Jet Propulsion Laboratory
California Institute of Technology

Thirteen years of Cassini RADAR observations of Saturn's moon Titan, and one last hurrah!

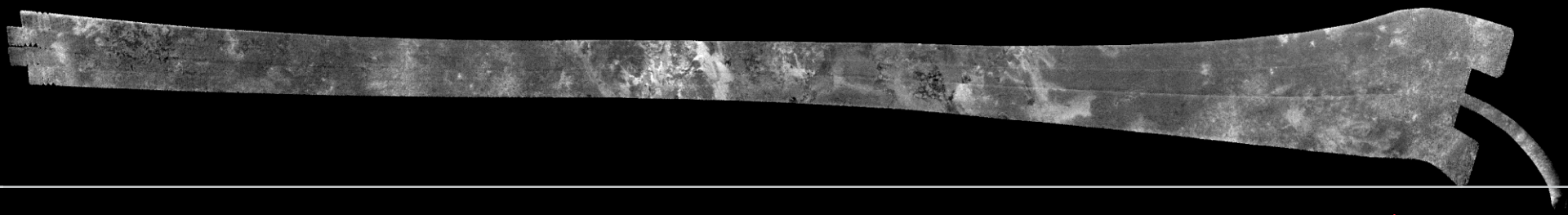
Karl L. Mitchell, Marco Mastrogiuseppe, Alex Hayes, Jason Hofgartner, Ralph Lorenz, Alice Le Gall, Michael Janssen, Rosaly Lopes, Jani Radebaugh, Jonathan Lunine and the Cassini RADAR Team.

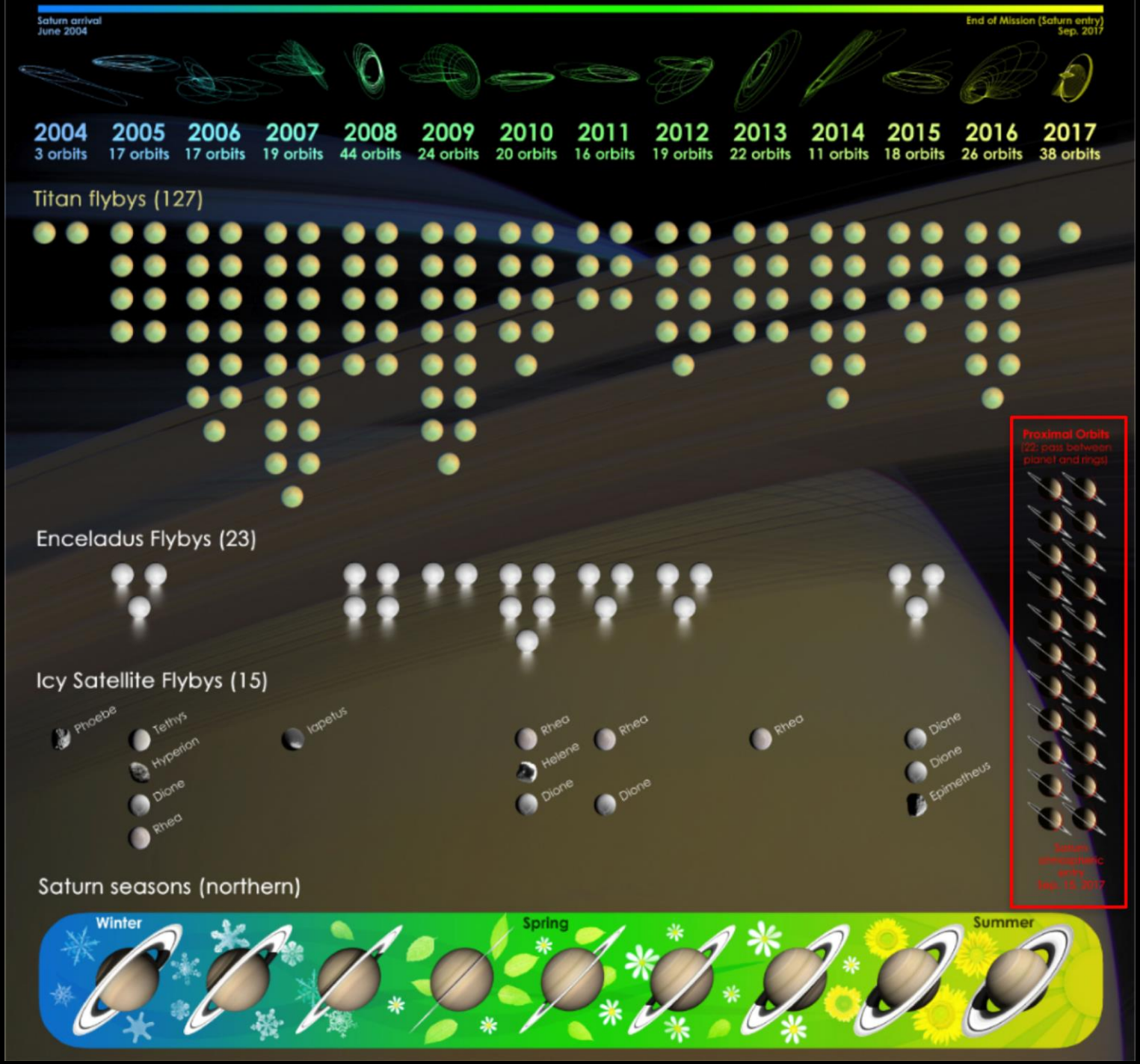
Geological Society of America Annual Meeting, Seattle, WA, Oct 22-25, 2017.

Cassini's RADAR Instrument

Peering through the haze and microwaving Titan's organic soup

- The Cassini spacecraft arrived in the Saturn system in 2004, close to northern Winter Solstice.
- The mission continued until 2017, allowing an unprecedented study of the Saturn system spanning 13 Earth years, or half a Saturn year.
- Due in part to its large size and gravitational influence, which is useful for modulating Cassini's trajectory, 127 close fly-bys of Titan were possible.

