

Titan's Methane Weather

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We started the week hearing about cosmology, large scale structure, & galaxy formation. Today we zoomed in to extrasolar planets. So, let's zoom in from thinking about planet's around other stars to an object in our own solar system

Today I would like to talk about a project we have been working on using Gemini and other telescopes to study weather and climate on Saturn's largest moon Titan.

Acknowledge collaborators.

I would like to spend the first few minutes giving a brief introduction to Titan.



Gregory Roe (Lowell Observatory)
Thomas Schaller (IfA, University of Hawaii)
Michael Brown (Caltech)
Chadwick Trujillo (Gemini Observatory)

20 May 2009 - Joint Subaru/Gemini Science Meeting

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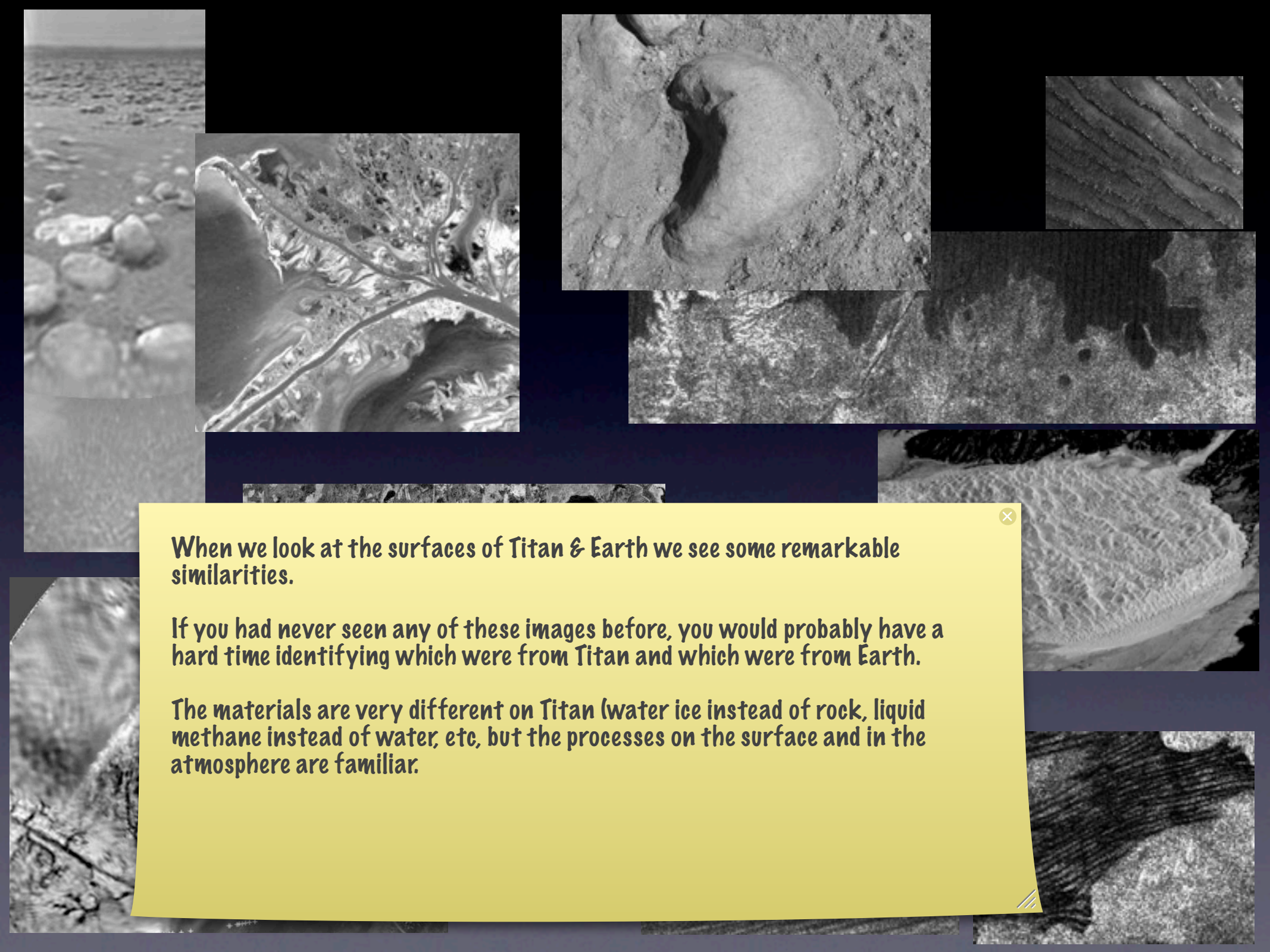
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When we look at the surfaces of Titan & Earth we see some remarkable similarities.

If you had never seen any of these images before, you would probably have a hard time identifying which were from Titan and which were from Earth.

The materials are very different on Titan (water ice instead of rock, liquid methane instead of water, etc, but the processes on the surface and in the atmosphere are familiar.



