A New Phase in Validation of Satellite NO_2 products—Berkeley Contribution to DISCOVER-AQ and preparation for GEO-CAPE

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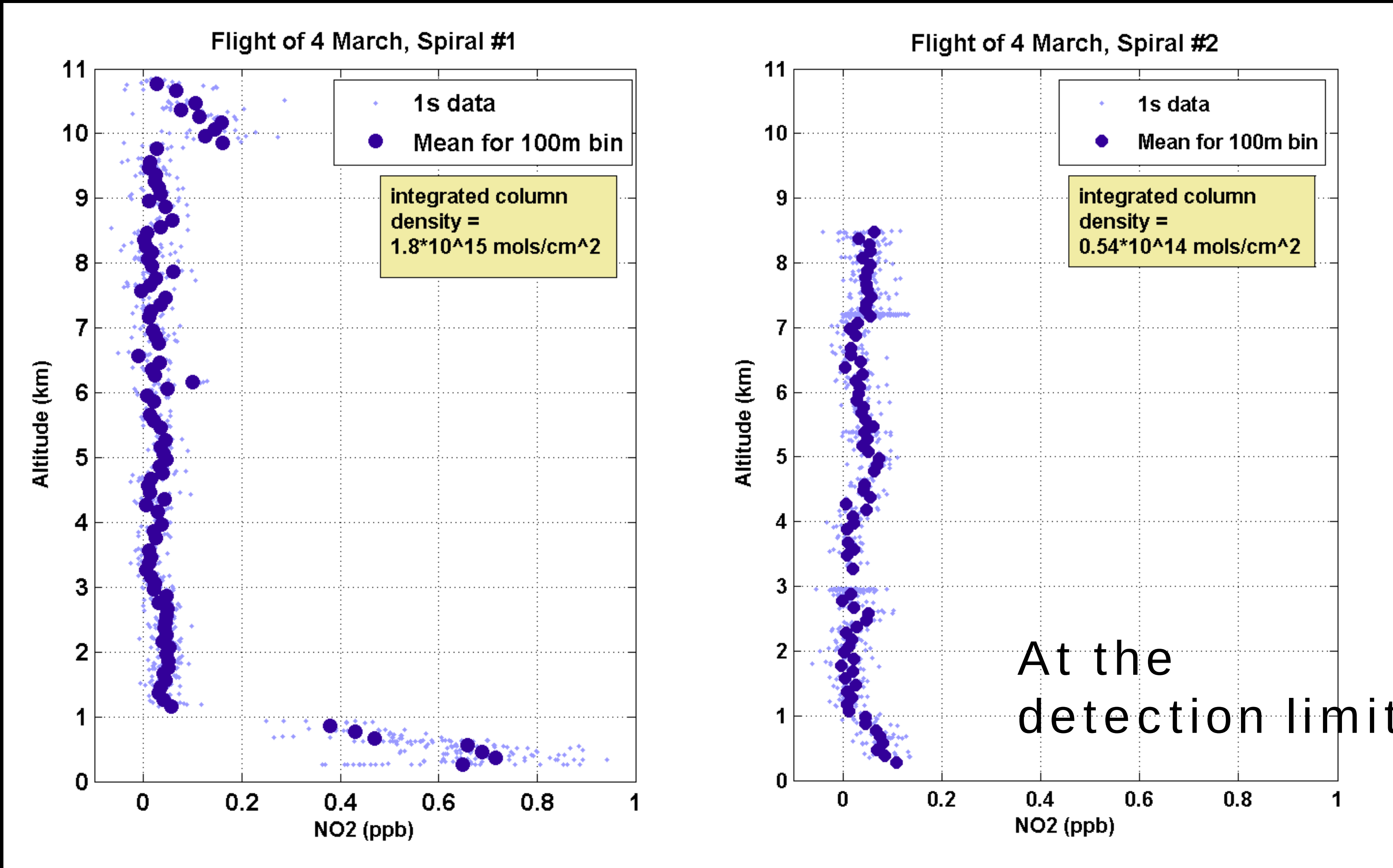
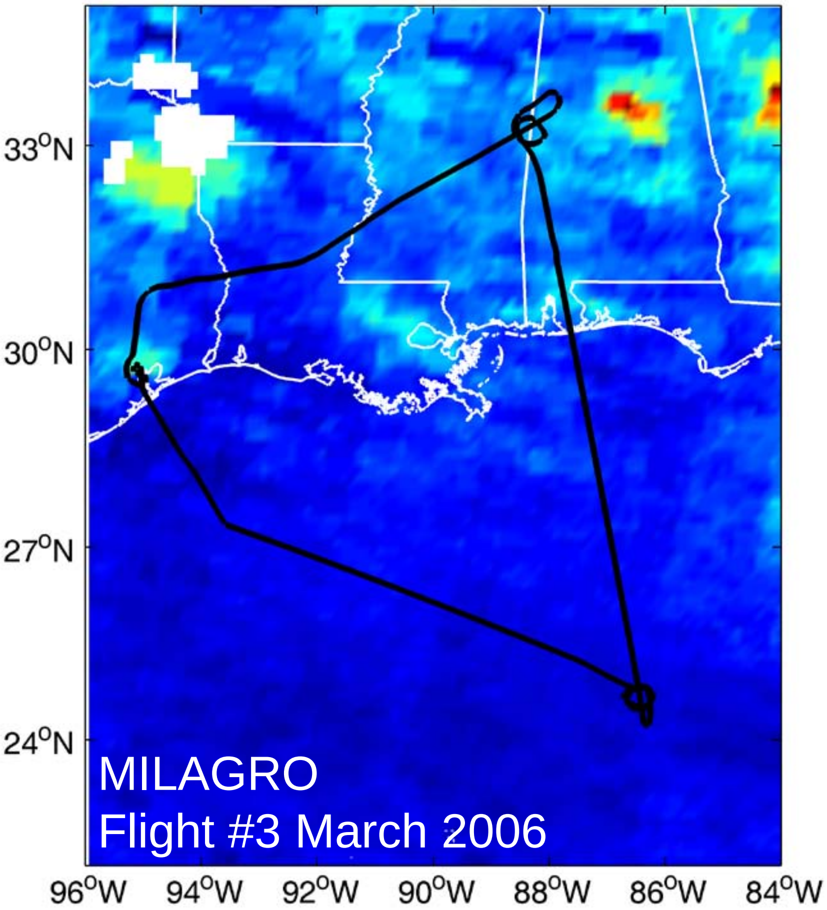
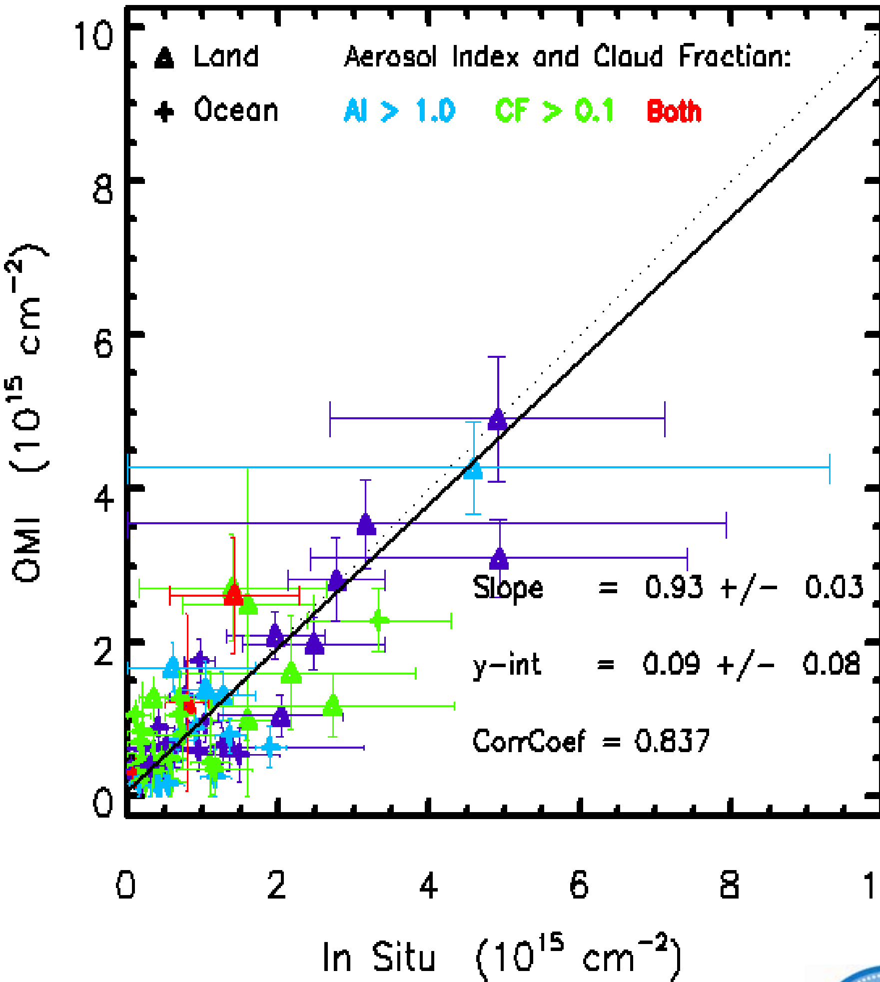
Validation of NO_2 products to date

1) Spirals in nadir
2) Comparison to seasonal and interannual trends observed from surface stations
3) Comparison to models—sanity checks



At the detection limit


33°N
30°N
27°N
24°N
MILAGRO
Flight #3 March 2006
96°W
94°W
92°W
90°W
88°W
86°W
84°W

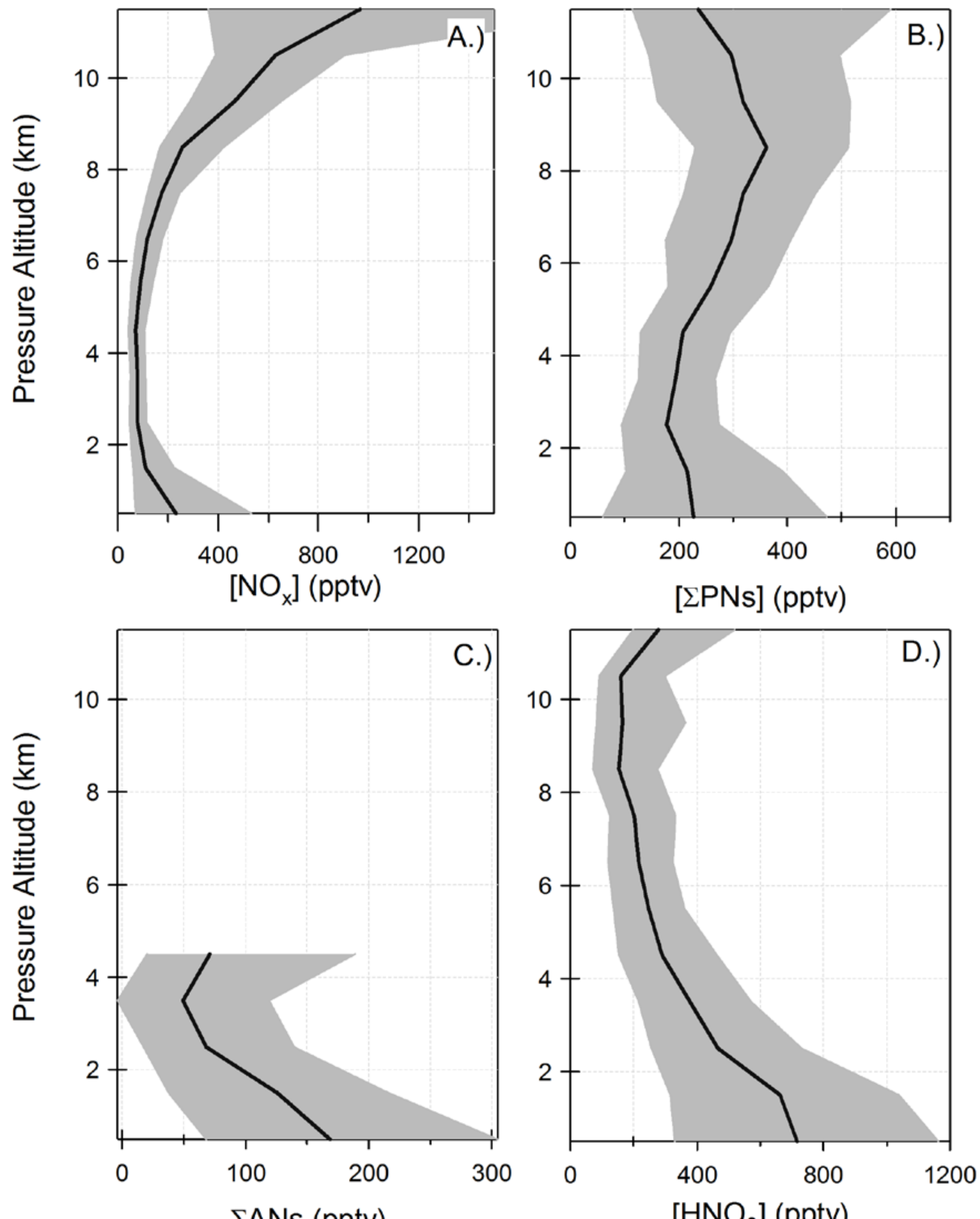

Land
Ocean
Aerosol Index and Cloud Fraction:
AI > 1.0
CF > 0.1
Both
Slope = 0.93 +/− 0.03
y−int = 0.09 +/− 0.08
CorrCoef = 0.837
OMI (10^15 cm^−2)
In Situ (10^15 cm^−2)

