Monitoring Traveling Ionospheric Disturbances with a Global Mobile Device Network

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2. MIT
3. Scientific Solutions, Inc.

IES - 2015

OUTLINE

- Review – Why TIDs?
- Mahali Project
- TID Campaign: 10 -22 April 2015

What is a TID ? (Nathaniel Frissell, Va Tech)

Traveling Ionospheric Disturbance:

- Moving variation in ionospheric density
- First reported in a letter to Nature in 1948 by G. H. Munro.
- Reported a quasi periodic disturbance.
- Active area of research ever since !!!

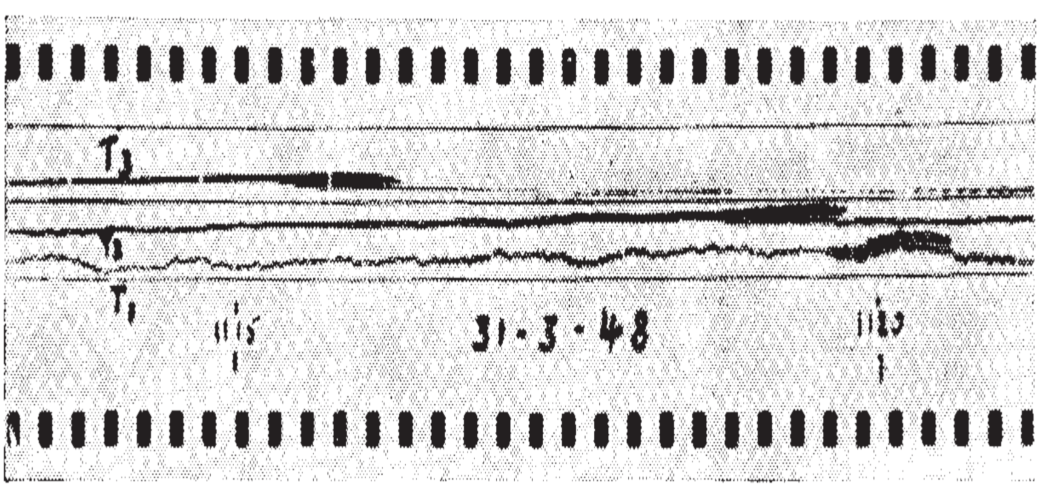


Fig. 2. *F* region echoes from spaced transmitters observed at R_3

in the *D* region and for contour measurements of broad and narrow solar absorption lines in the region of the line Ca 4227 are now in process of measurement. A full account of the new fringe systems, and of these applications, will shortly be communicated to the Royal Astronomical Society.

P. J. Treanor, *S.J.*

University Observatory,
Oxford.
Oct. 1.

[1] Burns, K., and Meggers, W. F., *Pub. Allegheny Obs.*, **6**, 105 (1927).
[2] Shane, C. D., *Lick Obs. Bull.*, **19**, 119 (1941).

Short-Period Changes in the *F* Region of the Ionosphere

Radio observations designed to detect horizontal movements in the ionospheric regions and to investigate the relation of these to previously observed changes occurring above a single observing point have been in progress for some months in the vicinity of Sydney, New South Wales. The present system uses three transmitters (T_1, T_2, T_3) placed at the apexes of a right-angled triangle with its shorter sides approximately north–south and east–west and of length 13 miles and 27 miles respectively (Fig. 1). The

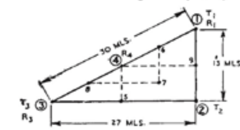


Fig. 1

transmitters are operated on the same frequency and with the same repetition frequency, and are so phased, by either mains synchronization or pulse triggering technique, that the three pulses are spaced about 50 km. apart on a normal type of time base such as is used for ionospheric observations. It is thus possible to record the three sets of echoes simultaneously on a single film. Standard 35-mm. film is used, moved continuously with a film speed of ¾ inch per minute. Observations can be taken at one or more of three points, two being at the most widely spaced transmitting sites (R_1 and R_3), and a third at a point approximately midway between these (R_4).

Assuming that a reflexion point is vertically above a point on the ground midway between transmitter and receiver, we have eight possible points for checking uniformity of motion.

During seven months of operation (November 1947–May 1948), it has been observed very frequently that several types of clearly defined changes which occur in echoes from the *F* region show a time difference of occurrence at the spaced points.

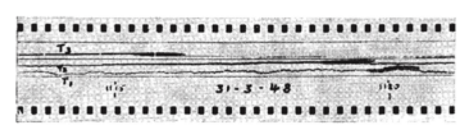


Fig. 2. *F* region echoes from spaced transmitters observed at R_3

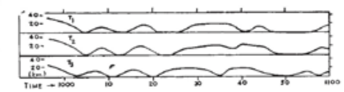


Fig. 3. Comparison of 'splits' observed at point R_3

Fig. 2 shows a particularly clear example of one type recorded at R_3. In this case the traces are produced by applying the signal to the intensifier electrode only of the cathode ray tube. The uniform lines are height marks spaced 100 km. apart. The top trace is the *F* region echo from transmitter T_3. The time base and height marker are initiated by this transmitter, so that the changes in virtual height are real.

The transmitters T_2 and T_1 are synchronized with T_3 through the 50-cycle power supply grid. Their traces (at R_3), therefore, show different amounts of phase fluctuation relative to T_3 and to the height marker, and their apparent changes in height may not be real. Corrections can be made if a ground ray is also visible on the screen; but this requires a closer scale with some loss of resolution. The transmitters T_1 and T_2 are interrupted for a few seconds at intervals of one minute (except every tenth minute on R_1), to provide time marks on the records.

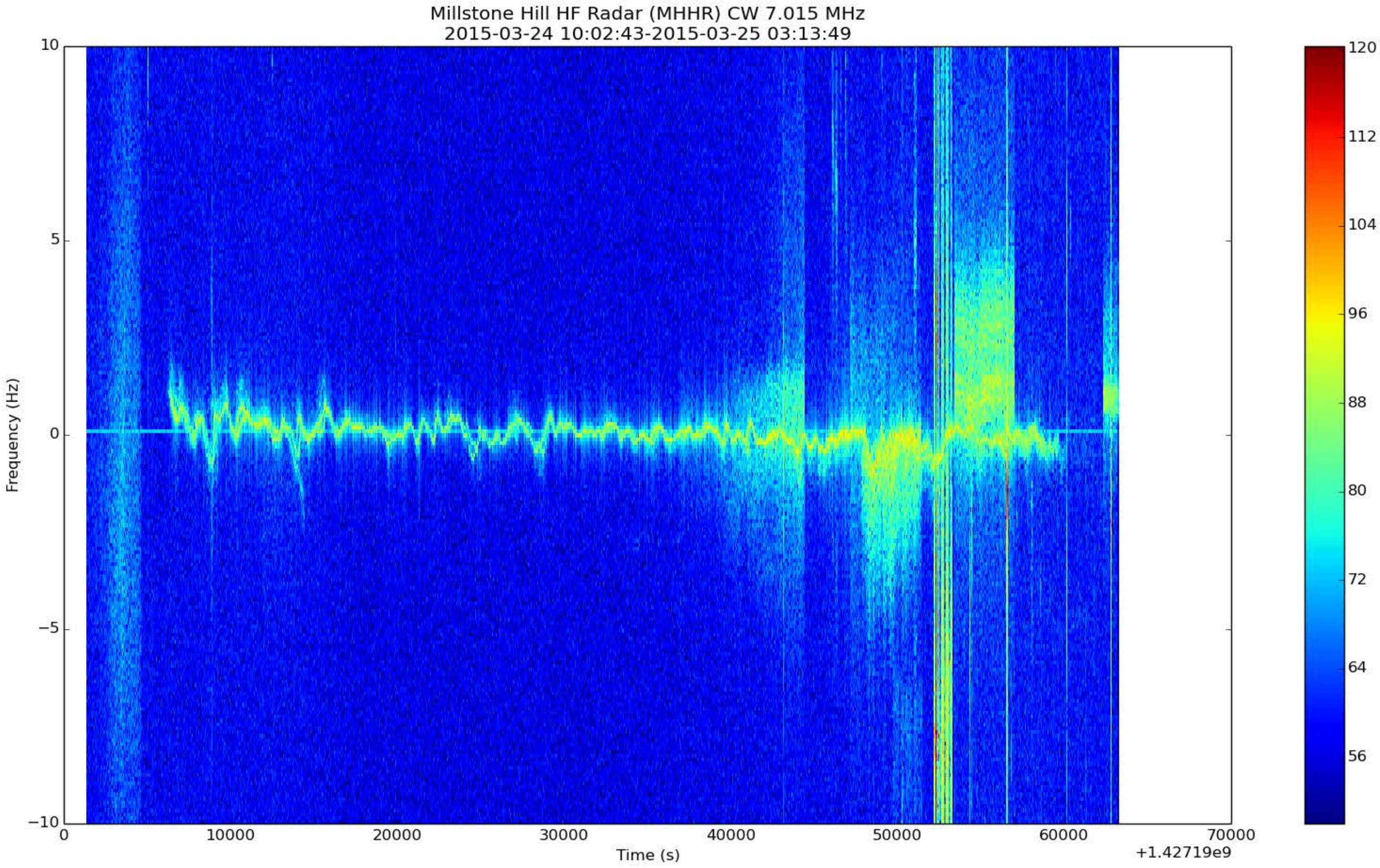
It will be observed that there is a sudden disturbance on each trace in the form of a temporary splitting of the echo lasting about one minute (not easily seen in the reproduction). It occurs first on T_3, three minutes later on T_2 and a further minute later on T_1. An almost identical pattern was recorded four minutes later at R_1, which eliminates any possibility of the time differences being due to slight differences in frequency or to the small differences in the angles of incidence. The deduced direction of horizontal motion in this case is 60° east of north, and the velocity in this direction 3·9 miles per min.

Another common type of variation is shown in Fig. 3, which is a condensed plot of the amount of 'split' (difference in virtual heights of ordinary and extraordinary rays) for the three echoes as observed at R_3 over a period of one hour on the following day. It will be observed that quasi-periodic variations appear in almost the same form on all three traces, but with time differences which are of the same order as in Fig. 2.

Fig. 4 is a plot for the following hour of the virtual heights of the two components as observed at vertical incidence at R_3 and R_1. Here it will be seen that the two magneto-ionic components at each point (as shown by the full line and the dotted line) go through a very similar sequence of changes, but there is a time lag between the dotted and full-line curves. It will be noticed, however, that the time of travel from R_3 to R_1 is the same for both components. The time difference in this case is about seven minutes, as we are observing the full distance R_3 to R_1 and not the half-distance as in Figs. 2 and 3.

