

Impact of Ionospheric Storm Phase and TIDs on Ionospheric Bubble Formation

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Analyzed 39 storms with $Dst < -80$ nT during lifetime of C/NOFS spacecraft

- (April, 2008 – November, 2015)

Will show two storms here:

- August 5, 2011
- September 26, 2011

- Use DMSP to identify ionospheric storm phase
 - as electromagnetic energy inputs expand to low and middle latitudes during geomagnetic storm
 - storm enhanced densities
 - response strong in topside ionosphere
- GPS observations of TIDs
 - Both LSTIDs and MSTIDs
- Equatorial plasma bubbles observed by C/NOFS
 - Density
 - Plasma drifts

DMSP Orbits

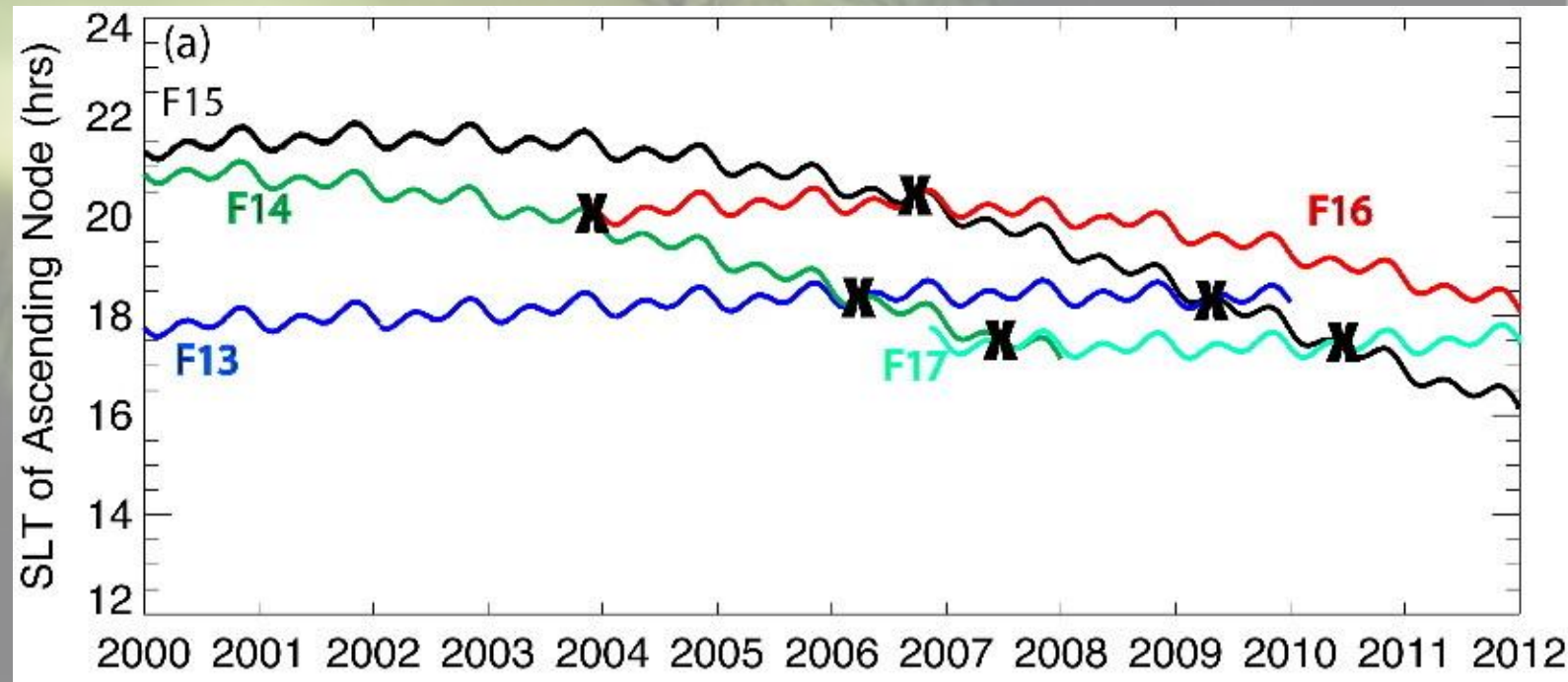
DMSP spacecraft are in sun-synchronous orbits with ascending node crossing times before, after and near 18 SLT, depending on launch selection and time in orbit

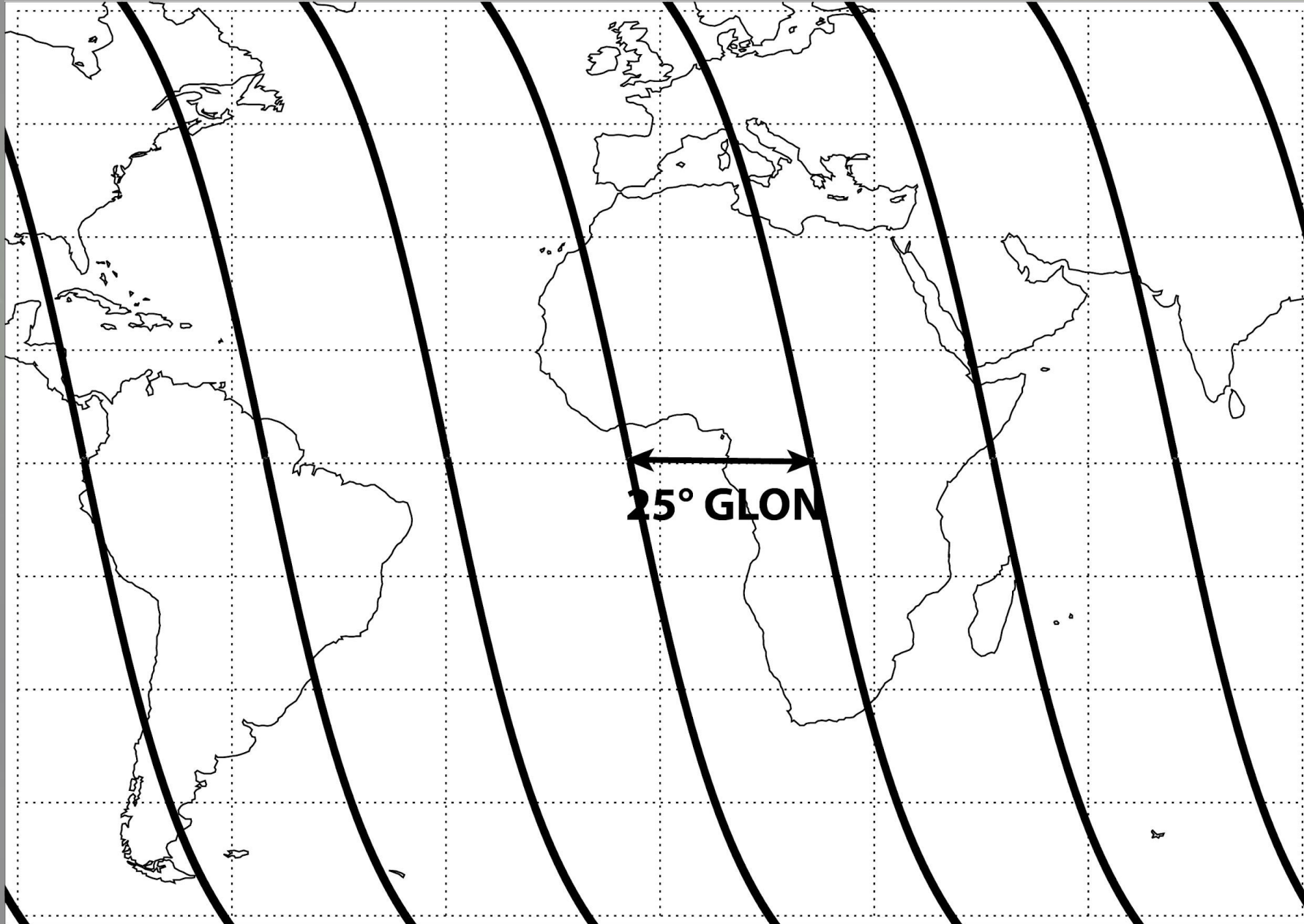
- Have specific altitude and inclination
 - ~840 km circular
 - 99° inclination

Orbit plane precesses keeping the angle between the orbit plane and the Sun-Earth line constant throughout the year

- Because the earth is an oblate spheroid

Local time varies slowly over the long term as satellite drag drops orbit altitude





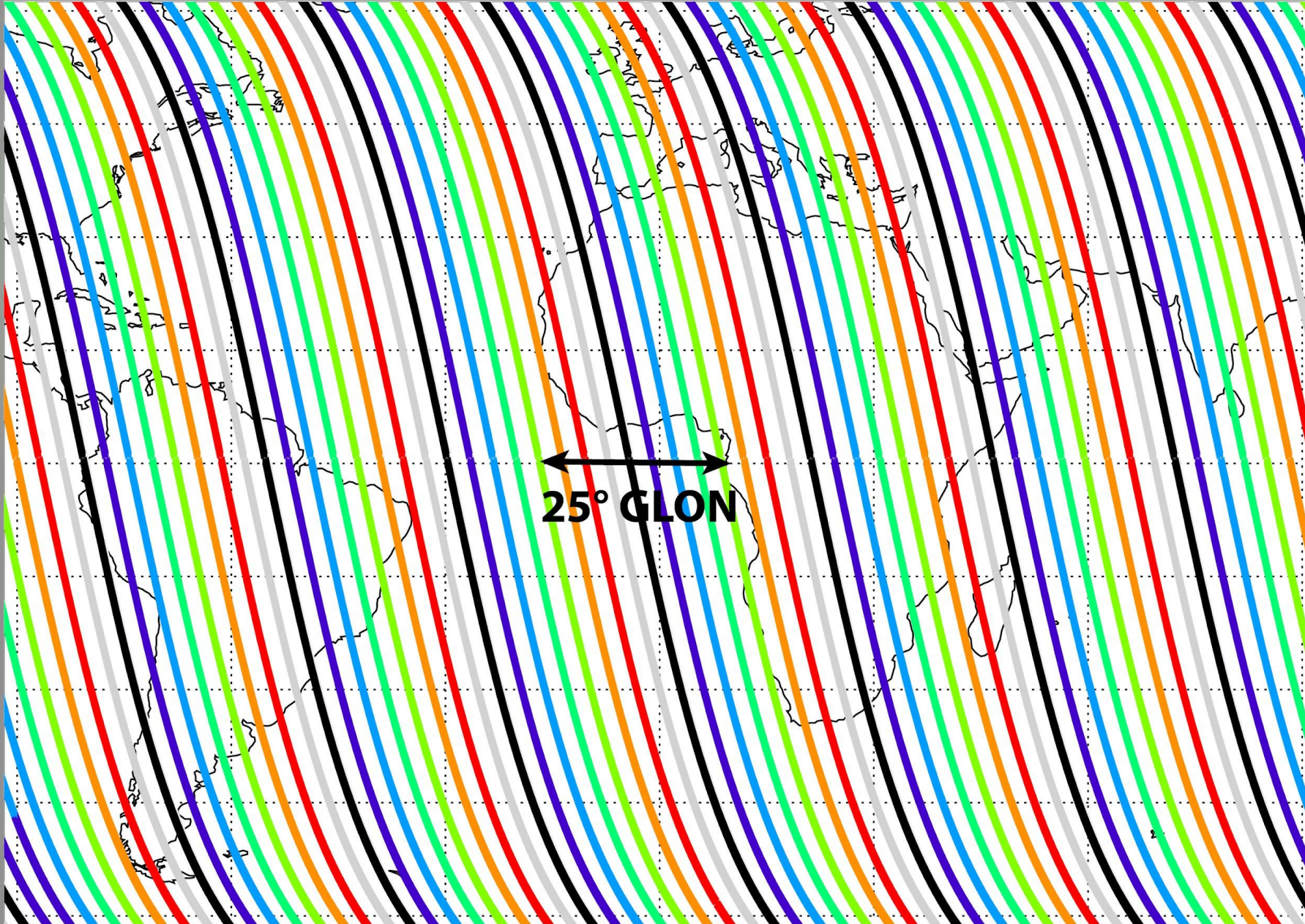
Orbit tracks of
ascending node
passes

~14.5 orbits per day

- (~100 min orbit period)

Move ~25° GLON
west per orbit

UT and GLON locked



Orbits shift $\sim 3^\circ$ west in GLON per day

In 8 days, approximately same orbit track.

UT and GLON locked.

