GEM-CEDAR Challenges: Measuring the Integrated Poynting Flux

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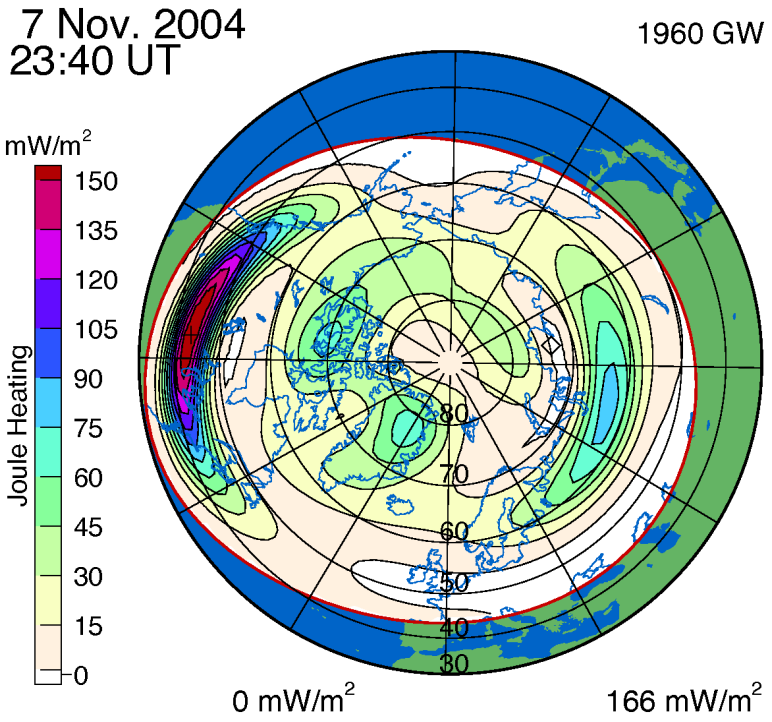
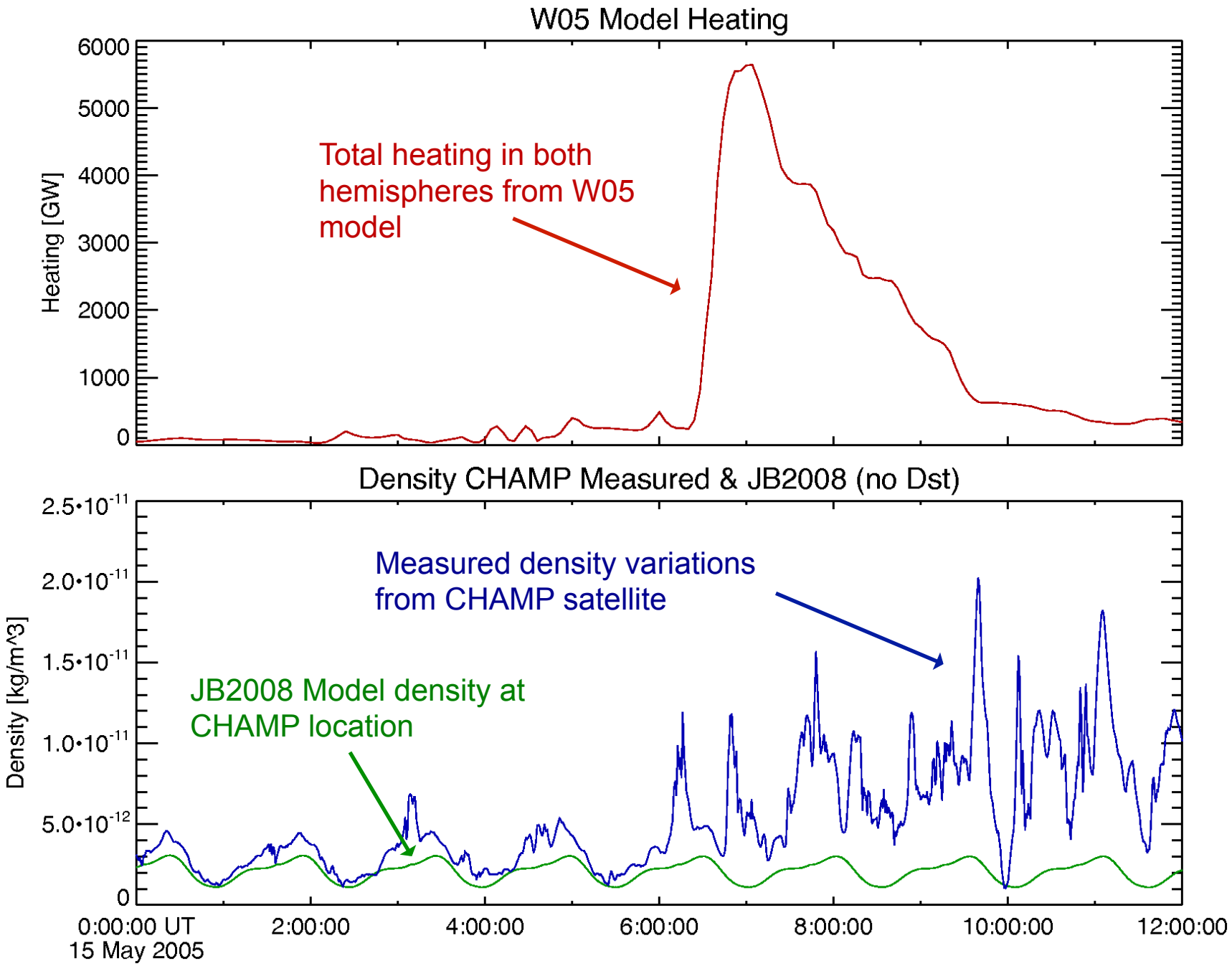
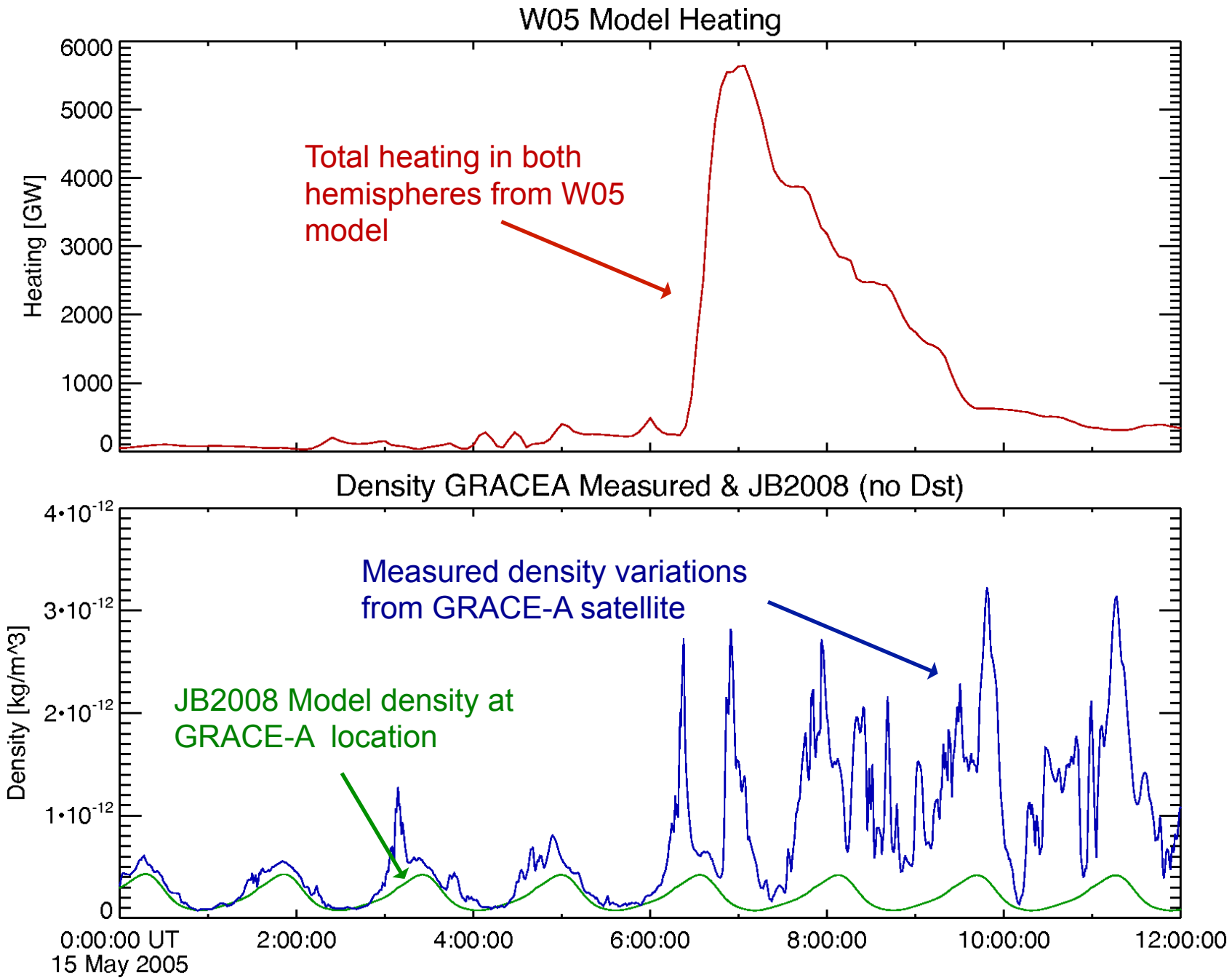


