Algorithm Overview and Status of OMPS NO_2 and SO_2 products

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- Stable performance and high signal-to-noise ratio measurements
- But has significant stray lights, and other instrumental artifacts
- New approaches and techniques enable sensitive tropospheric measurements

Objectives

Provide NO_2 and SO_2 data from SNPP/OMPS with sufficient quality to extend to the Aura/OMI record.

- Standard Products
  - SO_2 Vertical Columns
    - Volcanic SO_2 at various altitudes
    - Boundary Layer SO_2
  - NO_2 Vertical Columns
    - Tropospheric, Stratospheric, and Total NO_2
- Near-Real-Time (NRT) Products
  - SO_2 Vertical Columns
  - NO_2 Vertical Columns*

Algorithm for standard products

Direct Vertical Column Fitting (DVCF) Algorithm to achieve high quality products from SNPP/OMPS

- Improvement in algorithm physics: accurate representation of radiance contributions, especially their vertical and spectral variations, RRS contributions
- Accurate and effective techniques to account for instrumental effects: wavelength registration, spectral response, under sampling, and spectral interference

OMPS Radiance Measurements

Direct Vertical Column Fitting (DVCF) Algorithm

1. O_3 and SO_2

- SO_2 Retrieval: 308 – 360 nm
- SO_2/O_3 : 308 – 333 nm , reflectivity/cloud fraction, aerosol index : 333 – 360 nm

2. NO_2 and MLER parameters

- NO_2 Retrieval: 345 – 378 nm
- NO_2: 345 – 378 nm, reflectivity/cloud fraction, pressures, aerosol index: 350 – 378 nm
- Orbit-based strat-trop separation

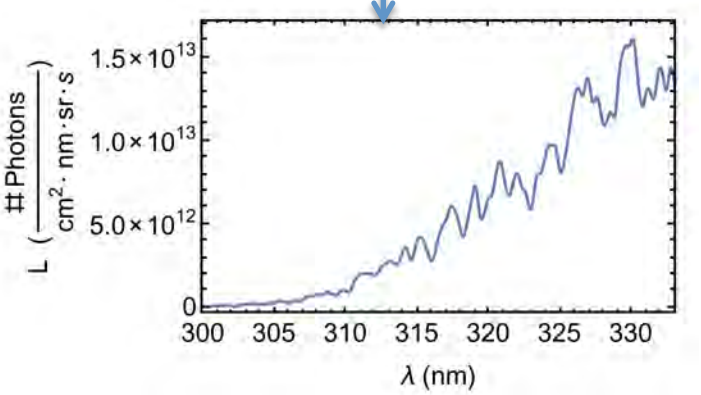
By-Products: O_3 profile and column, and surface parameters: reflectivity/cloud fraction, aerosol index, and pressure

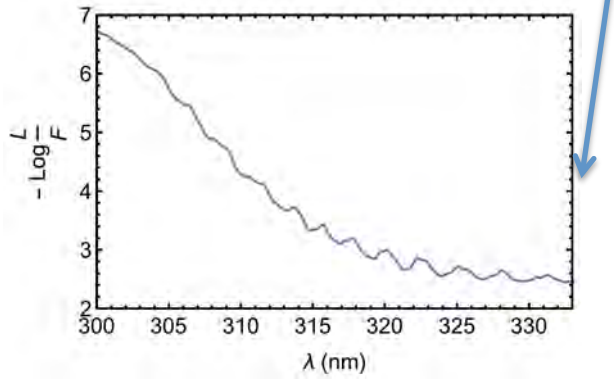
Spectral interference

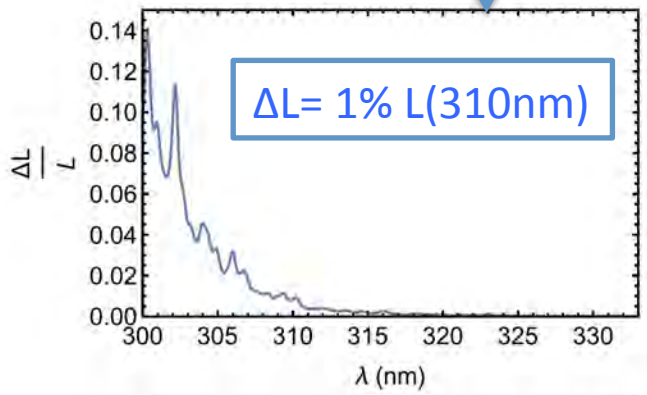
- Due to measurement imperfection and instrumental artifacts, such as stray lights, ghosting, etc.
- Spectral interference is the main factor limiting the sensitivity and accuracy of the retrieved tropospheric columns.

