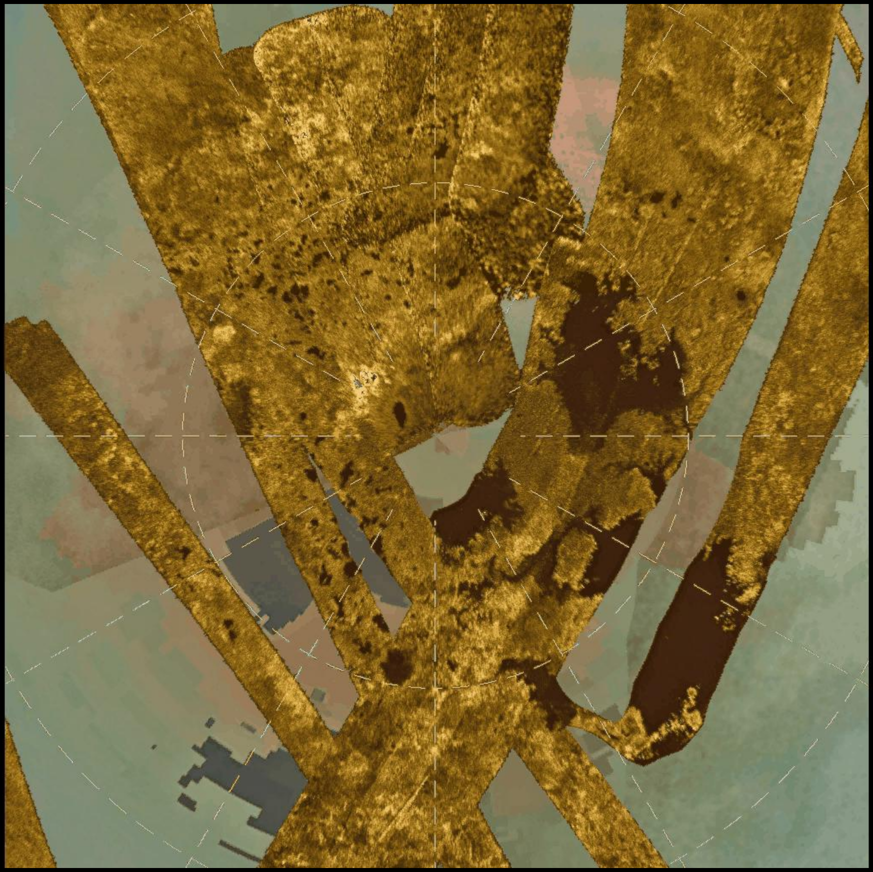
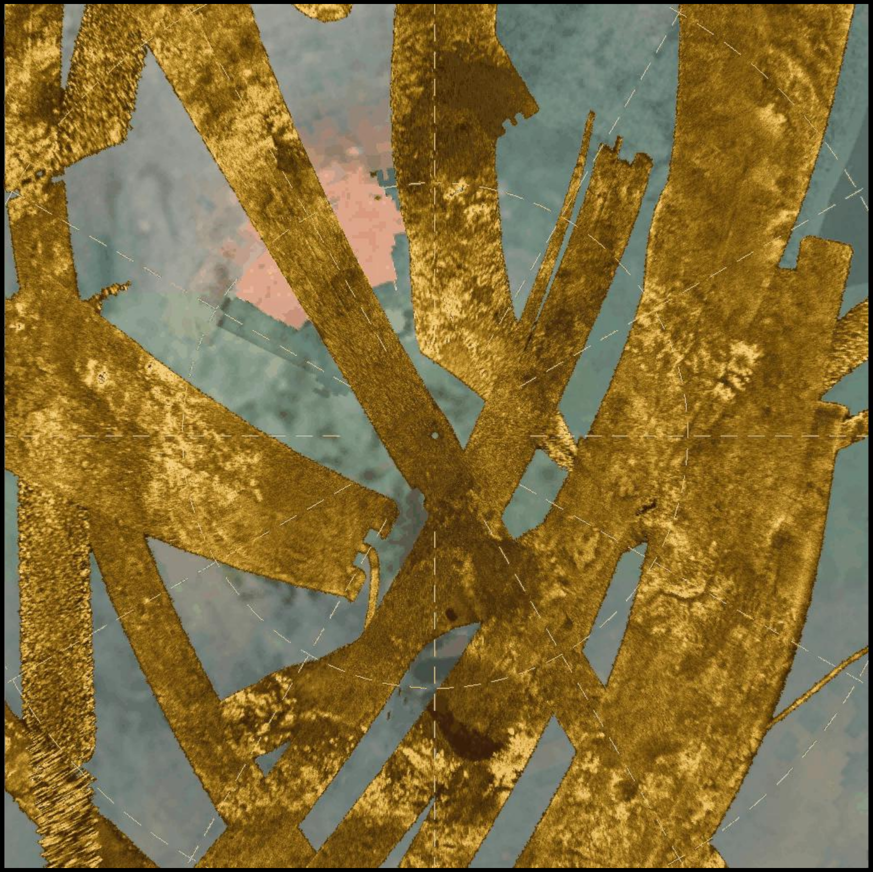
Liquid Properties on Titan

