High Resolution Global Topography of Itokawa from Hayabusa Imaging and LIDAR Data

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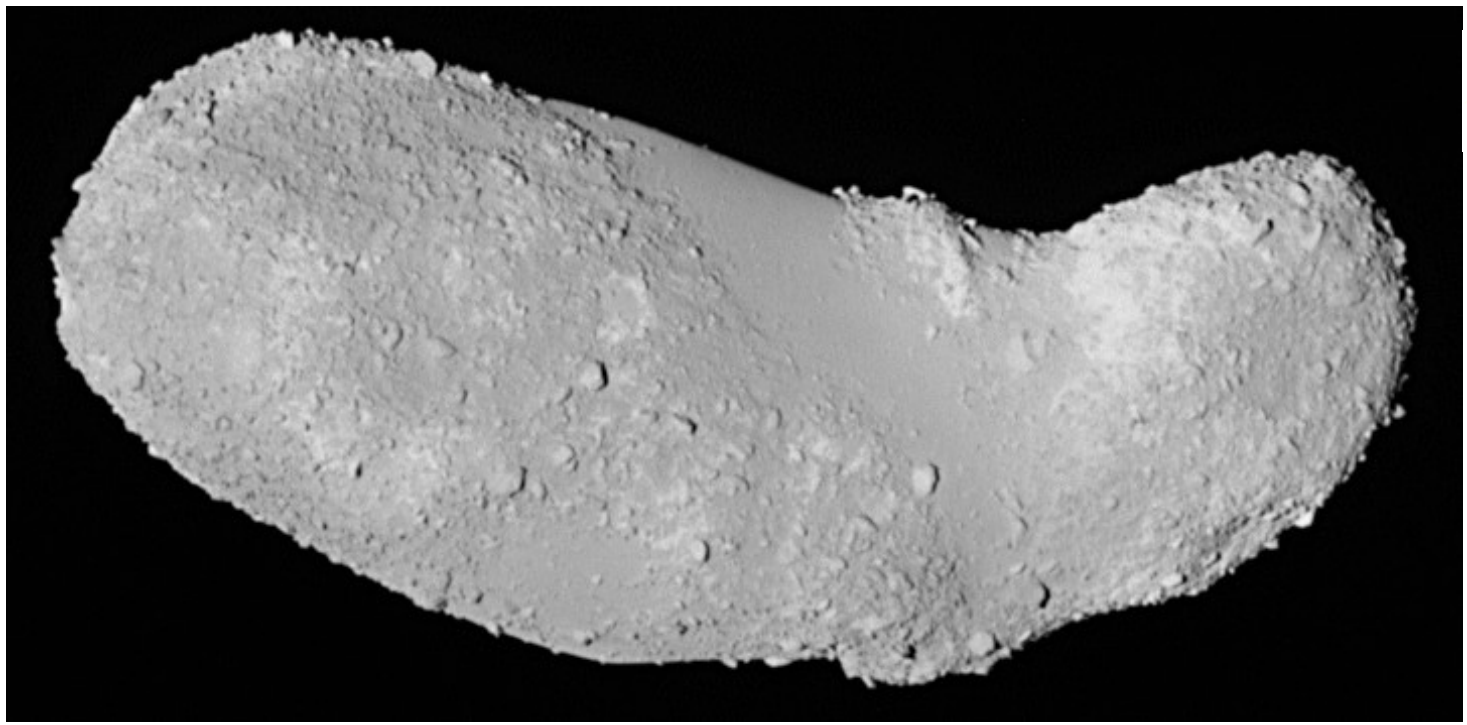
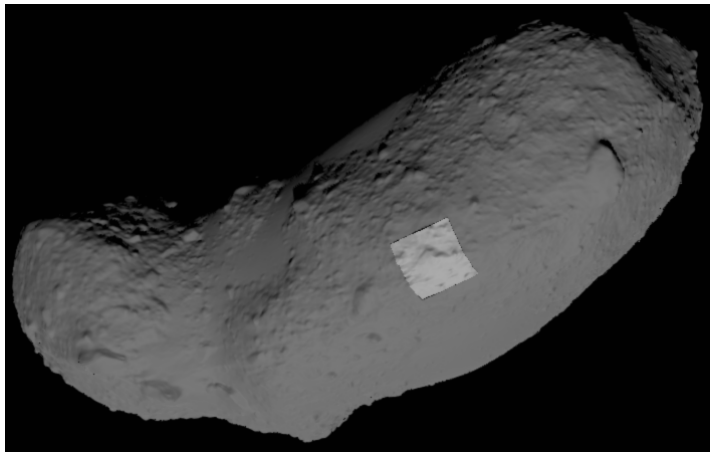
[1]JPL/Caltech, [2]APL/JHU, [3]U. Michigan, [4]Kobe University, [5]JAXA/ISAS.

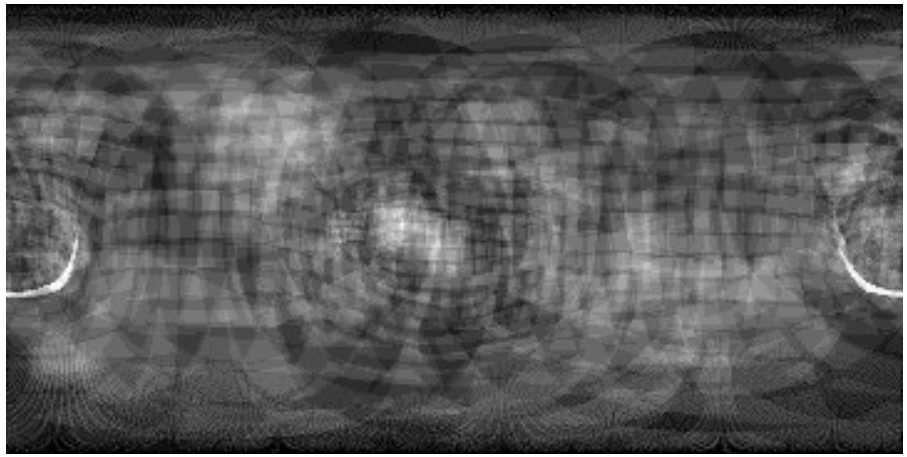


Procedure Summary

Basic data product: landmark map (L-map)
Digital topo/albedo map from SPC



Surface tiled with overlapping L-maps of varying resolution



Observables:

a) Image loc. of L-map
b) Limb loc. of L-map
c) L-map overlaps
d) Image brightness dist.
e) LIDAR, Doppler
f) Nominal values

Estimated Quantities (Inputs):

A) L-map center (a,b,c,B)
B) s/c location/attitude (a,b,e,f,A)
C) L-map slope/albedo (d,A,B,D)
D) L-map topography (b, A, C, D)
E) Pole (a, B)

