# Investigations of Polar Cap Ionosphere Structures using the Greenland Network (GNET)

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**Grand Goals:**

To determine the dominant mechanism of polar cap patch formation

To assess solar wind conditions (magnetotail topology) conducive for the formation of Sun-aligned polar cap arcs.

**Instrumentation**

55 GPS receivers that belong to the GNET network in Greenland and 10 GPS that belong to the CHAIN network in Canada (TEC data for December 2009).

630.0 nm images from Qaanaaq Greenland.

IMF parameters measured by ACE at Lagrange point, L1

**Observational Facts**

TEC enhancements can correspond to auroral arcs, polar cap patches (PCP), Sun-aligned arcs (S-AA), and Blobs.

PCPs move antisunward. S-AAs move in the dawn-dusk line.

PCP and S-AA can be differentiated due to their motion.

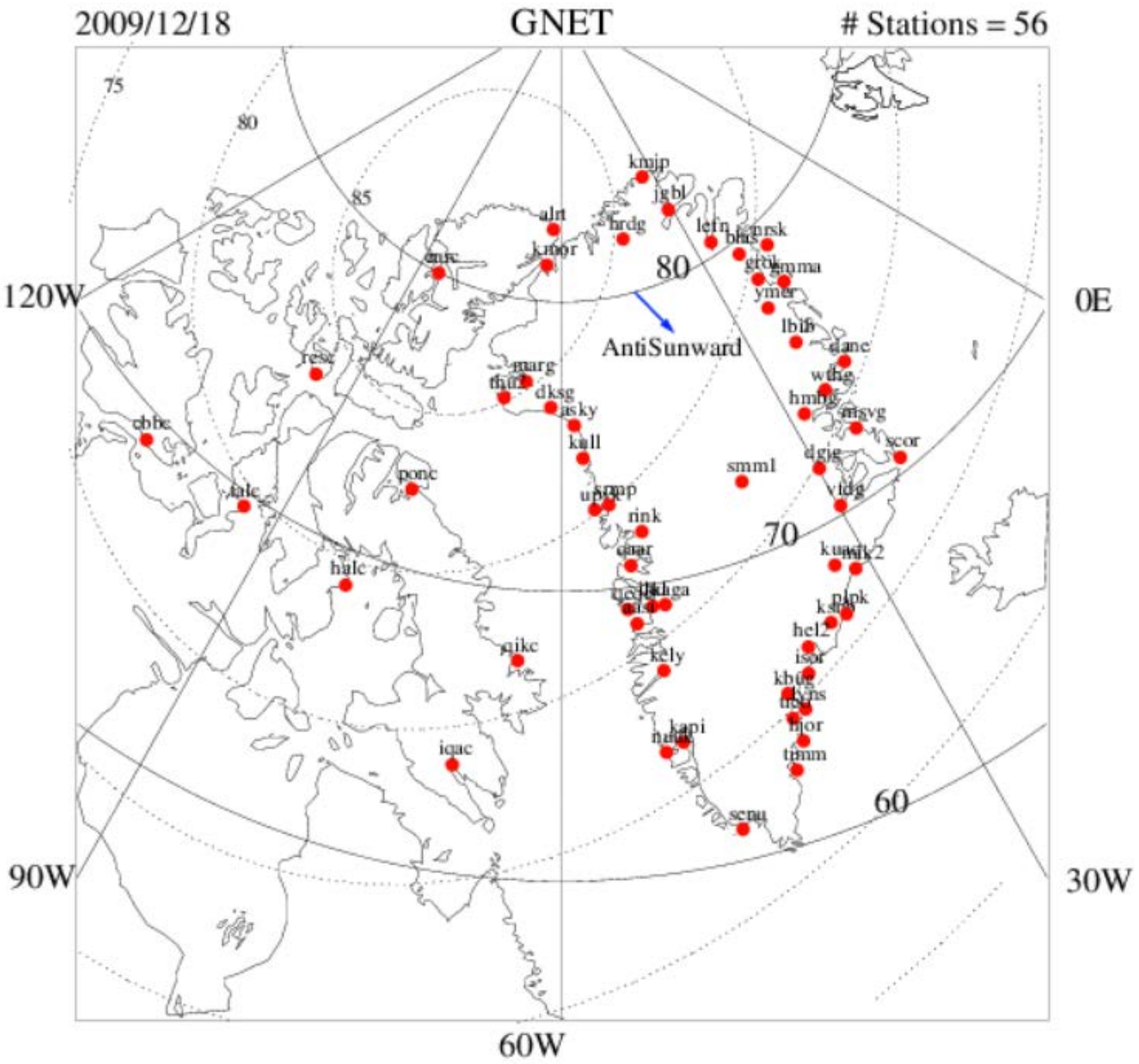
**Three tasks are described in this presentation:**

(1) Detection of TEC enhancements.

(2) Calculation of the motion of TEC enhancements.

(3) Differentiate between PCP and S-AA related enhancements.

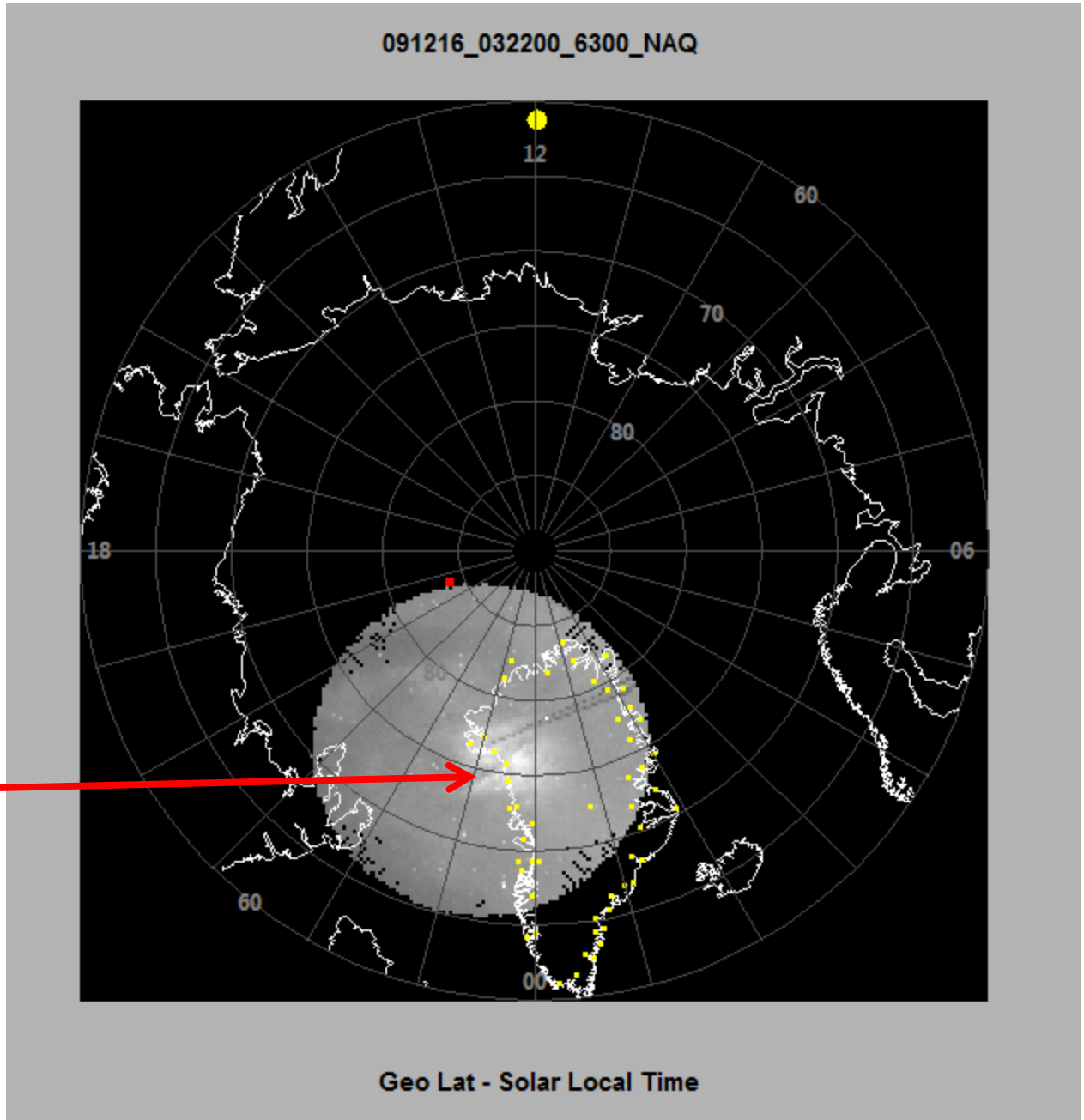
# Map of GPS receivers



# AFRL Imager in Qaanaaq, Greenland

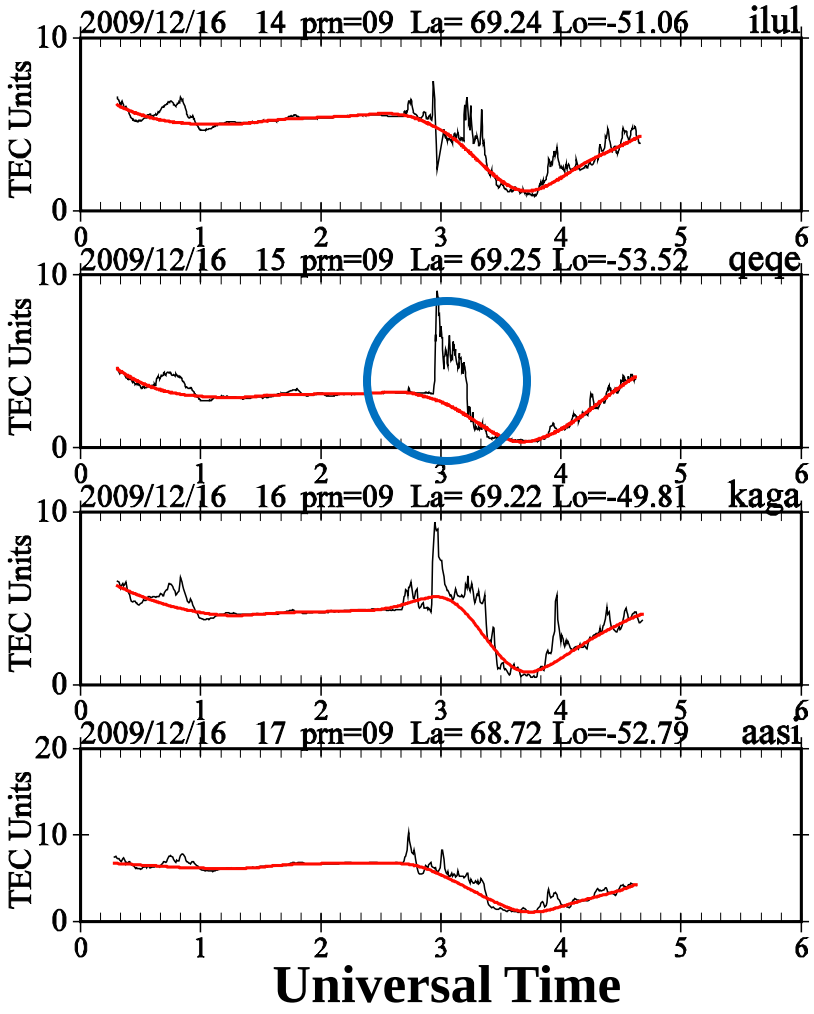
Observation of Polar Cap Patches using an all-sky imager that operates at Qaanaaq in Greenland.

