

Determinations of Titan's methane and haze variability

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Background: Cassini ISS

Overview

Variability of Titan's methane and haze

Cassini VIMS observations of methane and haze variation

Use Huygens site constraints to derive latitudinal profiles of methane and haze from VIMS and Keck determinations of relative profiles:

- CH_3D latitudinal profiles from Keck observations
- Methane and haze latitudinal profiles from VIMS observations
- Origin of the haze North/South asymmetry
- Solar heating variation

Variability in Titan's methane and haze

Clouds and lakes suggest spatial and seasonal variation in humidity:

- Near summer solstice, large clouds concentrated at S pole and 40° - 60° S
- Near equinox, clouds detected at tropical latitudes and near N polar lakes
- Lakes asymmetrically concentrate at the poles, and vary with time

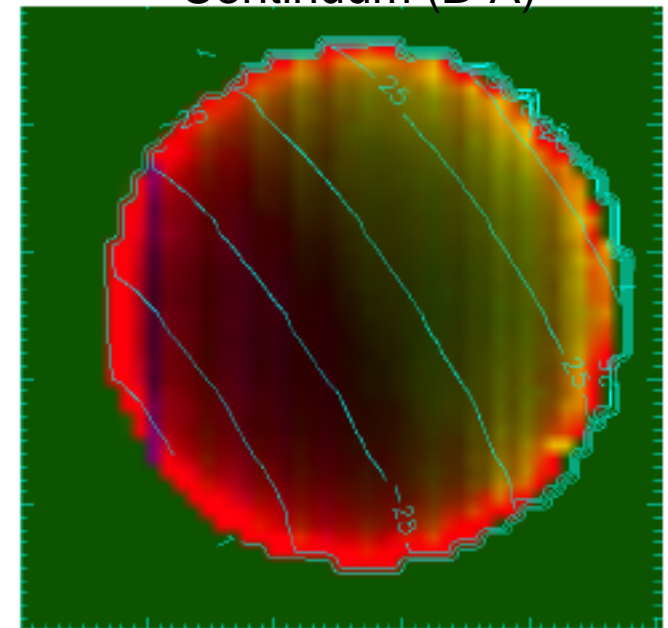
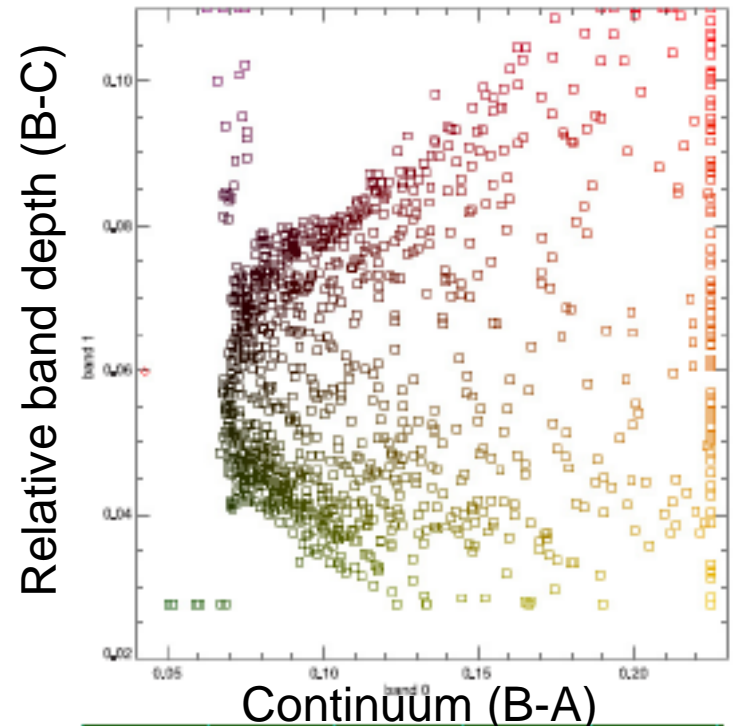
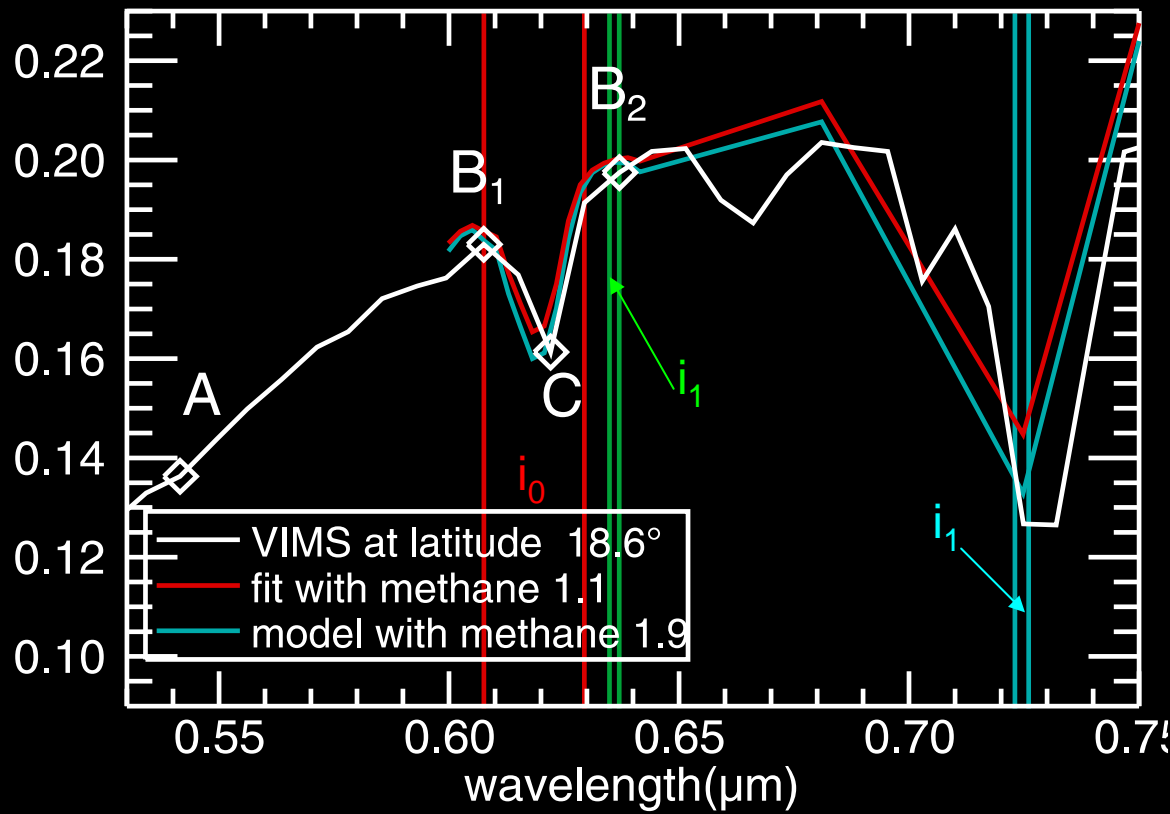
Haze has a pronounced N-S asymmetry

