Geometer User’s Guide

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**Introduction.**

Geometer was written to support the Cassini UVIS team in both observation design and post-observation analysis, particularly in interpreting datasets by providing a visual context of the geometry of the observation. Because much of the UVIS data does not provide an immediate indication of where bodies are in the data, Geometer was written to provide wireframe graphical representations of the sky or a target body with the UVIS fields of view drawn over it. It was also used to identify opportunities for stellar occultations. Later, the ability to load in data and paint it on sky plane together with the target body representations was added. This was in conjunction with the development of the UVIS-team Cube Generator software.

Geometer uses the JPL/NAIF SPICE toolkit of software in its IDL implementation. That software is available from the NAIF website. Geometer is written in IDL. Geometer does its geometric calculations with three different possible pointing assumptions: pointing refers to the line-of-sight to a star (“Star” pointing); pointing refers to the line-of-sight to the Sun (“Sun” pointing); pointing is taken from a C kernel. Geometer can also provide a general view of a target from the point of view of Cassini without doing any instrument pointing. Various geometric quantities are calculated by Geometer. These can be saved to an IDL save file or to an ASCII file. In addition, simple line plots can be made, and wireframe representations of the system from the point of view of Cassini can be generated.

Geometer provides several different viewing representations, and animations can be generated in any of these views.

**Usage.**

The NAIF “ICY” toolkit must be installed and loaded in IDL prior to running Geometer. When Geometer has been compiled, run the program by typing Geometer at the IDL prompt. This launches the main Geometer user window (Figure 1). All kernels needed for the time period to be studied should be loaded. They can be loaded through the Geometer File menu. C kernels only need to be loaded if pointing information from a C kernel is required. Geometer can render scene information from the point of view of Cassini without any pointing information, and it can also specify pointing information by aligning an instrument boresight with either a star or the Sun.

