Assessment of NO₂ Observations during DISCOVER-AQ and KORUS-AQ Field Campaigns

Sungyeon Choi^{1,2}, Lok Lamsal^{3,2}, Nickolay Krotkov², Joanna Joiner², Sergey Marchenko^{1,2}, Christoph Loughner⁴, Jay Herman^{5,2}, Ron Cohen⁶, Andrew Weinheimer⁷, and US OMI Core Team Members

¹Science Systems and Applications, Inc.; ²NASA Goddard Space Flight Center; ³Universities Space Research Association; ⁴Earth System Science Interdisciplinary Center; Univ. of Maryland at College Park; ⁵Joint Center for Earth systems Technology, Univ. of Maryland at Baltimore County; ⁶National Center for Atmospheric Research; ⁷Univ. of California at Berkeley

> 1st October 2018 GEMS Science Team Meeting

NO₂ Activities at NASA Goddard

- OMI NO₂ standard product (Aura/ACMAP-16, PI: Krotkov)
 - Release of Version 3.0 and 3.1
 - Ongoing works and future plans (next version)
- Operational SO₂ and NO₂ products from OMPS-NM (TASNPP-17, PI: Li)
 - Adapting OMI NO₂ algorithm in the UV (OMPS-NM and JPSS instruments)
- Development of long-term NO₂ record (MEaSUREs-17, PI: Lamsal)
 - NO₂ products from past and current UV-Vis instruments
- Assessment (intercomparison, validation) and interpretation (e.g., emission estimates) of satellite NO₂ observations
- Surface NO₂ from satellite measurements (Aura/ACMAP-16, PI: Lamsal)

Status of NASA OMI NO₂ Standard Product

- NASA team released a new version of NO₂ Standard Product (OMNO2 V3.0) in 2016 [Krotkov et al., AMT, 2017]:
 - New algorithm for slant column retrievals [Marchenko et al., JGR , 2015];
 - Higher-resolution (1° x 1.25°) GMI monthly a priori NO₂ profiles with year specific emissions.
- Released OMNO2 V3.1 in July 2018:
 - Minor updates to slant column retrievals, but a major revision to slant column uncertainty calculations;
 - Use of alternative solar data (OML1BIR2) instead of OML1BIRR in V3.0;
 - Use of new cloud products (OMCLDO2 V2) and improved treatment of terrain pressure;
 - OMNO2 V3.1 slant columns are consistent with other European estimates.
- Currently working towards our future version (OMNO2 V4.0):
 - Newly-developed O₂-O₂ cloud product (OMCDO2N);
 - Coupled cloud and NO₂ retrievals that account for surface anisotropy (use of MODIS BRDF).

NO₂ Observations during Field Campaigns



- DISCOVER-AQ & KORUS-AQ:
 - Five near monthly field deployments (Maryland, Texas, California, Colorado, and South Korea, 2011-2016)
- Various NO₂ measurements
 - Ground monitor (surface concentration)
 - Pandora (total column)
 - Two types of airborne instruments: NCAR (photolytic converter), Berkley (LIF) for vertical profile
- Aircraft (P3B) spiral (~4 km)
 - NCAR (~10% uncertainty)
 - TD-LIF (~10% uncertainty)

NO₂ Observations during Field Campaigns



- DISCOVER-AQ & KORUS-AQ:
 - Five near monthly field deployments (Maryland, Texas, California, Colorado, and South Korea, 2011-2016)
- Various NO₂ measurements
 - Ground monitor (surface concentration)
 - Pandora (total column)
 - Two types of airborne instruments: NCAR (photolytic converter), Berkley (LIF) for vertical profile
- Aircraft (P3B) spiral (~4 km)
 - NCAR (~10% uncertainty)
 - TD-LIF (~10% uncertainty)

- 1. How do these measurements compare?
- 2. What is the best way to make comparisons of space- and ground-based measurements?

Constructing "In-situ/airborne" Trop. NO2 VCD

- NO₂ profiles from aircraft measurements are integrated to obtain trop. Column (VCD_{Trop})
 - NO₂ VMR from ground-based surface monitors
 - Airborne in-situ NO₂ VMR from individual spirals
 - Daily composite median profiles for mid-troposphere
 - GMI model profiles for upper troposphere
- OMI NO₂ Standard Product (SP) is adjusted by tropospheric AMF calculated using in-situ NO₂ profiles



Flight track, colored by TD-LIF NO2 VMR (http://cohen.cchem.berkeley.edu/)

Comparison of NCAR, LIF, and Pandora NO₂ columns



Comparison of OMNO2 and In-situ VCD_{Trop}



Comparison of OMNO2 and In-situ VCD_{Trop}



Site Means: In-situ vs OMNO2



Ongoing Updates to OMNO2

OMNO2 v4.0: Coupled GLER-Cloud-NO2 algorithm

What changed?	V3.1	This work (V4 Beta)
O ₂ -O ₂ fitting algorithm	KNMI (OMCLDO2, V2)	NASA (OMCDO2N)
Cloud fraction & pressure	KNMI (OMCLDO2, V2)	NASA (OMCDO2N)
Terrain reflectivity	Climatological LER for both cloud and NO ₂ retrievals	GLER (MODIS-based) for both cloud and NO ₂ retrievals
Terrain pressure & height	At FOV (pixel) center	Average over FOV (defined by OMI pixel corners)

V4 Beta Improves Agreement with in-situ Meas.



Site Means: OMNO2 v3.1



Site Means: OMNO2 v4 Beta



Summary

- Effects on surface reflectivities (MODIS-BRDF derived GLER) have been accounted in both cloud and NO₂ retrievals from OMI;
- NO₂ columns are obtained from in-situ and ground-based instruments during DISCOVER-AQ and KORUS-AQ campaigns;
 - Agreement between the columns differ among campaigns;
- NO₂ columns from the five field campaigns are compared with OMI data reasonably well;
 - Accurate NO₂ profiles for AMF calculation are necessary;
- New updates lead to better agreement of OMI NO₂ retrievals with NO₂ observations from DISCOVER-AQ campaigns.

Future Plans

- Implementing high-resolution (~0.25°, global GMI-Replay simulation) NO₂ profile shapes;
- Improving retrievals over ice/snow;
- Accounting for aerosol effects in the cloud and NO₂ retrievals;
- Applying similar approach to other UV-Vis satellite instruments and creating consistent long-term NO₂ data record

Acknowledgment

NASA Earth Science Division for funding