High spatial resolution retrievals of NO_2: Insights from OMI

Ronald C. Cohen
UC Berkeley

$$ NASA Aura Science Team,TCP, ESSF

Conclusions

Observations and models at 4 km spatial resolution with hourly repeats will dramatically improve our understanding of mechanisms and processes related to AQ

By the time GEOCAPE is launched we will have an excellent idea of how to build accurate and precise NO_2 products at that resolution.

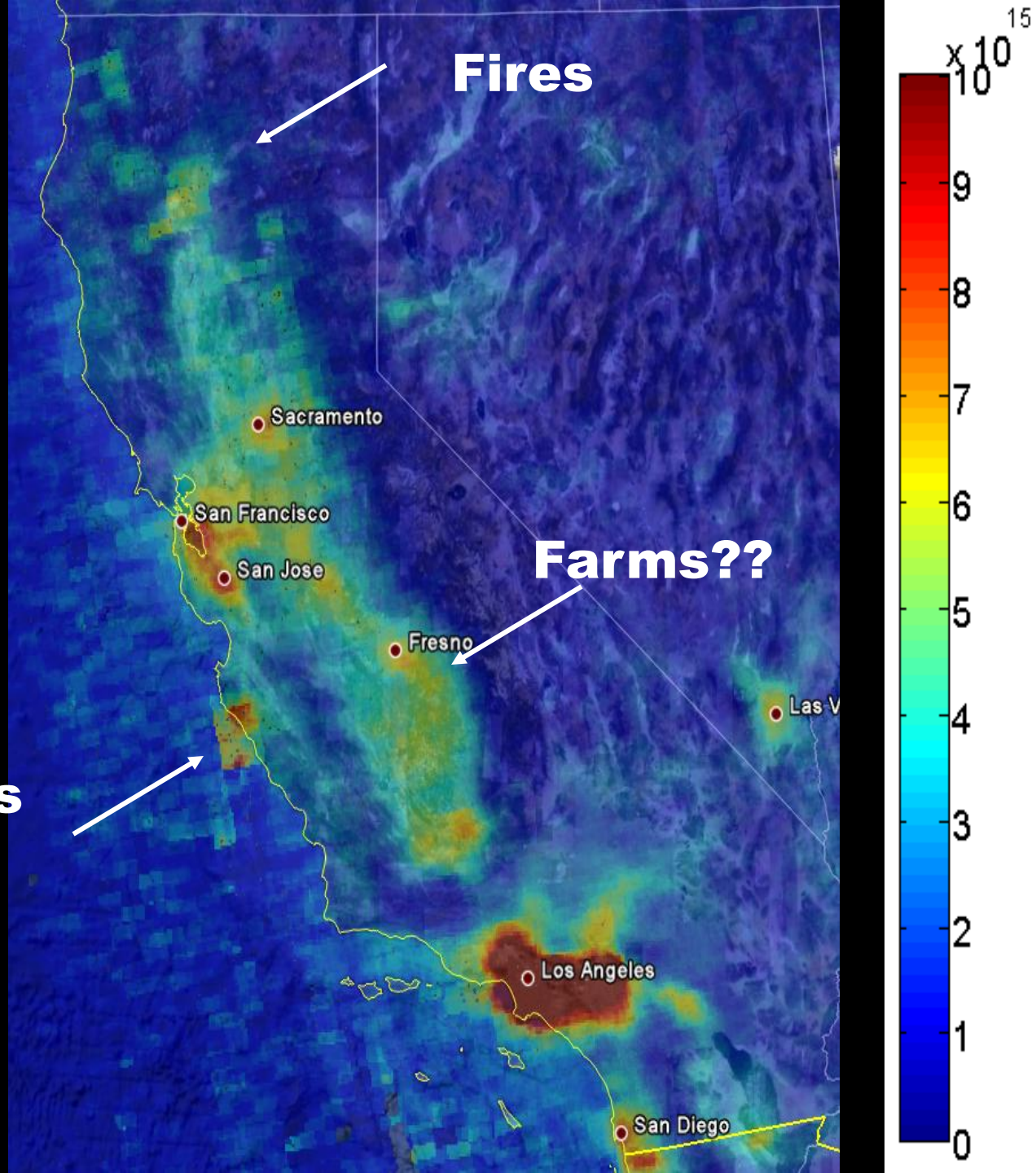
Columns and mole fraction

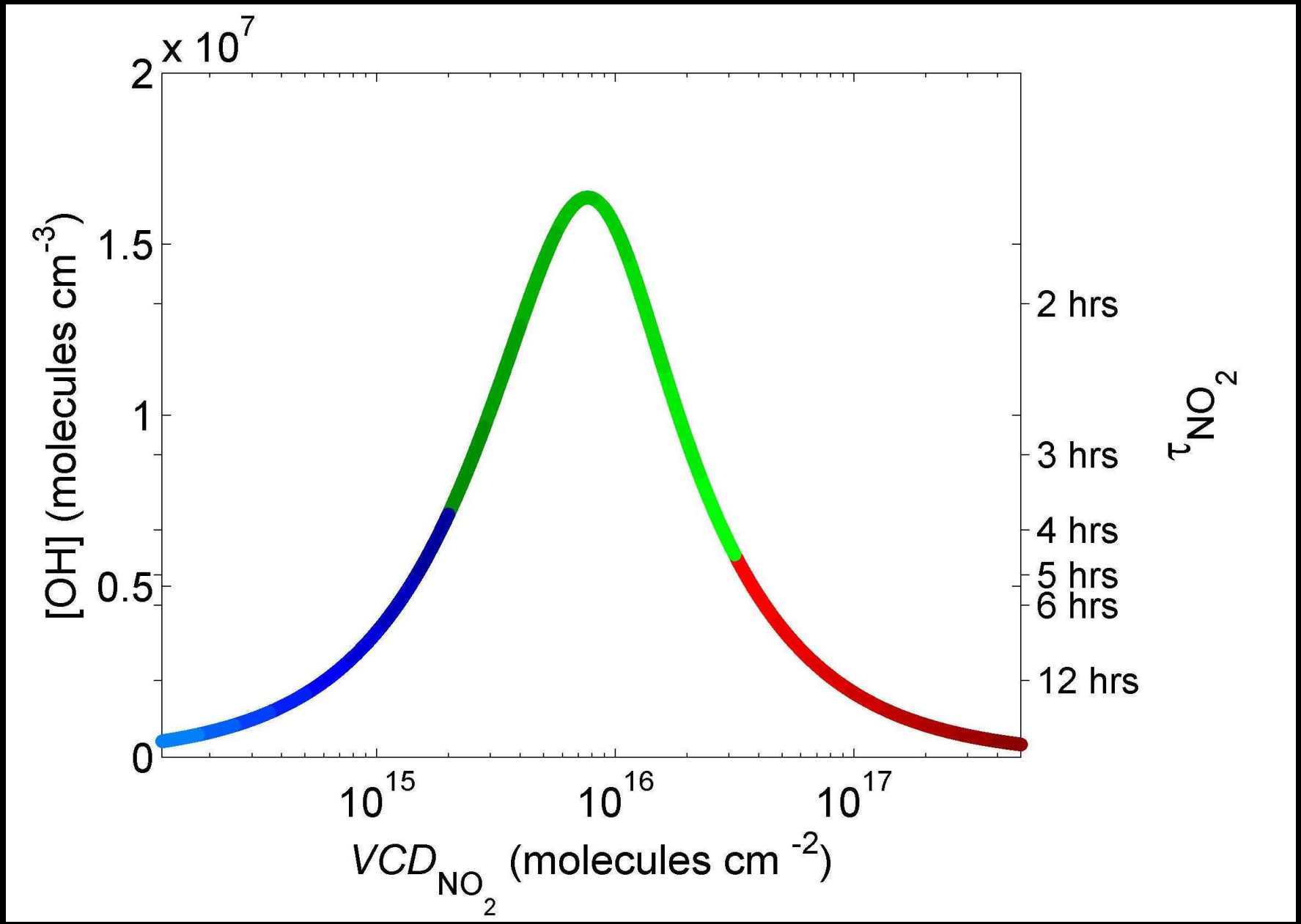
1×10^{15} molecules/cm^2 ~ 400ppt

