# Latest results from SOFIE / AIM

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7th Atmospheric Limb Conference
Institute of Environmental Physics
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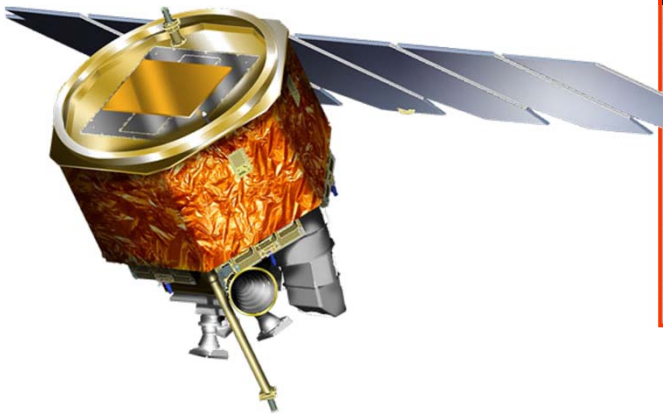
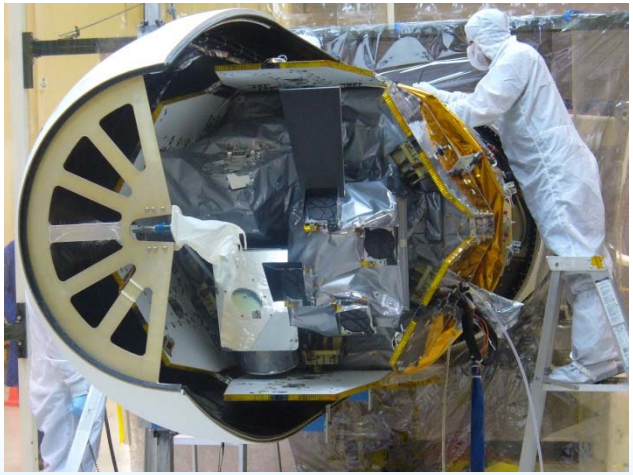
June 19, 2013

# Six years and going strong…




AIM = SOFIE + CIPS



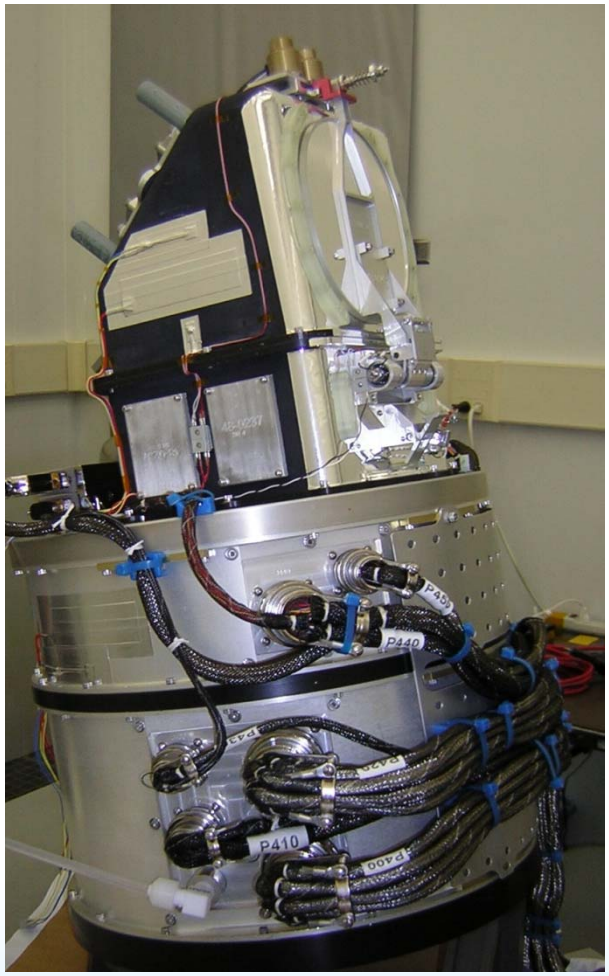
Launched April 2007 into 600 km orbit

SDL designed, fabricated, tested, and integrated the SOFIE instrument.

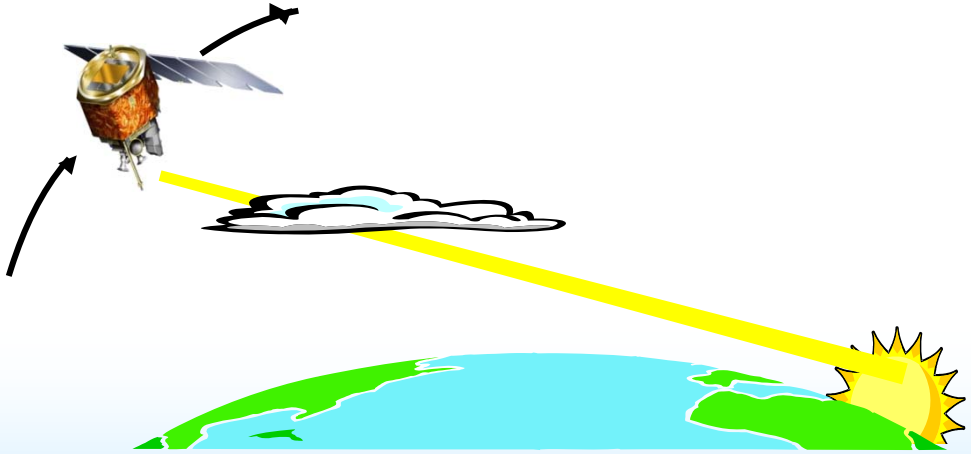
GATS is the SOFIE PI institution, leads the science analysis, and conducts flight ops.