Titan

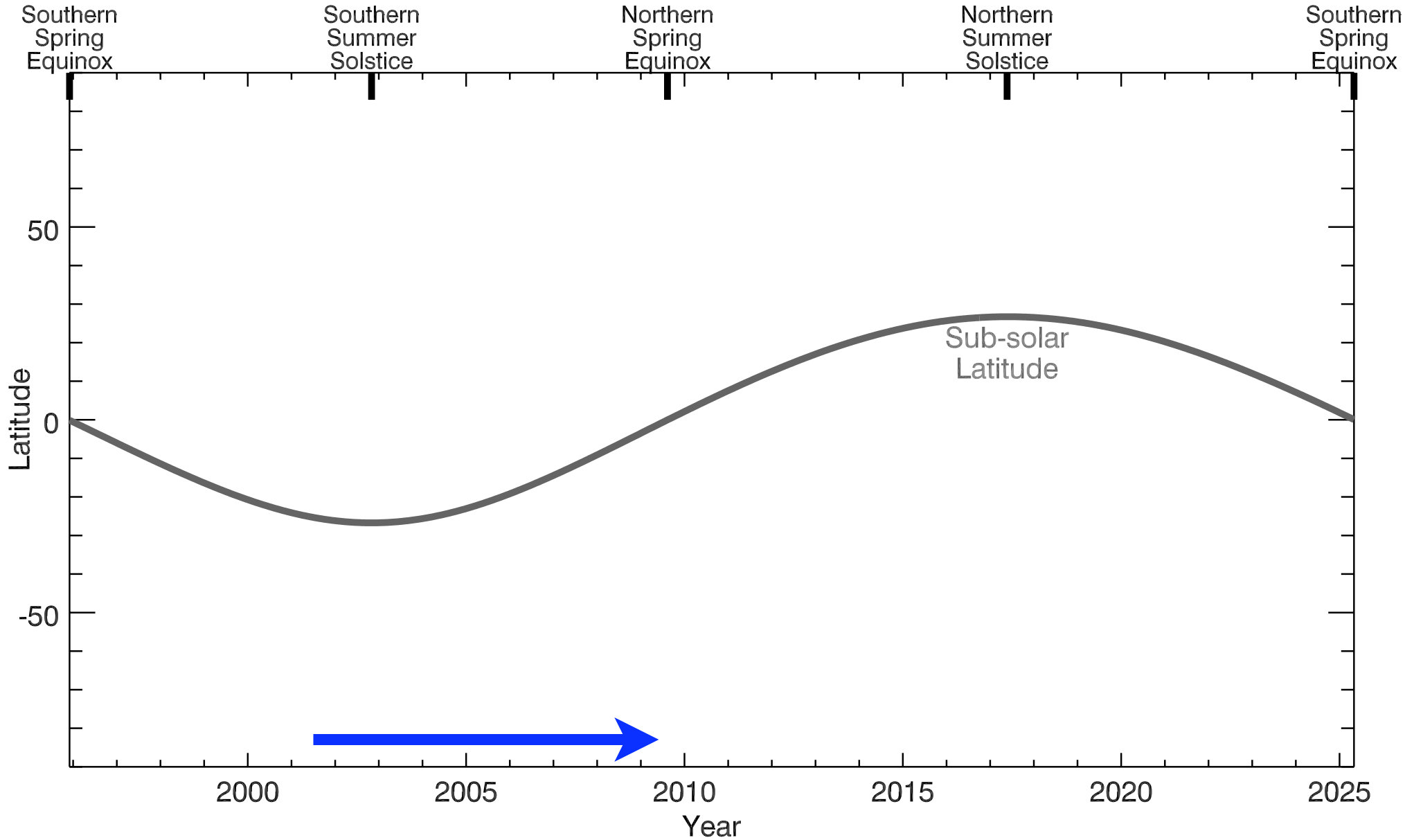
Earth

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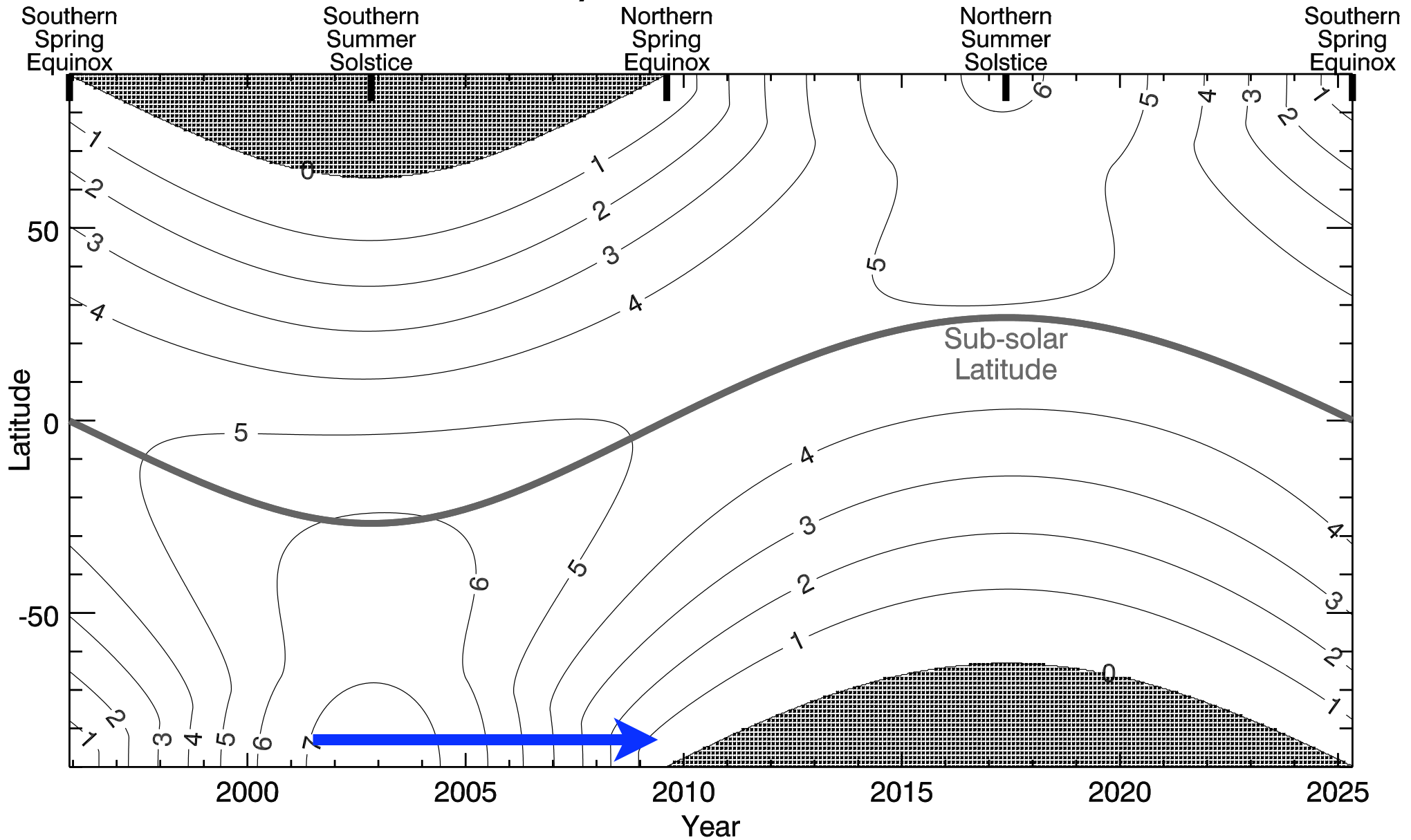
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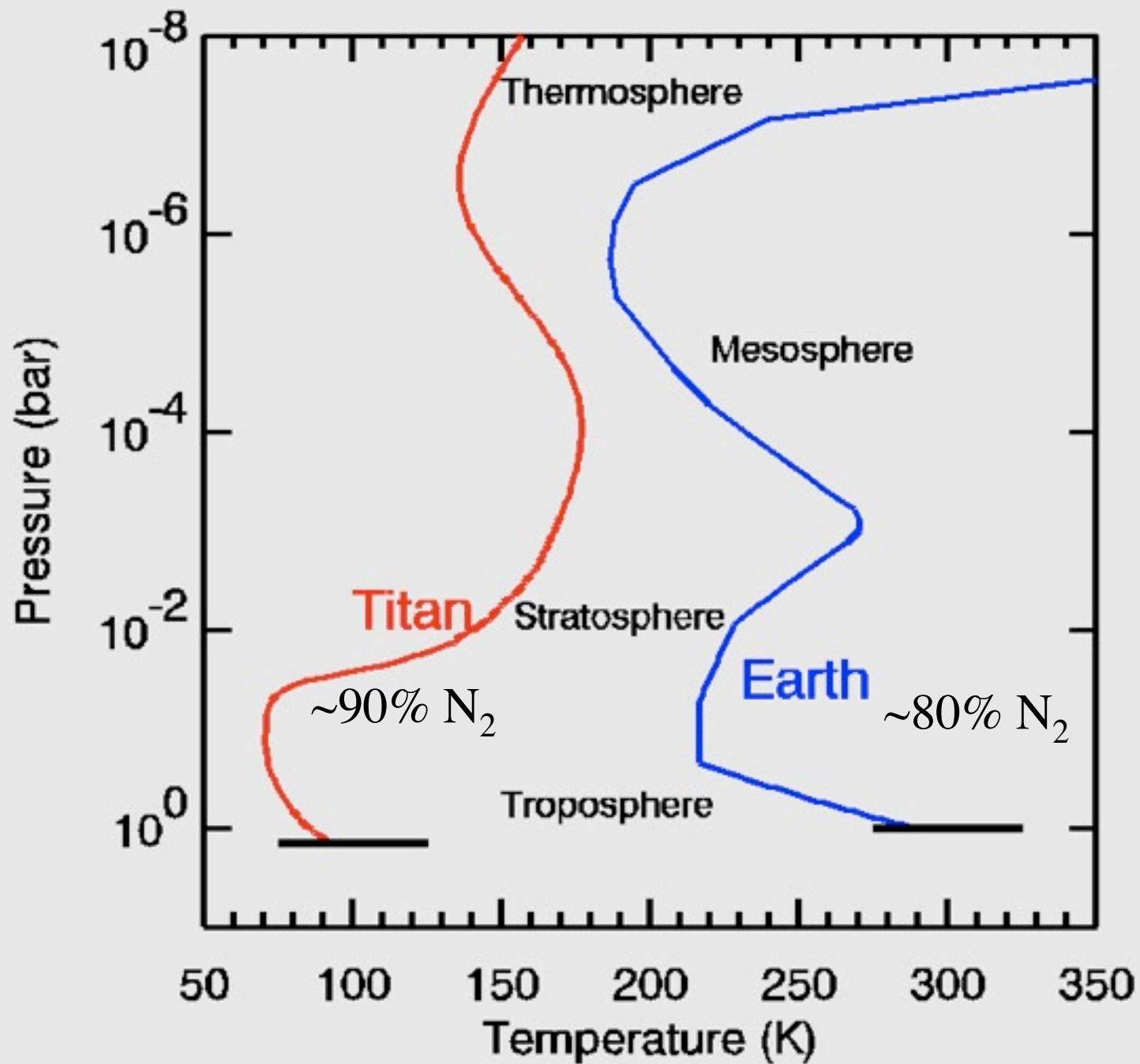
30-year Seasonal Cycle

