PUNCH: Connections to the Magnetosphere and the Aurora

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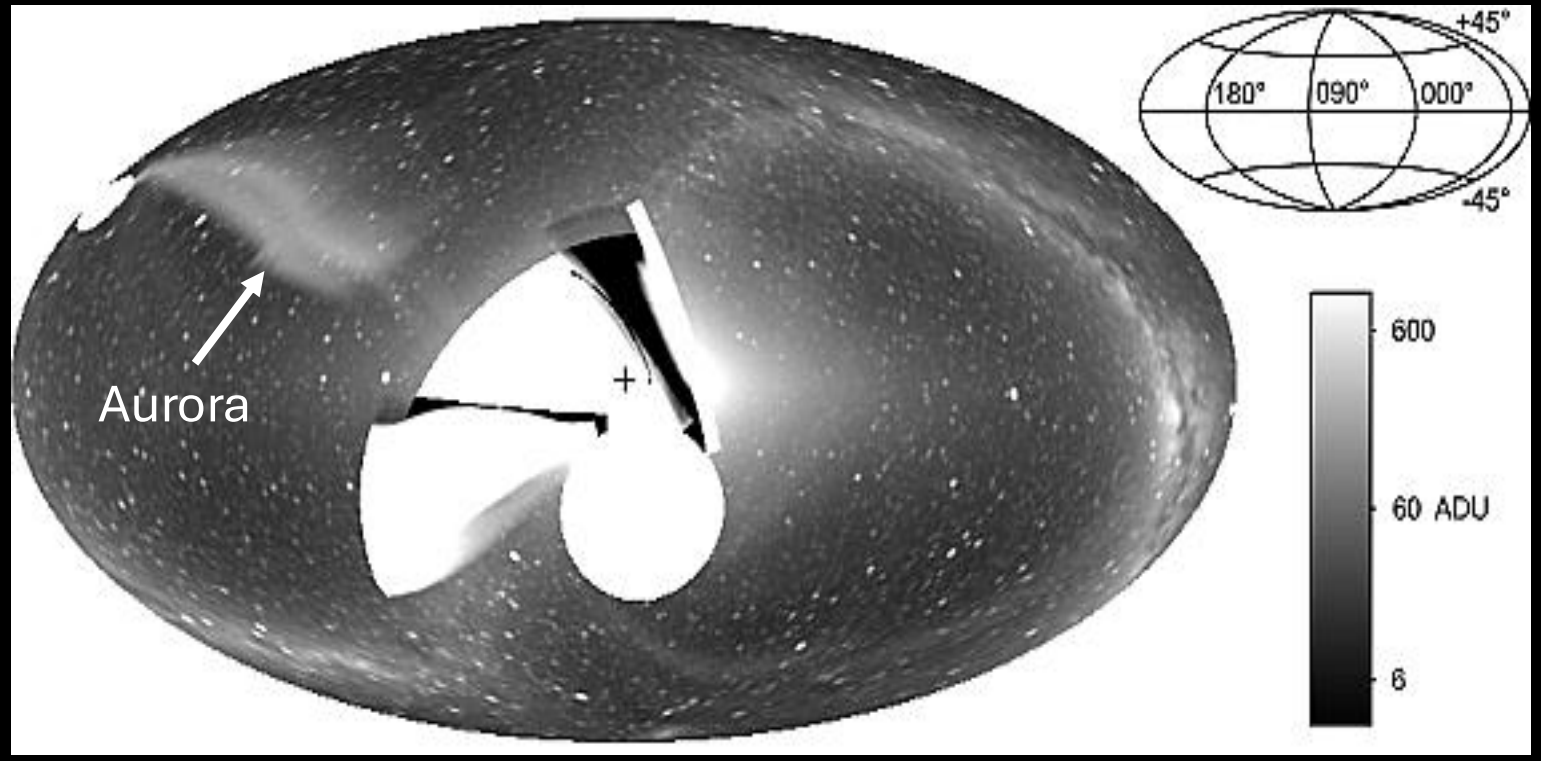
The mysterious very high-altitude aurora



[Mizuno et al., 2005]

- Aurora captured with the Solar Mass Ejection Imager (SMEI) on the Coriolis satellite
- The imager assembled an approximately all-sky image of the heliosphere in red-biased visible light once per orbit
- This high-altitude aurora was observed above 800km altitude
- The observations where within the auroral oval and the polar cap