To compare day to day variation, select passes $\pm 12.5^\circ$ GLON of center pass (at ascending node)

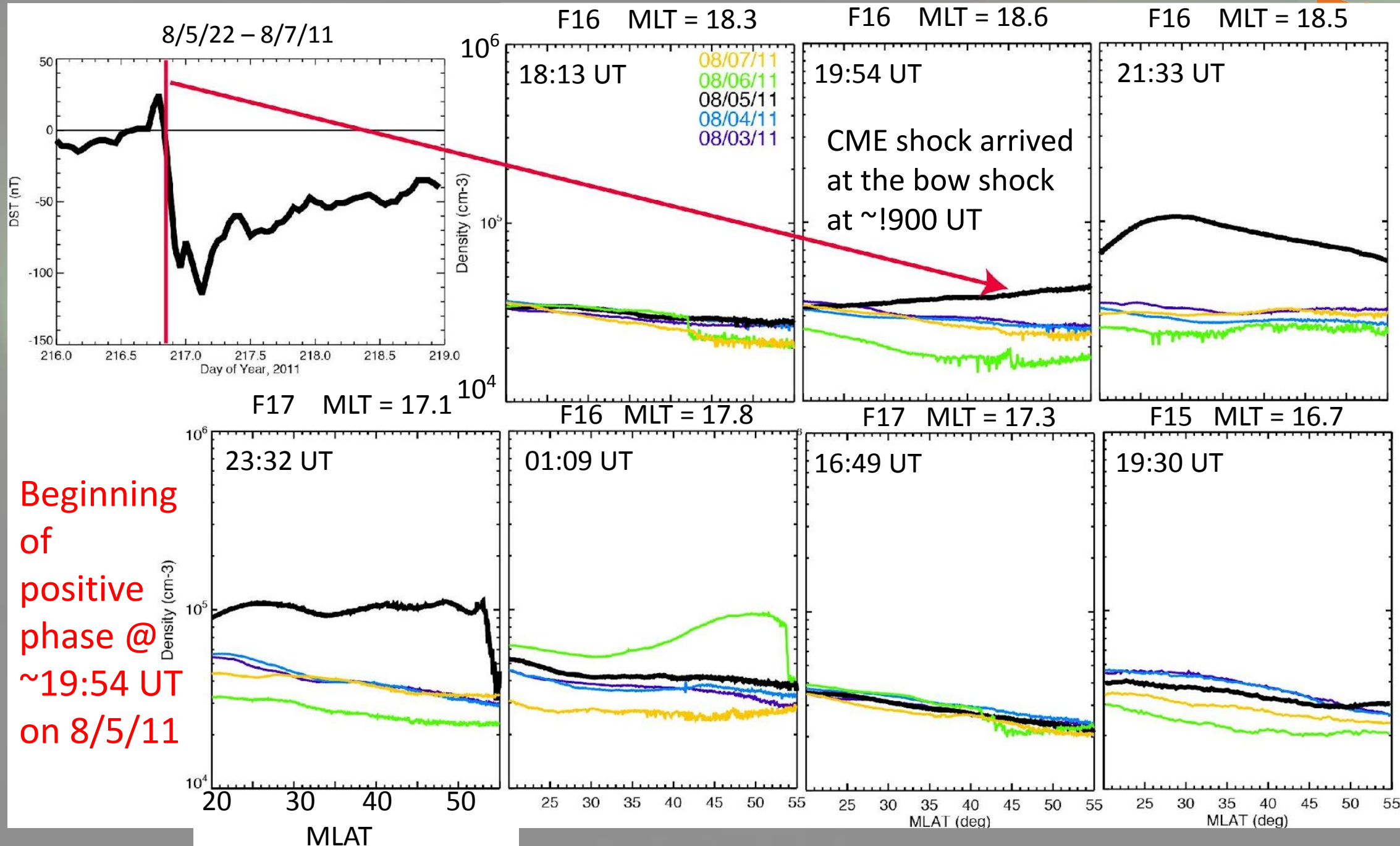
Over 8 days, will be within ± 45 minutes UT of center pass

(Over 5 days within ± 30 minutes UT)

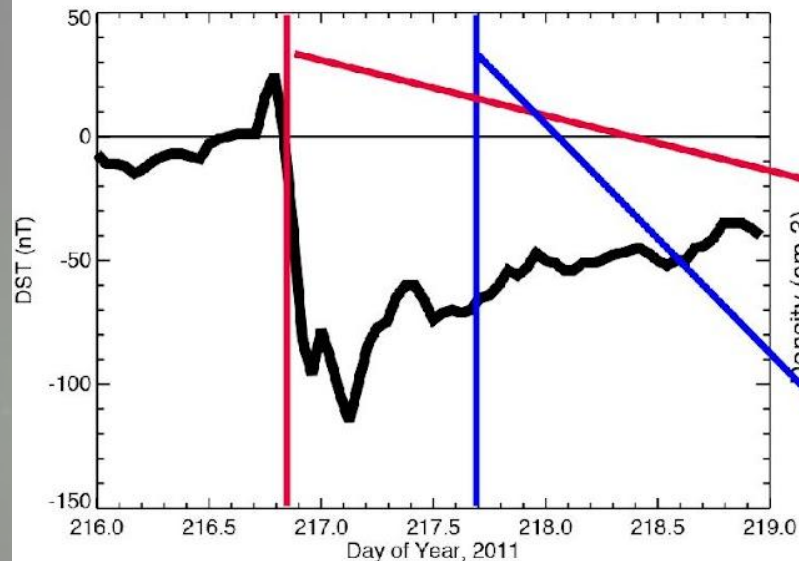
The background of the slide is a photograph of the aurora borealis (northern lights) in shades of green and yellow, with the dark silhouettes of trees visible in the foreground.

Ionospheric Storm Phase From DMSP

August 5, 2011 Storm



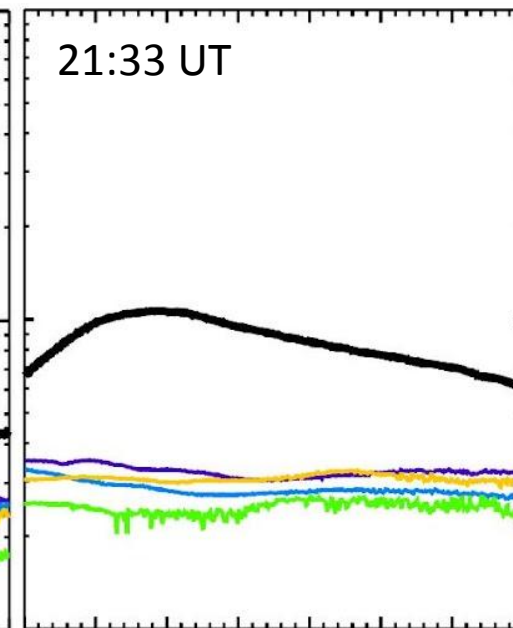
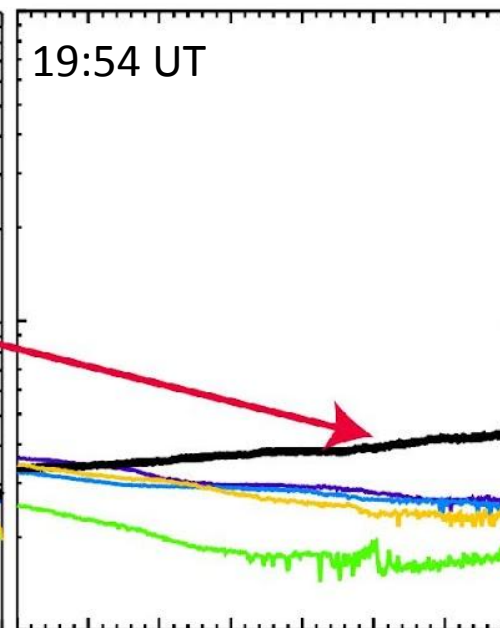
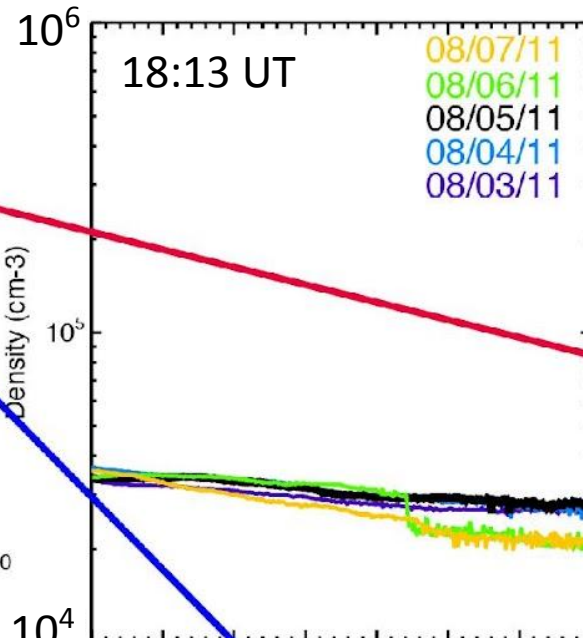
8/5/22 – 8/7/11



F16 MLT = 18.3

F16 MLT = 18.6

F16 MLT = 18.5

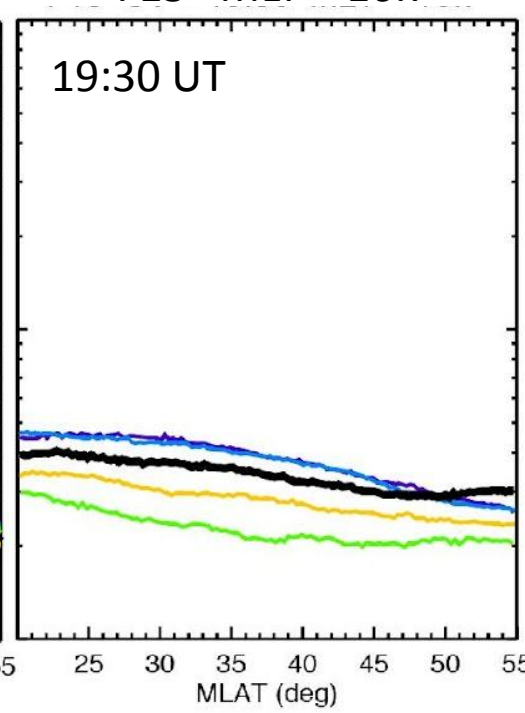
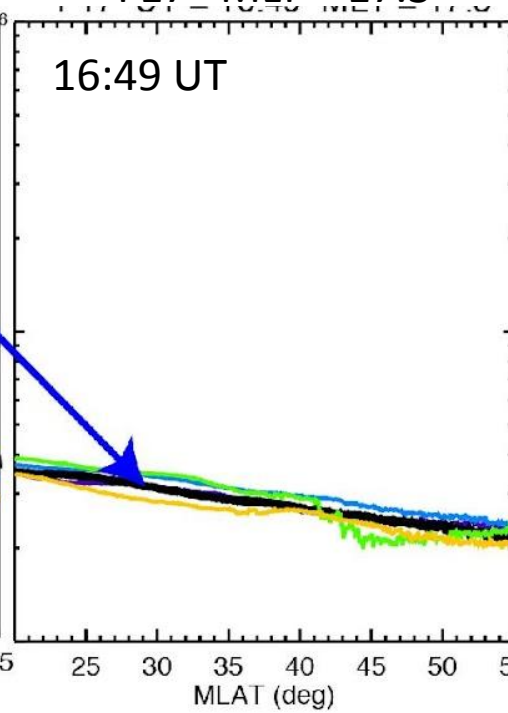
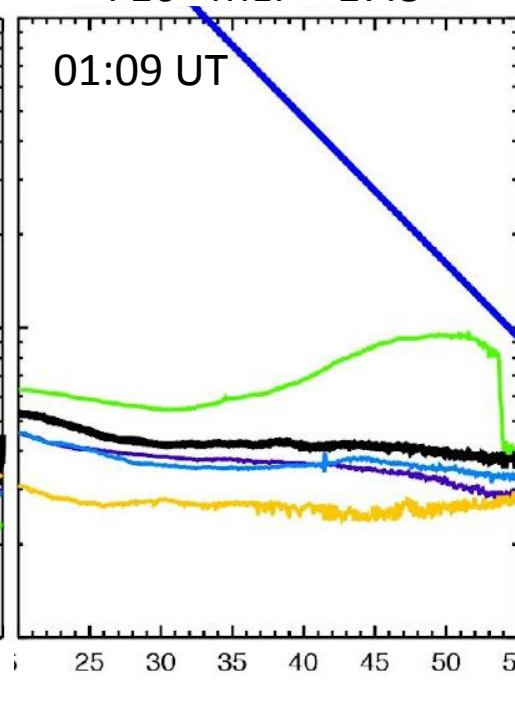
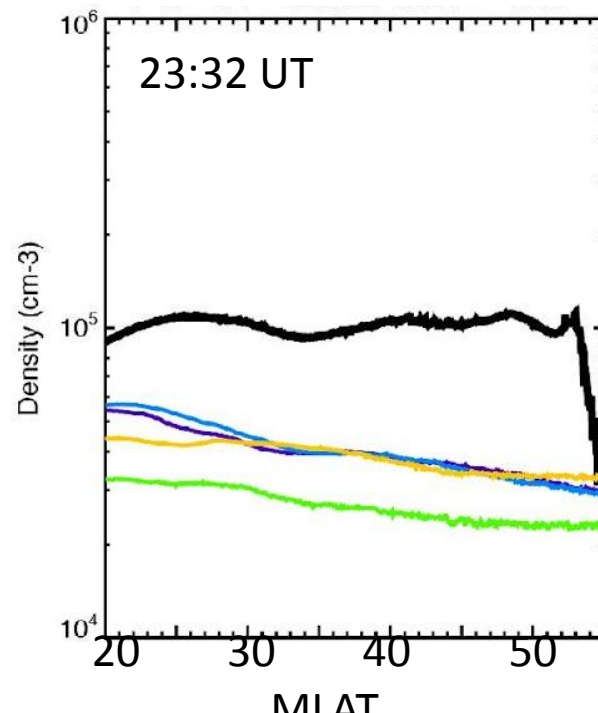


