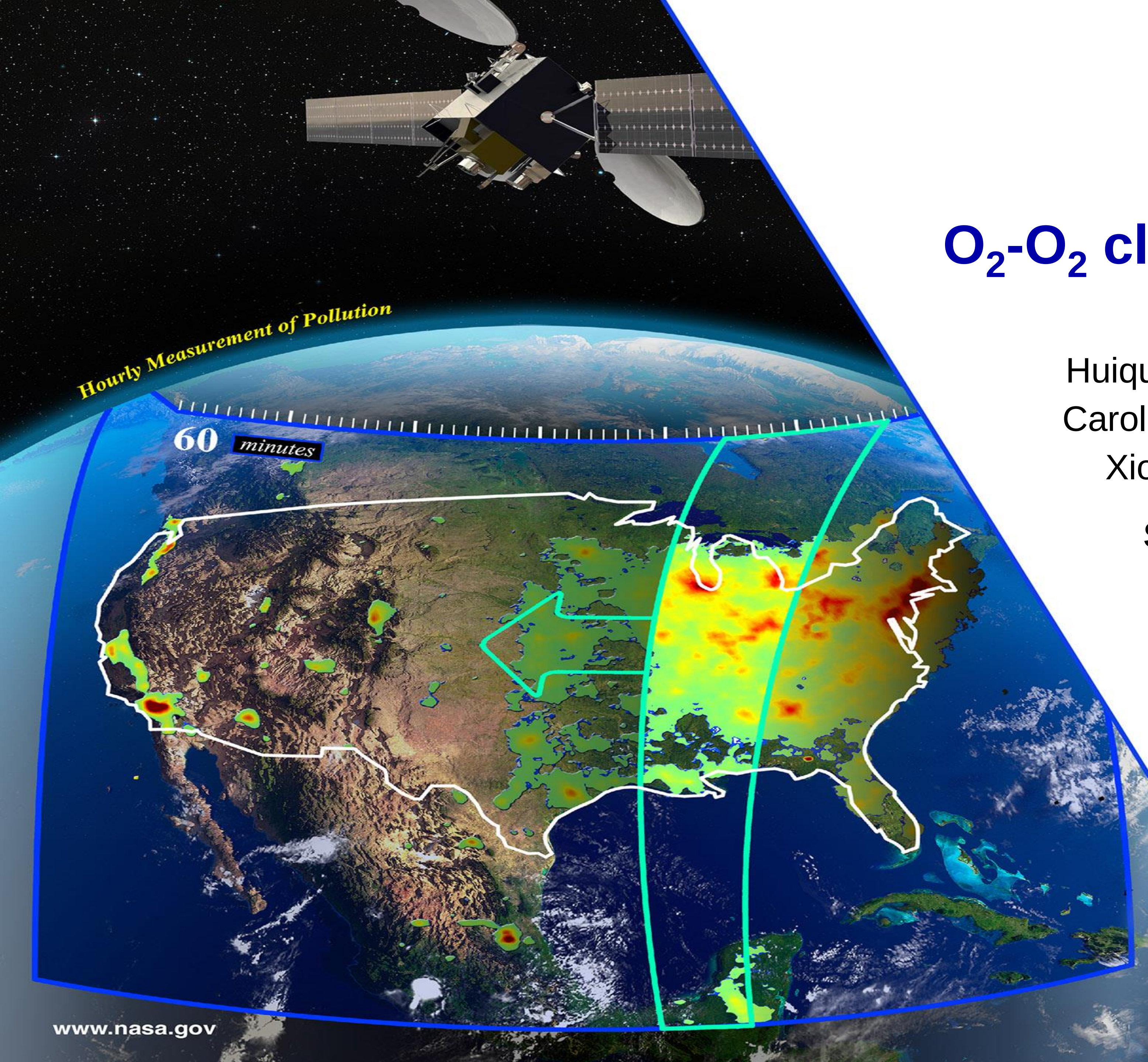


Tropospheric Emissions: Monitoring of Pollution

TEMPO

# $O_2$-$O_2$ cloud algorithm for TEMPO
## 1. Slant Column Retrieval

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**NASA Goddard Space Flight Center**

**TEMPO Science Team Meeting**
**June 02-03 2021**

Smithsonian

# Objective

- Take advantage of SAO’s existing trace gas fitting programs (OMI code, MEaSUREs code, TEMPO code),
- Develop an easily implementable algorithm for TEMPO $O_2$-$O_2$ SCD,
- Adapt Goddard OMI Cloud code for TEMPO.

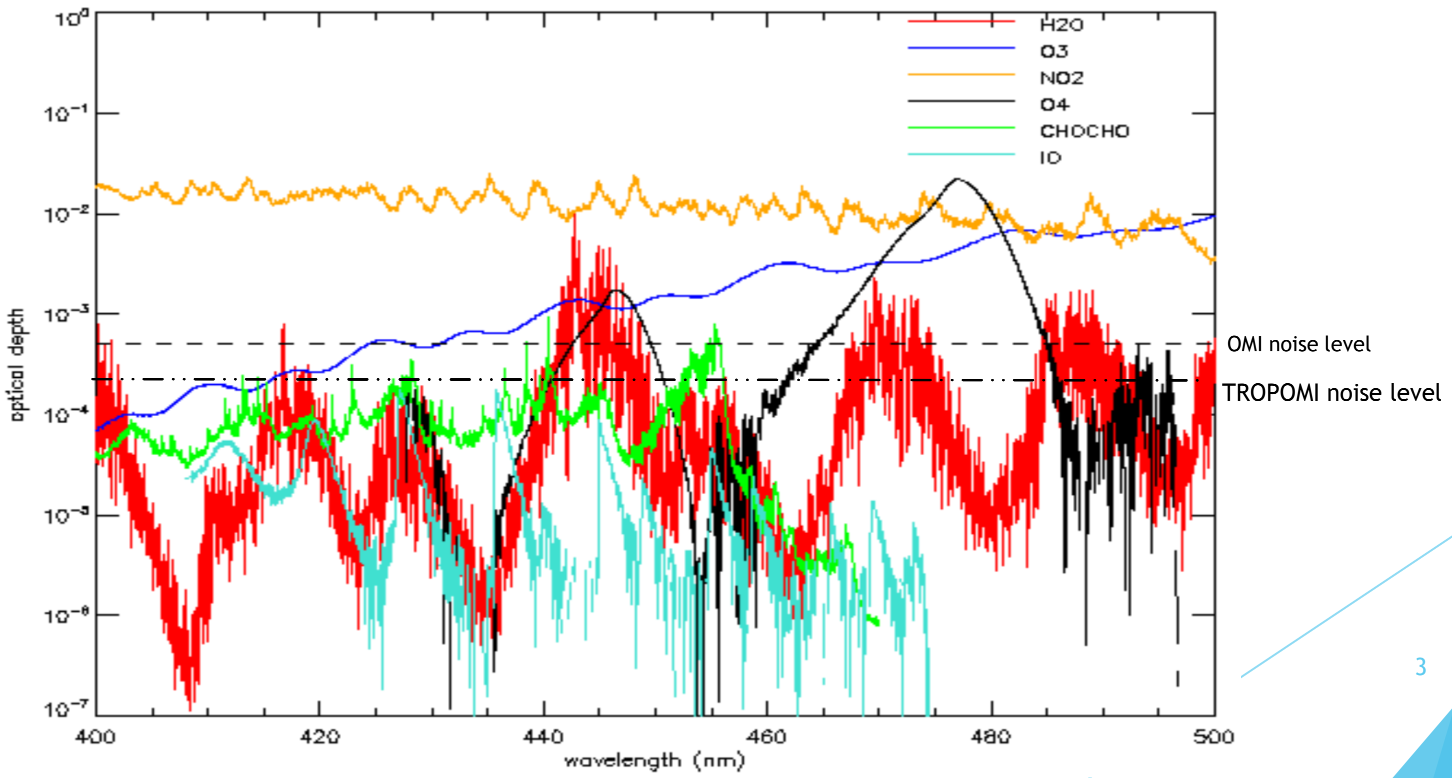
# Spectral Fitting Optimization Framework

