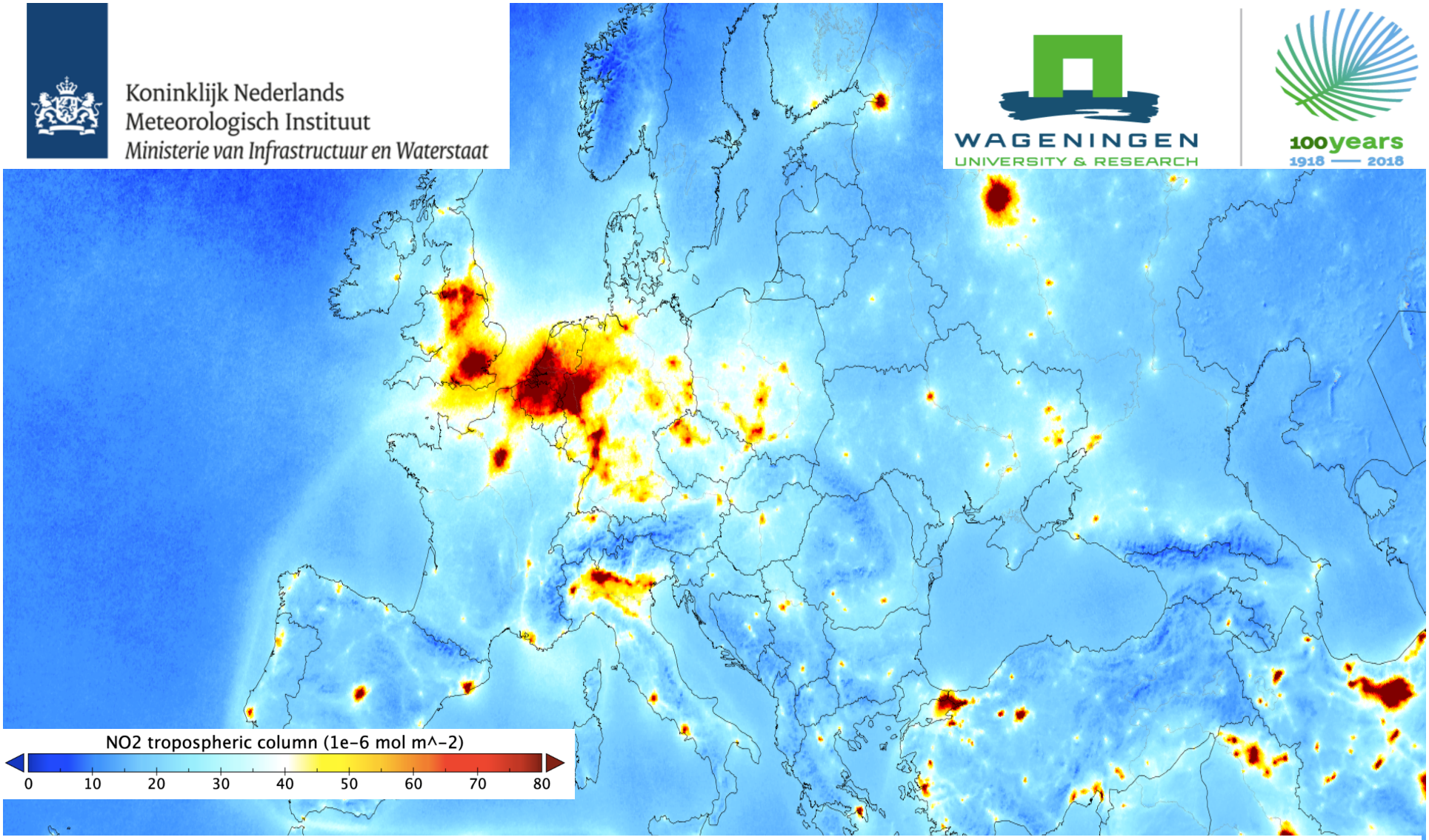
Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

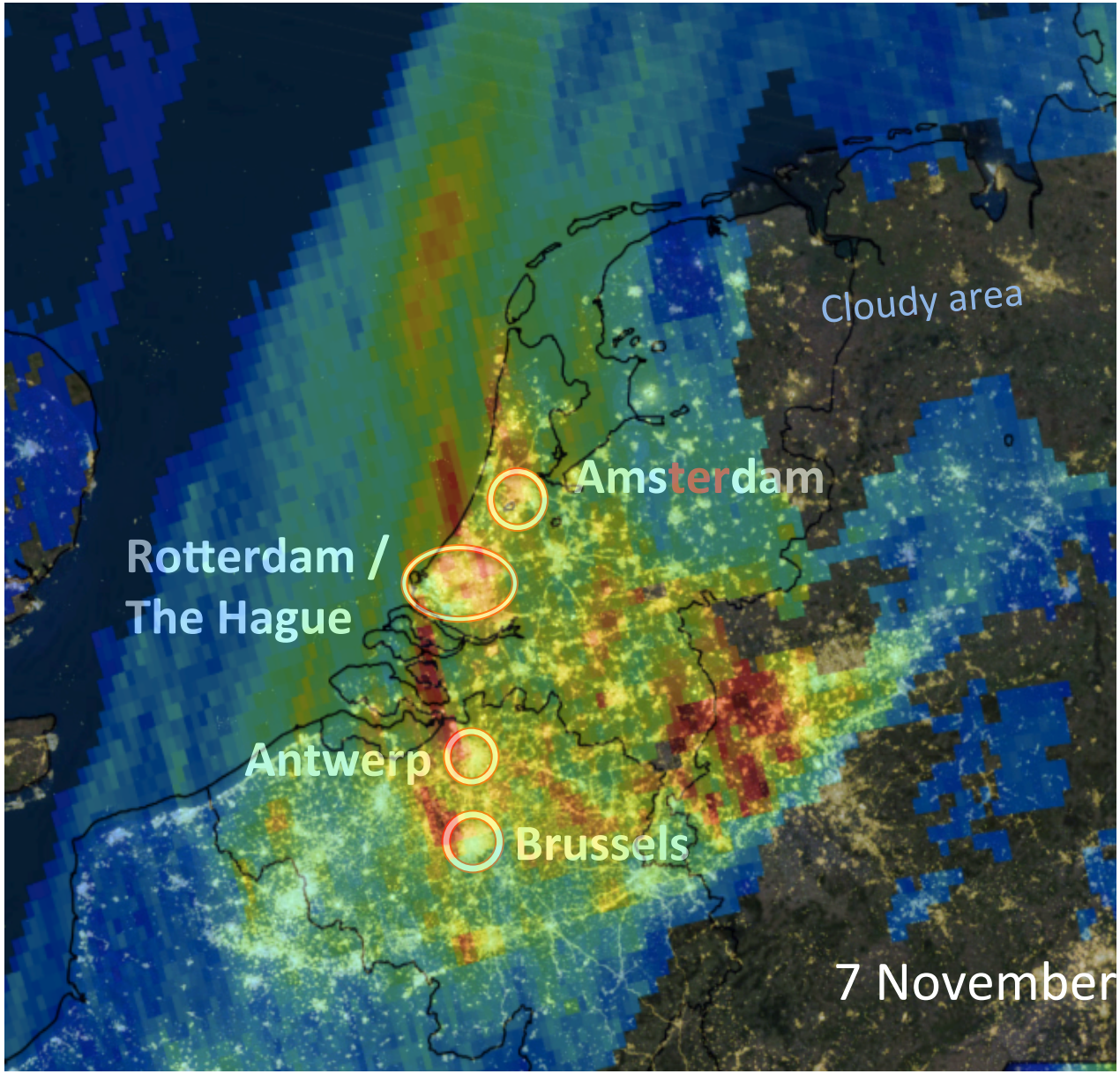


Quantification of nitrogen oxides emissions over Paris from build-up of pollution with TROPOMI & linking up with Ruisdael

Folkert Boersma

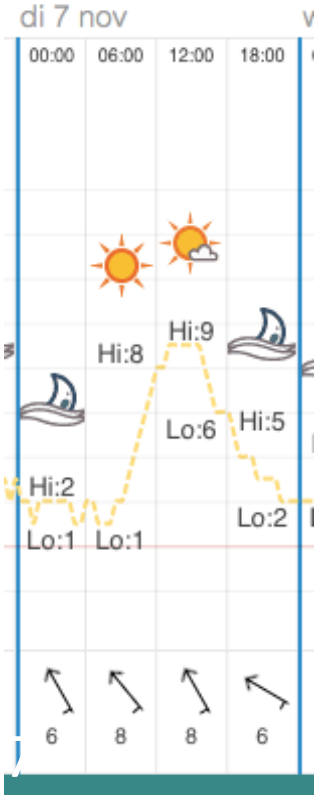
Alba Lorente, Henk Eskes, Pepijn Veefkind, Jos van Geffen, Maarten de Zeeuw, Hugo Denier van der Gon, Steffen Beirle, Ankie Piters, Tim Vlemmix, and Maarten Krol

NO_2 plumes in the Benelux



Right after instrument cooler opened

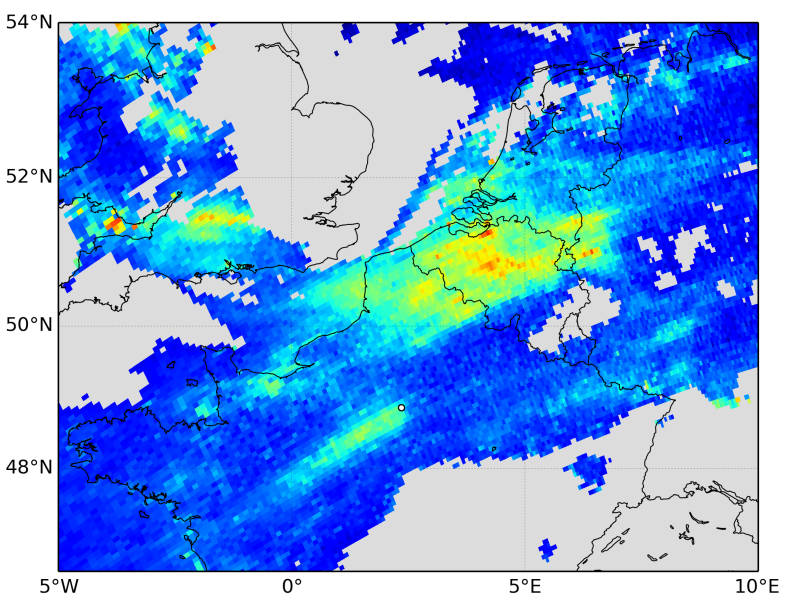
No measured solar irradiance spectrum yet



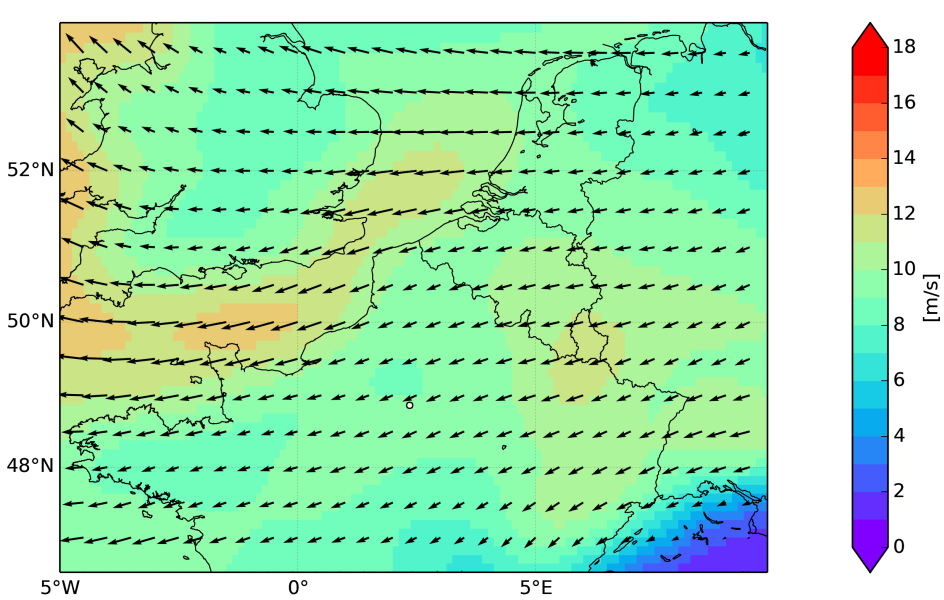
VIIRS nighttime lights

NO_2 plumes from Paris

TROPOMI NO_2 tropospheric VCD



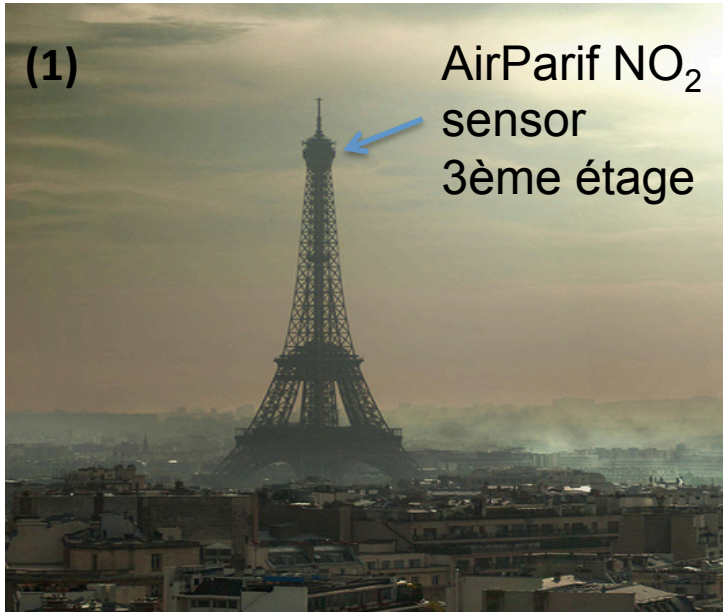
ECMWF ERA-I wind speed @BL



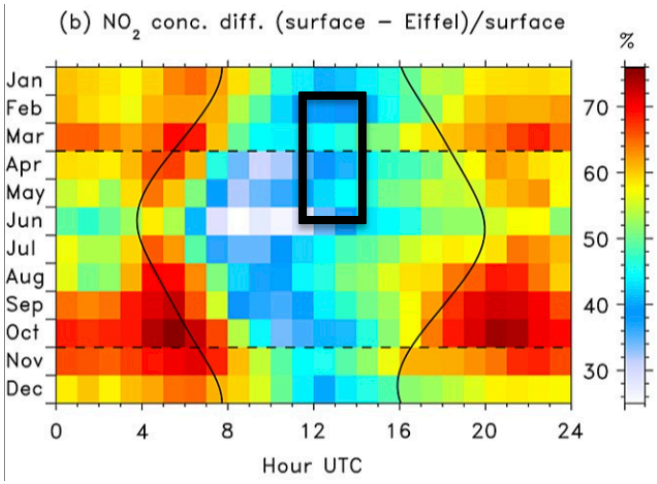
23 February 2018

Wind at 12 UTC

Validation of TROPOMI v1.1 at Eiffeltower

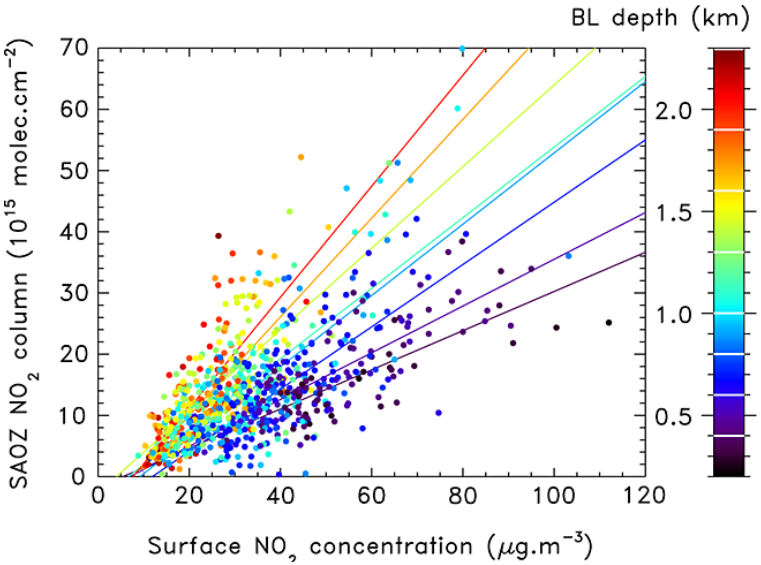


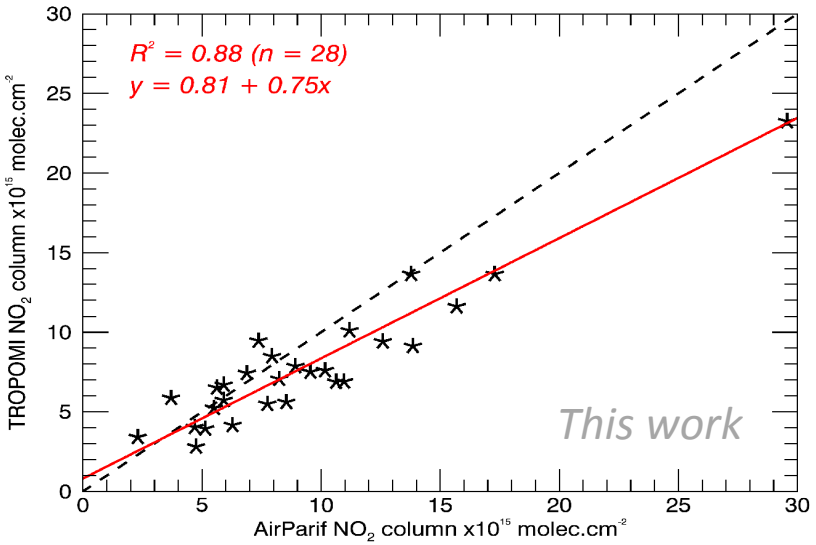
(2) Convert Eiffel Tower measurements to surface NO_2:



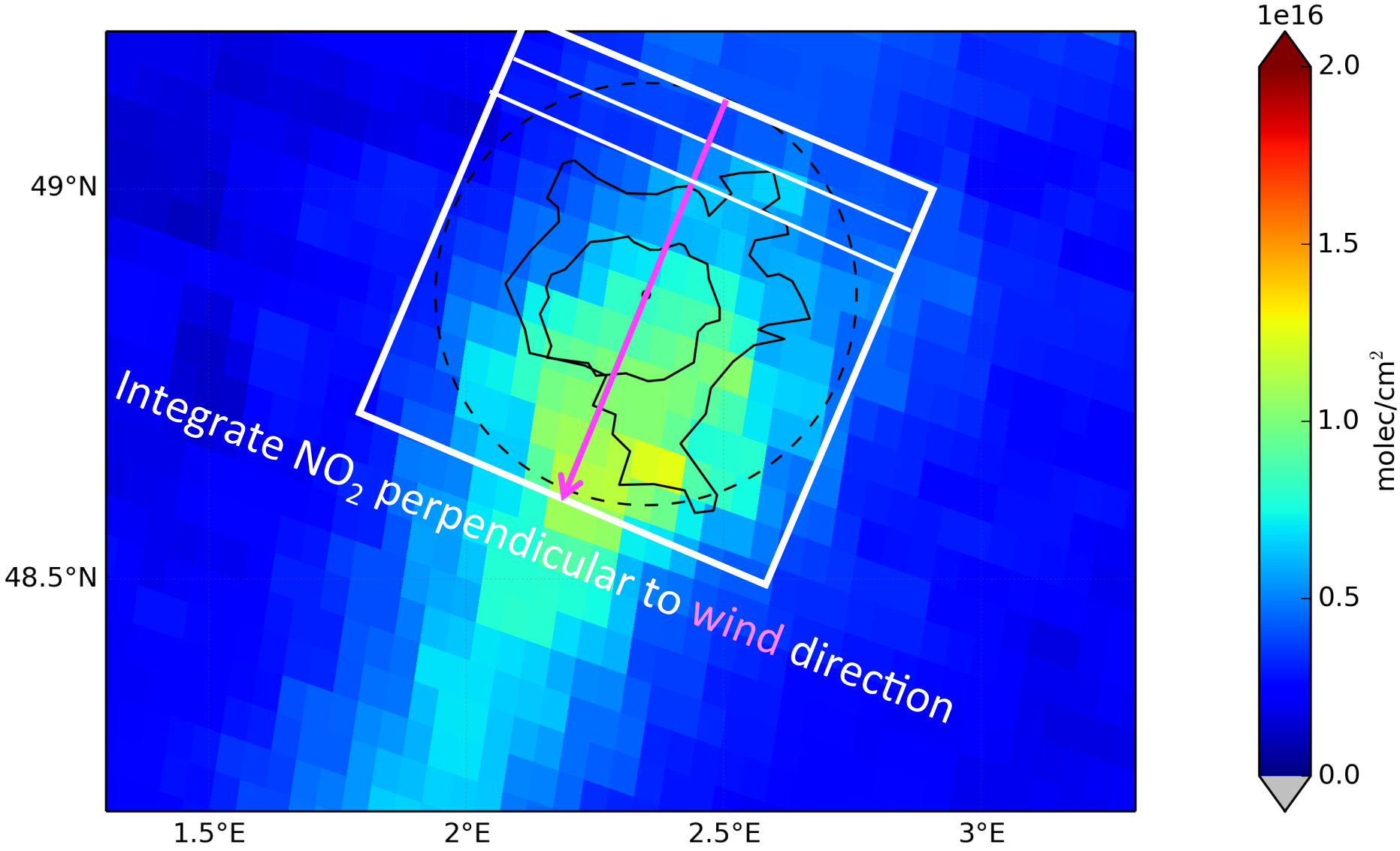
Dieudonné et al., GRL, 2013

(3) Convert surface NO_2 to column NO_2:

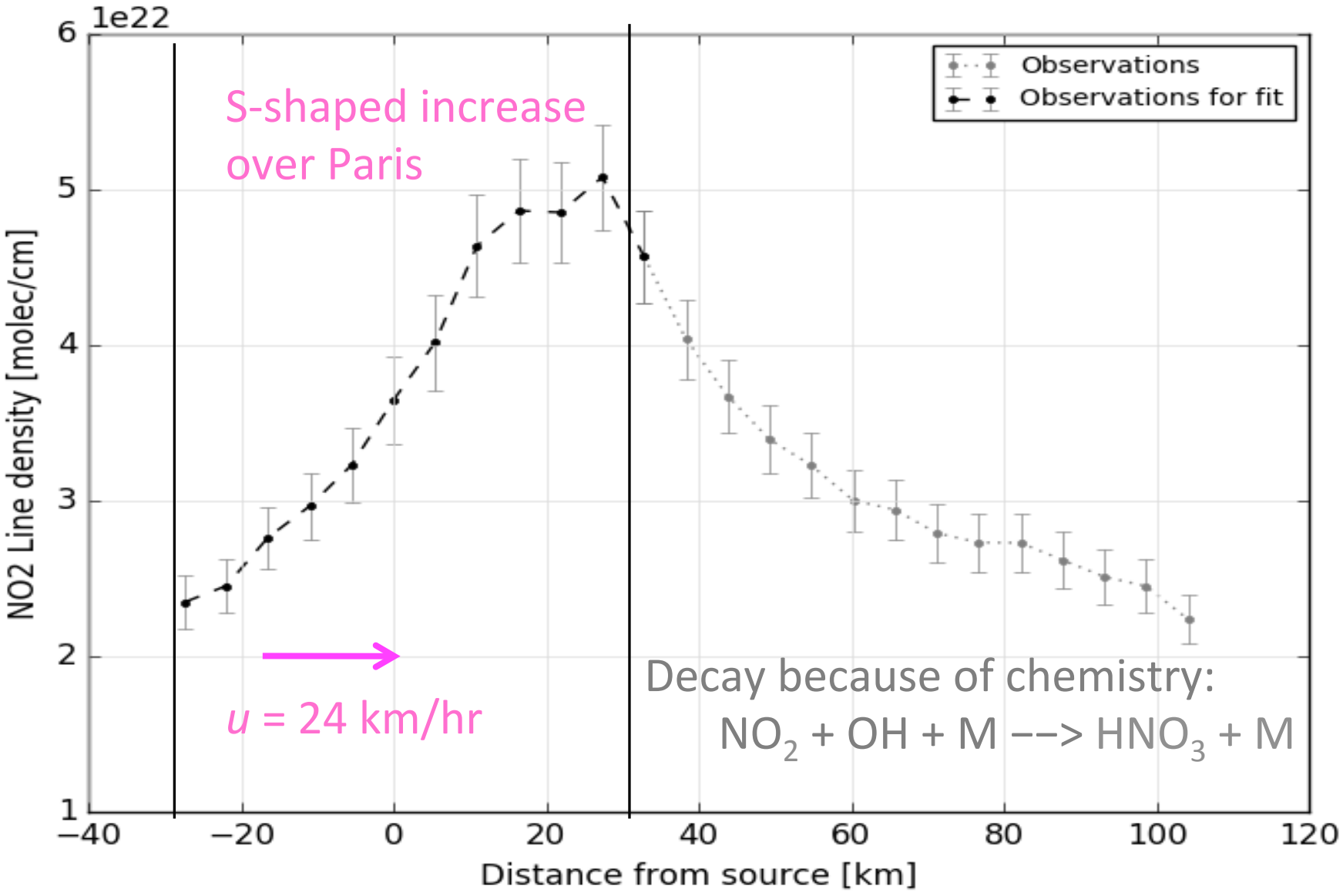




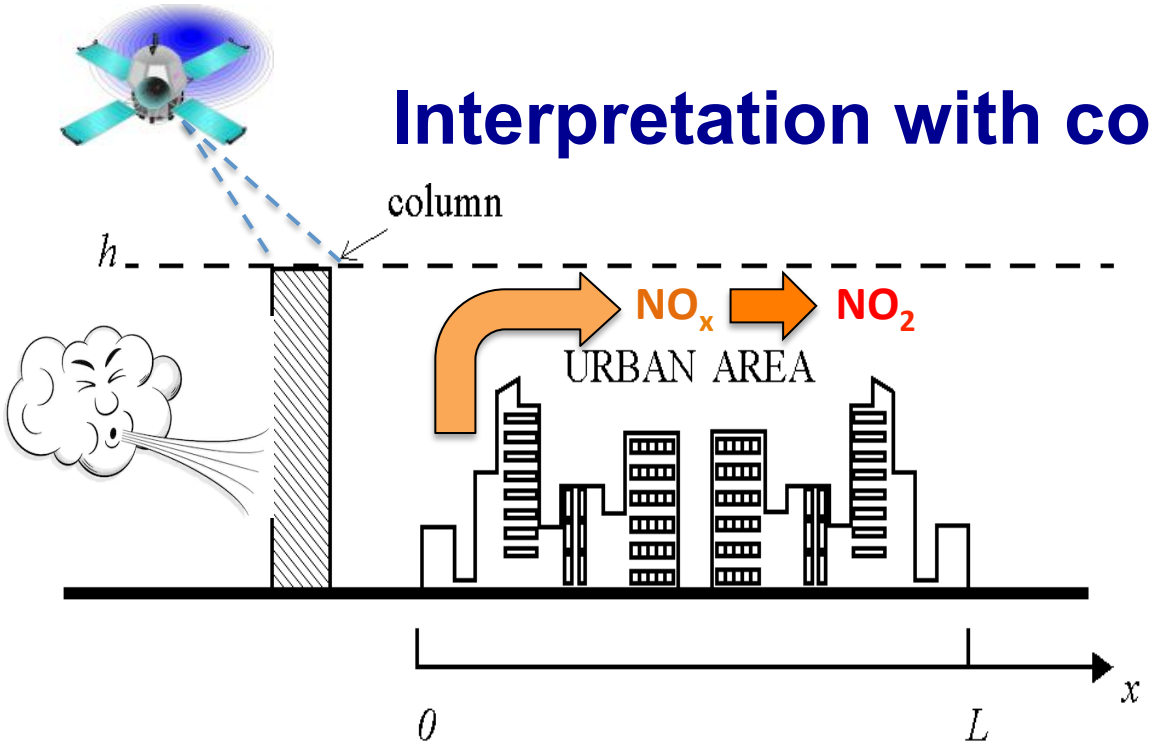
NO_2 line density over Paris



NO_2 line density over Paris

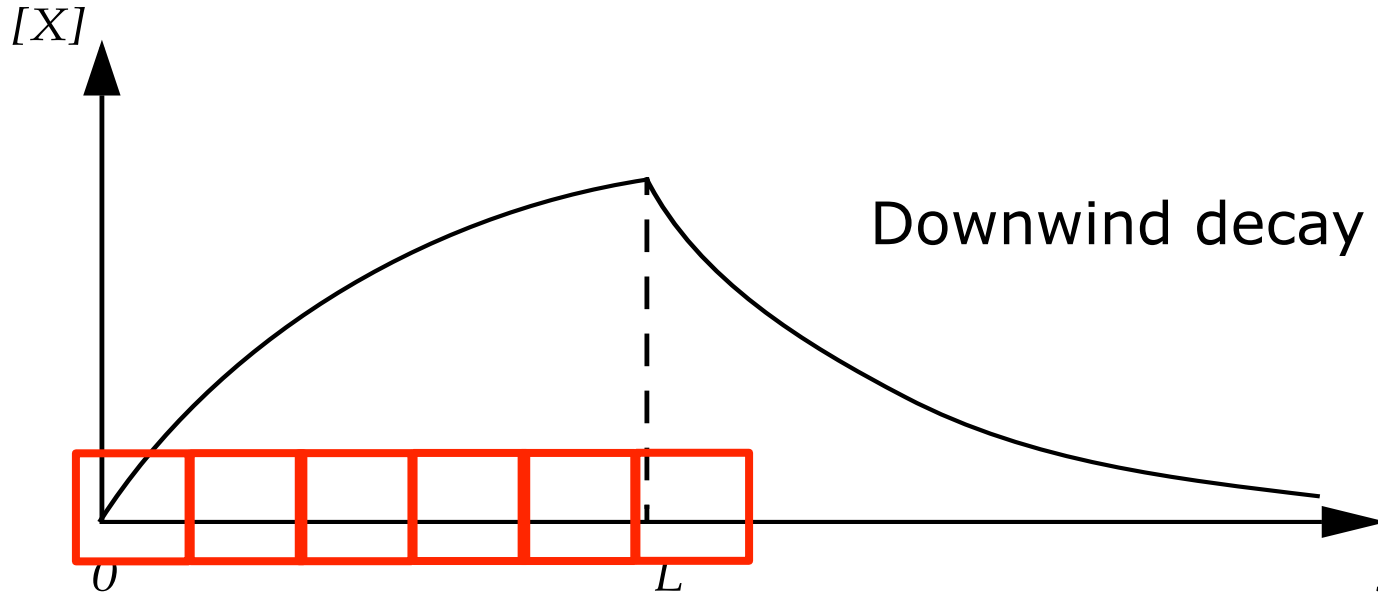


Interpretation with column model



$[NO_2]$ increases over the city

$$N(x) = \frac{E}{k}(1 - e^{-kx/u})$$



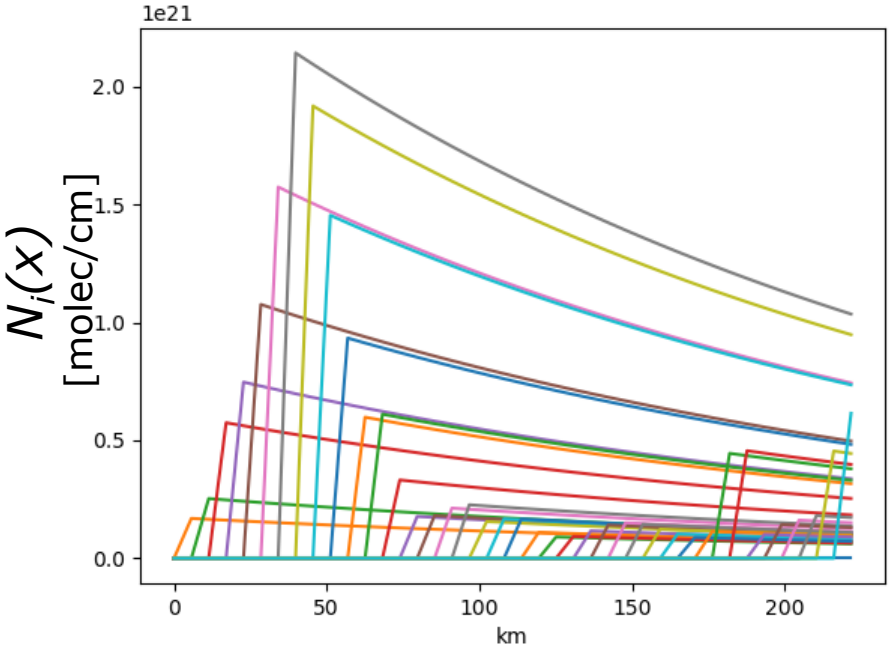
Emission pattern matters

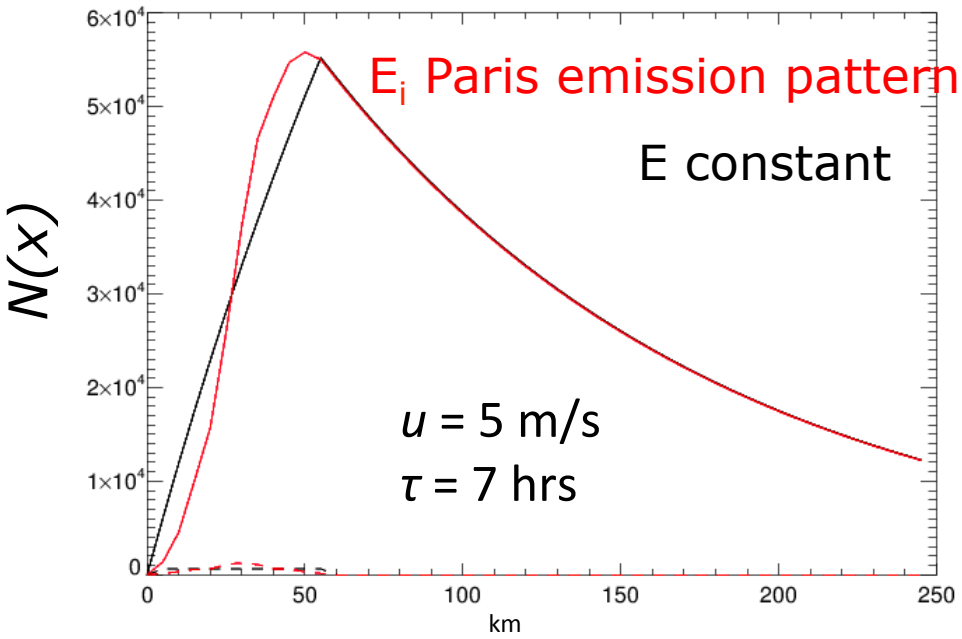
Simulate line density by accounting for spatially varying emissions

$$N_i(x) = \frac{E_i}{k}\left(1 - e^{-k(x-x_i)/u}\right) \quad \text{for } x \geq x_i$$

$$N_i(x) = 0 \quad \text{for } x < x_i$$

$$\Rightarrow \quad N(x) = \sum_{i=1}^{n} N_i(x)$$





Superposition model

Large ensemble of modeled line densities

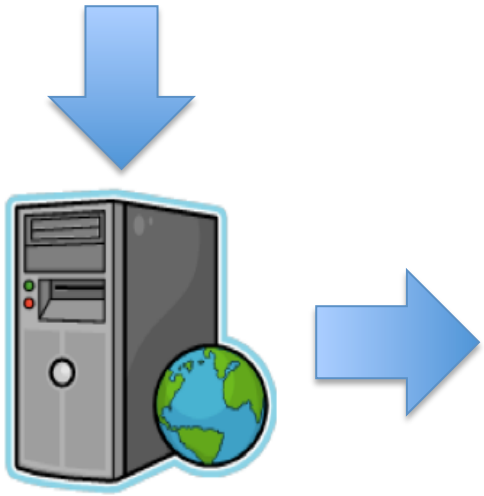
Fixed parameters

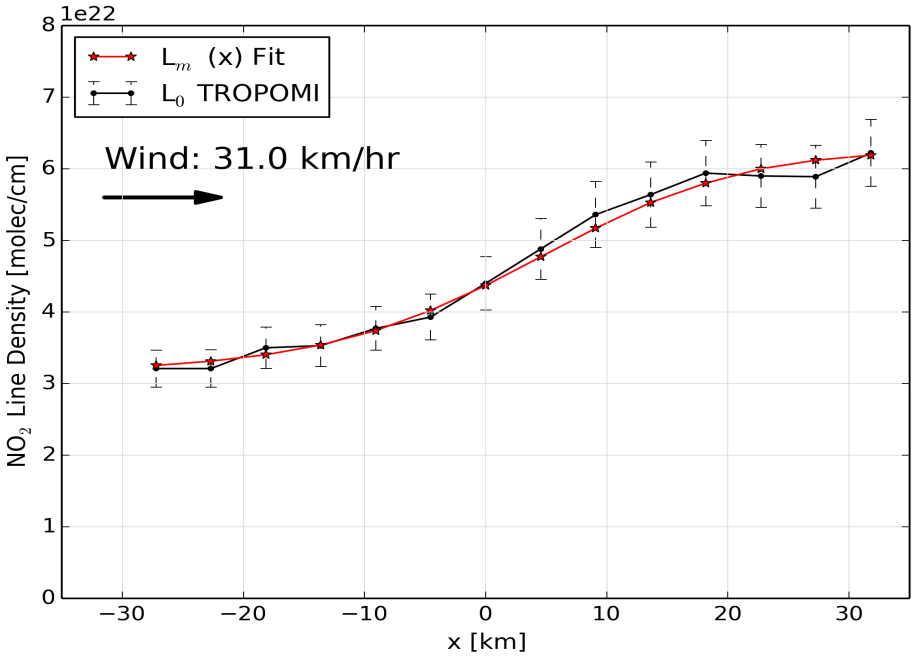
u	boundary layer mean ECMWF wind
NO_x:NO_2	boundary layer mean from CAMS model

Varied parameters (5+1)

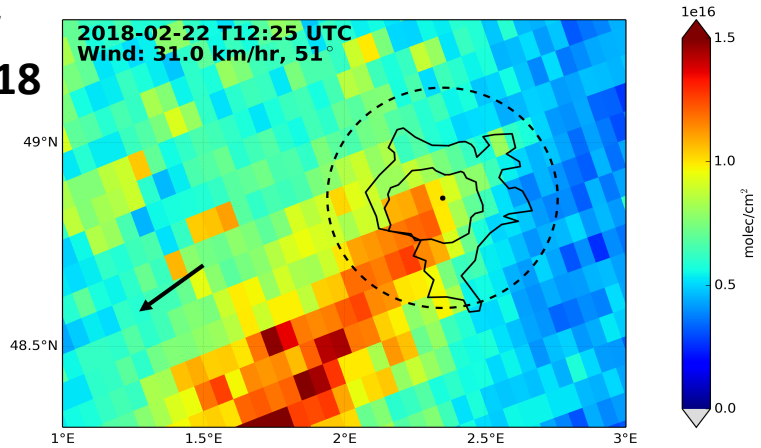
E_i – initial guess from TNO-MACC-III inventory

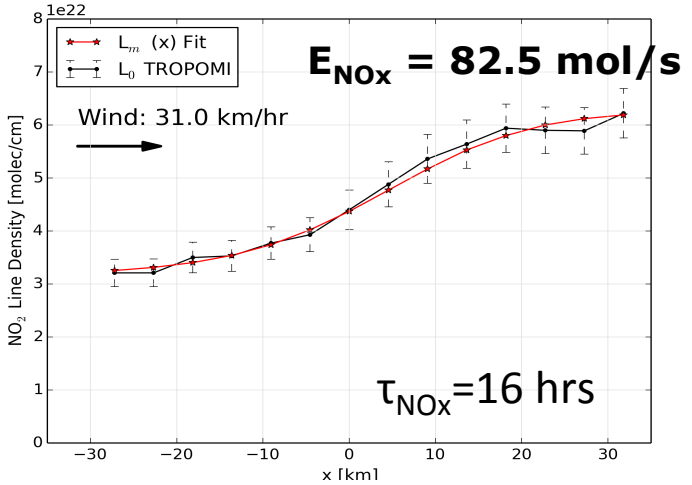
k – initial guess from CAMS model



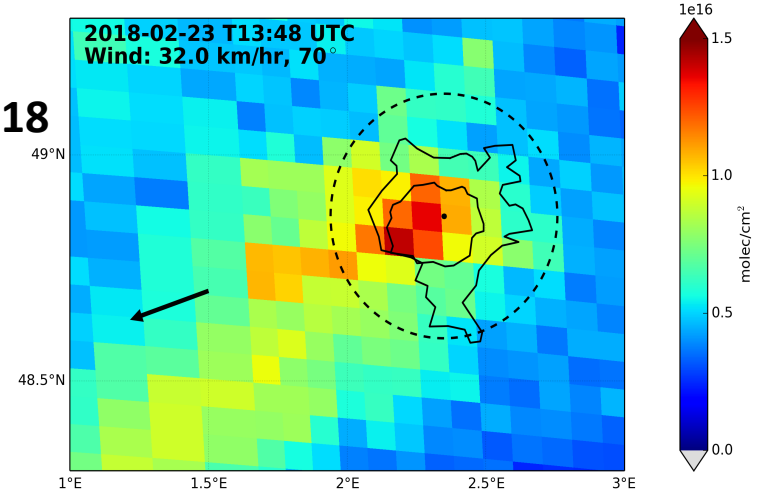


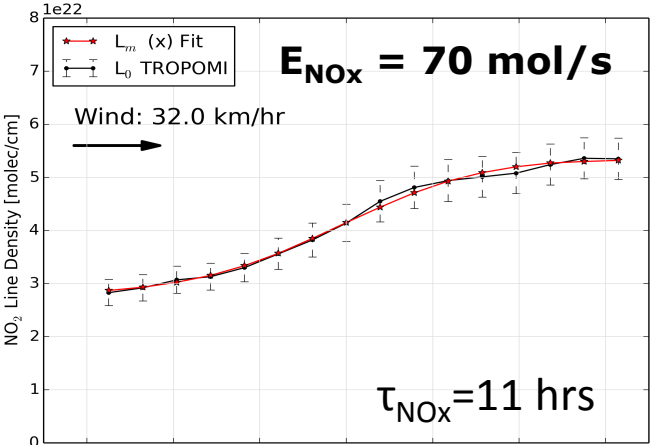
Thursday
22-02-2018
31 km/h



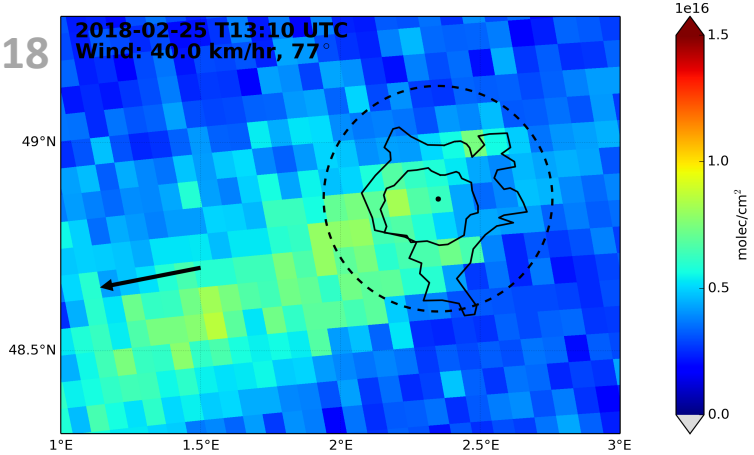


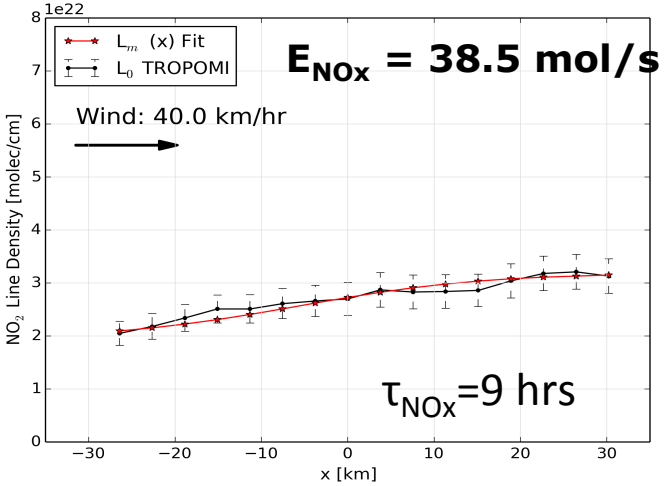
Friday
23-02-2018
32 km/h



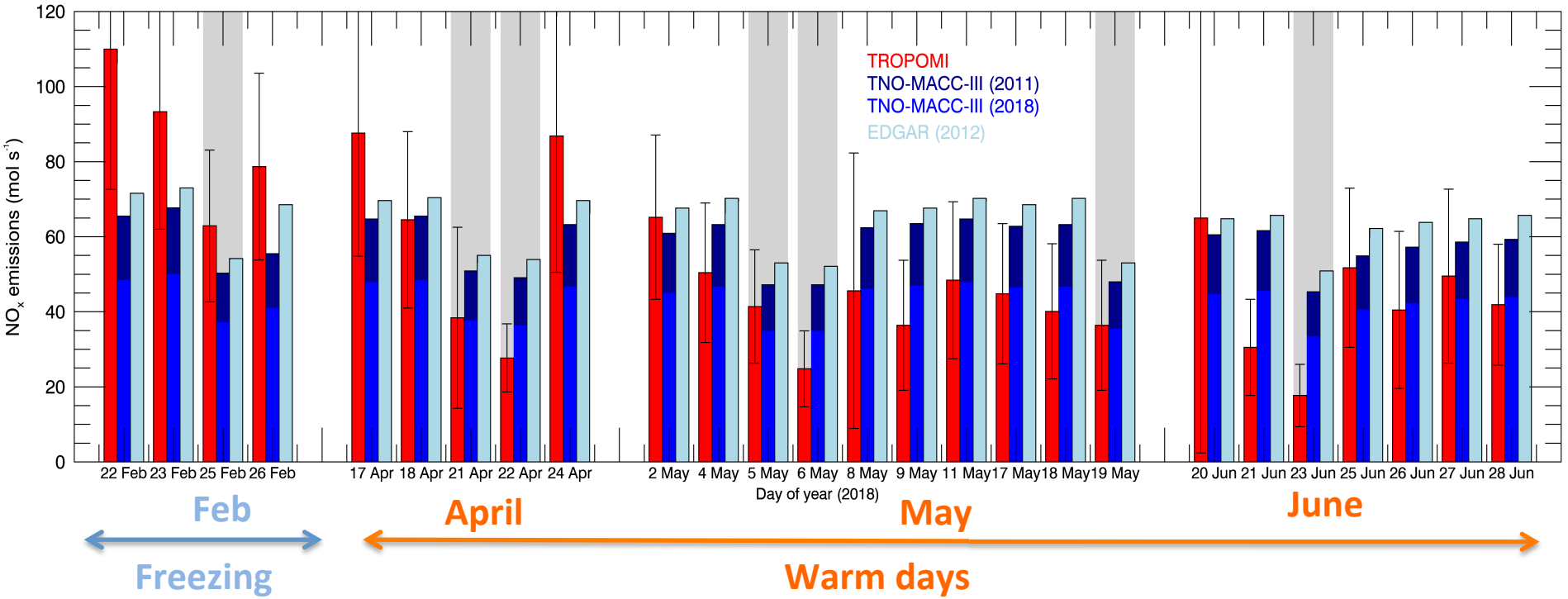


Sunday
25-02-2018
40 km/h





Paris NO_x emissions Feb - Jun 2018



- Daily emission estimates
- TROPOMI captures weekend reductions
- February: TROPOMI higher than predicted
- Apr-June: TROPOMI comparable to TNO-MACC-III (2018)

Uncertainties

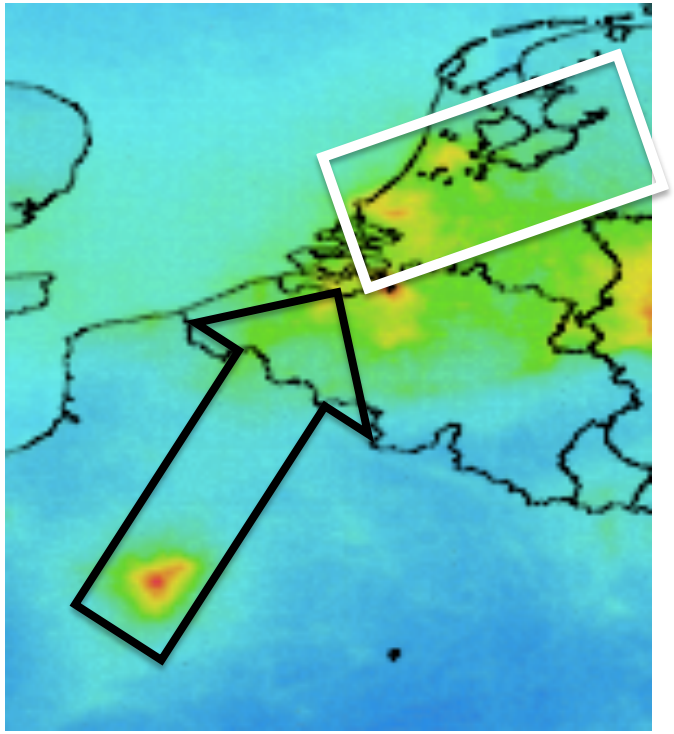
- Replace NO_x:NO2 ratio CAMS by Eiffel Tower: <3% difference
- Wind speed uncertainty of ±20% has similar effect
- Replacing CAMS by CLASS a priori [OH] has some effect
- Weak sensitivity to emission pattern

	Uncertainty	Effect on NO_x emissions
S5P-TROPOMI NO_2 column	30%	30%
NO_2:NO_x ratio	20%	<3%
Wind speed	20%	20%
A priori NO_x loss rate	50%	15%
A priori emission pattern	20%	10%
Total uncertainties assuming uncorrelated error contributions		±50%

Discussion

Clear-sky days only, emissions for noon-time
Method requires advection in well-defined direction
(no re-circulation)

Application and improvement for Ruisdael domain



Goals

1. Improve TROPOMI NO_2 satellite measurements
2. Better estimate NO_x emissions from the TROPOMI obs.
3. Explore how interactions between radiation, dynamics and chemistry drive the distribution of NO_x and ozone

1. Improving TROPOMI NO_2 within Ruisdael

- Improve TROPOMI NO_2 retrievals by moving away from simplified approaches and course prior information, to more physically realistic radiative transfer and high-resolution prior information on the scale of individual pixels.

Approach: improve

- Vertical information on aerosols and clouds
- Vertical information on NO_2

used in retrievals

Ruisdael contribution (?)

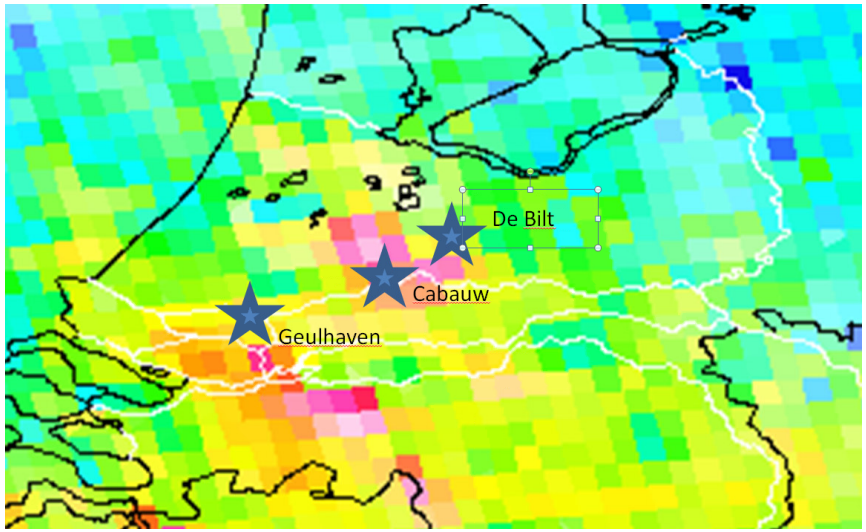
- Modeling clouds and aerosols with DALES / MicroHH
- Hi-res modeling of NO_2 vertical profiles

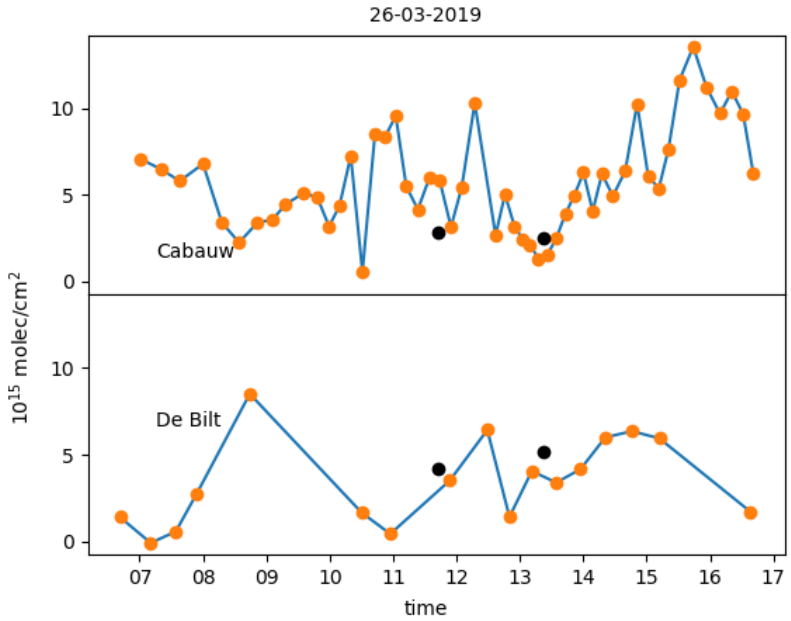
- Observations of aerosols and clouds
- Observations of NO_2 columns and profiles

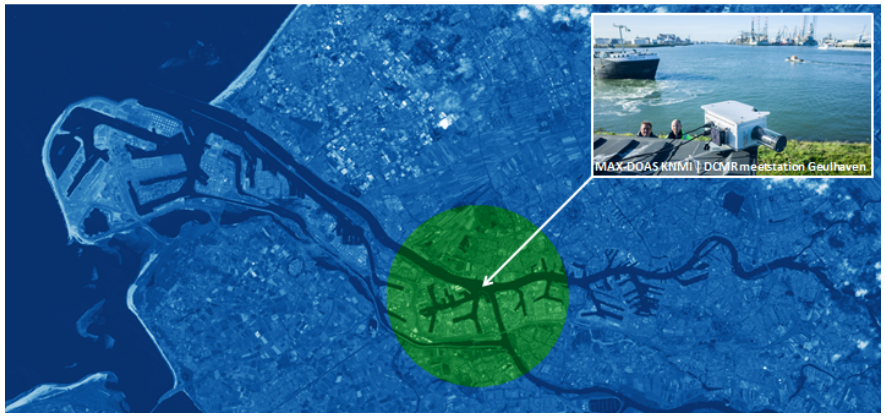
for retrieval testing and validation

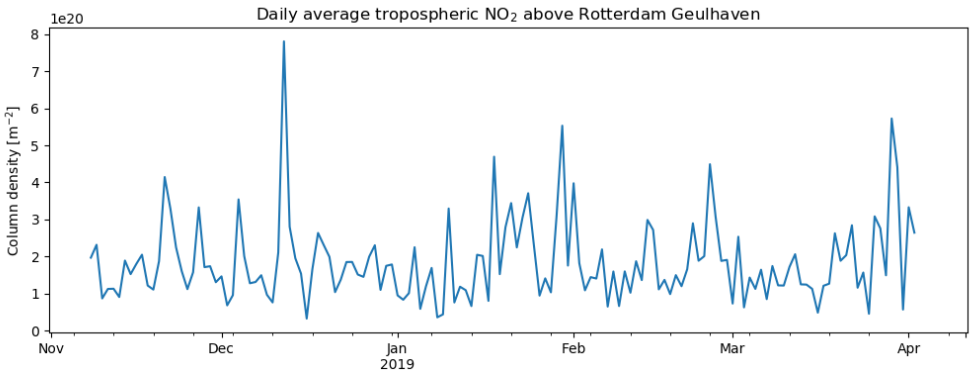
Figure 1. Clouds casting shadows over Amsterdam on an afternoon in September 2018. Note the strong darkening of the surface in the foreground. Viewing direction is towards North.

Observations to test TROPOMI NO_2 within Ruisdael







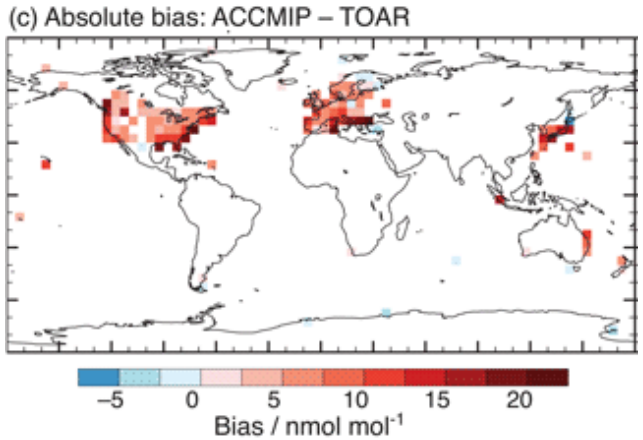


Strong day-to-day variability in columns

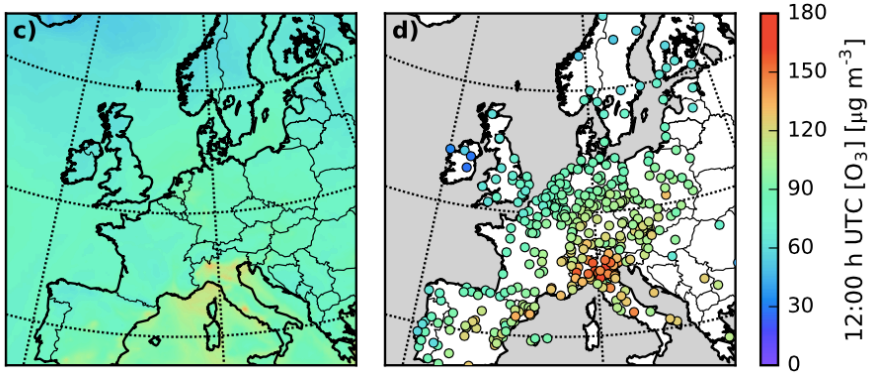
Ankie Piters, Tim Vlemmix

3. The future of air quality modeling

Global models (1° x 1°)



Regional models (0.1° x 0.1°)



Approach

set up high-resolution modeling experiments accounting for interaction

- between dynamics and chemistry (chemical segregation)
- between clouds and chemistry (via modified photolysis rates),
- between clouds and dynamics (shading suppressing mixing),

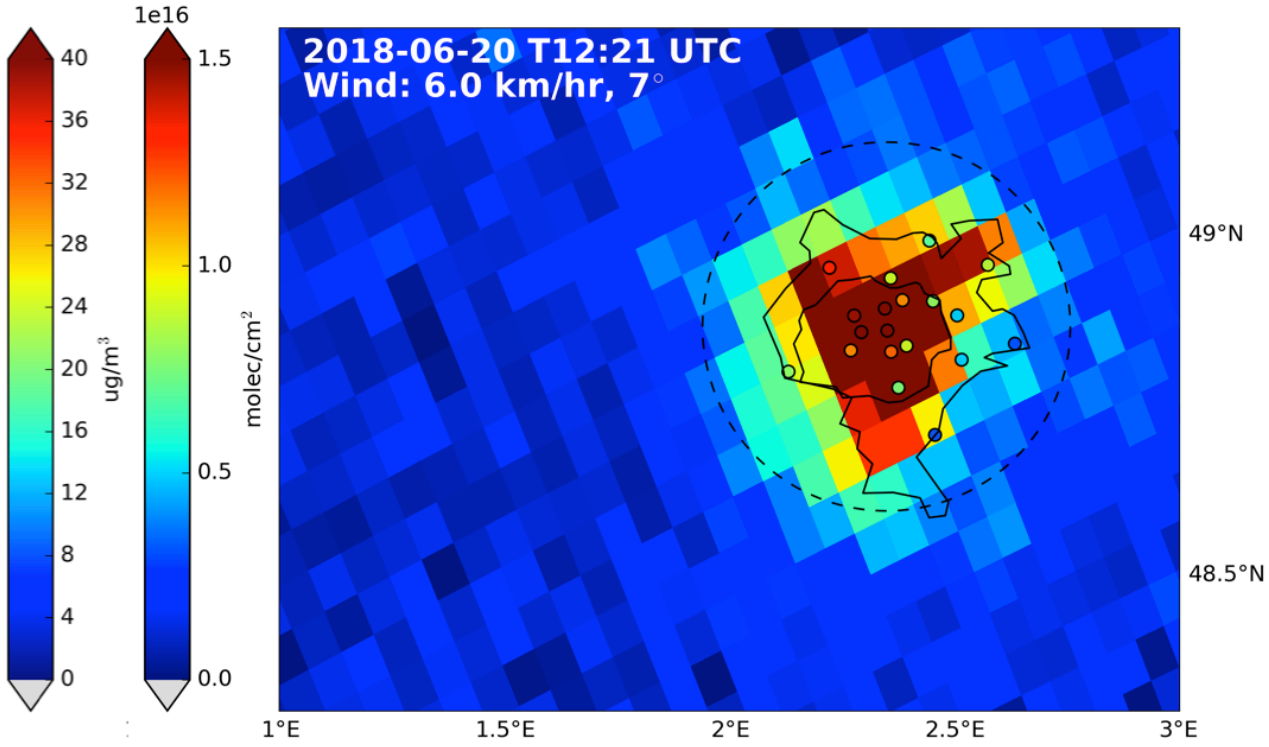
Ruisdael contribution

- Modeling of NO_x and O_3 with DALES and WRF-Chem & TM5 for comparison
- Observations of NO_x and O_3 to test DALES and develop params.

Summary

- TROPOMI captures build-up of NO_2 over a source region
  - Information on spatial distribution of emissions
- Estimate noontime NO_x emissions on a day-by-day basis
  - Weekend effect clearly seen
- TROPOMI NO_x emissions 5-15% lower than inventory for 2012

Day with stagnation



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