EXPERIMENTAL SIMULATIONS OF LIQUID METHANE EVAPORATION UNDER TITAN SURFACE CONDITIONS

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Introduction: Various evidence from the Cassini-Huygens mission showed the unambiguous presence of liquids on the surface of present-day Titan. The exact composition and nature of these lakes and seas is not well understood, but are thought to be composed of ethane and methane to a large extent [1].

The lakes are mainly confined to the supposedly more humid polar regions, while at the low latitude areas vast longitudinal dunes are pervasive [2]. Even though the dunes are indicative of a desert-like environment, the presence of fluvial channels and subsurface methane moisture detected by the GCMS at the Huygens landing site (e.g. [3])show evidence for liquid at low latitudes in some form and amount.

Although methane is thought to dominate, other hydrocabons may also participate in Titan's cycle(s) (often referred to as 'methalogical') - similarly to the hydrological cycle on Earth - involving evaporation, rainfall events, and possibly replenishment from the subsurface. The dense and active Titanian atmosphere provides an interacting medium for such processes.

[4] report a large, low latitude storm system accompanied by extensive surface changes detected by Cassini's ISS, and suggest that the observed fluvial features at low latitudes form as a result of occasional, heavy rainfall events.

While there is an abundance in sophisticated thermal models addressing the question of stability and evolution of the liquids on Titan's surface, quantitative experimental measurements to validate these are rather sparse. We have developed a simulation chamber, where Titan-relevant temperatures and pressure can be created, and methane and other hydrocarbons condensed, therefore, various processes occurring on Titan's surface can quantitatively be described.

Here we report on experiments and results on the evaporation of methane under Titan surface temperature and pressure conditions.

Experimental: Experiments are conducted in our Titan simulation chamber, where Titan-relevant surface temperatures and pressure can be generated and maintained over the course of our runs. A schematic of our system is shown in Fig. 1, and a detailed description of the simulation facility and data acquisition can be found in [5], [6]. In addition to the subsystems in Fig. 1, the facility is equipped with a gas chromatograph - flame ionization detector (GC FID), as well as an FTIR. The experimental methods follow those described in [6], [7], with a few modifications.

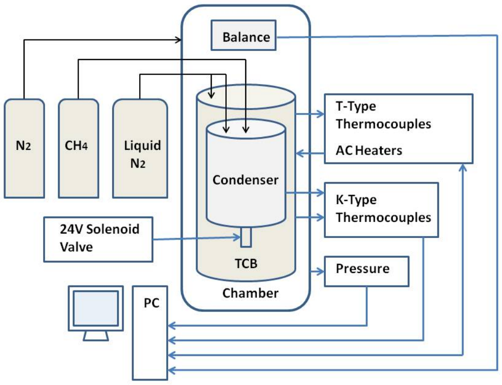

Figure 1: Schematic of the Titan simulation chamber.

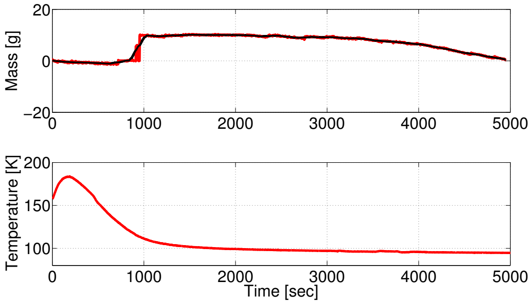

Figure 2: Mass (top) and temperature (bottom) over the course of a run. The red curve indicates the measured values, while the black line in the top figure shows the data corrected for instrument error. The sudden increase in mass in the top figure corresponds to liquid methane in the pan right after condensation.

Titan surface temperatures are achieved by liquid N_2 flow through coils within the simulation chamber, while the atmosphere is simulated with N_2 gas maintained at 1.5 bar. When the temperature reaches the proper regime, methane is condensed and poured into a Petri dish. A sudden, sharp jump in mass is observed right after (Fig. 2),

