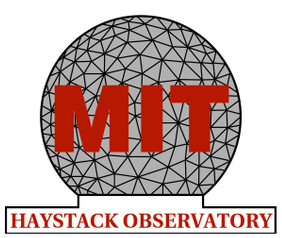
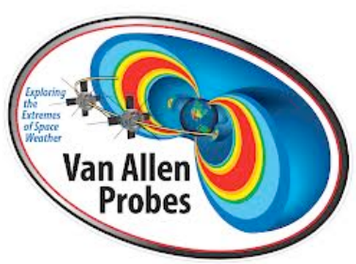
Analysis of localized ionospheric signatures at L=4 to 5 during electron + ion (substorm) injection events: February 2, 2013

P. J. Erickson, J. C. Foster
MIT Haystack Observatory
SuperDARN team @ Virginia Tech

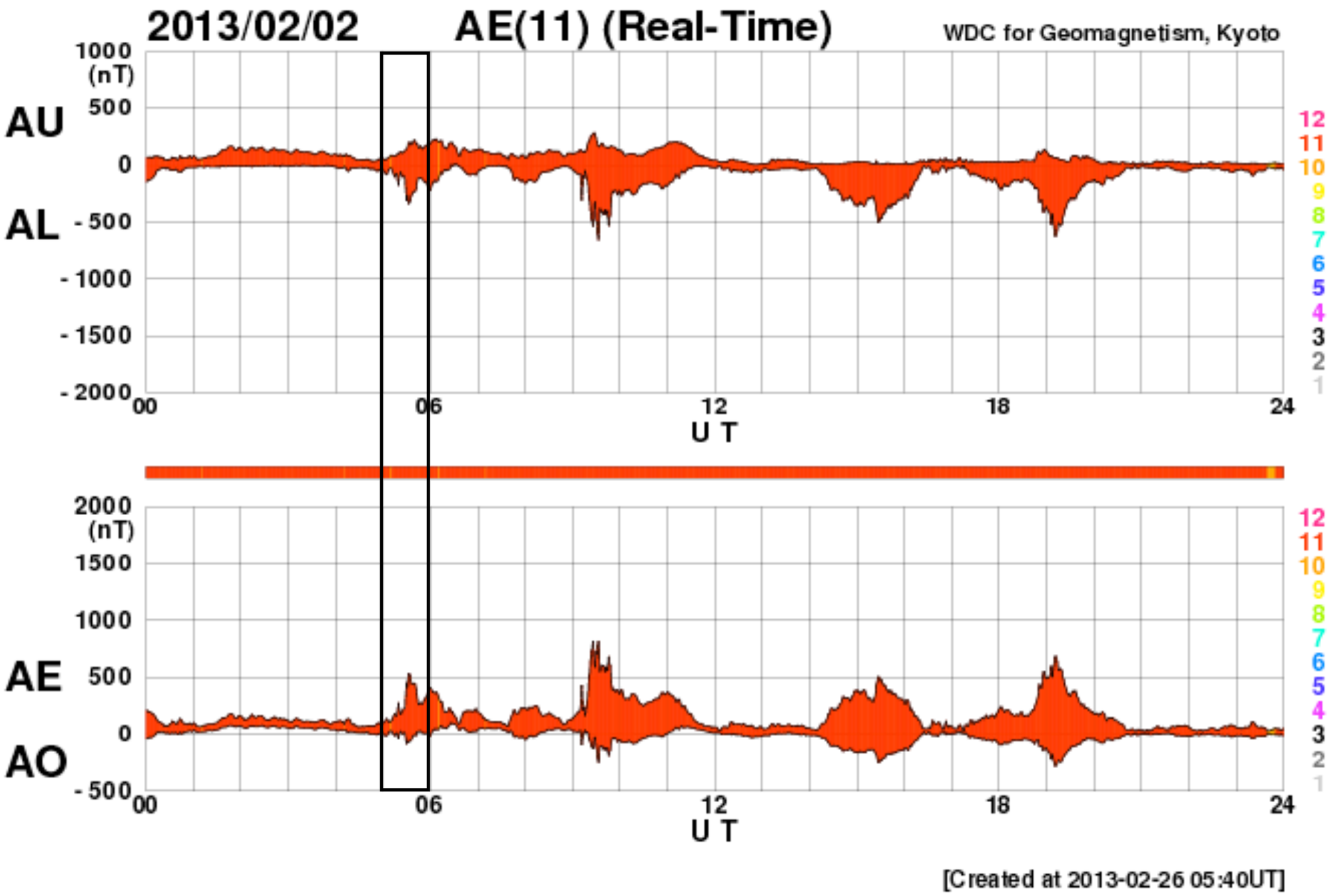
RBSPICE team
MagEIS team
CARISMA team
THEMIS GBO ASI team
BARREL team
etc. ...

February 26, 2013
Injection events session - SWG



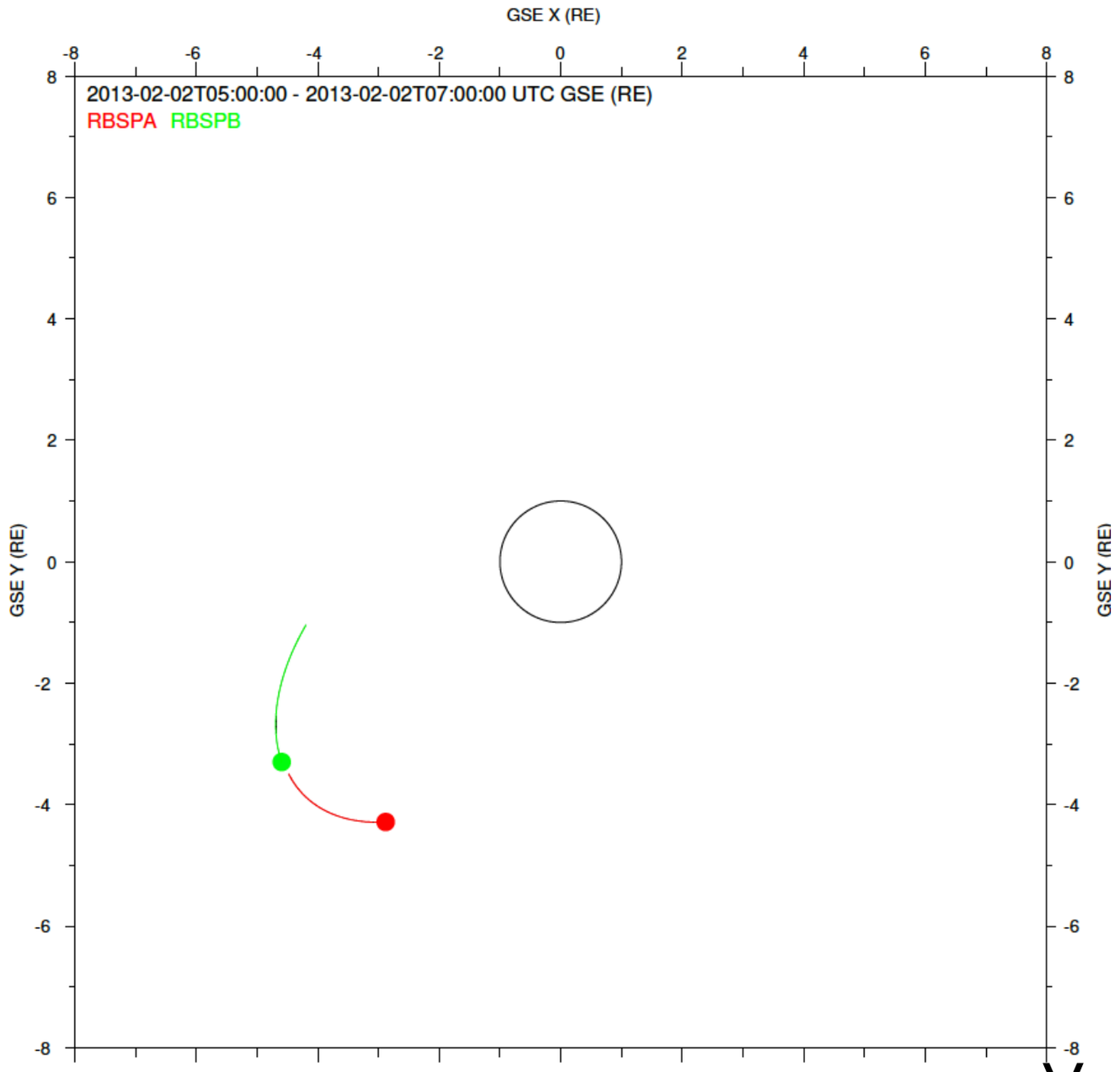


Overall conditions: AE = 500 nT@ 0500-0600 UTC DsT: -18 nT @ 0600 UTC



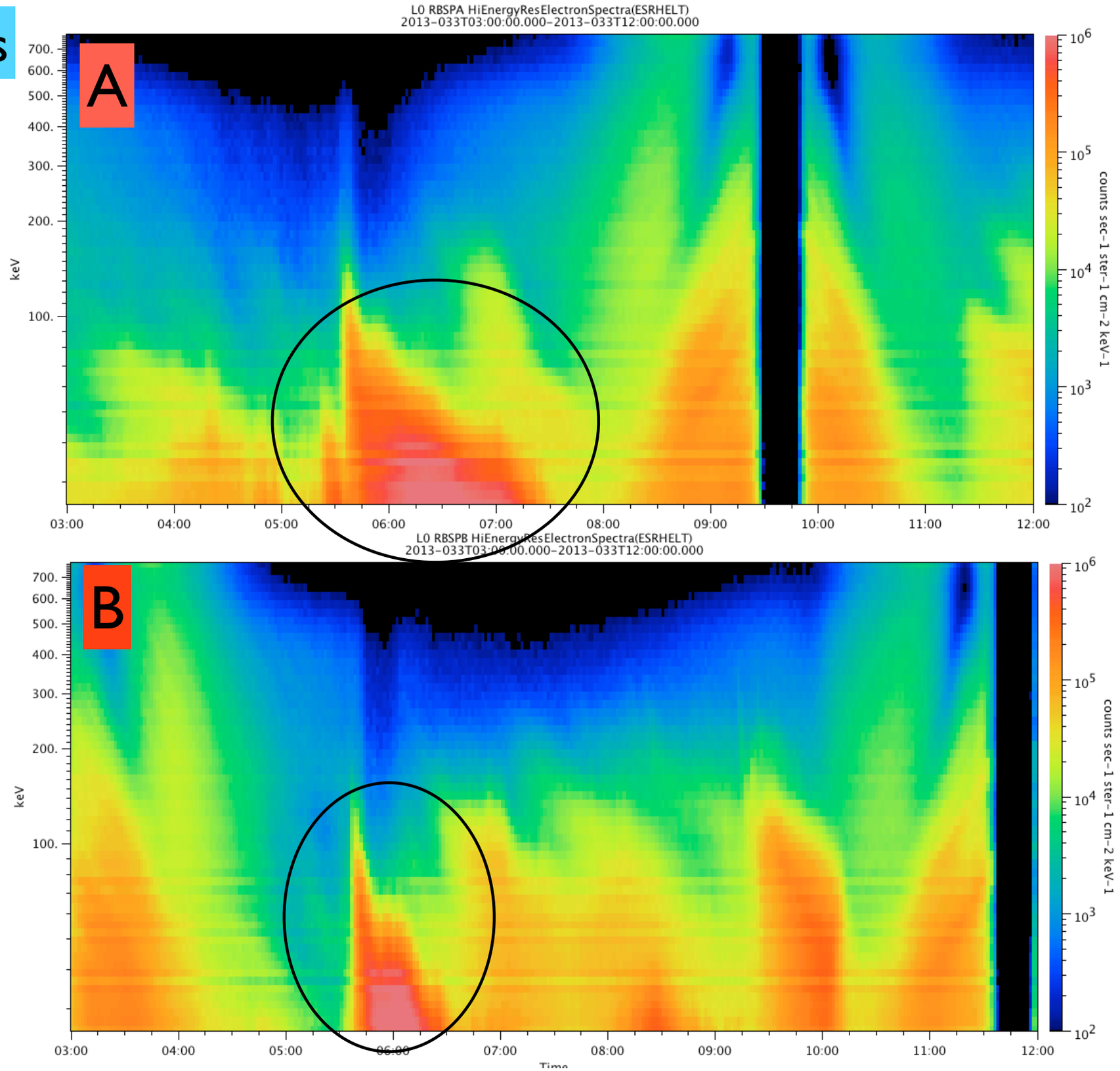
Focus on midnight sector in N America: approx 00 MLT

February 2 05:00-07:00



Van Allen Probes
s/c locations

Electrons

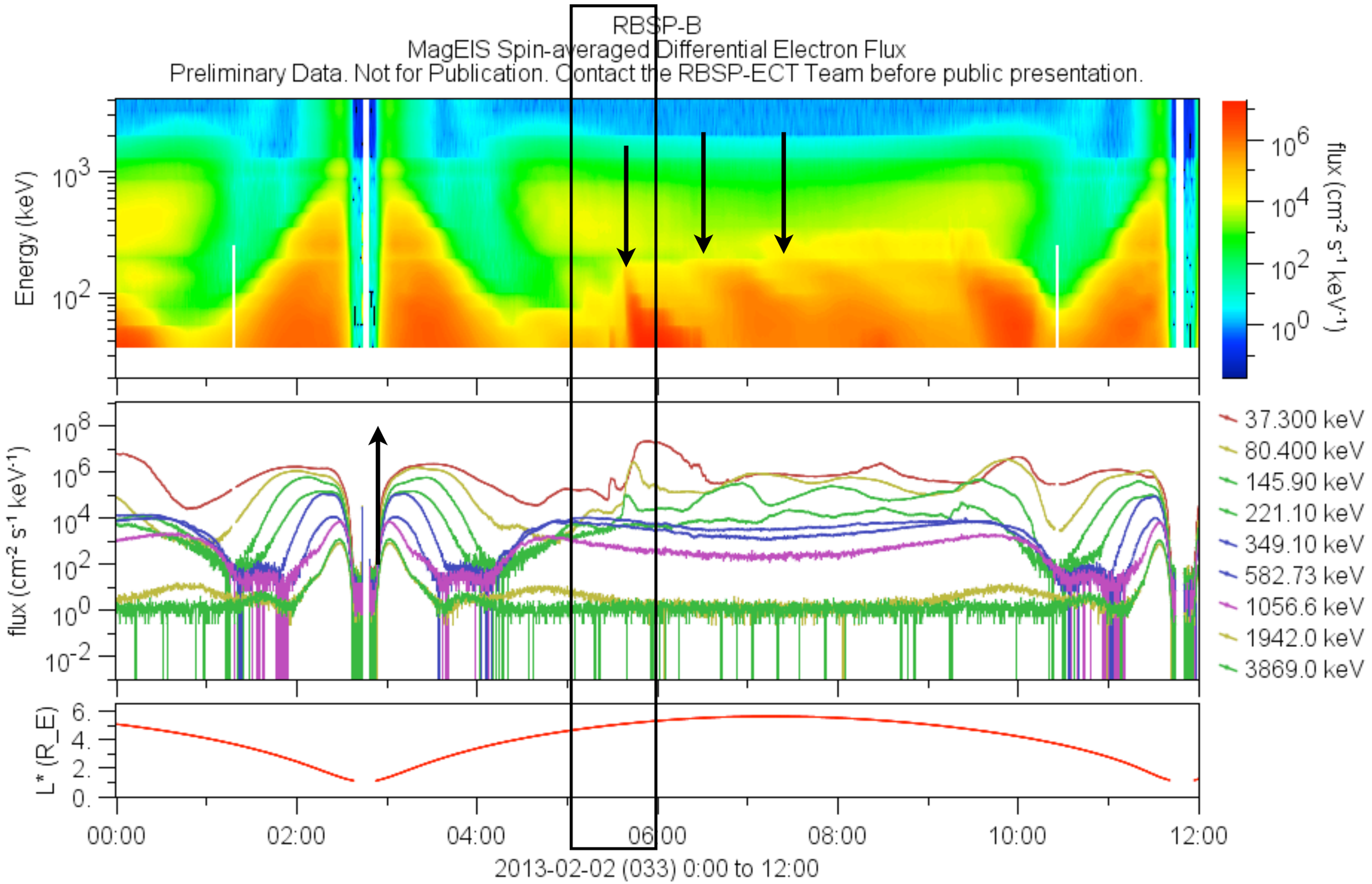


RBSPICE

(RBSPICE / M. Gkioulidou)

Electrons

Drift periods

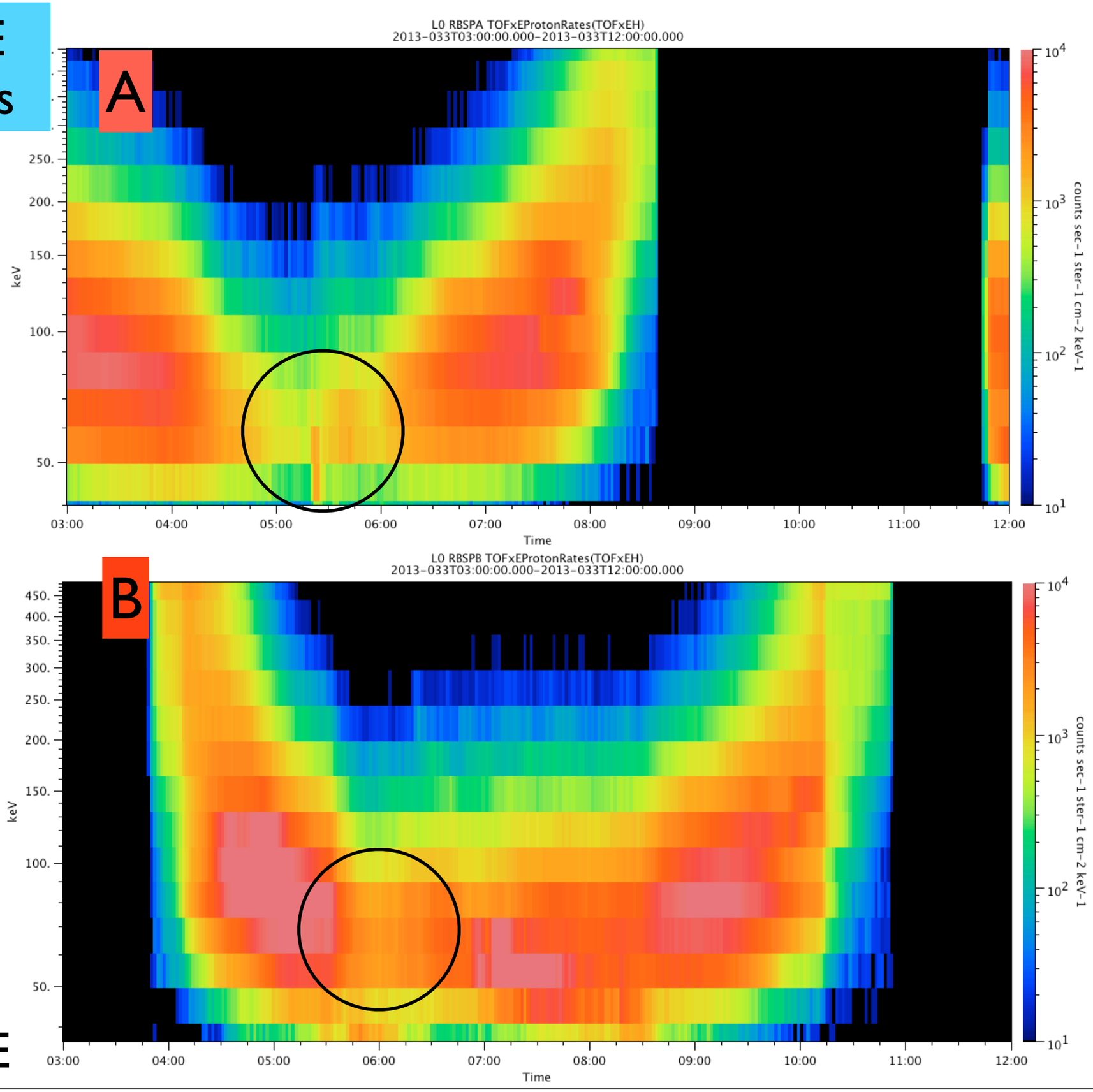


Injection at 200 keV and below
05:30 UTC

MagEIS B

(MagEIS / H. Spence)