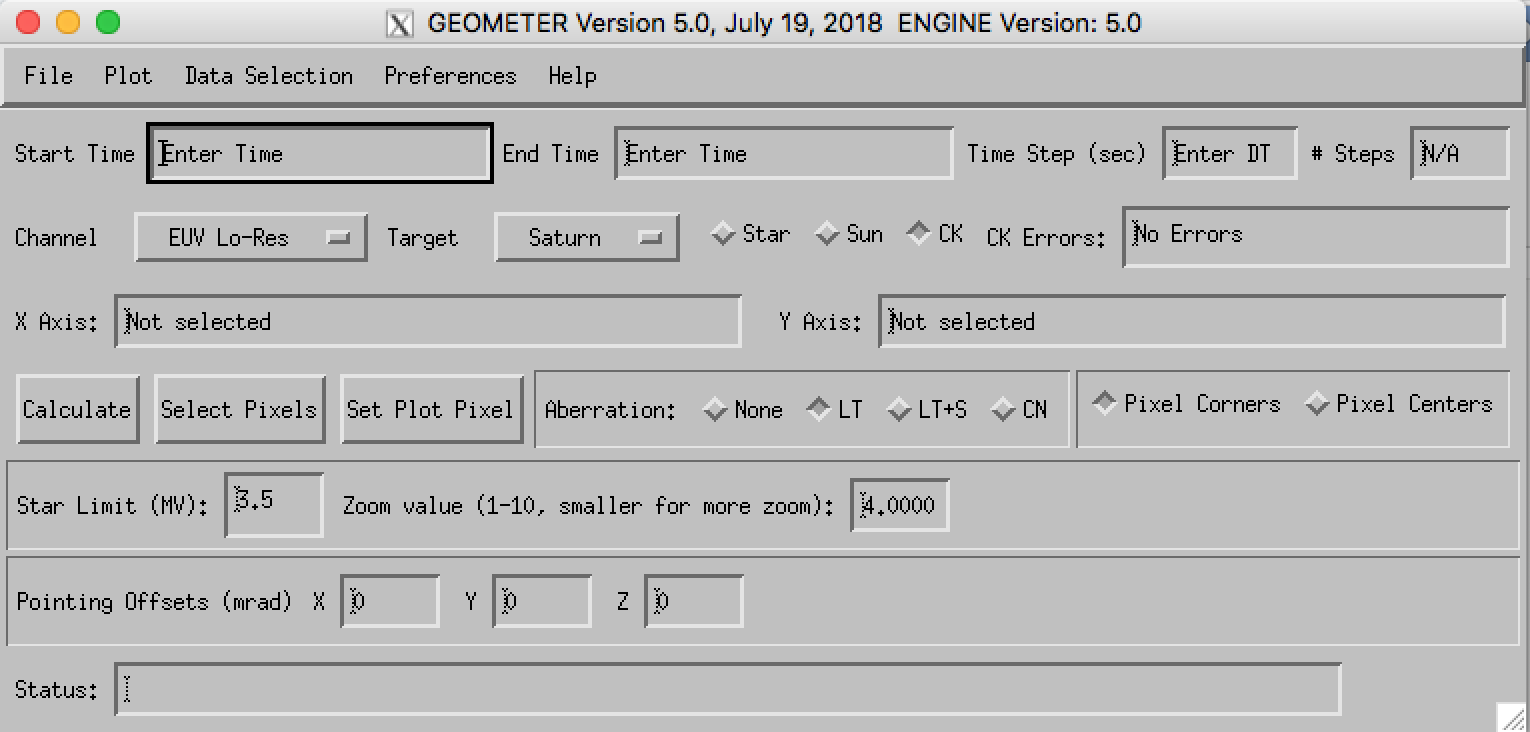


Figure : The main Geometer Graphical User Interface.

The minimum operations needed to calculate geometry data are to enter a start time, an end time, and a time step size in the top row of the Geometer GUI. Geometer accepts any SPICE-compliant string time format for the start and end times. The enter or return key must be pressed for Geometer to accept the input time. It will then redisplay the time in a day-of-year format. Enter the time step in seconds. The number of time intervals will be displayed in the “# Steps” window. Saturn is the default target body. Select any other target body from the “Target” dropdown menu. The “Channel” dropdown menu only needs to be selected if a C kernel is being used and pointing information is desired for a particular instrument. Click either “Star”, “Sun”, or “CK” to set the method of determining the spacecraft orientation and/or pointing information. If “Star” or “Sun” is selected, then all pointing information calculated by Geometer will refer to the single vector from Cassini to the Sun or the selected star. If “CK” is selected but no C kernel is loaded, Geometer will display an error in the “CK Errors” window and stop computation. If information is desired without loading a C kernel, select “Sun” or “Star”. If “Star” is selected, the user will be prompted to enter a star name. The name must match a name in the “GeometerStars.txt” file in the Geometer directory. After selecting the pointing method, click the “Calculate” button. Geometer then computes geometry information for all time steps.

**Visualizations.**

After calculating the geometry for a time period, various methods of visualization are available from the Plot menu. The Direct Maps sub-menu offers Ringmap, Bodymap, Skymap, and Target views. Ringmap provides a polar map of the rings, and Bodymap provides a simple rectangular latitude/longitude map of the selected target body. These views are most useful for seeing the coverage of the field of view on the target body. Selecting any Direct Map option will open a control panel where attributes of the plot can be set. The Skymap options produces a rectangular map of the sky in right ascension and declination ().

