V&V Efforts of Auroral Precipitation Models: Preliminary Results

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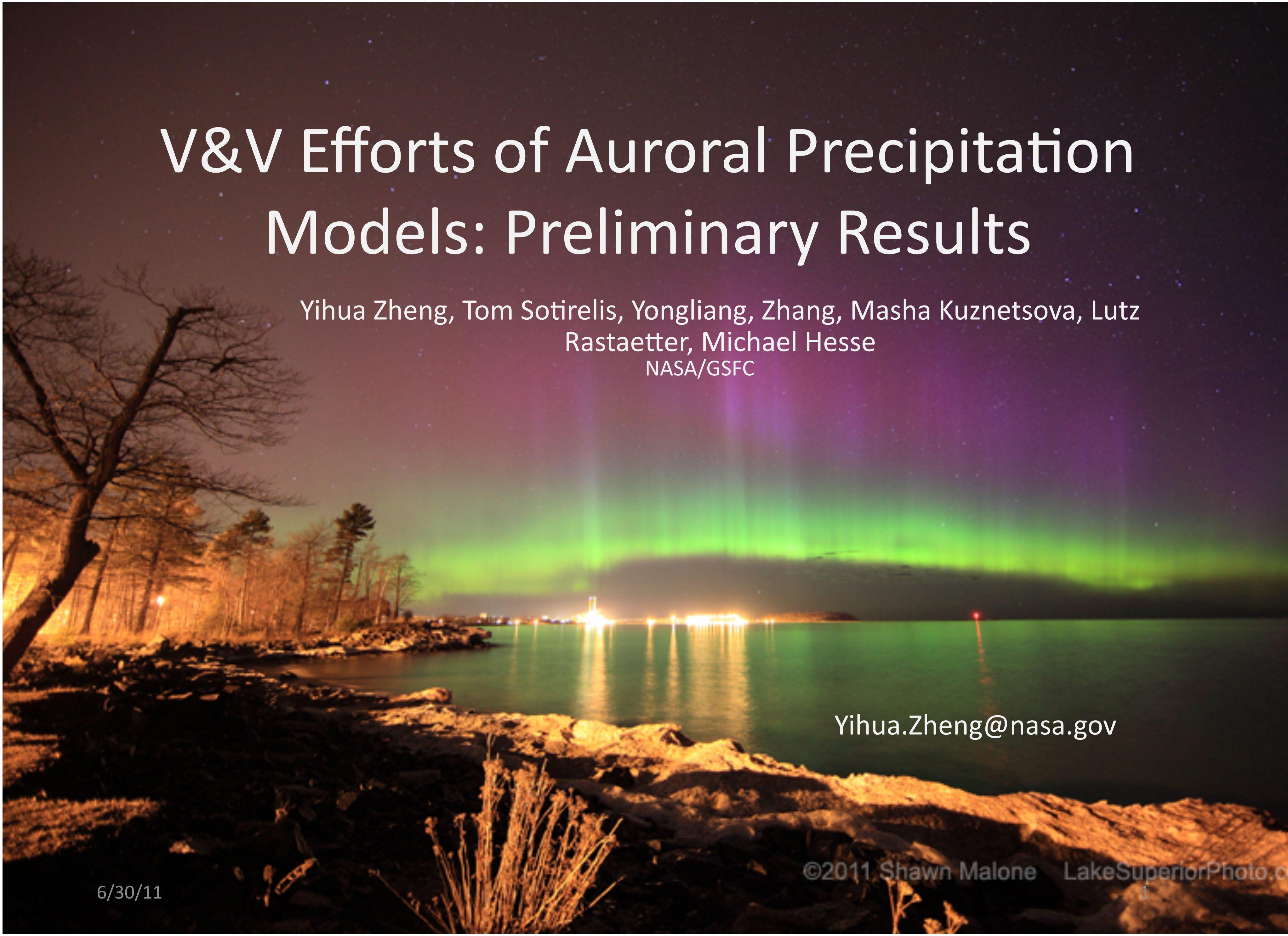


Motivation

- Auroral precipitation models have been valuable both in terms of space weather applications and space science research.
  - ionospheric conductance
  - Field-aligned currents (FACs)
  - Poynting flux – ion outflow
  - Joule Heating
- Yet very limited testing has been performed regarding model performance.
- A variety of auroral models are available, including empirical models that are parameterized by geomagnetic indices or upstream solar wind conditions, nowcasting models that are based on satellite observations, or those derived from physics-based, coupled global models.

Challenges

- What physical quantity/quantities to choose
- How to define the physical quantify/quantities from model and data
- Which data sets to use

Validation already been done

Newell, P. T., T. Sotirelis, K. Liou, A. R. Lee, S. Wing, J. Green, and R. Redmon (2010), Predictive ability of four auroral precipitation models as evaluated using Polar UVI global images, Space Weather, 8, S12004, doi: 10.1029/2010SW000604

Instantaneous

1. Brautigam IMF model (r=0.68)
2. Evans nowcast model (r=0.70)
3. Hardy Kp model (r=0.72)
4. Ovation Prime (r=0.75)

Hourly averages

1. Brautigam IMF model (r=0.69)
2. Hardy Kp model (r=0.74)
3. Ovation Prime (r=0.76)
4. Evans nowcast model (r=0.77)

Physical parameter: Precipitating power

Using Polar/UVI
during 1996 -1997

Validation Methodology

Physical quantities: equatorward boundary

Poleward boundary

Define the boundary: not trivial

Method 1: a threshold in flux (50 eV - 20 keV) as in Hardy model

Method 2: Newell et al. approach, where different identified regions have physical meanings

Method 3: Remond et al approach, constant value in flux (sub energy range of DMSP: 1.39 keV -30 keV) as a threshold

