Resolution Dependence of Storm Time Response using WACCM-X/GAMERA

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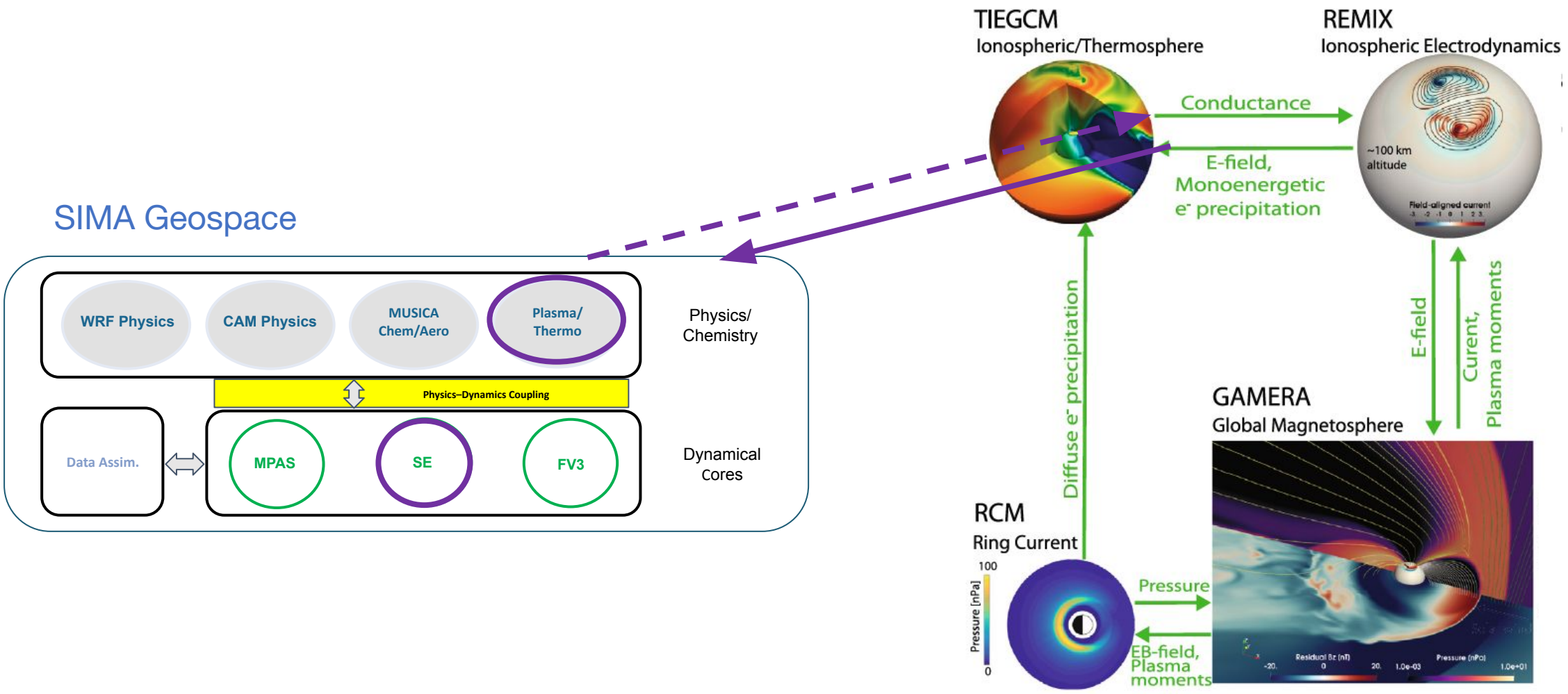
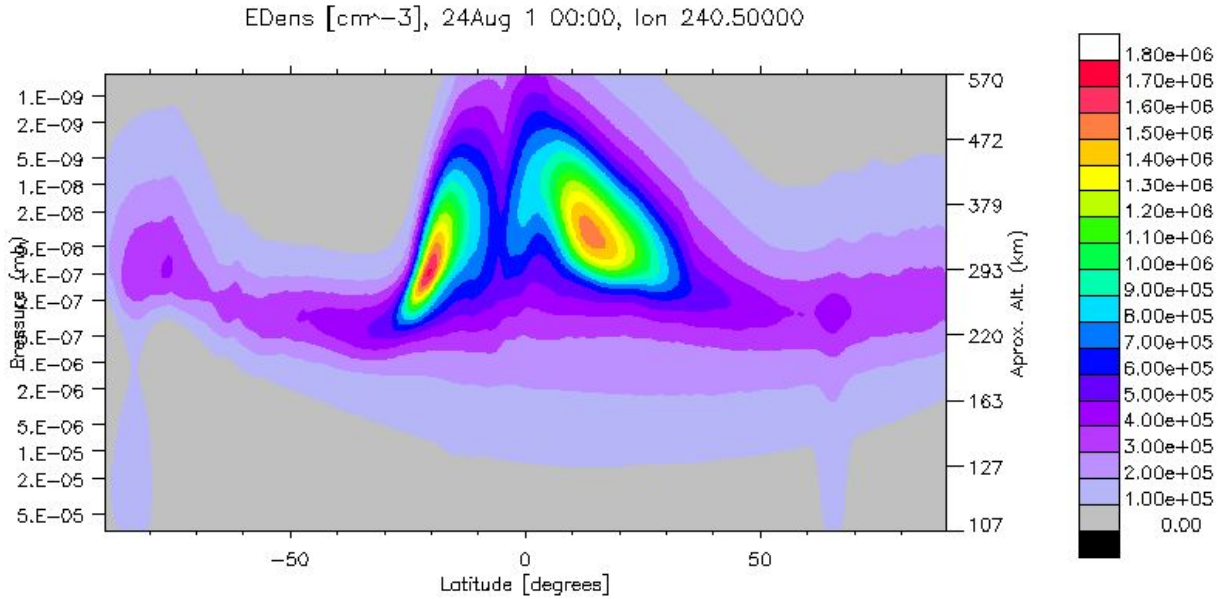
WACCM-X and GAMERA

