
Impact of high speed solar wind streams on the thermosphere/ionosphere

Jiuhou Lei

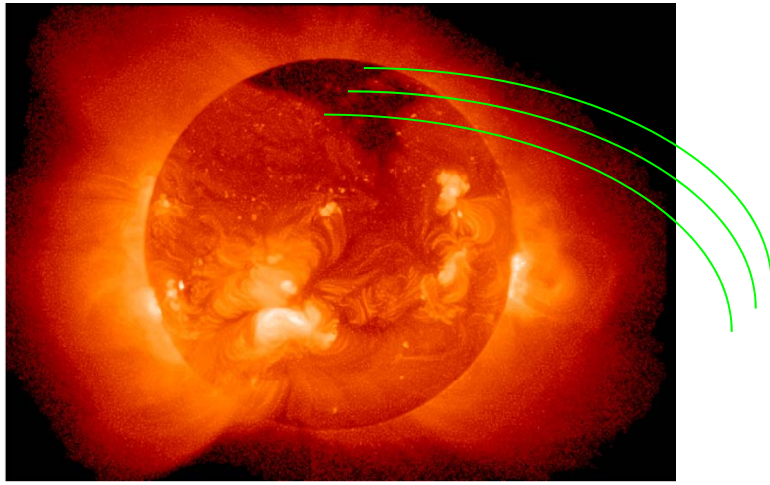
Aerospace Engineering Sciences
University of Colorado

Acknowledgement:

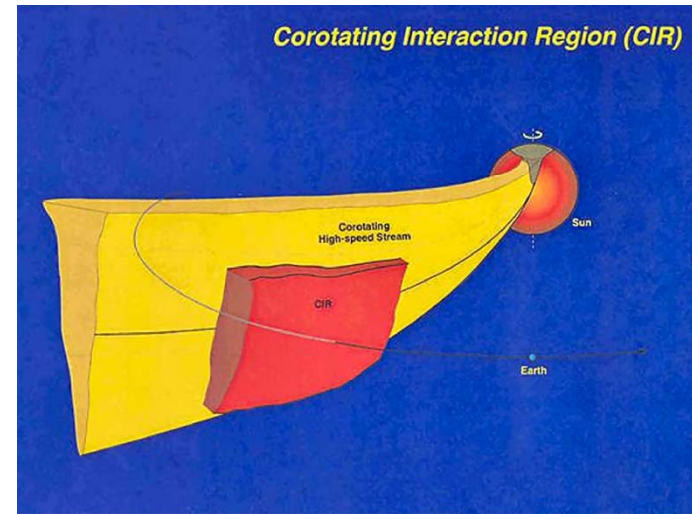
J. P. Thayer, J. M. Forbes, E. Sutton, L. C. Chang, S. E. Palo (CU), G. Crowley (ASTRA), M. Mlynczak (NASA), M. Temmer, and A. M. Veronig (Austria), Q. Wu, L. Qian, S. Solomon, S. E. Gibson, B. A. Emery, G. de Toma (NCAR), J. J. Sojka (USU)



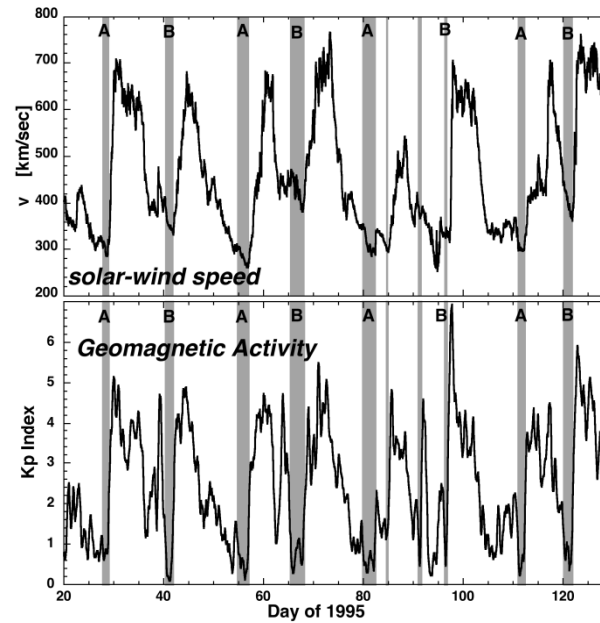
Origin of High Speed Solar Wind Streams



Yohkoh image-soft X rays



Tsurutani et al., JGR, 2006



Borovsky and Steinberg, JGR, 2006

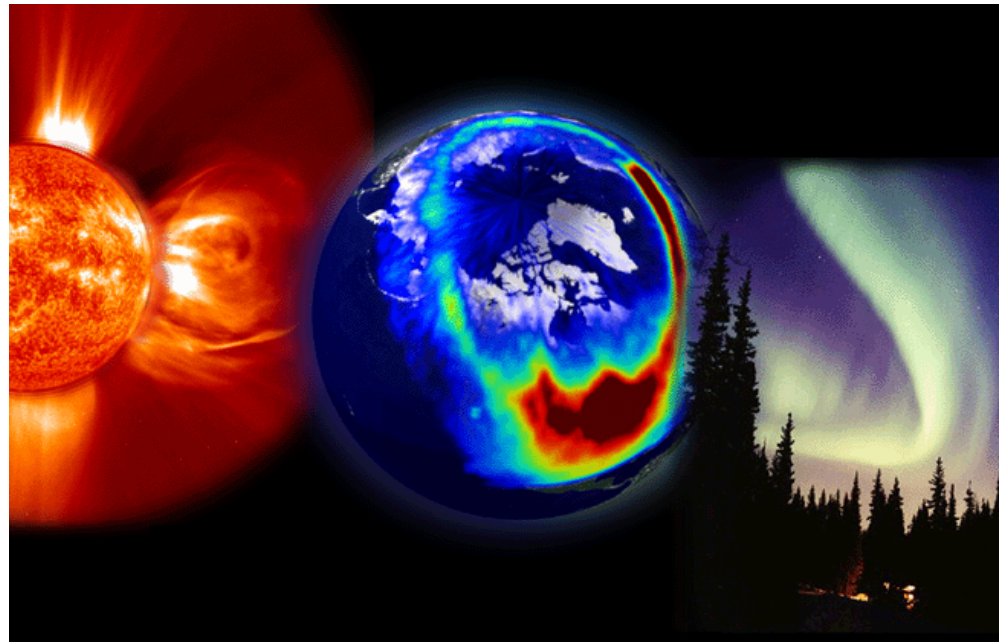
Borovsky and Denton, JGR, 2006

Upper Atmosphere Episodes of Change at Multi-Day Periodicities

Discovery: Recent measurements have discovered episodes of change in the Earth's upper atmosphere at periods near **5, 7 and 9 days** that are attributed to recurrent high speed solar wind stream disturbances and coronal hole distributions on the sun.

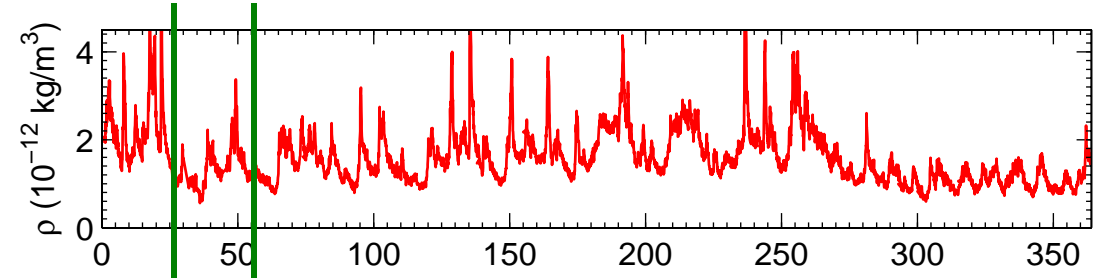
Thermosphere / Ionosphere Properties:

- Thermosphere Mass Density at 400km
- NO and CO₂ IR emissions
- Columnar O/N₂ ratio
- Global total electron content
- ISR ion temperature
- F-region Neutral Temperature and Winds
- SABER MLT Temperature