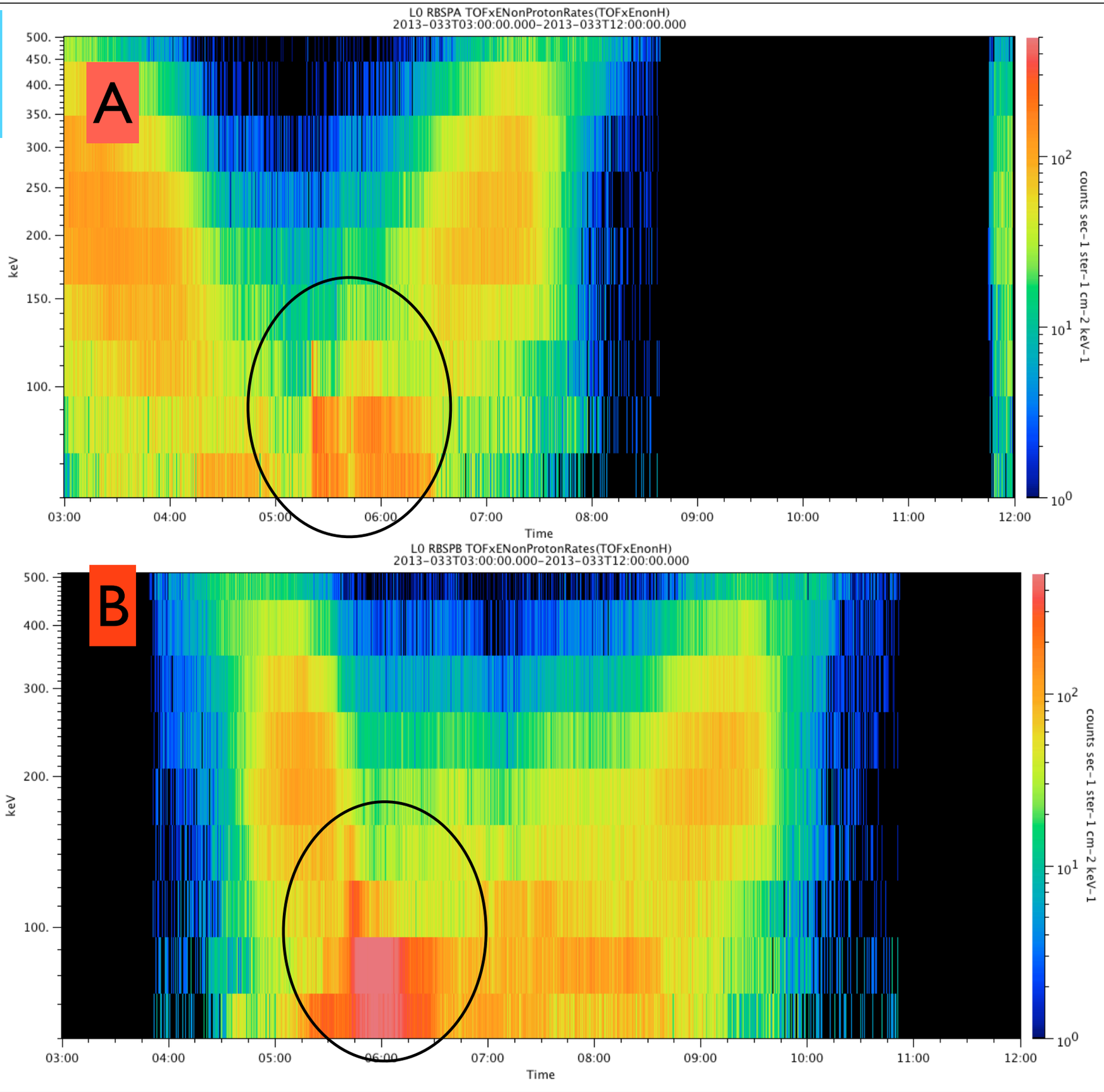
TOFxE protons



RBSPICE

(RBSPICE / M. Gkioulidou)

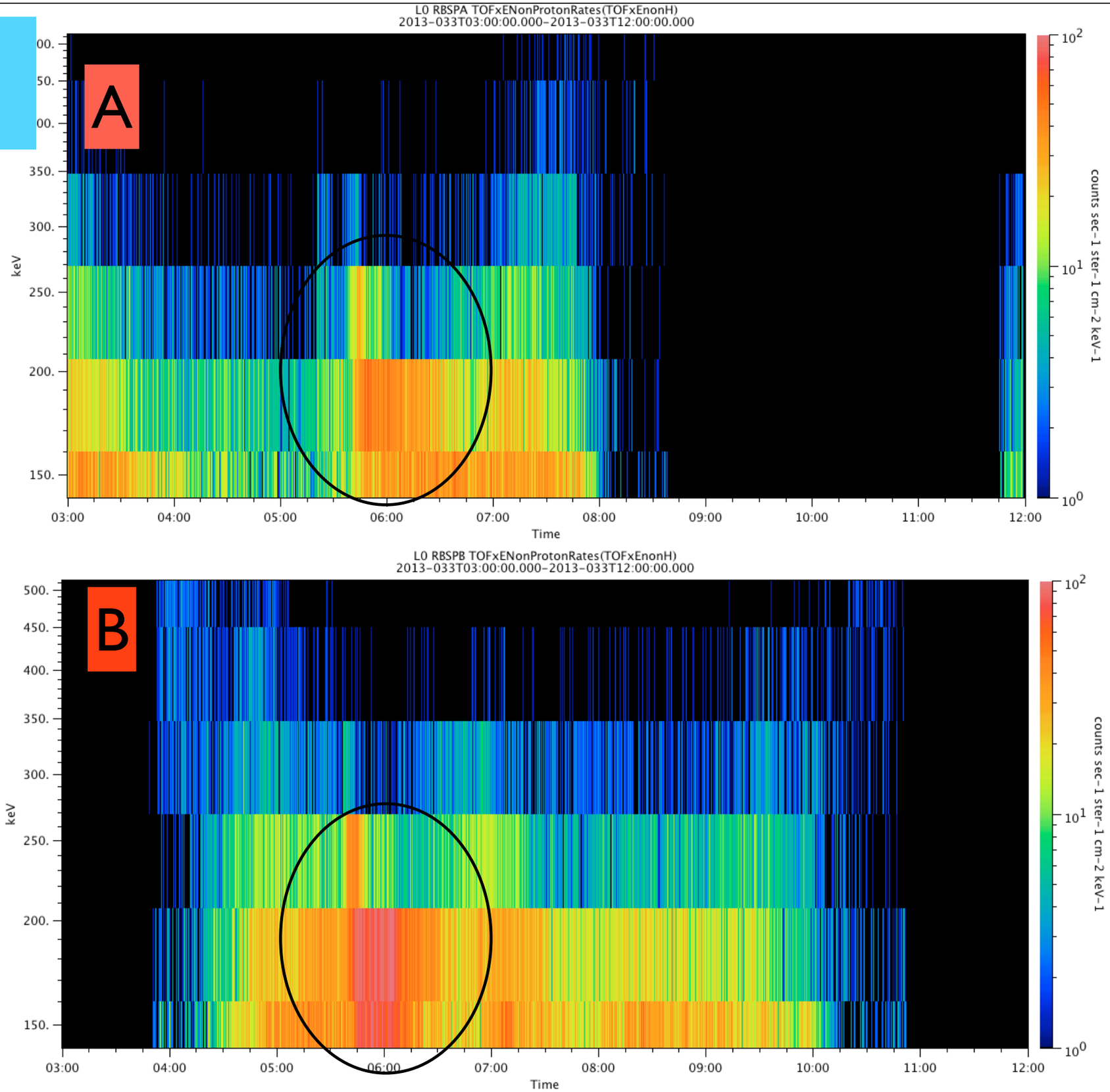
TOFxE Helium



RBSPICE

(RBSPICE / M. Gkioulidou)

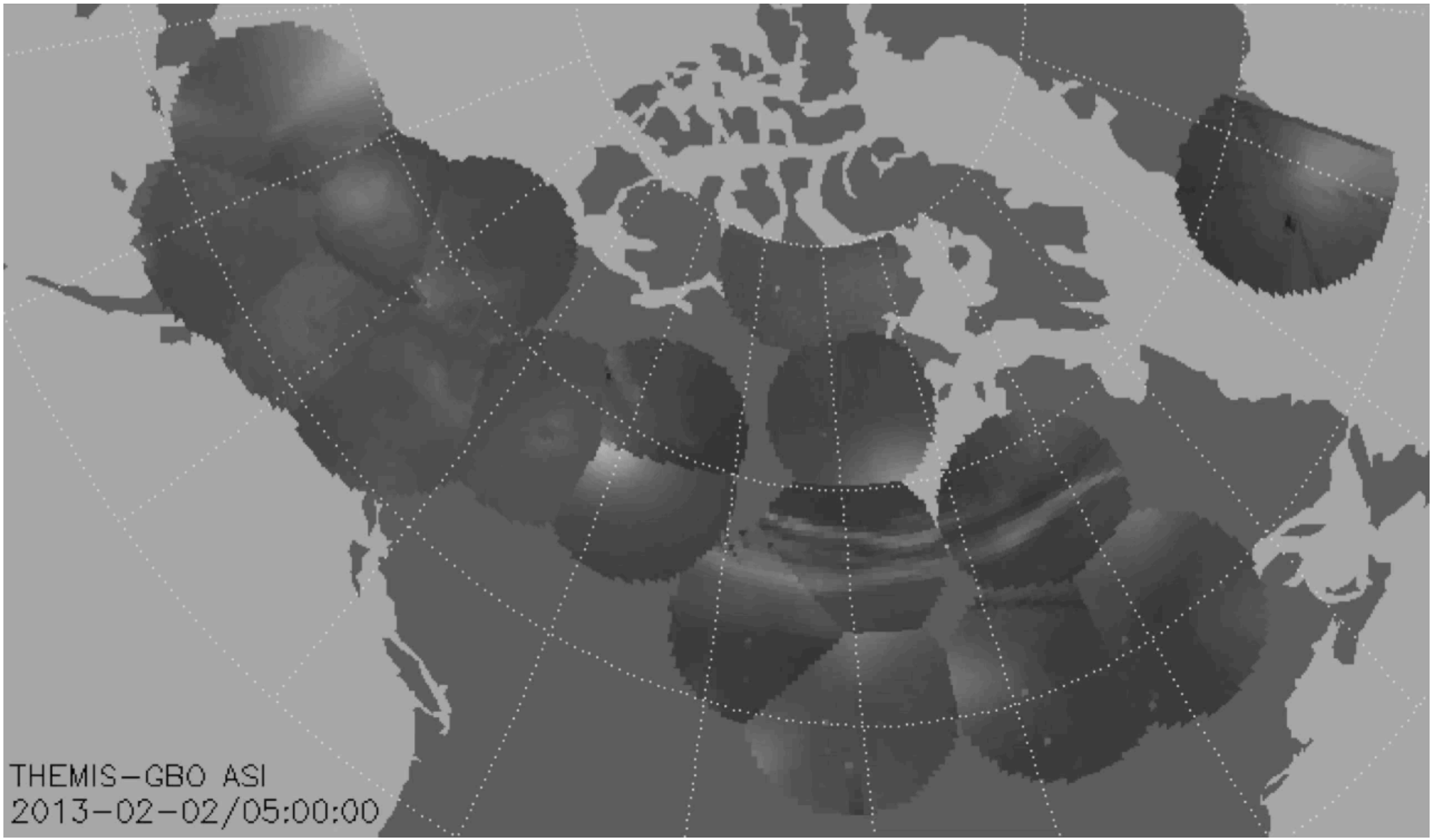
TOFxE Oxygen



RBSPICE

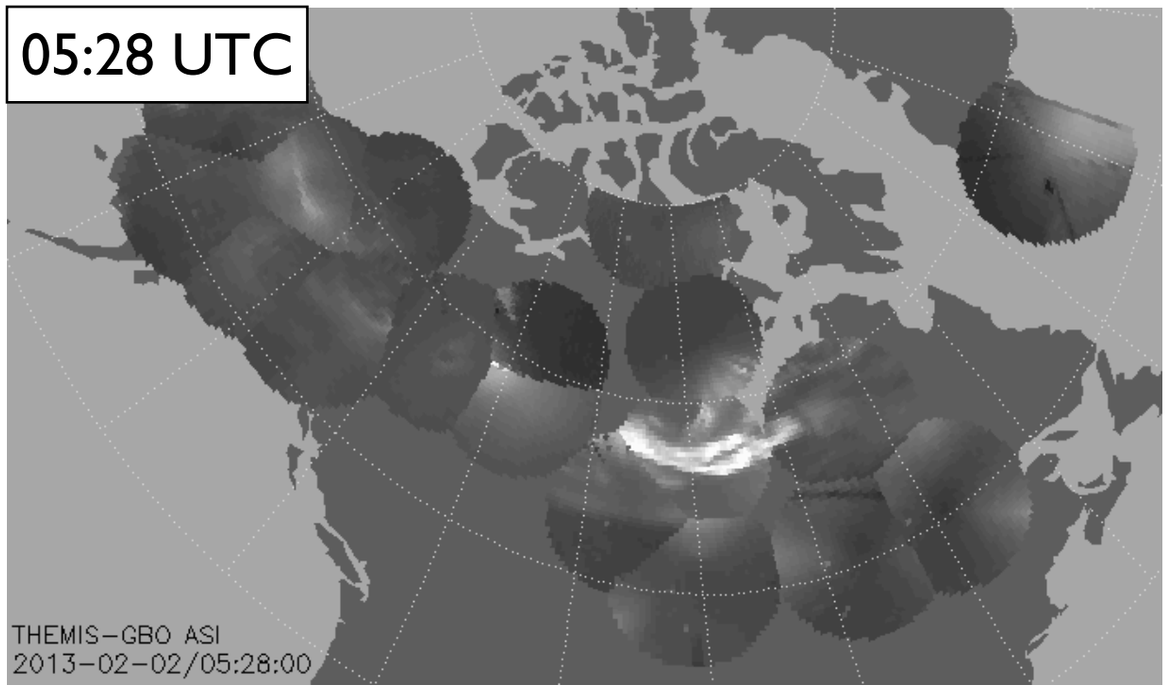
(RBSPICE / M. Gkioulidou)

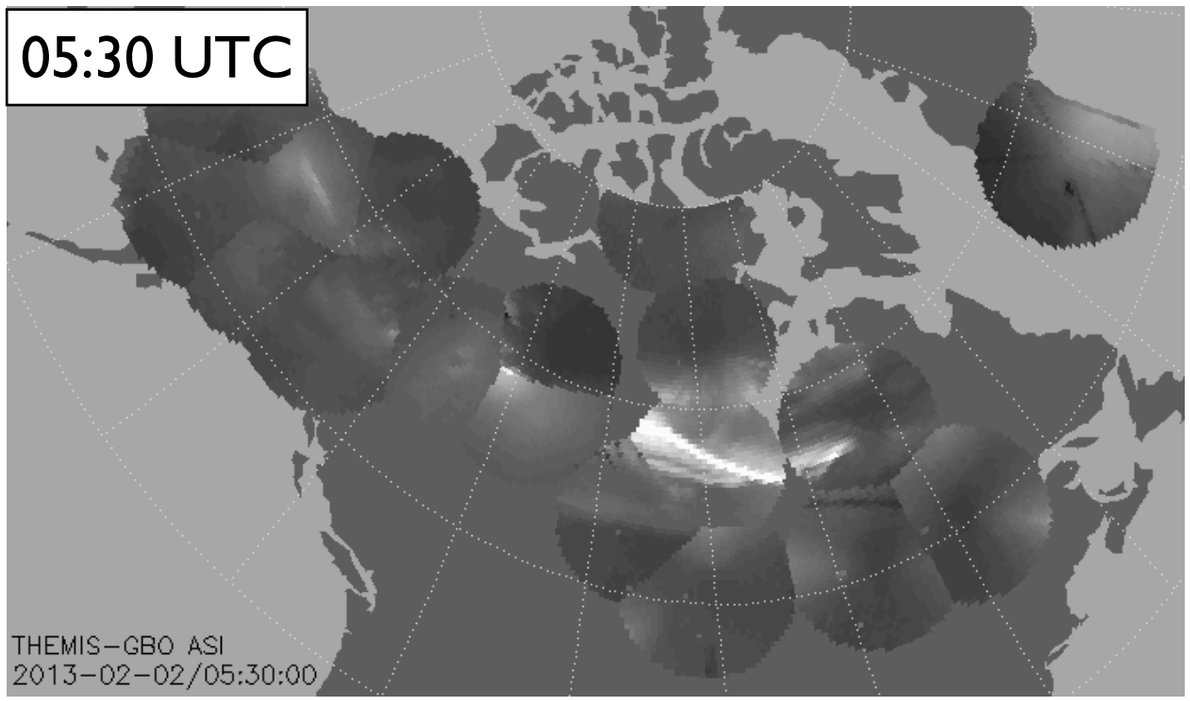
THEMIS GBO All-Sky Imager Mosaic

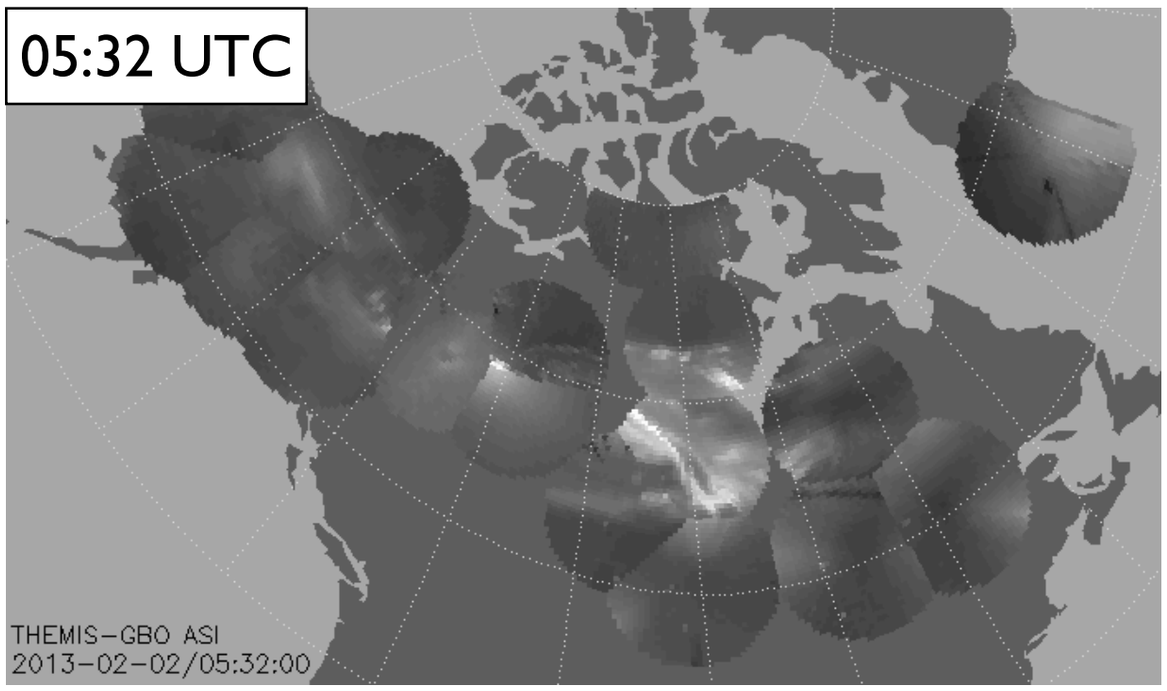


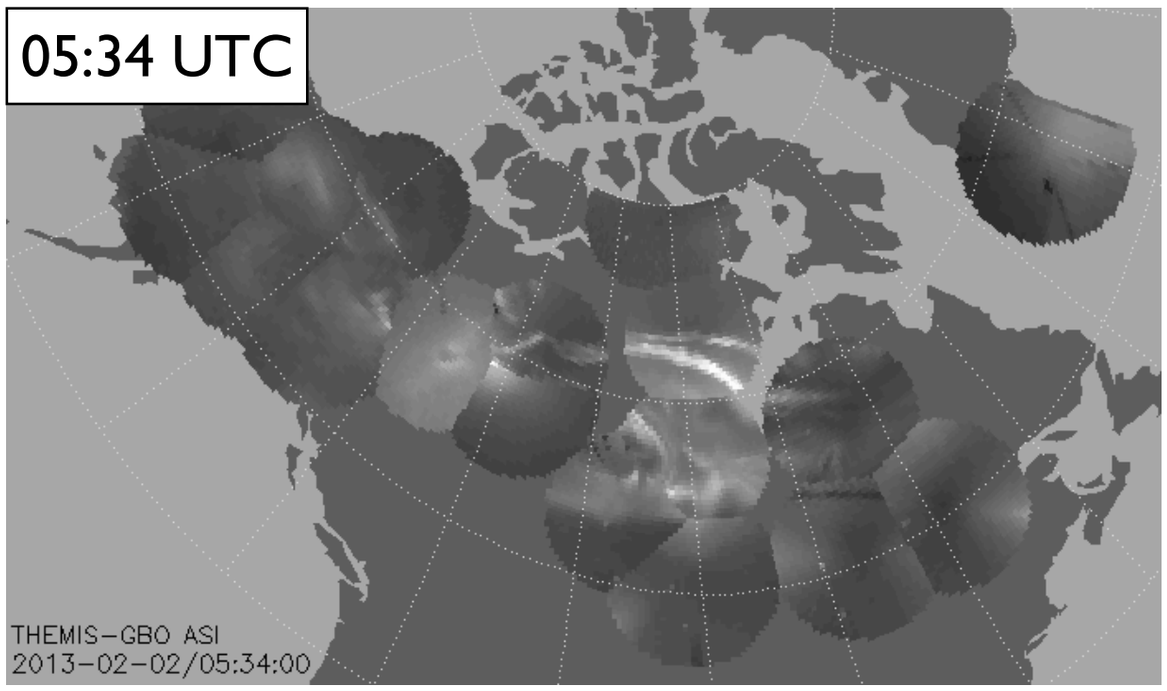
(from THEMIS GBO ASI web site)

