CAMEO WP6: Uncertainty estimates of CAMS source receptor policy Products: how the findings and work of this project can contribute to better modelling for assessment and planning

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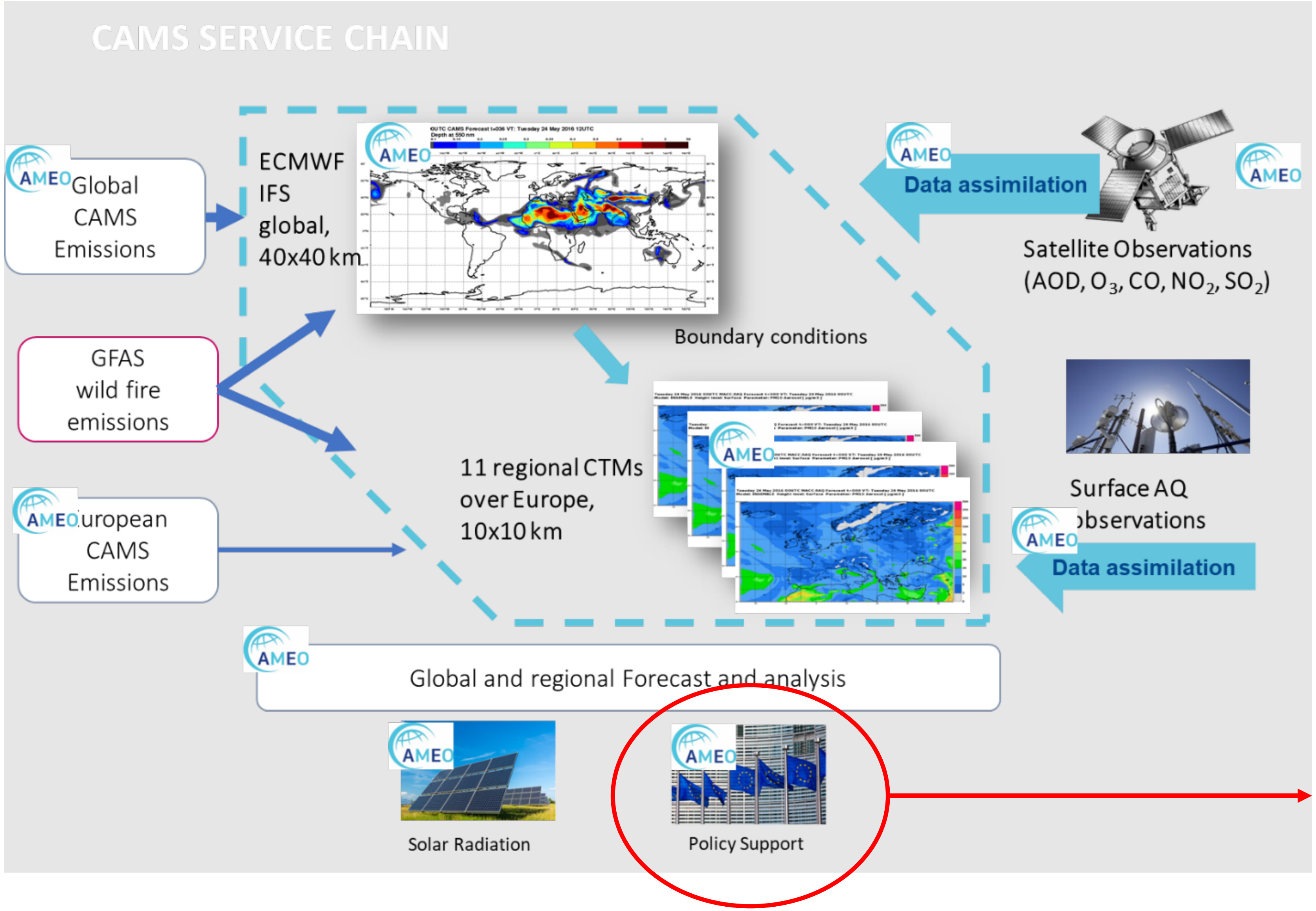
CAMEO project (2023-2025) – cams service evolution



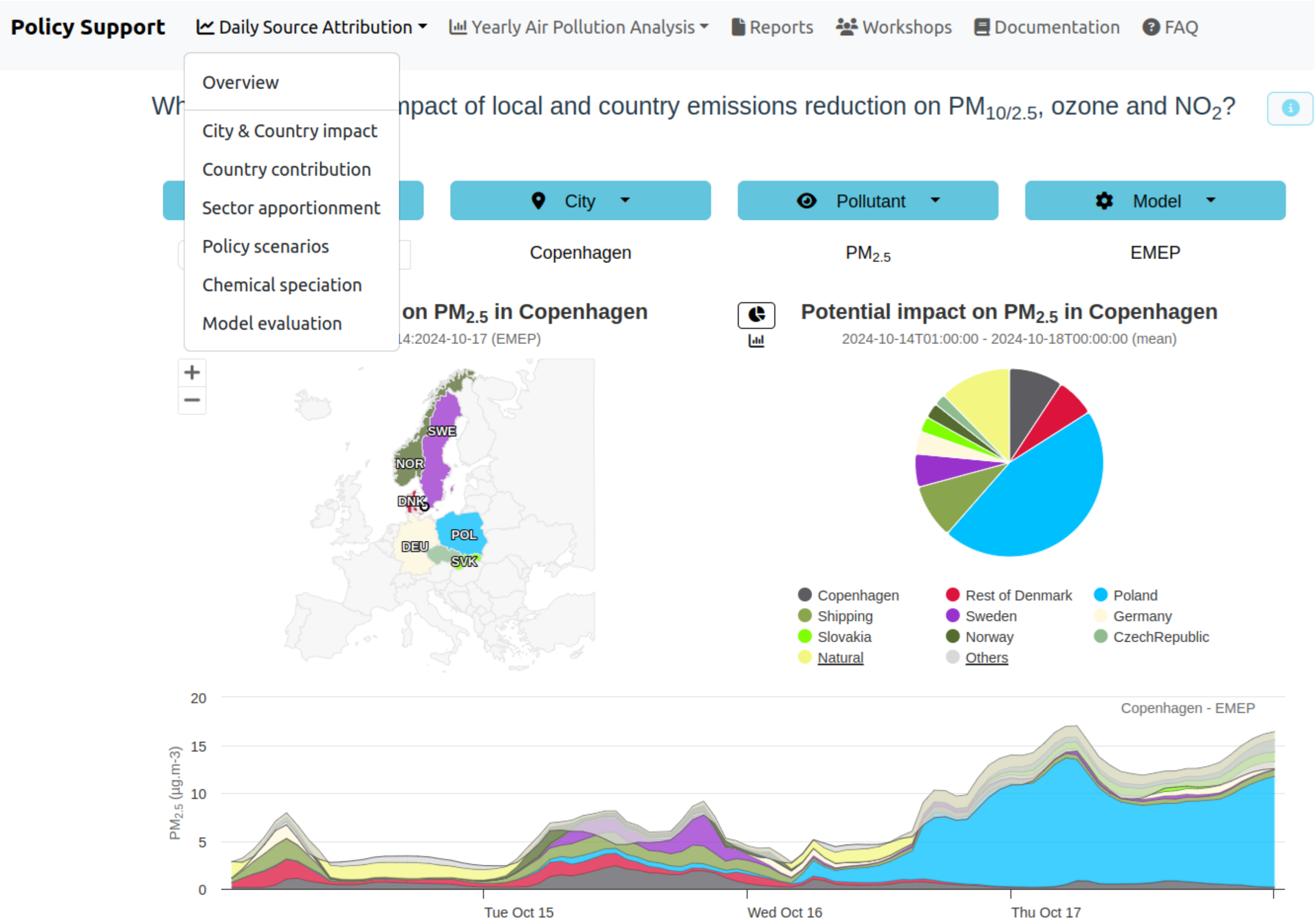
Objective:

To **enhance the quality and efficiency of the CAMS service** and help CAMS to better respond to policy needs such as air pollutant and greenhouse gases monitoring, the fulfilment of sustainable development goals, and sustainable and clean energy.