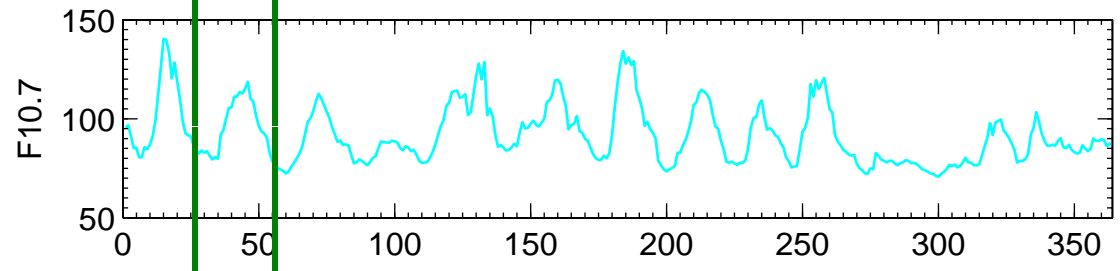


Periodic Thermosphere Mass Density Perturbations in 2005

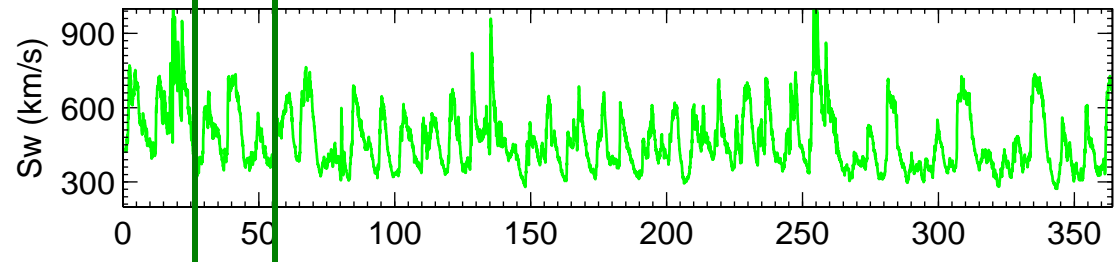
Density - 400km altitude



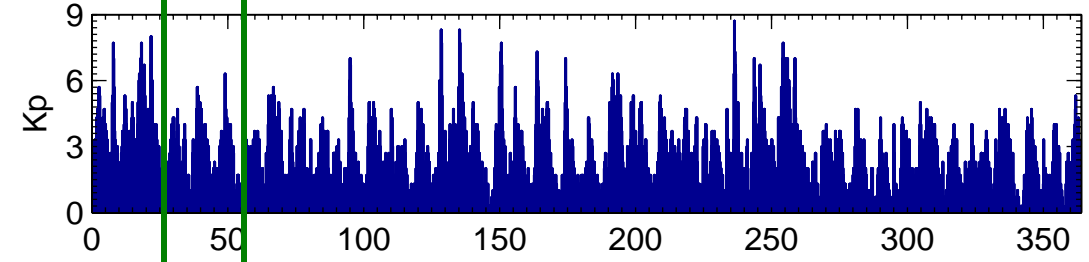
Solar flux proxy



Solar wind speed



Geomagnetic Activity Index



Day of Year, 2005

2005 Periodograms – Subharmonics of a Solar Rotation

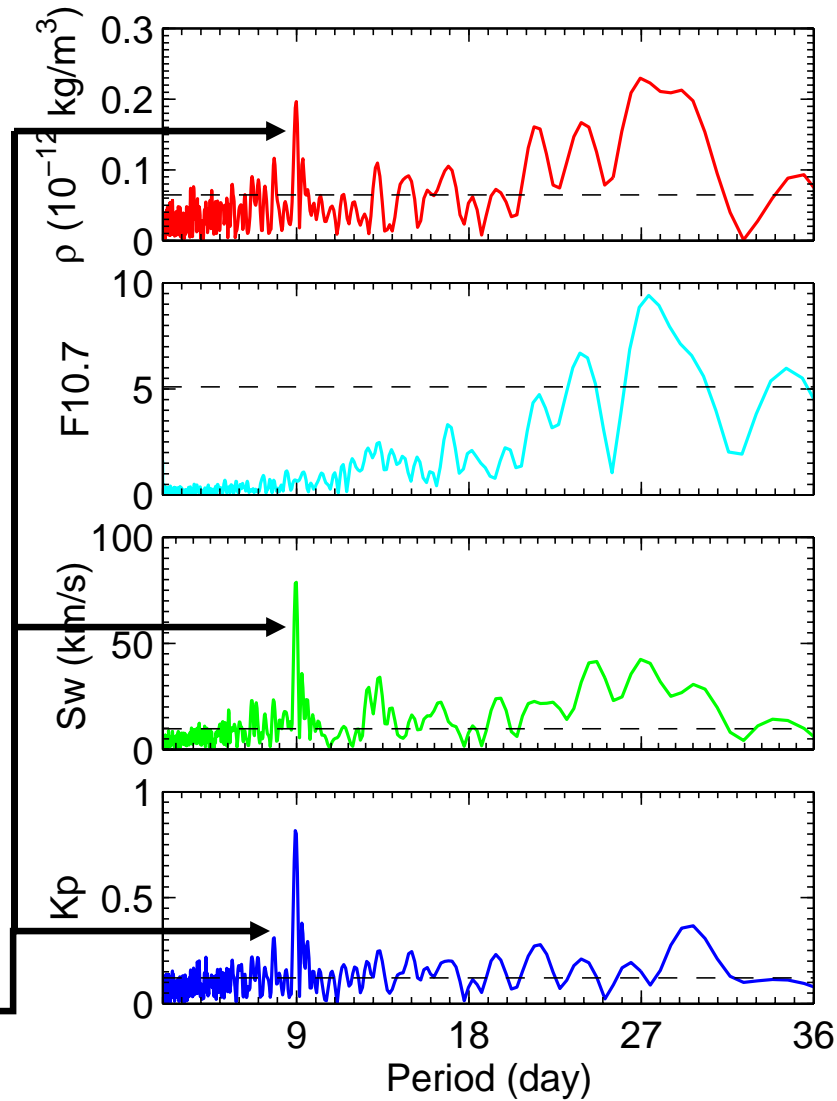
Density - 400km altitude

Solar EUV flux index

Solar wind speed

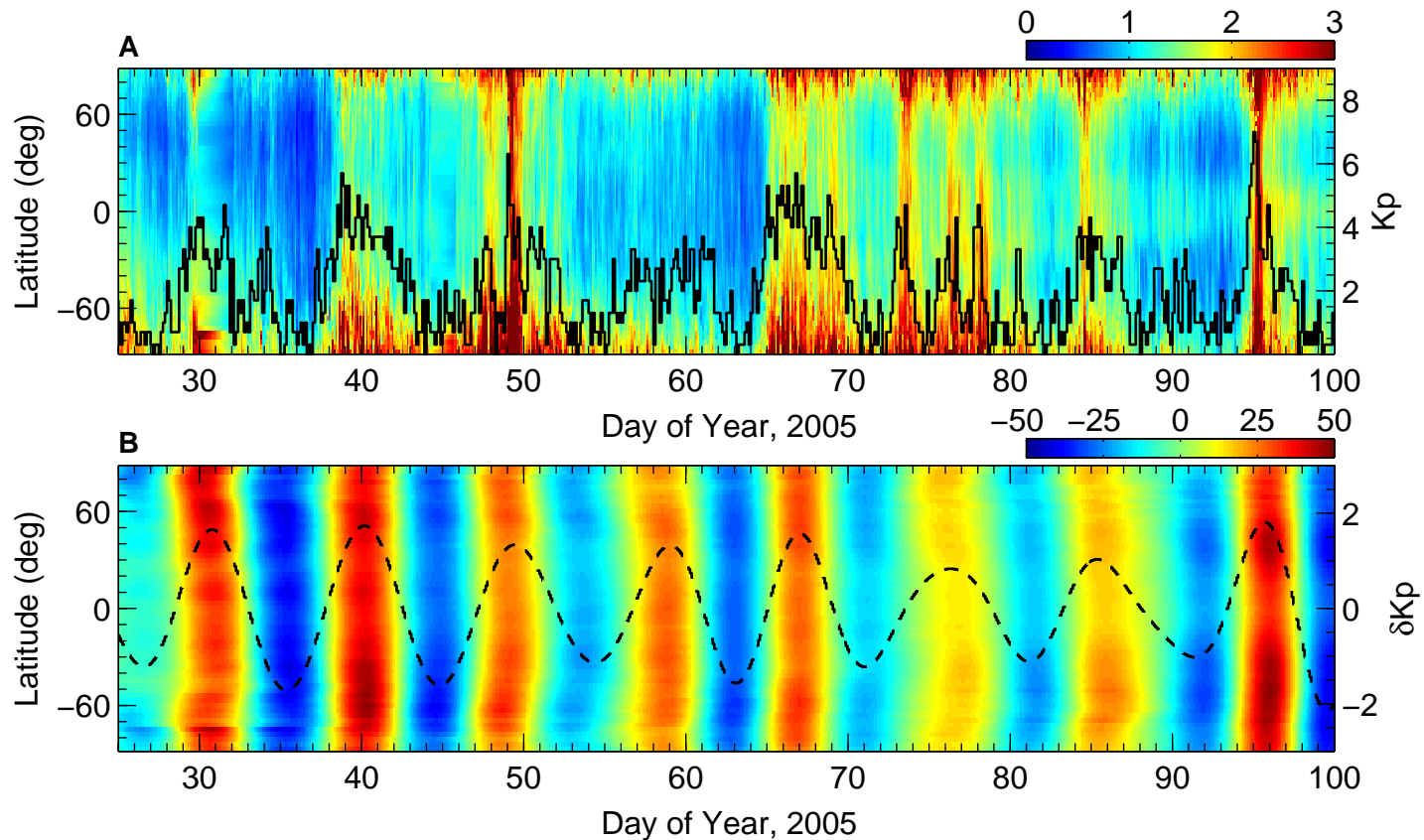
Geomagnetic Activity Index

27 days/3



The recurrent geomagnetic activity effects can be isolated

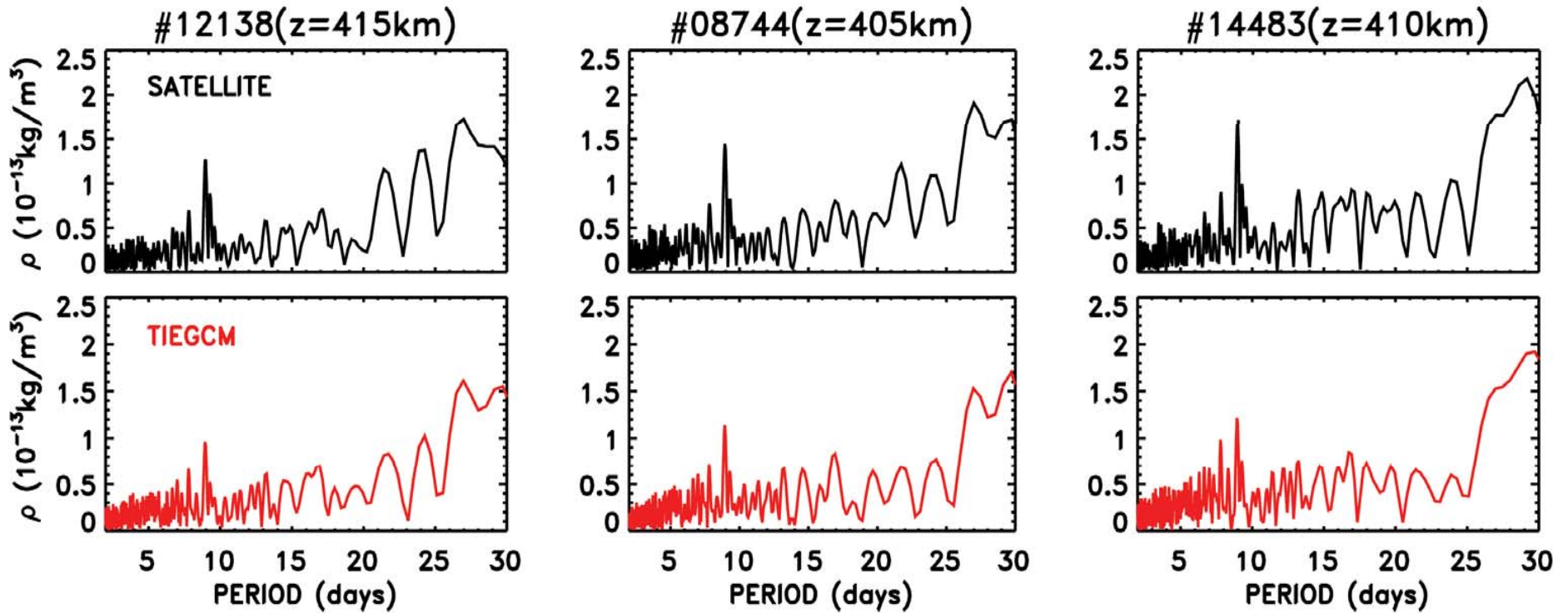
Latitudinal Structure of 9-day Oscillations in Neutral Density



