An Update on Tropospheric NO$_2$ Trends over the United States Using OMI and GOME-2 Data

Kenneth Pickering, NASA-Goddard
Ana Prados, UMBC/JCET
Robert Pinder, US EPA
Dale Allen, UMD
Edward Celarier, UMBC/GEST
James Gleason, NASA-Goddard
Shobha Kondragunta, NOAA/NESDIS
What has happened to Eastern US NO$_x$ emissions since 2002?

- US EPA mandated power plant NO$_x$ emission reductions under the 1998 NO$_x$ State Implementation Plan Call. Nearly 40% reductions between 2002 and 2005 were documented by Kim et al. (2006) using SCIAMACHY NO$_2$ data.

- Program has evolved into what is now called the “NO$_x$ Budget Trading Program”. Results in further summertime power plant emission reductions over the regulated region (19 eastern states) as a whole, but trading program allows flexibility concerning the magnitude of reduction at specific facilities. Over 2500 large combustion units affected.

- Clean Air Interstate Rule (CAIR) – would have resulted in further reductions (28 states), but rule thrown out by courts; then reinstated; implementation procedures still being decided. Some companies reduced emissions in response to more stringent state rules and court orders.
**Tier II Tailpipe NO$_x$ Emission Standards** – 5% reduction in emissions per year for new vehicles over 2002 to 2010. Increasing Vehicle Miles Traveled largely negated the reductions until 2008. But, most recent national inventory including vehicle emissions is for 2005.

US Monthly Vehicle Miles Traveled
Continuous Emission Monitoring System (CEMS) -- Absolute Changes

July 2008 vs. July 2005

OMI Trop. NO2 -- % change
Extending the Trends Through 2009

Uncertainties on use of OMI Standard Product for trends in 2009:

1) Row anomaly become more significant in January 2009; lesser number of valid samples than in prior years

2) Change in albedo climatology (GOME → OMI) in February 2009

Therefore, Summer 2009 was reprocessed using GOME albedo climatology for use in trend analysis

Extended analysis to include MetOp-A/GOME-2 Trop. NO2 from NOAA/NESDIS:

Slant columns – using Harvard algorithm, but with differences from KNMI minimized as much as possible

Otherwise, all portions of tropospheric NO2 column algorithm are the same as for OMI Standard Product; GOME albedo climatology used.

Morning overpass; 40 x 80 km pixels
July 2009-2008

PA: 0 to -20%
NY → MD: 0 to -20%
IA, MO: +20 to +50%

# of days
July 2009-2005

SD → MO:
+10 to +50%

Chicago:
-40 to -20%

PA:
-10 to +40%

NYC-VA:
-40 to -10%

OH Valley:
-25 to +25%

June – less negative trends

August – more negative trends
For comparing means between years and instruments:
Use statistic called the “standard deviation of the mean” = $\sigma/N^{1/2}$
Too small to be visible on these plots!

CEMS emission trend reversed from 2008 to 2009; OMI agrees only in July; GOME-2 agrees in June & July

OMI PM obs. become closer to GOME-2 AM obs. going from June to August. NO2 loss rate becomes slower.
Generally, steeper decline in OMI NO2 when OMI albedo climo is used.
OMI trends with use of OMI albedo climo are in better agreement with CEMS.

Would GOME-2 trends with OMI albedo climo also be in better agreement with CEMS?
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2005 – 2009 Trends Summary

• Large summertime reductions in NO2 seen over much of eastern US over 2005 to 2008, except in the state of Pennsylvania.

• After reprocessing with consistent surface albedo, some reversals of these trends are seen for 2008 to 2009 (e.g., Penna, Iowa).

• Trends from 2008 to 2009 for regional monthly mean OMI NO2 retrieved using OMI albedos better agree with CEMS than those using GOME albedos.

• Overall 2005 to 2009 summer trends remain strongly negative over much of the Eastern and Central US (with exceptions and with some regions having especially large downward trends).
Trends Summary

• Monthly mean difference between GOME-2 and OMI tropospheric column values decreases from June → August, reflecting slowing of NO$_2$ daytime loss rate.

• Changes in motor vehicle emissions must be a bigger factor for tropospheric NO2 over this region than has been thought.

• Entire OMI NO2 period of record will be reprocessed using a new algorithm and consistent albedo climatology in the next year or so, allowing better trend assessment.

• Loss of data due to row anomaly suggests that for trend analysis we should reprocess prior years using only the same pixel positions that were available for 2009.
The Future for NO$_2$ Air Quality from Space

- **DISCOVER-AQ** -- a NASA Earth Venture - 1 airborne and ground mission to improve understanding of the relationship between column gas and aerosol observations from space and surface air quality (J. Crawford, PI; K. Pickering, Project Scientist)
  Focus is on NO$_2$, O$_3$, and aerosols. Series of four field experiments. In-situ profiling, airborne remote sensing, surface-based remote sensing, surface in-situ air quality

- **GEO-CAPE** -- NRC Decadal Survey Tier II mission – geostationary observations of trace gases and aerosols over North America. Hourly measurements at 4-km resolution.
  NO2, O3, HCHO, SO2, CO, aerosol
  Will lead to better understanding of emissions, transport and chemistry