

# The Radar instrument on-board Cassini

Yann Chemin

Titan

Energy Balance

Atm. Layers

Atm. Profile

Radiation Budget

Energy Budget

Oceans & Lakes

Polar lakes

T91 Fly-by

Ligeia Mare

Lake bathymetry

Evaporation

Rainfall/Run-off

Rainfall

ITCZ

Conclusions

## RS of Planetary Surfaces

B.Sc. Planetary Sciences with Astronomy

4<sup>th</sup> Year, Remote Sensing of Planetary Surfaces



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## Cassini RADAR

<http://saturn.jpl.nasa.gov/spacecraft/cassiniorbiterinstruments/instruments>

### Hydrocarbons

Surface and atmospheric hydrocarbon

Methane ( $CH_4$ ) of solar system origins

Ethane ( $C_2H_6$ ) rainfall

### Hydrocarbons

Triple phase temperature range (solid, liquid, gas)

Atmospheric photolysis of  $CH_4$  to  $C_2H_6$

Oceans & Lakes as source of atmospheric content

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Image Credit: NASA/JPL-Caltech

<http://photojournal.jpl.nasa.gov/jpeg/PIA06160.jpg>

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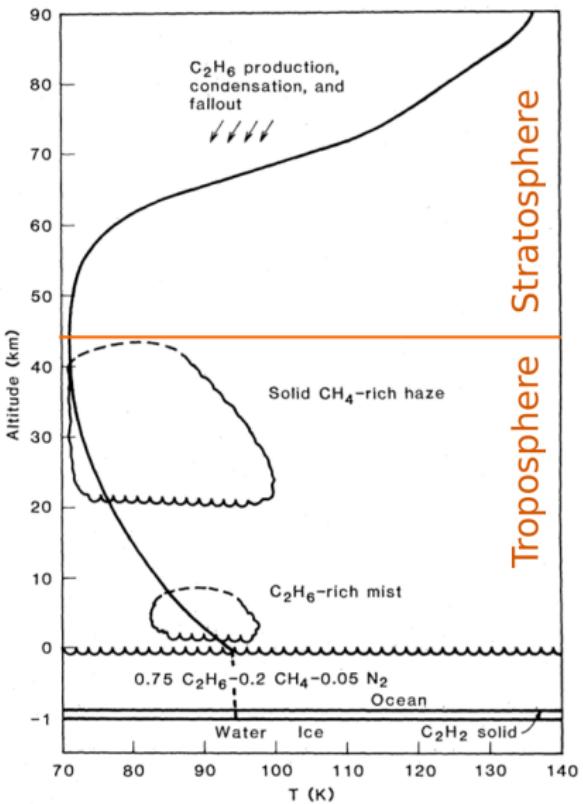


Figure Credit: Lunine et al. (1983)

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The generic longwave greybody/blackbody radiation:

$$GE = \varepsilon BB = \varepsilon\sigma T^4 \quad (1)$$

The radiation budget at planetary surface:

$$R_{net} = SW_{bal} + LW_{bal} \quad (2)$$

Radiation budget generic extension at planetary surface:

$$R_{net} = (1 - \rho)\tau_{sw}E_s + (1 - \varepsilon_0)\sigma T_0^4 + (\varepsilon_{atm} - 1)\sigma T_{atm}^4 + \epsilon \quad (3)$$

This provides the constraint on the available energy for conduction, convection and vaporization processes at surface