F17 MLT = 17.1

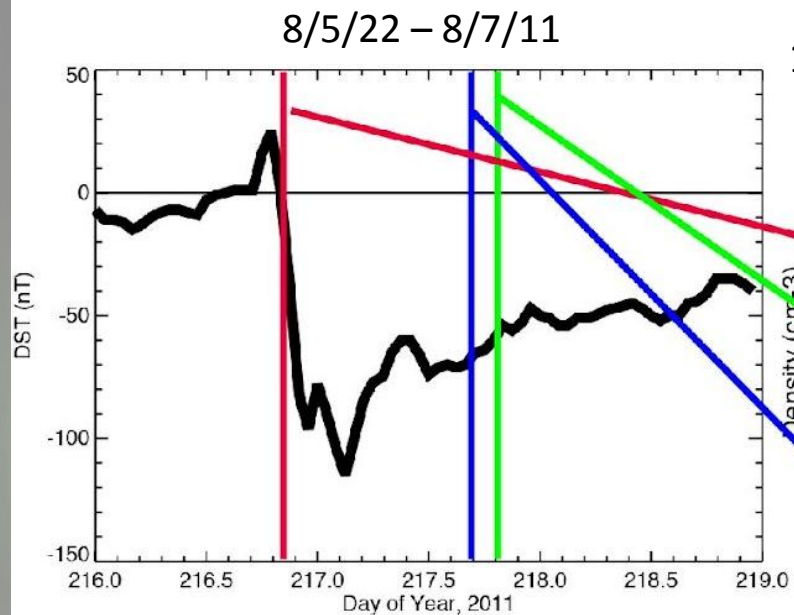
F16 MLT = 17.8

F17 MLT = 17.3

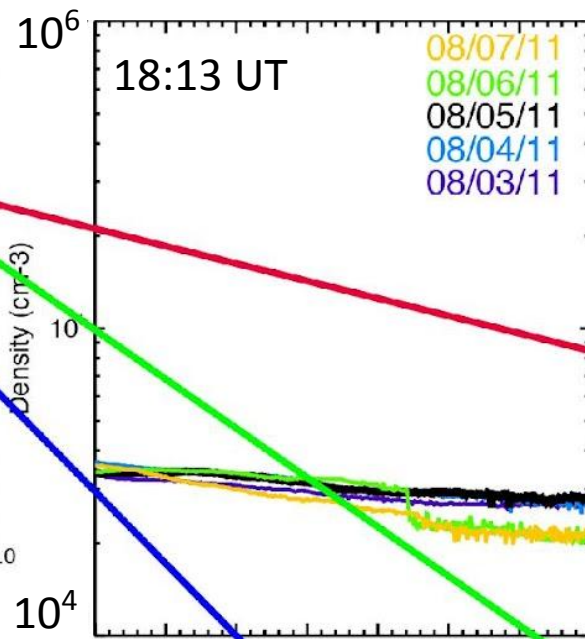
F15 MLT = 16.7



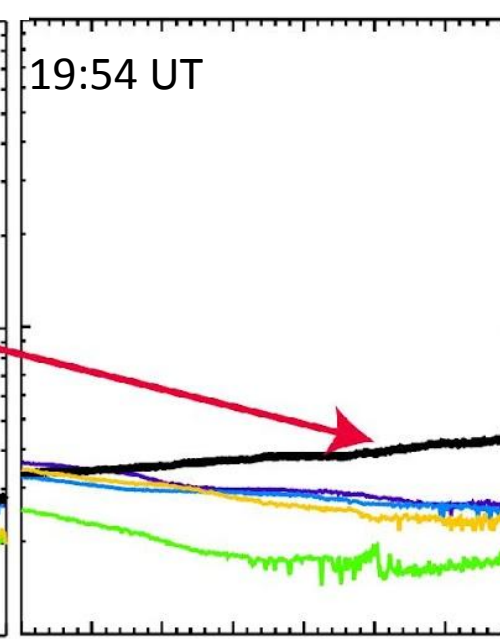
End of
positive
phase @
~16:49
UT on
8/6/11



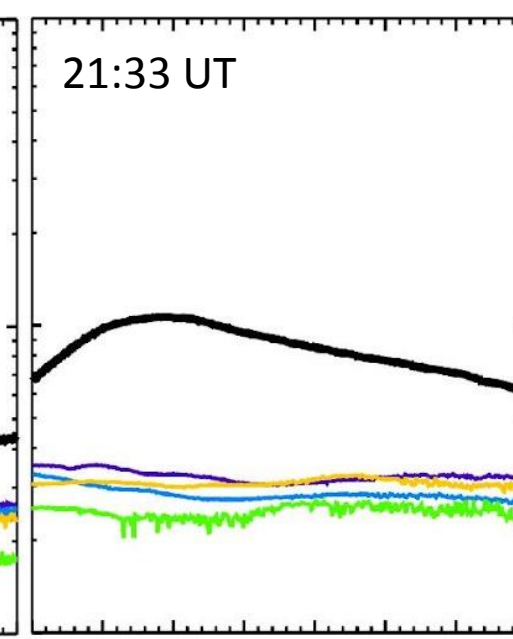
F16 MLT = 18.3



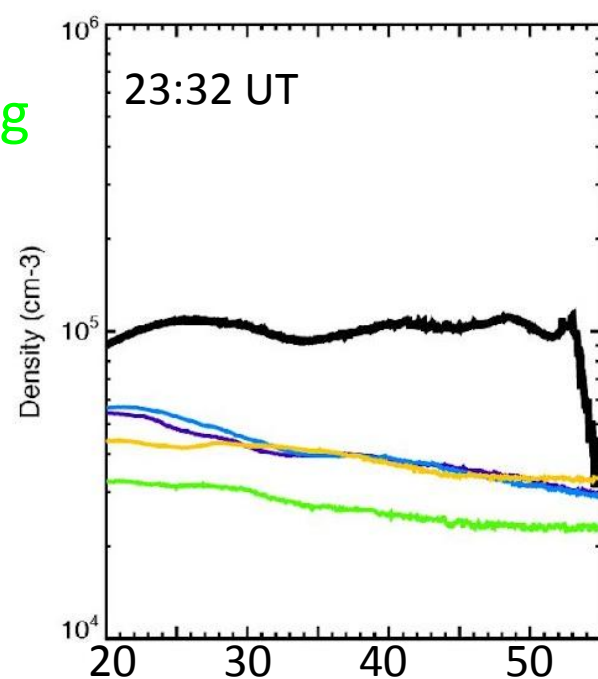
F16 MLT = 18.6



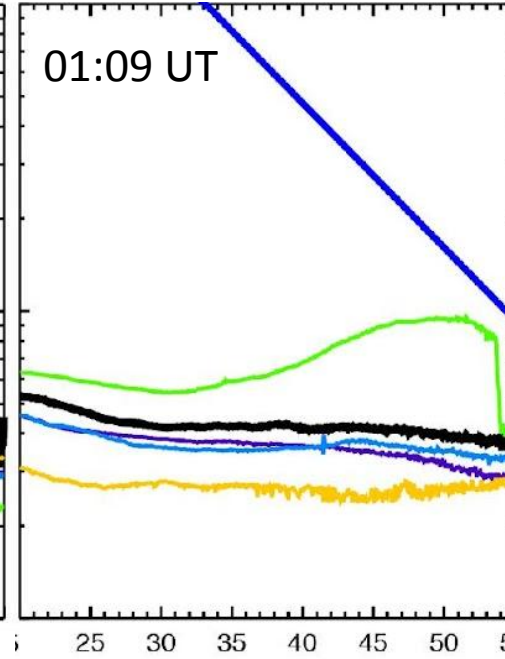
F16 MLT = 18.5



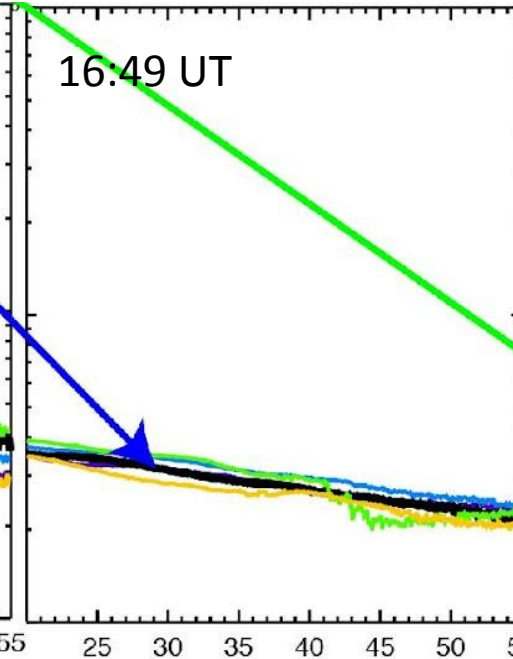
F17 MLT = 17.1



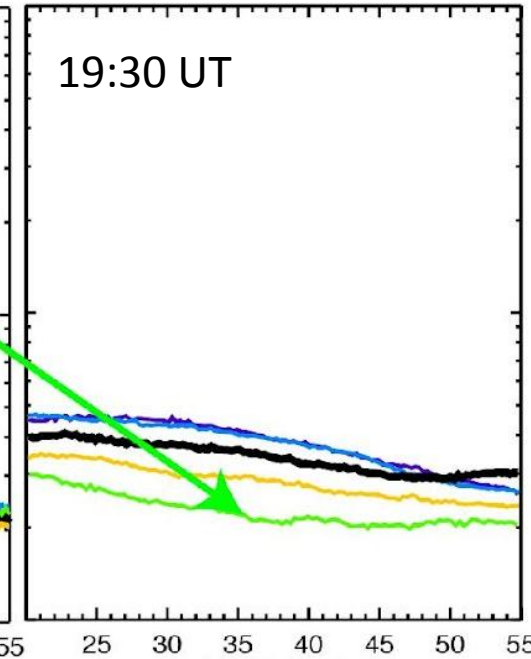
F16 MLT = 17.8



F17 MLT = 17.3



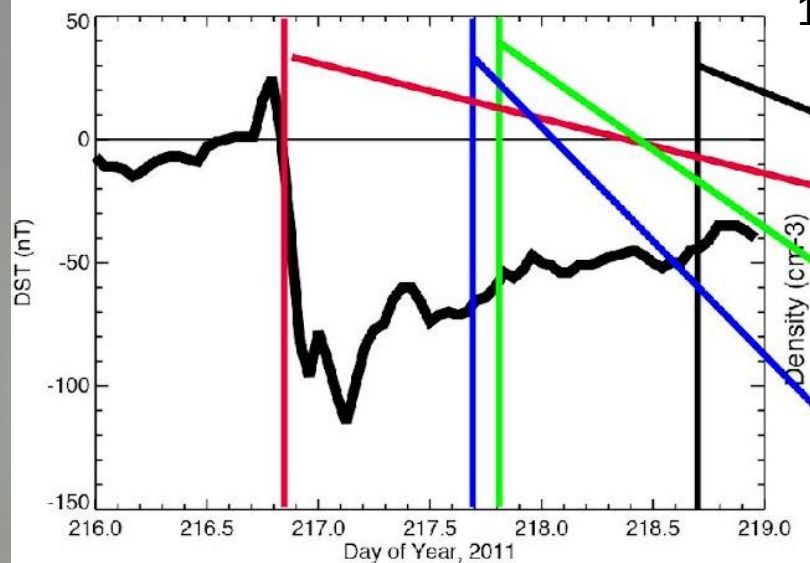
F15 MLT = 16.7



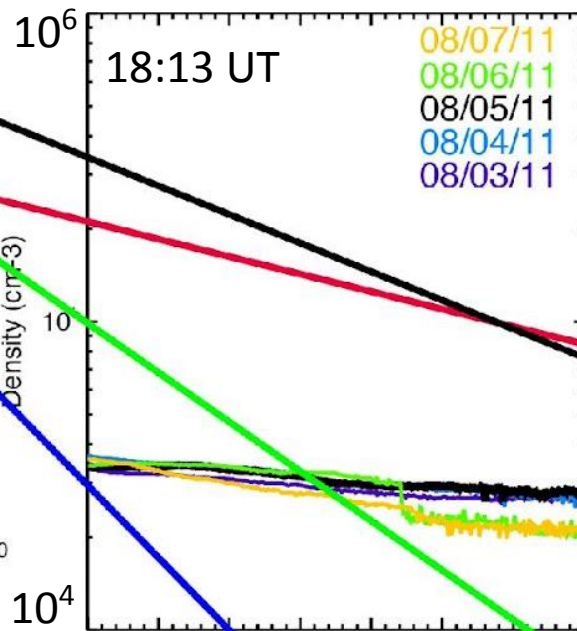
Beginning
of
negative
phase @
~19:30
UT on
8/6/11

