Magnetopause standoff position and response time changes due to solar wind conditions: Models and Observations

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MHD and Empirical Models Used

<table>
<thead>
<tr>
<th>MHD Model</th>
<th>BATS-R-US</th>
<th>OpenGGCM</th>
<th>LFM</th>
<th>GUMICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>v20110131</td>
<td>4.0</td>
<td>LTR-2_2_0</td>
<td>4-HC-20140</td>
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<td>Coordinate System</td>
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<td>GSE</td>
<td>SM</td>
<td>GSE</td>
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<td>Update dipole</td>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Conductance Model</td>
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<td>Auroral</td>
<td>Auroral</td>
<td>Constant</td>
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<td>Corotation</td>
<td>Real</td>
<td>Real</td>
<td>Real</td>
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<td>Grid</td>
<td>Cartesian, rectangular blocks-refined</td>
<td>Cartesian, cell-refined</td>
<td>Cylindrical, not refined</td>
<td>Cartesian-not refined</td>
</tr>
</tbody>
</table>

\[
 r_0 = \begin{cases} 
 \frac{1}{a_4} &  
 \frac{1}{a_4} & B_z \geq 0 \\
 \frac{1}{a_4} & -8nT \leq B_z < 0 \\
 \frac{1}{a_4} & B < -8 \text{ nT} \\
\end{cases} \\
\frac{1}{a_4} (a_1 + a_2 B_z)(D_p) \\
\frac{1}{a_4} (a_1 + 8a_3 - 8a_2 + a_3 B_z)(D_p) \\
\frac{1}{a_4} (a_1 + 8a_2 - 8a_3 B_z)(D_p) \\
\frac{1}{a_4} (a_1 + 8a_3 - 8a_2 + a_3 B_z)(D_p) \\
\]

This empirical model has the same functional form as Shue et al. 1997, but the way \( r_0 \) (standoff distance) depends on \( B_z \) and \( D_p \) (dynamic pressure) is different.

Coefficients used with our analysis:
\( a_1 = 11.646 \), \( a_2 = 0.216 \), \( a_3 = 0.122 \), and \( a_4 = 6.215 \).
Solar Wind Conditions: March 24, 2001

Disturbed conditions:

- N between 10 and 25 cm\(^{-3}\)
- \(V_x\) between -420 and -450 km/s
- \(B_y\) between +5 and -5 nT
- \(B_z\) between +5 and -10 nT
Results: March 24, 2001

BATSRUS = 26 mins
LFM = 16 mins
OpenGGCM = 41 mins
GUMICS = 36 mins
Average ≈ 30 min
Magnetopause Observations near the sub-solar point: June 20, 2007

OMNI solar wind

THEMIS orbits

S/C in Magnetosphere . . . .
S/C in Magnetosheath . . . . .
S/C in Solar Wind ________
Comparison with model

June 20, 2007

THEMIS-A and B magnetic fields

X position and SWMF current density
Comparison with models

June 20, 2007

Magnetosphere standoff [R_E]

15:00 16:00 17:00 18:00 19:00 20:00

SWMF
OpenGGCM
Observations by 2 spacecraft

March 7, 2007

Cluster and Geotail orbits
Cluster 1 and Geotail

X position and SWMF current density
Conclusions

- The MHD models give very different standoff positions of the dayside magnetopause for the same solar wind conditions.
- In average the magnetopause takes about half an hour to get to a minimum position distance within all 4 models.
- Magnetopause crossing observations have also been studied, but only times with nominal solar wind conditions have been encountered with one or more spacecraft crossing from one area to the other.
- In the case of June 20, 2007 the 2 models shown, BATS-R-US and OpenGGCM, show different magnetopause standoff position, but similar reaction behavior.
- In two nominal solar wind cases, the BATS-R-US model shows the magnetopause crossing at similar times as the observations for the THEMIS, Geotail and Cluster satellite do.