Assessment of transboundary contributions to PM in European cities using different models and source attribution methods

results from CAMEO project

TFMM meeting 5-7 May 2025

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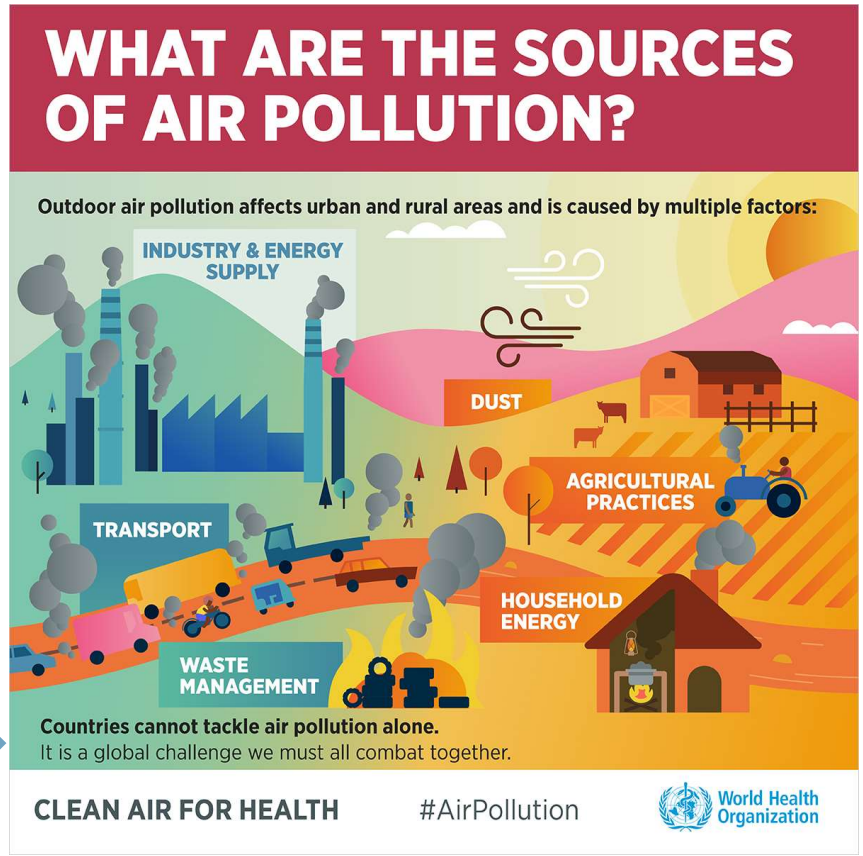
INTRODUCTION

For policy makers and reporting obligations (AAQD) it is crucial to identify the main sources of air pollution contributing to exceedances of limit values and negative health impacts



- Which part of the pollution is from national sources?
- Which part is from neighbouring countries
- Which part is from natural sources, such as Saharan dust?

IDENTIFICATION OF SOURCE REGIONS WITH MODELS

Soon also NO_2, SO_2, O_3

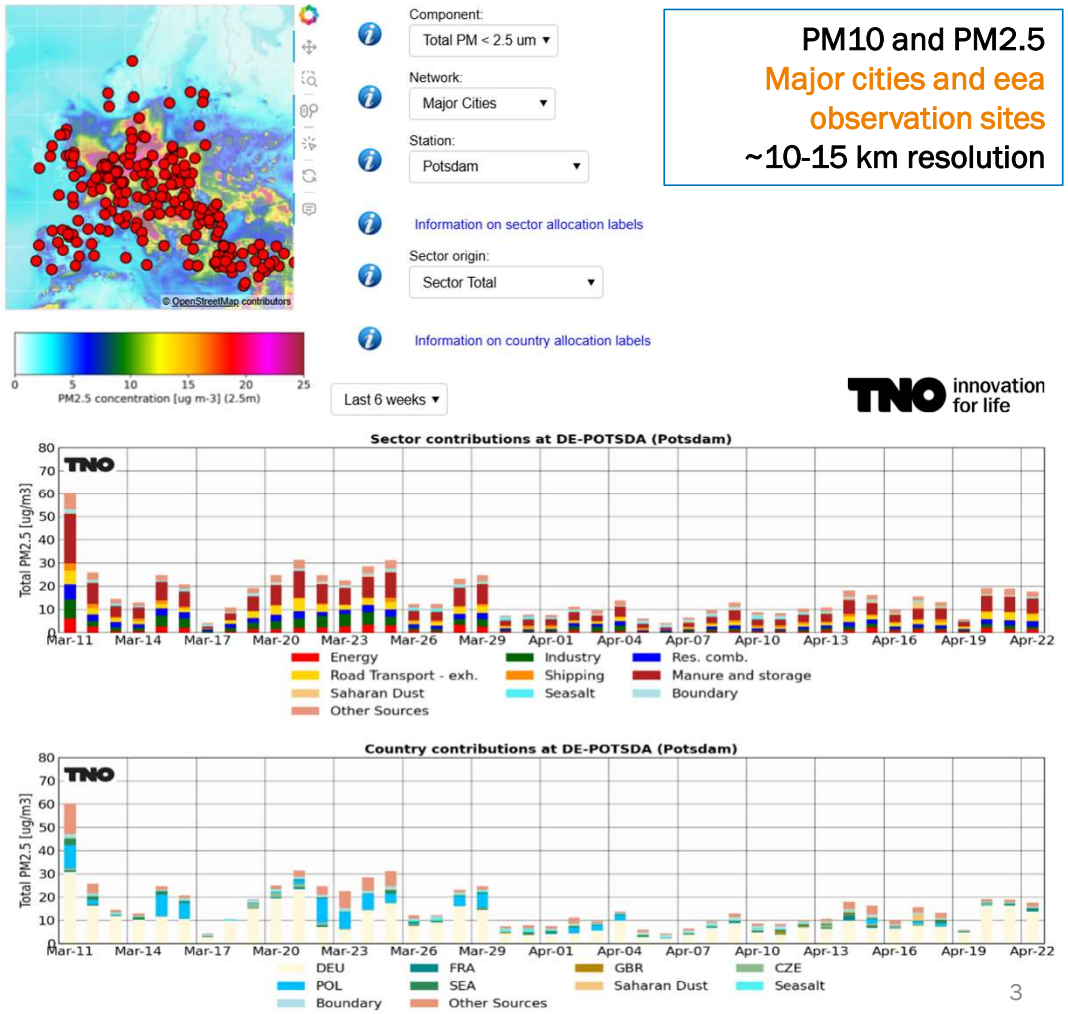
Measurements do not provide direct information on the source regions of pollution→ dependent on models that can relate concentrations to emission locations