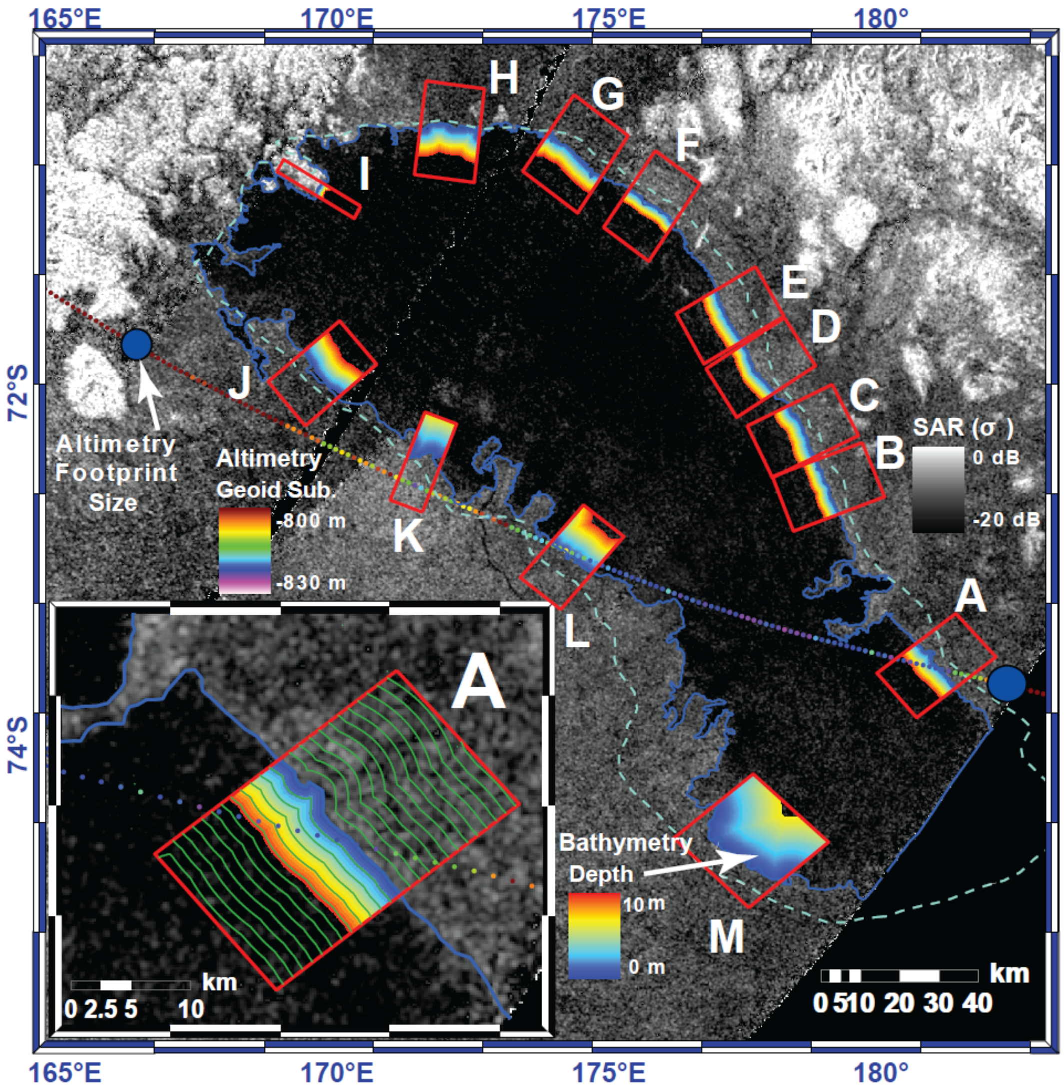


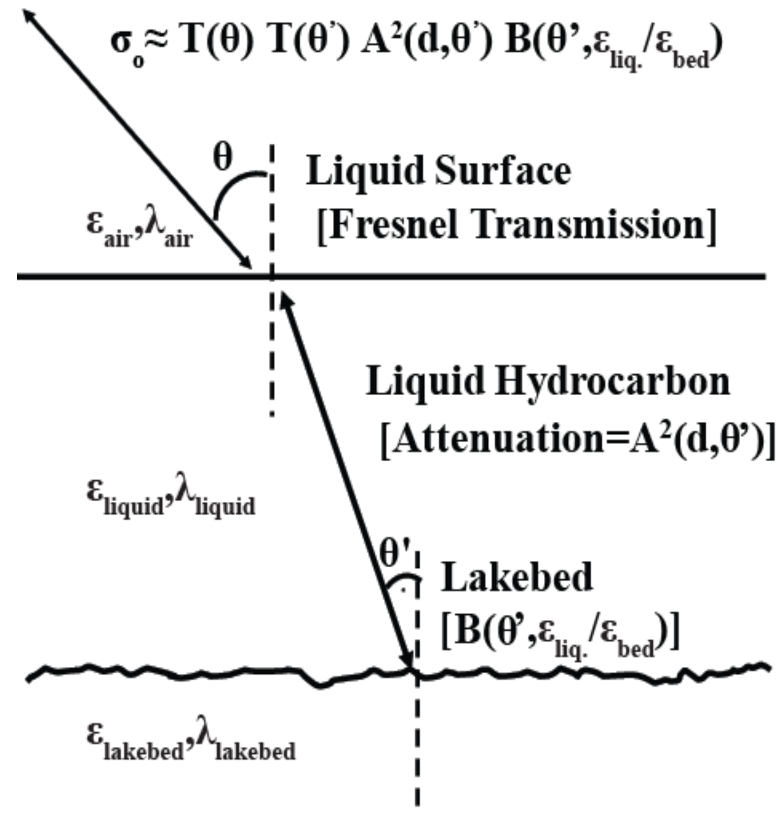


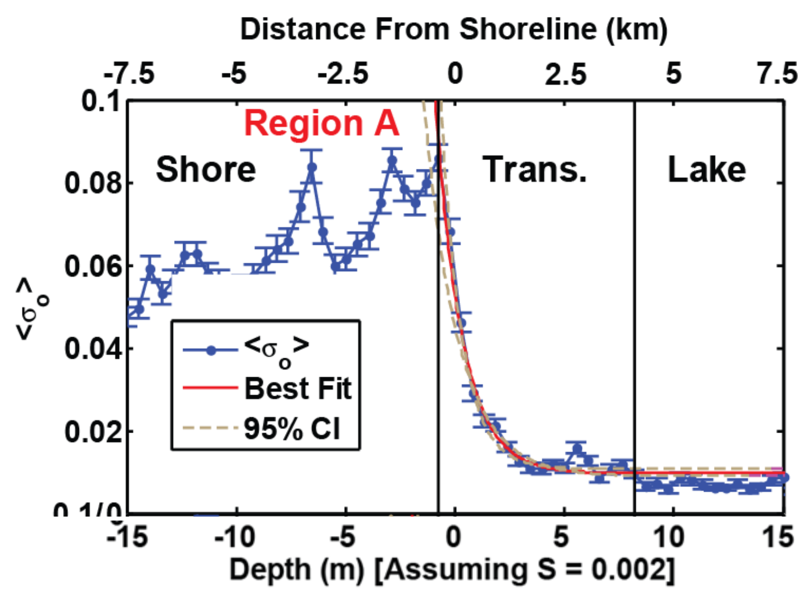
Alexander G. Hayes (Caltech)