NO_2

ΣPNs

ΣANs

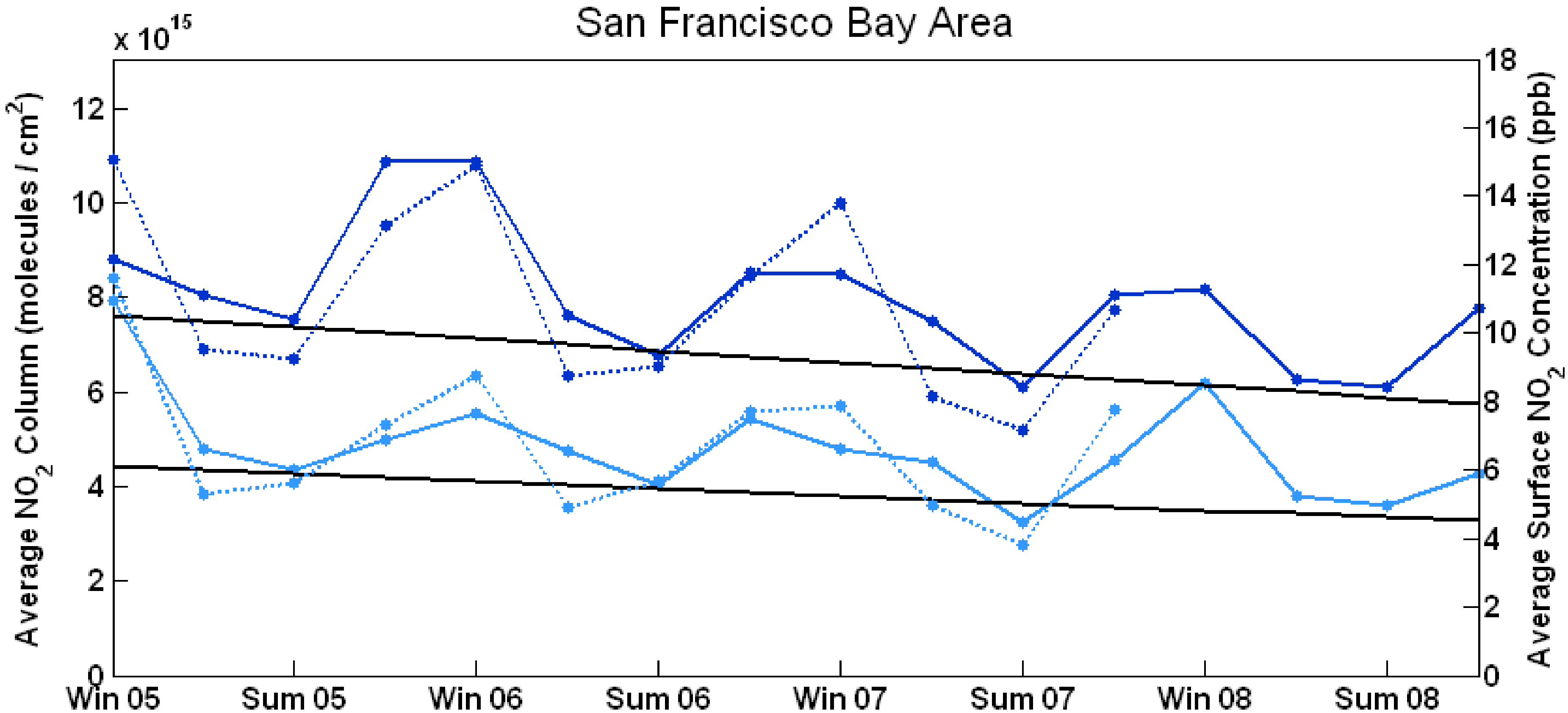
HNO_3



Trends in OMI match trends at surface stations

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.



OMI: ~7%/year decrease
Inventory: ~4% / year

Lessons learned from validation of NO_2 products to date

1) The NO_2 products from GOME, SCIAMACHY, OMI and GOME-2 are accurate to better than a factor of two. Long term precision of OMI is better than a few %. The relative accuracy of the different instruments also appears to be quite high, in the neighborhood of 10%.

2) the high spatial resolution of OMI presents different challenges/opportunities than do the lower res instruments.

Lessons learned from validation of NO_2 products to date

3) Time varying a priori profile shapes are needed—a single annual profile introduces biases estimated to be as large as 60%--but these introduce significant model information into the experimental product making it challenging to understand how it is possible—if at all-to use the observational product as an independent test of models.

4) high resolution albedo, terrain and profiles does produces a product that is has a narrower spread compared to reference data.

R.C. Hudman, et al.

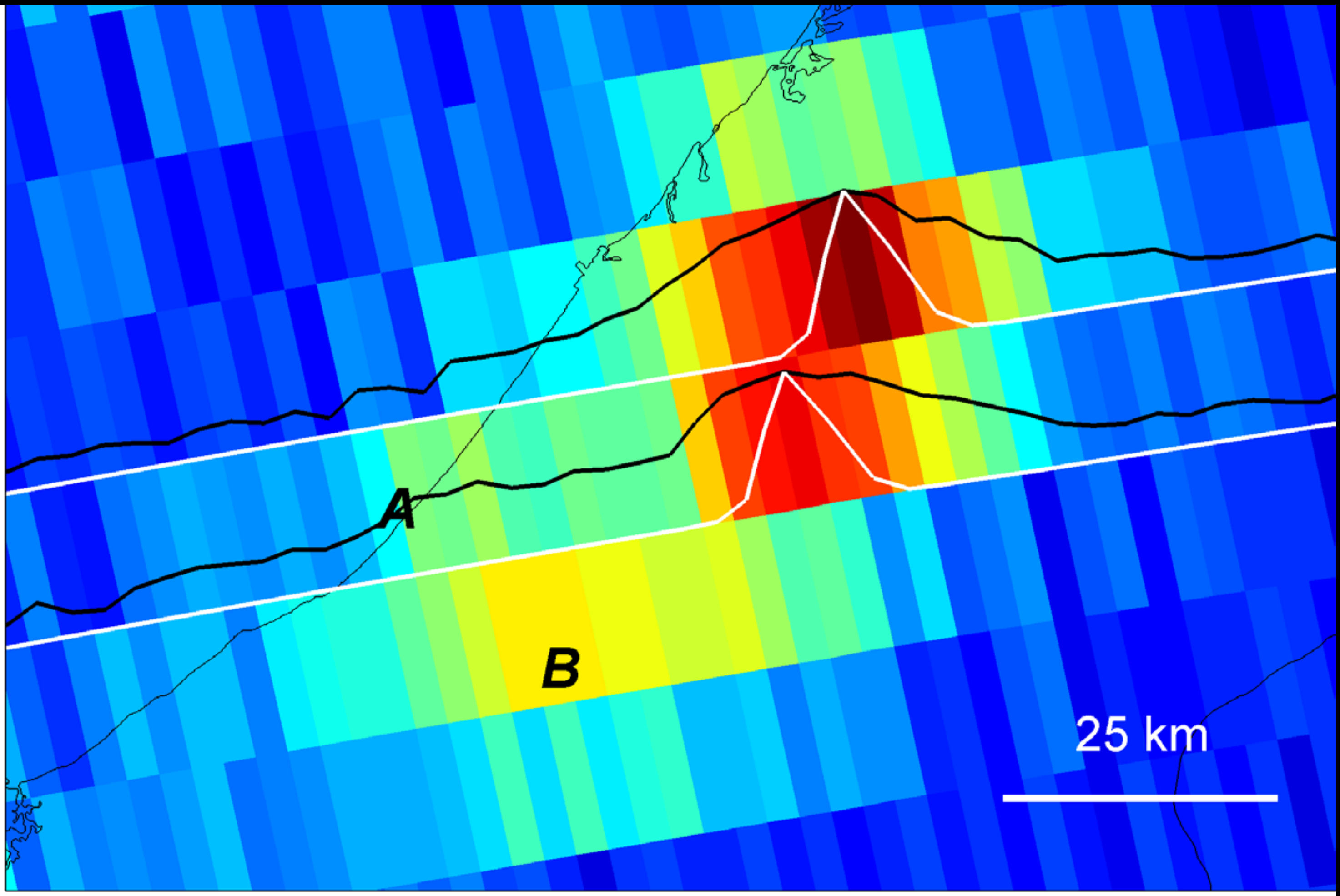
Interannual variation in soil NOx emissions observed from Space

ACPD 10, 13029-13053, 2010. ACP, in press

Report a difference between standard product and DOMINO product in the vicinity of thunderstorms that affects magnitude of pulsing.
Stratosphere?

