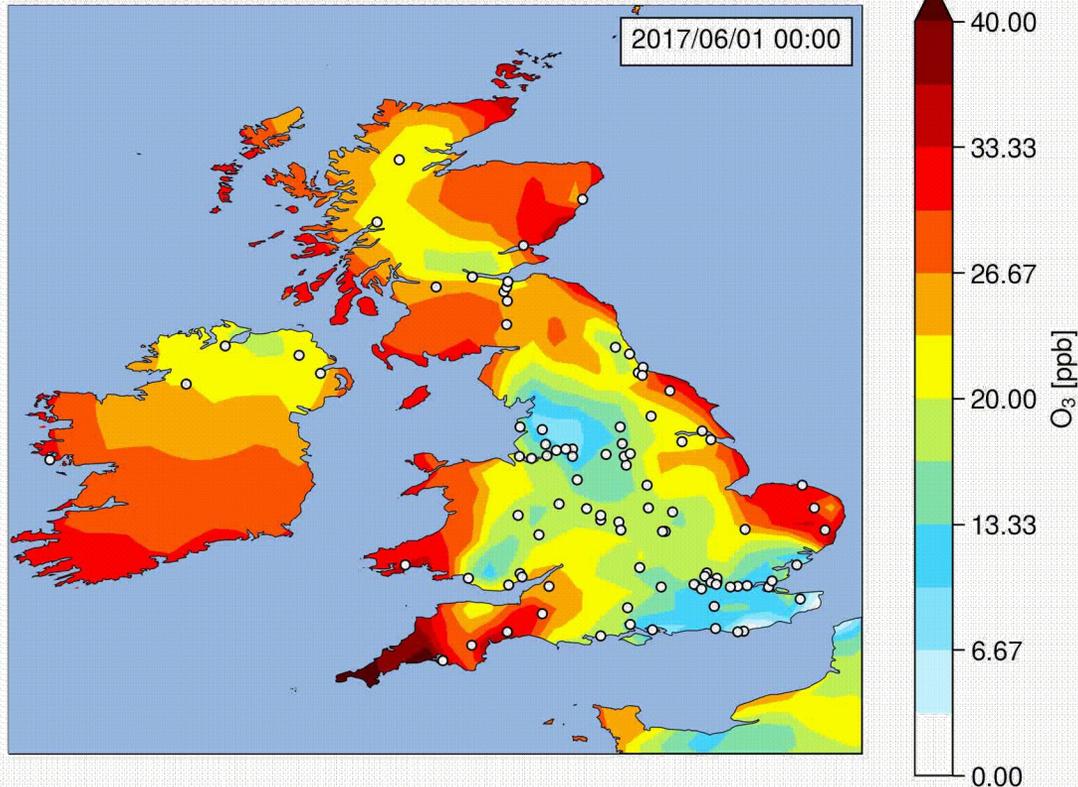


Modelling UK Air Pollution

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2. Wolfson Atmospheric Chemistry Laboratories, University of York, UK

Surface O₃



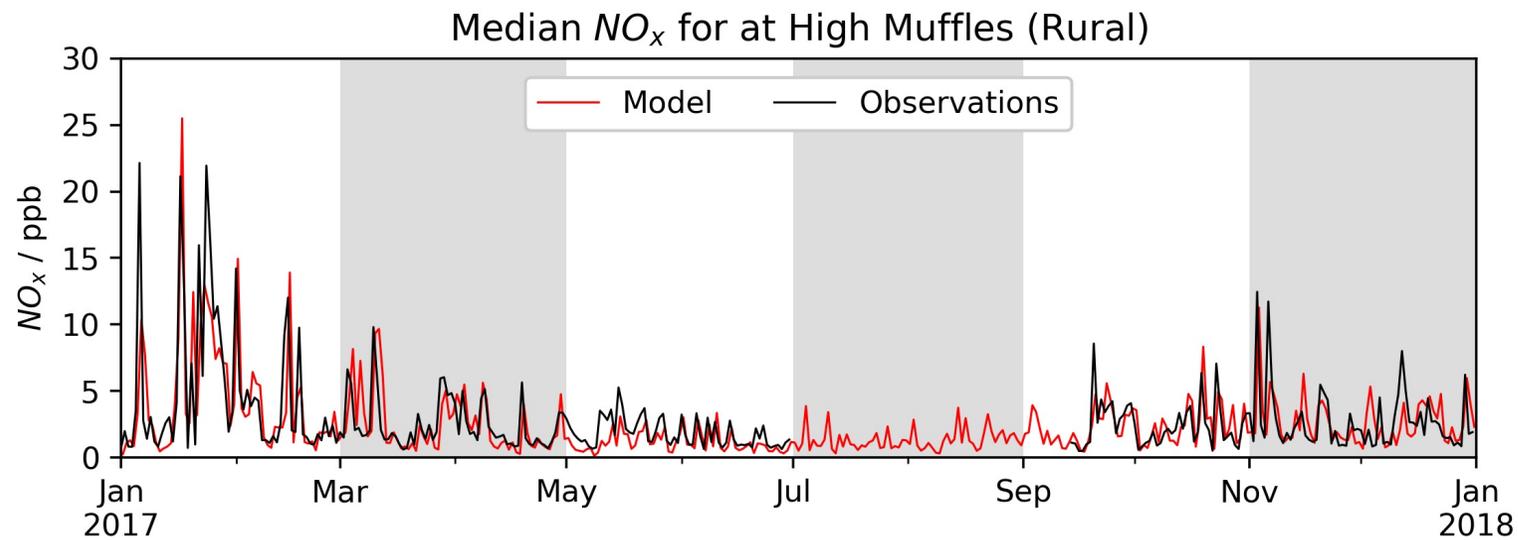
GCC v13.1 over the UK at 0.25x0.3125 with EMEP (European) emissions for 2017.

Comparing surface (10m) concentrations with UK monitoring network measurements for:

- NO, NO₂
- O₃,
- CO
- NH₃
- SO₂
- PM_{2.5}
- VOCs: ethane, propane, alkanes (≥C₄), alkenes (≥C₃), benzene, toluene, xylene, isoprene
- Inorganic aerosols: Sulphate, Nitrate, Ammonium

