

Sunloop User Guide

Version 2.0

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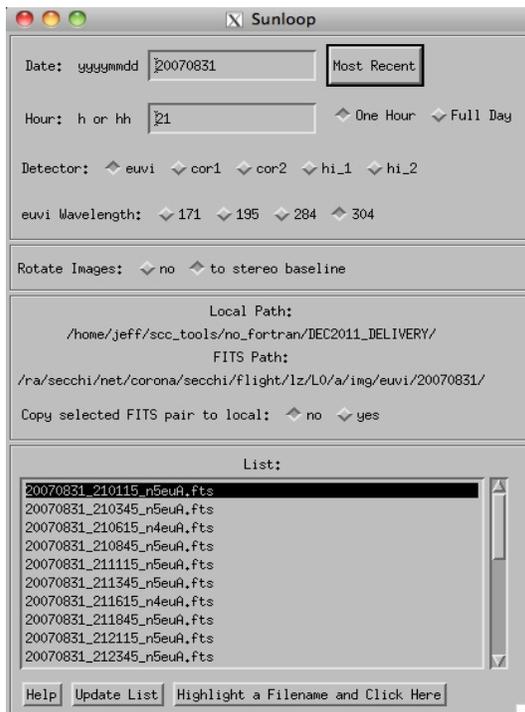
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SUNLOOP QUICK START

\$ sswidl

IDL> **sunloop**

Click **Update List** button

Click **Highlight a Filename and Click Here** button

Scroll to lower right corner of image (there is a CME at the default date/time)

Define two or more tiepoints in **tiepointer** (mouse click to add tiepoint, middle or option-mouse to move, right-click to delete)

Click **scc_triangulate** button

Click **Yes** in the dialog to bring up **line3d**

Read this **User Guide** for options along the way

This tool is dependent on having the environment variable \$secchi or \$secchi_lz defined. If you are a mirror site then you are set to go. If not a mirror site then it is possible to replicate a portion of the mirror site to contain the data that you are interested in. That replication is beyond the scope of this document.

SUNLOOP OPTIONS

Most Recent button will search \$secchi/ or \$secchi_lz/ for the most recent available data. If the telescope selection is changed, the search will occur again. If the date or hour is changed then the search will be called off.

Date should be formatted yyyyymmdd.

Hour (if **One Hour** is selected) may be specified as single or double digits. May specify as hhmm or hhmmss, as well.

One Hour and **Full Day** apply to the search criteria. To some extent this will depend on what you are searching for. Specifying **One Hour** will narrow the search criteria to the hour in the **Hour** box. Specifying **Full Day** will require longer searches when **Update List** button is clicked, but will return a longer **List** that may be useful. If the One Hour option returns no results, try using Full Day because there are times when no SECCHI data was collected from one of the spacecraft, or when HI_2 has data only on even-numbered hours.

Detector specifies the telescope: euvi, cor1, cor2, hi_1 and hi_2.

euvi Wavelength specifies the EUVI filter wavelength.

Update List button will populate the **List** with STEREO-A filenames that are paired with a synchronized STEREO-B image. Choose an image pair by double-clicking a name in the **List** or by highlighting a name and clicking the **Highlight a Filename and Click Here** button. If the update process appears to be taking too long then you

may **Cancel** and narrow the selection criteria. If no matching files are found then “none found” will appear as a message in the **List**.

Rotate Images: “no” leaves images in their native alignment and tiepoint movement is unconstrained (epipolar line is not drawn.)

Rotate Images: “to stereo baseline” aligns images so that epipolar lines equate to image rows. Tiepoint movement is constrained to image rows (default.)

For reference your **Local Path** and the **FITS Path** are shown. For convenience is an option to **Copy selected pair of raw FITS to local** which simply copies the FITS pair to your current working directory after you make a selection.

