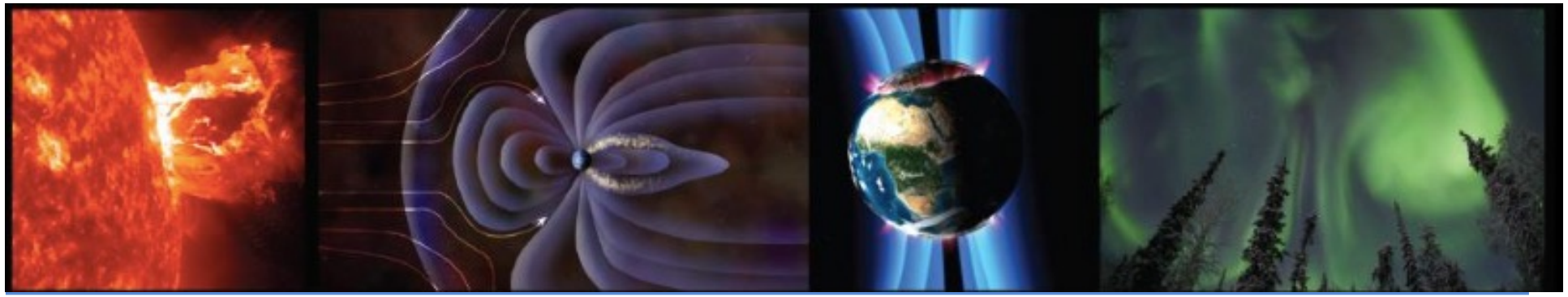

Exploiting data for ionospheric research

Anthea Coster, MIT Haystack Observatory

The case for merging TEC with other data:

TEC and incoherent scatter radar
TEC and data from the Image atellite
TEC and SuperDARN
Differential TEC and All-sky cameras (TIDs)
Differential TEC and Ampere data
Summary

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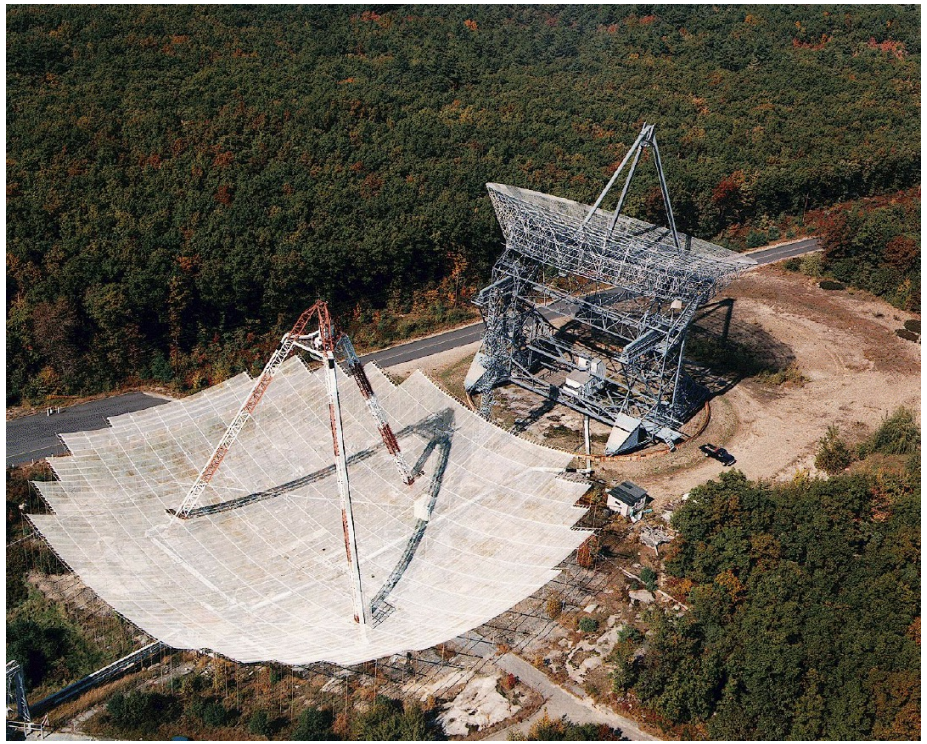
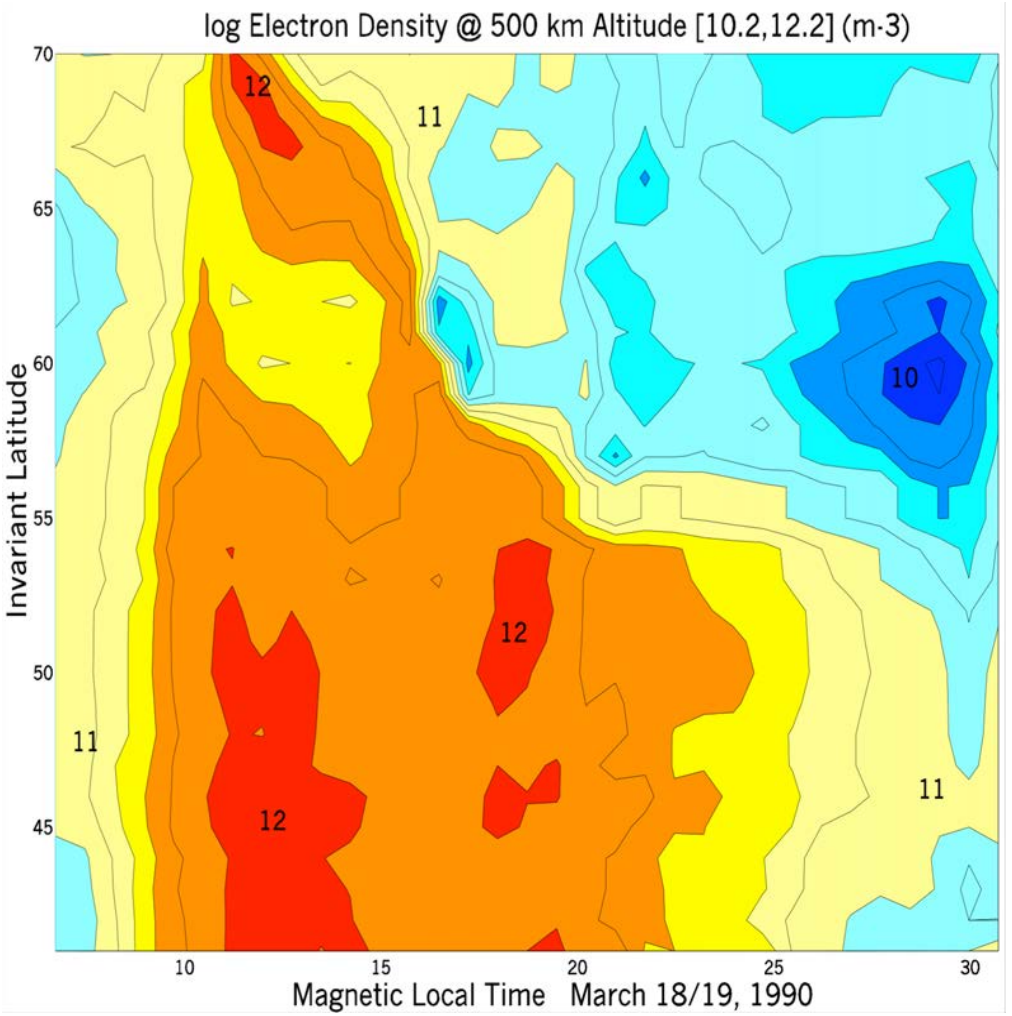
Incoherent Scatter measurement 18-19 March 1990





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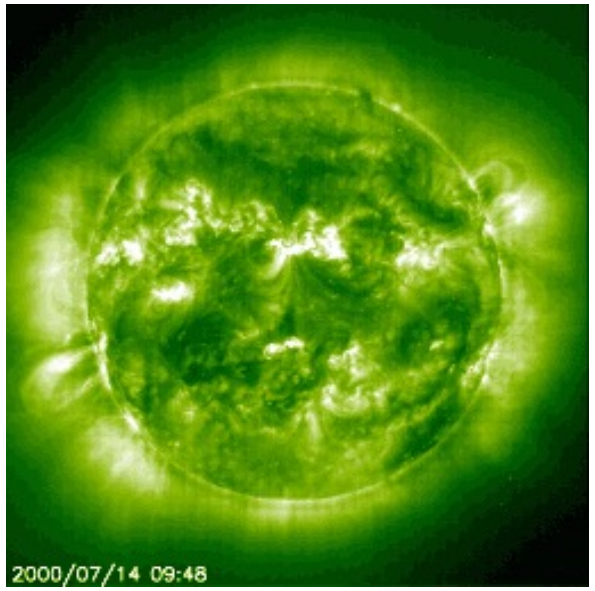
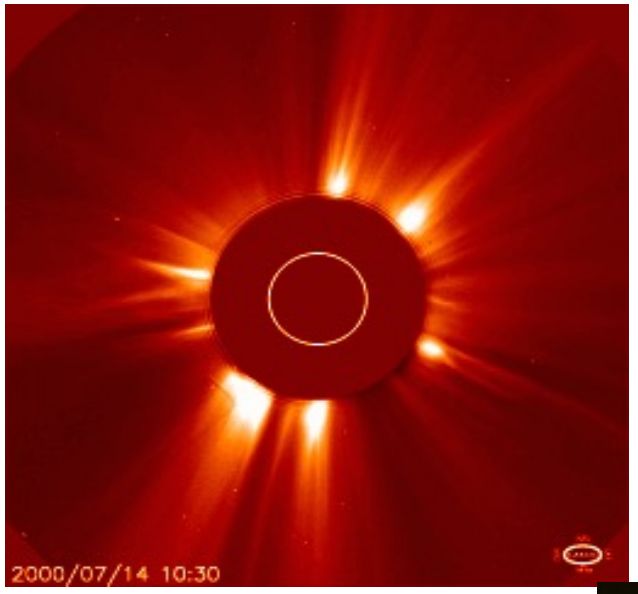
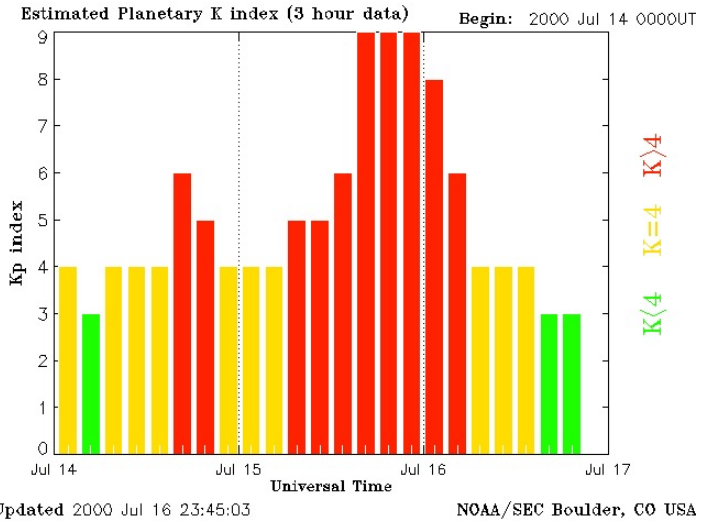
Solar Flare of 14 July 2000

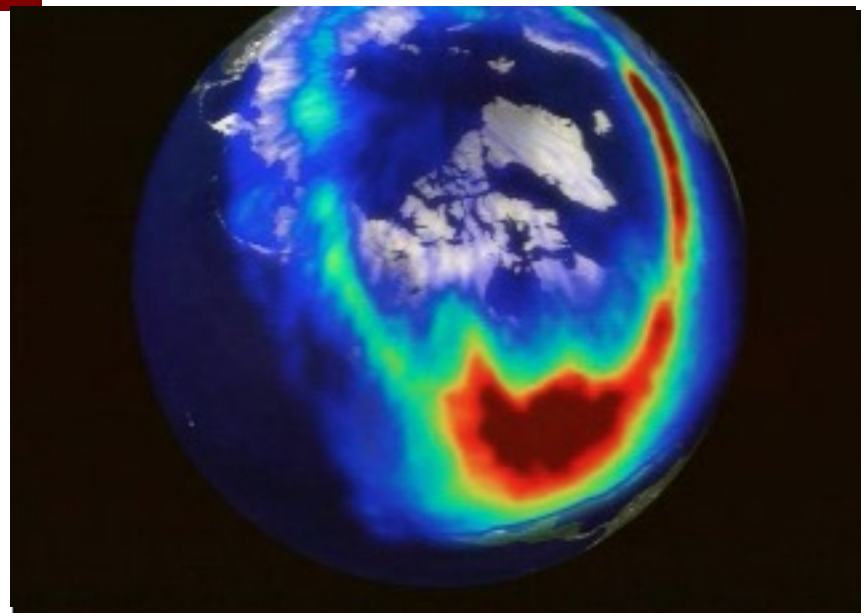




Biggest Solar Storm in Nine Years

Caused very large magnetic storm and ionospheric effects





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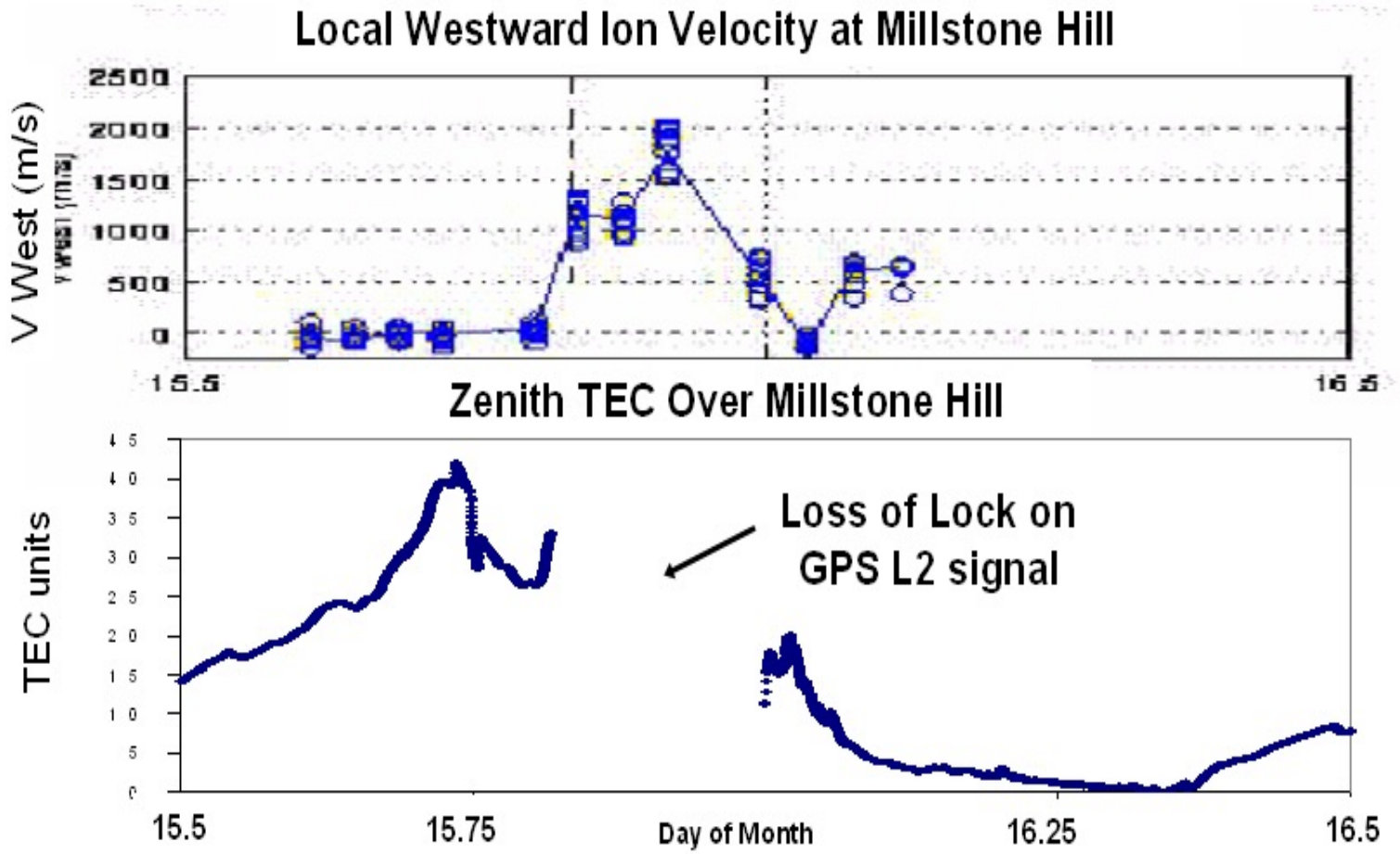
GPS Loss of Lock at Millstone Hill



