OMI NO$_2$ Product and its Application for Evaluating AQ Models

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Overview

1. Algorithm summary
   a) Slant columns
   b) Stratospheric columns
   c) Tropospheric columns

2. Validation of tropospheric NO$_2$
   a) Ground-based MAX-DOAS and Pandora
   b) In situ aircraft
   c) In situ surface measurements

3. Model-satellite comparison
Slant column NO$_2$ by radiance fitting using DOAS

$I_o$ (solar) + $I_B$

405-465 nm

NO$_2$

Viewing geometry

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Retrieval of stratospheric and tropospheric NO$_2$

- Viewing and solar angles
- Cloud
  - Reflectivity
  - NO$_2$ profile shapes, temperature
  - Topography

**Step I**
- AMF computation
  - $A_{strat}$

**Step II**
- Destriping

**Step III**
- Stratospheric NO$_2$

**Step IV**
- Tropospheric NO$_2$

- Level 3
  - Gridded
  - Cloud fraction < 0.2
Errors in tropospheric NO\textsubscript{2} retrievals

- Slant column
- Tropospheric NO\textsubscript{2} product
- Stratospheric NO\textsubscript{2}

AMF

- Albedo
- Profile shape
- Cloud fraction
- Cloud pressure
- Surface pressure
- Aerosols

Total retrieval error

- \( \sim 30\% \) clear sky
- \( > 50\% \) cloudy

- Slant column: \( \sim 0.5 \times 10^{15} \) molec cm\textsuperscript{-2}
- Stratospheric NO\textsubscript{2}: \( \sim 0.2 \times 10^{15} \) molec cm\textsuperscript{-2}
Validation of tropospheric NO$_2$ retrievals is a challenge

Variable sources, short lifetime, and large spatial gradient makes NO$_2$ validation difficult.

Suitable validation datasets are limited

- **In situ aircraft**: Excellent, but expensive, few, extrapolation problem
- **MAX-DOAS**: Promising, but few
- **Pandora**: Valuable, but it is point measurement and provides total column. Dense network and long-term data helpful.
- **In-situ surface measurements and bottom-up emissions**: Great information, but difficult to compare with satellite columns
- **NO$_2$ lidar and balloon sonde**: Promising, but evolving
Validation results: Comparison with Pandora measurements

- Data period: 2010-2012
- Agreement better in winter and fall
- Difference likely due to:
  - Local sources
  - Inconsistent treatment of temperature effect in NO₂ cross-section
  - Pandora has largest uncertainty in summer due to absolute calibration errors
Validation results: Comparison with aircraft measurements

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- Fairhill, Aldino, Padonia, Beltsville agree within 15%.
- Edgewood and Essex: location not great for comparison.
Validation results: Comparison with MAX-DOAS and in-situ OMI with MAX-DOAS

Japan

Hedo
Tsukuba

OMI with in-situ surface NO₂

GA, USA
Comparison between model simulation and OMI retrievals

Comparison 1:

\[ \text{Model as is} \quad V_{\text{Model}} \quad \text{vs} \quad V_{\text{OMI}} \]

Comparison 2:

\[ \text{Model as is} \quad V_{\text{Model}} \quad \text{vs} \quad V_{\text{OMI}} \]

\[ \text{OMI retrieval, using model AMF} \]

\[ \text{AMF}_{\text{Model}}^{\text{trop}} = \frac{\sum W_i \times P_i^{\text{Model}}}{\sum P_i^{\text{Model}}} \]

\[ V_{\text{OMI}} = \frac{S_{\text{trop}}}{\text{AMF}_{\text{Model}}^{\text{trop}}} \]

\[ \text{polluted NO2 profile shape factor} \]

\[ 440 \text{ nm} \]

\[ \text{nadir surf alb} = 0.05 \quad \text{sza} = 42 \text{ deg} \]
Comparison between model simulation and OMI retrievals

Comparison 2

Due to profile shapes only
A-priori NO\textsubscript{2} profiles and OMI NO\textsubscript{2} retrievals

Aircraft – P3B (DISCOVER-AQ)

GMI simulation
OMI NO$_2$ changes in

North America

East Asia