NSF Post-doc Report:

Magnetospheric energy input uncertainty and its impact on the thermosphere/ionosphere

Yue Deng

University of Texas, Arlington

The University of Texas ARLINGTON

Acknowledgement:

- **Supervisor:** Timothy Fuller-Rowell
- **Collaborators:**

University of Michigan: Aaron Ridley

HAO: Arthur Richmond and Qian Wu

NOAA: Rashid Akmaev, David Evans

University of Colorado: Jiuhou Lei, Delores Knipp and Jeff Thayer

University of Texas: Ramon Lopez, Yanshi Huang

- **NSF support:**

NSF CEDAR/GEM Post-doc Fellowship (grant ATM0823689)

… … … … … …

Outline:

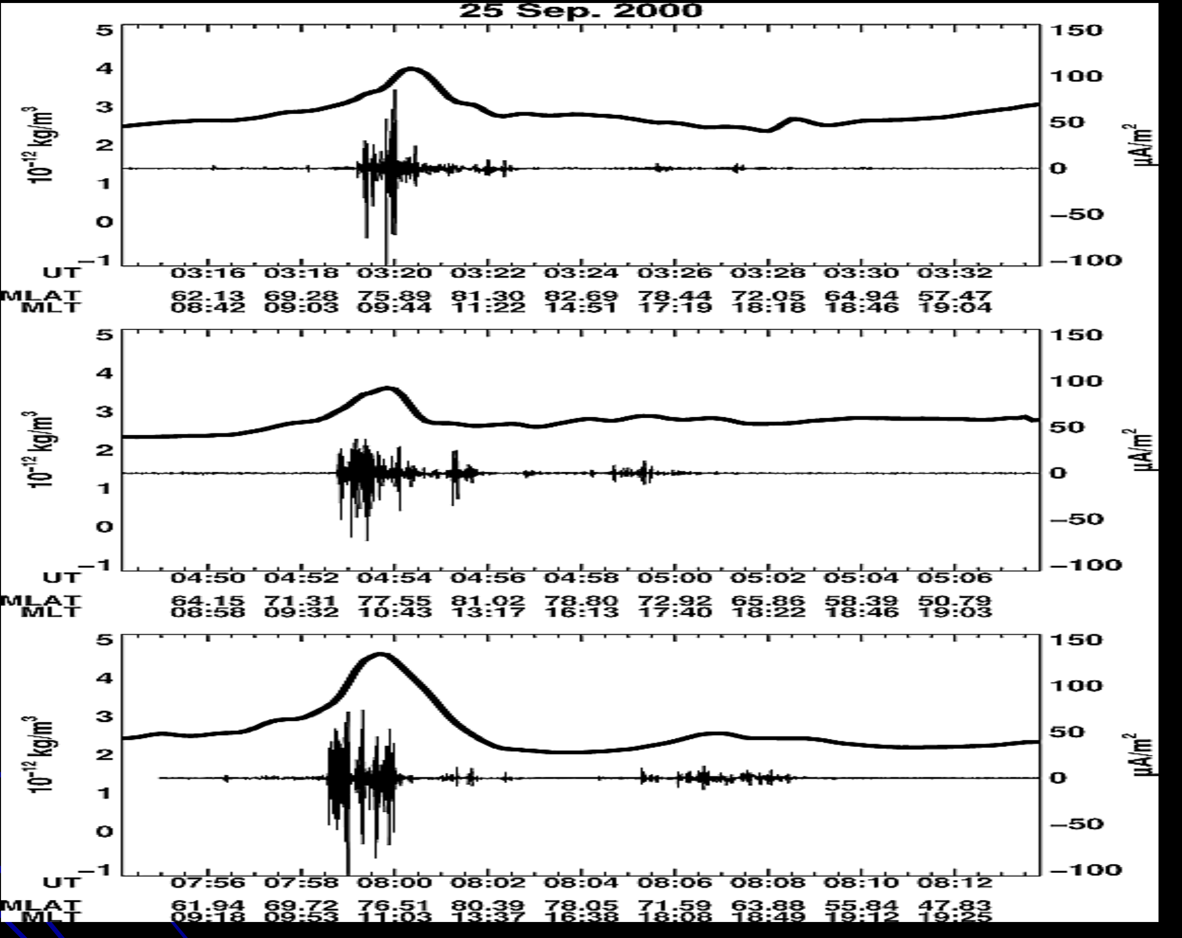
- magnetospheric energy input into the upper atmosphere associated with high speed solar wind streams
  Huang, Y., et al., CEDAR poster, 2010
- Primary heating mechanisms for the substantial neutral density enhancement in the cusp region
- Impact of the altitudinal energy distribution on the thermosphere

2. Primary heating mechanisms for the substantial neutral density enhancement in the cusp region

Yue Deng[1], Timothy Fuller-Rowell[2], Delores Knipp[2], David Evans[2], Aaron Ridley[3] and Ramon Lopez[1]