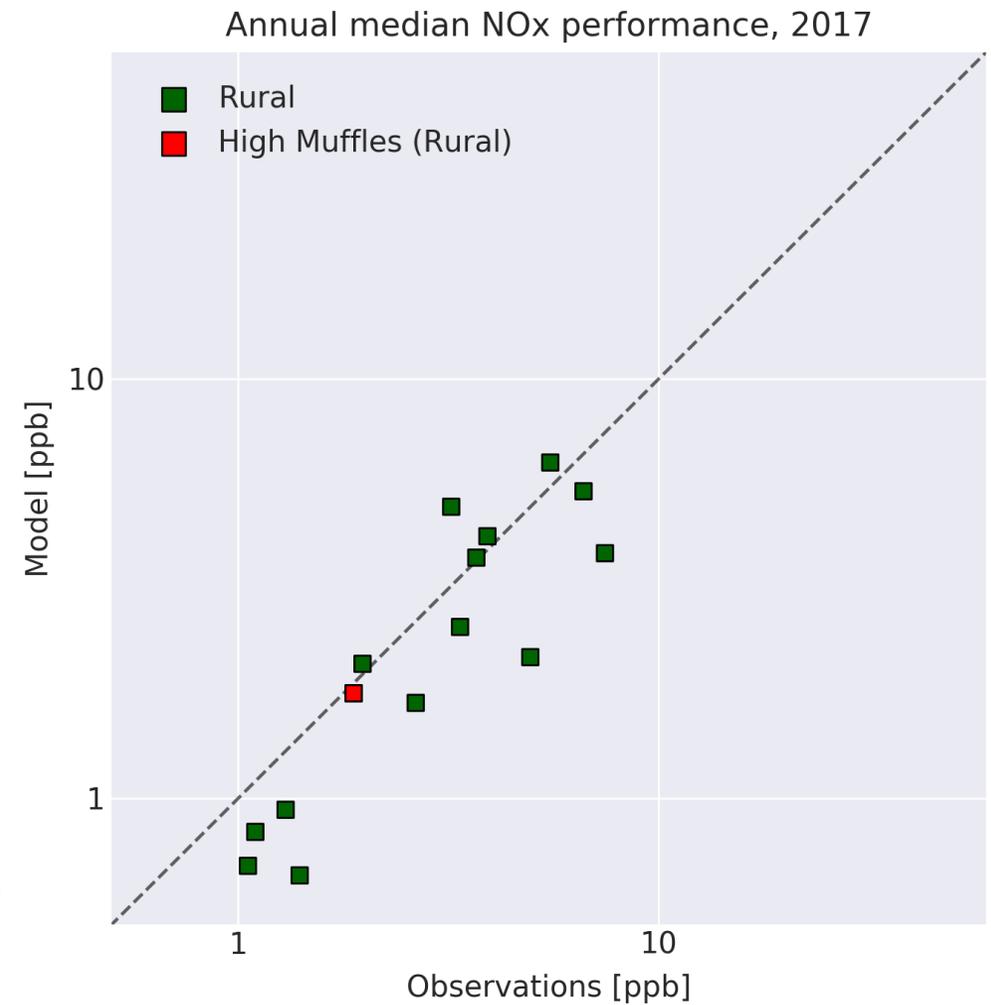
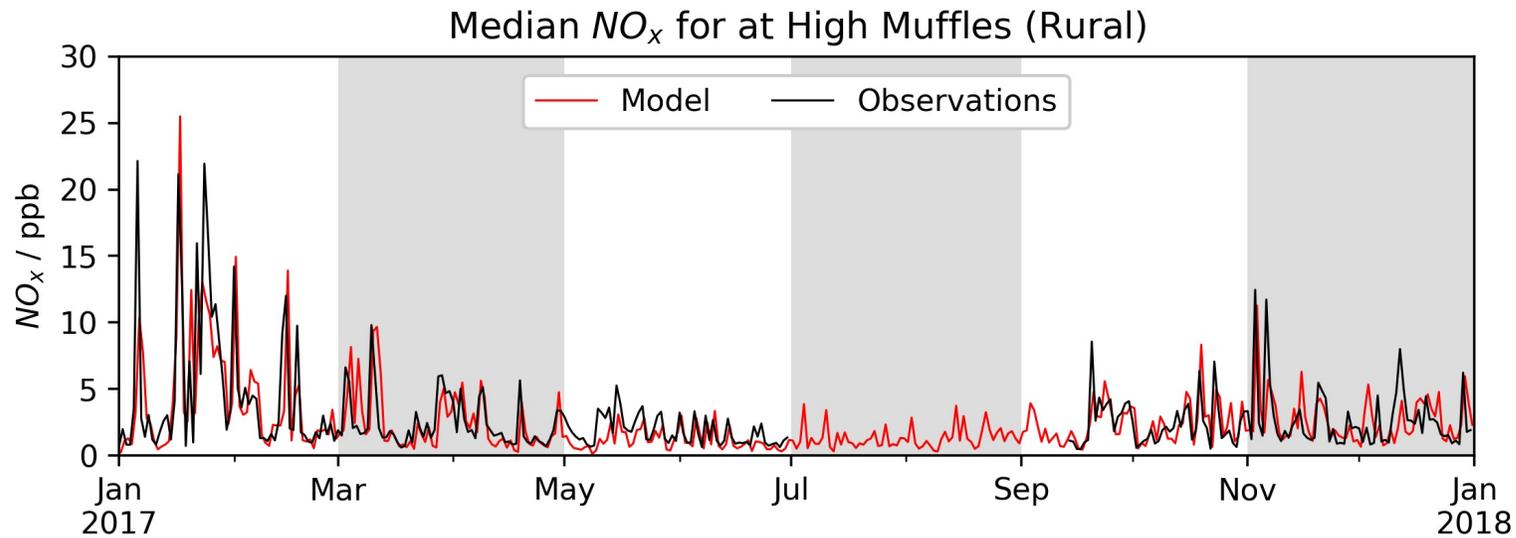
NO_x performance

