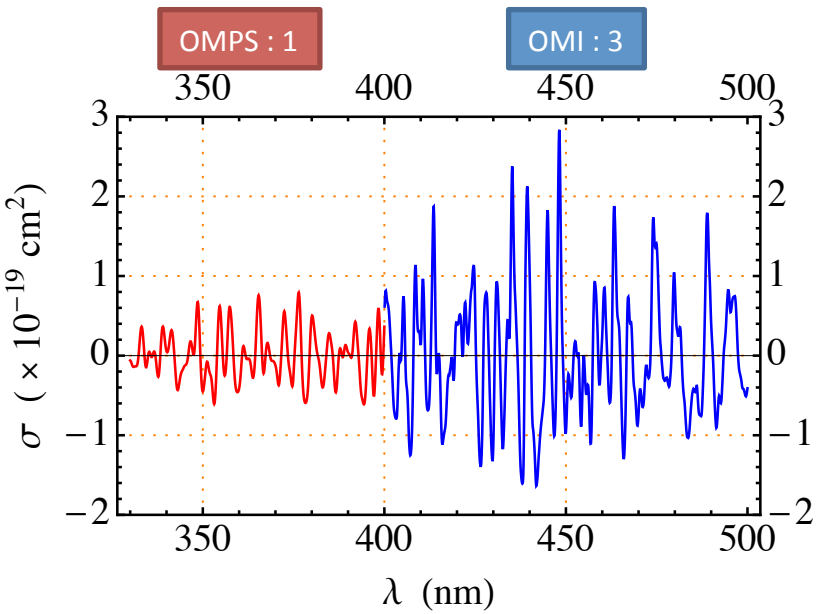
Advancing Measurements of Tropospheric NO_2 from Space : New Techniques and Application to OMPS

Kai Yang (UMCP)
Simon A. Carn (MTU)
Cui Ge, Jun Wang (UNL)
Russell R. Dickerson (UMCP)

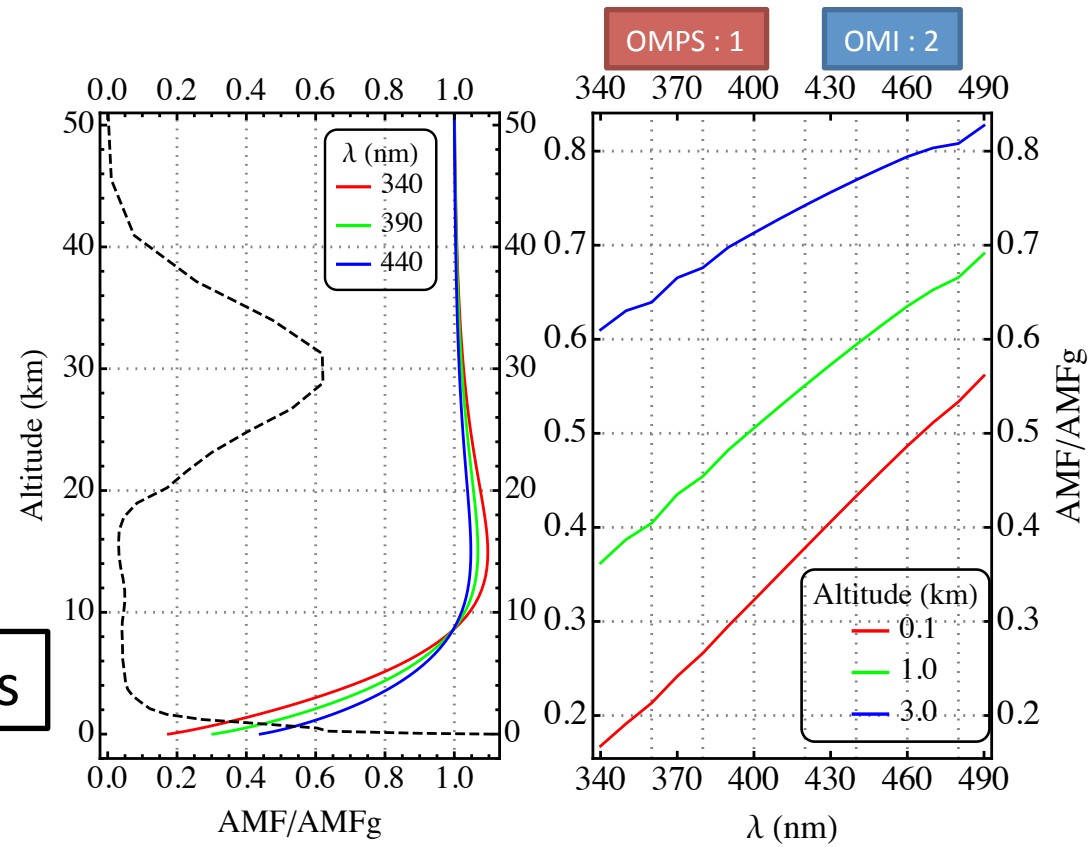
Outline

- Algorithm Basis: NO_2 Measurement Sensitivity
- New NO_2 Retrieval Technique:
  Direct Vertical Column Fitting Algorithm
- New Strat-Trop Separation Technique:
  Sliding Median
- Application to S-NPP/OMPS and Comparisons with Aura/OMI
- Future Development

