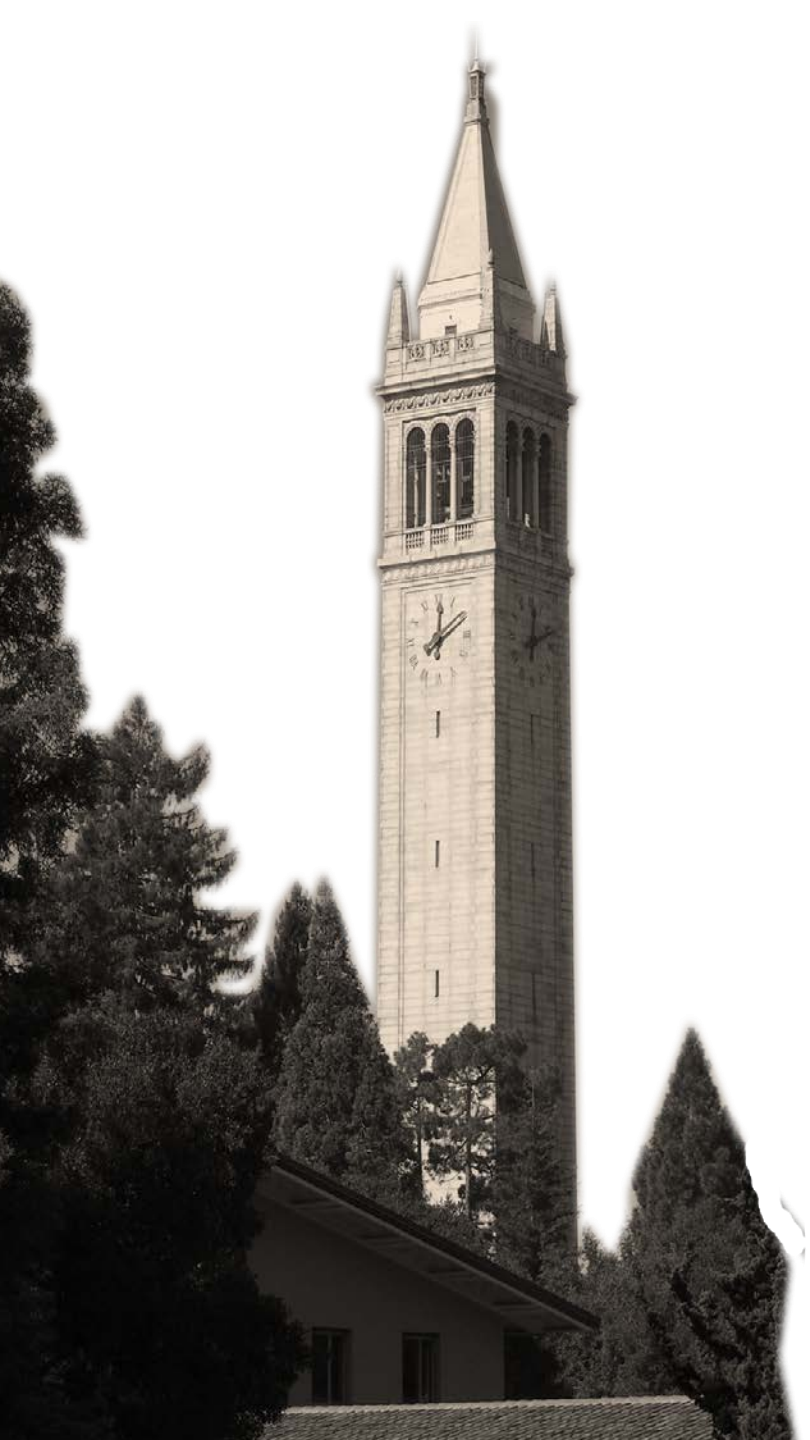

NO_2, Wind Speed, and the Chemical Removal Rate of Tropospheric NO_x

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UC Berkeley

$ NASA

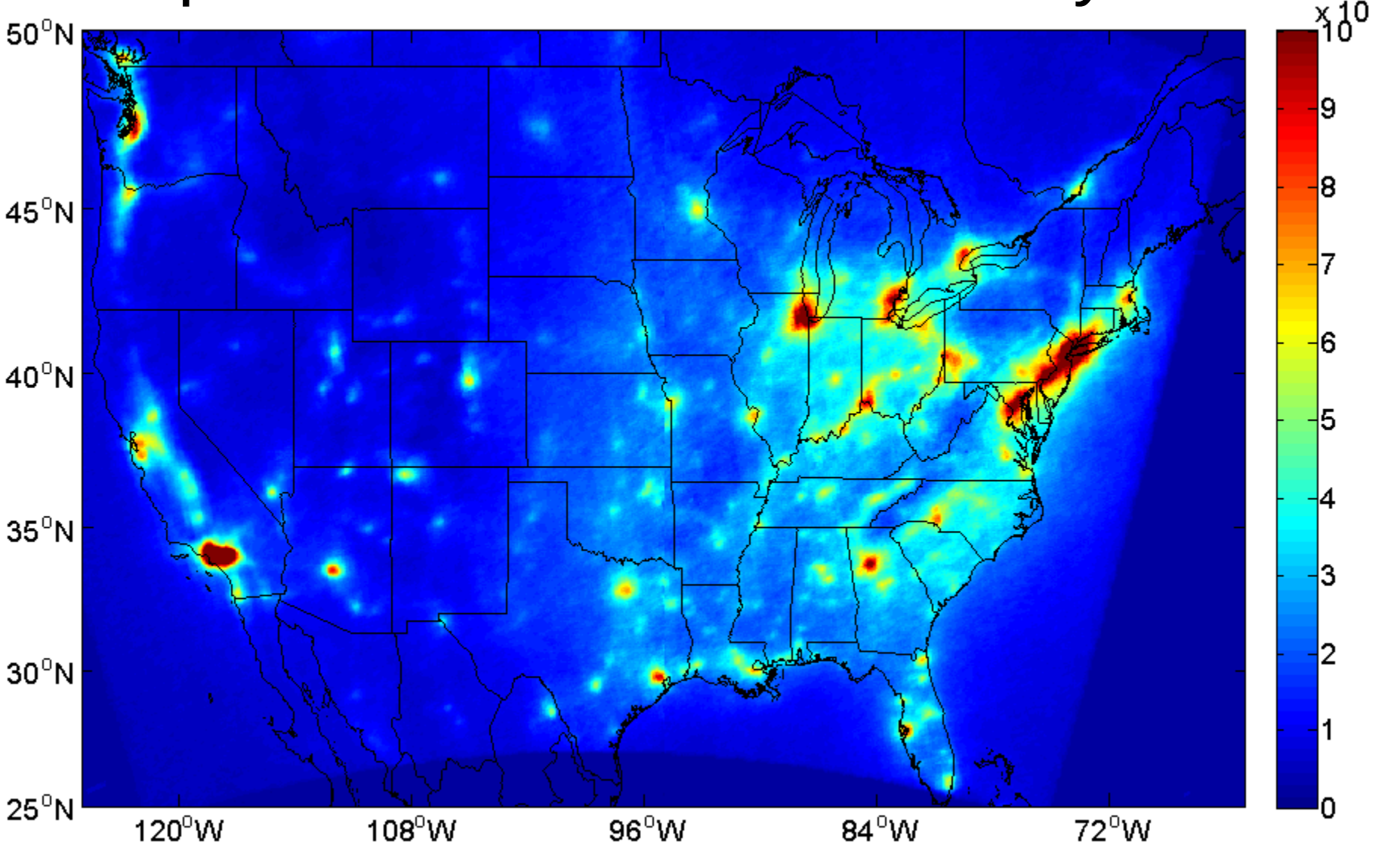
Ashley Russell
PhD May 2012

Berkeley High Resolution Retrieval (BEHR)

	NASA standard	BEHR
Terrain pressure	High-res terrain database, center of OMI footprint	High-res terrain database, average over OMI footprint
Terrain reflectivity	Monthly 1° × 1°	MODIS, 8 day 0.05° × 0.05°
NO_2 profile shape	Annually 2° × 2.5°	WRF-Chem, Monthly 4 × 4 km^2 (CA&NV) 12 x 12 km^2 U.S.
Clouds	OMI cloud product	MODIS cloud product