1×10^{16} molecules/cm^2 ~ 4 ppb

within a 1 km thick well mixed boundary layer

2008 summer weekday



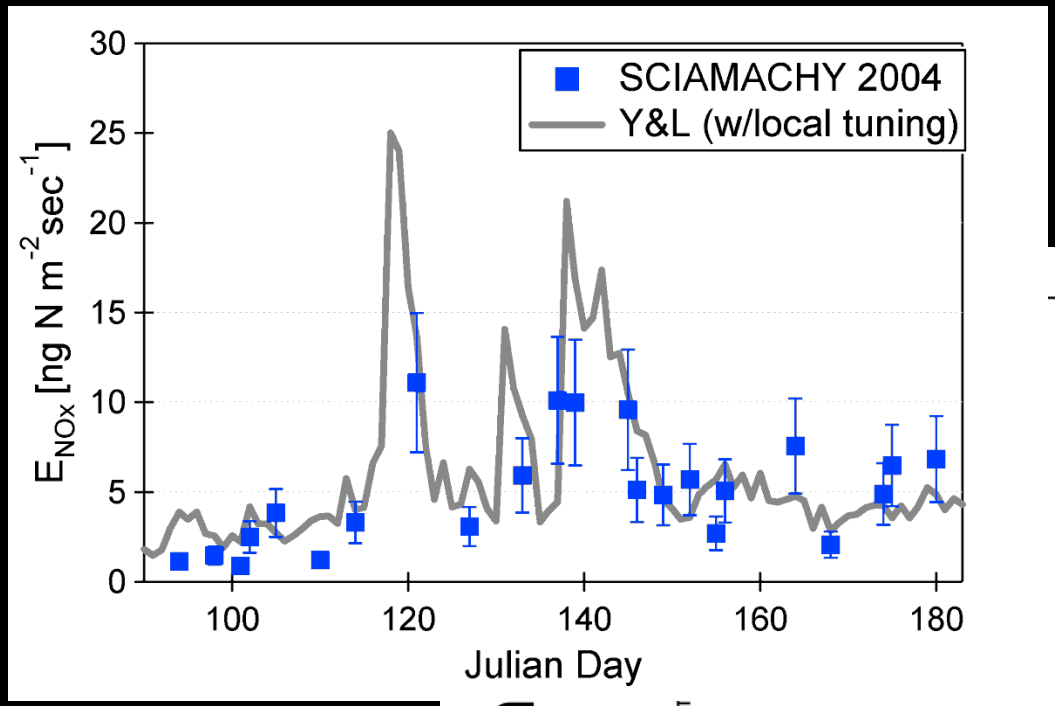

x 10^7
2
1.5
1
0.5
0
[OH] (molecules cm^-3)
10^15
10^16
10^17
VCD_NO2 (molecules cm^-2)
2 hrs
3 hrs
4 hrs
5 hrs
6 hrs
12 hrs
τ_NO2

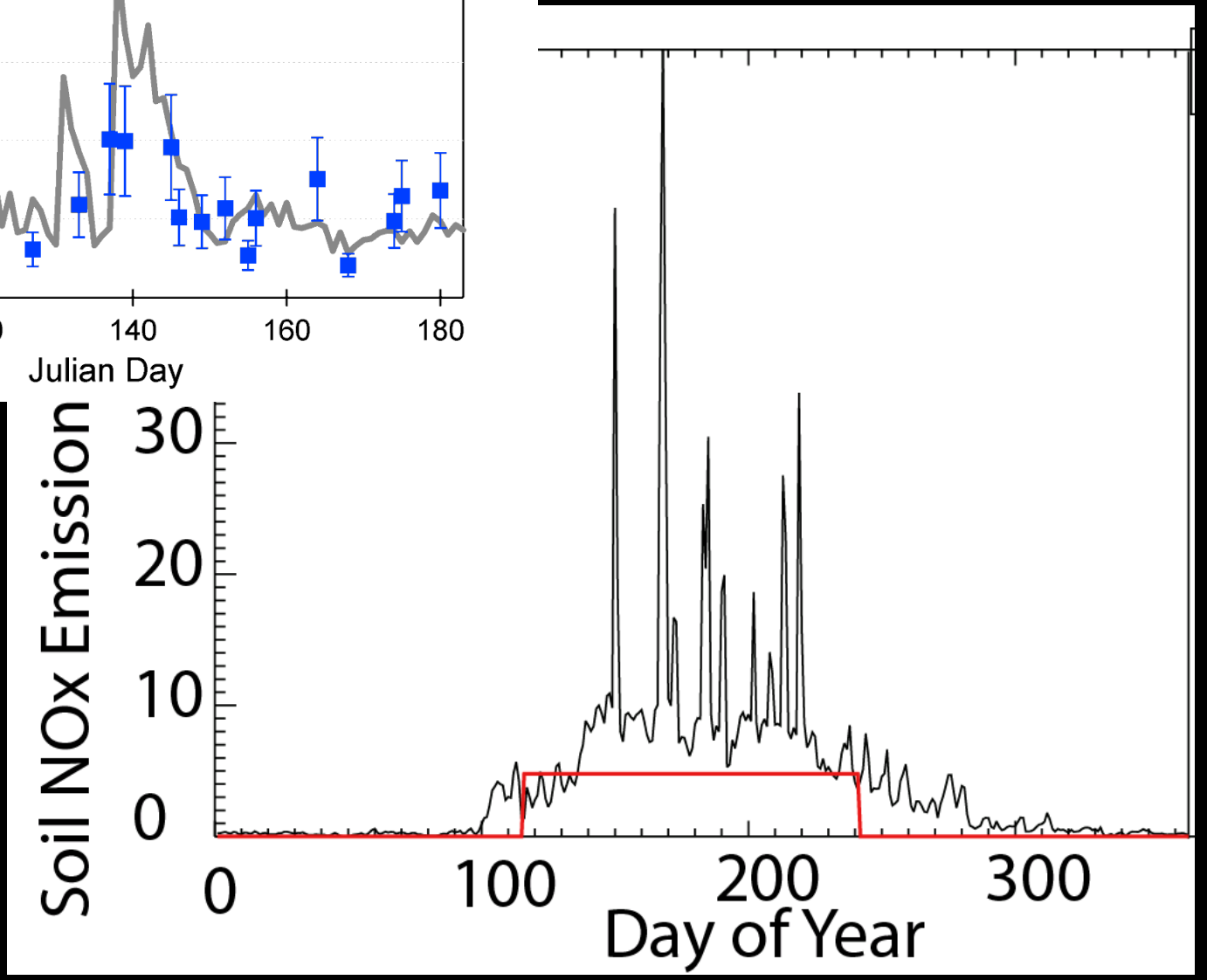
My goals for GEOCAPE Science

Observations that will change our understanding of mechanisms and processes affecting AQ

R.C. Hudman, et al. *Interannual variation in soil NOx emissions observed from Space* ACP, 10, 9943-9952, 2010.

