The Active Sun[1]

Comment [1]
This lab is aimed at students in an observational astronomy course or similar setting. It presumes previous exposure to physical reasoning at the level of introductory astronomy or conceptual physics courses, and familiarity with wavelength as a proxy for temperature in a thermal environment.

Through programs such as NASA's Living with a Star, research-grade observational data and computer simulation results covering all facets of heliophysics are being made publicly available. By learning to manipulate the data products used to serve these data to scientists, you can access high-resolution, near real-time images of the solar photosphere, chromosphere, and corona, as well as archived images for more than a full solar cycle.

In this exercise, you will familiarize yourself with the iNtegrated Space Weather Analysis (iSWA; pronounced ice-wah) interface and use it to explore full-disk solar images at a variety of wavelengths. You may come back to this interface later, to explore manifestations of the solar wind and its interaction with the magnetosphere and ionosphere of the Earth. Through this exercise, you should learn:

- how to find and display images of the Sun at different wavelengths for a specified date and time,
- what wavelengths correspond to each region of the solar atmosphere as described in lecture (photosphere, chromosphere, corona),
- which markers of solar activity (sunspot groups, prominences, flares, etc.) are visible in each type of image, and
- what timescales are typical for changes in some of these markers (seconds, minutes, hours, days).

Instructions:

First, watch at least the first three minutes of the brief tutorial at the following URL, https://www.youtube.com/watch?v=vHk_8VVmLpo, to familiarize yourself with the controls for the iSWA interface. In this video, you should learn how to browse information describing each data product (called a "cygnet," in reference to baby swans, because the iSWA system was formerly called SWAN), how to add a data product to your display or "layout," and how to manipulate the time of one (or all) of the data products in your layout. Make notes on each process, below:

1) Two ways to determine what data a cygnet will link to:[2]

   Comment [2] Mouse over icon for short description; use Help button at top of screen to link to wiki for long descriptions

2)

3) How to add a cygnet to your layout:[3]
Comment [3] Click cygnet's icon, drag, and drop onto screen

4)

5) How to access your custom layout in the future:[4]
Comment [4] Use Save Layout button and copy custom URL for future reference

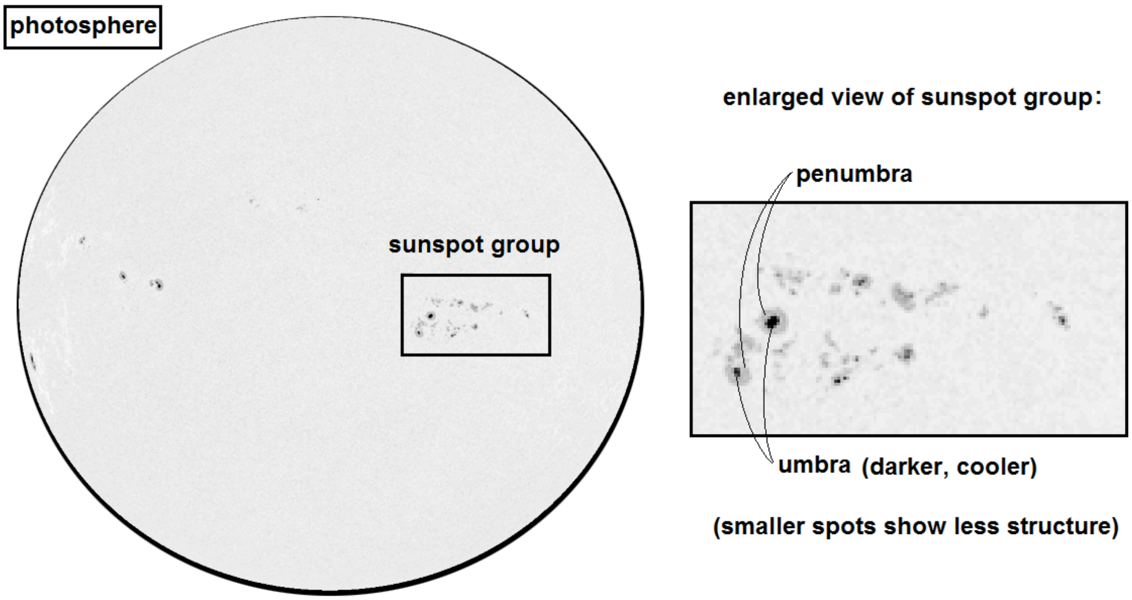
6)

7) How to reset the lookup time on one cygnet:[5]
Comment [5] Use pull-down arrow on time box at bottom of cygnet to choose new time, then hit apply to reset to desired start time

8)

9) How to synchronize the times of all cygnets in your layout:[6]
Comment [6] Use Global Date/Time button at top of screen, then pull-down arrow and Update - applies to all cygnets in your layout

Finding full-disk images of the Sun:



Next, use the image of the photosphere, above, combined with techniques you identified in question 1) to determine which of the data products show full-disk images of the solar photosphere. Do not include magnetograms, which will be discussed later, nor full disk images of other regions, like the chromosphere or corona. List at least three here, by cygnet name:[7]

