# A Sensitive Search for Biomarker Gases on Mars: Vertical Distribution of Polar Ozone Using CSHELL at IRTF


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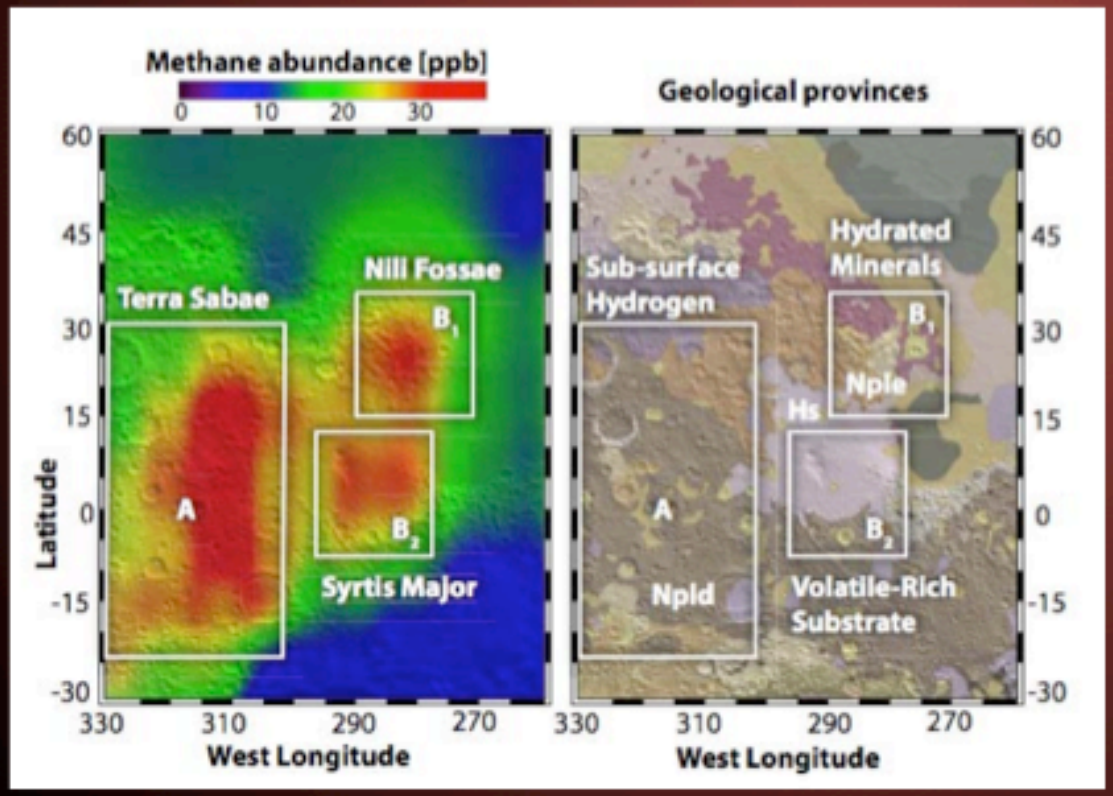
**Summer Internship at the**
**Goddard Center for Astrobiology**
**June - August 2010**

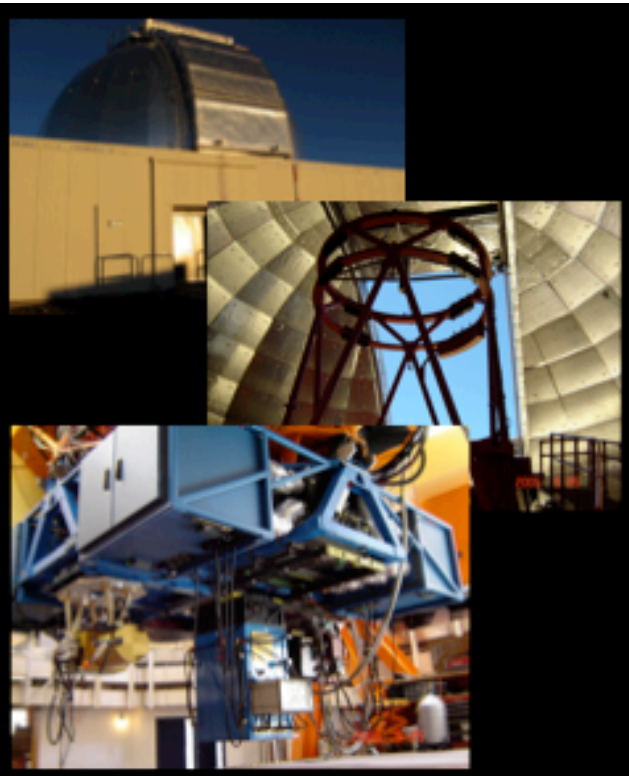
# Motivation

- Mapping of $O_2(a^1\Delta_g)$, ozone, and water abundances
- Astrobiological implications
  - Chemical variations and (dis)equilibriums




Mapping methane on Mars, from Mumma et al. 2009

# Datasets and Methodologies
# Application
# Scientific Results



Data of Mars were taken using CSHELL at NASA-IRTF atop Mauna Kea (HI).