# SOFIE: Solar Occultation for Ice Experiment

## Differential absorption radiometer



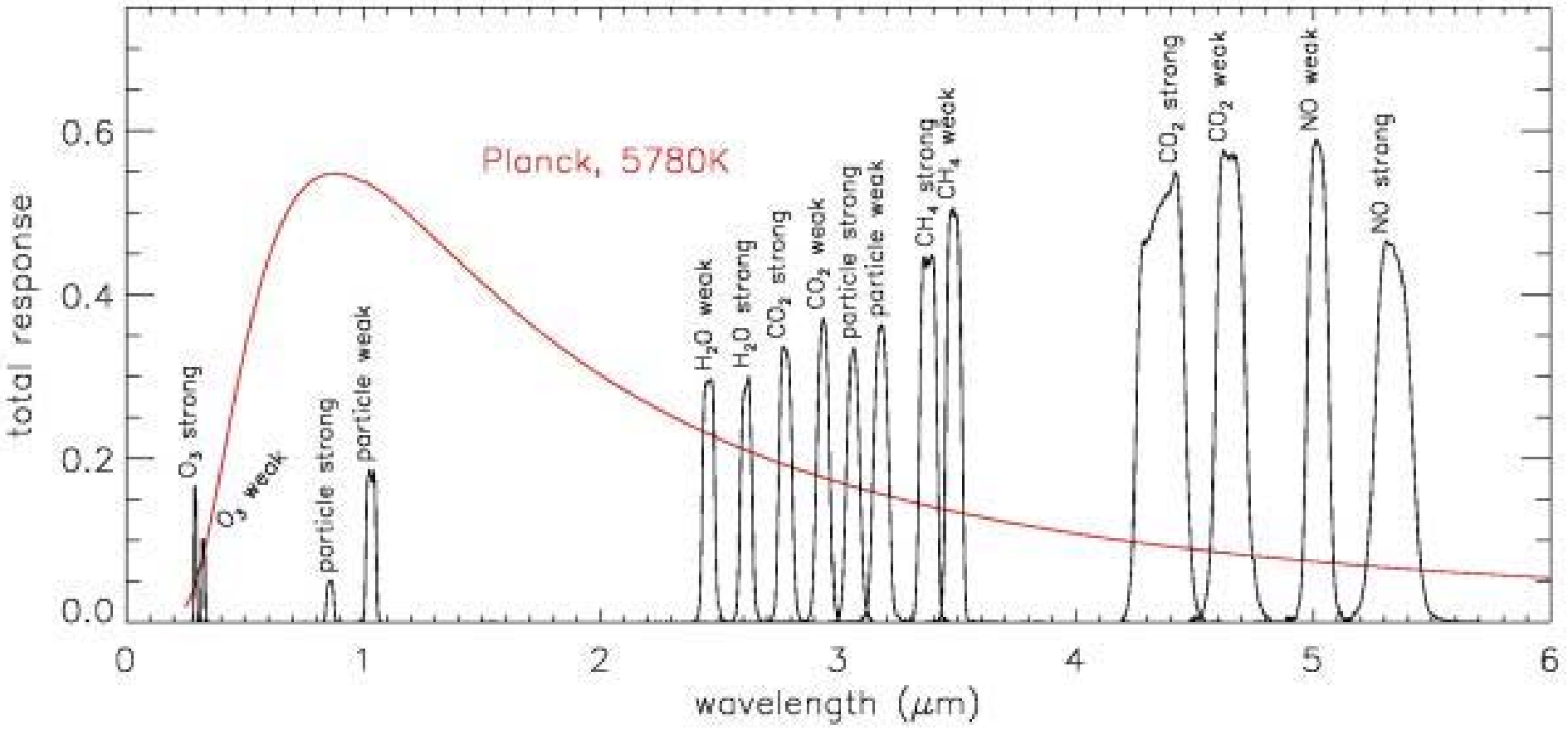

- 16 channels from UV to IR (0.3 - 5.3 $\lceil \mu$)
- T, PMCs, $CO_2$, $H_2O$, $CH_4$, NO, $O_3$, aerosols, cosmic smoke
- 2 km vertical resolution with unprecedented fidelity



# SOFIE Measurement Bands

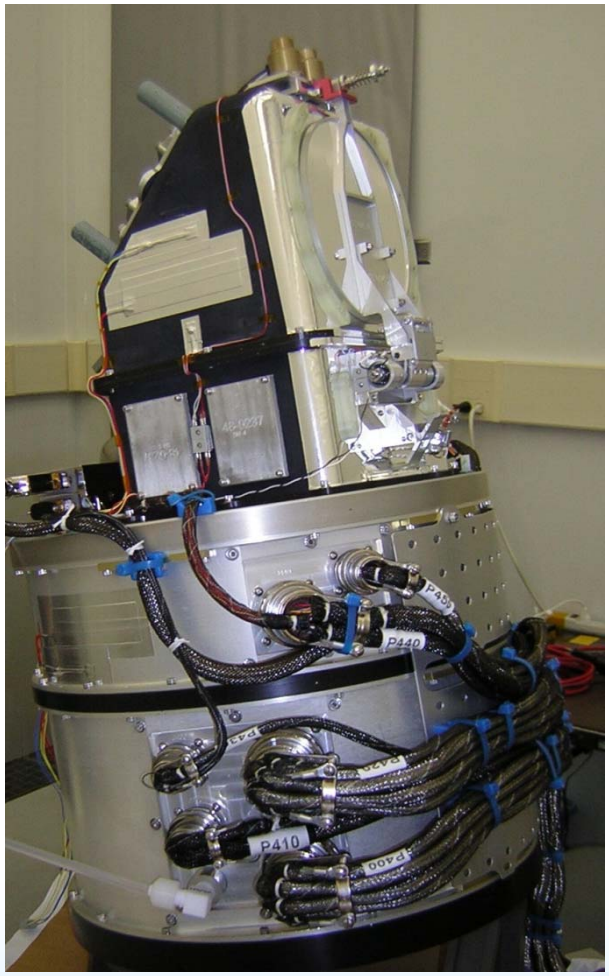
16 wavelengths (8 pairs)

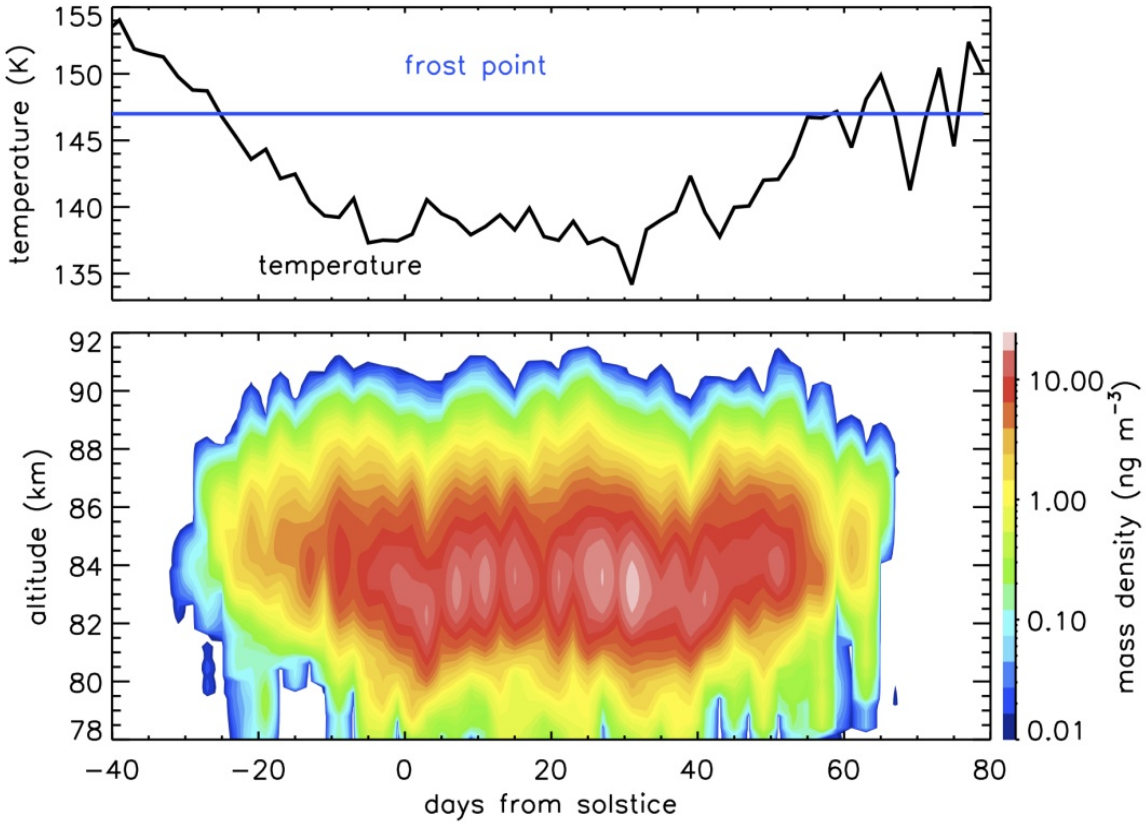
- each channel pairs a strong and weak absorption band



# Comprehensive new view of PMCs

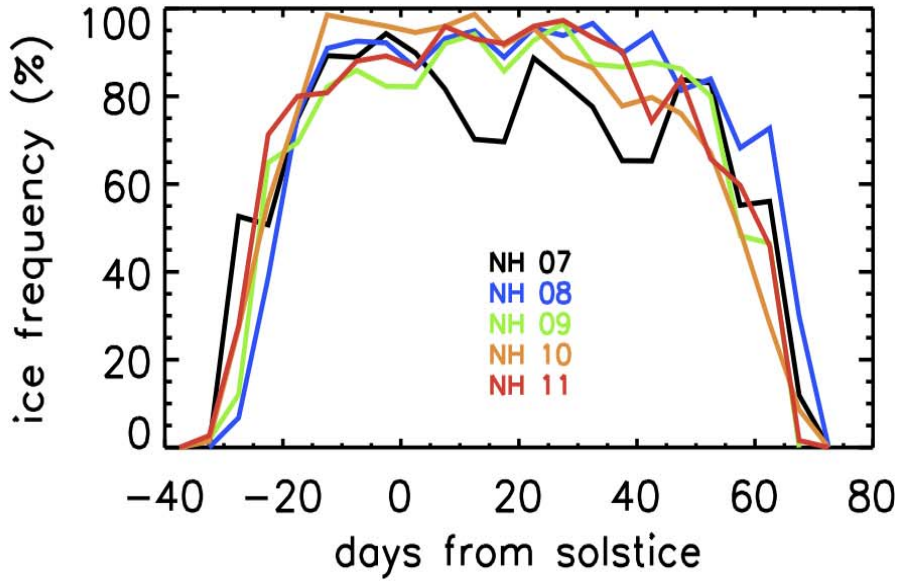
- Measurements display ice forming in a broad region from 78  to 90 km.
- Visible layer lies in a narrower range centered near 83 km.





