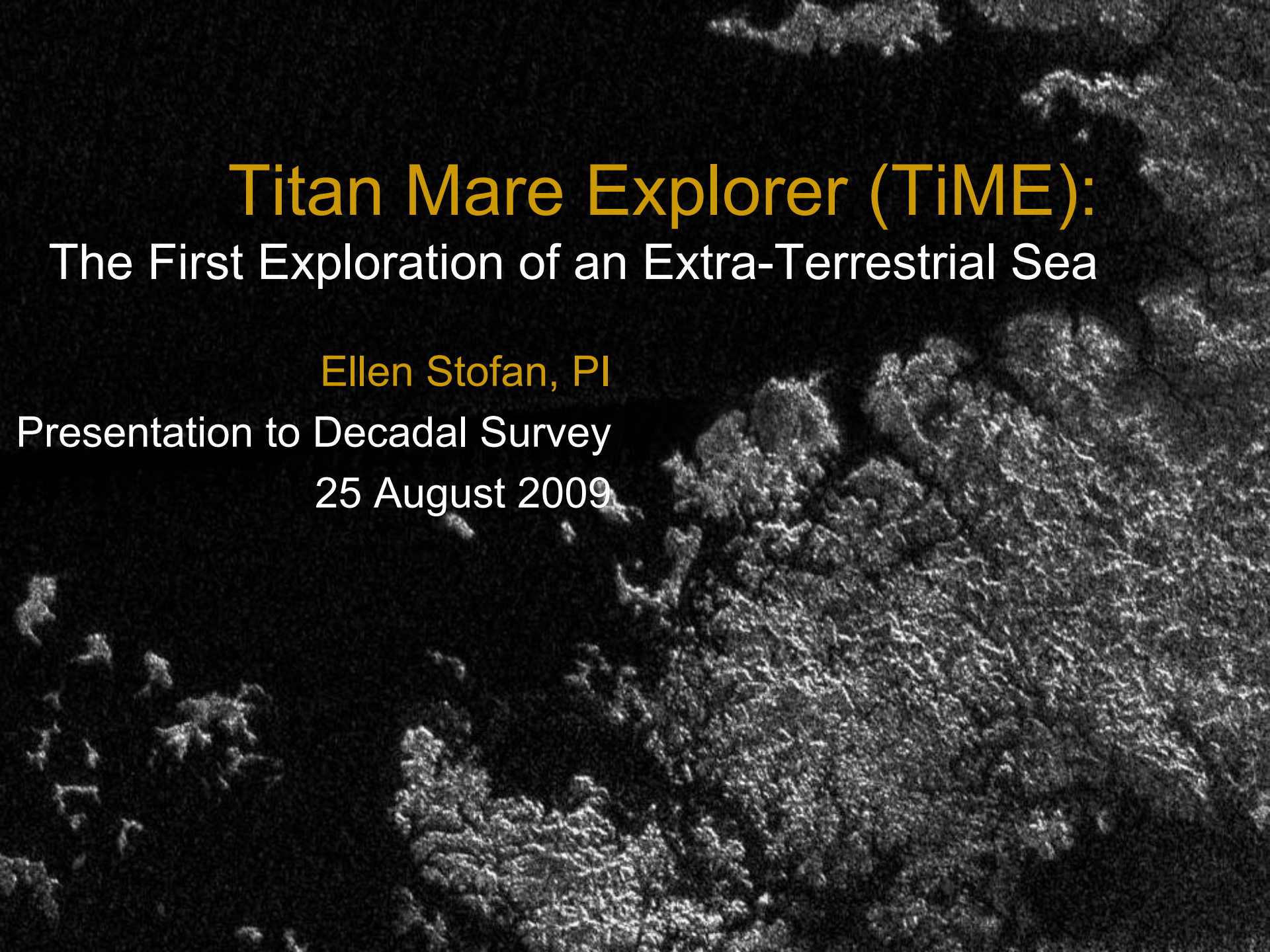


Titan Mare Explorer (TiME):

