A Magnetopause Survey Using the Cluster Spacecraft

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1. Abstract

Since their launch in 2000, the four Cluster spacecraft have encountered the terrestrial magnetopause ten thousand times. The evolution of their highly-elliptical polar orbits has resulted in the spacecraft crossing the magnetopause over a wide range of latitudes and local times during a mission that has spanned an entire solar cycle. Applying an automated algorithm to Cluster magnetic field and plasma data, we have determined the location and orientation of the magnetopause during Cluster traversals between 2002 and 2010. Our findings are compared to an empirical magnetopause model and will be added to recent surveys by other satellite missions.

2. Methodology

We exploit eight years of Cluster data as it sweeps through the magnetosphere (see Figure 1).

Criteria for determination of a magnetopause crossing, modified from the Ivechenko et al. method[1]:

1. A crossing should be completed within 32 seconds.
2. The standard deviation of |B| in the magnetosphere must be < 40% than in the magnetosheath.
3. The magnitude of the radial component of B (in spherical co-ordinates) must be ≥10nT inside the magnetosphere.
4. Inside the magnetosphere |Br| must be ≥1.3x than in the magnetosheath.
5. Multiple crossings must not occur within 10 minutes.

We can then use the time of the crossing to compare its location with that predicted by the Shue et al. model[2].