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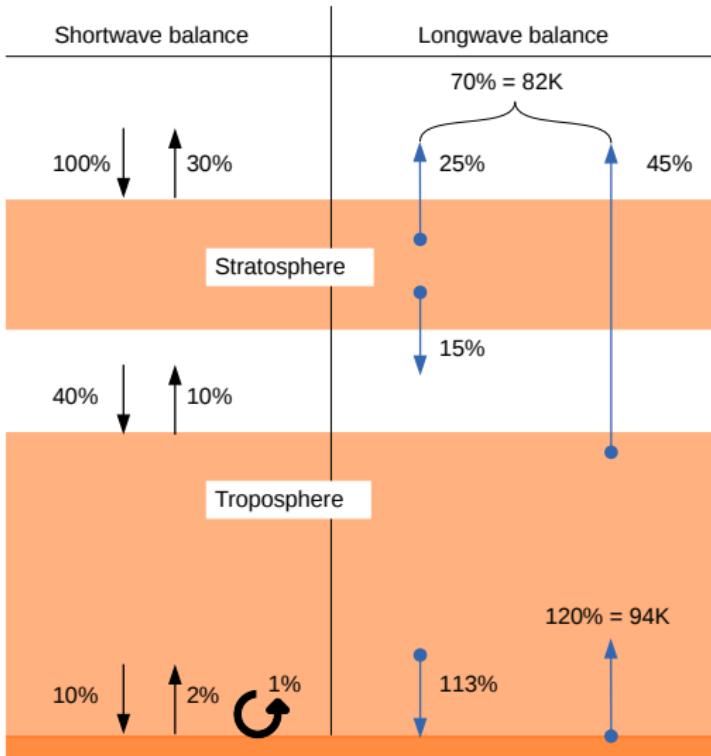


Figure Credit: recreated after McKay et al. (1991)

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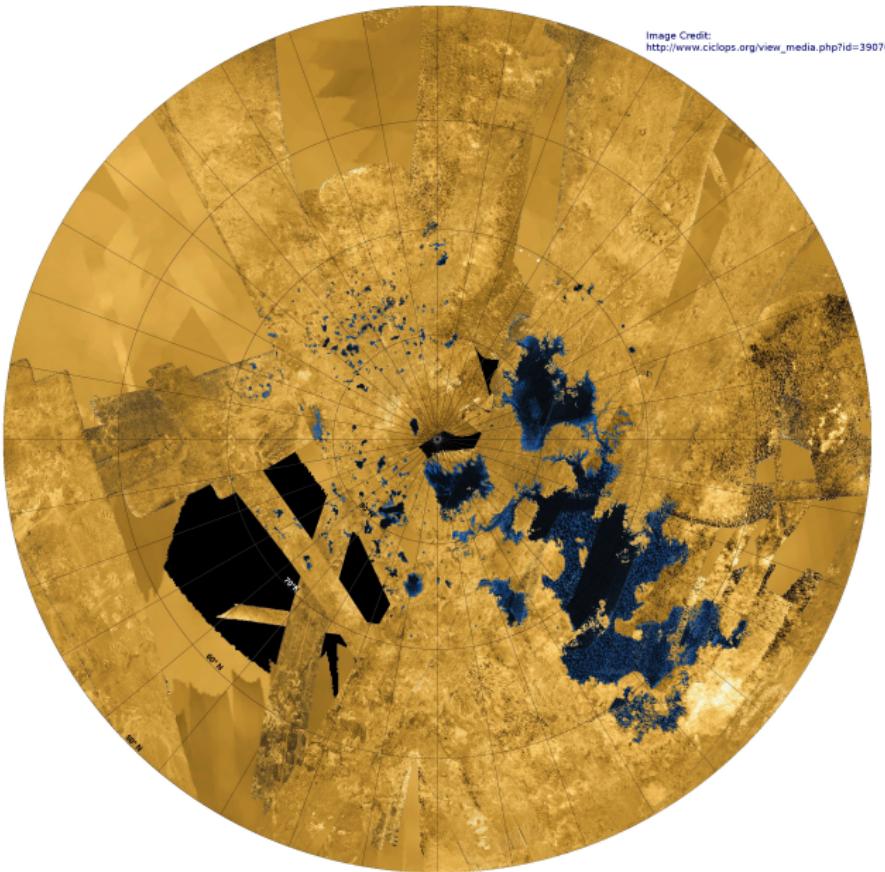