The periodic oscillations in neutral density are felt globally, and are proportional to the periodic Kp perturbations at the same frequency.



Periodicity of Measured and Modeled Neutral Density in 2005

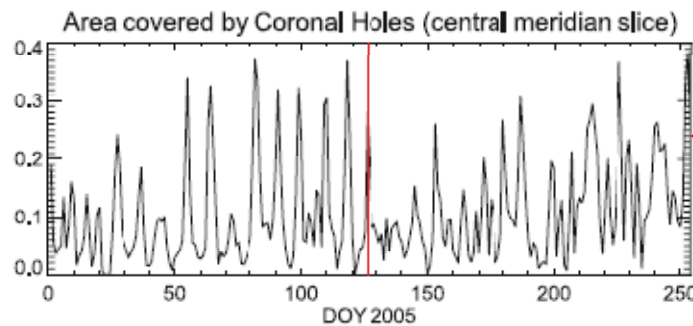
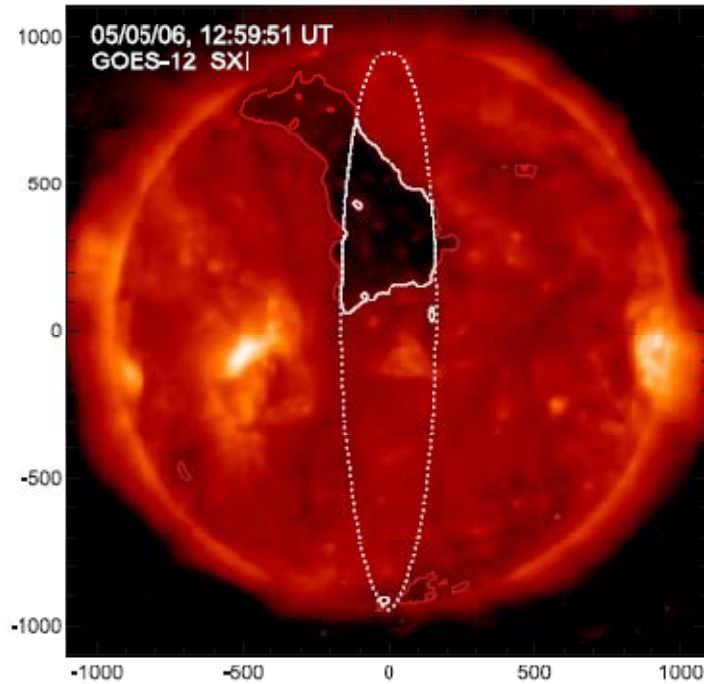


No planetary wave effects in this simulation

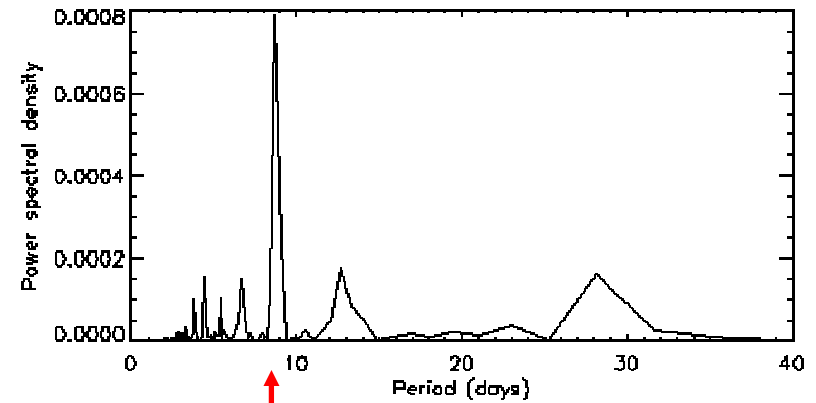


Courtesy of L. Qian and S. Solomon

Coronal Holes Distribution



2005

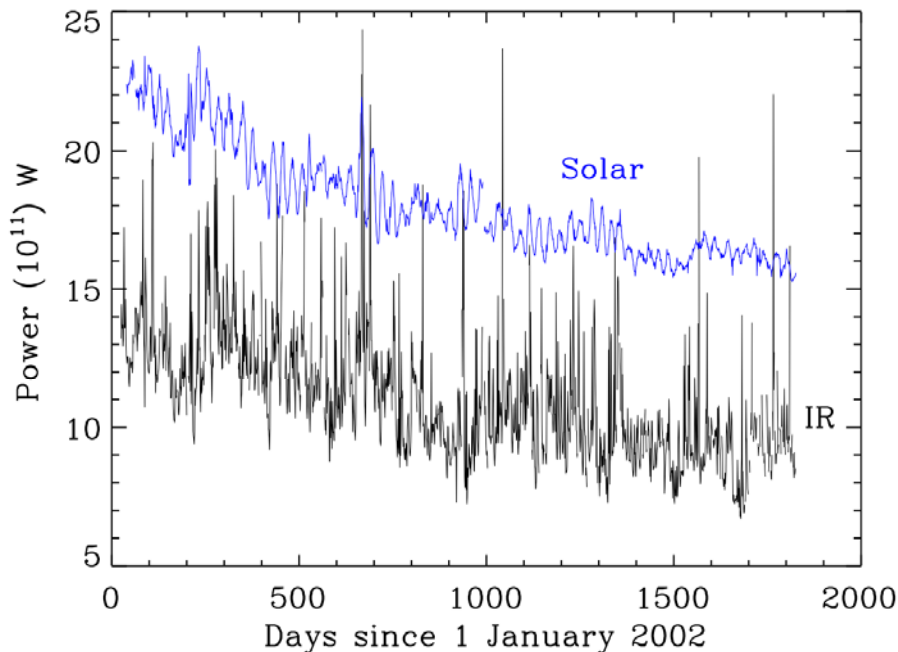


Temmer et al., Sol. Phy., 2007

Solar coronal holes distributed roughly 120 degrees apart in longitude

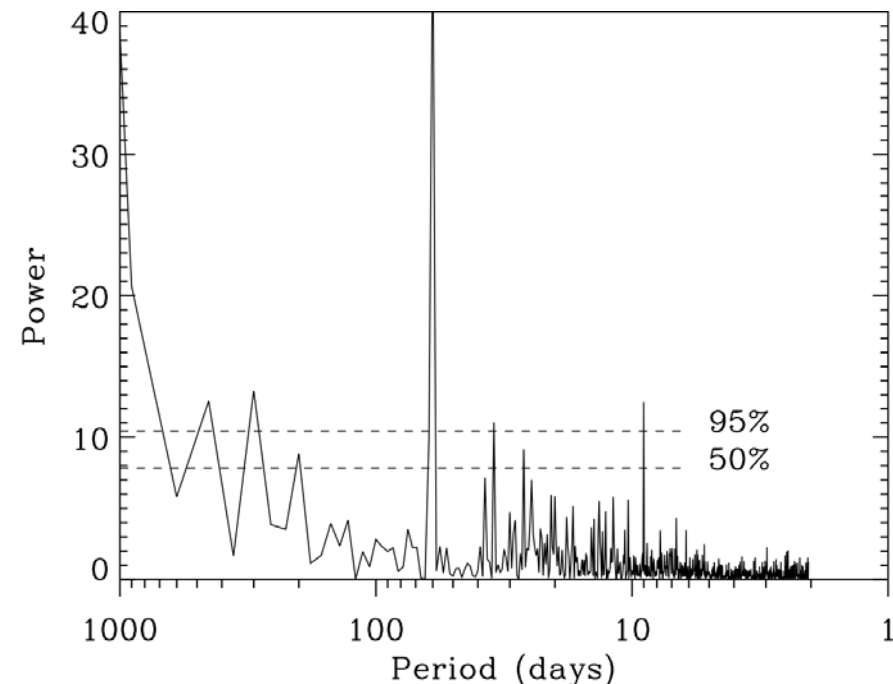
The periodic connection suggests an element of predictability

