TOUTATIS: 2012 RADAR OBSERVATIONS

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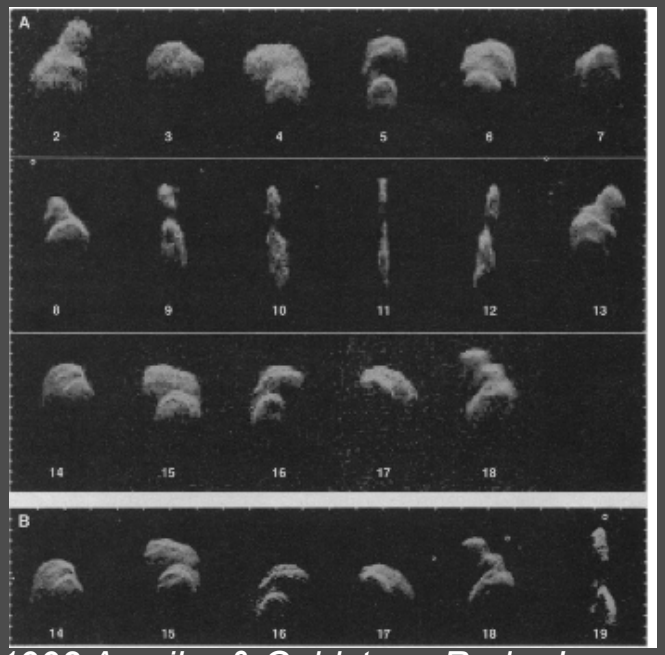
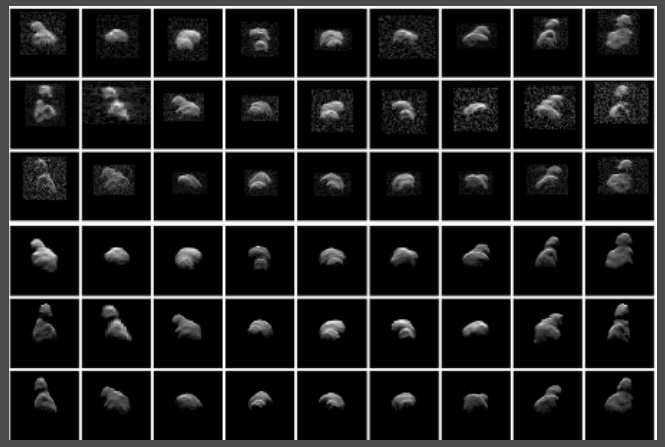
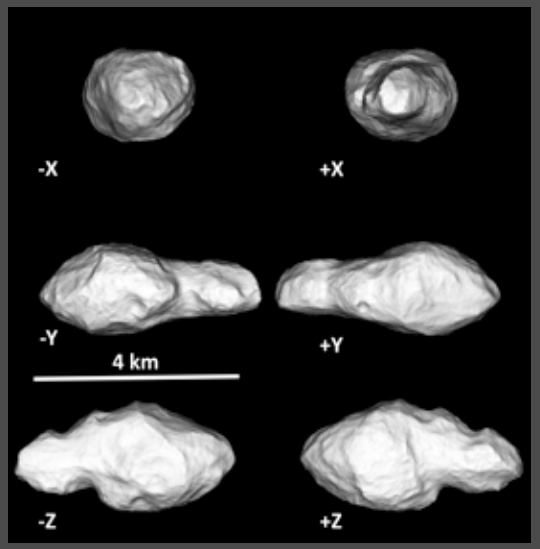
Background: 1992-1996