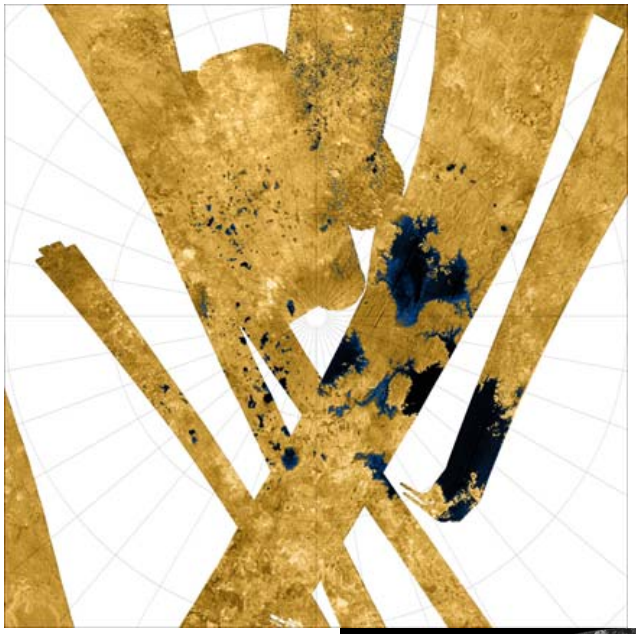
The First Exploration of an Extra-Terrestrial Sea