[Gonzalez Abad et al., 2015]

$$I = \left[\left(a I_0 + \sum_i \alpha_i X_i\right) e^{-\sum_j \alpha_j X_j} + \sum_k \alpha_k X_k\right] \sum_n \alpha_n X + \sum_m \alpha_m X_m$$

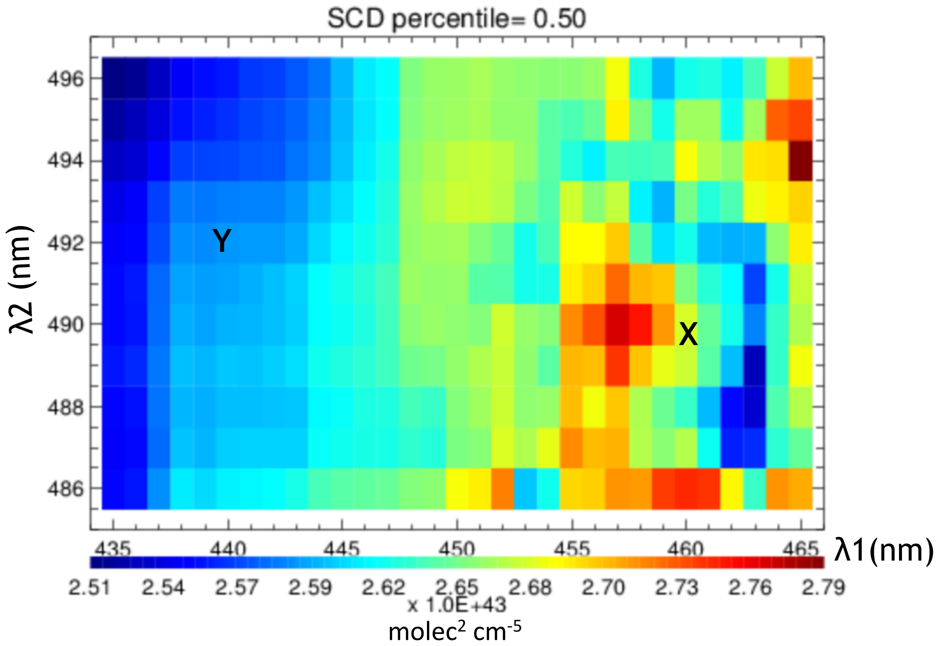
Irradiance ($I_0$); Radiance ($I$); Beer-Lambert; Add 1st; Add 2nd; Scaling; Baseline