AS

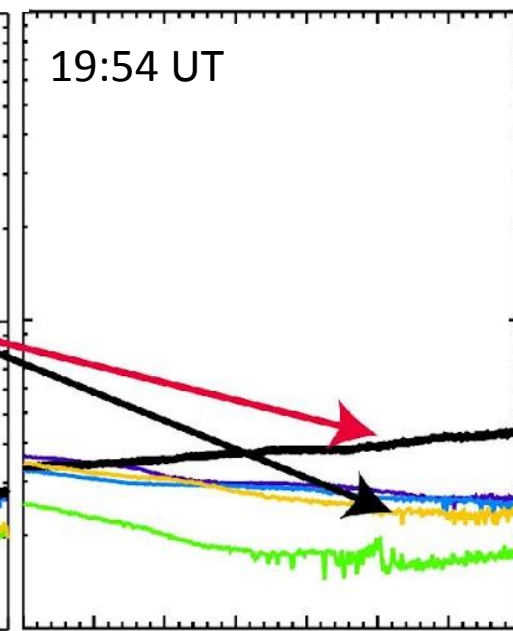
8/5/22 – 8/7/11



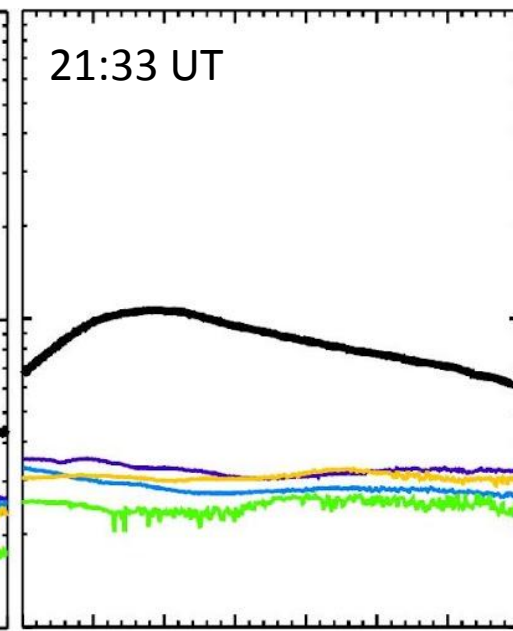
F16 MLT = 18.3



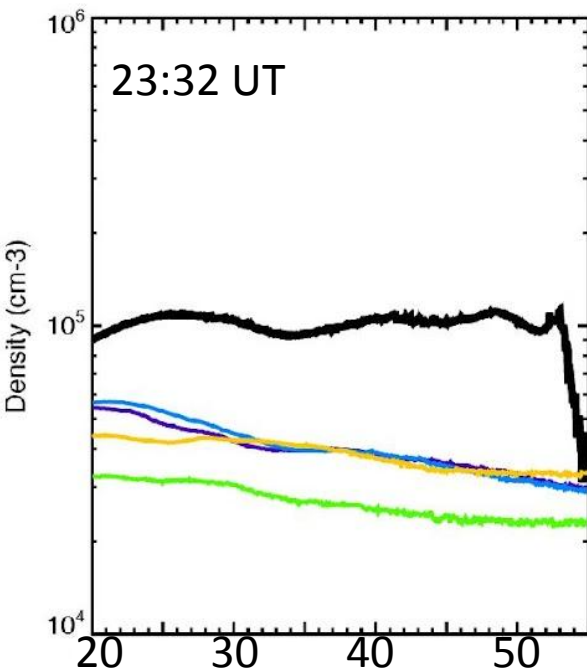
F16 MLT = 18.6



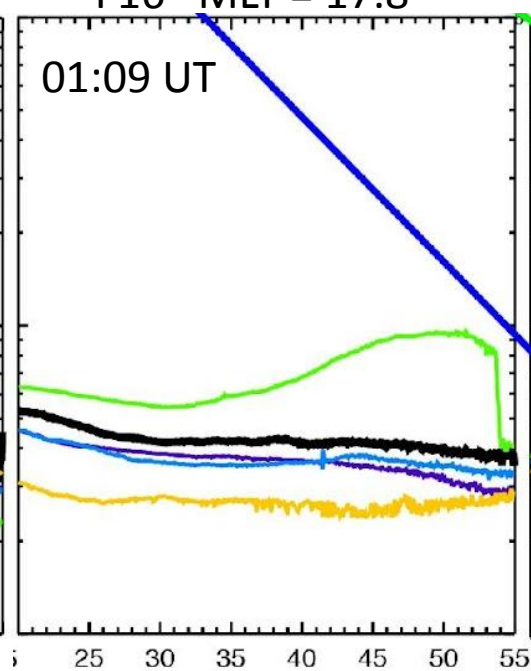
F16 MLT = 18.5



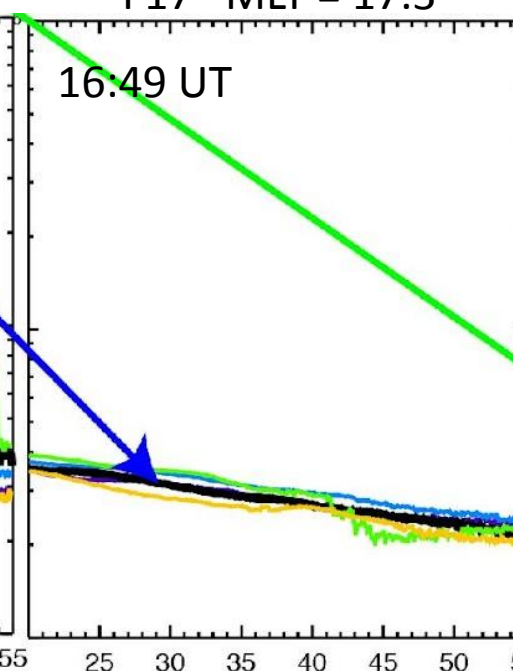
F17 MLT = 17.1



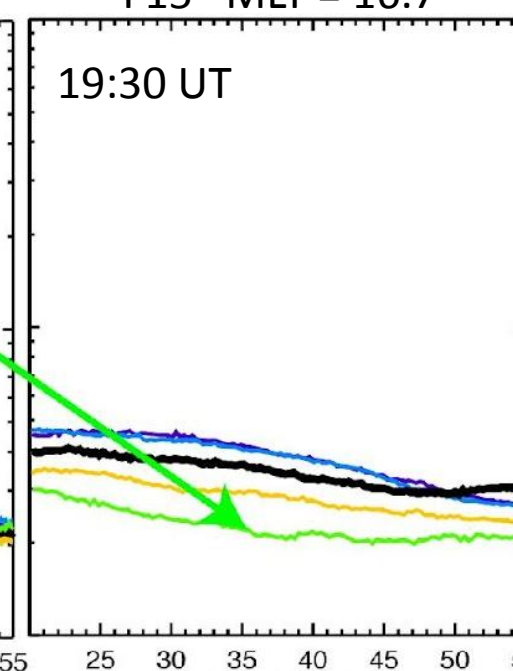
F16 MLT = 17.8



F17 MLT = 17.3



F15 MLT = 16.7

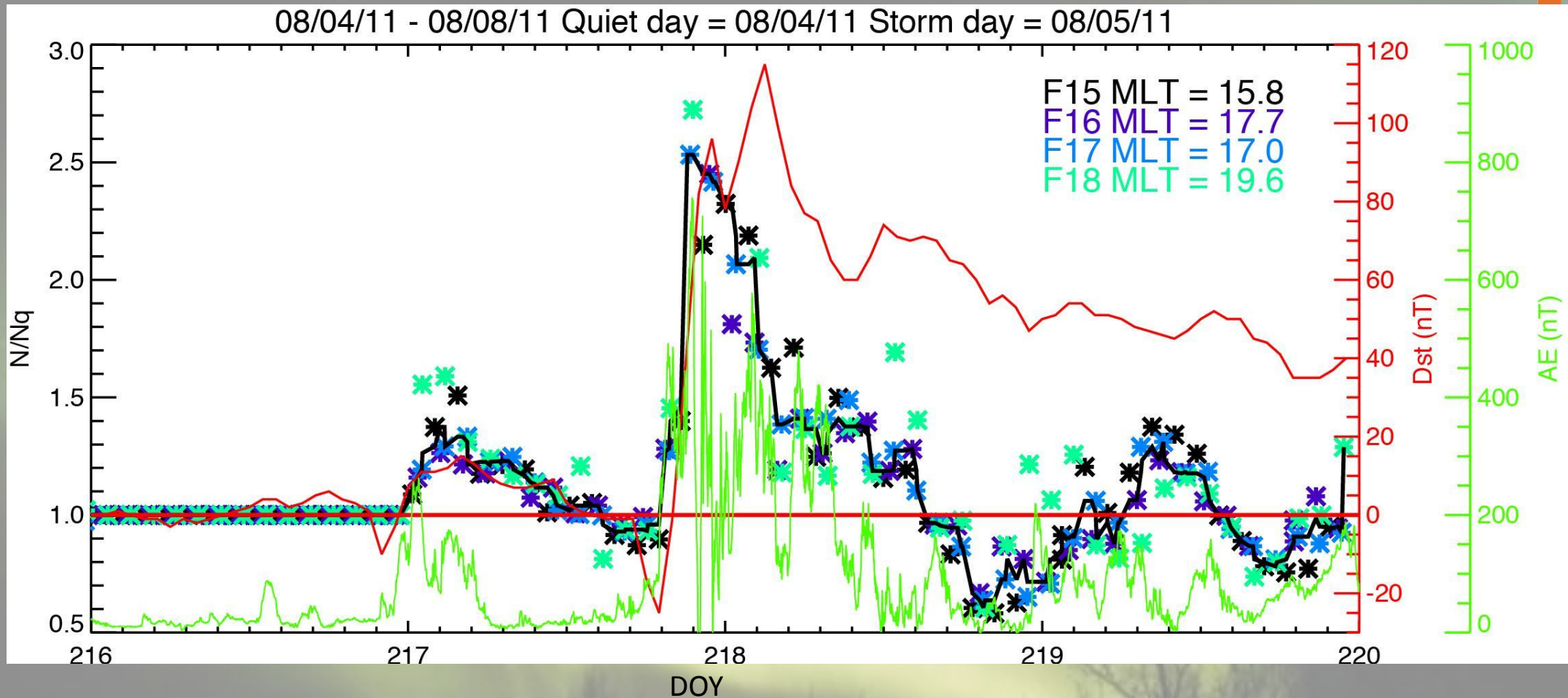


End of
negative
phase @
~ 19:54
UT on
8/7/11

MLAT

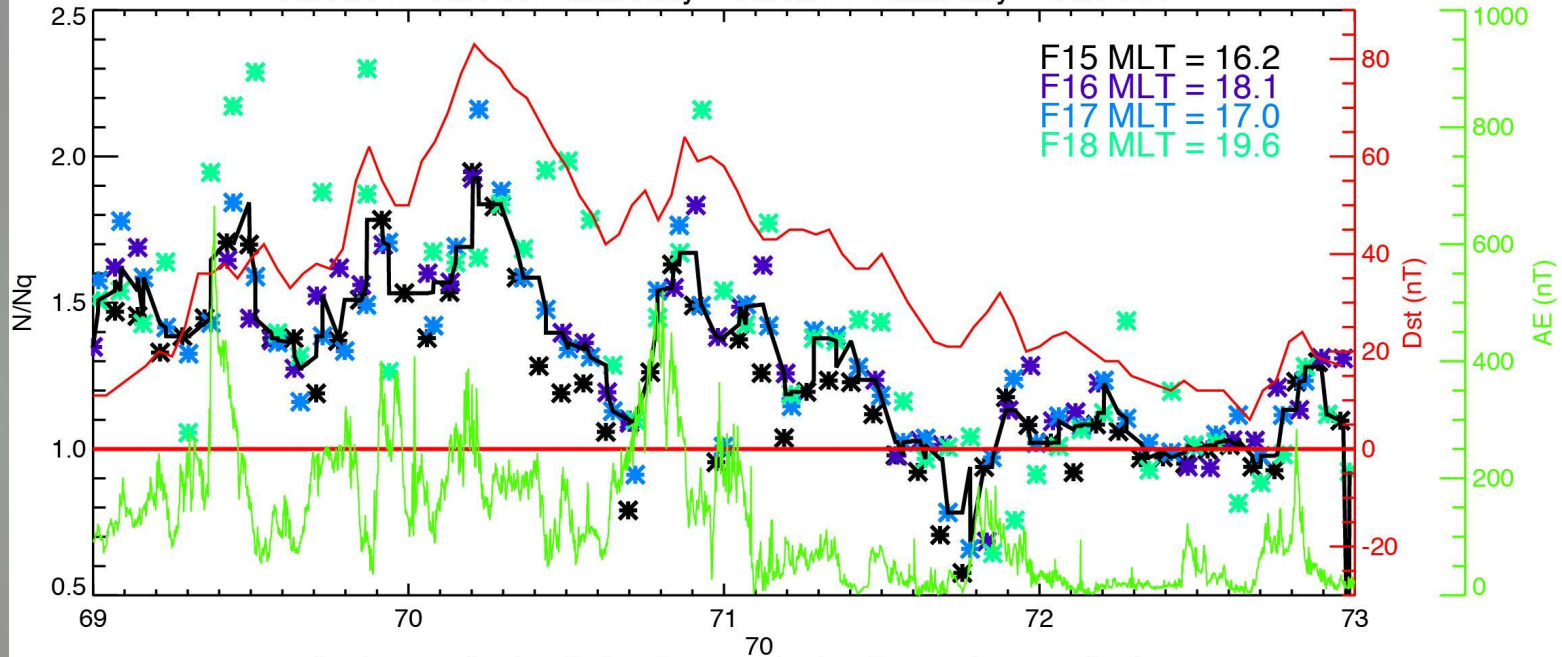
MLAT (deg)

MLAT (deg)

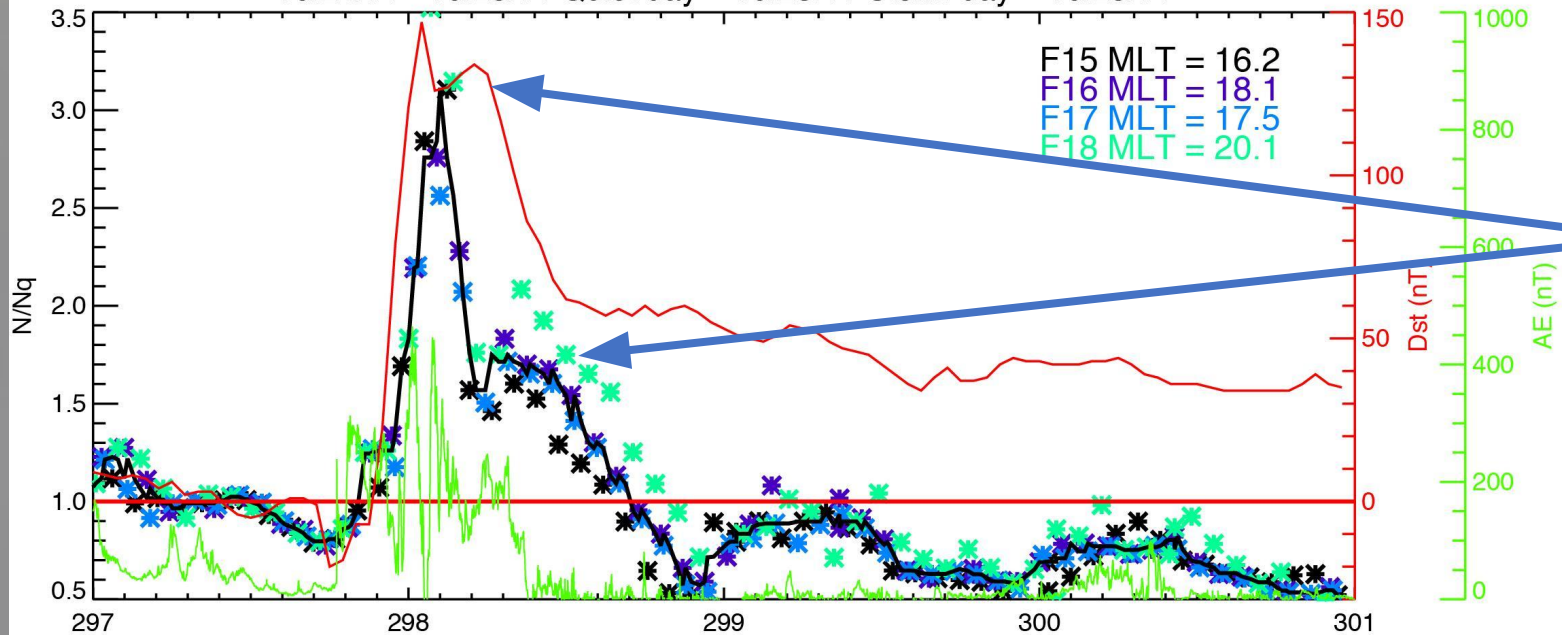


- Red lines – negative Dst