Oded Aharonson, A. Aubrey

Future Missions to Titan: KISS; May 26th, 2010





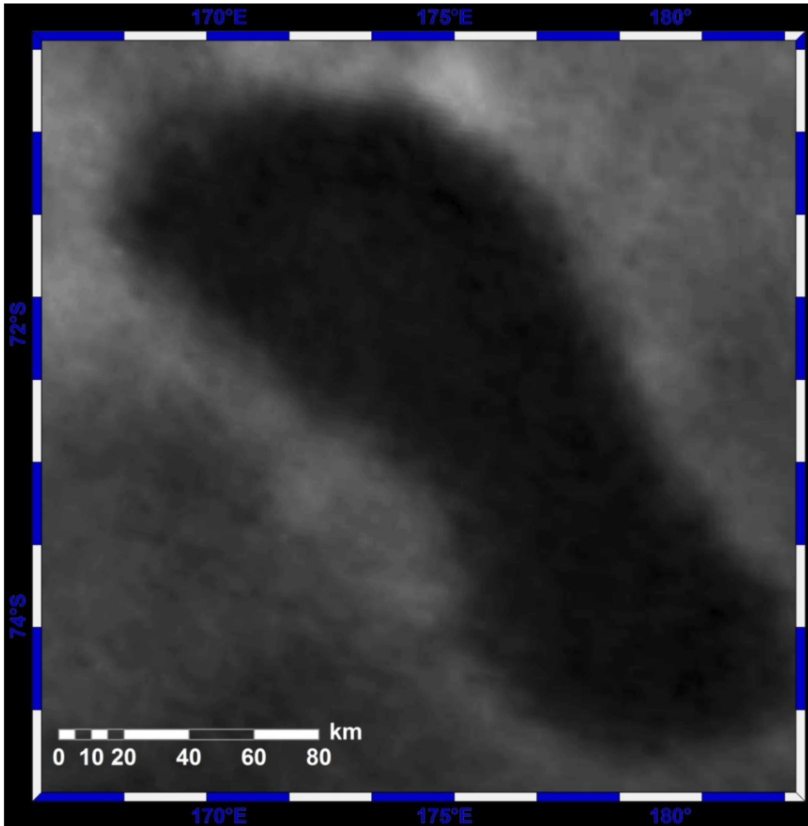


$$\sigma_o = \sigma_1 + \sigma_2 e^{\left(\frac{-8\pi\ \kappa\ d}{\lambda\ \cos\theta_{liq}}\right)}$$