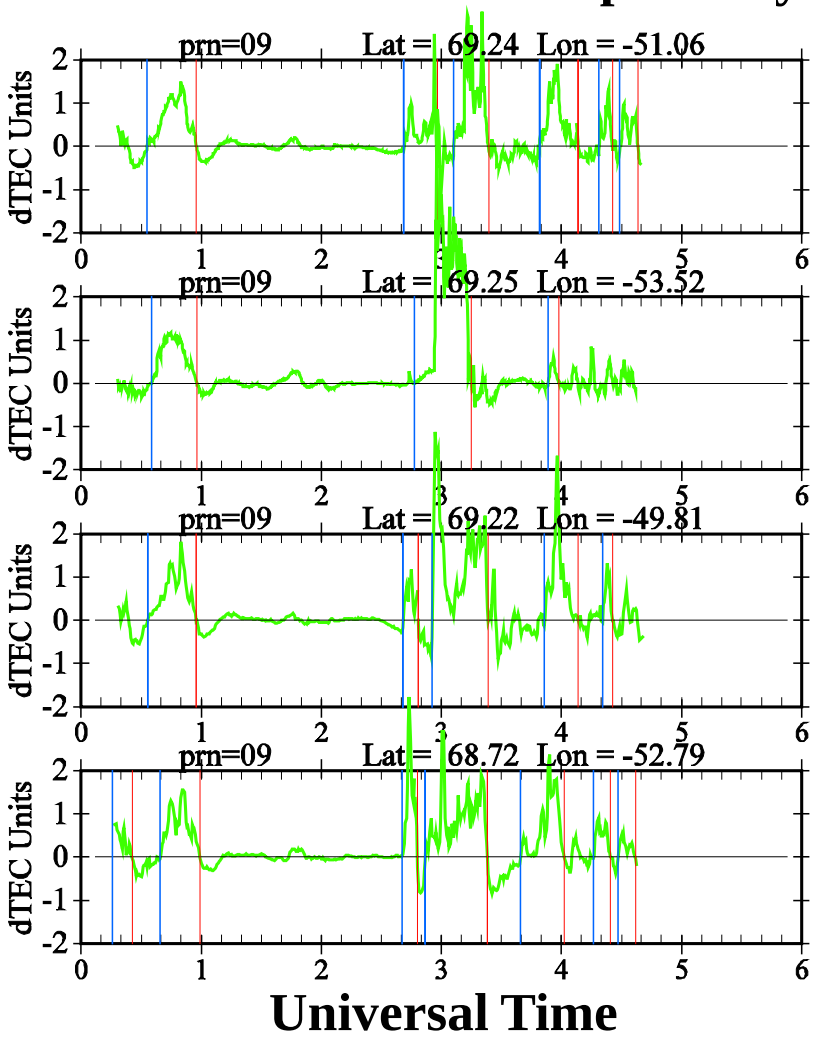
"cigar" shaped patches observed on December 16, 2009 at 0322 UT



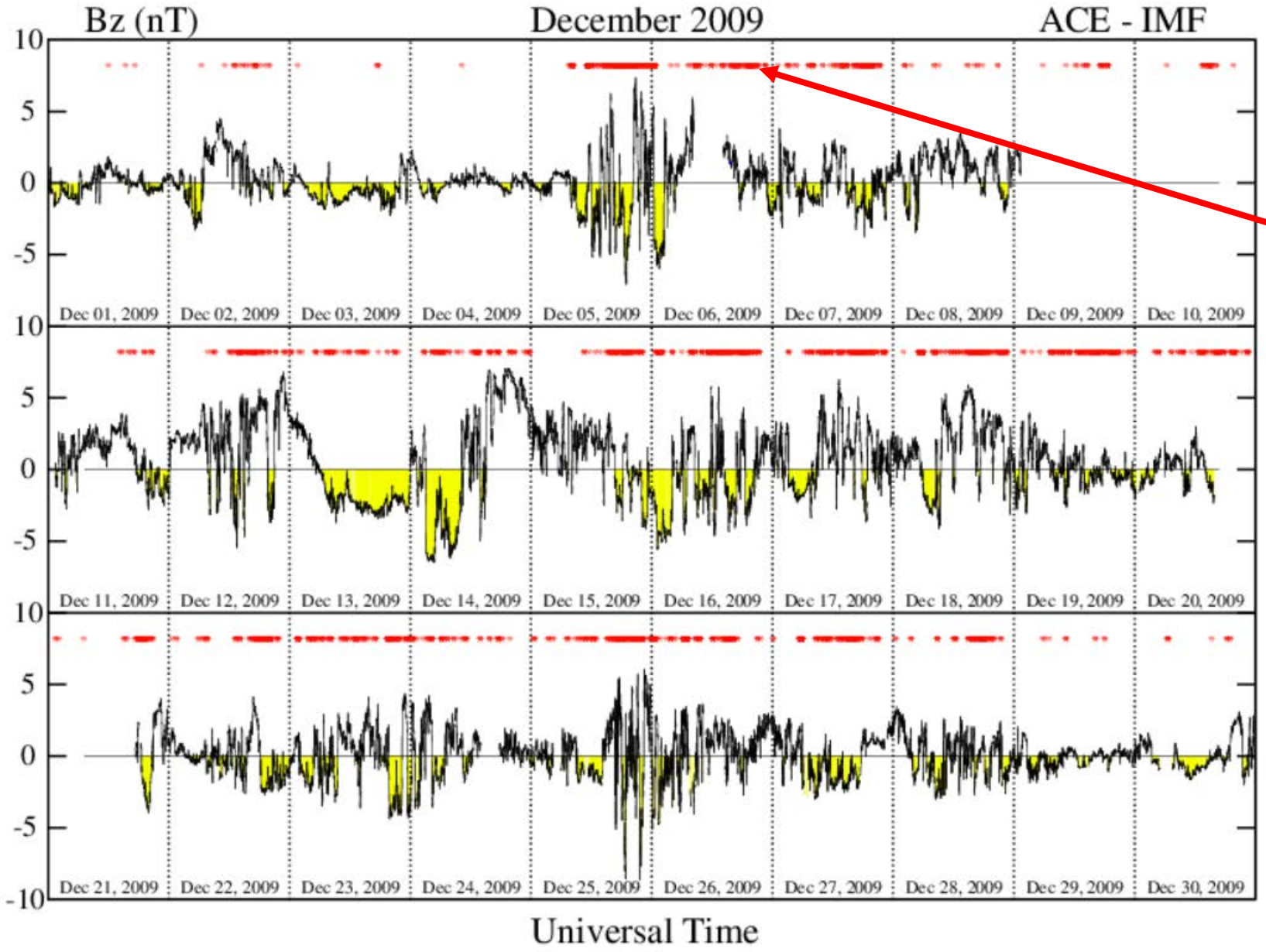
**The black trace is the measured TEC at 4 stations for PRN=09. The red line displays a fit to the "undisturbed" TEC. Values larger than the red curve correspond to patches or arcs.**

**Green curve displays dTEC, this is the difference between the black and red curves of the left panels. Start and end of the TEC enhancements are indicated with blue and red lines respectively.**