THEMIS GBO All-Sky Imager Mosaic





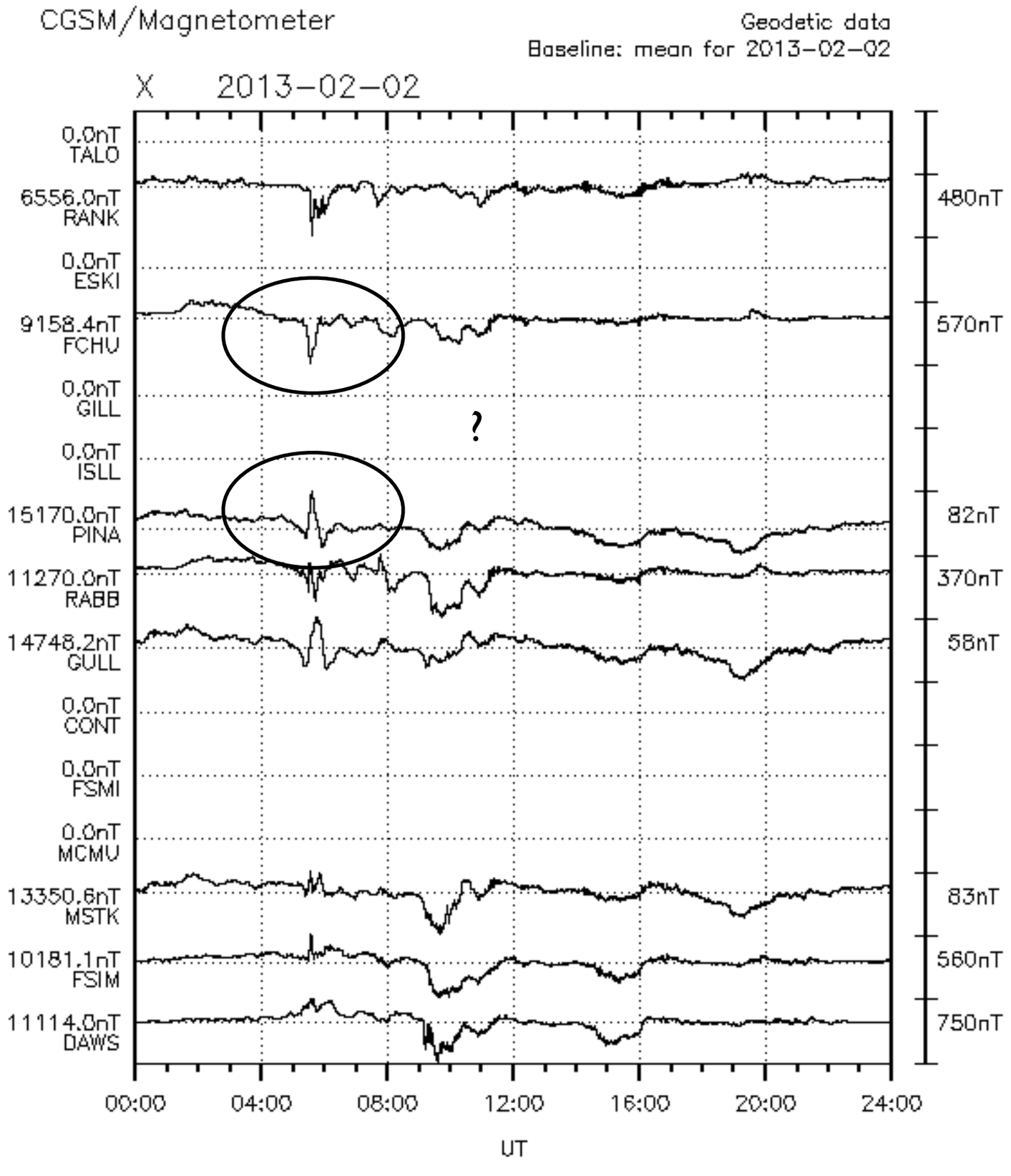




(from THEMIS GBO ASI web site)

CARISMA
Churchill line

Induction coil
magnetometers



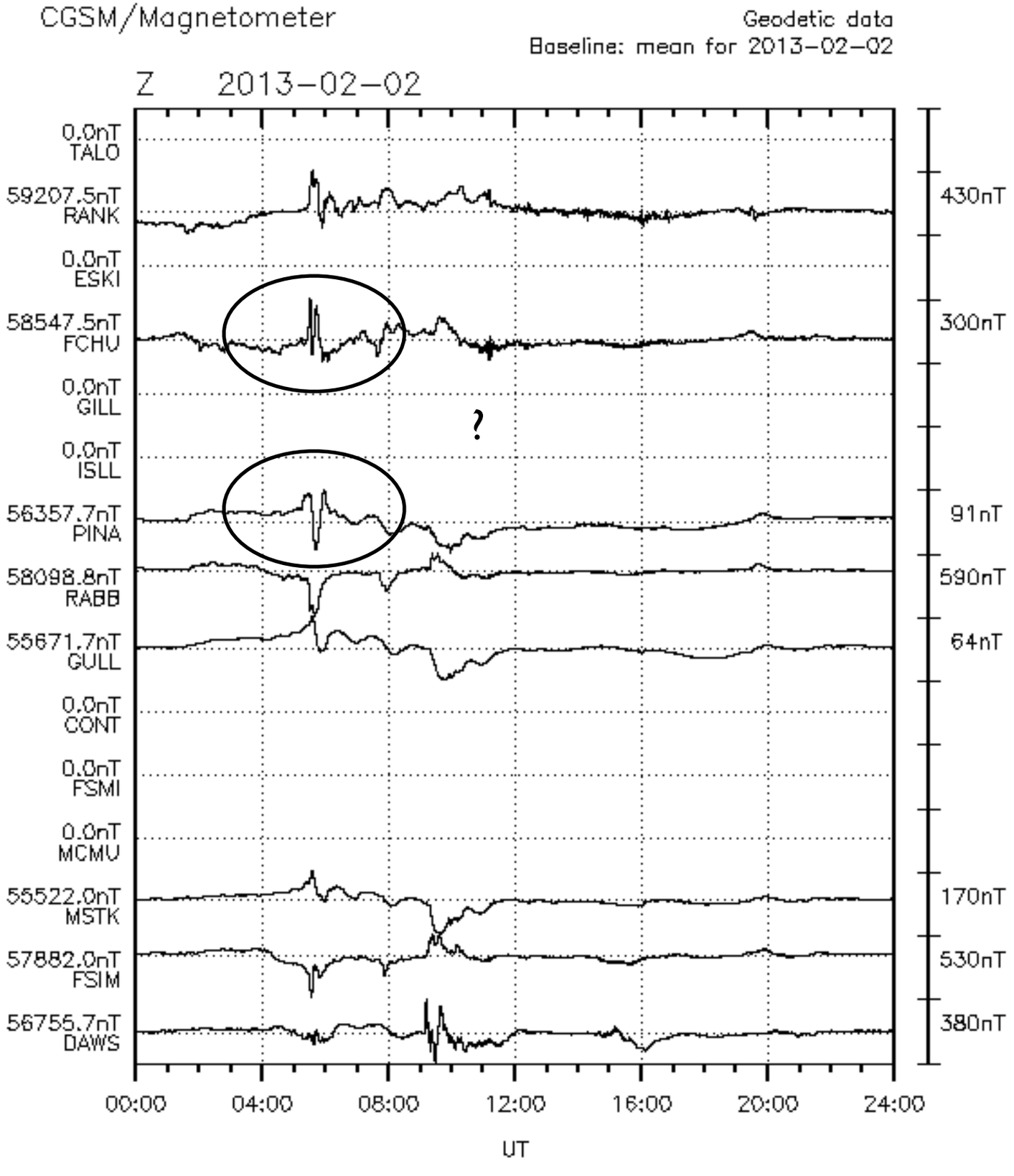
(from CARISMA web site / Ian Mann)

CARISMA
Churchill line

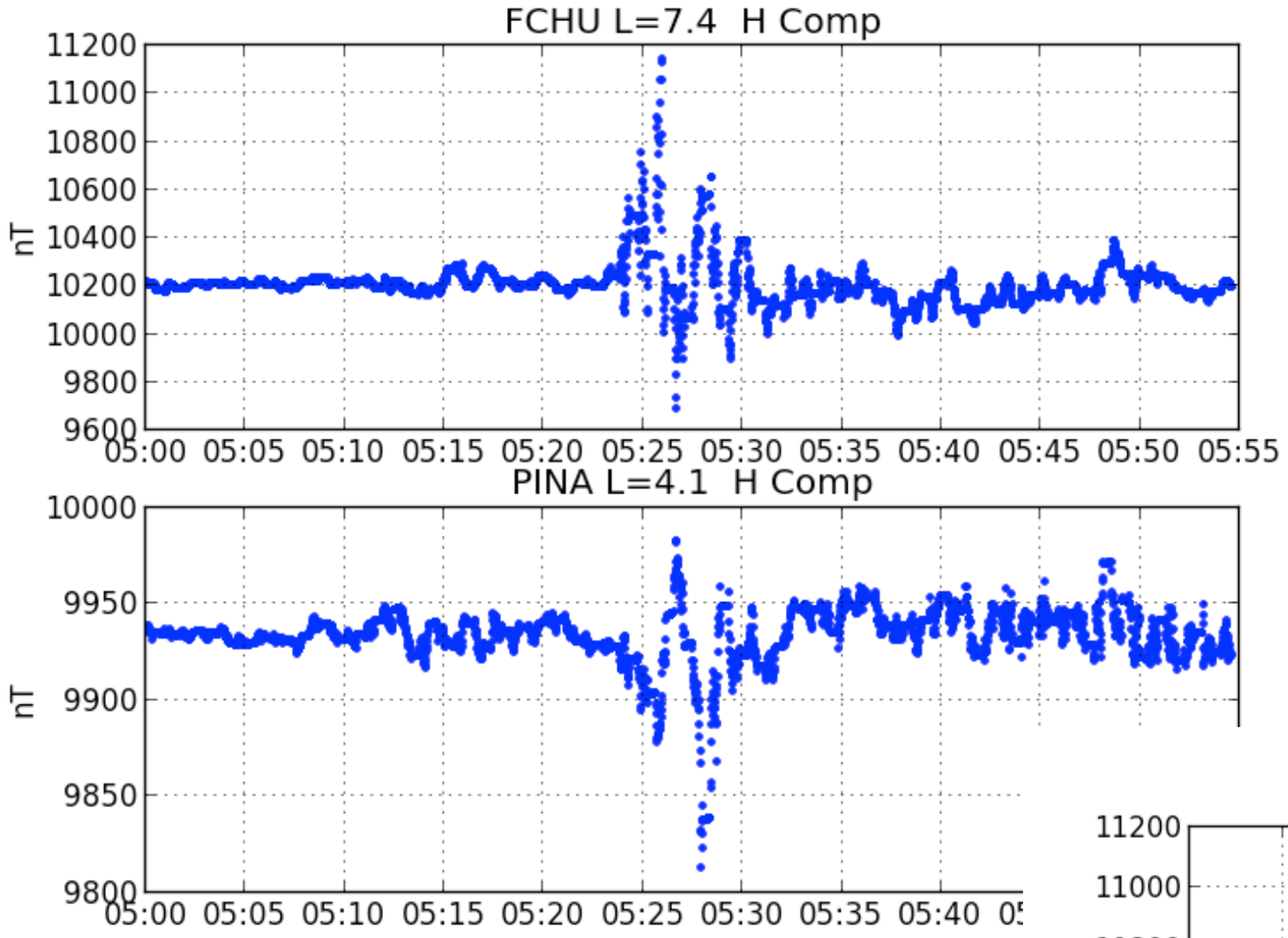
Induction coil
magnetometers

68.3 MLat CGM
L=7.4

60 MLat CGM
L=4.06



(from CARISMA web site / Ian Mann)

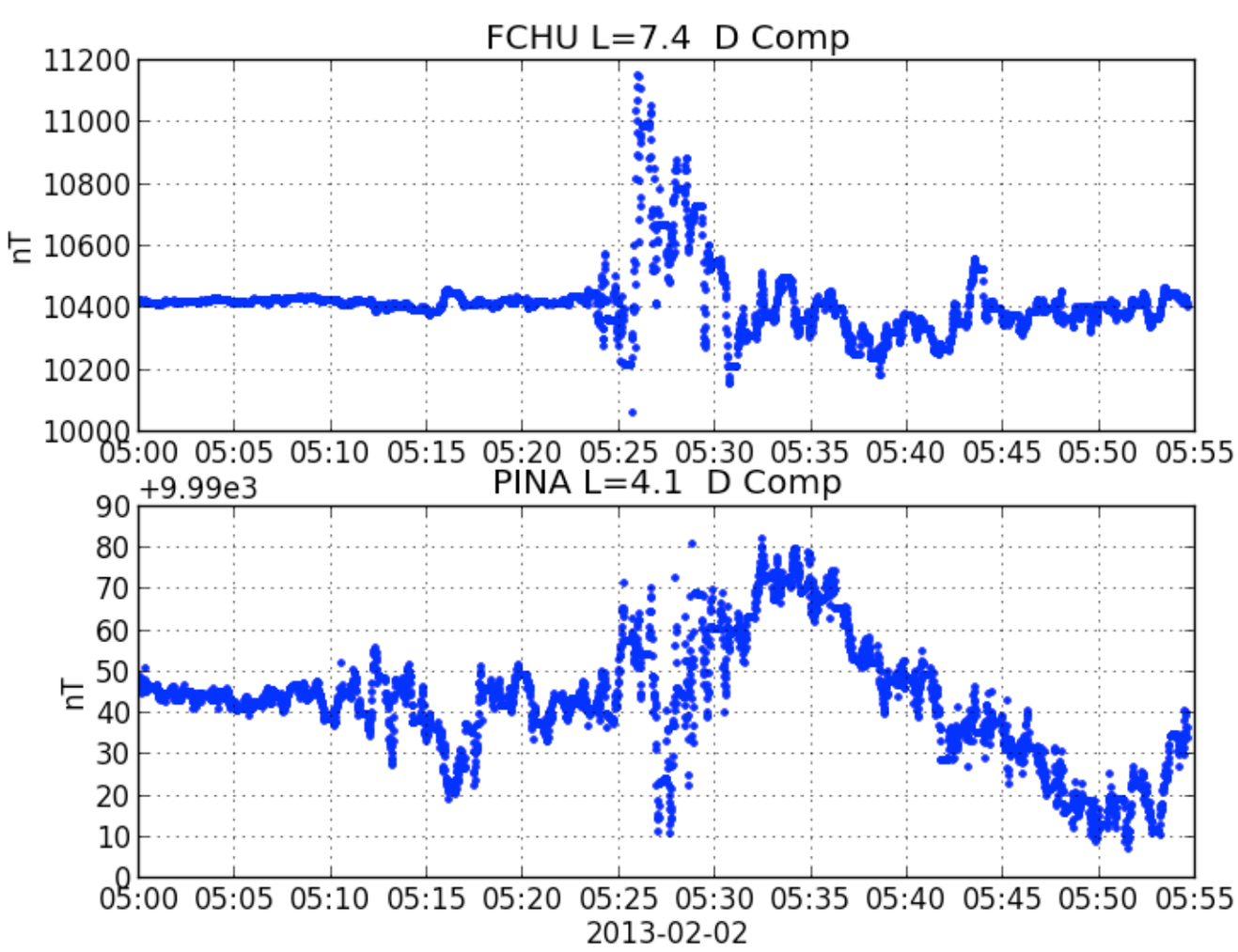


(from CARISMA web site / Ian Mann)

CARISMA
Churchill line

Induction coil magnetometers

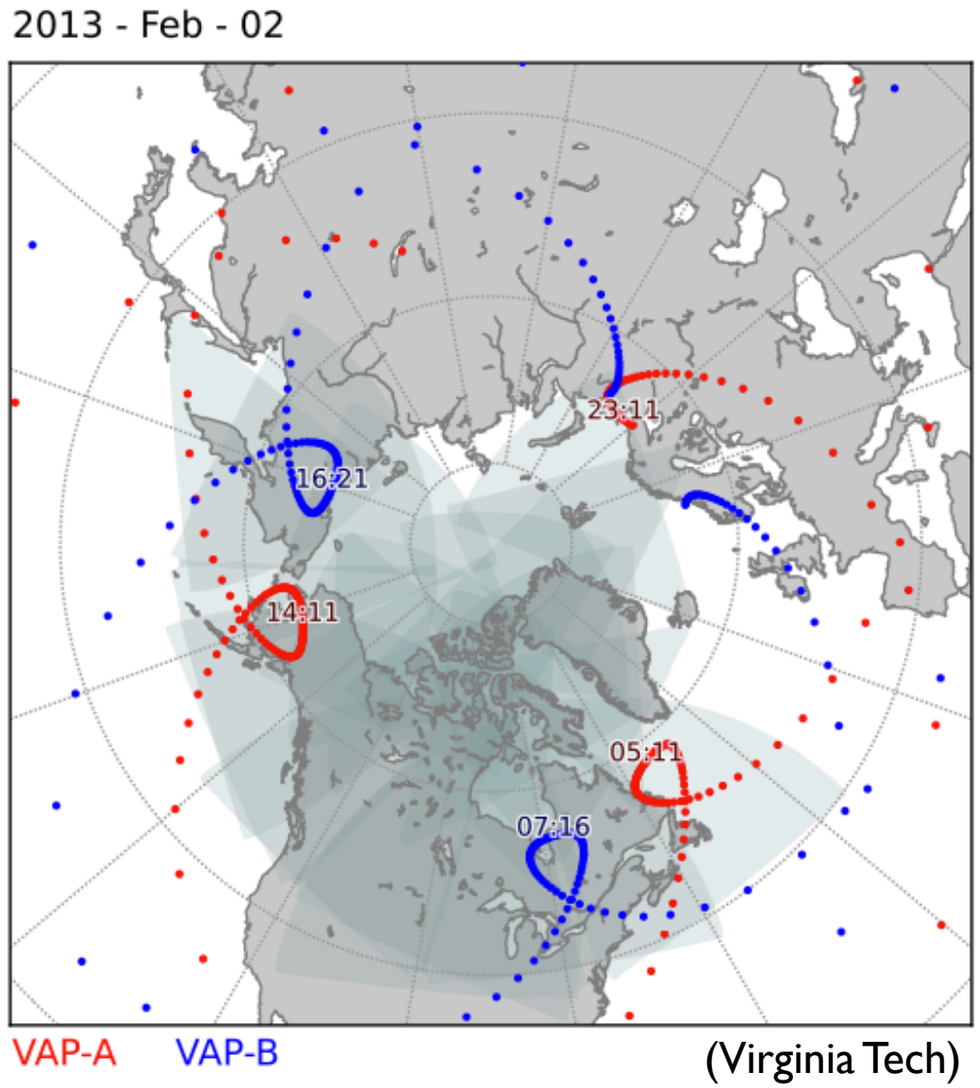
Closeup



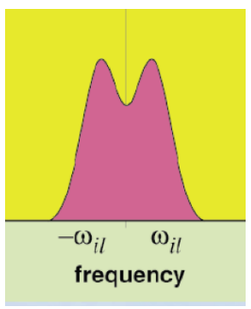
Ground track of s/c -A, -B
with Millstone Hill,
Mid-latitude SuperDARN network
plus GPS TEC