TIMED Measured Power in UV and IR Emissions from 2002-2006



Daily TIMED SEE UV measurements from 0-175 nm

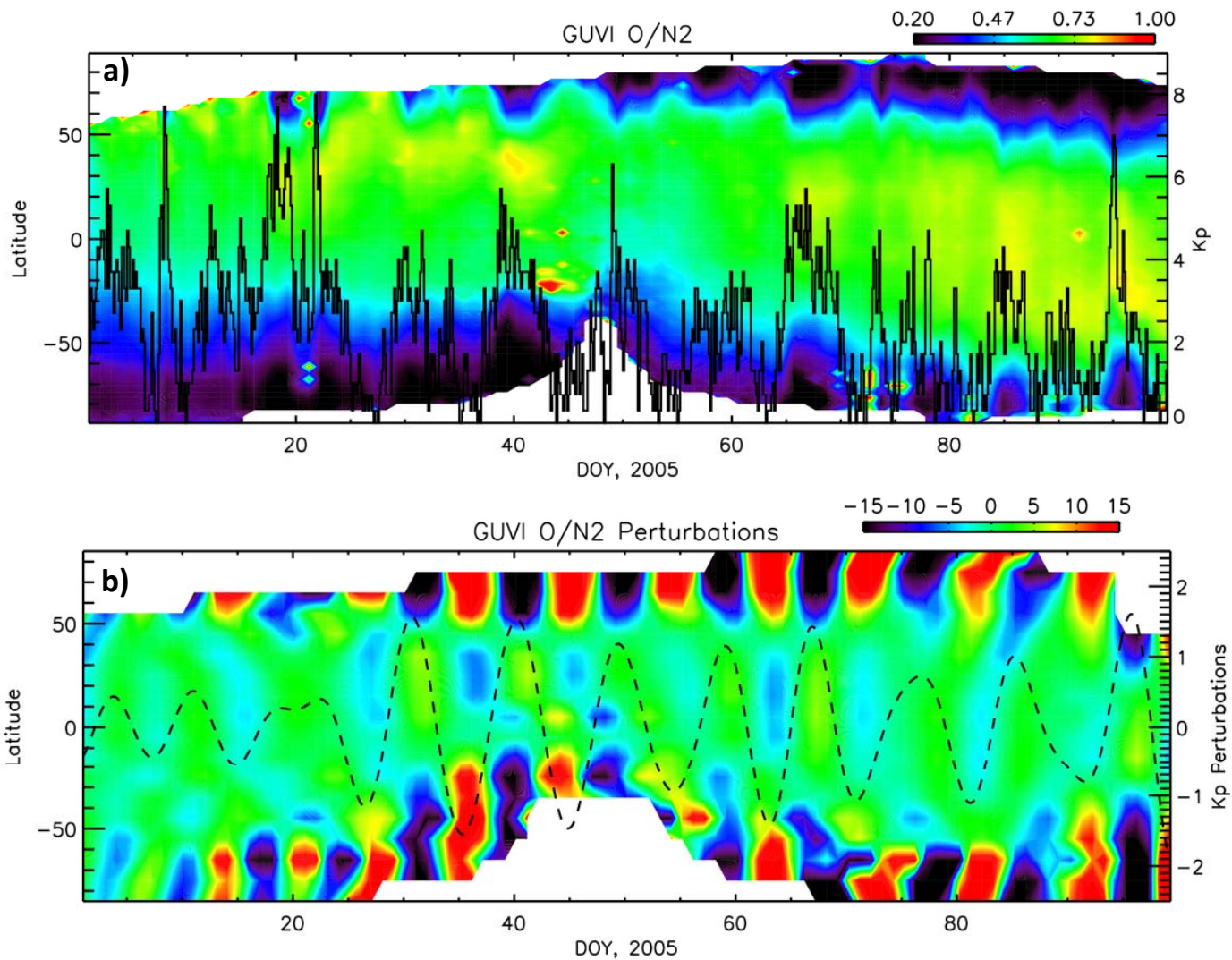
Daily, global SABER IR Emissions: Integrated CO₂ and NO Power from 100-200km