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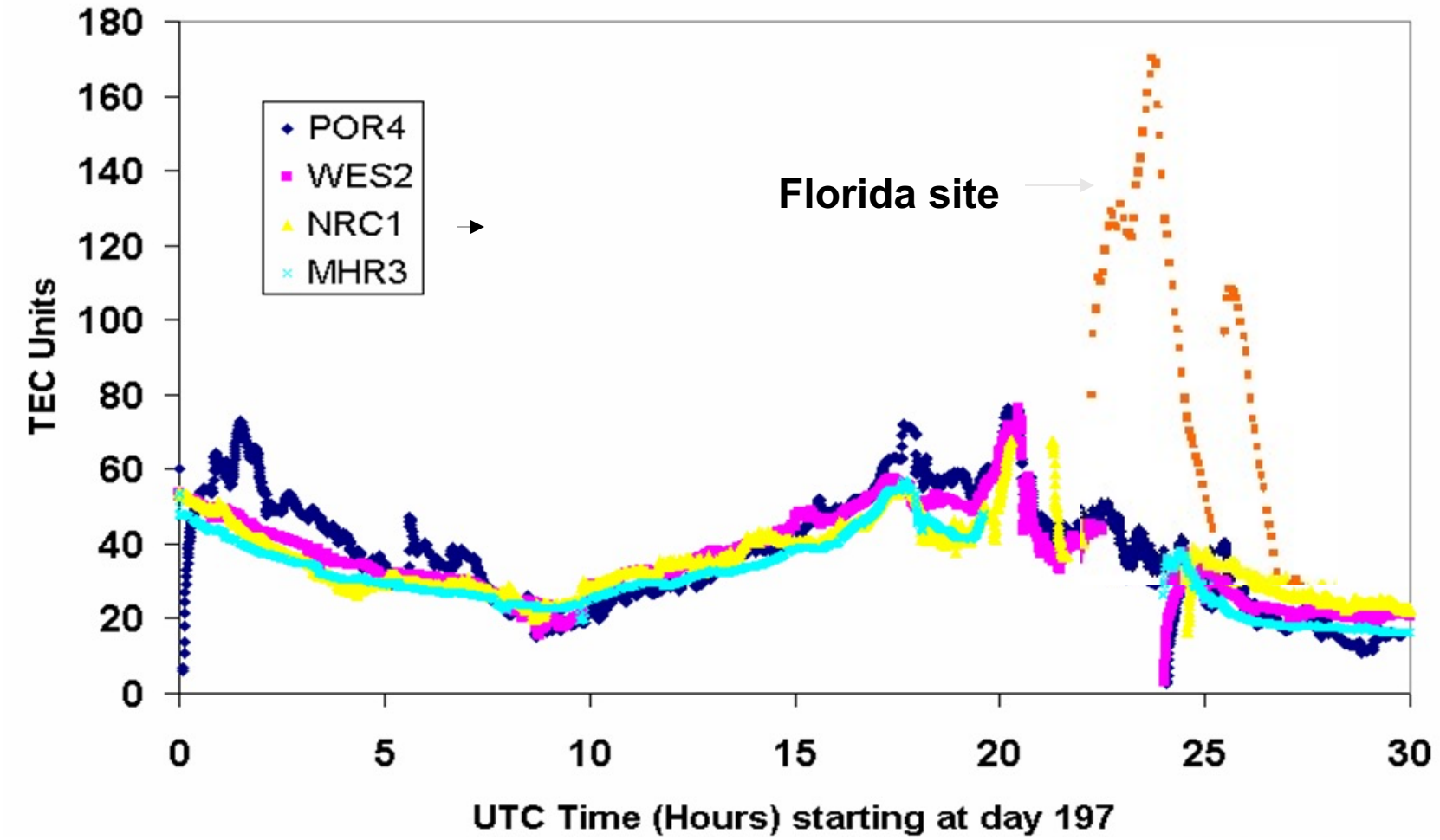
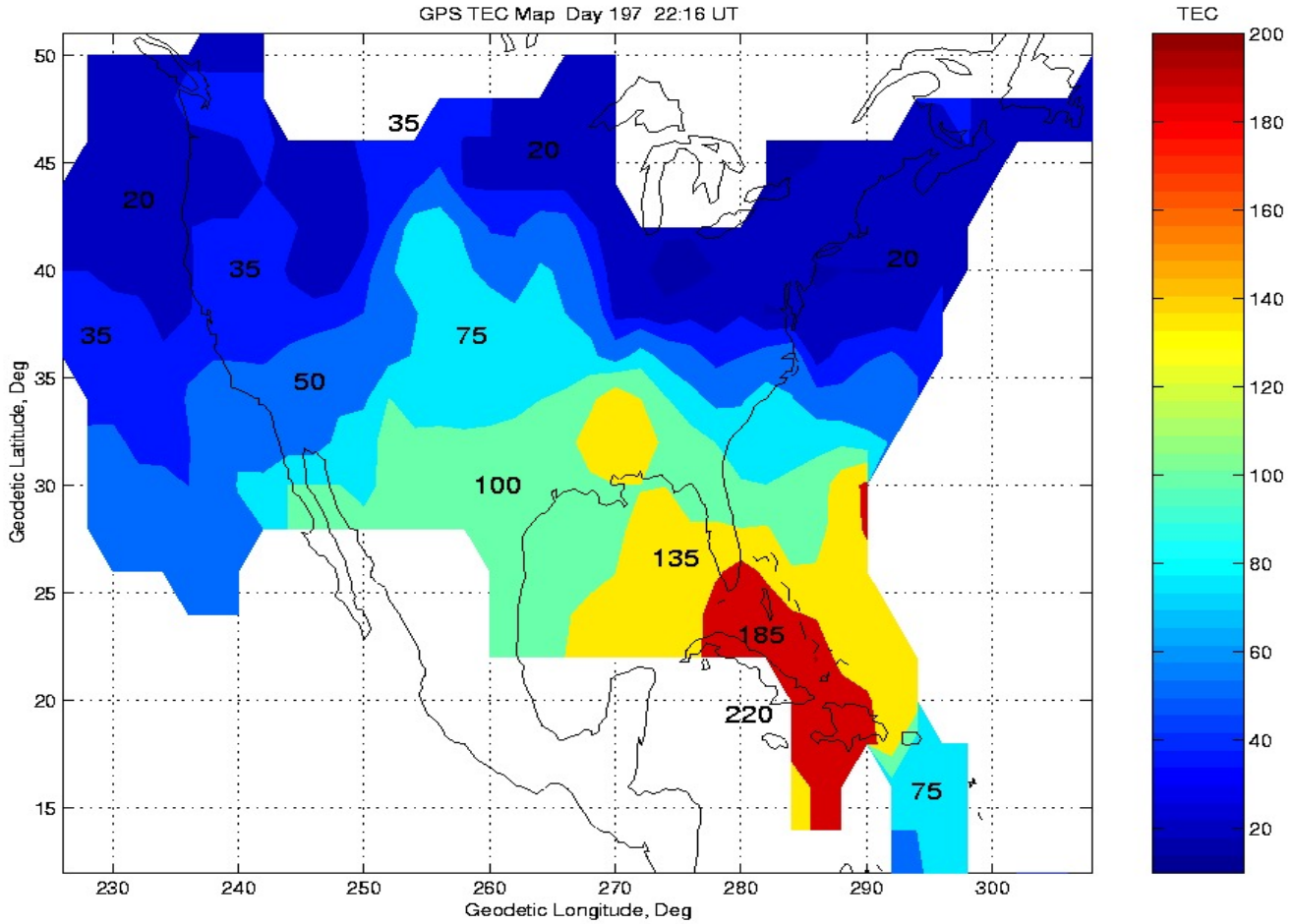
TEC Disturbances on 15 July 2000



First SED Plume imaged by GPS – July 14, 2000



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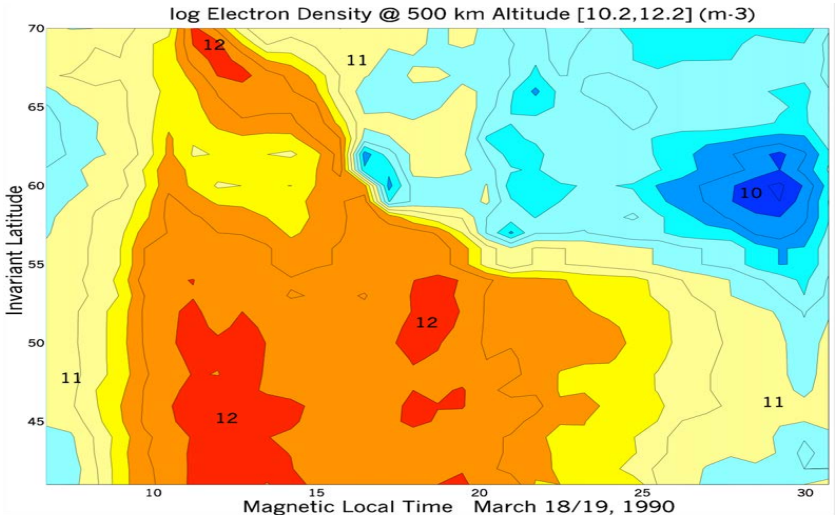
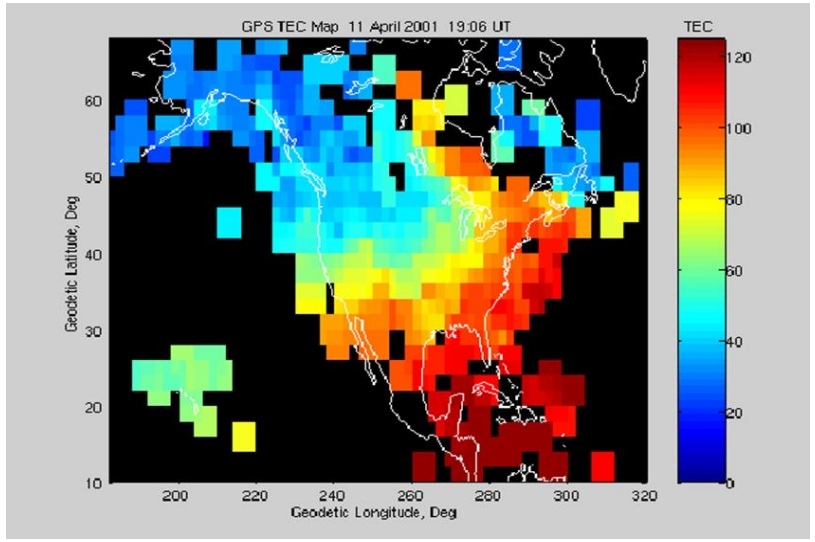
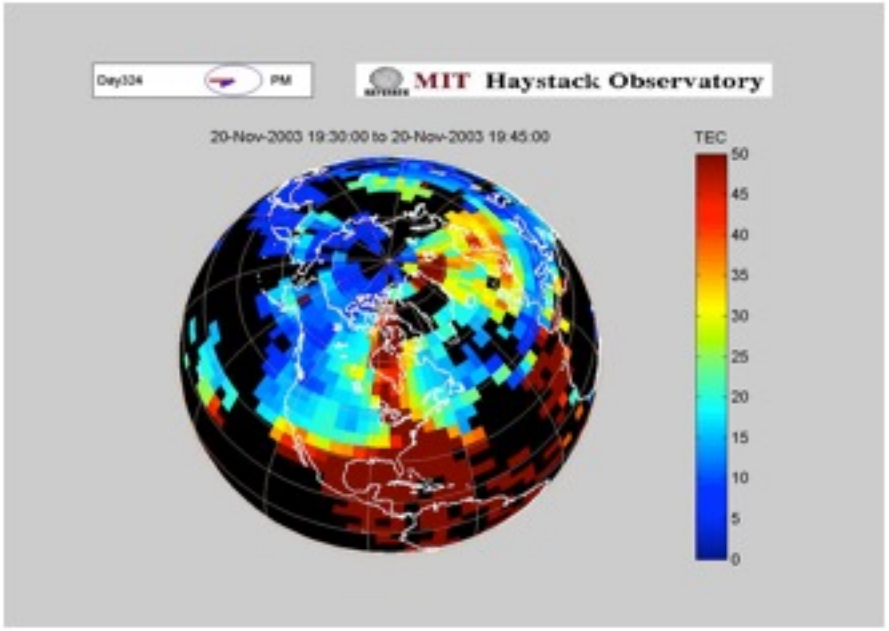
Day 90, 2001



Day 101, 2001



Day 324, 2003



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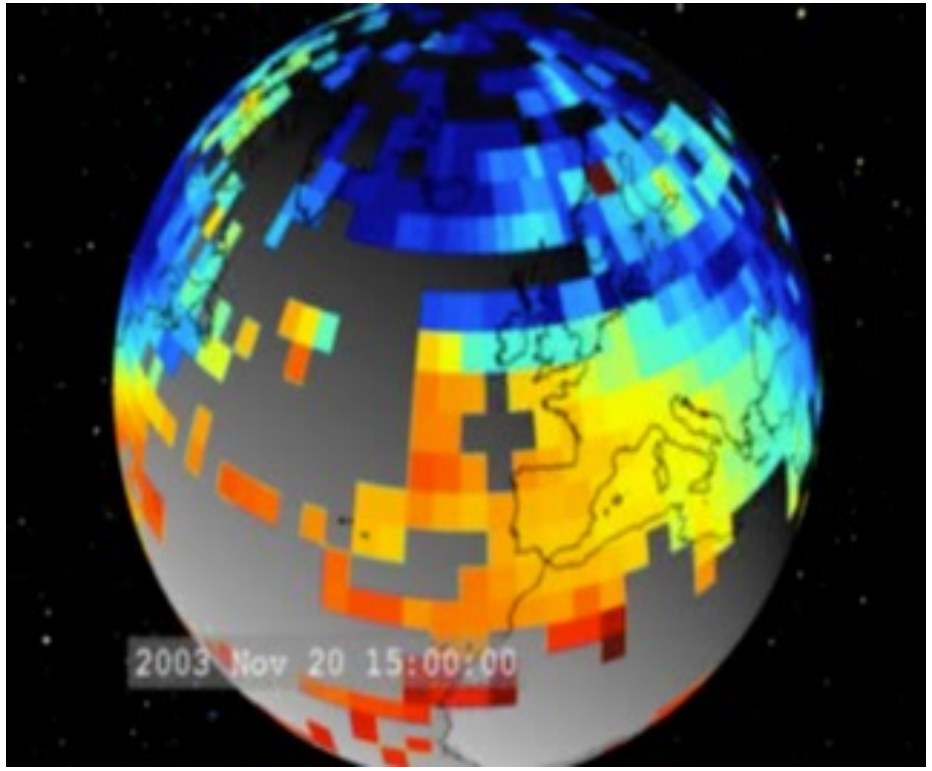
20 November 2003



