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Linking local to global scales in modelled $PM_{2.5}$ source apportionment in GAINS

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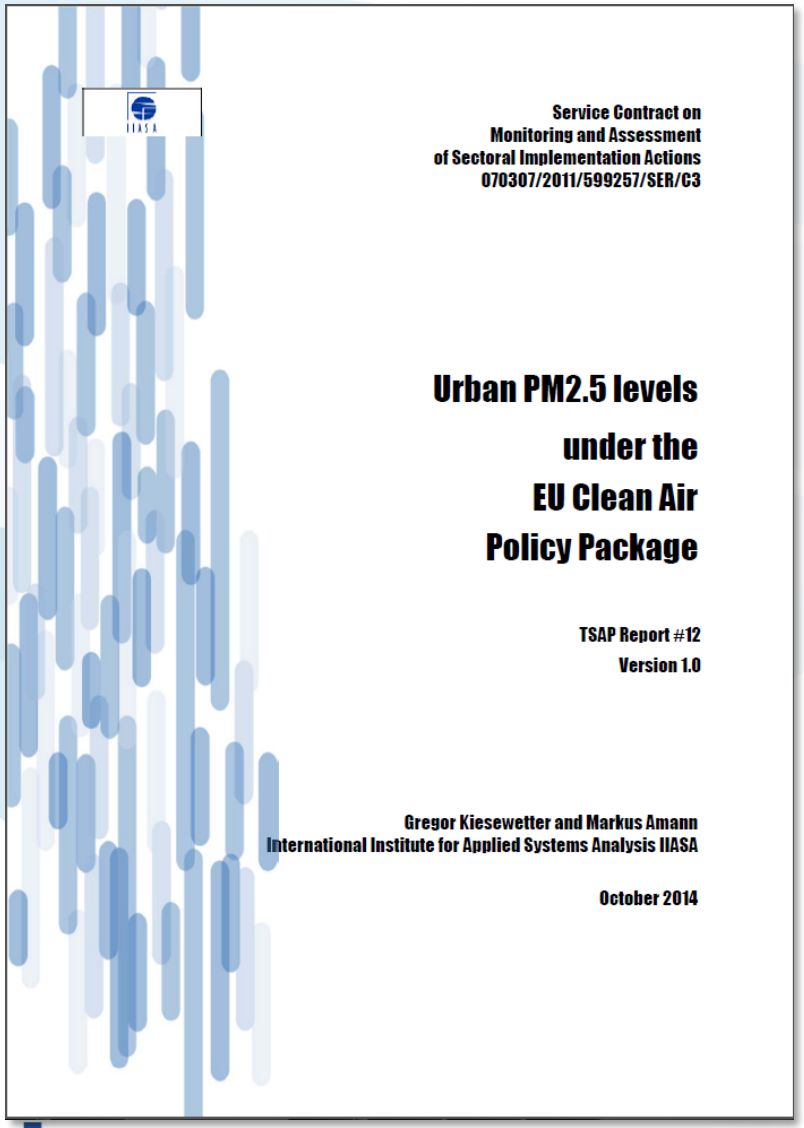
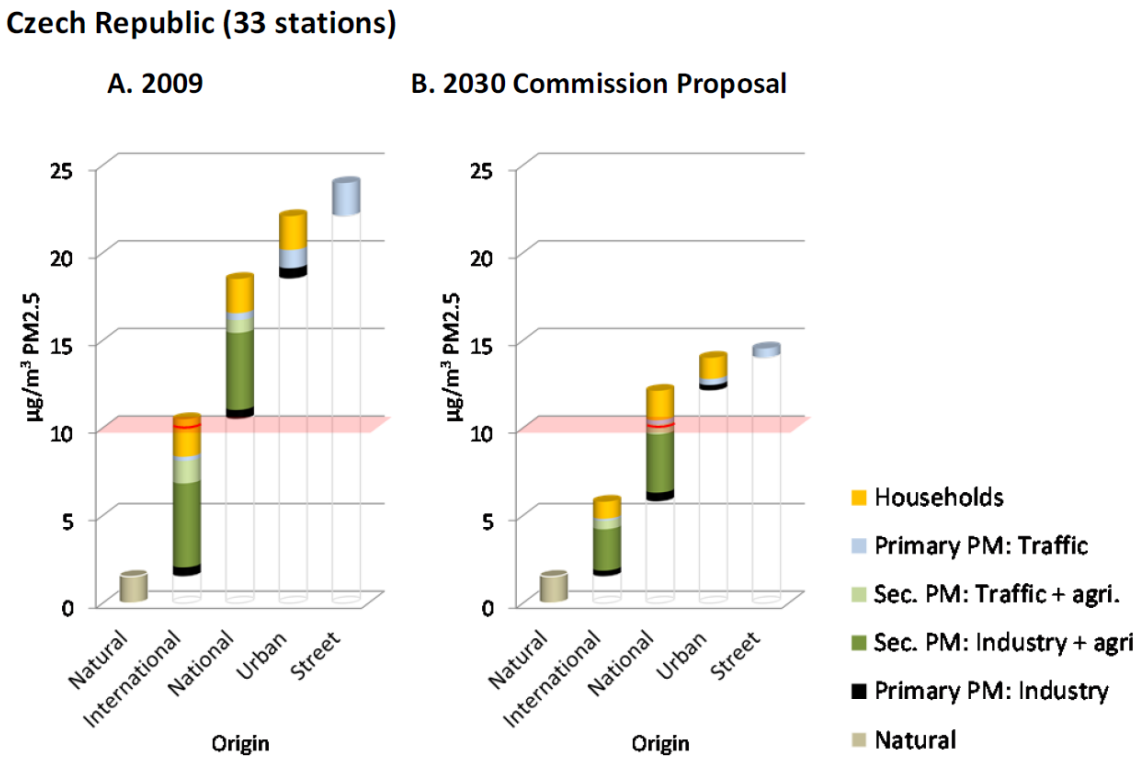
Source apportionment in GAINS-Europe



- Fusion approach combining model and observations, mainly following the Lenschow approach
- Source attribution covers ~1900 AirBase stations
- Data heavy – not feasible in other world regions



GAINS model global extension

- Emission calculations have been global: currently 170 regions
- Recent development: atmospheric transfer calculations extended to global domain
- European calculations unchanged: EMEP 0.25°x0.5° + “7km” downscaling based on CHIMERE
- Resolution outside Europe: 0.5º + downscaling 0.1°
- Methodology: Perturbation simulations (brute-force) with EMEP global CTM
- EMEP model simulations:
  - Base case simulation 0.5º
  - 15% reduction for each precursor pollutant of $PM_{2.5}$ and source region 0.5º
  - 15% reduction run for low-level emissions of PPM for each source region, to take account of the different dispersion behavior of near ground PPM sources
  - Base case simulation 0.1º with refined residential emission gridding pattern
  - Urban 30% reduction simulation (all pollutants) 0.1º with refined residential emission gridding pattern

