

# Noctilucent clouds

shedding light on the atmosphere

Bodil Karlsson

LASP

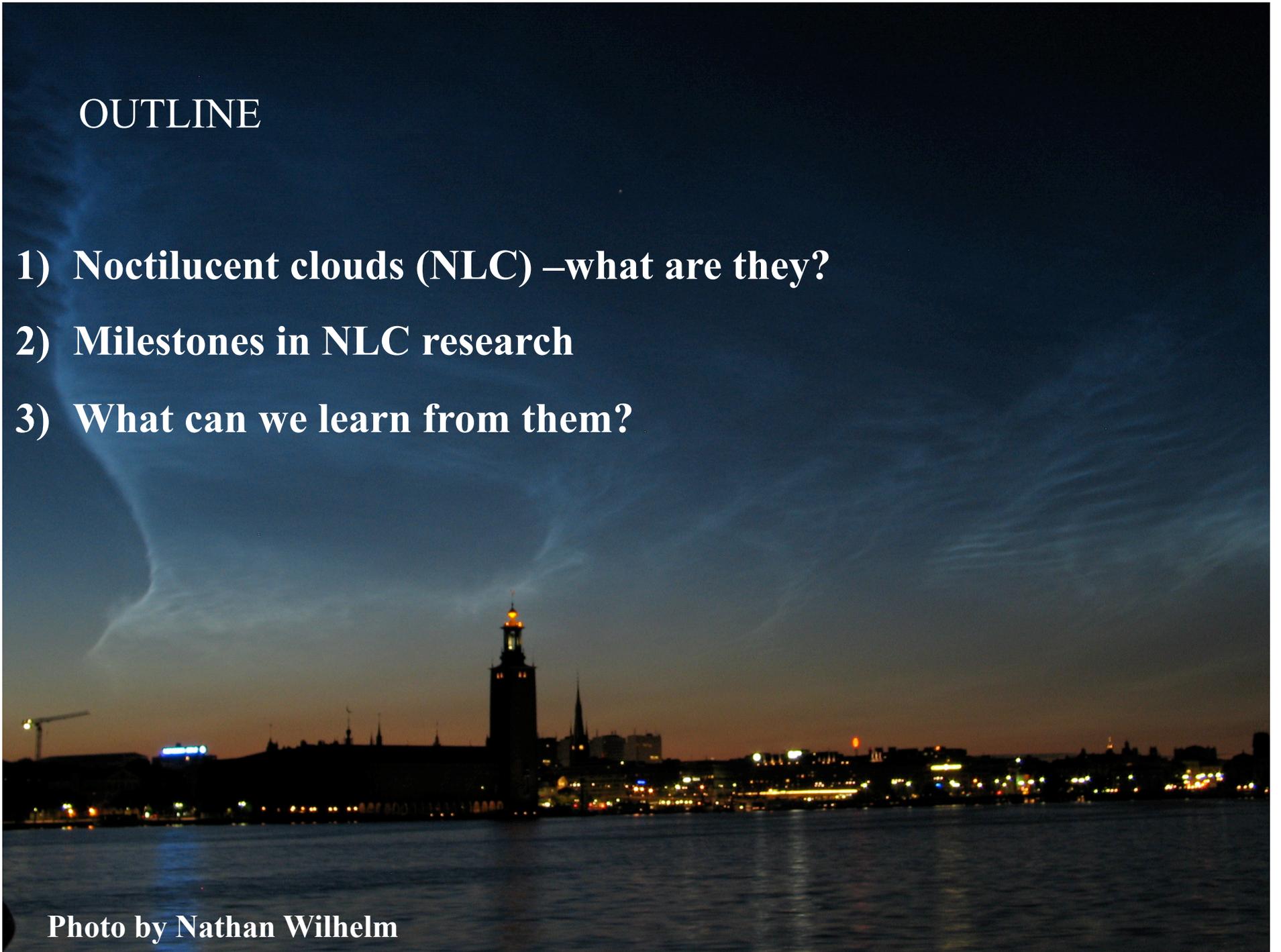
November 4, 2009

Photo by Nathan Wilhelm

## OUTLINE

- 1) **Noctilucent clouds (NLC) –what are they?**
- 2) **Milestones in NLC research**
- 3) **What can we learn from them?**

**Photo by Nathan Wilhelm**

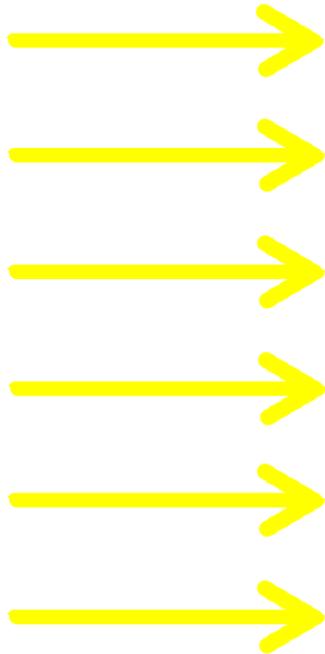


# Noctilucent clouds – what are they?

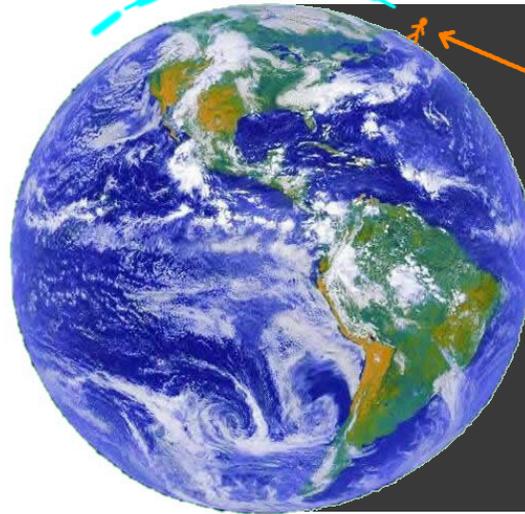
- Only in the summer
- Only poleward of typically  $50^\circ$  latitude in both hemispheres
- Only at very high altitudes
- Only visible to the naked eye in twilight



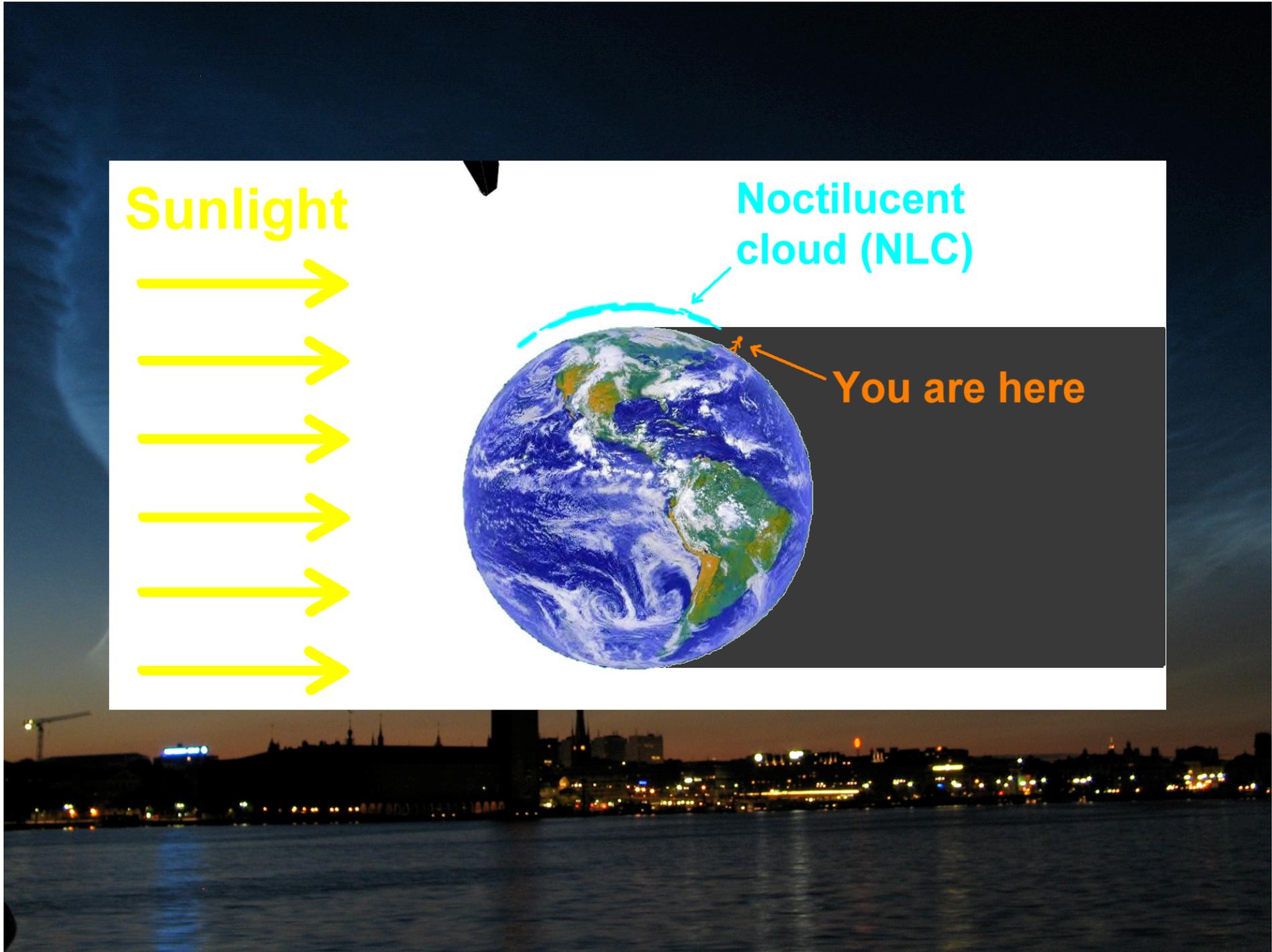
**Sunlight**



**Noctilucent  
cloud (NLC)**



**You are here**



Movie from the roof of  
Stockholm University

# What is special with these clouds?

- Late discovery...

**Table 1.**

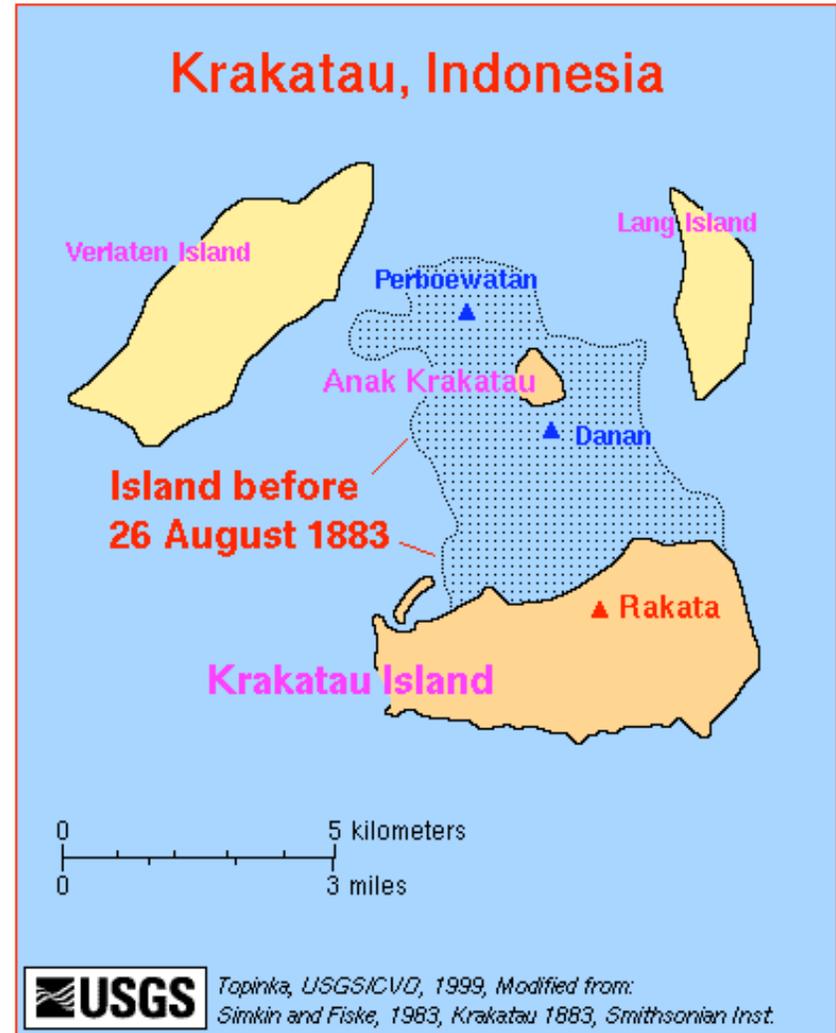
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## Another Big Bang in history

The eruption of Krakatoa on August 26–27, 1883, was among the most violent volcanic events in modern and recorded history.



The explosion was heard as far away as Perth in Western Australia, about 1,930 miles (3,110 km) away, and the island of Rodrigues near Mauritius, about 3,000 miles (5,000 km) away.



