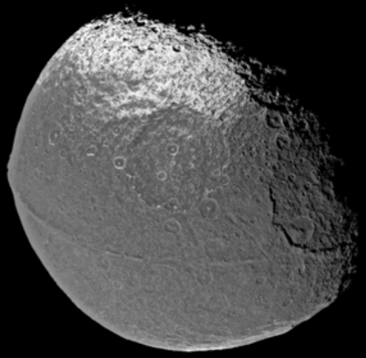
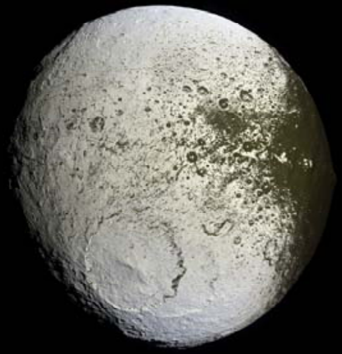
# Probing the Mysteries of Iapetus:
## *the September 2007 Cassini Flyby*



CHARM

October 30 2007



Roger Clark, Cassini VIMS team

Tilmann Denk, Cassini ISS team

Amanda Hendrix, Cassini UVIS team

Steve Ostro, Cassini Radar team

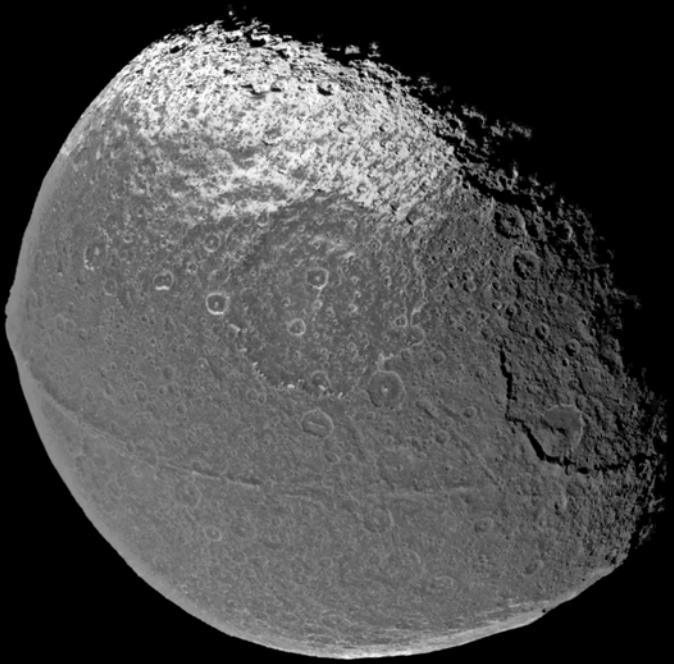
John Spencer, Cassini CIRS team

# What we knew about Iapetus going into the September 2007 flyby

- Iapetus has been known to have a dramatic albedo dichotomy
  - Source of dark material, processes are unknown
  - Discussed more later
- Iapetus:
  - 3rd largest moon of Saturn (~1460 km diameter)
  - Tidally locked: orbital period is 79.3 days (slow)
- Cassini performed a flyby of Iapetus on December 31, 2004
  - ~123,000 km altitude
  - Primarily over low-albedo leading hemisphere and bright north polar region

# Results from 2004 Iapetus flyby

*Dark material is almost certainly exogenic in origin…*



:

Equatorial ridge!

Streaks in transition zone at north polar region; bright polar-facing crater walls

# September 2007 Flyby

*. . . but there’s more to the story*

- The flyby was inbound over the unilluminated (nightside) low-albedo hemisphere
  - Good opportunity to do Radar imaging
- Excellent views of the bright-dark boundary on the anti-Saturnian hemisphere
  - Opportunity to confirm/check exogenic pattern seen in north polar boundary region in previous flyby
  - Also great equatorial ridge views
- Thermal segregation is very important…
- Next are results from
  - John Spencer (thermal segregation model)
  - Tilmann Denk (imaging results)
  - John Spencer (CIRS results)
  - Roger Clark (VIMS results)
  - Amanda Hendrix (UVIS results)
  - Steve Ostro (Radar results)

# Thermal Segregation and Global Volatile Migration on Iapetus

John Spencer
Southwest Research Institute, Boulder

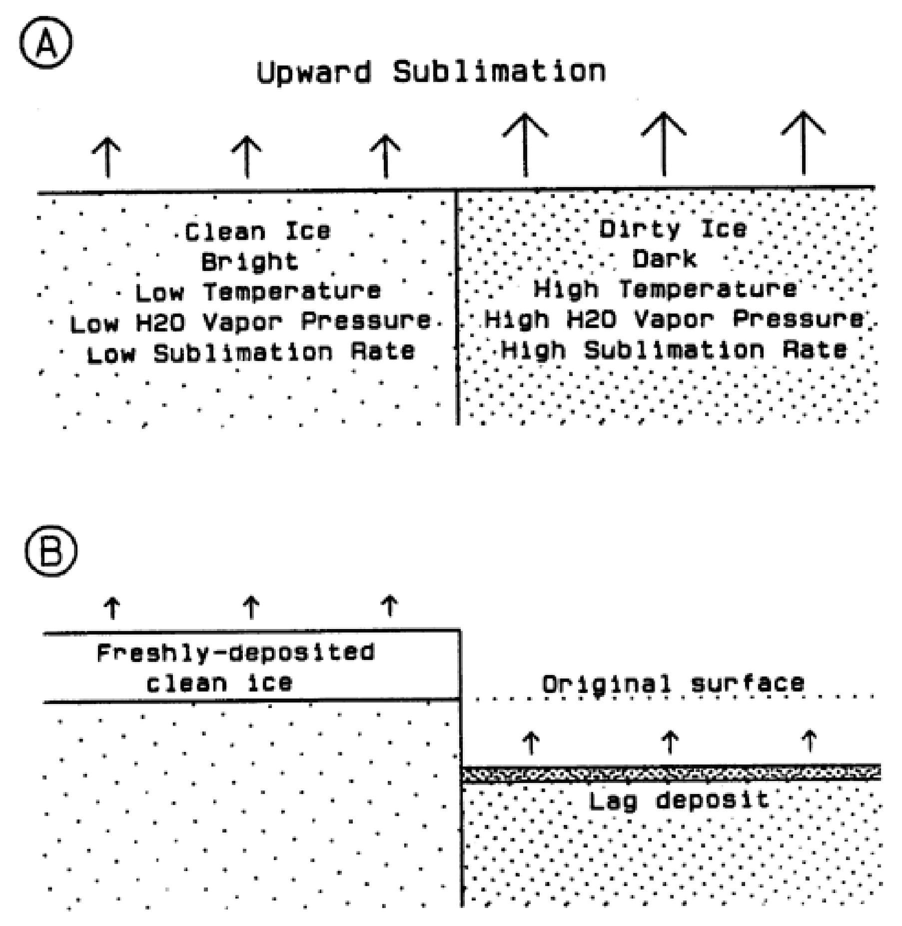
# Ice Sublimation on Iapetus

- Most (all?) of Saturn’s moons have water ice on their surfaces
- On most moons, the ice is hard-frozen and stays put
- On Iapetus ice can get relatively warm, due to:
  - Dark surface which absorbs most incoming sunlight
  - Slow rotation giving lots of time to heat up during the day
- Ice can therefore evaporate (“sublime”) and move around
  - Movement can be local or global

# Local Ice Movement: Thermal Segregation

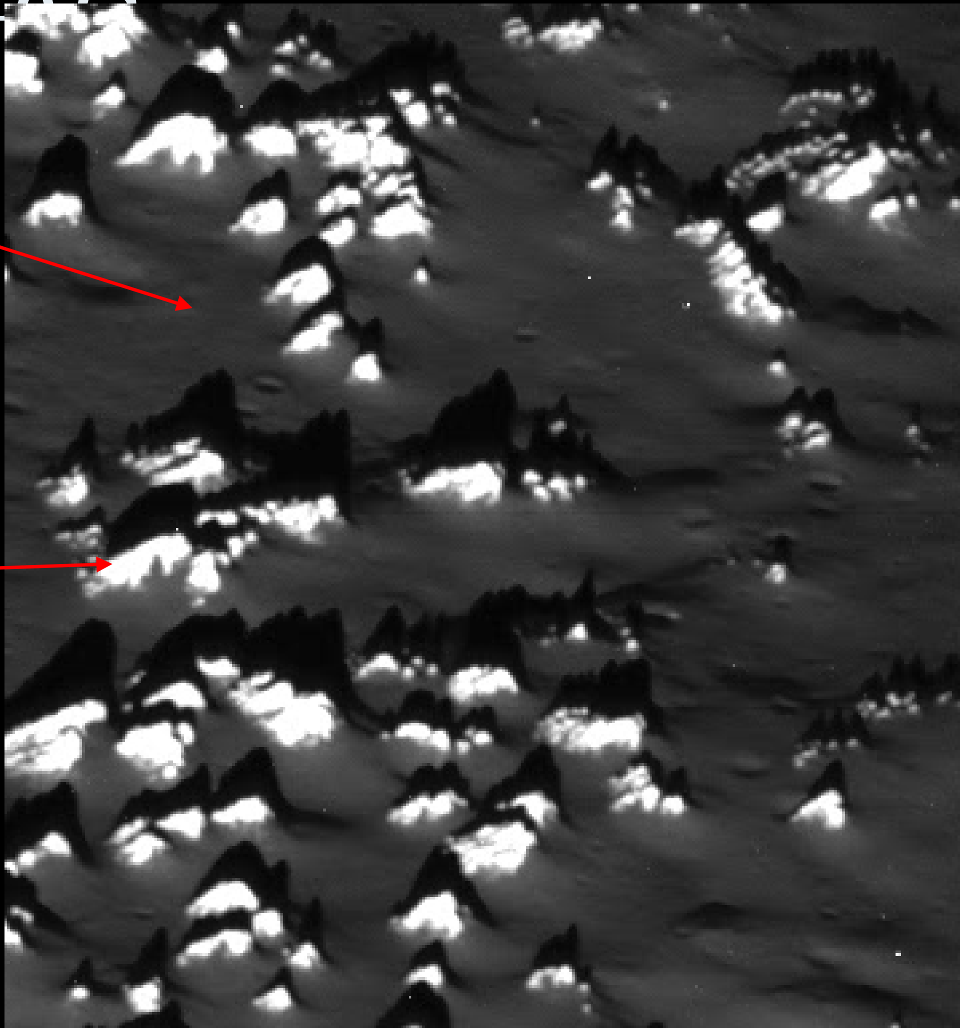
Warm dark ice on Iapetus is likely to undergo thermal segregation:

- Small initial temperature differences (due to albedo or topography) will trigger a runaway process
  - Alll ice is lost from the warmer regions, which get warmer and darker
  - Ice concentrates in cold regions, which get brighter and colder



Spencer, 1987

# Thermal Segregation First Seen on the Galilean Satellites, late 1990s



Surface darkened by frost sublimation and accumulation of an ice-free lag deposit

Surface brightened by frost deposition from nearby or distant dark regions

Callisto from Galileo

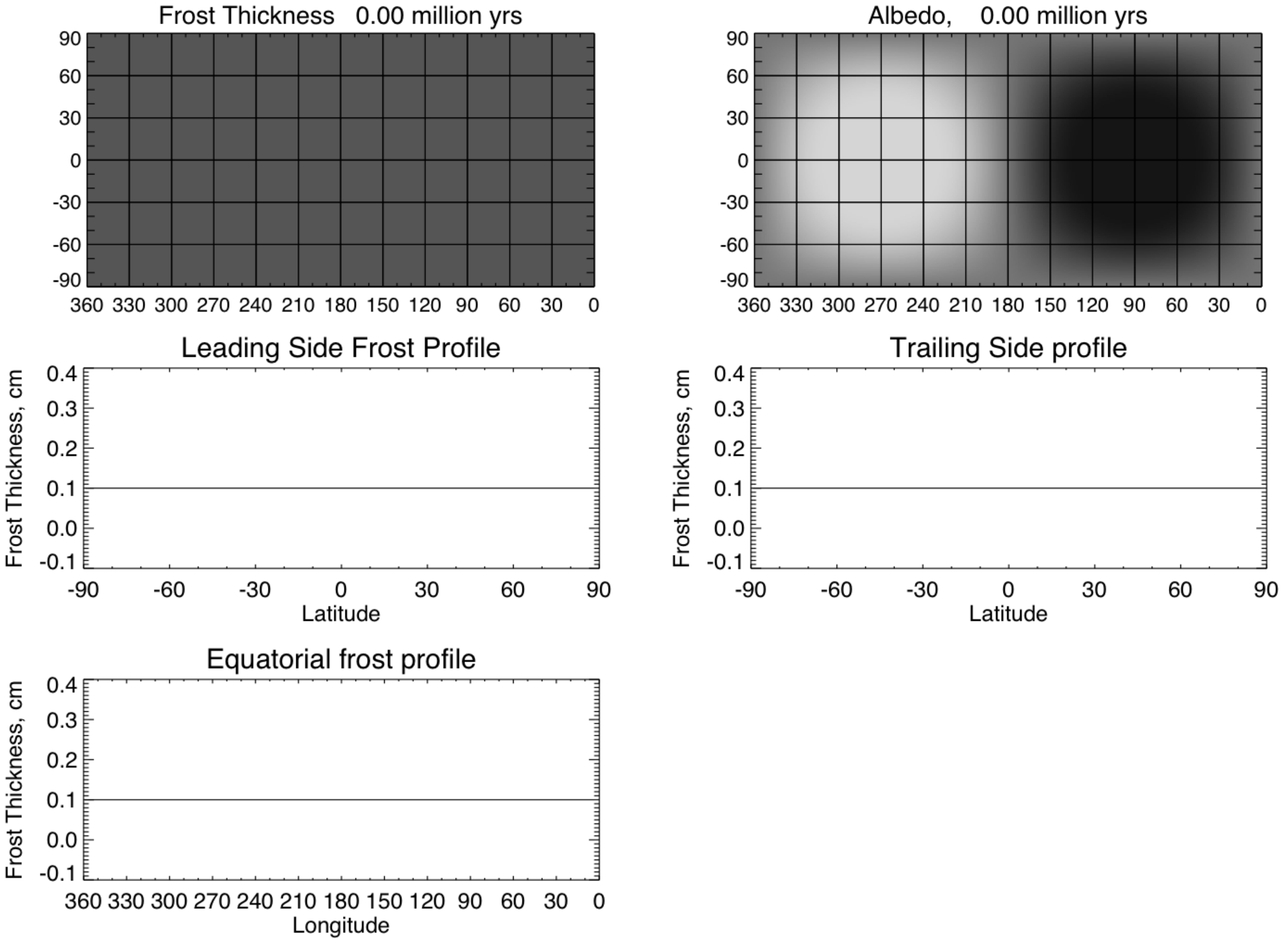
# Global Ice Movement:
# 2005 Model

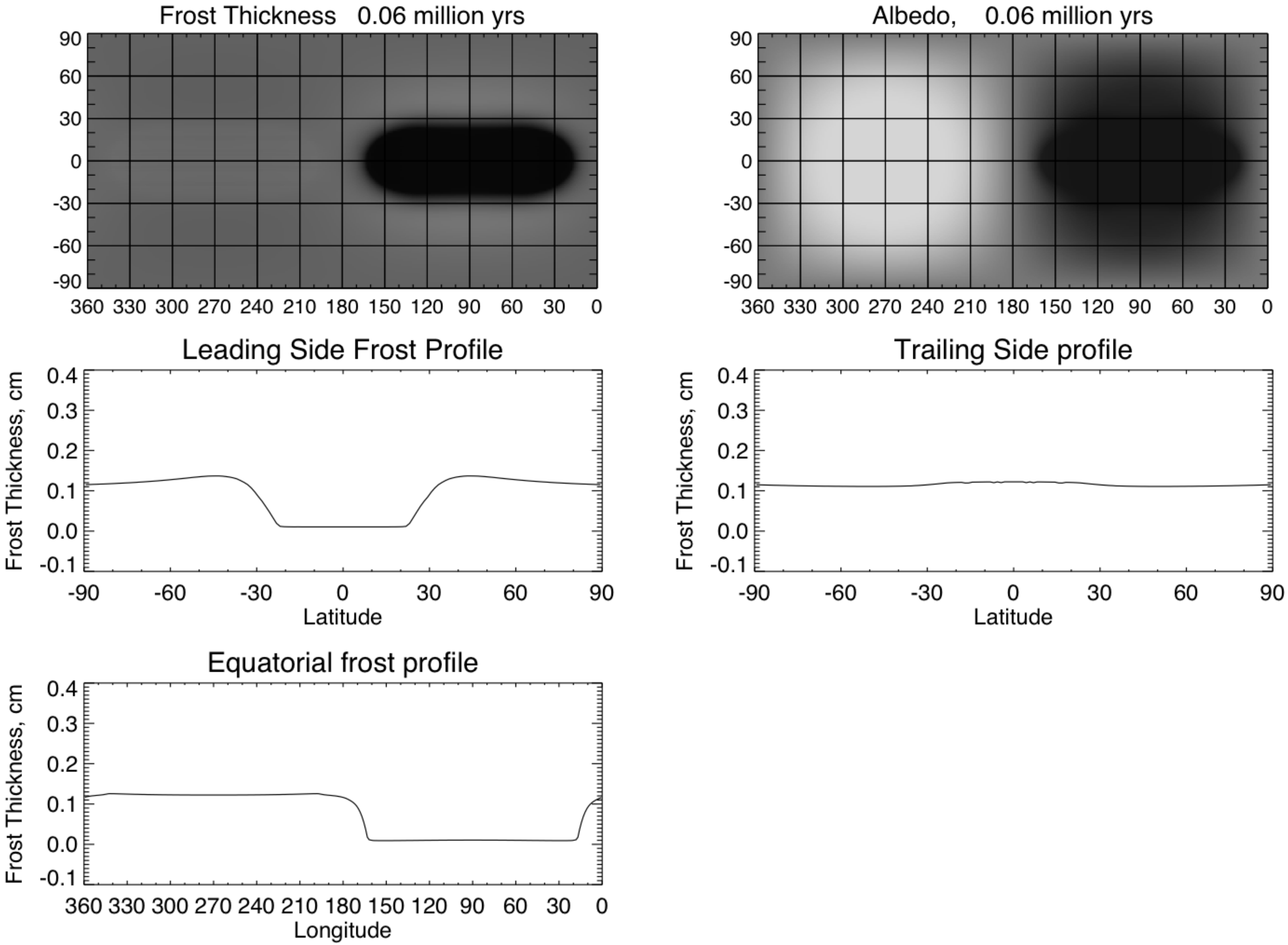
- Simple models of dark material infall darken the leading hemisphere, but Iapetus is not so simple
  - Iapetus' bright material extends over the poles
  - Dark material extends around the equator
- Thermal ice migration can explain this…
  - Originally proposed by Mendis and Axford in 1974

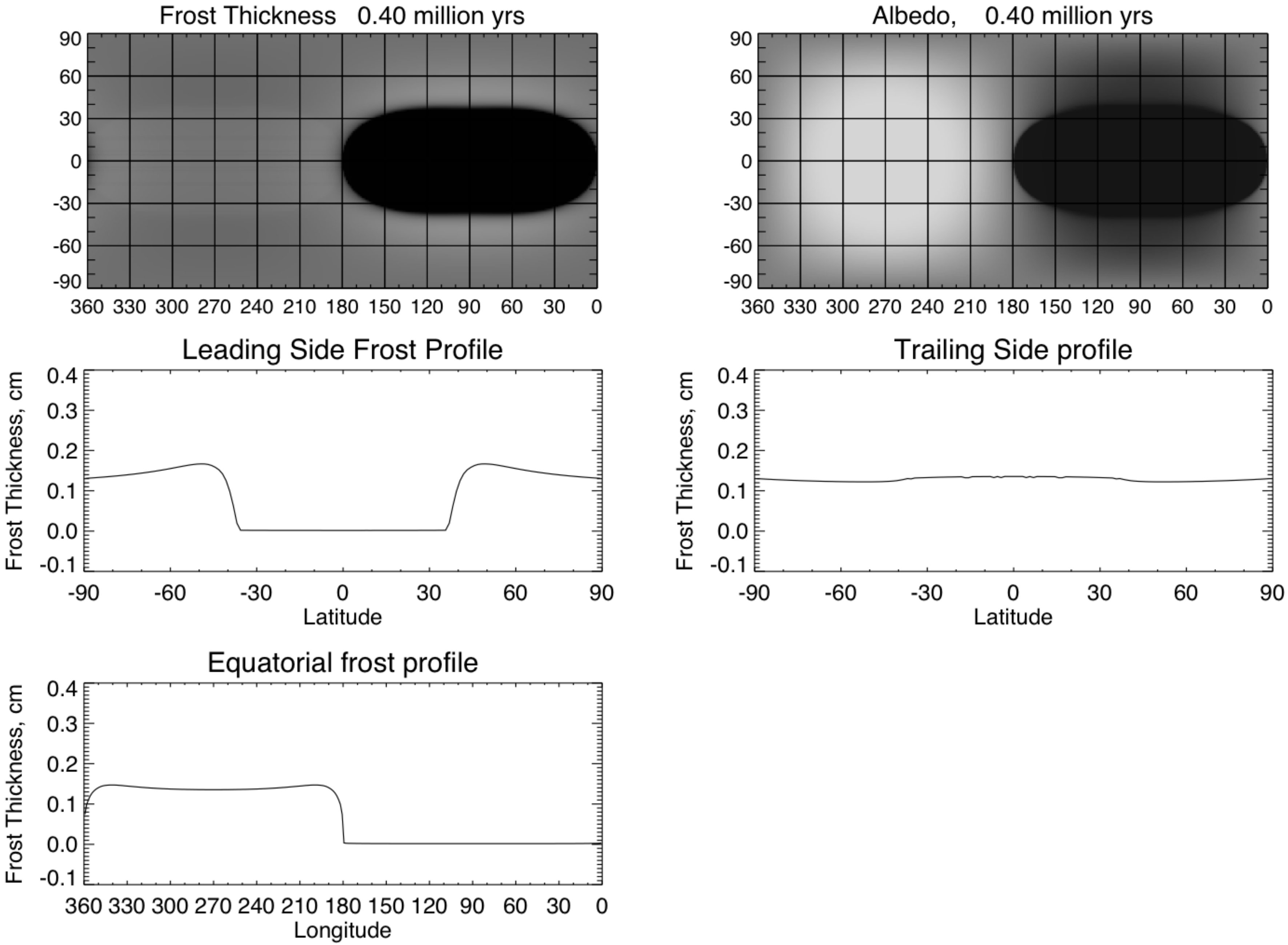
Iapetus map by Steve Albers

# Frost Migration Model

- Assume Iapetus is covered in ice
- Infalling material darkens the leading side
- Dark, warm, ice evaporates and recondenses elsewhere
- Evaporation shuts off when 1mm of ice has been lost
  - Ice layer is exhausted
  - Or lag deposit forms


Frost Thickness 0.00 million yrs
90
60
30
0
-30
-60
-90
360 330 300 270 240 210 180 150 120 90 60 30 0
Albedo, 0.00 million yrs
90
60
30
0
-30
-60
-90
360 330 300 270 240 210 180 150 120 90 60 30 0
Leading Side Frost Profile
Frost Thickness, cm
0.4
0.3
0.2
0.1
0.0
-0.1
-90 -60 -30 0 30 60 90
Latitude
Trailing Side profile
Frost Thickness, cm
0.4
0.3
0.2
0.1
0.0
-0.1
-90 -60 -30 0 30 60 90
Latitude
Equatorial frost profile
Frost Thickness, cm
0.4
0.3
0.2
0.1
0.0
-0.1
360 330 300 270 240 210 180 150 120 90 60 30 0
Longitude


Frost Thickness 0.06 million yrs
Albedo, 0.06 million yrs
90
60
30
0
-30
-60
-90
360 330 300 270 240 210 180 150 120 90 60 30 0
Leading Side Frost Profile
Trailing Side profile
Frost Thickness, cm
0.4
0.3
0.2
0.1
0.0
-0.1
-90 -60 -30 0 30 60 90
Latitude
Equatorial frost profile
Longitude



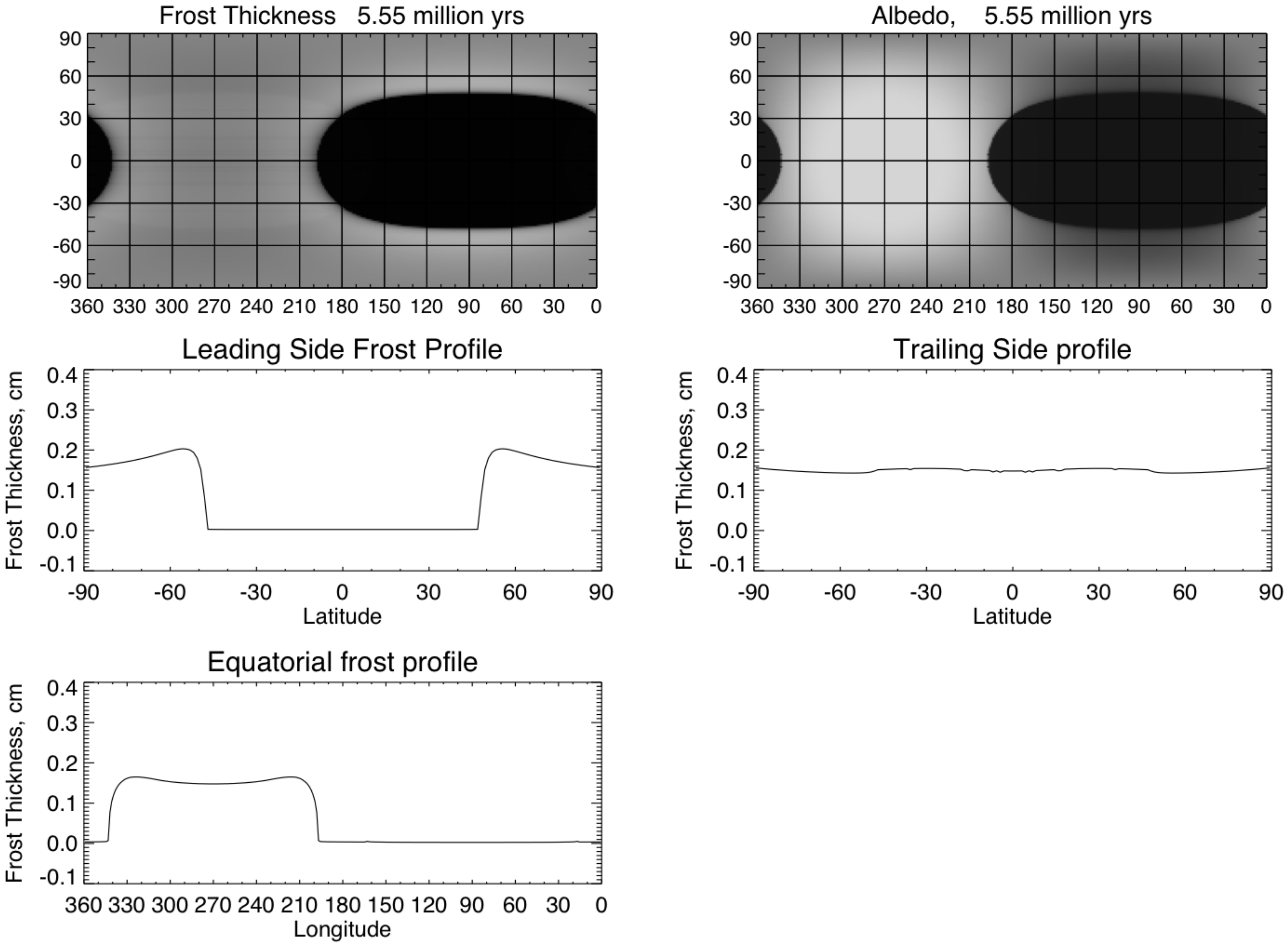
Frost Thickness 0.40 million yrs

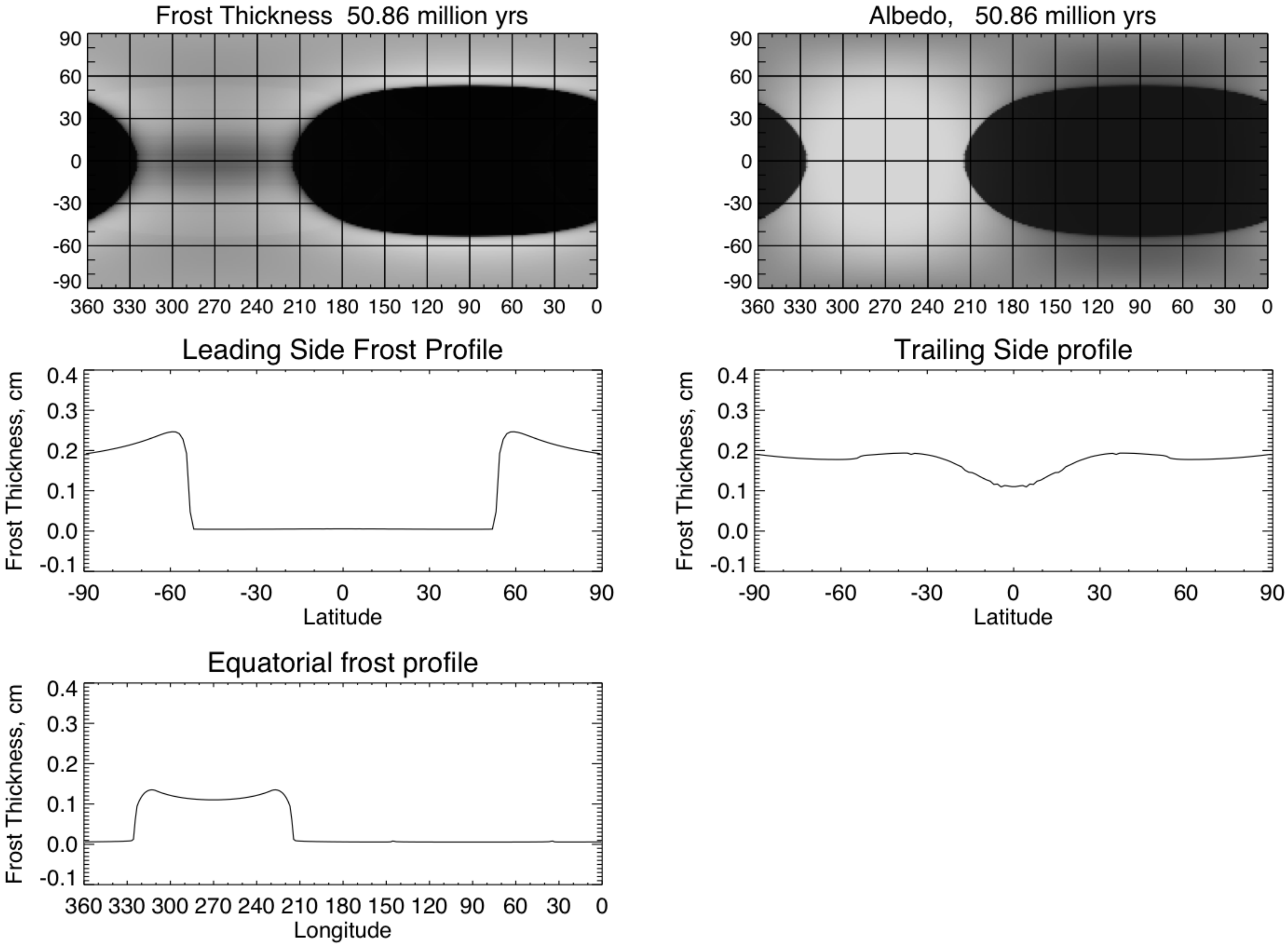
Albedo, 0.40 million yrs

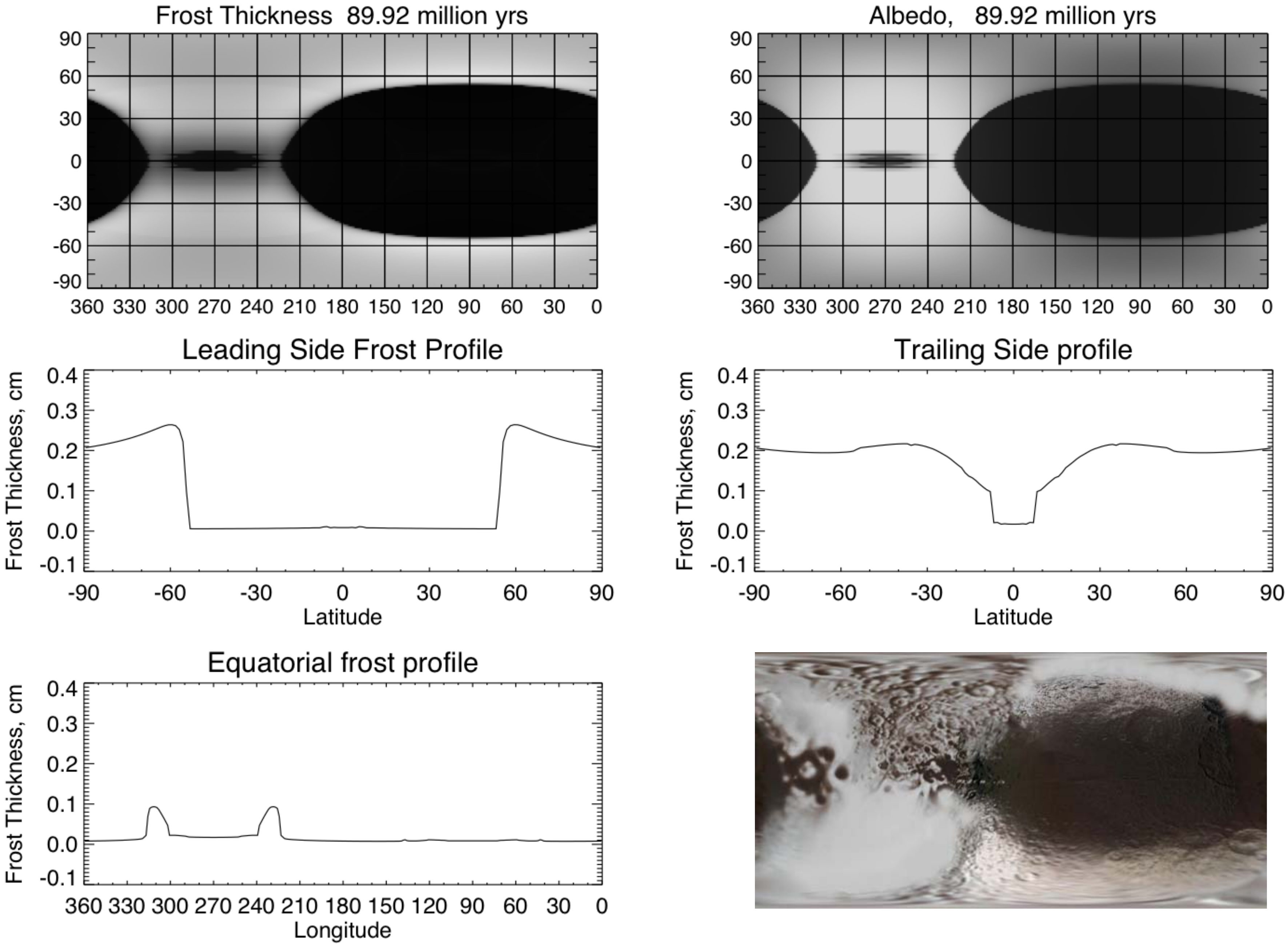
Leading Side Frost Profile

Trailing Side profile

Equatorial frost profile


Frost Thickness 5.55 million yrs
Albedo, 5.55 million yrs
Leading Side Frost Profile
Trailing Side profile
Equatorial frost profile
Frost Thickness, cm
Latitude
Longitude
90
60
30
0
-30
-60
-90
360
330
300
270
240
210
180
150
120
90
60
30
0
0.4
0.3
0.2
0.1
0.0
-0.1