List contains the filenames for STEREO-A for which a matching synchronous STEREO-B filename was found. These are filenames for images that meet the search criteria. Initially the **List** will contain the message “**click on Update List**”. This message will say “**none found**” if no matching files were found after clicking on the **Update List** button. The **List** will clear when any of the selection criteria are changed and it will be necessary to click on the **Update List** button to repopulate the list using the changed criteria. Cor1 and cor2 filenames in the list will have a partial directory path to indicate the image type of **img** or **seq**.

Highlight a Filename and Click Here button will process the highlighted filename pair and send the processed images to the tiepointer tool, which is called tiepointer.pro. This is the same as double-clicking a filename in the **List**.

TIEPOINTER

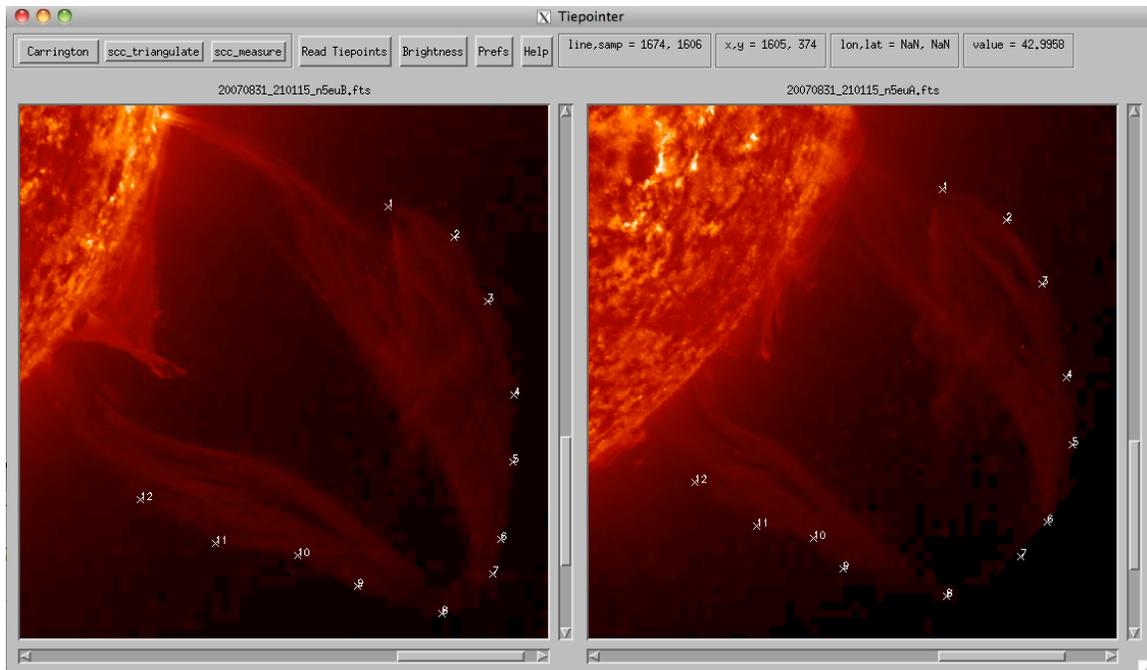
Tiepointer will be automatically called after the image pair is processed. Here are the tiepoint instructions:

Add - left mouse click

Move - middle or option-mouse

Delete - right or command-mouse

Apple computers without 3 button mouse: It may be necessary to open **X11 Preferences** and, under the **Input** tab, select **Emulate three button mouse**.



A tiepoint may be added to either image. The initial "other" tiepoint is automatically drawn at the same x,y in the "other" image. This initial matching tiepoint is sometimes on the opposite side of the "other" image from where one might think that it should appear, depending on the spacecraft viewing geometry. Subsequent tiepoints will be drawn nearby.

Select all tiepoints for a feature in an image pair during a single tiepoint session. (Additional tiepoints may be added to a feature by first reloading an existing .xy tiepoint file.)

Scc_triangulate button will save the x,y tiepoints in a .xy file and process them into 3-D coordinates which are saved in a .xyz file. The .xy file may be reloaded later and more tiepoints may be added, moved or deleted.