TNO Operational Pollution Attribution Service (TOPAS)

Contributions at any place and time

Tagging approach
LOTOS-EUROS CTM

https://airqualitymodeling.tno.nl/topas/topas-eu/



PM10 and PM2.5
Major cities and eea observation sites
~10-15 km resolution

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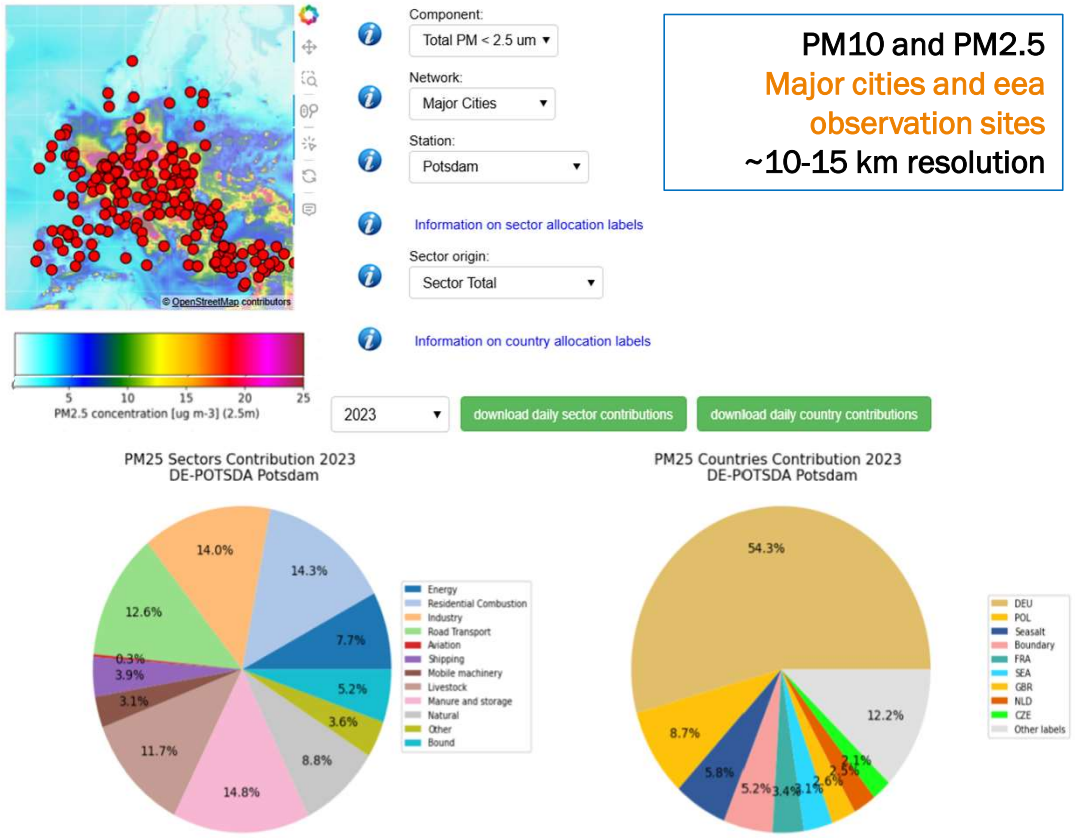

