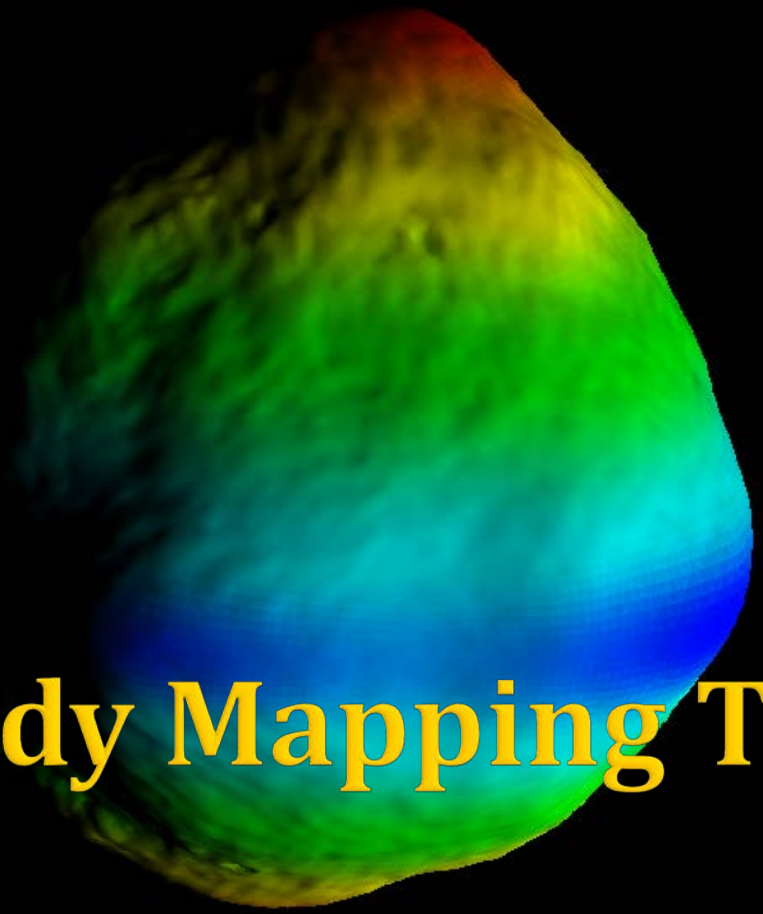
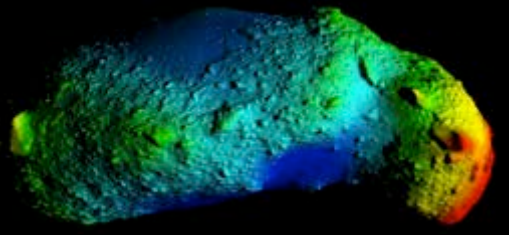


Small Body Mapping Tool Tutorial

Olivier Barnouin, Russell Turner, Philip Twu, Lillian Nguyen, Michael Zimmermann

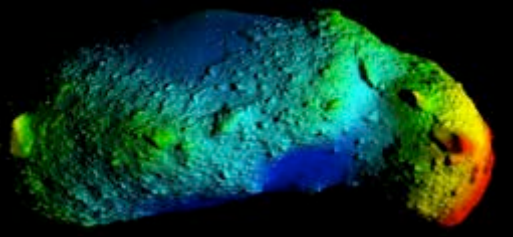
Johns Hopkins University Applied Physics Laboratory

Overview



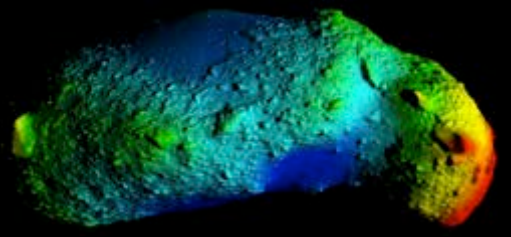
- Architecture of Small Body Mapping Tool (SBMT)
- Tutorial guiding you through how to start up and use the SMBT including a discussion of
  - General features of the tool
  - Case study of the NEAR landing site

SBMT Architecture Overview



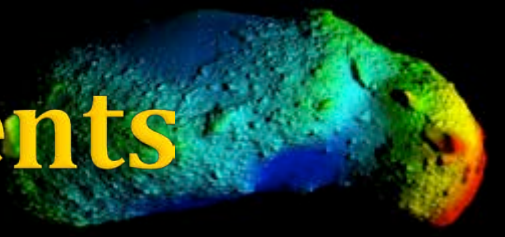
- The SBMT consists of 2 parts:
  - SBMT Client
  - SBMT Server

SBMT Client



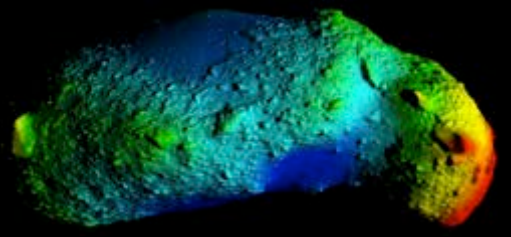
- The SBMT client is a program that runs on the desktop and communicates with the server to download data and perform queries.
- Written in the Java (version 8) programming language for cross platform support
- Uses additional 3rd party libraries:
  - VTK (http://vtk.org) for 3D visualization
  - Apache Commons Math for some mathematical procedures
  - JFreeChart for plotting
- Additional Components
  - Bob Gaskell's Mapmaker tool (in Fortran; about to converted to Bigmaps)
  - Implementation (in C++) of algorithms for computing the gravity of a general polyhedron (either Werner and Scheeres or Cheng et al).

SBMT Client Requirements



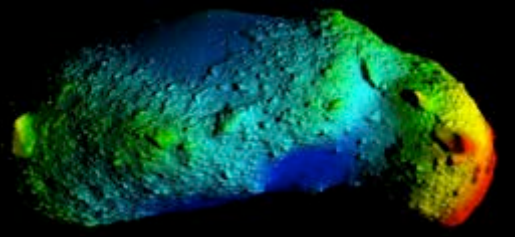
- Supported on:
  - Mac OS X (10.5 or later)
  - Windows (Window 7)
  - Linux (most recent distributions)
- The tool works best with
  - lots of memory
  - lots of bandwidth
  - good graphics card

SBMT Server



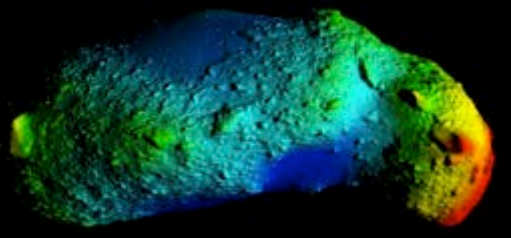
- The server consists of 2 components
  - A web server with PHP support
  - A MySQL database for storing metadata of images, spectra.
  - Judicious file structure for lidar datasets.
- SBMT client can be configured to point to a server at different location
- Searched data is cached on users local machine and only downloaded again if updated on the server
- Currently over 2 TB of data on server
- Much of data is publically available on PDS

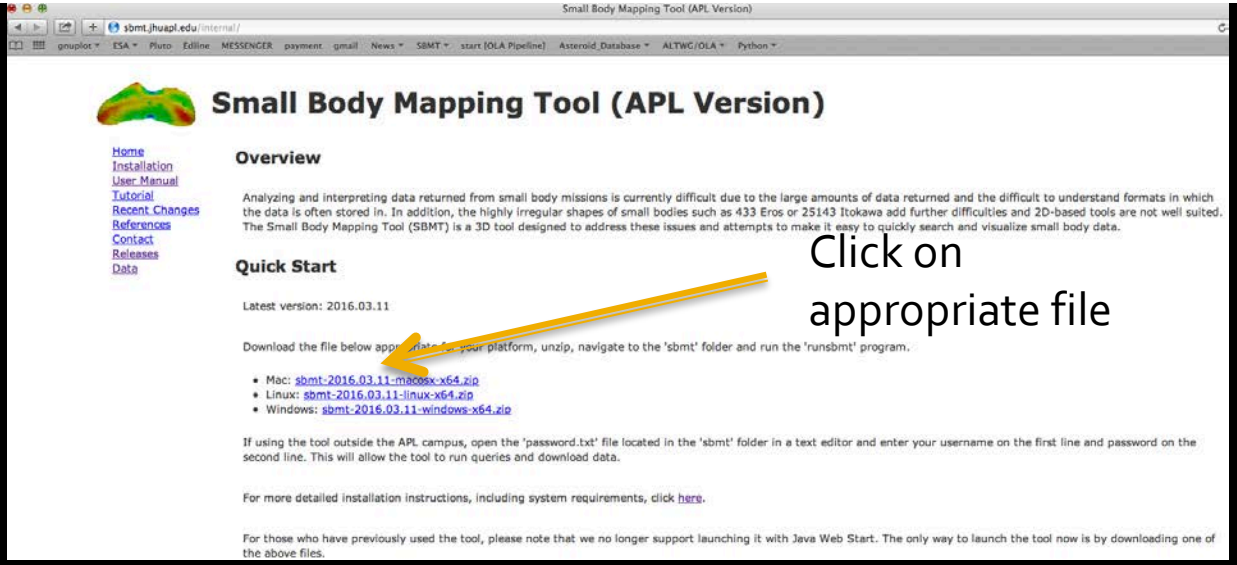
Available Datasets



- Gaskell Shape Models
  - Bennu: Nolan, 2 truth models (4 not yet ready). Mapcam, Polycam images for all phases of the DRM Rev C for shape model 3; OLA data
  - Eros: MSI, NIS, and NLR, Gaskell maplets
  - Itokawa: AMICA, and LIDAR
  - Vesta: FC
  - Ceres (for Dawn team only): FC
  - Bennu: Gaskell maplets
  - Phoebe
  - Mimas
  - Phobos
  - Pluto, Charon, Nix, Hydra
- Thomas shape models
- Stooke shape models
- Hudson (radar) shape models
- Details of origin are listed in the help section of SBMT

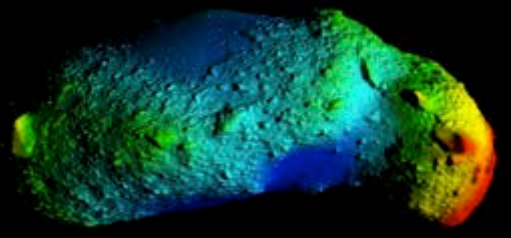
Obtaining the Small Body Mapping Tool



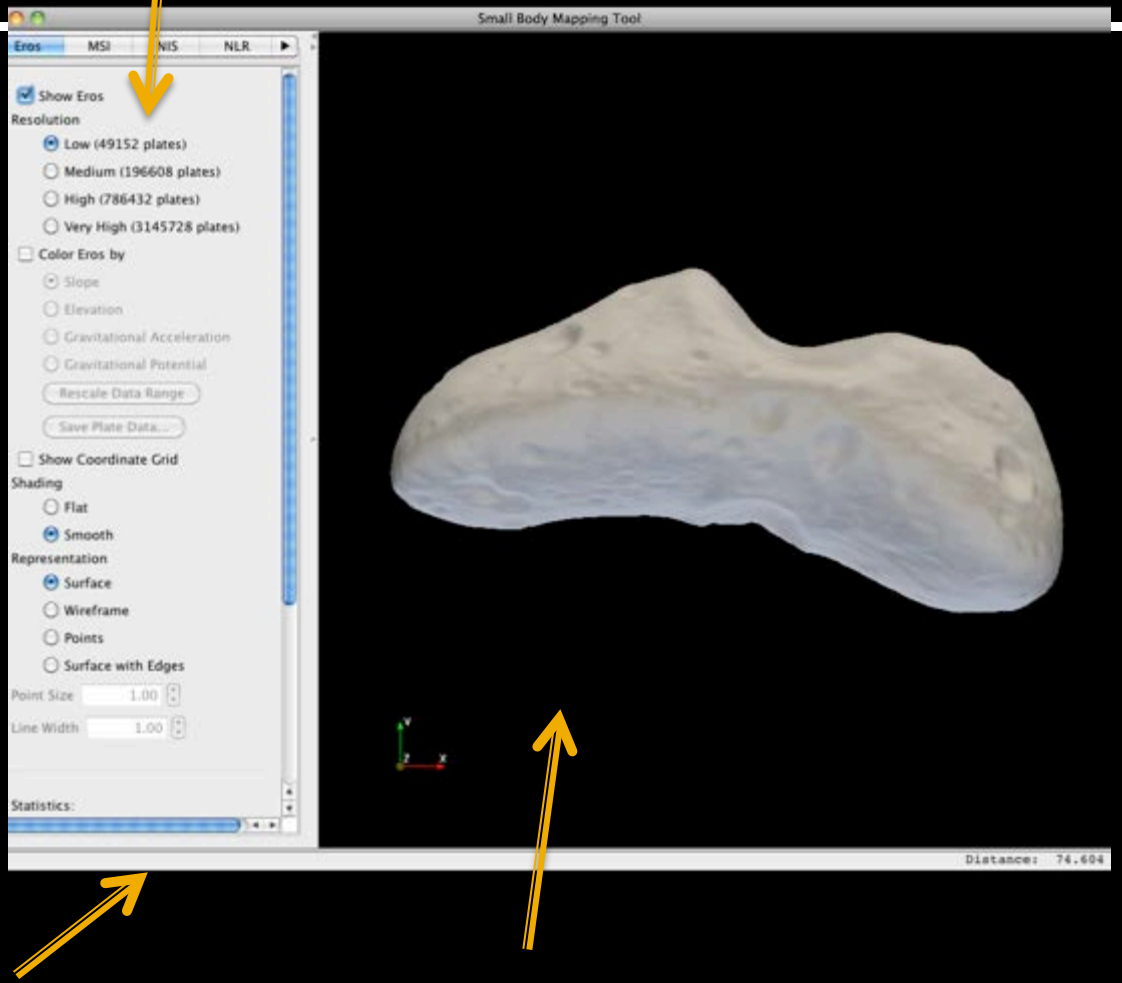


- Open
  - http://sbmt.jhuapl.edu/internal/
- Outside APL, enter your username and password in password.txt file (similar to license file) in same directory where you keep your SMBT application or put it in the hidden ./neartool
  - Mac and linux users: ~/.neartool
  - PC users: C:\Users\<username>\.neartool
- You will need Java 8 or higher installed on your computer
- Read the Download and Installation page for system requirements and detailed installation information.

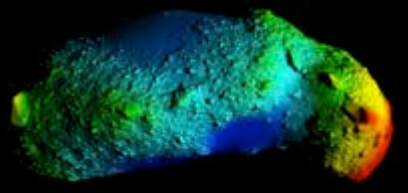
The Basics



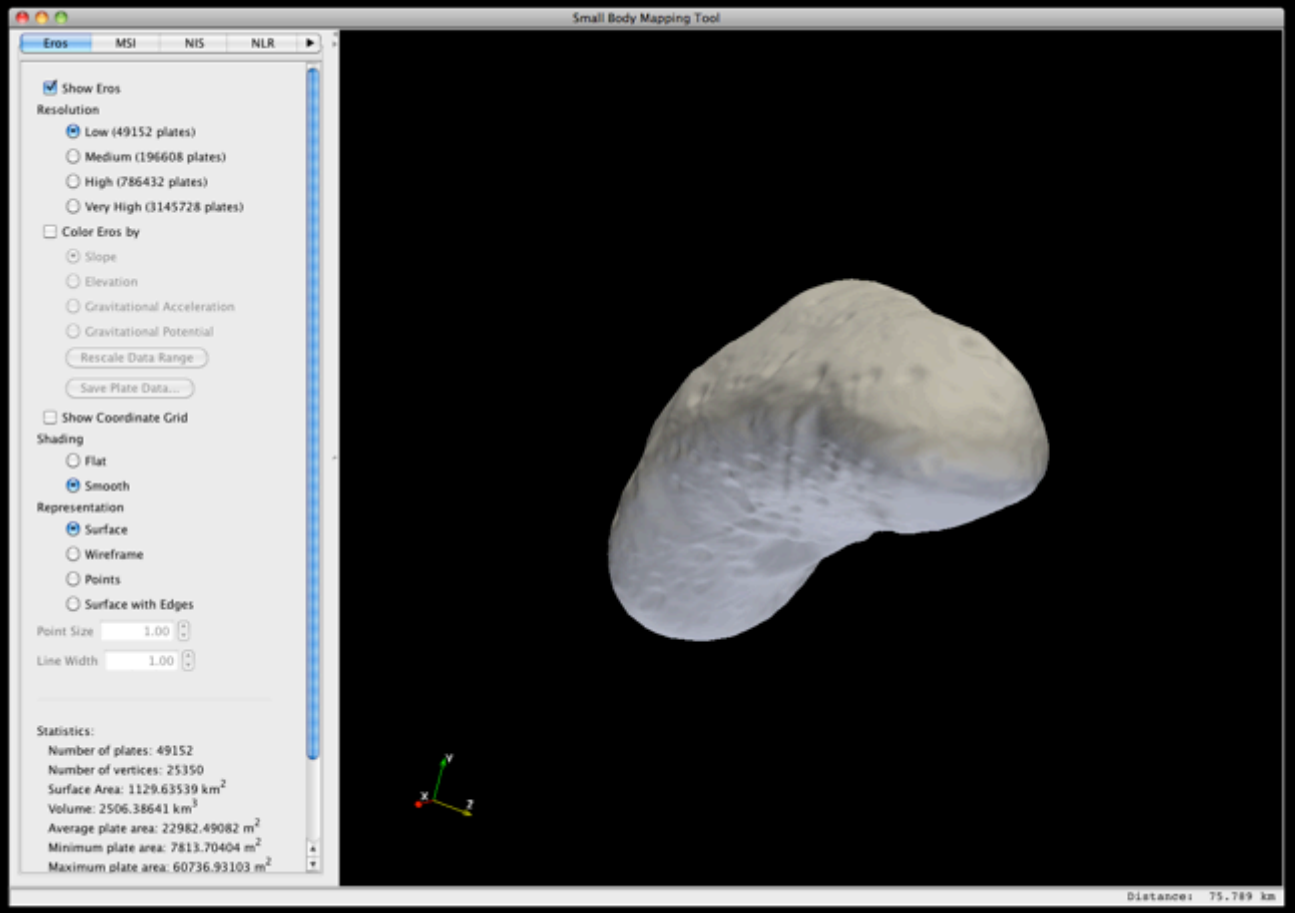
- The tool is divided into 2 main parts: A renderer panel on the right and control panel on the left. The renderer panel displays data in 3D and the control panel is used to control what gets displayed in the renderer.
- In addition, there is a menu bar on top with additional options and a status bar on the bottom



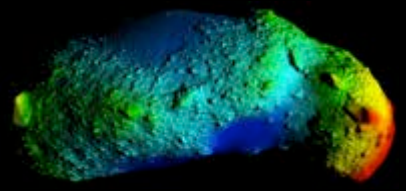
Rotating Shape Model



In the renderer view, rotate the asteroid by dragging the mouse while holding down the left mouse button.

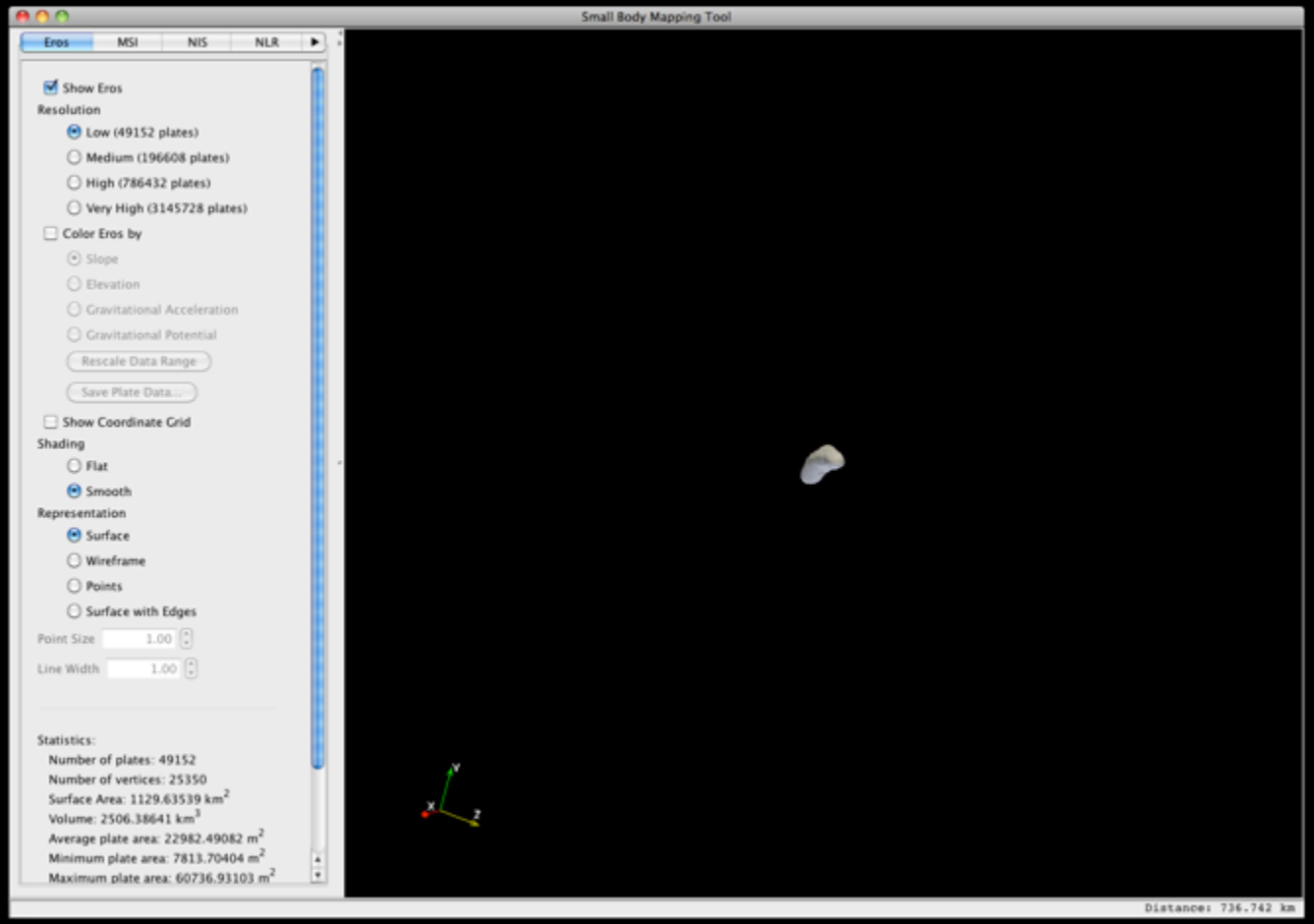


Zooming in and out of the Renderer

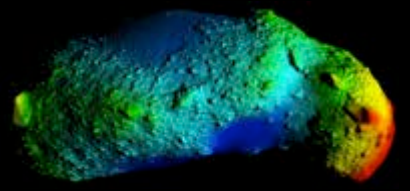


There are 2 ways to zoom in and out of the renderer.

1. Use the mouse wheel
2. Drag the mouse in the **upward** direction while holding down the right mouse button to zoom in. Drag the mouse in the **downward** direction while holding down the right mouse down to zoom out.

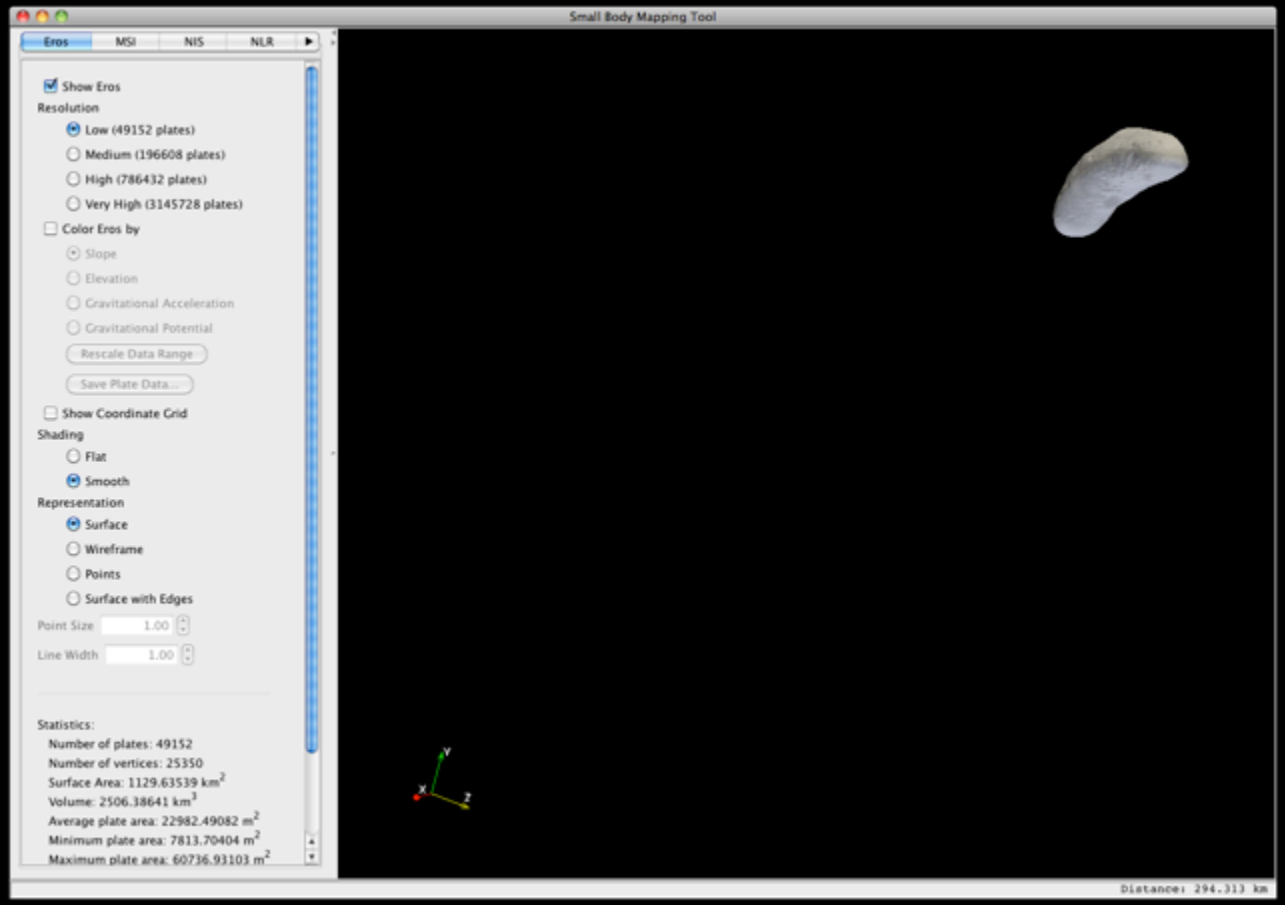


Panning the Shape Model

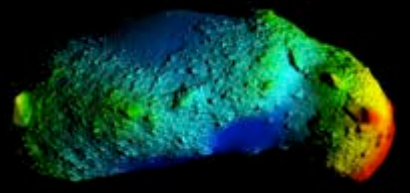


Panning moves the shape model sideways without rotating it.