$$\kappa = (6.1 \pm 1.6)\times 10^{-4}$$

$$\tan\Delta = (9.2 \pm 2.4)\times 10^{-4}$$

Hayes et al., JGR 2010
Hayes et al., Icarus 2010



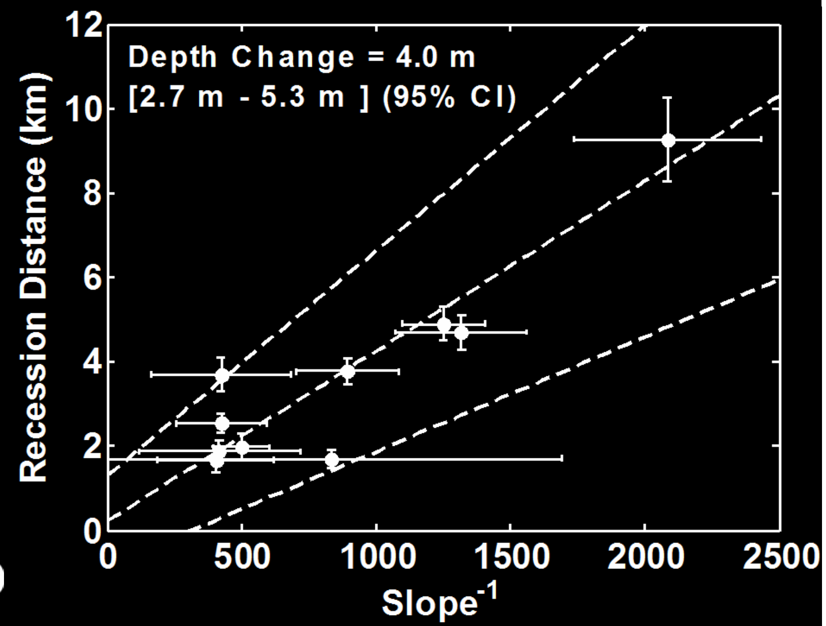
June 2005

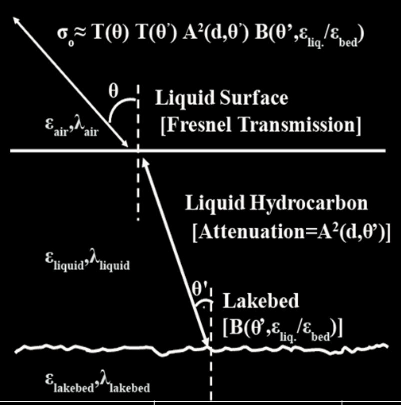
March 2009

July 2009

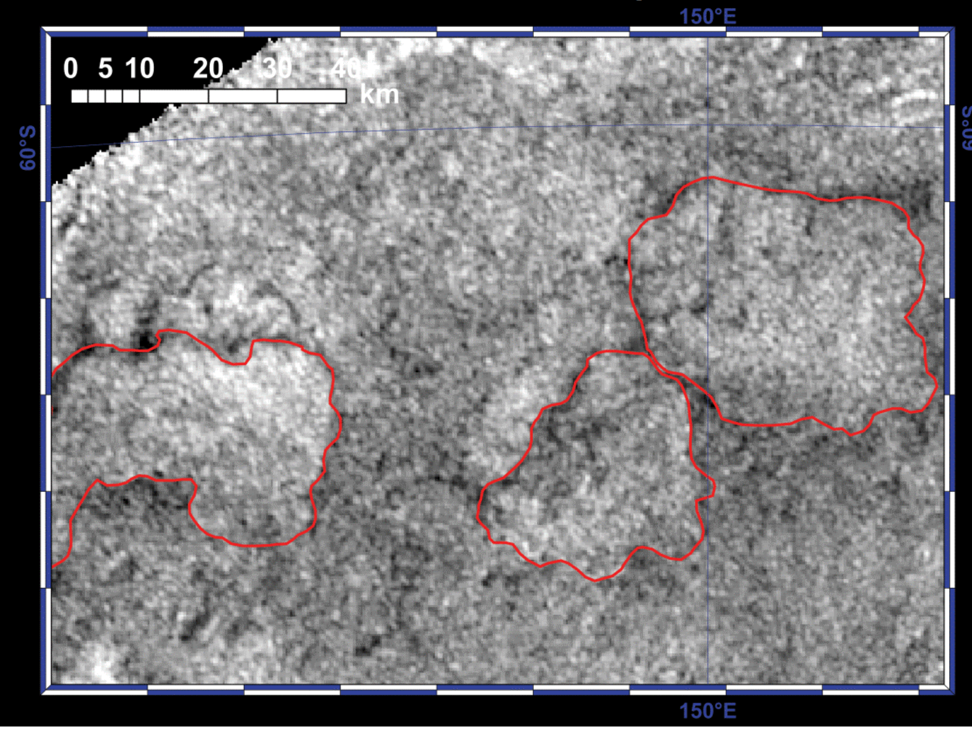
January 2010

Hayes et al., *Icarus* 2010

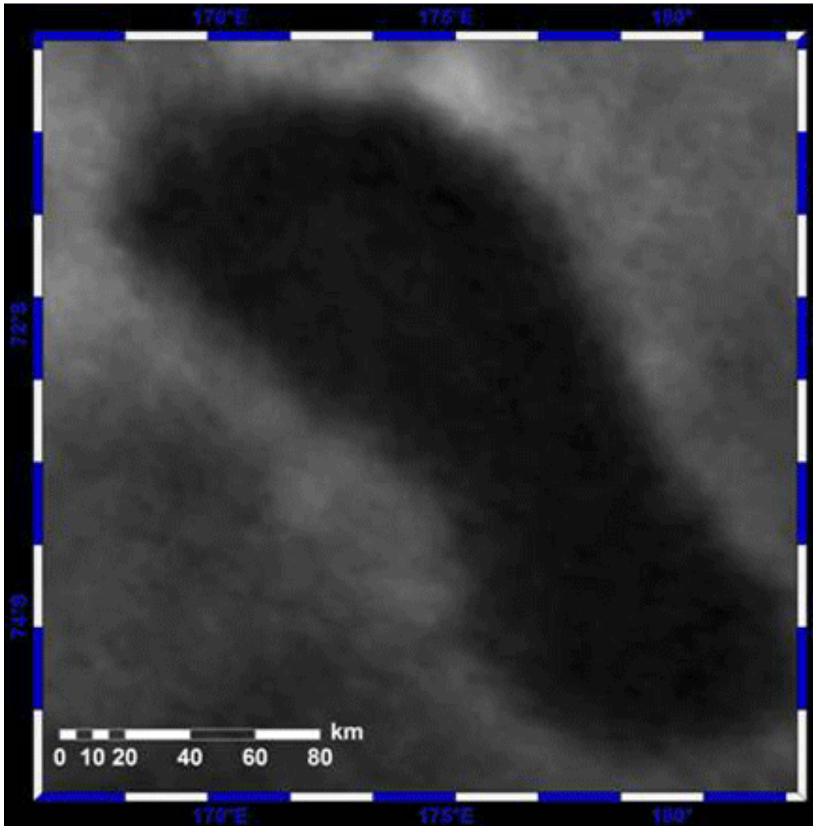




Swaths		Transition	Depth	Flux
T39	T55	Par.-filled to Empty	1.11±0.26 m	0.74±0.17 m/yr