- Green lines – AE
- Quiet day – determined by last day with Dst < 20 nT and AE < 200 nT
- Colored asterisks – ratio of disturbed to quiet day average density between 20° and 50° MLAT (northern hemisphere) time tagged at 35°
- Black line – 5-point median

03/10/11 - 03/14/11 Quiet day = 03/06/11 Storm day = 03/11/11

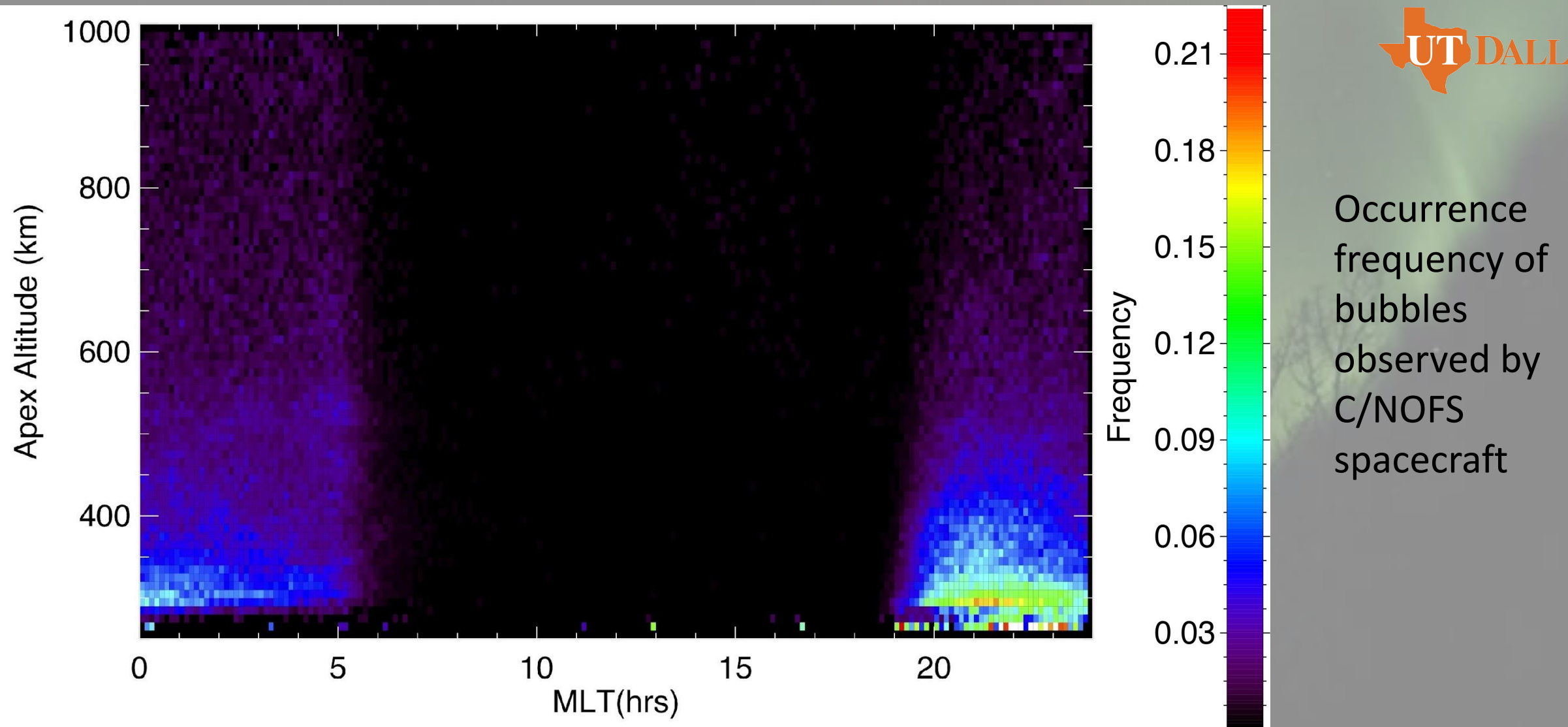


10/24/11 - 10/28/11 Quiet day = 10/23/11 Storm day = 10/25/11



Dst and variations in topside storm enhanced densities are extremely well correlated, especially in the afternoon.

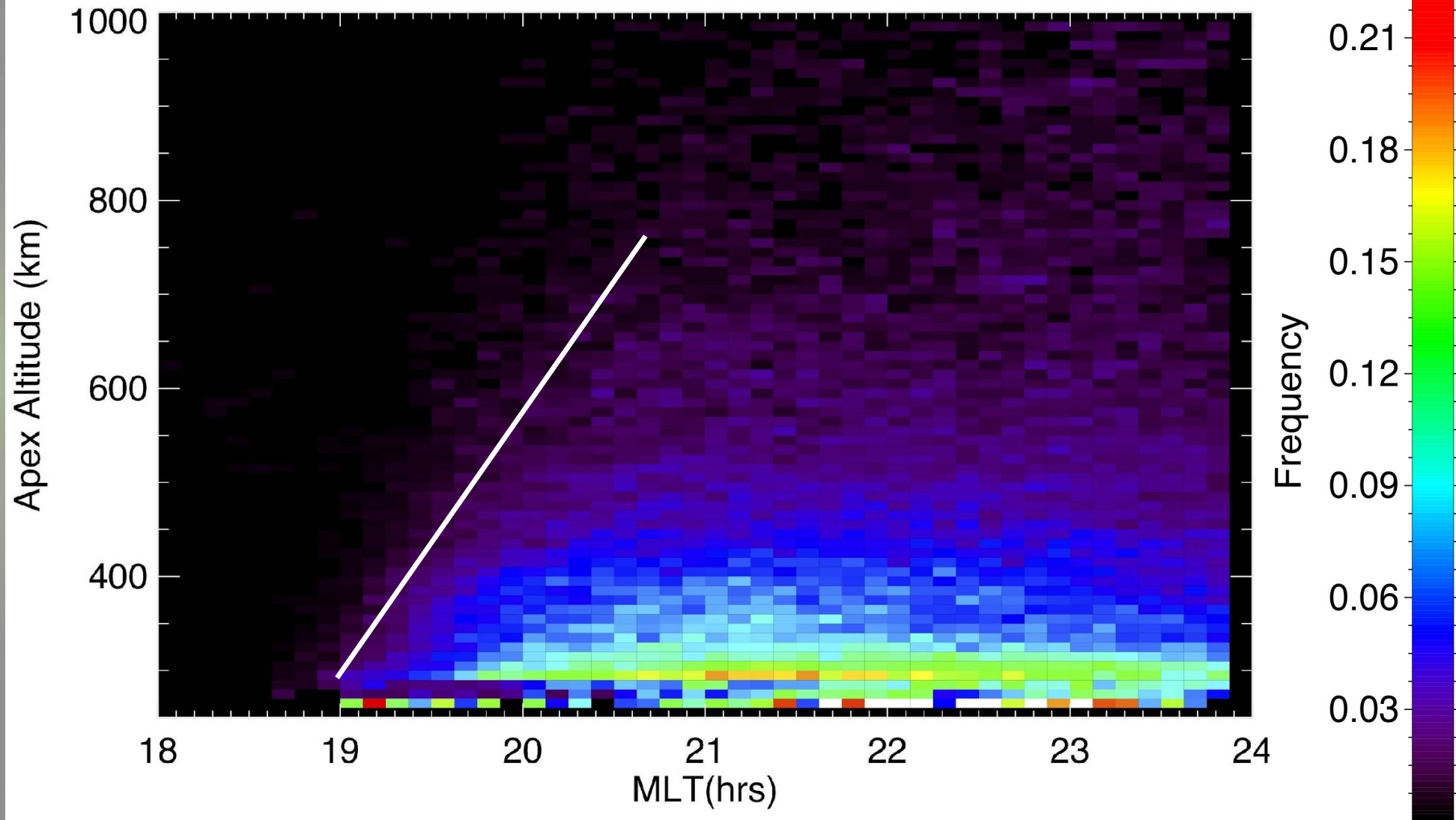
Even small variations in Dst show response