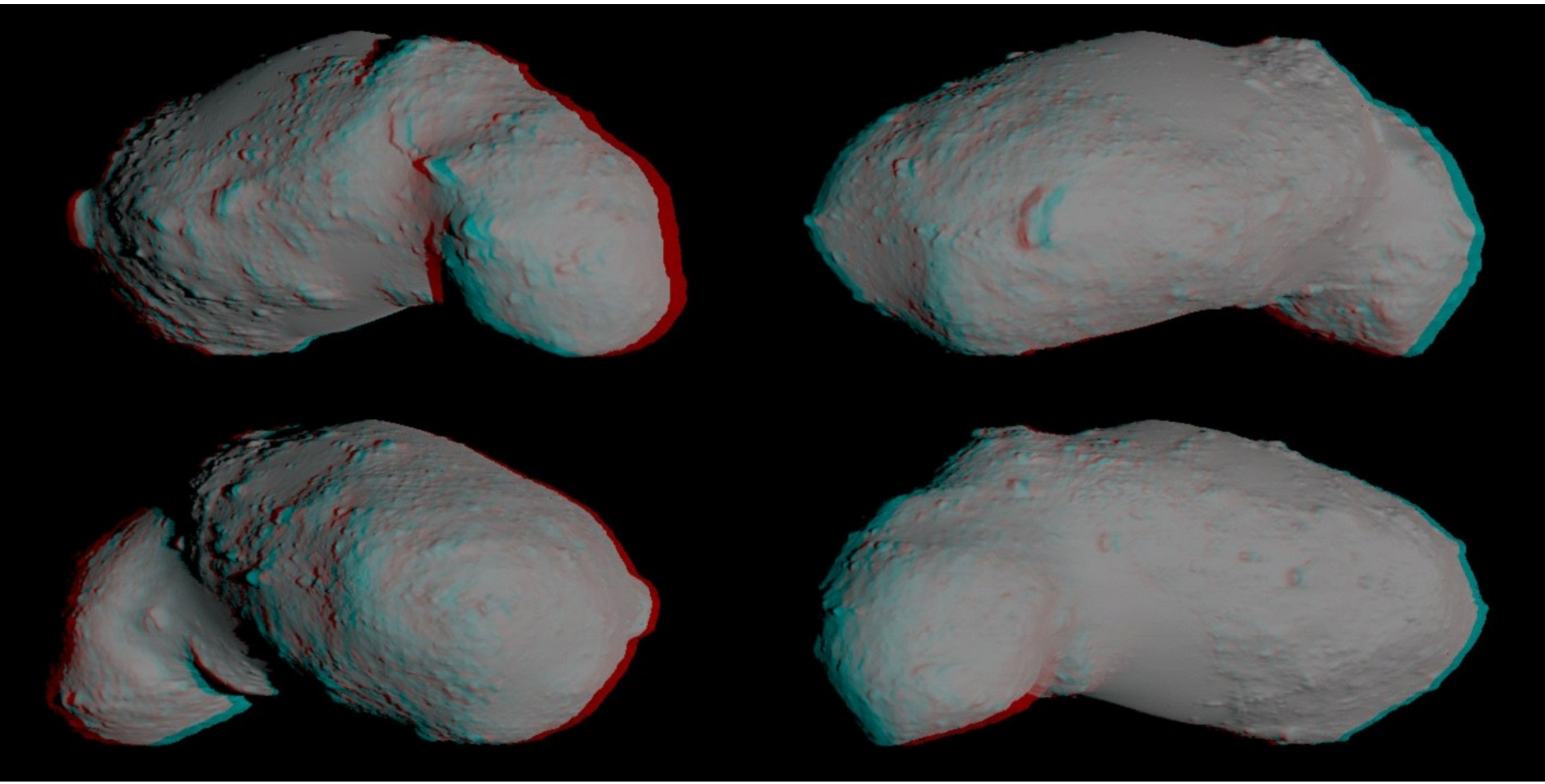
Iterative estimation process

Errors:

10 times smaller than LIDAR
100 times smaller than stereo
Itokawa surface error: 20 cm
Hayabusa s/c error: 1.5 m
Point-to-point slope error < 5º
Pole error < 0.1º

Global Topography Model (GTM)

800 individual L-maps, representing almost 8 million vectors went into constructing this 1.57 million vector global model.



Physical Properties

Volume: 0.0177 km^3 Surface/ Area: 0.403 km^2

GM: 2.36 ± 0.15 km^3/s^2 Mass (10^{10}kg): 3.54 ± 0.2 Density: 1989 ± 120 kg/m^3

Pole (Earth Equatorial): 90.026º ± .013, -67.027º ± .003

Pole (Ecliptic): 268.771º, -89.534º

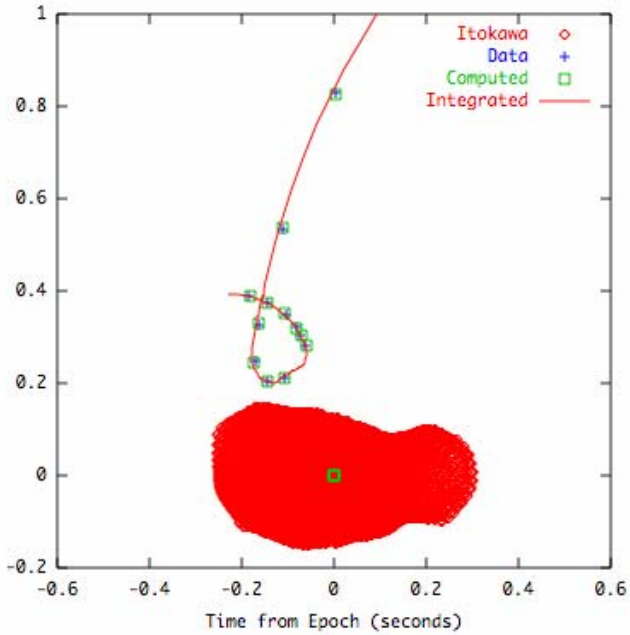
$$I/M: \begin{matrix} 0.00635 & 0.00073 & -0.00004 \\ 0.00073 & 0.02122 & -0.00002 \\ -0.00004 & -0.00002 & 0.02234 \end{matrix} \ km^2$$

Principal Axis Frame:

I/M: (0.00631, 0.02126, 0.02234 km^2

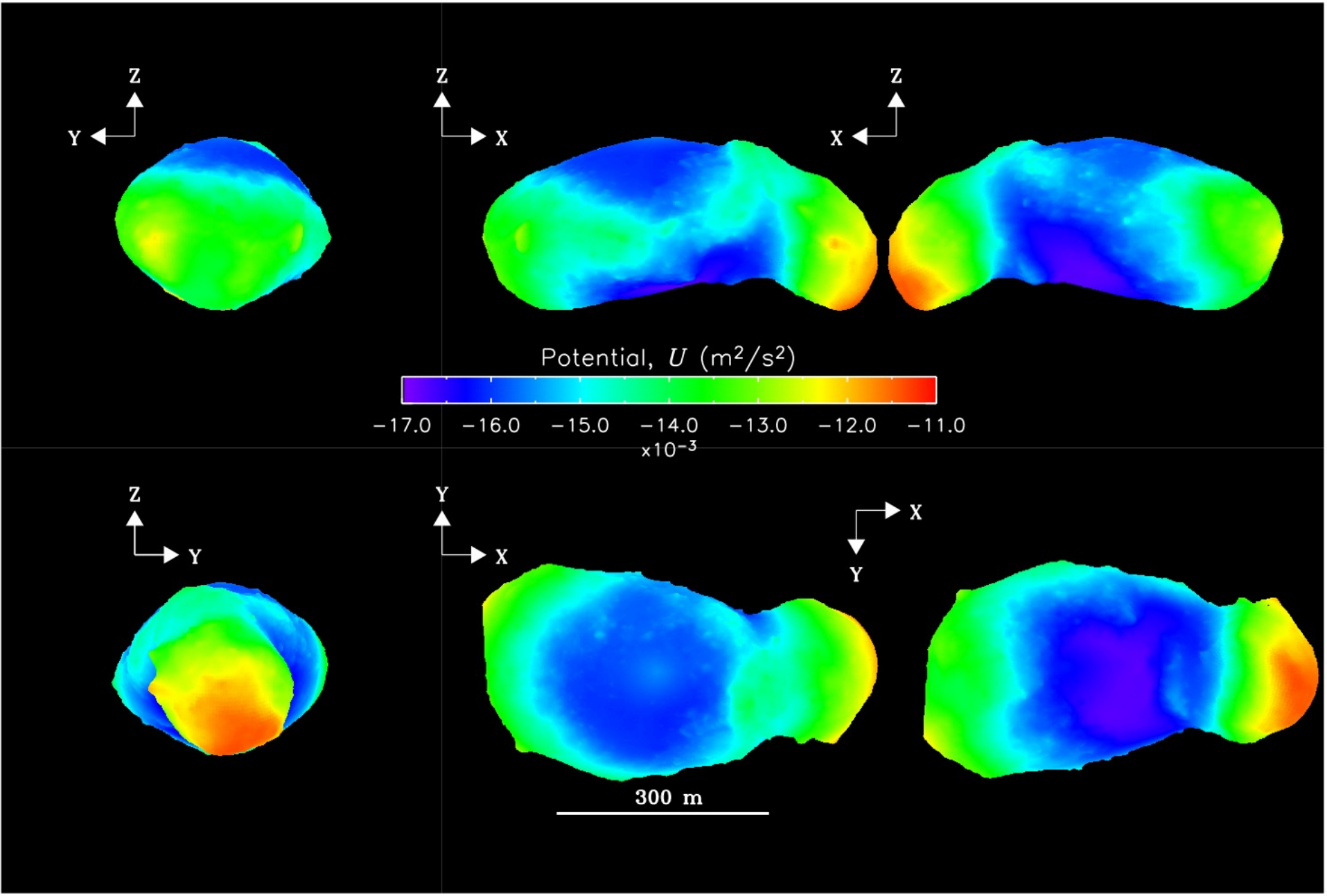
Pole: (0.0000, 0.0178, 0.9998) (1.01º from z-axis)

Equivalent Ellipsoid: (0.3053, 0.1361, 0.1146) km

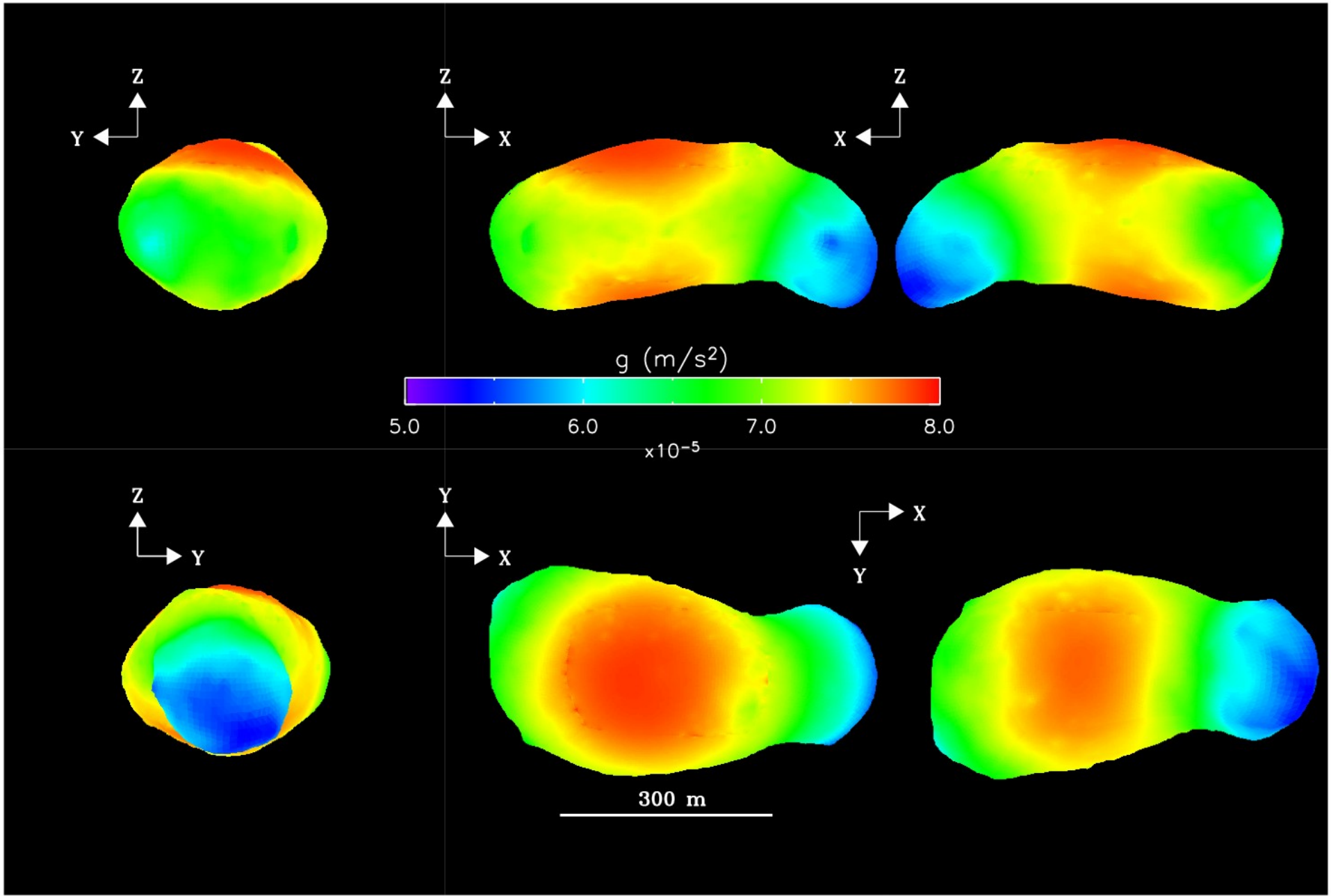


Mass determination from landmark navigation (Nov.12)