NO_2 Measurement Sensitivity : Cross Section × Air Mass Factor



NO_2 Differential Cross Sections



Sensitivity to tropospheric NO_2 : OMI 4 to 8 times > OMPS

Altitude-Resolved AMFs

K. Yang, 2nd TEMPO Science Team Meeting, May 21 – 22, 2014, NIA, Hampton, VA

New NO_2 Algorithm: Direct Vertical Column Fitting (DVCF)

Basic approach: Iterative spectral fitting to minimize the difference between measurements and radiative transfer simulations

$$\ln I_m(\lambda) - \ln I_{TOA}(\lambda) = V \int_0^\infty \frac{\partial \ln I_{TOA}(\lambda)}{\partial \tau_z} S_z \sigma(\lambda, T_z) dz - \sum_i \xi_i \sigma_i(\lambda, T_i) + \epsilon.$$

- NO_2 vertical column : V
- NO_2 Shape factor : S_z
- Other absorber slant column : ξ_i
- Altitude-resolved Air Mass Factor : $-\frac{\partial \ln I_{TOA}}{\partial \tau_z}$

Improvements over DOAS

New algorithm allows more complete treatment of algorithm physics

- Self consistency: surface reflection, cloud (MLER) parameters, and their spectral dependence are retrieved from the same spectral range. Enable better handling of surface reflectance variation and cloud/aerosol conditions.
- More accurate in accounting for the effects of spectral and altitude variations in measurement sensitivity

Artifact and Bias Correction

Radiance correction schemes developed with the new algorithm:

- Soft calibration of measured radiance based on internal consistency
- Residual analysis to derive static and dynamics corrections to remove biases and spectral interferences
- Stable instrument performance allows corrections derived from one time period to be effective for other time periods.