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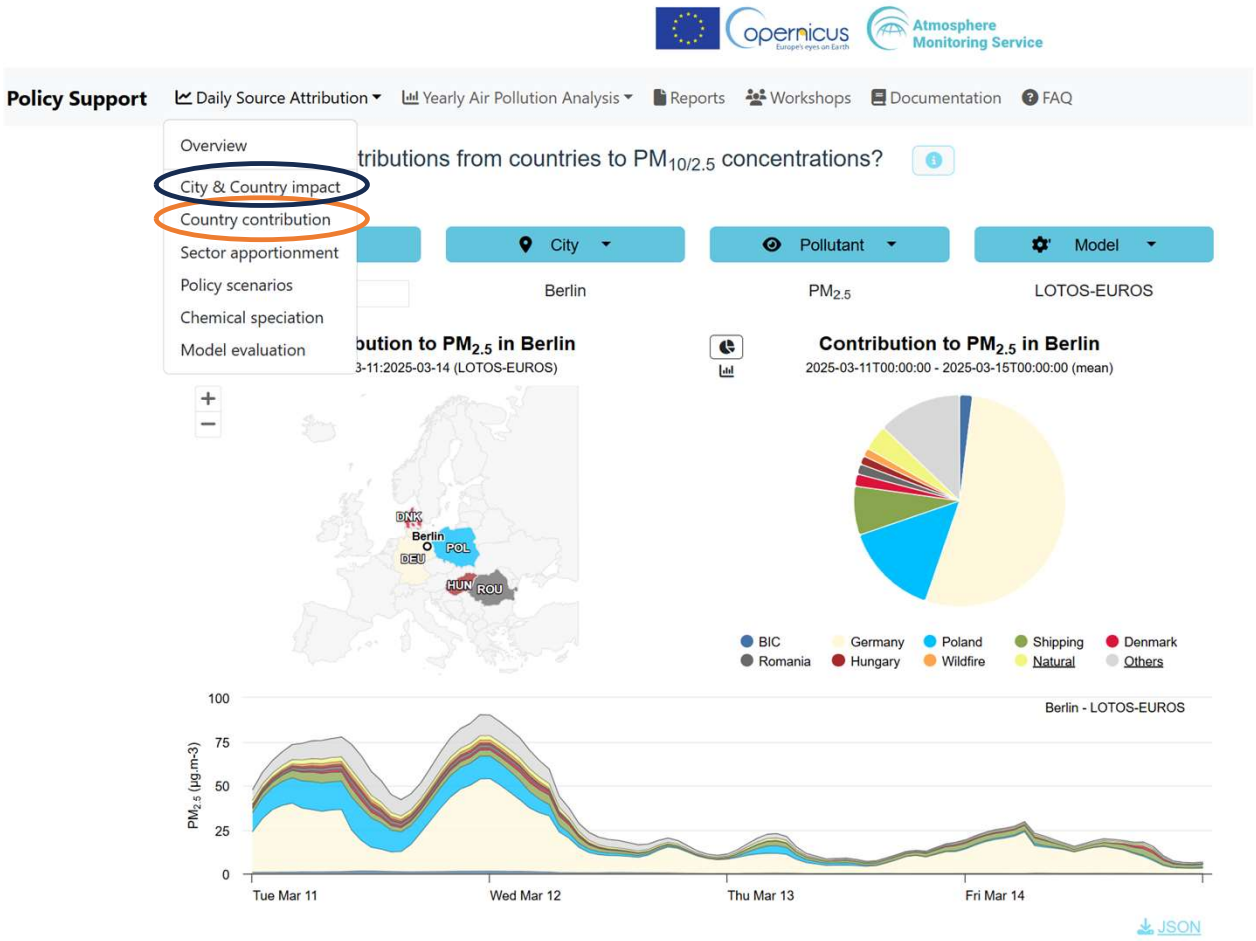
CAMS policy support service

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

Models and source attribution methods in CAMS source region attribution

TNO
LOTOS-EUROS
Tagging

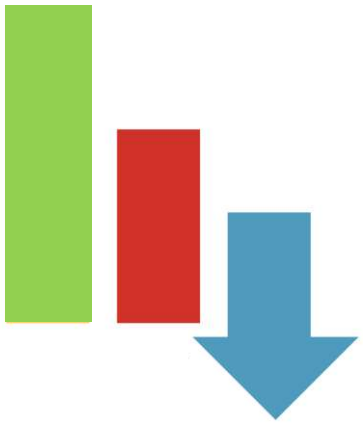
Sensitivity (15% ER)

Contribution of sources at given location and time

Metnorway
EMEP
Sensitivity (15% ER)

Local fraction

Potential impact of ER (scaled to 100%)