Tiepoints must be saved in linear order as they describe the feature. There is currently no built-in mechanism to reorder the tiepoints. A workaround would be to save the .xy file and manually reorder it using a text editor then reload the reordered .xy file back into tiepointer.

Images are displayed 1:1 on the screen (1 data pixel per screen pixel.) There is no zoom function. Use the scroll bars to move around.

TIEPOINTER OPTIONS

Carrington allows changing to **Stonyhurst Heliographic**. By default, EUVI is in Carrington and all others are in Stonyhurst. This will affect the cursor readout for longitude and other longitude calculations. (Scc_measure is always Stonyhurst.)

Scc_triangulate performs a series of functions:

1. tiepoints are written to a .xy file.
2. tiepoints are sent to scc_triangulate and processed into x,y,z.
3. x,y,z values are written to a .xyz file.
4. offers to send the x,y,z to the 3D viewer, which is called line3d.pro. If only a single tiepoint is selected then it will not be visible in the 3D viewer. A minimum of two points are required for a line to be formed and be visible in the 3D viewer. However the x,y,z values may be calculated for a single tiepoint.

The .xy and .xyz filenames use the following convention:

```
tiepoints_[FITS filename]_saved_[timestamp].xy  
tiepoints_[FITS filename]_saved_[timestamp].xyz
```

Example:

```
tiepoints_20081212_075615_n4euA.fts_saved_20111208_104158.xy  
tiepoints_20081212_075615_n4euA.fts_saved_20111208_104158.xyz
```

Timestamp records when the files were saved and makes the filenames unique. The .xy and .xyz filenames will have the same timestamp making them a matched pair.

Scc_measure sends the pair of FITS filenames to scc_measure which is another 3D coordinate measure tool. No tiepoints are sent to scc_measure and it may be used simultaneously in tandem with Sunloop's tiepointer tool. Scc_measure differs from Sunloop's tiepointer tool in one important regard: scc_measure constrains tiepoints to the epipolar line without first aligning the images, whereas sunloop's tiepointer tool depends upon image processing to first align the stereo pair and then constraining tiepoint motion to image rows which become equivalent to epipolar lines. The two tools may be used simultaneously (for cross referencing) even though they have different methods. (Scc_measure results are in Stonyhurst.)

Read Tiepoints button enables reading a previously selected .xy file. Any .xy file may be associated with any image pair but the .xy filename contains the original STEREO-A FITS filename (including FITS time) to maintain the original association.

Brightness button houses image adjustment controls. This can assist when tiepointing off-limb features which may benefit from having the **max** value reduced

by an order of magnitude. The **gamma** sliders provide for non-linear adjustments. The **Actual Left Image Min**, etc., buttons invoke histogram values.

Prefs button houses several preferences:

Prefs: Reference Graphics toggles the markings for sun center and R_{sun} radial circles.

Prefs: Grid draws a lon/lat grid on the sun's surface. Useful for EUVI images. Unfortunately does not draw all longitude lines.

Prefs: Tiepoint Numbers can assist in situations where tightly clustered tiepoints are better viewed with numbers turned off. The option of **First and Last Only** is intended as a reminder of the direction in which the tiepoints are ordered while minimizing the amount of numbers shown on screen.

Prefs: Color Table self explanatory.

Prefs: Cursor Tolerance defines how close the cursor must be to the tiepoint in order to grab it for moving. When tiepoints are clustered very close together this setting can be reduced to make tiepoint grabbing more precise.

Prefs: Computer Speed adjusts how much redrawing is performed while a tiepoint is being moved.

Help button displays the location of this User Guide in solarsoft:
\$SSW/stereo/secchi/idl/display/sunloop/**sunloop_user_guide.pdf**

Cursor readouts are provided for **(line,samp)**, **(x,y)**, **(lon,lat)** and pixel **value**. Values for **(lon,lat)** are valid only within the solar disk. Longitude value will reflect the selection of Carrington or Stonyhurst.