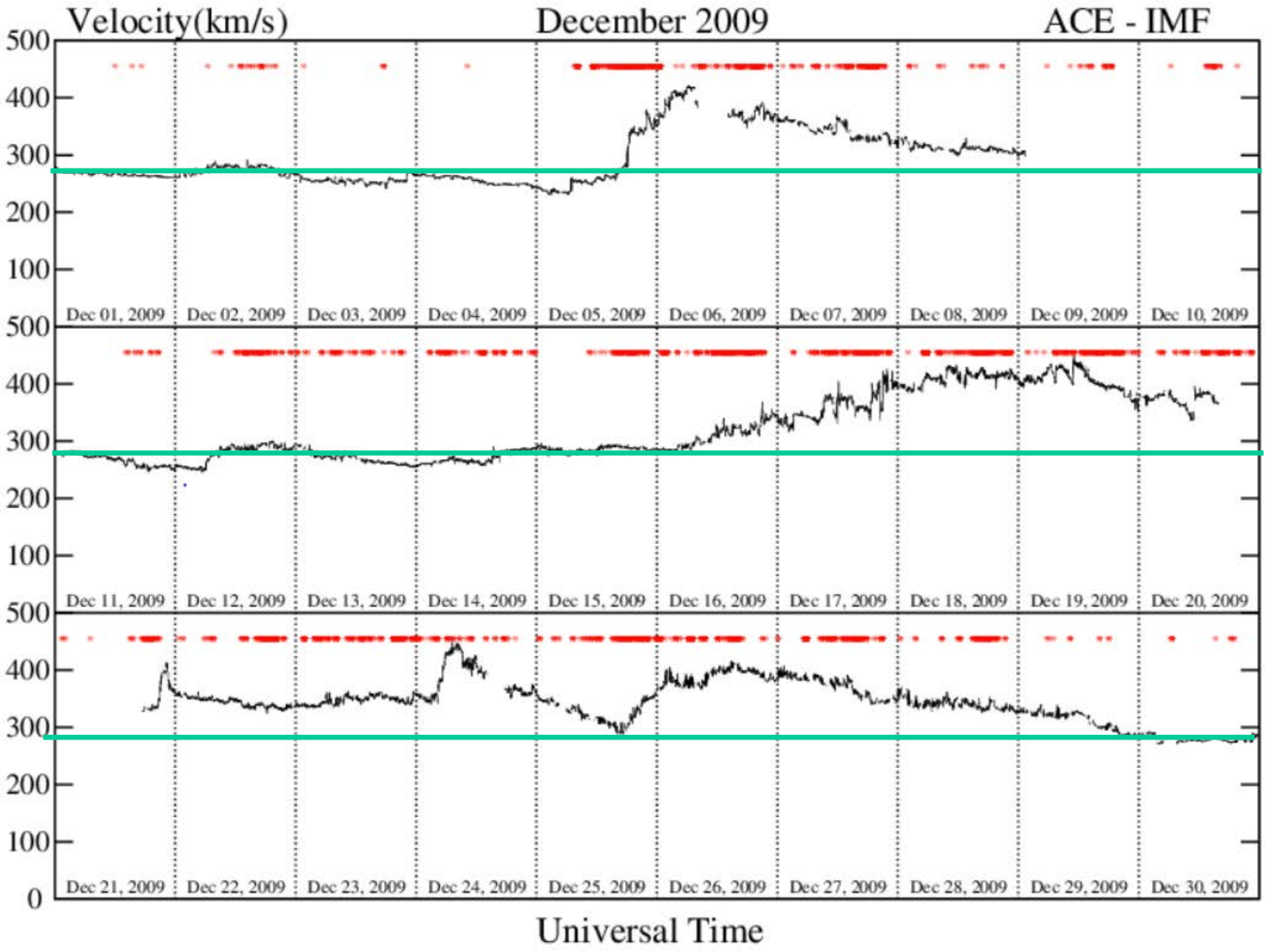



# $B_z$ IMF component for each day between Dec 1 and 30, 2009



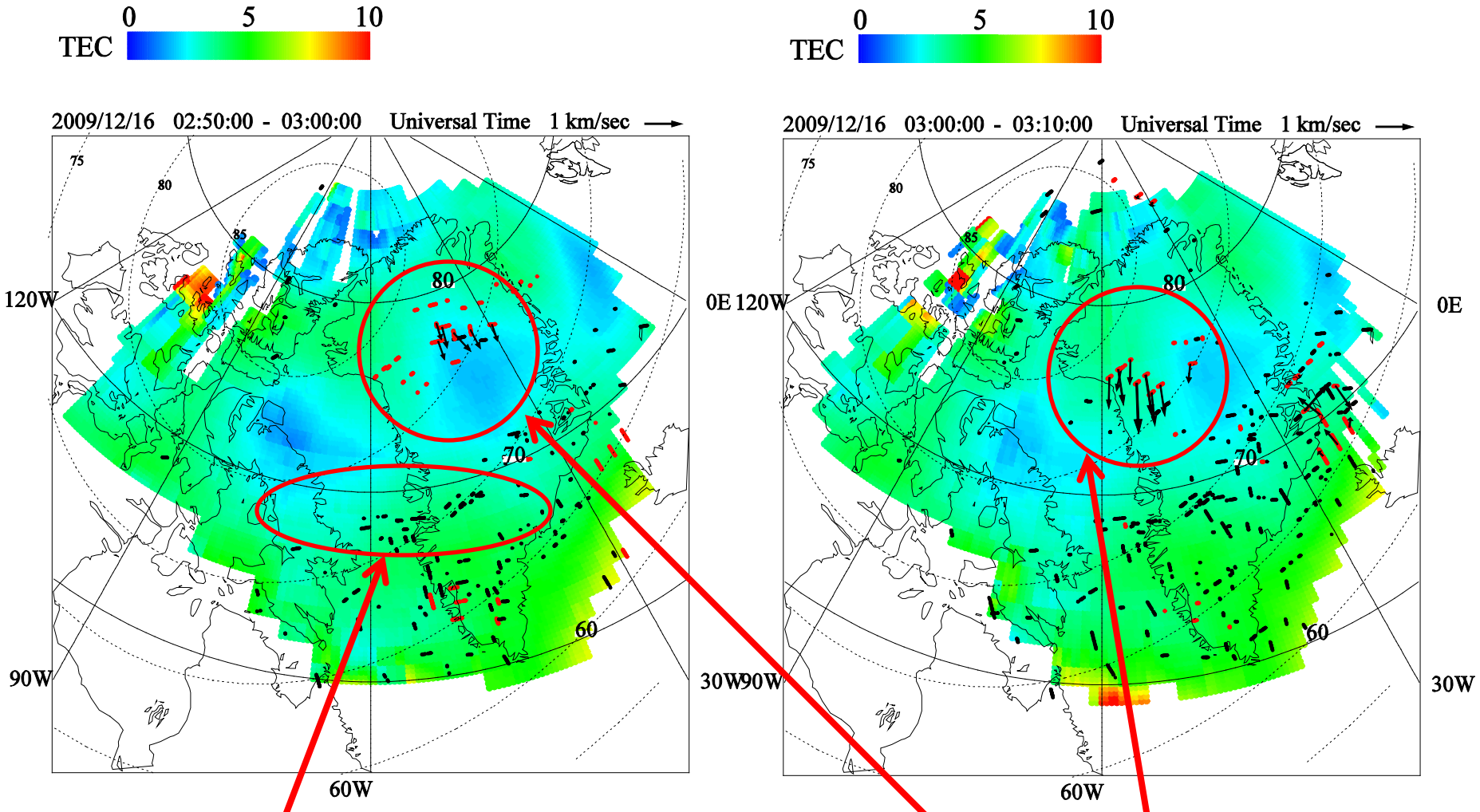

**TEC enhancement inside polar cap (>74° mLat)**

# Solar wind velocity for every day between Dec 01 and 30, 2009




TEC enhancements are observed within polar cap, when solar wind is above 285 km/s.

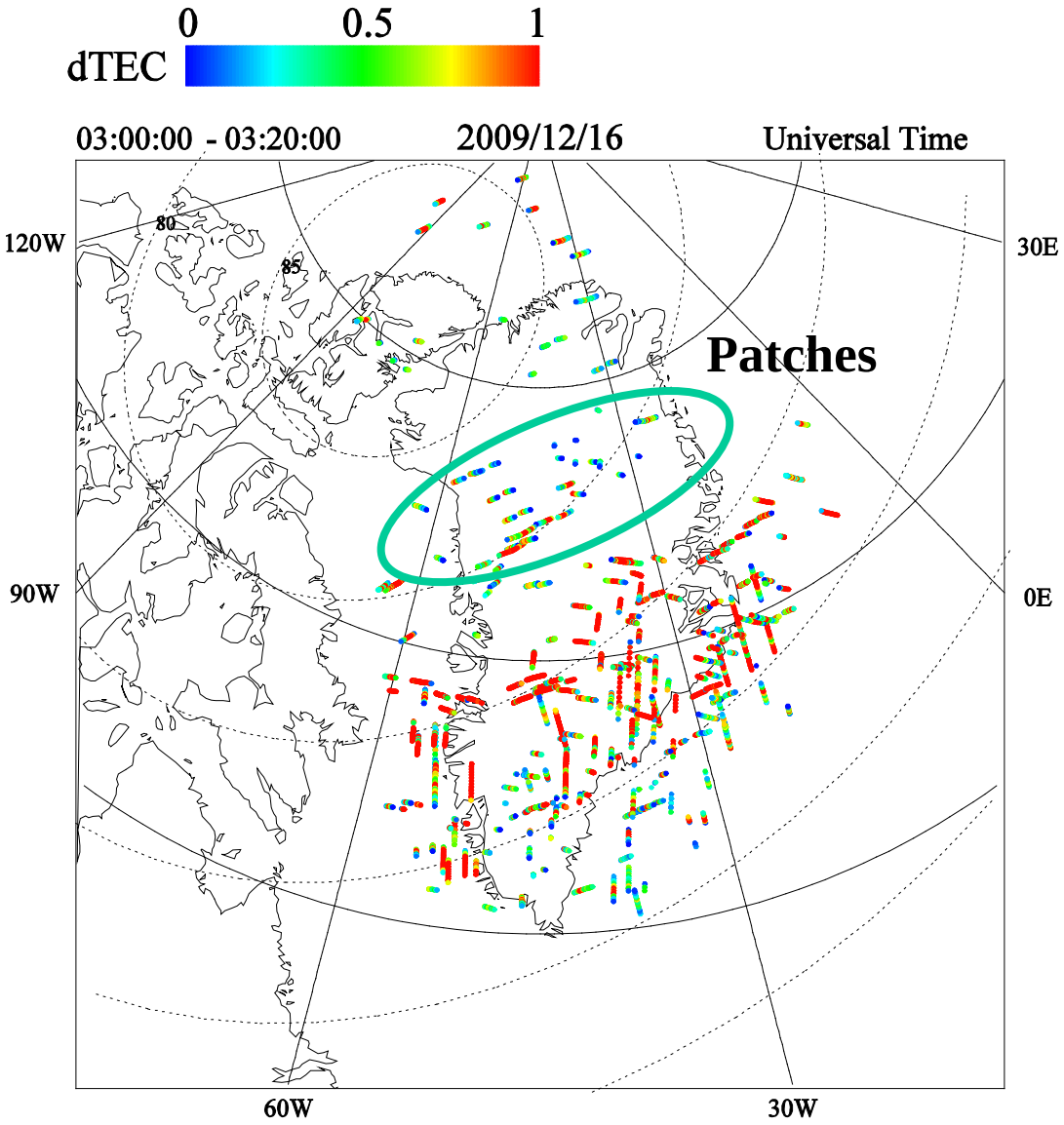
# TEC & TEC enhancements observed on December 16, 2009

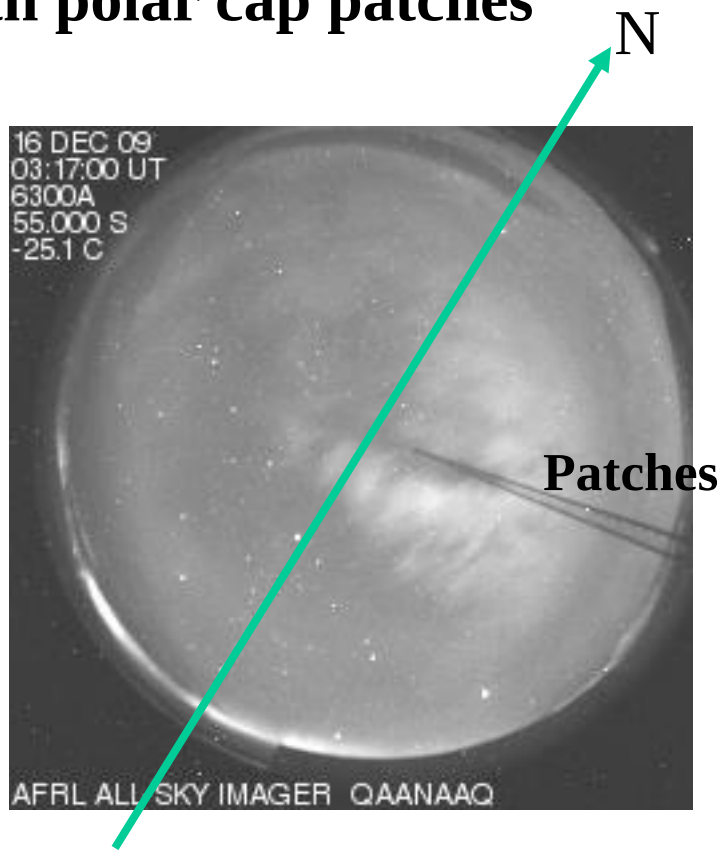



**Auroral Arcs**

**TEC enhancements associated with polar cap patches moving antisunward**

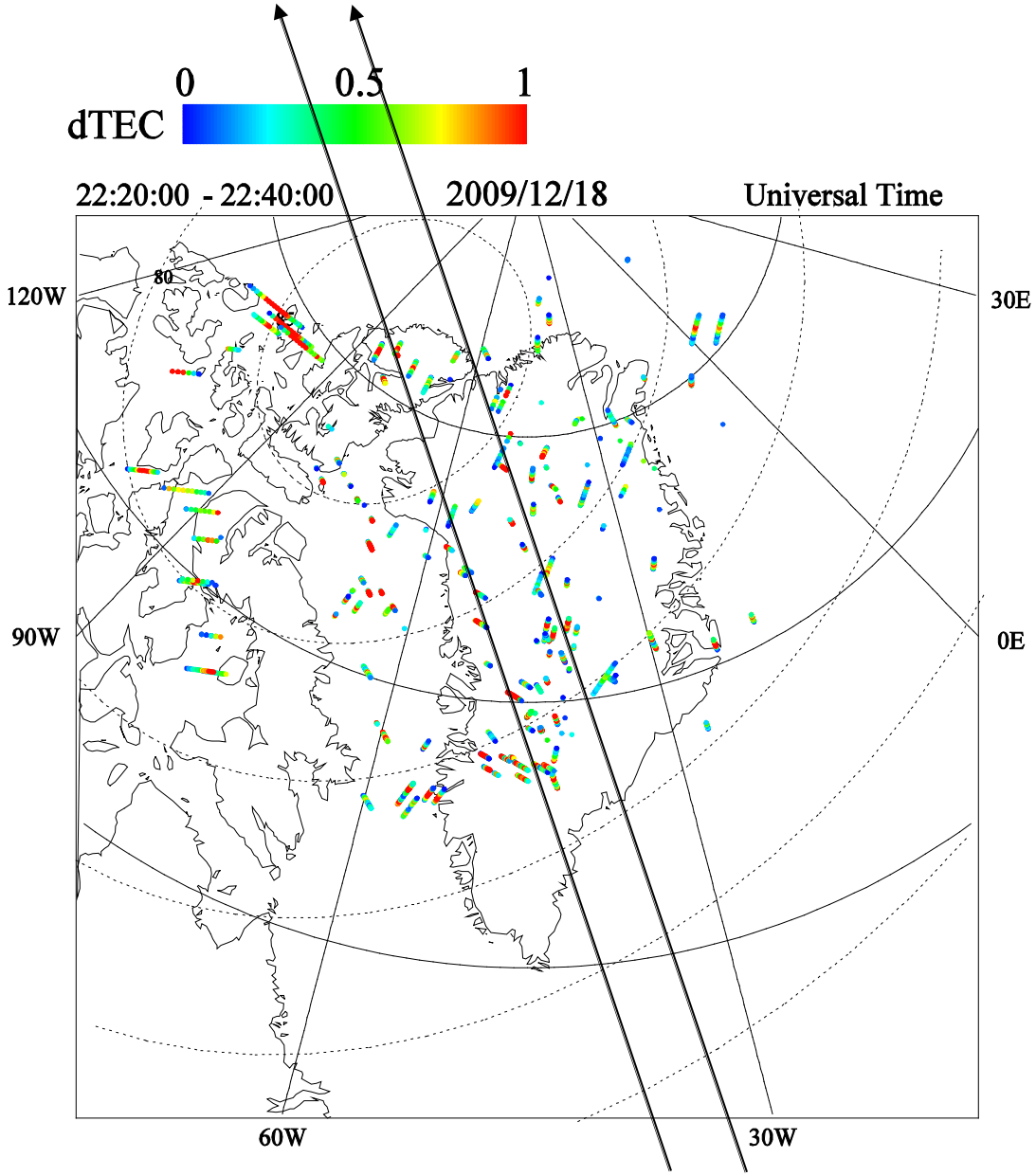
# TEC enhancements associated with polar cap patches

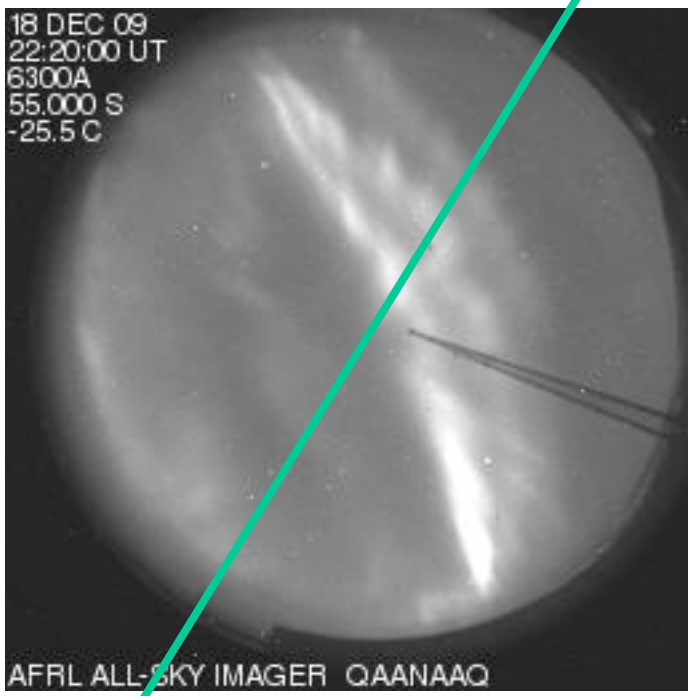



Patches seen with an imager tuned at 630.0 nm observed airglow enhancements produced by the transit of the PCP. Similar TEC enhancements were observed with the GNET receivers (see next slide).