L.C. Valin, et al. *Observation of slant column NO2 using the super-zoom mode of AURA OMI,* in preparation

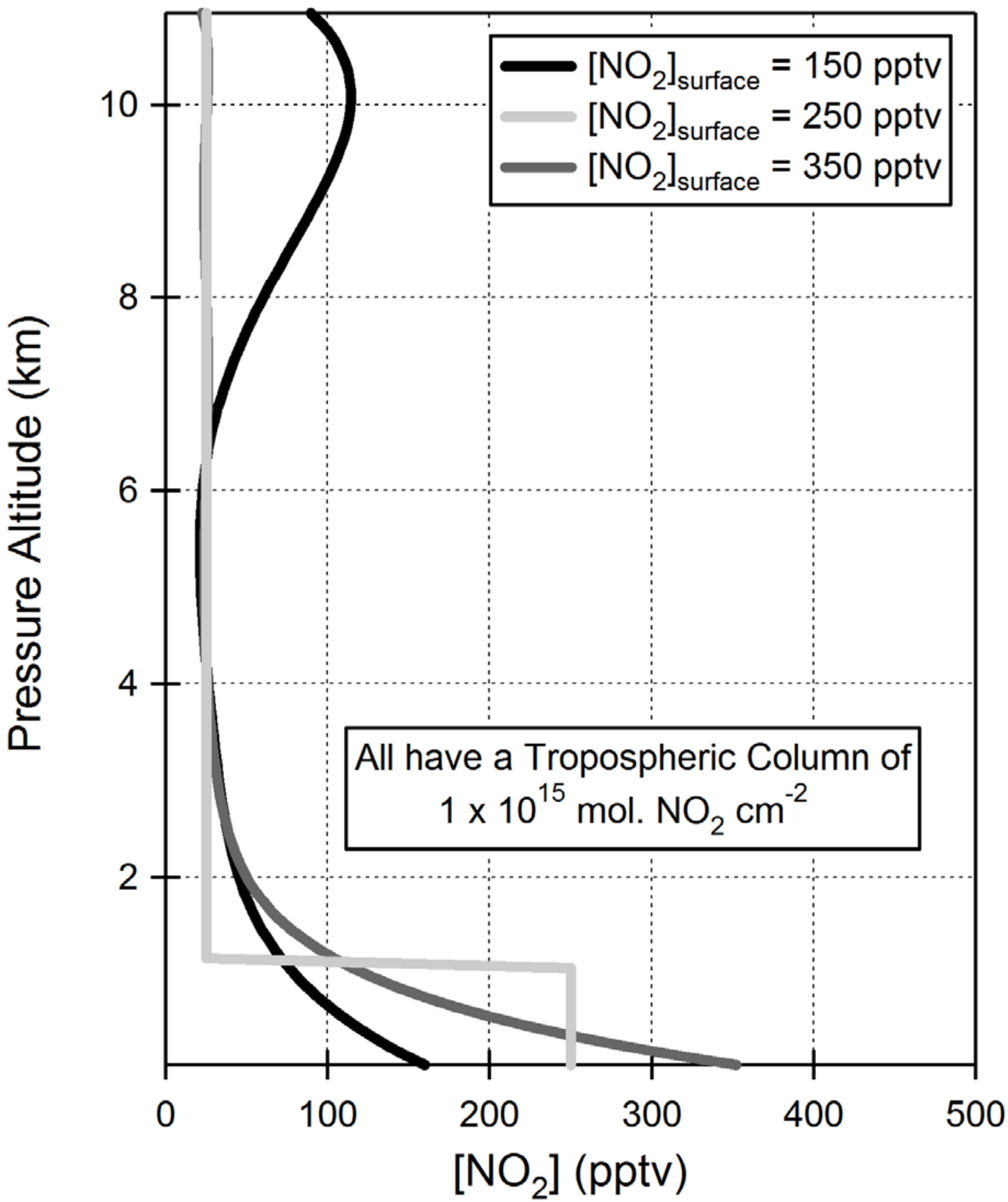
OMI observations at a spatial scale comparable to the GEO-CAPE target of 13 x 6 km



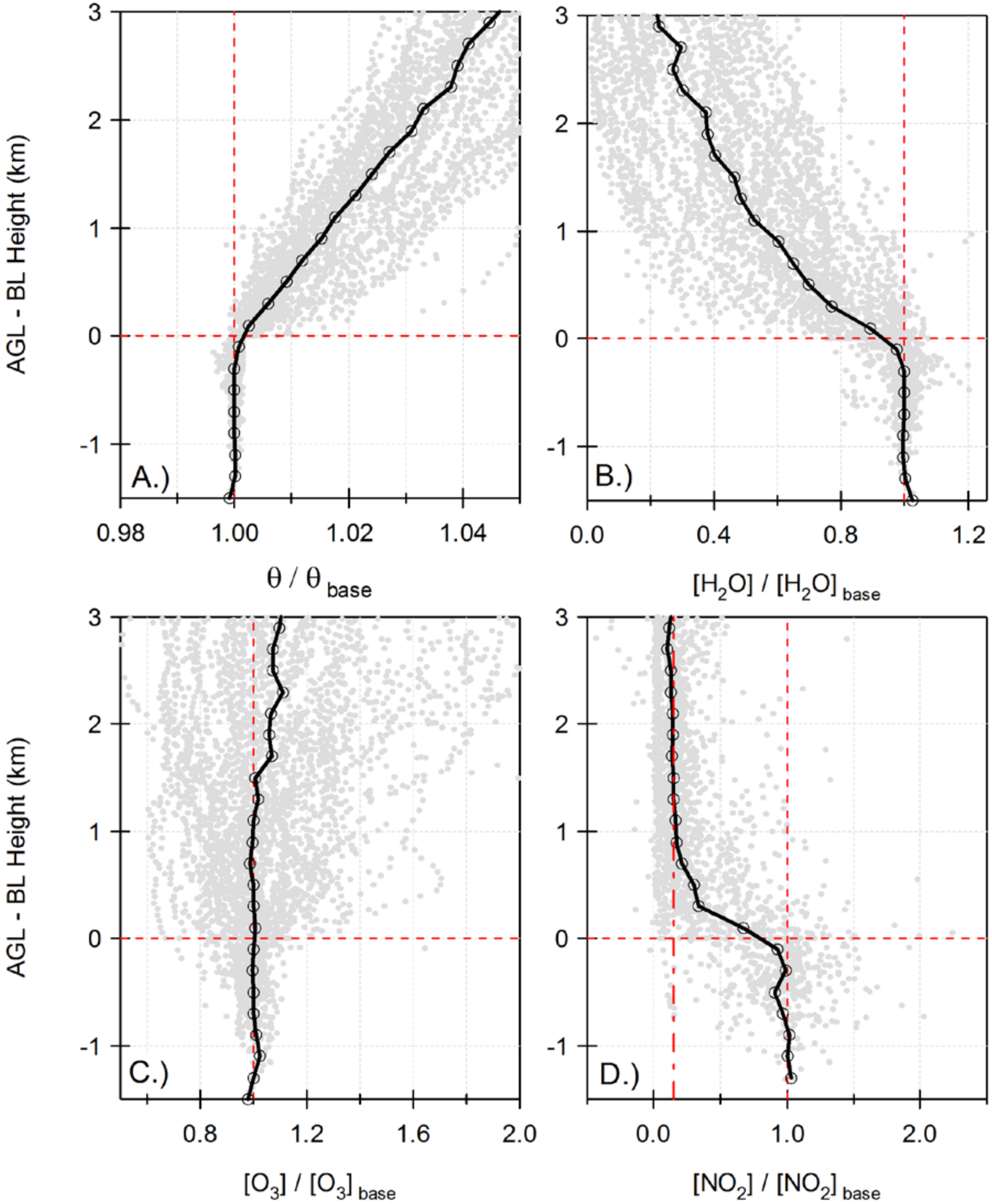
Some of the things that are missing from the validation of NO_2 products to date

1) There has been essentially no validation off of nadir, and certainly no systematic comparison of the retrievals at nadir with those at larger angles.

2) There has been no systematic comparison to profiles at different times of day—that would provide an independent reference for the relative accuracy of the different instruments.