T.H. Bertram, et al., *Satellite measurements of daily variations in soil NO_x emissions*, Geophys. Res. Lett. 2005

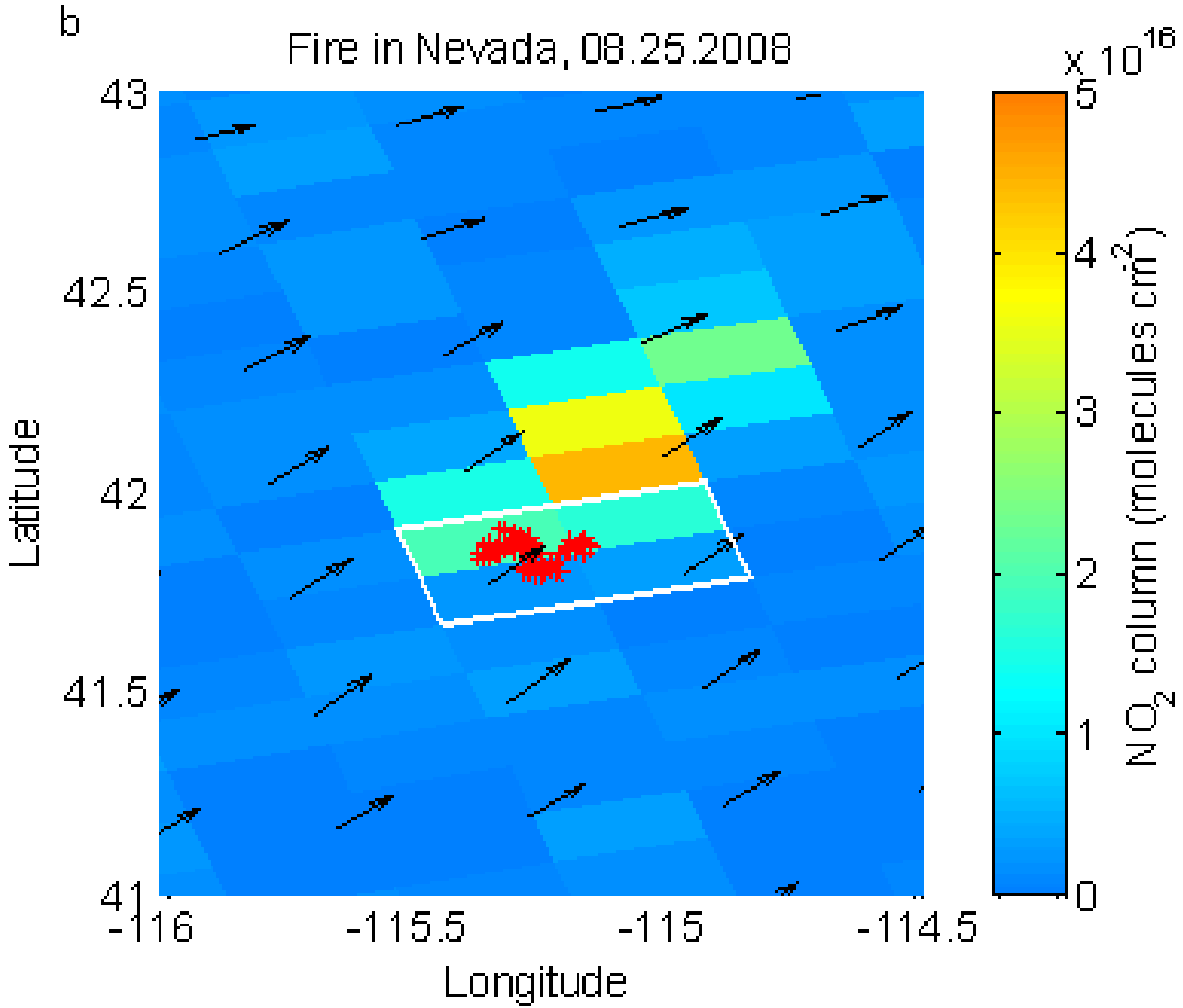

SCIAMACHY 2004
Y&L (w/local tuning)
E_{NOx} [ng N m^{-2} sec^{-1}]
Julian Day
0
5
10
15
20
25
30
100
120
140
160
180