# TEC enhancements associated with polar cap arcs

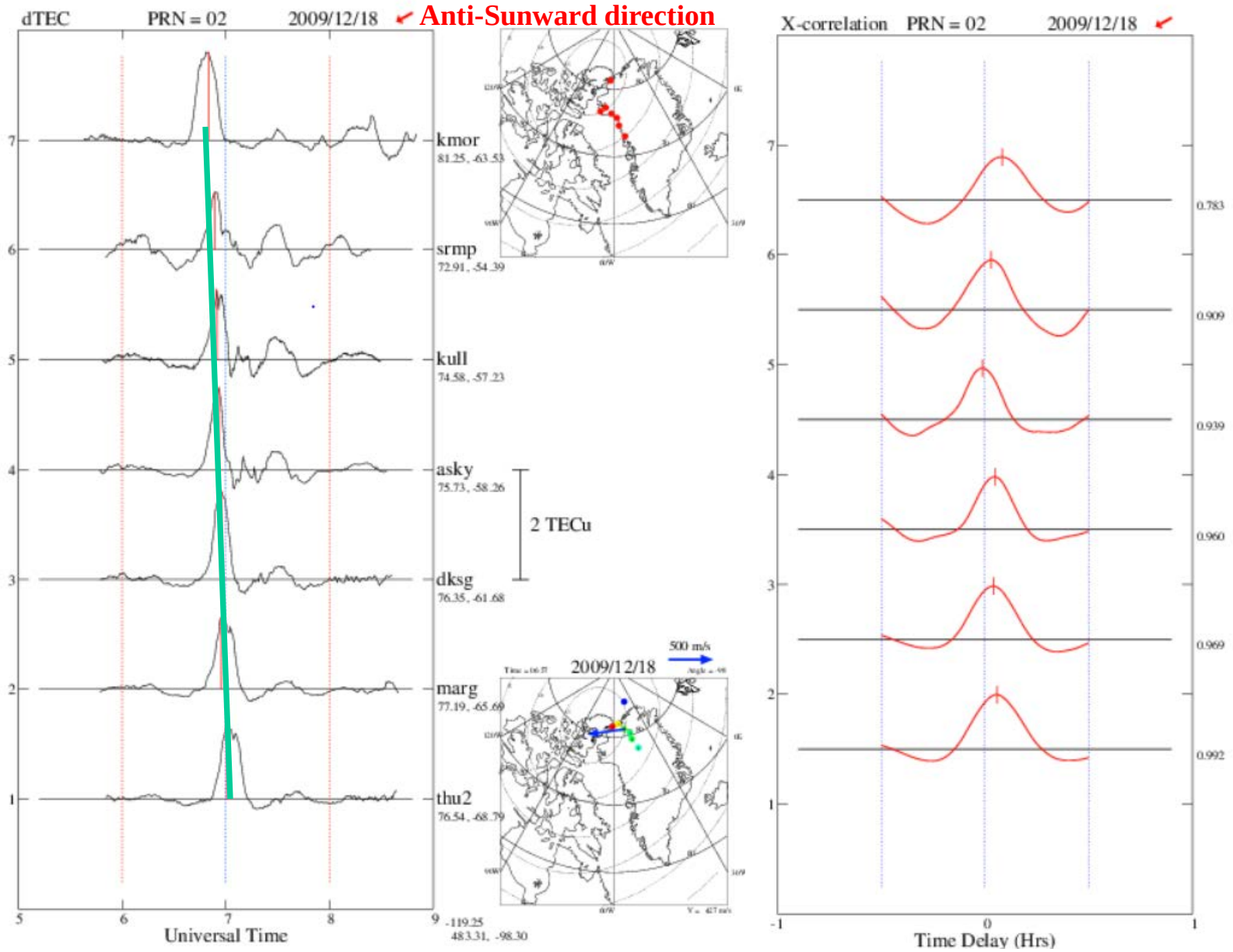



N

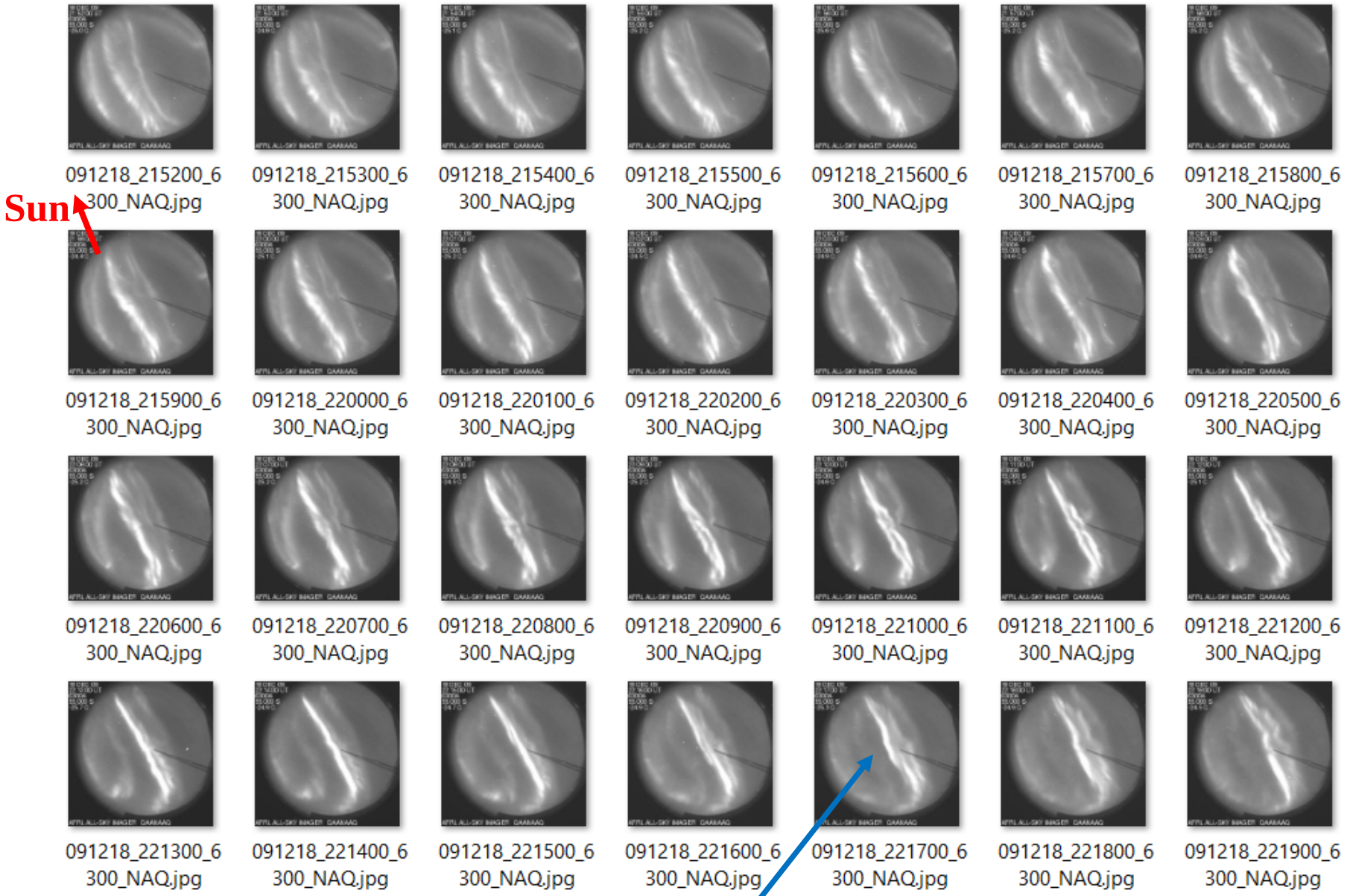
Polar cap arcs seen with an imager tuned at 630.0 nm located at Qaanaaq, Greenland. Similar TEC enhancements aligned in an anti-sunward direction were observed with the GNET receivers.

# TEC perturbations and x-correlation functions for patches



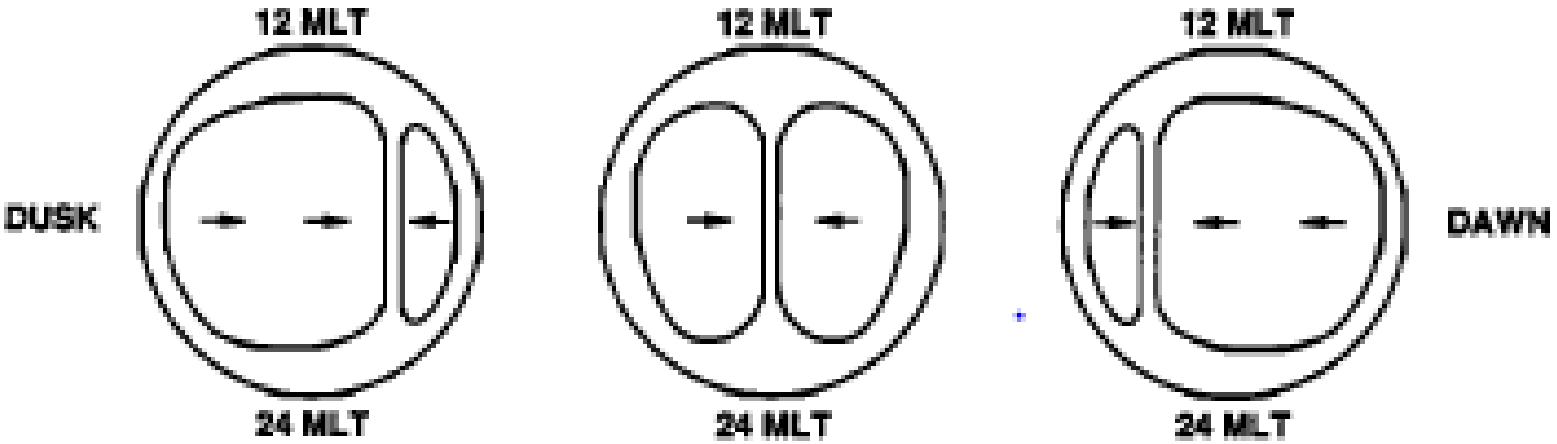

# PCP moves westward (92° counter-clockwise from North) at 412 m/s

# Sun-aligned arcs observed at Qaanaaq on December 18, 2009




# S-AAs develop wavy features, multiply, and disappear

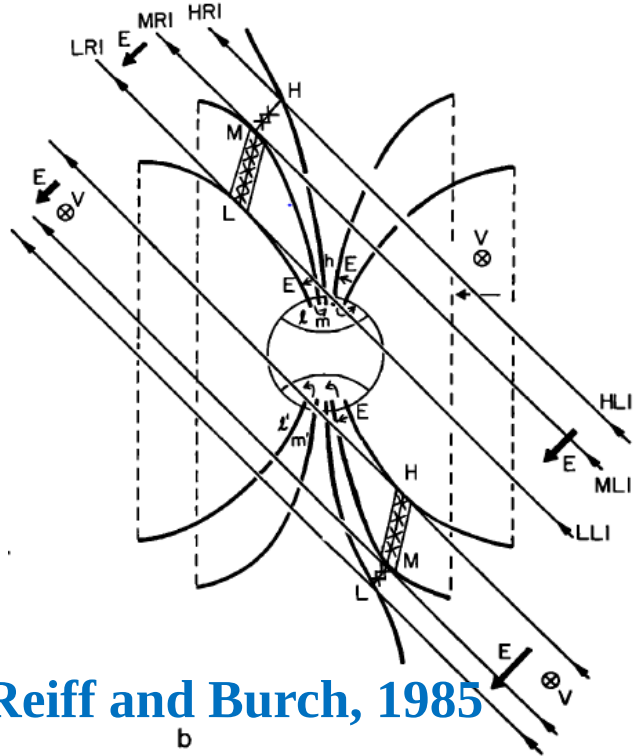
# Dawn-dusk motion of Polar Cap Arcs (S-AAs)