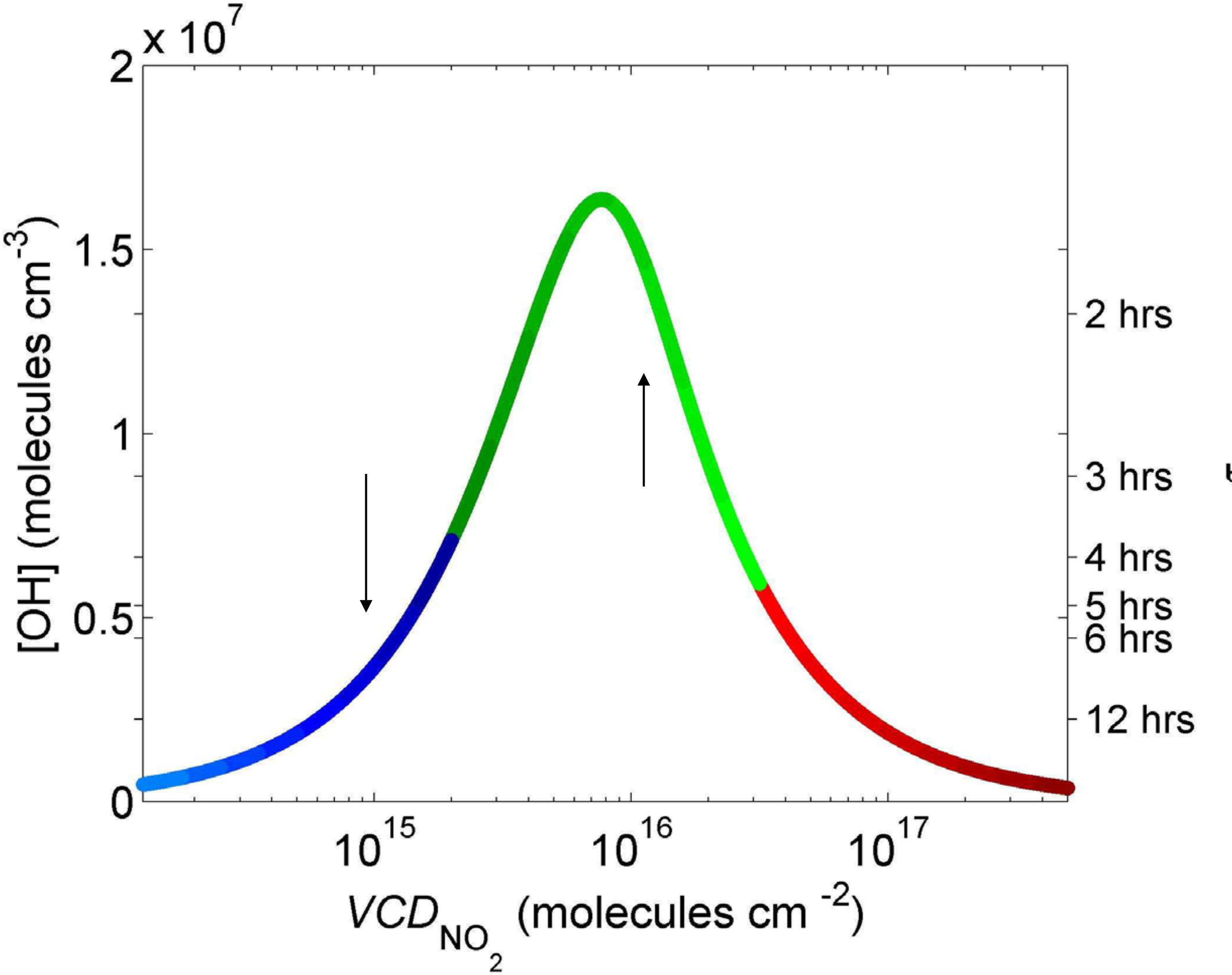
Profile Shapes



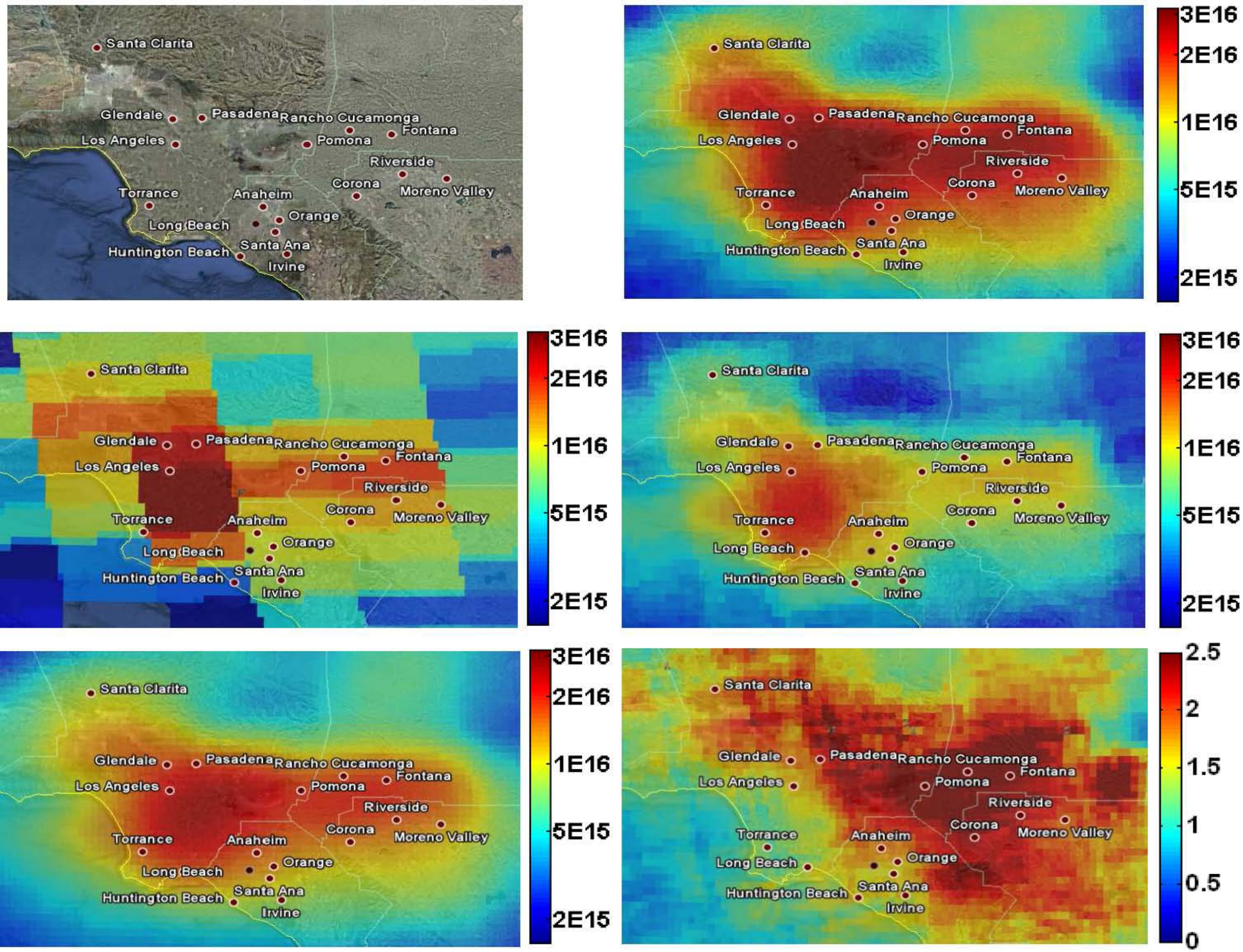
Summary of profiles from INTEX-A

(10 second observations)

What controls NO_2 gradients at the edge of and within urban and other plumes?



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

