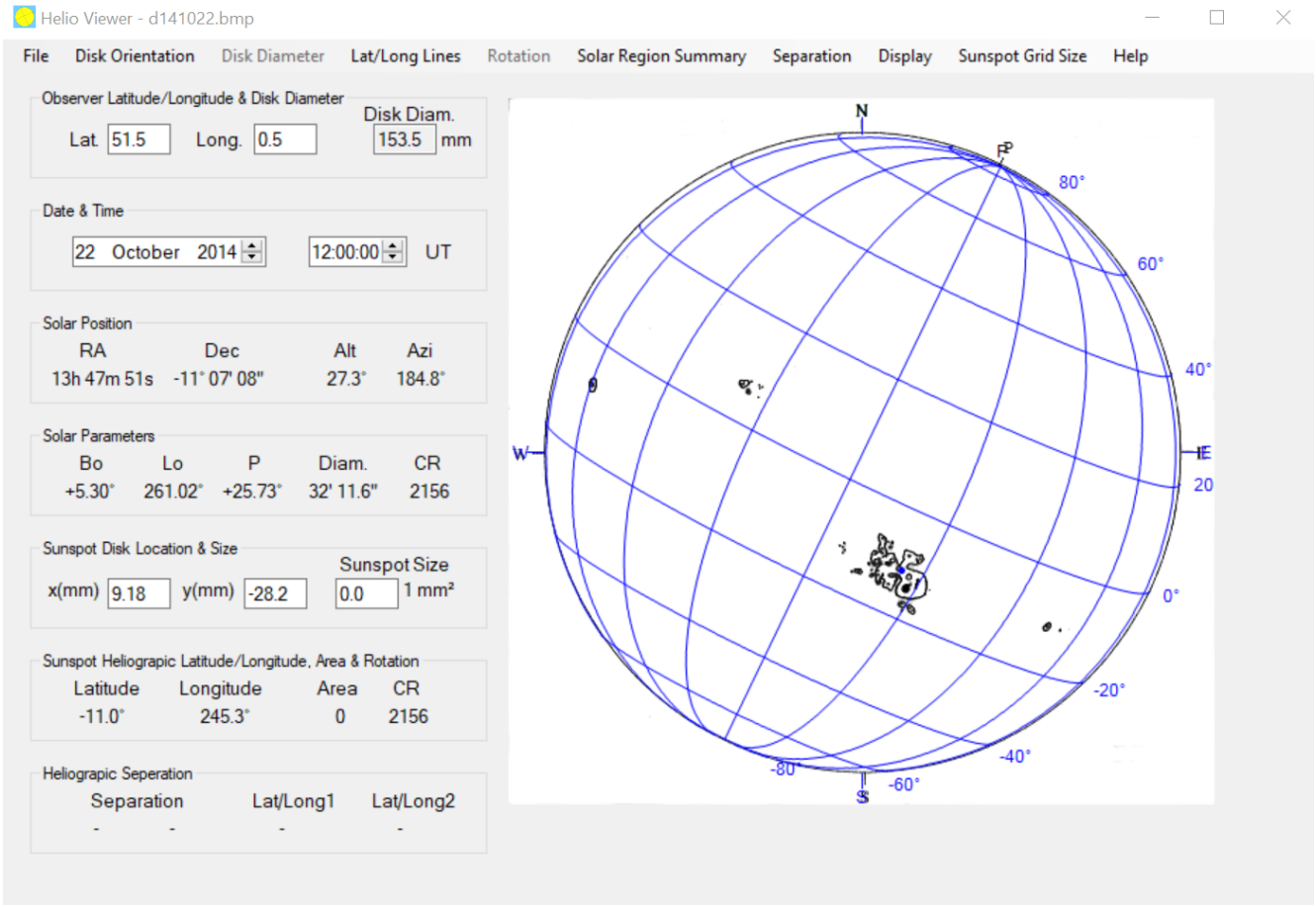
Helio Viewer v2.4 User Guide



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1. Introduction

As a solar observer who makes full disk drawings (see [1]) and who wished to determine the latitude/longitude and area of spots groups, I wanted an easy way of measuring these parameters without the need for lots of hand calculations. Developed from Helio, Helio Viewer drastically reduces the time required to analyse my solar observations.

There are two basic modes of operation: with the artificial Sun (as appears at program startup) or a user full disk solar image. Helio Viewer has the following features:

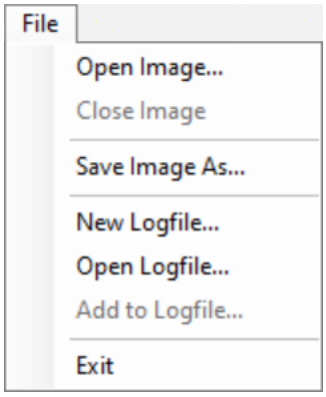
- Input of a user full disk image, such as those on this web site or those with a solar disk surrounded by a black background, in a variety of formats including .bmp, .png & .jpg.
- Determine the solar position (RA, Dec, altitude and azimuth) and solar parameters (Bo, Lo, P, apparent diameter and Carrington rotation of the central meridian) for a given date and time, and observer latitude and longitude.
- Select the diameter of the artificial Sun or display the user solar image at its full size.
- Select the orientation of the solar disk (including equatorial and altazimuth).
- Display the central meridian, solar equator, latitude lines and longitude lines.
- Input or select the position of a sunspot directly by clicking on the solar disk.
- Calculate the sunspot latitude and longitude.
- Calculate the sunspot area (in millionths of a solar hemisphere).
- Display the Carrington Rotation number at the location of the sunspot.
- Track a sunspot across the disk and from one rotation to the next (or previous) using either Carrington or differential rotation rates (artificial Sun only).
- Superimpose the Solar Environment Center (SEC) Solar Region Summary (SRS) report to show the location, region number, group type and area.
- Measure the separation between two points on the solar disk or outside the solar disk.
- Produce a log file for sunspot measurements

Warning: never look at the Sun with the naked eye or with any optical instrument unless you are familiar with safe solar observing methods.

2. Menus

Here the various menu items shown along the top of the Helio Viewer program are explained. Changes to users selectable parameters are stored in the Helio Viewer Settings file (see Appendix A) for subsequent executions of the Helio Viewer program (i.e. changes from initial settings only need to be performed once).

File



The 'Open Image...' menu item opens a user solar image and shows this image in the 'Solar disk display' panel (see section 3). Similarly 'Close Image' closes the user image and the artificial Sun is re-displayed in the Solar Disk Display. 'Save Image As...' save the current contents of the 'Solar disk display' panel, i.e. save the artificial Sun or users solar image (including any added annotation).

A logfile can be used to output your measurement results to a text file. 'New Logfile...' enables a new logfile to be opened while 'Open Logfile...' opens an existing logfile. The default logfile name for both menu items is HelioLogfile.txt. Note that using the 'New Logfile' menu item to open an existing logfile will remove any previous contents. Using the 'Open Logfile' menu item will append new measurement results to the end of the logfile. Once the logfile has been opened, measurements are added by using the 'Add to Logfile' menu item or by using the 'control left click' with the mouse (Appendix D) anywhere on the 'Solar disk display panel'. If this mouse method is used and the logfile has not been opened an error message will appear. The following are written to logfile for each measurement result (the heading for each parameter is given in brackets):-

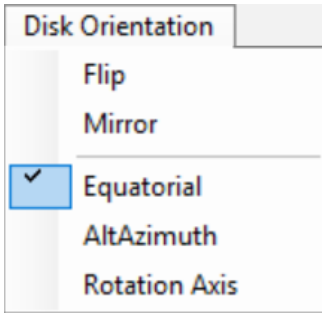
- Date in year, month, day, hour, minute and second format (YYYY MM DD HH MM SS)
- Date in decimal year format (Date)
- Right Ascension of the Sun in Hours (RA)
- Declination of the Sun in degrees (Dec)
- Solar altitude in degrees (Alt)
- Solar azimuth in degrees (Azi)
- Solar parallactic angle in degrees (PA)
- Heliographic latitude in degrees (B0)
- Heliographic longitude in degrees (L0)
- Position angle of axis of rotation in degrees (P)
- Solar diameter in arc minutes (SDiam)
- Carrington rotation (CR)
- Disk orientation (of upper right quadrant) (DO)
- Disk diameter in mm (DDiam)
- Sunspot x coordinate in mm (X)
- Sunspot y coordinate in mm (Y)
- Measured size of sunspot in mm^2 (Size)
- Sunspot heliographic latitude in degrees (SLat)

