# Neutral heating at various altitudes over the northern polar cap during magnetic storms

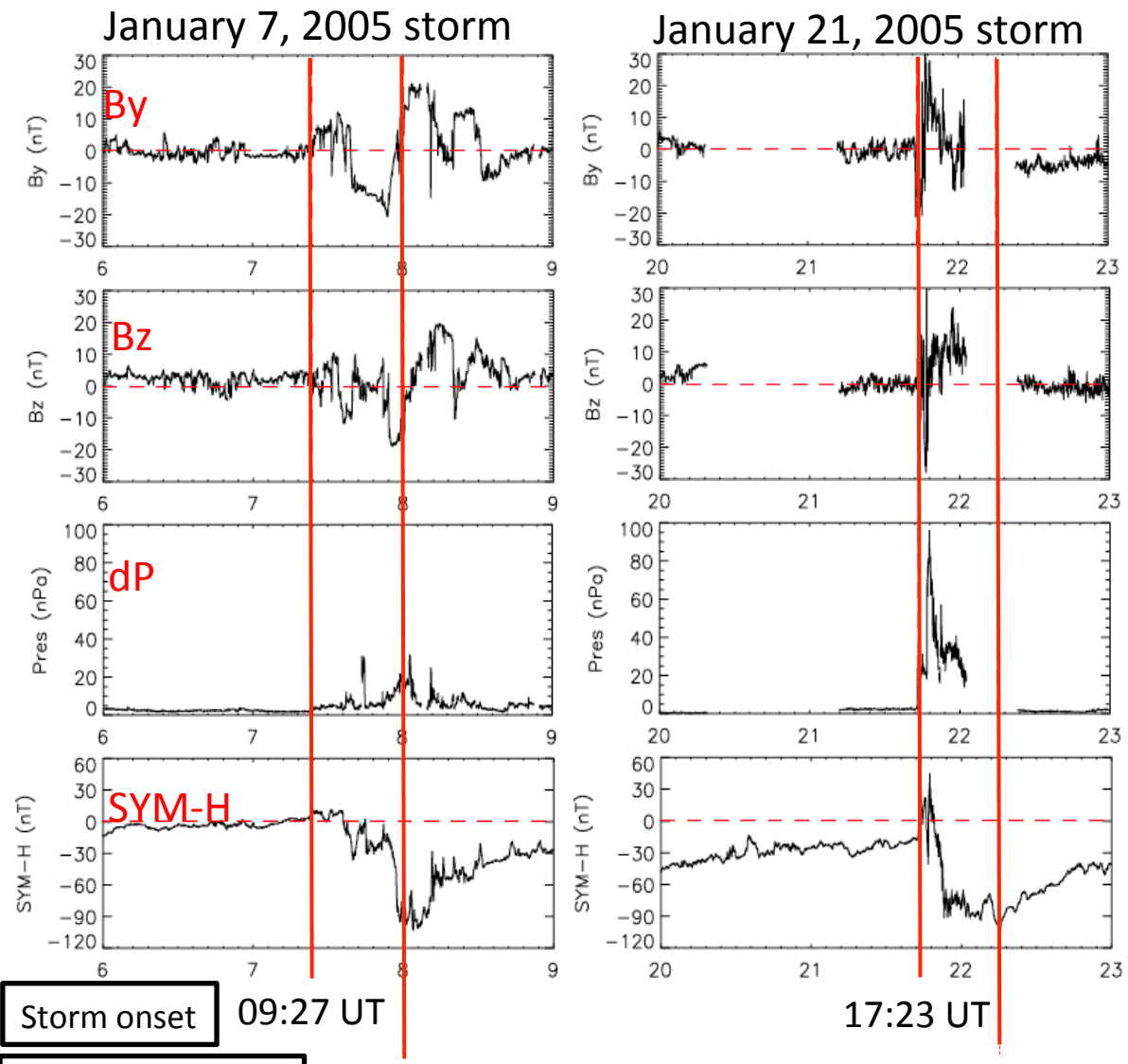
Yanshi Huang[1]
Qian Wu[2]
Cheryl Huang[3]
Yi-Jiun Su[3]