T39	T55	Par.-filled to Par.-filled	1.14±0.28 m	0.74±0.19 m/yr
T36	T49	Par.-filled to Empty	0.85±0.20 m	0.68±0.16 m/yr
T36	T49	Par.-filled to Par.-filled	1.32±0.38 m	1.0±0.30 m/yr



Hayes et al., *Icarus* 2010



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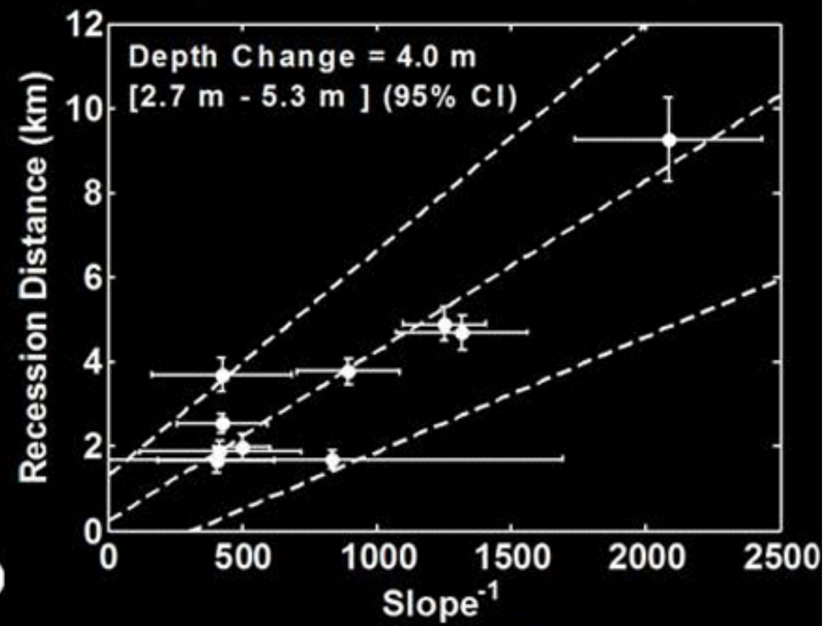

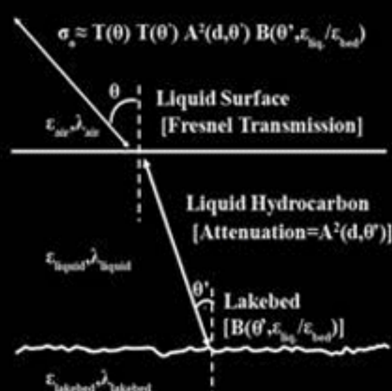

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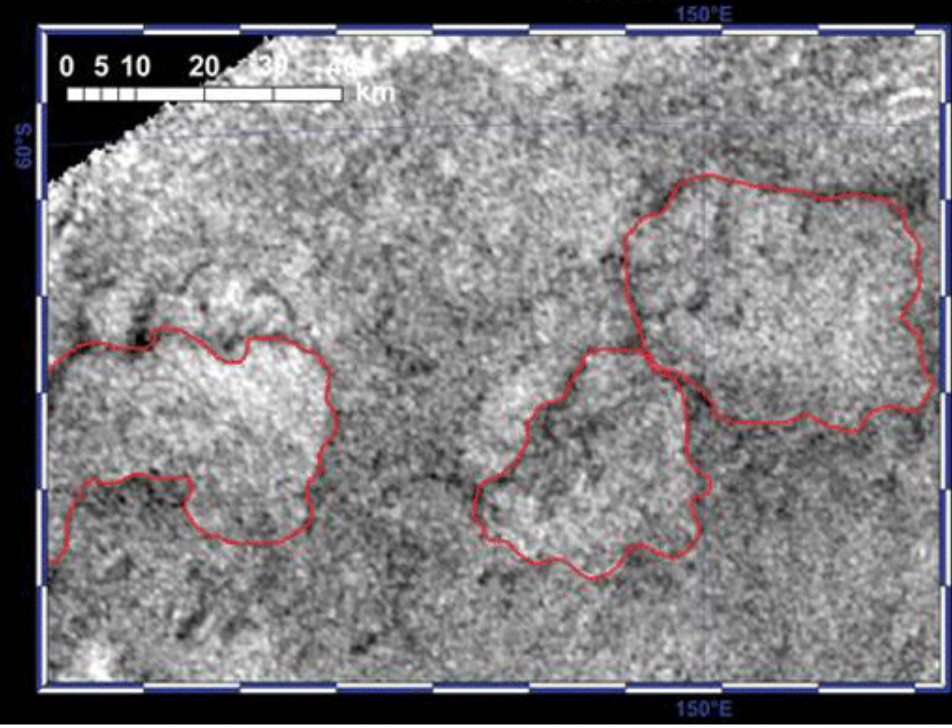

