

SMEI Display tutorial

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1 Introduction

This document takes you through a simple example of the basic facilities of the SMEI display tools. It can't cover everything, but aims to give a starting point.

It is assumed that you have a working SolarSoft installation with the SMEI package installed, and that you have the data available.

Paragraphs in *italics* provide extra information on what is going on or alternative methods of doing things.

The labels of buttons to be pressed or of text boxes are given in **sans serif font**.

Text values to enter are given in *typewriter font*. Commands to be entered at the IDL> prompt are given on a line by themselves.

- Items with a solid bullet are the key steps in the tutorial.
- Items with an open bullet are either alternatives or additional possibilities.

2 Getting Started

Firstly start the SolarSoft environment:

```
[lnxn @ 13:52] :_sswidl
-----
Running SSW, Last Updated: Wed May 18 19:16:23 GMT 2005

PROBLEMS? - e-mail TO: freeland@penumbra.nascom.nasa.gov
-----
IDL Version 6.0 (linux x86 m32). (c) 2003, Research Systems, Inc.
Installation number: 400519.
Licensed for use by: STARLINK: University of Birmingham

Executing SSW IDL_STARTUP for: GEN
Executing SSW IDL_STARTUP for: SMEI
Executing SSW IDL_STARTUP for: SITE
IDL>
```

Provided you see the GEN and SMEI lines and an IDL prompt you are all set (if you have other instruments enabled, then you may see other messages as well). Now it is time to create your first SMEI sequence.

- At the IDL> prompt type

```
smei_menu, ss
```

This will bring up the main sequence menu (Figure 1). Most of the buttons are currently disabled as their actions are meaningless until some images have been loaded. The argument `ss` is a variable name which will contain the sequence object, this can be any valid IDL variable name, however the supplied procedures for the calculator (Section 3.2) assume that the input sequence is called `ss` unless they are told otherwise.

- Now click on the Add Images button.

As this is the first time you have done this in your current SSWIDL session, there will be some delay while the program checks the images and generates a list; after an initial delay, progress monitors will show the progress of the scanning. When that has completed then the selection menu will appear (Figure 2).

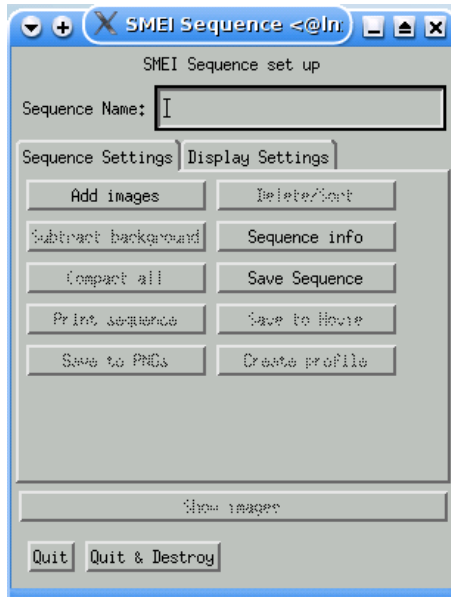


Figure 1: The main SMEI sequence menu before any images are loaded.

- To select a date range, enter the start and end times in the Start date and End date boxes.

The tab character will move you from one “focusable” item to the next. Note that for a change entered via a text box to take effect you must either enter a carriage return or move to another focusable item in the menu.

For this example we will look at the May 2003 halo event.

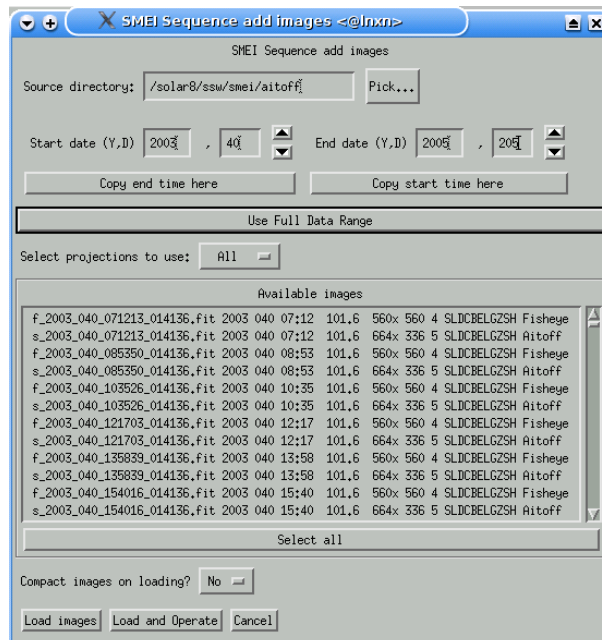


Figure 2: The image selection menu as it initially appears.