LINE3D

After selecting tiepoints and clicking **scc_triangulate** a small dialog will offer to send the calculated x,y,z points to the 3D viewer called line3d. Line3d employs a simple orthogonal view. Line3d initializes with a rotating view so the 3D nature of the tiepoints can be immediately appreciated. The default zoom keeps the x,y,z points entirely within the view during rotation. Rotation is left to right for features in the near-field side of the sun.

LINE3D OPTIONS

MOTION CONTROLS, SCREEN AND DATA:

SCREEN COORDINATES mode is used to manipulate axes associated with the screen window. Controls in this mode include rotation, translation, zoom, numerical rotation, and various reset buttons. Reset to View of **CME feature** will set the view such that the CME feature will remain entirely within the view window as the graphics object rotates 360 degrees around (this is the initial default view). Reset to View of **Spacecraft** will do likewise with regard to the STEREO-A and -B spacecraft positions in space. The row of buttons that include **EUVI**, **COR1**, **COR2**, **HI_1**, and **HI_2** will set the view such that the frames at the ends of the frustrums for that instrument will be entirely within the view during a full rotation. These buttons are useful when **Frustrum Lines** are **On**, and even more so when **Images** are **On**. The small **t** buttons will set the view at a point midway between two instruments.

DATA COORDINATES mode is used to rotate axes of the graphics object. Controls in this mode are limited to rotation and reset.

Rotate controlled by dragging the cursor in the window. Rotate may be used either while the graphics are rotating or after clicking the **Stop** button. **Rotate** may be constrained by **axis** or used in unconstrained **Free** mode. **Rotate** changes the orientation of the model in the view.

Rotate X, **Rotate Y** and **Rotate Z** allow numeric control in degrees. The resulting orientation will be affected by the order in which the axes are changed. These values change the orientation of the model in the view.

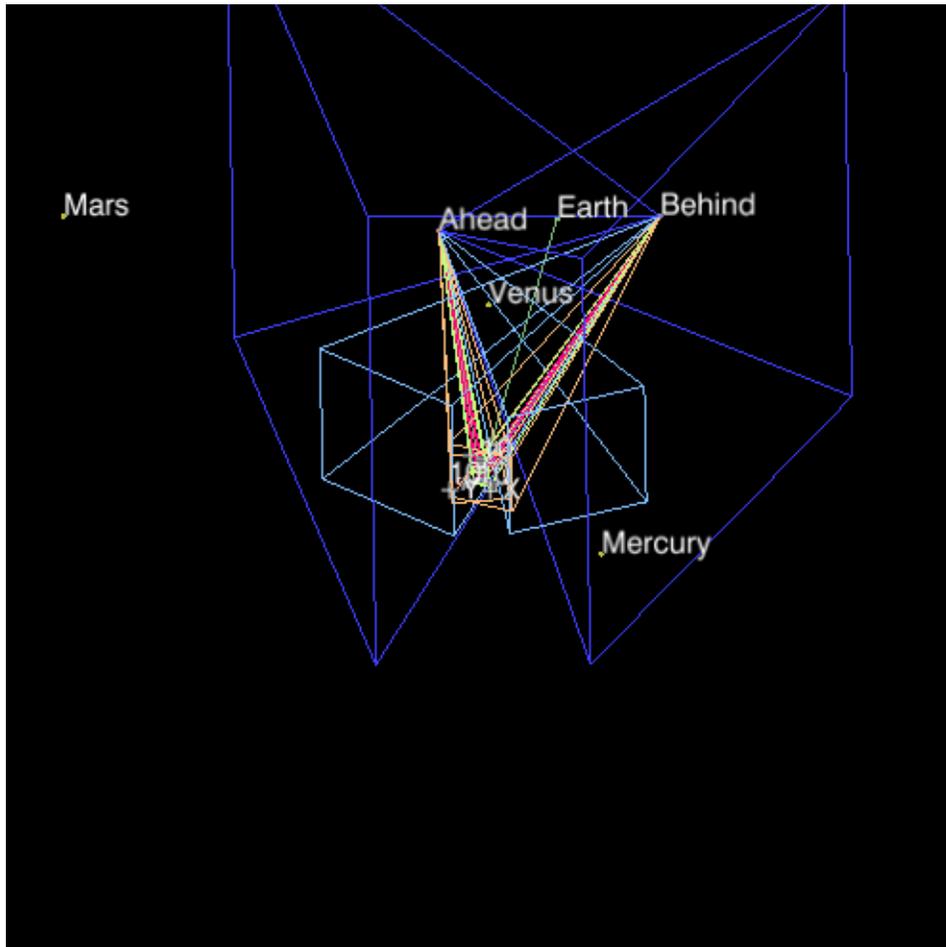
Zoom selection enables scale control by slowly dragging the cursor in the window. Drag slowly for best results. **Zoom** has a variety of presets:

Button	Description
-----	-----
CME feature	keep x,y,z points entirely within view while rotating
Spacecraft	fit spacecraft locations within view while rotating
EUVI	keep end of EUVI frustrum within view while rotating
t	transition zone between EUVI and COR1
COR1	keep end of COR1 frustrum within view while rotating
t	transition zone between COR1 and COR2
COR2	keep end of COR2 frustrum within view while rotating
t	transition zone between COR2 and HI_1
HI_1	keep end of HI_1 frustrum within view while rotating
t	transition zone between HI_1 and HI_2
HI_2	keep end of HI_2 frustrum within view while rotating

Zoom presets have the effect of resetting the view should it get messed up. For example, it is easy to use **Translate** to move the entire model off screen, or zoom too quickly such that the model is not visible. Using one of the presets will bring it back.

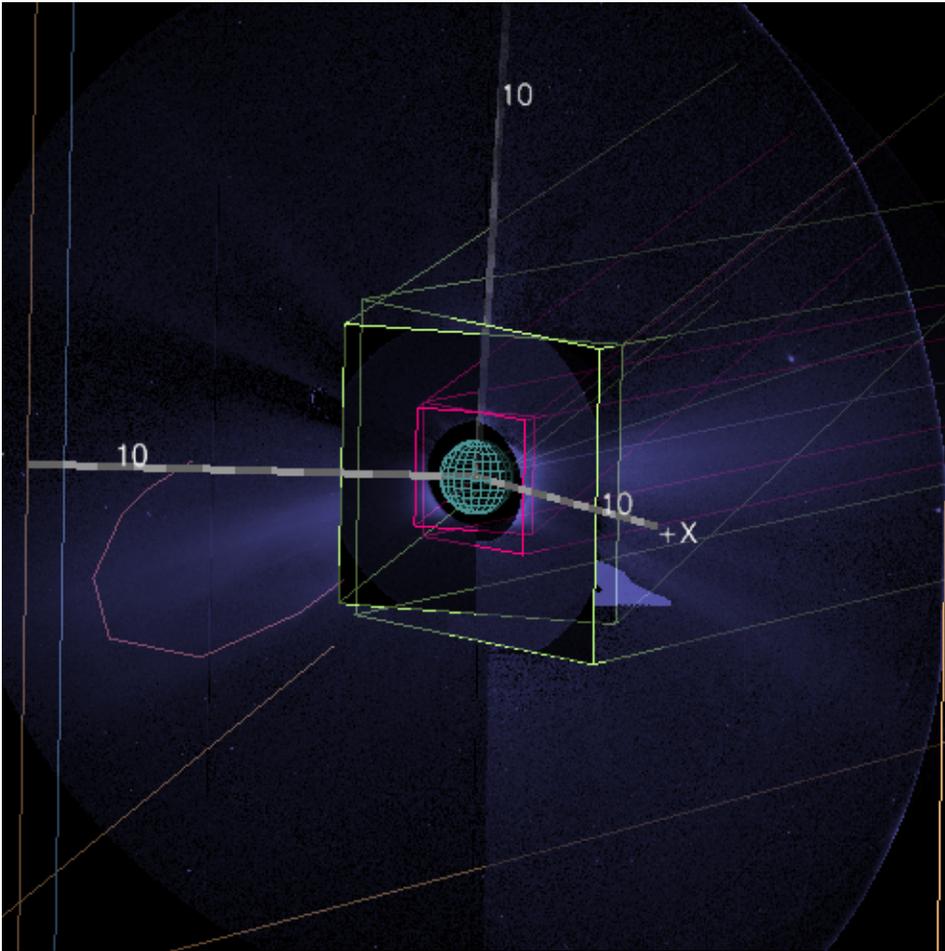
Thomson Spheres may be turned **On**. These spheres are attached to the light source (sun) on one side and the observer (spacecraft) on the other side. Thomson Spheres represent all right angles between the light source, particle and observer. Right angles are where particles appear brightest to the observer. Sphere graphics may be made **brighter** or **dimmer** (the button itself changes name.)