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⇒ Source-receptor coefficients for ambient $PM_{2.5}$ from:

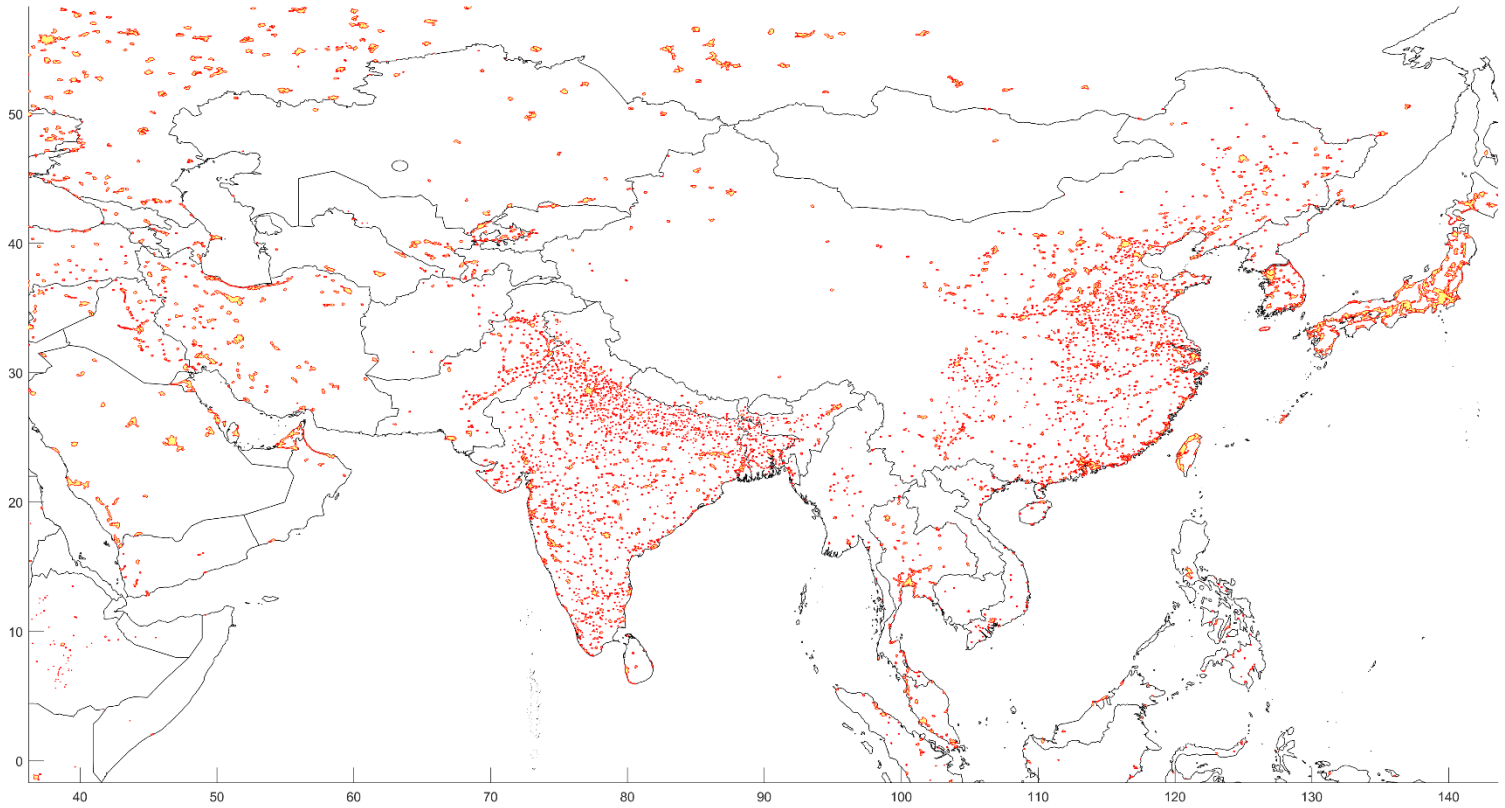
$PPM_{2.5}$ urban low-level / rural low-level / other
SO_2 urban low-level / other
NO_x urban low-level / other
NH_3
NMVOC

From each GAINS region to 0.1° / 0.5° grid

Emission re-gridding

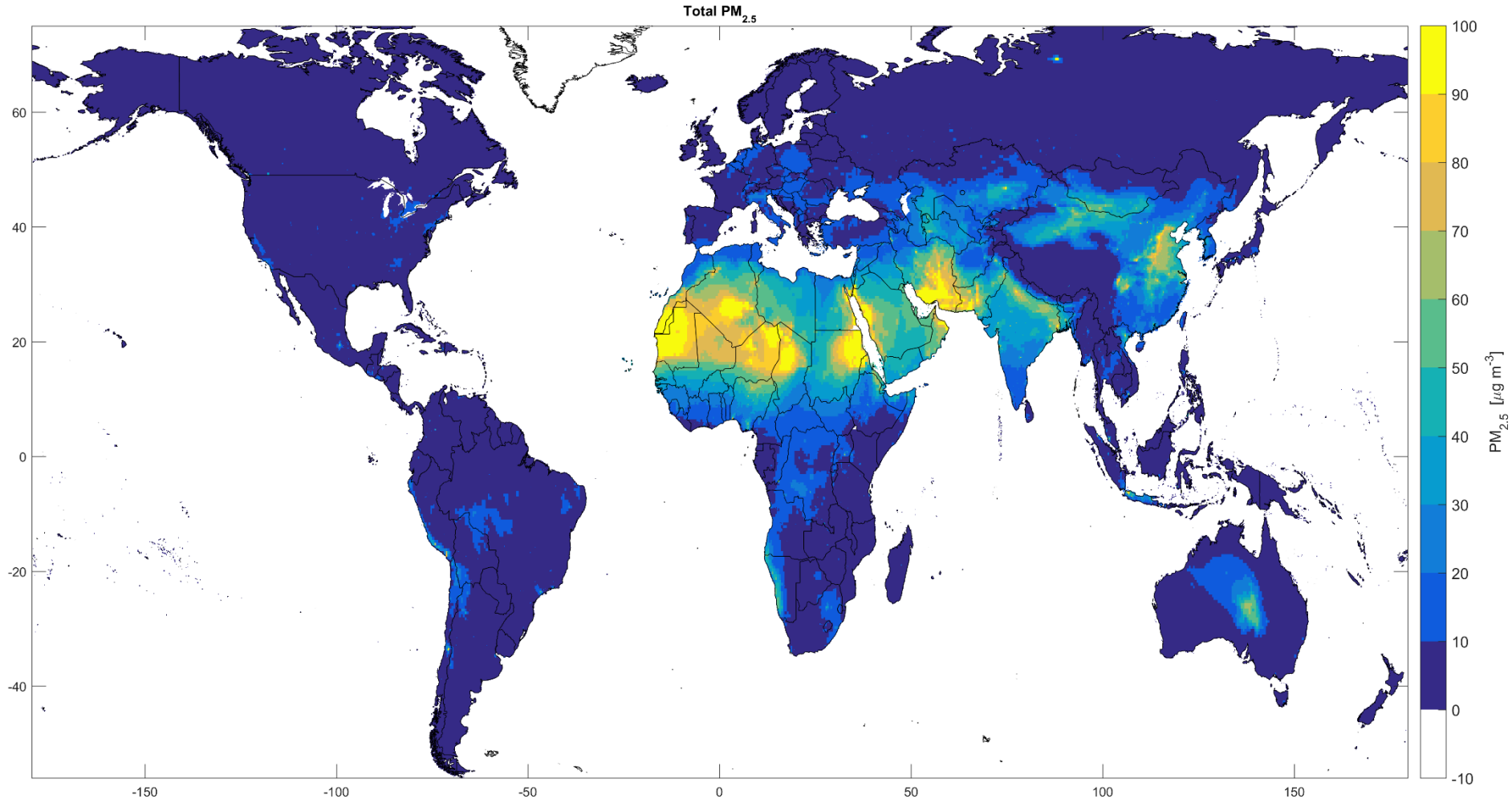
- Global gridded emissions from GAINS usually at 0.5° resolution
- For finer resolution modelling, gridded emissions are needed at higher resolution, which are not necessarily available everywhere
- Mainly of interest for higher resolution: low-level emissions (residential combustion, traffic, waste burning)
- Fine scale proxy available globally: high-resolution population (JRC 250m, worldpop 100m)
- Access to clean residential fuels differs strongly between urban and rural areas: Information on urban/rural residential fuel use from WHO household database
- Identification of urban areas >100,000 inhabitants: GRUMP dataset $\Rightarrow$ ~5,000 cities
- Re-gridded residential emissions at 0.1° with urban-rural distinction
- Allows for the generation of dedicated urban low-level source-receptor coefficients (PPM, NO_x, SO_2)