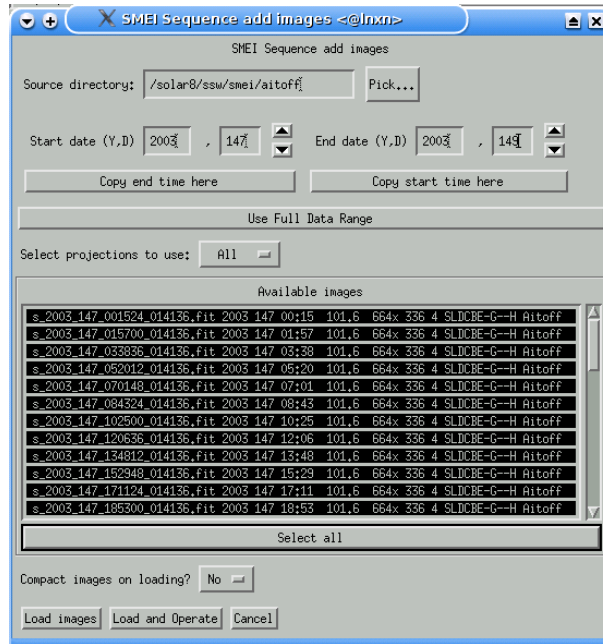


Figure 3: The image selection menu with the aitoff images for the May 2003 halo selected.

- The first box is likely to already contain 2003, so click on the second start date box, delete its current contents and enter 147.
- Now click on the **Copy start time here** button located below the end-time entry boxes. This will copy the start year and day to the end time.
- Click twice on the upward triangle button to the right of the end-time entry boxes to change the end day to 149.
- In this case, there are no fisheye images, but if there are both fisheye and aitoff images, then you need to select which projection to use with the **Select projections to use** pulldown menu. Trying to mix projections is an error and will generate lots of tedious dialogues during loading.

The list of images should now just have the aitoff images for days 147-149 of 2003 inclusive.

- Now select all the images by clicking on the **Select all** button below the image list (Figure 3).
- Finally click on the **Load images** button to read the images and create the sequence.

Images can also be selected by clicking on their lines in the list of matching images. A plain click selects the clicked image only, shift-click selects all images between the previous click and this one and control-click toggles the selection state of the clicked image.

3 Making the data useful

You should now have a sequence with images in it. However if you try to display it now, you won't be able to see much, you need to subtract backgrounds and set the display ranges so that you can see the transient. There are two ways to remove backgrounds, each of which has advantages and disadvantages. Since some transients are only visible in one or the other it is as well to be familiar with both techniques.

At this stage your main menu should look like the left-hand panel of Figure 4.

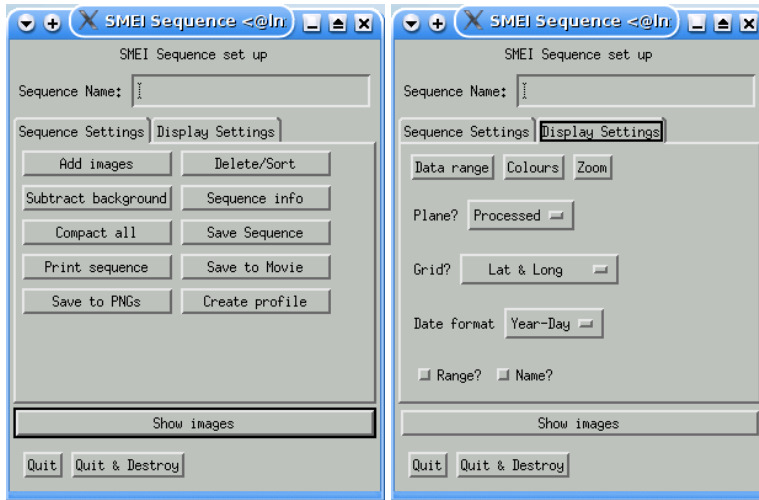


Figure 4: The main menu after images have been loaded. Left: The processing options; Right: The display options.

3.1 Background Subtraction

The first technique for removing background is to use the daily¹ background models. These models are generated empirically from the images and you may need to try several different models to get the best results (the processing is such that the subtraction is always from the original data); generally those with short smoothing intervals (models 8 and 9) produce the best results for transients.

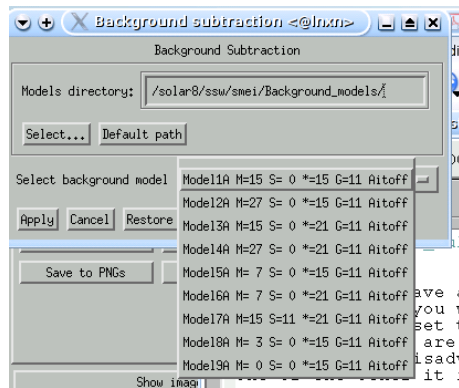


Figure 5: The background model selection menu, showing the available models.