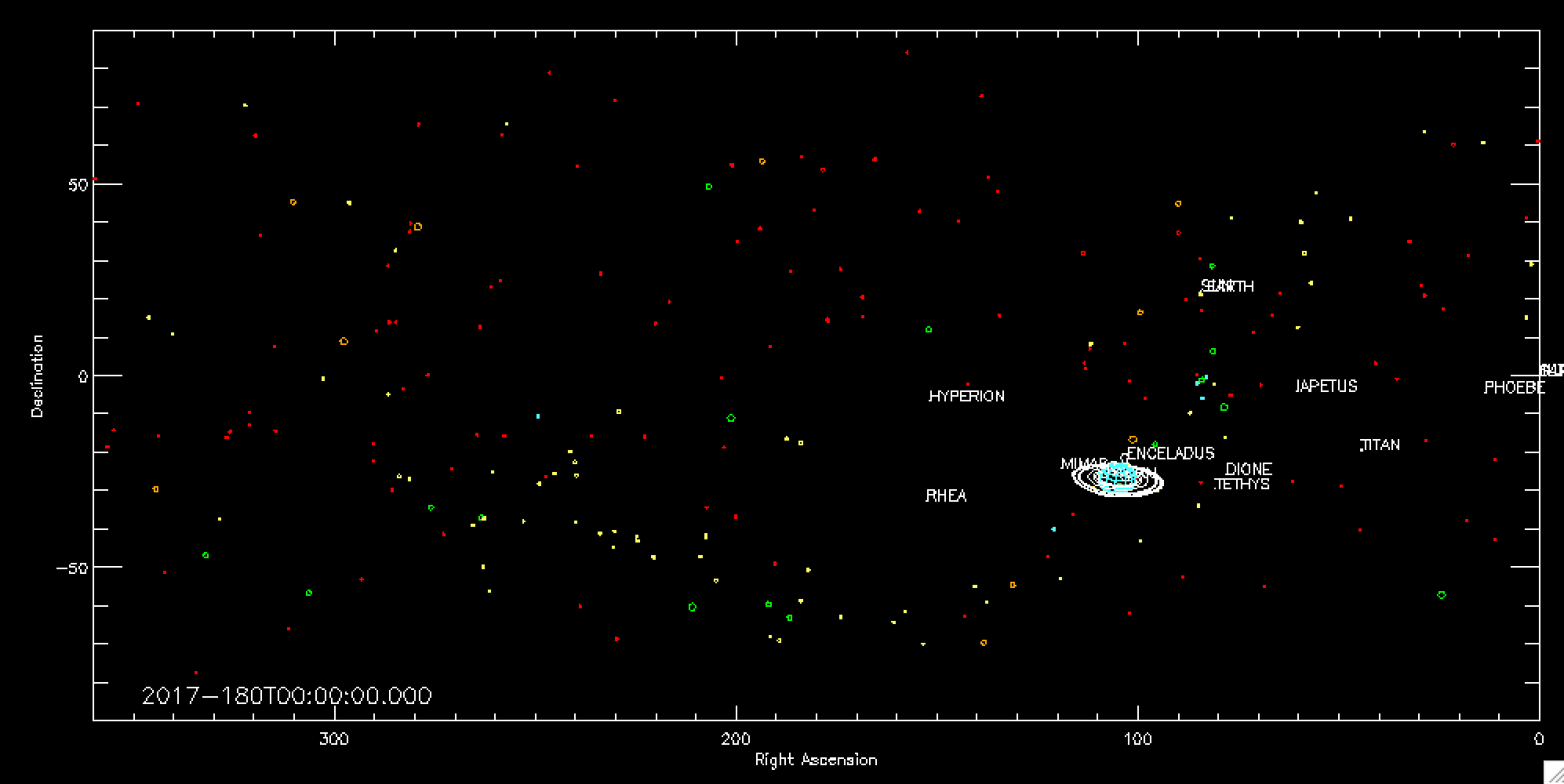


Figure : Example Skymap visualization. Stars are color-coded by spectral type.

In order to produce a visualization like that shown in , the Direct Skymap Options window will open (). To produce a plot the user must specify whether to use the times entered on the main Geometer GUI (“Use Entered Times”) or whether to use times in a loaded data cube (“Use Data Times”), if one has been loaded. For information about data cubes, see documentation for the UVIS tool “Cube Generator”. After selecting the times to be used, click “Make It So” to generate the plot. The red, green, and blue channel information is used to control the color table when a data cube has been loaded. A plot can be generated at any time within the user-entered time window by specifying the map time. Click the Animate button to make a movie over the time period specified either by the entered user times or in the data cube. To make an image file instead of plotting to the screen, select the appropriate output style at the bottom of the window where the output file can also be specified.