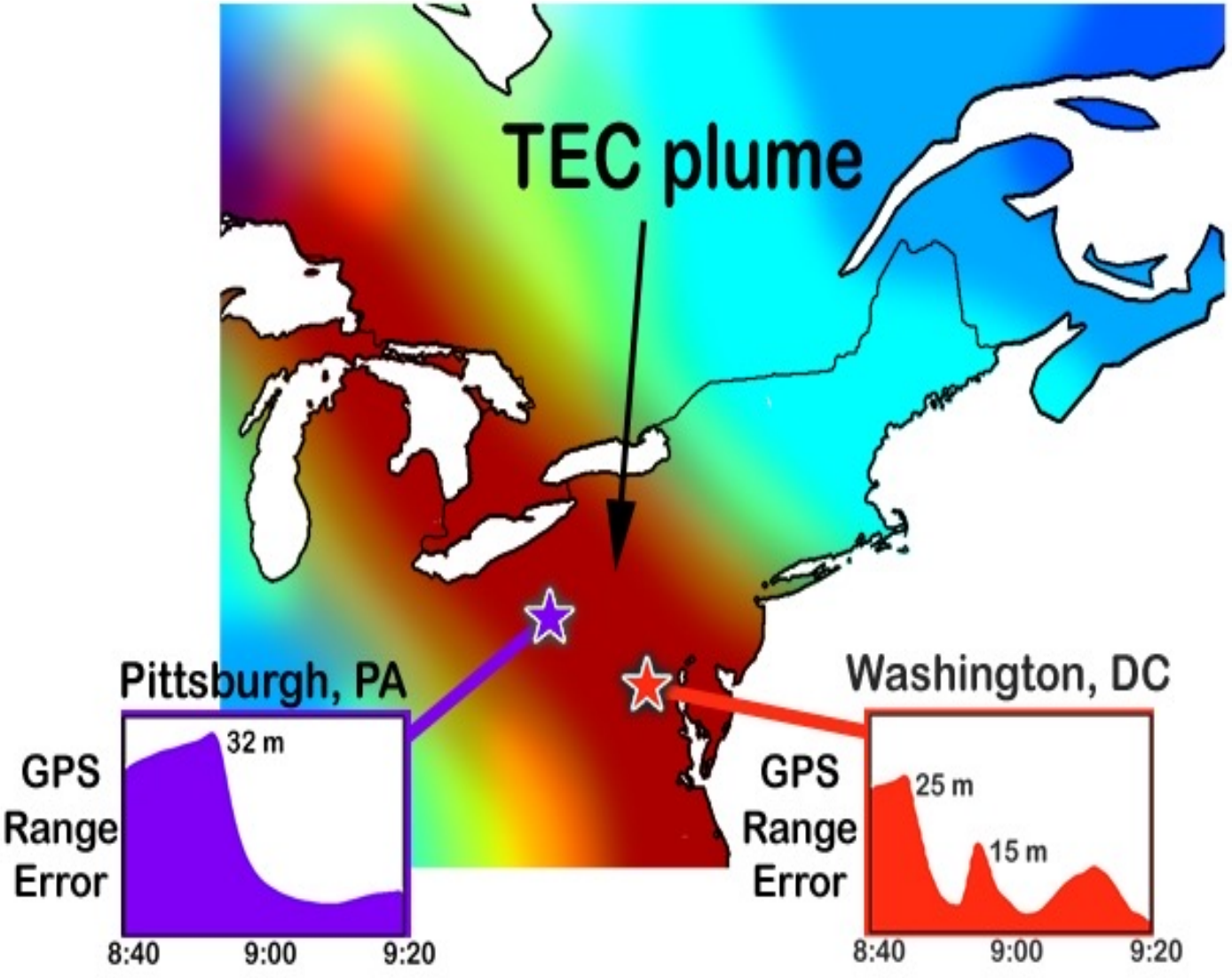


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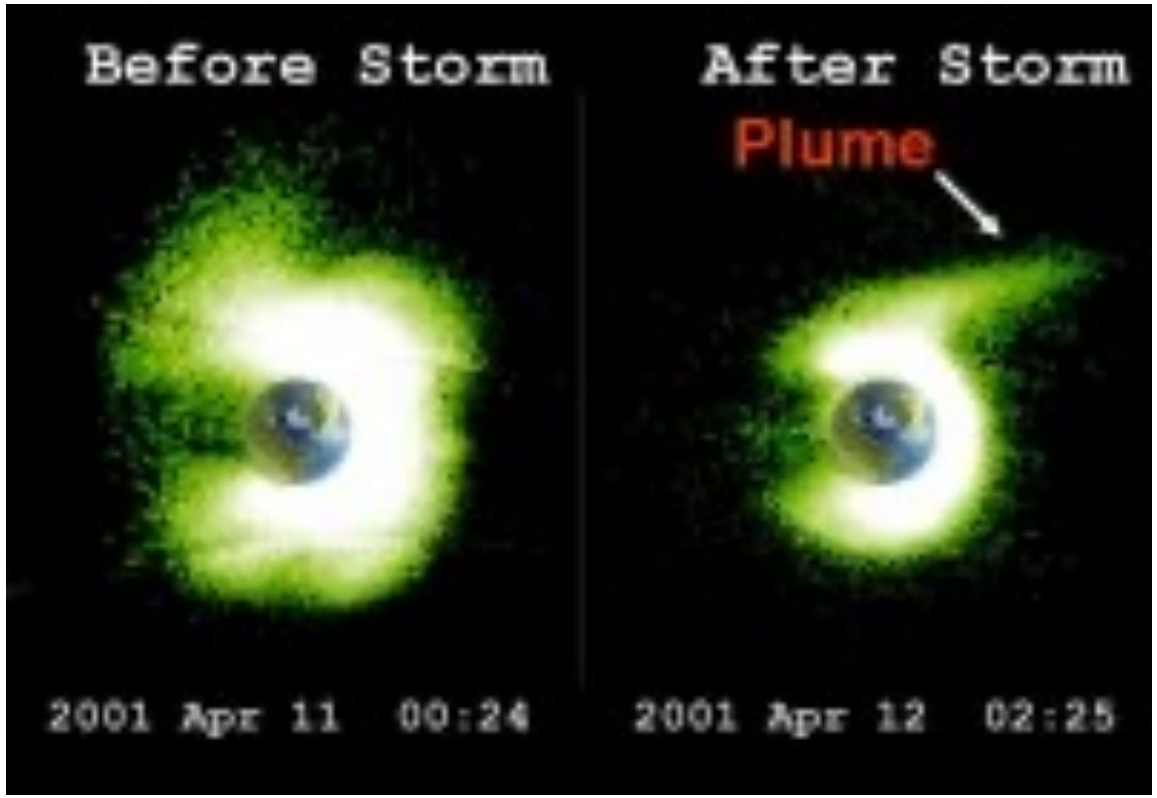
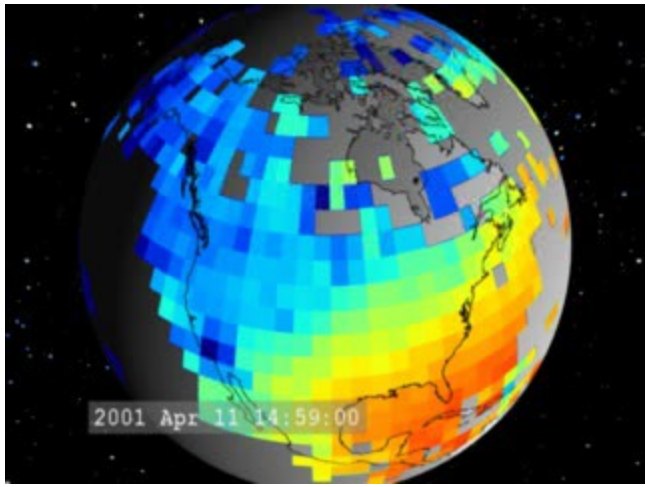
IMAGE Data of Plasmasphere





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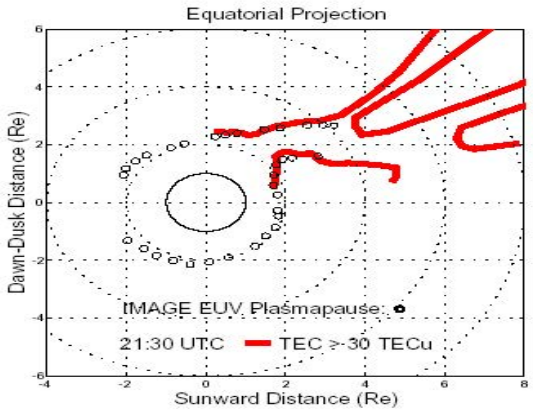
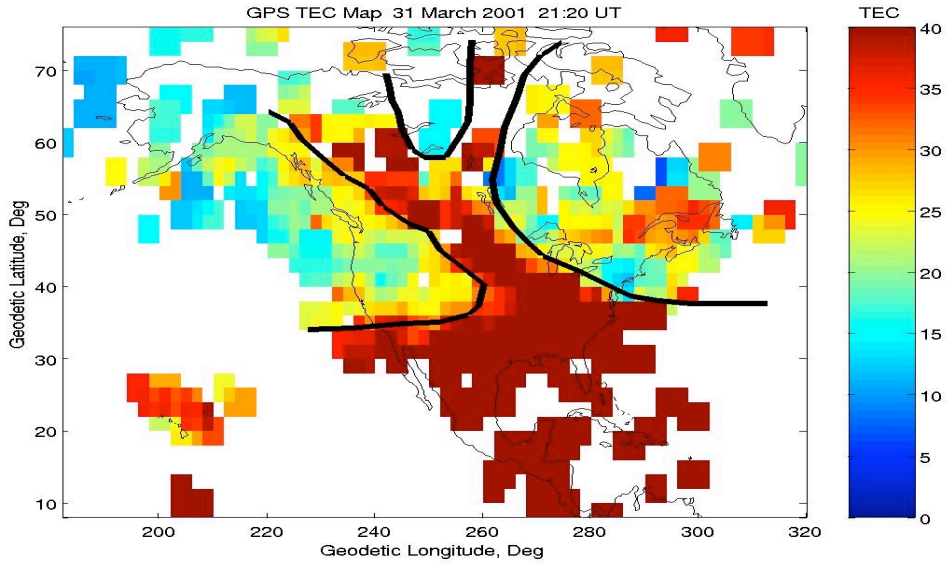
Plasmaspheric Tails and Storm Enhanced Density





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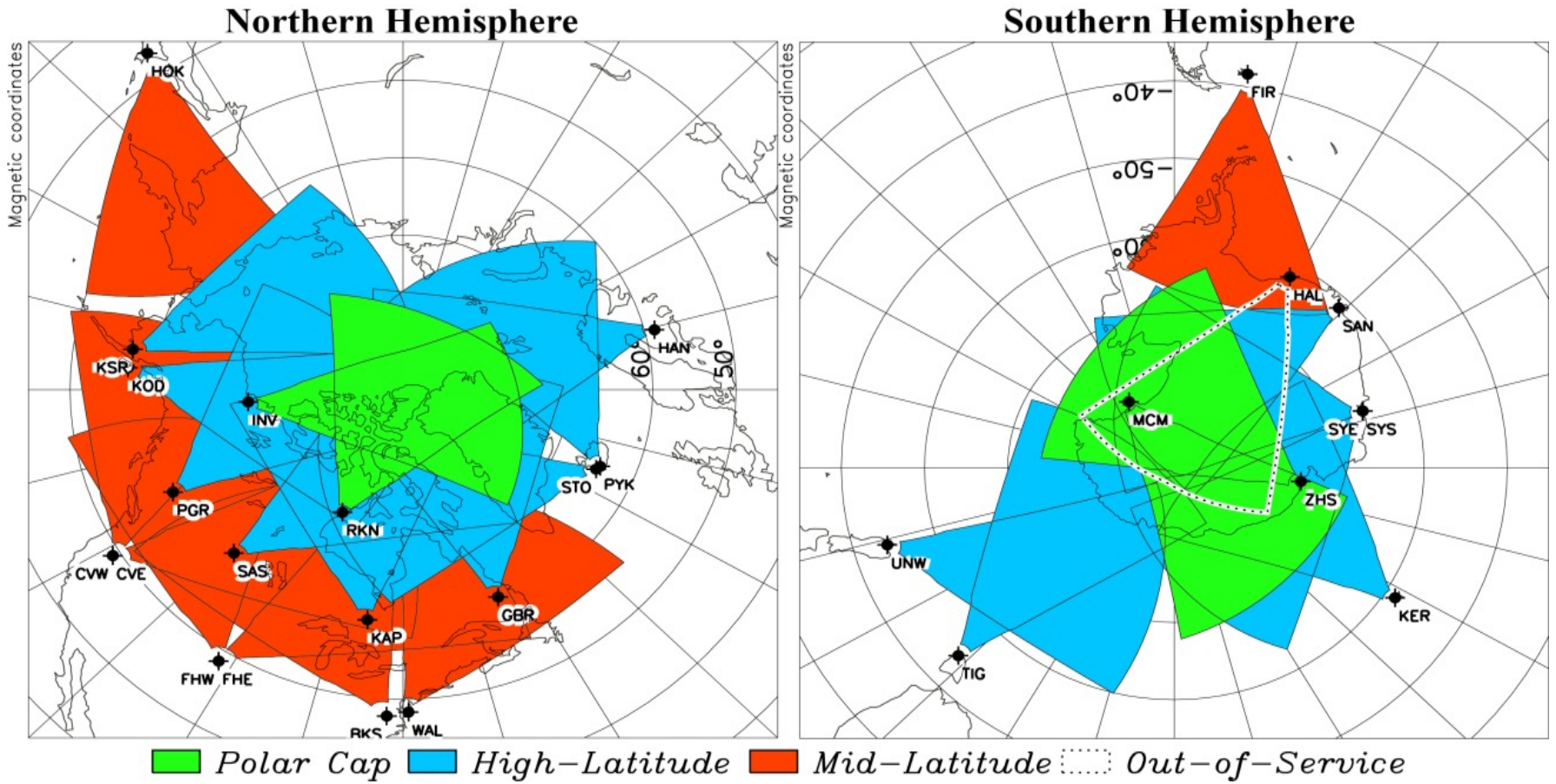
Super Dual Auroral Radar Network

SuperDARN

- OTH Radar System for measuring ionospheric convection.
- Coherent Radar System
- Frequency agile between 8 and 20 MHz.
- Frequency choices determined by PI of radar or by committee.