Database of bubbles observed by the C/NOFS spacecraft created using a rolling ball algorithm

- consistent with known statistics
- none observed before about 19 MLT or after about 6 MLT

□ Notice slope of outer envelope near dusk

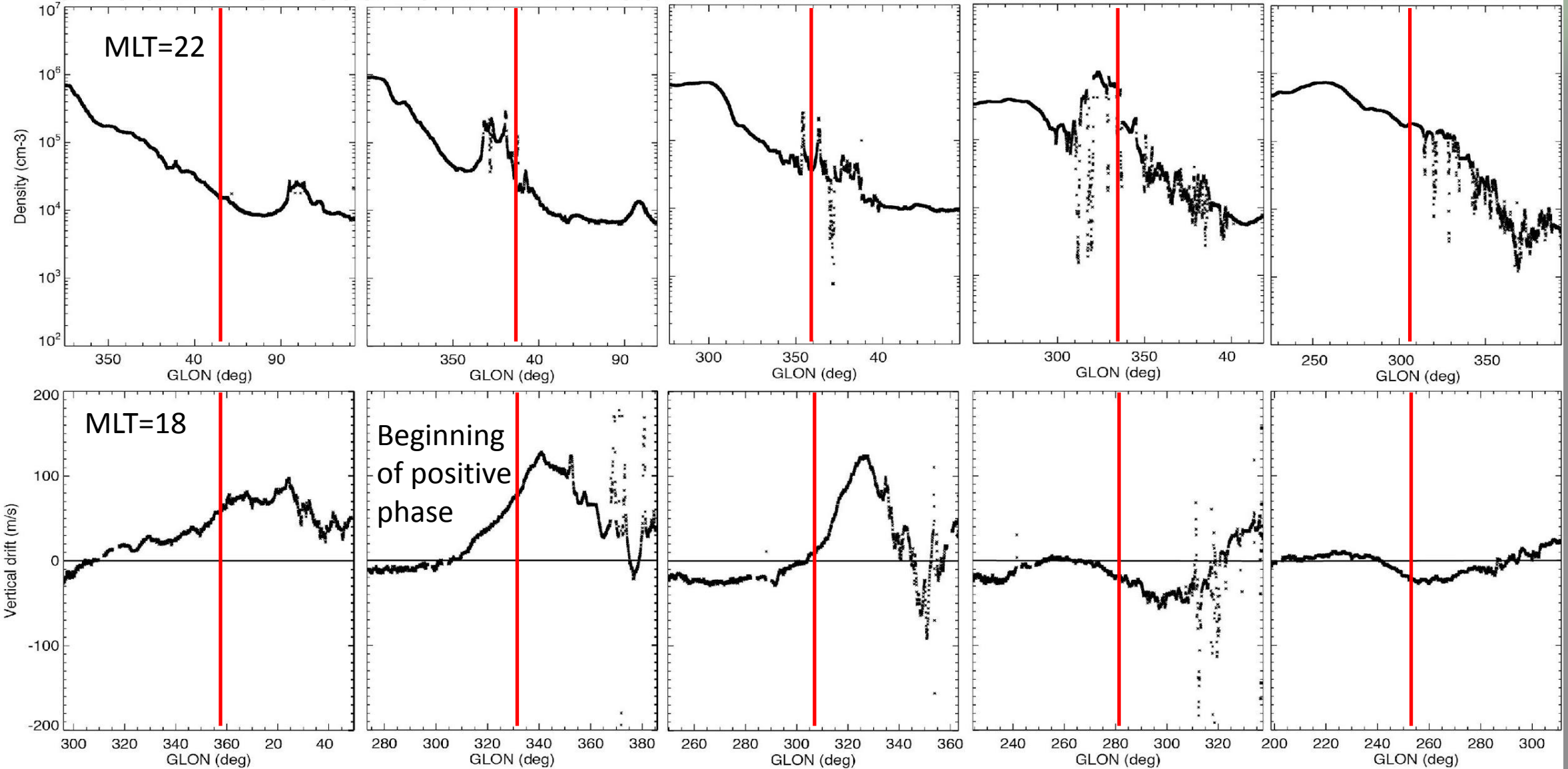


Line drawn along outer envelope

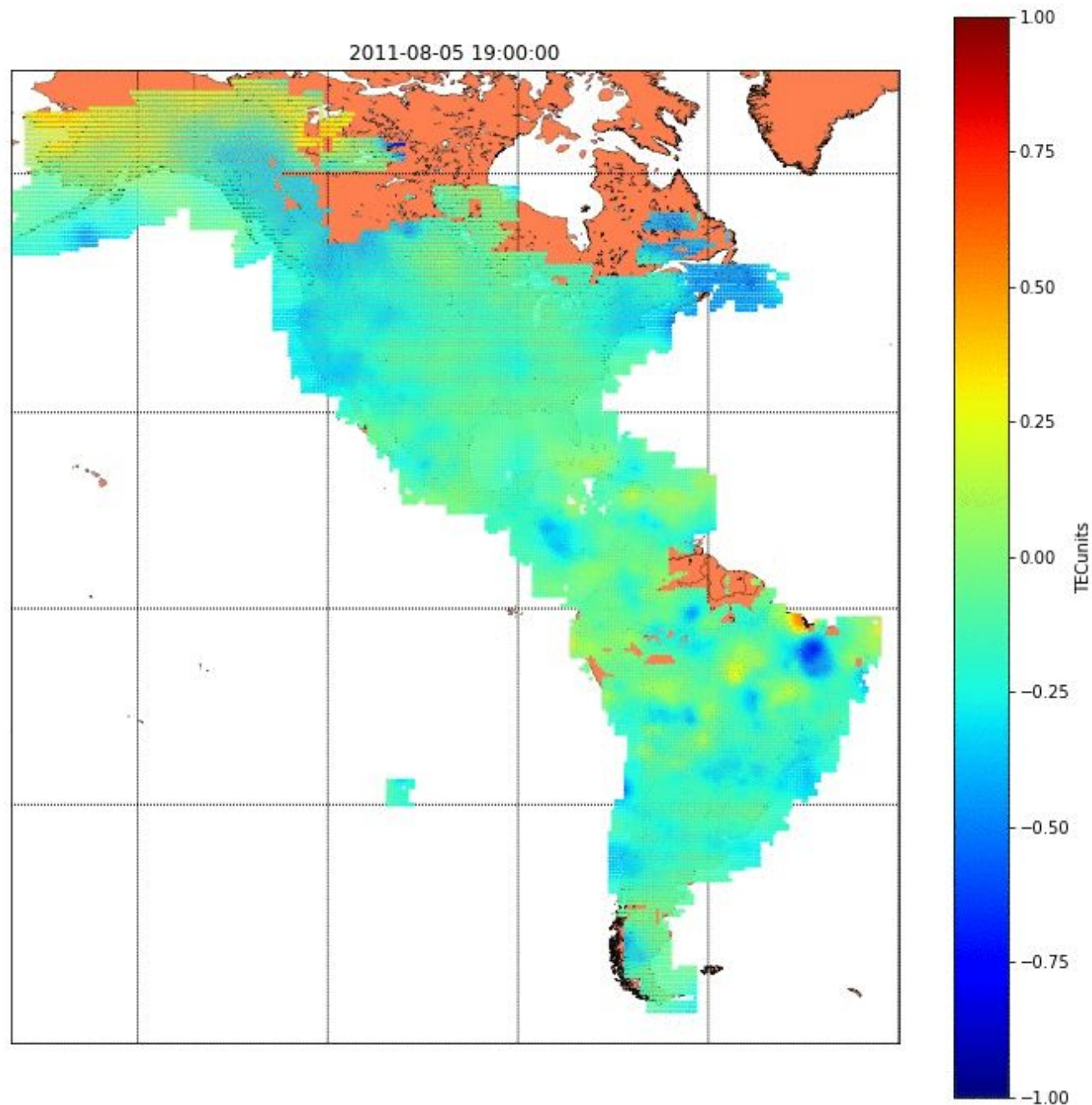
- Slope is ~ 100 m/s
- Consistent with typical vertical drifts associated with bubbles
- Bubbles not observed at high altitudes until had time to reach them

C/NOFS densities and vertical drifts on 8/5/11 – 8/6/11

UT = 18:40 MLAT = 1.3 Alt = 516. UT = 20:17 MLAT = 1.4 Alt = 515. UT = 21:54 MLAT = 1.4 Alt = 515. UT = 23:30 MLAT = 1.4 Alt = 508. UT = 01:06 MLAT = 1.4 Alt = 503.



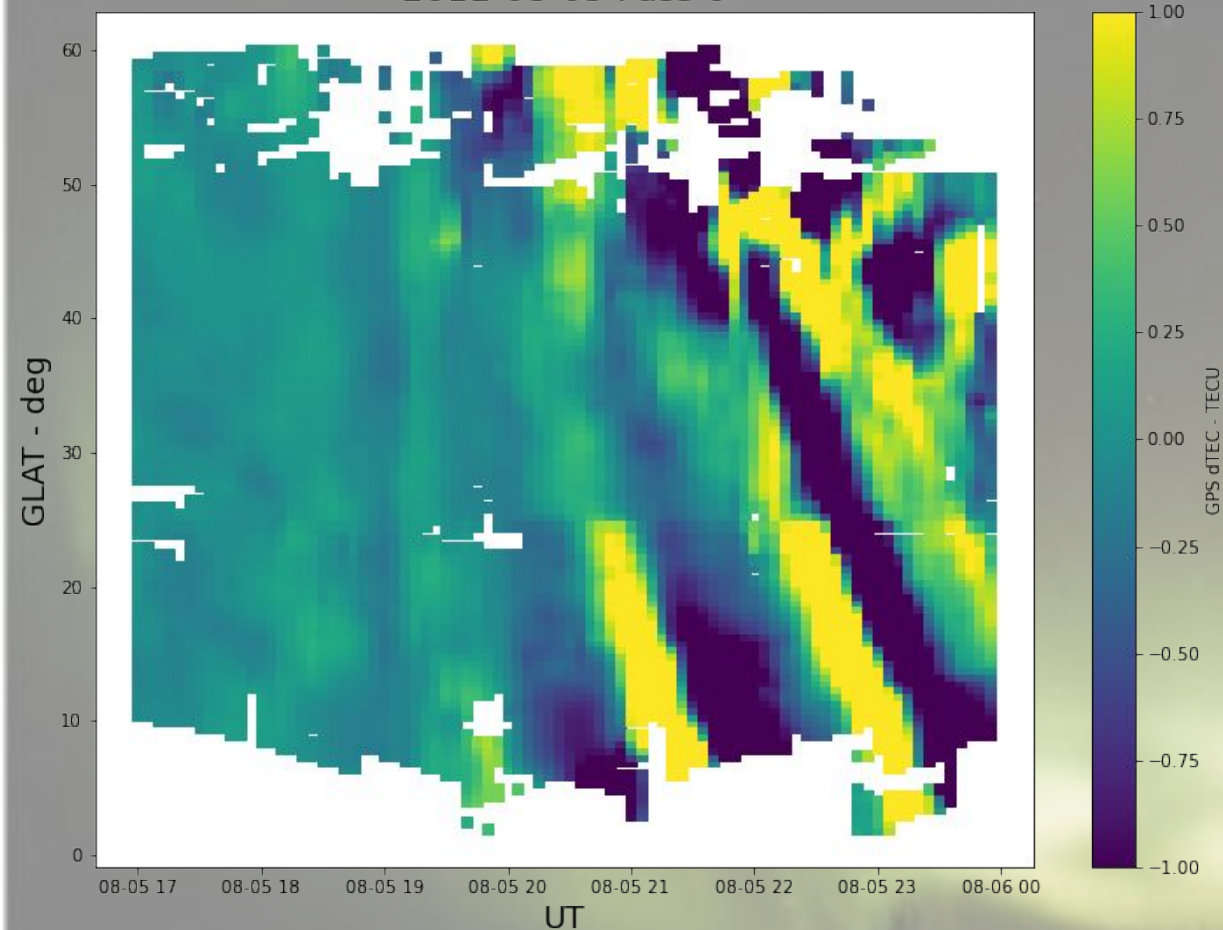
- Densities (top panels) are plotted from 16 to 04 MLT (centered at MLT=22)
- Vertical drifts (bottom panels) are plotted from 14 to 22 MLT (centered at MLT=18).



