

Summer School Lab Activities

Lab #2: Exploring the Structure of the Solar Magnetic Field

Introduction

In this lab you will explore the structure of the Sun's magnetic field from its surface to out beyond the solar corona. During these activities you will look closely at magnetograms, which are measurements of the magnetic field of the sun at the solar surface, and the structure of the magnetic field out to 10's of solar radii as computed by a magnetohydrodynamic (MHD) model called Magnetohydrodynamics Around a Sphere (MAS).

Goals: When you are finished with this lab you should be able to:

- identify sunspots with magnetic active regions
- identify the difference in structure of active regions between the northern and southern hemisphere
- compare the properties of active regions over the course of a solar cycle
- compare the structure of the solar magnetic field at solar minimum and solar maximum
- compare the properties of active regions from one solar cycle to the next
- compare coronal magnetic field structure to coronagraph images

Before Beginning

In your group:

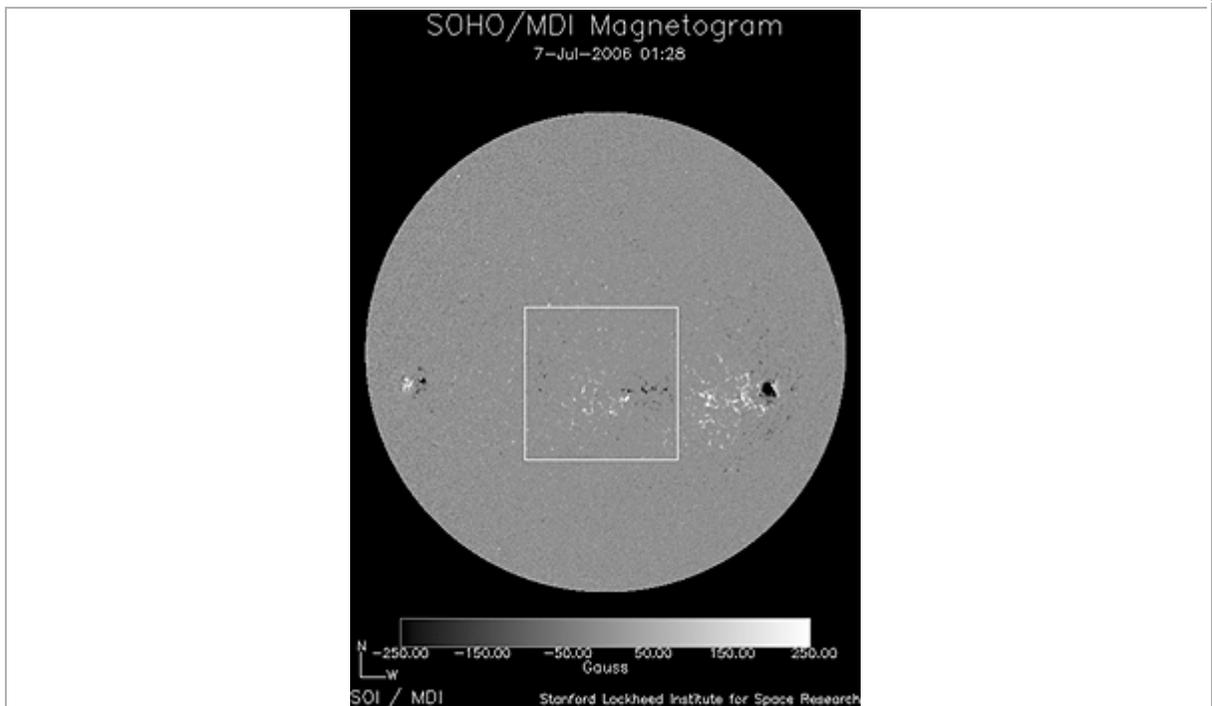
- *Sketch what you think the solar magnetic field looks like at solar minimum and solar maximum.*

Activity 1: Introduction to Solar Photospheric Magnetograms and Synoptic Maps

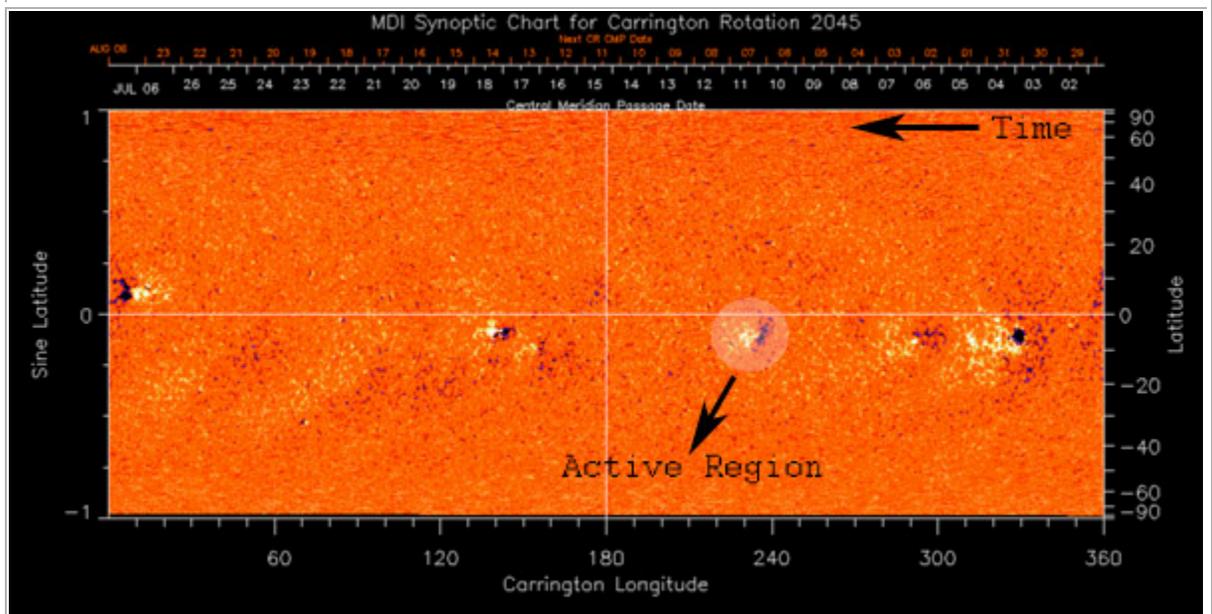
Magnetograms are images of the solar magnetic field at the photosphere. They are derived by measuring the size of line splitting due to the Zeeman Effect. (Electrons in the same energy level, but with different angular moment will have their energies changed slightly when a magnetic field is applied. This appears in the atomic spectrum as split spectral lines.) These magnetograms are used as the inner boundary conditions for coronal models such as Wang-Sheeley-Arge (WSA) and Magnetohydrodynamic Around a Sphere (MAS).