- Asymmetry quickly switches hemispheres near equinox
- Indicates a Hadley circulation moving haze from summer to winter

Haze / methane mapping with VIMS

Cassini VIMS mapping of the 0.61 μm band and nearby continuum show higher band depths on the south

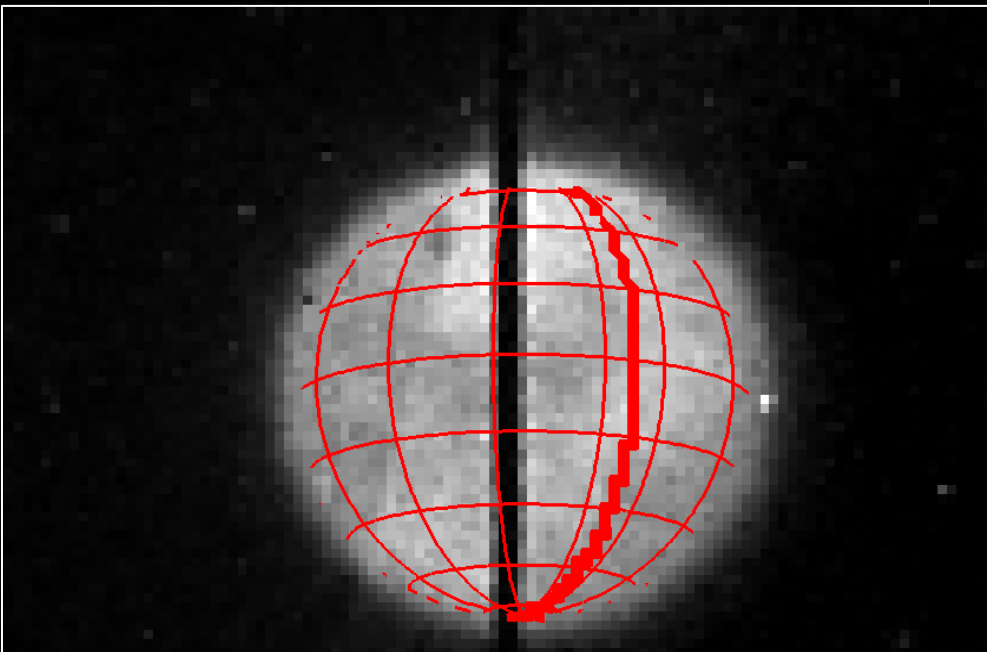
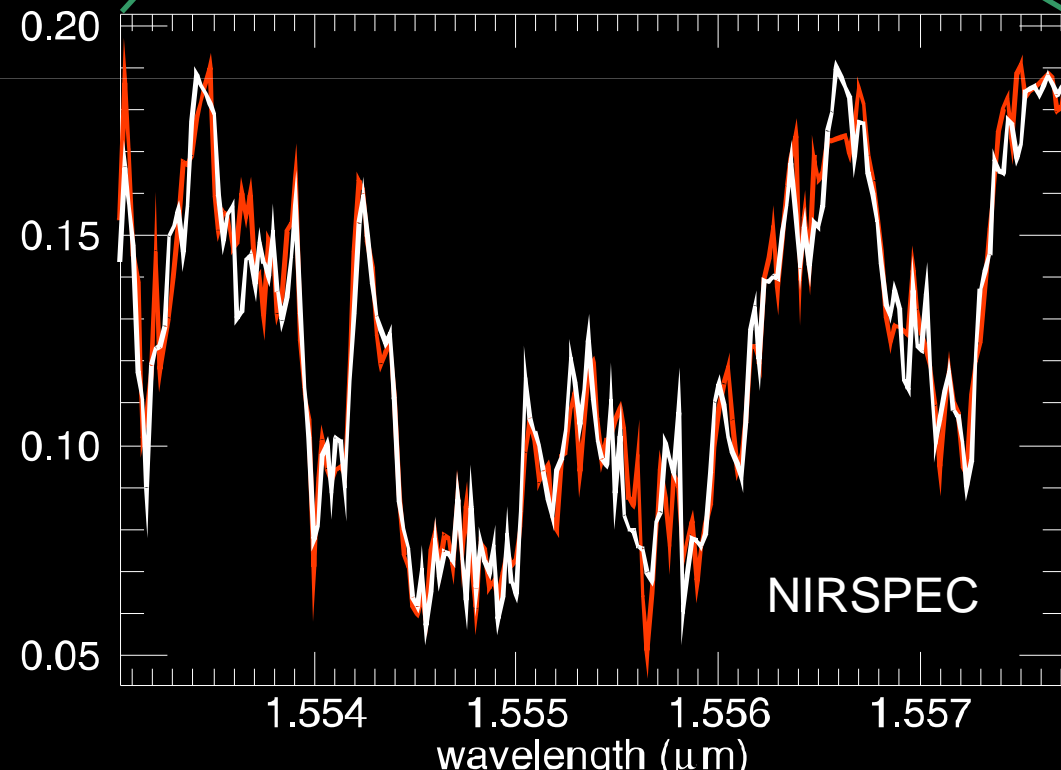
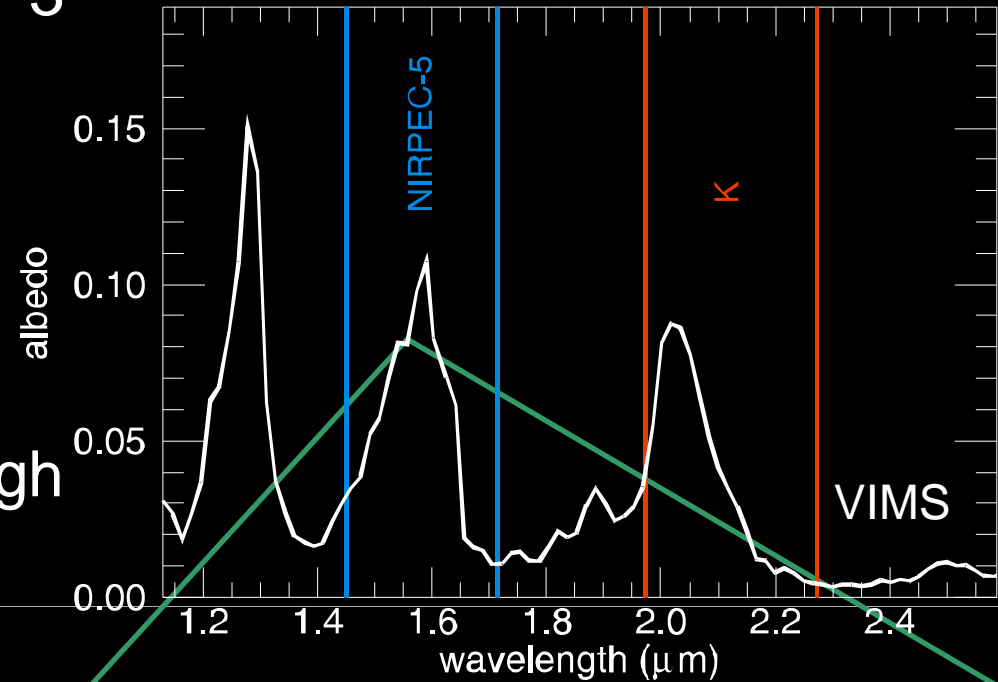
Could be due to more methane or less haze towards the south



