CCMC Workshop:

Ionosphere (TDIM) Driven by Magnetosphere (NRL-MHD)

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October 29 – November 2, 2001
Maui, Hawaii

Ionospheric Weather

Various “regions;” i.e., sun, magnetosphere, and terrestrial atmosphere, cause ionospheric weather:

- Solar EUV Variability (flares)
- Neutral Atmosphere Variability (gravity waves)
- Magnetospheric Electric Fields
- Magnetospheric Precipitation
- Magnetospheric Currents Closing in the Ionosphere
- Magnetospheric Heat Fluxes

If D-region is also being considered, then Solar X-rays and other high energy particles from various sources also contribute.

Magnetospheric electric field is the dominant F-layer high latitude driver.

Magnetosphere Model

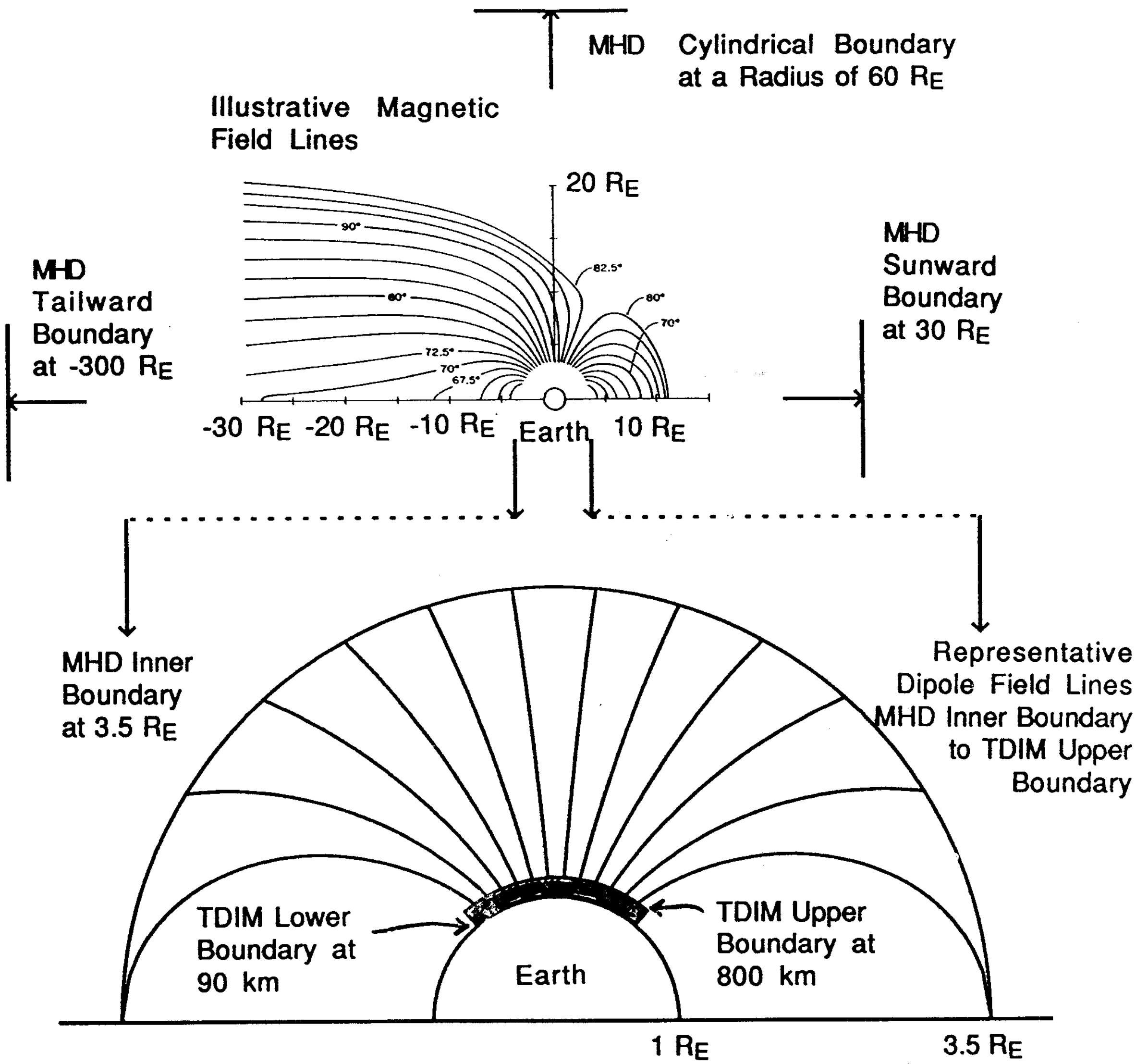
- Joel Fedders' Team, NRL
- Carried Out (published) Three Case Studies
- Key One is a Magnetic Cloud Passage (Sustained Large IMF Values)