## Typical Beer-Lambert Contributions of Molecules

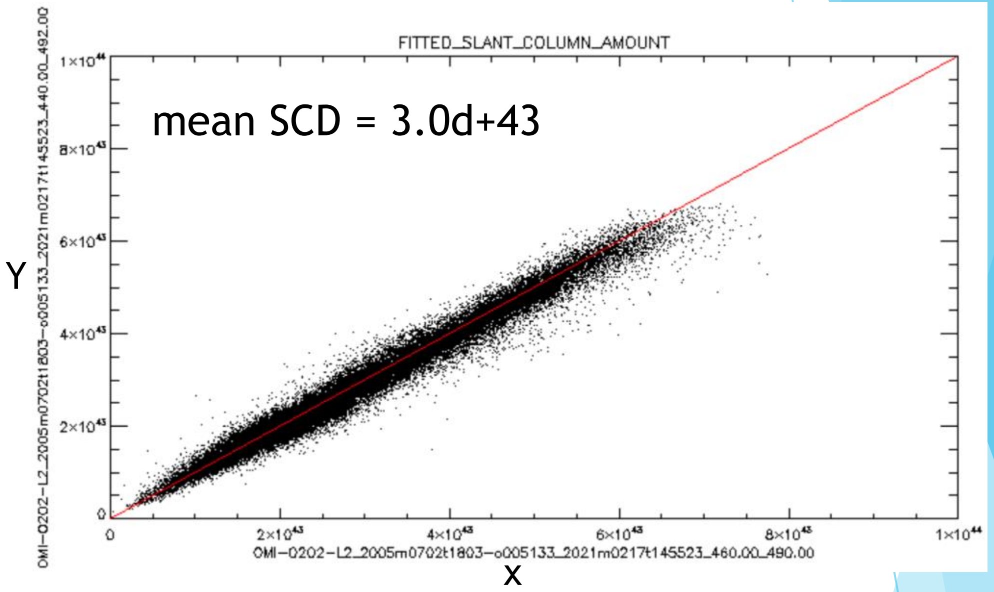


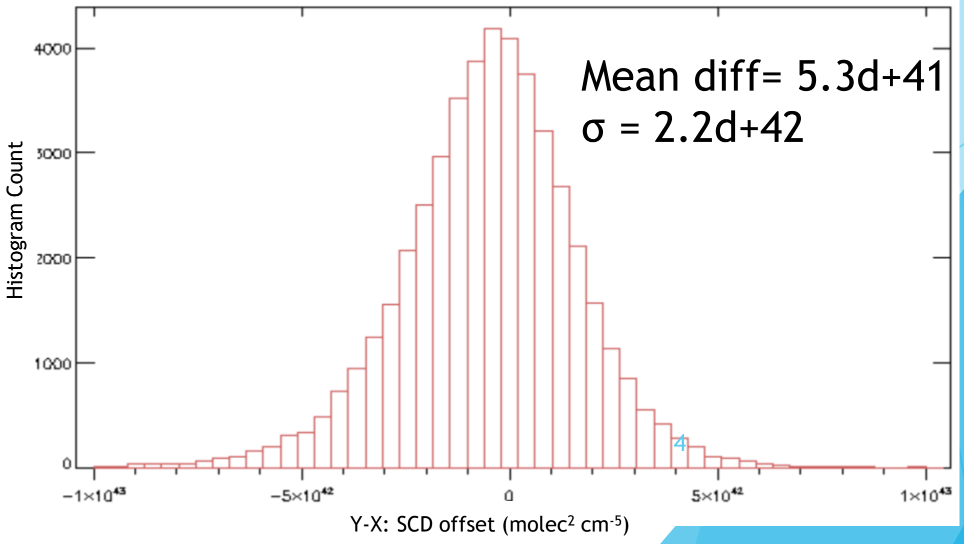
# $O_2$-$O_2$ SCD Retrieval Window Dependence

OMI orbit 5133 Eastern US
fitted slant column amount $O_2$-$O_2$




Up to ~10% variation of SCD
due to retrieval window



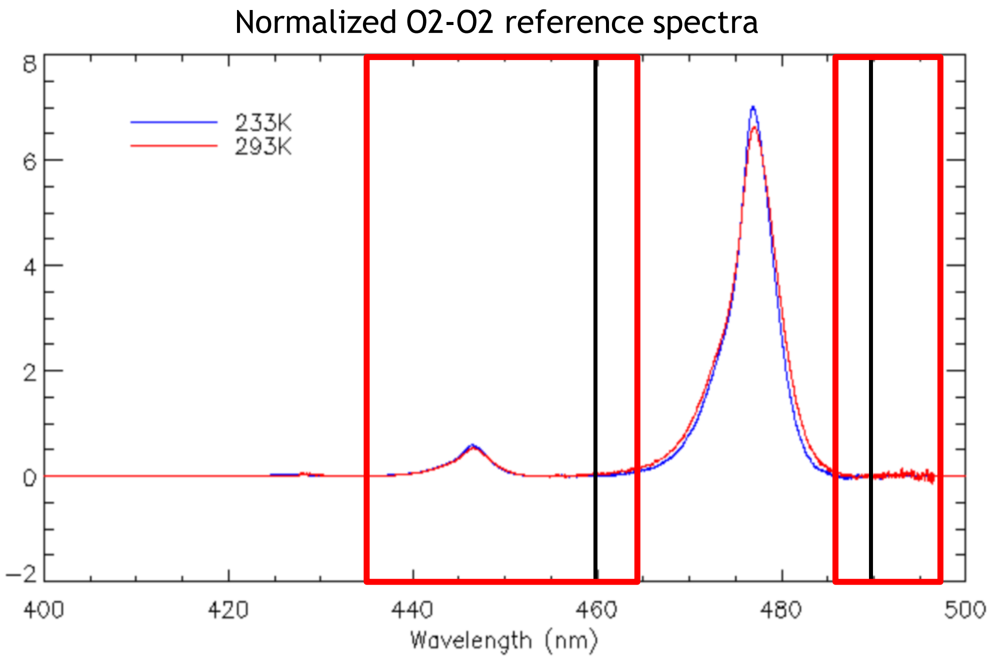
# Spectral Fitting Optimization Framework

[Gonzalez Abad et al., 2015]

Irradiance    Beer-Lambert

$$I = \left[\left(a I_0 + \sum_i \alpha_i X_i\right) e^{-\sum_j \alpha_j X_j} + \sum_k \alpha_k X_k\right] \sum_n \alpha_n X + \sum_m \alpha_m X_m$$