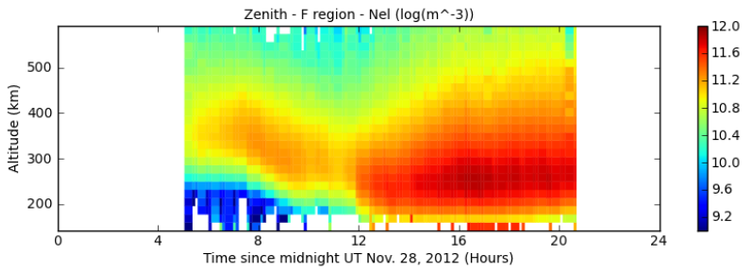
2013-02-02
0500 - 0600 UTC

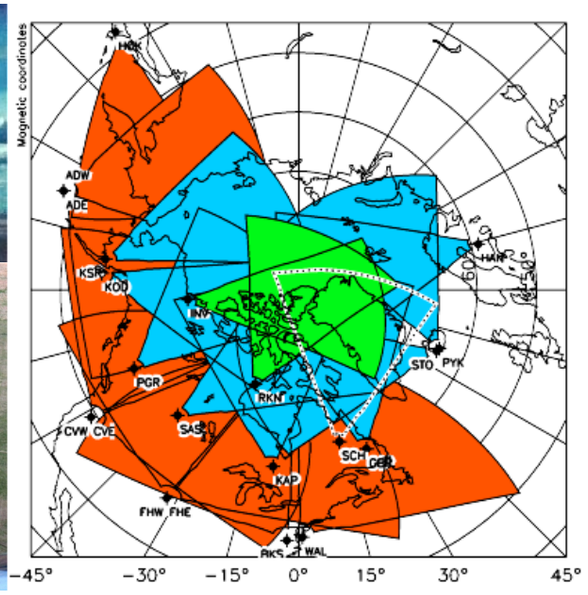
Part of a regularly scheduled
Van Allen Probes conjunction experiment



(Virginia Tech)







20130202

5:00 UT 5:00 UT 6:00 UT

Magnetic coordinates

HOK

DW ADE

HAN

STO PYK

CVW CVE

KAP

GBR

FHW FHE

12 MLT

80° 70° 60° 50°

05:29

05:27

05:25(F18)

05:23

05:21

(F18)

−45° −30° −15° 0° 15° 30° 45° MLON

RBSP−A

RBSP−B

875

750

625

500

375

250

125

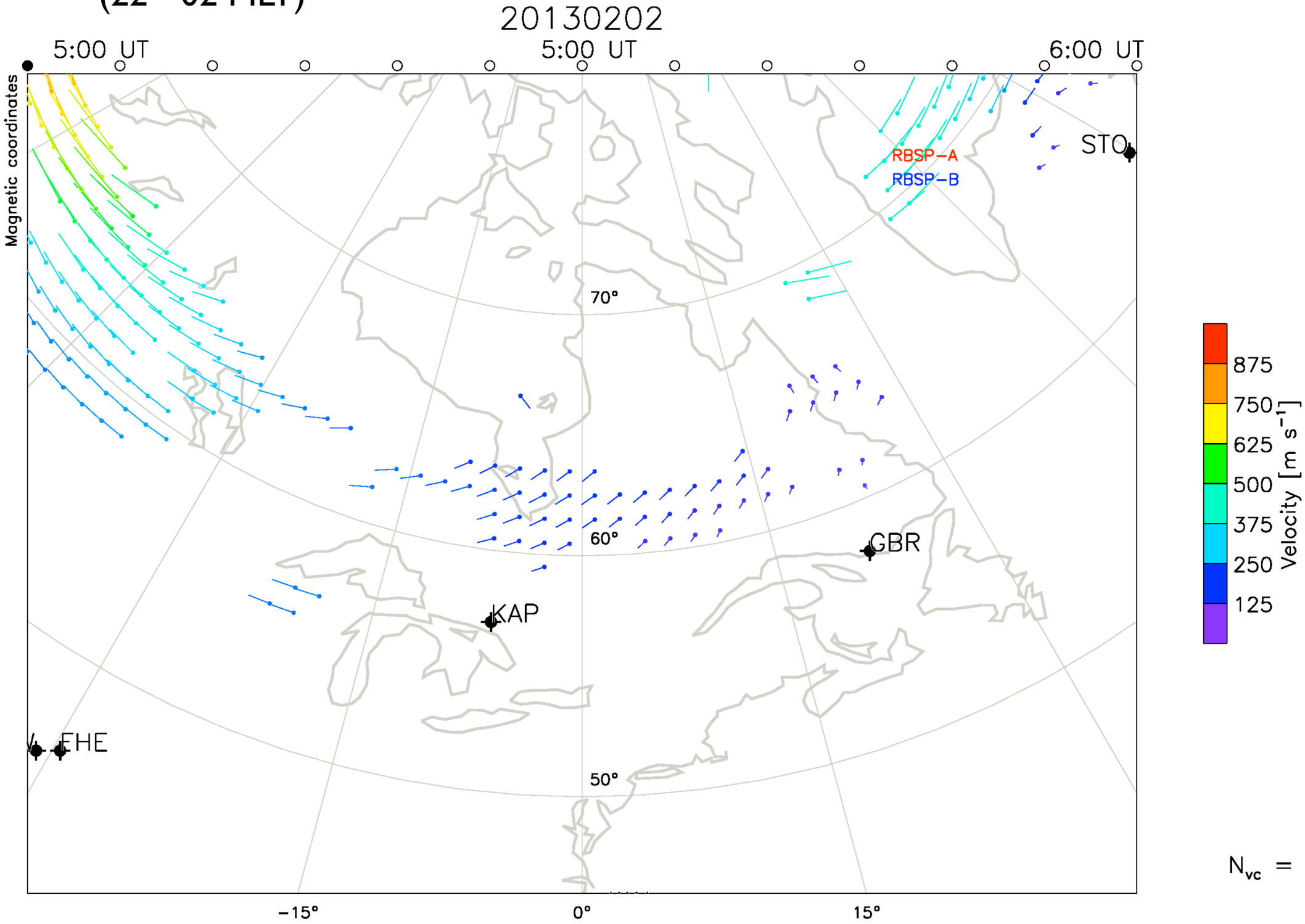
Velocity [m s^{-1}]

N_{vc} = 477 pts

(B. Kunduri, Virginia Tech)

Zoom in on N America
~00 MLT in center of plot @ 05 UTC
(22 - 02 MLT)

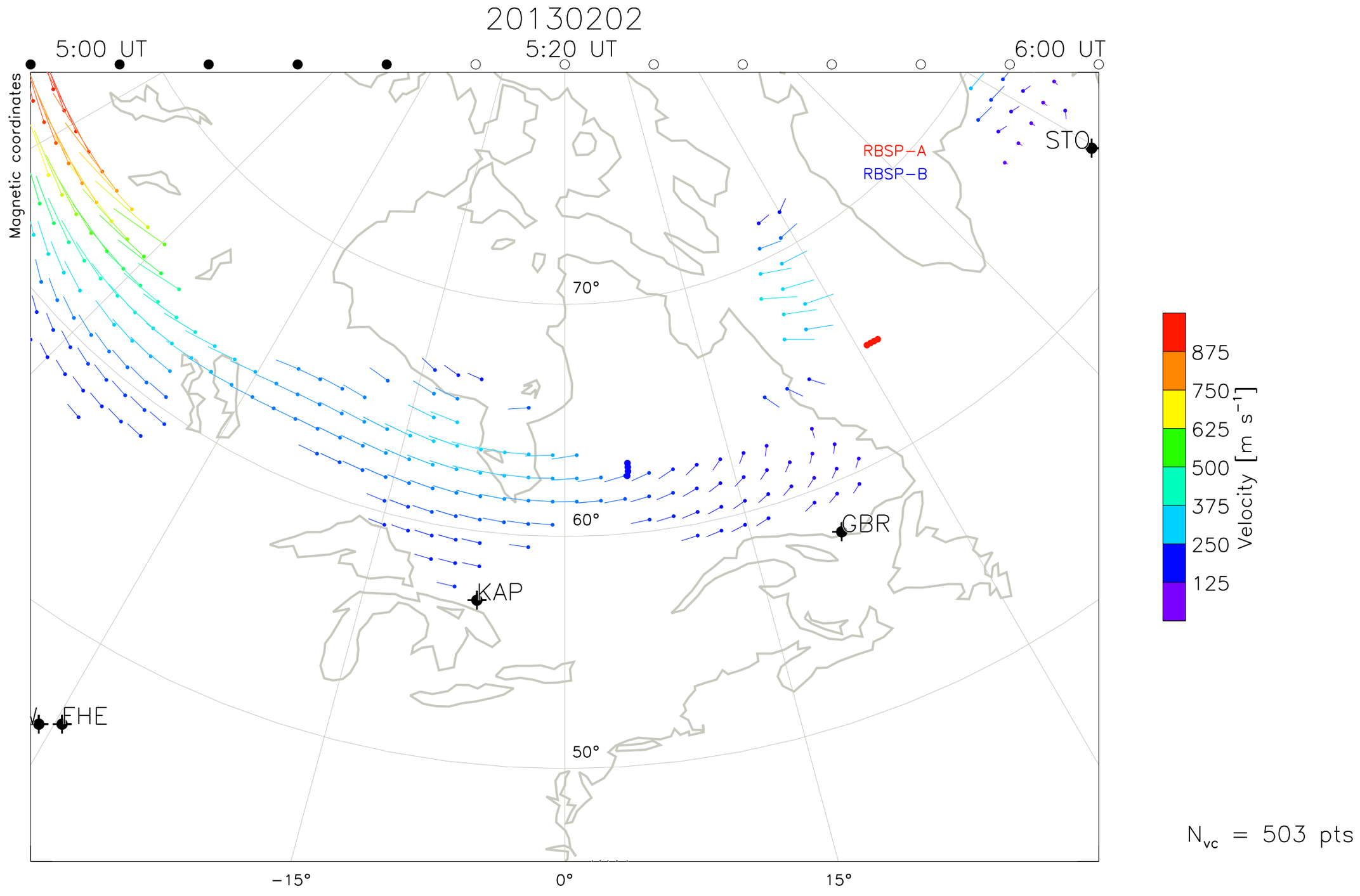
(movie)



N_{vc} = 477 pts

(B. Kunduri, Virginia Tech)

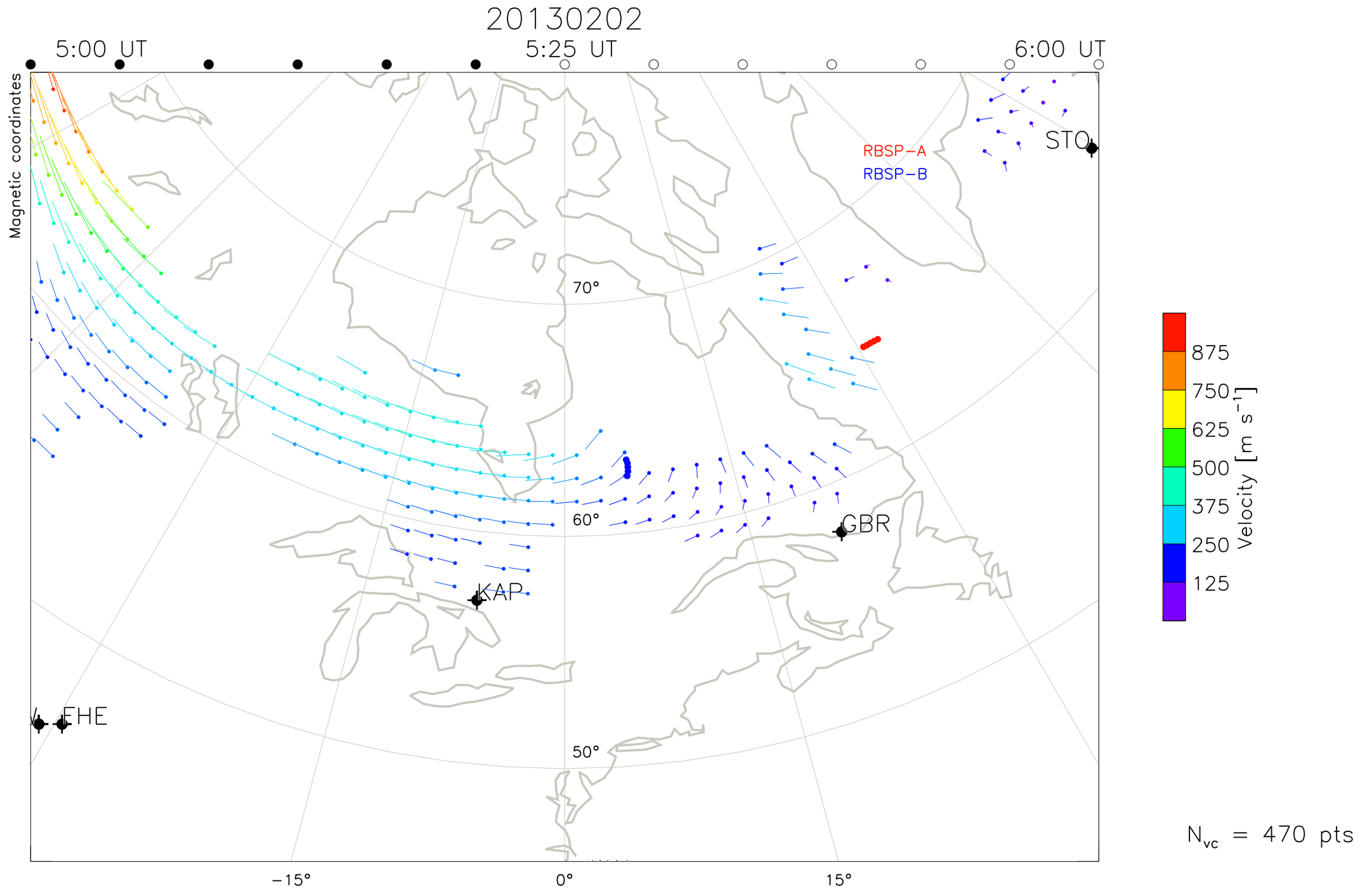
Zoom in on N America
~00 MLT in center of plot @ 05 UTC
(22 - 02 MLT)



N_{vc} = 503 pts

(B. Kunduri, Virginia Tech)

Zoom in on N America
~00 MLT in center of plot @ 05 UTC
(22 - 02 MLT)



N_{vc} = 470 pts

(B. Kunduri, Virginia Tech)

Zoom in on N America
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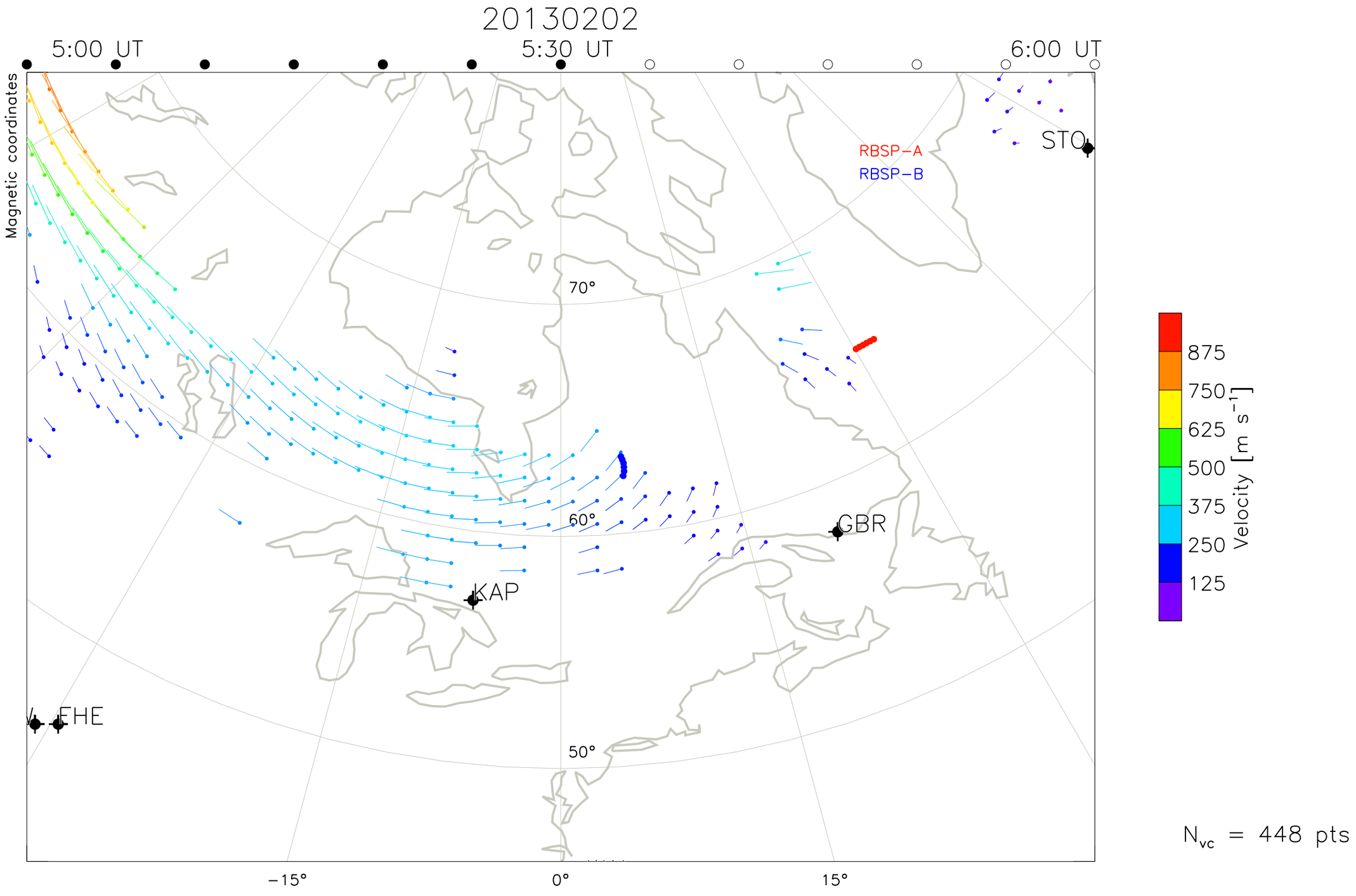
(22 - 02 MLT)



N_{vc} = 448 pts

(B. Kunduri, Virginia Tech)