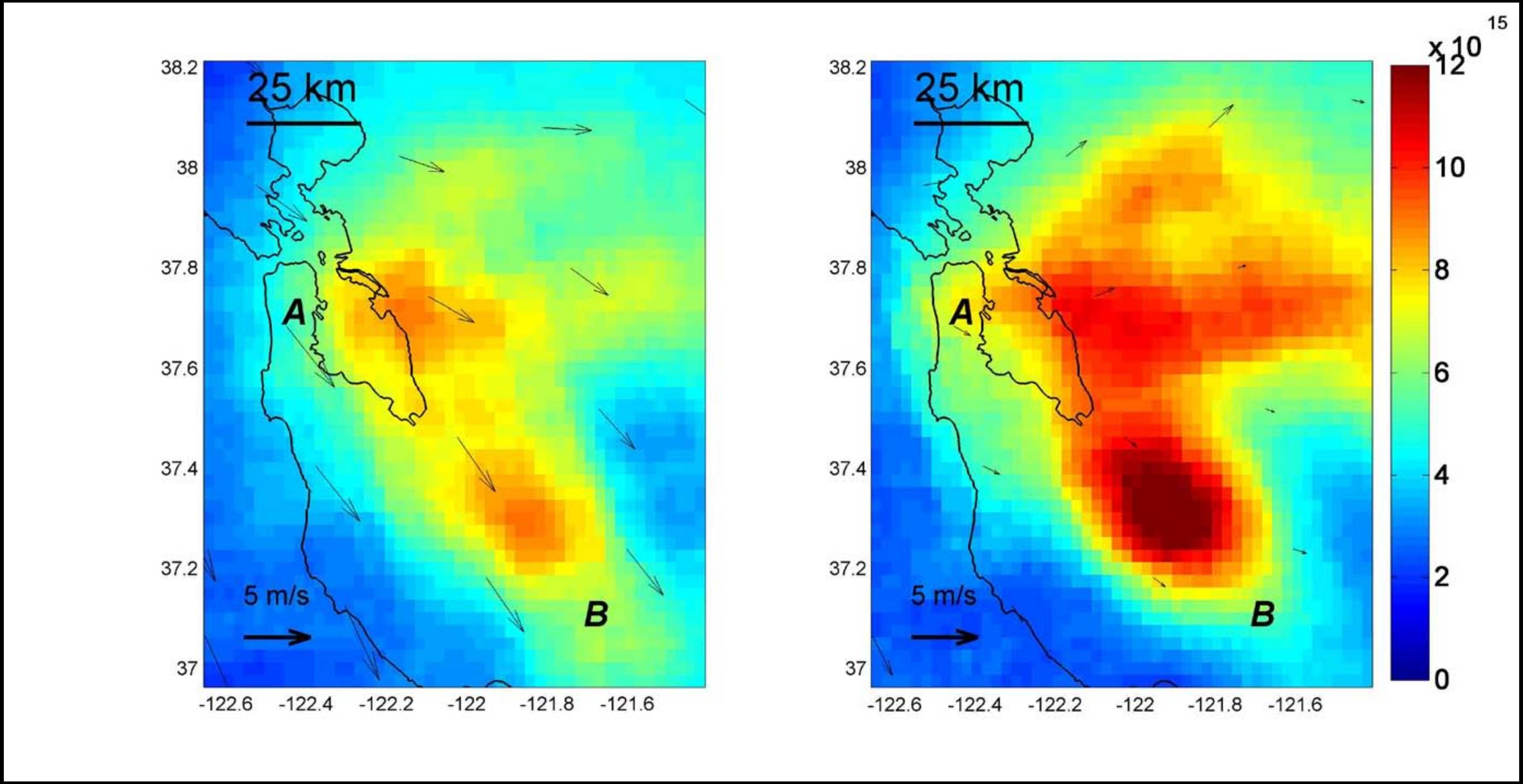


weekdays

weekends

ratio

7 day average



high winds
low NO_2

high OH

low winds
high NO_2

low OH

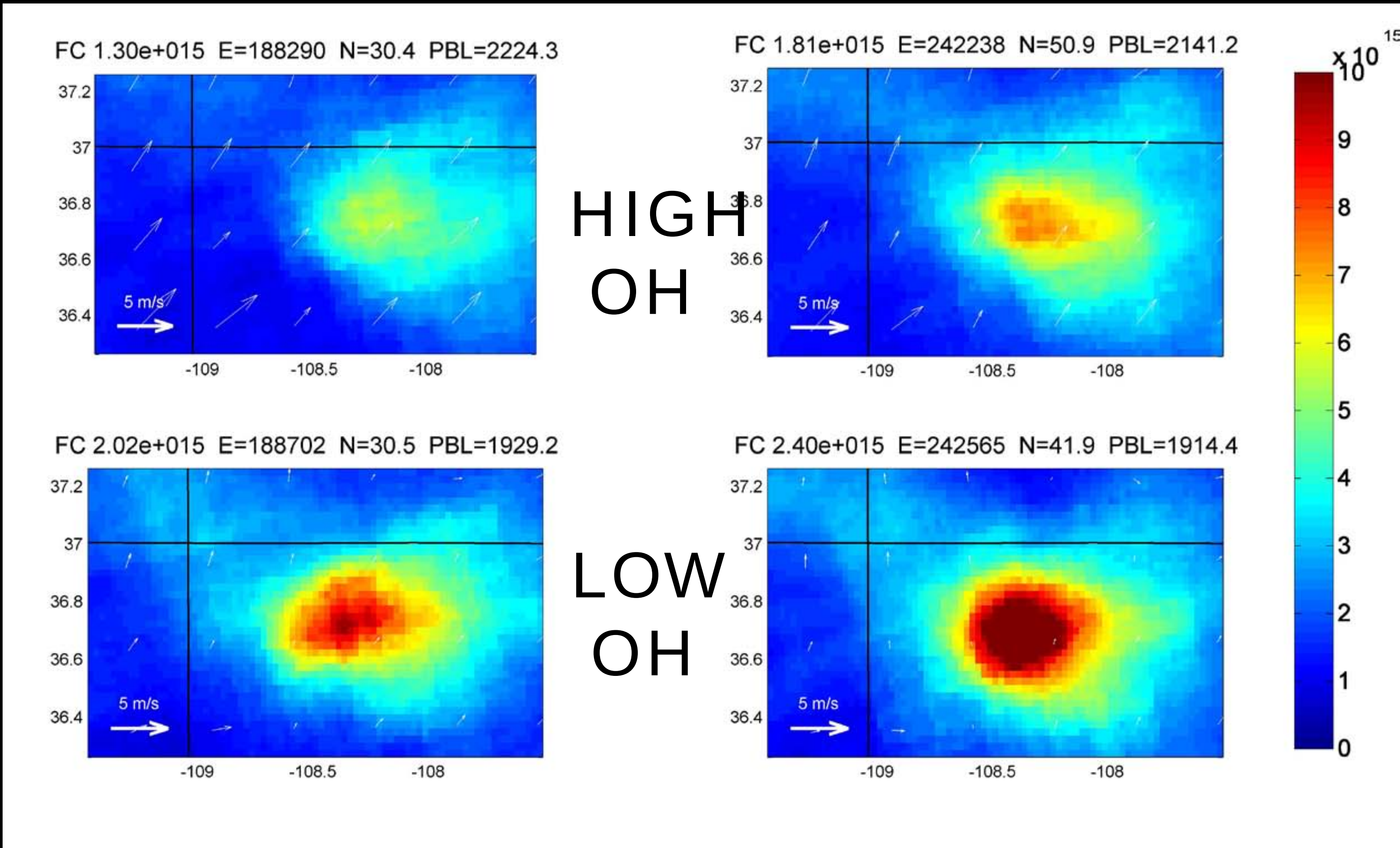
Four Corners Power Plant

Emissions (CEMS)

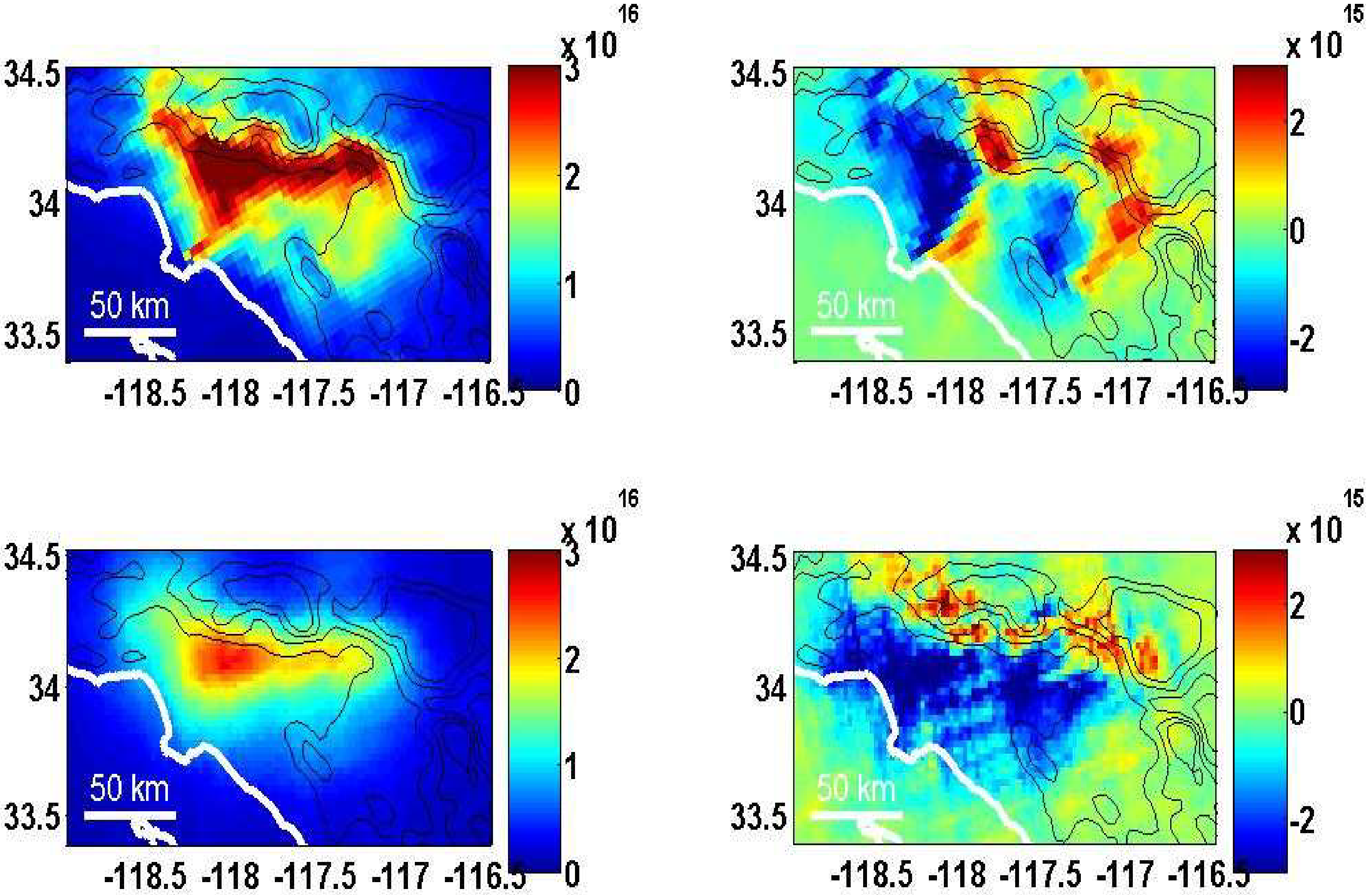
Low (50-75%) High (75-100%)