The first image on the next page is a magnetogram synoptic map. It can be thought of as a projection of the solar surface onto a flat plane. All of the magnetogram synoptic maps are compiled from solar magnetograms such as those taken from SOHO like the one above on the right. To construct these synoptic maps only the central portion of the SOHO image is used. A series of such images are taken as the sun rotates and are pasted

together to construct a map over the course of a rotation. Some weighted averaging is done for areas that overlap.



Courtesy of SOHO/MDI consortium. SOHO is a project of international cooperation between ESA and NASA.



All magnetograms shown here are provided by the [Stanford Solar Group](http://soi.stanford.edu/) (<http://soi.stanford.edu/>) and can be found from their [Carrington Rotation Search Page](#)

(<http://soi.stanford.edu/magnetic/index6.html>).

Answer the following questions in your lab note book.

- *Look at the axes on all sides. Notice that the left/right and top/bottom label pairs are different from each other. How do you interpret all the axes labels?*
- *There are two sets of dates at the top? What do you think these dates mean? (Notice the date on the raw magnetogram on the left. Also notice the direction that dates proceed on the synoptic map.)*
- *Why might the data near the poles be suspect?*
- *Which region of the raw magnetogram corresponds to the active region labeled on the synoptic map? (Hint: Check the dates.)*
- *Do the structures of the magnetogram and the synoptic map on the match exactly? If not, why not?*

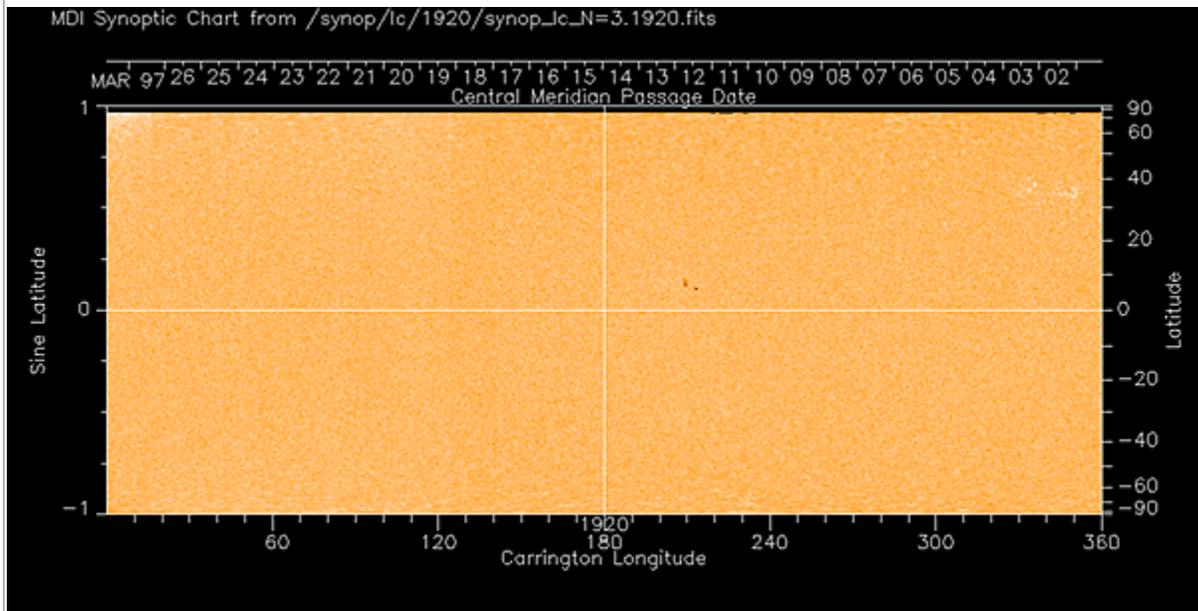
Activity 2: Sunspots and Magnetic Active Regions

Based on the images below answer the following questions in your lab notebook. These images were downloaded from the [Stanford MDI synoptic map data base](http://soi.stanford.edu/magnetic/index6.html) (<http://soi.stanford.edu/magnetic/index6.html>).

