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Source contributions to city level PM2.5 under future scenarios for Europe and EECCA

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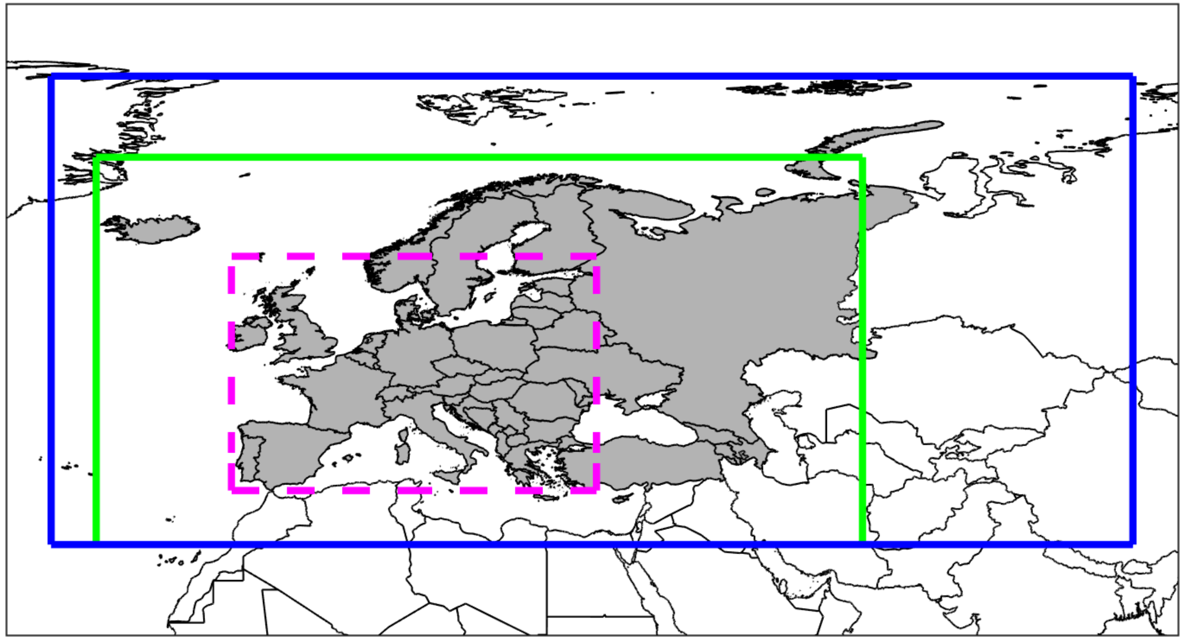
Domains in GAINS



45 GAINS-Europe emission regions

“28km” impact domain

“7km” downscaling

New EMEP domain
covering all EECCA countries

⇒ New transfer coefficients needed
(MSC-W end of 2021)

⇒ New downscaling needed (uEMEP)

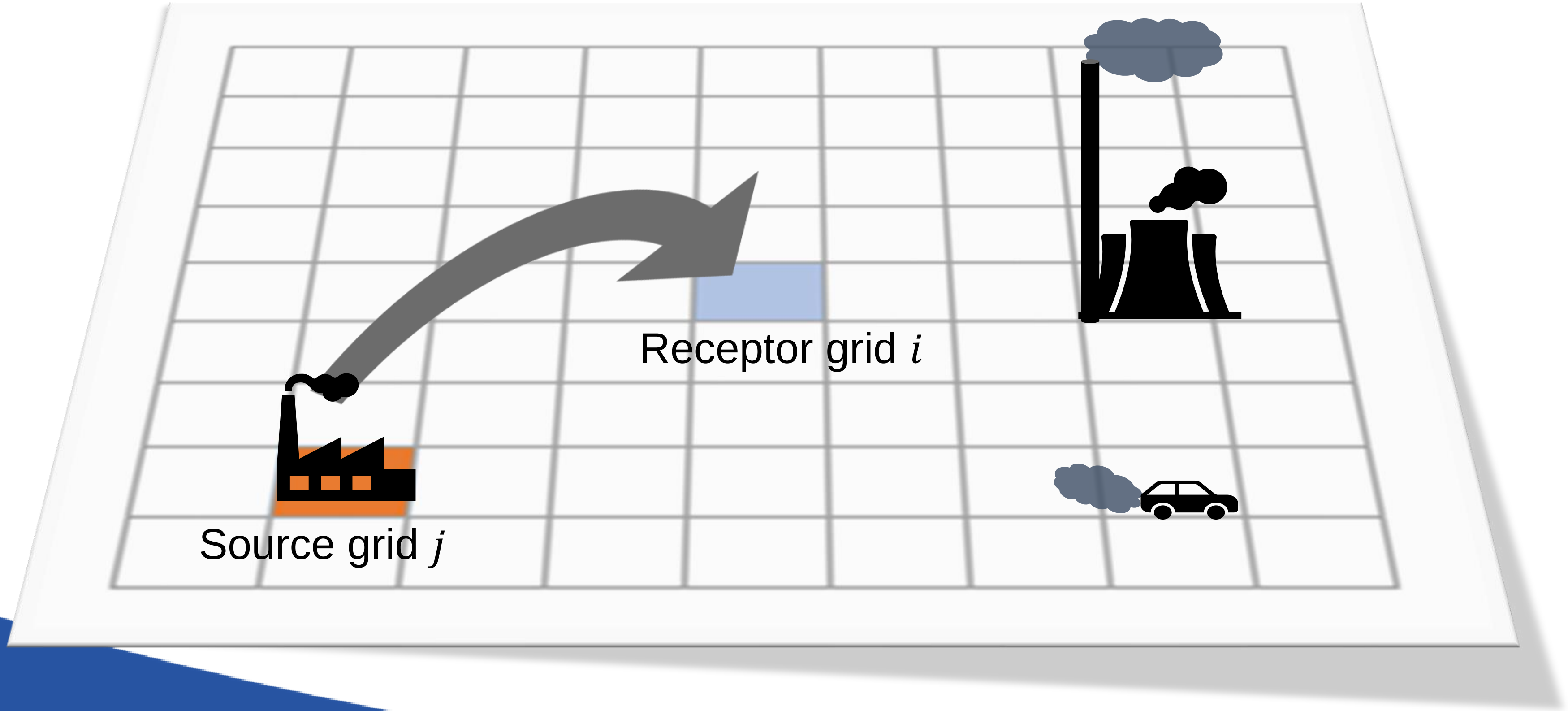
New transfer coefficients in GAINS

- Extended EMEP domain
- Resolution: 0.3°x0.2°
- Base case: 2030 Baseline scenario
- Reduction simulations for 50 land regions (incl split of Turkmenistan, Uzbekistan, Tajikistan) and 10 sea regions (5 seas, inside/outside 12nm)
- 5 met years
- 5 source pollutants (PPM, SO_2, NOx, NH_3, VOC)
  - Separate reduction for soil NOx
  - No separate treatment of dispersion of condensable PM (yet)
- Endpoints:
  - concentrations of $PM_{2.5}$, O_3 (SOMO35, AOT), NO_2
  - Health impacts from $PM_{2.5}$, O_3
  - Deposition -> ecosystem impacts (using updated CLs, yet to be implemented)

Extension with grid-to-grid tracking of PPM

- EMEP CTM can track PPM contributions grid-to-grid (0.1°)
- 4 different vertical emission "layers" (low-level 1&2, industry, power)
- monthly results allow for sector-specific time patterns