Spectral Interference: Signal Dependence

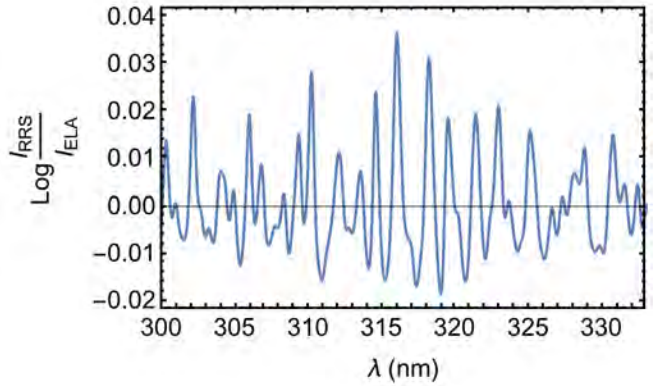
$$Log\left[\frac{L+\Delta L}{F}\right] = Log\left[\frac{L}{F}\right] + \frac{\Delta L}{L}$$







ΔL= 1% L(310nm)



Ring Spectrum

Characterizing Spectral Interference

Error Covariance Matrix:

$$Cov[i,j] = \langle \varepsilon(\lambda_i) \cdot \varepsilon(\lambda_j) \rangle$$

where $\varepsilon(\lambda_i)$ is the residual:

$$\varepsilon(\lambda_i) = \mathrm{Log}[\, I_{measured}(\lambda_i)/I_{modeled}(\lambda_i)]$$

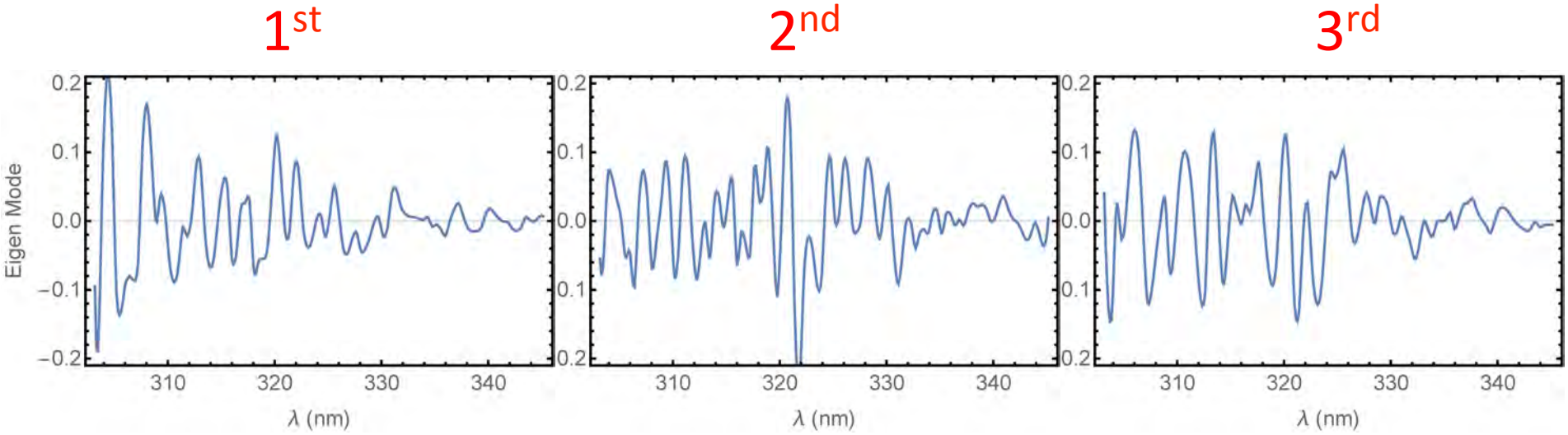
$I_{measured}$: Sun-normalized radiance measurements

$I_{modeled}$: Radiance from accurate RT modeling

Covariance Matrices : constructed for various conditions, such as solar and viewing angles, and scene reflectivity