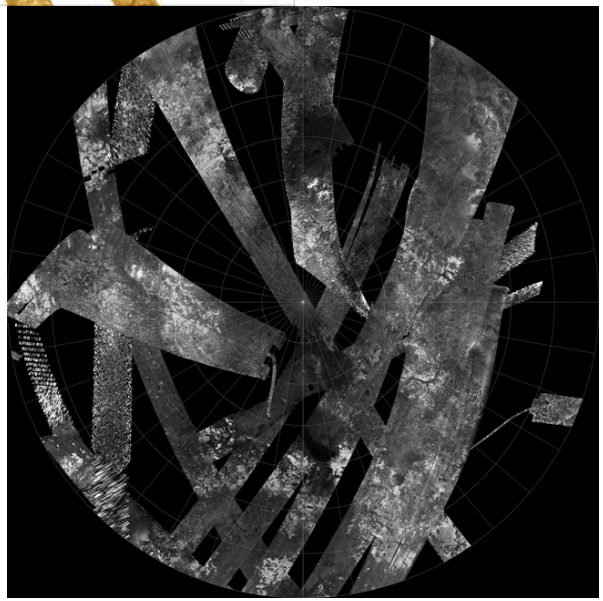
Ellen Stofan, PI

Presentation to Decadal Survey

25 August 2009

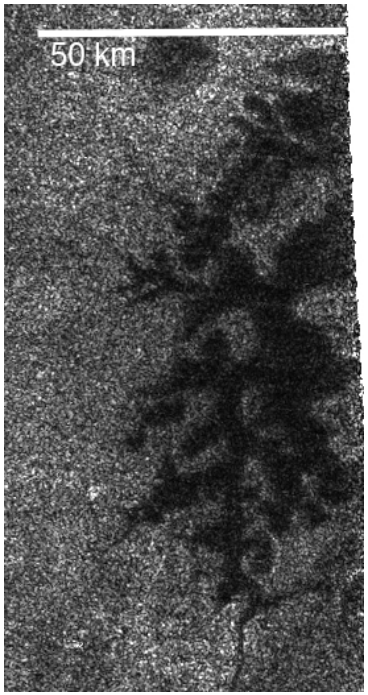
TiME Science

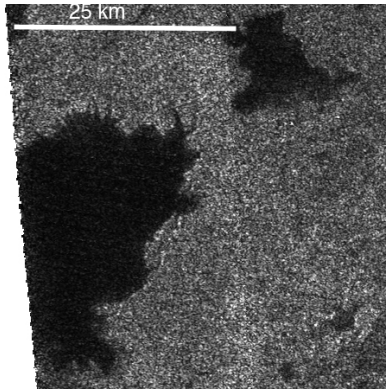


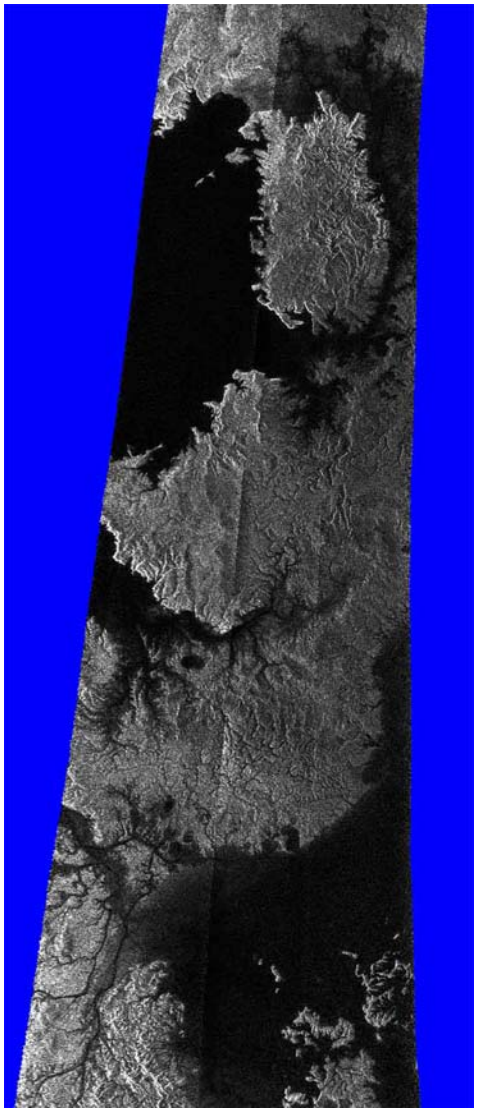


- Discovery of lakes and seas in Titan's northern hemisphere confirmed the expectation that liquid hydrocarbons exist
- Detection of the presence of ethane in Ontario Lacus near the South Pole (Brown et al., 2008)
- 2 distinct types of features- lakes and seas, likely 10's, >100 m deep

TiME Science

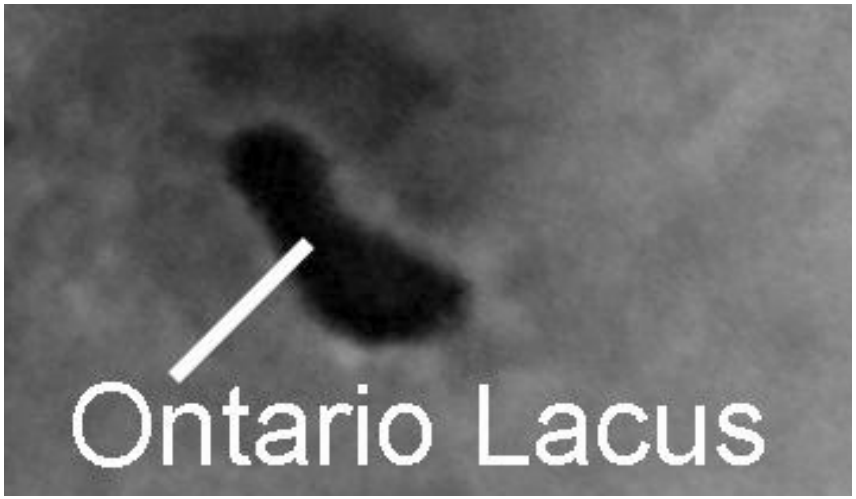






- Post-Cassini, major questions will remain on the chemistry of lake liquids, their role in the overall methane cycle, the origin of lake basins, and lacustrine seasonal processes and variability

