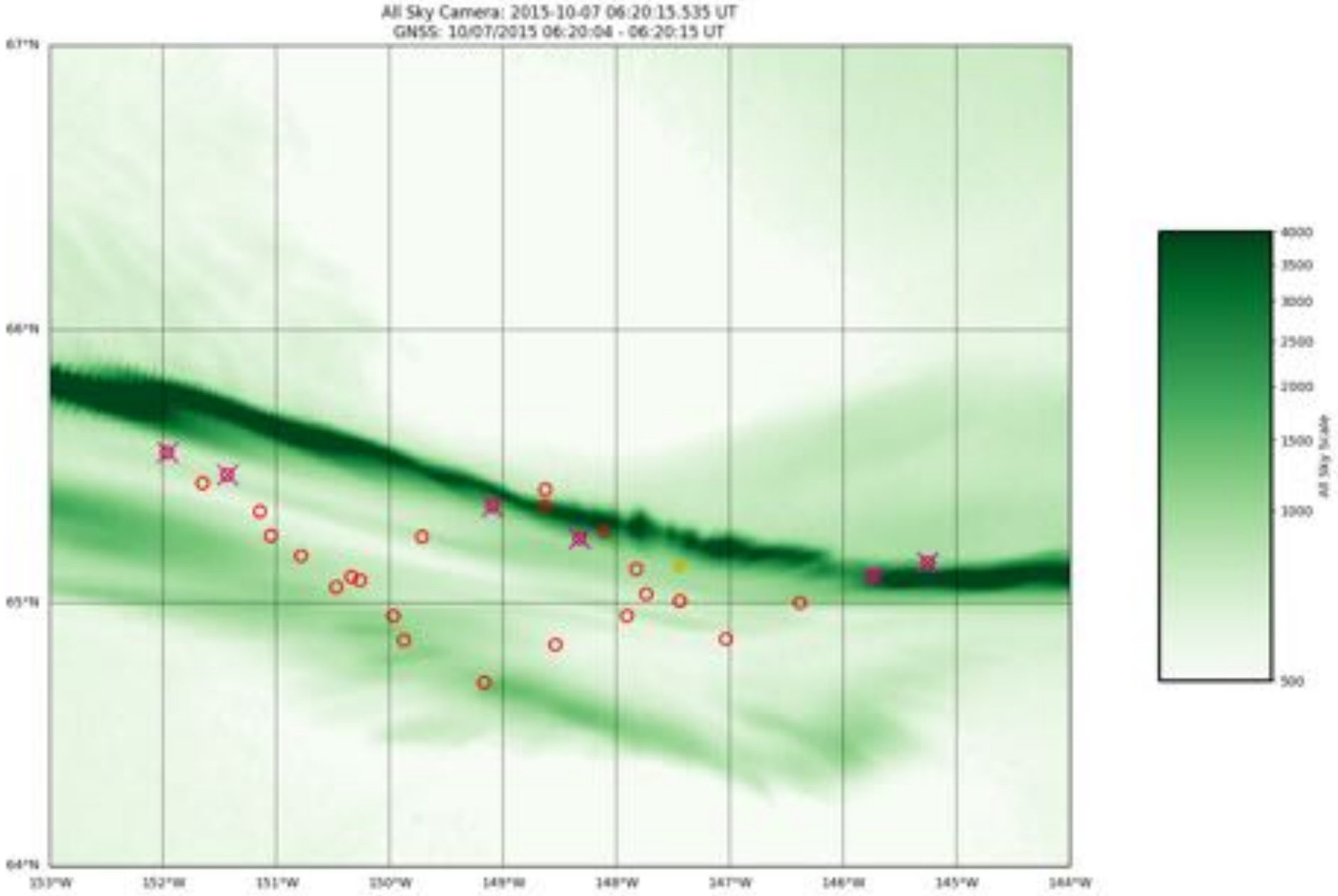
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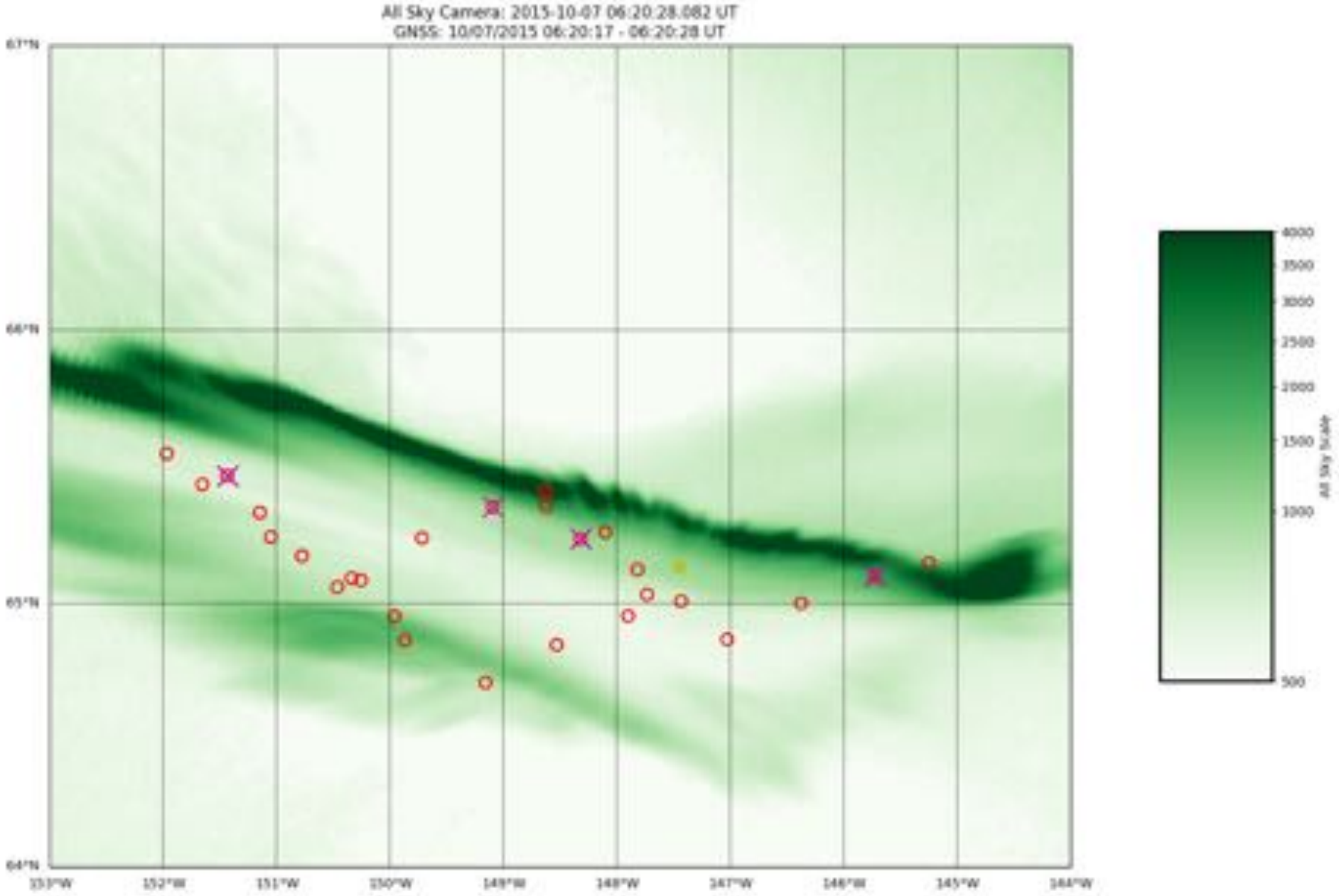