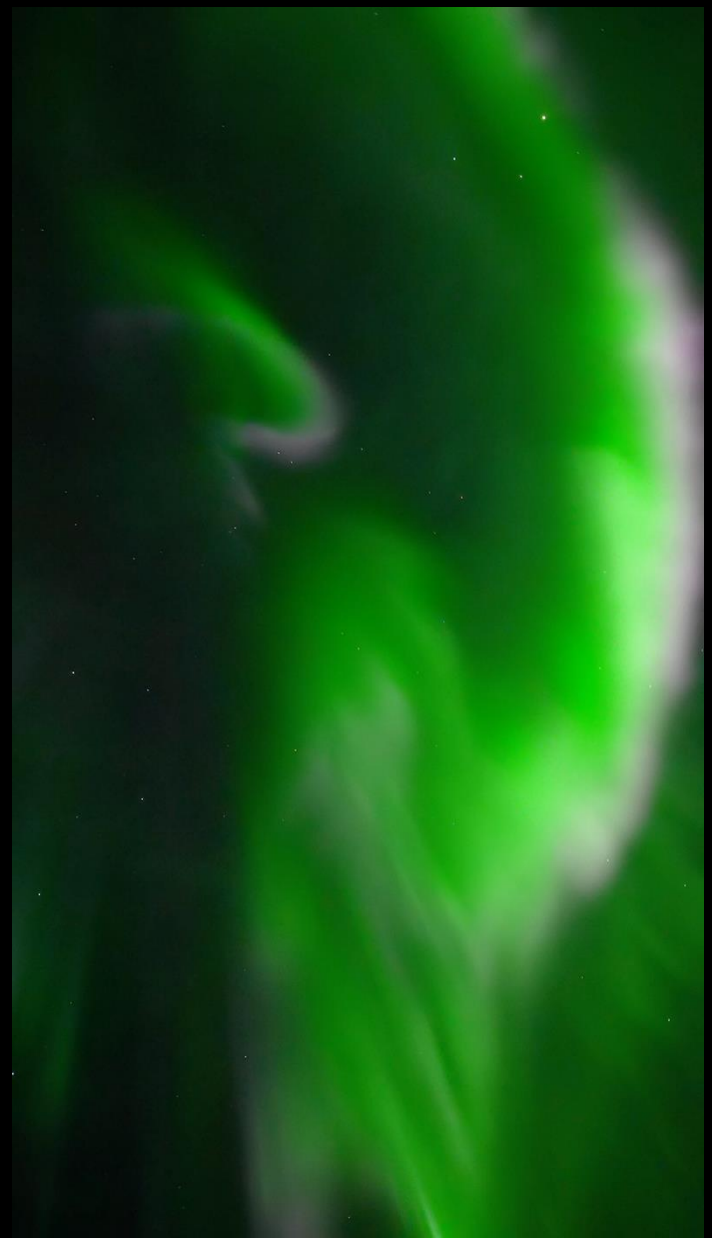
- High-altitude aurora has correlation with increased geomagnetic activity
- It is theorized that this high-altitude aurora is produced by the presence of N_2^+ at high-altitude due ion outflow
- If true, this could represent the first imaging experiment of ion outflow

PUNCH and the aurora

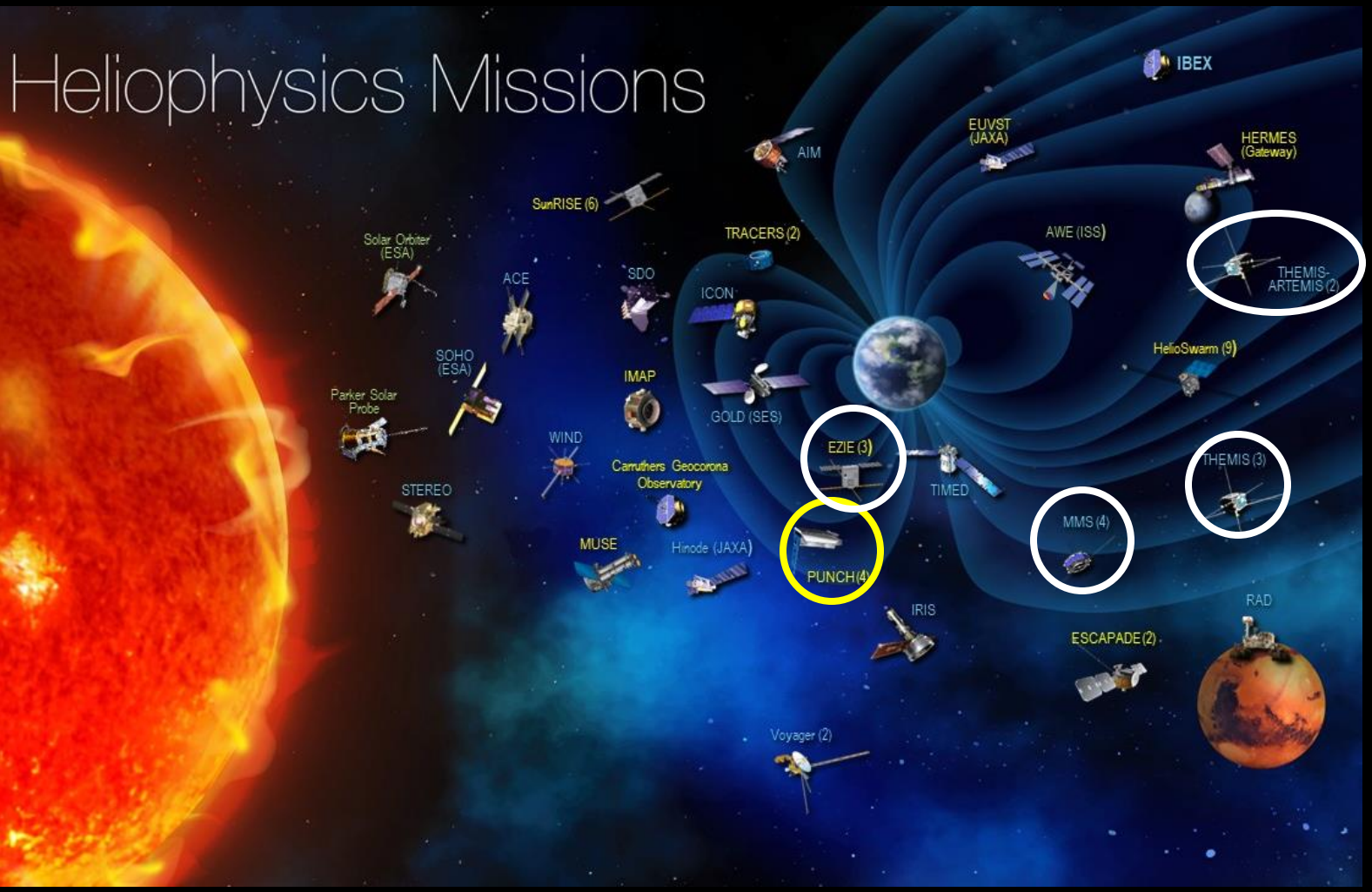
PUNCH will also make observations of the high-altitude aurora!