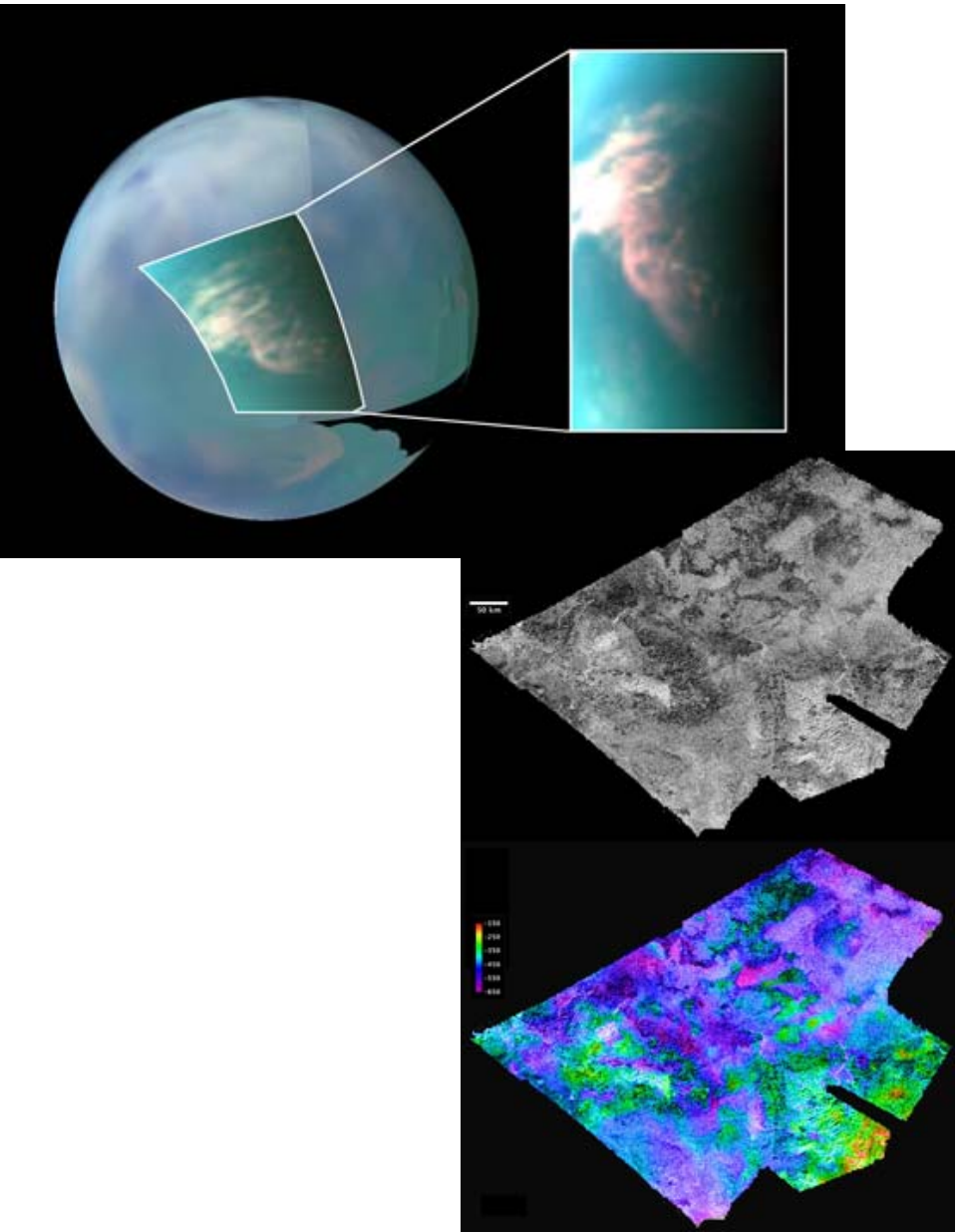
New Results from Ontario Lacus



ISS image

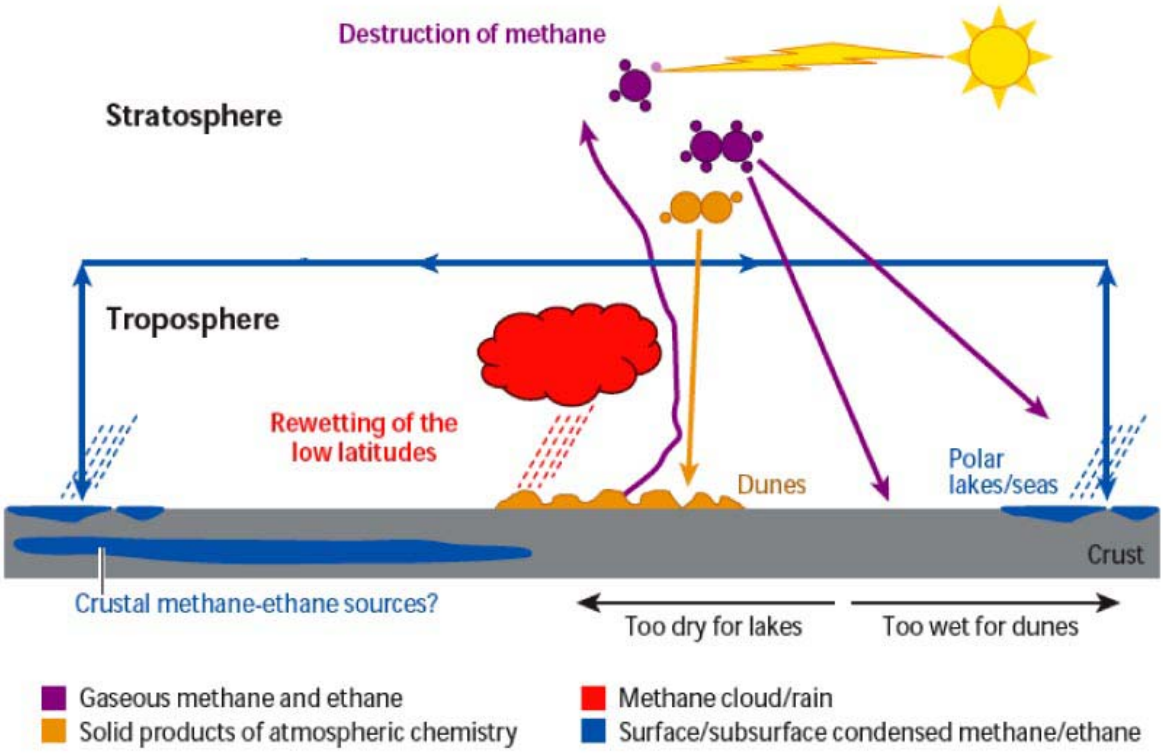
- Wye et al.- lake surfaces can be extremely smooth
- Shoreline morphology suggests seasonal change

Active Titan processes



- Previous observations of south polar storms plus new observations of storms in equatorial region (Schaller et al.) provide evidence of active methanologic processes
- Potential cryovolcanic features indicate resupply of methane from interior

