EZIE Mission Overview

CEDAR Workshop
Wednesday, 6/28/23

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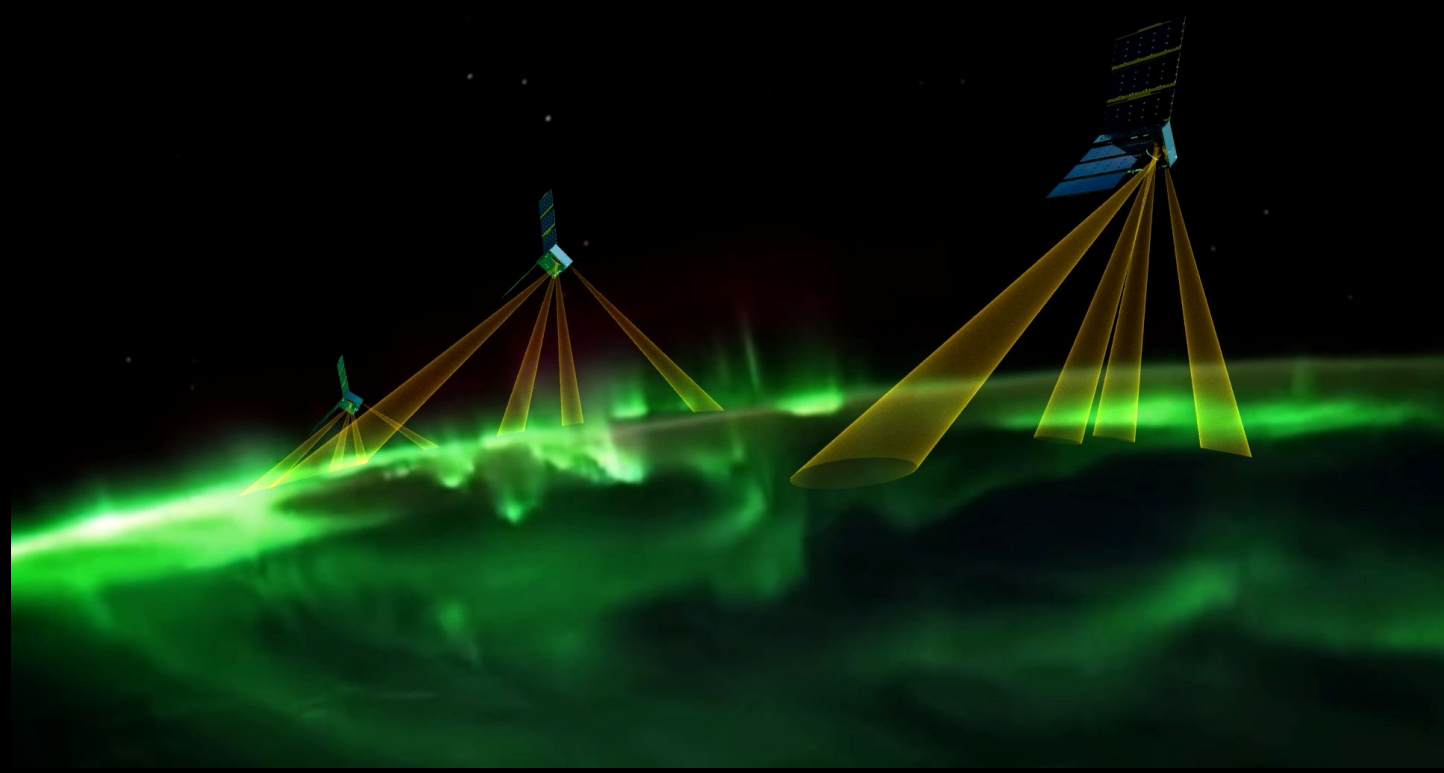
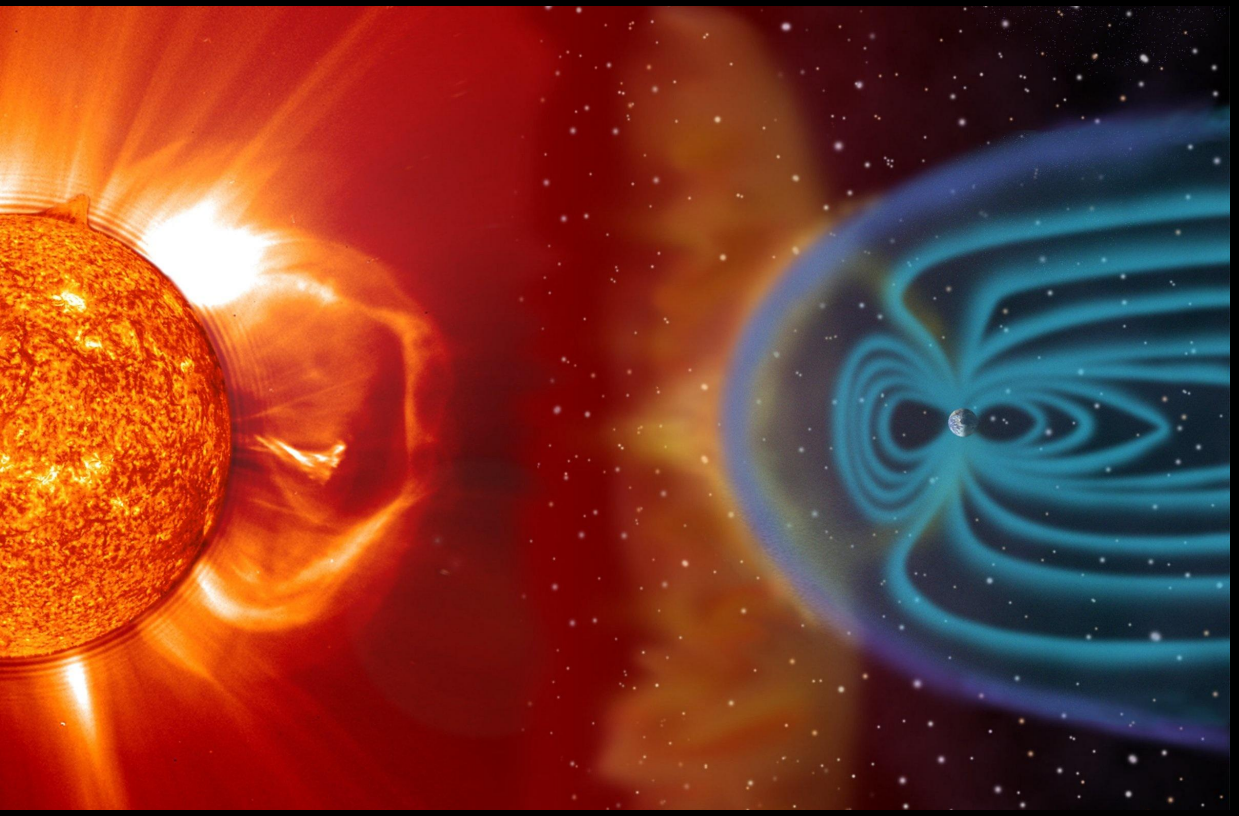
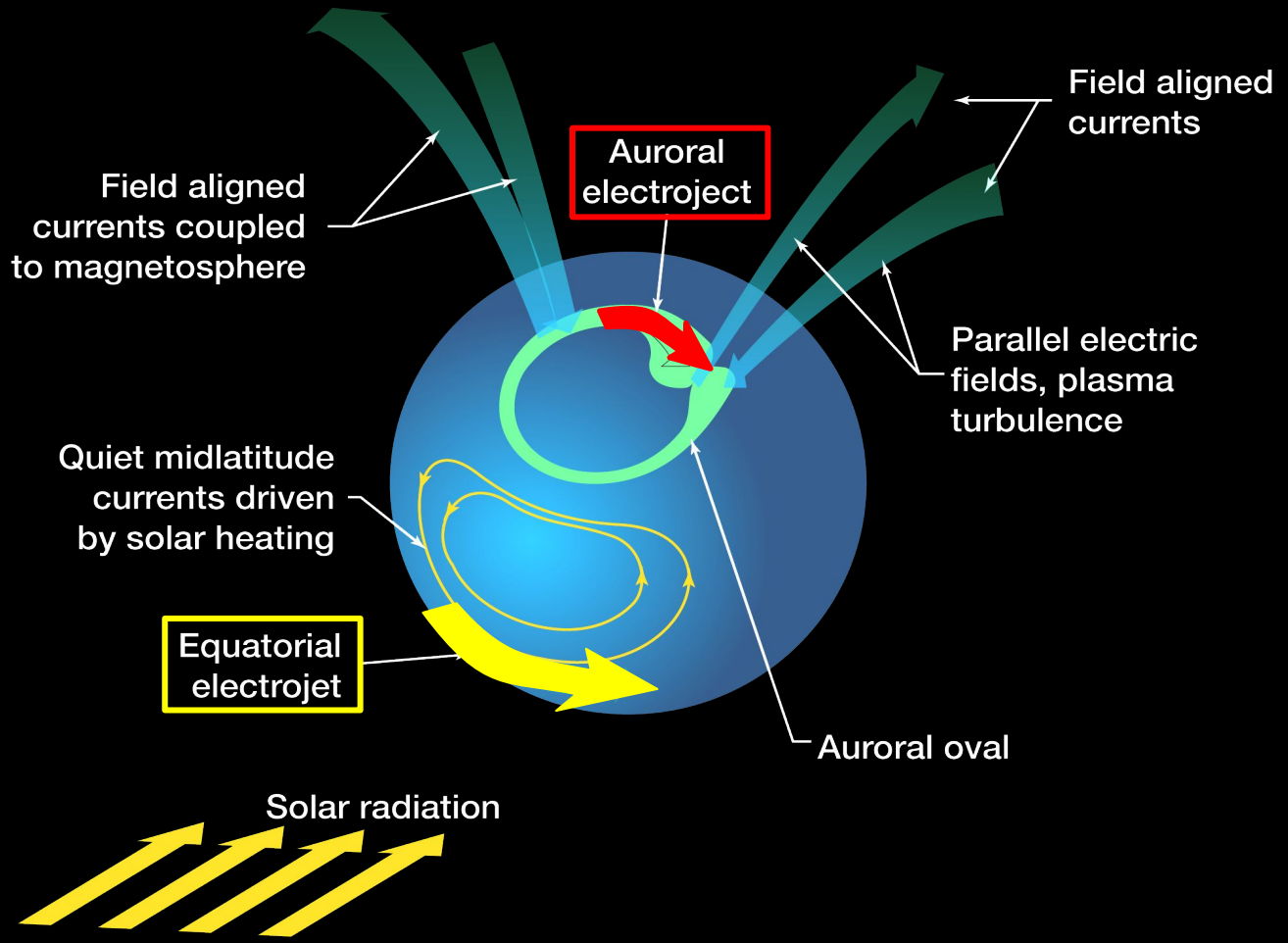
EZIE: An NASA Mission to Study the Mesoscale Structure and Temporal Evolution of the Electrojets