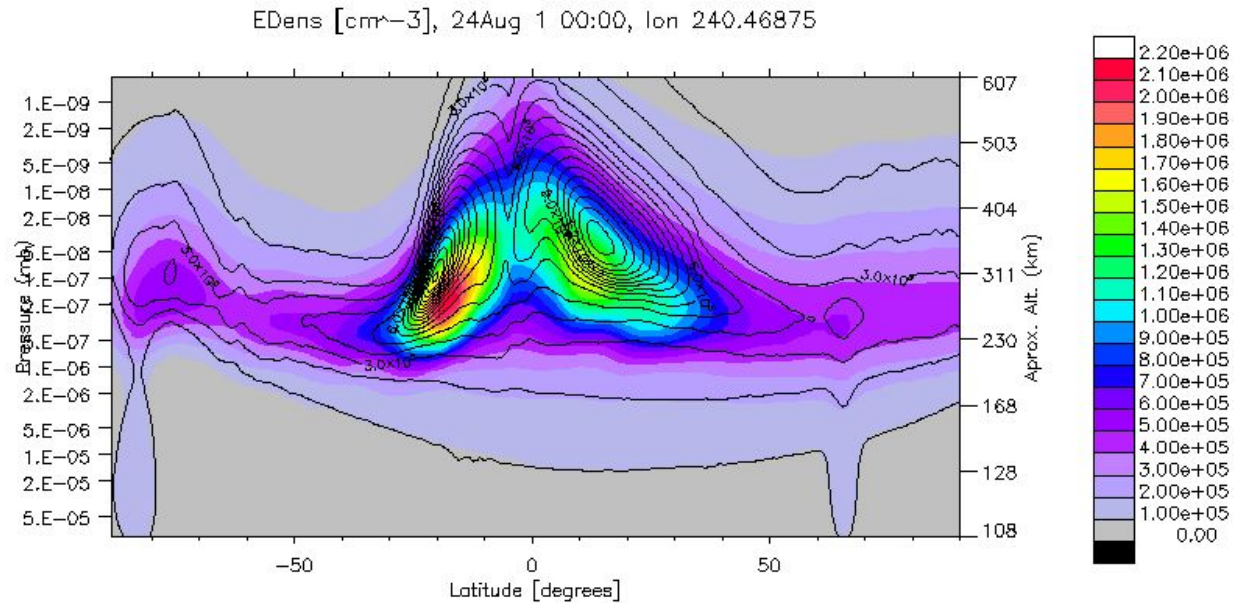
- WACCM-X:
  - WACCM-X species dependent spectral element dynamical core on a cubed-sphere grid
  - One of the atmosphere components of CESM
  - Geospace component of SIMA for space weather applications
  - Regular resolution configuration (NE30/L130): ~100 km/0.25 scale height
  - High resolution configure (NE120/L273): ~25 km/0.1 scale height
  - High latitude electric potential specified by GAMERA
- GAMERA:
  - Grid-Agnostic MHD for Extended Applications is a new magnetosphere MHD code.
  - Part of the Multiscale Atmosphere Geospace Environment (MAGE) model, developed by the NASA DRIVE Center: Center for Geospace Storms (CGS).
  - Oct-resolution (~0.5 deg) simulation for August 24 2005 geomagnetic storm.

Space Weather Application: Storm Time Response

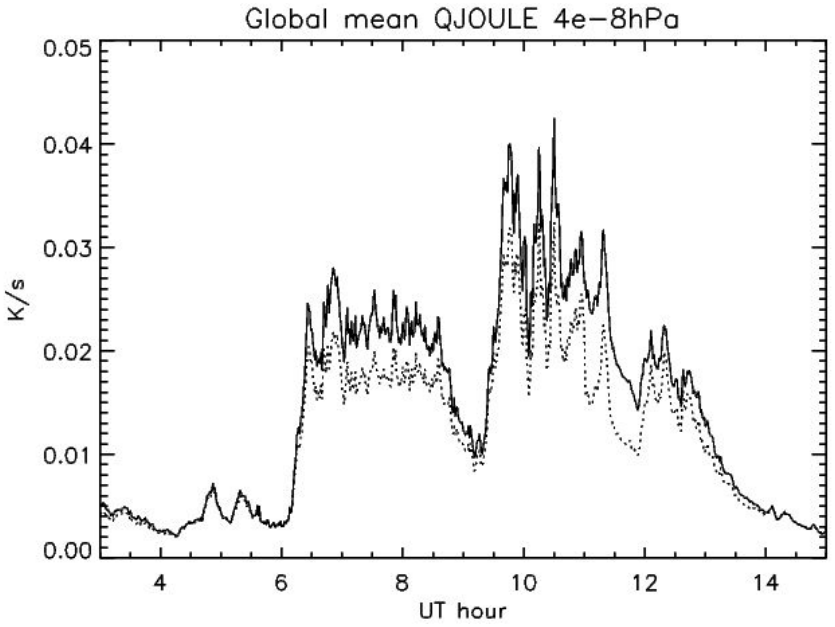
Multiscale Atmosphere Geospace Environment (MAGE) v1.0

