TITAN'S SHAPE, RADIUS AND LANDSCAPE FROM CASSINI RADAR ALTIMETRY. R. D. Lorenz[1], P. S. Callahan[2], Y. Gim[2], G. Alberti[3], E. Flamini[4], R. Seu[5], G. Picardi[5], R. Orosei[5], H. Zebker[6], J. Lunine[7], G. Hamilton[2], S. Hensley[2], W.T.K. Johnson[2], S. Shaffer[2], S. Wall[2], R. West[2], G. Francescetti[8] [1] Space Department, Johns Hopkins University Applied Physics Lab, Laurel, MD 20723, USA (ralph.lorenz@jhuapl.edu) [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA. [3] CORISTA, Viale Kennedy 5, 80125 Naples, Italy,[4]Agenzia Spaziale Italiana, 00198 Rome, Italy. [5]U. di Roma La Sapienza, 00184 Rome, Italy [6]Stanford University, Stanford, CA 94305,, USA [7]Lunar and Planetary Lab, U. Arizona, Tucson, AZ 85721, USA., [8]Facoltá di Ingegneria, U. di Napoli, 80125 Naples, Italy

Introduction: Initial topographic profiles from the Cassini RADAR altimeter show Titan to be typically (but not always) rather flat, with 300-600 km long altimetry tracks showing height variations of ~150m or less (slopes of <0.1^o), although occasional elevation changes of ~500m are found over footprint-scale spans (~50km, slope of ~1^o). The mean Titan radius measured is 2575.5 km +/- 0.1 km.

Previous Data: Prior to Cassini, the only published data on Titan's topography was the Voyager 1 radio occultation[1], which gave planetary radii (determined by the abrupt drop in received signal strength) of 2575.0 km (+/-0.5 km) at 6.8^oN, 258.8^oE (ingress) and 8.8^oS, 76.8^oE (egress). A Cassini altimeter profile from TA was presented in early work[2], but the poor ephemeris hampered interpretation. Stereo correlation of images acquired by the Descent Imager Spectral Radiometer (DISR) on the Huygens probe[3] suggests that the bright hills to the north of the landing site were ~100-150 m higher than the dark plains where the probe ended its descent. Data from the radar altimeter on the probe are still being analyzed.

Some Titan topographic information has been recovered from SAR images, via radarclinometry (dunes up to ~150m [4], mountains several hundred meters high[5], the dome Ganesa Macula[6]) and from layover measurements of the crater Sinlap (~1300m deep [7]. Preliminary stereo radar measurements are in work (Kirk et al., this meeting) as are other approaches to recovering topography from SAR.

Observations: Altimetry is typically acquired for 10-15 minutes outside the SAR observation on RADAR passes : the spacecraft altitude typically varies from 5000-10,000km and thus the beam-limited footprint diameter varies from 20~50km (although the footprint becomes more pulse-limited at higher altitudes); the groundtrack during this period being several hundred km long. Altimetry observations to date (Fig.1) have been made and recovered on TAo, T3io, T8io,T13i, T16io, T19io and T21o (i and o refer to inbound and outbound: T7 and T13o were lost due to spacecraft problems).

The raw altimeter data product is an echo profile – intensity versus spacecraft clock time – resulting from compressing the 4.2MHz chirped pulse, giving a range resolution of ~30m.

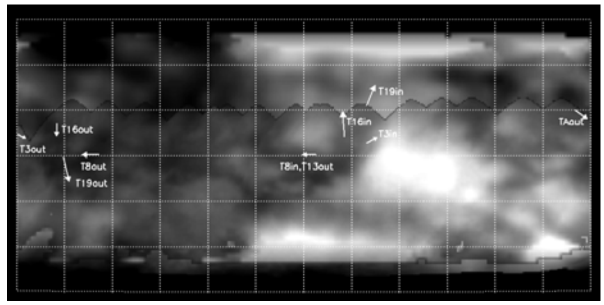

Figure 1: Location of TA-T19 altimetry swaths

The echo delay is related via the reconstructed ephemeris to distance from Titan's center : Fig.2 shows the result from TA – as reported previously, a gentle slope of ~0.1^o giving a drop of ~100m over ~150km is followed by a more shallow rise of ~50m over ~200km.

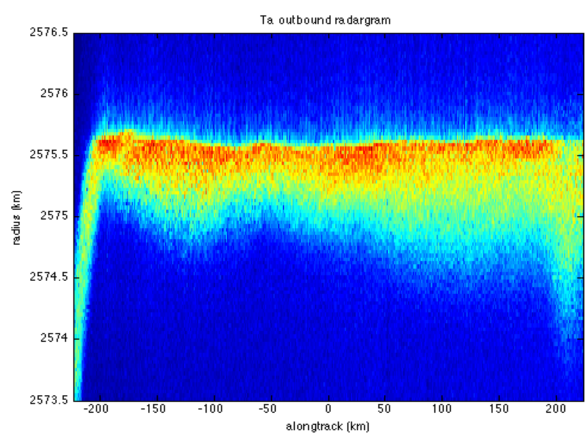

Figure 2: Echogram of TAo altimetry : red/yellow reprrsents strongest echo : top of red area defines the probable topographic profile while scattering off nadir contributes to the downward tail. Beam is mispointed prior to -180km.

