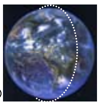
STUDIES OF THE LOW TO MID LATITUDE THERMOSPHERE DENSITY RESPONSE TO SOLAR WIND FORCING USING CHAMP DATA

Chantal LATHUILLÈRE[(a)] & Michel MENVIELLE [(b)]

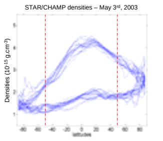
[(a)] Laboratoire de Planétologie de Grenoble, CNRS/UJF/OSUG, Grenoble, France, [(b)] CNRS/IPSL, Université Versailles-St-Quentin, LATMOS, Saint Maur, France, and Univ. Paris Sud, Orsay, France

The data

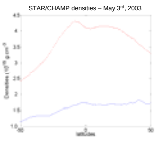
STAR atmosphere density along CHAMP trajectory …



The orbit LT drift is of few minutes per 24 hours; during the same period, the altitude of the satellite varies by less than few hundreds of meters at given latitude.



… between -50° and 50° in latitude, with a 1° sampling period with respect to the latitude



daytime and night time orbit sections are considered separately

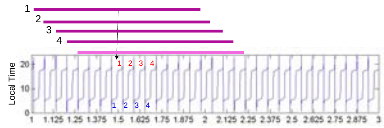
During periods of magnetic quietness, density variations along 50N–50S orbit segments are expected to be very similar during a 24-hour period.

Data analysis: running 15-orbit SVD analysis

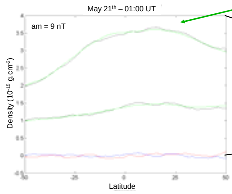
SVD analysis using a sliding window of 15 consecutive orbits.

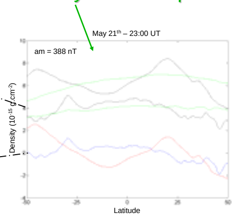
South-North and North-South bounds are considered separately.

The results are associated to the orbit #8; we only consider the first singular vector ($\mathbf{u}_1$) and the projection coefficient c_1 of the data on this vector.



Examples of results for orbits during magnetic quiet and very disturbed periods





Orbit during magnetic quietness:

- the projection on the first singular vector ($c_1\mathbf{u}_1$, green curve) accounts for almost the whole variance in the density variation (~99%);
- the intensity of the residual is negligible.

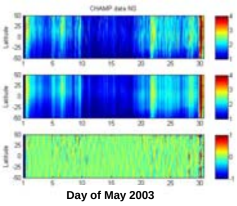
Orbit during very intense magnetic disturbance :

- the projection on the first singular vector ($c_1\mathbf{u}_1$, green curve) accounts for almost the whole variance in the density variation (~97%). its intensity is significantly larger than during magnetic quietness. c_1 has the dimension of a density;
- the intensity of the residual is not negligible.

Separation according to spatial scale

Altitude/latitude variations + planetary response to magnetic activity forcing

Gravity waves generated by Joule heating?



CHAMP/STAR density estimates along the NS orbit segments, as a function of latitude and UT time during May 2003. Altitude and latitude variations are combined in this colour plot.

projection of the CHAMP/STAR density data on the first singular vector (i.e., $c_1\mathbf{u}_1$ variation)

residuals, i.e. differences between the CHAMP/STAR densities and their projection on the first singular vector.

LT at the satellite position varies from 5:40 am to 2:55 am. For the three panels, the density variations are displayed using the colour scale displayed on the right; they are expressed in terms of 10^{-12} kg.m^{-3} units.

Time dependence of large scale spatial variations

Time variations of the large scale spatial variations in the density are captured by the c_1 projection coefficient.

NRLMSIS-Quiet c_1 values are computed for the same situation, but without magnetic activity by means of NRLMSIS-00 model with MgII index (scaled to F10.7, see Lathuillère et al., 2008) and ap set to 4

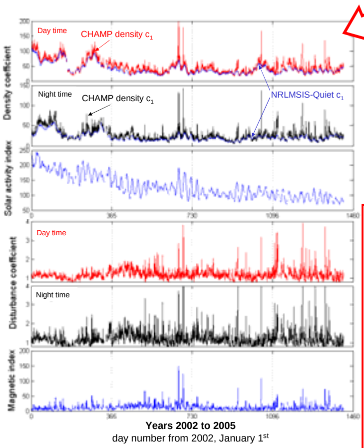
CHAMP density c_1 values are larger during day time than during night time

CHAMP density c_1 values are modulated by LT and solar UV activity.