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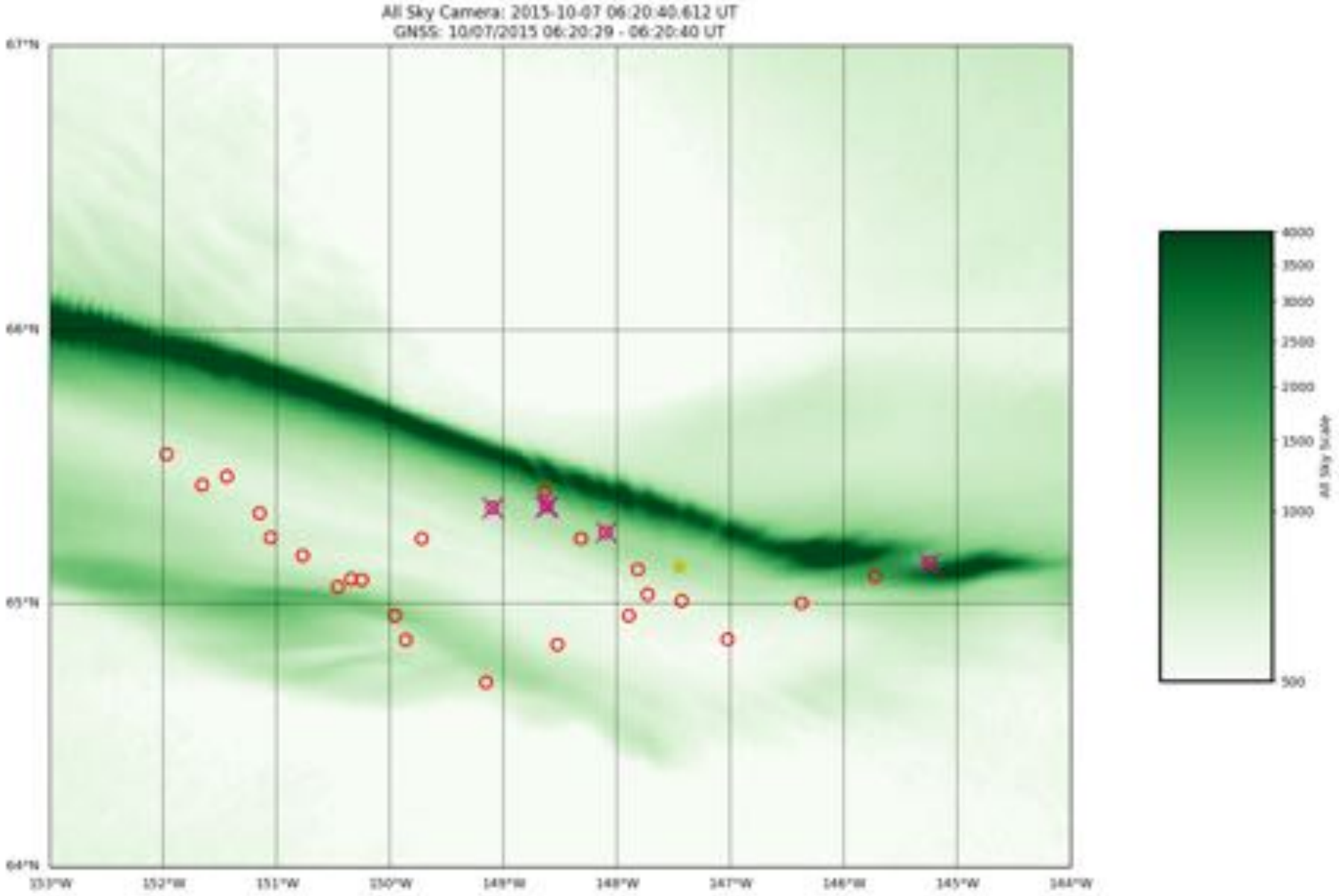
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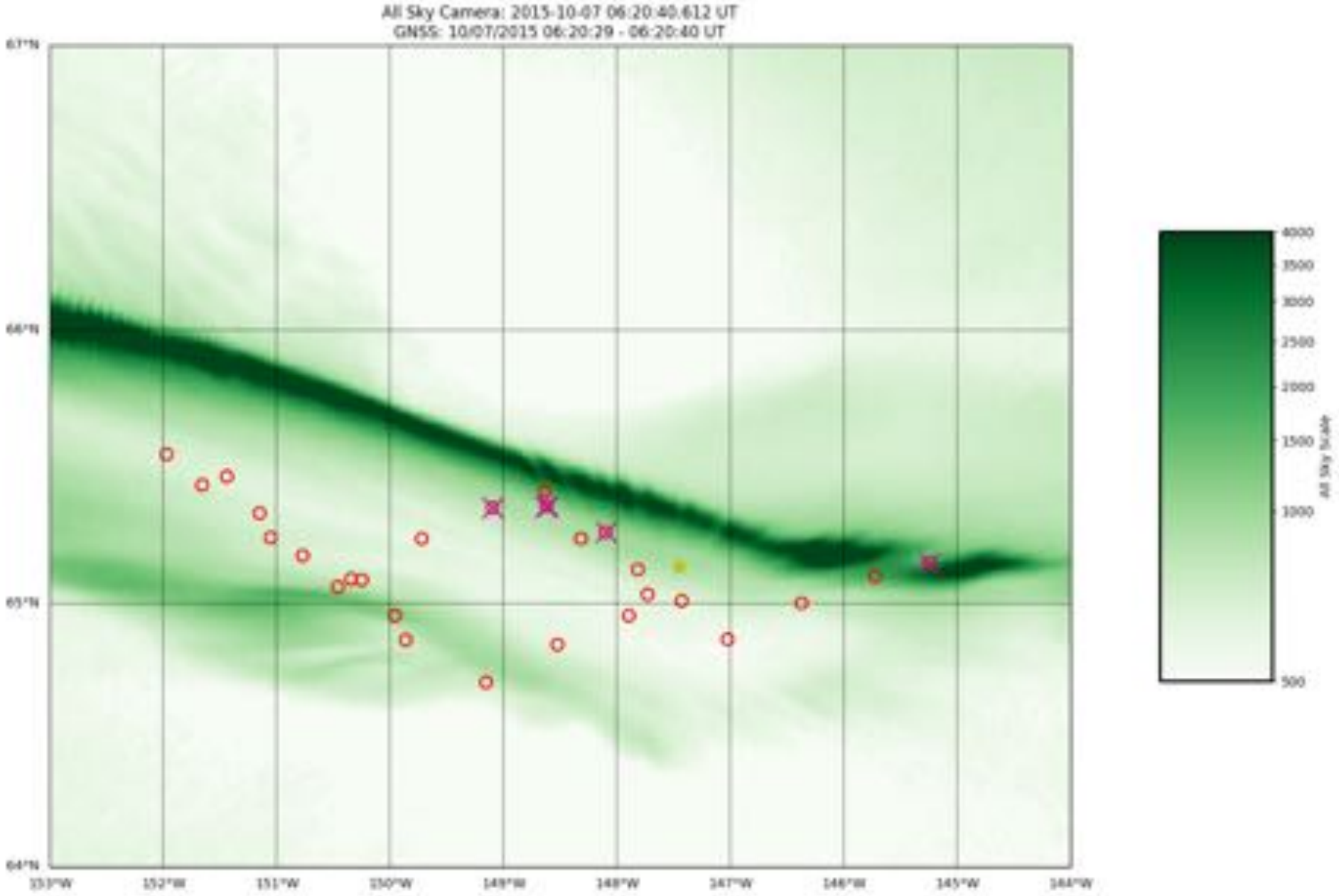
