Effects of model resolution and meteorology on NO$_2$ plumes observed from OMI

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A.R. Russell, et al.,
*Space-based Constraints on Spatial and Temporal Patterns of NOx Emissions in California, 2005-2008*

R.C. Hudman, et al.

*Interannual variation in soil NOx emissions observed from Space*

ACP D 10, 13029-13053, 2010. ACP, in press
L.C. Valin, et al. Observation of slant column NO2 using the super-zoom mode of AURA OMI, submitted to AMTD September 2010
A. Mebust, et al.

Improved parameterization of wildfire NO\textsubscript{x} emissions using MODIS fire radiative power and OMI tropospheric NO\textsubscript{2} columns

Manuscript in prep, see poster
See also posters

Ashley Russell
Retrievals and Validation

Luke Valin
Day-of-week effects and VOC effects on NO$_2$ columns
Can we learn about OH from space based measurements of NO$_2$

Luke Valin’s work

Ronald C. Cohen
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Columns and Mixing ratio

$1 \times 10^{15} \sim 400\text{ppt}, 1 \text{ km PBL}$

$1 \times 10^{16} \sim 4 \text{ ppb}, 1 \text{ km PBL}$
WRF 1km – Power Plant Plume

NO$_2$ column

OH Column
high winds
low NO₂
high OH

low winds
high NO₂
low OH
Four Corners Power Plant

Emissions (CEMS)
Low (50-75%)  High (75-100%)

High Winds

Low Winds
Effects of model spatial resolution on coupling of NO$_2$ mixing ratio, OH and therefore feedback on the NO$_2$ lifetime
A plume in 1-d

A point source advected by constant winds at constant noon and constant VOC
Effects of Spatial resolution of a model

\[ E_{\text{NO}_2} = 7.8 \times 10^4 \text{ mole hr}^{-1} \]

\[ E_{\text{NO}_2} = 7.8 \times 10^3 \text{ mole hr}^{-1} \]

\[ E_{\text{NO}_2} = 7.8 \times 10^2 \text{ mole hr}^{-1} \]
A point source in 2-d
Conserved Tracer

\[ \log_{10} VCD_{\text{NO}_2} \text{ (molecules cm}^{-2}\text{)} \]

a) 2 x 2 km\(^2\)

b) OH = f(NO2) - fig. 8

\[ \log_{10} VCD_{\text{NO}_2} \text{ (molecules cm}^{-2}\text{)} \]

c) 12 x 12 km\(^2\)

d) 288 km

e) 48 x 48 km\(^2\)

f) 288 km
Black Constant OH $5 \times 10^6 / \text{cm}^3$
Application in 3-d: WRF-CHEM

4km met emissions at different resolutions compare NO$_2$ column

Gray biases of more than +25%
Black biases more than -25%
4 and 12 km

48 and 192 km
4 and 12 km

48 and 192 km
Conclusions

Deriving OH from the shape of NO$_2$ plumes is promising

We have many pieces of information:

- variation with day of week
- variation with met (wind speed, pbl height)
- trends over multiple years
- variation with time of day

But we have more to learn before we know how to use all of these pieces of information.
Thank you!
Steady state OH decreases with increasing VOC.
\[ \tau_{\text{NO}_x} = 5.4 \text{ hrs} \]

\[ \lbrack \text{OH} \rbrack_{\text{eff}} = 8.5 \times 10^6 \text{ cm}^{-3} \]

High Winds

\[ \tau_{\text{NO}_x} = 4.1 \text{ hrs} \]

\[ \lbrack \text{OH} \rbrack_{\text{eff}} = 6.0 \times 10^6 \text{ cm}^{-3} \]

Low Winds

\[ \tau_{\text{NO}_x} = 5.8 \text{ hrs} \]

\[ \lbrack \text{OH} \rbrack_{\text{eff}} = 6.4 \times 10^6 \text{ cm}^{-3} \]
\[ \tau_{NOx} = 3.7 \text{ hrs} \]
\[ [OH]_{eff} = 9.4 \times 10^6 \text{ cm}^{-3} \]

\[ \tau_{NOx} = 5.8 \text{ hrs} \]
\[ [OH]_{eff} = 6.0 \times 10^6 \text{ cm}^{-3} \]
In a power plant plume:

1) Initially mixing increases NO$_2$ (as viewed from space) because there is insufficient O$_3$ to convert all of ppm levels of NO to NO$_2$

2) Then mixing reduces the local concentration of NO and NO$_2$ (expanding the volume that is at high NO$_2$) and enhances OH
This OH effect is not linear—so an average NO\textsubscript{2} will not necessarily represent typical behavior—since the distribution of NO\textsubscript{2} columns is likely not Gaussian.