We thus appear to have definite evidence of some form of horizontal progression in the *F* region. The great majority of cases analysed so far have given horizontal directions between 30° and 60° east of north, and deduced velocities between 3 and 5 miles

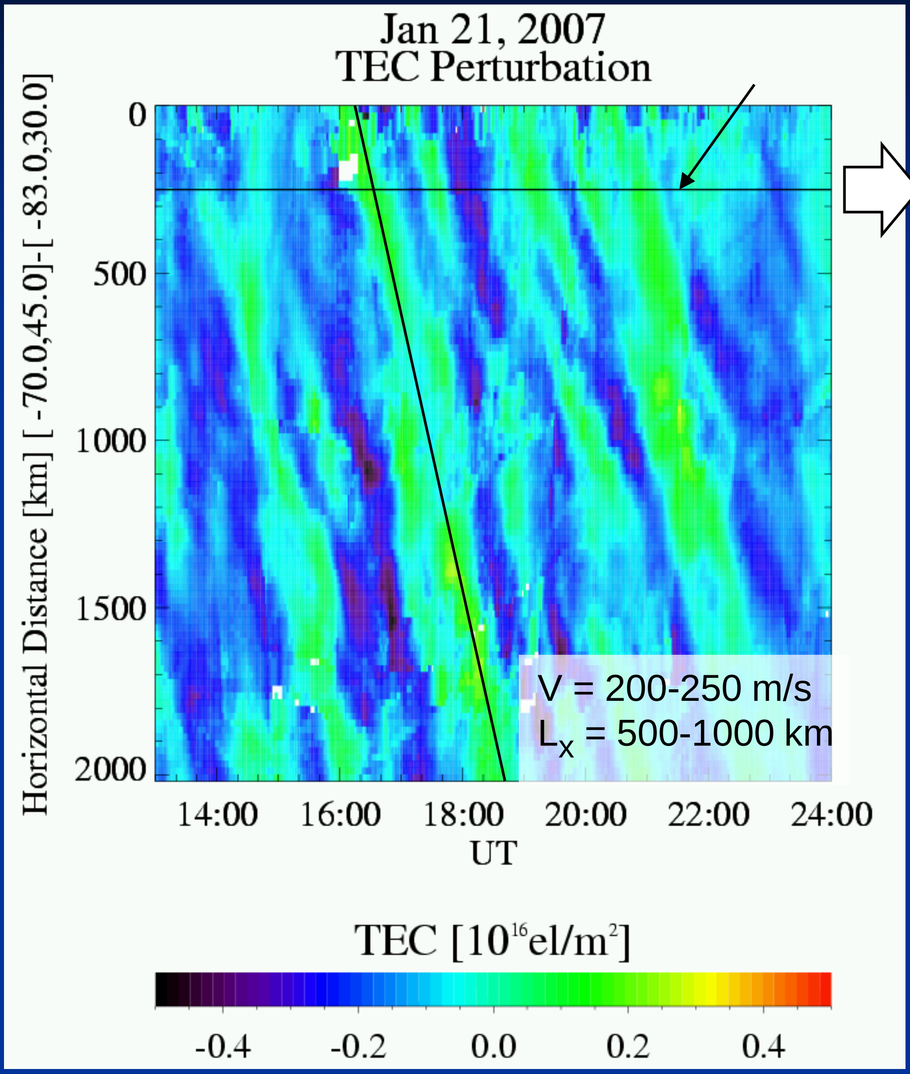
Juha Vierinen's HF radar/Ionosonde

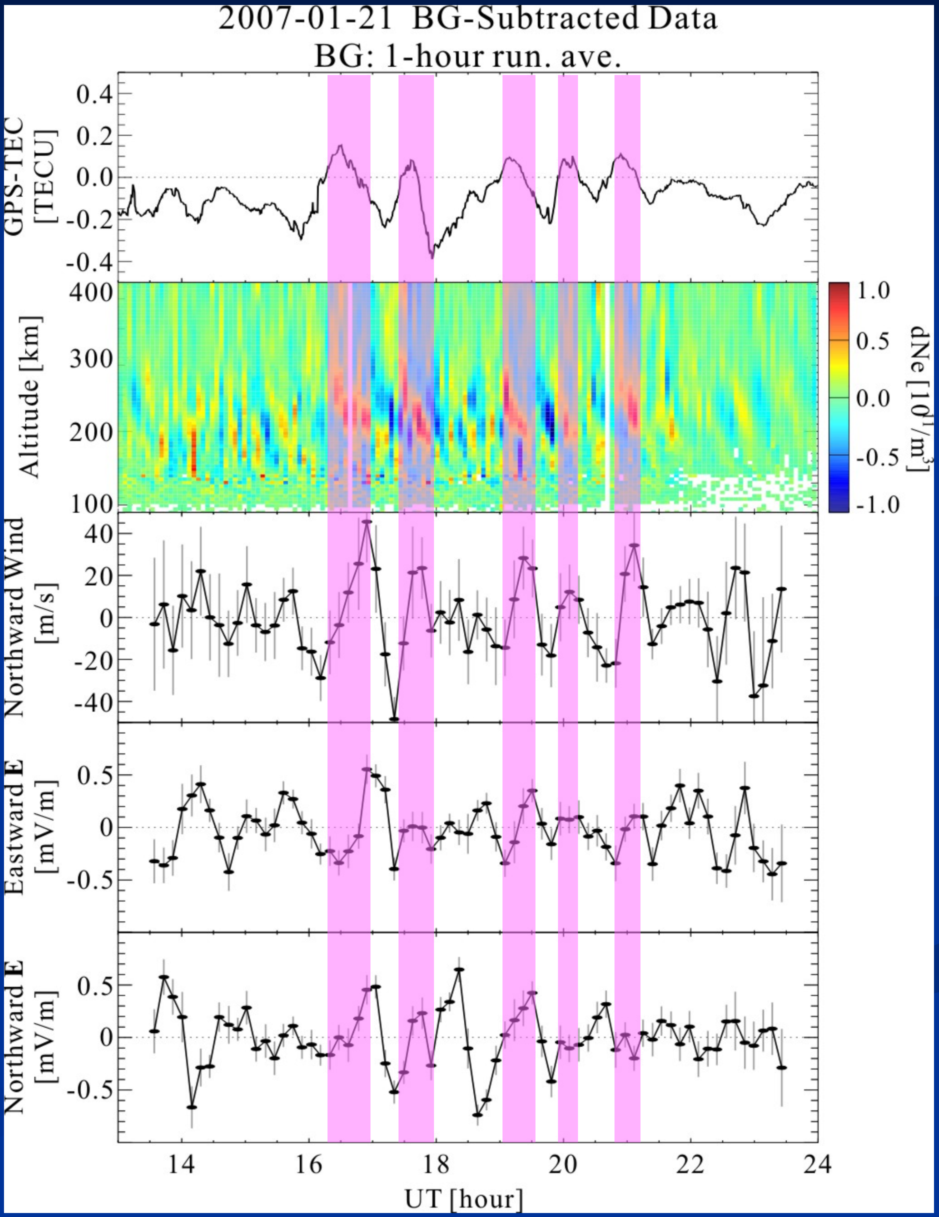


HF Geolocation, Communication

- Understanding the bottom side fluctuations in the ionosphere is important for correctly estimating the propagation path → necessary to geolocate.

