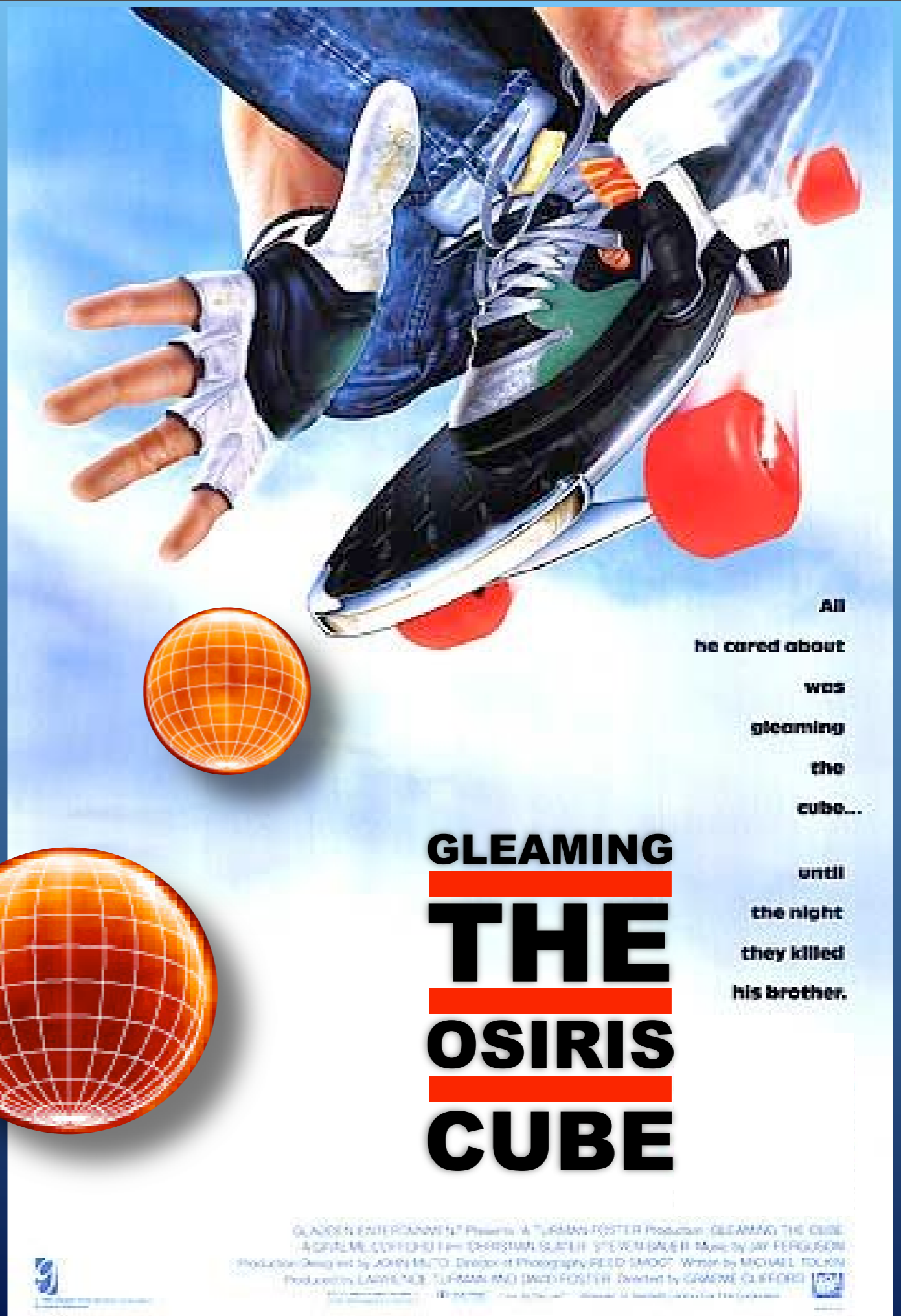


Titan Science



MÁTÉ ÁDÁMKOVICS
ASTRONOMY/CIPS
U.C. BERKELEY
CFAO 2007 SANTA CRUZ



All
he cared about
was
gleaming
the
cube...

until
the night
they killed
his brother.

GLEAMING **THE** **OSIRIS** **CUBE**

GLADSON ENTERTAINMENT Presents A TURMAN FOSTER Production GLEAMING THE CUBE
A GLEAMING THE CUBE FILM CHRISTIAN SLATER STEVEN MACKEL Music by JAY FERGUSON
Production Designed by JERRY MUTO Director of Photography REED SHOOT? Writer by MICHAEL TOLSON
Producers LAURENCE TURMAN M.D. (M.D.) FOSTER Directed by GAWWNE CLIFFORD

Closing the methane cycle

Properties of Methane (CH₄) on Titan

- Photochemical lifetime $\sim 10^7 - 10^8$ years
 - CH₄ turns into aerosol haze driven by solar UV
- Part of 'methalogical' cycle
 - Titan surface temp & pressure near CH₄ triple point
- Source(s) unidentified
 - must be interior/surface but how?

The Methane Cycle

processing is unknown

CH₄ (gas)

fluxes are uncertain

photochemical
polymerization

Aerosol haze

condensation

Clouds & Rain

unobserved

eruption

fast

evaporation

slow

Surface

Interior

?

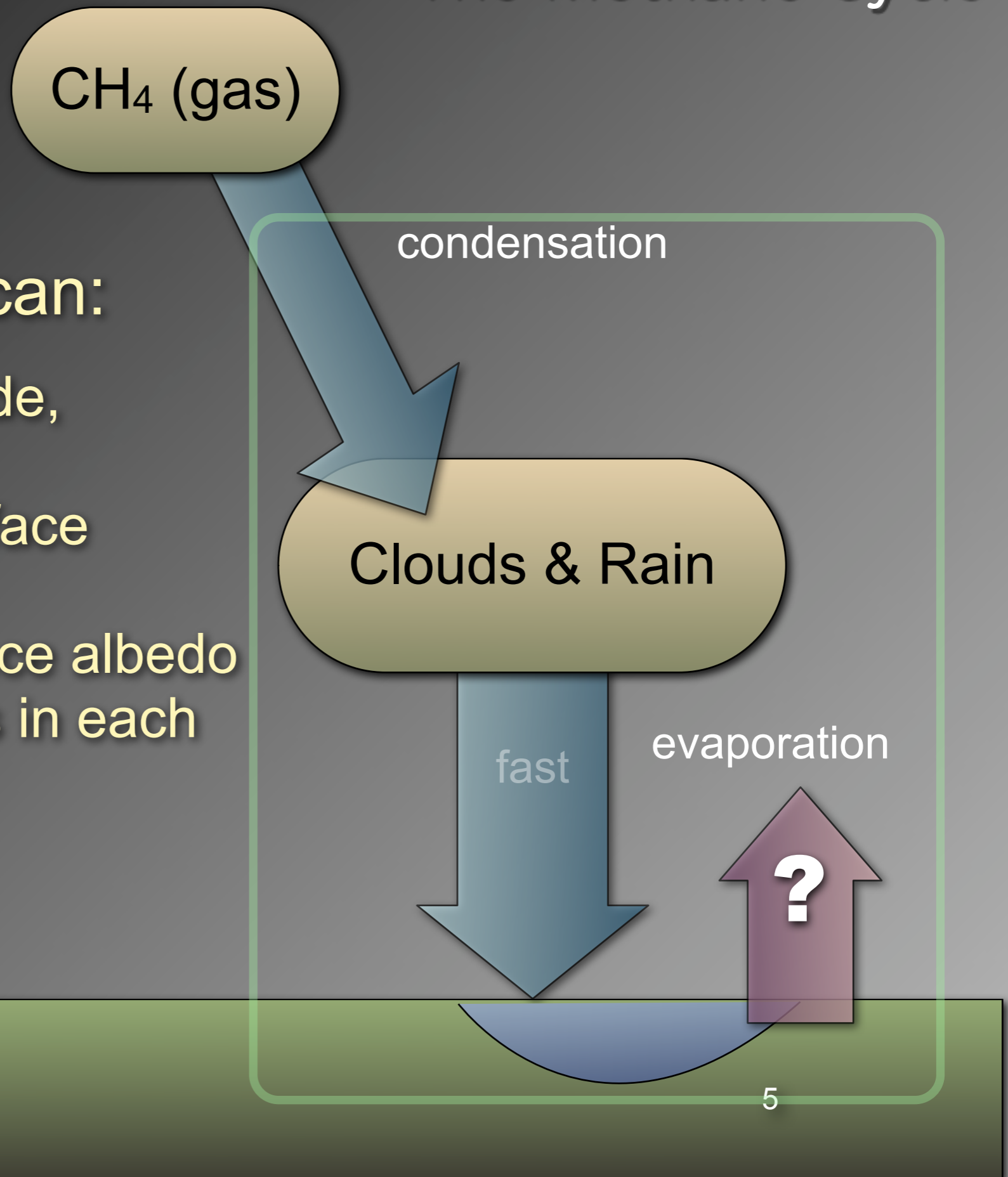
?