To pan, drag the mouse while holding down the middle mouse button or hold shift button and drag

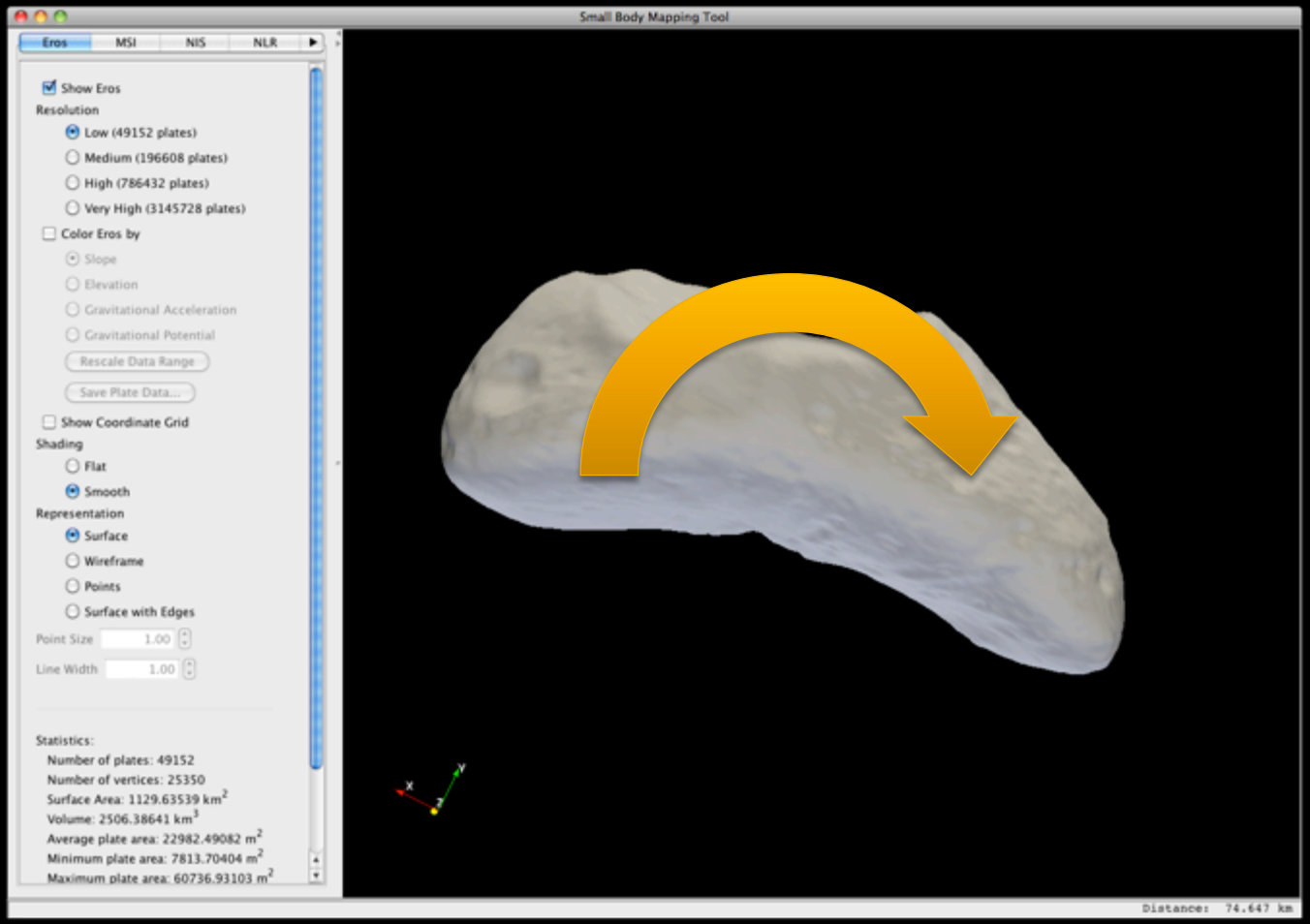


Spinning the Shape Model

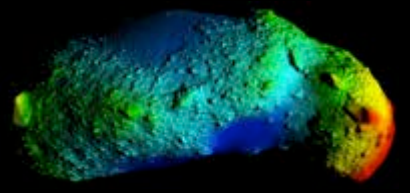


Spinning rotates the shape model around an axis that points into the center of renderer view.

To spin, drag the mouse while holding down the left mouse button **and the control key**.



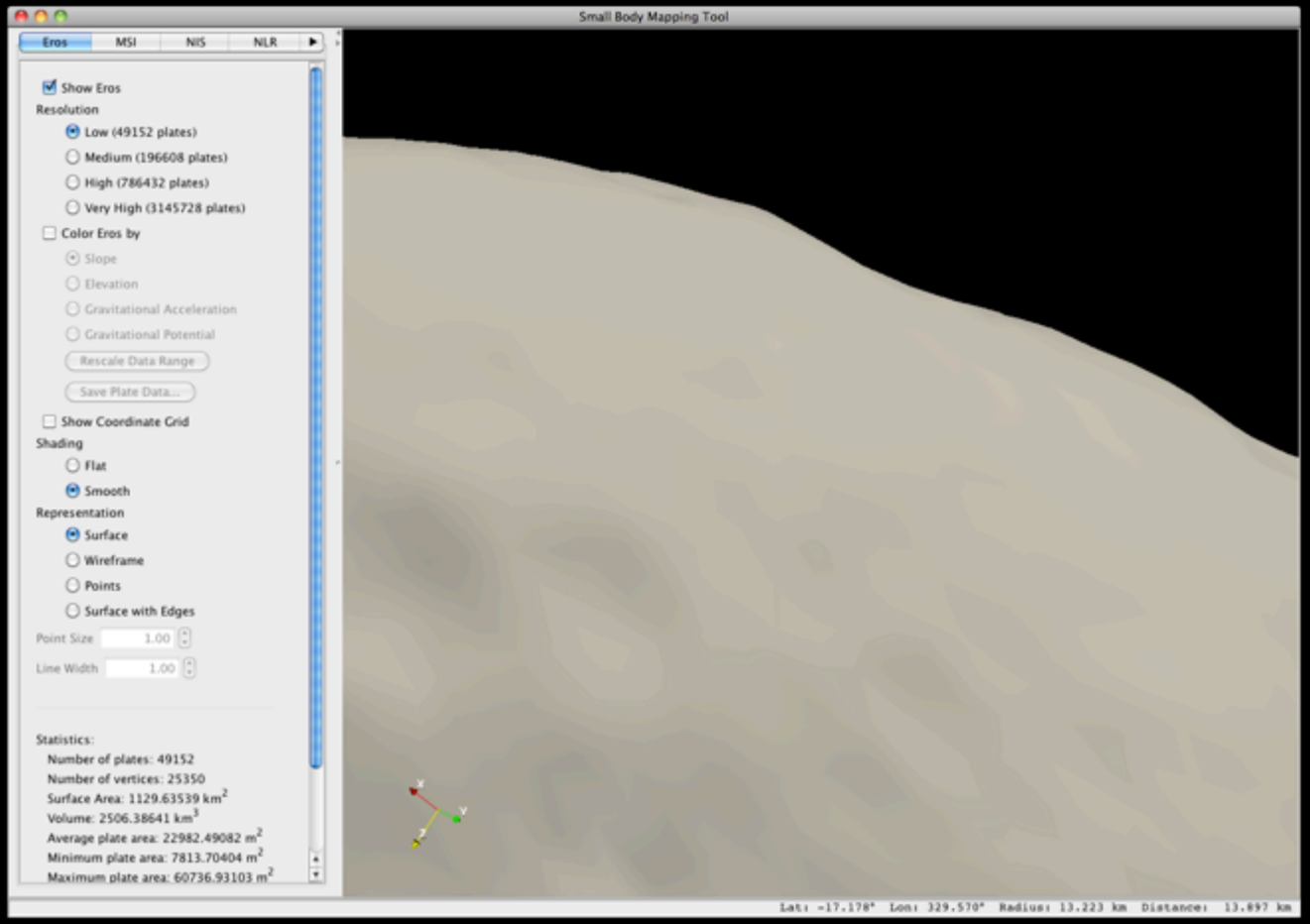
Change Center of Rotation



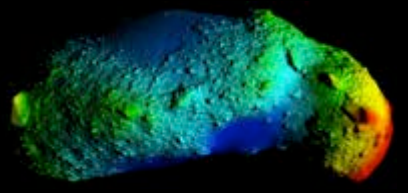
By default when rotating the camera (while dragging with left mouse button), the shape model rotates around the center of the shape model.

To rotate around a different point on the shape model, position the mouse over that point and press the ‘c’ key.

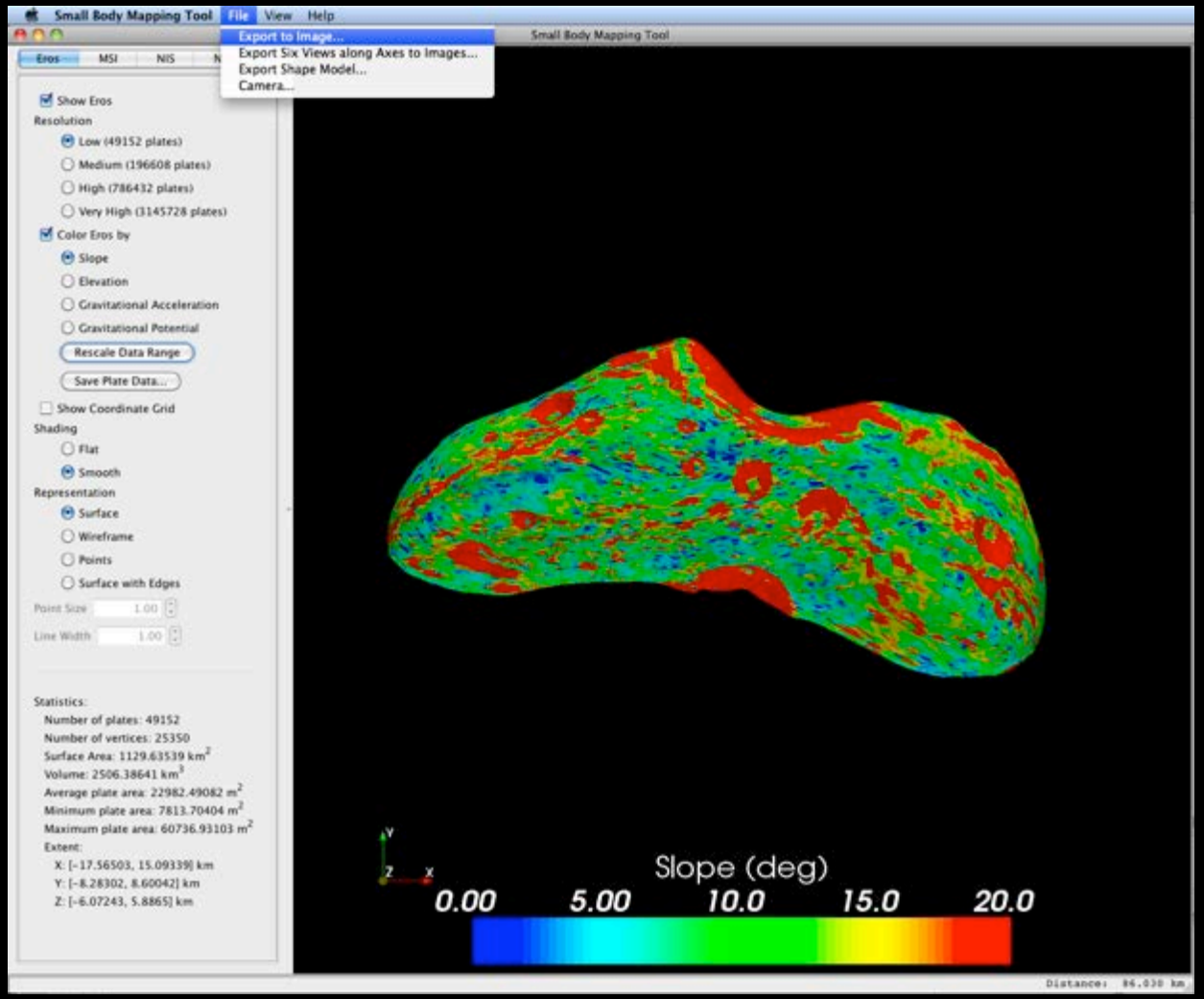
To return to the default center of rotation, press the ‘r’ key (for reset).



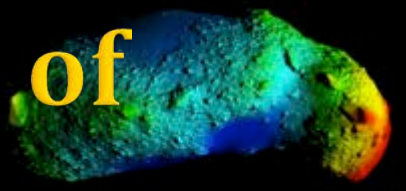
Save renderer view as image



Click on the “Export to Image…” in the File menu. Choose a format and name for the image.



Change Camera Vertical Field of View and Distance



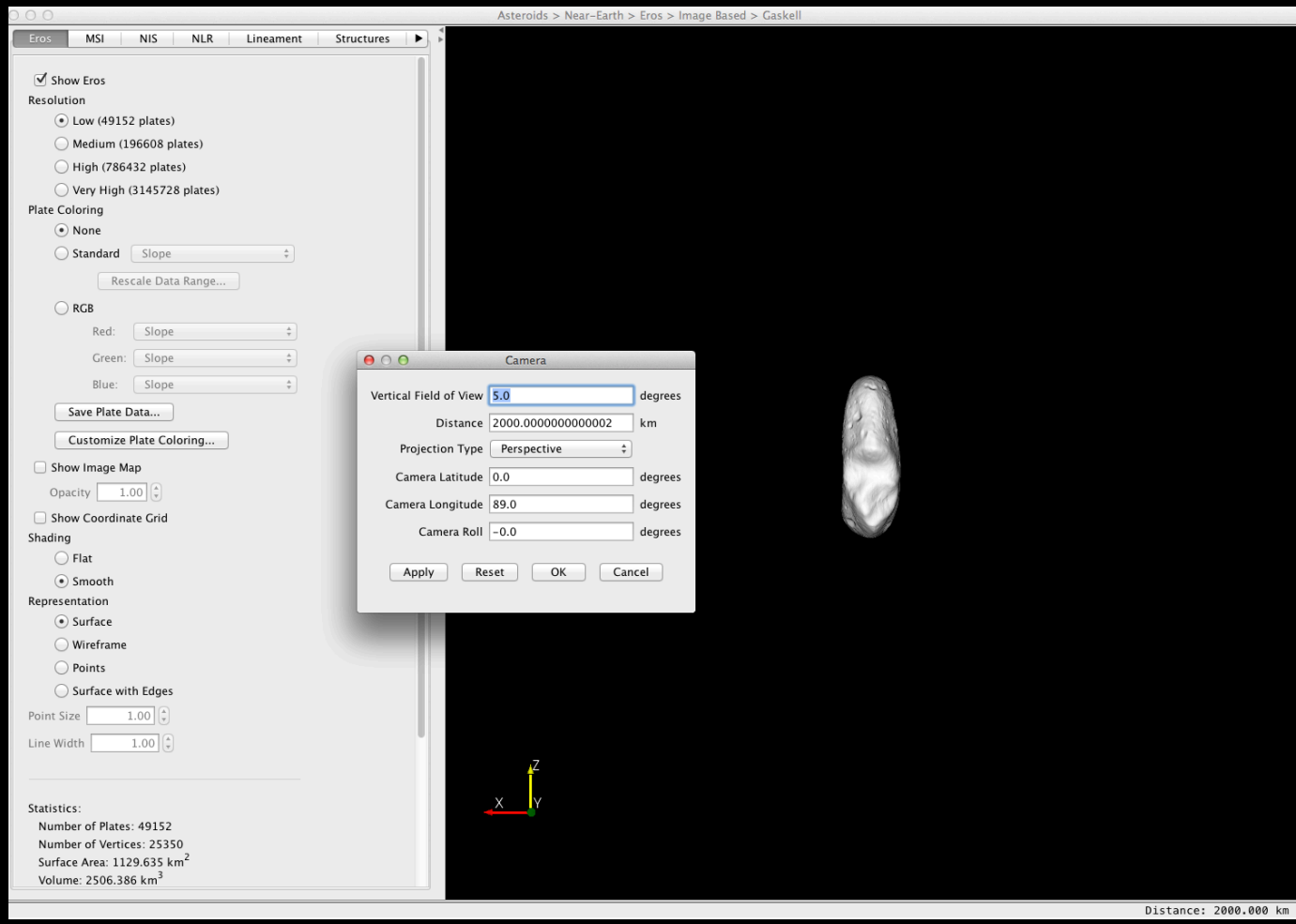
By default the vertical field of view of the camera is 30 degrees and the distance is chosen so the entire shape model fits in the renderer view.

To change these values, open the Camera… dialog in the File menu.

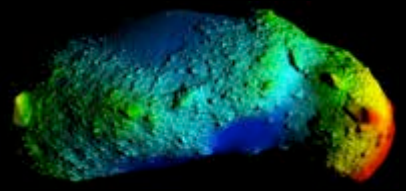
Enter a field of view of 5 degrees.

Enter a distance of 2000 km.

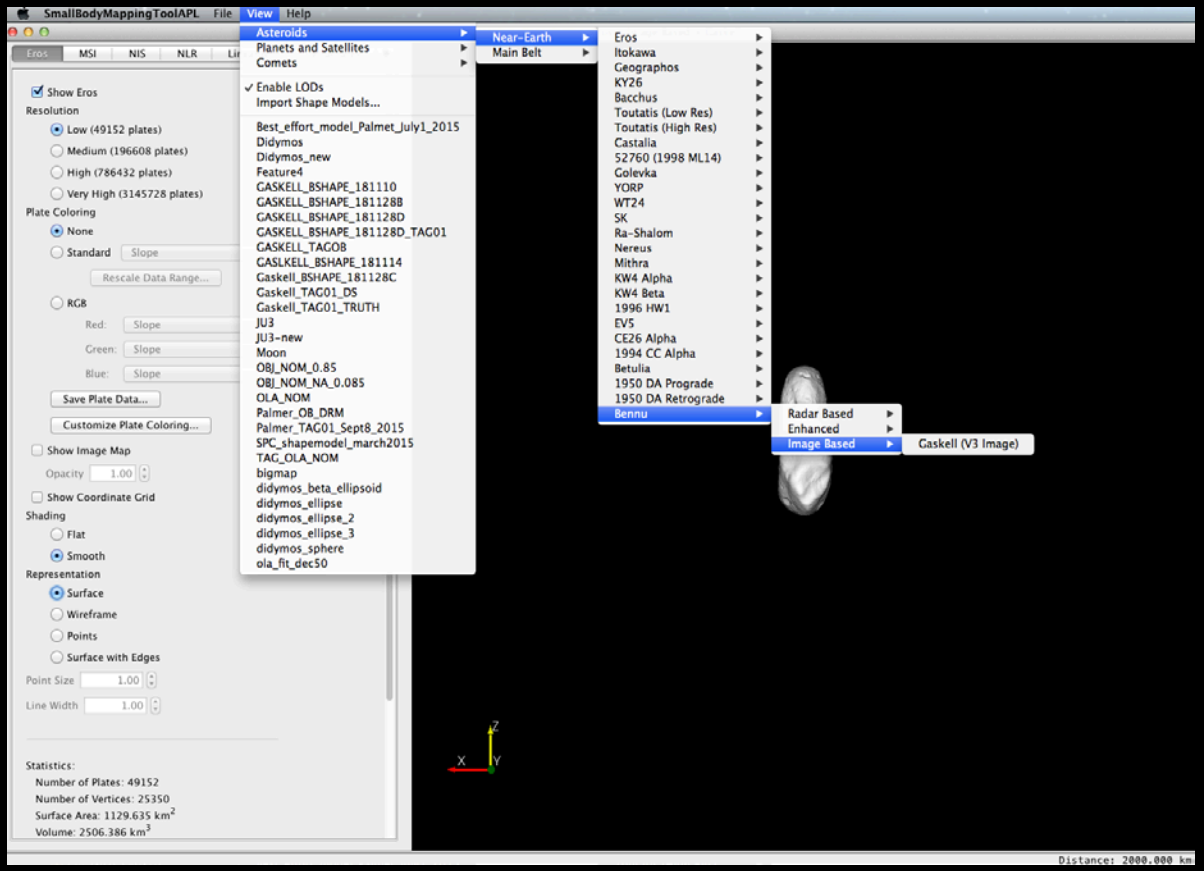
Then click OK



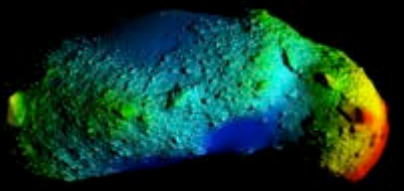
Go to Bennu V3 Data



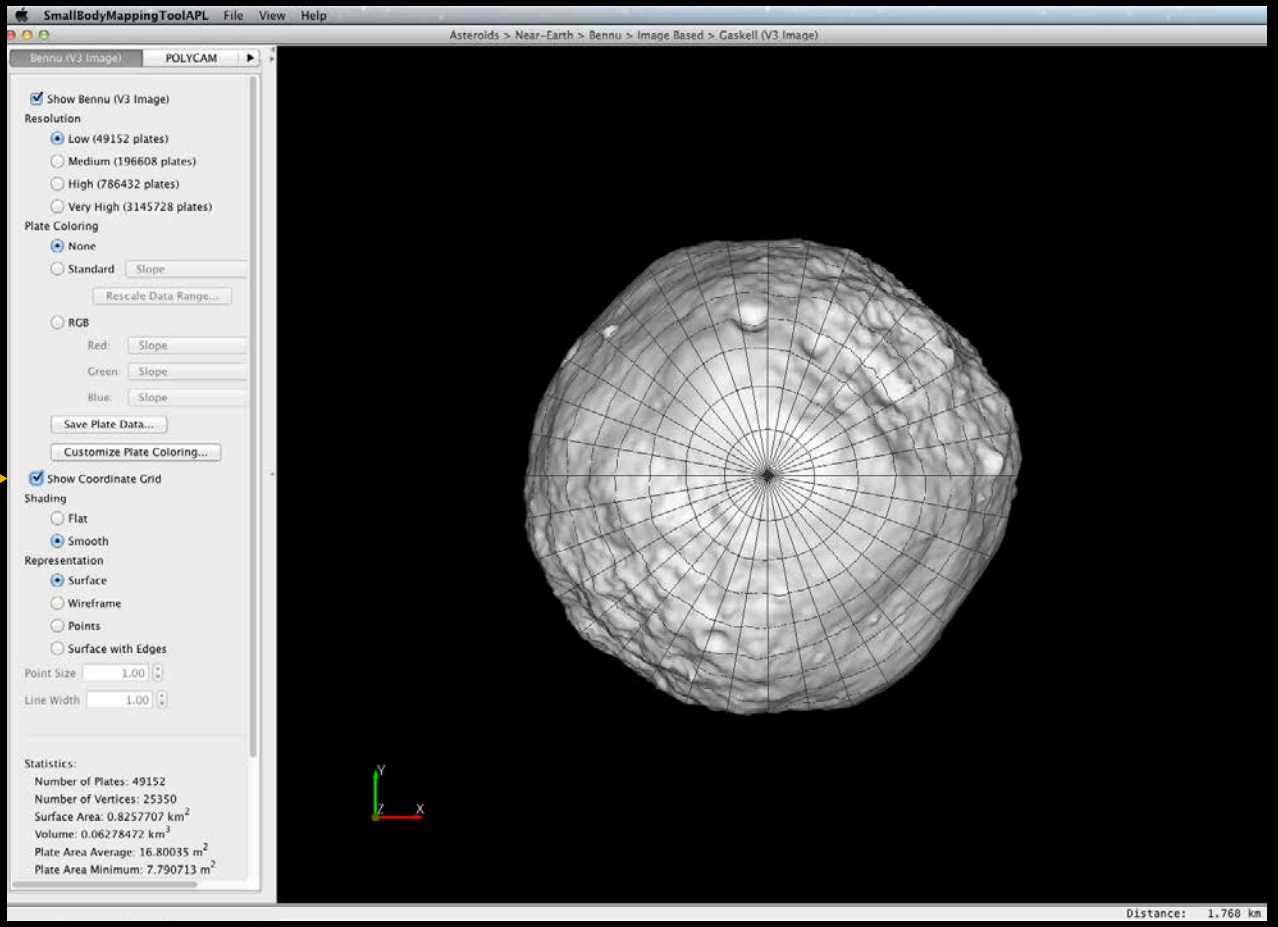
In the View menu, click on the Asteroids -> Near-Earth-> Bennu-> Image Based -> Gaskell (V3 Image) option.