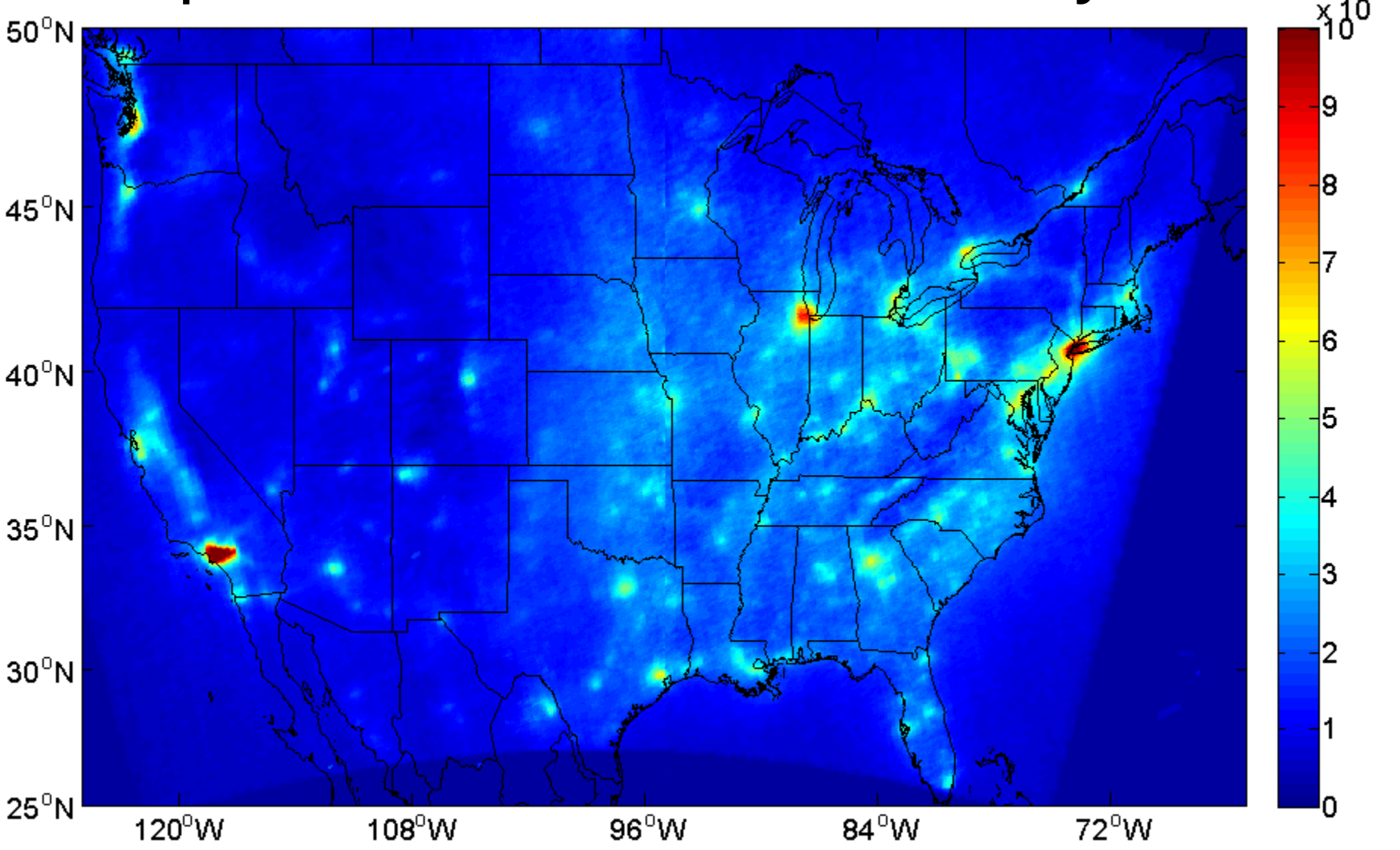
Russell et al., Atmos Chem & Phys **11**, 8543-8554, 2011