?

The Methane Cycle

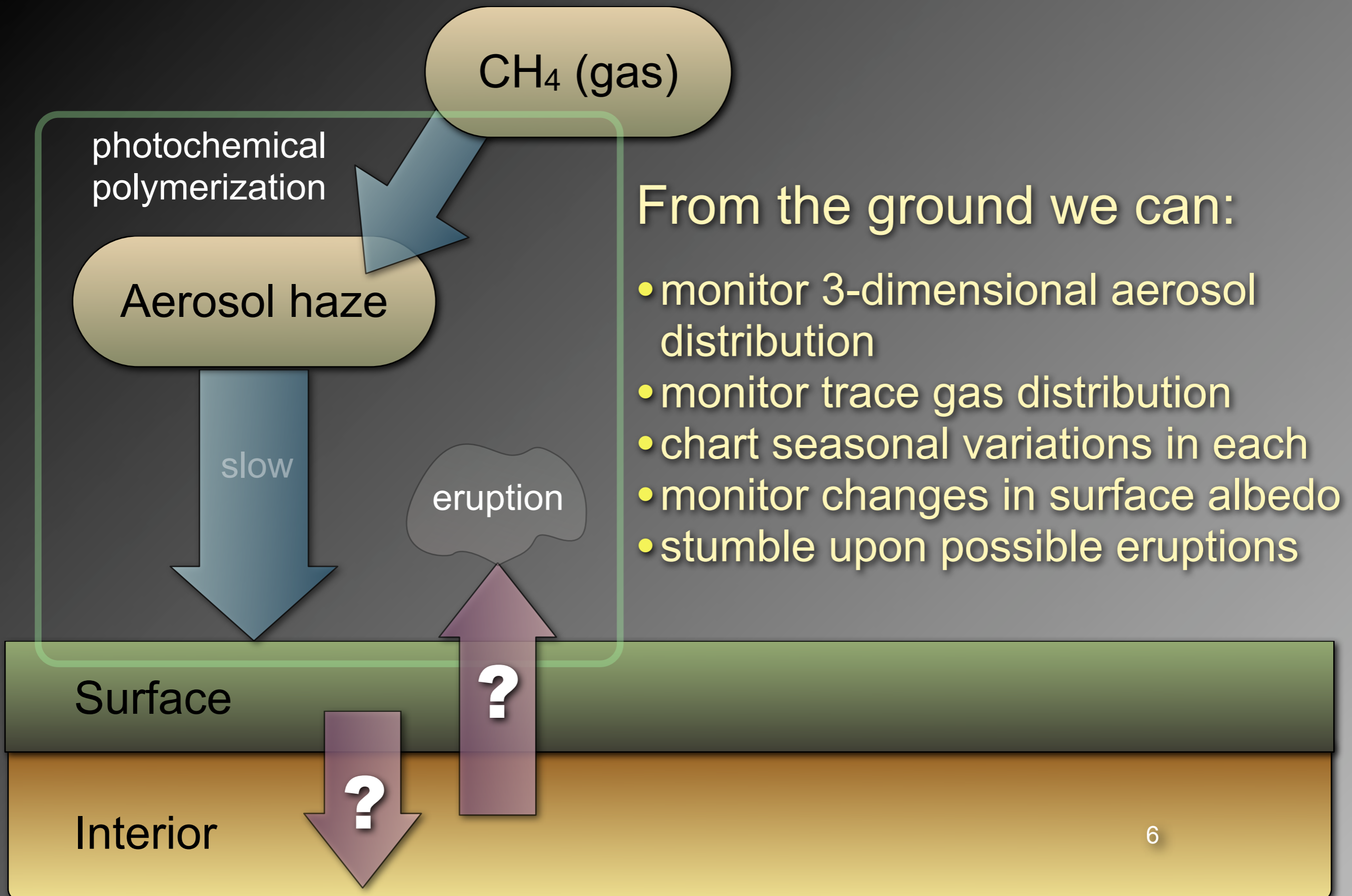
From the ground we can:

- monitor cloud size, altitude, frequency and lifetime
- monitor opacity near surface (e.g., rain, mist, fog)
- monitor changes in surface albedo
- chart seasonal variations in each