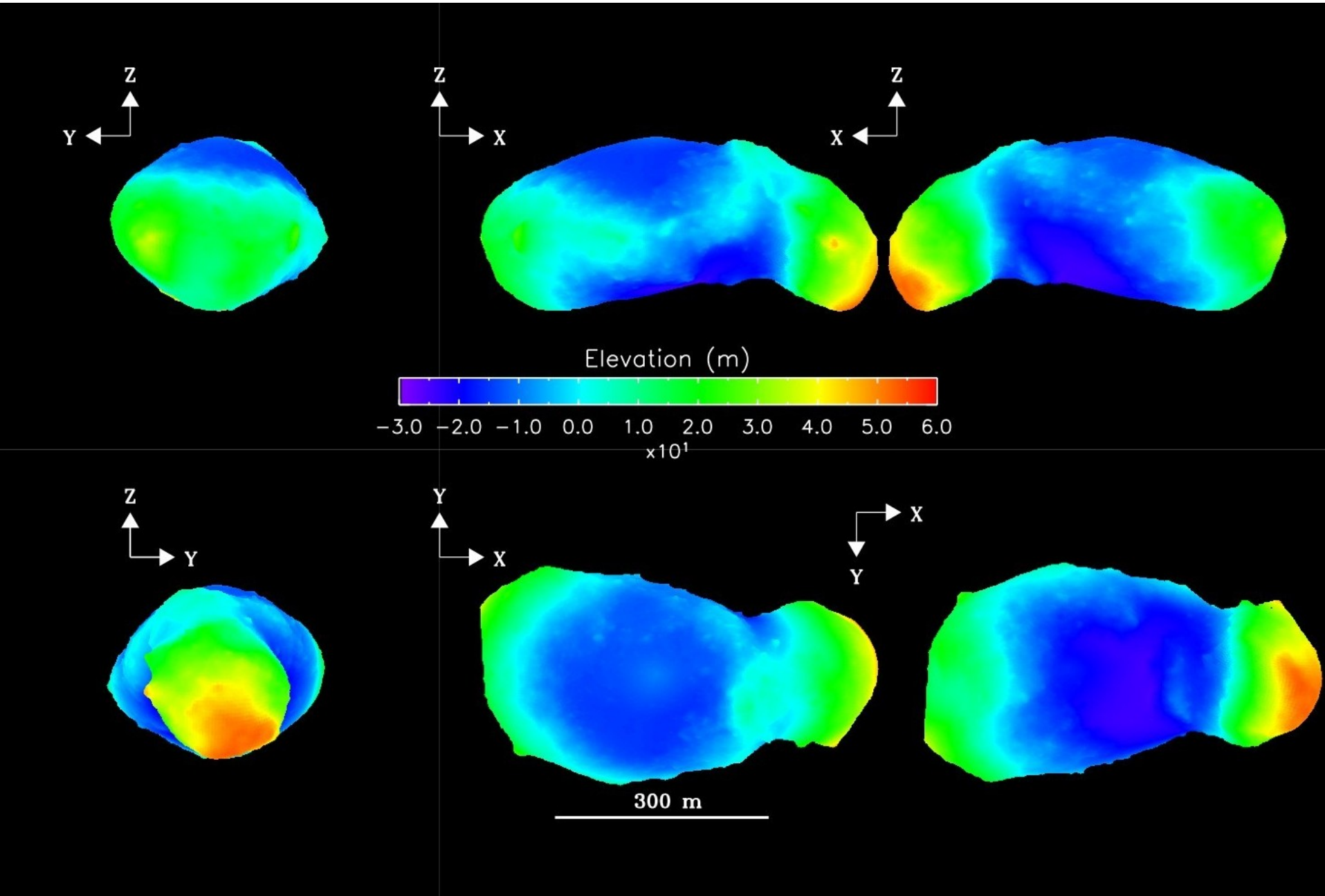
Gravitational/Rotational Potential (100k vector model)



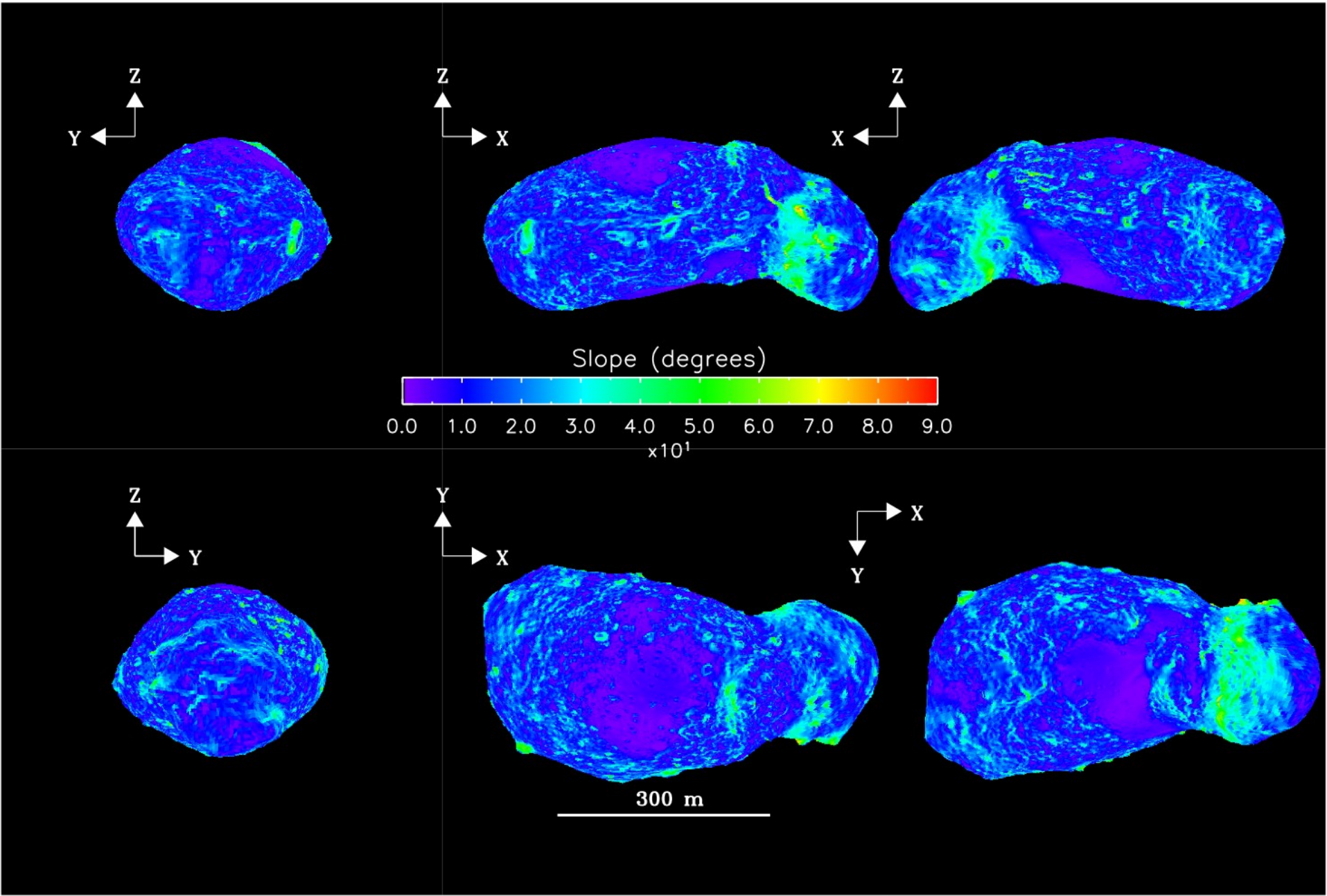
Surface Gravity (10^{-5} m/s^2)



Geoid Relative Elevation (m x 10)