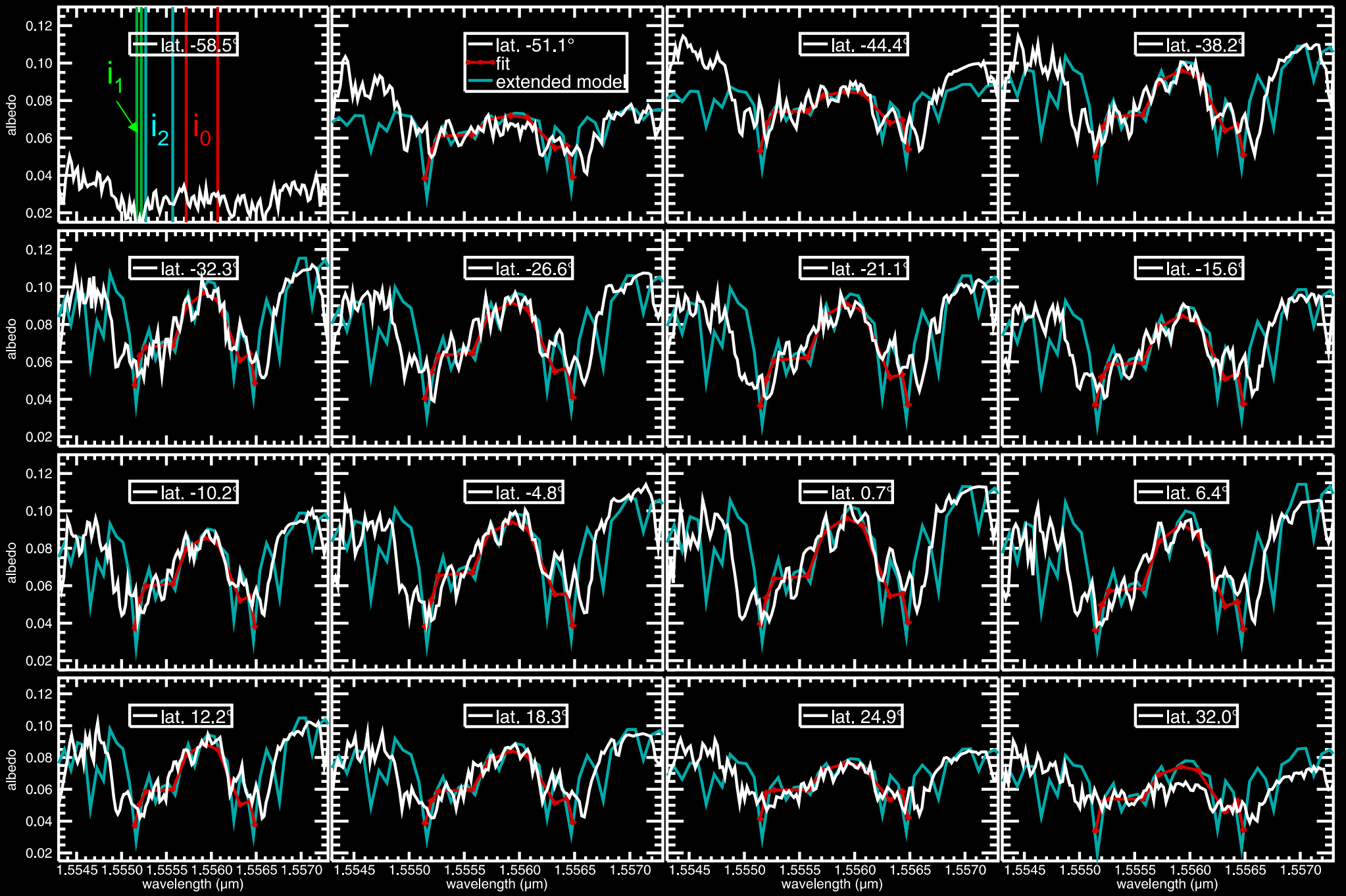
Keck observations of CH₃D lines

- Weaker haze effects
- Unsaturated CH₃D lines
- Sensitive to methane variations below 10 km altitude

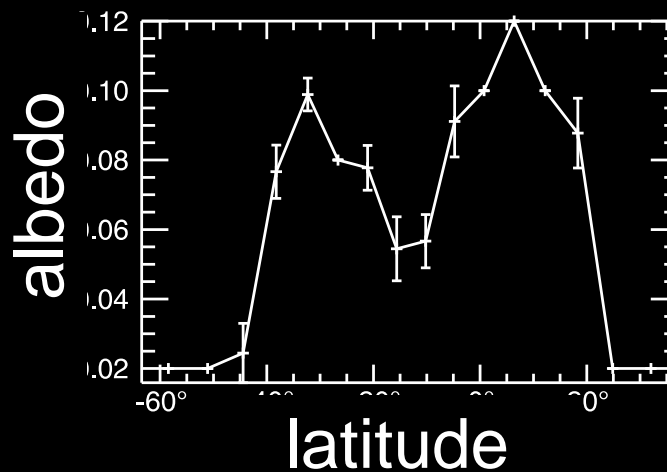
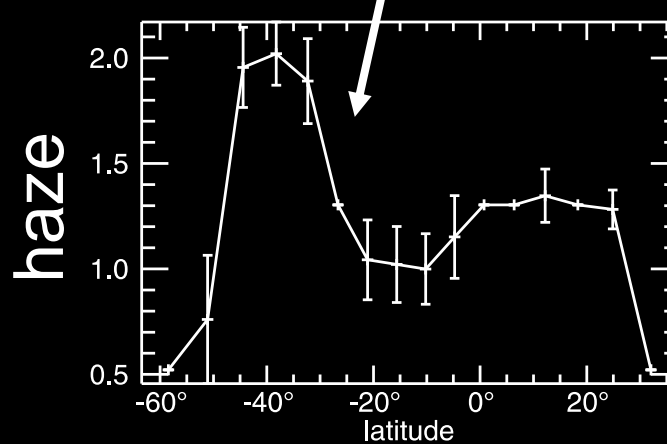