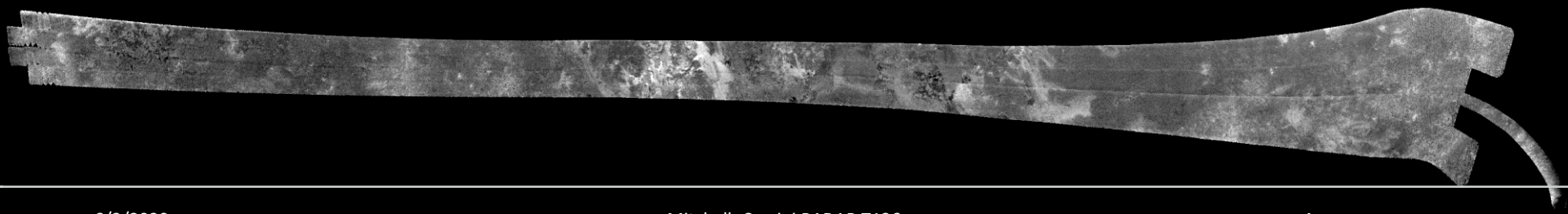



Saturn arrival
June 2004
End of Mission (Saturn entry)
Sep. 2017
2004
3 orbits
2005
17 orbits
2006
17 orbits
2007
19 orbits
2008
44 orbits
2009
24 orbits
2010
20 orbits
2011
16 orbits
2012
19 orbits
2013
22 orbits
2014
11 orbits
2015
18 orbits
2016
26 orbits
2017
38 orbits
Titan flybys (127)
Proximal Orbits
(22; pass between planet and rings)
Saturn atmospheric entry
Sep. 15, 2017
Enceladus Flybys (23)
Icy Satellite Flybys (15)
Phoebe
Tethys
Hyperion
Dione
Rhea
Iapetus
Rhea
Helene
Dione
Rhea
Dione
Rhea
Dione
Dione
Epimetheus
Saturn seasons (northern)
Winter
Spring
Summer

Cassini's RADAR Instrument

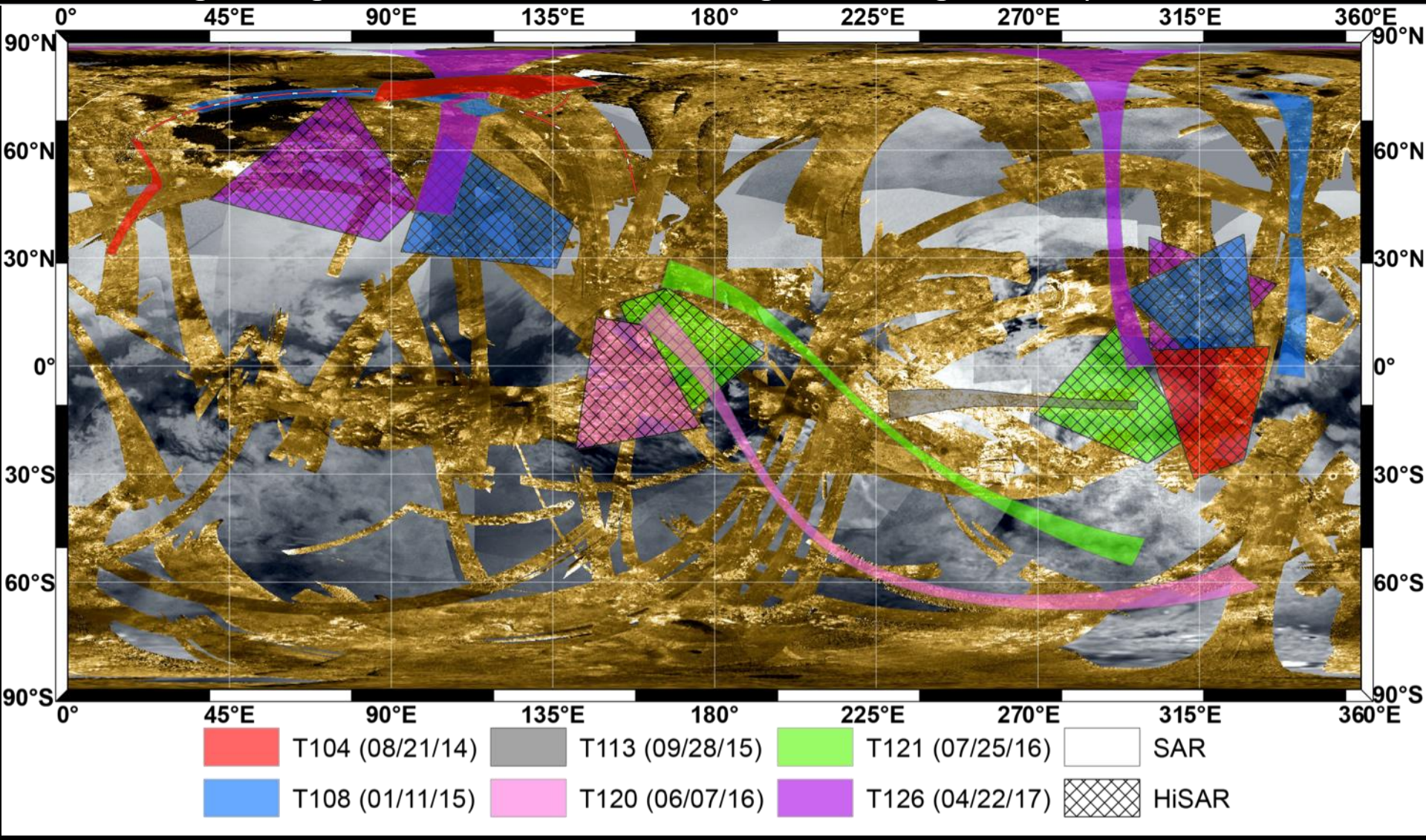
Peering through the haze and microwaving Titan's organic soup

- The Cassini spacecraft arrived in the Saturn system in 2004, close to northern Winter Solstice.
- The mission continued until 2017, allowing an unprecedented study of the Saturn system spanning 13 Earth years, or half a Saturn year.
- Due in part to its large size and gravitational influence, which is useful for modulating Cassini's trajectory, 127 close fly-bys of Titan were possible.
- Cassini's 5-beam Ku-band RADAR was designed primarily to observe Titan through its thick, obfuscating atmosphere, using 4 modes: SAR, Altimetry, Scatterometry, Radiometry.
- 45 SAR swaths have been produced, imaging about half of the surface at 300-1700 m resolution.