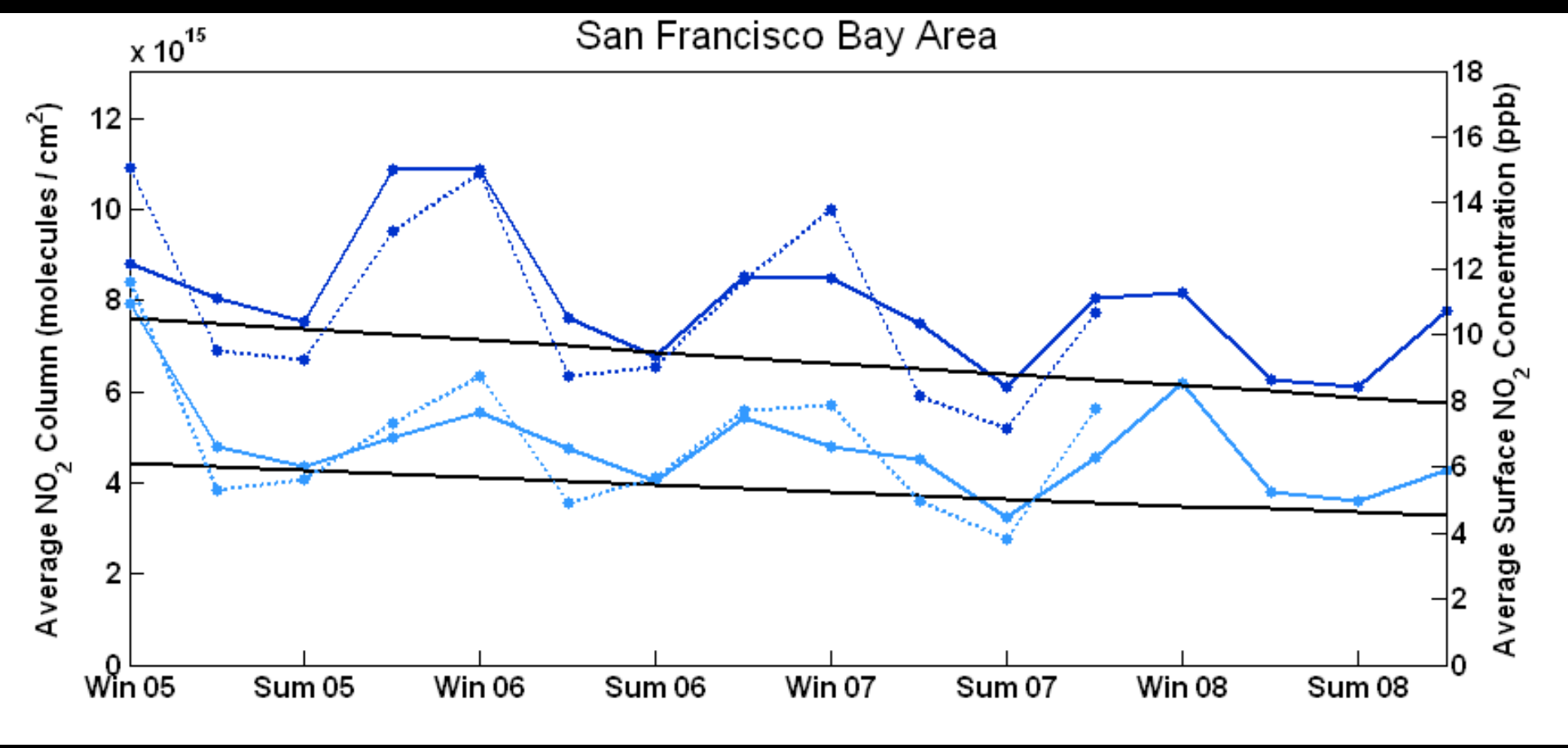

Soil NOx Emission
Day of Year
0
10
20
30
0
100
200
300

A. Mebust, et al.

Characterization of wildfire NO_x emissions using MODIS fire radiative power and OMI tropospheric NO_2 columns

submitted to ACP


b
Fire in Nevada, 08.25.2008
43
42.5
42
41.5
41
Latitude
-116
-115.5
-115
-114.5
Longitude
x 10^16
5
4
3
2
1
0
NO2 column (molecules cm^-2)



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

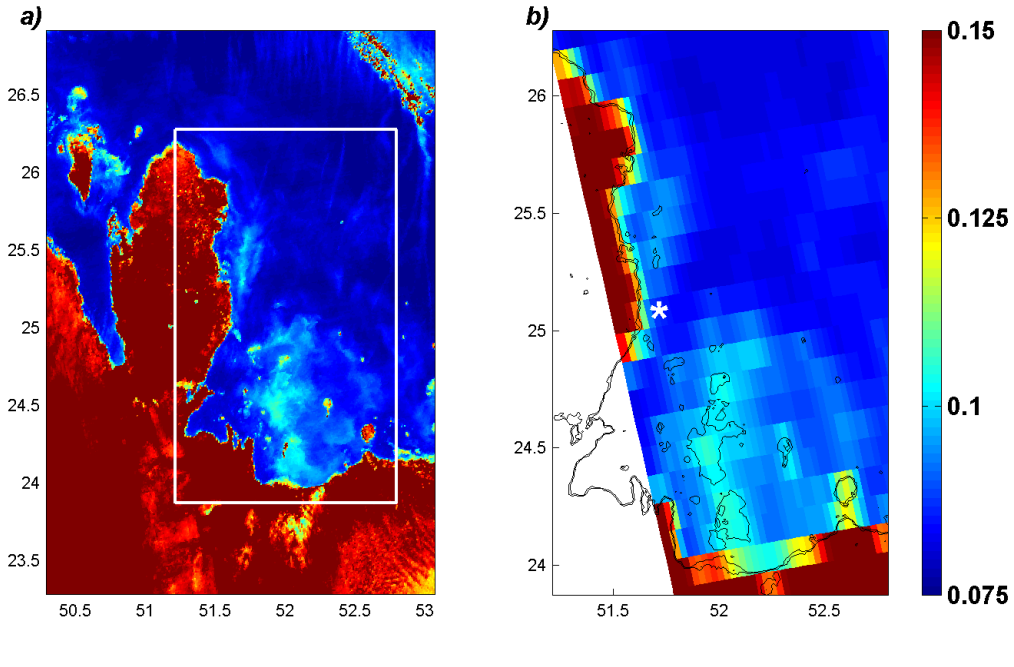
On spatial resolution of observations, retrievals and models

Observation of slant column NO_2 using the super-zoom mode of AURA OMI
Atmos. Meas. Tech. Disc. 4, 1989-2005, 2011

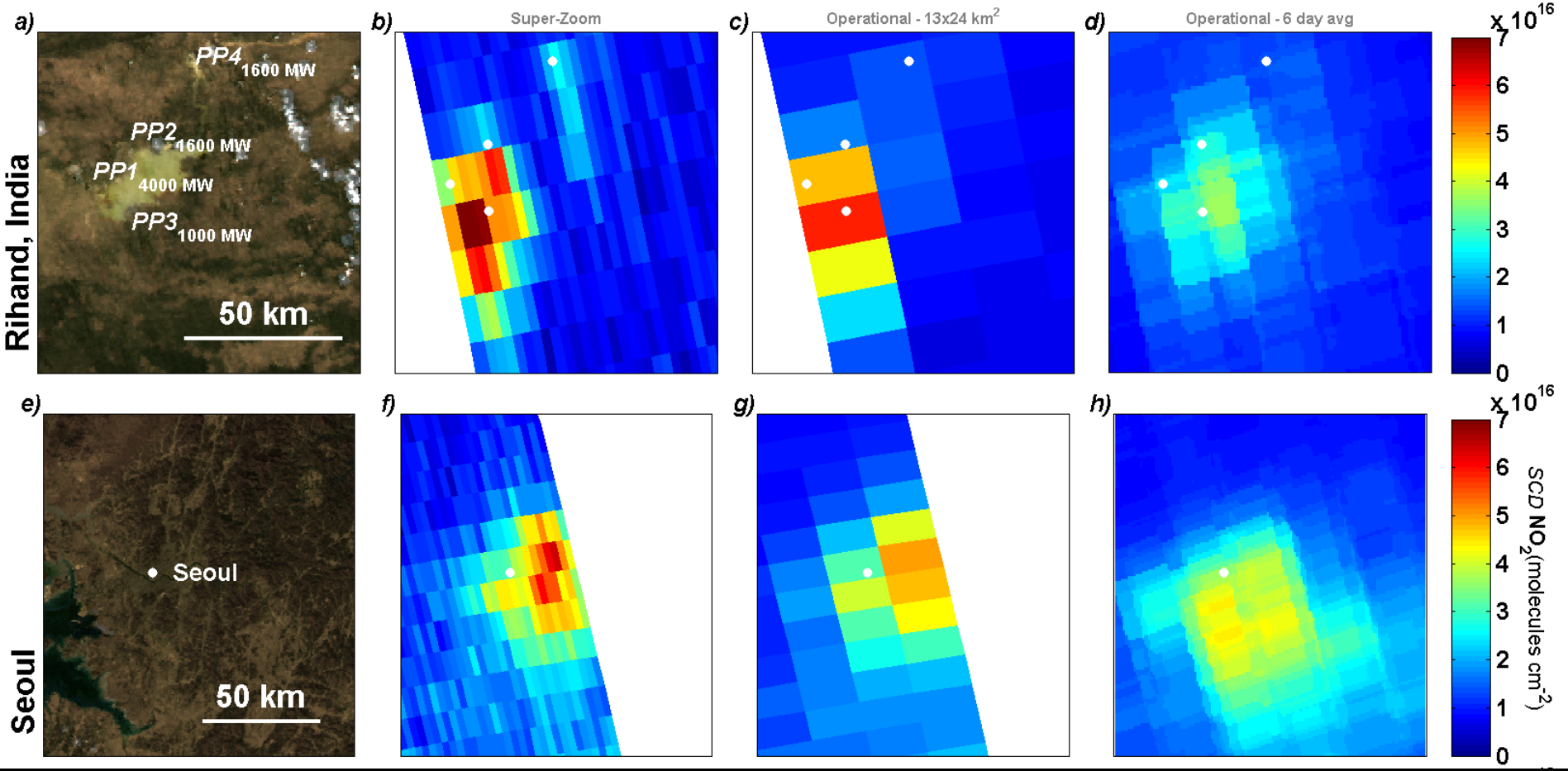
***A high spatial resolution retrieval of NO_2 column densities from OMI: Method and Evaluation*,**
Atmos. Chem. Phys. Disc. 11, 12411-12440, 2011

***Effects of model spatial resolution on the interpretation of satellite NO_2 observations*,**
submitted to Atmos. Chem. Phys. Disc.