http://behr.cchem.berkeley.edu

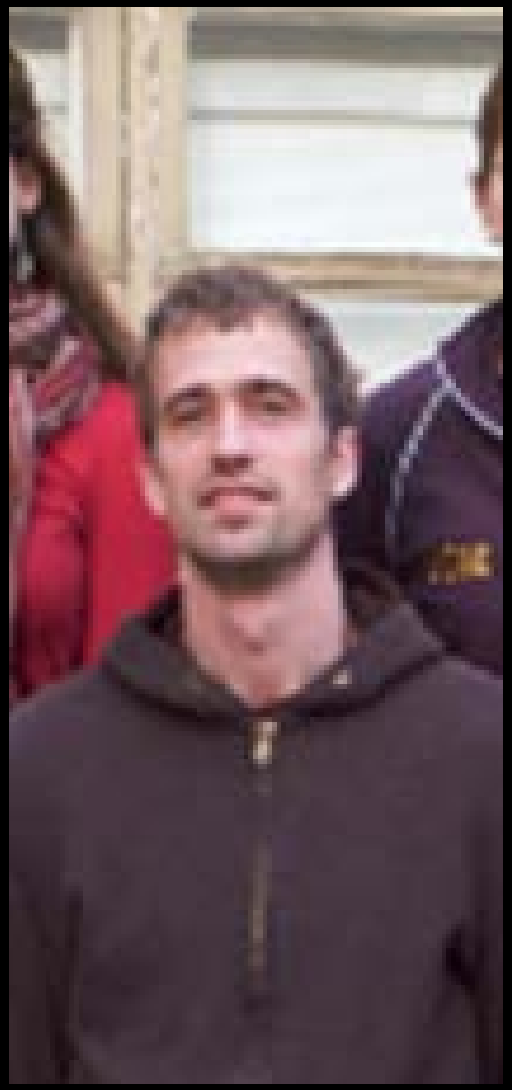


Summer 2005

http://behr.cchem.berkeley.edu

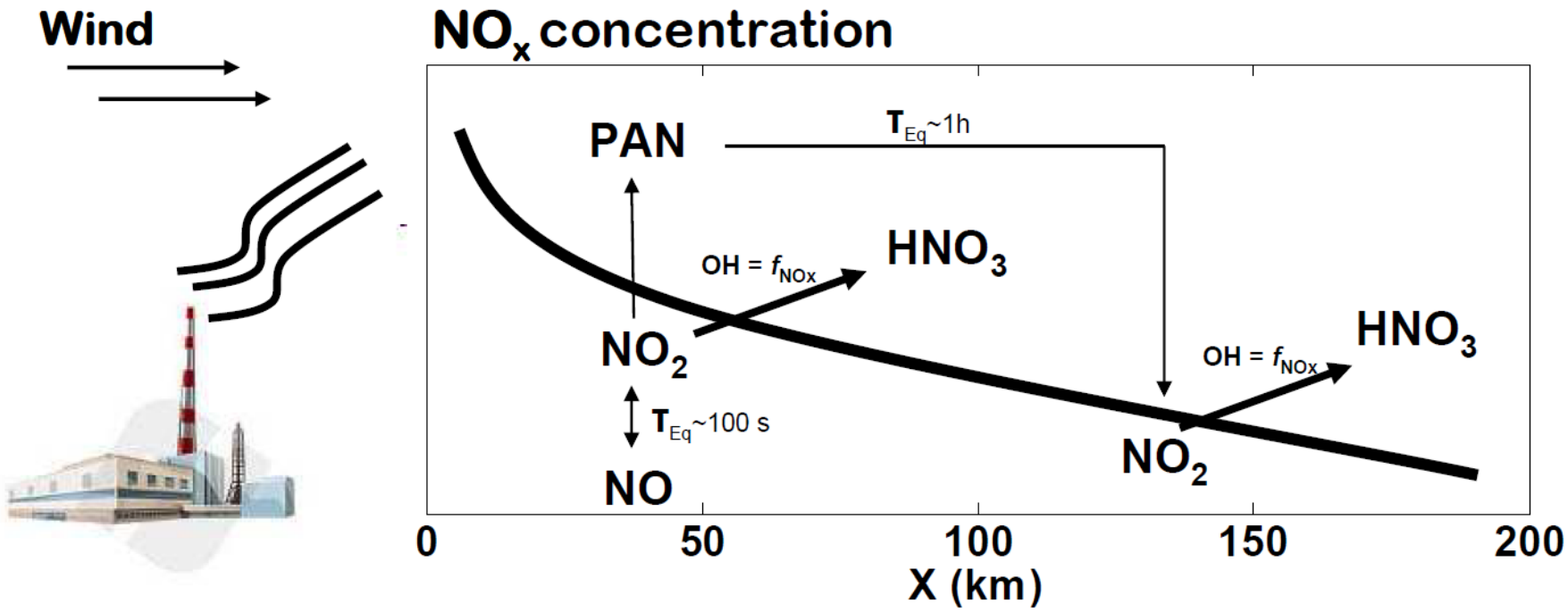


Summer 2011

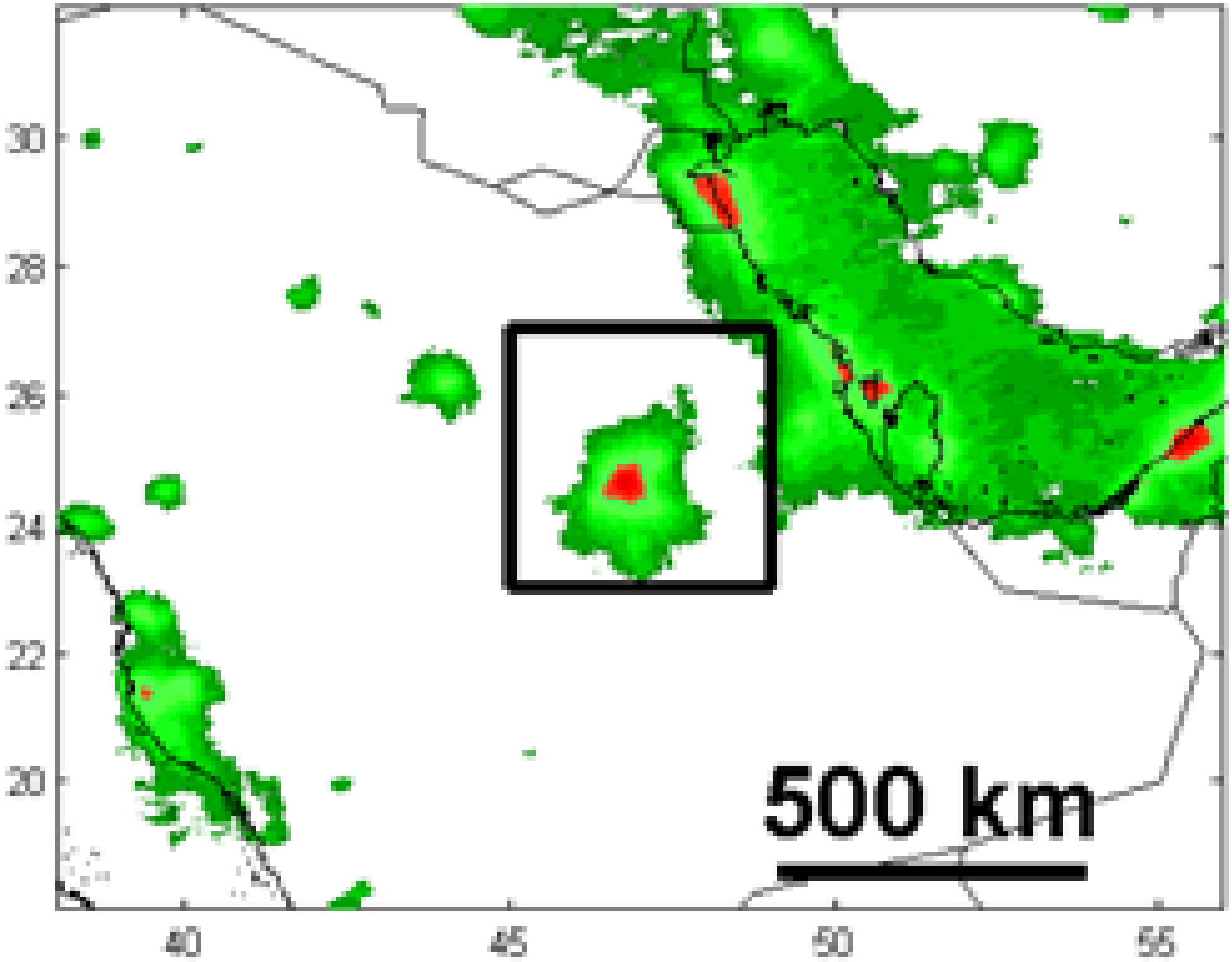


NO_2, Wind Speed, and the Chemical Removal Rate of Tropospheric NO_x

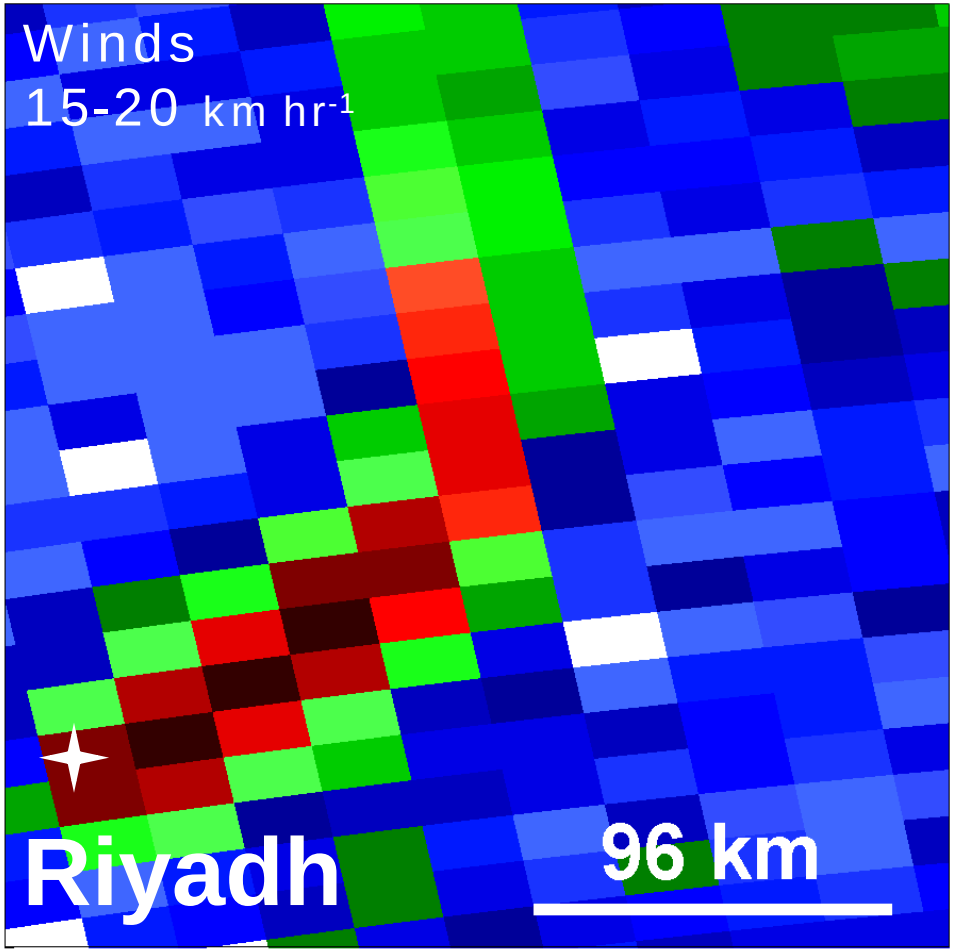
Luke Valin
PhD November 2012


Wind
NOx concentration
PAN
TEq~1h
HNO3
OH = fNOx
NO2
HNO3
OH = fNOx
TEq~100 s
NO2
NO
0
50
100
150
200
X (km)