Radiance    Add 1st    Add 2nd    Scaling    Baseline




Optimization start with 3rd order Scaling and Baseline polynomials

$O_2$-$O_2$

Wavelength calibration

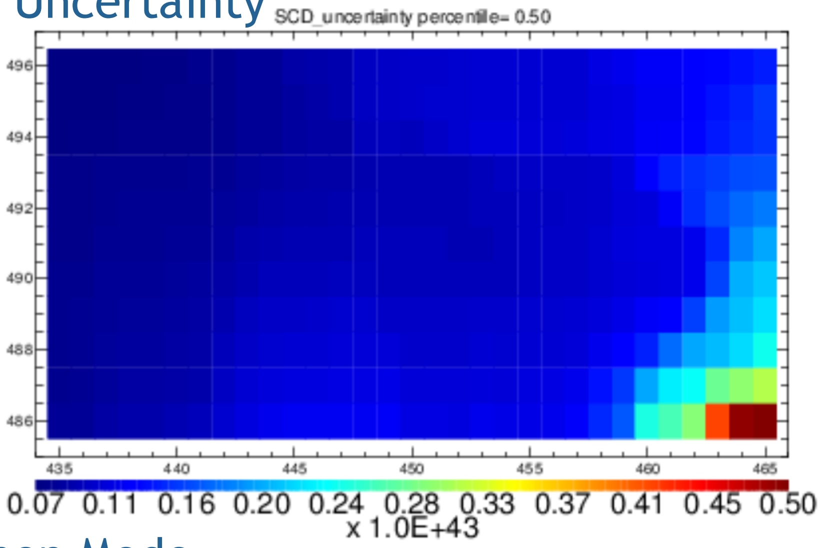
Super Gaussian Slit function

Molecular Ring, Vibrational Raman of lq$H_2O$, Under-Sampling

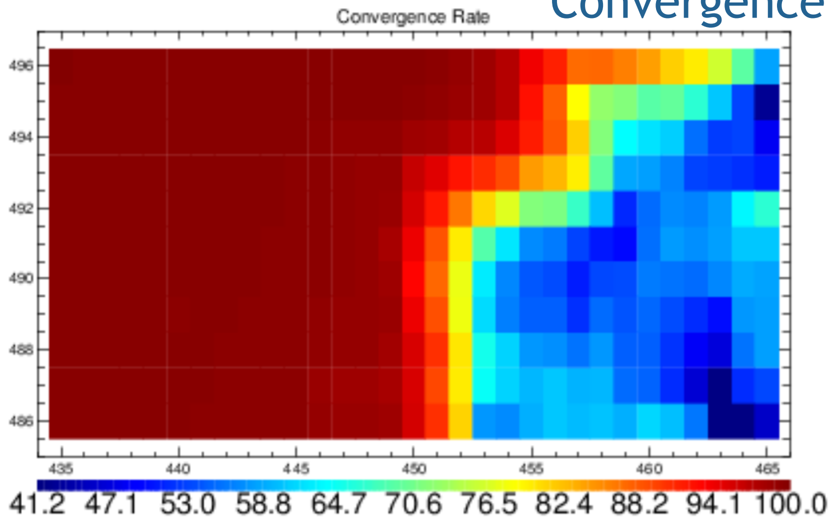
$O_3$, $NO_2$, $H_2O$, Lq$H_2O$

# Criteria for Retrieval Window Selection

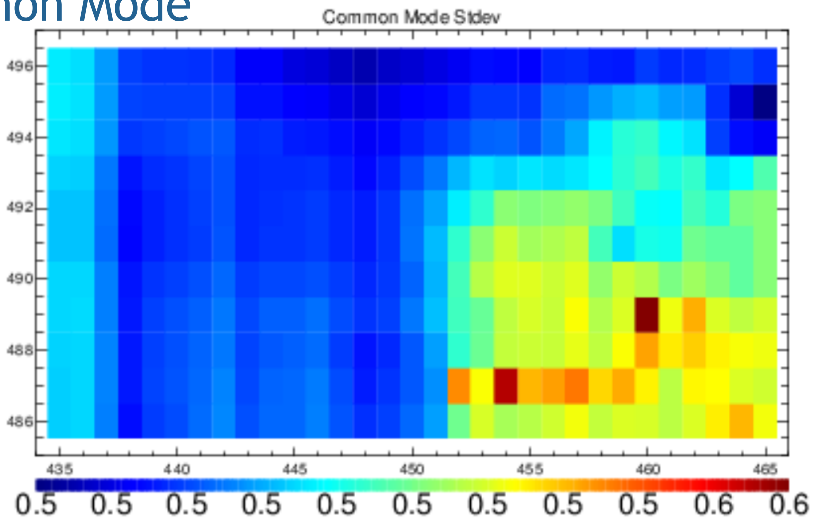
Fitting Uncertainty



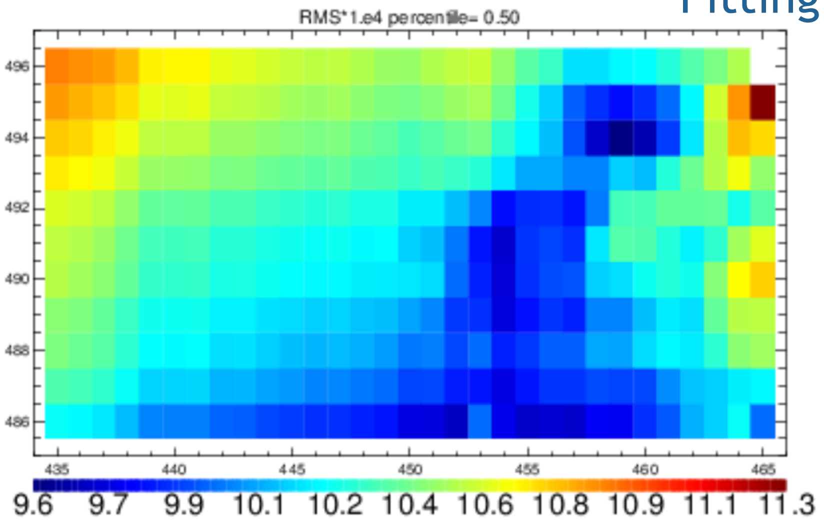

Convergence Rate




Common Mode




Fitting RMS




<u>Non-unique</u>

<u>*Compromise*</u>

# Options

Science

## Option a (long)

Window: [439, 488]nm

Calibration: sin, shi, hwe, sgk, usamp1, usamp2

Closure:
$3^{rd}$ order baseline
$3^{rd}$ order scaling

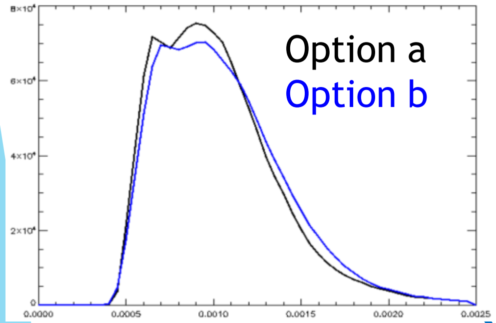
Interference:
Ring
no2_t2 (220K)
o3_t1 & o3_t3 (223K & 293K)
o2o2
h2o
lqh2o (Lee_CleanSea)
vraman
glyox

More physics

Less aliasing

Better fitting RMS

Histogram




Fitting RMS

Operational

## Option b (short)

Window: [460, 488]nm

Calibration: sin, shi, hwe, sgk, unsamp1, unsamp2

Closure:
$2^{nd}$ order baseline
$1^{st}$ order scaling

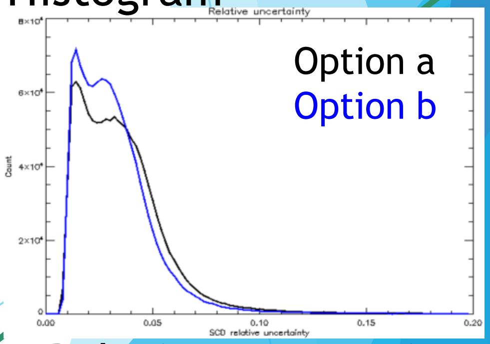
Interference:
Ring
no2_t2 (220K)
o3_t1 (223K)
o2o2
h2o