$B_y < 0$ $B_y = 0$ $B_v > 0$

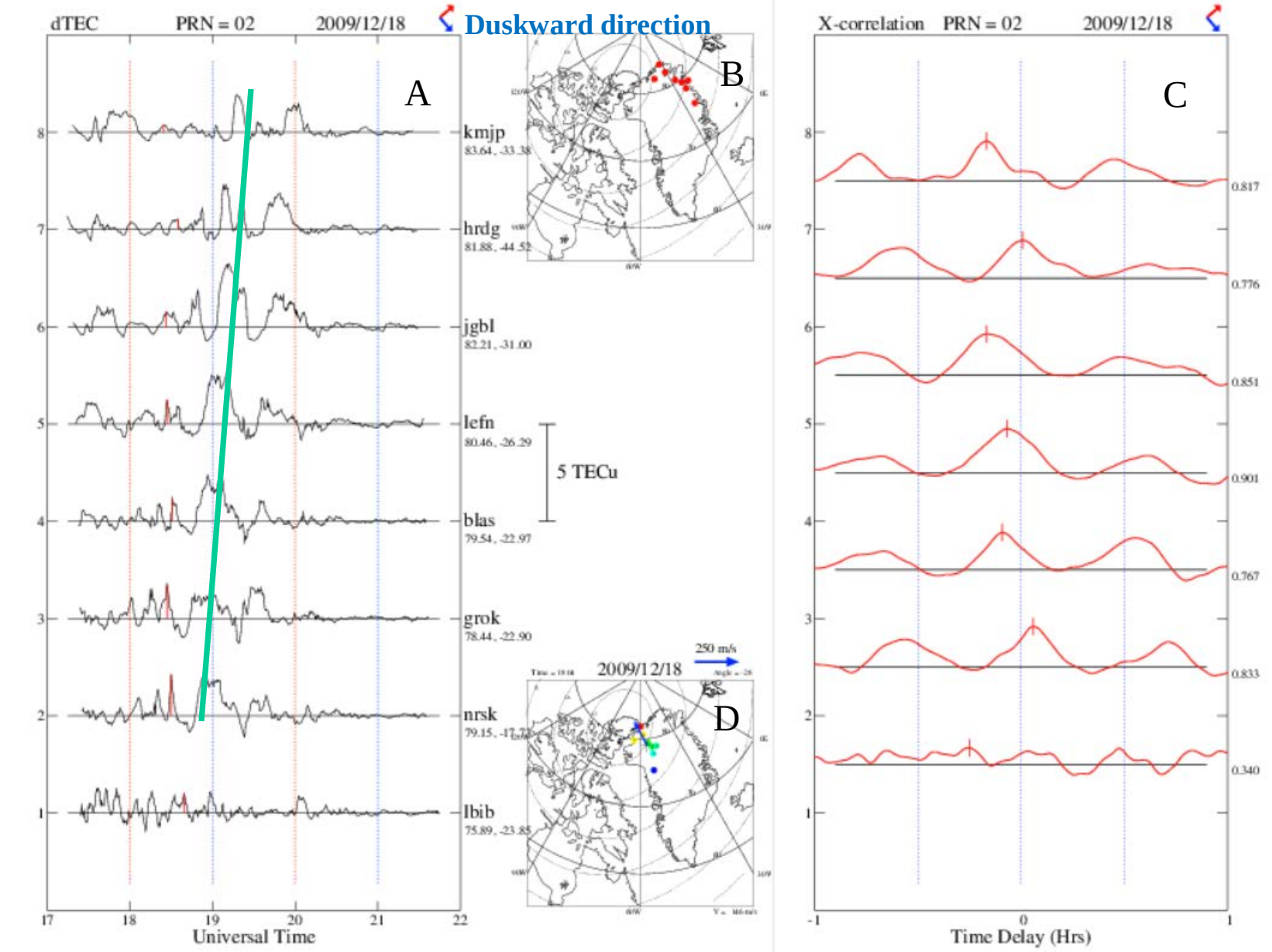
The arc direction of motion depend on both the $B_y$ IMF component and the location of the arc within the polar cap. For a given value of By, two well-defined regions (or cells) exist. Within each cell the arcs move toward the cell boundary. The arcs located in the duskside move dawnward; those in the dawnside move duskward. The relative size of these regions (or cells) are controlled by the magnitude $B_y$. The dawn-dusk motion of the polar cap arcs is interpreted in terms of newly open flux tubes entering the polar cap and exerting a displacement of convecting cells and the polar cap arcs that are embedded within them.

**Valladares et al., 1994**



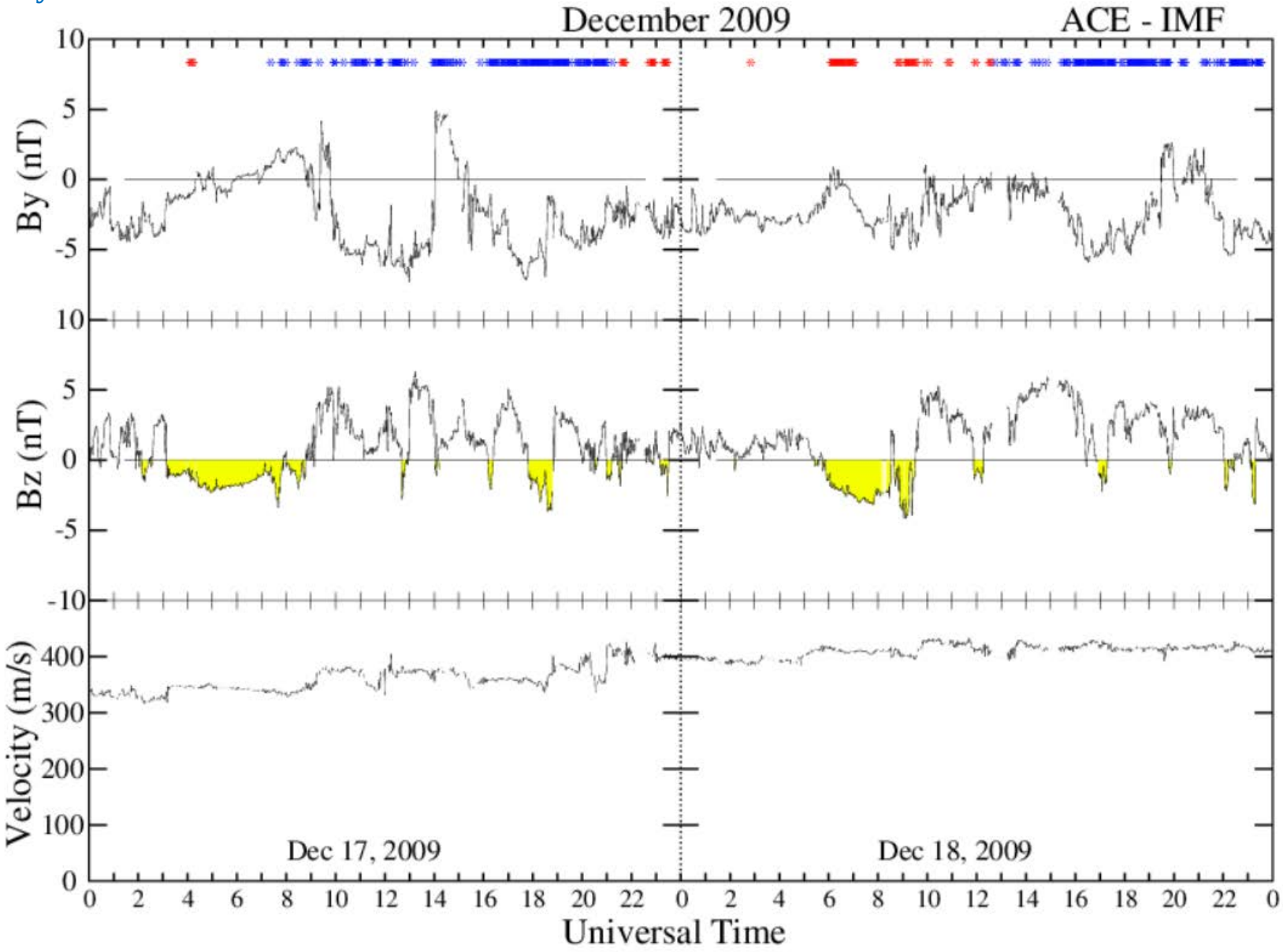

**Reiff and Burch, 1985**

# TEC perturbations and x-correlation functions for polar cap arcs




S-AAs move 28° counter-clockwise from North at 146 m/s (Dawnward)

# $B_y$, $B_z$ IMF, and Solar wind velocity for December 17-18, 2009




Red stars correspond to patches, blue crosses indicate Arcs

# Conclusions

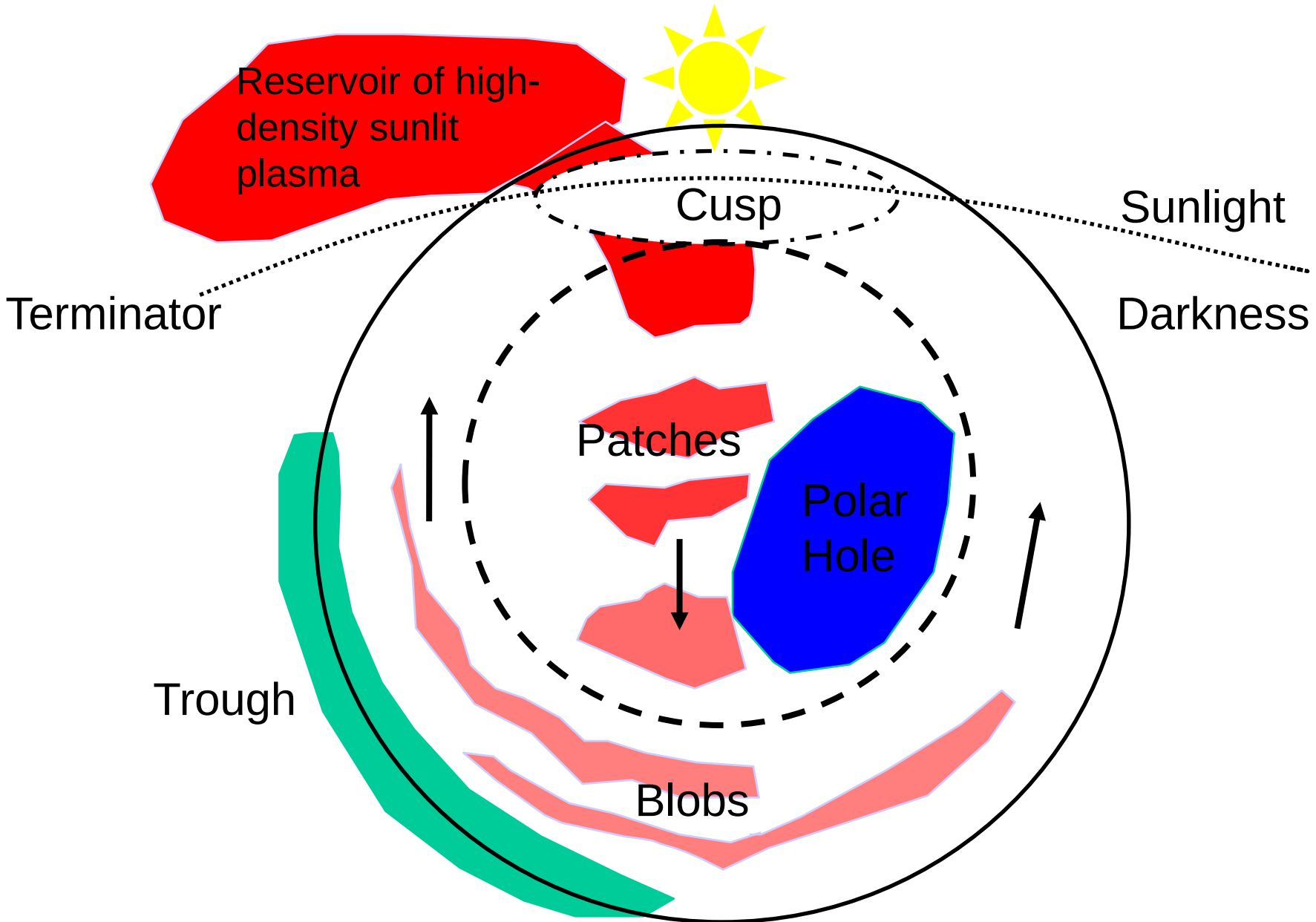
GNET can be used to identify TEC enhancements that are associated with auroral arcs. This is not the purpose of the present investigation.