Frustrum Lines may be turned **On**. These display the fields of view of the cameras and are useful for understanding the complex viewing geometry of the STEREO spacecraft. The **FITS List** button shows the filenames that were utilized for building the frustrums at that particular time step (if multiple time steps are loaded the display will freeze at one time step while the **FITS List** is displayed.)



Frustrum Lines: On

Images may be turned **On**. This option will load images onto the frustrum screens. These screens are defined as a cross-section of the frustrum positioned at the Thomson Sphere. Unfortunately this option is currently only available at JPL. Since JPL provides public access to the TIFF files, it would be possible to replicate a portion of JPL's TIFF mirror site to enable the Images option. Such site replication is beyond the scope of this document. The button for **TIFF List** displays the filenames that were used for the images shown.



Images: On

Background Color may be set to **white** or **black**. Brightness of some lines will be adjusted accordingly.

Xyz mean line may be turned **On**. This will draw a line from the sun center to the centroid point of all xyz points that describe the feature(s).

Line Thickness of certain lines may be adjusted using the **slider**.

Rotation Speed may be adjusted using the **slider** and toggled using the **stop / start** button.

Resizing the line3d display window will sometimes halt the rotating animation and sometimes redraw will fail. Clicking on **Rotation Speed: Stop** followed by **Start** (the button changes its name) will force a redraw and re-start the rotating animation.

The last group of options involve saving screen shots:

Save Movie

Save 360 still frames to comprise one full rotation (auto-rotation must be turned on. For one full rotation the **Rotation Speed** must be adjusted to **1.0** otherwise 360 frames will be saved that represent more or less than one rotation depending on the speed setting.)

Save Still: TIFF

Save screen shot in LZW compressed TIFF format.

Save Still: VRML 2.0

Save the entire 3D model including frustrums and images if they are loaded.

Command Line

Line3d can be called from the command line to load a list of time steps. This is useful for displaying orbital characteristics of the spacecraft over specified time steps. Example:

```
IDL> line3d, timesteps = [ '20090401_000000', '20090501_000000',  
'20090601_000000', '20090701_000000', '20090801_000000', '20090901_000000',  
'20091002_000000' ]
```

This example will load times steps for the 1st of each month from April to October, 2009. The resulting display will, after **Frustrum Lines** are turned **On**, be rotating and stepping through the times. The display will show the spacecraft positions relative to Earth at each step. During this period the spacecraft positions reveal their substantial north-south and somewhat circular movements relative to Earth's orbit.

Using **line3d** on the command line in this manner is similar to using **animator**, except that animator loads features defined by .xyz files, in addition to loading the time steps associated with those .xyz files.