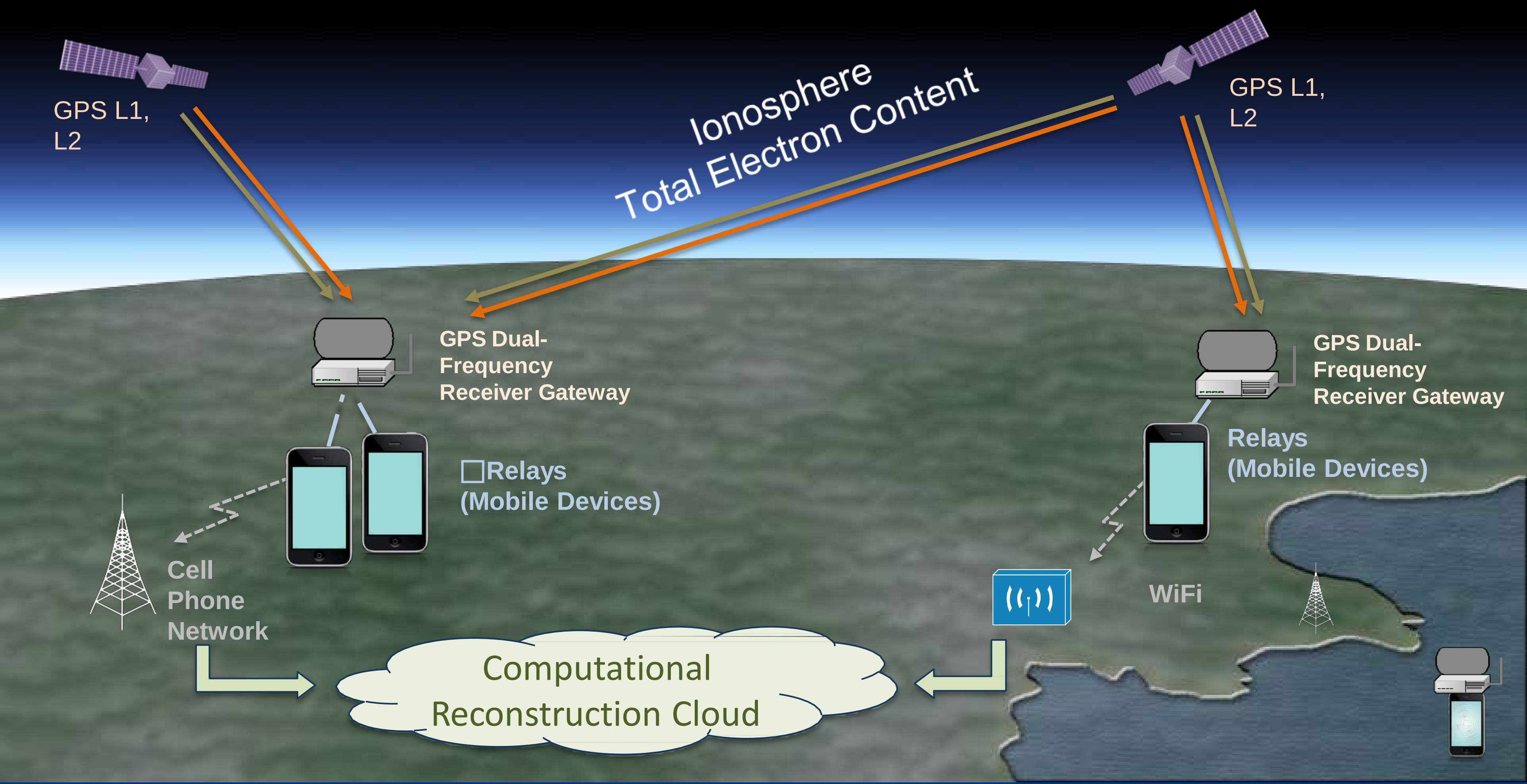
1h BG-Subtracted Data : Jan 21, 2007

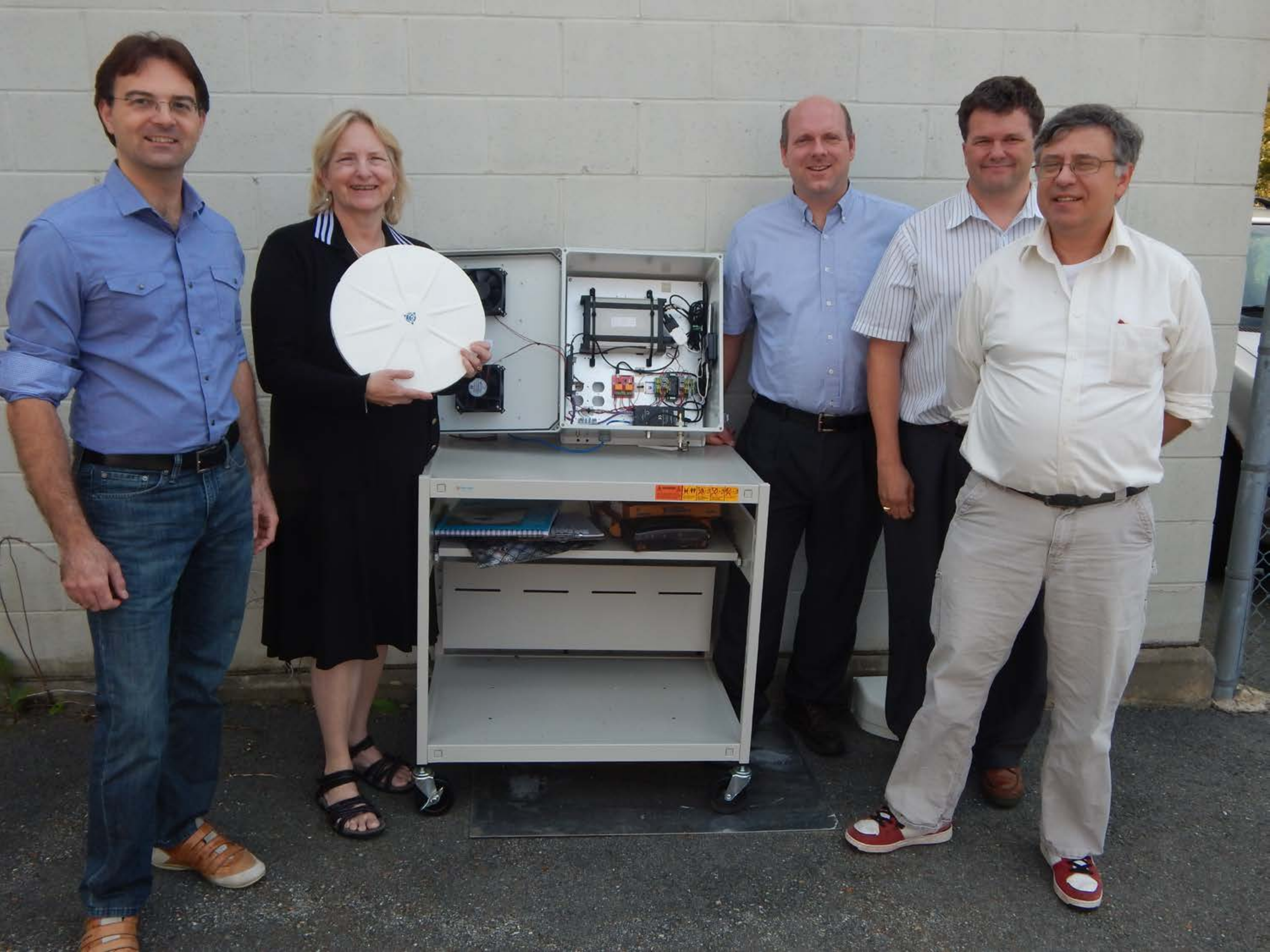




- GPS-TEC along the horizontal distance axis.

Mahali: Space Weather Monitoring Everywhere





Science Plan

Testing in Brazil

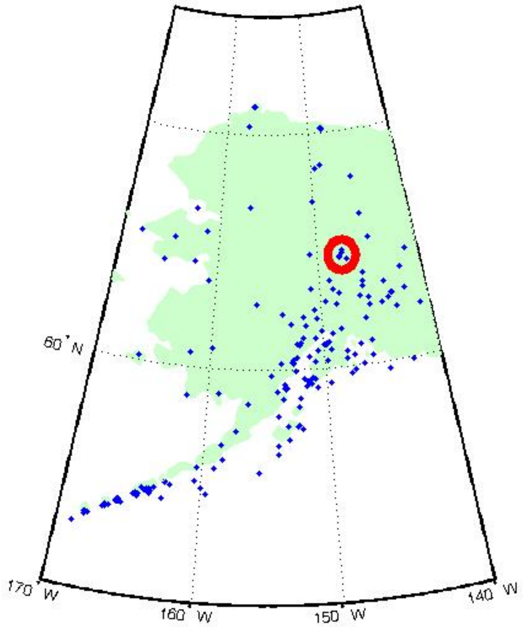
Two extended scientific campaigns:

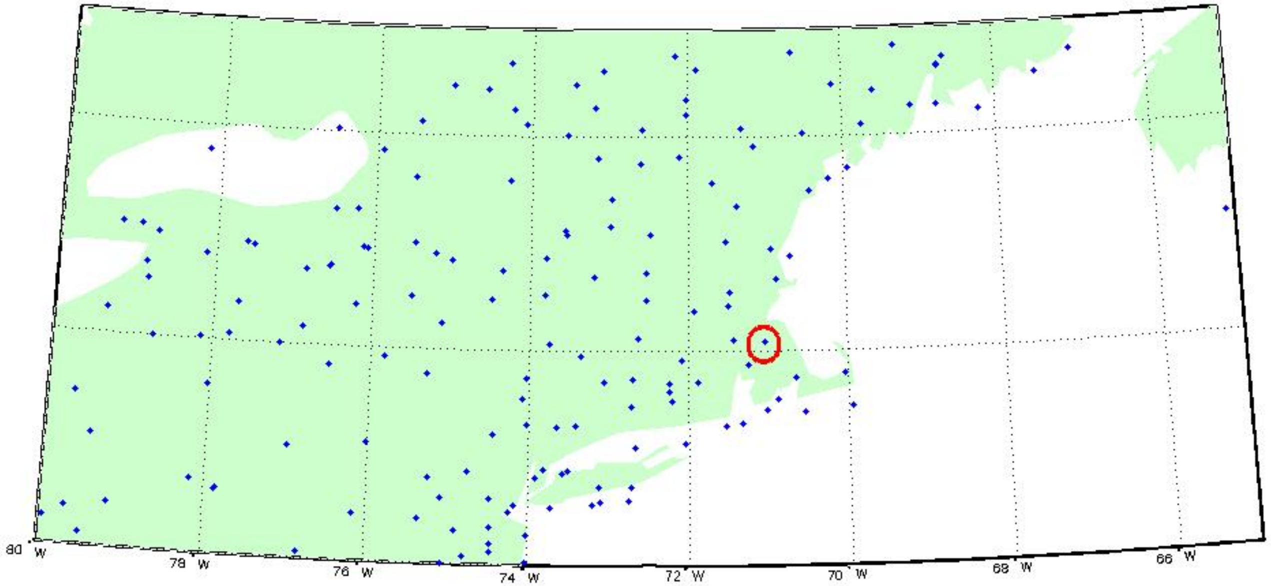
Haystack Deployment

– – Spring 2015

PFISR/Alaska Deployment

– – Fall 2015





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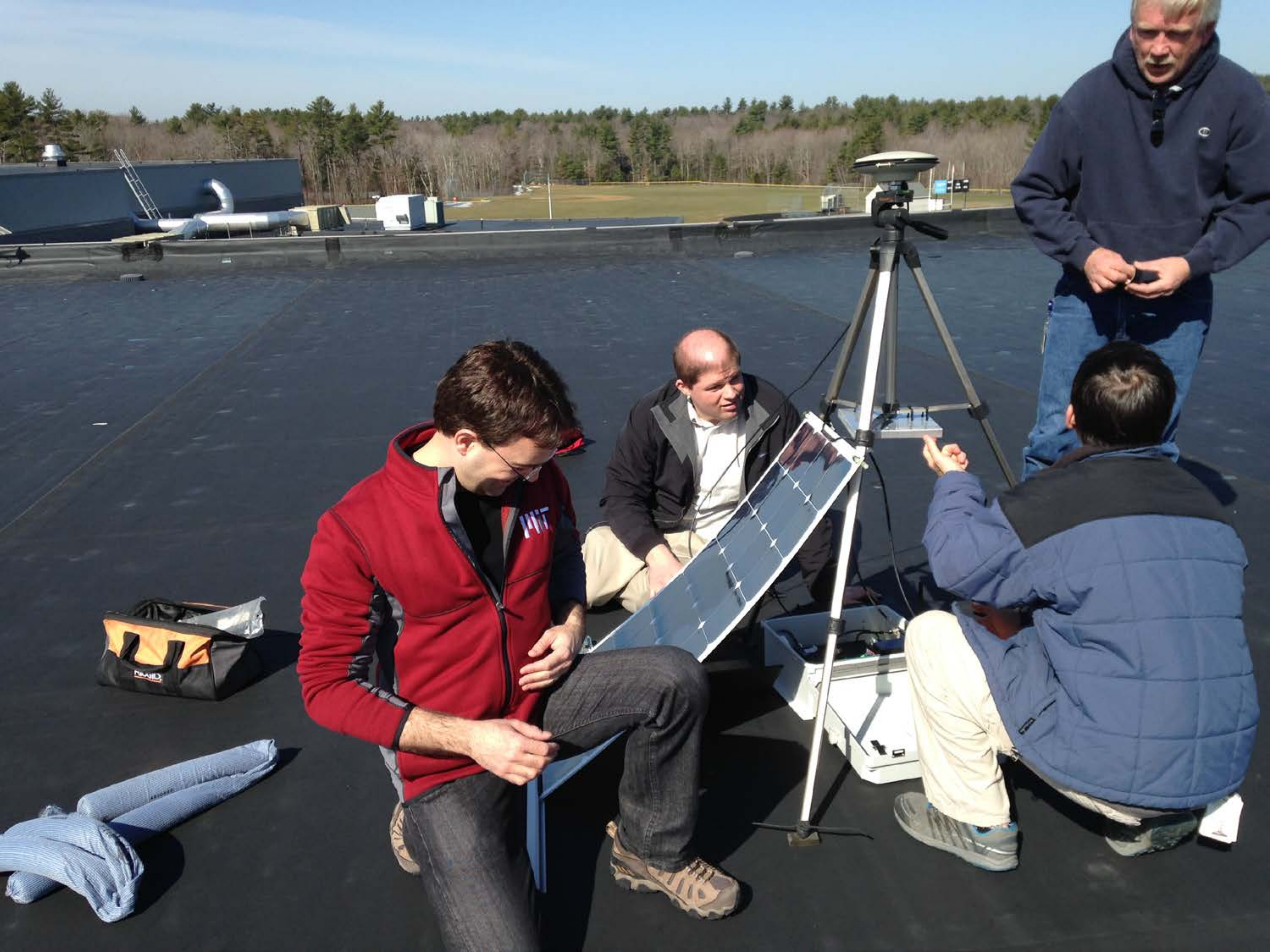
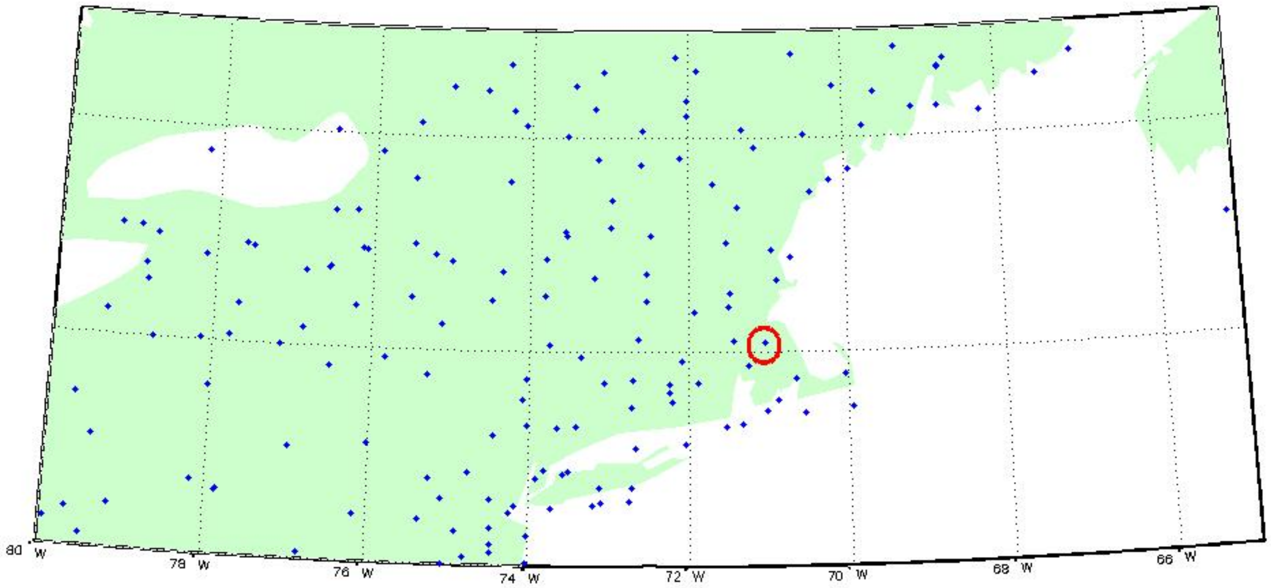




Maine – Maine Department of Transportation (single baseline).