New Strat-Trop Separation (STS): Orbit-Based Technique

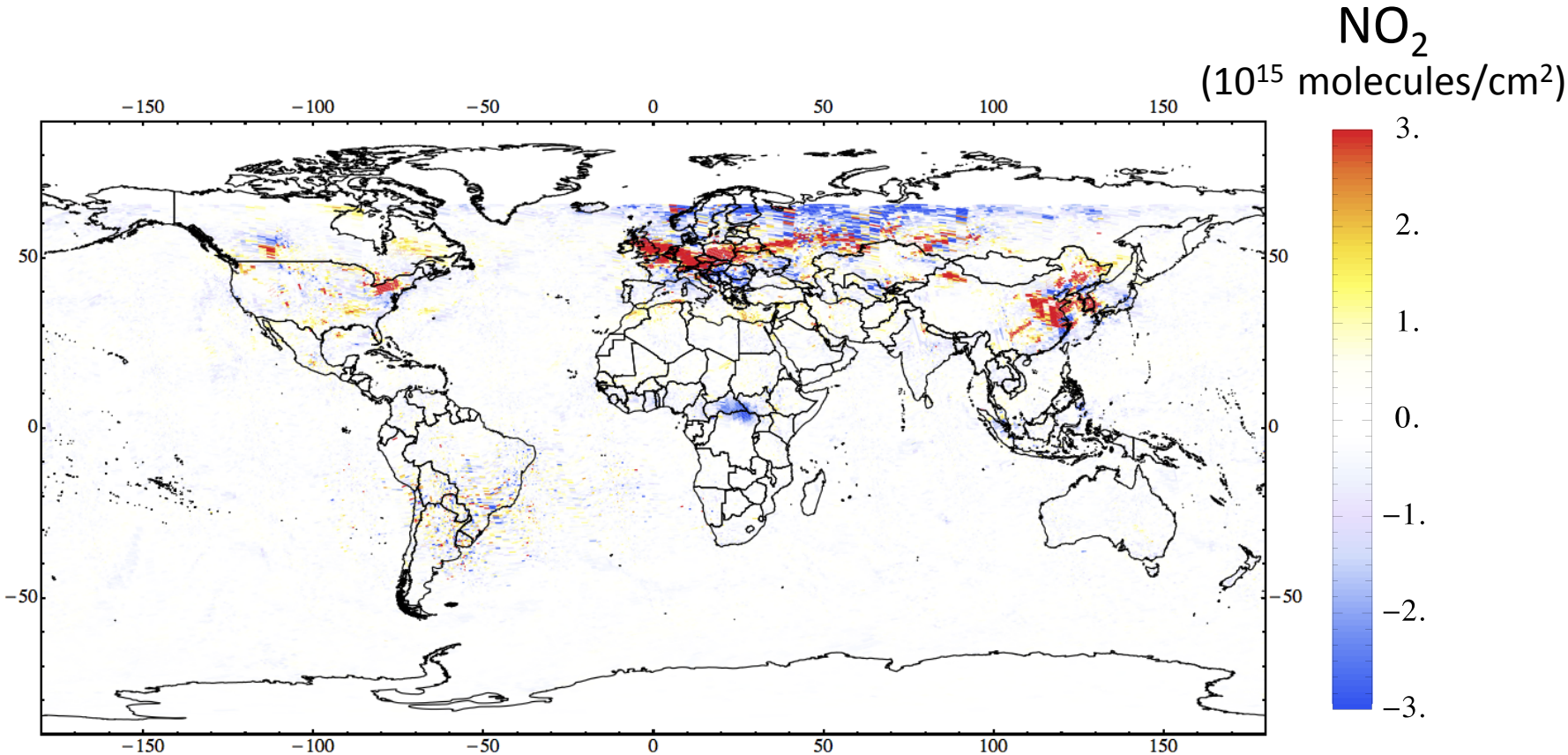
Basic idea

- Localized (small scale) features in the strat fields are attributed to tropospheric signals due to shape factor prescription mismatch.
- Smoothing out these localized features improve both strat and trop NO_2 fields.

Orbit-Based STS: Procedures

- Initial STS done using tropopause and shape factor
- Two smoothed strat fields from sliding median of each cross-track position of an orbit: ~2° and ~20° latitude bands
- The excesses (+) and deficits (–) of strat NO_2 are the difference between the two smoothed fields.
- Trop columns adjustment: strat excesses are added to and deficits are subtracted from the trop fields, whilst accounting for their different measurement sensitivities.

Orbit-Based Example: Tropospheric Adjustment



Orbit-Based STS: Advantages

- Each cross track done independently: without mixing measurements at different local time
- Measurement characteristics preserved: without increasing tropospheric NO_2 noise

S-NPP OMPS NO_2

New techniques applied to OMPS observations in the spectral range : 345 – 378 nm

First Global NO_2 Measurements form UV

OMPS: NO_2 Total Slant Columns

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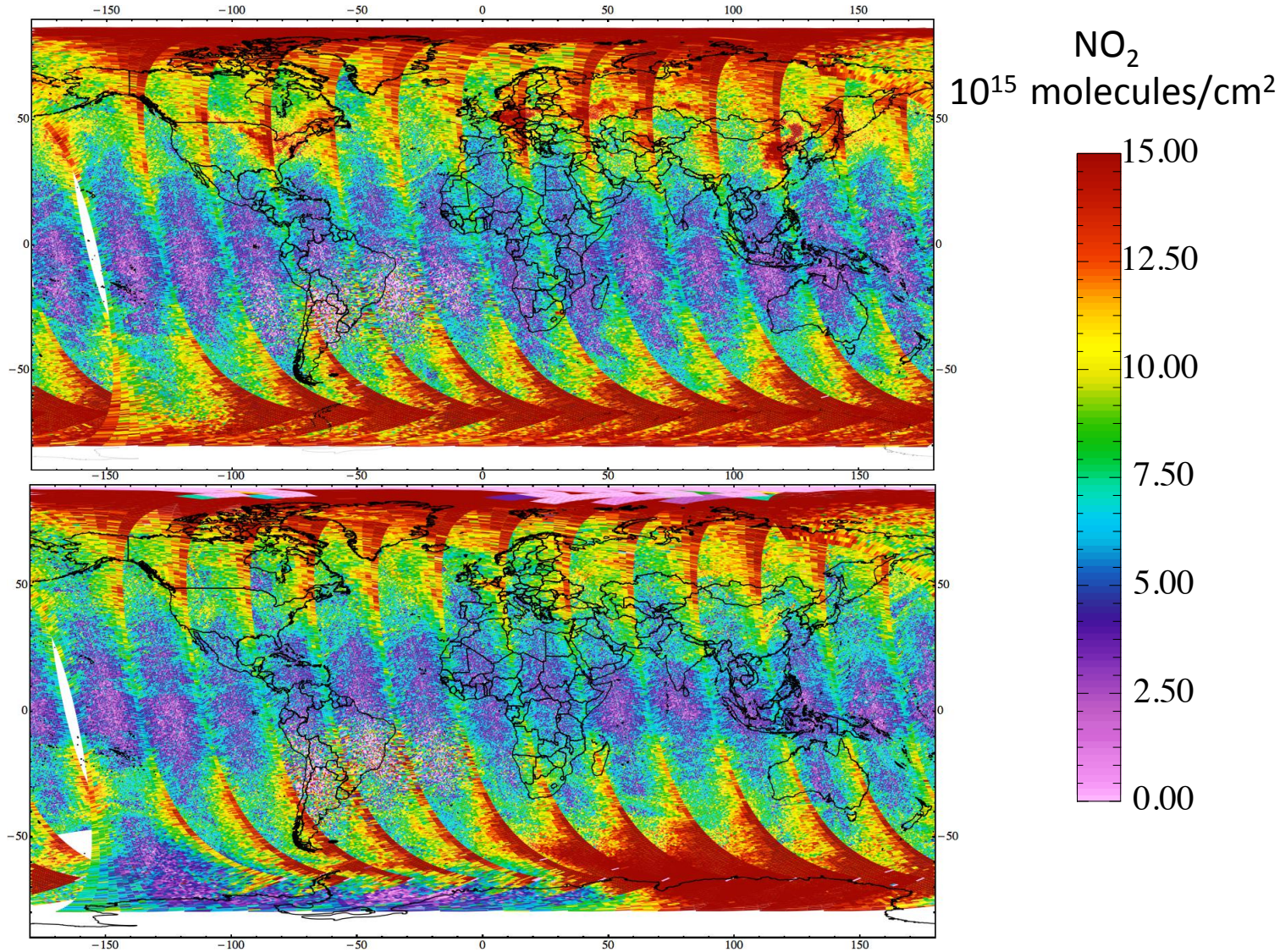
03/21/2013