SuperDARN
Extended Coverage in both Hemispheres



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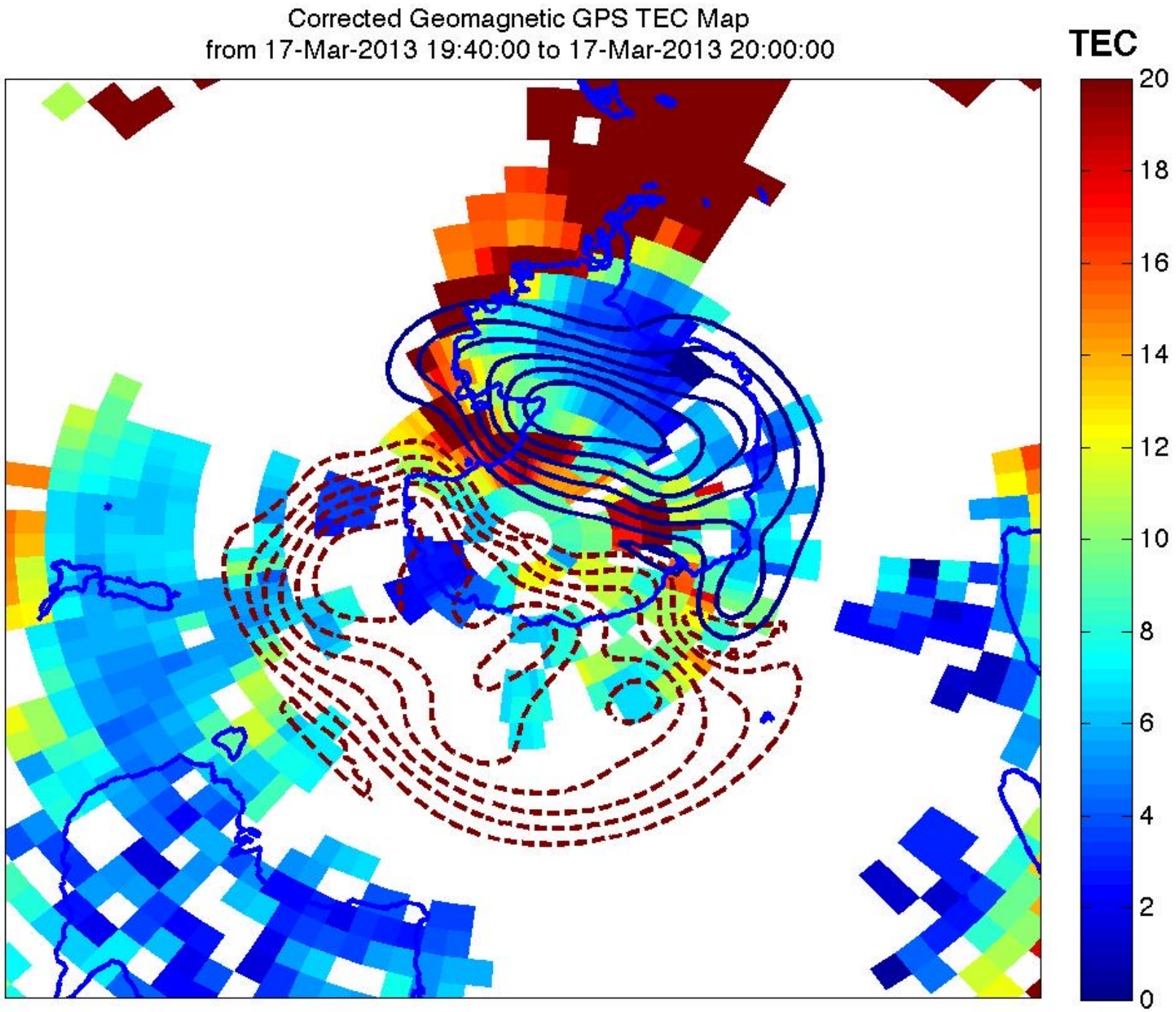
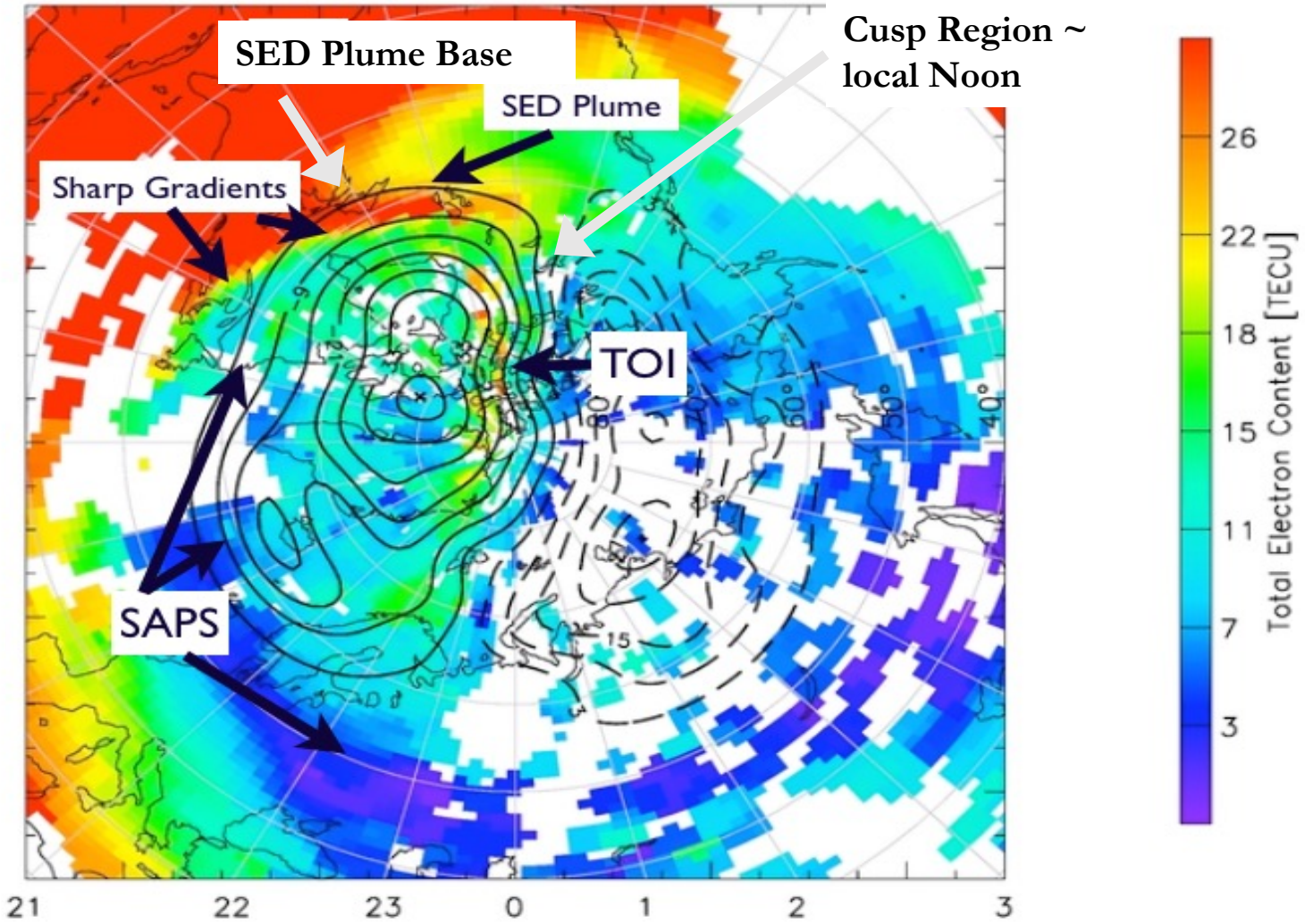
OBSERVATORY


Corrected Geomagnetic GPS TEC Map
from 17-Mar-2013 19:40:00 to 17-Mar-2013 20:00:00
TEC
20
18
16
14
12
10
8
6
4
2
0

Common Features observed in TEC during geomagnetically disturbed conditions

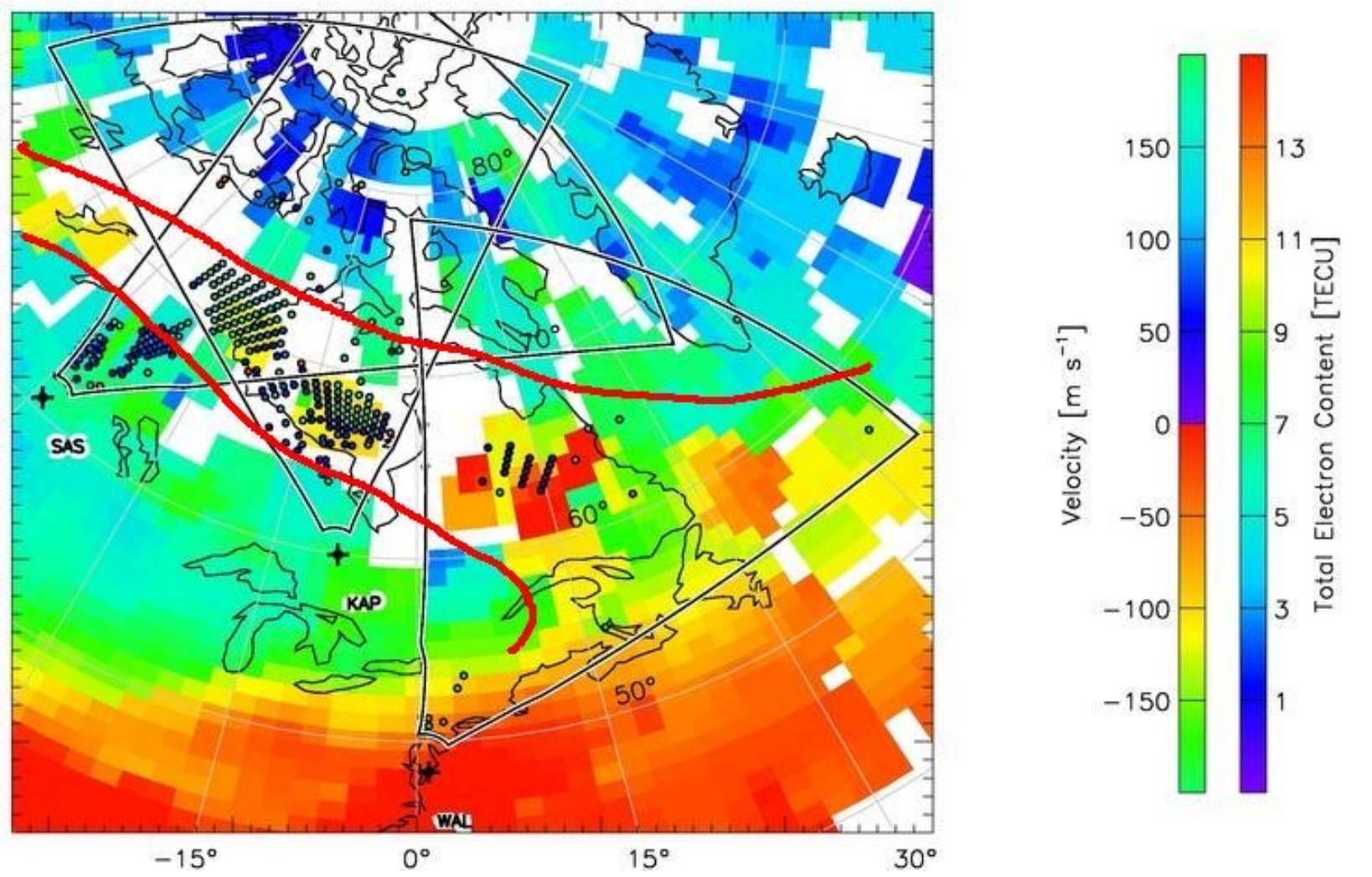


MIT HAYS OBSE

TOTAL ELECTRON CONTENT

Median Filtered, Threshold = 0.01

04/Feb/2009 18:50:00.0
to
04/Feb/2009 18:55:00.0

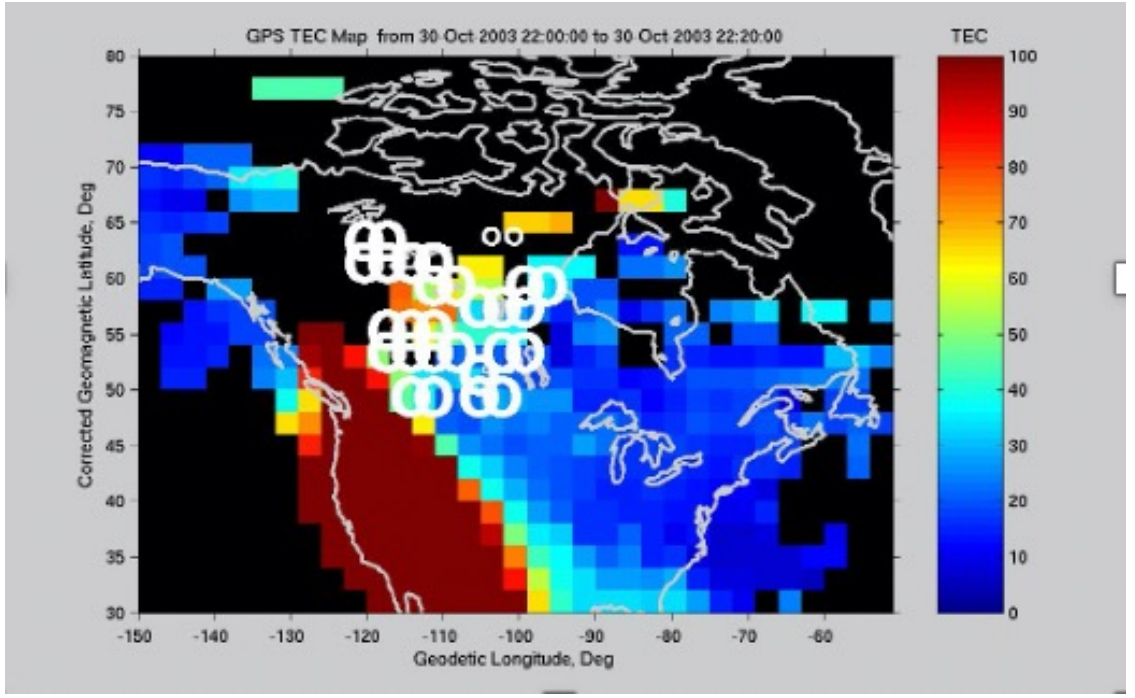


First Observations of Mid-Latitude Scintillations (2002)

Temporal properties of intense GPS L1 amplitude scintillations at midlatitudes

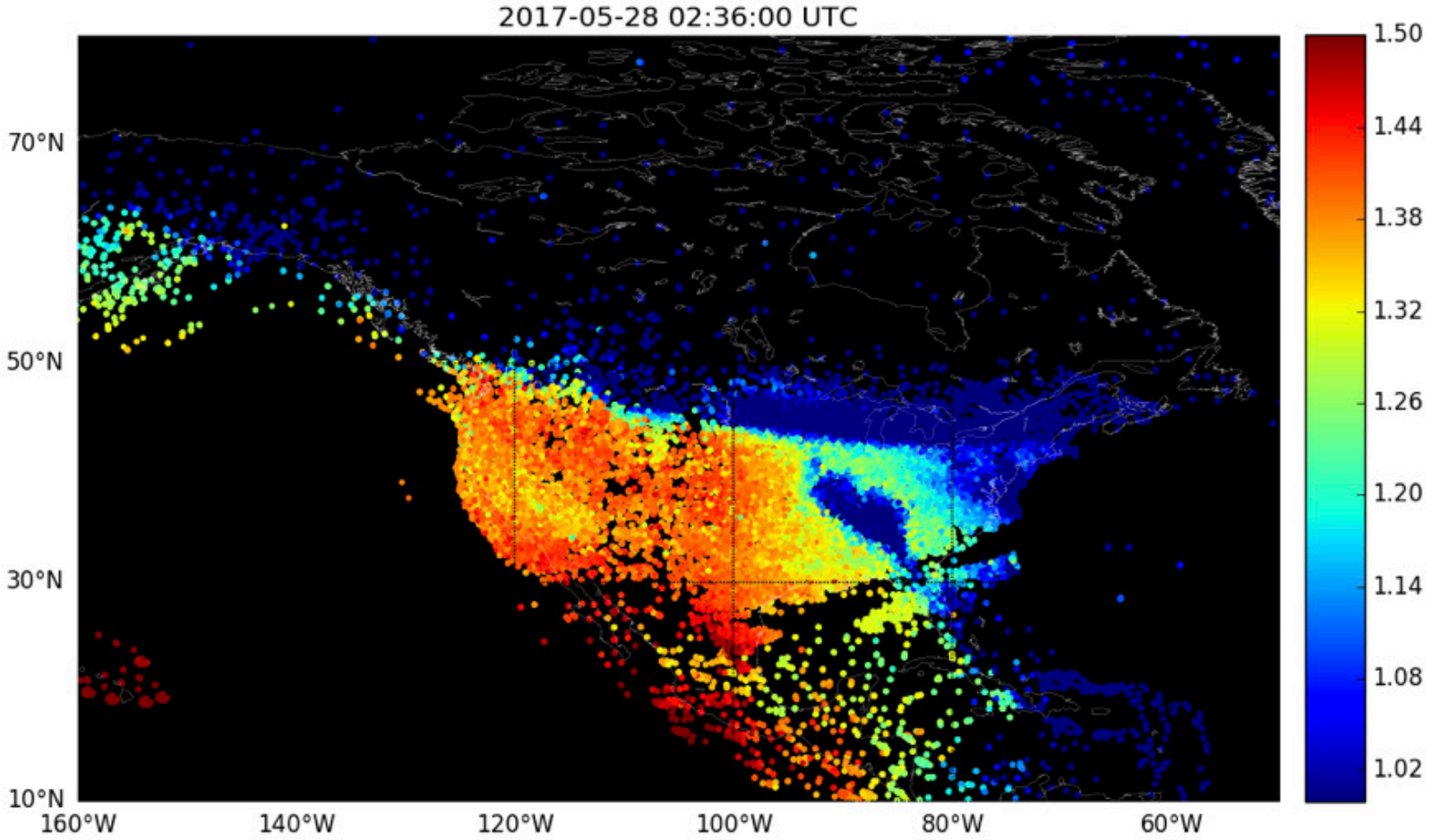
B. M. Ledvina ; P. M. Kintner ; J. J. Makela