Model simulates Rural sites well



NO_x performance

Model simulates **Rural** sites well

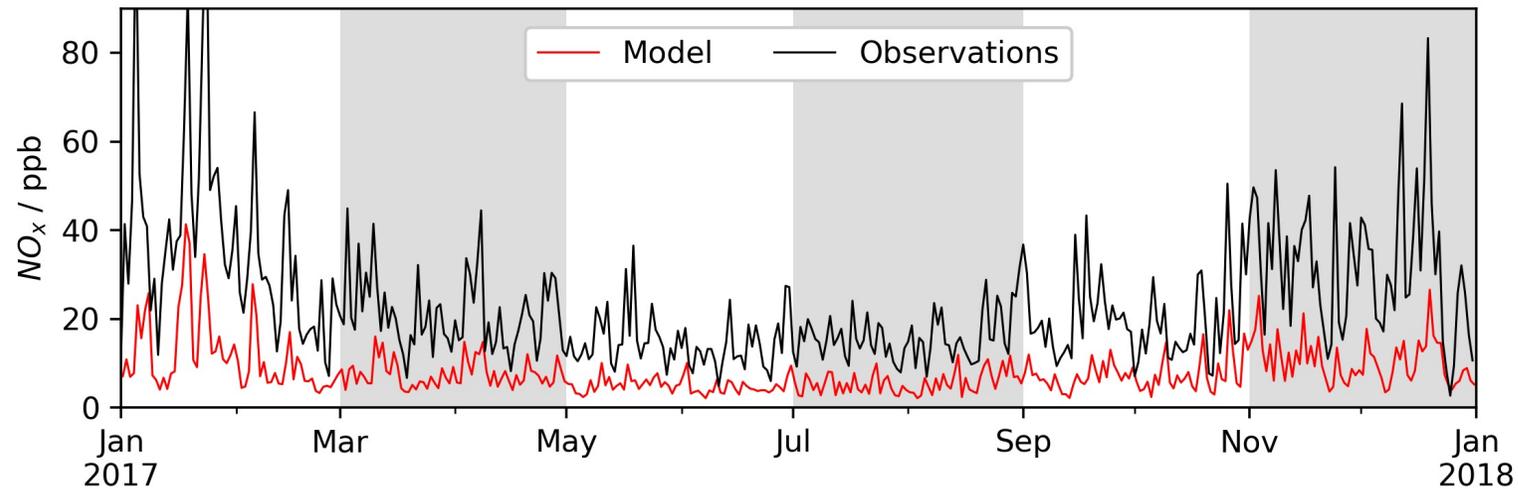


NO_x performance

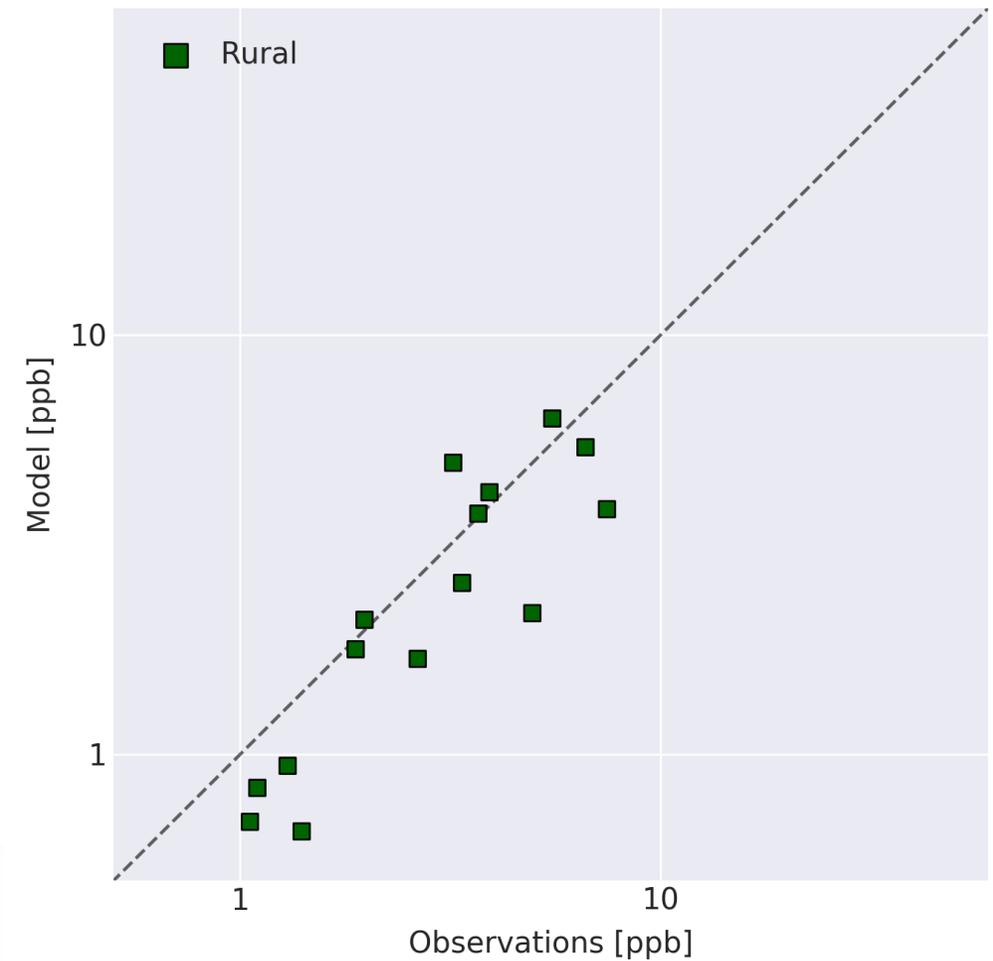
Model simulates **Rural** sites well

Underestimates **Urban** sites by a factor of ~2

Median NO_x for at Nottingham Centre (Urban)



Annual median NO_x performance, 2017



NO_x performance

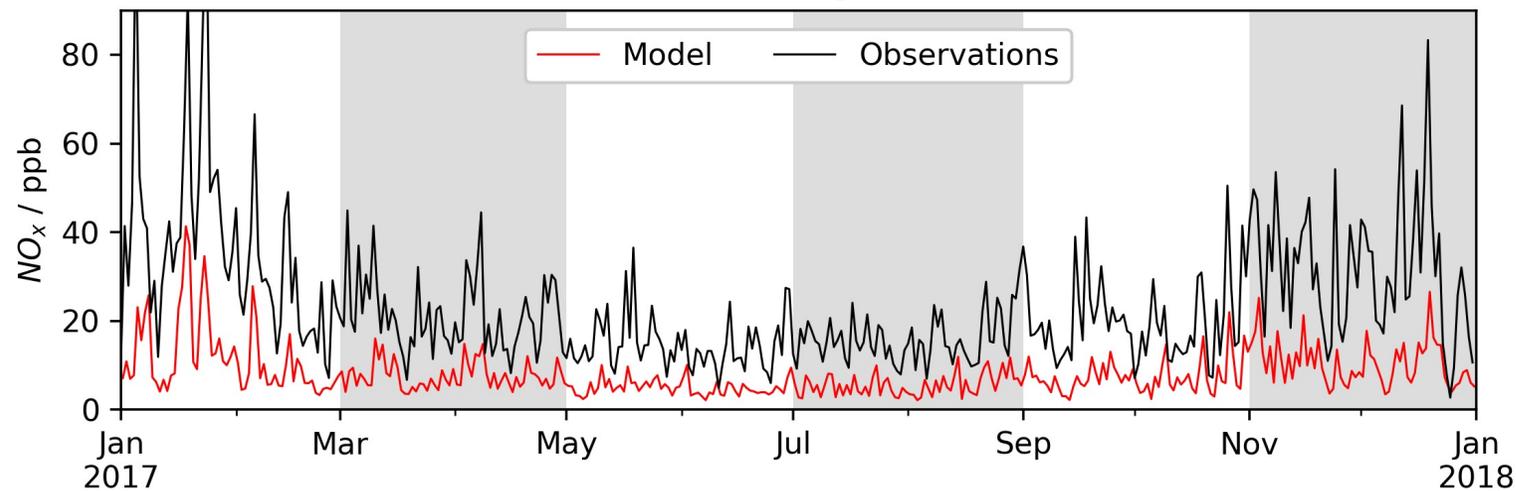
Model simulates **Rural** sites well

Underestimates **Urban** sites by a factor of ~2

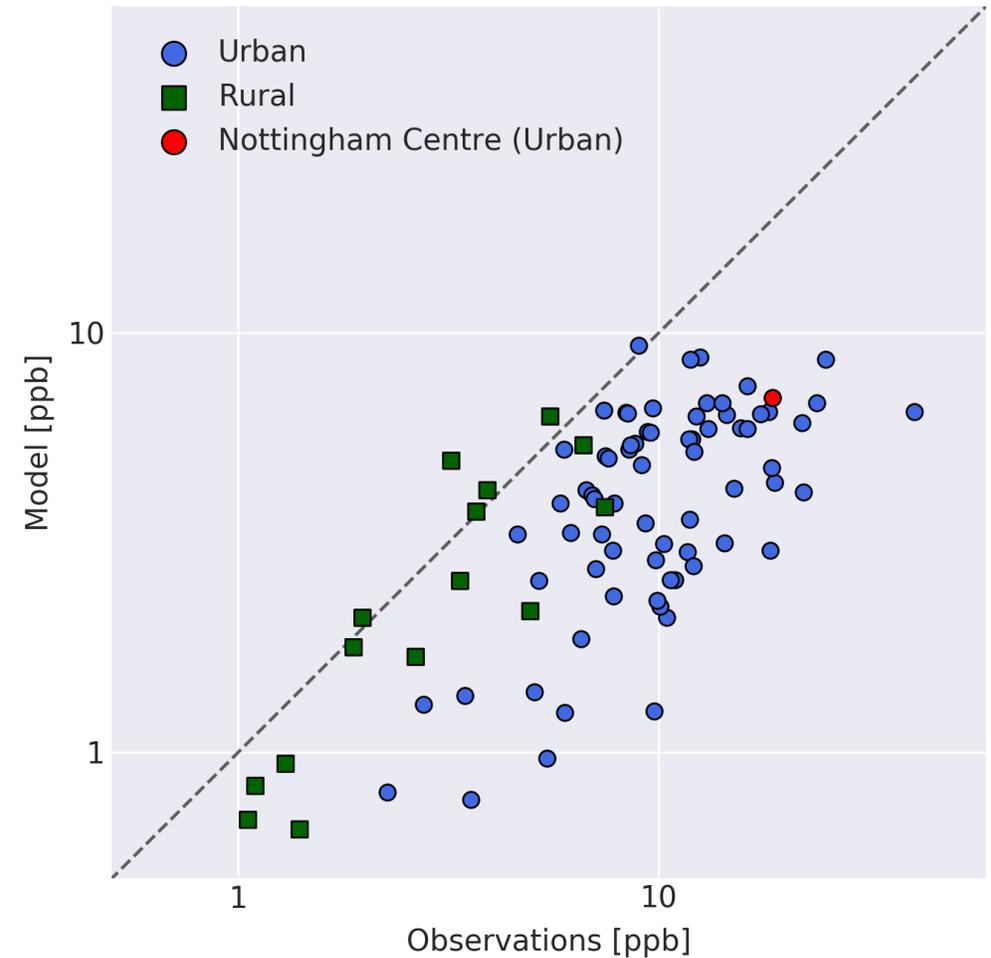
We could put this down to emissions error.