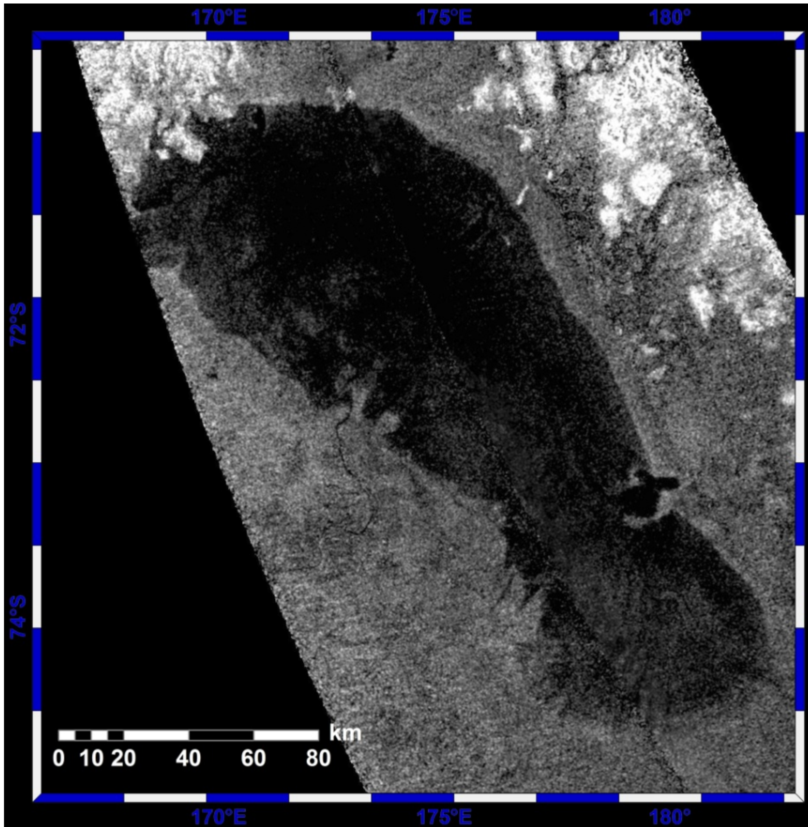

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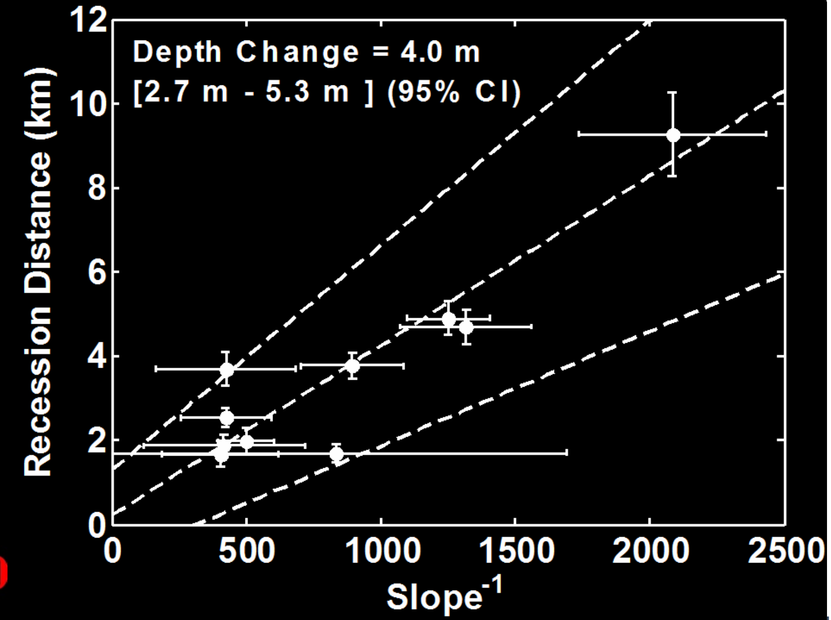
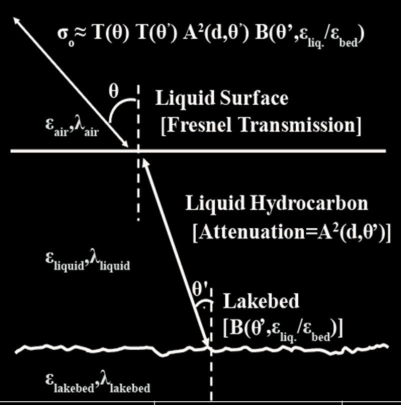
Hayes et al., *Icarus* 2010