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

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

Investigation performed in the Horizon project CAMEO

→ Recommendations for users on applicability of the models/methods

Set-up comparison study

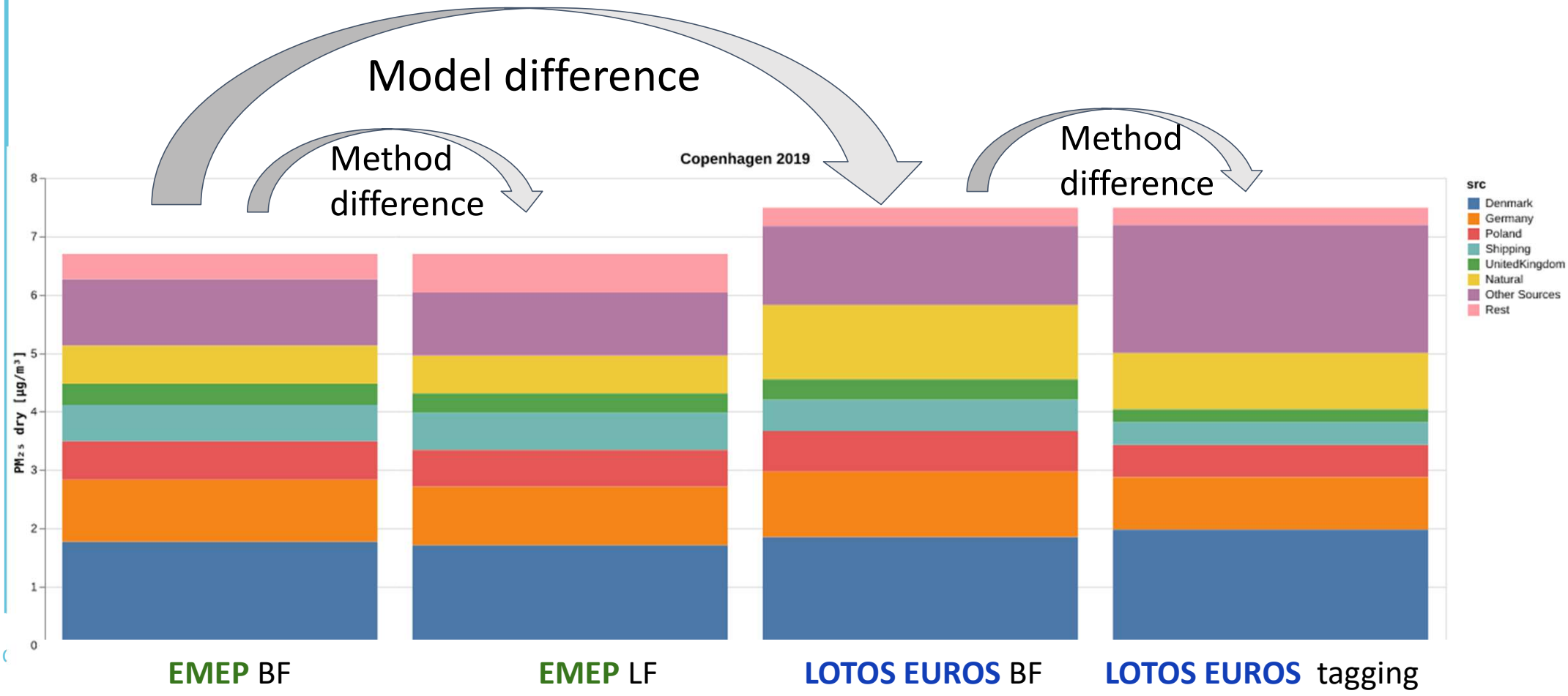
Harmonised set-up between models

- 2019
- CAMS-REG version 6.1 emissions
- CAMS-TEMPO emission time profiles
- Heating degree days for residential combustion
- Boundary conditions and meteo IFS
- 0.2x0.1 resolution (4-10 km)
- Output for 79 cities

Comparison of methods & models used in CAMS policy products

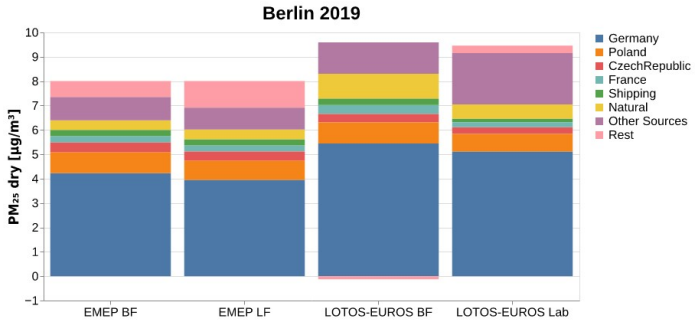
LOTOS-EUROS tagging boundary contributions (in other sources in plots) also includes natural contributions from the boundaries (as they were not explicitly separated into a fine and coarse fraction).