Maryland – No public service.

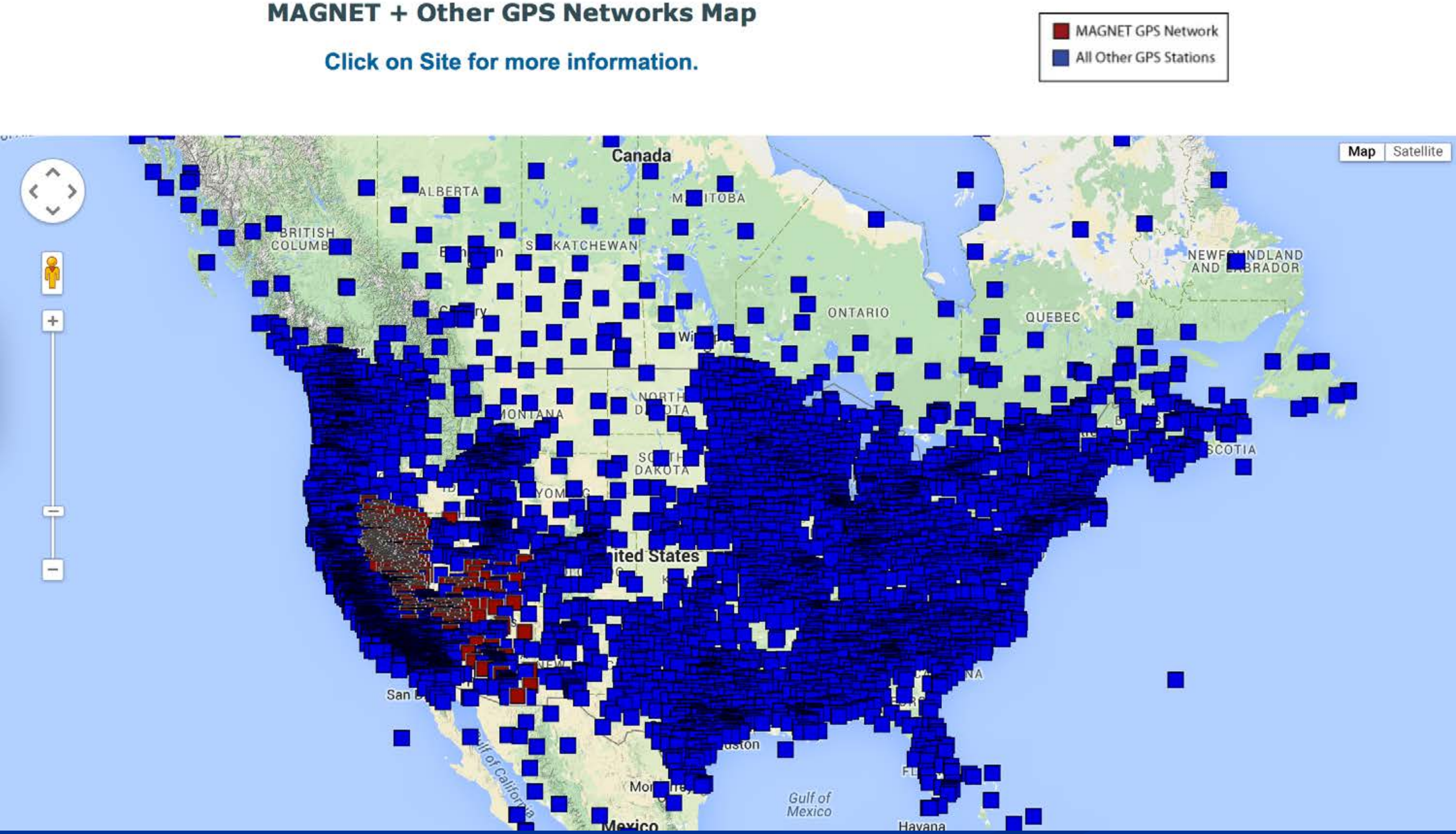
Massachusetts – Massachusetts Department of Transportation. Leica network.

Michigan – Michigan Department of Transportation. Leica network.

Minnesota – Department of Transportation. Trimble network.

MAGNET + Other GPS Networks Map

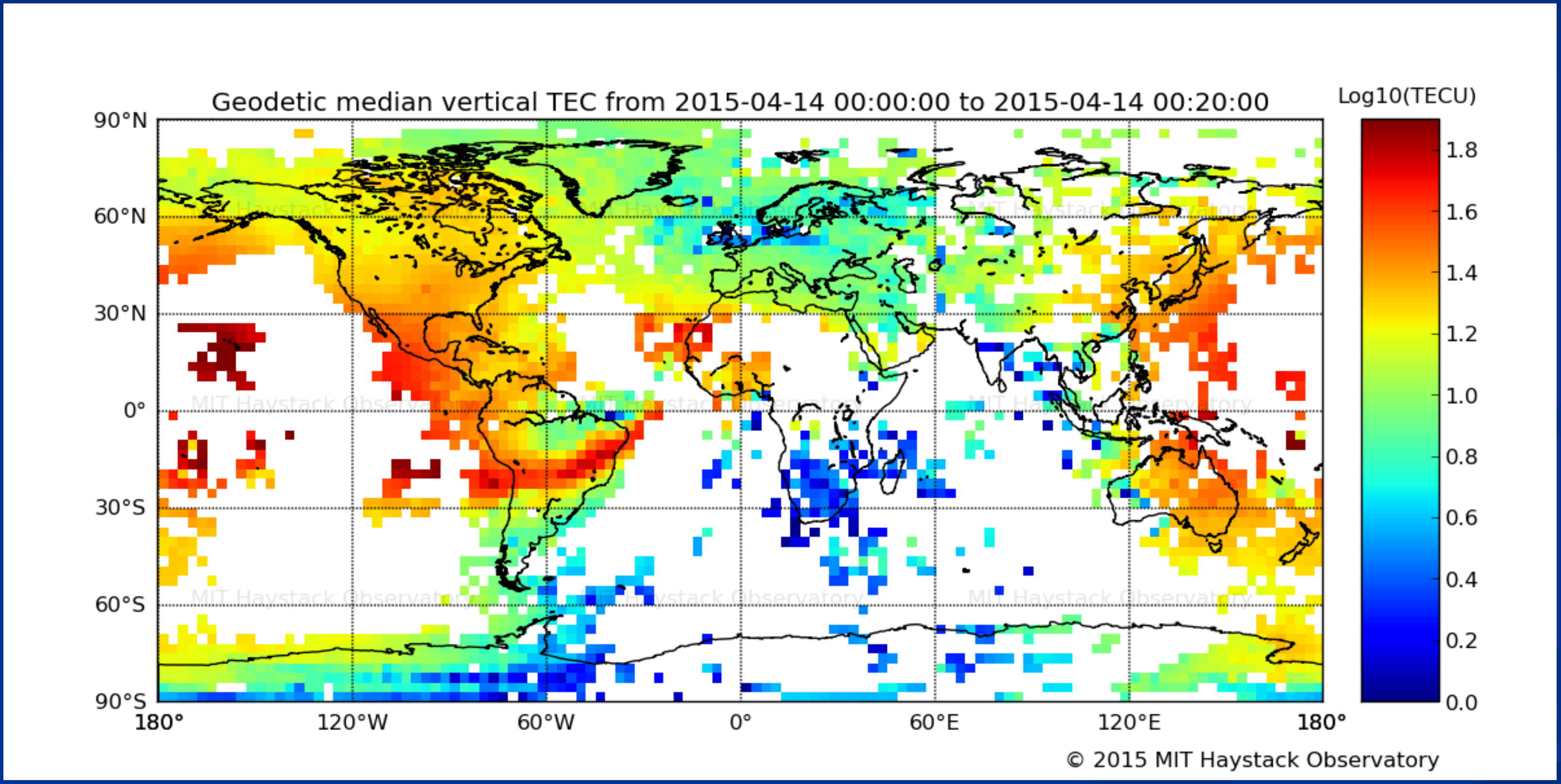
Click on Site for more information.