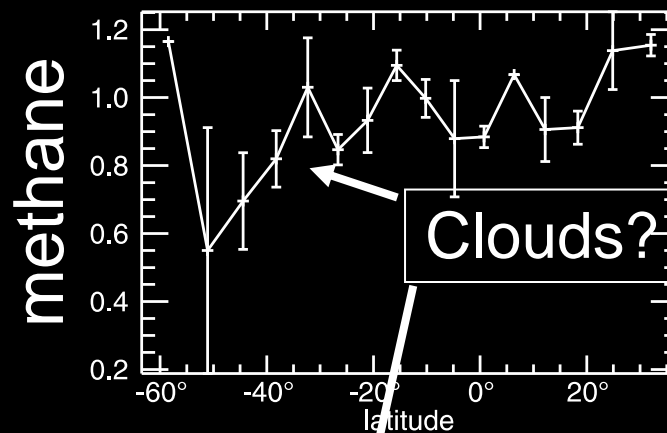
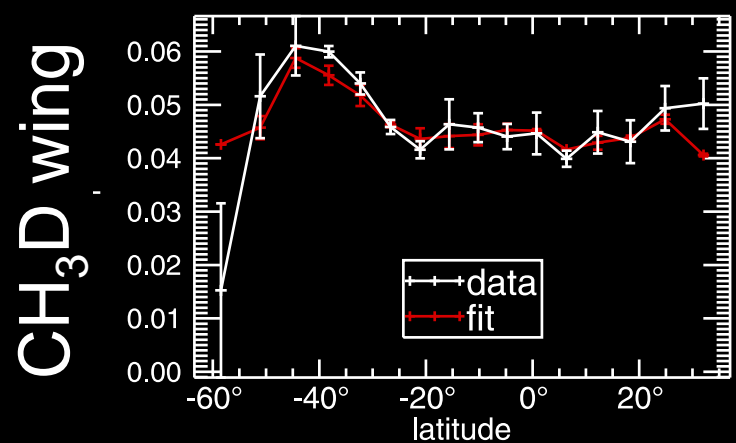
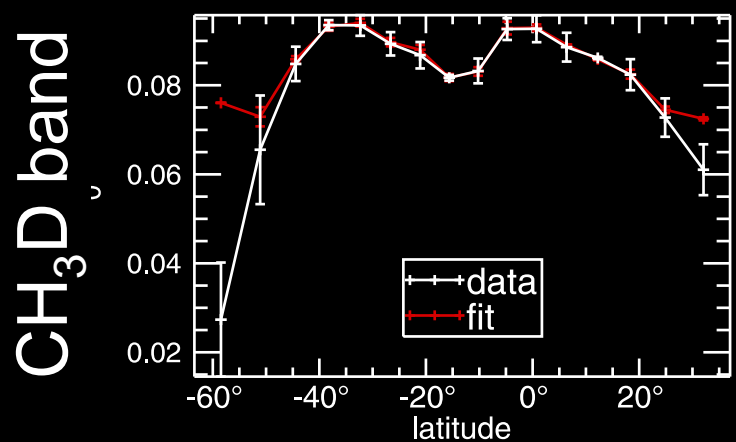
• Keck + NIRSPEC/AO provide enough spatial and spectral resolution to measure the CH₃D variation