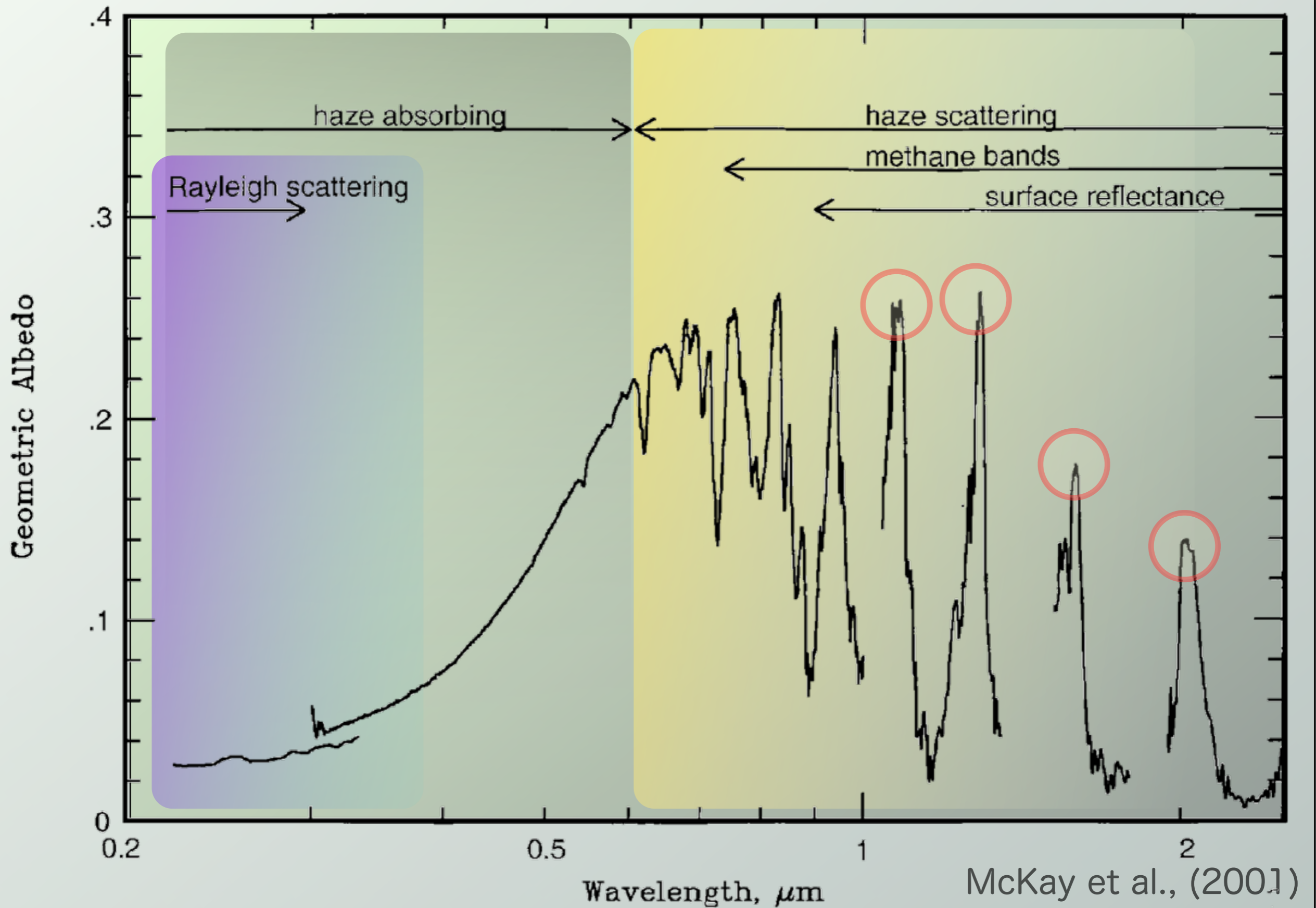


Surface

The Methane Cycle



The Spectrum of Titan



The Radiative Transfer Model

- **Two-stream & discrete ordinates solutions for RT equation**
(Toon et al., 1989 & Stamnes et al., 1988)
- **16 homogenous scattering layers, 0 - 200 km**
(McKay et al., 1989)
- **Temperature and pressure profiles from Huygens (same as Voyager)**
(Fulchignoni et al., 2005 & Tomasko et al., 2005)
- **CH₄ *k*-coefficients from lab spectra at range of appropriate *T* and *P***
(Irwin et al., 2005)
- **One-term Henyey-Greenstein aerosol scattering phase function**

OLD SCHOOL

- **Co-located CH₄ and 1.5 μ m-aerosol extinction profiles consistent with Huygens**
(Fulchignoni et al., 2005 & Tomasko et al., 2005)
- **Latitudinal trends in stratospheric haze opacity from VLT/SINFONI**
(Ádámkovics et al., 2006)
- **South (summer) polar haze enhance fit to observations**
(Ádámkovics et al., 2006 & current work)

RECENT

- **Surface reflectivity in 2 μ m window adapted from Cassini/VIMS**
(Barnes et al., 2006)
- **Surface spectrum empirically fit to observations with two Gaussian absorptions**
(current work)
- **Spectra fit for each observed pixel and convolved with calibration stage PSF**
(current work)