Frost Thickness 50.86 million yrs
Albedo, 50.86 million yrs
90
60
30
0
-30
-60
-90
360 330 300 270 240 210 180 150 120 90 60 30 0
Leading Side Frost Profile
Trailing Side profile
Frost Thickness, cm
0.4
0.3
0.2
0.1
0.0
-0.1
-90 -60 -30 0 30 60 90
Latitude
Equatorial frost profile
Longitude


Frost Thickness 89.92 million yrs
Albedo, 89.92 million yrs
90
60
30
0
-30
-60
-90
360 330 300 270 240 210 180 150 120 90 60 30 0
Leading Side Frost Profile
Trailing Side profile
Frost Thickness, cm
0.4
0.3
0.2
0.1
0.0
-0.1
-90 -60 -30 0 30 60 90
Latitude
Equatorial frost profile
Longitude

# Conclusions

- Ice migration is important on Iapetus
  - Produces local thermal segregation
    - We expect ice to have entirely evaporated from the dark terrain
  - Explains the shape of the leading/trailing hemisphere boundary

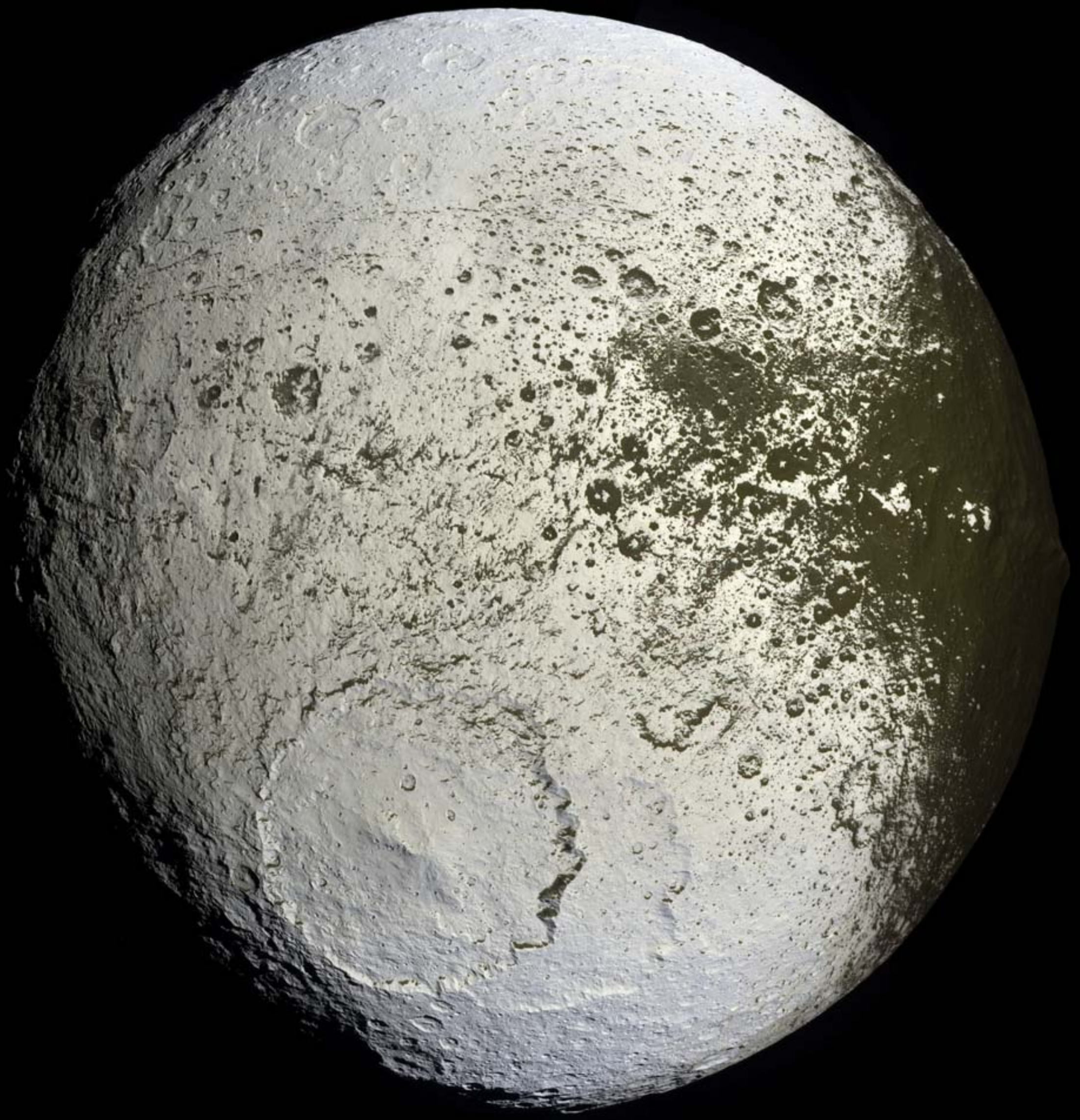
# Tilmann Denk

Cassini Imaging Team

Tilmann Denk
Imaging Team associate
Freie Universität
Berlin, Germany

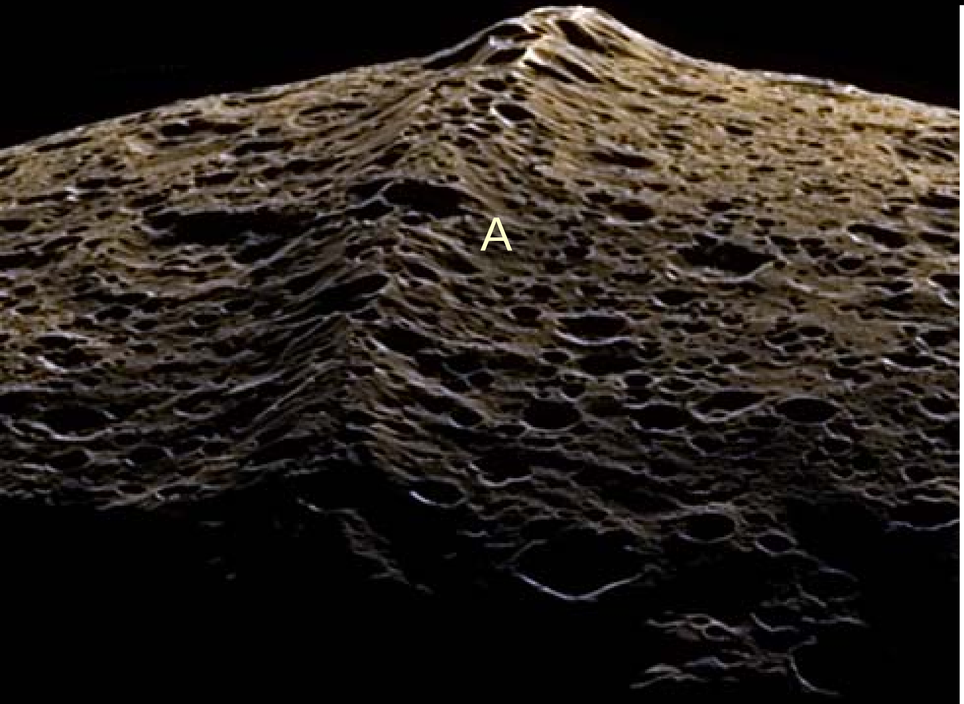
www.fu-berlin.de/planeten

# Trailing Side of Iapetus



north ⬆

# Equatorial ridge

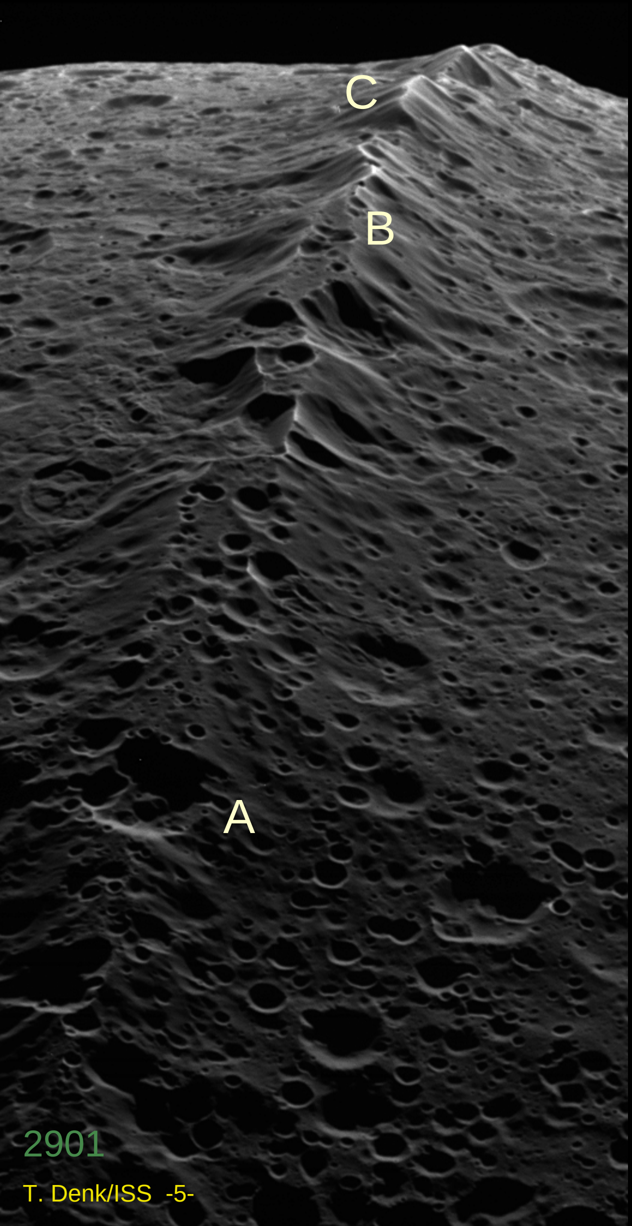


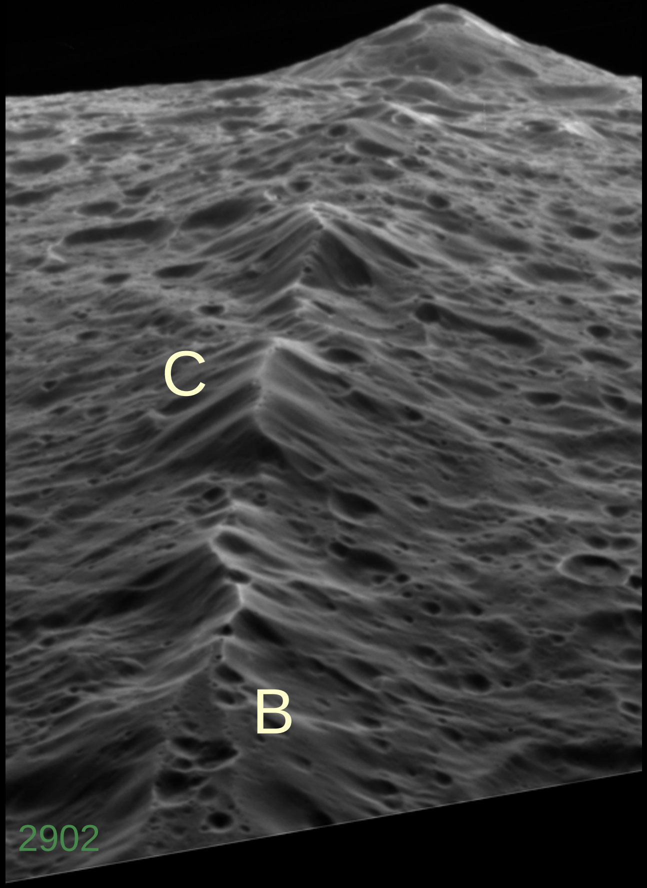
10 Sep 2007

north ➡

31 Dec 2004

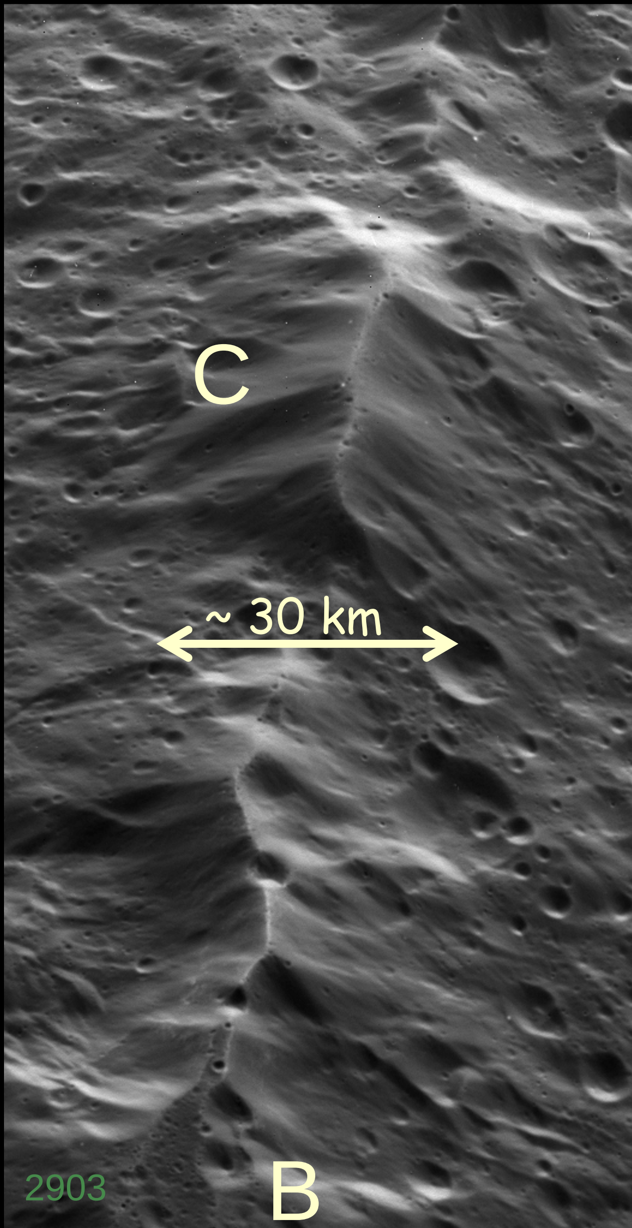
# Equatorial ridge





longitude of 'C' ~ 165° W

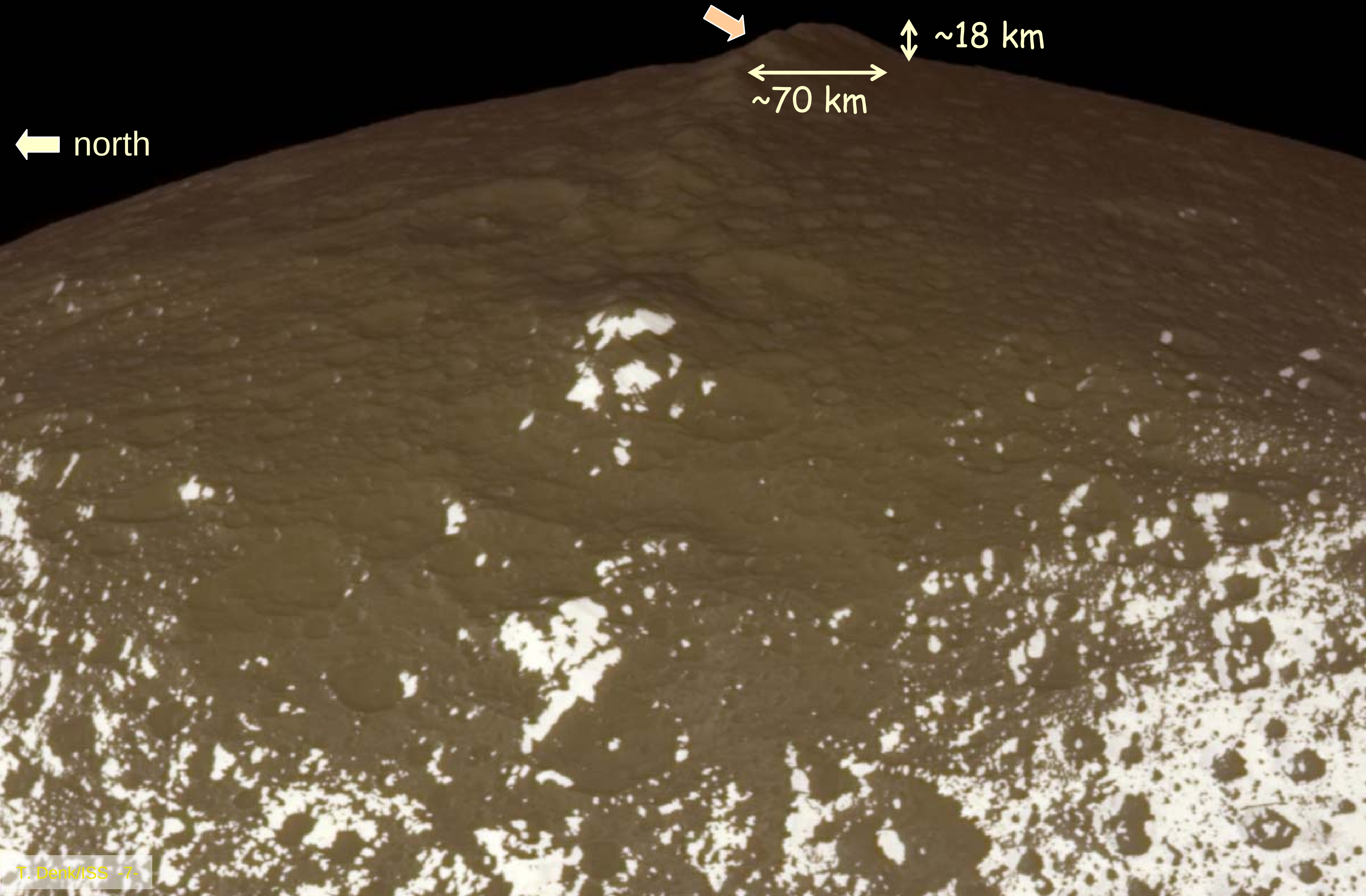
north ➡



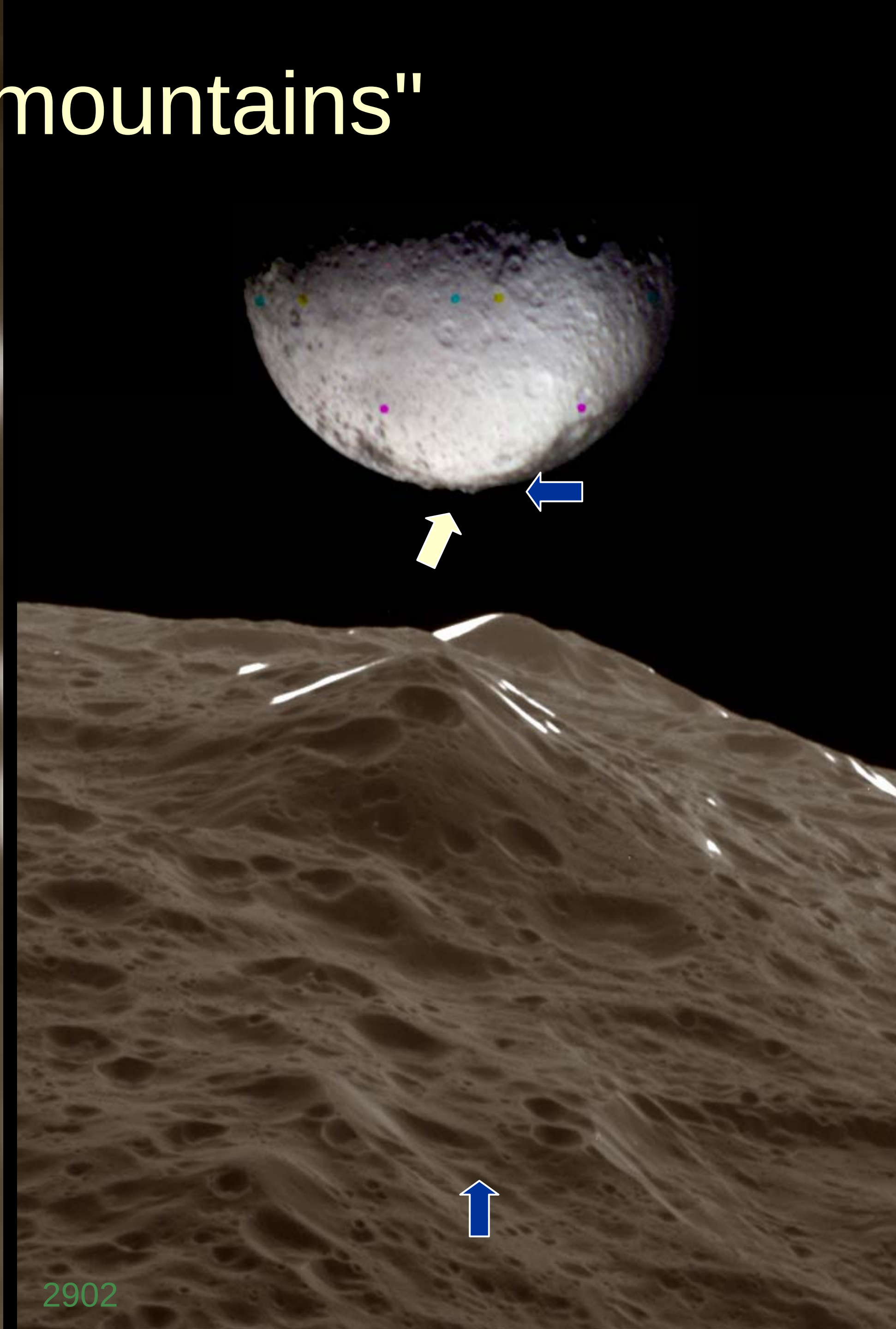
# Equatorial ridge

2903 WACs

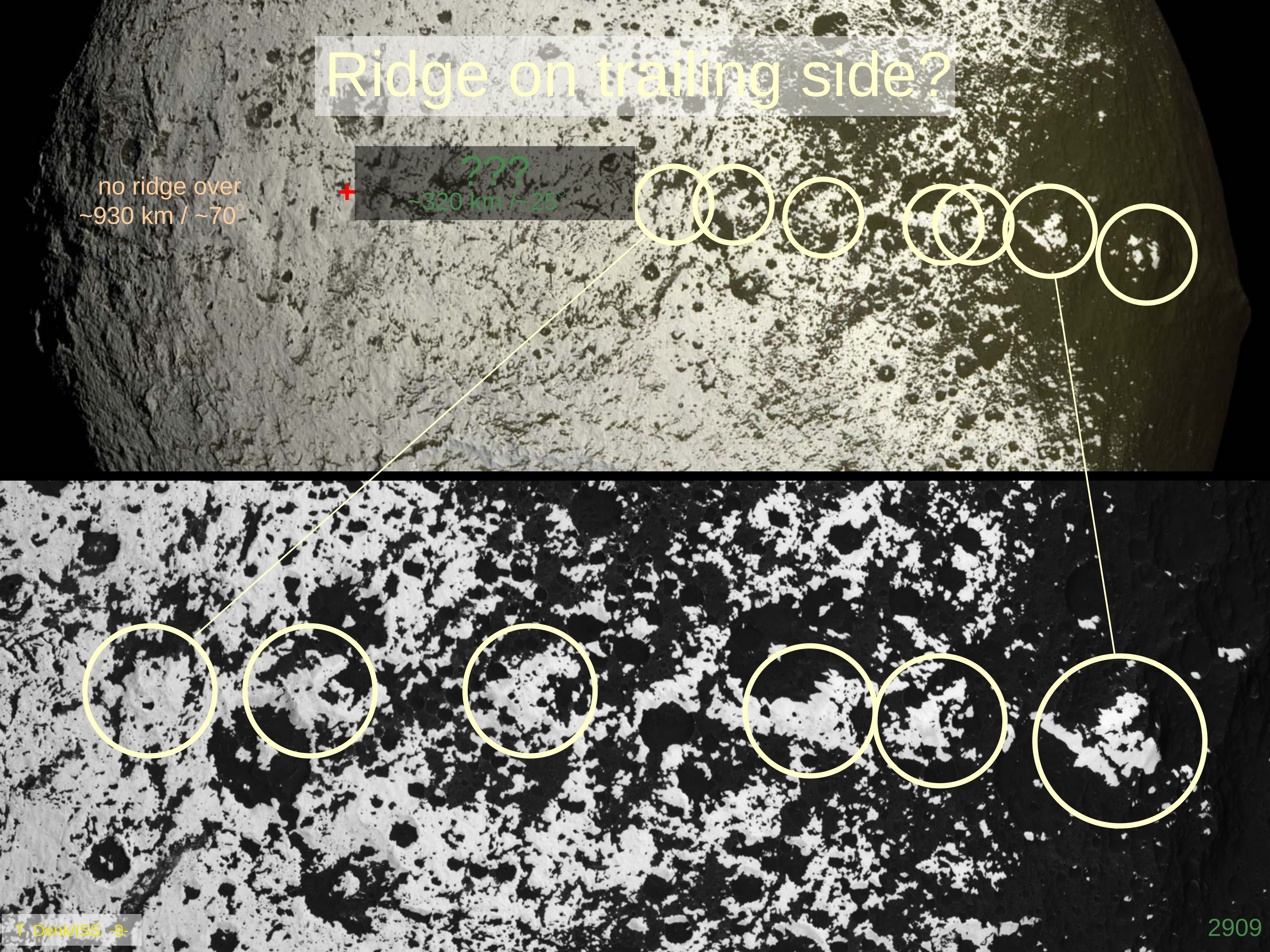
# Equatorial ridge



# "Voyager mountains"



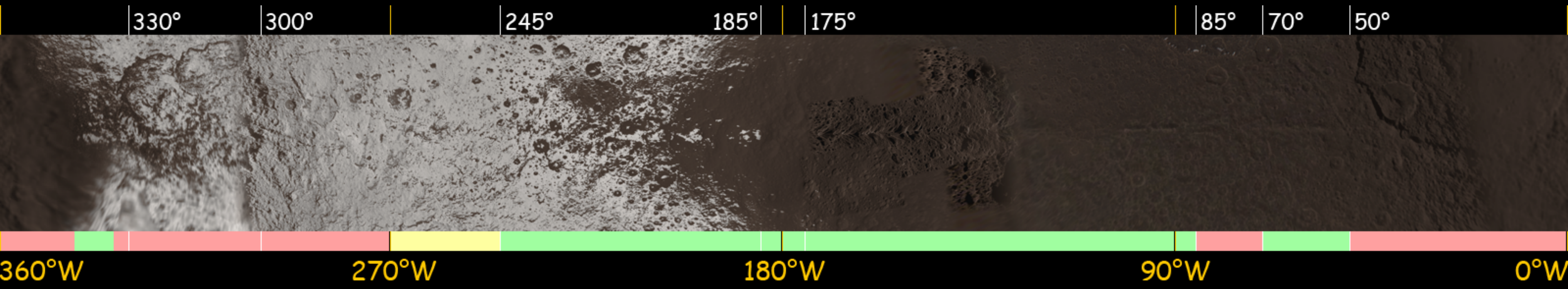
# Ridge on trailing side?