"EZIE is a cost-effective three CubeSat mission flying in a pearls-on-a-string configuration that uses compact multi-beam instruments and an innovative remote sensing technique to image, for the first time, electrojets. flowing at altitudes of ~100–130 km, which are notoriously difficult to explore.



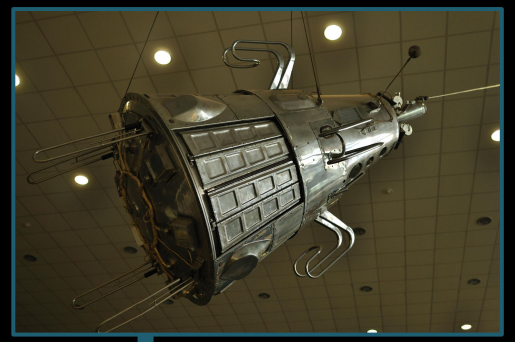
EZIE Studies the Electrical Currents in the Earth Ionosphere, Fundamental to Energy Transfer within the Sun-Earth System



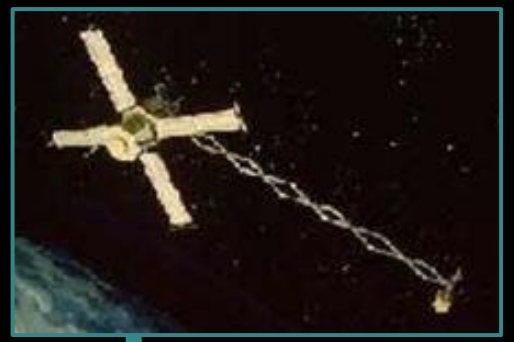


EZIE Focuses on A New Frontier of Near-Earth Magnetic Field Measurements: The Study of Mesoscale Variations of Electrojets

Sputnik 3 (1958–1960)

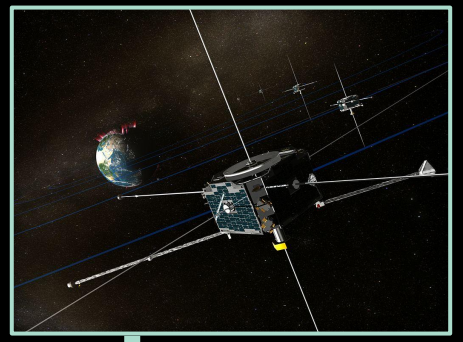


Magsat (1979–1980)

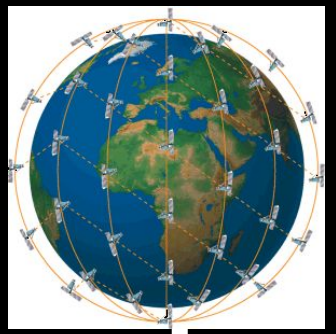


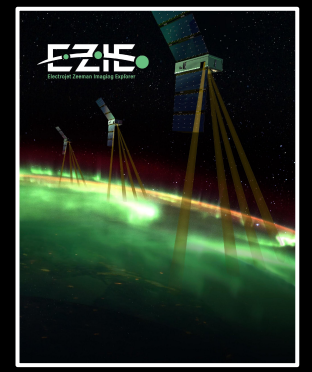
SAC-C (2000–2013)

THEMIS (2007–?)



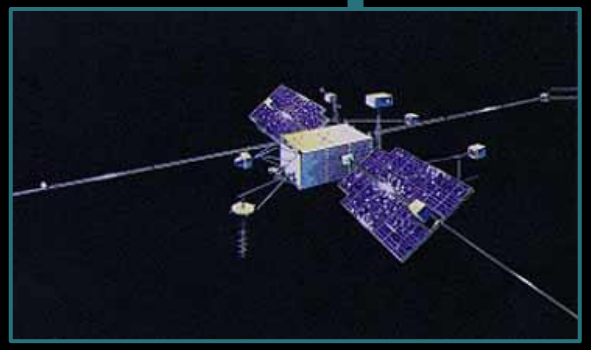
AMPERE Iridium (2010–?)





EZIE (2024–?)

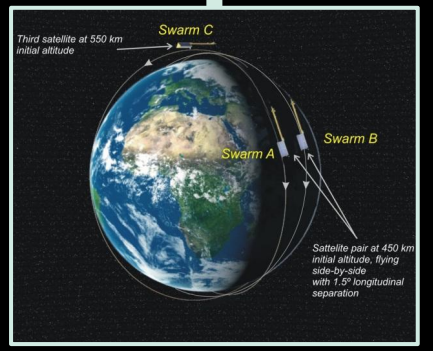
OGO-2, -4, -6 (1965–1971)



Ørsted (1999–?)

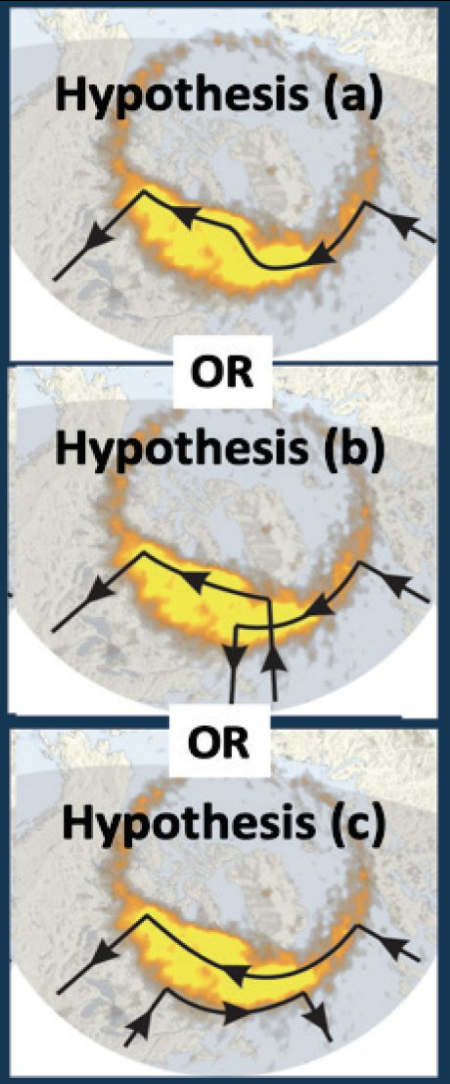
CHAMP (2000–2010)

Swarm (2013–?)