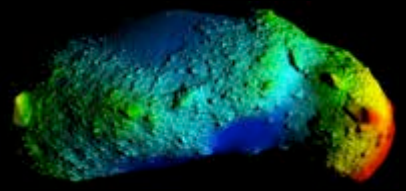
Control panel features: Show Coordinate Grid



Click “Show Coordinate Grid”



Add ancillary data



Find some ancillary data. Go to:
http://osiris-rex.jhuapl.edu/altwg/outputdata/bennu_altwg/truth_products/bennuv3/TRUTHBennuV3-products.html

ALTWG TRUTHBennuV3-Products

osiris-rex.jhuapl.edu/altwg/outputdata/bennu_altwg/truth_products/bennuv3/TRUTHBennuV3-products.html

gnuplot ESA Pluto Edline MESSENGER payment gmail News SBMT start [OLA Pipeline] Asteroid_Database ALTWG/OLA Python

Time to generate all products: 0.3080906 hours

ALTWG TRUTH Products

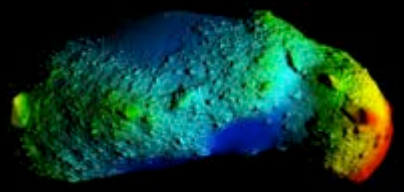
Global Shape Model

Ground Sample Distance	OBJ	Global DTM	Ancillary FITS Normal Vector	Ancillary FITS Gravity Vector	Ancillary FITS Gravity Magnitude	Ancillary FITS Potential
1278cm	g_1278cm_tru_obj_0000n00000_v100.obj.gz	g_1278cm_tru_dtm_0000n00000_v100.fits	g_1278cm_tru_nvp_0000n00000_v100.fits	g_1278cm_tru_grv_0000n00000_v100.fits	g_1278cm_tru_grm_0000n00000_v100.fits	g_1278cm_tru_pot_0000n00
0646cm	g_0646cm_tru_obj_0000n00000_v100.obj.gz	g_0646cm_tru_dtm_0000n00000_v100.fits	g_0646cm_tru_nvp_0000n00000_v100.fits	g_0646cm_tru_grv_0000n00000_v100.fits	g_0646cm_tru_grm_0000n00000_v100.fits	g_0646cm_tru_pot_0000n00
0327cm	g_0327cm_tru_obj_0000n00000_v100.obj.gz	g_0327cm_tru_dtm_0000n00000_v100.fits	g_0327cm_tru_nvp_0000n00000_v100.fits	g_0327cm_tru_grv_0000n00000_v100.fits	g_0327cm_tru_grm_0000n00000_v100.fits	g_0327cm_tru_pot_0000n00
0166cm	g_0166cm_tru_obj_0000n00000_v100.obj.gz	g_0166cm_tru_dtm_0000n00000_v100.fits	g_0166cm_tru_nvp_0000n00000_v100.fits	g_0166cm_tru_grv_0000n00000_v100.fits	g_0166cm_tru_grm_0000n00000_v100.fits	g_0166cm_tru_pot_0000n00
0085cm	g_0085cm_tru_obj_0000n00000_v100.obj.gz	g_0085cm_tru_dtm_0000n00000_v100.fits	g_0085cm_tru_nvp_0000n00000_v100.fits	g_0085cm_tru_grv_0000n00000_v100.fits	g_0085cm_tru_grm_0000n00000_v100.fits	g_0085cm_tru_pot_0000n00

30cm Maps

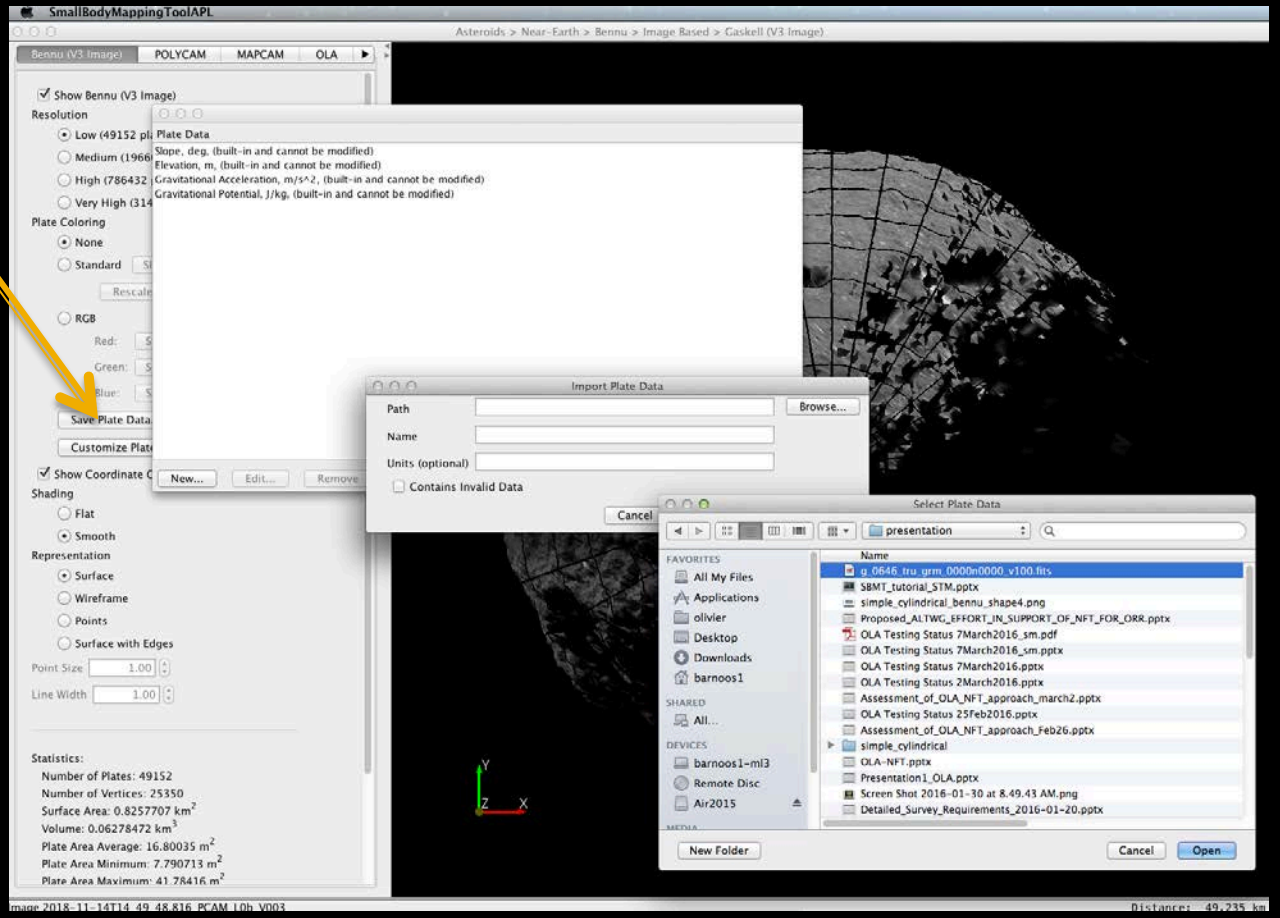
Latitude	Longitude	OBJ	FITS	NFT FITS	Ancillary FITS Normal Vector	Ancillary FITS Gravity Vector	Ancillary FITS Grav
0.000	15.000	l_0030cm_tru_dtm_0000s01500_v100.obj.gz	l_0030cm_tru_dtm_0000s01500_v100.fits	l_0030cm_tru_nftdtm_0000s01500_v100.fits	l_0030cm_tru_nvp_0000s01500_v100.fits	l_0030cm_tru_grv_0000s01500_v100.fits	l_0030cm_tru_grm
0.000	45.000	l_0030cm_tru_dtm_0001s04500_v100.obj.gz	l_0030cm_tru_dtm_0001s04500_v100.fits	l_0030cm_tru_nftdtm_0001s04500_v100.fits	l_0030cm_tru_nvp_0001s04500_v100.fits	l_0030cm_tru_grv_0001s04500_v100.fits	l_0030cm_tru_grm
0.000	75.000	l_0030cm_tru_dtm_0000n07500_v100.obj.gz	l_0030cm_tru_dtm_0000n07500_v100.fits	l_0030cm_tru_nftdtm_0000n07500_v100.fits	l_0030cm_tru_nvp_0000n07500_v100.fits	l_0030cm_tru_grv_0000n07500_v100.fits	l_0030cm_tru_grm
0.000	105.000	l_0030cm_tru_dtm_0000s10500_v100.obj.gz	l_0030cm_tru_dtm_0000s10500_v100.fits	l_0030cm_tru_nftdtm_0000s10500_v100.fits	l_0030cm_tru_nvp_0000s10500_v100.fits	l_0030cm_tru_grv_0000s10500_v100.fits	l_0030cm_tru_grm
0.000	135.000	l_0030cm_tru_dtm_0001n13500_v100.obj.gz	l_0030cm_tru_dtm_0001n13500_v100.fits	l_0030cm_tru_nftdtm_0001n13500_v100.fits	l_0030cm_tru_nvp_0001n13500_v100.fits	l_0030cm_tru_grv_0001n13500_v100.fits	l_0030cm_tru_grm
0.000	165.000	l_0030cm_tru_dtm_0000s16500_v100.obj.gz	l_0030cm_tru_dtm_0000s16500_v100.fits	l_0030cm_tru_nftdtm_0000s16500_v100.fits	l_0030cm_tru_nvp_0000s16500_v100.fits	l_0030cm_tru_grv_0000s16500_v100.fits	l_0030cm_tru_grm

Add ancillary data

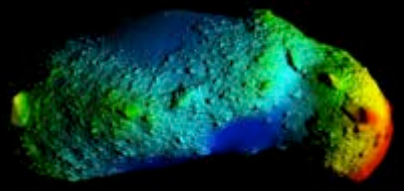


Click “Customize Plate coloring”

Navigate to ancillary data by clicking browse



Add ancillary data



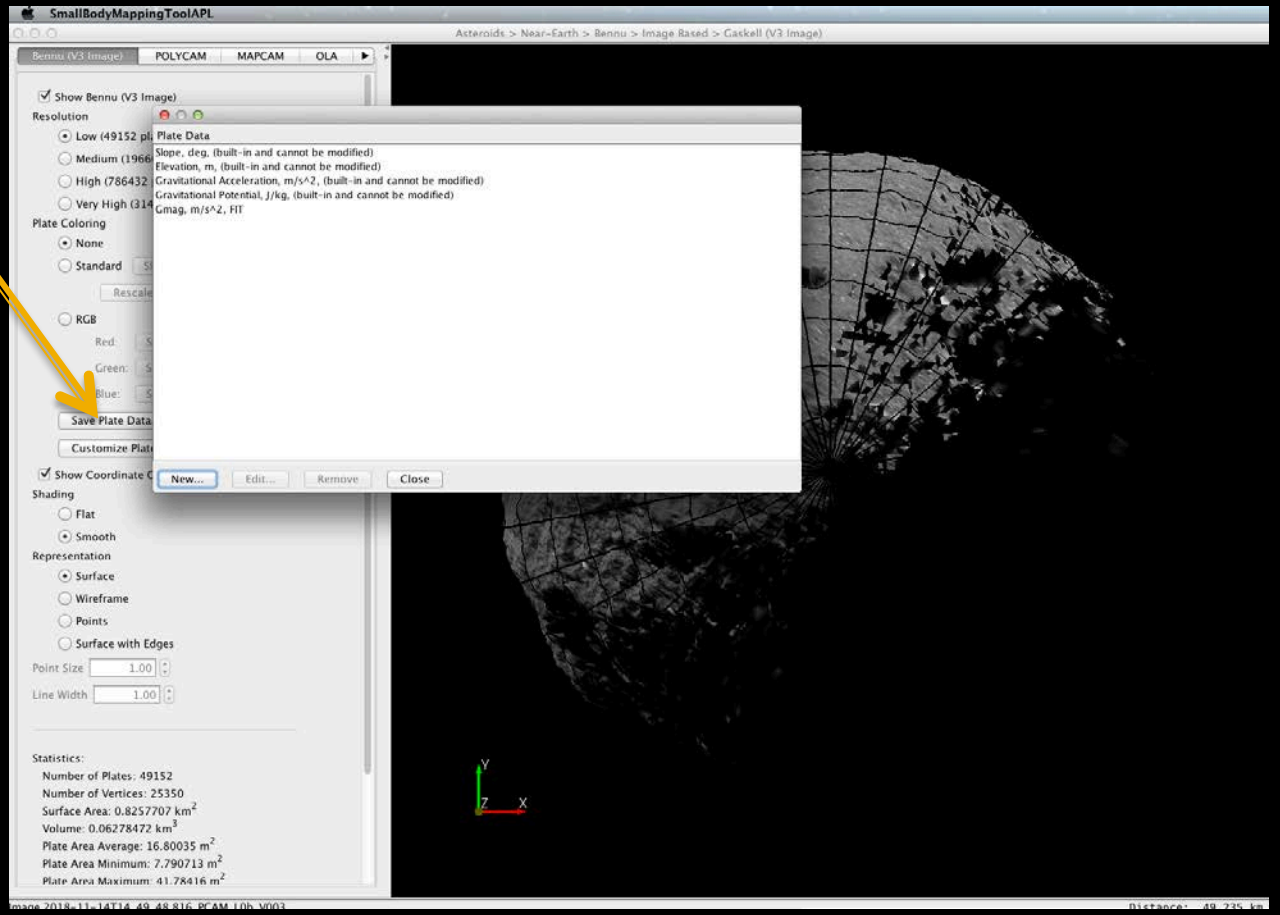
Click “Customize Plate coloring”

Navigate to ancillary data by clicking browse

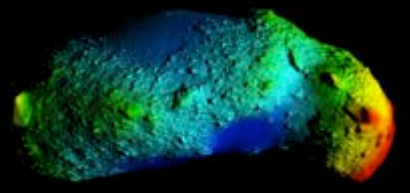
Name the data whatever you want, and add units if desired

Click close

You have now added an new layer in Plate Coloring ->Standard

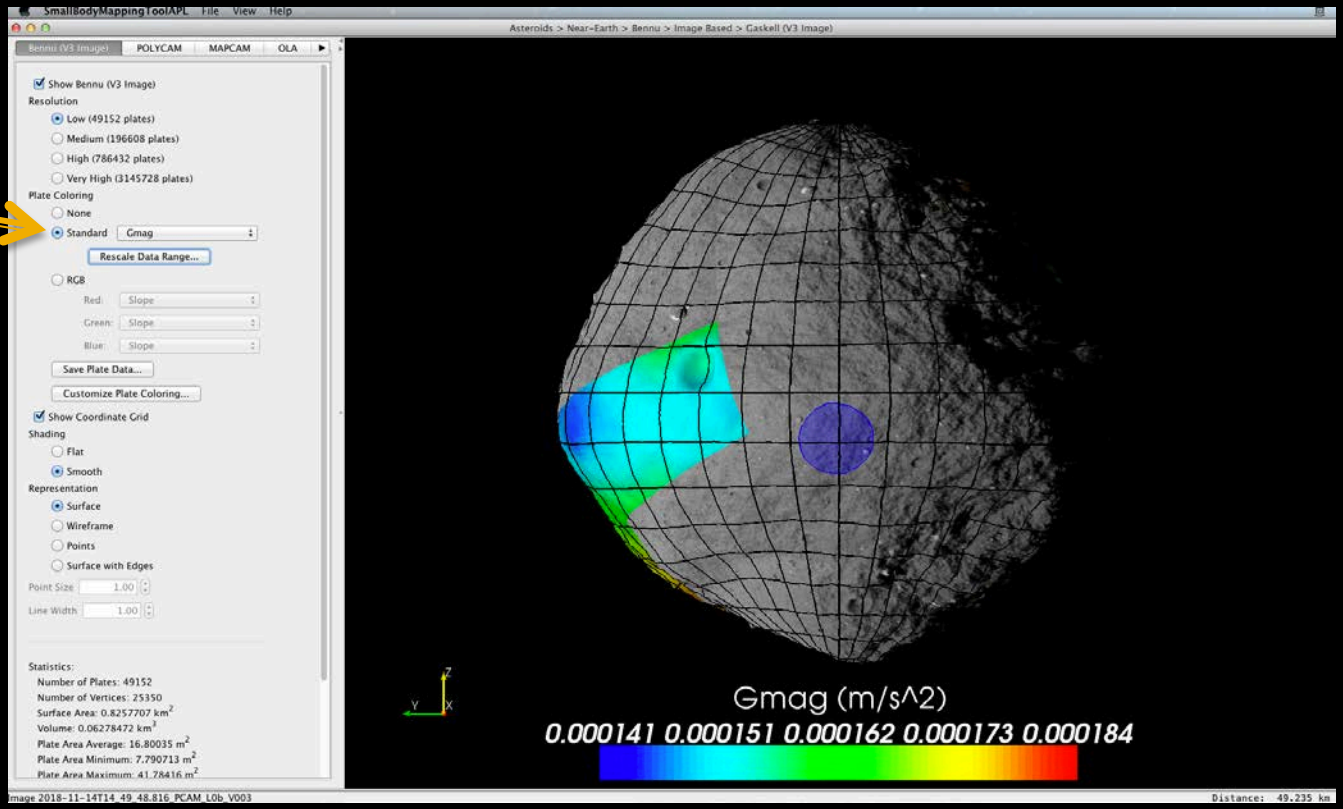


Add ancillary data

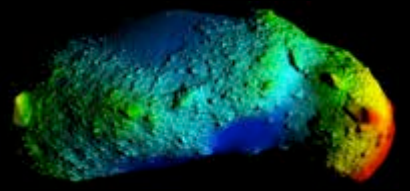


Click on Plate coloring standard toggle.

Choose the new layer you added: Gmag

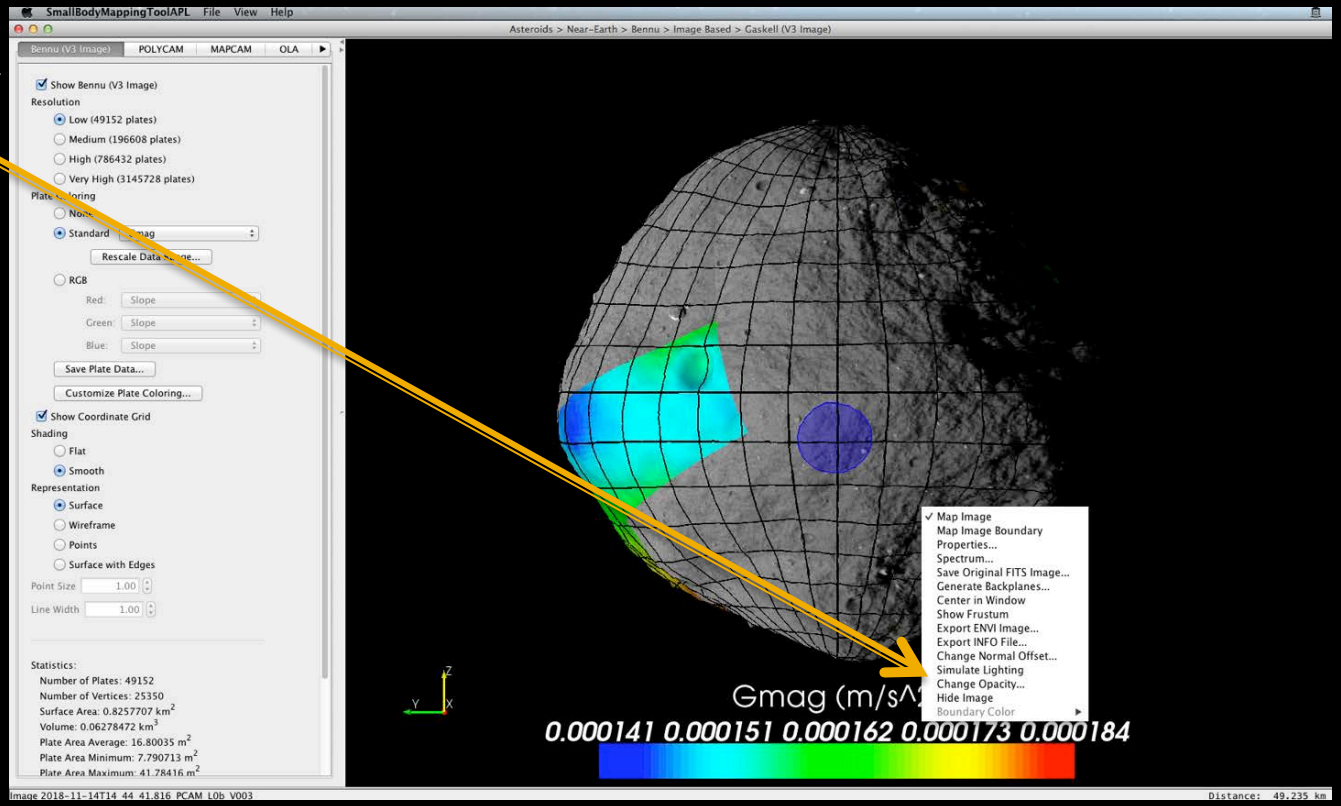


Transparent images

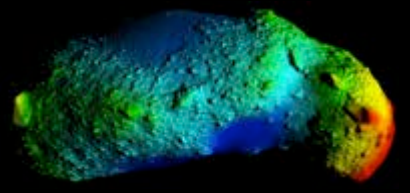


Right click on image

Choose Change Opacity

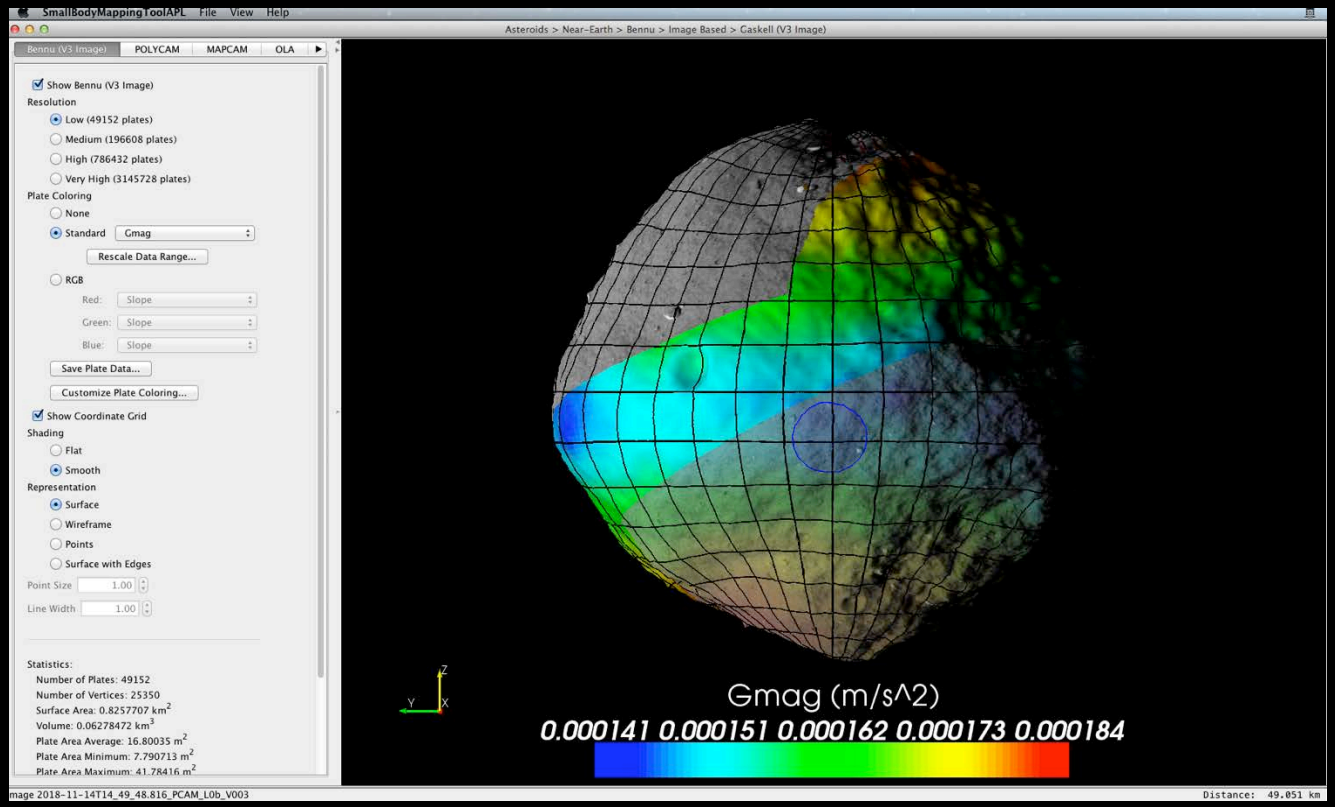


Transparent images

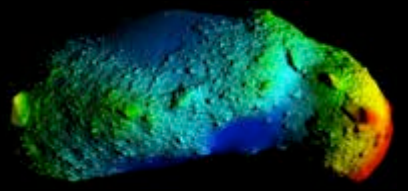


Right click on image

Choose Change Opacity



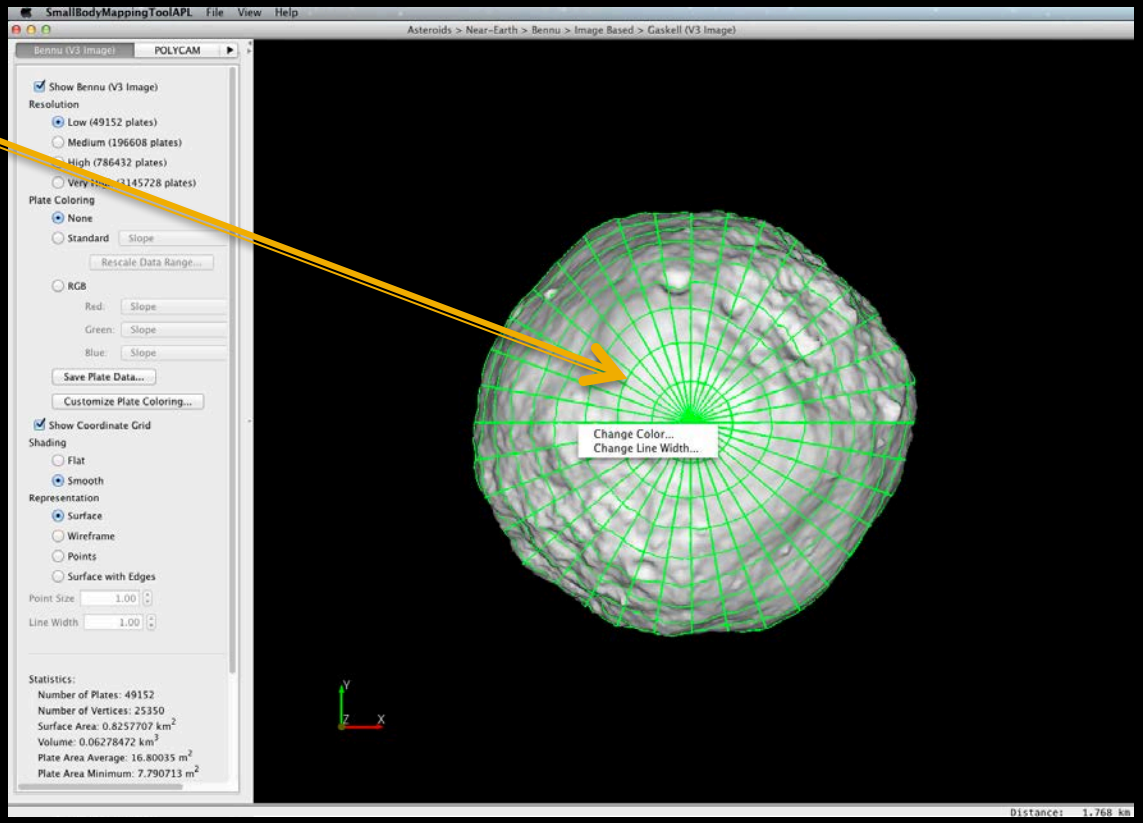
Renderer panel: change color of coordinate grid



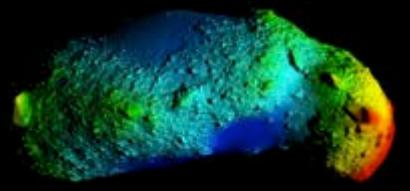
Context Menu

Right click on any part of the coordinate grid. A context menu will appear on the renderer where you clicked.