Thermospheric density Disturbance coefficients are defined as :

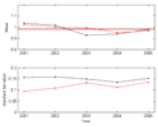
$$\text{Disturbance coefficient} = \frac{\text{Observed thermospheric coefficient}}{\text{Reference thermospheric coefficient}}$$

Disturbance coefficients are correlated to geomagnetic activity.



Assessment of the reference

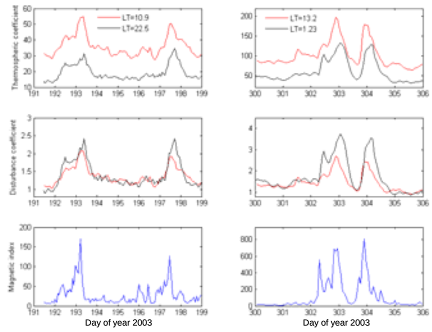
Mean and standard deviation of the disturbance coefficient for quiet days (Ap<5)



Time delay of the thermosphere density response to geomagnetic activity

Examples of events occurring in July 2003 (left) and October 2003 (right) showing that the global low to mid latitude disturbance occurs earlier during day time that during night time.

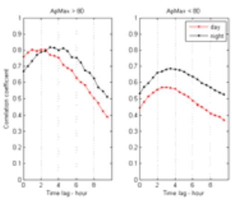
The magnetic indices displayed on the lower panel are 30-minute rms indices (see poster by Menvielle et al.)



Statistics over 3 years show that

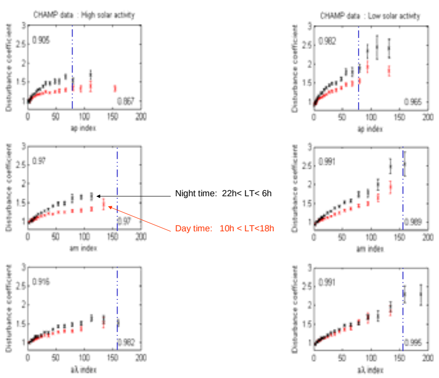
For the larger storms (Ap > 80, like the 2003 Halloween ones displayed above), the time delay of the low to mid latitude thermosphere response to geomagnetic activity is ~2 hours smaller during day time than during night time

For the other storms (Ap < 80, like the one occurring on July 2003 displayed above), the difference between day and night time delays is much smaller



Correlations between 30-minute rms geomagnetic indices and observed CHAMP Disturbances Coefficients for daytime (in red) and night time (in black). Calculations have been done for 22 storms occurring between January 2002 and December 2004. The storms are separated in two classes, according to the maximum daily Ap value .

Statistical behavior of the disturbance coefficient using 3-hour planetary geomagnetic indices



Disturbance coefficients are binned as a function of the previous 3-hour geomagnetic indices. A limit of Kp = 6 (indicated by the blue line) is used for correlation coefficient estimation given in each panel

★ The increase of Disturbance coefficient with increasing magnetic activity

is

larger during periods of low Solar activity than during periods of high Solar activity

and it is as well

larger during night time than during day time

★ The correlation with am

is better than

the correlation with ap

am stations are evenly distributed with respect to longitude in both hemispheres while ap stations are mostly (11 from 13) located in Northern America and Western Europe

★ The difference between night time and day time Disturbance coefficients is larger when binned with respect to planetary index am than when binned with respect to regional index aλ.

Density data from the SWARM constellation will allow to increase the storm data base during the next solar cycle maximum, and to probe the thermosphere at two different Local Time for the same UT.

References:

Lathuillère, C., M. Menvielle, A. Marchaudon, and S. Bruinsma (2008), A statistical study of the observed and modeled global thermosphere response to magnetic activity at middle and low latitudes, J. Geophys. Res., 113, A07311, doi:10.1029/2007JA012991

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Picone, J.M., A.E. Hedin, D.P. Drob and A.C. Aikin (2002), NRLMSISE-00 empirical model of the atmosphere: Statistical comparisons and scientific issues, *J. Geophys. Res.*, **107**, 1468, doi:10.1028/2002JA009430.