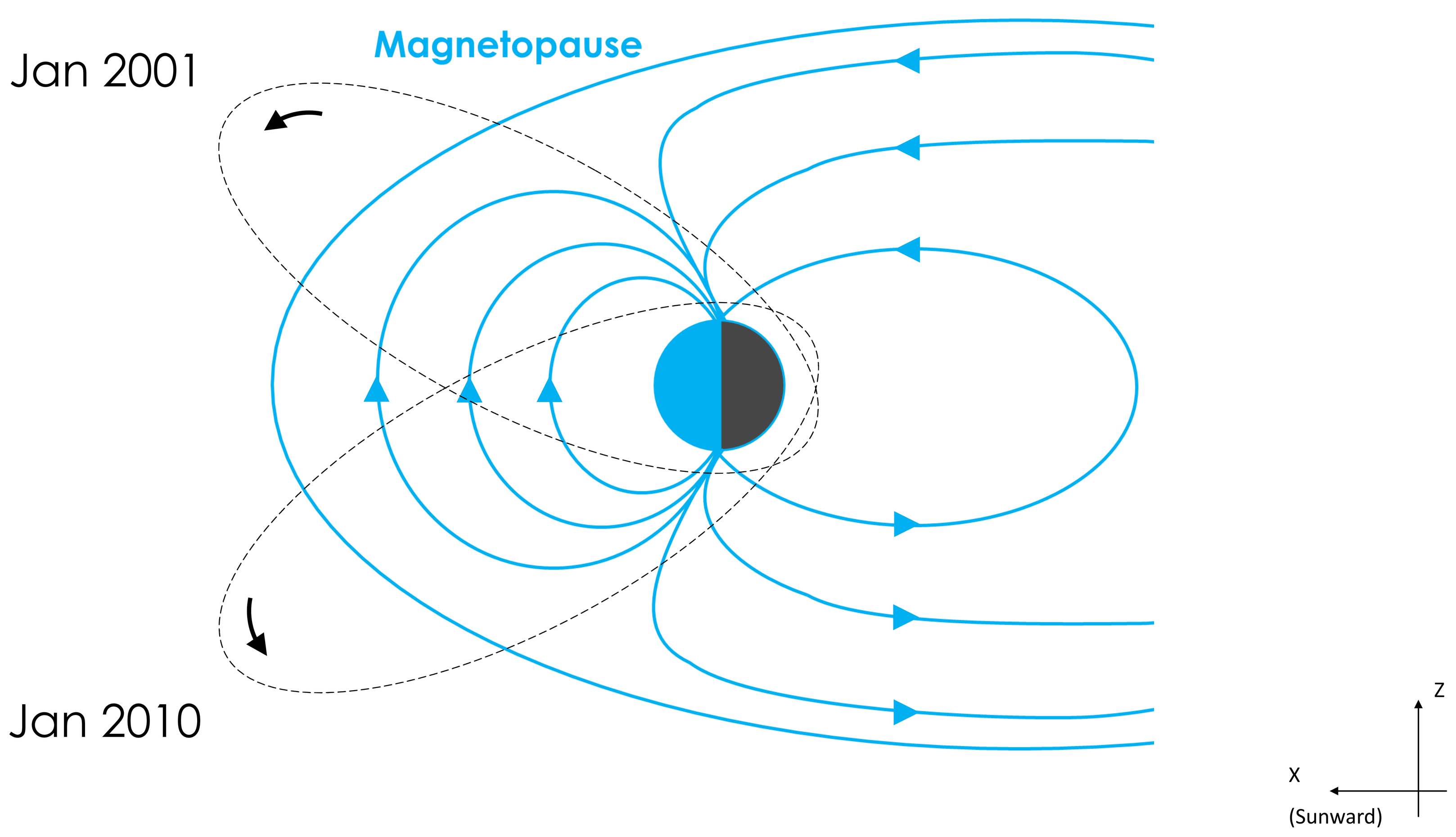


Figure 1. A schematic diagram of Cluster magnetopause crossings

3. Crossing identification

Examples of magnetopause boundary crossings are shown in Figures 2 and 3. A common cause for a crossing not being detected is when the magnetosheath magnetic field is similar to the magnetospheric field resulting in only a small discontinuity at the boundary.