Global cities > 100.000 inhabitants

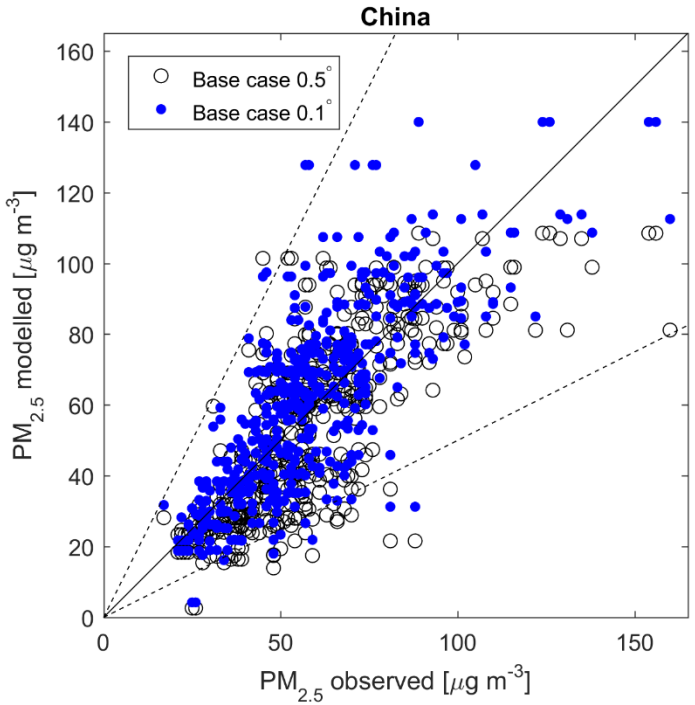


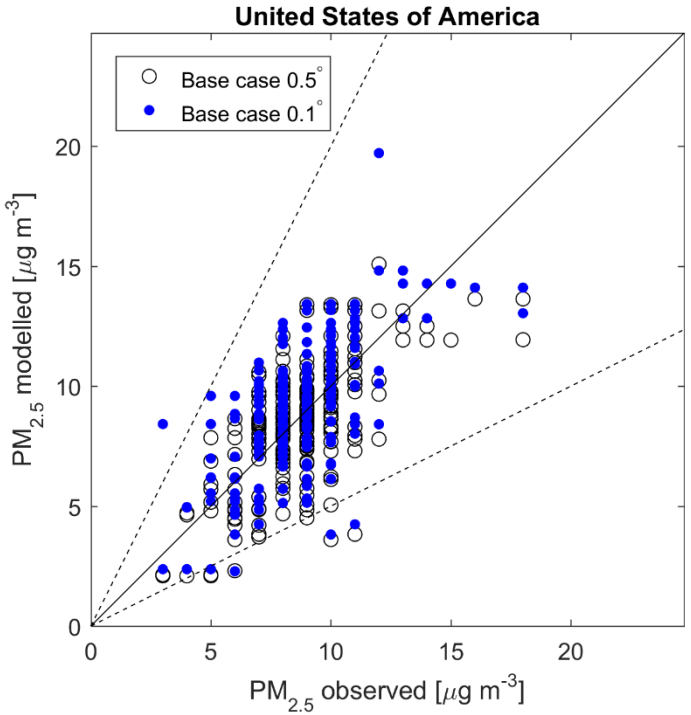
Total base case PM2.5 (0.1° resolution)

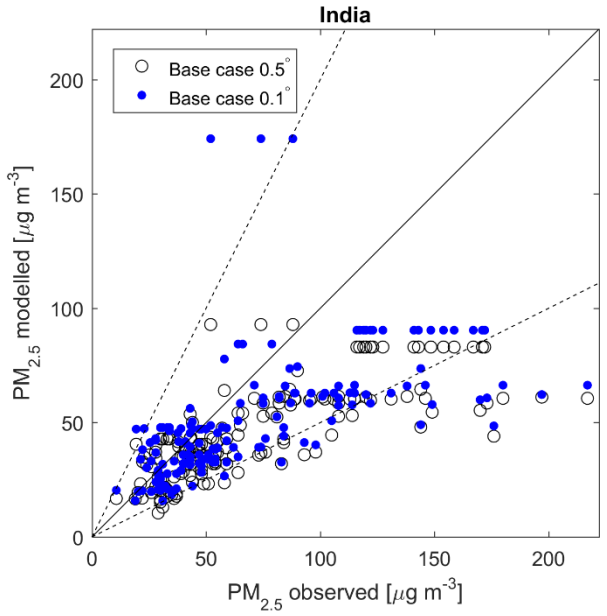
Annual mean, 2015 emissions & meteorology

