# MEASURING EVAPORATION RATES OF LIQUID METHANE UNDER TITAN SIMULATED CONDITIONS

T. Cornet [1], A. Luspay-Kuti [2], F. C. Wasiak [2], W. D. D. P. Welivitiya [2], V. Chevrier [2] and L. Roe [2]

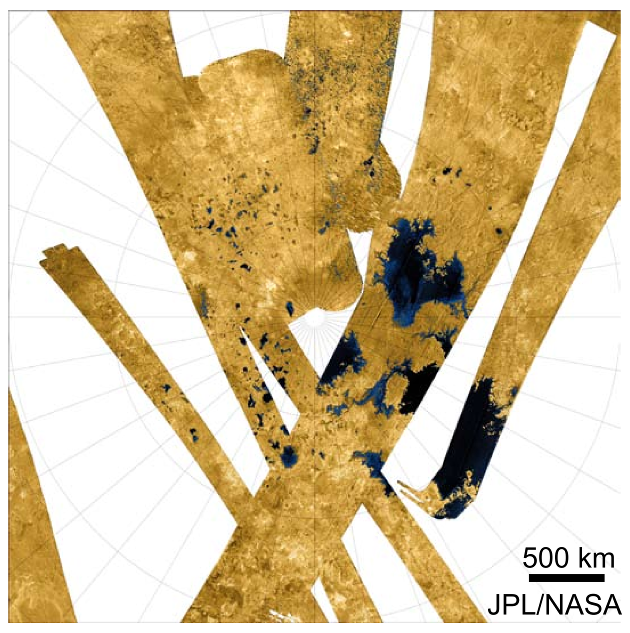
[1]: Laboratoire de Planétologie et de Géodynamique de Nantes, UMR 6112, CNRS, Université de Nantes, France.
[2]: Arkansas Center for Space and Planetary Sciences, Fayetteville, Arkansas, USA.

@ : Thomas.Cornet@univ-nantes.fr

## INTRODUCTION

Evidences for liquid bodies have been found on Titan's surface (Figure 1) [1, 2].
Titan's atmosphere: nitrogen (N2) and methane (CH4).
Surface conditions: P = 1.5 bar, T = 90 - 94 K, close to the triple point of CH4 (Figure 2).
Methane cyle similar to water cycle on Earth [1, 3]: potential liquids on Titan's surface [4, 5].
Evaporation of liquids: shoreline changes ? (Ontario Lacus on Titan [6, 7])