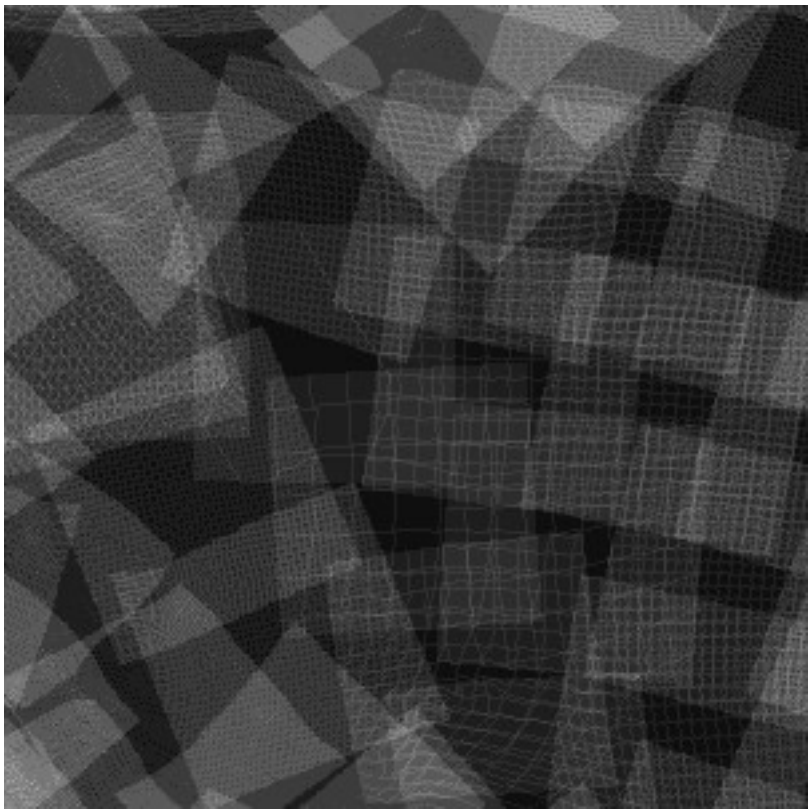
Geoid Relative Slope (x 10 degrees)



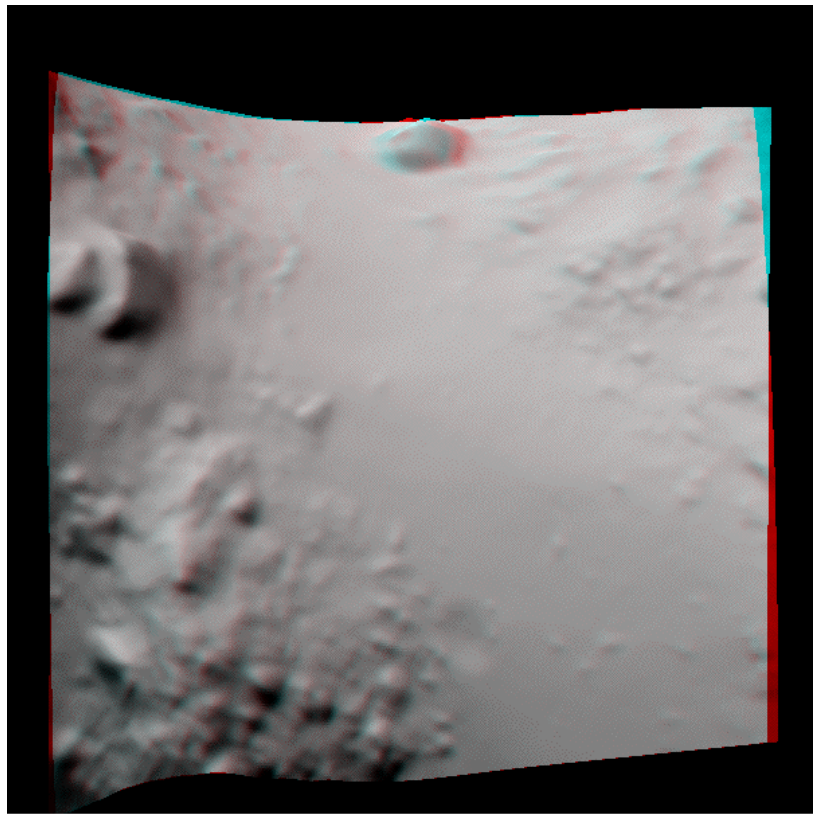
High Resolution Topography Maps

An averaged-slope-to-height integration is used to construct composite high-resolution topography maps of selected regions.

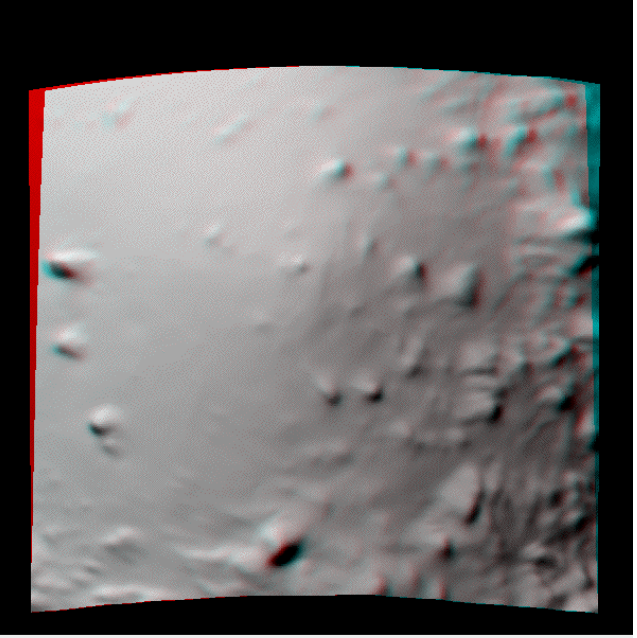
Highest resolution maps used in construction: 40 cm/pixel.



3D image of high-resolution map of Hayabusa landing site (20° slant).