09/22/2013



OMPS: NO_2 Stratospheric Vertical Columns

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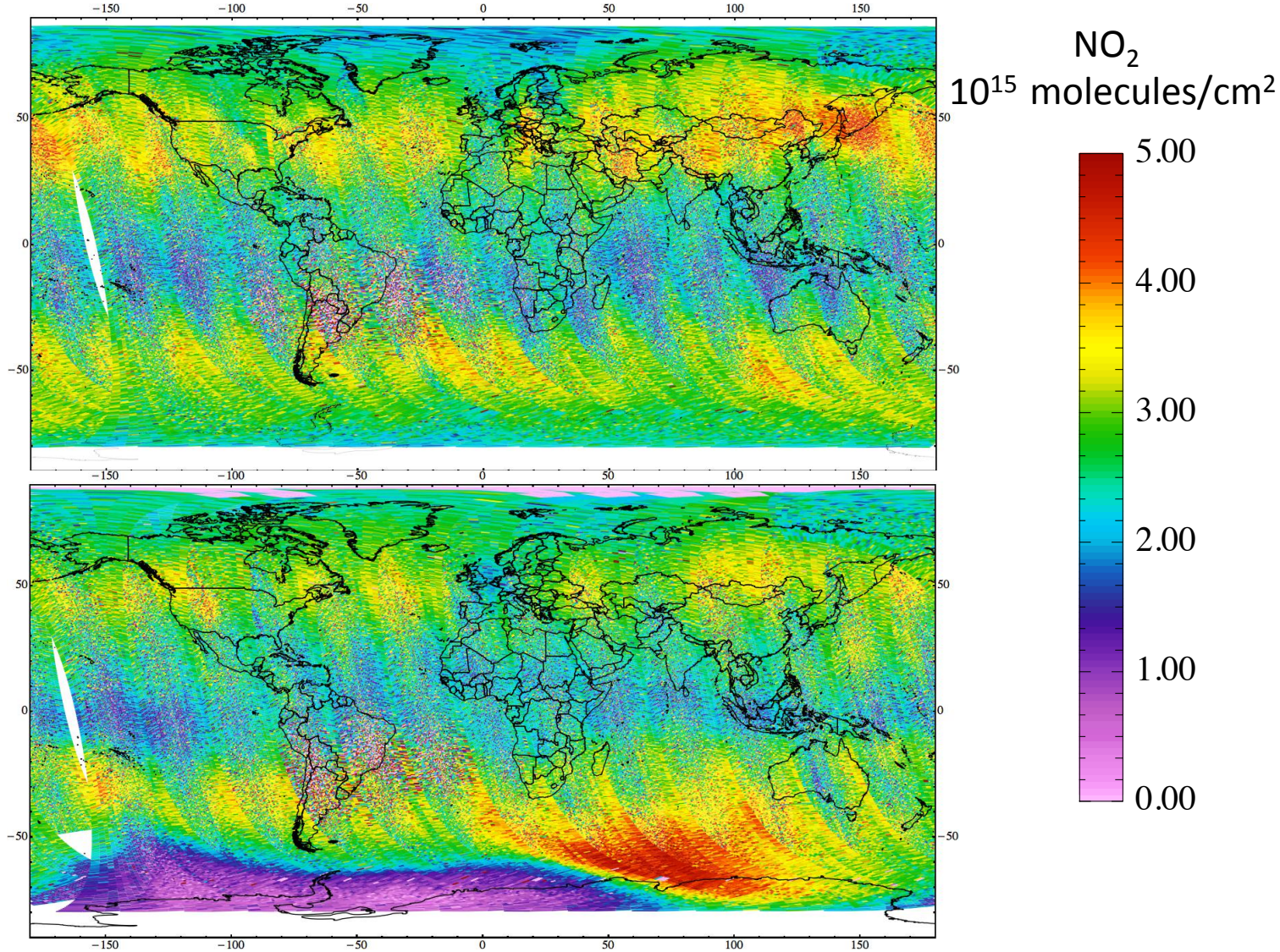