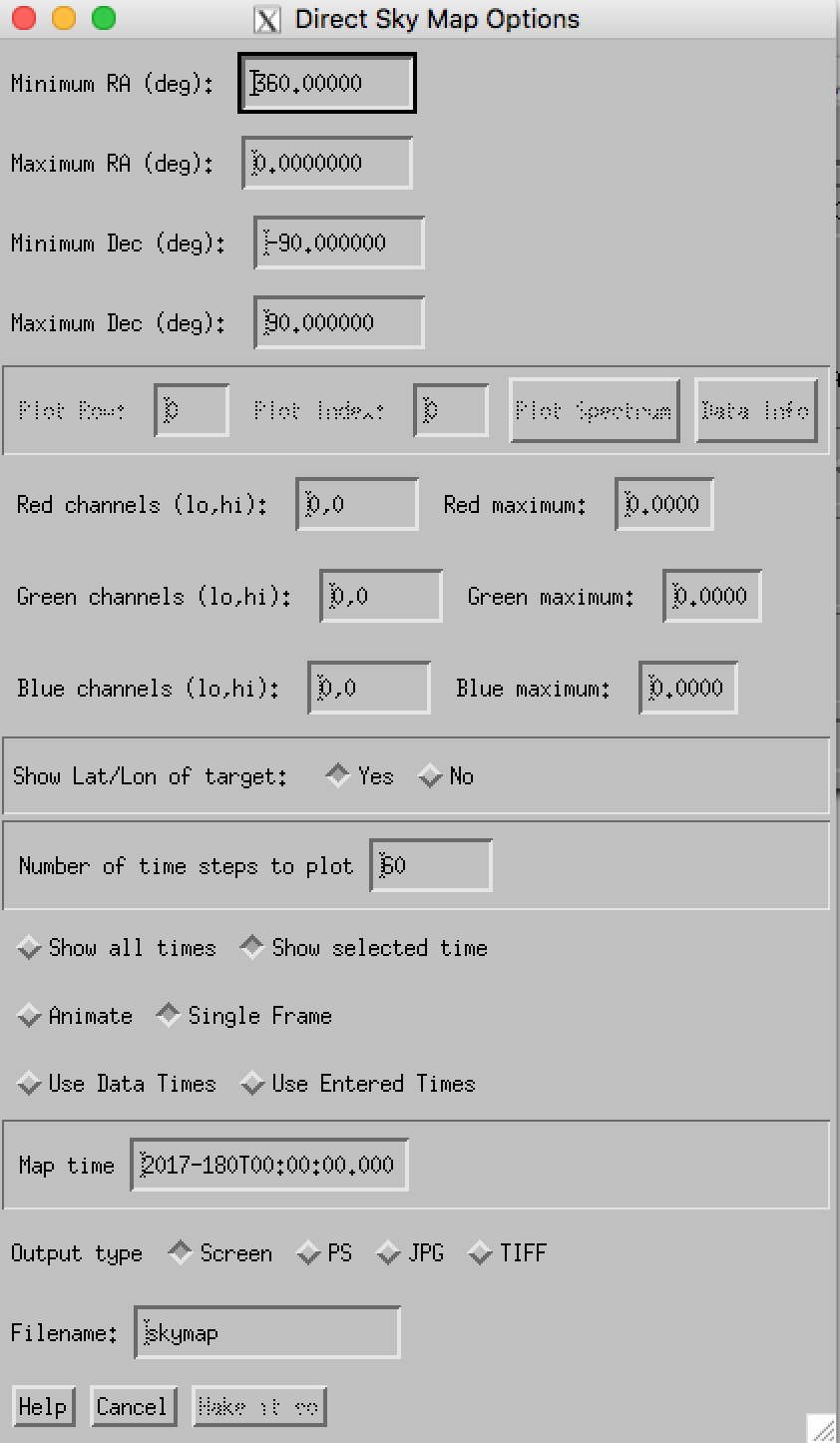


Figure : The Sky Map tool parameter window.

The Target view provides a perspective view of the target body from the point of view of Cassini. The zoom setting for the target view is on the main Geometer window rather than on the Target parameter window. The default zoom setting of 1 will cause the target body to roughly fill the plot window, while a value of 2 will have the target body fill roughly half the plot window. A setting of 2 is optimal for viewing Saturn, while smaller values may be better for satellites.

To create a Target view, select either users times or data times on the Direct Target Options window (). Click “Make it so” and a plot will be generated using default plot settings (). In addition to setting the zoom parameter on the main window, precise limits on the RA/Dec region to be plotted can be set at the top of the Direct Target Options window. The “Exact Coords” button must be set to “Yes” to use these values.