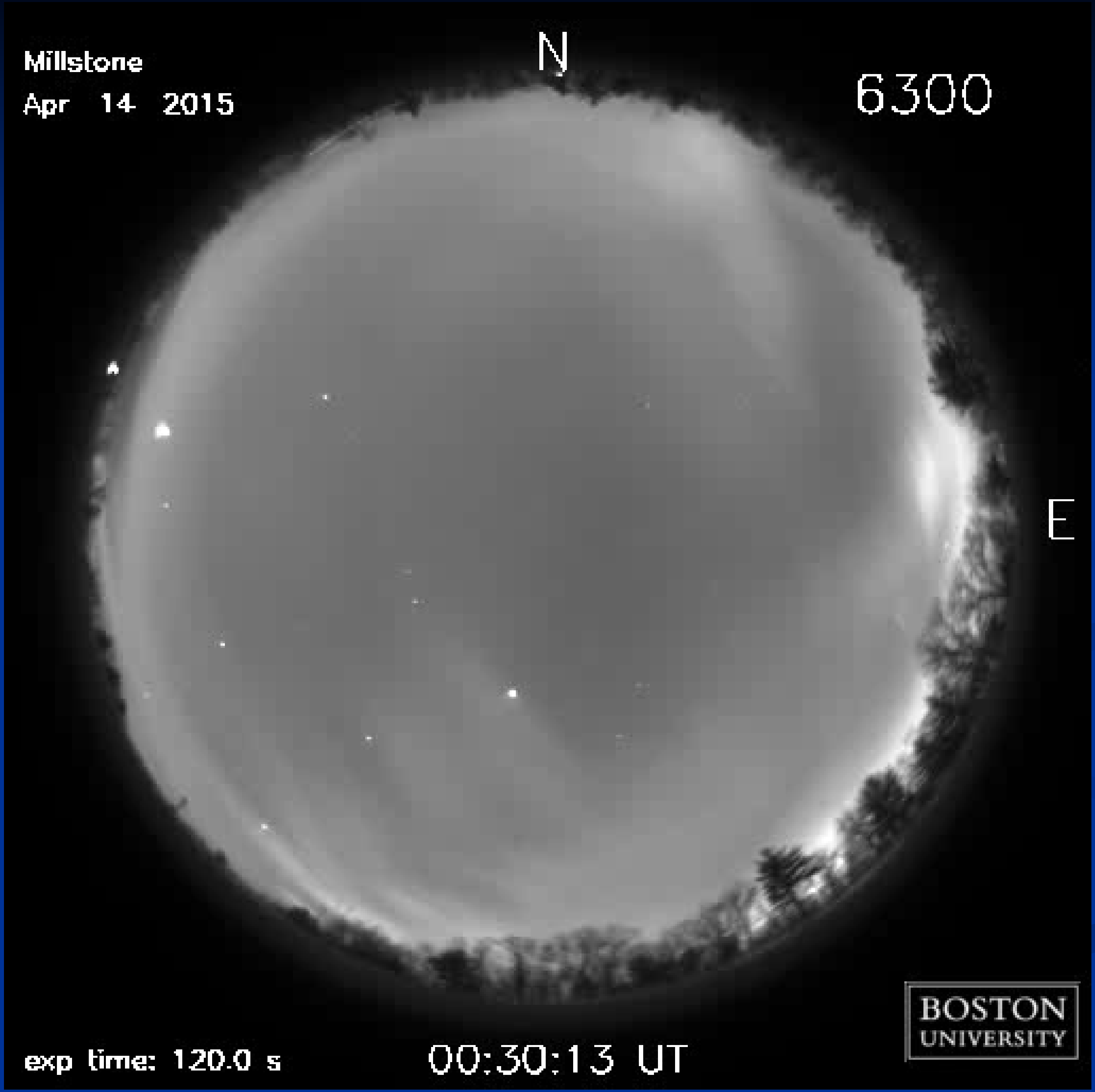


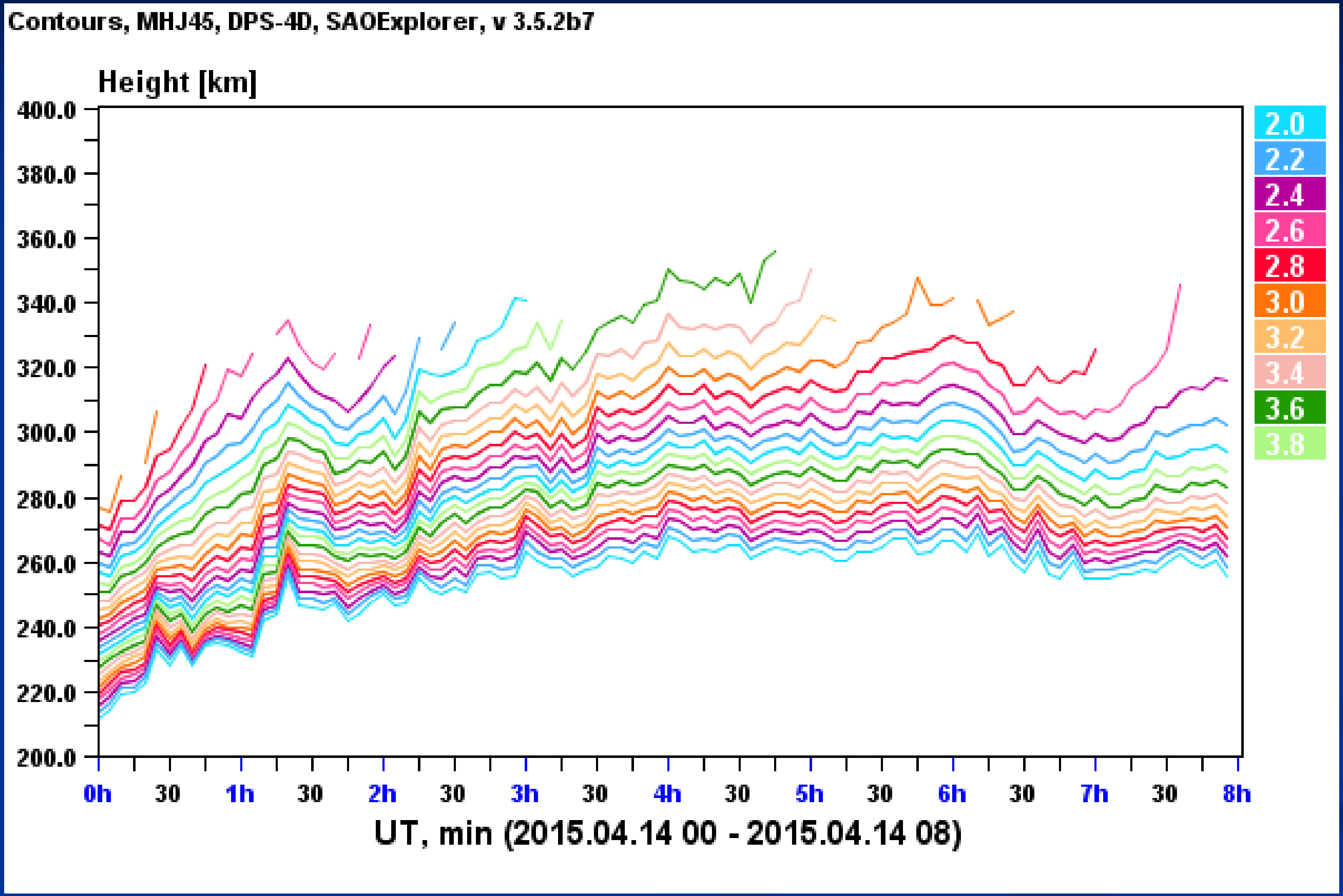
TID experiment – April 10-23, 2015

- Millstone Hill Incoherent Scatter
- Scientific Solutions Fabry Perot Interferometers
- U Mass Lowell Digisonde
- GPS network with MAHALI receivers deployed

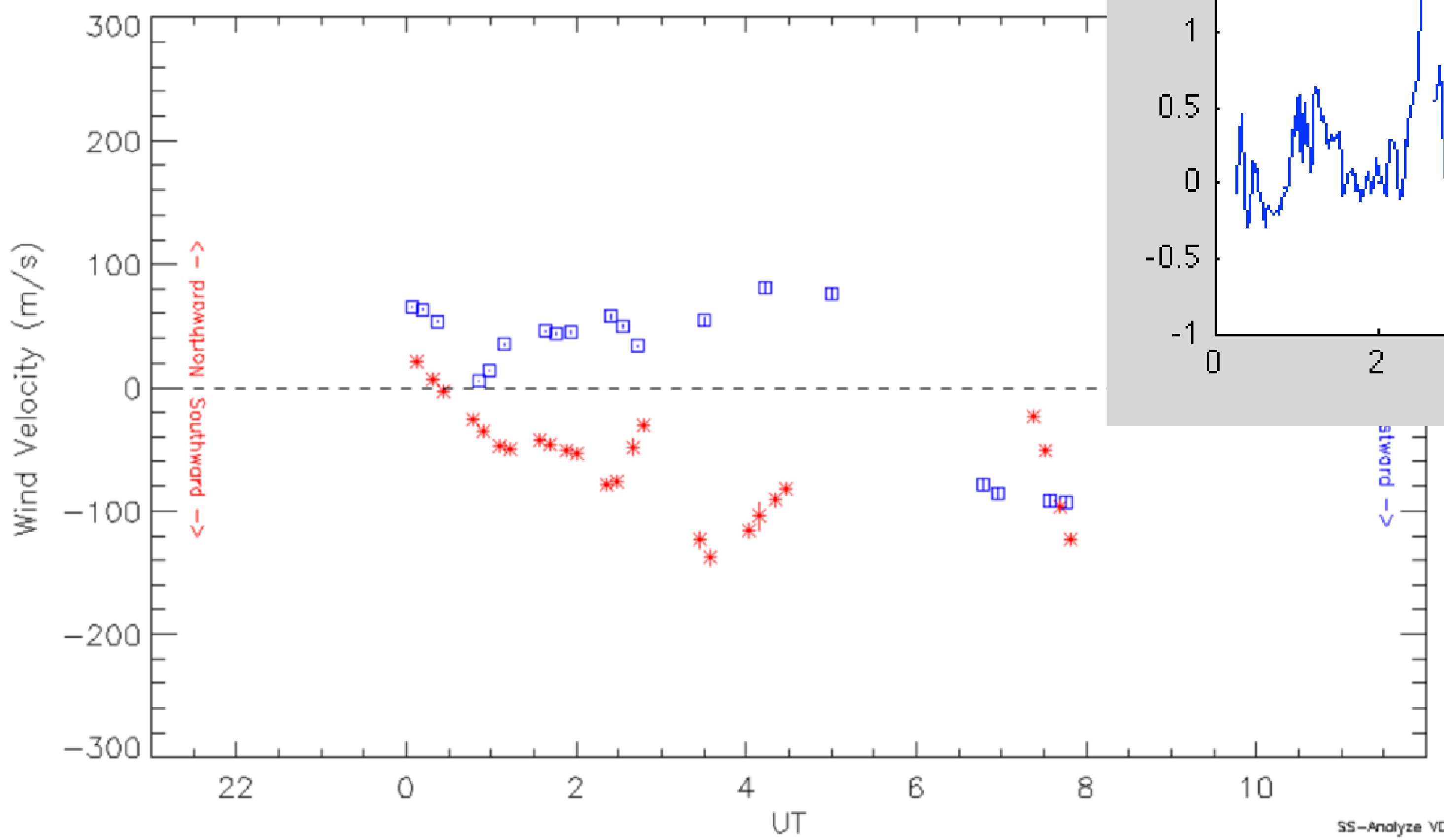
14 April 2015

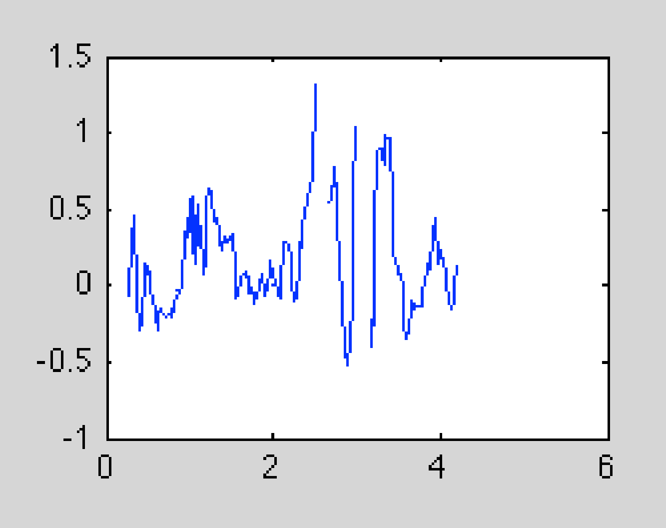



Millstone
Apr 14 2015
N
6300
E
BOSTON UNIVERSITY
exp time: 120.0 s
00:30:13 UT


Contours, MHJ45, DPS-4D, SAOExplorer, v 3.5.2b7
Height [km]
400.0
380.0
360.0
340.0
320.0
300.0
280.0
260.0
240.0
220.0
200.0
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
0h
30
1h
30
2h
30
3h
30
4h
30
5h
30
6h
30
7h
30
8h
UT, min (2015.04.14 00 - 2015.04.14 08)