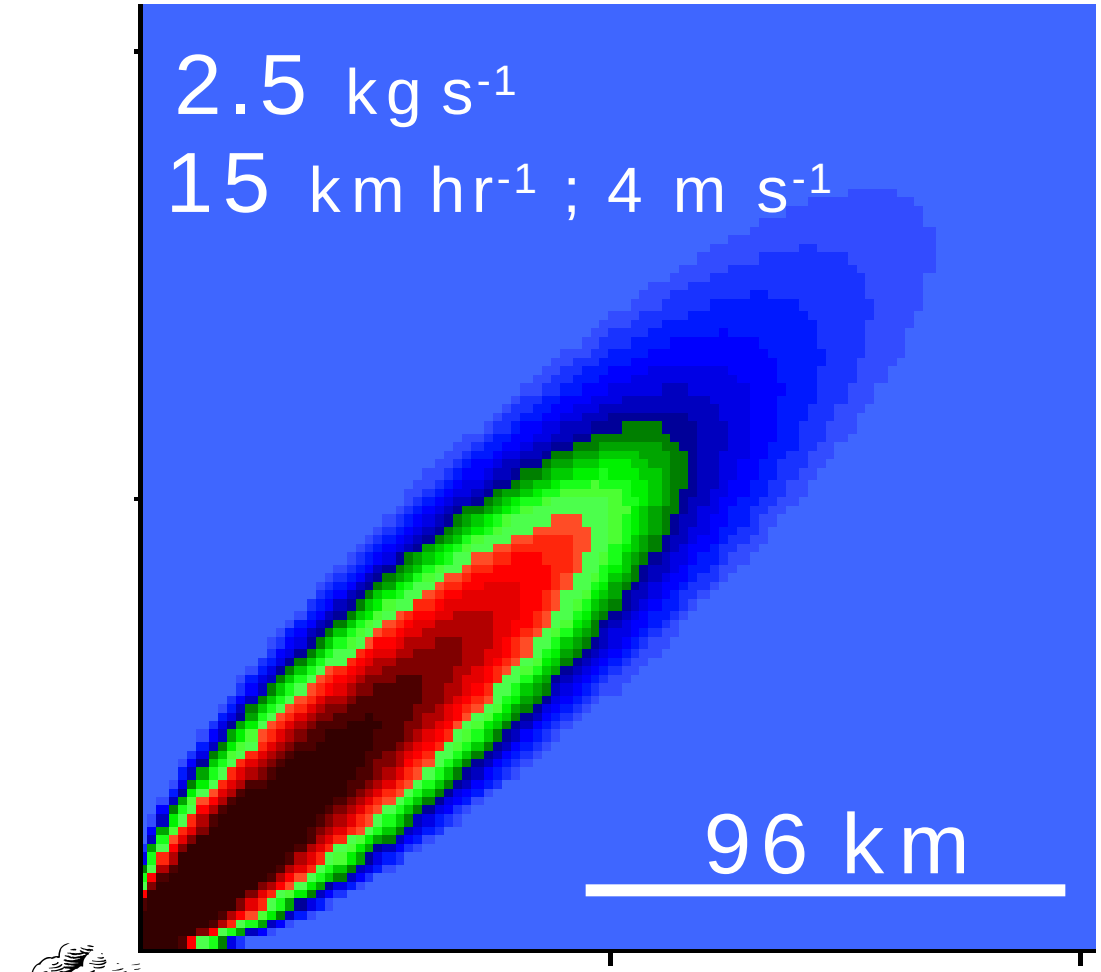
Riyadh



Riyadh urban plume (OMI)