Zoom in on N America
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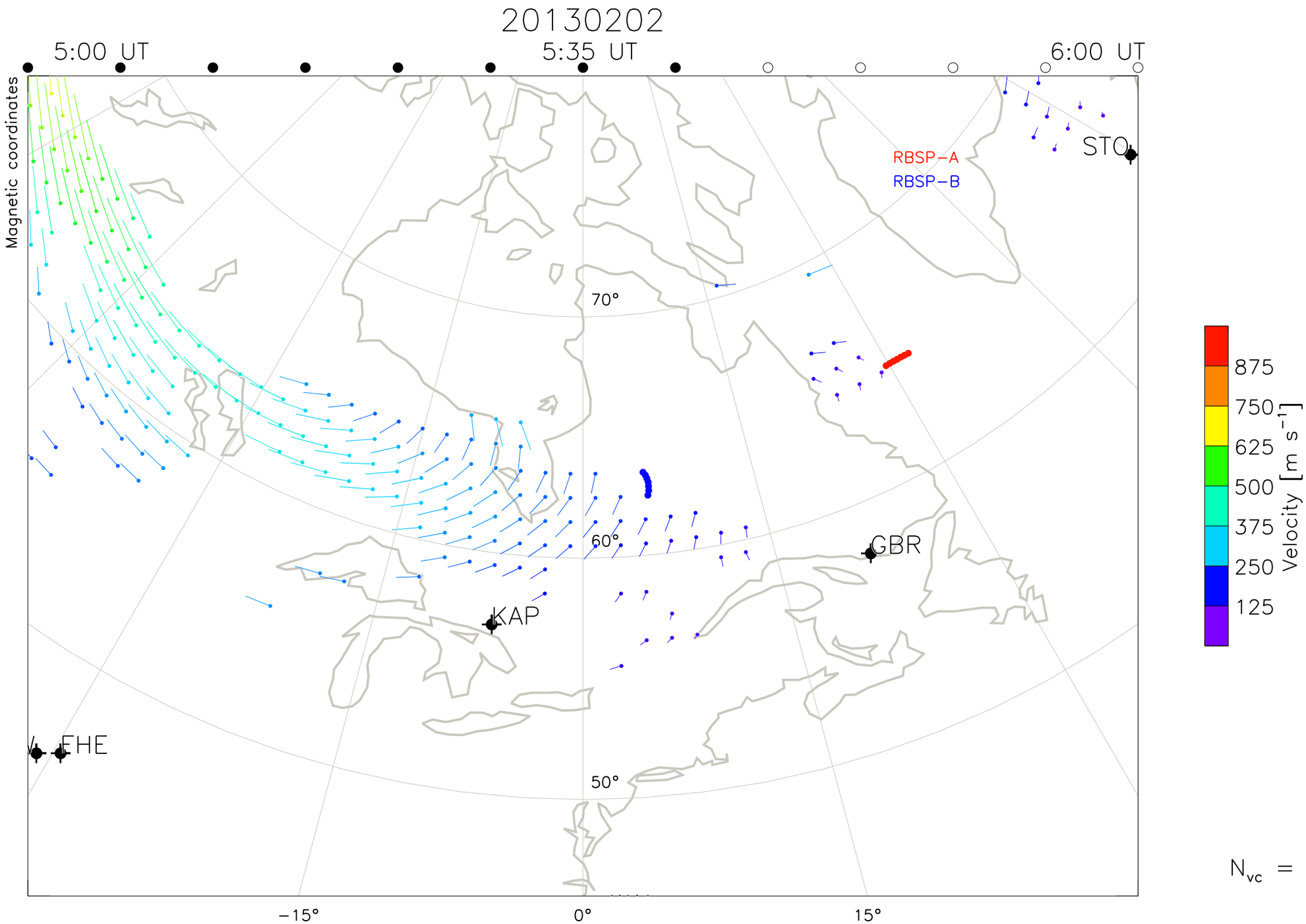
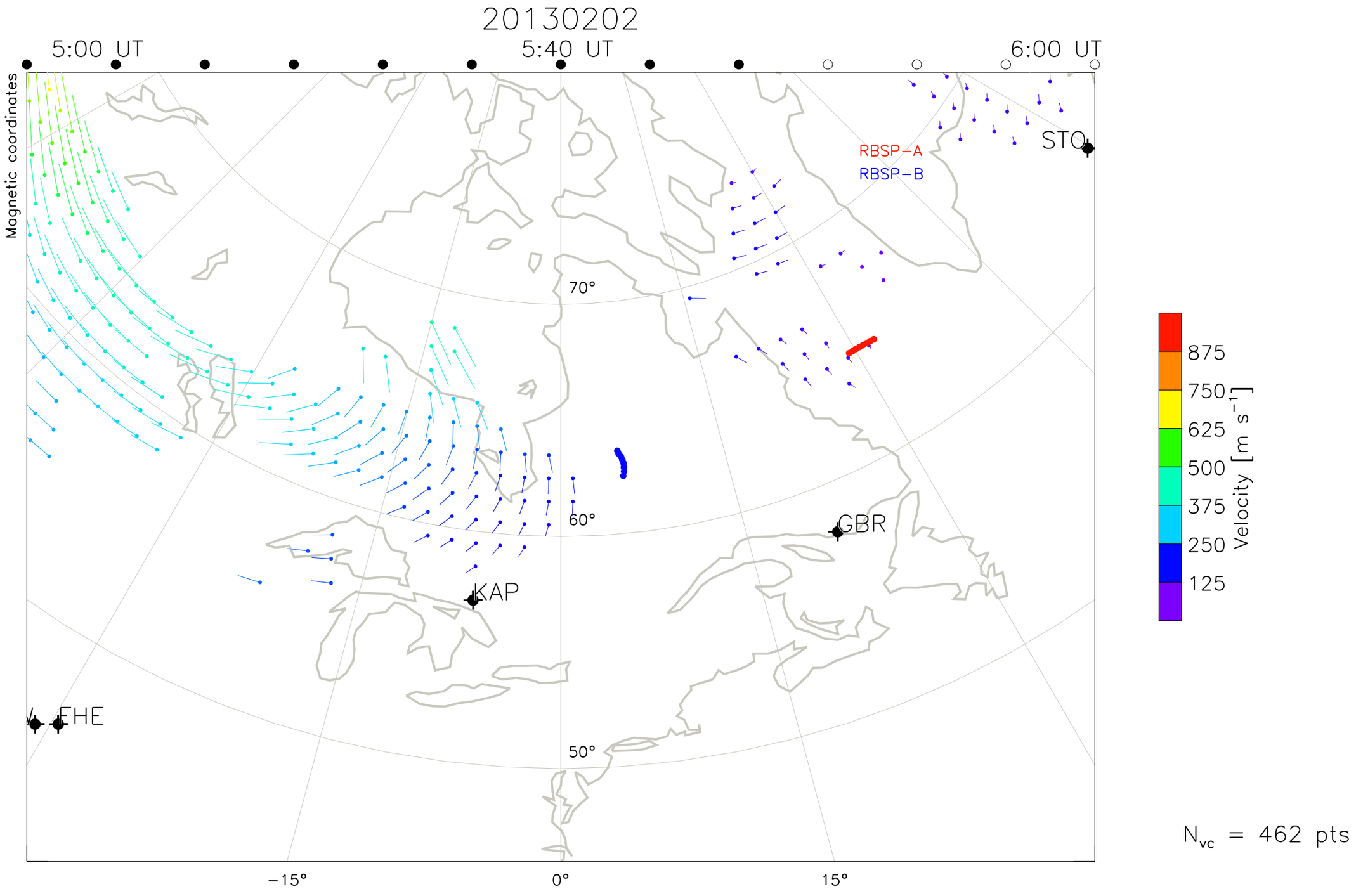
(22 - 02 MLT)



N_{vc} = 420 pts

(B. Kunduri, Virginia Tech)

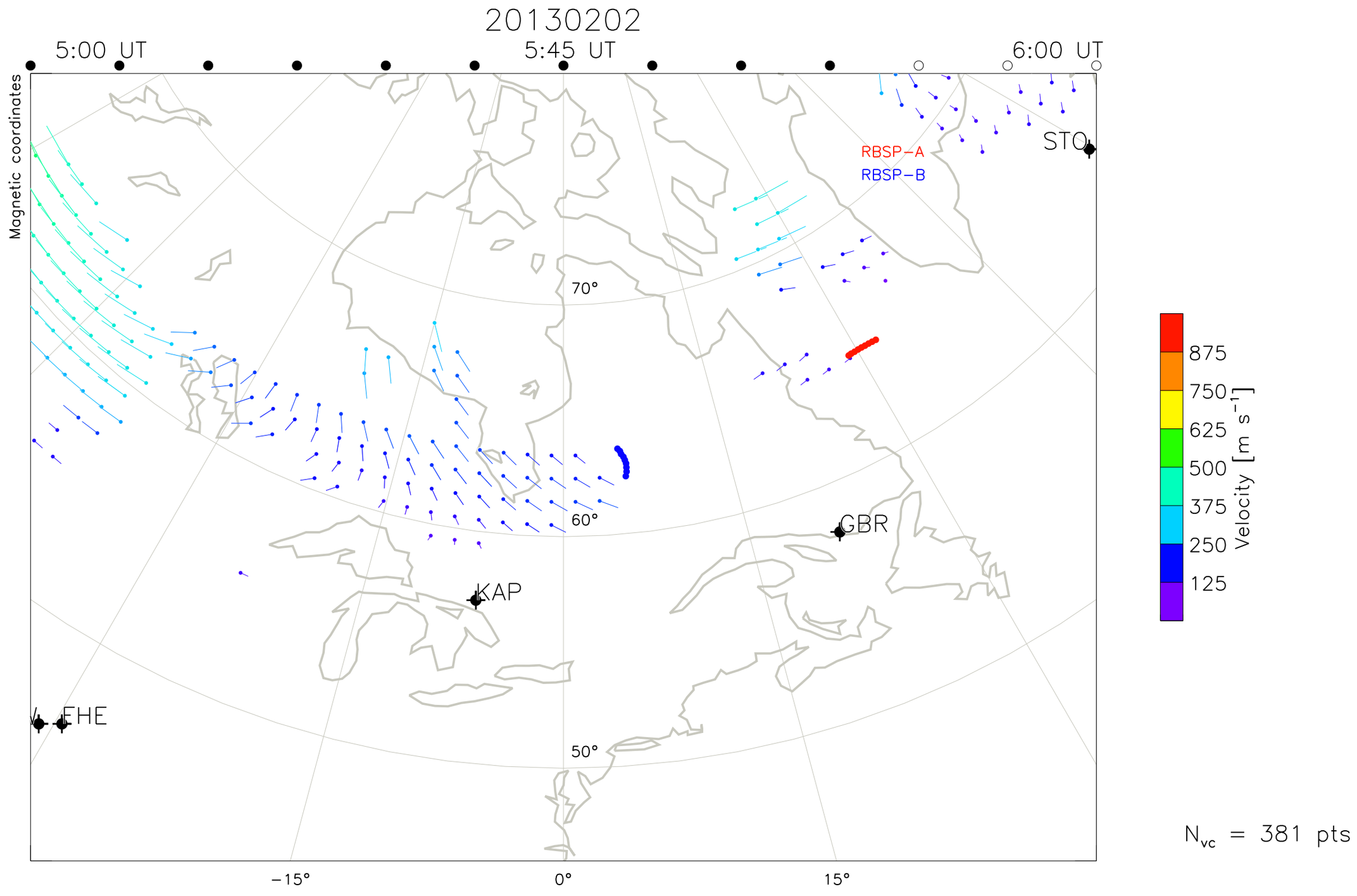
Zoom in on N America
~00 MLT in center of plot @ 05 UTC
(22 - 02 MLT)



N_{vc} = 462 pts

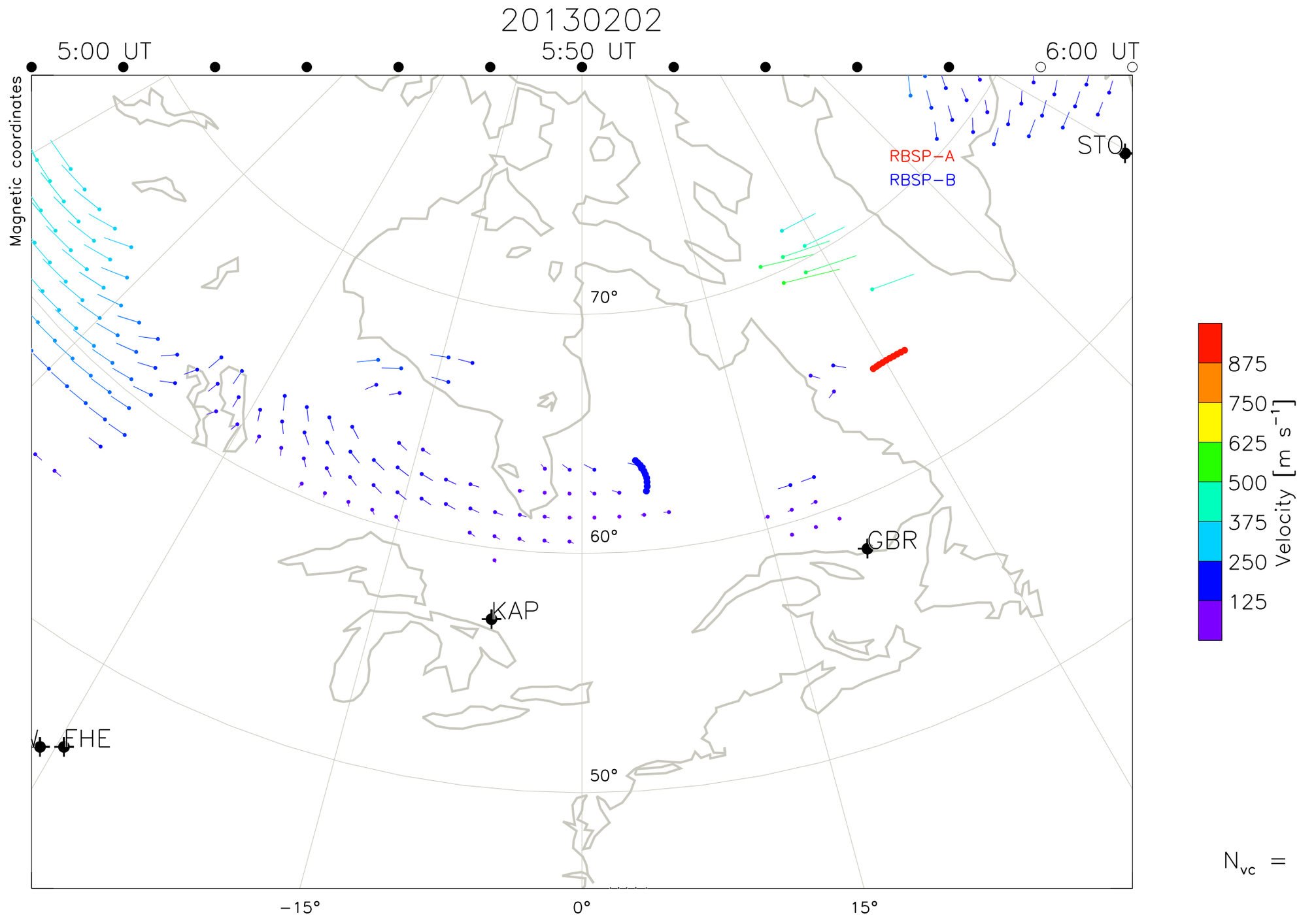
(B. Kunduri, Virginia Tech)

Zoom in on N America
~00 MLT in center of plot @ 05 UTC
(22 - 02 MLT)



(B. Kunduri, Virginia Tech)

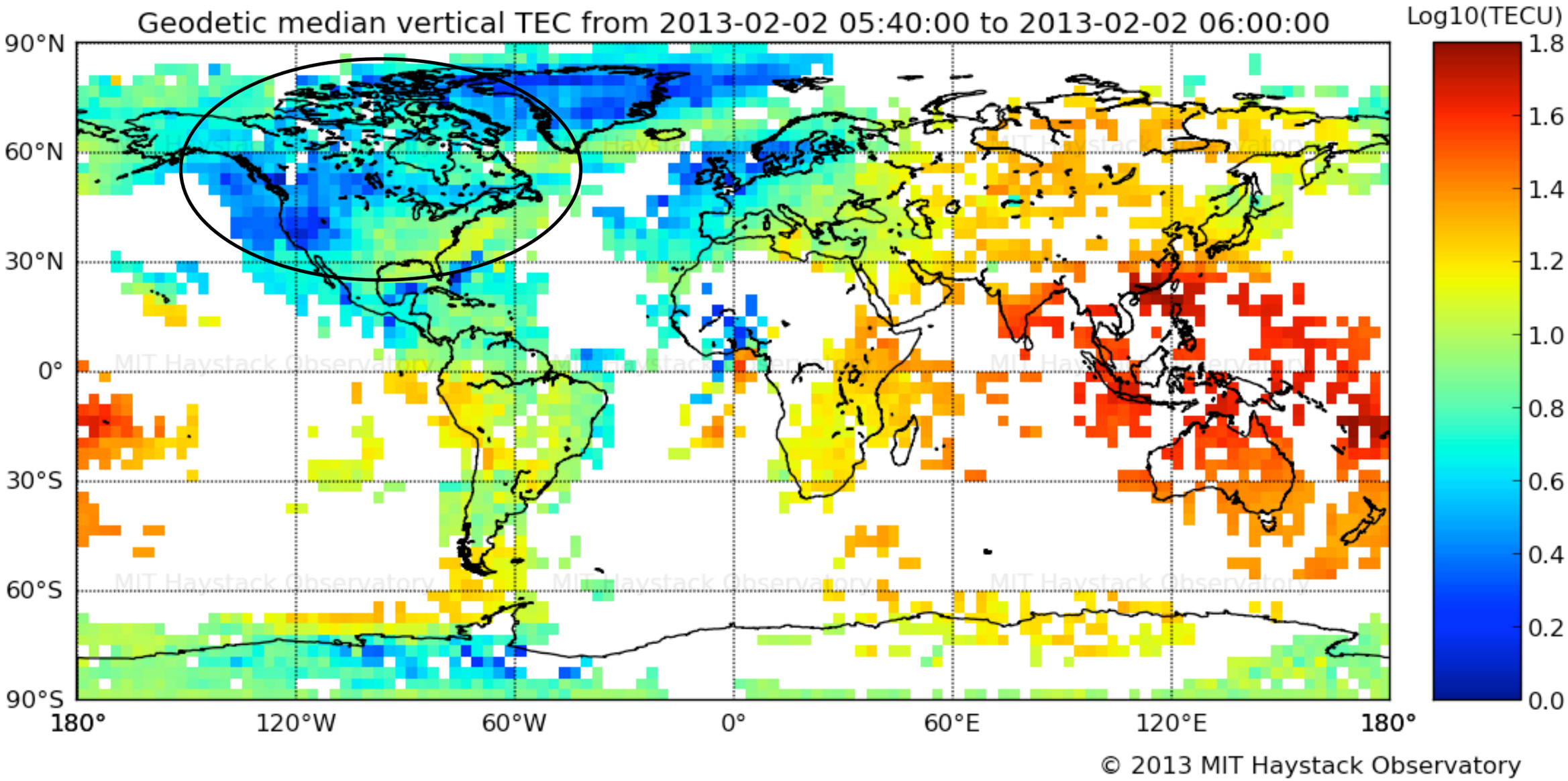
Zoom in on N America
~00 MLT in center of plot @ 05 UTC
(22 - 02 MLT)



N_{vc} = 334 pts

(B. Kunduri, Virginia Tech)

GPS TEC (plasmasphere to 3.2 Re)

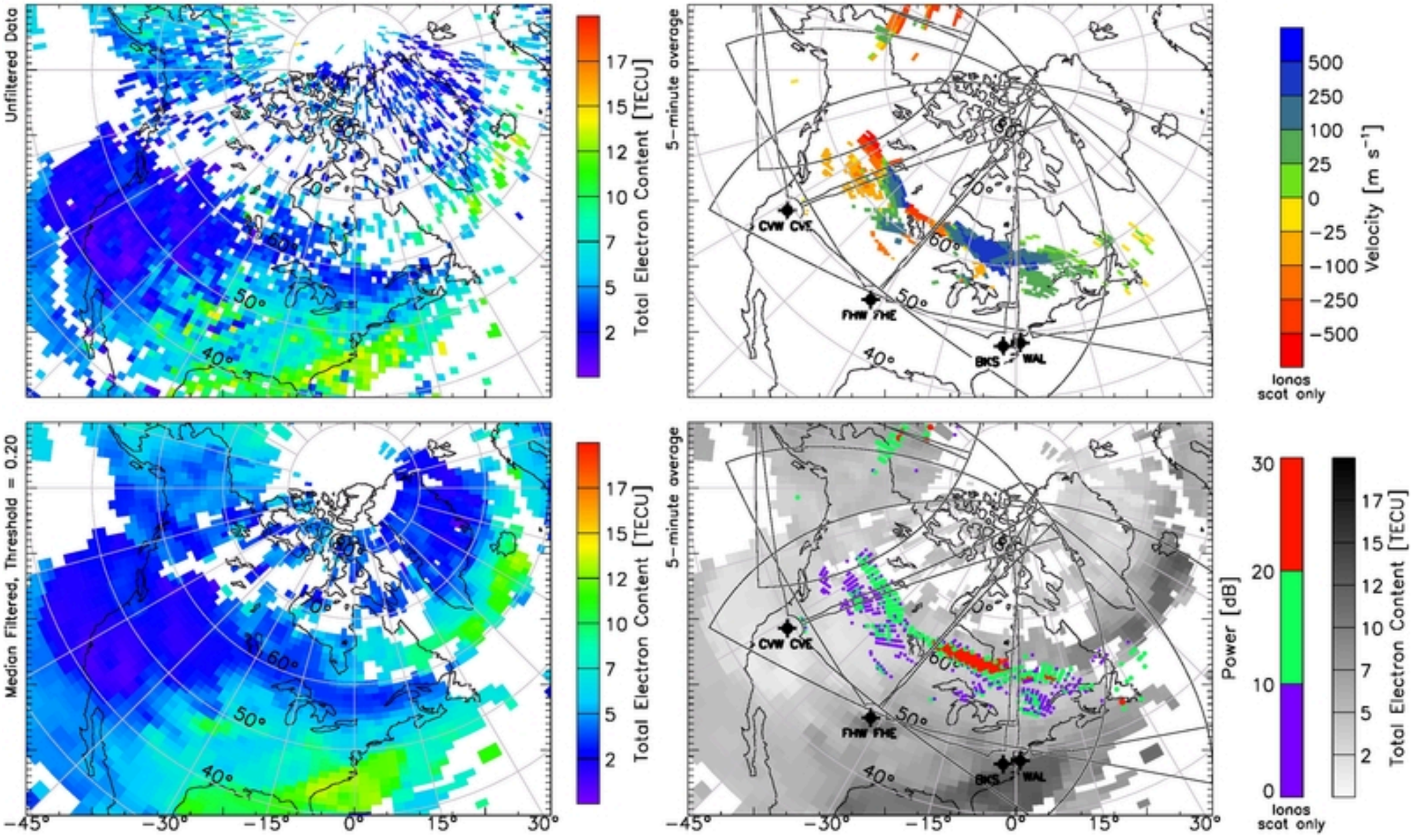


(MIT Haystack)