- To subtract a background model, click on the **Subtract background** button on the main menu. This will generate the menu for choosing a background model (Figure 5).
- From the pulldown select **Model 8**.

This is a model with a 3-pointing median for the slowly varying components and no other time-domain smoothing ($M=3$, $S=0$) the other parameters refer to the spatial scales used in separating the solar, stellar and galactic components.

¹Actually they are only approximately daily, the pointings of the sky maps are rounded to the nearest degree and each background model corresponds to one pointing so there are actually 360/year.

- Then click on **Apply** to do the subtraction.
- On the main menu, click on the **Display settings** tab to reveal the display options which should look like the right-hand panel of Figure 4.
- Right now the only thing we are going to change is the data range, so click on the **Data range** button.

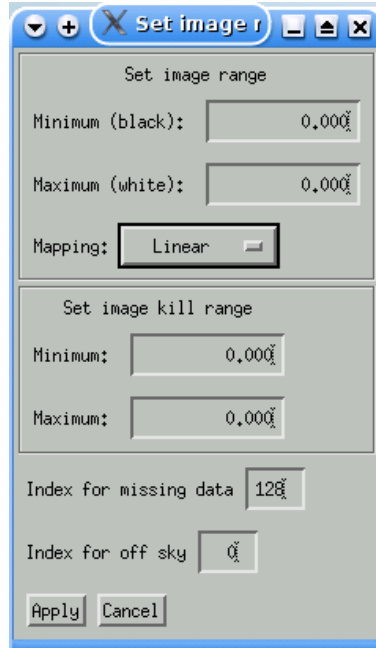


Figure 6: The data range setting menu

For background-subtracted images (and running differences) a suitable range is \pm a few ADU.

- In the **Set image range** area enter -2 in the minimum box and 2 in the maximum box. Leave the mapping as linear. N.B. If the values are equal then the full range of the data is used.

The kill range is used to eliminate regions with very high or low values which are very distracting if they change rapidly from frame to frame. Typically the kill range should be a few times the display range.

- In the **Set image kill range** area enter -6 in the minimum box and 6 in the maximum box.
- Then click on **Apply** to apply the changes.

We're now ready to view the sequence. On the main menu, click on the **Show Images** bar.

You should now see a new window with a movie displaying the sequence, as in Figure 7.

3.2 Running Differences

To produce a running difference sequence, it is necessary to generate a new sequence. In principal it shouldn't matter whether you have subtracted backgrounds first or not but to be on the safe side.

- Quit the display by clicking on the area of the displayed image (the drawing area) with the **right** mouse button and selecting the **quit** option.

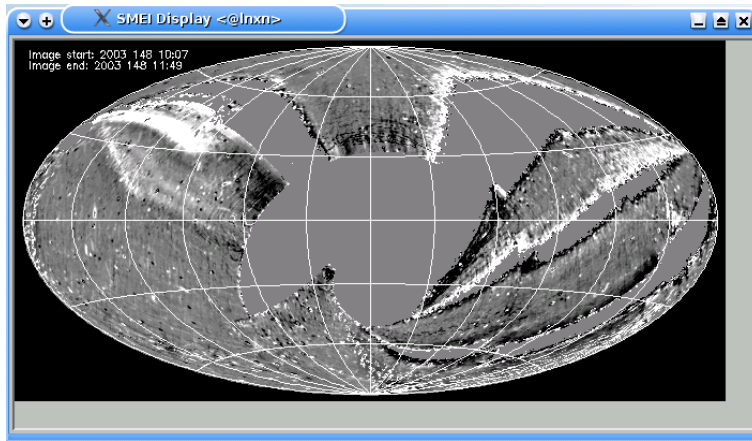


Figure 7: The window displaying the sequence.

- Select the Sequence Settings tab on the main menu.
- Click on Subtract background
- Finally on the backgrounds menu, click on Restore original.
- Now click on Quit (**NOT** Quit and destroy as that will delete the sequence) on the main menu. This will return you to the IDL> prompt.
- Now enter the command:

```
smei_calc_menu, ss1
```

The name `ss1` will be the name of the new running difference sequence (this *must* be different from the name of the original sequence).