More speed

Simpler setup

Better fitting uncertainty

Histogram

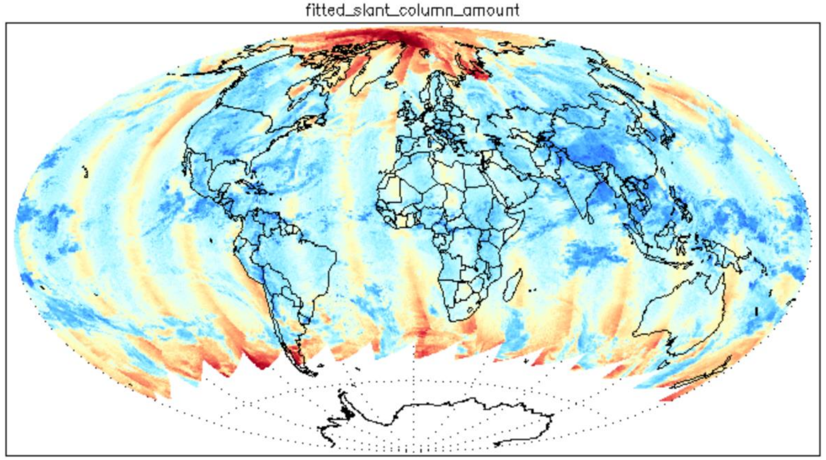



Relative Uncertainty

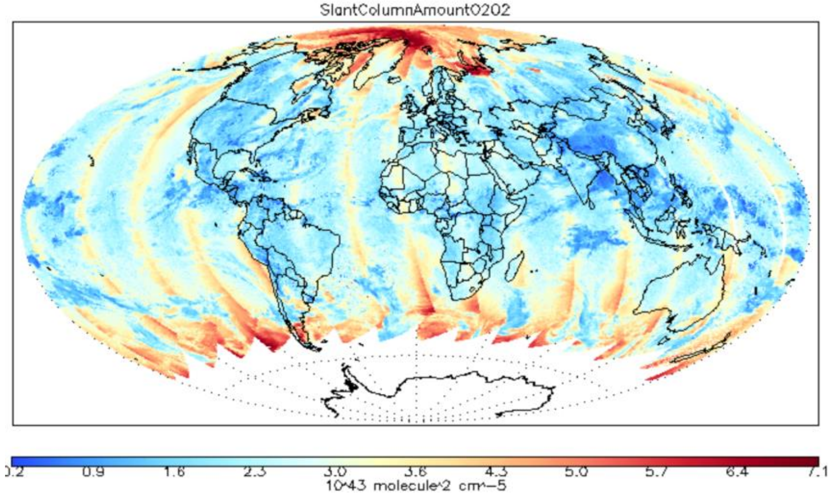
Non-unique choices; Each option can be further refined

# $O_2$-$O_2$ SCD correlation

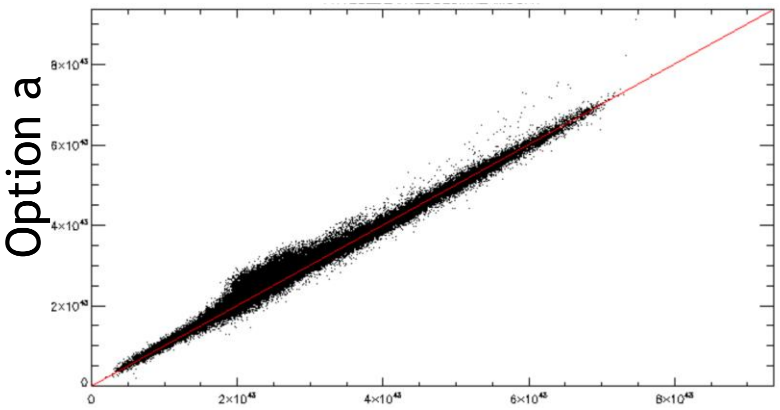
20050701 Option a (long)