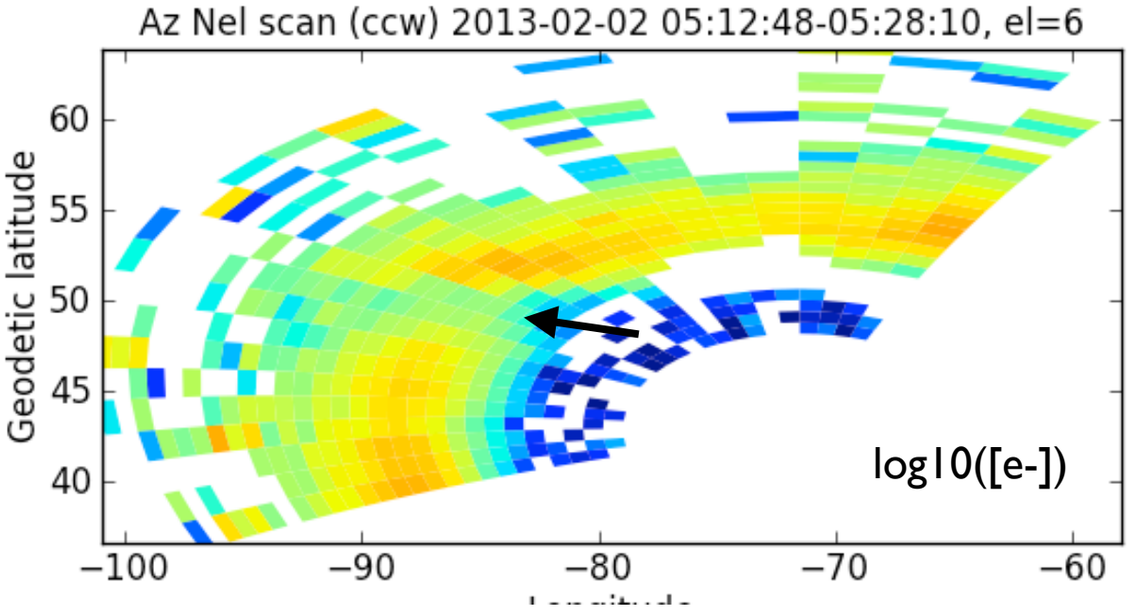
TEC Four Plot

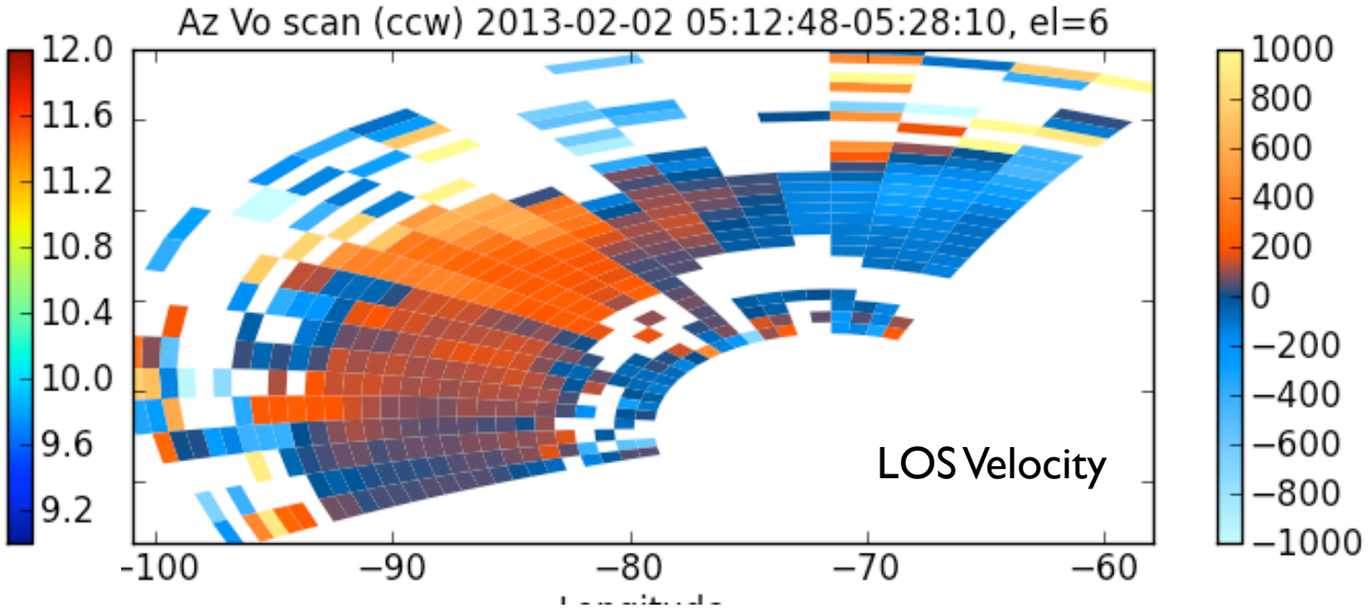
GPS Receiver Network (Millstone Hill)

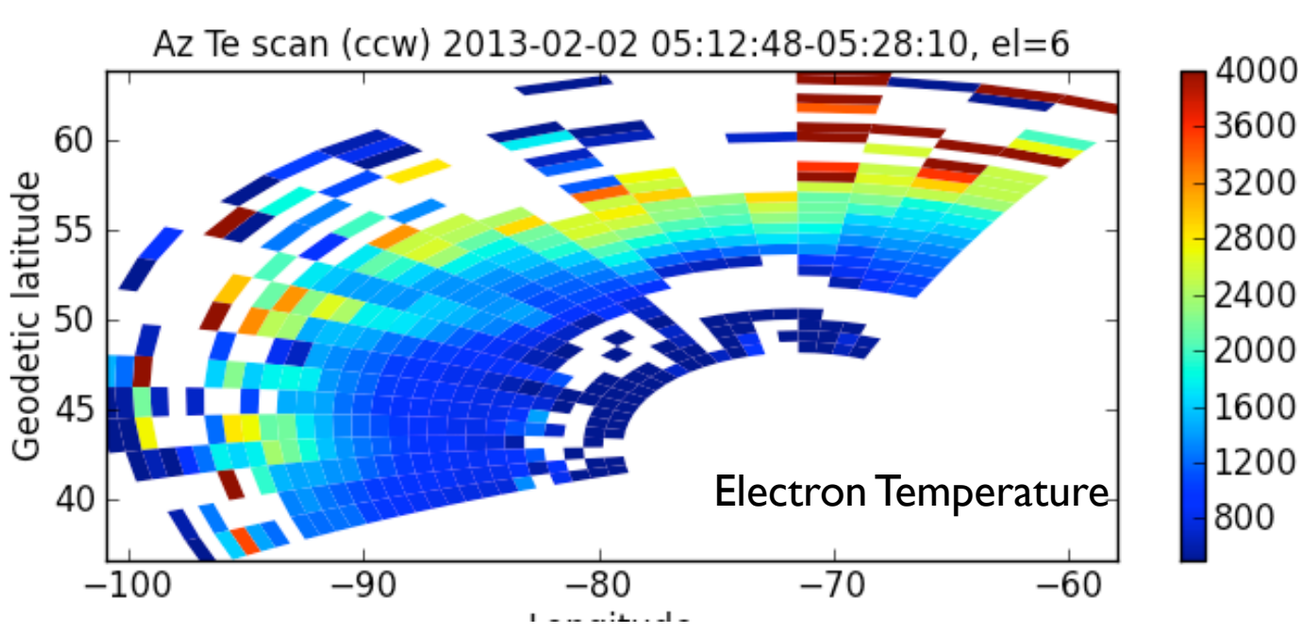
02/Feb/2013 05:30:00.0
to
02/Feb/2013 05:35:00.0



(E. Thomas, Virginia Tech)





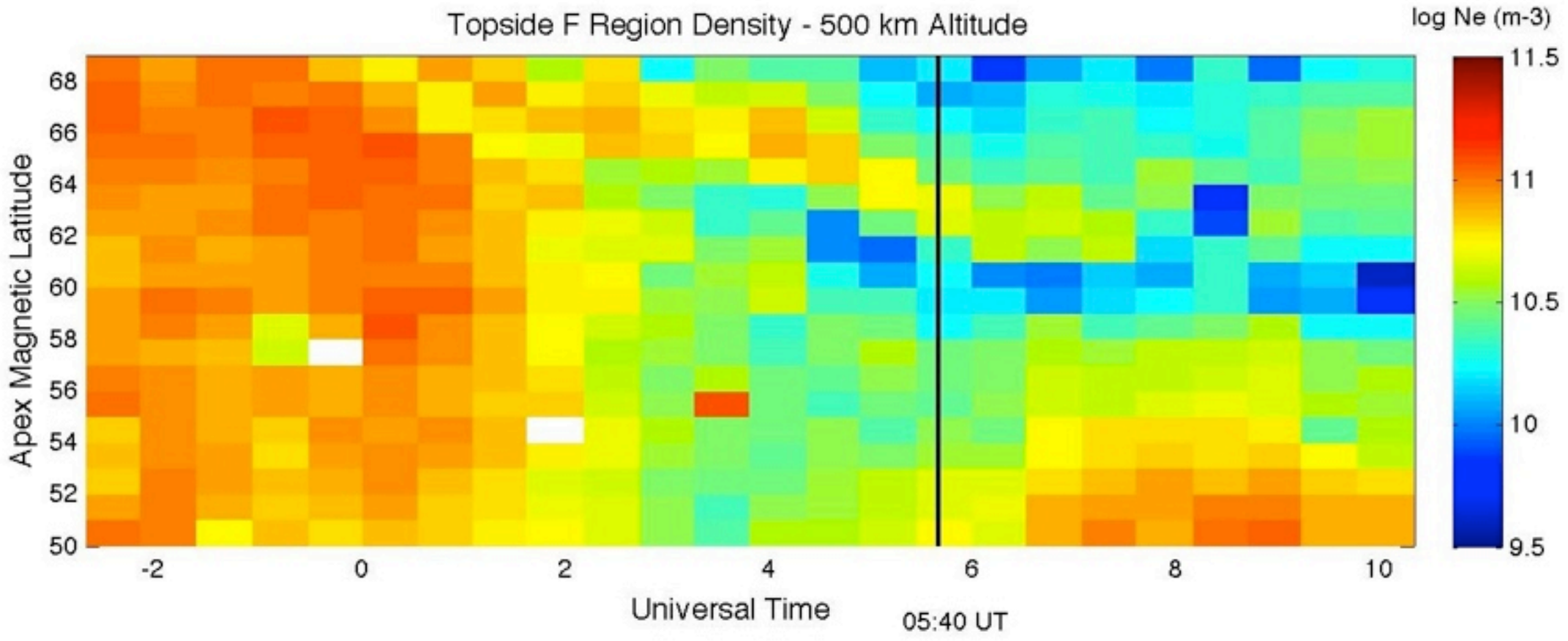


Millstone Hill Wide field scan

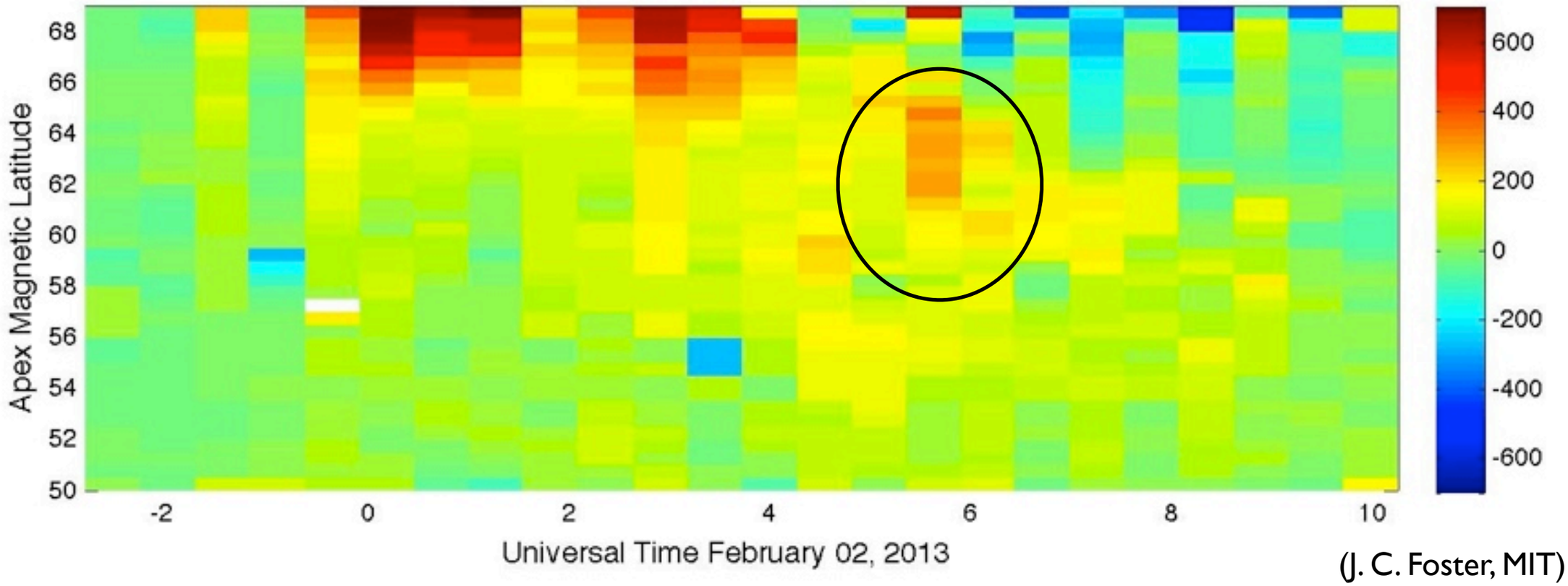
F region, topside plasma parameters

2013-02-02
05:12 - 05:28 UTC

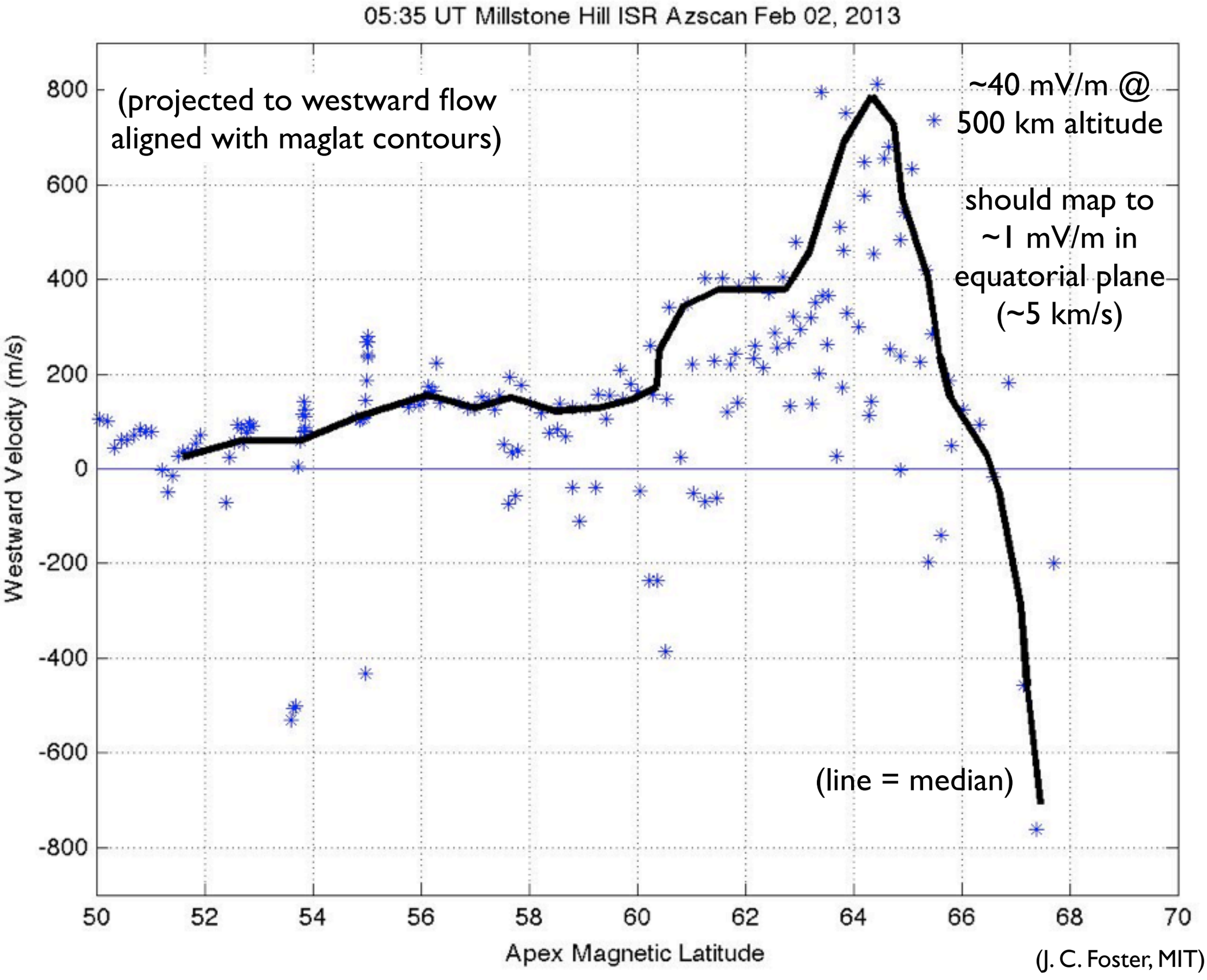
(MIT Haystack)



(Line-of-sight) Westward Ion Velocity - MHR Azimuth Scans

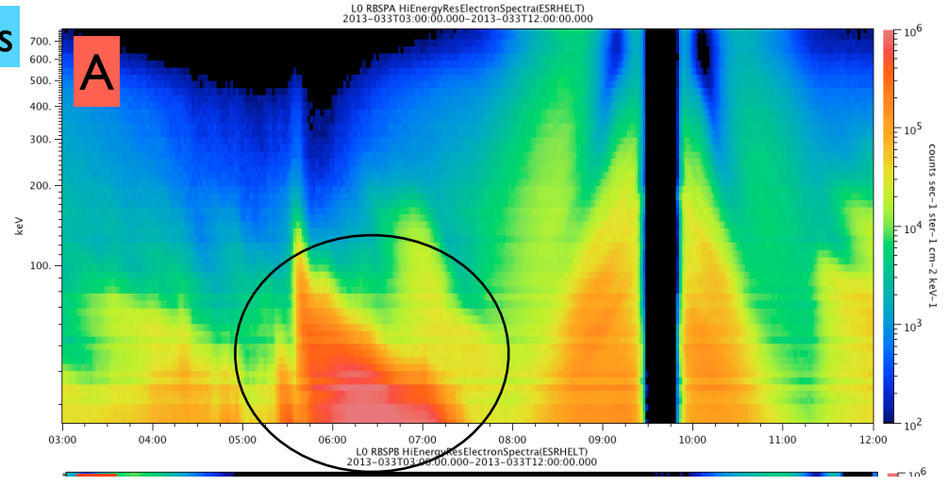


(J. C. Foster, MIT)

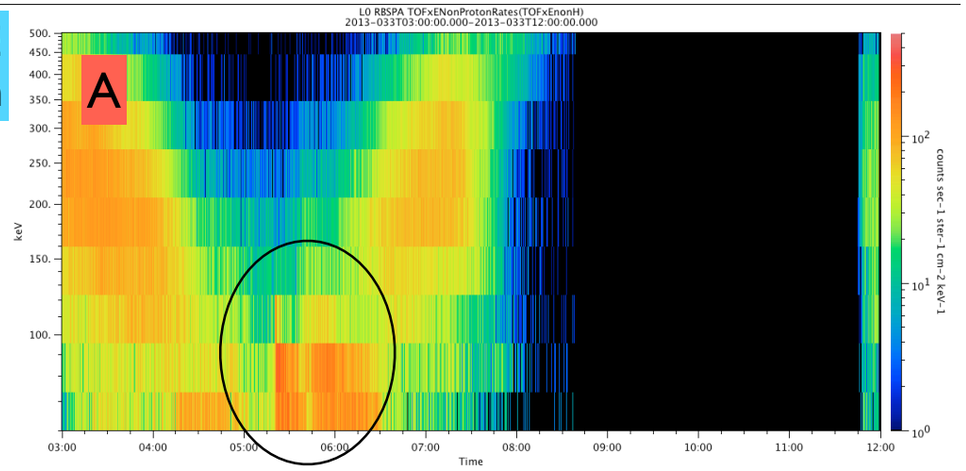


(J. C. Foster, MIT)

Electrons



TOFxE Helium



Initial conclusion for 2013-02-02 0500 - 0600 UTC:

Millstone, SD see westward flow burst associated with electron + ion injection

THEMIS ASI, Magnetometers confirm penetration to L=4 to 5

RBSPICE: Not all ions behave equally

Future:

~~THEMIS in-situ~~ (wrong place)

