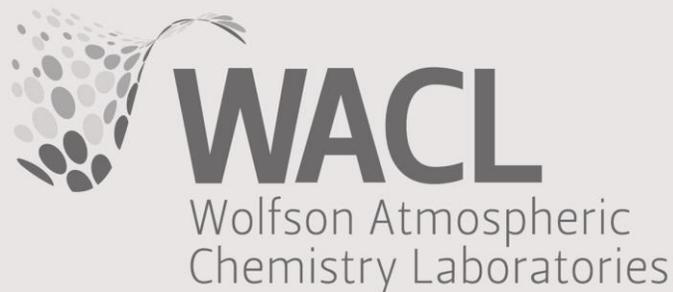


Measurement of NO_x and CO Fluxes from a Tall Tower in Beijing

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Chinese 'airpocalypse' affects half-a-billion people as smog crisis worsens

Pollution levels are six times higher than the World Health Organisation guidelines, Greenpeace says

Hannah Argentin | @HannahArgentin | Tuesday 20 December 2016 21:03 GMT



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China

Smog refugees flee Chinese cities as 'airpocalypse' blights half a billion

Thousands head to pollution-free regions as haze descends on the country's northern industrial heartland

Tom Phillips in Beijing

Wednesday 21 December 2016 10:05 GMT



Air pollution?
Never heard of it!

Pollution

China tops WHO list for deadly outdoor air pollution

More than 1 million people died from dirty air in one year, according to World Health Organisation

Adam Vaughan
@adamvaughan_uk
Tue 27 Sep 2016
07:00 BST

1538 87
This article is over 1 year old



NBC NEWS

NEWS > WORLD

Millions in China Learn to Live With Smog 'Airpocalypse'

by ED PLANAGAN

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China's 'airpocalypse' hits half a billion people

Worst air pollution this year shuts schools and grounds flights



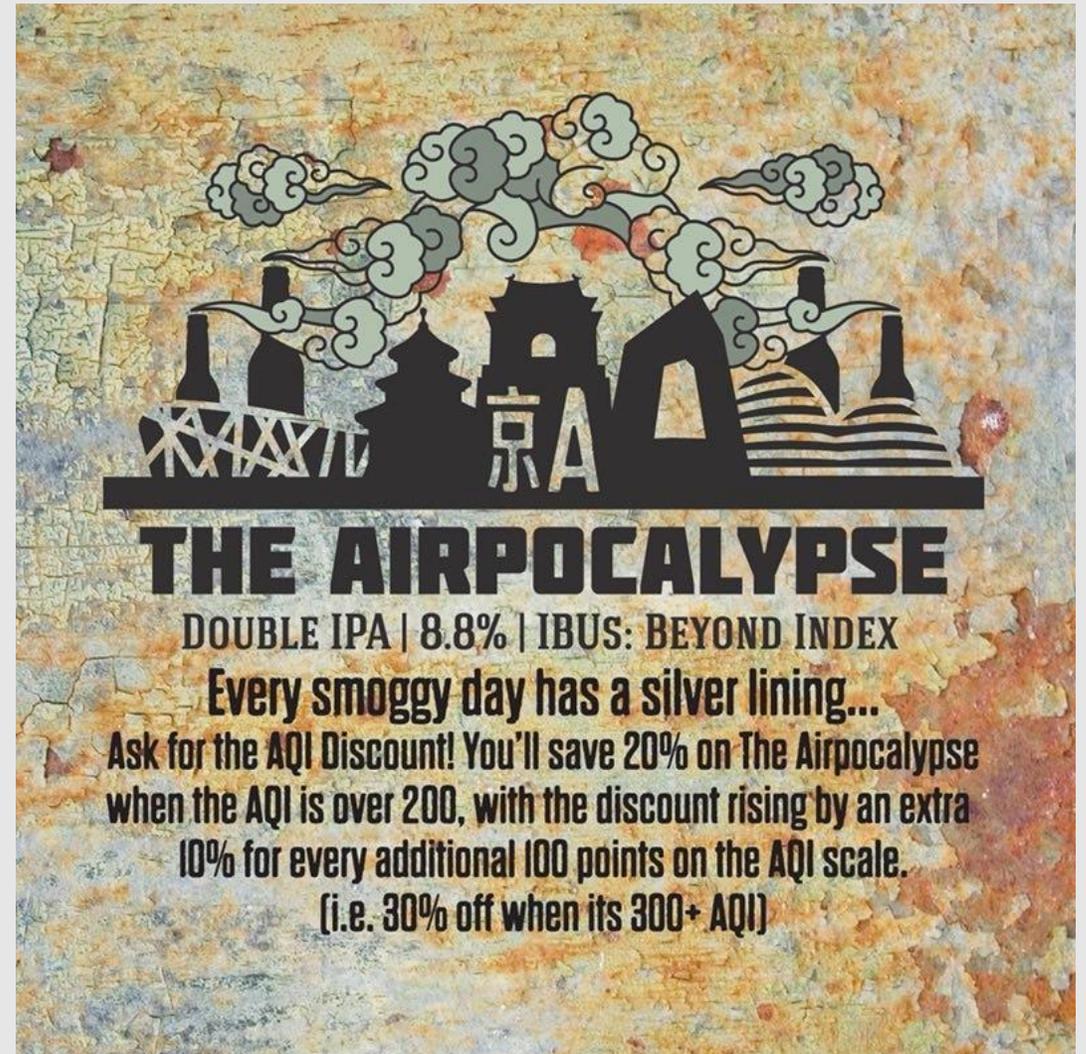
Return of 'airpocalypse' air pollution crisis in northern China

Read next

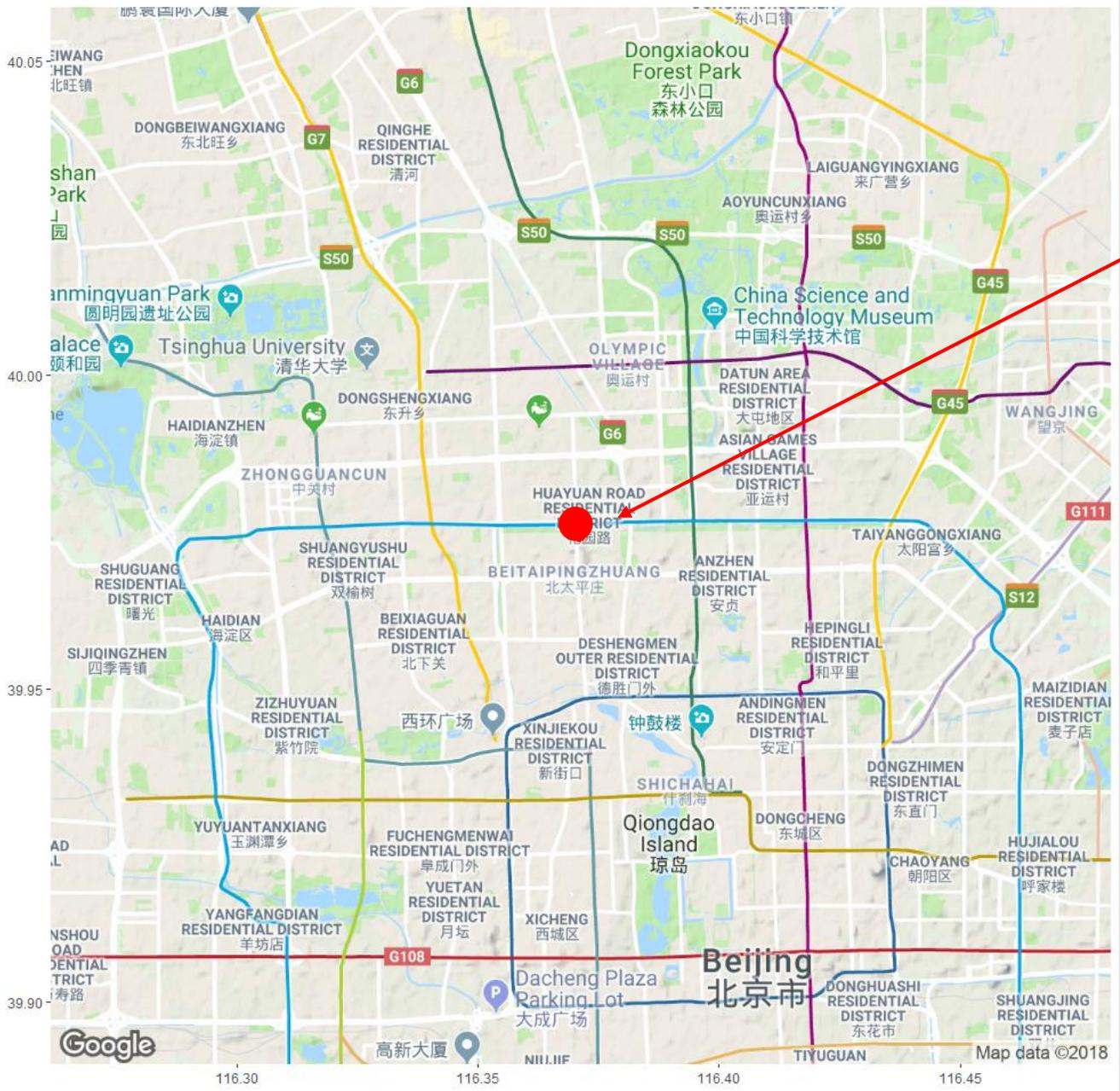
- Call to tackle China's soaring aluminium output
SUNDAY, 19 MARCH 2017
- Call to tackle China's soaring aluminium output
SUNDAY, 19 MARCH 2017
- Sharp drop in US emissions keeps global levels flat
FRIDAY, 17 MARCH 2017
- Trump becomes unlikely ally in climate change fight
FRIDAY, 17 MARCH 2017

Why do we care about air pollution?

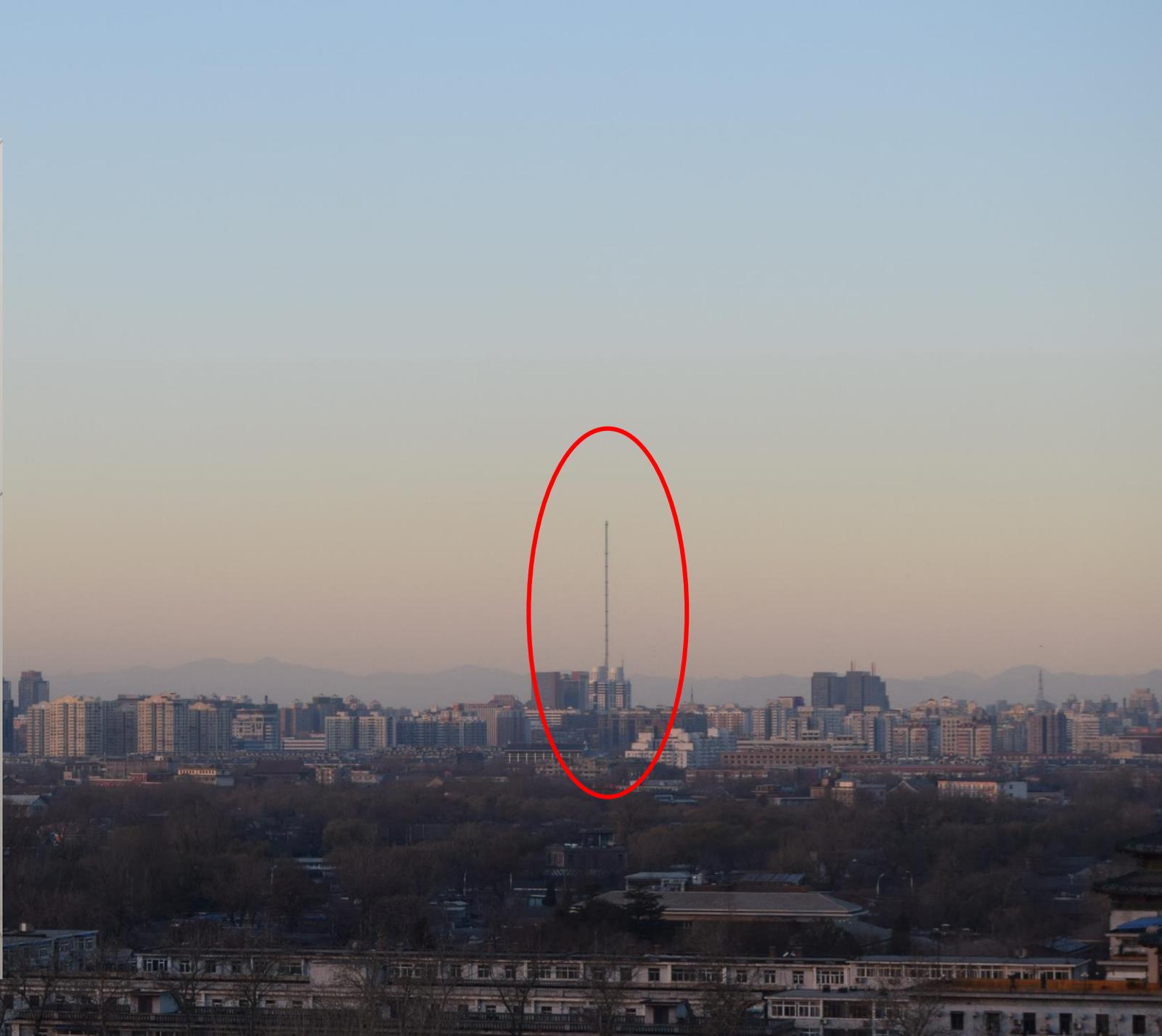
- Pollutant emissions impact on human health (in 2010, 1.2 million premature deaths were attributed to outdoor air pollution in China).
- Many pollutants influence climate (i.e. through aerosol or ozone formation).
- Air pollution can influence the price of beer!



THE AIRPOCALYPSE
DOUBLE IPA | 8.8% | IBUS: BEYOND INDEX
Every smoggy day has a silver lining...
Ask for the AQI Discount! You'll save 20% on The Airpocalypse when the AQI is over 200, with the discount rising by an extra 10% for every additional 100 points on the AQI scale.
(i.e. 30% off when its 300+ AQI)



Institute for
Atmospheric Physics



Experiment



2 campaigns; **Winter** (05/11/2016–11/12/2016) and **Summer** (22/05/2017–25/06/2017).

- NO_x measured with fast chemiluminescence instrument (Air Quality Designs).
- CO measured with fast resonance fluorescent instrument (AeroLaser).
- Wind data (Gill Windmaster Pro Sonic Anemometer).

Flux Measurements

Difference between instantaneous and mean vertical wind speed

$$F = \overline{w'c'}$$

Difference between instantaneous and mean pollutant concentration

Flux measurements enable us to quantify NO_x and CO *emission* and therefore identify emission sources!

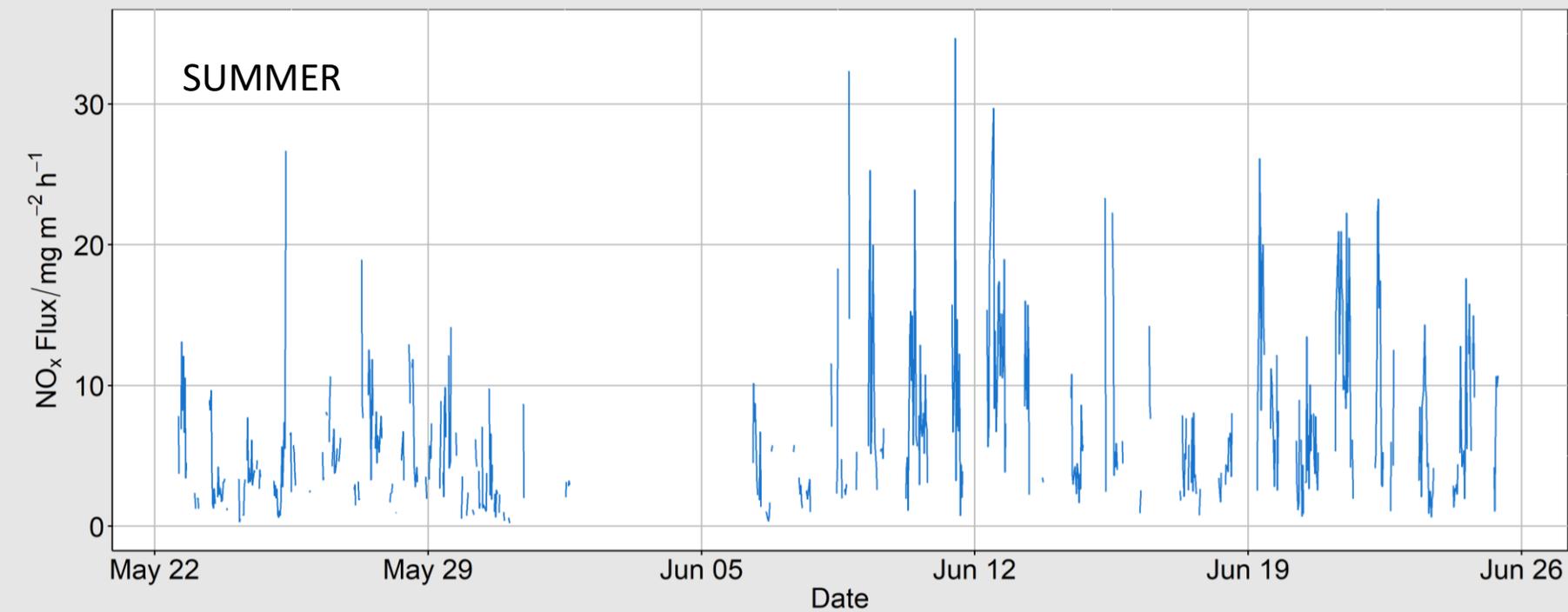
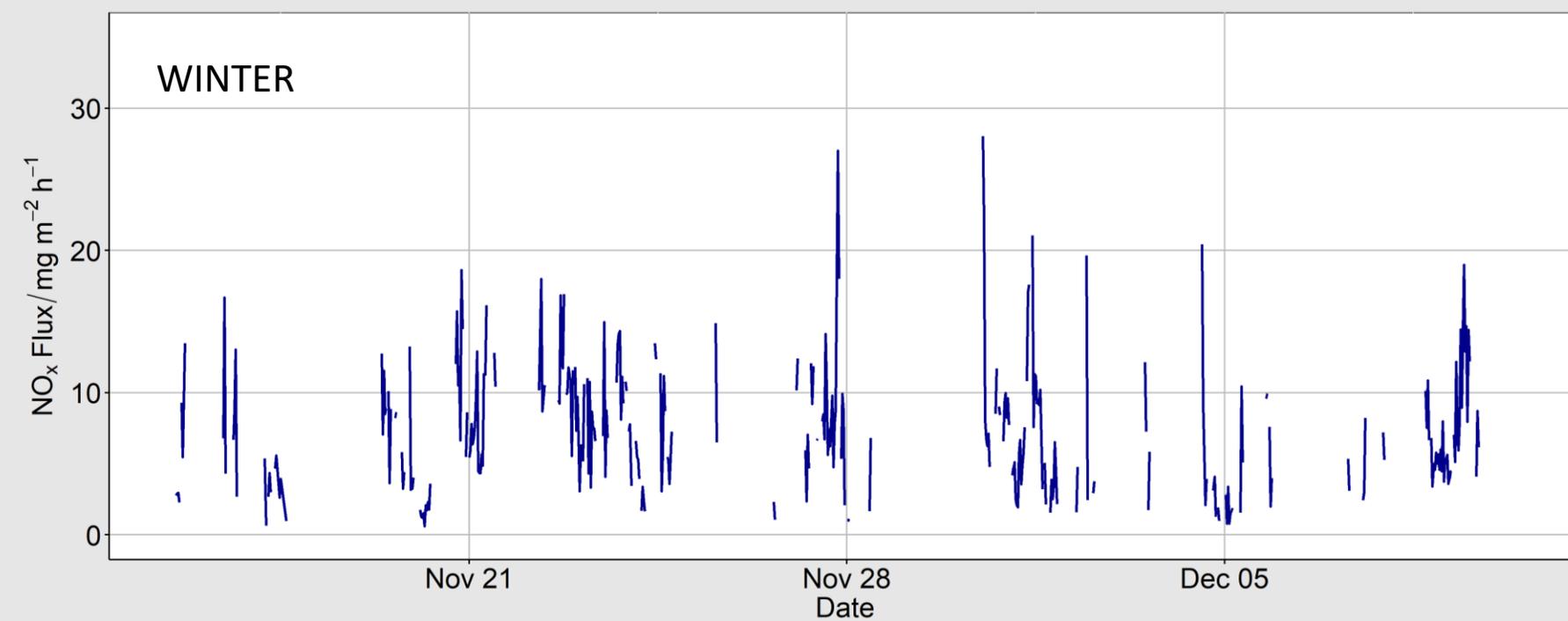
Eddy Covariance



Assumptions

- Measurements are carried out within the boundary layer.
- Flux is fully turbulent – most of the net vertical transfer is done by eddies.

Image source: Burba, G., 2013. Eddy Covariance Method for Scientific, Industrial, Agricultural and Regulatory Applications: a Field Book on Measuring Ecosystem Gas Exchange and Areal Emission Rates. LI-COR Biosciences, Lincoln, USA

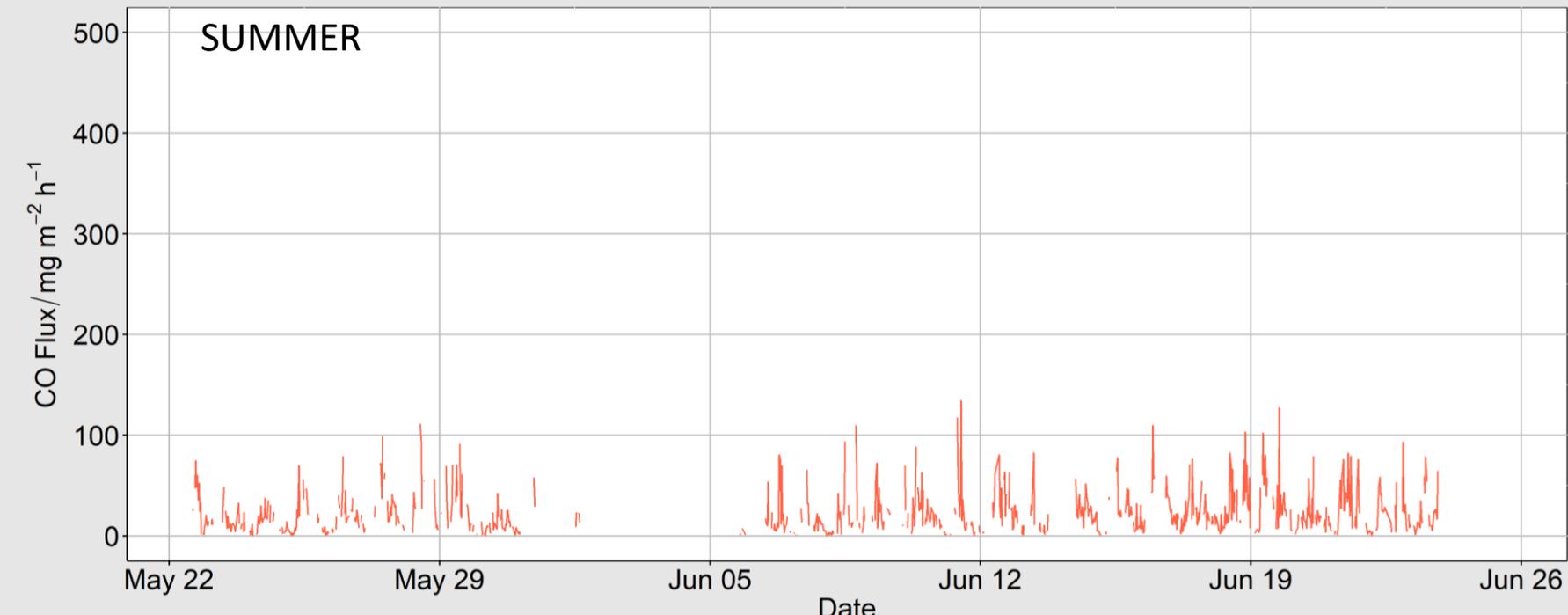
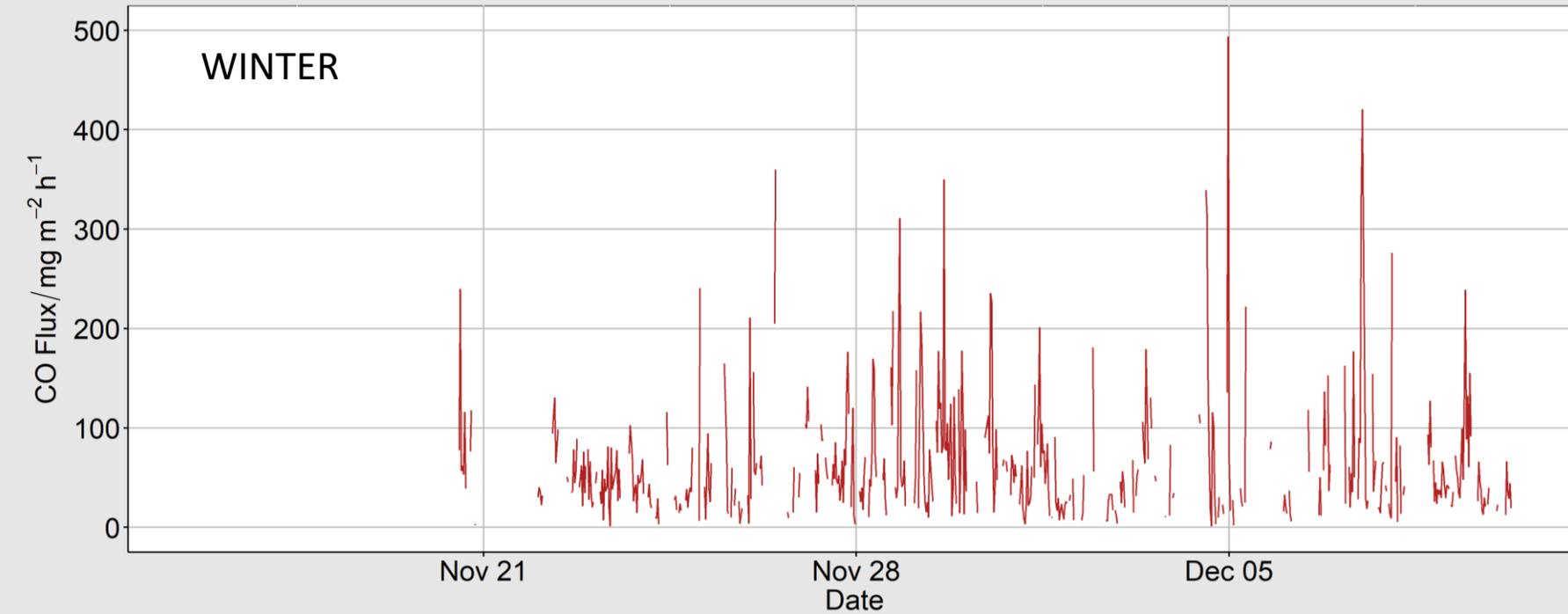


NO_x Emission Time Series

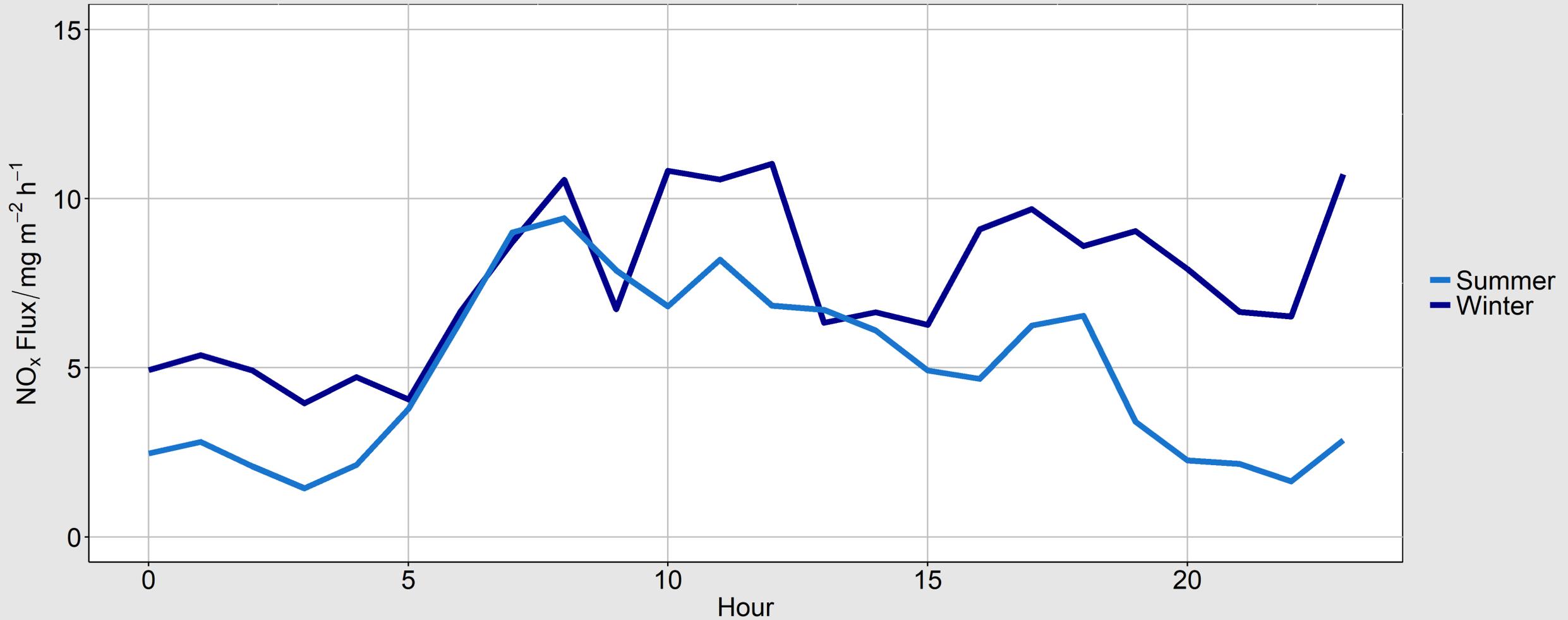
- Winter has more data gaps (lack of turbulence) and due to some instrument issues.
- Magnitude very similar between the two campaigns, suggesting common sources during the campaigns.

CO Emission Time Series

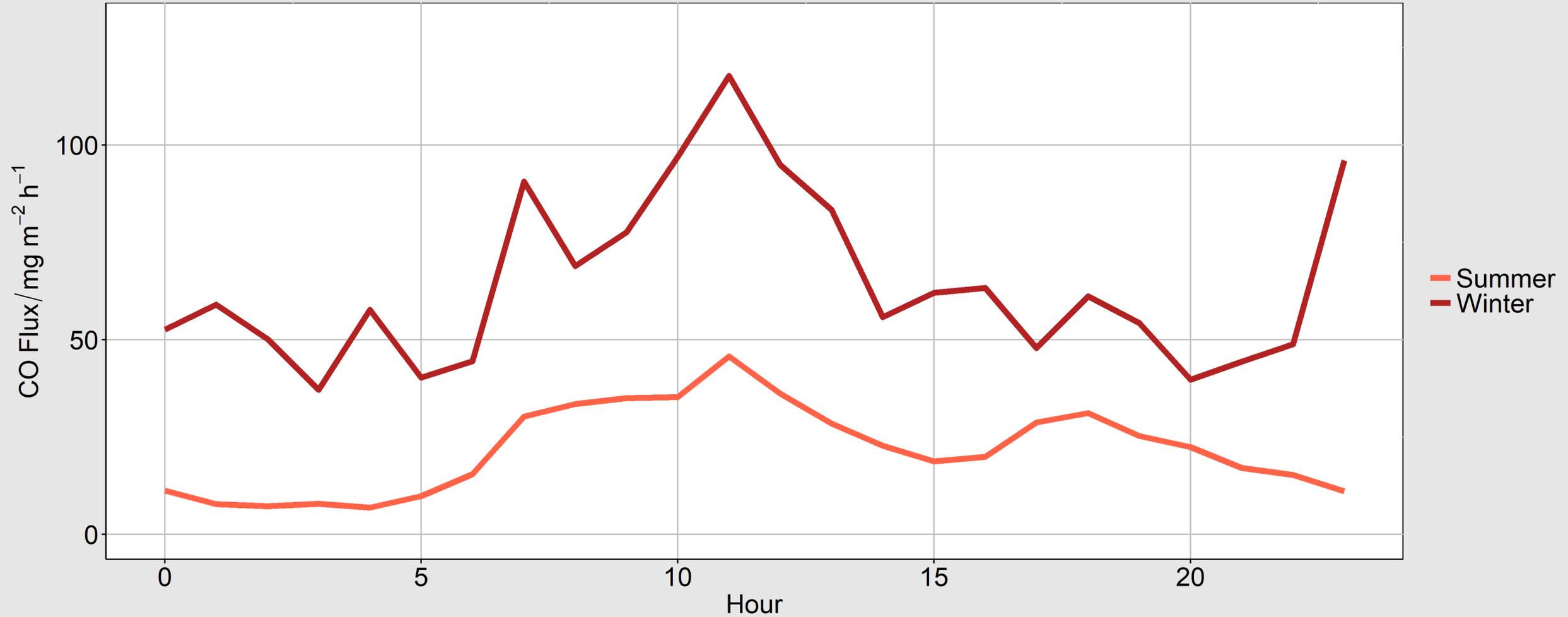
- Delayed in getting the CO instrument online so data gaps at start of the campaign.
- Additional source in winter. Emissions seem to be ~ 3 times higher in winter (on average).



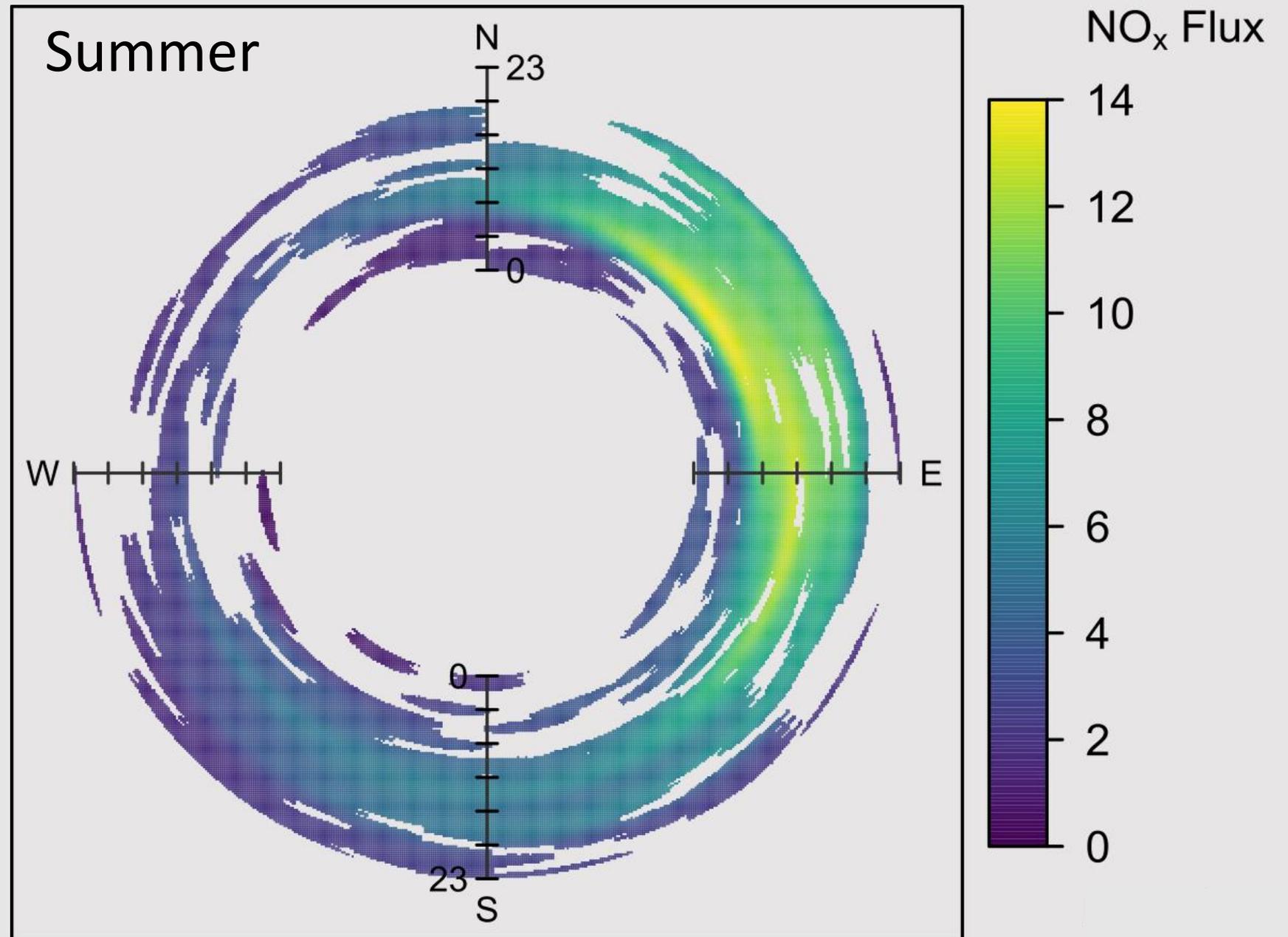
NO_x Emission Flux



CO Emission Flux

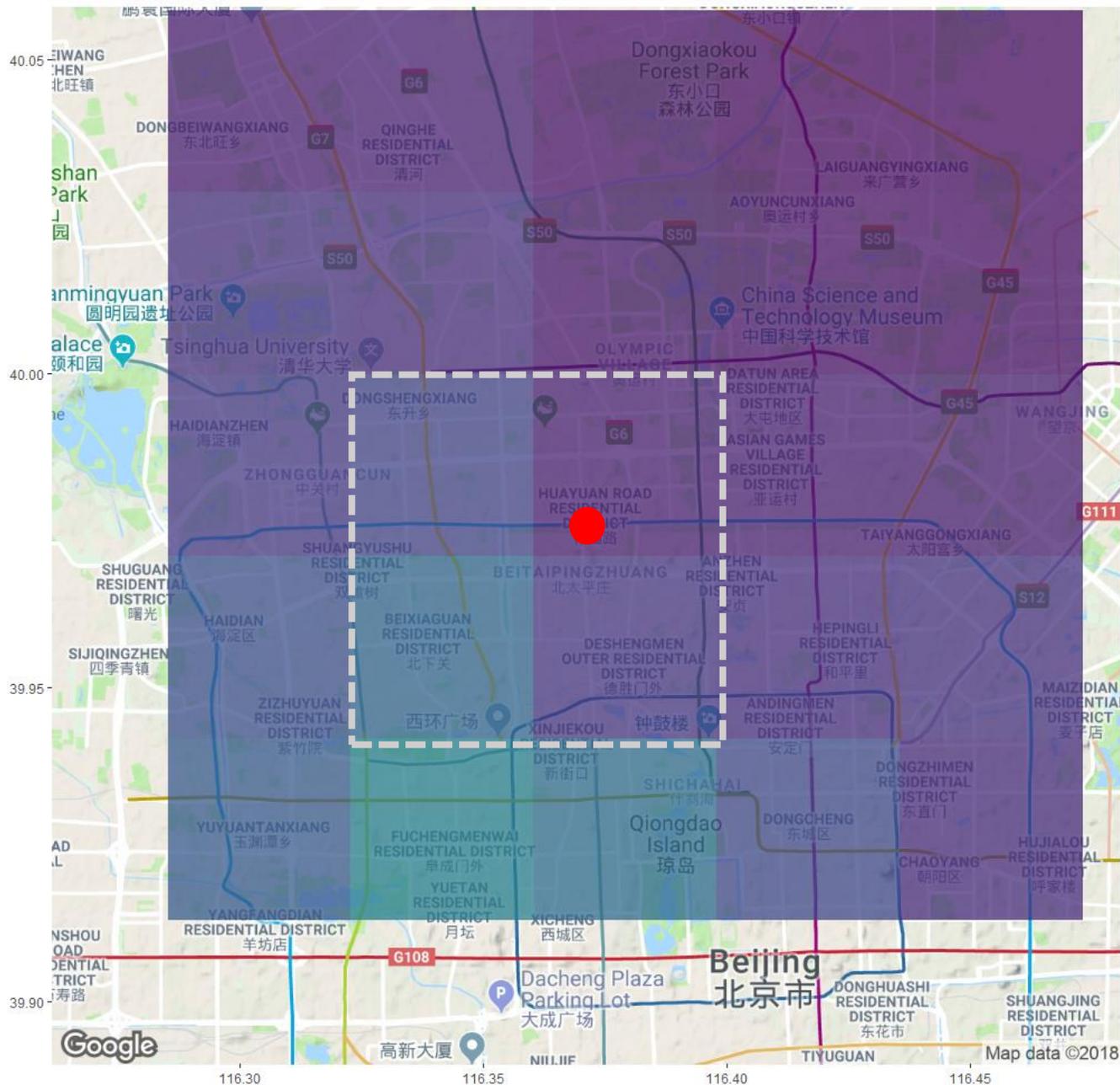


Consider
wind
direction...

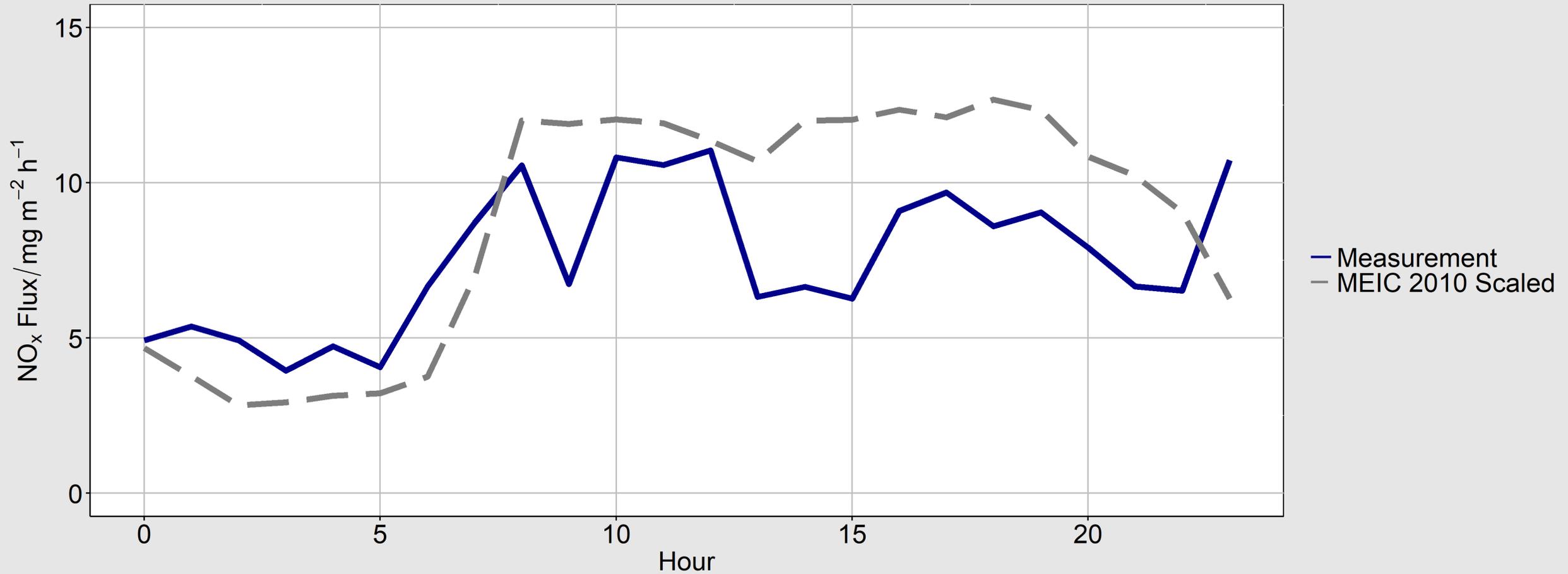


MEIC

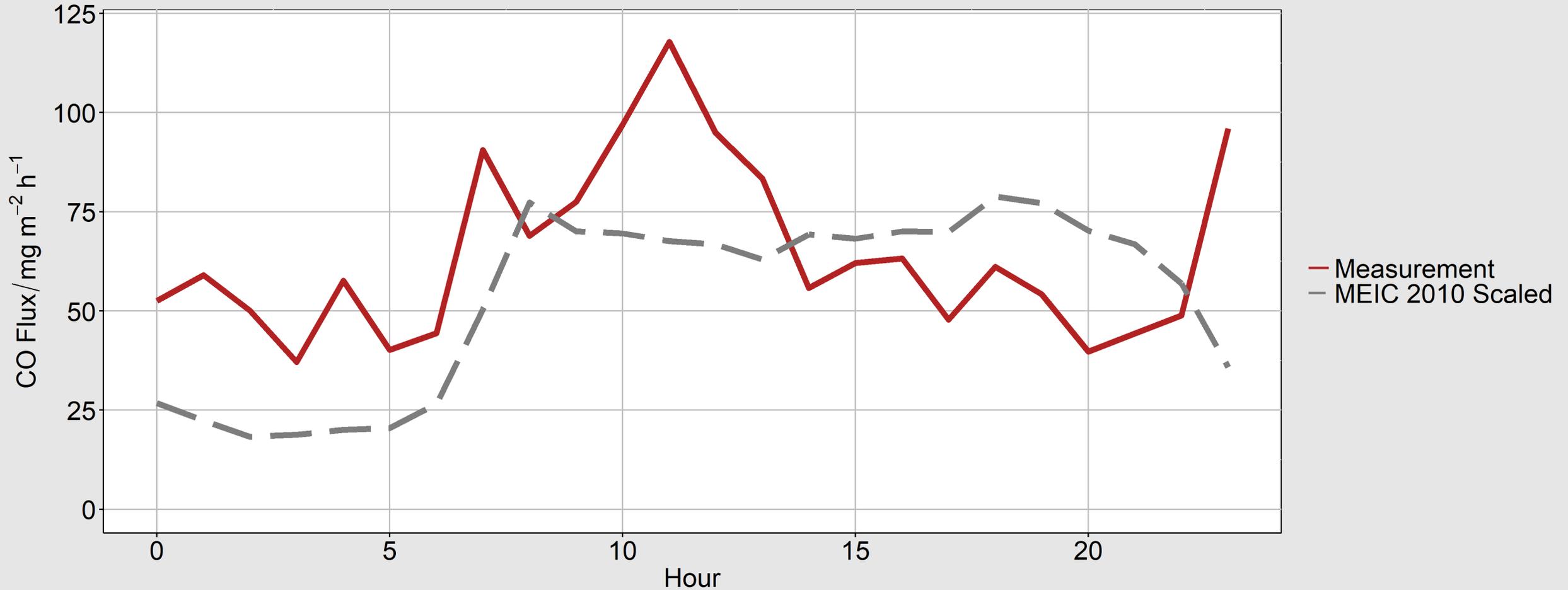
- October 2010 Multi-Resolution Emissions Inventory for China (MEIC).
- 3 km² resolution.
- Scaled down by 25 % to reflect expected change in NO_x emission for October 2016.
- Average emission from surrounding 4 squares and multiplied by time-of-day scaling factor.



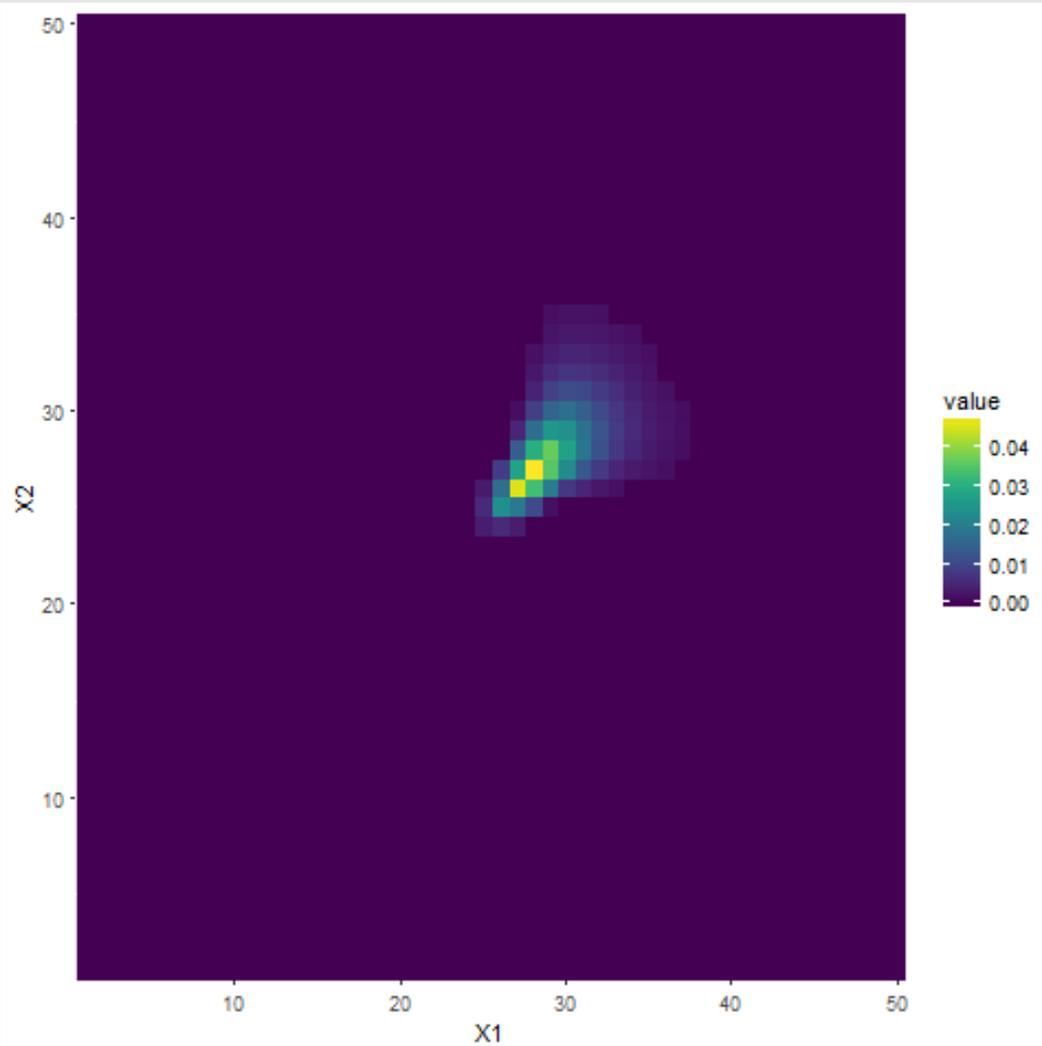
NO_x Emission Flux and MEIC Inventory



CO Emission Flux and MEIC Inventory

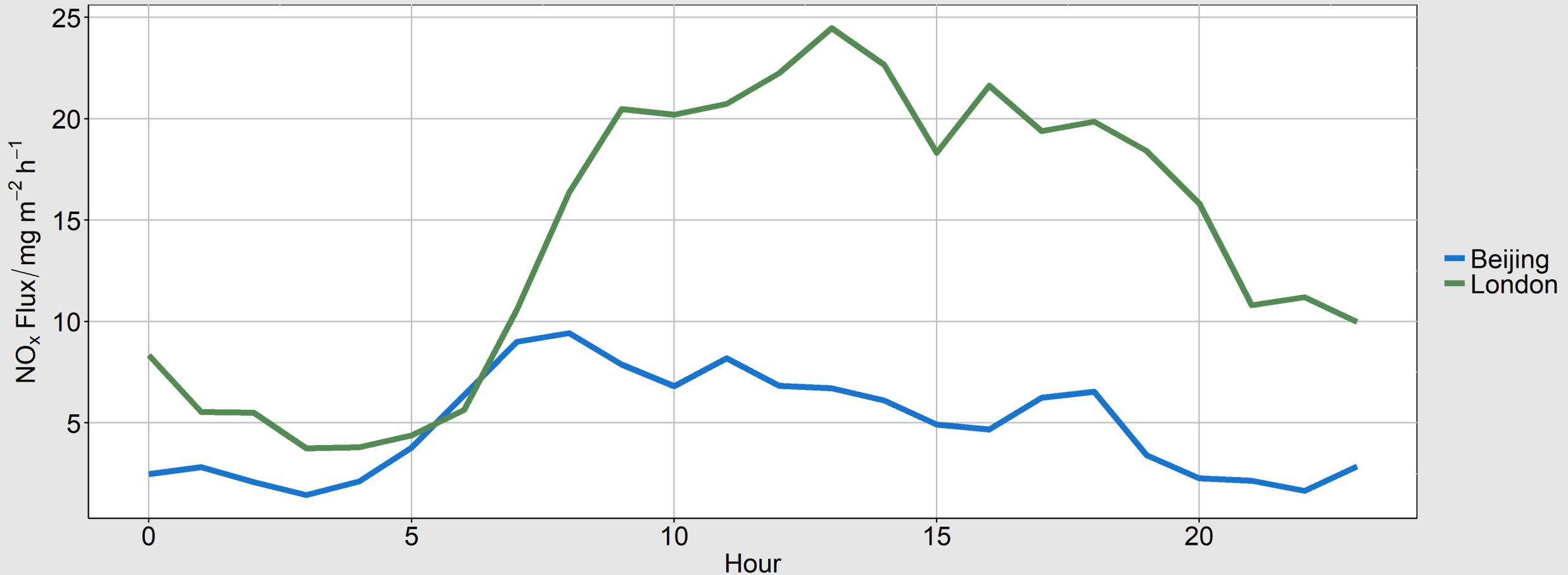


Next steps



- Parameterisation of the backward Lagrangian model of Kljun et al. (2002, 2004) described in Metzger et al. (2012, 2013).
- Create a weighting matrix that predicts the ground influence of a particular cell contributing to the observed emission flux.
- Footprint is then calculated by multiplying inventory grid by this weighting matrix.
- Future work will involve this analysis carried out using a higher resolution inventory (1 km² resolution for 2013).

Comparison with London (May – June '17)



Eddy Covariance Measurements Assessing NO_x Emission in London

Will S. Drysdale^a | James D. Lee^a | Ruth M. Purvis^a | Freya A. Squires^a | Adam R. Vaughan^a
Stefan Metzger^{b,c} | Sue Grimmond^d

Previous NO_x measurements in London

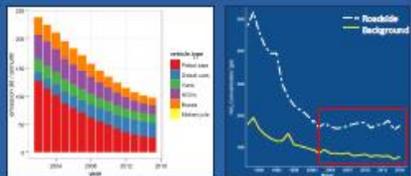


Figure 1. Left - NAEI projected NO_x emissions from Vehicles in central London^a
Right - NO_x concentrations in central London - box matches left x-axis

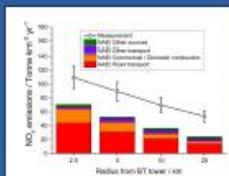


Figure 2. NO_x Flux measurements compared with NAEI projected emissons, separated by footprint radius^a

Projected reductions in vehicle emissions of NO_x in central London has not been reflected in concentrations measured across the city. (Fig 1)

NO_x fluxes measured in 2012 showed significant underestimation of NO_x emission by National Atmospheric Emissions inventory (NAEI). (Fig 2)

Flux measurements in 2017

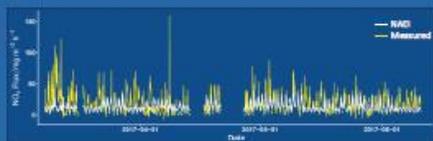


Figure 3. Top - 1 hour fluxes calculated using EddyFlux
Bottom - Day of Week Diagnostics for the above timeseries
Both are compared to the NAEI, scaled for Hour, Day and Month

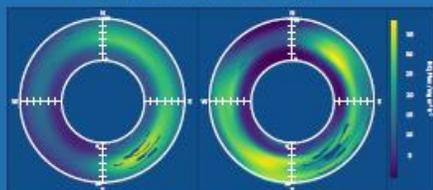


Figure 4. Diurnal profiles from hour 0 inside to hour 23 outside. Separated by wind direction. Left shows NAEI, right shows measured data

Figures 3 and 4 highlight both the general underestimation of the NAEI compared to measurement. Figure 4 especially demonstrates that the underestimation may not be homogeneous, but that certain areas of the inventory perform worse than others

Instrument



During Mar - Jun 2017, 5 Hz NO_x fluxes have been measured at the BT Tower in London using a dual channel ADD NO_x instrument (left). It utilises blue light conversion and chemiluminescence techniques. 5 Hz wind vectors are logged from a Gill R3-50 sonic anemometer, co-located with the sample inlet

Future Work

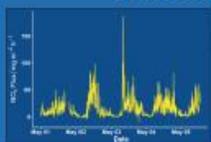


Figure 5. 6 minute fluxes produced using EddyFlux^a



Figure 6. Top - Flight tracks used for mass balance calculations. Bottom - NAEI constrained by HYSPLIT trajectories

Coupling high time resolution fluxes and footprint models will allow more precise assessment of the inventory Alternative assessments of the bulk emissions from London will be performed using data from the FAAM and DLR aircraft during the EMERGE campaign in 2017, alongside model comparisons (Fig 6)

Will Drysdale
Eddy Covariance
Measurements Assessing
 NO_x Emission in London
Poster Board 14

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¹ A. R. Vaughan et al., *Atmospheric Science*, 2014, 118, 439-472.
² J. D. Lee et al., *Atmospheric Science & Technology*, 2015, 48, 1525-1538.
³ S. Metzger et al., *Atmospheric Measurement Techniques*, 2012, 5, 1889-1917.
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