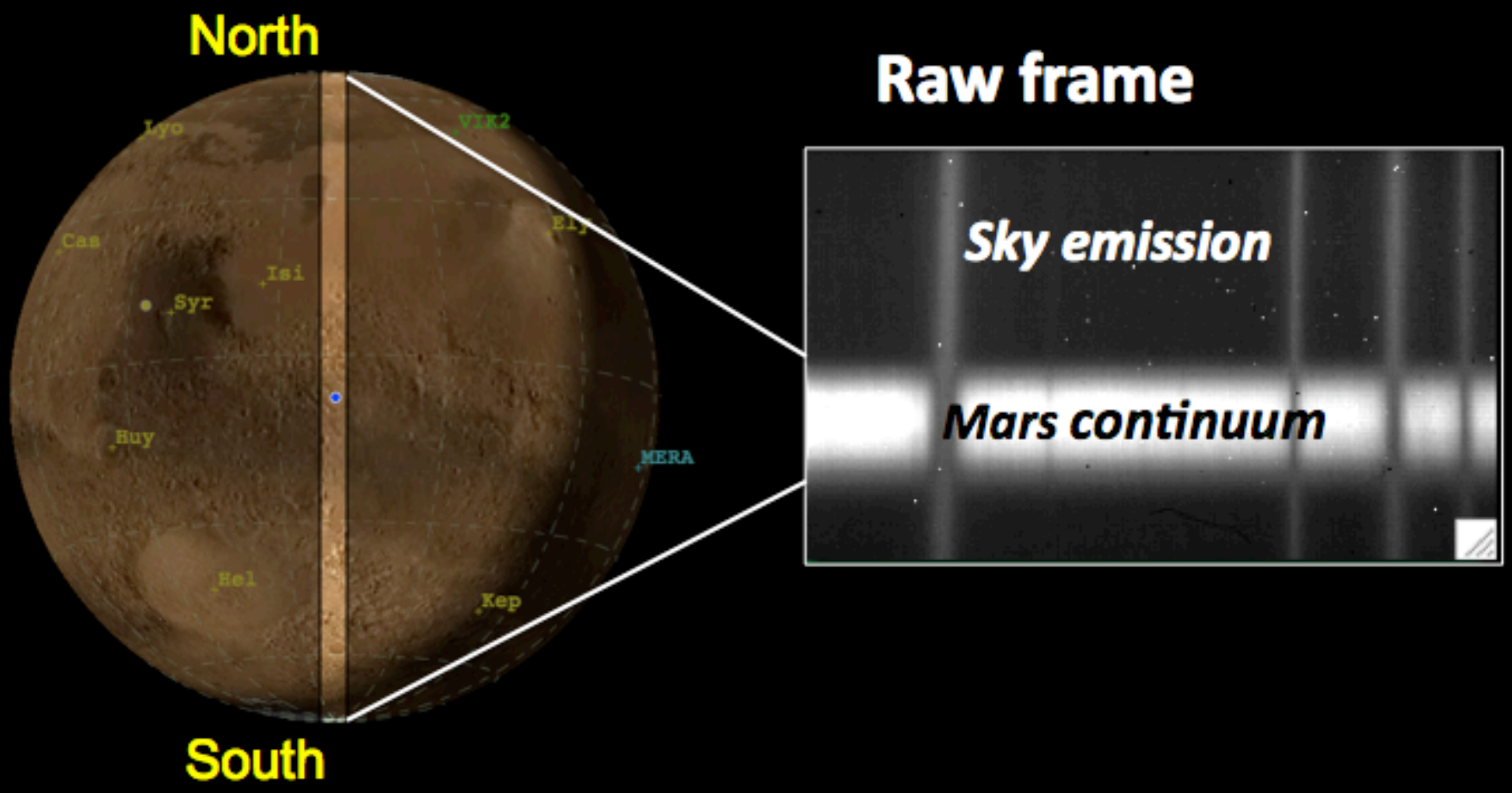
CSHELL is a 1 - 5.5 µm high resolution single-order echelle spectrograph.

These data are part of a multi-instrument campaign (Aug/2009 to June/2010)

We sampled numerous trace gases (e.g. $CH_4$, $O_2$, $H_2O$, HDO) globally in Northern Winter, Spring and Summer (Ls = 324° - 0 - 102°).

- 17 observing dates and 28 datasets

# Slit Spectrometers



# Data Processing of all 28 settings (6440 raw frames)

## *"IBATCH"*

- Crop
- Clean
- Spatial alignment
- Spectral alignment and correction for anamorphicity

## *"IPLANET"*

- Retrieval of weather forecast data for each slit position
- Extraction of spectral residuals
- Retrieval of atmospheric quantities ($P_{surf}$, $T_{air}$, abundances)