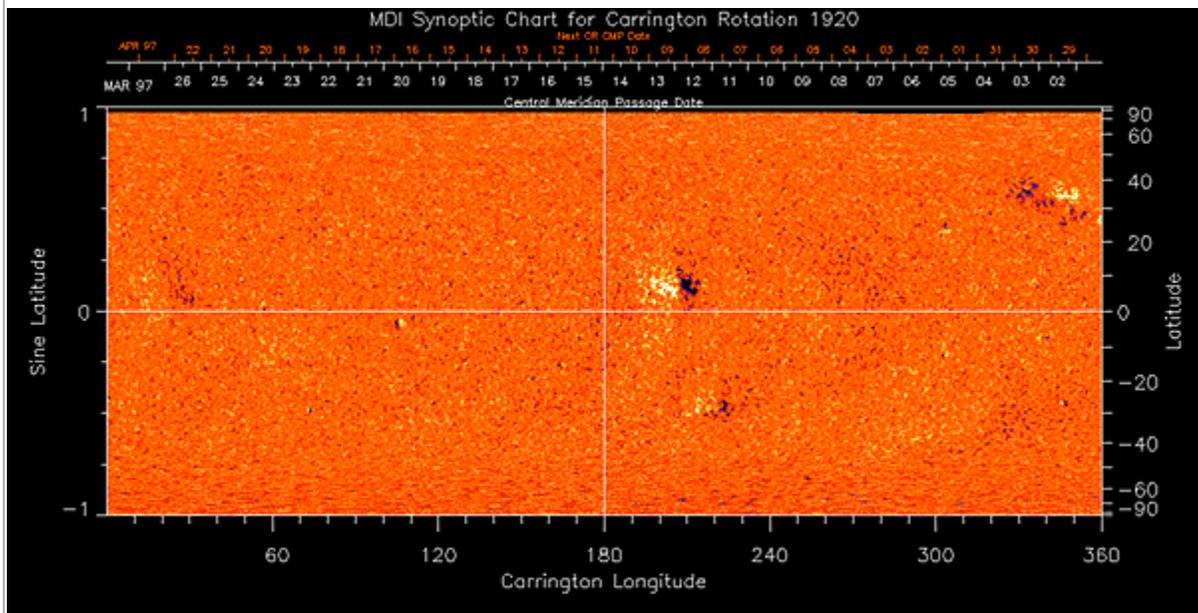
- *What is the relationship between sunspots and magnetically active regions?*
- *Are all sunspots associated with magnetically active regions?*
- *Are all magnetically active regions associated with sunspots?*
- *How does the structure of the active region differ between the northern and southern hemisphere?*

Solar Minimum (CR 1920)

White Light Intensity

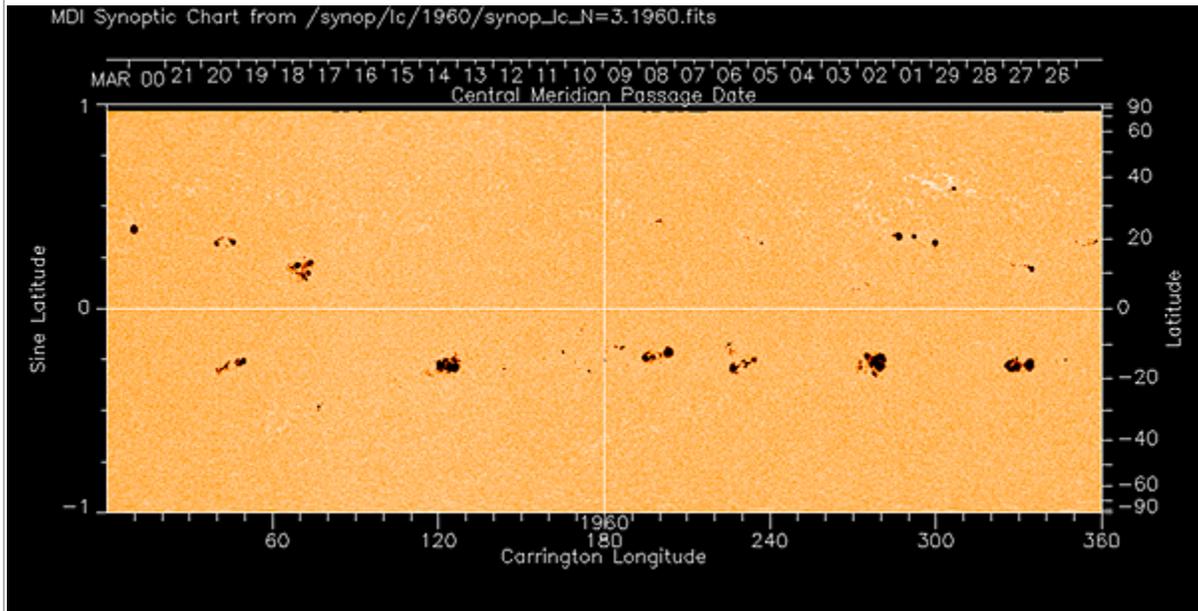


Magnetogram

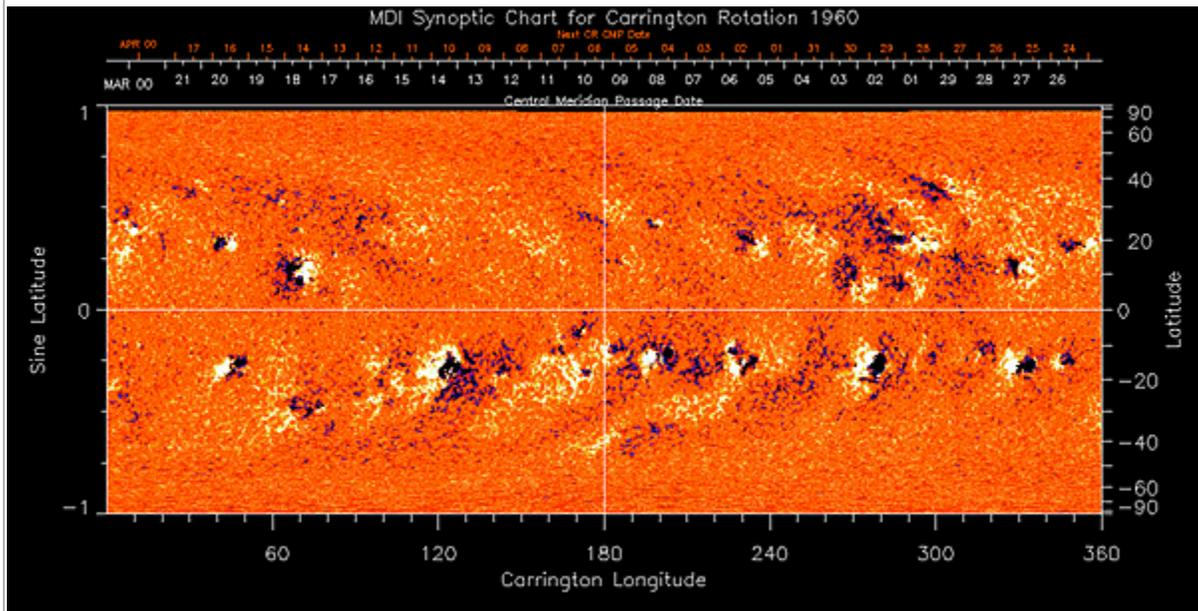


Solar Maximum (CR 1960)