Fig 2. Crossing detected

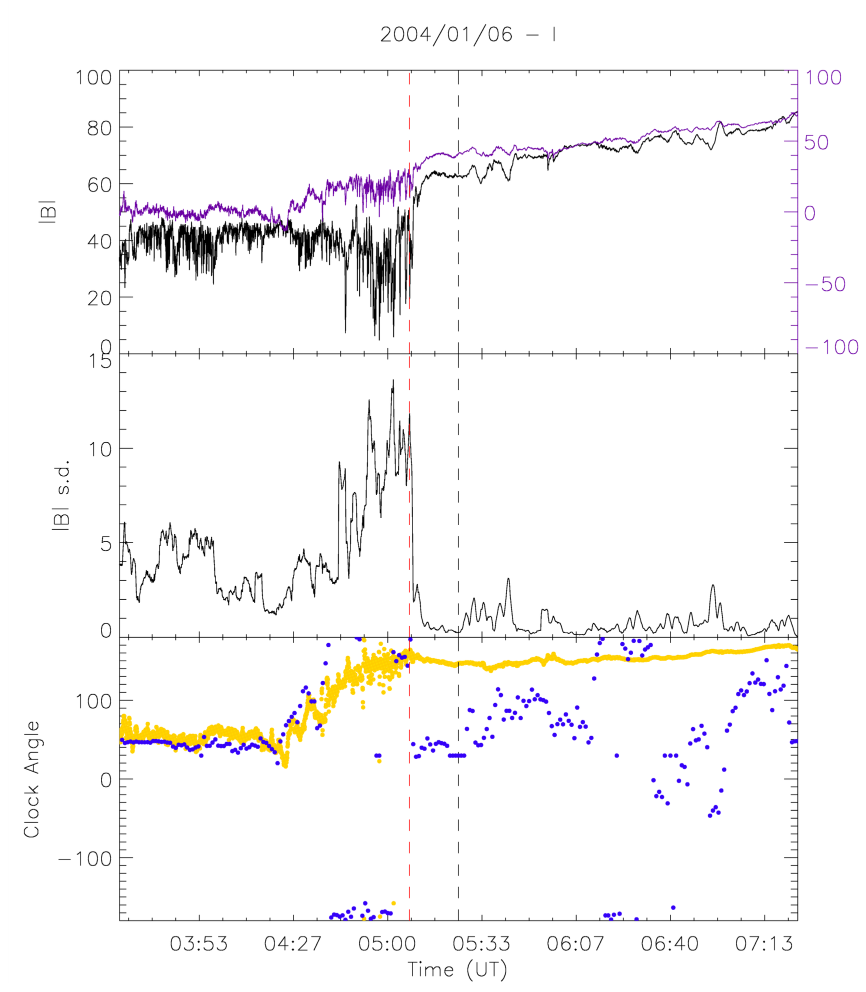
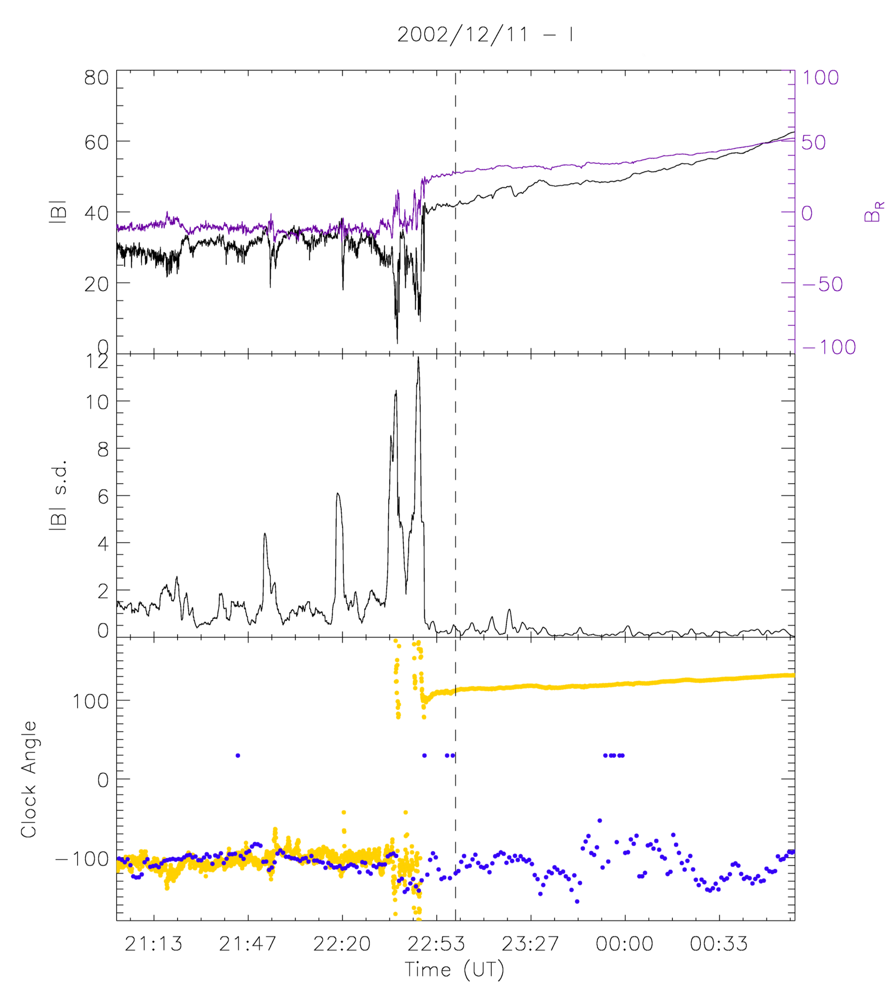


Fig 3. Crossing not detected



Dashed red line - identified inward crossing.
Dashed black line - predicted crossing.
Yellow dots - Cluster clock angle.
Blue dots - OMNI predicted clock angle.

Our method identified 2269 crossings over an eight year span. We combine the locations of the identified crossings in Figure 4.