WP6:
Quantify uncertainties in CAMS source receptor policy products

‘CAMS source receptor policy products’

https://policy.atmosphere.copernicus.eu/



Use of the Policy Products:

- understand origin of episodes
- understand impact of mitigation measures (policy planning)
- identify sources
- compliance checking support
- communication towards the public

Uncertainties due to:

- **SA methodology**
- **Model resolution**
- **Uncertainties in emissions**

Source apportionment methodology

Evaluate uncertainties and comparability of methods

TNO
LOTOS-EUROS
Tagging

Sensitivity (15% ER)
Surrogate model

↓

Contribution of sources at given location and time

Metnorway
EMEP
Sensitivity (15% ER)

Local fraction

↓

Potential impact of ER (scaled to 100%)

INERIS
CHIMERE
Surrogate model (ACT)
= Fitting of polynomials to BF training runs

↓

Estimate of potential impact of measures

Are differences due to to different methods (non linear chemistry) or different CTM models?

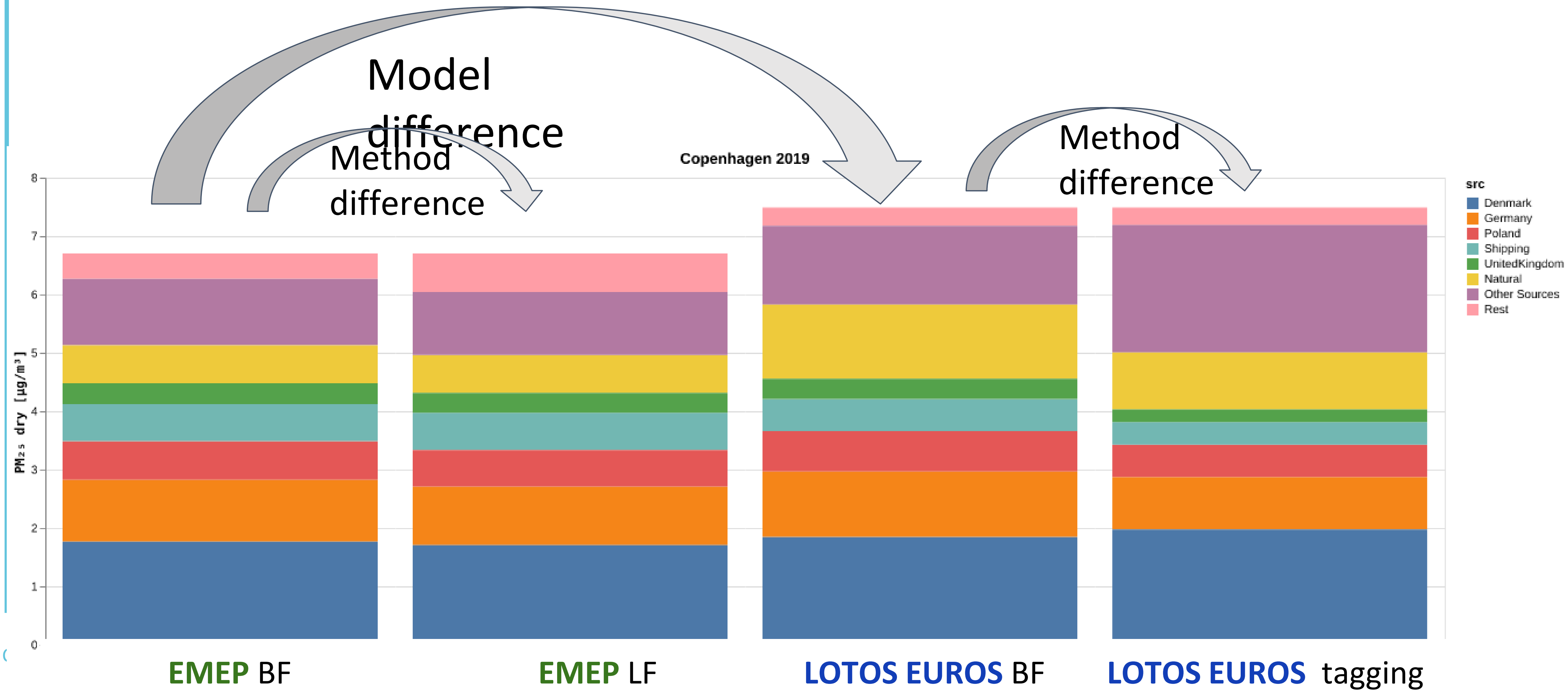
Under what circumstances do the methods provide similar or different results?

When are the method interchangeable and when complementary?

→ Recommendations for users on applicability of the models/methods

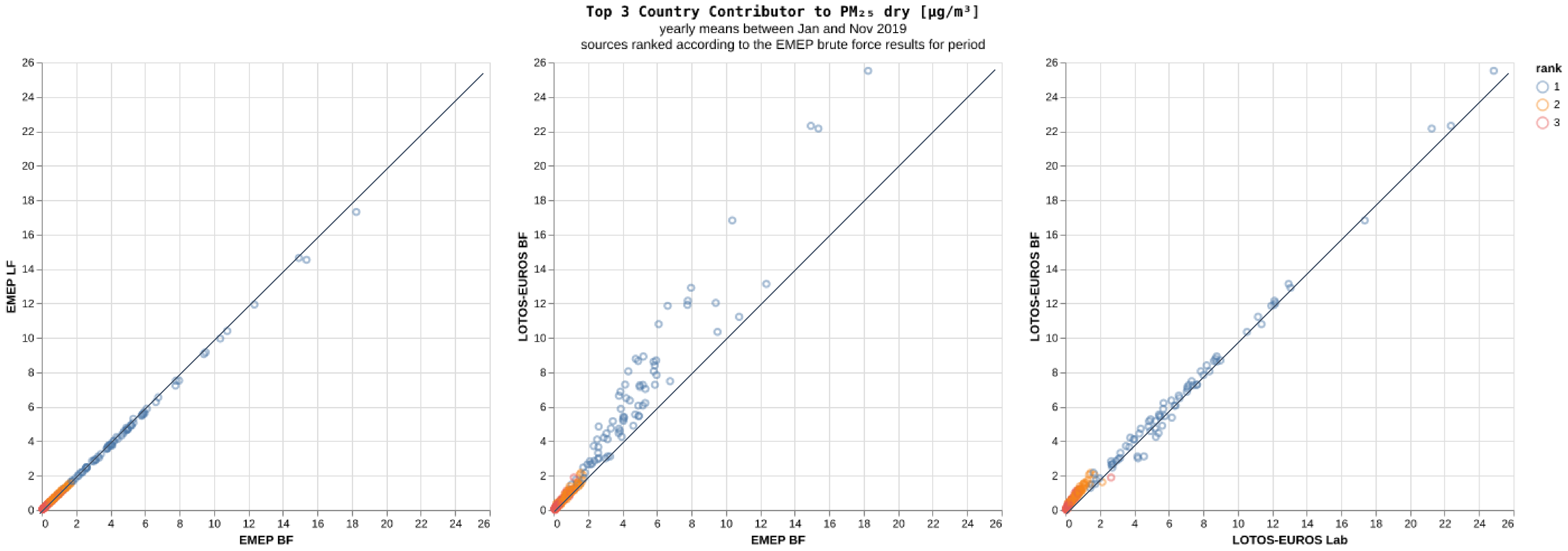
Comparison of methods & models used in CAMS policy products