1992 Arecibo & Goldstone Radar Images

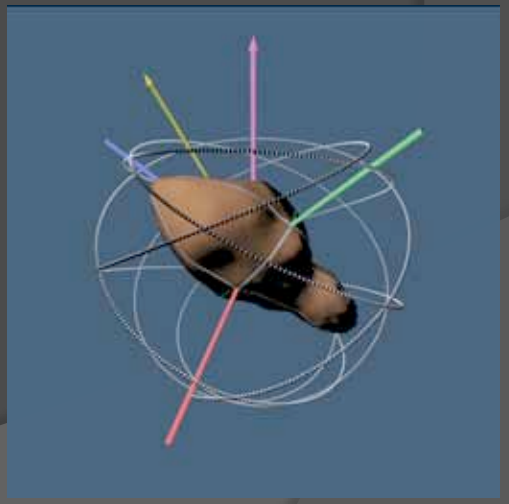


1996 Arecibo & Goldstone Radar Images

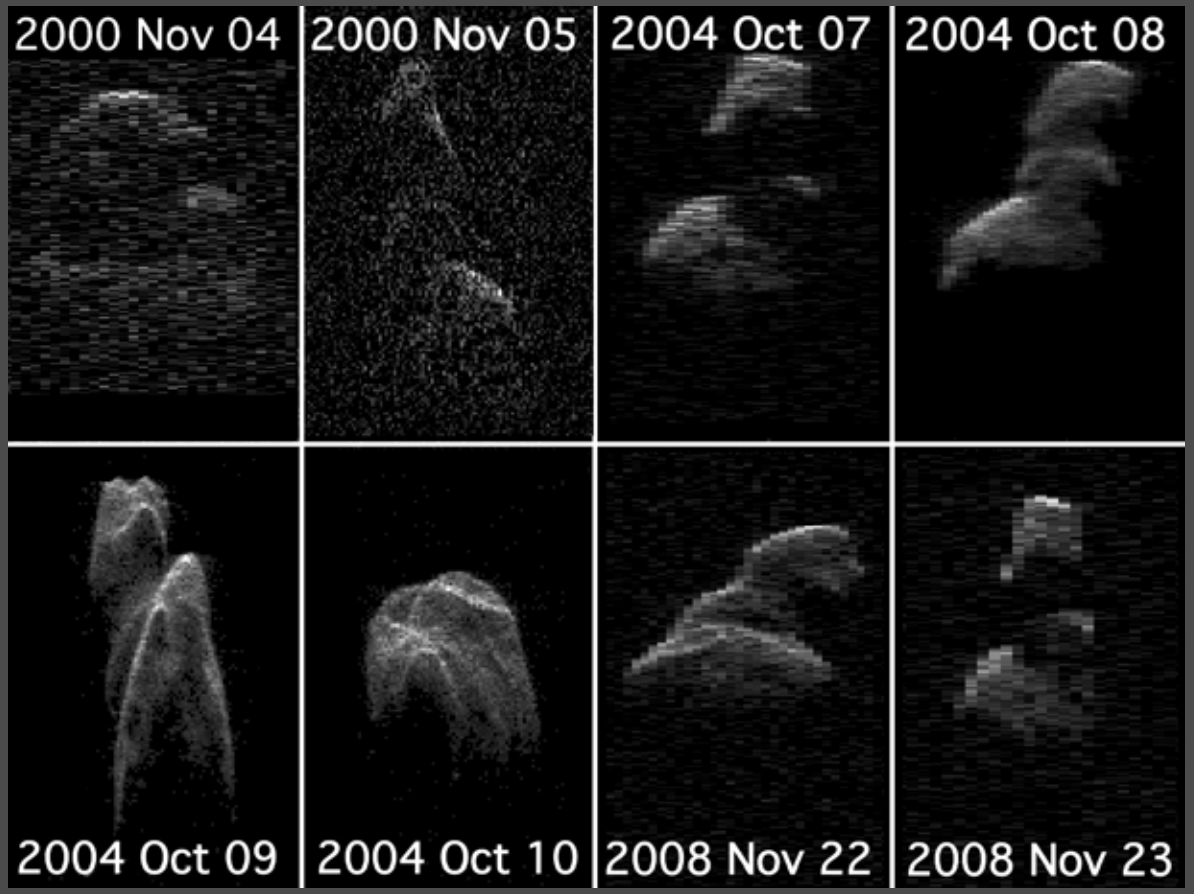


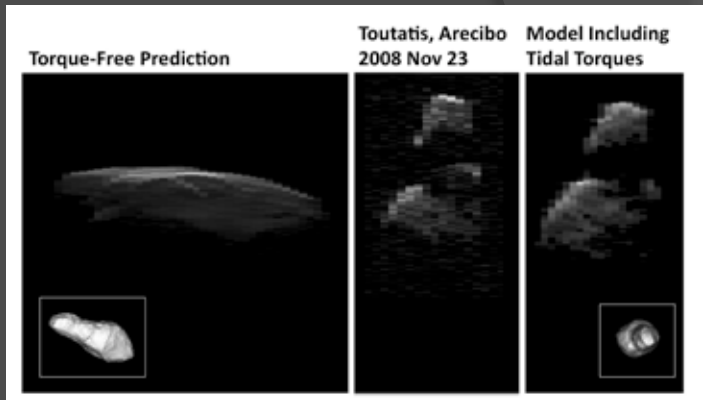
Observations led by Steve Ostro, shape and spin state models led by Scott Hudson.