[1]University of New Mexico
[2]High Altitude Observatory, NCAR
[3]Air Force Research Laboratory

# Data

- DMSP (F13, 15, 16): Poynting flux
- GRACE: neutral density @ 470 km (normalized using NRLMSISE2000 model)
- CHAMP: neutral density @ 360 km
- Fabry-Perot Interferometer (FPI) at Resolute Bay: neutral temperature and winds @ 250 km
  - Resolute Bay, Canada: located deep inside polar cap
  - 74.73°N, -94.89°E
  - 83.10° MLAT, -38.94° MLON @250 km in Jan 2005.

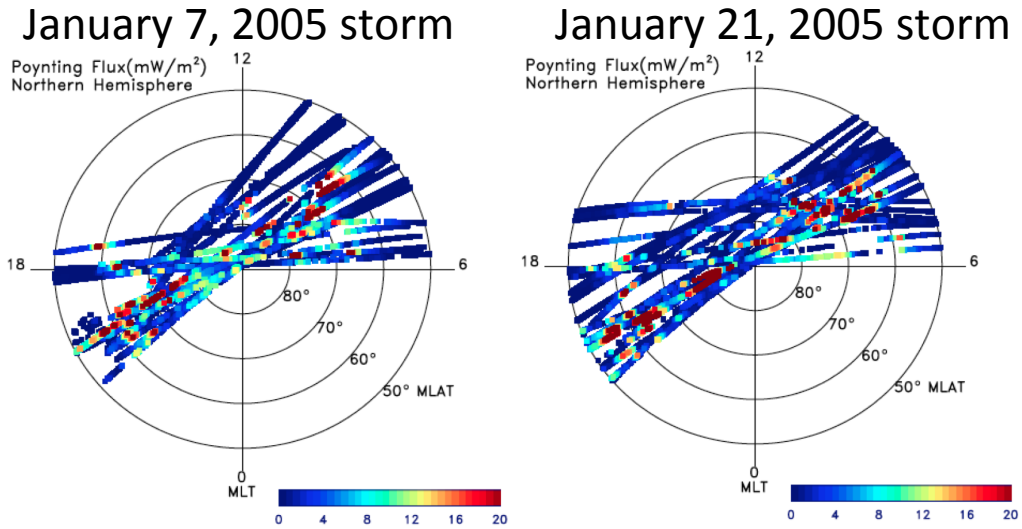
# Solar wind condition and geomagnetic variation



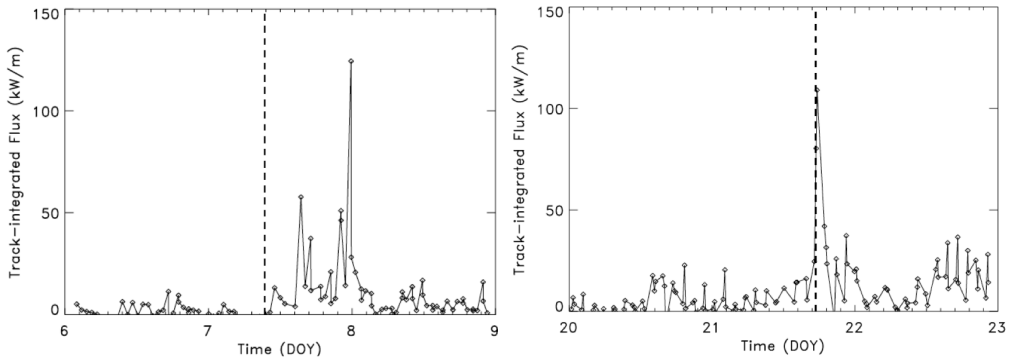

- The maximum solar wind pressure of the second event (~100 nPa) is much higher than that of the first storm (~30 nPa).
- For both events, moderate geomagnetic variations have been observed with minimum SYM-H index of -112 nT and -101 nT, respectively.