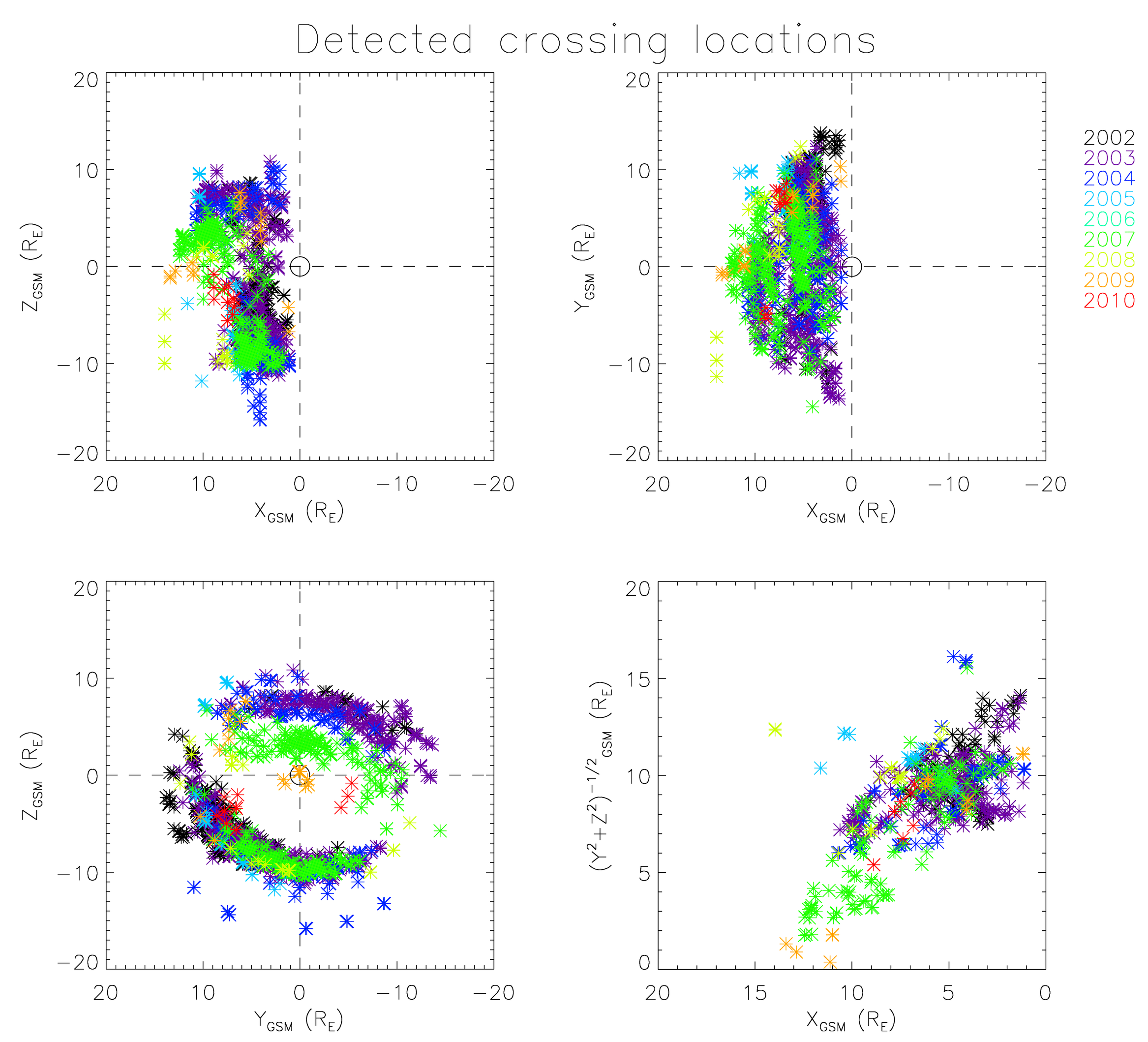


Figure 4. Detected magnetopause crossings in different geo-coordinates, coloured by year of orbit.

4. Model Comparison

Knowing the time of detected crossing and the spacecraft position at that time, we find the radial difference between the detected crossing location and the predicted magnetopause location.