Spectral variation observed

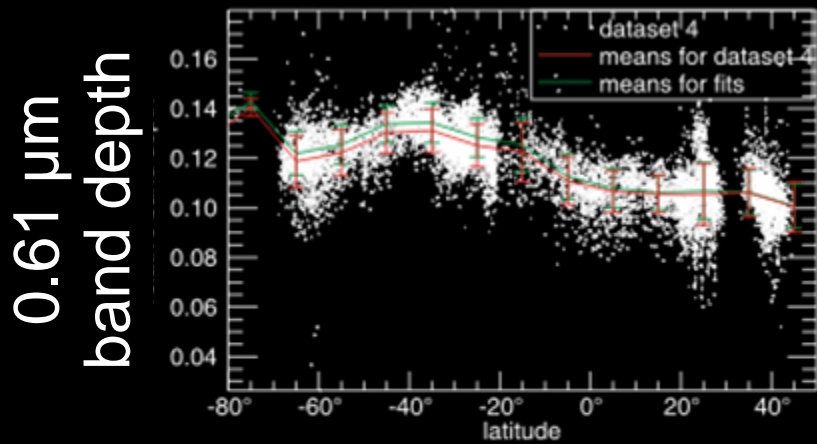


Latitudinal variation of spectra and determined parameters



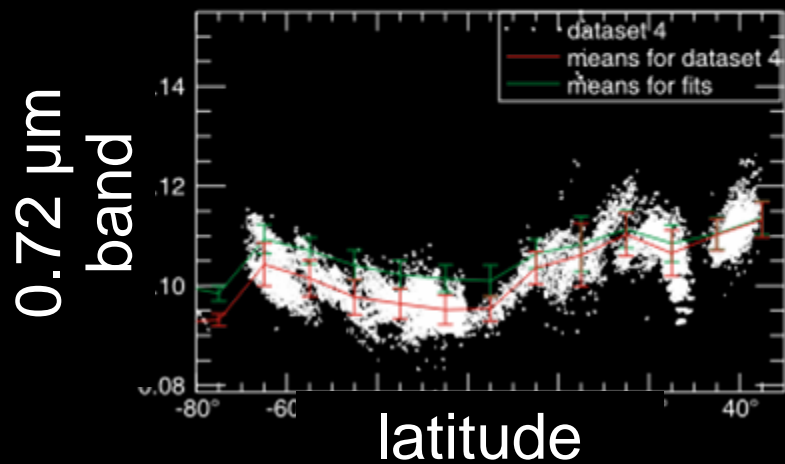
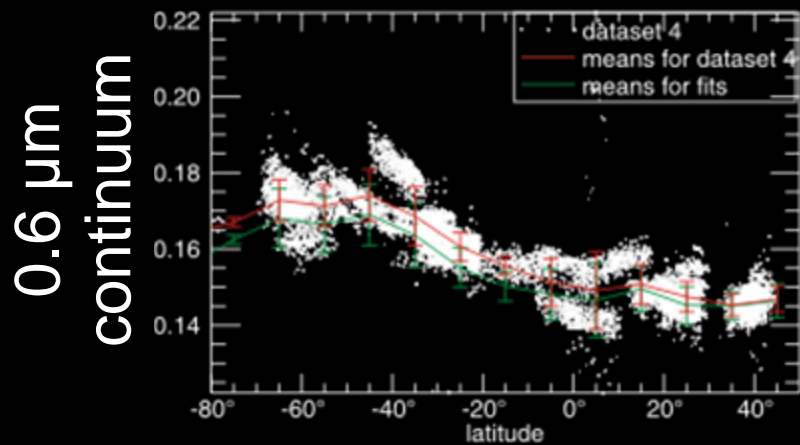
Methane
does not vary
by more than
20% over
35° S-18° N