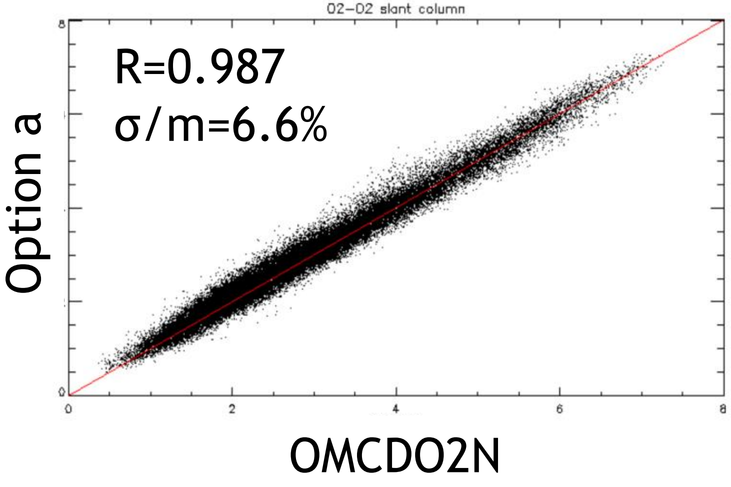

20050701 OMCDO2N



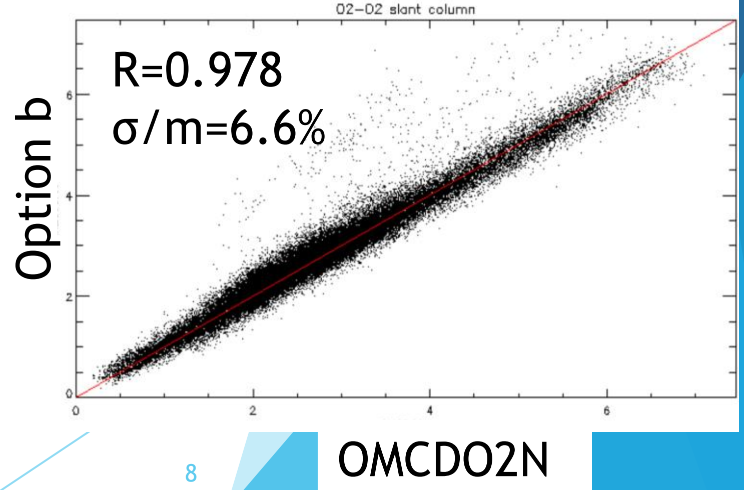

SCD Scatter Plot




SCD Scatter Plot

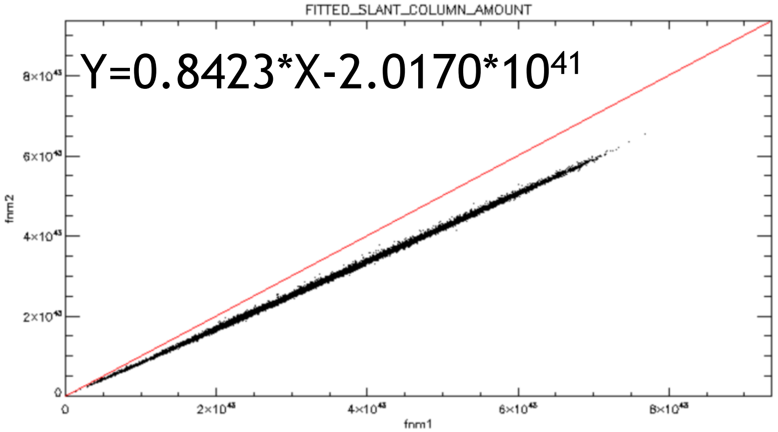



SCD Scatter Plot

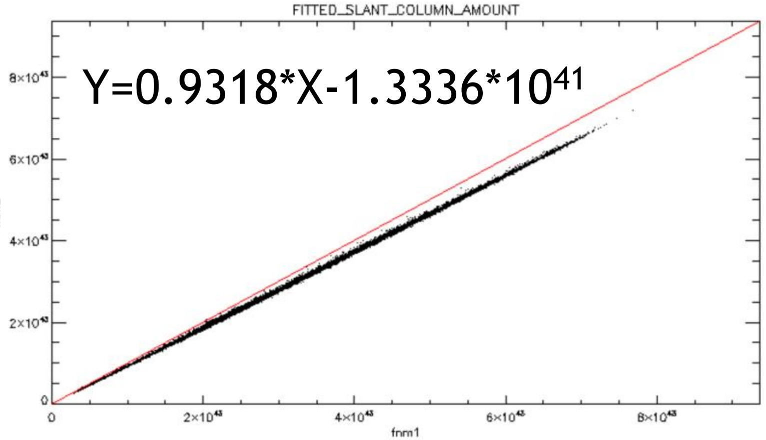


# SCD dependence on $O_2$-$O_2$ reference temperature

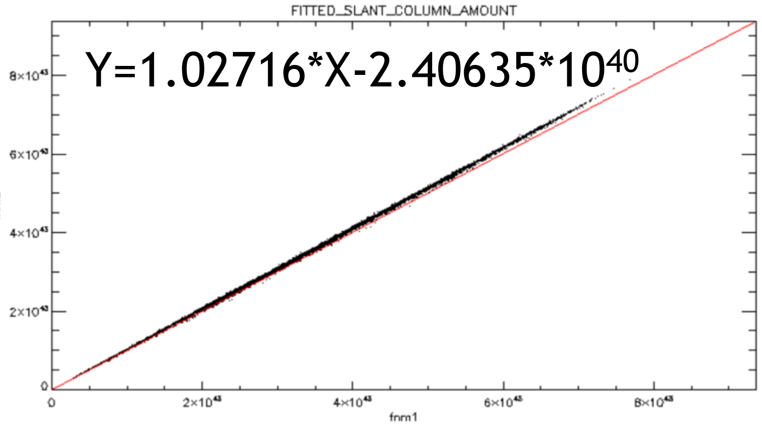
Use 203K




Use 233K

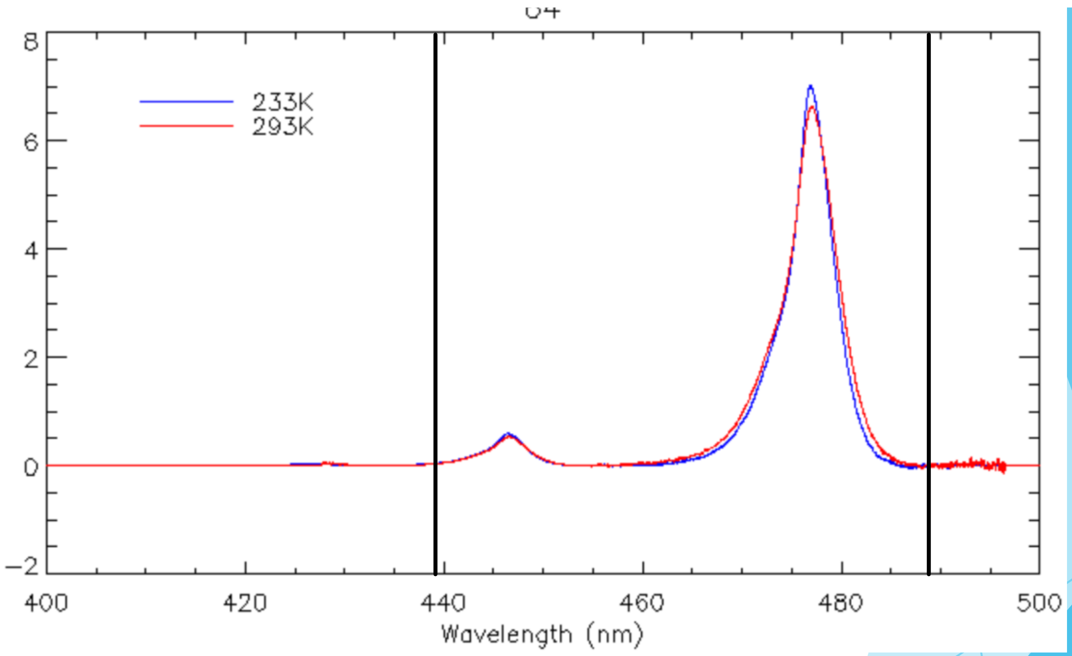



SCD use 293K




SCD use 273K

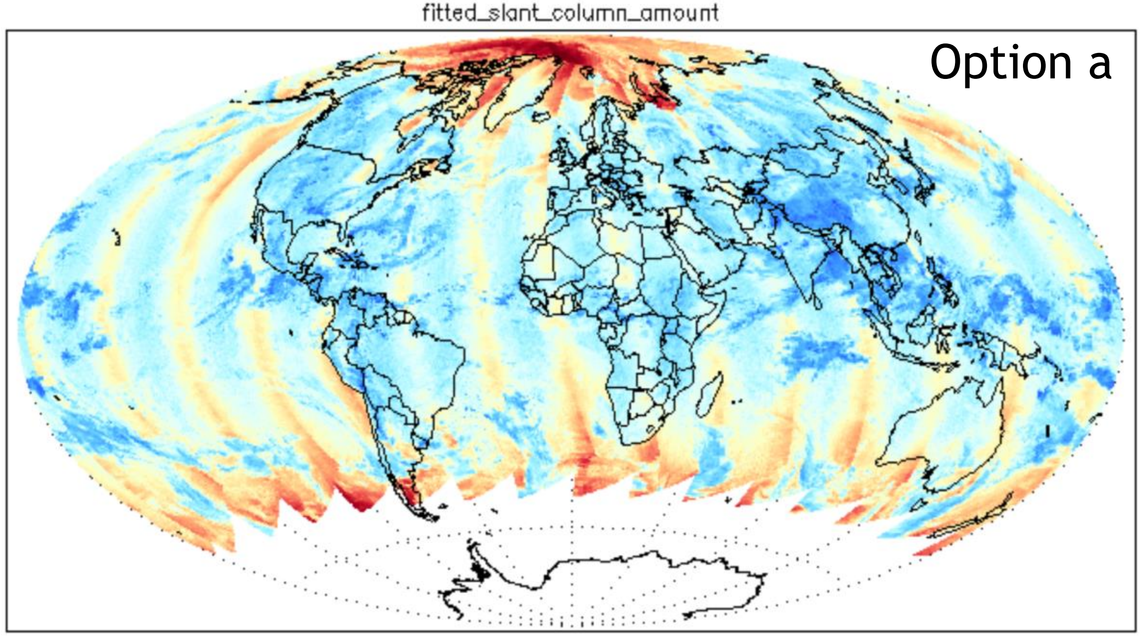
Thalman and Volkamer [2013] O4 reference spectrum