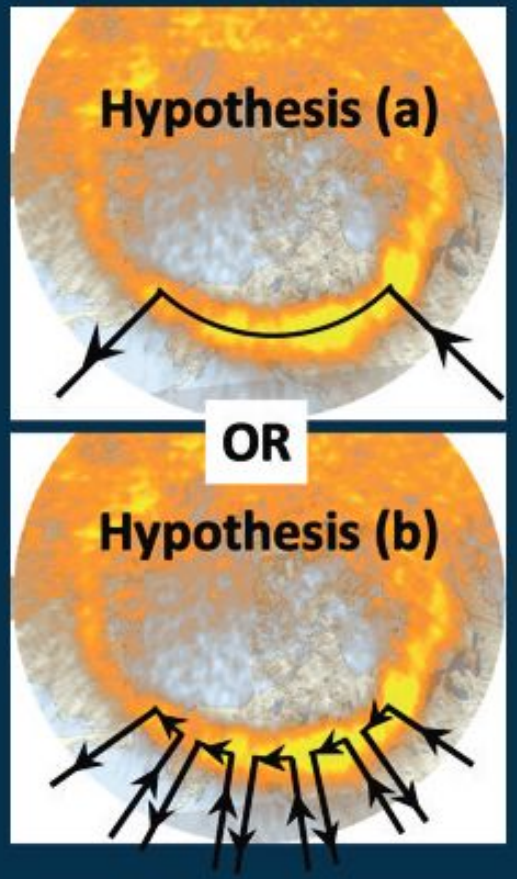


EZIE Objectives are to Resolve ~50 Year-old Hot Debates on the Structures of the High-Latitude Current System

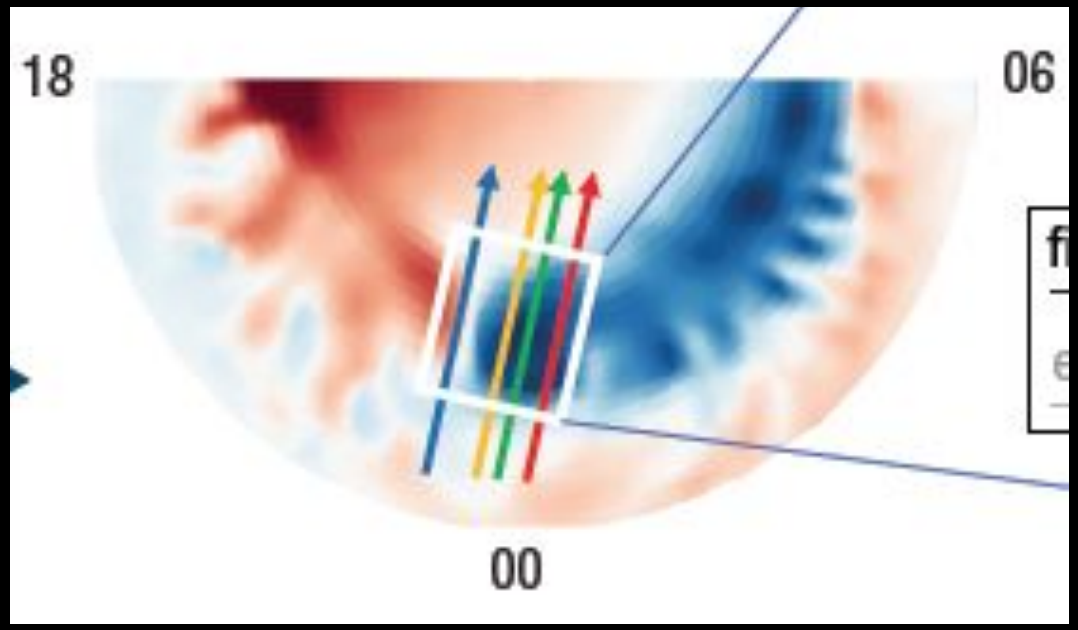
TSQ 1:
EZIE will resolve the decade old debate about the substorm current wedge (SCW) configuration. Figure shows three published SCW scenarios as wire models superposed onto auroral images from the NASA Polar VIS Earth Camera.

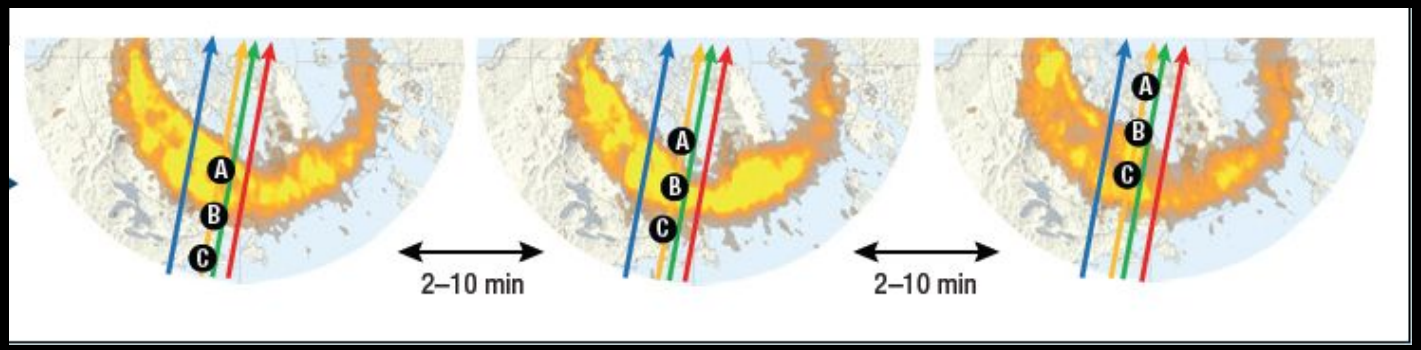


TSQ 2:
EZIE will determine to what extend the electrojet consist of small current wedgelets. Figure shows (a) the classical auroral electrojet configuration and (b) the recently much promoted wedgelet scenario.