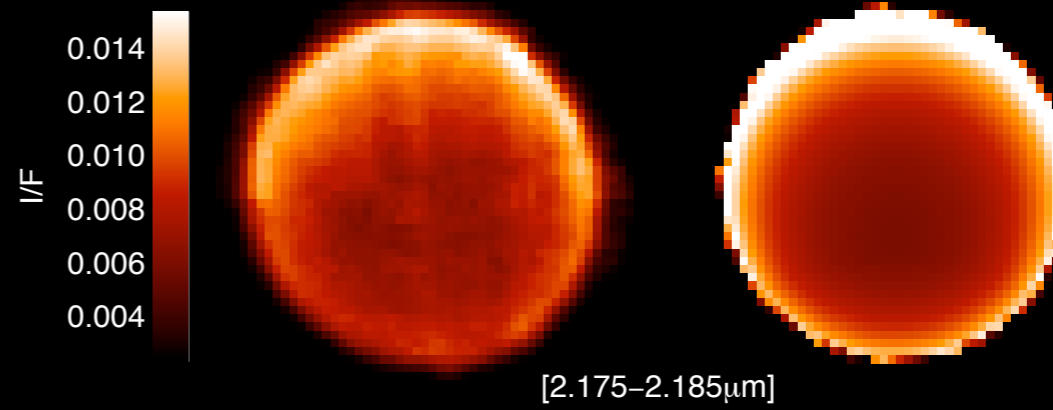
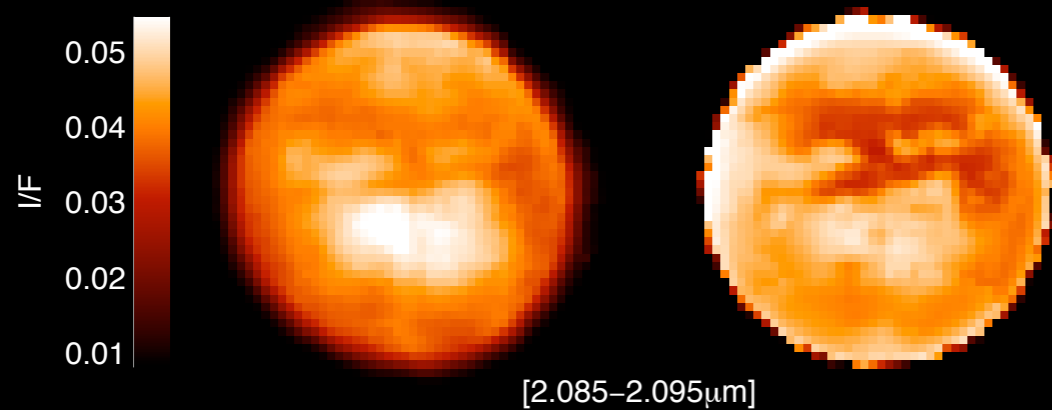
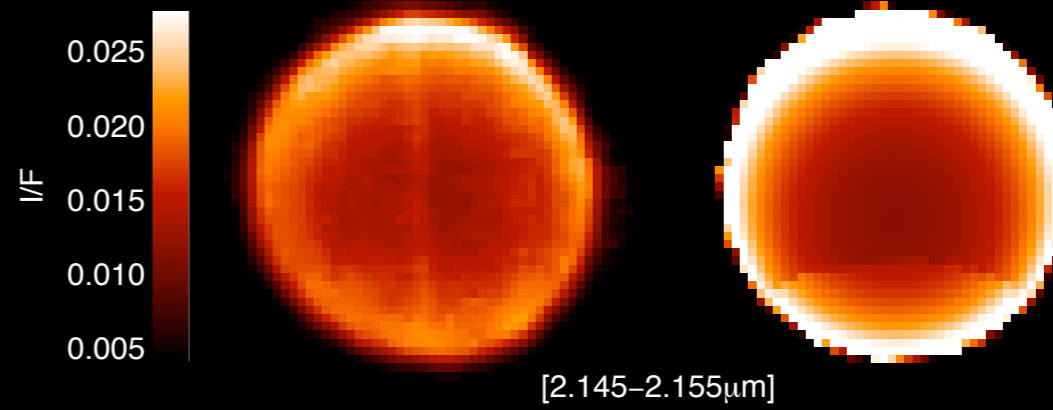
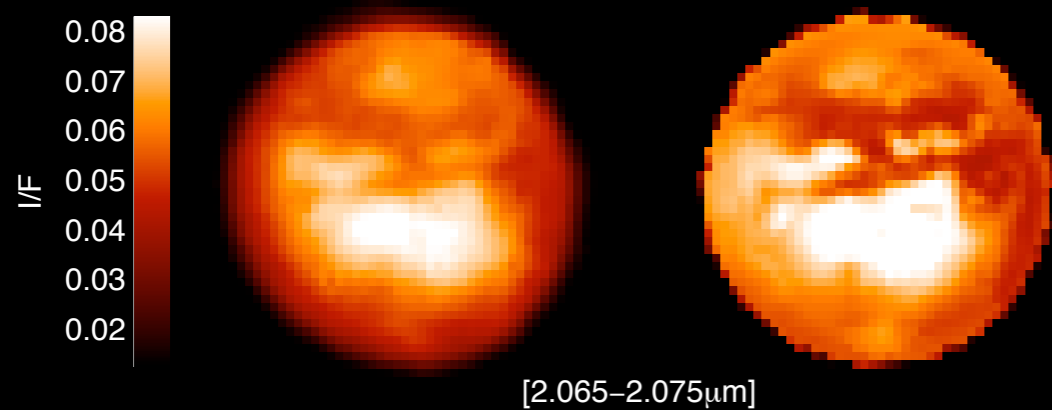
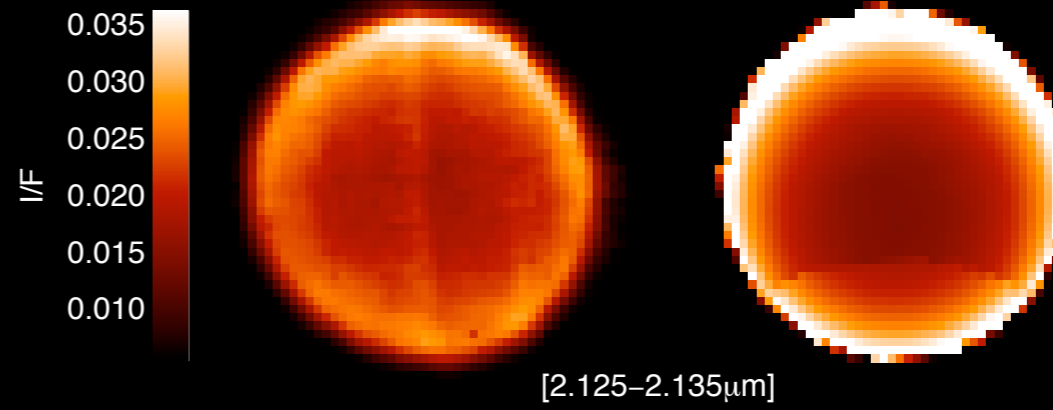
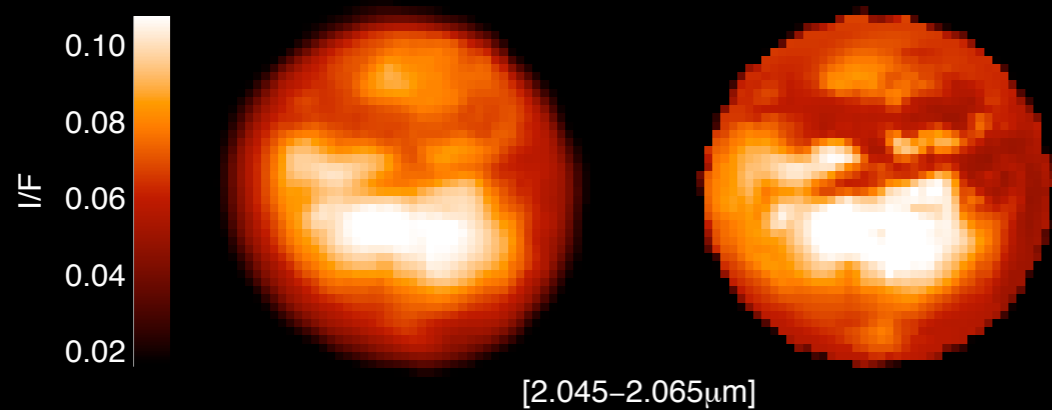
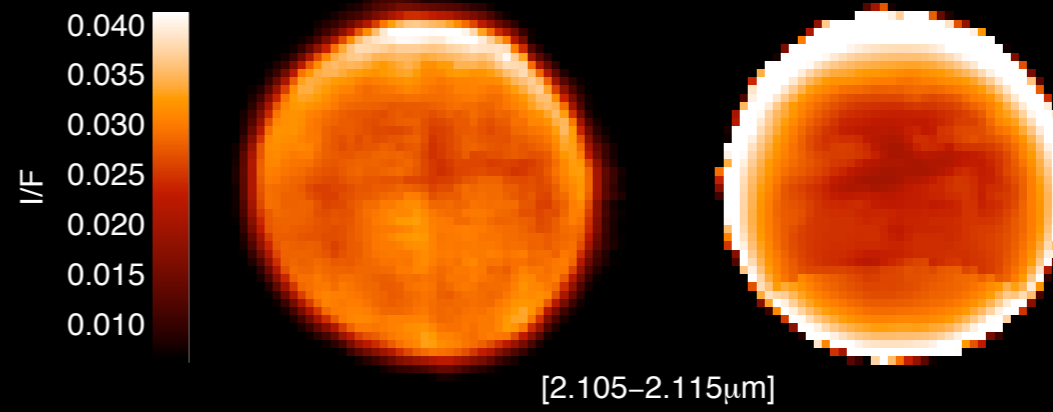
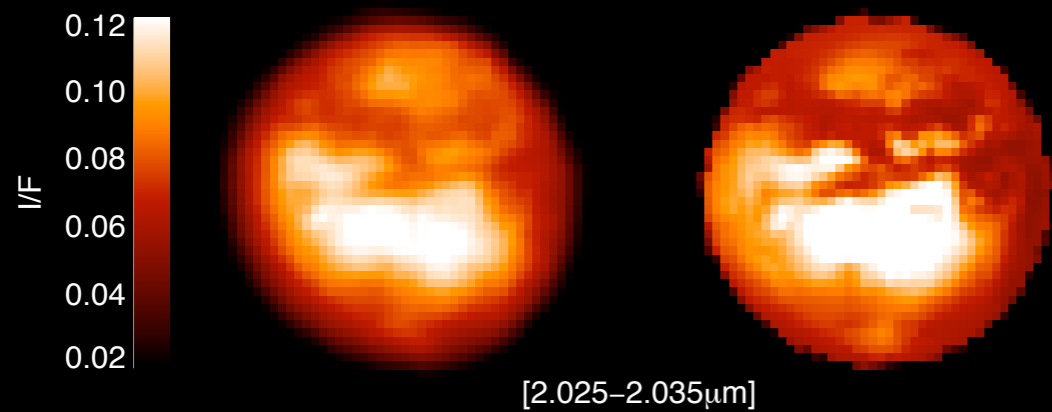
NEW HERE

2006 Apr OSIRIS

Model

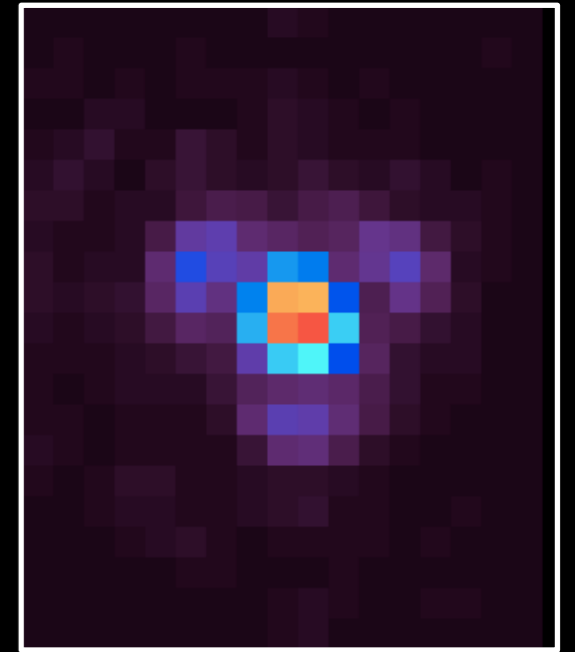
2006 Apr OSIRIS

Model



Surface Reflectivity Retrieval

The observed I/F range (0.0 to 0.18) at surface probing wavelengths expanded by $\sim 10\%$ to match observations when accounting for PSF.