Cassini's RADAR Instrument

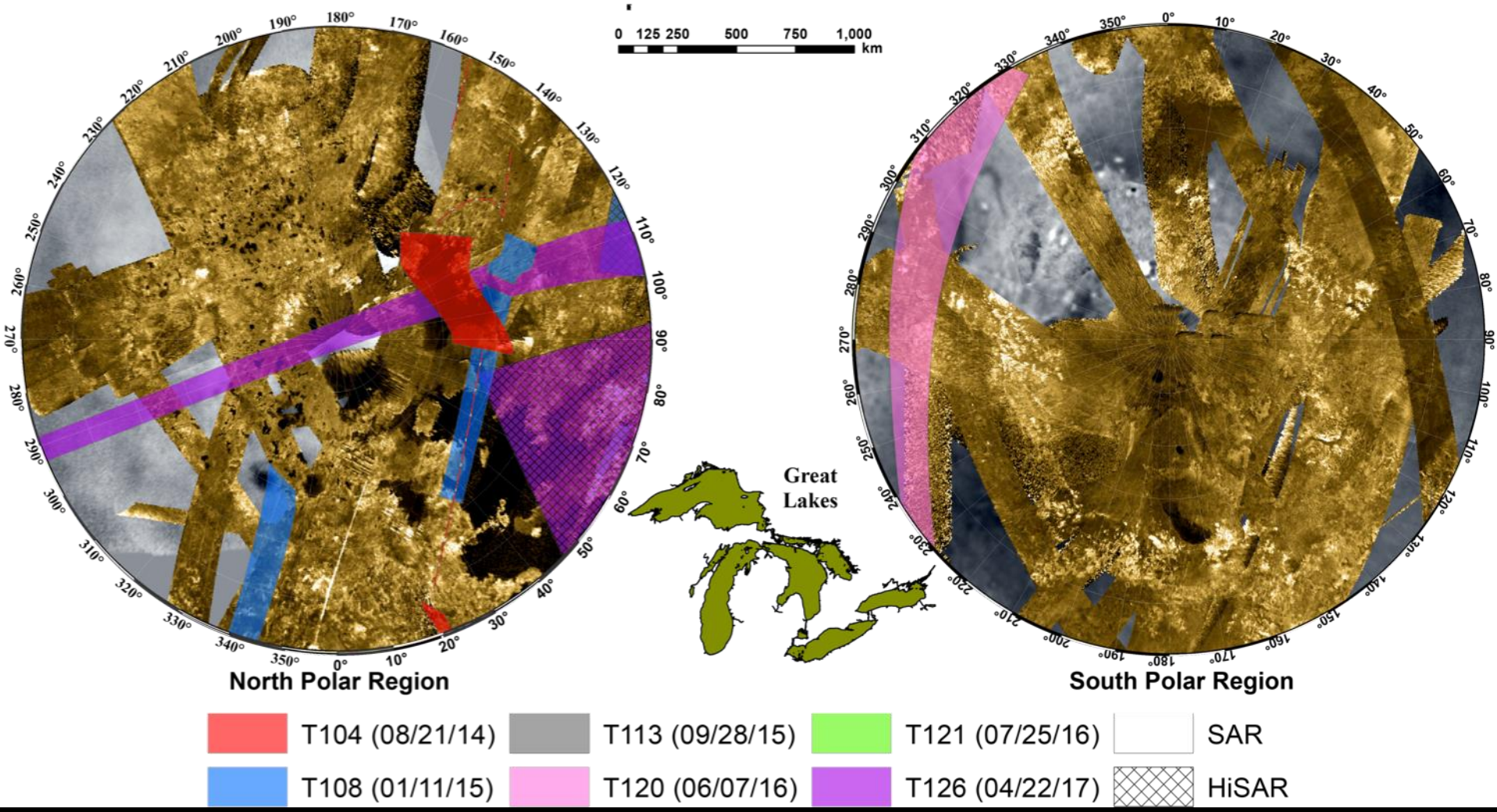
Peering through the haze and microwaving Titan's organic soup



SAR coverage ~46%; SAR+HiSAR coverage ~66%; SAR stereo/repeat coverage: ~13%.

Cassini's RADAR Instrument

Peering through the haze and microwaving Titan's organic soup



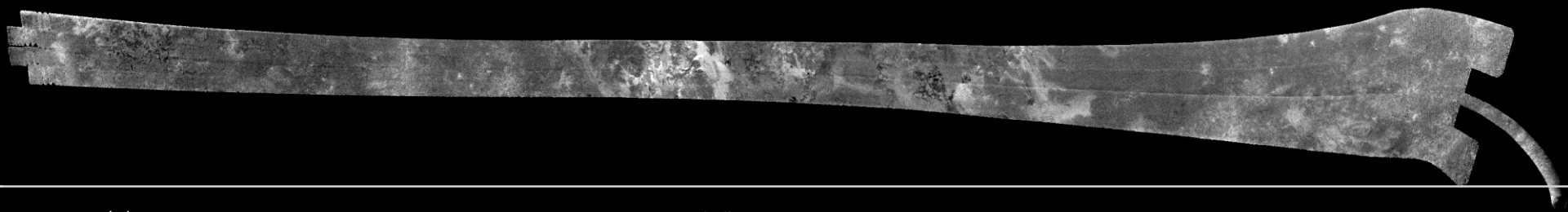
Arctic: SAR coverage ~60%; SAR+HiSAR coverage ~86%; SAR stereo/repeat coverage: ~28%.

Antarctic: SAR coverage ~63%; SAR+HiSAR coverage ~78%; SAR stereo/repeat coverage: ~24%.

Cassini's RADAR Instrument

Peering through the haze and microwaving Titan's organic soup

- The Cassini spacecraft arrived in the Saturn system in 2004, close to northern Winter Solstice.
- The mission continued until 2017, allowing an unprecedented study of the Saturn system spanning 13 Earth years, or half a Saturn year.
- Due in part to its large size and gravitational influence, which is useful for modulating Cassini's trajectory, 127 close fly-bys of Titan were possible.
- Cassini's 5-beam Ku-band RADAR was designed primarily to observe Titan through its thick, obfuscating atmosphere, using 4 modes: SAR, Altimetry, Scatterometry, Radiometry.
- 45 SAR swaths have been produced, imaging about half of the surface at 300-1700 m resolution.
- RADAR has obtained a rich dataset, archived in the PDS, vastly improving our understanding of Titan's geology, geophysics and chemistry.