$PM_{2.5}$, 2019, Copenhagen



Top 3 country contributors to yearly PM2.5

average over 79 CAMS cities

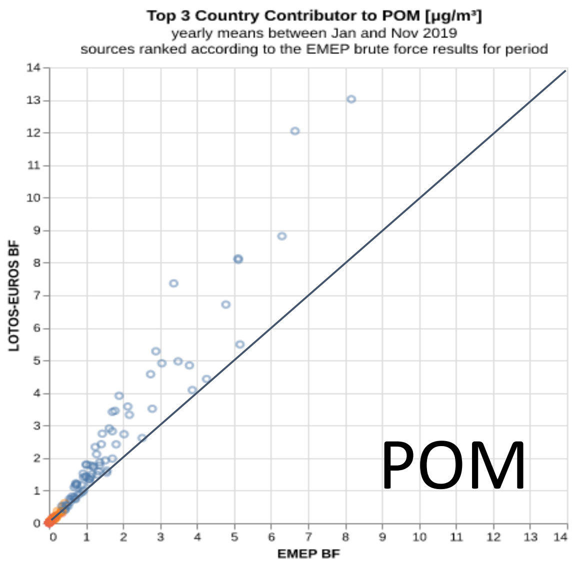


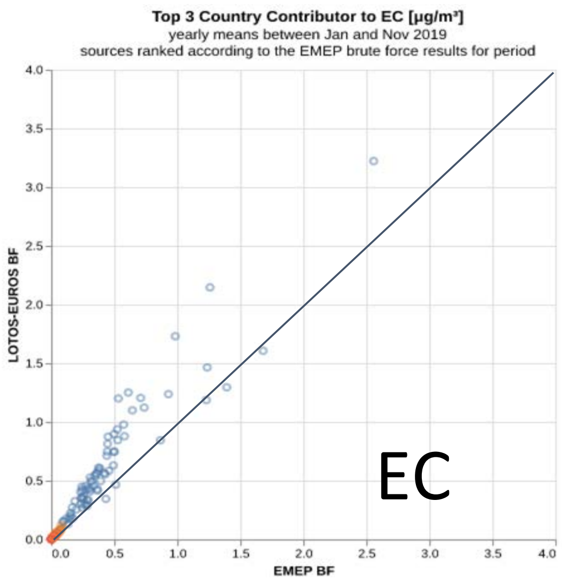
EMEP LF vs. EMEP BF

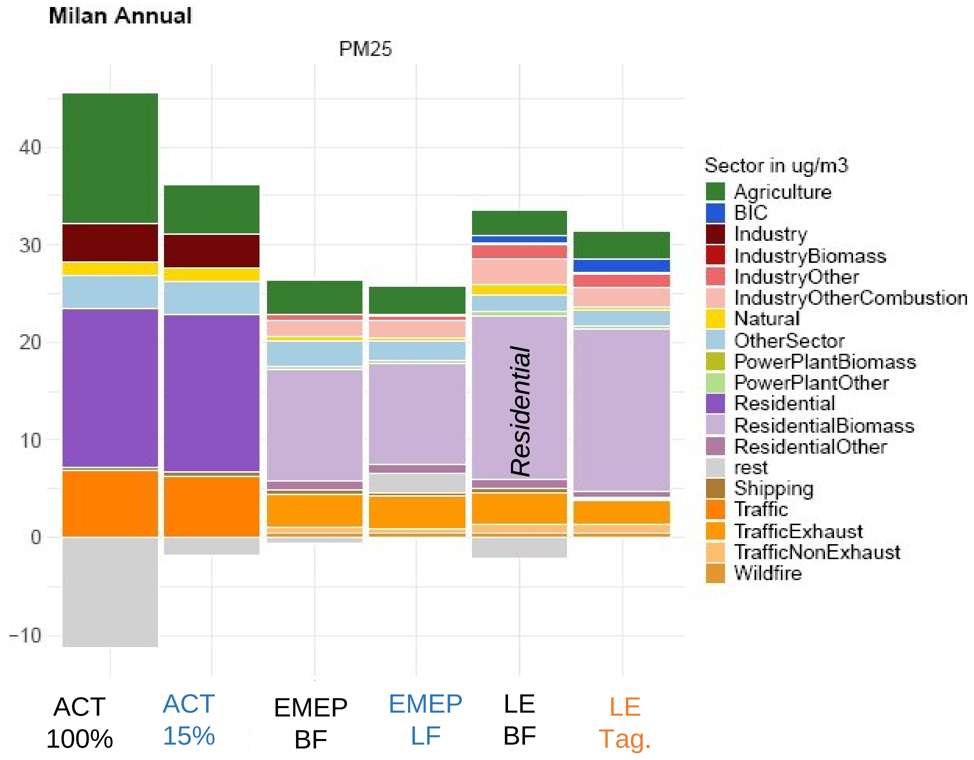
LE BF vs. EMEP BF

LE BF vs. LE tagging

Annual comparisons between models/methods



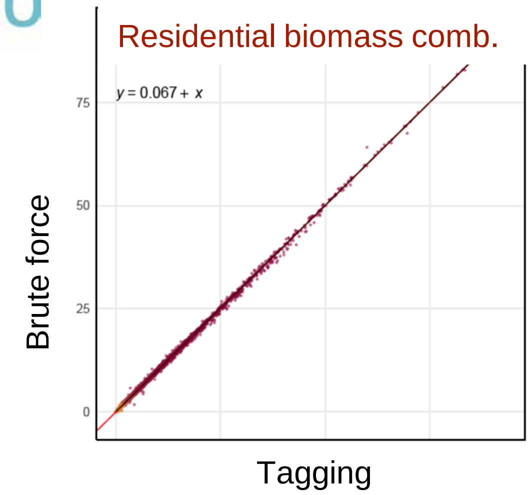




The primaries are causing the difference

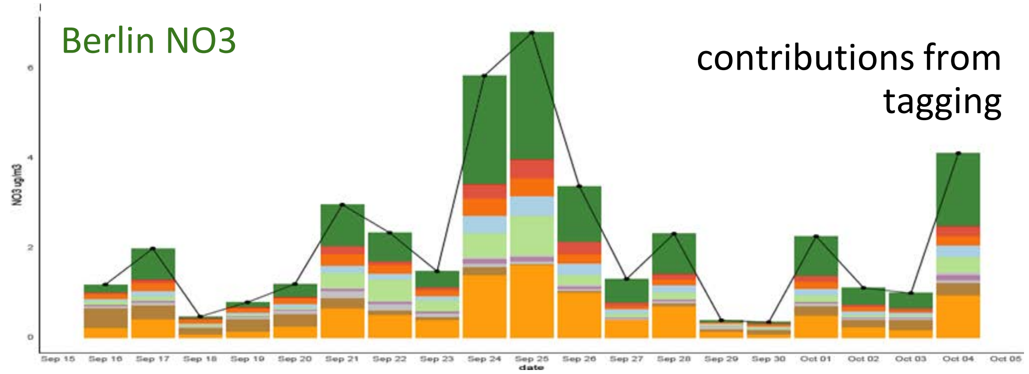
- Overall for yearly $PM_{2.5}$, **differences are larger between models than methods** → mainly attributed to primaries from residential combustion, difference in model surface layer depth (20 versus 50 meter)