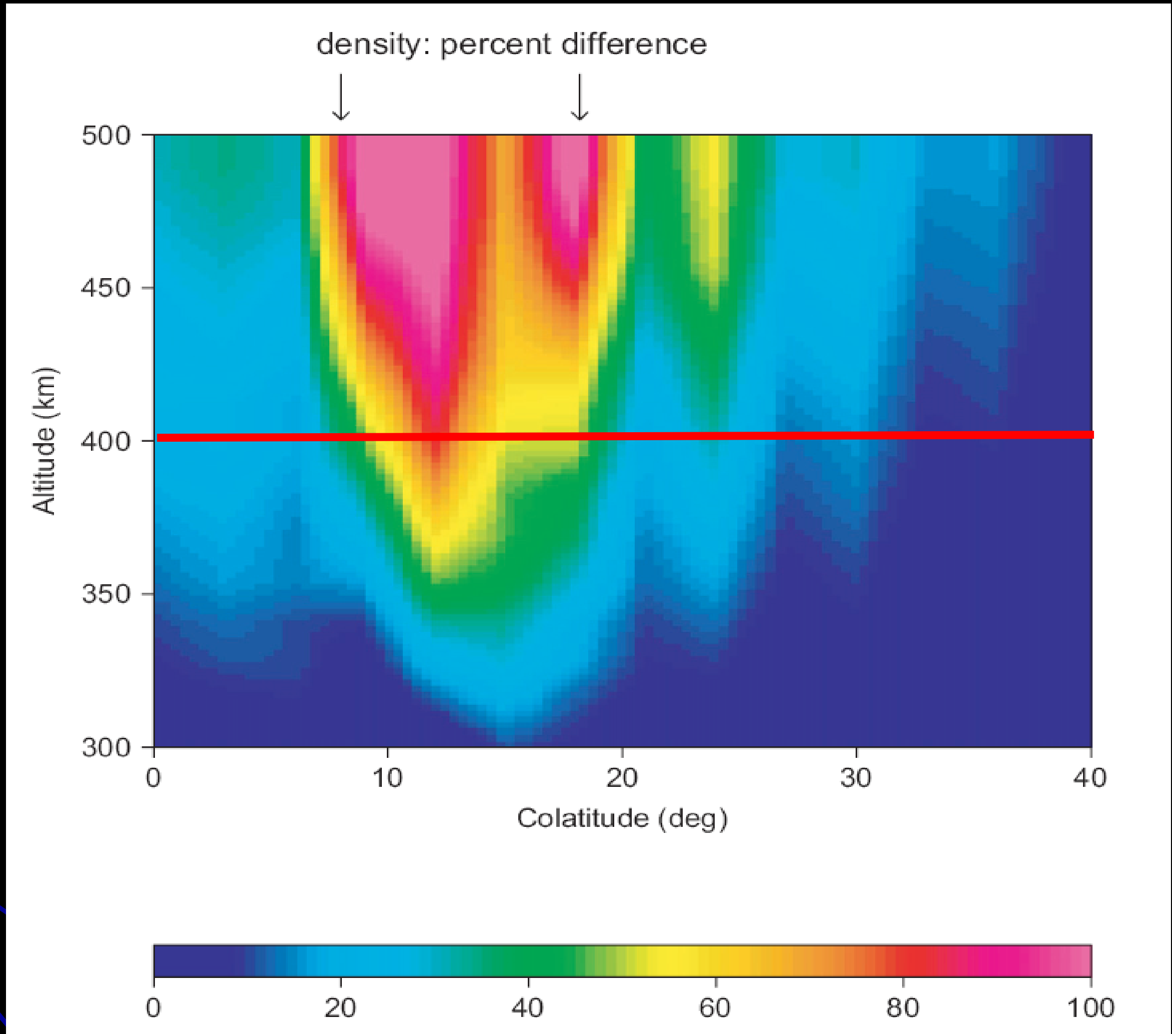
University of Texas, Arlington
University of Colorado, Boulder
University of Michigan, Ann Arbor

Motivation: Mystery of Neutral Density



Luhr et al, GRL 2004.

- Neutral density enhancements in the cusp from CHAMP measurements.
- How much total energy inputs to the cusp region?
- What is the primary driver for the large density enhancement?



Demars & Schunk, JASTP, 2007

- Increase JH by 110 times.
- Percentage difference reaches 80% @ 400 km.