Map from Wikipedia

80 S 3 143 NW 18 80

**The 1883 eruption ejected approximately 21 cubic kilometres (5.0 cu mi) of rock and ash into the atmosphere.**

**Consequences:**

**-Darkness for about 40 hours after the eruption**

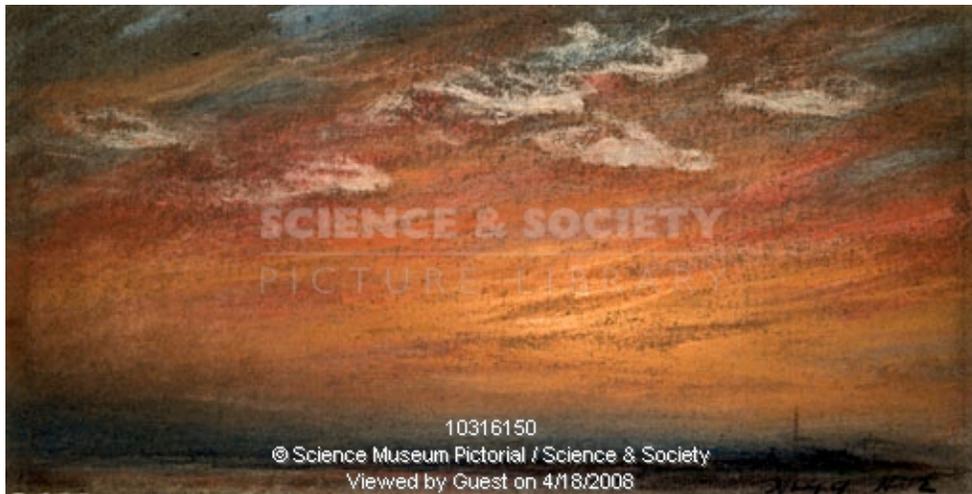
**-Enhanced cloud albedo for several years afterwards, reducing the global mean temperature with about 1.2° C.**

**-A large amount of water was injected into the atmosphere**

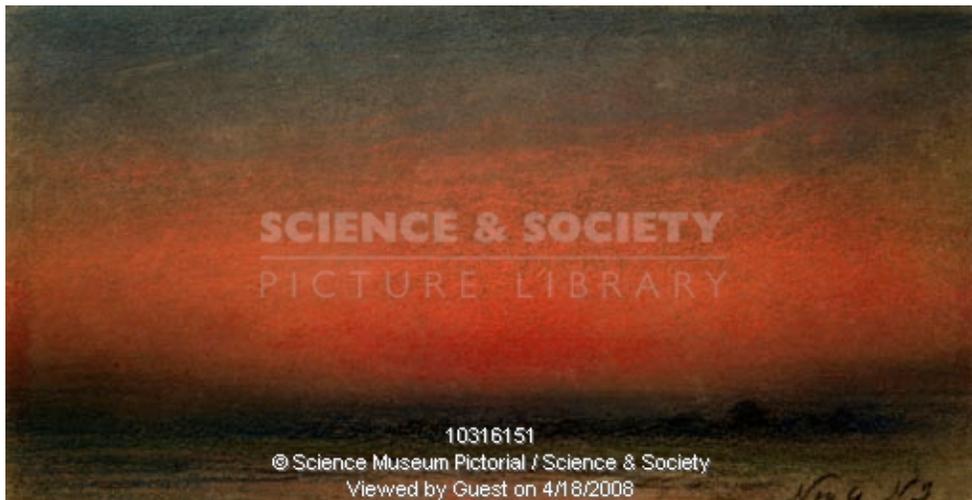
**Picture from Discovery channel**



## Sunset and afterglow caused by the eruption of Krakatoa, November 1883



## Afterglow caused by the eruption of Krakatoa, 9 November 1883



Art by William Ascroft

**Sunset and noctilucent cloud, 6 July 1885.**



William Ascroft

**Sunset and afterglow, Chelsea, London, 12 July 1886.**



**Sustained light after sunset, 12 July 1886**



William Ascroft



©www.extremeinstability.com

[www.spaceweather.com](http://www.spaceweather.com): July 15, 2009

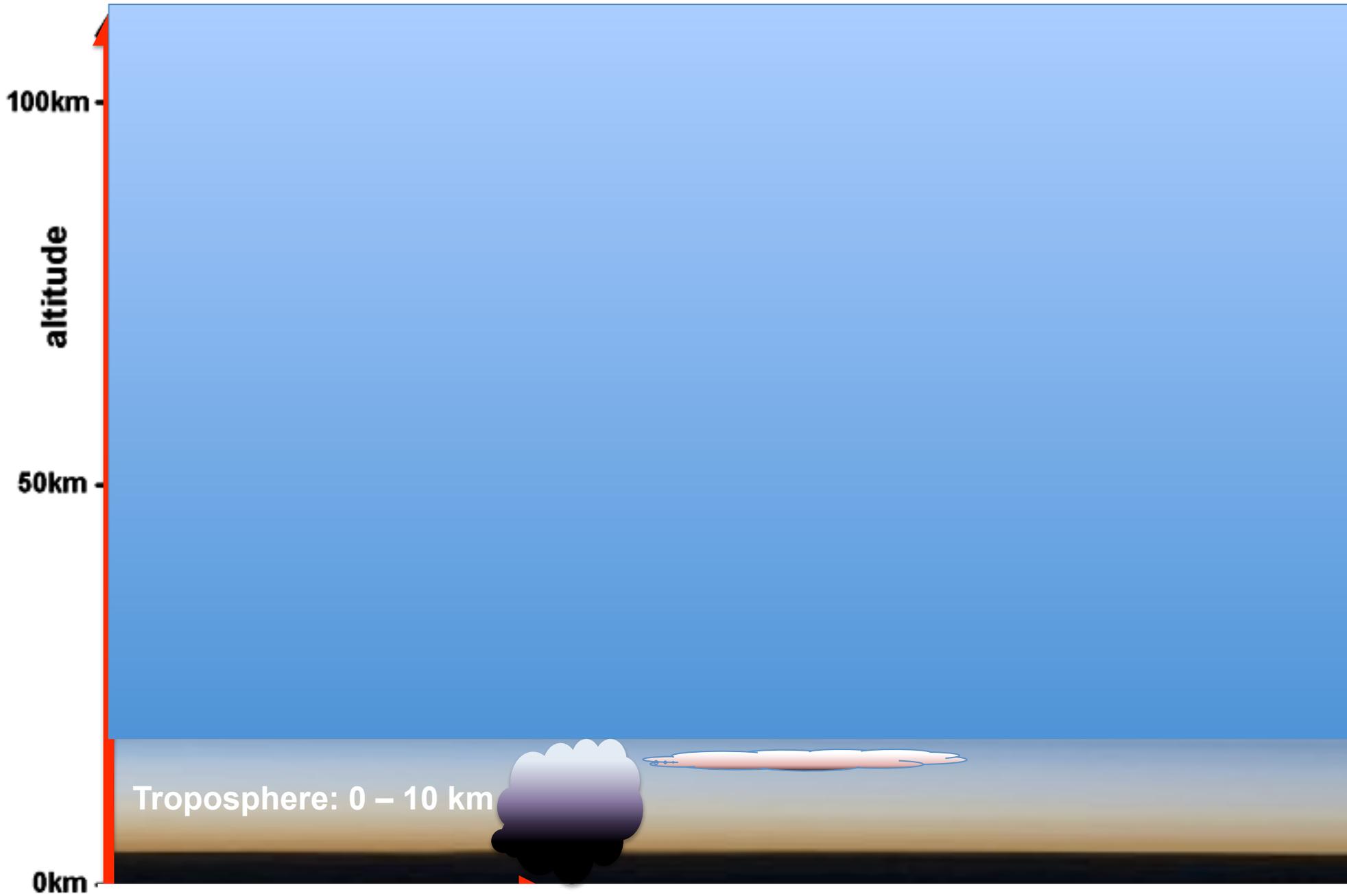
Blair, Nebraska

# What is special with these clouds?

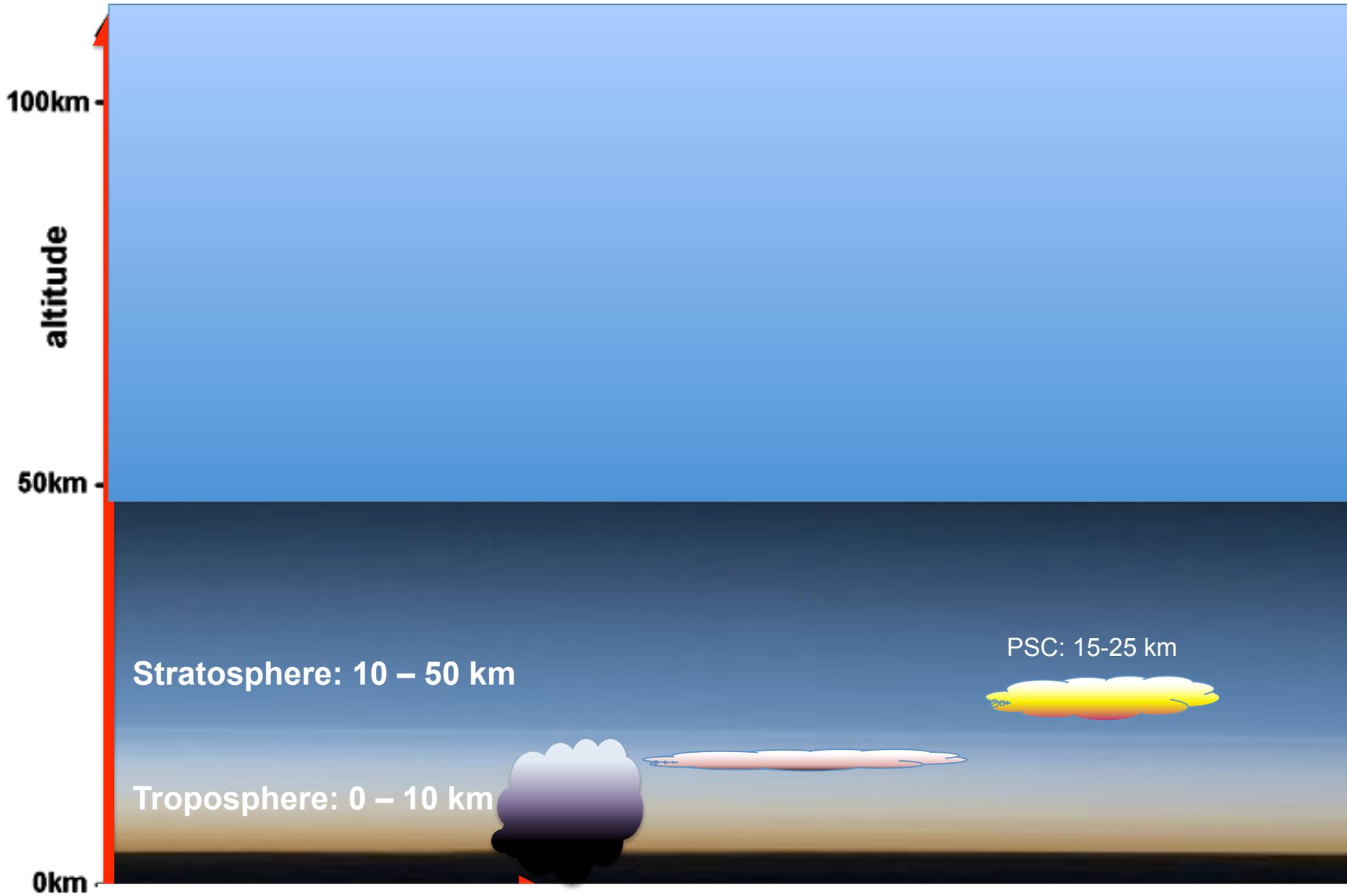
- Late discovery...
- Very high up! How high? And why?

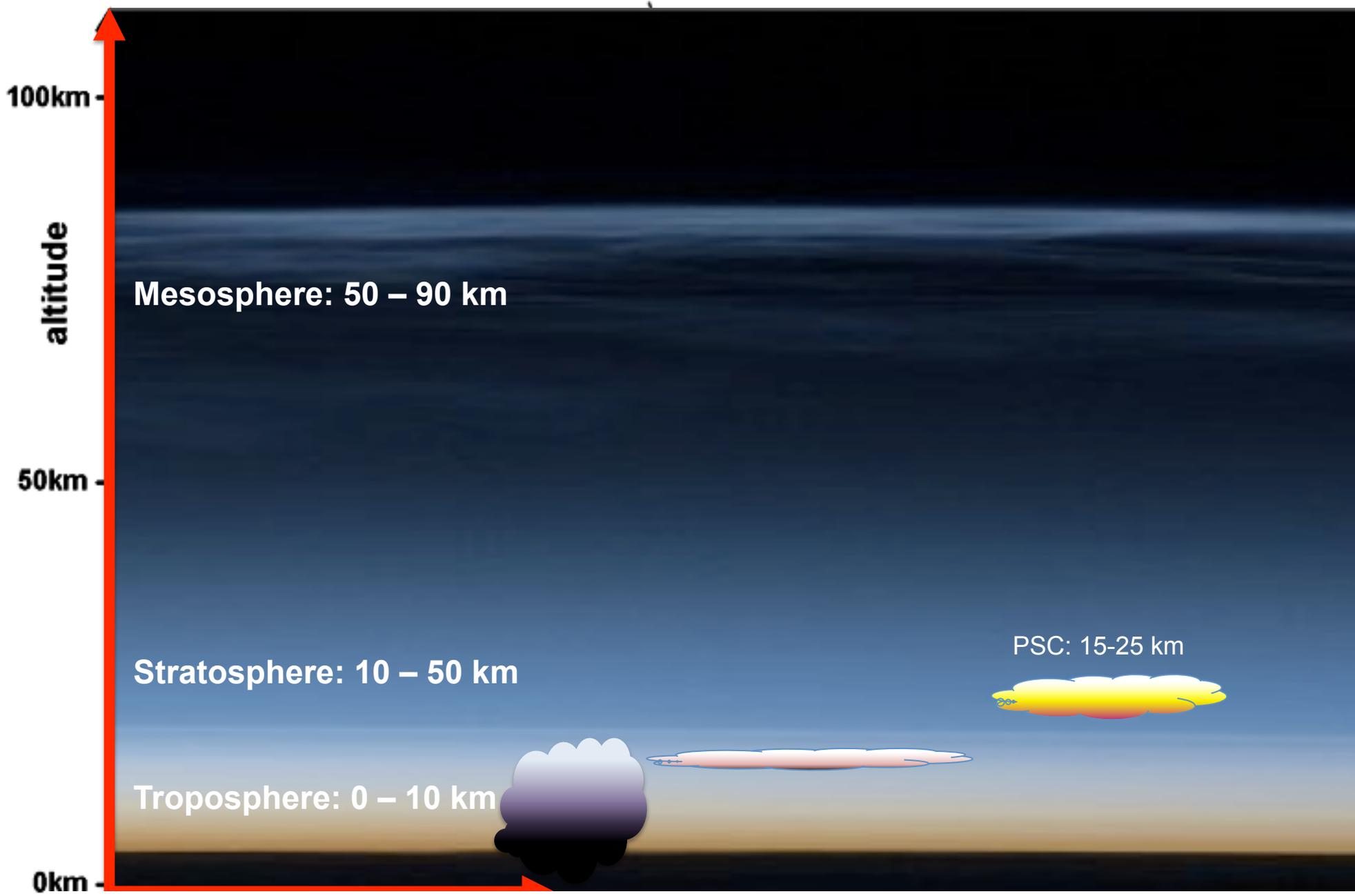
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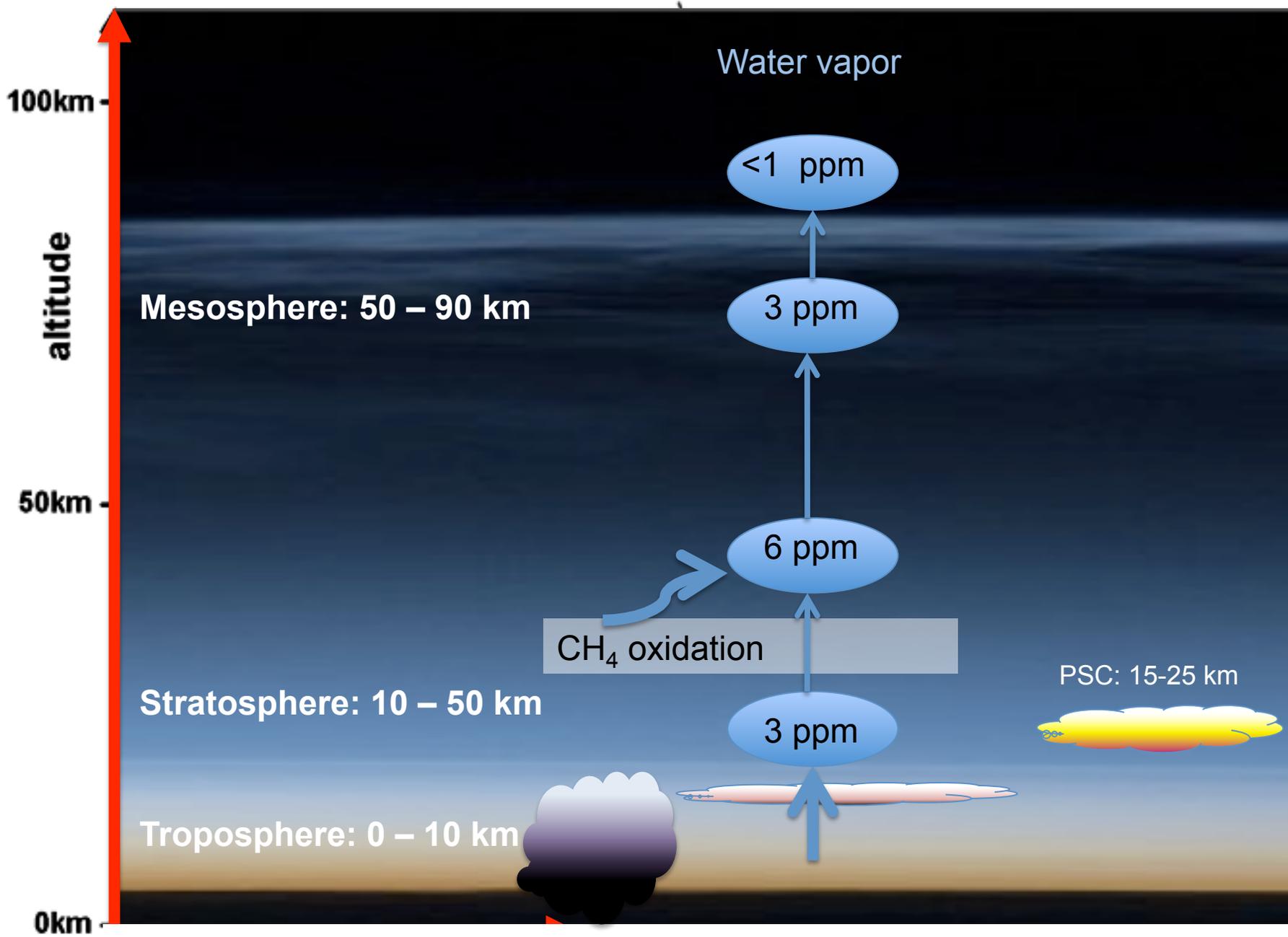