# PMC season turns on and off abruptly

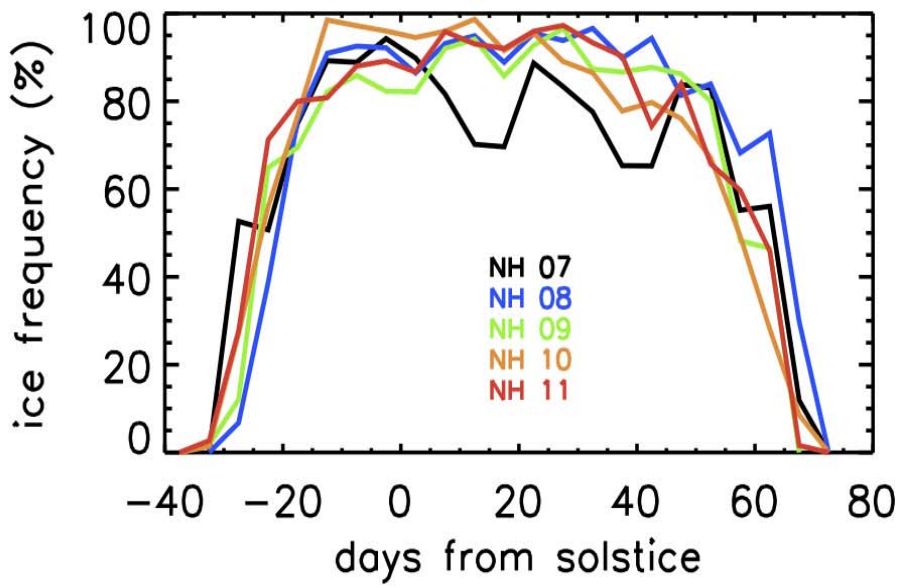
## Northern Hemisphere



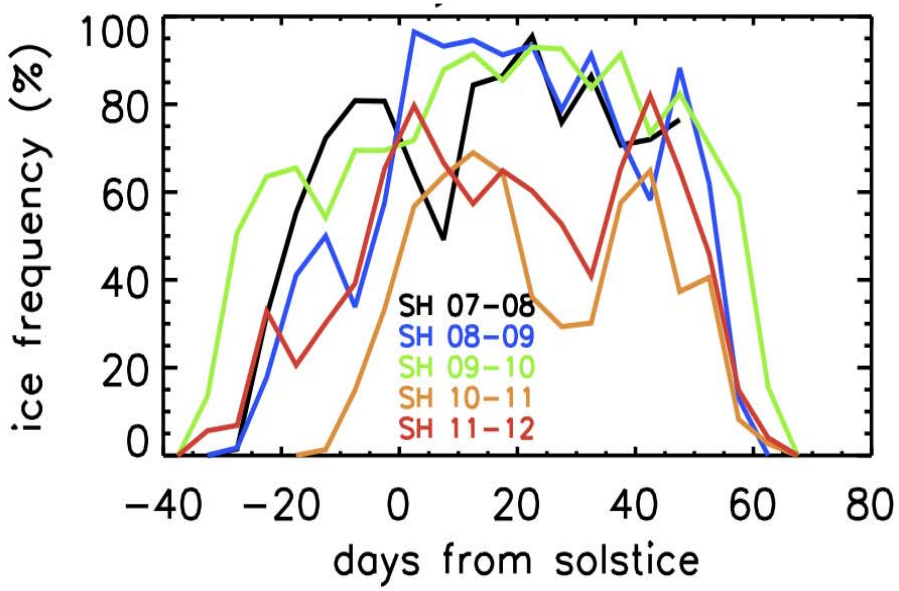

The atmosphere transitions from no clouds to >80% occurrence frequency in 10 days

# PMC season start times and frequencies are highly variable in the south

## Northern Hemisphere




## Southern Hemisphere



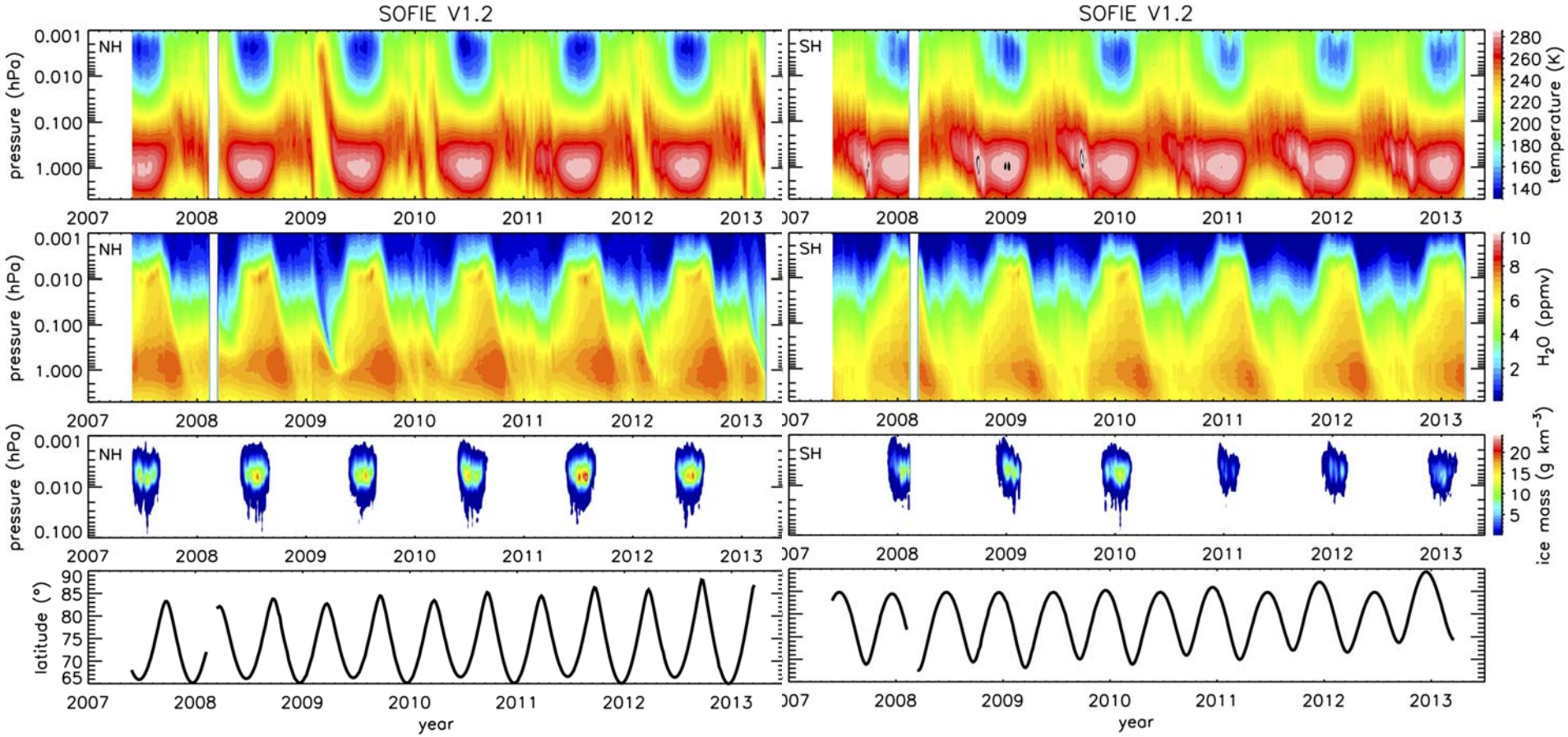

SH season start times are affected by the timing of the breakdown of the winter polar vortex

