Impact of NO_2 Profile Shape in OMI Tropospheric NO_2 Retrievals

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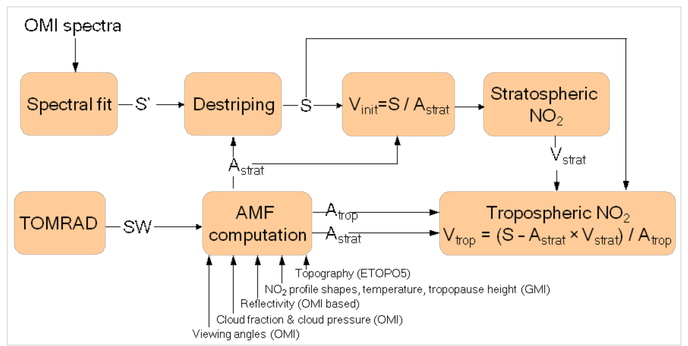
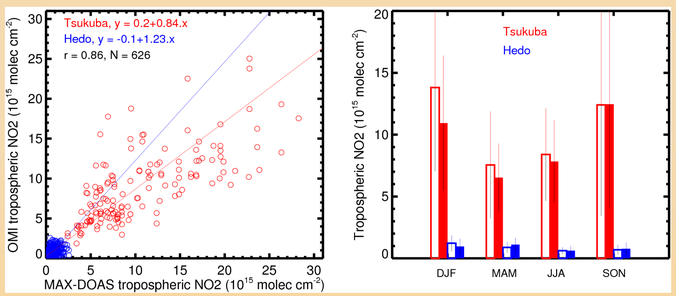
Overview

Nitrogen oxides (NO_x = NO + NO_2) are key actors in air quality and climate change. Tropospheric NO_2 columns from the nadir-viewing satellite sensors have been widely used to understand sources and chemistry of NO_x. We have implemented several improvements to the operational algorithm developed at NASA GSFC and retrieved tropospheric NO_2 columns. Here, we present some validation studies of the new product using ground-based and in-situ aircraft measurements. We show how vertical profile of scattering weight and a-priori NO_2 profile shapes, which are taken from chemistry-transport model, affect air mass factor (AMF) and therefore tropospheric NO_2 retrievals. Users can take advantage of scattering weights information that are made available in the operational NO_2 product. Improved tropospheric NO_2 data retrieved using thoroughly evaluated high-resolution NO_2 profiles are helpful to test models.

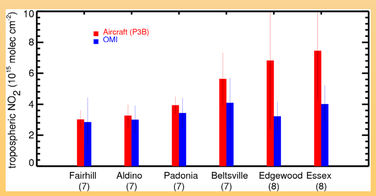
Operational OMI NO_2 retrieval and validation



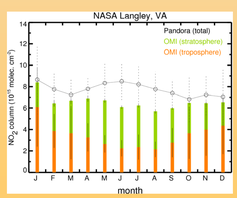
S' →measured slant column density, S →destriped slant column density, SW → scattering weight, A_{trop} → tropospheric AMF, A_{strat} → Stratospheric AMF.



Comparison of OMI tropospheric NO_2 with MAX-DOAS measurements at a polluted (Tsukuba) and an unpolluted site (Hedo) in Japan. Measurement period covers 2006-2011.



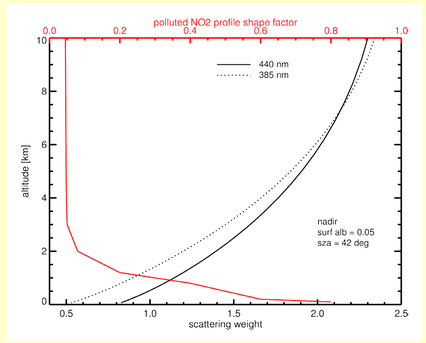
Comparison of OMI tropospheric NO_2 with P3B measurements during DISCOVER-AQ in July 2011.



Comparison of OMI NO_2 with PANDORA measurements at NASA Langley during 2006-2011.

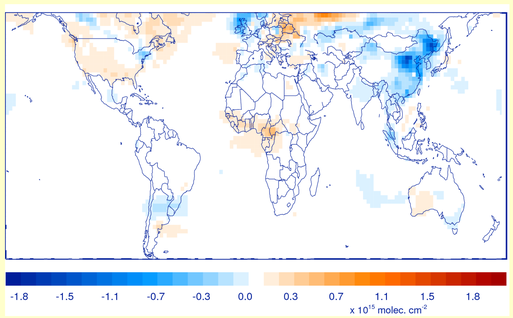
Modeled a-priori NO_2 vertical profile shape and NO_2 column retrievals

NO_2 shape factor and scattering weight for AMF



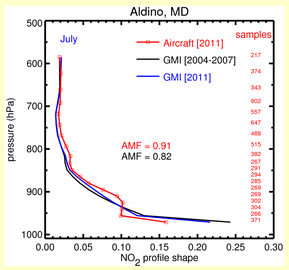
NO_2 vertical profile shape for polluted condition (red line) and scattering weight for a measurement condition (black line) at two wavelengths; 440 nm represents the middle of NO_2 spectral fitting window. Tropospheric AMF derived from the two is critically important for NO_2 vertical column retrievals.