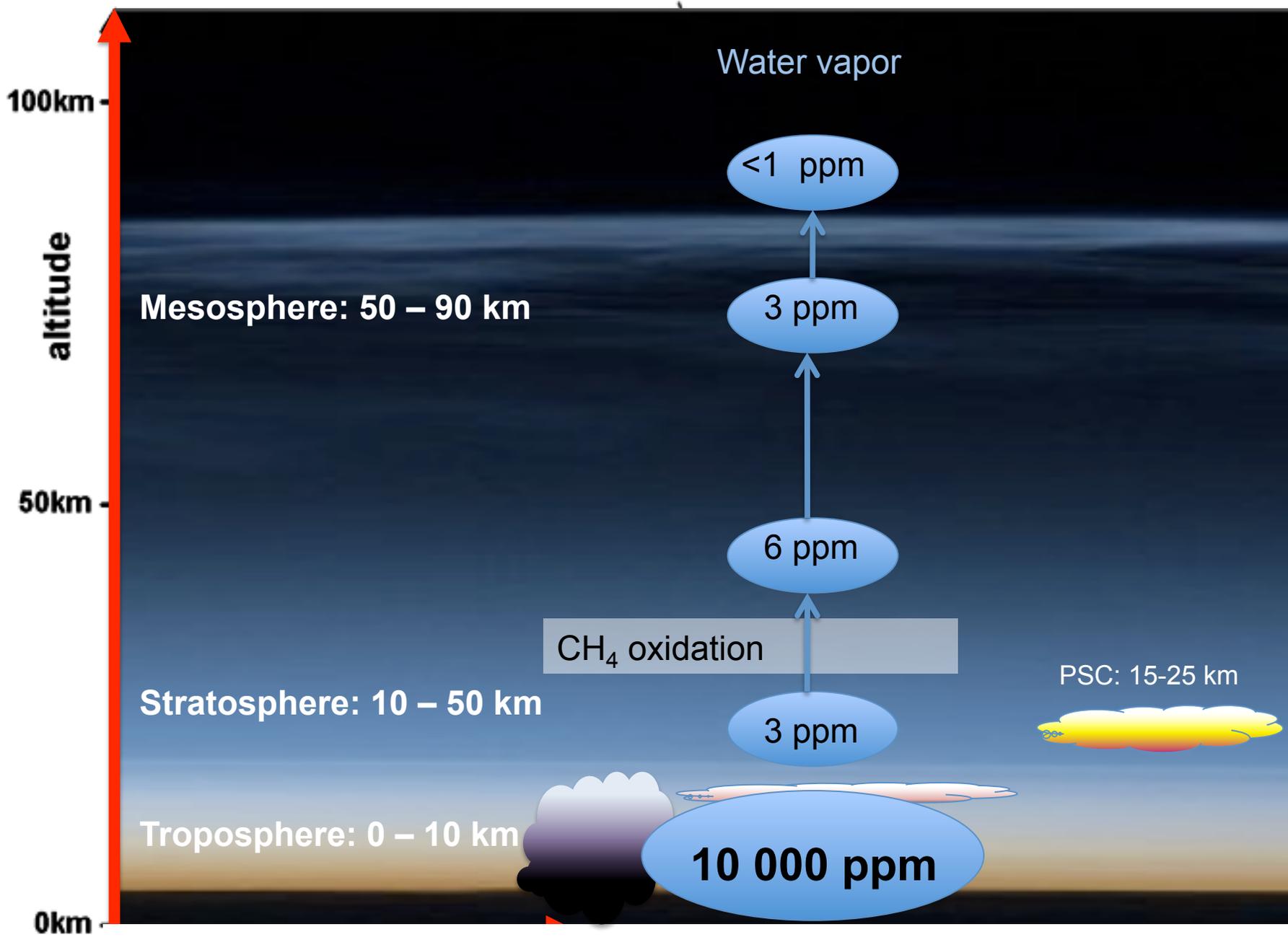
Troposphere: 0 – 10 km





Picture modified from [http://science.nasa.gov/headlines/y2008/25aug\\_nlc.htm](http://science.nasa.gov/headlines/y2008/25aug_nlc.htm)





# What is special with these clouds?

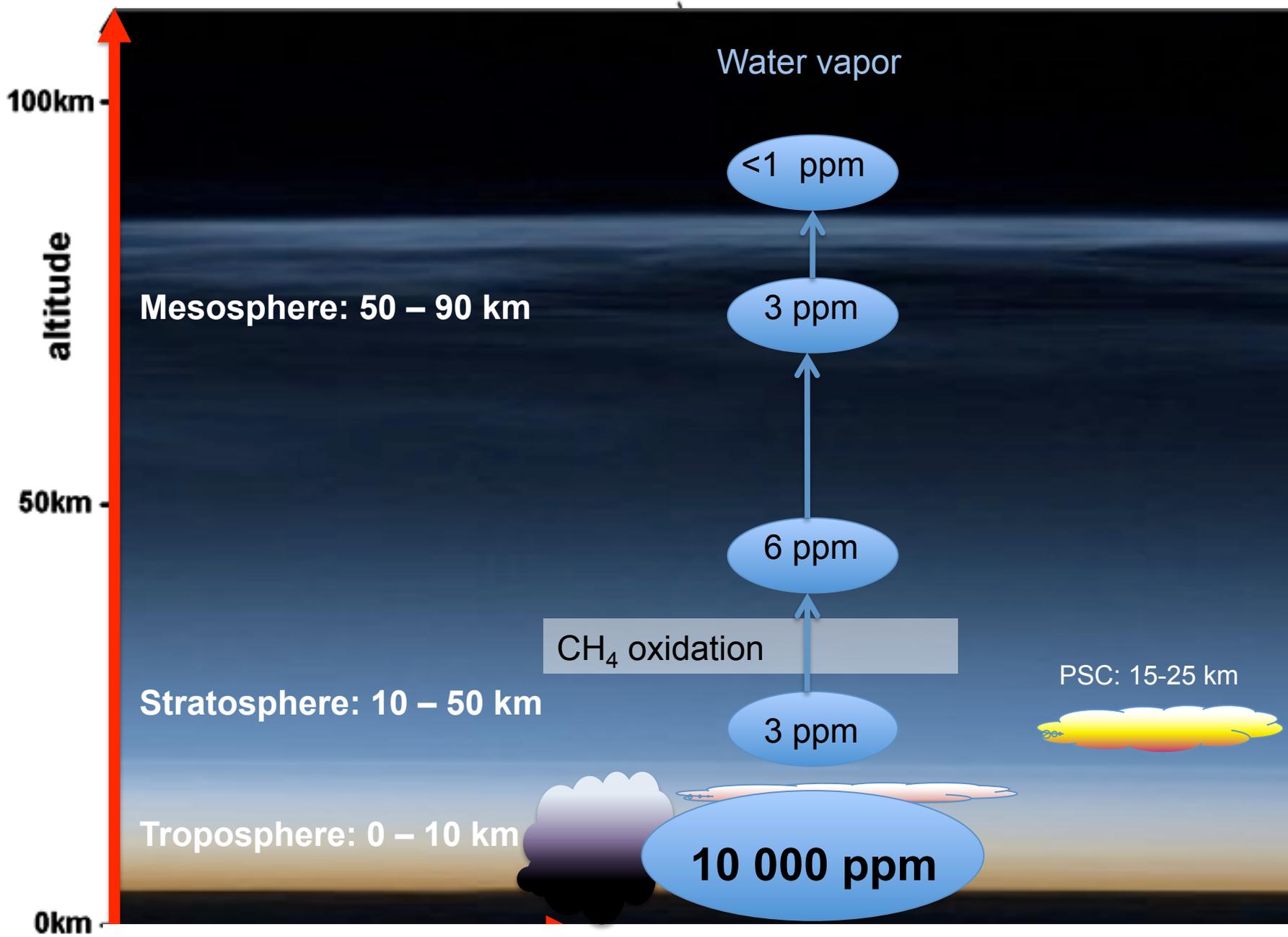
- Late discovery...
- Very high up!
- The place where the NLC 'chill out'

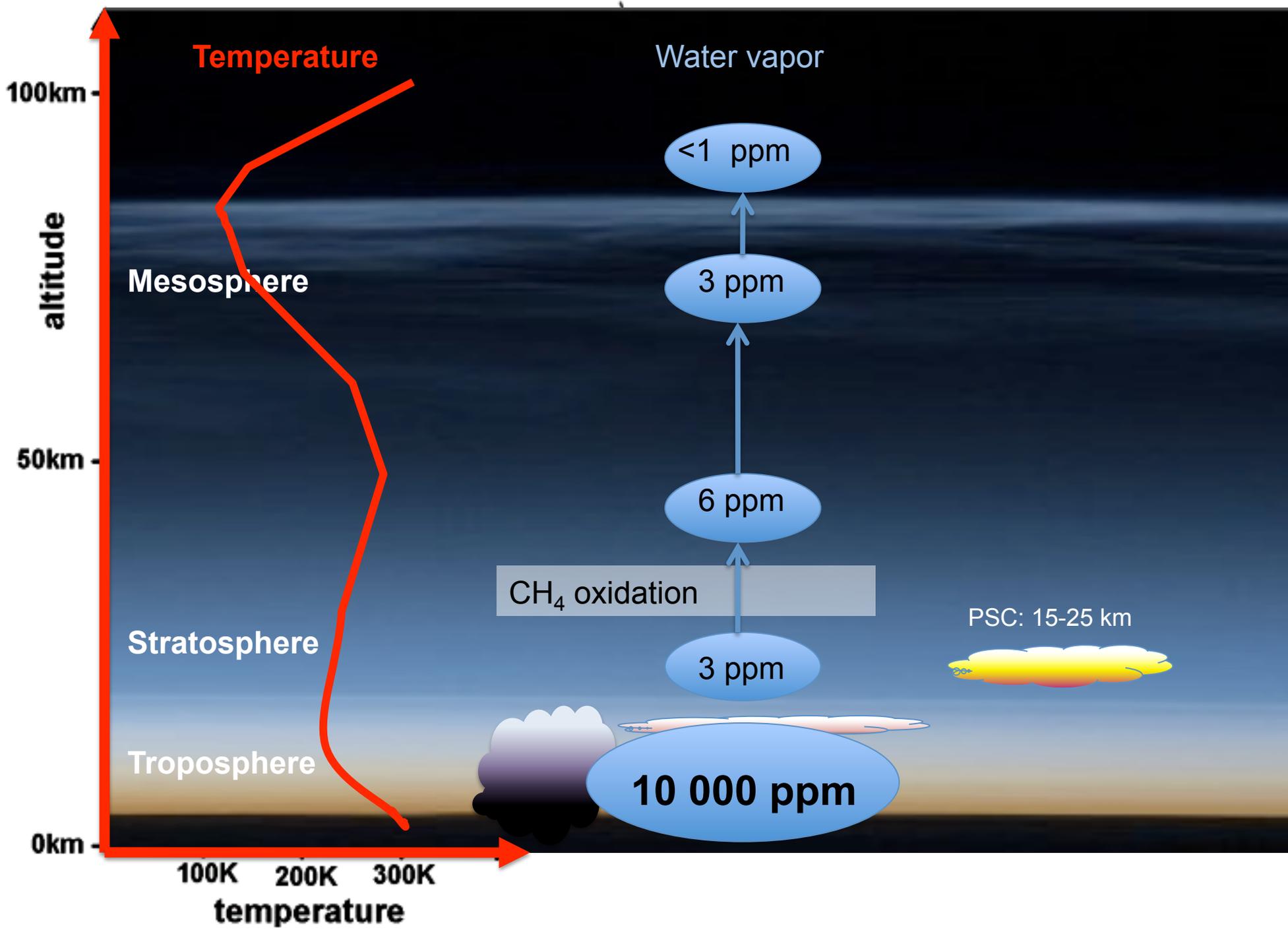
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Georg Witt, Lars Rey (t. h. på bilden) och delar av en nossektion som genomborrat himlar, och tagit ned en bit av okända moln! Foto Kerstin Björling. Sidan mitt emot: En lysande eldbana i den lappländska natten . . . de första större vetenskapliga raketerna skjuts från svensk mark. Foto H. Hammargren