The aurora on Earth

Courtesy of Vincent Ledvina, The Aurora Guy

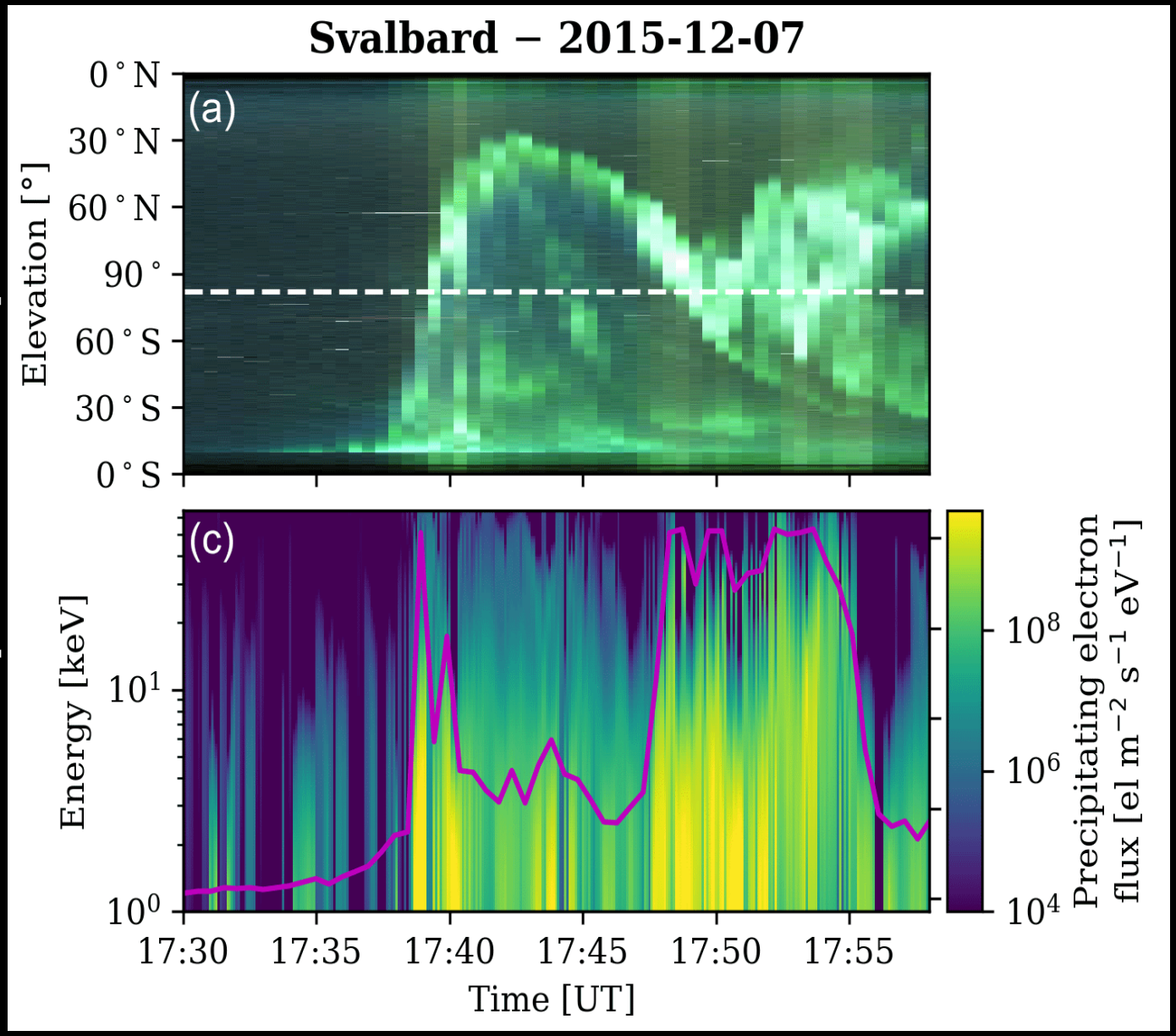


The aurora and the Heliophysics System Observatory



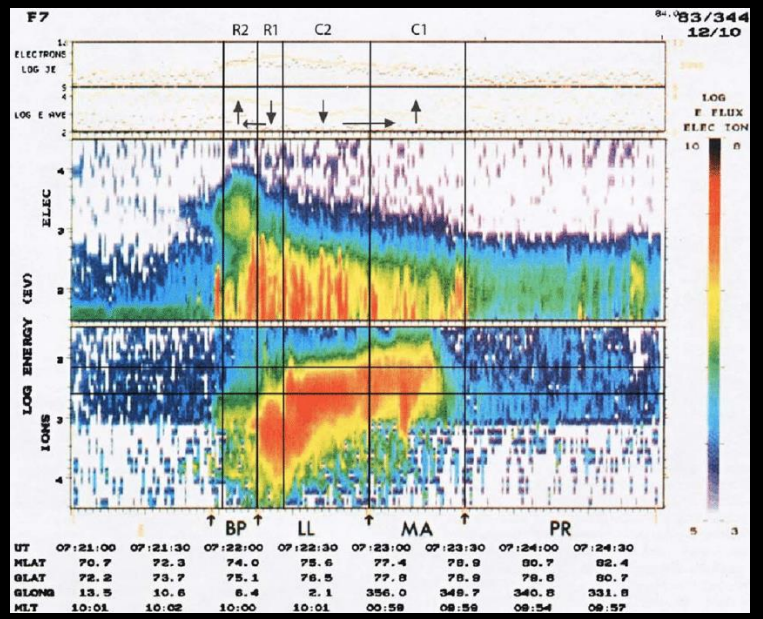
- The Heliophysics System Observatory (HSO), particularly satellites within the magnetosphere, provides valuable information about the aurora
- THEMIS is a great example, with its five spacecraft analyzing magnetotail dynamics. These observations help explain structures observed within the auroral oval
- EZIE (lectrojet Zeeman Imaging Explorer) will explore the auroral electrojet and the associated currents. EZIE will launch days after PUNCH!