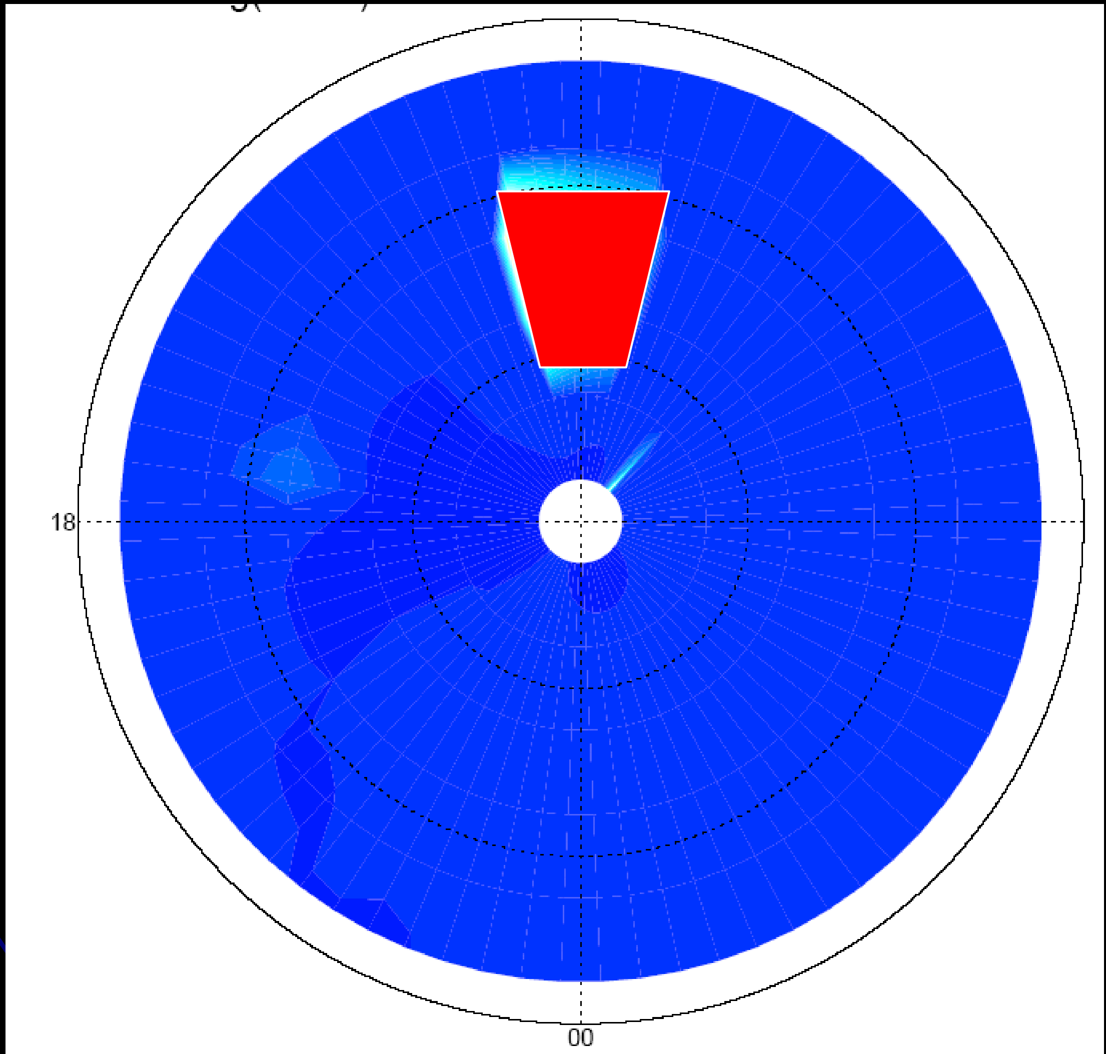
1: Poynting flux

Poynting flux:
100 mW/m^2

Lat: 70^0 – 80^0
LT: 11 – 13

~ Pedersen conductivity

Summer
F10.7 = 150
HP = 15 GW
Bz = -10 nT
SW = 400 km/s



Rho @ 400 km 0300 UT

~26%

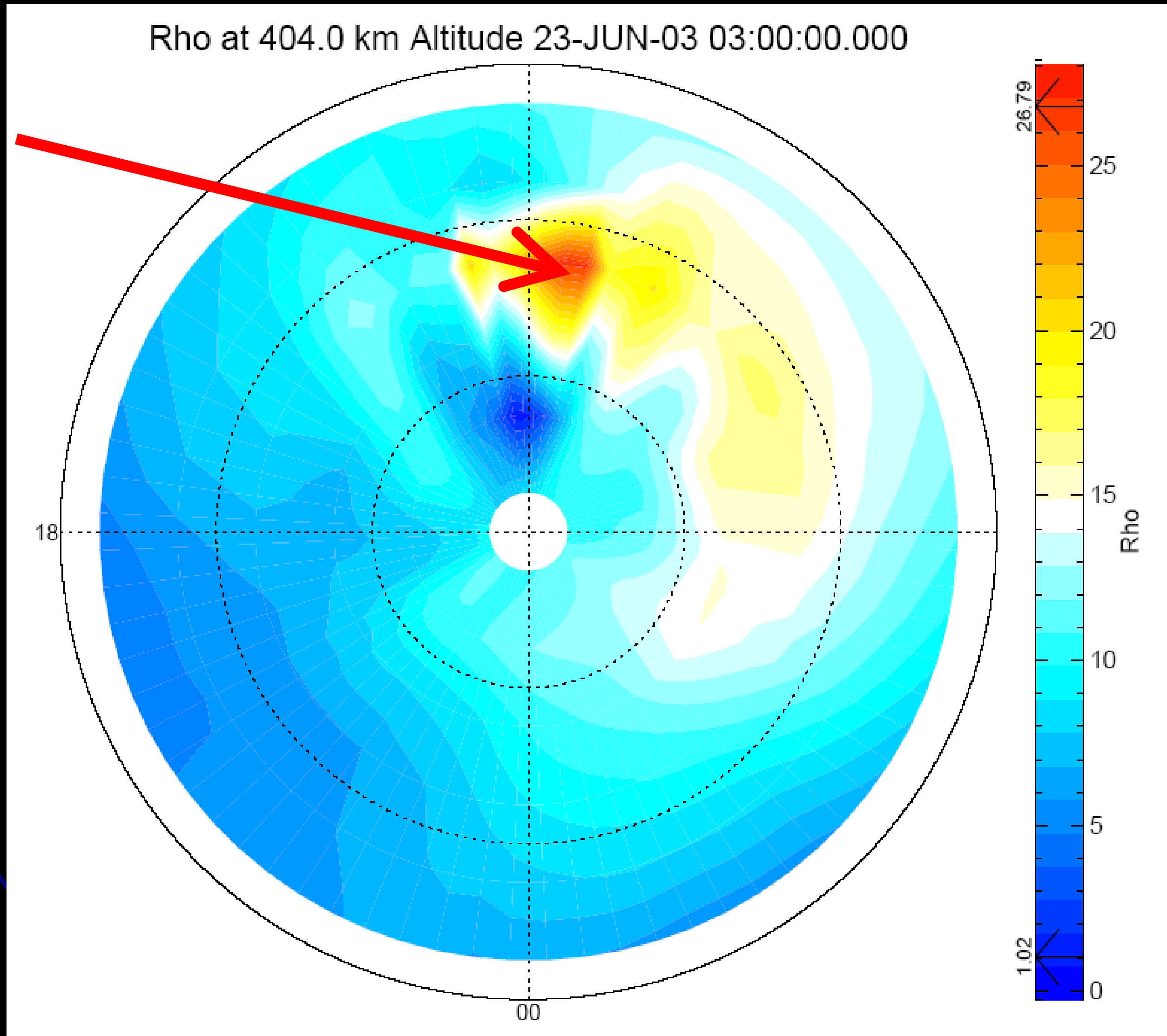
% difference between 2 cases

@ 400 km altitude

@ 0300 UT

Thermal expansion + upwelling →Rho ↑

26% < 50 – 100%



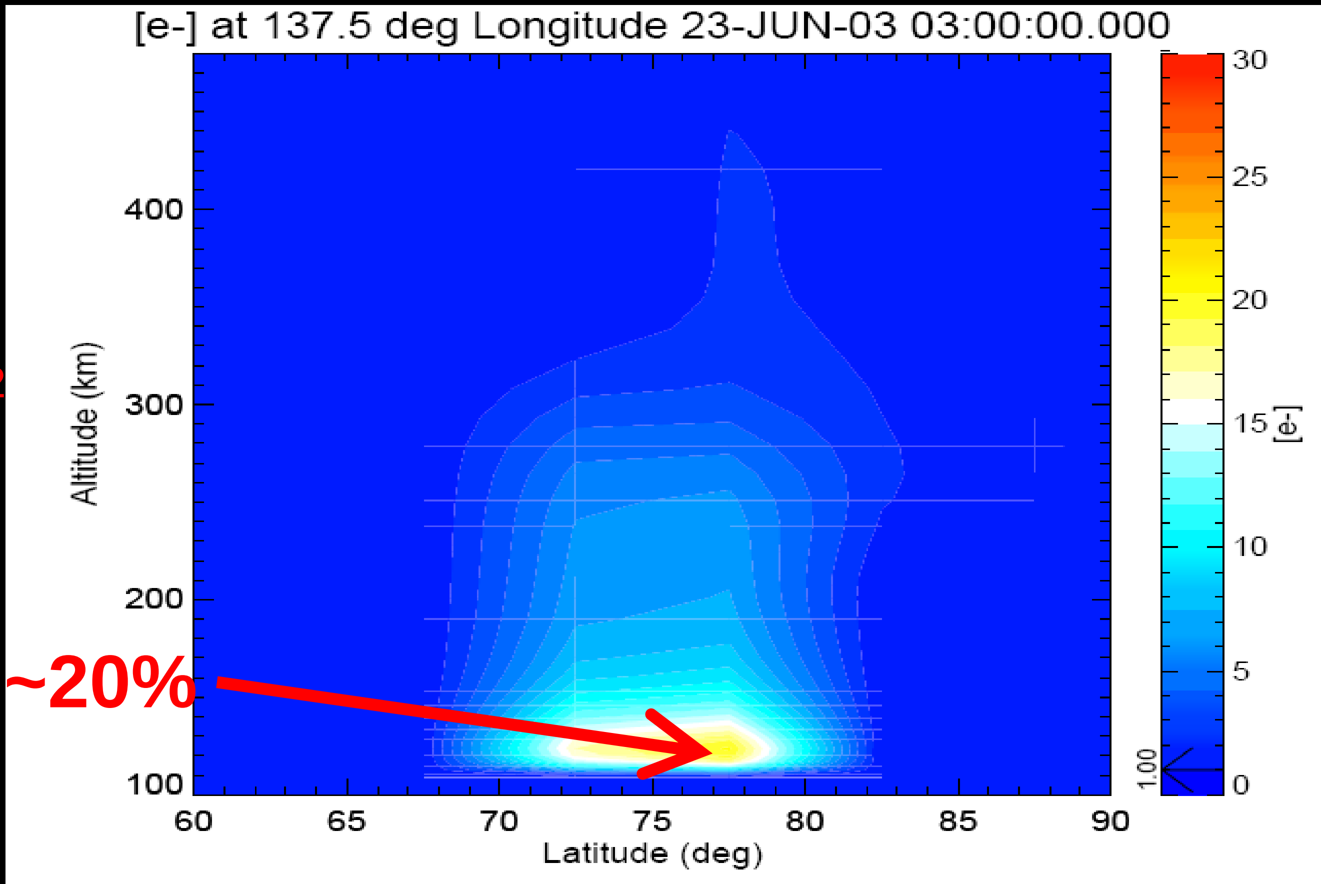
2: Low-energy Proton

Lat: 70⁰ – 80⁰
LT: 11 – 13

