



SaVi - satellite constellation visualization

INTRODUCTION AND INSTRUCTIONS FOR USE

Constellations lecture by Lloyd Wood, International Space University Summer Session '06.

1. To launch SaVi

SaVi is installed on the lab's Windows computers using *Cygwin*, which emulates a unix environment. To launch *SaVi*, follow the following steps:

1. first launch *Cygwin* by double-clicking the green-and-black *Cygwin* icon on the left of the desktop. The black *Cygwin* command window will appear.

2. Launch the X desktop by typing:

```
startx &
```

in the black *Cygwin* command window. A white xterm window will appear. If a white xterm does not appear, wait, quit *Cygwin*, and relaunch it.

3. In the white xterm window, type:

```
runsavi3d &
```

to run *SaVi* together with *Geomview*, which provides *SaVi* with three-dimensional rendering capabilities. When using *Geomview*, the Look, Fly and Rotate buttons in its toolbar are the most useful; the stationary axes allow you to see the Earth rotating against something fixed as you spin your camera view around.

Alternatively, you can type

```
Runsavi &
```

to run *SaVi* standalone. When *SaVi* is run without the 3D component, *SaVi* does not use X, so can be launched directly from the black *Cygwin* command window without first doing `startx`.

Note that *SaVi* has a number of simple command-line options that can be seen by:

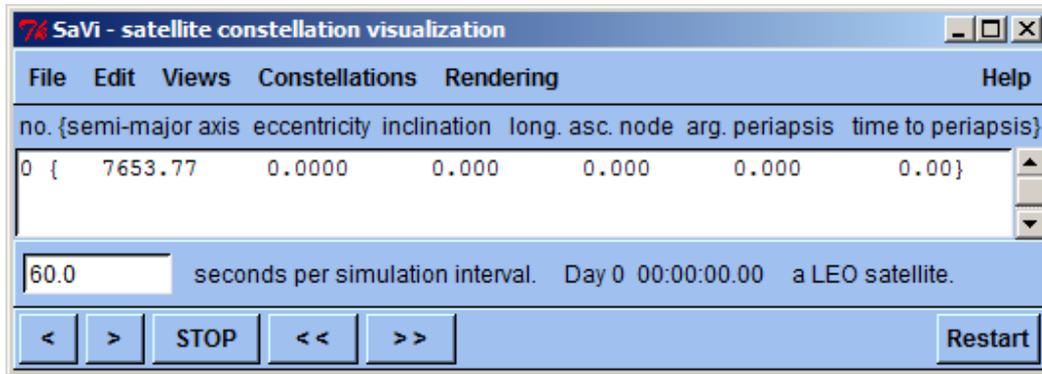
```
runsavi -help
```

SaVi without *Geomview* is also more robust in the *Cygwin* environment. *Geomview*'s pipe handling is currently very weak under *Cygwin* (unlike on glibc-based unix systems) and *Geomview* can be made to fail with a 'can't seek back on pipe' error by either:

- a. loading in large satellite constellations.
- b. turning on footprints or coverage cones in *SaVi*'s main window's Rendering menu.
- c. doing something that has previously worked just fine.

Here is a brief guide to the main features of *SaVi*'s graphical user interface:

2. The main SaVi window

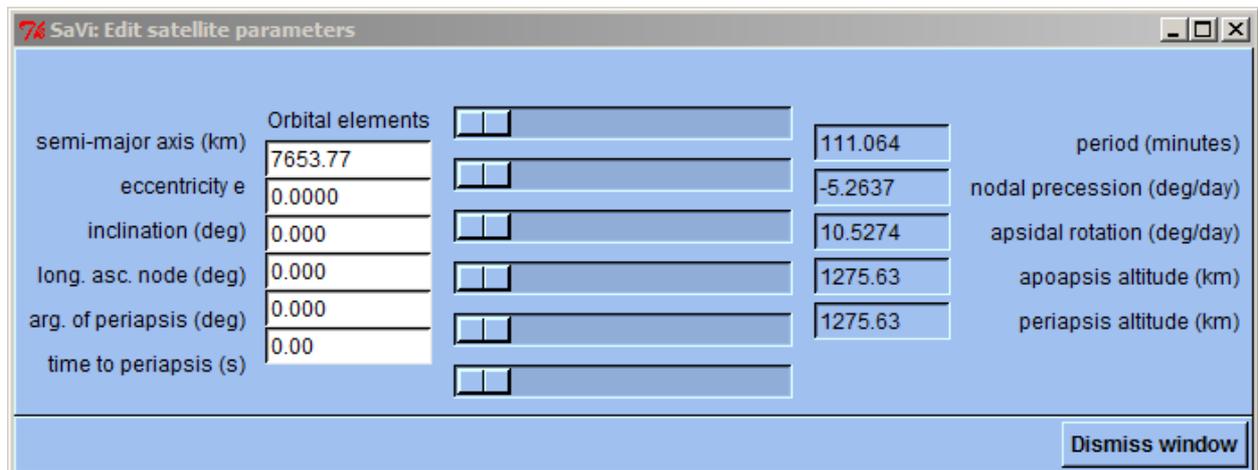


Main window – to see, launch SaVi. See above.