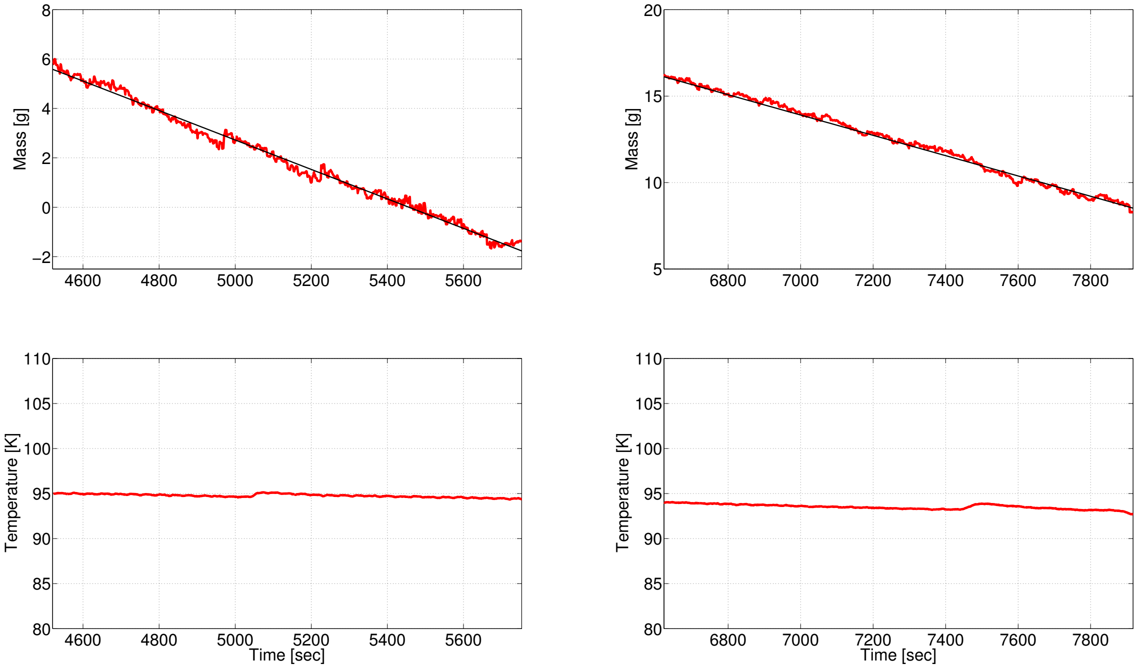

Figure 3: Mass of CH_4(top) and corresponding temperatures (bottom) vs. time for two runs. The evaporation rates are 0.36 (top left) and 0.354 g min^{-1} (top right), as calculated from the slope of the linear fit (black solid line).

and evaporation rates are calculated by continuously measuring mass over the course of the runs at Titan-relevant temperatures of 90-95 K. Methane partial pressure is determined using a GC to measure concentration in the simulation chamber.

Results: Representative data plots used to determine the evaporation rate of methane are shown in Fig. 3, and give consistent results, with an average of 2.7 mm hr^{-1}. The mass indicated on the y-axes in Fig. 3 is not absolute.

Discussion: Our experimental results imply a much higher evaporation rate than documented earlier for Titan's south polar region [8] from Cassini data analysis. The reason for the discrepancy may be that our experiments with the current setup better represent the low latitude regions. Our simulated temperatures are currently closer to the upper limit of 94-95 K for the most part of the runs, therefore are warmer than the poles [9]. Equatorial regions are also arid, therefore larger evaporation rates would be expected than at the more humid polar regions. Based on GC FID concentration measurements during our runs, the relative humidity in the simulation chamber is $\sim$15%, somewhat lower than found at the Huygens landing site. If the observed fluvial features and subsurface moisture are in fact caused by occasional, large storm events, such as reported by [4], smaller methane ponds would be expected to form, that would more rapidly disappear due to the lower relative humidity and higher temperatures.

Cassini measurements thus far only cover late southern summer through early northern spring of a Titan year, therefore are not necessarily representative of any given part of the satellite at any time of the year. Further observations, combined with modeling and experiments, such as the one presented here are required to understand the stability of liquids and their relationship to Titanian weather patterns.

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References: [1] D. Cordier, et al. (2009) *ApJ* 707:L128. [2] R. D. Lorenz, et al. (2009) *GRL* 36:L03202. [3] H. B. Niemann, et al. (2005) *Nature* 438:779. [4] E. P. Turtle, et al. (2011) *Science* 331:1414. [5] F. C. Wasiak, et al. (2012) in *43^{rd}LPSC* abstract. [6] F. C. Wasiak, et al. (2011) in *42^{nd} LPSC, 1322*. [7] A. Luspay-Kuti, et al. (2011) in *42^{nd}LPSC, 1736*. [8] The Cassini Radar Team, et al. (2011) *Icarus* 211:655. [9] D. E. Jennings, et al. (2009) *ApJ* 691:L103.