The aurora, particle precipitation, and DMSP

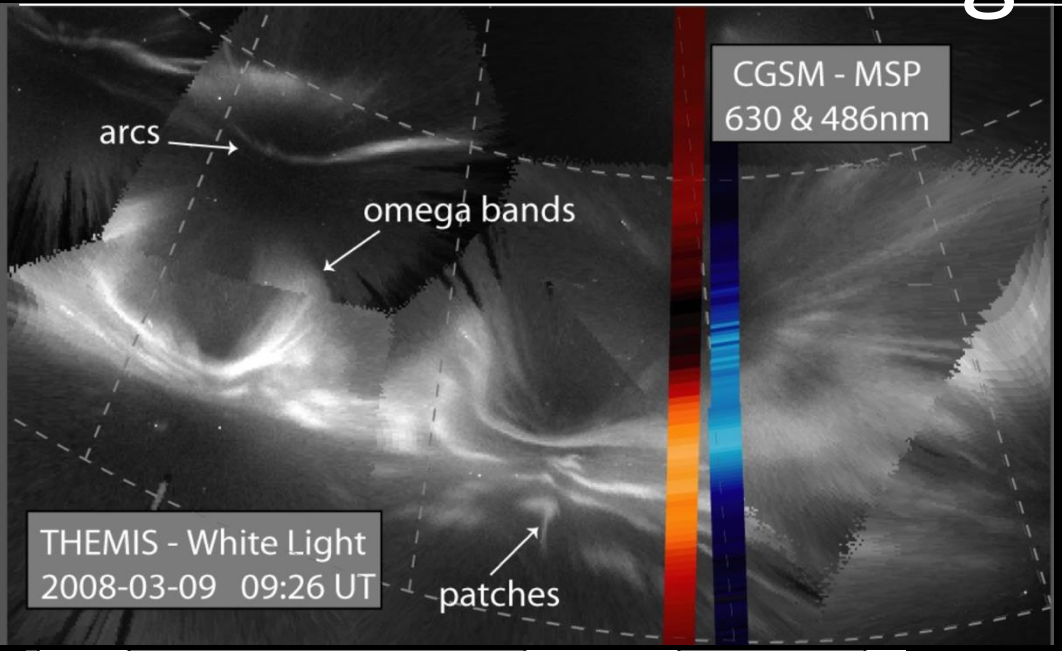


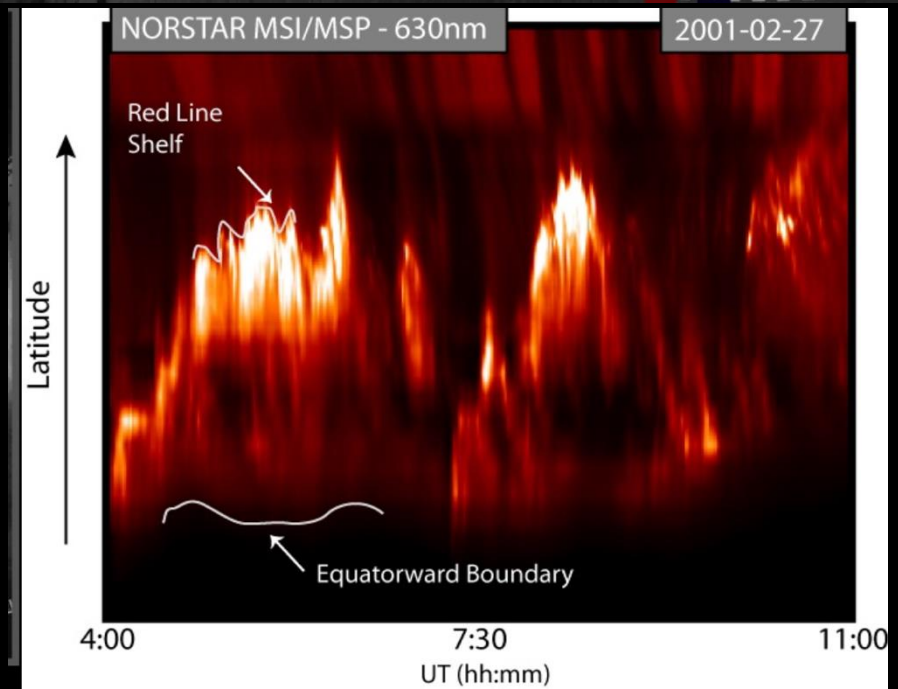
[Grandin et al., 2024]

- The Defense Meteorological Satellite Program (DMSP) has a dawn-dusk orbit similar to PUNCH.
- This series of satellites has been extensively used to study auroral particle precipitation by directly measuring energy flux.
- DMSP provides algorithms for determining auroral boundaries.
- Potential conjunctions with PUNCH could help identify the types of particles present in high-altitude auroras.