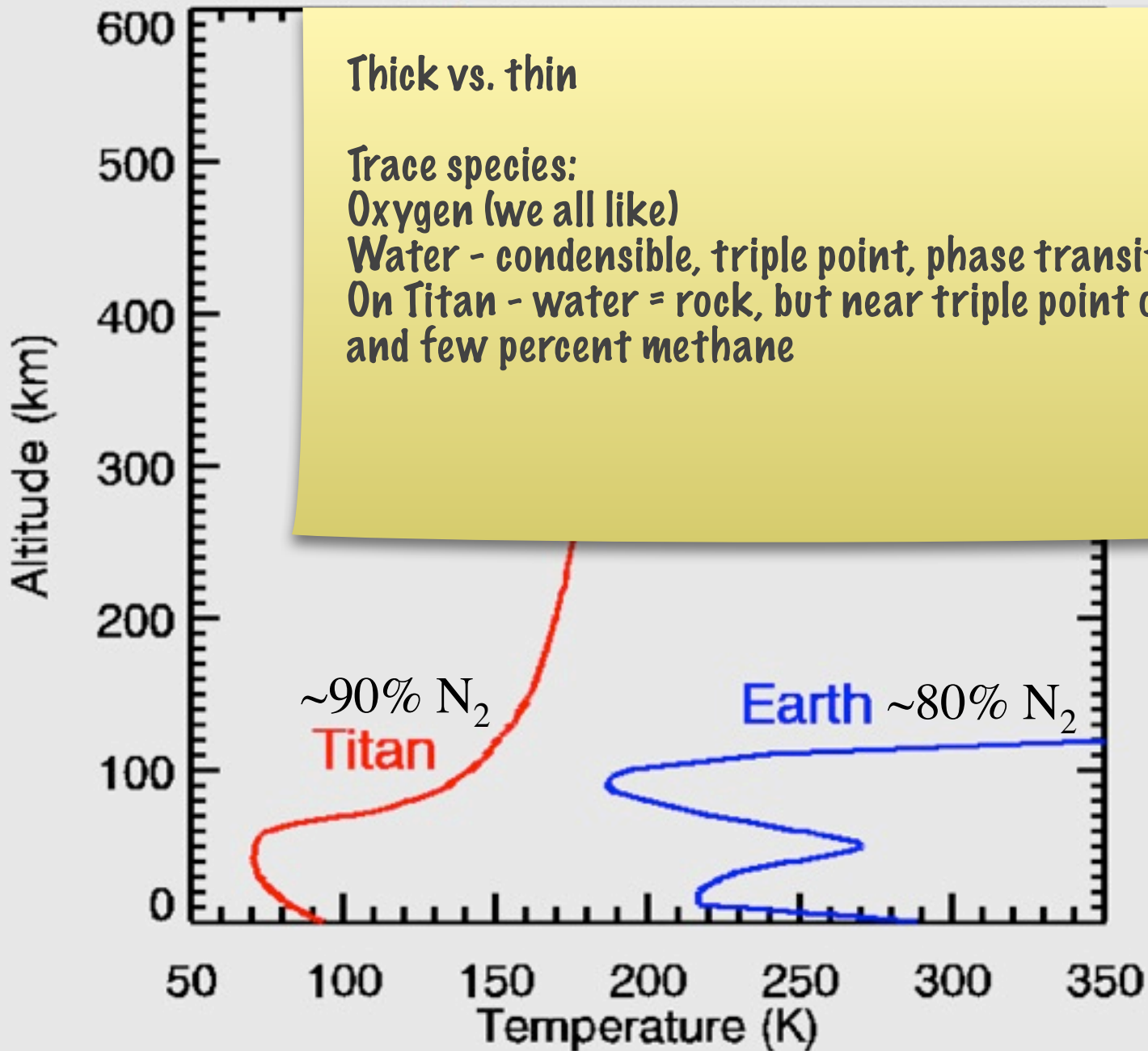


30-year Seasonal Cycle

Mean daily insolation on Titan







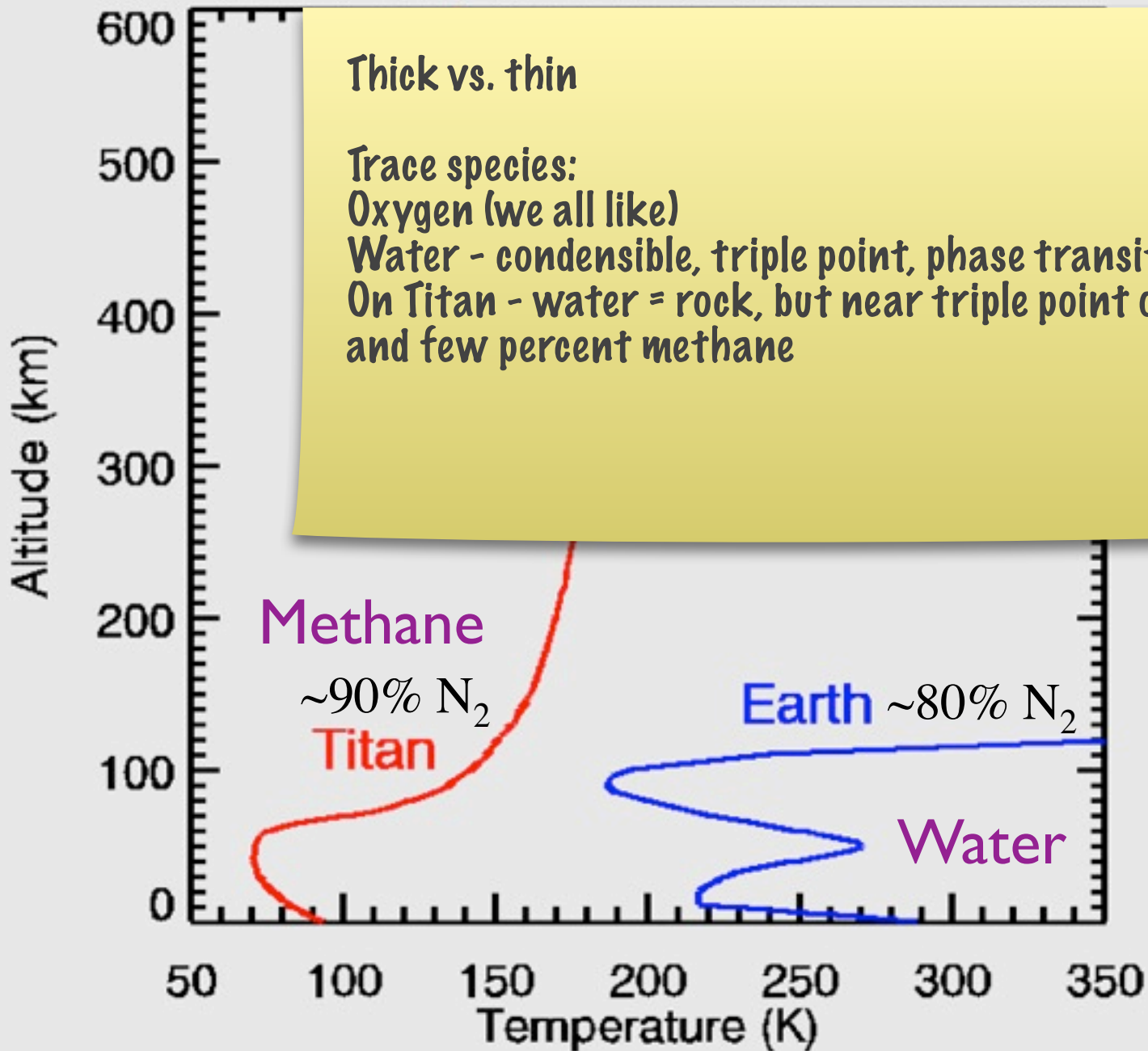
Thick vs. thin

Trace species:

Oxygen (we all like)

Water - condensible, triple point, phase transitions

On Titan - water = rock, but near triple point of methane and few percent methane



Thick vs. thin

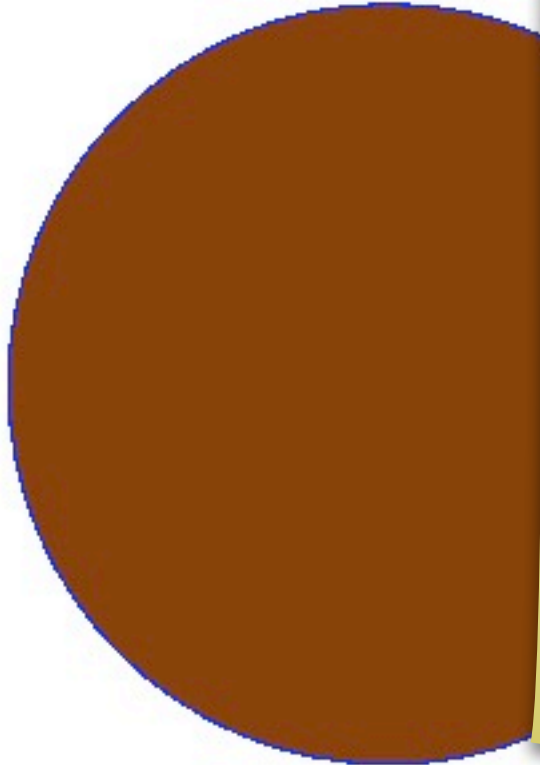
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Earth



Thin shell

even though surface area
much less:

Titan/Earth atmos mass = 2x

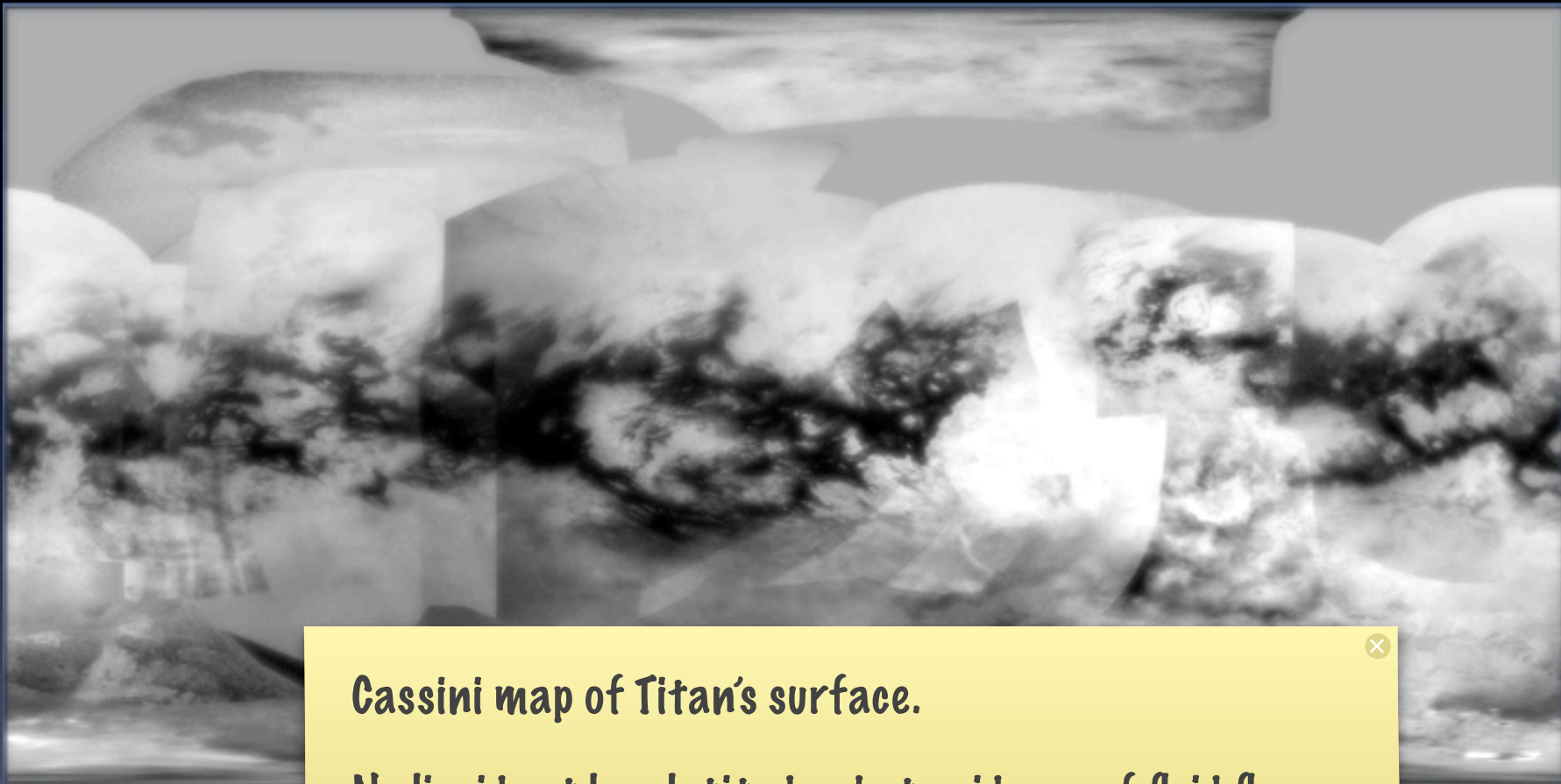
Titan: 4m/10cm

Earth: 1-10cm/1m

With that much condensable in the
atmosphere, where's liquid on surface?
How to look for it?

Solid
Atmosphere

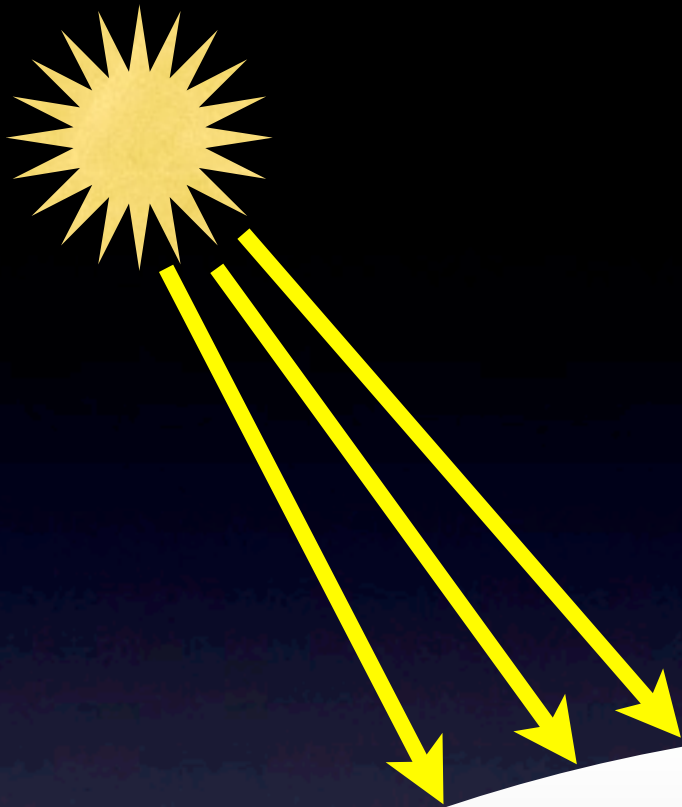
Titan's Surface Mapped by Cassini



Cassini map of Titan's surface.

No liquids at low latitudes, but evidence of fluid flow everywhere. Lots of lakes in North, a few in south.