Image Credit:  
[http://www.ciclops.org/view\\_media.php?id=39076](http://www.ciclops.org/view_media.php?id=39076)

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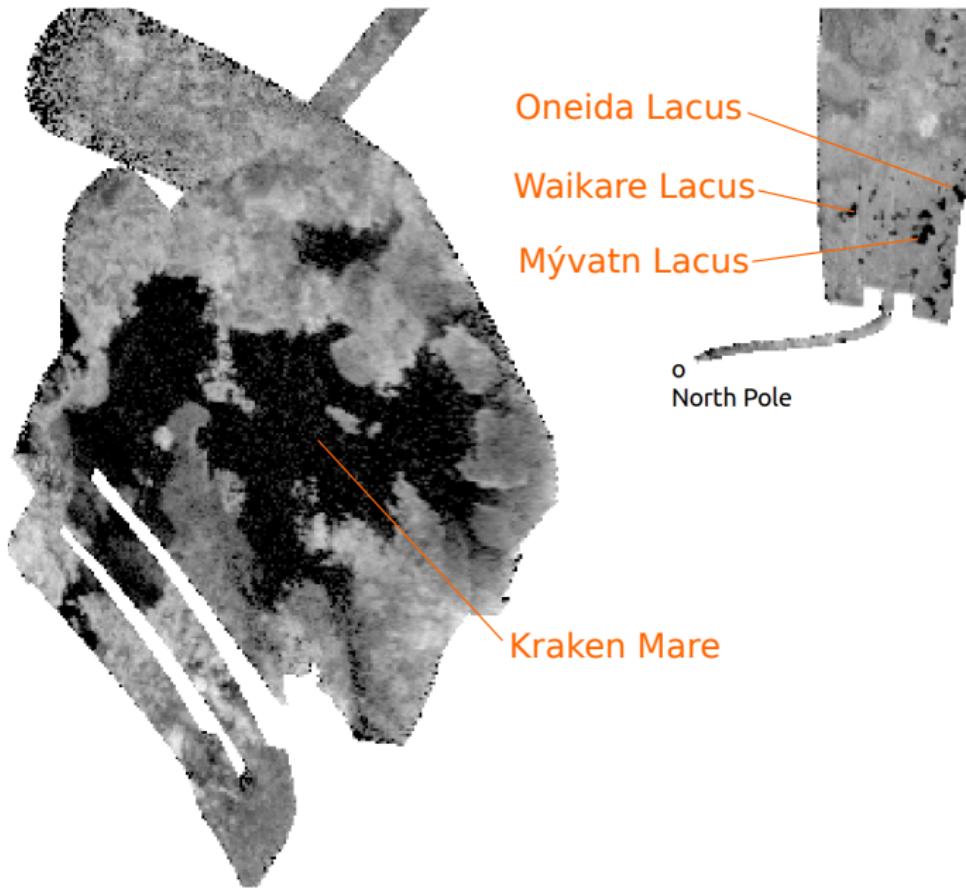
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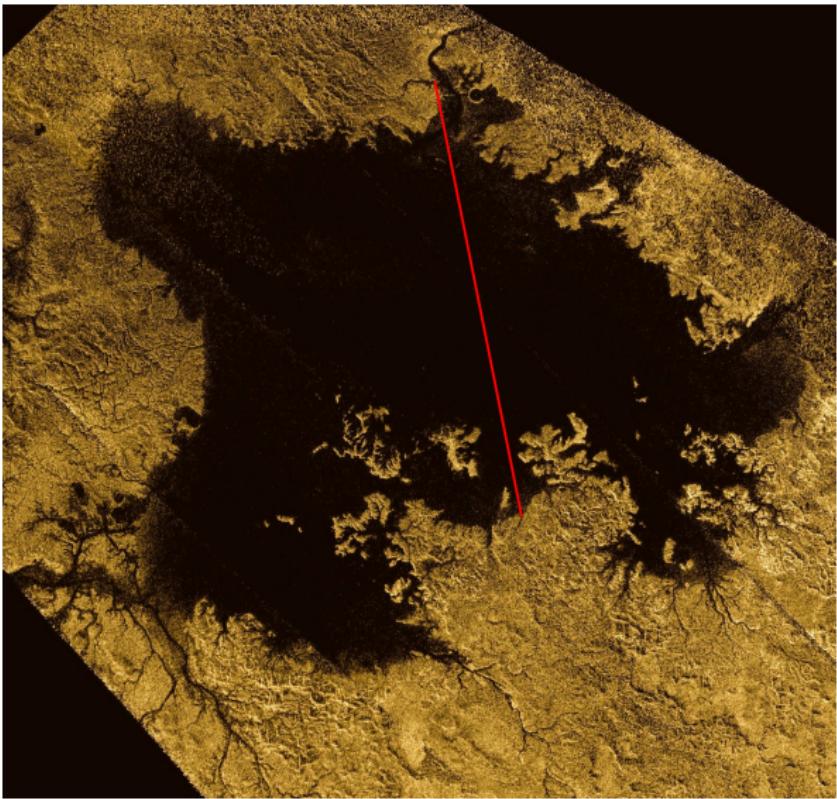
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Radar Image Credit: NASA/JPL-Caltech