# Downward Poynting flux(PF) in northern hemisphere (DMSP F13, F15, F16)

Distribution of the PF along DMSP tracks during main phases

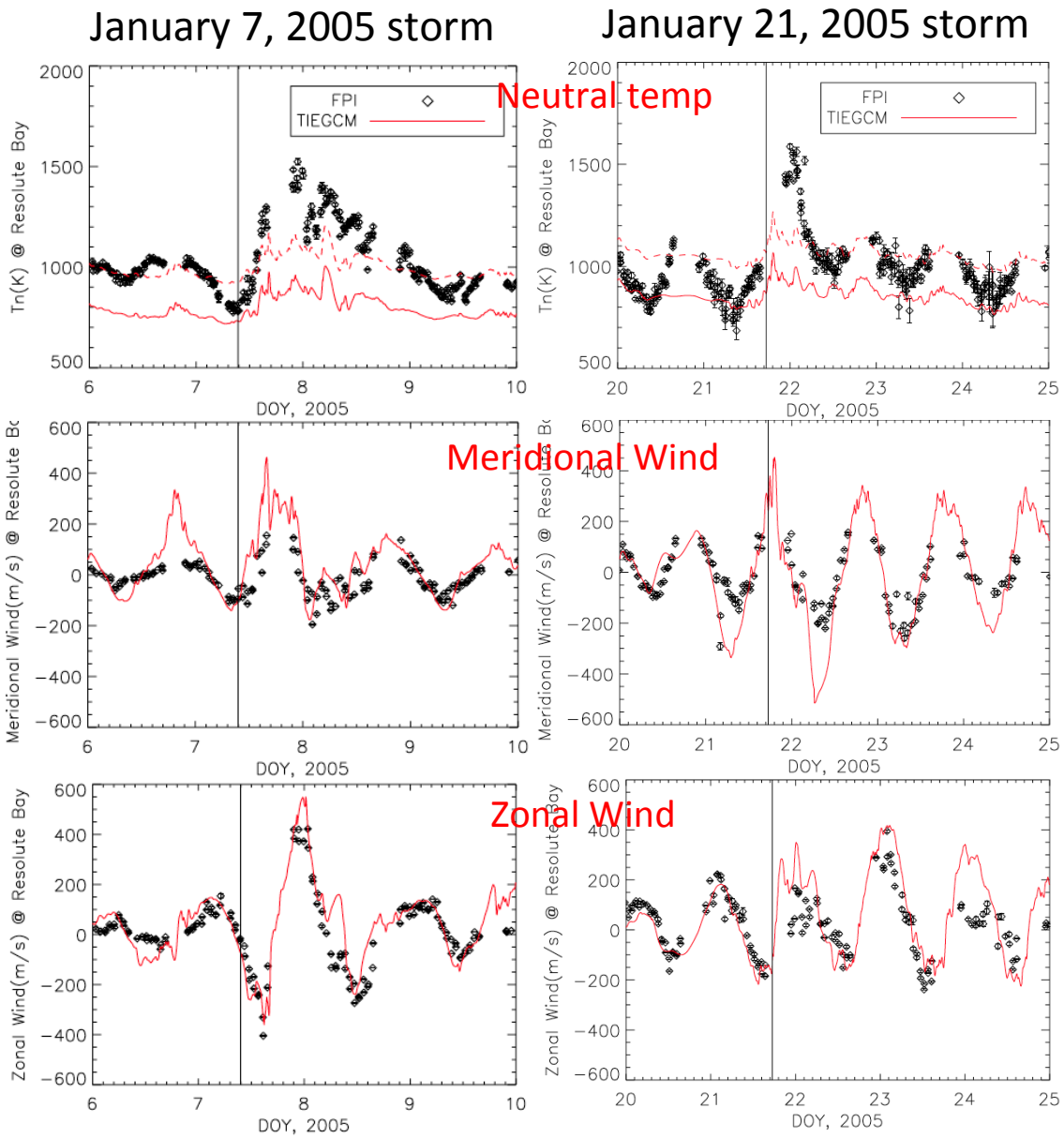



Along-track integrated PF (ATIP) for each DMSP path above 50 MLAT




- Enhanced PF observed at very high MLATs as well as in auroral zones.
- Clear increases of ATIP found with maximum values above 100 kW/m.
- Temporal variation of ATIP shows good correlation with that of the solar wind dynamic pressure.