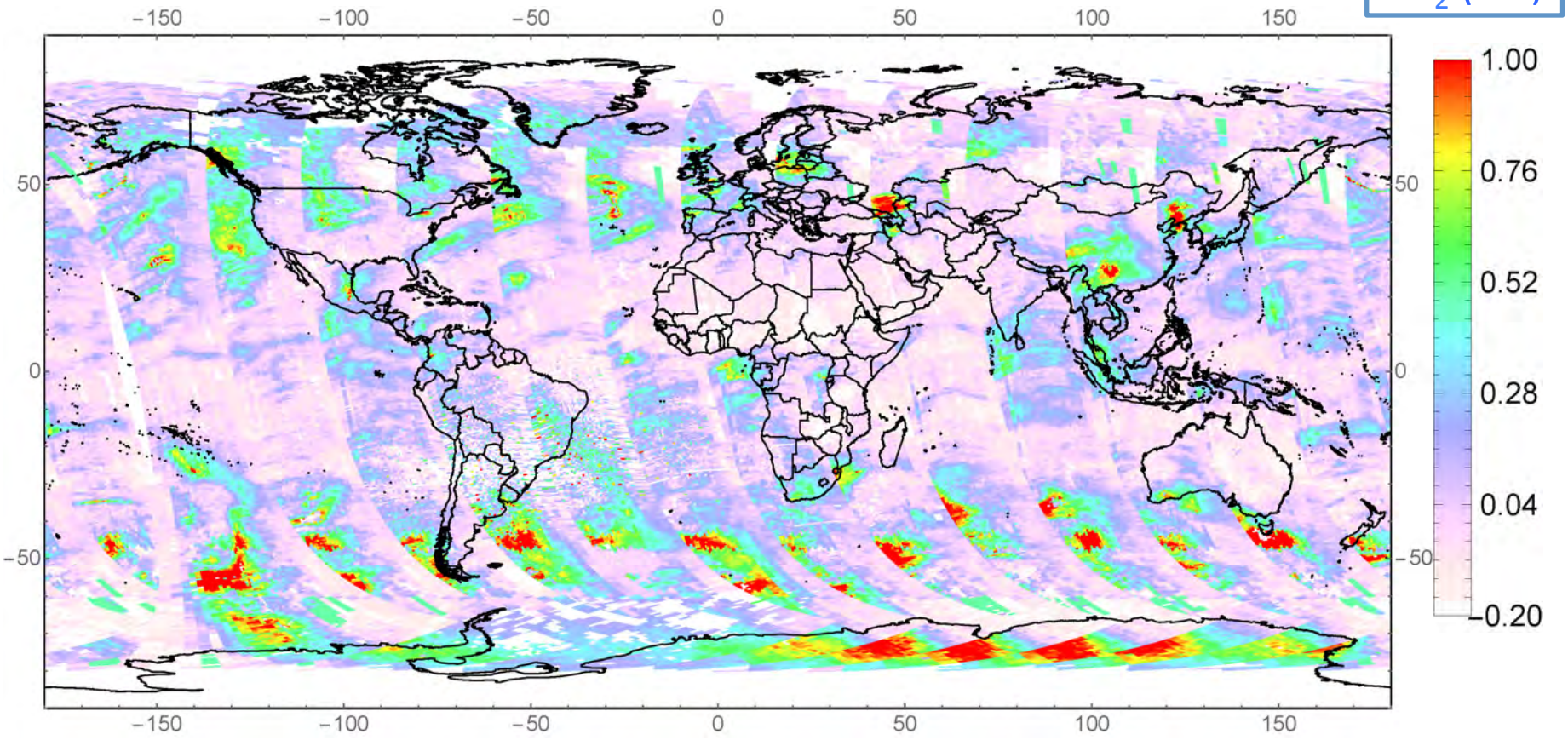
Mitigating Spectral Interference

Eigen functions of the Covariance Matrix

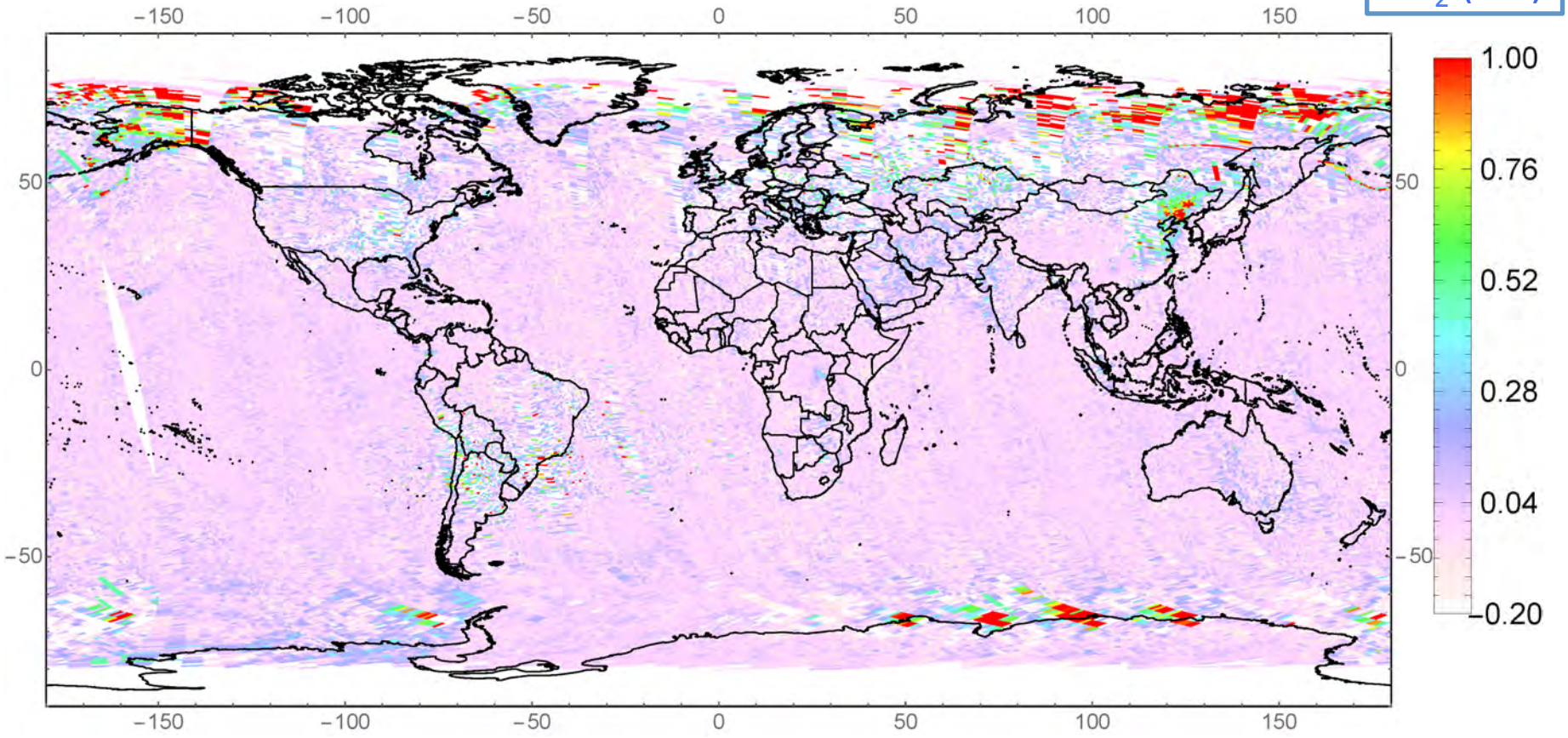


- Fitting of the first few Eigen functions would significantly reduce the impacts of spectral interference