LSTIDs observed during storm

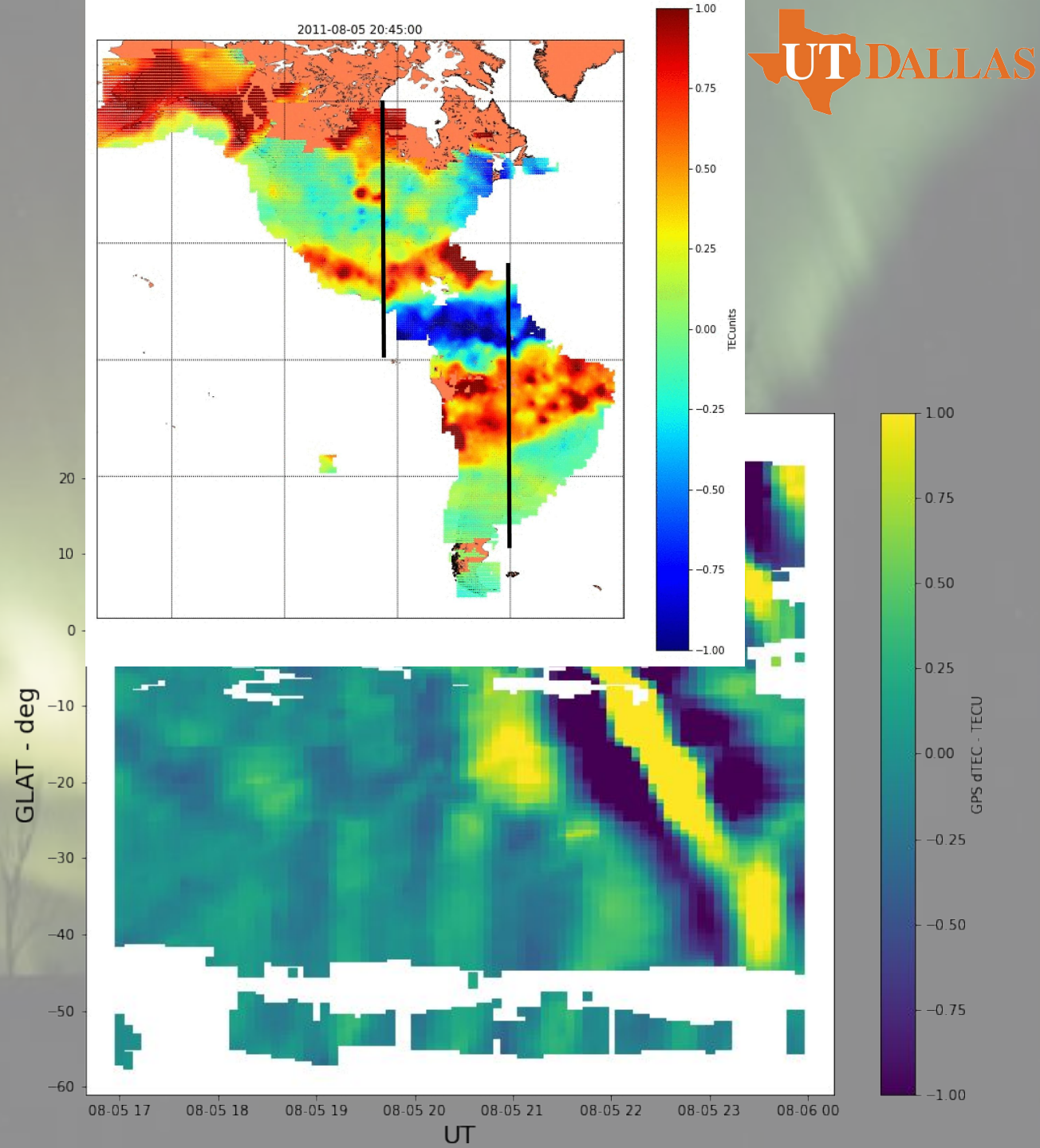
- Begin about 20:00 UT
- Hemispherically asymmetric

2011-08-05 Pass 0



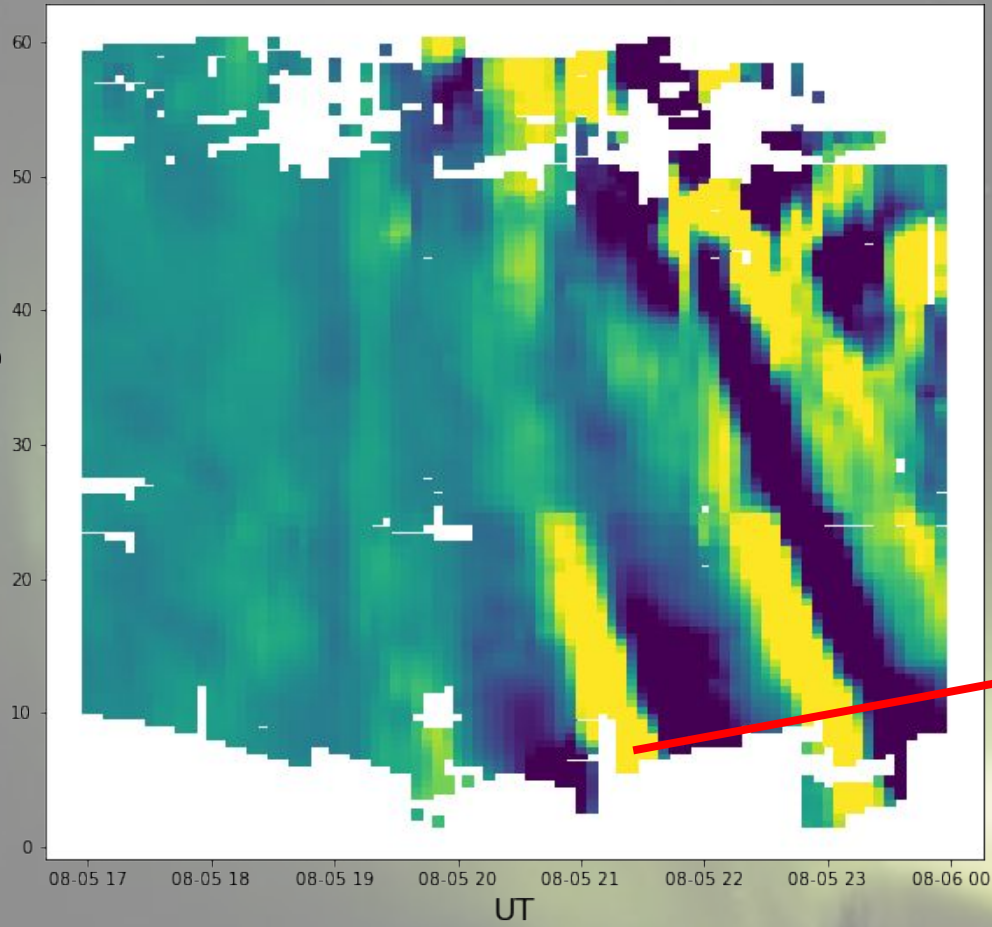
Keograms created along two longitude meridians

- One covering South America – from -60° to 20° GLAT
- One covering North America – from 5° to 60° GLAT



2011-08-05 Pass 0

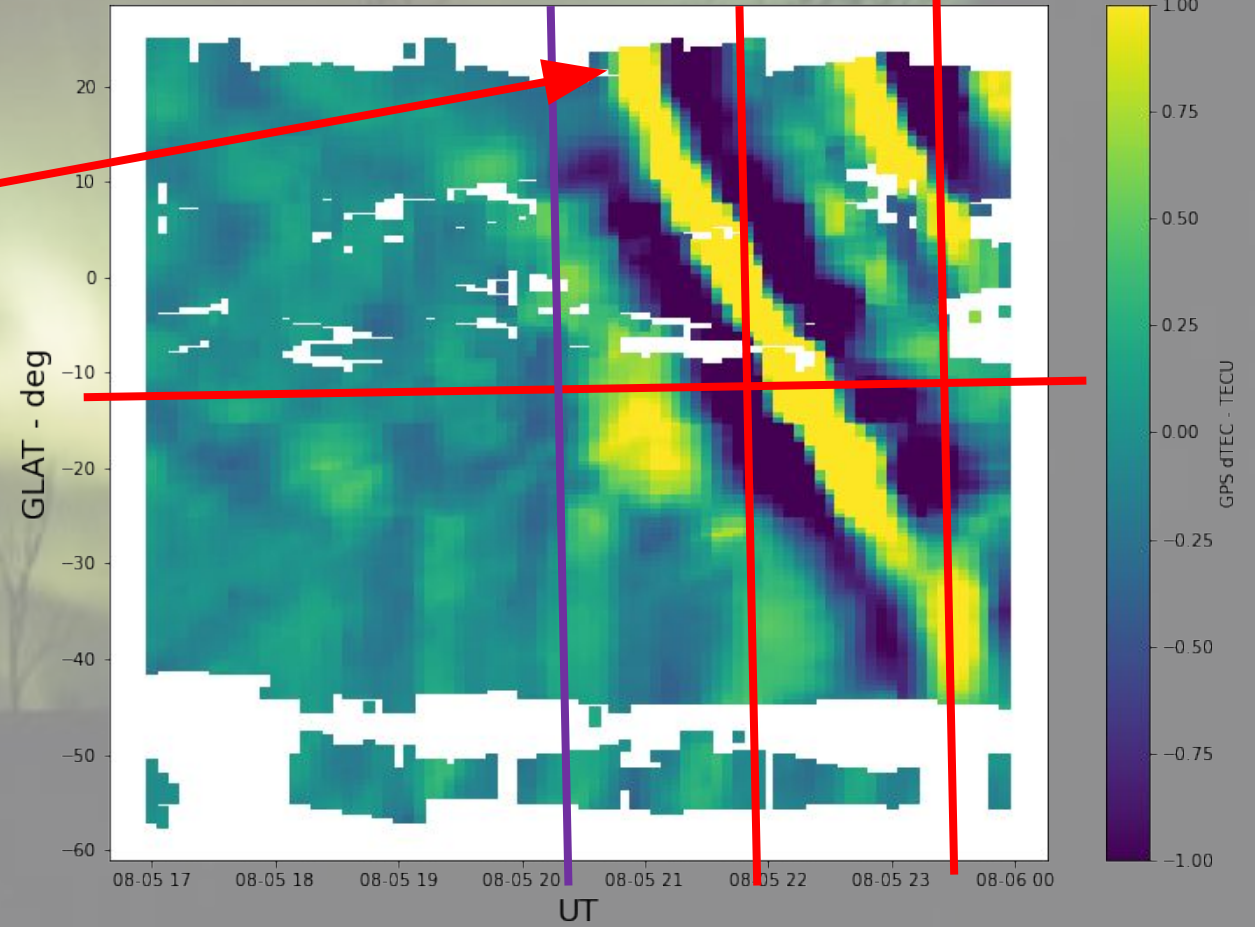
GLAT - deg



GPS dTEC - TECU

Intersection of vertical and horizontal red lines indicate where bubbles are observed by C/NOFS – near peak of positive ionospheric storm phase