Cassini VIMS observations



Relative 0.61 μm band depth decreases towards the north

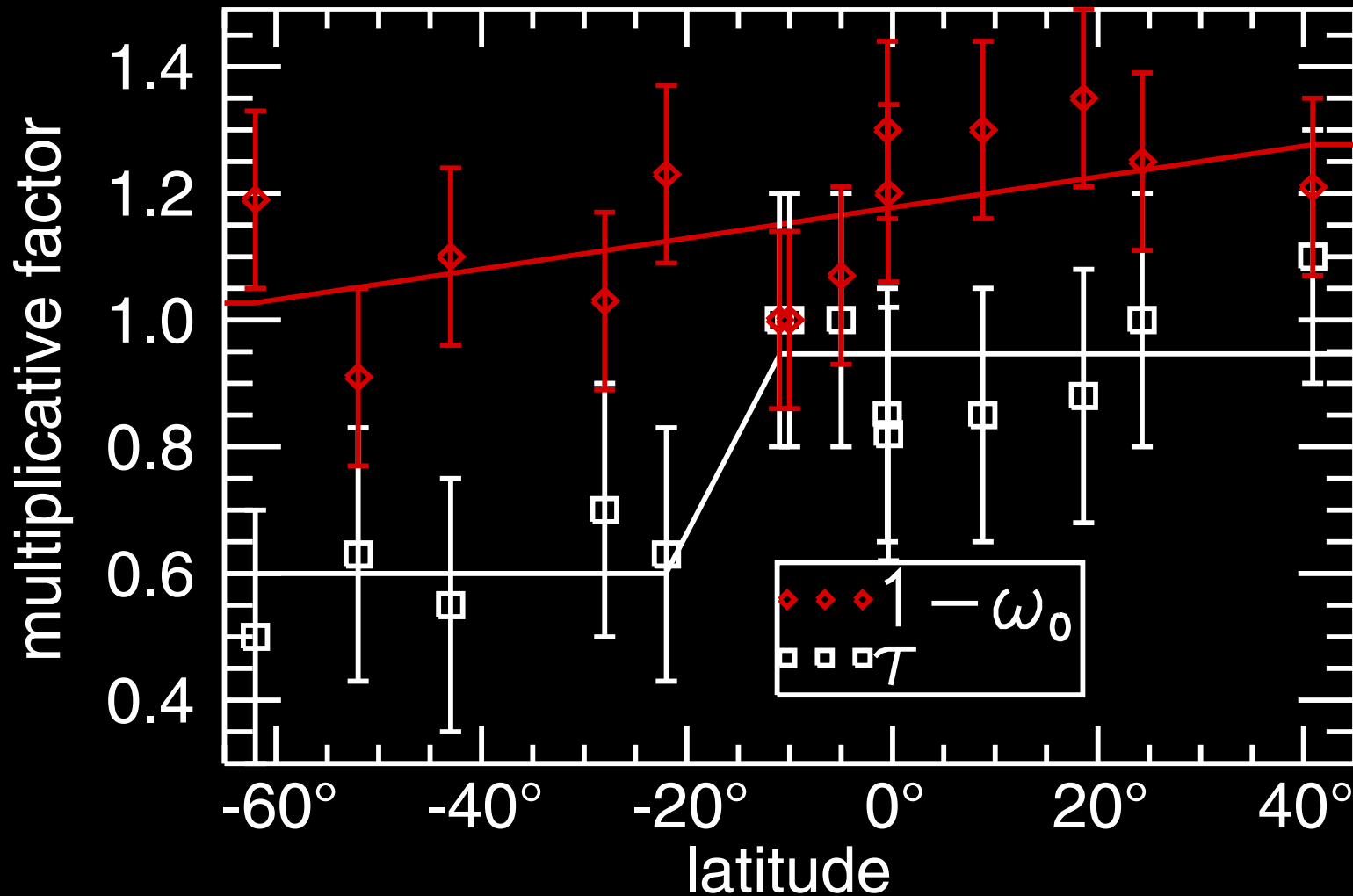
Can indicate less methane or more haze (obscure methane) towards the north



Haze derived from constant methane