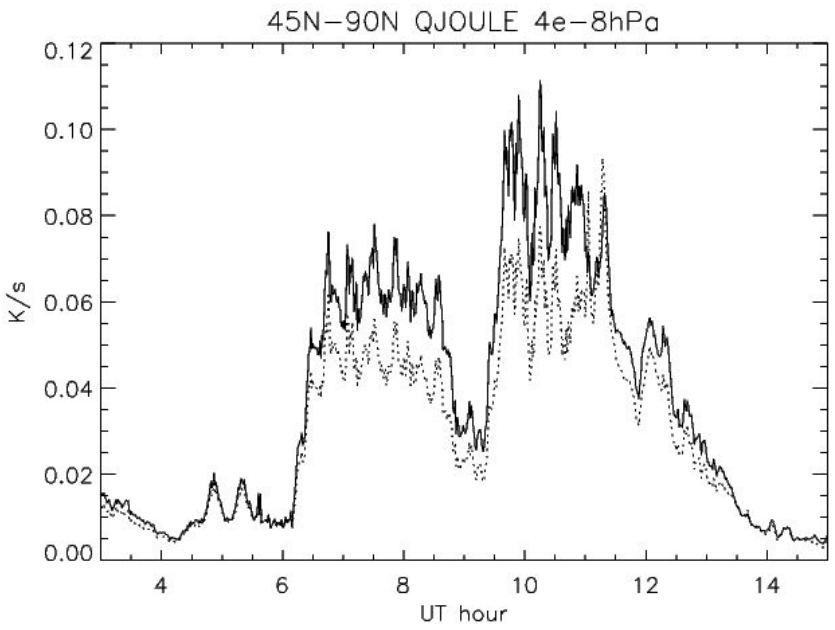


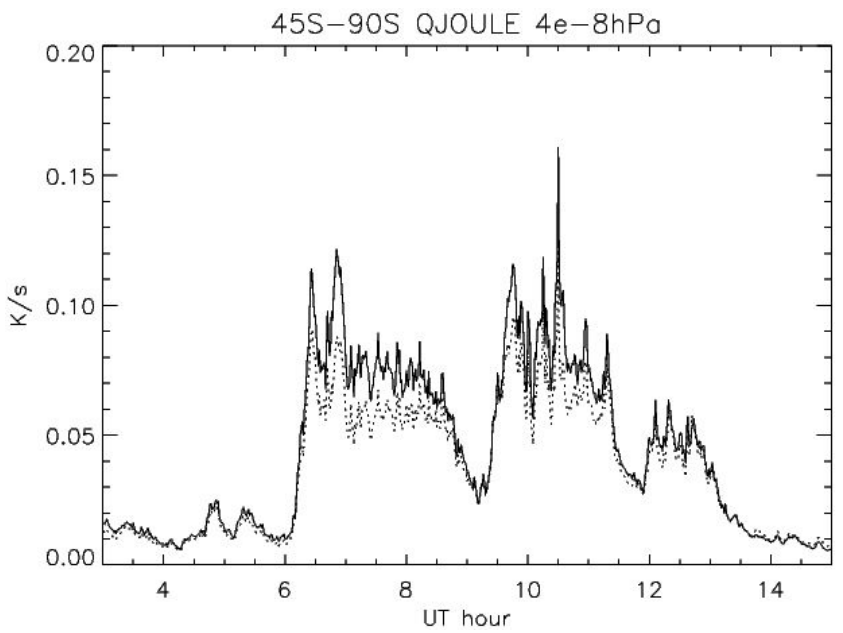

EDens [cm^-3], 24Aug 1 00:00, lon 240.50000
Pressure (mb)
1.E-09
2.E-09
5.E-09
1.E-08
2.E-08
5.E-08
1.E-07
2.E-07
5.E-07
1.E-06
2.E-06
5.E-06
1.E-05
2.E-05
5.E-05
Aprox. Alt. (km)
570
472
379
293
220
163
127
107
-50
0
50
Latitude [degrees]
1.80e+06
1.70e+06
1.60e+06
1.50e+06
1.40e+06
1.30e+06
1.20e+06
1.10e+06
1.00e+06
9.00e+05
8.00e+05
7.00e+05
6.00e+05
5.00e+05
4.00e+05
3.00e+05
2.00e+05
1.00e+05
0.00

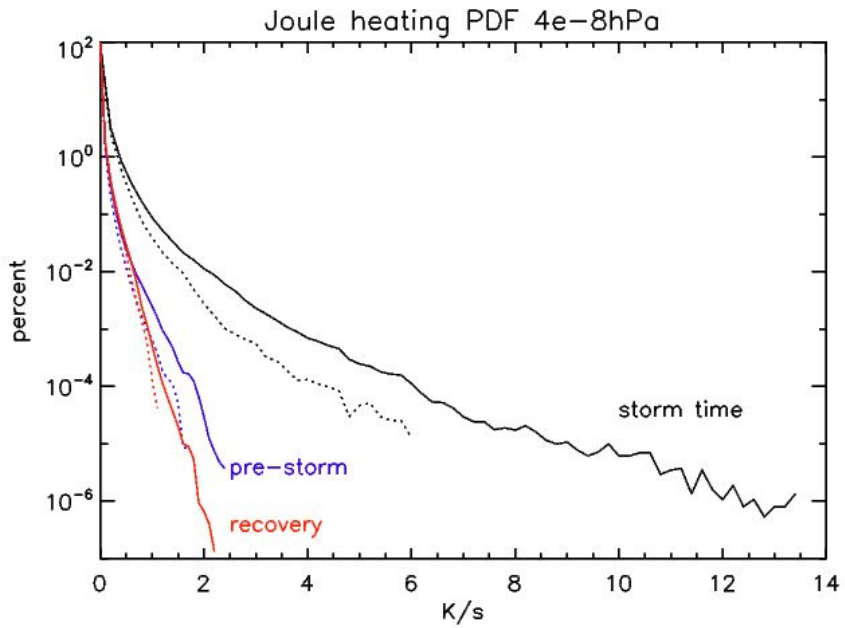

EDens [cm^-3], 24Aug 1 00:00, lon 240.46875
Pressure (mb)
1.E-09
2.E-09
5.E-09
1.E-08
2.E-08
5.E-08
1.E-07
2.E-07
5.E-07
1.E-06
2.E-06
5.E-06
1.E-05
2.E-05
5.E-05
Aprox. Alt. (km)
607
503
404
311
230
168
128
108
-50
0
50
Latitude [degrees]
3.0x10
2.20e+06
2.10e+06
2.00e+06
1.90e+06
1.80e+06
1.70e+06
1.60e+06
1.50e+06
1.40e+06
1.30e+06
1.20e+06
1.10e+06
1.00e+06
9.00e+05
8.00e+05
7.00e+05
6.00e+05
5.00e+05
4.00e+05
3.00e+05
2.00e+05
1.00e+05
0.00