Calibration star PSF

RT Model

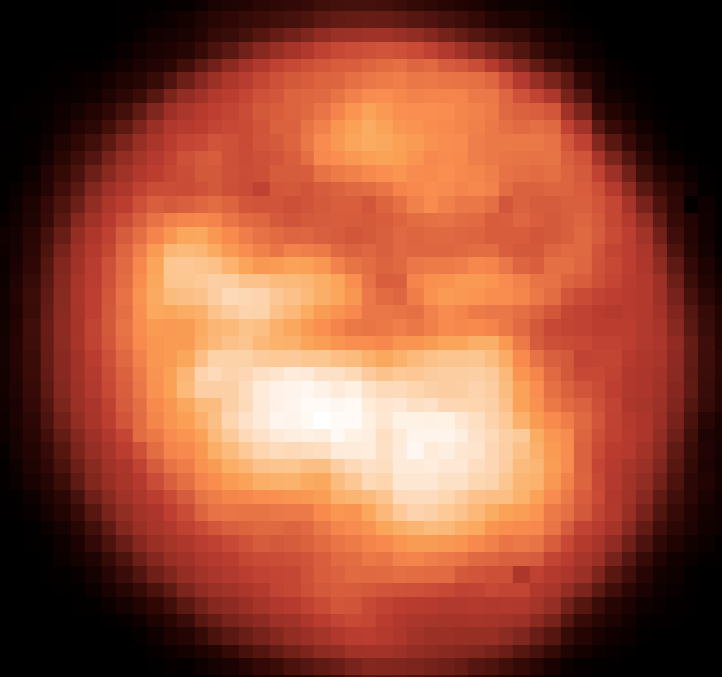


2.018 μm I/F map from Cassini/VIMS
(Barnes et al., 2007)

RT Model + PSF



2006 Apr OSIRIS

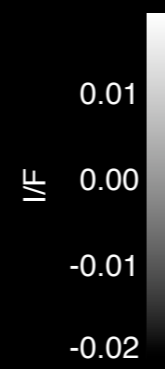
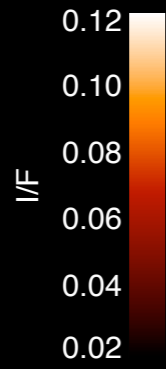


2.040 - 2.056 μm

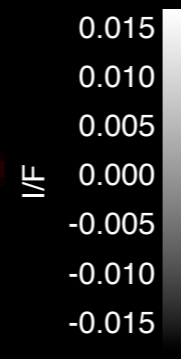
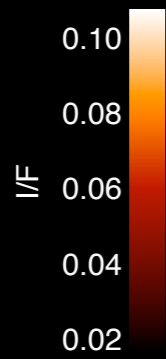
2006 Apr Keck

Model

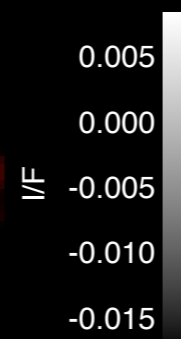
Residual



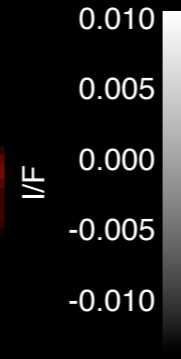
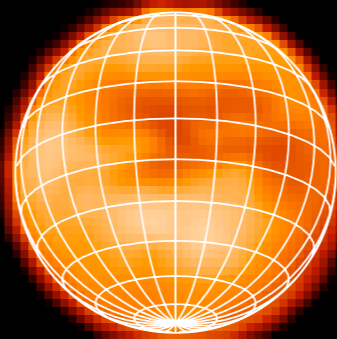
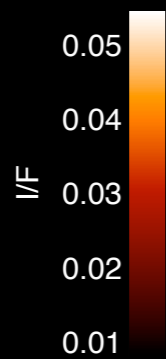
[2.025–2.035 μ m]



[2.045–2.065 μ m]



[2.065–2.075 μ m]

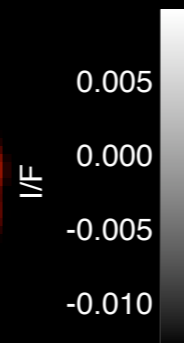
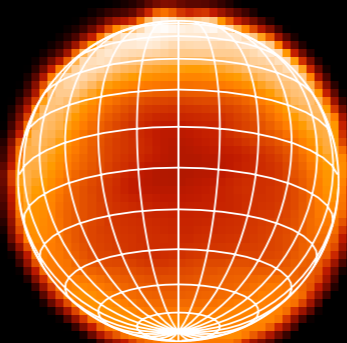
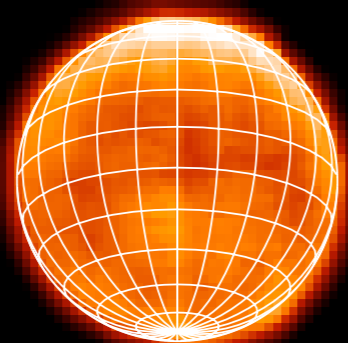
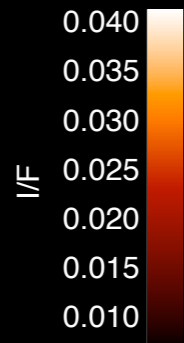


[2.085–2.095 μ m]

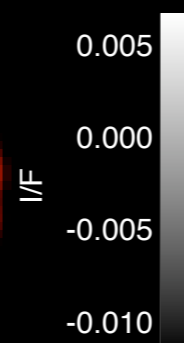
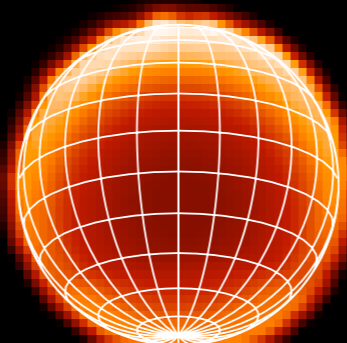
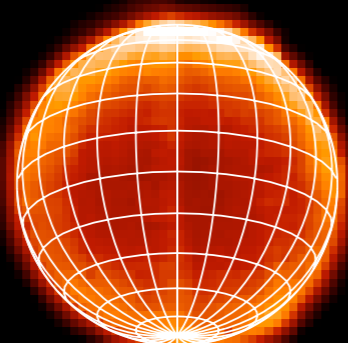
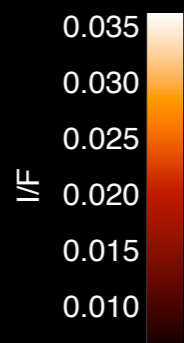
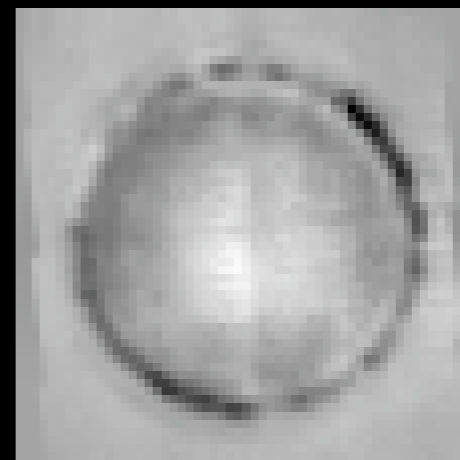
2006 Apr Keck

Model

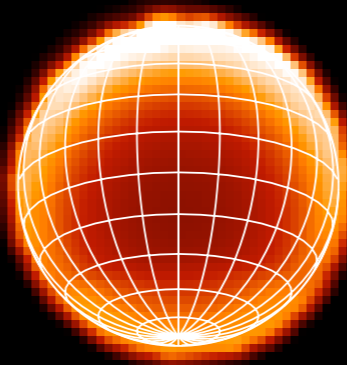
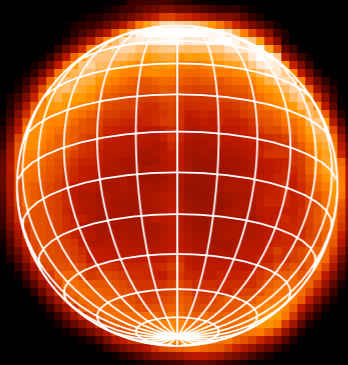
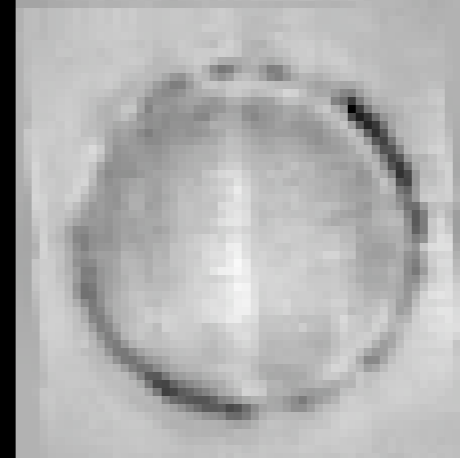
Residual