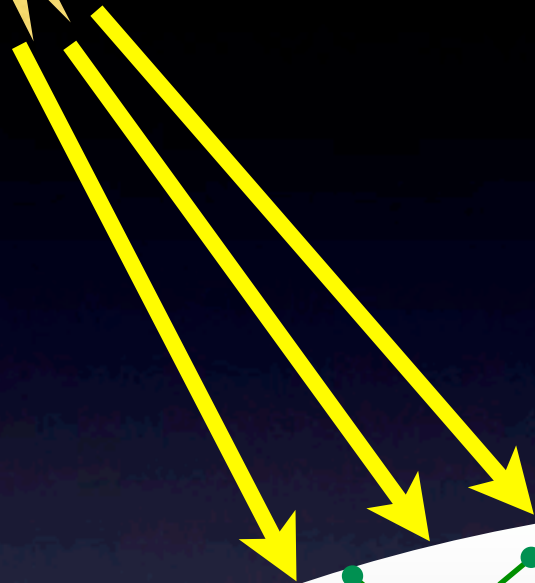
opportunity to discuss, temporal coverage of Cassini vs. ground-based



 Methane

Titan

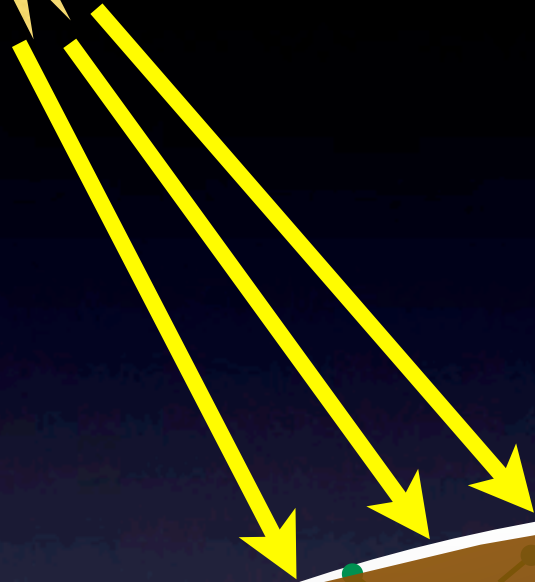
Methane in atmosphere
Irreversible loss of
methane at top of
atmosphere
All methane gone in 10myr



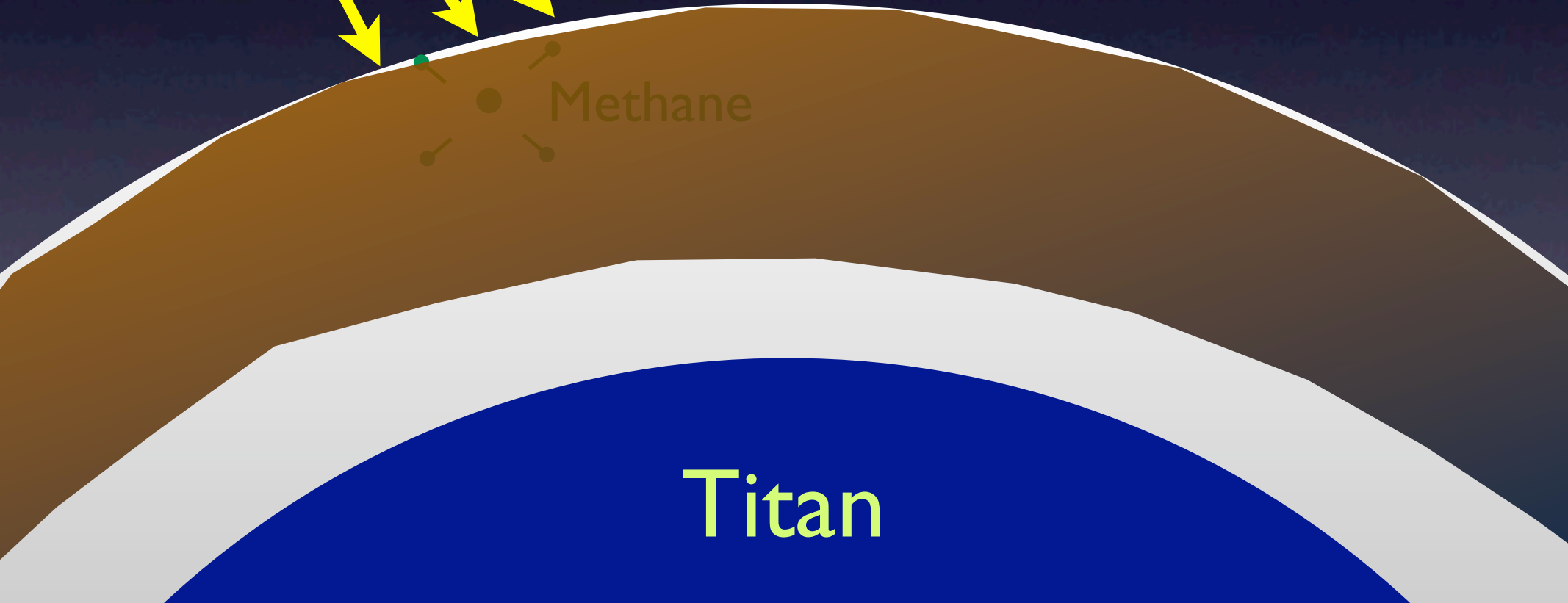
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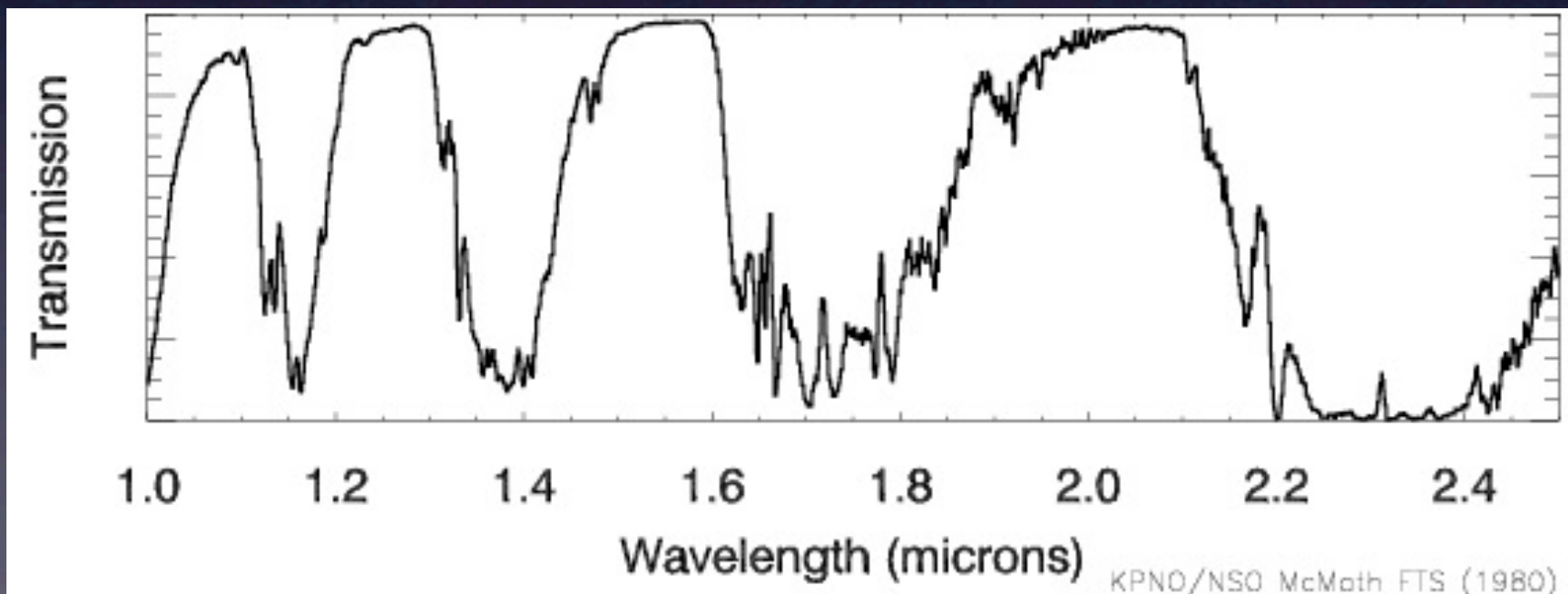
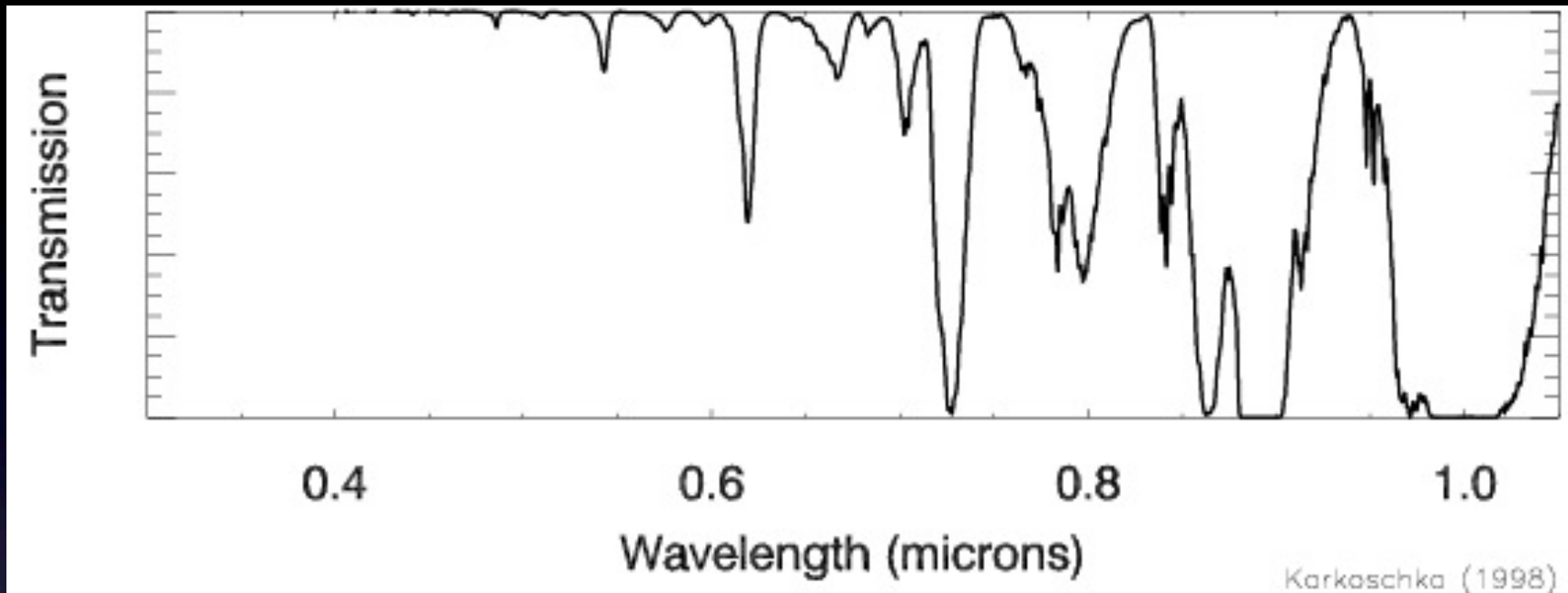
Titan