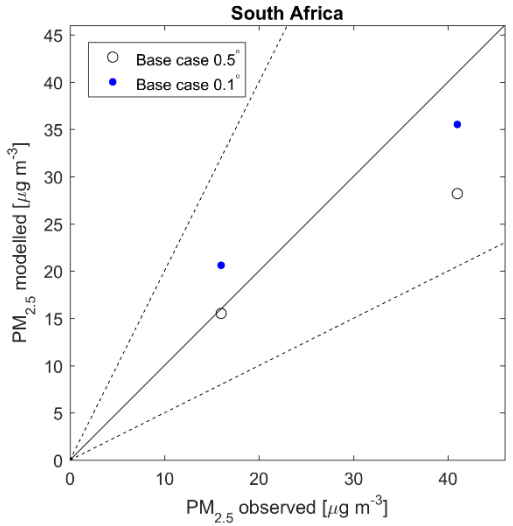


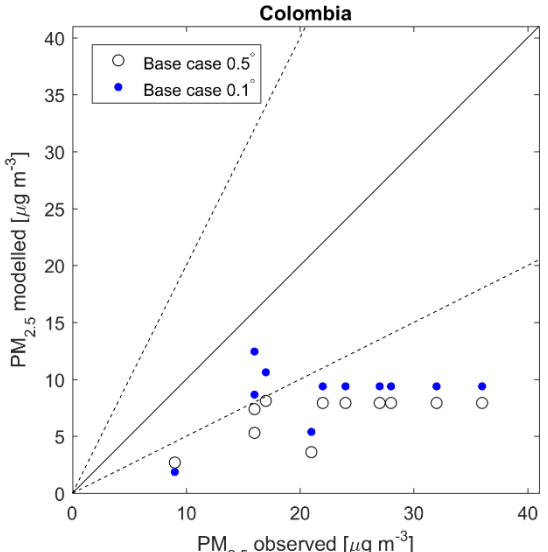
Validation (not really)