Ionosphere Model

- Bob Schunk's Team, USU
- Interfaces the Auroral Electron Precipitation and Magnetospheric Electric Fields to Ionosphere
- Ionospheric F-Layer Weather Very Different from Climatology Driven by Statistical Electric Fields and Precipitation

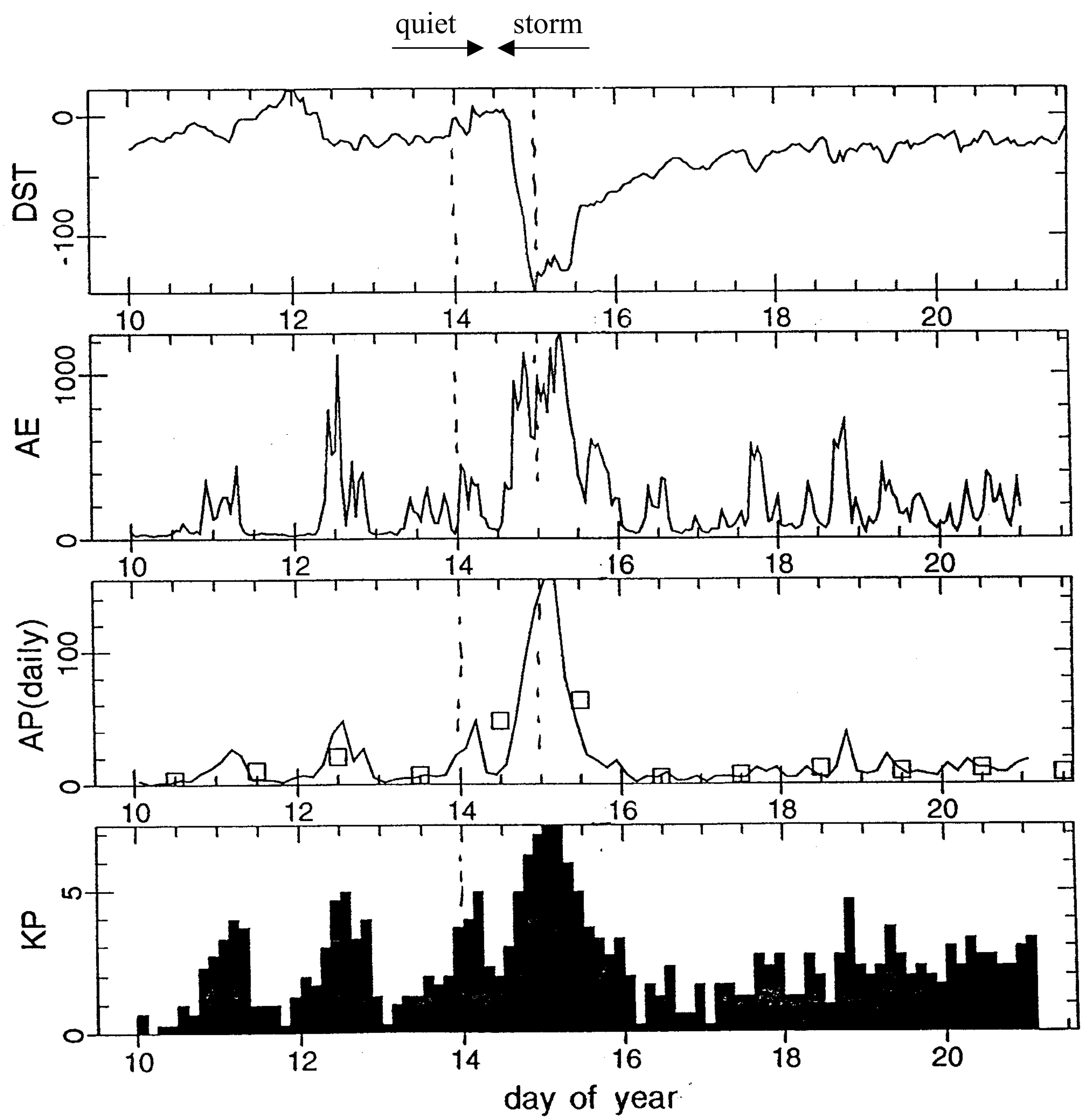
NRL MHD – TDIM "Coupling" Issues

- Grids (ionosphere is Langrangian, magnetosphere is uneven grid)
- Ionosphere-Magnetosphere GAP ($\approx 2\ R_E$ of real estate not included)
- Knight Relationship Used to Obtain Electron Precipitation, But Ionosphere Can be Very Sensitive to Low Energy (<1 keV) Precipitation and "Diffuse" Precipitation is Not Well Handled by the Knight Relationship.
- Boundary of MHD at L ~ 3.5 R_E.
- Boundary at 3.5 R_E has an Enforced Potential Solution. Mid-Latitude Penetration Electric Fields, etc., Not Handled.
- Time Step, Not an Issue.