High Winds

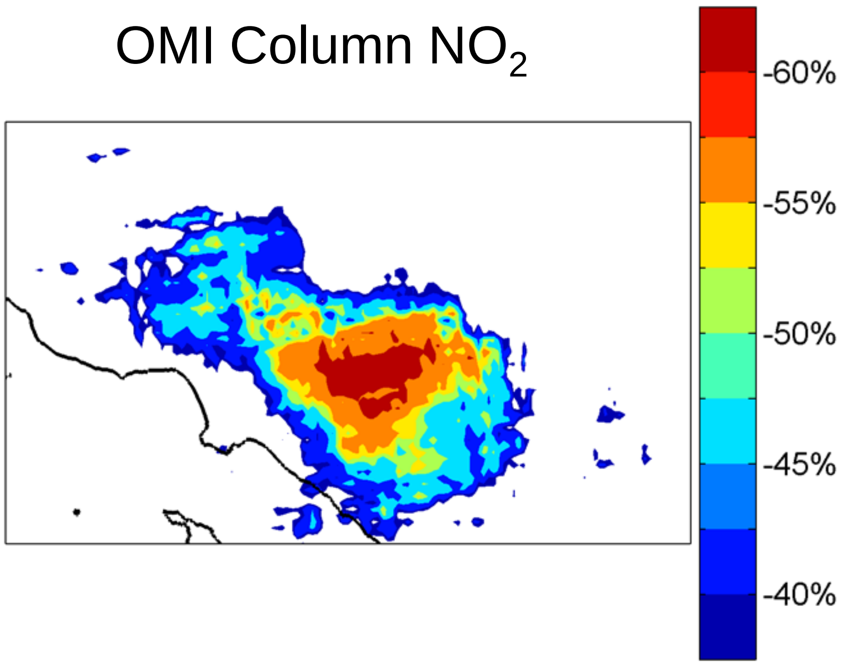
Low Winds

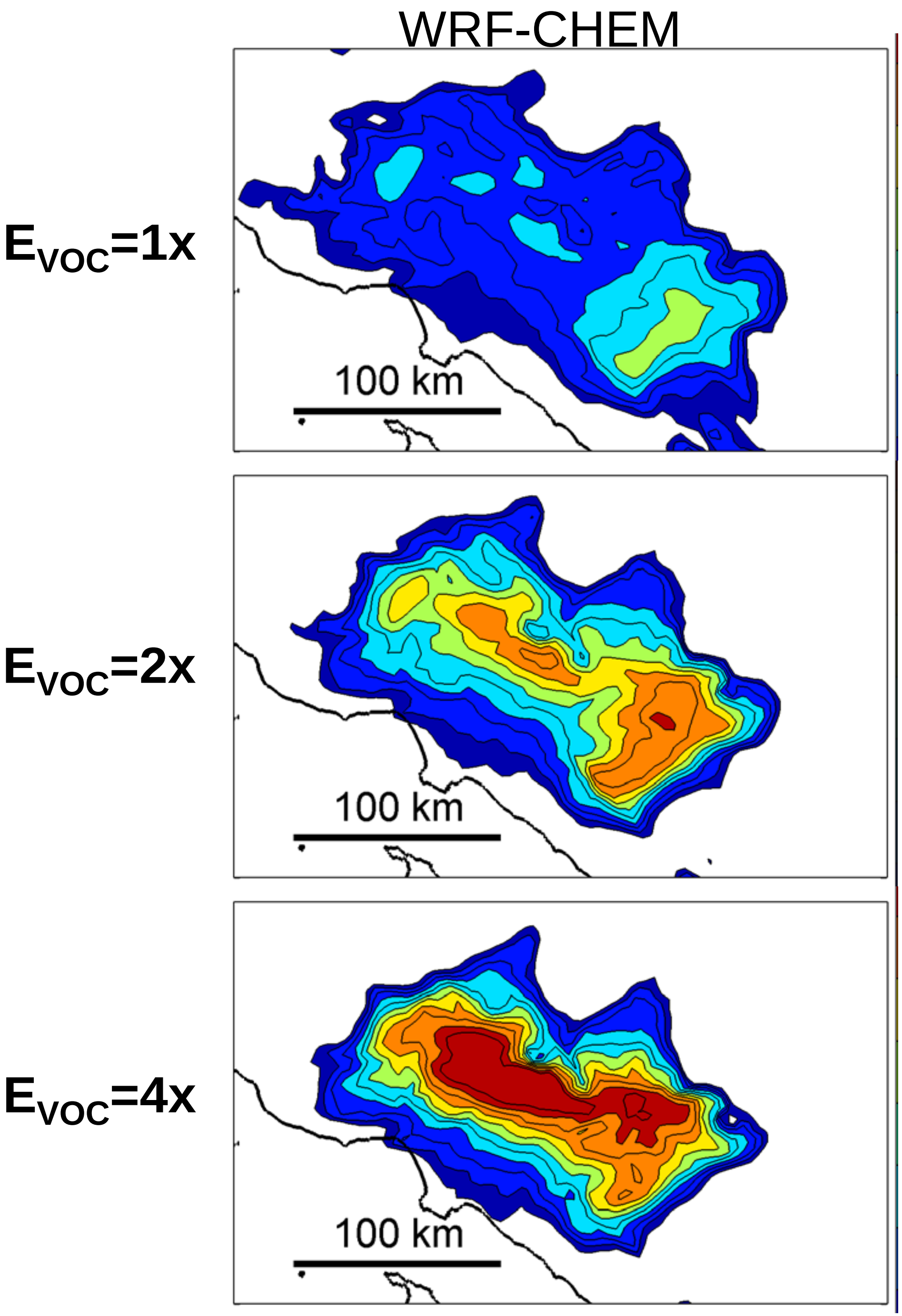


OMI SP & Berkeley 1:00 and 1:30-1:00



Percent Decrease on Weekends





Application in 3-d: WRF-CHEM

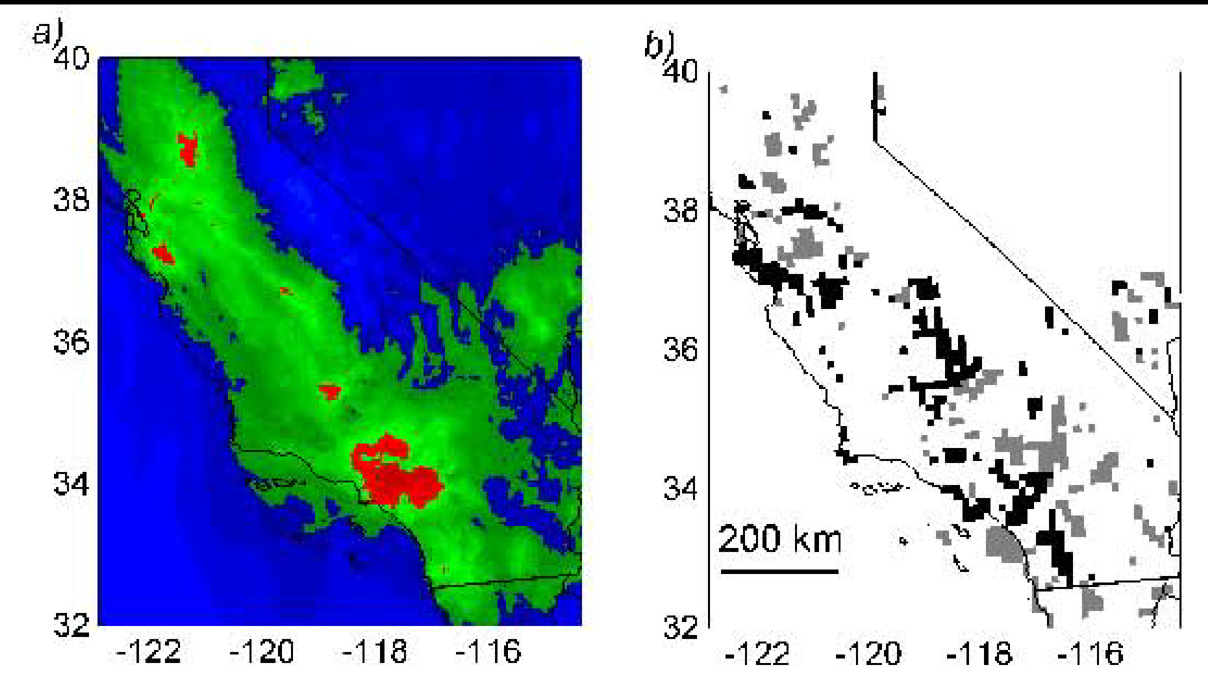
4km met

emissions at different resolutions

compare NO_2 column

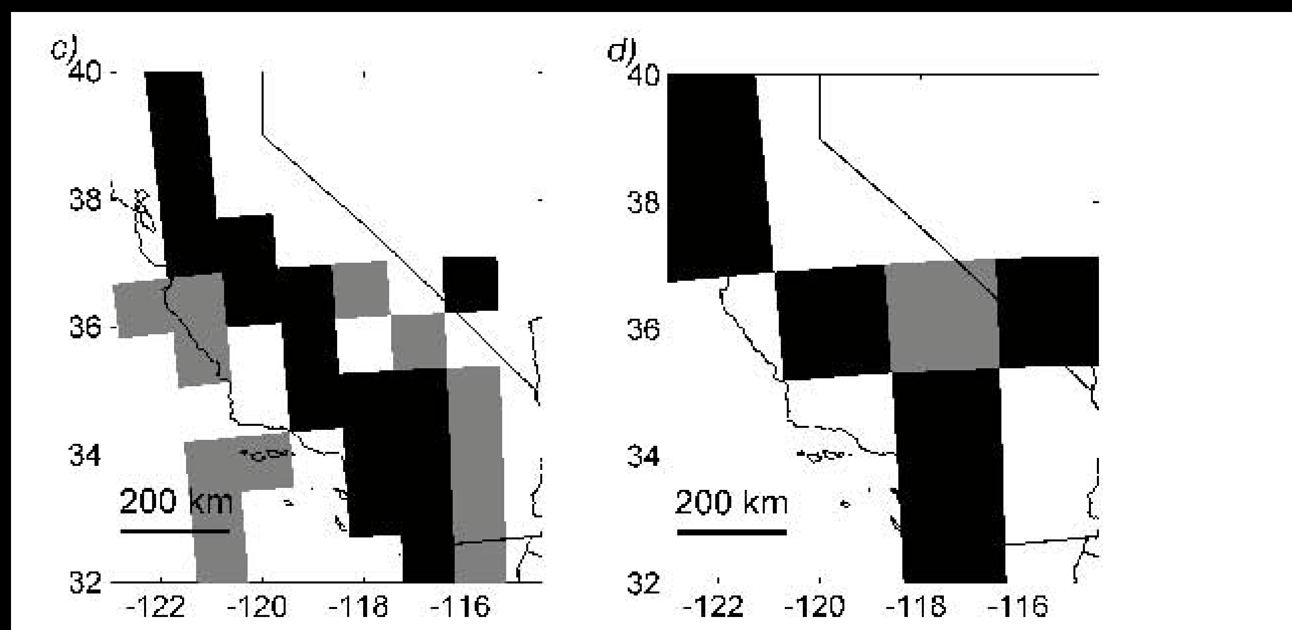
Gray biases of more than +25%

Black biases more than -25%

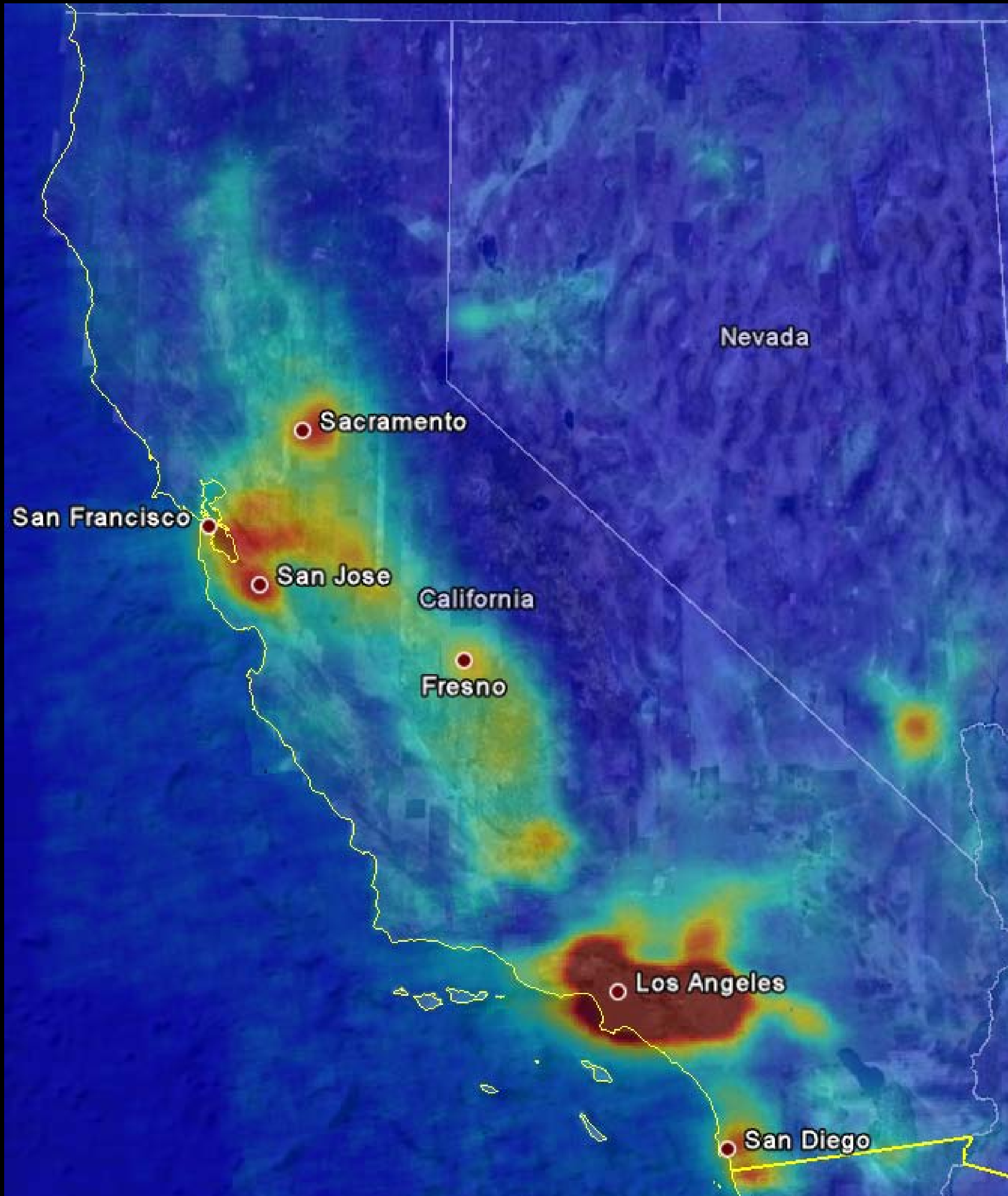


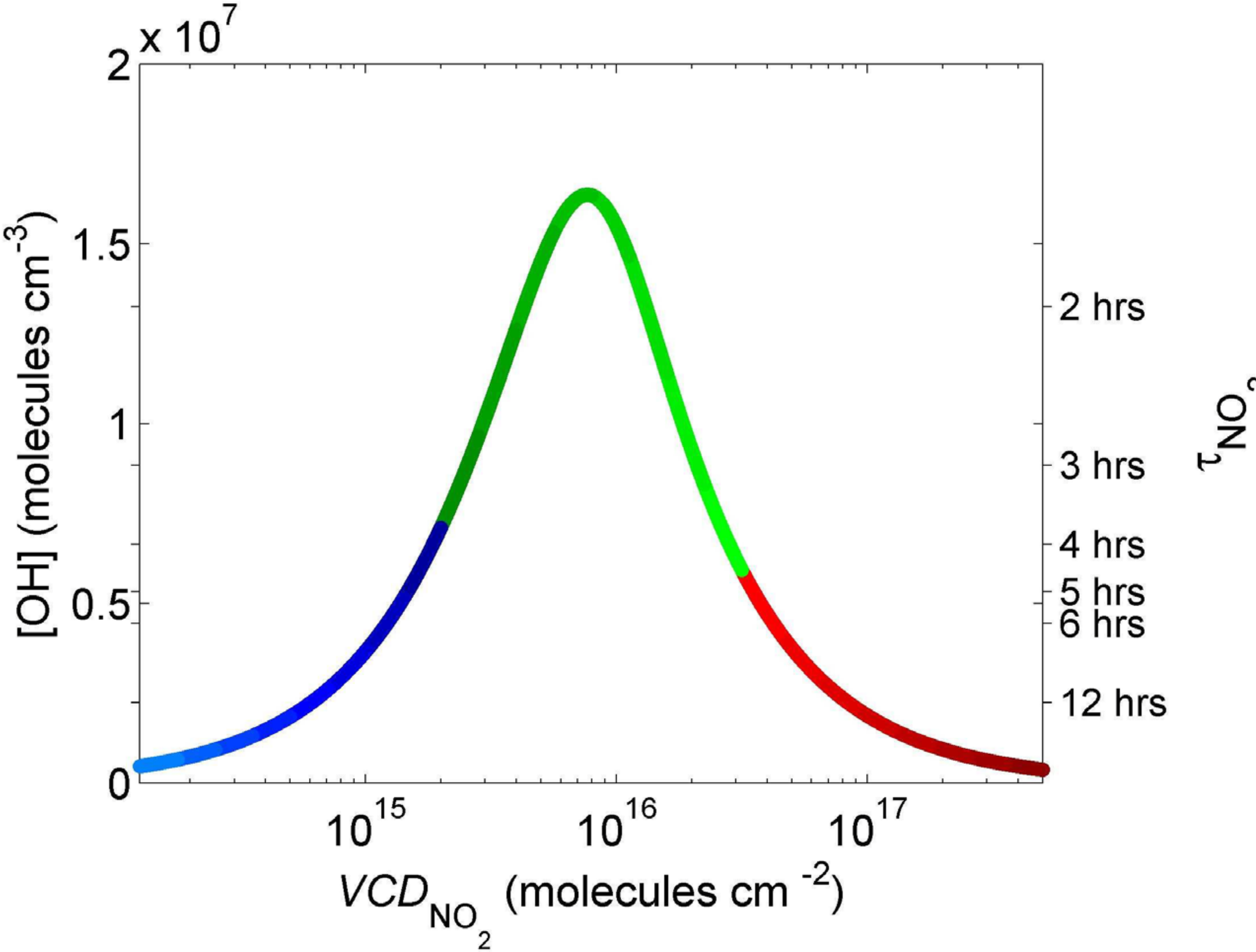
4 and 12 km

48 and 192 km



Thank you!


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



x 10^7
2
1.5
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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