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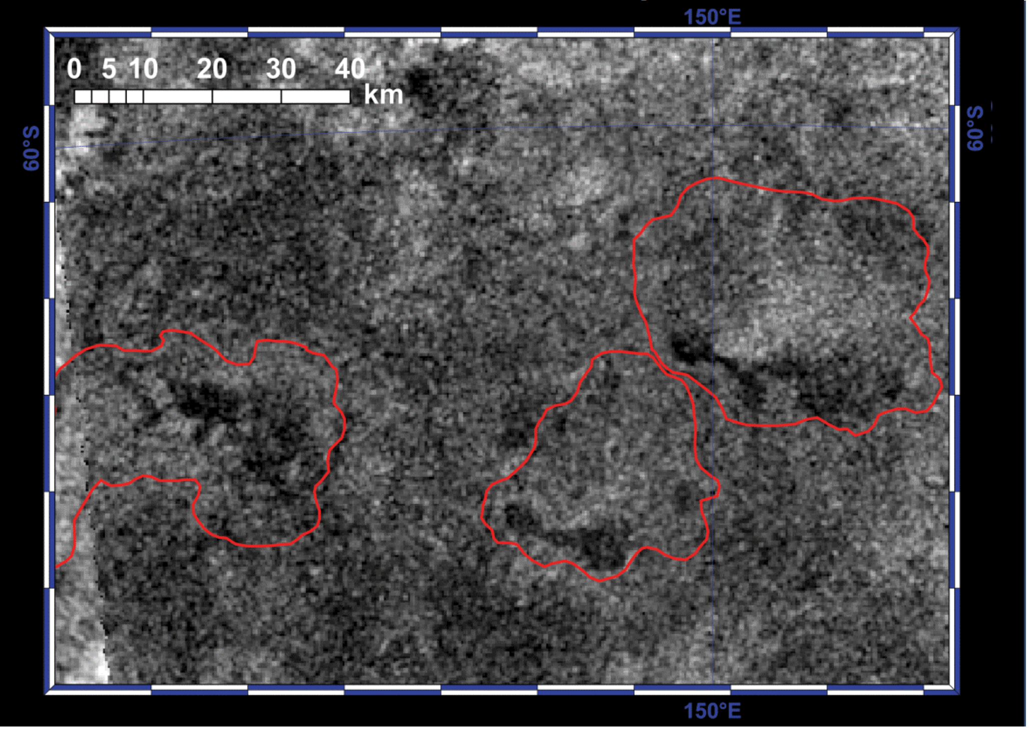
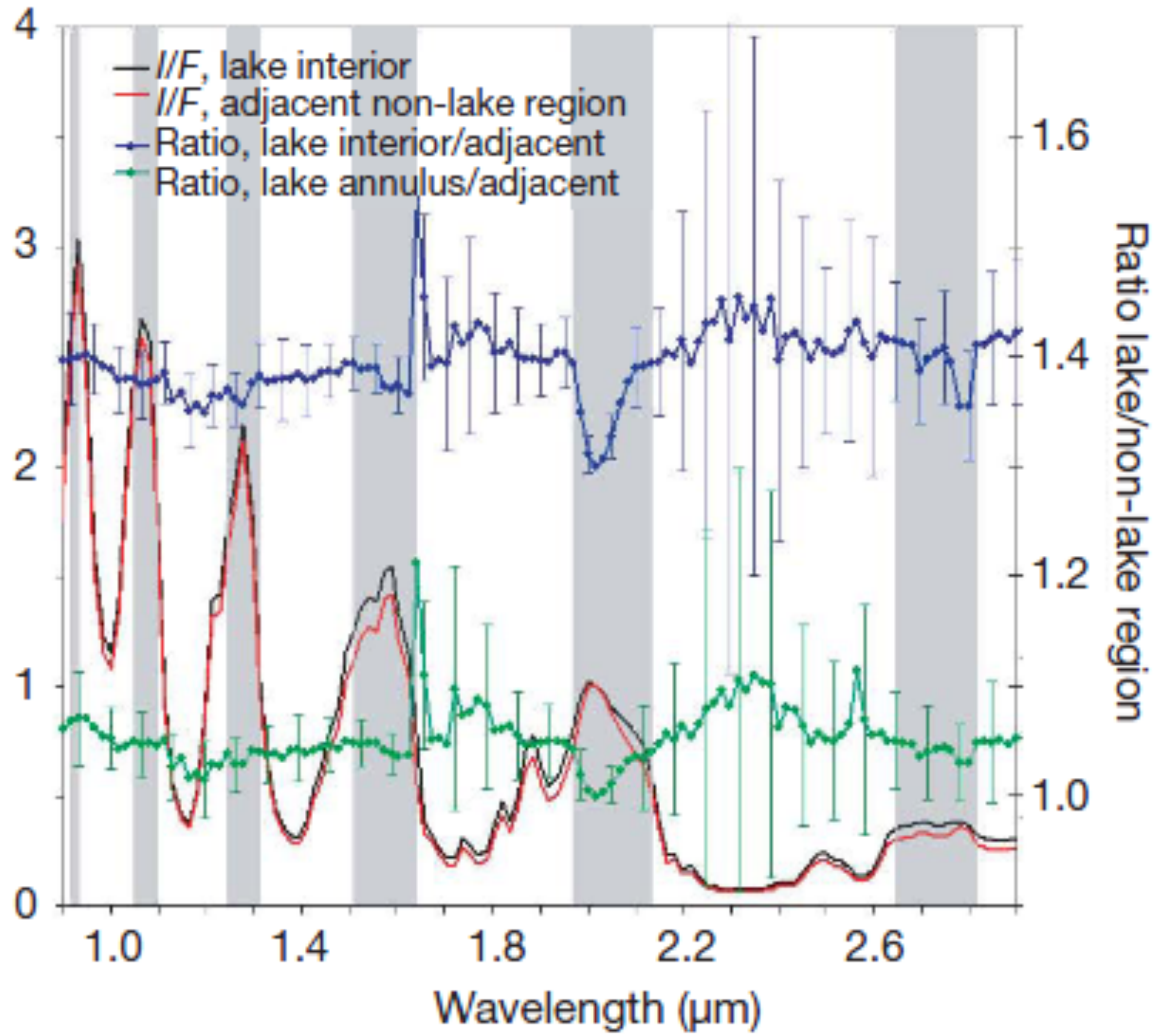


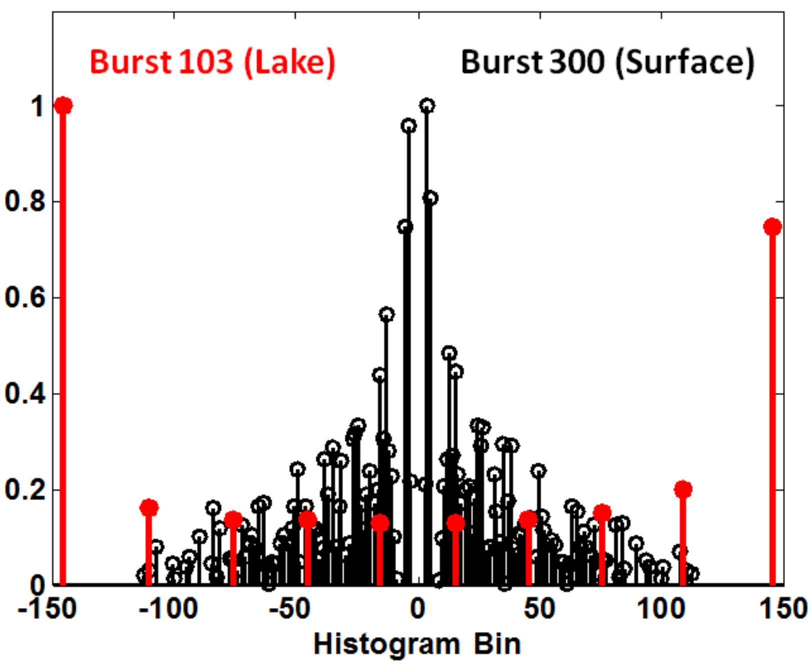
	Poles (90 K)
Main composition (⋆)	
N_2	4.90×10^{-3}
CH_4	9.69×10^{-2}
Ar	5.01×10^{-6}
CO	4.21×10^{-7}
C_2H_6	7.64×10^{-1}
C_3H_8	7.42×10^{-2}
C_4H_8	1.39×10^{-2}
H_2	3.99×10^{-11}
Solutes (⋆)	
HCN	2.09×10^{-2} (s)
C_4H_{10}	1.21×10^{-2} (ns)
C_2H_2	1.15×10^{-2} (ns)
C_6H_6	2.25×10^{-3} (ns)
CH_3CN	9.89×10^{-4} (ns)
CO_2	2.92×10^{-4} (ns)