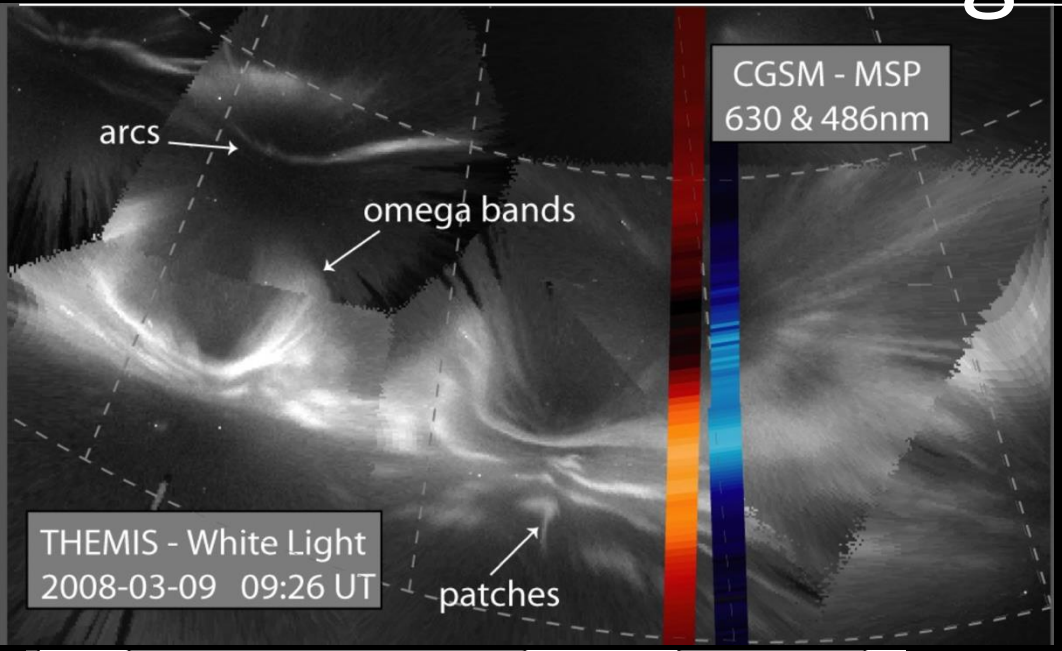
The aurora from the ground

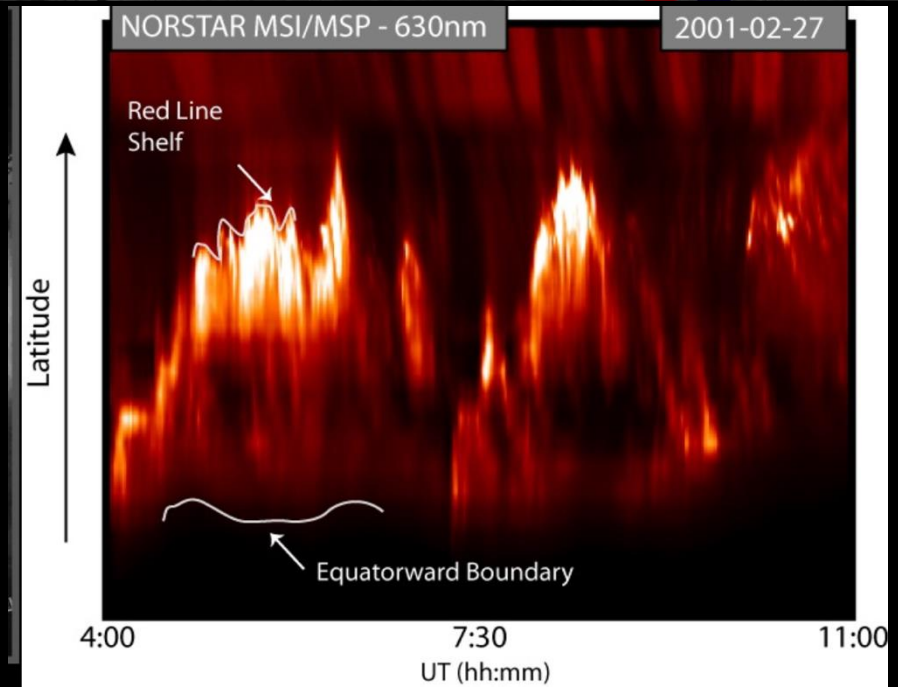




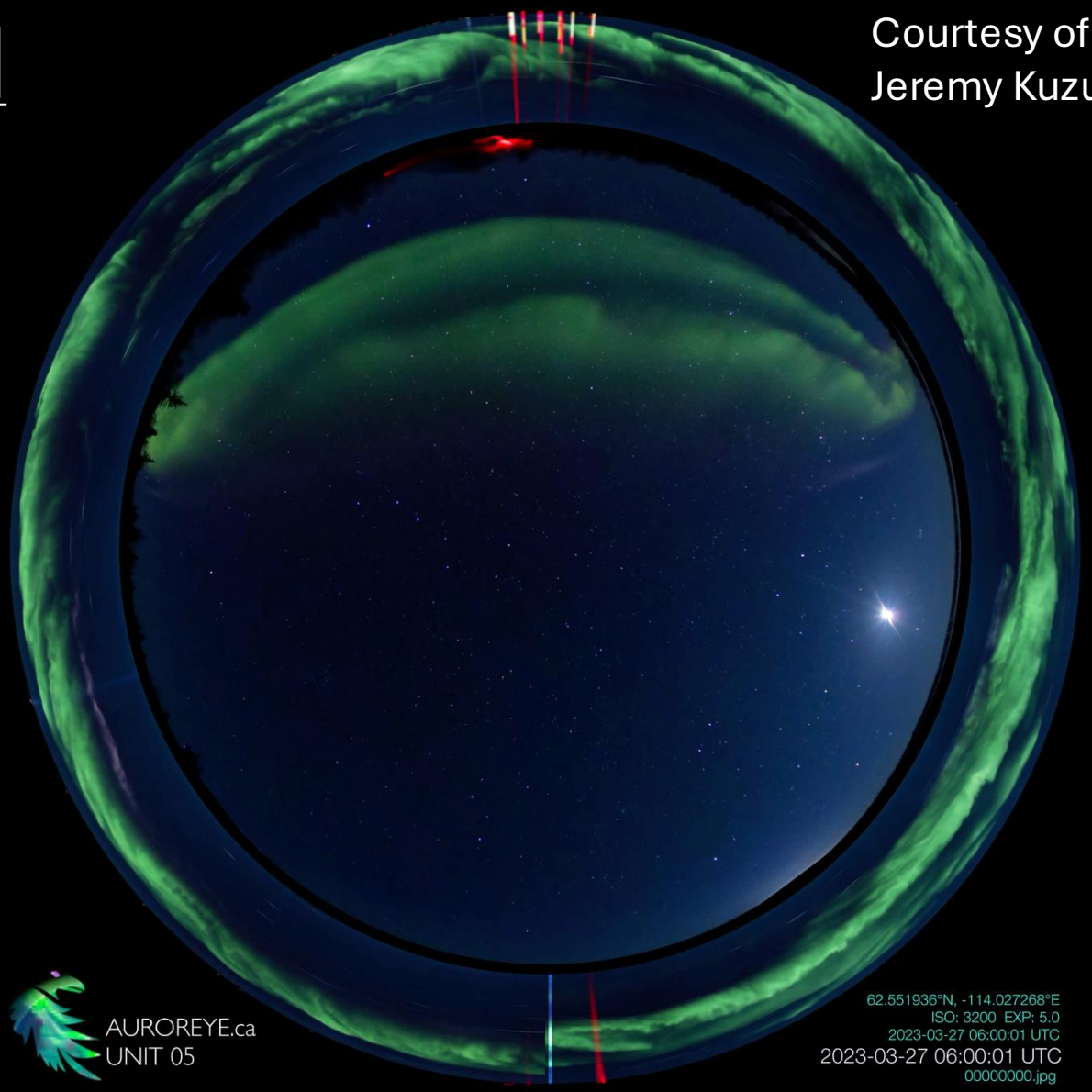
- From the ground, we study the aurora with almost every available optical dataset