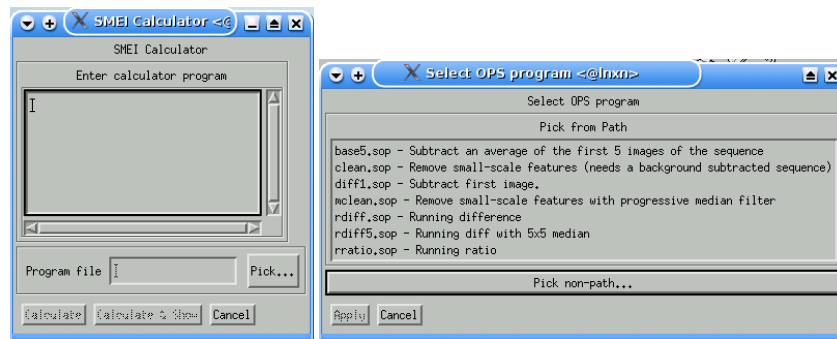


Figure 8: The calculator menu (left) and the program selection menu (right) for SMEI calculations.

This will produce the calculator menu (Figure 8, left).

- Click on the Pick button, which will generate a list of possible “canned” calculations (Figure 8, right).
- Click on the `rdiff.sop` line, then on Apply.
- Now click on Calculate on the original calculator menu. When the calculation has completed you will be returned to the IDL> prompt.

- Now enter

```
smei_menu, ssl
```

to bring up the main menu for the new sequence.

You will see that some options such as background subtraction are not available for this sequence. Note also that unlike the previous section, the IDL> prompt is available while the menu is present; the general rule is that if the sequence exists before `smei_menu` is called then the prompt is available but if you are creating a new sequence it is not².

- Set the data range as you did for the original sequence in Section 3.1.
- Then display it by clicking on **Show images**.

Suitable ranges for running differences are similar to those for background-subtracted sequences.

Note that about 1 image per day will be unusable because of the pointing changes.

For the “canned” calculations, the `.sop` programs assume that the image will be called `ss` if it has a different name then you need to give the command as: `smei_calc_menu, ssl, ss=myseq` (where `myseq` is the name you gave your sequence).

4 Things to do with the data

The material here can be done with either the background-subtracted sequence or the running-difference sequence.

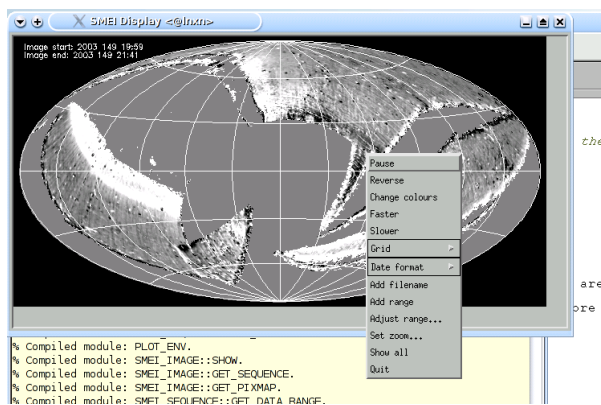


Figure 9: The sequence display window showing the context menu.

4.1 The context menu

Firstly we need to get familiar with the context menu.

- Bring up the main menu for one of the sequences:

²The reasons for this are related to the need for internal sanity checks which cannot be properly carried out for a non-blocking menu and an incompletely defined sequence.


```
smei_menu, ss
```

or

```
smei_menu, ss1
```

and display the sequence (if you are using the original sequence you will need to redo the background subtraction stage (Section 3.1) as we undid it before making the running difference).

- When you have the movie running, click in the area of the image (not the surrounds) with the **right** mouse button. You should now see a menu like that in Figure 9.

Most of the items allow changes to the display format (adding or removing annotations etc.). To select an option from the menu, keep the right button pressed down and move the pointer over the desired item, then release.

4.2 Pausing and manoeuvring

- For doing anything more than just looking at the images, you need to pause the movie, by selecting the **Pause** option in the context menu.

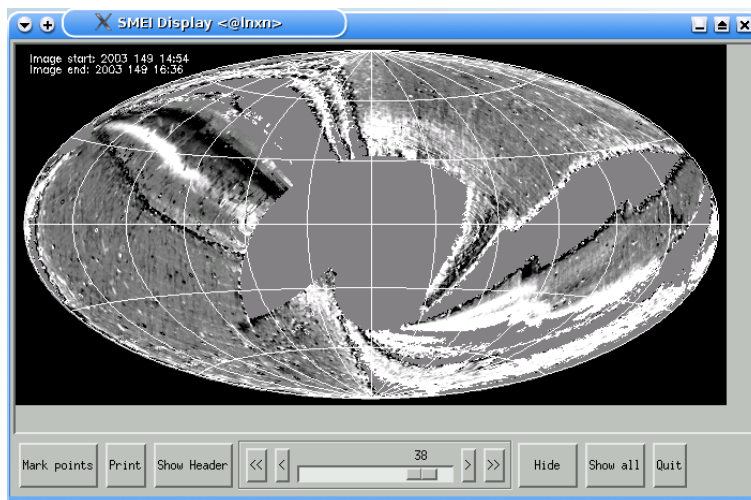


Figure 10: The movie display window in a paused state, showing the extra controls.