GEOPHYSICAL RESEARCH LETTERS, VOL. 29, No. 14, 1659, 10.1029/2002GL014770, 2002



MIT HAYSTACK OBSERVATORY

May 28, 2017



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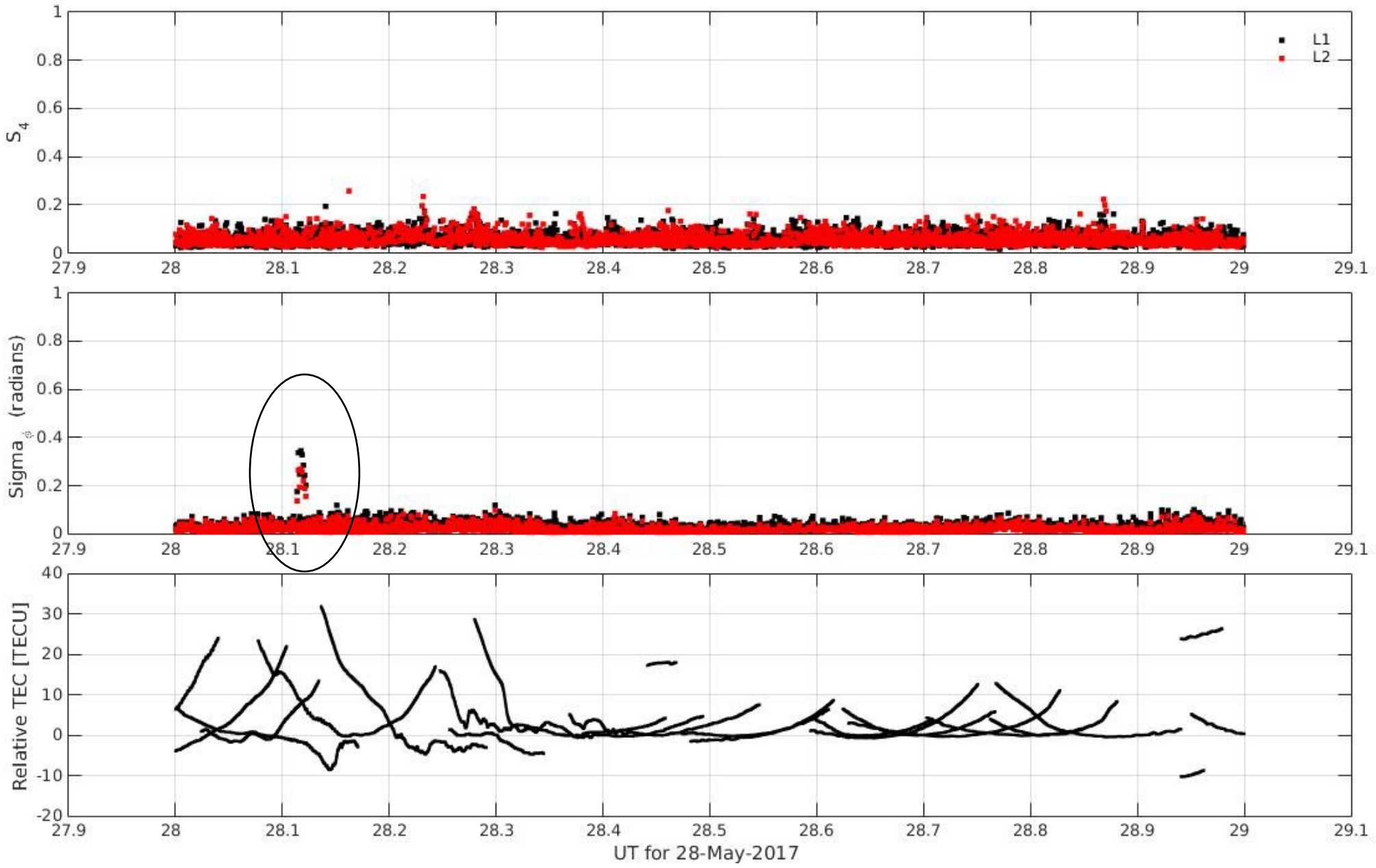
Courtesy of
Prof. Fabiano Rodrigues

UTD



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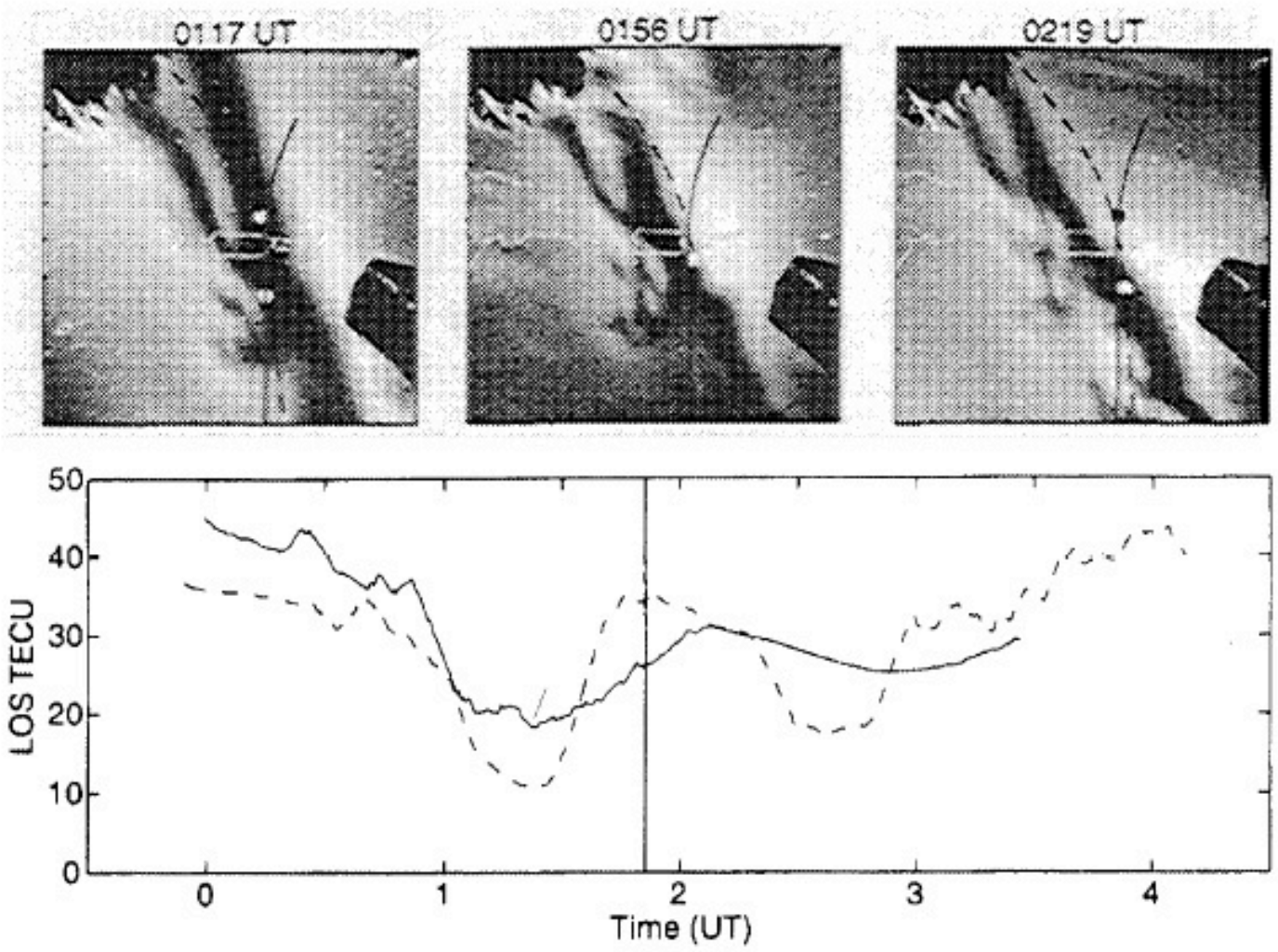
HAYSTACK
OBSERVATORY

GPS and Optical



Makela et al., Radio Science 2001

CEDAR 2004 Applications for GPS/AJM@

June 28, 2004

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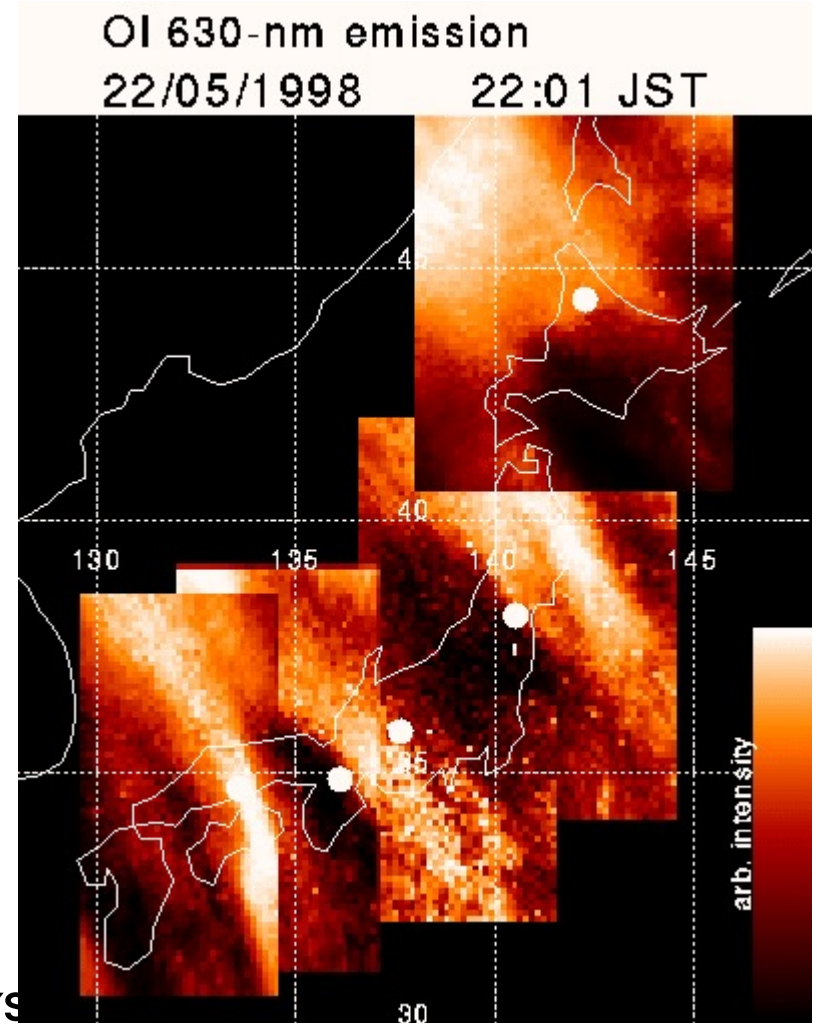
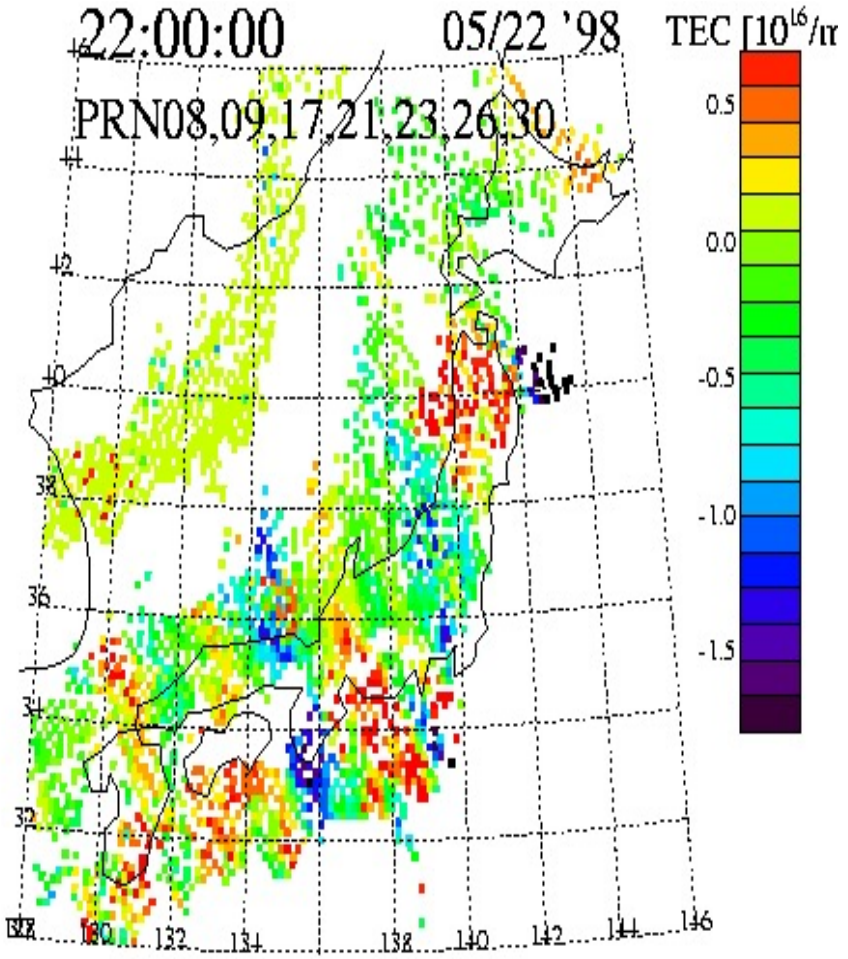
Nighttime MSTID Observations (TEC, Airglow) [*Saito et al.*, 2001]





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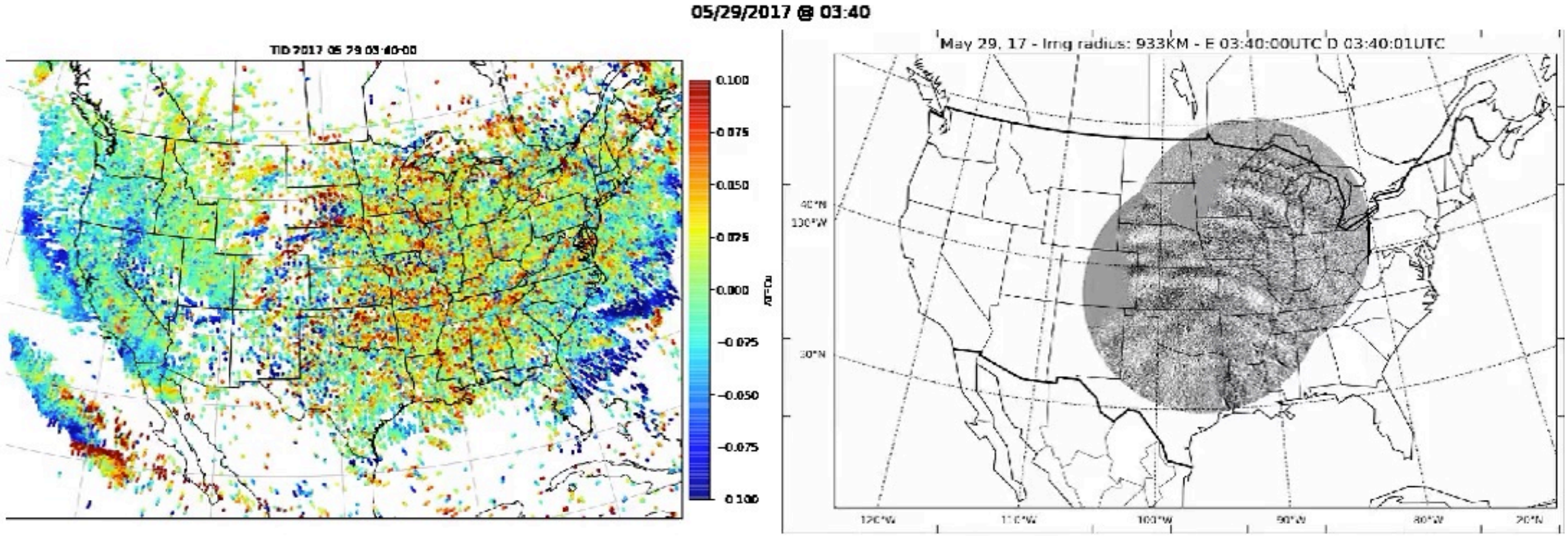
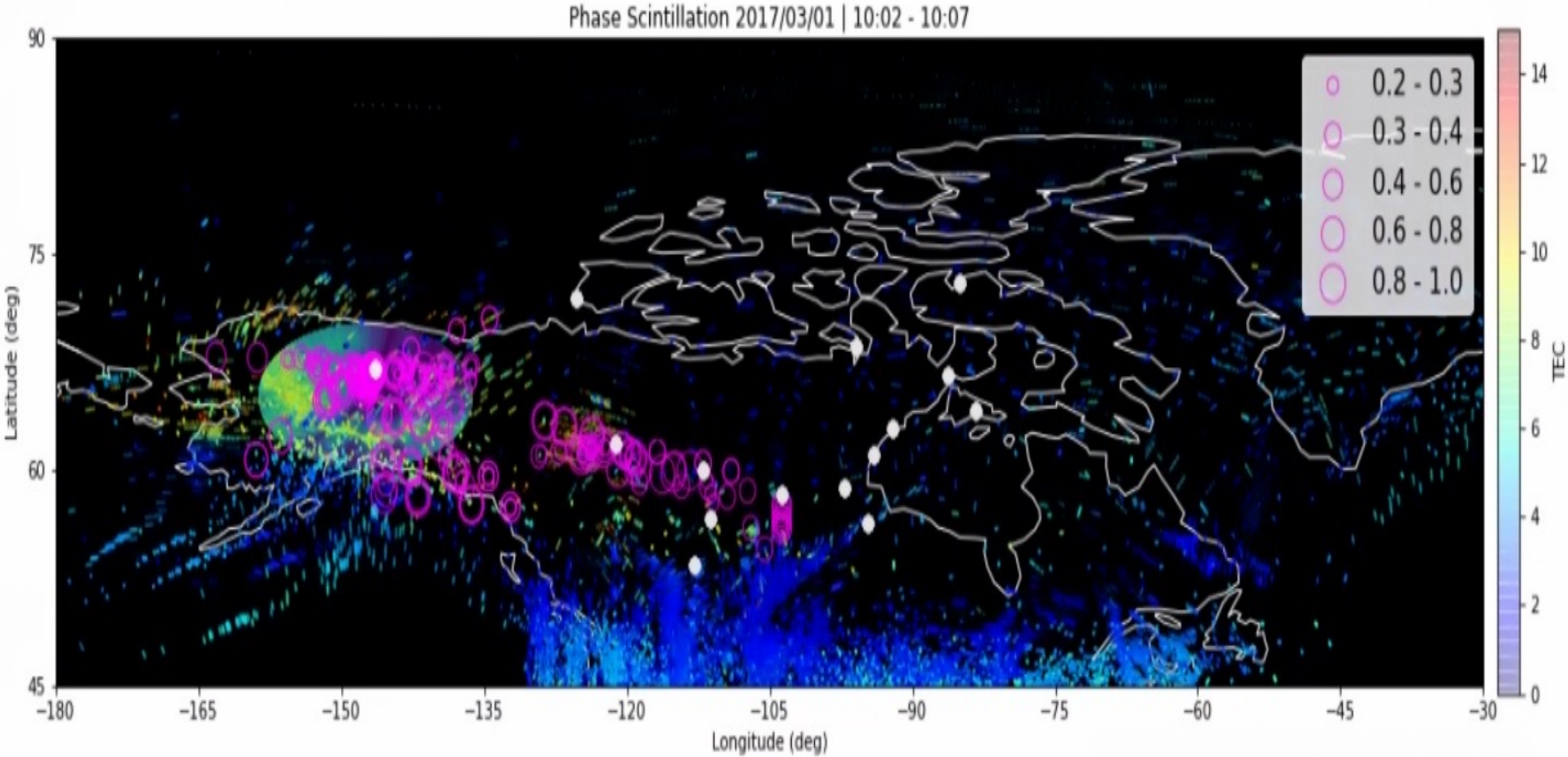
TID’s in Optical and differential TEC