# What is special with these clouds?

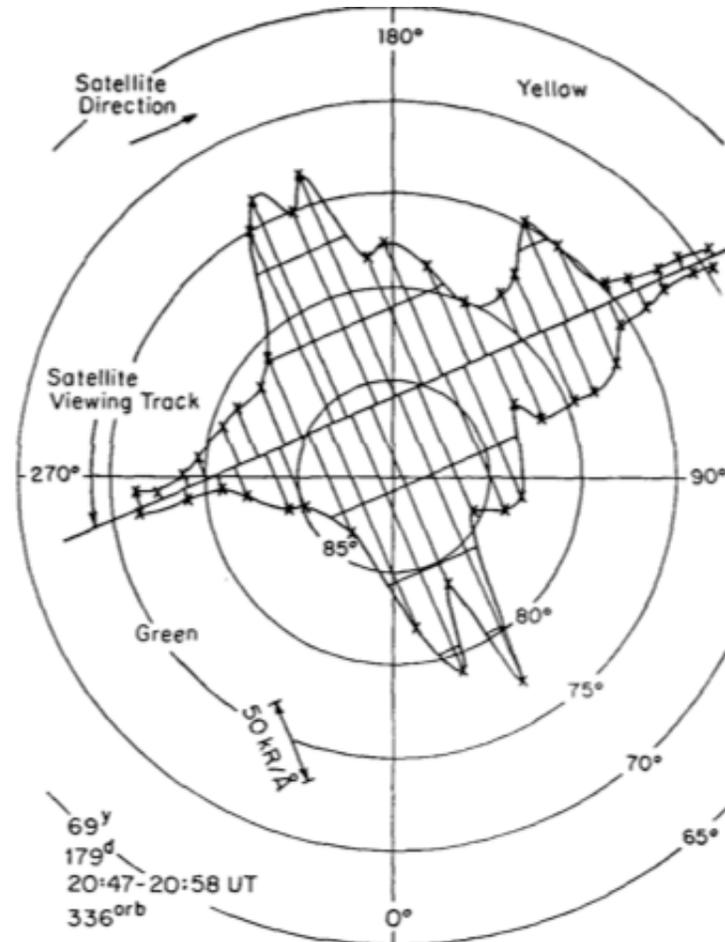
- Late discovery...
- Very high up!
- The coldest place on earth
- In the polar regions?

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Donahue et al., 1972:  
Noctilucent clouds in daytime: Circumpolar particulate layers  
near the the summer mesopause

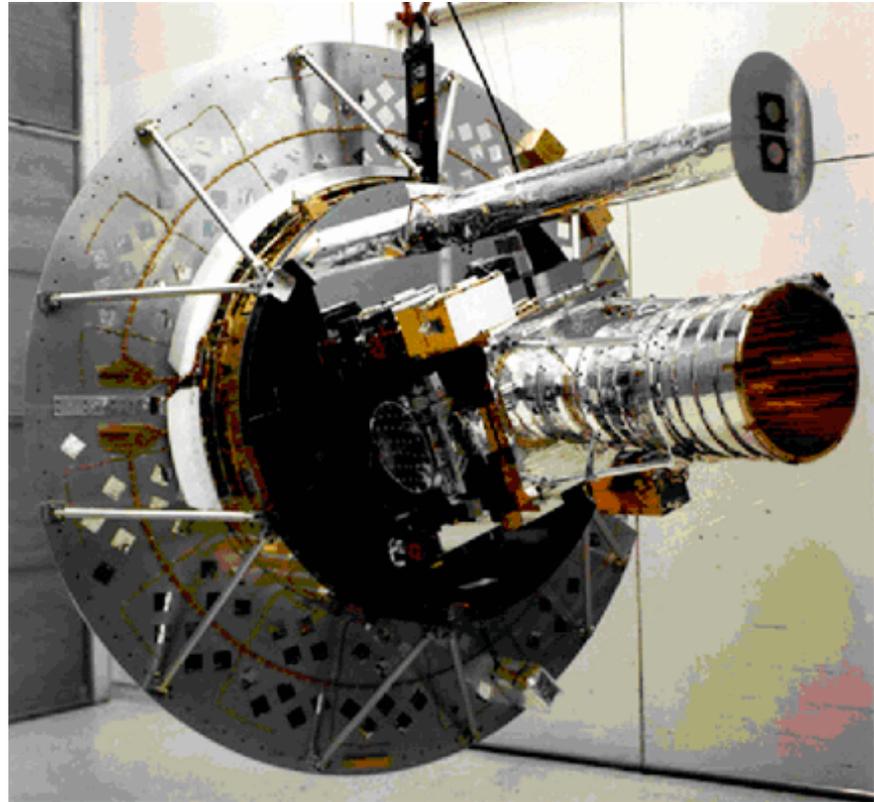
Observations from the  
OGO-6 satellite  
showing scattering  
layer above the pole





Gary Thomas

and the SME-satellite

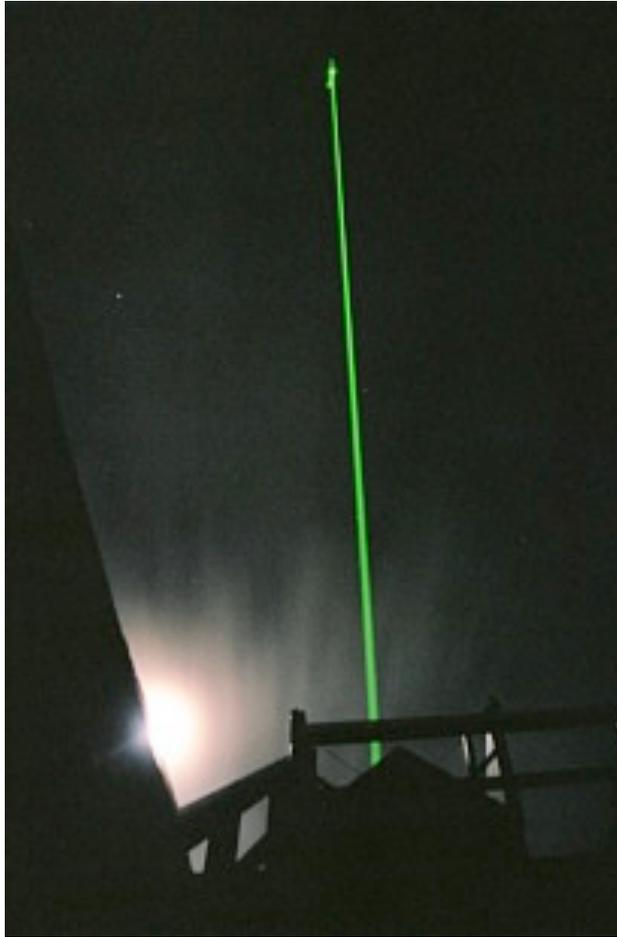


Thomas, G. E., *Solar Mesosphere Explorer measurements of polar mesospheric clouds (noctilucent clouds)*, *J. Atmos. Terr. Phys.*, 46, 819, 1984.

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# LIDAR

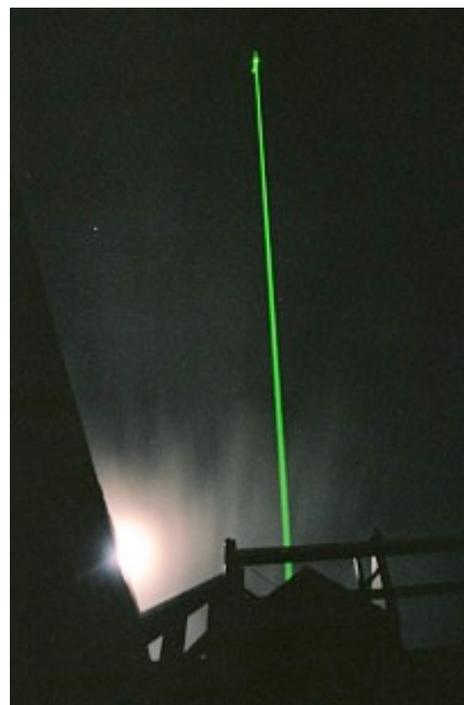


How we observe NLC/PMC today:

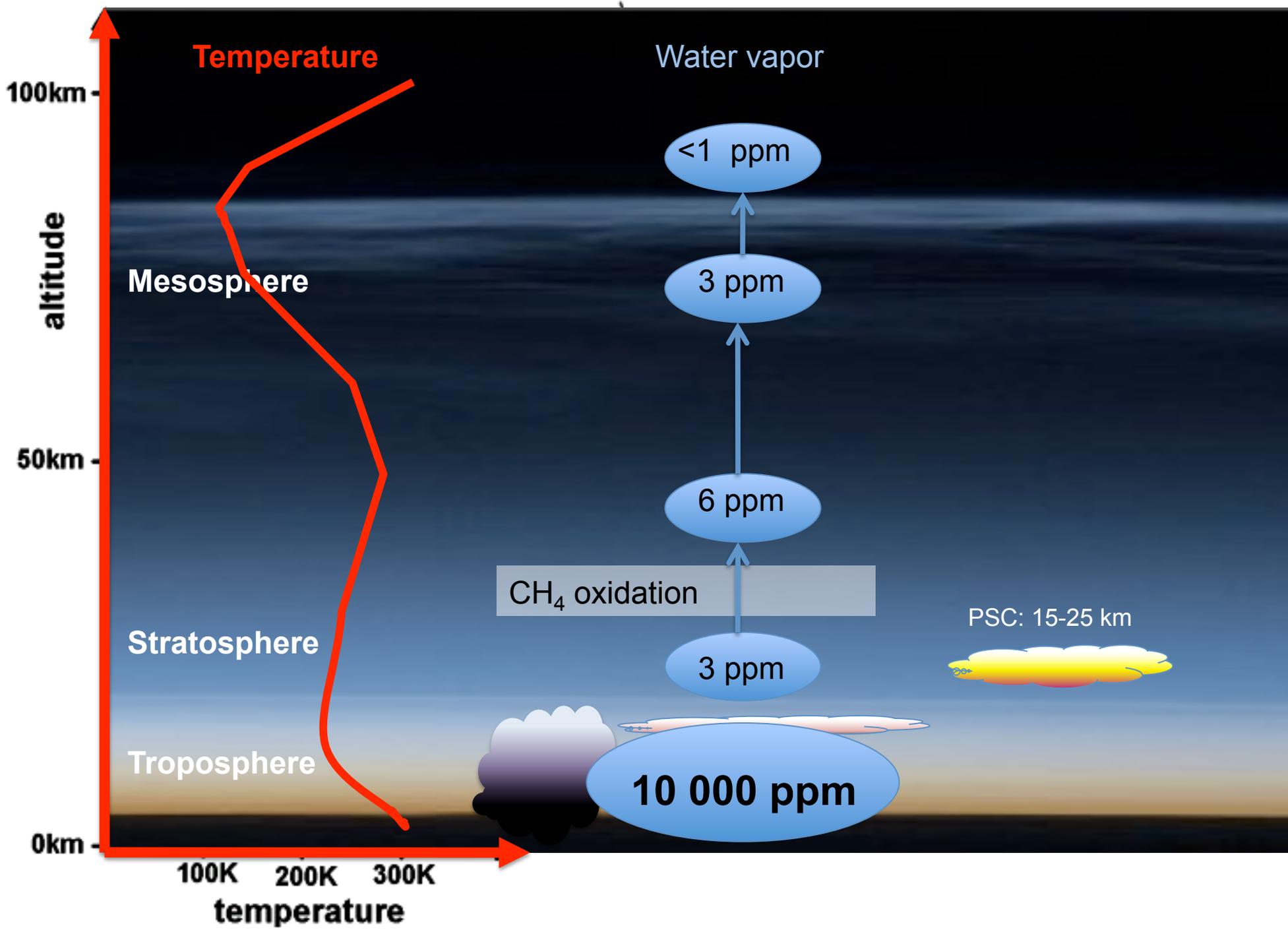
satellites

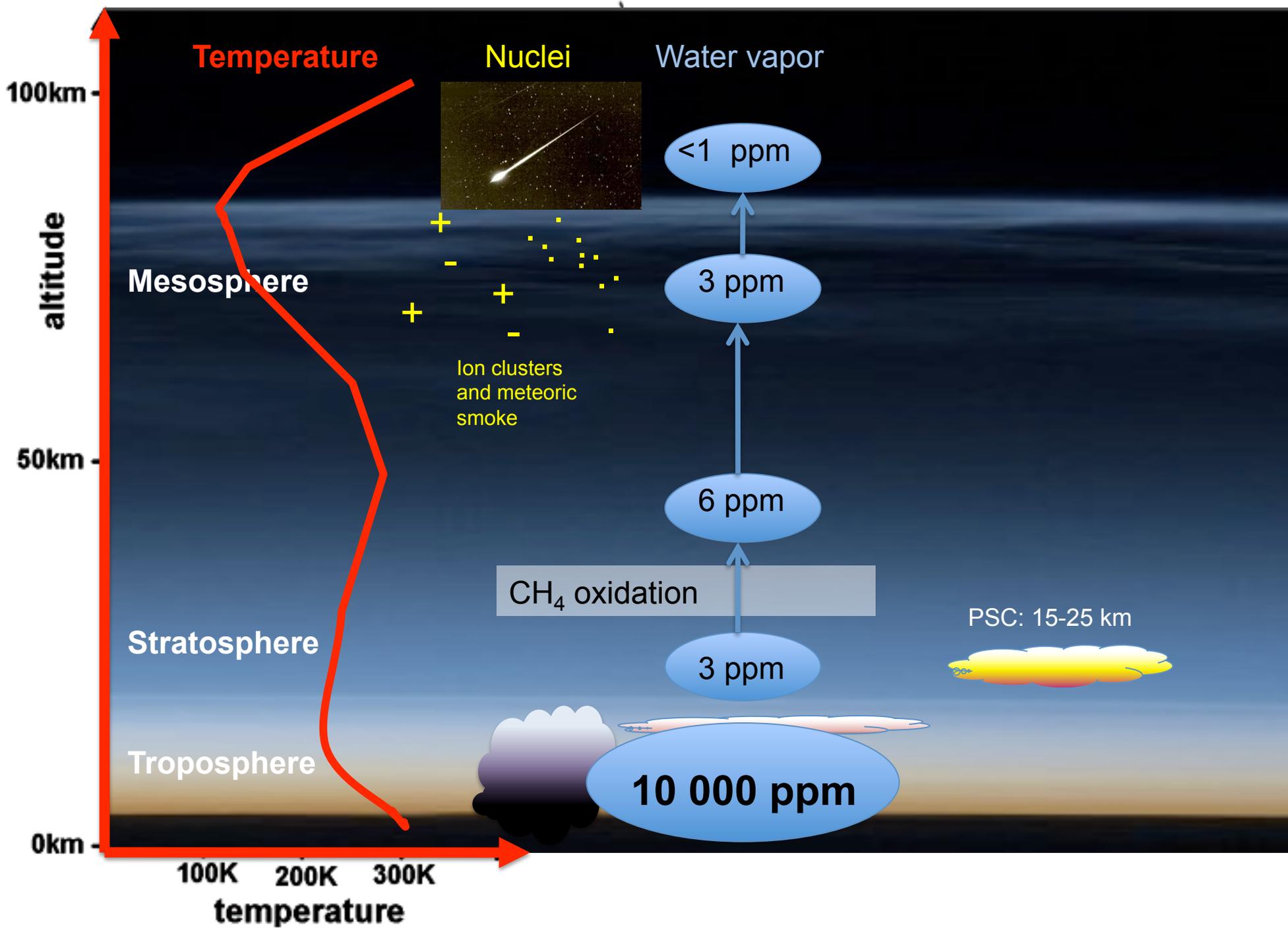


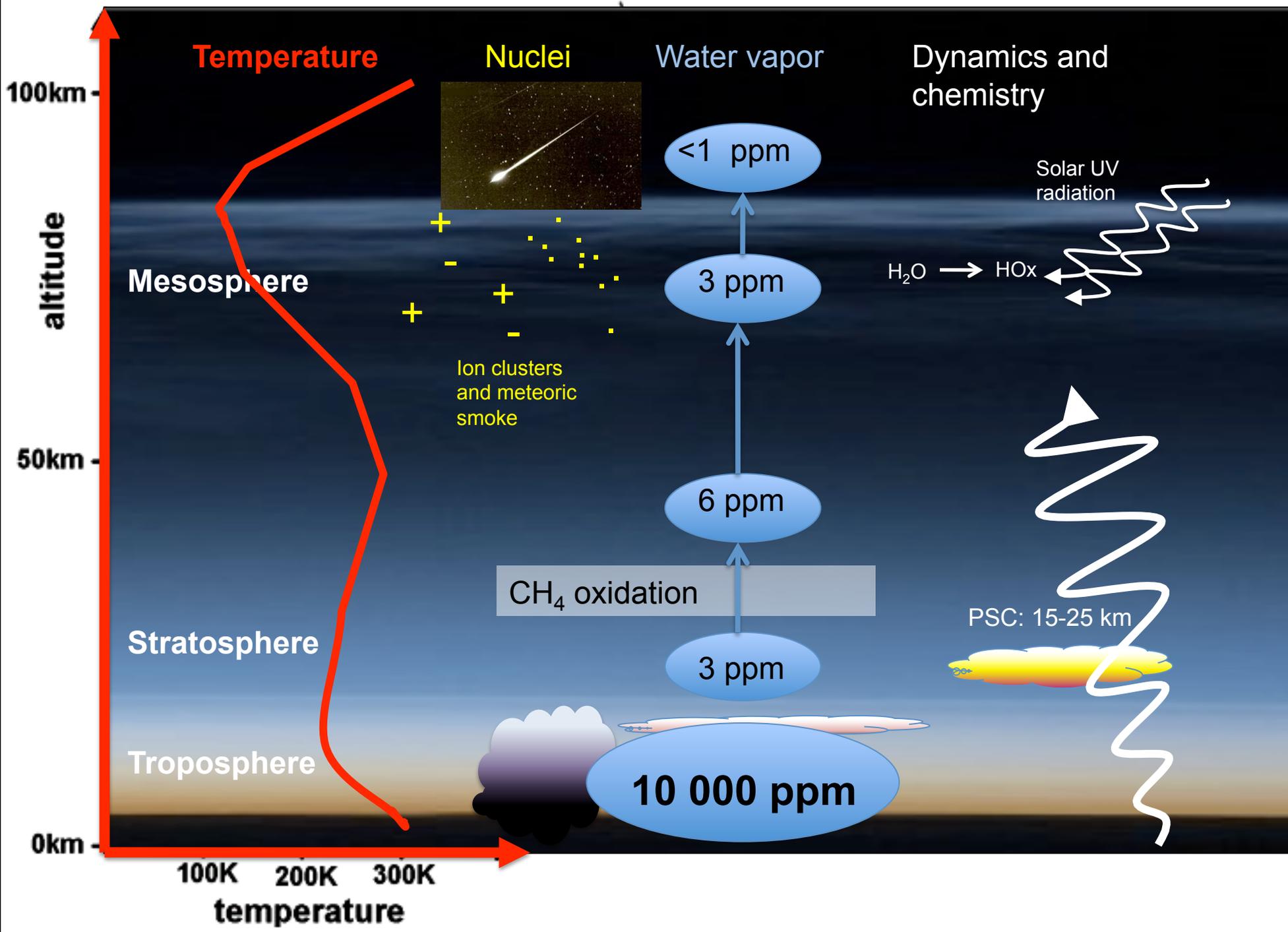
rockets



lidars



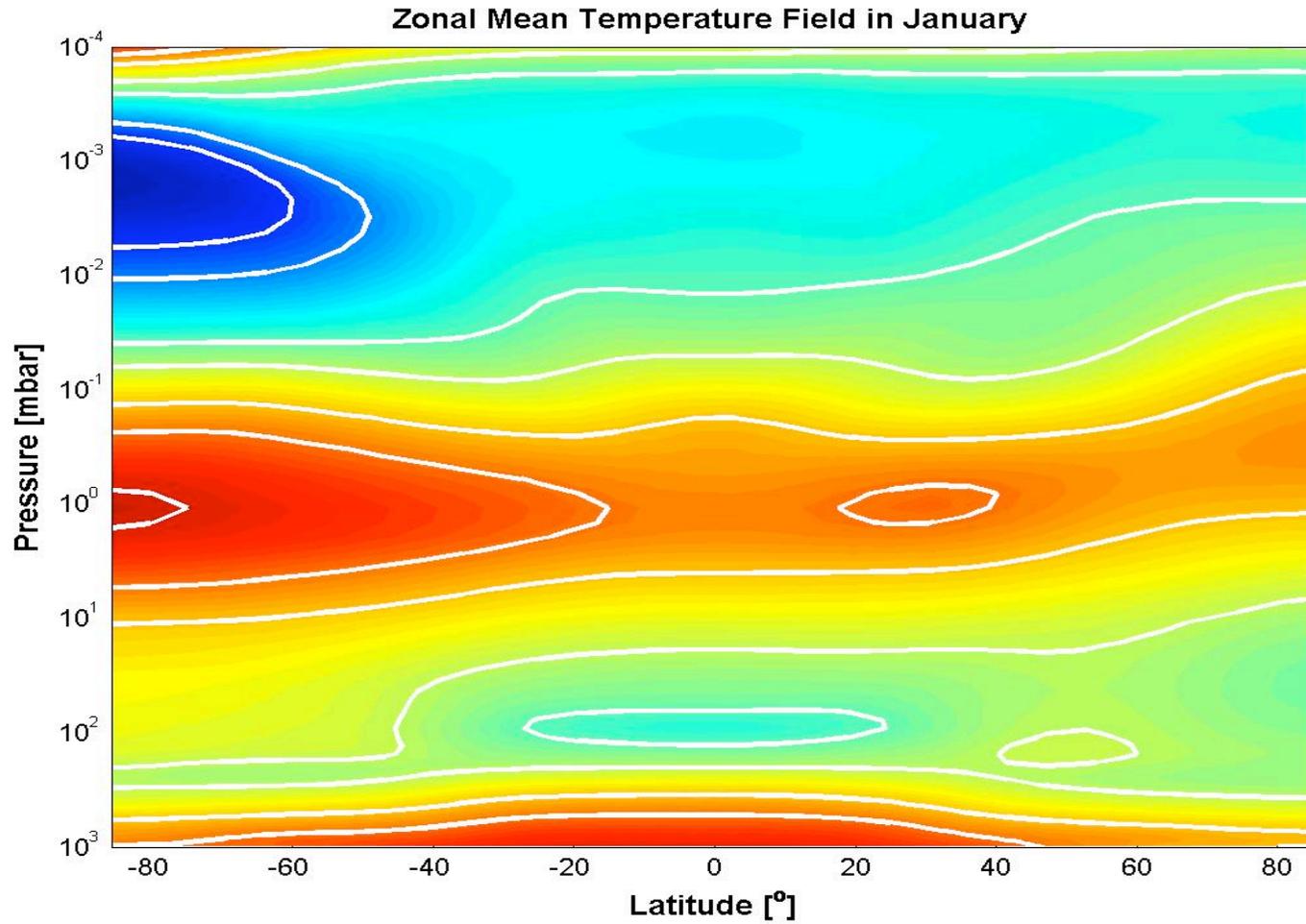




The part of the atmosphere where noctilucent clouds form is actually sunlit almost around the clock...

What makes it so cold in the summer polar mesopause region??

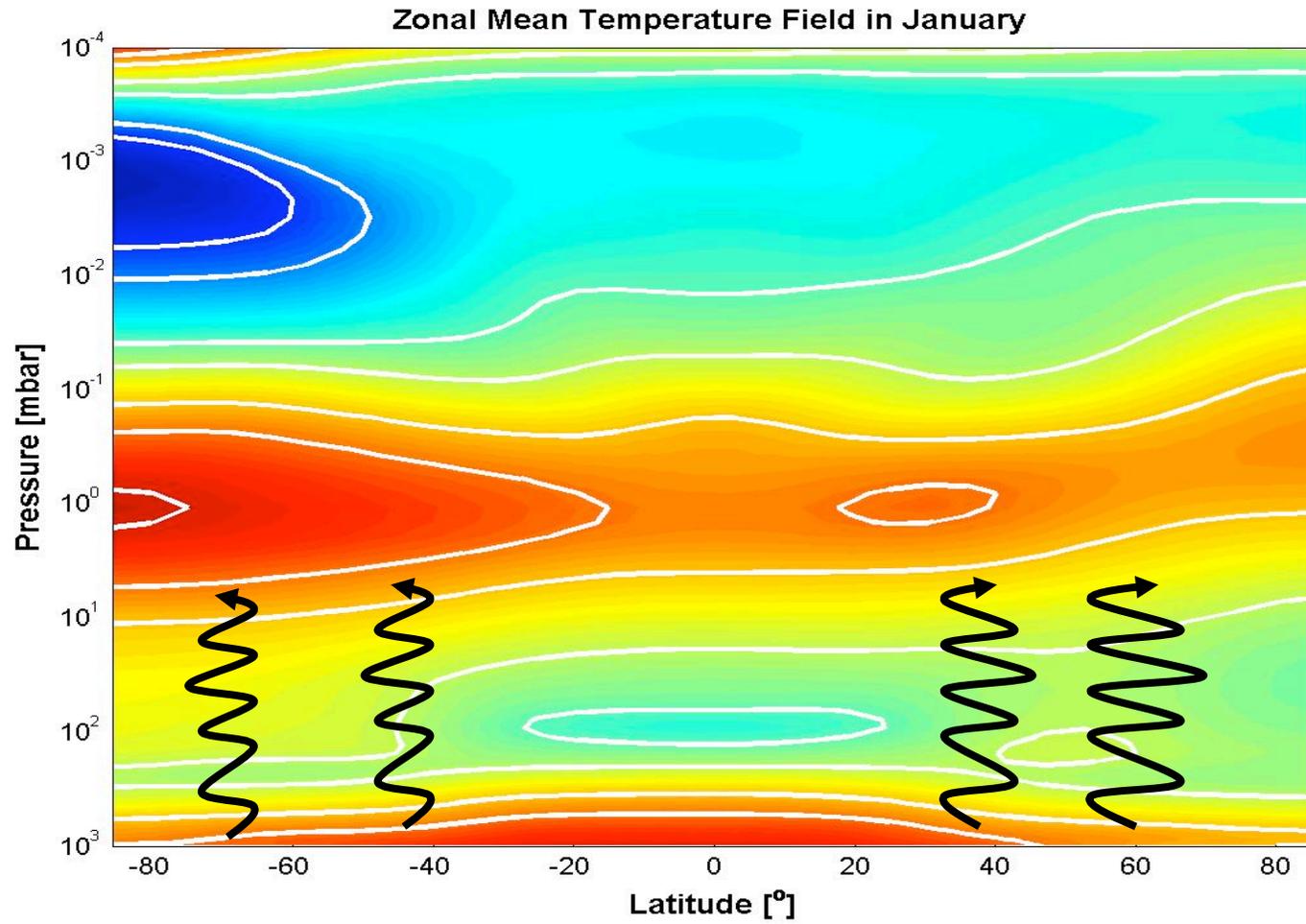
# Zonal Mean Temperature Field in January