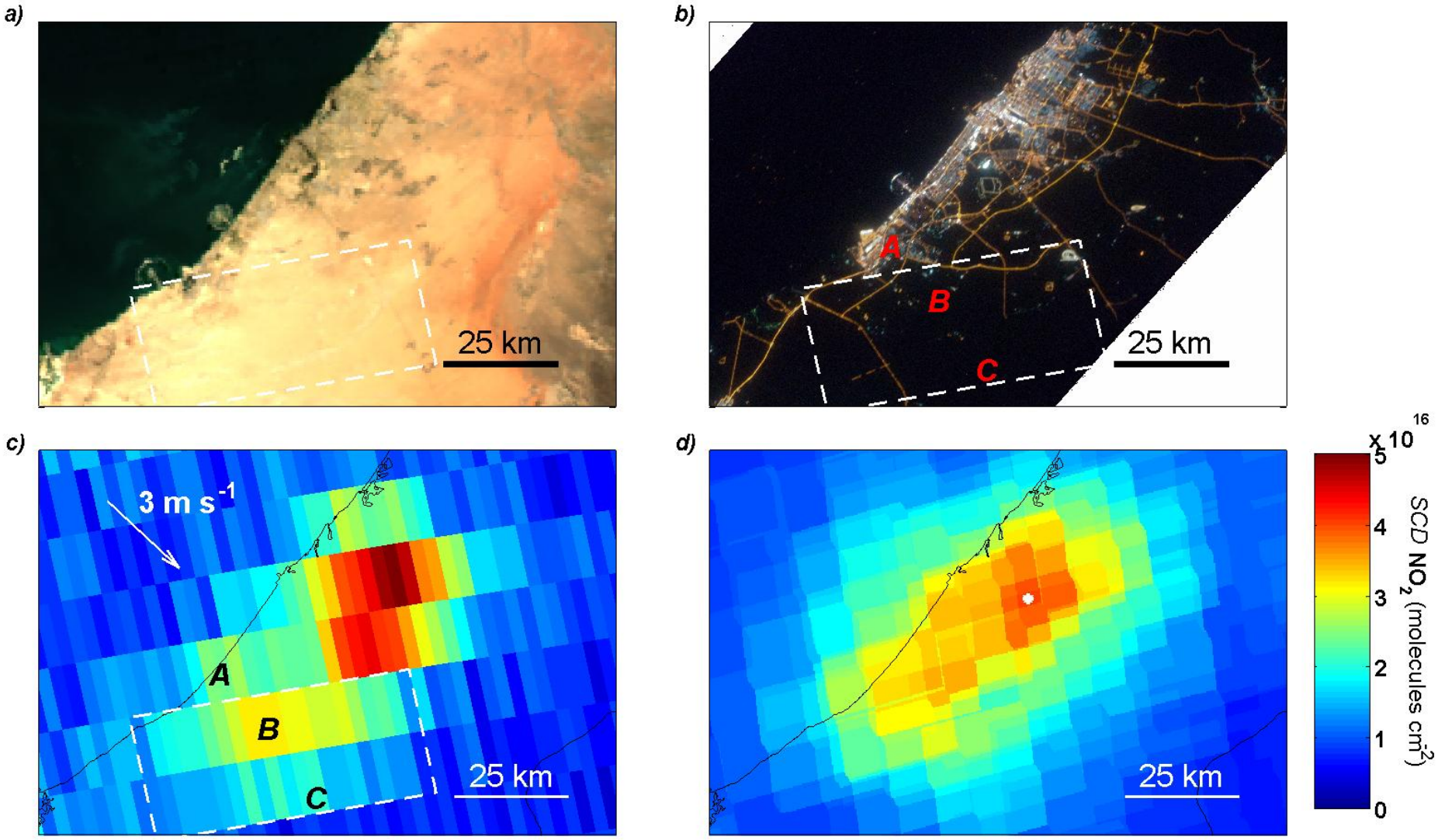
Top-of-Atmosphere Reflectance MODIS (500 m) vs OMI (7 km fwhm on-ground)



NO_2 Slant Column



Dubai – Lifetime from gradient; Downtown plume (NE) vs Port (SW)