Mlynczak et al., GRL, 2008

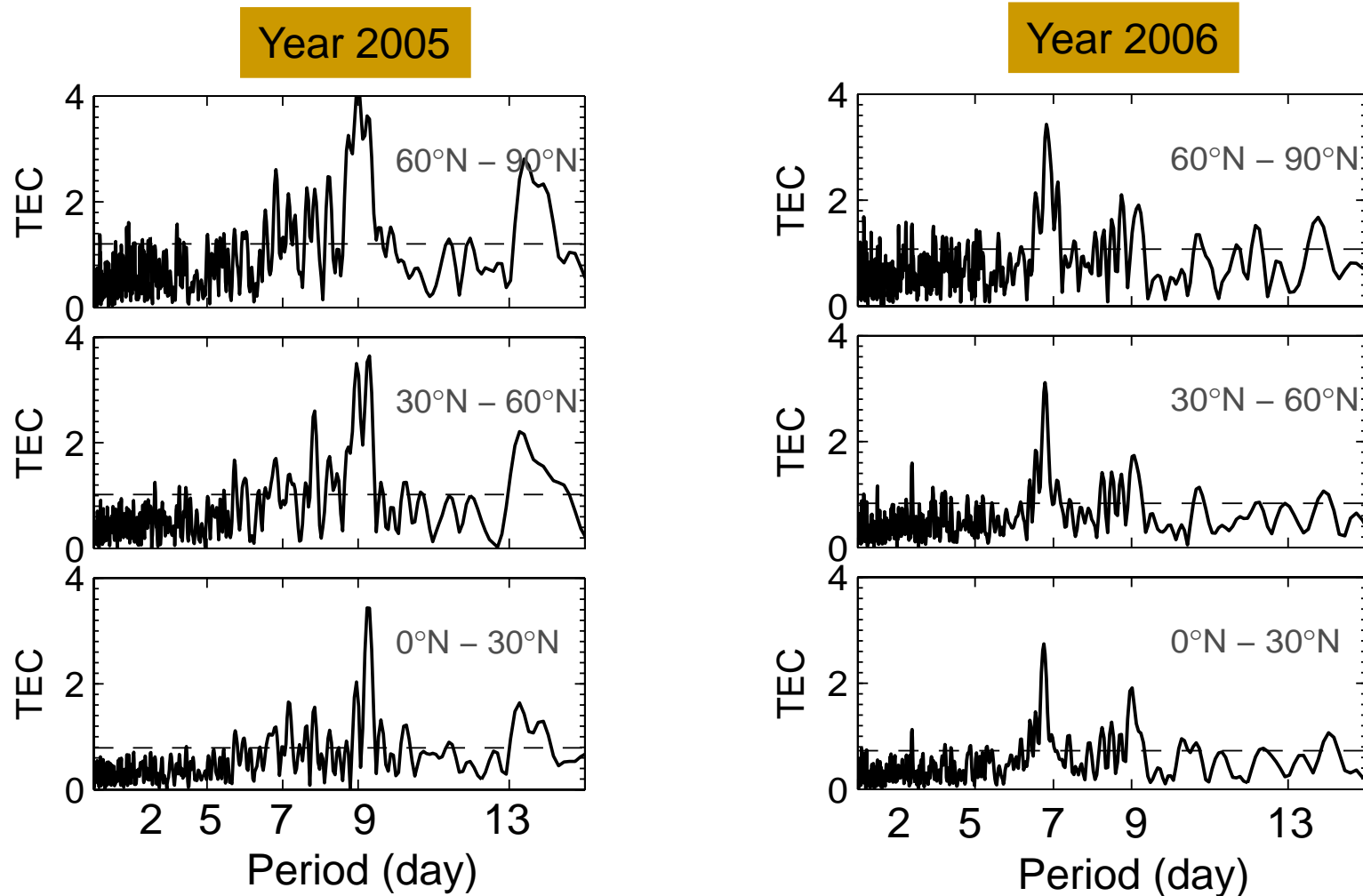


GUVI $\Sigma O/N_2$ ratio for 2005



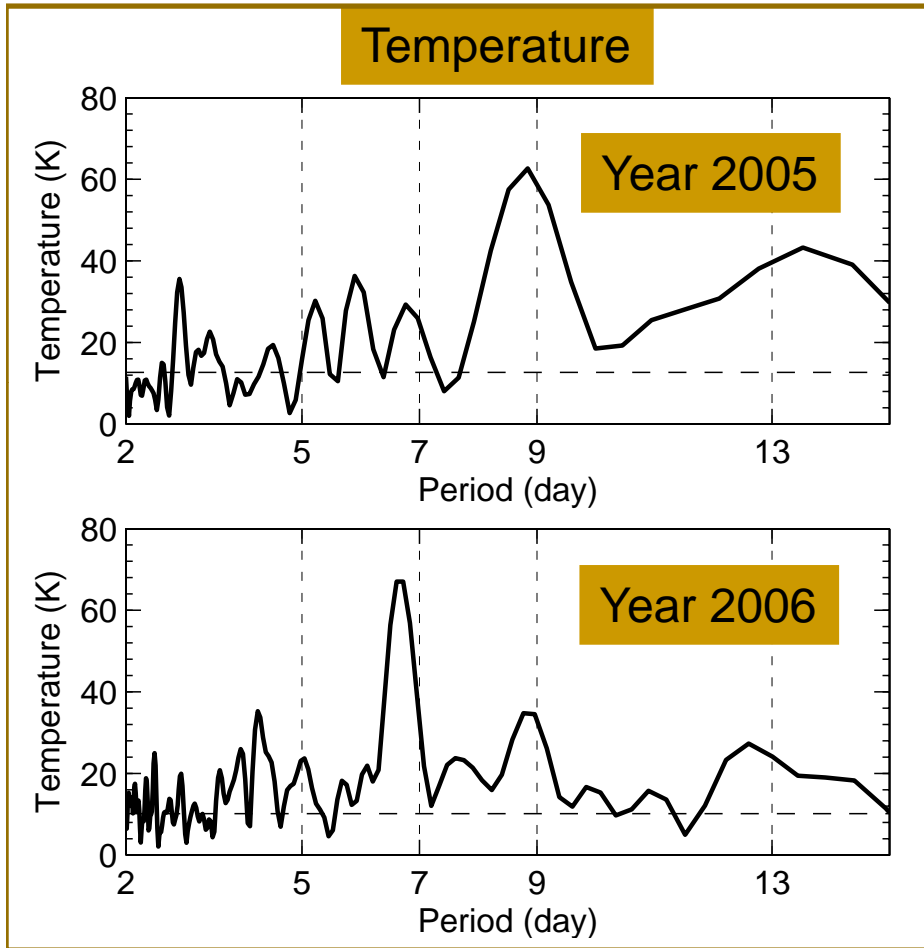
Crowley et al., GRL, 2008

Periodogram of Global Total Electron Content from 2005 and 2006 with Latitude

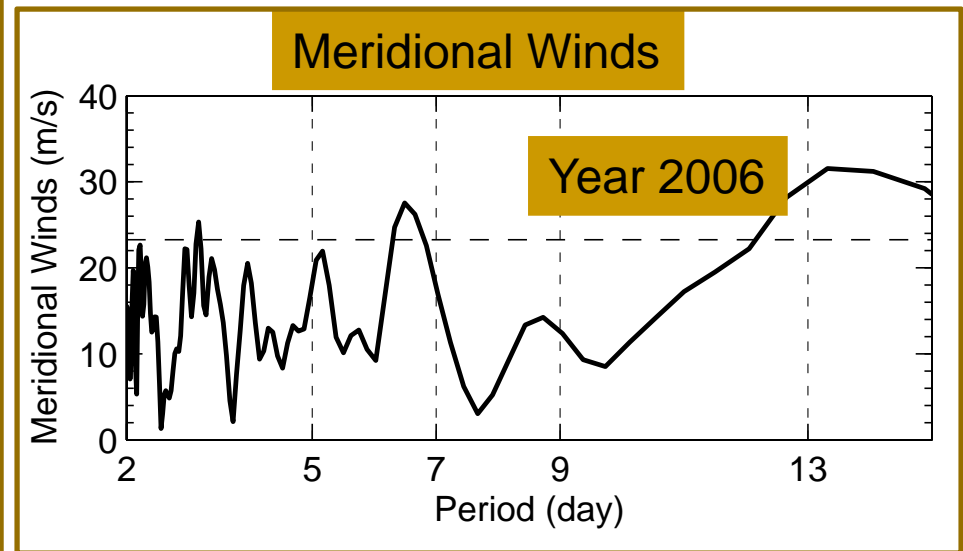


Lei, J., J. P. Thayer, J. M. Forbes, Q. Wu, C. She, W. Wan, W. Wang (2008), Ionosphere response to solar wind high speed streams, , *Geophys. Res. Lett.*, 35, L19105, doi:10.1029/2008GL035208.

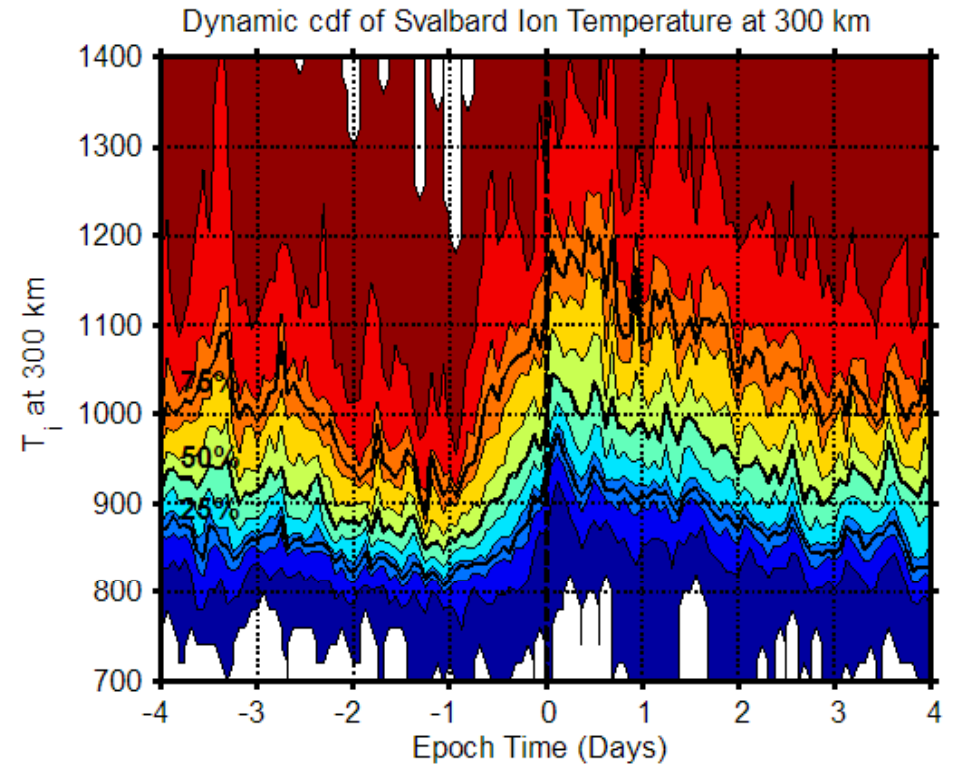
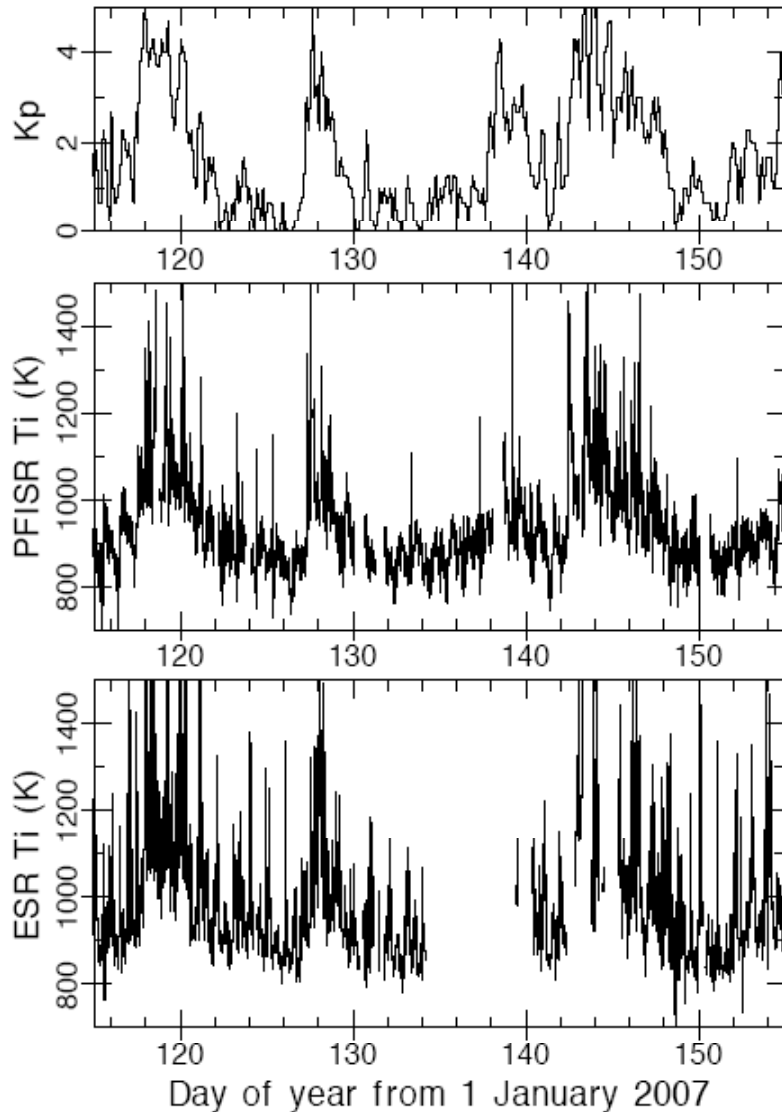
F-region Neutral Temperatures and Winds from 2005 and 2006 Show 7 and 9 Periodicities