Cassini's RADAR Instrument

Peering through the haze and microwaving Titan's organic soup

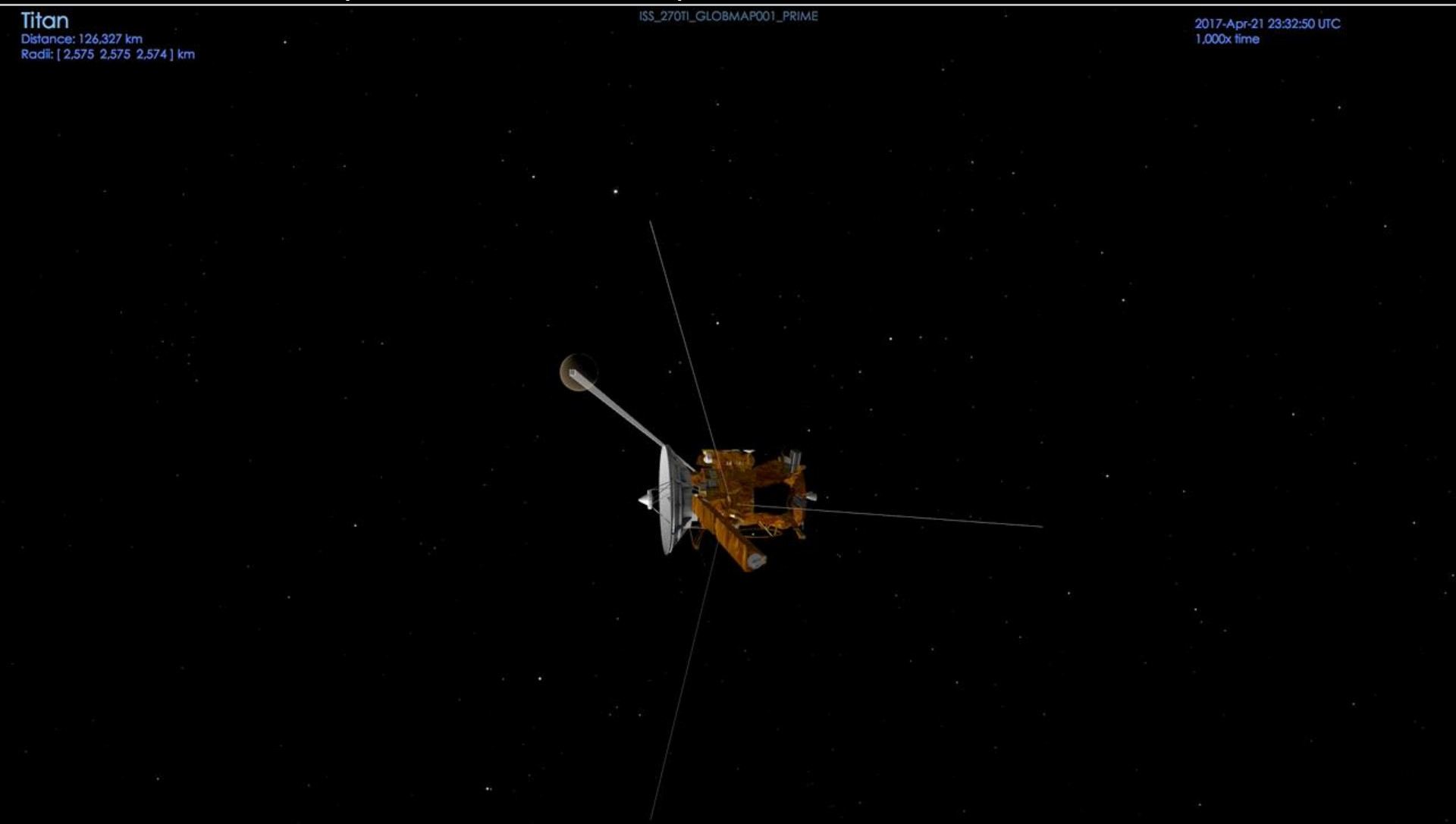
- RADAR has revealed a complex world, Earth-like in any ways, with:
  - a icy world surface dominated by non-water-ice materials, mostly organic solids,
  - giant sand dunes of solid organics, possibly electrostatic,
  - relatively few craters suggests a fairly young, dynamic surface,
  - rare tectonic faults, mostly obscured by the young organic surface layers,
  - rivers, both active (mostly polar) and dormant (at all latitudes),
  - polar alkane lakes, often smooth, sub-circular shaped, raised rims and incised basins,
  - polar seas dominated by methane, with waves, currents and complex shorelines,
  - karstic landforms, suggesting a rich subsurface hydrology and soluble organics,
  - putative cryovolcanoes, which may explain the persistent atmospheric methane.