**NEED CONSTRAINTS ON EVAPORATION RATES OF LIQUID HYDROCARBONS**



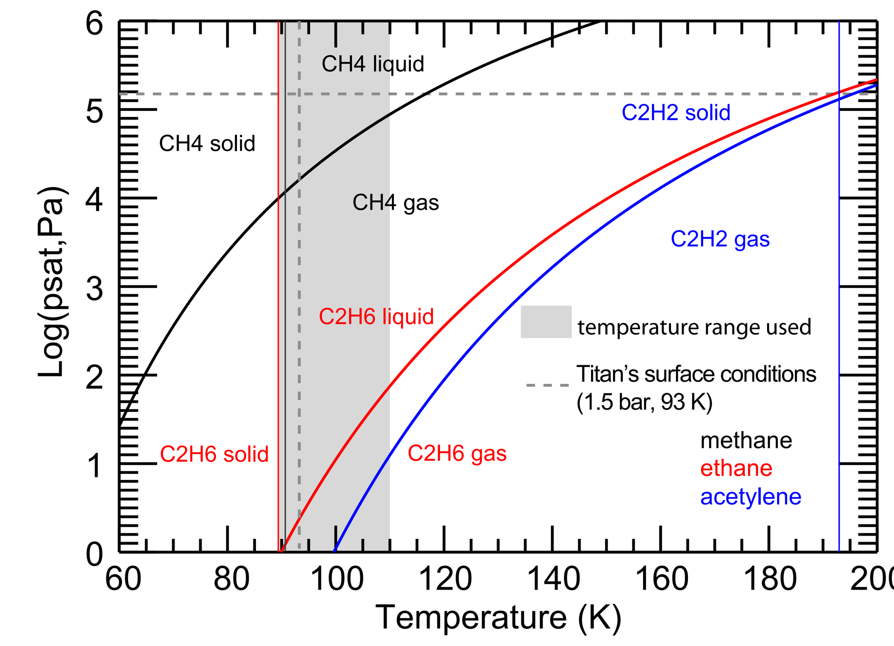




**Figure 1 (left):** RADAR SAR mosaic, centered on the North Pole of Titan.

**Figure 2 (right):** Phase diagram of hydrocarbons. Under Titan's conditions, methane and ethane both can be liquids.

## THE TITAN MODULE [8, 9]

- Temperature Control Box (TCB) to get Titan's temperature
- Condenser to form liquid hydrocarbons
- Petri dish to collect the samples
- Balance for the mass recording
- Fiber optics to obtain FTIR measurements
- 2 digital cameras for a direct look inside the chamber

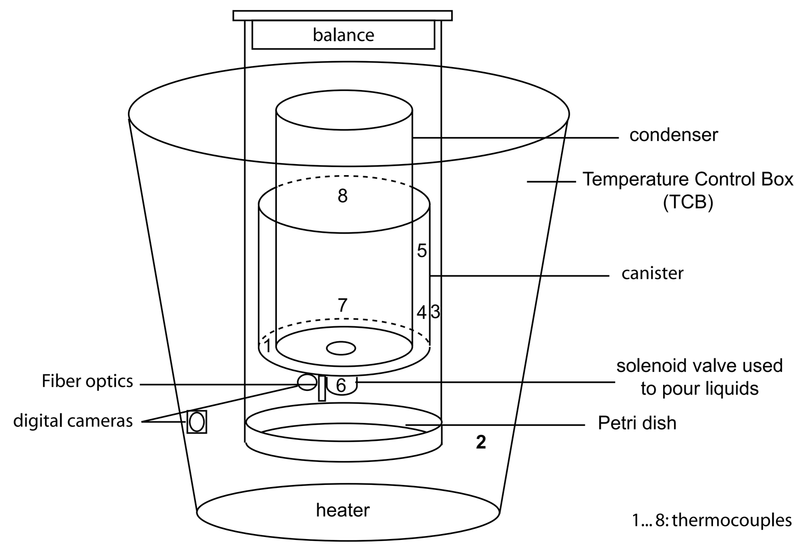



**Figure 2:** Schematic view of the Titan Module

***Procedure:***

- Purge by N2 to simulate Titan's atmosphere (P=1.5 bar)
- Cooling of the chamber to Titan's temperatures by flowing liquid nitrogen (LN2) into the coils surrounded the TCB.
- Cooling of the Condenser with LN2 to form liquid CH4 (111.6 K, TC 7 - 8) .
- Pouring of the liquids into the Petri dish at T = 90 - 94 K