Recorded Temperatures and Winds from FPI data at Resolute Bay



Impact of high speed streams on the ionosphere

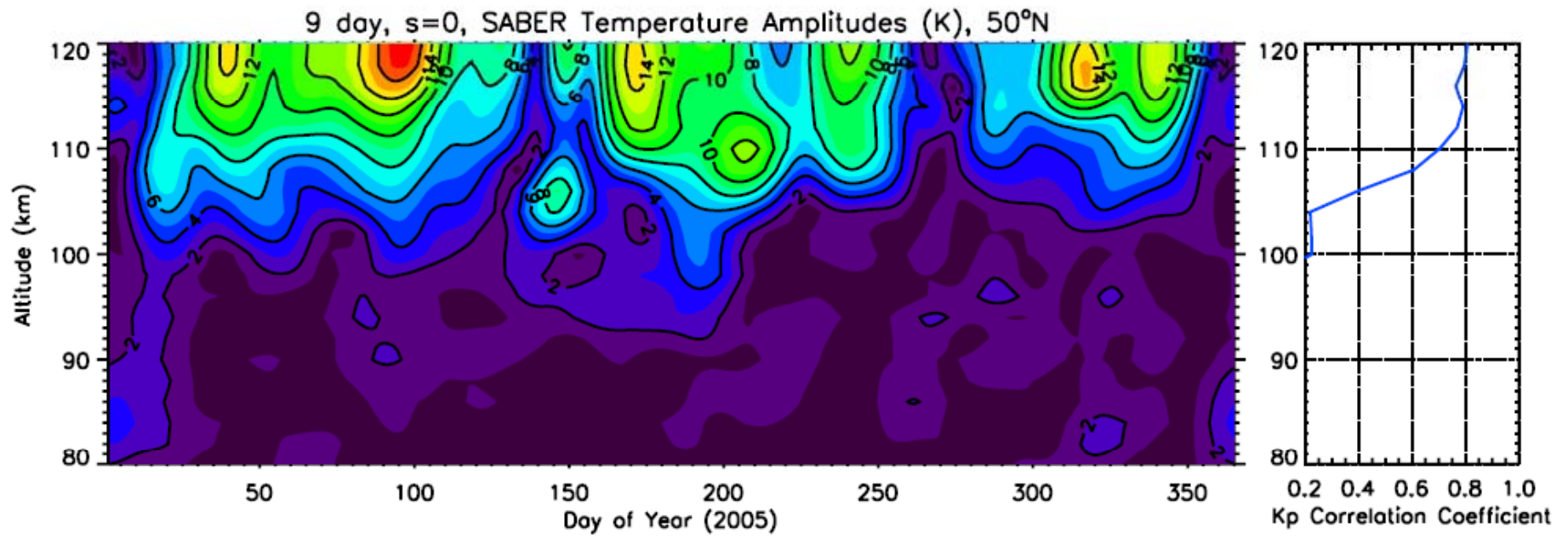


IPY Observations

J. Sojka, et al., submit to GRL, 2009



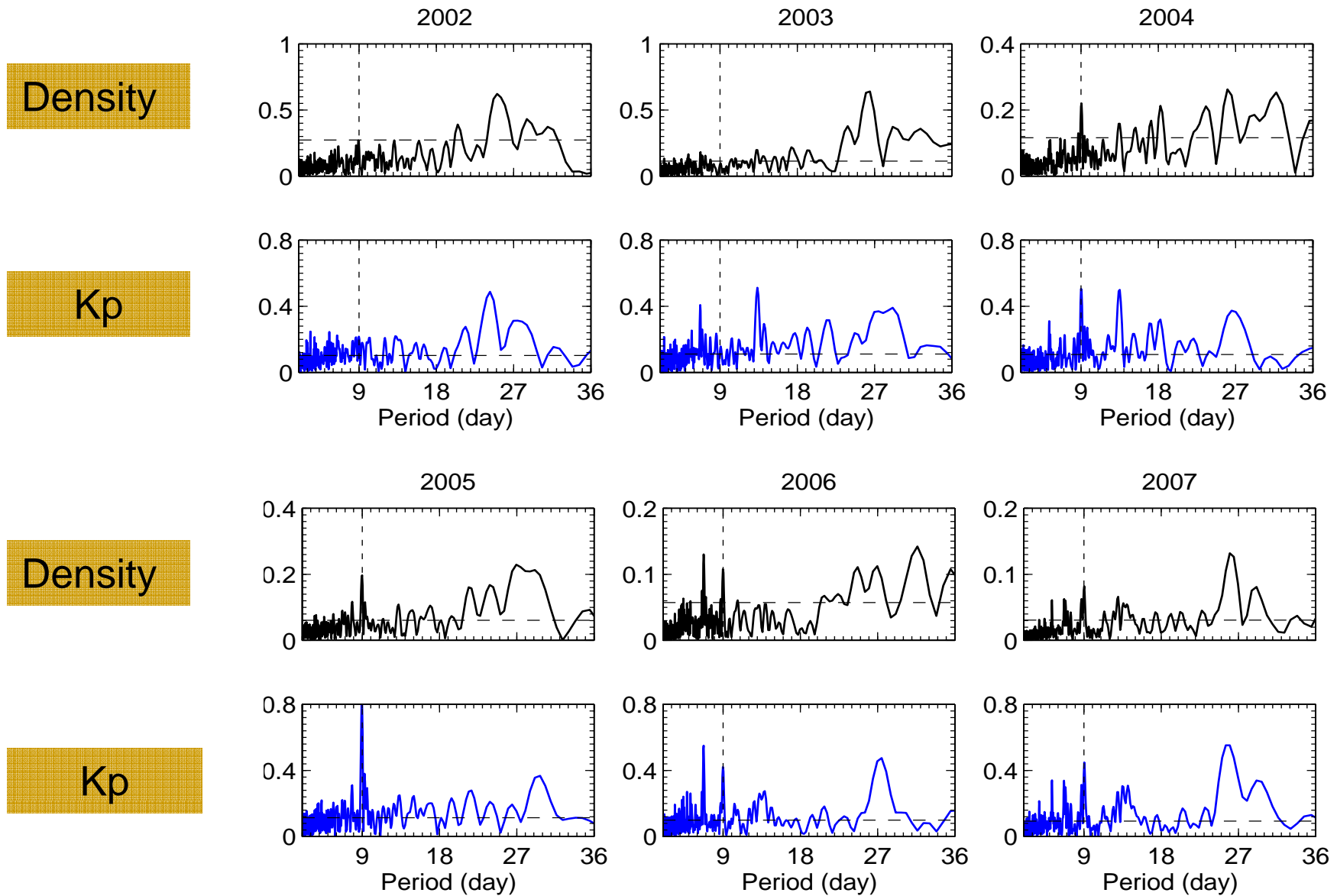
Impact of solar wind on the lower thermosphere



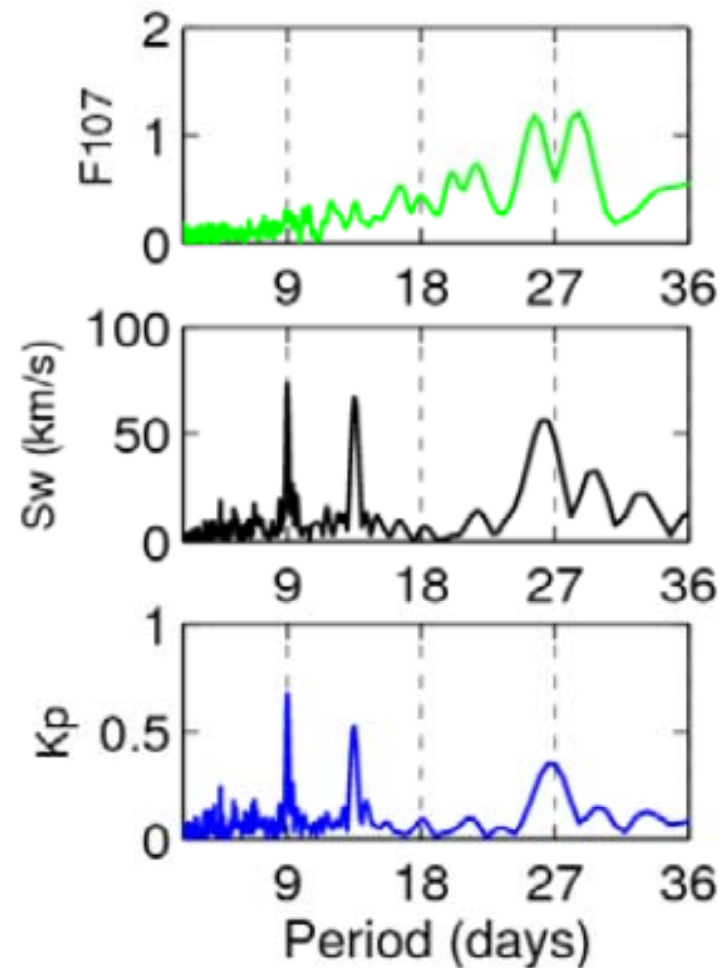
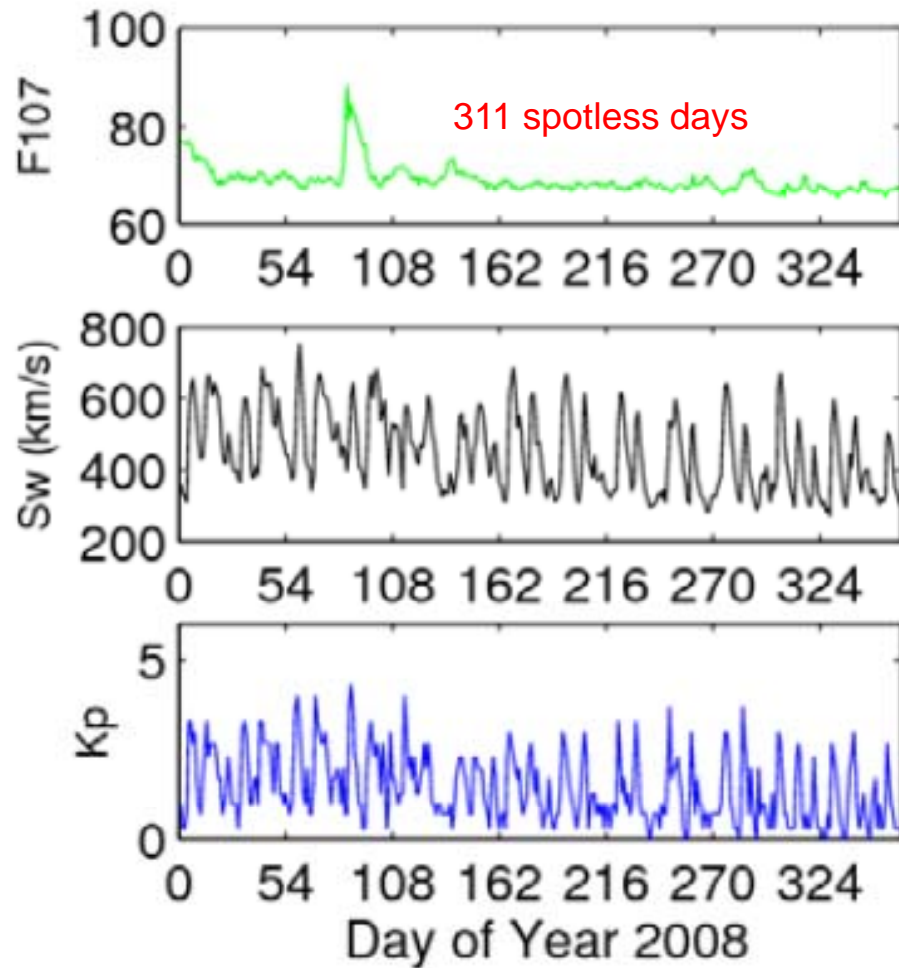
Chang, L. C., J. P. Thayer, J. Lei, and S. E. Palo (2009), Isolation of the global MLT thermal response to recurrent geomagnetic activity, submitted to Geophys. Res. Lett, doi:10.1029/2009GL039305.