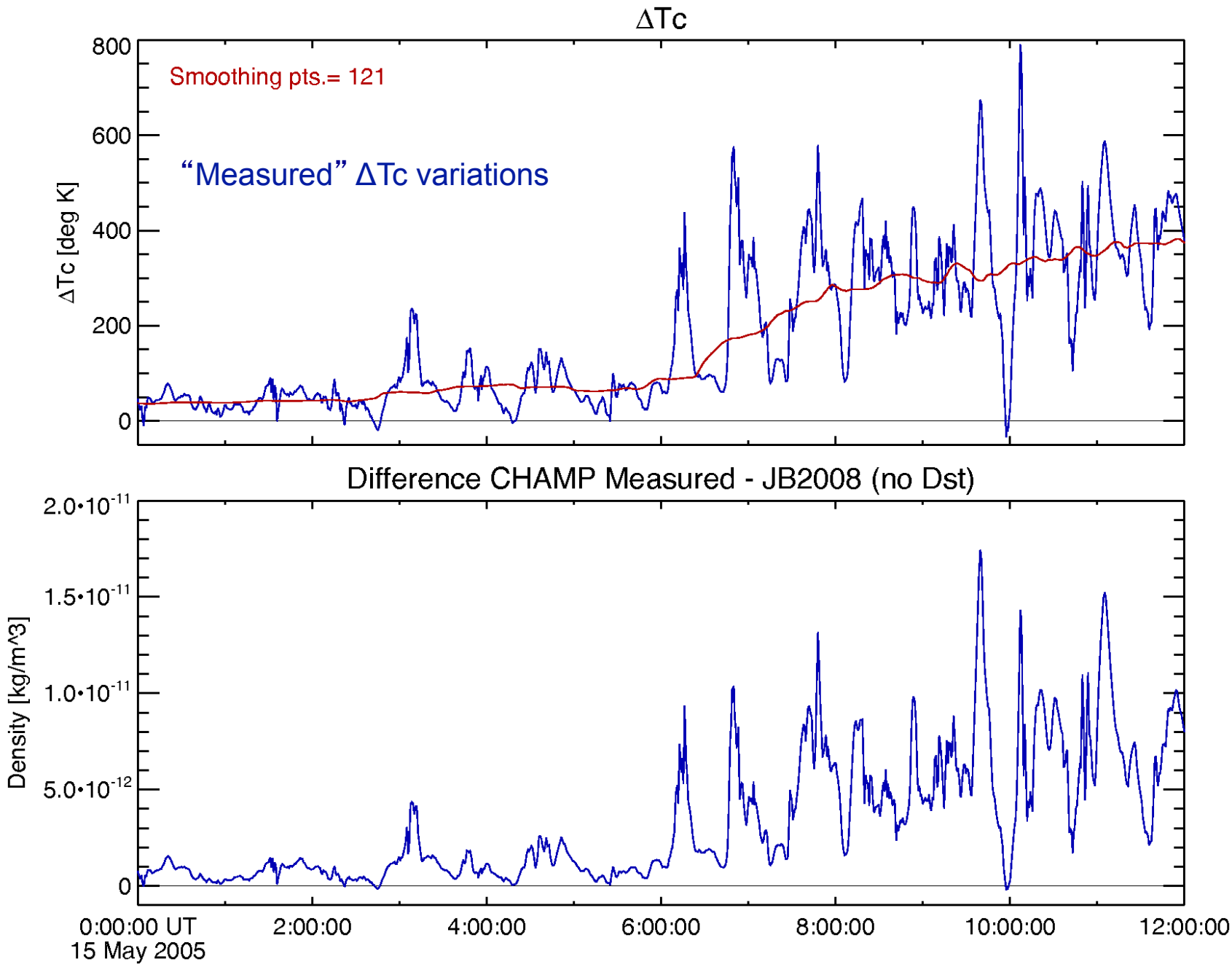
- The GEM-CEDAR Challenge presently includes Poynting flux (Joule heating) along DMSP tracks as a selected physical parameter for modeling.
- But these measurements have a sparse, uneven sampling, and don't tell much about the total heating, which is what we really want to know.
- The "Joule heating (or Poynting flux) integrated over each hemisphere in GW" is now only an "Additional time series in support of simulations results analysis."
- The integrated heating could be elevated to a "selected physical parameter.
- The thermosphere acts as a giant "calorimeter."
- Densities derived from accelerometers on the CHAMP and GRACE satellites (and future Swarm) can be used to obtain an estimate of the total heating.