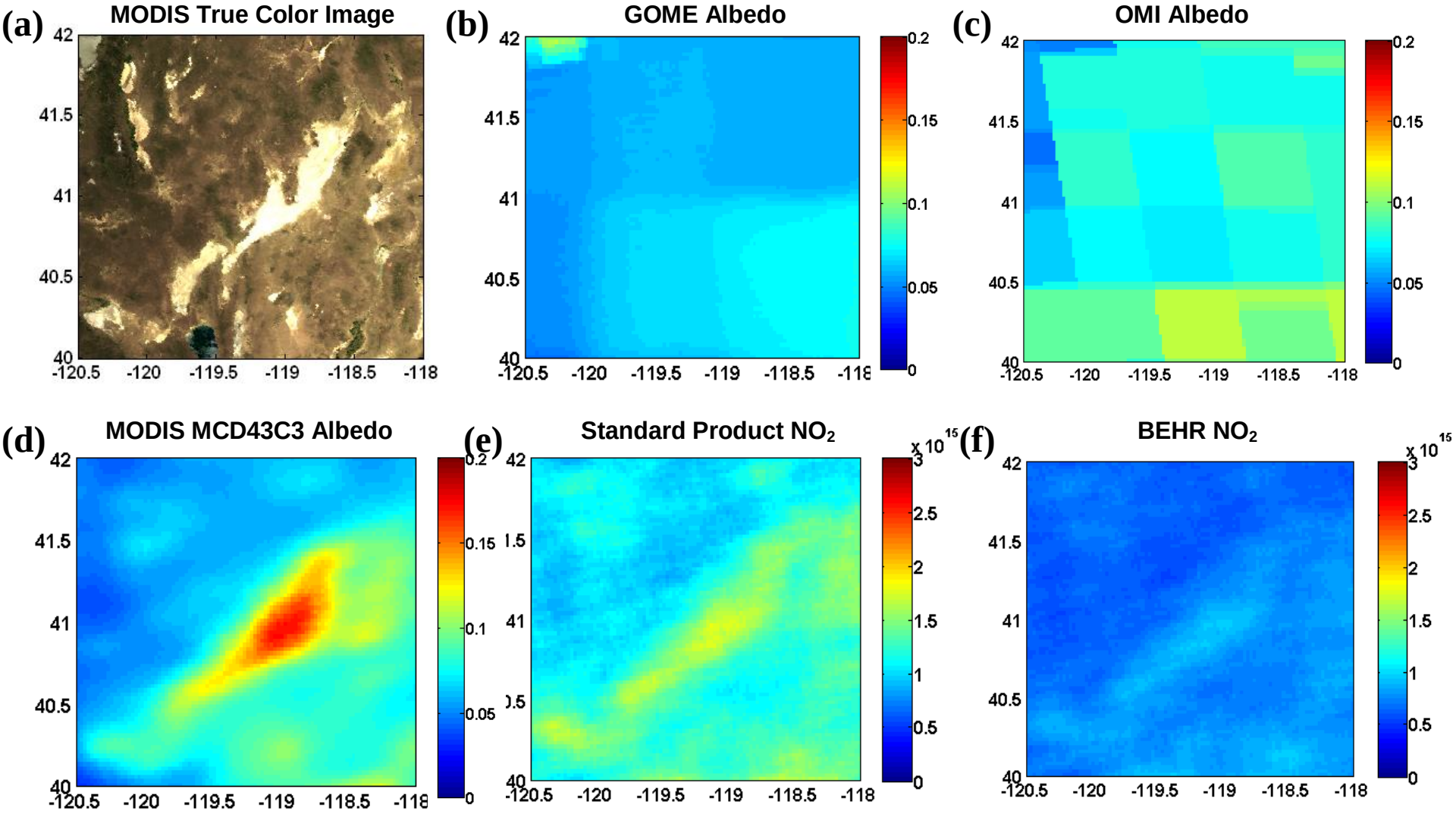


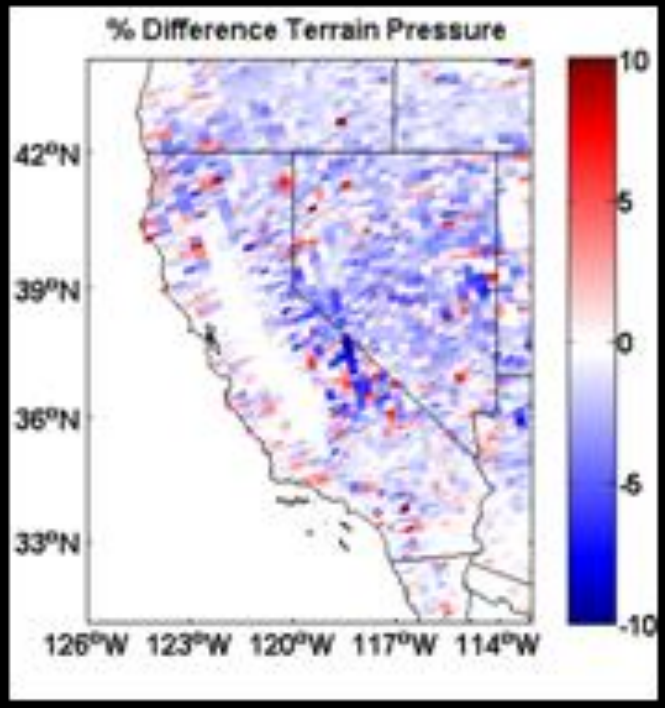
On spatial resolution of observations, retrievals and models

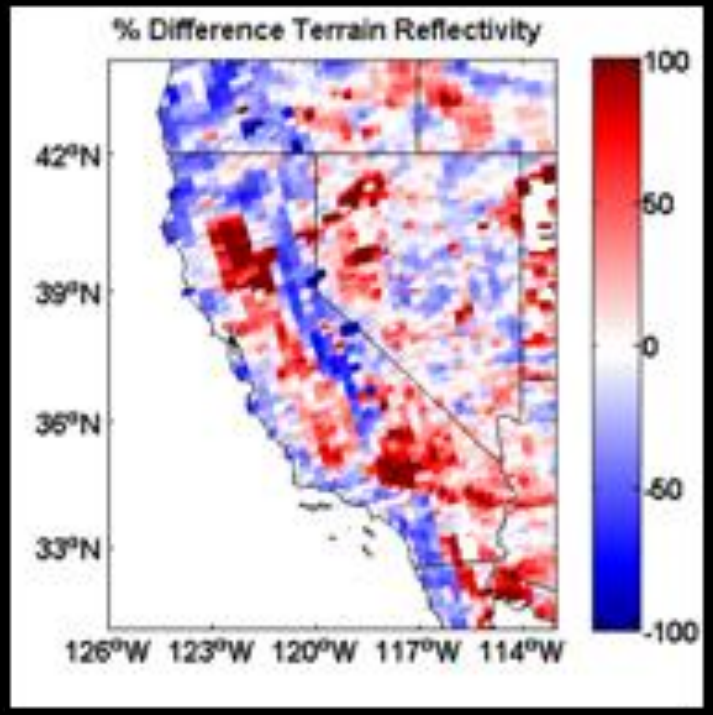
Observation of slant column NO_2 using the super-zoom mode of AURA OMI
Atmos. Meas. Tech. Disc. 4, 1989-2005, 2011

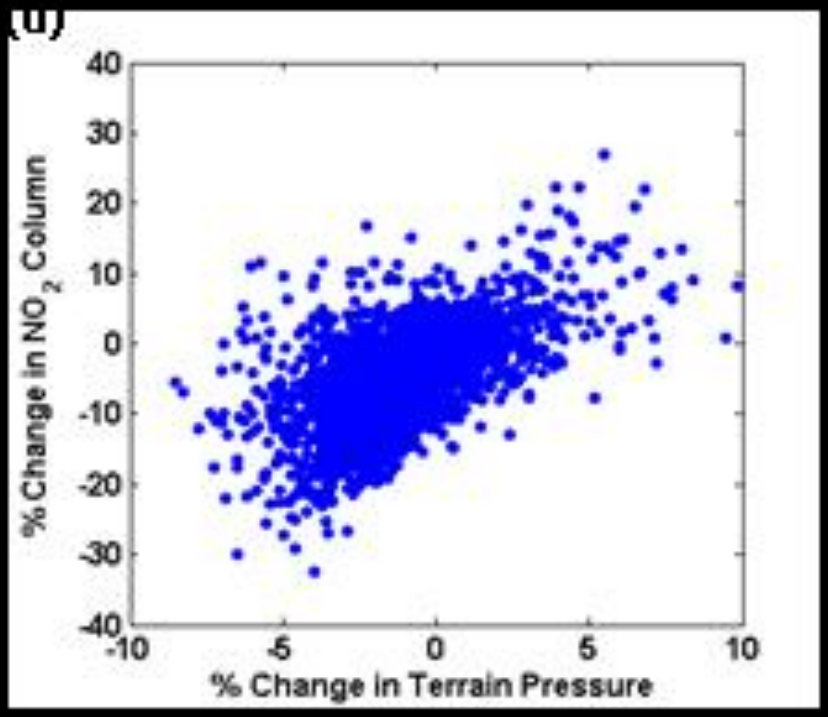
A high spatial resolution retrieval of NO_2 column densities from OMI: Method and Evaluation,
Atmos. Chem. Phys. Disc. 11, 12411-12440, 2011