Methane

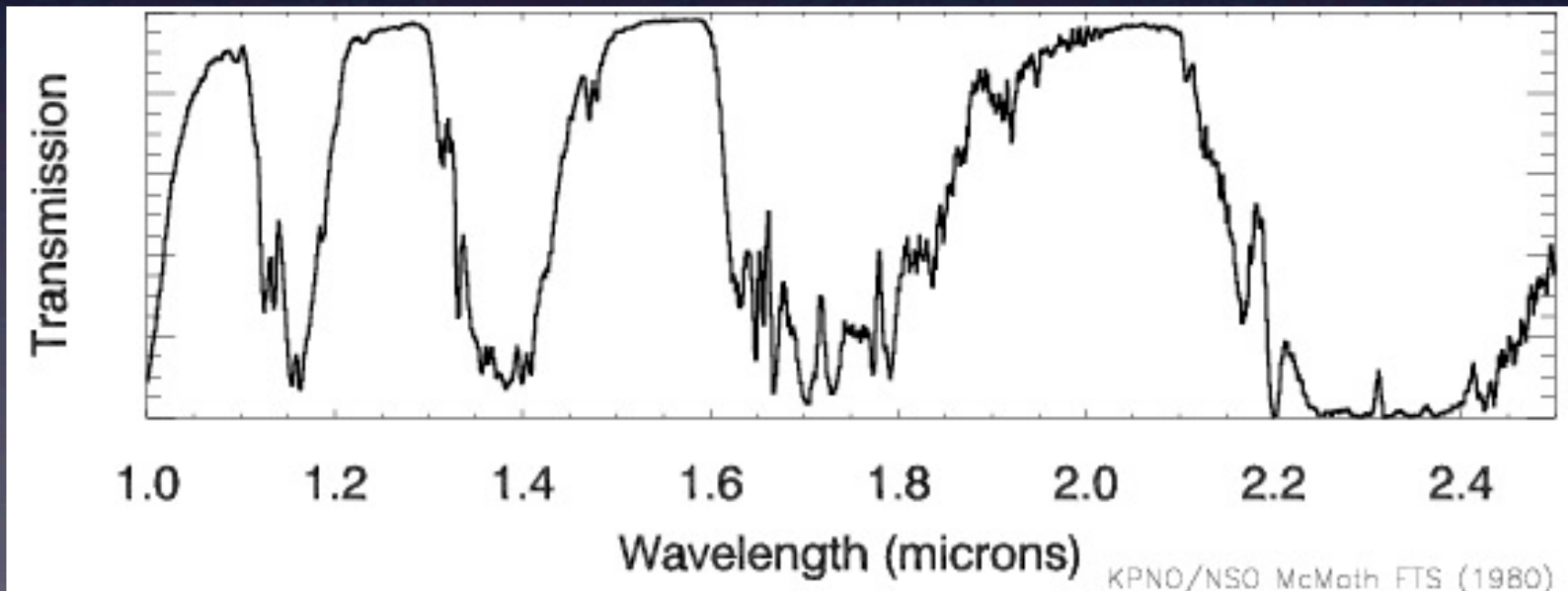
Some Questions

- Methane weather? Where? When? How?
- Source of methane?
- Hydrology/Meteorology: Where? When? How?
- Seasonal climate change; Massive monsoon?

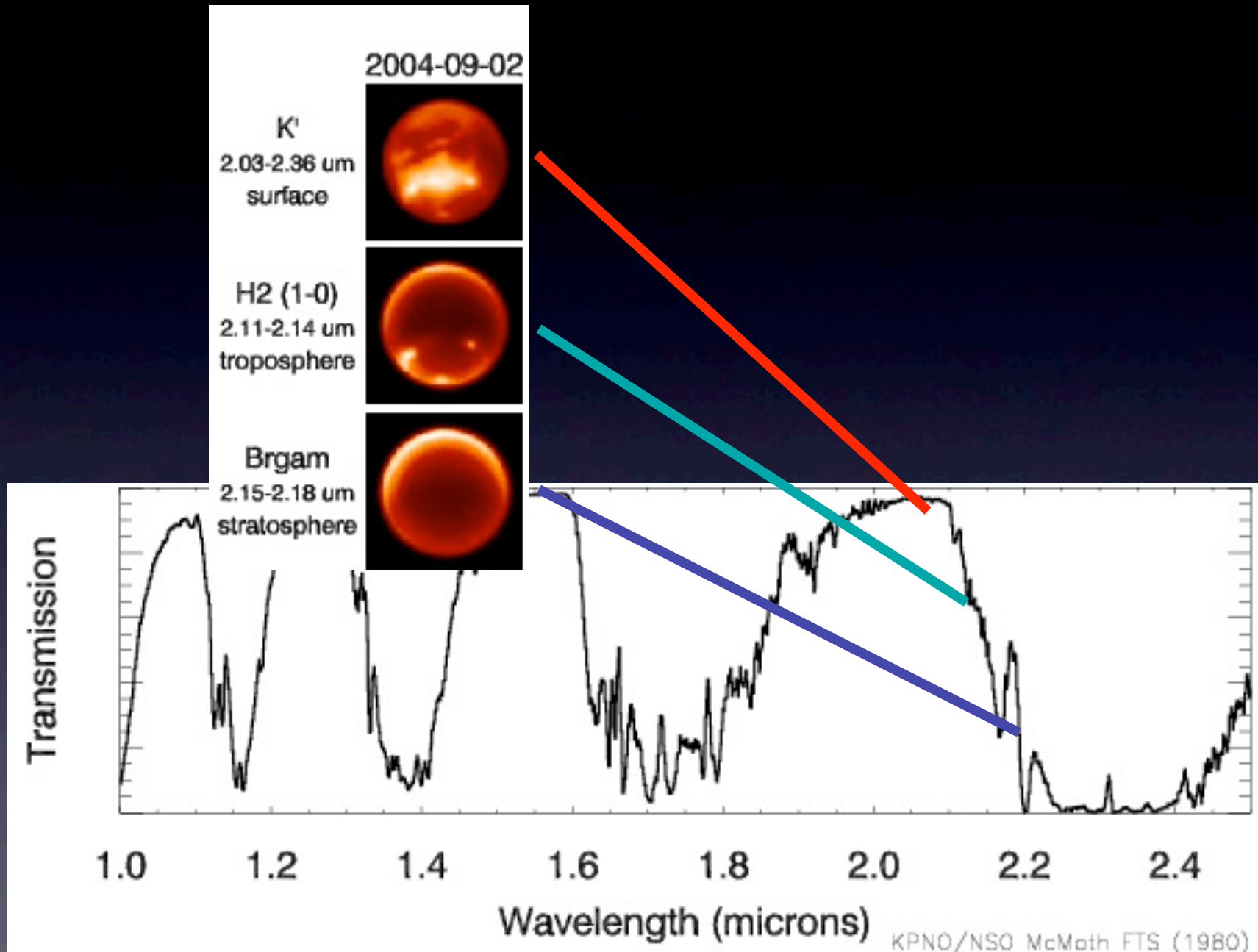
Methane transmission



Methane transmission



Methane transmission





Small angular size

As Joe Jensen discussed on Monday:

Flexibility of Gemini Operations are key

Importance of Queue!

Snapshot needs only 15-20 minutes

Maximize efficient use of Gemini with small telescopes to trigger ToO's and fill-in temporal record.



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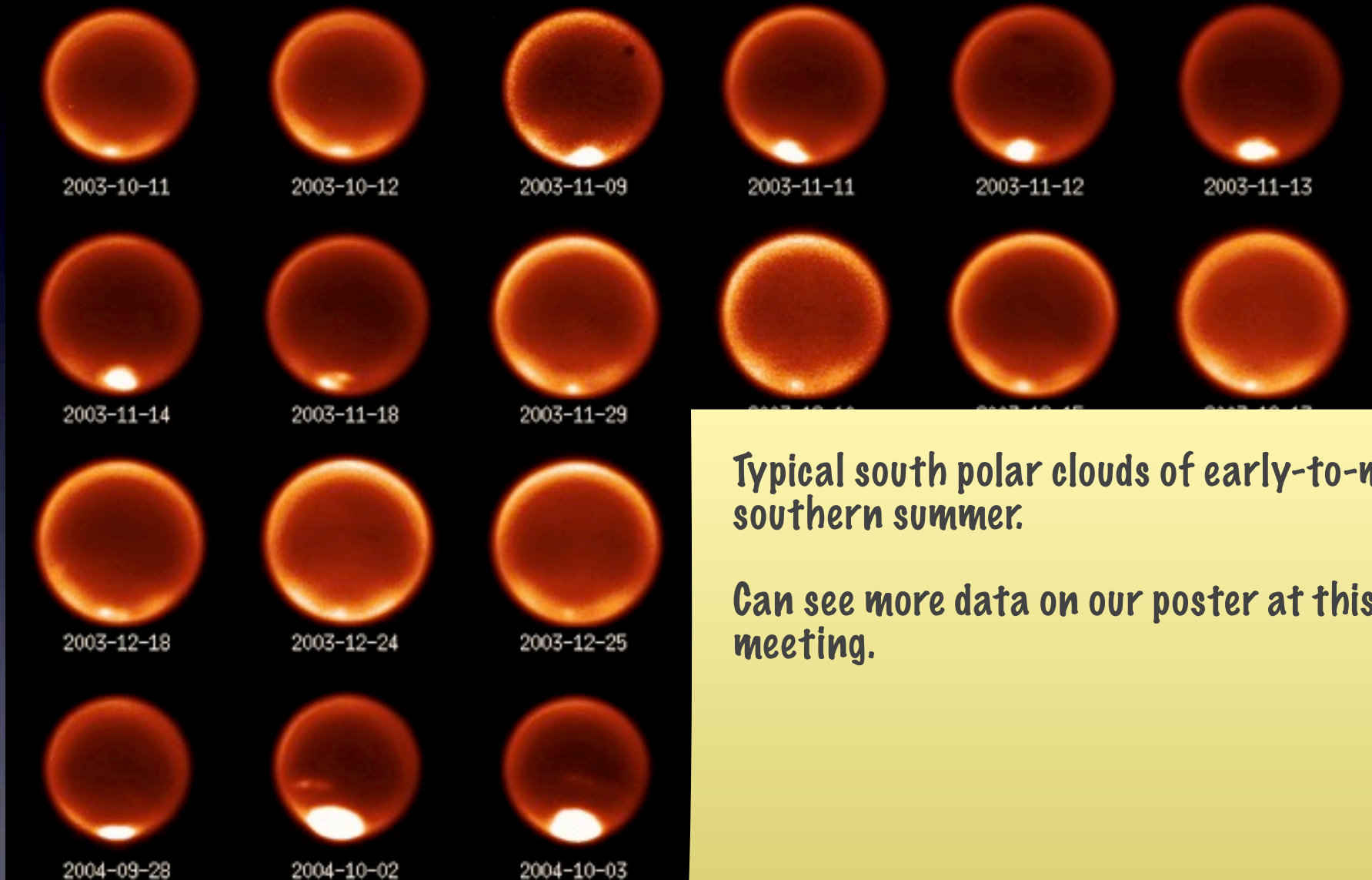
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Results