- Sunspot heliographic longitude in degrees (SLong)
- Sunspot Carrington rotation (SCR)
- Sunspot area in millionths of the sun's visible hemisphere (Area)
- Observer latitude in degrees (OLat)
- Observer longitude in degrees (OLong)
- Heliographic separation between two points in degrees or arc minutes (SpAng)
- Heliographic separation between two points in km (SepDist)
- Heliographic latitude and longitude of first point for separation in degrees (S1La & S1Lo)
- Heliographic latitude and longitude of second point for separation in degrees (S2La & S2Lo)

A new logfile can be opened at any stage of using Helio Viewer (even after a previous logfile has been opened).

Using the 'Exit' menu item exits the program.

Disk Orientation

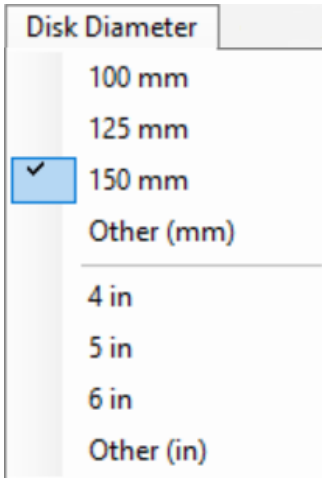


With the menu item set to 'Equatorial' or AltAzimuth, the north/south and east/west orientation of the Sun display in Helio Viewer can be changed to correspond to that of your solar image depending on whether you are using an equatorial or altazimuth telescope mounting. Appendix E describes in more detail the orientation of the Sun using an altazimuth mounting. The 'Flip' menu item reverses the north and south solar cardinal points while the 'Mirror' menu reverses the east and west solar cardinal points. Note that the north/south cardinal points do not correspond to the north/south points of the solar central meridian (and thus to the poles of the Sun). Similarly, the east/west cardinal points do not correspond to the east/west points of the solar equator. This is due to the fact that the Sun's and Earth's axes of rotation are inclined by 7.25° and 23.5° to the vertical of the ecliptic plane respectively. Consequently, the position angle of the Sun's axis of rotation changes throughout the year (as does the latitude of the centre of the solar disk).

With the menu item set to 'Rotation' Axis, the vertical line through the centre of the Sun becomes the rotation axis of the Sun. Now 'Flip' reverses the top/bottom of the Sun while Mirror reverses the left/right of the Sun.

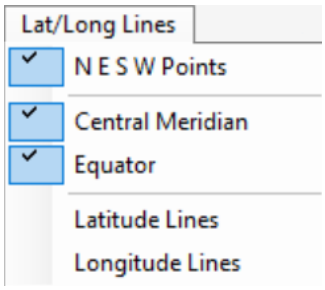
Disk Diameter

This menu enables the diameter of your solar image to be selected. There are 6 pre-set diameters (3 in mm and 3 in inches) and two user input diameters (one in mm and the other in inches). For the user selectable disk diameters, the input window adjacent to the observer lat/long is used to input any diameter required. For the pre-set diameters, this input window in read-only.



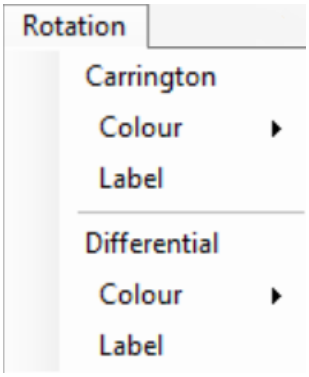
Lat/Long Lines

The north, east, south and west points can be displayed, as well as the central meridian and the equator by selecting the appropriate menu item. The north point of the central meridian is marked with a 'P' which corresponds to the position angle of the axis of rotation. Latitude and longitude lines spaced at 20° intervals can also be displayed.



Rotation

Solar latitude and longitudes are calculated assuming that the surface of the Sun rotates like a solid body with a fixed rotation rate. The sidereal period of rotation is 25.38 mean solar days, which corresponds to a mean synoptic rotation period of 27.2753 days. This rotation rate is known as the Carrington rotation period. We all know that the assumption that the Sun rotates as a solid body is incorrect and consequently, the rotation rate of the photosphere is fastest at the solar equator and slower towards the poles. This type of rotation is known as differential rotation.



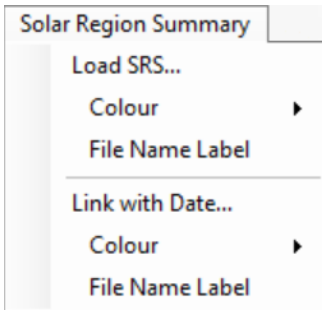
With a sunspot location measured, Helio Viewer can be used to track the movement of the sunspot with time, either forwards or backwards. The rotation rate used can be either or both of the Carrington and differential rates (see Appendix B). This is done by selecting the 'Carrington' and/or the 'Differential' menu items and then by altering the date or time with the artificial Sun displayed. If the date/time is increased, the location of the sunspot on the solar disk will move in the direction of the solar rotation (towards the west) while the opposite will happen of the date/time is decreased. Should the sunspot pass round a limb, the sunspot on the solar disk will change from a solid disk to a hollow disk. Selecting a colour from the 'Colour' menu item will change the colour of the sunspot on the disk. A label can also be displayed above the

sunspot (C for Carrington or D for Differential). Colour and labels are useful if both the Carrington and differential rotation rates are selected.

Note that the parameters shown in the 'Sunspot disk location and size' panel (x, y and sunspot size) and the sunspot area do not change as the sunspot moves across the disk. If the differential rotation rate is selected, the heliographic longitude displayed is that determined by the differential rotation (heliographic latitude is not altered by differential rotation). If only the Carrington rate is selected, then the latitude and longitude remain constant. Appendix B gives details of the differential rotation rates as a function of latitude used in Helio Viewer.

This menu is useful seeing when a sunspot will pass around the solar limb and for the tracking of previous and future rotations of a sunspot.

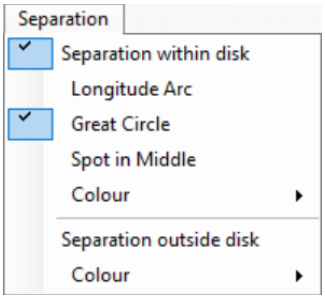
Solar Region Summary



Here the sunspot groups contained within the Space Environment Center (SEC) Solar Region Summary (SRS) products (Appendix C) are displayed on the artificial Sun or a user solar image. There are two methods for importing the SRS files. The first is to manually load an SRS file: the 'Load SRS' menu item enables a SRS product to be input into Helio Viewer. Assuming the longitude of the sunspot regions within the SRS product is appropriate for the displayed Sun, then the SRS number, modified Zurich classification of the group and area are shown above and below a '+' which indicates the position of the group. The 'Colour' menu item enables the colour used to show the SRS information to be selected. The 'File Name Label' menu item displays the file name of the SRS product in the lower left portion of the 'Solar disk display' panel.

The second method, 'Link with Date', is to automatically load an SRS file for the same date as shown in the Date & Time panel. Changing the date automatically imports a new SRS file. The 'Colour' and 'File Name Label' menu items are the same and linked to those for the 'Load SRS' menu. If the SRS file is not present for the current date an error message appears.