Thermospheric density response to CIR during 2002-2007



High speed solar wind streams in 2008



Geospace was not quiet under this extremely solar minimum!!



Summary

- Periodic oscillations in thermosphere / ionosphere properties at sub-harmonics of the solar rotation period (9, 6.75 and 5.4 days) have been discovered and related to high speed solar wind streams and the heliolongitude distribution of coronal holes.
- The periodic nature of this connection suggests an element of predictability for the recurrent geomagnetic activity.
- Little change in EUV flux at these multi-day periods allows for geomagnetically driven affects on the thermosphere and ionosphere to be solely studied and identified.





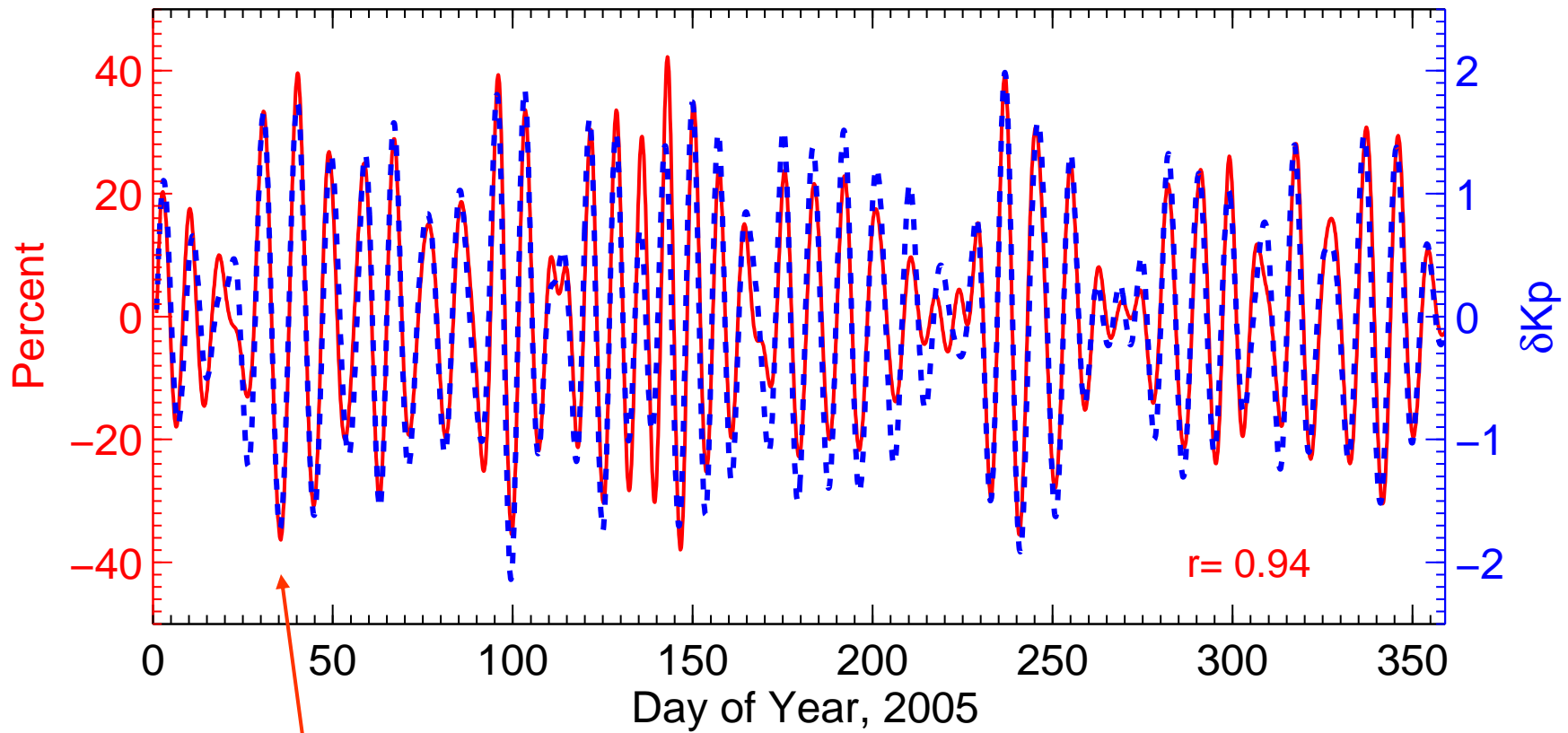
**Thanks for
your attention**

Question?

Backup slides



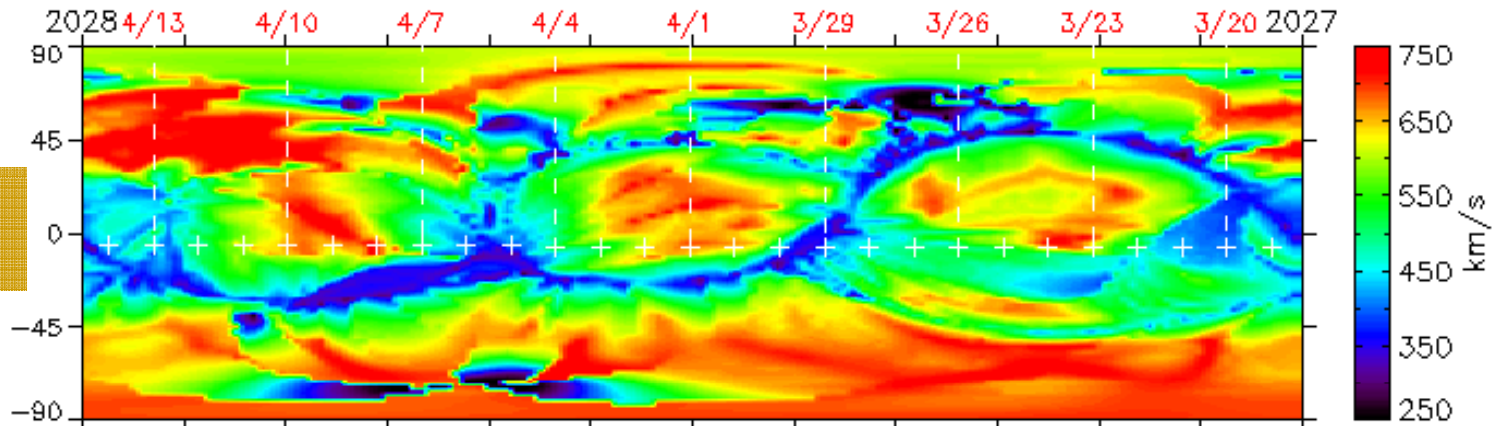
Correlation between Density Oscillations and Kp



Percent of the band-pass filter density residuals to 11-day running mean. The band-pass filter was centered at the period of 9 days, with half-power band of 3 days.