White Light Intensity



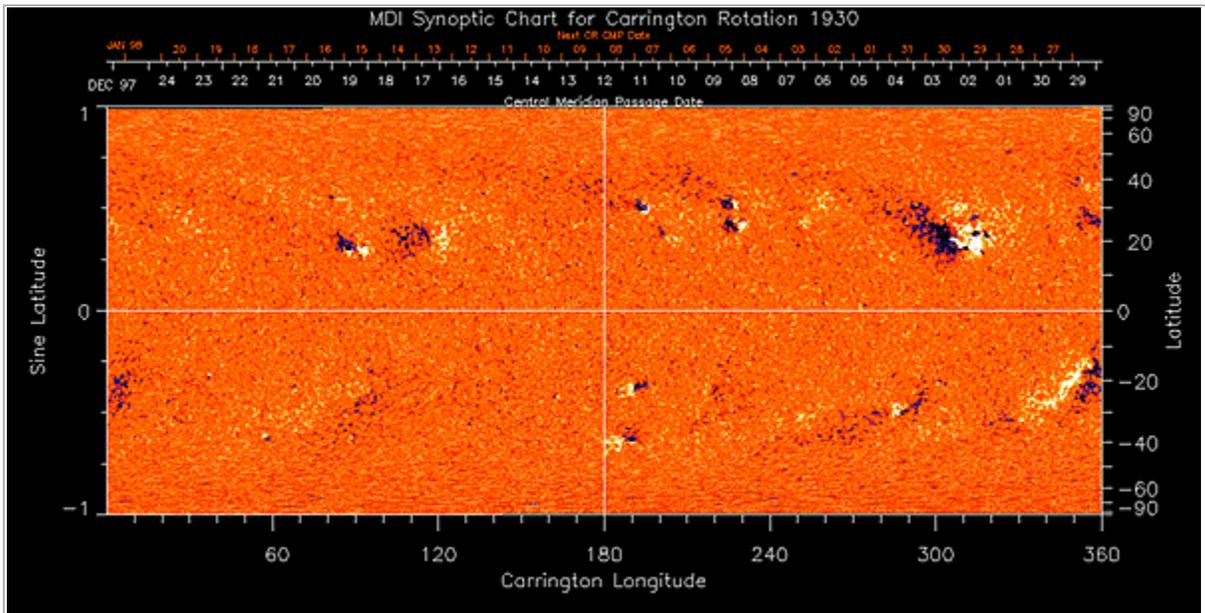
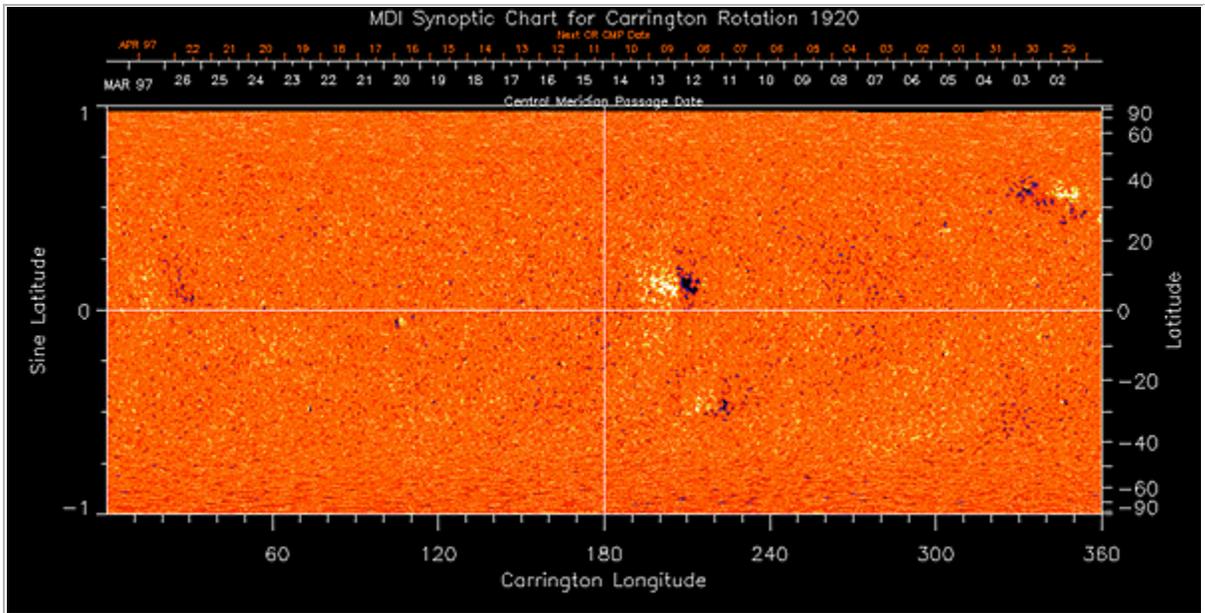
Magnetogram