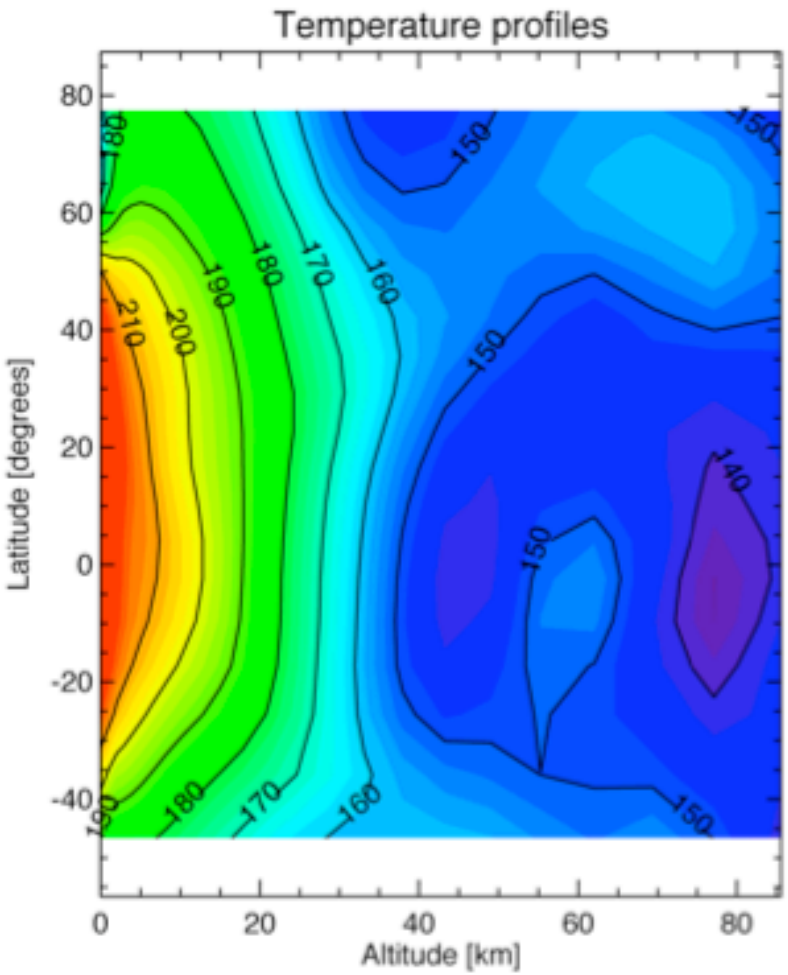
Datasets and Methodologies

Application

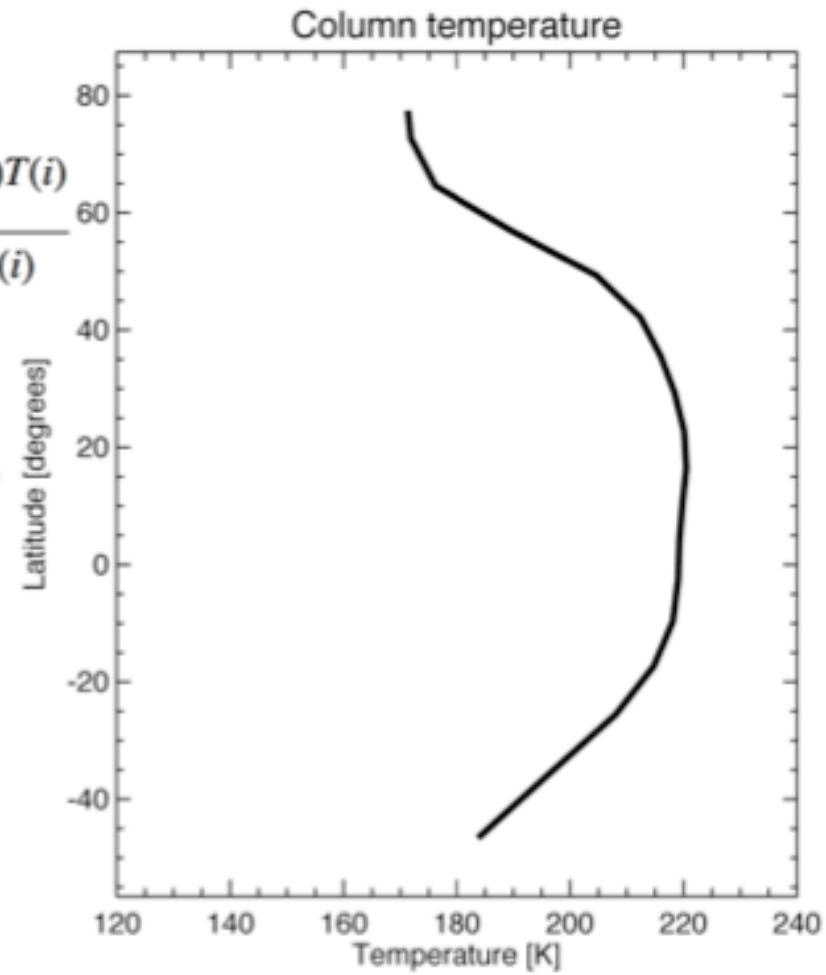
Scientific Results

# "IPLANET"

# General Circulation Model (GCM) parameters

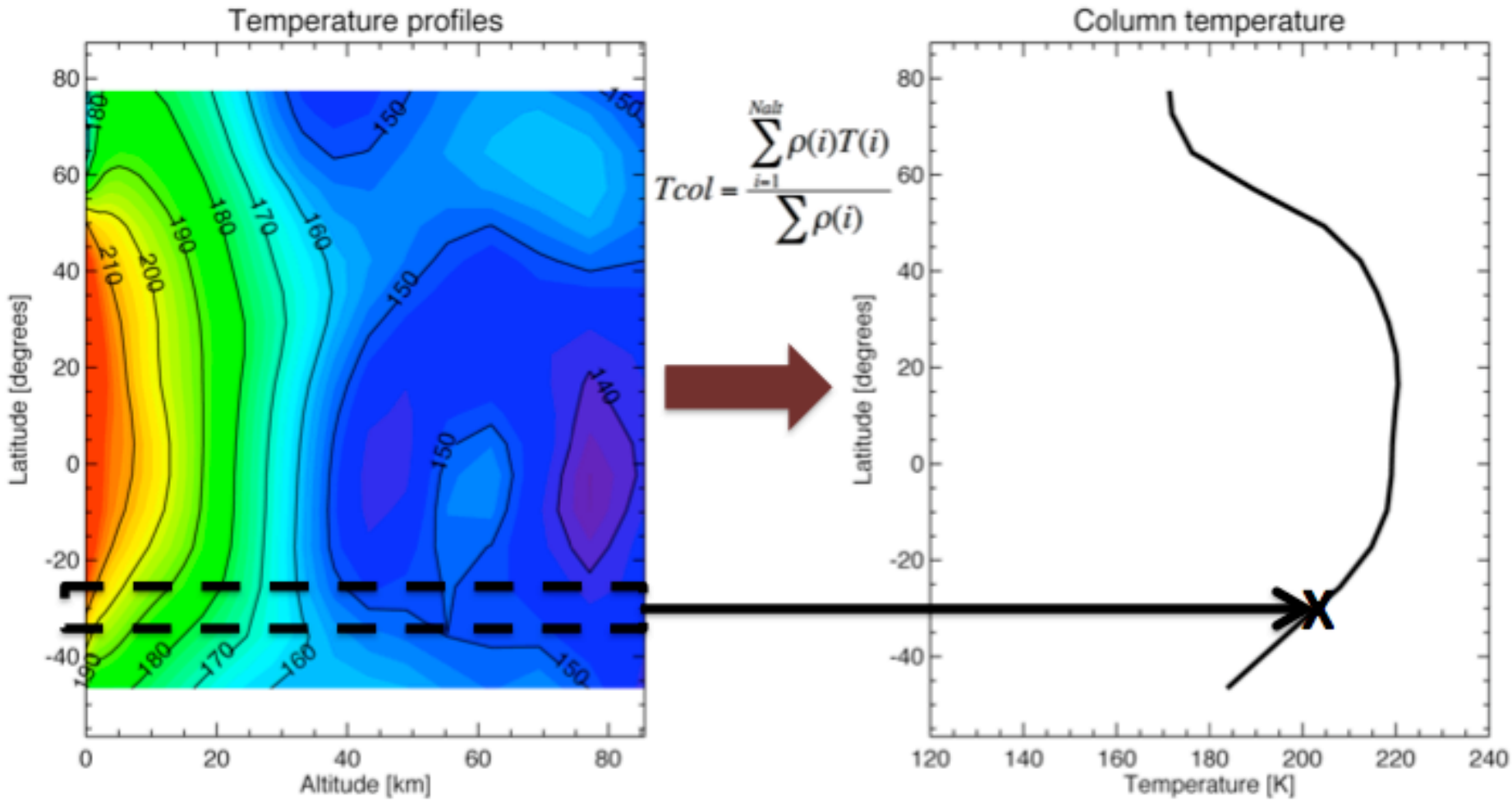



$$Tcol = \frac{\sum_{i=1}^{Nalt} \rho(i)T(i)}{\sum \rho(i)}$$



# "IPLANET"

## General Circulation Model (GCM) parameters

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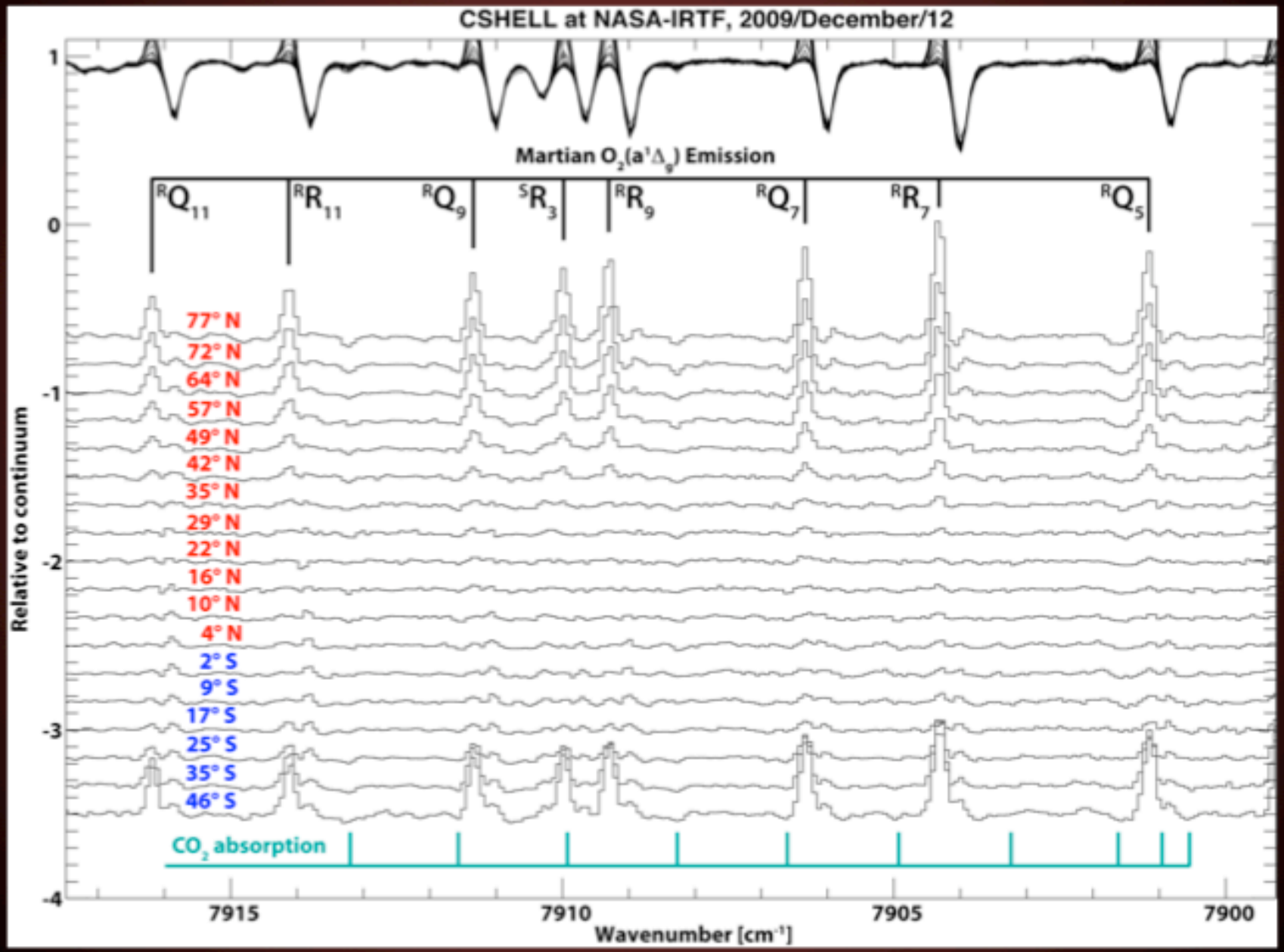
# "IPLANET": Extraction of spectral residuals