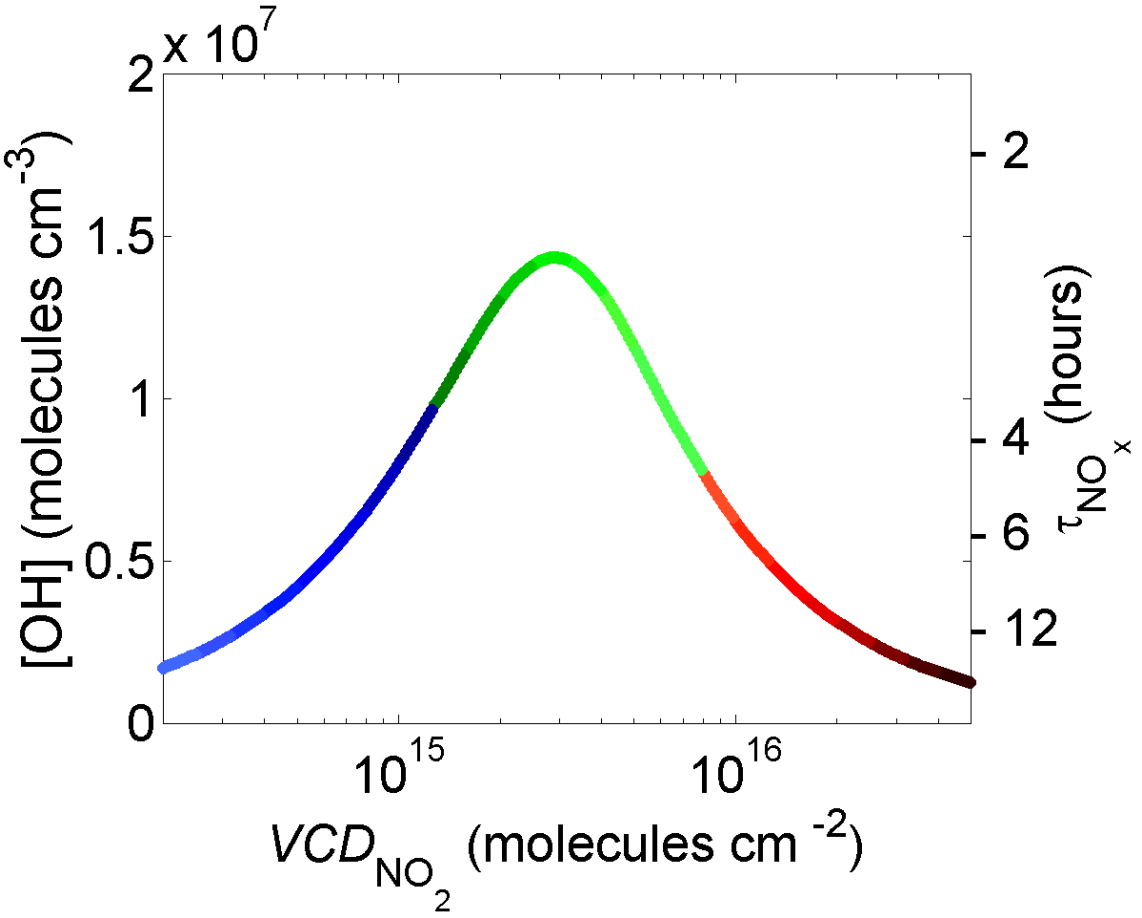


A plume simulated at 2x2 km²

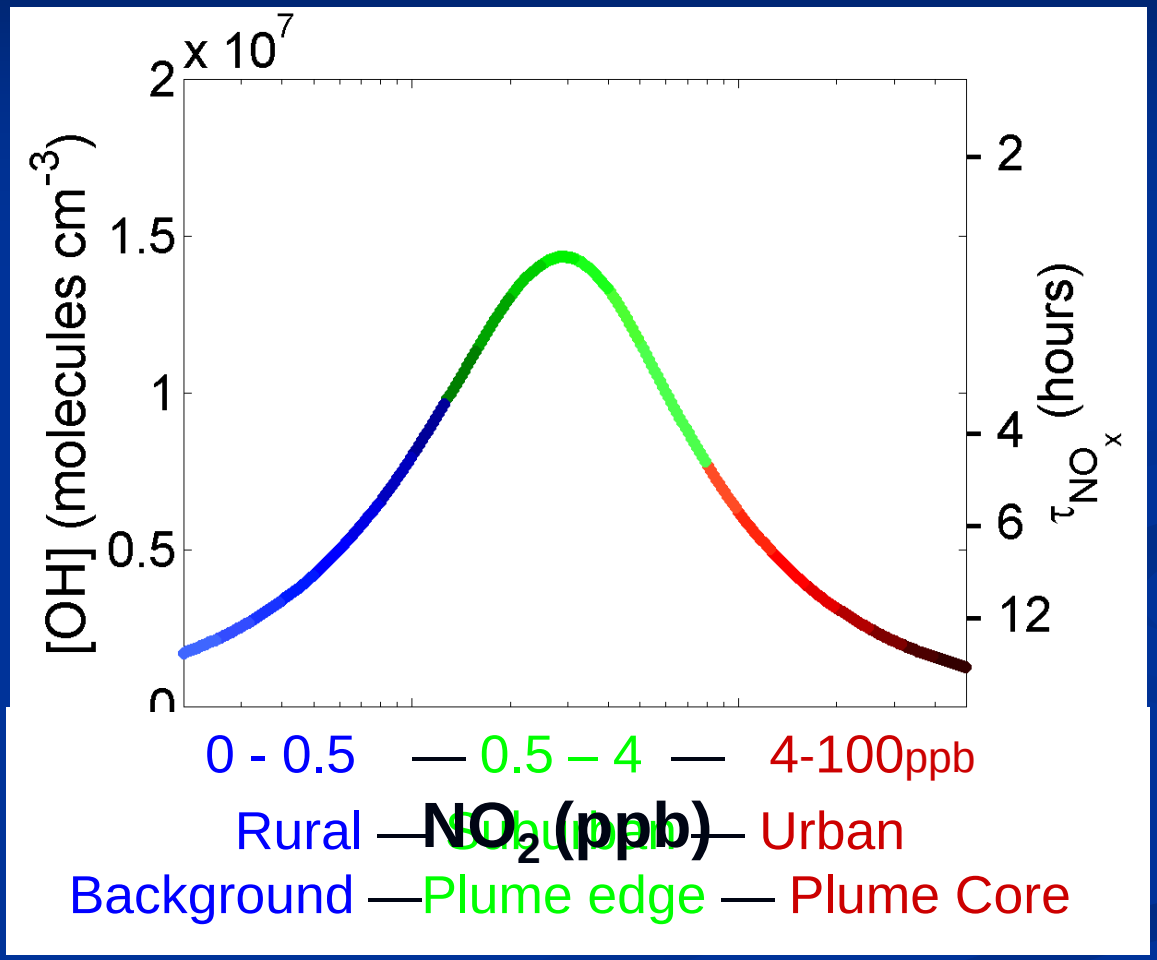


L Valin et al., *Atmos. Chem. Phys.* 2011

OH is nonlinear with NO_2



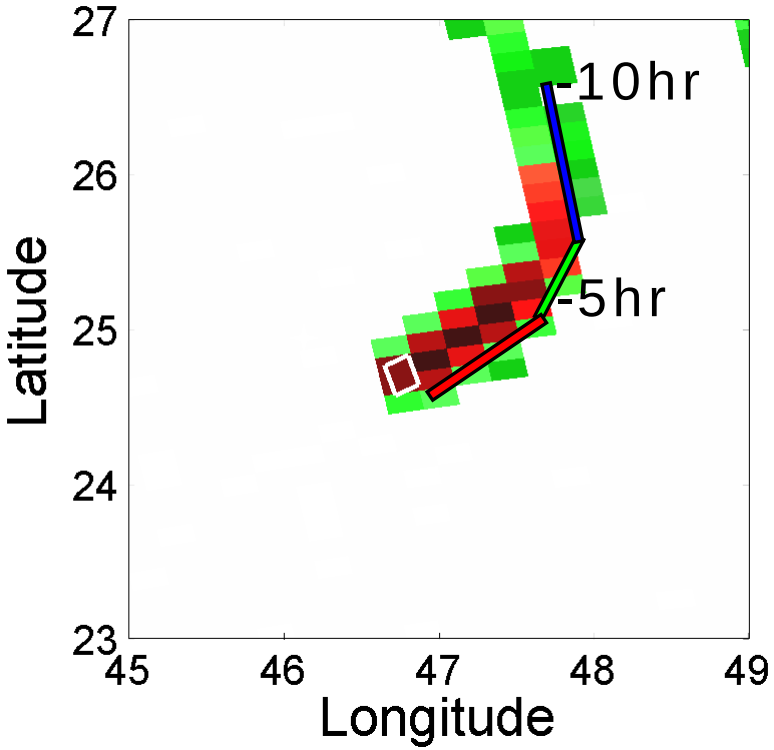
Rural — Suburban — Urban

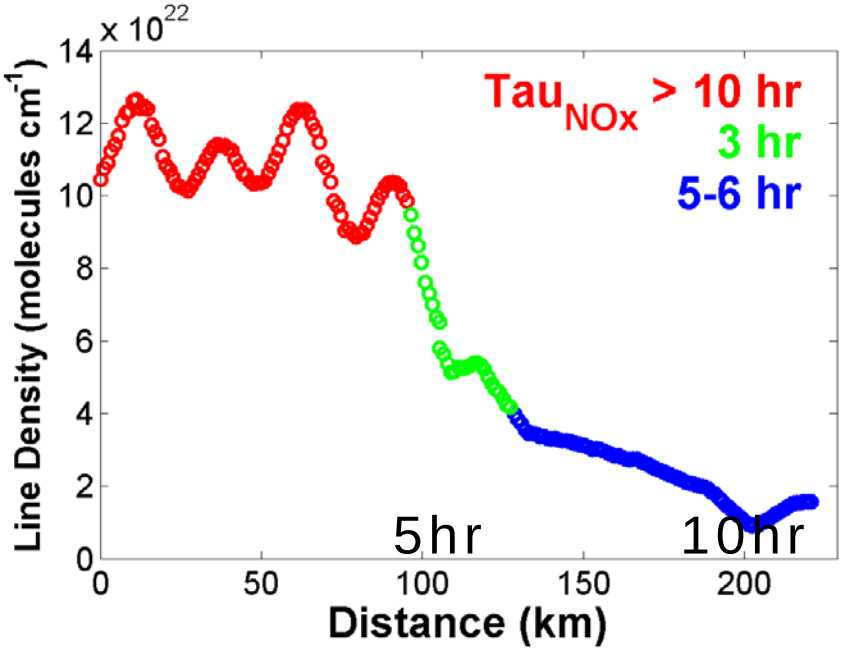

x 10^7
2
1.5
1
0.5
0
[OH] (molecules cm^-3)
2
4
6
12
τNOx (hours)
0 - 0.5
0.5 – 4
4-100ppb
NO2 (ppb)
Rural
Suburban
Urban
Background
Plume edge
Plume Core

Steep nonlinear relationships between NO_2 and OH and the associated direct ($OH + NO_2$) and indirect ($OH + VOC + NO_2 \rightarrow PAN$) have the result that

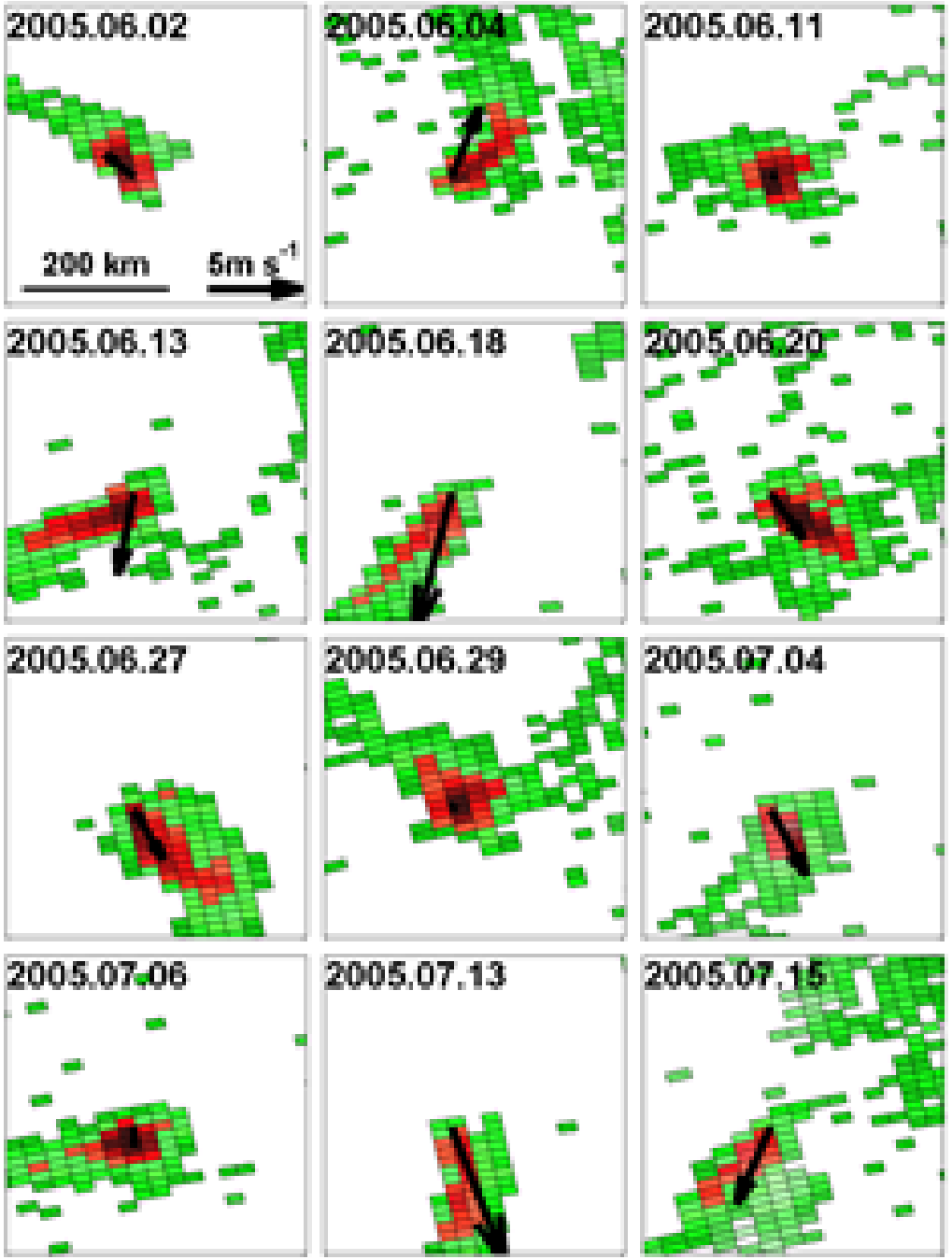
$$\langle [NO_2] \rangle \langle [OH] \rangle \neq \langle [NO_2][OH] \rangle$$