[http://www.ciclops.org//view\\_media.php?id=39071&js=1](http://www.ciclops.org//view_media.php?id=39071&js=1)

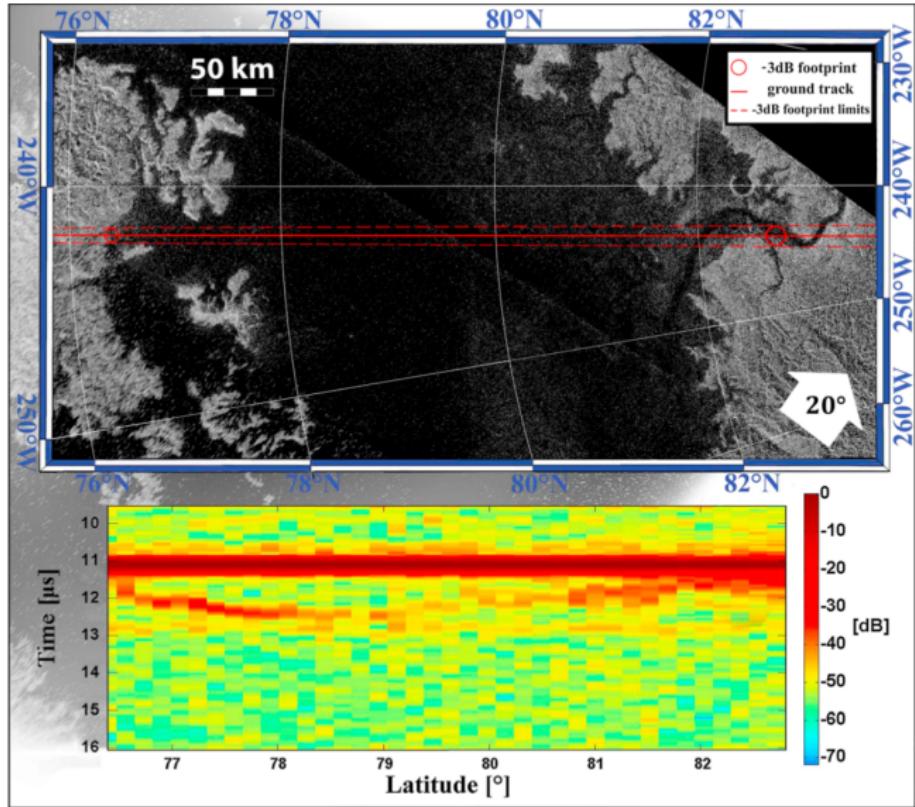


Figure Credit: Mastrogiuseppe et al. (2014)