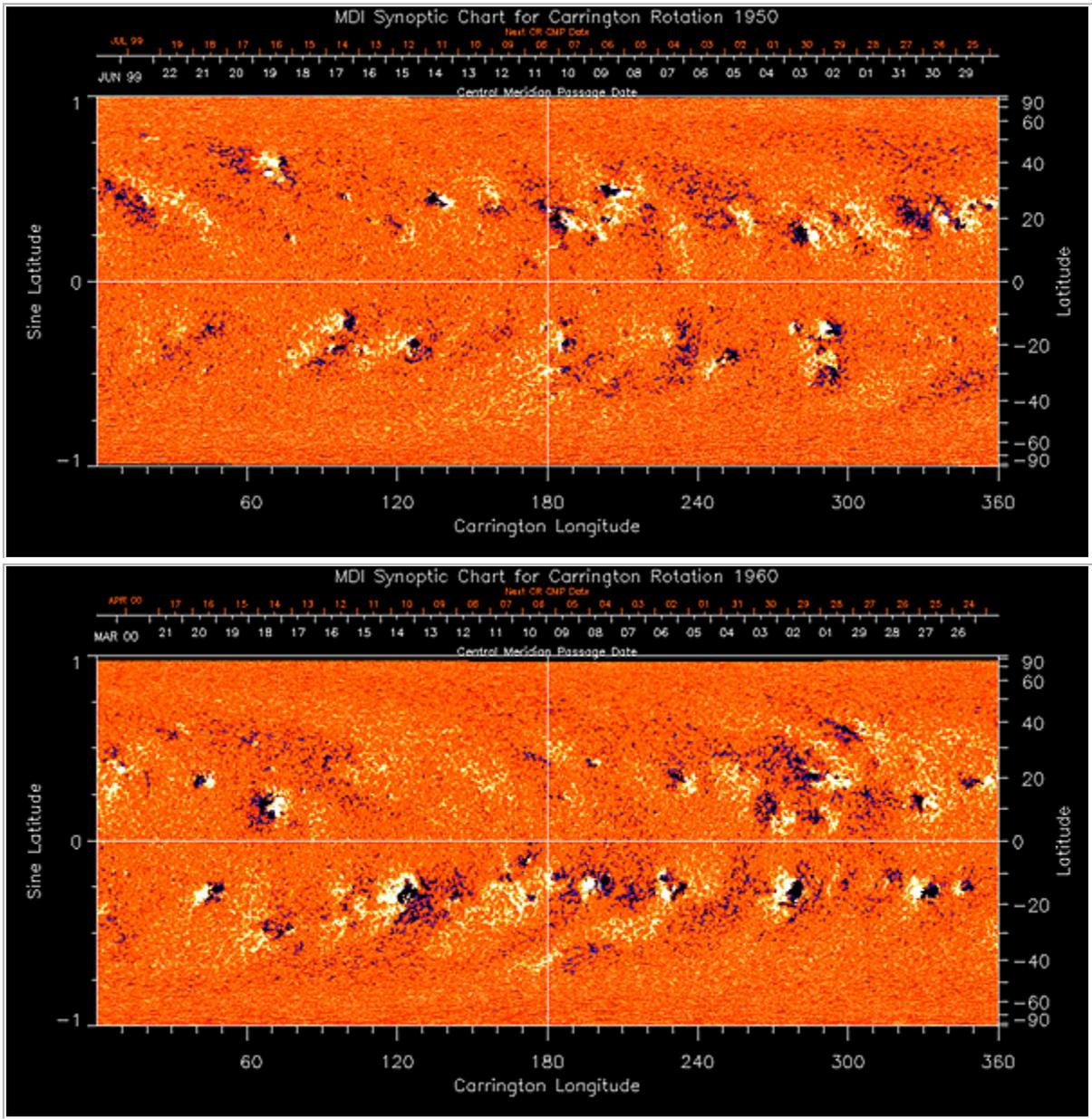
Activity 3: Active Regions Over the Solar Cycle

Below are a series of magnetogram synoptic maps. They are samples of maps from the last solar cycle (cycle 23), sampled every 10th Carrington rotation. Answer the following questions based on these images, answer the following questions. (*Note: If you are using the printed version of this, be sure to look at the electronic version in the lab2 folder for all of the images*)

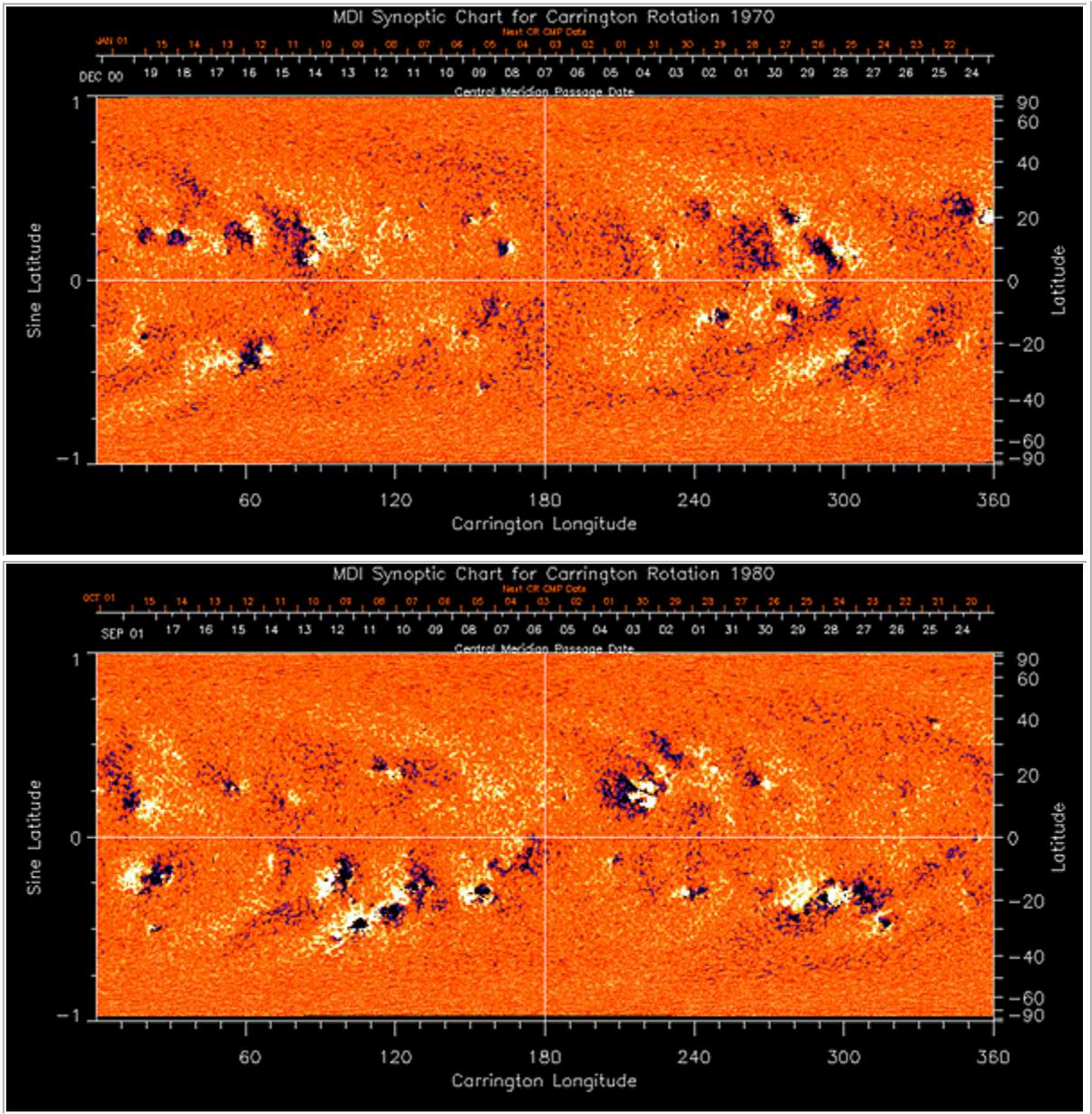
- *What happens to the average latitude of the active regions over the solar cycle?*
- *Which Carrington rotation depicted below indicates the beginning of Solar Cycle 23?*
- *Is the beginning of the solar cycle occur during solar maximum or solar minimum?*
- *What are the indicators for the beginning of the solar cycle?*