The lifetime on individual days



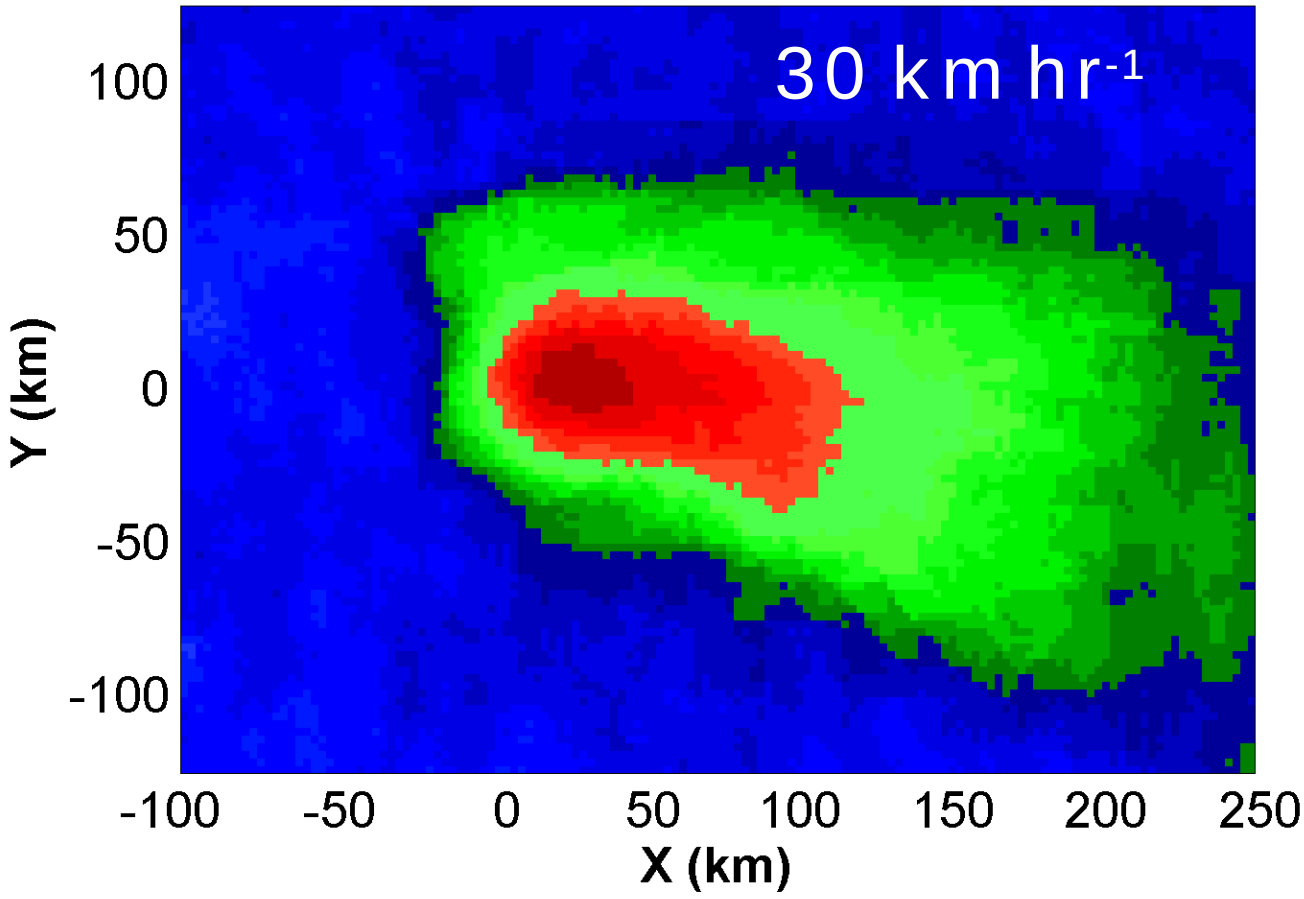


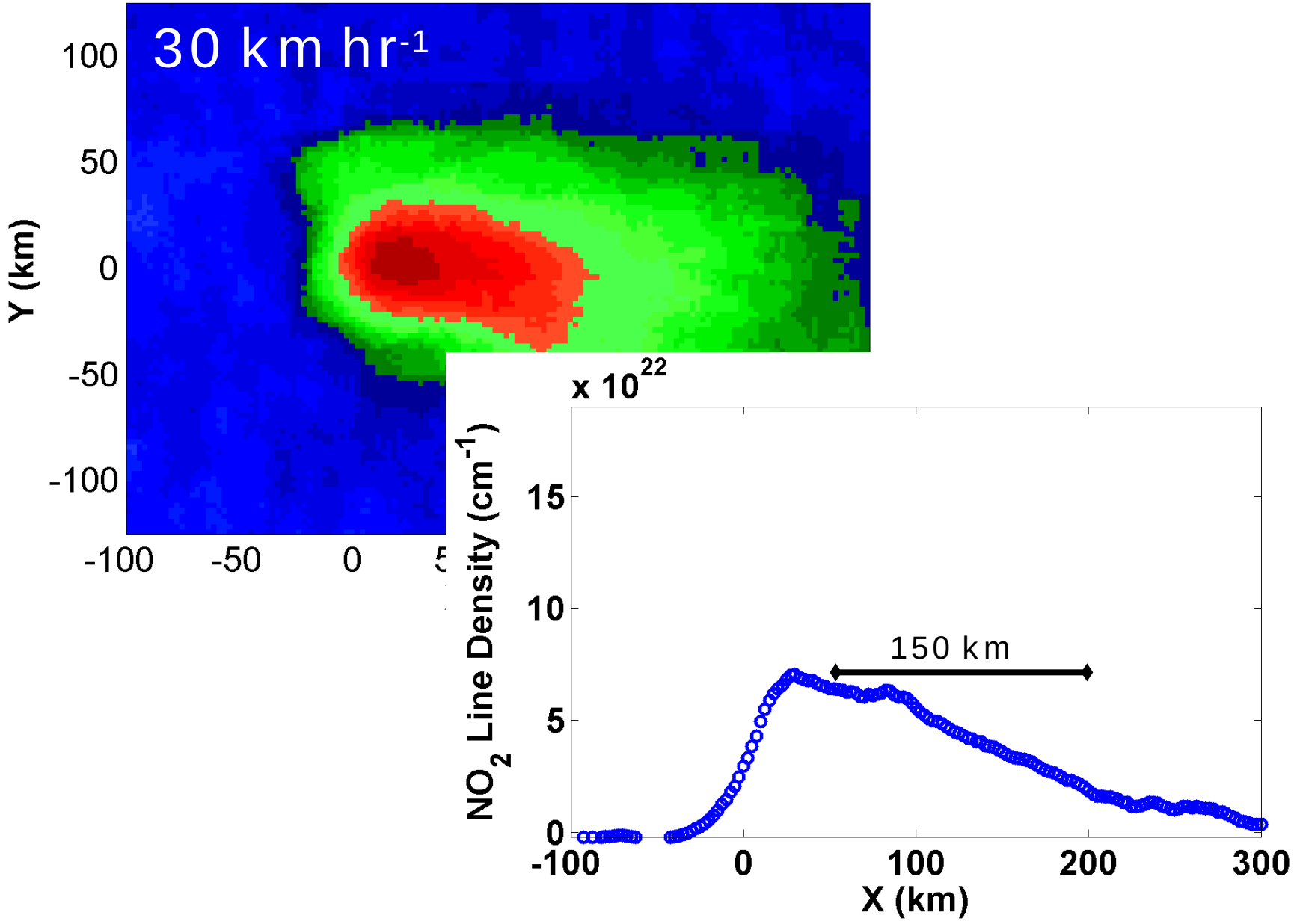
Riyadh


2005.06.02
200 km
5m s-1
2005.06.04
2005.06.11
2005.06.13
2005.06.18
2005.06.20
2005.06.27
2005.06.29
2005.07.04
2005.07.06
2005.07.13
2005.07.15

