TOPOGRAPHY OF TITAN'S ARCTIC LAKE DISTRICT: IMPLICATIONS FOR SUBSURFACE LIQUID ALKANE FLOW.
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Abstract: Previously, we proposed a karst-like origin for much of Titan's arctic lake district (e.g. [1]). Such terrain is typically highly permeable, facilitating subsurface flow and hydraulic adjustment of fluids. To test this model, we attempt to constrain the elevations of the polar terrain and lakes using multiple methods. In this paper we present the entire Arctic SARTopo [2] database (derived from T16, 18, 19, 25, 28, 29 and 30 RADAR scenes), and attempt to calculate the elevation of the weak SARTopo signal within the lakes. The implications for subsurface flow are discussed.

Introduction: The multi-beam nature of the Cassini RADAR instrument makes possible the application of the SAR Monopulse Amplitude Comparison method [3]. This technique estimates surface heights by comparing the calibration of overlapping Titan SAR imagery obtained from different antenna feeds (beams) of the RADAR instrument onboard the Cassini spacecraft. The result has been the development of the SARTopo product [2], which supplements the scant altimetric cover- age of Titan with data that are conveniently located with SAR footprints. In its original implementation, the SARTopo algorithms smooth the noisy data by 51 pixels, giving data that are ~9 km in horizontal resolution with a height uncertainty of <~75 m. However, this arbitrary degree of smoothing does not consider the actual signal strength, and so is excessive in areas of good radar return where topography varies within the measurement width, and insufficient in areas of low radar backscatter (e.g. the polar lakes and seas). This is particularly problematic around the lakes, the rims of which appear to exhibit considerable slopes.

Considerable improvement in the utility of SARTopo data for local studies can be gained using different smoothing strategies. Previously [4], we found that adaptive smoothing, at times down to the 5-pixel level, although more commonly at around the 9- to 11- pixel level, resulted in much finer detail along-track profile whilst maintaining vertical uncertainties that were suitable (<100 m) for lake shore studies, showing details in the morphology around polar lakes that were only previously possible to determine using radarclinometry, which is strongly backscatter model dependent, and stereo techniques, which requires SAR image overlap.

Processing constraints: For the first-run model, we processed the SARTopo data using the methods described in [4], targeting 75 m vertical precision. Examples of this are presented in Fig. 1, draped over their associated SAR BIDRs (imagery). Additionally, we attempt an estimate of the "best" fit for lakes crossed by each SARTopo track (also shown in Fig. 1). Since we cannot completely eliminate RADAR artifacts near the edge, we measure from a few pixels in. We do not assume whether these are surface or bathymetric returns. In order to do this, we have preliminarily assumed that the data have normal error statistics, which is not technically true, although is a good approximation where the number of looks used to generate the source SAR image data is large; this assumption will be revised at a future date.

Results: Visualisations of samples of these data are given in Fig. 1. In brief:

1) Titan lakes and seas appear not to exist on a simple equipotential surface, but the elevation distribution does appear to be non-random, approximately following the level of the surrounding terrain, which is sloped down towards the main seas.
2) Lakes and surrounding terrain tend to exhibit greater elevation in the western hemisphere (0-180 W) than in the eastern (180 – 360 W). Higher elevations correlate with small, rimmed lakes, and lower elevations with more diffuse seas.
3) All but 3 of 39 intra-lake samples are at elevations below that of their surrounds, lending credence to the method and giving confidence that the data are physically meaningful. The three exceptions (one in T25 underlined in red) were in SAR-dark expanses of sea close to the noise floor. There is also a generally good correlation with stereo-derived DTM (Fig. 2; [5]).
4) 2 of the 39 intra-lake samples are unexpectedly low in elevation. Both are internal to large expanses of fluids and so may represent similar nonphysical results to those described above. Both (one in Kraken Mare, T25; one in Neagh Lacus, T16) are under-lined in yellow, and are within large expanses of sea seen in the SAR image as above the noise floor, and so are difficult to dismiss.

Discussion: The good correlation of SARTopo intra-lake lows (<100 m) with those in the T25-T28 stereo-derived DTM (Fig. 2; [5]) leads to the tentative conclusion that we are seeing bathymetric (lake bottom) returns.

This study neither confirms nor refutes the existence of an hydraulically interconnected subsurface alkanifer system. Deviation of different lake levels from a global or regional equipotential may be the result of different rates of evaporative loss or resupply (either pluvial or from subsurface flow), or instead be the result of Bernoulli forces in a fractured ice regolith causing liquids to tend to follow the overlying terrain. Alternatively, the lake levels may be governed primarily by local drainage-basin scale surface and subsurface flow, as is commonly the case on Earth.

References: [1] Mitchell K. L. *et al.* (2008) *LPSC XXXIX*, Abstract #2170. [2] Stiles B. W. *et al.* (2009) *Icarus*, **202**, 584-598. [3] Chen C. W. and Hensley S. (2005) *J. Opt. Soc. Am. A*, **22**, 529–538. [4] Mitchell K. L. *et al.* (2010) *LPSC XLI*, Abstract #2740. [5] Kirk R. L. *et al.* (2009) *LPSC XL*, Abstract #1413.