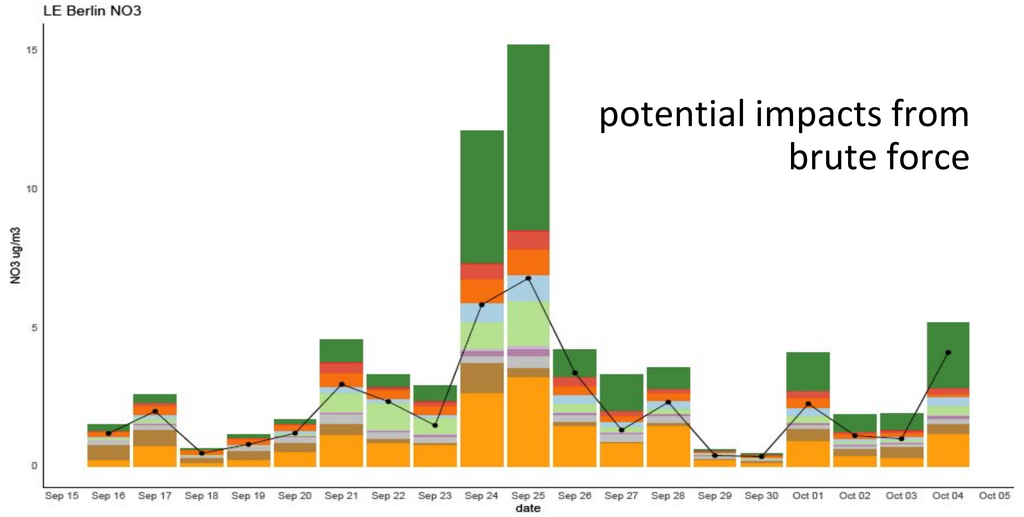
Brute force versus Tagging – all cities, daily PM2.5 contributions 2019



Residential combustion contributions dominated by primary PM

Agriculture and Traffic contributions influenced by non-linear formation of secondary PM



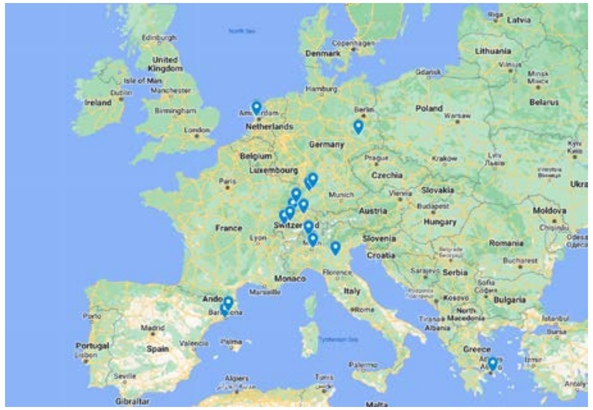


- For **shorter timescales** one should take into account the purposes of the different methods and use them in a complementary way

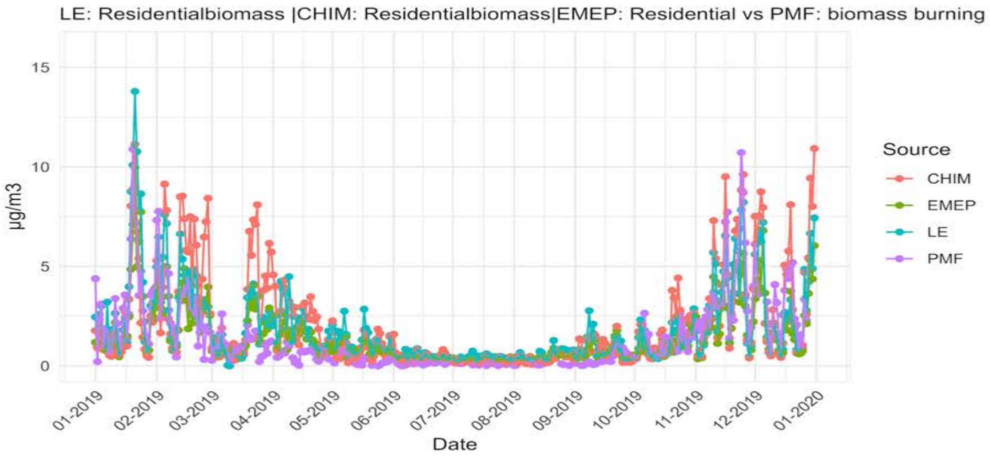
Comparison with observational based source attribution (PMF)

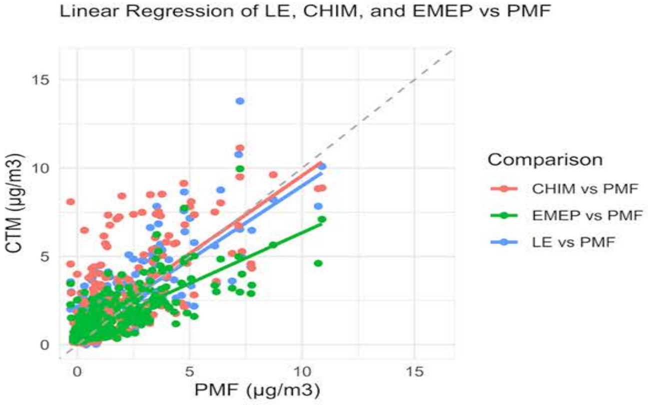
Initial PM_{10} comparisons finalized for 2018-2019

- High variability in performance between stations & CTMs, but:
- Moderate/good fit for : **Biomass Burning** / Seasalt / Sia components
- Poor fit: **Road transport**



Gartringen - residential biomass





comparison	slope	intercept	r_squared
LE vs PMF	0.836	0.632	0.625
CHIM vs PMF	0.882	0.754	0.504
EMEP vs PMF	0.574	0.603	0.595

- Comparisons to PMF data can be used to **gain confidence** in models and used emission input, but also provides **useful information** on missing/underestimated/ overestimated sources → need for improvement of spatial and temporal distribution of emissions