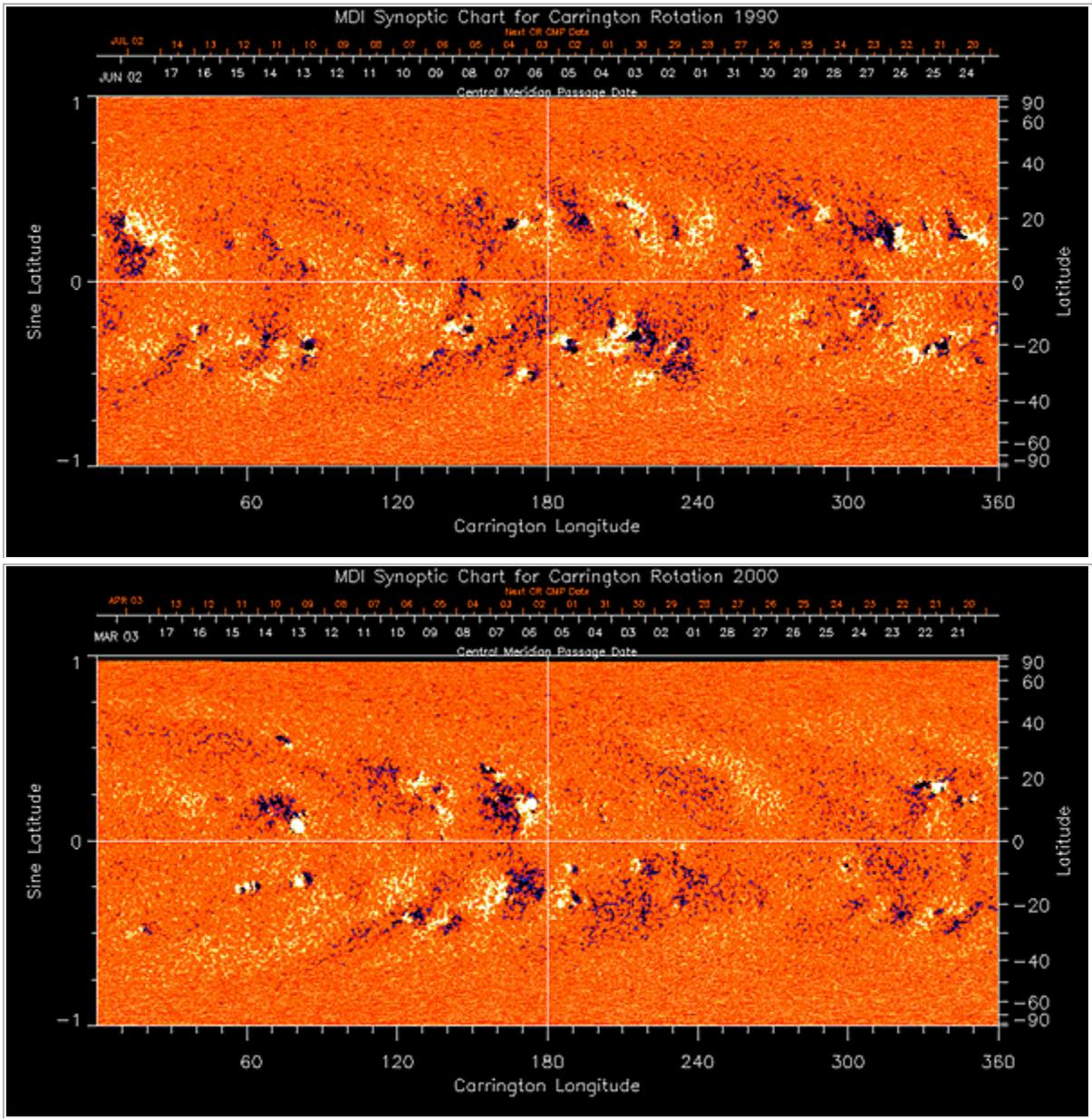
Data missing for CR 1940



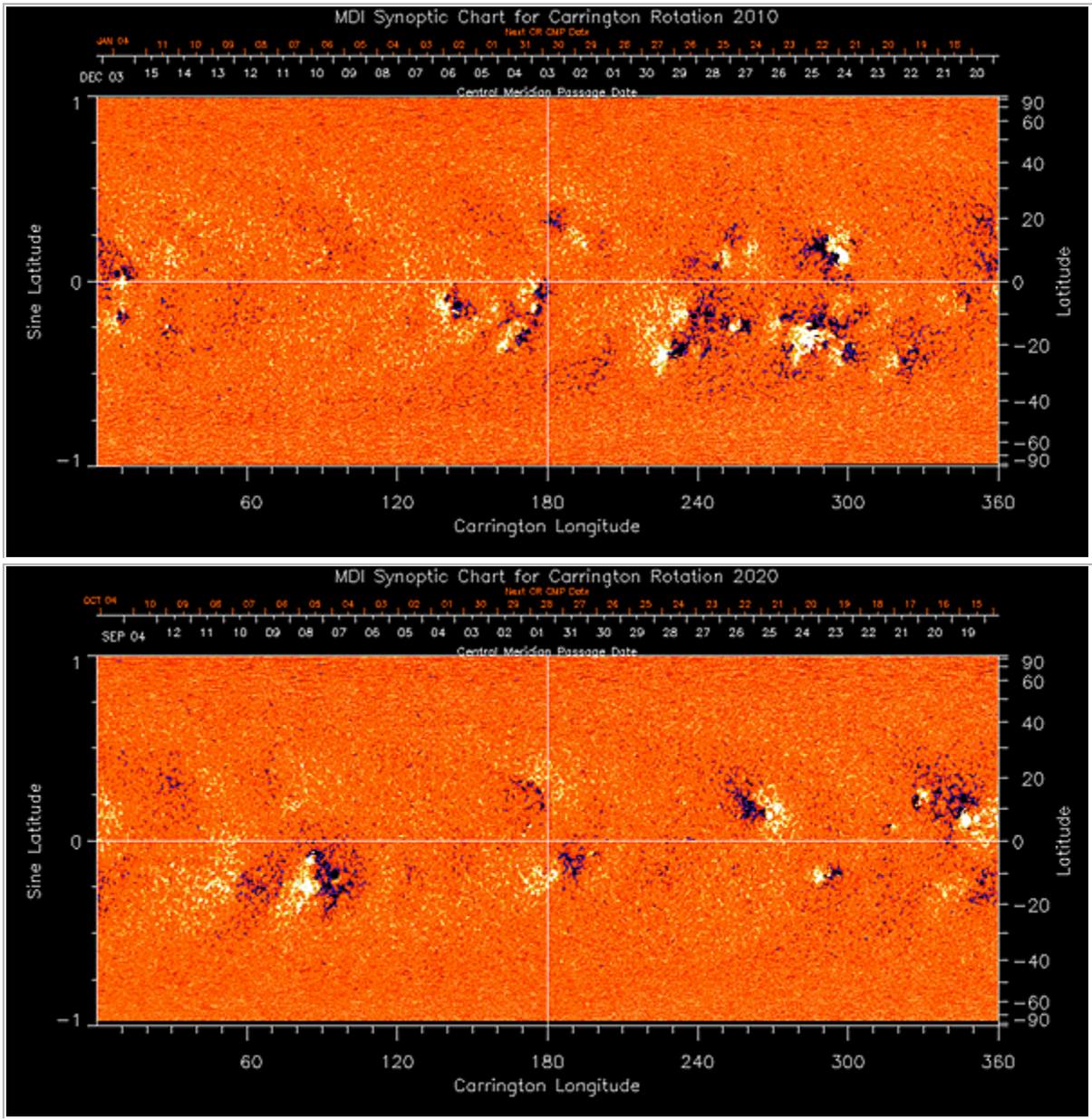
Lab #2: Exploring Solar Magnetic Structure