Rotate winds to x direction

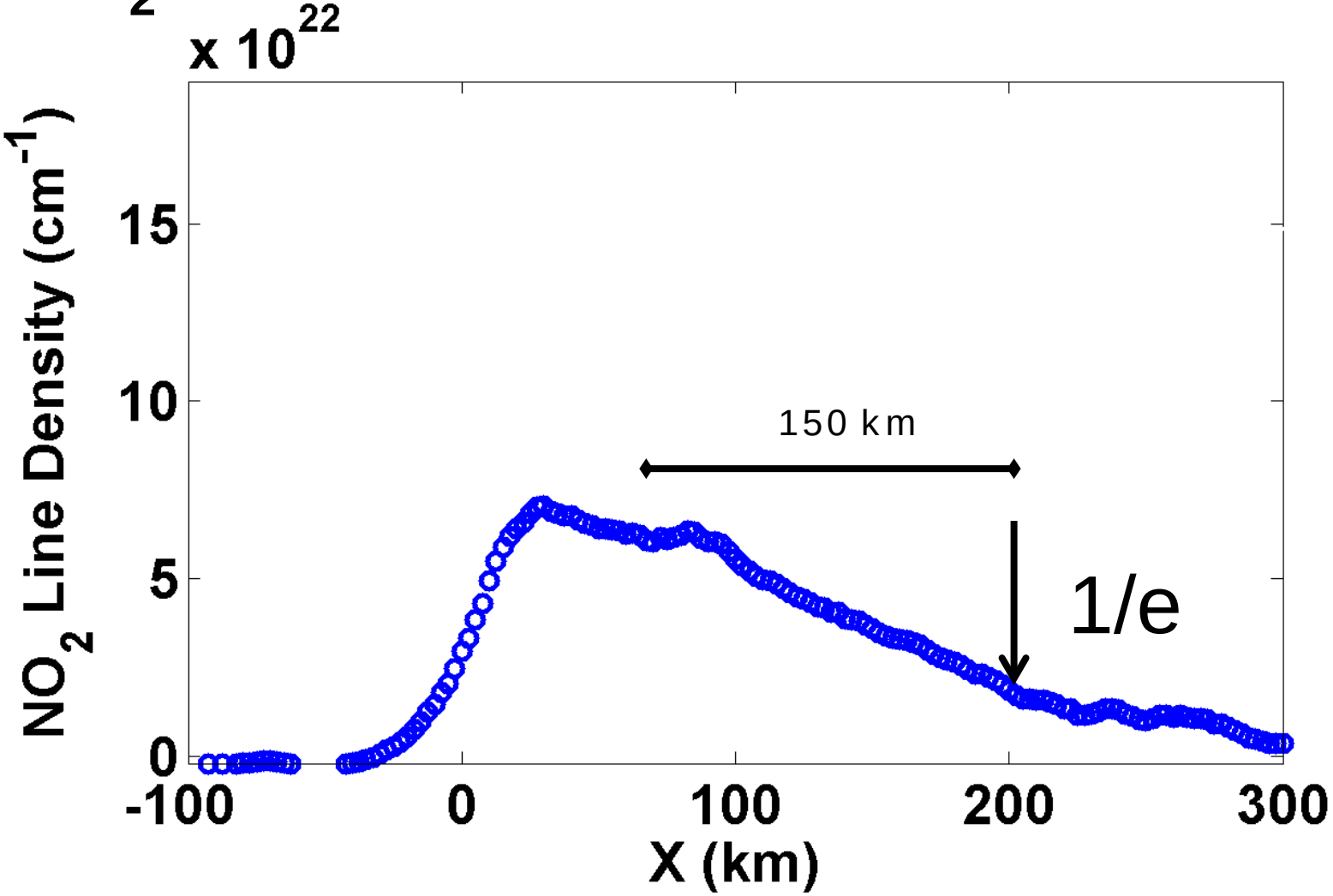
Sort by wind speed





L Valin et al., *In Preparation*

The NO_2 lifetime

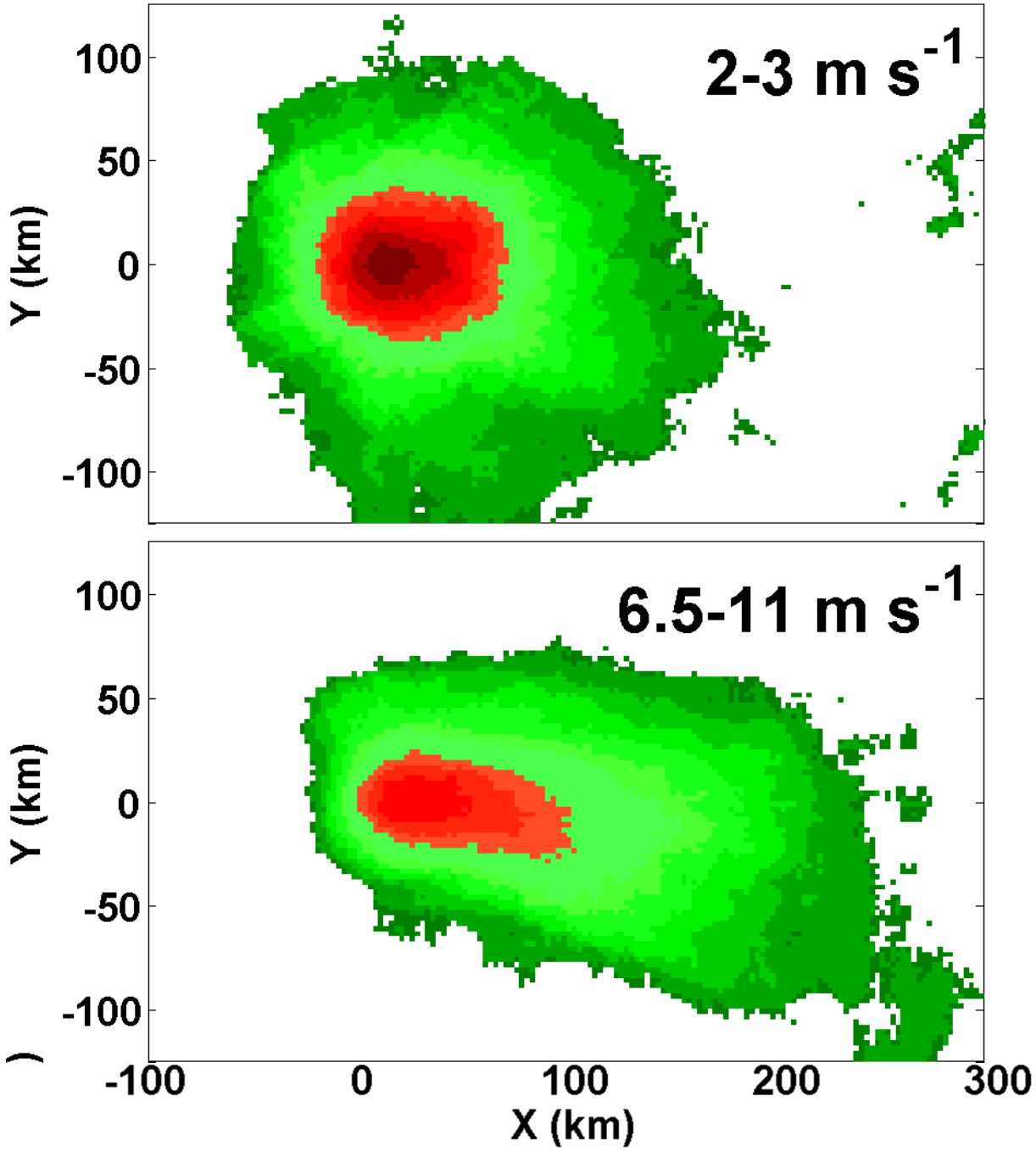


L Valin et al., *In Preparation*

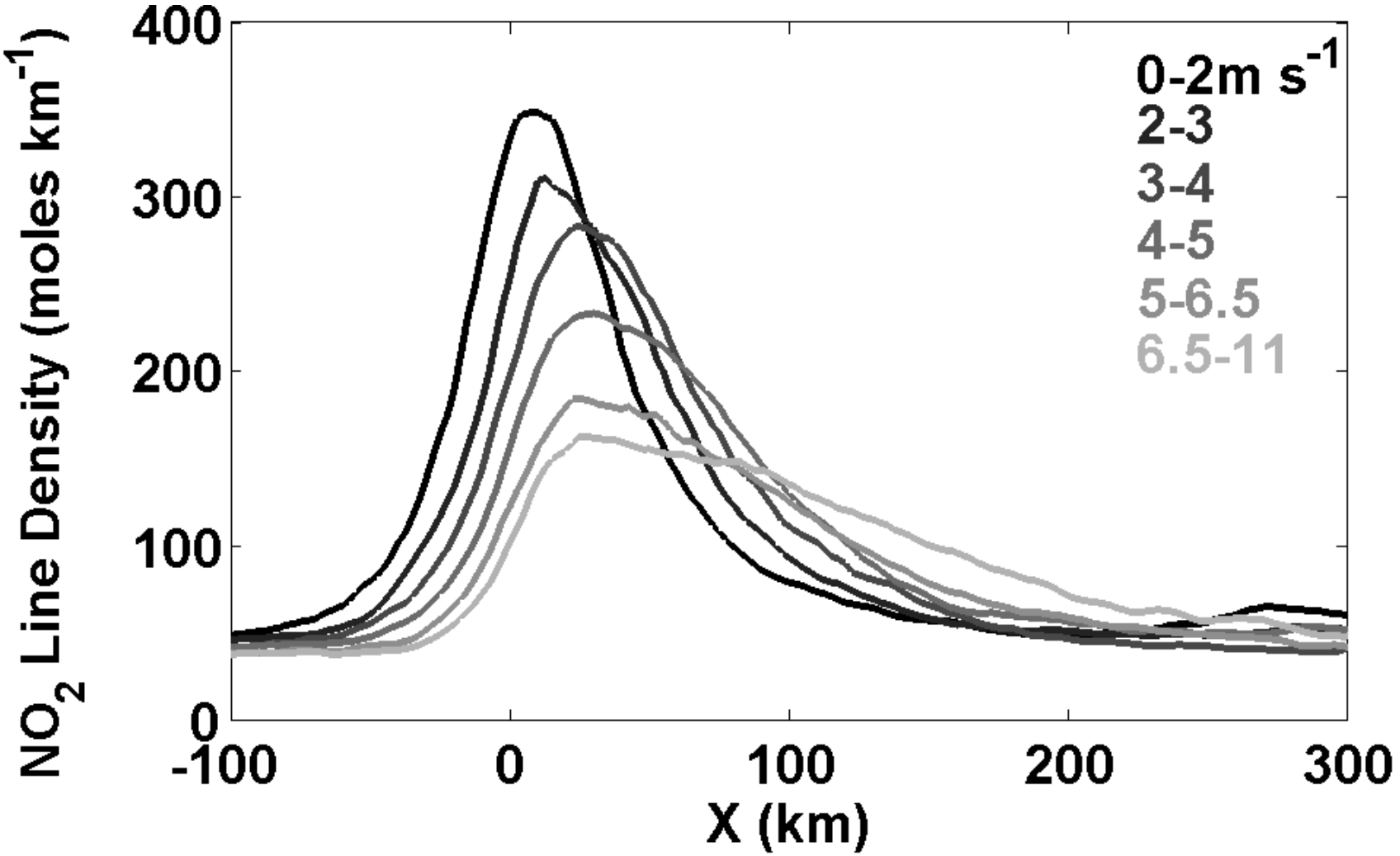
τ = 150 km / 30 km hr^{-1} = 5.0 hours

→ $OH_{effective}$ = 8.4×10^{6} cm^{-3}

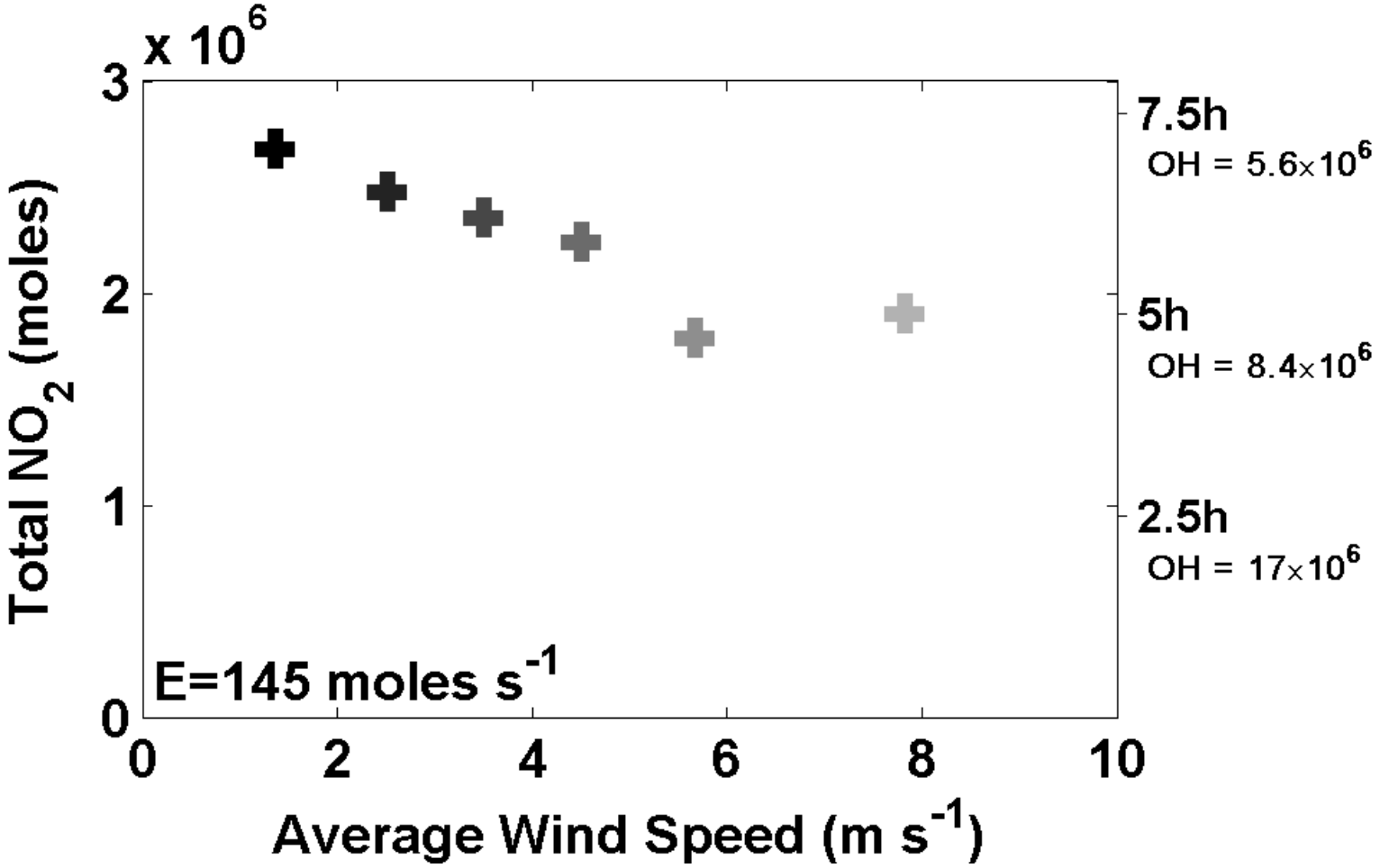
→ Emission rate = 145 mole s^{-1}


2-3 m s-1
6.5-11 m s-1
100
50
0
-50
-100
Y (km)
-100
0
100
200
300
X (km)

Integral perpendicular to wind



Integral of the entire plume



Conclusions:

We can accurately derive the lifetime of NO_2 in plumes (and effective OH) and the associated emissions. In the example here we find a single value of the emission rate and multiple lifetimes are consistent with expectations about the lifetime vs dilution rate (wind speed.

Not shown, one gets the wrong emission rate and lifetime if one averages over all wind speeds.

$$ NASA

Anna Mebust
Tomorrow Morning
Wildfires and NO_x
$$ NASA

Thank you