Low-energy proton:
2 kev, 0.5 mW/m²

Ignore particle Heating

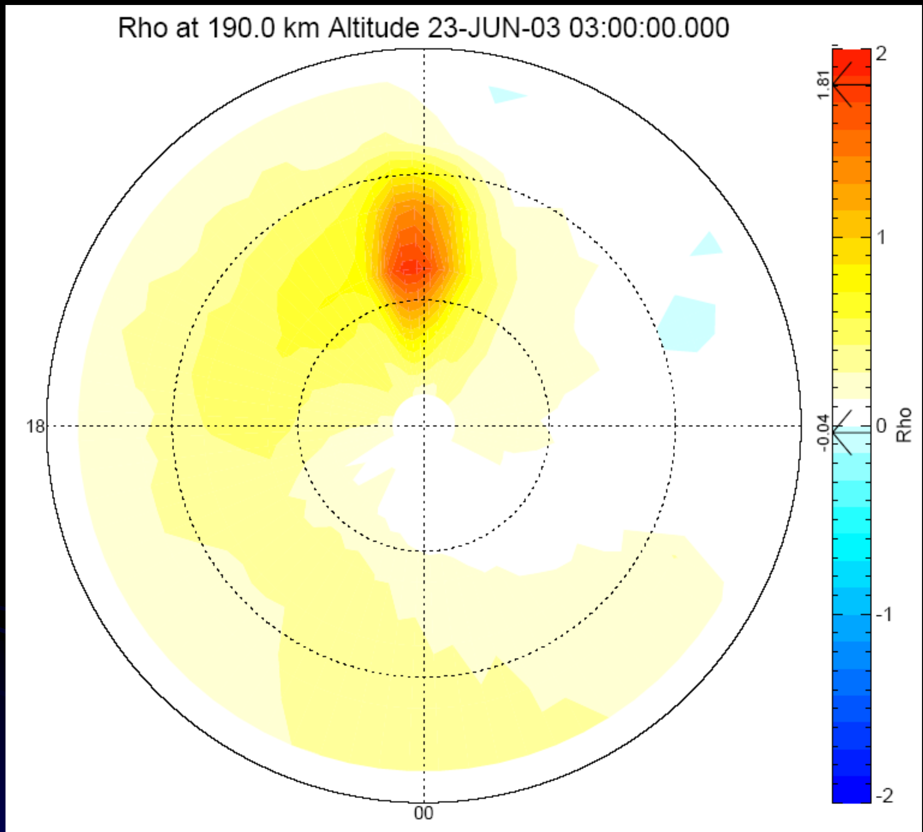
Galand et al., 1999.

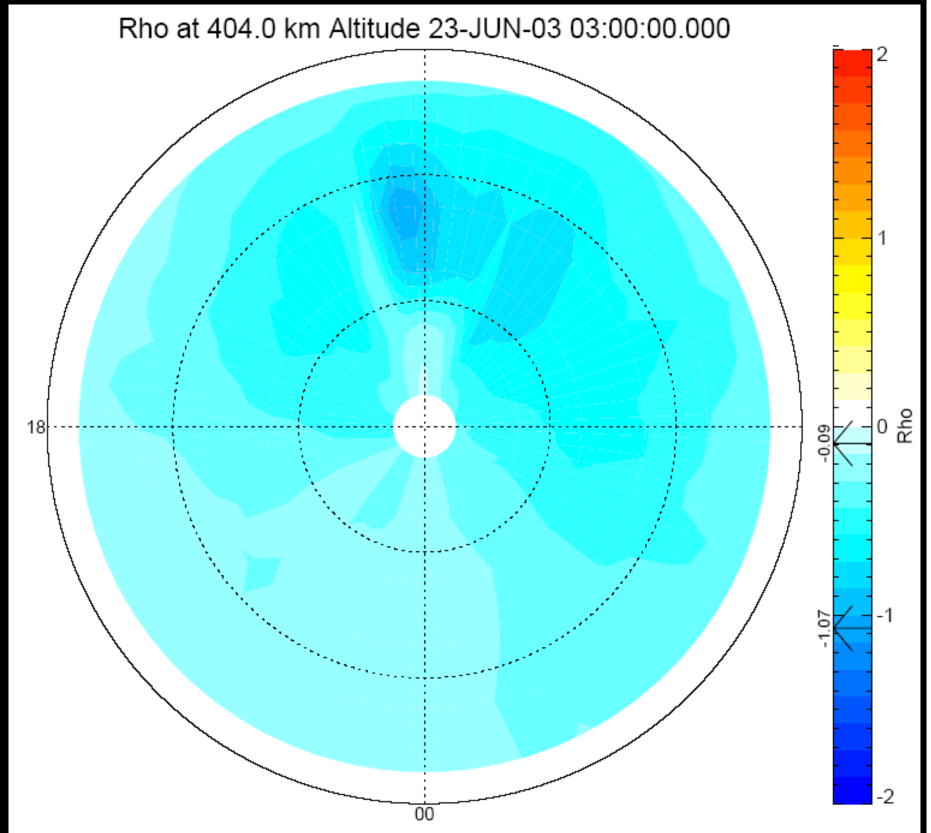


- % difference Ne between with and without proton
- Assume no change in the total Poynting flux
- Proton → Ne → Pedersen conductivity →Alt distribution JH

Rho @ 200 km:

Rho @ 400 km:





- % difference between with and without low-energy proton
- Rho Difference is -1% - 2% and depends on the altitude.