no ridge over
~930 km / ~70°

???
~320 km / ~25°

# "Ridge walk"

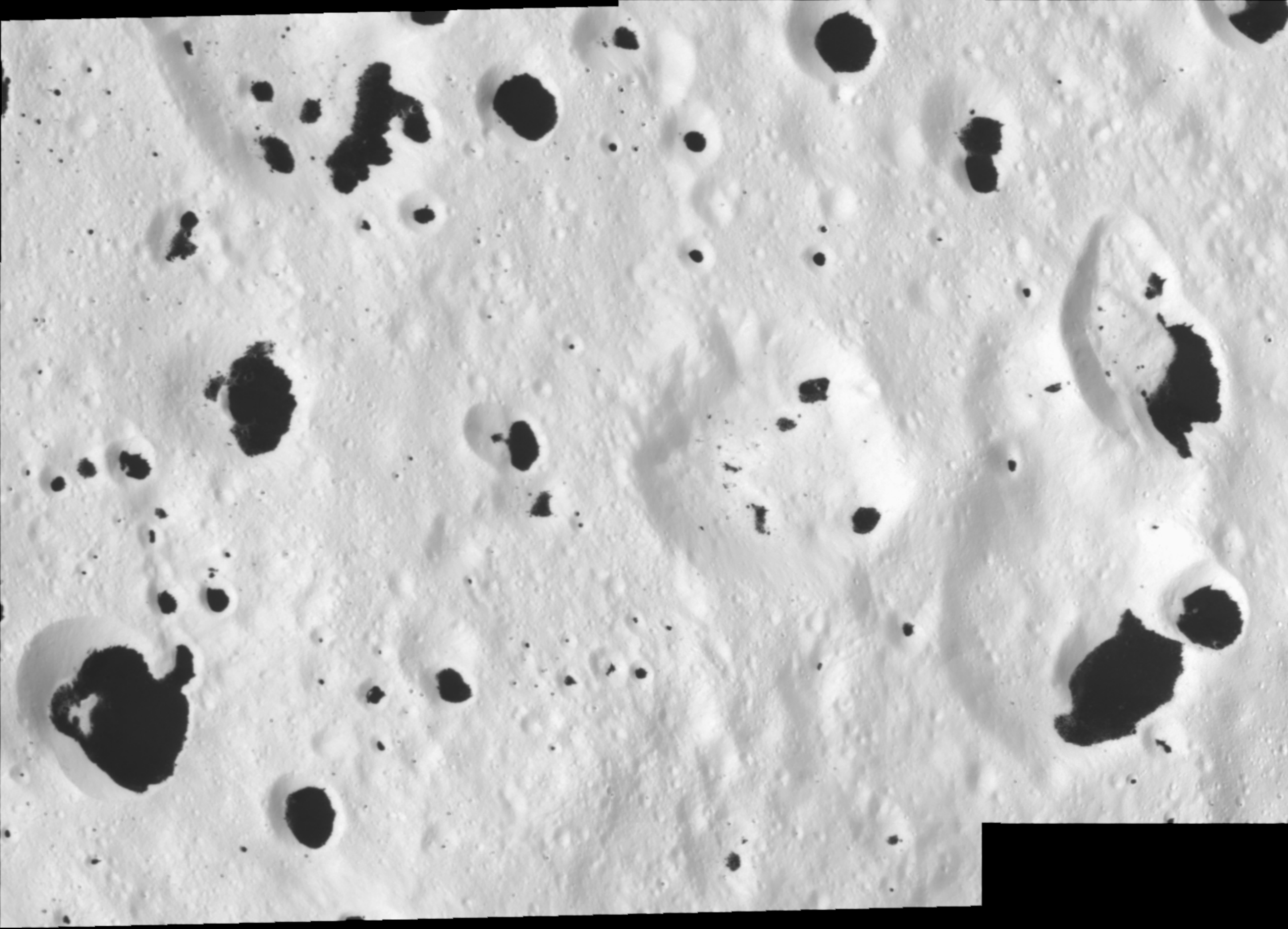


Map from Steve Albers (NOAA)

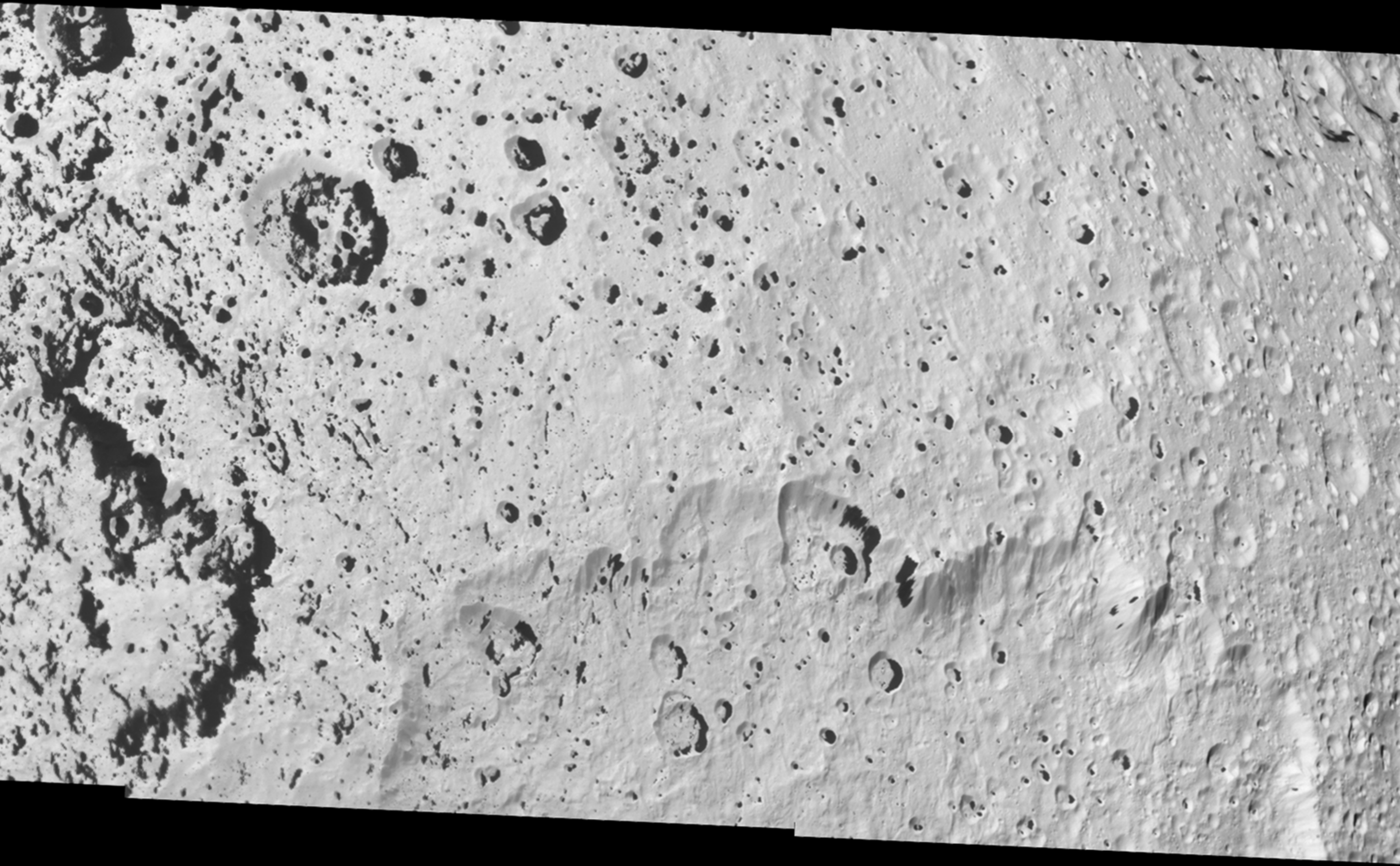
- Green: Ridge or isolated mountains at equator
- Red: Ridge or mountains absent
- Yellow: Uncertain

- ~85° to ~175° W longitude: Ridge most prominent
- ~185° to ~245° W: Isolated "Voyager" mountains

- ~340° W: Another mountain on sub-Saturn hemisphere

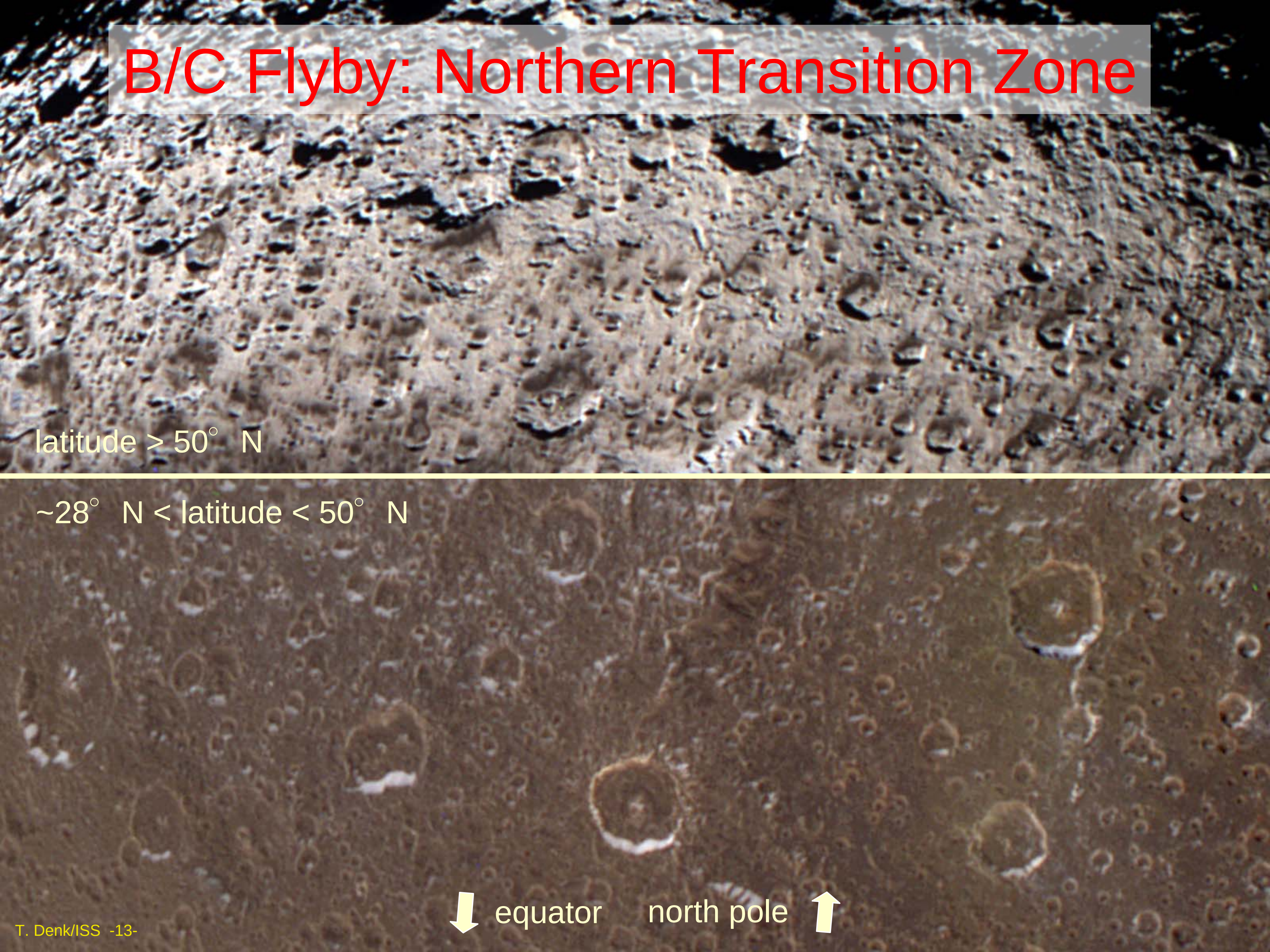


# Equatorward-facing slopes are dark



⬅ equator south pole ➡

# B/C Flyby: Northern Transition Zone



latitude > 50° N

~28° N < latitude < 50° N

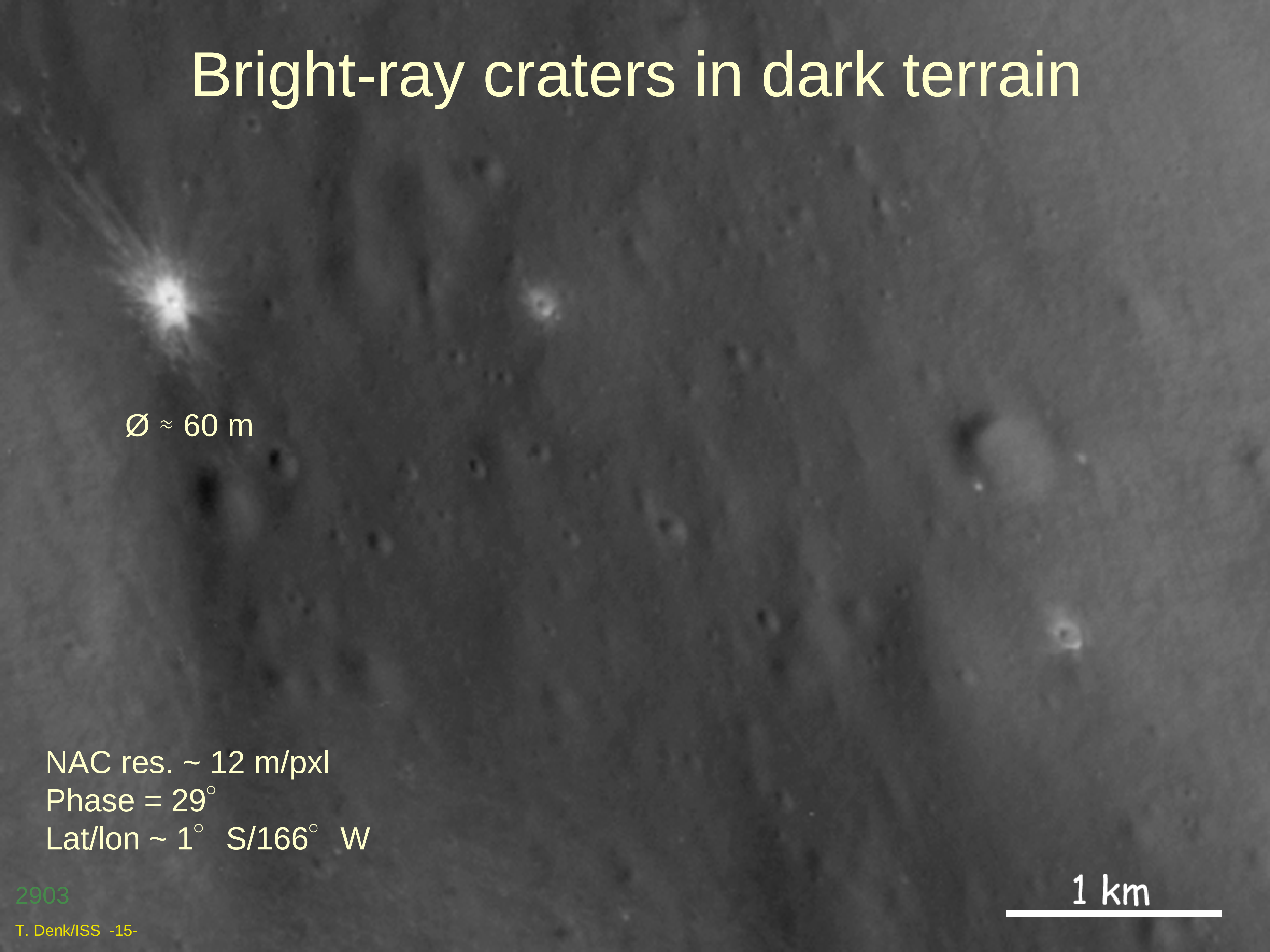
⬇ equator north pole ⬆

# Cassini Regio on Iapetus

... heavily cratered

... has no bright „holes“ (> ~½ km Ø)

# Bright-ray craters in dark terrain



NAC res. ~ 12 m/pxl
Phase = 29°
Lat/lon ~ 1° S/166° W

2903

# About the Albedo-Dichotomy Origin

## Possible classification of Iapetus global albedo dichotomy origin hypotheses *(pre-Cassini view)*:

### 1. Exogenic origin/ dust is coming in over long time

(a) Dark grayish dust from Phoebe hits Iapetus's leading side and gets chemically altered/ reddened
(Soter 1974, Burns et al. 1979, 1996; Hamilton 1997)
(b) Dark reddish dust from smaller retrograde outer saturnian satellites covers Iapetus's leading side (Buratti et al. 2002)

### 2. Asymmetric exogenic influence removes thin ice veneer from leading side, but not from trailing side and poles

***(a) Viewpoint of orbit mechanics:***
(a1) Circumsaturnian dust is the cause (from Phoebe or other outer Saturnian satellites)
(Cruikshank et al. 1983; Bell et al. 1985; Buratti and Mosher 1995)
(a2) Interplanetary micrometeoroid flux is the cause
(Cook and Franklin 1970; Squyres and Sagan 1983; Wilson and Sagan 1996)
***(b) Viewpoint of physical processes on the surface:***
(b1) Exposing of the dark subsurface layer by bright material erosion (Cook and Franklin 1970; Wilson and Sagan 1996)
(b2) enrichment of formerly intimately mixed dark material due to sublimation (erosion) of the bright ice component
(Cruikshank et al. 1983; Bell et al. 1985; Buratti and Mosher 1995)
(b3) synthesis of the dark material by chemical/irradiation processes made possible by bright icy material erosion
(Squyres and Sagan 1983)

### 3. Exogenic origin/ dust and debris originates from a major single event

(a) from collision with reddish Hyperion (Matthews 1992, Marchi et al. 2002)
(b) from collision with Iapetus itself (Tabak and Young 1989)
(c) from collision of an outer saturnian satellite with a heliocentric object with the result of a retrograde debris cloud crossing Iapetus's orbit (Denk and Neukum 2000)
(d) material comes from Titan (Owen et al. 2001)

### 4. Endogenic origin: Dark material from interior (Smith et al. 1981, 1982)

# Brightness dichotomy – key issues

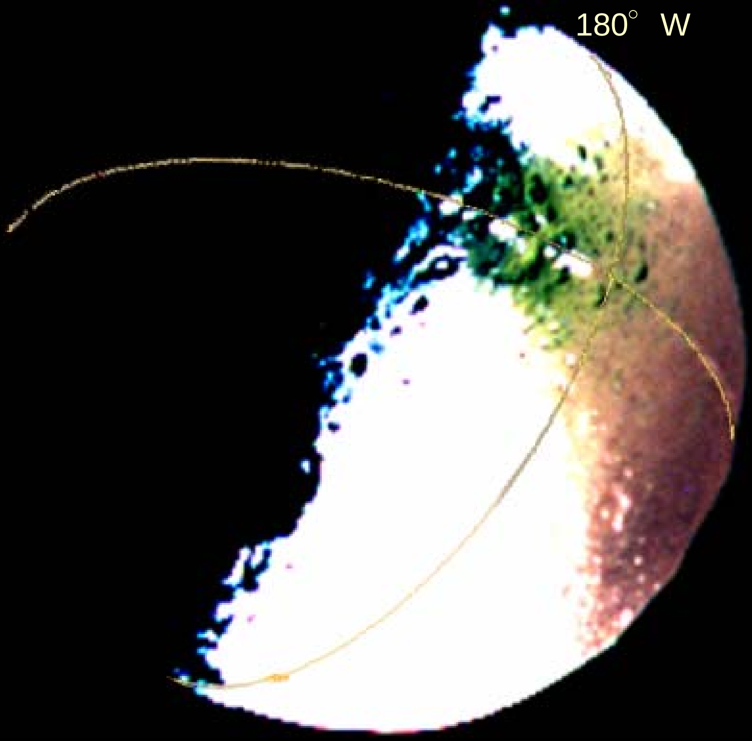
(1) Synchronous rotation

(2) Exogenic source for reddish material

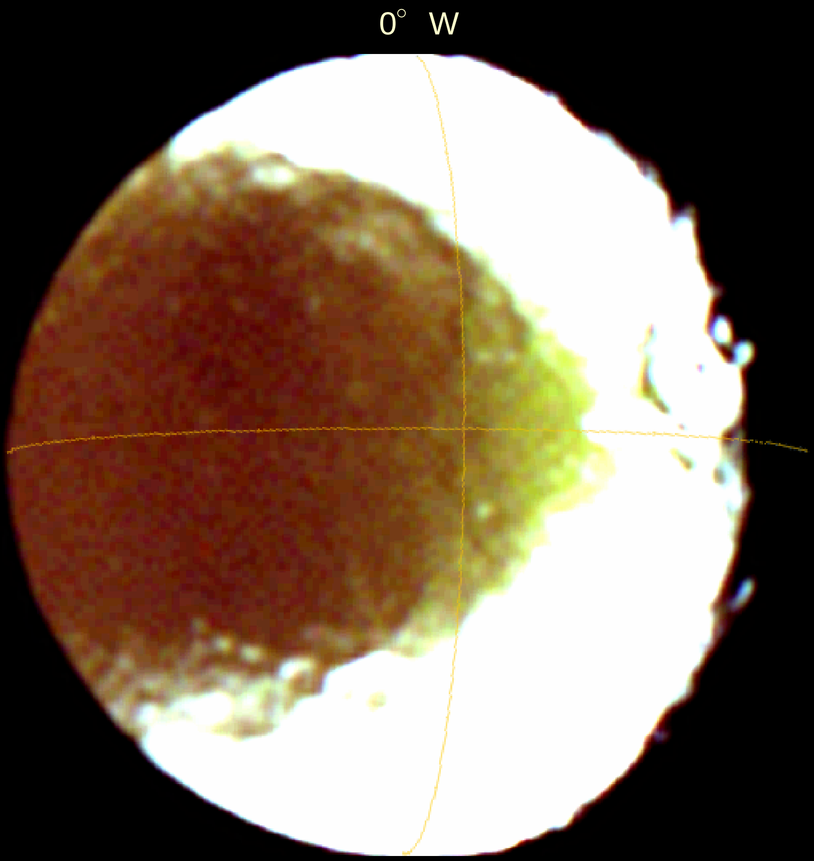
(3) Iapetus orbit is far out

# Iapetus: Color Dichotomy

## Discovered in Cassini ISS data



anti-Saturn side
7.3 km/pxl



sub-Saturn side
12.4 km/pxl

# Brightness dichotomy – key issues

(1) Synchronous rotation

(2) Exogenic source for reddish material

(3) Iapetus orbit is far out

(4) Very slow rotation (79.3 days)

(5) Dark blanket is thin

(6) Thermal segregation

# Brightness dichotomy – proposed story

(1) Outer satellite dust (Soter 1974, Buratti *et al.* 2002)

*causes*

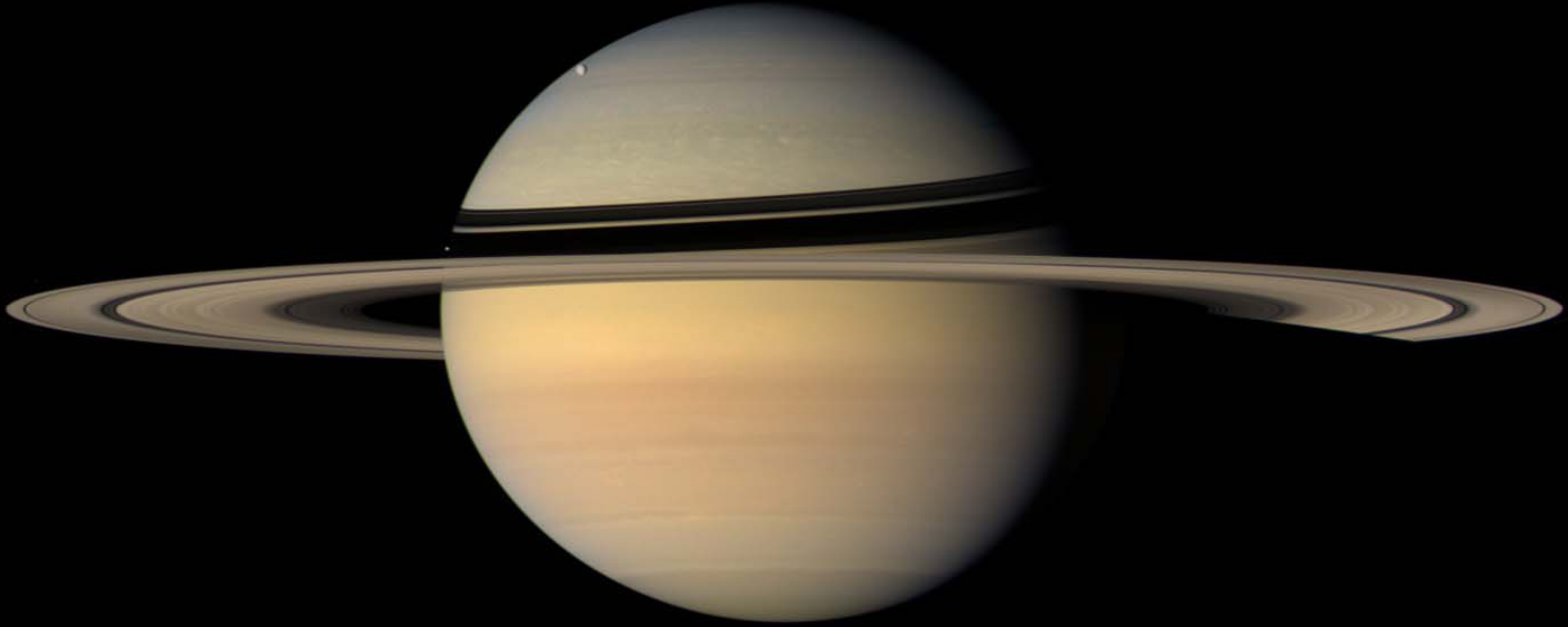
(2) Color dichotomy (leading/ trailing side)
(Denk *et al.* EGU 2006)

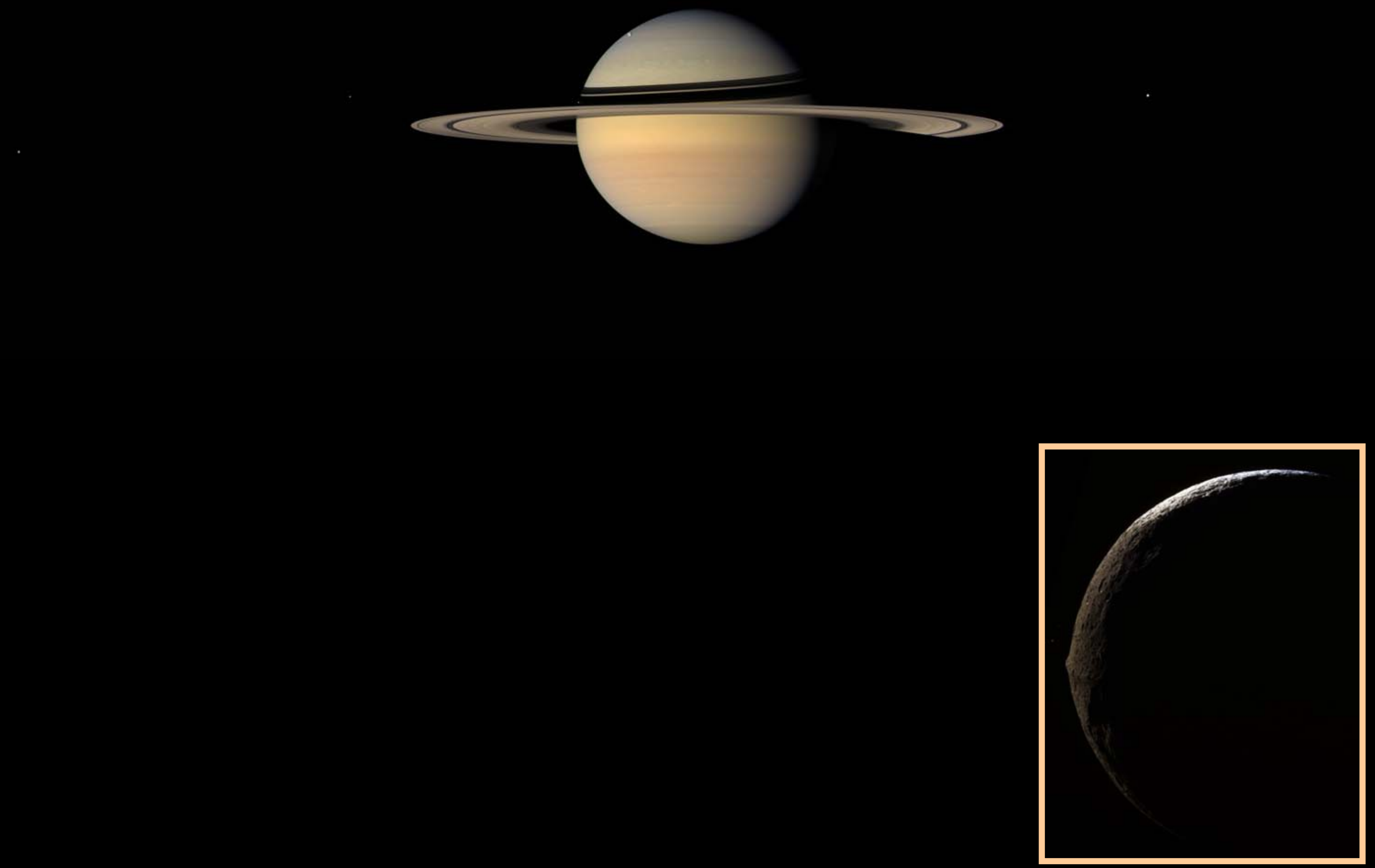
*triggers [with help of slow rotation of ~80 d => quite „high“ afternoon temp.]*

(3) Thermal re-distribution of bright material
(acting latitudinally; water ice removed from low latitudes)
(Mendis+Axford 1974, Spencer *et al*. LPSC 2005, DPS 2005, DPS 2007)

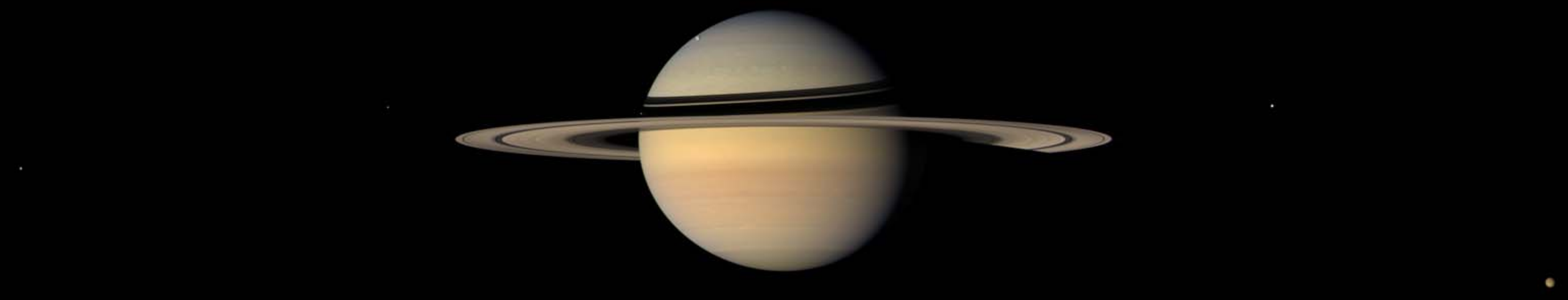
*The rev 49 flyby ISS and CIRS data support this scenario!*