Total Joule Heating at Peak Altitude

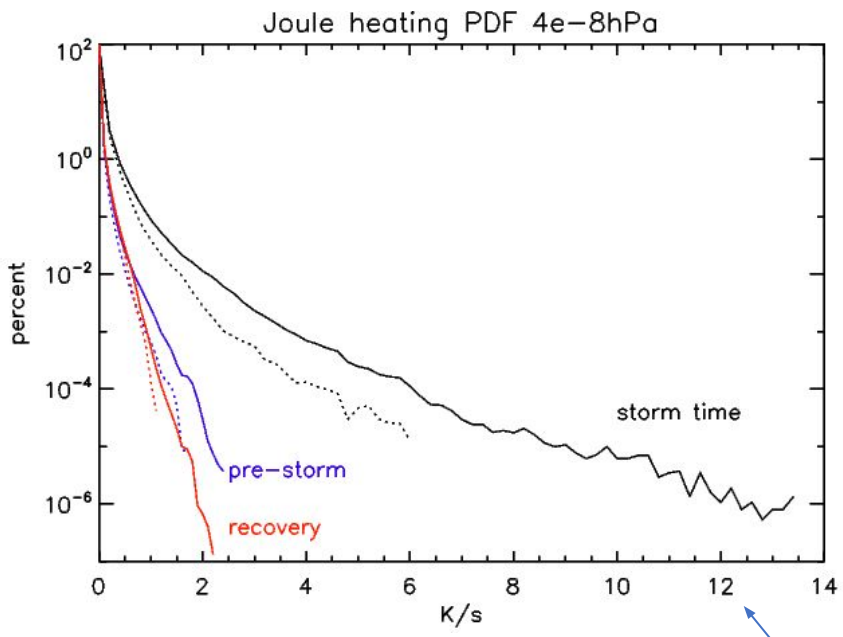


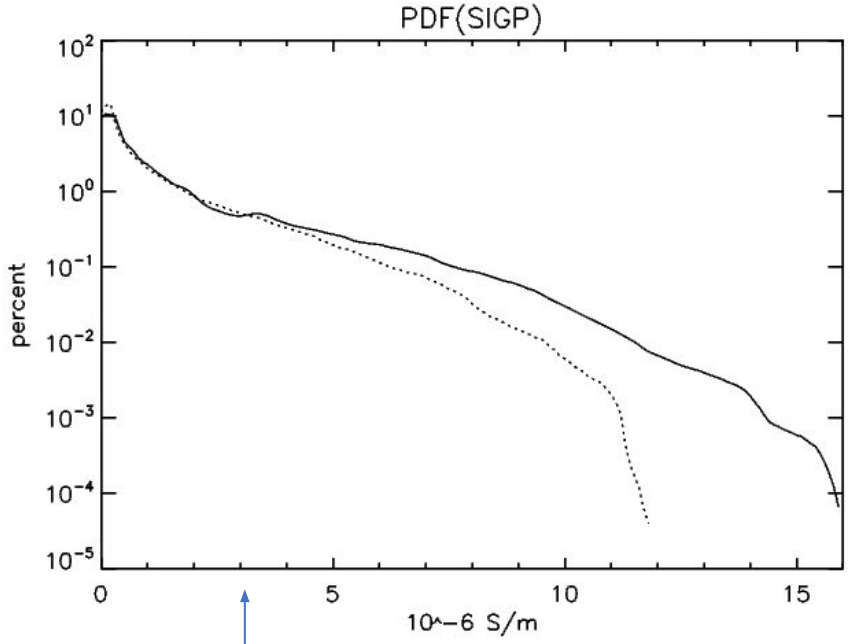


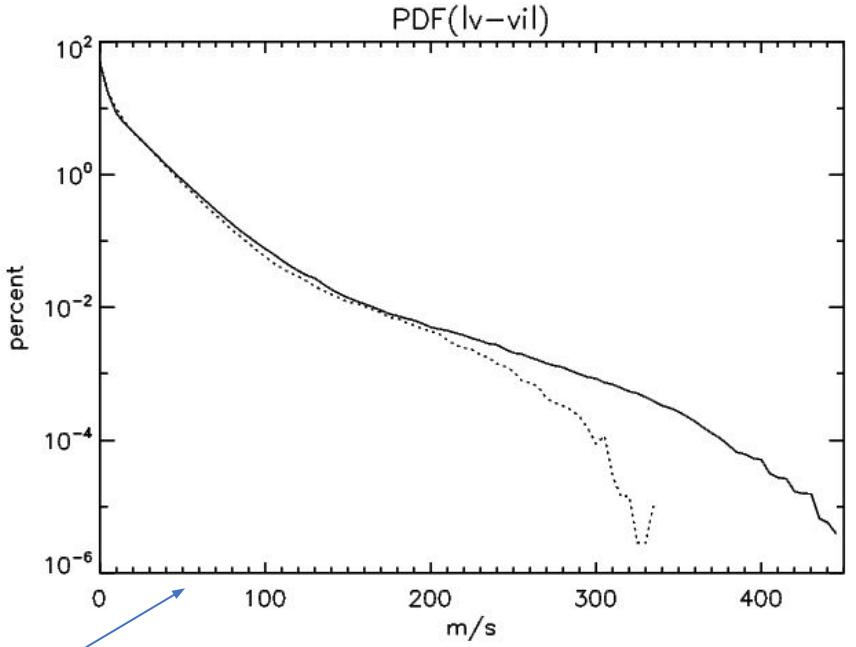




Statistics of Joule Heating

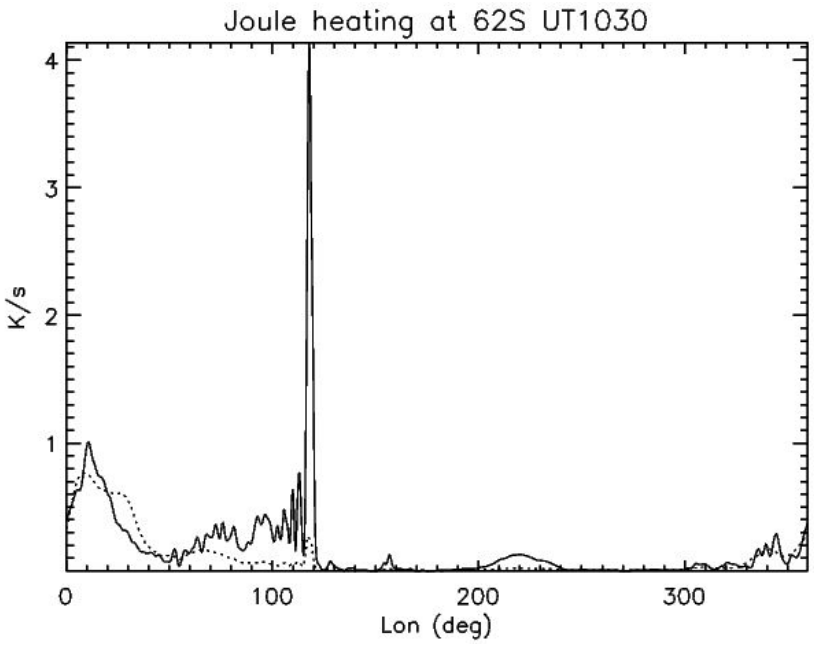


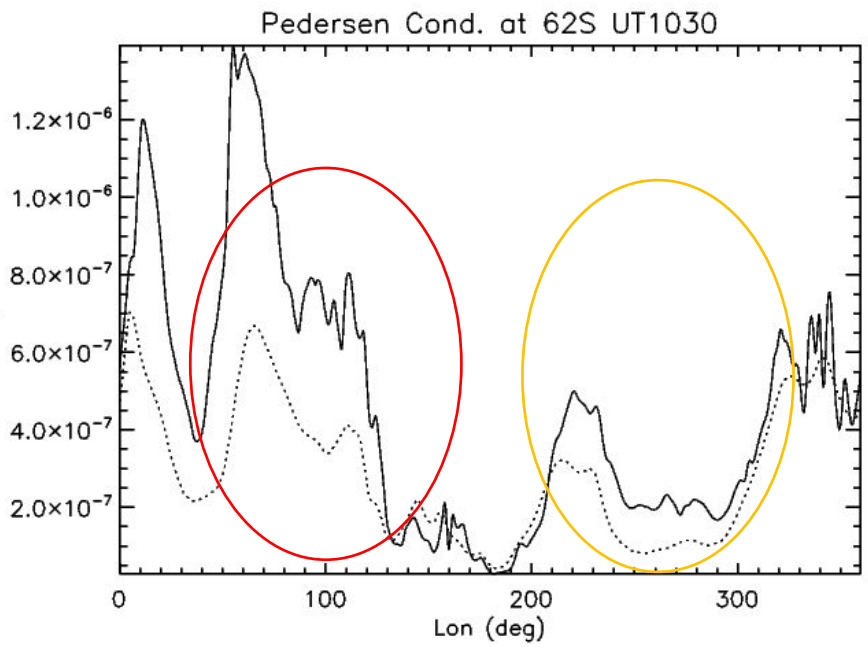


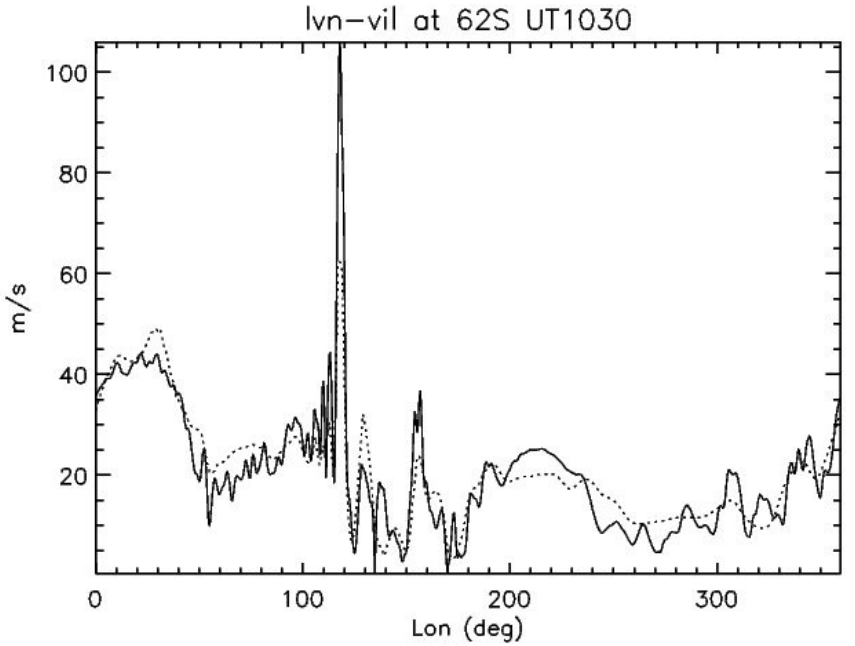


$$Q_J = \frac{\sigma_p B^2}{\rho} (\boldsymbol{V}_{\boldsymbol{E}\times\boldsymbol{B}} - \boldsymbol{V}_{\boldsymbol{n}\perp})^2$$