But let's consider emissions heterogeneity (sub-grid)

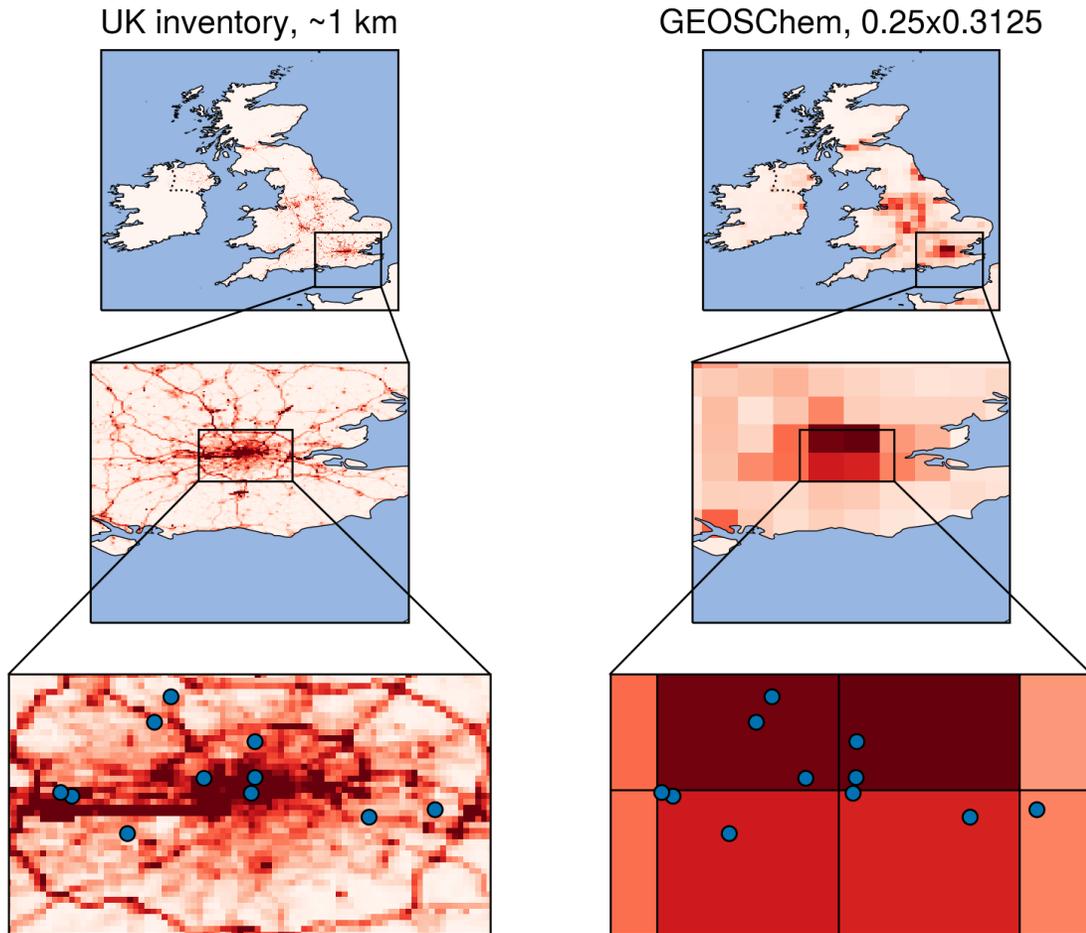
Median NO_x for at Nottingham Centre (Urban)



Annual median NO_x performance, 2017



Emissions Heterogeneity



NOx emissions over the UK, 2017.

As well as the $0.1^\circ \times 0.1^\circ$ EMEP emissions, we have $1 \text{ km} \times 1 \text{ km}$ UK emissions

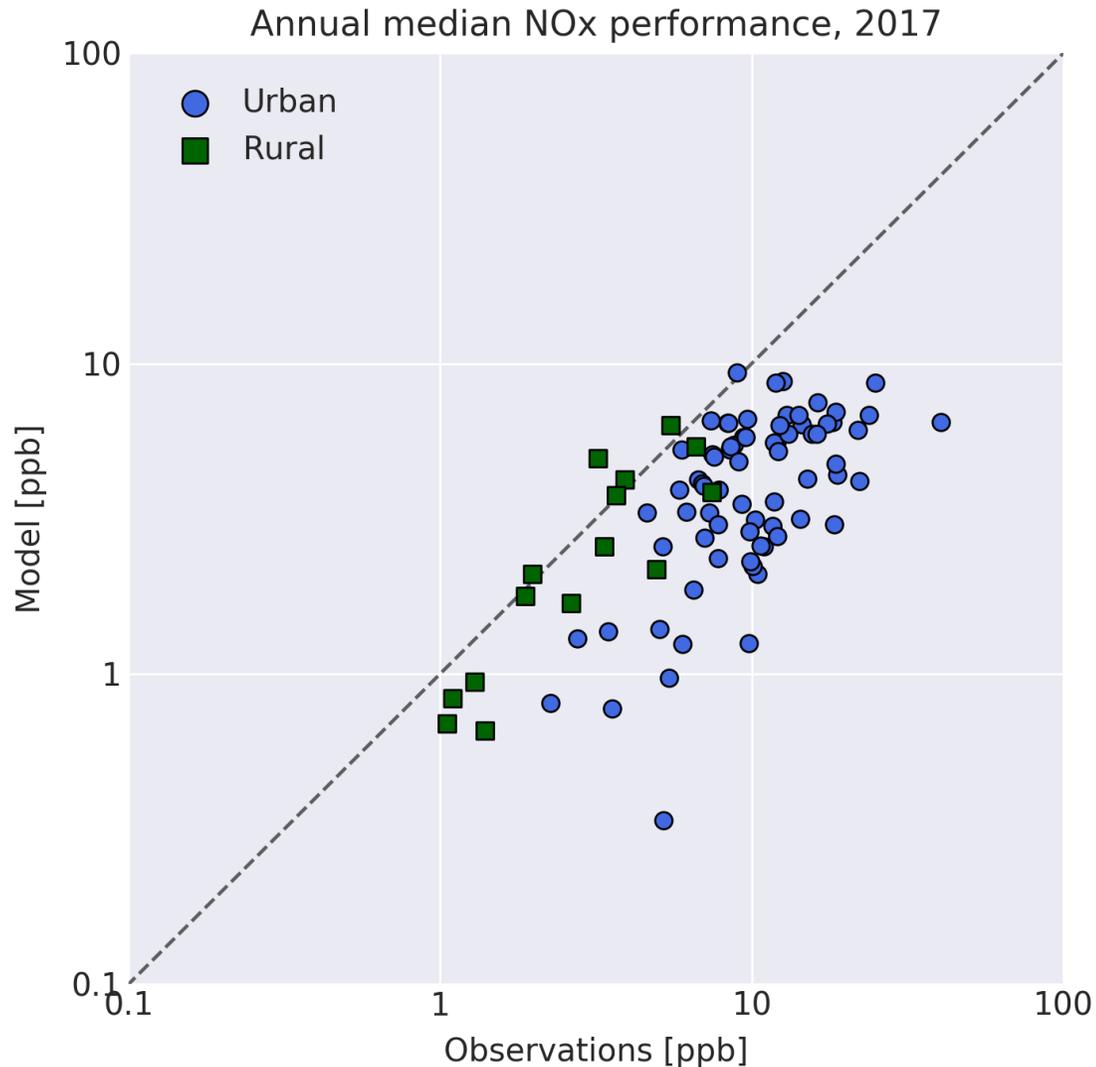
These show more heterogeneity than the model $0.25^\circ \times 0.3125^\circ$