Comment [7]
SDO – AIA – 4500
SDO – HMI Solar Continuum (Flattened Colorized Intensitygram)
SOHO – MDI Continuuum
Intensity - ** - NSO GONG (where ** could be any of these: Big Bear, Cerro Tololo, El Teide, Mauna Loa, Learmonth)
ASSA detected sunspot group plot on SDO HMI Continuum (kind of)
Solar Flare Monitor (kind of)

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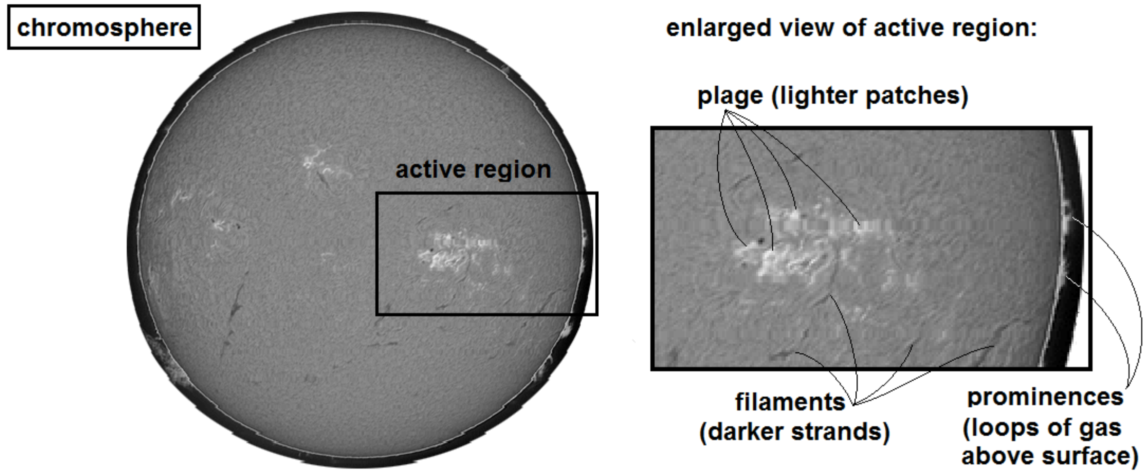
What are the observing wavelengths for each of the data products you chose?

____

In what part of the electromagnetic spectrum do those wavelengths lie?

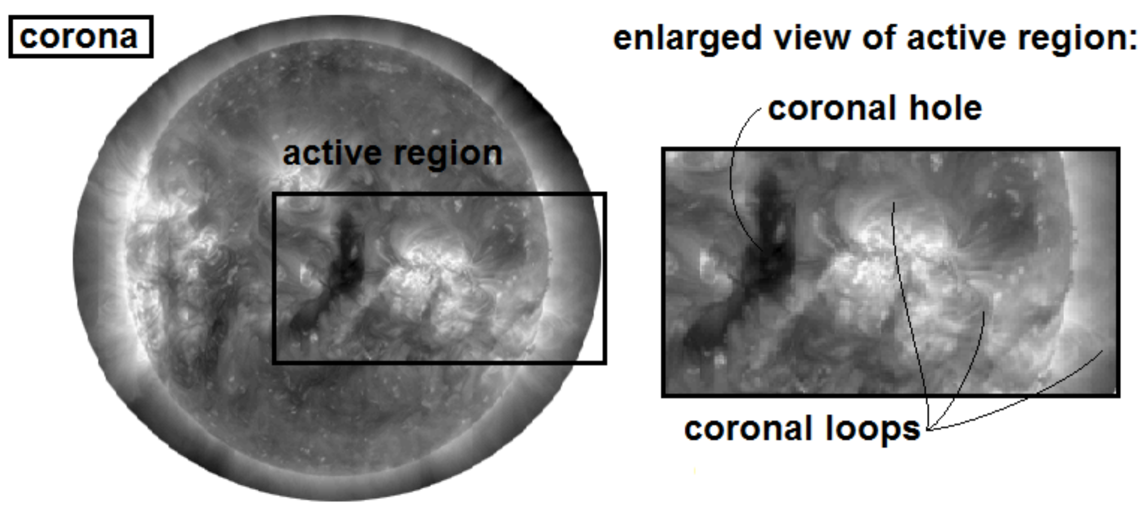
____



Repeat this process for the chromosphere, pictured above. That is, determine which of the data products show full-disk images of the solar chromosphere. List at least three here, by cygnet name:

What are the observing wavelengths for each of the data products you chose?

In what part of the electromagnetic spectrum do those wavelengths lie?



Finally, determine which of the data products show full-disk images of the solar corona, pictured above. List at least three below, by cygnet name:

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What are the observing wavelengths for each of the data products you chose?

____

In what part of the electromagnetic spectrum do those wavelengths lie?

____

Considering your answers for the wavelengths at which each region is observed, which region do you think is hottest? Why?