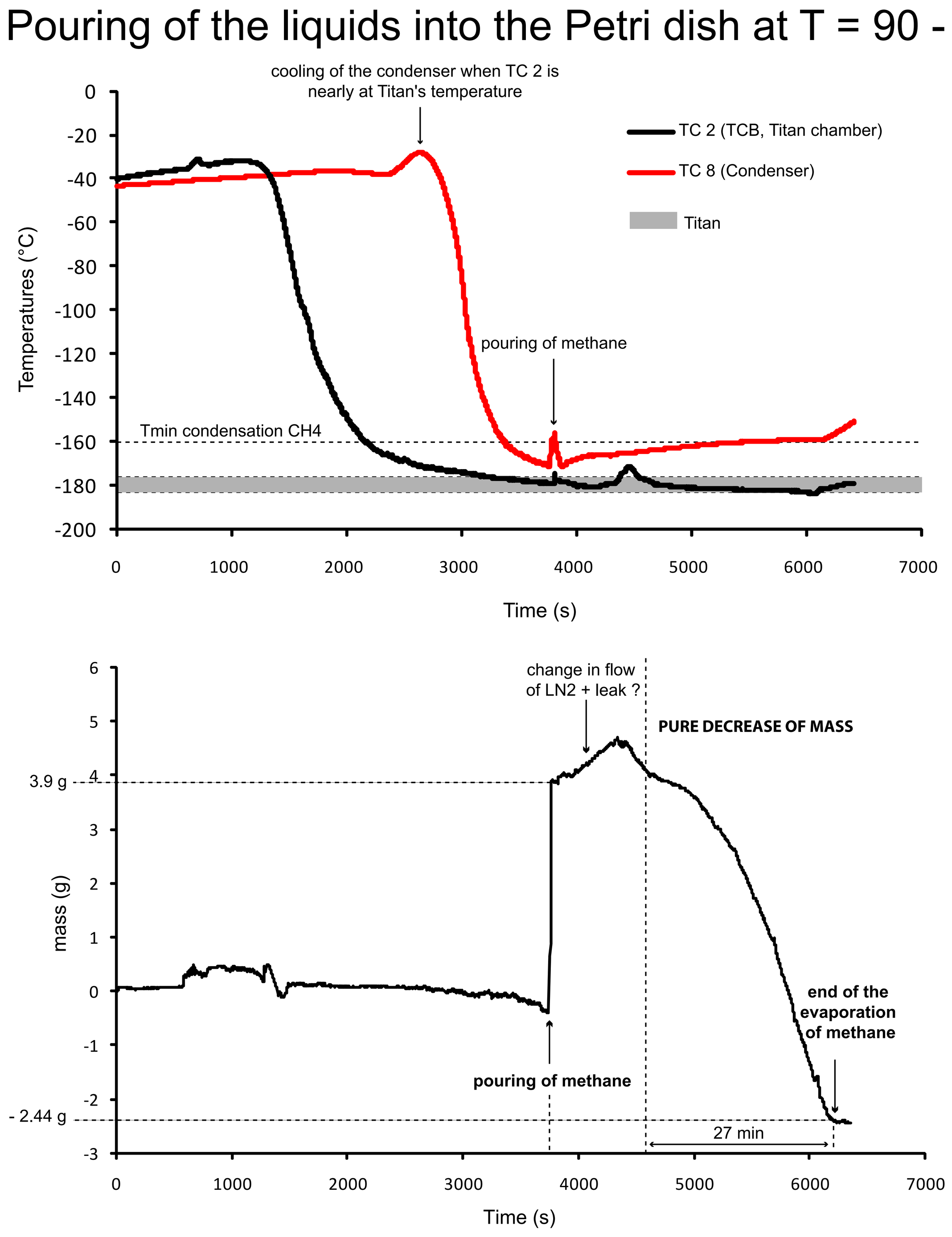



**Figure 3:** Simultaneous acquisition of mass and temperature data

## MASS MONITORING OF EVAPORATION

The evaporation of methane is recorded as a loss of mass under steady Titan's conditions (1.5 bar, 90 - 94 K).

1st approximation of evaporation rate: linear fit (Figure 4)
Result: 0.006 g/s, i.e. 2.79 mm/hr.

