Relationships and Trends among Satellite NO$_2$ Columns, NO$_x$ Emissions, and Air Quality in North America

Tiger Team Update

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“Any oil and gas out there?”
OMI: several retrievals to be used (DOMINO v2.0, NASA level-2 from Lamsal...)

Model: CMAQ 2010 AQAST TT, WRF-Chem SEAC4RS...

Year: probably 2010 and maybe one earlier year before row anomaly problem
Background: Quantifying source contributions to trends and variability in NO$_2$ columns: Multi-year (2004-2012) simulations (2°x 2.5°)

GEOS-Chem MERRA winds; v9_02; lightning from NLDN

Sensitivity simulations include:
- N. Amer. Background (zero N. Amer Anthr. Emis.)
- U.S. Background
- Zero soil NO$_x$
- Zero lightning NO$_x$

Some archived fields:
- NO$_2$ columns at 10:00 and 13:30
- Hourly surface NO$_2$
- Boundary conditions for regional models

→ Exploit unique signatures of variability (anomalies) associated with different sources to interpret and attribute trends in NO$_2$ columns to specific sources

L. Murray, A. Fiore, LDEO/Columbia

→ More info? Lee Murray’s poster
Cities: We are studying 40 U.S. cities/city clusters in detail (see next talk by Zifeng Lu)
Soils: Implementation of Berkeley-Dalhousie soil NO\textsubscript{x} scheme  
(Dan Cohan from AQAST 6 presentation on DYNAMO)

- Implemented in CMAQ with inline biogenics
- Compared to Yienger & Levy (1995)
- Next step: Compare with satellite & other data

August Average Soil NO Difference  
BDSNP-YL95

August Average Ozone Difference  
BDSNP –YL95
Power Plants: NO$_x$ emissions and lifetimes from large point sources
(Benjamin de Foy, Saint Louis University)

Isolated Power Plants with CEMS data (Duncan et al., AE 2013)

Estimates of Emissions and Chemical Lifetimes using the Exponentially-Modified Gaussian Method (Beirle et al., Science 20011)

EMG Emissions follow x=y line with some exceptions

EMG Lifetimes are very short (<2 hours) for most sites
Shown here: January 2007 OMI NO₂ (top right) versus CMAQ w/ WIFE + LADCO non-freight (center right) and CMAQ w/ all LADCO emissions (lower right).

In western areas, WIFE shows higher spatial correlations against OMI in both July and January.

Benefits of WIFE increase at smaller sub-domains with freight corridors.

Overall biases and errors are mixed, with LADCO performing better in January and WIFE better in July.
**Trends**: Changes in seasonal amplitude (Duncan, Lamsal...)

Test for a $5^\circ \times 5^\circ$ box in the Eastern U.S. (around NC). There is a clear trend in the seasonal amplitude that has to be accounted for when calculating the NO$_2$ trend.
For the same 5° × 5° box in the Eastern U.S. (around NC), various factors (seasonal variation, changes in seasonal amplitude, and linear trend) are extracted in order to be able to estimate an accurate NO$_2$ trend. The residual is indicative of how well those factors are taken out. The method needs minor refinement.
Trends: Resulting NO₂ trend: 2005-2008 vs 2010-2013

Calculation is for $1/2^\circ \times 2/3^\circ$ boxes. Gray areas show where the trend is not significant at 95% confidence.
Primary thrust for Summer 2014

Complete OMI processing and model runs for the entire U.S. and sort the NO$_2$ columns into source-dominant categories; then begin to compare NO$_2$ column amounts in each category with source-based emission estimates.