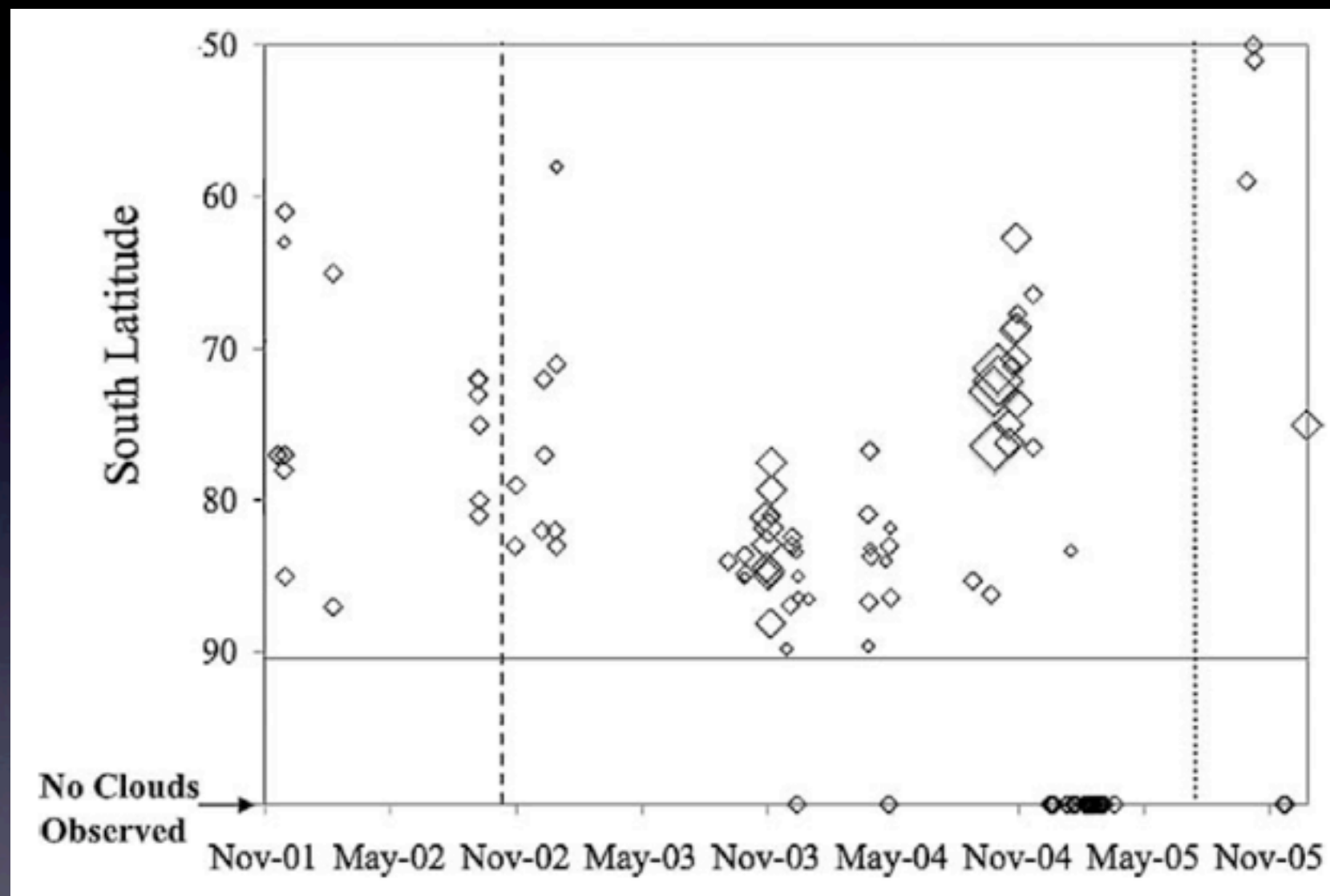
South polar clouds



Typical south polar clouds of early-to-mid southern summer.

Can see more data on our poster at this meeting.