http://ccmc.gsfc.nasa.gov/RoR_WWW/presentations/boundary_options.pdf

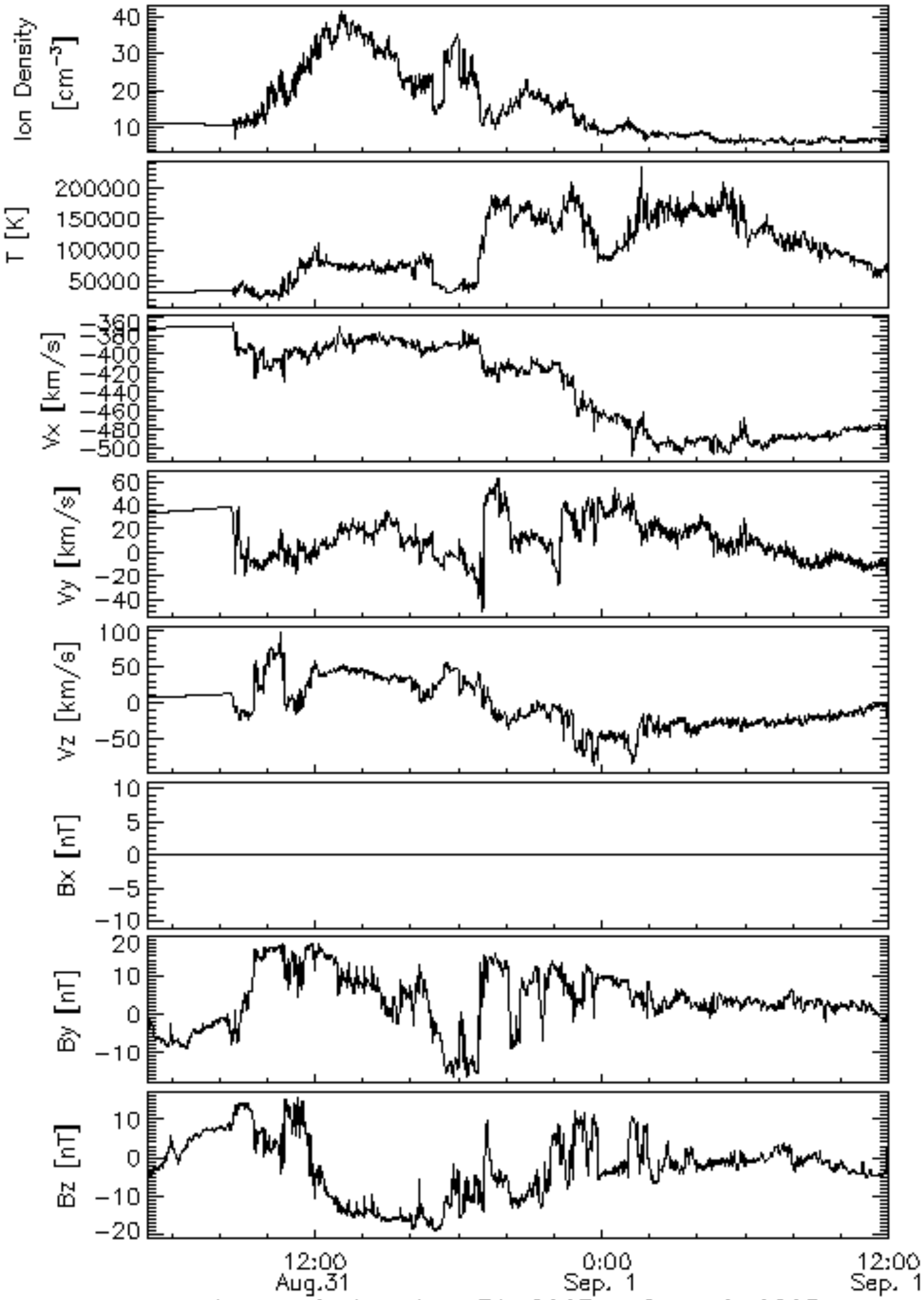
Boundaries from DMSP particle flux

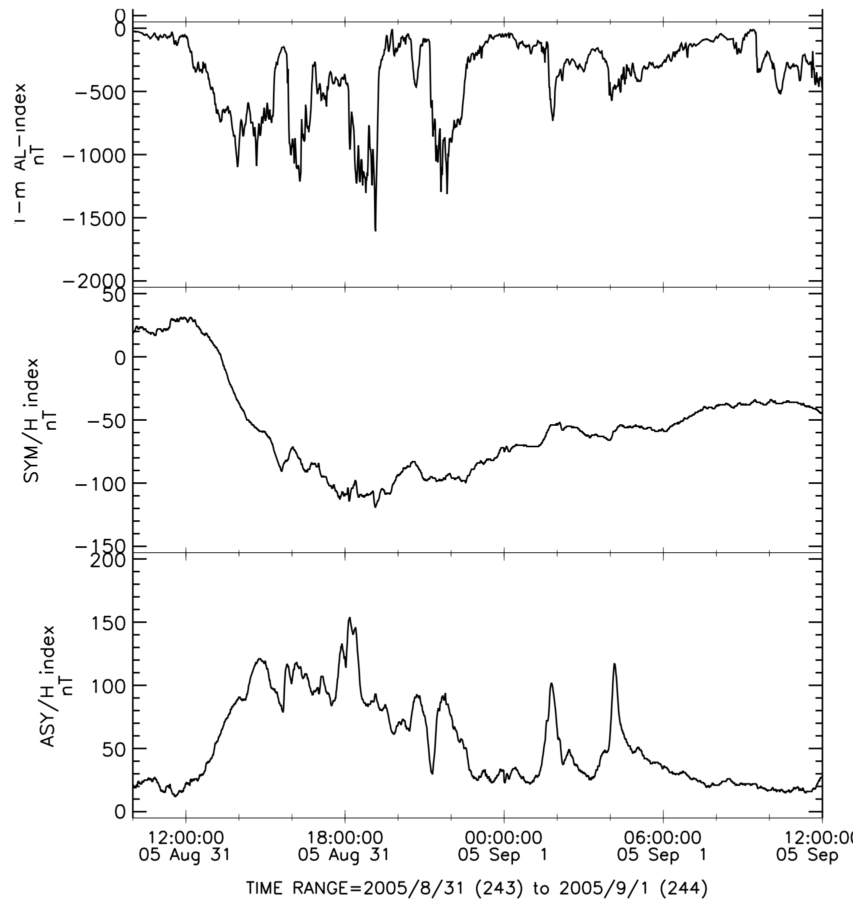
- For the dayside: The equatorward boundary is the equatorward edge of identified closed regions, The poleward boundary is the transition between closed and open regions. The dayside analysis consists of region identifications (CPS, BPS, void, cusp, mantle, polar rain, LLBL, etc.) which are then parsed to look for boundaries.
- For the nightside: Equatorward boundary is the equaotrward-most of b1e, b2i, b2e Poleward boundary is b6

Newell et al., 1991a, b; Newell et al.,1996.