EZIE Mission Science Implementation Approach

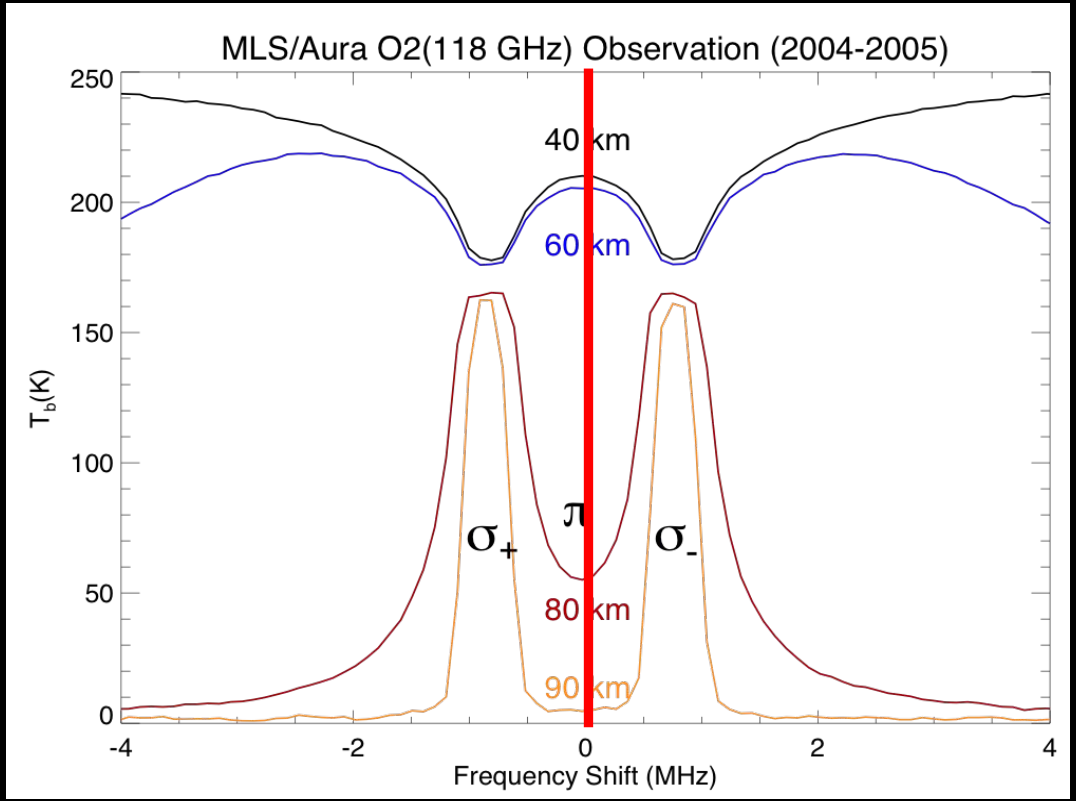




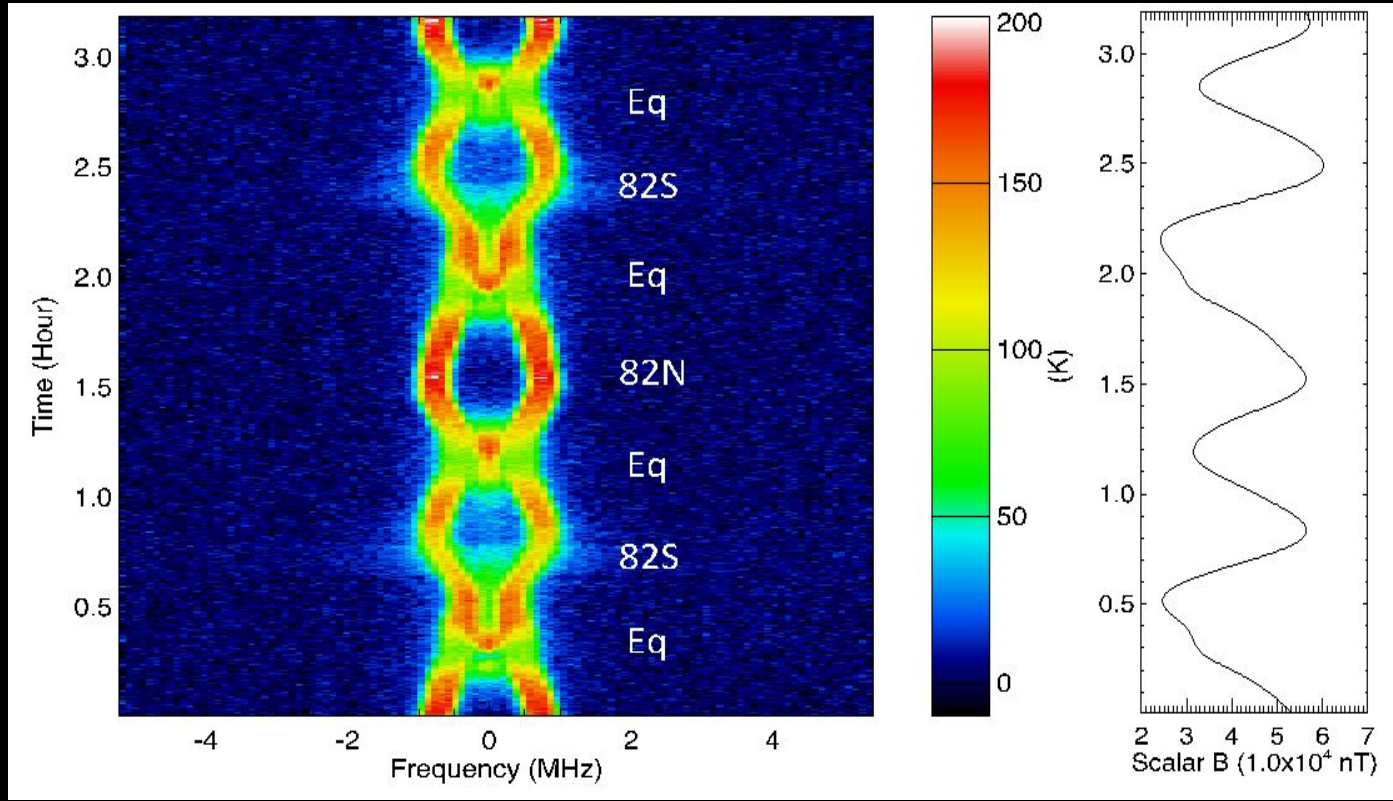
- Measurements of Electrojet Spatial Structure:
  - A compact payload consisting of four identical cross-track nadir-viewing O_2 118 GHz spectro-polarimeters to remotely measure and image electrojet induced magnetic fields.
- Measurements of Electrojet Temporal Evolution:
  - Three 6U CubeSat flying in a pearls-on-a-string formation with varying separation managed by differential drag.
- Operational orbit
  - Circular, 325- to 675-km altitude
  - ...ear Sun-synch, 09:00–13:30 or

EZIE Uses the Zeeman Effect on the O_2 (υ=0, J=1->0) 118 GHz Emission Line to Obtain Current Induced Magnetic Fields

Observed Aura/MLS O_2 118 Hz Limb Radiance Spectra at Various Tangent Heights

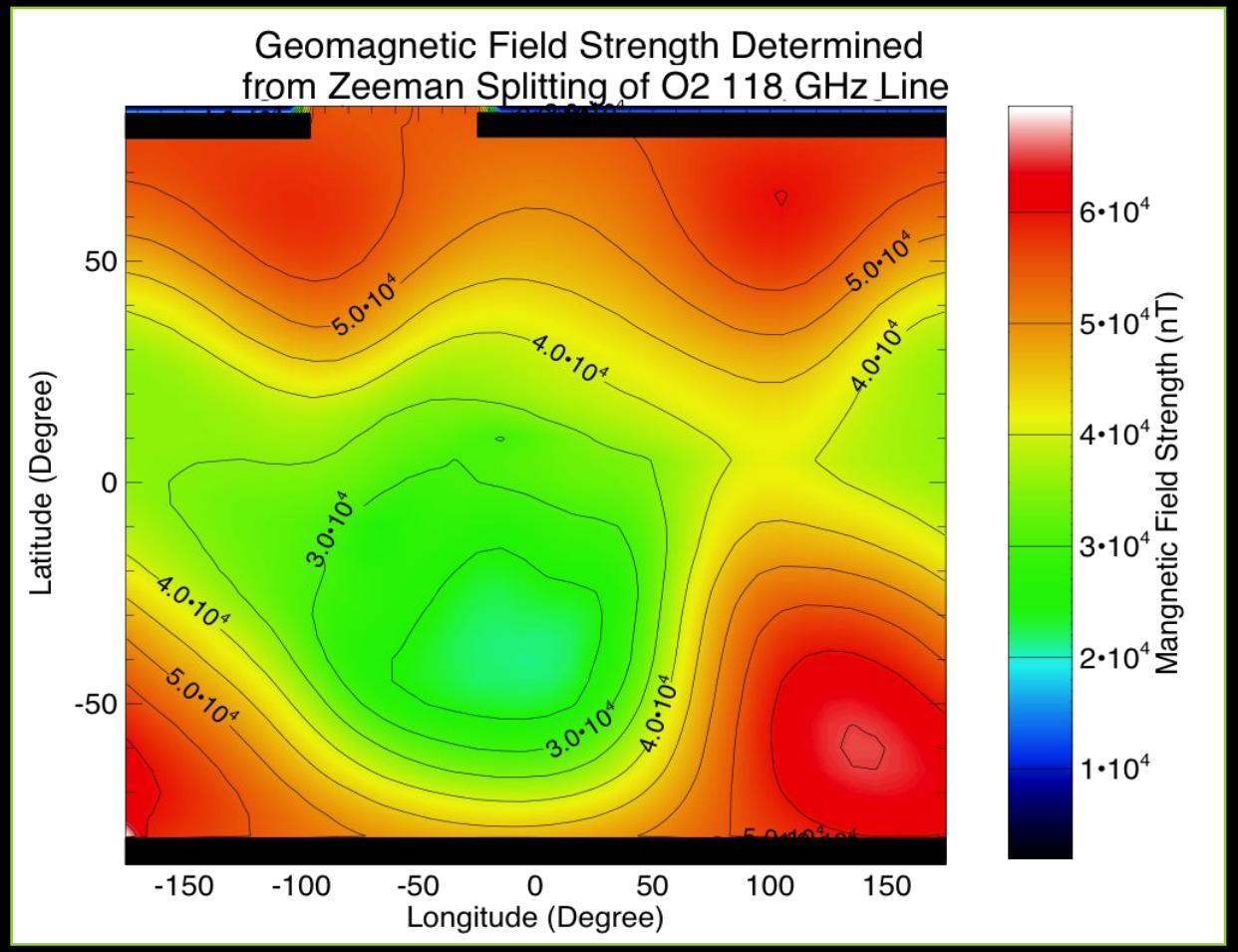


Observed Aura MLS O_2 118 GHz Limb Radiance Spectra on 1/1/2005 at 82-to 92-km Tangent Heights