*Karlsson et al., 2011*

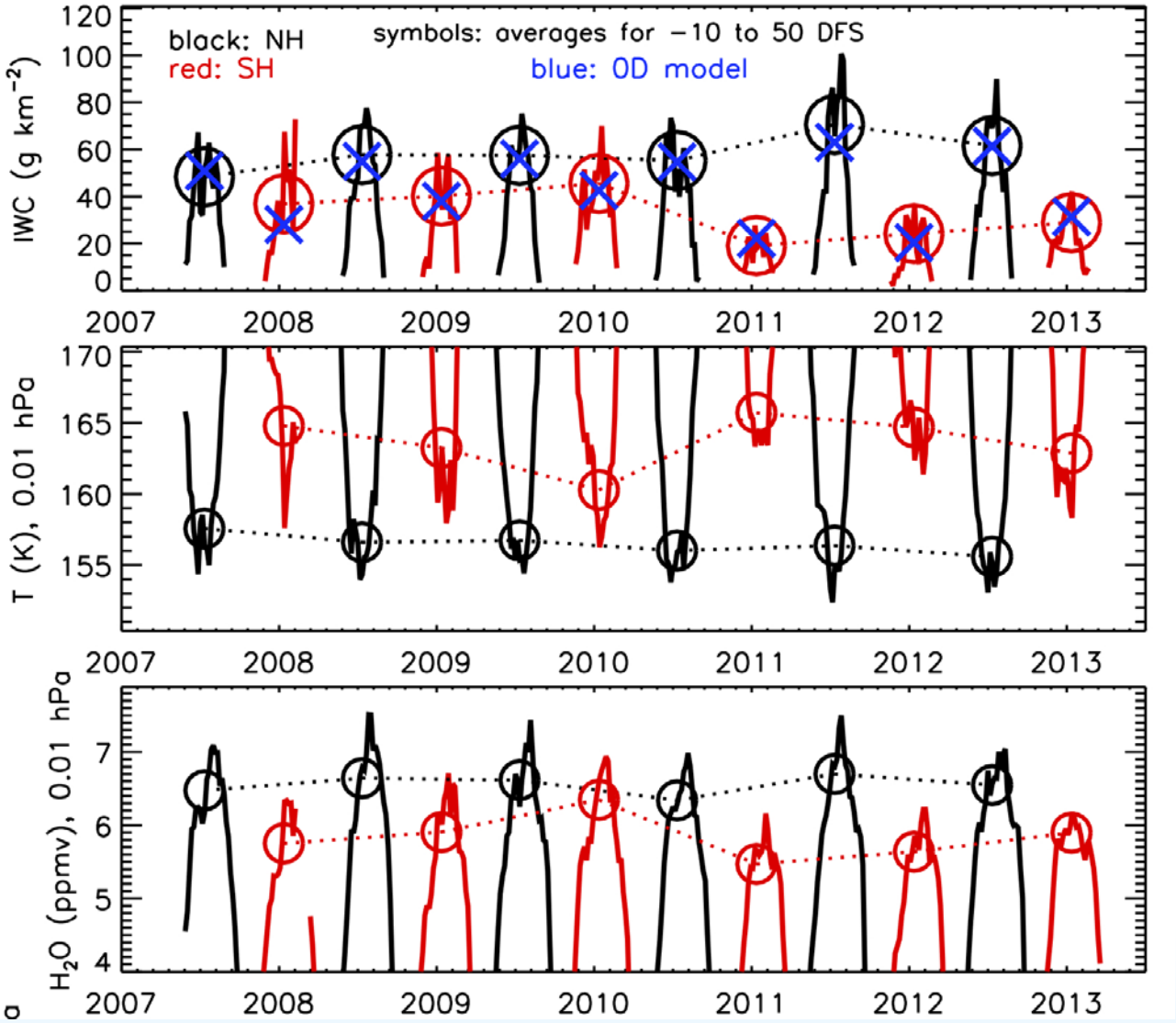
# Overview of Mission to Date

Northern Hemisphere

Southern Hemisphere



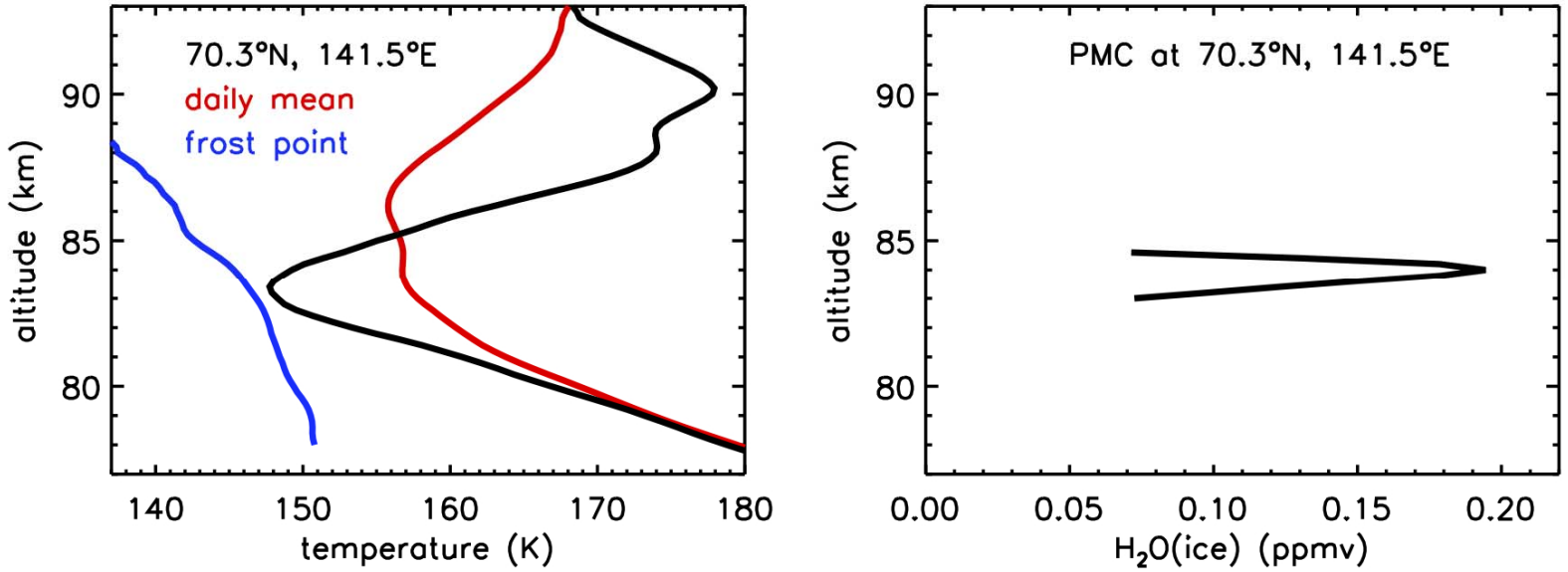
# Overview of six years (12 PMC seasons)



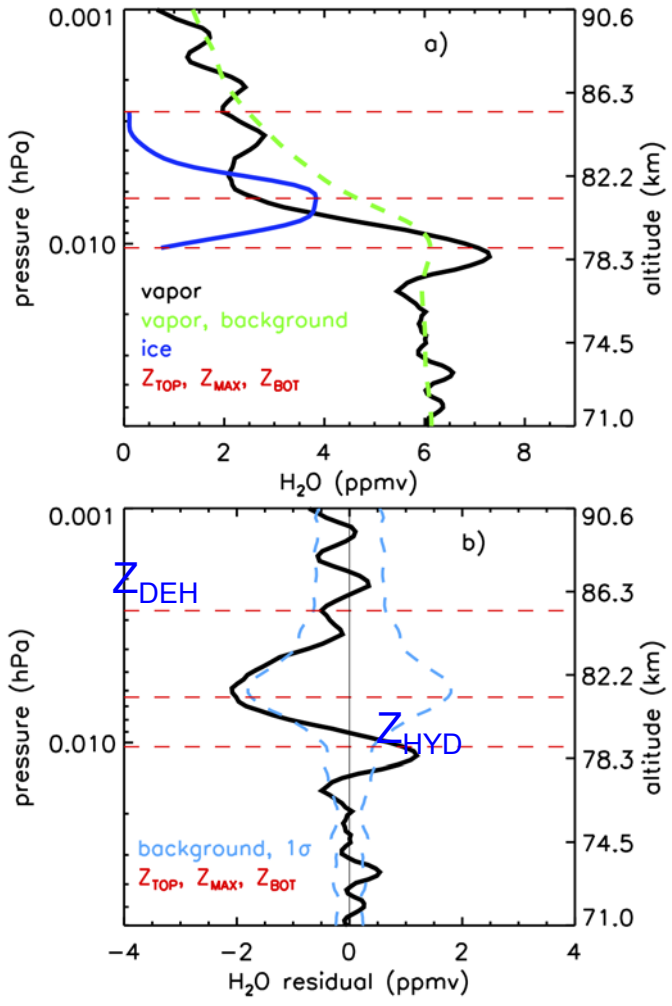
# Getting off to an early start this season

The first 2013 Northern Hemisphere PMCs appeared May 13, over a week earlier than the previous 6 NH seasons observed by SOFIE.

The early appearance of PMCs is tied to unusually cold temperatures, as observed water vapor levels were near average.