FPI - 14 April 2015

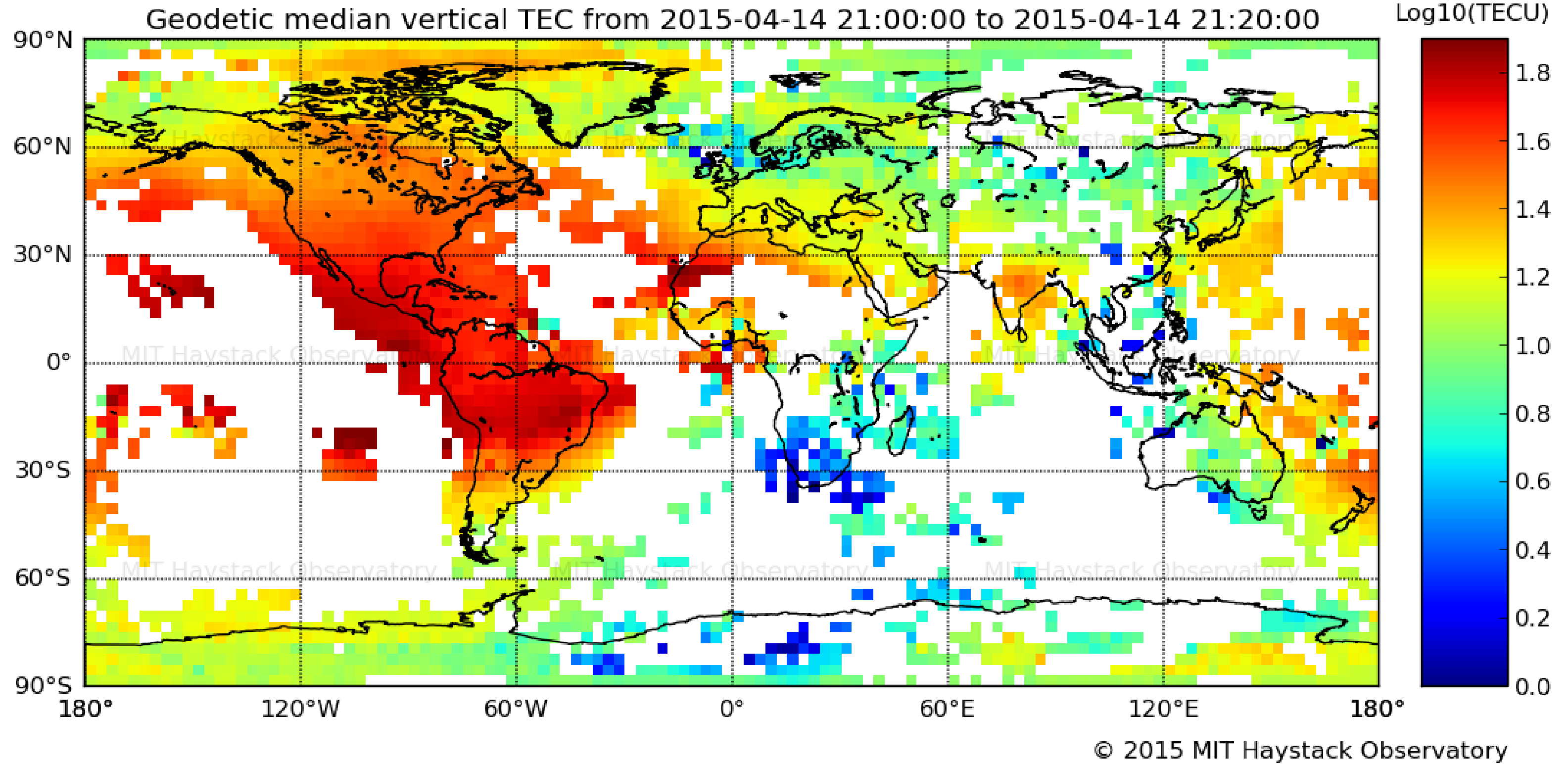


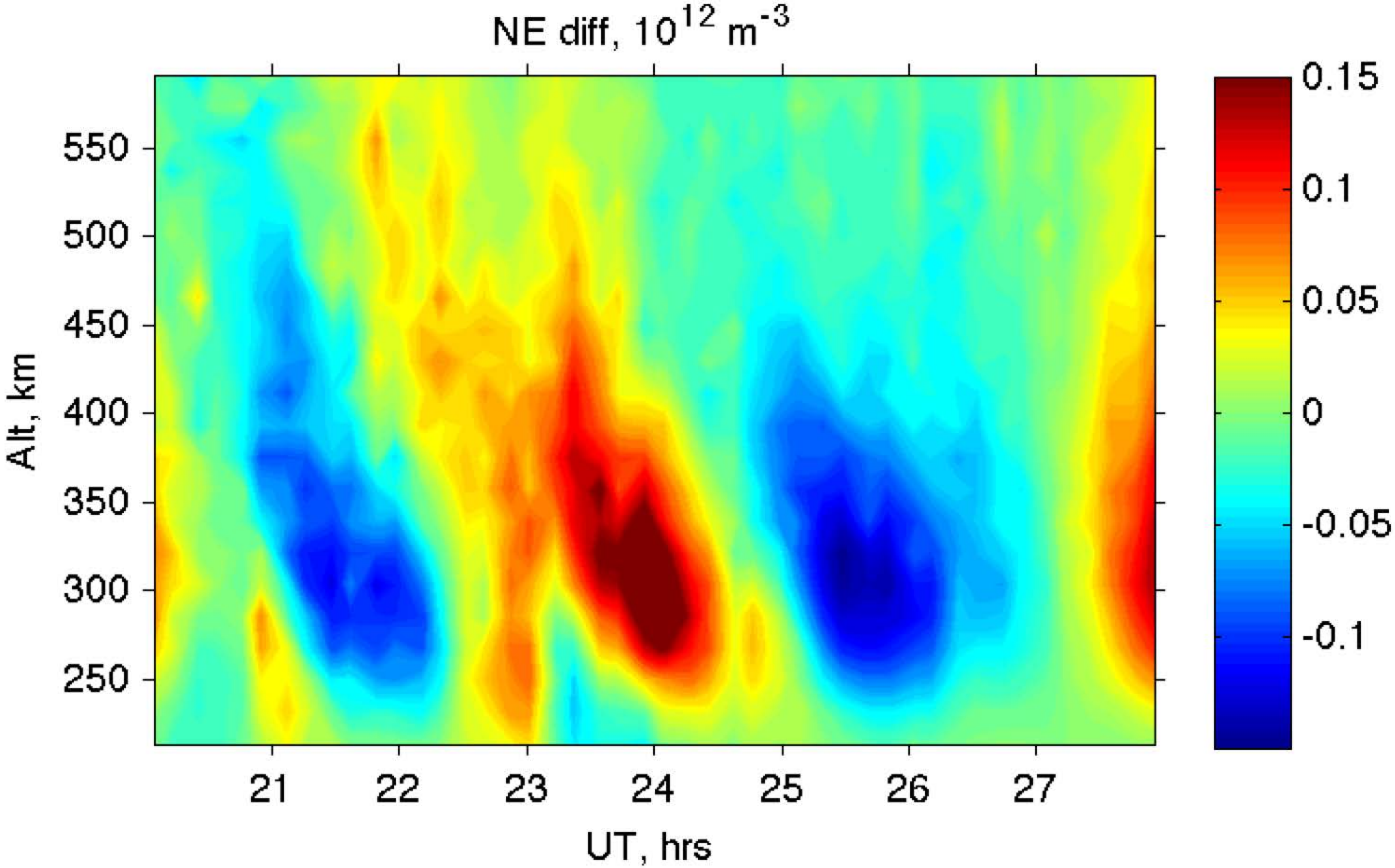


Jpeg plot of Meridional

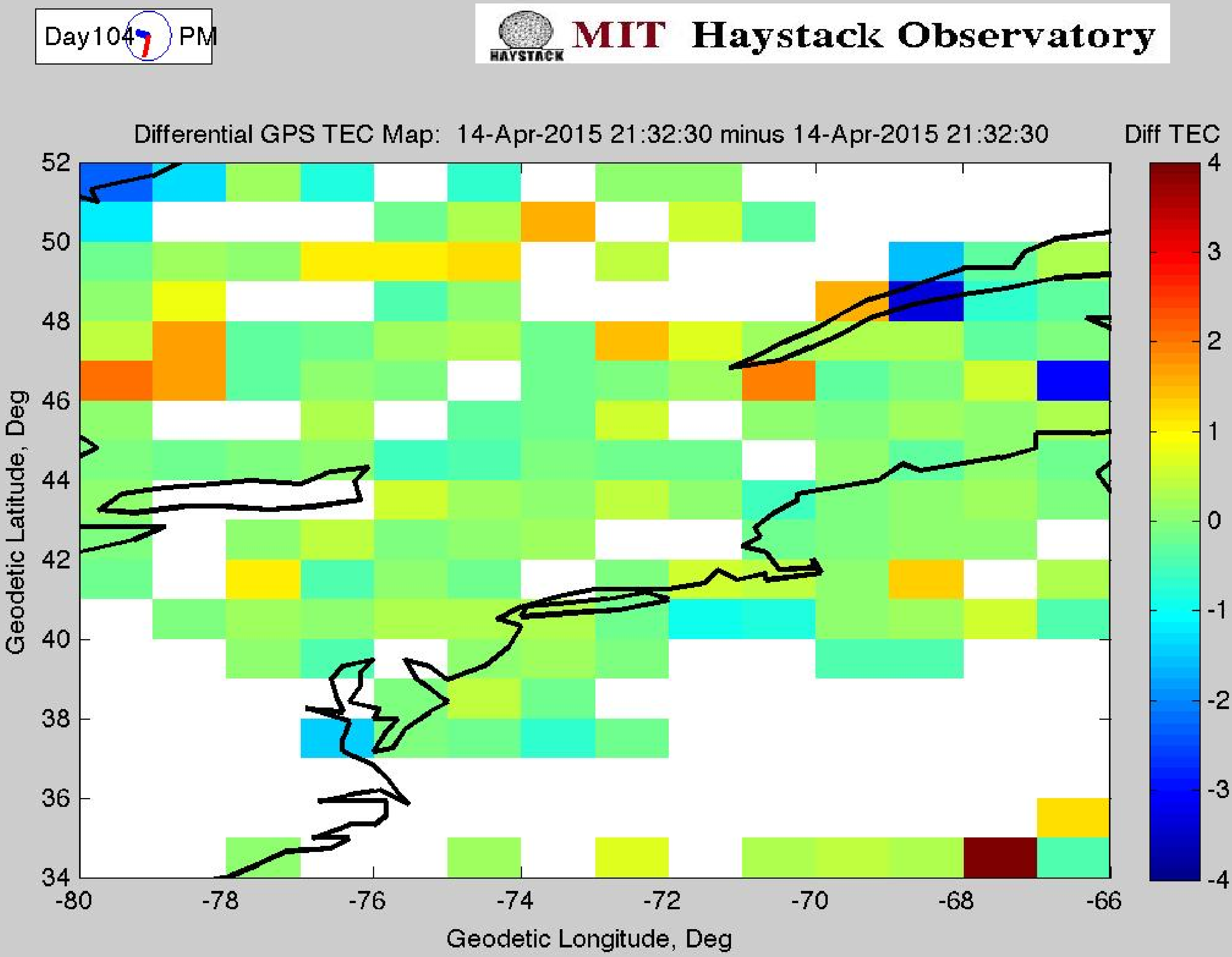
Red line FPI higher level vector wind data