Dissipation of south polar clouds



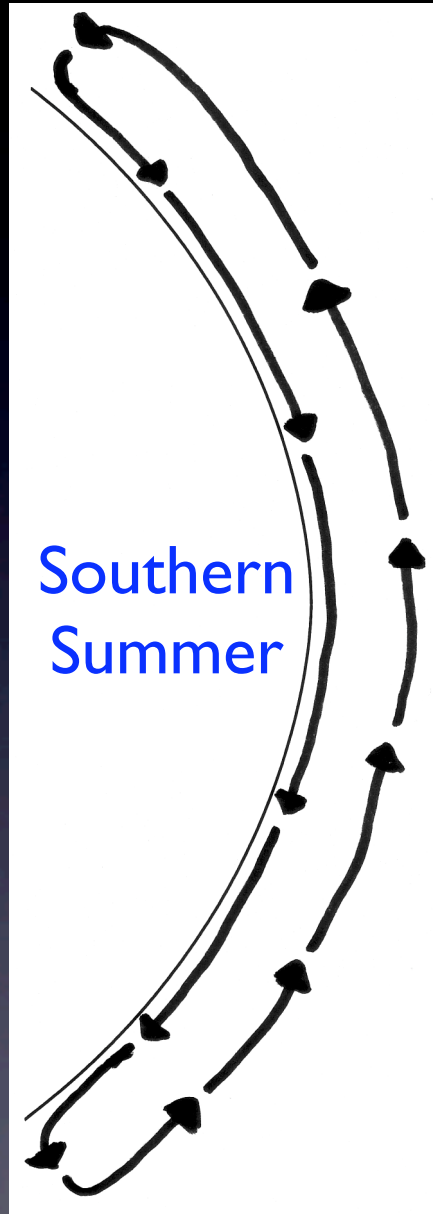
Schaller et al. 2006b *Icarus*

North Pole

Titan

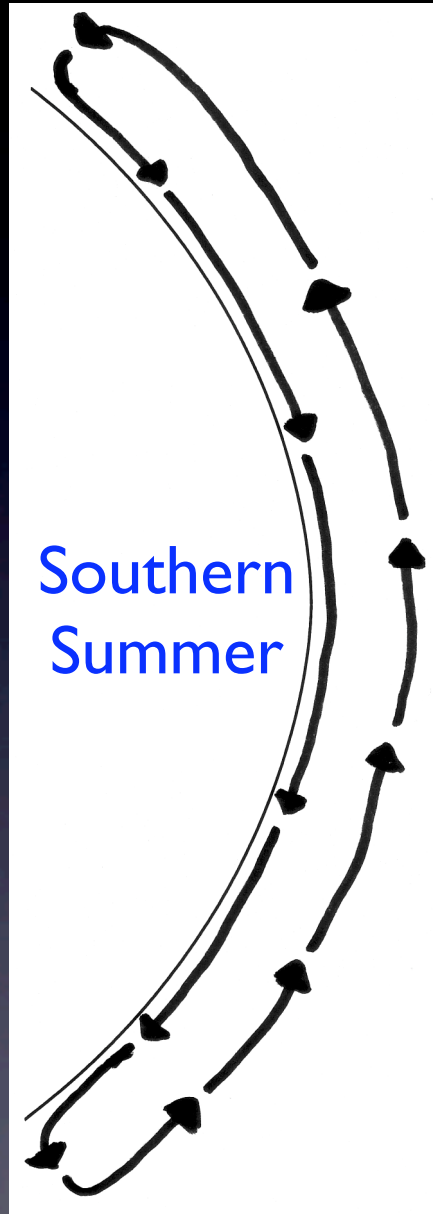
Southern Summer

South Pole



Titan

North Pole



Southern Summer

South Pole

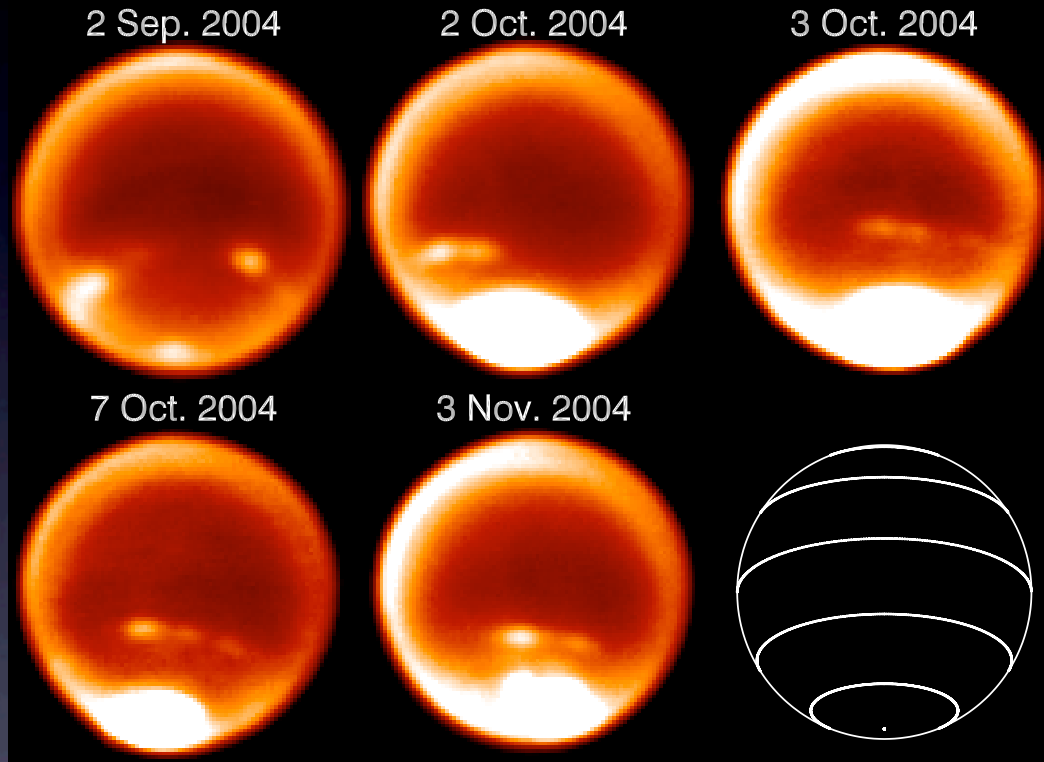
North Pole



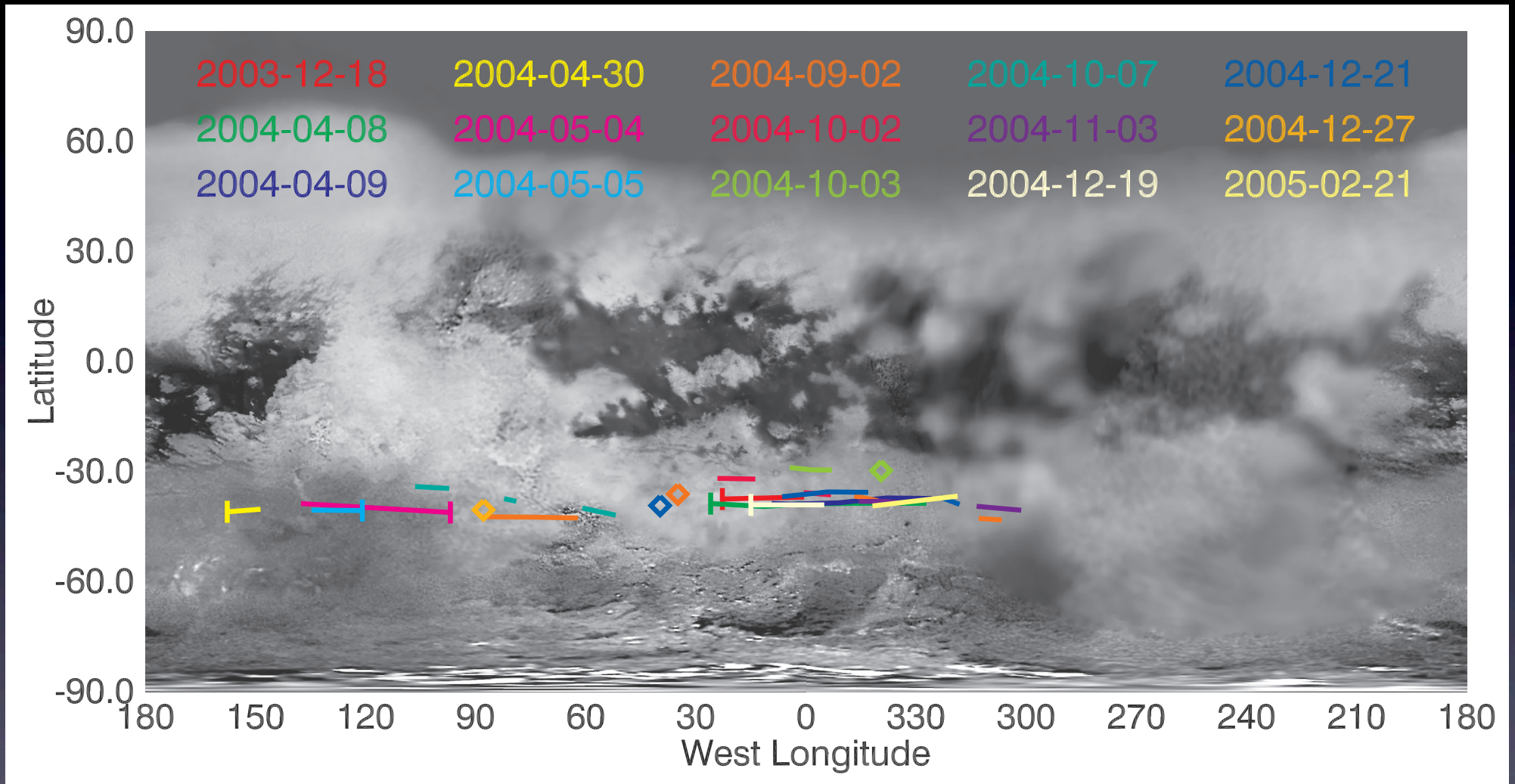
Southern Fall

South Pole

Discovery of mid-latitude clouds at 40°S

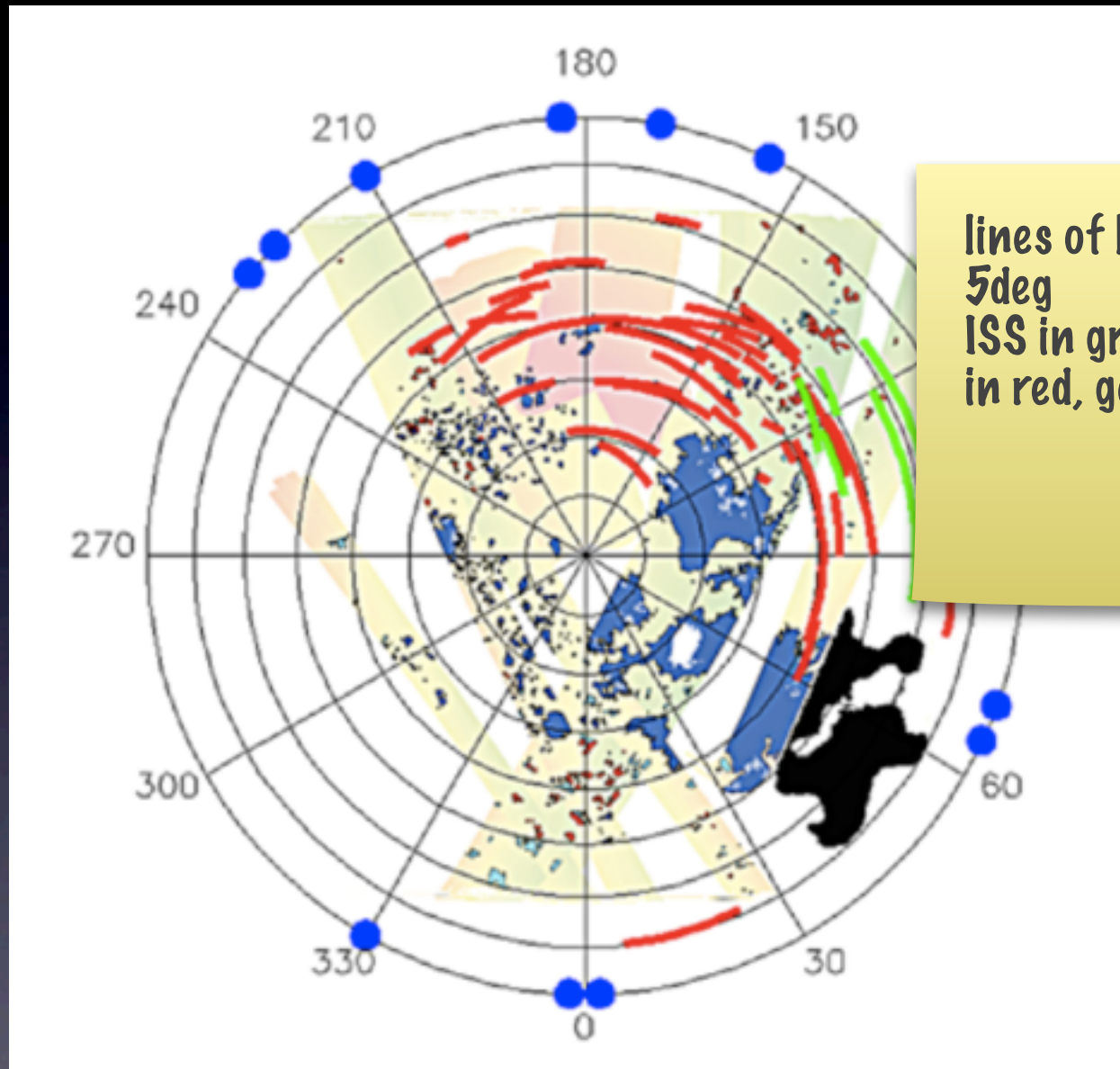


Geographic Control of mid-Latitude Clouds



Roe et al. 2005 Science

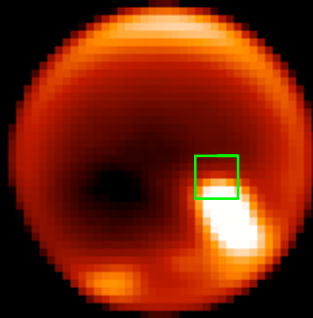
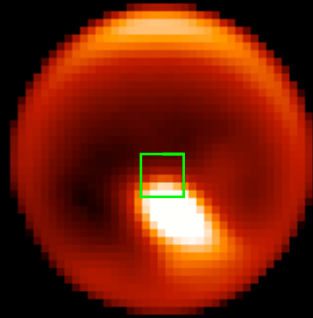
Lake-effect clouds in the north polar region



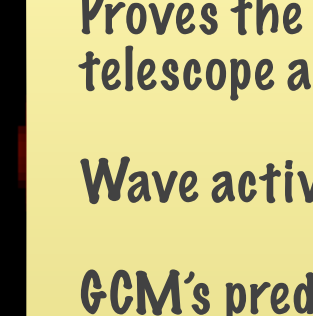
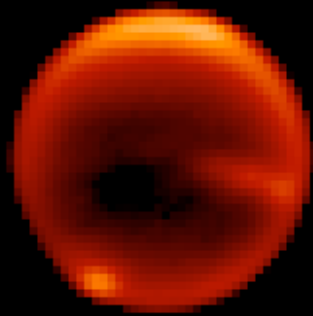
lines of latitude are 5deg
ISS in green, VIMS in red, gemini in blue

Tropical storms & atmospheric waves

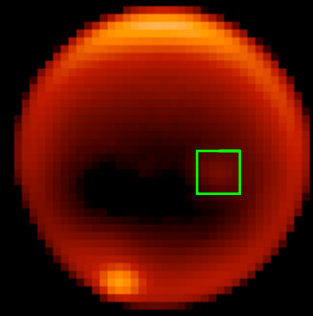
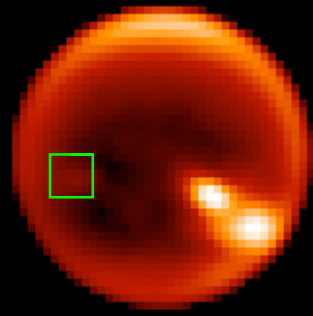
2008-04-14 (251°) 2008-04-15 (273°) 2008-04-16 (296°)



2008-04-18 (341°) 2008-04-20 (27°) 2008-04-22 (27°)



2008-04-28 (210°) 2008-05-01 (275°)

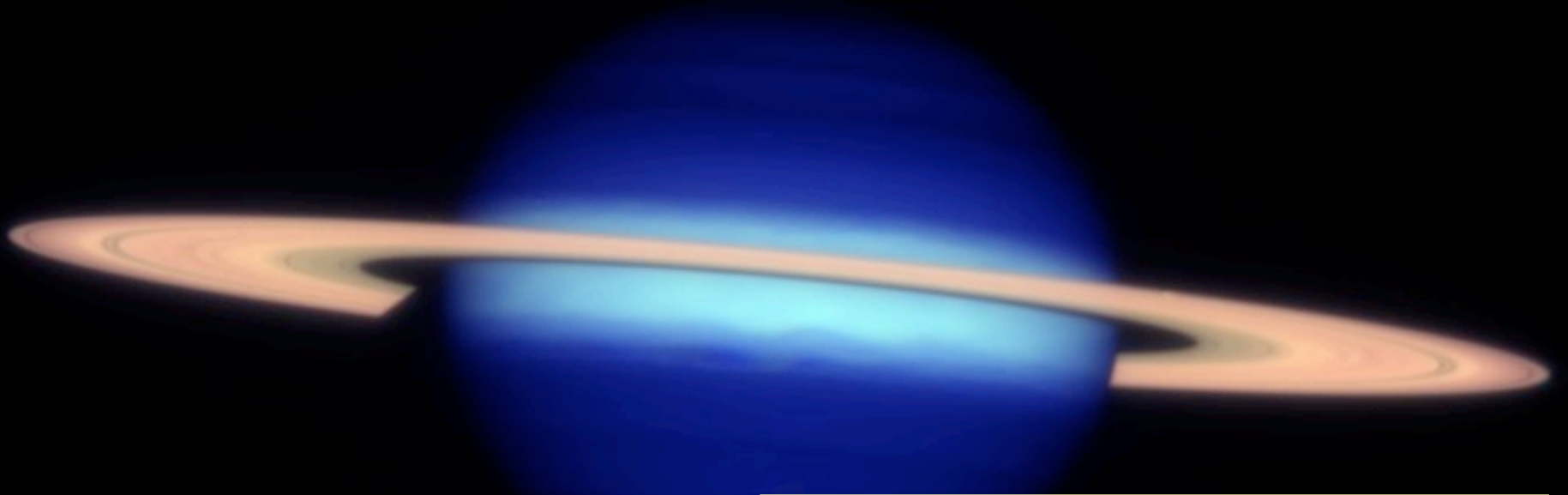


accepted to Nature
Event last spring
Proves the value of our multi-
telescope approach

Wave activity

GCM's predict no/few clouds
equatorially ever, AND
no southern clouds in current
season.