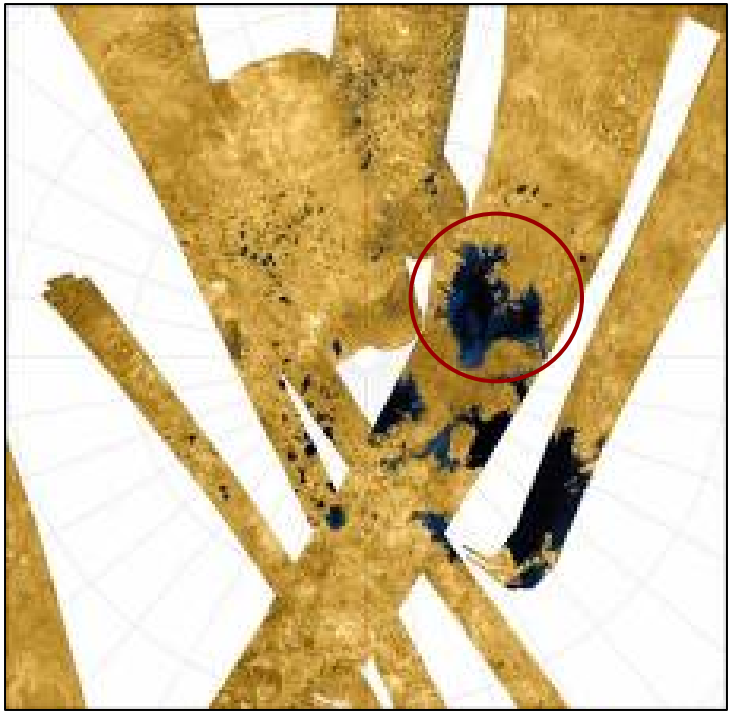
TiME Science

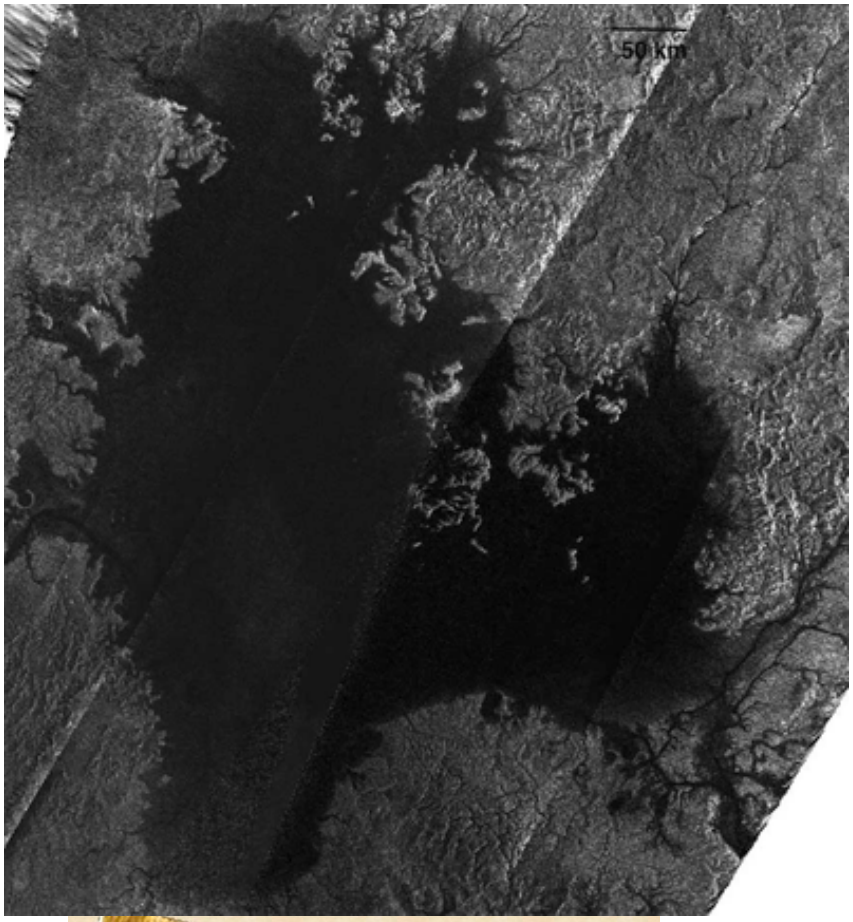


Titan's methane cycle is analogous to Earth's hydrologic cycle, with meteorological working fluid existing in condensed phase on surface and within crust, cycling through the surface atmosphere system and transporting mass and energy

- TiME will directly constrain the methane cycle of Titan and help us understand its similarities and differences to the hydrologic cycle on Earth

TiME Science Target





- Target: Ligeia Mare (78°N, 250°W)
  - One of the largest lakes identified to date on Titan, surface area ~100,000 km^2
  - Backup target- Kraken Mare

TiME Mission Objectives

- Relevance and Importance to NASA Planetary Objectives and the Decadal Survey:
  - **Decadal Survey – Volatiles and Organics, The Stuff of Life**
    - Directly measure the organic constituents on another planetary object
  - **Decadal Survey – Processes: How Planetary Systems Work**
    - First active measurement of liquid cycle beyond Earth
- First exploration of planetary sea beyond Earth
- Flight demonstration of ASRG in two environments: deep space and non-terrestrial atmosphere
- Pioneer low-cost, outer planet mission

TiME Science Team

- **PI:** Ellen Stofan (Proxemy Research)
- **Co-Is:**
  - Jonathan Lunine (Univ. of Az.) - Deputy PI
  - Ralph Lorenz (APL)- Project Scientist
  - Oded Aharonson (CalTech)
  - Beau Bierhaus (LM)
  - Ben Clark (SSI)
  - Erich Karkoschka (Univ. Arizona)
  - Randy Kirk (USGS)
  - Paul Mahaffy (Goddard)
  - Mike Ravine (MSSS)