# Inbound high phase:
# "Saturn as seen from Iapetus"





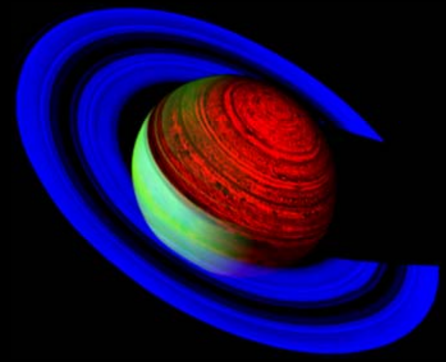
T. Denk/ISS

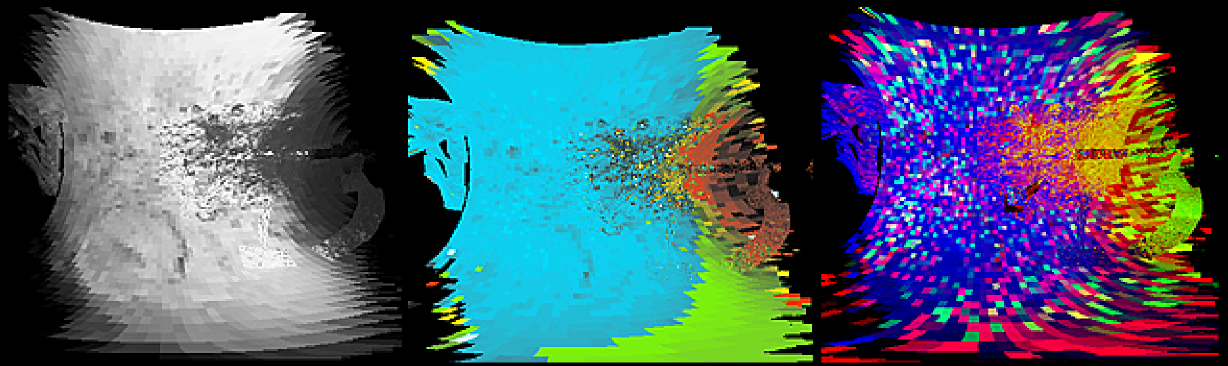


*Cassini Imaging Team:*
http://ciclops.org
(use "search" to find all Iapetus entries)

*Iapetus rev 49 flyby images at FU Berlin:*
http://www.geoinf.fu-berlin.de/projekte/cassini/cassini_gal_raw049IA.php
or
http://www.fu-berlin.de/planeten
and then "Quick Links" "Cassini Iapetus Sep. 2007"

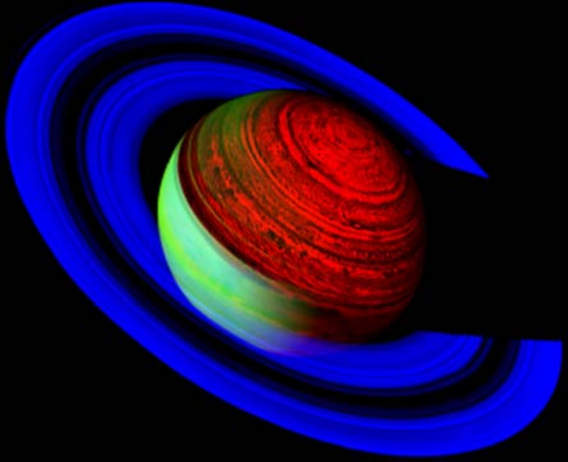
# Cassini's Fly-by of Iapetus: Early Results from VIMS

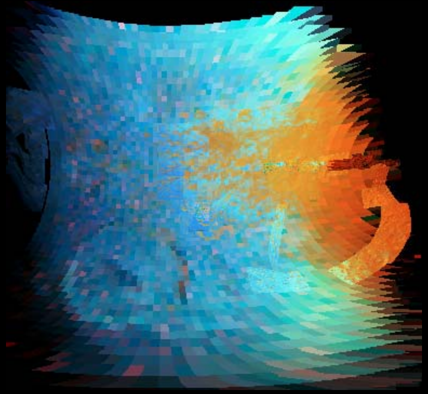




Roger N. Clark[1], R. H. Brown[2], D. P. Cruikshank[3], B. J. Buratti[4], R. Jaumann[5], Katrin Stephan[5], P. D. Nicholson[6], K. H. Baines[4], G. Filacchione[7], R. M. Nelson[4], VIMS Team

*[1]US Geological Survey, [2]U. Arizona, [3]NASA Ames, [4]JPL, 5DLR, Germany, [6]Cornell U., [7]INAF-IASF, Italy.*

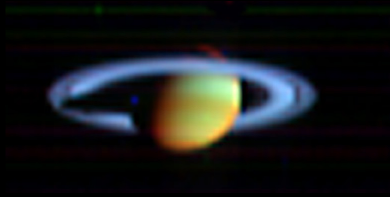




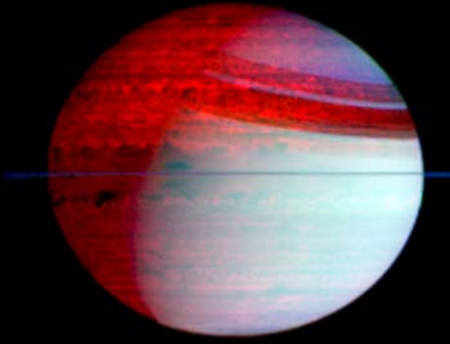
**RGB Mineral Map:**
Red =CO2 at 4.26 microns
Green = 1-micron albedo
Blue = 2-micron Ice

# VIMS

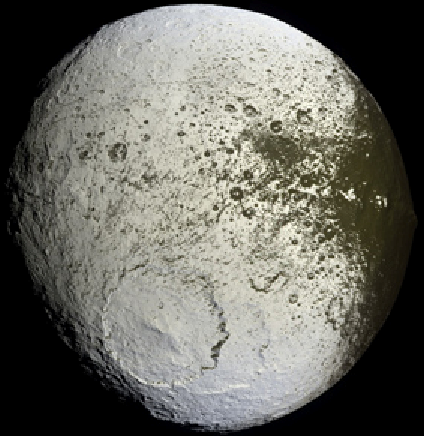
## Visual and Infrared Mapping Spectrometer



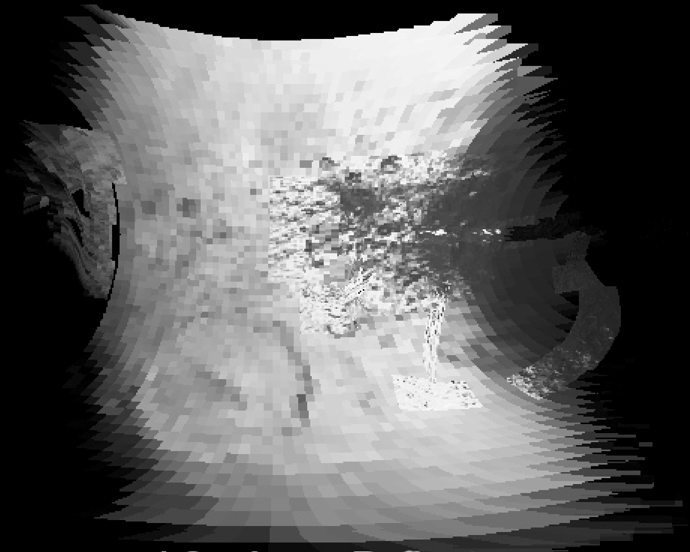
- 0.35 to 5.2 microns in 352 wavelengths
- IFOV: 0.5 x 0.5 mrad (standard)
  - (0.5 mrad = 1.7 arc-minutes)
- High resolution IR: 0.5 x 0.25 mrad
- High resolution VIS: 0.17 x 0.17 mrad
- Images up to 64 x 64 pixels square.



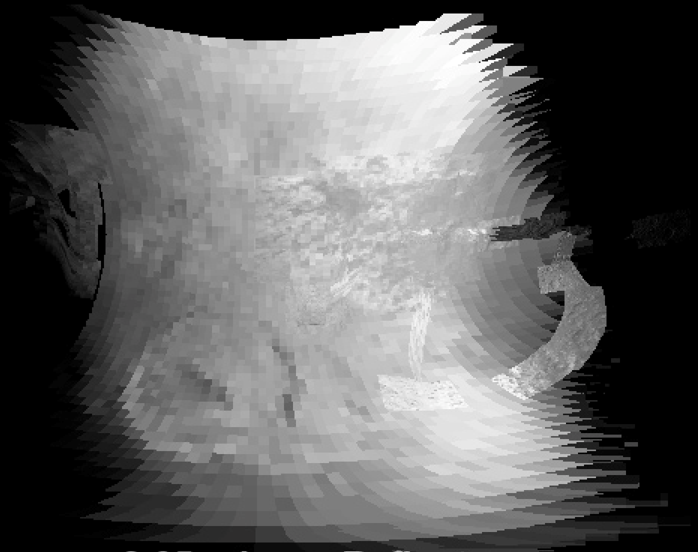
# Cassini VIMS Views of Iapetus



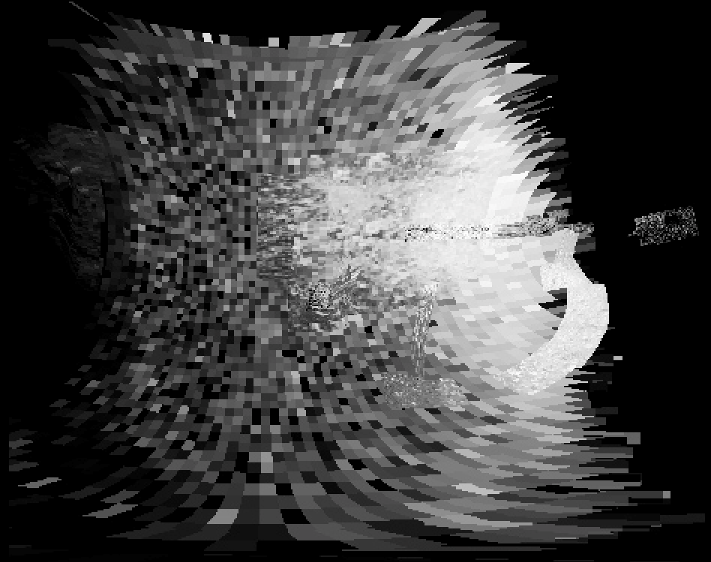
Iapetus:
ISS PIA08384



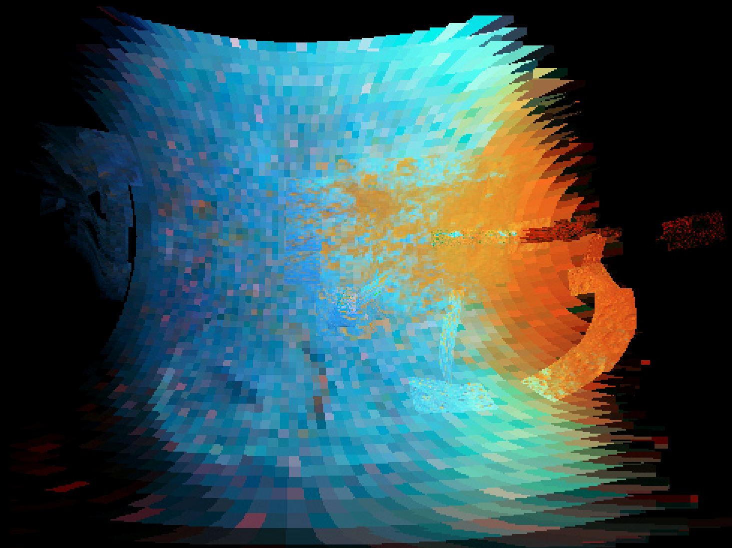
1.8-micron Reflectance



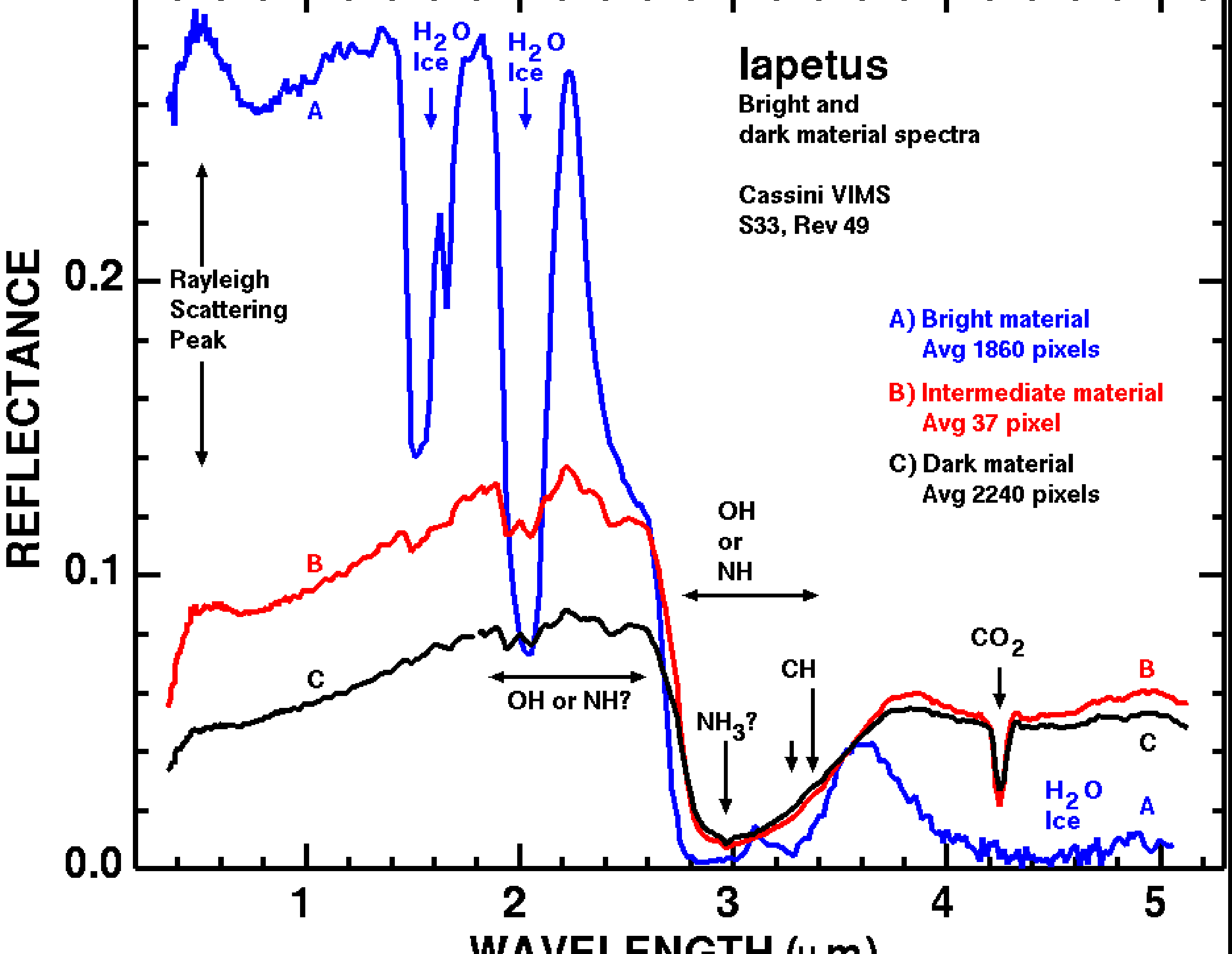
2.65-micron Reflectance



5-micron Reflectance

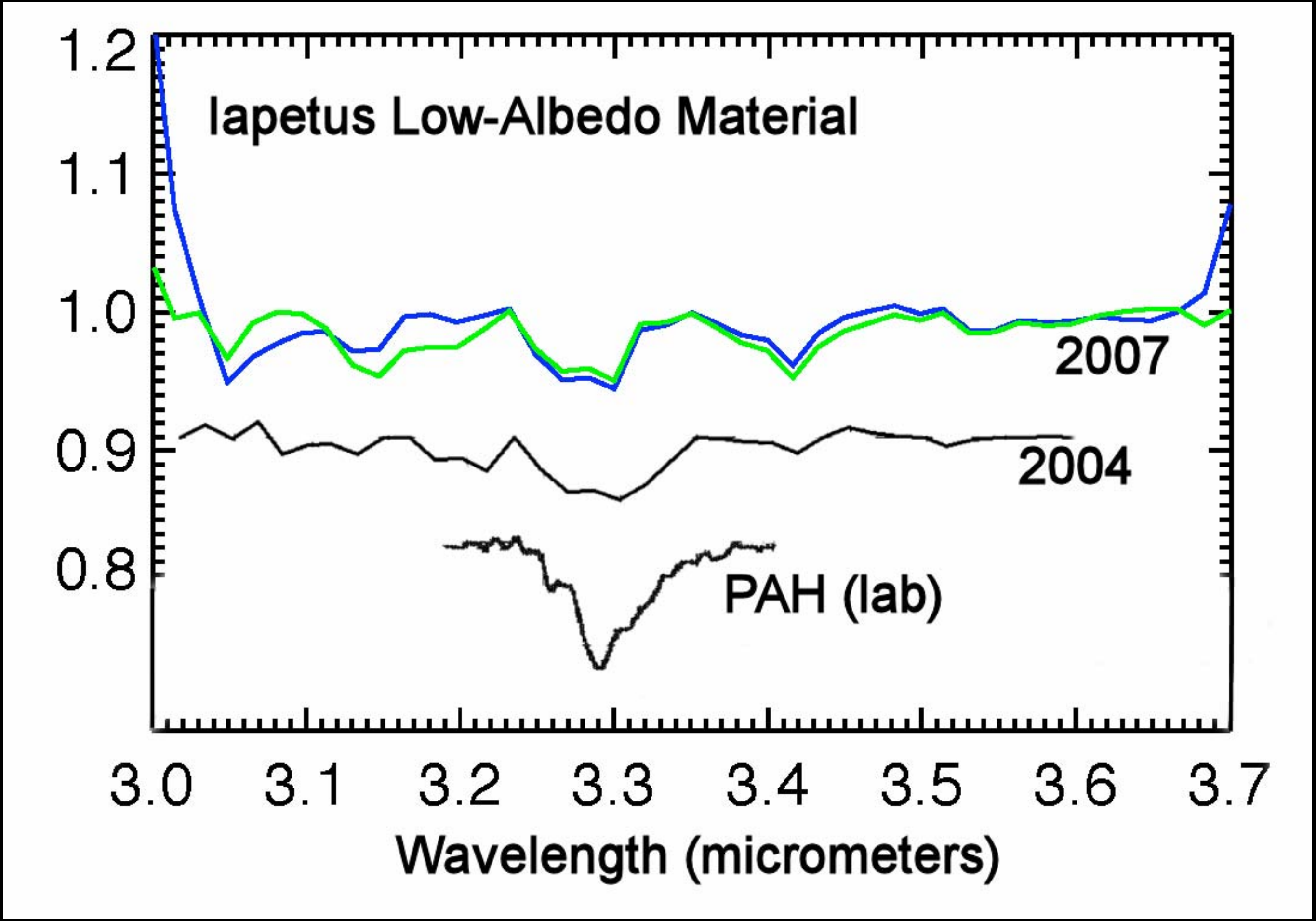


**Color Composite:**
Red = 5-micron Reflectance
Green = 2.65-micron Reflectance
Blue = 1.8-micron Reflectance


Iapetus
Bright and dark material spectra
Cassini VIMS
S33, Rev 49
A) Bright material Avg 1860 pixels
B) Intermediate material Avg 37 pixel
C) Dark material Avg 2240 pixels
$H_2O$ Ice
$H_2O$ Ice
A
Rayleigh Scattering Peak
B
C
OH or NH?
OH or NH
$NH_3$?
CH
$CO_2$
B
C
$H_2O$ Ice
A
REFLECTANCE
0.0
0.1
0.2
1
2
3
4
5
WAVELENGTH (µm)

R. Clark USGS

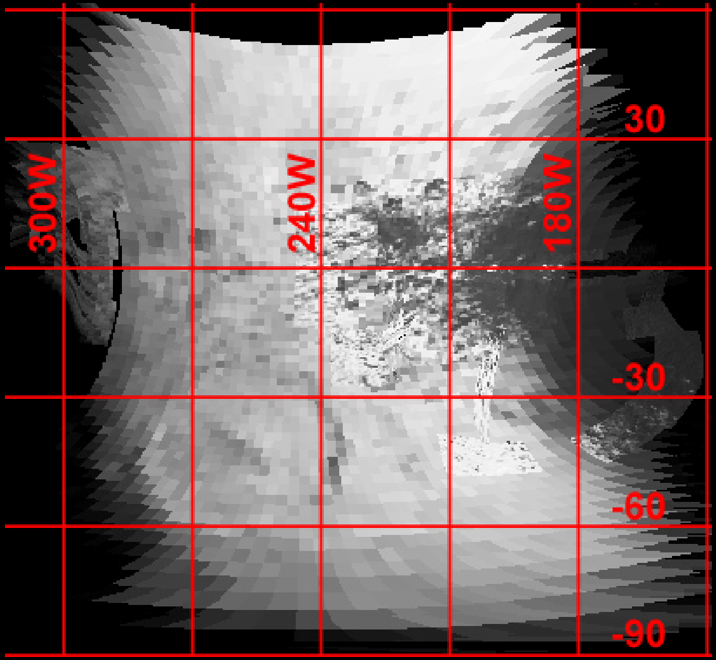
# Aromatic and Aliphatic Absorption Bands in the Low-Albedo Material of Iapetus

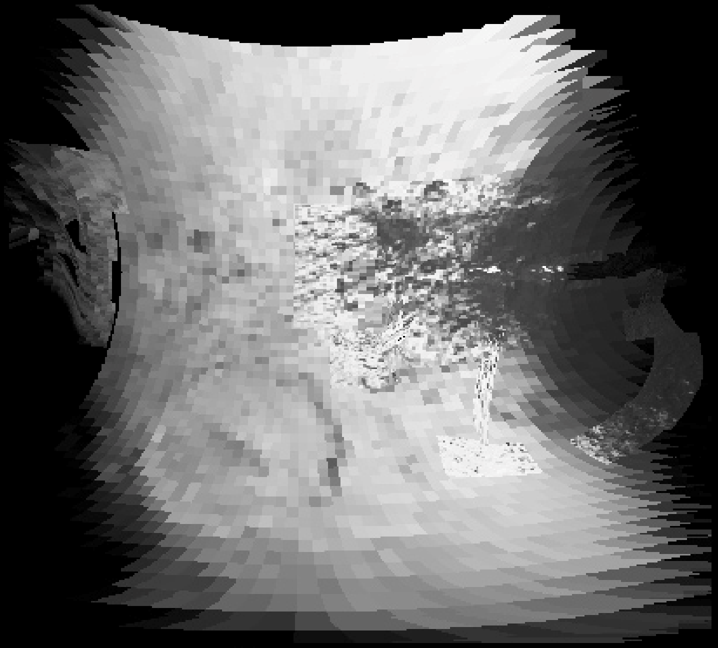


**2004 results: see Criukshank *et al. 2007* Icarus, In Press.**

# Iapetus
## Cassini Rev 49 fly-by

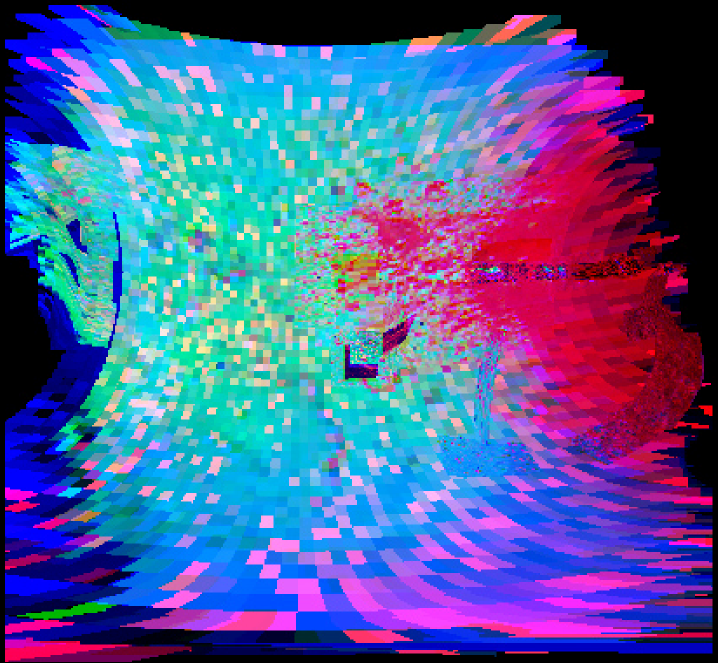
The Iapetus rev 49 fly-by was the only opportunity in the Cassini mission to resolve, in detail, surface features that may shed light on the origin of the dark material, and the data are living up to expectations.





VIMS 1.75-micron Reflectance

Ice, dark material and $CO_2$ in the dark material dominate this spectral map. Small dark particles in the ice create Rayleigh scattering.



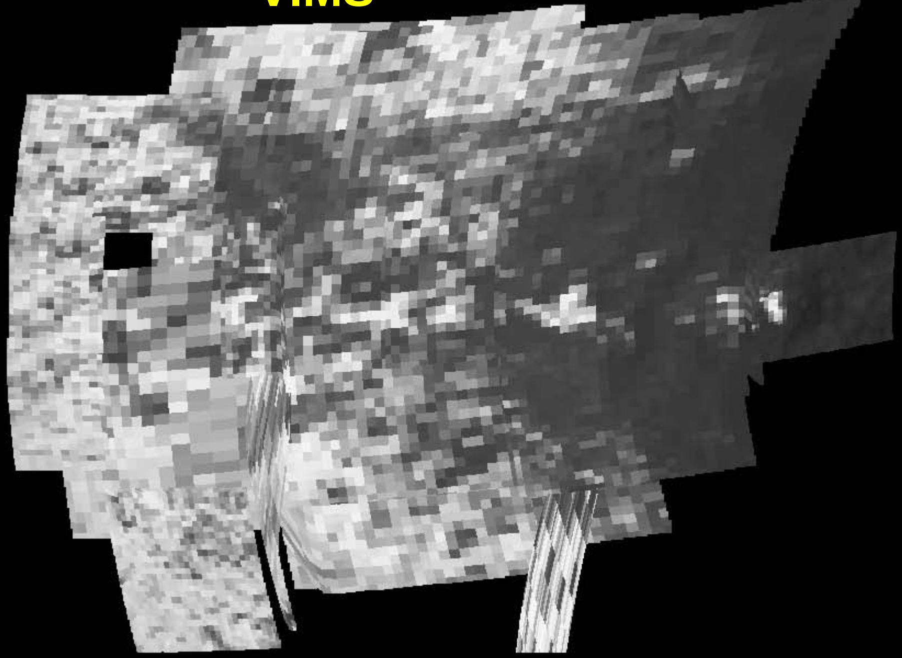
**VIMS Composition Map**

Red = $CO_2$ Strength

Green = $H_2O$ Ice strength

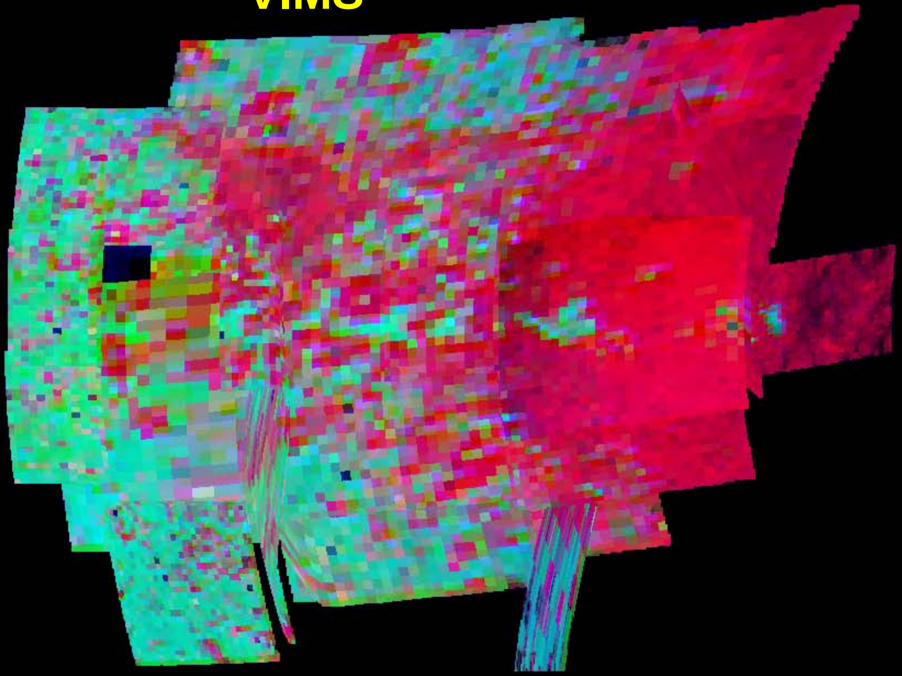
Blue = Rayleigh scattering strength (indicates sub-half-micron particles dispersed in the surface)

**VIMS**



1.75-micron Reflectance

**VIMS**



Iapetus Composition Map

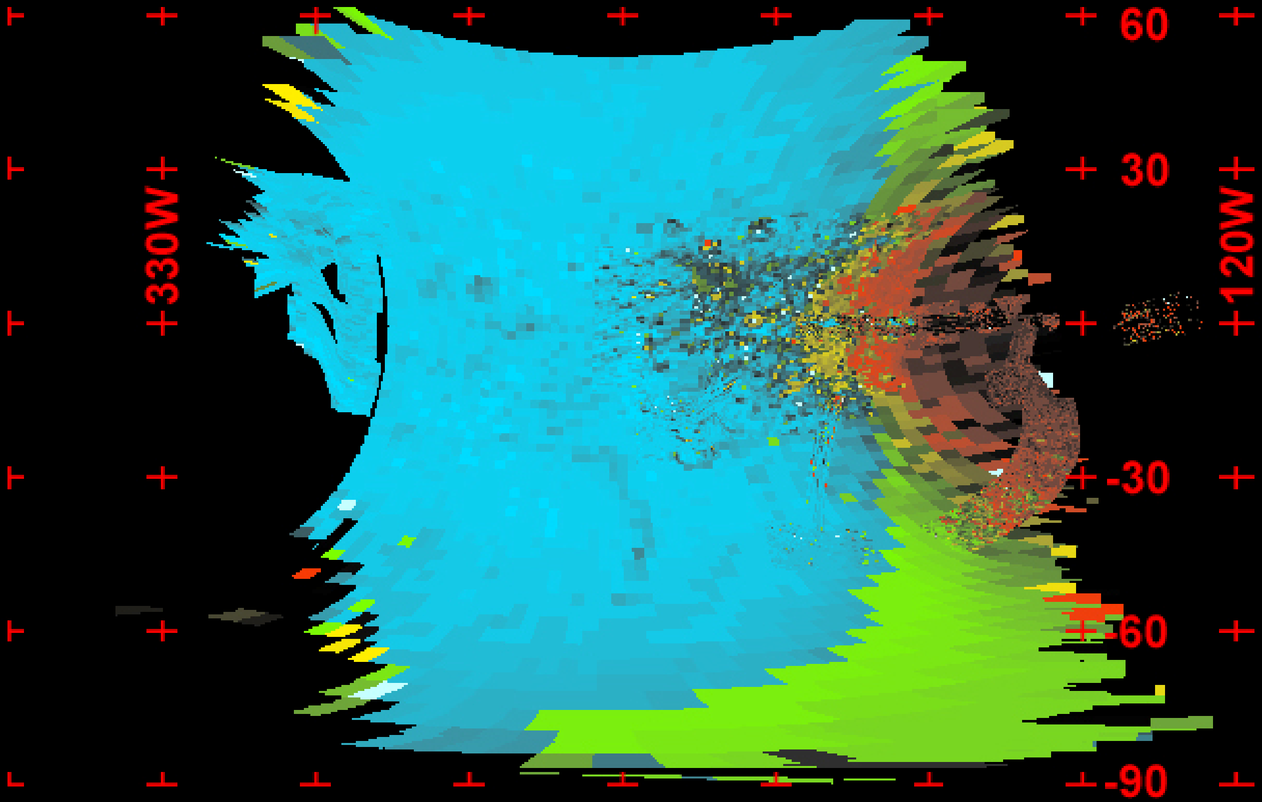
Red = $CO_2$ strength
Green = $H_2O$ strength
Blue = Rayleigh scattering strength

**PIA08384**
**ISS: visible reflectance**

VIMS observes $CO_2$ in the dark material at all scales. There is a tendency for the $CO_2$ concentration to increase near the transition zone to Ice.