ANIMATOR

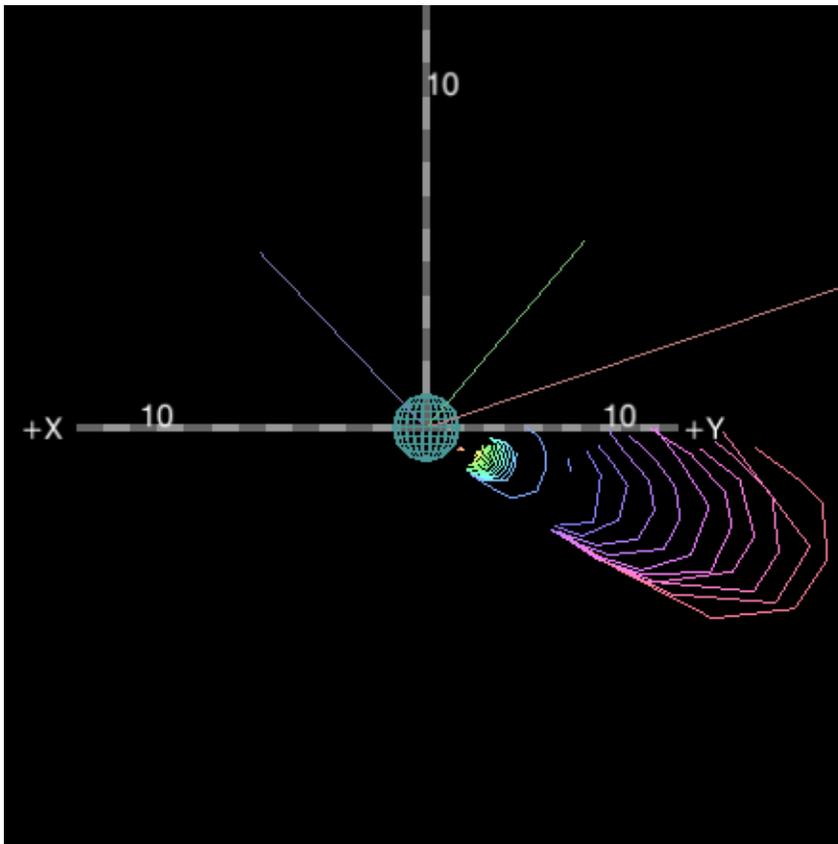
Animator allows multiple .xyz files to be loaded into **line3d** all at once. Animator will also display a height-time plot of the highest (greatest R_{sun}) point from each .xyz file. Additionally it will generate a PNG image of the height-time plot, and a text file containing the height-time information:

```
; #Velocity = linear fit
; #t_lin_rs = t0, linear extrapolation of time to center of sun
; #[Carrington|Stonyhurst] Lat (Lat max), lat mean (lat of highest feature)
; #[Carrington|Stonyhurst] Lon (Lon max), lon mean (lon of highest feature)
; # HEIGHT DATE TIME TEL xyzFilename
; 2.93 2007/05/19 13:24:04 EUVI filename.xyz
; 4.33 2007/05/19 13:36:04 COR1 filename.xyz
```

Example:

```
IDL> animator
```

This brings up the file chooser dialog. Highlight multiple (one works too) .xyz filenames and click **OK**. They will all be loaded into line3d.



Animator loads multiple .xyz files into line3d

You then have all the usual options provided by line3d. The advantage is you now have multiple .xyz files loaded, which can, for example, show a progression of a CME over time and across multiple instruments, if that's what you've defined in your .xyz files.

If you have access to the JPL TIFF files then you have the option of turning **Images: On** which will load a set of images (all instruments except EUVI) for each time step as defined by each .xyz file (it's in the .xyz filename.) For each instrument at each time step the closest TIFF image will be loaded. After they are all loaded the animation will play as the graphics object rotates. This can be very effective for comparing your .xyz data to the images from which they were derived.

Tiepointer allows the calculation of xyz points in Carrington or Stonyhurst. Animator allows the loading of .xyz files with mixed systems though it may not make sense. The user will be warned if .xyz files of mixed systems are selected.

Using **animator** to load multiple .xyz files is similar to using **line3d** on the **command line** (described above) except that using line3d on the command line only loads the time steps without any .xyz files.

ANIMATOR OPTIONS:

Same as for Line3d, see above. Multiple instances of animator and line3d may be run at the same time.