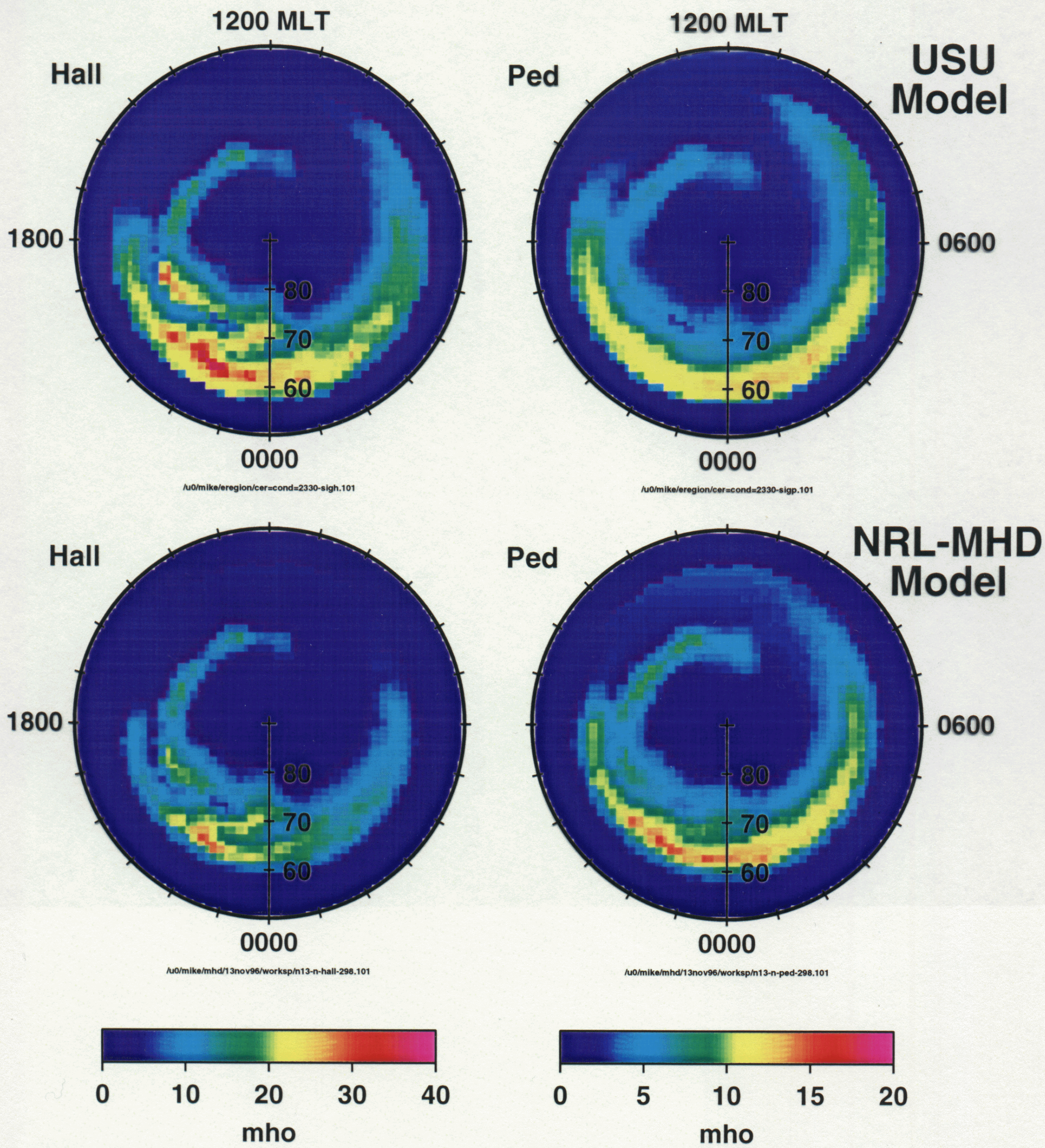


MHD and TDIM are in both hemispheres.

10-21 January 1988 Geomagnetic Indices
Magnetic Storm on 14 January 1988
– Space Weather –