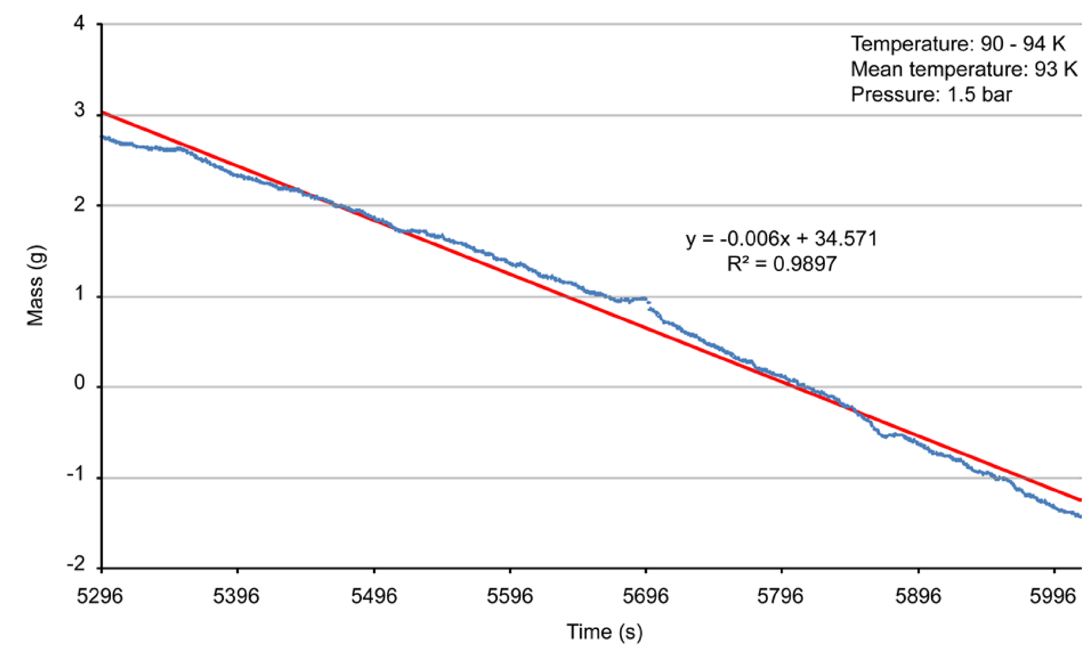



**Figure 4:** Empirical linear fit applied to the decreasing part of the mass data (Figure 2).

***Comparison with theoretical calculations:***

Theoretical calculations of methane evaporation rates using Ingersoll's equation [10] (Figure 5).

First measurements of evaporation rates of methane under Titan's condtions are close to the theoretical calculations.