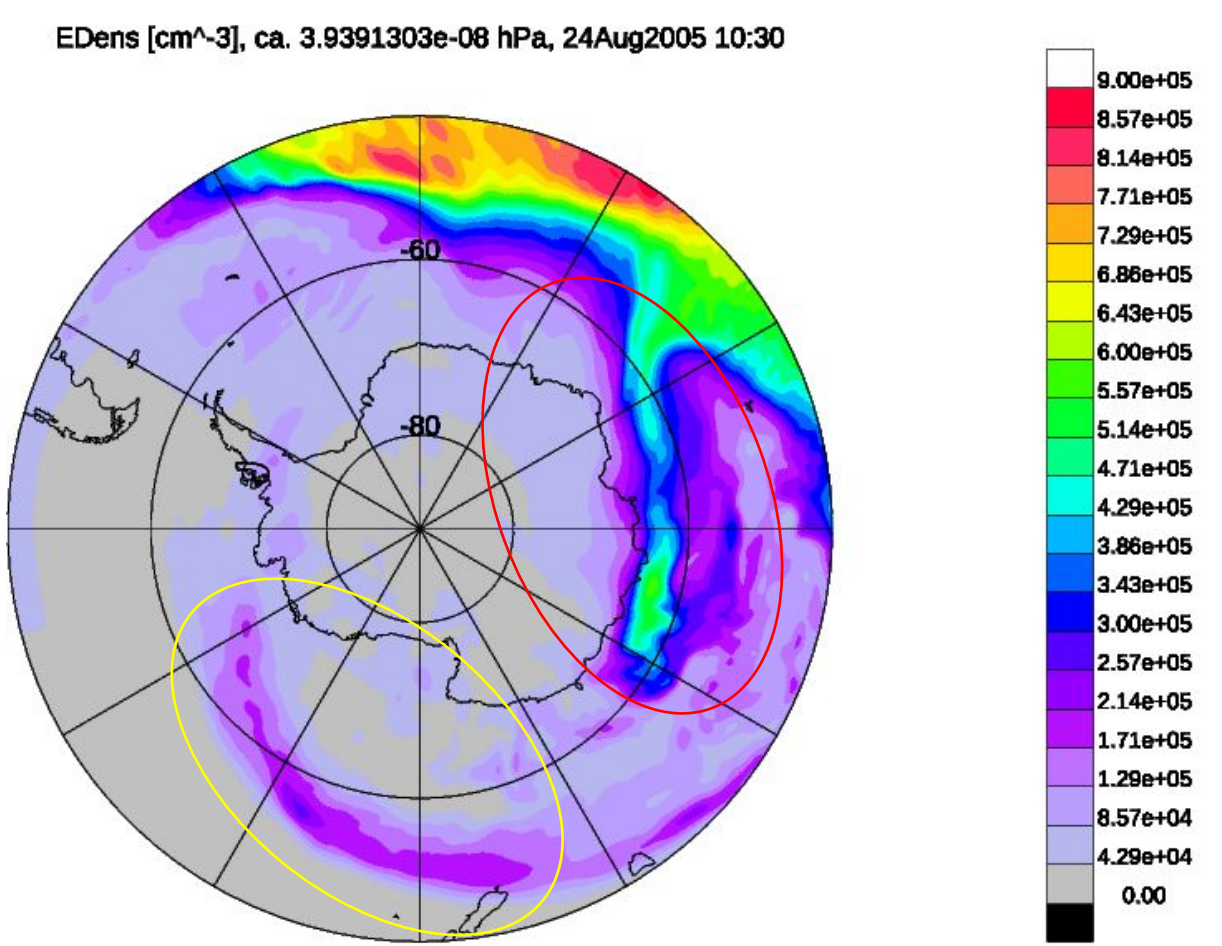
Joule heating: Conductivity and Wind/Drift Diff.