1. Toutatis is bilobate, ~4.5 km long.
2. It has an aperiodic NPA spin state.
3. NPA spin depends on Toutatis' moments of intertia.



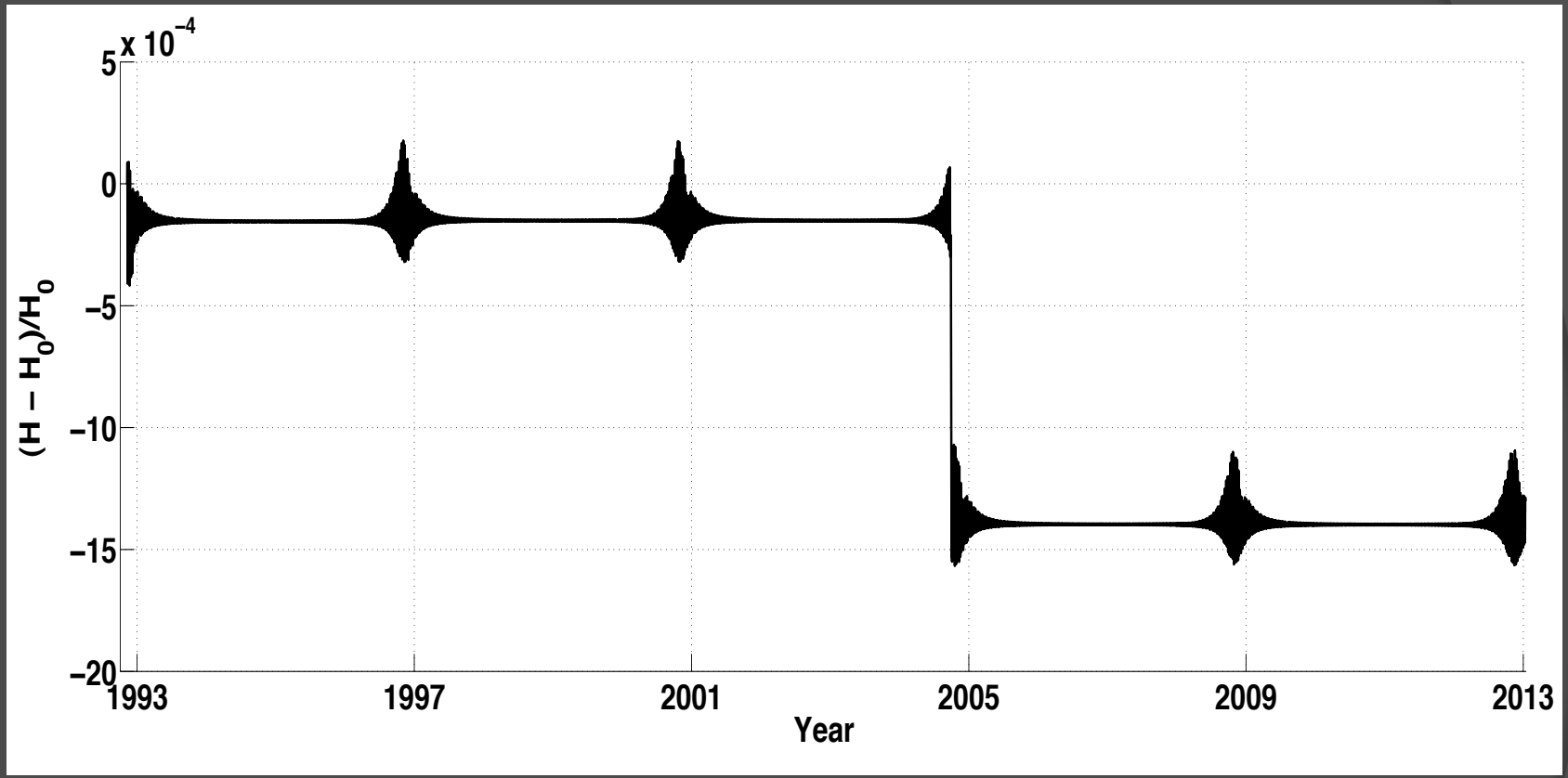
Background: 2000-2008





- Radar images: Goldstone ‘00, Arecibo ‘04 & ‘08.
- Mismatch between ‘92-‘96 spin state fit and later images.

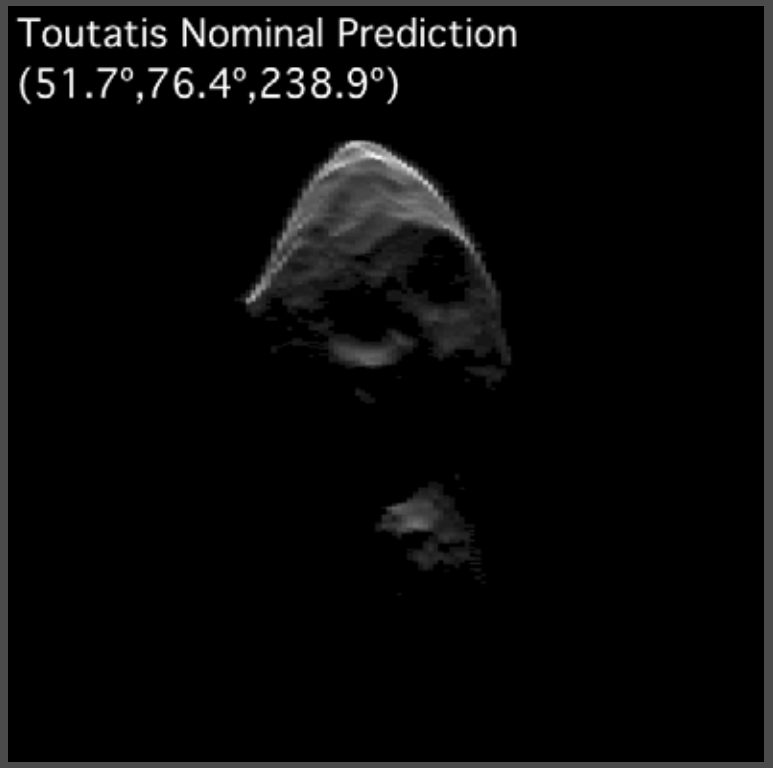
Toutatis' Changing Spin State



Changes in Toutatis' angular momentum from Dec 1992 to Dec 2012. Chart and fit from Yu Takahashi.

- Toutatis is torqued by tides from the Sun and Earth. The largest spin state change since 1992 was during the '04 flyby.
- Moment of inertia ratios from '92-'08 spin state fit: $I_s/I_l = 3.23 \pm 0.01$ and $I_i/I_l = 3.087 \pm 0.005$

Predictions for 2012



1992-2008 spin state fit run forward to **2012 Dec 4 03:30 UT**. Simulated 18.75 m/pixel image (0.125 usec x 0.032 Hz)

Simulated Chang'e 2 out-bound Toutatis image (unblurred).