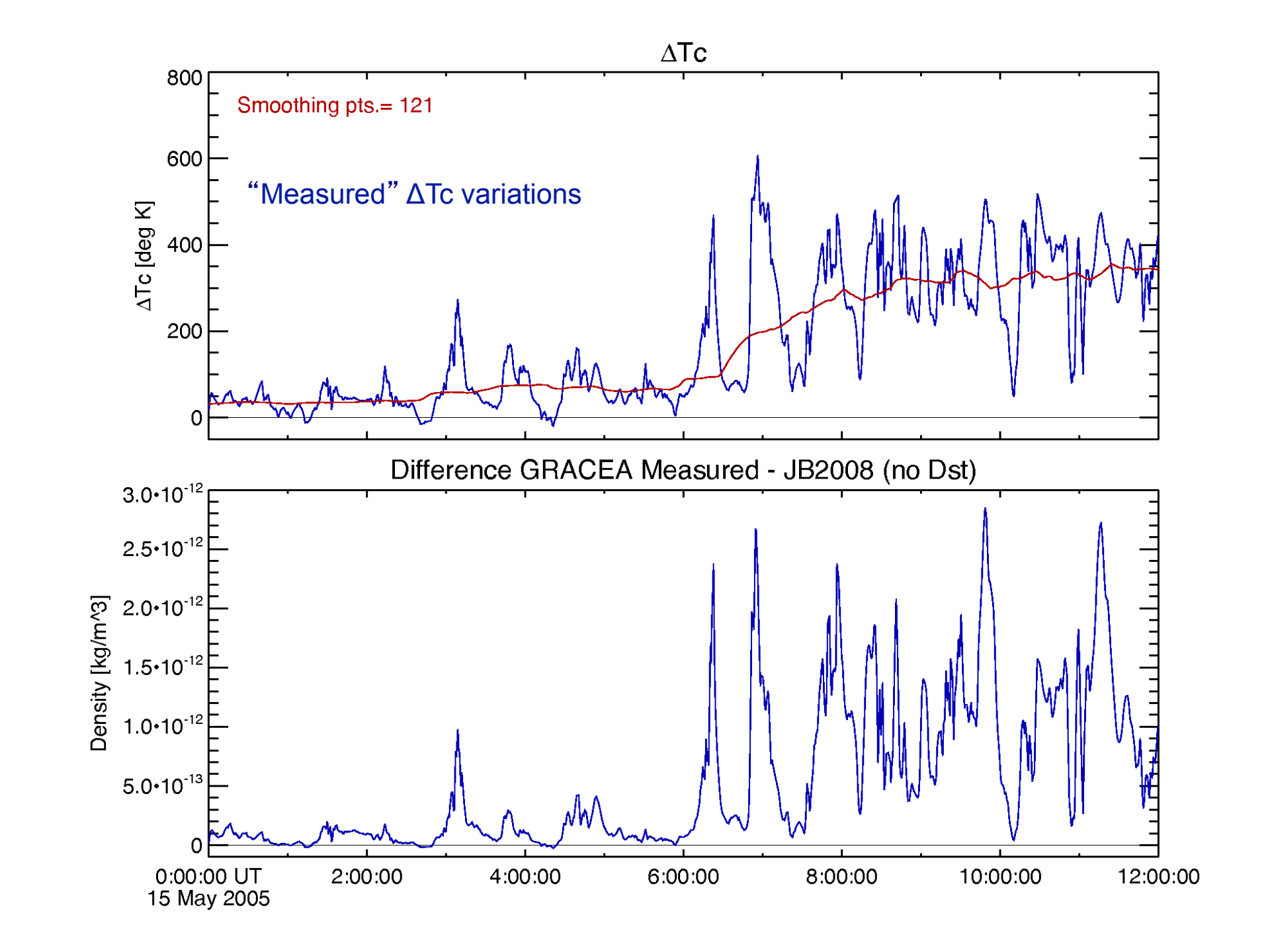
- The Jacchia-Bowman 2008 (JB2008) density model* is used.
- JB2008 code uses a parameter named T_c, representing the "global nighttime minimum exospheric temperature." Exospheric temperatures, and altitude density profiles, at all locations are derived from Tc.
- Slowly varying, "background" level of T_c is calculated from indices of solar EUV and X-ray flux.
- Faster variations, named ΔT_c, are due to auroral heating.
- ΔT_c is obtained by matching density from JB2008 with measurements.
- Burke [2008] found that 1ºK increase in ΔT_c raises the total energy in the thermosphere above 100 km altitude by 1.01•1014 Joules.
- Serves as a method to use CHAMP & GRACE data as a proxy measurement of thermosphere's temperature and energy.