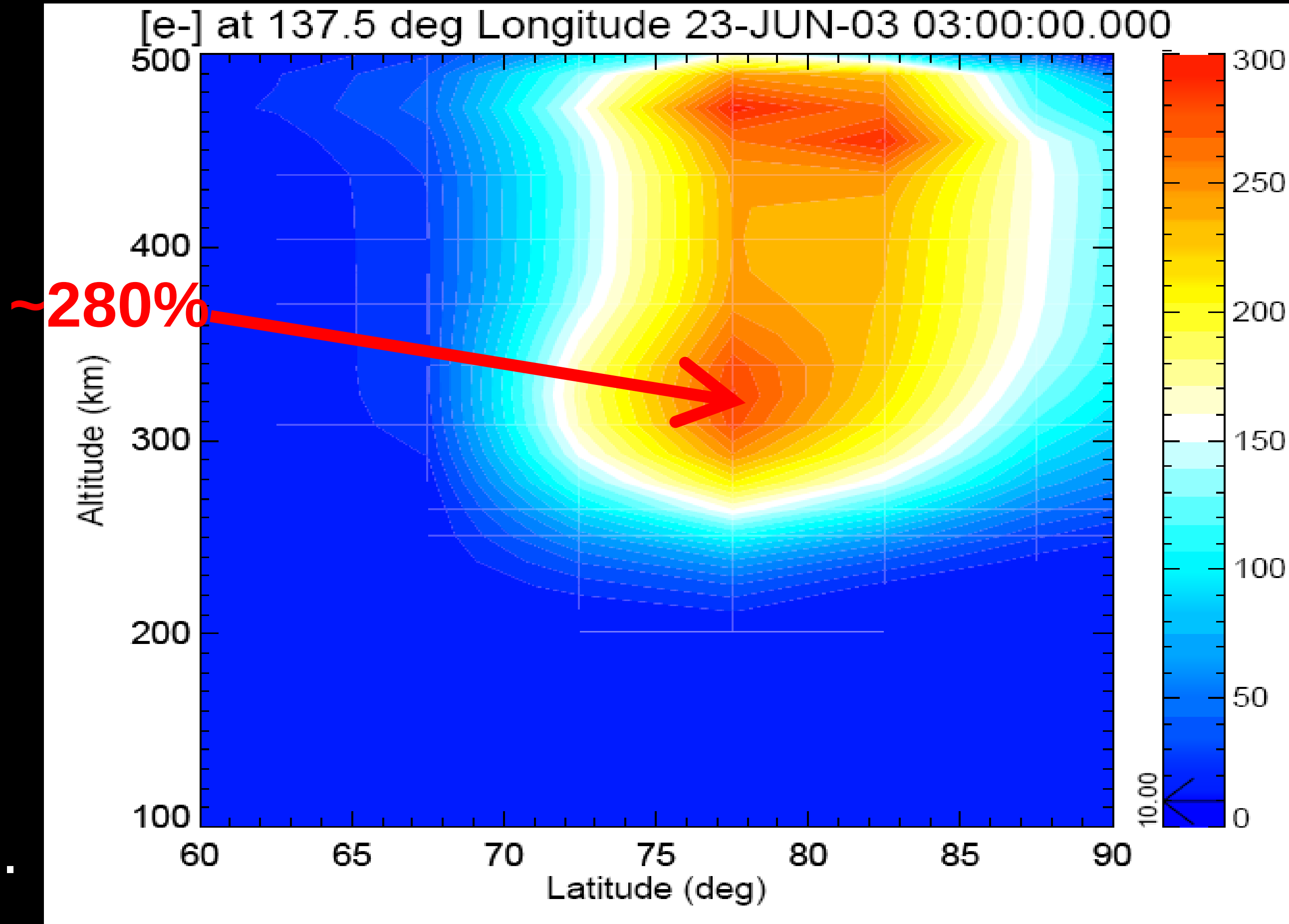
3: Low-energy Electron (100ev)

Lat: $70^0 – 80^0$
LT: 11 – 13

Low-energy electron:
100 ev, 2 mW/m^2

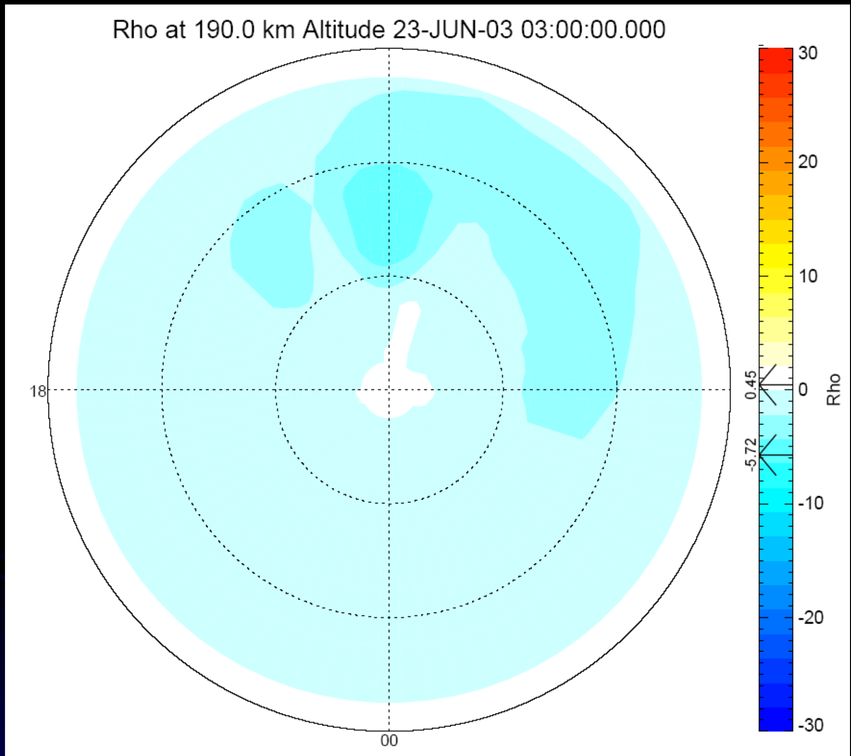
Ignore particle Heating

electron ionization [*Fang et al*., *2008*].