____

Watching for changes:

Simplify your layout a bit, to look only at the following three cygnets:

- SDO HMI Solar Continuum (Flattened Colorized Intensitygram)
- H alpha – (any middle label) – NSO GONG
- SDO – AIA 193 – Space Weather Product

Synchronize these cygnets to date and time 2/25/2014 00:15:00

To view a series of images in succession, click the filmstrip icon in the lower right corner of each cygnet. Because of the different observing cadences (frequency with which each type of image is taken), the “movies” will not match up from cygnet to cygnet. In which cygnet does the Sun’s rotation appear most noticeable?

____

What does that imply about the time between images displayed by that cygnet?

____

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Figure out the time between images for each cygnet by pausing the playback and using the backward/forward cursors on either side of the frame marker bar across the bottom to step by one image at a time. Record your results in the table below:

Cygnet:	Time between (min[8])	
SDO HMI		
H-alpha NSO GONG		
SDO – AIA 193		

Comment [8]
SDO HMI, 15 min
H-alpha GONG, 5 min
SDO AIA 193, about 3 min, with gaps; Perhaps the instrument was taking images at another wavelength every so often, or maybe there was some other process that was delaying things – filter wheel change, perhaps, or downloading data to a buffer for sending later?
Extra column: 11, 30, 27 (see below)

Which of your three results was not exact? Did you notice longer gaps between some images? What might the spacecraft have been doing instead of taking images?

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___

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Now look at features in each set of images to see if they change shape, size, or intensity from frame to frame. Note your observations below, for each feature:[9]
Comment [9] No noticeable changes for sunspots themselves (do see solar rotation); some prominences change, even appearing or disappearing in the < 1hr viewed; No noticeable change in coronal holes, and only a few pinpoints where coronal streamers change, even

Sunspots (photosphere): ___

Prominences (chromosphere): ___

Coronal holes (corona): ___

Try adding frames to your movie of the photosphere. How many frames would you have to add to back up the darkest sunspot on the right all the way back to the center of the solar disk? (Doing this by trial and error will take some time if your internet connection is not very fast.)[10]
Comment [10] About 150

What does this tell you about the rotation period of the Sun? (Don't worry about finding an actual number – just try to conclude whether it's best measured in minutes, hours, days, or months.)[11]

Comment [11] Over about 2 days, spots moved from center to not quite half way projected to edge, so best measured in days

Rapid changes during solar flares:

Use the "Time between" data from your table, above, to set up different numbers of frames for each cygnet such that each movie runs from about 00:30 to 03:00 on 2/25/2014. (Make sure you set time to 03:00:00 each time you apply new frame settings, so that the cygnet doesn't accidentally end on the time of the frame that was showing when you clicked to reset the number of frames!) You will need to use trial and error to set a good frame number for the cygnet in which time steps are not always the same. Record the number of frames you decided upon for each cygnet in the extra column of the table above.

At approximately 00:45:00 UT on 2/25/2014, a solar flare occurred on the Sun. In which of your three cygnets was the flare detected?[12]

Comment [12] Detected in SDO AIA 193 (corona) and H-alpha NSO GONG (chromosphere)

About how long did it last?[13] (Explain how you judged when to measure it as "done.")

Comment [13] (In both images where it was detected, the region was still brighter than its surroundings even after a couple of hours, so judge duration by finding frame in which brightness at flare location returns to brightness of a typical bright region elsewhere in the image.)
In the H-alpha image, region was back to brightness typical of other bright spots in image after about 20 frames (100 min, about 1.6 hrs). In AIA 193 image, region was back to brightness typical of other spots by about 1:55, which was 70 minutes after the flare erupted.

For further investigation:

Use your new skills with the iSWA interface to examine additional solar images. Develop your own project to compare solar images in some way – perhaps comparing images from a single atmospheric layer on different dates, or tracking the appearance of an active region in all three layers, or searching for coronal flares over some time period, for example. Describe your project below:

Homework assignment:[14]

Comment [14]
Evaluation rubric (level of achievement rated as 2 = satisfactory, 1 = developing, 0 = not in evidence):
Student describes a project that can be completed with the iSWA data products.
Student accesses iSWA data products to carry out project.
Student correctly identifies solar atmospheric layer(s) and wavelength(s) for iSWA cygnets used.
Student correctly identifies solar features relevant to project.
Student provides relevant numerical or qualitative data in a clear, easy to understand format.
Student provides appropriate citation to references consulted.
Student follows standard conventions for good writing.

Carry out the data project you described above and report your results. Write this assignment as a brief, typed report, using full sentences, standard paragraph structure (one major idea per paragraph), and proper grammar, punctuation, and spelling. Include references to any outside sources (print or electronic) you use in completing this assignment. Be sure to include a description of your project in your report. Include images, graphs, or tables in your report, too, to make your results clearer and easier to understand.

References:

http://iswa.gsfc.nasa.gov/iswa/iSWA.html (iSWA interface)
http://iswa.ccmc.gsfc.nasa.gov/wiki/index.php/Main_Page (iSWA wiki)
http://iswa.gsfc.nasa.gov/iswa/Tutorials.html (links to additional tutorials)
http://solarscience.msfc.nasa.gov/feature1.shtml (for features of photosphere)
http://solarscience.msfc.nasa.gov/feature2.shtml (for features of chromosphere)
http://solarscience.msfc.nasa.gov/feature3.shtml (for features of corona)