This is where satellite parameters are edited and where *Geomview* (if it is in use) is controlled from the **Rendering** menu. The simulation is run forwards and backwards in time using the >> and << buttons on the playbar at the bottom of the window. > and < step forwards a single interval of time; the default time interval is set to sixty seconds for each step.

Double-click a line listing satellite parameters to open the 'Edit satellite parameters' window and edit values directly. Press return after entering each value to update the satellite and change the simulation. A custom list of edited satellites can be saved for posterity as a script to be loaded in again later - see the **File** menu.

The **Edit** menu allows you to copy, cut and cut satellites, or edit existing or new satellite parameter lines, via an edit box. Like all SaVi windows, this can be left open while other windows are active.



Edit window – To see, use the Edit menu.

Altering simulation constants from Earth normal is not for the faint-hearted.



Simulation constants – to see, use the Edit menu.

The **Views** menu allows you to open the coverage panel and fisheye window, discussed below. Other options in the **Views** menu duplicate the playbar at the bottom of the window, including the 'Restart' button to reset the clock to time 0.

The **Constellations** menu allows you to load in simulations of known satellite constellations, both existing and proposed. The simulations on this menu are split into several groups:

- theoretical constellations
- systems in use
- navigation constellations
- huge broadband proposals of the 90s (fast unix machines only!)
- other system proposals (not built)
- sample TLE (two-line element) files. Although *SaVi* has elementary TLE parsing capabilities, simulation from TLEs is not at all accurate! This is still experimental, and not recommended for use.

Note that loading in a constellation from the menu replaces all existing satellites. To add a constellation to existing satellites you want to preserve, use Load... in the File menu, and load in a Tcl script from *SaVi*'s data/ directory (e.g. /home/lloyd/savi/data/). To save an existing constellation you have created, such as one generated using the Ballard rosette tool, use the **File** menu's Save satellites as Tcl script... option. To begin from scratch, either delete all satellites, or select Empty space, and confirm the dialog that comes up.



Empty space of satellites dialog – to see, use Constellations menu.

The **Rendering** menu includes a 'Real-time mode' option that attempts to synchronise *SaVi* to the computer's clock, so that an interval is simulated every second. If you set to 1 second per interval, *SaVi* attempts motion in real time. This mode option is most useful on very fast computers

The **Rendering** menu is complete when *SaVi* is running with Geomview. The full menu allows you to control how Geomview shows the constellations in its Camera windows. To change the satellite type, select a marker type from the top section. To restore the default green dots, select the marker type again.

Showing footprints and coverage cones causes problems for *Geomview* on non-glibc-using systems like *Cygwin*, and is best avoided. We can use coverage map texturemapping to substitute for vector footprints.

By turning off 'Show central body', an outline Earth is produced. This is useful when used with *Geomview*'s spherical projection (in the *Geomview* window's **Space** menu.)

'Animate in Geomview' can be turned off if *Geomview* becomes problematical, so *SaVi* can be used standalone.

The Help menu identifies *SaVi* and provides brief information.

3. The coverage panel

The coverage panel is where most viewing work in *SaVi* is done. It is likely that this will be the first option selected once *SaVi* is running, and that most work will be done with the menus at the top of this window.

In the coverage panel a map projection of the Earth and visible coverage is shown. This map is 600x300 pixels (or, if the `-large-map` command-line option is chosen for a large screen, 1024x512 pixels.) A number of different map projections can be chosen:

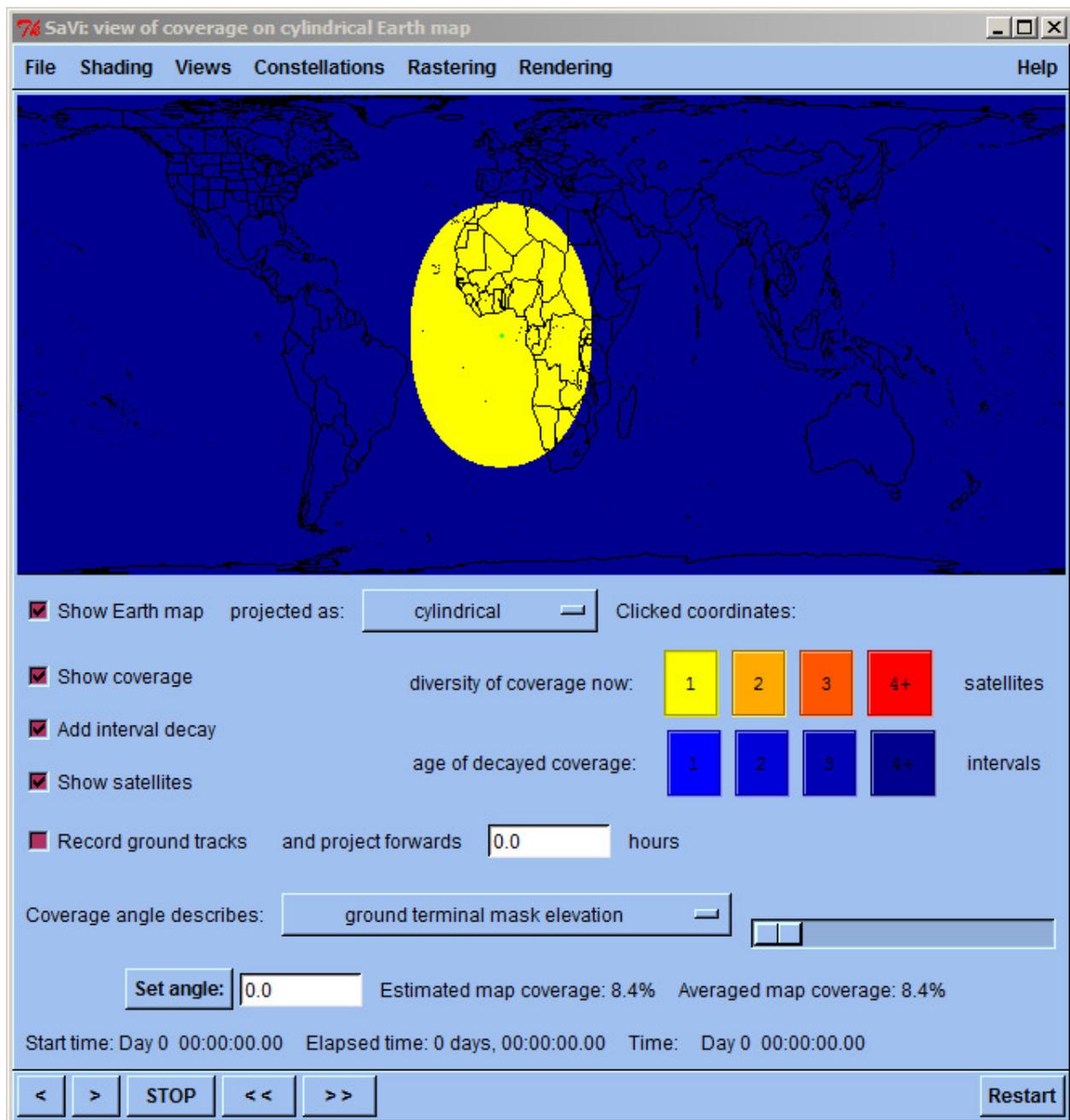
- The cylindrical view is useful for sending texturemaps to *Geomview*, as a cylinder can be easily mapped onto a sphere. This is controlled from the coverage panel's **Rendering** menu.
- The unprojected map shows high latitudes and poles much more clearly than the cylindrical view.
- The spherical view is a poor substitute for not running *Geomview*, to gain an idea of 'real' coverage on a globe.
- The sinusoidal view may be of use for US coverage.

Clicking in the map sets coordinates that are passed to the fisheye window, and can then be set in that window.

Satellite coverage (which defaults to yellow/red) is intended to give an idea of the number of satellites visible from a point, or available diversity. The higher the number of satellites covering a point, the deeper the shade of red.

Interval decay (which defaults to shades of blue) is intended to give an idea of where a satellite footprint has been and is going, even when you look at a still map snapshot. Turning this off replaces blue with white.

Map colours can be controlled to taste by the **Shading** menu or by clicking the colour wells in the key individually. 'Change shading' will always produce ranges of tasteful hues.



Coverage panel – to see, use Views menu on main window.

Still map snapshots can be saved from the **File** menu. A simple ppm bitmap format is used, and compressed with gzip. These files can be read directly with the gimp (GNU Image Manipulation Program, <http://www.gimp.org>).