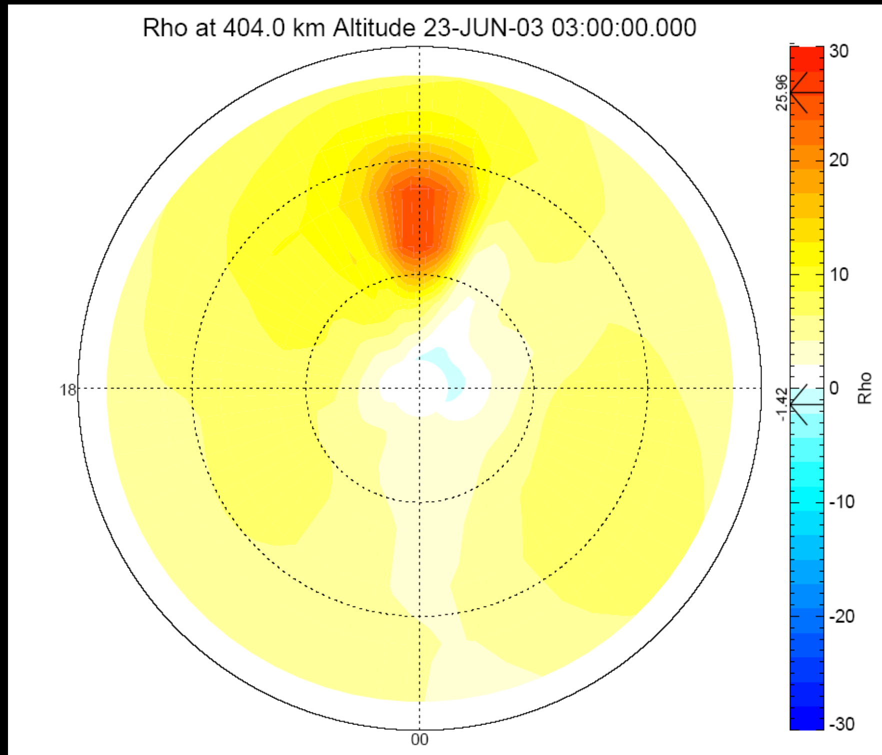


- % difference between with and without low-energy electron
- Low-energy electron → F region altitudes

Rho @ 200 km:



Rho @ 400 km:



- % difference between with and without low-energy electron
- Rho Difference is -5% ~ 25% and depends on the altitude.

Conclusion:

- Poynting flux is very efficient to increase the neutral density in the cusp region. But Poynting flux alone is not enough (~26%).
- The impact of low-energy proton to the neutral density is small (< 2% @ 400km).
- Low–energy electron (100ev) can significantly increase the neutral density @400 km (~25%).
- Poynting flux + low-energy electron ~ 50% (comparable with observations)

Future work:

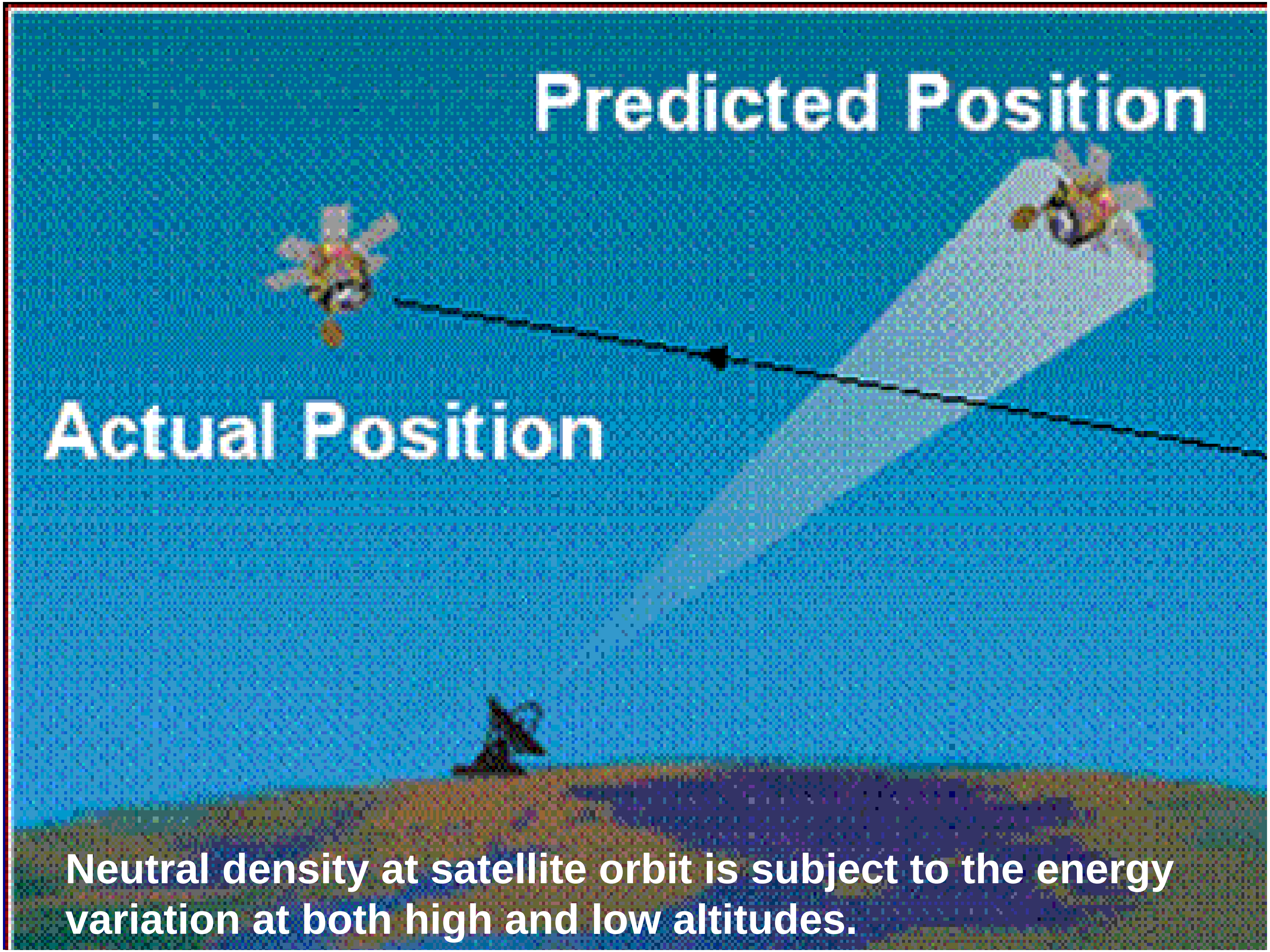
- Event study and data-model comparison.
- The significance of thermal flow.