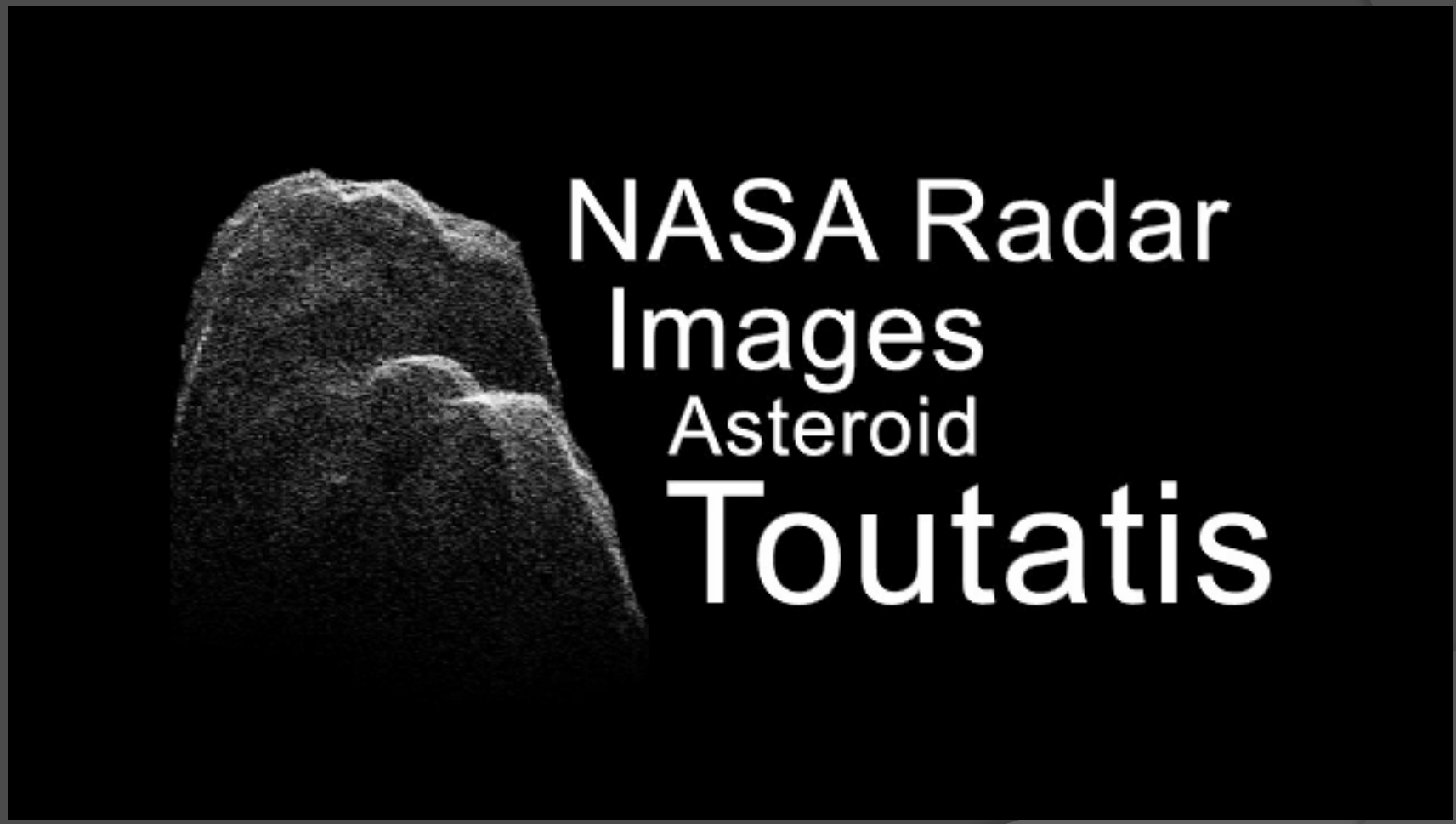
Orientation of Toutatis in 2012 December was uncertain by 20º-30º.