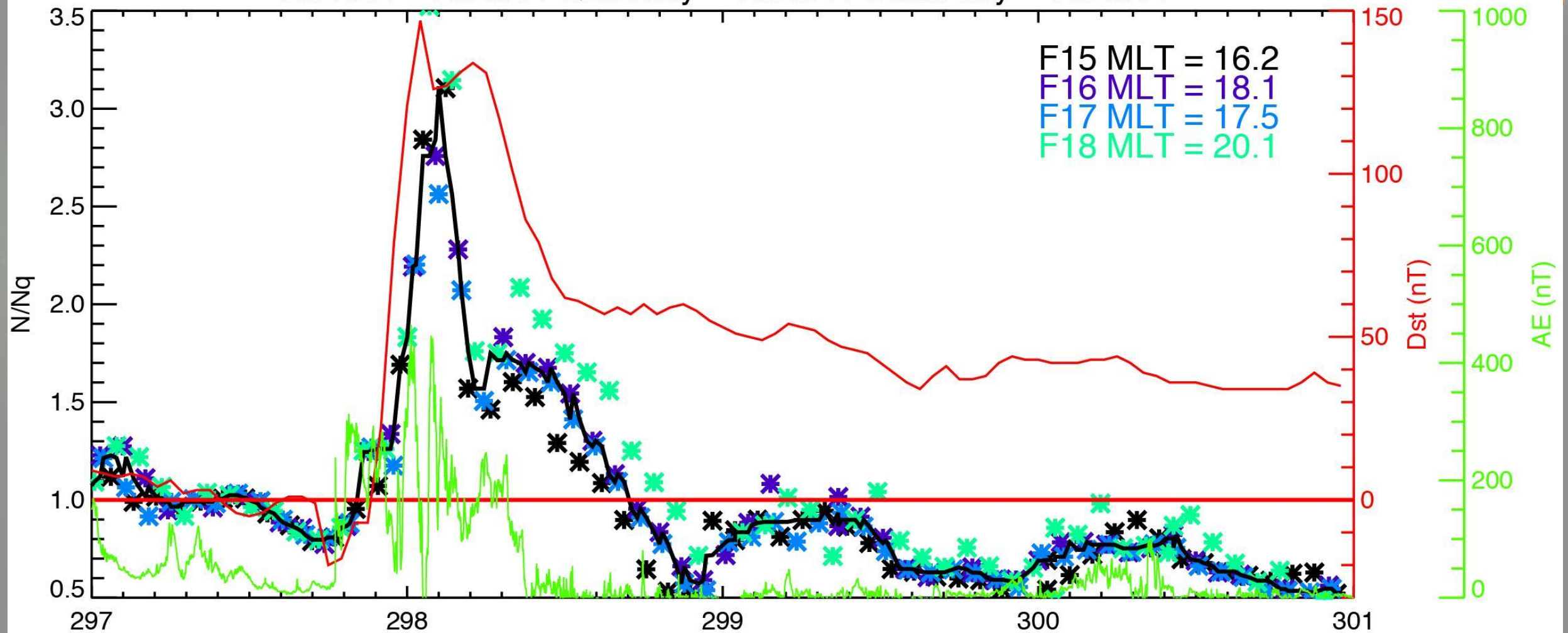
2011-08-05 Pass 1



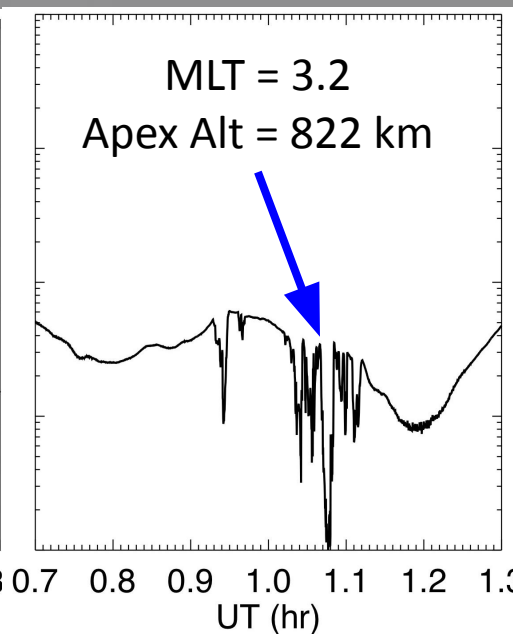
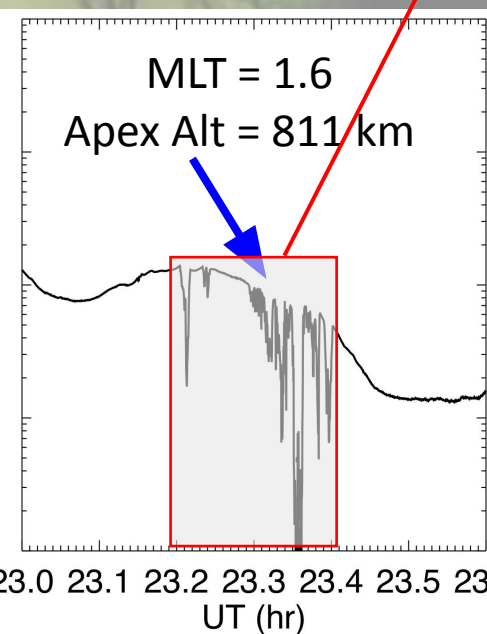
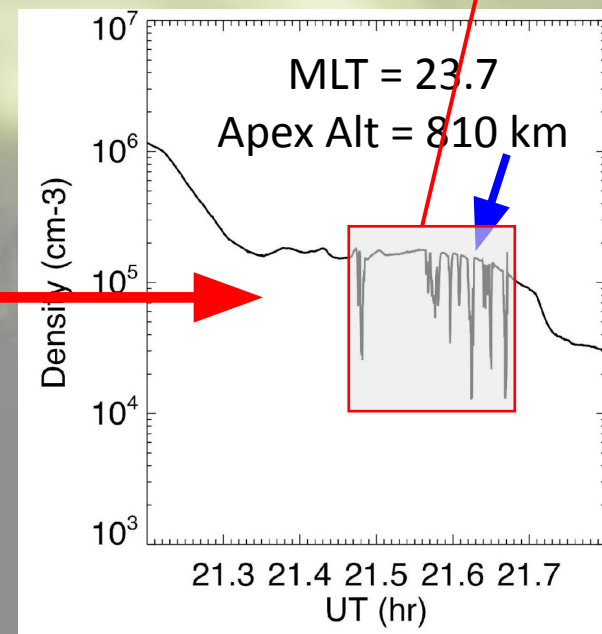
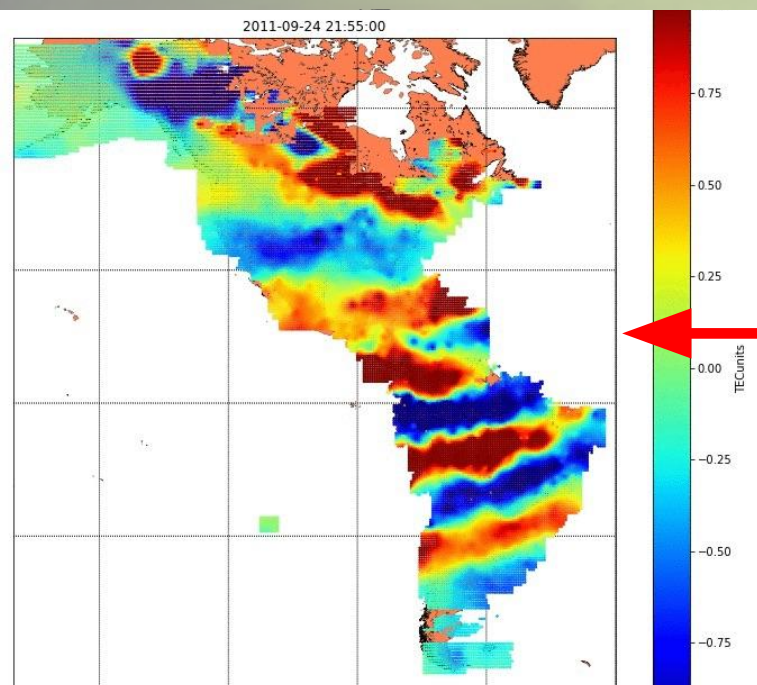
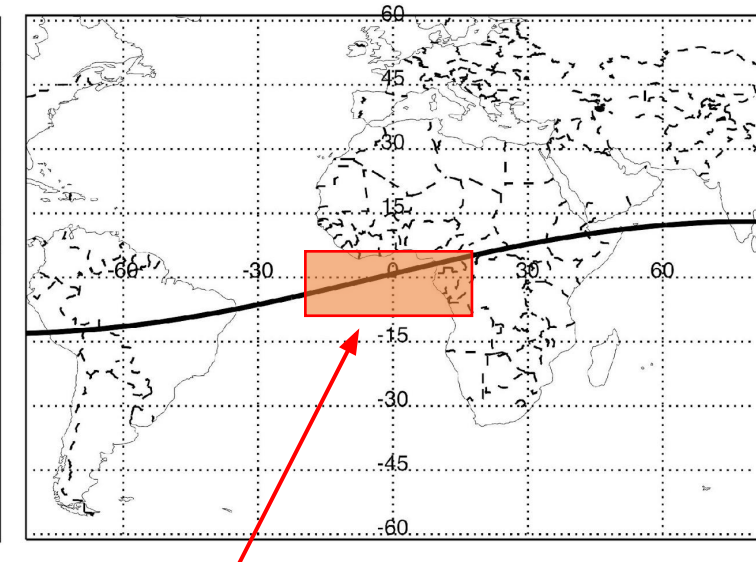
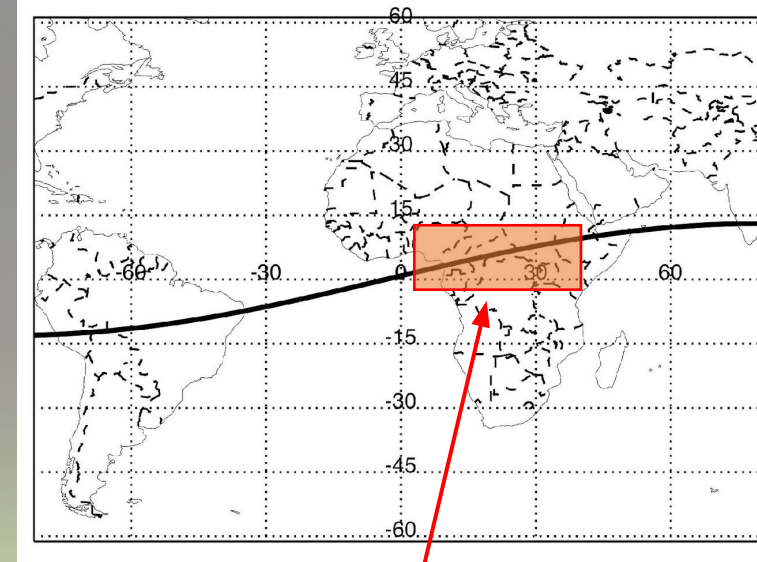
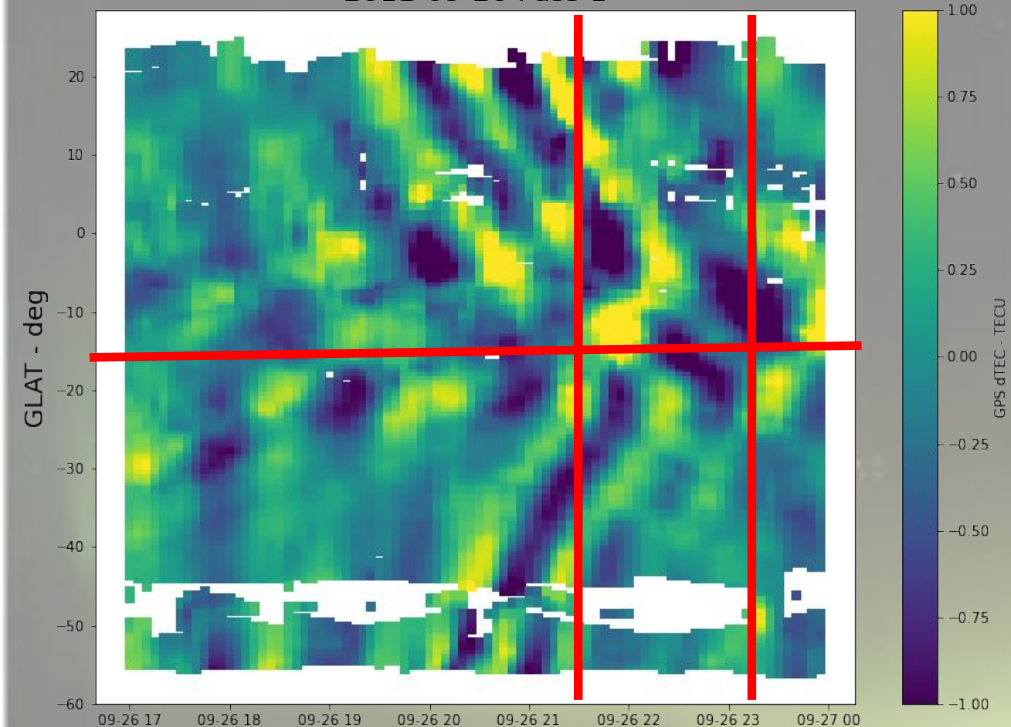
Continuation of LSTIDs can be seen from northern hemisphere to southern hemisphere in figures

September 26, 2011 Storm

10/24/11 - 10/28/11 Quiet day = 10/23/11 Storm day = 10/25/11



2011-09-26 Pass 1



- DMSP measurements in the midlatitude topside ionosphere provide storm phase timing
 - Dst and variations in topside storm enhanced densities are extremely well correlated, especially in the afternoon
 - Even small variations in Dst show response
- Database of bubbles during C/NOFS lifetime created
 - Shows delay in bubble appearance with altitude
 - Consistent with typical vertical drifts of ~ 100 m/s associated with bubbles
 - Bubbles not observed at high altitudes until had time to reach them
- May 5, 2011 Storm
 - Bubbles seen to begin as LSTIDs reach equatorial region
 - Large hemispherically asymmetric LSTID launched from northern auroral zone
 - Vertical flows observed as bubbles form
 - Spate of bubble formation during positive phase
- September 26, 2011 Storm
 - Bubbles again seen when LSTIDs reach equatorial region
 - Brief spate of bubble formation
 - Same bubbles clearly observed on subsequent orbits – no apparent new bubbles