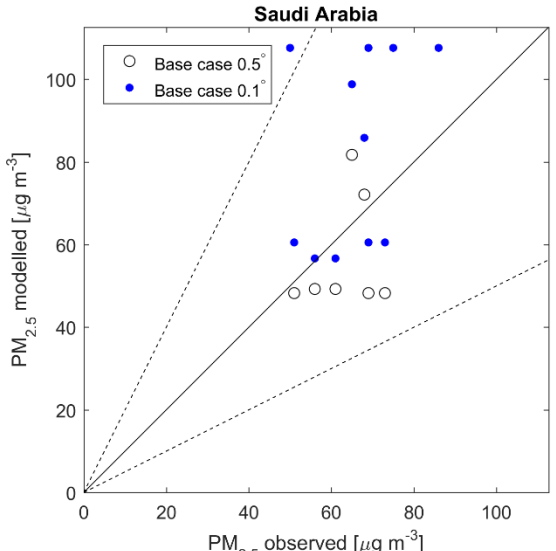




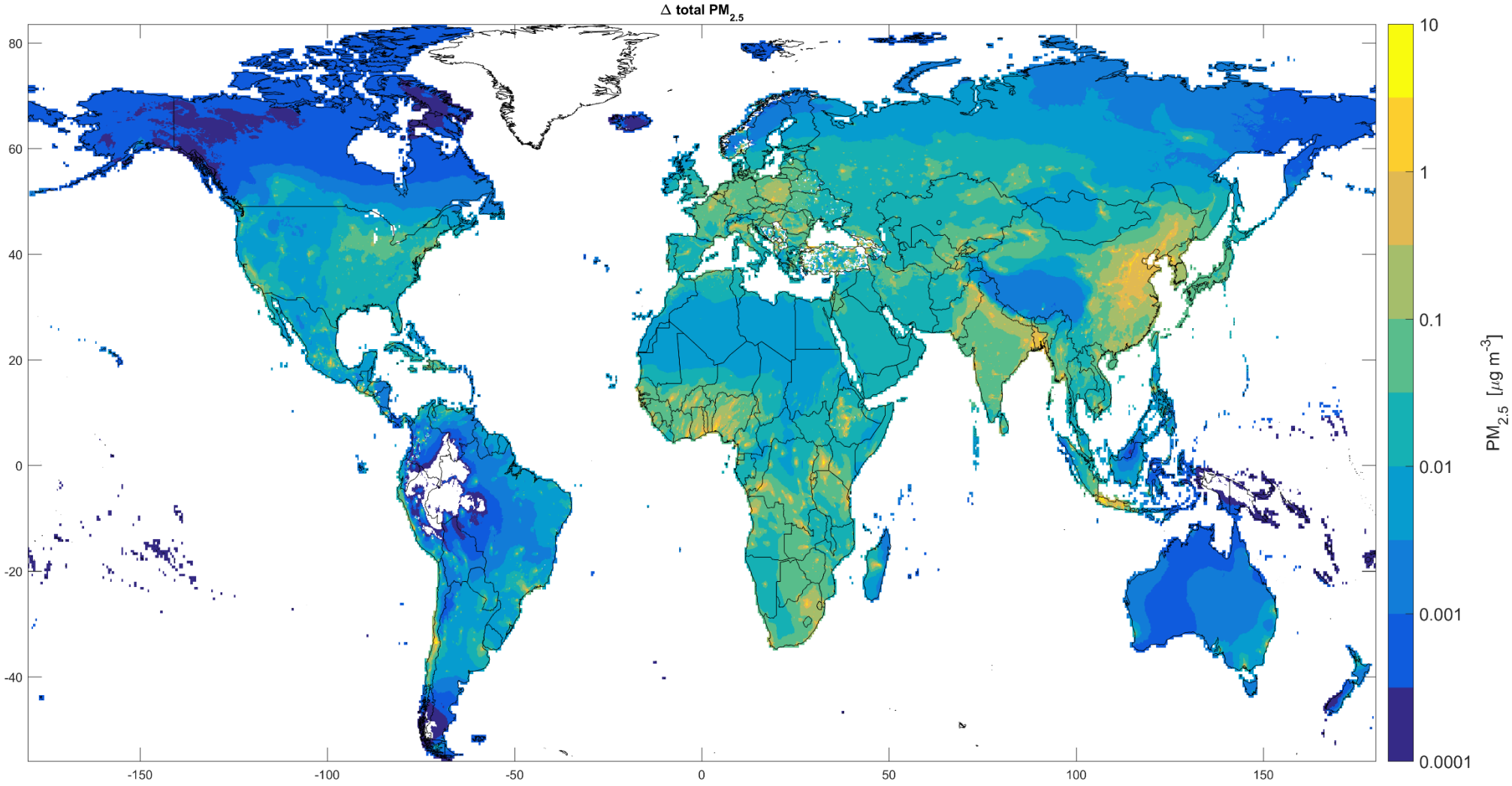




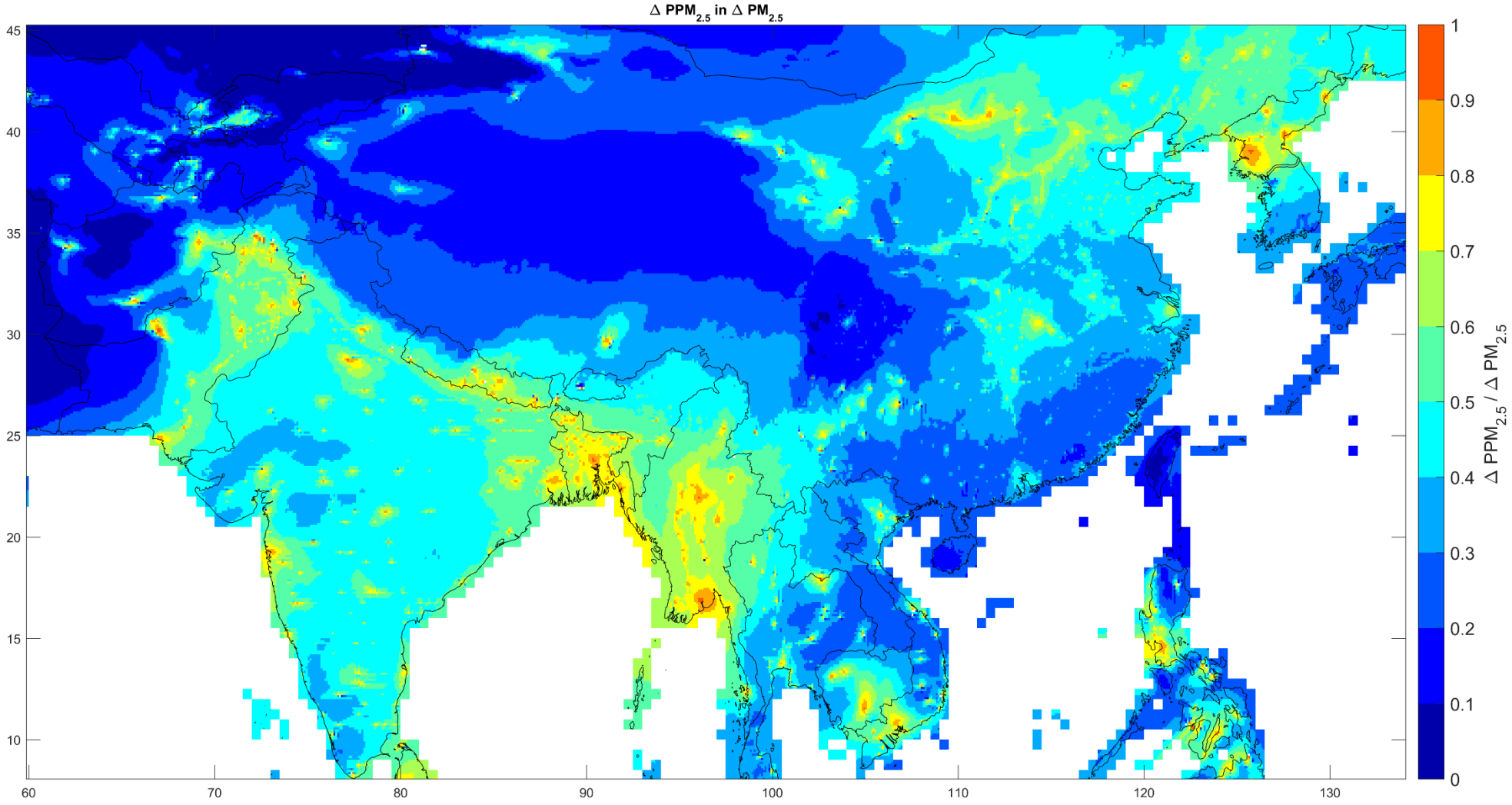




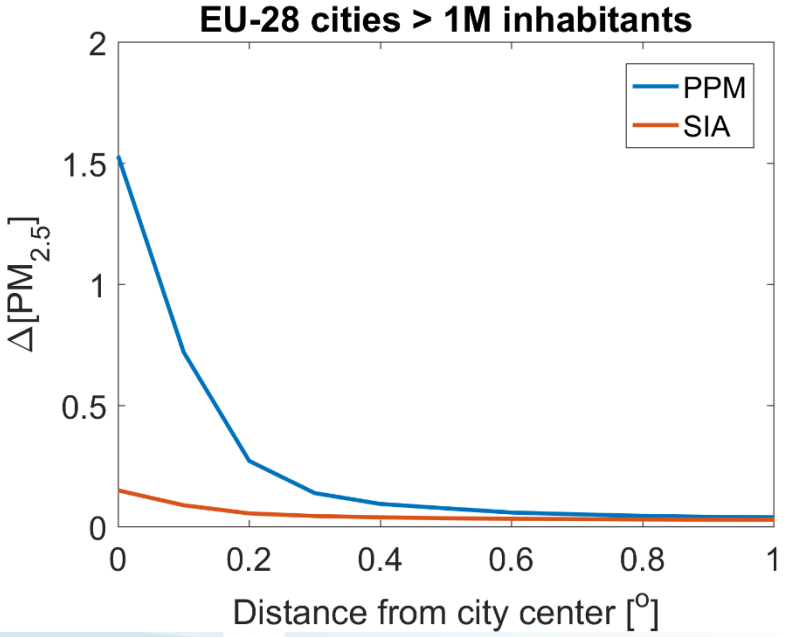
Delta from urban 30% reduction

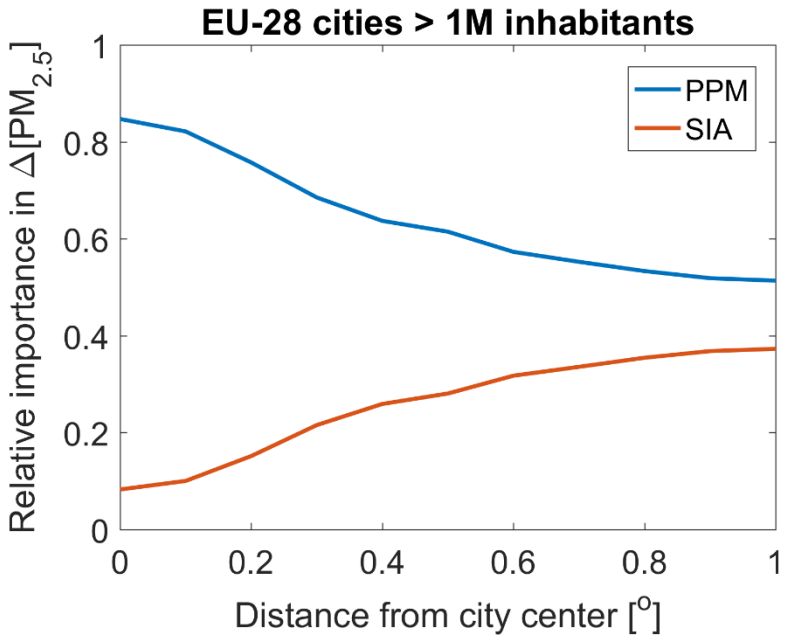