Separation



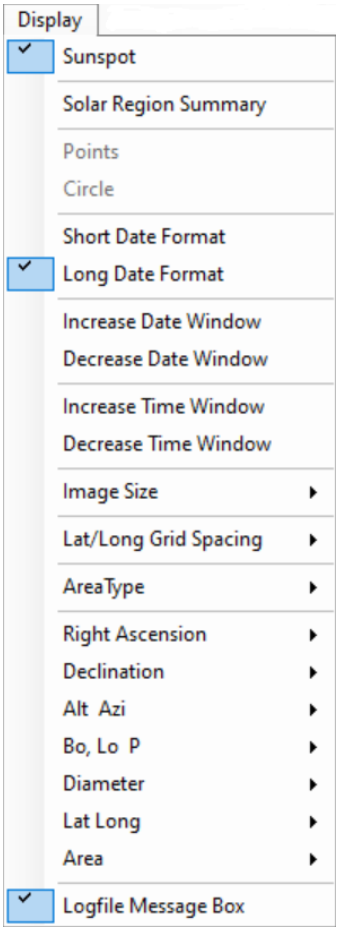
The heliographic separation between two points on the surface of the Sun can be calculated using this menu (the Separation within disk). The separation is given in degrees and km. The start and end of an arc are selected by using a 'Shift Left' mouse click at two different locations. To ensure that the end of the arc is on the solar limb, the second 'Shift Left' mouse click should be outside the solar disk. Two different arc types can be selected - a 'Longitude Arc' where either end of the arc is at the same latitude (an average of the input latitudes) or a 'Great Circle' which is the shortest distance between the two input locations. The 'Longitude Arc' is useful to measuring the length of sunspot groups as these generally lie at the same latitude. The user can select to have the Sunspot

calculated and displayed in the middle of the arc. The colour of the arc is user selectable.

The separation of two points outside the solar disk can also calculated. The separation is given in arc minutes and km. The start and end of the line are selected by using a 'Shift Left' mouse click at two different locations. To ensure that the end of the line is on the solar limb, the second 'Shift Left' mouse click should be anywhere inside the solar disk (the second point will automatically be the centre of the solar disk). The colour of the line is user selectable. This 'outside disk' separation is useful for measuring the size of prominences.

Note that it is not necessary check the 'Separation within disk' or 'Separation outside disk' menu items to calculate the separation between two points - just 'Shift Left' mouse click at two different locations. To remove an arc or line, uncheck either the 'Separation within disk' or 'Separation outside disk' menu items.

Display



Whether the Sunspot is displayed or not is determined by the 'Sunspot' menu item. Similarly, the Solar Region Summary data can be selected in a similar manner.

For user input images, Helio Viewer detects the edge of the solar disk and then fits a circle to these points. These points and the fitted circle can be displayed via the 'Points' and 'Circle' menu items.

The user can select whether to display a short or long version of the date (e.g. 26/09/20 or 26 September 2020). The exact format for the date and time display within Helio Viewer depends on the settings of your computer. The size of the Date and Time window can be increased or decreased to be compatible with that of your computer.

The size of the input image can be reduced by a factor of 2 or 4 when displayed. Note that the appropriate setting needs to be made before the image in input.

The spacing of the latitude/longitude grid can be selected between 20°, 10° or 5°.

The area display can be either corrected area only or projected area, the rho angle (the angle from the centre of the disk to the sunspot) and corrected area.

The user can change the precision to which the solar right ascension, solar declination, altitude and azimuth of the sun, the parallactic angle (PA) when using the Altazimuth disk orientation, the B0, L0 and P parameters, the solar diameter, sunspot latitude & longitude and sunspot area are displayed. For example, the sunspot latitude and

longitude can be display either to a precision of 1° or 0.1° by selecting the appropriate sub-menu item.

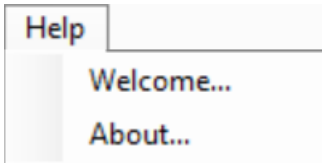
Finally, the user can select whether to display a message box every time a sunspot measurement is added to the Logfile.

Sunspot Grid Size



For the measurement of sunspot area, a grid is used and the number of grid squares covering the sunspot is input into Helio Viewer. There is a choice of grid sizes: 1mm by 1mm or 1/25 inch by 1/25 inch. Only used for the artificial Sun (not for imported images).

Help



The help menu gives the Helio Viewer on-line help information, the welcome window and the about box. The welcome window appears when Helio Viewer is started for the first time and at every successive start if the tick box in the lower left is not ticked. The about box includes the web address where additional information about solar observing can be found [1].

3. Display

Here the various parts of the Helio Viewer display (as shown in the cover page of this document) are explained:-

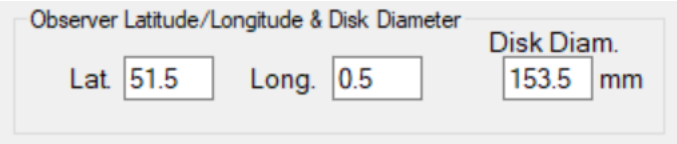
Menus

These are described in section 2.

Observer Latitude/Longitude & Disk Diameter Panel

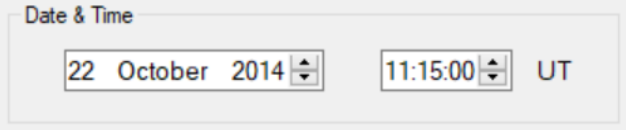
Here user inputs their latitude and longitude for the calculation of the solar altitude and azimuth angles. For observers in the northern hemisphere, latitude is positive while those in the southern hemisphere, latitude is negative. Longitudes can be either in the range 0° to 360° or -180° to 180° where negative longitudes are to the west of the Greenwich meridian and positive longitudes are to the east.

The disk diameter box is used when the user inputs a selectable disk diameter via the 'Disk Diameter' menu.



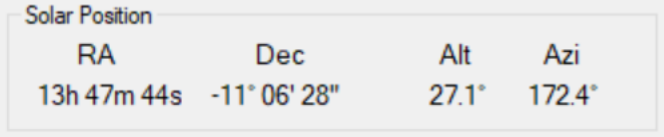
Date & Time Panel

Here the date and time are selected. By default, pressing the up or down arrows to the right of the date will increase or decrease the day of the month. If the day to be increased is at the end of a month, then the month will automatically increment (the same is true for the year when a day is incremented from the last day of the year). The month or year can be increased/decreased by first highlighting the month or year (by clicking the month or year) and then pressing the up/down arrows. The time is altered in a similar way to the day (if the time increase/decrease straddles the start or end of a day, the date will also change). The date/time format and/or the size of the date/time boxes can be altered by using the 'Date & Time Display' menu.



Solar Position Panel

This panel shows the right ascension and declination of the Sun at the date and time selected in the above panel. Also shown at the solar altitude and azimuth angles of the Sun from the observer's latitude and longitude.

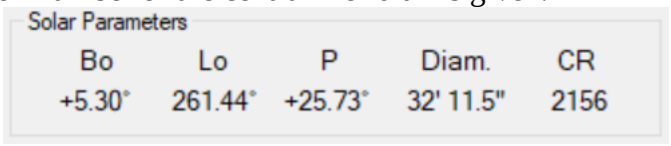


If the Altazimuth disk orientation is selected, the parallactic angle η is also shown:



Solar Parameters Panel

The heliographic latitude & longitude of the centre of the disk are shown together with the position angle of the axis of rotation and disk diameter. Finally, the Carrington rotation number of the central meridian is given.



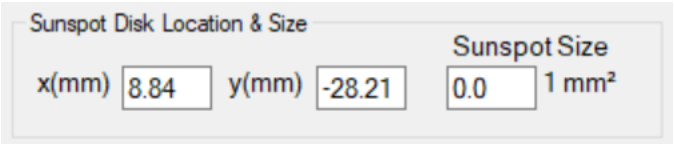
Sunspot Disk Location & Size Panel

Here the position of a sunspot with respect to the centre of the disk is input as well as the size of the sunspot for the area determination. The position is input by the x and y coordinates of the sunspot (x = 0 and y = 0 corresponds to the disk centre). For example, if the disk diameter is 100mm and a sunspot is on the right cardinal point (to the right of the disk centre) then it will have x = 50 and y = 0. If a sunspot is on the left cardinal point (to the left of the disk centre) then it will have x = -50 and y = 0. Similarly, if there were a sunspot on the top cardinal point will have x = 0 and y = 50 where as if there were a sunspot on the bottom cardinal point will have x = 0 and y = -50.