HAYSTACK OBSERVATORY

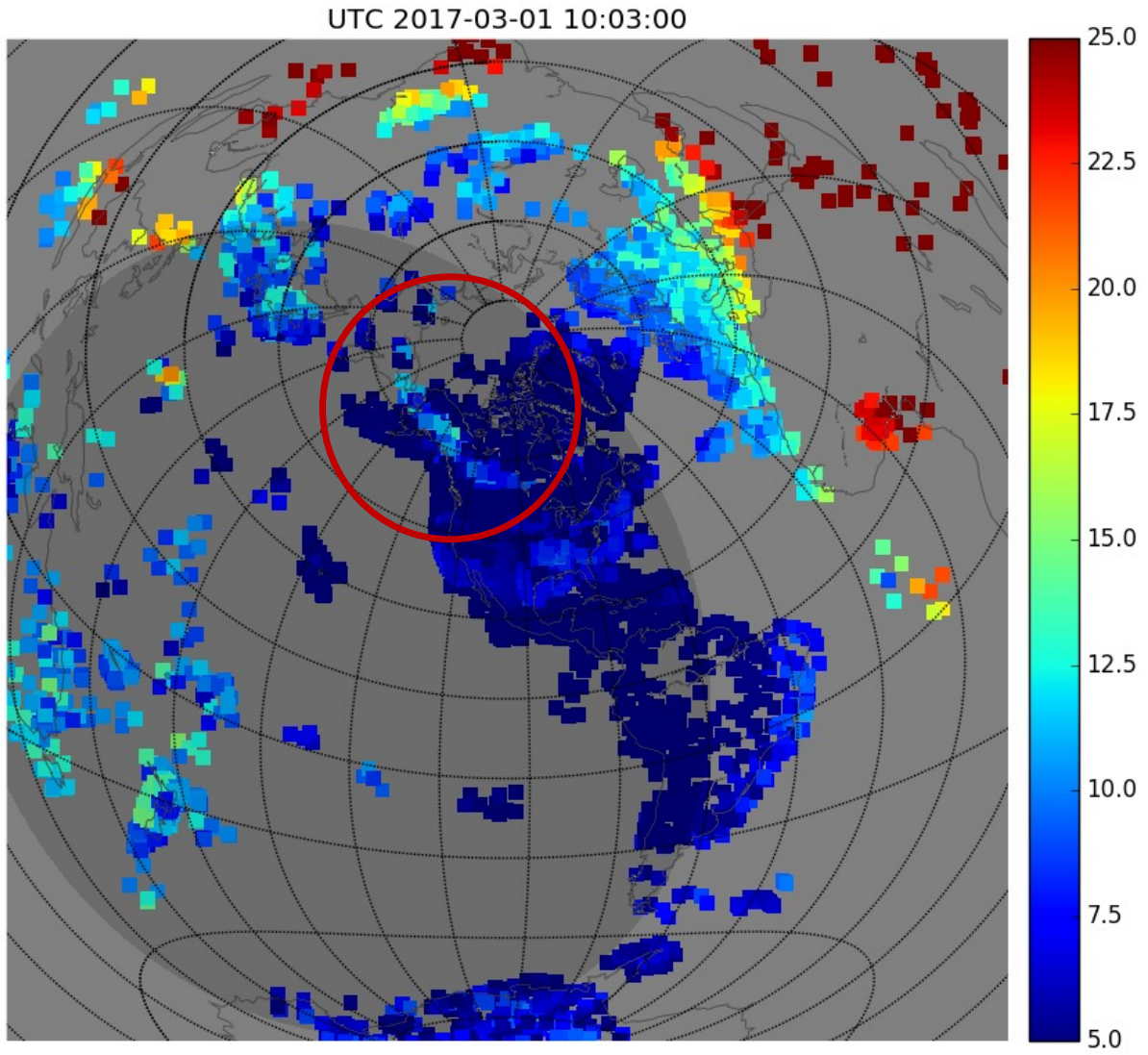


MIT
HAYSTACK
OBSERVATORY

Venetie, Alaska 1 March 2017

MIT
HAYSTACK
OBSERVATORY

10:03 UT



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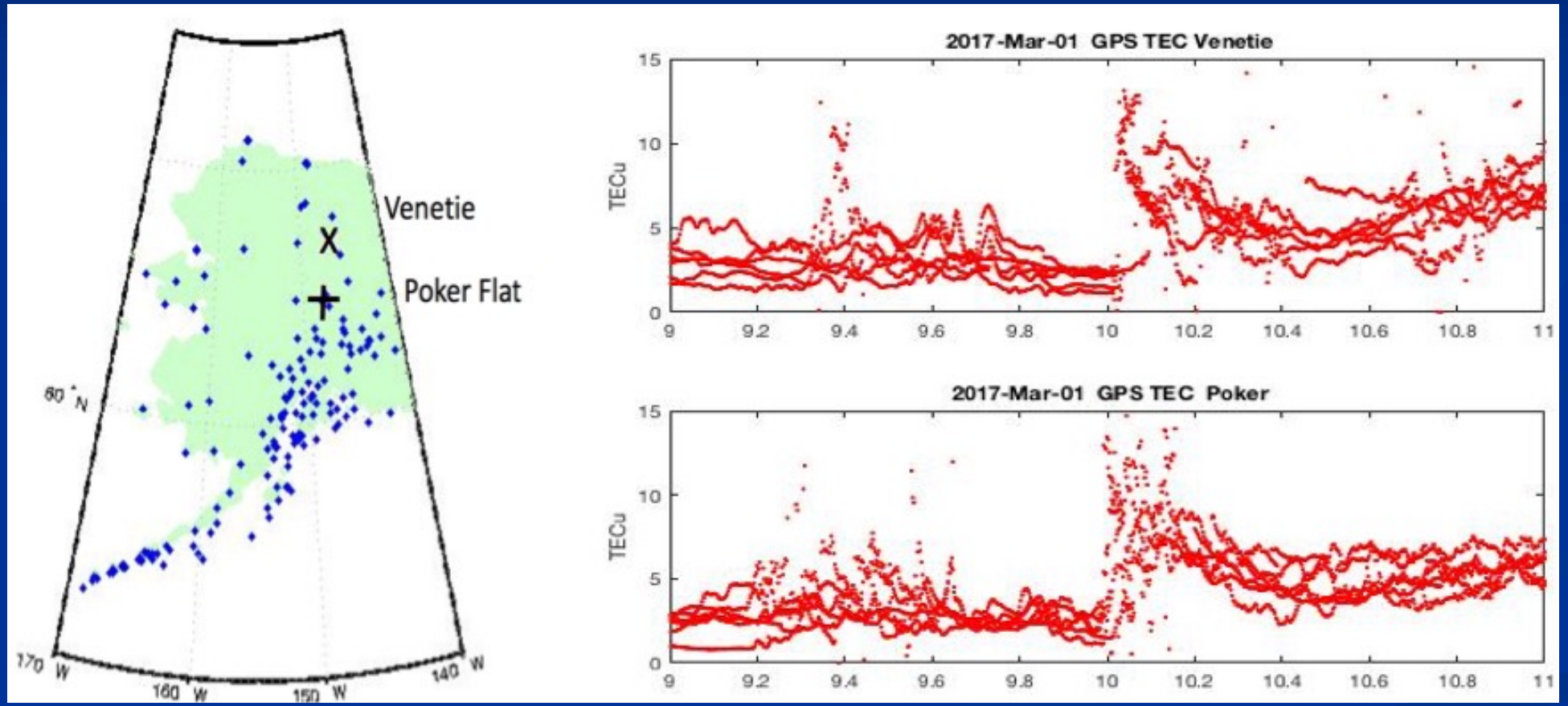
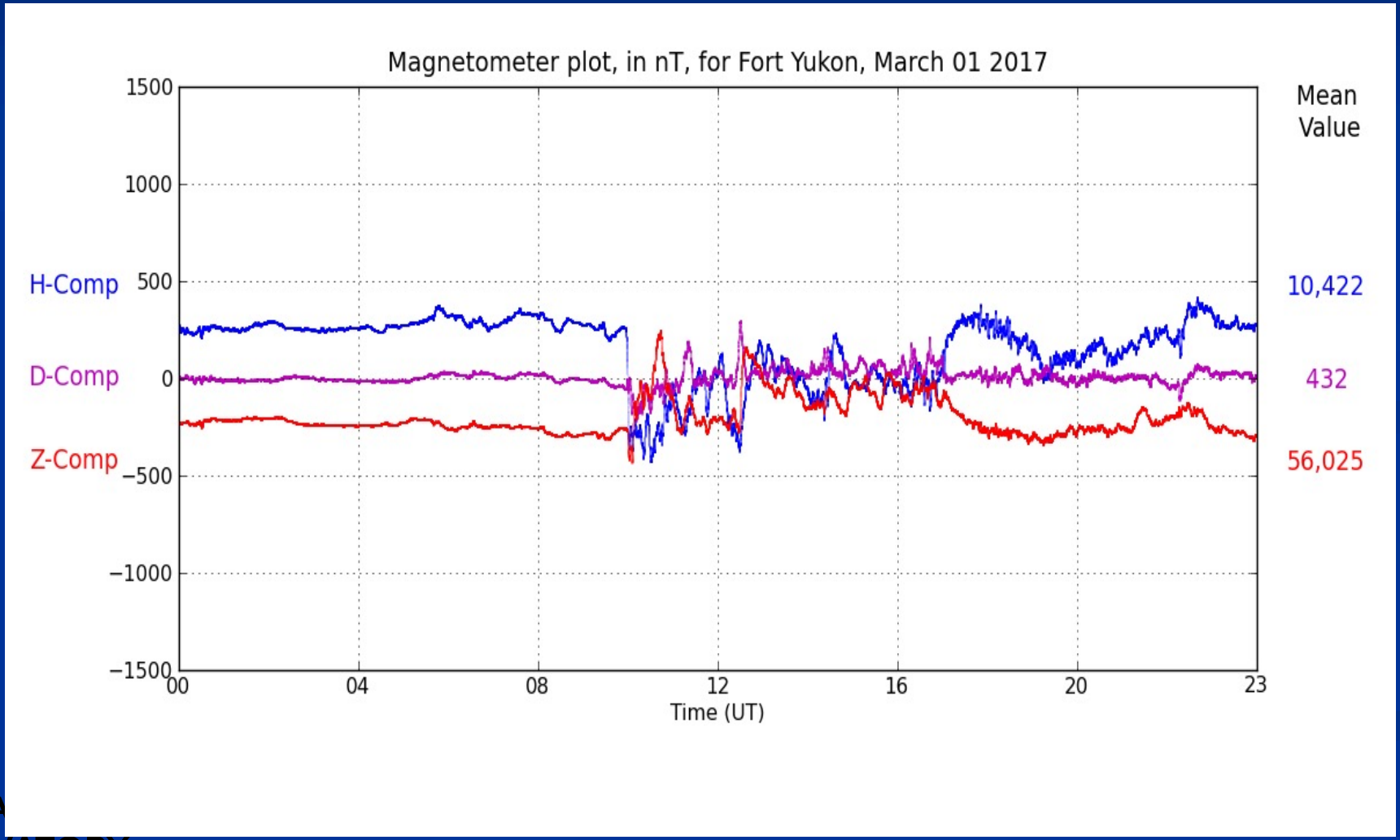
TEC increase at beginning of a substorm