# Iapetus
# Cassini Rev 49 fly-by

VIMS Composition Map



🟥 1.95, 2.05, 2.15-micron triplet (Dark region material)

🟨 1.95, 2.05, 2.15-micron triplet + Ice (Dark region material)

🟩 Water Ice (asymmetric 2-micron absorption)

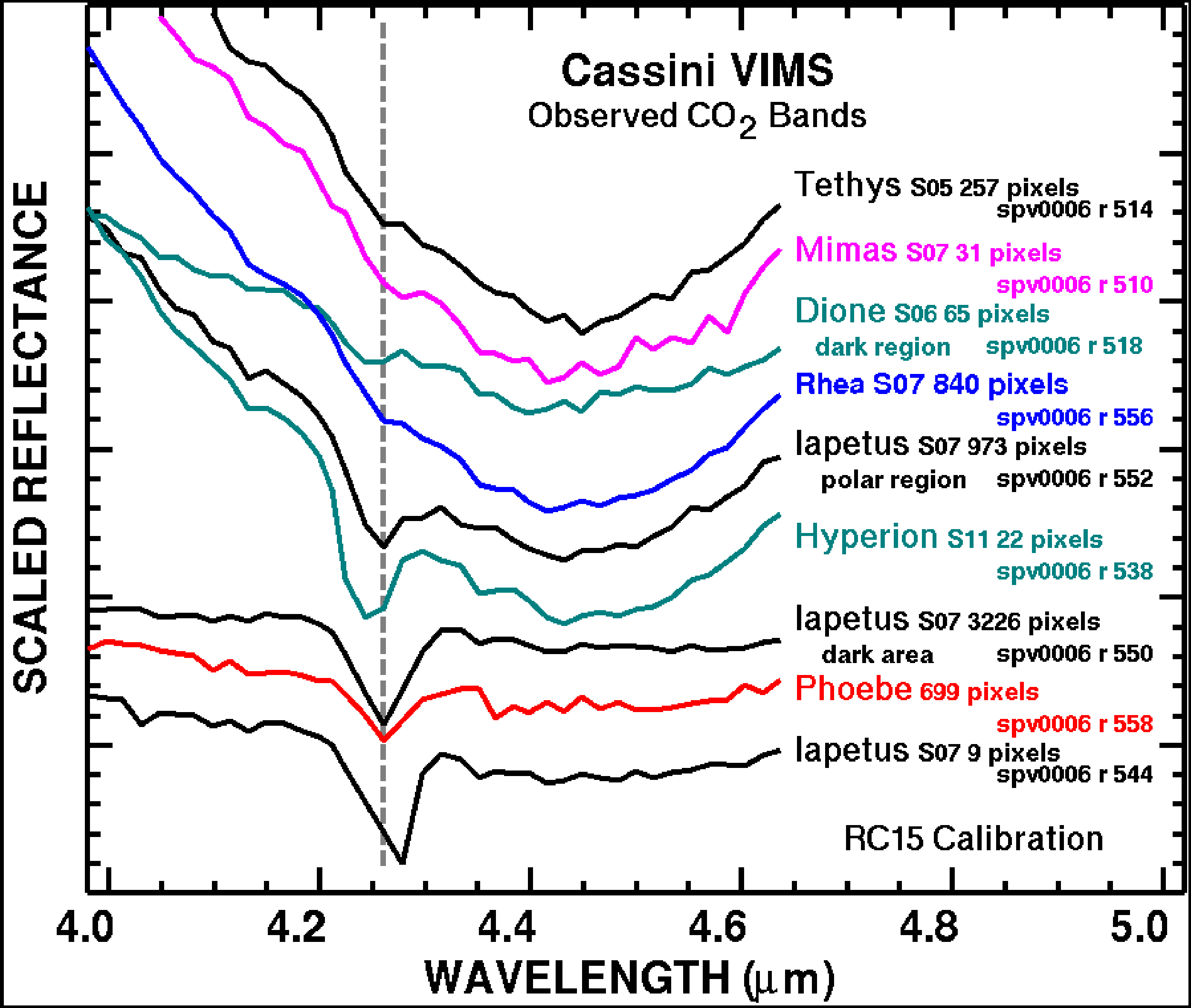
🟦 Water Ice, slight 2-micron asymmetric absorption

⬜ Water Ice, medium grained, 2-micron symmetric absorption

Tetracorder 3.7vims_ice-b1
R. Clark, USGS

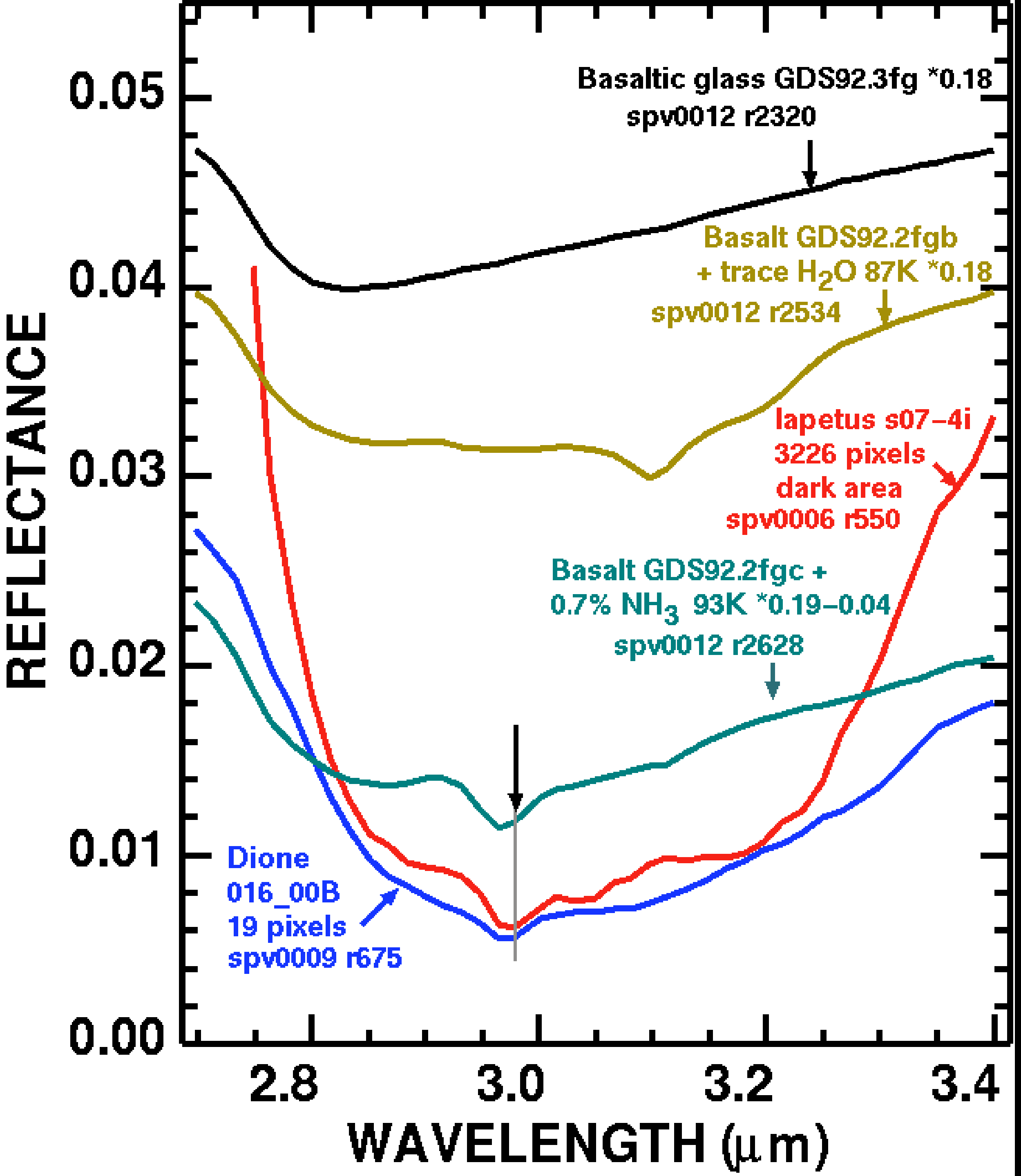
# VIMS observes The greatest diversity in $CO_2$ band positions on Iapetus.

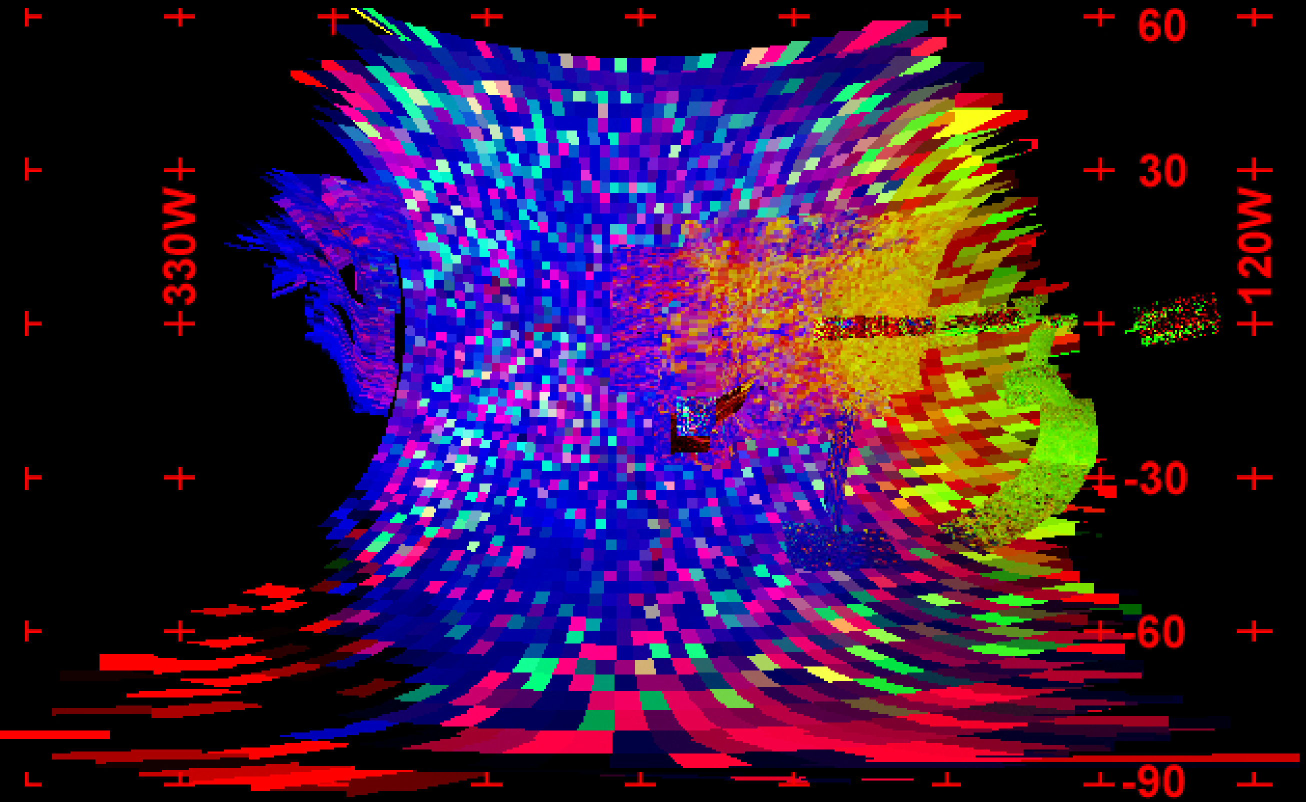
The close Iapetus rev 49 fly-by provides the highest resolution opportunity in the Cassini mission to map and understand these absorptions.



VIMS has tentatively detected trace ammonia on Iapetus (and Dione).

Clark *et al*., 2007, Icarus, in press.





# Iapetus
# Cassini Rev 49 fly-by

VIMS Composition Map

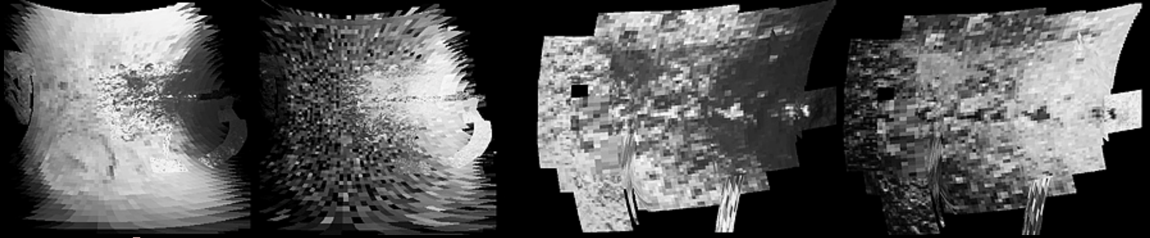
🟥 $CO_2$ (4.26-micron band)

🟩 $NH_3$? (2.97-micron band)

🟦 $H_2O$ Ice (1.5-micron band)

Tetracorder 3.7vims_ice-b1
R. Clark, USGS

# Conclusions



- **VIMS detects several compounds on Iapetus**
  - **Water ice (visibly bright).**
  - **$CO_2$ (strongest signature of any surface in the Saturn system) and dominates the dark material.**
  - **CH (organics) in the form of polycyclic aromatic hydrocarbons (PAH), trace amounts.**
  - **Probably trace ammonia ($NH_3$), though controversial within the team due to calibration. The new Iapetus data should help resolve controversies.**
  - **Several unknown absorptions for which we have no match to any compound in our spectral databases.**
- **Rayleigh scattering is caused by dark particles embedded in the water ice causing a blue reflectance peak.**
  - **Particles must be less than 0.5 micron in diameter.**
  - **Particles must be less than about 2% by weight.**
- **The same absorption features are observed in dark material on Phoebe, Iapetus, Dione, and in Saturn's rings and small satellites.**
  - **This implies a common origin for the composition and the same material is pervasive throughout the Saturn system.**
  - **Spatial patterns imply surface coatings.**
- **Composition, Rayleigh scattering, and surface coatings imply the origin is external to the moons, and may be external to the Saturn system.**

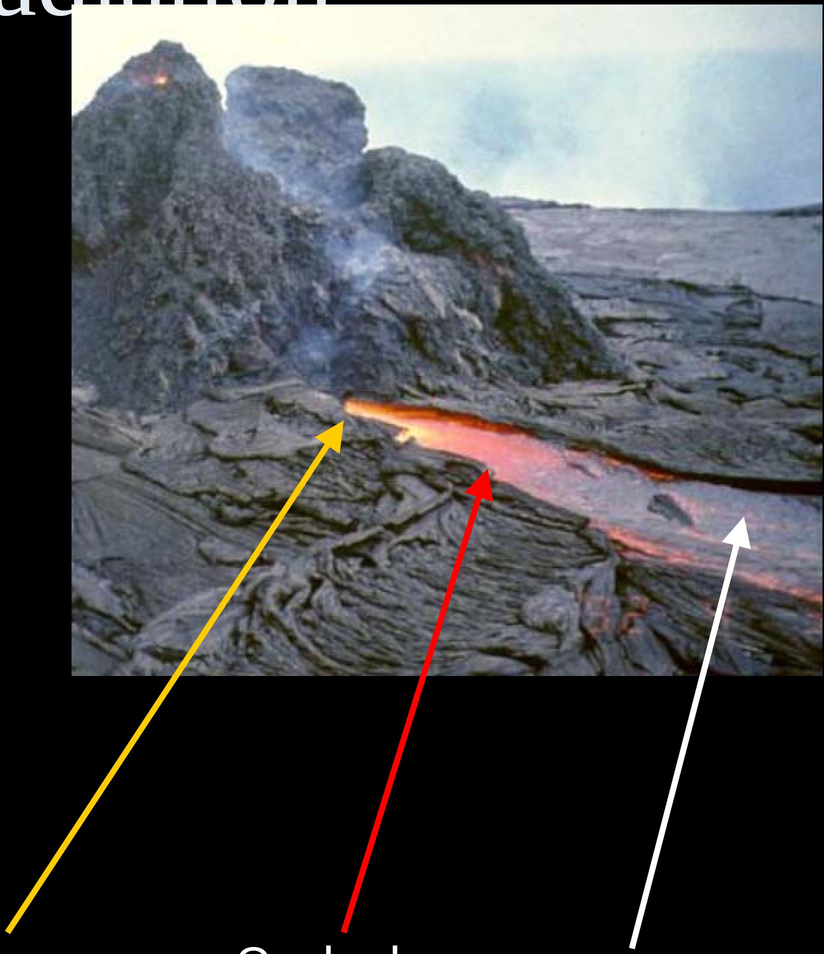
# New Cassini CIRS Observations of Temperatures on Iapetus

John Spencer (SwRI), John Pearl,
Marcia Segura, Michael Flasar, and
the CIRS team (NASA-Goddard)

Cassini CHARM Telecon
October 30th 2007

# Black-body Radiation

- Any object warmer than absolute zero emits heat radiation
- The hotter the surface, the shorter the wavelength of the radiated light
  - Brightness and wavelength of the radiation gives the temperature
- Objects as cold as those in the Saturn system emit their radiation at long infrared wavelengths



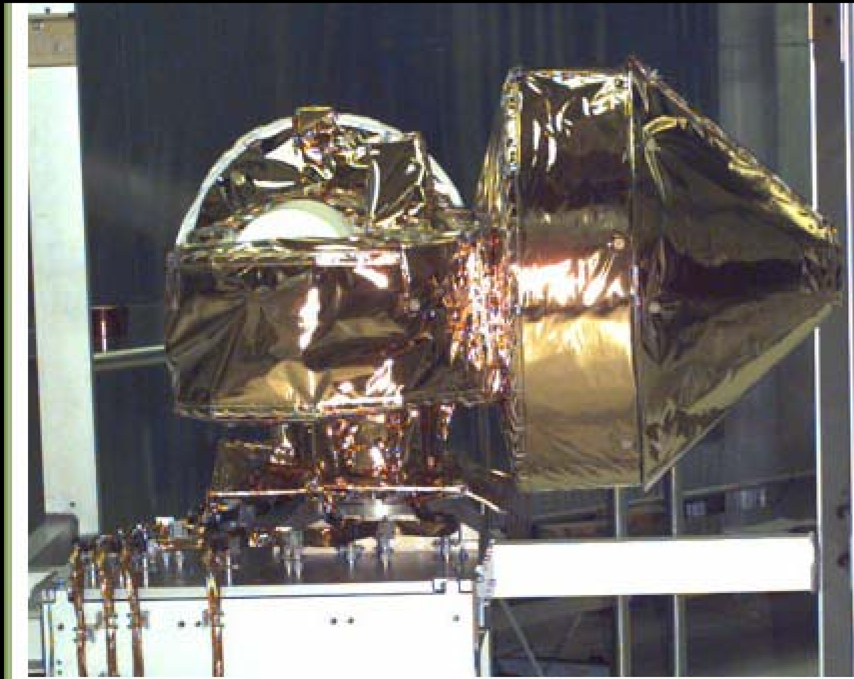
Hot lava emits infrared, red, and yellow light

Cooler lava emits infrared and red light

Even cooler lava emits only infrared light

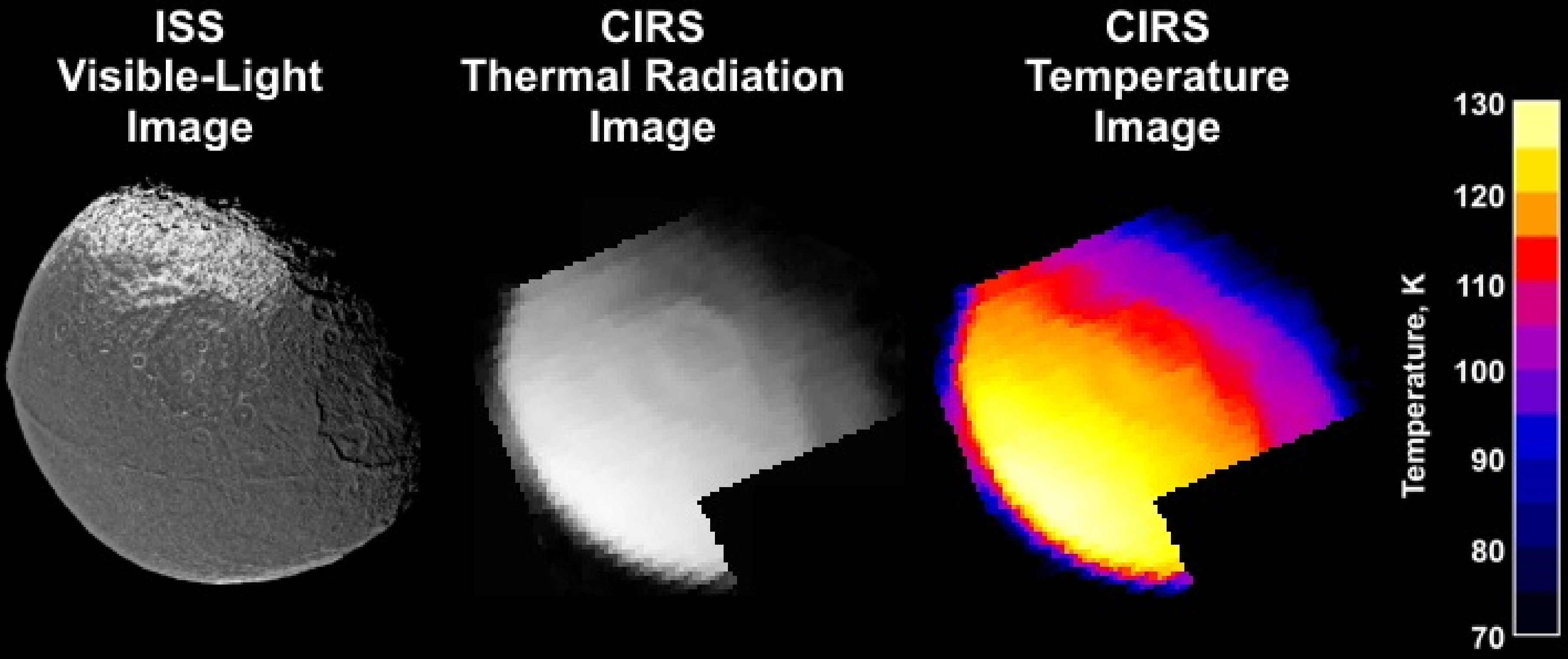
# CIRS: Composite Infrared Spectrometer

- Measures long-wavelength infrared (heat) radiation from Saturn, its rings, and moons.
- Sensitive to wavelengths between 7 and 300 microns (14 – 600 times longer wavelength than visible light)
- For objects with atmospheres (Saturn and Titan), CIRS provides detailed information on atmospheric composition and temperature.
- For objects without substantial atmospheres (Saturn’s rings, and its smaller moons) CIRS provides mostly temperature information (though we might learn something about composition if we’re lucky).



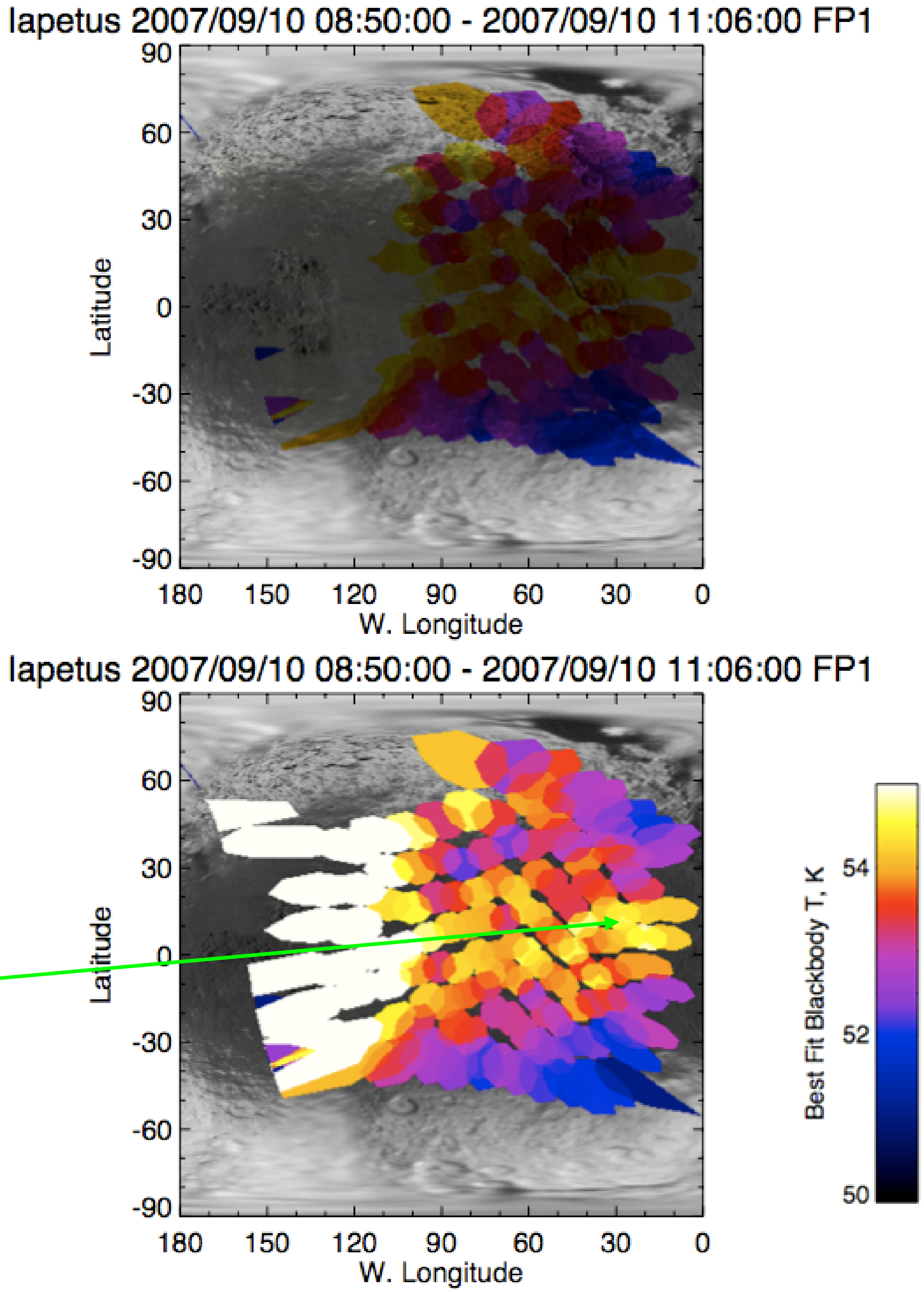
# Recap New Year 2005 Flyby: Daytime Temperatures

- 9 - 16 microns, best resolution ~35 km
- Peak dark side noon temperatures ~130 K (-225 F)
- Poor sampling of nighttime temperatures
- No sampling of daytime bright-hemisphere temperatures



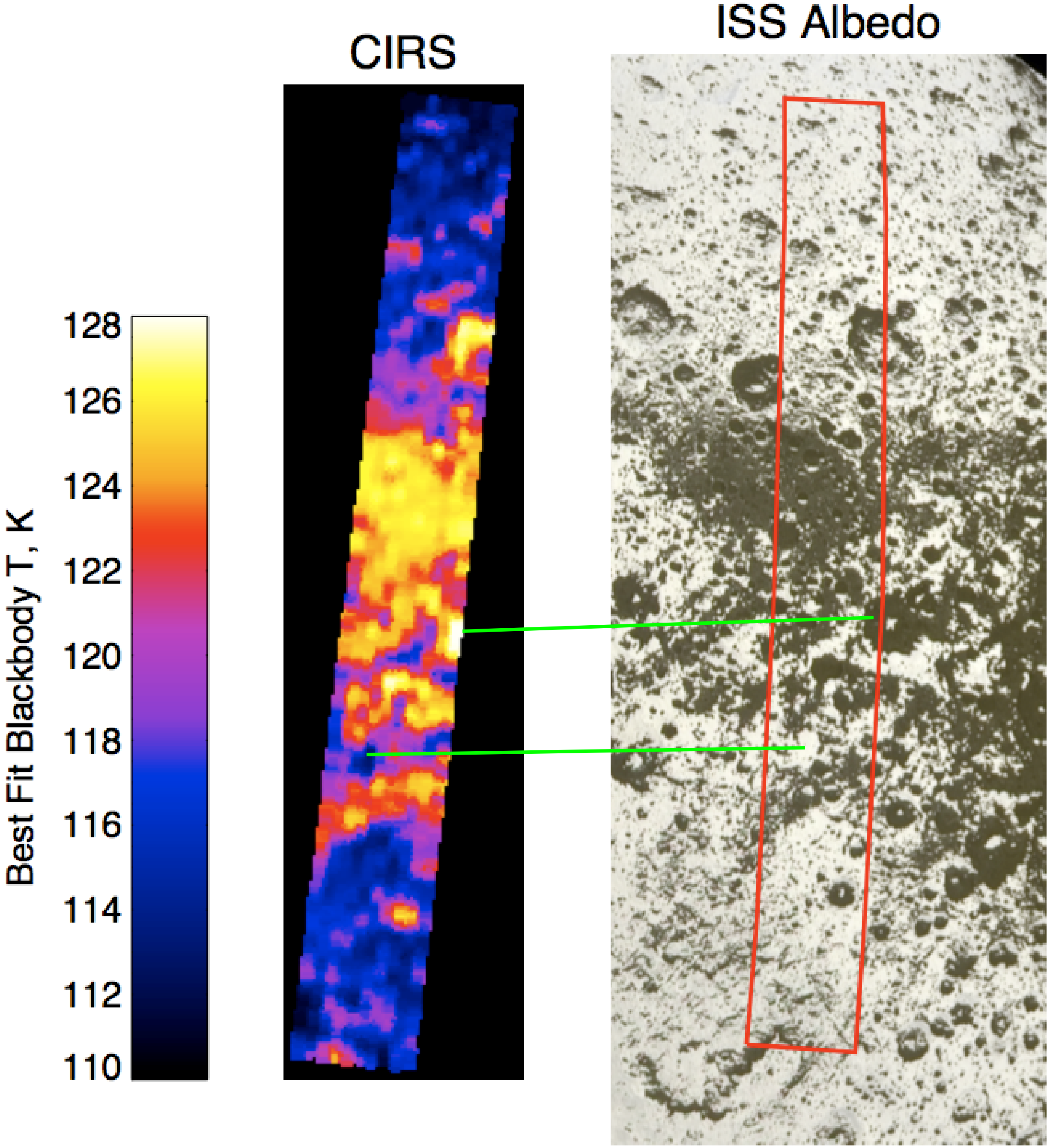
# Sept. 2007 Nighttime Map

- Dark side at night
- Wavelength 20 - 200 microns
- 50-55 K (-369 - -360 F) nighttime temperatures
  - Rapid nightside cooling implies a very fluffy surface, similar to other Saturn moons
- Warm region near 0 N, 20 W
  - Less fluffy?