APPENDICES

Epipolar Plane:

As the spacecraft approach, then reach and surpass the 180-degree separation point, be aware of the following when using the default and recommended option “**Rotate Images: to stereo baseline**” This option invokes `scc_stereopair.pro` and will rotate the images to the epipolar plane as defined by the sun and two spacecraft.

As the spacecraft pass the point of 180 degrees of separation, they pass slightly to the south of the sun center. This means that the epipolar plane flips under the sun during this time. The epipolar plane re-emerges on the farside but is now upside down. Sunloop and the tiepointer tool will operate correctly during and after this time, but be aware the images will be rotated to match the epipolar plane. The amount of rotation is gradual over this period of time. After this transition is complete the images will be rotated entirely upside down.

Use reference images to understand the rotated orientation. The resulting `x,y,x` points will be correctly positioned in 3-D space, even though the tiepoint collection process may seem unusual. It’s actually quite logical, considering the orientation of the epipolar plane and stereo viewing geometry.

GUI Hierarchy

Basic GUI tree diagram:

```
Sunloop GUI
- tiepointer GUI
-- line3d GUI
```

The basic rule is that killing any GUI window will cleanly kill any items below it. All GUI kills are clean and will not mess up the IDL session. Sunloop may be killed and restarted from the command line. Tiepointer may be killed and restarted from sunloop. Line3d may be killed and restarted from tiepointer. Multiple instances of sunloop, tiepointer and line3d may be run at the same time. Multiple instances become branches that do not interact with other branches.

(“Kill” means closing the window using the [mac] red dot or [linux] x button.)

Killing the sunloop GUI for will kill the entire hierarchy under that instance of sunloop.

Killing the tiepointer GUI will kill any instances of line3d running from it. Sunloop remains operational.

Killing line3d will leave tiepointer operational. Tiepointer may be used to restart line3d, the side effect will be that another set of .xy and .xyz files will be generated.

Killing the **progress bar** employed by sunloop's **Update List** button is designed to be benign, but will occasionally throw an error. The **Cancel** button is preferred.

Sun, planets and spacecraft

These are objects represented by spheres in the line3d display window. The sun is scaled correctly. The other objects are sized to be visible and are all the same size as the sun.

SPICE

In line3d the locations of planets and spacecraft are derived from SPICE kernels using ICY as distributed with Solarsoft. Many of the ICY calls are encapsulated in WCS routines.

Using Sunloop with non-FITS images

Input images with detached headers are supported. They must be read into IDL before calling Sunloop. For example:

```
restore,'headers.sav'  
ia=reform((read_png('20100228_132030_195_304_a.png'))[0,*,*])  
ib=reform((read_png('20100228_131530_195_304_b.png'))[0,*,*])  
sunloop,ia,ib,ha,hb,/no_secchi_prep,/rotate
```

xyz2r1xyz.pro

Read one .xyz file. Flatten xyz points to surface of sun. Write new .xyz_r1 file.

X11

Apple computers without 3 button mouse: It may be necessary to open **X11 Preferences** and, under the **Input** tab, select **Emulate three button mouse**.

When using Apple X11 2.3.6, sunloop would occasionally crash when resizing the line3d display window. Upgrading to XQuartz 2.7.1 resolved that problem.

In line3d, occasionally resizing the display window will halt the rotating animation and occasionally a redraw will fail. Clicking on **Rotation Speed: Stop** followed by **Start** (the button changes its name) will force a redraw and re-start the rotating animation. This issue was not seen when using Apple X11 2.3.6, but has been seen with XQuartz 2.7.1.

Comments

(Pertaining to version 1.0)

Jan 13, 2010

I was able to bring up the program by passing in the filenames directly.

```
IDL> sunloop,list.sc_a[0],list.sc_b[0]
```

Bill [Thompson]

Jan 14, 2010

Paulett, Jeff:

Some more comments on the sunloop program. I managed to get the program working in the browse mode by editing get_closest_fits_filename.pro and sunloop.pro. I've attached my edits. In doing so, I noticed a few things which you might want to address.

Bill

(Issues have been addressed in version 2.0)