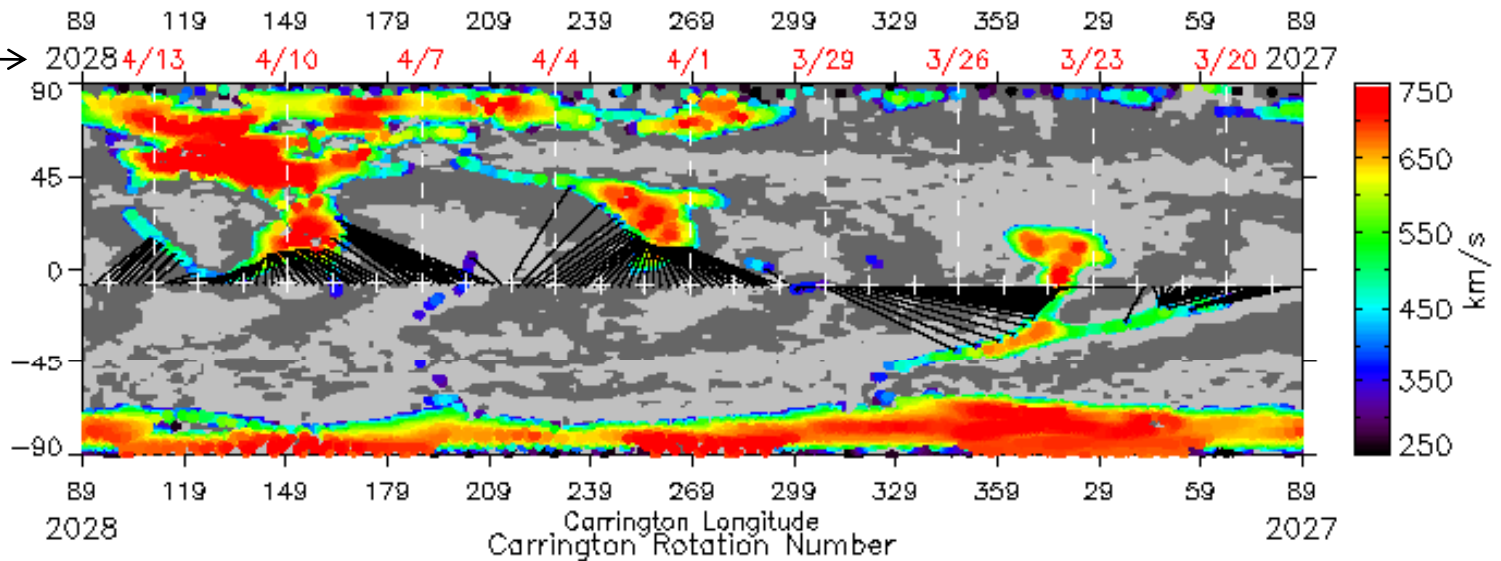
Why 9-day Oscillations in Solar Wind?

Solar Wind Speed
NSO



Date longitude lies
in the Sun-earth line

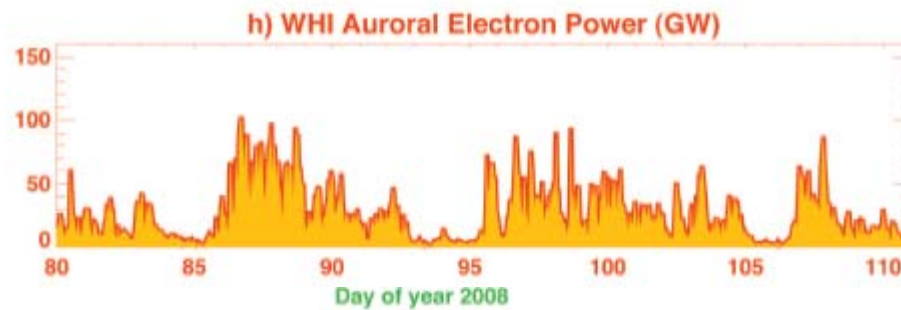
Derived Coronal
Holes



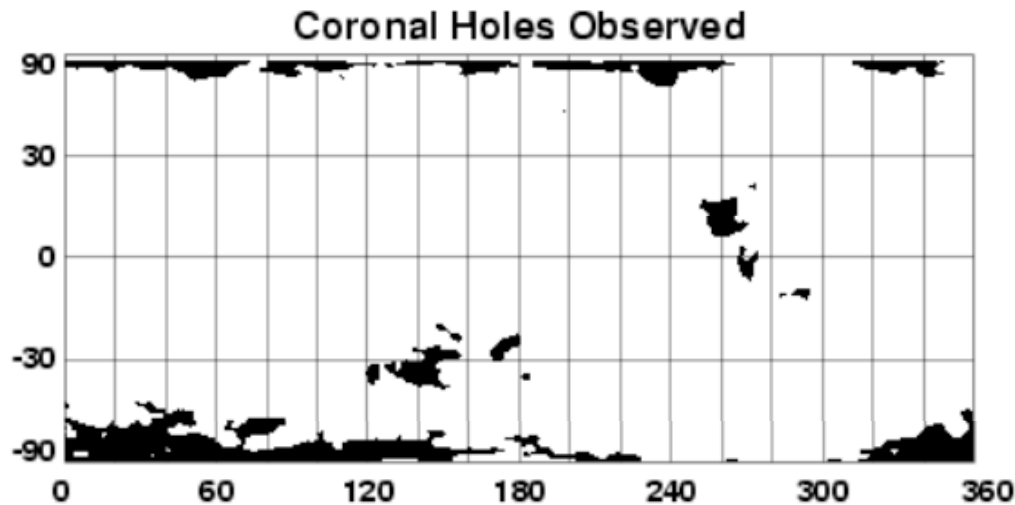
The periodic connection suggests an element of predictability



High speed solar wind streams during spotless days



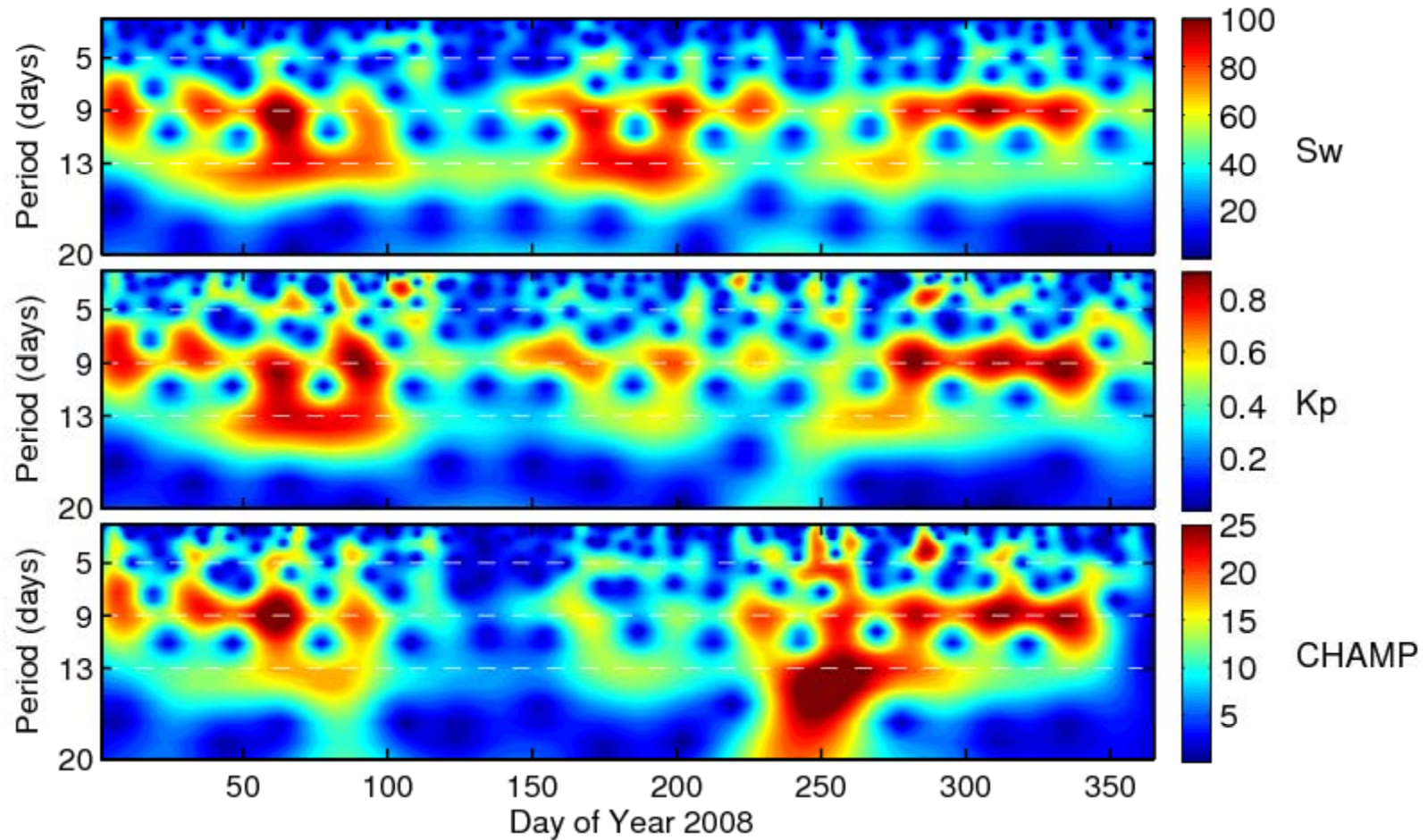
S. E. Gibson, et al., JGR, 2009



Courtesy of G. de Toma



High speed solar wind streams during spotless days



Geospace is not quiet under spotless days