A statistical comparison of Cluster magnetic data with the Tsyganenko 2001 model.

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1 Introduction

We are conducting a detailed comparison of Cluster II data with the Tsyganenko magnetic field models with the aim of improving external geomagnetic field modelling as part of the UK GEOSPACE consortium.

The scientific aims of GEOSPACE are to unravel and model the various sources contributing to the measured magnetic field and its time variation to a much higher degree of accuracy than previously achieved.

In this poster we show the results of an analysis of data from Cluster 1 for 2002 to 2004 inclusive.

2 Cluster II

The four spacecraft that comprise Cluster II orbit the Earth in an elliptical orbit with a perigee of -19,000 km and an apogee of -119,000 km. One orbit takes -57 hours and they precess around the Earth in one year.

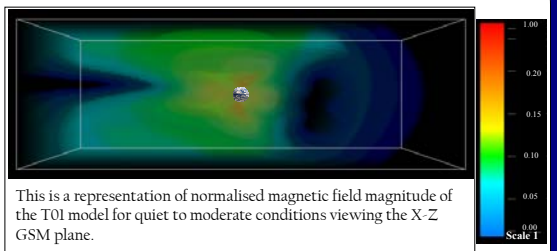
We are primarily using data from the flux-gate magnetometer (FGM)

3 Tsyganenko models

We have used the T01 version of the Tsyganenko models in the following analysis [Tsyganenko 2002a, 2002b]. This is an empirical model of magnetospheric magnetic fields. We have used the International Geomagnetic Reference Field (IGRF) version 10 as our model of the Earth's internal magnetic field.

In the following plots the residuals are all DATA-MODEL, and therefore a positive residual is an underestimate of the data. Please note that these are absolute rather than relative residuals.

Everything has been calculated in Geocentric Solar Magnetic (GSM) coordinates.



This is a representation of normalised magnetic field magnitude of the T01 model for quiet to moderate conditions viewing the X-Z GSM plane.

4 Dayside Perigee passes

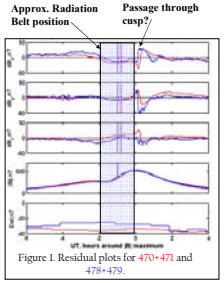


Figure 1. Residual plots for 470+471 and 478+479.

Figure 1 shows the X_{GSM}, Y_{GSM} and Z_{GSM} residuals in the top three panels for two orbits separated by 8 orbits.

The dashed vertical lines show the perigee for each of the two orbits shown.

The 4th panel shows in solid lines |B| from Cluster, and in dashed lines |B| from the T01 model using only the ring current contribution to the overall external field (IGRF is included).

The 5th panel shows the Dst index.

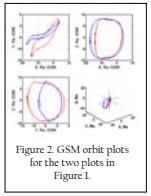


Figure 2. GSM orbit plots for the two plots in Figure 1.

Orbits are numbered from perigee to perigee, so the two lines shown are each a combination of two half orbits.

The orbits are shifted relative to each other so that the peaks in $|B_{IGRF}|$ line up with each other – hence the x-axis is time relative to this maximum.

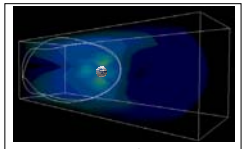
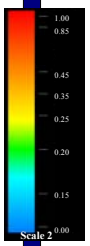


Figure 3. A representation of the two orbital paths over the T01 model magnetic field magnitude (same conditions as previous representation, different colour scale – see Scale 2, right)

Figure 4. A slice through Figure 3 showing the orbits passing through the Birkeland currents as described in T01



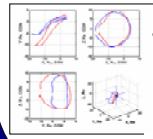


Figure 5. GSM orbit plots for the two plots in Figure 6.

A slightly later pair of orbits - the "blue" orbit is during more intense geomagnetic activity.