Columns and Mixing ratio

1×10^{15} ~ 400ppt, 1 km PBL

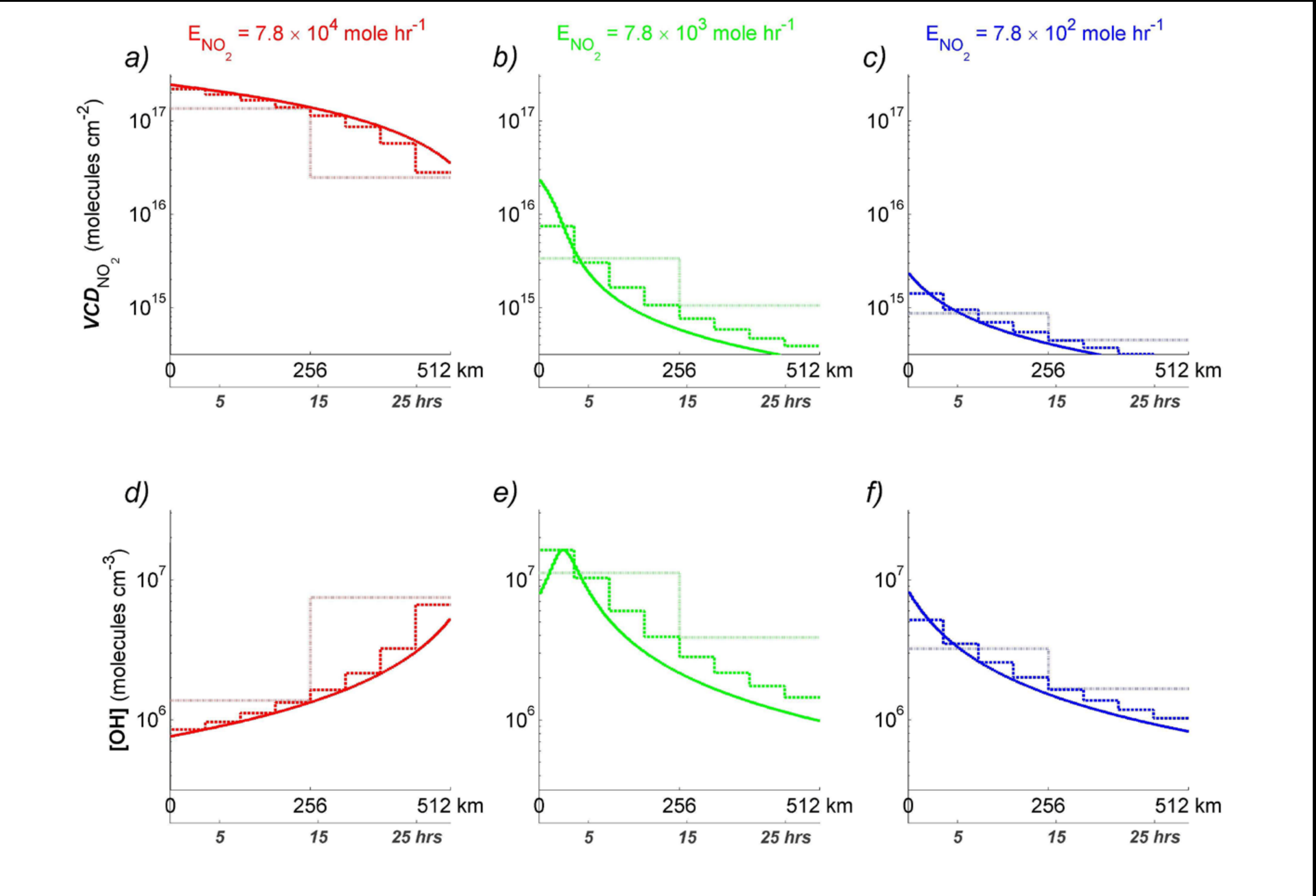
1×10^{16} ~ 4 ppb, 1 km PBL

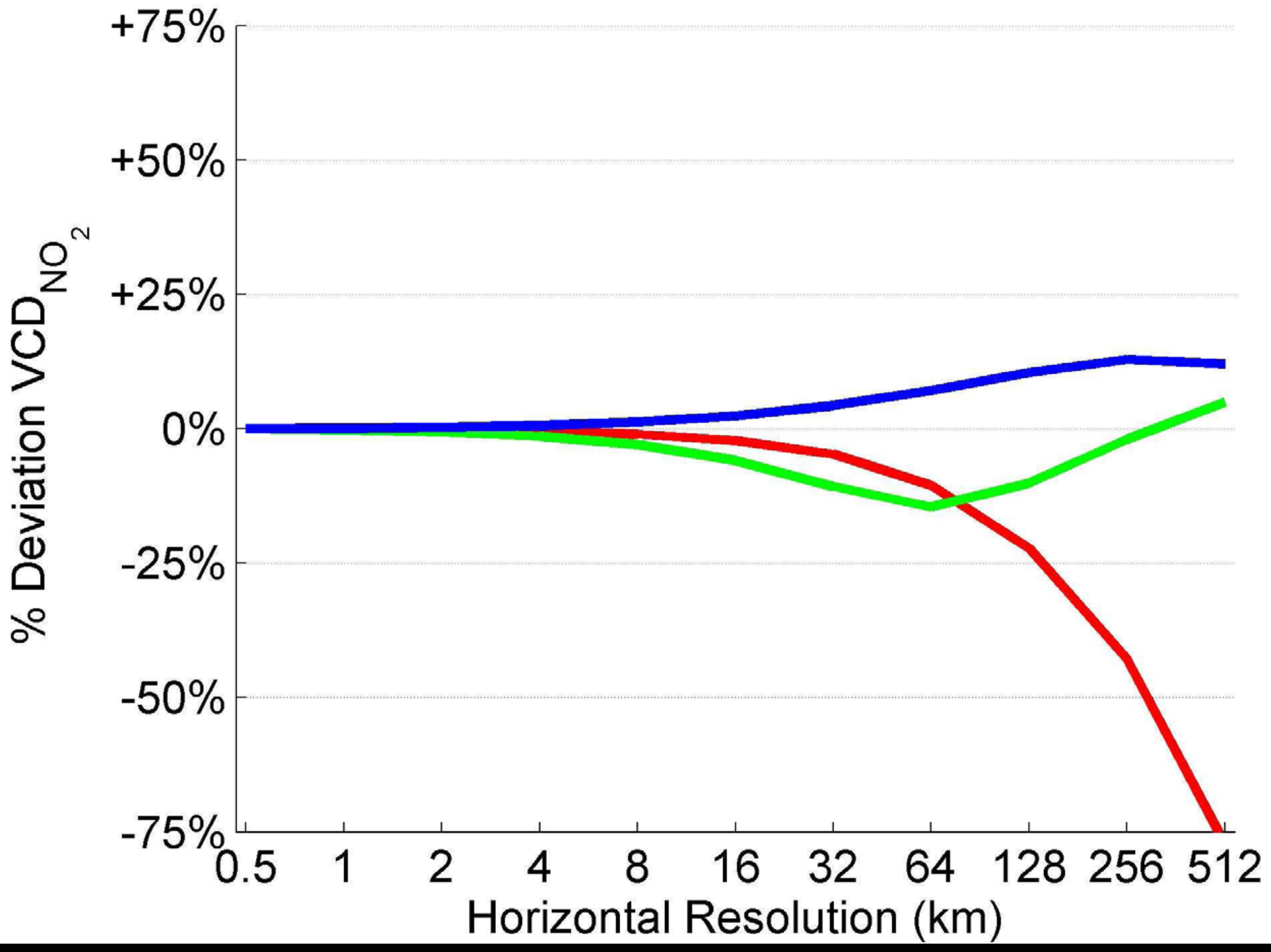
Effects of model spatial resolution on coupling of NO_2 mixing ratio, OH and therefore feedback on the NO_2 lifetime

A plume in 1-d

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

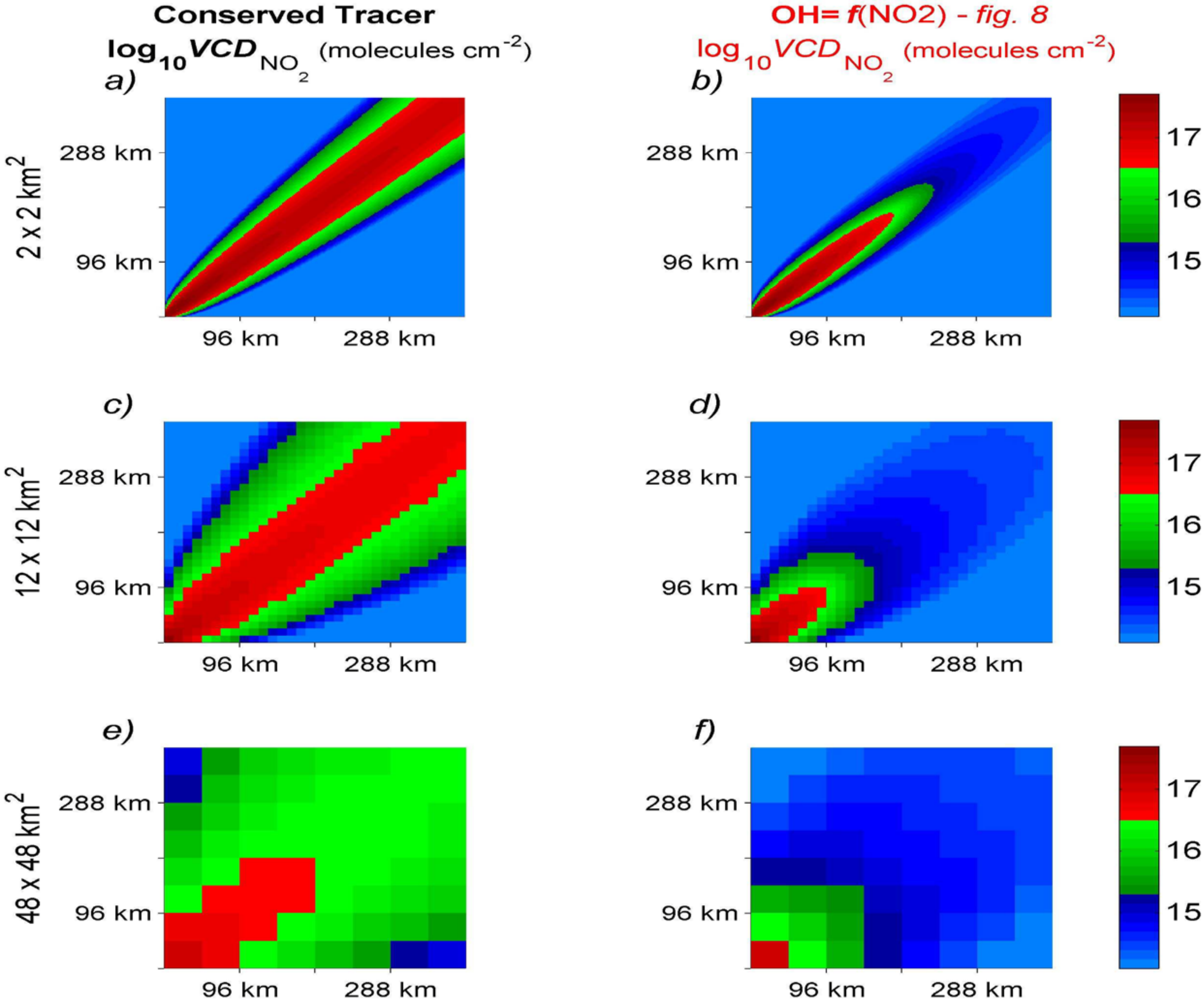
Effects of Spatial resolution of a model