Model resolution and subgrid variability

in progress

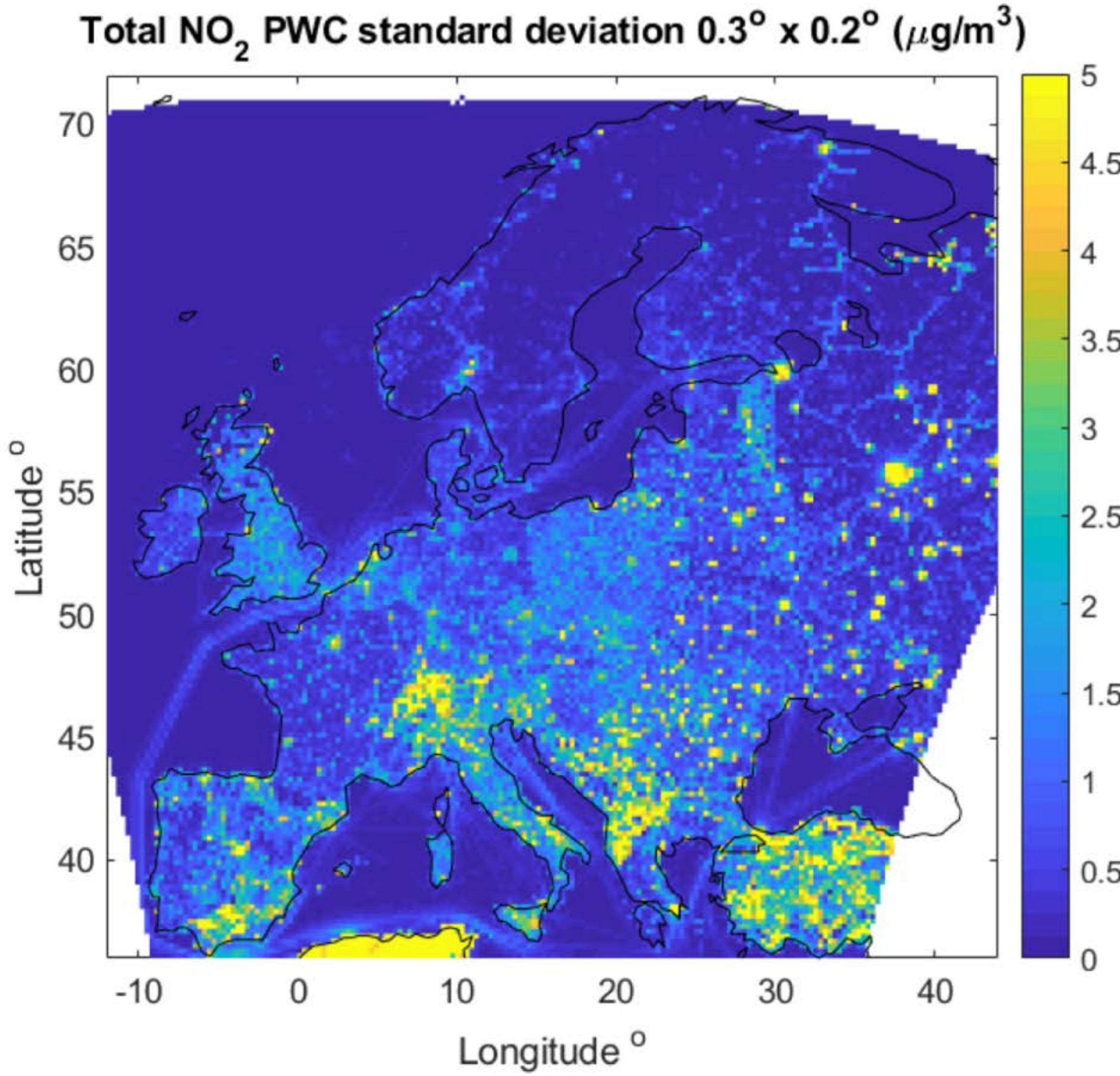
Aims and earlier assessments of subgrid variability

What is the uncertainty due to model spatial resolution?

Can a correction be made to represent the subgrid variability?

… or is it simply that higher resolution is required?

Earlier work (Denby et al., 2024) has shown significant subgrid variability, particularly for NO_2 (7000 subgrids/grid)



Bruce R. Denby, Gregor Kiesewetter, Agnes Nyiri, Zbigniew Klimont, Hilde Fagerli, Eivind G. Wærsted, Peter Wind,Sub-grid Variability and its Impact on Exposure in Regional Scale Air Quality and Integrated Assessment Models: Application of the uEMEP Downscaling Model, Atmospheric Environment, Volume 333, 2024, 120586, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2024.120586.

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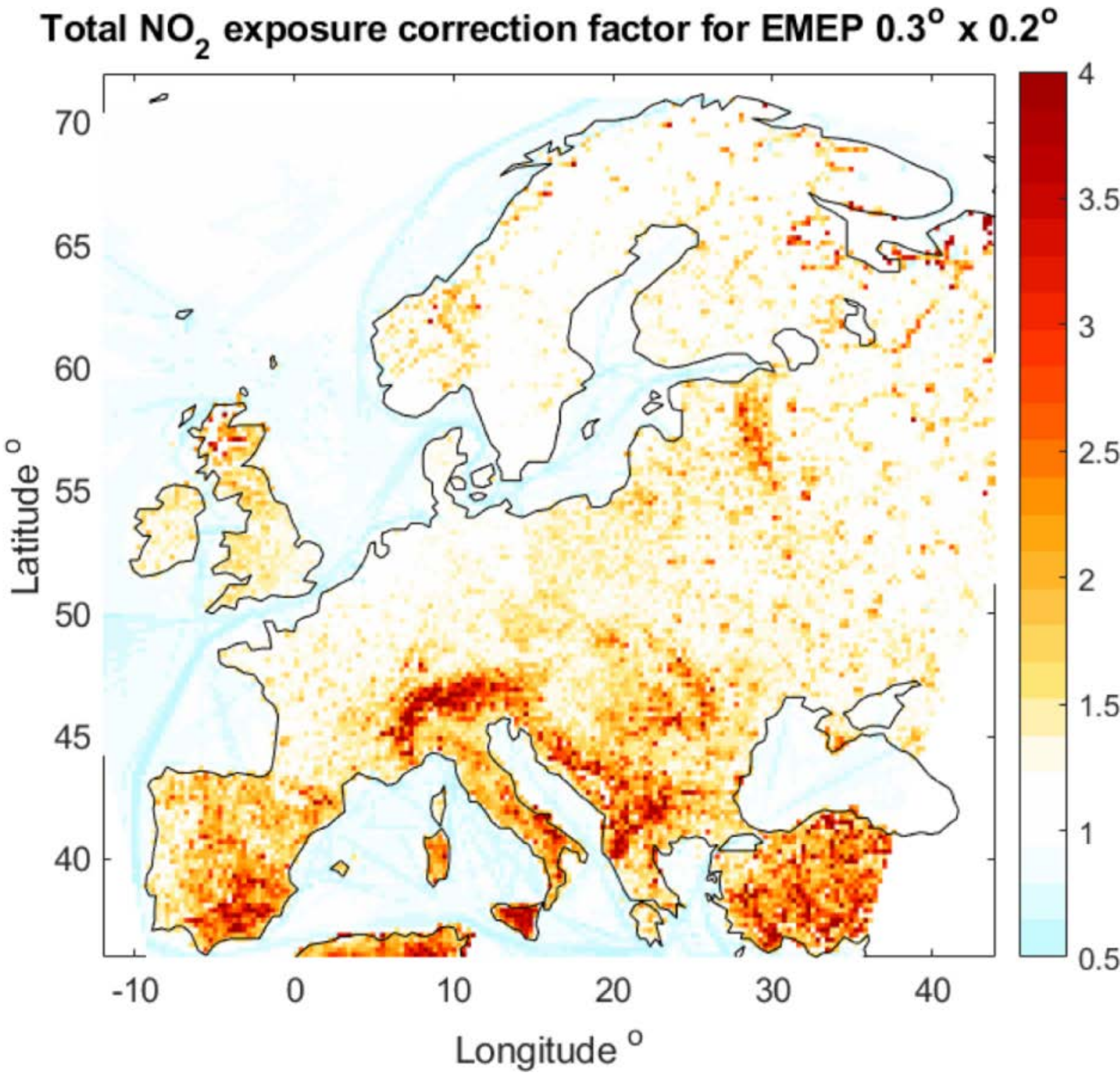
As well as deriving a correction factor for this subgrid variability