Sector specific transfer coefficients

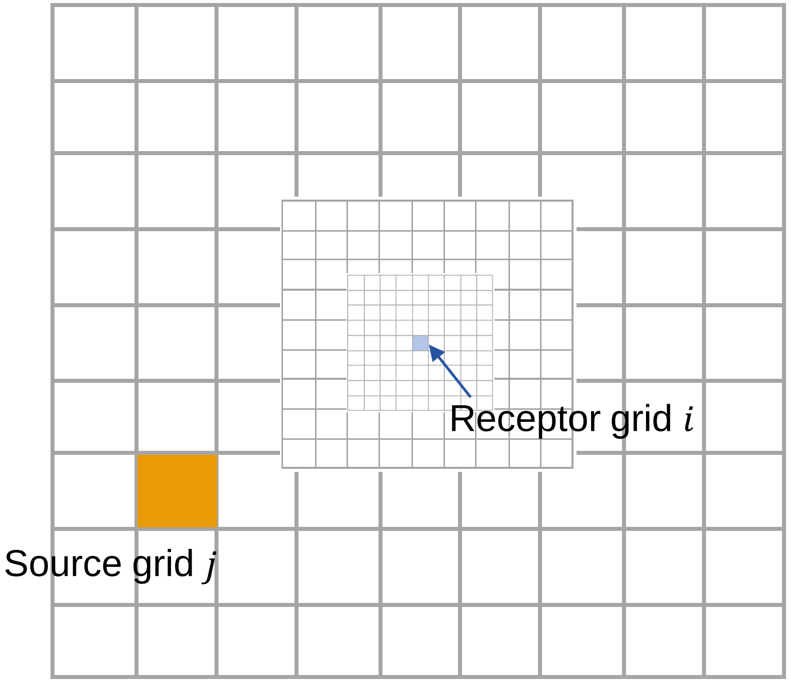


Extension with grid-to-grid tracking of PPM

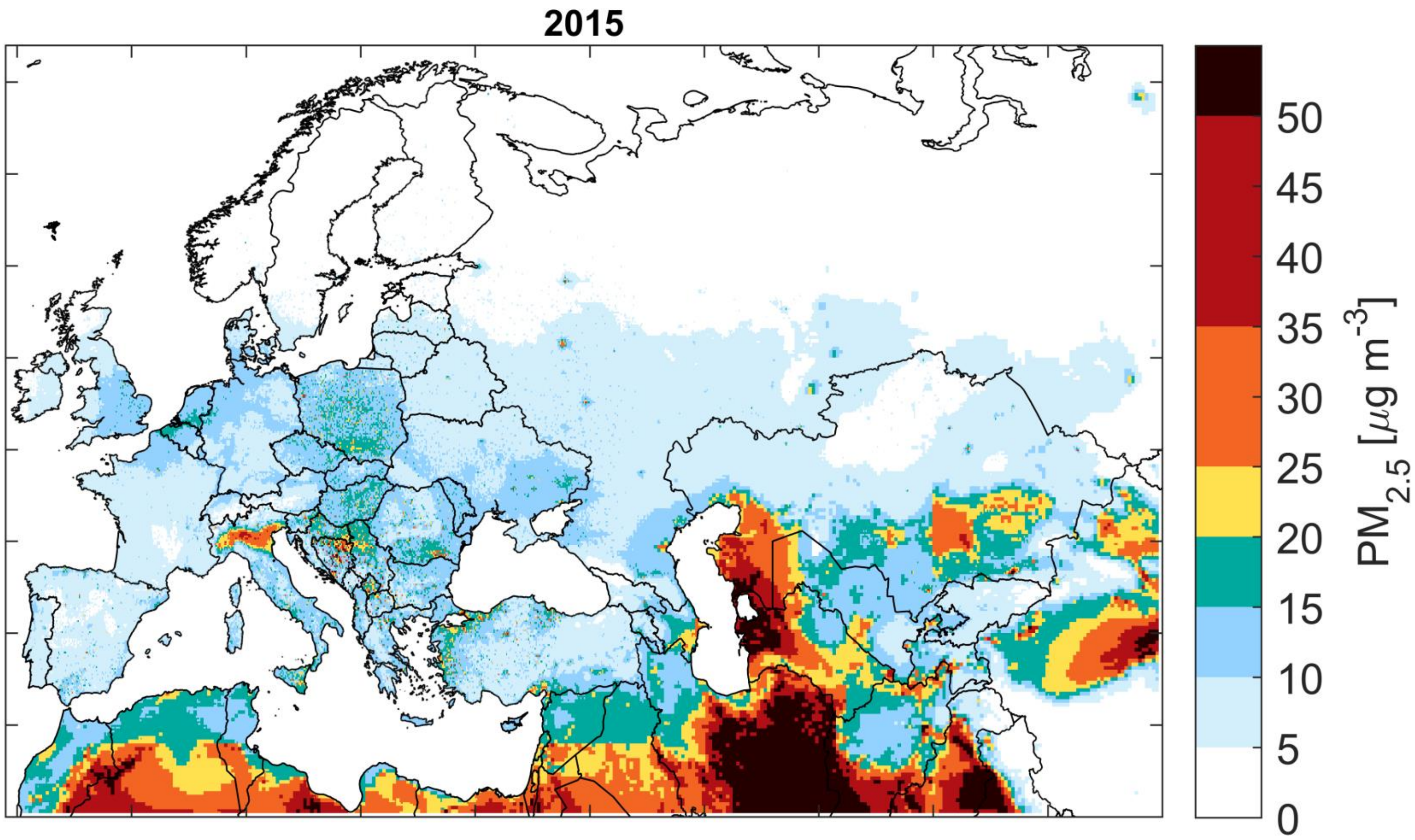
- EMEP CTM can track PPM contributions grid-to-grid (0.1°)
- 4 different vertical emission "layers" (low-level 1&2, industry, power)
- monthly results allow for sector-specific time patterns
- five nested resolutions for source grids: 0.1° / 0.2° / 0.5° / 1° (/ 2°)

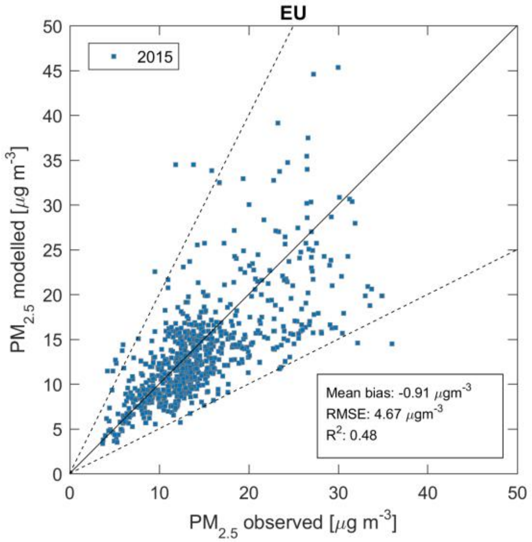
Sector specific transfer coefficients (0.1°)

20 grid cells in each direction => Complete domain coverage



Ambient $PM_{2.5}$ concentrations

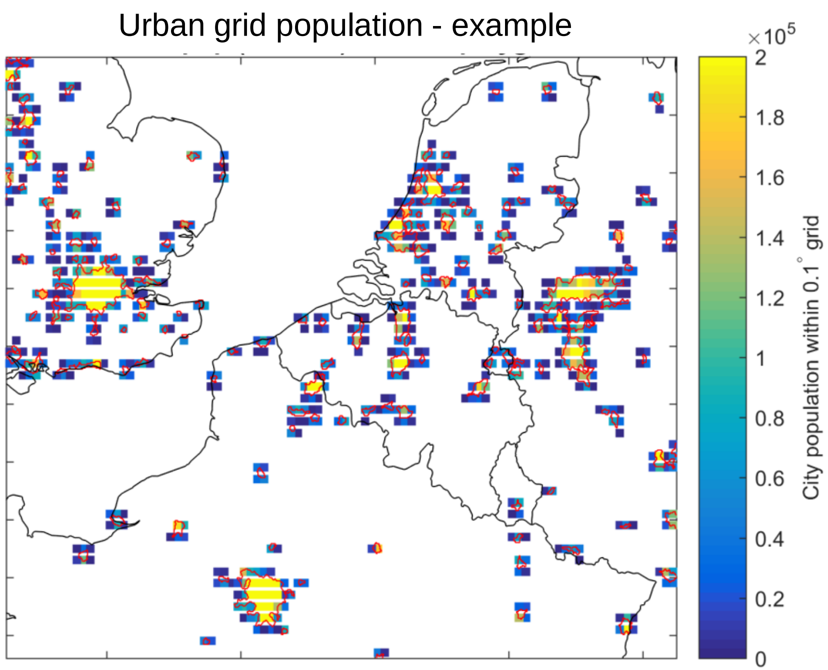




Preliminary results!