# FPI measurement (black) vs. TIEGCM simulation (red)

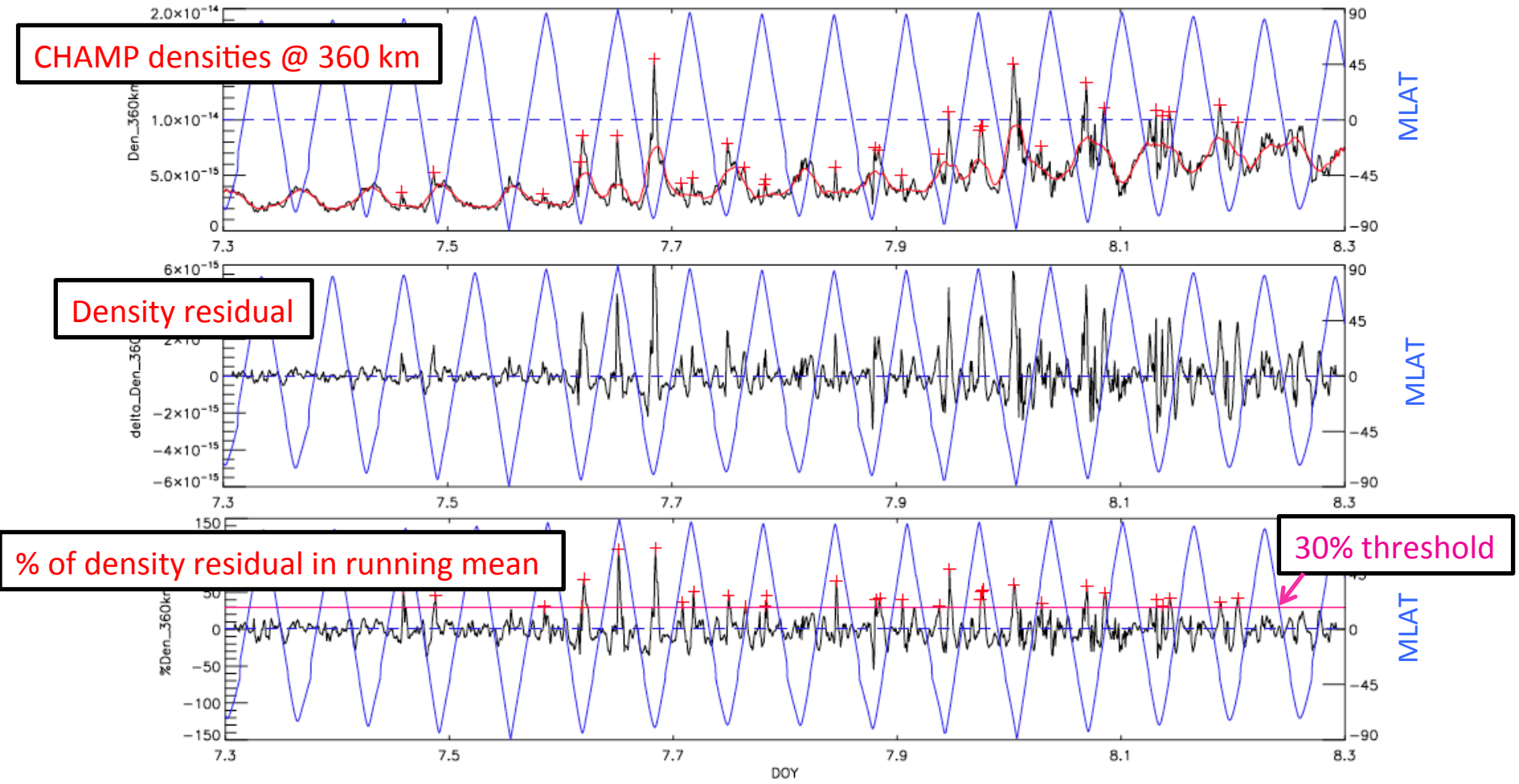



- FPI temperatures are not calibrated, so absolute values are not available.
- Relative changes demonstrate the true temperature changes.
- TIEGCM reproduces the neutral winds fairly well.
- Simulated neutral temperature increases by about 260 K and 280 K for two events, much lower than the observed temperature changes (750 K and 900 K).