This stops the playing of the movie and generates a set of controls below the image (Figure 10). It is now possible to manoeuvre through the images in several different ways which have some differences.

1. It is possible to move through the sequence with the slider. This is the quickest way to get into the right part of the sequence but is imprecise especially for longer sequences (indeed for very long sequences it may not even be possible to access every image directly from the slider).
2. It is possible to move with the *single* arrow buttons that are located at each end of the slider. These move by one image and always go to the next image even if it is hidden (4.3).
3. If you have a wheel on your mouse, you can use that to move through the sequence. To do this, move the pointer into the image area and move the wheel, each click round move by one image forward or back but skipping hidden images. For detecting transients, this is usually the most convenient way to operate.

To restart playing the sequence as a movie, click on the double forward arrow button (or **resume** on the context menu). To play backwards click on the double back arrow button. The direction of play can be reversed at any time with the **reverse/forward** options in the context menu.

4.3 Hiding images

If an image is corrupt for some reason (e.g. the pointing change images in running difference sequences) then it is often better to hide it so that it doesn't distract the eye when scanning the sequence.

- To hide an image scan to the image in the paused sequence, then click on the **Hide** button (whose label will then change to **Unhide**). A hidden image remains in the sequence but is skipped when playing as a movie or scanning with the mouse wheel.
- To unhide a specific image, scan to it in the paused sequence with the slider and/or the single step buttons, then click on **Unhide**.
- To reveal all hidden images, use the **Show all** button on the paused sequence or the **Show all** option on the context menu.

4.4 Height-time measurements

Now we are ready to do what you've all been waiting for; measuring the progress of a transient through the SMEI field.

- With the sequence paused, click on a feature in the image while holding down the **CONTROL** or **SHIFT** key on the keyboard. This will print details of the location to the terminal e.g.:

```
2003 149 16:36 Pix= 115 127 Long= 118.3 Lat=-18.0
      Elong=116.8 P=0.893
      PA= 110.2 RA=11.89 Dec=-18.9 Value=      0.170
```

This gives the start time of the image, the pixel coordinate, ecliptic latitude and longitude, the elongation angle, the perpendicular distance from the line of sight to the Sun (= \sin Elongation), the position angle measured anti-clockwise from ecliptic north, the celestial coordinates of the point and the value of the pixel. While this gives us a chance to quickly check where something is, it would be tedious to construct a height-time plot this way.

We will now generate a height-time plot that can be used.

- Click on the **Mark points** button. You should now see the pointer over the image change from a cross to a right-pointing arrow, this is the indication that you are in marking mode.

In marking mode, the manoeuvring tools still operate as in normal mode.

To mark a point, click with the **Left** mouse button. To exit marking mode, click with the **Right** mouse button. To suspend marking mode (the marked points are remembered and added to when you next enter marking mode), click with the **Middle** mouse button.

If you have used the example sequence and have all the data available, the transient should be clearly visible to the north from about image number 30.

- Try to mark the heights from there to the end of the sequence.

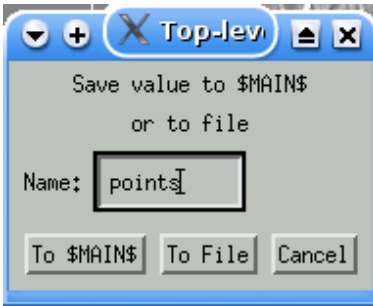


Figure 11: The height-time saving dialogue

Field	Type	Contents
DATE	DOUBLE[2]	The julian day numbers for the start and end of the image.
LONGITUDE	FLOAT	The ecliptic longitude of the marked point (degrees).
LATITUDE	FLOAT	The ecliptic latitude of the marked point (degrees).
RA	FLOAT	The celestial right-ascension of the marked point (hours).
DEC	FLOAT	The celestial declination of the marked point (degrees).
VALUE	FLOAT	The image value at the marked point (ADU).
P	FLOAT	The perpendicular distance from the Sun to the line of sight corresponding to the image point (=sin(elongation)) (AU).
ELONGATION	FLOAT	The elongation angle of the marked point (degrees).
PA	FLOAT	The position angle of the marked points (degrees measures anti-clockwise from ecliptic north).
X	LONG	The pixel x-coordinate of the marked point.
Y	LONG	The pixel y-coordinate of the marked point.

Table 1: The fields of the marked points structure

- When you have finished, **right**-click on the image to exit marking mode. You will be asked whether to save to a variable or a file (Figure 11).
 - To save to a variable, enter the desired name in the text box (default is `points`), then click on the **To \$MAIN\$** button. This will produce an array of structures at the main program level in IDL. The structure tags are listed in Table 1.
 - To save to a file, click in the **To file** button. You will then get a standard IDL file selector to choose the filename to use. The marked points will be written out one line per point with a header line at the top of the file. The information in the file is the same as in the variable. If you give it the extension `.csv` then the file should be easy to read into a spreadsheet.