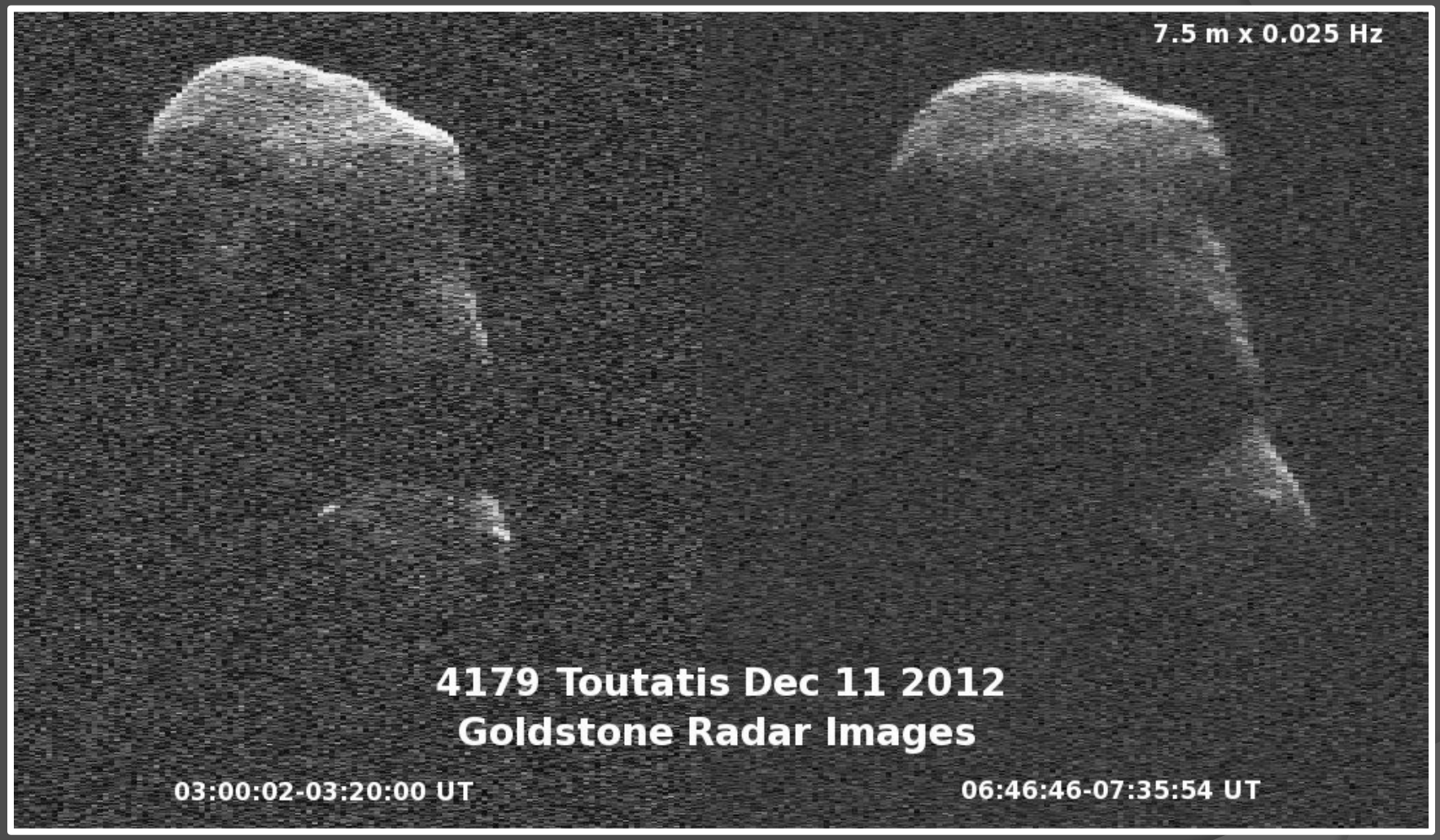
Data from 2012

- Goldstone radar imaging on 16 days between 2012 Dec 4 and Dec 22.
  - Dec 13 images overlap CE2 flyby.
- Image resolution: 18.75 m to **3.75 m** per range pixel.
- Radar speckle tracking from Dec 18 to Dec 22.