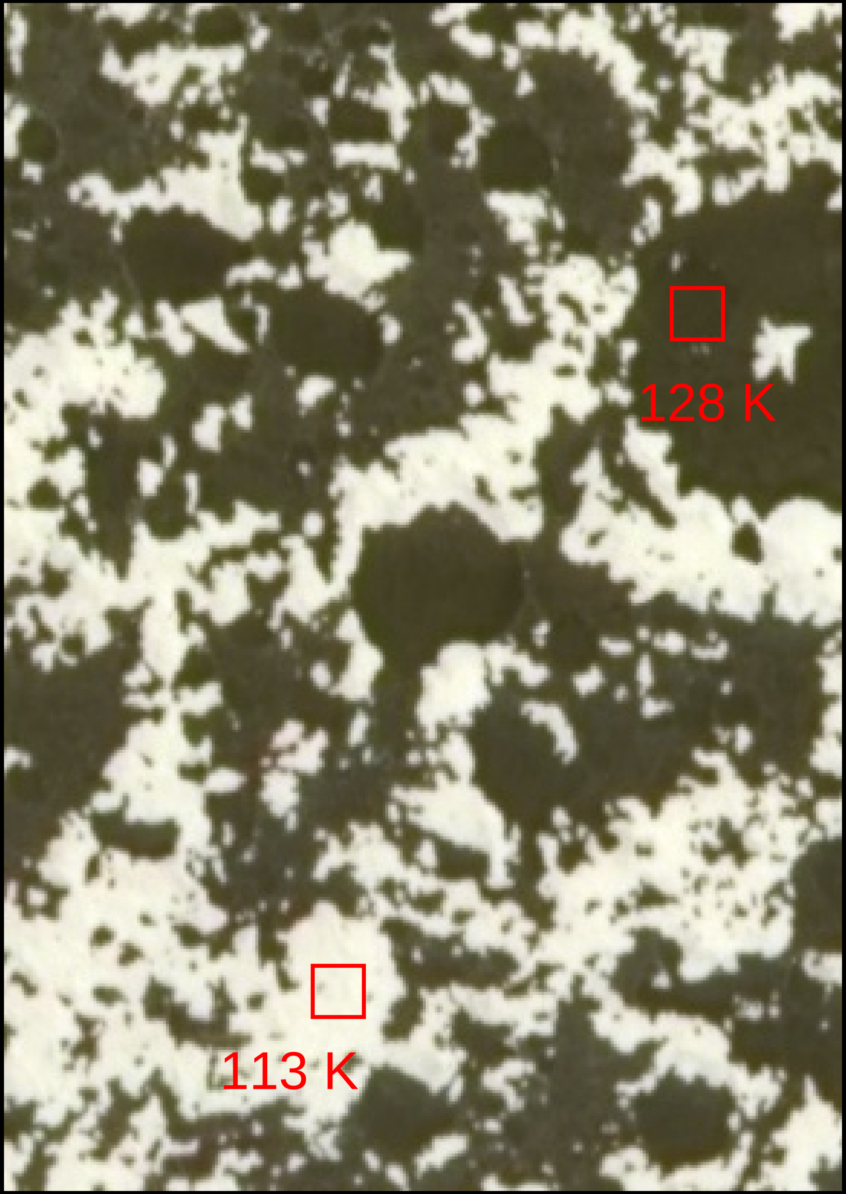
# Hi-Res Noontime Scan

- Resolution = 8 km
- Dark regions are warm, bright regions are cold
- Peak temperature = 128 K (-229 F)
- Minimum equatorial temperature = 113 K (-256 F)



# Hi-Res Daytime Scan

- 8 km resolution is sufficient to sample ~pure bright and dark material



# $H_2O$ Ice Sublimation Rates

- Temperature allows calculation of how fast ice should sublime (evaporate) from Iapetus’ surface
  - Bright terrain: ~10 cm per billion years
    Impacts will remix material on similar timescales
  - Dark terrain: ~20 m per billion years - fast!
  - Dark ice is unstable and will evaporate
- Consistent with
  - Presence of thermal segregation
  - Bright pole-facing slopes
  - The shape of the bright/dark boundary

# Conclusions

- September 2007 Iapetus CIRS data directly measure daytime temperatures for pure bright and dark terrain
- Ice is fairly stable against sublimation in the bright terrain, highly unstable in the dark terrain
  - Explains the observed thermal segregation seen in the ISS images
  - Explains the shape of the bright/dark boundary on Iapetus

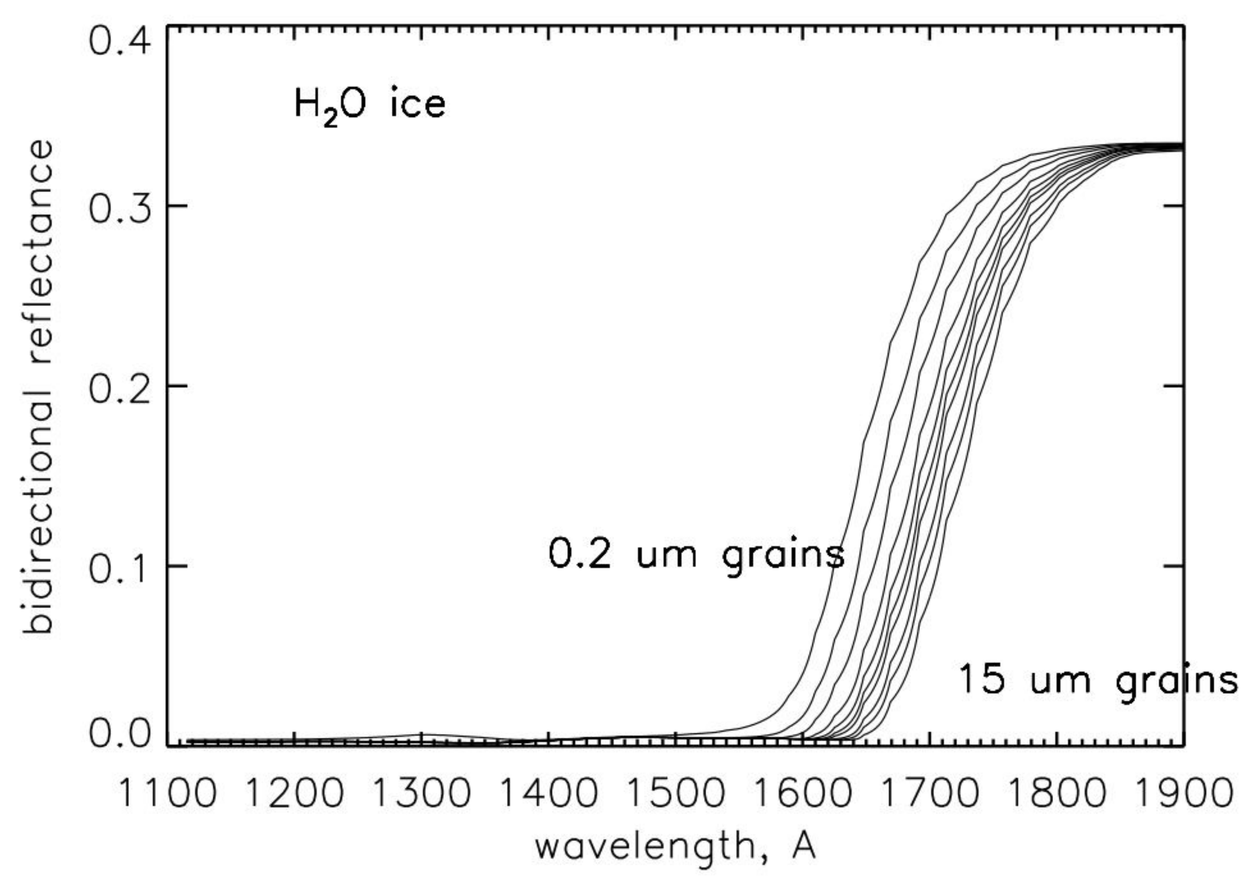
# UVIS measurements of Iapetus: the September 2007 flyby

Amanda R. Hendrix, Candice J. Hansen,
the UVIS Team

# Cassini UVIS Iapetus Observations

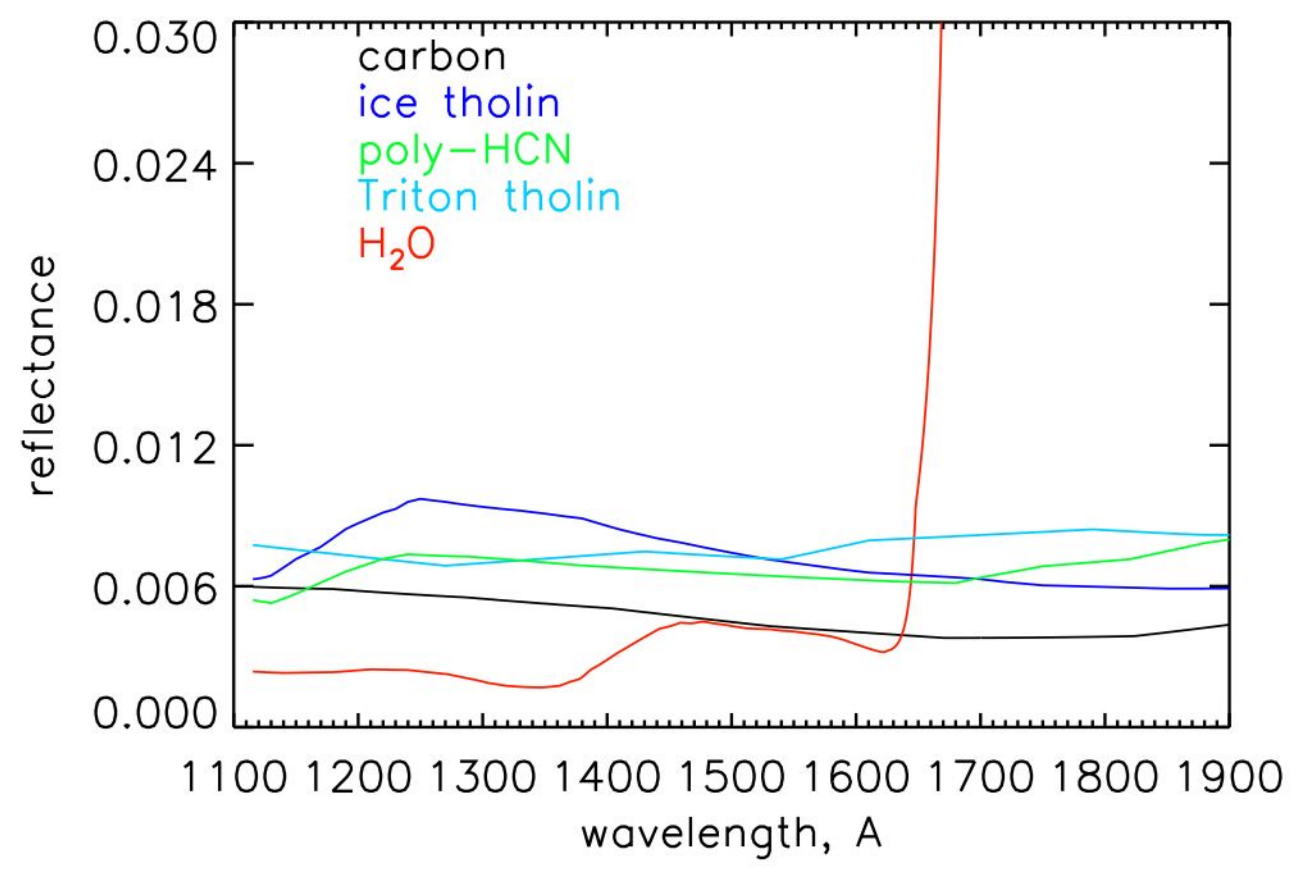
- Imaging spectrometer
  - Two-dimensional detector
    - 1024 wavelengths x 64 spatial rows
  - FUV channel: 110-190 nm
- Iapetus Observations
  - September 10, 2007: ~1644 km flyby
  - Stellar occultation
  - mapping of water ice, non-ice; thermal segregation studies

# $H_2O$ ice in the FUV



# Some non-ice species

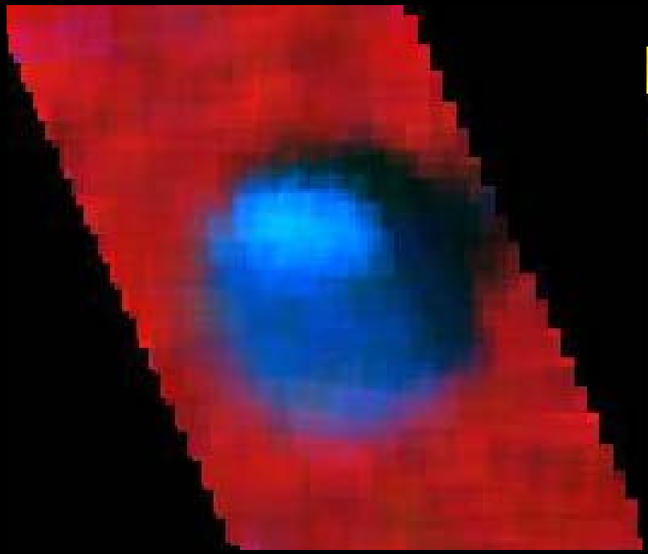
## *compared with $H_2O$ ice*



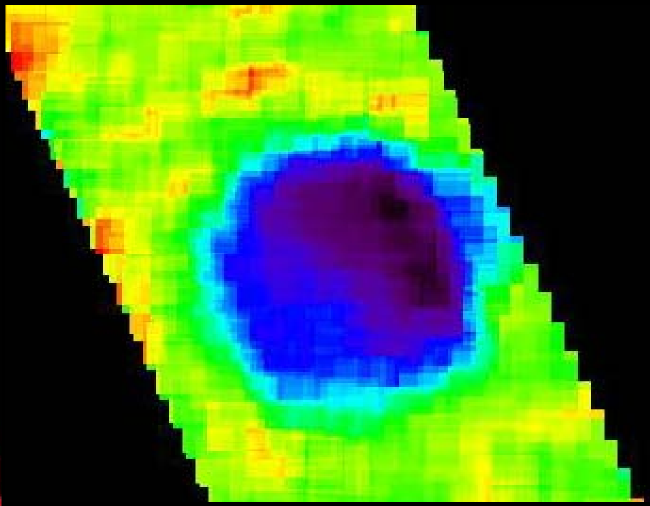
Water ice is darker than most non-ice species at λ<165 nm

# Previous results: December 2004 flyby

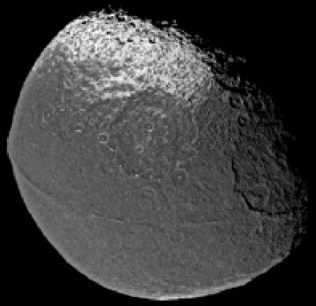
- Dark leading hemisphere, bright pole
  - Iapetus displays spectral reversal
  - Recall that water ice gets very dark in the FUV
    - most non-ice materials are brighter than water ice



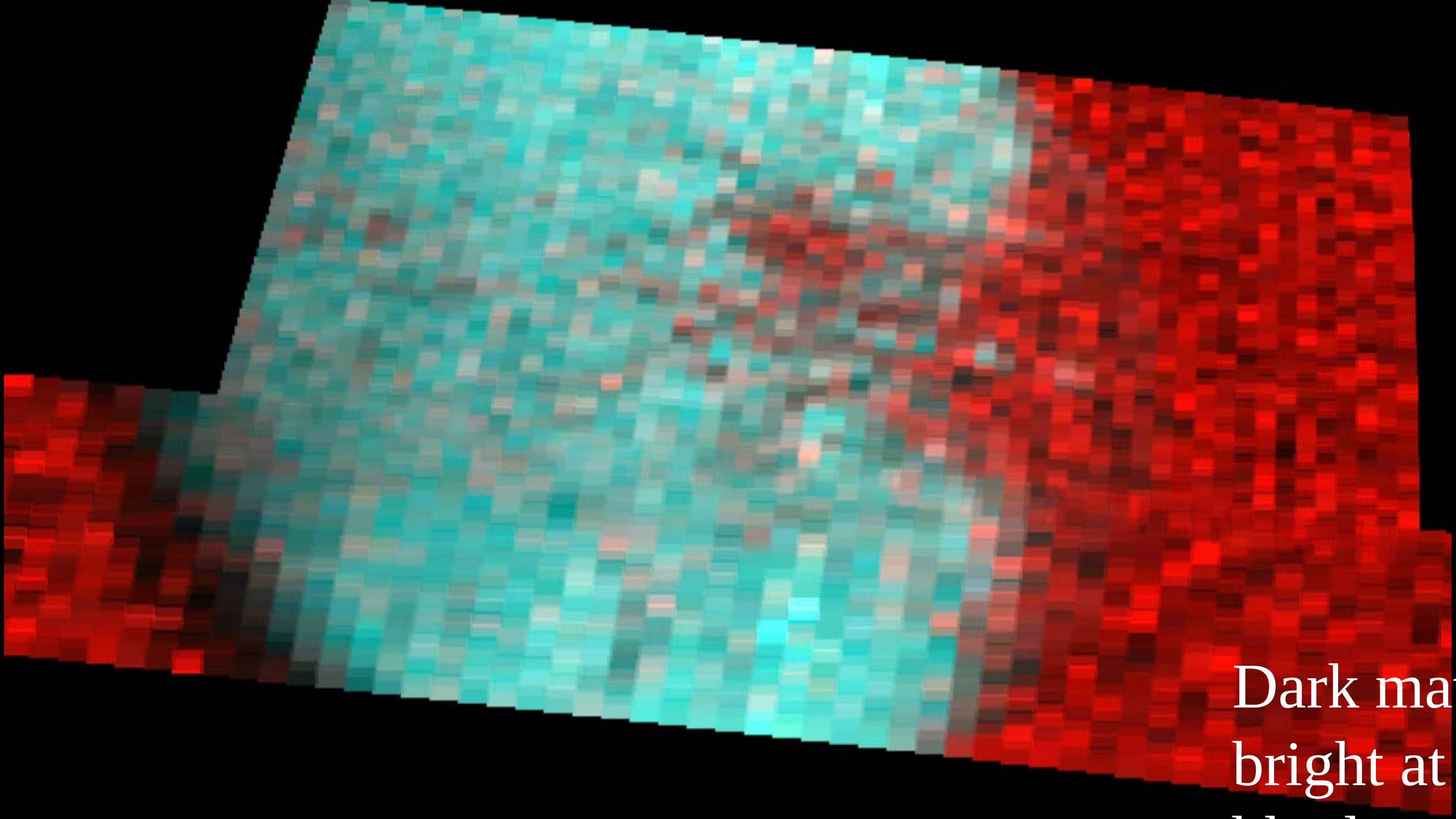
3-color



Ly-α

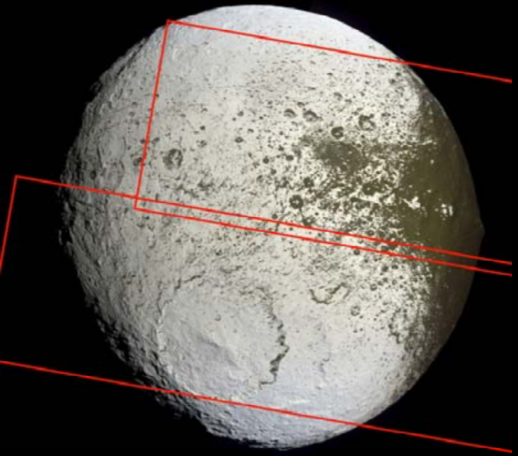


ISS image



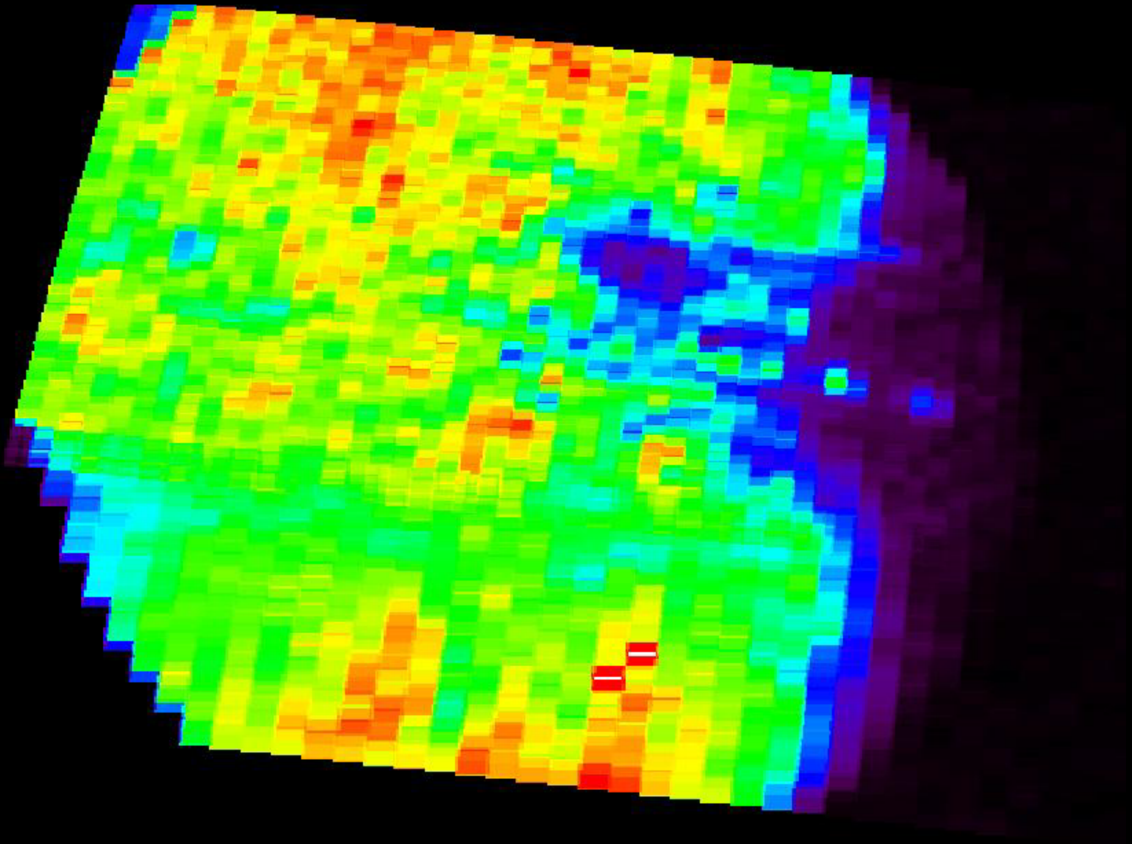
Voyager mtns are visible; large crater is also faintly apparent.

Dark material is as bright at Ly-α as sky bkgd

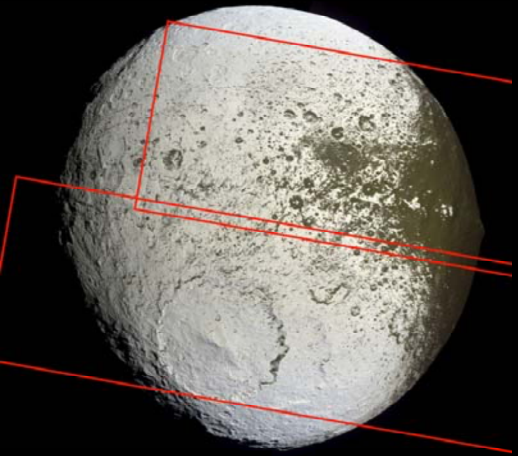


ISS image for reference

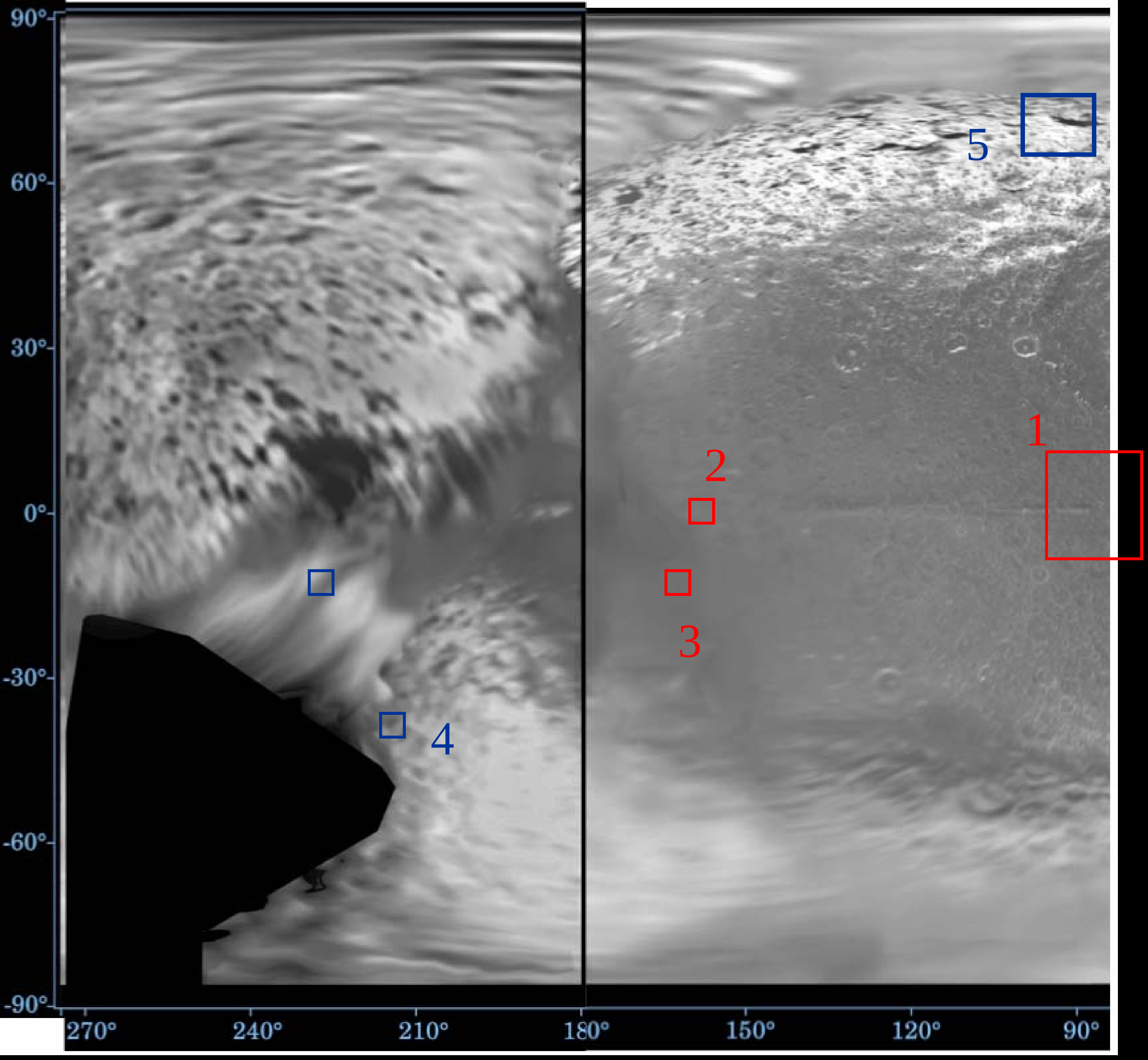
Red=Ly-α
Blue-green=long FUV λ (reflected solar, $H_2O$ ice)



$H_2O$ ice map (long-λ map with simple correction for solar incidence)