Event 4: August 31, 2005 (DOY: 243) 10:00 UT - September 1, 12:00 UT

Dst_min: ~ -120 nT





Models/data

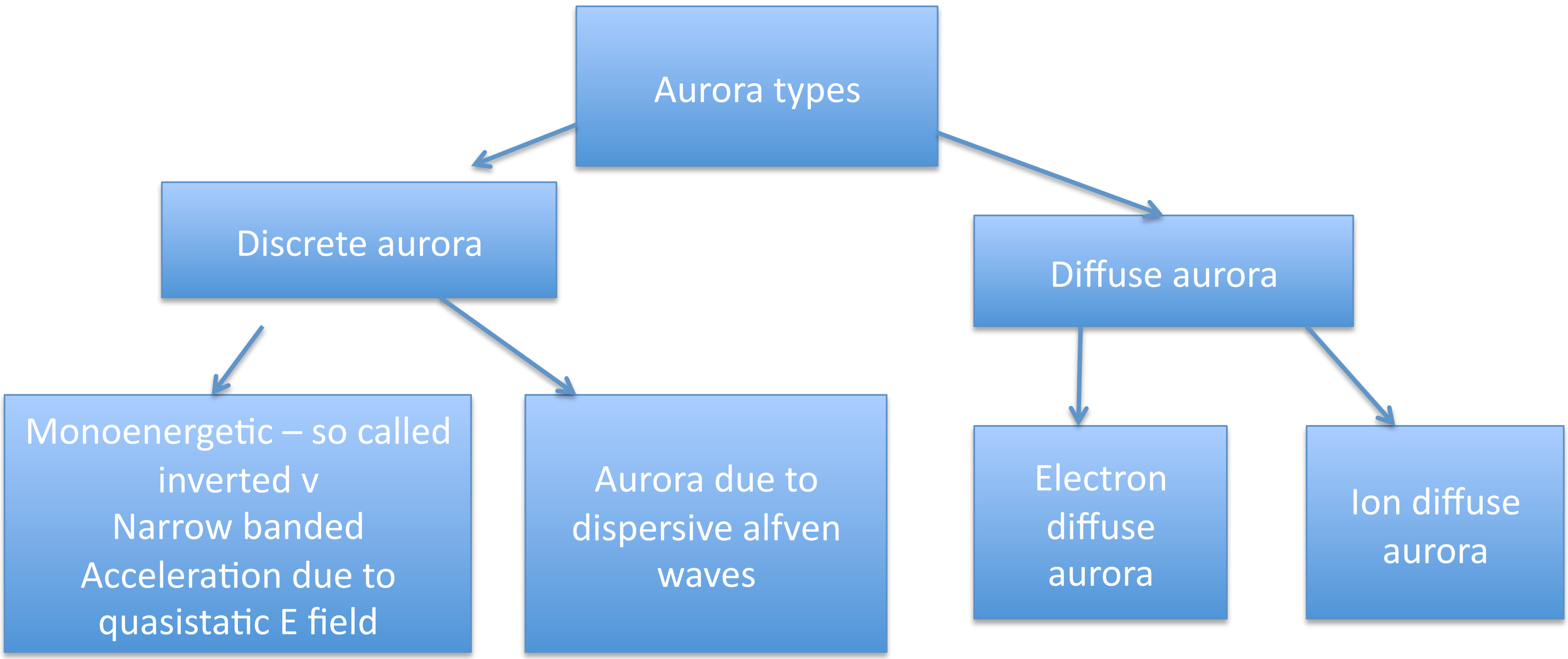
For obtaining the equatorward boundary

- DMSP particle flux
- DMSP SSUSI: threshold 0.4 ergs/cm^2/s
- Ovation Prime: threshold 0.4 ergs/cm^2/s
- SWMF+Fok RC
- Weimer

1erg=10.^(-7) joule
1 eV=1.6*10.^(-19) joule
Threshold 0.4 ergs/cm^2/s =2.5*10^11 eV/cm^2/s

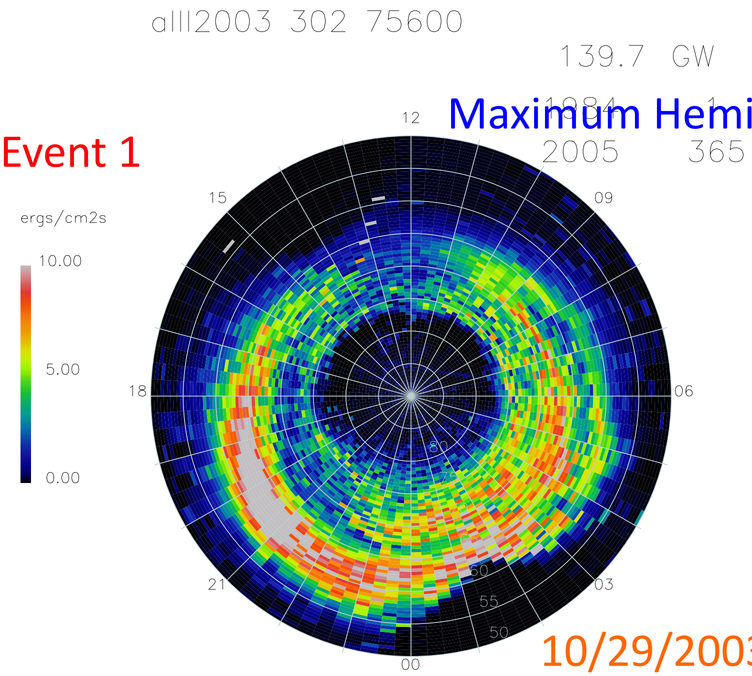
Ovation Prime

- Parameterized by solar wind coupling functions, not just Kp
- Four types of aurora, including seasonal dependence