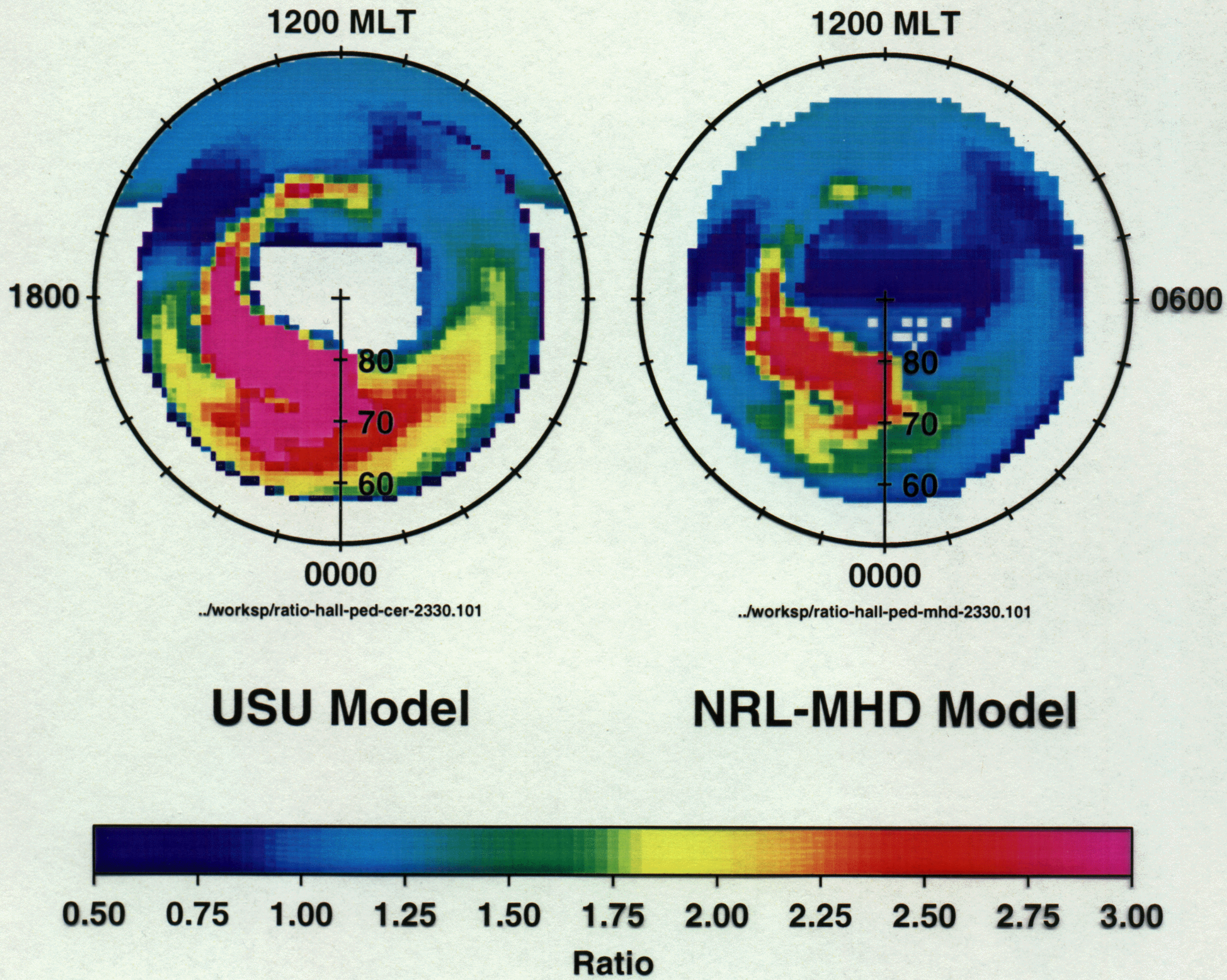
UT 2330 13 Nov 96
Hall and Pedersen Conductivities