Cordier et al., ApJ 2009

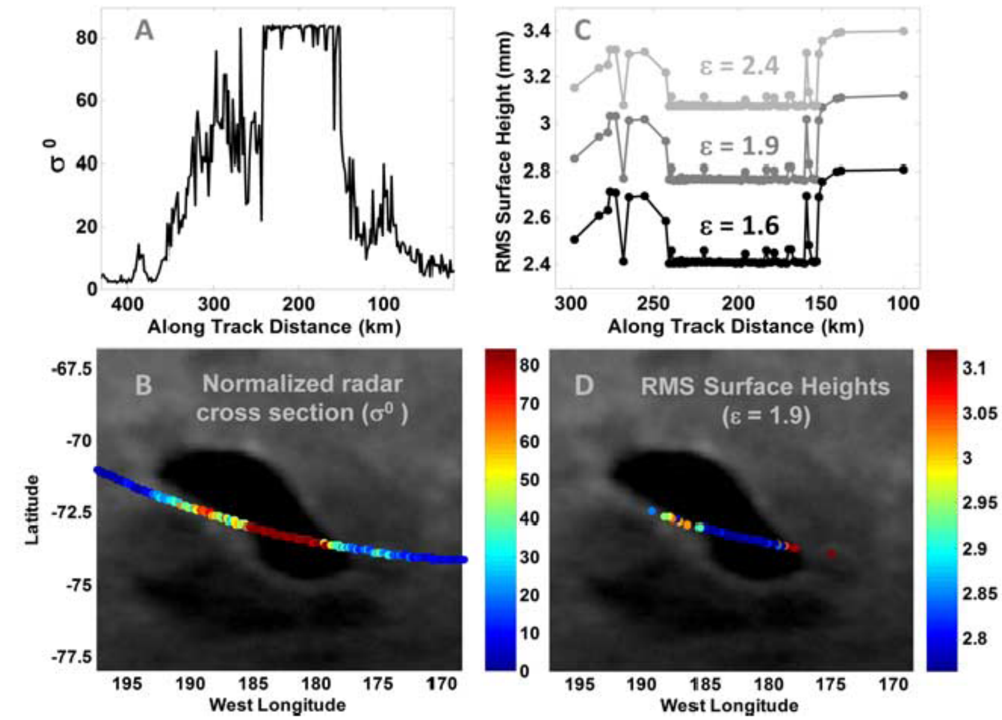


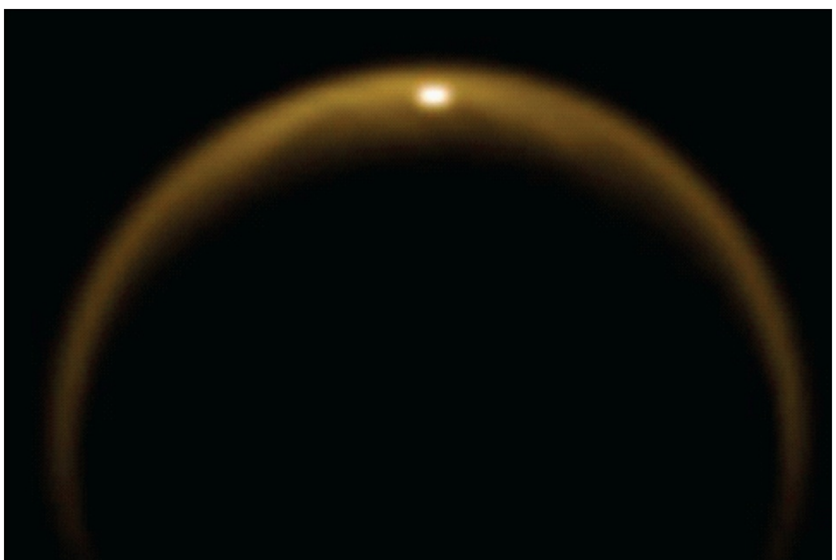
Brown et al., Nature 2008

Wye et al, *GRL* 2009

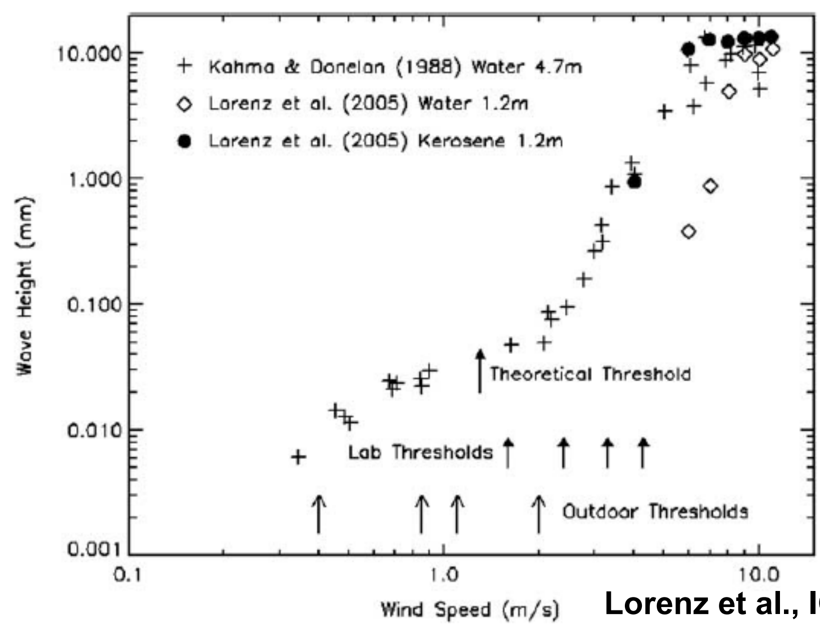


WYE ET AL.: SMOOTHNESS OF TITAN'S ONTARIO LACUS





Stephan et al., GRL 2010



Lorenz et al., ICARUS 2010

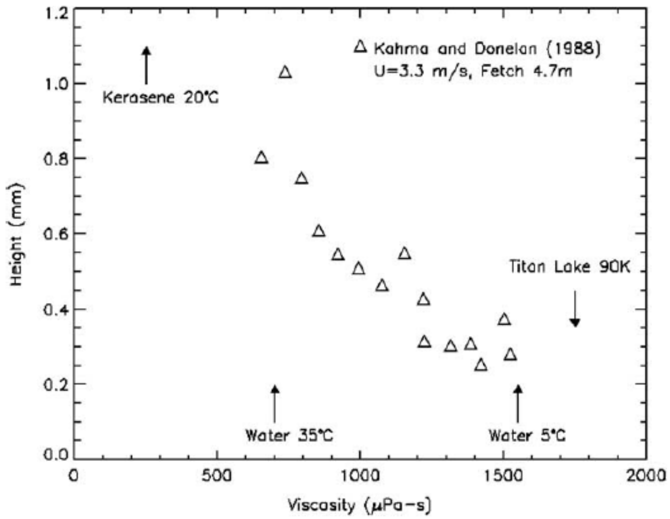


Fig. 3. Height of capillary waves in water at various temperatures as measured by Kahma and Donelan (1988) in a wind tunnel with freestream flowspeed of 3.3 m/s and a fetch of 4.5 m. The data have been plotted against tabulated viscosity of water at the relevant temperatures – the strong dependence of wave height on viscosity is evident, and the predicted viscosity of Titan lakes containing heavy compounds (Table 1) is higher than the maximum for water. The dynamic pressure of terrestrial air at 3.3 m/s corresponds to Titan winds of 1.6 m/s.

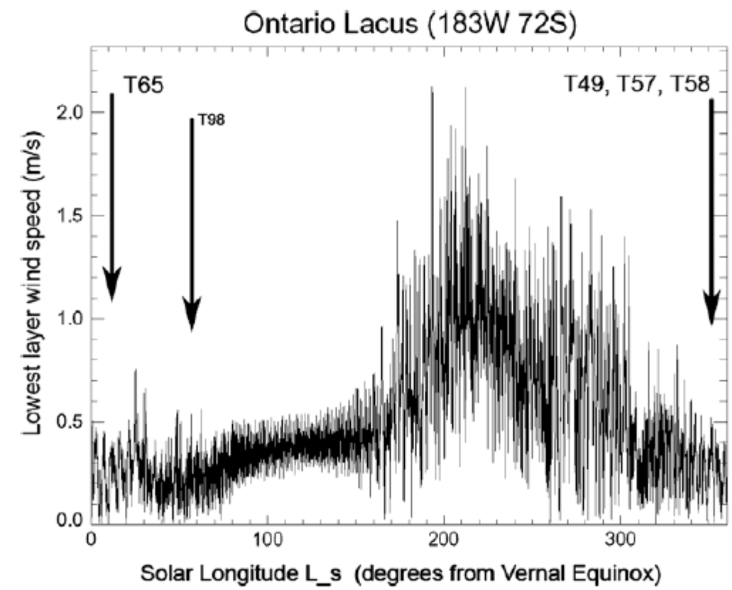


Fig. 4. Near-surface windspeeds (calculated in the TitanWRF model at ~90 m altitude) over Ontario Lacus as a function of solar longitude *Ls*. Winds are strongest, peaking at 1.5–2 m/s in early southern summer (*Ls* ~ 200–240°). Cassini observations have been and will be exclusively when low winds (<0.5 m/s) are predicted. The VIMS T38 observation in December 2007 was at *Ls* = 340°.

Lorenz et al., ICARUS 2010

Table 1
Physical properties of candidate Titan lake compositions and comparison fluids. Top section denotes assumed conditions and composition, *X* denoting mole fraction of the respective component. The Cordier (simp) compositions denote a simplified variant of the Cordier et al. (2009) composition where all compounds heavier than propane are lumped with propane, to determine the effect of the butane fraction.

Context	Pure CH_4	Pure CH_4	Rain	Rain	Pure C_2H_6	Pure C_2H_6	Cordier	Cordier	Cordier (simp)	Cordier (simp)	Water	Liquid nitrogen	Toluene
T (K)	94	92	90	94	92	94	90	94	90	94	290	77	293
$X[C_2H_6]$					100	100	74	74	74	74			
$X[N_2]$			25	25			0.5	0.5	0.5	0.5			
$X[CH_4]$	100	100	75	75			10	10	10	10			
$X[C_3H_8]$							7	7	15.5	15.5			
$X[C_4H_{10}]$							8.5	8.5					
Density (kg/m^3)	454	456	531	518	650	647	662	658	654	650	1000	800	867
Specific heat Cp (kJ/kg K)	3.29	3.29	3.21	3.25	2.25	2.27	2.35	2.4	2.39	2.42	4.2	2.05	1.67
Sound speed (m/s)	1574	1589	1294	1260	1985	1975	2026	1905	2028	1931	1482	945	1345
Viscosity (μPa s)	208	222	167	151	1246	1141	1736	1423	1528	1263	1000	155	585
k (W/m/k)	0.229	0.232	0.192	0.18	0.252	0.251	0.248	0.245	0.245	0.244	0.6	0.13	0.134
Refractive index	1.287			1.272		1.38					1.33		1.497
Dielectric constant	1.65			1.61		1.917						1.4	2.4
Surface tension (N/m)	1.80E−02					1.80E−02					0.073	0.03	0.028

90-95 K Fundamental Challenges in Liquid Sample Acquisition on Titan

300 K ?

Figure 1. A technology gap exists today between sample acquisition and sample analysis tools. Integrated science payload packages need an

Bearman and Kossakovski, IEEE 2001

1.Low temperature (90-95 K) environment

- **Must inject sample into analysis system without alteration (acquisition system also at 90-95K)**

2.Thermal gradient between sample tube inlet and sample collection chamber

- **Thermal Volatilization of sample**
  - **Particulates and high order hydrocarbons may not volatilize**
  - **Potential for real-time TV analysis (complex thermal model)**
- **Volume (pressure) increase**

3. Contamination of sample handling system (Condensation in plumbing)