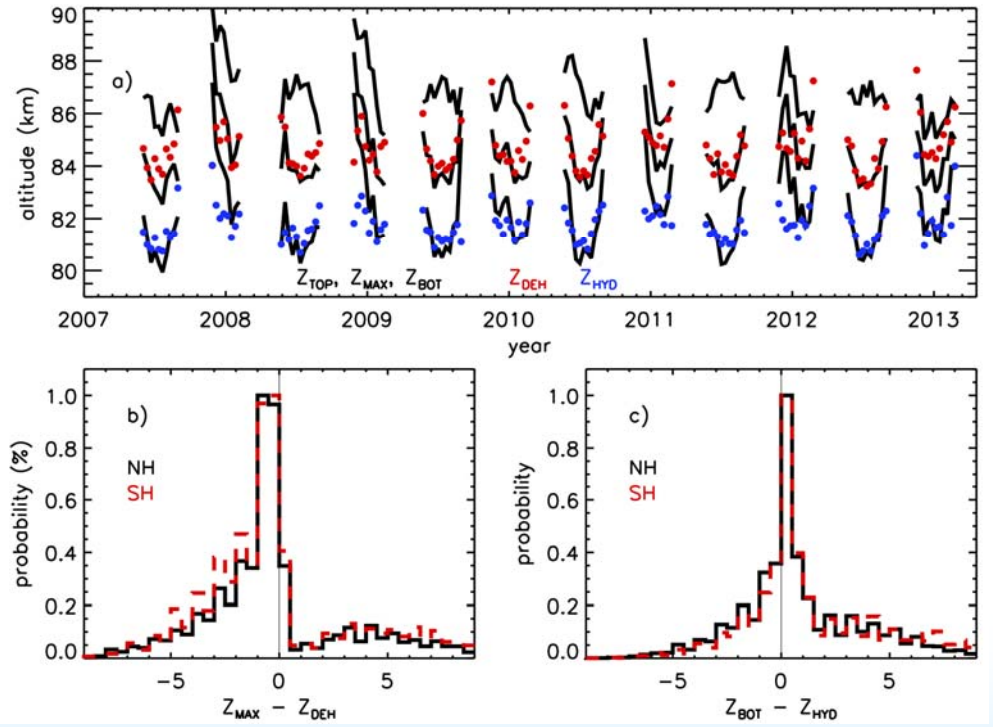


# PMCs - Water Vapor Interactions




Dehydration at peak ice altitude

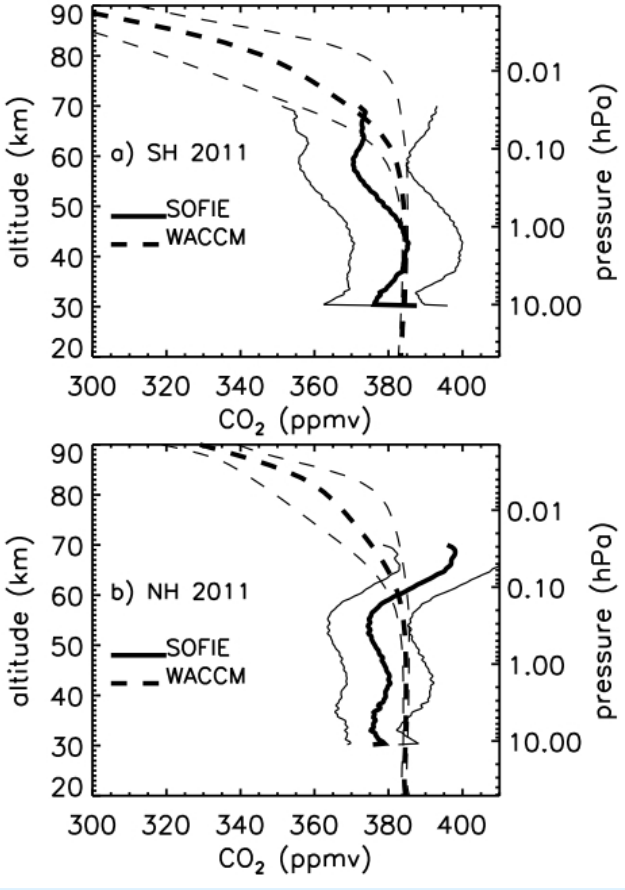
Excess water near cloud base (sublimation)



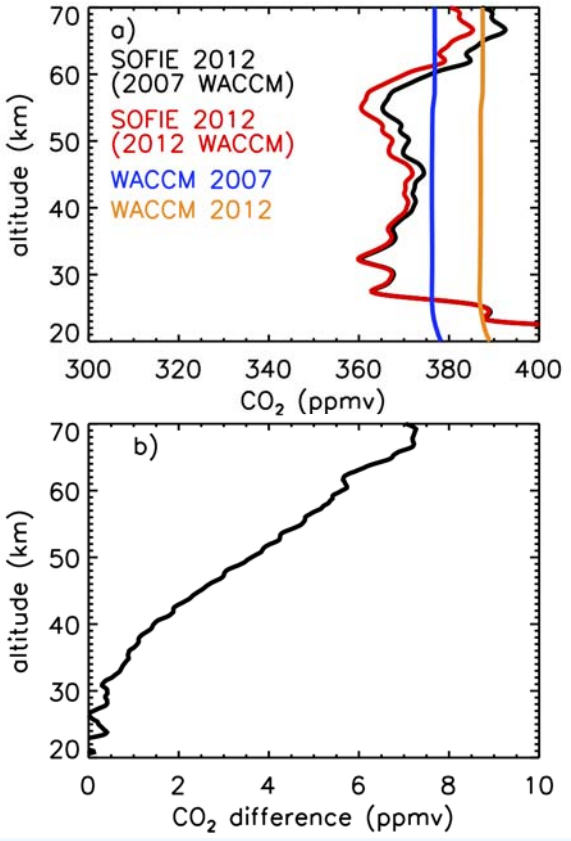
# SOFIE $CO_2$ Overview

$CO_2$ retrieved from either 2.7 or 4.3 μm transmissions, at altitudes where T/P is retrieved from refraction.

- ~50 km for single events
- ~70 km for signal averages

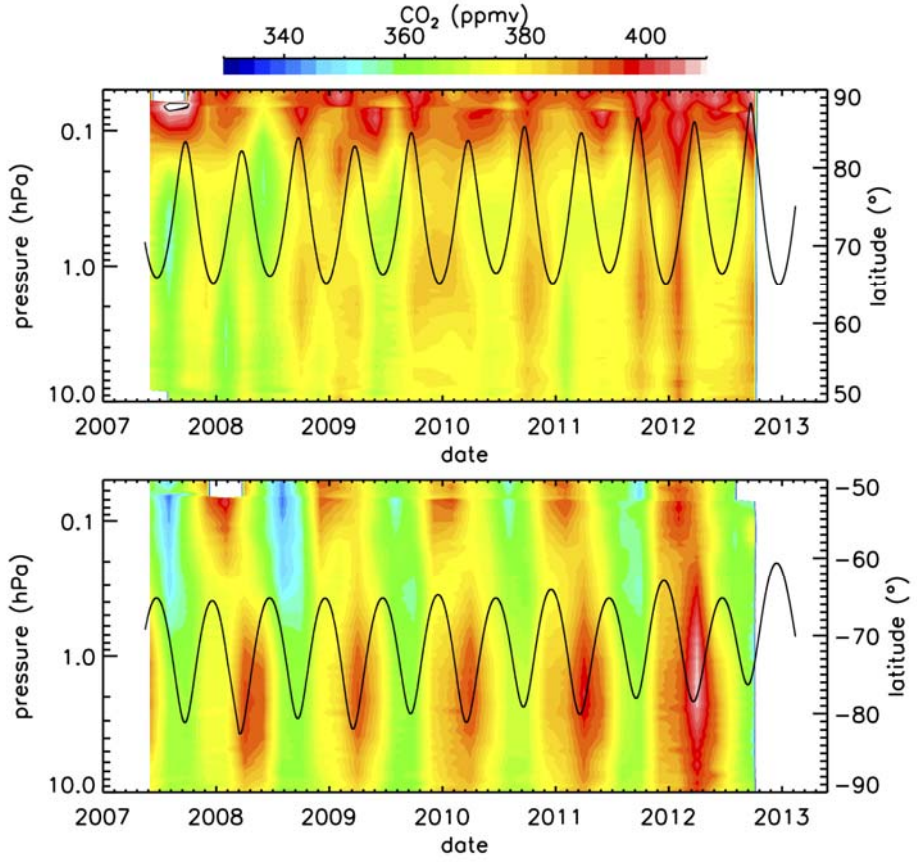



SOFIE $CO_2$ sensitivity to WACCM a priori:

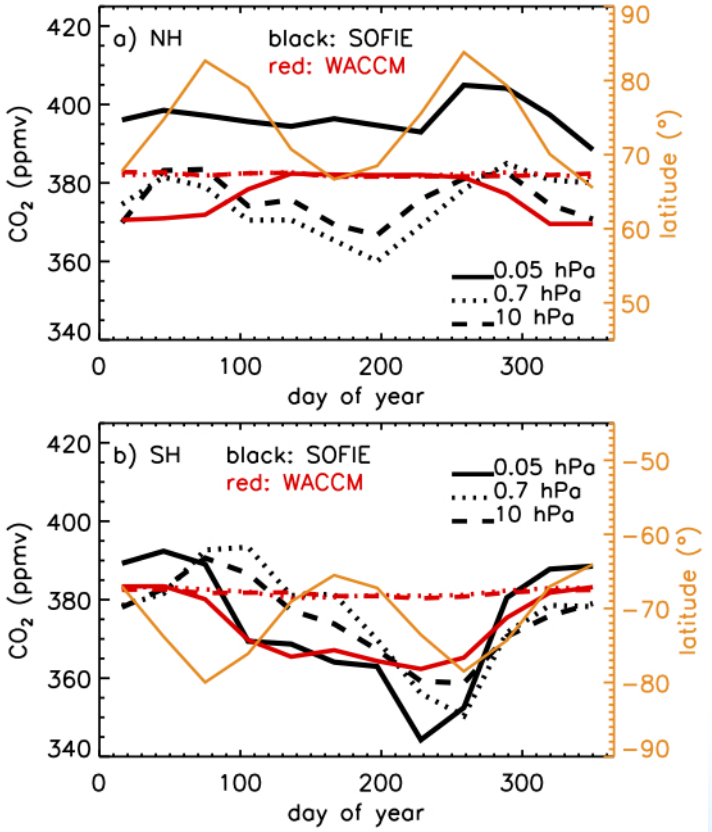


# SOFIE $CO_2$, Seasonal Cycle

SOFIE indicates a $CO_2$ seasonal cycle in the SH at 10-0.05 hPa, but no seasonal cycle in the NH.

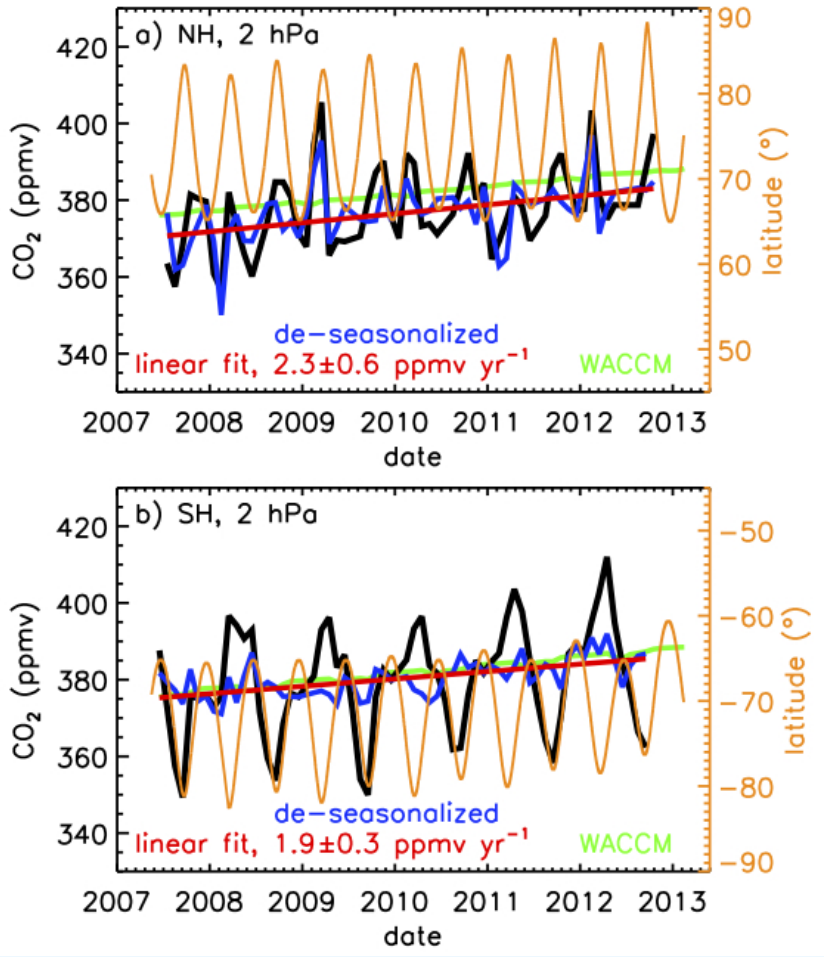



WACCM indicates a seasonal cycle for P < ~0.05 hPa, stronger in the SH.

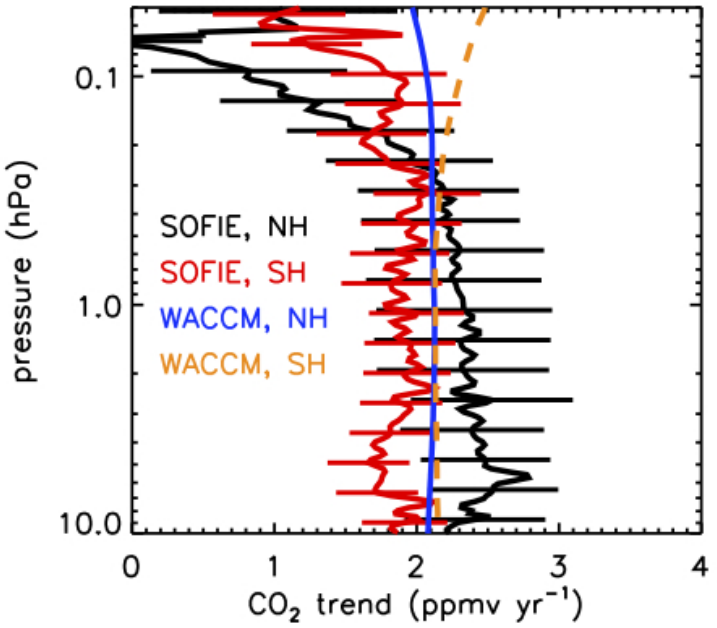


# SOFIE $CO_2$ Trends

Remove the seasonal cycle, then do a linear regression.




Trends agree with Mauna Loa and ACE.



# Meteoric Smoke

- 10 - 100 tons of meteoric material enter atmosphere each day
- 70% of incoming meteors ablate in upper atmosphere
- resulting meteoric smoke particles (MSPs) reside between 70 and 110 km, and have radii of 0.2 - 10 nm.

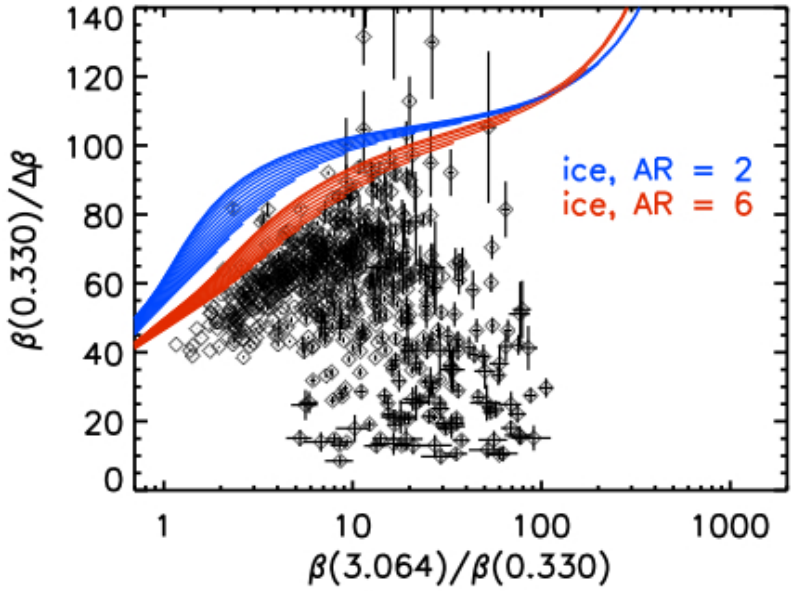
MSPs are important to:

- Middle atmosphere neutral and ion chemistry.
- Stratospheric aerosol nucleation (sulfates & PSC).
- Mesospheric ice nucleation
- Long term accumulation of extraterrestrial material in polar ice.