T126

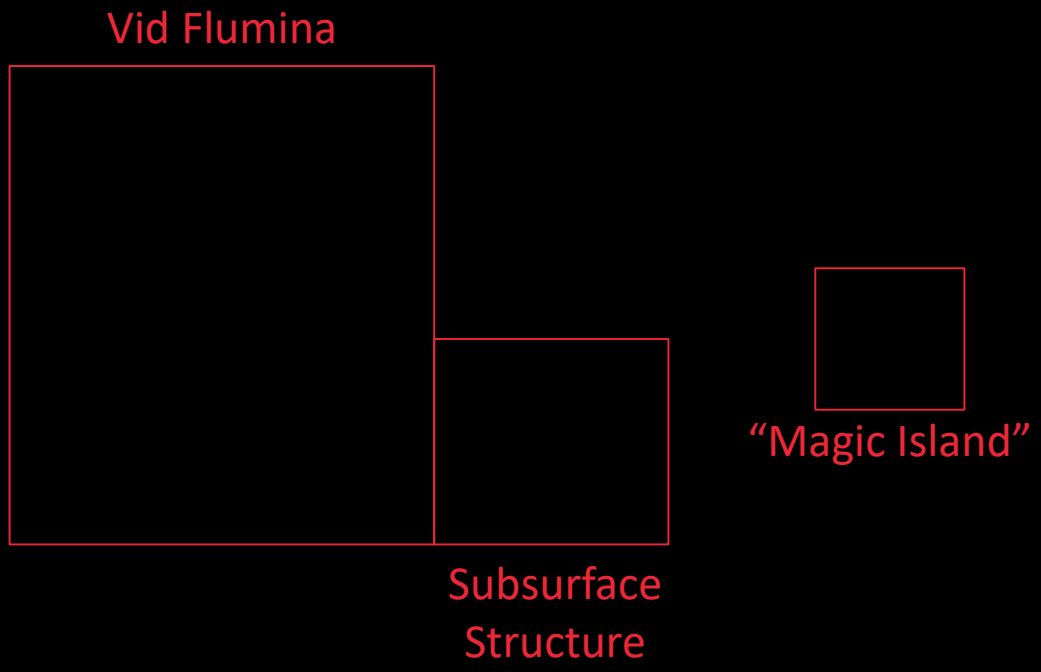
The final targeted fly-by of Titan

Animation of the T126 fly-by

Thanks to Marty Brennan, Cassini Operations Team, JPL



T126 RADAR Swath Part One
Inbound, across Ligeia Mare



100 km

T126 RADAR Swath Part Two
Outbound, southwards, east of Ganesa and into Fensal

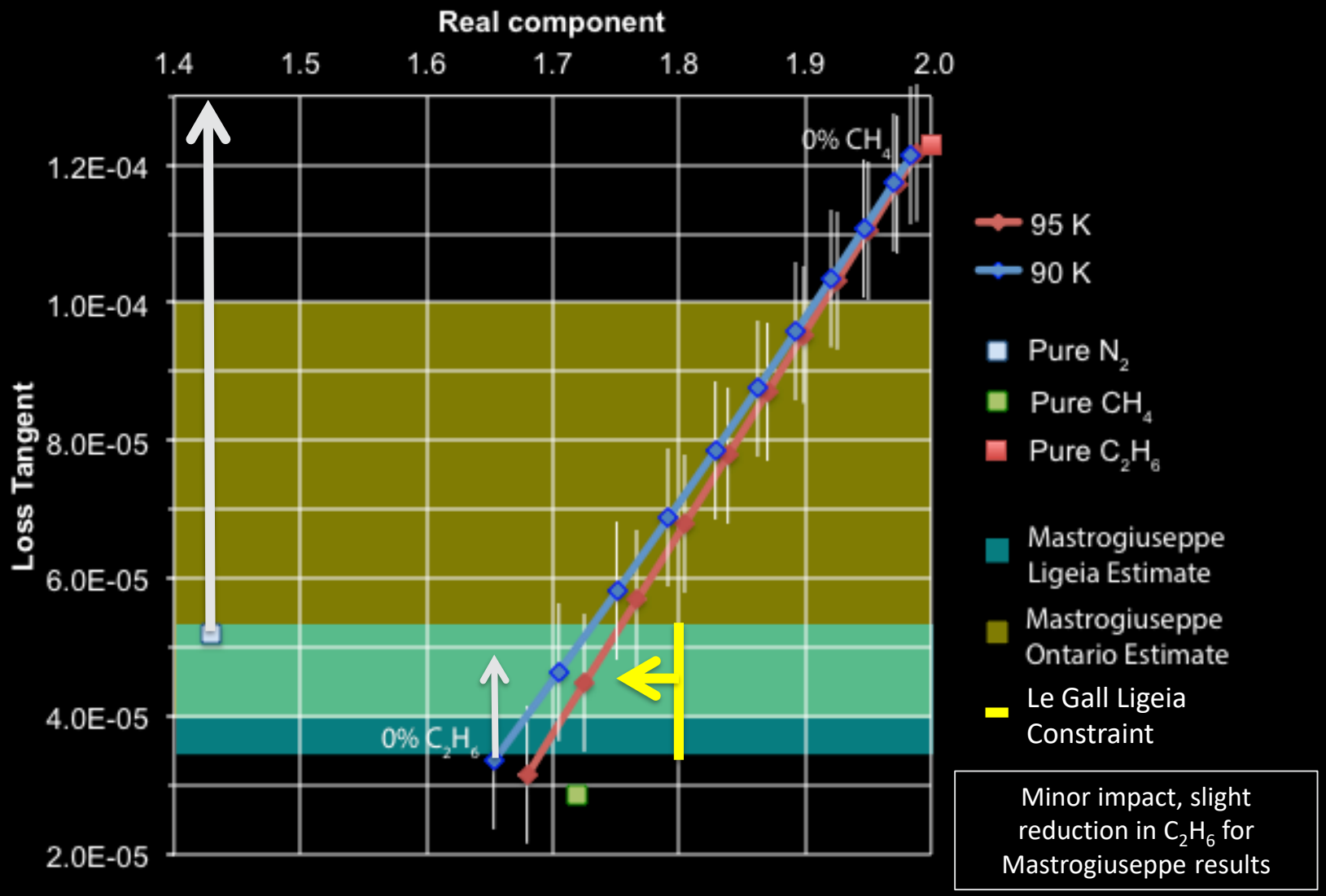
100 km

T126

Lake bathymetry and composition

Composition of Titan's lakes and seas

From remote sensing and laboratory measurements

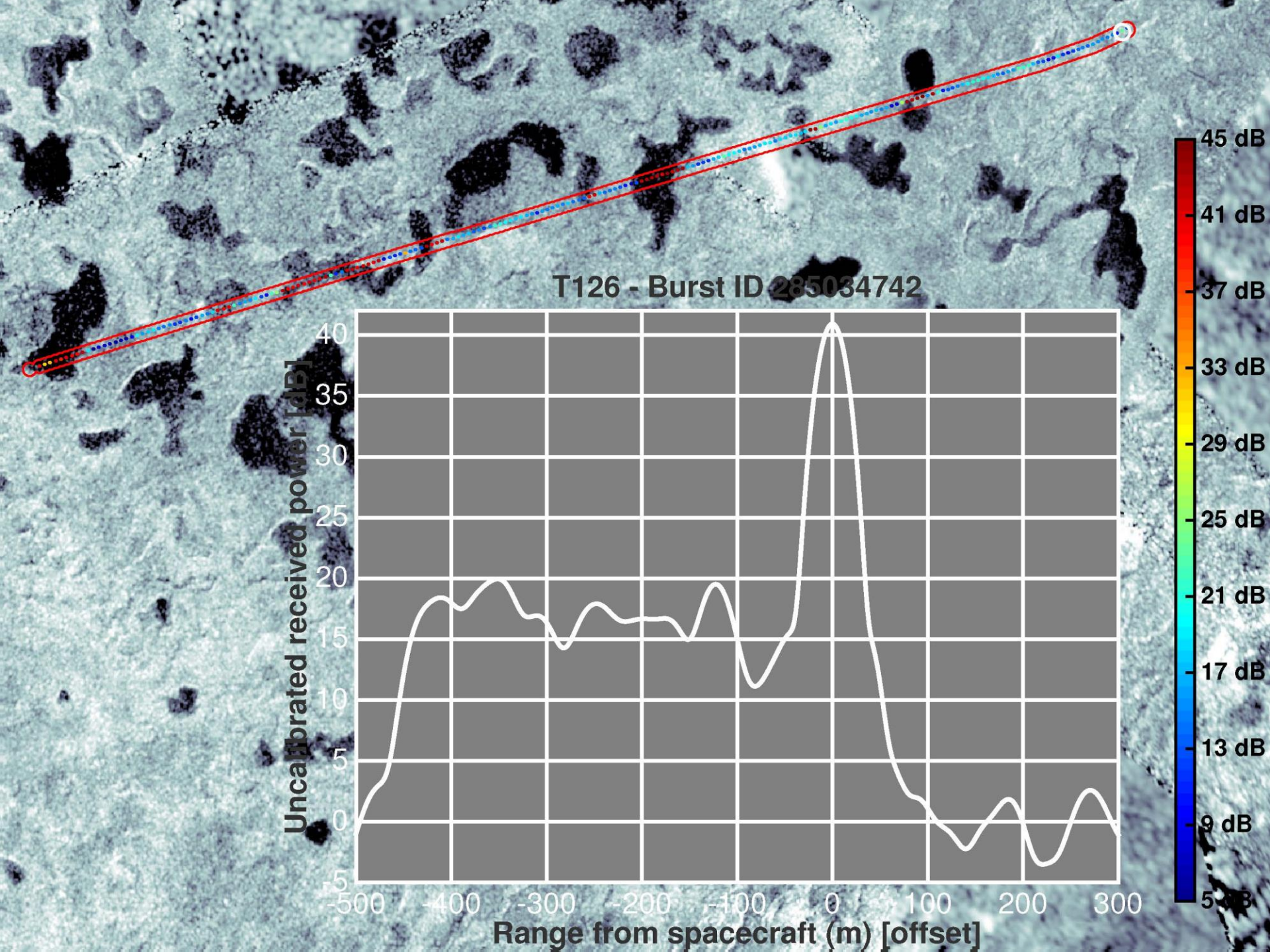