Polar cap TEC enhancements are observed when the solar wind velocity is above 285 km/s. This relationship will be investigated for other seasons and other years.

Patches and S-A arcs have been detected and characterized using TEC values from GNET. Their characteristics have been corroborated with the Qaanaaq imager. The unique property of the GNET network of continuous and permanent observations will be used to single out the formation mechanism of polar cap structures and the solar wind conditions (magnetotail topology) during the development of S-A arcs.

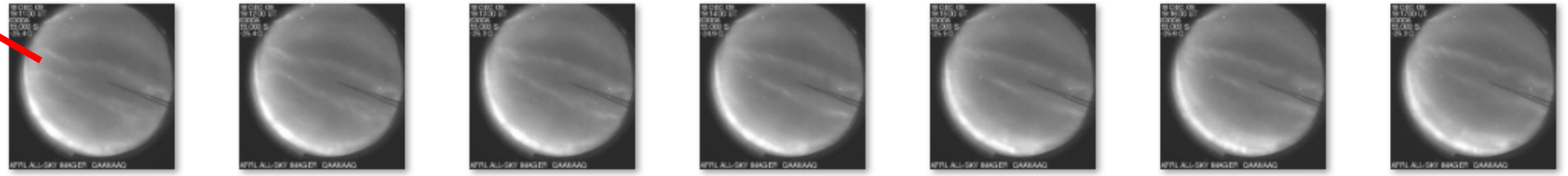
This technique is the only one, between ground and space instrumentation that can provide continuous (24/7) data over a large region. We should call GNET an ionospheric observatory!

# Polar Ionosphere Density Regimes
## (Winter, Bz < 0)



# Sun-aligned arcs observed at Qaanaaq on December 18, 2009

Sun



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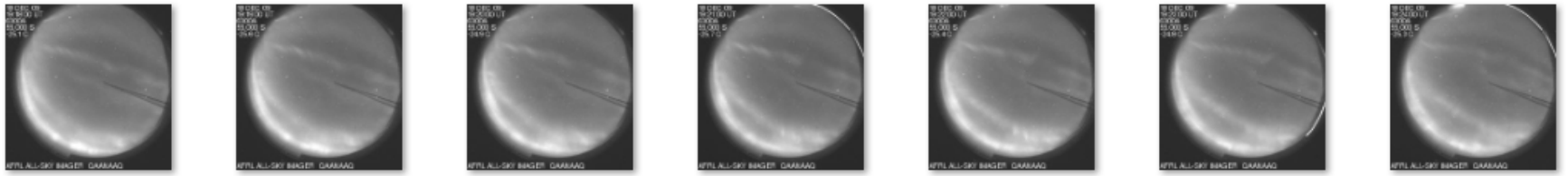

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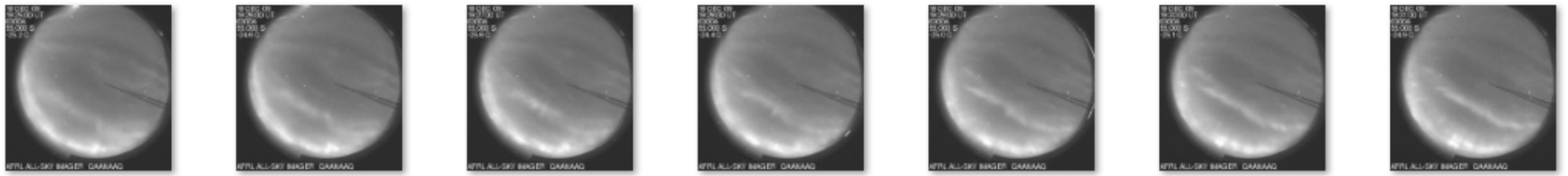

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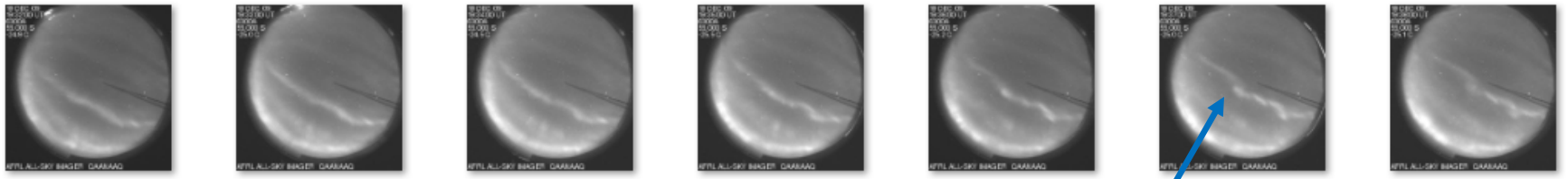