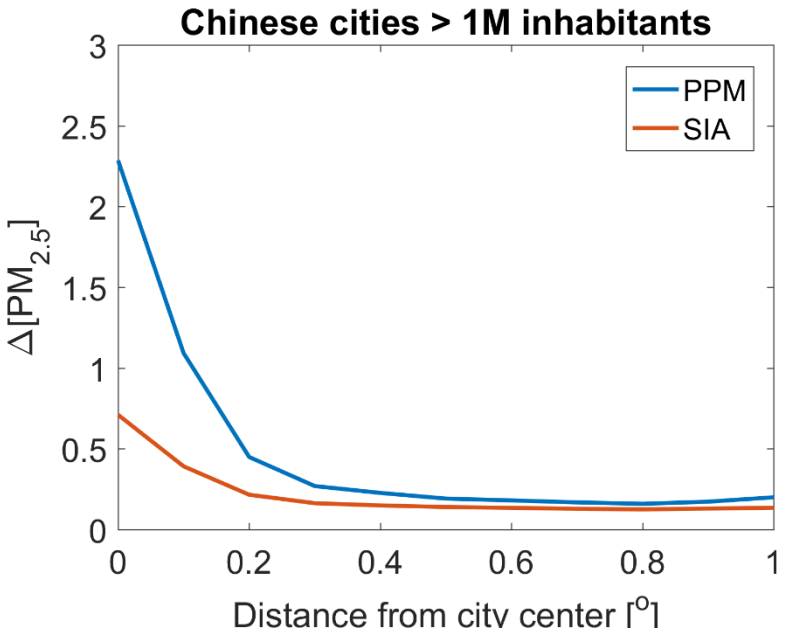
Delta from urban 30% reduction: PPM share

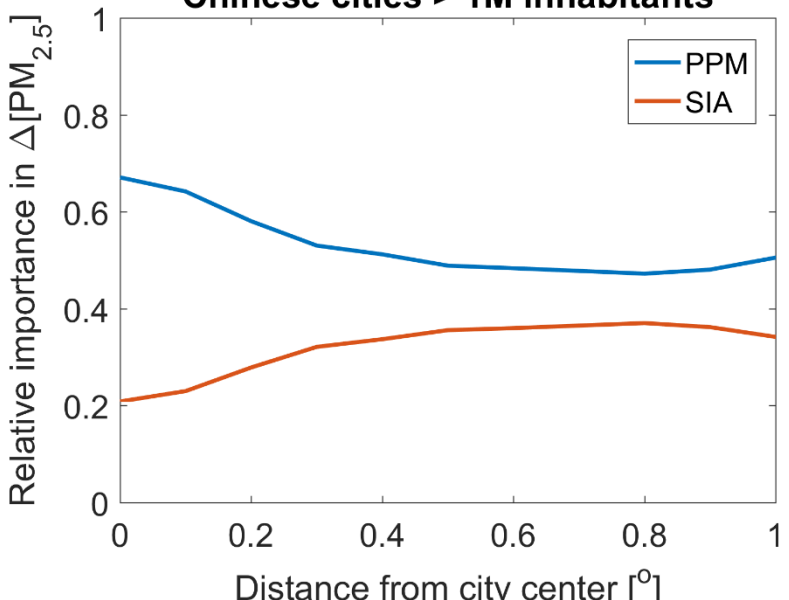


Delta from urban 30% reduction: PPM vs SIA

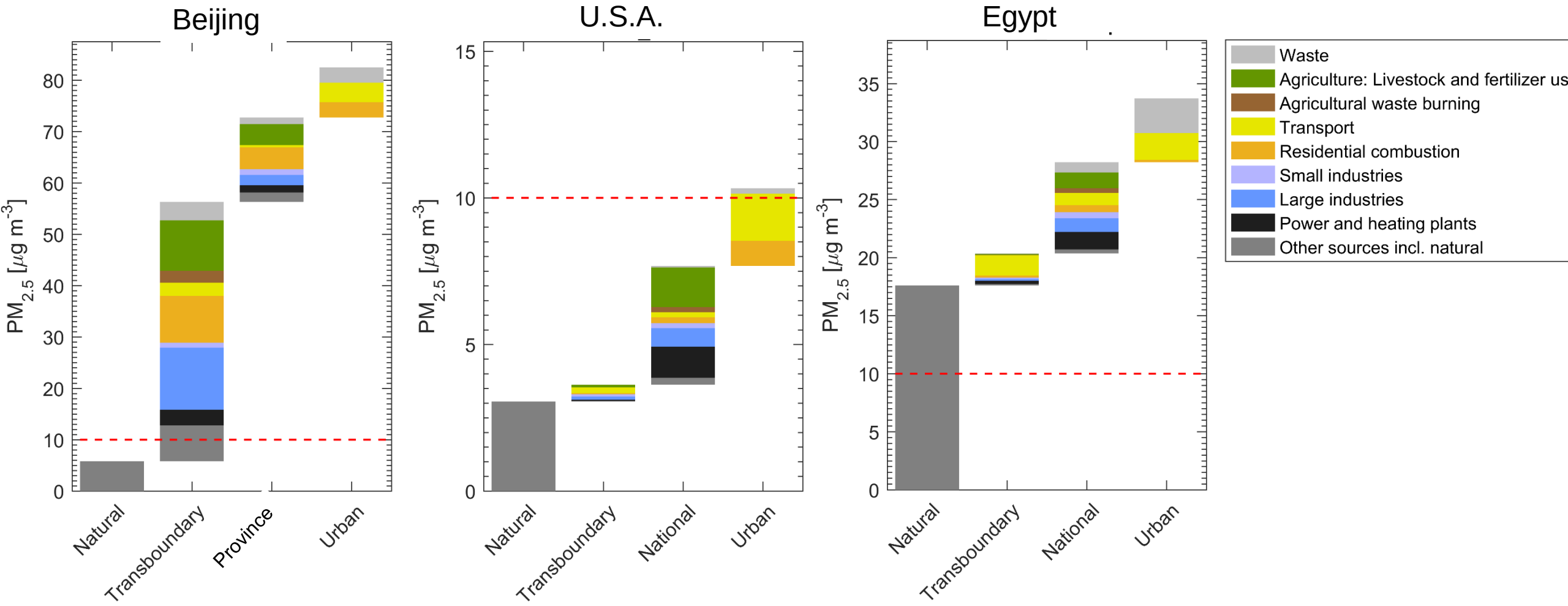








Source apportionment for cities (preliminary!)