Rather than input the x and y coordinates in the two boxes in this panel, the user can click on the solar disk display to move the location of the sunspot (Appendix D). The value appearing in these two boxes changes to that of the mouse click.

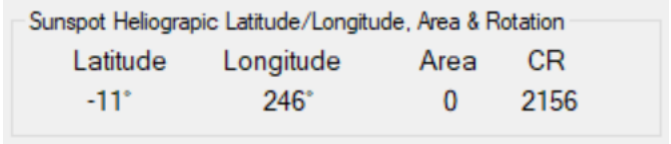
The third box in this panel is used to input the size of a sunspot in either mm^2 or 1/25 in^2 (the units are changed via the 'Sunspot Grid Size' menu). This box is only displayed for the artificial Sun (not for imported images).

Pressing the tab key will move from the x to y and the area boxes (and then the date and time boxes before returning to the x box). Pressing shift and tab moves between these boxes in reverse order.



Sunspot Heliographic Latitude/Longitude, Area & Rotation Panel

This panel gives the heliographic location of the sunspot, the sunspot area and the Carrington rotation at the location of the sunspot. The sunspot latitude and longitude are given to the nearest degree. If a sunspot is more than 60° away from the centre of the disk, the area is given in red text to indicate that the area measurement may be inaccurate [2].



Heliographic Separation Panel

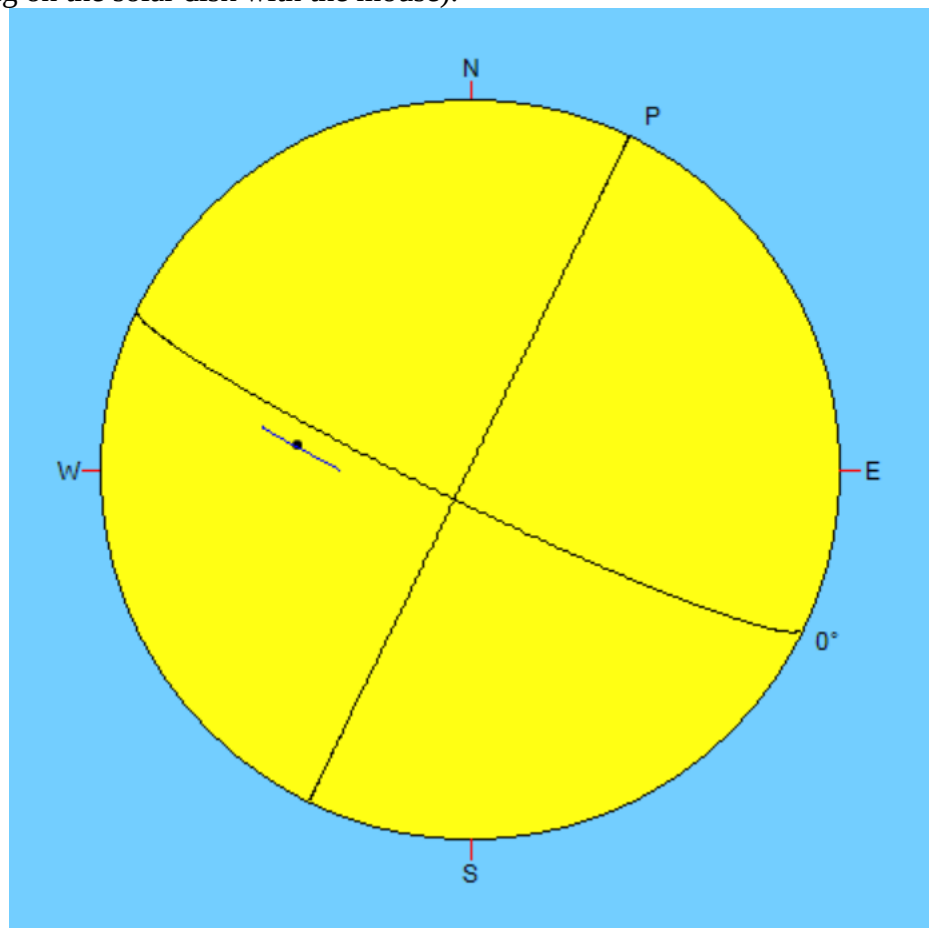
This panel shows:

- the separation of an arc on the solar disk expressed in degree and km together with the latitude and longitude of the arc end points
- or the separation of a line outside the solar disk in arc minutes and km together with the latitude and longitude of the line end if this on the solar limb.



Solar Disk Display

The solar disk display shows the Sun and surrounding sky. On the solar disk, the user can choose to include the central meridian, solar equator and latitudes and longitudes at 20° intervals (all via the 'Lat/Long Lines' menu). The north, east, south and west cardinal points are marked around the solar disk together with the position angle of the axis of rotation (if the central meridian is shown) and latitudes (if the solar equator and latitudes are shown). The small black dot shows the position of the Sunspot as determined by the sunspot x and y coordinates (as selected by the x and y boxes or by clicking on the solar disk with the mouse).



4. Operation

The use of Helio Viewer is outlined below:-

Date & Time

It is firstly necessary to select the date and time corresponding to your observation (in UT). This is achieved by:

- selecting the day, month, year, hour, minute or second (by clicking on one of these so that it is highlighted) and using the up/down arrows to the right of the date and time boxes,
- selecting the day, month, year, hour, minute or second and using the key board up/down arrow keys or
- the day, year, hour, minute or second and typing the required number. Moving between the items within each window can be achieved by using the keyboard left and right arrow keys.

The size of the date & time windows can be altered using the 'Date & Time Display' menu to suit those of your computer settings.

Disk Orientation

The orientation of the Sun display towards the right of the Helio Viewer window needs to be the same as that of your observation. The orientation is changed using the 'Disk Orientation' menu.

Disk Diameter

You will need to enter the disk diameter of your observation into Helio Viewer using the 'Disk Diameter' menu.

Input Solar Image

A solar image can be input and displayed using the 'Open Image...' item from the 'File' menu (in a variety of formats including .bmp, .png & .jpg). Helio Viewer fits a circle to the edge of the solar disk. To see the detected points around the solar disk and the fitted solar disk, check the 'Points' and 'Circle' items from the 'Display' menu. Unchecking these two menu items removes the points and circle from the solar display.

Latitude/Longitude Lines

Latitude and/or longitude lines can be displayed using the 'Lat/Long Lines' menu, as can the solar equator and central meridian, and the north, east, south and west points. This applied to both the artificial Sun and the user input solar image.

Logfile

The measurements you make can be stored in a logfile for further analysis. The contents of this logfile can be found in Section 2. The logfile is opened using the 'File' menu and measurements added using either the 'Add to Logfile' menu item or by right clicking anywhere on the 'Solar Disk Display'.

Observer Latitude and Longitude

The solar altitude and azimuth angles requires the observer latitude and longitude. These are input via the 'Observer Latitude/Longitude & Disk Diameter' panel.

Rotation

Once a sunspot measurement has been made, it is possible to track the movement of this sunspot across the solar disk (using the artificial Sun only). One or both of two different rotation rates (Appendix B) can be selected using the 'Rotation' menu. By altering the date or time the location of the sunspot will move across the disk (solid disk) and behind the Sun (hollow disk) and back onto the visible disk. This is particularly useful if you wish to track a sunspot from one rotation to the next.

Save Solar Image

It is possible to save whatever is displayed in the solar disk display (in .bmp format). This is done using either the 'Save Image' or 'Save Image As...' items from 'File' menu.