Warning: Selecting the **Cancel** option in the file selector dialogue will loose the information, it will not return you to the original selector.

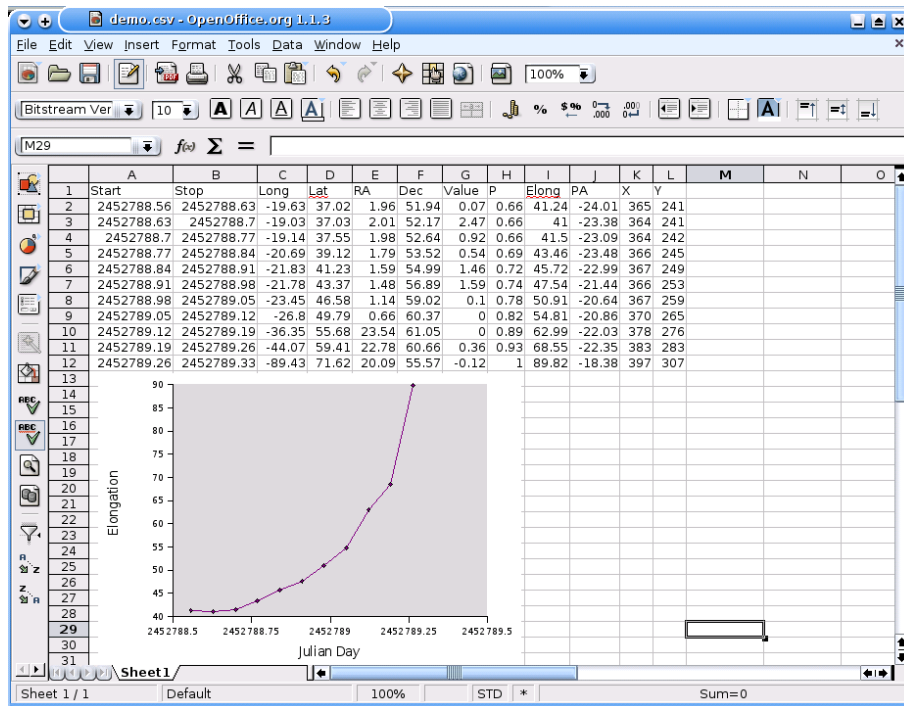


Figure 12: OpenOffice spreadsheet with a height time plot generated from the example sequence.

If you save your height-time plot to a file and open in a spreadsheet it should be possible to get something like Figure 12.

4.5 Other things

4.5.1 Zooming

There are two type of zooming available with the SMEI display software.

Firstly, you can change the zoom factor at which the sequence is displayed by selecting the **ZOOM** option in the context menu or the **ZOOM** button on the **Display settings** tab of the main menu. This allows the sequence to be displayed at one of a few zoom factors. Be warned that with large zoom factors it is possible to run out of memory.

It is also possible to examine a portion of the image in a separate window by clicking on the centre of the region of interest with the **middle** mouse button while in normal mode. Details of the capabilities of this feature are described in the **User's Guide**.

4.5.2 Printing

By clicking on the **Print** button in a paused sequence, you can print the displayed image. This generates the print menu shown in Figure 13, which allows you to set almost all the options that you can set in image display.

4.5.3 Etc.

To change the colour table, you can use the context menu's **Change colours** option to bring up IDL's colour table selection tool. The exact behaviour of the colours depends on the colour model in use by your X-server.

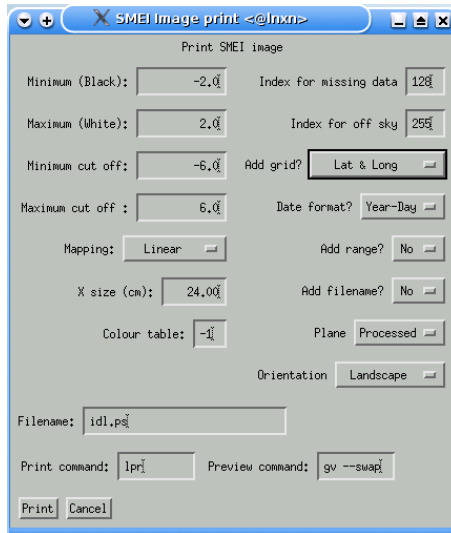


Figure 13: The image printing menu.

To find out more than you want to know about the current image in a paused sequence, click on the **Show** header button to display the FITS header of the current image.

5 Operating on the whole sequence

In the previous section we looked at things to do with the data on an image-by-image basis from the display window. There are also a set of operations that are applied to the whole sequence which are accessed from the main menu.