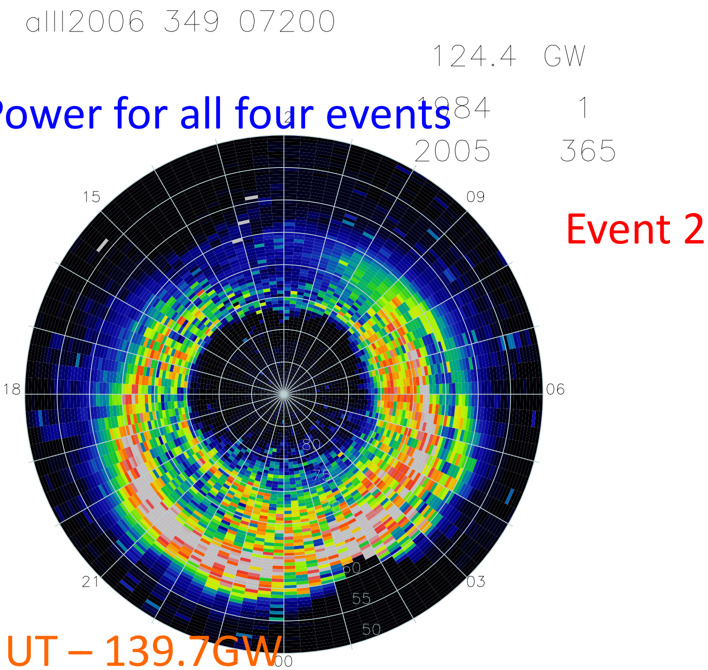


Maximum Hemispheric Power for all four events

Event 1

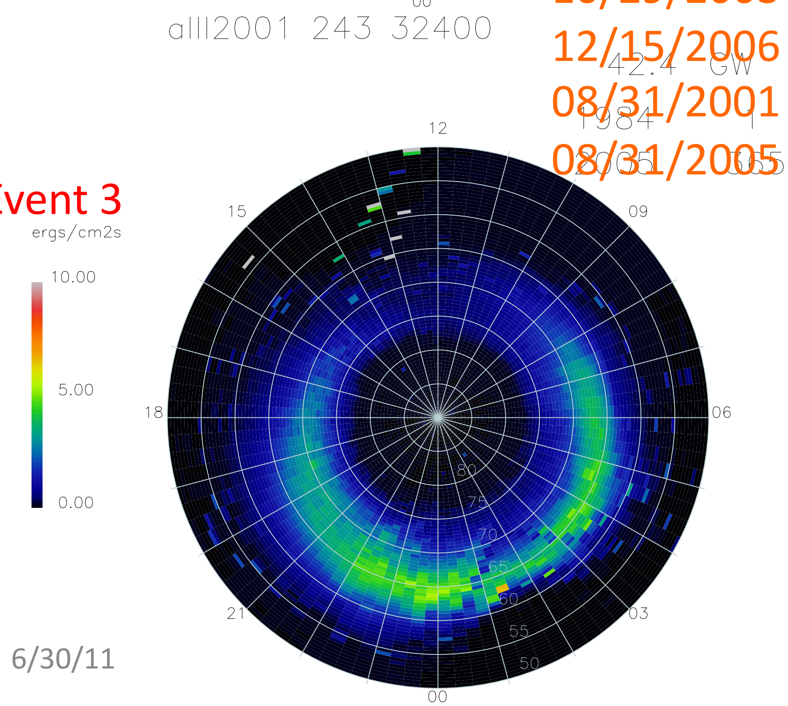


Event 2

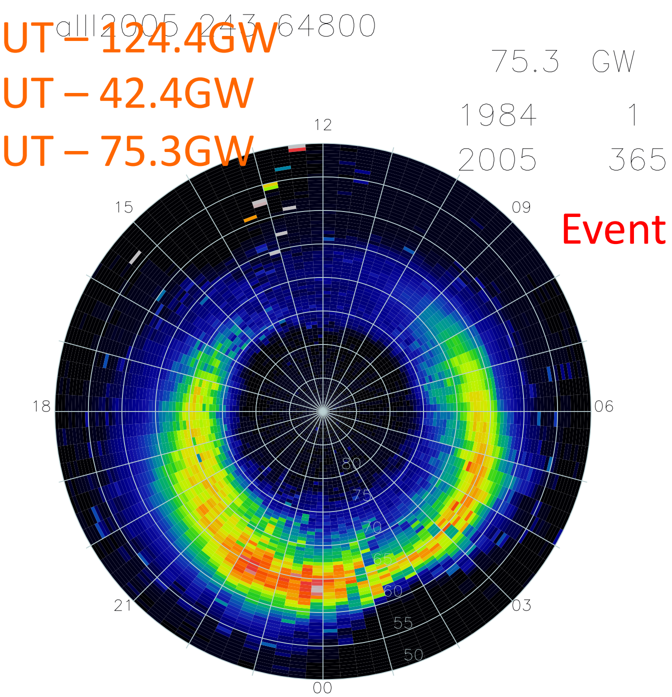


10/29/2003 @2100 UT – 139.7GW
12/15/2006 @0200 UT – 124.4GW
08/31/2001 @0900 UT – 42.4GW
08/31/2005 @1800 UT – 75.3GW