Contributions to $PM_{2.5}$ in cities: Approach

- Application of the grid-to-grid PPM transfer coefficients: For each city, split sectoral PPM transfer coefficients into contributions from the same city and outside
- City definition: JRC GHS urban core shapes (UCDB), consistent with the 250m population



- 1270 cities > 50,000 inhabitants in the extended GAINS-Europe domain
- So far: "urban background" (0.1°) - downscaling based on uEMEP will be implemented

Emission scenarios analyzed

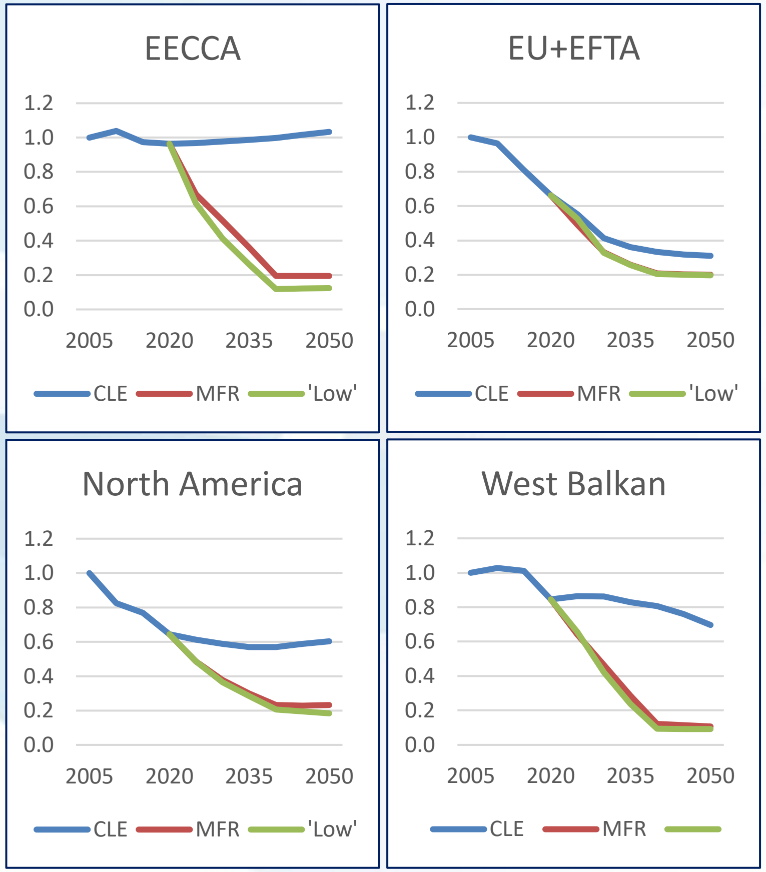
- *Baseline* (air pollutants and methane up to 2050)
  - Update of the historical data and comparison and validation with nationally reported emissions in 2021; *jointly with CEIP*
  - Review of the recent policies and measures and national implementation progress and plans
  - Energy and agriculture for the EU – Green Deal (Fit for 55); the MIX55 scenario
  - For West Balkan, Rep of Moldova, Georgia, and Ukraine newly developed PRIMES and CAPRI model scenarios
  - EFTA, Turkey, and remaining EECCA activity projections derived from IEA World Energy Outlook and FAO
  - Recent shock events have not been considered; scenarios developed before the Ukraine war

- Maximum technically Feasible Reduction '*MFR*' (air pollutants and methane)

- Alternative '*Low*' scenario
  - Climate policies compatible with Paris goals; for the whole region
  - *MFR* for air quality, including shipping sources
  - 'Healthy diet' and more – scenarios for *Growing better*… study (https://www.foodandlandusecoalition.org/)

Emission trends (1)

PM2.5

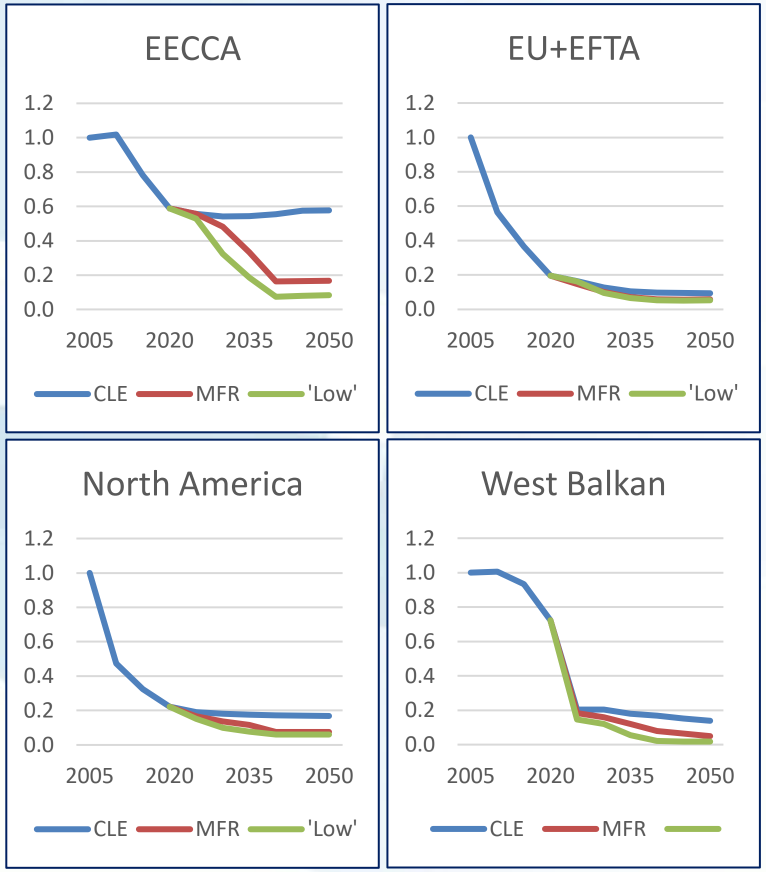


- primary PM2.5 – except EU+, large potential exists, especially in EECCA and West Balkan (industry and residential sector coal and wood)
- For SO_2 – apart from EECCA, most of the further mitigation potential committed in current legislation – assuring enforcement essential!
- For NOx – similar picture to SO_2, although more further mitigation potential available; note that remoting sensing data (and N deposition measurements) indicate that emission inventories overestimate decline in emissions in the last decade
- For NH_3 – current policies very shy of mitigation, similar further potential exists across all regions (some differences for single countries where policies more advanced since a while); Overall mitigation potential much smaller than for other air pollutants - need for structural and behavioral changes (will bring significant CH_4 co-benefits) – the 'Low' scenario provides significant additional potential
- The newly developed 'Low' scenario offers significant further mitigation for NH_3 only, and co-benefits for methane (not shown); for SO2, NOx, PM2.5, additional mitigation not large but in relative terms might halve emissions in 2050

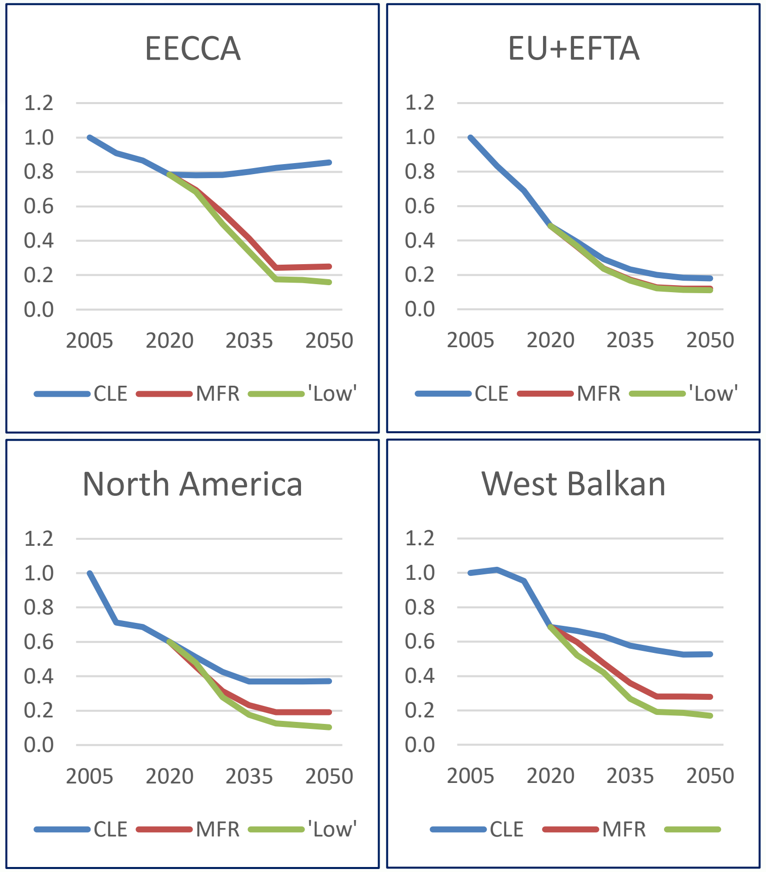
EECCA – here includes also Turkey

Emission trends (2)

