

Solar Activity

Part 2: Models

Introduction

In this lab you will explore structure of the solar magnetic field using visualizations of simulation results. After this lab you should:

- understand the structure of magnetic fields around active regions
- identify the origins of open and closed field lines
- compare the structure of the solar magnetic field at solar minimum and solar maximum

Getting Started

Open the “Space Weather Explorer” (SWX) which has a link on the desktop. Use the File selector to navigate to the “Solar” directory. Open the “mas_cr2080.cdf” file. The simulation results in this file were generated using the MAS (“Magnetohydrodynamics around A Sphere”, insert links) model for Carrington Rotation (CR) 2080 near Solar Minimum in December of 2008.

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- Click the “+” button to add a surface.
- Click the “tool” button to open the surface settings. The “R” component should be set with the “constant value” near “1”
- Choose the “B_r” variable to display on this surface. “B_r” is the radial component of the magnet which is very near that which is extrapolated from the solar magnetograms. Click “ok”.

The image should be very close to the synoptic map of the magnetogram synoptic map below and depicts the magnetic field near the surface of the Sun. For this model, the magnetograph synoptic map sets the inner boundary condition

You can compare it to the SOHO synoptic magnetogram at

http://soi.stanford.edu/magnetic/synoptic/carrot/M/2080/synop_MI_0.2080.gif

Exploring the Solar Corona Solar Minimum

- In the “View” menu, click on “3D View” to see this image wrapped onto a sphere representing the solar surface magnetic field.
- You can rotate the image by using “click in drag” and zoom out using the mouse wheel.

1. **What general conclusions can you draw about the magnetic field at the surface of the sun during Solar Minimum? Is there a magnetic active region?**

2. **Draw what you think the solar magnetic field should look like in this case, and discuss it with your group.**
3. **What is the configuration of the field near the poles?**
4. **... near the active regions?**

You can choose some field lines by clicking on the solar surface in the original window.

- Start by clicking on field lines near the active region.
1. **What is the configuration of those lines? Do all the lines do the same thing?**
- Click on lines near the poles.
1. **What is the configuration fore these lines?How does this compare to you predictions above?**
 2. **For field lines that begin and end on the surface of the sun, what can you say about the relative polarity of the foot points?**
 3. **Approximately, what is the furthest extent that closed field lines extend out from the Sun?**

Clicking on the map provides seed points from which field lines are drawn. We can also import set of seed points from a text file. To explore the magnetic field more carefully, we can import a “regular” set of seed points.

- From the “View” menu, click on “Seed Points”.
 - To remove the points you have chosen click on “Remove all”
 - Click the “Import” button and navigate to the “Solar” directory. The .csv files in this directory are text files with regularly spaced seed points. Choose “Global-1.5Rs.csv” to plot seed points starting at 1.5 solar radii. Click “ok” and hit the “Go” button on the 2D map. You may have to reopen the 3D view to see the field lines.
- **What generalizations can you make about the origin of “open” and “closed” field lines?**
 - **Where do most of the field lines that reach the boundary originate from?**
 - **Where do most of the “closed field lines” originate from?**

Solar Maximum (Homework)

The example we will use for solar maximum is from CR 1965 which occurred during the last solar maximum, July of 2000.

- Use the “File” menu to navigate to the “mas_cr1960.cdf” file in the Solar directory.
 - IncludClear the seed positions.
- **What do you notice about the number and position of the magnetic active regions?**
 - **Draw what you think the solar magnetic field might look like for this CR.**
- Click on a few points on the map and explore the magnetic field structure.
- **What conclusions can you draw about the structure of the closed field lines? Is it a regular structure? Do closed field lines only connect from one pole of an active region to the other pole of the same active region?**
 - **What about open field lines? Where do they originate?**
- Confirm your conclusions by using the regular seed points at 1.5 Rs and 28 Rs

Conclusion

Open field lines that reach out into the heliosphere tend to originate from coronal holes where much of the solar wind originates.

- **What conclusions can you draw about the source of the solar wind at solar minimum and solar maximum? At what latitudes does the solar wind originate from on the Sun?**
- Return to the iSWA window.
[http://iswa.ccmc.gsfc.nasa.gov:8080/IswaSystemWebApp/index.jsp?
i_1=71&l_1=419&t_1=269&w_1=451&h_1=373&i_2=5&l_2=662&t_2=633&w_2=395&
h_2=427&i_3=4&l_3=218&t_3=644&w_3=417&h_3=428&i_4=137&l_4=15&t_4=253&
w_4=388&h_4=400&i_5=139&l_5=907&t_5=261&w_5=399&h_5=409](http://iswa.ccmc.gsfc.nasa.gov:8080/IswaSystemWebApp/index.jsp?i_1=71&l_1=419&t_1=269&w_1=451&h_1=373&i_2=5&l_2=662&t_2=633&w_2=395&h_2=427&i_3=4&l_3=218&t_3=644&w_3=417&h_3=428&i_4=137&l_4=15&t_4=253&w_4=388&h_4=400&i_5=139&l_5=907&t_5=261&w_5=399&h_5=409)
- Choose a date near the Solar minimum case above near December of 2008. Notice the model output in the middle of the screen. This model is the (PSFF) model.
 - **Are the field lines shown here consistent with what you saw in the MAS model?**
 - **What conclusions can you draw about the relationship between the “coronal holes” seen in the SOHO EIT (Extreme Ultraviolet Images).**