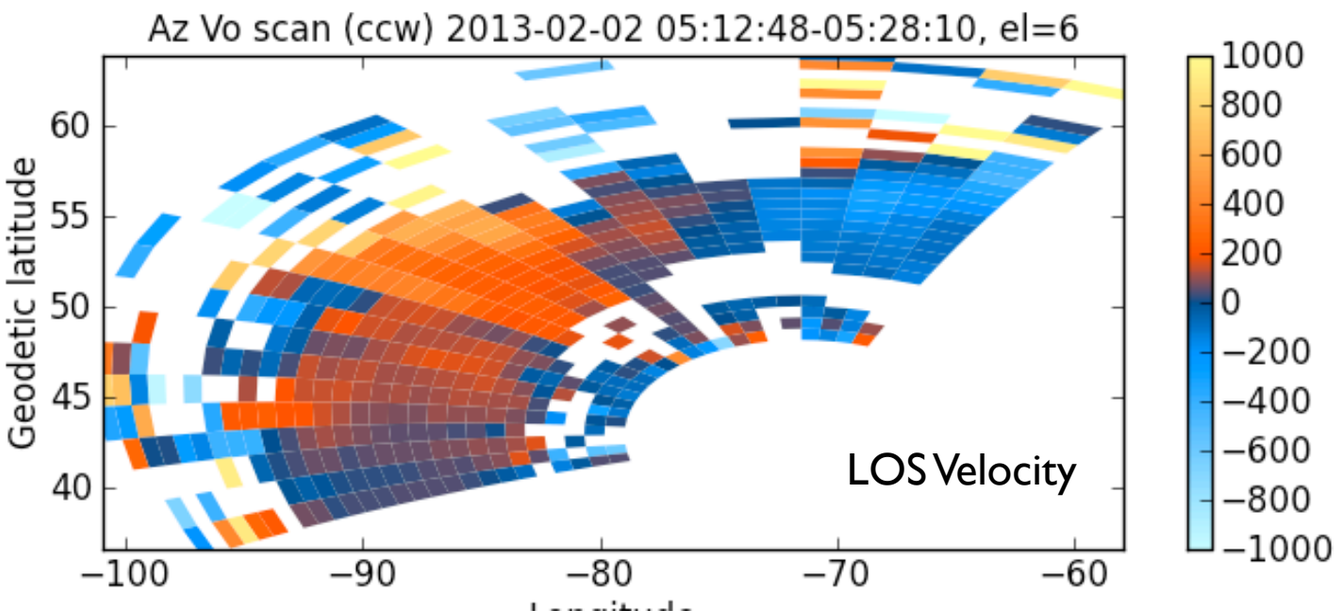
EFW DC, AC field comparisons

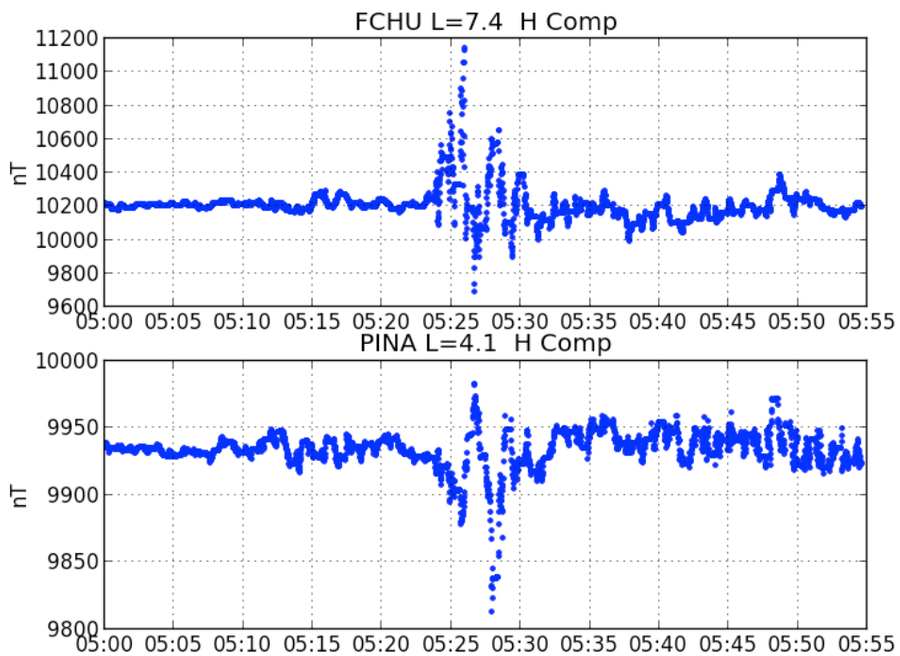
EMFISIS

BARREL (2 balloons conjugate!)

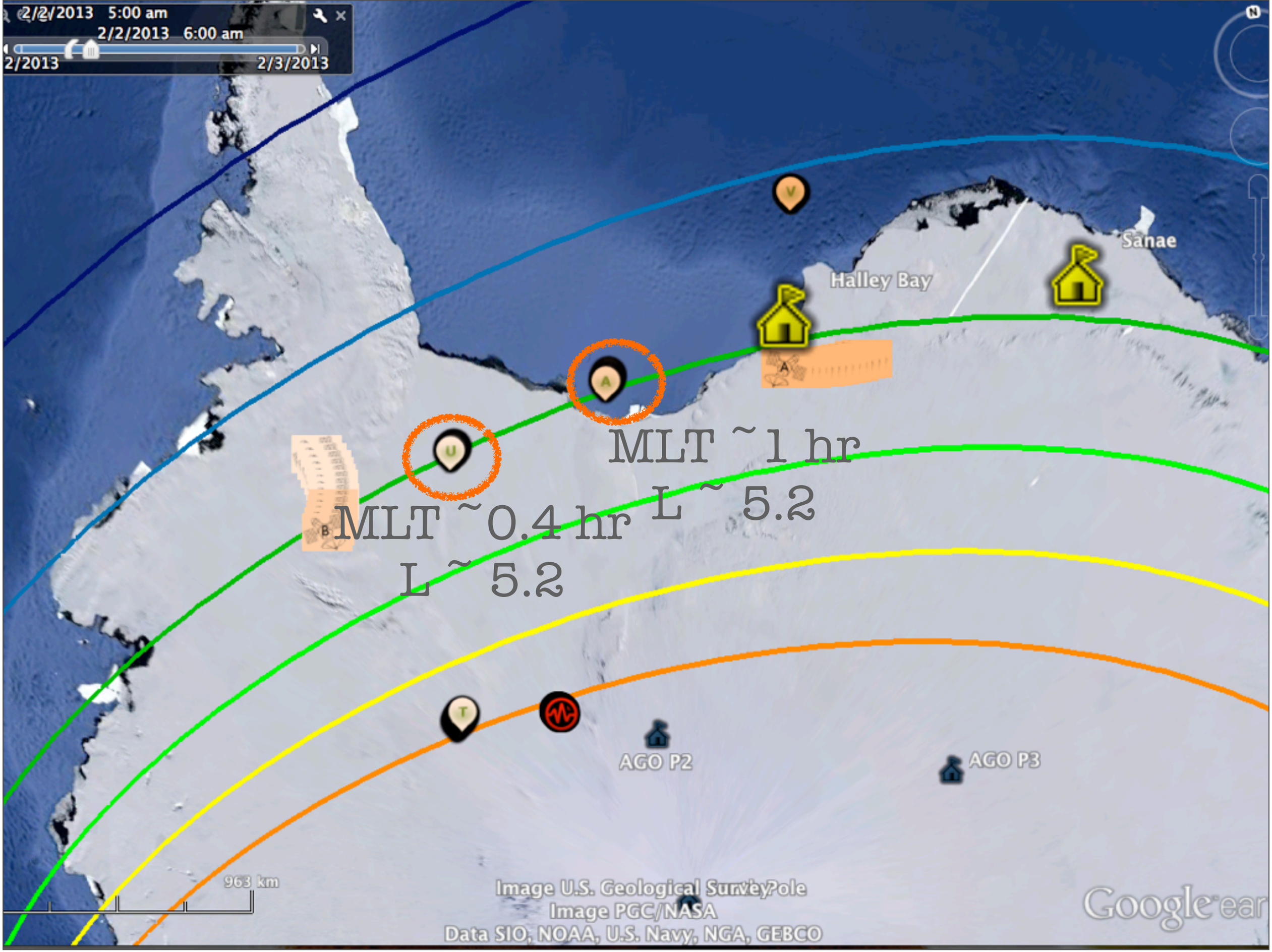
More, more, more!

Collaborations greatly desired!

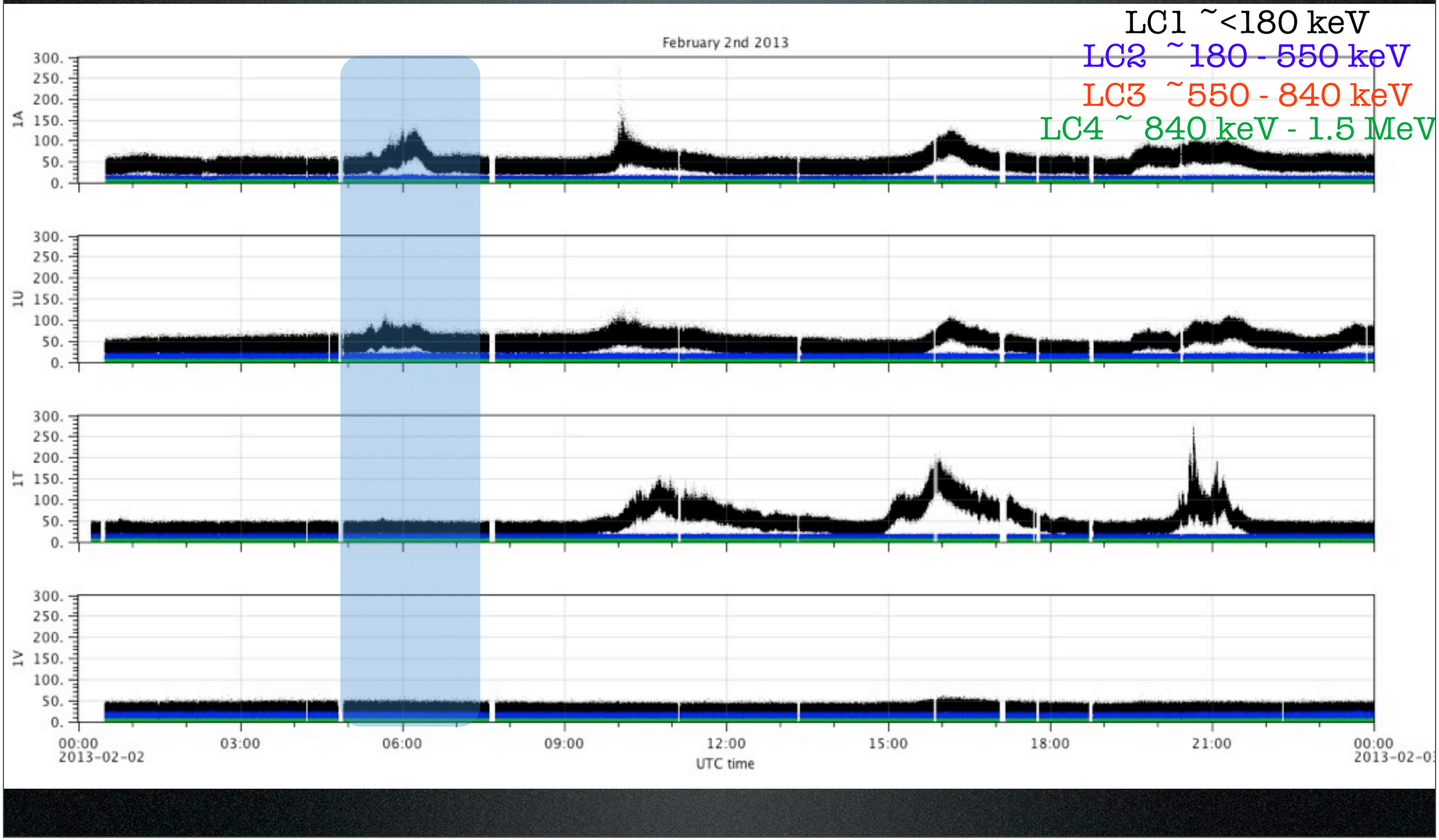


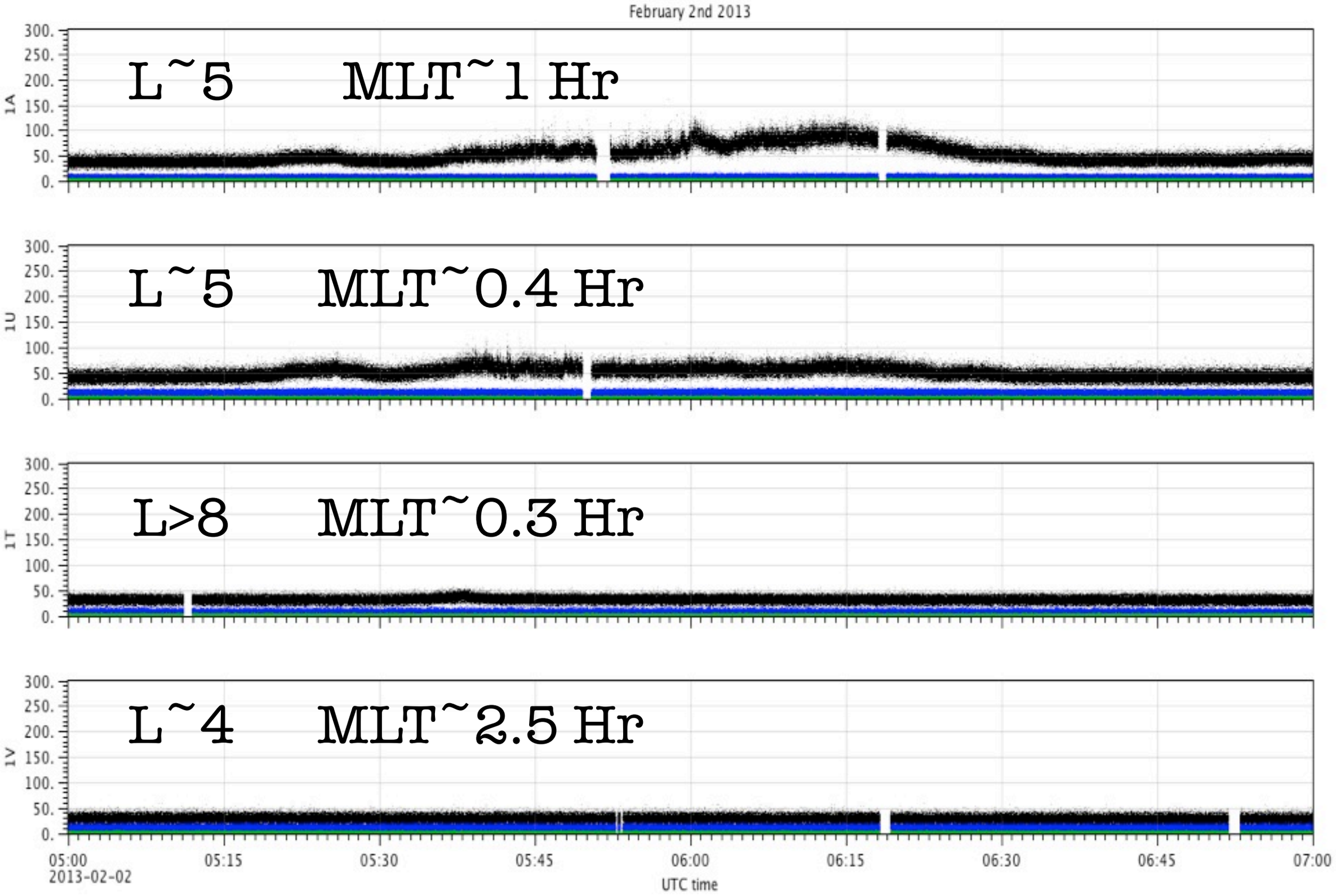


Supplementary Materials

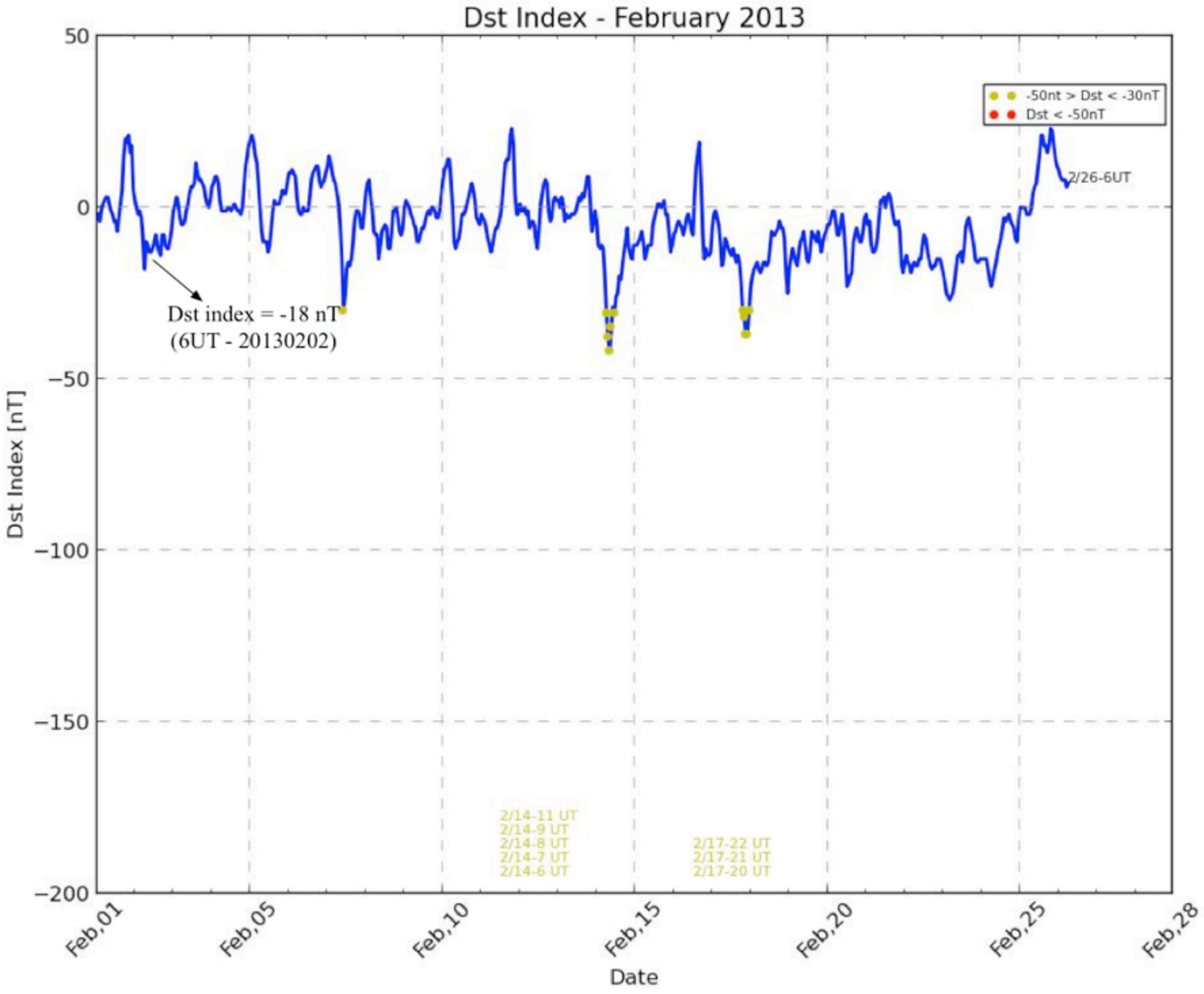


Tuesday, 26 February 13


February 2nd 2013
LC1 ~<180 keV
LC2 ~180 - 550 keV
LC3 ~550 - 840 keV
LC4 ~ 840 keV - 1.5 MeV
1A
1U
1T
1V
300.
250.
200.
150.
100.
50.
0.
00:00
2013-02-02
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
UTC time


February 2nd 2013
L~5 MLT~1 Hr
L~5 MLT~0.4 Hr
L>8 MLT~0.3 Hr
L~4 MLT~2.5 Hr
1A
1U
1T
1V
300.
250.
200.
150.
100.
50.
0.
05:00
2013-02-02
05:15
05:30
05:45
06:00
06:15
06:30
06:45
07:00
UTC time