Ligeia: 74% CH_4, 9% C_2H_6, 17% N_2 (mol) Ontario: 54% CH_4, 36% C_2H_6, 11% N_2 (mol)

First Look: T126 Altimetry Over Small Lakes

T126 Cassini footprint : 6 km

Marco Mastrogiuseppe
Valerio Poggiali
Alex Hayes


T126 - Burst ID 285034742
Uncalibrated received power [dB]
40
35
30
25
20
15
10
5
0
-5
-500
-400
-300
-200
-100
0
100
200
300
Range from spacecraft (m) [offset]
45 dB
41 dB
37 dB
33 dB
29 dB
25 dB
21 dB
17 dB
13 dB
9 dB

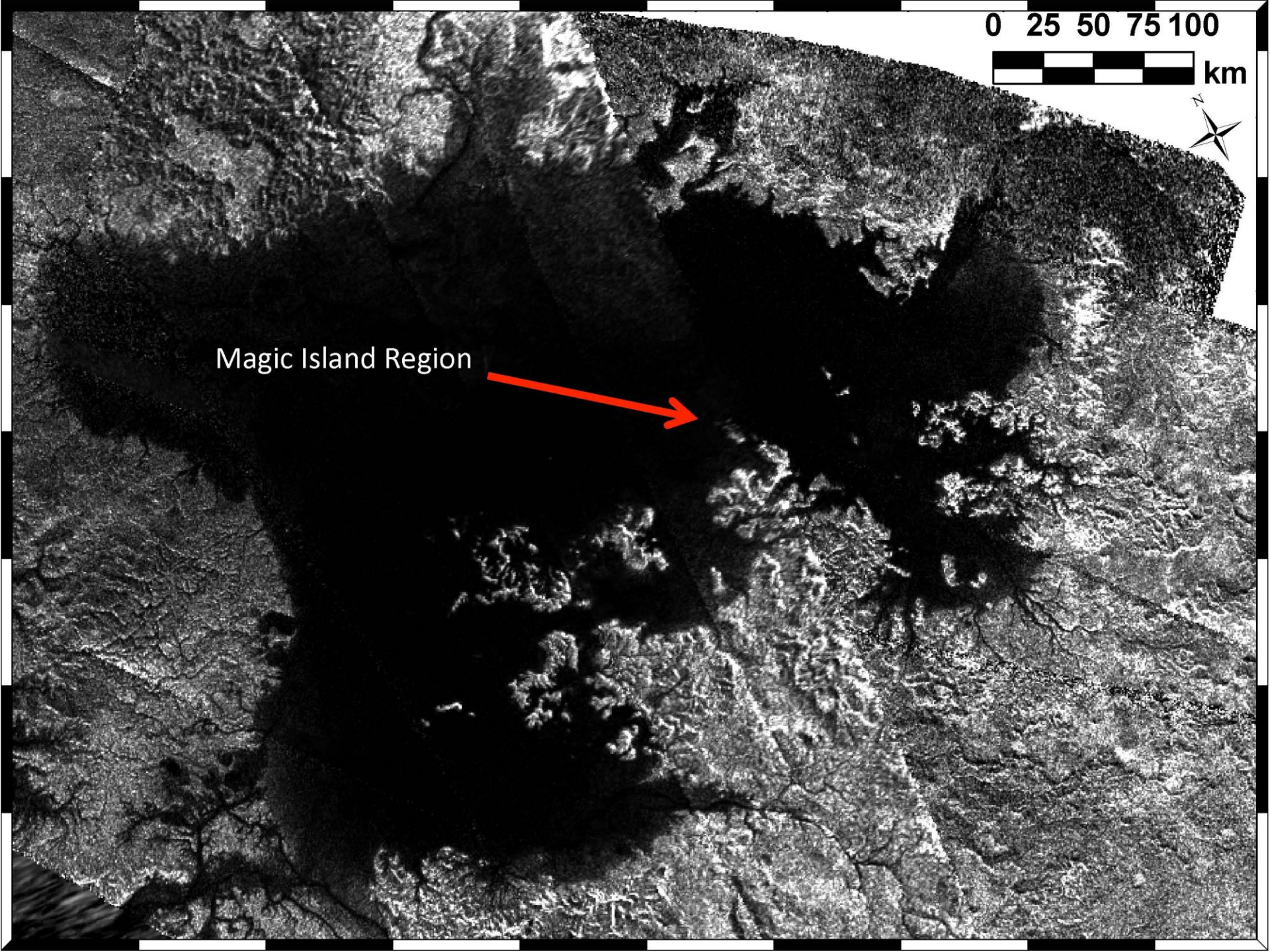
Bathymetry and composition of Titan's lakes and seas