We can calculate the emissions for the measurement site at $1 \text{ km} \times 1 \text{ km}$ and compare to the average emissions in the model gridbox

We can try and account for this with Correction Factors:

$$F_{\text{species,site}} = \frac{\text{Emissions}_{1 \times 1 \text{ km}}}{\text{Emissions}_{\text{model}}}$$

Emissions Heterogeneity: NOx



Urban sites underestimated NOx.
Rural sites were relatively similar to the observations.

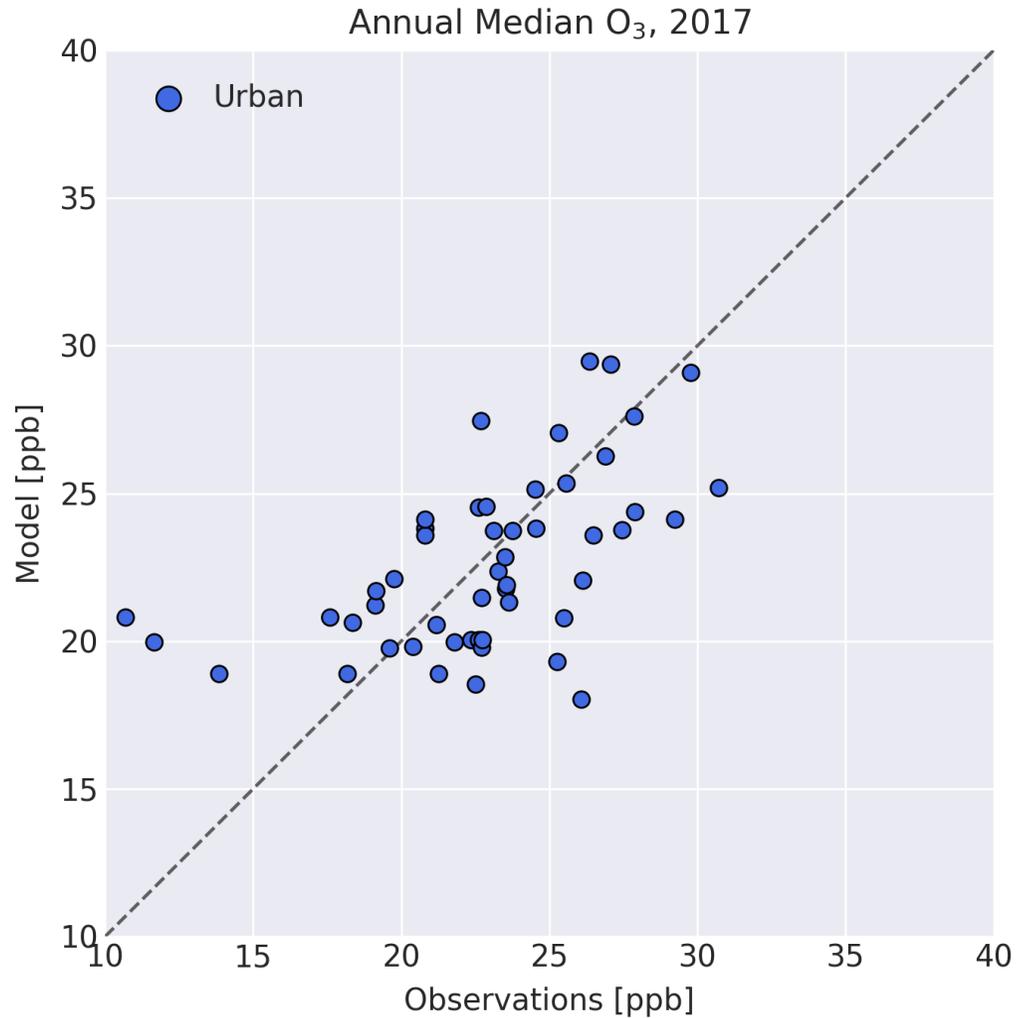
To scale the model concentration by correction factors:

$$C_{corrected} = C_{model} \times F_{species,site}$$

Assuming [NOx] is entirely set by the local emission rate.