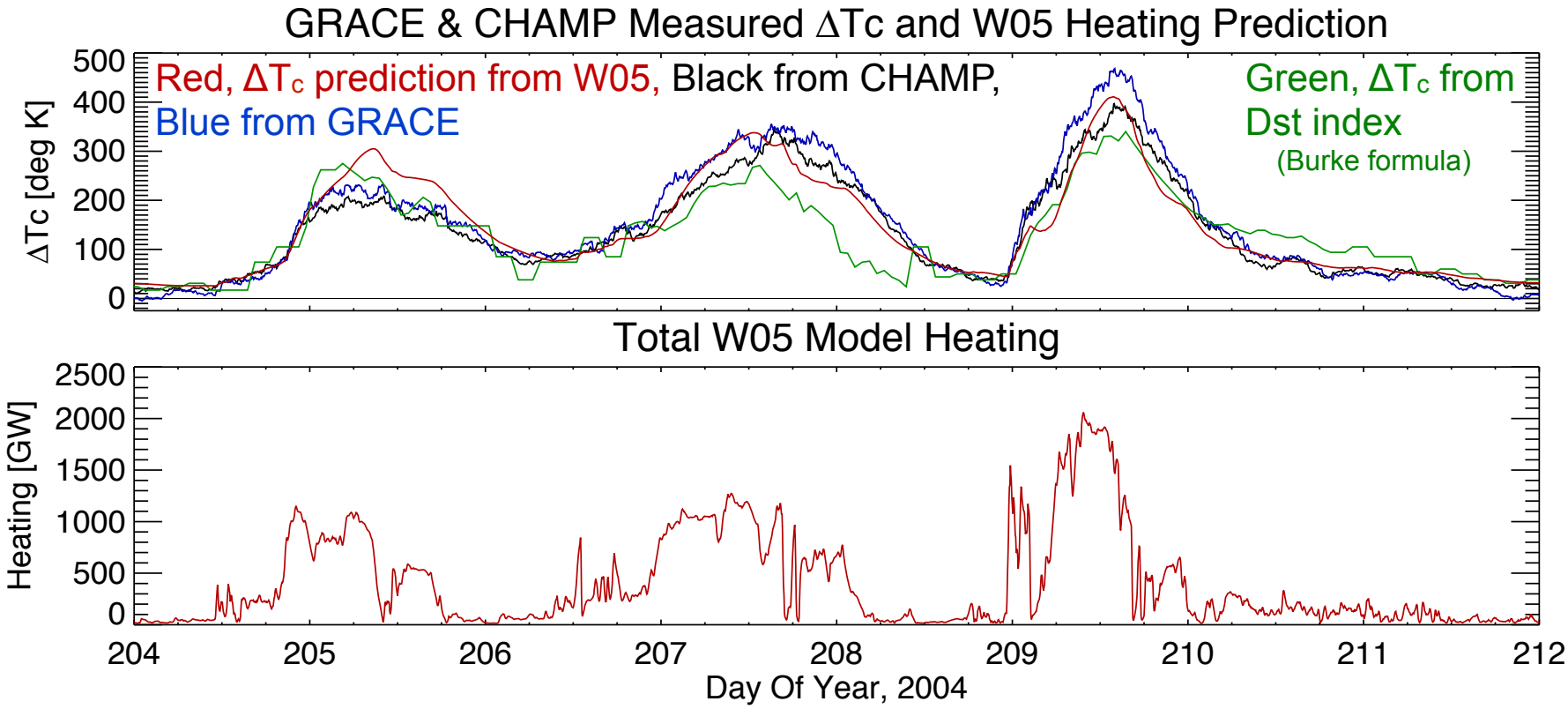
* Bowman, B. R., W. K. Tobiska, F. A. Marcos, C. Y. Huang, C. S. Lin, and W. J. Burke, A new empirical thermospheric density model JB2008 using new solar and geomagnetic indices, in AIAA 2008-6438, AIAA Astrodynamics Conference, Honolulu, HI, 2008.