The aurora from the ground





Courtesy of Jeremy Kuzub



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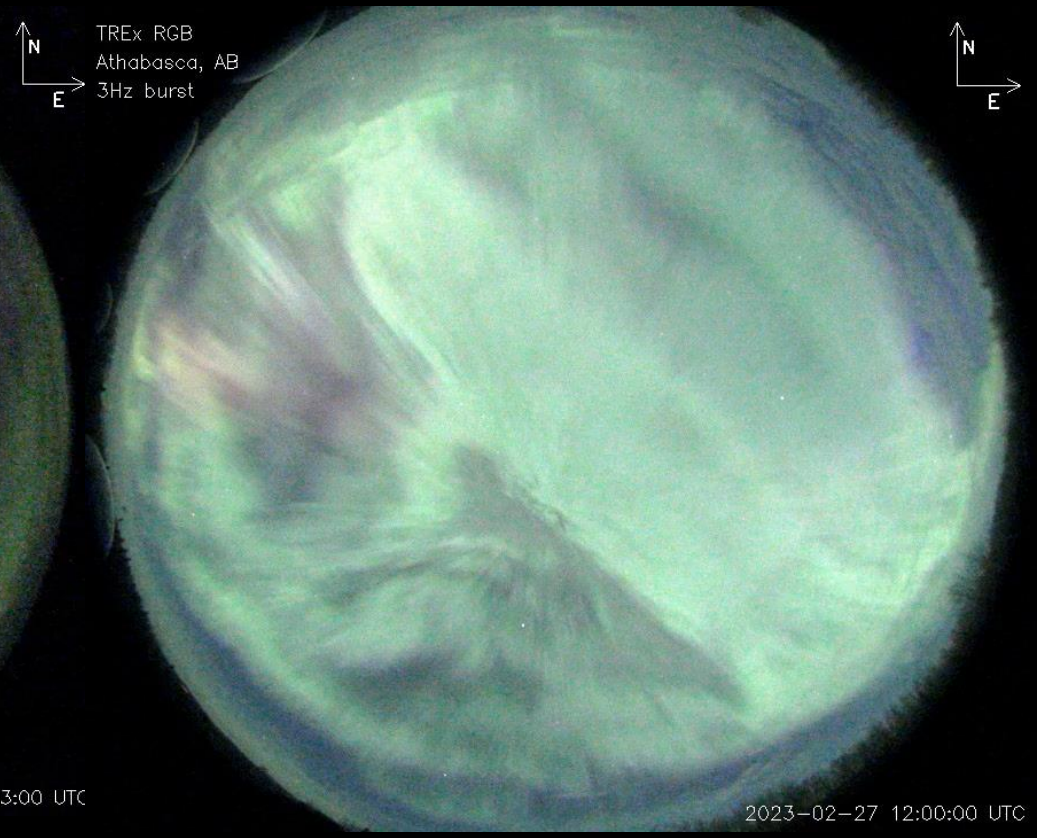
The aurora from the ground—TREx system