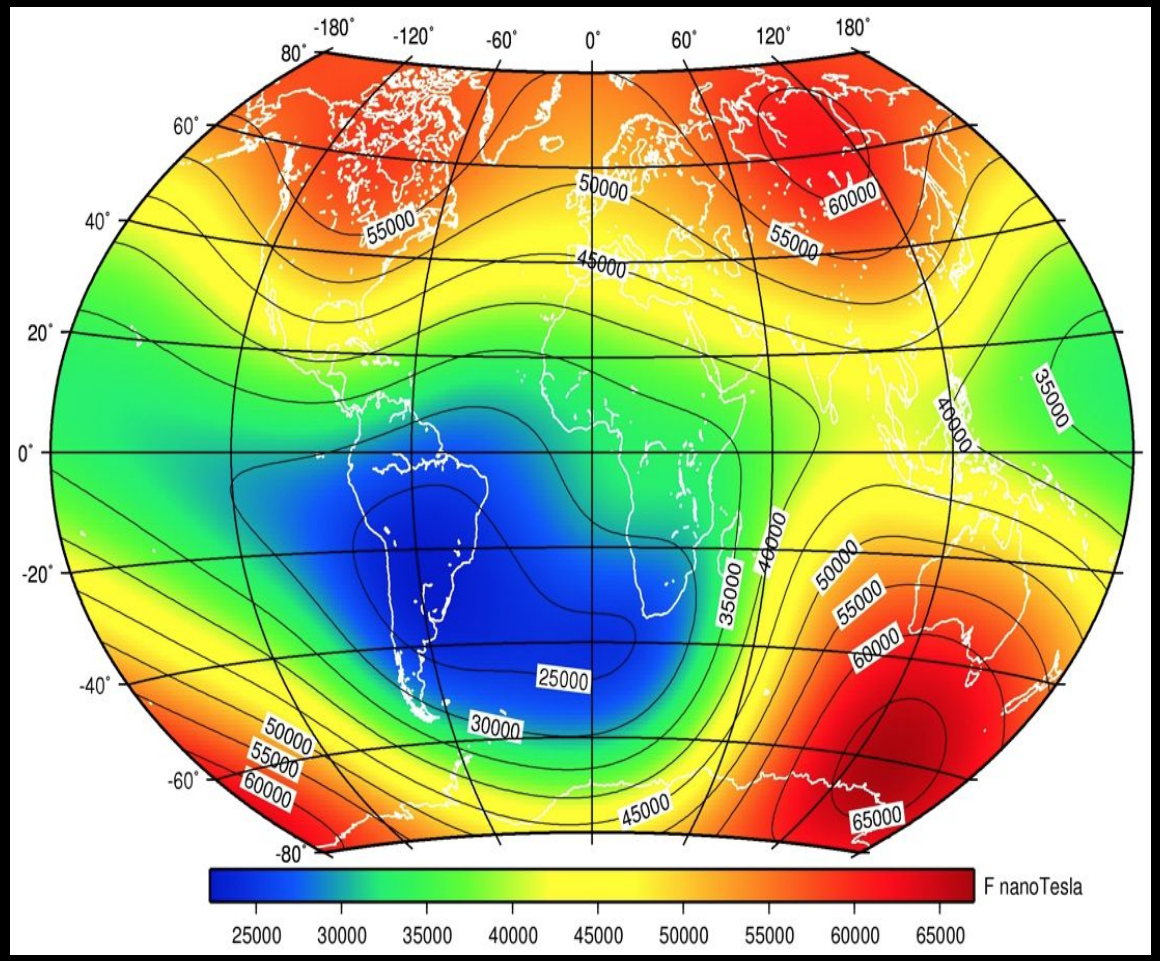


Taken from Yee et al. [2017]

First Proof-of-Concept of Using Zeeman Technique to Sense Earth's Magnetic Fields Remotely From Space



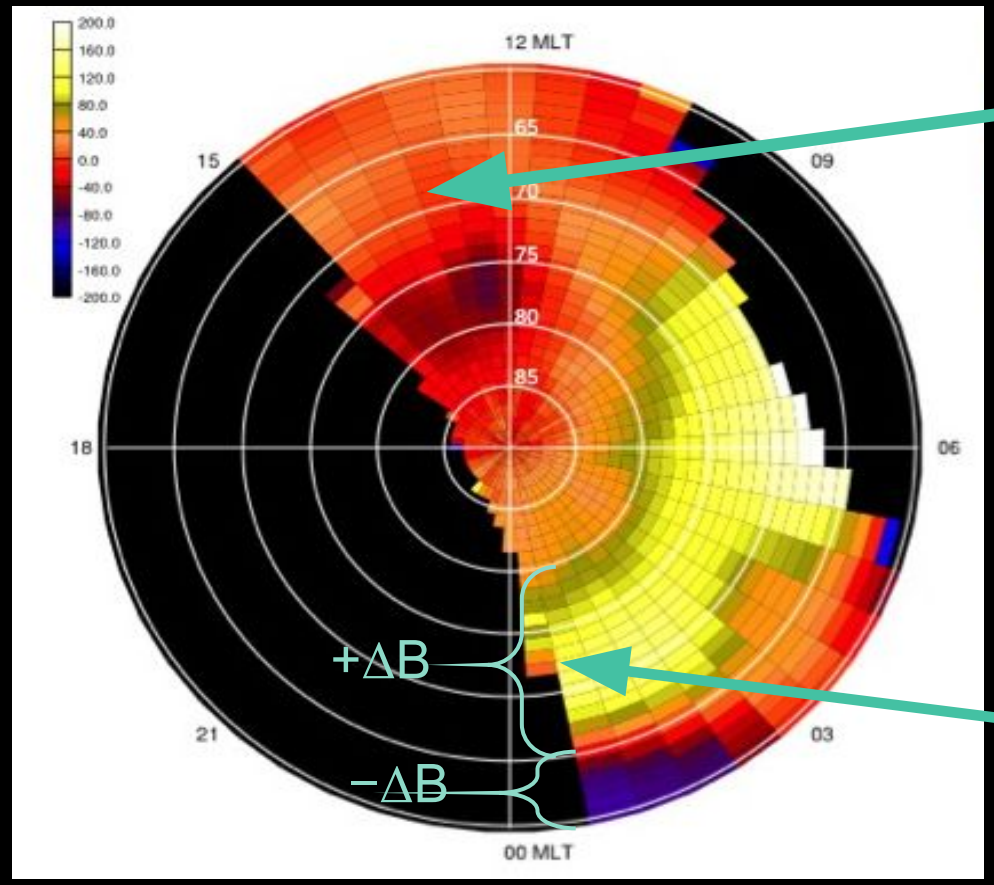
Line-of-sight Magnetic Field Strengths Derived from MLS Measurements taken in 2004.



Magnetic Field Strengths Predicted by the IGRF Model.

First Successful Demonstration of Zeeman Sensing Technique for Ionospheric Current-Induced B Measurements

Derived ΔB_{MLS} Polar Maps for a Typical Auroral Electrojet Activity (AE > 400 nT)