➢ Insufficient neutral heating in the simulation.

# Local neutral density peaks

January 7, 2005 storm

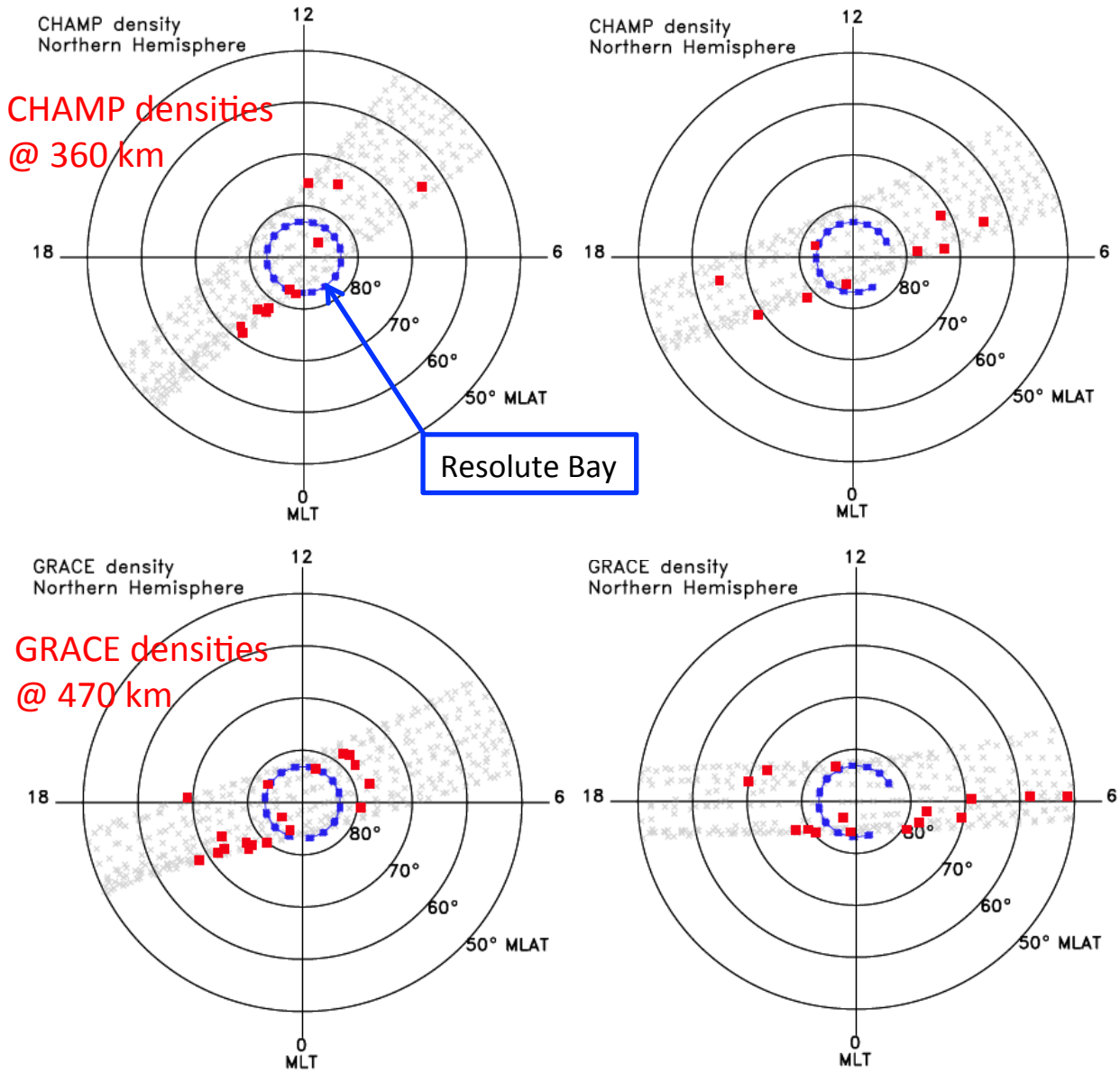



- A 23-minute moving window that is about 90° in latitude is used to calculate the running mean (red line).
- A threshold of 30% is selected here to indicate significant density perturbations.