- Get rid of the display window, via the **Quit** button when paused or with the **quit** option of the context menu, and select the **Sequence settings** tab of the main menu (Figure 4 (left)).

We have already discussed background subtraction (3.1).

5.1 Saving the sequence

A very important feature is the option to save the sequence to an IDL save file.

- To do this, click on the **Save sequence** button. This will produce a dialogue to choose a filename to which to save the sequence. This uses IDL's internal **SAVE** file format. When a sequence has been saved to a file, it can then be restored using the `smei_restore` procedure. Try this with your current sequence (for the sake of argument give it the name `test.sav` in the current directory).
- Now exit from IDL, and restart `sswidl`. At the `IDL>` prompt, enter the command

```
smei_restore, rseq, /menu
```

Two things to note here: First, the name you give the sequence when you restore it doesn't have to be the same as the original name; and second, the `/menu` key tells `smei_restore` to start the main menu after restoring the sequence.

5.2 Movies etc.

For presentations it is nice to be able to show movies of your favourite transient(s), so the display tools allow you to do this (provided that you have suitable encoding tools installed).

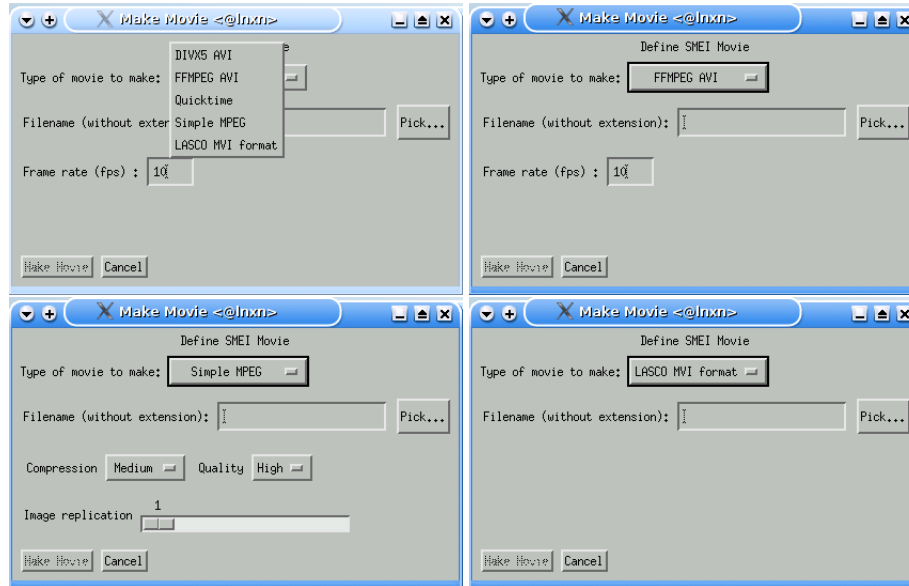


Figure 14: The movie creation menu. Top left: With the format selector displayed (if necessary external software is not found, then some of these formats may not be available), Top right: The options for DIVX, FFMPEG and Quicktime, Bottom left: The options for “simple” mpeg format and Bottom right: for LASCO MVI format

- From the main menu of your sequence click on the **Save to movie** button. This will generate a menu to choose the format of the movie (Figure 14) and the options. The options available depend on the format chosen.
 - For all formats you need to specify a file name (this must be without the extension), the **Pick** button allows you to use a file-selection dialogue to select directories and a name, or the name can be entered in the text box.
 - For the formats generated by `transcode`, namely DIVX5, FFMPEG and Quicktime (Figure 14 (Top right)) you only need to specify the frame rate in frames per second. These movie types are only available if `transcode` is installed on your system.
 - For the “simple” mpeg generated by `mpeg_encode` (Figure 14 (Bottom left)), you need to specify the compression and quality, and an image replication factor (the effective frame rate is $25/(\text{replication factor})$ frames per second). This movie type is only available if `mpeg_encode` is installed on your system.
 - MVI movies are a LASCO-specific format that can be encoded on any system and played on any system with the LASCO SolarSoft module installed. There are no options for this format.
 - If you have `transcode` available, there is probably little reason not to use the FFMPEG format unless you find problems playing the results on your systems.
 - If you do not have either `transcode` or `mpeg_encode` installed, you can use the **Save to PNGs** button on the main menu to save the individual images to PNG (Portable Network Graphics) image files and then use any movie making software on them (Figure 15). The files from the example will be called `bgs00.png`, `bgs01.png` etc..



Figure 15: The save to PNG menu.