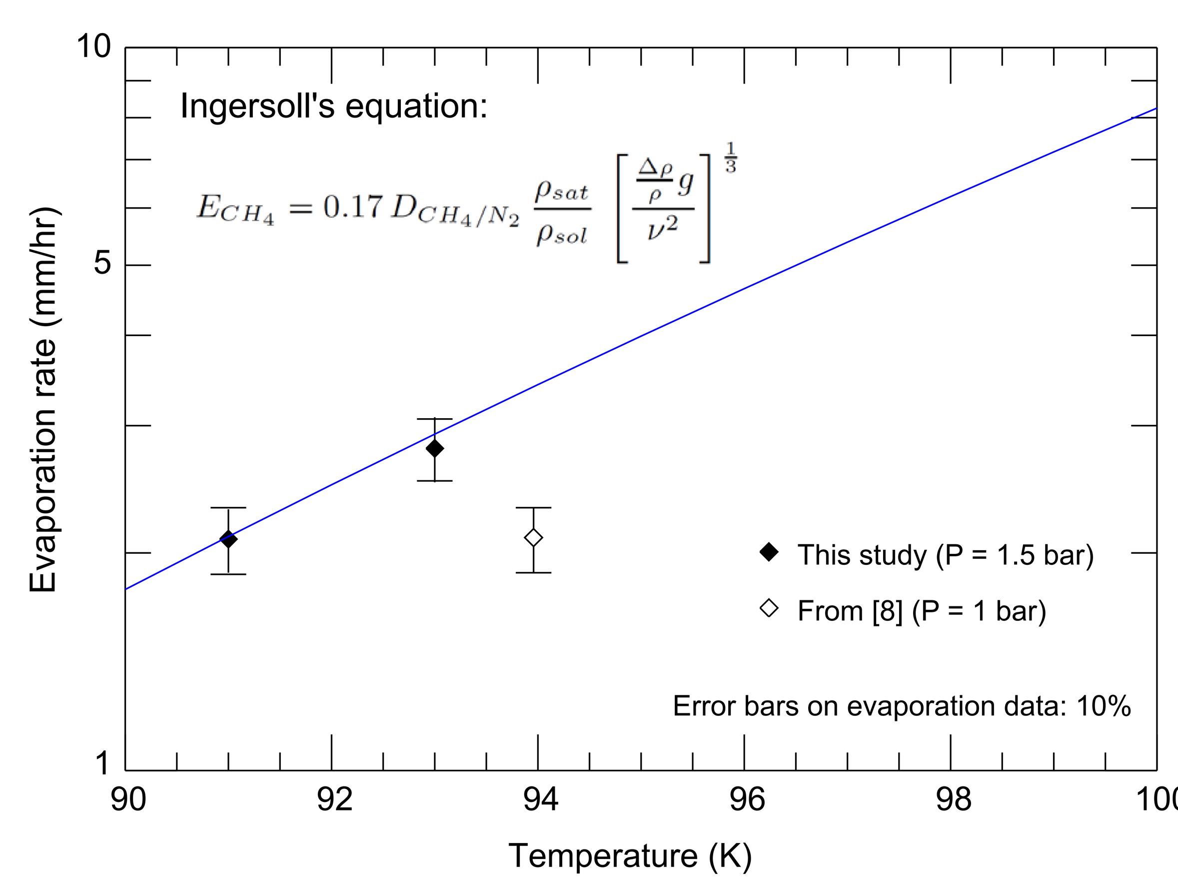



**Figure 5:** Comparison between the methane evaporation rates measured under Titan's conditions using the Titan Module (diamonds), and the methane evaporation rates inferred from Ingersoll's equation (solid blue line).

## FTIR MONITORING OF EVAPORATION

Nicolet 6700 FTIR Spectrometer to acquire IR spectra during the evaporation.
Wavelength range: from 1.0 to 2.6 µm.

Methane absorption bands:
1.16, 1.33, 1.41, 1.66, 1.72, 1.79 and 1.85 µm [11]