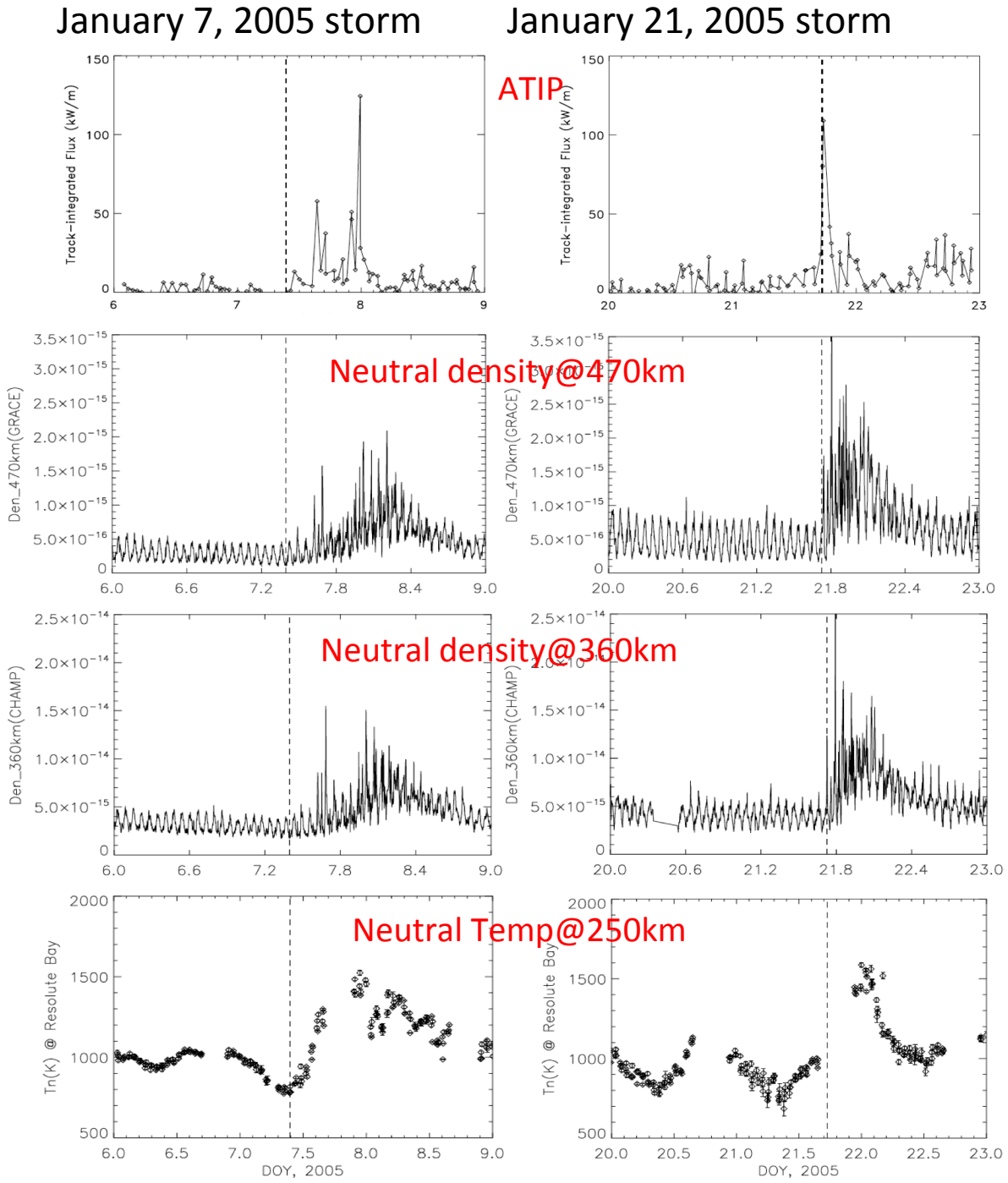
# Local neutral density peaks

January 7, 2005 storm

January 21, 2005 storm




- Geomagnetic locations of Resolute Bay is denoted by blue dots (83.10°MLAT).
- At both 360 km and 470 km, density enhancements are found poleward of 80° MLAT.
- Implying magnetospheric wave energy dissipated and transferred to neutrals at very high MLATs during storms.




