Lab 3: Magnetosphere 1: A Different Magnetosphere

Introduction
This lab will use model results to explore how changing parameters of the magnetosphere - dipole strength and dipole tilt - will change or not change the character of the magnetosphere and its interaction with "typical" solar wind conditions at 1 AU.

Before you begin we need to agree on some definitions for regions in the magnetosphere. As a group, define how you would identify the following features using results from simulations:

- the leading edge of the bow shock
- the magnetopause
- the width of the magnetosheath
- the reconnection point (assuming the solar wind IMF is southward

Be sure that your definitions reference plasma parameters derived from simulation results. Be prepared to discuss these with the whole group.

Day Side Effects of Differing Magnetic Field Strengths
We will start by exploring changes in the dipole strength of the Earth while keeping the relative tilt at 11 degrees.

This link is to a table of runs for different dipole strengths.
http://ccmc.gsfc.nasa.gov/support/HSS_2013/dmearth.php
The table not only gives links to the run outputs, but also gives you the run parameters. Notice that the solar wind conditions for all the runs are the same. "Dm" refers to the dipole moment of the Earth.

- What aspect of these solar wind conditions are unrealistic? (Here is a link to the solar wind conditions measured by ACE over the last 7-days http://www.swpc.noaa.gov/ace/MAG_SWEPAM_7d.html)

We recommend opening each run in a different tabs or windows. You may want to compare one run to another.
- *Start with the "Dm=2.*Dm_earth" run. Select the "View Magnetosphere" link and then click "Update Plot"*
- What parameter is plotted?
- Can you visually identify the features of the magnetosphere in this image?

Let's try looking at a line plot of some plasma variables.
- *Select "Line (1D) from the "Plot Mode" drop down.*

- *In "Choose quantities", select quantities based on the definitions you came up with in the beginning. (One possible set is "N", "V_x", and "B_z")*
- *In the "Plot Area" section, set:*
  X1 to "0" and X2 to "20"
  Y1, Y2, Z1 and Z2 to "0"
- *Choose "Update Plot"*
- From this line plot can you identify the features of the magnetosphere defined above?
- Does this plot take you directly through the "Nose" of the magnetopause
- *Constrain the "X" variables a little to get more detail.*

- From this plot identify the position of the bow shock and magnetopause, the position of the reconnection point ("X"- point), the width and maximum density of the magnetosheath.
- Do these features occur in the order you expect them to be?

Now lets look at the other cases.
- *Click the links for one of the other simulation modes (Suggest that you work from high "Dm" down to low)*
- *On the large shared work space, make a table for the values that you just collected above for all of the runs.*

- What general trends do you see in the results?
- Can you compare the trend in the simulation stand off distance to an estimation from a simple model (for example https://en.wikipedia.org/wiki/Magnetopause#Estimating_the_standoff_distance_to_the_magnetopause)?
- Do any of the simulation results raise any concerns on your part?

Tail Effects of Differing Magnetic Field Strengths
First we have to define what we mean by the "magnetotail"
- Discuss in your groups what features you might look for in the tail?
- How would you find the plasma sheet?
- Be prepared to talk about this with the whole group.

One feature to look for is the neutral plasma sheet. This can be identified using the "Jy", the current across the night side tail.
- *Start by looking at the X-Z cut plane again. The easiest way to do this is to return to http://ccmc.gsfc.nasa.gov/support/HSS_2013/dmearth.php and open up each page again.*
- *Again click on each run link and choose "View Magnetosphere".*
- *In the "Quantity" Q1 drop down menu choose "J_y" and hit update plot.*

- Can you identify the night side current sheet? (You may want to adjust the "Plot Area" using the "X" and "Z" values to zoom in)
- How far down the tail does the current sheet first develop?
- What is the maximum value of the J_y current?

- *Again construct a table for the different runs and compare the results.*
- What general trends and surprises do you see?

You may want to use the line plots to investigate these values more carefully.
- How might a simple line plot mislead you?

Different Dipole Tilts
Another variable we can change is the dipole tilt. This page
http://ccmc.gsfc.nasa.gov/support/HSS_2013/tileangle.php
has links to three runs with the dipole tilt at 11 degrees, 45 degrees and 90 degrees.

- *Investigate these first by using the 2D plots of the plasma density.*
- Do the structures we defined in the beginning still make sense?

Use the definitions and tools we developed above to explore these runs. Make a table of the values ask for above.