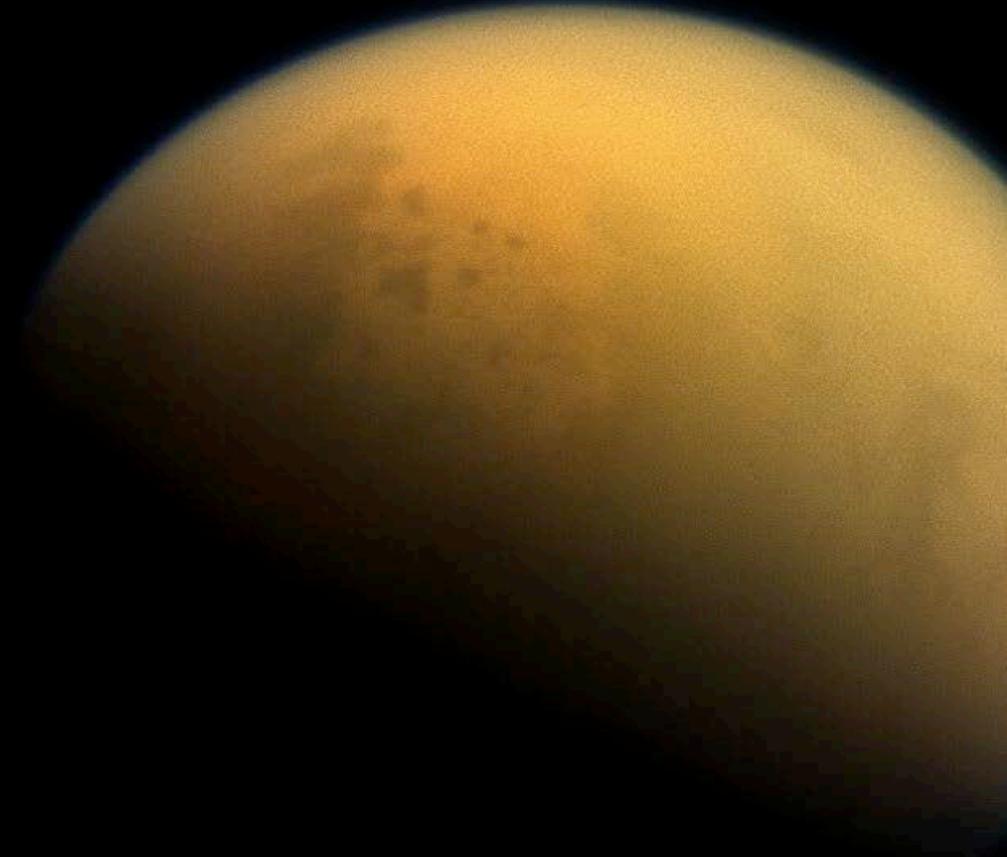


CHARM: Cassini-Huygens Mission to Saturn 10th Anniversary!!

Titan Highlights

Zibi Turtle, JHU/APL



Cassini Mission Overview

Four-Year Prime Tour, Equinox Mission, and Solstice Mission (Proposed), May 2004 - September 2017

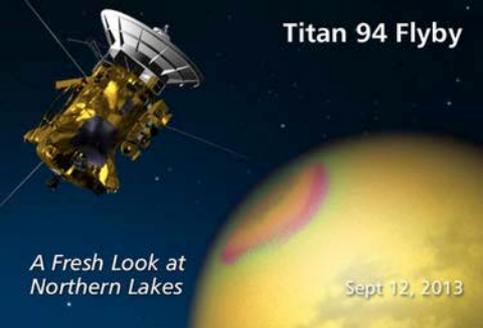
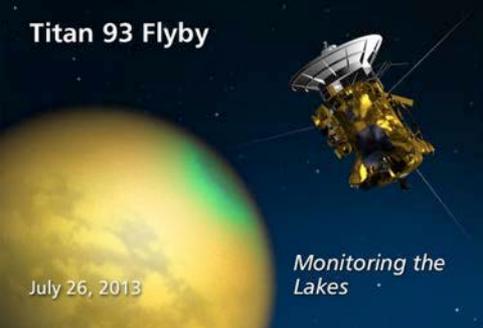


EOM
Sep 15,
2017

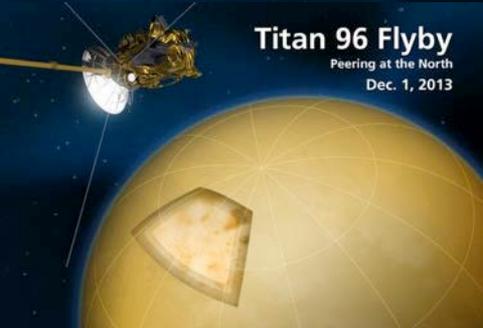
Saturn
(seen from Sun)
26 August 2014



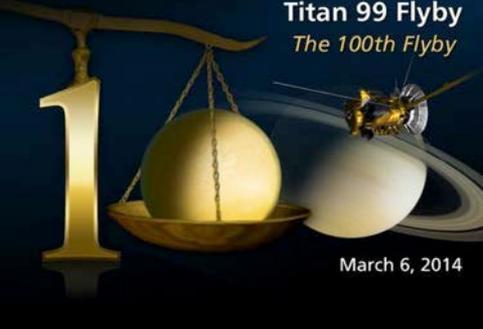
CHARM: Cassini's 10th Anniversary -- Titan!



T96, 1 Dec 2013
 T97, 1 Jan 2014
 T98, 2 Feb 2014
 T99, 6 Mar 2014
 T100, 7 Apr 2014
 T101, 17 May 2014
 T102, 18 Jun 2014
 T103, 20 Jul 2014
 T104, 21 Aug 2014



Titan flybys:
 T92, 10 Jul 2013
 T93, 26 Jul 2013
 T94, 12 Sep 2013
 T95, 14 Oct 2013



26 August 2014

CHARM: Cassini's 10th Anniversary -- Titan!

3

10 years of exploring Titan with Cassini

- Long-term, dedicated, complementary observations essential to understanding such a complex system...
- ...to build up global views...
 - North pole in winter darkness when Cassini arrived
 - RADAR SAR swaths now cover >40%
 - Global ISS, VIMS, RADAR radiom./scatterometry
- ...& witness temporal variability (~1/3 Titan yr)
 - Changes in weather patterns
 - Changes in haze distribution (altitude, hemisphere)

From Cassini's 1st anniversary CHARM telecon, June 2005!

Titan's Atmospheric Variability

detached haze
150 km higher
than observed
by *Voyager*

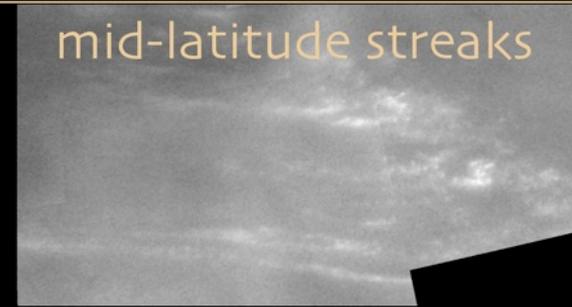


complex, variable haze structure



Seasonal
changes in
weather
patterns

mid-latitude streaks



South-polar convective clouds



From Cassini's 1st anniversary CHARM telecon, June 2005!

Titan's Atmospheric Variability

detached haze
150 km higher
than observed
by *Voyager*

- Returned to *Voyager* level around equinox

complex, variable haze structure

Seasonal
changes in
weather
patterns

- Weather has changed but storms have yet to pick up at northern latitudes

mid-latitude streaks

South-polar convective clouds

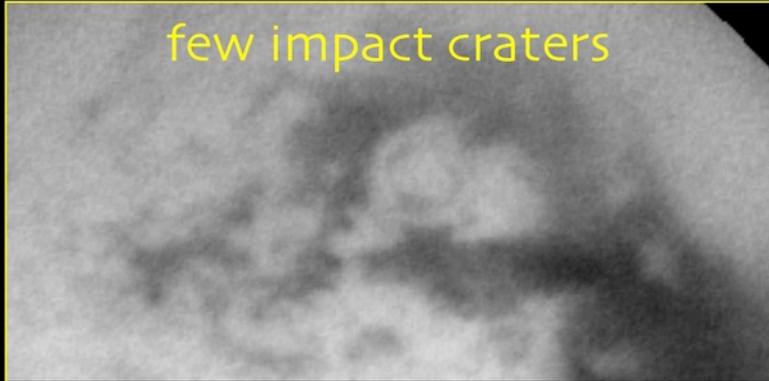


From Cassini's 1st anniversary CHARM telecon, June 2005!

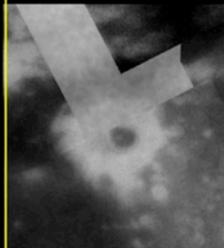
Titan's intricate albedo patterns reveal an Earth-like combination of surface processes



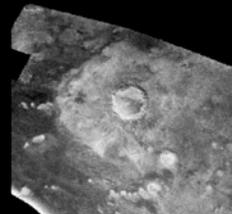
possible channels
but no direct
evidence of
surface liquids



few impact craters



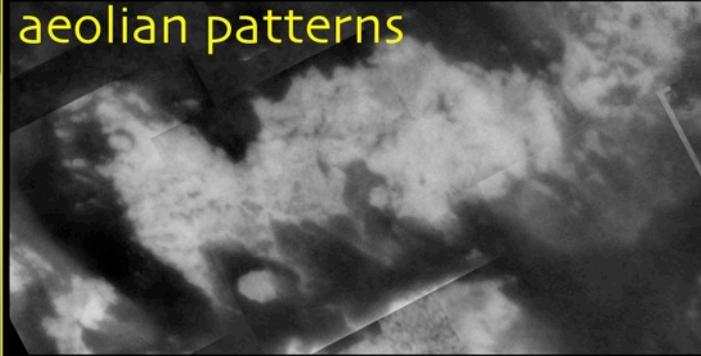
ISS



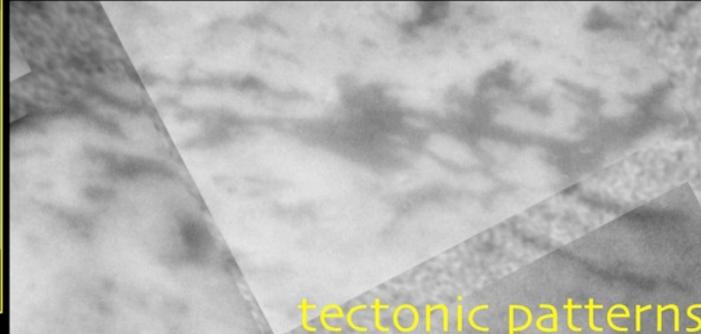
RADAR



VIMS



aeolian patterns



tectonic patterns

Titan's intricate albedo patterns reveal an Earth-like combination of surface processes

- Surface liquids confirmed at high latitudes in July 2006

possible channels but no direct evidence of surface liquids



- Still only 8 named impact structures (40-400 km); ~50 candidates



ISS

RADAR

VIMS

aeolian patterns

- Vast expanses of dunes at low latitudes

- Tectonic and cryovolcanic features identified

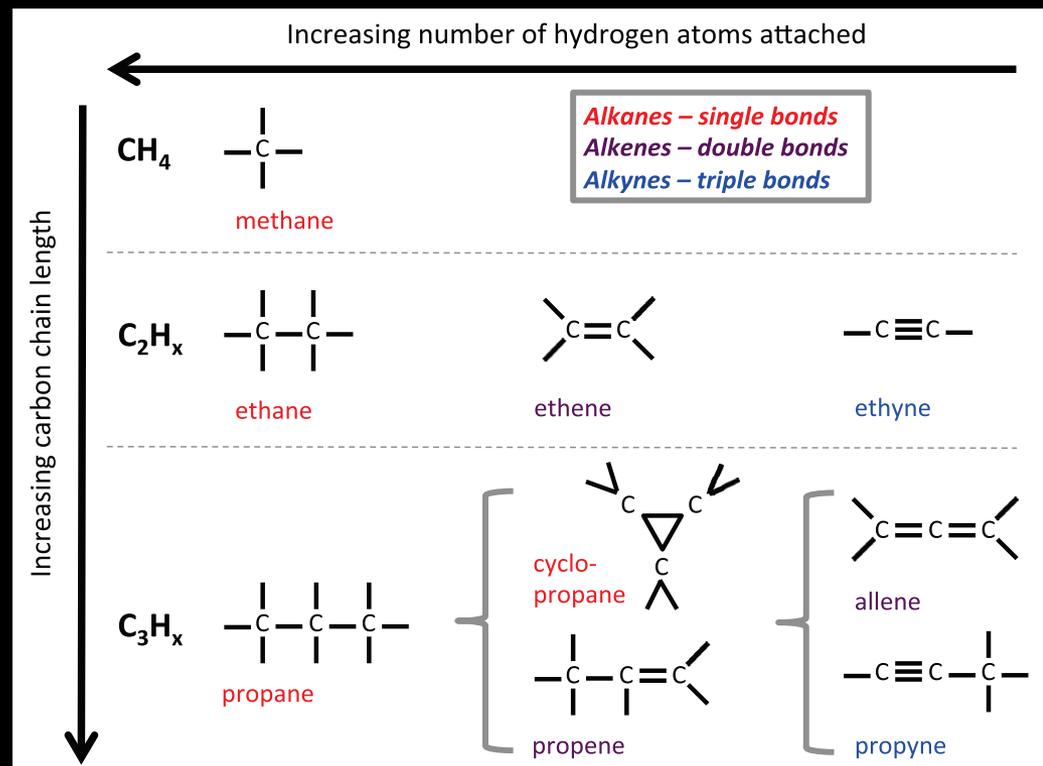
tectonic patterns

CIRS identifies propylene in Titan's lower atmosphere



Nixon et al. (2013):

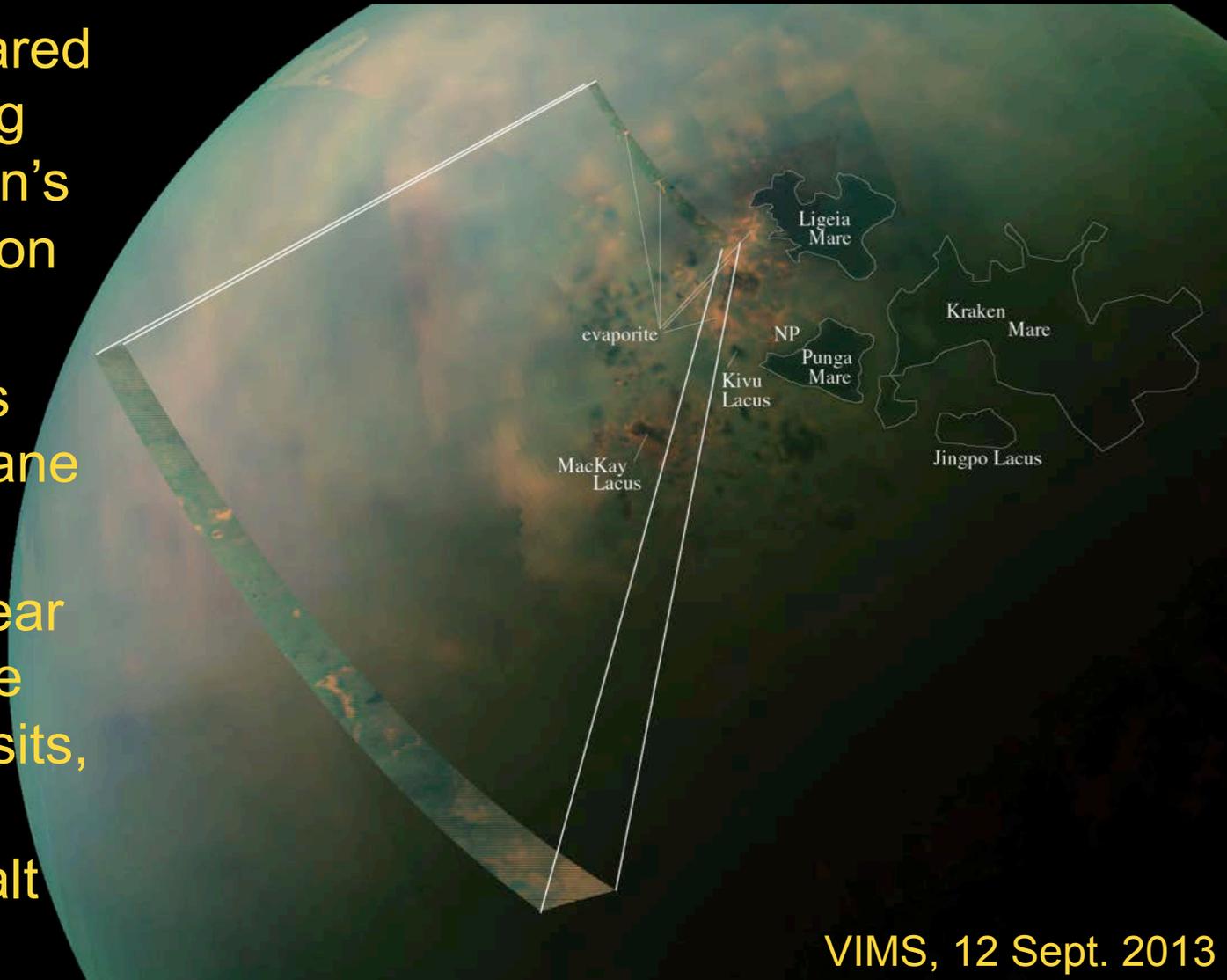
- Thermal infrared spectra of Titan's stratosphere reveal propylene (or propene), the chemical that forms the plastic polypropylene (recycling code #5), at 100-200 km altitude



Nixon et al., 2013

VIMS and ISS capture best near-IR views of Titan's lake district and seas

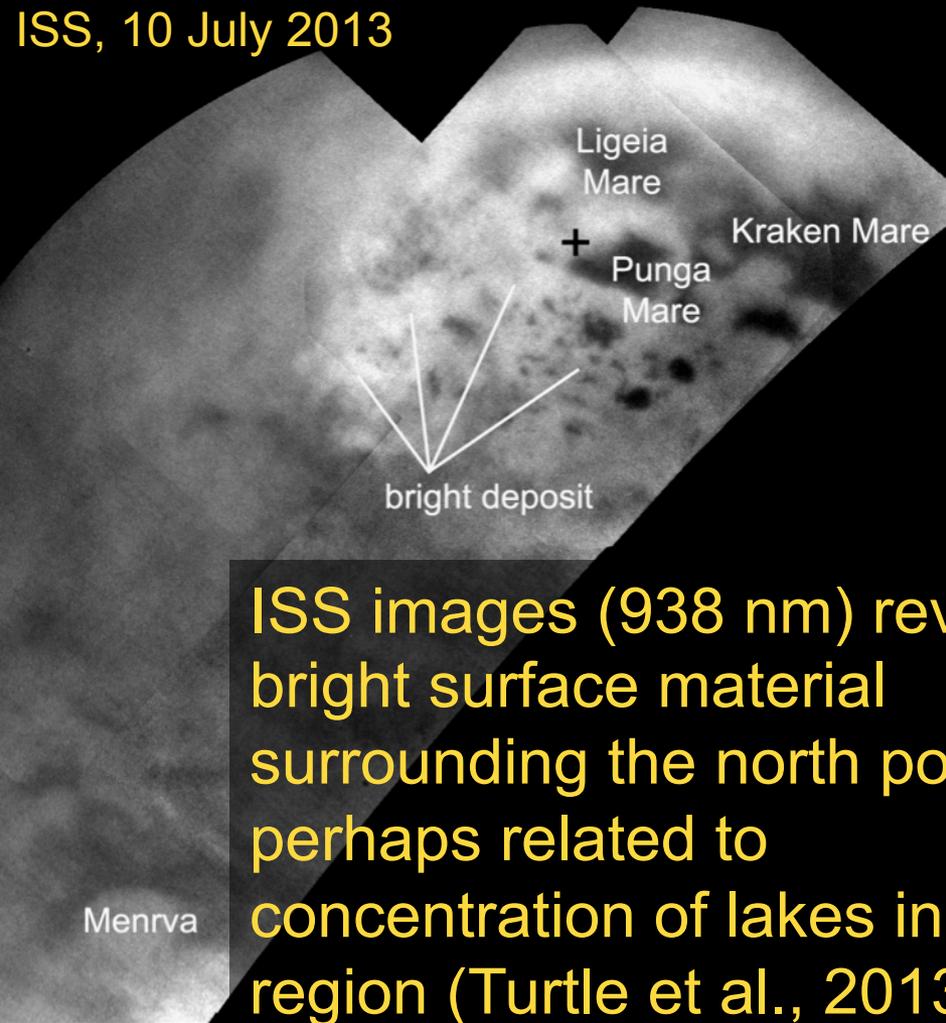
- VIMS near-infrared spectral imaging (1-5 μm) of Titan's north polar region (false-color)
- Lakes and seas are liquid methane and ethane
- Areas that appear orange might be evaporite deposits, Titan's organic equivalent of salt flats on Earth



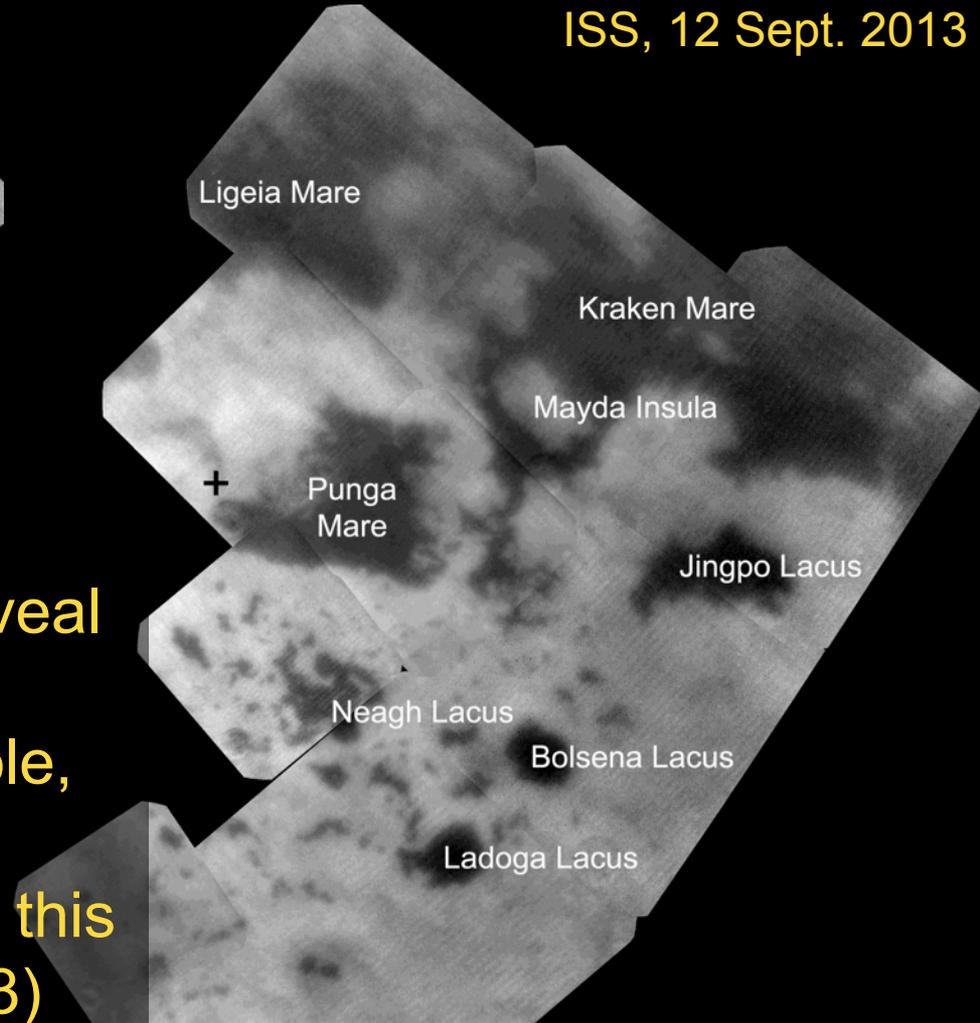
VIMS, 12 Sept. 2013

VIMS and ISS capture best near-IR views of Titan's lake district and seas

ISS, 10 July 2013

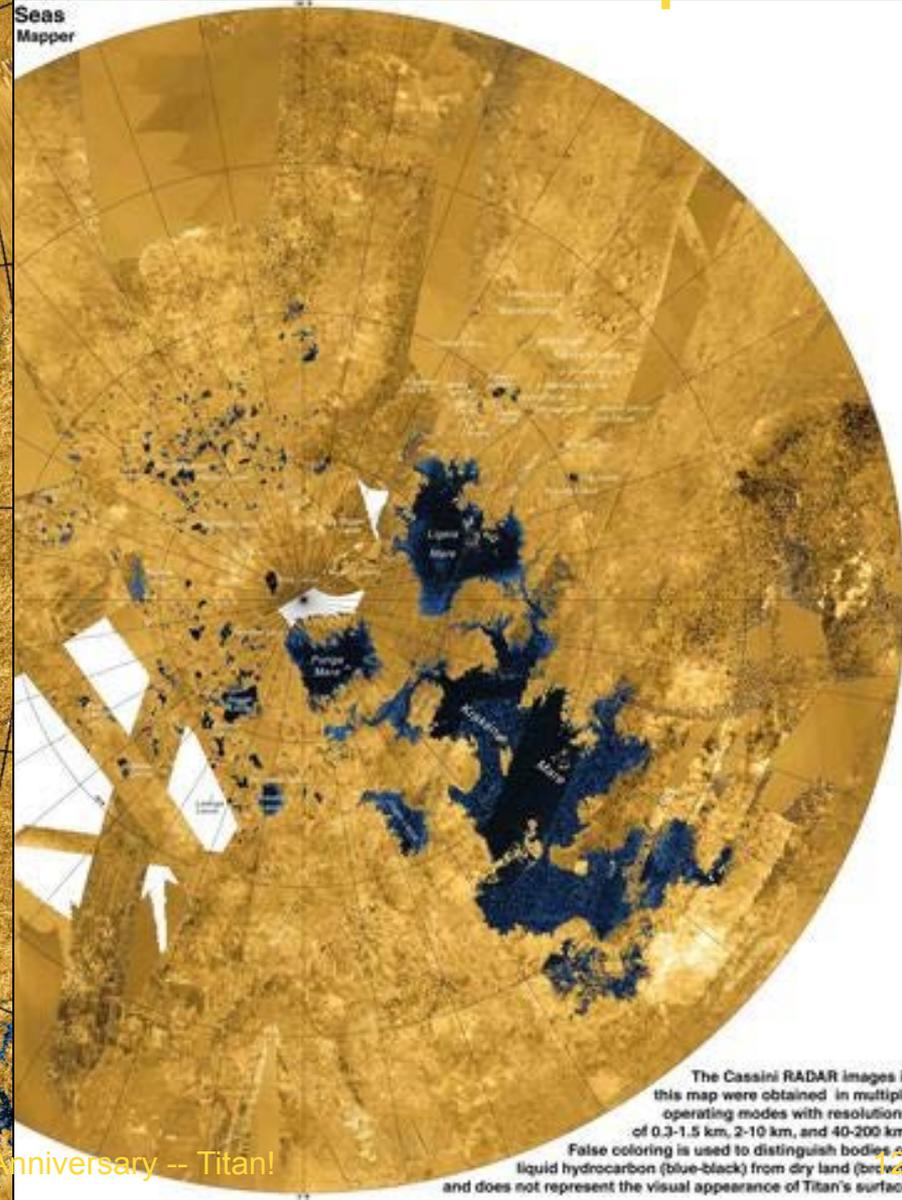
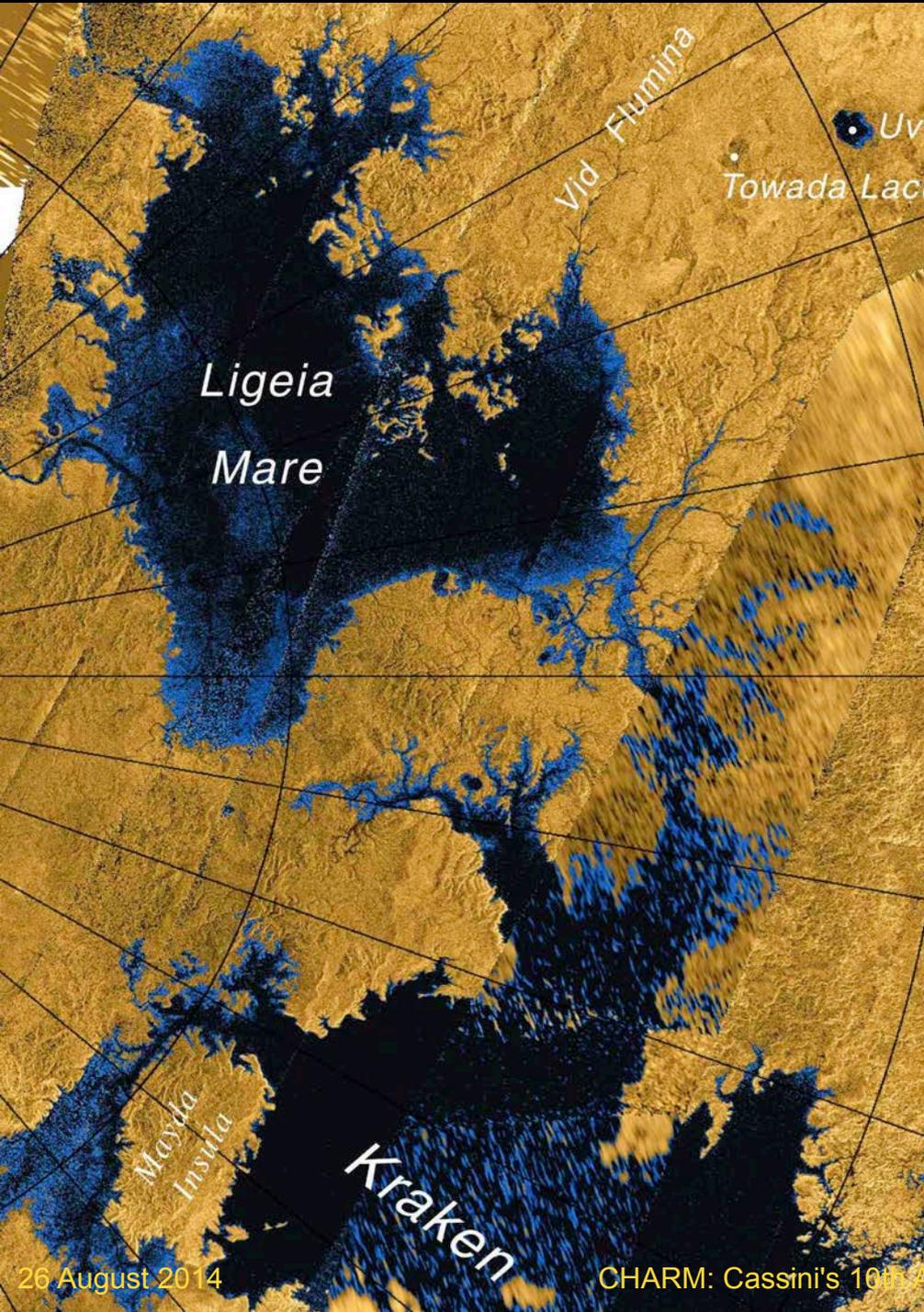


ISS, 12 Sept. 2013



ISS images (938 nm) reveal bright surface material surrounding the north pole, perhaps related to concentration of lakes in this region (Turtle et al., 2013)

RADAR map of Titan's north pole



The Cassini RADAR images in this map were obtained in multiple operating modes with resolutions of 0.3-1.5 km, 2-10 km, and 40-200 km. False coloring is used to distinguish bodies of liquid hydrocarbon (blue-black) from dry land (brown), and does not represent the visual appearance of Titan's surface.

Links to RADAR map & flyover movie

- <http://photojournal.jpl.nasa.gov/catalog/PIA17655>
- <http://photojournal.jpl.nasa.gov/catalog/PIA17656>
- <http://saturn.jpl.nasa.gov/video/videodetails/?videoID=271>
- <http://photojournal.jpl.nasa.gov/archive/PIA17656anno-640.mov>
- <http://photojournal.jpl.nasa.gov/archive/PIA17656-640.mov>

Continuing development of south polar cloud as southern winter progresses

ISS, 13 July 2013

West et al. (2013):

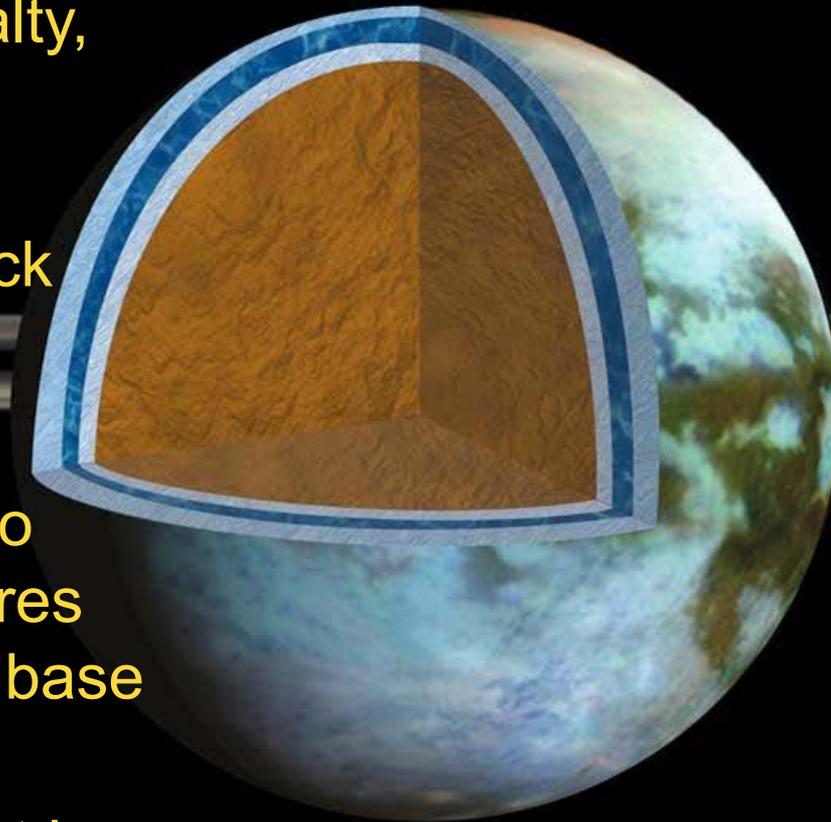
- Formed
late 2011 to
early 2012
- ~300 km altitude



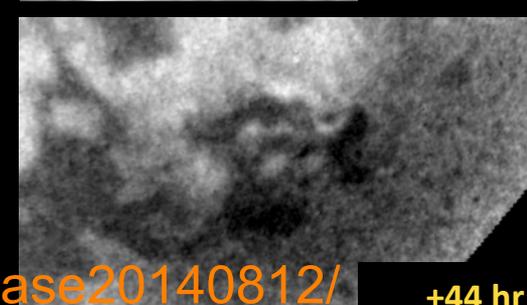
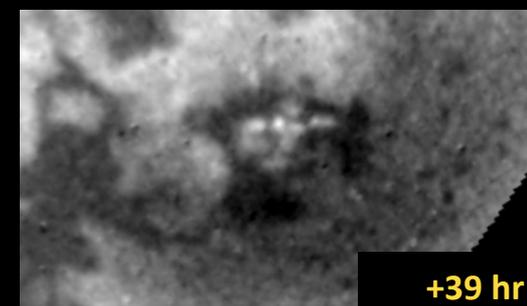
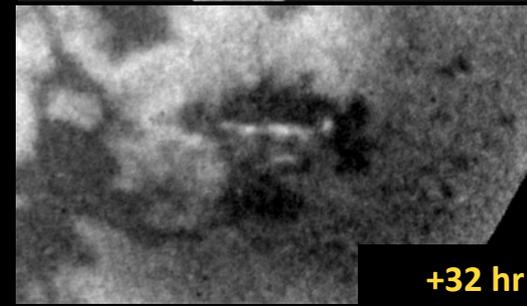
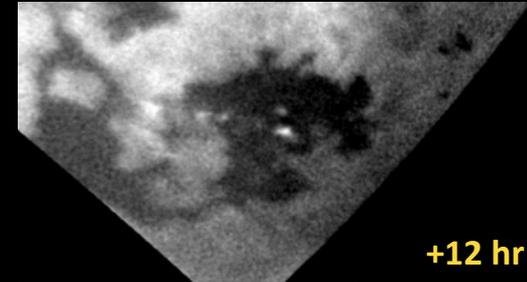
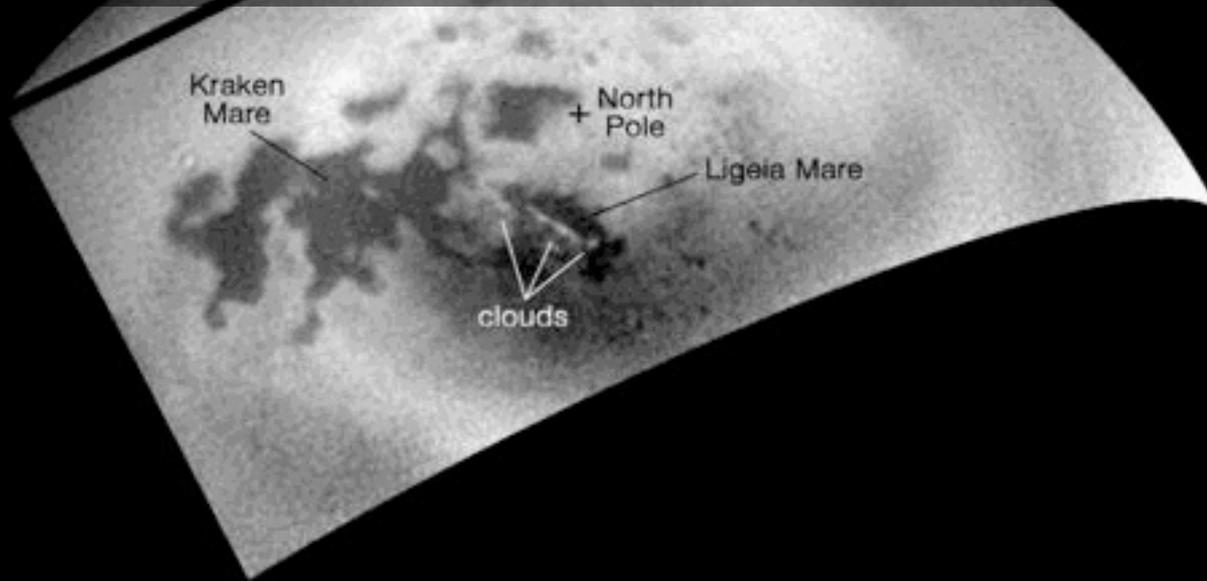
Cassini gravity and topography data constrain Titan's ice shell and interior ocean