Spectral variation can be reproduced without methane change

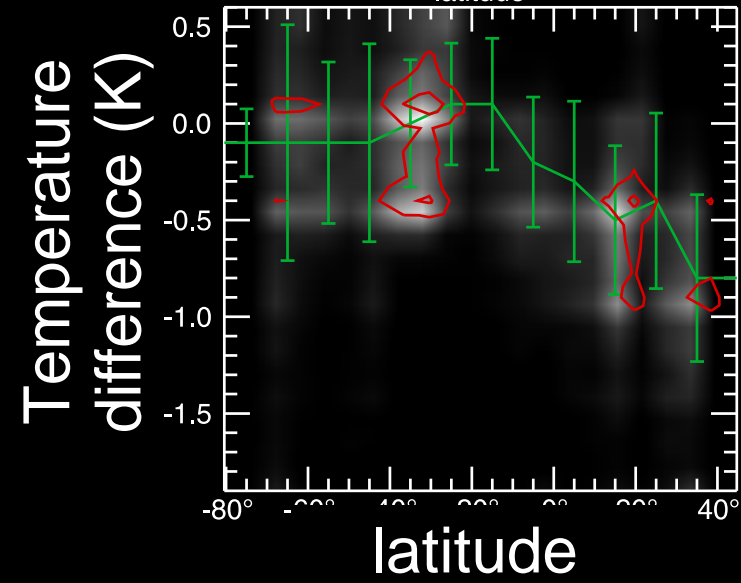
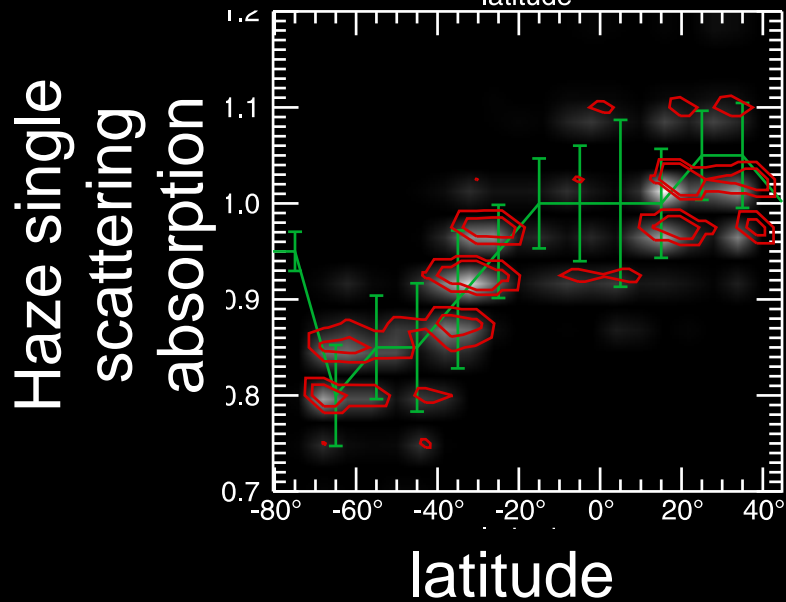
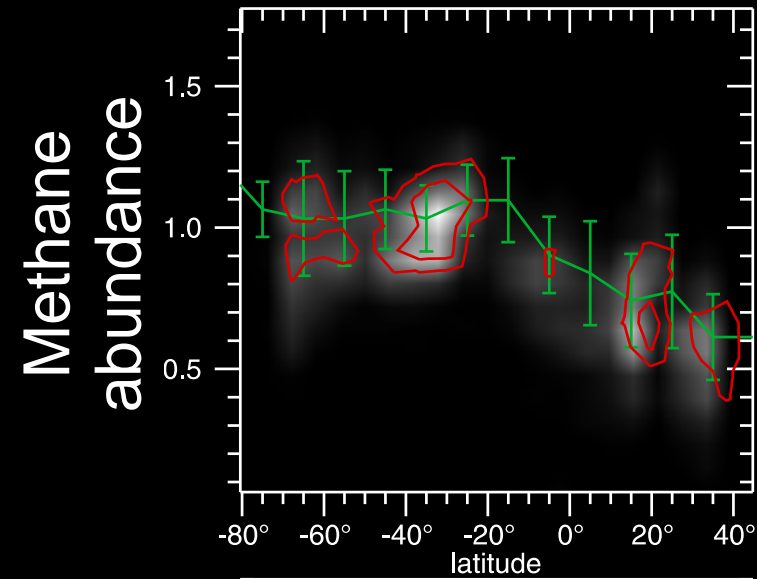
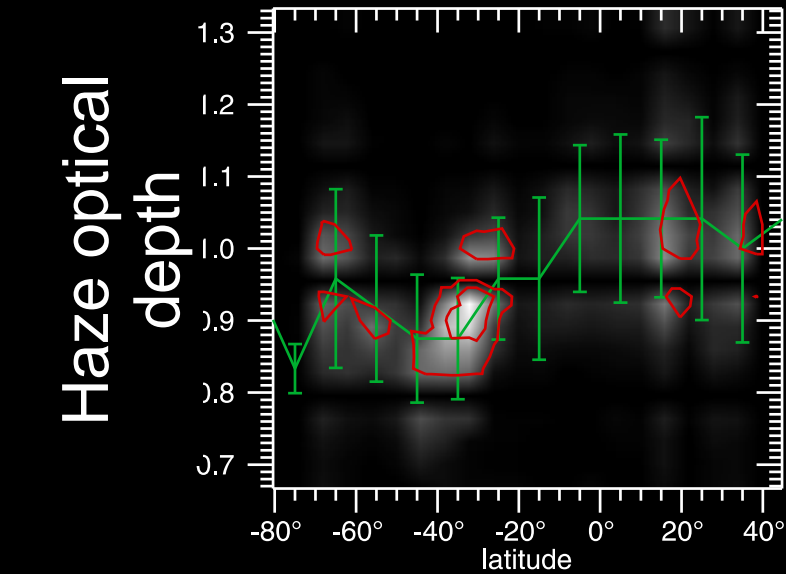
60% increase in haze above 80 km between 20° S and 10° S