Retrievals benefit from NO_2 profiles with updated emissions



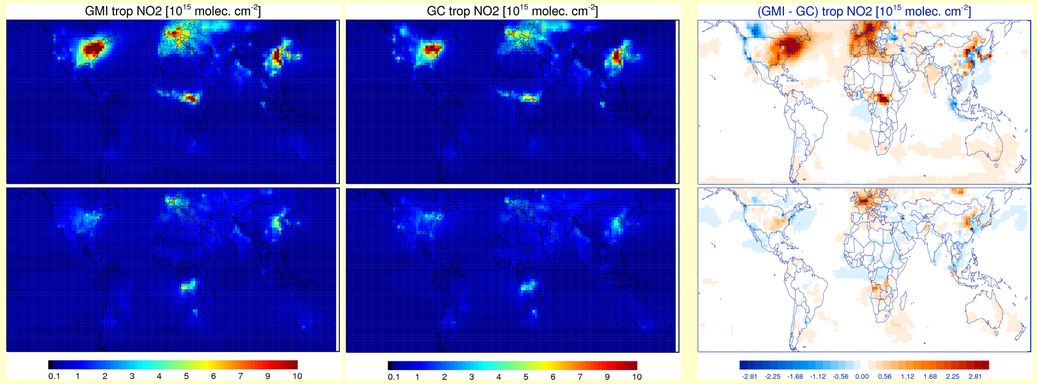
Difference in OMI tropospheric NO_2 retrievals due to emission changes. Tropospheric NO_2 columns were retrieved with GEOS-Chem NO_2 profiles simulated with emissions for the year 2000 and 2005. Use of outdated emission leads to lower columns over China and higher column over the US.

Both the emissions and resolution matter



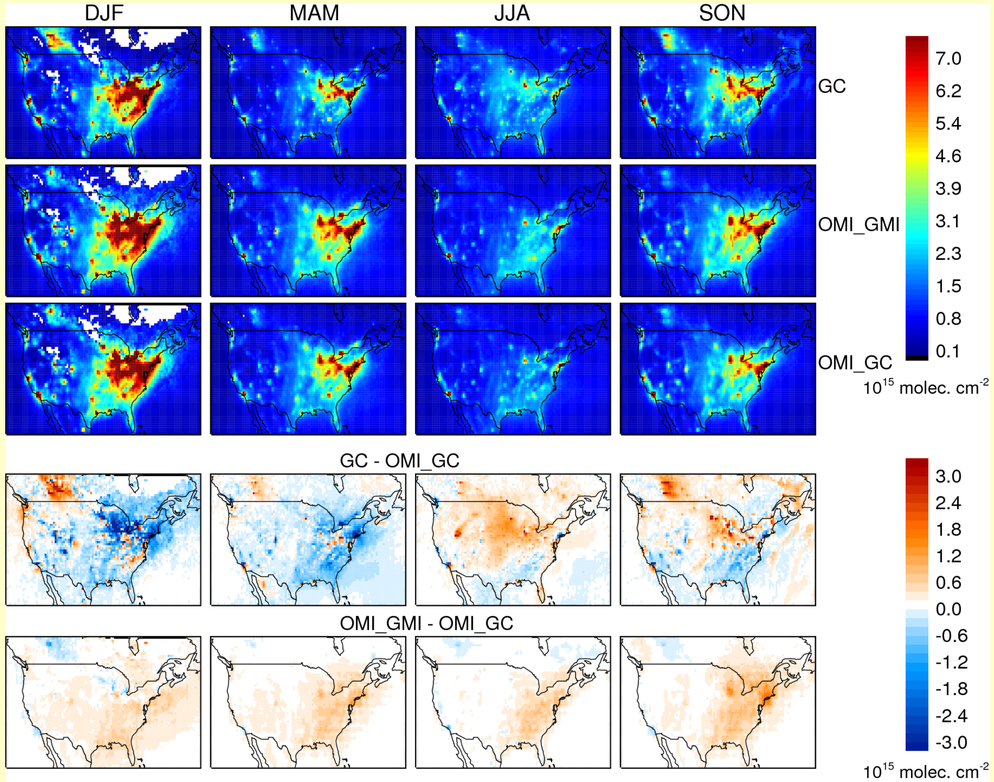
Comparison of NO_2 profile shape from aircraft (red) with those from GMI simulations with old (black) and updated emissions (blue). Models benefit from emission updates, but have difficulties to capture the true profile shape that can lead to errors of up to 15% in AMF.

Models differ in NO_2 simulation



Tropospheric NO_2 columns from (left) GMI and (middle) GEOS-Chem simulations for (top) January and (bottom) July, 2005. The difference between the GMI and GEOS-Chem simulations in the right panel largely reflect the difference in emissions.

Use of scattering weight and NO_2 shape factor to calculate AMF and tropospheric NO_2



The operational OMI NO_2 product makes scattering weights available to users that allow calculation of their own AMF and tropospheric NO_2. Use of improved high-resolution NO_2 profile shapes can eventually reduce the errors due to a-priori profiles.

References:

Bucsela et al. (2013), A new algorithm stratospheric and tropospheric NO_2 retrieval algorithm for nadir-viewing satellite instruments: applications to OMI, AMTD.

Lamsal et al. (2013, in preparation), Evaluation of improved operational standard tropospheric NO_2 retrievals from Ozone Monitoring Instrument using in situ and surface based NO_2 observations.

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