# PMC Composition

SOFIE PMC observations are *not* explained by pure ice …

Considering: Axial ratios from 1 – 6, and many Gaussians ($r_m$ =1-150 nm, Δr =1-30 nm)




Observations for SH 2009-10 at $Z_{max}$, and errors < 25%.

# PMC Composition

SOFIE PMC observations are *not* explained by pure ice …

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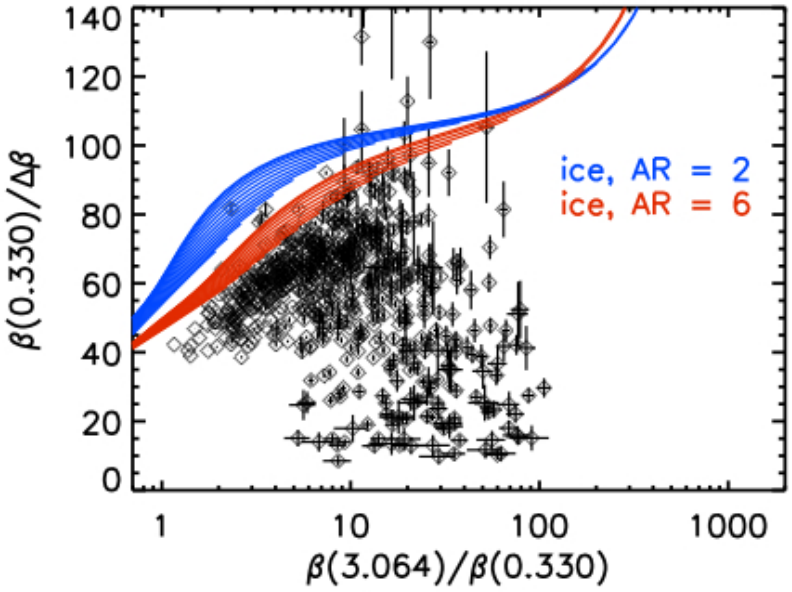
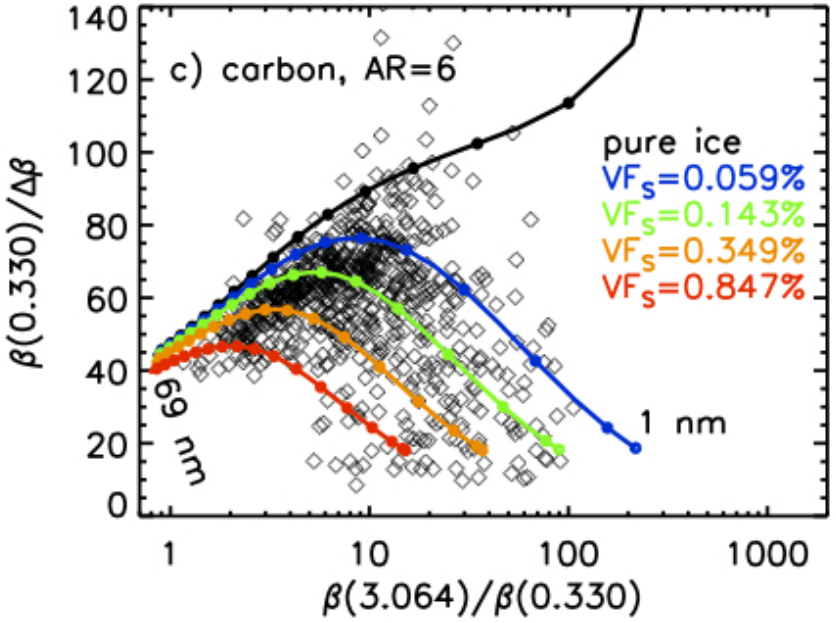
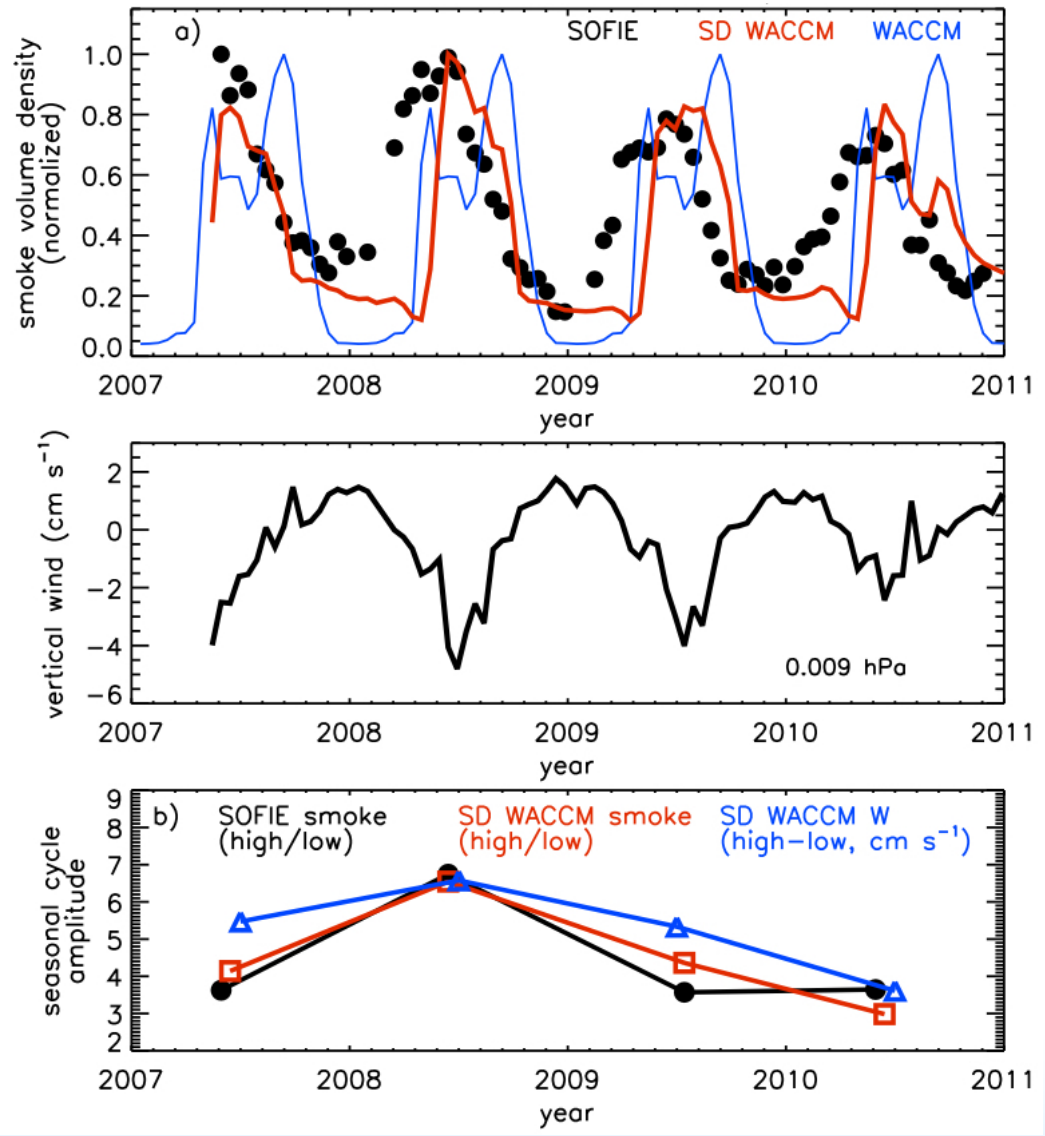
… but *are* consistent with ice – smoke mixtures




Observations for SH 2009-10 at $Z_{max}$, and errors < 25%.

# Smoke & Global Circulation




SOFIE compared to models:

WACCM used a climatological atmosphere.

SD WACCM assimilates concurrent meteorology.