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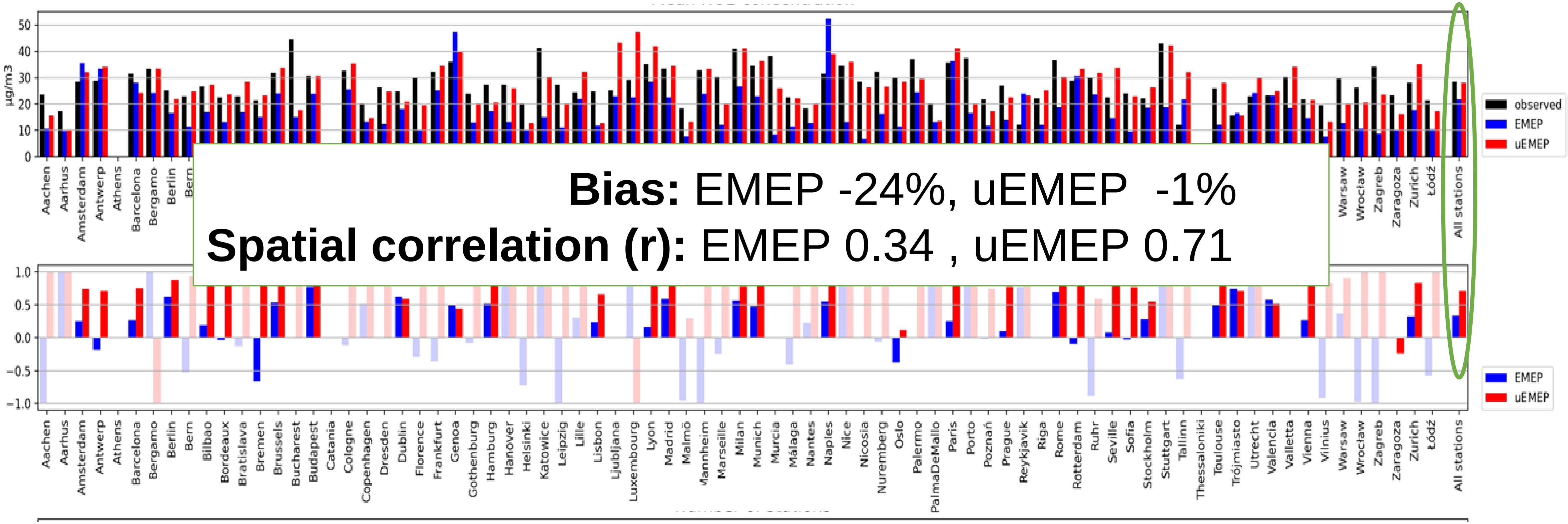
First steps: Compare EMEP 0.1° with uEMEP 50 m for 80 cities

- Results demonstrate improved performance with uEMEP for NO_2

Annual mean NO_2 concentration 2019



Bias: EMEP -24%, uEMEP -1%

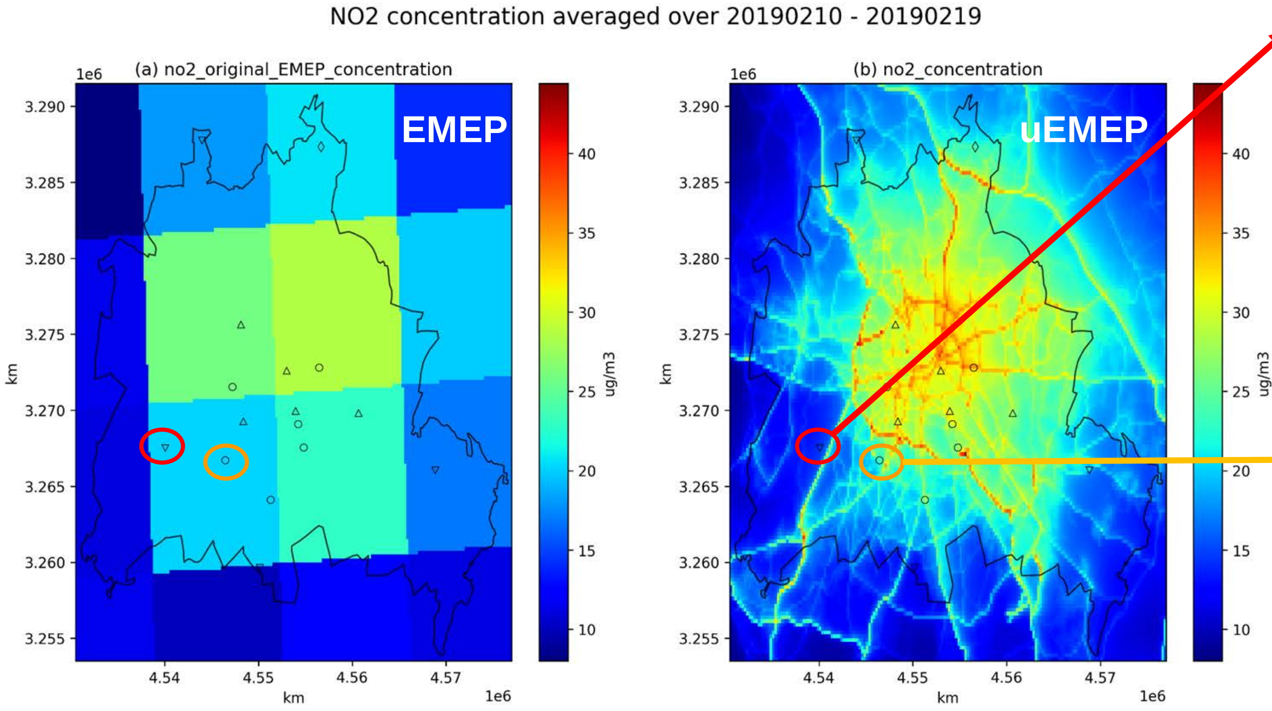
Spatial correlation (r): EMEP 0.34 , uEMEP 0.71

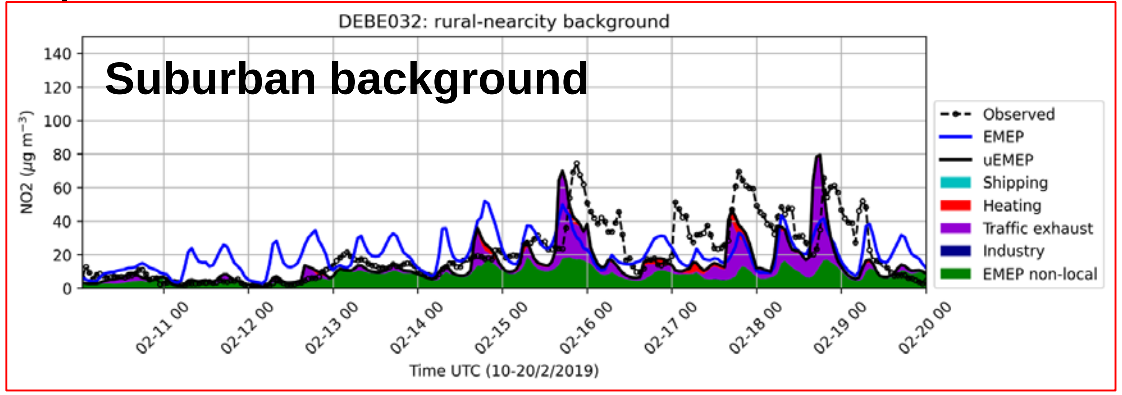
NB: Using EMEP emissions instead of CAMS-REG-AP, due to issues with NO_x emissions for cities

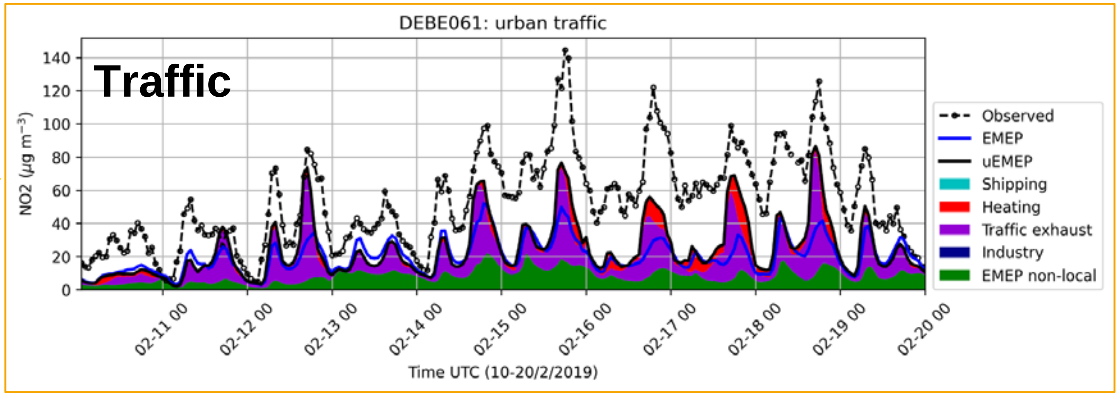
Berlin episode: Comparison of two stations within the same EMEP grid