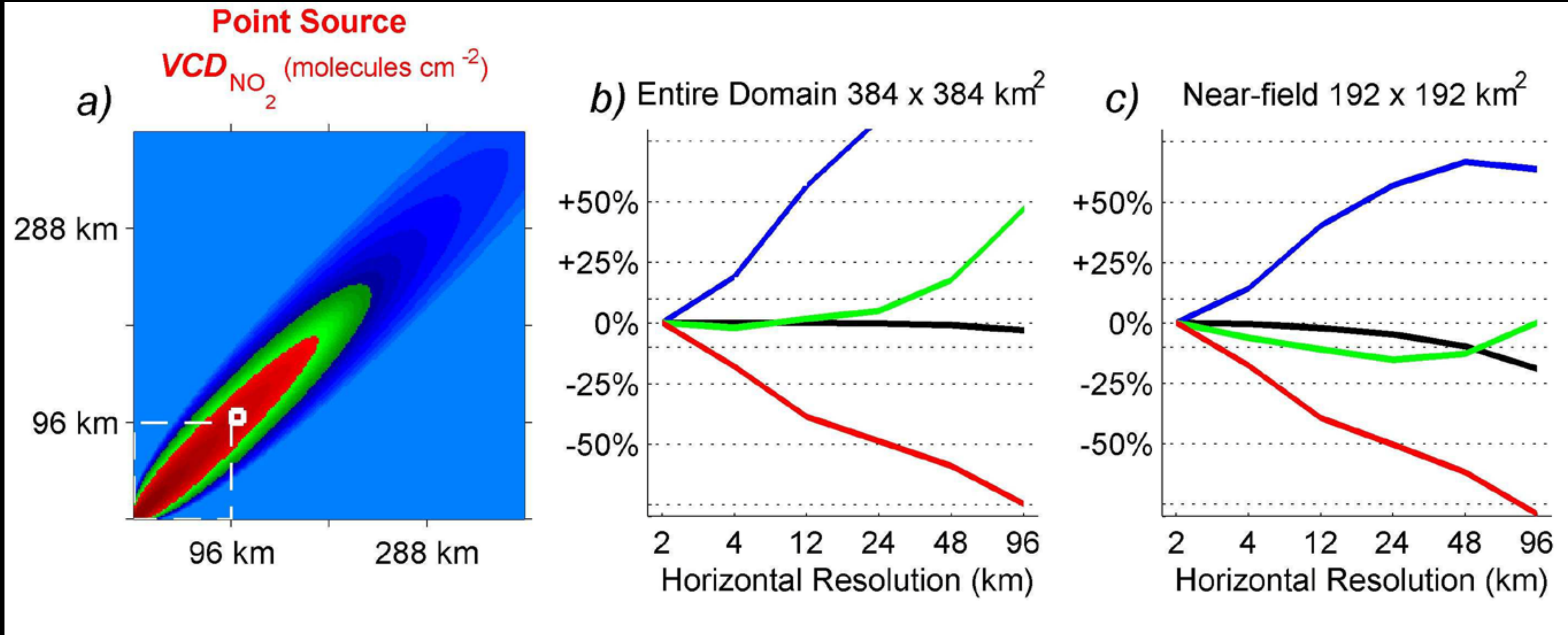


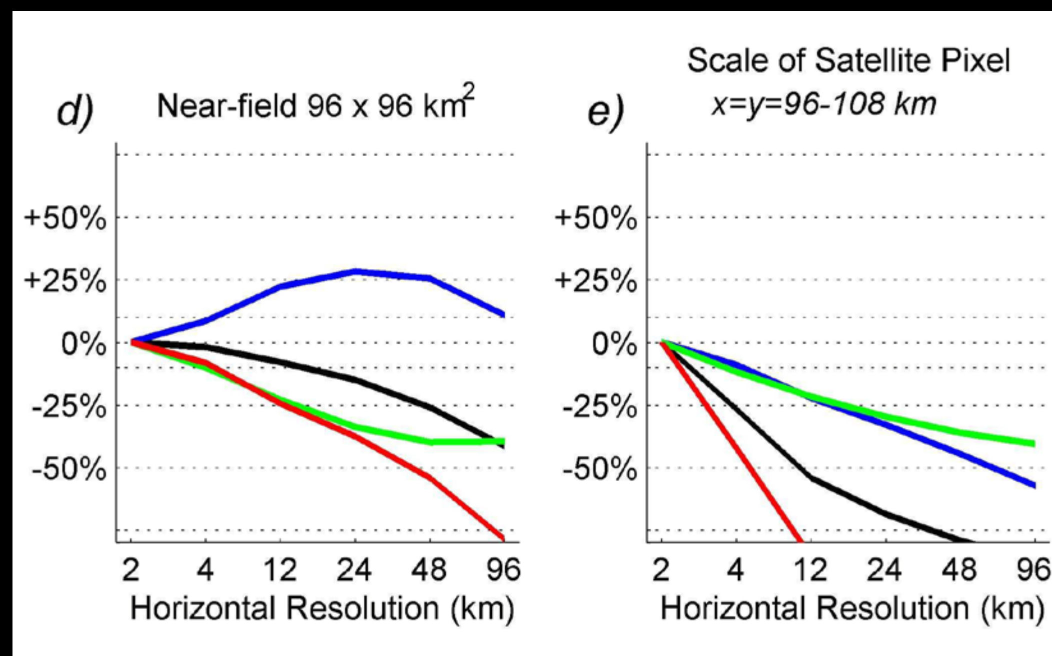
+75%
+50%
+25%
0%
-25%
-50%
-75%
% Deviation VCD_{NO_2}
0.5
1
2
4
8
16
32
64
128
256
512
Horizontal Resolution (km)

A point source in 2-d

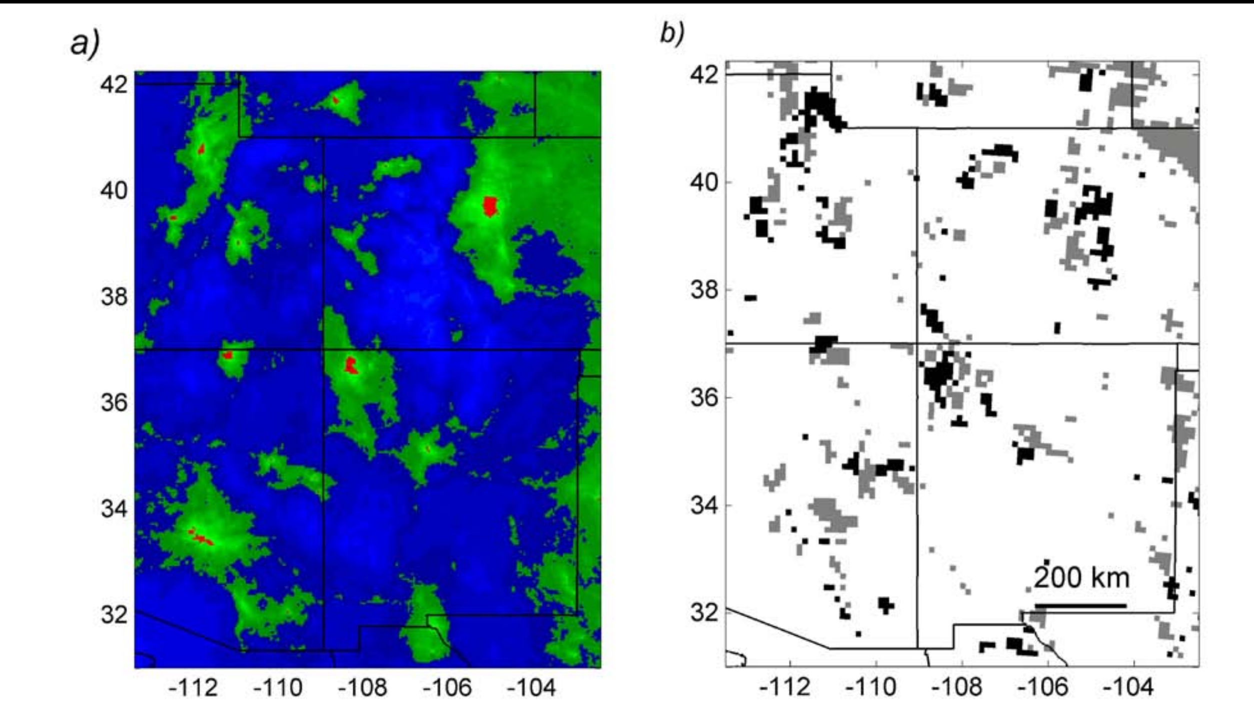


Conserved Tracer
log10 VCD NO2 (molecules cm-2)
OH= f(NO2) - fig. 8
log10 VCD NO2 (molecules cm-2)
a)
b)
c)
d)
e)
f)
2 x 2 km2
12 x 12 km2
48 x 48 km2
288 km
96 km
96 km
288 km
17
16
15



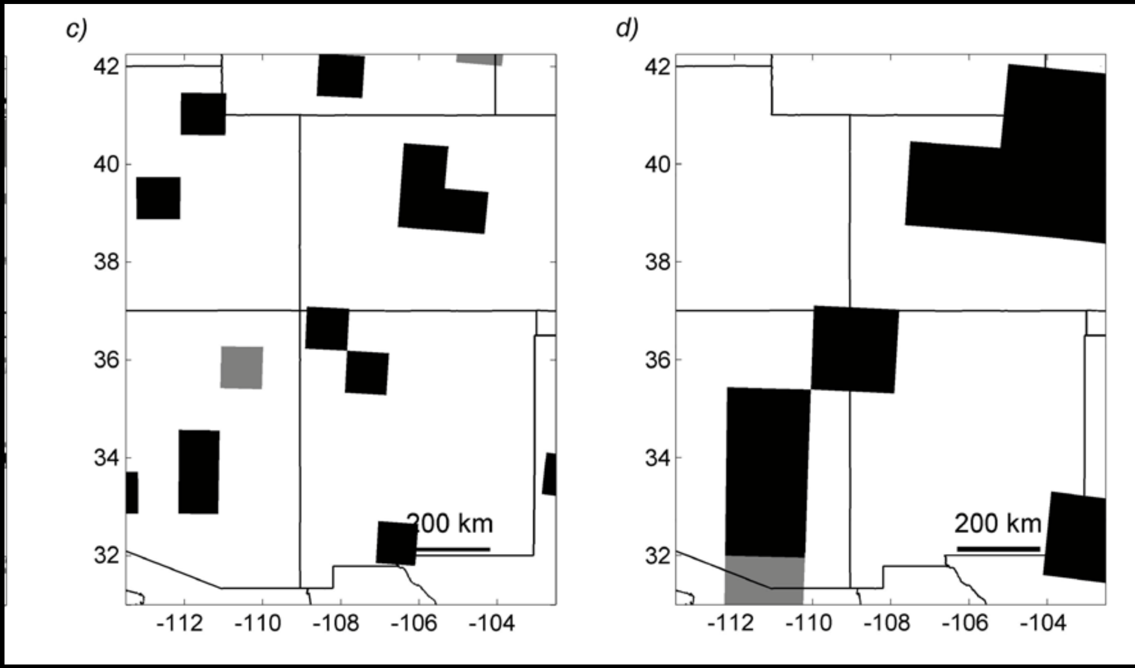


Black
Constant OH
$5 \times 10^6 / cm^3$



4 and 12 km

48 and 192 km



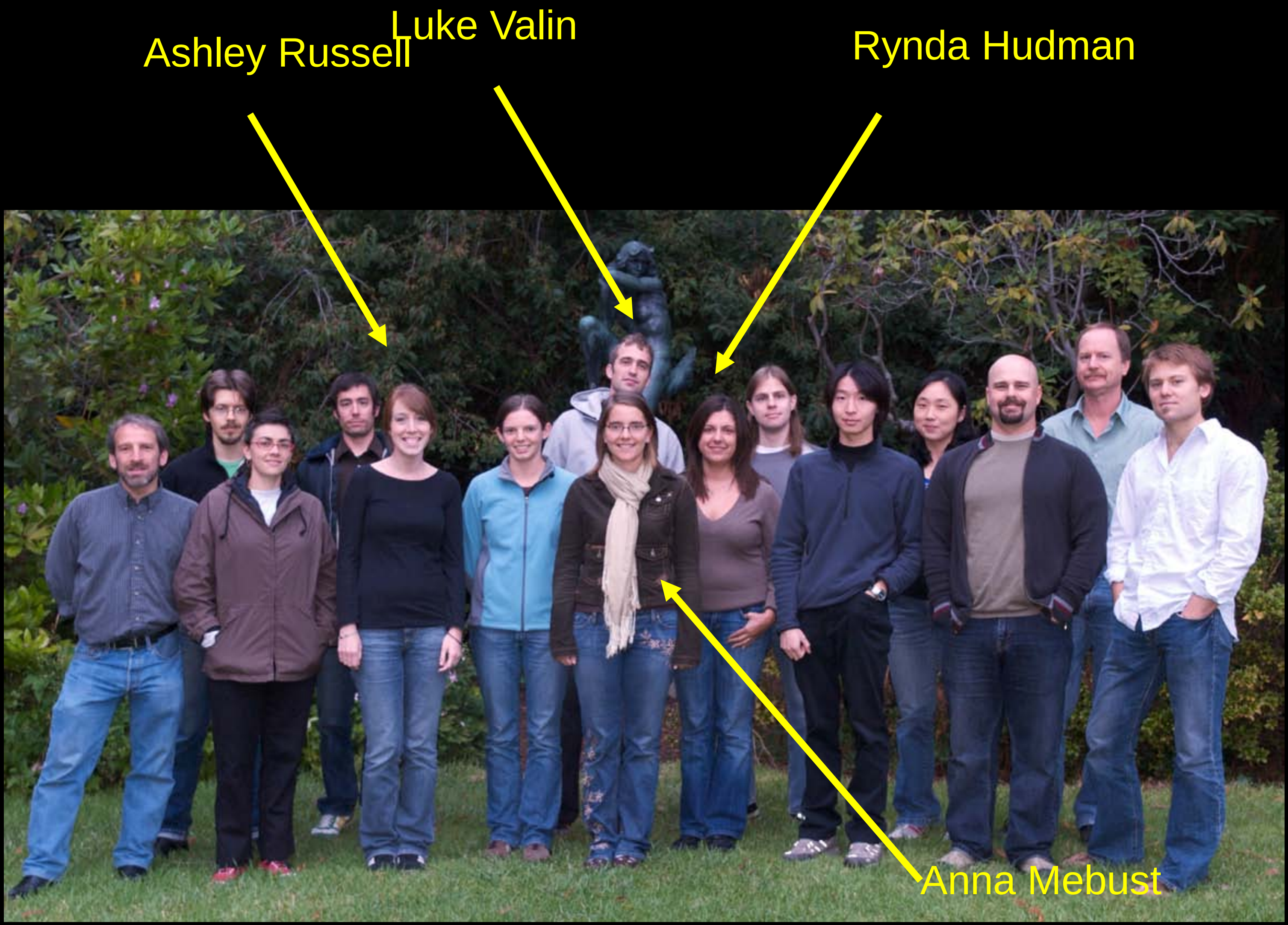
Conclusions

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.


Ashley Russell
Luke Valin
Rynda Hudman
Anna Mebust