5.3 Profiles

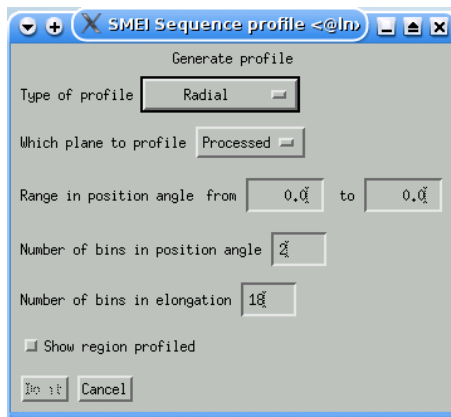


Figure 16: The profile creation menu.

Another useful facility is the ability to create radial or circumferential profiles.

- Click on the **Create profile** button on the main menu. This should produce the profile creation menu (Figure 16).
- The type can be **Radial** or **Circumferential**. Radial profiles always go from the Sun to the anti-solar point for airtoffs, or to the edge of the image for fisheye images. Circumferential profiles always cover the full 360° of position angle. You need to specify a range in the other direction.
 For this example let's make a radial profile in the north-west, so leave the type selection as **radial**, and the plane as **processed** (you will seldom need any other planes). In the range in position angle enter 330 and 360.
- The default of 2 bins is a pretty coarse resolution in position angle so we will make 2° bins by setting the number of bins in position angle to 15.
- Likewise the default elongation bins are rather big, so set those to 90 (again 2°).
- The option to show the region profiled is really only useful if you are not sure you are looking in the right place as it really slows things down.
- Now click on **Do it**. Don't worry about the numbers scrolling through in the terminal at this point, it's just that the `AITOFF` function in SolarSoft prints out all the off-sky points every time it is called.
- When the profile is generated, you can either save it to a file or as a set of variables. For this example, let's save it to the default variables. These will then be available in IDL for interactive manipulation (e.g.):

```

IDL> help, profile,elong,pa,date
PROFILE          FLOAT      = Array[15, 90, 43]
ELONG            FLOAT      = Array[90]
PA              FLOAT      = Array[15]
DATE            DOUBLE     = Array[2, 43]
IDL> plot, elong, profile[9,*,38]
IDL> oplot, elong, profile[9,*,40]
IDL> oplot, elong, profile[9,*,36]
IDL>

```

The resultant plot should look like Figure 17.

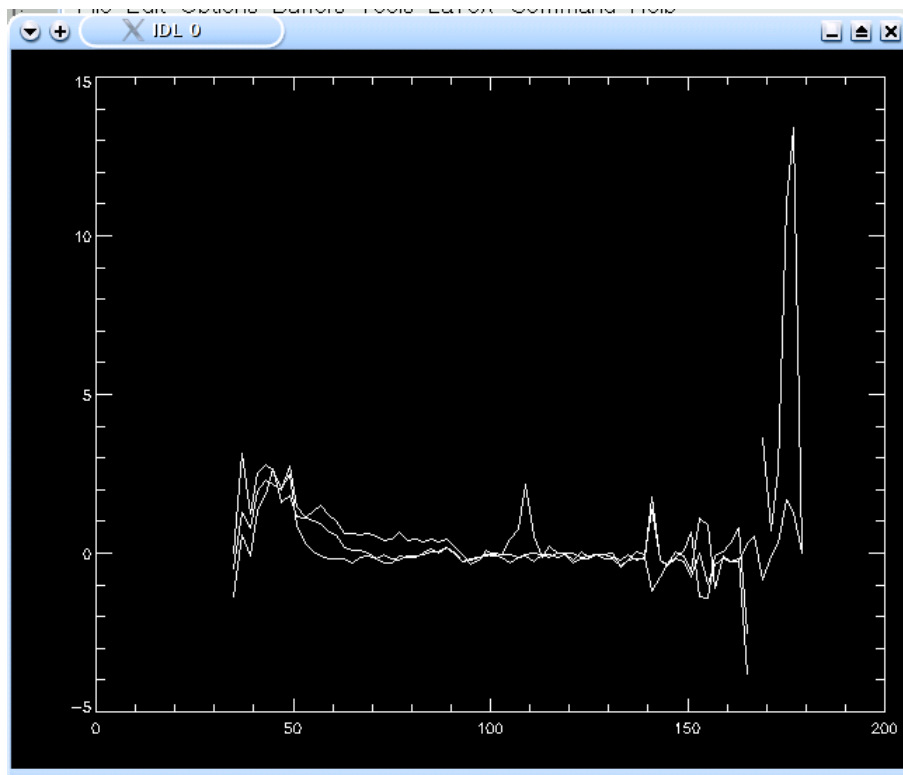


Figure 17: Plot of 3 of the profiles generated by the example given in the text.

6 Endnote

That's probably enough for a tutorial, and should get you started. For more information on detailed options and other capabilities you should refer to the [User's Guide](#). For the gory details of what every individual routine does see the [Reference Manual](#). For advice on installation see the [Administrator's Guide](#).

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