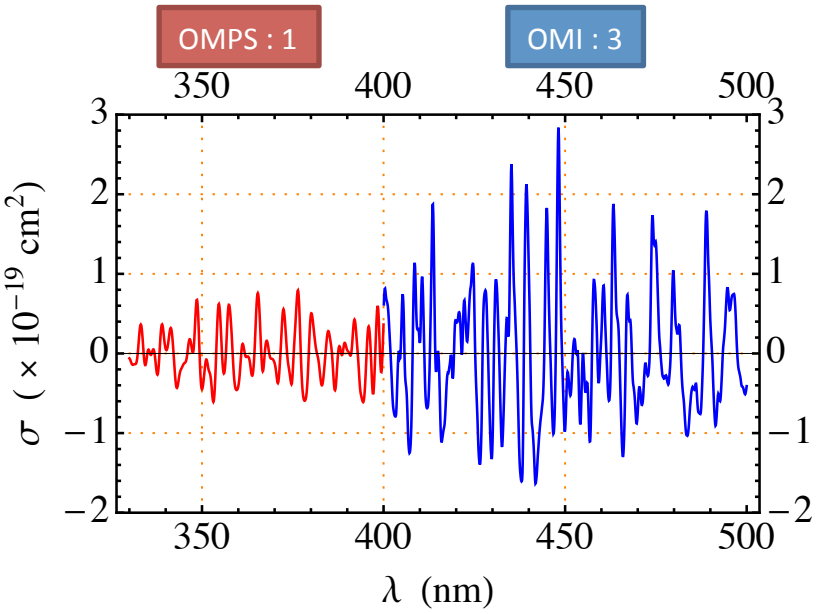
OMPS Boundary Layer SO_2: Without Correction



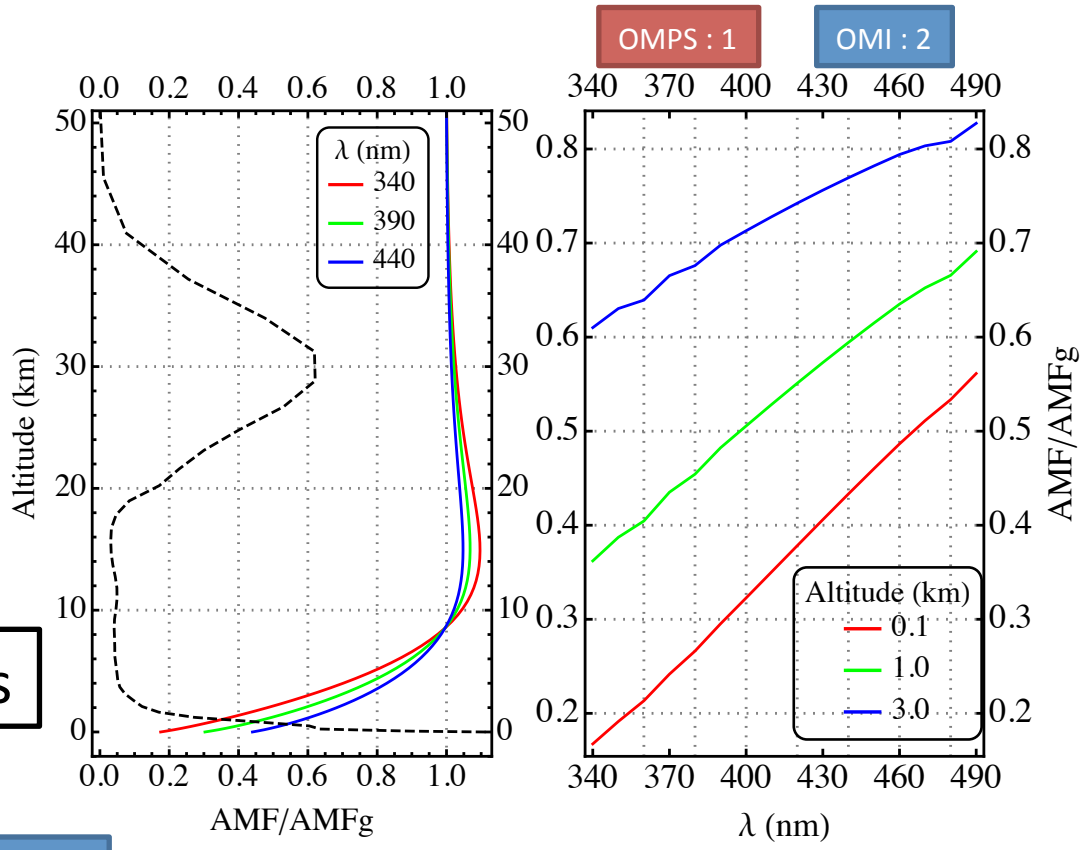
OMPS Boundary Layer SO_2: With Correction