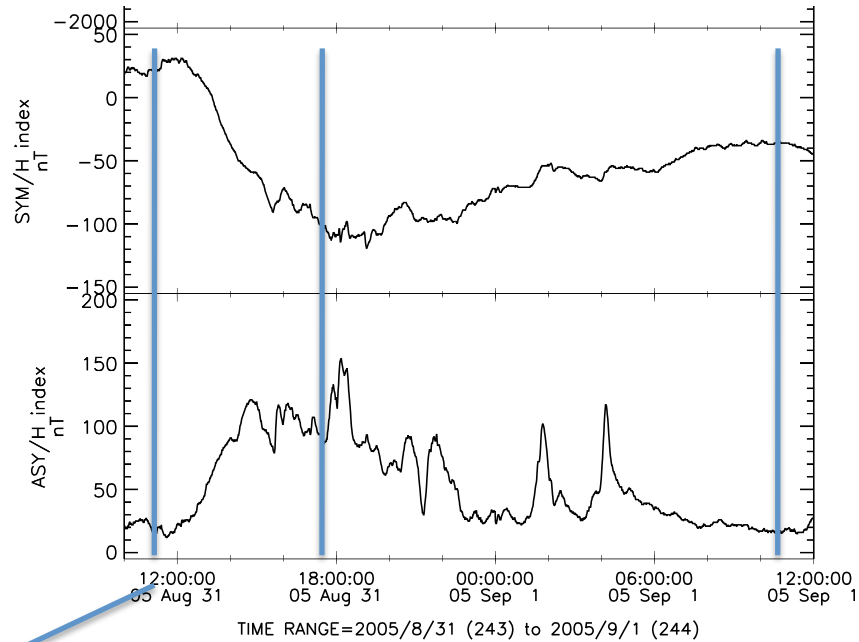
Event 3

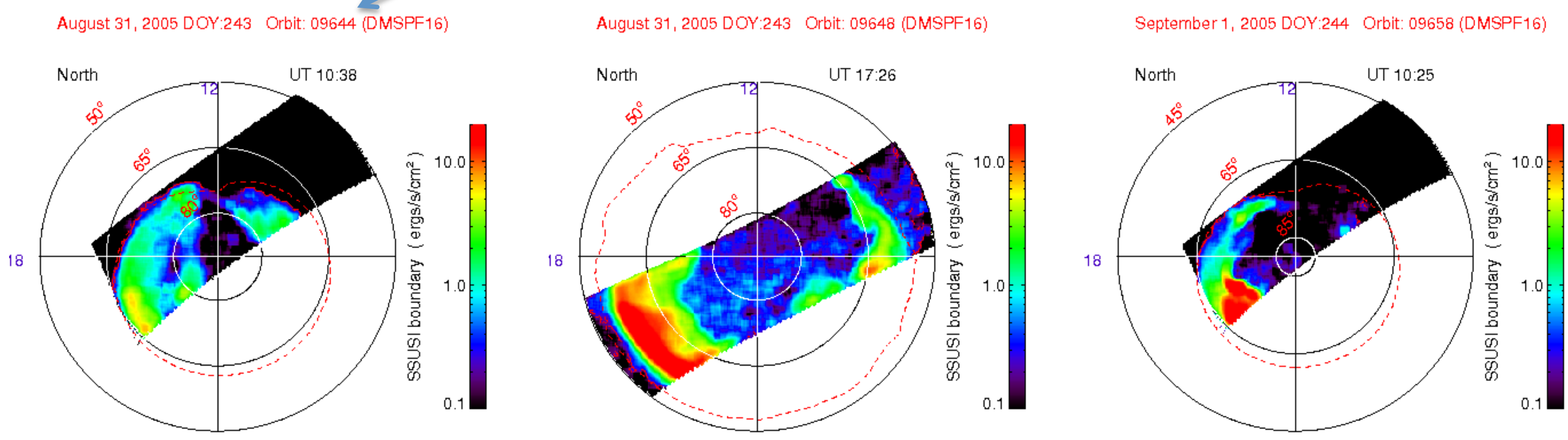


Event 4

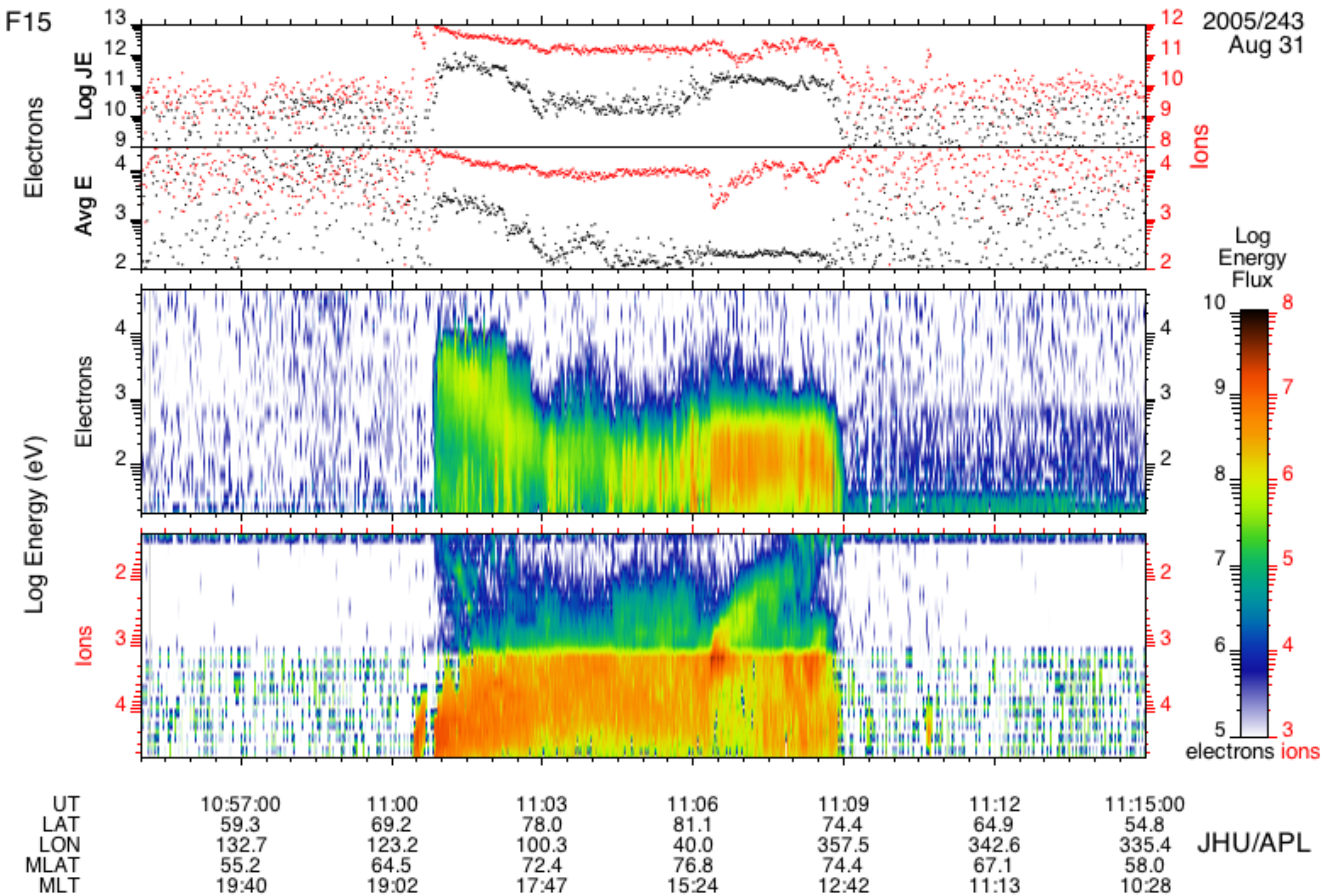


DMSP/SSUSI



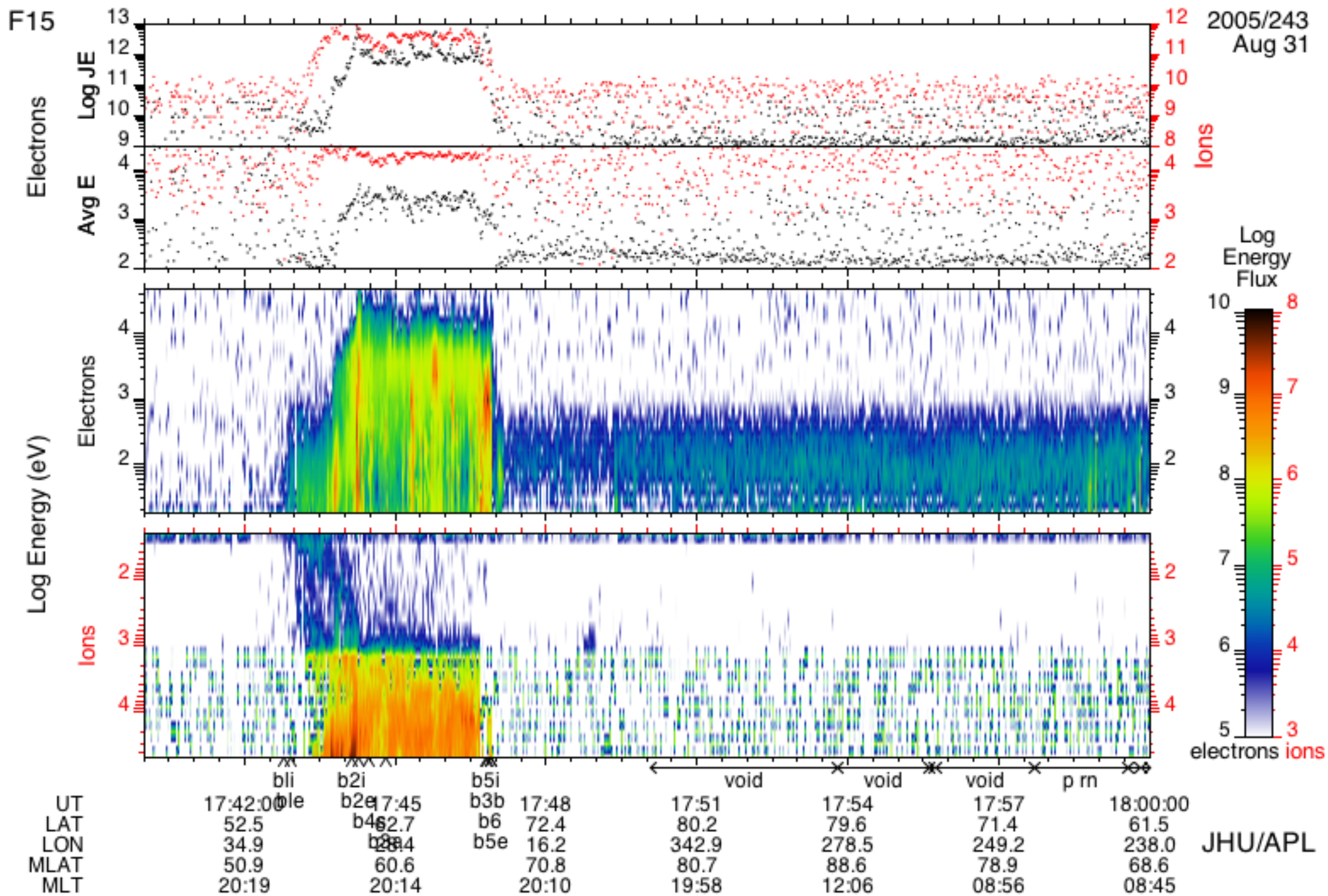


427.8nm and 630nm

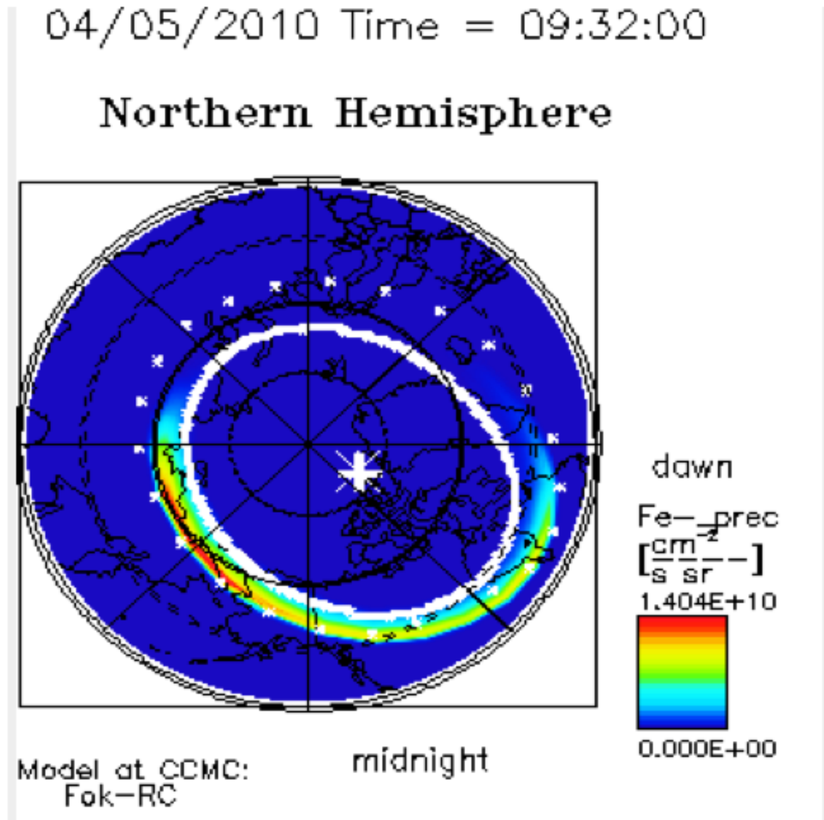


F15
2005/243
Aug 31
Electrons
Log JE
Avg E
Ions
Log Energy (eV)
Electrons
Ions
Log
Energy
Flux
electrons ions
UT 10:57:00 11:00 11:03 11:06 11:09 11:12 11:15:00
LAT 59.3 69.2 78.0 81.1 74.4 64.9 54.8
LON 132.7 123.2 100.3 40.0 357.5 342.6 335.4
MLAT 55.2 64.5 72.4 76.8 74.4 67.1 58.0
MLT 19:40 19:02 17:47 15:24 12:42 11:13 10:28
JHU/APL