Example: Period of high NO_2 concentrations in Berlin February 2019

- uEMEP improves spatial variability in NO_2 concentrations
- Increasing concentrations near roads and decreasing concentrations away from roads
- uEMEP still does not completely capture the episode







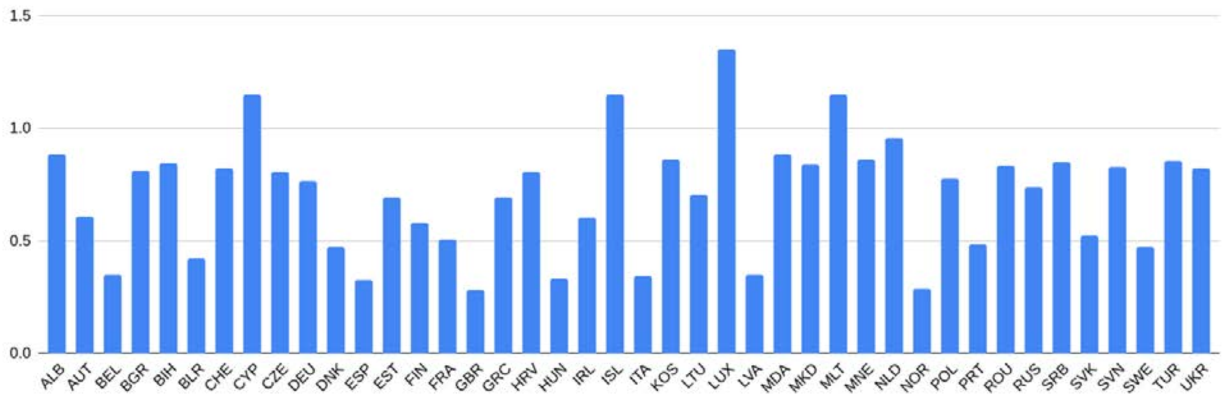
Emission uncertainty

in progress

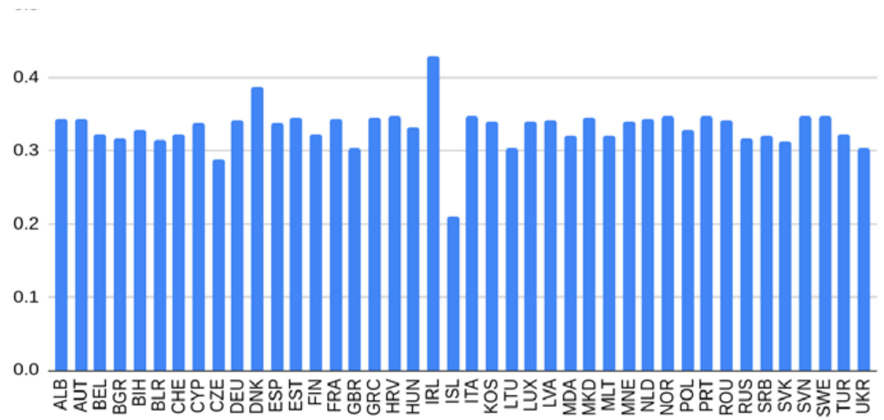
Propagation of emission uncertainties

- TNO have derived uncertainty estimates for PPM, SOx, NOx, NH3, VOC for European emissions (country, sector, component specific, for PPM also gridded)
- BSC have provided uncertainties in temporal variation - not used yet
- EMEP LF model runs have been performed including all these country & sector & component derivatives - equivalent to approx 50x13x5= 3250 Brute Force runs for 2022
- Combine the country & sector & component emissions-to-concentration in grid response with uncertainty per country & sector & component