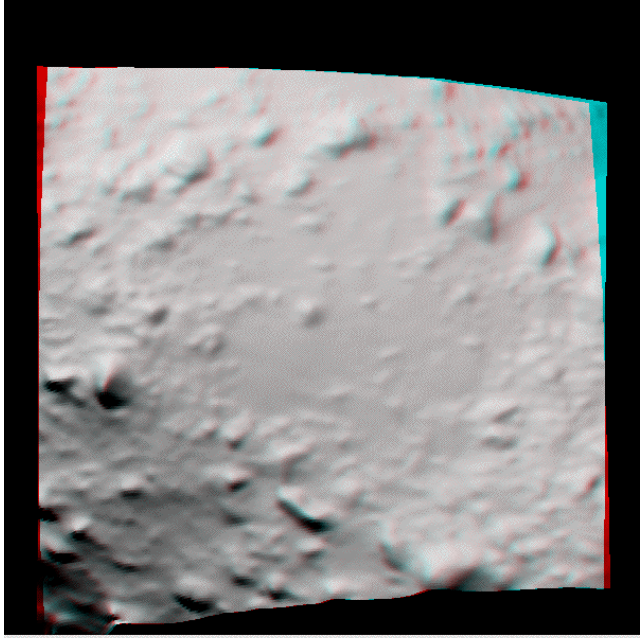


MUSSEA Lt=10.00S Ln=320.00W Rd= 0.123 Sz=0.120 km



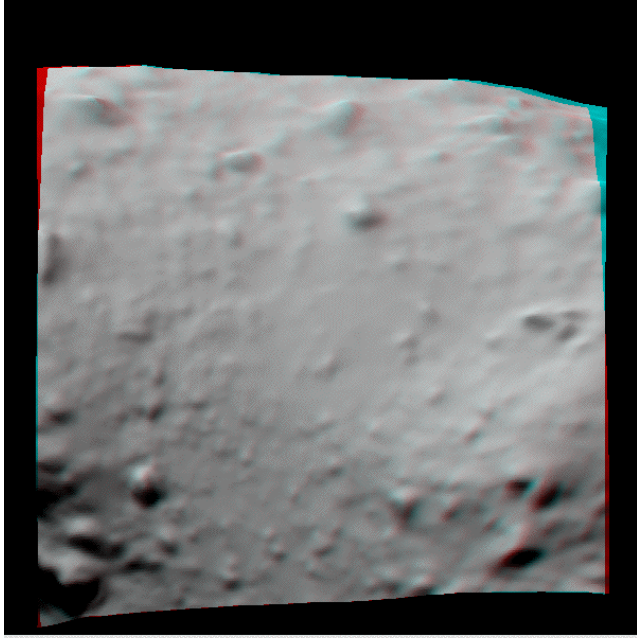
NOPOLE Lt=89.90N Ln= 0.00W Rd= 0.124 Sz=0.103 km

North Pole



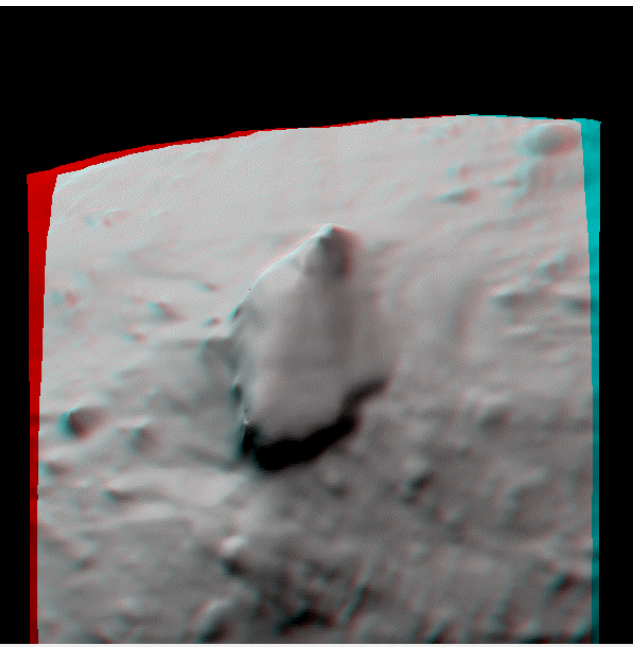
UCHINO Lt=44.50N Ln=256.00W Rd= 0.127 Sz=0.126 km

Uchinoura



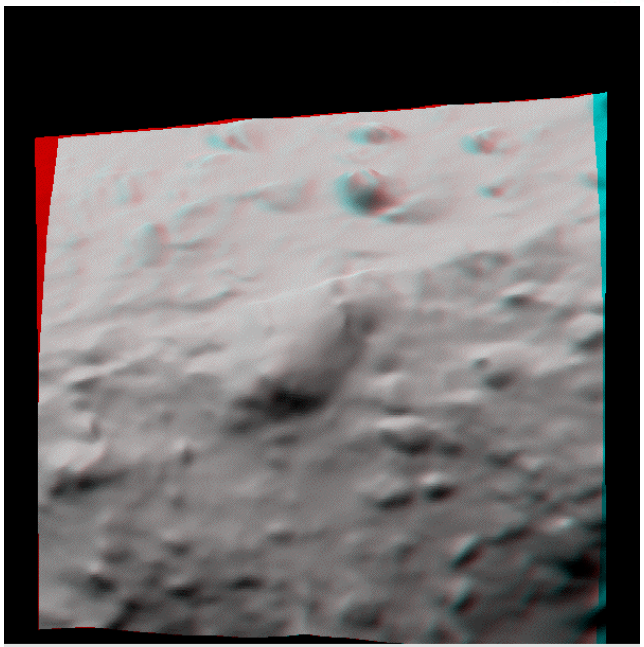
WOOMER Lt=12.00S Ln=185.00W Rd= 0.245 Sz=0.103 km

Woomera



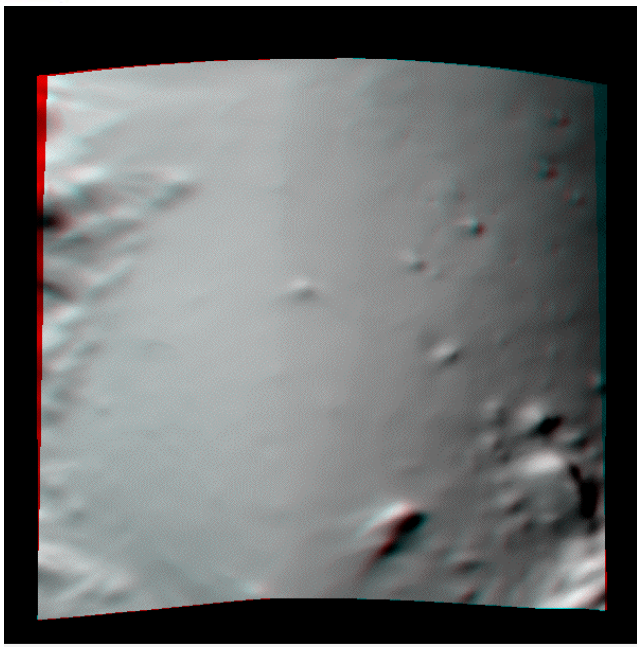
YOSHIN Lt= 4.10S Ln=150.18W Rd= 0.228 Sz=0.103 km