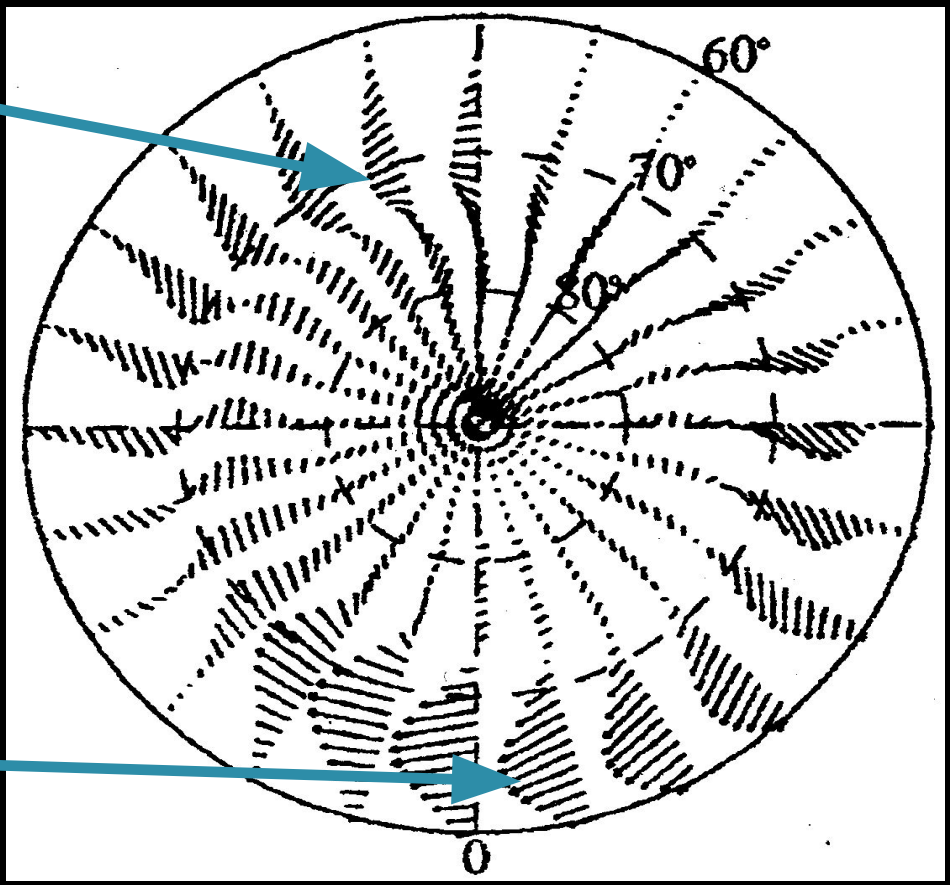


Weak Post-noon Eastward Electrojet Current

Yee et al., 2017

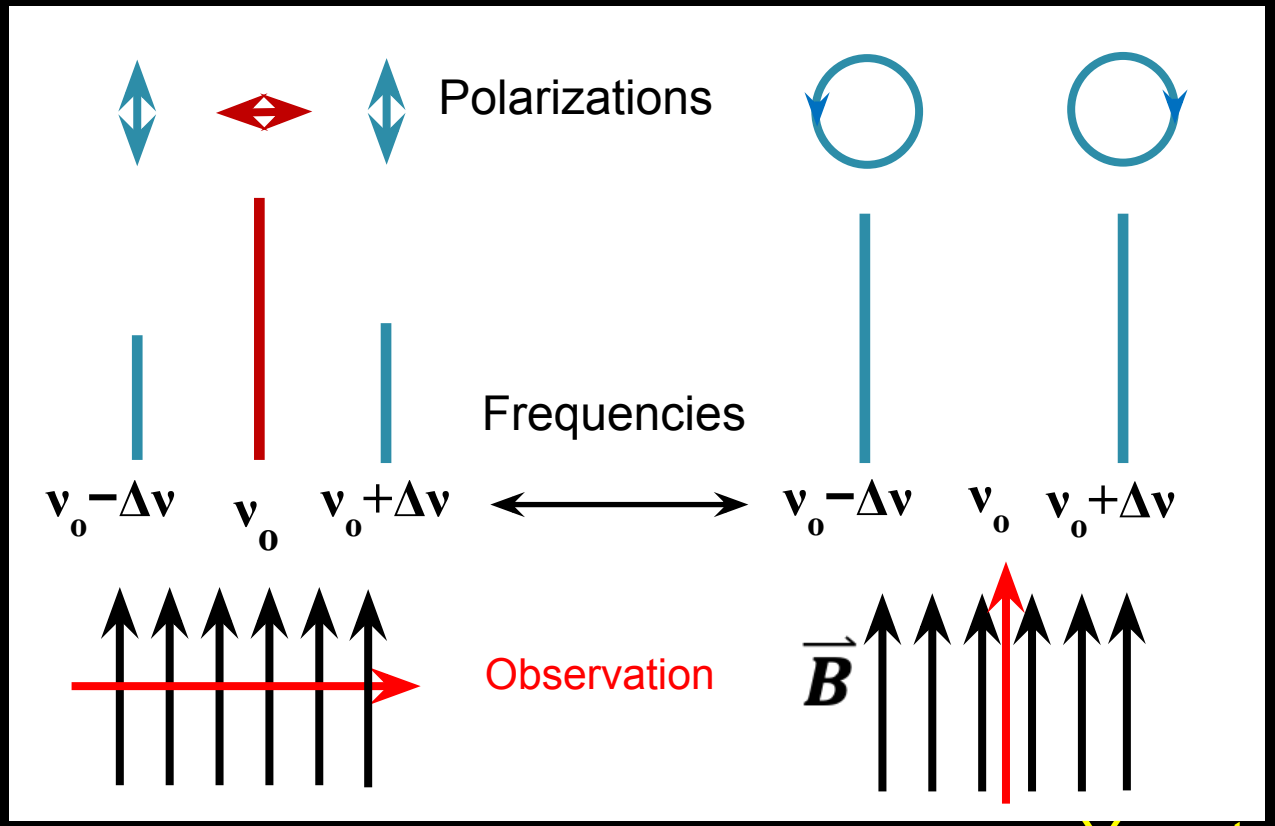
Strong Post-Midnight Westward Electrojet Current

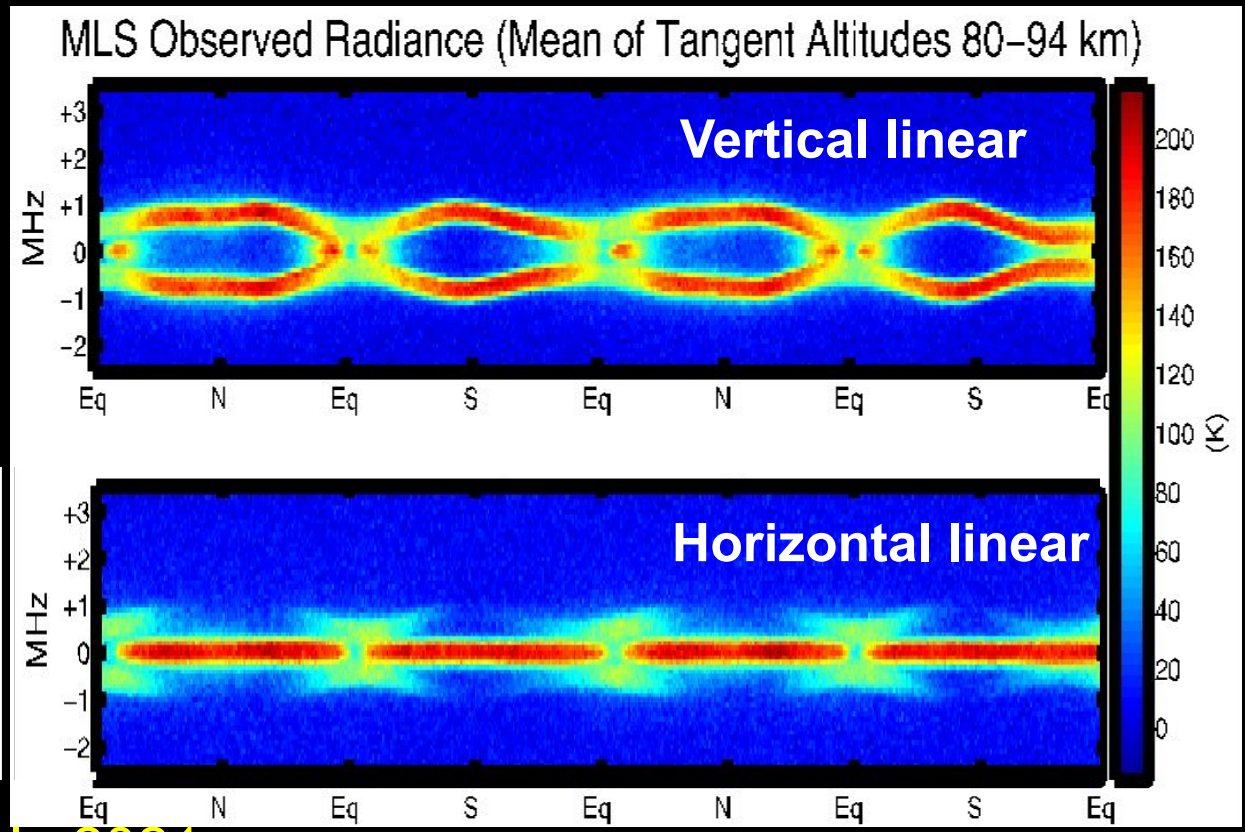
Average Electrojet Distributions (e.g., Kamide and Kokubun, 1996)



EZIE B-Field Zeeman Sensing Technique Improvement #1: Full-Stokes Polarimetric Measurements To Obtain $\vec{B}$ Vectors

- Zeeman lines are polarized and their relative intensities and polarizations depend on angles between viewing line of sight and $\vec{B}$.