# Neutral heating at various altitudes

- Neutrals at all altitudes respond very quickly to the magnetospheric energy input.
- ➢ quick and strong vertical ion-neutral coupling in polar cap regions.
- All measurements show enhancements at very high latitude poleward of 80° MLAT.
- ➢ Substantial heating is supplied to polar cap during storms.
- Also suggests that the energy is mainly dissipated at altitudes below 250 km.

# Conclusion

- We analyze various neutral measurements at different altitudes over polar cap region for the two magnetic storm events in January 2005:
  - ❑ neutral temperature at 250 km (FPI @ Resolute Bay)
  - ❑ neutral density at 360 km (CHAMP) and 470 km (GRACE)
  - ❑ Poynting flux observed (DMSP)
- All the measurements show enhancements at very high latitude poleward of 80° MLAT during storms.

➢ Substantial heating is supplied to the polar cap during storms.

- Neutrals at all altitudes respond very quickly to magnetospheric energy input.

➢ Quick & strong vertical ion-neutral coupling in polar cap regions.

- Comparison of neutral temperature change between FPI and TIE-GCM indicates insufficient Joule heating at very high latitudes in the model.

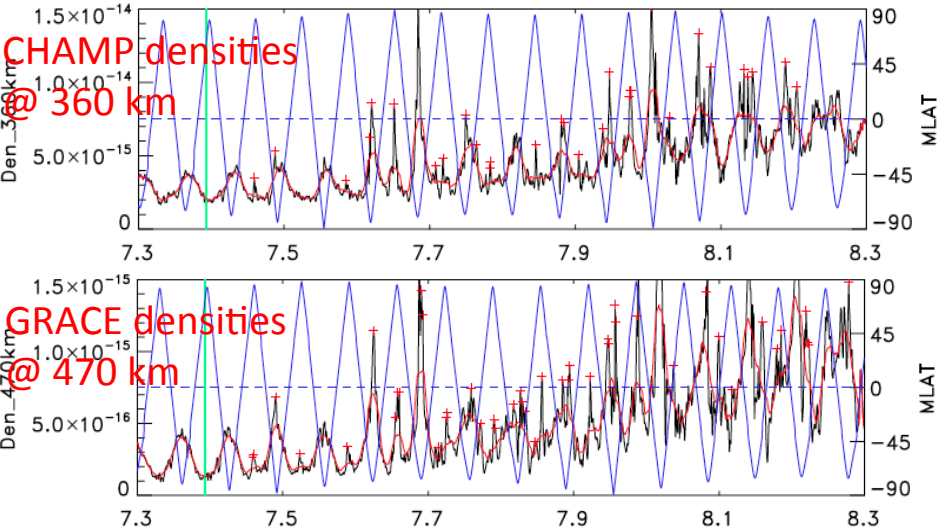
# Local neutral density peaks

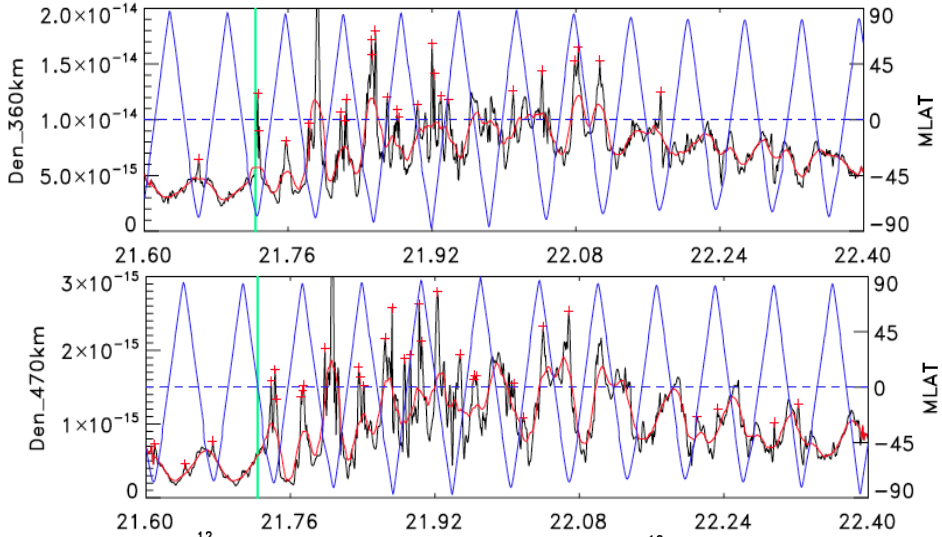
January 7, 2005 storm

January 21, 2005 storm

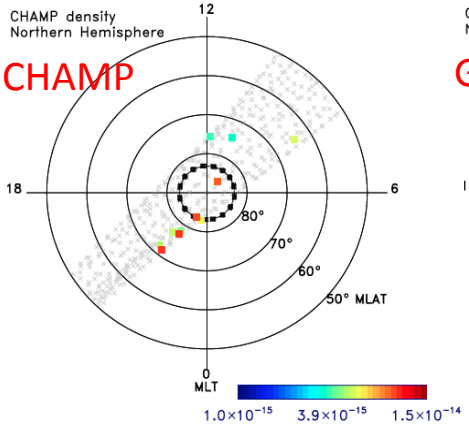
CHAMP densities @ 360 km

GRACE densities @ 470 km

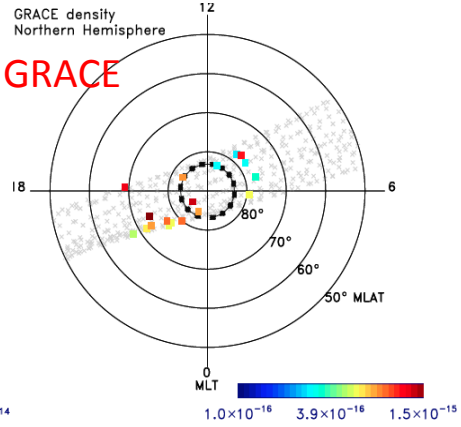


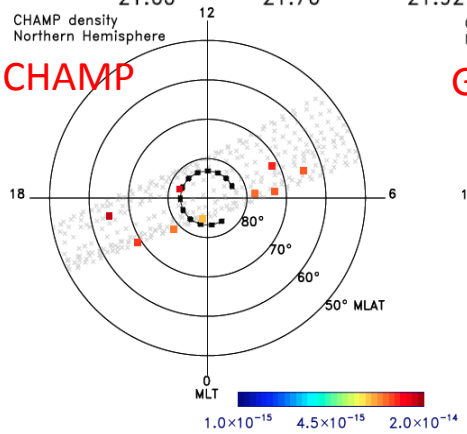

CHAMP



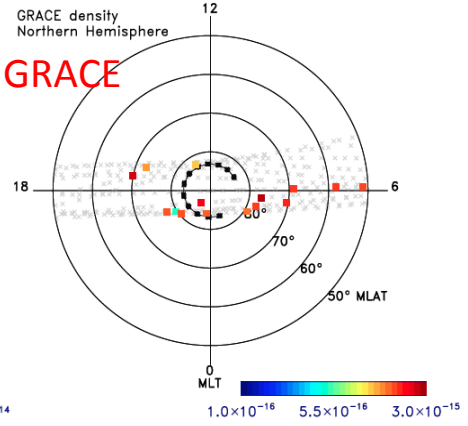

GRACE




CHAMP




GRACE




- Geomagnetic locations of Resolute Bay is denoted by black dots inside 80° MLAT.
- At both 360 km and 470 km, density enhancements are found poleward of 80° MLAT.
- Suggesting magnetospheric wave energy dissipated and transferred to neutrals at very high MLATs during storms.