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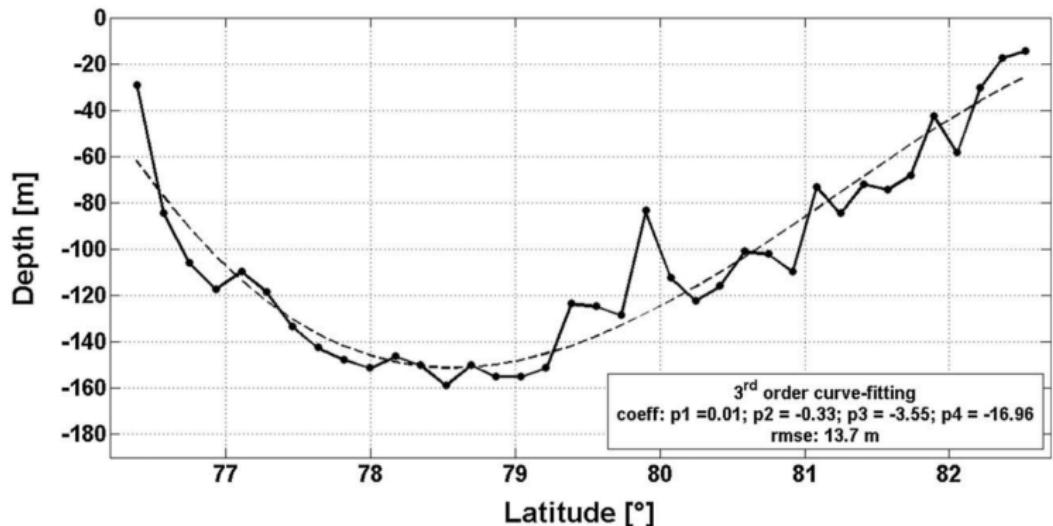


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## Evaporation

20mm/week at poles

1mm/week at equator

The vaporization heat adapted to Titan:

$$H_L = \frac{n_a L}{\eta} C (q_s - q_a) = \frac{n_a L}{\eta} C \delta q \quad (4)$$

$\eta$  the Avogadro's number

L the latent heat of vaporization of methane

C the bulk transfer coefficient

q the mole fraction of methane at liquid surface (saturated state:  $q_s$ ) and at a given height (typically few meters) in the atmosphere above ( $q_a$ )

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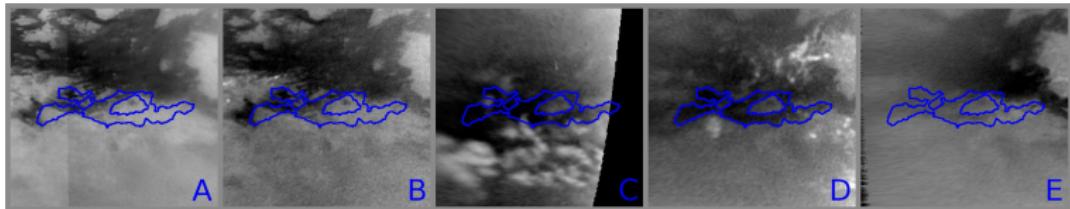
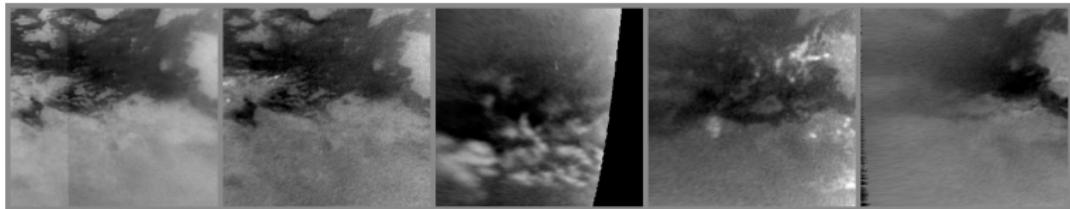
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# Rainfall on Belet (-5N,255E)

The change of surface albedo from Cassini VIMS, darkening after a large cloud passed on the Belet Albedo feature, and brightening again after some time.