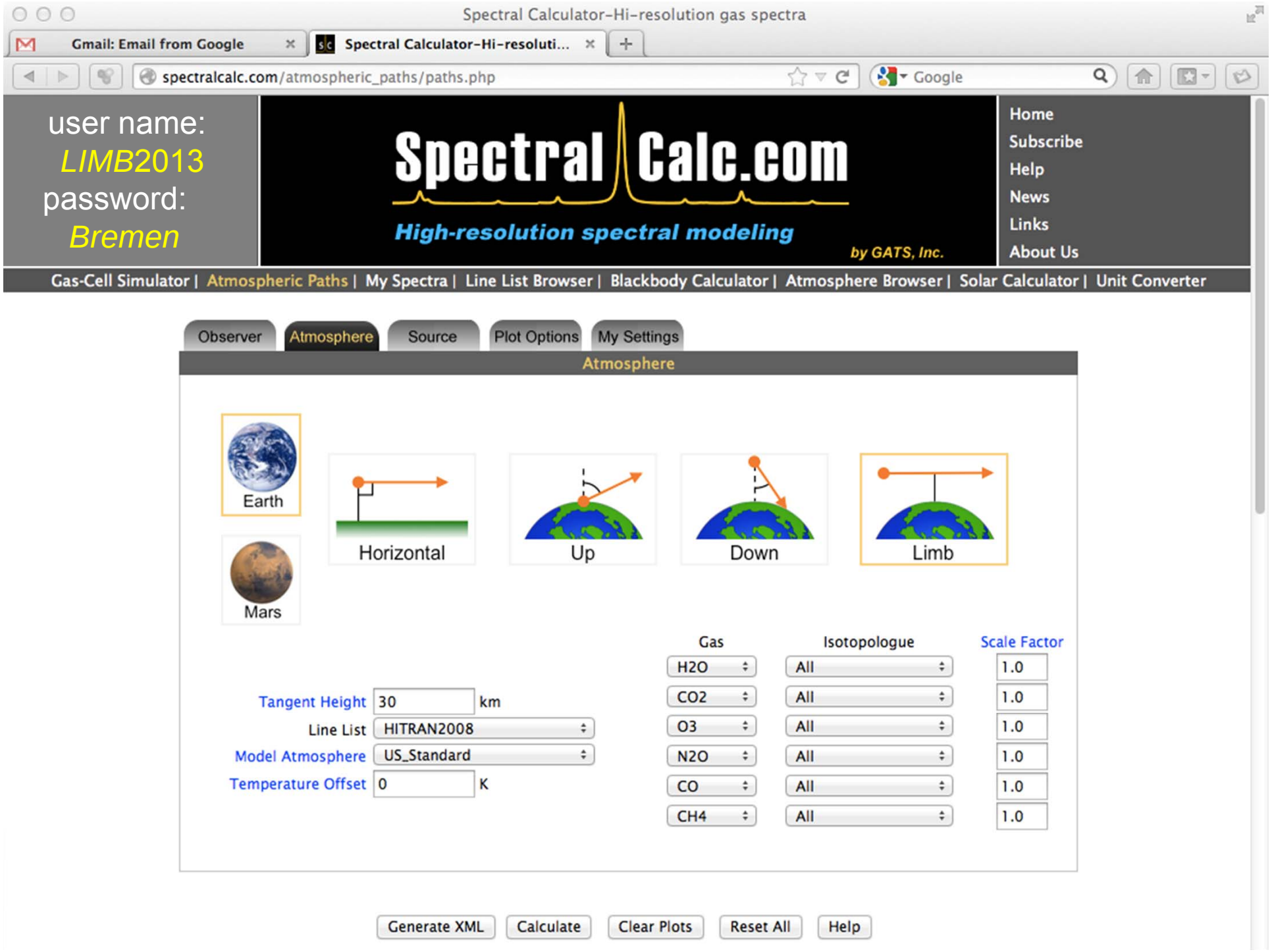
# Science Summary

- Results from six NH and six SH seasons show that the seasons turn on and off abruptly like a geophysical “light bulb”
- In the absence of a polar vortex, temperature controls when the PMC season starts and ends
- Data suggest that in an average sense, H2O controls changes during the season
- The timing of the PMC season start and occurrence frequency are much more variable in the SH than in the NH and the timing is strongly affected by the breakdown of the SH polar vortex
- Planetary waves can extend the PMC season length and gravity waves cause PMCs to dissipate
- SOFIE data show that PMC particles are made up of a mixture of ice and meteoric smoke

# Continuing Applications

- It is now clear that the narrow altitude region where PMCs form harbors information on key processes that affect our entire atmosphere. AIM observations are providing a major tool for analyses to understand the combined effects of:

– Coupling by atmospheric dynamics from below
– Coupling by the meridional circulation across hemispheres
– Atmospheric temperature and H2O changes
– Changing solar conditions
– Varying inputs of cosmic dust into our atmosphere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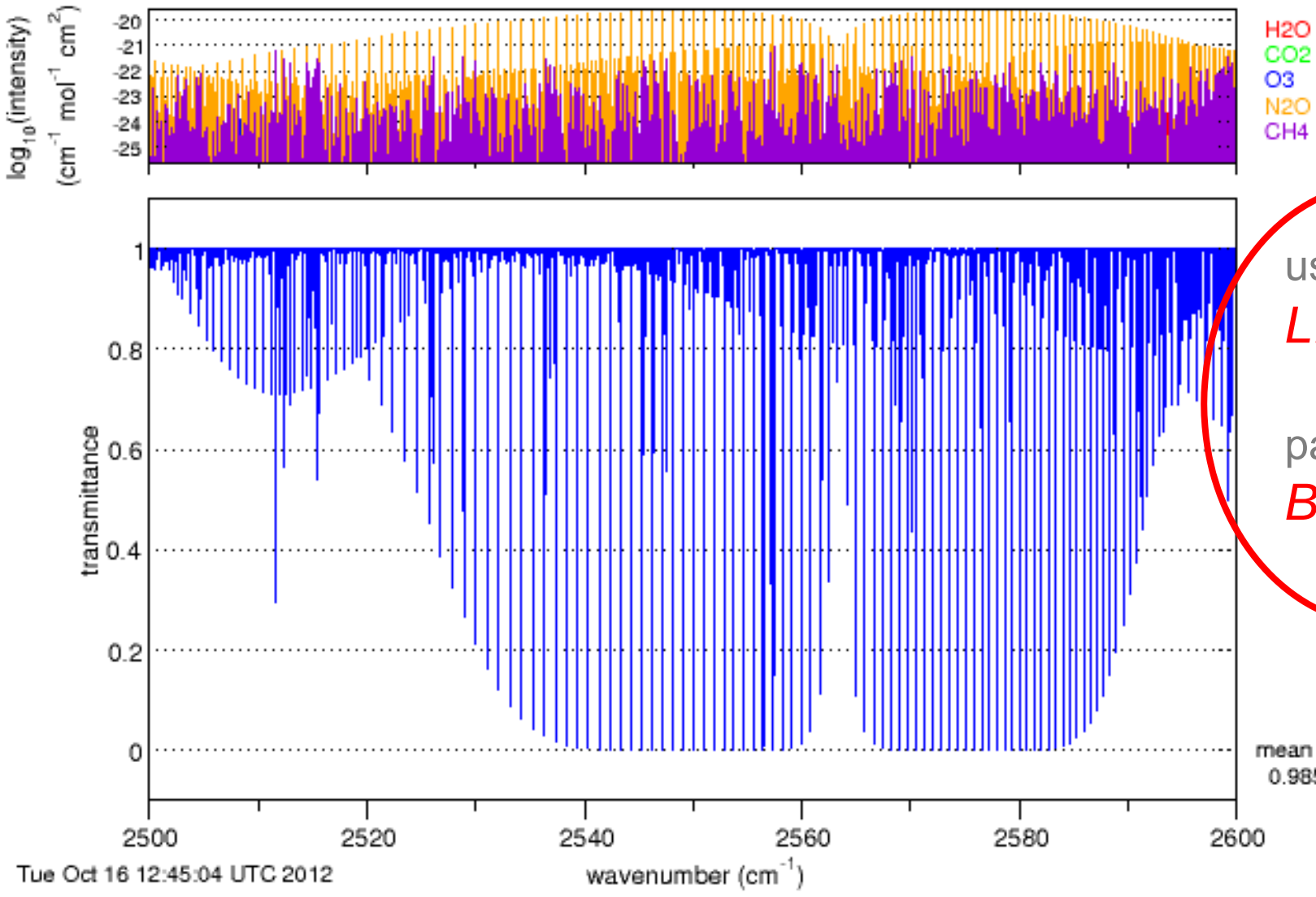


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