Methane derived minimizing haze variation

Spectra can also be fit with a 50% drop in methane and 20% increase in haze (above 80 km) over 25° S-35° N.

Equivalent to a 1.5 K tropopause temperature drop

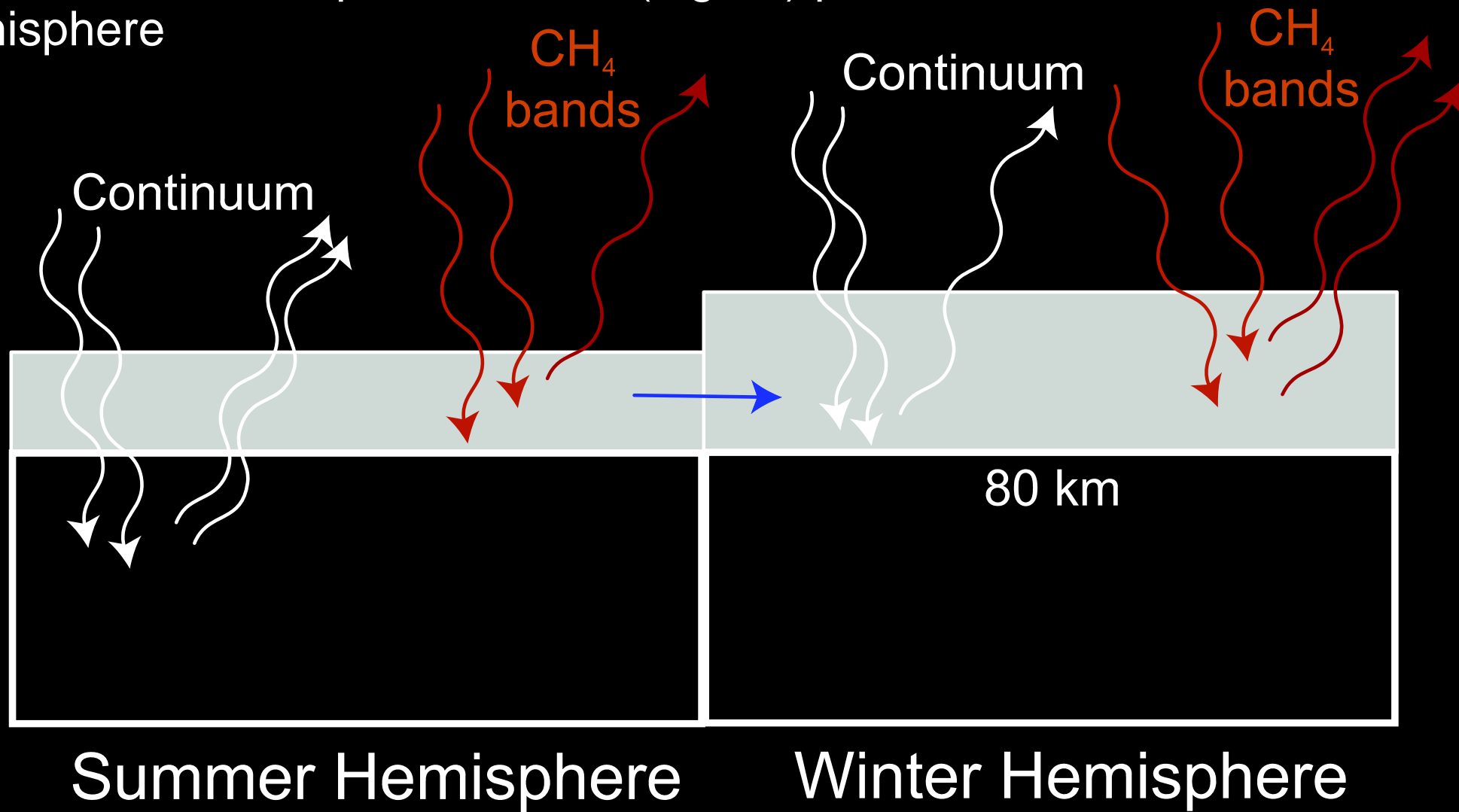


NSA origin

In the continuum, more haze causes more absorption: darker in the visible

In the CH_4 bands, more haze causes more scattering by haze before absorption by CH_4 : brighter in the IR

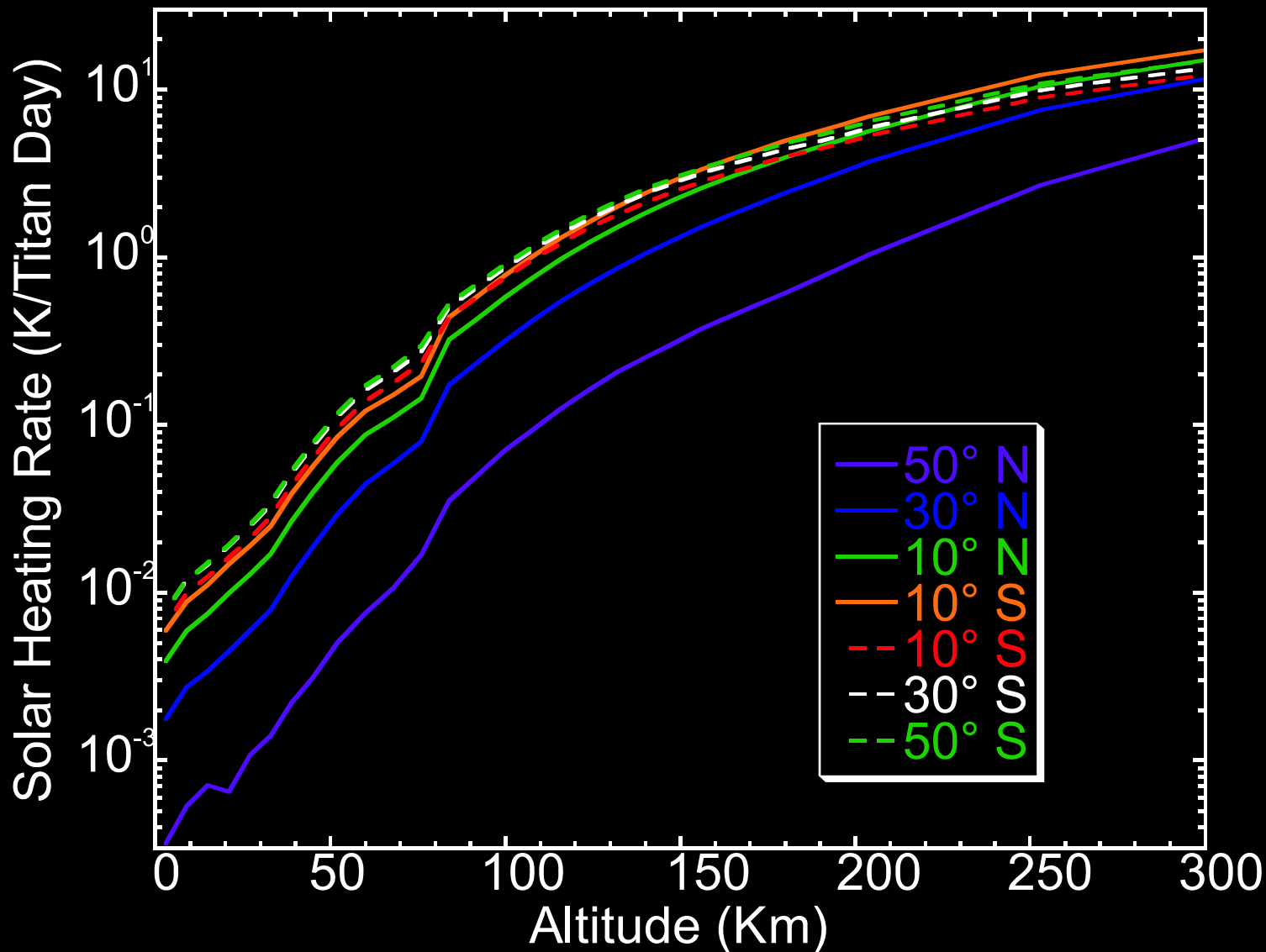
NSA indicates transport of darker (higher) particles to the winter hemisphere



Solar heating variation

The 60% increase in haze optical depths from S to N mostly changes the altitude of absorption

Changes solar heating by only 10-15% across the S/N boundary



Summary

- Ground-based observations of CH_3D probe Titan's methane below 10 km altitude:

No variation above 20% over 35° S - 18° N

- Cassini VIMS spectra probe Titan's methane near the tropopause (20-50 km altitude):

Methane and haze variations are coupled

From a constant methane abundance to a 50% drop over 27° S – 19° N

Haze above 80 km increases by up to 60% from S to N

- Haze variation consistent with transport of darker particles above 80 km from summer to winter hemisphere (as proposed by Lorenz et al. 1999)

- Haze asymmetry changes solar heating by only 10-15%