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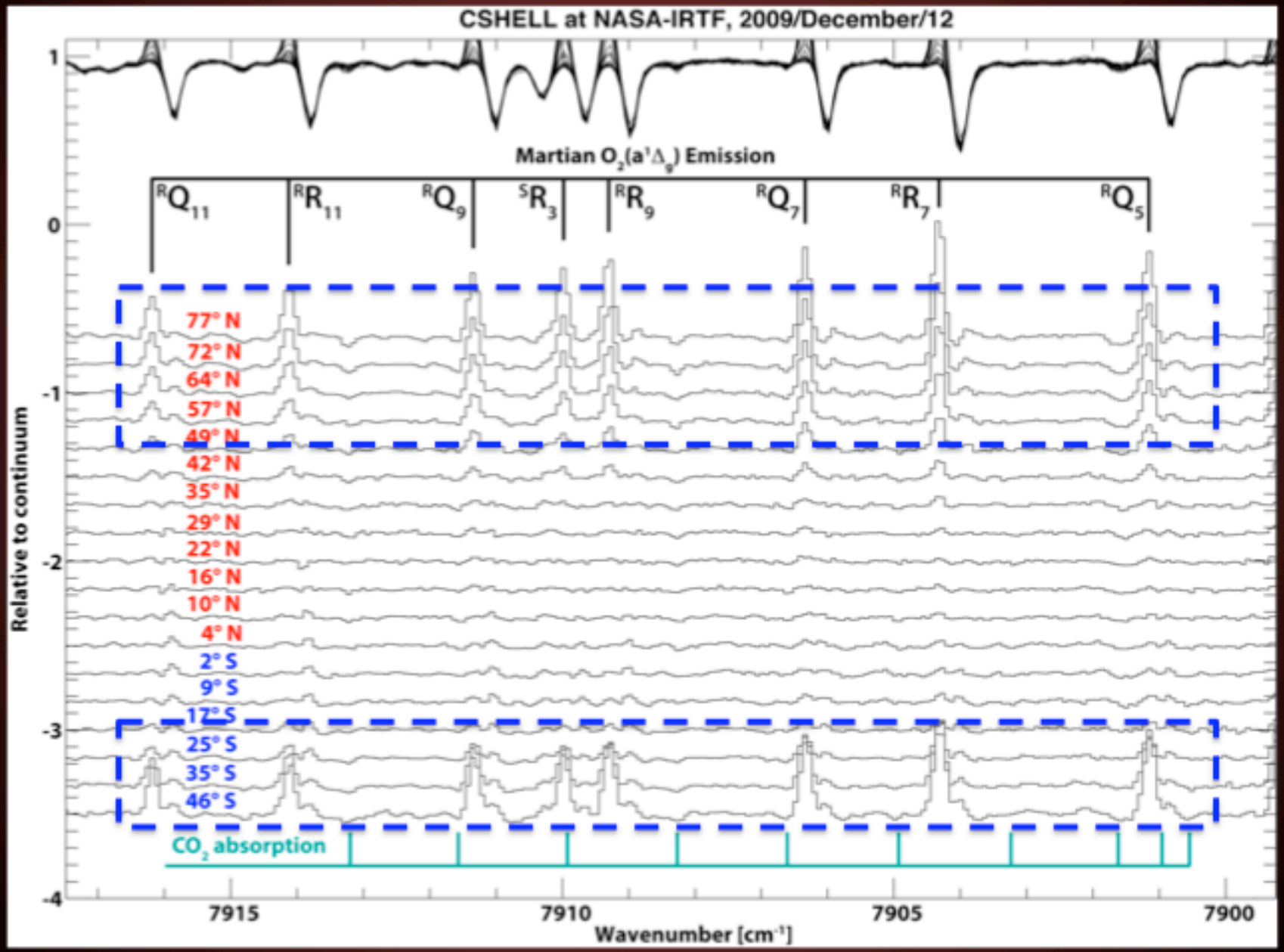