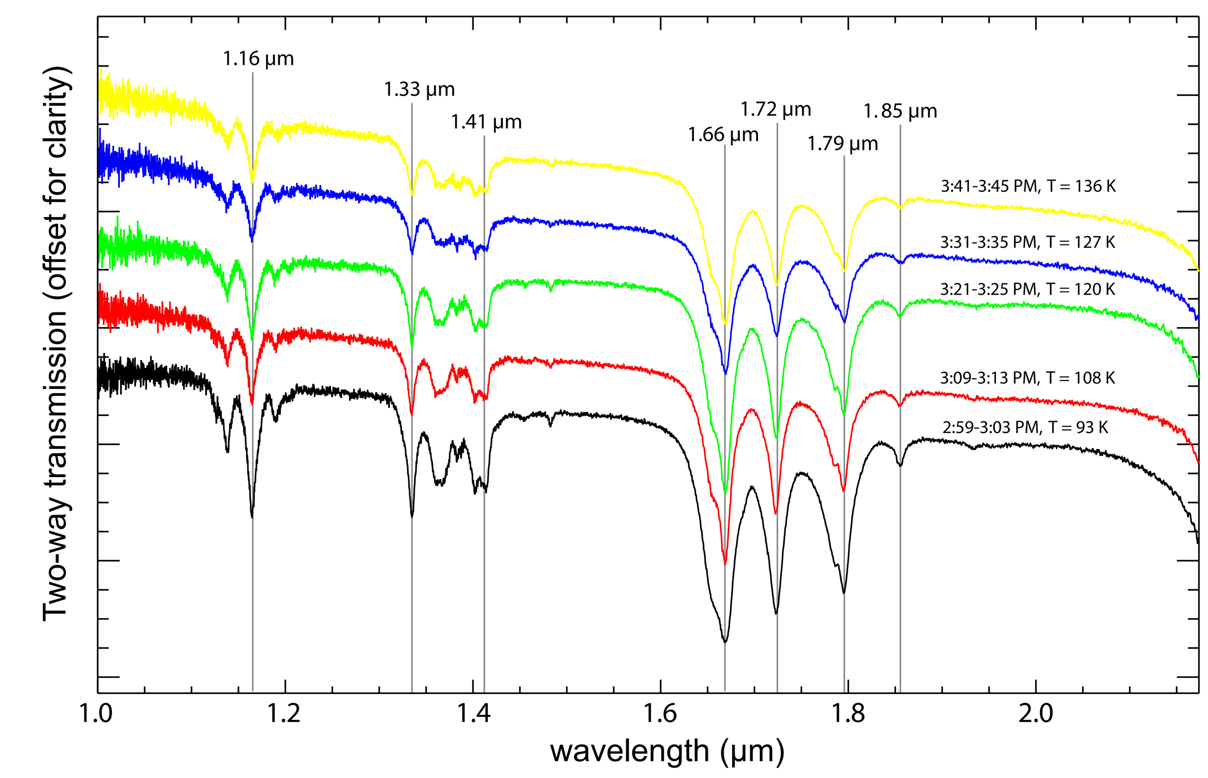
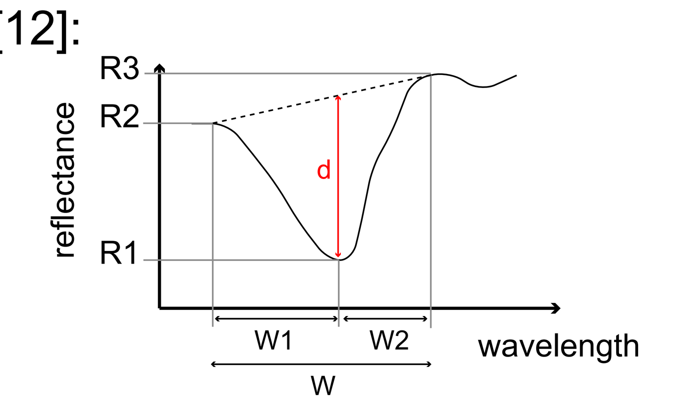



**Figure 6:** Two-way tranmission spectra through liquid methane acquired during the evaporation of liquid methane at Titan's pressure.

***Methane absorption band depths computation:***

Computation of methane absorption band depths based on the following formula [12]:

$$d = 1 - \frac{R1}{R2*(W1/W) + R3*(W2/W)}$$



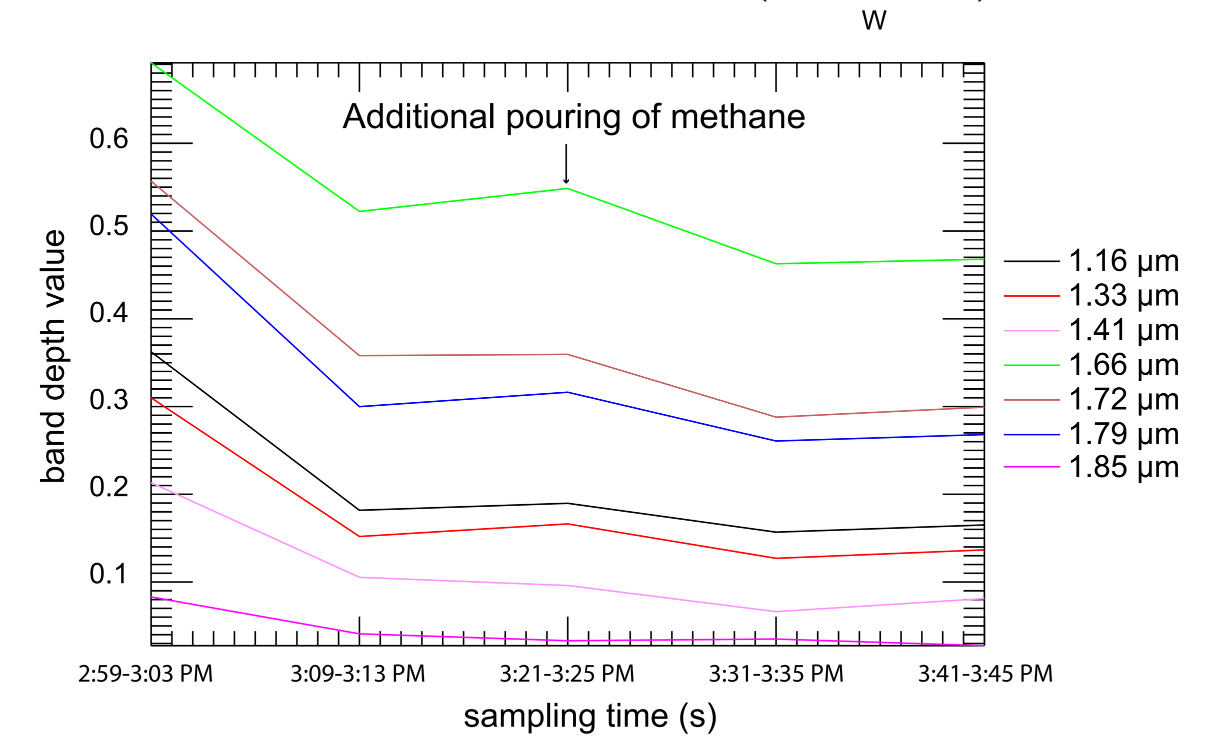




**Figure 7:** Methane absorption band depths over the time.

## CONCLUSION

- Experiments done using the Titan Module specially designed to reach Titan's surface P,T conditions (1.5 bar, 90 - 94 K).
- First measurements of liquid methane evaporation rates in close agreements with theoretical calculations.
- Preliminary results of the FTIR experiment: methane absorption band depths decrease during the evaporation.

**FUTURE WORK :** Acquisition of evaporation data (mass, FTIR, Gas Chromatographer) of liquid hydrocarbons: methane, ethane and methane-ethane mixtures.

Crystallisation experiment of dissolved compounds implied in Titan's lakes chemistry (acetylene...) [13] since Titan's lakes morphologies suggest the presence of dissolution processes on the surface [14, 15].

**ACKNOWLEDGEMENTS :** This work has been funded by NASA Grant project # NNX10AE10G.

## REFERENCES

[1] A. Hayes et al., GRL 35, L09204, 2008; [2] E. R. Stofan et al., Nature 445, 61 - 64, 2007; [3] R. D. Lorenz, PSS 41, 647 - 655, 1993; [4] S. K. Atreya et al., PSS 54, 1177 - 1187, 2006; [5] R. D. Lorenz, Science 290, 467 - 468, 2000; [6] A. G. Hayes et al., Icarus 211, 655 - 671, 2011; [7] E. P. Turtle et al., Icarus 212, 957 - 959, 2011; [8] A. Luspay-Kuti et al., 42nd LPSC, 1736., 2011; [9] F. C. Wasiak et al., 42nd LPSC, 1322, 2011; [10] A. P. Ingersoll, Science 168, 972 - 973, 1970; [11] R. N. Clark et al., JGR 114, E03001, 2009; [12] M. Massé et al., GRL 113, E12006, 2008.[13] D. Cordier et al., The Astr. Journ. 707, L128 - L131, 2009; [14] Bourgeois et al., 39th LPSC, 1733, 2008; [15] Cornet et al., 42nd LPSC, 2581, 2011.