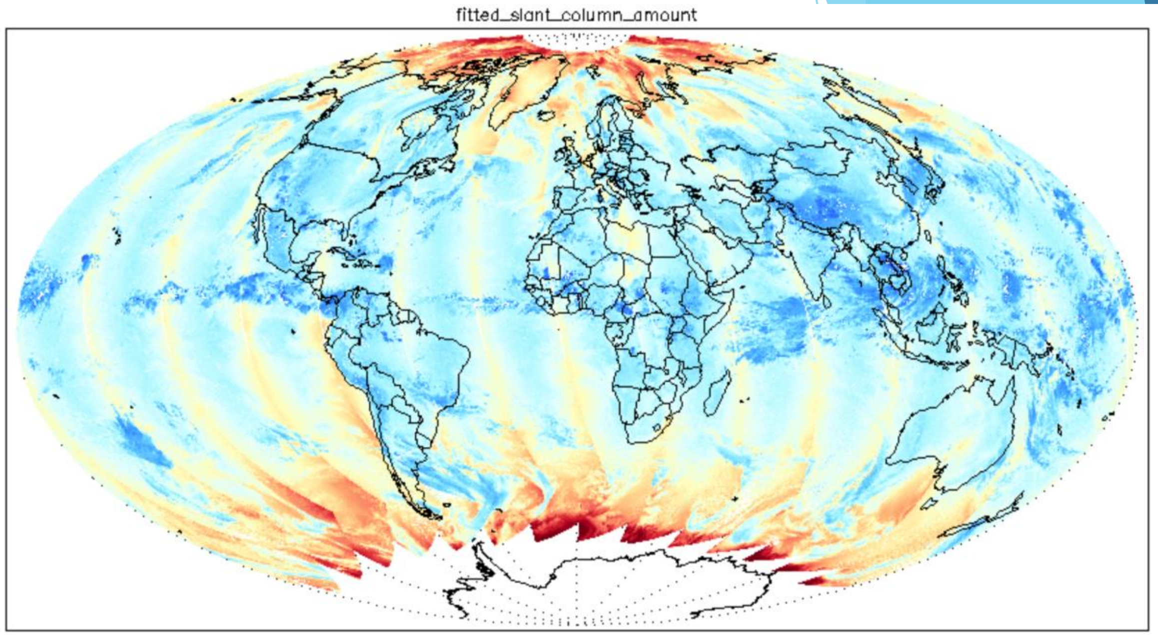

Including Temperature correction to SCD
Reduces differences between SAO retrievals and OMCDO2N slightly