Goldstone 2012 Dec 12 delay-Doppler radar image, 3.75 m/pixel in range

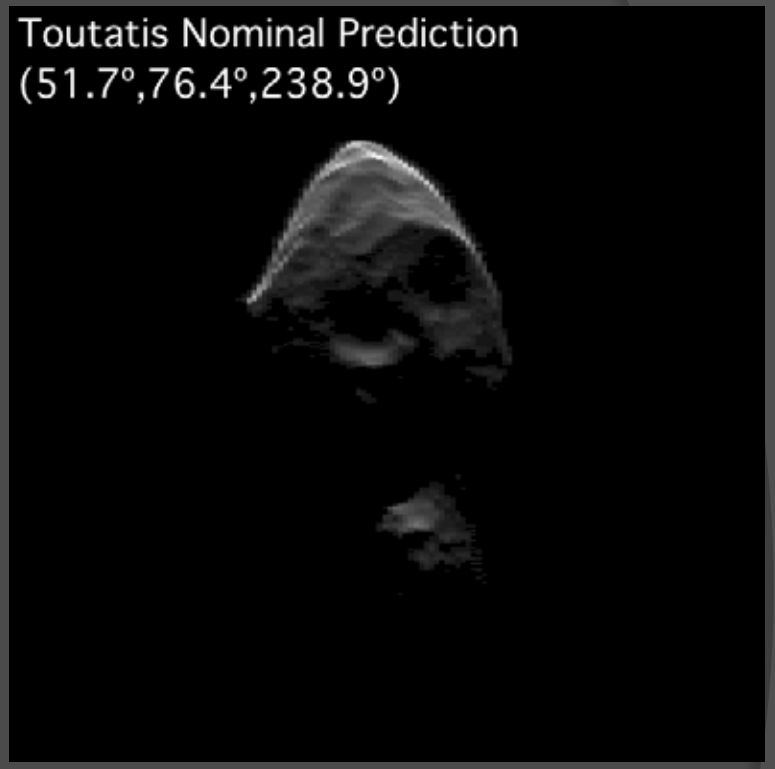
Images from 2012 Dec 12 & 13 UT





7.5 m/pixel and 3.75 m/pixel images of Toutatis show some 10-m-scale bright features. Boulders?

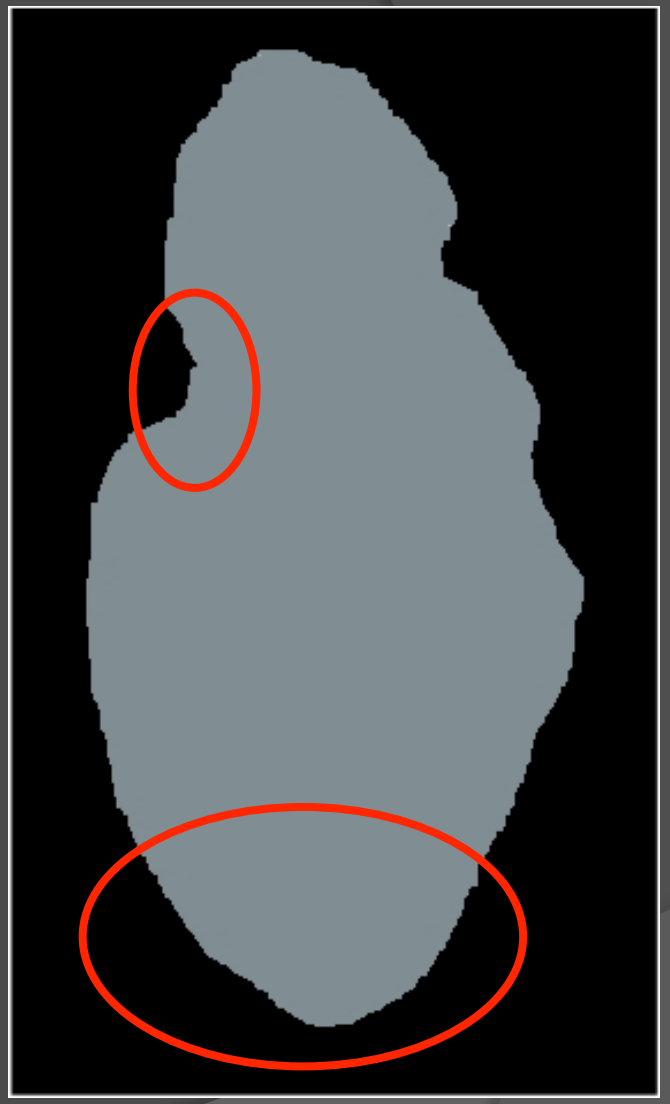
How Good Was The Shape Model?



- Spin state predictions were quite good.
- Radar and Chang'e 2 images imply errors in the shape model of *perhaps 3% by volume*.
- Limitations of **SHAPE** software: initial ellipsoid model of the big end was preserved throughout later shape fits.

What Happens Next?

- Improve the spin state model with both radar imaging and speckle tracking data.
- Correct the shape model:
  - Radar images from this year allow both higher resolution and correction of errors on the big end.
  - Eventually, combine CE2 and radar data (stereo mesh from CE2 + radar over rest of the surface)
- Consider implications for internal structure.



Silhouette of Toutatis shape model from –z direction, with largest errors highlighted.