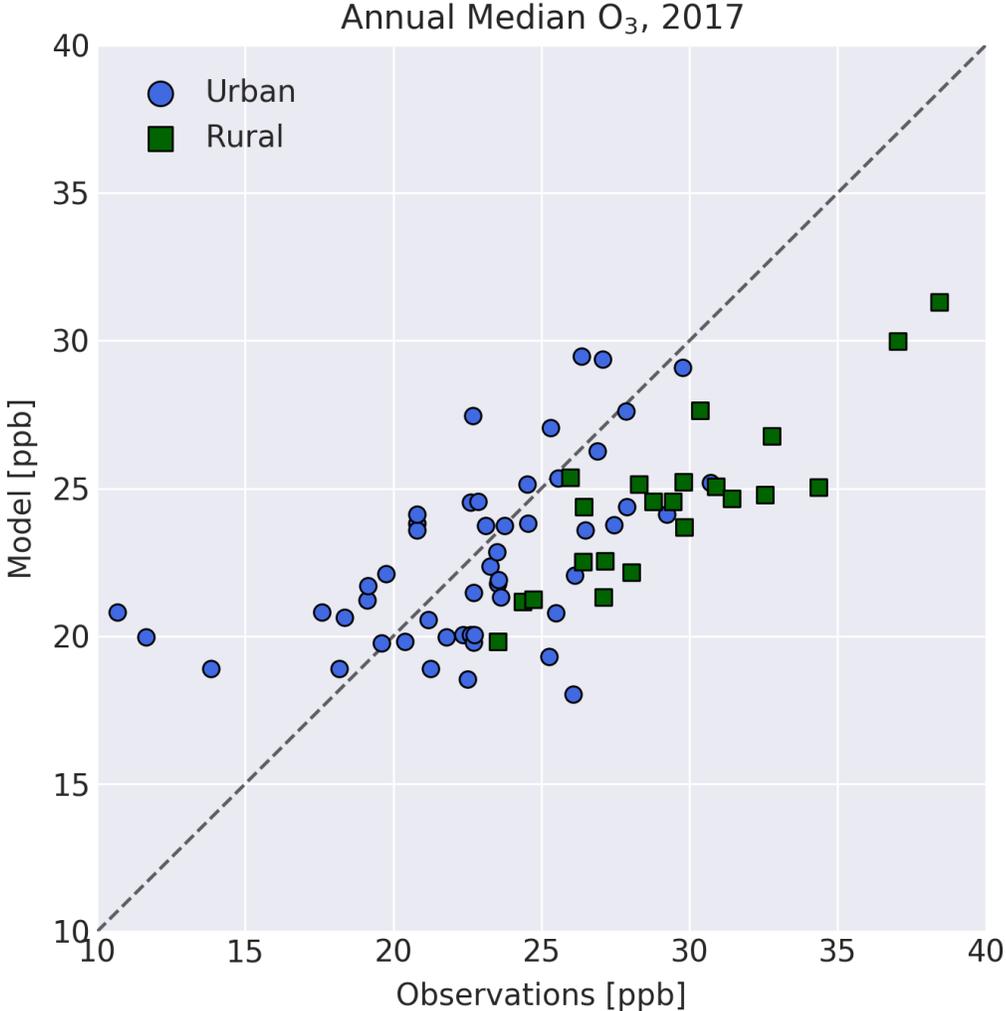
Model O₃ Performance

Despite NO_x error, Urban O₃ are relatively good.



Model O₃ Performance

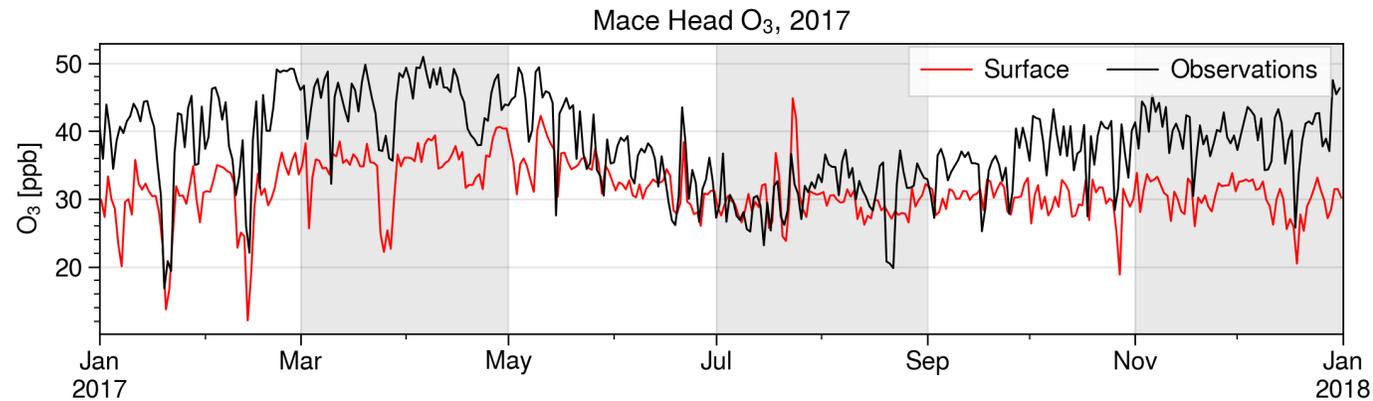
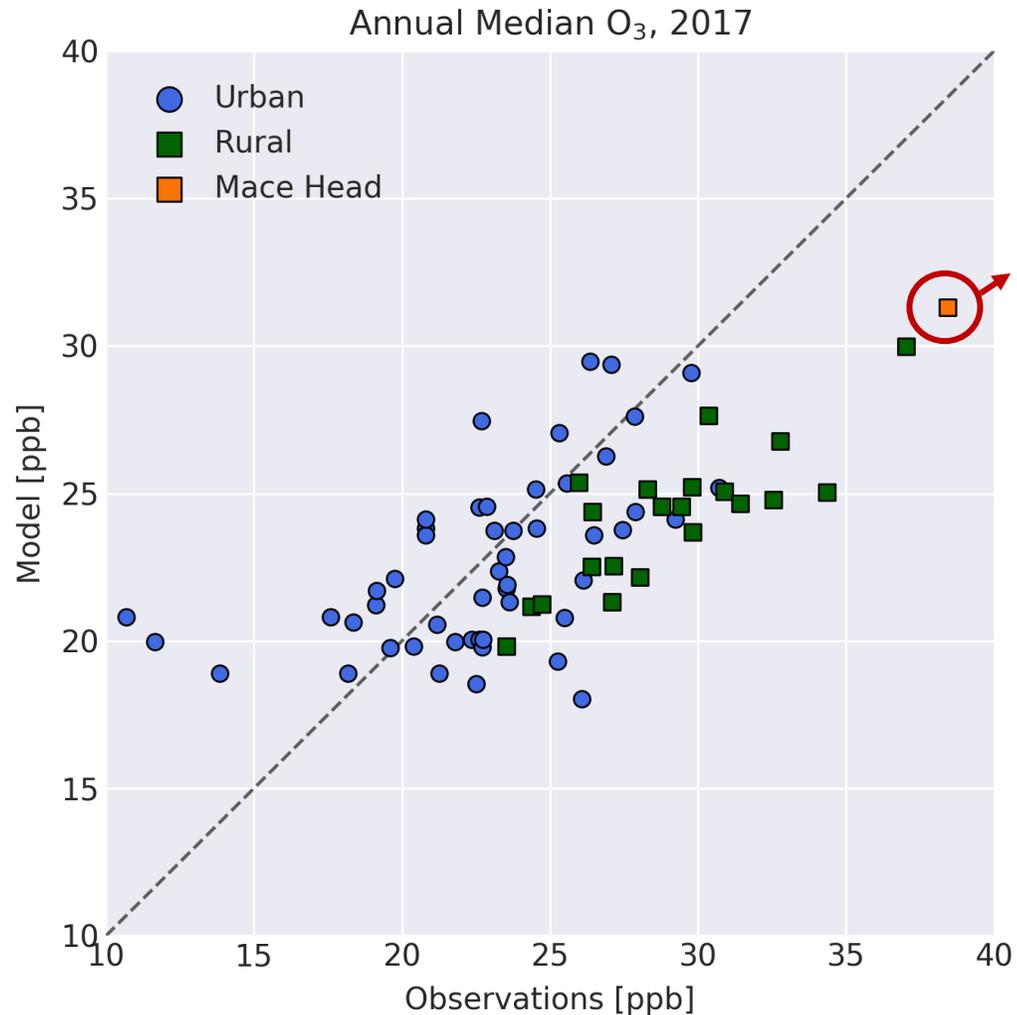
Despite NO_x error, Urban O₃ are relatively good.
Rural concentrations were low by 4-7 ppb.



Model O₃ Performance

Despite NO_x error, Urban O₃ are relatively good.