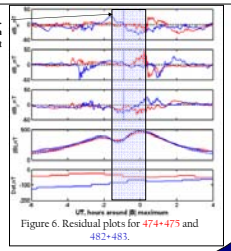


Figure 6. Residual plots for 474+475 and 482+483.

5 Nightside Perigee passes

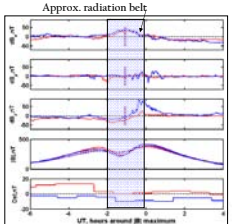


Figure 7. Residual plots for 397+398 and 405+406.

Figure 7 is in the same format as previously but this is a nightside perigee pass.

Now the major contributor to the larger residuals is the ring current as can be seen below in Figures 9 and 10.

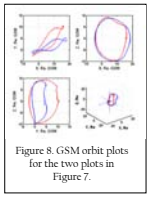


Figure 8. GSM orbit plots for the two plots in Figure 7.

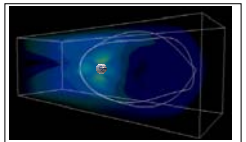


Figure 9. A representation of the two orbital paths in Figure 7 over the T01 model magnetic field magnitude (for colour scale – see Scale 2, left)

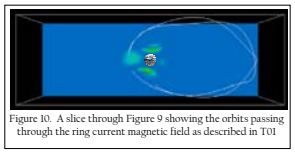


Figure 10. A slice through Figure 9 showing the orbits passing through the ring current magnetic field as described in T01

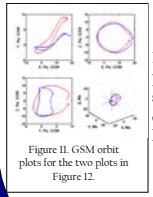


Figure 11. GSM orbit plots for the two plots in Figure 12.

Figure 12 is also a nightside perigee pass. The red line shows the enhanced effect of ring current during higher activity.

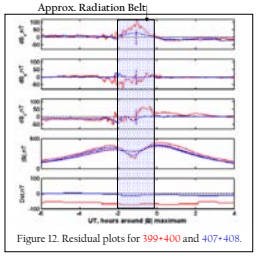


Figure 12. Residual plots for 399+400 and 407+408.

6 Average residuals

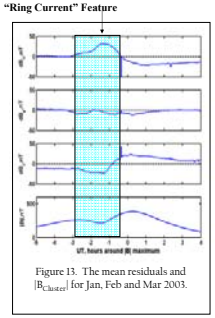


Figure 13. The mean residuals and $|B_{Cluster}|$ for Jan, Feb and Mar 2003.

Figure 13 shows the mean residuals and $|B_{Cluster}|$ for January, February and March of 2003. The "ring current" feature is clearly persistent. No sorting for activity has been applied here.

Figure 14 shows the same thing for the first quarter of 2004 – when the satellites will be in the same orbital location as they were the year before. A similar result to Figure 13 is seen

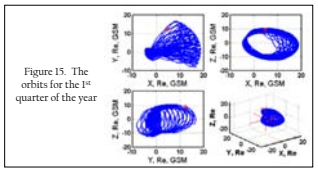


Figure 15. The orbits for the 1st quarter of the year

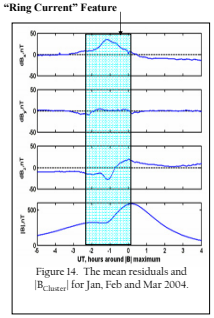


Figure 14. The mean residuals and $|B_{Cluster}|$ for Jan, Feb and Mar 2004.

7 Summary

We have found consistent, significant offsets of the T01 Tsyganenko model from Cluster data. These occur in two primary areas:

1) the nightside ring current region for nightside perigee passes.
2) The cusp regions for dayside perigee passes

References

N.A. Tsyganenko, A model of the near magnetosphere with a dawn-dusk asymmetry: 1. Mathematical structure, J. Geophys. Res., 107, 10.1029/2001JA000219, 2002.

N.A. Tsyganenko, A model of the near magnetosphere with a dawn-dusk asymmetry: 2. Parameterization and fitting to observations, J. Geophys. Res., 107, 10.1029/2001JA000220, 2002.

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