MODELING THE STABILITY OF ONTARIO LACUS ON TITAN

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Introduction: Since the arrival of the Cassini-Huygens mission to the Saturn system, numerous liquid-filled lakes have been identified to date. The area of the lakes vary between <10 km^2 to over 100,000 km^2 [1]. The largest of them in the south polar region is Ontario Lacus, that was first identified as a radar dark feature having low reflectivity and smooth, rounded boundary, resembling shorelines on Earth.

During the T38 flyby, *Brown et al. 2008* [2] identified absorption features characteristic of ethane in VIMS spectra in Ontario Lacus, probably present in liquid solution with methane, nitrogen and other low molecular-weight hydrocarbon species. However, the chemical composition of the lakes is still under debate and is a challenge to determine precisely, partially because of the strong atmospheric absorption of CH_4. *Cordier et al. 2009* [3] proposed that the lakes are indeed composed of CH_4 to a large extent ($\sim$5-10%), following C_2H_6.

The first detailed geometric analysis of Ontario Lacus' shore reveals two distinct annuli around the lakebed itself, indicating shoreline variations over time [4]. *Moriconi et al. 2010* [5] characterized Ontario Lacus and its adjacent regions with three distinct regions based on VIMS data in the 5 µm spectral window: the lake itself, which appears to be dark as a result of nearly full extinction of solar radiation, a dark-gray "ramp", most probably adequate with exposed lakebed sediments, and a bright, outer irregular ridge. It was also proposed that the weak C_2H_6 absorption feature detected by *Brown et al. 2008* [2] at shorter wavelengths is rather present in the region adjacent to the lake [5]. The supposed lakebed sediments may have been exposed by seasonal evaporation of methane and is indicative of lake level change over time [4]. Furthermore, the asymmetric morphology of Ontario Lacus found by *Wall et al. 2009* [6] and the raised beach site on the north-eastern side also indicate former lake shorelines from times when the lake level was probably higher.

Recent results of *Wye et al. 2010* [7] estimate the maximum depth of Ontario Lacus to be 9 m, while depths over the rest of the lake are proposed to be less than 5 m.

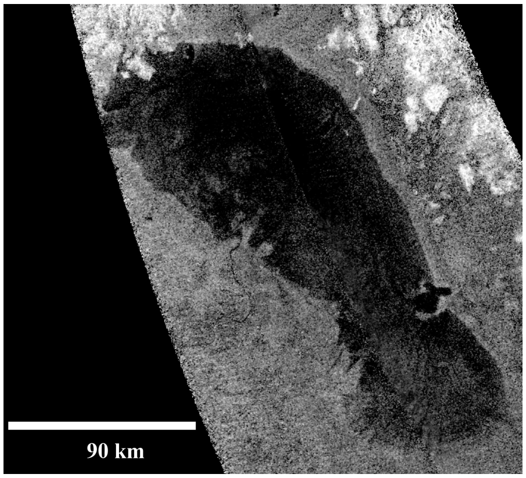

Figure 1: Radar image of Ontario Lacus, located at 72° S, 183° W. Credit: NASA/JPL.

Here we present the results of our theoretical model of coupled heat and mass transfer applied to Ontario Lacus.

Modeling: We estimated the evaporation rate of Ontario Lacus over the course of one Titan year. For this purpose, we applied a model that combines heat transfer with mass transfer to calculate the lake recession rate, using the same approach as *Rivera-Valentin et al. 2009* and *Chopra et al. 2011* [8], [9]. Taking the latitudinal extension of the lake into account, temperature variation over the lake area is minor [10]. For that reason, even evaporation is expected over the entire surface.

A depth of 9 m [7] was used to model the deepest parts of the lake. Based on our findings, that is well beyond the skin depth of the lake ($\sim$ 1.8 m).

After constructing the vertical temperature profile of the lake (Fig. 2), we estimate the mass flux leaving the surface of Ontario Lacus due to evaporation in one Titan year, then from the resulting change in height in unit area we calculate the total change in volume.

As a first approach, in the present work we used pure liquid methane for the composition of the lake.

Results: Figure 3 shows the cumulative change of height per unit area for one Titan year. By Ls = 360, the height of a unit area at the location of Ontario Lacus decreases with about 13 cm. The evaporation of liquid methane is expected to be the same over the entire area

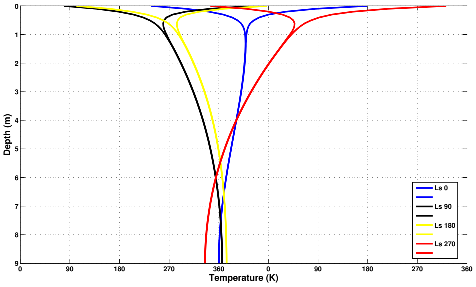

Figure 2: Vertical temperature profile of Ontario Lacus for different Ls, from the surface (0 m) to a depth of 9 m.

of the lake, as mentioned before, and so the evaporation rate for Ontario Lacus results to be 0.1311m/yr. Assuming an ellipse for the shape of the surface area of Ontario Lacus, the volume of the lake is 98.96 km^3. The volume of liquid lost over the course of a Titan year is 1.4% of the initial volume, and so 1.425 km^3 is evaporated.

Based on the results presented here, Ontario Lacus with a depth of either 5 m or 9 m is stable and so the total evaporation of the lake over one year is highly unlikely. However, shoreline variations are expected to be observed over several Titan years in the lack of a methane source supplying all the evaporated methane, which is in agreement with observations indicative of shoreline changes. In this case, it would take over 64 Titan years for Ontario Lacus, composed of pure methane, to fully evaporate.

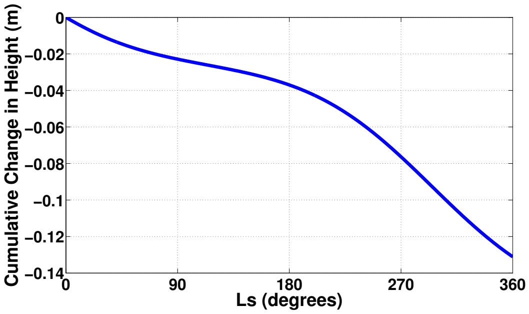

Figure 3: Cumulative change in height of lake per unit area for a Titan year. Based on the model, by the end of the year, 0.1311 m of methane evaporates evenly over the area of Ontario Lacus.

As indicated before, we have assumed a pure methane composition, however, that is probably not the case for Ontario Lacus. The lakes may not even contain a large amount of methane, or other compounds could be more dominant. For this reason we are going to modify the model with different lake compositions.

These results can be considered as first approximation, and more accurate results will be presented in the next couple of weeks.

Furthermore, comparing the results of the used model to experimental data will provide invaluable information on the behavior and stability of liquids on Titan, and will let us revise and validate the model used here.

References: [1] A. Hayes, et al. (2008) *GRL* 35:9204. [2] R. H. Brown, et al. (2008) *Nature* 454:607. [3] D. Cordier, et al. (2009) *ApJ* 707:L128. [4] J. W. Barnes, et al. (2009) *Icarus* 201:217. [5] M. L. Moriconi, et al. (2010) *Icarus* 210:823. [6] S. Wall, et al. (2010) *GRL* 37:5202. [7] L. Wye, et al. (2010) in *Bulletin of the American Astronomical Society* 42, 1076. [8] E. G. Rivera-Valentin, et al. (2010) in *LPS XLI* Abstract #1446. [9] N. Chopra, et al. (2011) in *LPS XLII,* Abstract submitted. [10] D. E. Jennings, et al. (2009) *ApJ* 691:L103.