W05 Model Heating
Heating [GW]
6000
5000
4000
3000
2000
1000
0
Total heating in both hemispheres from W05 model
Density CHAMP Measured & JB2008 (no Dst)
Density [kg/m^3]
2.5•10^-11
2.0•10^-11
1.5•10^-11
1.0•10^-11
5.0•10^-12
0
Measured density variations from CHAMP satellite
JB2008 Model density at CHAMP location
0:00:00 UT
15 May 2005
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00


W05 Model Heating
Heating [GW]
6000
5000
4000
3000
2000
1000
0
Total heating in both hemispheres from W05 model
Density GRACEA Measured & JB2008 (no Dst)
Density [kg/m^3]
4•10-12
3•10-12
2•10-12
1•10-12
0
Measured density variations from GRACE-A satellite
JB2008 Model density at GRACE-A location
0:00:00 UT
15 May 2005
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00


ΔTc
Smoothing pts.= 121
"Measured" ΔTc variations
ΔTc [deg K]
800
600
400
200
0
Difference CHAMP Measured - JB2008 (no Dst)
Density [kg/m^3]
2.0•10^-11
1.5•10^-11
1.0•10^-11
5.0•10^-12
0
0:00:00 UT
15 May 2005
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00


ΔTc
Smoothing pts.= 121
"Measured" ΔTc variations
ΔTc [deg K]
800
600
400
200
0
Difference GRACEA Measured - JB2008 (no Dst)
Density [kg/m^3]
3.0•10^-12
2.5•10^-12
2.0•10^-12
1.5•10^-12
1.0•10^-12
5.0•10^-13
0
0:00:00 UT
15 May 2005
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00


GRACE & CHAMP Measured ΔTc and W05 Heating Prediction
Red, ΔTc prediction from W05, Black from CHAMP,
Blue from GRACE
Green, ΔTc from
Dst index
(Burke formula)
ΔTc [deg K]
500
400
300
200
100
0
Total W05 Model Heating
Heating [GW]
2500
2000
1500
1000
500
0
204
205
206
207
208
209
210
211
212
Day Of Year, 2004

For more information:

Bowman, B. R., W. K. Tobiska, F. A. Marcos, C. Y. Huang, C. S. Lin, and W. J. Burke, A new empirical thermospheric density model JB2008 using new solar and geomagnetic indices, in AIAA 2008-6438, AIAA Astrodynamics Conference, Honolulu, HI, 2008.

Burke, W. J., Stormtime energy budgets of the global thermosphere, in Mid-Latitude Ionospheric Dynamics and Disturbances, Geophys. Monogr. Ser., vol. 181, edited by P. M. Kintner and et al., pp. 235–246, AGU, Washington, DC, 2008.

Burke, W. J., C. S. Lin, M. P. Hagan, C. Y. Huang, D. R. Weimer, J. O. Wise, L. C. Gentile, and F. A. Marcos, Stormtime global thermosphere: A driven-dissipative thermodynamic system, J. Geophys. Res., 114, A06306, doi: 10.1029/2008JA013848, 2009.

Weimer, D. R., B. R. Bowman, E. K. Sutton, and W. K. Tobiska, Predicting global average thermospheric temperature changes resulting from auroral heating, J. Geophys. Res., 116, A01312, doi:10.1029/2010JA015685, 2011.