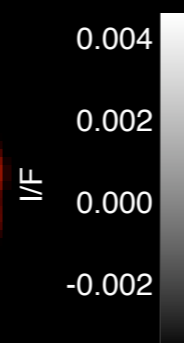
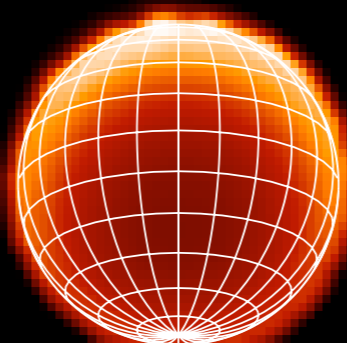
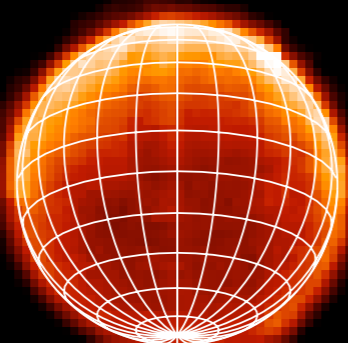
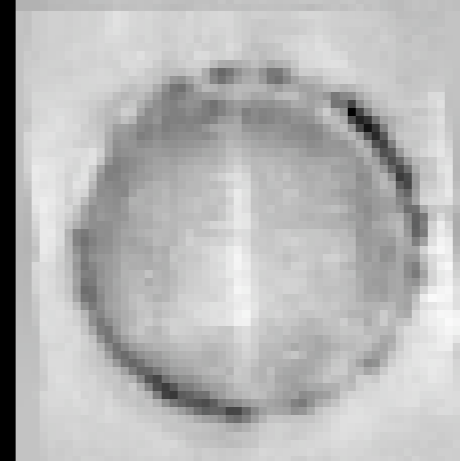
[2.105-2.115 μ m]



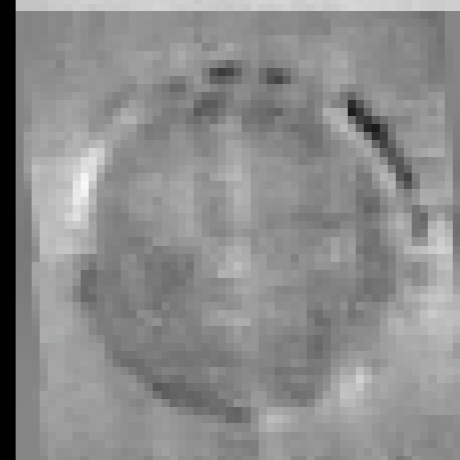
[2.125-2.135 μ m]



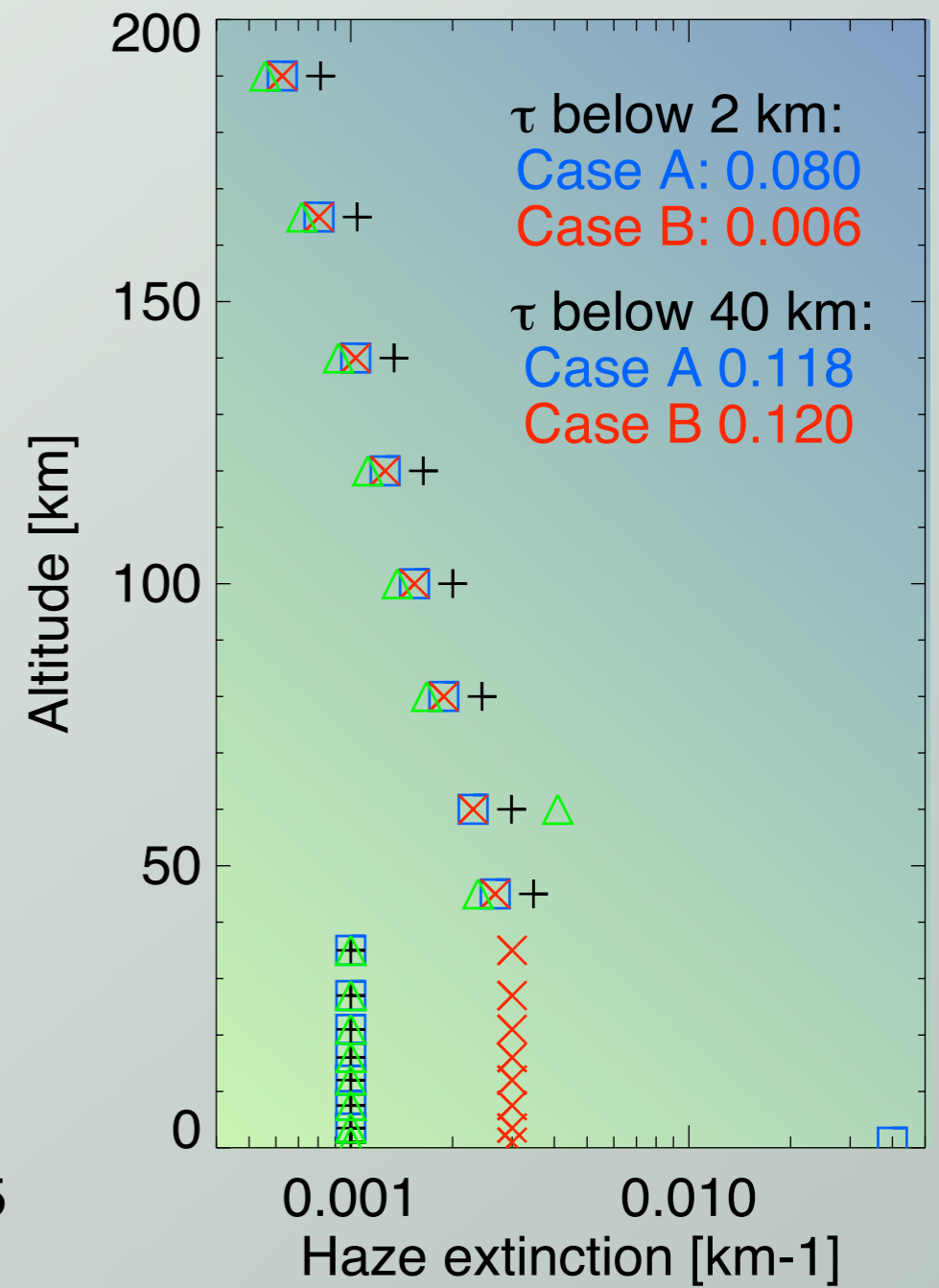
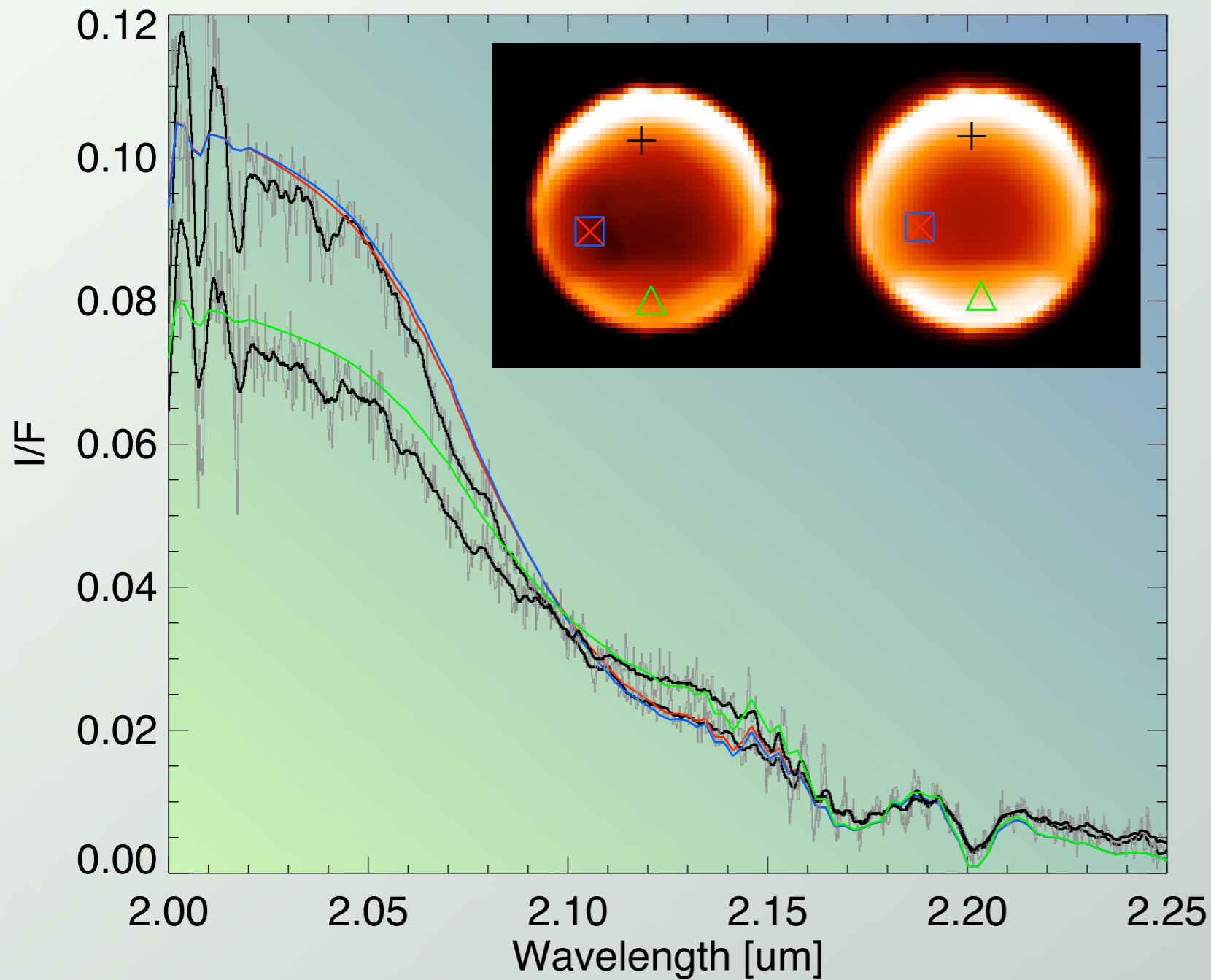
[2.145-2.155 μ m]