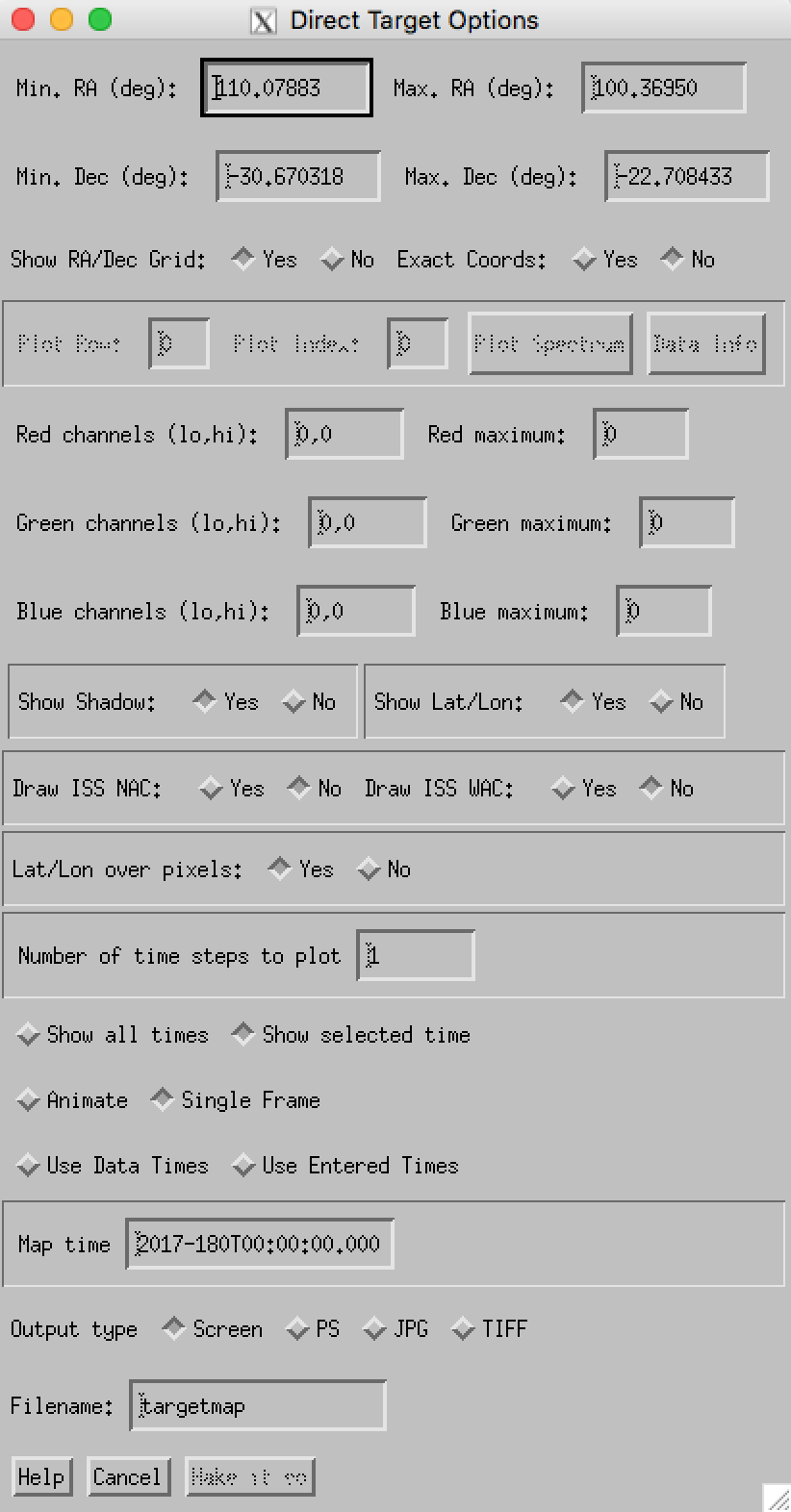


Figure : Target View parameter selection window. Click either “Use Entered Times” or “Use Data Times” (if a data cube has been loaded) and the click “Make it so” to produce a plot.