OMPS: NO_2 Tropospheric Vertical Columns

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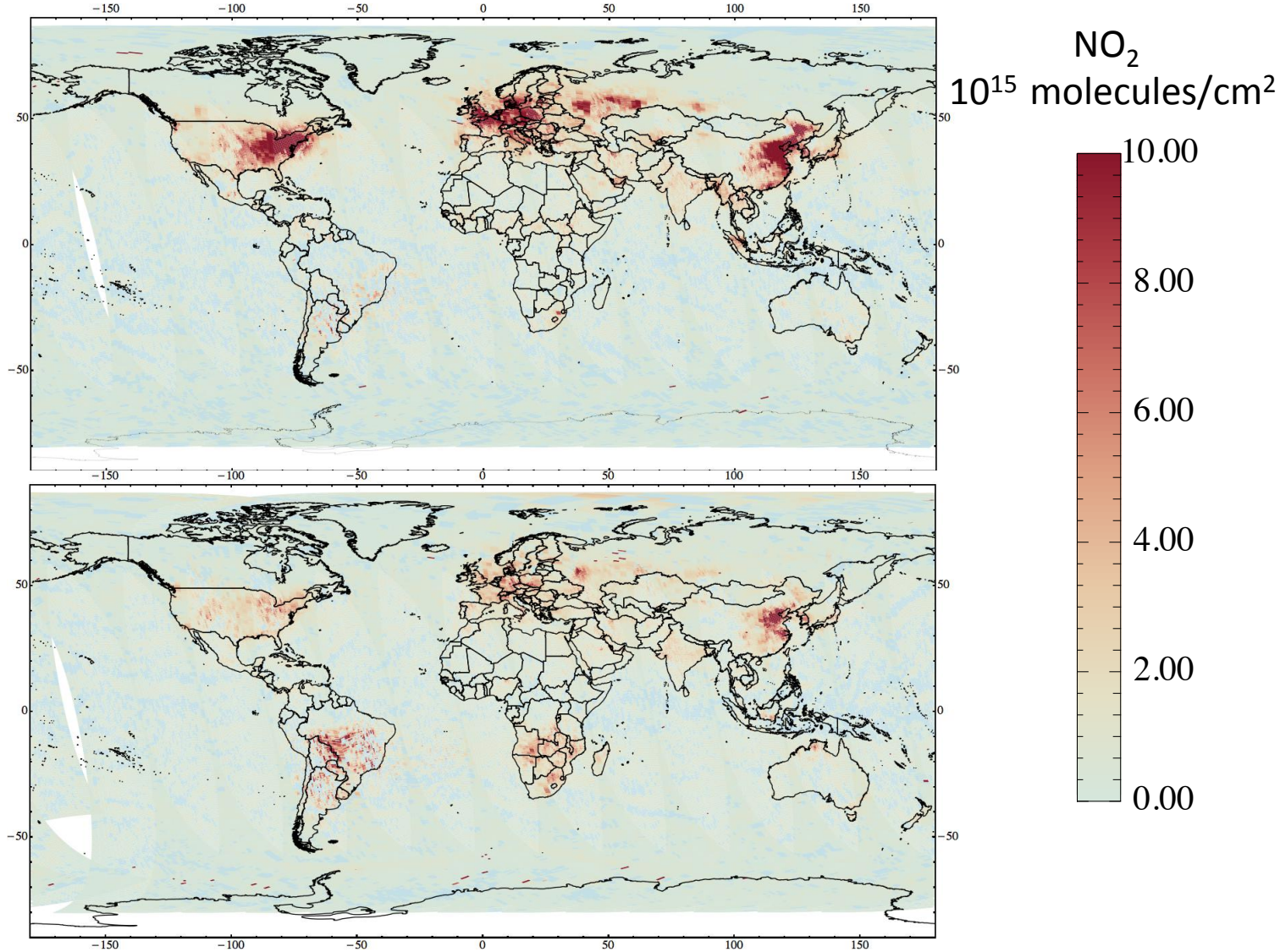


Comparisons with OMI

OMPS tropospheric NO_2 measurement sensitivity is similar to that of OMI achieved with standard operational (DOAS-based) algorithm:

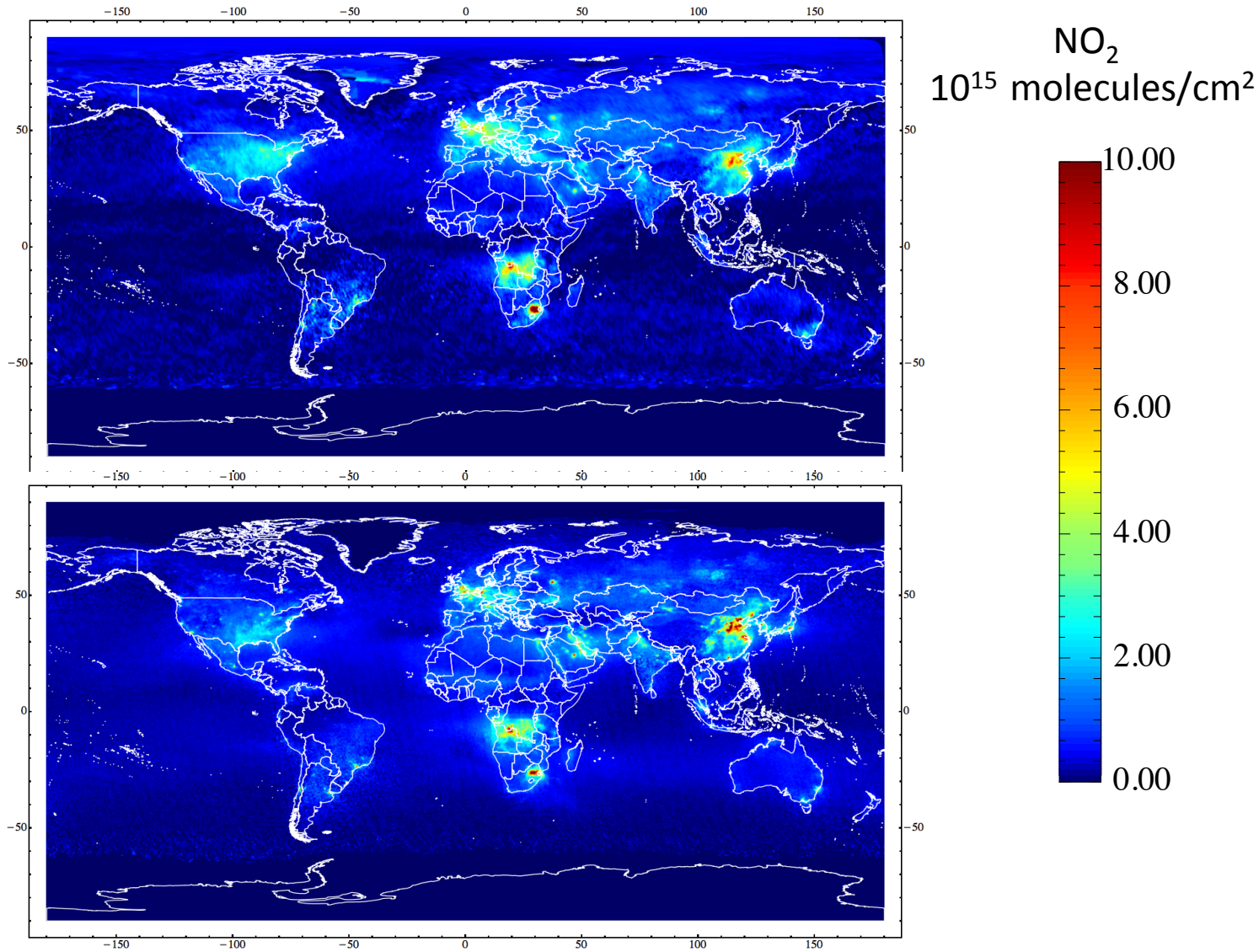
- OMPS slant column precision is better than 10^{15} molecules/cm^2, but slightly less than OMI
- Tropospheric column precision ~ 3×10^{14} molecules/cm^2, better than OMI