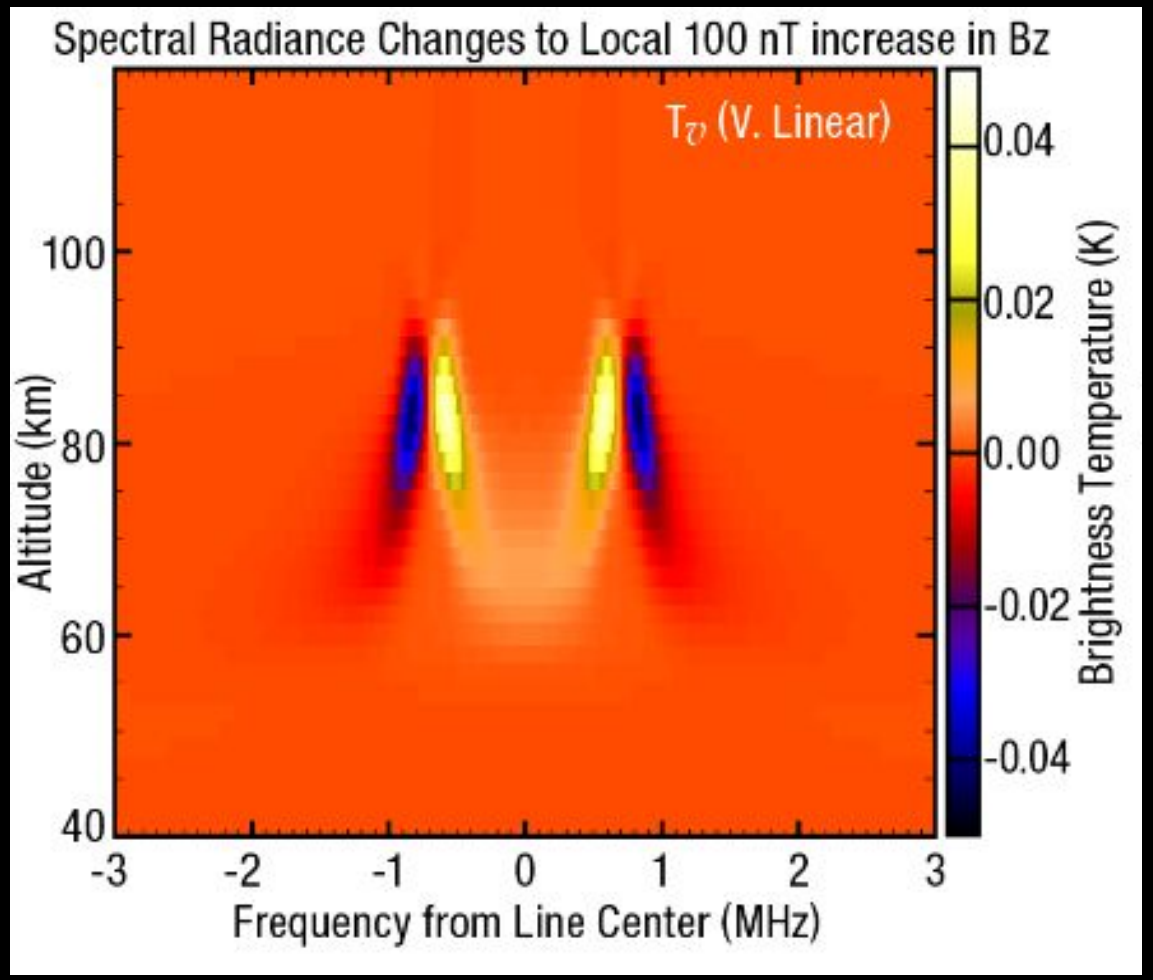




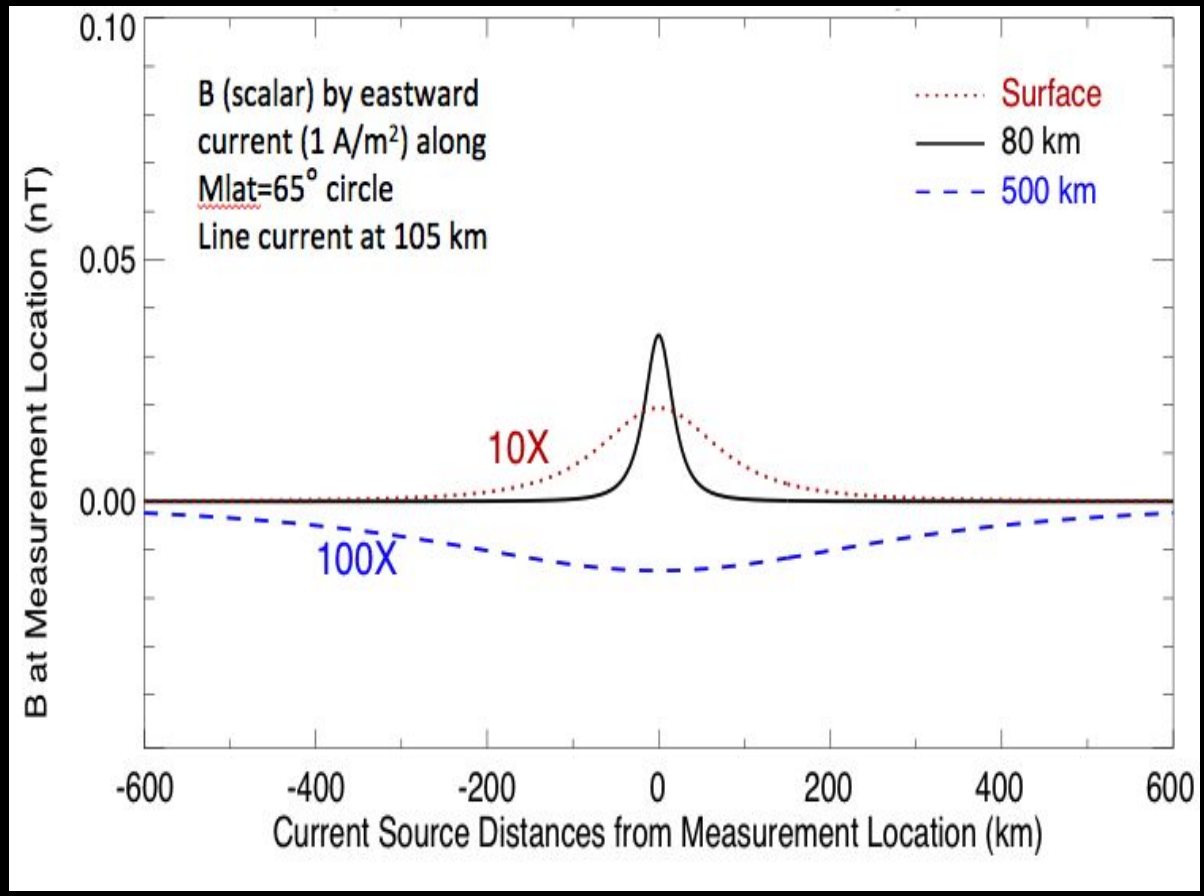
Yee et al., 2021

EZIE B-Field Zeeman Sensing Technique Improvement #2: Viewing Nadir To Obtain $\vec{B}$ at Higher Spatial Resolution