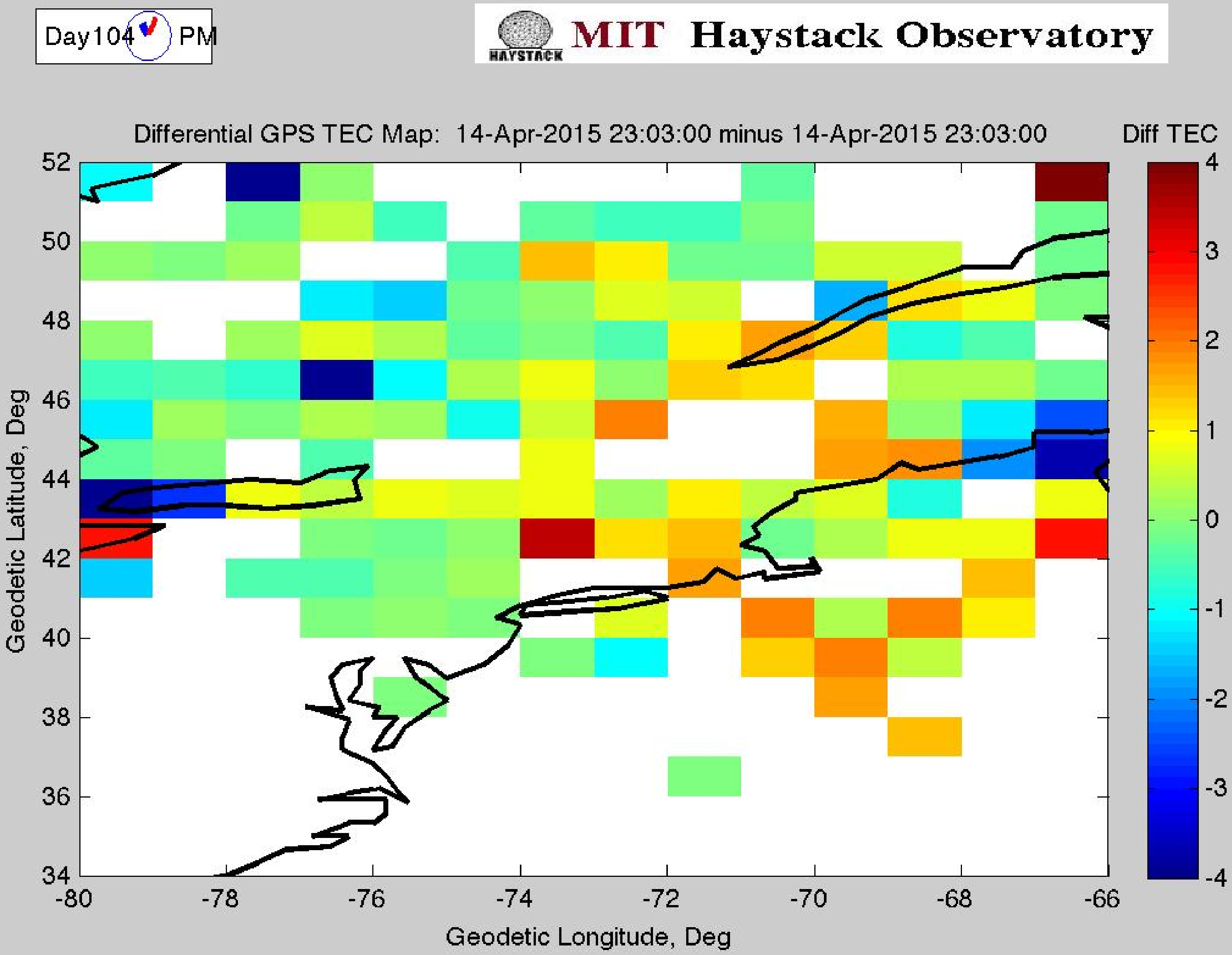
14 April 2015





NE diff, 10^12 m^-3
Alt, km
550
500
450
400
350
300
250
21
22
23
24
25
26
27
UT, hrs
0.15
0.1
0.05
0
-0.05
-0.1


Day104 PM
MIT Haystack Observatory
Differential GPS TEC Map: 14-Apr-2015 21:32:30 minus 14-Apr-2015 21:32:30
Diff TEC
4
3
2
1
0
-1
-2
-3
-4
52
50
48
46
44
42
40
38
36
34
Geodetic Latitude, Deg
-80
-78
-76
-74
-72
-70
-68
-66
Geodetic Longitude, Deg


Day104 PM
MIT Haystack Observatory
HAYSTACK
Differential GPS TEC Map: 14-Apr-2015 23:03:00 minus 14-Apr-2015 23:03:00
Diff TEC
Geodetic Latitude, Deg
Geodetic Longitude, Deg
52
50
48
46
44
42
40
38
36
34
-80
-78
-76
-74
-72
-70
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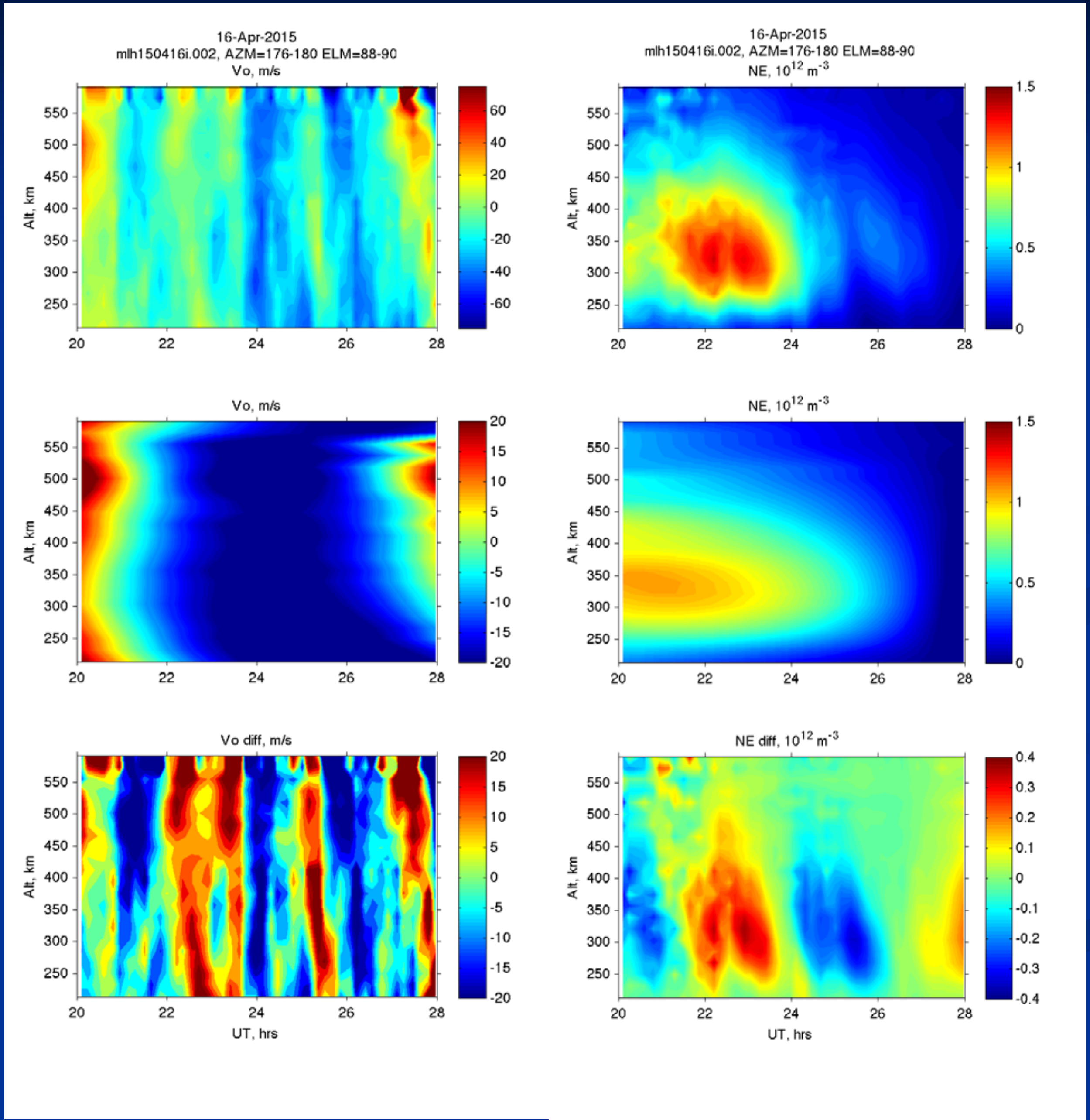
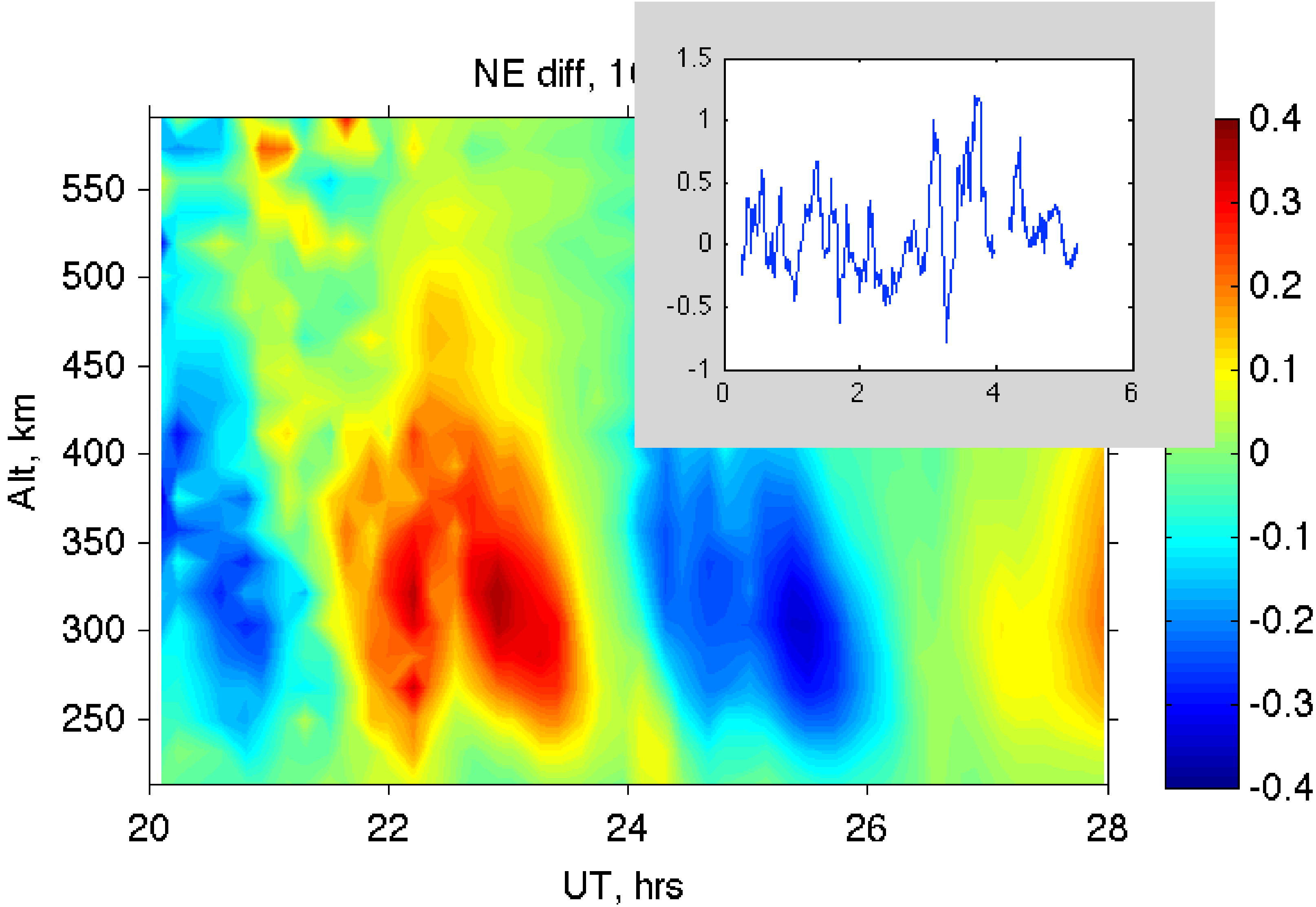
-66
4
3
2
1
0
-1
-2
-3
-4

17-18 April 2015





NE diff, 1(
Alt, km
550
500
450
400
350
300
250
UT, hrs
20
22
24
26
28
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
1.5
1
0.5
0
-0.5
-1
0
2
4
6

Summary

MAHALI TID campaign analysis has begun! Portability of MAHALI boxes will aid in field deployments.