Click on the Change Color… option and select a new color.



Polycam Image Search



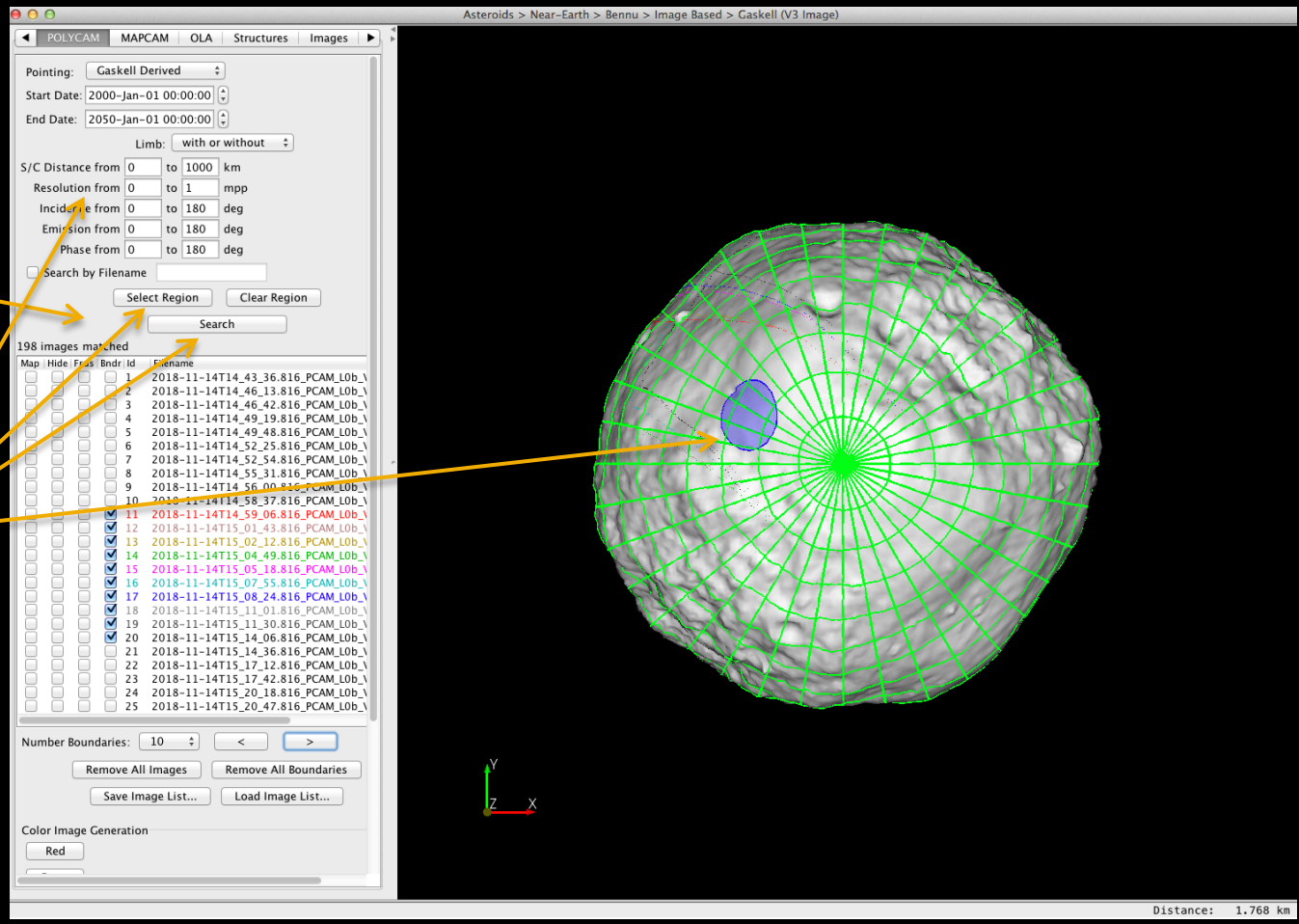
Switch to the POLYCAM tab. This tab is used for searching and displaying POLYCAM images.

Click the Search region to perform a search using the default search options.

Click on select region, draw a search region, edit resolution and then click search to find images

A list of images will be returned sorted by date.

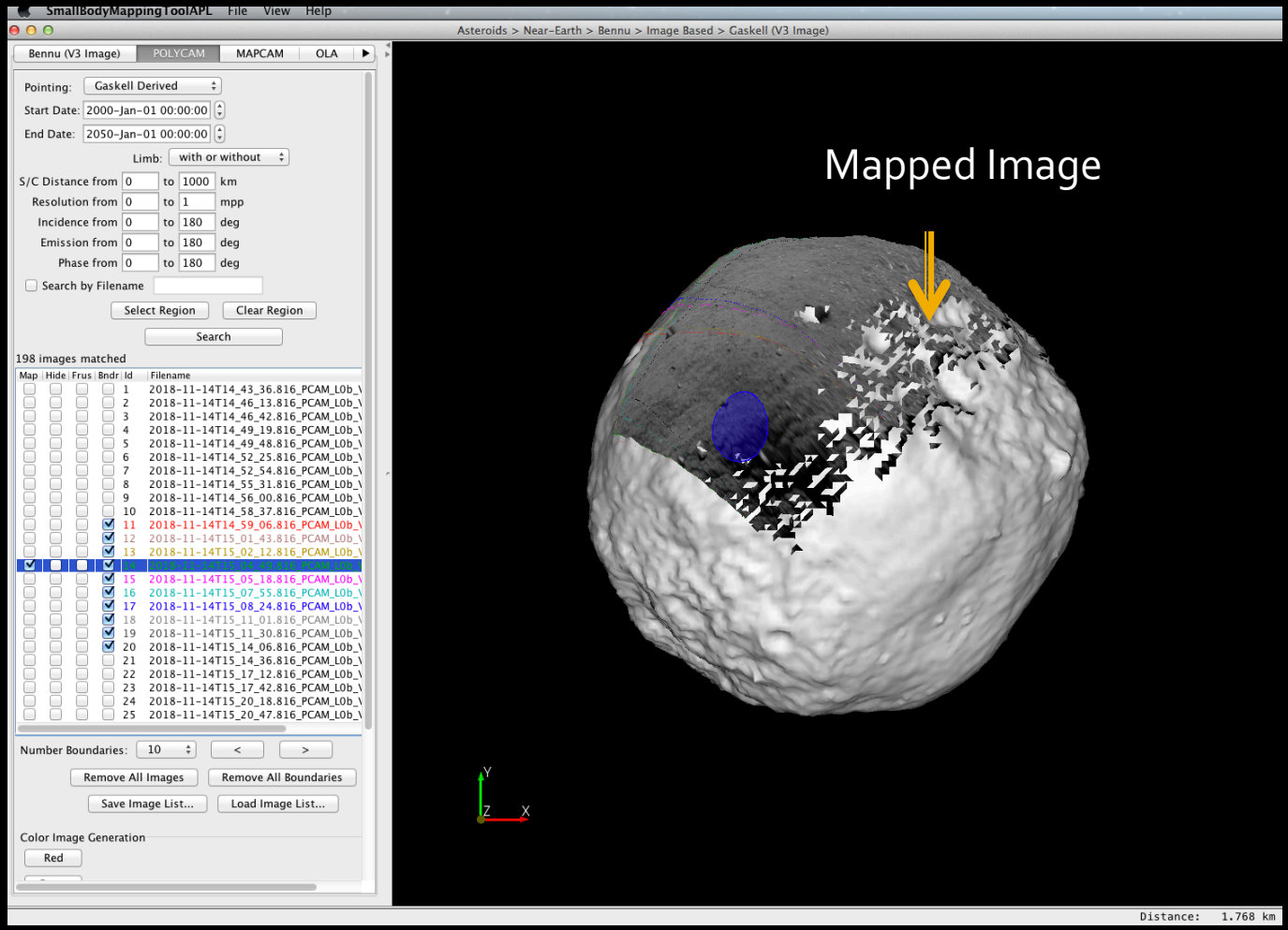
Boundaries of images will appear if images are smaller than object.



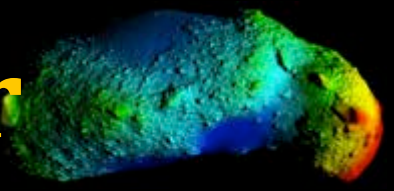
Map Image in Returned List

By default the boundaries of the first 10 matched images are shown in red in the renderer. If none or seen, it is because most images exceed size of observed object. You can see more boundaries by changing the boundary number or clicking the forward arrow. To map the image to the shape model, right click on the image and click “Map Image”

You can right click either on an item in the list or a boundary in the renderer view

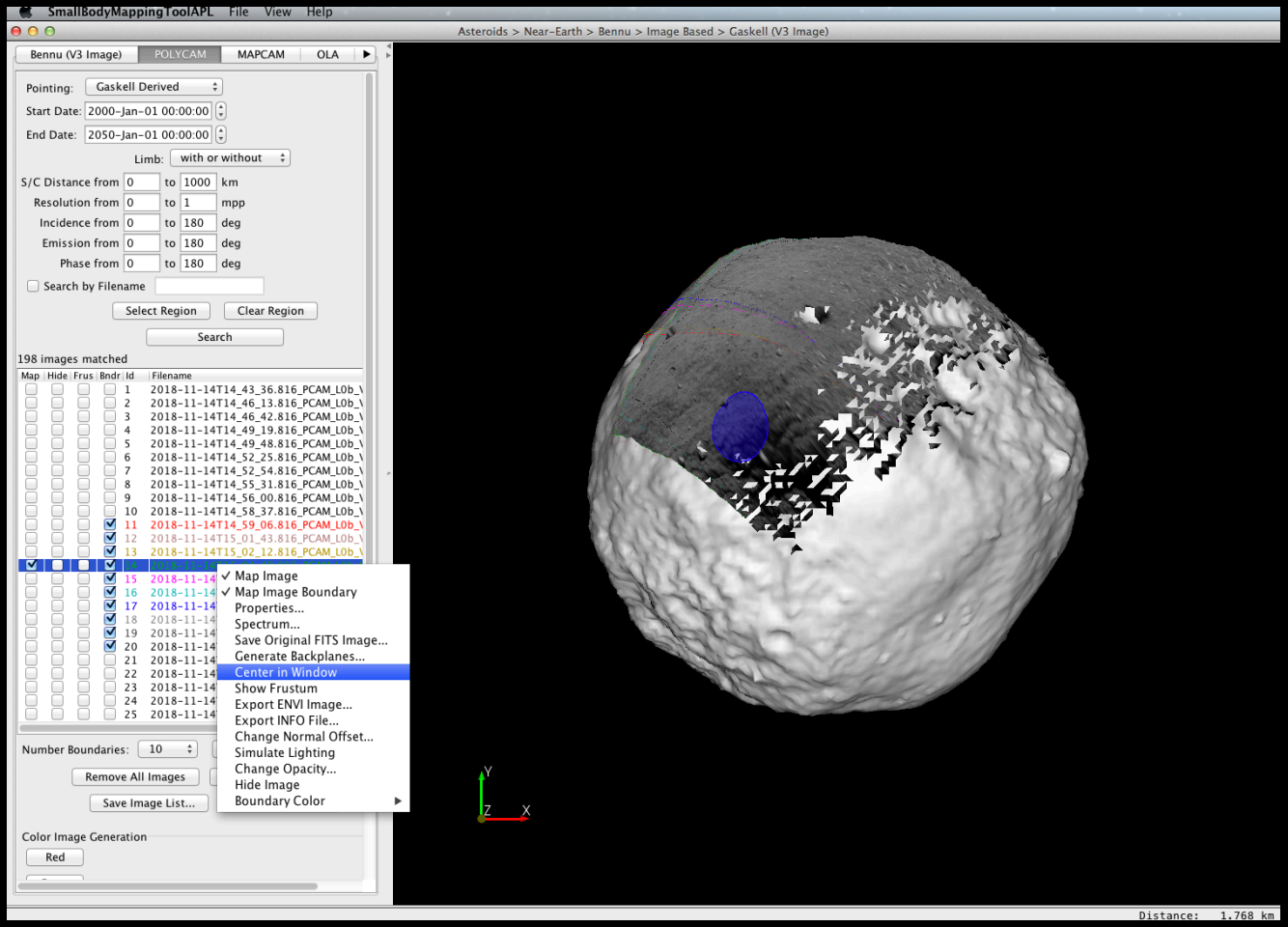


Center Image in Renderer View

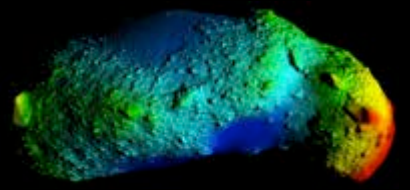


You can center the image in the renderer view which reorients the shape model to mimic how the spacecraft viewed the shape model when it acquired the image.

Right click on an image and click “Center in Window”

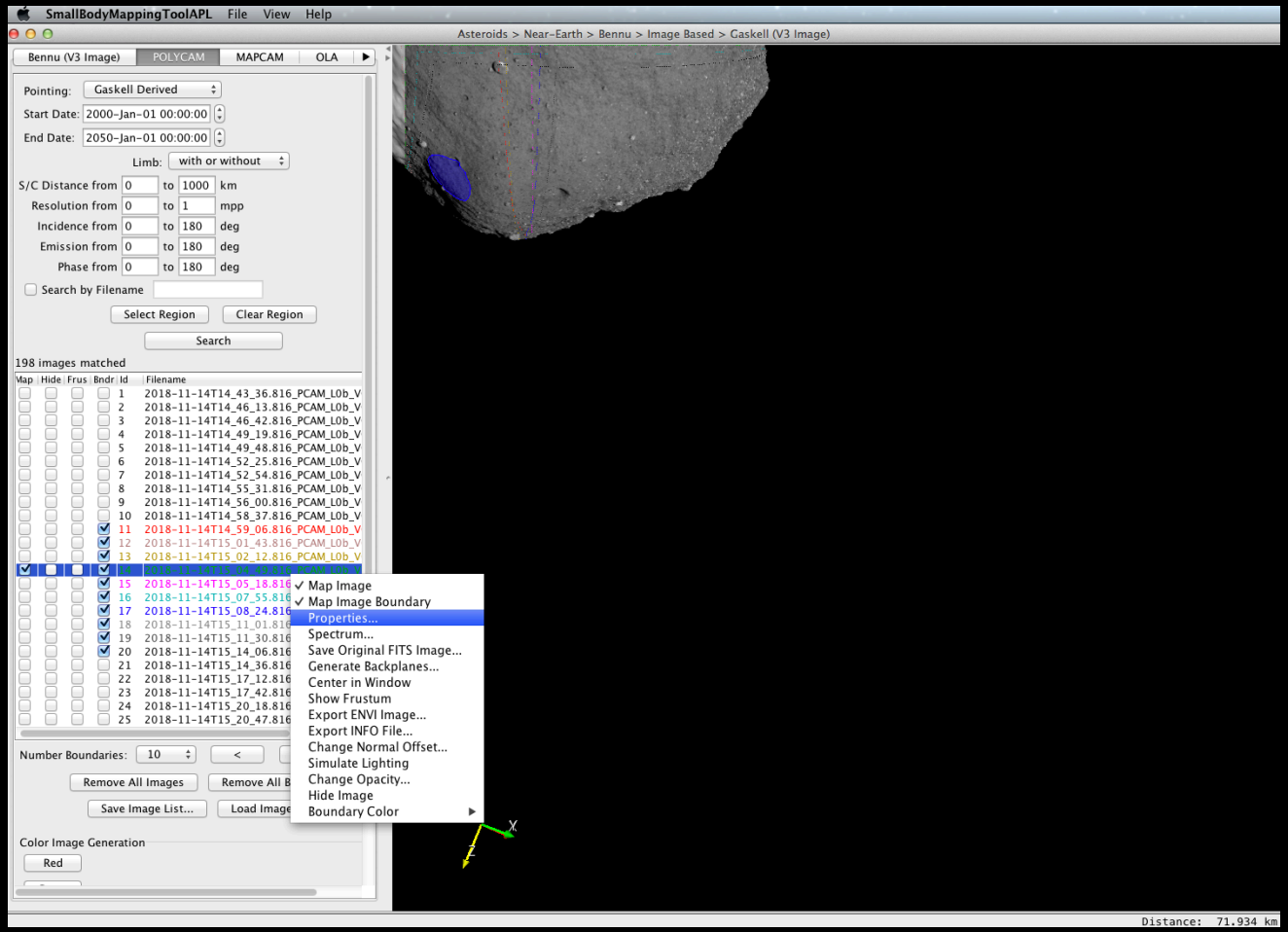


View asteroid as seen by camera



You can center the image in the renderer view which reorients the shape model to mimic how the spacecraft viewed the shape model when it acquired the image.

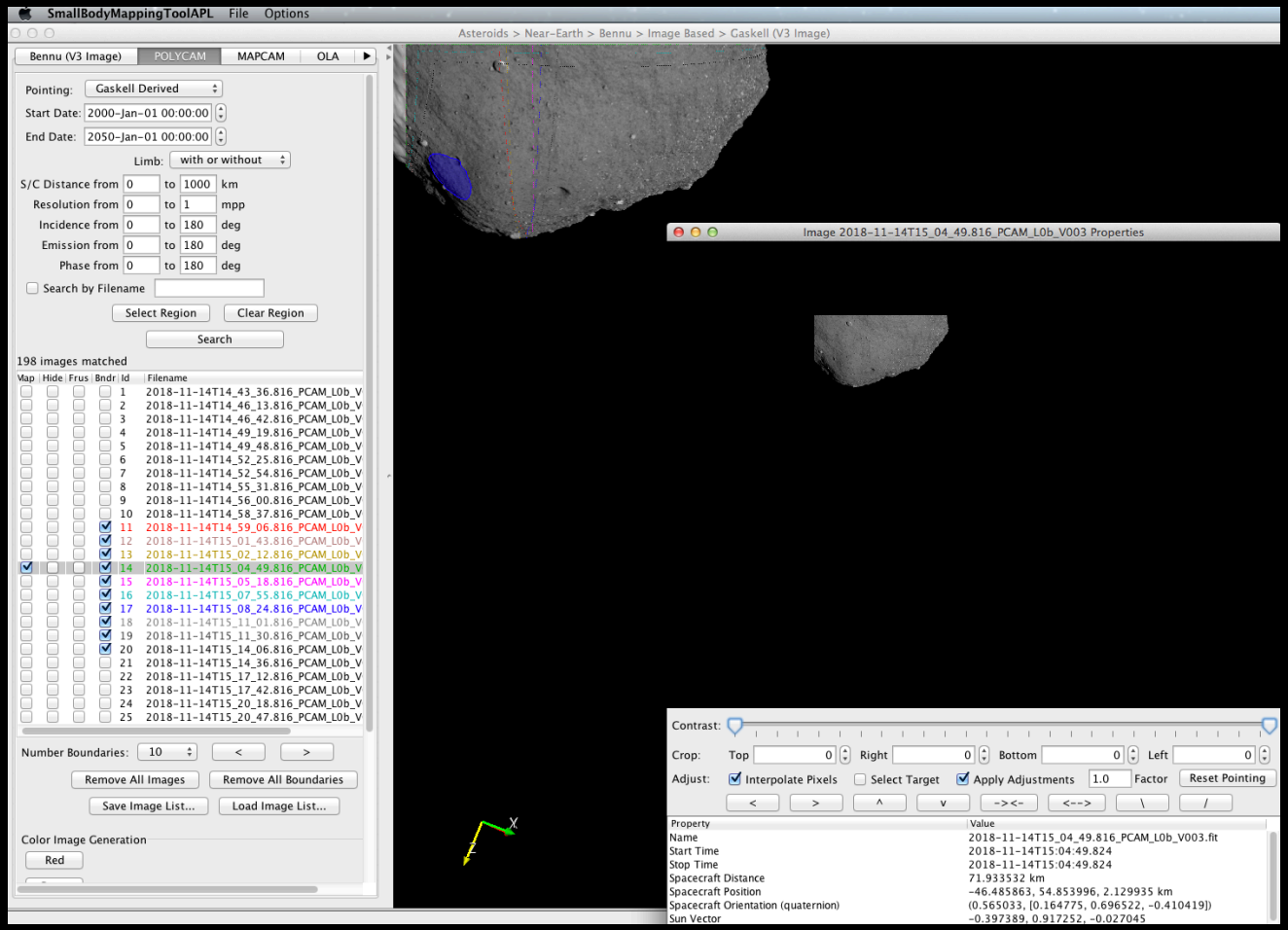
Right click on an image and click “Center in Window”



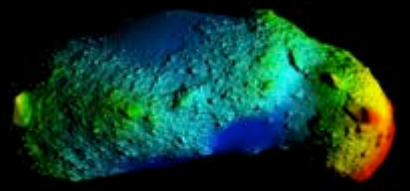
Check out properties of image and stretch

You can look at the original POLYCAM image and stretch it for visualization on the shape model by right clicking on the image highlighted in the list or the image boundary.

You can stretch the image, or physically move it if it doesn't align properly. You can save adjustments you have made.



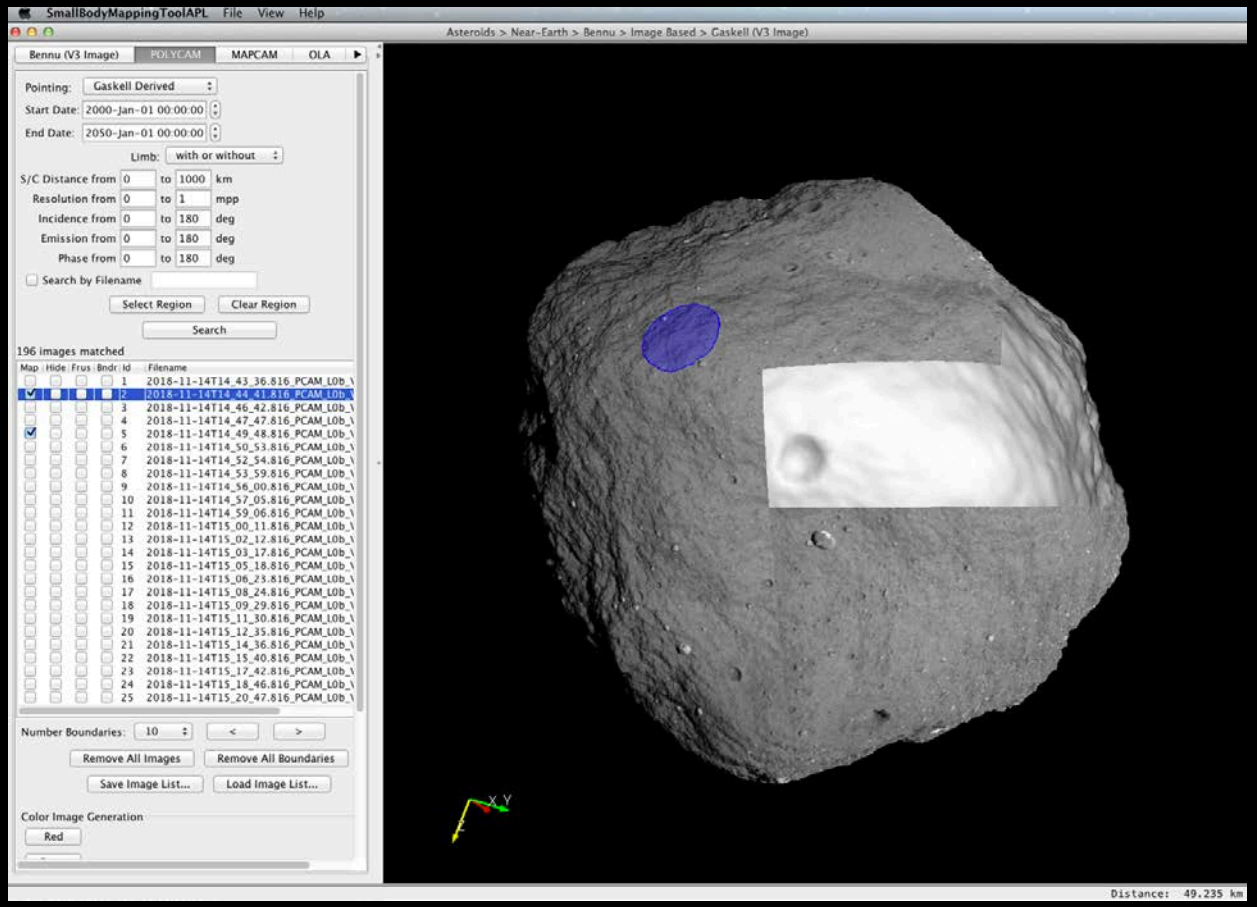
Quick mosaic



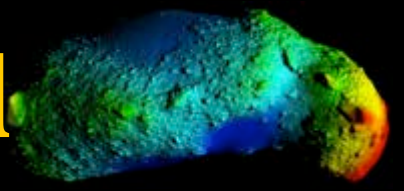
Map more than one image and play with stretch to get images to match up.

Currently can simply export result as a png which via fie>export to image.

As some point will be able to export a mosaic as a fits or Envi file.