Various approaches to developing topographic profiles are under evaluation, including simple threshold detection and a maximum-likelihood fitting, which helps compensate for mispointing effects. Results are discussed in more detail elsewehere [8]. Relative topography estimates are at the ~30m range resolution, although ephemeris uncertainty is the dominant contributor to surface radius estimates. All the radius estimates from TA-T13 are within 200m of 2575.5km, suggesting Titan is fractionally bigger than was previously thought. It should be noted, however, that all these measurements are within 30^o of the equator : more recently-acquired and upcoming data will measure higher latitudes, providing some constraints on Titan's polar flattening and additional data may possibly even constrain Titan's tidal bulge.

Topography and Echo shape: Beyond the simple radius in each swath, the topographic profile is of geological and geophysical interest. Comparison with near-IR and maps of radar backscatter (from SAR and radiometry) suggests that darker areas tend to be flatter. Notably, the dark region Shangri-La, parts of which have been observed to be dune-covered is strikingly flat (Fig.3) – detailed study of the threshold profile shows elevations that deviate by no more than +/-30m over the entire altimetry track of ~400km. Such flatness (which does not show topographic features, such as dunes, that have a scale smaller than the 20~50km footprint) supports the idea of a sedimentary deposit, presumably a basin.

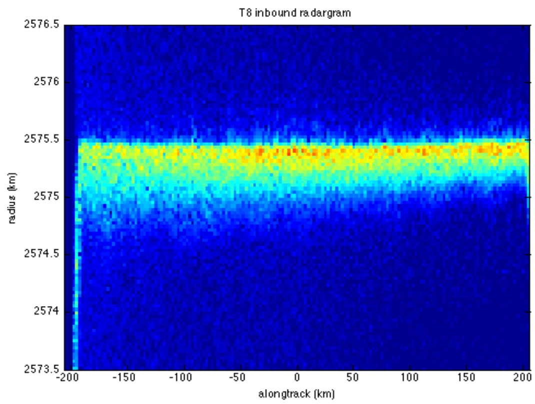

Figure 3. T8i, showing a remarkably flat area in Shangri-La, probably covered in dunes.

Other areas show more variation, although typically of only a couple of hundred meters: the largest excursion seen so far was on T19o (Fig.4) of ~400m. However, it should be emphasized that the coverage so far is very small – the swaths so far cover only about 0.1% of Titan's surface.

The echo shape yields additional information: some evidence of double-peaked echoes over suspected fields of sand dunes have been noted, confirming radarclinometric estimates. More generally, off-axis echoes may contribute to the long tails, e.g. Fig.4 (typically, reflectors ~50km off the footprint center will have ranges ~1km later than center) and upcoming SAR-altimetry overlaps will help develop this modeling effort.

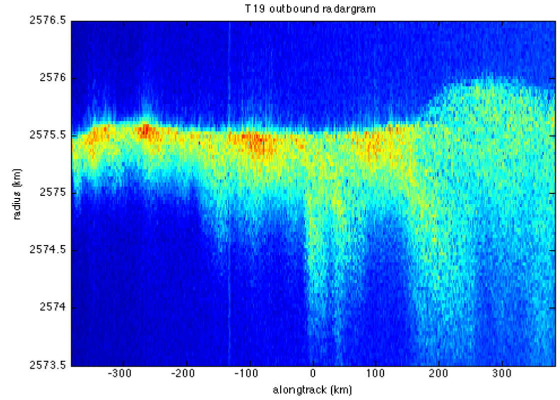

Figure 4. T19o, showing an apparent scarp or plateau of ~400m, with additional late echoes perhaps indicating off-axis reflections from rough terrain .Regional variation in the backscatter near nadir is also evident.

Conclusions: The Cassini RADAR altimeter yields topographic profiles that facilitate interpretation of geological and meteorological processes on Titan, and will be a vital reference for other methods of topographic measurement. The echo shape requires further work to be modeled adequately but provides additional information on the surface. Altimetry data from the Cassini nominal and extended mission will provide useful constraints on Titan's tidal/rotational shape and on a representative selection of regional slopes along a few dozen ~500km-long tracks. A global topography dataset to fully understand fluvial and meteorological processes like that generated by MOLA for Mars must await a follow-on mission to Titan : the Cassini altimeter results will be useful in designing such a mission and its instrumentation.

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