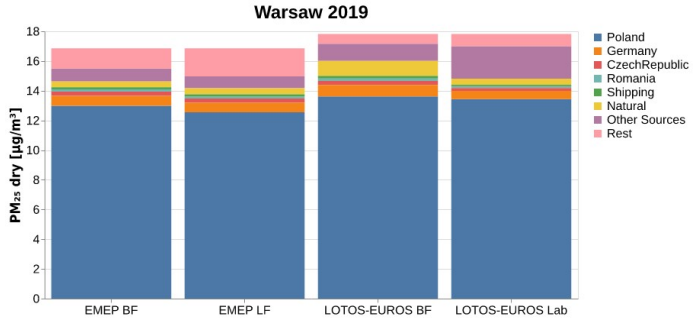
$PM_{2.5}$, 2019, Copenhagen

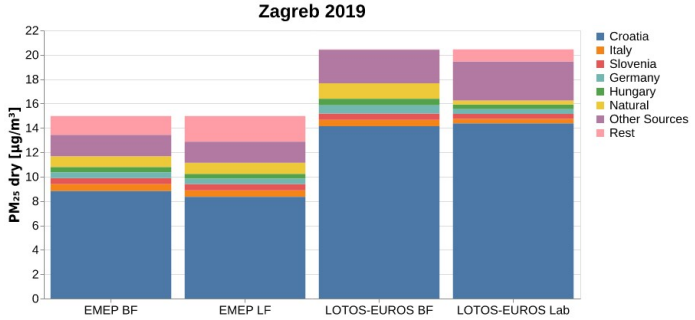


Yearly PM2.5 – three cities

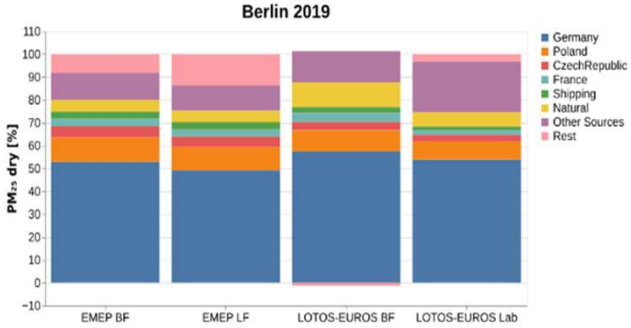
absolute

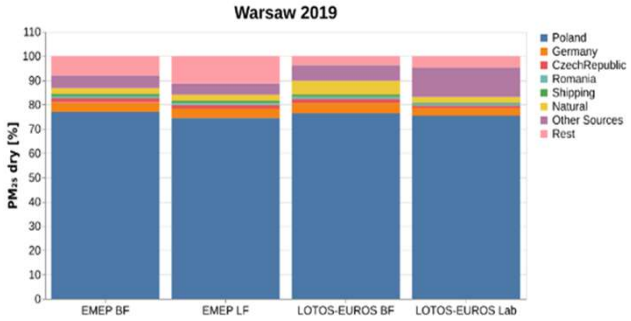


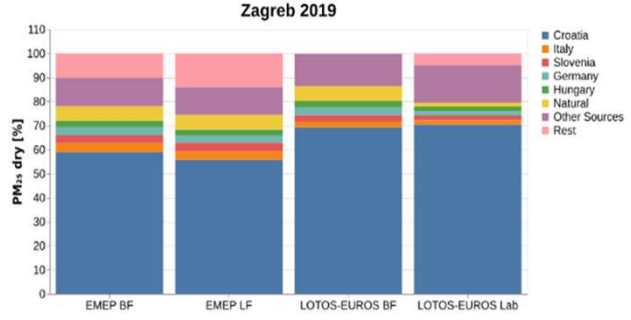




relative