Summer

Winter

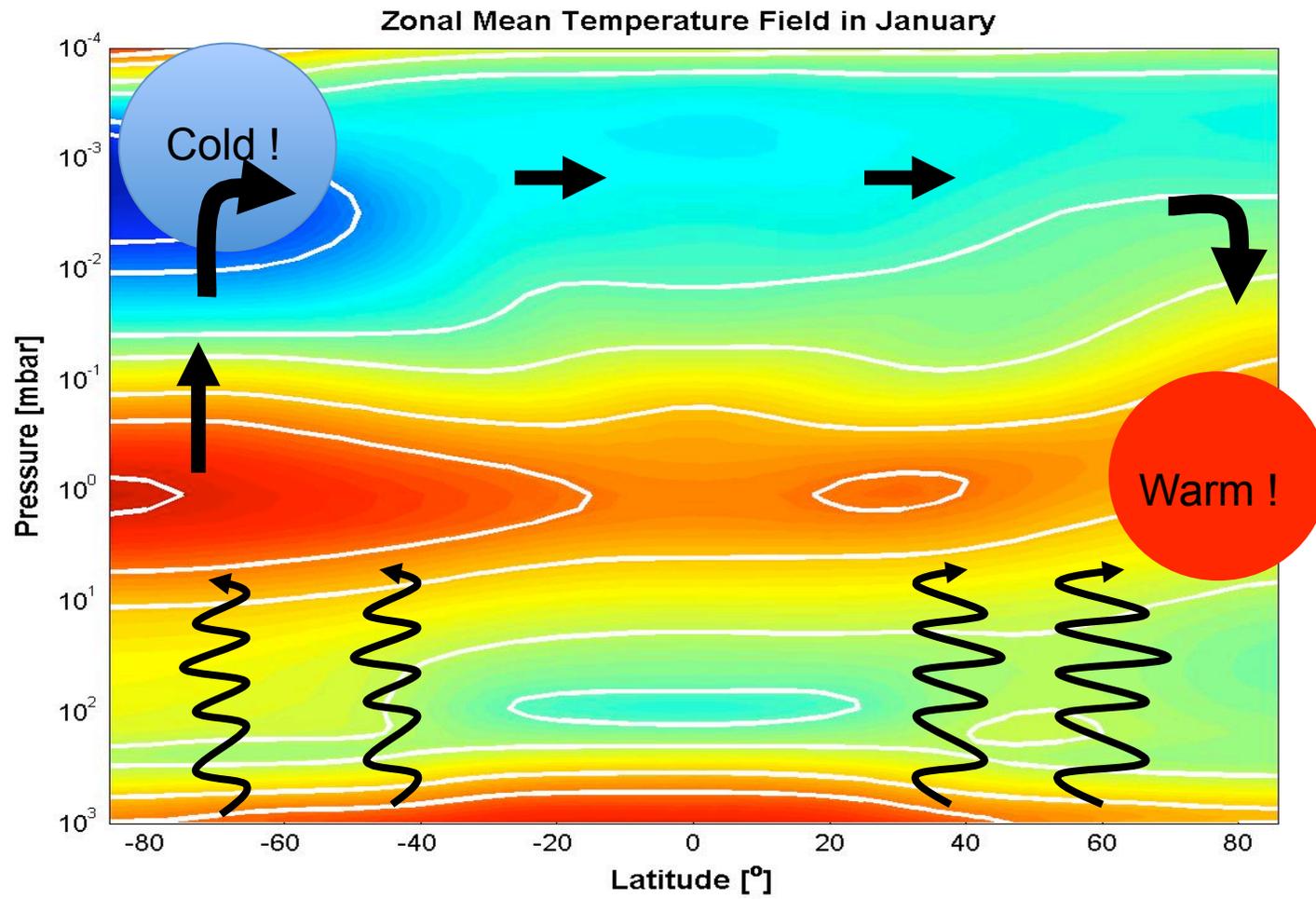
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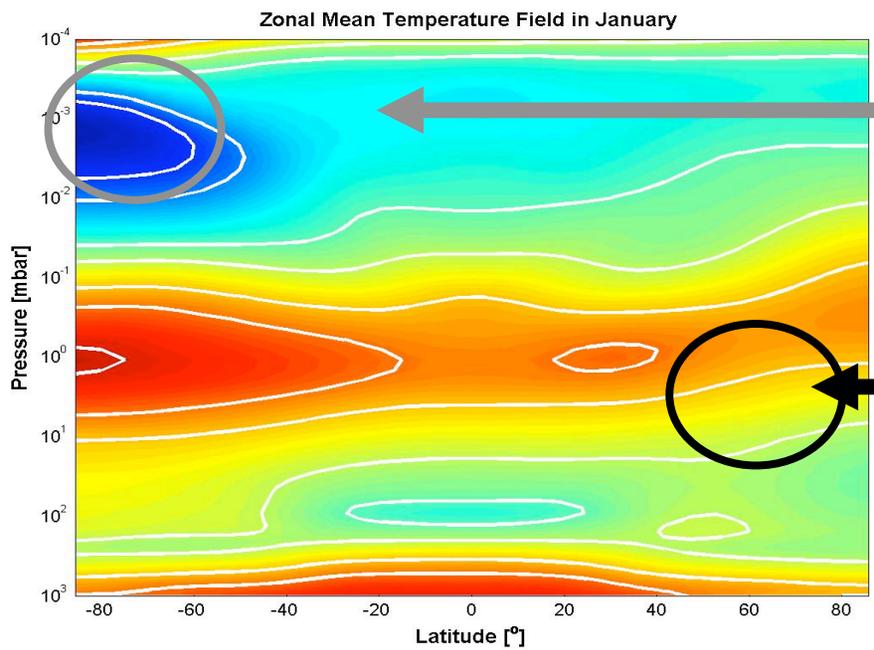
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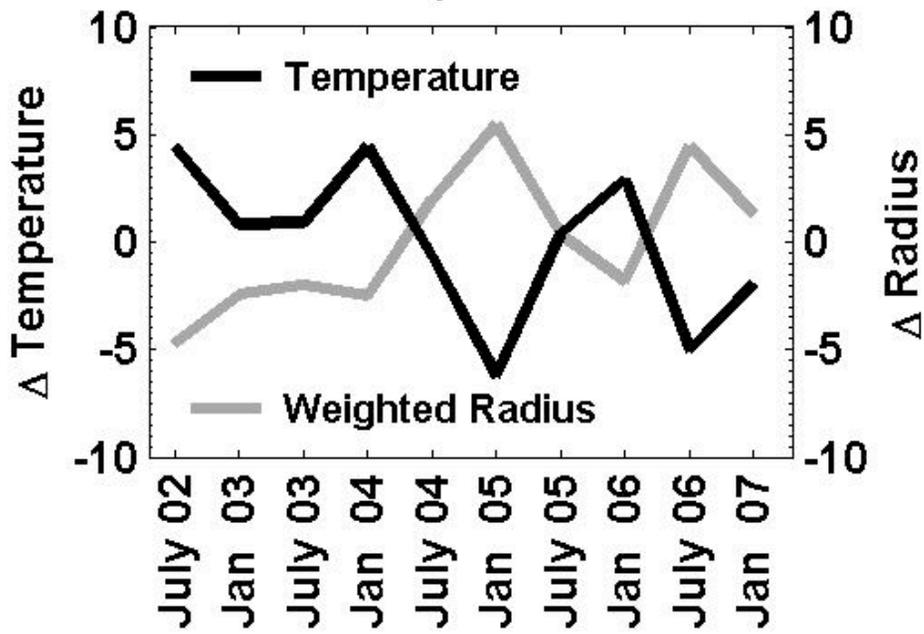
Is it just as cold every summer??



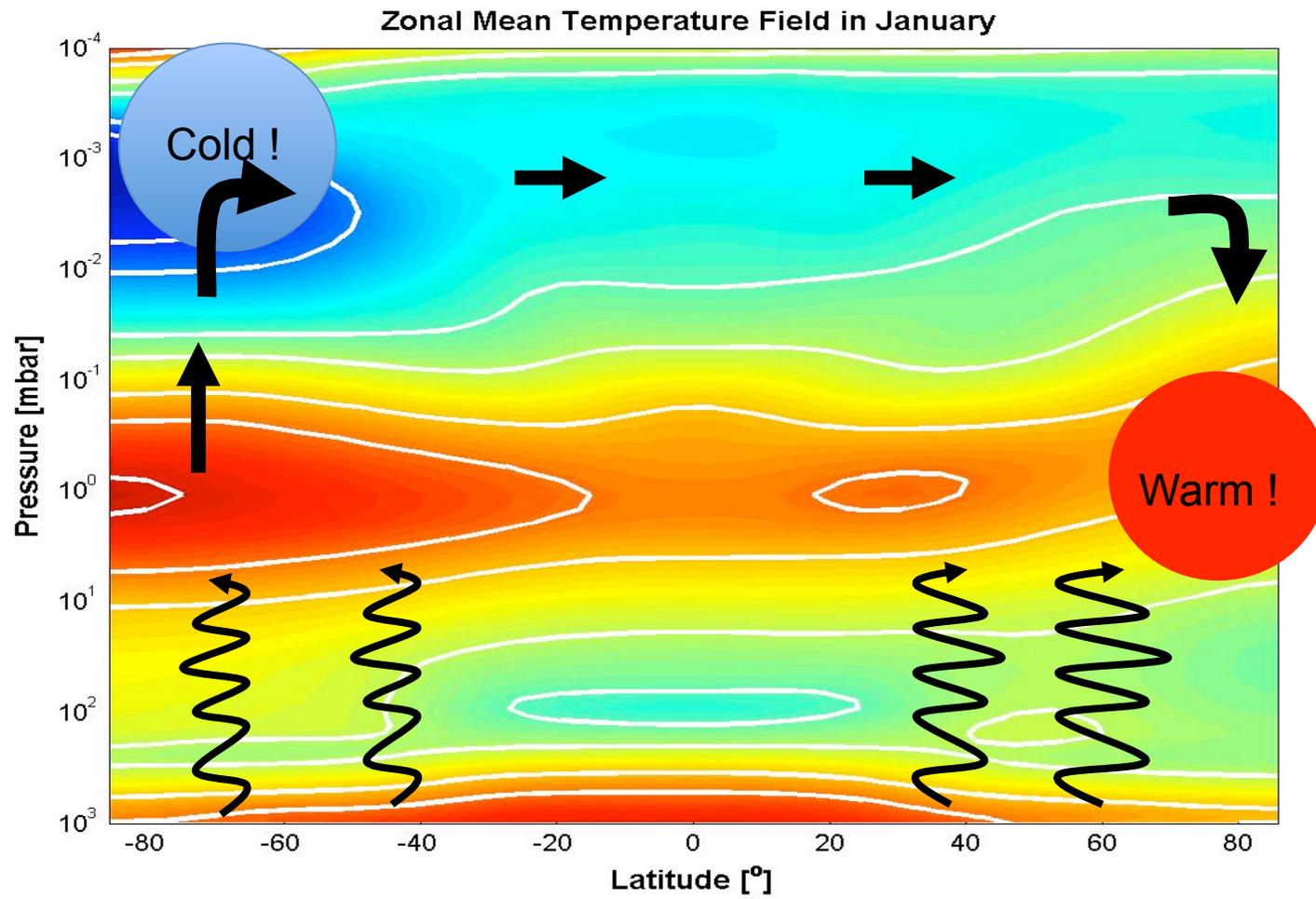
5 year variation of NLC properties in the summer mesosphere (Odin)

and temperature in the winter stratosphere (ECMWF) as proxy for planetary wave activity

Karlsson et al., GRL 2007



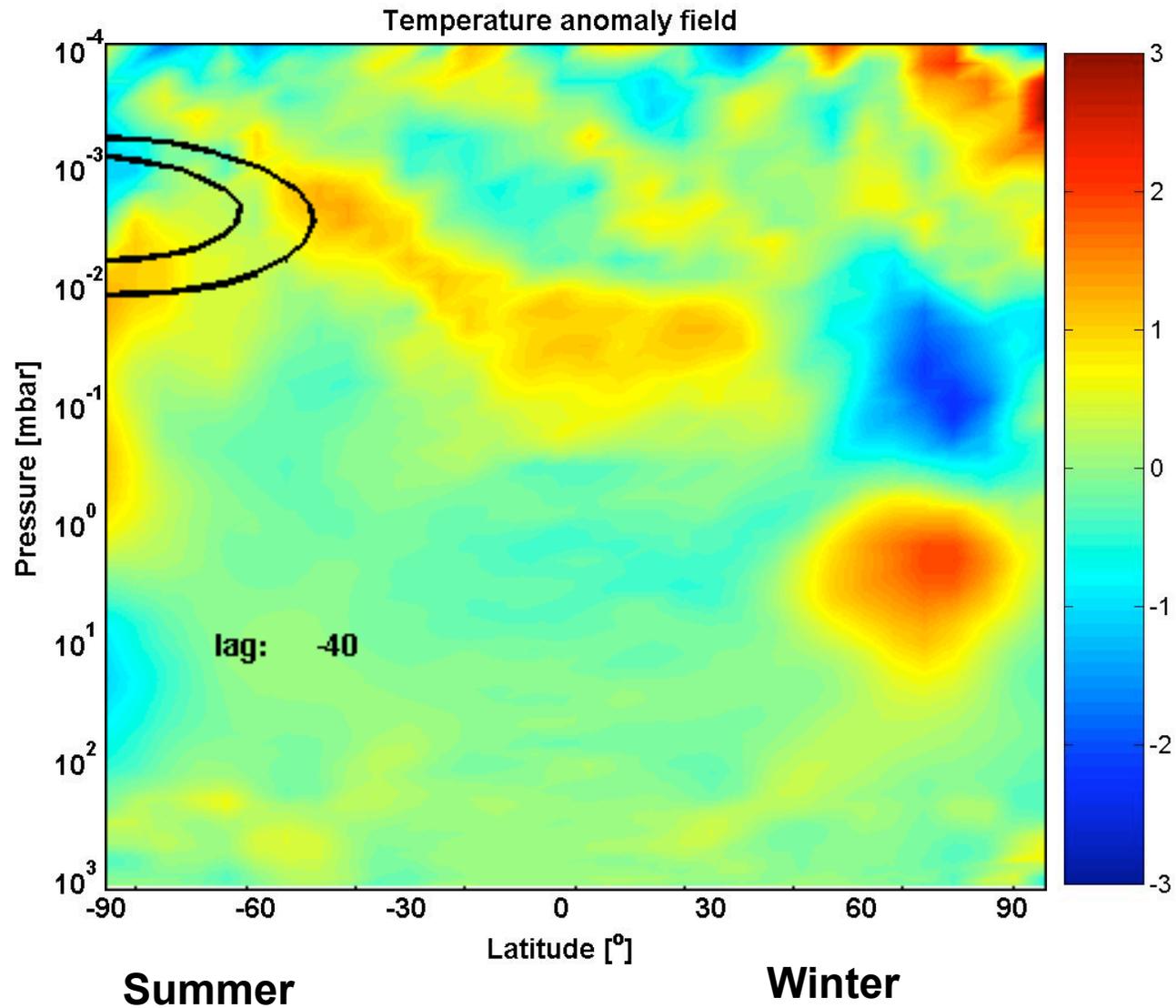
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# An average event of high planetary wave activity in Canadian Middle Atmosphere Model

