The Dynamic Magnetosphere

Introduction

In the first part of this lab we will explore the effects on the magnetosphere for an "artificial" situation where the solar wind conditions change abruptly from moderate wind with northward IMF to strong wind with southward IMF. We will look at both the global effects on the magnetosphere as well as the specific effects on the ring current. Following that we will explore a real event.

After you are finished you should understand:
- the magnetosphere dynamic effects of variations in the solar wind conditions
- the effects of reconnection and plasmoid release in the tail on the inner magnetosphere
- source of the ring current and the physics that describes it
- the relationship between global magnetosphere models and embedded ring current and radiation belt models.

Getting Started

On the CCMC "View Results" page, search for run number HSS2012_SWMF_052212_1. Click on the available link to view the run page.
- To understand this run, you will first need understand the solar wind conditions that drive it. Click on the "solar wind input data" link.
    - **Note the initial solar wind values, when they changed, and the final values.**

- Now go back and click on the "View Magnetosphere" link. Click the "Update Plot" button to get a view of the magnetosphere. You should be able to identify all the regions of the magnetosphere that we defined previously.
    - **Note the time at the top of the image. Is this the beginning or the end of the run?**
    - **What cut plane are we looking at? What is being plotted? What direction is north?**
- Scroll down to the "Choose data time" menu and choose a time near the beginning of the run. Choose a time value near the beginning of the run before the solar wind conditions change.

Magnetic Field Configuration

Plot field lines using the following.

- Scroll down to "Plot Mode" and choose the "Color+Vector+Flowlines" option.
- Set the "Q3" quantity to "B_x" (this will tell the flowline generator to use the B field to generate flowlines).
- Hit the update button.
  - **Describe the structure of the magnetosphere. Is it consistent with the solar wind conditions?**

Zoom in on the Magnetosphere nose.
- Scroll down to "Choose Plot Area". Change the plot region to zoom in on the nose of the magnetosphere while still looking at some of the tail. Try:

X1 = -50	X2 = 25
Y1 = -20	Y2 = 20
Z1 = -20	Y2 = 20

(We are looking at a constant "Y" cut plane, the "Y" settings don't matter.)
  - **Where are the reconnection points?**

Magnetosphere Dynamics
- Return to the "Choose data time" menu and begin choosing times near the solar wind transition time that you found in the beginning of the activity.
- Find where the solar wind change first becomes visible in the simulation. Continue to step forward in time and to see how the magnetosphere changes.
  - **What changes do you see in the magnetosphere?**
  - **What can you say about the changes in the features and position of the bow shock and magnetopause?**
- You may want to use the line plot to view the changes in this. Try opening that in a different window to compare the line plot and the cut plane.

	position	features
Bow Shock		
Magnetopause		

  - **What happens to the reconnection regions?**
  - **What happens in the tail?**
  - **Can you find the tailward moving plasmoid?**
    Try viewing the current "J" on the cut plane.
  - **What time is the plasmoid released?**

Events	Time
Magnetopause compression	
Plasmoid release	

Creating a Movie
• Under the "Choose data time" select the "Create GIF movie" radio button and enter your email address.
• Your video should be ready in a few minutes.
• A version of the movie should be in the "Lab 2" Folder.

Inner Magnetosphere

In this last section we will look at the
• Return to the run page for "HSS2012_SWMF_052212_1"
  (you may want to do this in a separate window)

• Choose "View Fok Ring Current Electrons" and then select "Update Plot"
    • **Examine the image you see.**
    • **What cut plane is presented?**
    • **What is the time in the simulation?**
    • **What does the color scale represent?**
• There are two lines on the plot.
    • The solid line is the magnetopause.
    • The dotted line represents geosynchronous orbit (at about 6.6 R_e).

Different Energy Channels
• Scroll down to "Choose Plot Area". In the lower right is pull down menu that sets the energy channel. Choose a different energy channel and update the plot.
    • **Do you see a change in the electron flux?**
• Choose the 22KeV to focus on.