B-Measurement Close to the Electrojet



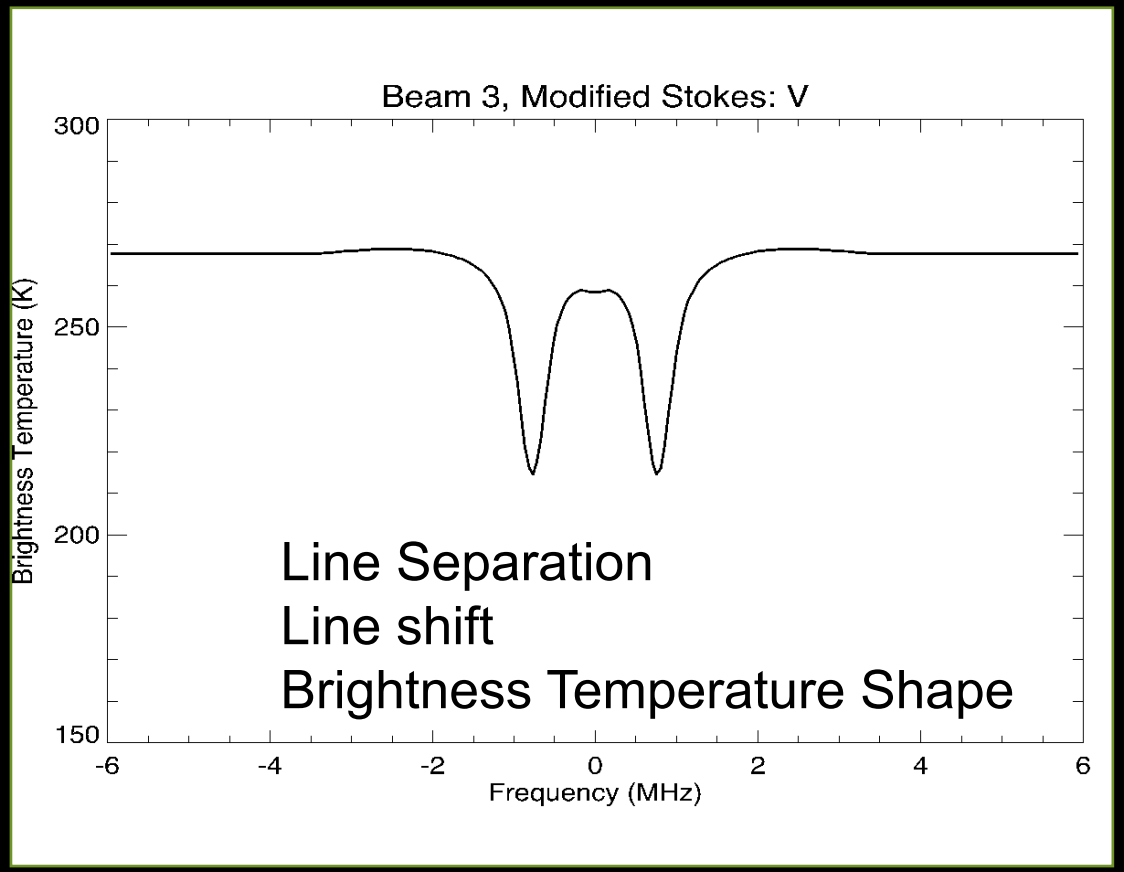
Increasing Spatial Resolution

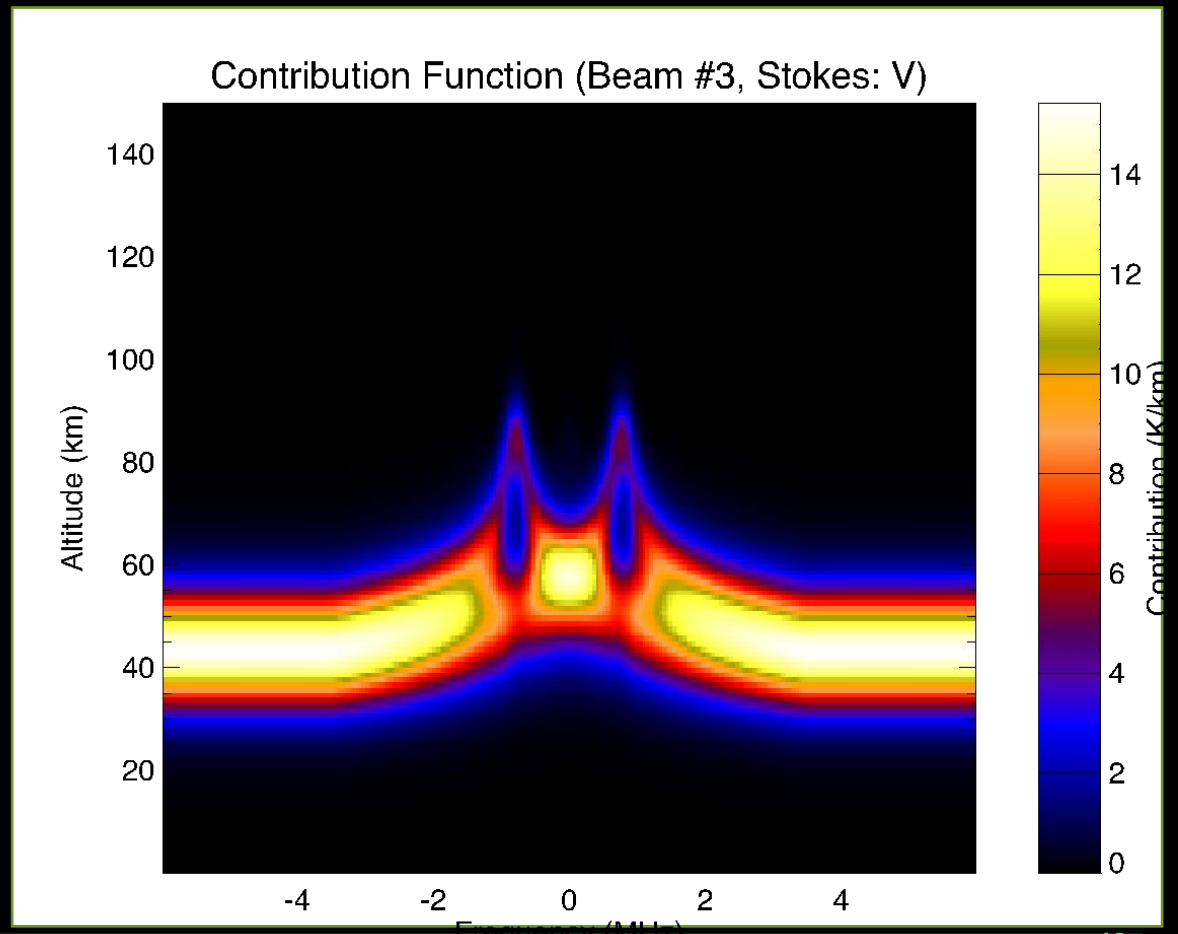


Yee et al., 2021

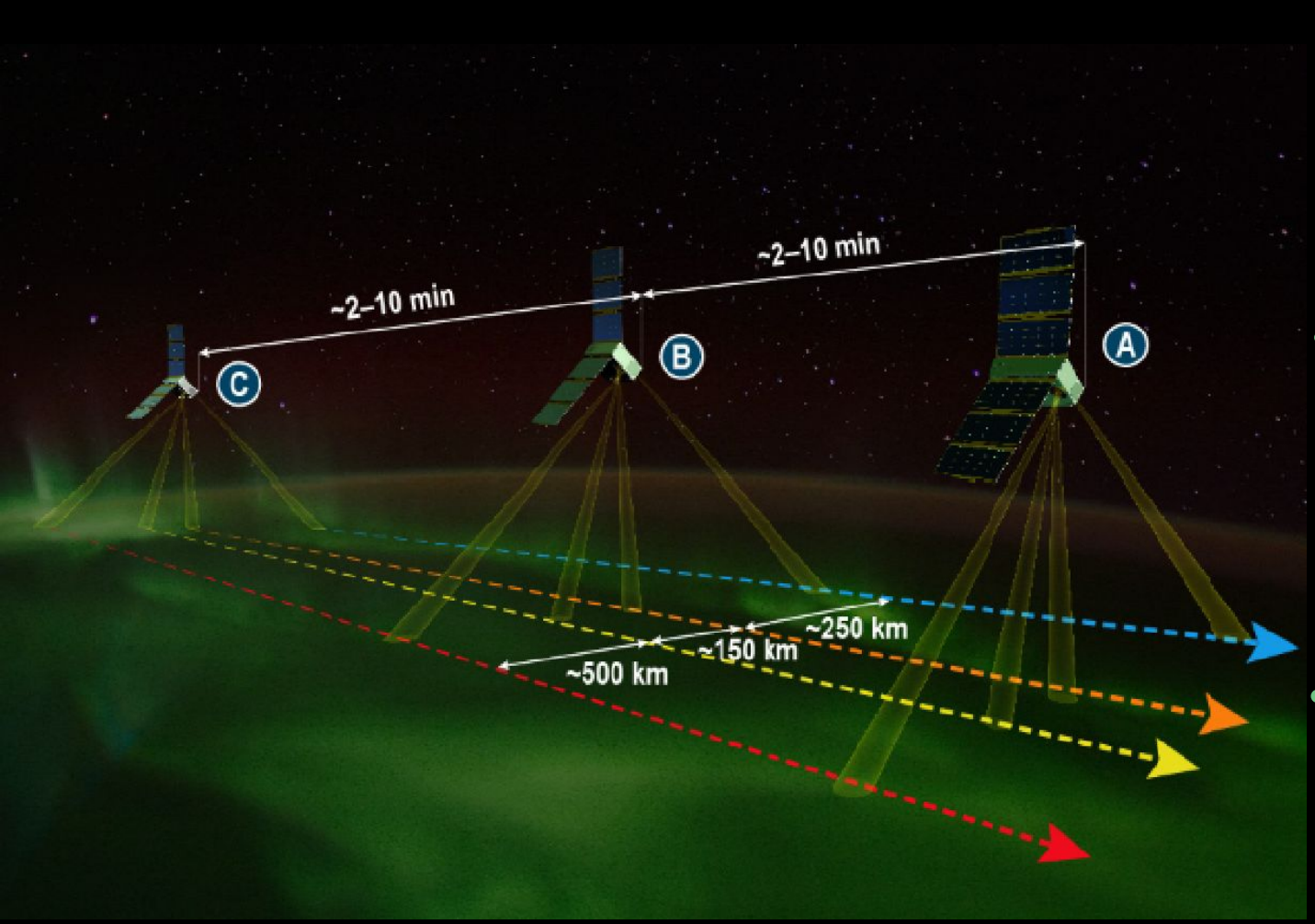
Primary and Secondary EZIE Measurement Products

In addition to $\overrightarrow{B}$ (and the derived 2-D equivalent current map), EZIE also obtains line-of-sight winds and temperature profiles every second from the Doppler shifts and brightness temperature of the O_2 118 GHz spectral radiances.





EZIE Mission Summary



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- Measurement of Electrojet Spatial Structure:
  - A compact payload consisting of four identical O_2 118 GHz spectro-polarimeters to remotely measure and image electrojet induced magnetic fields
- Deployment orbit:
  - Circular, 425- to 650-km altitude
  - Near Sun-Sync, 09:00–11:00 or 22:30–00:30 LTAN
  - Launch Date: Late 2024 or early 2025

EZIE

Thank You!
Collaborations are welcome.

Web Site: https://ezie.jhuapl.edu

Open Science Workshop :

When: 9/18-9/19 2023

Format: Virtual and On-site at APL

Registration: Open

Yee, J. H., Gjerloev, J., Wu, D., &S chwartz, M. J. (2017). First application of the Zeeman technique to remotely measure auroral electrojet intensity from space. Geophysical Research Letters,44, 10,134–10,139. https://doi.org/10.1002/2017GL074909.

Yee, J. H., Gjervoev, J., and D. Wu (2021), Remote Sensing of Magnetic Fields Induced by Electrojets From Space Measurement Techniques and Sensor Design, First published: 23 March 2021, https://doi.org/10.1002/9781119815631.ch21 Book Series Geophysical Monograph Series