R_{SC} - Spacecraft (at detected crossing) radial position

R_{SM} - Shue et al. modelled radial position

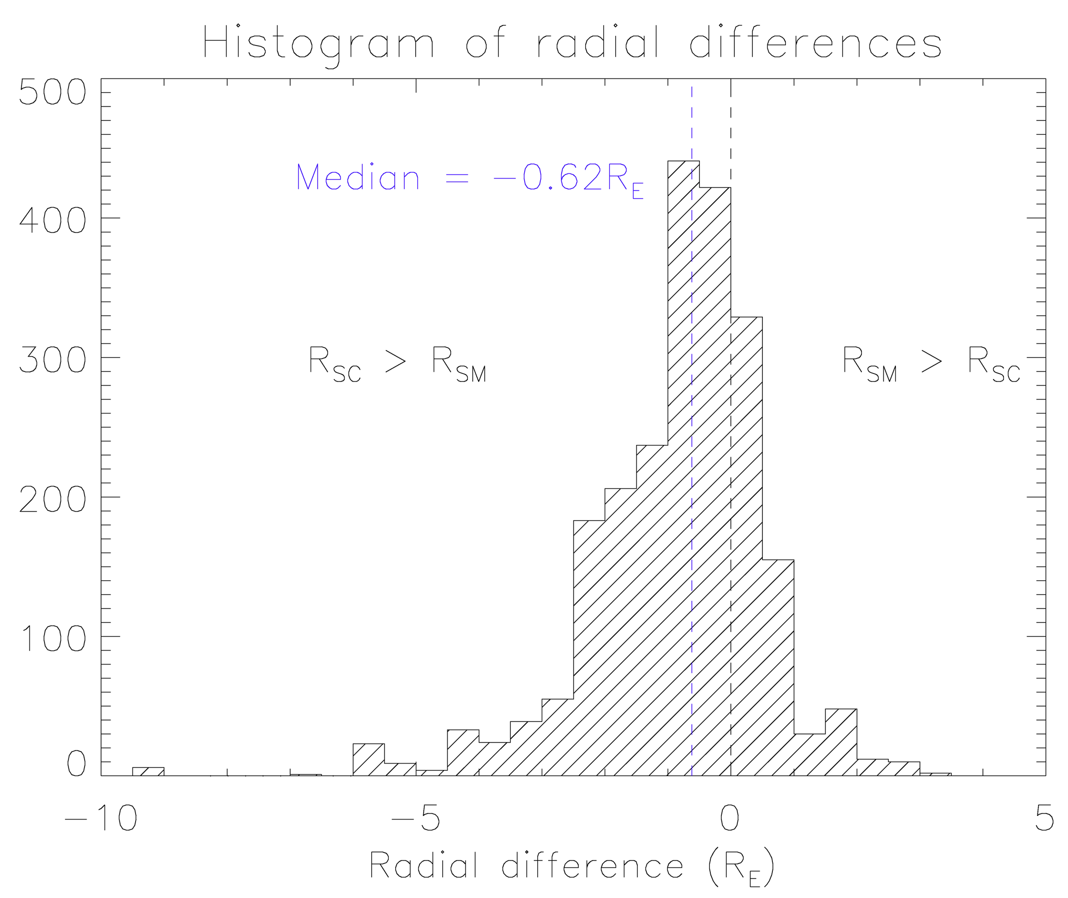


Figure 5. A histogram of the difference between the magnetopause locations

The asymmetry of the histogram suggests that the model underestimates the radial distance of the magnetopause, further investigation is required to determine whether what may cause this - i.e. an inaccurate flaring parameter.

5. Conclusions & Further Work

- We identify 2269 crossings which can be compared to the Shue et al. model.
- We find that the radial differences are distributed about a median of –0.62R_E.
- The distribution is not symmetrical suggesting that the model underestimates the radial distance of the magnetopause.
- We will now determine what effect, if any, solar wind parameters and the year of orbit have on the radial differences.
- We will extend this to other magnetopause models.
- We will make our results freely available online for use in other studies interested in the magnetopause location and plan to combine with previous studies to make a large database of magnetopause locations.

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1. Ivchenko, N. V., D. G. Sibeck, K. Takahashi, and S. Kokubun (2000), A statistical study of the magnetosphere boundary crossings by the Geotail satellite, *Geophys. Res. Lett.*, 27(18), 2881–2884, doi:10.1029/2000GL000020.
2. Shue, J.-H., J. K. Chao, H. C. Fu, C. T. Russell, P. Song, K. K. Khurana, and H. J. Singer (1997), A new functional form to study the solar wind control of the magnetopause size and shape, *J. Geophys. Res.*, 102(A5), 9497–9511, doi:10.1029/97JA00196.