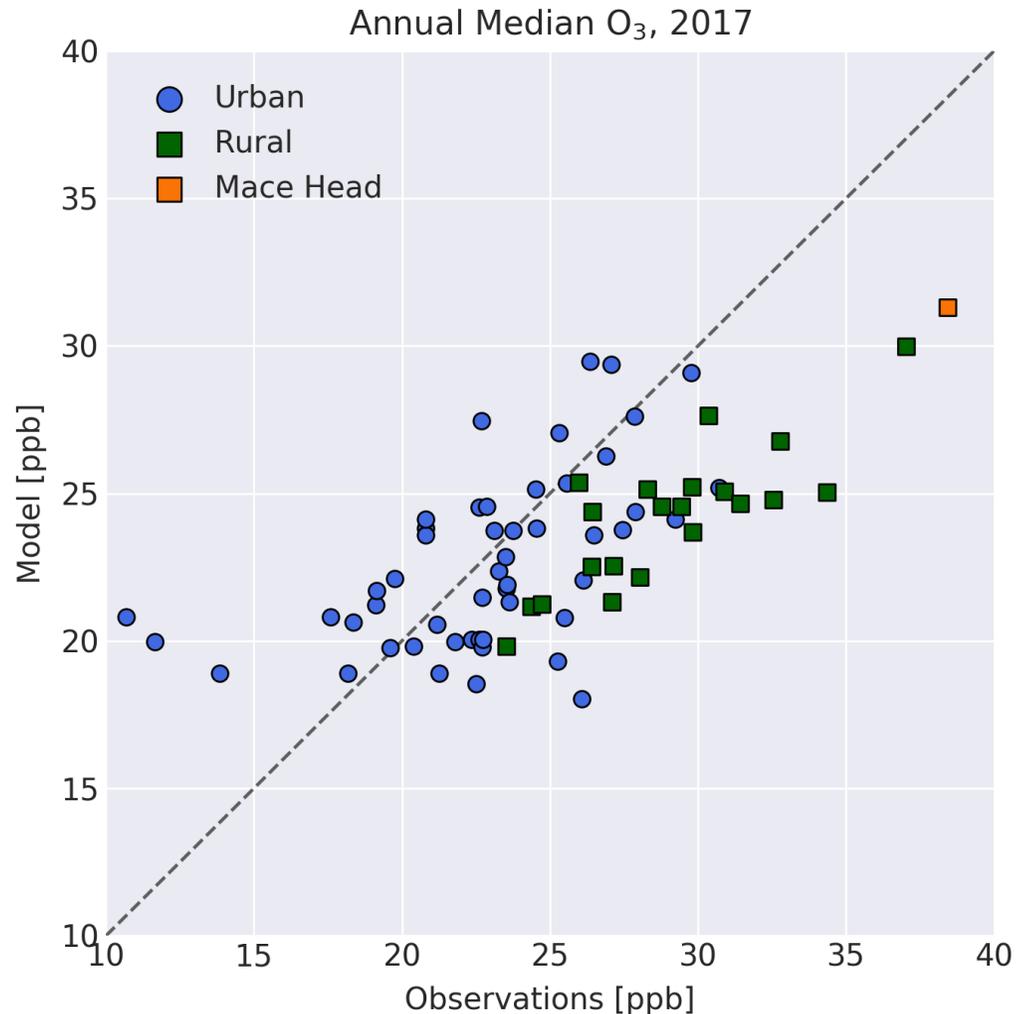
Rural concentrations are low by 4-7 ppb.



Background O₃ entering the UK from the west (Mace Head) was underestimated by ~7 ppbv

Known problem in V13.1

Emissions Heterogeneity: O₃



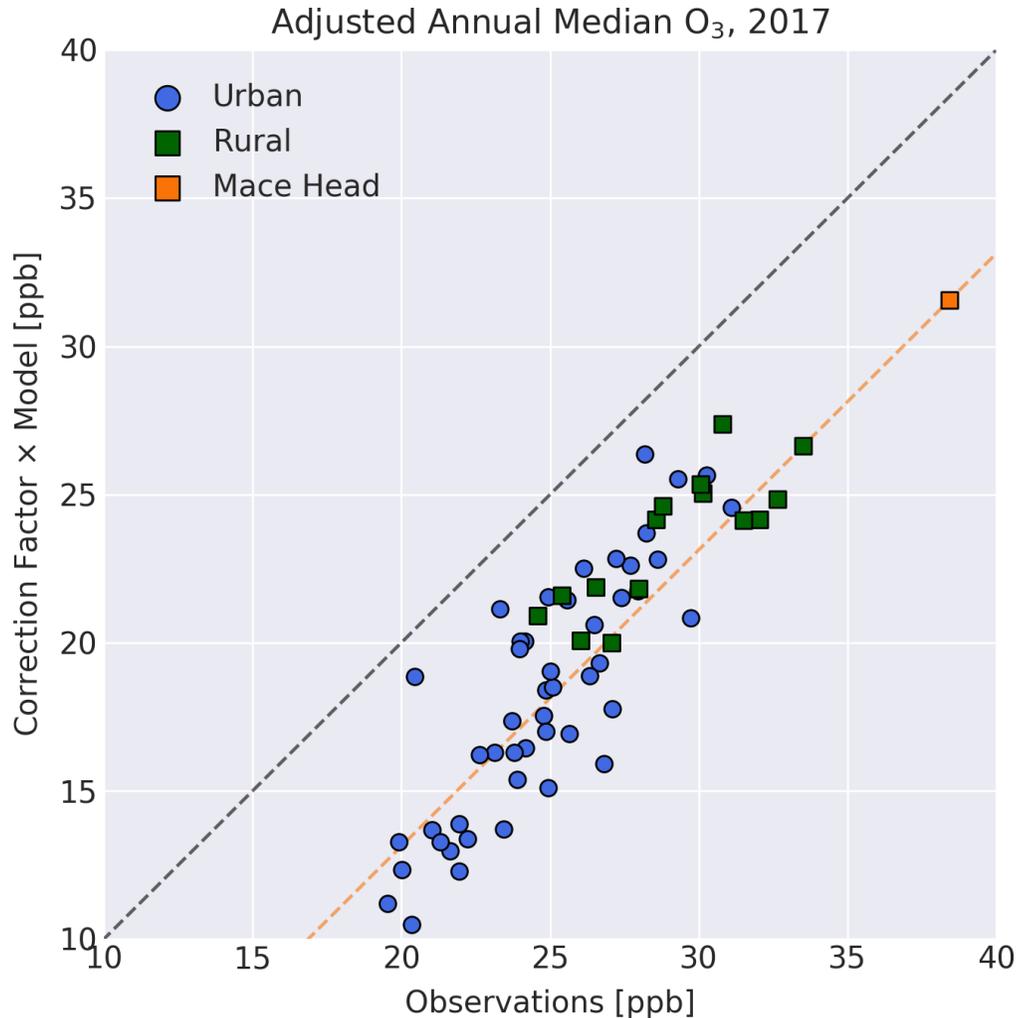
If the NO_x concentrations are too low because of site placement, local titration of O₃ will be underestimated:



And O₃ will be *overestimated* as a result

We can evaluate this effect by calculating modelled O_x (O₃+NO₂) and subtract the observed NO₂ to find the O₃ concentrations consistent with the sub grid issue

Emissions Heterogeneity: O₃



Urban O₃ bias is now comparable with the Mace Head bias.

Ozone error has two major components:

- NO_x underestimates (emissions or emissions heterogeneity)
- Background O₃ underestimates

These two sources of error combined to make Urban estimates look right.

Conclusions

NO_x

Underestimates could be due to emissions, but there is likely a sampling bias component at this coarse resolution.

We can reduce this bias with local correction factors, but it doesn't solve the problem, integration with more advanced down-scaling approaches might be necessary.