Uncertainty in PPM emissions industry

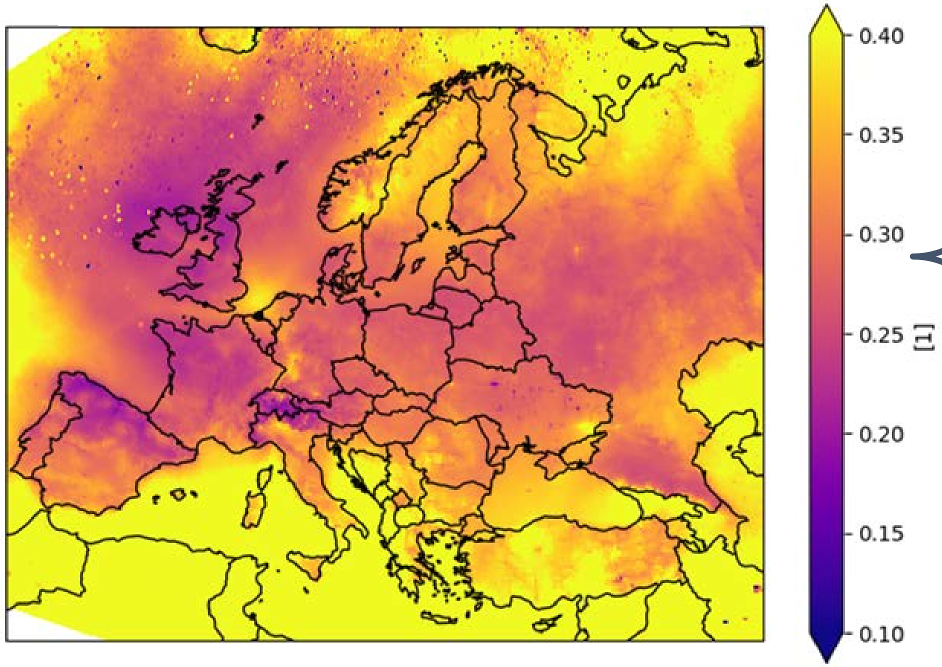


Uncertainty in PPM emissions residential

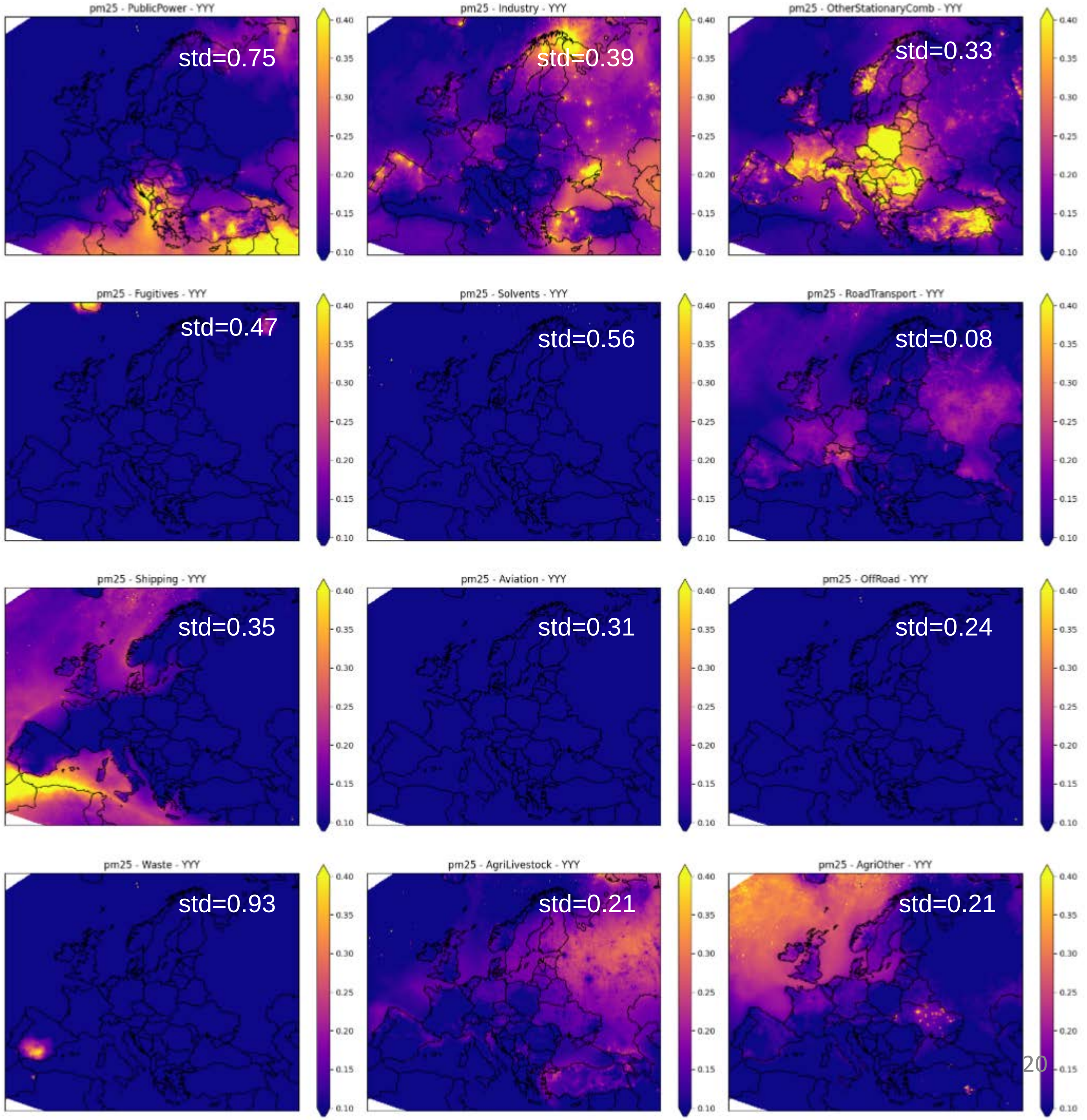


Relative contribution from different GNFR emission sectors to $PM_{2.5}$

Relative standard deviation



Concentration uncertainty when assuming full correlation



Propagation of emission uncertainties

- We need to consider how the emission errors are correlated, with the following extremes:

  a. **Uncorrelated between countries and sectors**

     Every country’s emission inventory is made totally independently with different methods for every sector (EMEP?)

  a. **Sectors correlated between countries**

     Same methodologies are used by every country for each of the sectors (CAMS?)

  a. **Fully correlated between both countries and sectors**

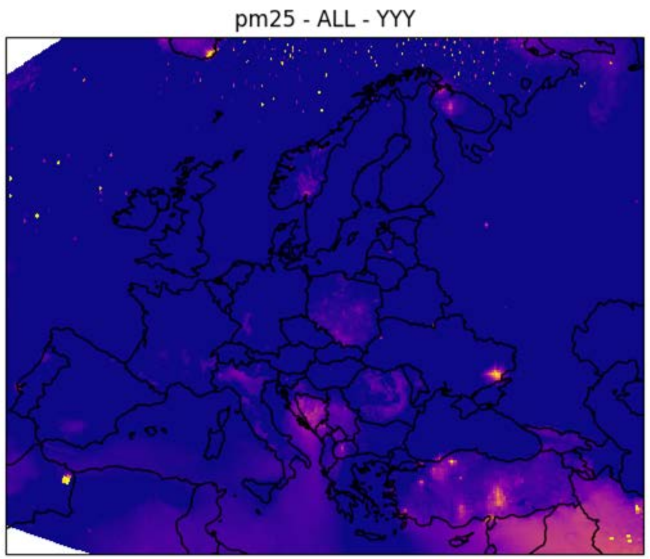
     All countries use exactly the same methods/data sources to make emissions (Unlikely?)

- Each case yields a special representation of the variance formula which allows for computational shortcuts

We have investigated these different cases across seasons and the entire year

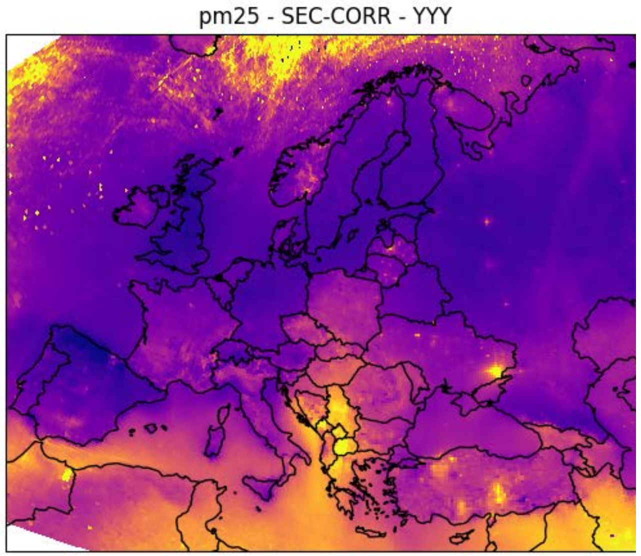
Propagation of emission uncertainties

Countries and sectors uncorrelated



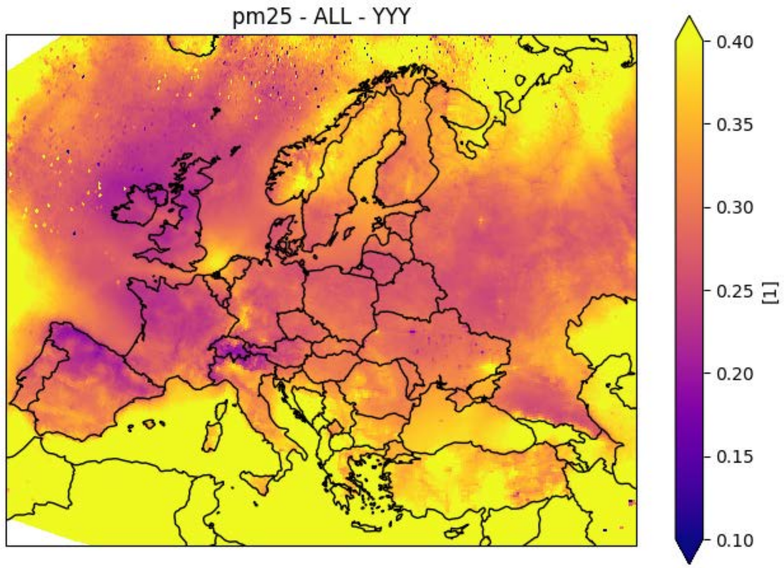
Low uncertainty
(10 - 20 %)

Sectors correlated between countries



Intermediate uncertainty
(15 - 30 %)

All countries and sectors correlated



High uncertainty
(25 - 40 %)

Conclusions

CAMEO will:

- demonstrate the uncertainty in models versus uncertainty in methods (for SA), when methods are interchangeable and when complementary
- demonstrate how downscaling of CAMS products can provide better results, either directly or through subgrid variability correction factors
- provide a better understanding of how uncertainties in emissions propagate into different CAMS products

25

OLD SLIDES

26