OMPS continues and extends Aura/OMI long-term data records

Comparison: OMI vs OMPS Monthly Mean: July 2013

OMPS

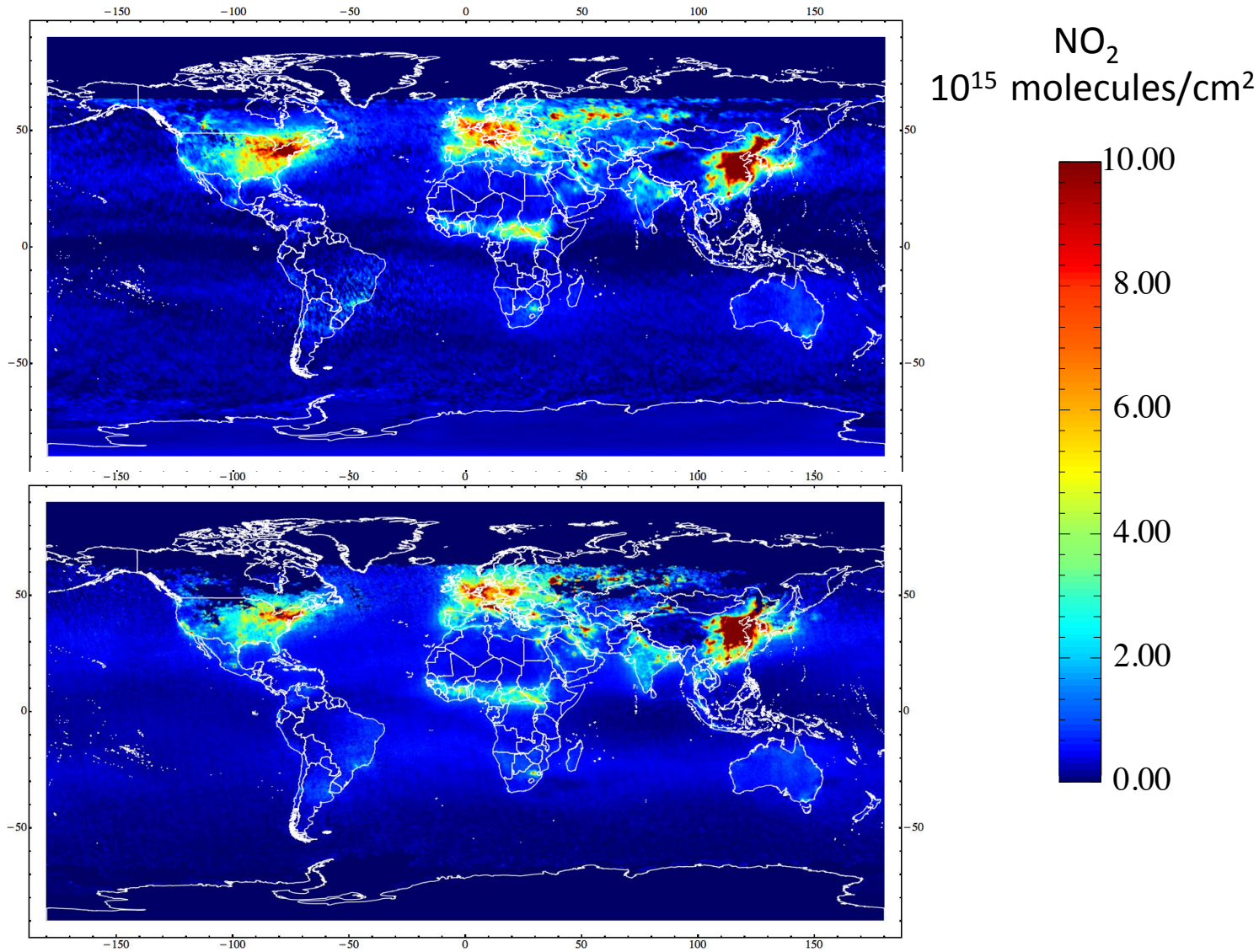
OMI



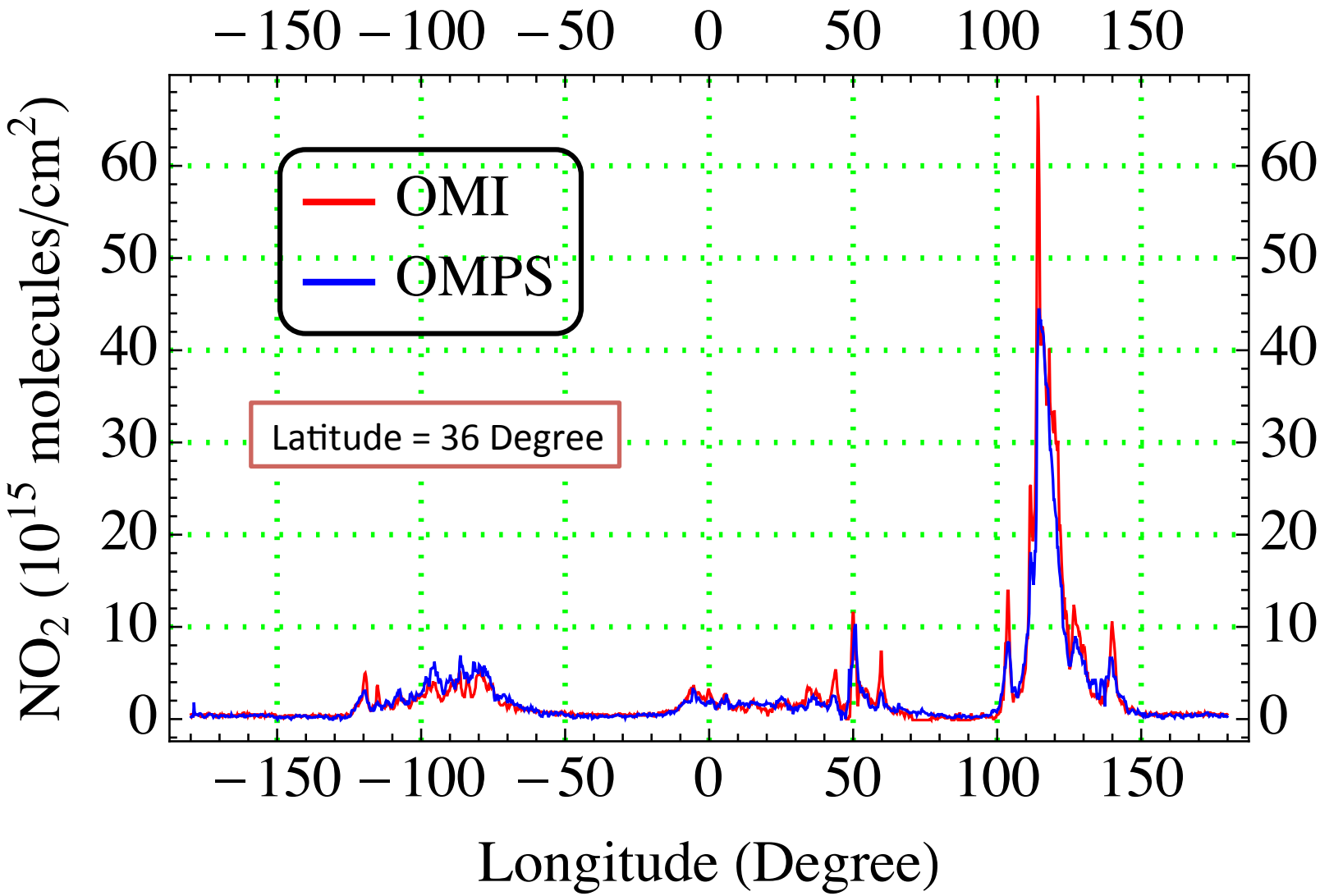
Comparison: OMI vs OMPS
Monthly Mean: December 2013