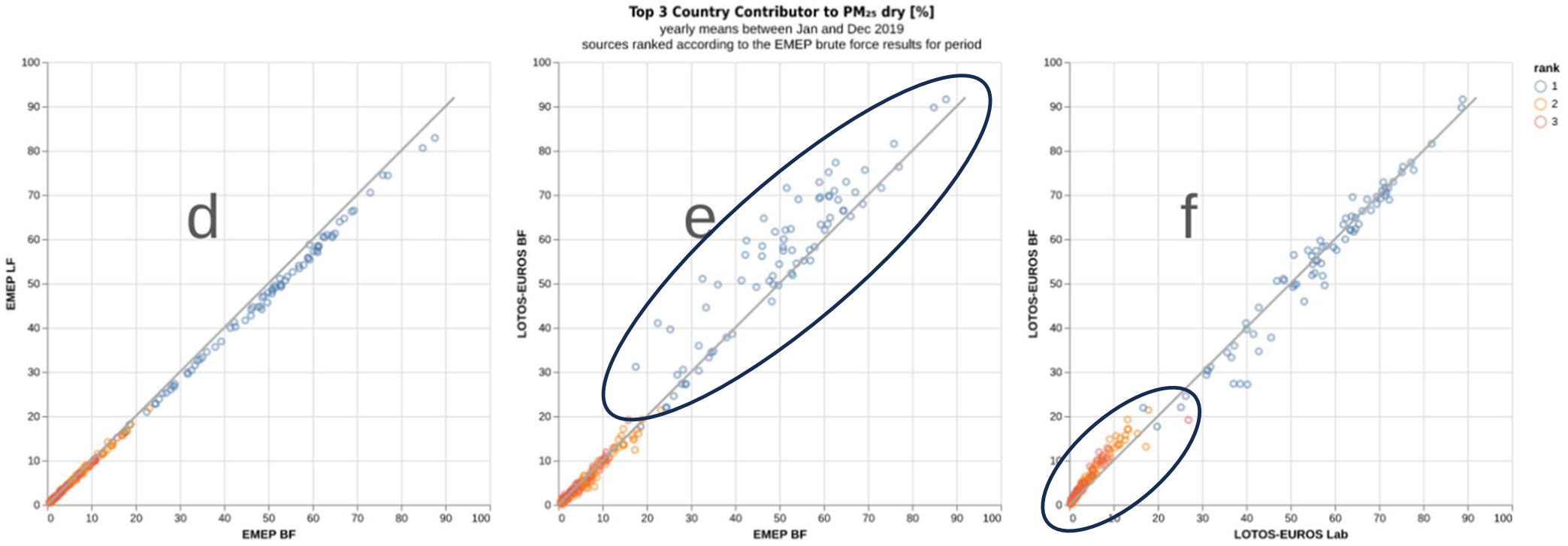






Top 3 country contributors to yearly PM2.5 – in %

average over 79 CAMS cities

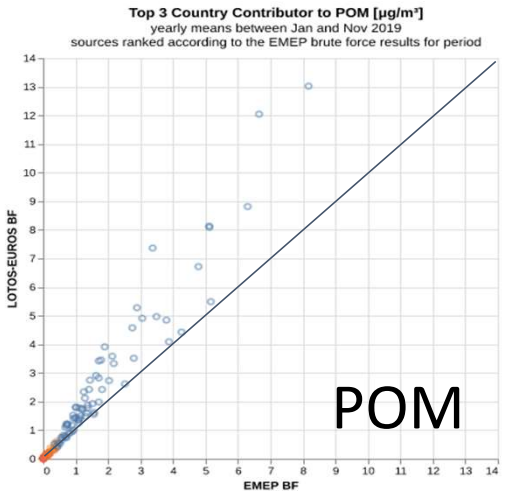


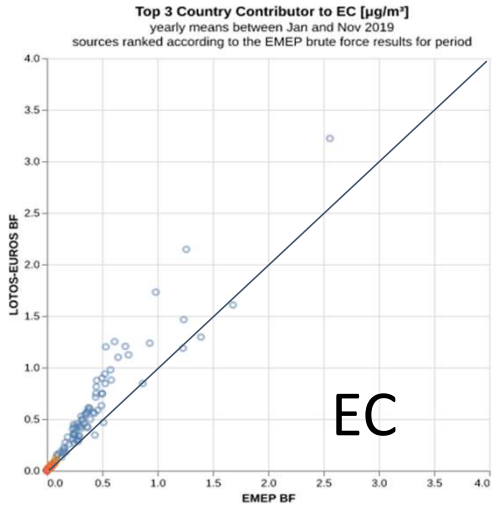
EMEP LF vs. EMEP BF

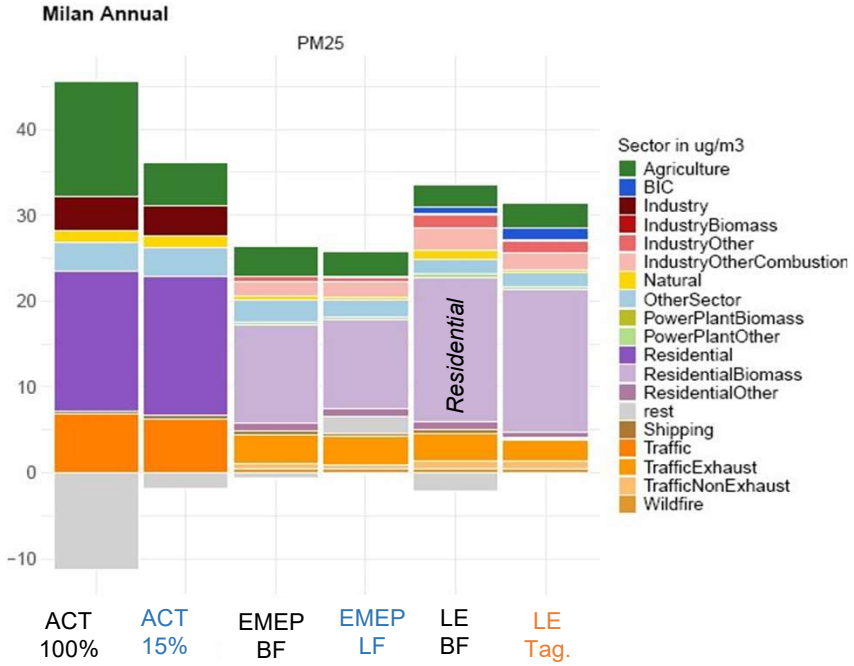
LE BF vs. EMEP BF