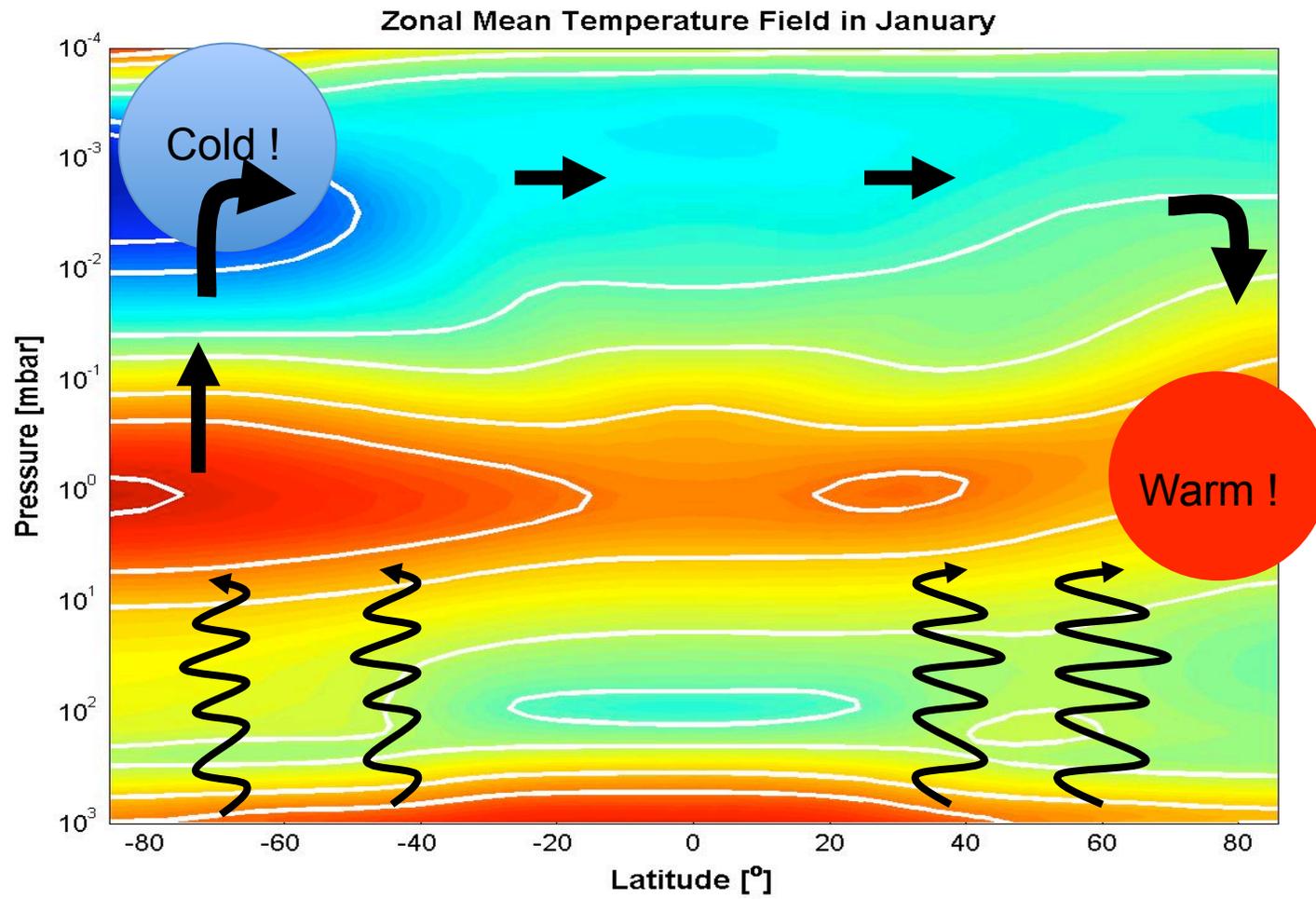


Ongoing...

Ongoing...

- The Magic Dust Nuclei problem...

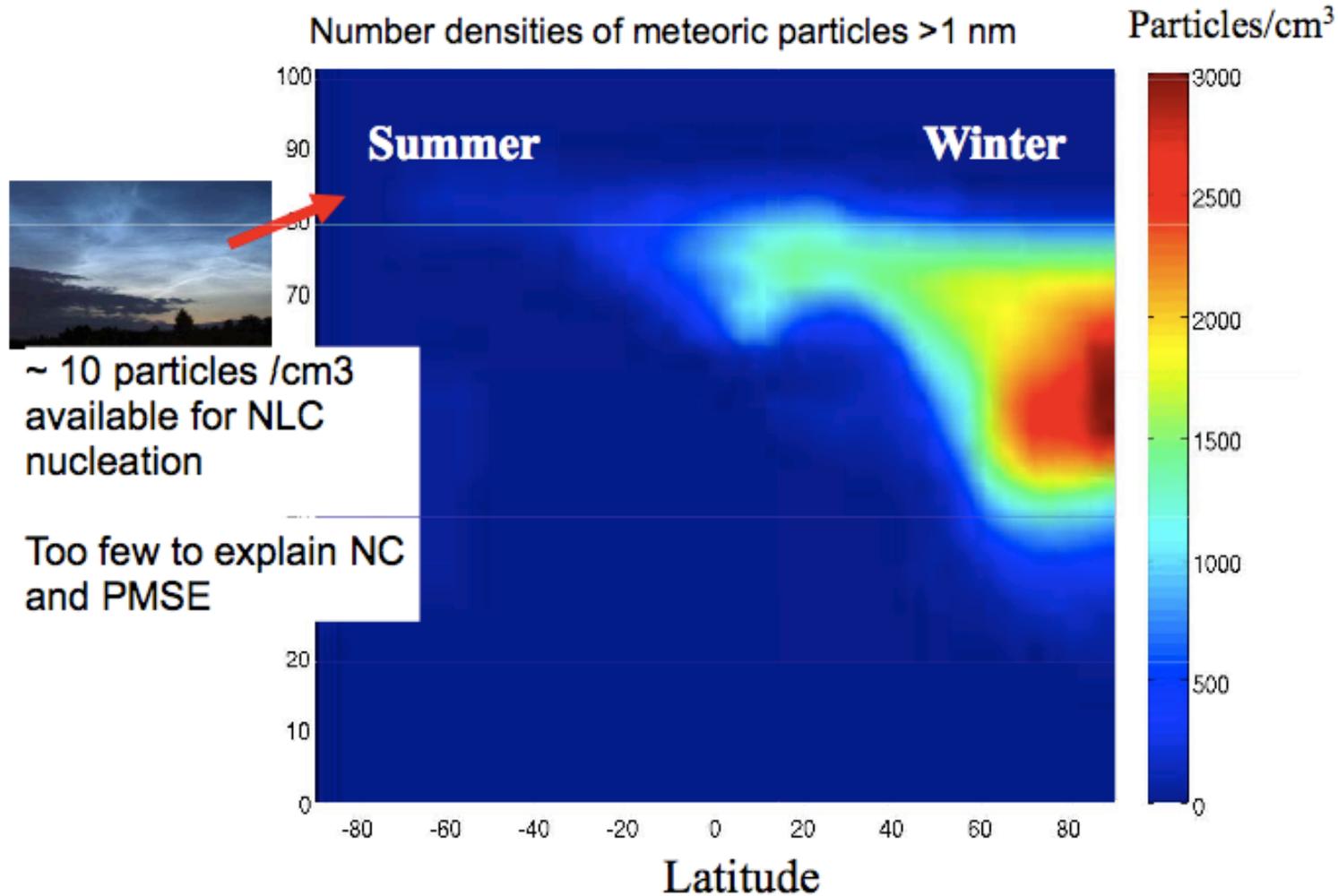
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## Distribution of meteoric material when including transport

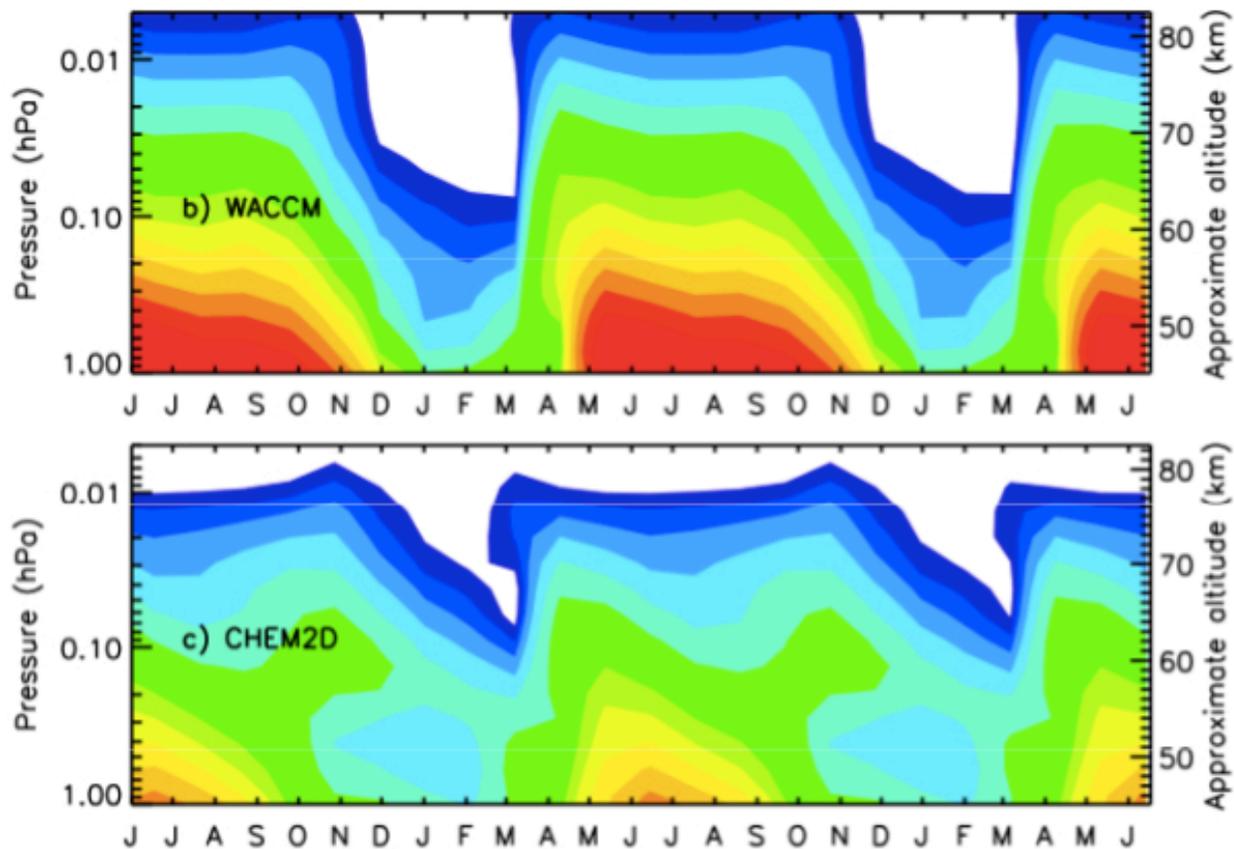


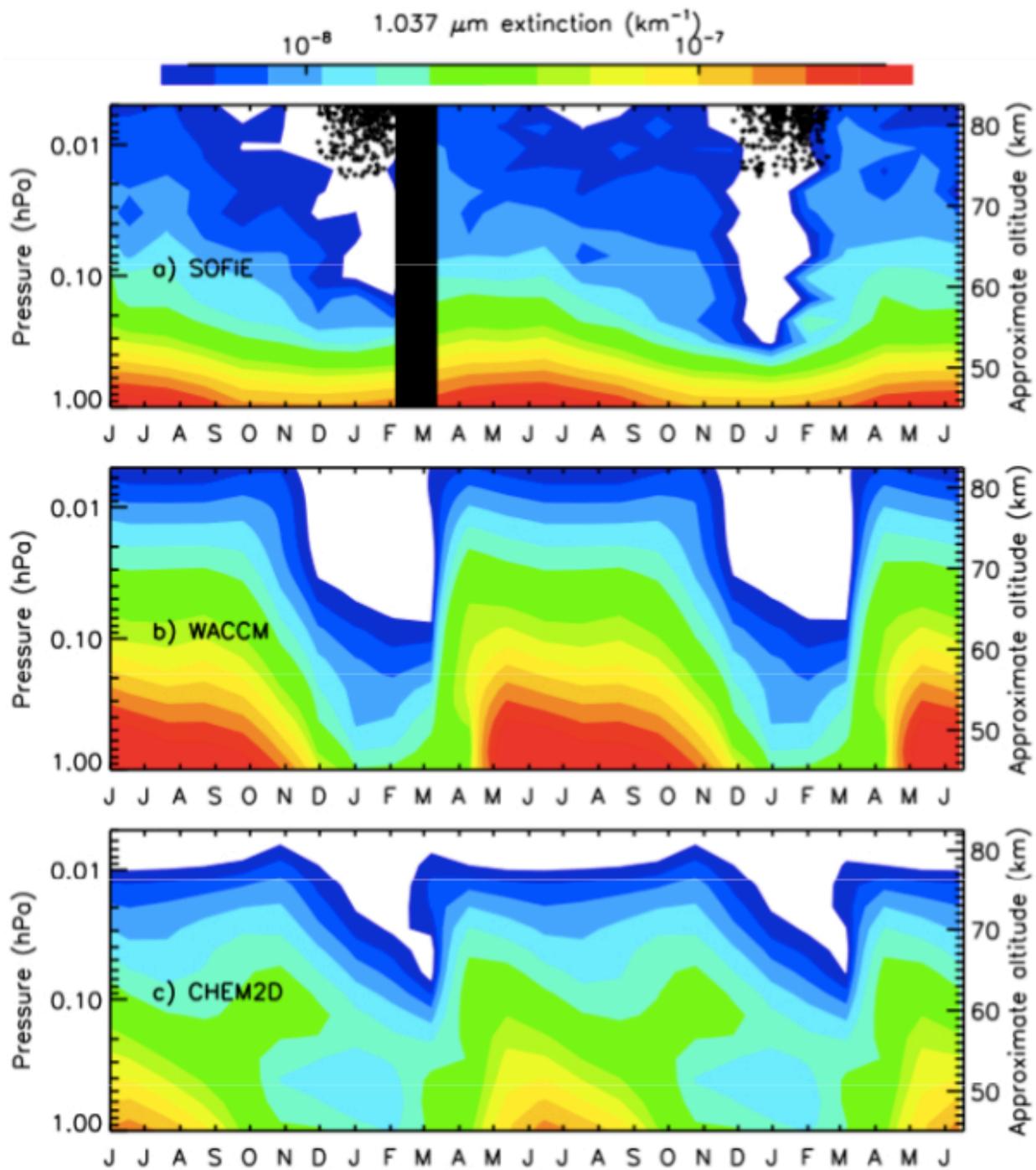
Courtesy: Linda Megner

Linda Megner  
Stockholm



Charles Bardeen  
Boulder





Ongoing...

- The Magic Dust Nuclei problem...

**Options:**

**Are the particles charged??**

**Sulfates?**

**Homogeneous nucleation...**

Ongoing...

- The Magic Dust Nuclei problem...