Radar Image Credit: NASA/JPL-Caltech/SSI

<http://www.titanexploration.com/TitanImages2011Plus/TitanImages2011.htm>

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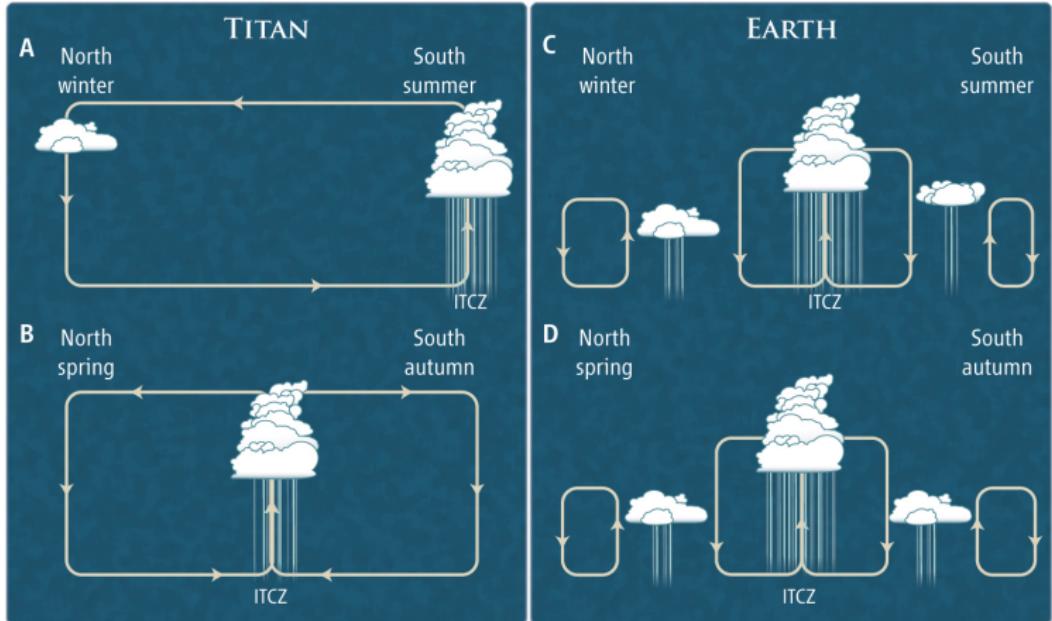


Figure Credit: Tokano (2013)

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The (m)ethonological cycle, its energy budget and spatio-temporal dynamics are just starting to be discovered.

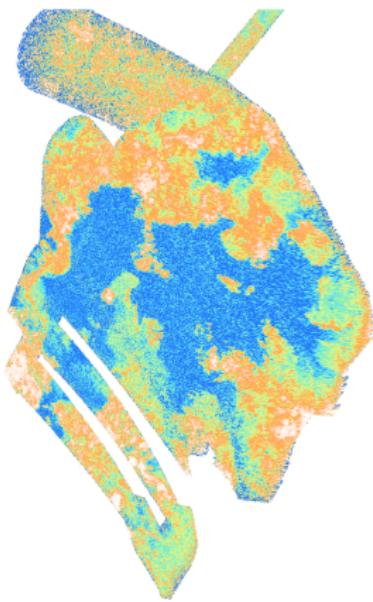
## Now

Every additional fly-by of Cassini  
Treasure trove for Titan science

## Future missions

- ▶ **Rainfall:** microwave sensor on-board orbiter/lander (TRMM type)
- ▶ **Run-off:** orbital radar altimeter (Magellan Venus radar type)
- ▶ **Geomorphology:** sub-clouds aerial Lidar altimeter + multi/hyperspectral (TSSM/Mongolfière type)
- ▶ **Energy budget:** Thermal profiler in orbit, vessel on lakes/oceans (TSSM/TiME type)

# Thank you



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