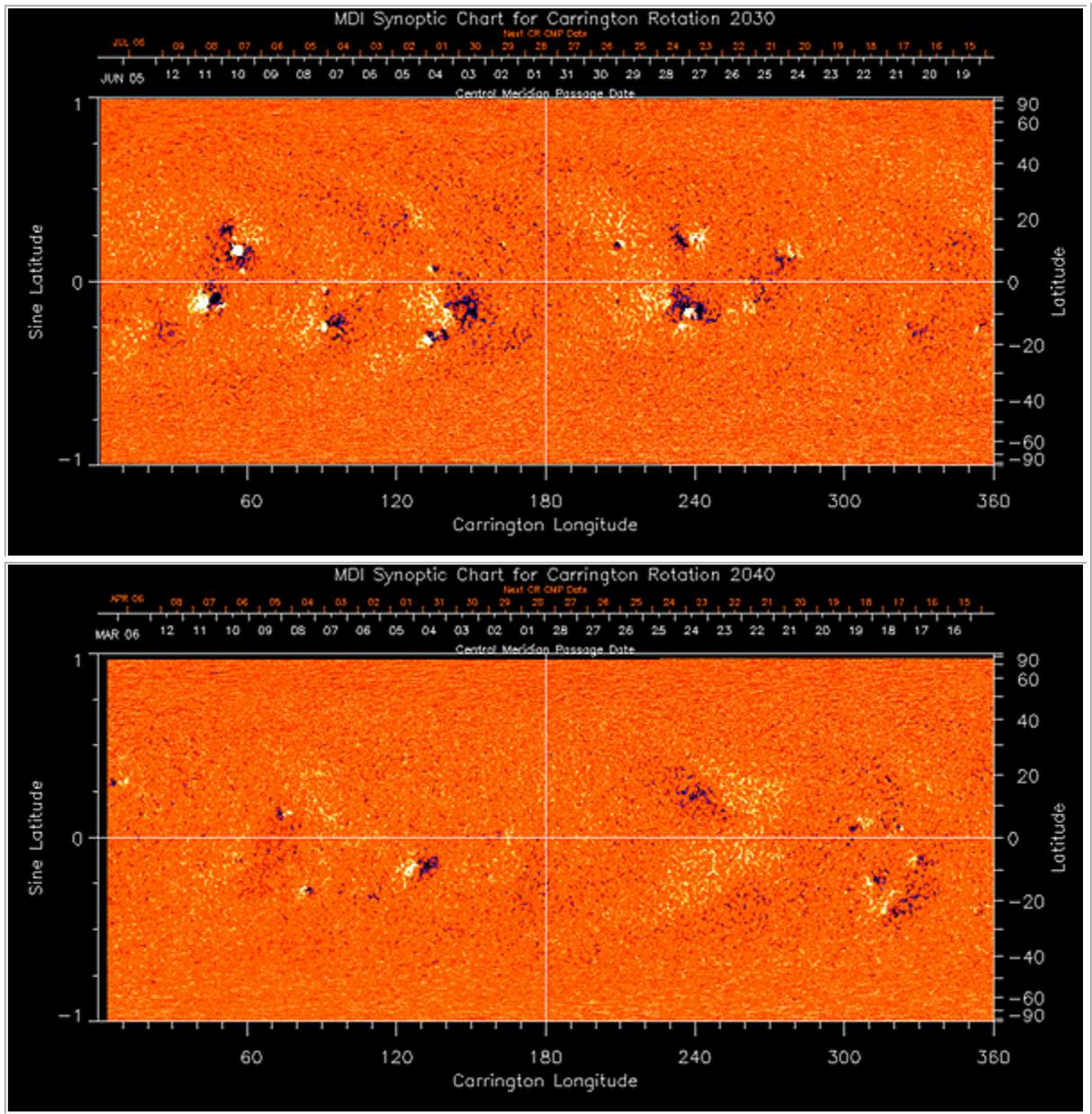
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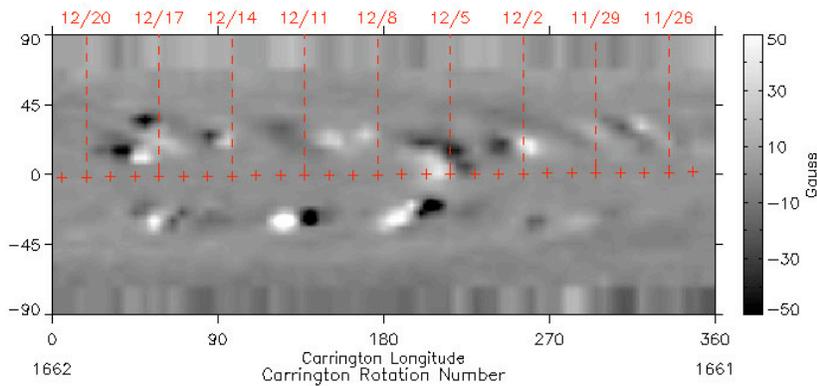
Activity 4: Active Regions From Cycle to Cycle