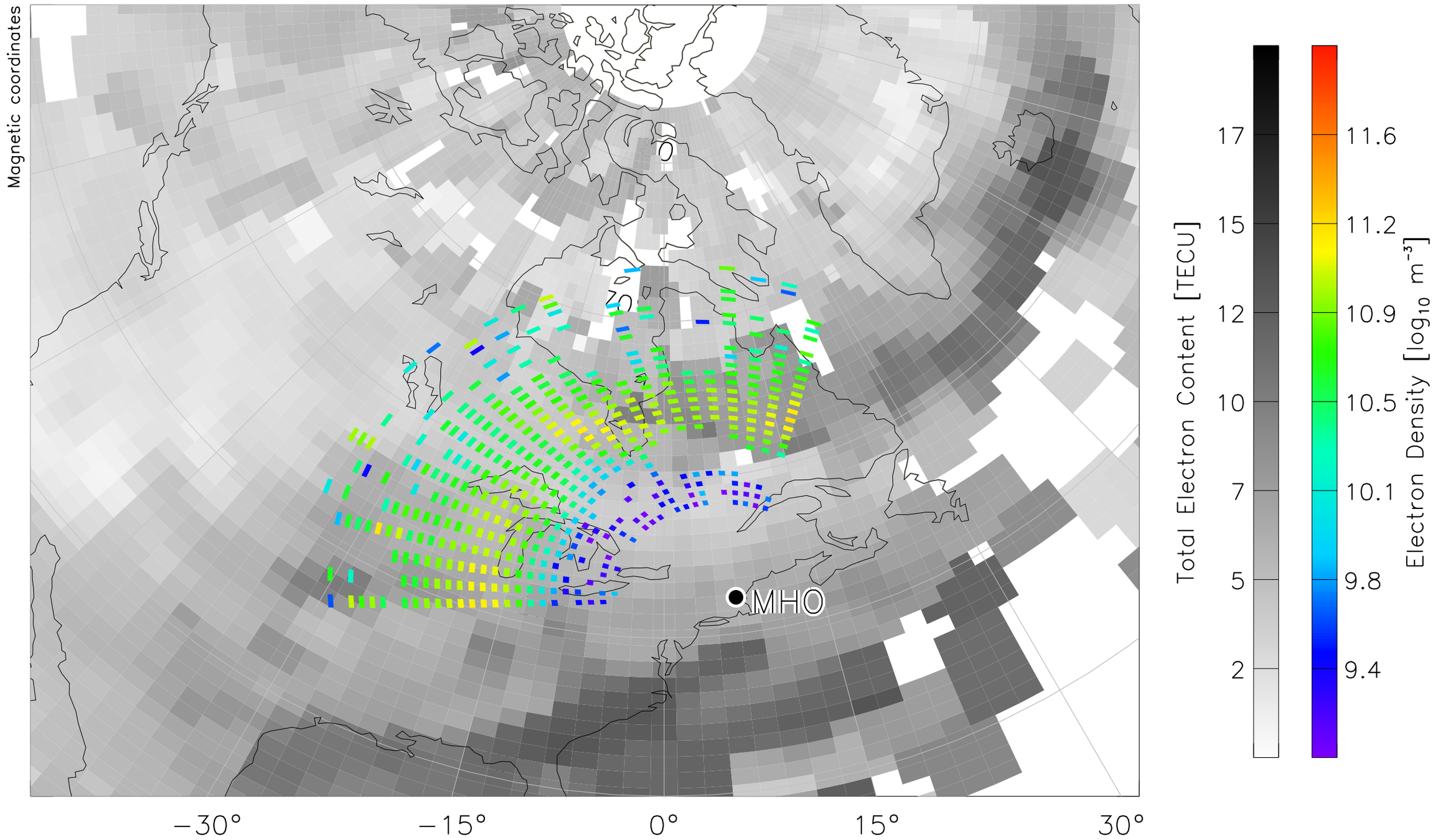
Overall conditions: AE = 500 nT@ 0500-0600 UTC DsT: -18 nT @ 0600 UTC



(B. Kunduri, Virginia Tech)

Van Allen Conjunction
SuperDARN/TEC – 05:20

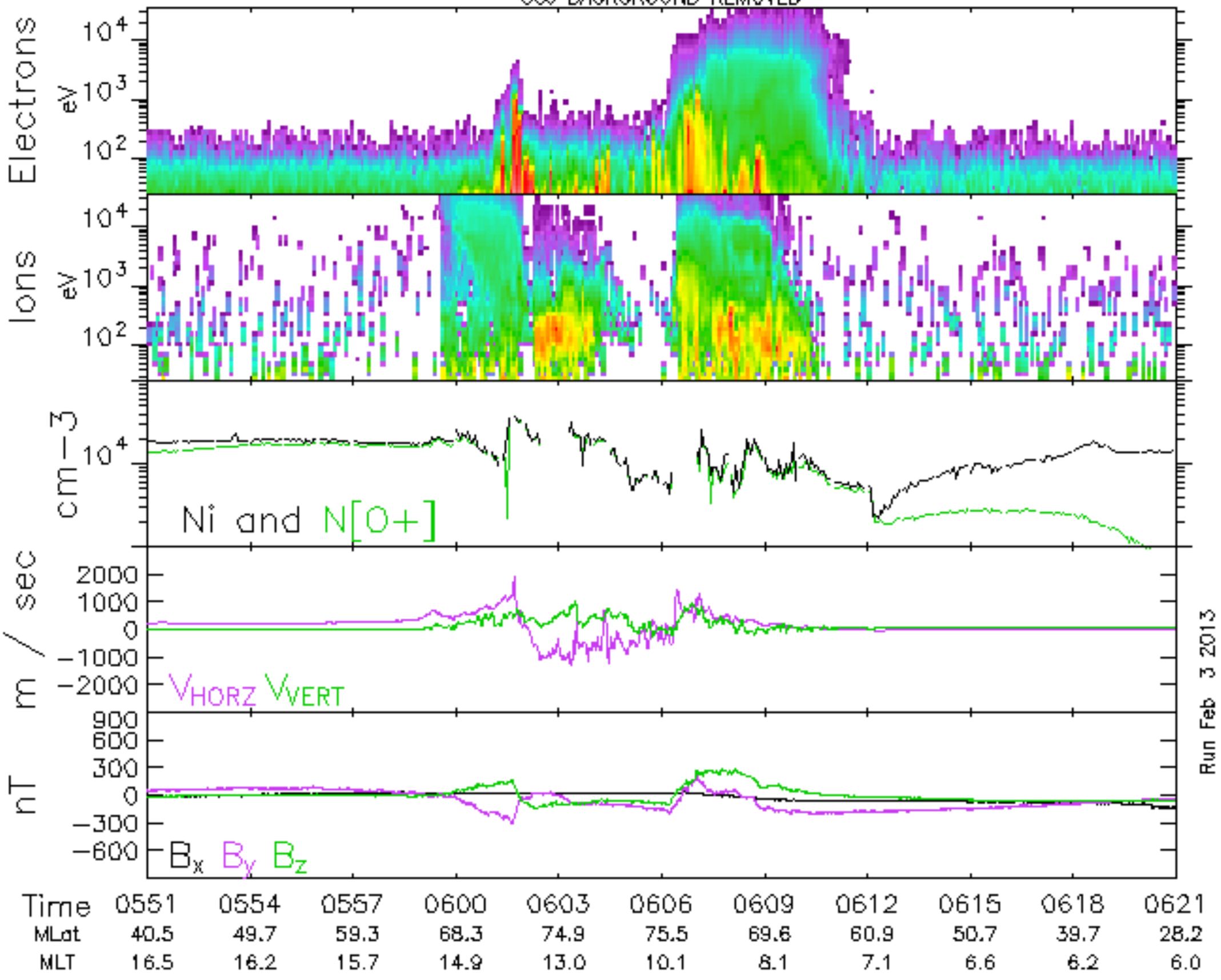
02/Feb/2013 05:13:09
to
02/Feb/2013 05:28:28



(B. Kunduri, Virginia Tech)

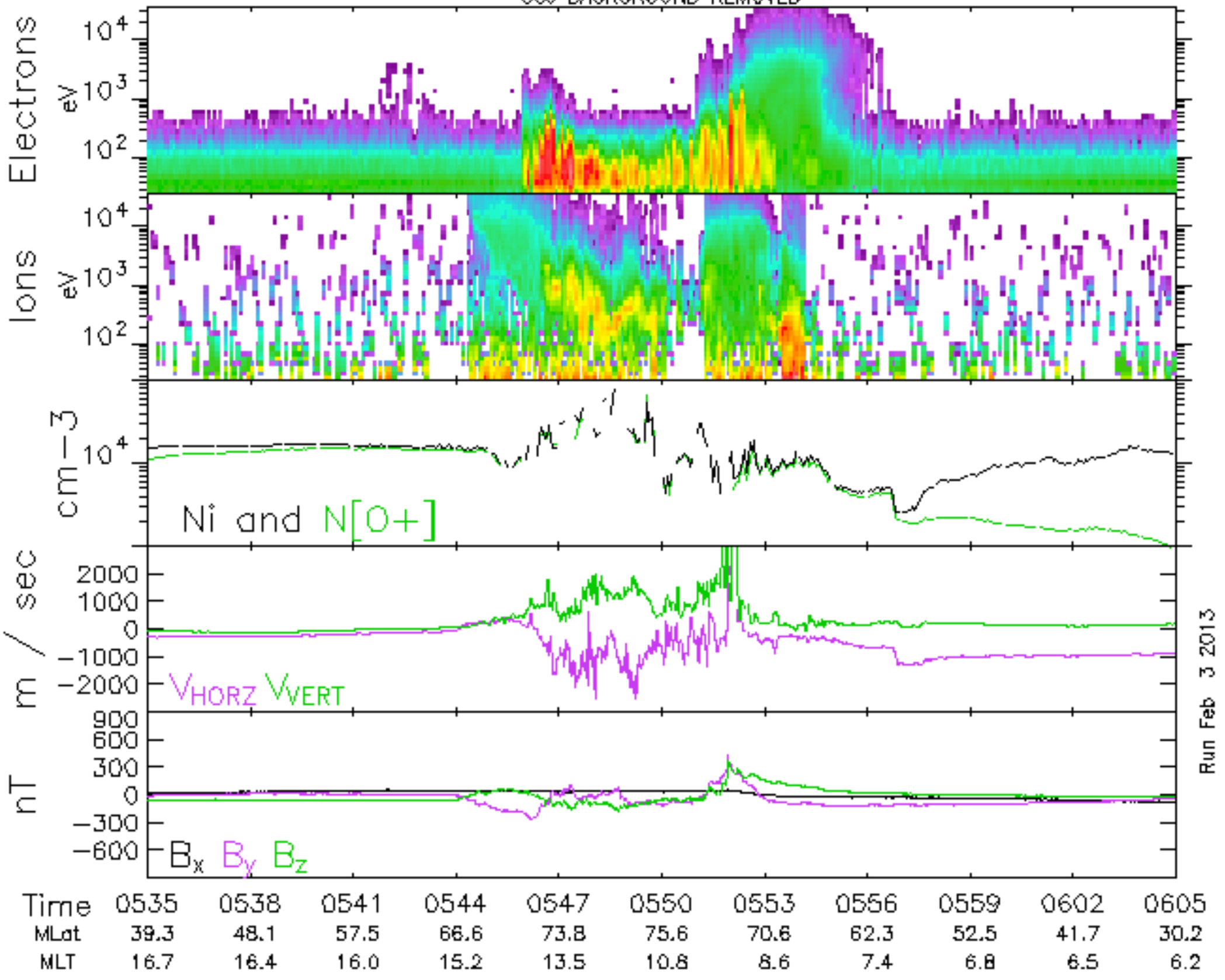
DMSP F16A – 02–Feb–2013 (Day 033)

SSJ BACKGROUND REMOVED



DMSP F17A – 02–Feb–2013 (Day 033)

SSJ BACKGROUND REMOVED



Time	0535	0538	0541	0544	0547	0550	0553	0556	0559	0602	0605
MLat	39.3	48.1	57.5	66.6	73.8	75.6	70.6	62.3	52.5	41.7	30.2
MLT	16.7	16.4	16.0	15.2	13.5	10.8	8.6	7.4	6.8	6.5	6.2

DMSP F18A – 02–Feb–2013 (Day 033)

SSJ BACKGROUND REMOVED

Electrons

eV

10^4

10^3

10^2

Ions

eV

10^4

10^3

10^2

cm−3

10^4

Ni and N[O+]

m / sec

2000

1000

0

−1000

−2000

V_{HORZ} V_{VERT}

nT

900

600

300

0

−300

−600

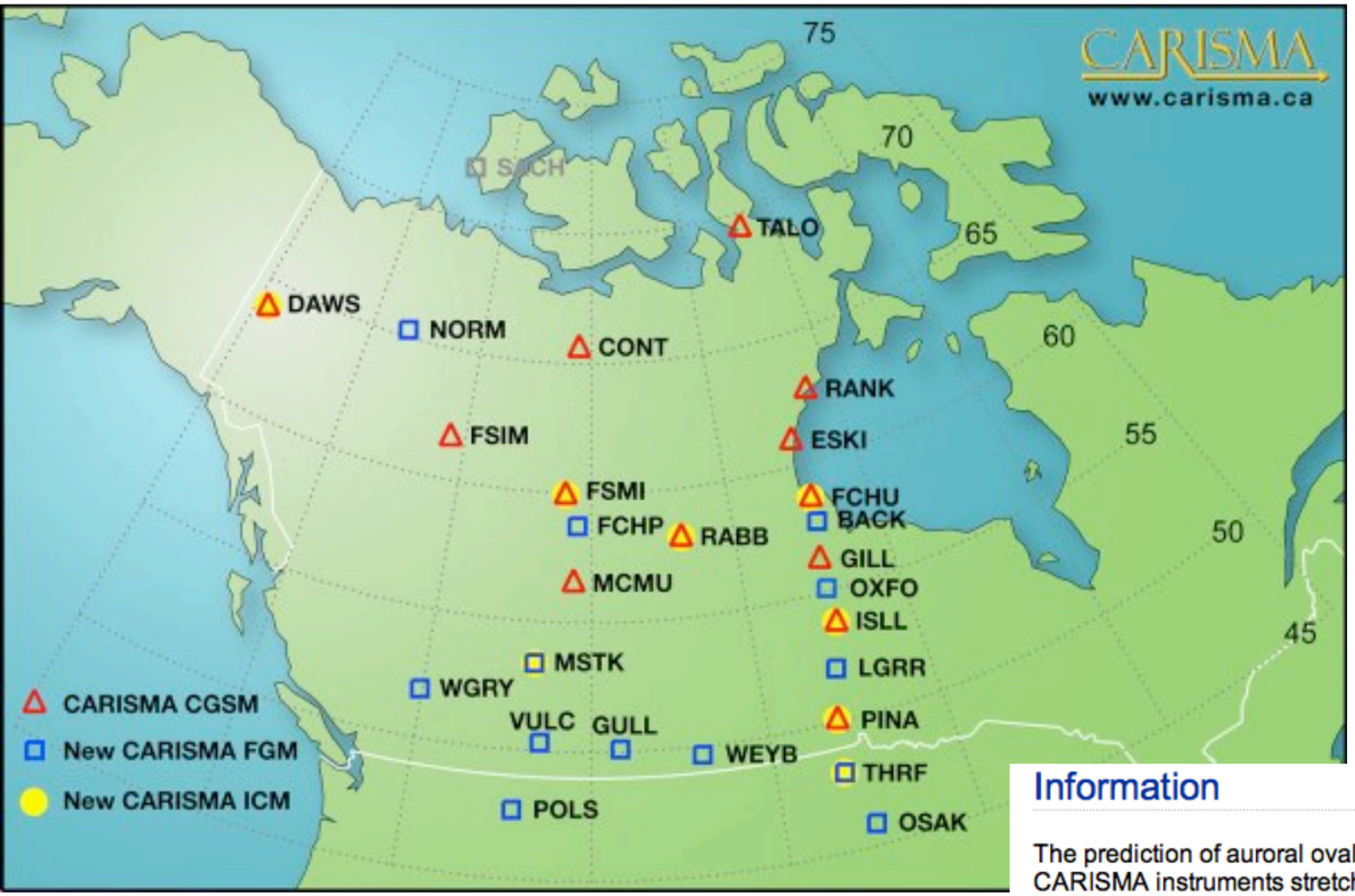
B_x B_y B_z

Run Feb 3 2013

Time	0518	0521	0524	0527	0530	0533	0536	0539	0542	0545	0548
MLat	38.7	47.1	55.6	64.0	71.4	75.7	73.7	67.0	58.3	48.8	39.1
MLT	18.9	18.6	18.1	17.5	16.3	14.1	11.5	10.0	9.2	8.7	8.5

DMSP	UTC	ion	elec	MLT
F16	06:00	67.0	70.7	13.7
F17A	05:30	67.4	69.1	14.1
F18A	05:30	----	69.1	17.1

F16: SAPS @ 66.3, 13.7 MLT



Site Code	Site Name	Geodetic Latitude	Geodetic Longitude	CGM Latitude	CGM Longitude	L
ANNA	Ann Arbor	42.417	276.098	52.88	349.51	2.79
BACK	Back Lake	57.707	265.794	67.32	333.52	6.83
CONT	Contwoyto	65.754	248.750	72.82	304.82	11.64
DAWS	Dawson City	64.048	220.890	65.90	273.89	6.09
ESKI	Eskimo Point	61.106	265.950	70.52	333.15	9.13
FCHP	Fort Chipewyan	58.769	248.894	66.23	308.55	6.25
FCHU	Fort Churchill	58.763	265.920	68.32	333.54	7.44
FSIM	Fort Simpson	61.756	238.770	67.23	294.29	6.78
FSMI	Fort Smith	60.017	248.050	67.28	306.90	6.81
GILL	Gillam	56.376	265.360	66.03	333.05	6.15
GULL	Gull Lake	50.061	251.739	58.20	314.92	3.66
ISLL	Island Lake	53.856	265.340	63.62	333.36	5.15
LGRR	Little Grand Rapids	52.035	264.537	61.81	332.38	4.55
MCMU	Fort McMurray	56.657	248.790	64.17	309.20	5.35
MSTK	Ministik Lake	53.351	247.026	60.61	307.99	4.22
NORM	Norman Wells	65.257	233.311	69.53	285.74	8.31
OSAK	Osakis	45.871	264.917	55.81	333.20	3.22
OXFO	Oxford House	54.929	264.713	64.60	332.28	5.52
PINA	Pinawa	50.199	263.960	59.98	331.75	4.06
POLS	Polson	47.664	245.791	54.71	308.04	3.04
RABB	Rabbit Lake	58.222	256.320	66.85	319.11	6.57
RANK	Rankin Inlet	62.824	267.890	72.22	335.97	10.89
SACH	Sachs Harbour	71.980	234.770	76.17	280.31	N/A
TALO	Taloyoak	69.540	266.450	78.28	330.93	N/A
THRF	Thief River Falls	48.027	263.635	57.82	331.49	3.58
VULC	Vulcan	50.367	247.020	57.65	308.84	3.55
WEYB	Weyburn	49.693	256.200	58.55	320.93	3.73
WGRY	Wells Gray	51.883	239.974	57.75	299.92	3.57

Information

The prediction of auroral oval location and activity level is made using ground magnetometer data from the line of CARISMA instruments stretching along a common meridian (approximately) from Taloyoak in the north to Pinawa in the south. The magnetometers are triaxial, measuring the north -south component of the magnetic field (X), the east-west component (Y) and the vertical component (Z). The plots in the top left corner of the web page show latitude profiles of those three components at each time a prediction is made.

If you think of the auroral region as carrying a large electric current, that current either flows eastward (in the evening hours) or westward in the morning hours. An eastward electrojet makes a positive X-component perturbation and the westward electrojet makes a negative X-component perturbation. The Z-component tells us about the location of the edges of these east-west currents, and we use the peaks in the Z-component to identify the poleward and equatorward edges of the electrojet every 5 minutes.

On the bottom panel , you can see the time evolution of the electrojet width and position since the start of the UT day, at the longitude of the Churchill line. While the Churchill line gives apposition of the borders at only one local time, we use a statistical data base of prior information to construct the oval which requires you know the edges of the current system at all local times.

Risk is computed from an algorithm that involves how far equatorward the poleward edge of the oval has been pushed and how long it has been there. The dotted white line on the bottom panel shows the position of the poleward edge of the oval under average activity conditions. We are only trying to predict big events, so we are interested in how far below the average position of the poleward edge of the oval the instantaneous position has moved. If the instantaneous position of the poleward edge of the electrojet is at or poleward of the average position, we say there is no risk of a really big event.

But....what do we mean by "event"? For us an "event" is a substorm, the largest of the auroral disturbances which usually occurs in the hours around midnight. The energy for these disturbances is stored in the earth's magnetic tail and how much energy is stored can be estimated from the size of the polar cap - the area poleward of the auroral oval. The bigger the polar cap...the more energy is stored which can be released suddenly to make a big disturbance. Our Risk algorithm is an estimator of the size of the polar cap, and how long it has been expanded also has some impact on how big the disturbance will be when it comes.