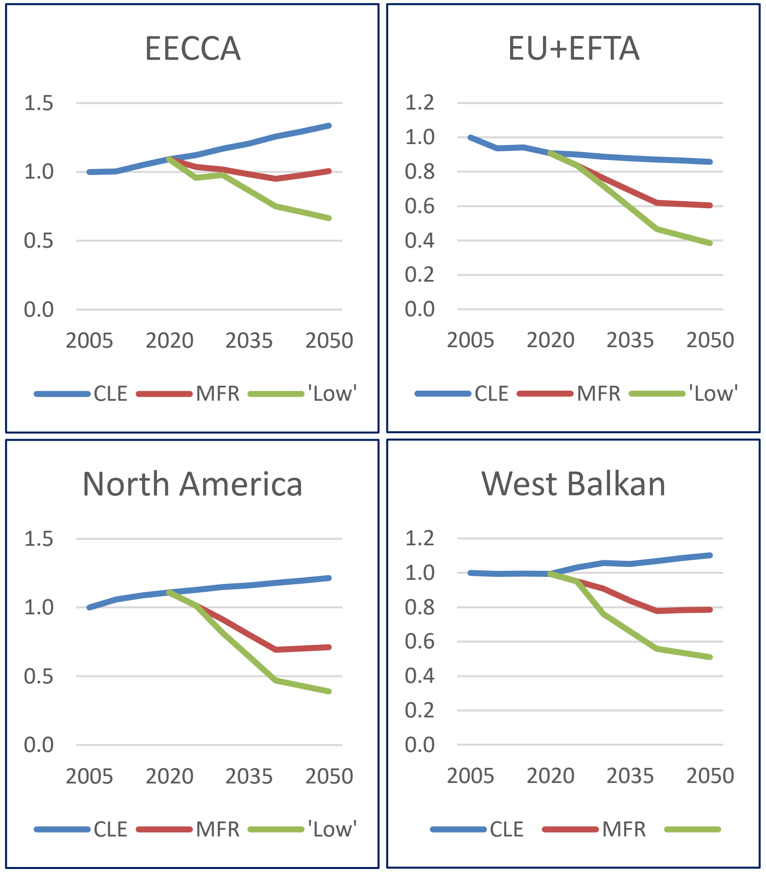
SO_2



NO_x

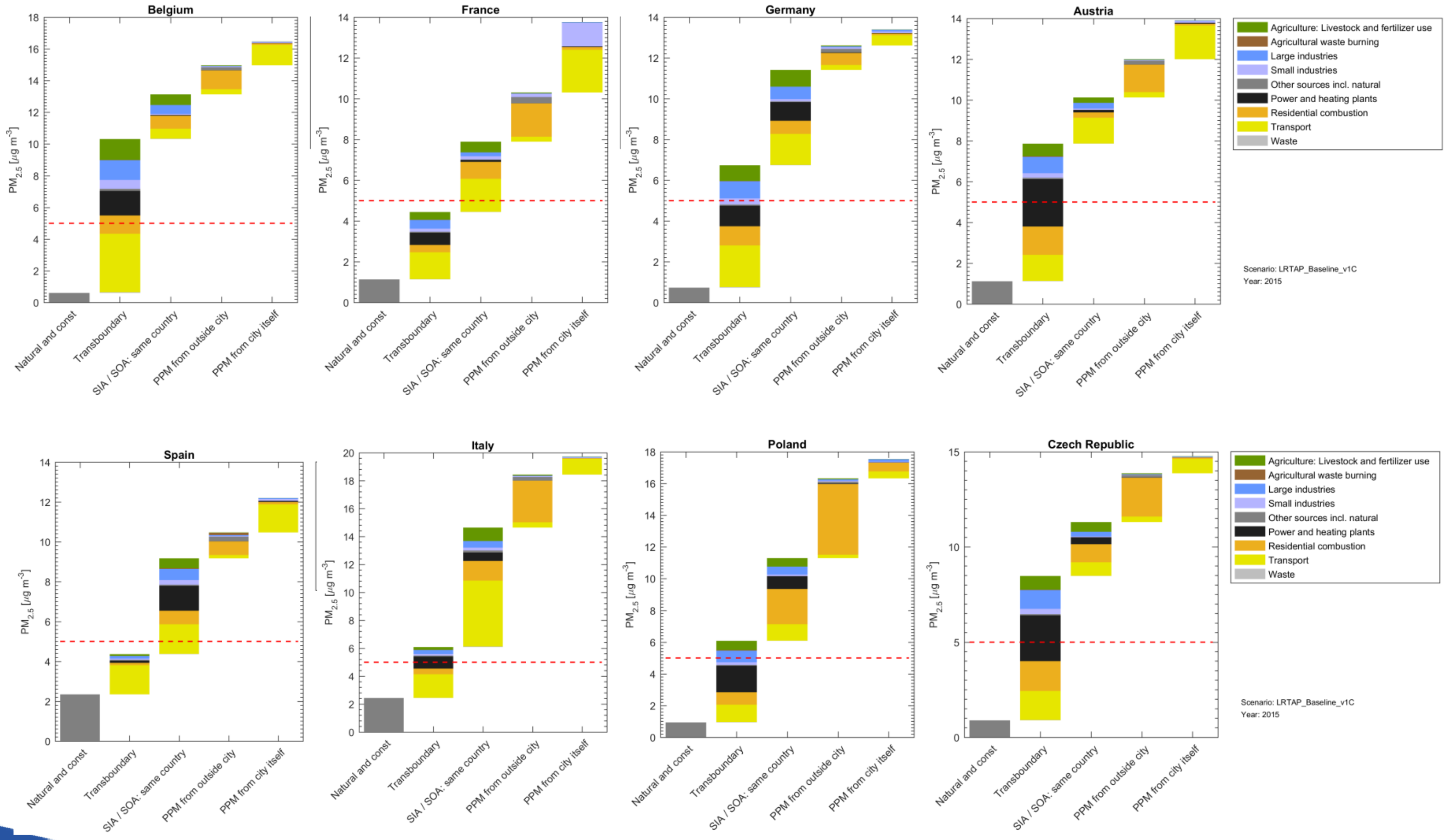


NH_3



EECCA – here includes also Turkey

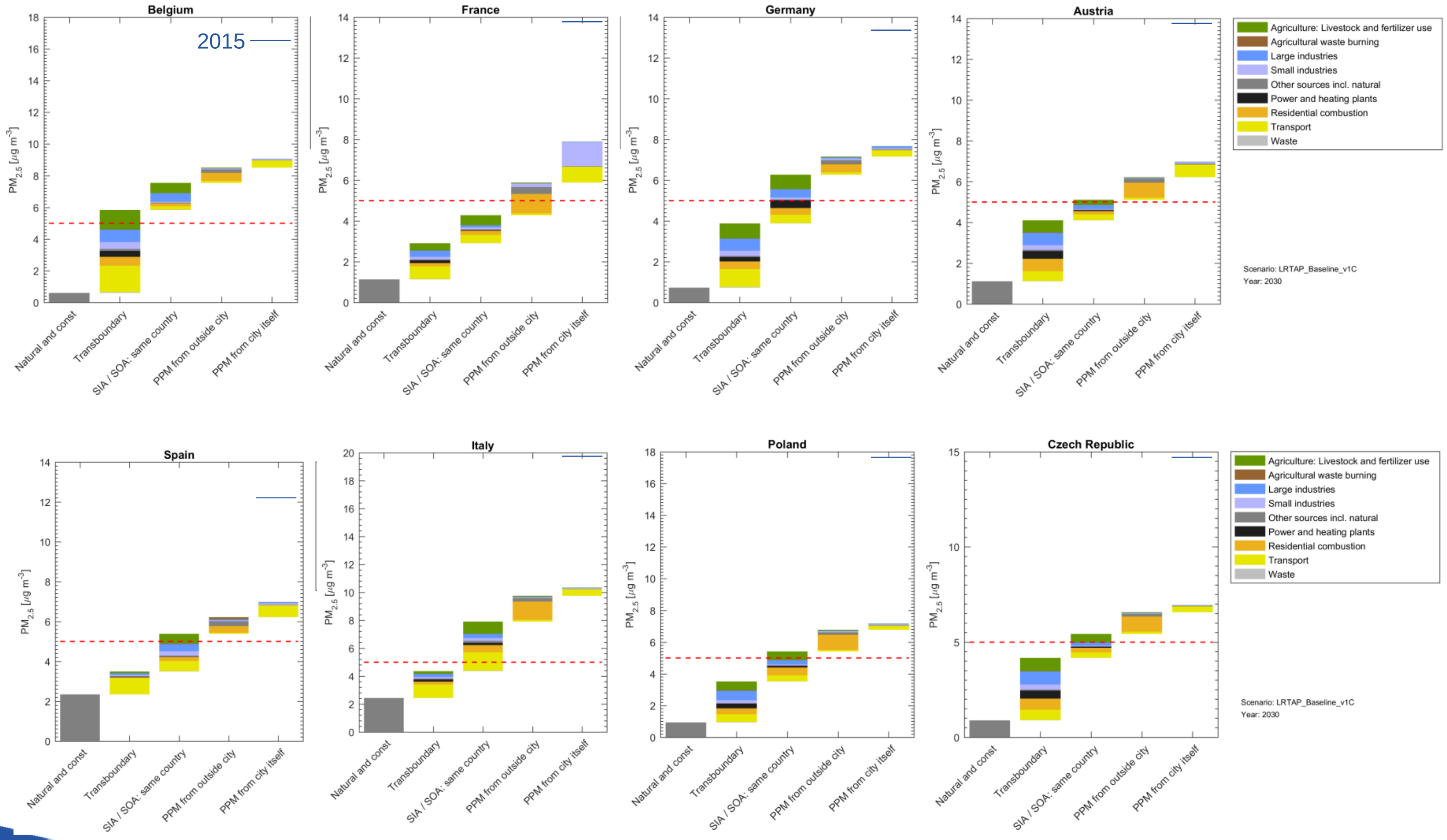
Country averages of cities: 2015, EU