NO_2 Measurement Sensitivity :
Cross Section × Air Mass Factor



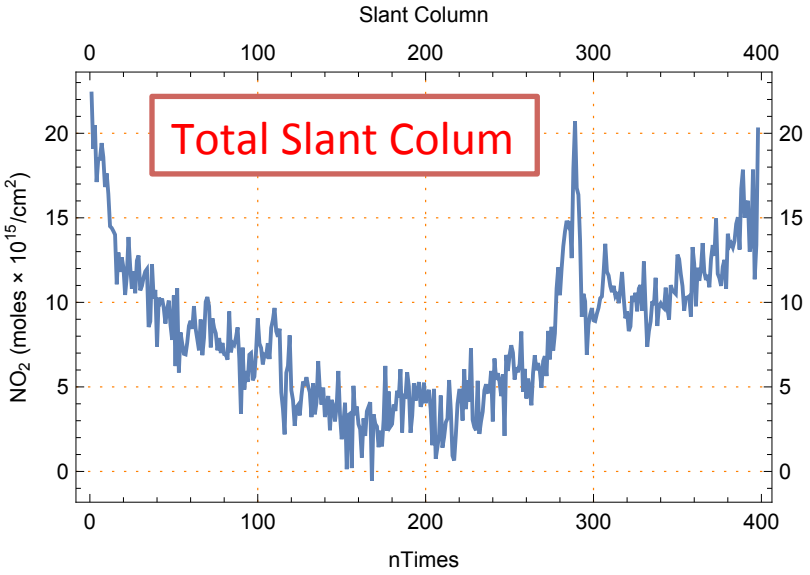
NO_2 Differential Cross Sections



Sensitivity to tropospheric NO_2 :
OMI 4 to 10 times > OMPS

Altitude-Resolved AMFs

OMPS NO_2 Measurement Sensitivity



Precision of slant column:

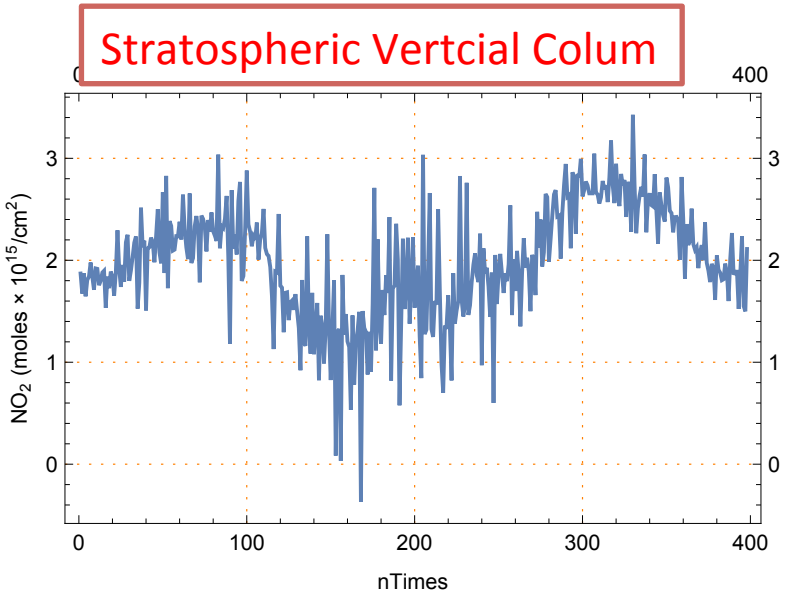
OMPS ~ $1x10^{15}$ molecules/cm^2

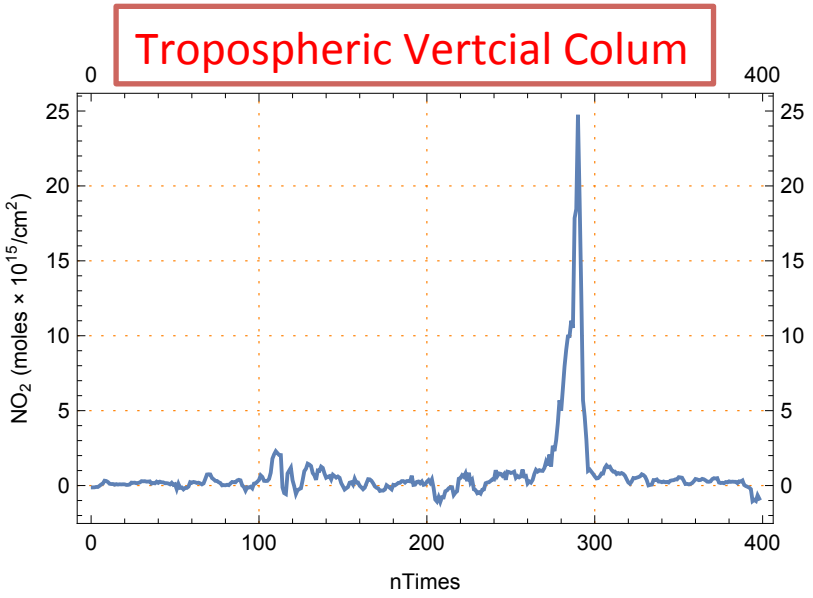
OMI ~ $1x10^{15}$ molecules/cm^2

Precision of vertical tropospheric column:

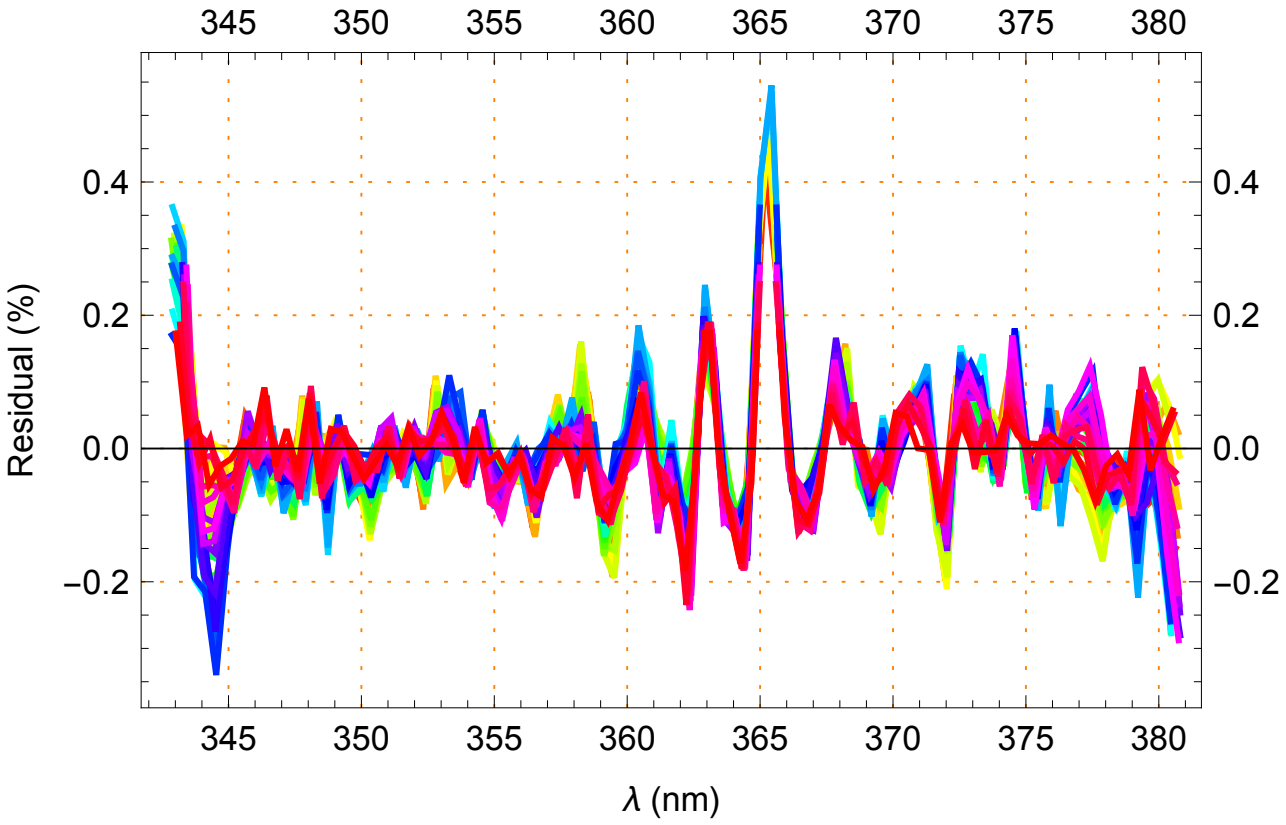
OMPS ~ $0.5x10^{15}$ molecules/cm^2

OMI ~ $1.0\ x10^{15}$ molecules/cm^2





Radiance Correction for NO_2



Note: each line represent one cross-track position, 36 lines (or colors) in this figure.