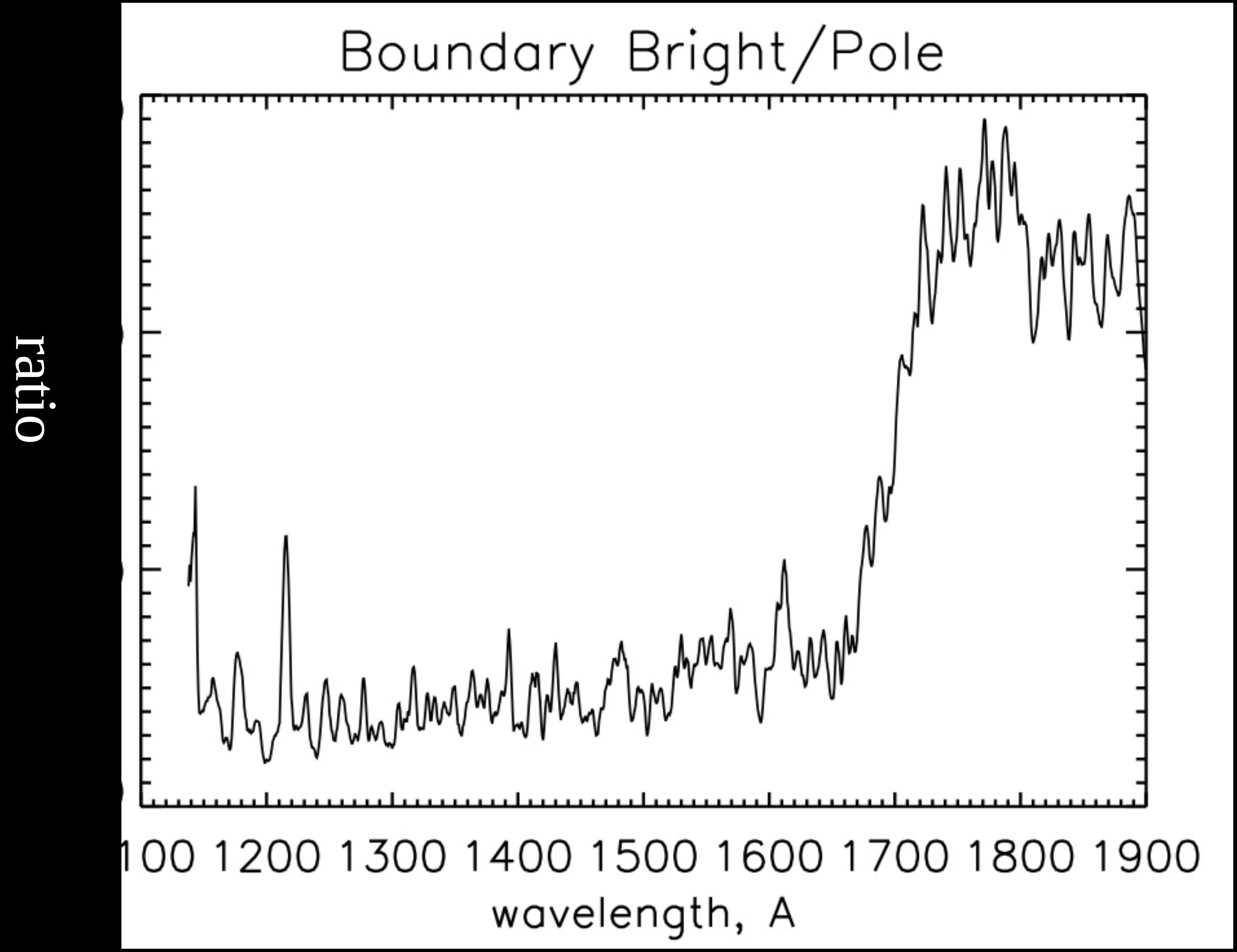


ISS image for reference

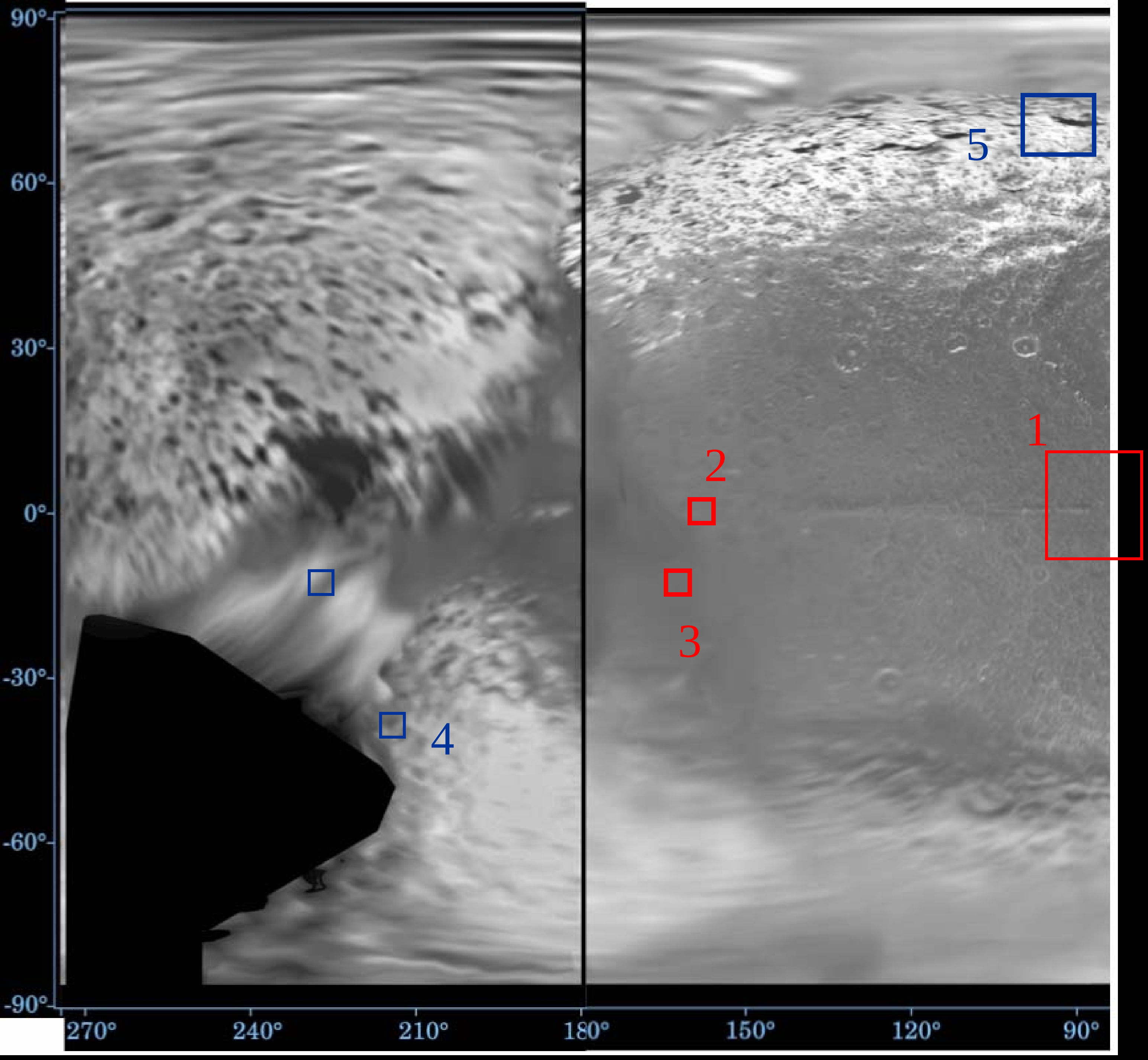


ISS map

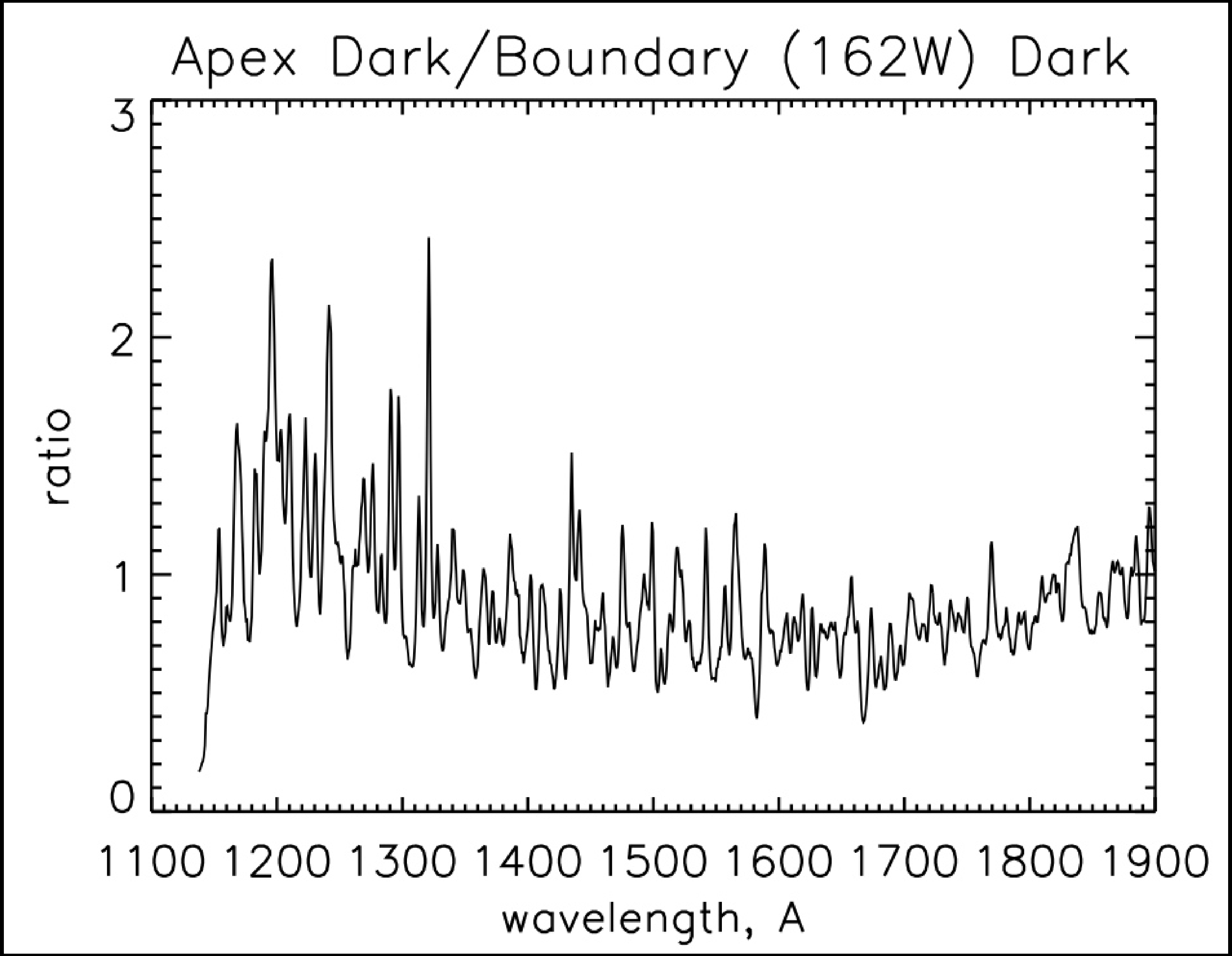
# Bright regions: boundary/pole



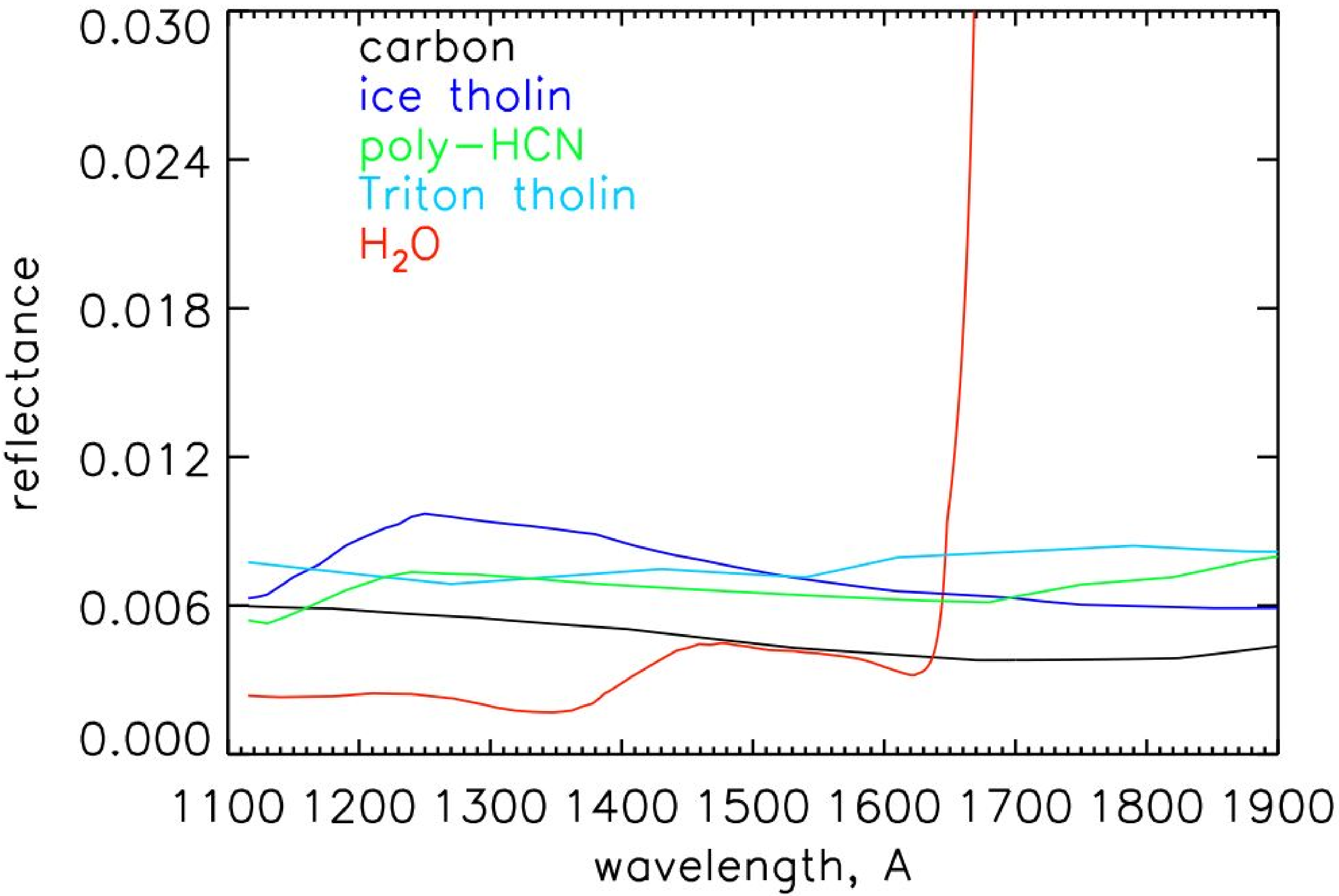
The bright terrain in region 4 is richer in $H_2O$ ice than LH polar region;
May also be richer in a non-ice, reddish material.

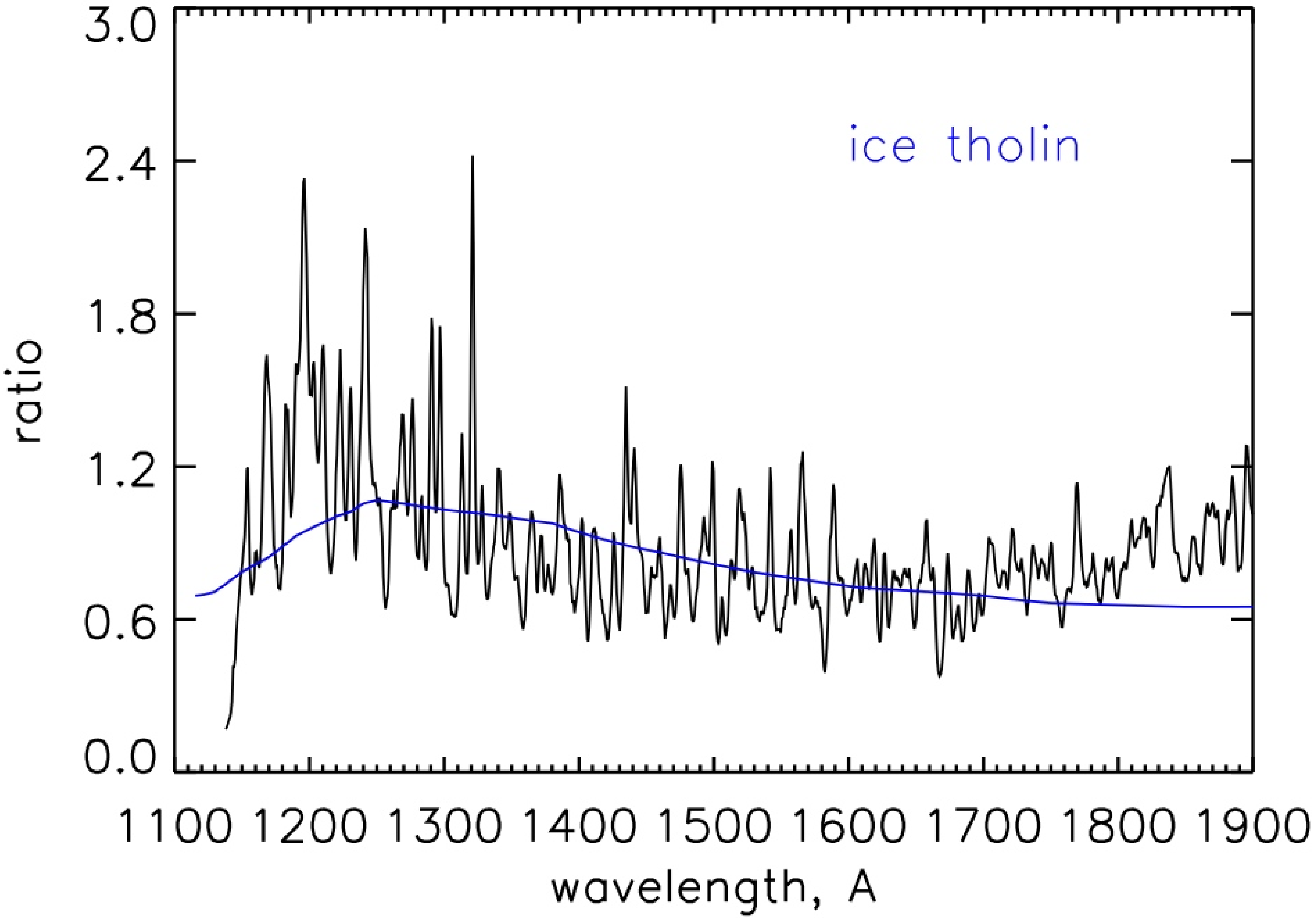


ISS map

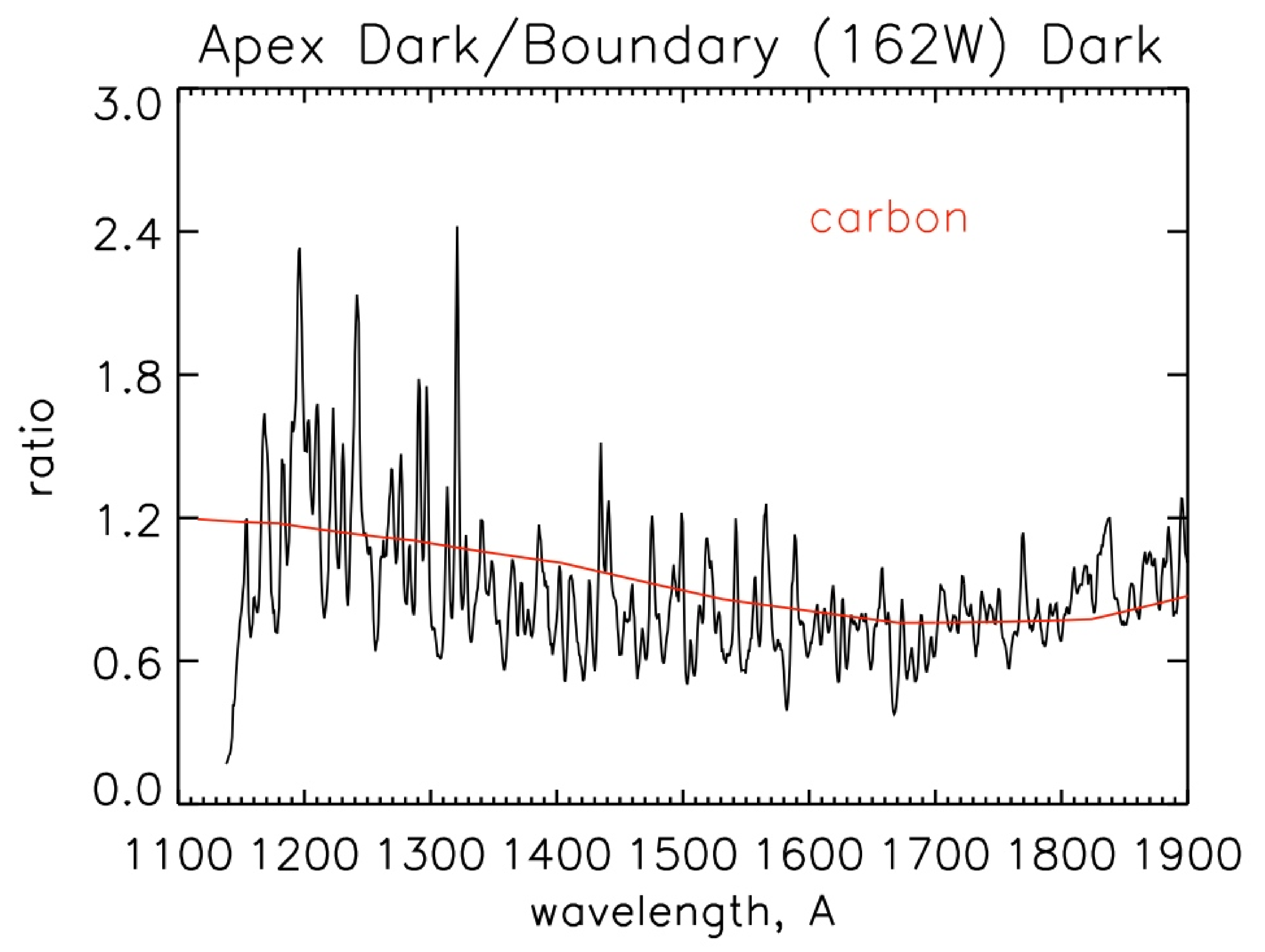


DARK TERRAIN: Region 1 (apex) ratioed to region 2 (boundary)


carbon
ice tholin
poly−HCN
Triton tholin
$H_2O$
reflectance
0.030
0.024
0.018
0.012
0.006
0.000
1100
1200
1300
1400
1500
1600
1700
1800
1900
wavelength, A



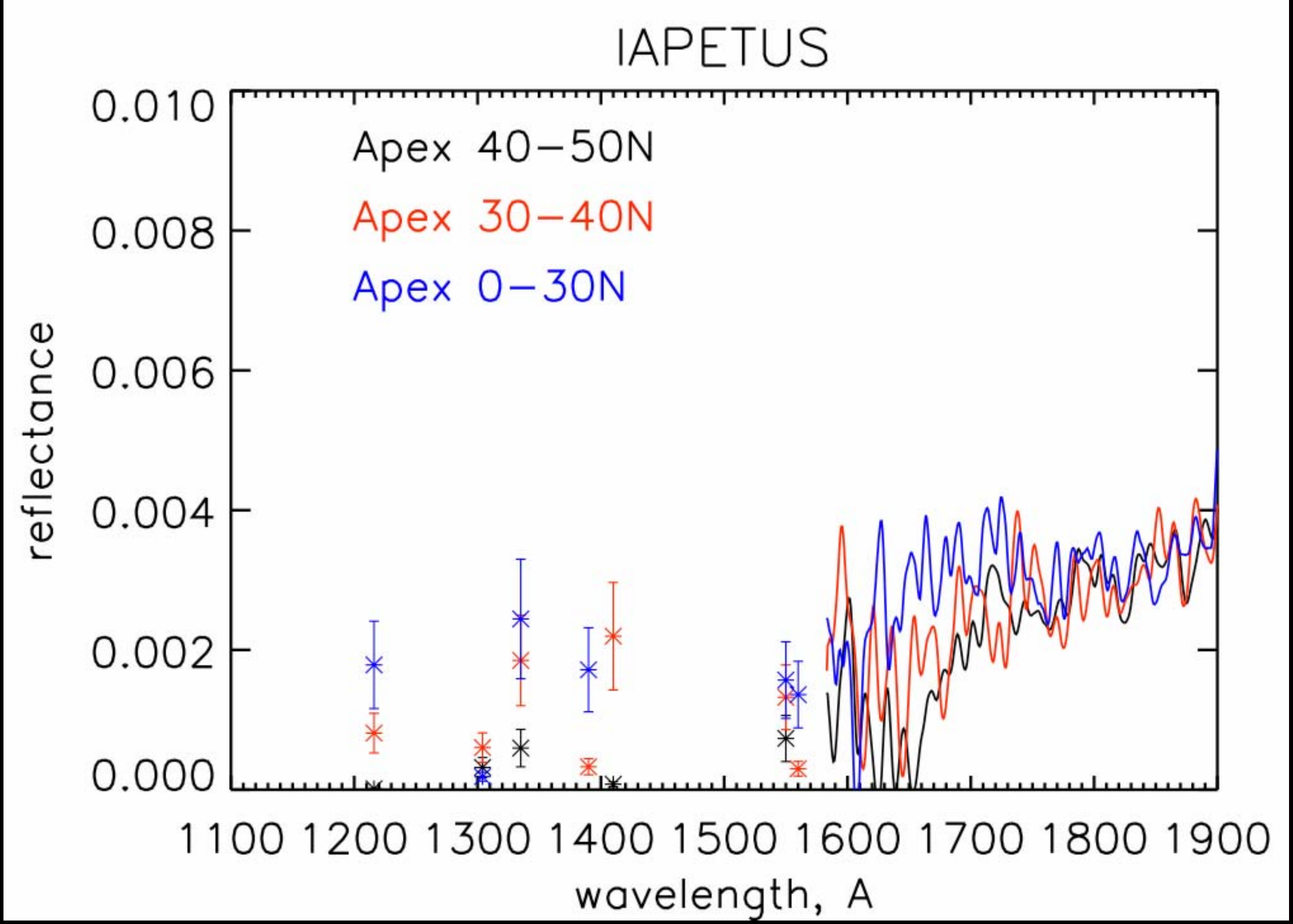
Apex Dark/Boundary (162W) Dark



Apex Dark/Boundary (162W) Dark

# Previous results, from apex region:

Water ice absorption feature is present even at low latitudes;
Strength of the feature increases with latitude (decreasing temperature)



Hendrix & Hansen, in press, *Icarus*

# Variations within the Dark Terrain

- Three regions under comparison:
  - Region 1: Apex (from previous flyby)
  - Region 2: Near 162° W, 0° N
  - Region 3: Near 165° W, 15° S
- Region 3 (165° W, 15° S) has more $H_2O$ ice than Regions 2 (162° W, 0° N), 1 (apex)
  - Could have $H_2O$ ice intimately mixed at least at UVIS resolution
- Region 2 (162° W, 0° N) does *not* have more $H_2O$ ice than Region 1 (apex)
  - Consistent with thermal segregation (both at equator)
  - Recall that UVIS found more $H_2O$ ice with latitude in apex (as temperature decreased)
- Region 1 exhibits a broad absorption feature relative to Region 2
  - Possibly consistent with carbon
  - Due to fresher coating?? Thicker?? Or mixture of native material away from apex??

# Implications

- *Material on leading hemisphere is compositionally different from dark material in boundary region*
  - May be more carbon-rich
- *At low latitudes, both the apex and the boundary regions have similar amounts of $H_2O$ ice.*
  - Consistent with loss of volatiles to colder higher latitudes
  - Consistent with ongoing/recent emplacement process

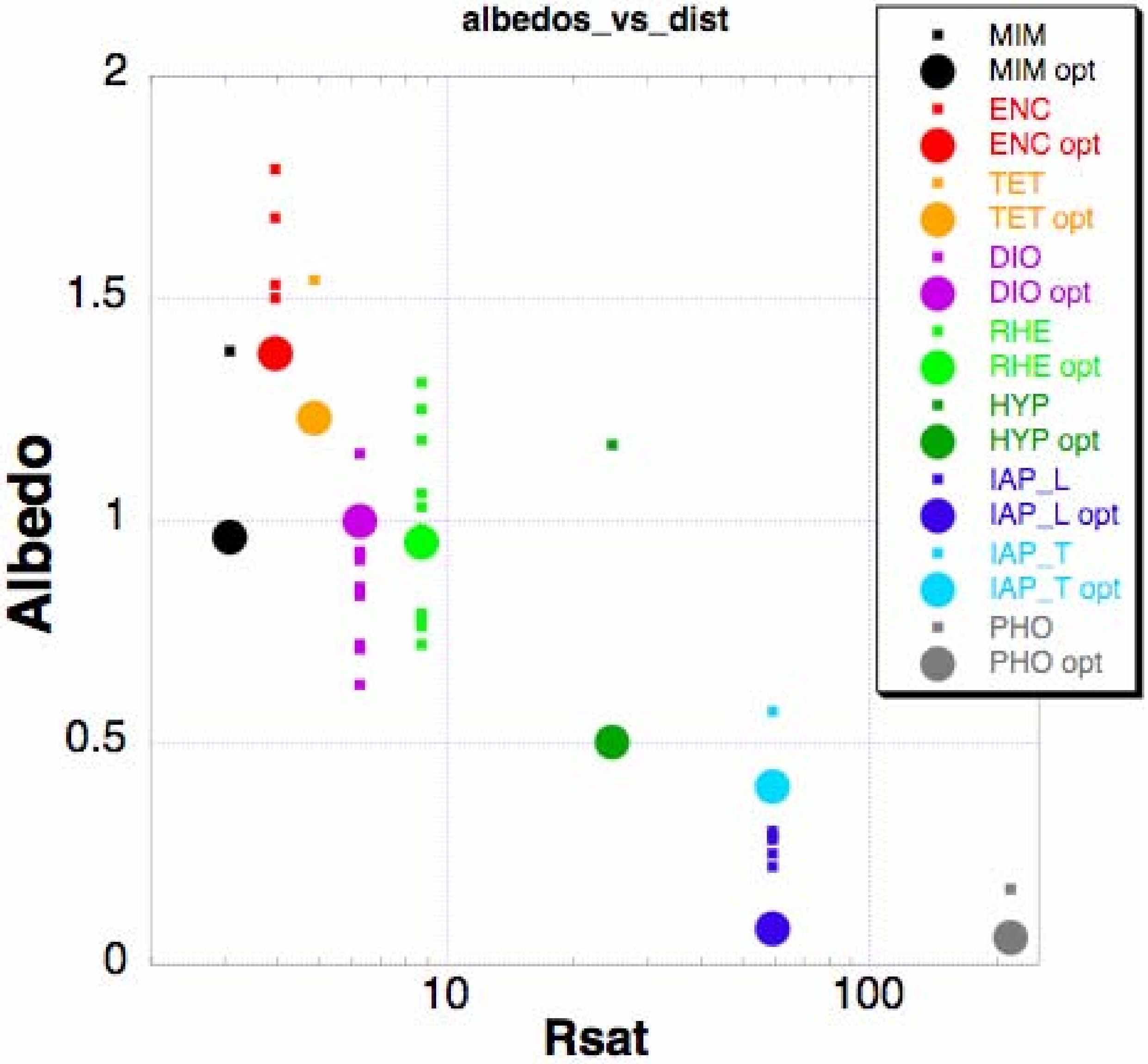
# summary

- UVIS obtained a great data set on recent flyby
  - Still a lot to do!
- UVIS data are being used to map $H_2O$ ice
  - Investigate extent & importance of thermal segregation
    - (why does Iapetus look like it does?)
- UVIS data are being used to map non-$H_2O$ (dirty, primitive) materials
  - Investigate compositional differences within the dark terrain
    - (what is the non-native dark material and where does it come from?)
- UVIS data are consistent with Spencer’s model of water ice migration to cold/bright regions

# Iapetus RADAR

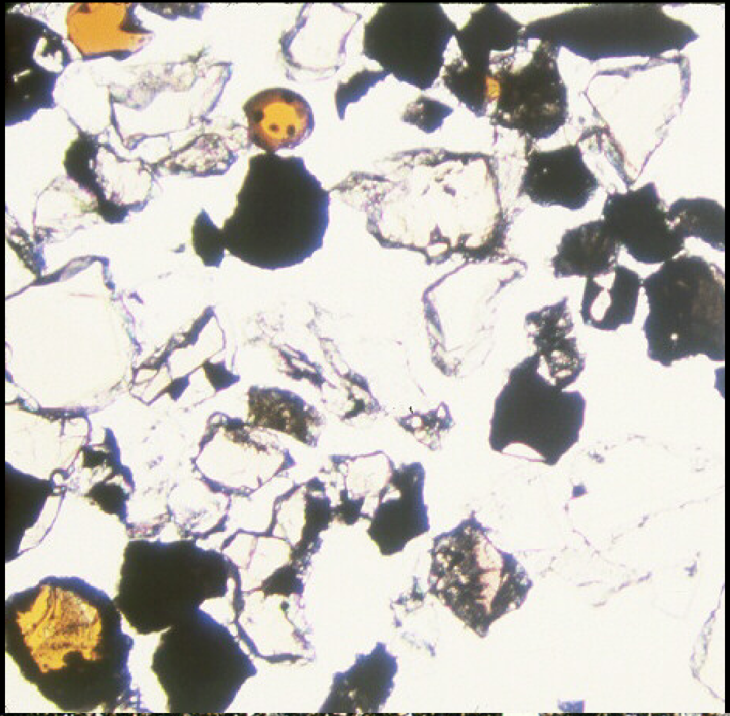
Steve Ostro, JPL

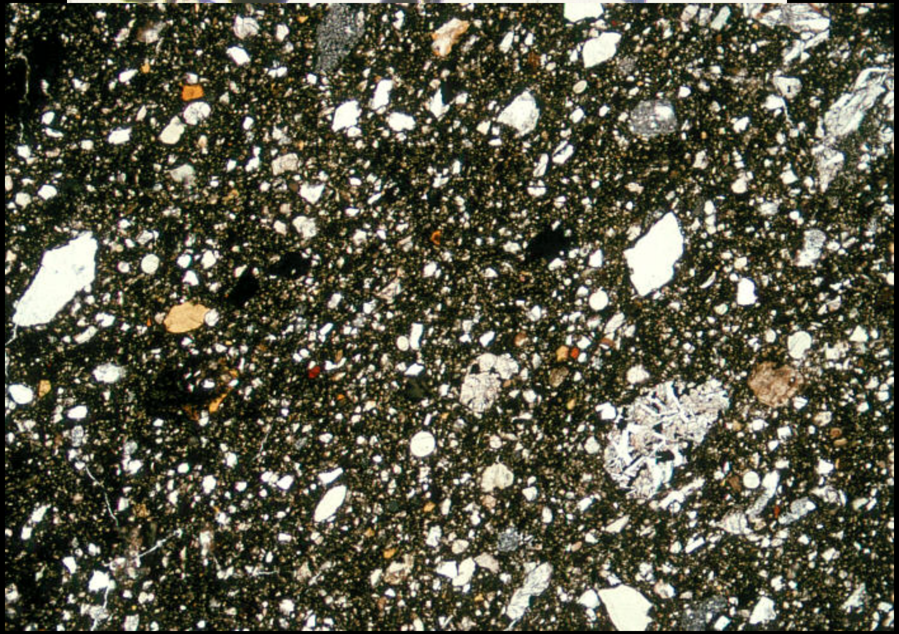
# Radar SL Albedos and Optical Geometric Albedos



# Coherent Backscattering

The anomalously large radar albedos and polarization ratios of radar echoes from certain icy surfaces arise from phase-coherent, multiple scattering within a dielectric medium that is heterogeneous **and** nonabsorbing.





Contamination of water ice with virtually any other substance decreases its radar transparency and hence the radar brightness of icy surfaces.

---

1/*e* one-way power absorption length: $L_{abs} = (\lambda/4\pi) \{( K_r/2) [(1+\tan^2\delta)^{1/2} -1]\}^{1/2}$

---

| Material | $L_{abs} /\lambda$ |
|---|---|
| Water Ice | ~10,000 |
| Earth rocks, nonmetallic meteorites | ~1 to ~100 |
| Water ice + few % lunar soil | ~100 |
| Water Ice + 0.1% ammonia ($NH_3$) | ~1 to ~10 |
| Hematite ($Fe_2O_3$) | <1 |
| Tholin | <10 |

Iapetus’ 2.2-cm radar albedo shows a strong dichotomy between optically dark, leading-side material and optically bright, trailing-side material.