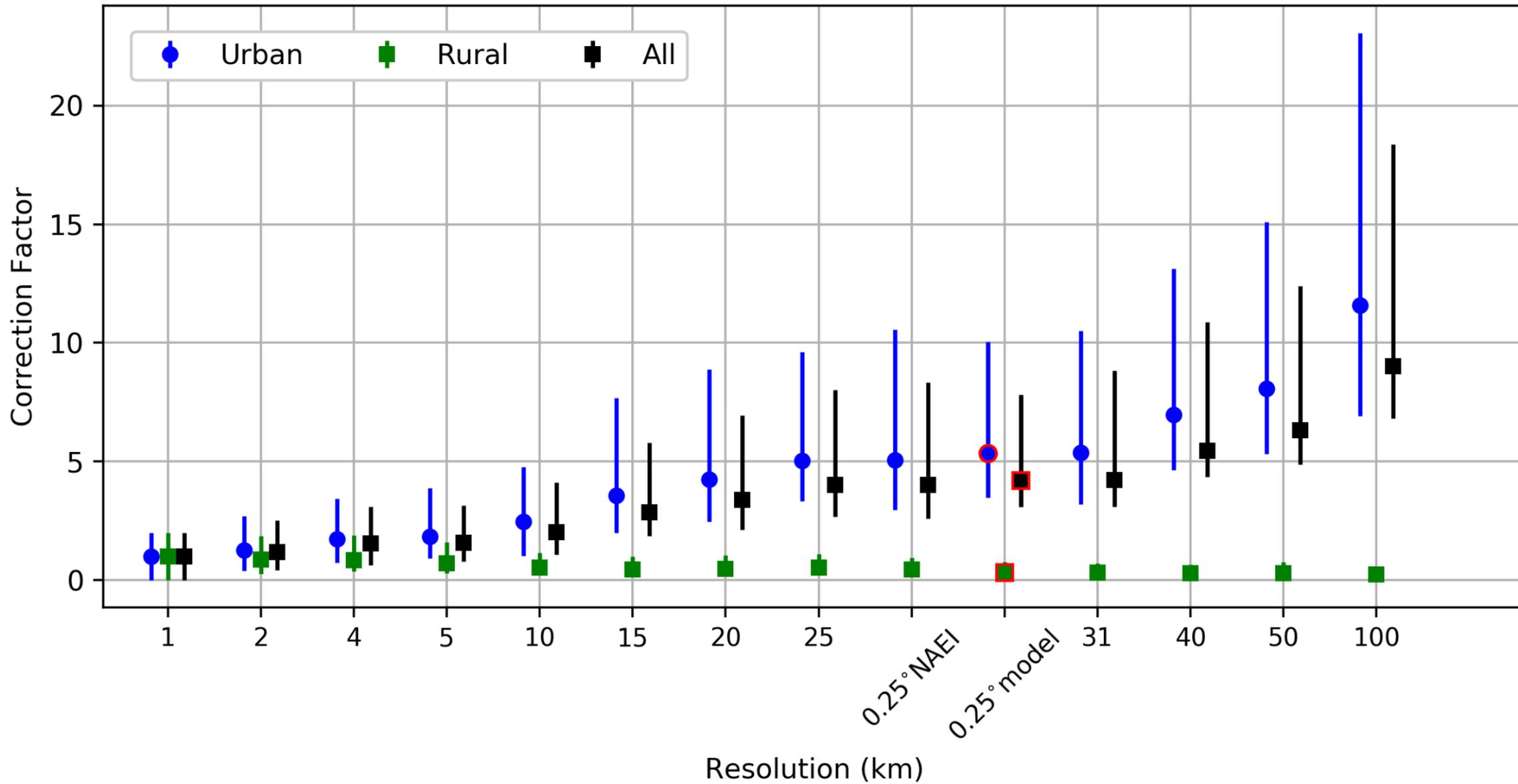
O₃

Two major errors: background O₃ underestimates and underestimated NO titration.

These resulted in urban O₃ looking right for the wrong reasons.

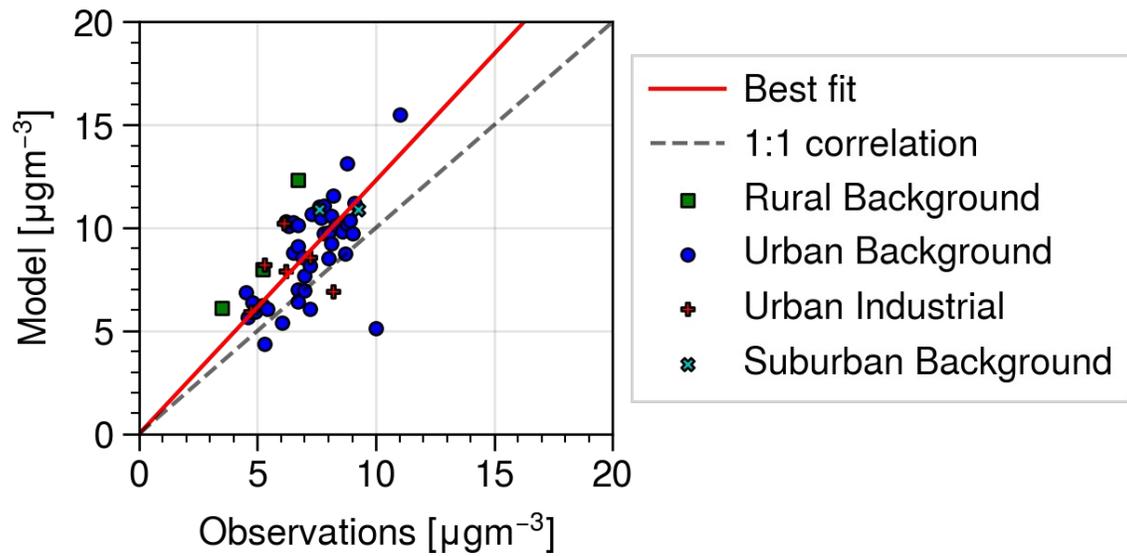
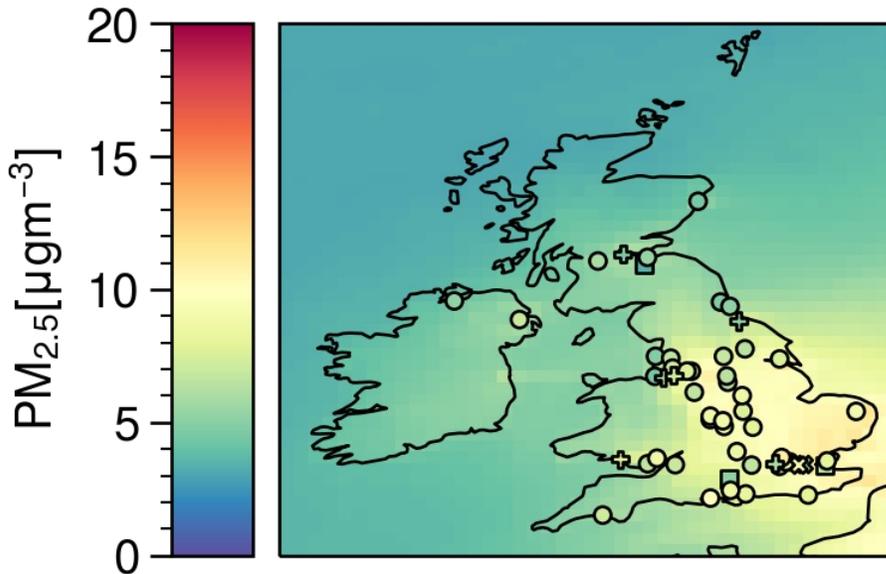
Even higher resolutions could help us to accurately simulate these 'background urban' sites. However, we may still struggle with those particularly close to emissions sources.

Correction Factors and emission resolution



PM_{2.5}

Annual averages



Daily Averages