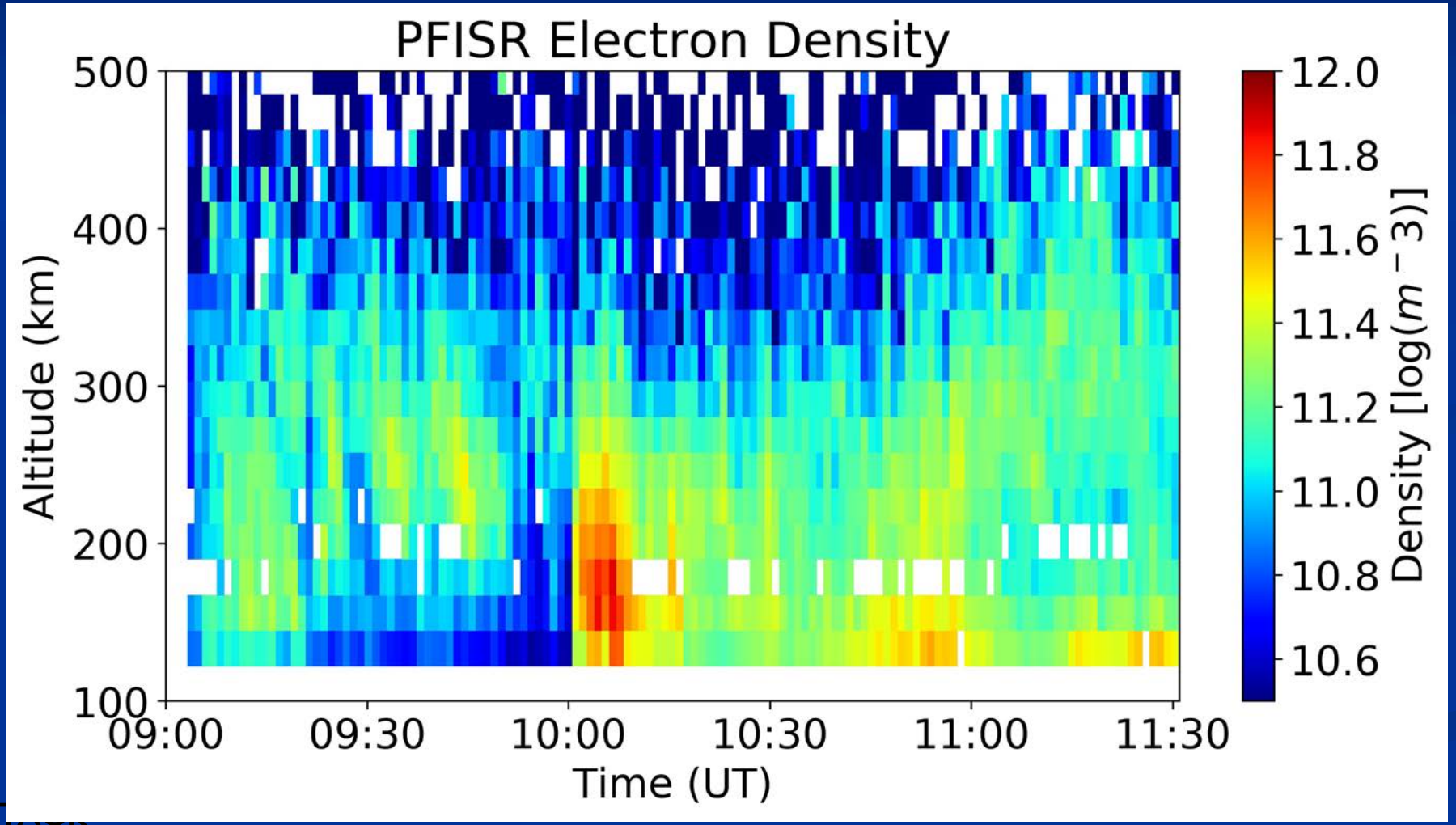
MIT HAYSTACK OBSERVATORY

Magnetometer plot Ft Yukon 1 March 2017

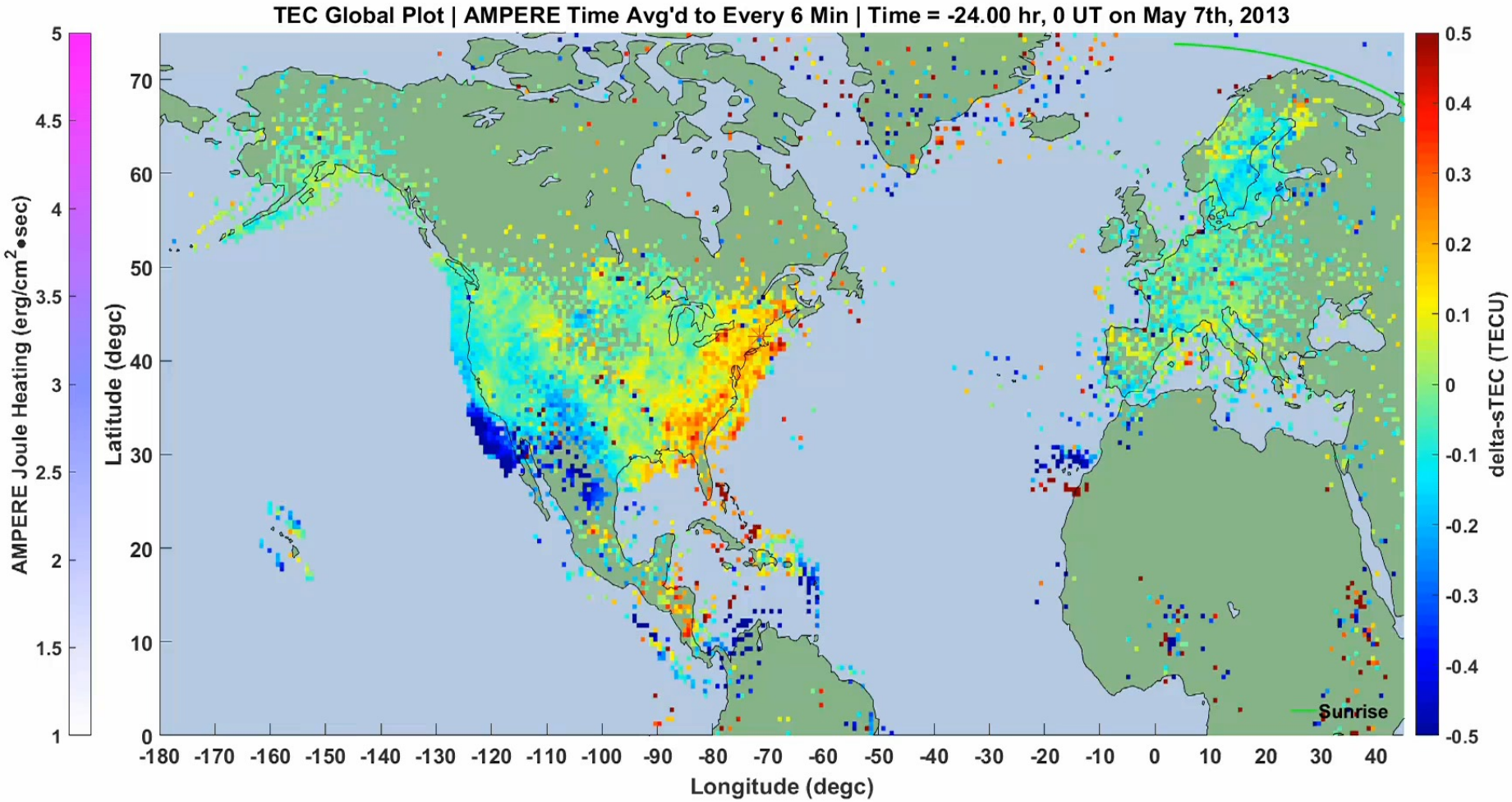


MIT HAYSTACK OBSERVATORY

PFISR Electron Density



MIT HAYSTACK OBSERVATORY



The square pixels are about the size of the original Milstone-centered 50 km radius circular patch. Although data density is low, note the strong suggestion of these “waves” over Arecibo Observatory.

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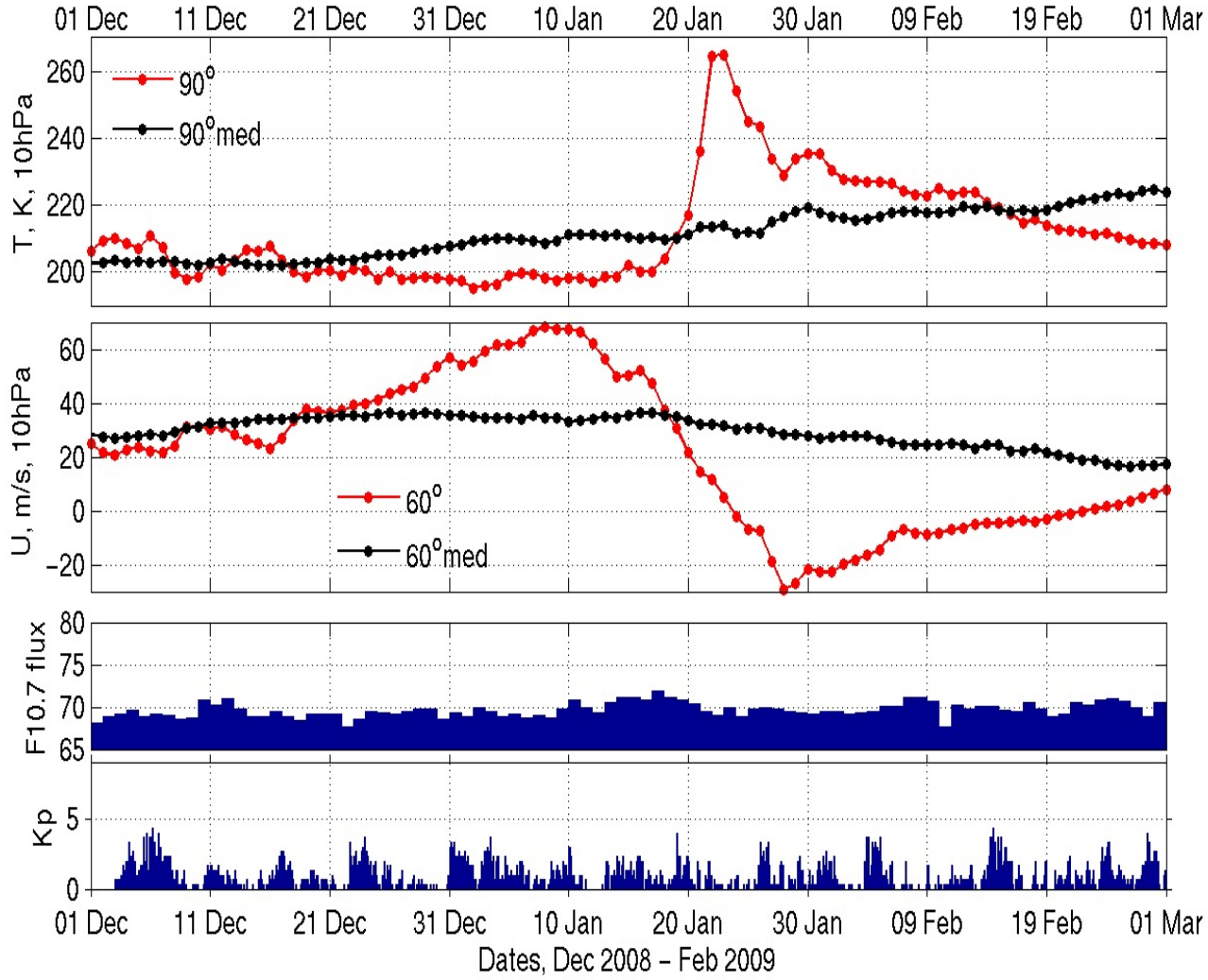
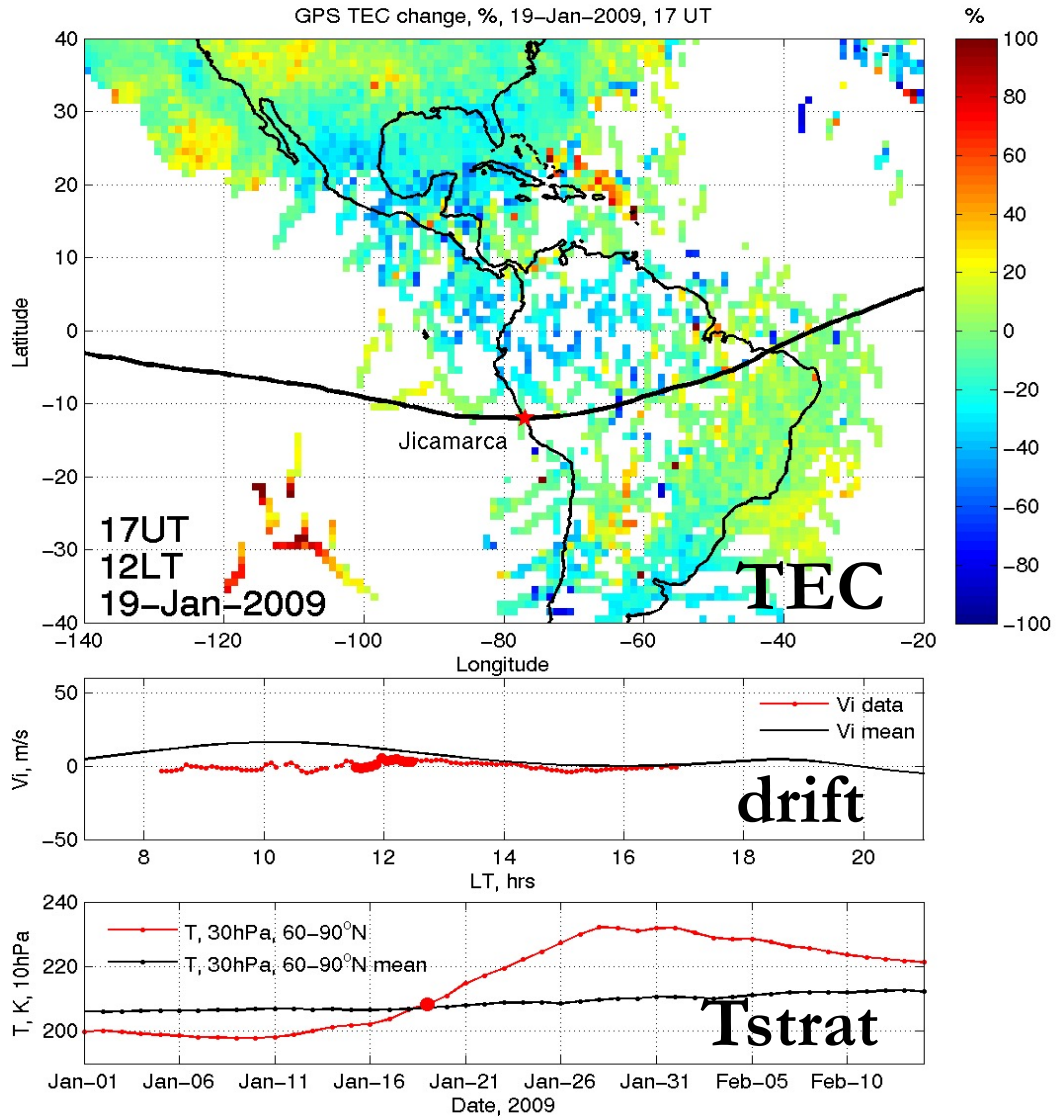
Sudden Stratospheric Warming and Solar Parameters [Jan 2009]



Stratospheric Temperature over the Arctic

GPS TEC change – no warming



Before the warming, TEC change is 10-20% from mean and vertical drift is small

GPS TEC (Total Electron Content) data show large-scale picture of ionospheric behavior

The mean is Jan 1-14, 2009

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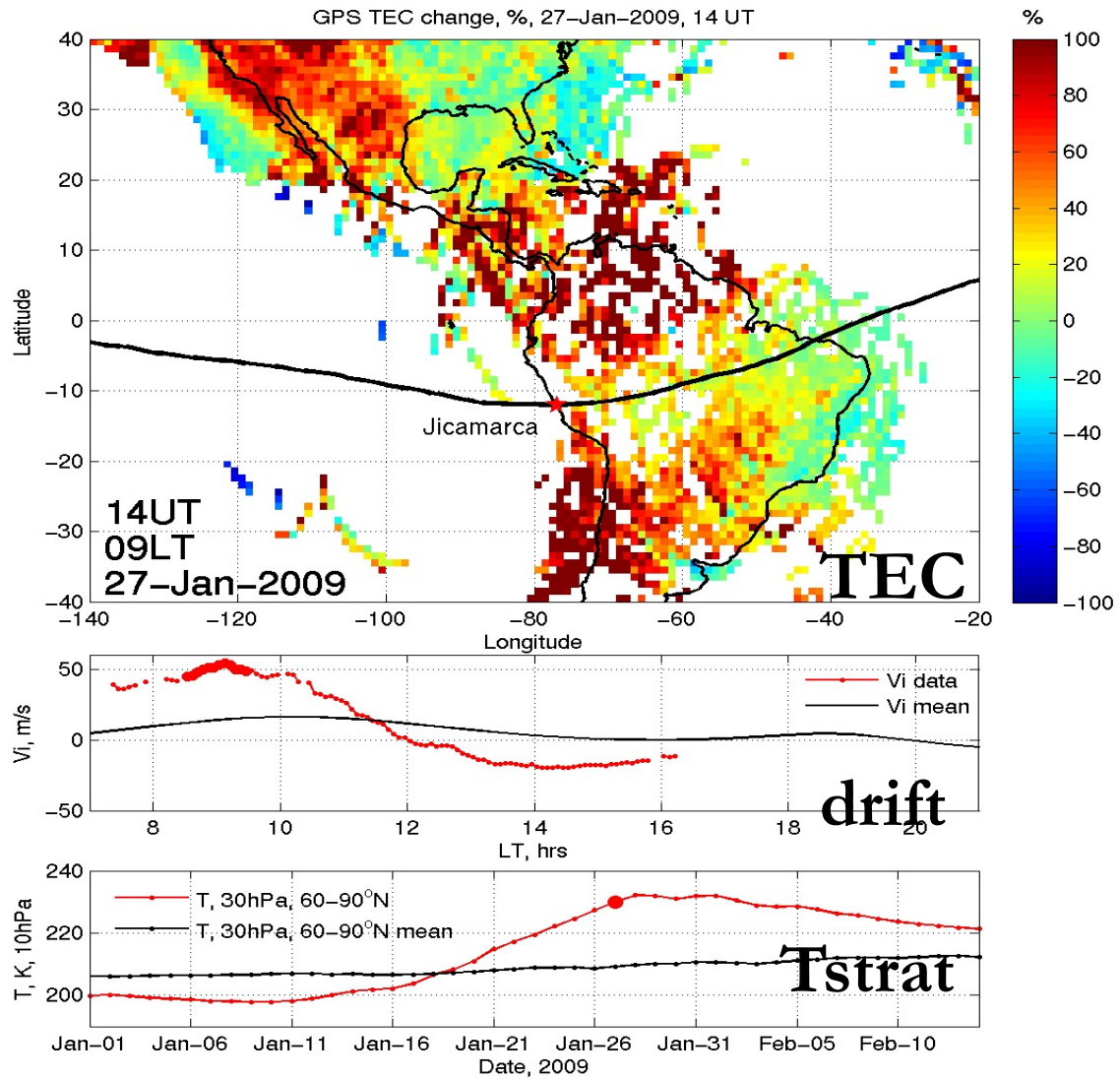
GPS TEC during warming: morning sector