Large contributions transboundary and SIA. Local contributions very limited (traffic dominated).

Preliminary results!

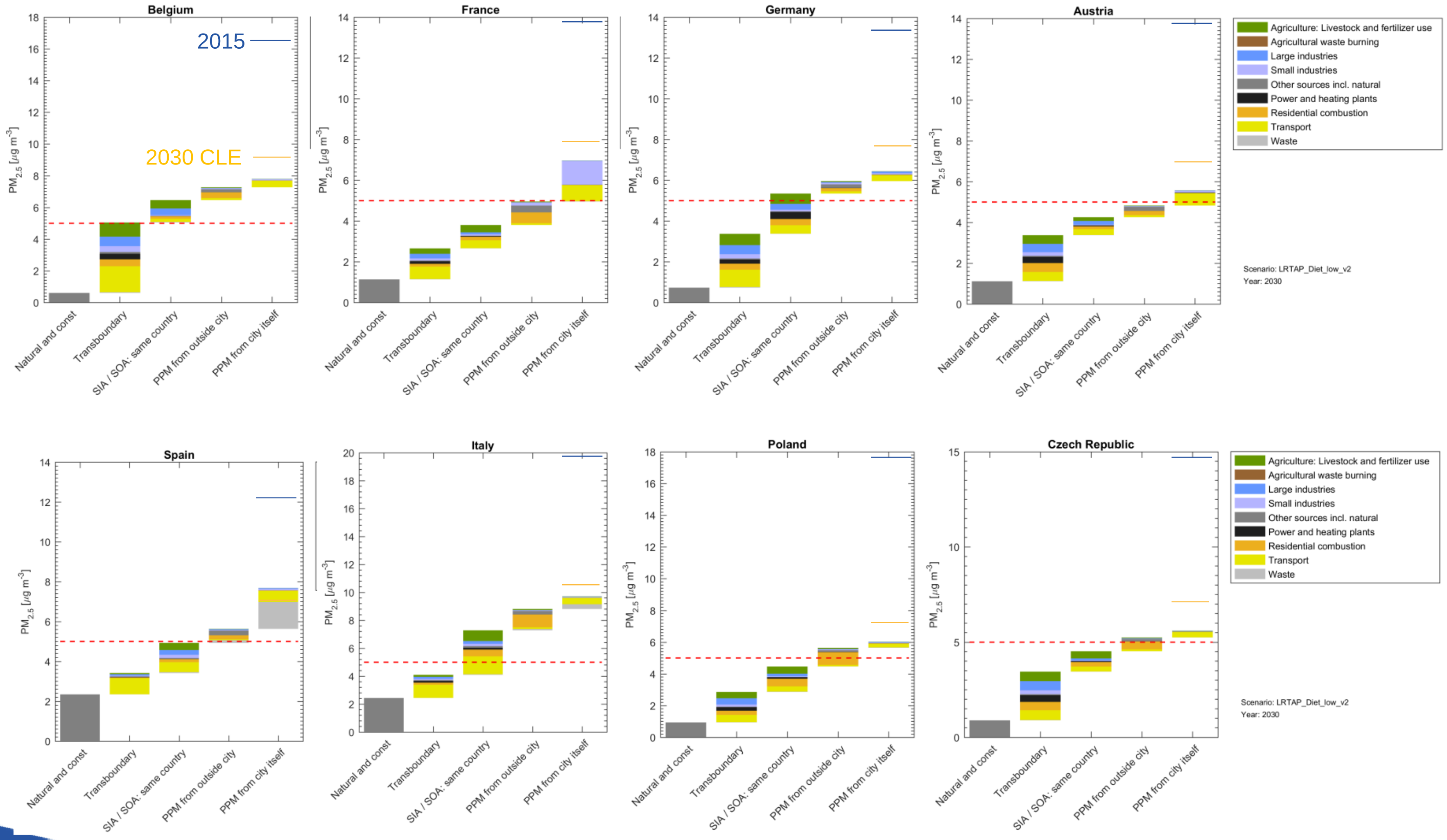
Country averages of cities: 2030 CLE, EU



Strong decreases expected under current legislation.

Preliminary results!

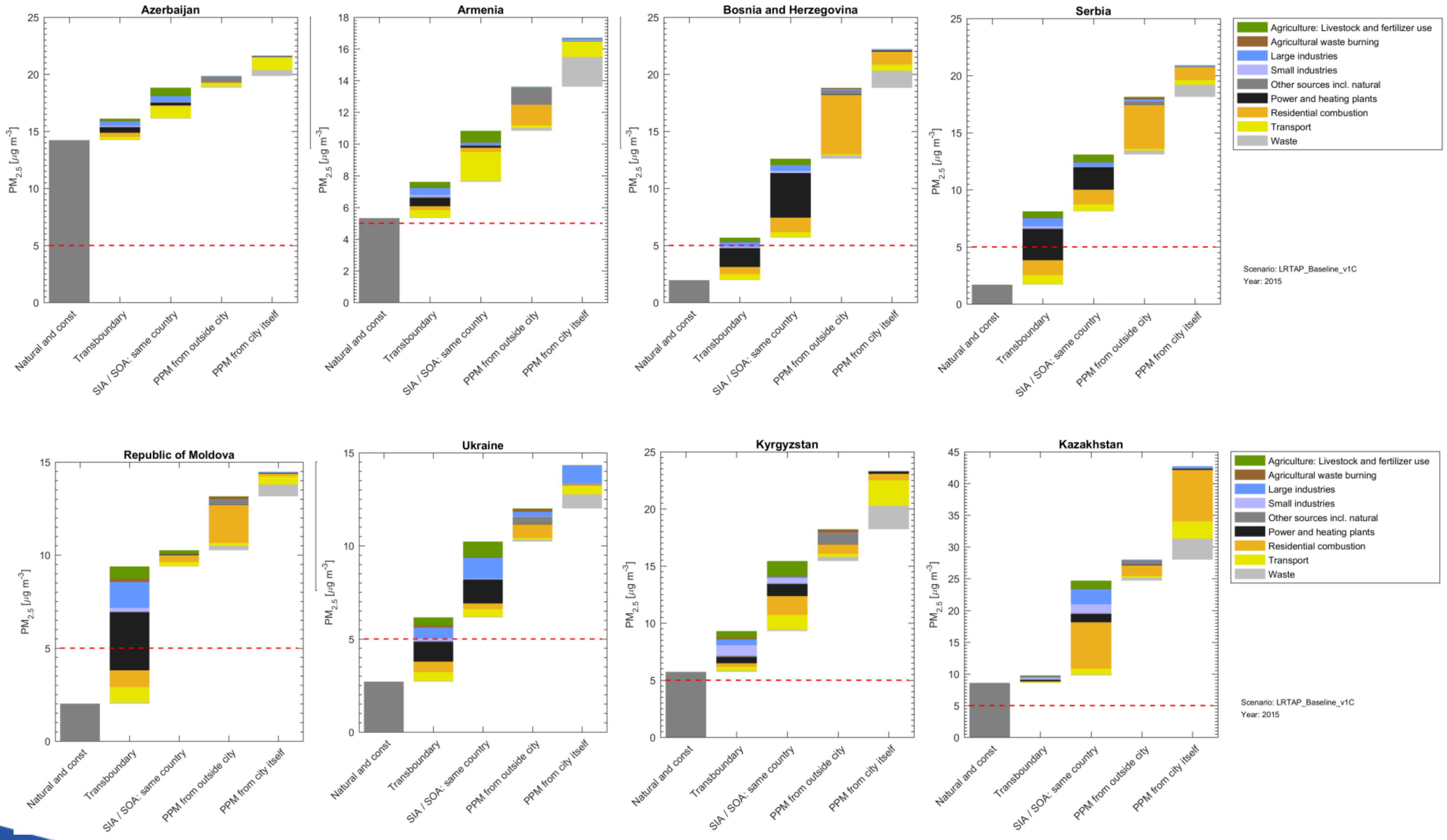
Country averages of cities: 2030 Low, EU



Low MFR could bring some further decreases

Preliminary results!

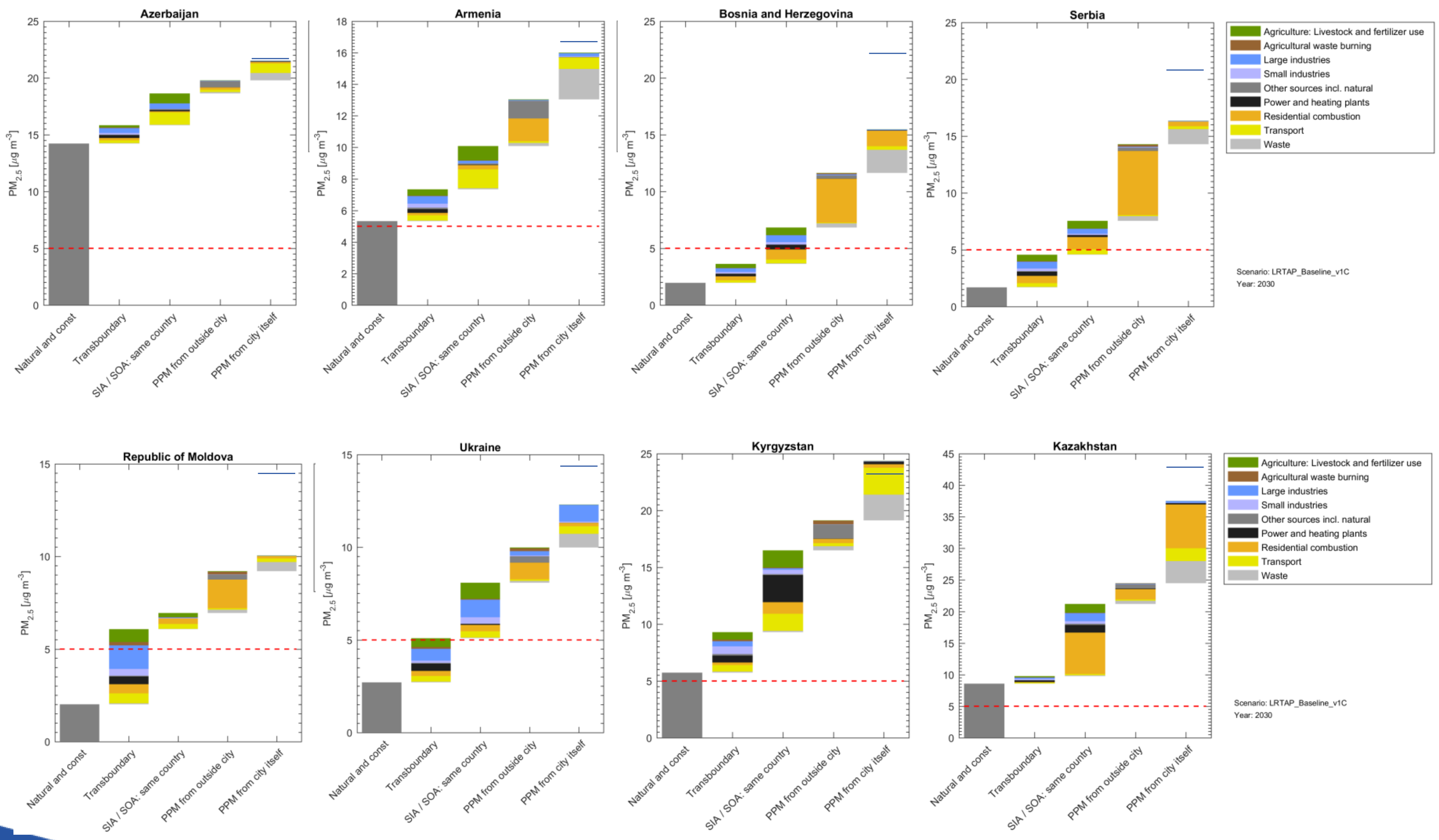
Country averages of cities, non-EU: 2015



Many countries face higher concentrations than in EU. Larger role of residential and power sector.

Preliminary results!