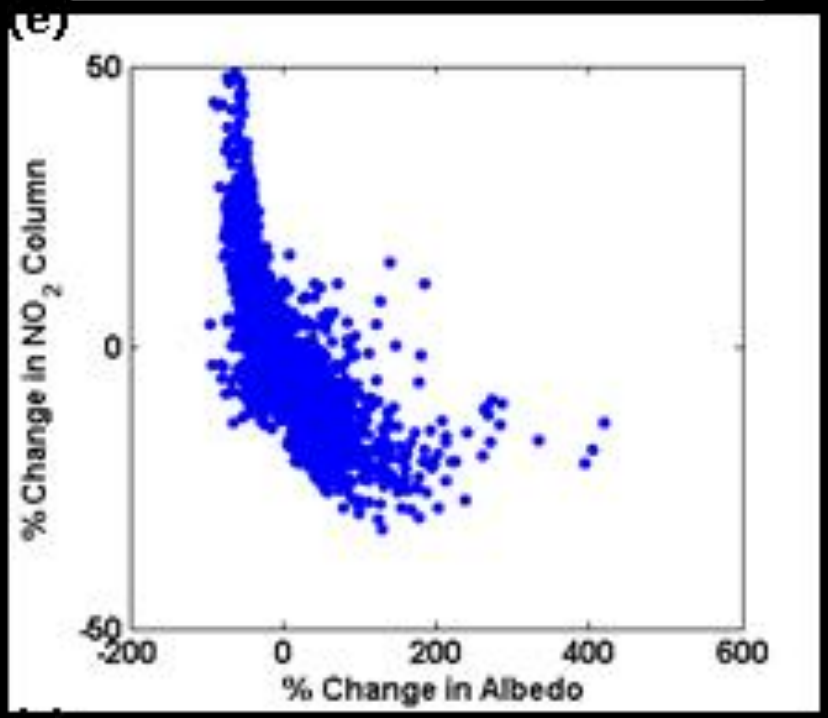
Effects of model spatial resolution on the interpretation of satellite NO_2 observations,
submitted to Atmos. Chem. Phys. Disc.


(a)
MODIS True Color Image
(b)
GOME Albedo
(c)
OMI Albedo
(d)
MODIS MCD43C3 Albedo
(e)
Standard Product NO2
(f)
BEHR NO2
x 10^15
42
41.5
41
40.5
40
-120.5
-120
-119.5
-119
-118.5
-118
0.2
0.15
0.1
0.05
0
3
2.5
2
1.5
1
0.5

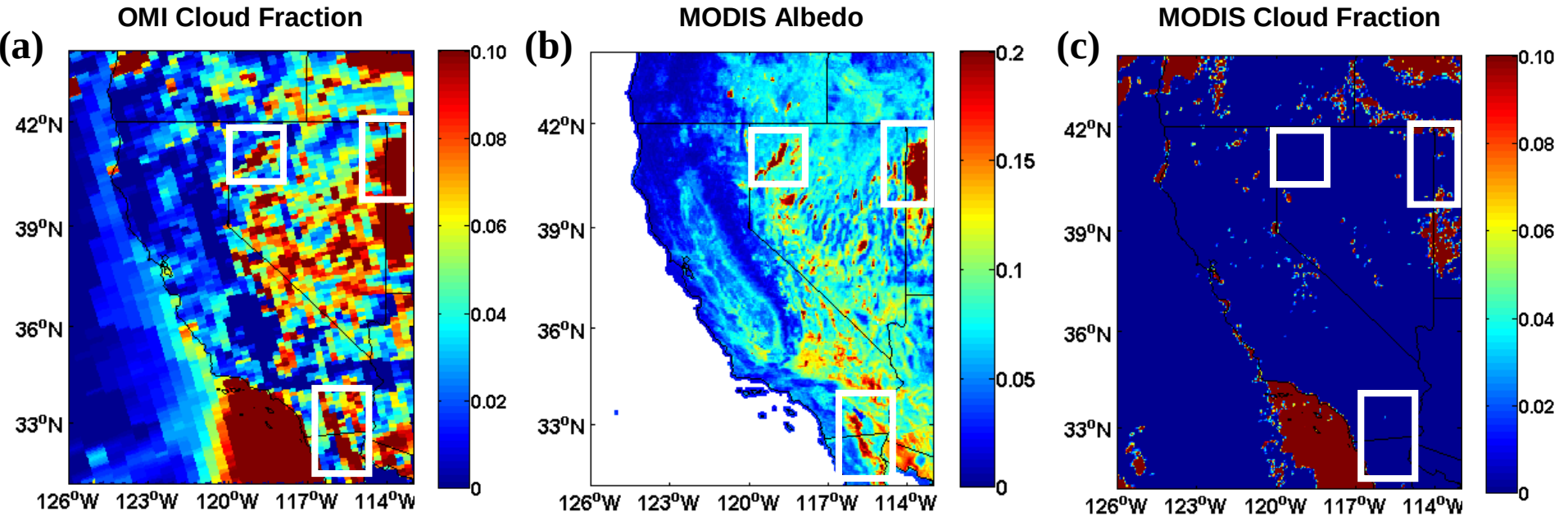

% Difference Terrain Pressure
42°N
39°N
36°N
33°N
126°W 123°W 120°W 117°W 114°W
10
5
0
-5
-10


% Difference Terrain Reflectivity
42°N
39°N
36°N
33°N
126°W 123°W 120°W 117°W 114°W
100
50
0
-50
-100


(d)
% Change in NO2 Column
% Change in Terrain Pressure
40
30
20
10
0
-10
-20
-30
-40
-10
-5
0
5
10


(e)
% Change in NO2 Column
% Change in Albedo
50
0
-50
-200
0
200
400
600

Clouds and Albedo



Correlations with aircraft NO_2 observations

	OMI cloud fraction < 20%	MODIS cloud fraction = 0%
Standard Product	$y = 0.99x + 4 \quad 10^{14}$ $R^2 = 0.72$	$y = 1.04x + 5 \quad 10^{14}$ $R^2 = 0.86$
DOMINO	$y = 1.78x - 1 \quad 10^{15}$ $R^2 = 0.65$	$y = 1.70x - 5 \quad 10^{13}$ $R^2 = 0.83$
BEHR	**$y = 0.96x - 5 \quad 10^{14}$** **$R^2 = 0.83$**	**$y = 1.03x - 1 \quad 10^{14}$** **$R^2 = 0.91$**