OMPS: NO_2 Stratospheric Vertical Columns

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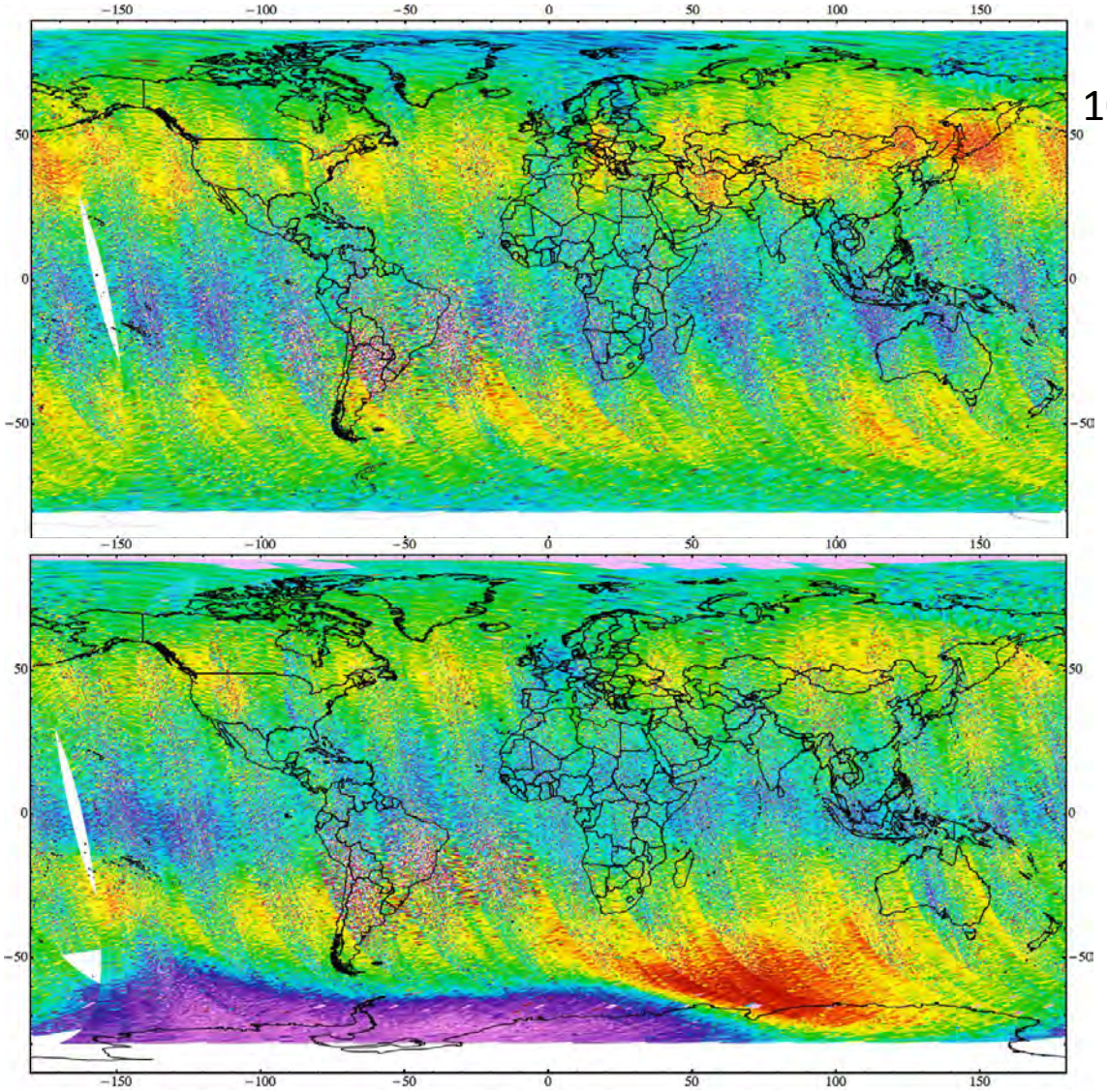
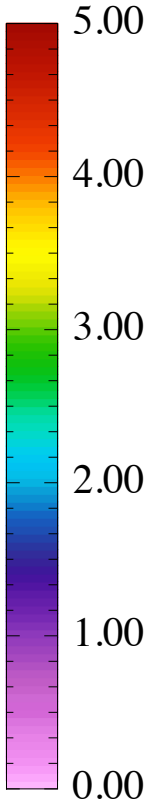
03/21/2013