Downloading the original image or a backplane

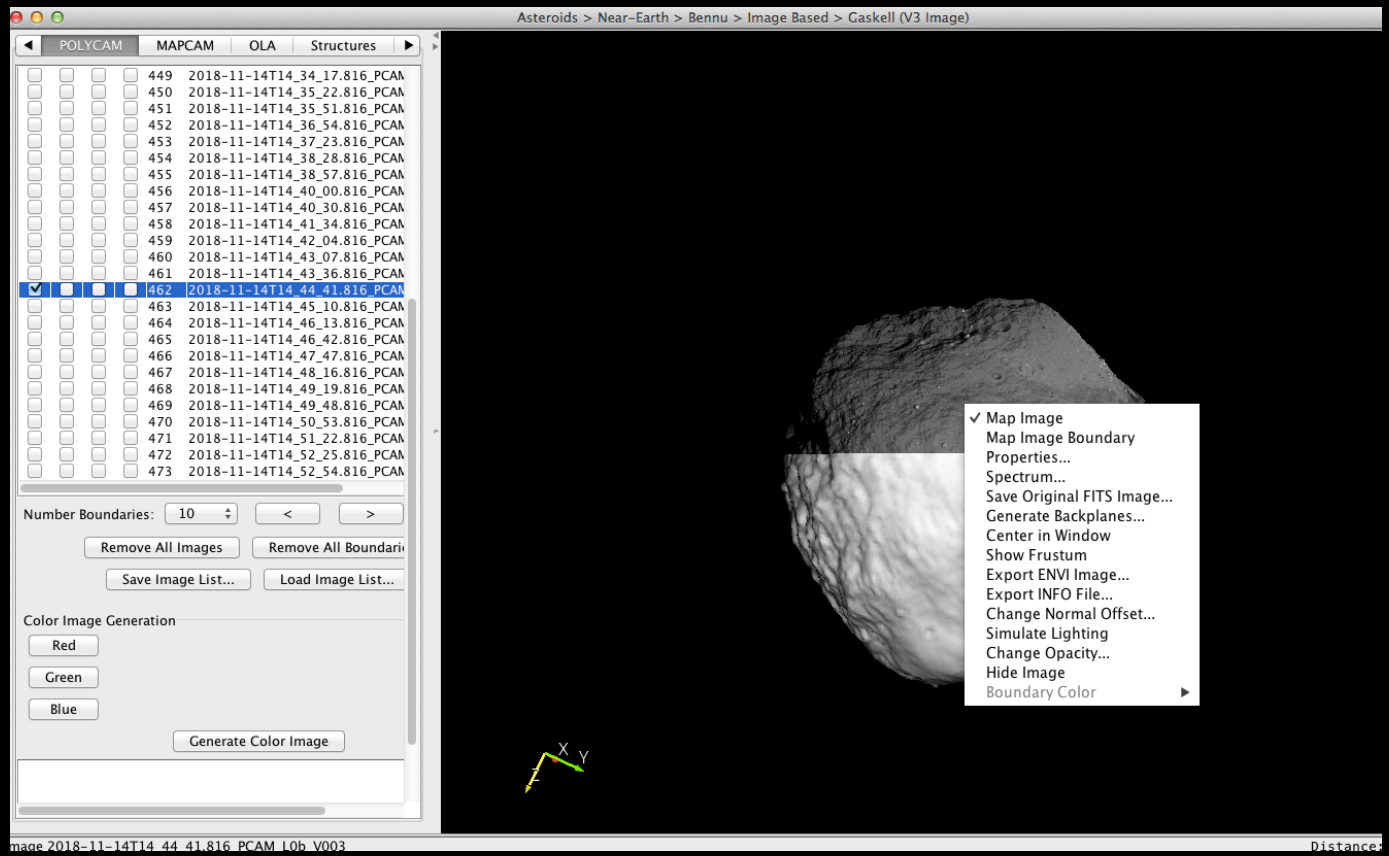


To obtain the original image left click on image and then click on save original fits file

Also useful to download info file if you plan to manipulate file and want to bring what you created back into SBMT.

To obtain a “backplane” image with incidence, emission, phase, lat, long, radius, x, y, z, elevation, slope and so (from shape model currently selected) and left click on image in render or in list.

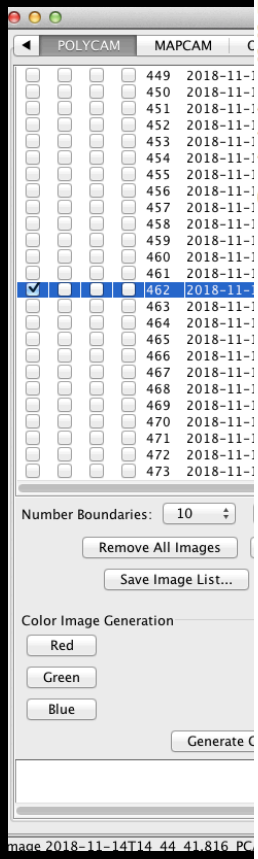
Image is output as a DDR.IMG file with PDS 3 label



Downloading a back plane to an image

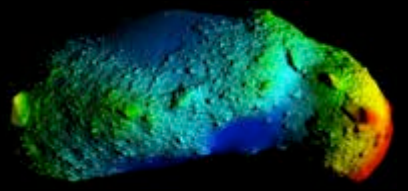
To obtain a "backplane" image with incidence, emission, phase, lat, long, radius, x, y, z, elevation, slope and so (from shape model currently selected) and left click on image in render or in list.

Image is output as a DDR.IMG file with PDS 3 label




```
2 barnoos1-ml3% [/Users/barnoos1]more 2018-11-14T14_44_41.816_PCAM_L0b_V003_DDR.LBL
PDS_VERSION_ID               = PDS3

PRODUCT_TYPE                 = DDR
PRODUCT_CREATION_TIME        = 2016-03-14T19:31:28
PRODUCER_INSTITUTION_NAME    = "APPLIED PHYSICS LABORATORY"
SOFTWARE_NAME                = "Small Body Mapping Tool"
SHAPE_MODEL                  = "Bennu low"

/* This DDR label describes one data file:                              */
/* 1. A multiple-band backplane image file with wavelength-independent,  */
/* spatial pixel-dependent geometric and timing information.            */

OBJECT                       = FILE
  ^IMAGE                     = "2018-11-14T14_44_41.816_PCAM_L0b_V003_DDR.IMG"
  RECORD_TYPE                = FIXED_LENGTH
  RECORD_BYTES               = 4096
  FILE_RECORDS               = 16384

  OBJECT                     = IMAGE
    LINES                    = 1024
    LINE_SAMPLES             = 1024
    SAMPLE_TYPE              = IEEE_REAL
    SAMPLE_BITS              = 32
    CORE_NULL                = 16#F49DC5AE#
    BANDS                    = 16
    BAND_STORAGE_TYPE        = BAND_SEQUENTIAL
    BAND_NAME                = ("Pixel value",
                                "x coordinate of center of pixel, km",
                                "y coordinate of center of pixel, km",
                                "z coordinate of center of pixel, km",
                                "Latitude, deg",
                                "Longitude, deg",
                                "Distance from center of body, km",
                                "Incidence angle, deg",
                                "Emission angle, deg",
                                "Phase angle, deg",
                                "Horizontal pixel scale, km per pixel",
                                "Vertical pixel scale, km per pixel",
                                "Slope, deg",
                                "Elevation, m",
                                "Gravitational acceleration, m/s^2",
                                "Gravitational potential, J/kg")


  END_OBJECT                 = IMAGE
END_OBJECT                   = FILE

END
```

Find OLA data

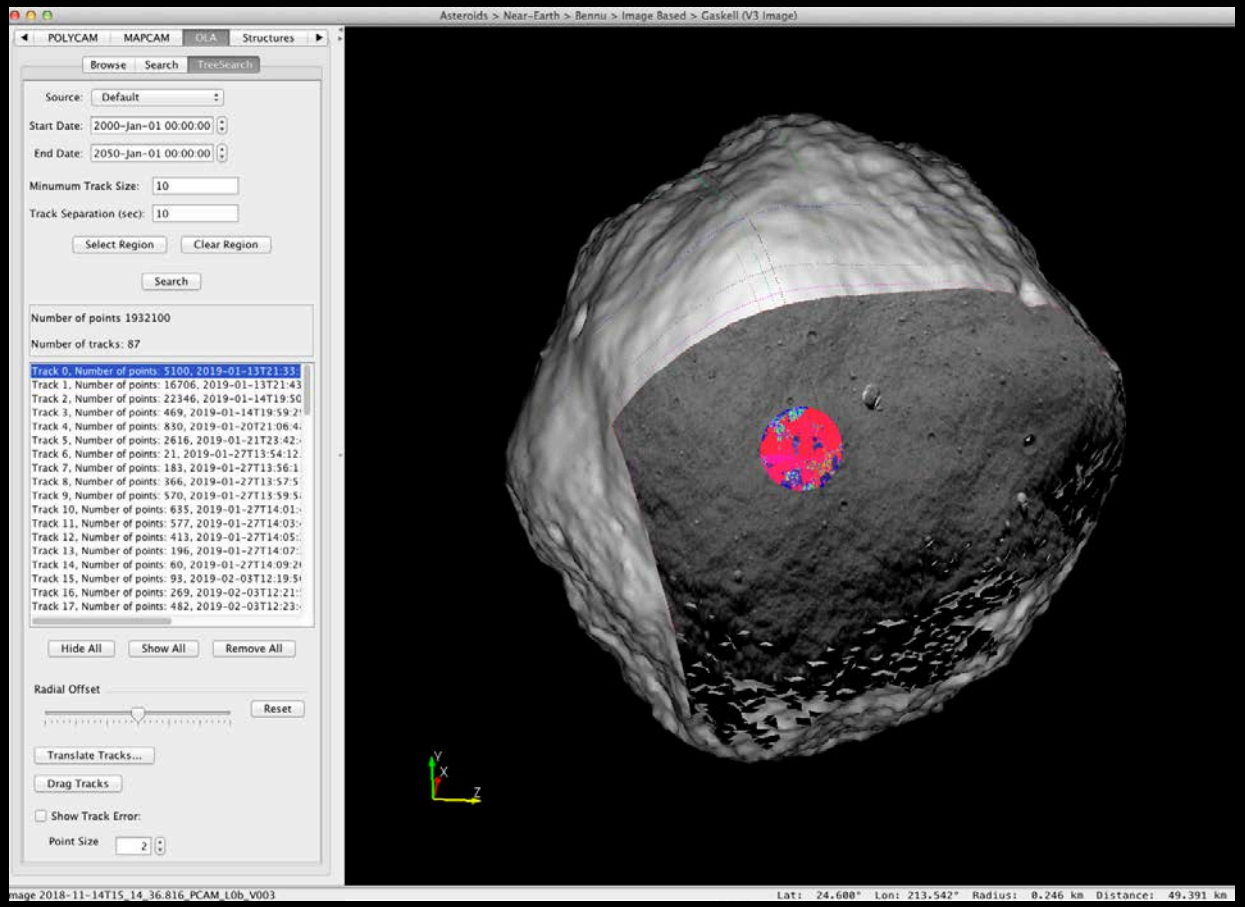


Navigate to OLA -> TreeSearch Tab

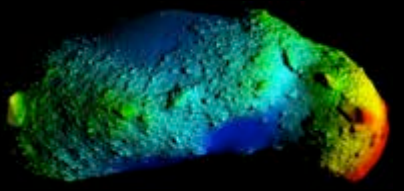
Click on select region.

Choose a feature where you want OLA data. Then click search.

A little slow – but will provide all the data



Find Individual OLA data



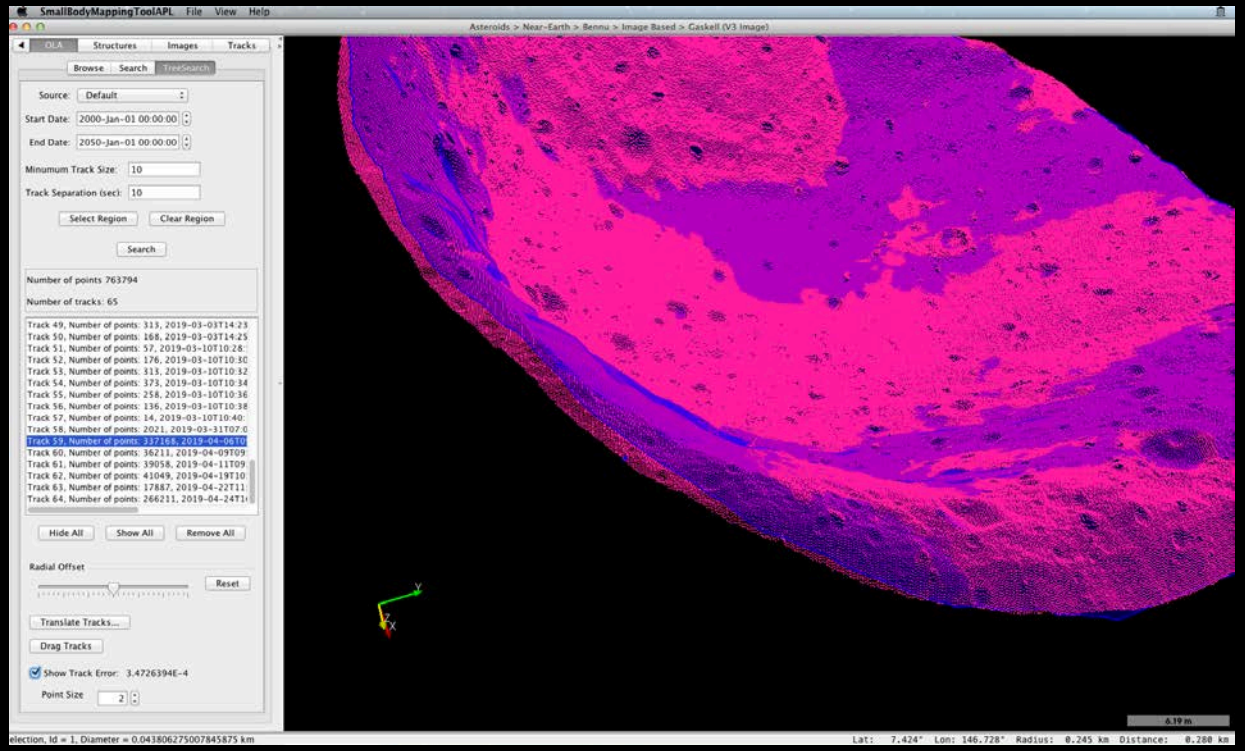
To identify a single OLA shot of interest

Disable LODs

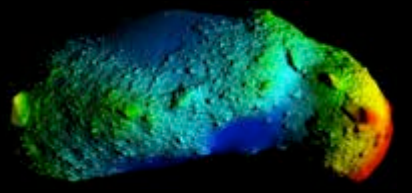
Then click on point of interest

Status shows when data was collected

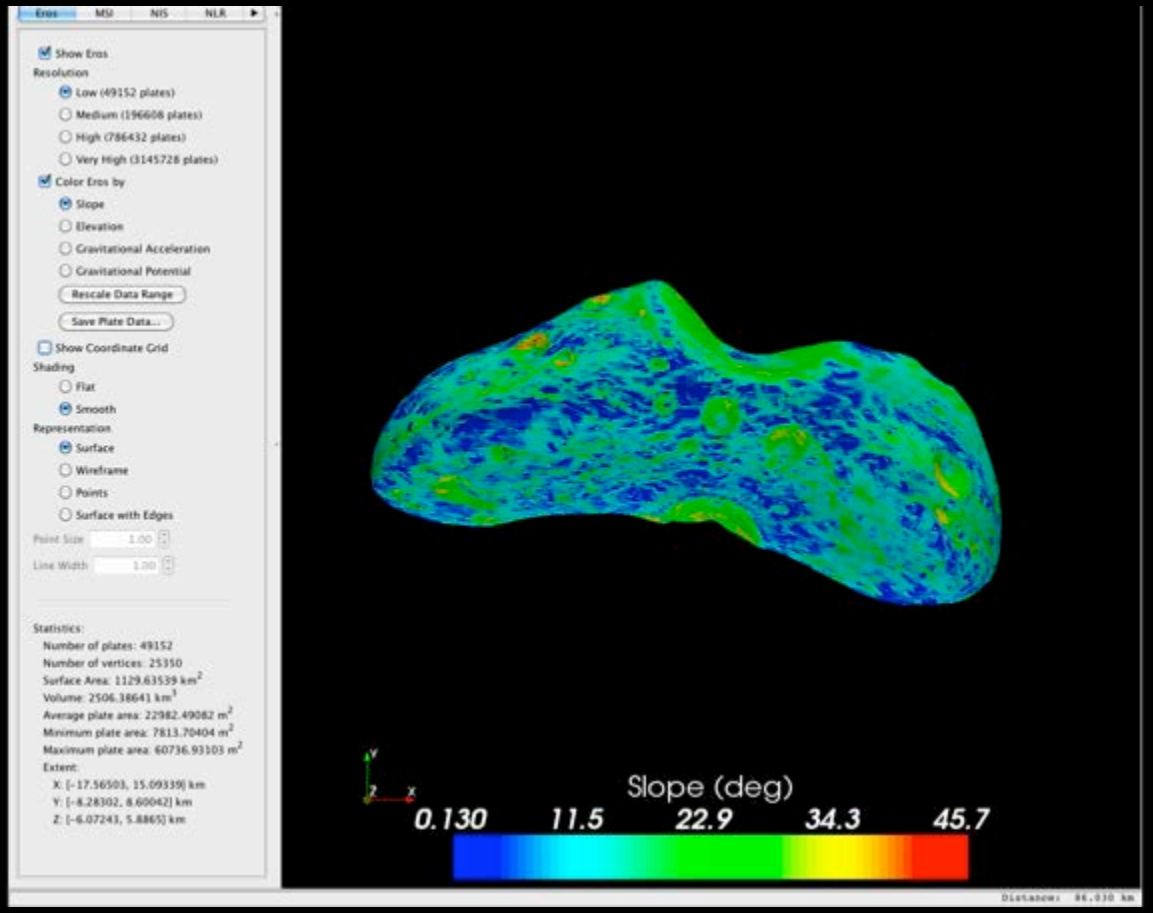
Highlights track of interest.



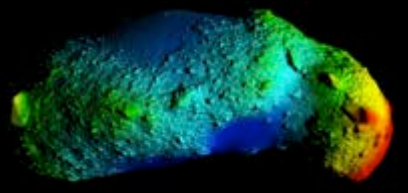
Control panel features: Show Slope map of Eros



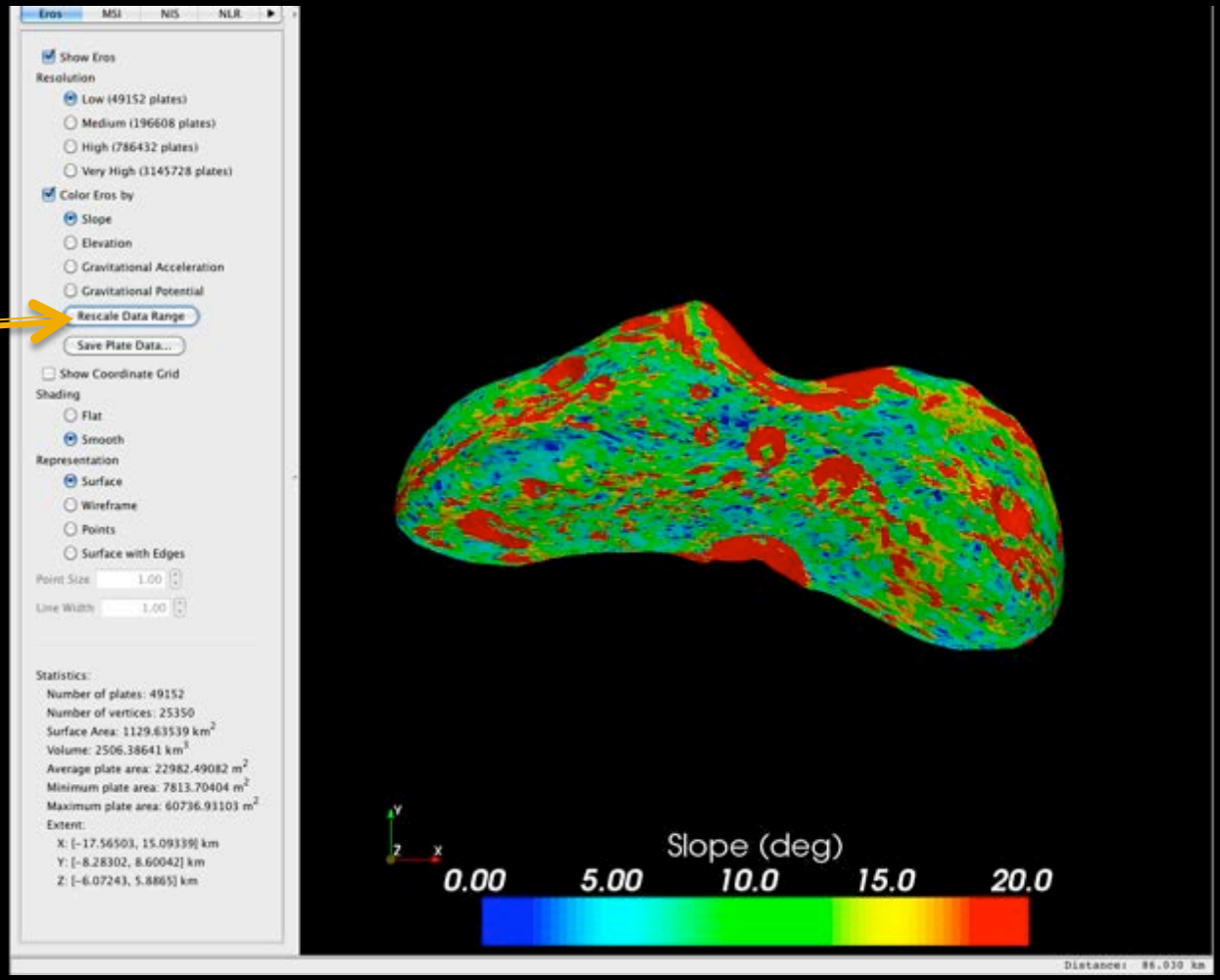
Check the “Color Eros by” checkbox. You will now see the asteroid colored by slope.



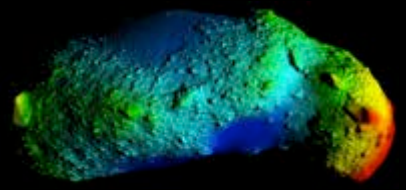
Control panel features: Rescale range of slopes



The slope base map ranges from close to zero to about 45 degrees. We will now change the range from 0 to 20 degrees. Click the “Rescale Data Range” button. In the new window, Enter 0 for the minimum and 20 for the maximum. Then click OK.

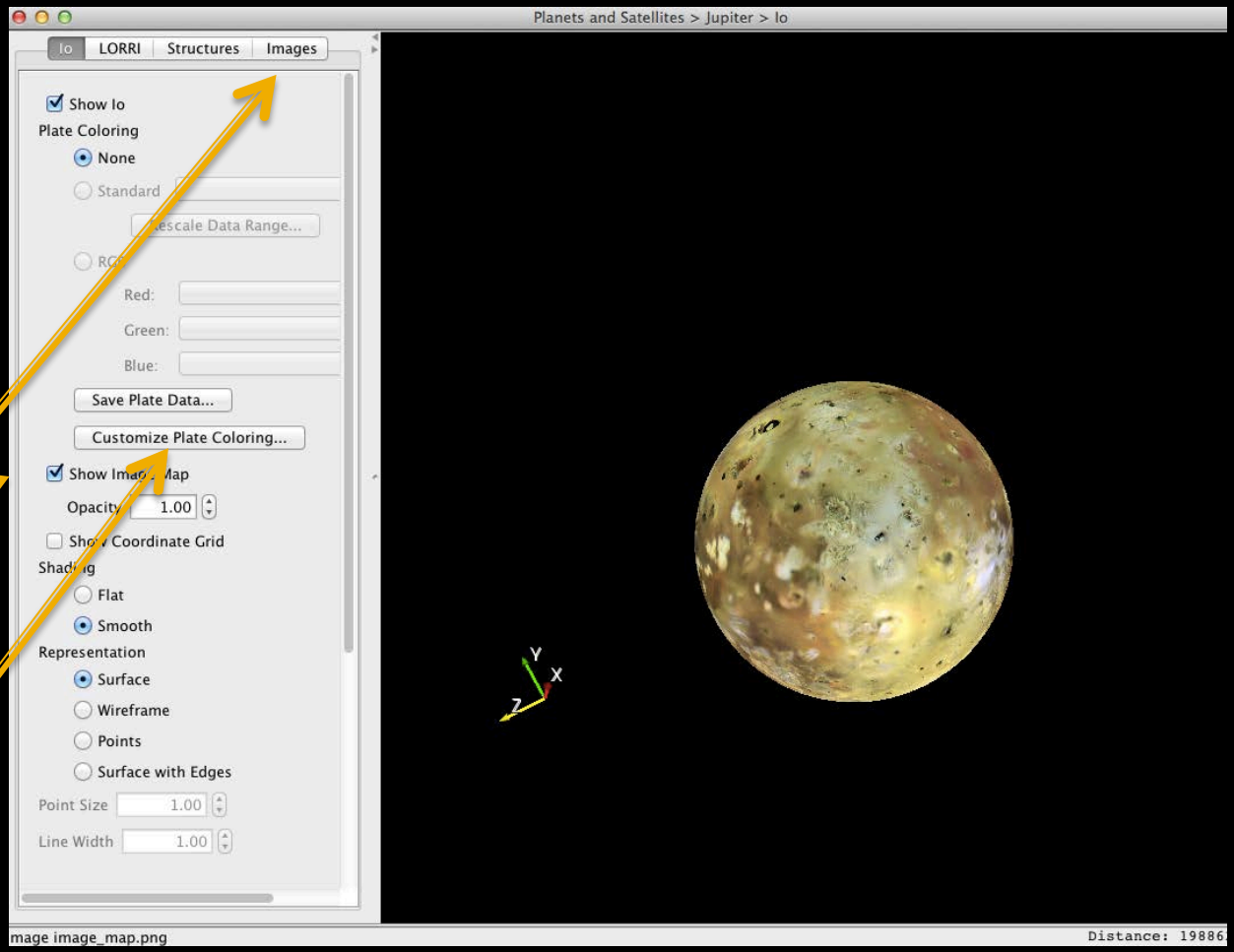


Show base map

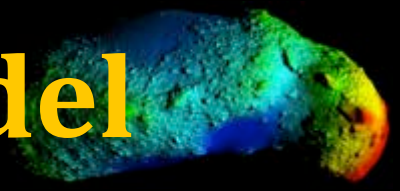


If base maps are available, these can be shown by clicking the show map feature.