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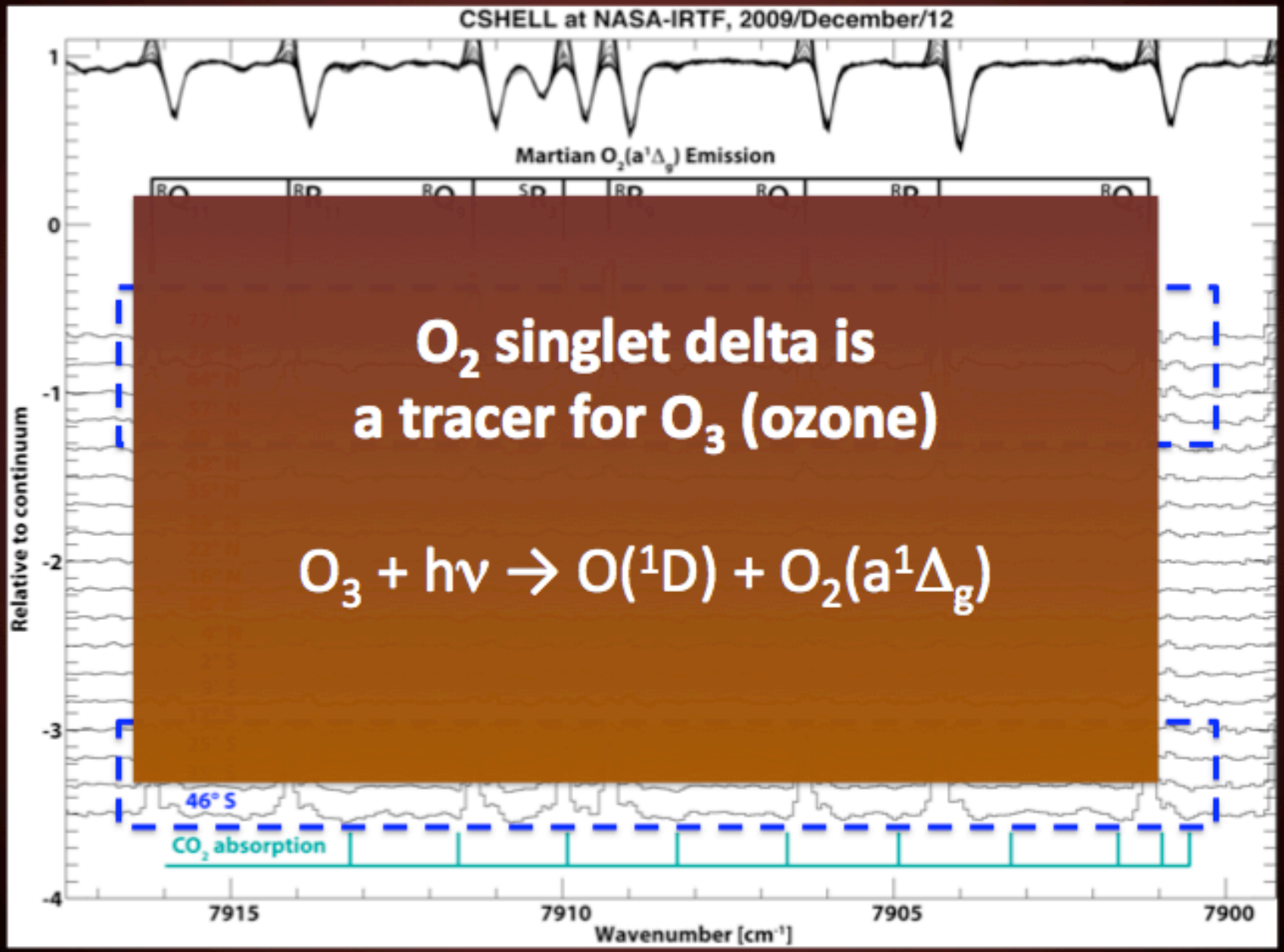


$O_2$ singlet delta is
a tracer for $O_3$ (ozone)