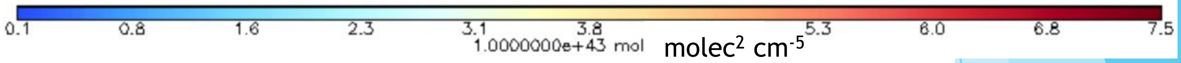
# Exercise on TROPOMI data

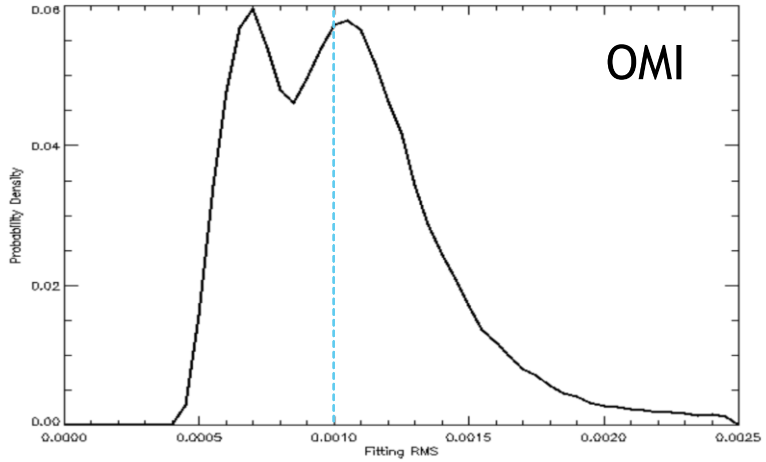
OMI 20050701 $O_2$-$O_2$ SCD

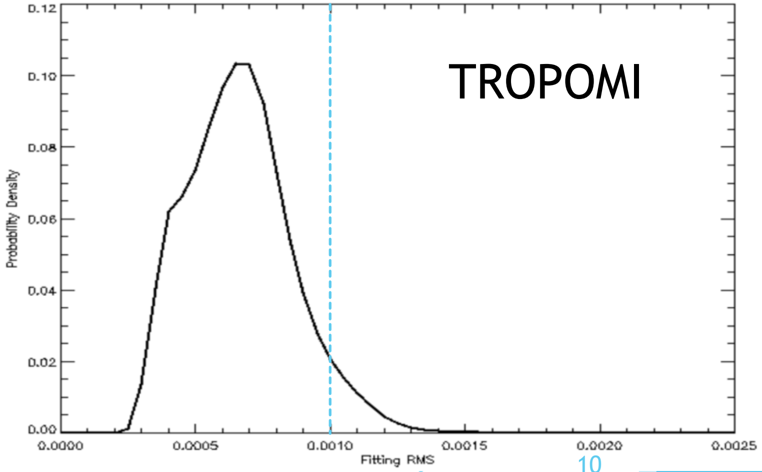



TROPOMI 20190828 $O_2$-$O_2$ SCD



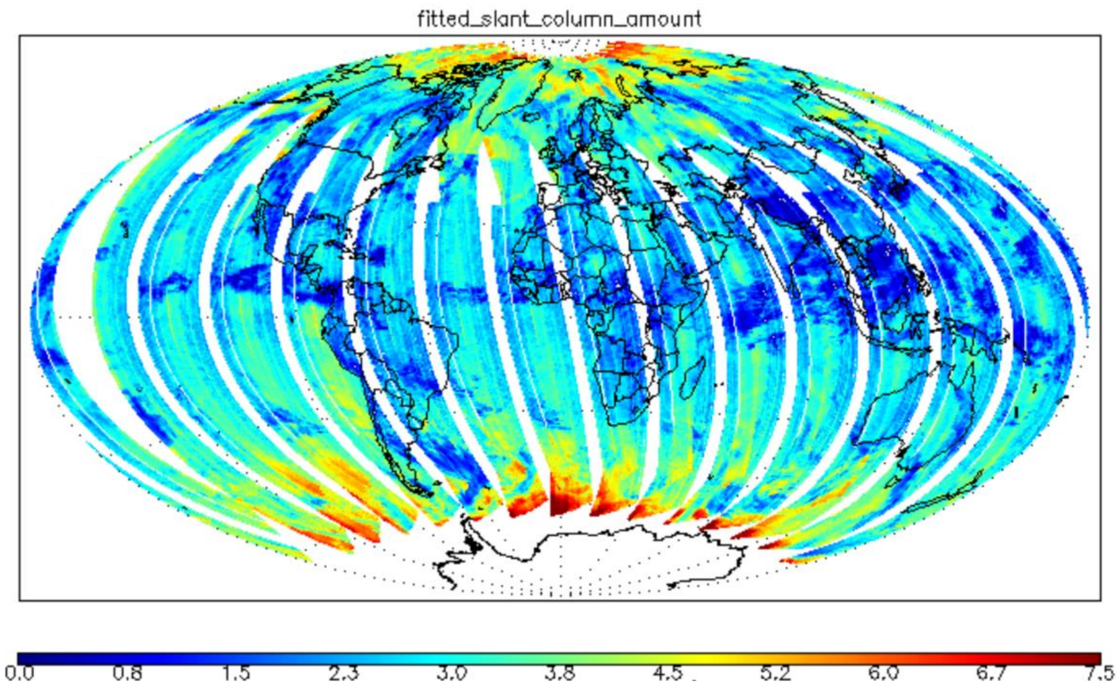



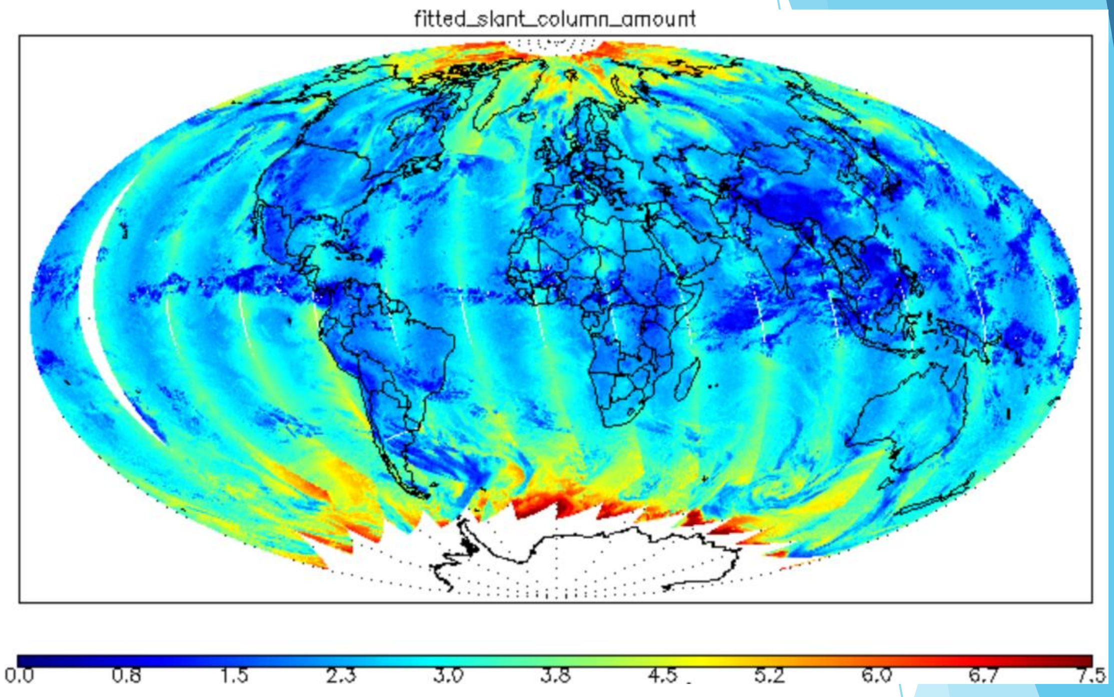

TROPOMI: ~30% improvement in median fitting RMS (& fitting precision) w.r.t. OMI

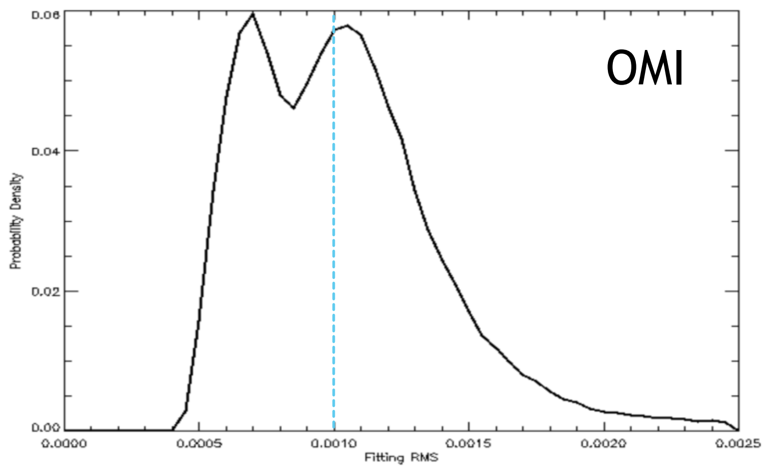
# Exercise on TROPOMI data

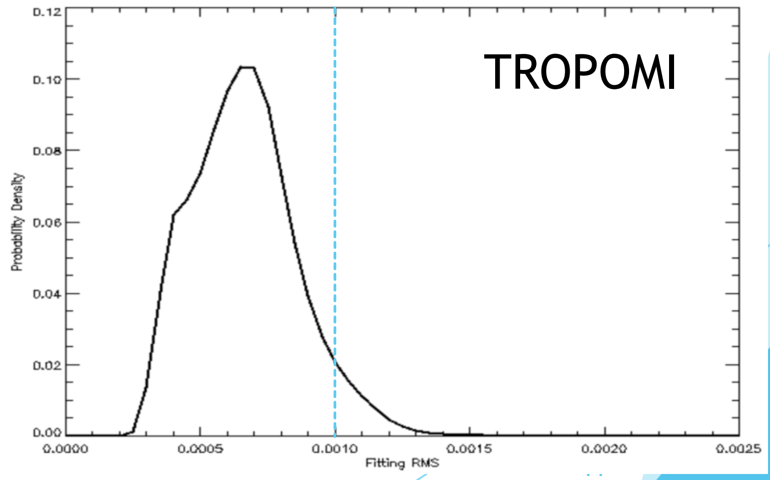
OMI 20190828




TROPOMI 20190828




TROPOMI: ~30% improvement in median fitting RMS (& fitting precision) w.r.t. OMI

# TEMPO O2-O2 SCD retrieval