Yoshinodai



TSUKUB Lt= 0.00S Ln= 84.50W Rd= 0.146 Sz=0.103 km

Tsukuba

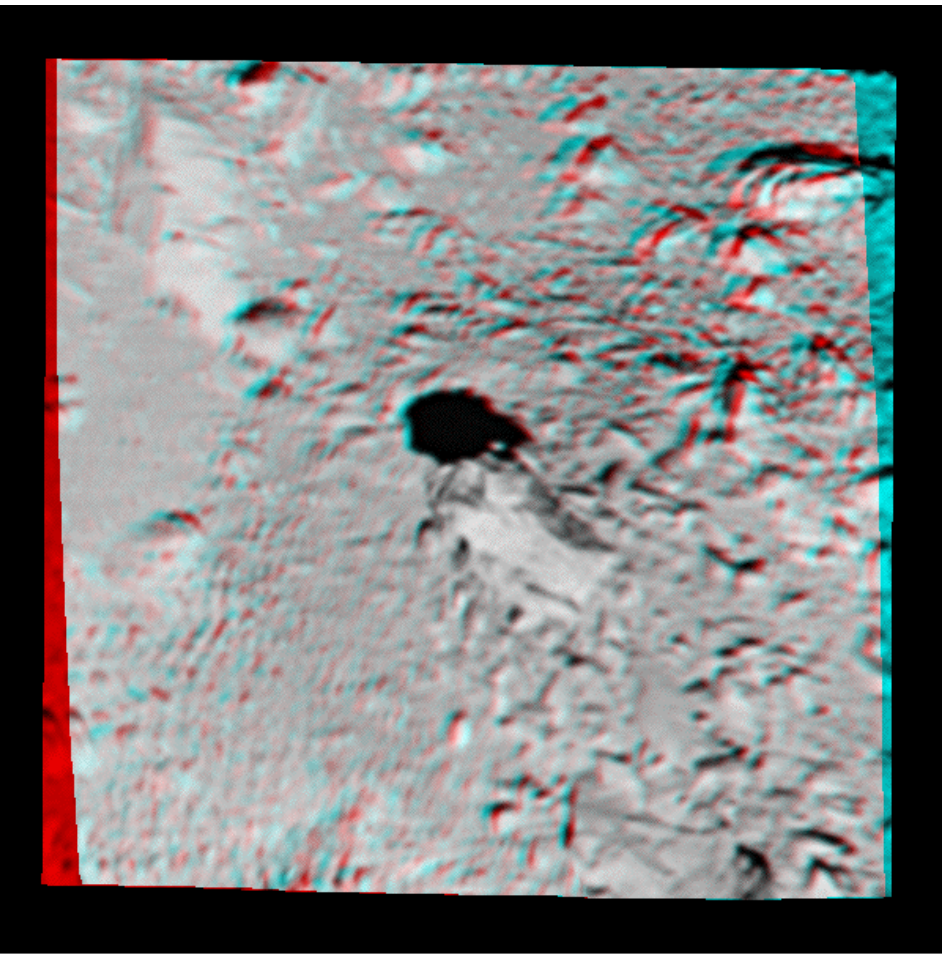


SOPOLE Lt=89.90S Ln= 0.00W Rd= 0.093 Sz=0.103 km

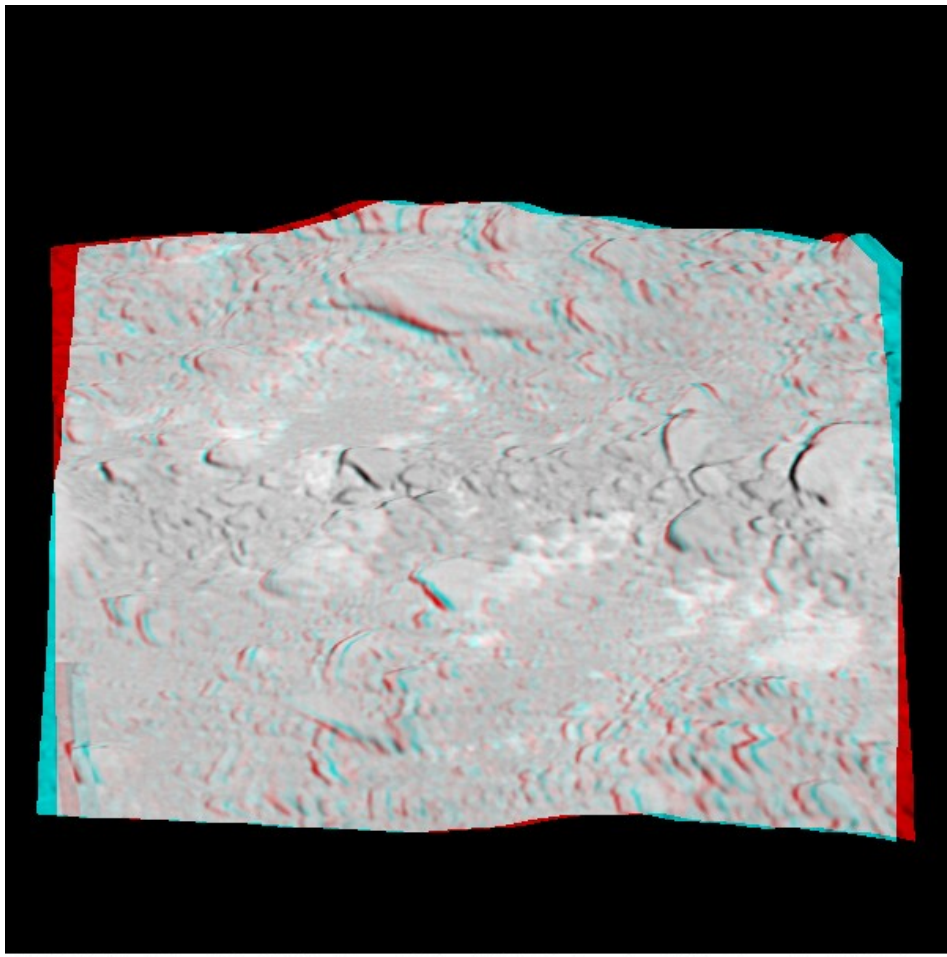
South Pole

Three Dimensional Image Reconstruction

Topography from a high-resolution composite map is used to re-sample imaging data for three dimensional viewing.