- TREx (Transition Region Explorer) is composed of seven ground-based cameras measuring in true RGB color
- Cameras operates in 3 second time resolution and a 3Hz burst mode as a campaign mode for certain events



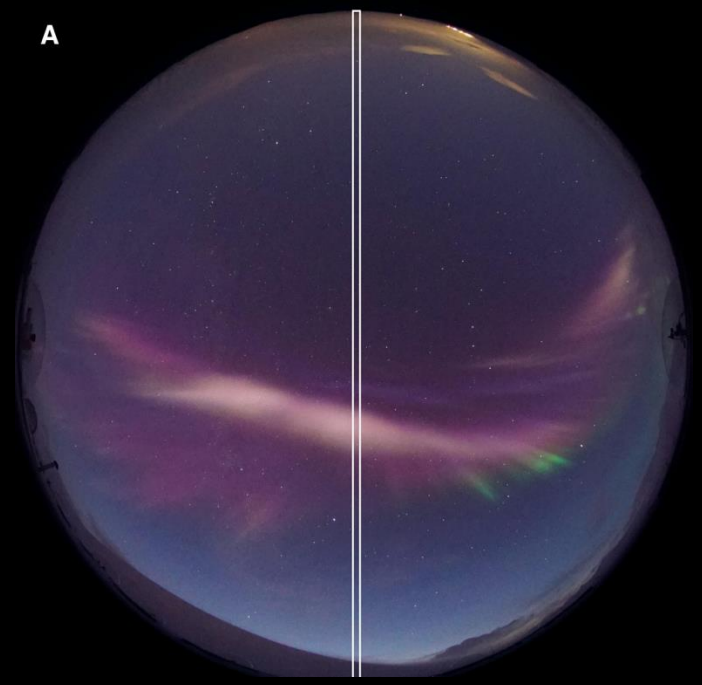
- Besides the RGB ASIs, the array also provides NIR ASIs and Blue line ASI at all 7 sites
- In addition, 3 imaging spectrographs are available

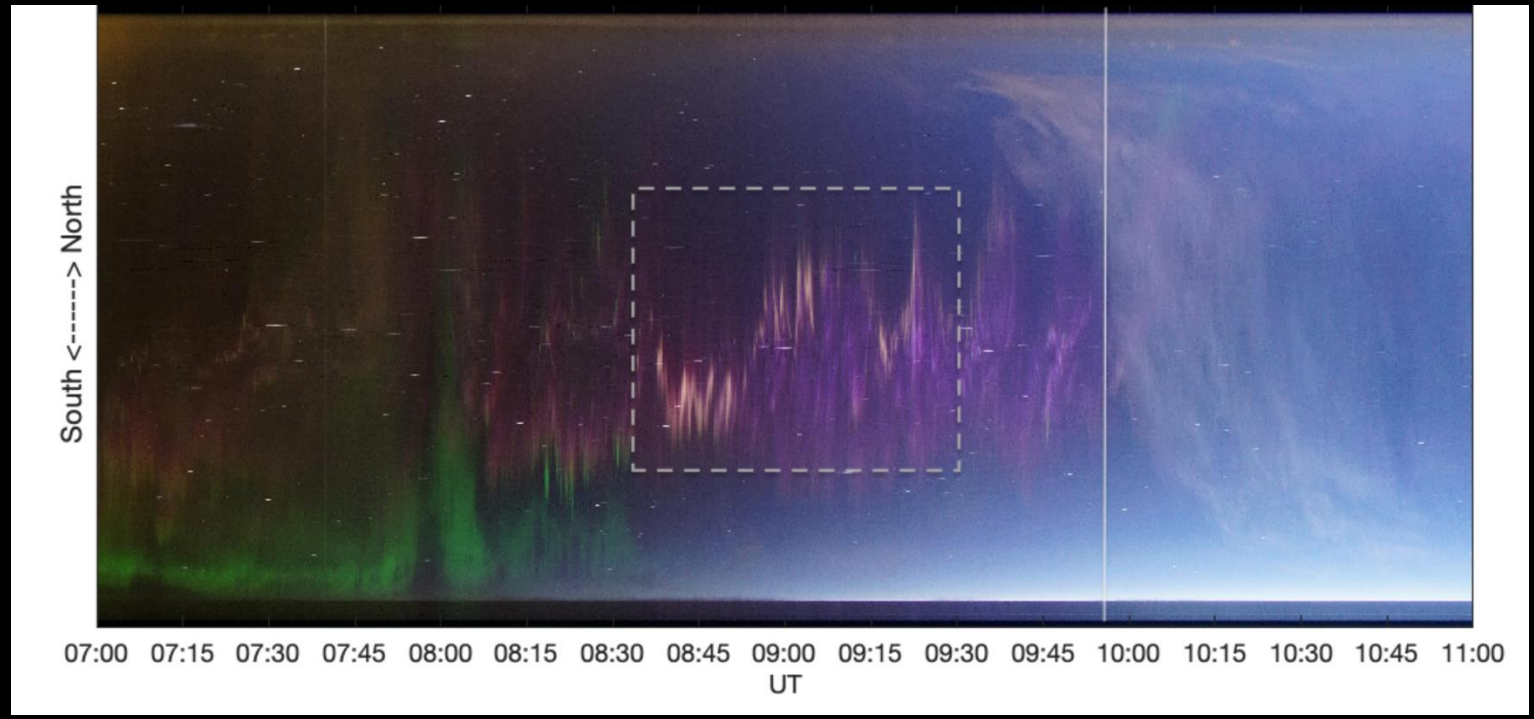
The aurora from the ground—Dayside aurora at Svalbard