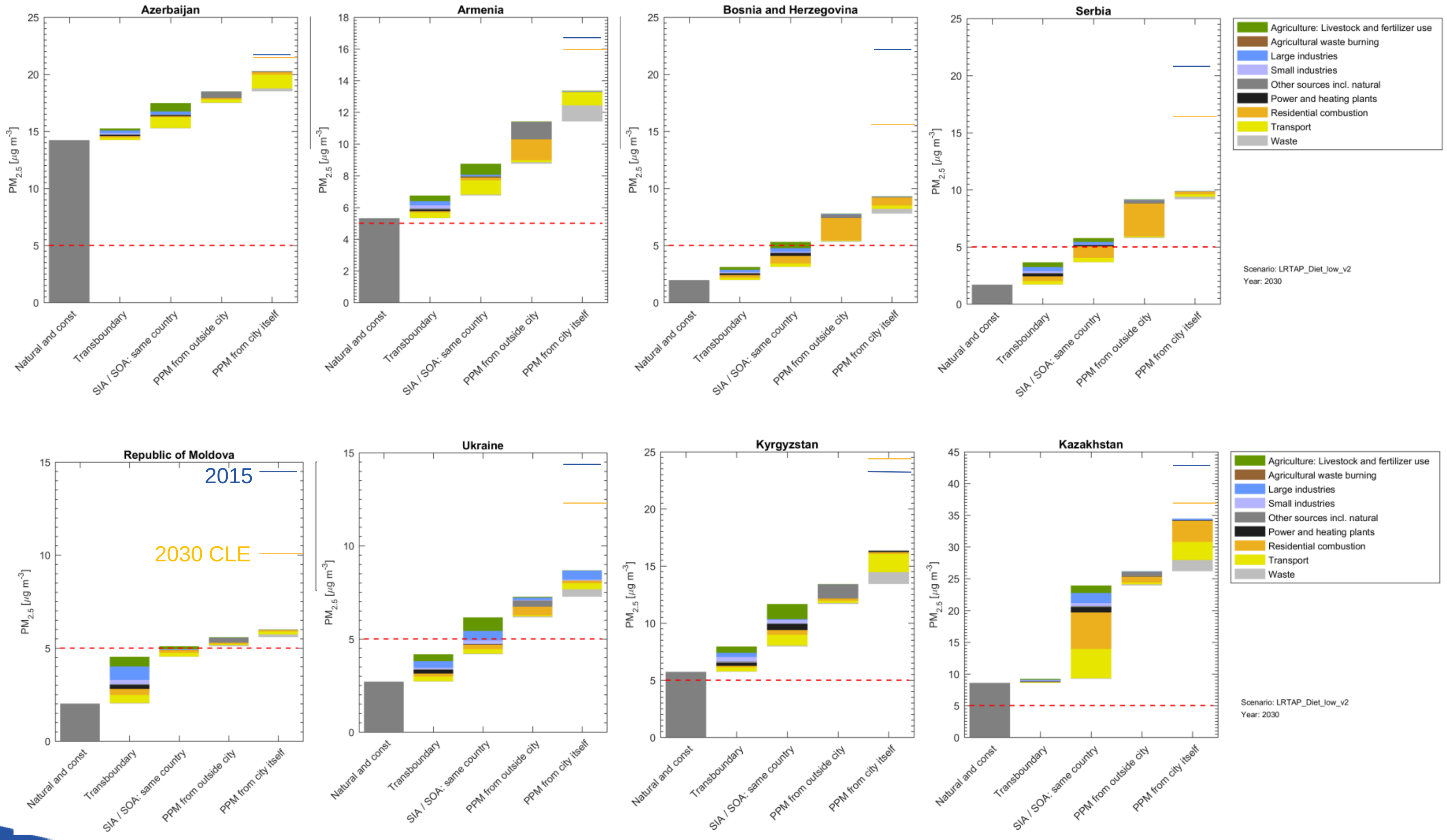
Country averages of cities, non-EU: 2030 CLE



Only moderate decreases under current legislation. Notably coal phase out in West Balkan

Preliminary results!

Country averages of cities, non-EU: 2030 LOW



Low MFR could substantially improve the situation.

Preliminary results!

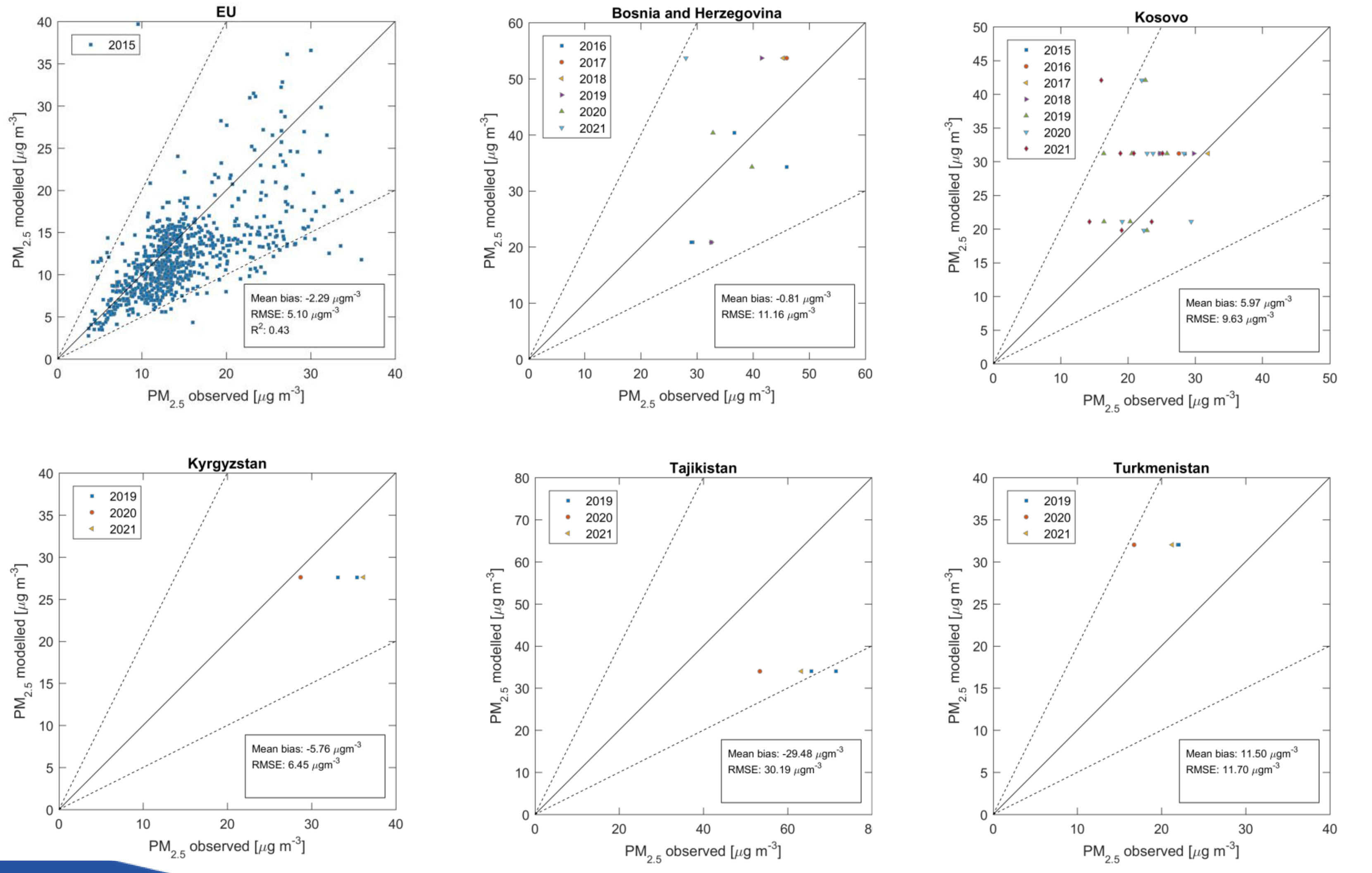
Conclusions

- Preliminary implementation of new transfer coefficients for the extended domain done
- Complemented by grid to grid tracking for PPM to derive sector specific transfer coefficients and splits for urban areas
- Preliminary city specific contributions (at 0.1°) have been derived for ~1270 cities in Europe+
- Contributions depend strongly on the quality of the underlying emission patterns. Thanks to the methodology, there is room for improvement – data on urban/rural splits needed.
- In the EU, strong decreases of ambient PM in cities are expected by 2030 with current legislation, limited scope beyond (local measures not considered here!)
- In West Balkan & EECCA, residential emissions and power/heating plants dominate; local contribution is often higher than in Western Europe. CLE brings decreases but does not solve the problem; there is scope for significant further reduction.

Thank you!