$$O_3 + h\nu \rightarrow O(^1D) + O_2(a^1\Delta_g)$$

Datasets and Methodologies

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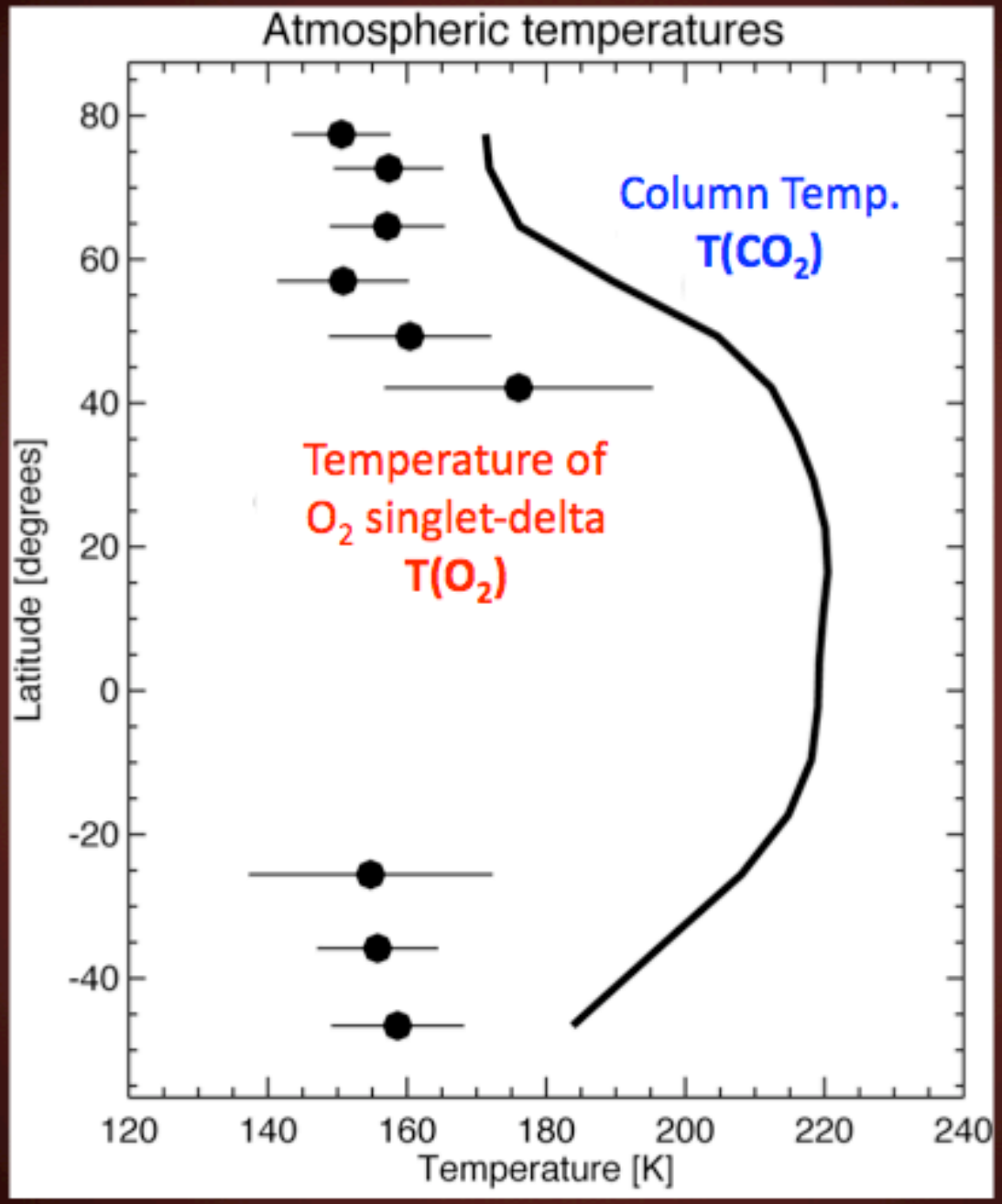
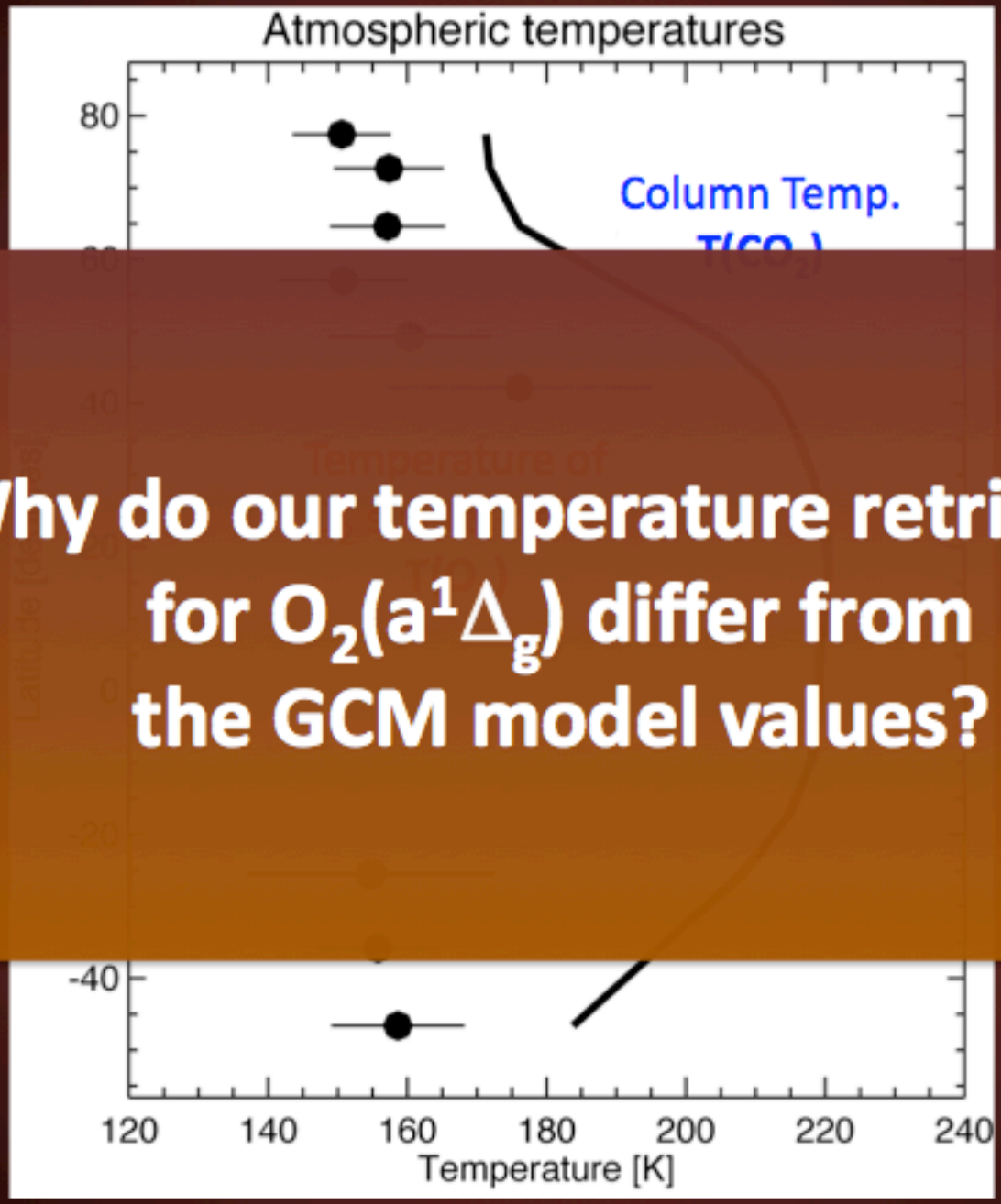
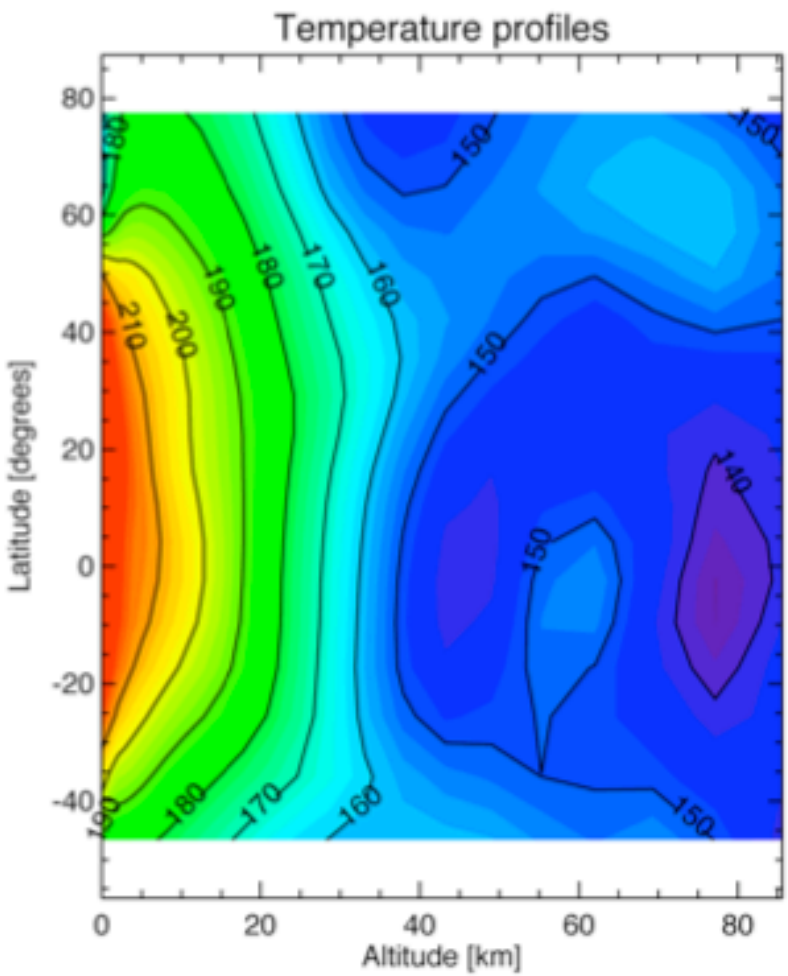

Atmospheric temperatures
Column Temp.
T(CO2)
Temperature of
O2 singlet-delta
T(O2)
Latitude [degrees]
80
60
40
20
0
-20
-40
120
140
160
180
200
220
240
Temperature [K]