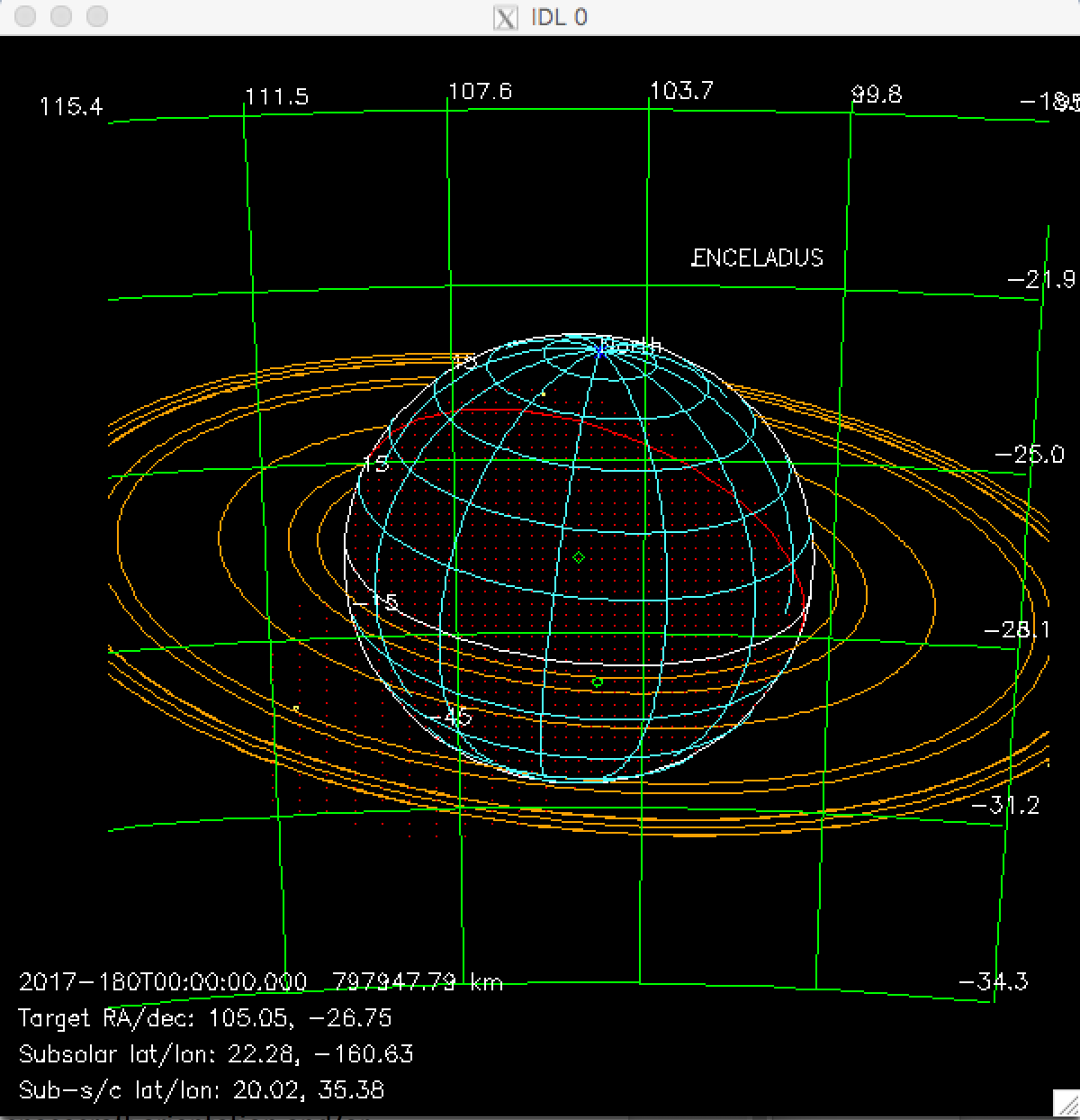


Figure : A Target Map view of Saturn. The green lines are the RA/Dec grid. These can be turned off before rendering the plot with controls on the Target Map parameter window (). Other aspects of the plot can also be controlled from that window, but the zoom is set on the main geometer window. This view is with a zoom setting of 2. Smaller values make the target fill more of the plot area.

Line plots can be generated of any geometric parameters by selecting the desired parameters from the Data Selection menu and then generating a plot from the Plot menu.

All computed data can be saved to an IDL save file from the File menu. Individual parameters can be saved to ASCII files. The parameters saved are those selected from the Data Selection window.

**Preferences.**

Default paths for kernels and Geometer output can be set in the Preferences menu. In addition, default formats for time and other parameters can be set in this menu. Once set, the preferences can be saved to an IDL save file, again from the Preferences menu. Previously saved preferences files can also be loaded from this menu. Geometer will calculate longitudes either from the inertial IAU\_Saturn frame, or relative to a moon of Saturn. This can also be set in the Preferences menu.

**List of Parameters Calculated by Geometer.**

Geometric calculations are carried out in the geometer\_engine.pro subroutine of Geometer. Default units in geometer are degrees for angles, km for distances, and km/s for velocities.

Angles refer to the direction and intercept point of the selected instrument boresight. If “Star” or “Sun” pointing is selected, then the vector to the Sun or selected star is used as the instrument boresight. In cases where a look vector is undefined or does not intercept a target body, a value of -1000 is returned for angles relating to that look vector.