Iapetus’ 13-cm results show much less of a dichotomy and give a mean radar reflectivity several times lower than the reflectivity measured at 2.2 cm.

Total-Power Radar Albedos

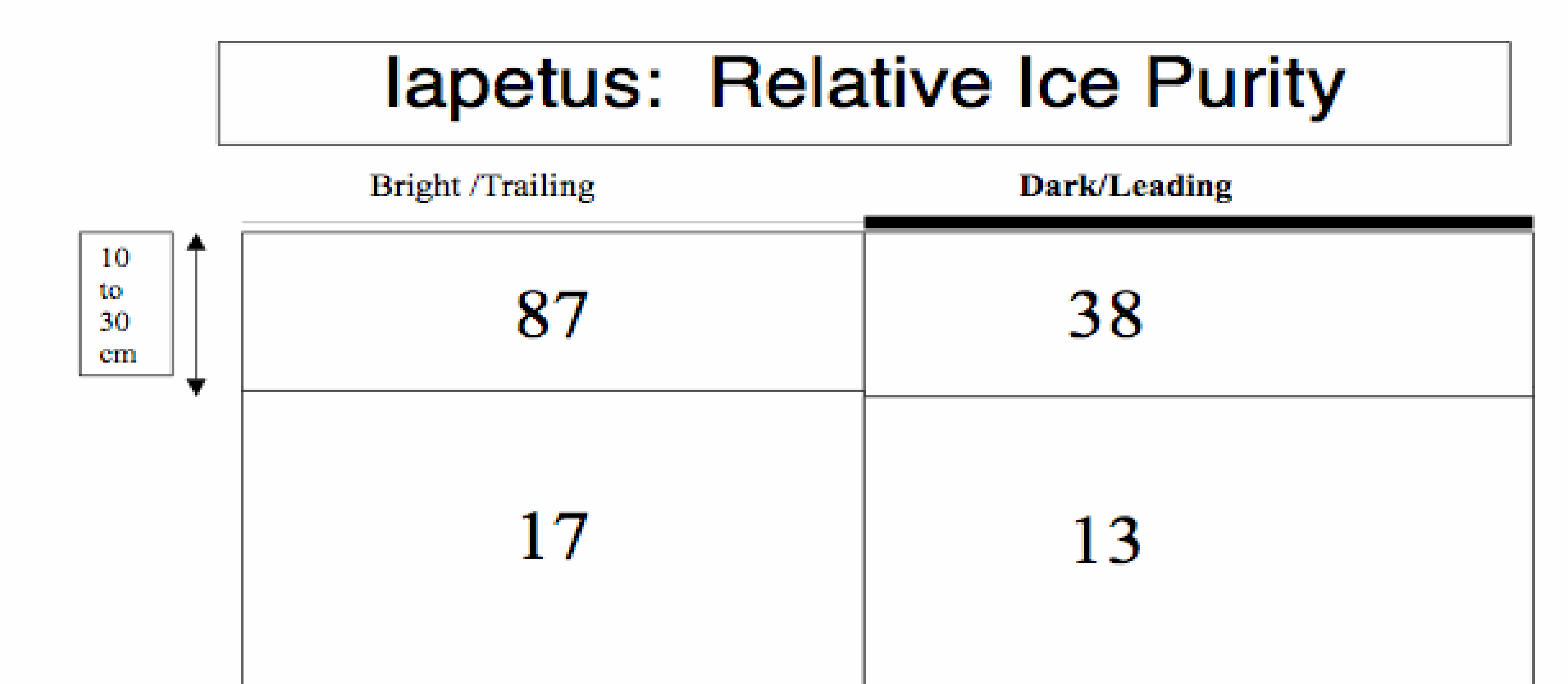
| | Dark/Leading | Bright/Trailing |
|---|---|---|
| 2.2-cm | 0.38 ± 0.06 | 0.87 ± 0.08 |
| 13-cm | 0.13 ± 0.04 | 0.17 ± 0.04 |

Main-belt-asteroid mean: 0.15 ± 0.10

These Iapetus results are understandable if

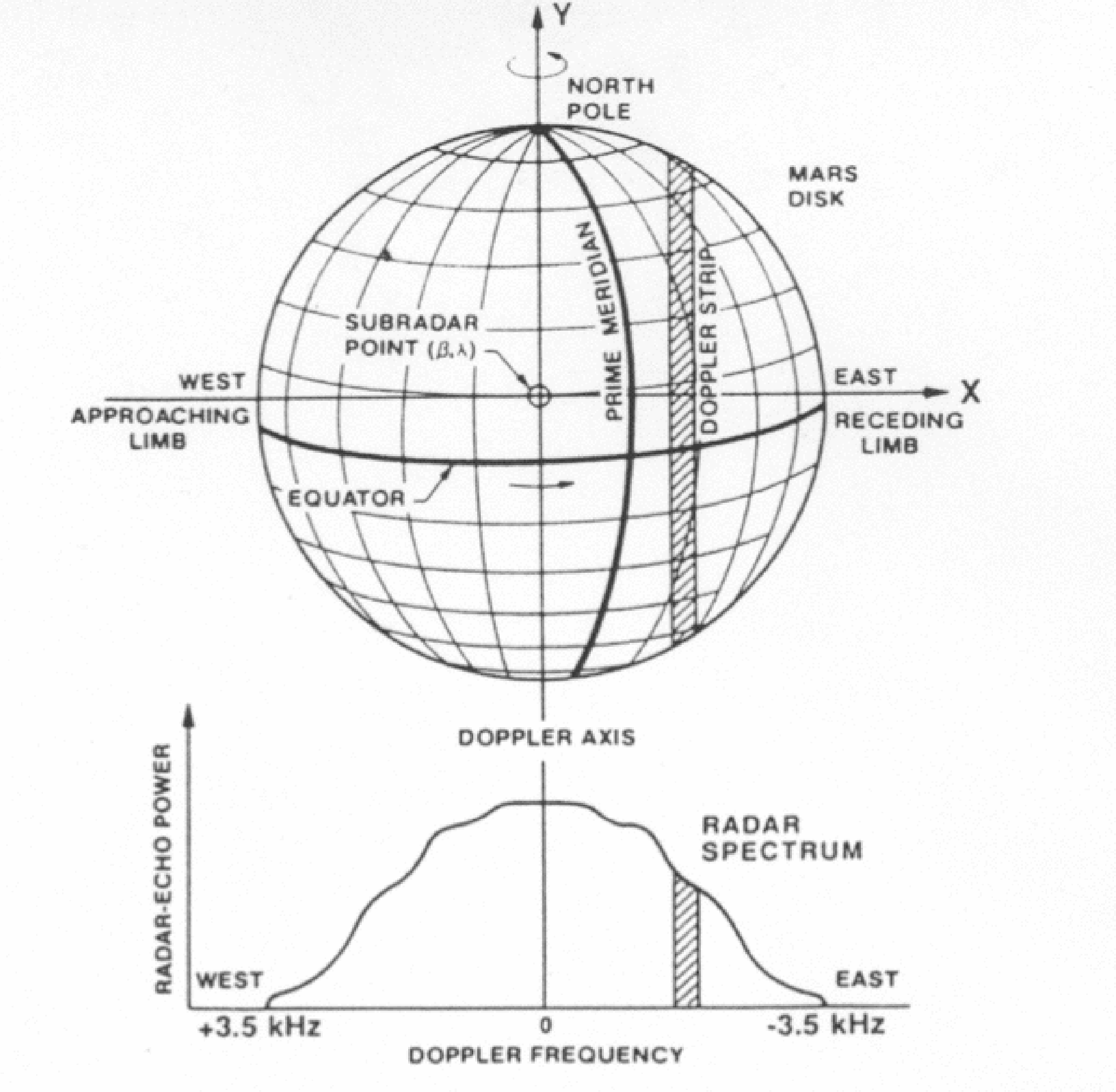
(1) Ammonia* and/or some other radar-absorbing contaminant is globally much less abundant within the upper one to several decimeters than at greater depths, and

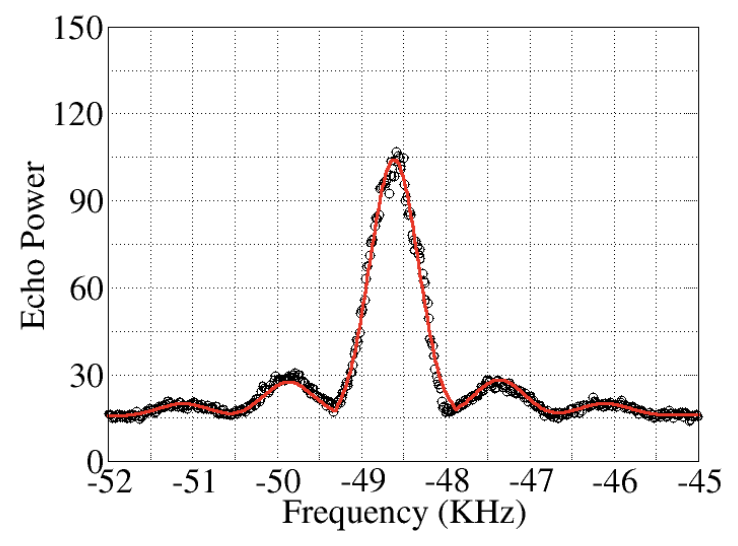
(2) the leading side's optically dark contaminant is present to depths of at least one to several decimeters.

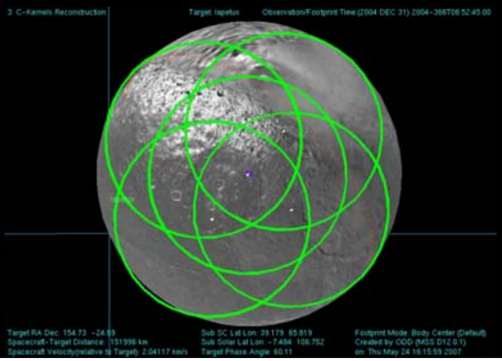


Iapetus: Relative Ice Purity

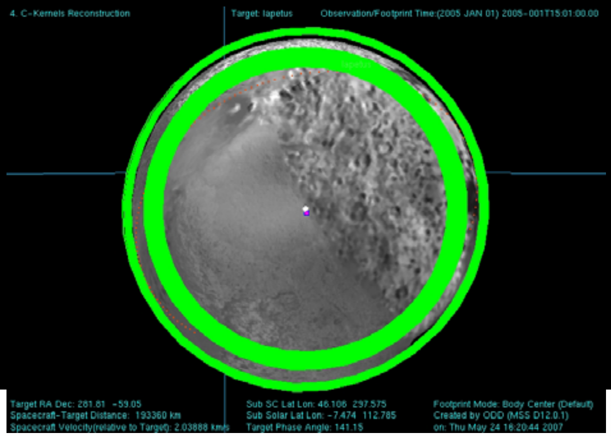
| | Bright /Trailing | Dark/Leading |
|---|---|---|
| 10 to 30 cm | 87 | 38 |
| | 17 | 13 |


Y
NORTH POLE
MARS DISK
SUBRADAR POINT (β, λ)
PRIME MERIDIAN
DOPPLER STRIP
WEST
APPROACHING LIMB
EAST
X
RECEDING LIMB
EQUATOR
DOPPLER AXIS
RADAR-ECHO POWER
RADAR SPECTRUM
WEST
EAST
+3.5 kHz
0
-3.5 kHz
DOPPLER FREQUENCY

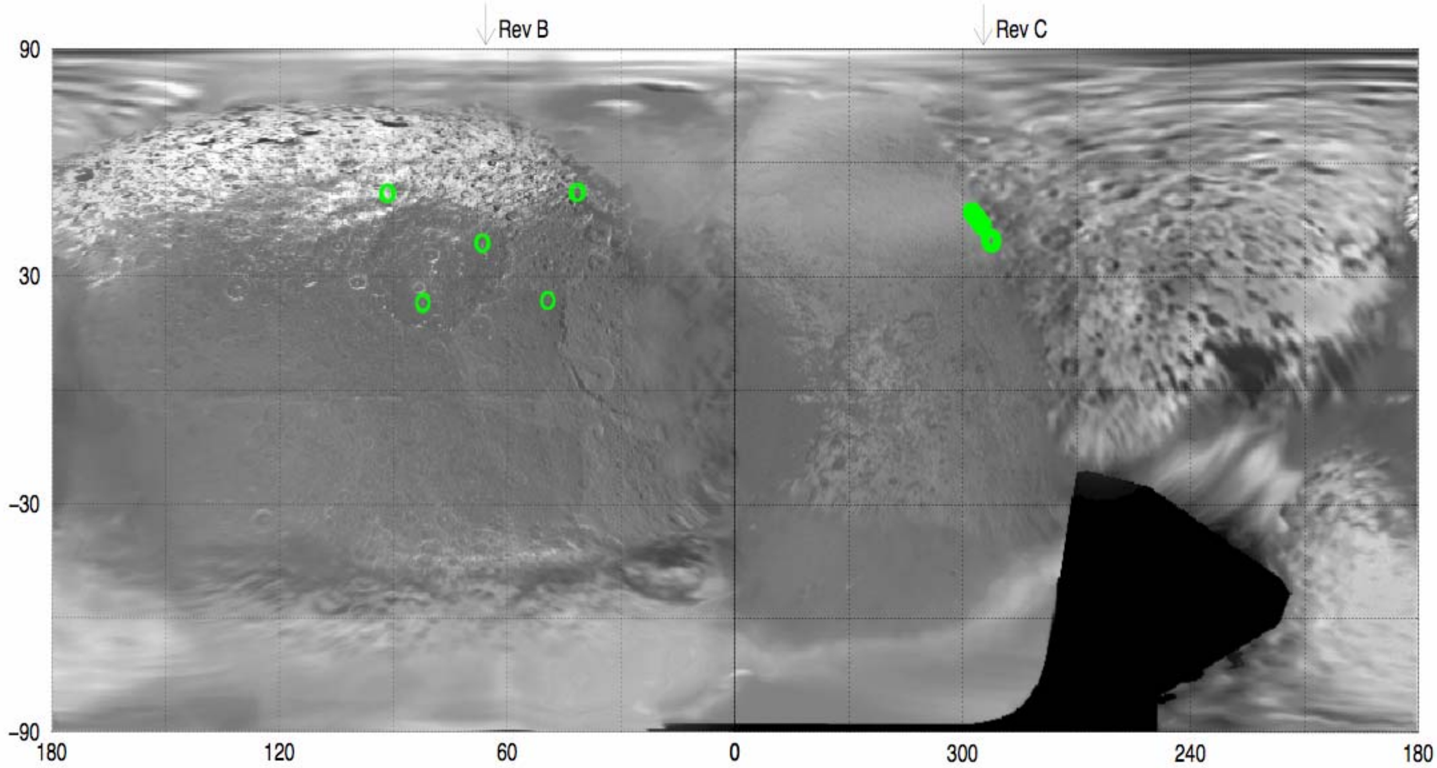

150
120
90
60
30
0
Echo Power
-52
-51
-50
-49
-48
-47
-46
-45
Frequency (KHz)



3. C-Kernels Reconstruction
Target: Iapetus
Observation/Footprint Time:(2004 DEC 31) 2004-366T08:52:45.00
Target RA Dec: 154.73 -24.69
Spacecraft-Target Distance: 151996 km
Spacecraft Velocity(relative to Target): 2.04117 km/s
Sub SC Lat Lon: 39.179 65.619
Sub Solar Lat Lon: -7.484 106.752
Target Phase Angle: 60.11
Footprint Mode: Body Center (Default)
Created by ODD (MSS D12.0.1)
on: Thu May 24 16:15:59 2007

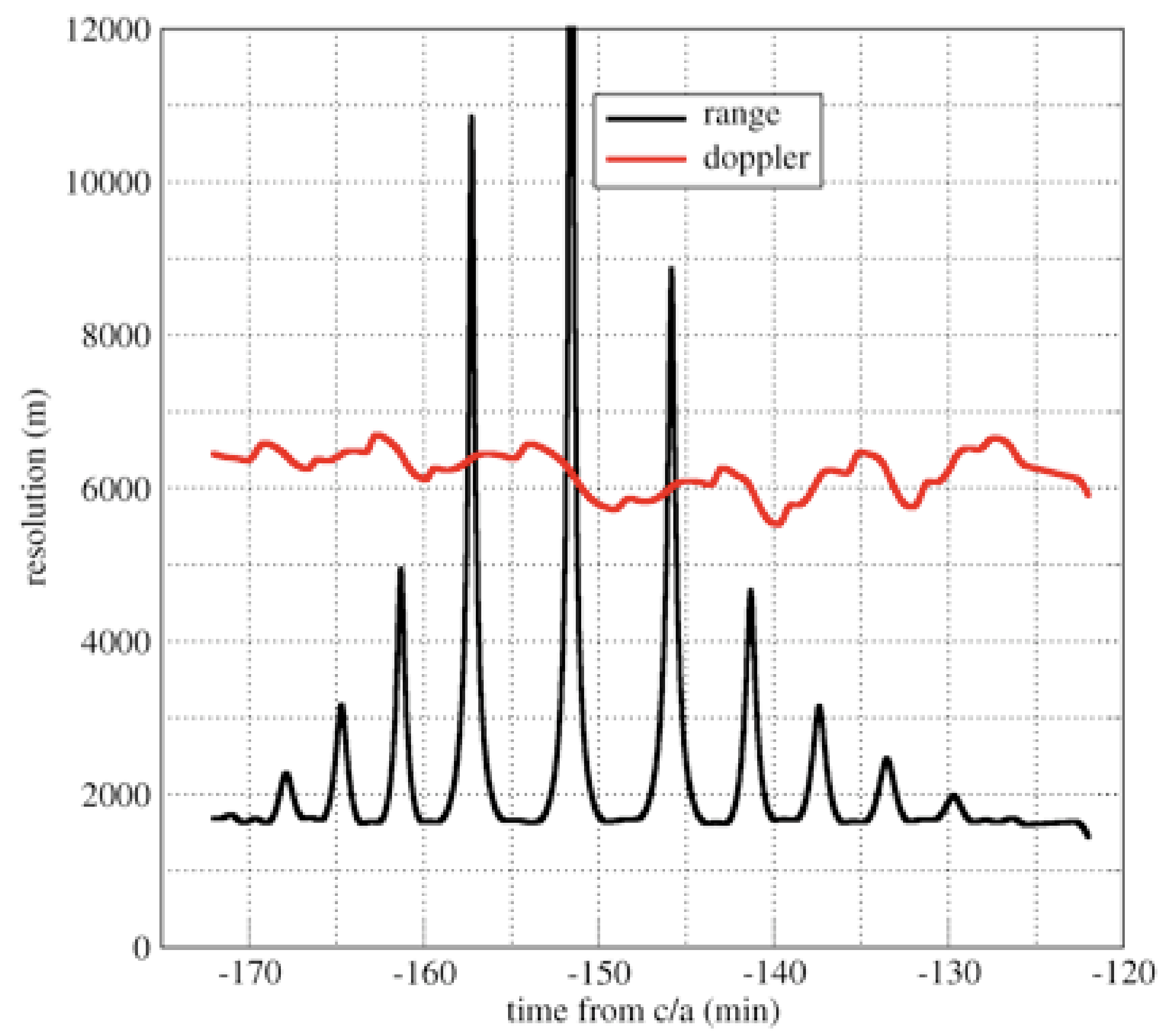


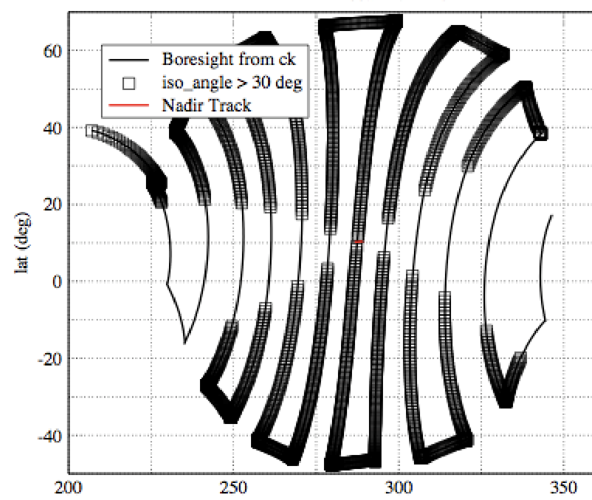
4. C-Kernels Reconstruction
Target: Iapetus
Observation/Footprint Time:(2005 JAN 01) 2005-001T15:01:00.00
Target RA Dec: 281.81 -59.05
Spacecraft-Target Distance: 193360 km
Spacecraft Velocity(relative to Target): 2.03888 km/s
Sub SC Lat Lon: 46.106 297.575
Sub Solar Lat Lon: -7.474 112.785
Target Phase Angle: 141.15
Footprint Mode: Body Center (Default)
Created by ODD (MSS D12.0.1)
on: Thu May 24 16:20:44 2007

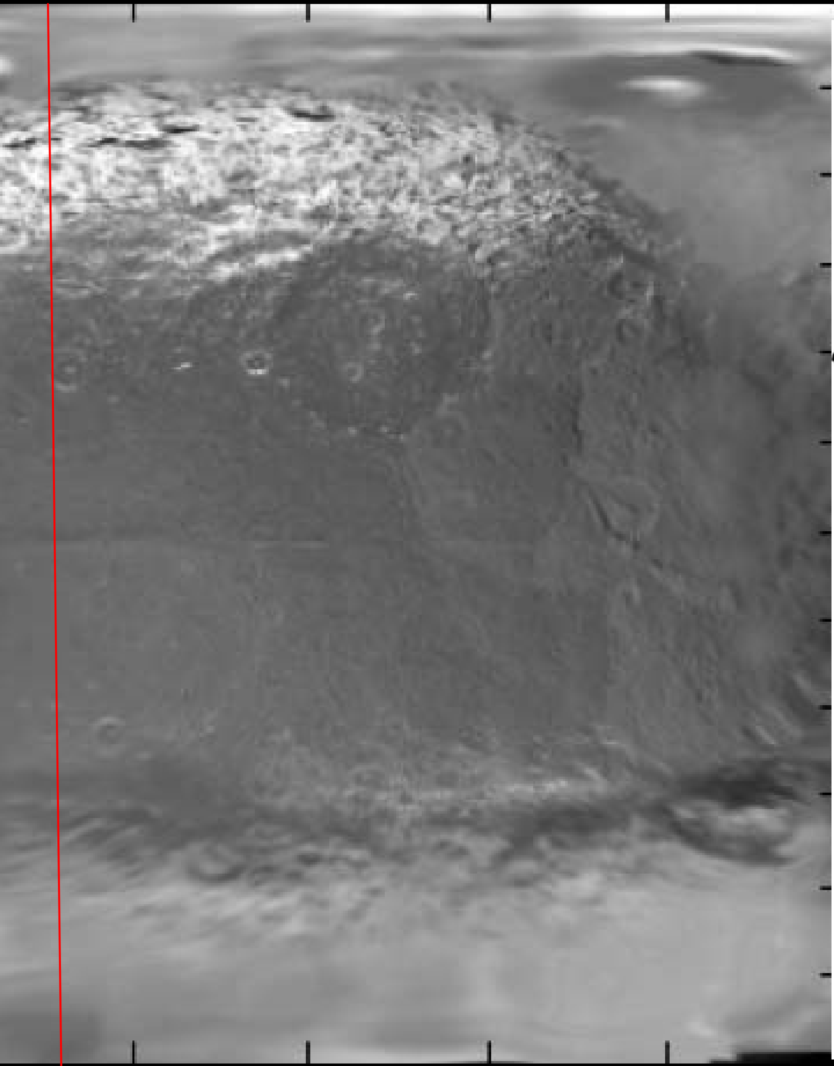


ISS Map (PIA07778, Dec. 2005)

# Surface Resolution

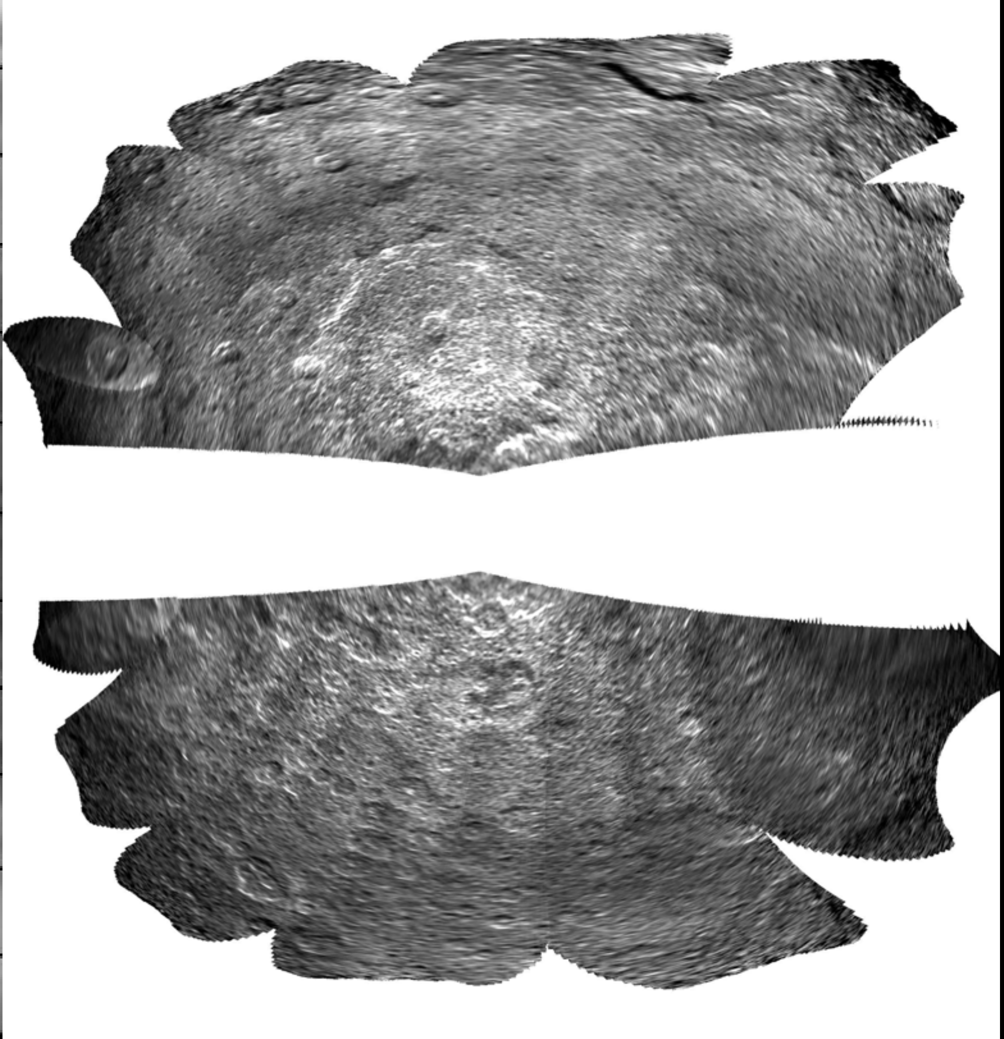






ISS Map (PIA07778, Dec. 2005)

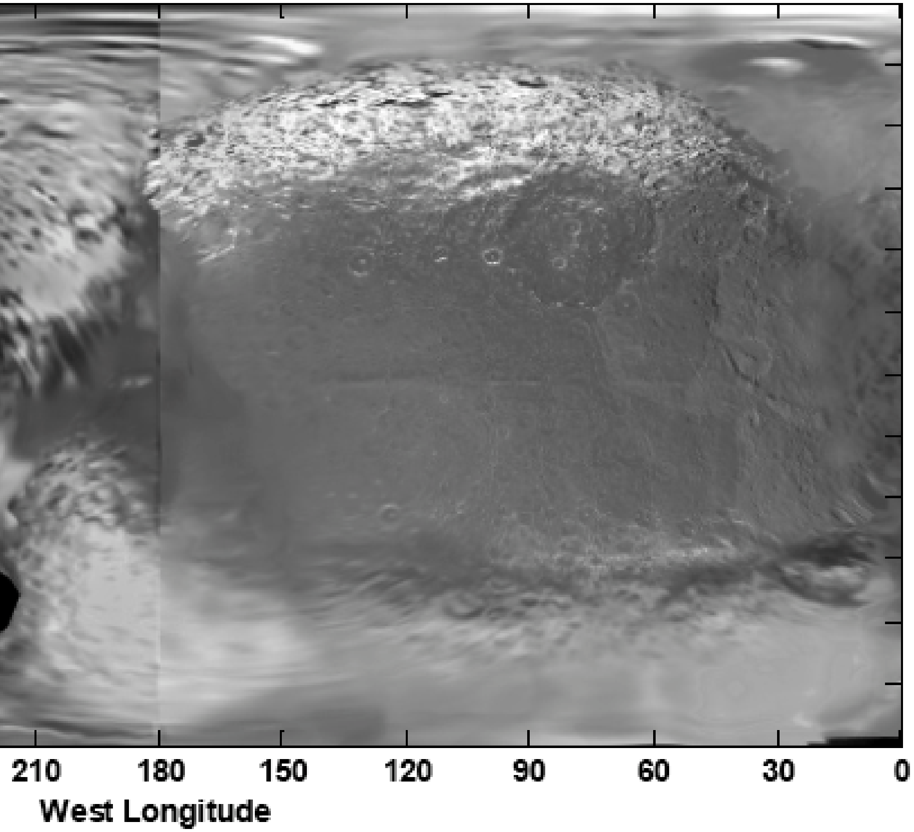
----> No ISS IAP 49 hires imaging

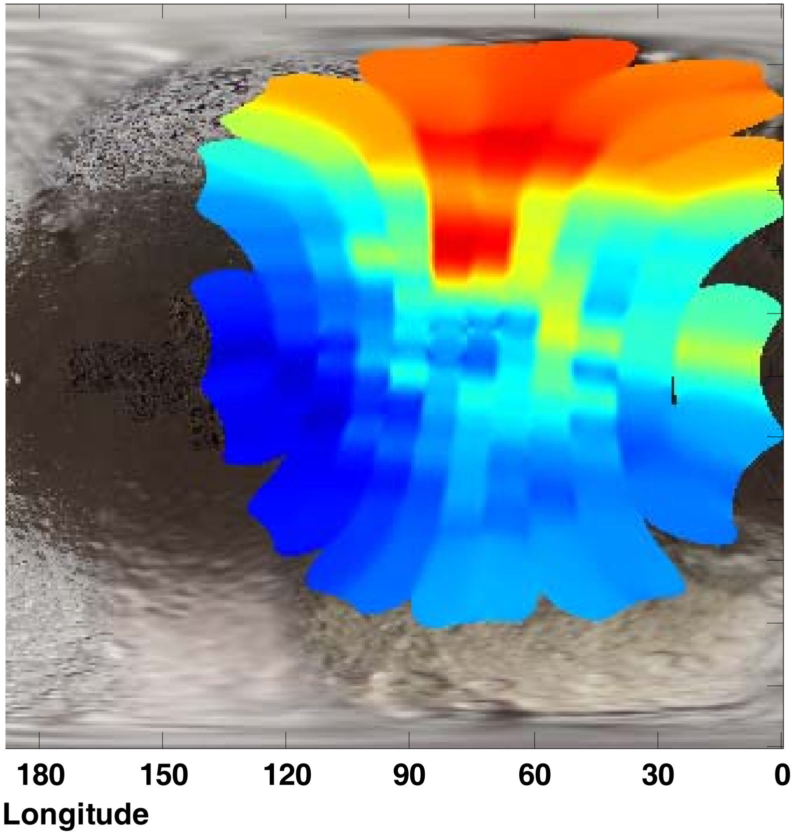


RADAR SAR, Sep. 2007

(Oct. 5 unfocused and uncalibrated reduction)

# Real-Aperture (Full-Beam) Scatterometry





ISS Map (PIA07778, Dec. 2005)