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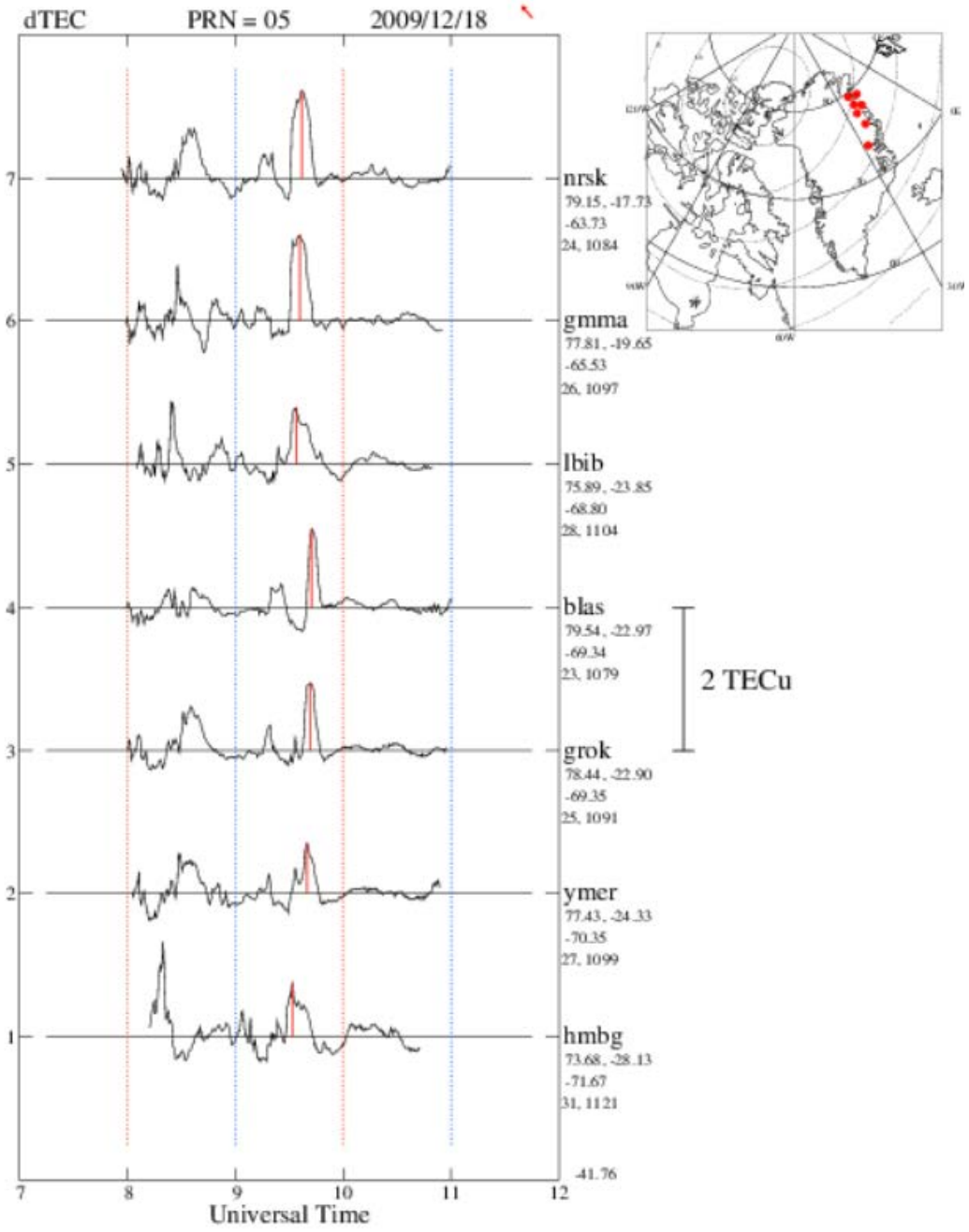
S-AAs develop wavy features or disappear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28, 1104
blas
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23, 1079
grok
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-69.35
25, 1091
ymer
77.43, -24.33
-70.35
27, 1099
hmbg
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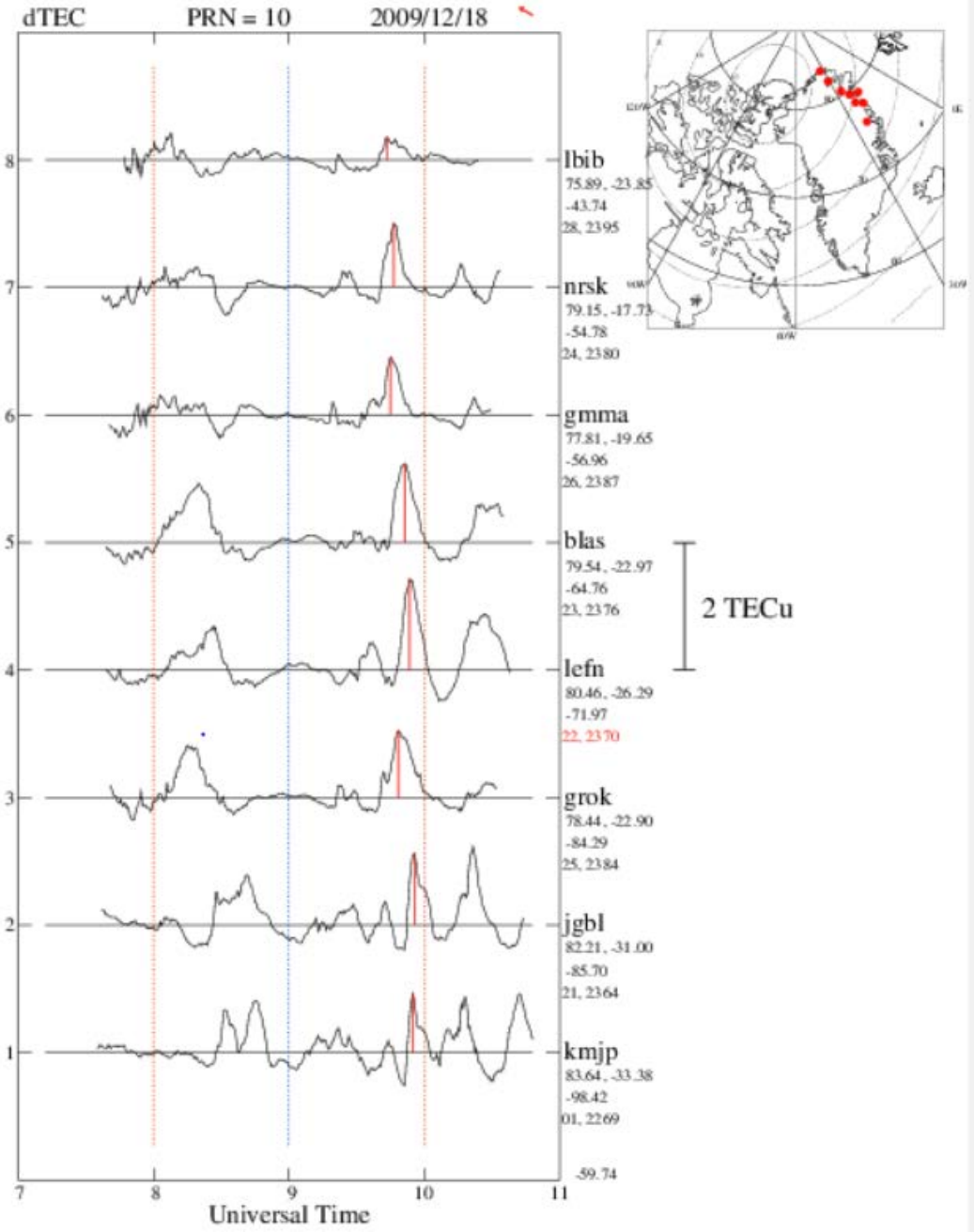
12
Universal Time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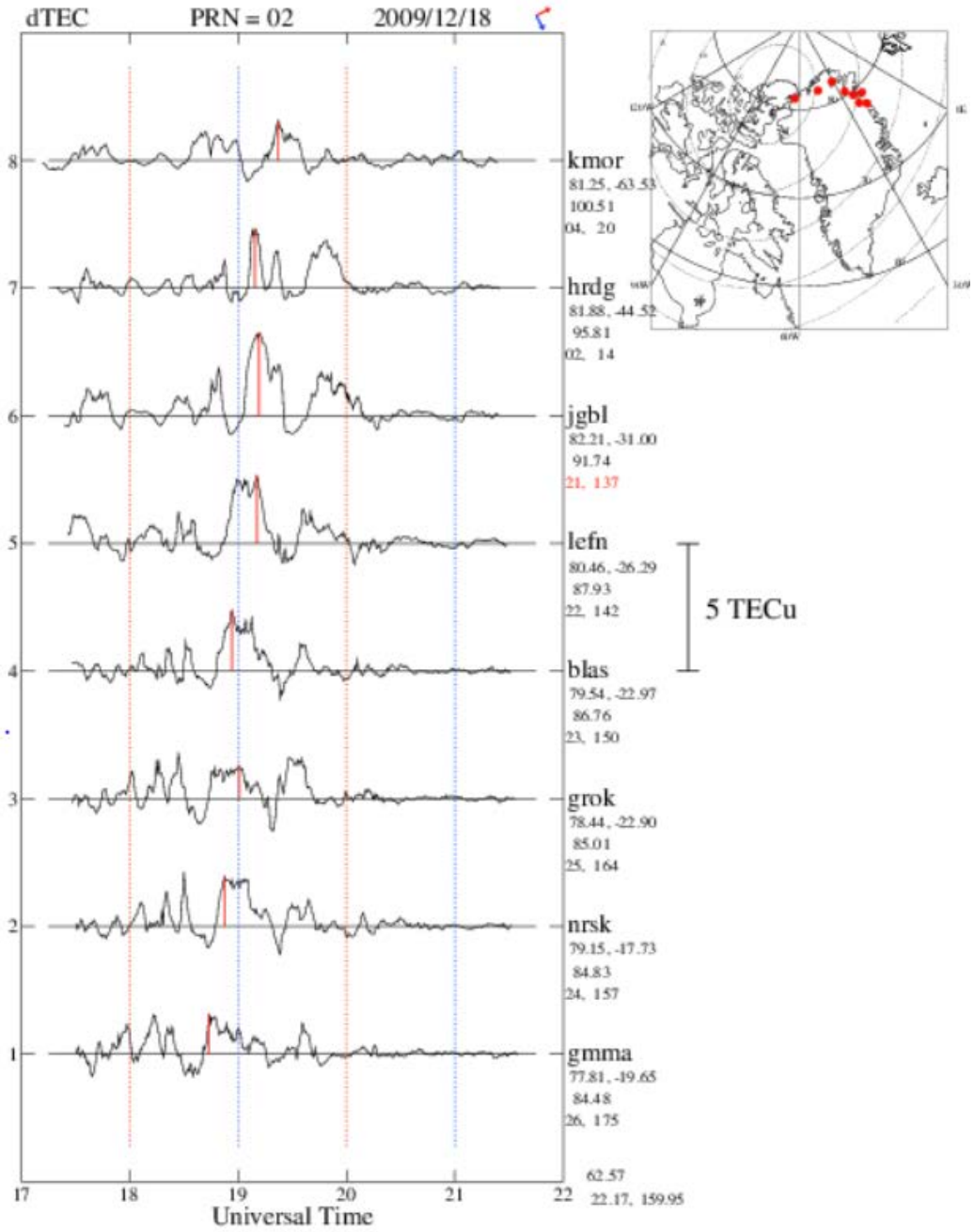
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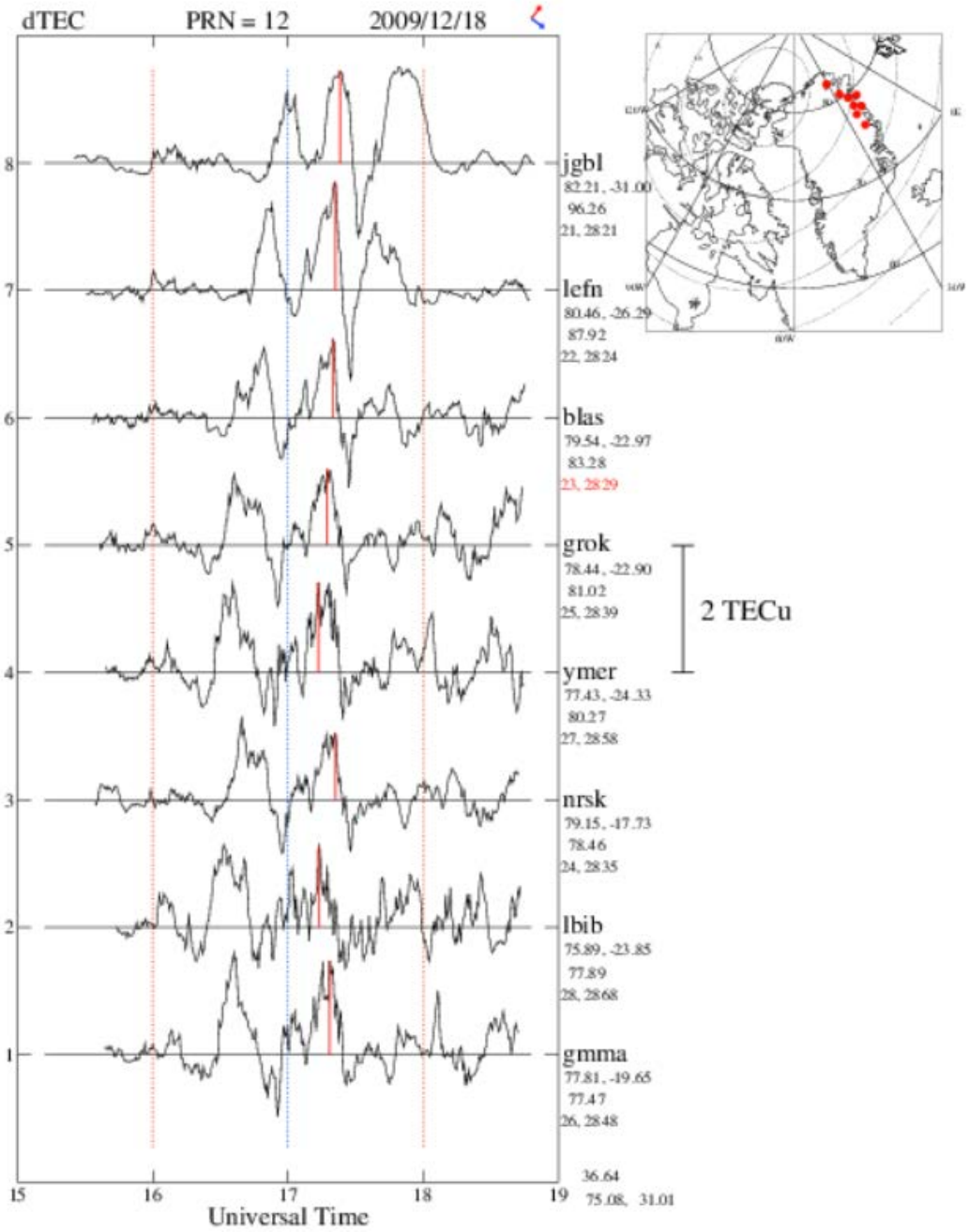
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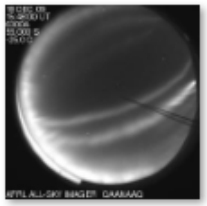
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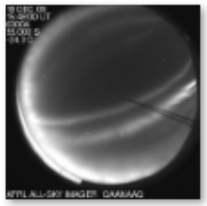
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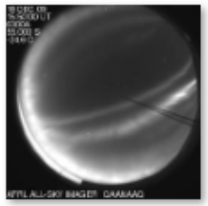
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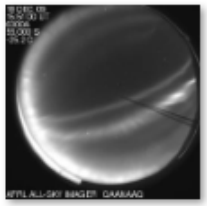
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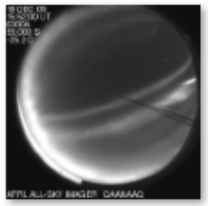
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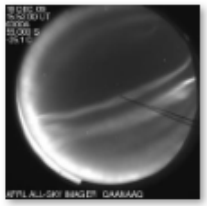
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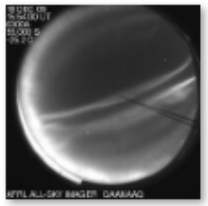
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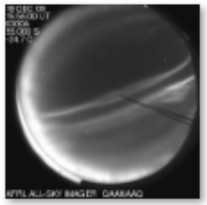
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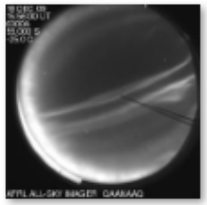
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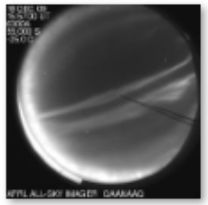
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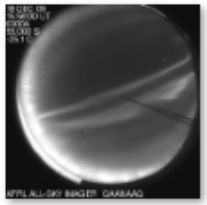
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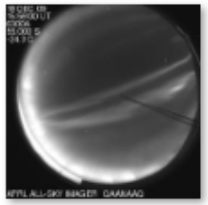