LE BF vs. LE tagging

Annual comparisons between models/methods





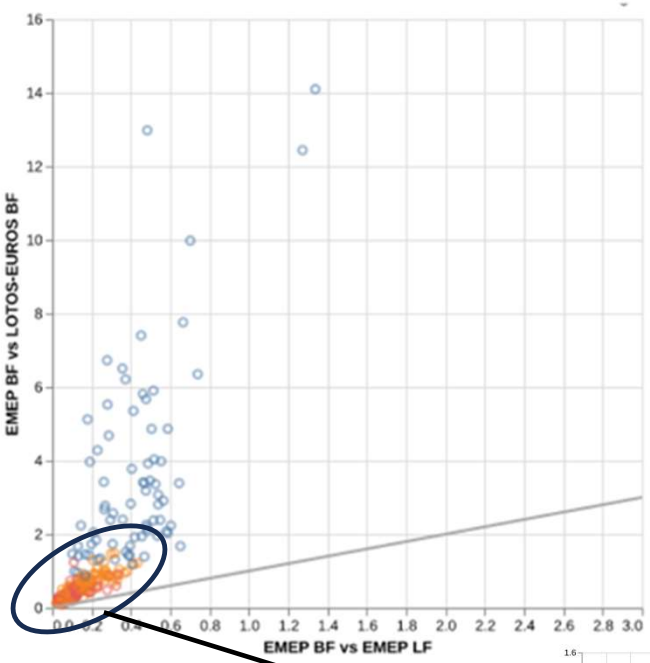


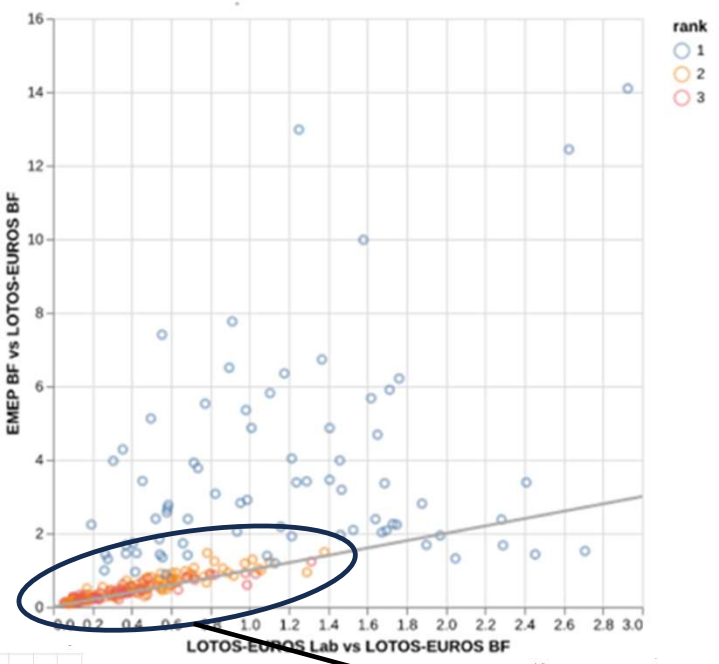
The primaries are causing the difference

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

Differences due to model or method?