Name
Program
Email
Web

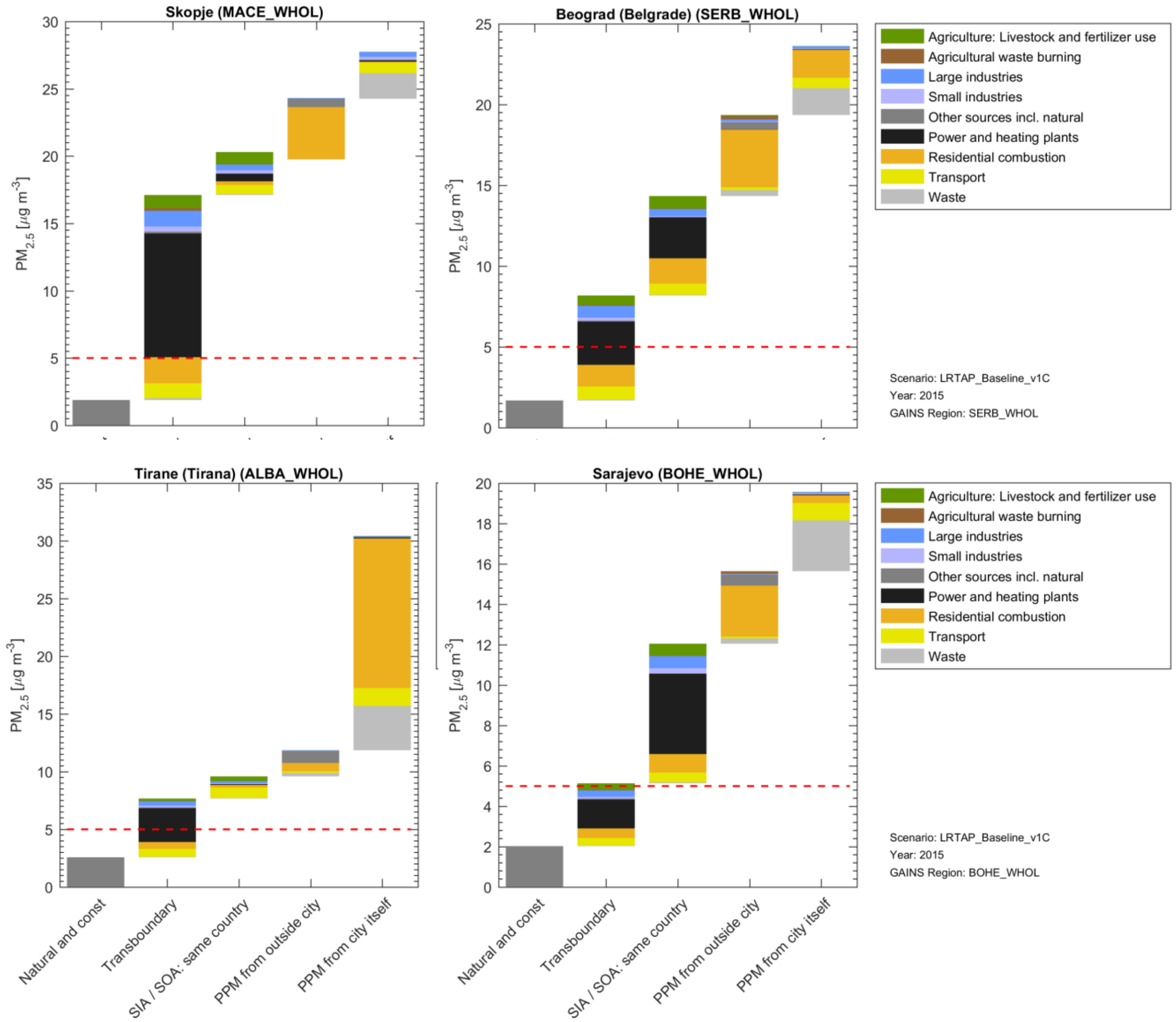
Ambient $PM_{2.5}$ concentrations – validation



Non-EU: Not many stations available… (WHO DB 2022, AirBase, US Embassies)

Preliminary results!

Source contributions to cities: West Balkan (2015)

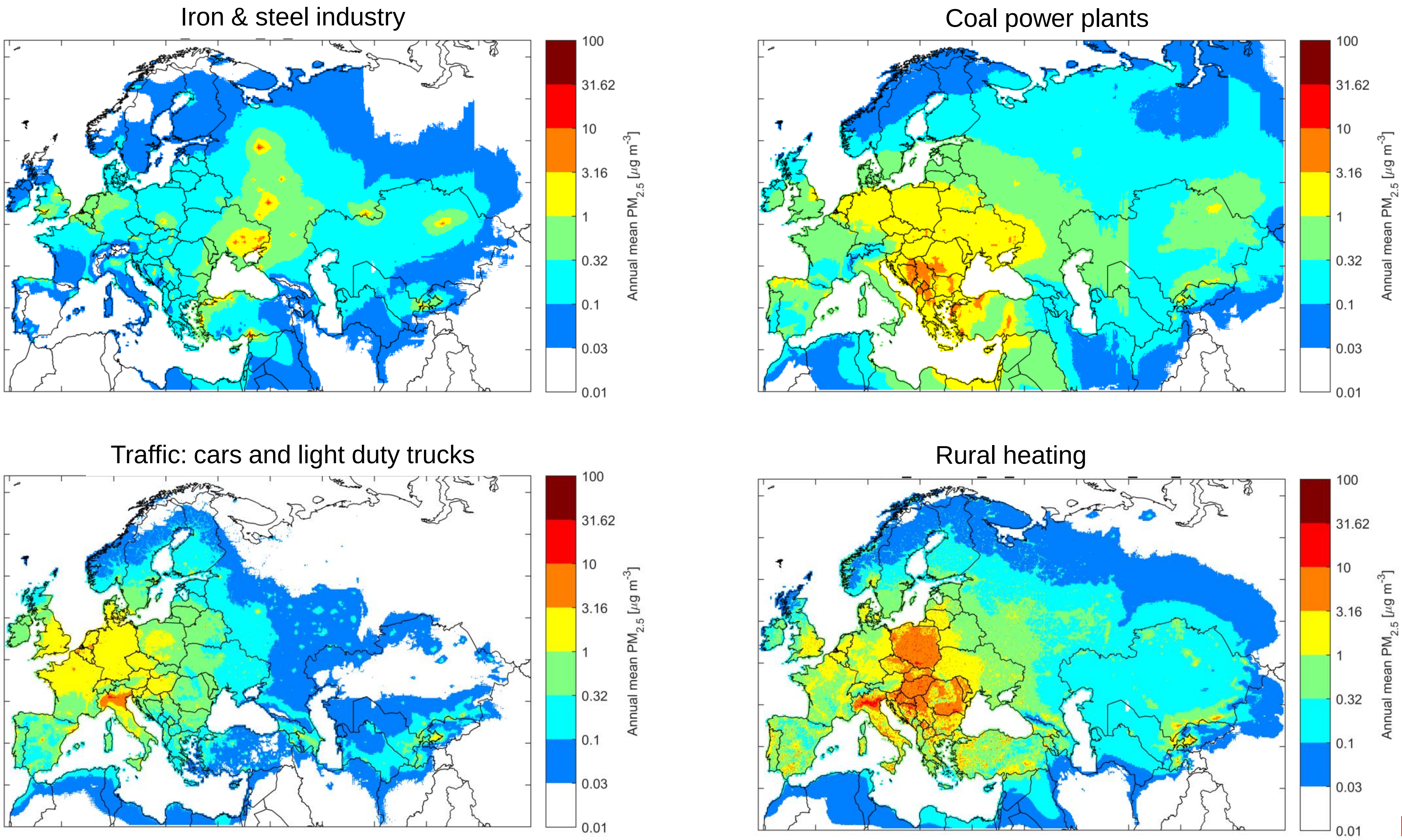


- Important role of power/heating plants
- Also residential sector

Availability of district heating needs to be checked! (both at national and city level)

Preliminary results!

Ambient $PM_{2.5}$: Contributions from sectors (2015)



Done for ~40 sectors.

Preliminary results!

Combination: Sector specific transfer coefficients

- GAINS transfer coefficients for secondary aerosols: linear approximation of EMEP CTM

  From source regions r, source pollutant p, to PM2.5 in receptor grid cell i:

$$T_{r,p,i} = \frac{[PM_{2.5}]_{i,base} - [PM_{2.5}]_{i,red}}{0.15 \cdot Emis_{r,p}}$$

- Grid to grid tracking ("local fraction") of PPM with EMEP CTM at 0.1^0, monthly results

  => sectoral transfer coefficients for PPM:

$$T_{r,s,i} = \frac{1}{12} \cdot \sum_{t=1}^{12} \sum_{j} D(r,s,l(s),j) \cdot \tau(s,j,t) \cdot G(j,i,l,t)$$

r... source region, s... source sector, i... receptor grid cell (0.1^0), j... emission grid cell (0.1^0), l...vertical emission layer, t...month

$D(r,s,l,j)$ ... spatial emission distribution pattern

$\tau(s,j,t)$ ... temporal (monthly) emission share

$G(j,i,l,t)$... grid-to-grid transfer coefficient from j to i in month t for emission layer l

- So that $[\mathrm{PM}_{2.5}]_{i,scen} = \delta_i + \sum_s \sum_r \sum_p Emis_{r,s,p,scen} \cdot T_{r,p,s,i}$

  (applying relative sectoral contributions also to SO_2 and NOx transfer coefficients)