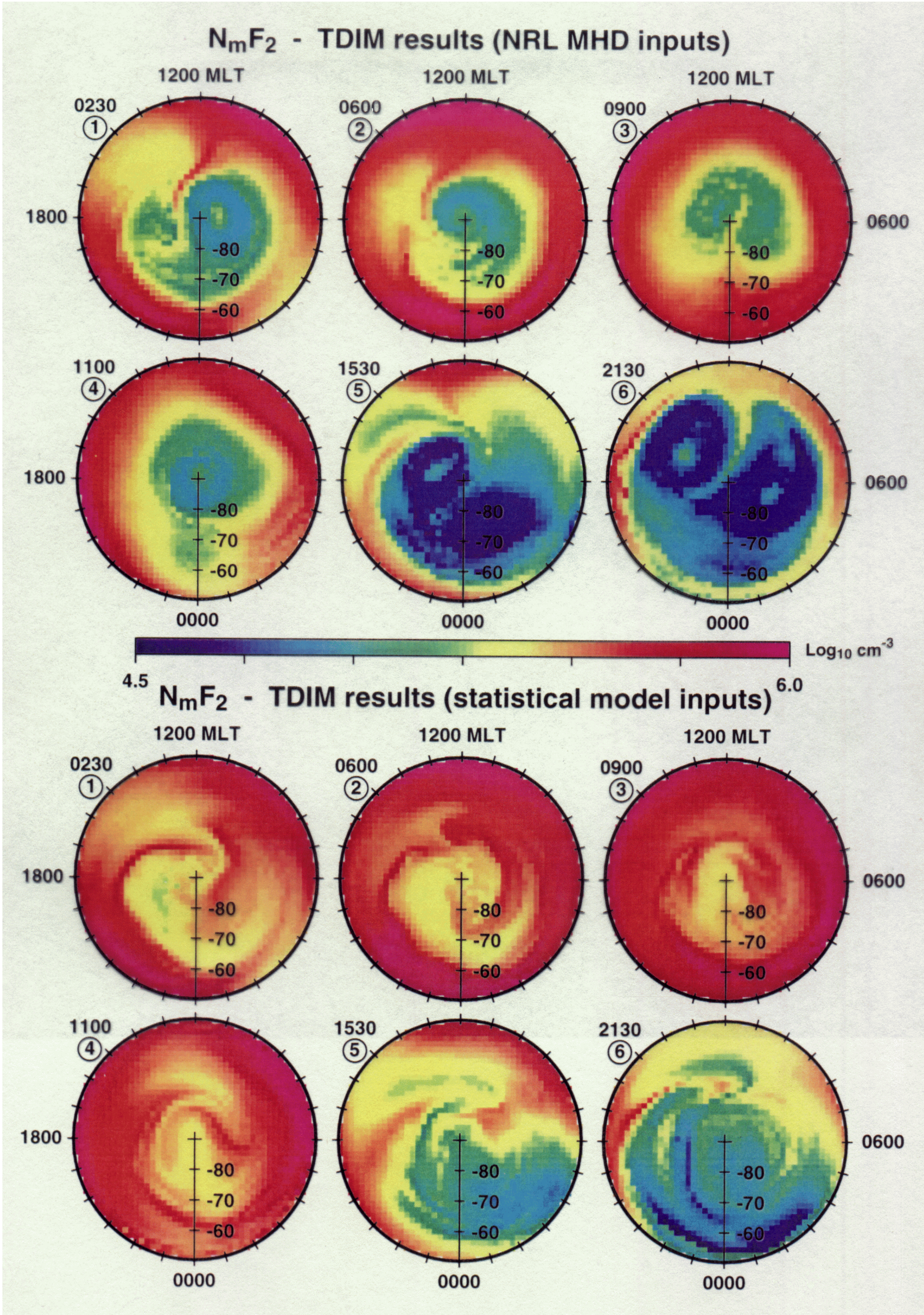


29-Nov-98 15:32:46 plot-4-conds.f

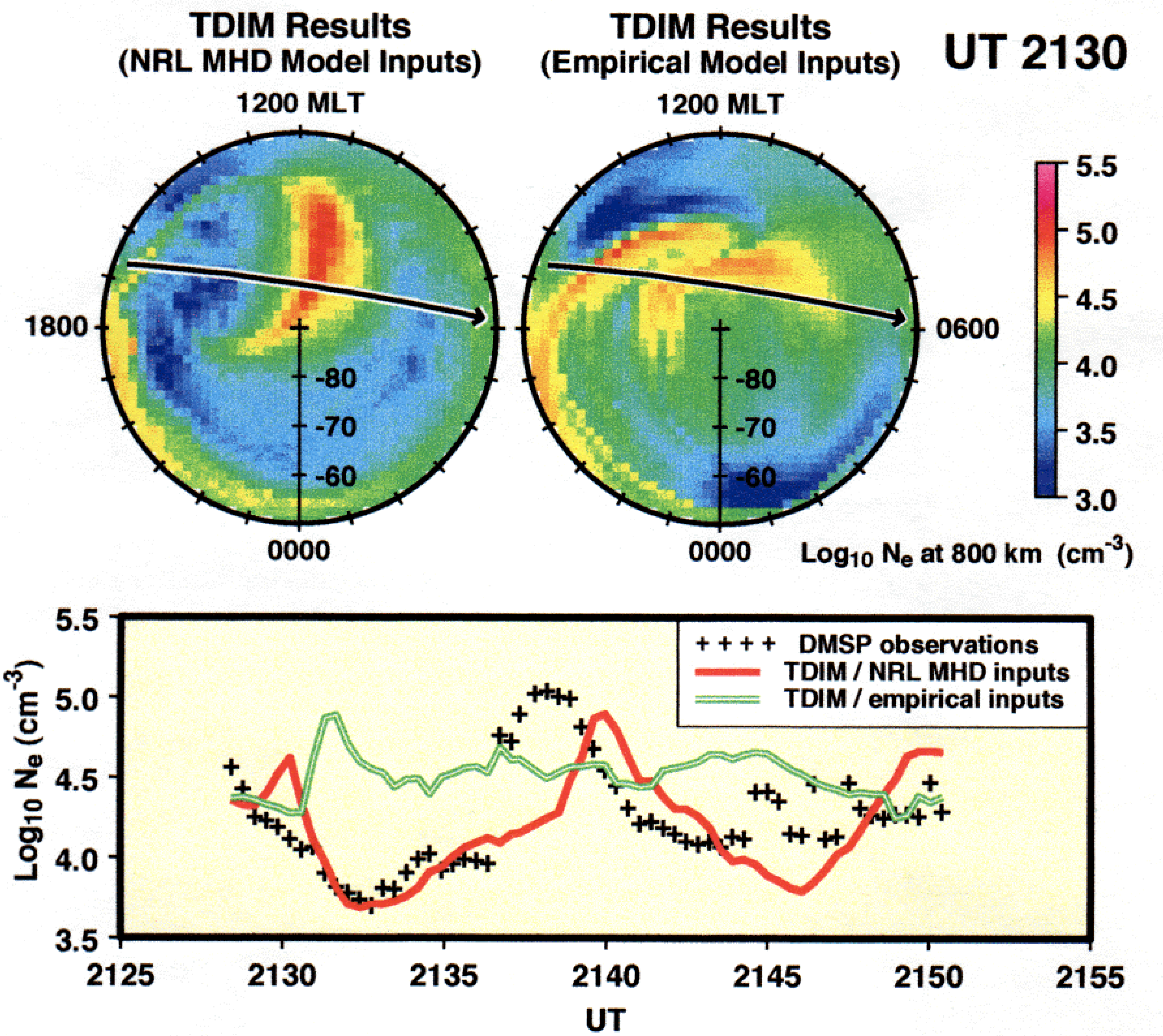
2330 UT 13 Nov 96

Ratio Hall / Pedersen

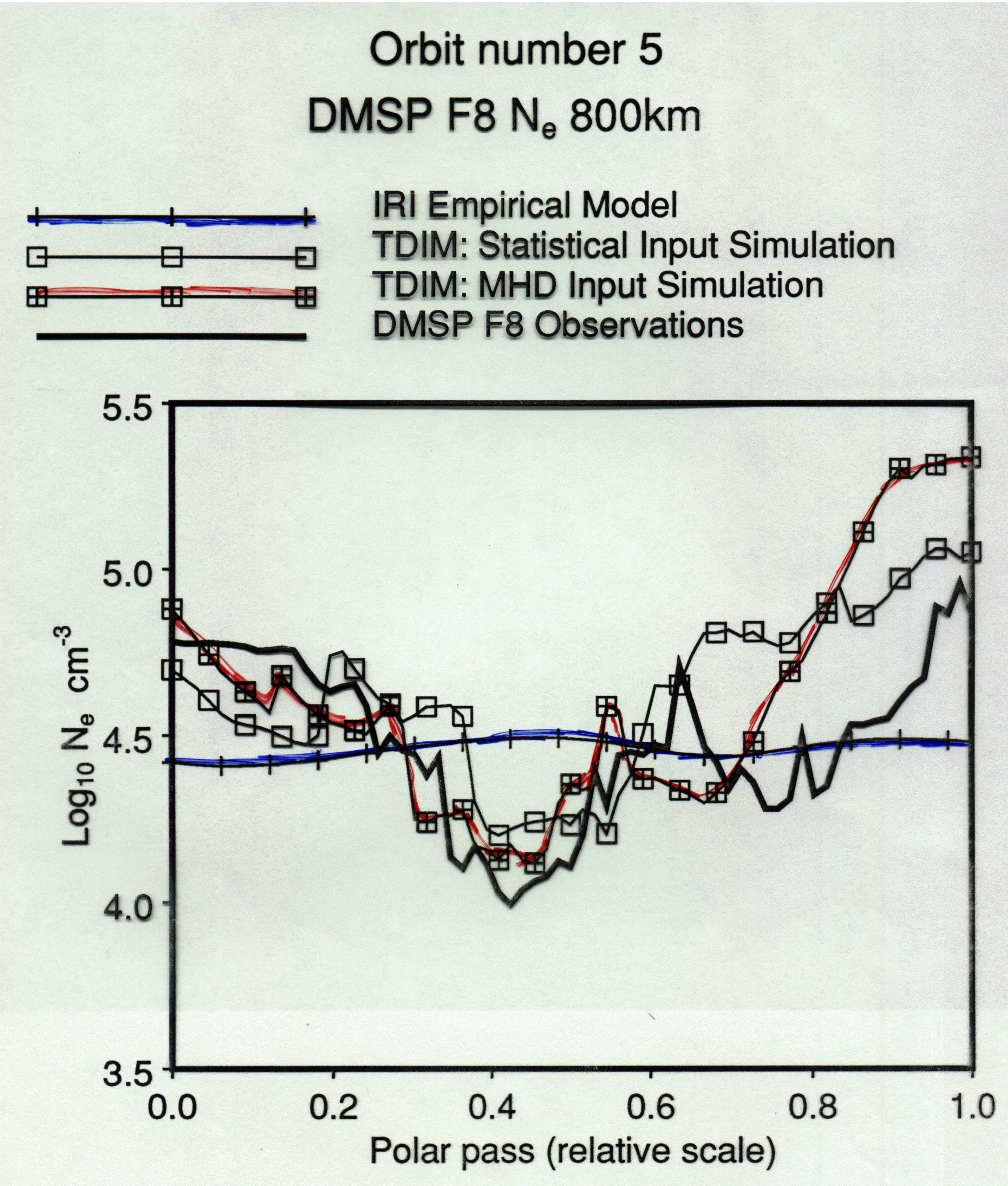




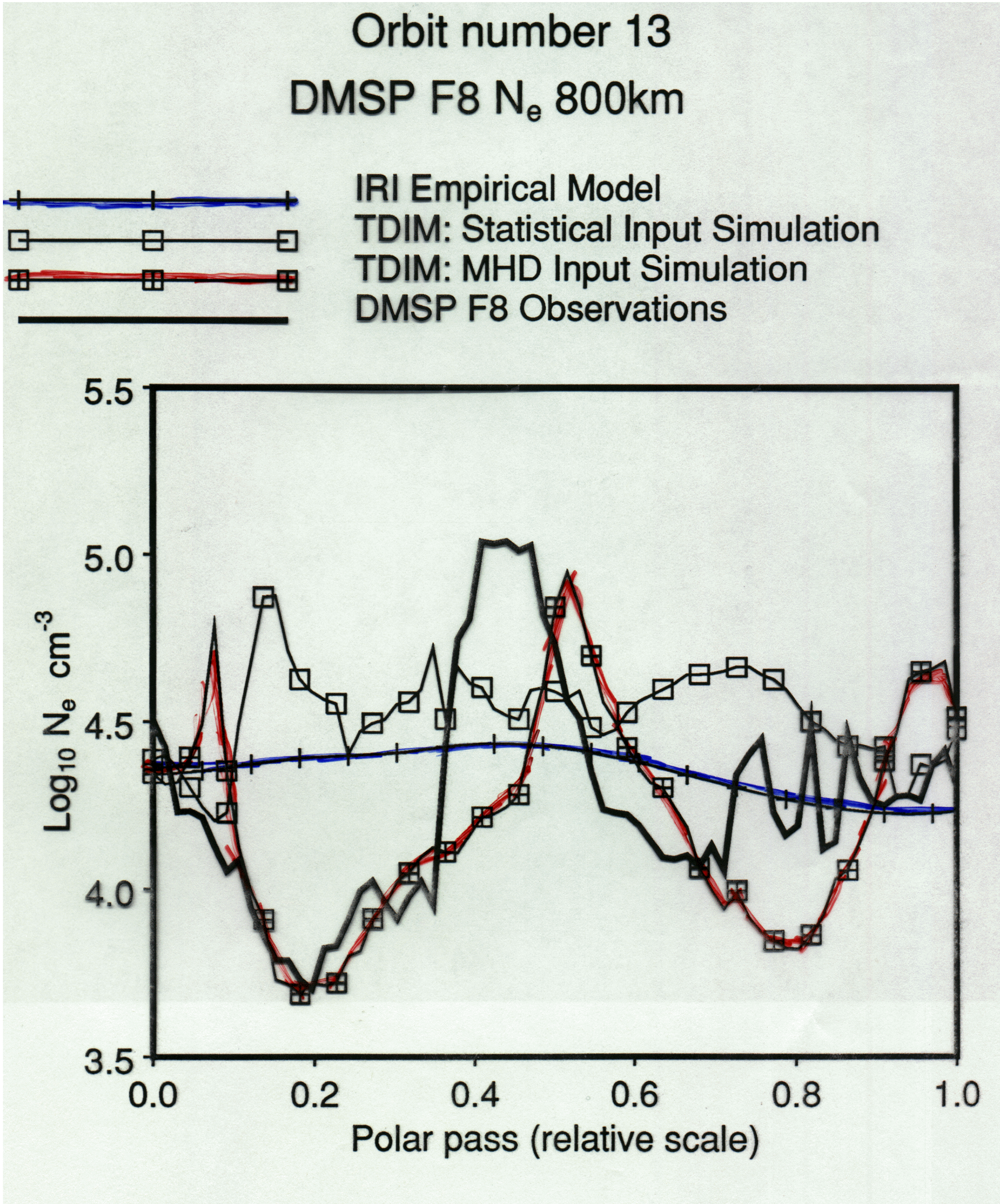
NmF2 - TDIM results (NRL MHD inputs)
1200 MLT
0230
1
0600
2
0900
3
1100
4
1530
5
2130
6
1800
0600
0000
-80
-70
-60
Log10 cm-3
4.5
6.0
NmF2 - TDIM results (statistical model inputs)



TDIM Results
(NRL MHD Model Inputs)
TDIM Results
(Empirical Model Inputs)
UT 2130
1200 MLT
1200 MLT
1800
0600
-80
-70
-60
0000
0000
5.5
5.0
4.5
4.0
3.5
3.0
Log10 Ne at 800 km (cm-3)
++++ DMSP observations
TDIM / NRL MHD inputs
TDIM / empirical inputs
Log10 Ne (cm-3)
5.5
5.0
4.5
4.0
3.5
2125
2130
2135
2140
2145
2150
2155
UT



Orbit number 5
DMSP F8 N_e 800km
IRI Empirical Model
TDIM: Statistical Input Simulation
TDIM: MHD Input Simulation
DMSP F8 Observations
5.5
5.0
4.5
4.0
3.5
Log_{10} N_e cm^{-3}
0.0
0.2
0.4
0.6
0.8
1.0
Polar pass (relative scale)