In this page you will explore how the structure of magnetic active regions as they change from one solar cycle to the next. Below are the magnetogram synoptic maps from the rising phase of solar cycles 21, 22 and 23. As you review these images, consider how the structure of the photospheric magnetic field changes from cycle to cycle. Keep the following questions in mind and record the answers in your notebook.

- *How does the structure of the magnetic active regions change from one solar cycle to the next? What happens to the difference in structure between active regions in the northern and southern hemisphere?*
- *Can the change you observed in the active regions also be observed at the poles?*
- *How does the magnetic structure of the active region in one hemisphere relate the the polar magnetic field in that hemisphere?*

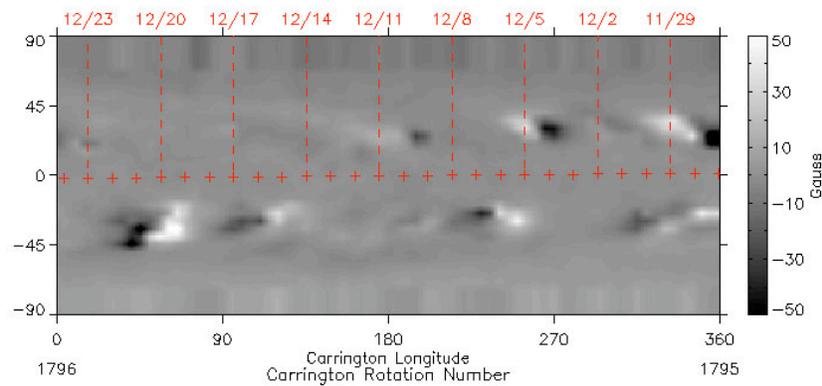
Solar Cycle 21 (CR 1662)

Observed Photospheric Field from Mt Wilson Solar Observatory



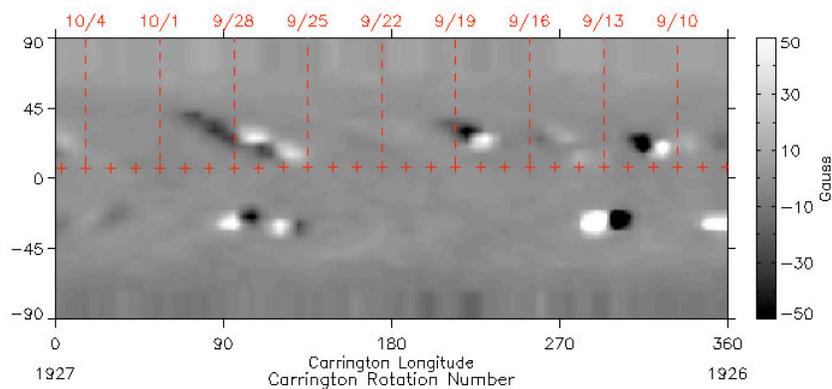
Solar Cycle 22 (CR 1796)

Observed Photospheric Field from Mt Wilson Solar Observatory



Solar Cycle 23 (CR 1927)

Observed Photospheric Field from Mt Wilson Solar Observatory



These magnetogram synoptic maps were developed from data taken at the [Mt Wilson Observatory \(MWO\)](http://www.astro.ucla.edu/~obs/intro.html) (<http://www.astro.ucla.edu/~obs/intro.html>).

Activity 5: Exploring the Structure of the Corona Magnetic field

This activity involves visualizing the results of the MAS computer model runs for various solar conditions using CISMDX. The manual for this activity can be found in a separate PDF file.