Y-axis: Difference (RMSE) in models

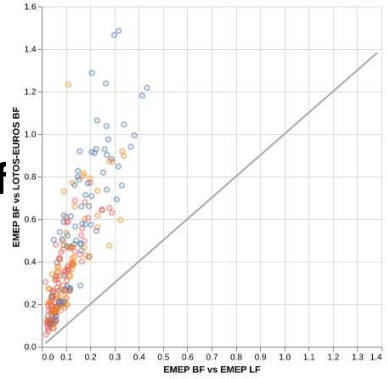


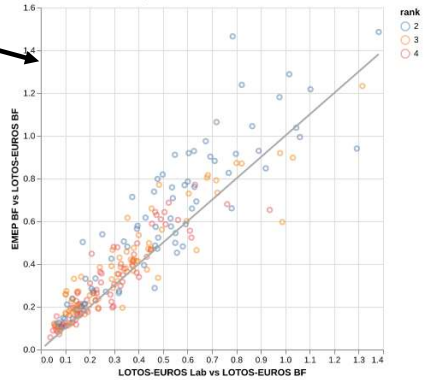


Local fraction vs BF

labelling vs BF

X-axis: Dif veen methods



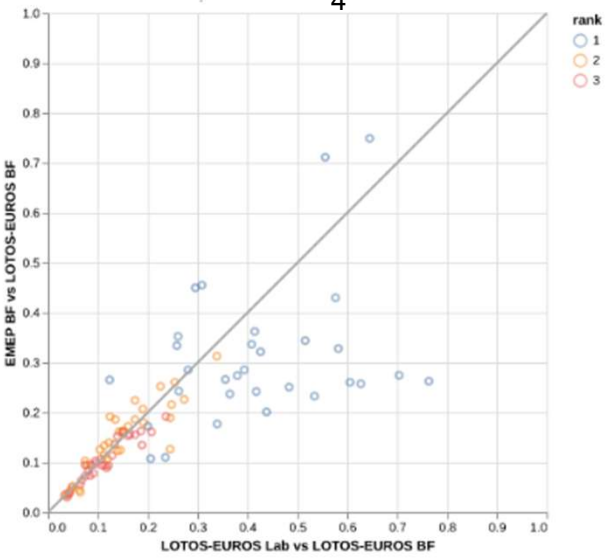


Comparison of Secondary inorganic PM

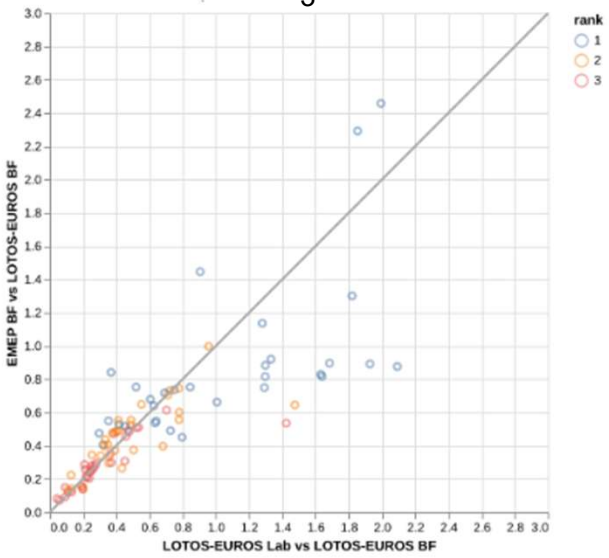
For **primaries** differences between tagging and BF are in principle zero, for **secondaries** differences are caused by non-linear chemistry

Y-axis: Difference (RMSE) in models

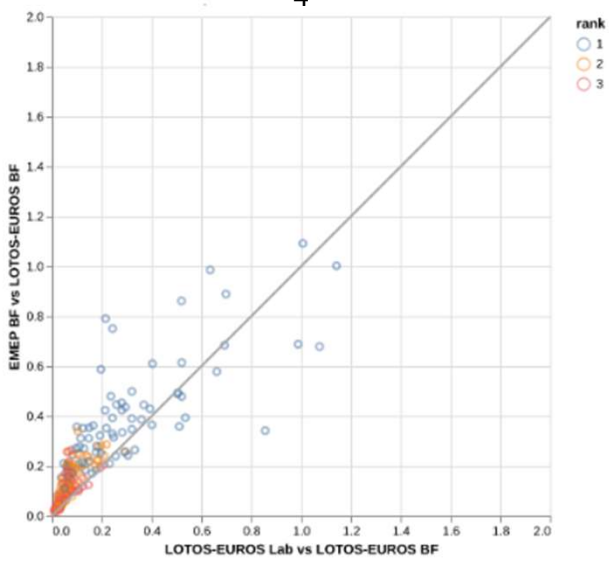
NH_4



NO_3



SO_4



X-axis: Difference (RMSE) between methods (labelling vs BF)

Potential impacts from BF provide a different answer than contributions from labelling
Methods can provide complementary information

Summary

We have showed a comparison of PM apportionment to countries from:

- **Tagging** which provides apportionment for assessment of contributions to actual concentrations
- **Brute force** (BF) and **Local fraction** (LF) which provide apportionment for assessment of potential impacts of emission reductions

- Overall for **yearly** $PM_{2.5}$ differences in **national** contribution are larger between models than methods – associated with model settings such as surface layer depth
- For the **countries ranked 2nd and 3rd** differences due to the model is of the same magnitude as for BF vs labelling – in general all models and methods show good agreement

- **Local fraction** provides very similar results to **brute force** in EMEP model

- For **primaries** differences between **tagging** (contributions) and **BF** (potential impacts) are in principle zero
- For the **non-linear species** (e.g. NH4+, NO3-) the difference due to the model is of the same magnitude as for **BF** vs **labelling** – differences due to method become more relevant on shorter timescales- one should take into account the different purposes of the methods and use them in a complementary way

Thank you for your attention!

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