Simple cylindrical projected maps can also be injested via the Images tab or by assigning values to the shape model plates



Draw Paths on Shape Model



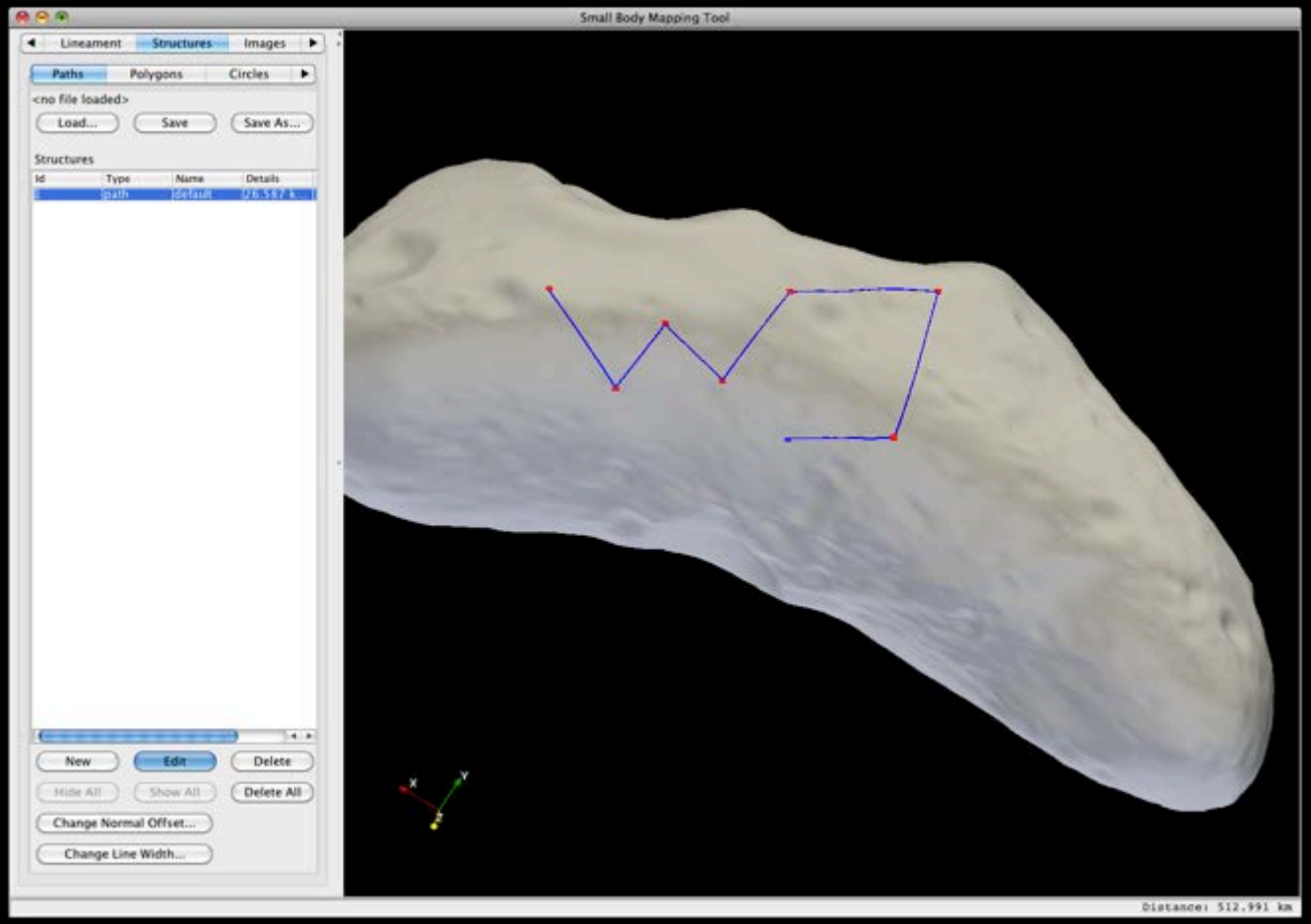
Switch to Structures tab and within that tab click on the Paths tab.

Press New to begin drawing a Path.

You will be in Edit mode in which the shape model is frozen in the renderer and you will not be able to rotate, zoom and pan.

In the renderer view click on the shape model to specify the vertices of the Path.

When finished drawing the Path, press the Edit button to return to normal navigation mode.



Draw Polygons on Shape Model

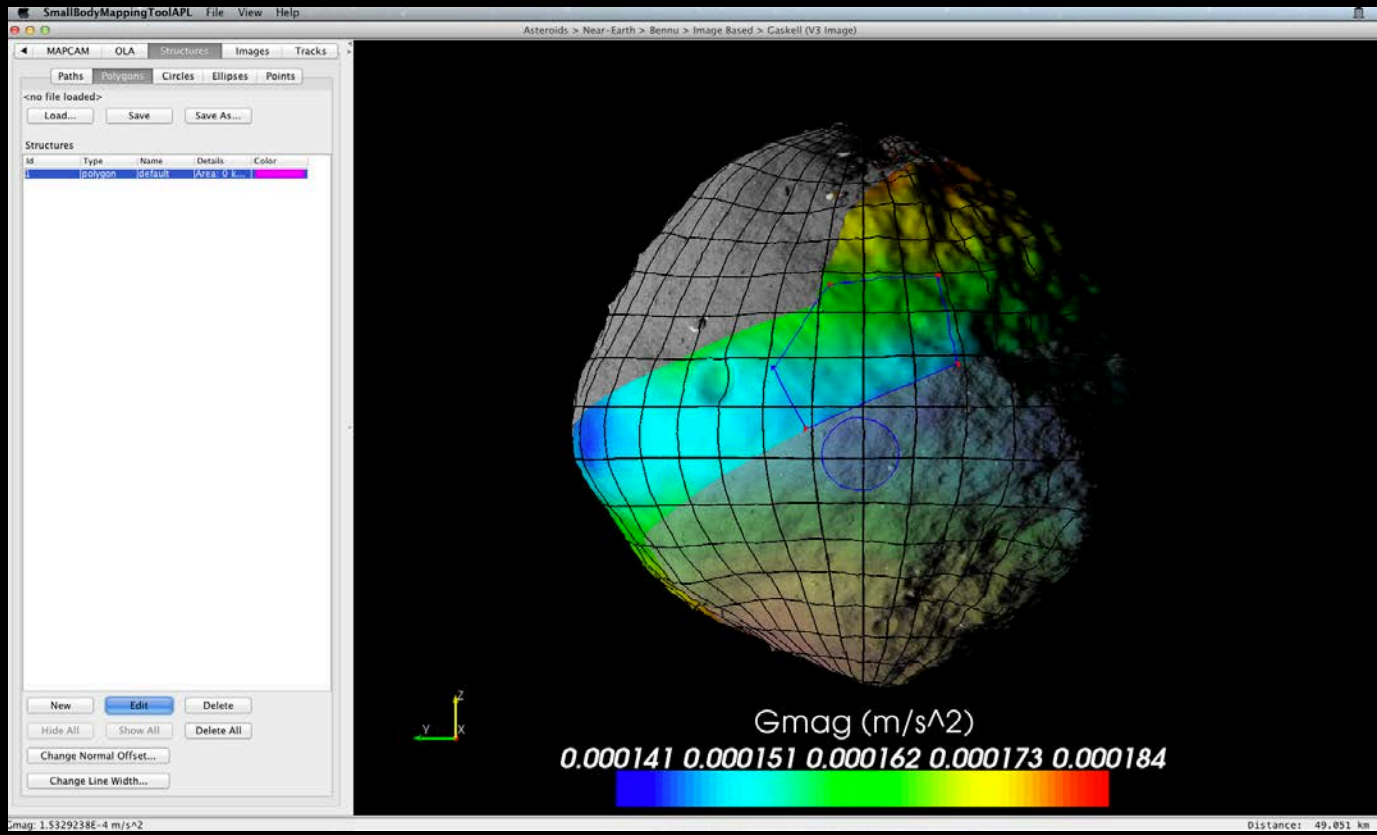
Switch to Structures tab and within that tab click on the Polygons tab.

Press New to begin drawing a polygon.

You will not be in Edit mode in which the shape model is frozen in the renderer and you will not be able to rotate, zoom and pan.

In the renderer view click on the shape model to specify the vertices of the polygon.

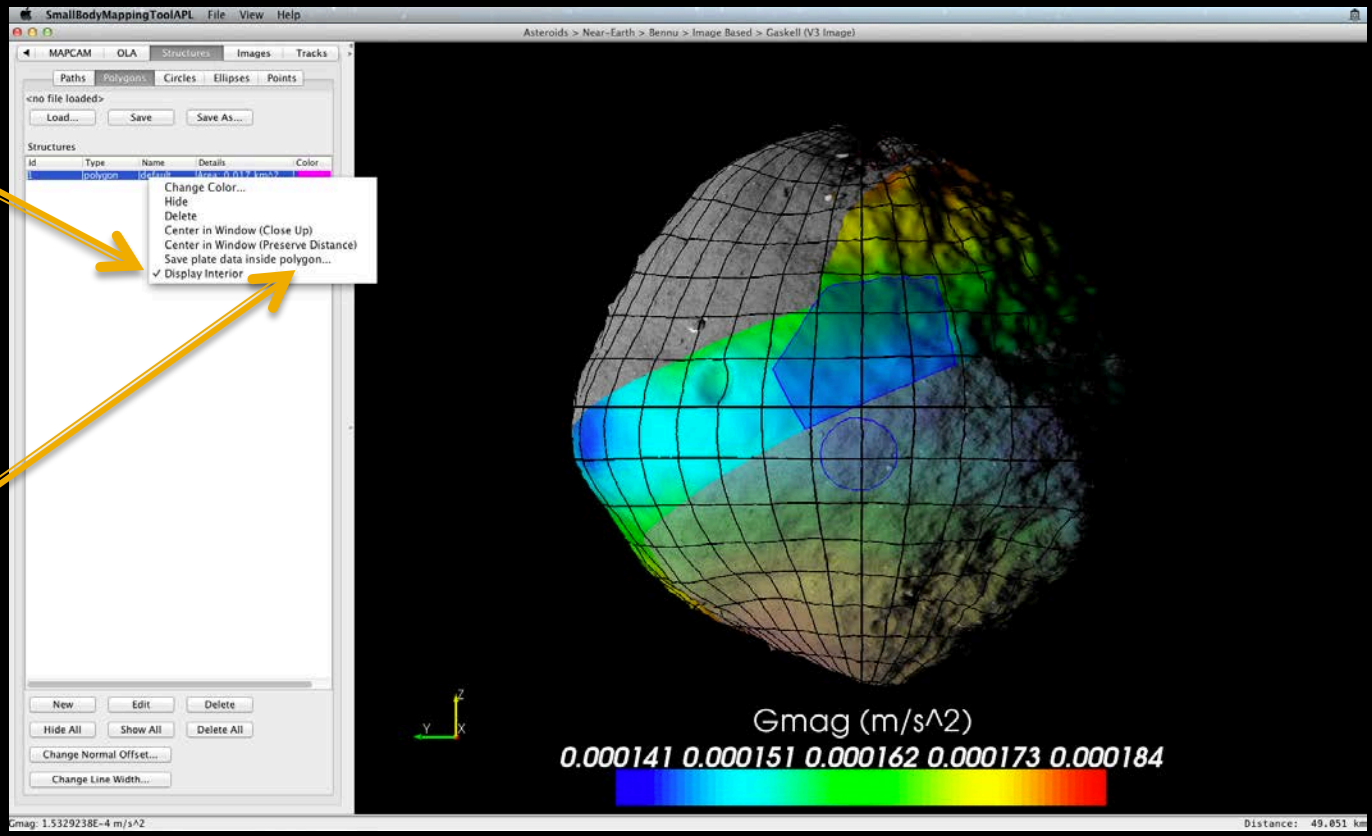
When finished drawing the polygon, press the Edit button to return to normal navigation mode.



Draw Polygons on Shape Model

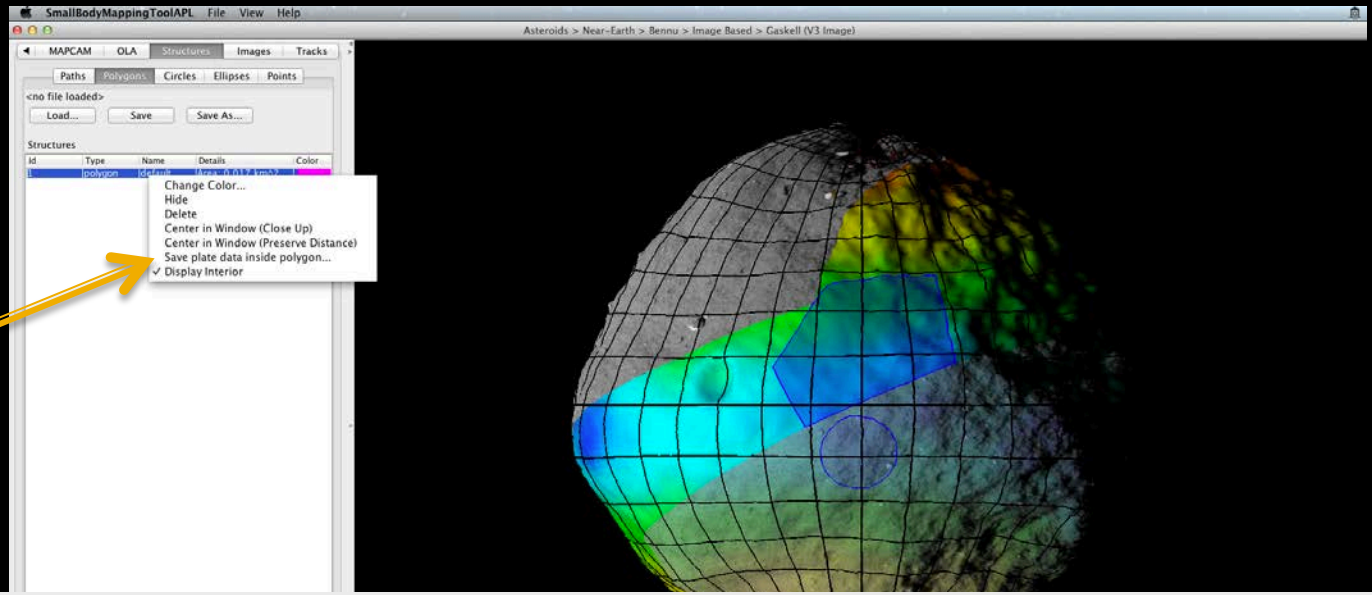
To determine the area in the polygon, right click on polygon in control panel, and click on display interior.

If you want to save the information on the facets in the polygon (including the ancillary data you have added) use save plate data.



Draw Polygons on Shape Model

If you want to save the information on the facets in the polygon (including the ancillary data you have added) use save plate data.

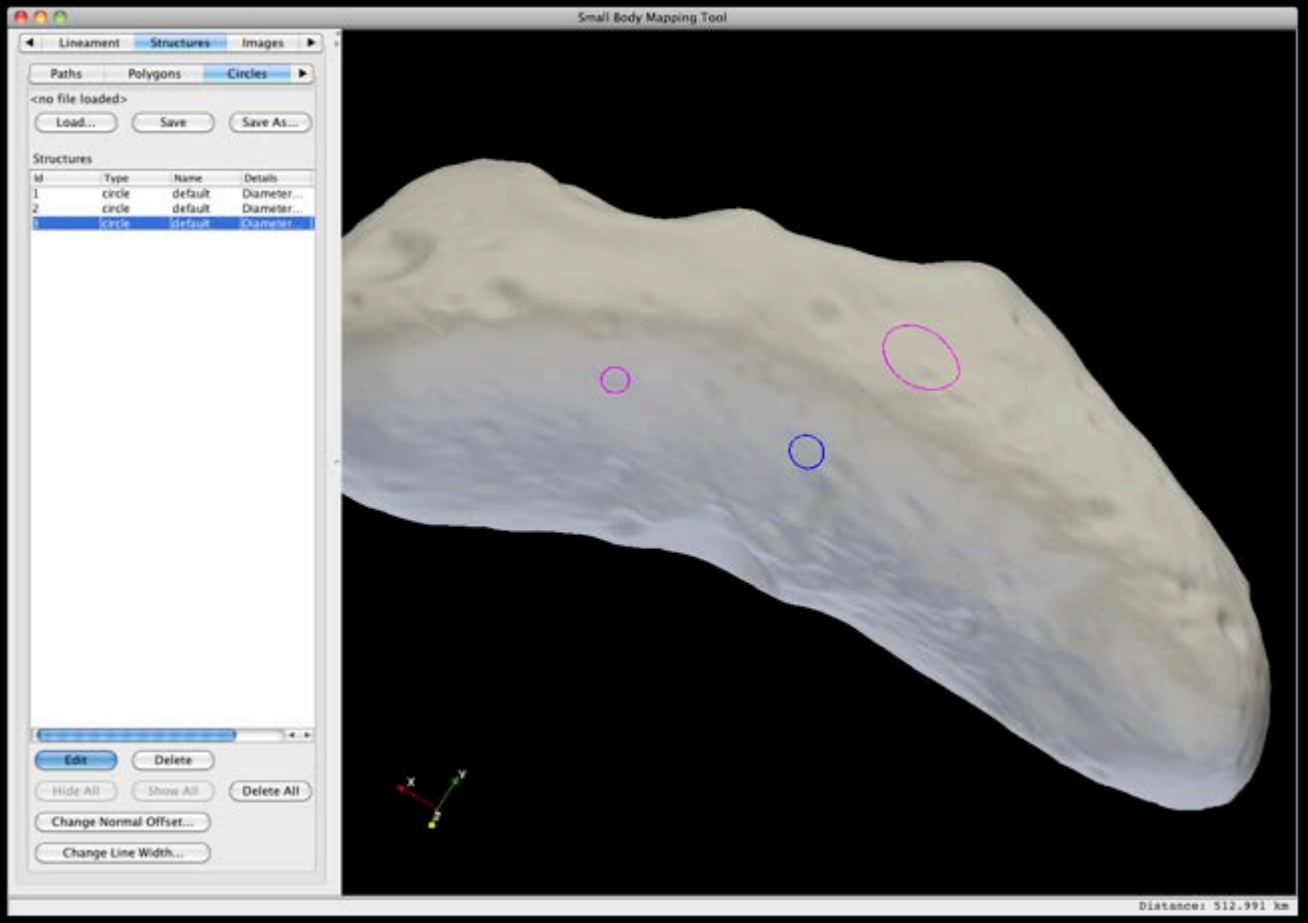


File Path ▾ : ~/olivier/Missions/osiris/ALTWG_processing/presentation/platedata.txt

platedata.txt

	Plate Id	Latitude	Longitude	Slope	Elevation	Gravitational Acceleration	Gravitational Potential	Gmag
2	18734	10.950568574439112	162.4189952543034	7.099864959716797	-43.888397216796875	3.105592986685224E-5	-0.021903563290834427	1.5595569857396185E-4
3	18735	10.532466241891214	161.94855166281224	5.960484027862549	-44.52454376220703	3.063910116907209E-5	-0.021904759109020233	1.5548242663498968E-4
4	18736	9.721529899694238	162.41144695329615	8.29542064666748	-46.14929962158203	2.9867482226109132E-5	-0.021918930113315582	1.5476172848138958E-4
5	18737	9.262788147727381	161.95036567906848	13.14810562133789	-47.07585906982422	2.945857704617083E-5	-0.021927354857325554	1.5446587349288166E-4
6	18738	8.420330860956131	162.41882943750466	3.3140244483947754	-48.851348876953125	2.867749208235182E-5	-0.021941501647233963	1.5364293358288705E-4
7	18739	7.998073950277136	161.95250060224	2.377408266067505	-49.67405700683594	2.8283749998081475E-5	-0.021945536136627197	1.532923779450357E-4
8	18740	7.195170161064397	162.41082287116254	7.977161407470703	-51.435752868652344	2.745545862126164E-5	-0.021952759474515915	1.5254017489496619E-4
9	18741	6.752886273030785	161.94668842624077	5.9917893409729	-52.37575149536133	2.7116768251289614E-5	-0.021960828453302383	1.5230484132189304E-4
10	18742	5.917264390697863	162.41230658282777	5.01509428024292	-54.2802619934082	2.632920404721517E-5	-0.02196972444653511	1.5157772577367723E-4
11	18858	13.61184894266593	163.80742101643594	9.766447067260742	-38.46563720703125	3.2976167858578265E-5	-0.021809017285704613	1.5767743752803653E-4
12	18859	13.154245950389587	163.3459641428628	18.945268630981445	-39.47356414794922	3.2652373192831874E-5	-0.021829472854733467	1.5745768905617297E-4
13	18860	12.336097931861268	163.80706530010684	23.770036697387695	-41.239437103271484	3.202594962203875E-5	-0.02186129987239837 6	1.5694026660639793E-4
14	18861	11.857638001877755	163.34675313343035	12.038606643676758	-42.29296112060547	3.177579856128432E-5	-0.021884460002183914	1.5673604502808303E-4
15	18862	11.024609885549513	163.80690618093087	16.41254997253418	-44.12941360473633	3.113955244771205E-5	-0.021914737299084663	1.5617757162544876E-4
16	18863	10.574164872196725	163.34383054720877	11.991397857666016	-44.88774490356445	3.076399661949836E-5	-0.021921493113040924	1.5570347022730857E-4

Draw Circles on Shape Model



Switch to Structures tab and within that tab click on the Circles tab.

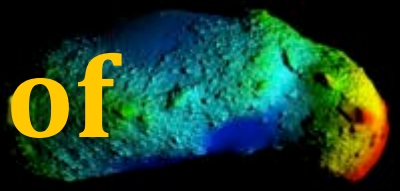
Press Edit to begin drawing circles.

In the renderer view click on the shape model 3 times on the perimeter of the circle. After clicking the third point, a circle will appear through the 3 points.

Click on another 3 locations to draw a second circle.

When finished drawing circles, press the Edit button again to return to normal navigation mode.

Change position and Size of Circle

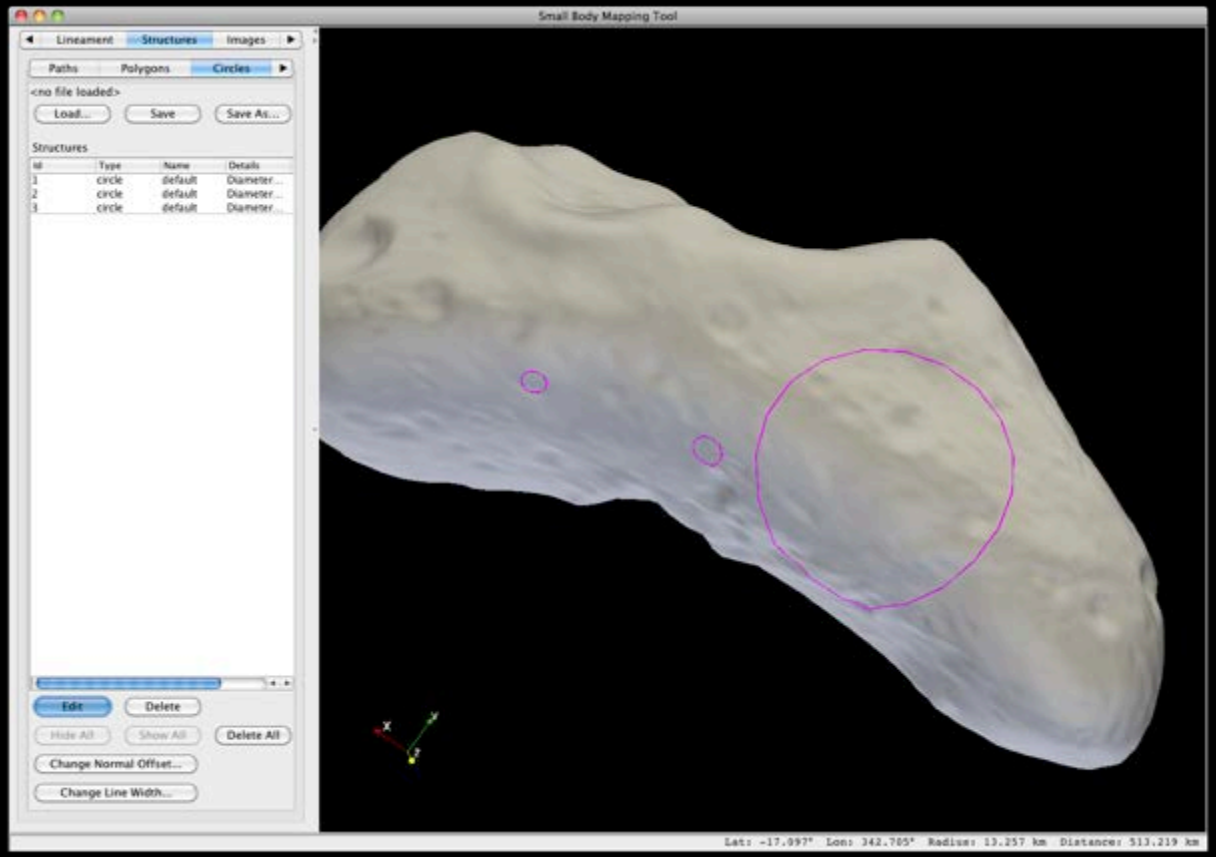


Click on the Edit button to enable Edit mode.

Position the cursor over a circle. The cursor will change to a hand shape.

Drag the circle while holding down the left mouse button to move it to a new location

Drag the circle while holding down both the left mouse button **and** the control or shift button to change its size.