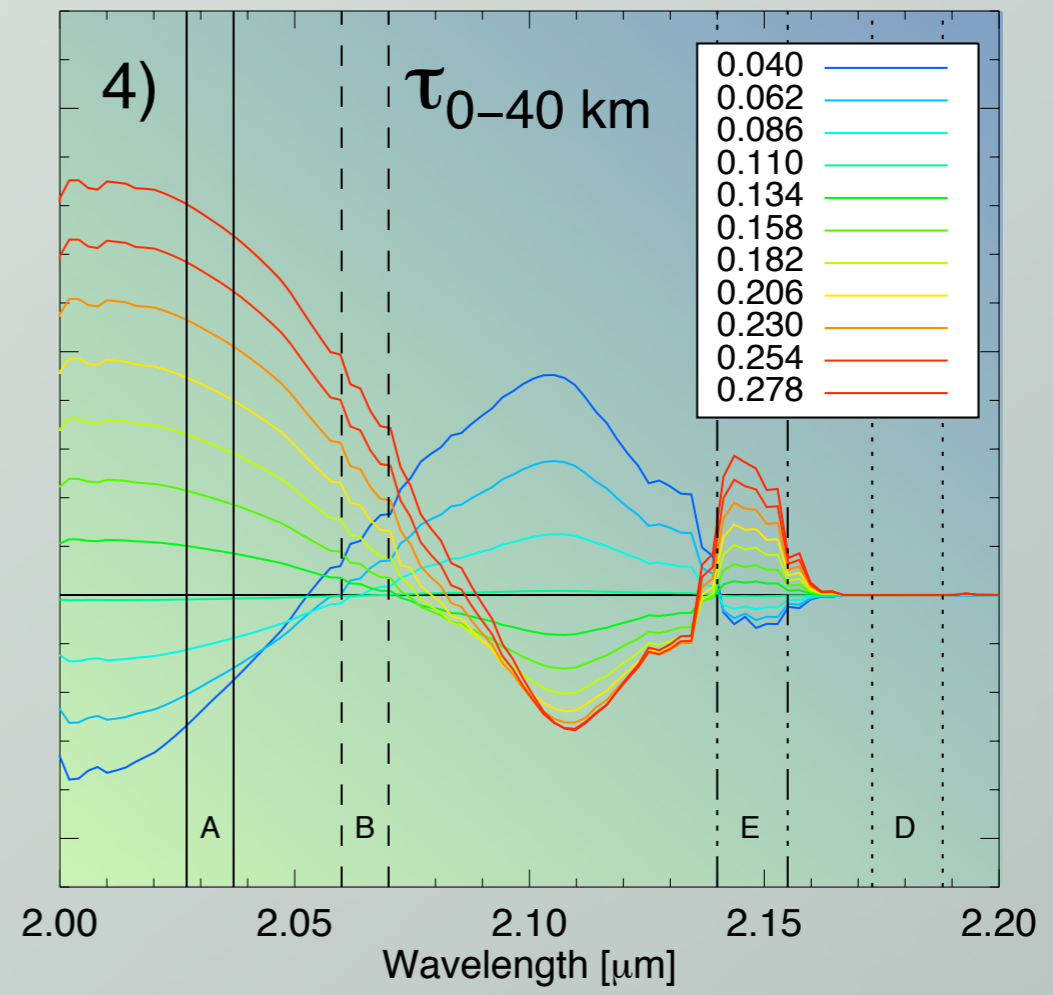
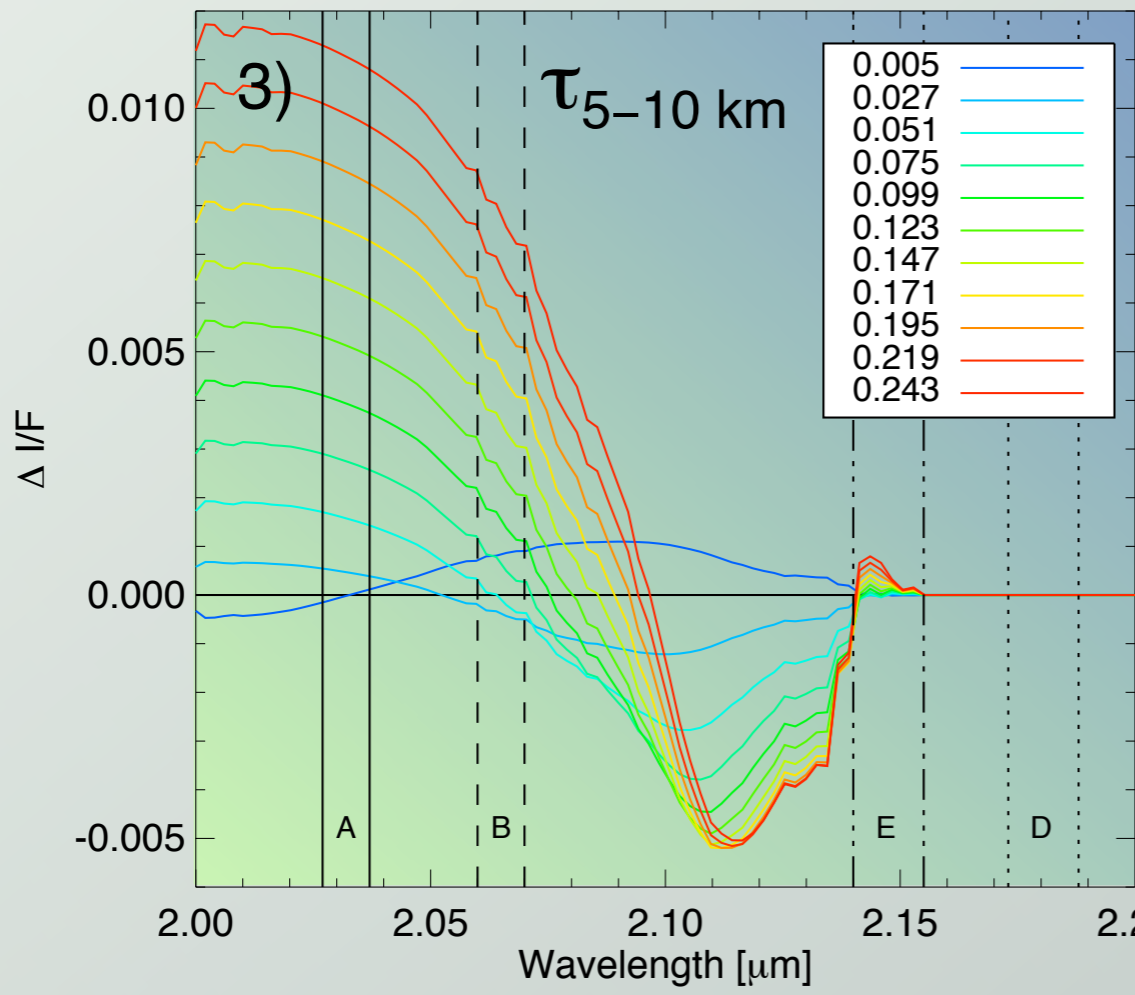
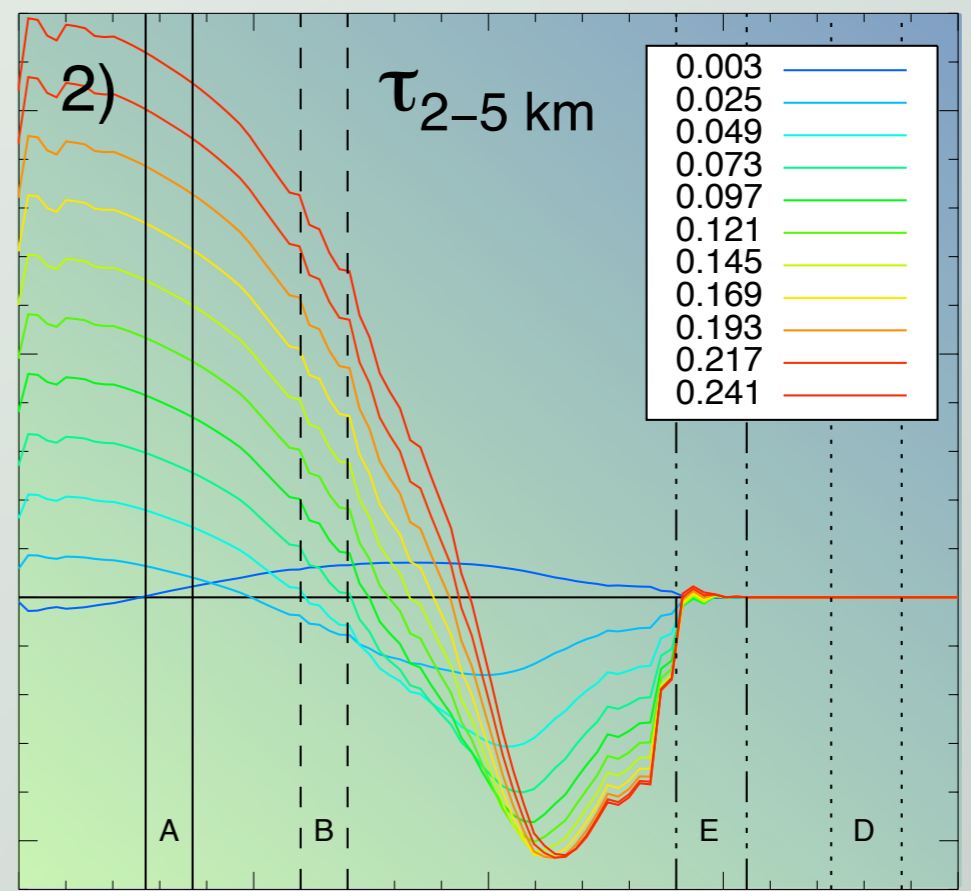
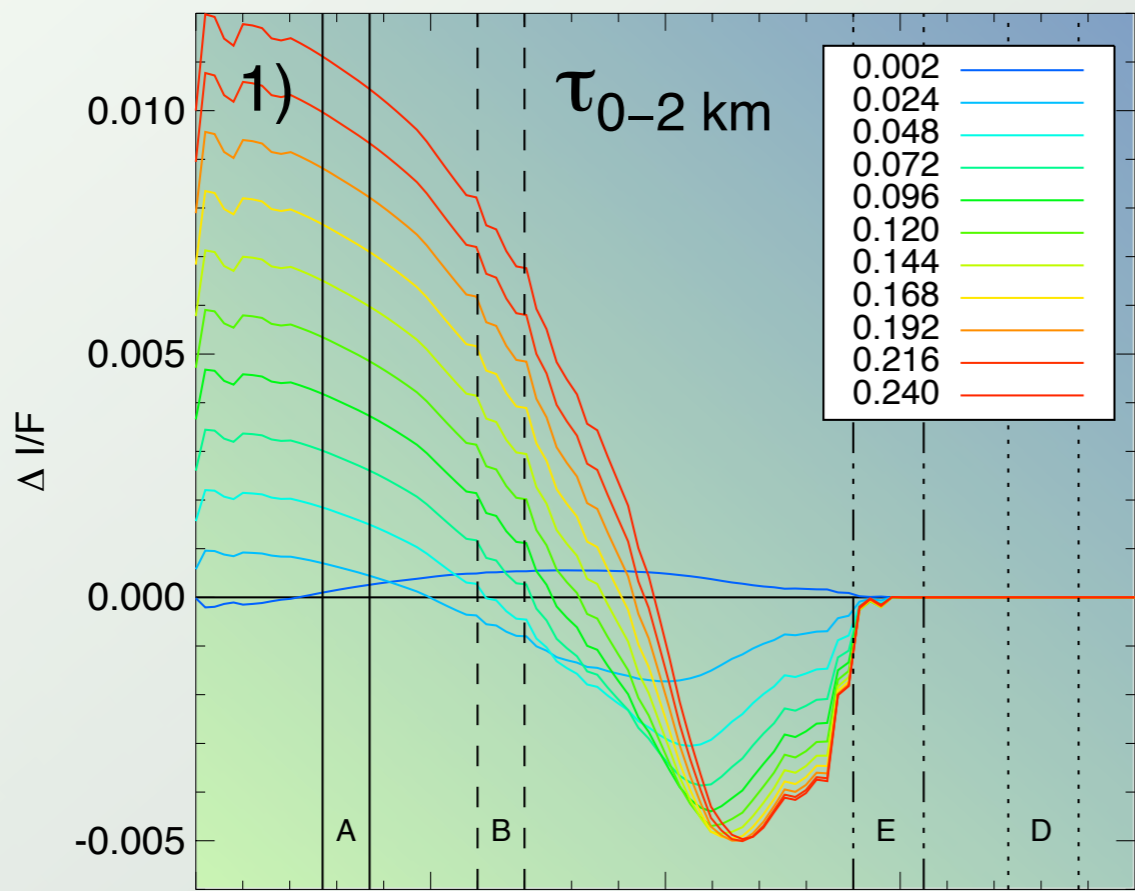


[2.175-2.185 μ m]



Tropospheric Opacity Retrieval





What have we learned so far?

- Surface reflectivity ~10% greater than observed I/F
- South Polar Haze (SPH) enhancement localized (in altitude) above the tropopause, sink of CH₄ not in direct contact with surface.
- Near-surface opacity due to CH₄ droplets is measured and may be dominant method for deposition of CH₄

Problems to overcome (in pipeline?)

- Mosaicking uncertainty and sub-pixel alignment.
- Relative flux/poor weather problems.