Separation

The separation between two points either on the solar disk or outside it can be determined by using clicking on either the artificial Sun or user solar image (see Appendix C). To remove an arc or line, uncheck the 'Separation within disk' or 'Separation outside disk' items in the 'Separation' menu.

Solar Region Summary

To superimpose the data from a Solar Environment Center (SEC) solar region summary (SRS) product, load the product using the 'Solar Region Summary' menu and 'Load SRS...' or 'Link with Date' menu item. It is also possible to display the product name in the lower left part of the solar display.

Sunspot X and Y Position

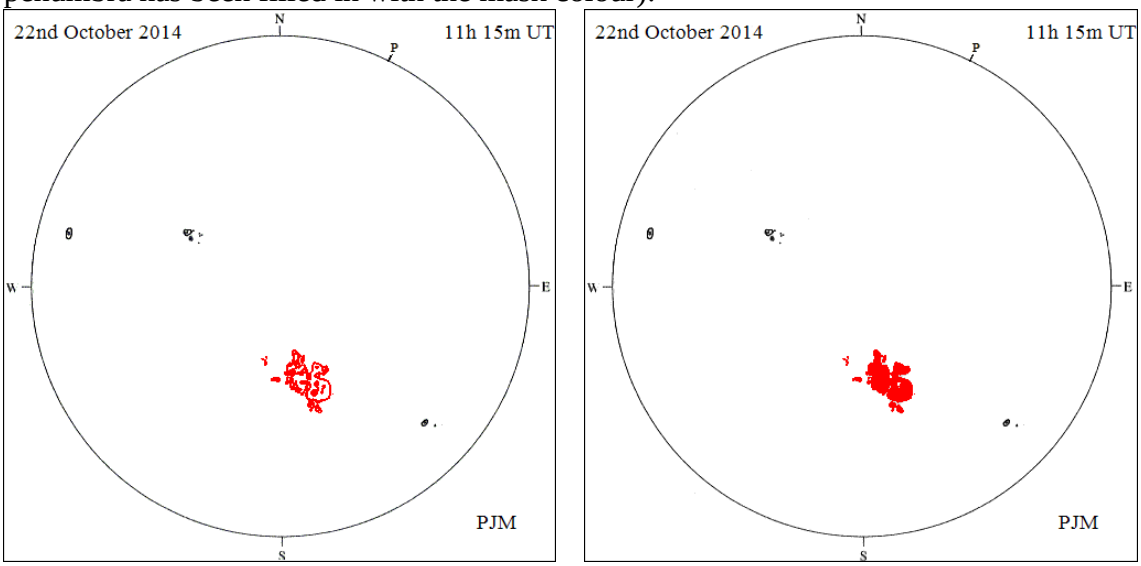
The position of a sunspot is (i) measured from your observation and input into the x and y coordinate boxes or (ii) input by clicking with the left mouse button on the artificial Sun or your solar image. These coordinates are relative to the center of the disk ($x = 0$ and $y = 0$) and are measured in mm. Left clicking on the sun disk will give the x and y coordinate of this location and move the black disk to this location; this is useful for determining the coordinate required for the inputting of your sunspot positions. The sunspot latitude and longitude values are given in the lower left panel of the Helio Viewer window.

Sunspot Area

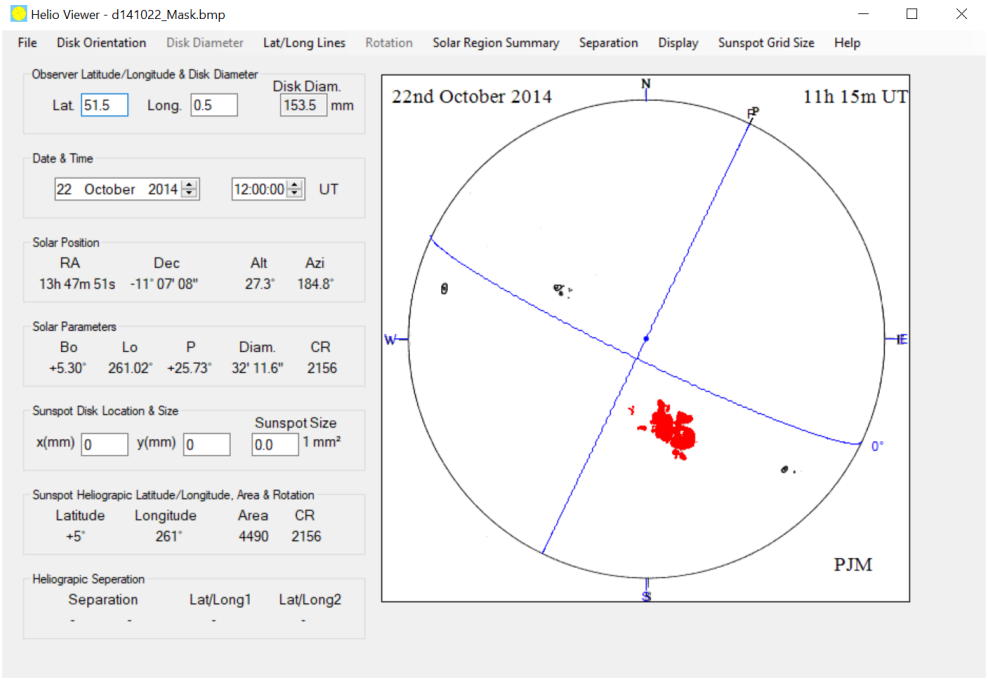
The area of a sunspot is measured from your observation by either (i) counting the number of small squares (1 by 1mm or 1/25 by 1/25 inch) that cover the sunspot or (ii) using a sunspot mask and summing the area of each mask pixel.

For the first approach, the number of squares is entered in the Sunspot Size box, and the resulting sunspot area, in millionths of the Sun's visible hemisphere, is output in the lower left panel. If the angular distance from the centre of the solar disk to the sunspot is more the 60°, then the sunspot area is shown in red. This indicates that the area measurement may be inaccurate [2]. Also output is the Carrington Rotation at the location of the sunspot.

For the second, more accurate method, a mask is created using the Helio Image Creator program. This program converts the black pixels of the sunspot outlines from disk drawings to a mask colour (red). The output mask image from the Creator program will need to have all the pixels of each sunspot manually converted the mask colour (e.g. for sunspot penumbra). This can be done using any basic image manipulation program such as Paint. Below left is the mask output from Creator for just AR 12192, while on the right is the final mask drawing (i.e. after the group penumbra has been filled in with the mask colour).



By default, when a mask image input into Helio Viewer, the area is calculated for all the mask pixels in the drawing. In the above case, a mask has been created for just the large group and so the calculated area is for just this group. If a mask had been created for all groups, then the default area would be for all groups (corrected for foreshortening). An example is shown below:



If the mask has been created for several groups, the area of an individual group can be calculated by pressing down, dragging and lifting up the right mouse to generate a

blue box. As for Helio Image Creator, a box can be de-selected by pressing shift and the right mouse button within any blue box.

Further information on calculating sunspot areas can be found in references [3], [4] and [5].

References

[1] Meadows, P.J., 'Solar Observing', https://www.petermeadows.com.

[2] Bray, R.J & Loughhead, R.E., 1964, 'Sunspots', Reprinted Dover Publications, 1979.

[3] Meadows, P.J., 'The measurement of sunspot area', Journal of the British Astronomical Association, 112(6), 353-356 (2002).

[4] Meadows, P.J., ‘Remeasurement of Solar Observing Optical Network sunspot areas’, Monthly Notices of the Royal Astronomical Society, Volume 497, Issue 1, September 2020, Pages 1110–1114, https://doi.org/10.1093/mnras/staa2007.

[5] Meadows, P.J., ‘SOHO/MDI and SDO/HMI Sunspot Area Measurement and Analysis’, RAS Techniques and Instruments, Volume 4, 2025, https://doi.org/10.1093/rasti/rzaf024.

Glossary

- Altitude: the angular distance of the Sun above the observer's horizon
- Azimuth: the angular distance measured along the horizon from the north point through east.
- Central meridian: great circle passing through the poles and the centre of the solar disk (as a straight line from the position angle of the north end of the axis of rotation passing through the centre of the disk)
- Declination: the angular distance on the celestial sphere north and south of the celestial equator.
- Parallactic angle: the angle between the great circles that pass through the Sun and the zenith and the Sun and the celestial pole.
- Right ascension: right ascension is the angular distance on the celestial sphere measured eastwards along the celestial equator from the vernal equinox.
- Sidereal period of rotation: the rotation period of the Sun relative to the stars.
- Synoptic period of rotation: the rotation period of the Sun as seen from the Earth.
- UT: Universal time

Appendix A: Helio Viewer Settings File

This file contains the user selected parameters. The contents of the file should not be changed via a text editor - they are altered by selecting the user parameters from within the Helio Viewer program itself. Below, the default parameters are given together with a brief explanation.

Parameter	Explanation
false	Welcome window ticked (true or false)
1	Flip disk orientation setting (1 or -1)
1	Mirror disk orientation setting (1 or -1)
mm	Disk diameter units (mm or inch)
150.0	Disk diameter
long	Date format (long or short)
60 75 180 72 258 19	Short date, time and UT caption left position and width
29 140 200 72 278 19	Long date, time and UT caption left position and width
mm	Sunspot size units (mm or inch)
51.5 0.5	Observer latitude and longitude
true	North, East, South & West Marks displayed (true or false)
true	Central meridian displayed (true or false)
true	Solar equator displayed (true or false)
false	Latitude lines displayed (true or false)
false	Longitude lines displayed (true or false)
false Black false	Carrington rotation set (true or false), colour of sunspot and label displayed (true or false)
false Black false	Differential rotation set (true or false), colour of sunspot and label displayed (true or false)
true	Sunspot displayed on solar disk (true or false)
false	Points on user solar disk edge shown (true or false)
false	Fitted circle to user solar disk shown (true or false)
Black	Colour of Solar Region Summary product data
false	SRS file name displayed (true or false)
true	Separation longitude arc selected (true) or great circle arc selected (false)
true	Spot in middle of arc selected (true or false)
Blue	Colour of arc within solar disk
Red	Colour of line outside solar disk
1	Disk orientation set to either Equatorial (1), Altazimith (3) or Rotation Axis (2)
1	Lat/Long Grid Spacing
3	Precision setting for Right Ascension
3	Precision setting for Declination
2	Precision setting for Altitude and Azimuth
2	Precision setting for B0, L0 and P
2	Precision setting for Solar Diameter
1	Precision setting for Sunspot Latitude and Longitude
1	Precision setting for Sunspot Area

true	Area display type (Corrected only or Projected, Rho and Corrected)
1	Image size (x1, /2, /3 or /4)
1	Load image file type
0	Setting for LogFile Message Display

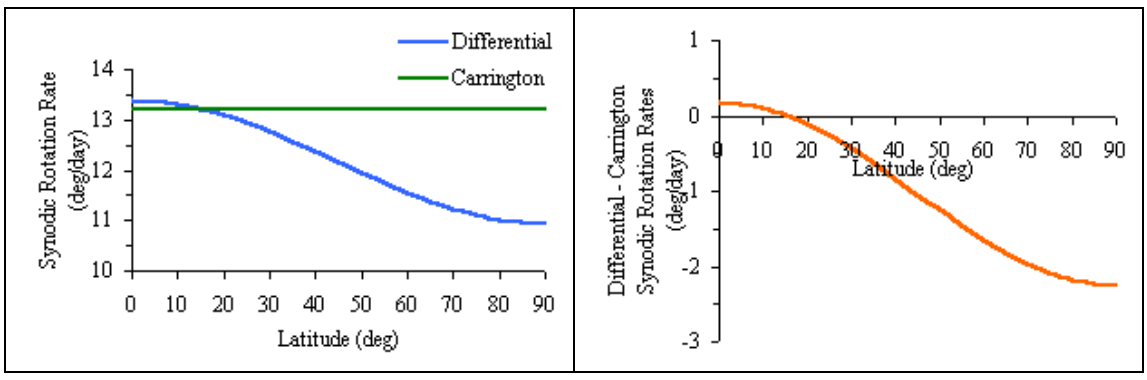
Appendix B: Differential Rotation

The expression used for the differential rotation in Helio Viewer is (references [3, 4]):-

$$\omega = 14.37 - 2.60\sin^2 B$$

where, ω = Sidereal rotation rate (deg/day) and B = Heliographic latitude (deg). The following table shows the differential sidereal rate derived using the above expression as a function of heliographic latitude together with the differential and Carrington synodic rotation rates. The final column gives the difference between the differential and Carrington rotation rates. The plots below show graphically the data in the table.

Latitude (B) (deg)	Differential Sidereal Rate (deg/day)	Differential Synodic Rate (deg/day)	Carrington Synodic Rate (deg/day)	Differential - Carrington Rates (deg/day)
0	14.37	13.37	13.20	0.17
5	14.35	13.35	13.20	0.15
10	14.29	13.30	13.20	0.10
15	14.20	13.21	13.20	0.01
20	14.07	13.09	13.20	-0.11
25	13.91	12.94	13.20	-0.26
30	13.72	12.77	13.20	-0.43
35	13.51	12.58	13.20	-0.62
40	13.30	12.37	13.20	-0.83
45	13.07	12.16	13.20	-1.04
50	12.84	11.95	13.20	-1.25
55	12.63	11.75	13.20	-1.45
60	12.42	11.56	13.20	-1.64
65	12.23	11.38	13.20	-1.81
70	12.07	11.24	13.20	-1.96
75	11.94	11.11	13.20	-2.08
80	11.85	11.03	13.20	-2.17
85	11.79	10.97	13.20	-2.23
90	11.77	10.95	13.20	-2.25



Appendix C: Solar Region Summary Product

The sunspot group information contained in the Solar Environment Center (SEC) (http://www.sec.noaa.gov) solar region summary (SRS) product can be superimposed on either the artificial Sun or input solar image. These SRS products can be obtained from the SEC web site or by requesting the product to be send by email daily. If the latter option is chosen, then the product needs to be copied to the appropriate directory to be loaded into Helio Viewer. The SRS filename needs to be yyyymmddsrs.txt where yyyymmdd is the year, month and day appropriate for the sunspot group data within the product. Note that this is 1 day earlier than the SRS product issue date.

The latitude and longitude of the sunspot group in the SRS product is given to a precision of 1 degree. By comparison of the SRS group locations with those from solar images from a variety of sources has shown that the location information in SRS product has not particularly accurate (sometimes a few degrees different).

The following information about the SRS product have been extracted from its readme file:-

The Solar Region Summary is a daily report, compiled by SEC, about the active solar regions observed during the preceding day. It contains a detailed description of the active regions currently visible on the solar disk.

The characteristics for each active region are compiled from approximately half a dozen observatories that report to the SEC in near-real time. The sunspot counts are typically higher than those reported in non-real time by the Sunspot Index Data Center (SIDC), Brussels, Belgium, and the American Association of Variable Star Observers.

Available:

via SEC Anonymous FTP server sec.noaaa.gov.
/pub/latest/SRS.txt --- most recent report
/pub/forecasts/SRS --- last 75 reports

via SEC Web site:
http://sec.noaa.gov/ftpdir/latest/SRS.txt
http://sec.noaa.gov/ftpmenu/forecats/SRS.html

via email:
The "srs" List Server list, see http://sec.noaa.gov/ListServer.html

Description:

Part I. Describes all active regions with sunspot groups:

Nmbr: An SESC region number assigned to a sunspot group during its disk passage.

Location: Sunspot group location, in heliographic degrees latitude and degrees east or west from central meridian, rotated to 2400 UTC.

Lo: Carrington longitude of the group.

Area: Total corrected area of the group in millionths of the solar hemisphere.

Z: Modified Zurich classification of the group.

LL: Longitudinal extent of the group in heliographic degrees.

NN: Total number of visible sunspots in the group.

Mag Type: Magnetic classification of the group.

Part IA. Describes previously numbered active regions which still contain plage but no visible sunspots.

Nmbr: SESC region number.

Location: Plage region location in heliographic degrees latitude and degrees east or west from central meridian rotated to 2400 UTC.

Lo: Carrington longitude of the region.

PART II. Active regions that where observed on the previous solar rotation and are due to reappear on the East limb in the next 3 days.

Nmbr: SESC region number.

Lat: Heliographic degrees latitude of the group on its last disk passage.

Lo: Carrington longitude of the group on its last disk passage.

Sample:

Joint USAF/NOAA Solar Region Summary
SRS Number 249 Issued at 0030Z on 05 Sep 2000
Report compiled from data received at SWO on 04 Sep
I. Regions with Sunspots. Locations Valid at 04/2400Z

Nmbr	Location	Lo	Area	Z	LL	NN	Mag Type
9143	S19W75	047	0000	Axx	00	01	Alpha
9145	S08W50	022	0030	Hsx	02	01	Alpha
9147	N08W22	355	0060	Cao	04	04	Beta
9149	N14W22	354	0220	Eai	14	27	Beta
9151	N09W09	341	0010	Bxo	03	03	Beta

9152	N18E22	310	0020	Hsx	01	01	Alpha
9153	S32W23	355	0020	Cso	06	08	Beta
9154	S19E06	326	0160	Dai	08	27	Beta
9155	S10E18	314	0020	Bxo	05	07	Beta

IA. H-alpha Plages without Spots. Locations Valid at 04/2400Z Sep

Nmbr	Location	Lo
9142	N16W76	049
9146	S23W58	031
9148	S18W46	019
9150	N12W01	334

II. Regions Due to Return 05 Sep to 07 Sep

Nmbr	Lat	Lo
9124	S13	233
9125	N28	232
9128	N13	220
9129	S05	206
9135	S11	225
9136	N09	221

Note that SRS number 10000 was reached in June 2002. As SEC products use 4-digit region numbers, the leading 1 is dropped for SRS numbers 10000 and greater. Thus the sequencing for Solar Region Numbers during this period was: 9998, 9999, 0000, 0001,...

Appendix D: Mouse Controls and Tab Order

The following mouse controls are used within Helio Viewer:

Mouse Control	Function
Left Click	Moves the sunspot on the solar disk to the position of the mouse click and calculate heliographic latitude and longitude
Shift Left Click	Selects the start or end of an arc to calculate angular separation within or outside the solar disk
Control Left Click	Opens or adds data to the log file
Right Click & Drag	Selects a box to create mask pixels
Shift Right Click	De-selects a mask box

The date, time, x, y and sunspot size boxes are in ascending tab order. Thus pressing tab moves the cursor between these boxes and in this order (shift tab moves the cursor between these boxes in the other order). This is useful if:

- you have several measurement for a single observation when you wish to move from x to y and size in succession for one measurement and then back to x for the start of the next measurement or

- if you have another observation and wish to alter the date/time before making sunspot measurements.

Appendix E: Orientation of the Sun using Altazimuth Telescope Mountings

Determining the orientation of the Sun using an altazimuth telescope mounting is more difficult than using the equatorial type of mounting. With a telescope on an equatorial mounting, the top and bottom points on the solar disk are on a great circle that passes through the celestial pole. This means that the north and south cardinal points are always at the top or bottom of the solar disk and the east and west cardinal point are to the left or right. The exact orientation depends on whether the solar image is mirrored and/or flipped. Using an altazimuth mounting the top and bottom points on the solar disk are on a great circle that passes through the zenith. Now the cardinal points of the solar disk slowly change from sunrise to sunset. Only when the Sun is on the meridian are the cardinal points coincident with the top, bottom, left and right points of the solar disk.

The differences in orientation of the Sun for the two telescope mounting types is illustrated in Figure E.1 when the Sun has just risen and is just about to set at the one of the equinoxes (i.e. when the Sun is on the celestial equator) for an observer at 51.5°N. For illustrative purposes, a rectangular field of view is shown for the two mounting types. The angle between these fields of view is the same angle as between the great circles that pass through the middle of the Sun and the celestial pole and the zenith. This angle is known as the parallactic angle (η) and is also shown in Figure E.1. Only when the Sun is on the meridian do the two fields of view coincide.

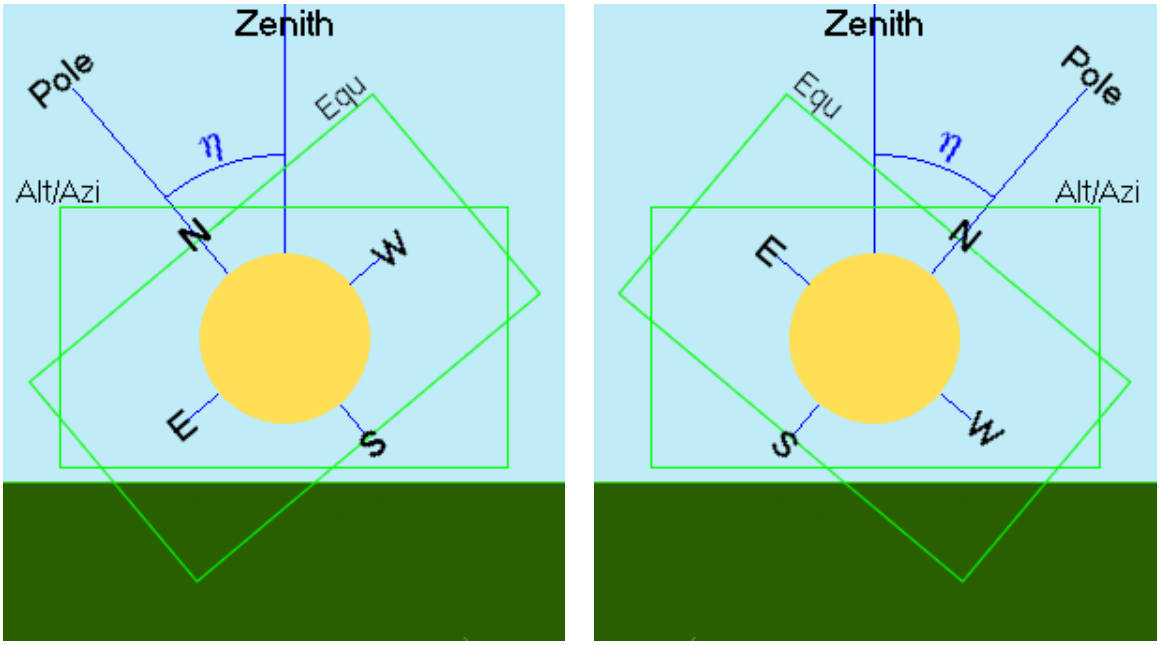


Figure 1. The naked eye view of the Sun just after sunrise and just before sunset at one the equinoxes and for an observer at 51.5˚N. The two rectangles show the field of view for an alt/azi and equatorial telescope mounting.

The parallactic angle can be calculated using one of the expressions given below:

$\sin(\eta) = \sin(A).\cos(\phi)/\cos(\delta)$

$\cos(\eta) = (\sin(\phi) - \sin(\delta).\cos(z))/(\cos(\delta).\sin(z))$

$\cos(\eta) = (\sin(\phi).\sin(z) - \cos(\phi).\cos(z).\cos(A))/\cos(\delta)$

where ϕ = observer latitude, δ = declination of the Sun and z = zenith distance (altitude = 90 - z) and A is azimuth angle of the Sun.

The range of the parallactic angle, η, values for an observer at London and Edinburgh are shown in Figure E.2. The dotted lines show when the Sun is on the horizon (i.e. at the time of sunrise and sunset). The curve for an η angle of 0° is when the Sun is on the meridian (i.e. due south). The parallactic angle has a positive value if the Sun is to the west of the meridian and negative to the east. Figure E.2 also shows that η changes fastest during mid-summer at the time when the Sun is on the meridian; for example at London η changes by a maximum of 19° per hour while it Edinburgh it changes by a maximum of 15° per hour. The largest parallactic angle also occurs in mid-summer but much earlier and much later in the day. During mid-winter the parallactic angle changes much slower when the Sun is on the meridian; for example 10° per hour for London and 8° per hour for Edinburgh.

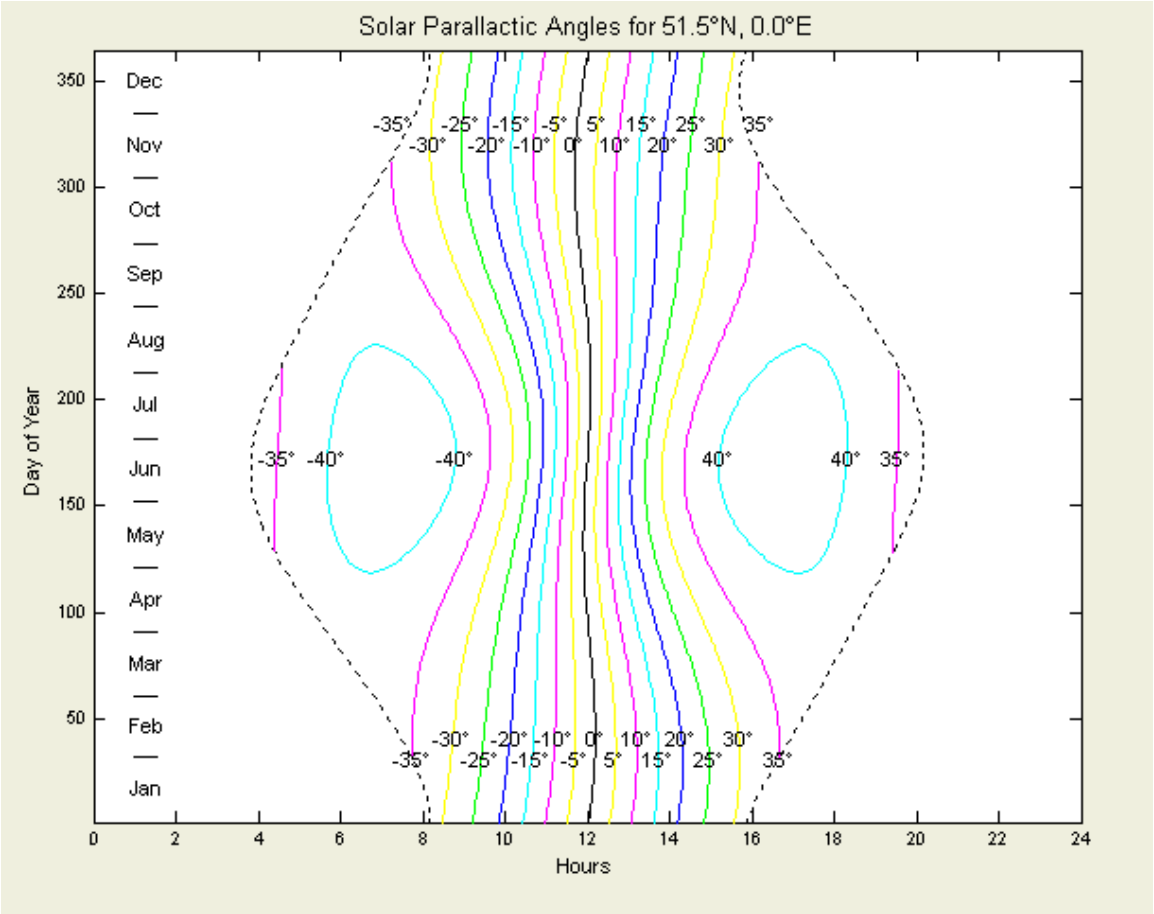


Figure 2(a). Solar parallactic angles for an observer at London (51.5˚N, 0.0˚E) during the period of a year. Time in UT. At this latitude the maximum and minimum values of η are -42.7˚ and 42.7˚ and which occur at the summer solstice.

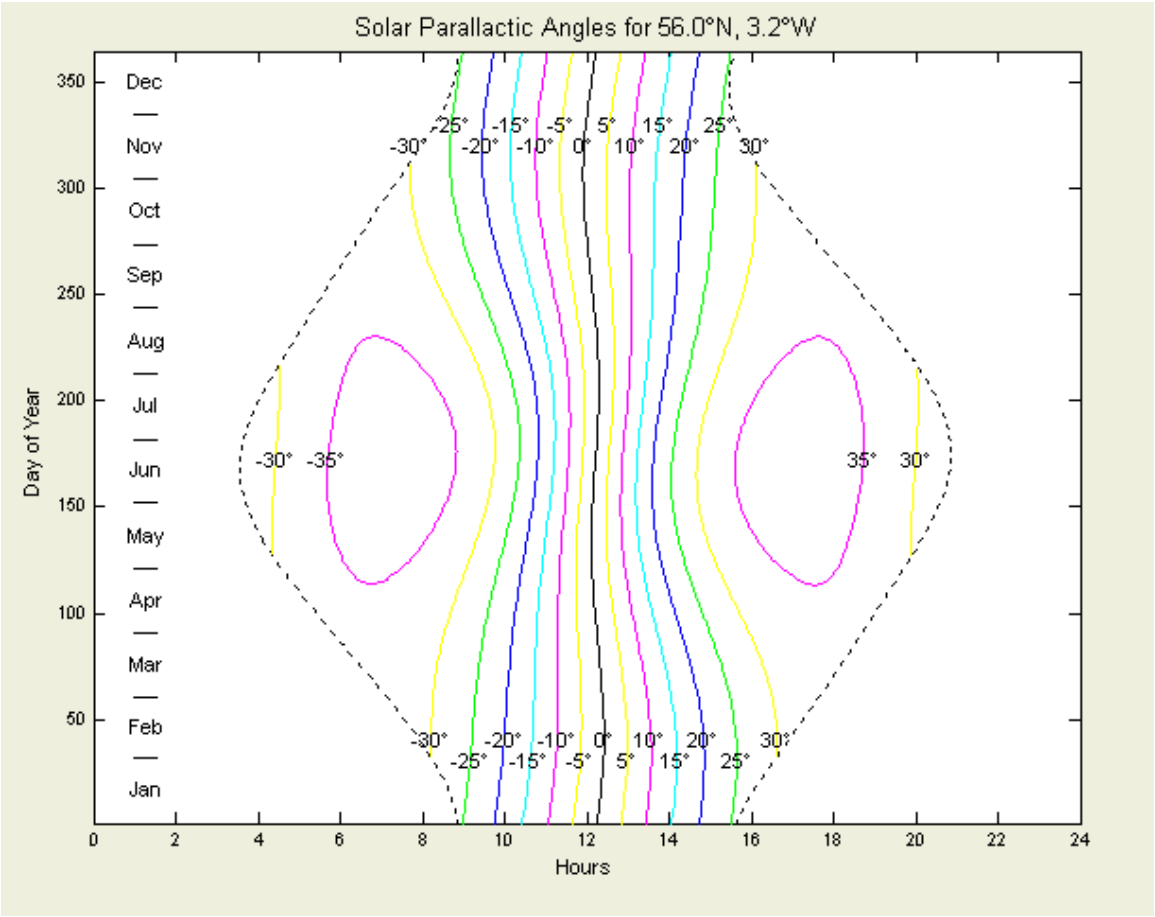


Figure 2(b). Solar parallactic angles for an observer at Edinburgh (56.0˚N, 3.2˚W) during the period of a year. Time in UT. At this latitude the maximum and minimum values of η are -37.6˚ and 37.6˚ and which occur at the summer solstice.