3. Impact of the altitudinal energy distribution on the thermosphere

Yue Deng[1], Timothy Fuller-Rowell[2], Rashid Akmaev[3] and Aaron Ridley[4]

University of Texas, Arlington
University of Colorado, Boulder
NOAA SWPC, Boulder
University of Michigan, Ann Arbor

Deng, Y., et al., *GRL*, 2010, submitted.

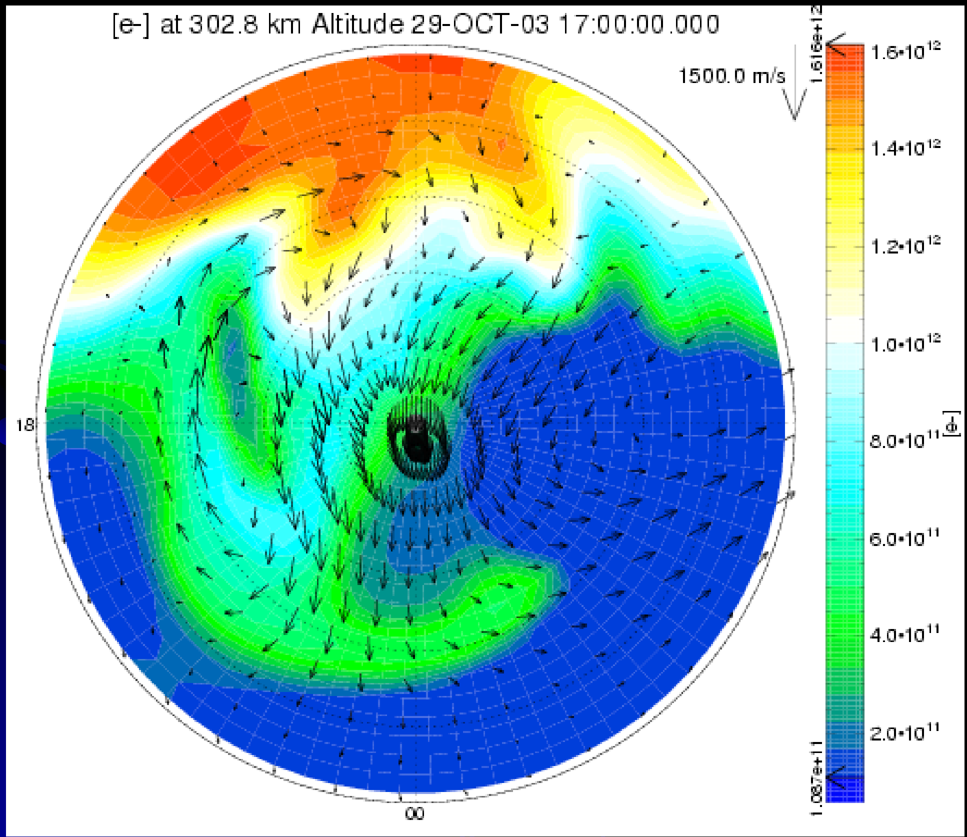


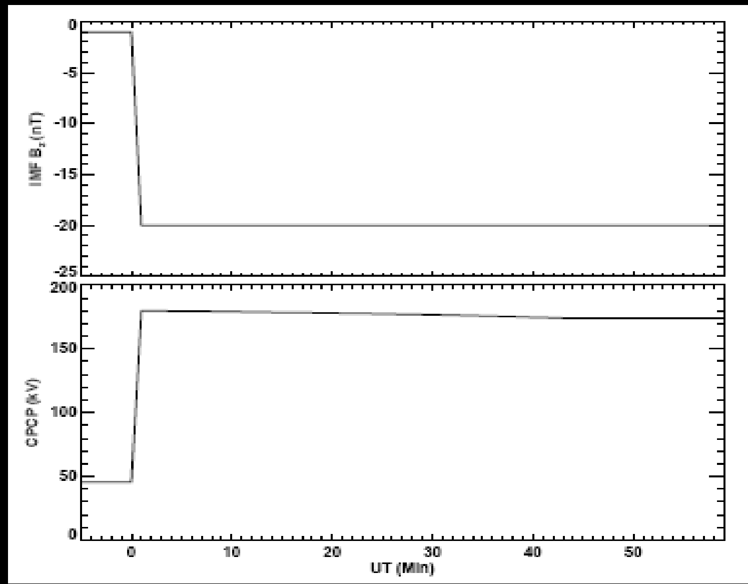
Neutral density at satellite orbit is subject to the energy variation at both high and low altitudes.

The Global Ionosphere-Thermosphere Model (GITM)

GITM solves for:

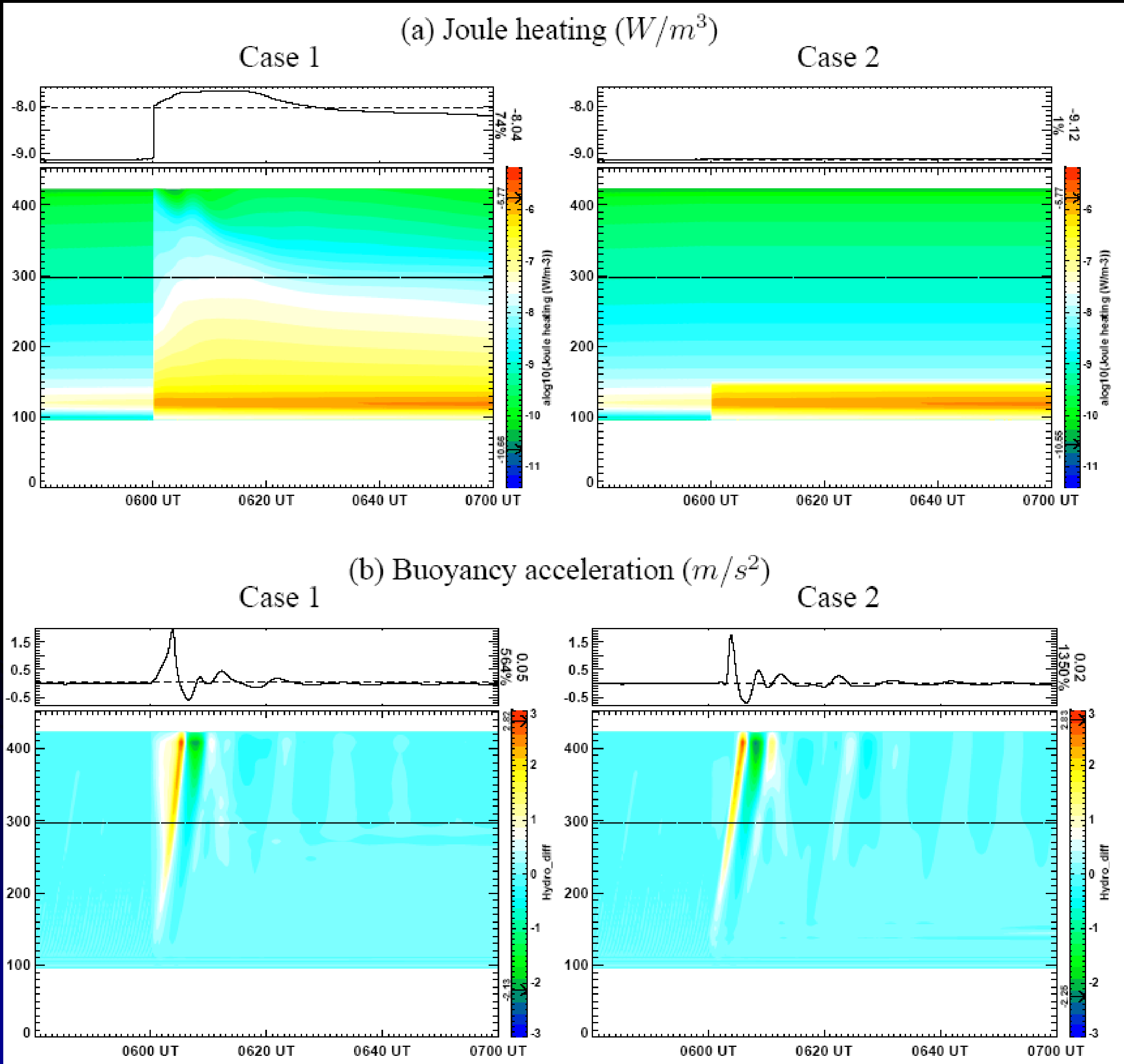
- **6 Neutral & 5 Ion Species**
- **Ion and Electron Velocities**
- **Neutral, Ion and Electron Temperatures**
- **Non-hydrostatic model with flexible resolution**