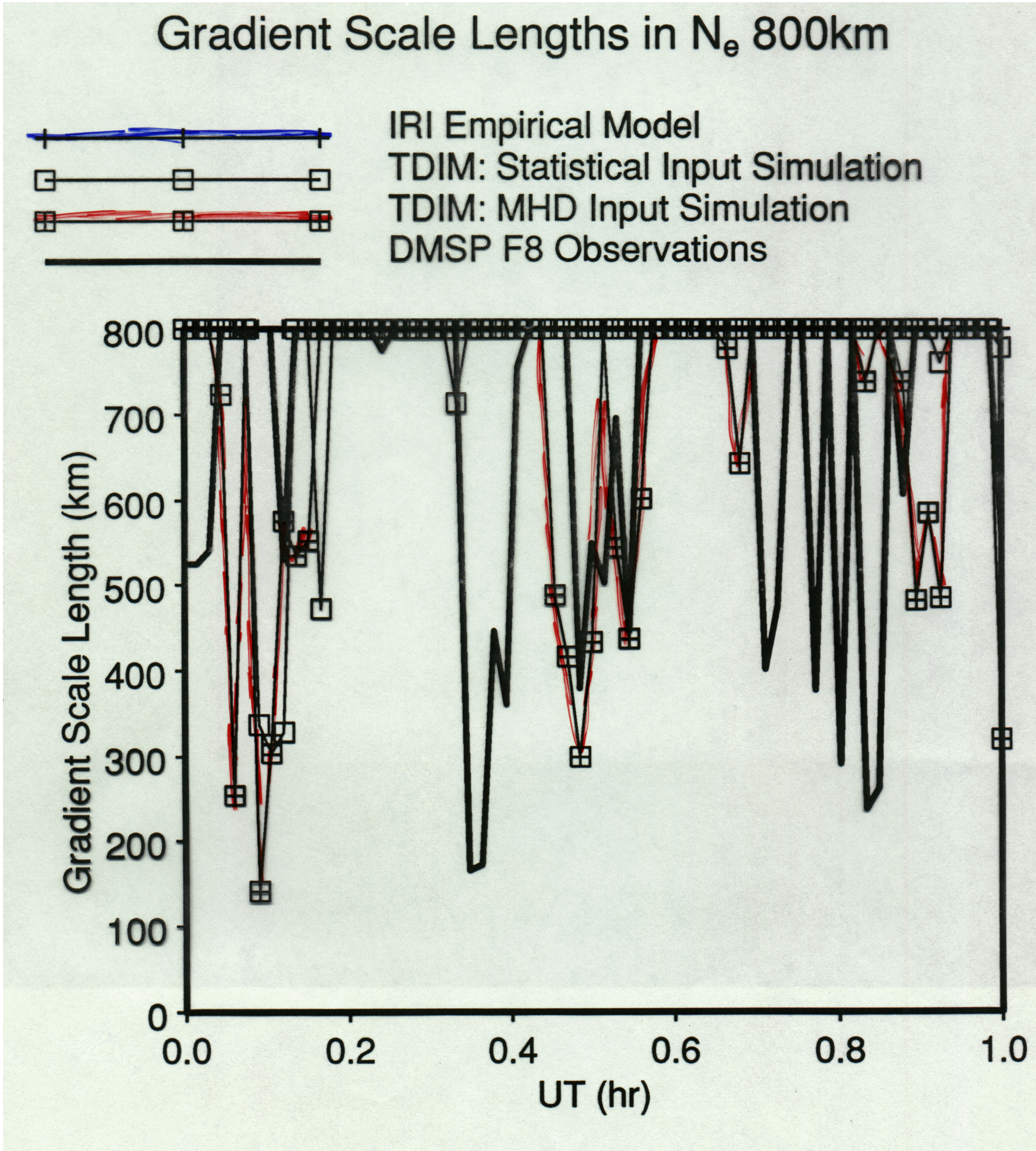

Orbit number 13
DMSP F8 N_e 800km
IRI Empirical Model
TDIM: Statistical Input Simulation
TDIM: MHD Input Simulation
DMSP F8 Observations
$Log_{10} N_e$ cm^{-3}
5.5
5.0
4.5
4.0
3.5
0.0
0.2
0.4
0.6
0.8
1.0
Polar pass (relative scale)

Correctness Ionospheric Models

– Gradients are Necessary for Scintillations –

- At High Latitudes, the Gradient Drift Instability (GDI) is thought to be Important.
- Instability Causes Irregularities Which can Lead to the Scintillations Phenomena.
- GDI Depends on Horizontal Density Gradients.
- Gradient Scale Length.

$$L = \left(\frac{1}{n_e} \frac{dn_e}{dx} \right)^{-1}$$


Gradient Scale Lengths in N_e 800km
IRI Empirical Model
TDIM: Statistical Input Simulation
TDIM: MHD Input Simulation
DMSP F8 Observations
Gradient Scale Length (km)
0
100
200
300
400
500
600
700
800
0.0
0.2
0.4
0.6
0.8
1.0
UT (hr)