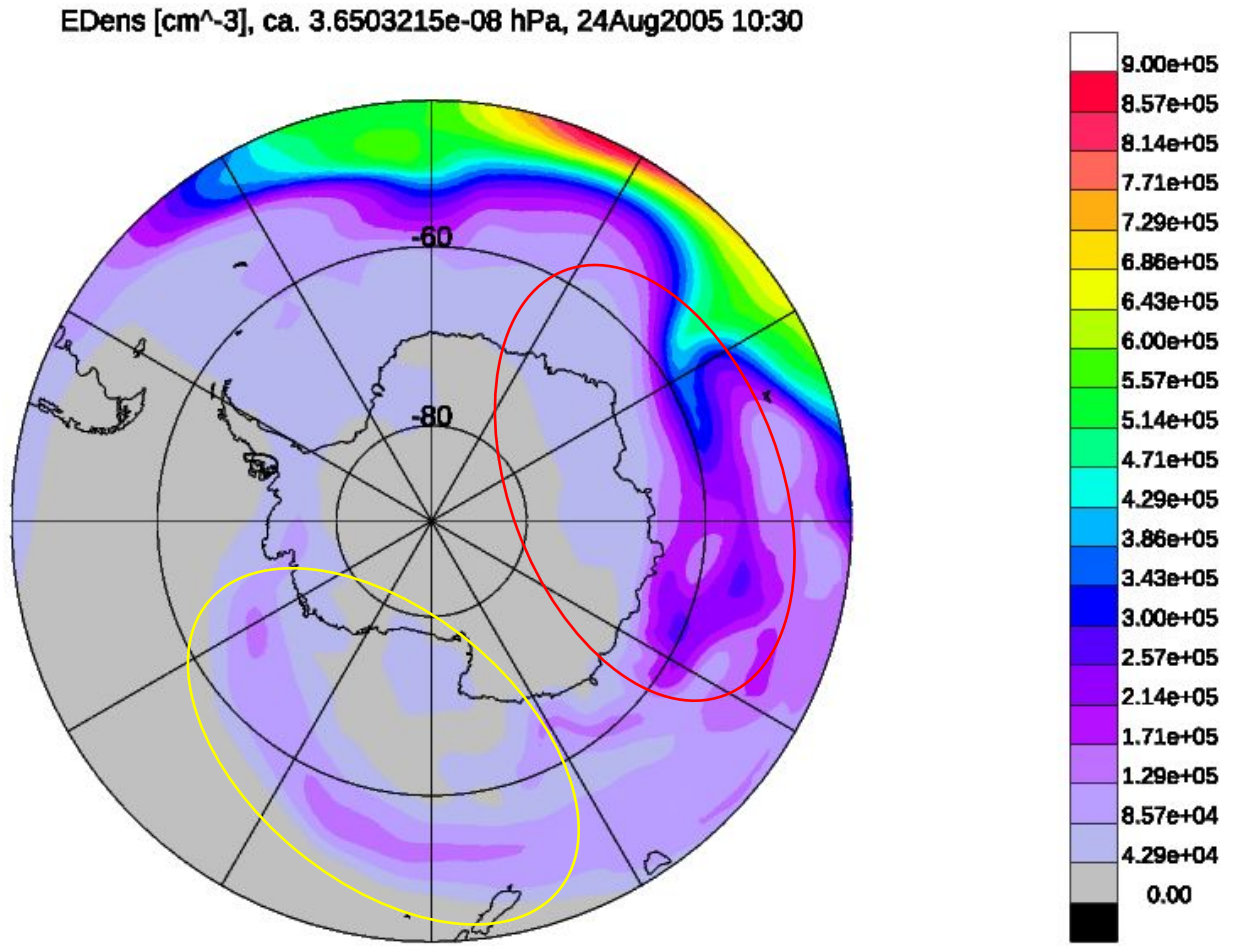




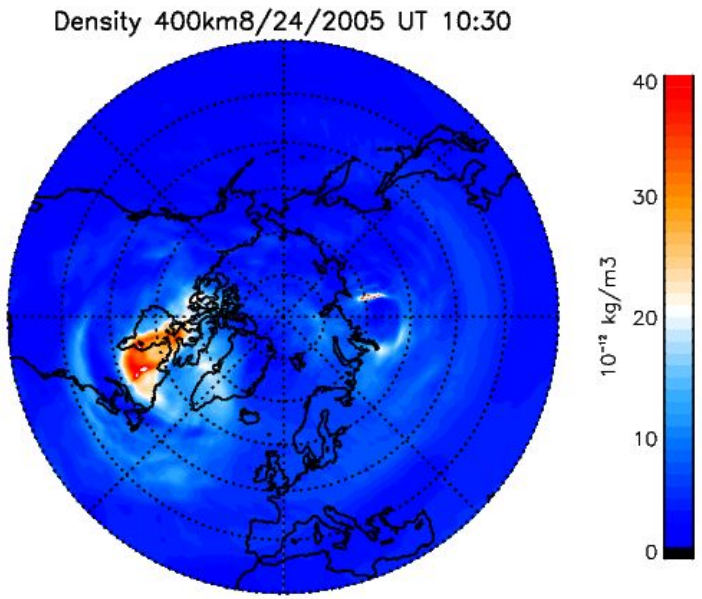


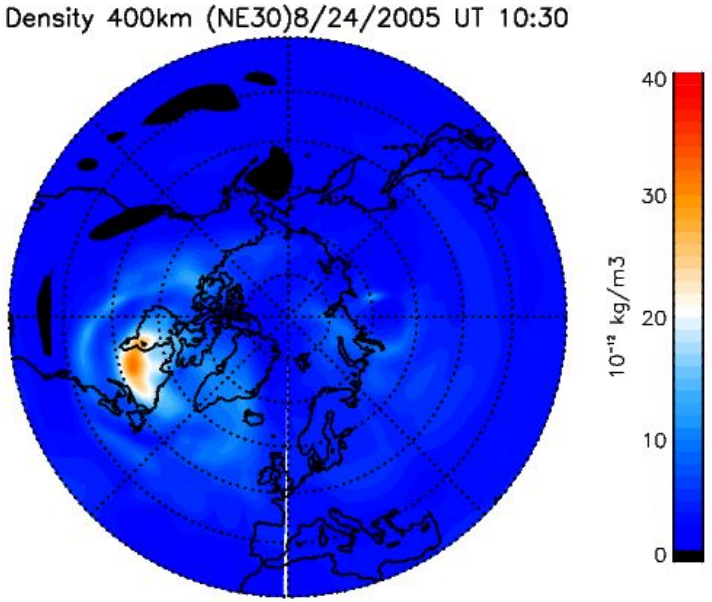
Electron Density:

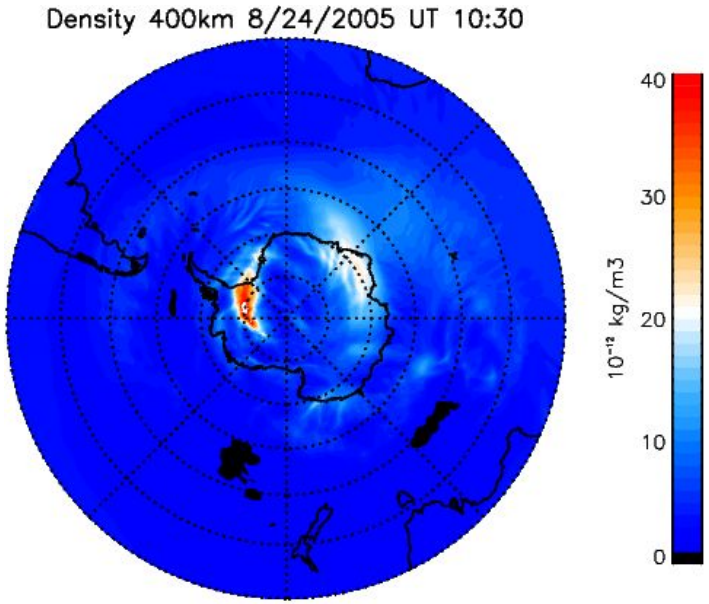


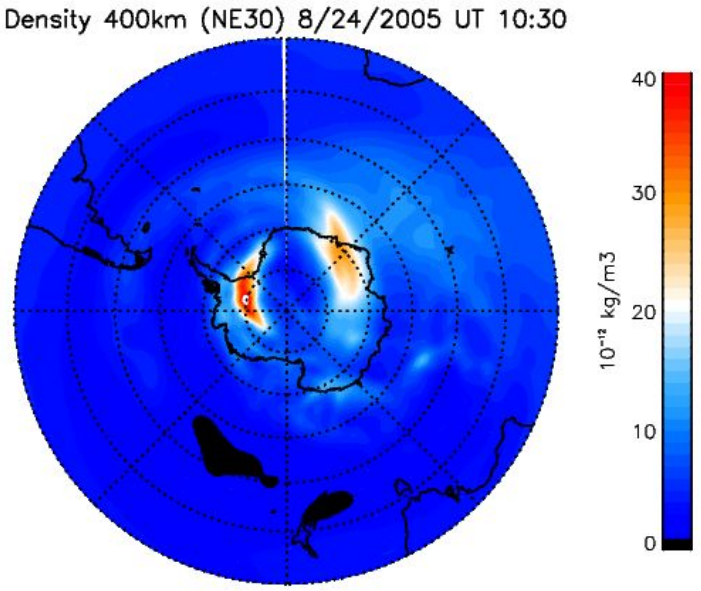


Neutral Density: UT1030

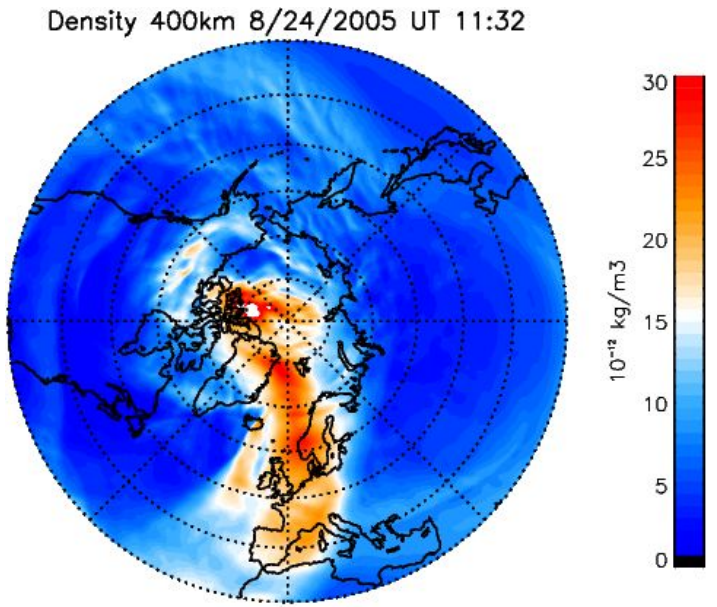


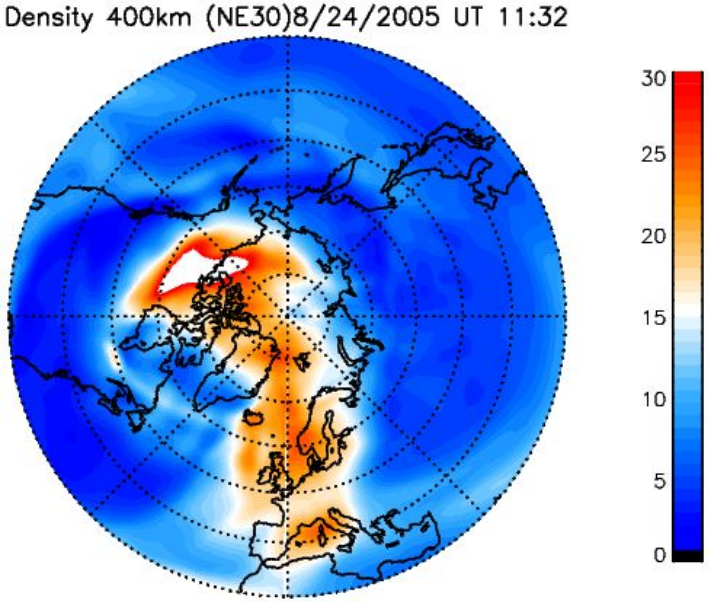


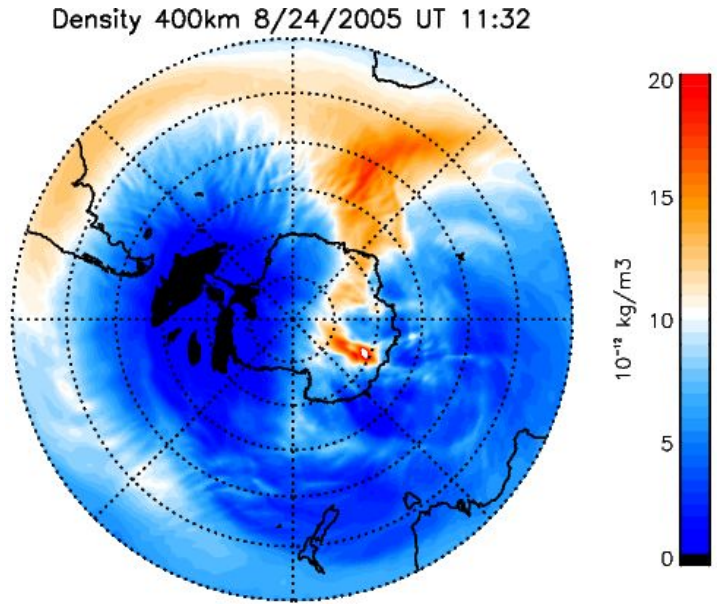


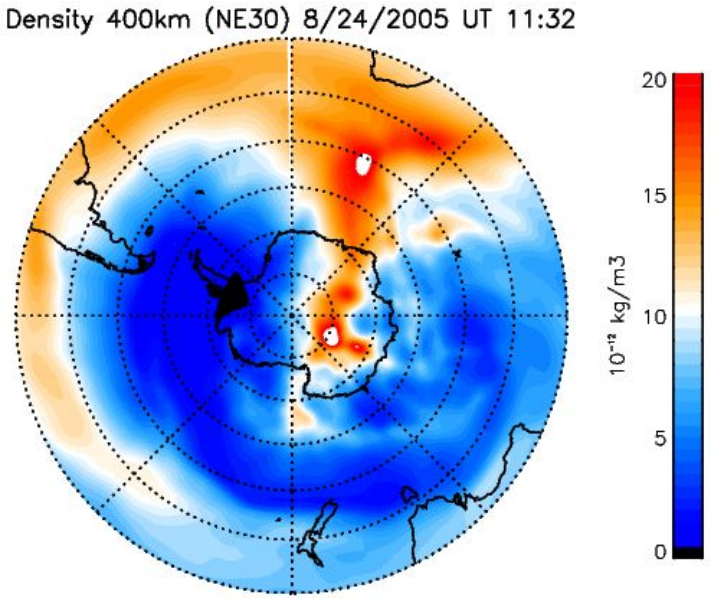


Neutral Density: UT1132

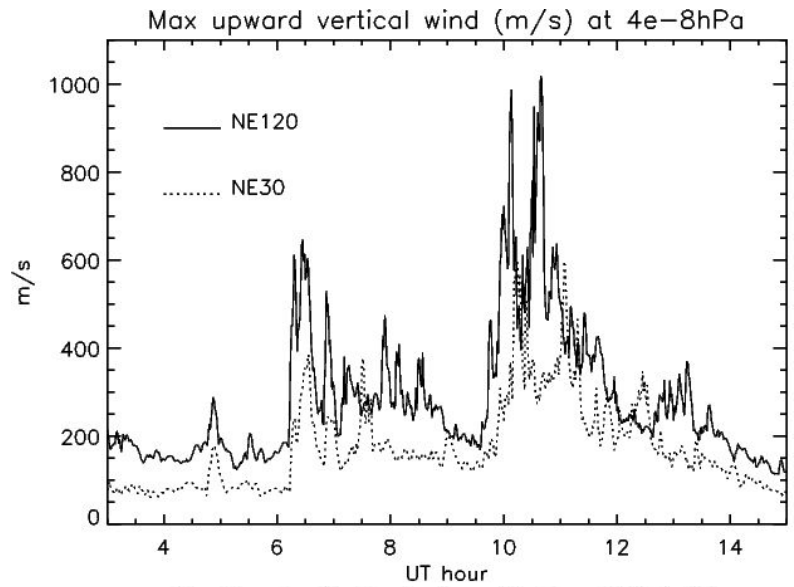


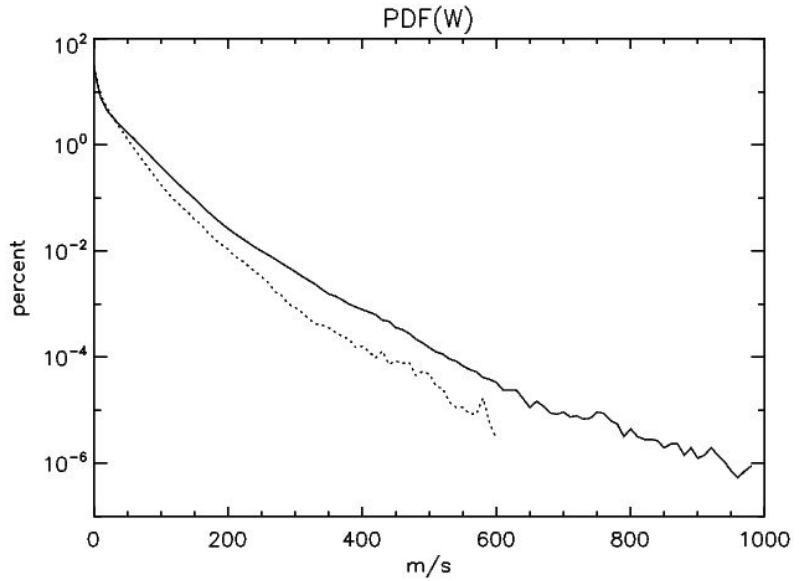


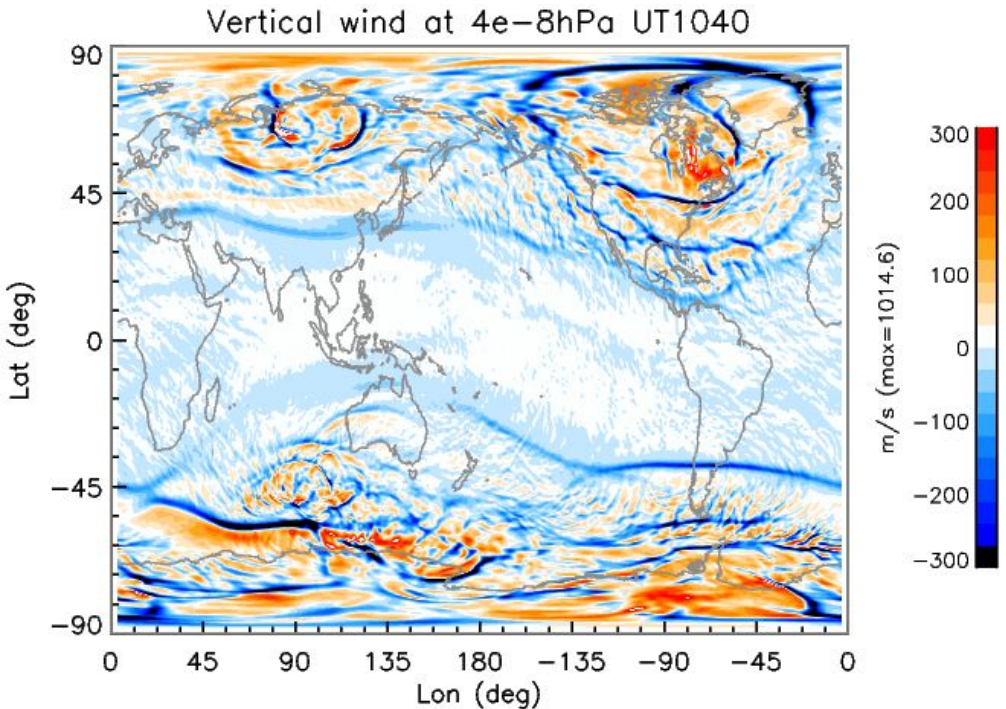


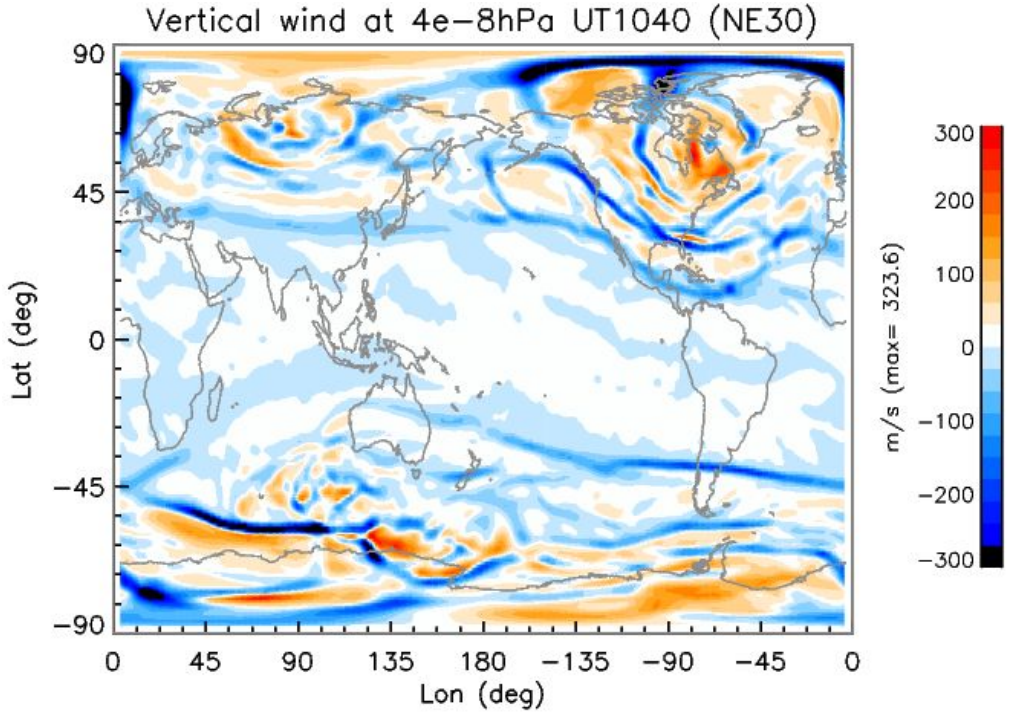


Vertical wind









Summary and Ongoing Work

- In response to the high latitude forcing from GAMERA, the energetics, dynamics, and transport display clear resolution dependence.
- Upper thermosphere Joule heating rates are generally larger in the high-resolution simulation, with larger electric conductivities and electric field perturbations.
- Much stronger tongue of ionization (TOI) is seen in the high-resolution simulation, suggesting stronger plasma transport, which leads to regional enhancement of electric conductivities.
- Stronger dynamical adjustment is seen in high-resolution simulations, both in terms of vertical motion and mesoscale wave structures.
- *Feedback effect to magnetosphere not accounted for.*
- *File-based two way WACCM-X/GAMERA coupling being tested.*