All cities within the respective GAINS region (province/country) averaged

Emissions: 2015 – latest GAINS global scenario (Eclipse v6a, March 2019)

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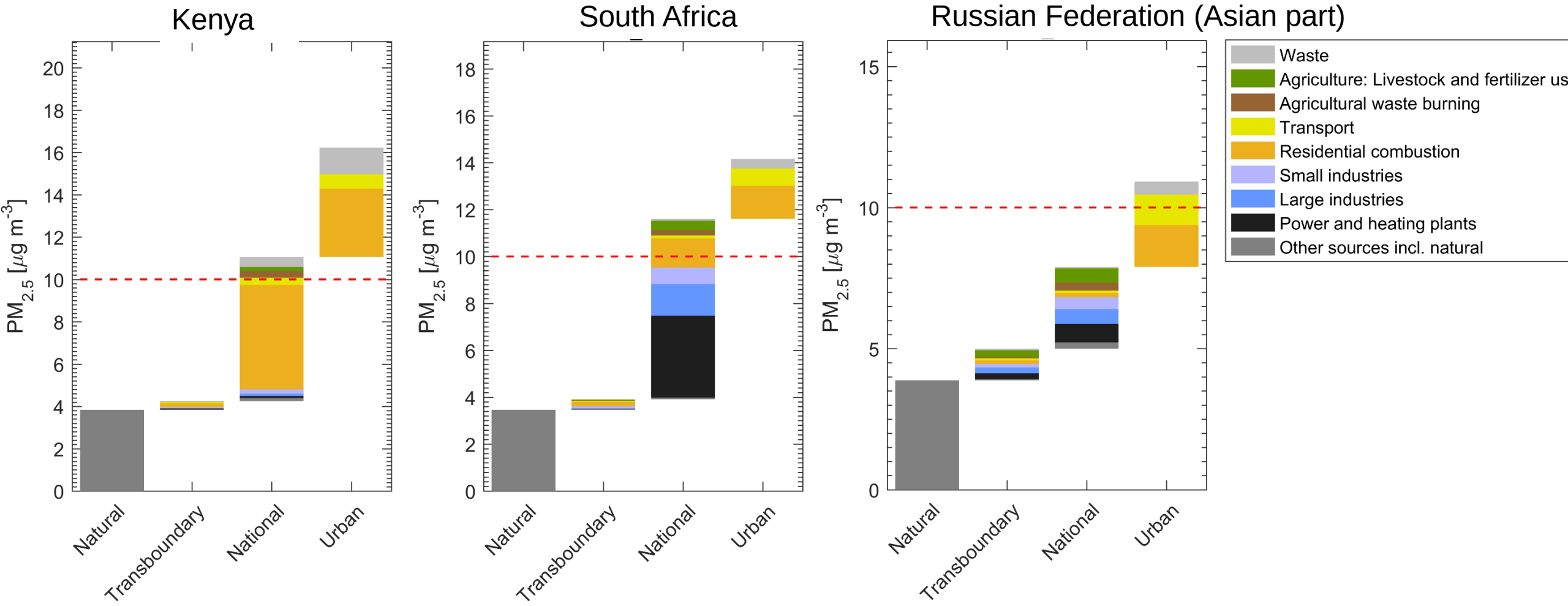