OMPS

OMI



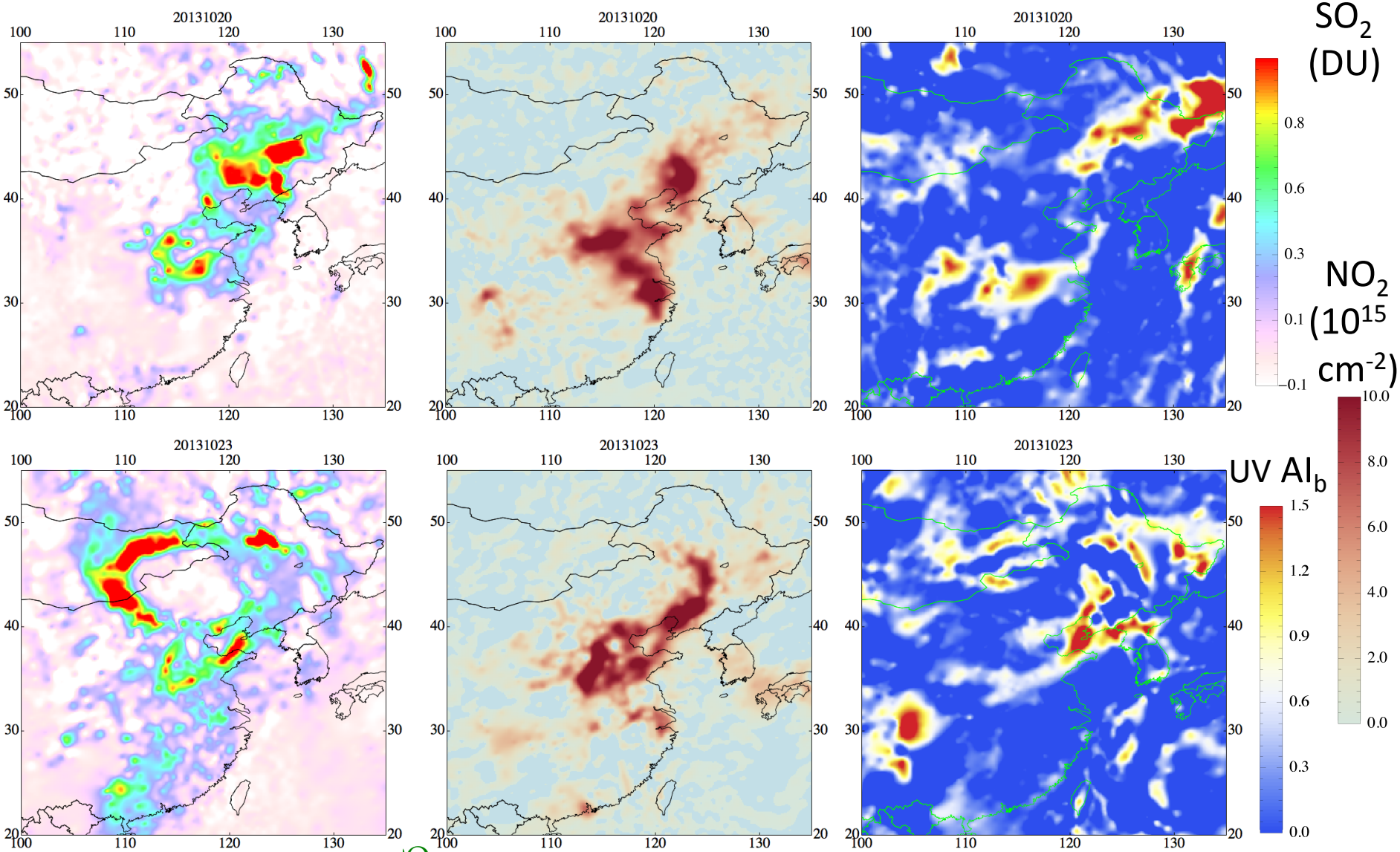
Comparison: OMI vs OMPS
Monthly Mean: December 2013



Summary

- A new algorithm for improved NO_2 retrieval from space-based UV/Vis spectral measurements: OMI, GOME-2, OMPS, TROPOMI, TEMPO, and …
- A new strat-trop separation approach, suitable for near-real-time application
- New correction schemes enabled by the new algorithm, for bias reduction and sensitivity enhancement.

Algorithm Advances Enable Daily Global Pollution Monitoring with OMPS



Unprecedented SO_2 Sensitivity

OMPS October 2013
Monthly Mean
ISF Algorithm