09/22/2013



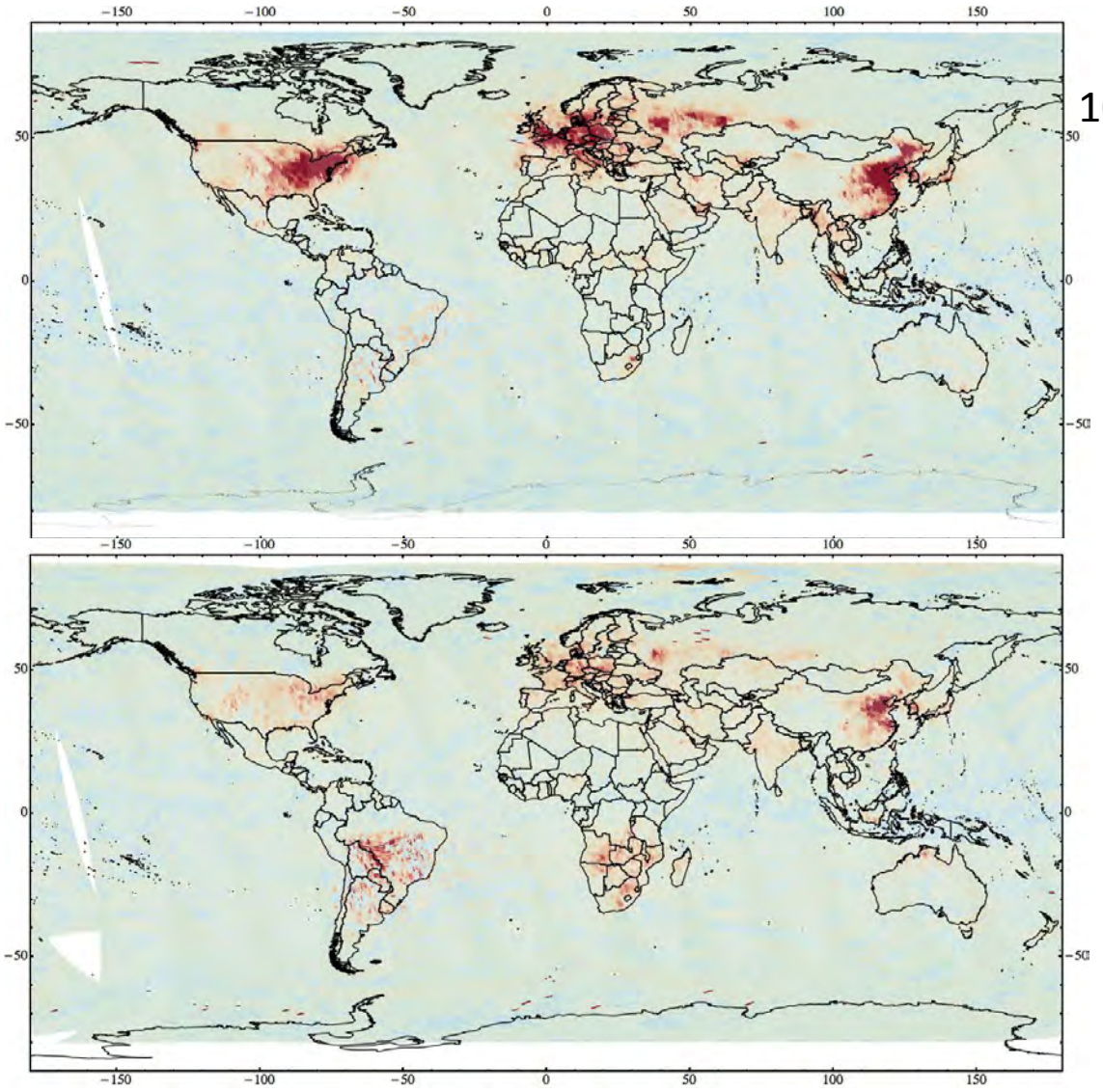
NO_2
10^{15} molecules/cm^2



OMPS: NO_2 Tropospheric Vertical Columns

03/21/2013

09/22/2013



NO_2
10^{15} molecules/cm^2

10.00
8.00
6.00
4.00
2.00
0.00

Summary

- Advanced algorithm with many improvements, including algorithm physics representation, instrumental effect modeling, and soft calibration, have been developed and implemented for OMPS processing.
- These advances have enabled sensitive and unbiased measurements of tropospheric SO_2 and NO_2 from SNPP/OMPS-NM, achieving data quality that matches or exceeds those of its predecessors.

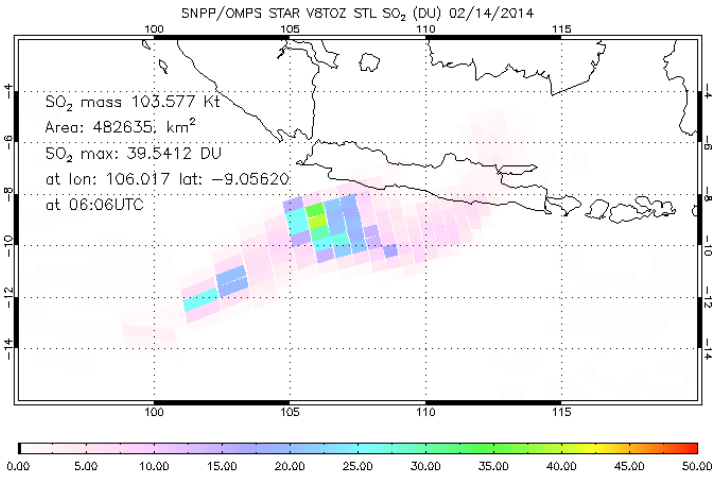
Status

- SO_2 and NO_2 processing codes for generate standard products are near completion.
- Start forward processing and reprocessing with 2 ~ 3 months (by 09/2015).
- Product release (by 12/2015).

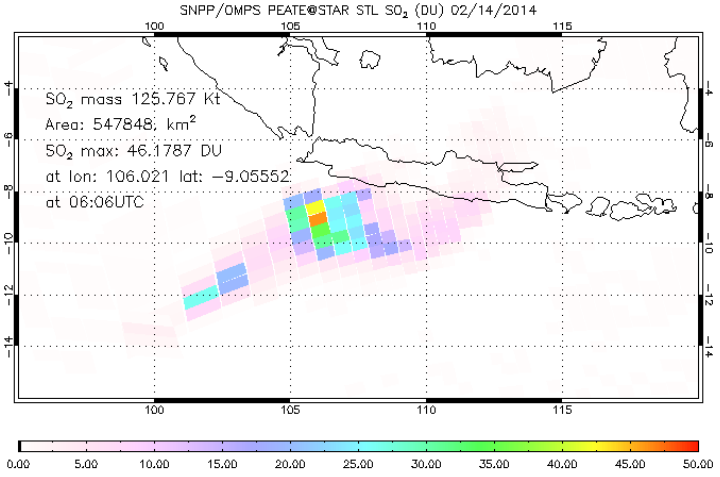
Status (Continued)

- NRT SO_2/Ash with LF algorithm processing is on-going, data available at Ozone SIPS and LANCE.
- LF algorithm successfully transferred to NOAA.
- Implement an improved NRT algorithm for SO_2/O_3

NOAA STAR



NASA OZONE SIPS



Eruption of Kelud 20140214. Figures from J. Niu (NOAA STAR)