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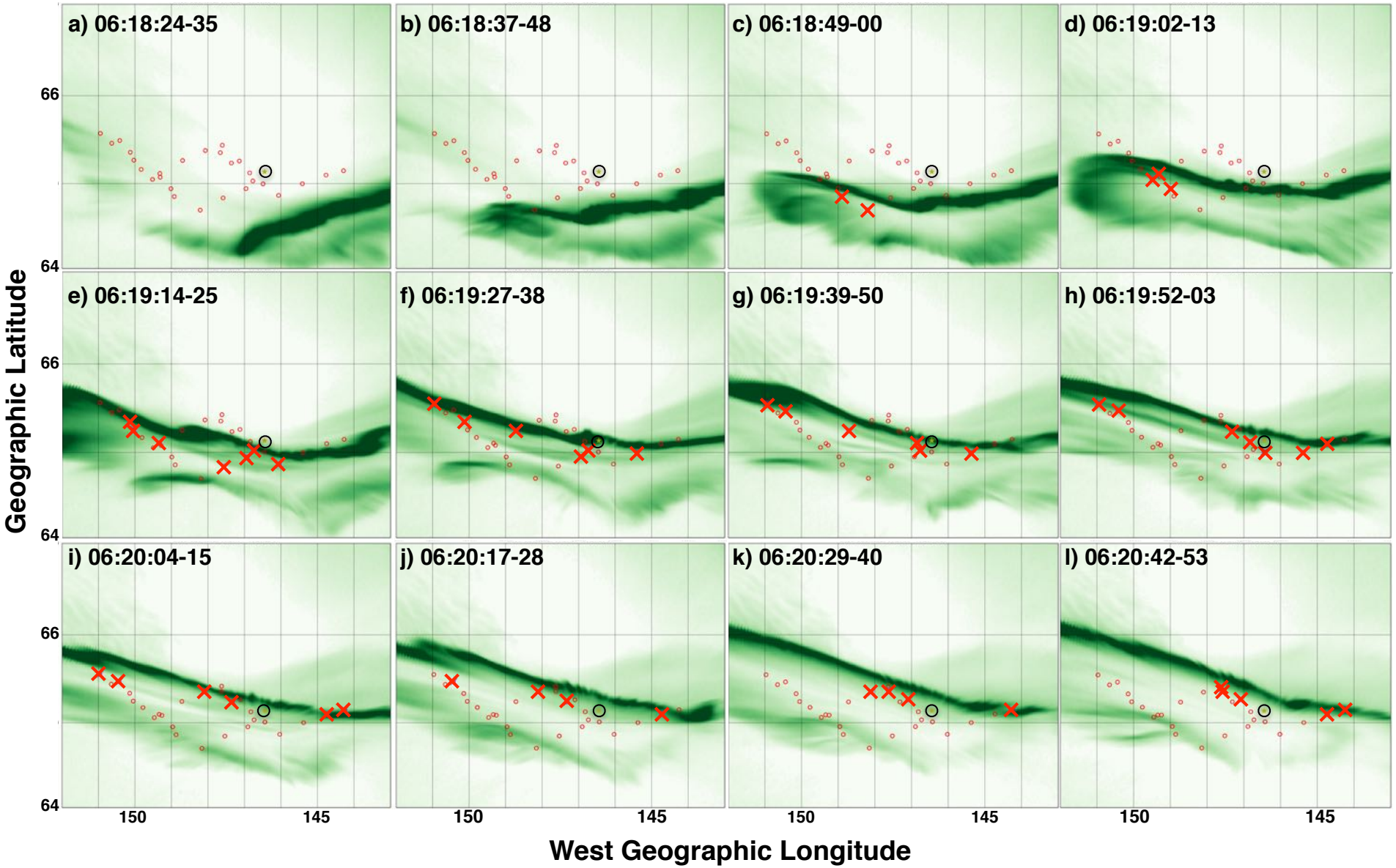

Strong phase scintillation observed only along the trailing edge of the westward traveling surge

Semeter et al., GRL 2017, Mrak et al JGRA 2017

Conclusion

- Dissipation of magnetospheric free energy occurs through a cascade of spatial scales, extending from ~100 km to ~10 cm.

- The role of small scale variability in modifying the energy dissipation process is poorly understood.