**phase**: phase angle on the specified target at the specified time at the point intersected by the instrument boresight or the nearest point on the line of sight to the target body (deg).

**emission**: emission angle on the specified target at the specified time at the point intersected by the instrument boresight or the nearest point on the line of sight to the target body (deg).

**incidence**: solar incidence angle, measured from the local target surface normal, at the point on the target that is intersected by the instrument boresight at the specified time or the nearest point on the line of sight to the target body (deg).

**ringplanerad**: Radius of occultation path in Saturn's ring plane (km).

**scloc**: 3-element vector with postion of S/C wrt to target (km) in inertial frame.

**scloc\_p**: 3-element vector with position of S/C wrt to target (km) in the target frame.

**scvel**: 3-element vector with velocity of S/C wrt to target (km/sec) in inertial frame.

**scvel\_p**: 3-element vector with velocity of S/C wrt to target (km) in the target frame.

**ra\_targ**: Right ascension of center of target body (deg).

**dec\_targ**: Declination of center of target body (deg).

**lat\_subpt**: latitude of sub-spacecraft point (using nearpoint method) (deg).

**lon\_subpt**: longitude of sub-spacecraft point (using nearpoint method) (deg).

**lat\_sunpt**: latitude of sub-solar point (using nearpoint method) (deg).

**lon\_sunpt**: longitude of sub-solar point (using nearpoint method) (deg).

**alt**: distance above target surface (km).

**phase\_targ**: phase angle at the sub-S/C point (deg).

**emission\_targ**: emission angle at the sub-S/C point (deg).

**incidence\_targ**: solar incidence angle at the sub-S/C point (deg).

**ckerror**: set to 1 if C kernel data not found, otherwise 0.

**rayheight**: minimum separation of the look vector and the NAIF-defined surface of the body (km).

**rayradius**: minimum distance between the look vector and the center of the target body (km).

**latocc** and **lonocc**: latitude and longitude of the point on the NAIF-defined surface of the target body that is closest to the look vector.

**ra**, **dec**: right ascension and declination of the instrument axis.

**sc\_wrt\_plan**: 6-element state of spacecraft with respect to planet (not the target if the target is a satellite, but with respect to the planet that satellite orbits).

**state\_sun**: 6-element position/velocity of Sun with respect to the target body.

**state\_planet**: 6-element position/velocity of planet with respect to the solar system barycenter.

**ramlat**, **ramlon**: the latitude and longitude of the point on the body that is in the ram direction as it orbits the central body (planetor Sun). (deg).

**sun\_elevation**: elevation of the Sun relative to Saturn’s ring plane (deg.).

**earth\_elevation**: elevation of the Earth relative to Saturn’s ring plane (deg.).

**sunearth**: angle between the direction to the Sun and the direction to the Earth from the target body center (deg.).

**losdist**: distance along the line of sight from Cassini to the target body intercept (km).

**sc\_sun**: 6-element state vector of the Sun with respect to Cassini in the inertial coordinate system.

**occpoint\_i**: a 3-element vector from Saturn center to the ring plane intercept point in the inertial frame. (km)

**ringoccphi**: for ring target, the angle between the local radial direction in the ring plane at the intercept point and the look direction to the star, measured counterclockwise from the positive radial unit vector. (deg).

**f\_peri**: the angle from the Saturn ascending node to the pericenter of the F ring. (deg.)

**rayradius**: the distance between the planet origin and the line containing the spacecraft position and the vector along the line of sight. (km)

**ringsolar**: the solar ring hour angle of the intercept point of the look vector in the ring plane.

**boresight\_p**: the unit vector for the instrument boresight (or stellar look direction) in the target body frame.

**boresight\_inert**: the unit vector for the instrument boresight (or stellar look direction) in the inertial frame.

**ra\_full**, **dec\_full**: the right ascension and declination of the boresight and four corners of each pixel or FOV.

**lat\_full**, **lon\_full**: the latitute and longitude intercept points on the target body of the boresight and four corners of each pixel or FOV.

**rrad\_full**: the ring plane intercept radius, in km, of the boresight and four corners of each pixel or FOV.

**inc\_full**: the incidence angle of the intercept on the target body of the boresight and four corners of each pixel or FOV.

**Lshell**: the lshell of Cassini in units of Saturn radii defined as 1RS = 60,268 km.