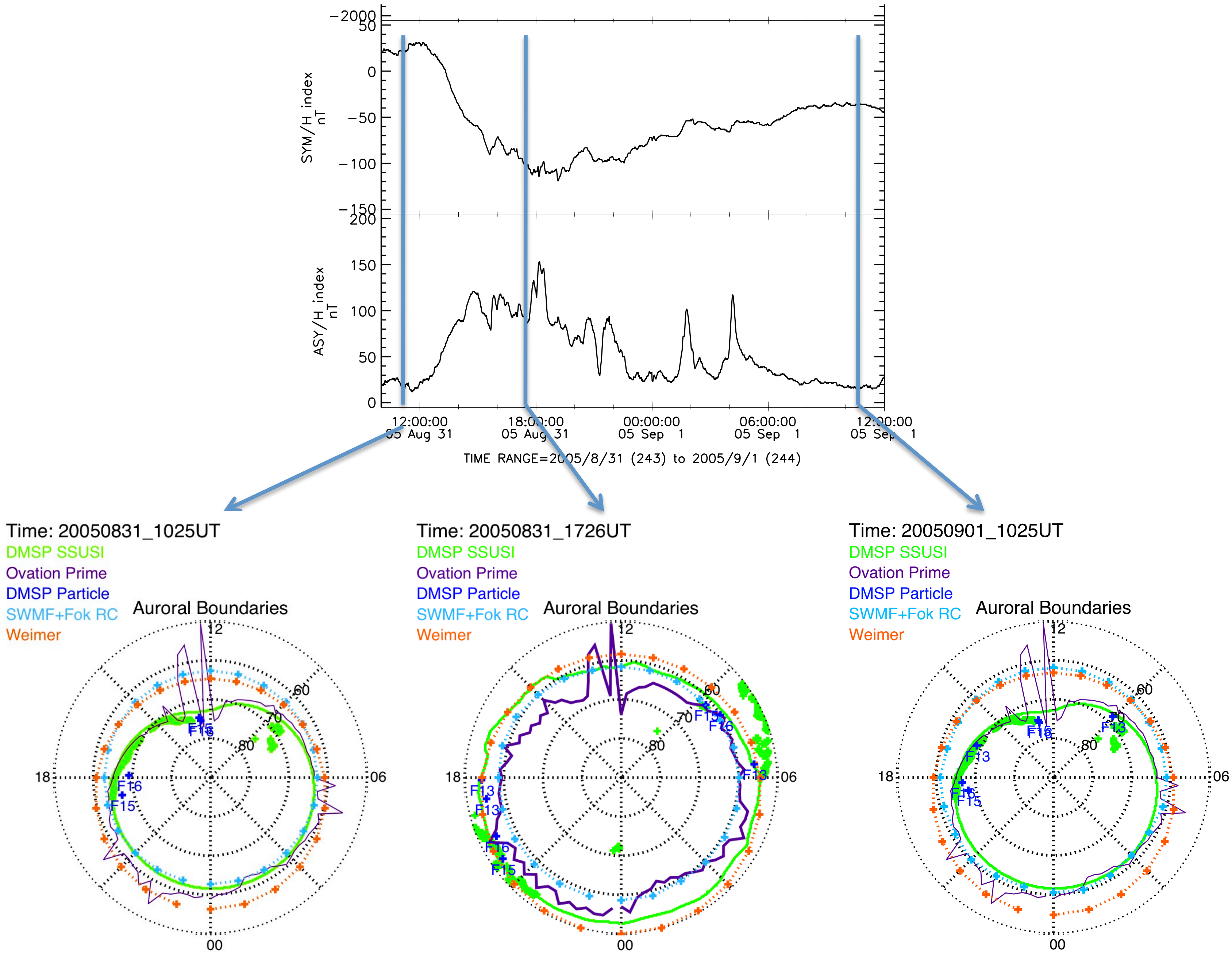
DMSP particle flux

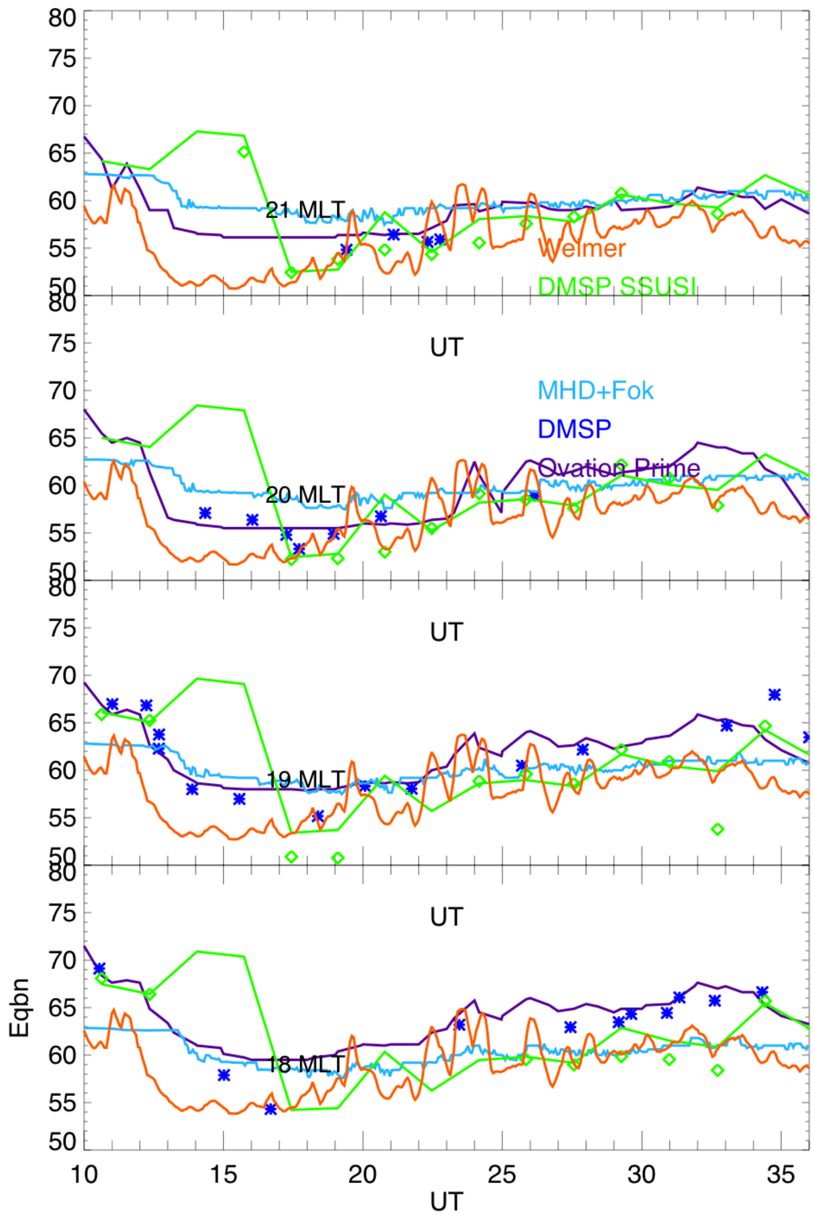


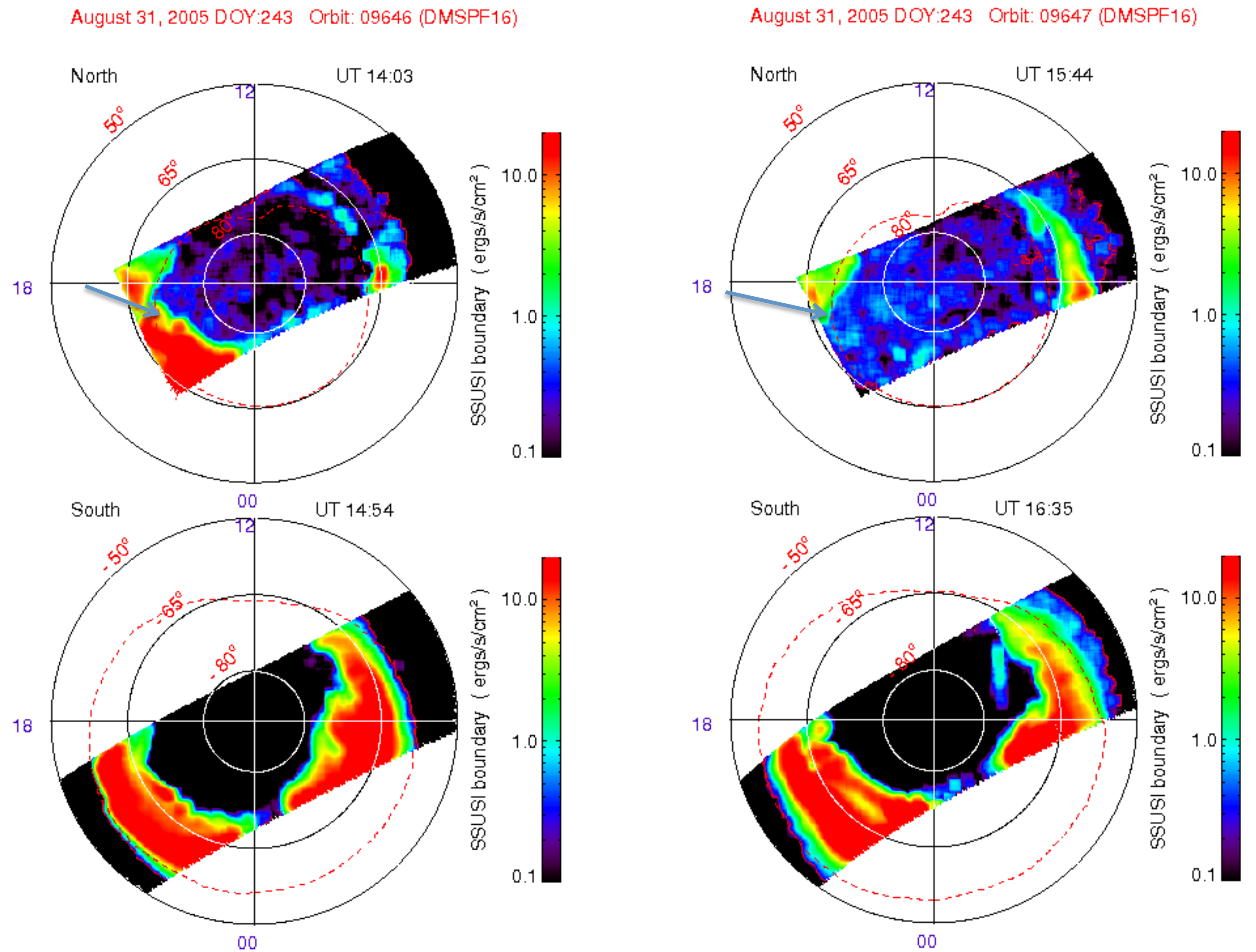
Model outputs from global MHD model + ring current
Available in different combos