This doesn't only includes the nightside! Dayside aurora can be captured in Svalbard. Kjell Henriksen Observatory (KHO), Svalbard

The polar cap can also be imaged at this location and from the American sector with redline imaging data Noora's data

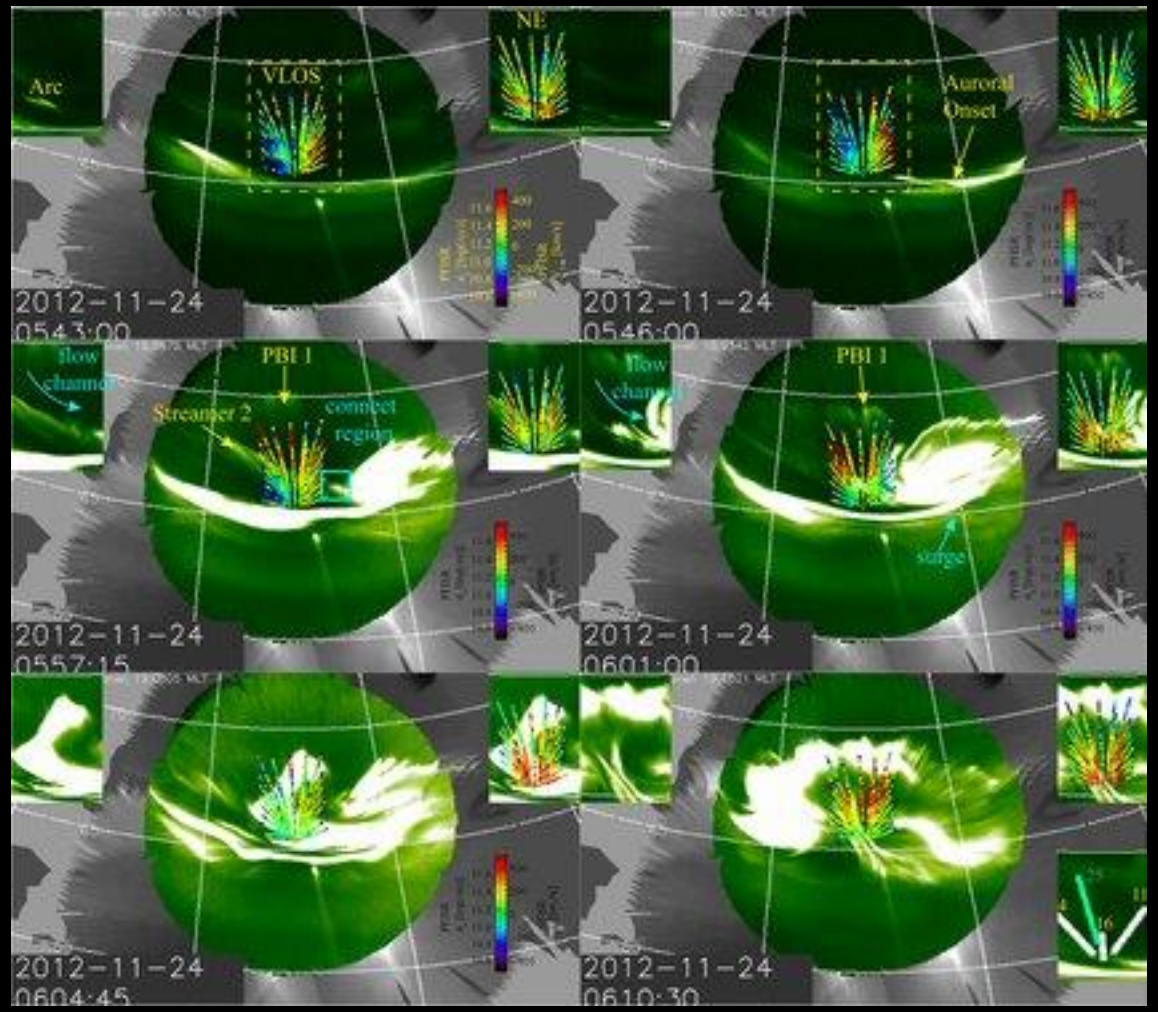
[Partamies et al., 2025]





Non-optical complementary ground-based instruments

- Incoherent scatter radars (ISR) are very powerful instruments that measure electron and ion density, temperature, and plasma velocities
- ISR distribution is limited, but conjunctions with other instruments are a power technique to understand plasma dynamicsx



[Nishimura et al., 2021]

Some of the most used instruments to study auroras from the ground

Instrument	Location
THEMIS ASI white light (21 ASIs)	North America
REGO (9 ASI)	Central Canada
TREx RGB, NIR, blue line (7 in each)	Central Canada
TREx Spectrographs (3)	Central Canada
KHO Observatory (2 ASIs+spectrograph)	Svalbard
ISR (3)	Alaska, Northern Canada(2)

- There is also extensive coverage of other ground-based instruments, such as magnetometers, GNSS receivers, coherent scatter radars, FPIs, etc.
- All the data from these instruments can be used to study auroras in different regions and are publicly available
- Also, sporadic/campaign instrumentation in Alaska, Antarctica, and other regions could be accessed

PUNCH presents a huge opportunity for interdisciplinary and collaborative science

- PUNCH offers a valuable opportunity to integrate data from missions within the Heliophysics System Observatory.
- Coordinating with ground-based instruments naturally enhances remote sensing of the aurora, creating exciting possibilities for campaigns and new collaborations.
- Utilizing non-traditional scientific data has proven highly effective, especially when working with experts who understand the challenges associated with these datasets.