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Three-Dimensional Views of Titan's Surface from Cassini RADAR Stereogrammetry

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By the end of its four-year prime mission, Cassini obtained 300-1500 m resolution synthetic aperture radar images of the surface of Titan during 19 flybys, with ∼2% of the surface imaged two or more times. Most image pairs have different viewing directions, and thus contain stereo parallax that encodes information about Titan's surface relief over distances of ∼1 km and greater. Our first step toward extracting quantitative topographic information was our development of rigorous "sensor models" that allowed the stereo systems previously used at the USGS and JPL to map Venus with Magellan images to be used for Titan mapping. The second major step toward extensive topomapping of Titan has been the reprocessing of the RADAR images based on an improved model of the satellite's rotation. Whereas the original images (except for a few pairs obtained at similar orbital phase, some of which we have mapped previously) were offset by as much as 30 km, the new versions align much better. The remaining misalignments, typically < 1 km, can be removed if necessary by a least-squares adjustment of the spacecraft trajectories before mapping.

The stereo coverage includes a large portion of Titan's north polar lake country, a continuous traverse of high resolution data from the lakes to mid-southern latitudes, and widely distributed smaller areas (more than 20 in all). Many of these areas are viewed and illuminated from very different directions, making image matching difficult, but we find that is possible to produce digital topographic models (DTMs) even from opposite-side image pairs by a combination of automatic image matching and interactive editing. We are collecting DTMs of all usable image pairs and will present the most interesting results. The first six areas mapped may be summarized as follows.

T25-T28-T29 We have mapped the 200x100 km overlap between the T25 and T28 images, covering parts of Titan's largest north polar sea, Kraken Mare. The most basic discovery is that the darkest areas occupy the topographic lows, consistent with their interpretation as lakes and seas of liquid hydrocarbons. The highest recorded elevations are about 1200 m above the shorelines, placing at least loose constraints on the probable depth of the seas, and thus on the liquid hydrocarbon inventory. Absolute heights agree well with SAR topography profiles except where the latter are biased by high image contrast along coastlines. We are currently processing the T28-T29 overlap, which will more than double the coverage of the seas, though with somewhat weaker stereo.

T8-T21 and T8-T41 These image pairs cross at high angles in the equatorial "sand sea" Belet, and include both dark dunes and lighter, dune-free areas. The second pair includes the Huygens landing site. Individual dunes are not resolved in the DTMs but the largest can be measured interactively, and have a height of 100-150 m, consistent with past estimates. The light areas are elevated and it appears that ∼200 m of relief is sufficient to truncate or divert the dunes, also consistent with the inferred dune heights. The T8-T41 DTM indicates a slope to the northeast near the Huygens landing point (and possibly also throughout the region), consistent with the direction of surface flows inferred from the probe images.

Ta-T23 We have mapped a subset of this pair, covering the 180-km quasi-circular feature Ganesa Macula, which in the images somewhat resembles steep-sided domes on Venus and has been hypothesized to be a cryovolcanic construct. Our DTM shows Ganesa as a whole is not elevated, but tilted (low in the west, high along the eastern margin). Other high and low areas with N-S trending margins alternate to the east of Ganesa. Low

areas are consistently filled by radar-bright (i.e., rough) channels and flow deposits. Thus, though Ganesa Macula may have originated as a cryovolcanic feature (or an impact crater, either of which would account for its distinct circular outline), it appears to have been extensively modified by both tectonic and fluvial processes.

T41-T43 This pair covers part of Hotei Arcus, an infrared-bright and possibly time-variable feature that has been hypothesized to be cryovolcanic, based on the presence of lobate flow-like features in the RADAR images. Our DTM shows that these flows are 100-200 m thick (which should lead to constraints on their rheology and composition), with radar-bright tops and dark margins. Narrow, bright channels nearby are incised into the mountains and display little elevation change, consistent with a less viscous fluid such as pluvial/fluvial liquid methane.

T13-T43 This pair covers part of the "middle rugged terrain" in the north central part of the continent-sized bright region Xanadu. The DTM does not resolve the many small (<10 km wide) mountains in the region, but clearly shows the largest peaks and chains to be elevated by hundreds of meters. The model also indicates a regional slope to the southwest, consistent with the apparent flow direction of numerous fluvial channels in western Xanadu.