PENCIL Lt= 6.71N Ln= 27.21W Rd= 0.223 Sz=0.100 km

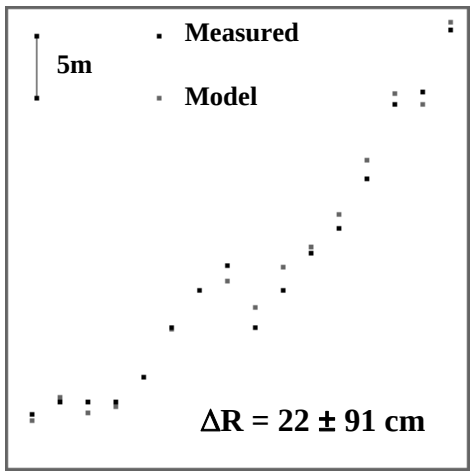


HIRDY2 Lt=15.95N Ln=310.63W Rd= 0.132 Sz=0.051 km

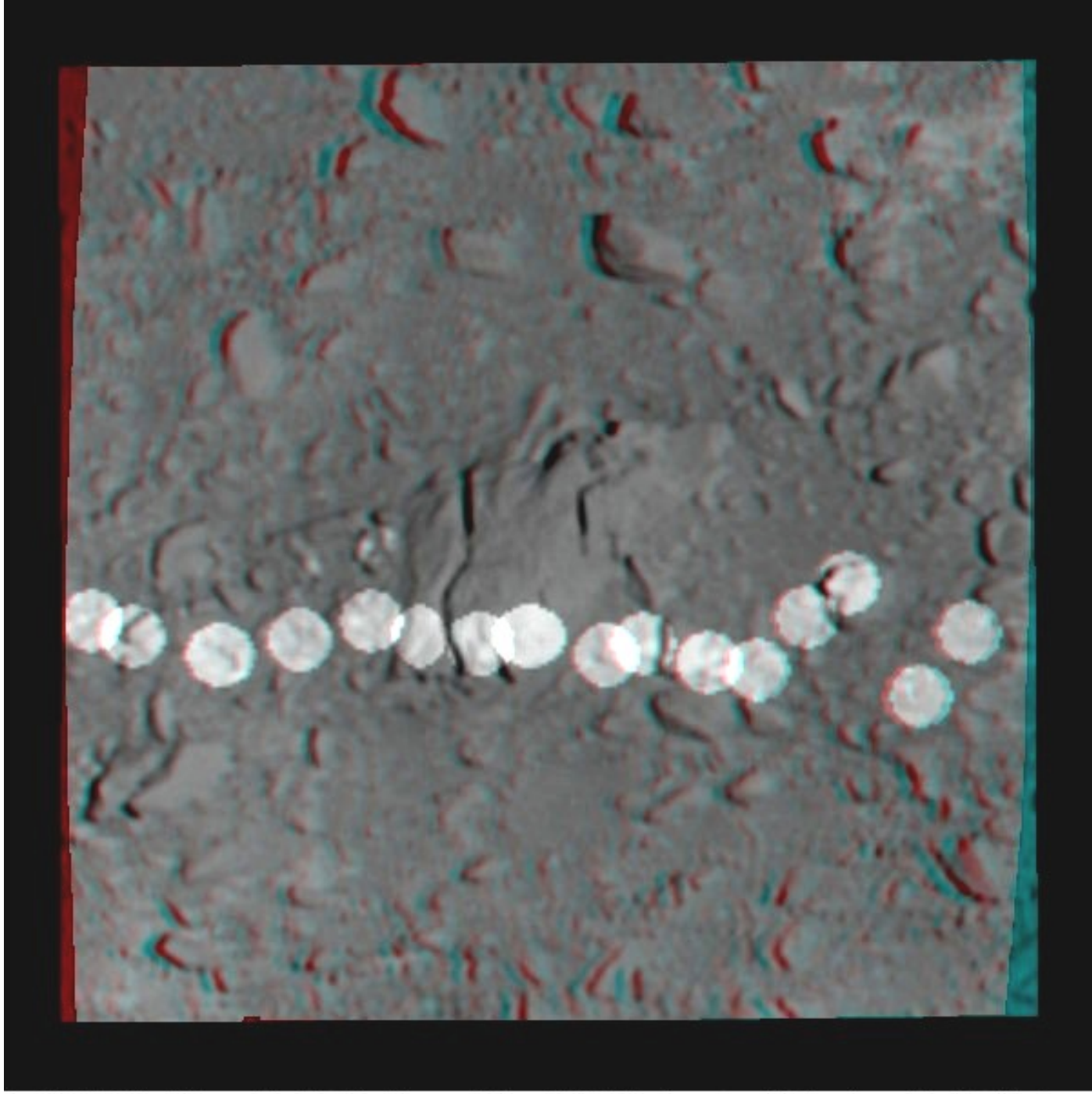
LIDAR

Crucial for navigation in low gravity environment.

Model response as the average of ranges from the 1 mrad FOV lidar footprint.



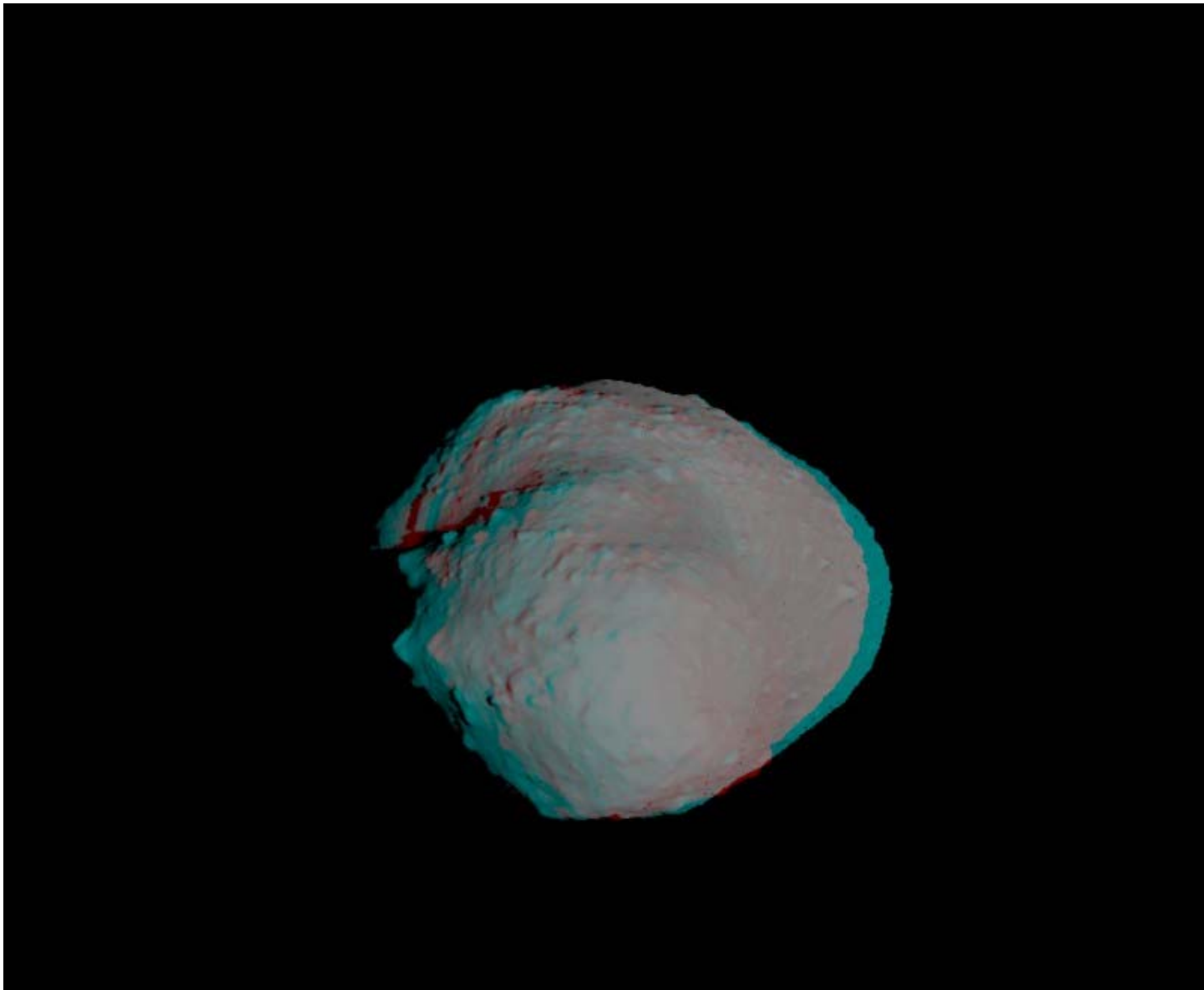
7.41 km - Range



TSUKUB Lt= 0.00S Ln= 84.50W Rd= 0.146 Sz=0.103 km

Summary

Principal Data Products: Ensemble of L-maps from SPC, Spacecraft state, Asteroid pole and rotation.



Secondary Products:

Global topography model, inertia tensor, gravity.

Composite high resolution topography.

Three dimensional image maps.