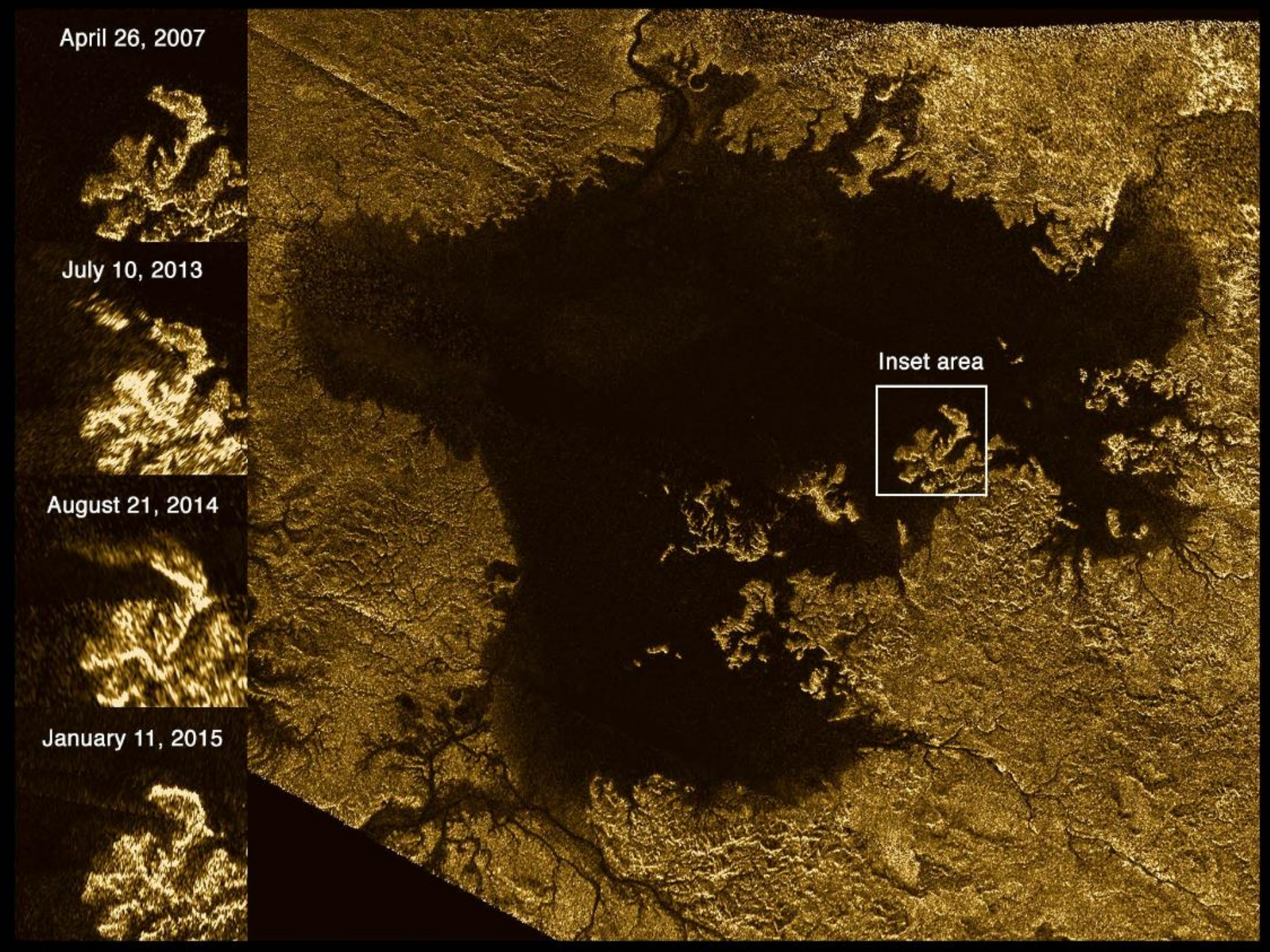
Variable depths of seas, consistent with a complex hydrology

- Depths of lakes are variable, ranging up to ~100 m.
- Preliminary assessment suggests that, like Ligeia Mare, they are likely to be methane-dominated.
- Analysis is on-going, and will be used to test and constrain hydrologic and compositional models, which may give insight into subsurface transport processes and karstic geology.
- See future work by Poggiali, Mastrogiuseppe, Mitchell, Malaska and others.