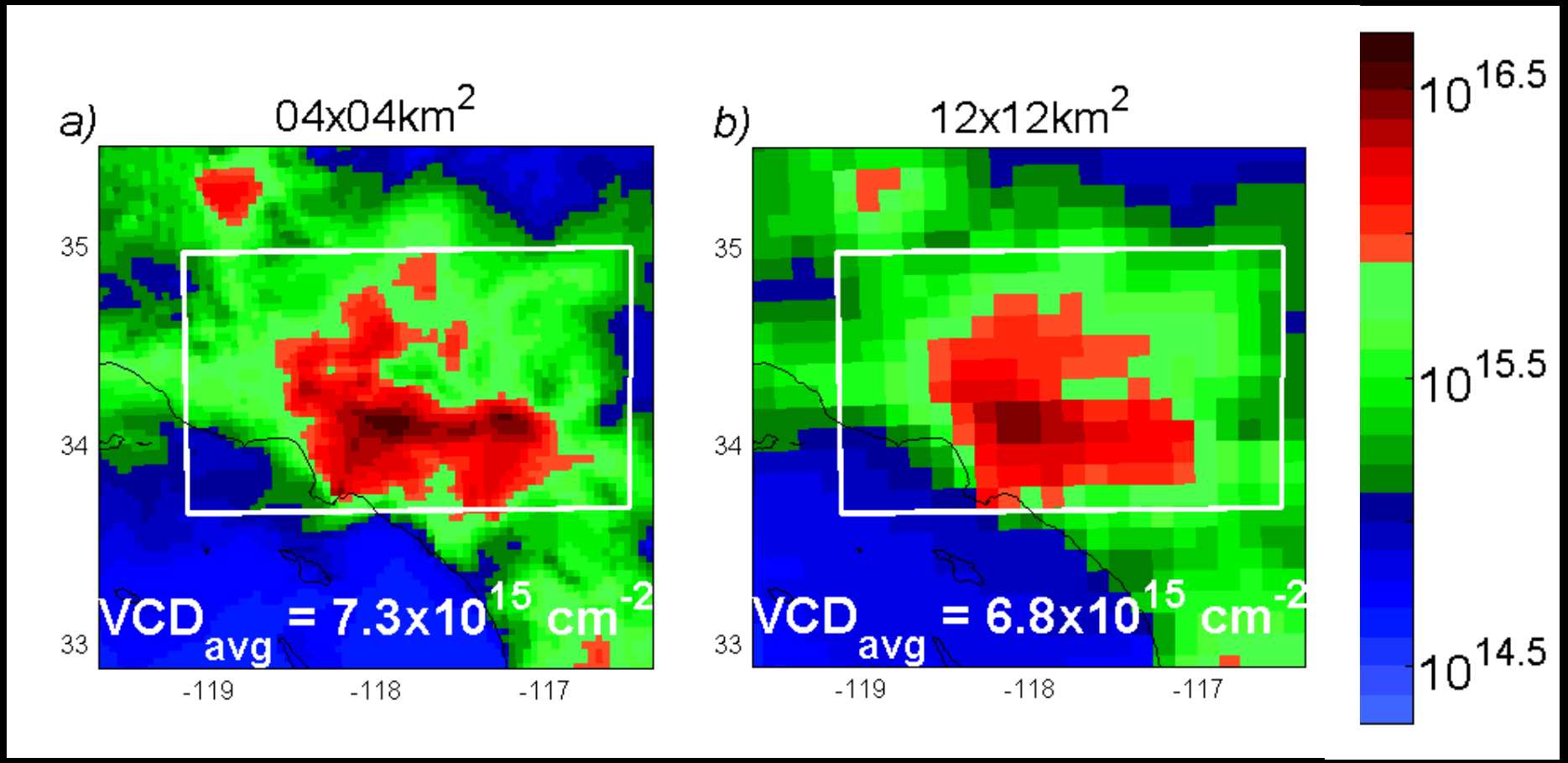
On spatial resolution of observations, retrievals and models

Observation of slant column NO_2 using the super-zoom mode of AURA OMI
Atmos. Meas. Tech. Disc. 4, 1989-2005, 2011

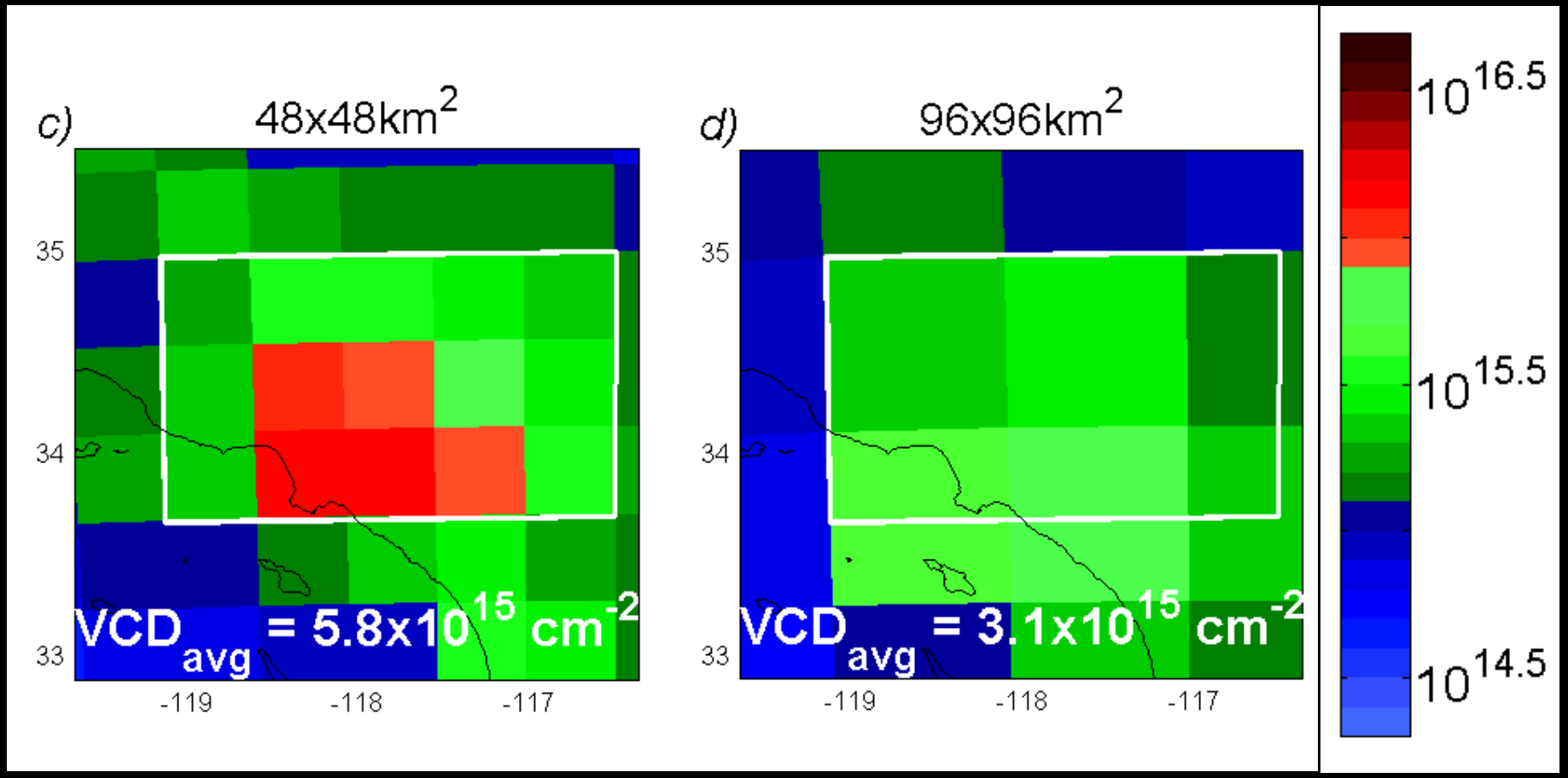
***A high spatial resolution retrieval of NO_2 column densities from OMI: Method and Evaluation*,**
Atmos. Chem. Phys. Disc. 11, 12411-12440, 2011

***Effects of model spatial resolution on the interpretation of satellite NO_2 observations*,**
submitted to Atmos. Chem. Phys. Disc.

Effects of model resolution on NO_2 Columns—Los Angeles



Effects of model resolution on NO_2 Columns—Los Angeles



Conclusions

Observations and models at 4 km spatial resolution with hourly repeats will dramatically improve our understanding of mechanisms and processes related to AQ

By the time GEOCAPE is launched we will have an excellent idea of how to build accurate and precise NO_2 products at that resolution.

Acknowledgments