TiME Science Objectives

- ***Science Objective 1.*** Determine the chemistry of seas to constrain Titan's methane cycle, look for patterns in the abundance of constituents in the liquids and analyze noble gases. ***Instruments:*** Mass Spectrometer (MS), Meteorology and Physical Properties Package (MP3).
- ***Science Objective 2.*** Determine the depth of the Titan sea to determine sea volumes, and thus, organic inventory. ***Instrument:*** Meteorology and Physical Properties Package (Sonar) (MP3).
- ***Science Objective 3.*** Constrain lacustrine processes on Titan by characterizing physical properties of sea liquids and how they vary with depth. ***Instrument:*** Meteorology and Physical Properties Package (MP3).
- ***Science Objective 4.*** Determine how the local meteorology over the seas ties to the global cycling of methane on seasonal and longer timescales. ***Instrument:*** Meteorology and Physical Properties Package (MP3).
- ***Science Objective 5.*** Analyze the nature of the sea surface and if possible, shorelines, to constrain physical properties of sea liquids and better understand origin, evolution, and subsurface methane/ethane hydrology of Titan lakes and seas. ***Instrument:*** Descent and Surface Imagers (DI, SI).

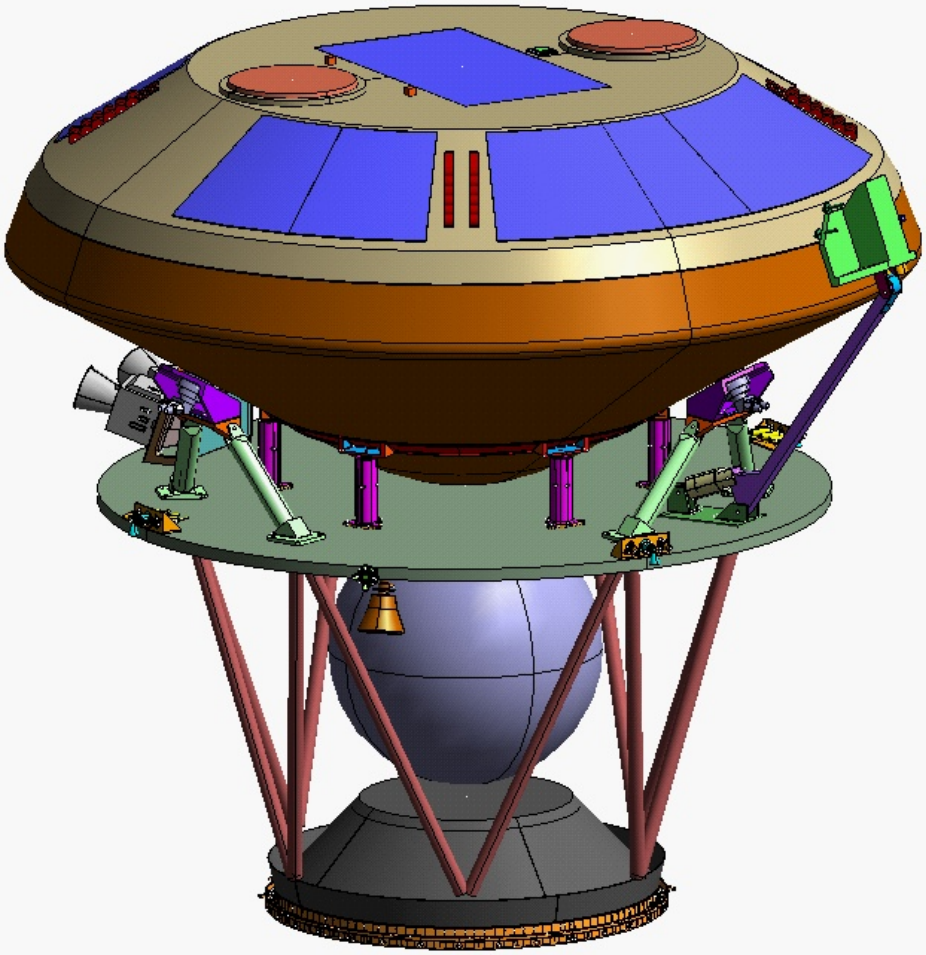
QuickTime™ and a
decompressor
are needed to see this picture.