T126

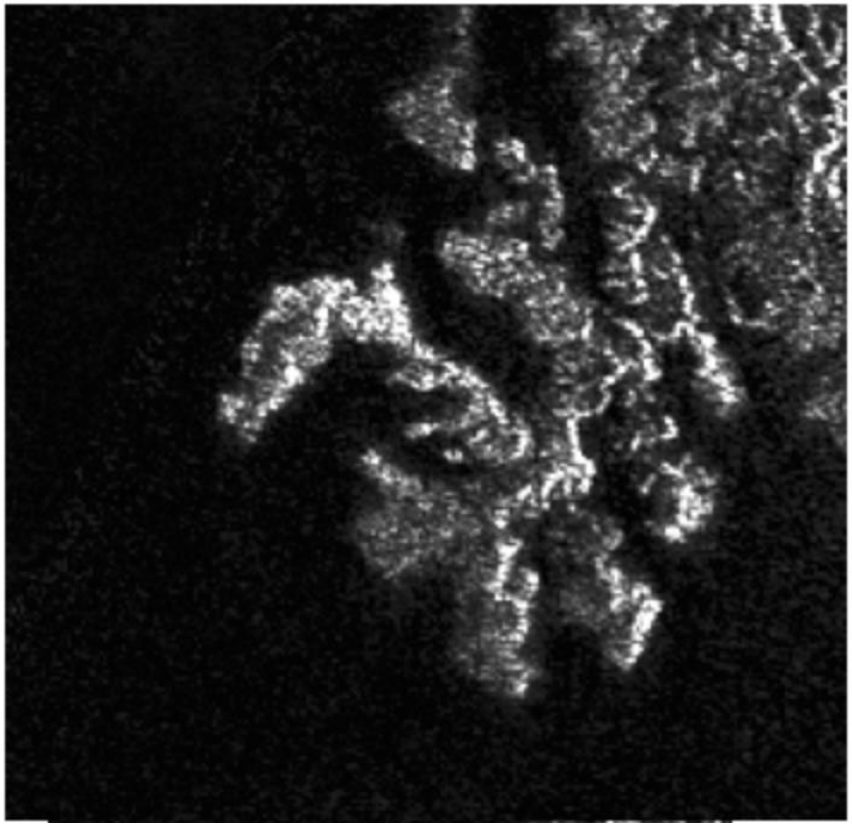
The Magic Island

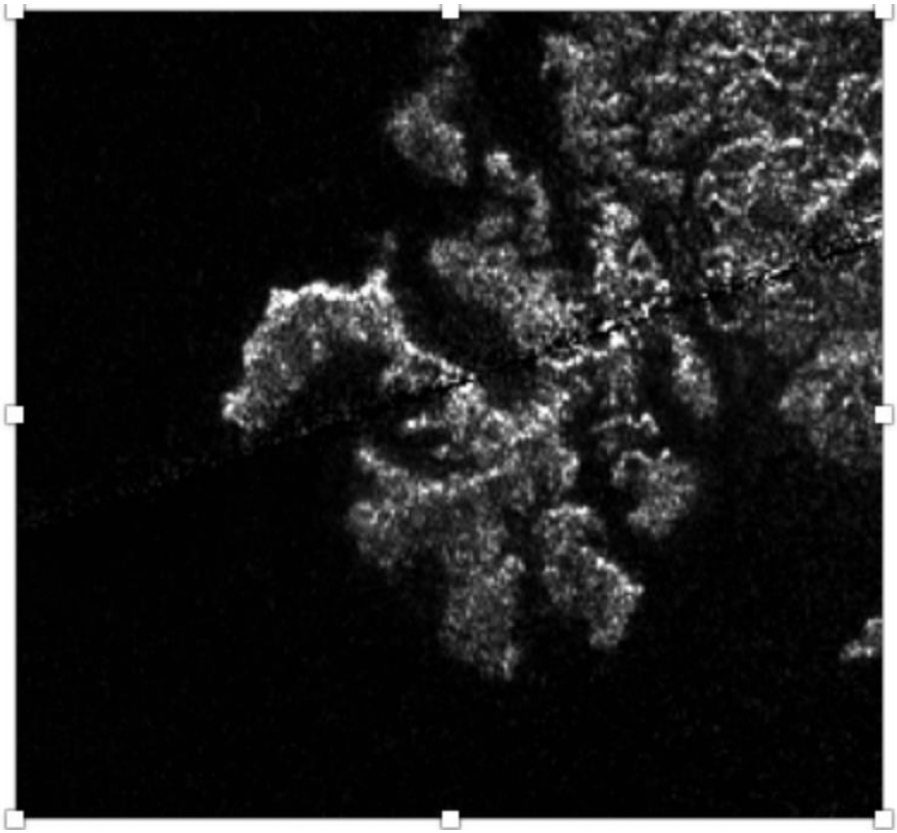

0 25 50 75 100
km
N
Magic Island Region


April 26, 2007
July 10, 2013
August 21, 2014
January 11, 2015
Inset area

The “magic island”

No detection in T126; It remains a mystery.



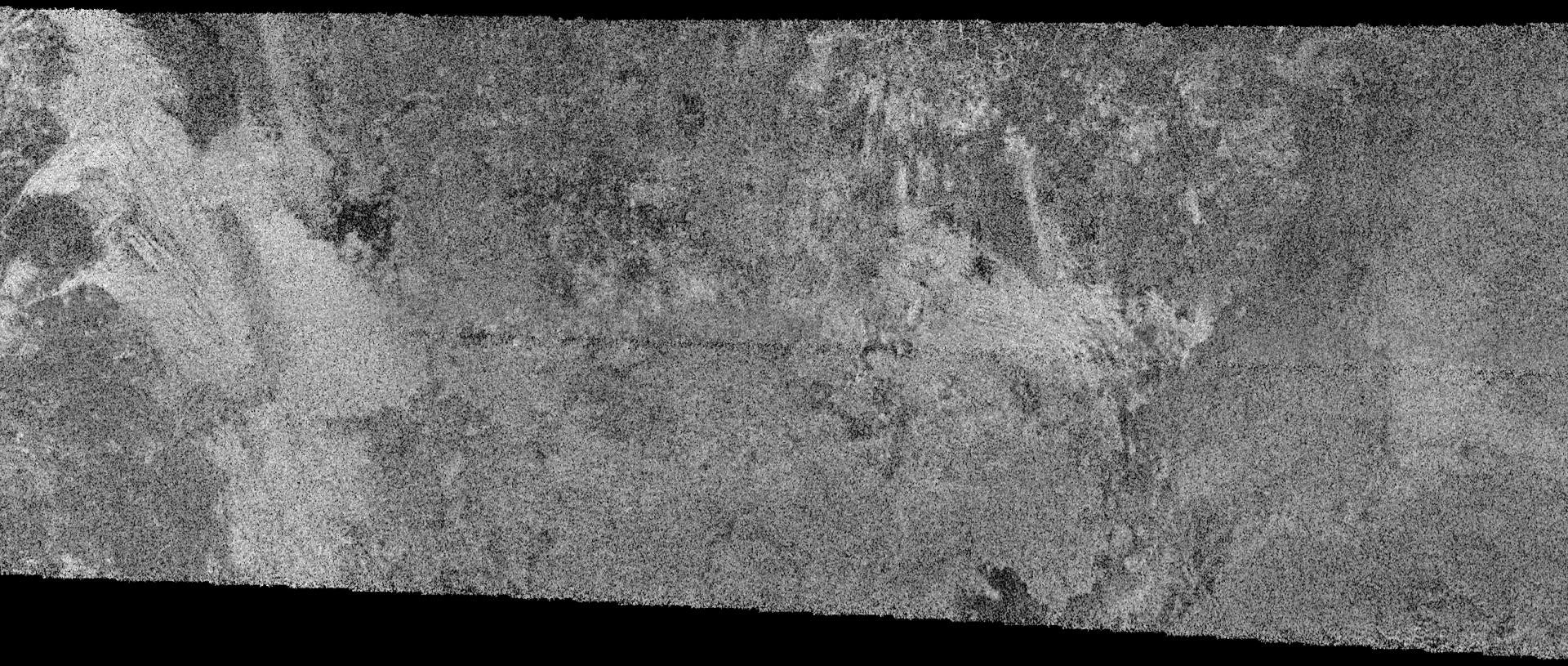


- Preliminary results: No magic island this time.
- Reconstructed ephemerides have changed such findings before, so inconclusive at present. Also, very close to beam seams.
- Analysis and interpretation are on-going. See future work by Hofgartner.

T126

Revisiting the first fly-by of Titan

Ta-T126 blink comparison
Longest timebase Cassini
RADAR comparison
(Ta horizontal; T126 vertical)



100 km

“We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time”

– T. S. Eliot, *Little Gidding*

Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov