Effects of model resolution and meteorology on NO_2 plumes observed from OMI

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

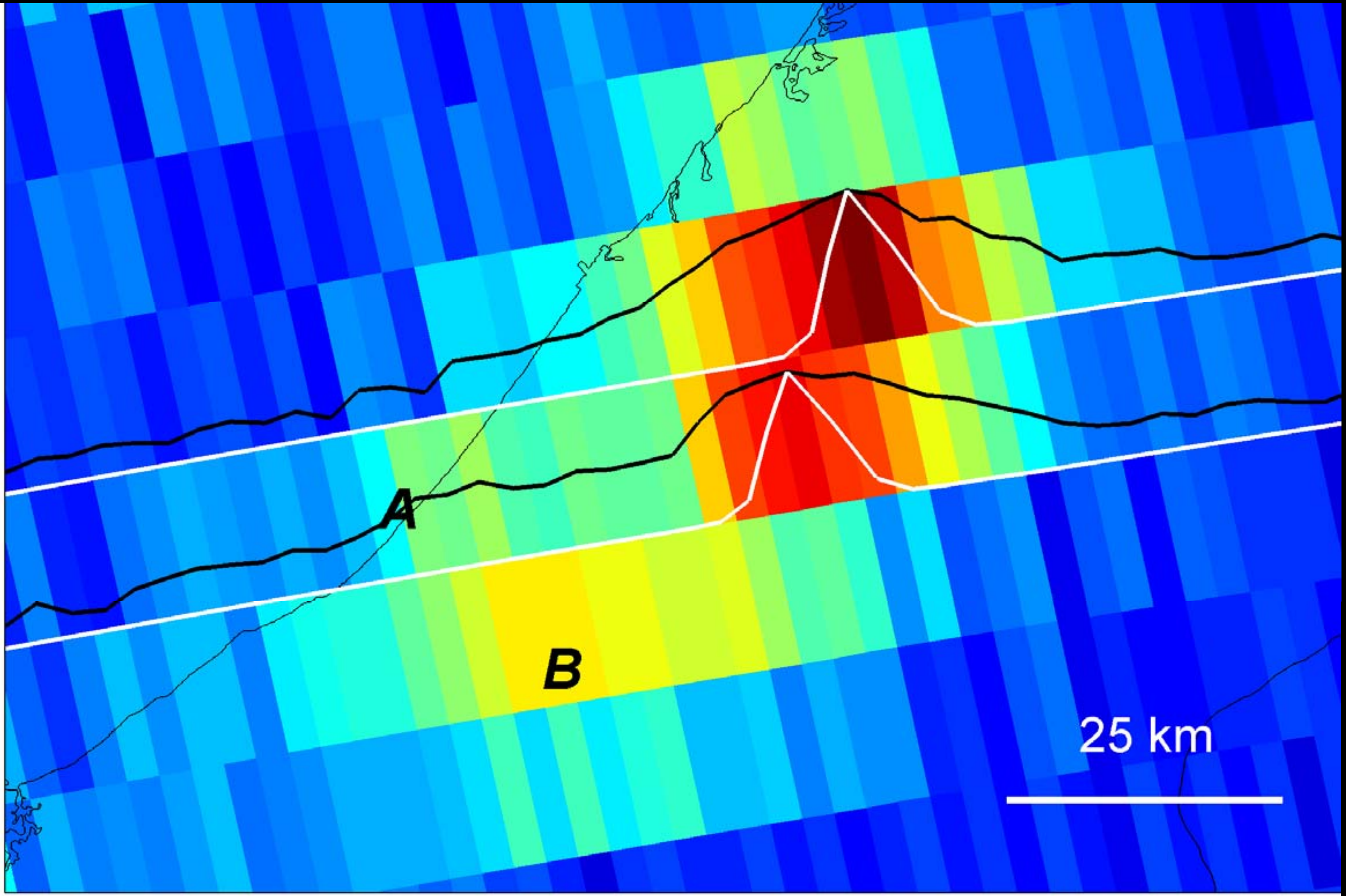
Env. Sci. & Tech. **44**, 3608-3615, 2010.

R.C. Hudman, et al.

Interannual variation in soil NOx emissions observed from Space

ACPD 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_x emissions using MODIS fire radiative power and OMI tropospheric NO_2 columns

Manuscript in prep, see poster

See also posters

Ashley Russell

Retrievals and Validation

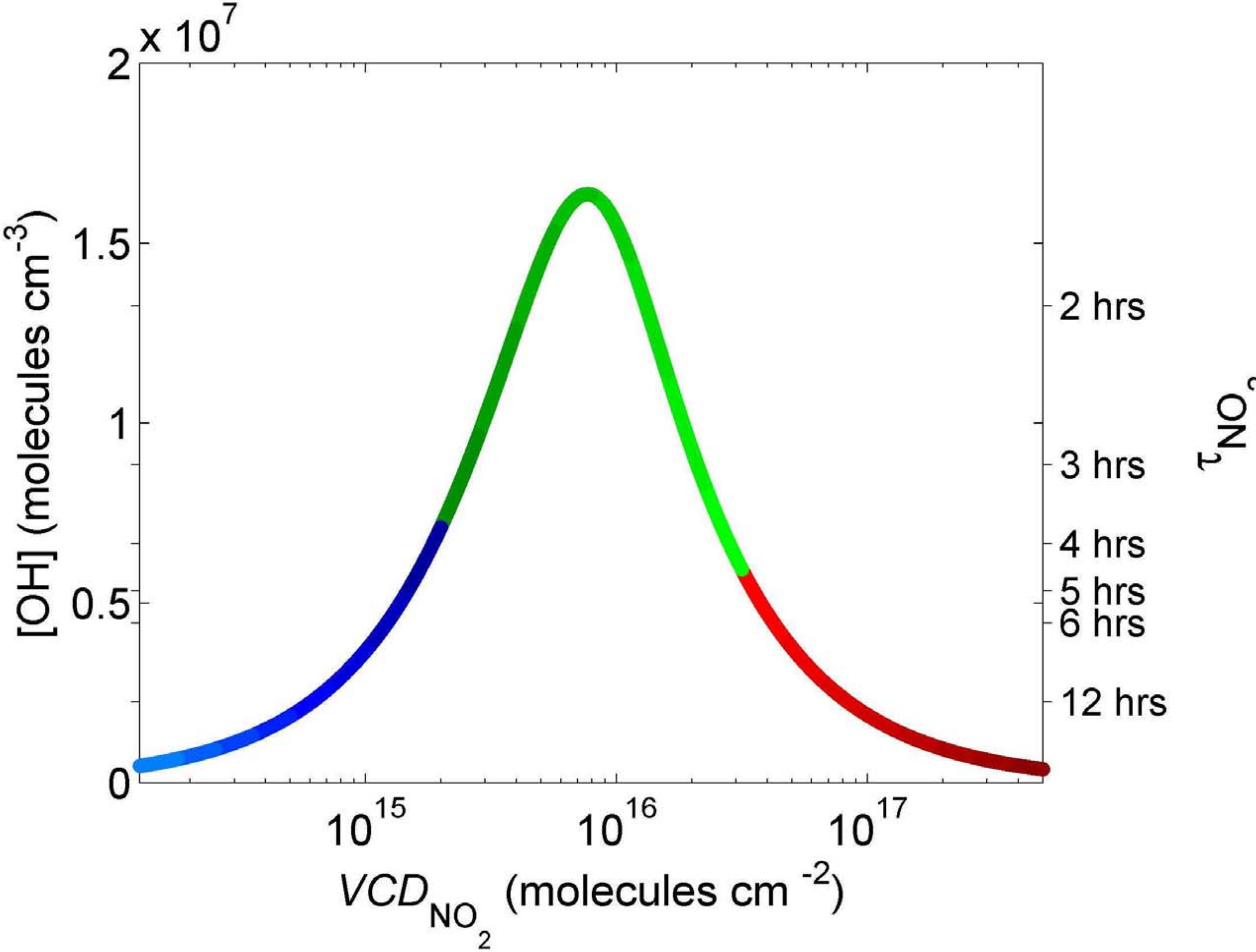
Luke Valin

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
University of California, Berkeley

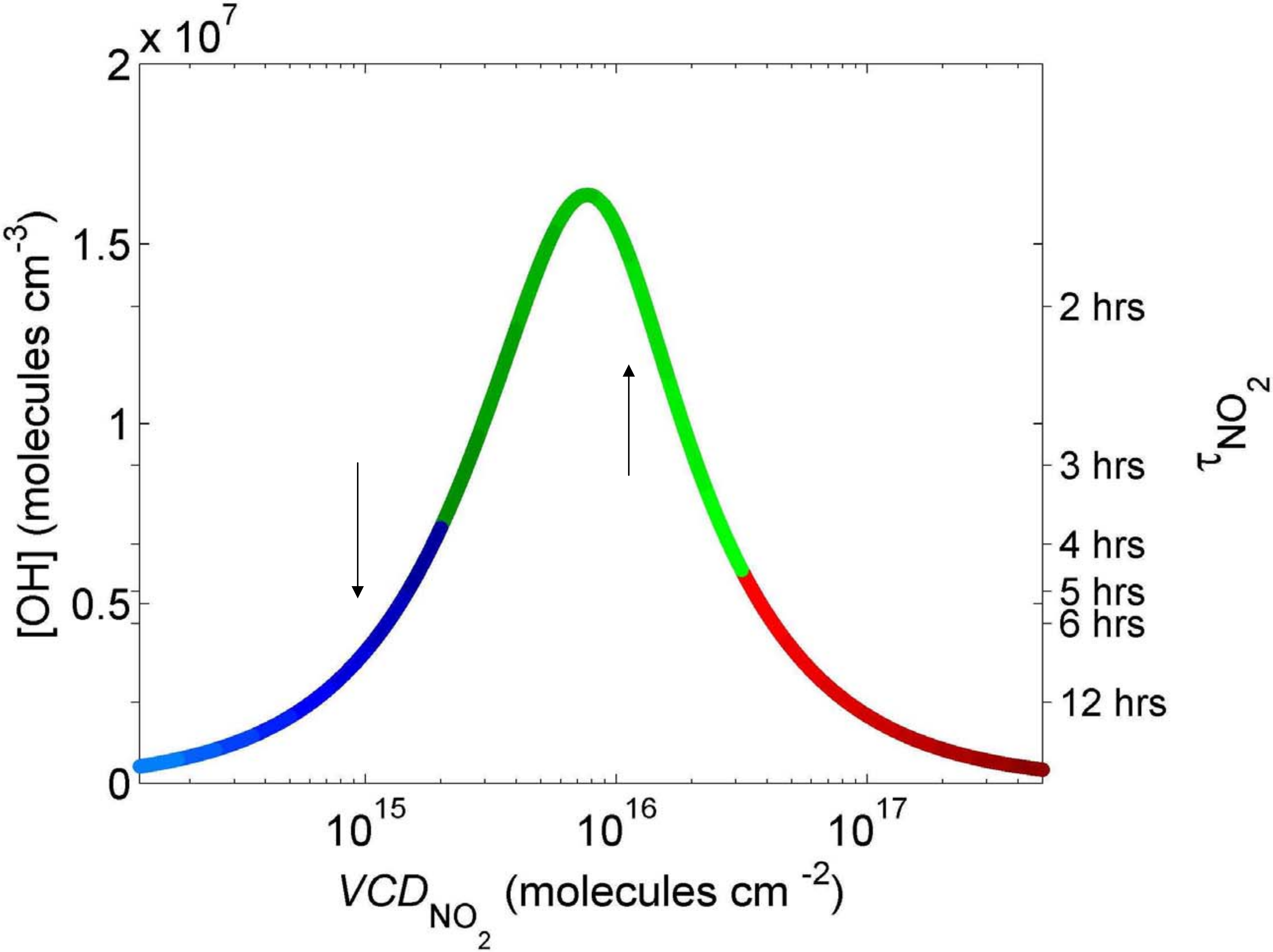


x 10^7
2
1.5
1
0.5
0
[OH] (molecules cm^-3)
2 hrs
3 hrs
4 hrs
5 hrs
6 hrs
12 hrs
τ_NO2
10^15
10^16
10^17
VCD_NO2 (molecules cm^-2)

Columns and Mixing ratio

1×10^{15} ~ 400ppt, 1 km PBL

1×10^{16} ~ 4 ppb, 1 km PBL



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2 hrs
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4 hrs
5 hrs
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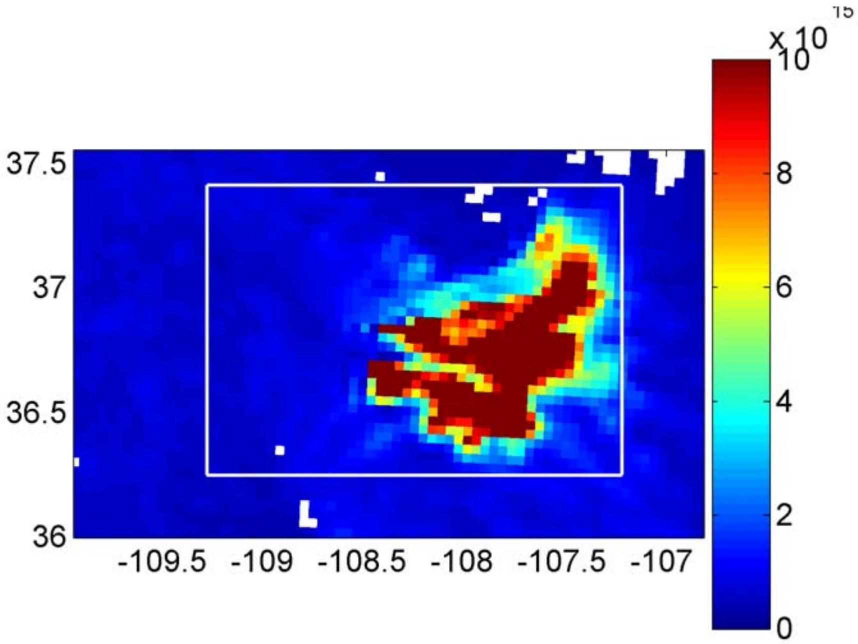
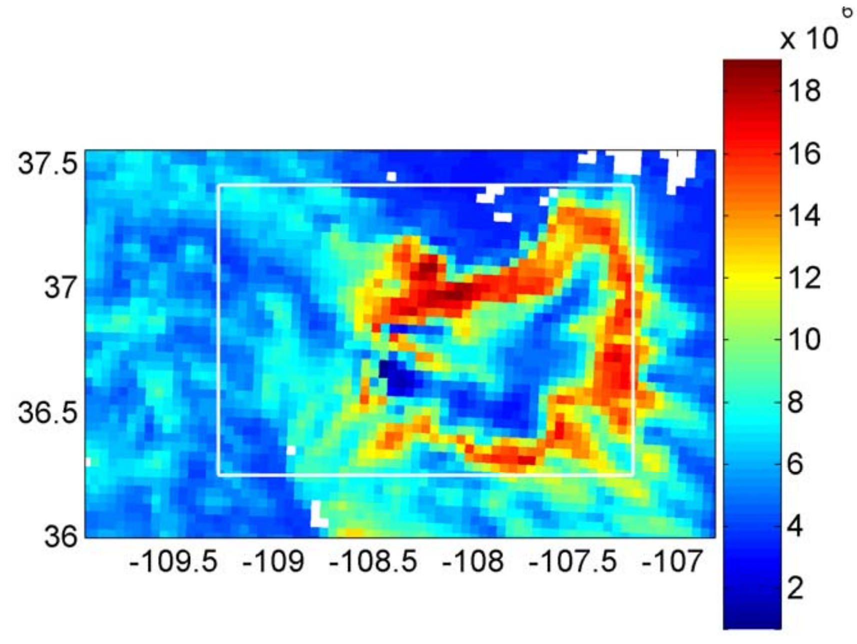
12 hrs
τ_NO2

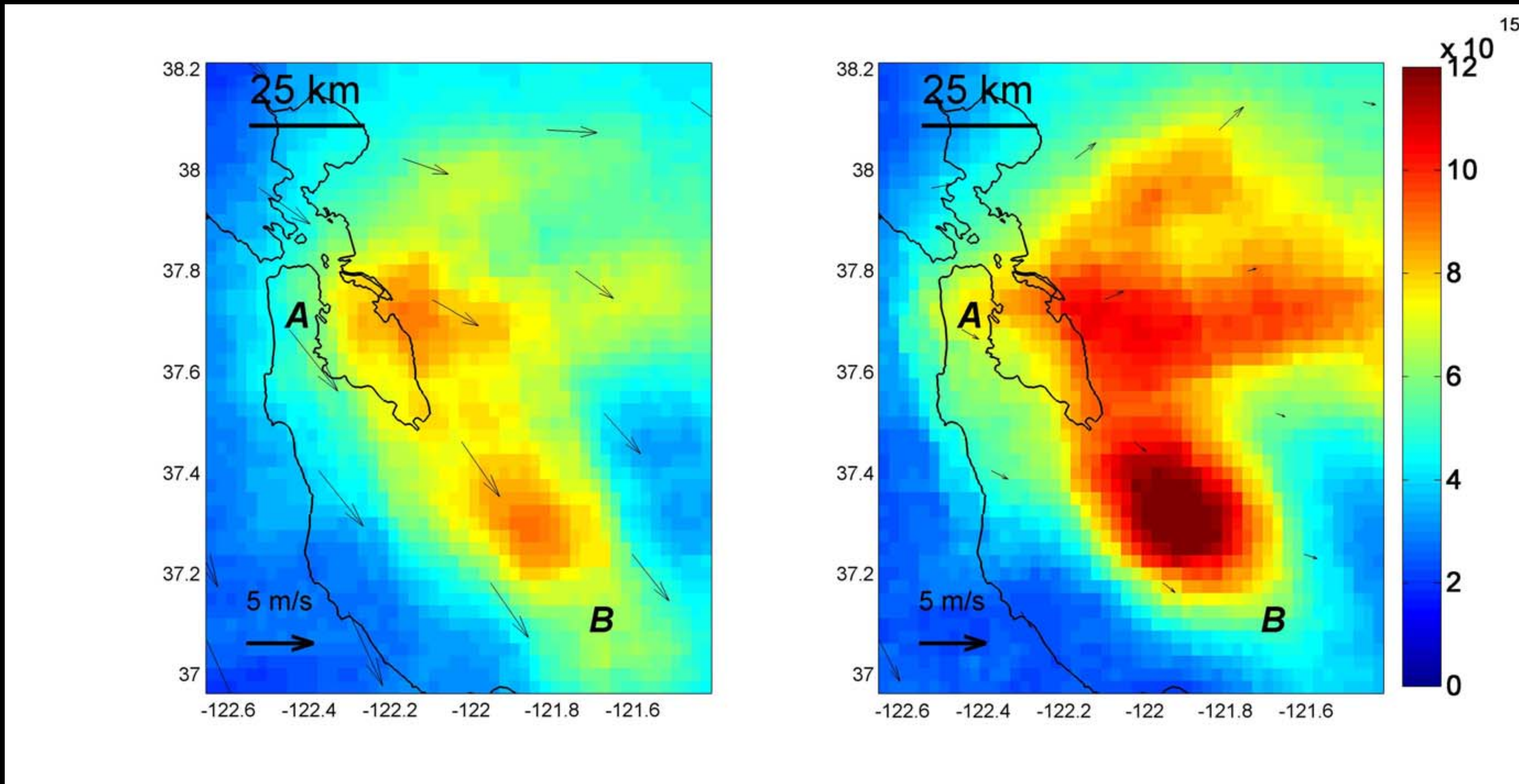
WRF 1km – Power Plant Plume





NO_2 column

OH Colum



high winds
low NO_2

high OH

low winds
high NO_2

low OH

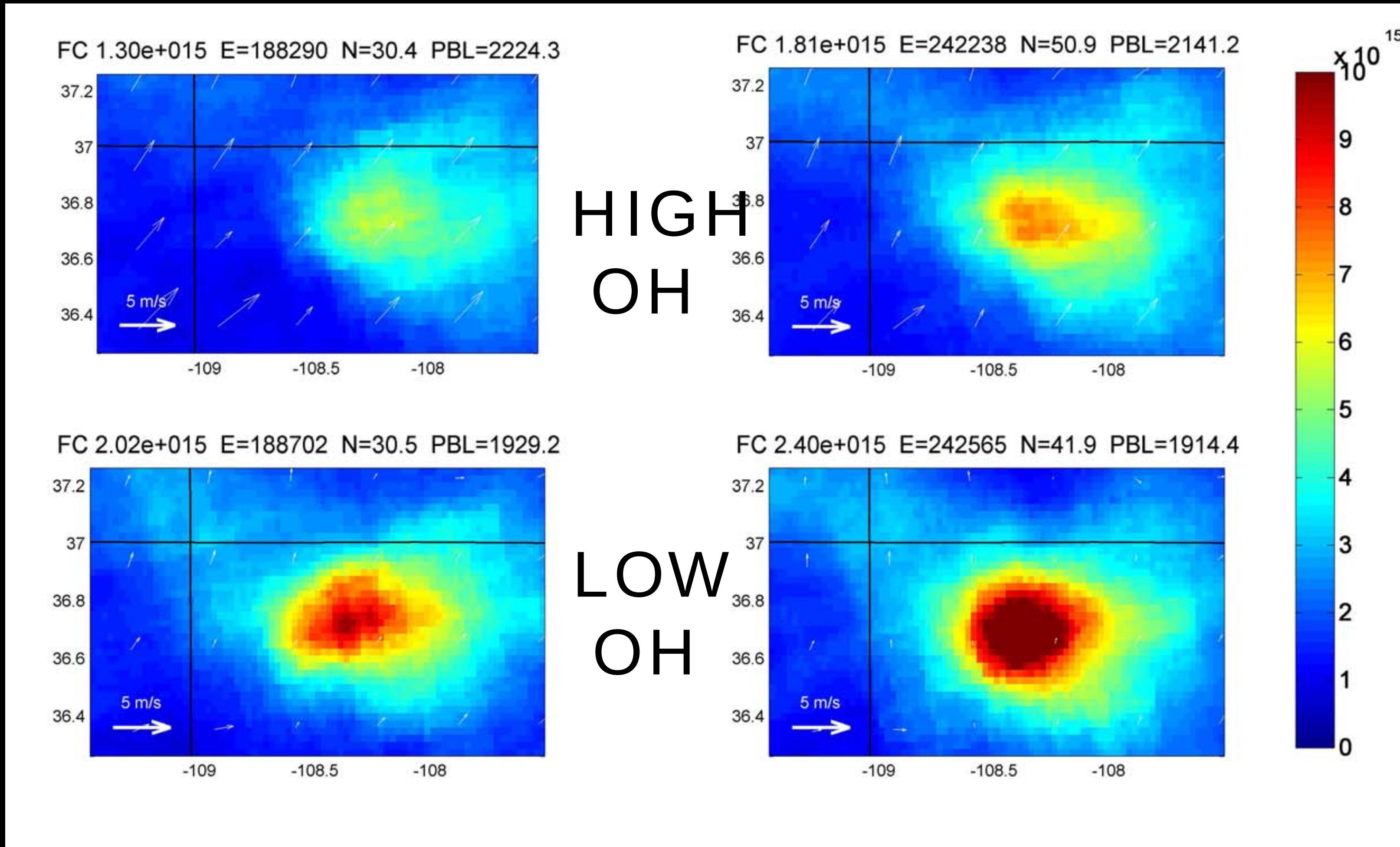
Four Corners Power Plant

Emissions (CEMS)

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

High Winds

Low Winds

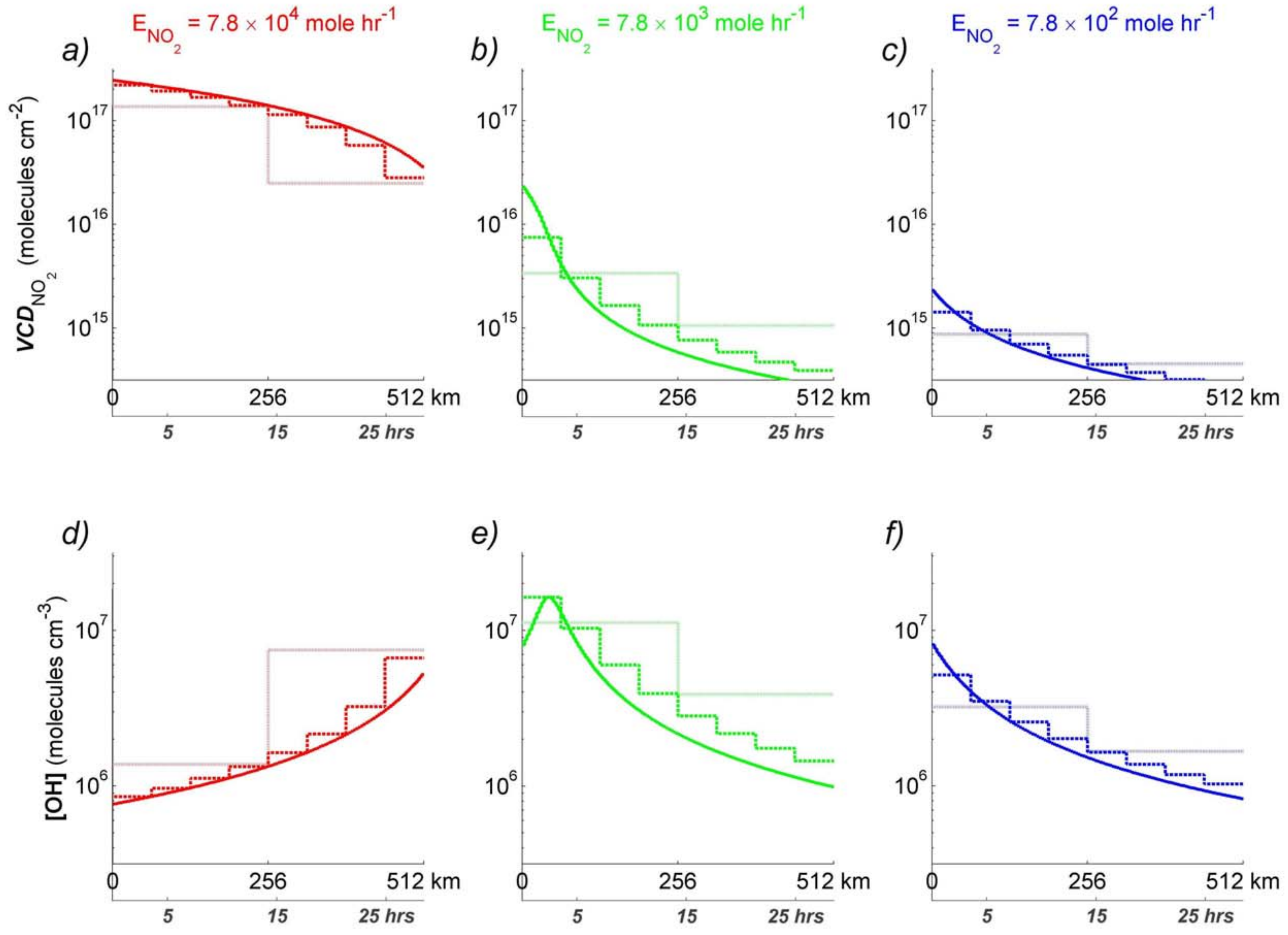


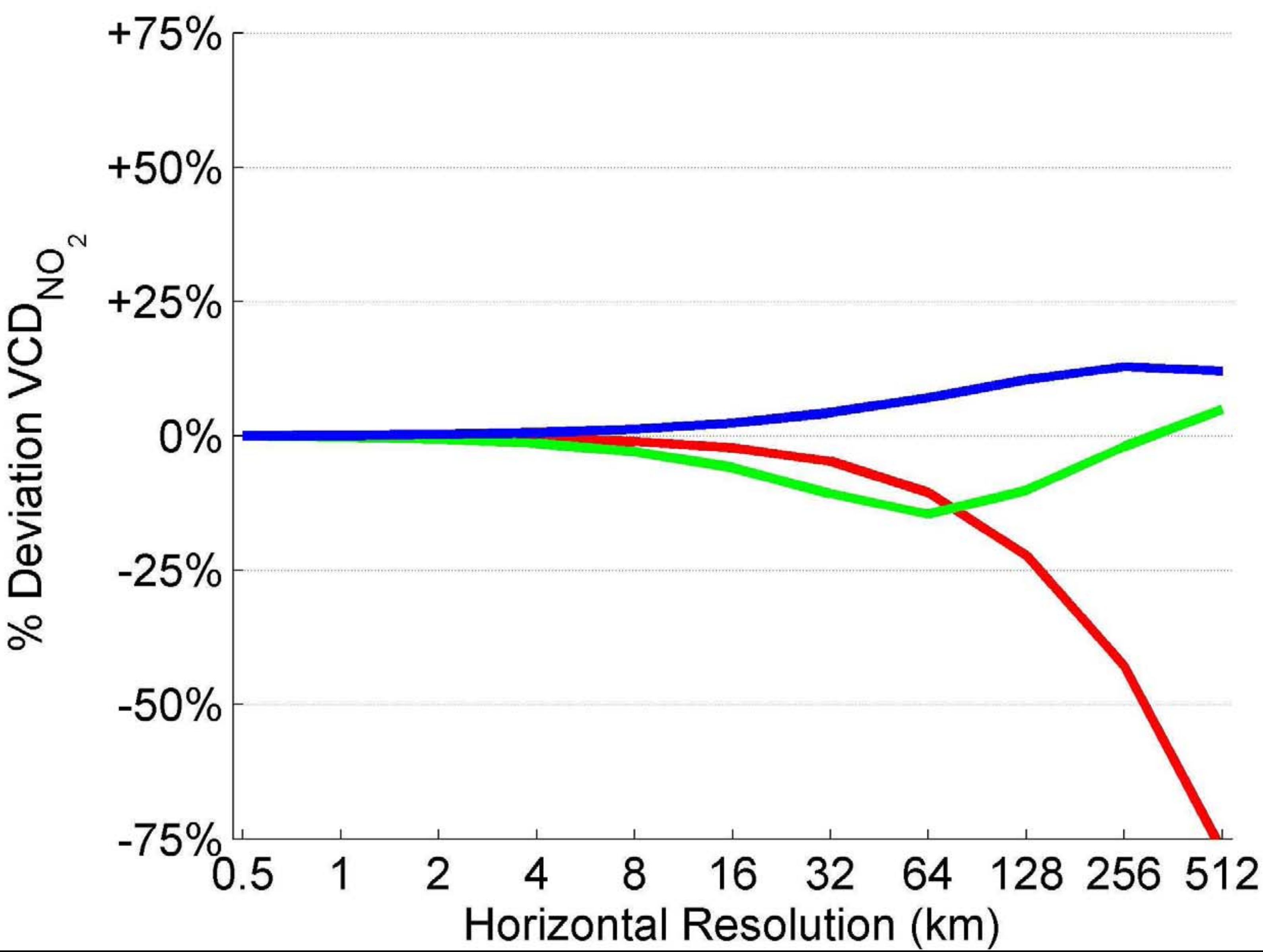
Effects of model spatial resolution on coupling of NO_2 mixing ratio, OH and therefore feedback on the NO_2 lifetime

A plume in 1-d

A point source advected by constant winds at constant noon and constant VOC

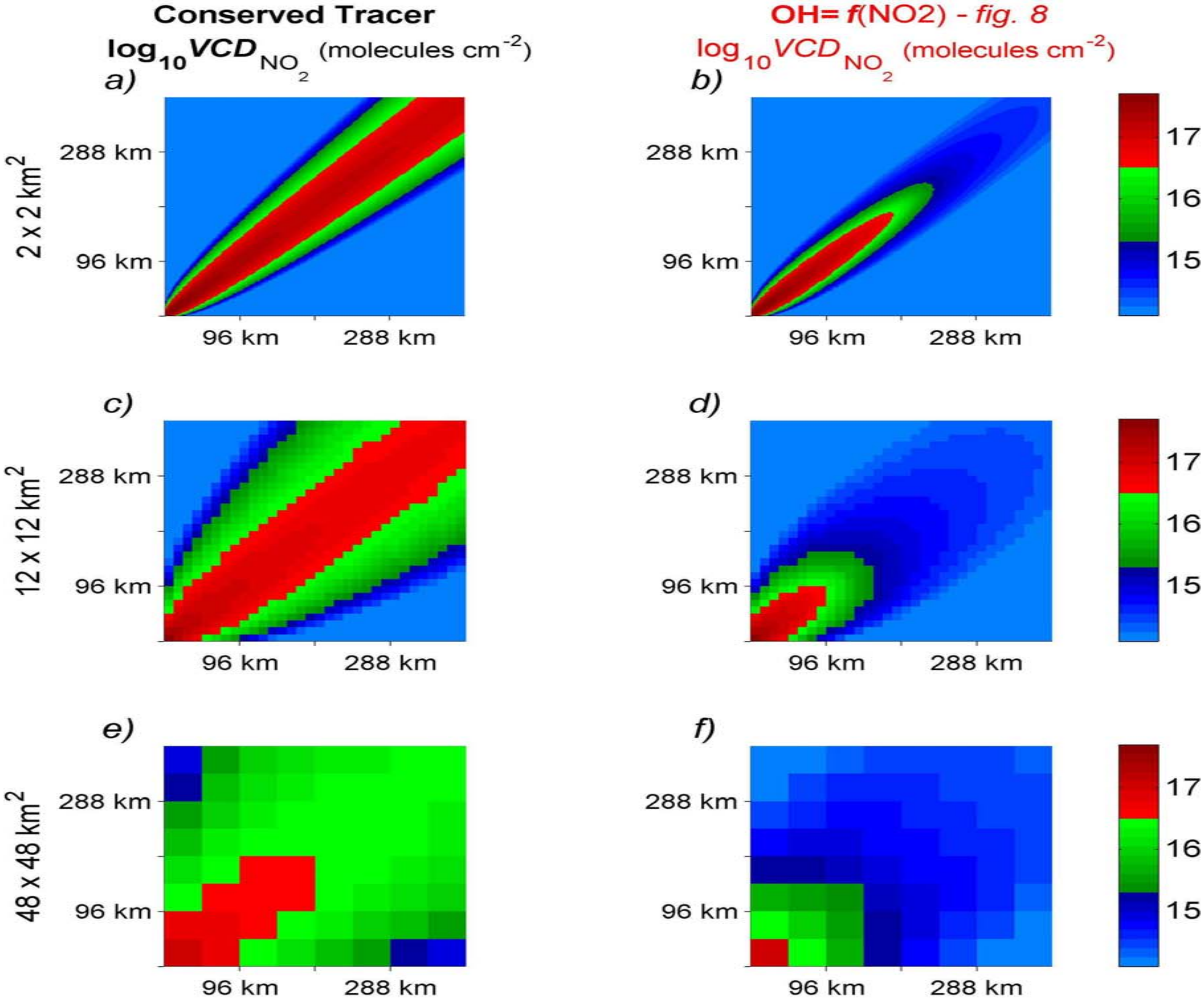
Effects of Spatial resolution of a model



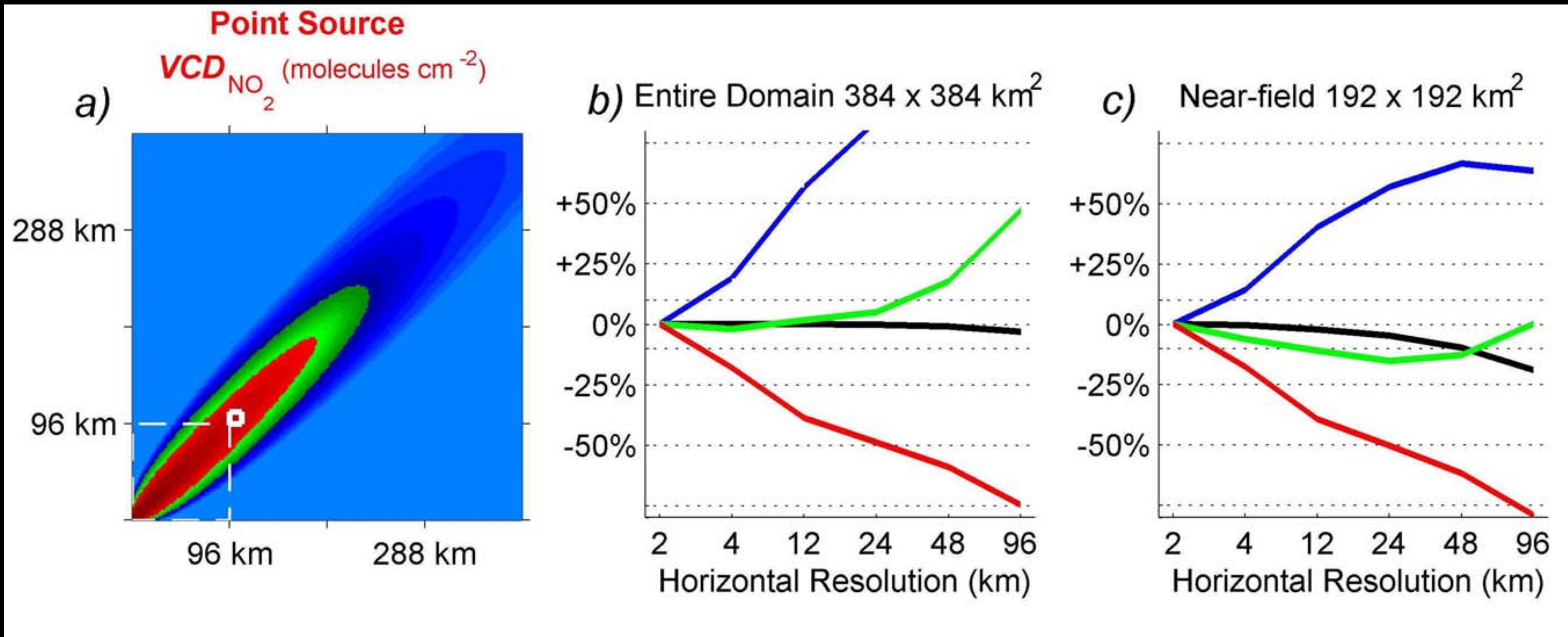


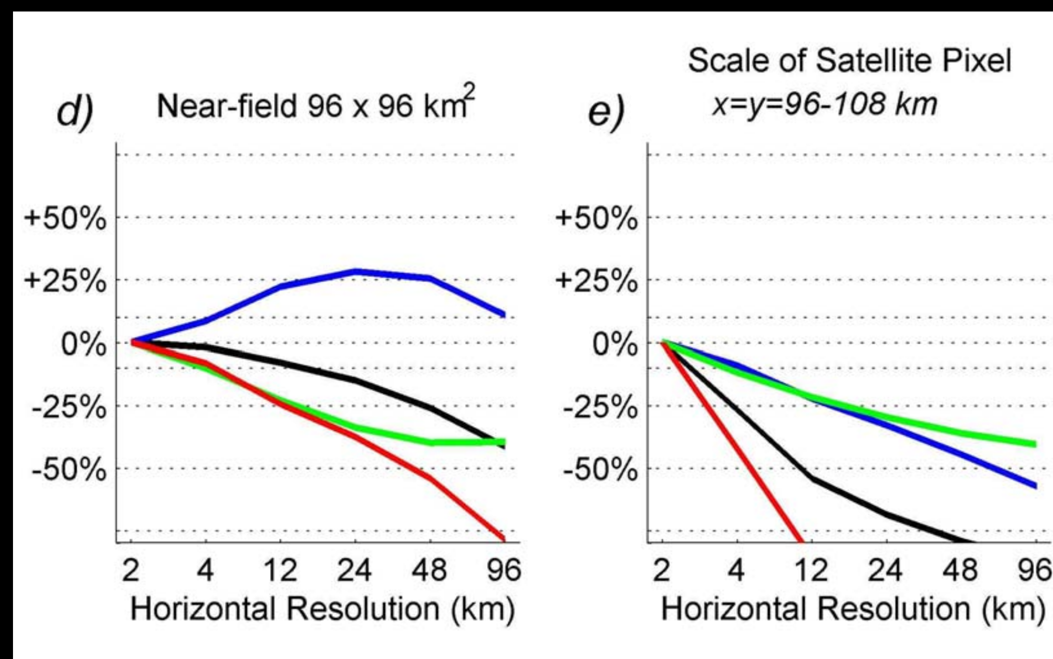
+75%
+50%
+25%
0%
-25%
-50%
-75%
% Deviation VCD$_{NO_2}$
0.5
1
2
4
8
16
32
64
128
256
512
Horizontal Resolution (km)

A point source in 2-d



Conserved Tracer
$\log_{10} VCD_{NO_2}$ (molecules cm^{-2})
OH= f(NO2) - fig. 8
$\log_{10} VCD_{NO_2}$ (molecules cm^{-2})
a)
b)
c)
d)
e)
f)
2 x 2 km^2
12 x 12 km^2
48 x 48 km^2
96 km
288 km
17
16
15





Black
Constant OH
$5x10^6 / cm^3$

Application in 3-d: WRF-CHEM

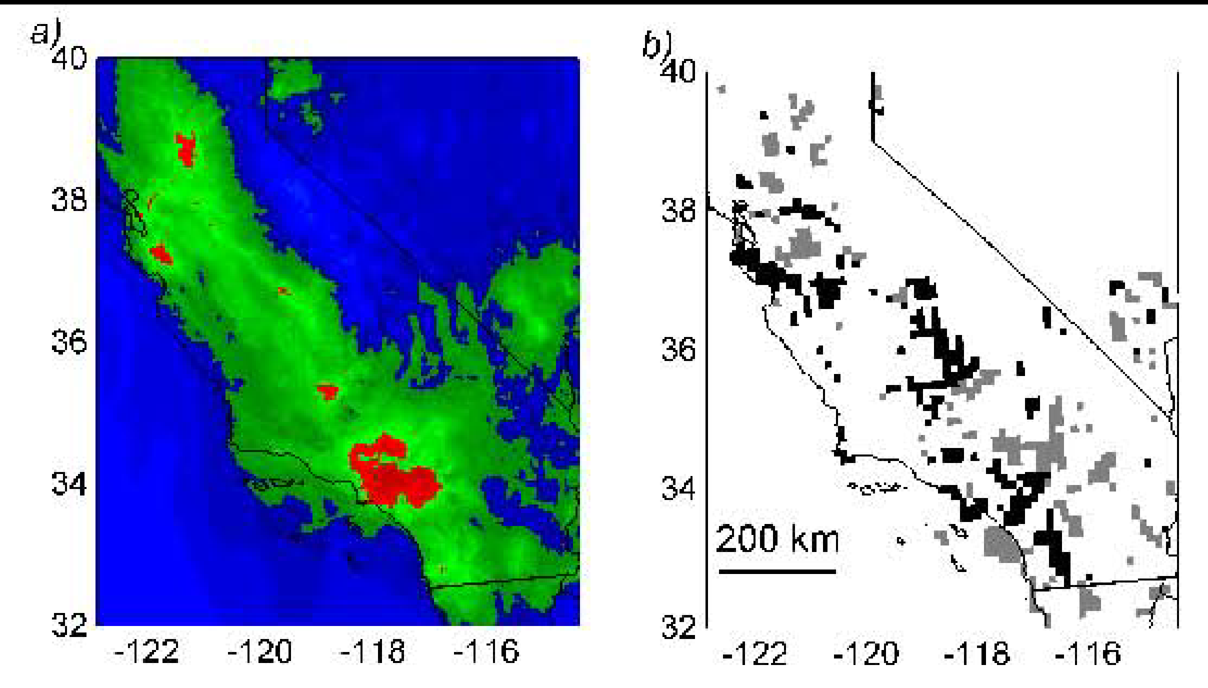
4km met

emissions at different resolutions

compare NO_2 column

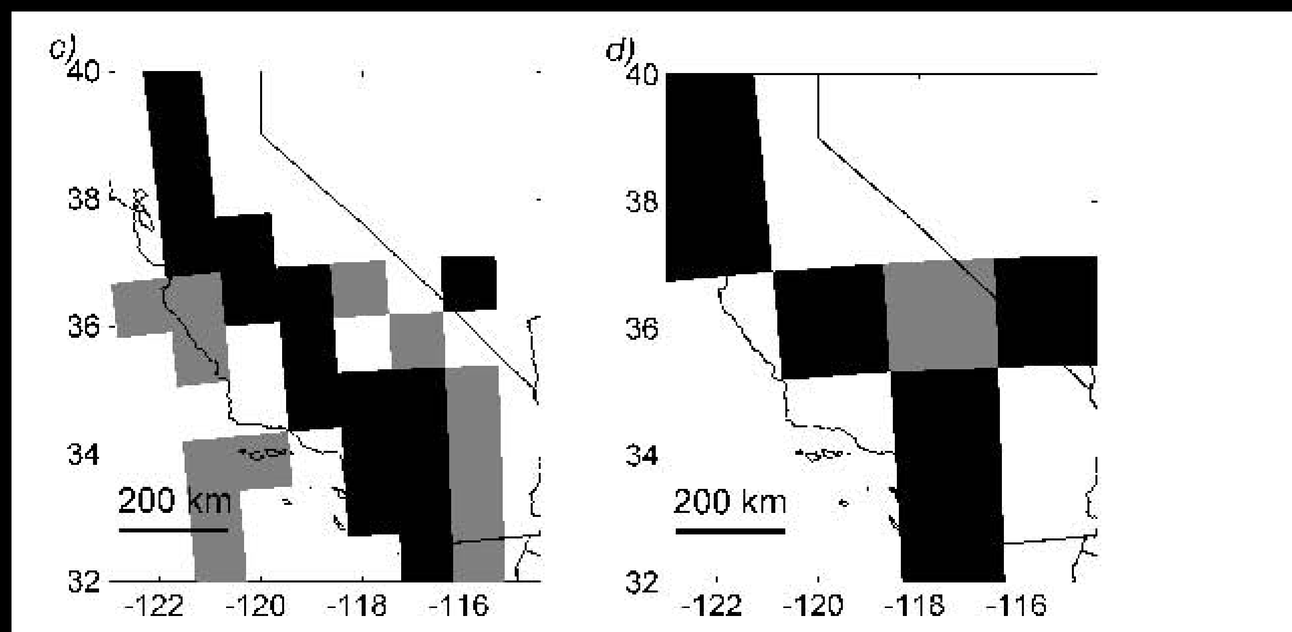
Gray biases of more than +25%

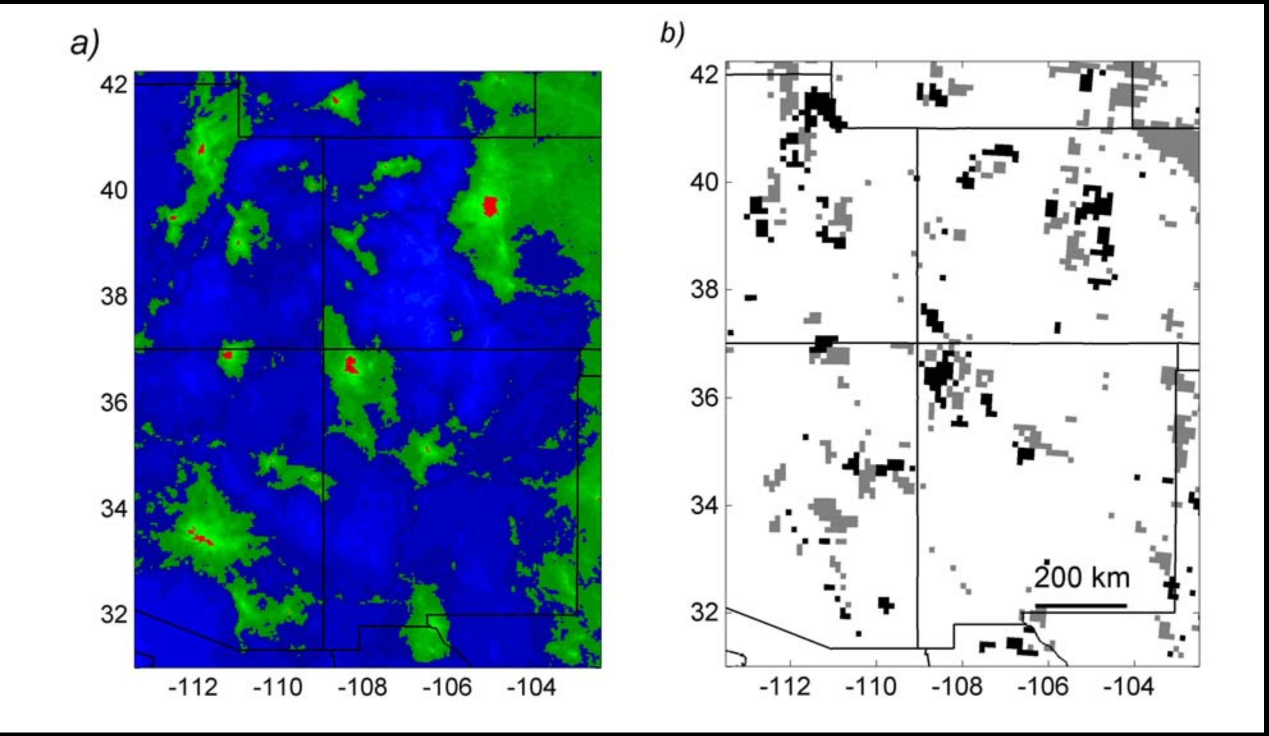
Black biases more than -25%



4 and 12 km

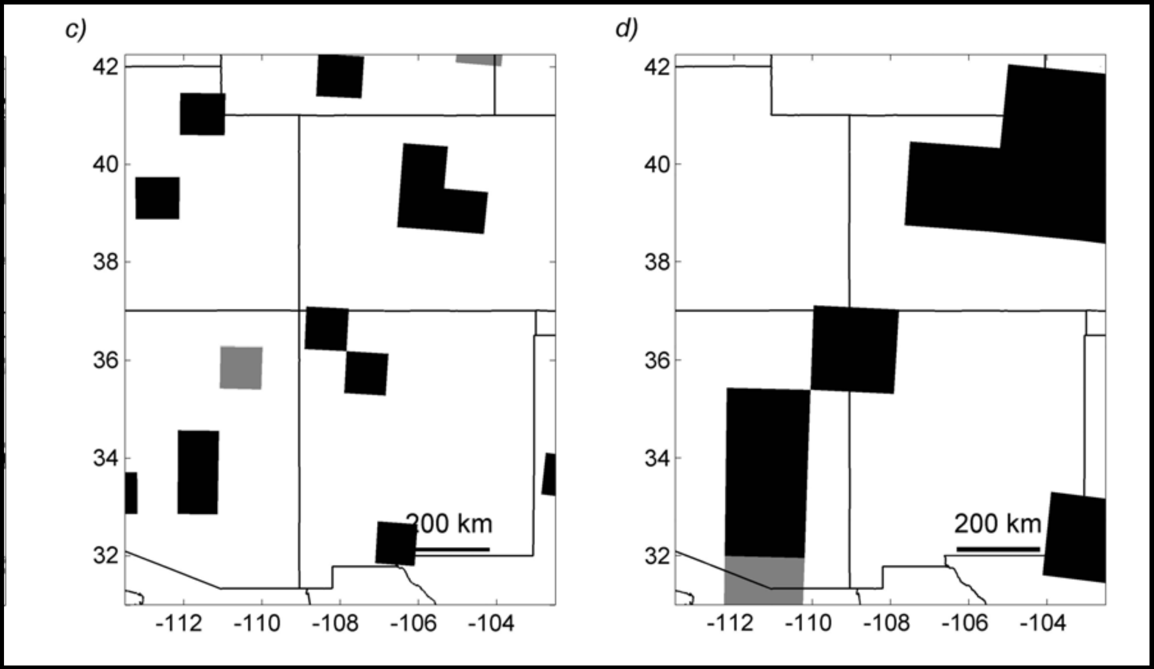
48 and 192 km





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:

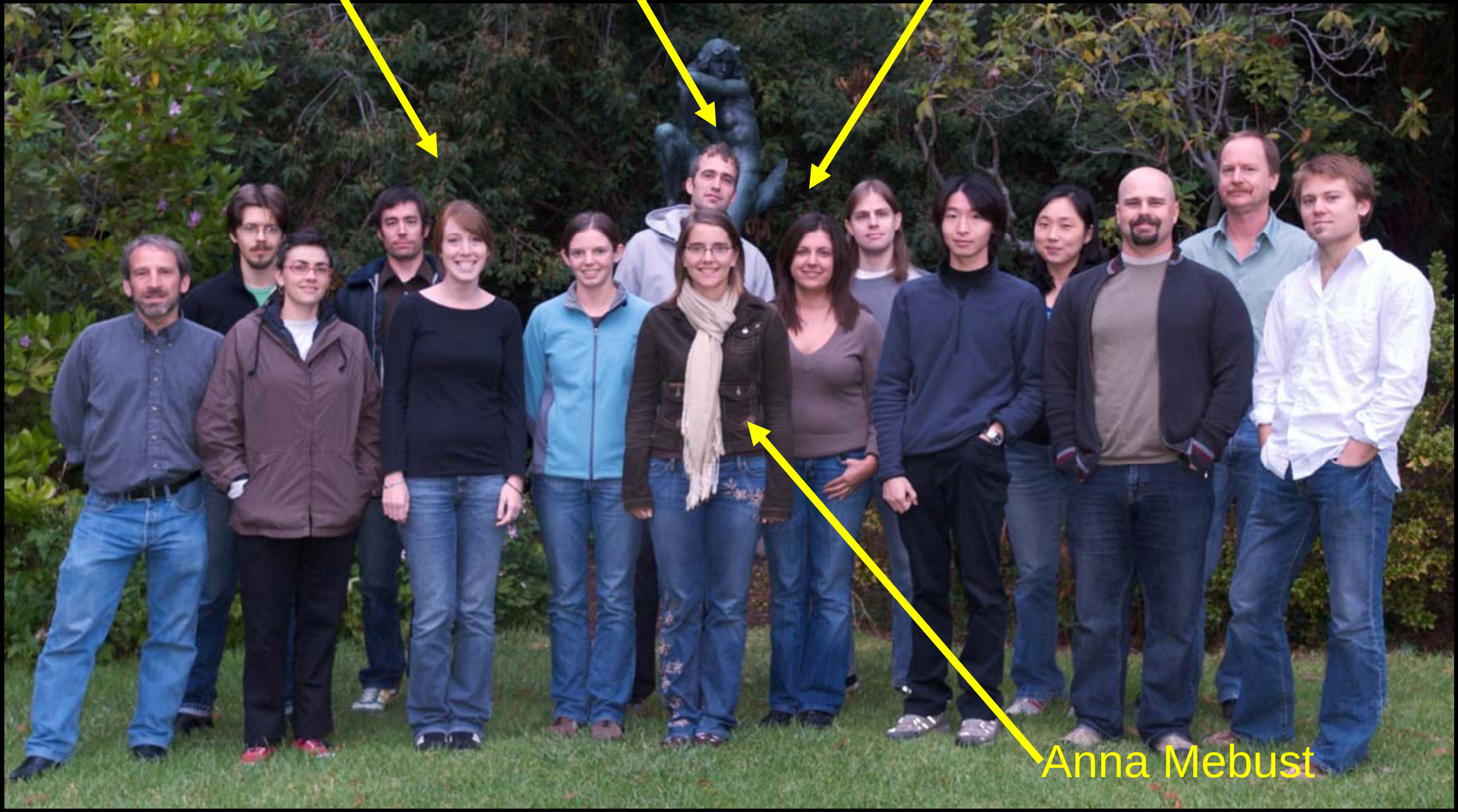
- variation with day of week
- variation with met (wind speed, pbl height)
- trends over multiple years
- variation with time of day

But we have more to learn before we know how to use all of these pieces of information.

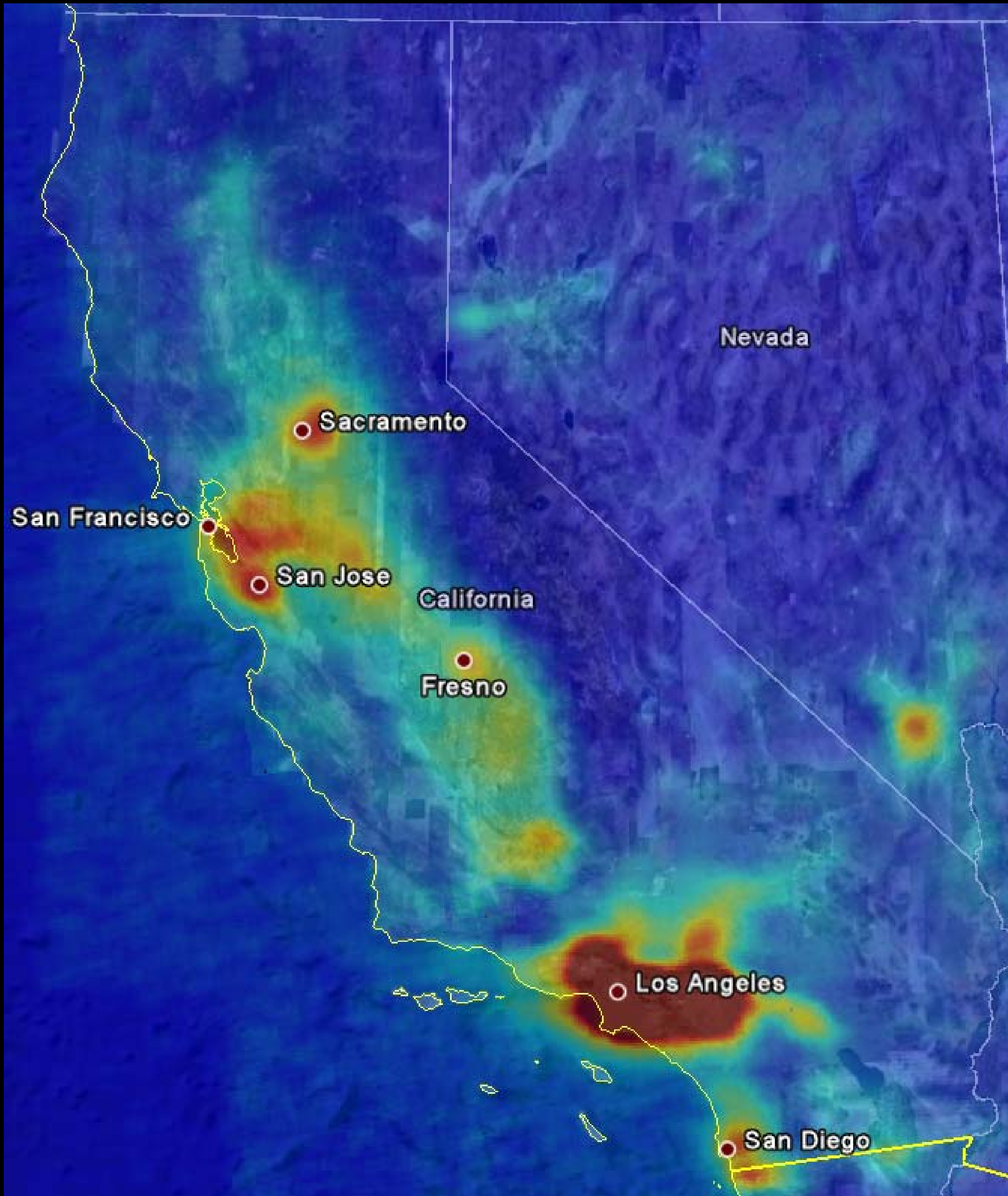
Luke Valin

Ashley Russell

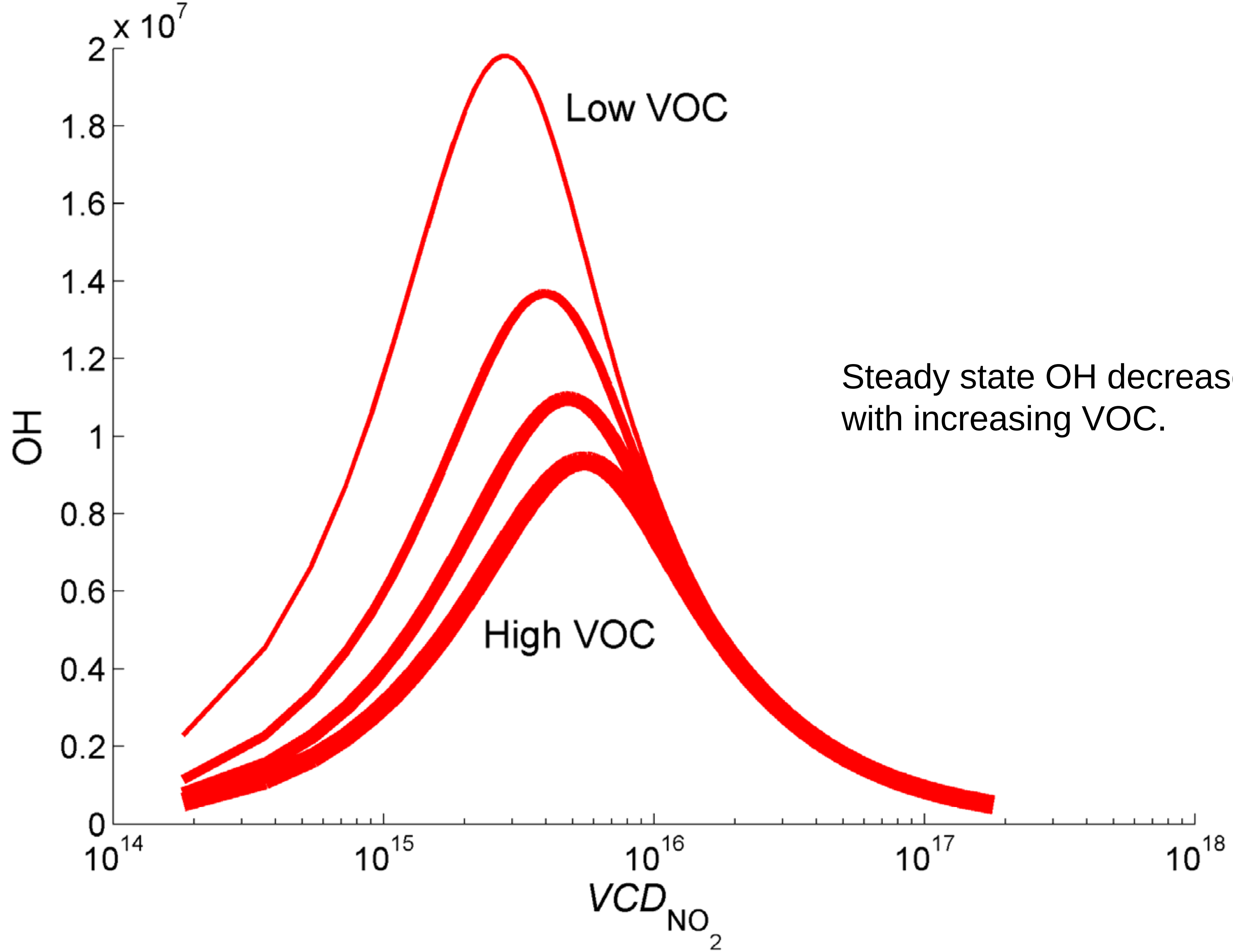
Rynda Hudman



Thank you!



Nevada
Sacramento
San Francisco
San Jose
California
Fresno
Los Angeles
San Diego



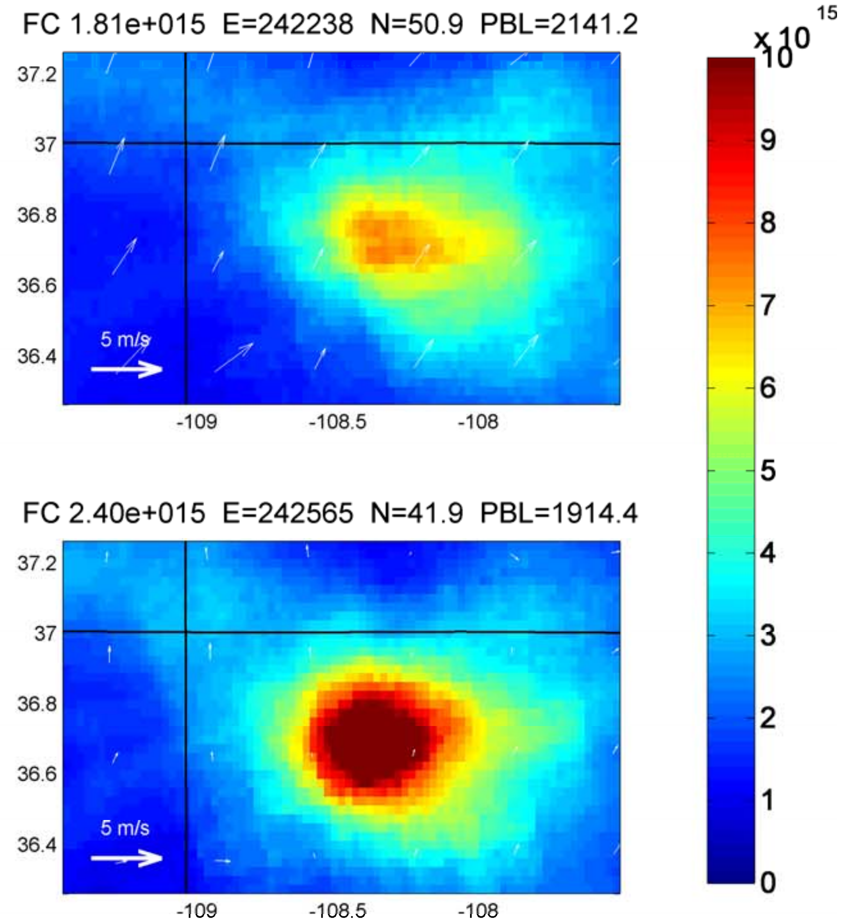
Steady state OH decreases with increasing VOC.

τ_{NOx} = 4.1 hrs

$[OH]_{eff}$ = 8.5 x 10^6 cm^{-3}

High Winds →

Low Winds →

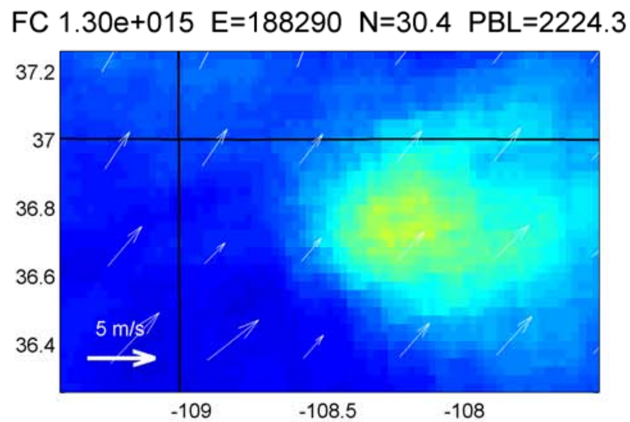


τ_{NOx} = 5.4 hrs

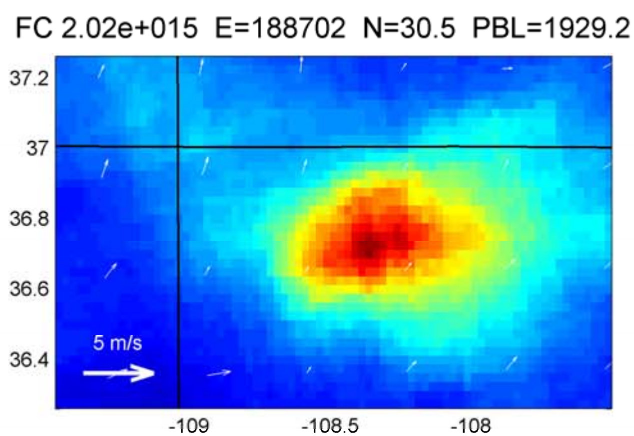
$[OH]_{eff}$ = 6.4 x 10^6 cm^{-3}

τ_{NOx} = 3.7 hrs

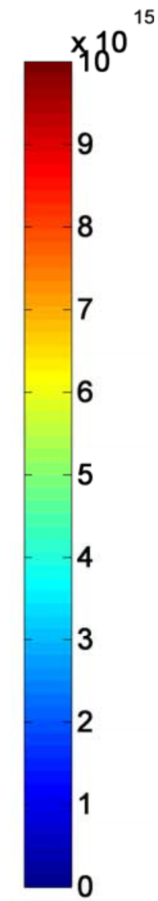
$[OH]_{eff}$ = 9.4 x 10^6 c



← High Winds

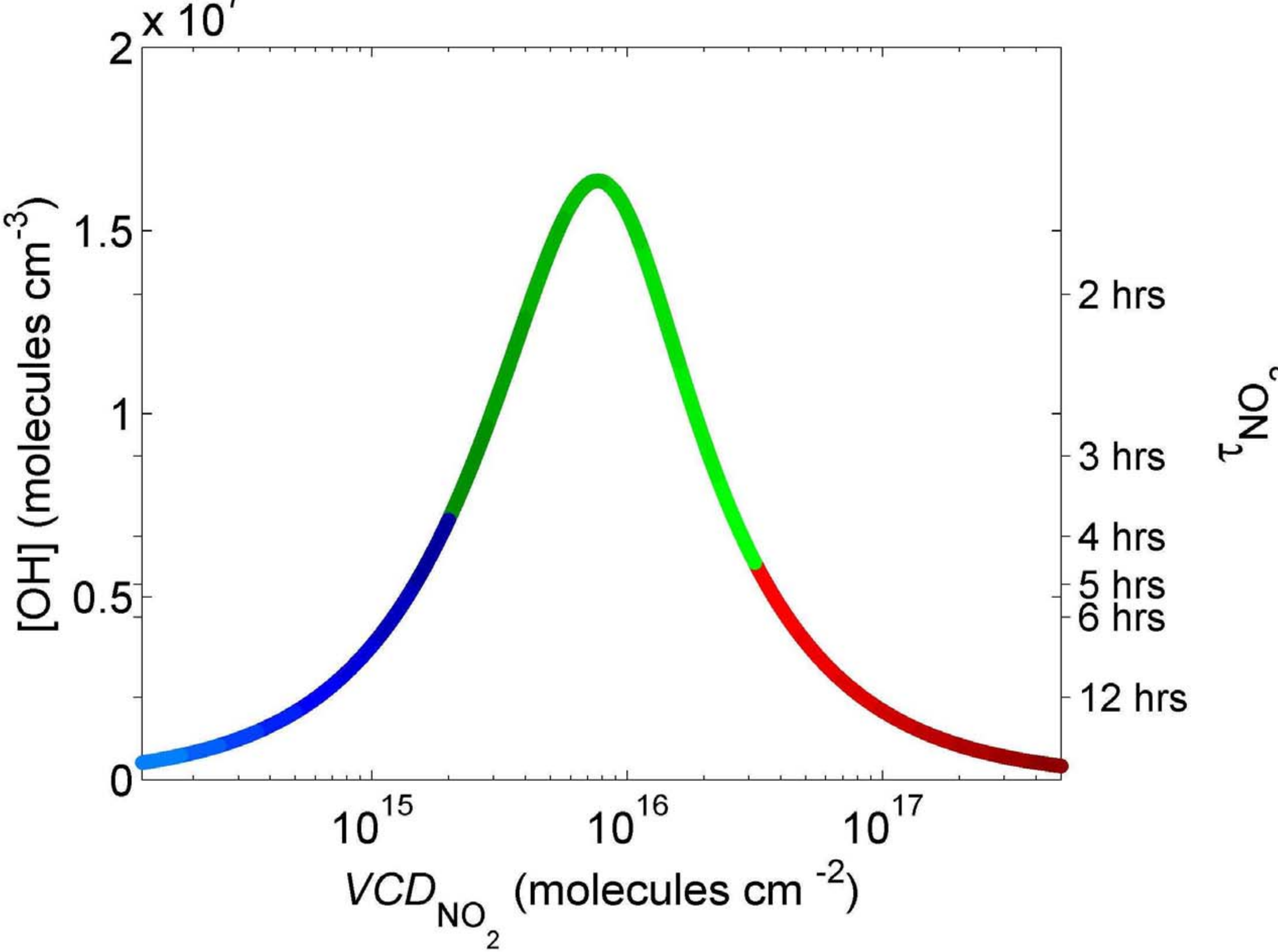


← Low Winds



τ_{NOx} = 5.8 hrs

$[OH]_{eff}$ = 6.0 x 10^6 cm^{-3}



x 10^7
2
1.5
1
0.5
0
[OH] (molecules cm^-3)
10^15
10^16
10^17
VCD_NO2 (molecules cm^-2)
2 hrs
3 hrs
4 hrs
5 hrs
6 hrs
12 hrs
τ_NO2

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_2 will not necessarily represent typical behavior—since the distribution of NO_2 columns is likely not Gaussian.