Mission Implementation Overview

- TiME

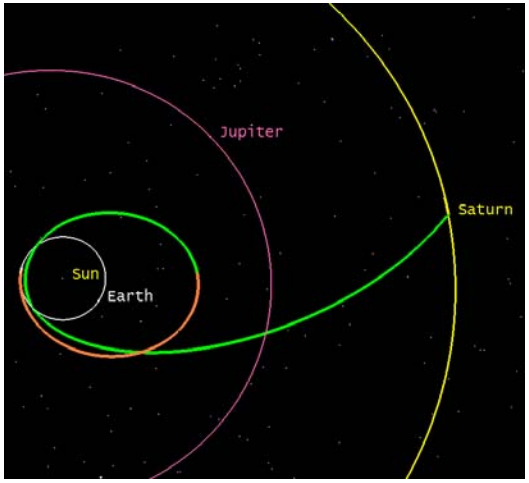
•Launch Vehicle: Atlas 411

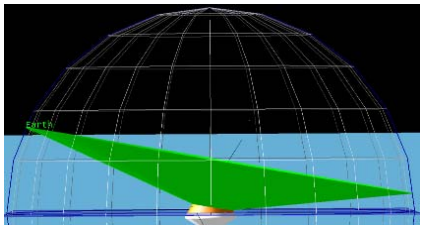
•21 day launch window opens 17 January 2015

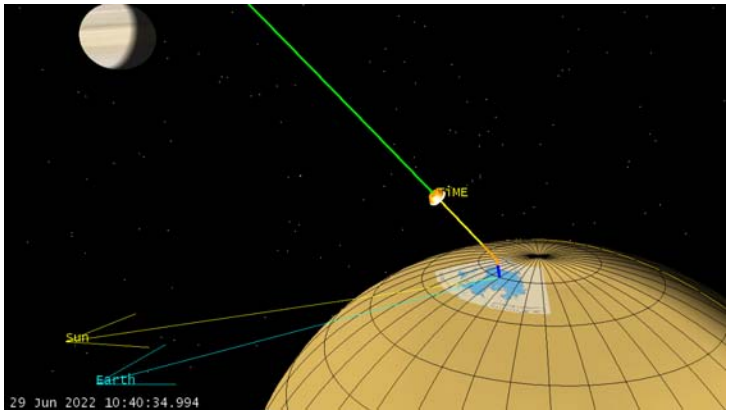


Lander: Overview

- Cruise: One DSM, one Earth and one Jupiter flyby en route to Saturn.
- Titan Entry: Cruise stage separates from lander shortly before Titan entry on 29 June 2022.







Earth & the Sun are above the horizon for the 3 month mission lifetime, during which TiME collects and transmits data on the lake and atmosphere.

ASRG Overview

- ASRG = Advanced Stirling Radioisotope Generator
- From Community Announcement NNH09ZDA009J: "Discovery Program investigations may propose the use of Advanced Stirling Radioisotope Generators (ASRGs) for missions enabled by radioisotope power systems. If selected for flight, NASA will provide up to two ASRGs, including the services associated with their provisioning on space missions, as GFE, and their costs will not be included in the cost cap."
- Public ASRG information available at the following link: http://discovery.larc.nasa.gov/PDF_FILES/SpaceRadioisotopePowerSystemsASRG.pdf
- Each ASRG expected to generate 140 -160 W of electrical power
  - 4x more efficient than previous RTG
- Mass is 21-23 kg
- Nominal lifetime of 14 years

TiME for Discovery

- TiME is a Discovery Class mission
  - Focused science objectives
  - High heritage instruments
  - ASRGs, launcher are GFE
  - Simple cruise- no flyby science
  - Entry conditions at Titan similar to Huygens and within conditions for previous low-cost LM missions (Stardust, Phoenix)
  - Simple surface operations

TiME for Titan

- First nautical exploration of an extraterrestrial sea
- Constrain the role of lakes and seas in Titan's active carbon cycle and search for signs of self-organizing organic chemistry
- Unique and wide-ranging EPO opportunity
- Low-cost approach
- ASRG validation in two environments
- Science from Titan by 2023