Initial Results


SYM/H_index nT
ASY/H_index nT
12:00:00 05 Aug 31
18:00:00 05 Aug 31
00:00:00 05 Sep 1
06:00:00 05 Sep 1
12:00:00 05 Sep 1
TIME RANGE=2005/8/31 (243) to 2005/9/1 (244)
Time: 20050831_1025UT
DMSP SSUSI
Ovation Prime
DMSP Particle
SWMF+Fok RC
Weimer
Auroral Boundaries
Time: 20050831_1726UT
DMSP SSUSI
Ovation Prime
DMSP Particle
SWMF+Fok RC
Weimer
Auroral Boundaries
Time: 20050901_1025UT
DMSP SSUSI
Ovation Prime
DMSP Particle
SWMF+Fok RC
Weimer
Auroral Boundaries


21 MLT
Weimer
DMSP SSUSI
UT
MHD+Fok
DMSP
Ovation Prime
20 MLT
UT
19 MLT
UT
18 MLT
Eqbn
UT



August 31, 2005 DOY:243 Orbit: 09646 (DMSPF16)
North
UT 14:03
South
UT 14:54
August 31, 2005 DOY:243 Orbit: 09647 (DMSPF16)
North
UT 15:44
South
UT 16:35
12
18
00
50°
65°
80°
-50°
-65°
-80°
10.0
1.0
0.1
SSUSI boundary (ergs/s/cm^2)

Measure of Performance

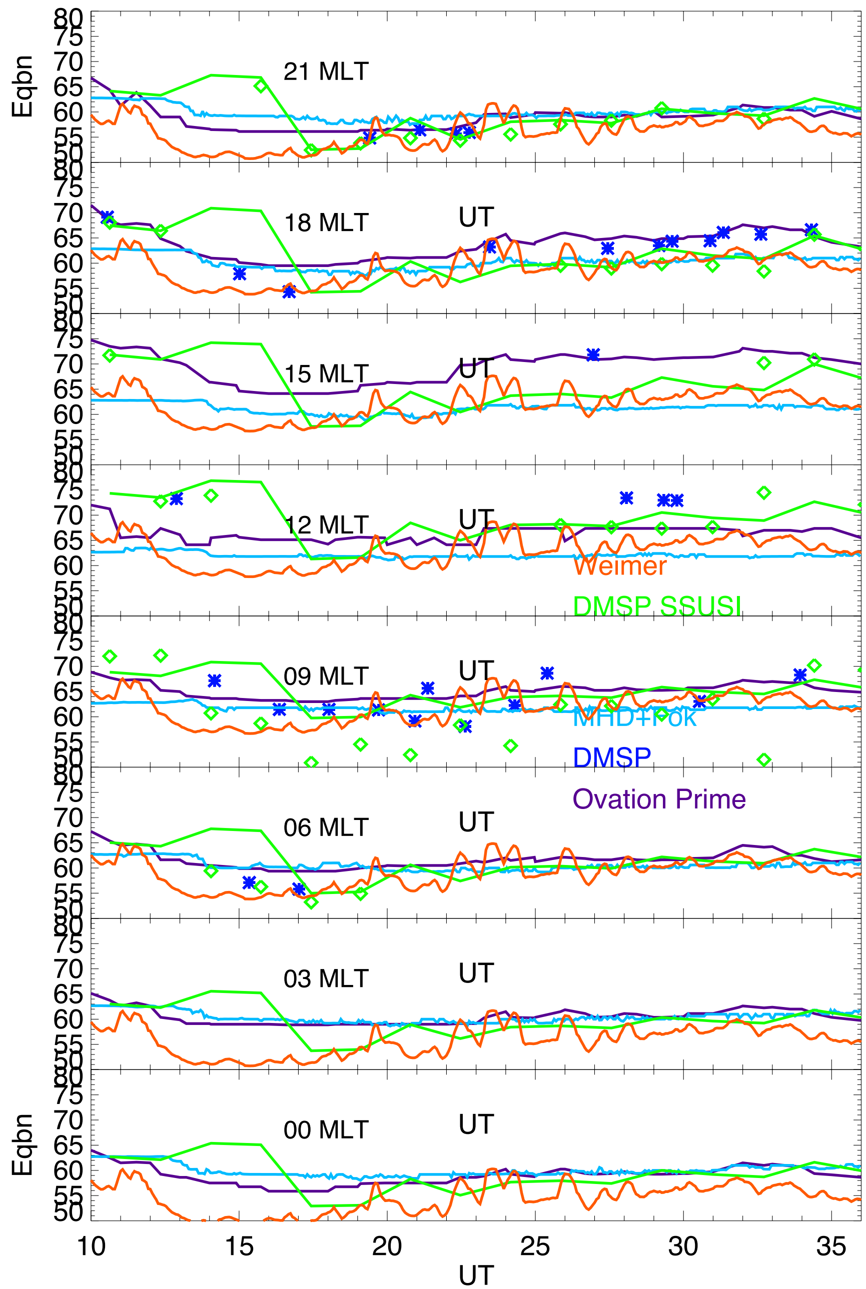
- Timeline of each local time (PE)
- Divided into different local time sectors – such as the dusk side
- Whether the deviation in all local time is uniform or not – a measure of whether the model captures the MLT feature

  correlation in MLT binned by activity level or for a specific time

- Temporal resolution

Next Steps

- Find consistent way to define the boundaries
- More events
- Report findings at space weather journal


Eqbn
21 MLT
18 MLT
15 MLT
12 MLT
09 MLT
06 MLT
03 MLT
00 MLT
UT
Weimer
DMSP SSUSI
MHD+Pok
DMSP
Ovation Prime
10
15
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UT