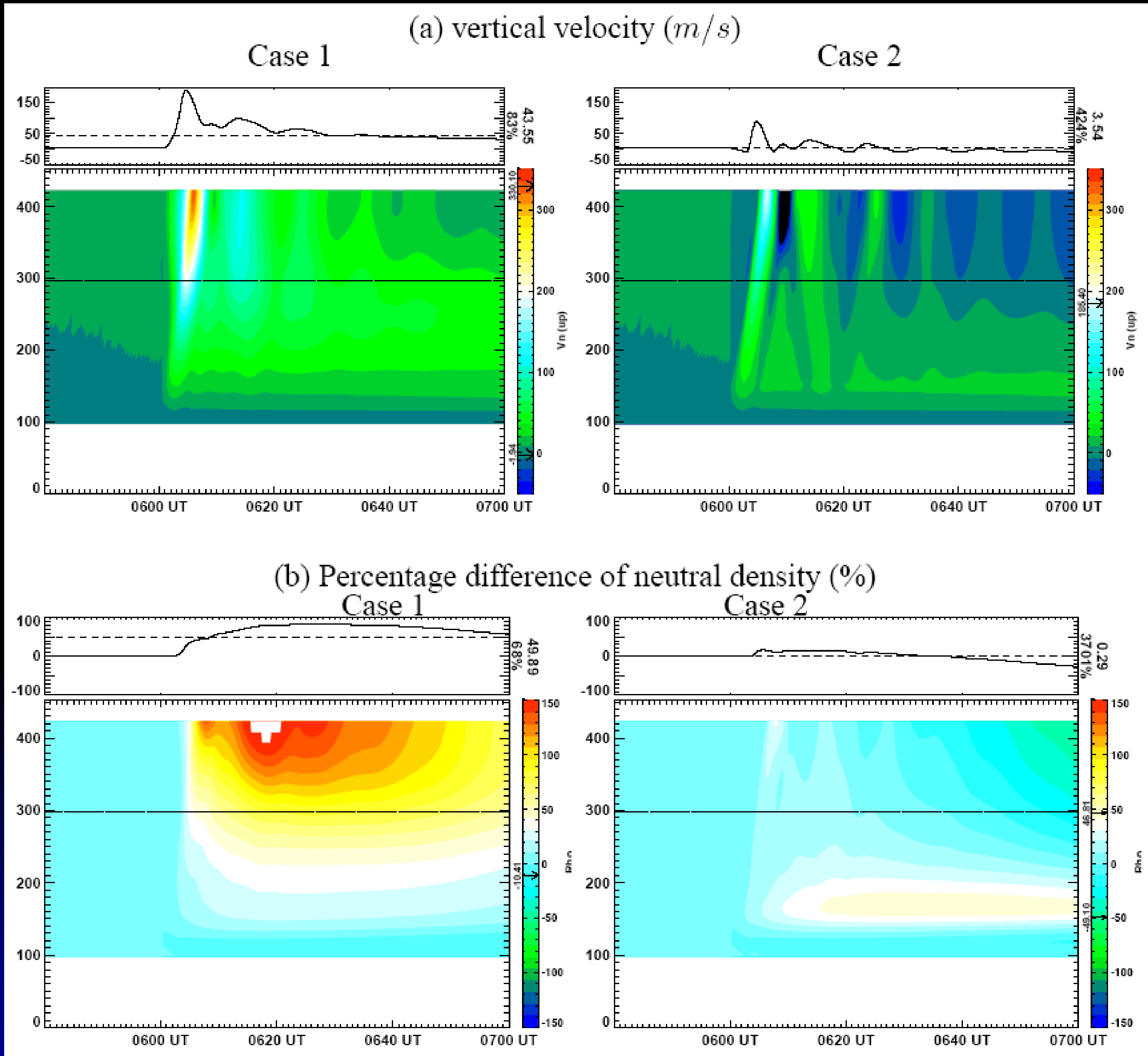
Ridley, A., **Deng, Y.,** and Toth, G. , *JASTP.*, 2006.

- 00 UT: Bz -1 → -20 nT
- CPCP: 45 → 180 kV
- Integrated JH increases by 20 times.



- JH ↑ @ 0600 UT
- $(77.5^0S, 22.5^oE)$

- Max is similar
- Case 2 starts later



- similar variation
- Aver_case1 is ~40m/s larger.

- Rho_case1 is ~50% larger.

Conclusion:

- Most of the non-hydrostatic effects at high altitudes (300km) arise from sources below 150km and propagate vertically through the acoustic wave.

- The heating above 150 km is responsible for a large increase of the average vertical velocity and neutral density at 300 km and higher altitudes.

Thank you!