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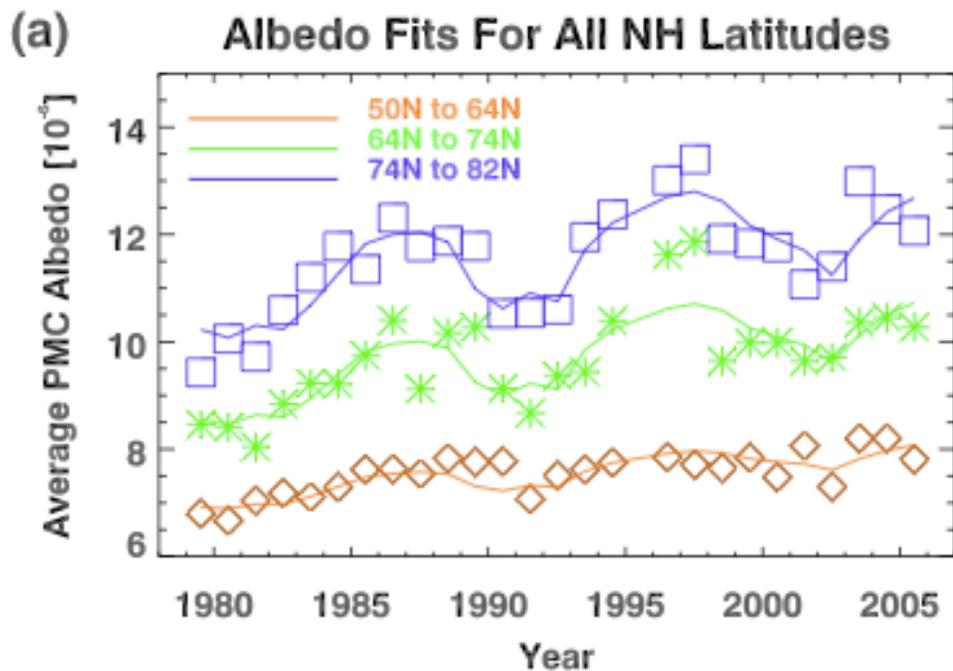
- Long-term trends and climate change...



Thomas, G. E., Olivero, J. J., Jensen, E. J., Schroeder, W., and Toon, O. B.:  
*Relations between increasing methane and the presence of ice clouds at the  
mesopause, Nature, 338, 490-492, 1989.*

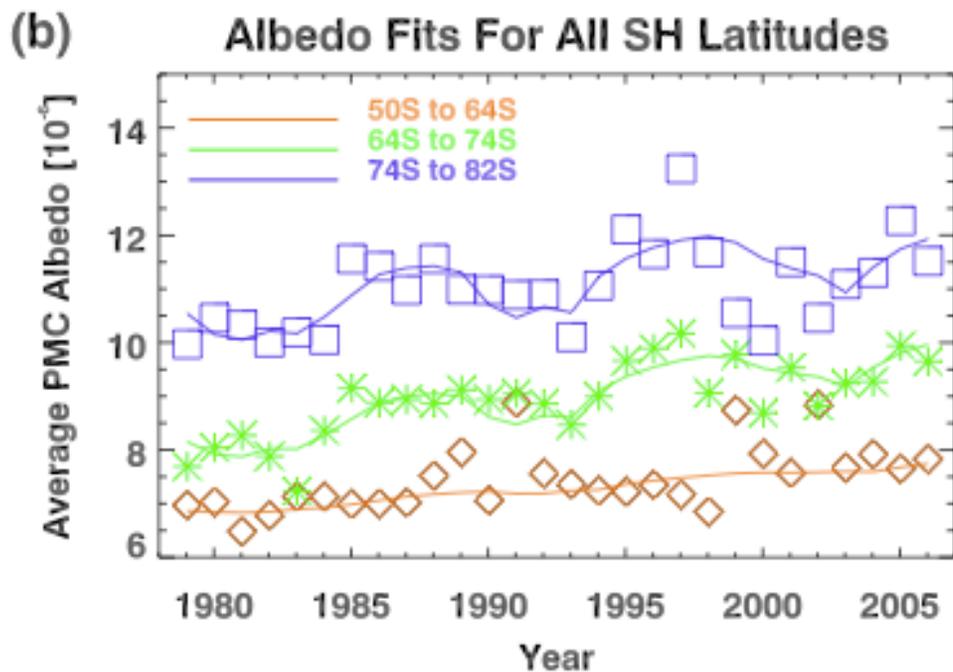
Thomas, G.E. , Global change in the mesosphere-lower thermosphere region:  
Has it already arrived?, J. Atmos. Terr. Phys., 58, No. 1, 1629-1656, 1996

Thomas, G.E. , Is the Polar Mesosphere the Miner's Canary of Global Change?,  
Adv. Space Res., 18, 3149-3158, 1996



Long-term trends?

30 years of noctilucent cloud albedo measured by SBUV



Deland et al., 2007

Ongoing...

- The Magic Dust Nuclei problem...

**Options:**

**Are the particles charged??**

**Sulfates?**

**Homogeneous nucleation...**

- Long-term trends and climate change...

**Options:**

**Increase in methane and/or carbon dioxide??**

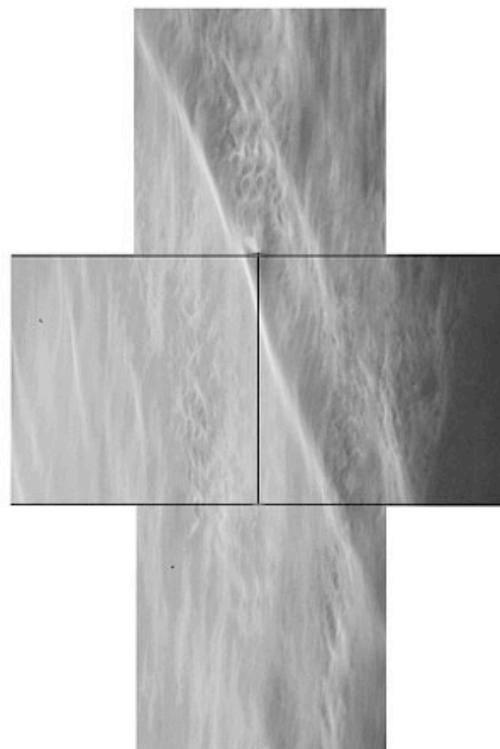
**Changes in dynamics?**

**Other mechanisms?**



**AIM**  
Exploring Clouds at the Edge of Space

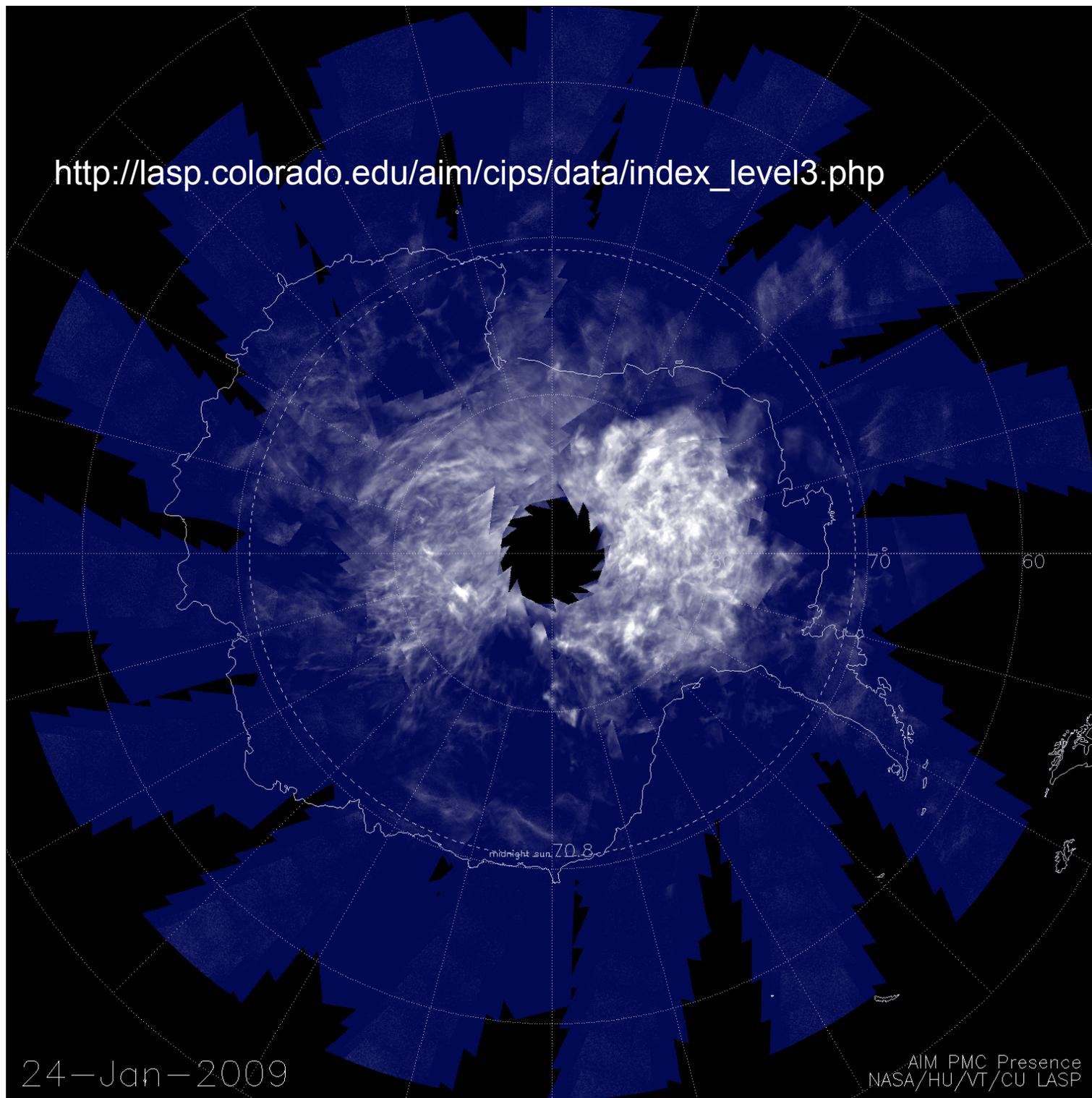
### CIPS: Cloud Imaging and Particle Size Instrument



**CIPS: Panoramic UV (265 nm) nadir imager**

**Provides: PMC images and Cloud properties with 2 km resolution. Total FOV is 1440 x 960 km at 83 km altitude**

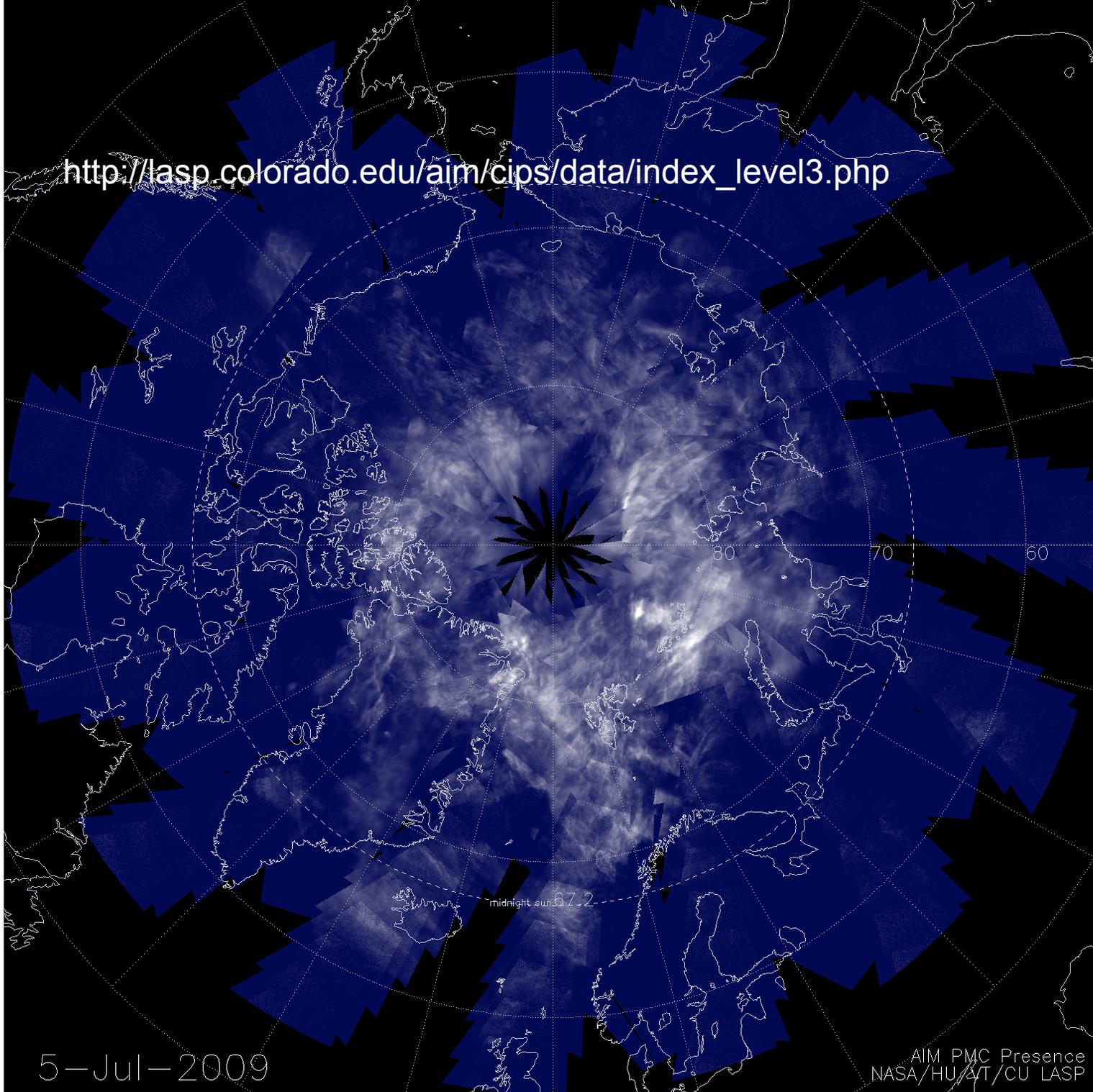
[http://lasp.colorado.edu/aim/cips/data/index\\_level3.php](http://lasp.colorado.edu/aim/cips/data/index_level3.php)



24-Jan-2009

AIM PMC Presence  
NASA/HU/VT/CU LASP

[http://lasp.colorado.edu/aim/cips/data/index\\_level3.php](http://lasp.colorado.edu/aim/cips/data/index_level3.php)



5-Jul-2009

AIM PMC Presence  
NASA/HU/AT/CU LASP

# Summary

Noctilucent clouds are sensitive to any changes in their environment and thus excellent tools for studying atmospheric processes!

The region in which they form is the coldest place on earth due to the circulation of the atmosphere.

The clouds are made of water ice that freezes onto a tiny nucleus. The origin and nature of this nucleus are not fully understood yet.

The year-to-year variability seen in the clouds are related to the dynamic activity in the lower atmosphere – particularly to the winter hemisphere.

The clouds appear to increase in brightness, occurrence frequency and latitudinal extent. This may be connected to global climate change. The mechanism is not pin-pointed yet.

Studying noctilucent clouds lead to a broader knowledge about many atmospheric processes!



**This photo is taken from the International Space Station!!**