Global Dry Deposition of Nitrogen Dioxide Inferred from Space-Based Measurements

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NO$_2$ Dry Deposition Flux

- NO$_2$ contributes nitrogen to soil and vegetation through dry deposition
- Impacts of nitrogen deposition
  - Eutrophication and loss of biodiversity
  - Acidification
  - Perturbation of carbon sequestration (e.g. Reay et al., 2008)
- Deposited NO$_2$ is a source of HONO
1. Directly (eddy covariance techniques etc.)
2. Inferential modeling

\[ F = - V_d \times C \]

- Usually concentrations come from *in situ* measurements at finite number of sites
- BUT, we can also get \( \text{NO}_2 \) surface concentrations from satellites (Lamsal et al., 2008)
Satellite Observations: OMI

- Ozone Monitoring Instrument on Aura satellite
- Measuring several trace gases using backscattered UV-visible spectra since 2004
- Resolution $13 \times 24 \text{ km}^2$ at nadir
- Satellites can provide global coverage
  - Data in regions with no *in situ* measurements
  - No need to interpolate to get continental deposition
OMI NO$_2$ Tropospheric Columns
2005 - 2007

(a)

NO$_2$ Vertical Columns [10$^{15}$ molecules cm$^{-2}$]
GEOS-Chem Global Chemical Transport Model

- Used to:
  - Calculate air mass factors for retrieval
  - Infer surface concentrations from measurements
  - Calculate deposition velocities at 0.1° × 0.1°
OMI Global NO$_2$ Dry Deposition at 0.1°×0.1°

- Annual regional budgets
  - USA 0.18 Tg N
  - Europe 0.20 Tg N
  - China 0.18 Tg N
  - Global 1.50 Tg N
Comparisons with Surface Data

- Challenges: differences in scale, biases in \textit{in situ} data, local traffic, NO\textsubscript{x} soil fluxes ....

\begin{itemize}
  \item OMI
  \item NitroEurope (Flechard et al., 2011)
\end{itemize}
Mean 9 – 35% of NO\textsubscript{y} dry deposition in urban areas is from NO\textsubscript{2}

Peak values of 85%
The Future

- $\text{SO}_2$ (done!), $\text{NH}_3$
- TROPOMI (2015)
- Geostationary instruments (2018+)
  - $\sim 4.5 \times 8 \text{ km}^2$
  - hourly
  - TEMPO (N. America)
  - Sentinel-4 (Europe)
  - GEMS (Asia)