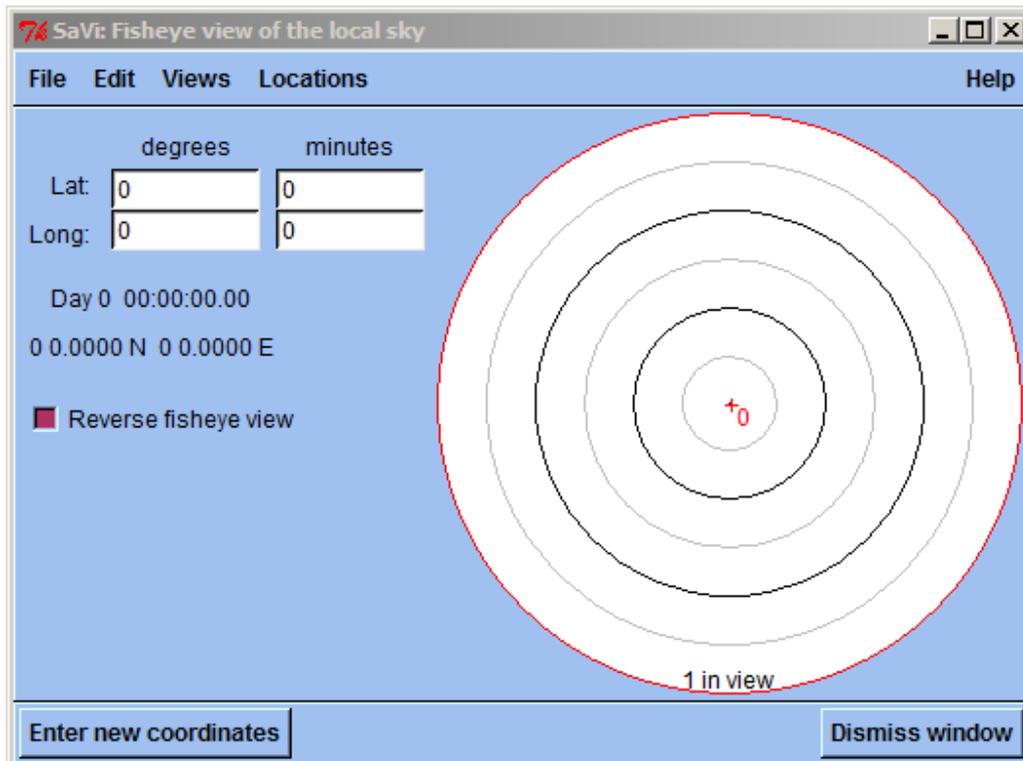
The coverage of all satellites is controlled by angle, pop-up menu, and slider. The angle is between 0 and 90 degrees. It can either indicate mask elevation - the minimum angle through the

atmosphere needed to establish communications with the satellite, or the angle of the satellite beamwidth. Mask elevation is more useful. The slider to the right alters the angle value directly.

Coverage estimates are not accurate.

The playbar is repeated at the bottom of this window for convenience.

4. The fisheye window



Coverage panel – to see, use Views menu on main window.

The fisheye window shows a view of the sky looking upwards from the ground, with the horizon around the outside of the circle. North is to the top of the map. The default location is at zero point (zero longitude, zero latitude, zero altitude, just off the coast of Africa.)

If 'ground terminal mask elevation' is selected from the coverage panel, the mask circle will be shown, and the time a satellite spends in view (i.e. within the mask area) will be indicated next to the satellite. Note that times are only accurate to +/- half the simulation interval, assuming that a satellite began outside the mask area.

'Enter new coordinates' updates the Fisheye to use the values in the white text boxes, which will be copied to the actual coordinates in the blue area below.

'Reverse fisheye view' switches East and West, to give an idea of satellites moving over the Earth. This can be compared with *Geomview's* spherical view with the central body turned off.

5. Further hints

The best, most accurate, way to simulate a custom constellation in *SaVi* is either to:

- a. write a Tcl script, similar to the existing Tcl scripts in the `savi/dev` directory. Discussion of Tcl and the SATELLITE keywords specific to *SaVi* is outside the scope of this note -- but much can be learned from existing scripts.
- b. Rewrite the TLE-handling code in `savi/tcl/constellations.tcl` so that it works properly, by staring at existing FORTRAN code and translating. This is likely not for the faint of heart.

The background colour in *Geomview* is set at the start of `savi/ogl/savi.ogl`.
0 0 0 is black.
255 255 255 is white.

Geomview can have multiple cameras open showing different views. Scripting of camera actions in *Geomview* (using its ogl object-oriented graphics language, which is a degenerate form of lisp) can be very powerful. Or so I'm told.

Notes on sources and for and details of simulated constellations can be found in the comments to each script. See the `/home/lloyd/savi/data` directory.

SaVi and *Geomview* together are much more robust on glibc-based unix systems (e.g. Debian Linux), and running *SaVi* and *Geomview* in a proper unix environment is recommended. *SaVi* and *Geomview* have been installed for use on a lab Debian machine.

Work on *Geomview* to address this problem with *Geomview*, and bring *Geomview* up to date with modern compilers and libraries, is ongoing.

Further information at:
<http://savi.sf.net/>

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