During stratwarming, TEC increases in excess of 50-100% in the morning

Large upward drift at Jicamarca

The magnitude of increase is similar to effects of severe geomagnetic storms

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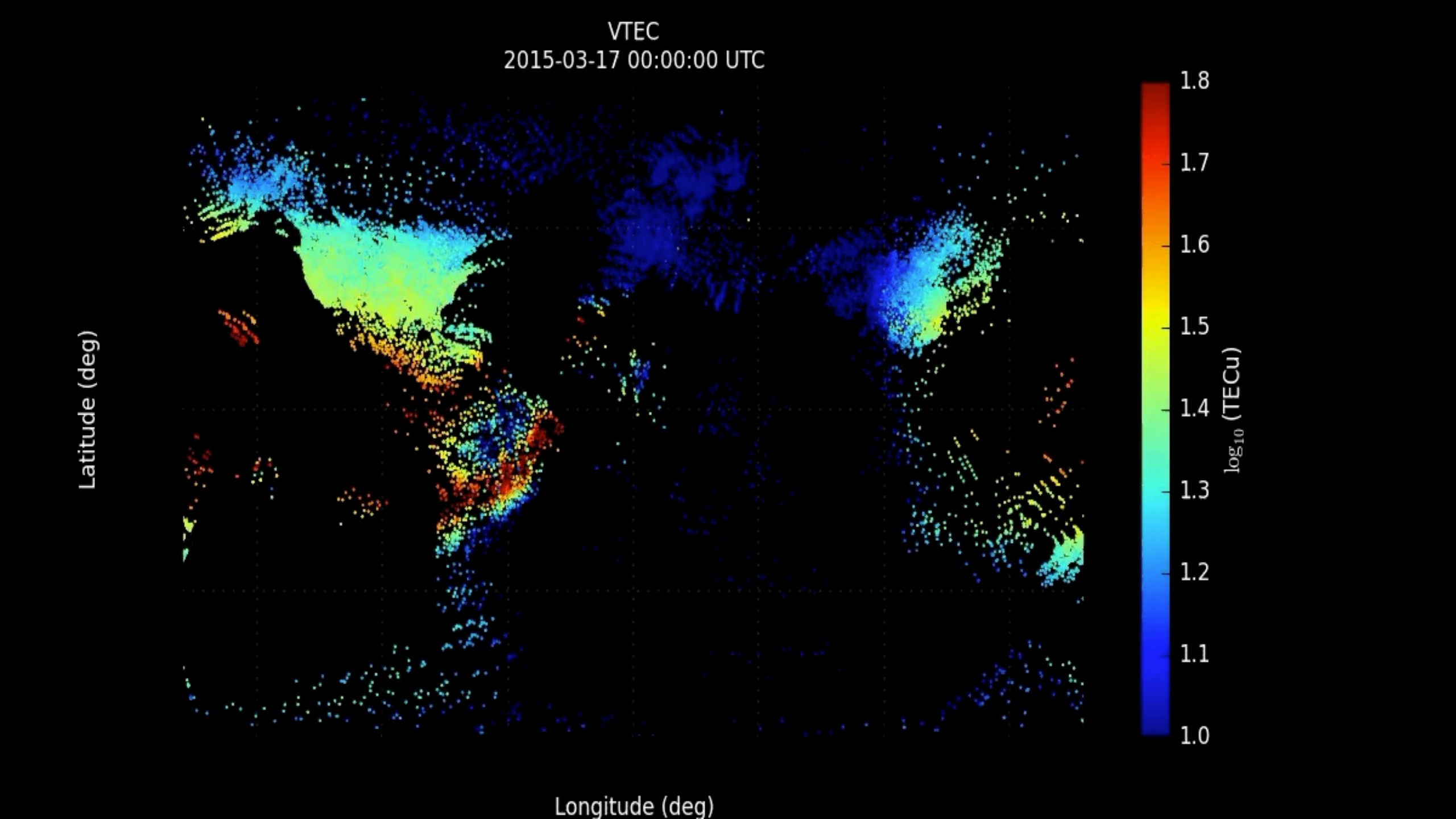
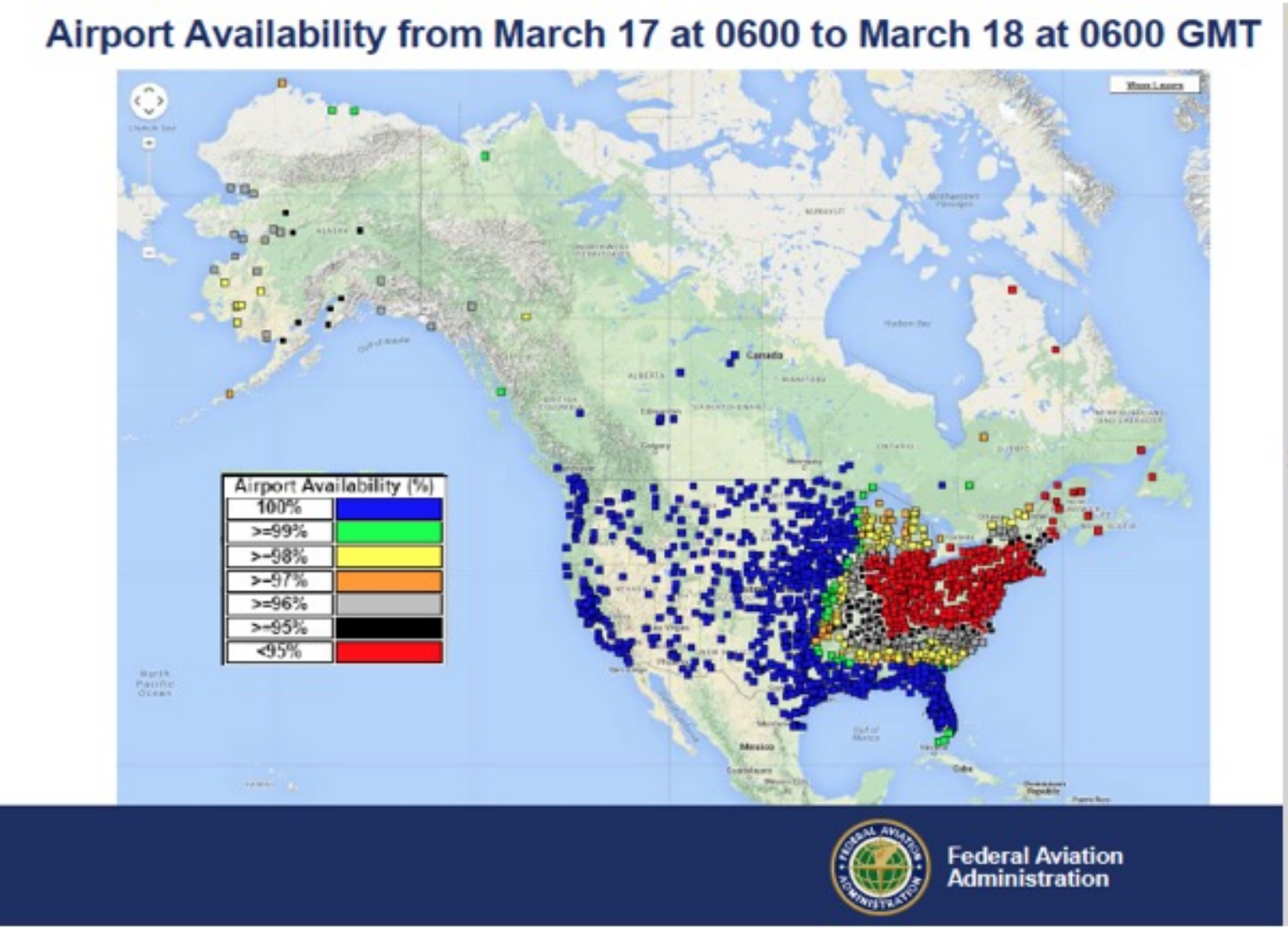
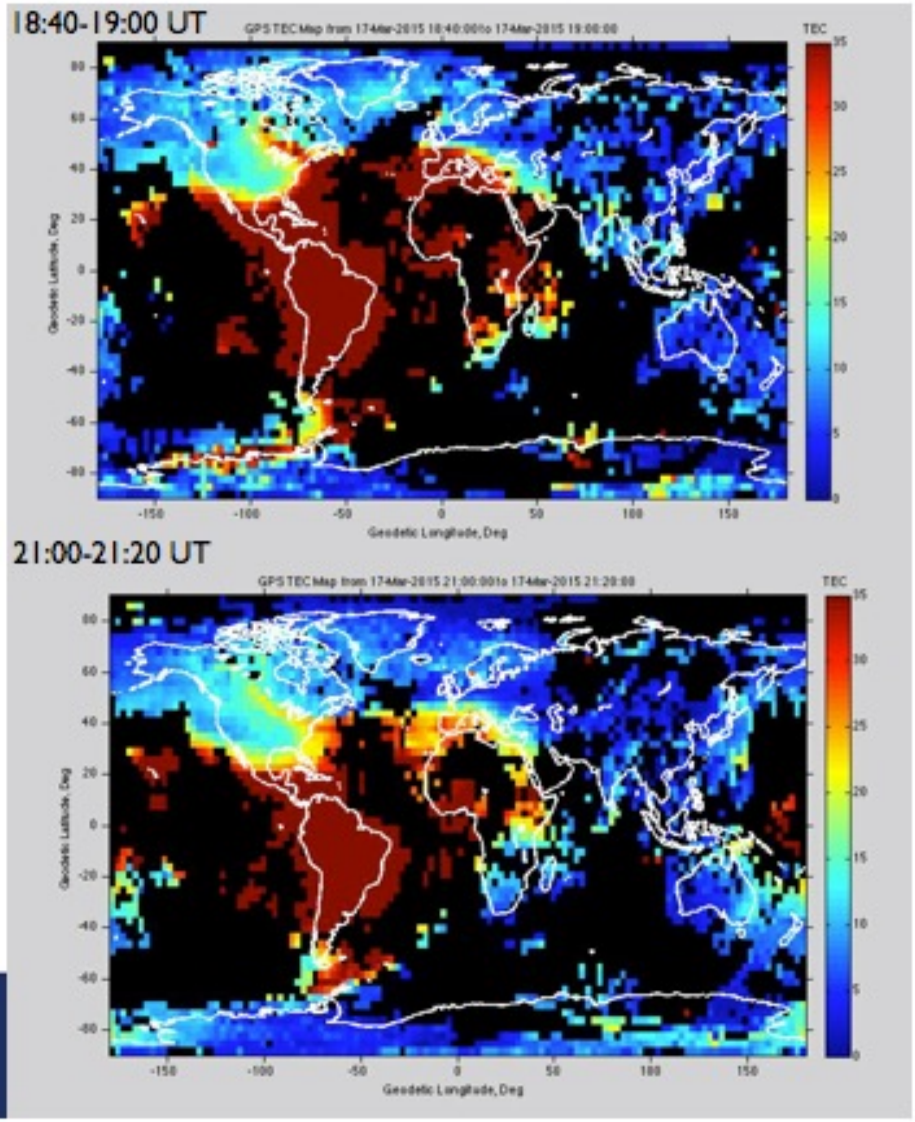

VTEC
2015-03-17 00:00:00 UTC
Latitude (deg)
Longitude (deg)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
log10 (TECu)

Consequences for the FAA

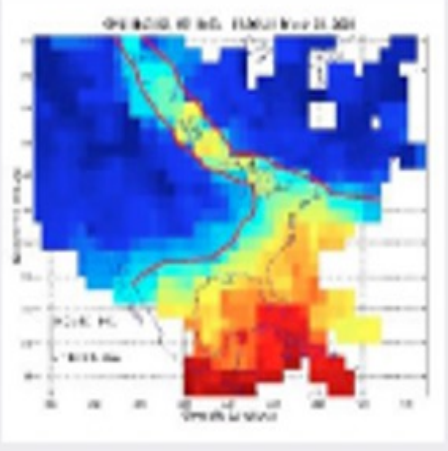




Summary

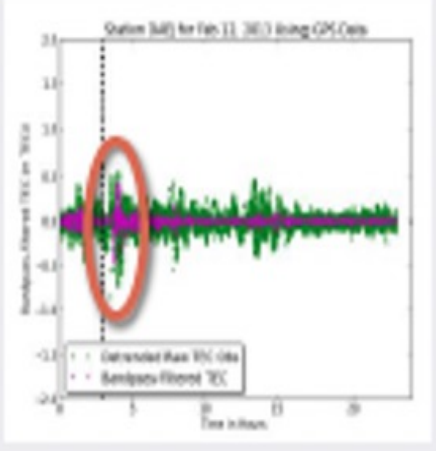
- There is still a lot left to be discovered, and interpreted, and understood
- New discoveries will be made by merging observations from different instruments and by looking for connections.

Storm Enhanced Density feature

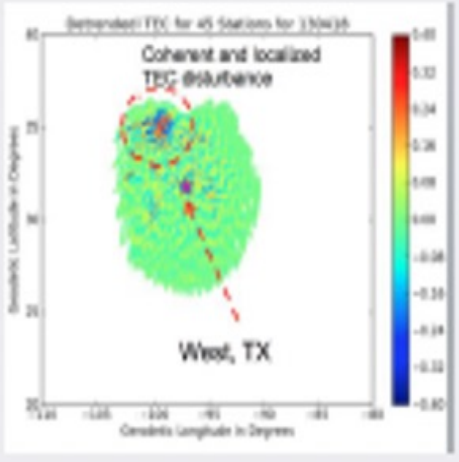


(Rideout & Coster 2006)

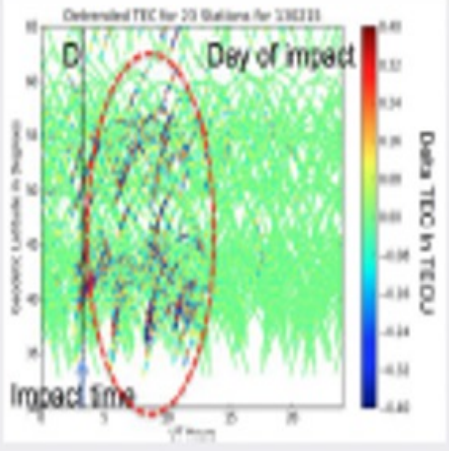
Feb 12, 2013 North Korea Nuclear Test



Texas Fertilizer Plant Explosion Apr 18

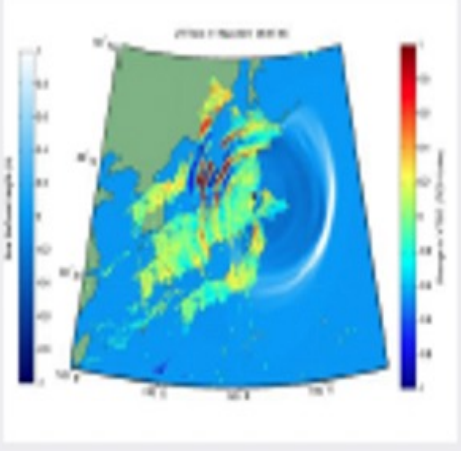


Chelyabinsk Meteor



(Komjathy, Yang, Butala, Ijima, Mannucci. Beacon Satellite Symp. 2013)

Tohoku-Oki Earthquake and Tsunami



(NASA JPL Photojournal PIA14430/Caltech, 2012)