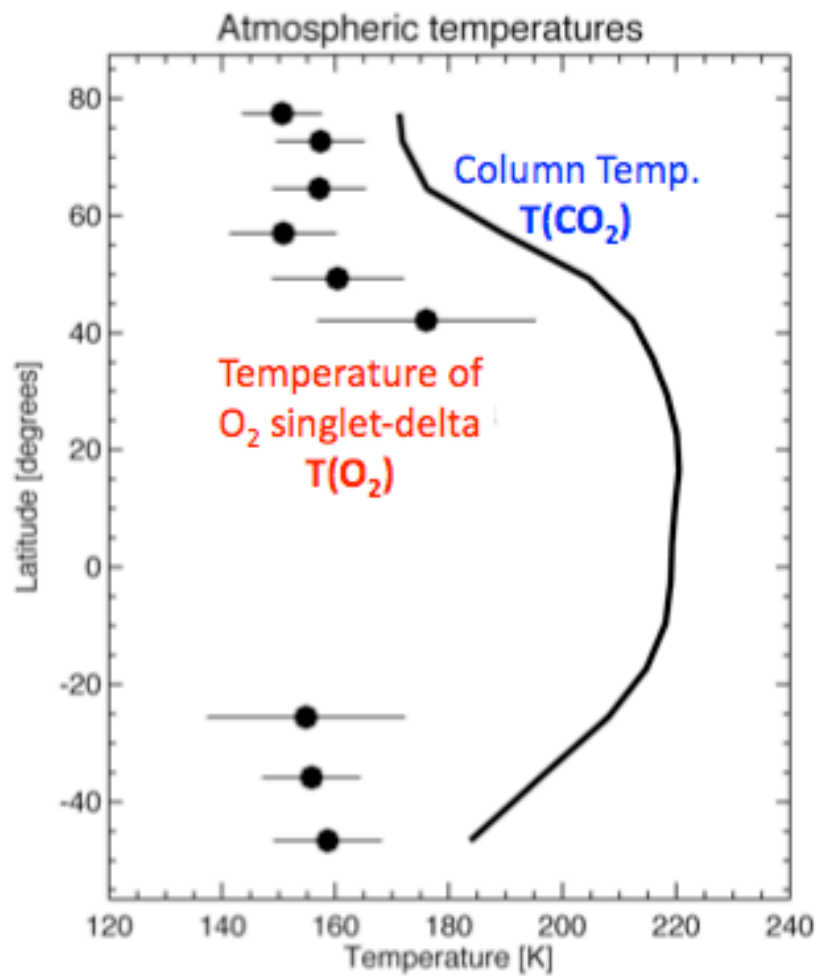

**Why do our temperature retrievals for $O_2(a^1\Delta_g)$ differ from the GCM model values?**

# MODEL

## GCM Temperatures




# RESULTS & MODEL

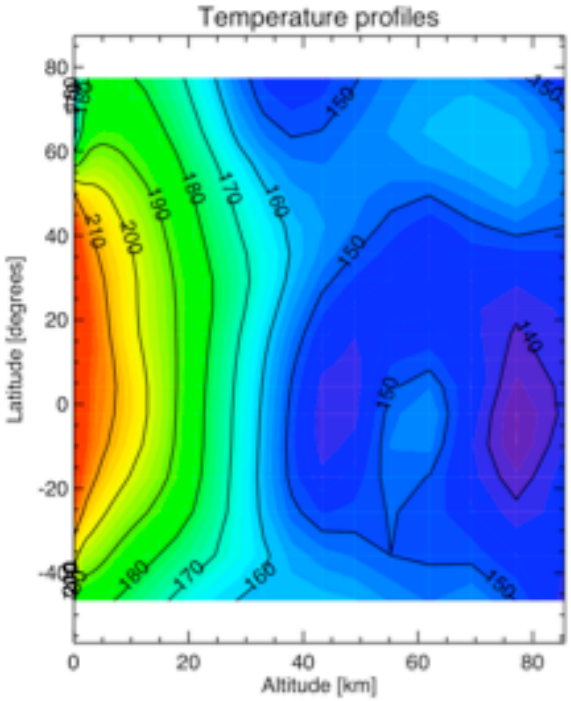


# Abundance Profiles

**We used the temperature information to retrieve the vertical distribution of the emission**

## MODEL

**GCM Temperatures**

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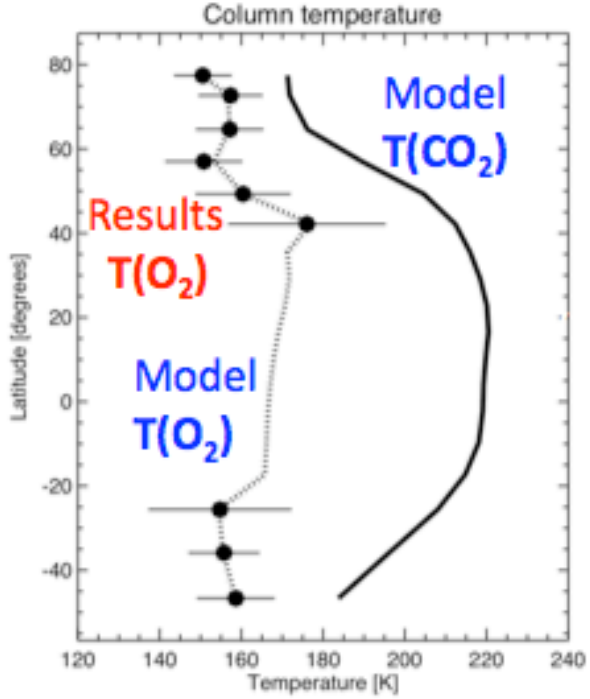
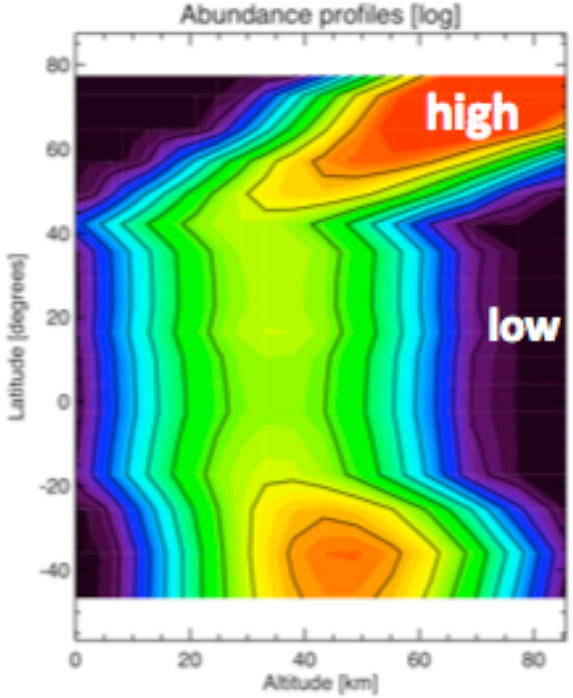