This shows how Titan's
atmosphere can generate clouds
& precip at time/places that
'should' be dry

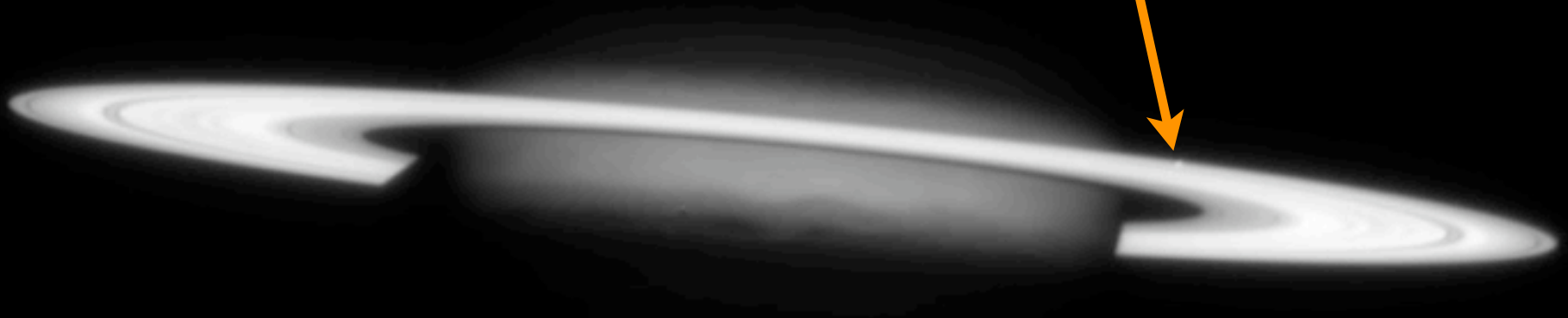


3-color image constructed from K, H210, & Br gamma

amazing amount of color variation in the rings

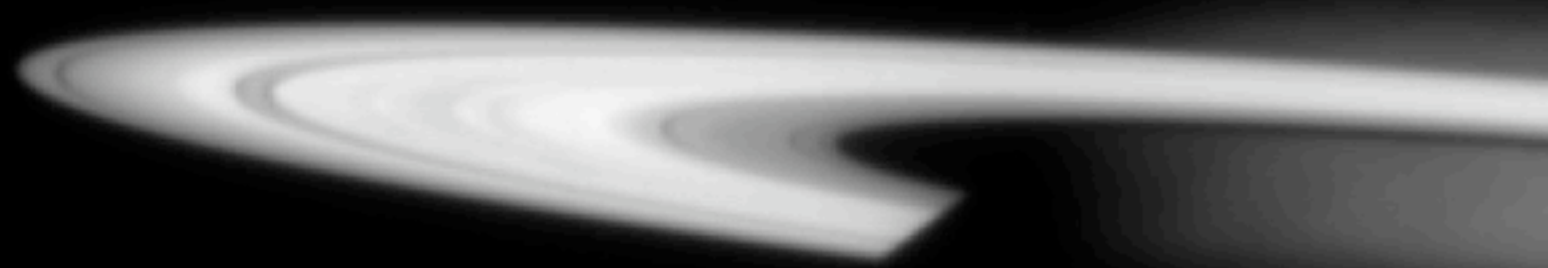
amazing amount of detail in dynamics of saturn atmosphere

Mimas



Mimas is "death-star moon" because of a large crater and its appearance

400 km across



F-ring & Pandora

Janus

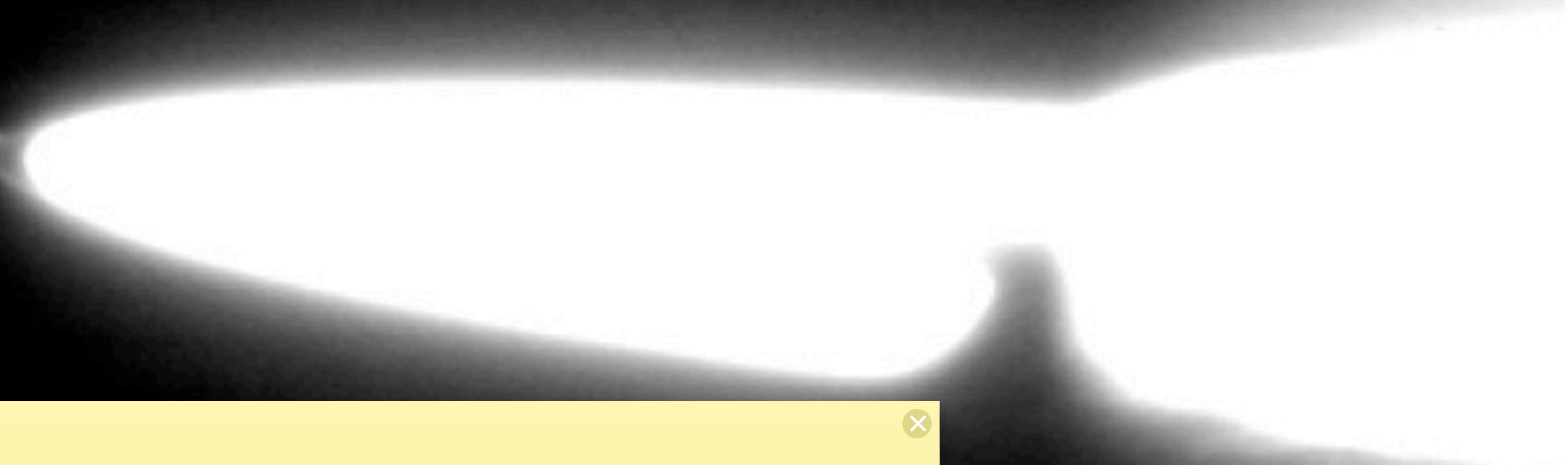


Janus is <200 km across

F-ring discovered in 1979 by the [*Pioneer 11*](#) imaging team.
Constrained by 2 shepard moons (Pandora & Prometheus)

Pandora <100km across

F-ring & Pandora

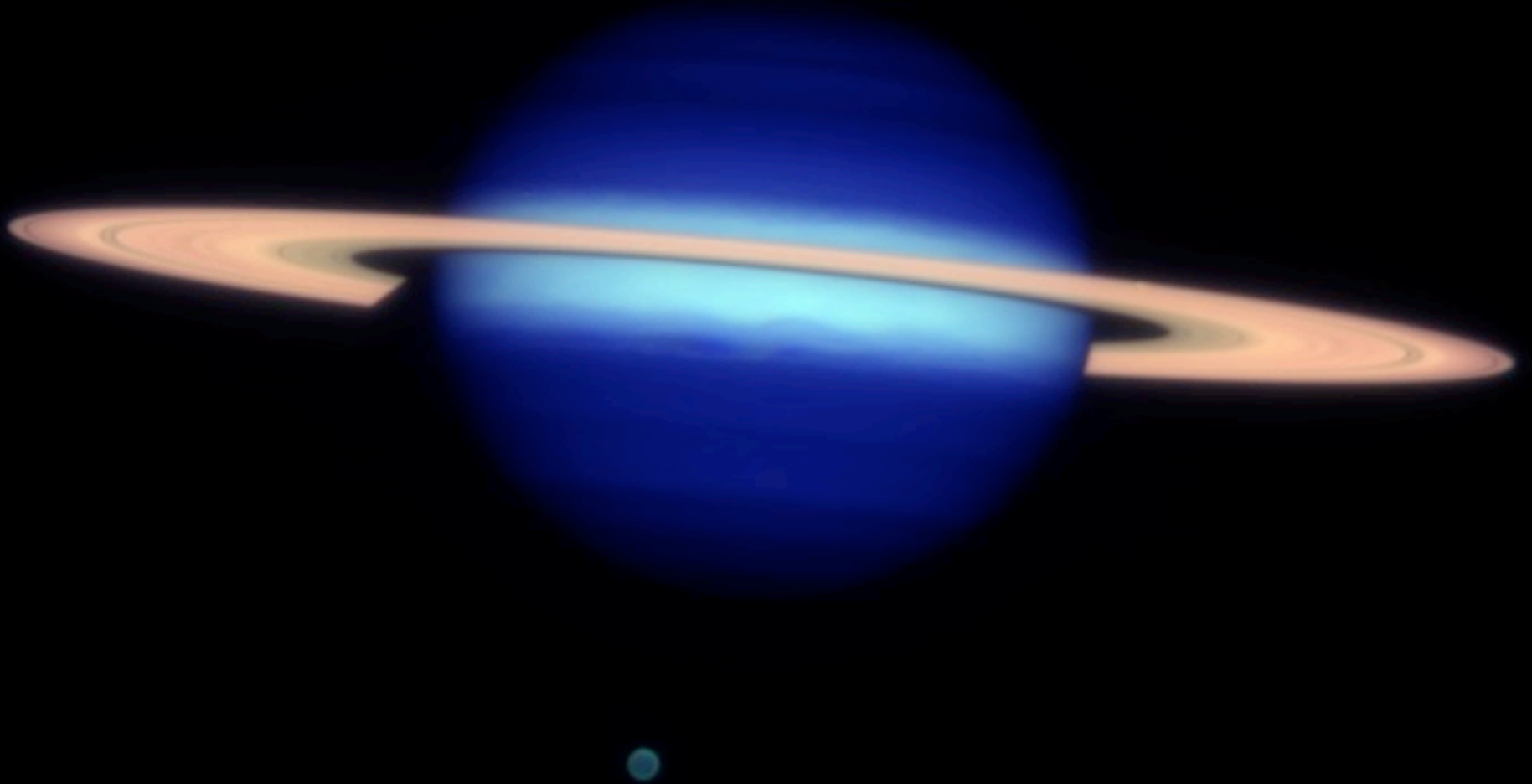


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Thank you to all the Gemini staff who
have helped with these observations!



Summary

- Titan has active methane meteorology
- Ground-based observing required to provide necessary temporal coverage
- Gemini is key to ground-based observing
- Discoveries in past 5 years include:
 - South polar cloud field in late southern spring
 - Seasonal shutdown of south polar cloud field (monsoonal shift of winds)
 - Mid-southern latitude clouds that are geographically controlled likely indicate region of geologic activity and methane resupply
 - Northern lake-effect clouds
 - Wave-activity can communicate globally and generate clouds at latitudes/seasons not predicted by global circulation models
- Have only observed a fraction of Titan's 30-year seasonal cycle → Need to continue observing!