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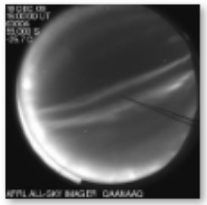
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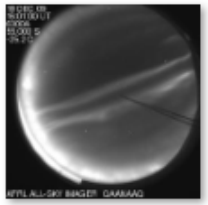
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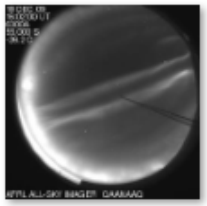
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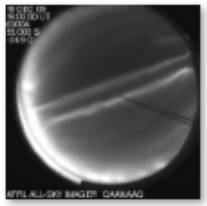
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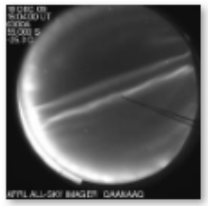
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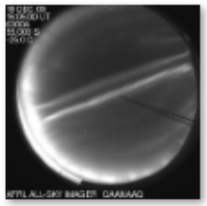
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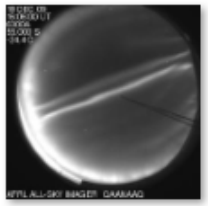
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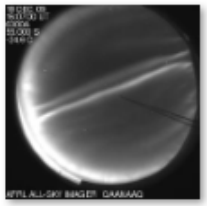
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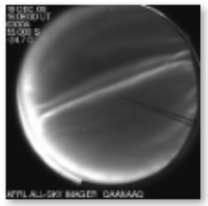
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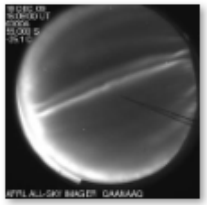
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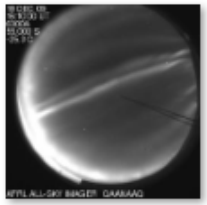
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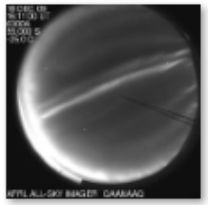
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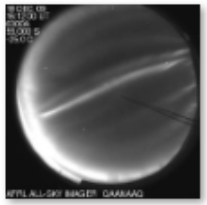
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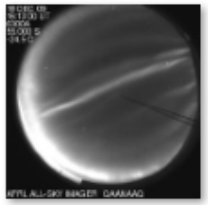
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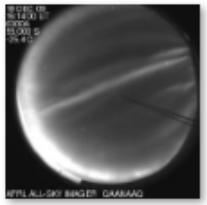
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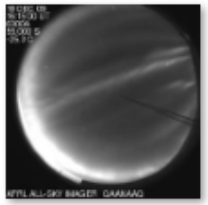
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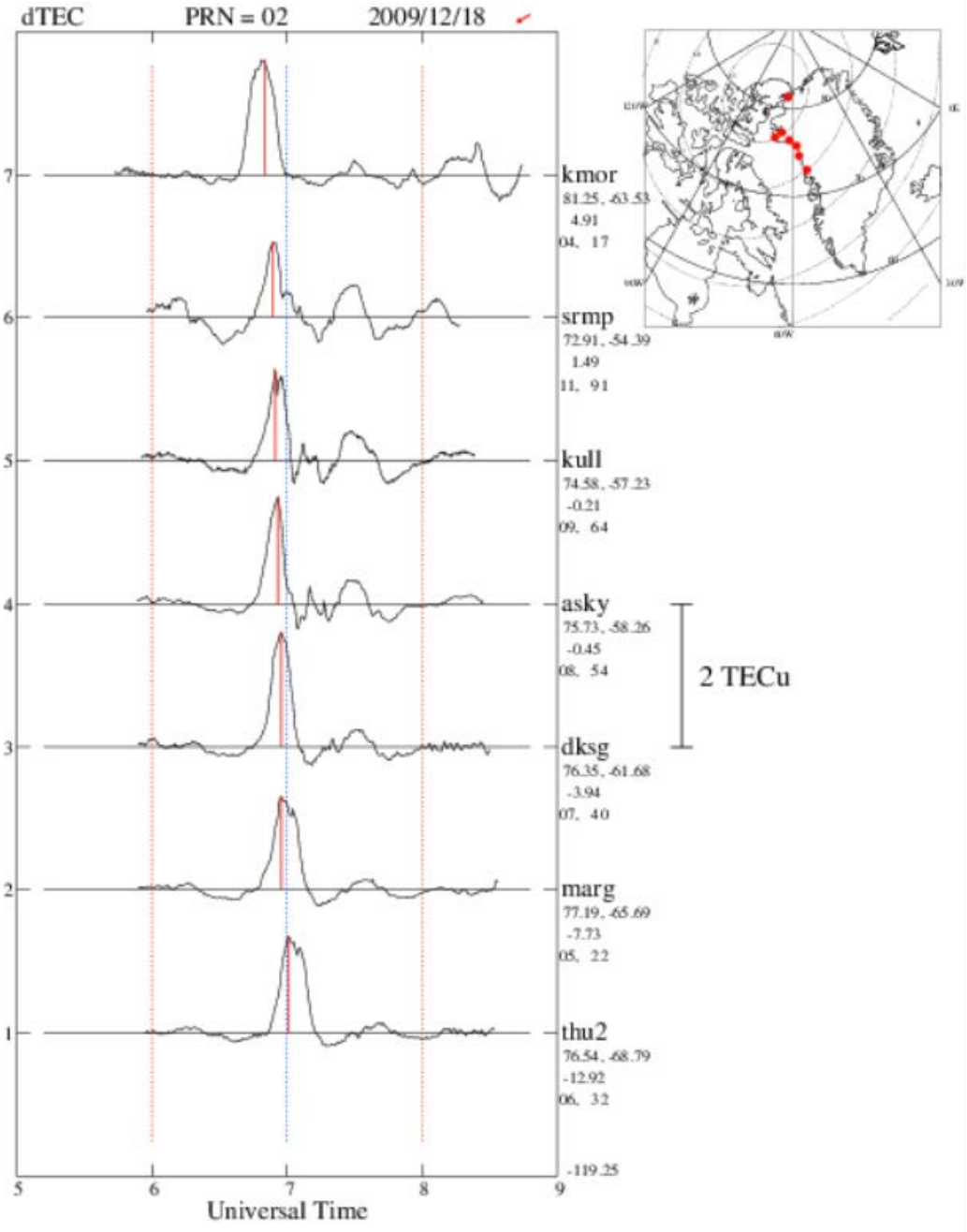
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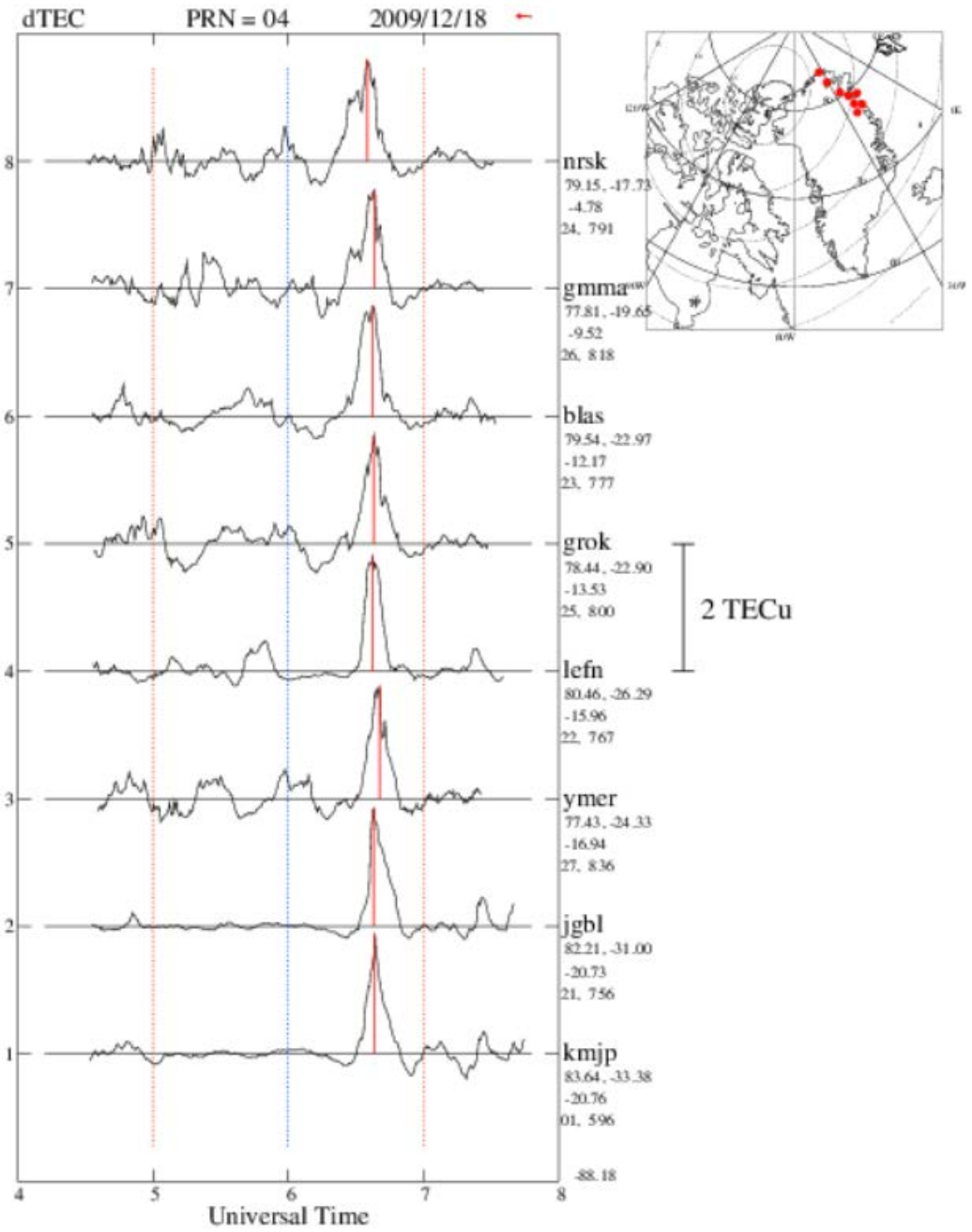
9
Universal Time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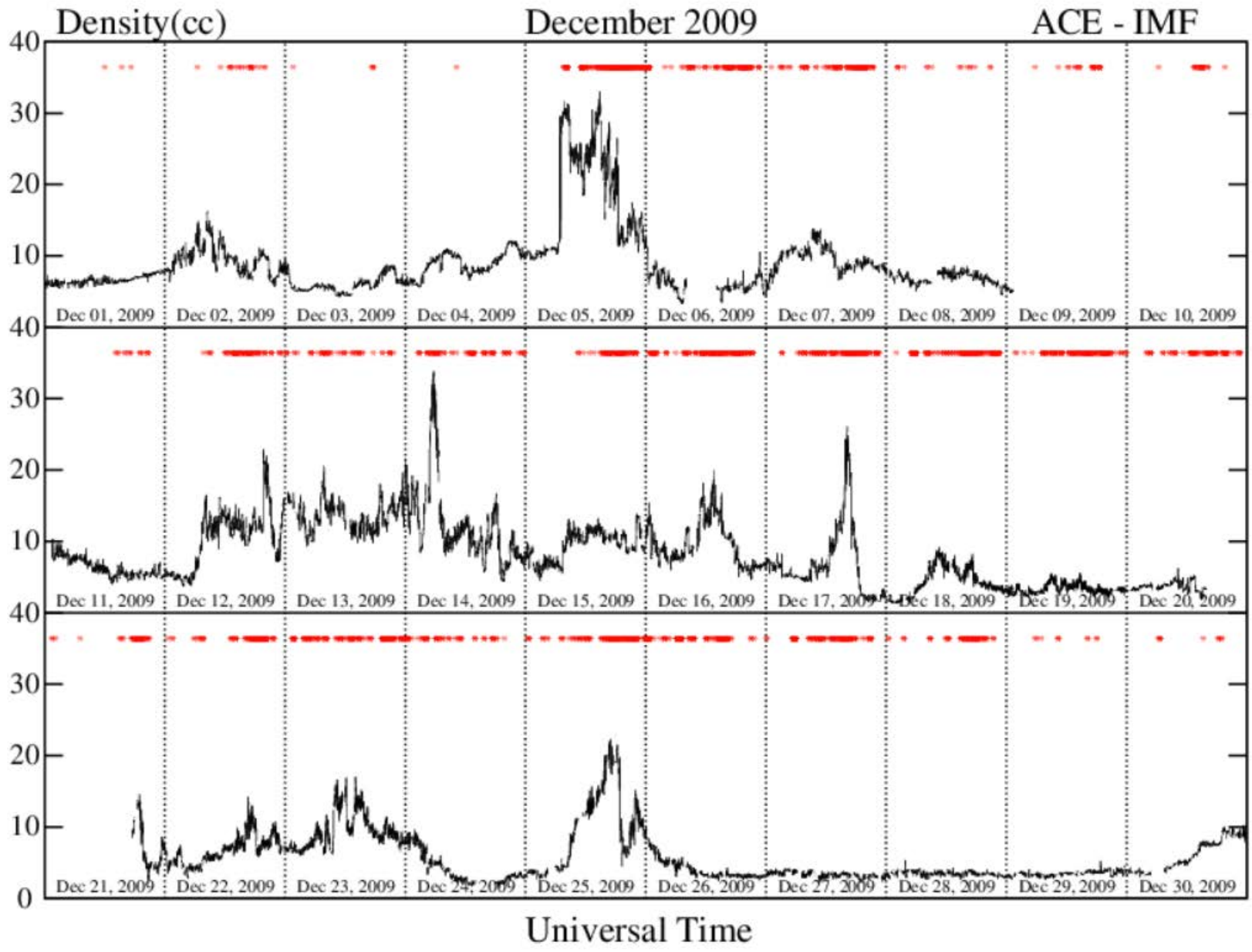
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