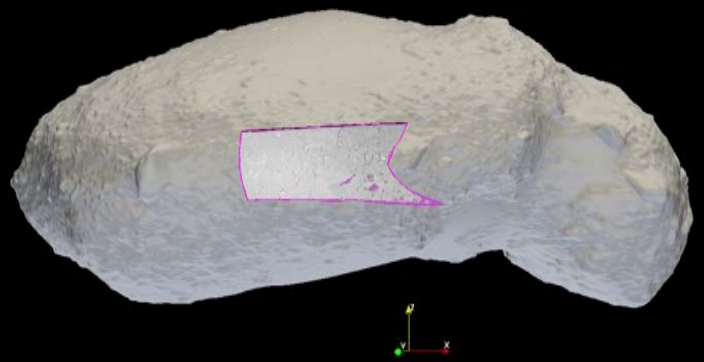
Draw Ellipses on Shape Model

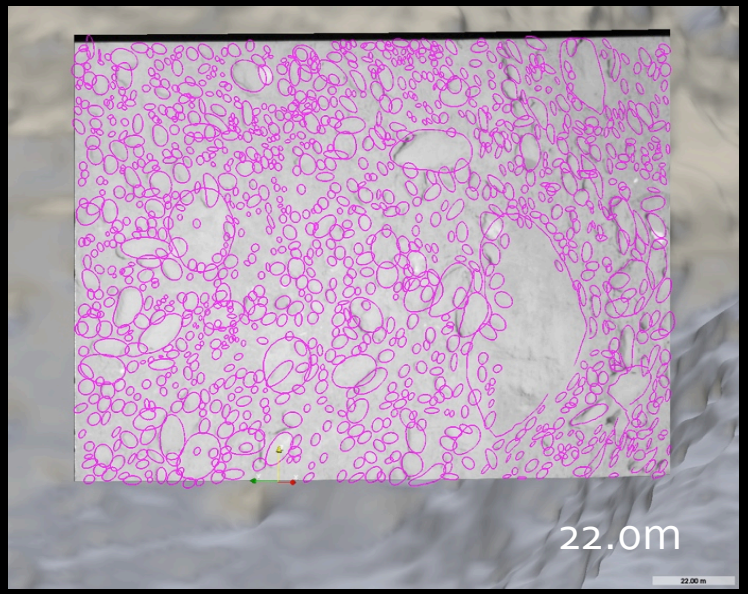
Switch to Structures tab and within that tab click on the Ellipses tab.

Press Edit to begin drawing ellipses.

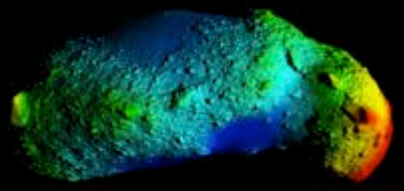
Click on the shape model 3 times, first along the semi-major axis, and then perpendicular along semi-minor axis. After clicking the third point, an ellipse will appear through the 3 points.

When finished drawing ellipses, press the Edit button again to return to normal navigation mode.





Change Flattening and Orientation of Ellipse



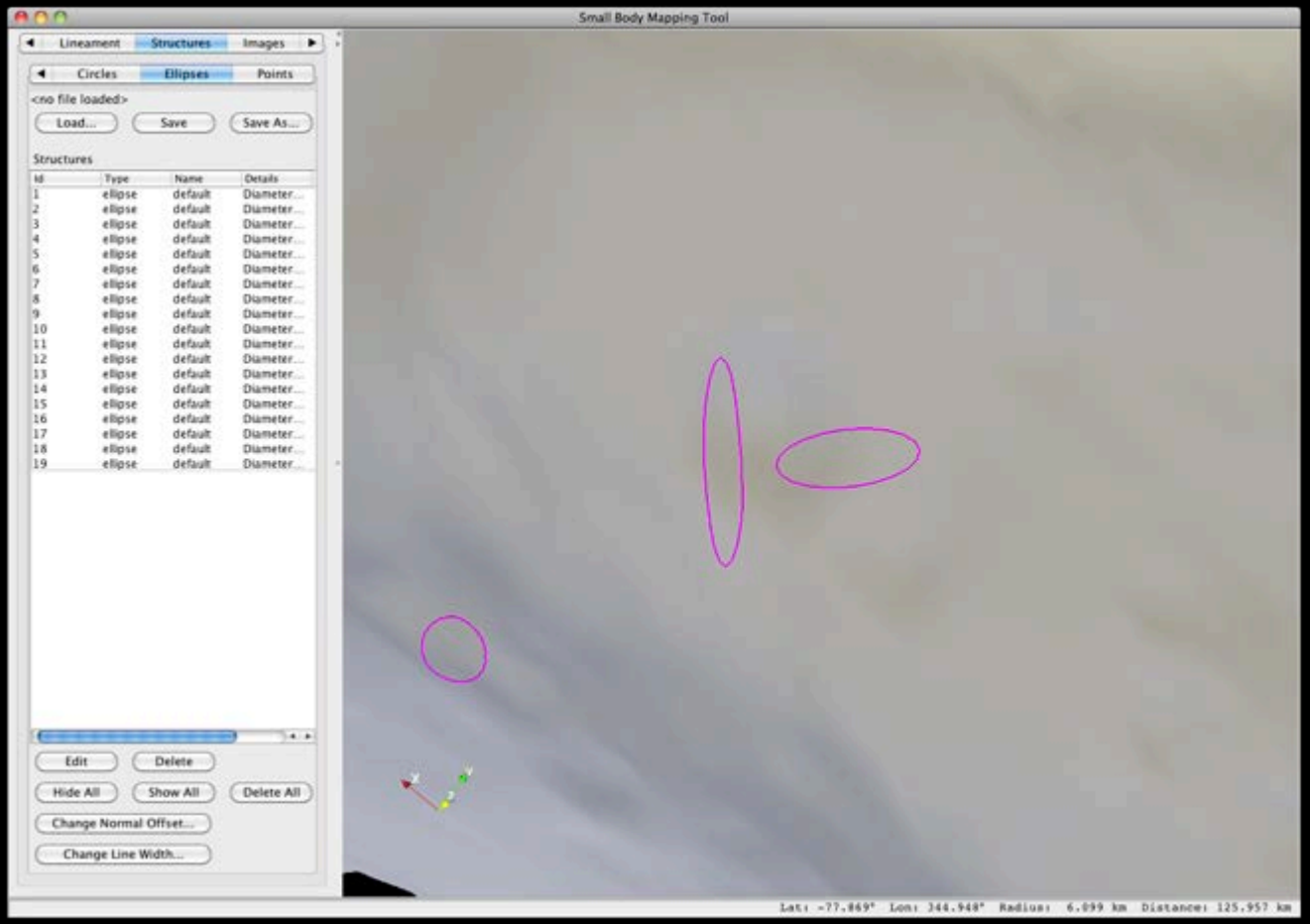
Click on the Edit button to enable Edit mode.

Position the cursor over an ellipse. The cursor will change to a hand shape.

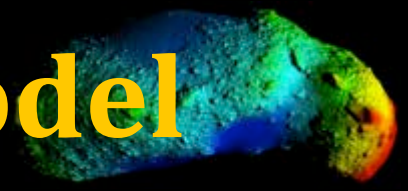
To change the flattening of the ellipse (ratio of semi-minor to semi-major axis), drag the ellipse while holding down the left mouse button and the ‘z’ or ‘/’ (forward slash) key.

To change the orientation of the ellipse, drag the ellipse while holding down the left mouse button and the ‘x’ or ‘.’ (period) key.

The position and size of an ellipse can be changed in the same manner as circles.



Draw Points on Shape Model

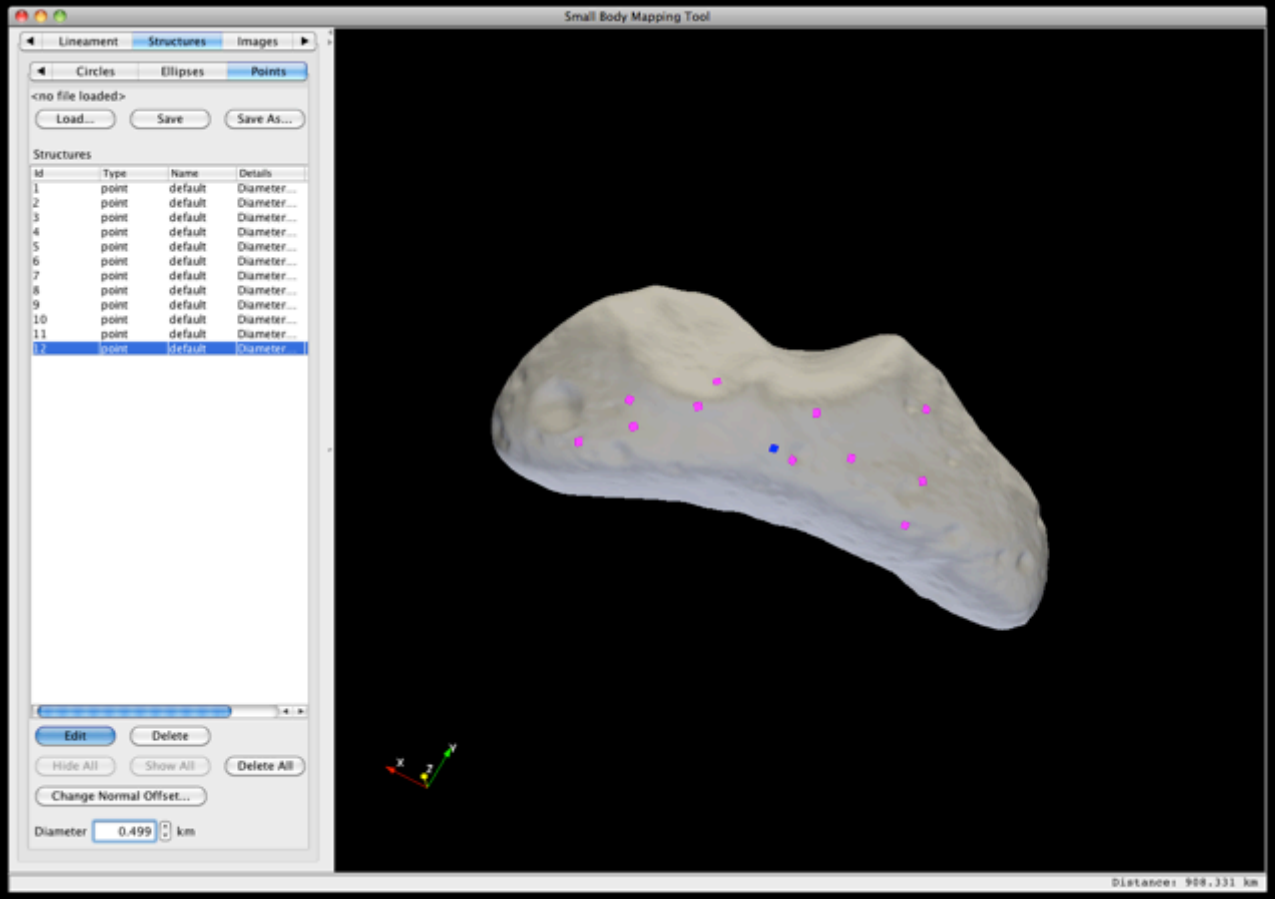


Switch to Structures tab and within that tab click on the Points tab.

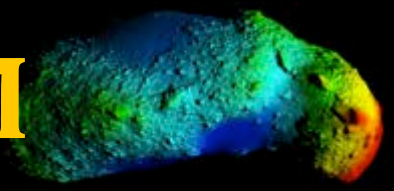
Press Edit to begin drawing points.

Each time you click on the shape model with the left mouse button, a point will appear at that location.

When finished drawing points, press the Edit button again to return to normal navigation mode.



Importing a regional DTM



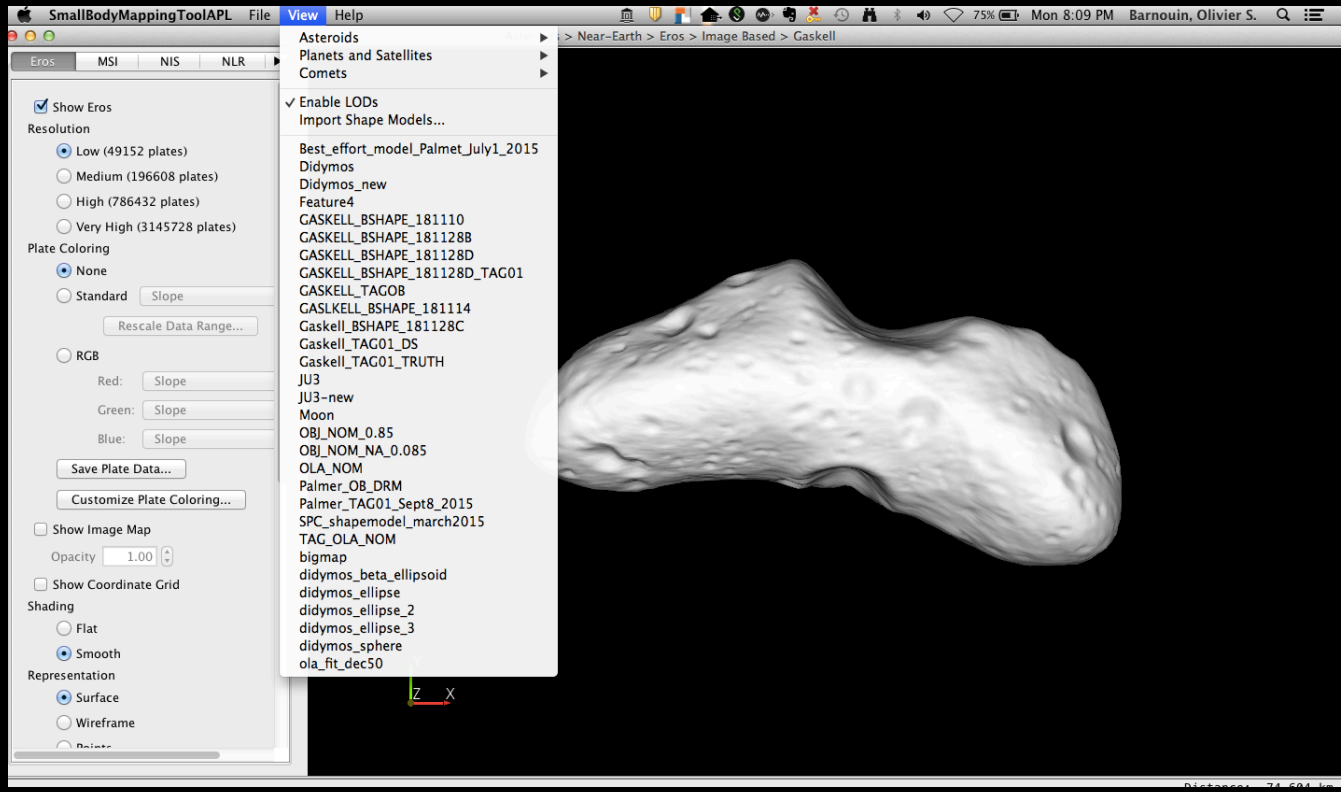
Two main ways to import a shape model into sbmt

Quick and dirty approach – you just made an obj and you want to take a look.

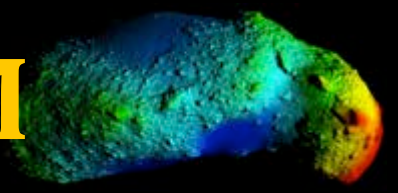
At command line run: Runsbmt nameoffile.obj

If you want to add ancillary data, images and so on.

View>import shape model



Importing a regional DTM

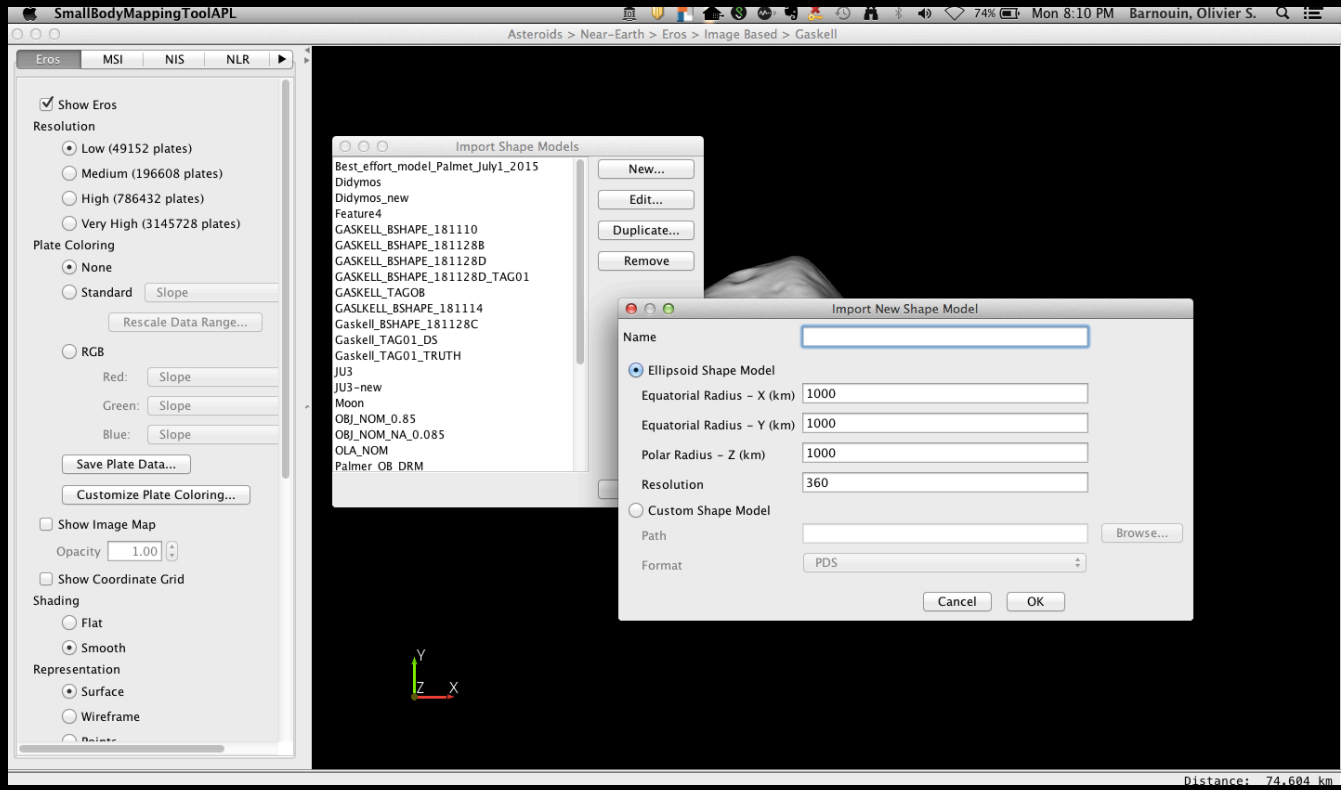


Click on New

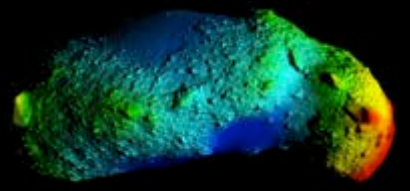
Type in name of new shape model.

Choose new model type: You have the option of generating an ellipsoid or adding a new shape model (OBJ, PLT – Gaskell plate format, or Vtk fomat)

Custom model: browse to model



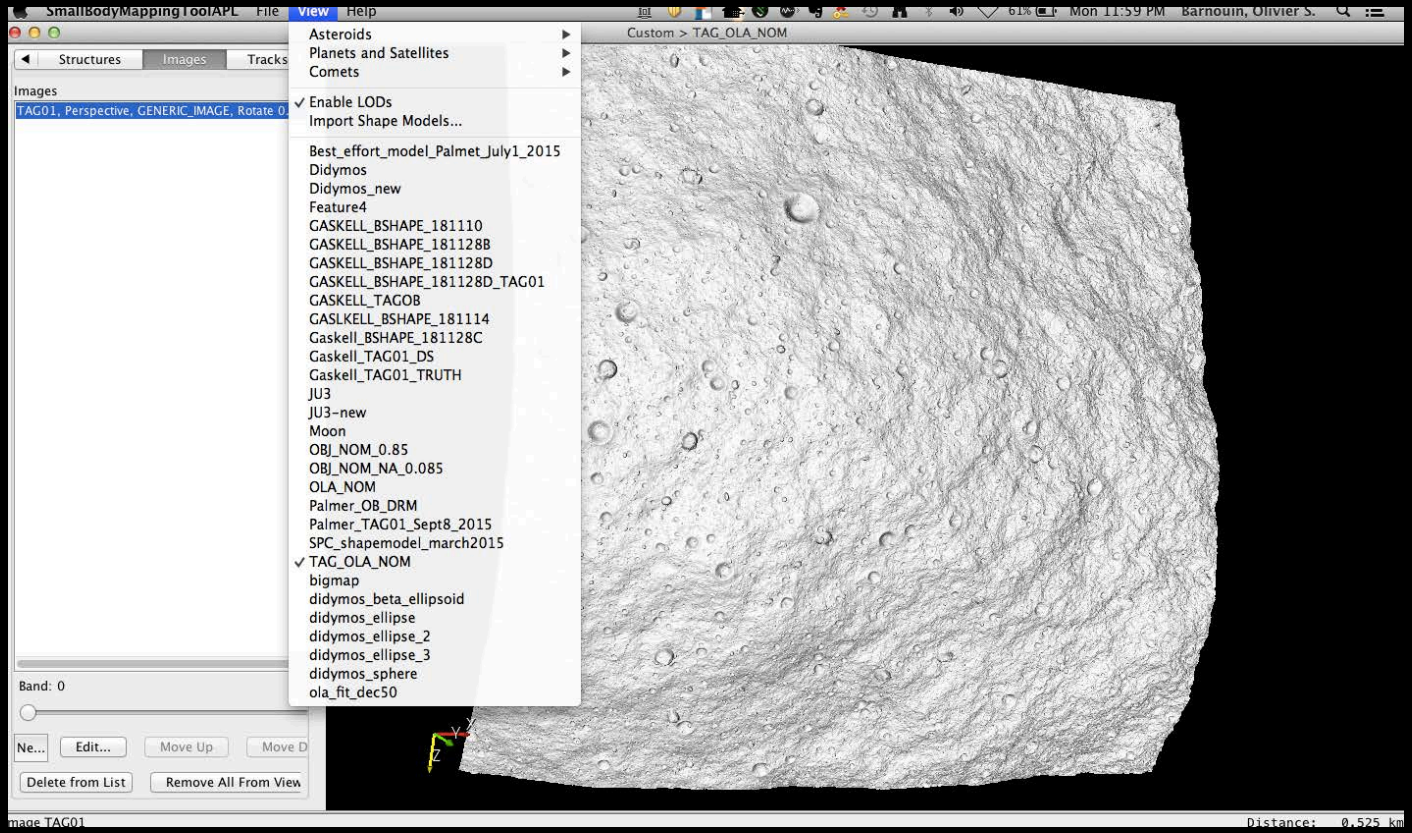
View Imported DTM



Click on View

Select from list of model you imported

Chose OLA DTM



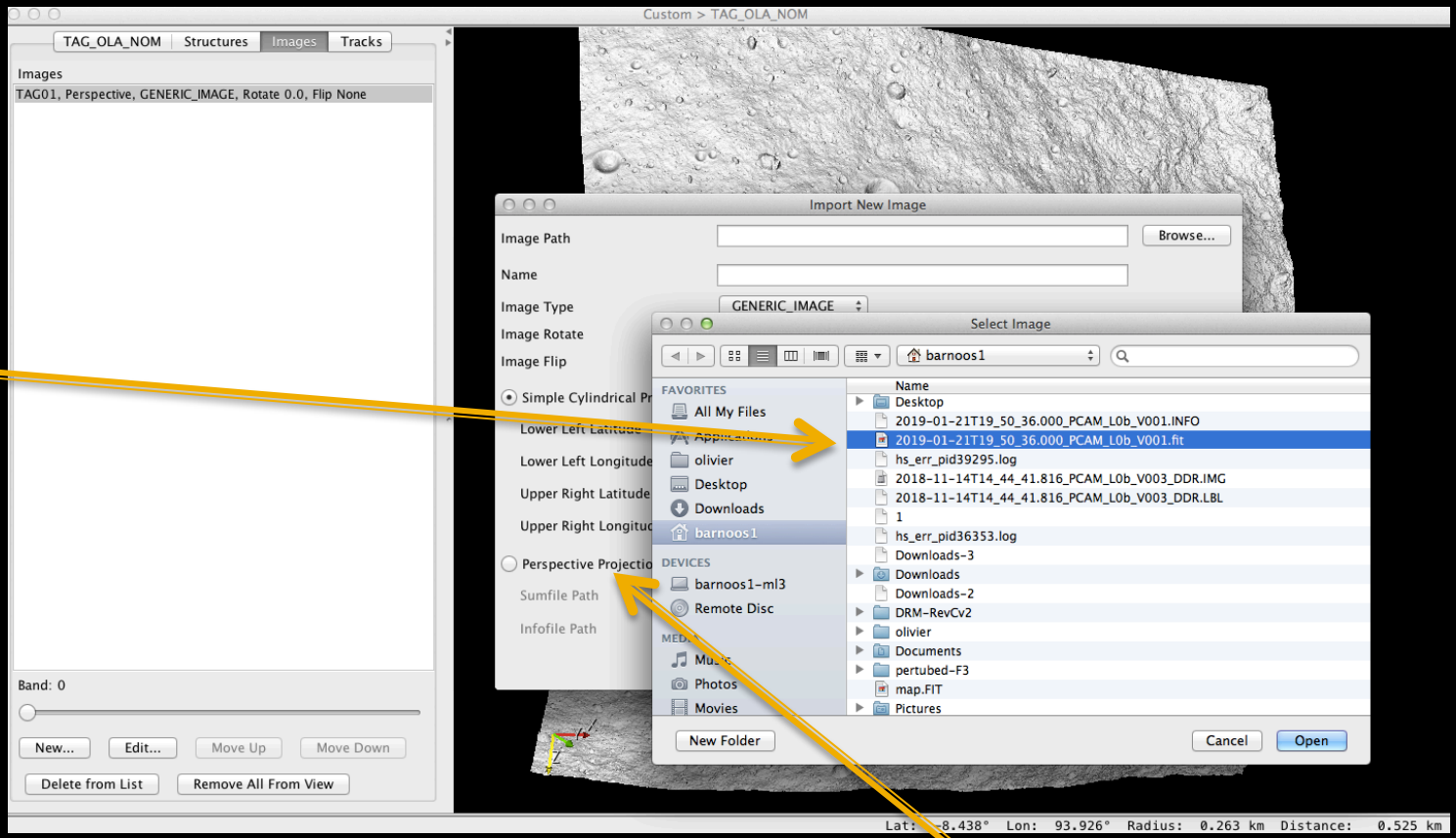
Overlay an Imported Image on Imported DTM