Mitri et al. (2014):

- Dense, likely salty, ocean
- Rigid ice shell ~50-100 km thick
- Topographic variations due to tectonic structures and freezing at base
- Any methane outgassing must be localized



Clouds over Ligeia Mare



- Cassini ISS followed evolution of clouds over Ligeia Mare for ~2 days, 20-22 July 2014 (after T103 flyby)
- Wind speeds ~3-4.5 m/s (7-10 mph)
- Start of northern summer storms??
- <http://photojournal.jpl.nasa.gov/catalog/PIA18420>
- <http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20140812/>

Seasonal changes - waiting for N summer storms...

<u>Event, Date</u>	<u>Time in Titan's year</u>
Voyager 1 flyby, Nov. 1980	29 March
Voyager 2 Flyby, Aug. 1981	8 April
Cassini SOI, 2 July 2004	Mid-January
Dissipation of high-altitude north-polar ethane cloud (VIMS), 2008-2009	Late N. winter
11 Aug 2009	N. vernal equinox
Decrease in altitude of detached haze (ISS), 2009-2010	Early N. spring
Low-latitude storm (ISS), Sept.-Oct. 2010	Early April
Rapid changes in south polar upper atmospheric temperatures and composition (CIRS), 2010-2011	N. spring
South polar vortex (ISS, VIMS), 2011/2012...	Late April
26 August 2014	Mid-May
Development of northern clouds (model predictions)	Spring? Summer??
May 2017	N. summer solstice



YEARS at SATURN

- Huygens: first landing on a moon in the outer solar system
- Titan revealed as an Earth-like world with rain, rivers, lakes & seas; wind & dunes; tectonic, cryovolcanic, & impact structures
- Complex prebiotic chemistry and discovery of subsurface ocean

Cassini Mission Overview

Four-Year Prime Tour, Equinox Mission, and Solstice Mission (Proposed), May 2004 - September 2017

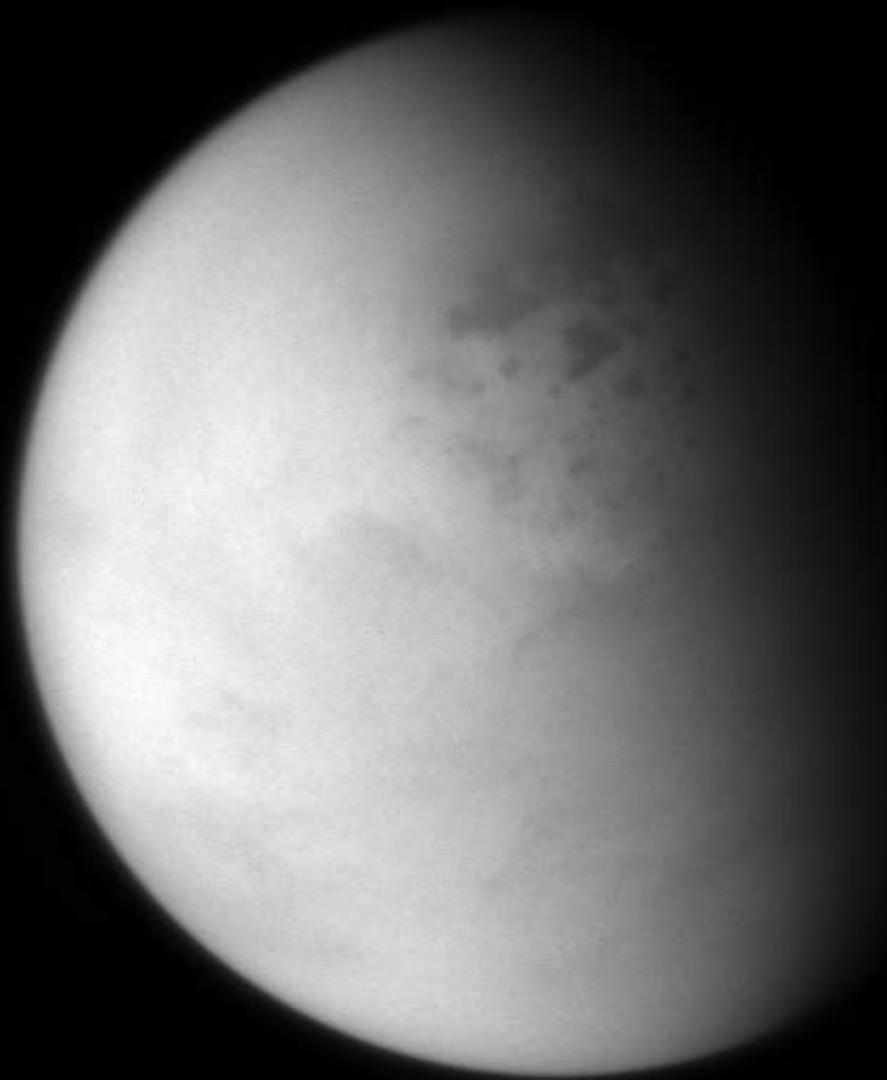


Saturn
(seen from Sun)
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CHARM: Cassini's 10th Anniversary -- Titan!

EOM
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2017



26 August 2014

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1 Jan 2014

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