Ring Current Dynamics
• Use the "Choose Data Time" menu to look at the relevant times you identified previously.
    • **What time do you see a sudden increase in the electron flux?**
    • **Which magnetosphere event does this correlate with?**
    • **What happens to the electron flux in the region of the geosynchronous orbit?**
    • **What direction do the electrons tend to drift?**

• In a separate window, return to the run page for "HSS2012_SWMF_052212_1" and choose "View Fok Ring Current Protons".
    • **Confirm the times above.**
    • **What direction do the protons appear to drift?**
    • **What physics causes the drift?**
    • **What does this say about the current? What physics causes these drifts and currents?**

What Killed Galaxy 15 (sort of)?!

Galaxy 15 is an American telecommunications satellite. It was originally positioned in geostationary orbit at a longitude of 133° West, from where it was used to provide communication services to North America. On April 5th 2010 (~ 9:48UT), Intelsat lost control of the satellite, and it began to drift away from its orbital slot, with the potential to cause disruption to other satellites in its path. At the time of failure the Galaxy 15 was located at the night side. One of the possible reasons for Galaxy 15 failure is surface charging that can be cause by increase flux in energy channel ~22Kev

The reports of my death are highly exaggerated.
- Mark Twain

To explore the event the killed Galaxy 15, follow the following link

http://iswa.gsfc.nasa.gov/IswaSystemWebApp/index.jsp?
i_1=327&l_1=9&t_1=2130&w_1=1372&h_1=403&s_1=2010-04-07%2000:00:00.0!3!
&i_2=335&l_2=32&t_2=300&w_2=800&h_2=400&s_2=2010-04-06%2022:30:00.0!3!
&i_3=41&l_3=878&t_3=734&w_3=495&h_3=416&s_3=2010-04-05%2010:00:00.0_0_1
0_3&i_4=51&l_4=858&t_4=1209&w_4=509&h_4=477&s_4=2010-04-05%2010:00:00.0
_1_80_3&i_5=337&l_5=836&t_5=300&w_5=800&h_5=400&s_5=2010-04-07%2000:00:
00.0!3!
&i_6=323&l_6=8&t_6=2552&w_6=1370&h_6=390&s_6=2010-04-07%2000:00:00.0!3!
&i_7=325&l_7=6&t_7=1700&w_7=1380&h_7=408&s_7=2010-04-07%2000:00:00.0!3!
&i_8=125&l_8=390&t_8=2965&w_8=646&h_8=418&s_8=2010-04-06%2023:56:00.0_0
_10_3&i_9=39&l_9=175&t_9=1226&w_9=493&h_9=409&s_9=2010-04-05%2010:00:00
.0_0_10_3&i_10=43&l_10=33&t_10=722&w_10=792&h_10=468&s_10=2010-04-05%2
010:00:00.0_0_10_3

This lay out from CCMC contains both data and simulations results
- *Solar Wind Data*
  - Scroll down to the bottom of the page and find the three plots from the ACE spacecraft which orbits at L1.
  - **Identify the time at which the CME passes ACE?**
    What is your criteria for the passage of the CME?
- *Kp Observation and Prediction*
  - Scroll up to the top to find the "Observed Kp" and "Predicted Kp".
  - The observed Kp is derived from magnetometer measurements.
  - The predicted Kp is calculated using an empirical formula that uses the solar wind measured at ACE as input.
  - **Based on the observed Kp, when does the geomagnetic storm begin.**
  - **Compare that to the ACE data. Why is there s difference in the two times?**
  - **Compare the observed to the predicted. How good is the model?**

- **Simulation Results**
    - Just below the Kp results are magnetosphere models for this event.
      Four panels show:
        - the global MHD model of the magnetosphere,
            - **Can you identify the cut plane and which direction is north?**
        - a view of the inner magnetosphere from the same model,
            - **What cut plane is shown here? How do you think the magnetopause is identified?**
        - a plot showing the stand off distance of the magnetopause as a function of time,
            - **Can you estimate when the storm starts? What indication do you use?**
        - output from a ring current model which is driven by the magnetosphere model.
            - **What effects do you see in the ring current when the geomagnetic storm occurs?**

•Each of the simulation results panels can be run as a "movie" by clicking on the movie button on the lower right hand side. If you down load the movies you can run the images or scroll through the images using the slider bar.
- **Can you correlate the what is happening in the magnetosphere model and the ring current model?**