Click on Images

Click on New

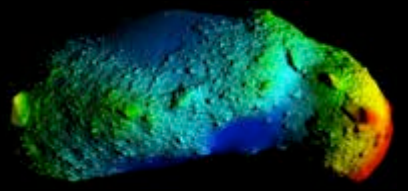
Click on Browse and find image you would like to place over model

You may need to rotate and flip image depending on camera (not required for these Polycam images)



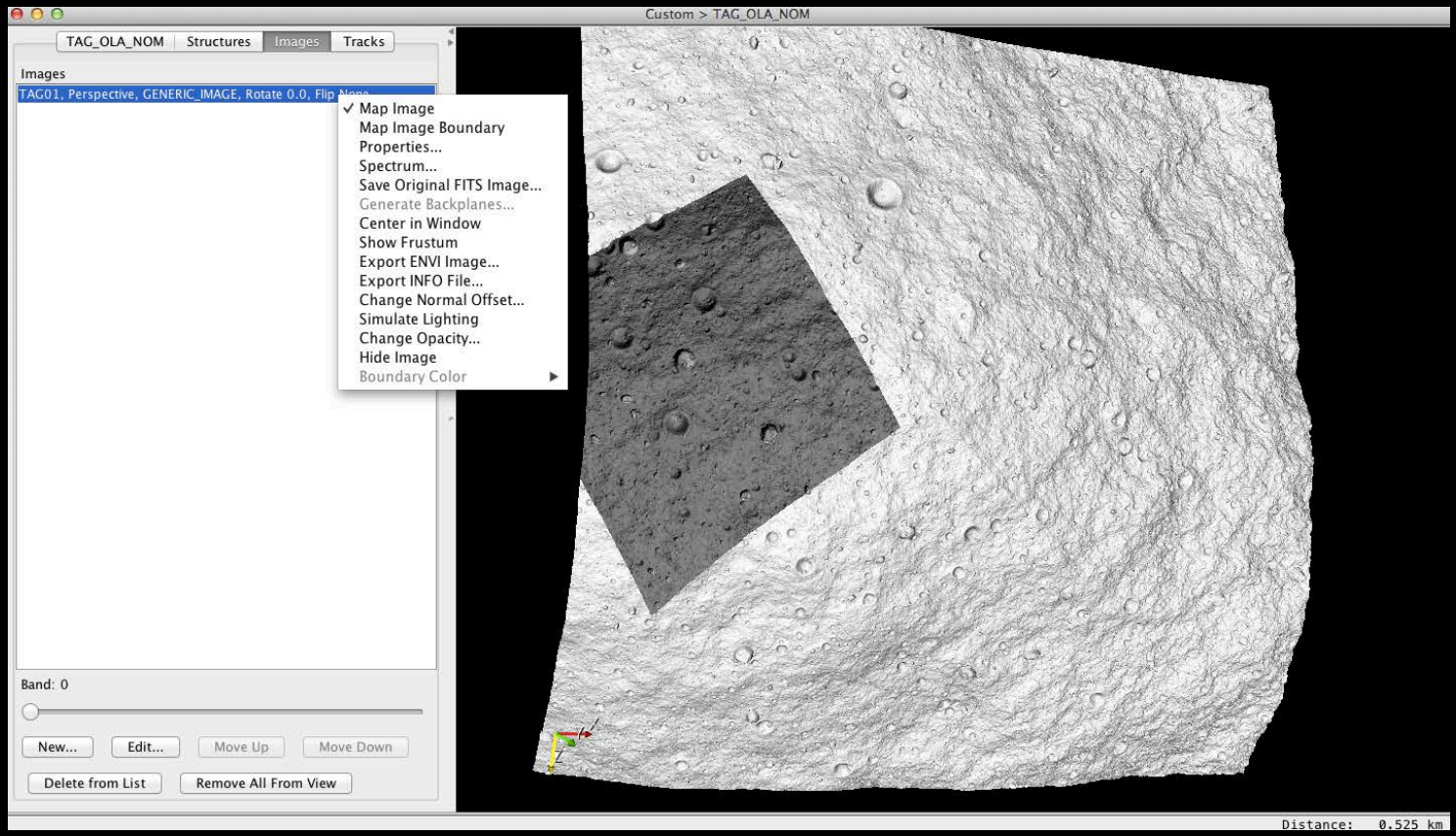
Can overlay image using simple cylindrical projection or sbmt infofile or gaskell sumfile. Infofiles can be generated once an image is saved from SBMT. They are also easy to compute.

View Imported Image on Imported DTM

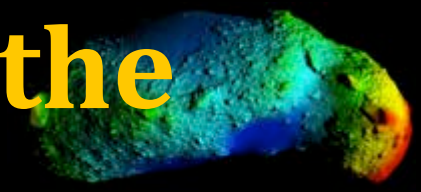


Left click on image that you imported

Click Map image



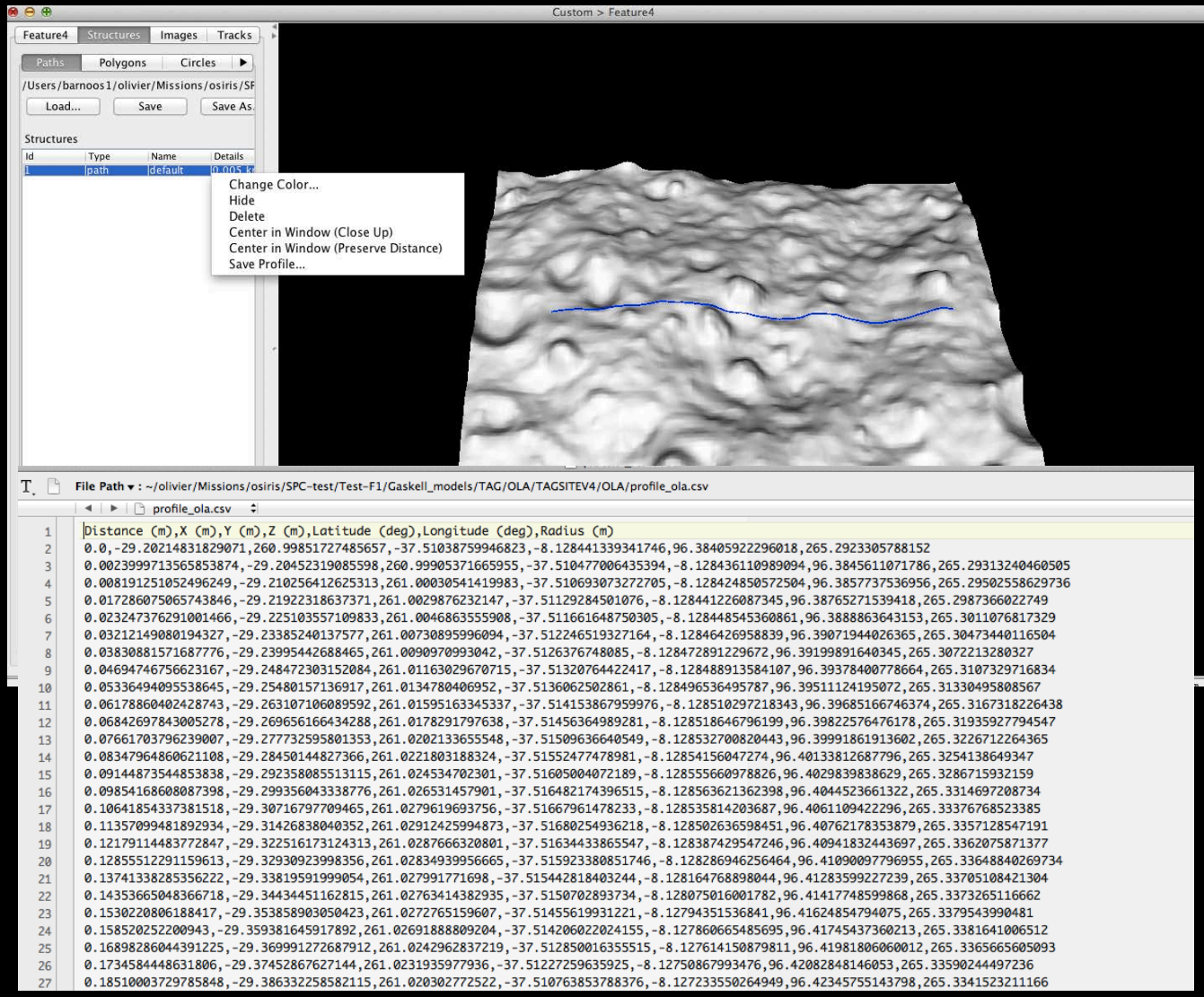
Drawing a profile across the asteroid



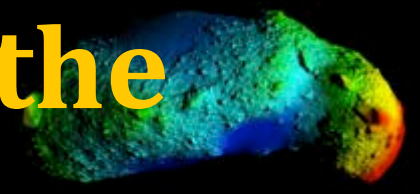
Switch to Structures tab and within that tab click on the Path tab.

Press Edit to begin drawing path. For profile use only two points.

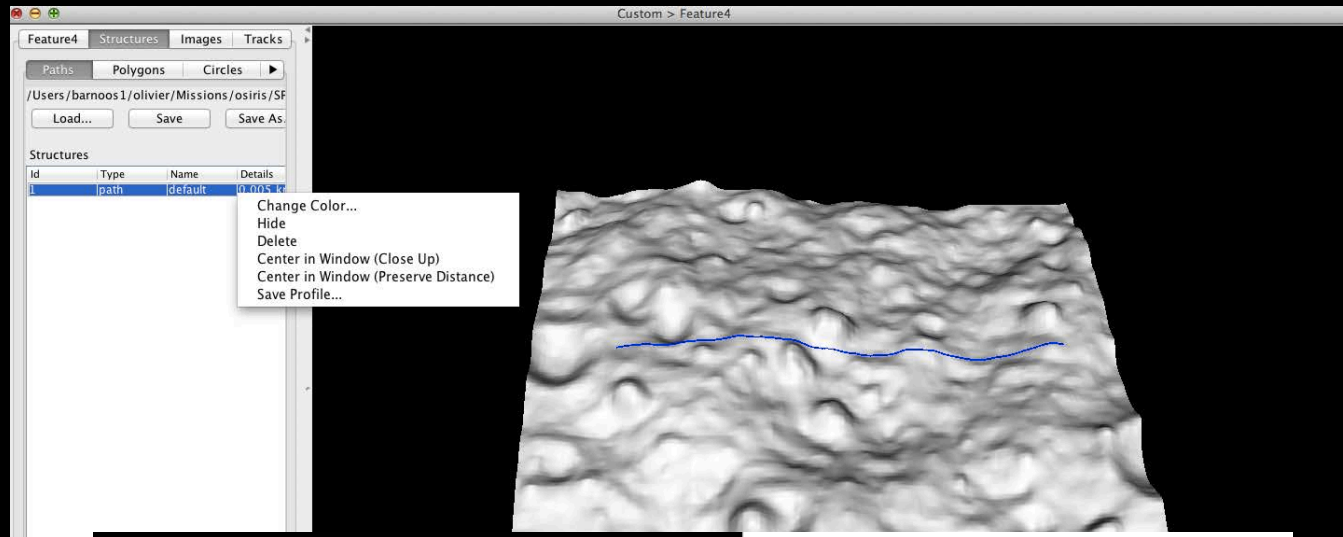
Press Edit to get out of edit mode. Then right click on the path you just created and save profile. It will output all available data associated with shape model along path.

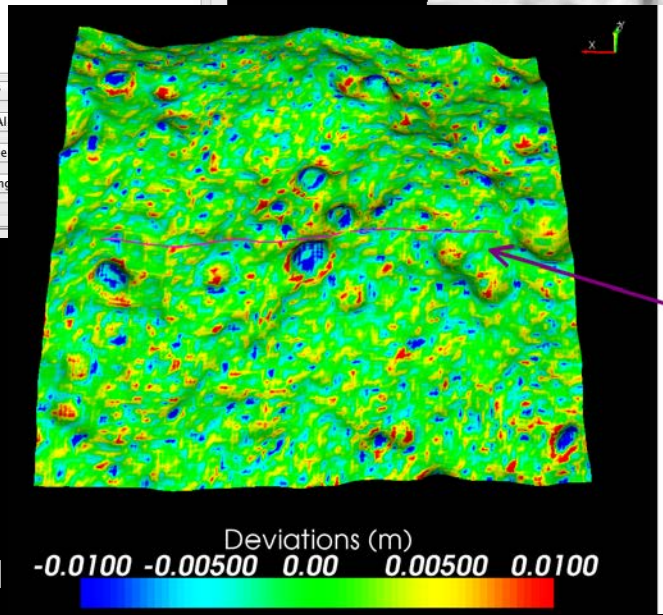


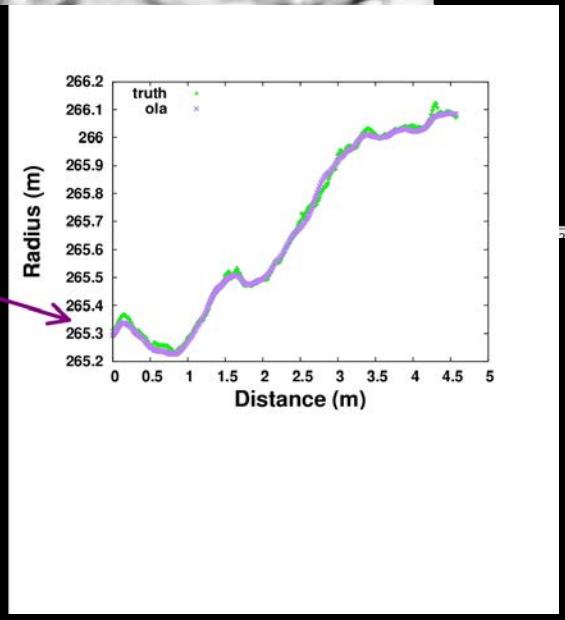
Drawing a profile across the asteroid



Import profile in your favorite plotting program (gnuplot output shown)

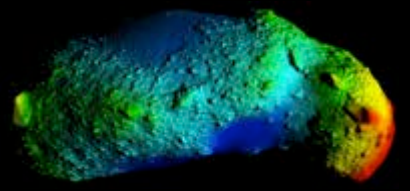




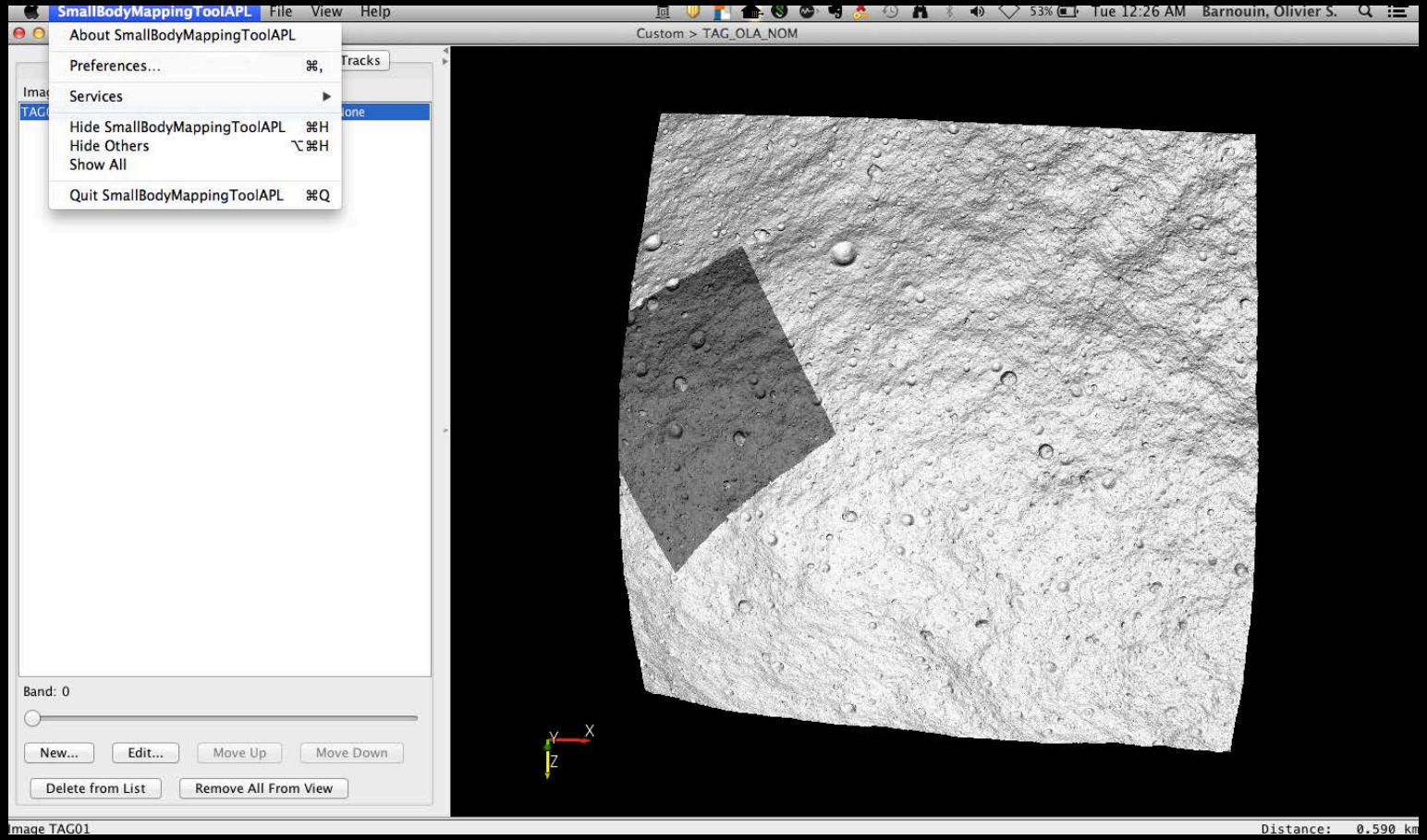


Difference between a truth DTM and a simulated OLA DTM

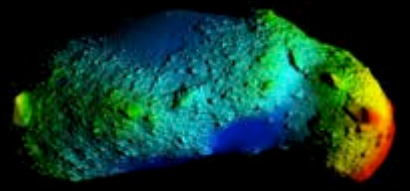
Changing preferences



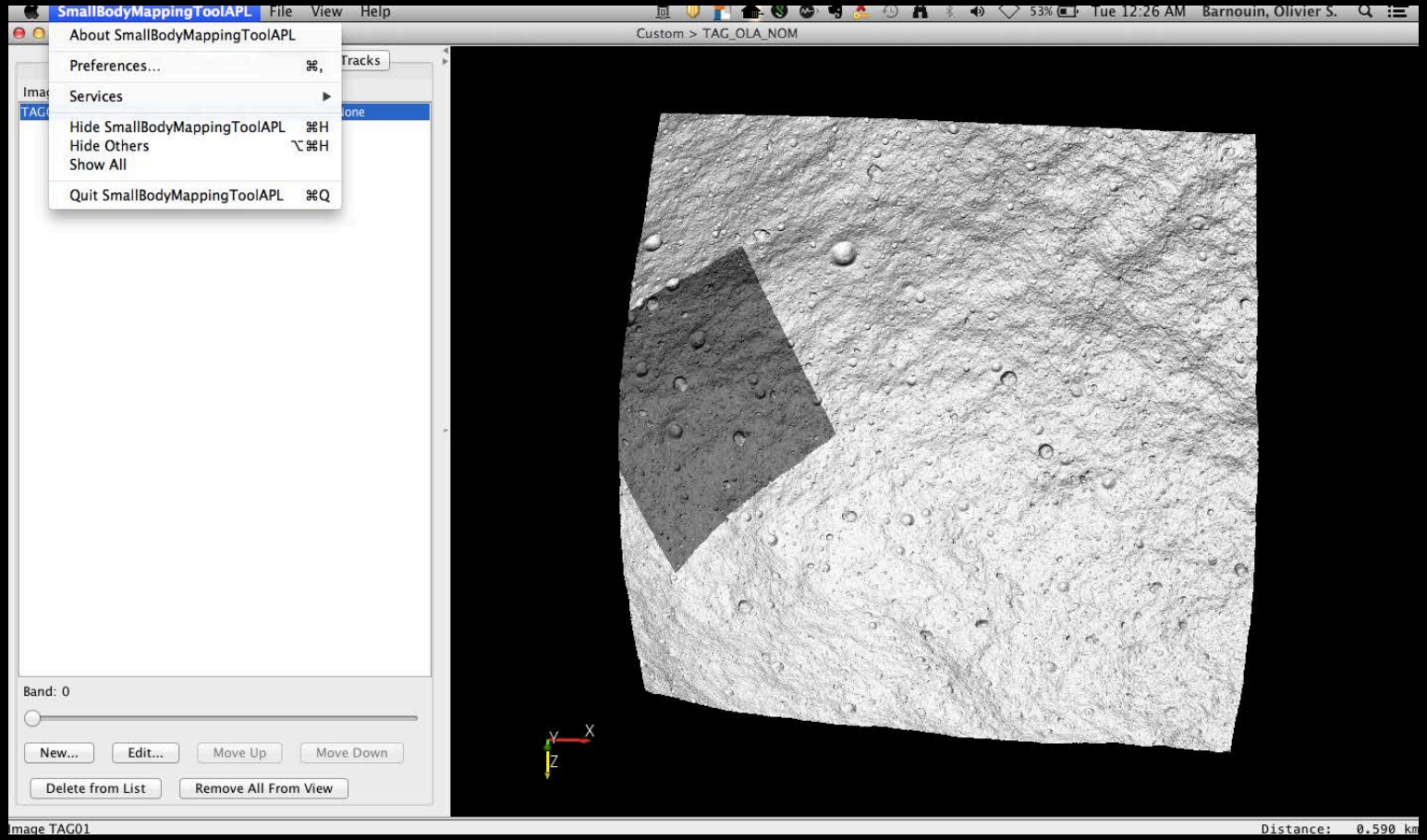
Want a white background? Change the color of the axes shown or remove it altogether?
Changing lighting of model?



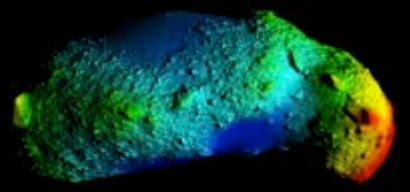
Changing preferences



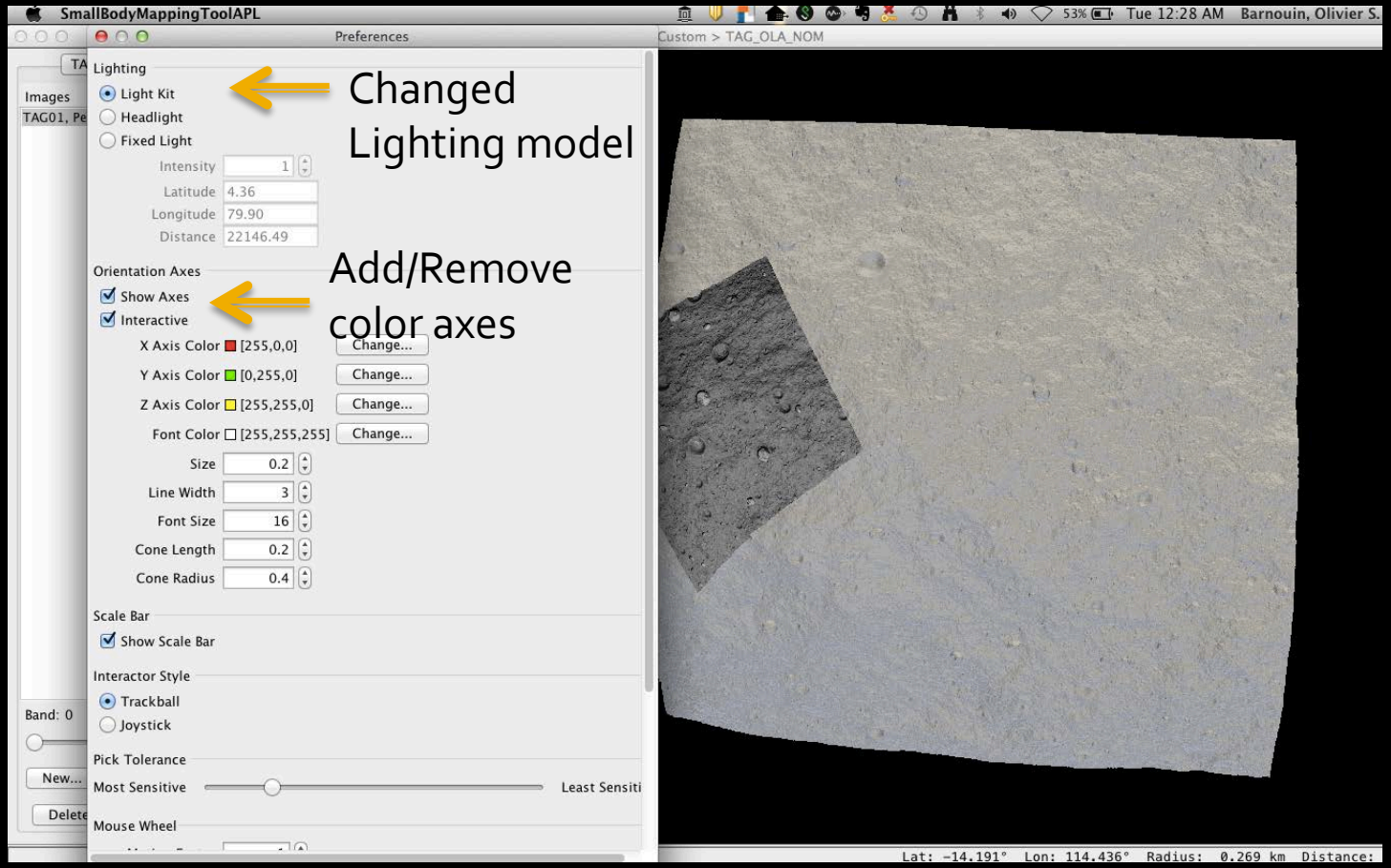
Want a white background? Change the color of the axes shown or remove it altogether?
Changing lighting of model?



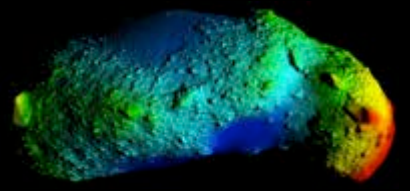
Changing preferences



Want a white background? Change the color of the axes shown or remove it altogether?
Changing lighting of model?



Changing preferences



Want a white background? Change the color of the axes shown or remove it altogether?
Changing lighting of model?