## RESULTS

**Retrieved vertical profiles from temperature information**



# Abundance Profiles

**We used the temperature information to retrieve the vertical distribution of the emission**

**MODEL**

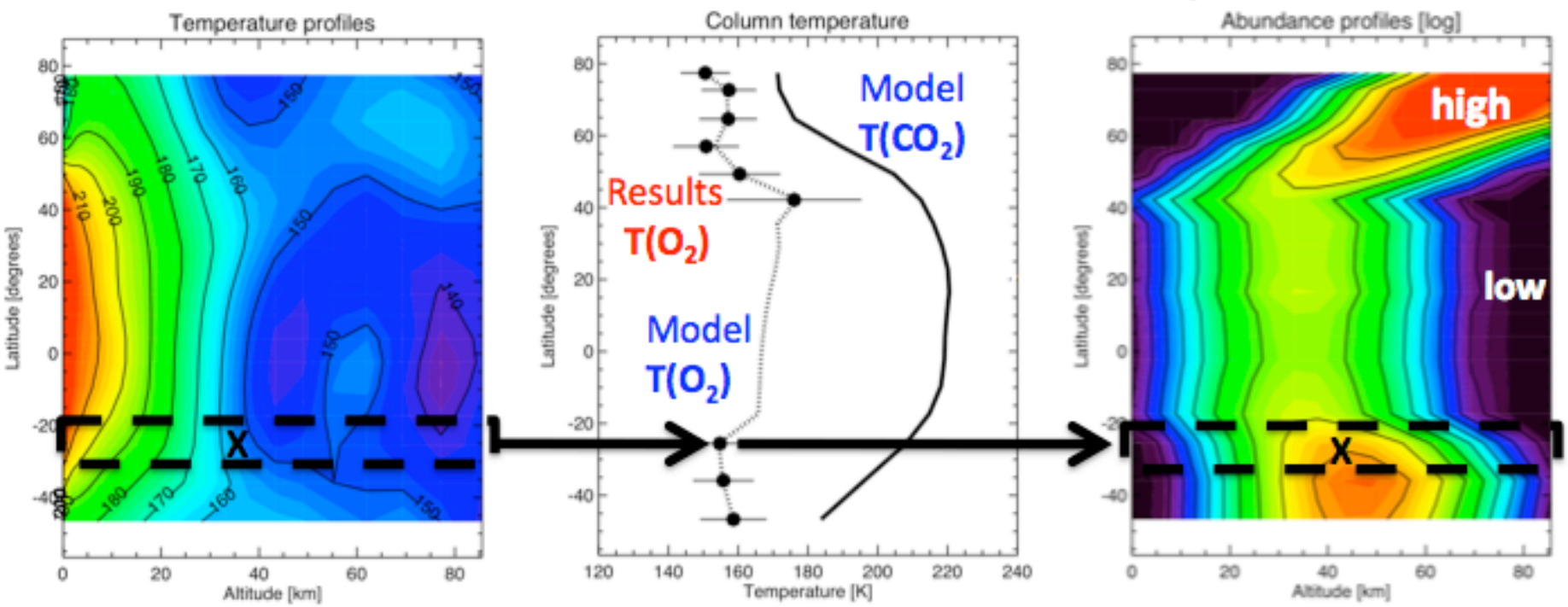
**GCM Temperatures**

**RESULTS**

**& MODEL**

**RESULTS**

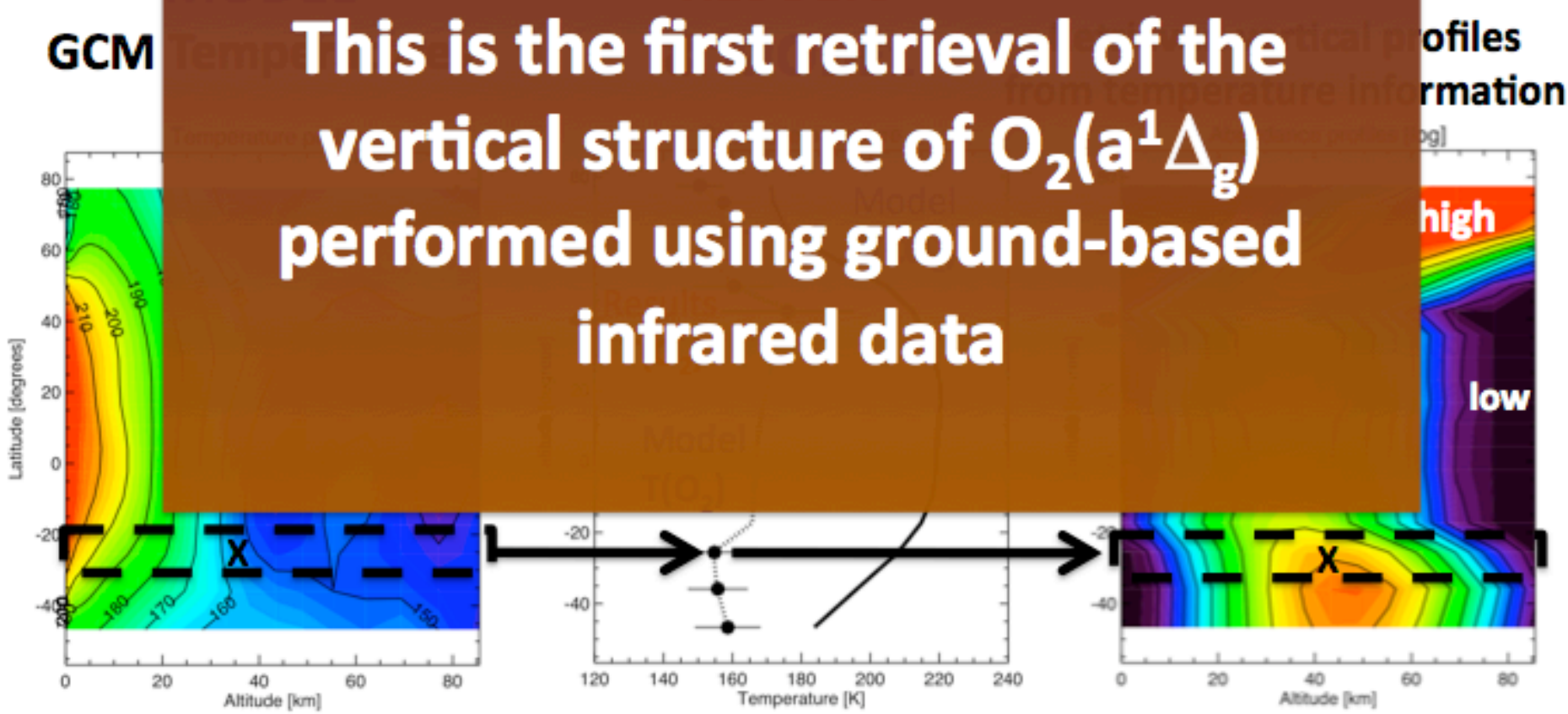
**Retrieved vertical profiles from temperature information**



# Abundance Profiles

**We used the temperature information to retrieve the vertical distribution of the emission**

**This is the first retrieval of the vertical structure of $O_2(a^1\Delta_g)$ performed using ground-based infrared data**



# Future Work

- Global mapping of $O_2(a^1\Delta_g)$, ozone, and water
- Extraction of sensitive limits for biomarkers
- Seasonal and diurnal variations

# Acknowledgements


- Dr. Gerónimo Villanueva
- Dr. Michael Mumma
- Corinne Eby
- NASA SUIA 2010


## Handbook!

(100 pages document)

HANDBOOK FOR
PROCESSING INFRARED DATA

IBATCH, IPLANET, ISTAR, ICOMET, AUTOMATOR
[22,000 IDL source lines of code, including ad-hoc developed routines]

Data analysis methods and
algorithms developed by

G. L. Villanueva, M. A. DiSanti,
B. P. Bonev, A. Mandell, M. J. Mumma

Documentation written by
R. Mickol and G. L. Villanueva

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