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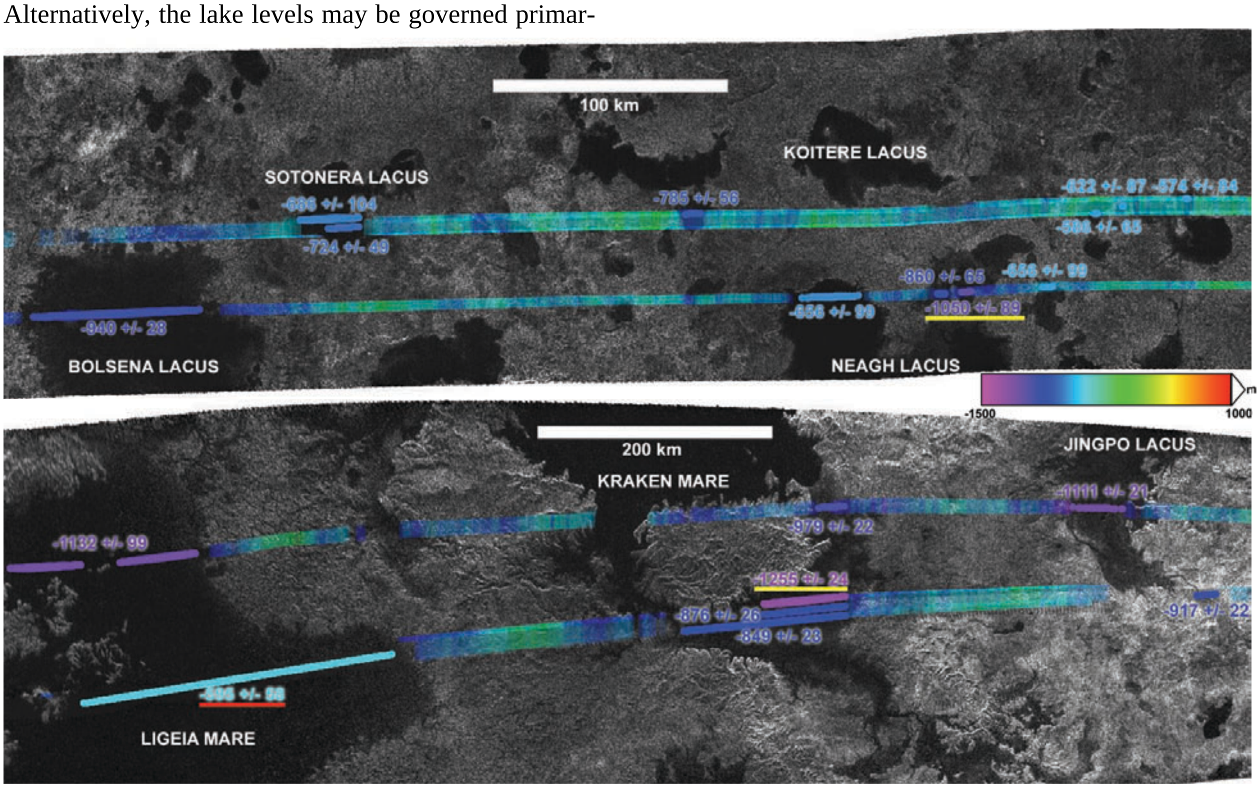

Figure 1: High resolution SARTopo of parts of the T16 and T25 RADAR swaths, draped over their associated BIDRs. Transparency gives a crude indication of certainty, being a representation of a function based on SARTopo footprint size and along-track distance from the footprint centre. No geoid correction has been performed on this version.

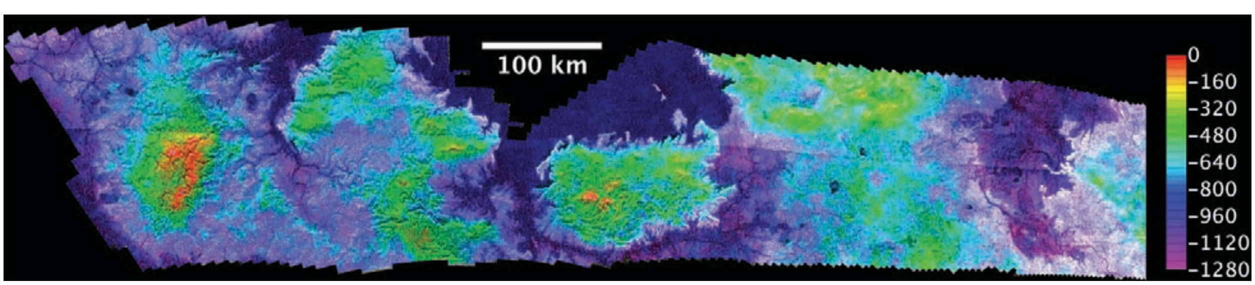

Figure 2: Stereo-derived DTM (courtesy: R. Kirk, USGS Flagstaff) for comparison with T25. No geoid correction has been performed, and the colour scale differs from that of Fig. 1. Absolute elevations are in good agreement with SARTopo, as coarser resolution SARTopo was used to adjust the stereo product. Local variations also appear to be in good agreement, providing cross validation. Further work will be performed to extend the comparison.