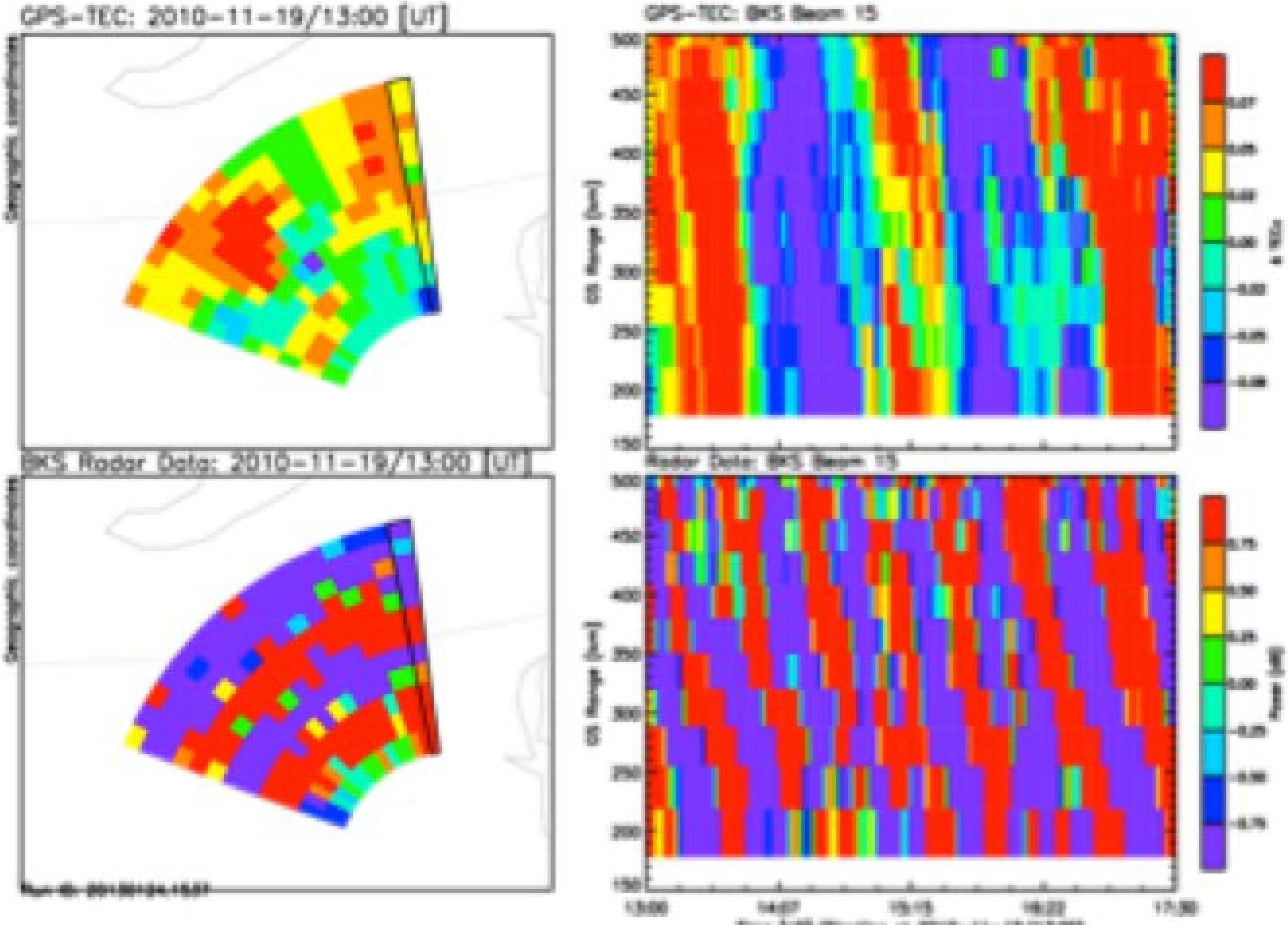
GPS TEC analysis does not always show the same TID structures observed by other analysis techniques (ionosondes).


BRA
LUTERANO DE MAN
Pesquisa
Desenvolviment
RESUMO
MATERIAL E MÉTODOS
RESULTADOS
CONCLUSÃO
REFERÊNCIAS
ULBRA
FAPEAM

SuperDARN and GPS-TEC

GPS-TEC vs SuperDARN Radar

GPSETEC)Data)and)processin
g)
provided)by)Tsugawa)et)al.)




19:03
Mahali GPS Logger
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Stopped
Edit GPS Config
Data capture is inactive
Previous Sessions:
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Size: 10.5 kB
150128_220327.nvd
Size: 184.9 kB
150128_215429.nvd
Size: 94.1 kB
150128_215022.nvd
Size: 105.0 kB
150128_203803.nvd
Size: 166.1 kB
150128_203130.nvd
Size: 29.4 kB
150128_202916.nvd
Size: 64.5 kB
150128_201230.nvd
Size: 51.6 kB
150128_192535.nvd
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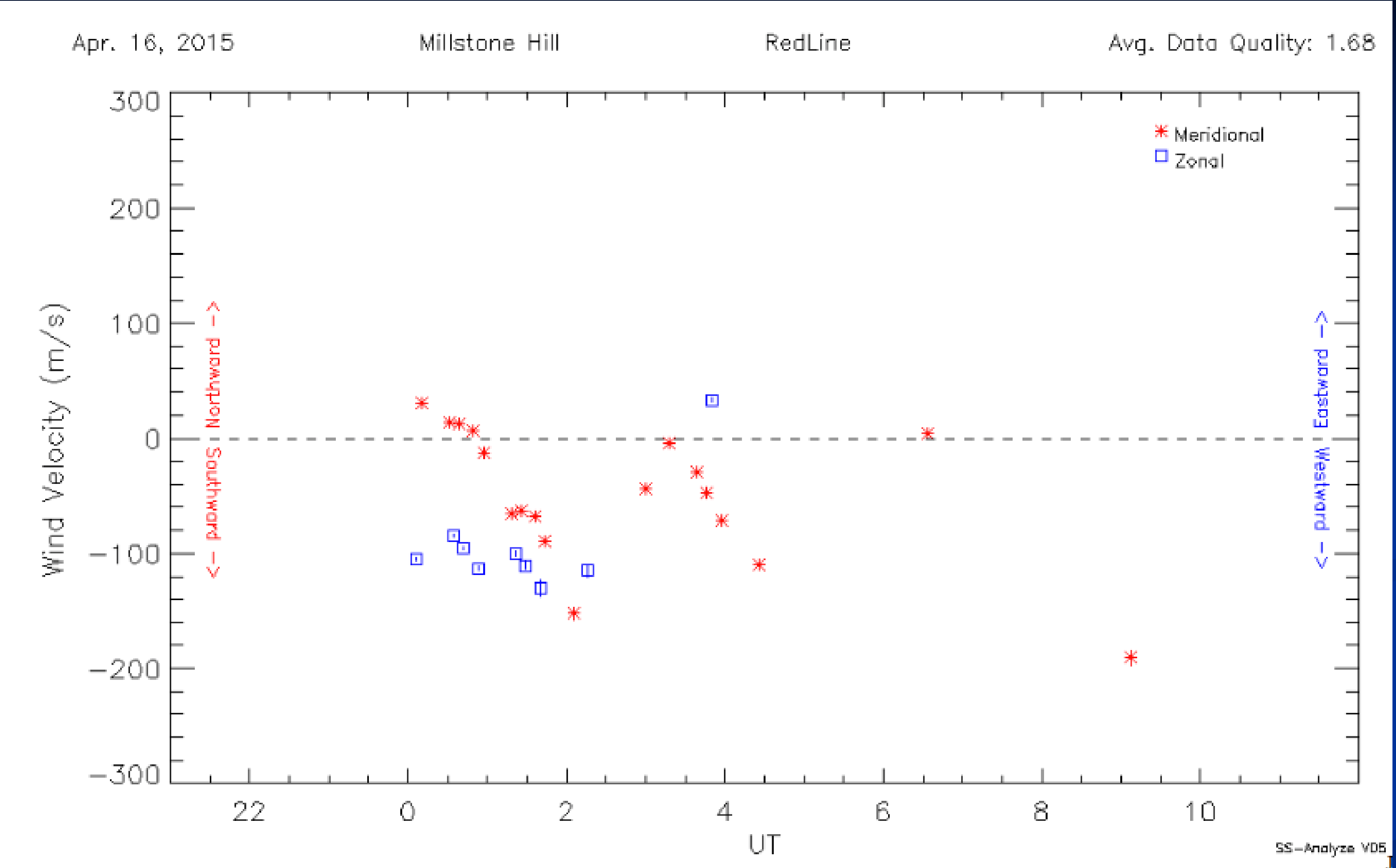
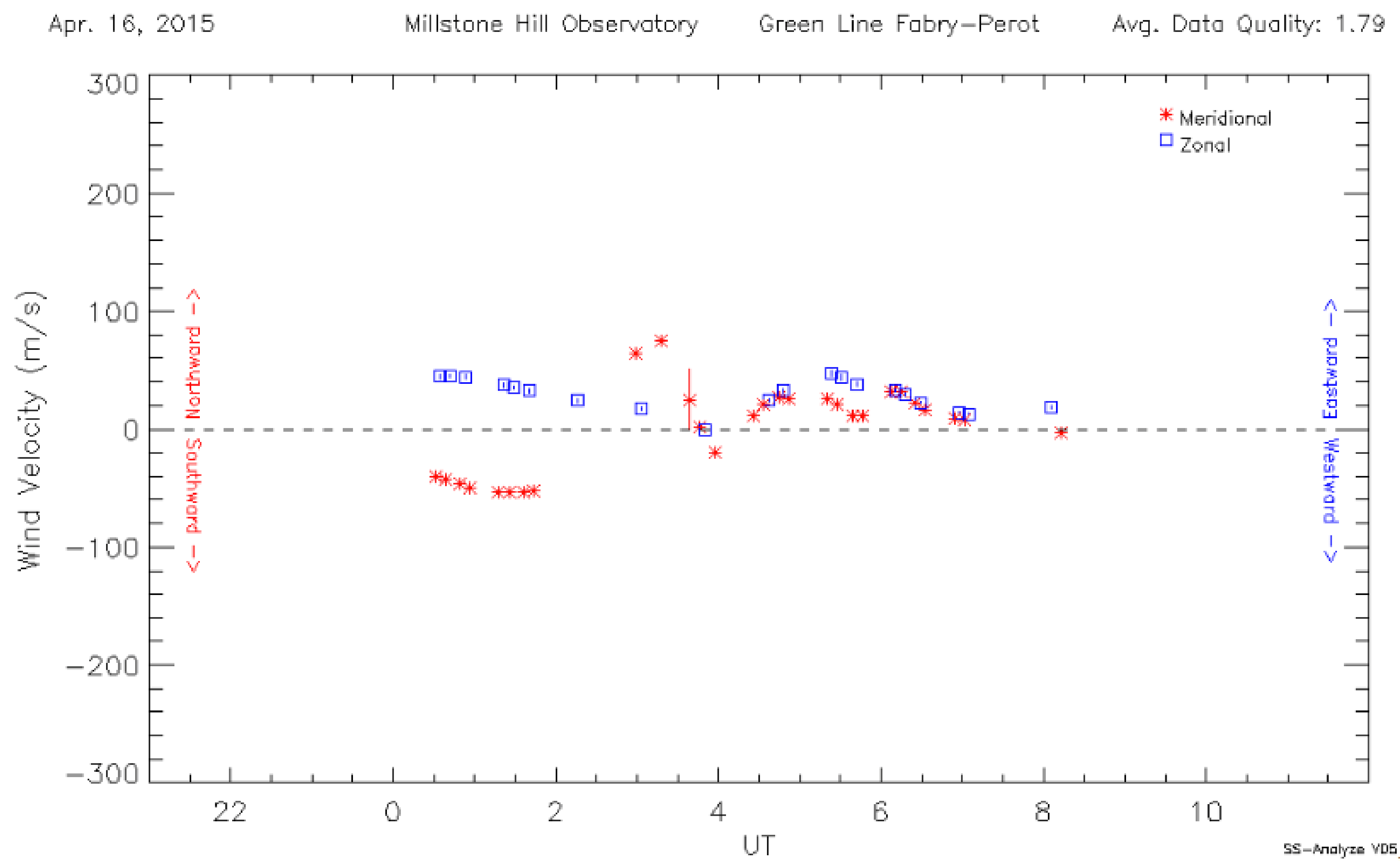
Size: 865.7 kB



UT for Red line FPI higher level vector wind data



UT for Green line FPI higher level vector wind data

14 April 2015