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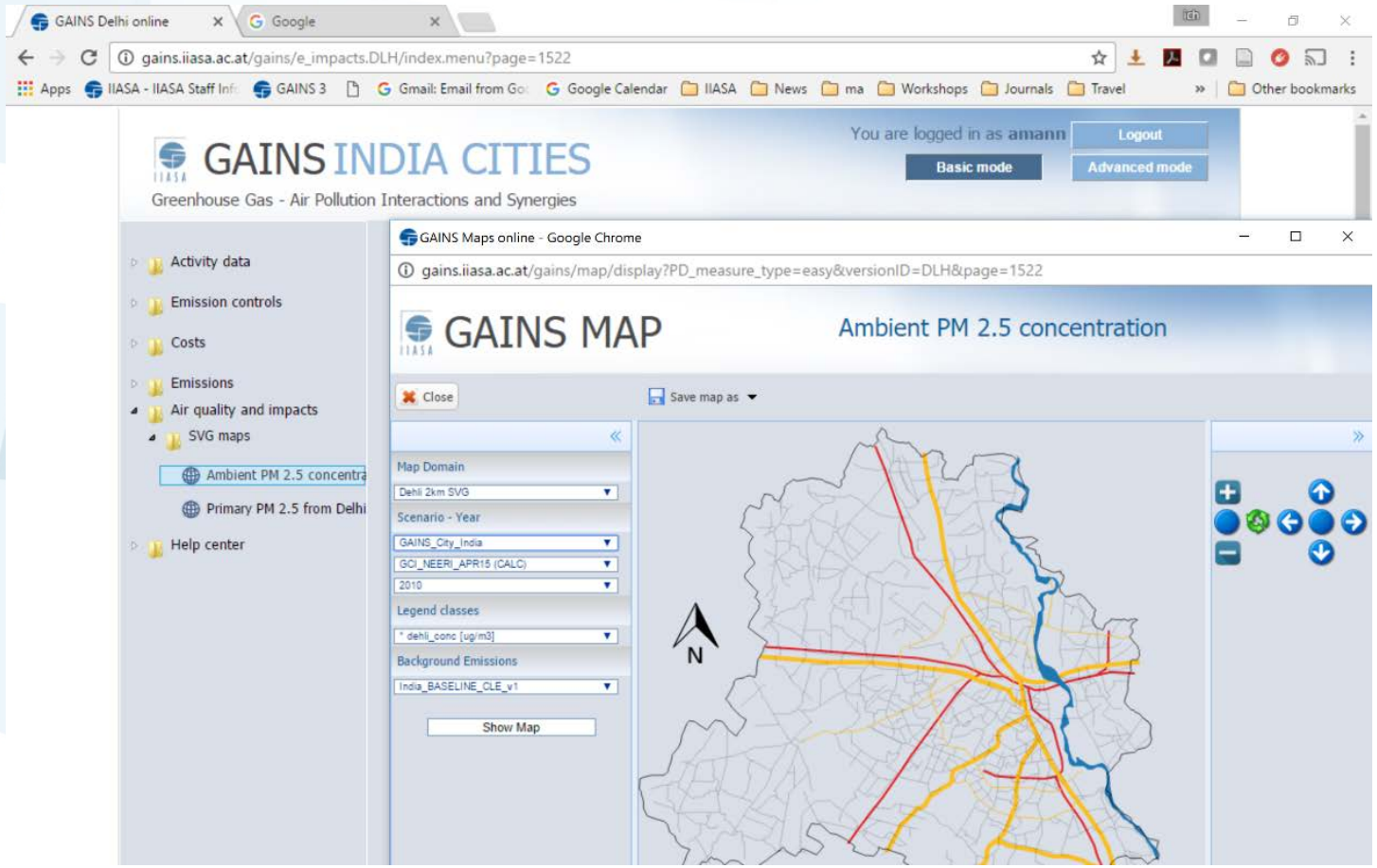
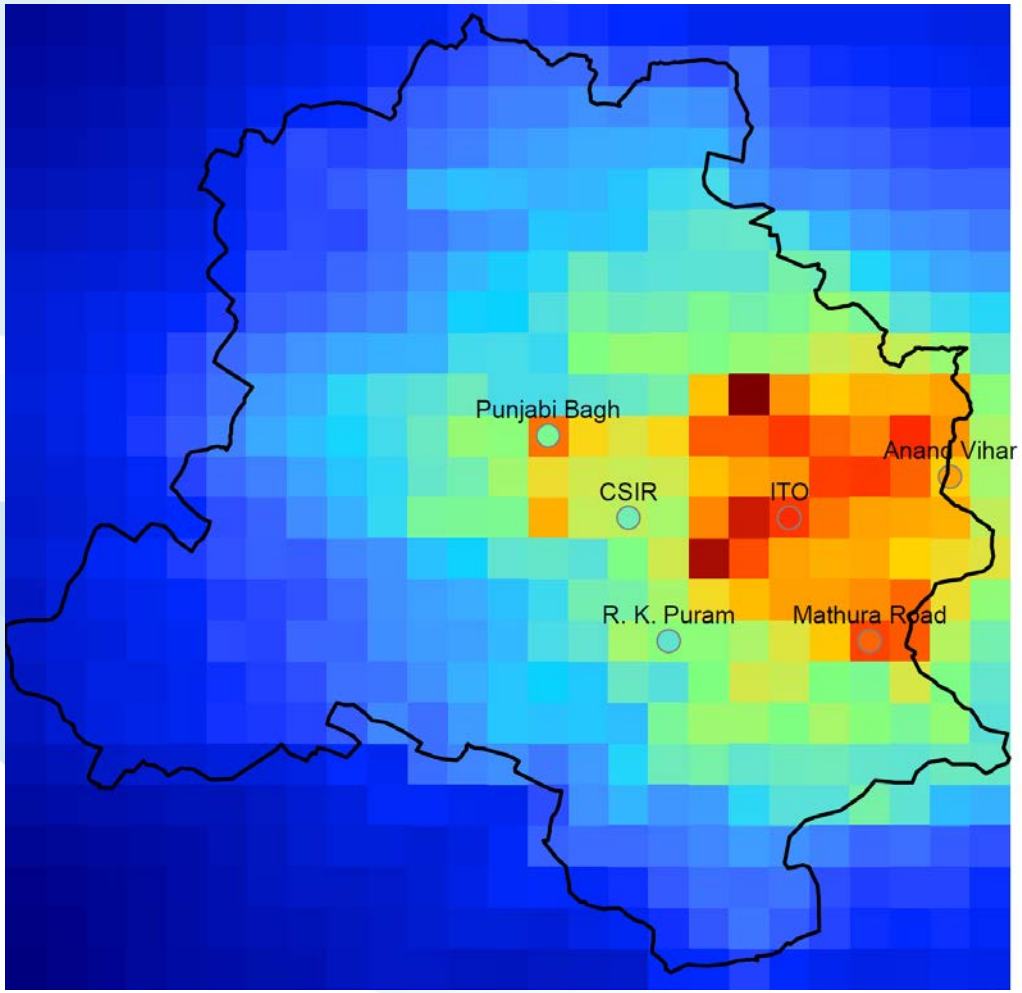
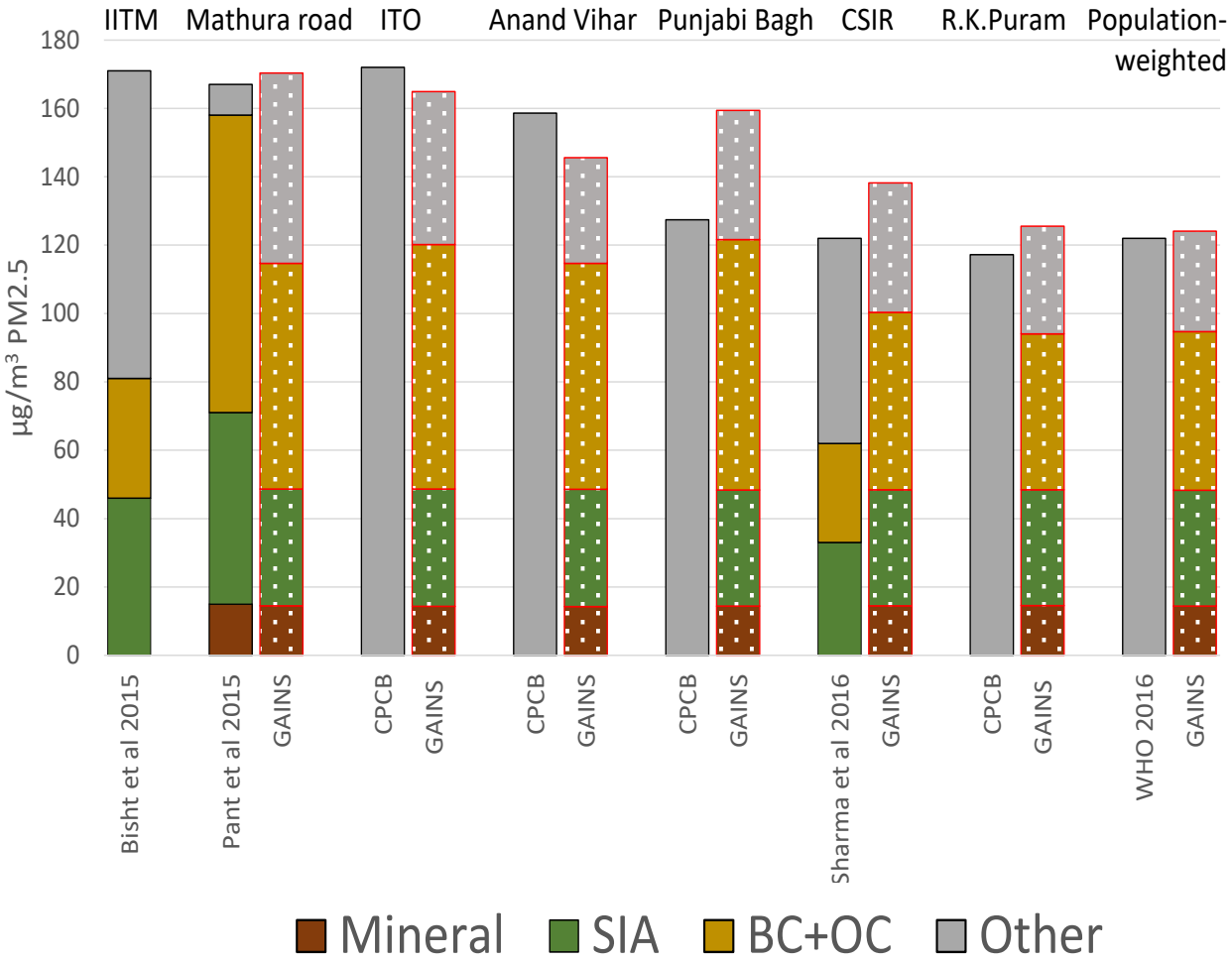
From global to local II: High-resolution model for Delhi

- Study for Delhi with local partners
- Local high-resolution sectoral transfer coefficients for PPM: AERMOD dispersion model
- Fully functioning “classical” GAINS model for Delhi:



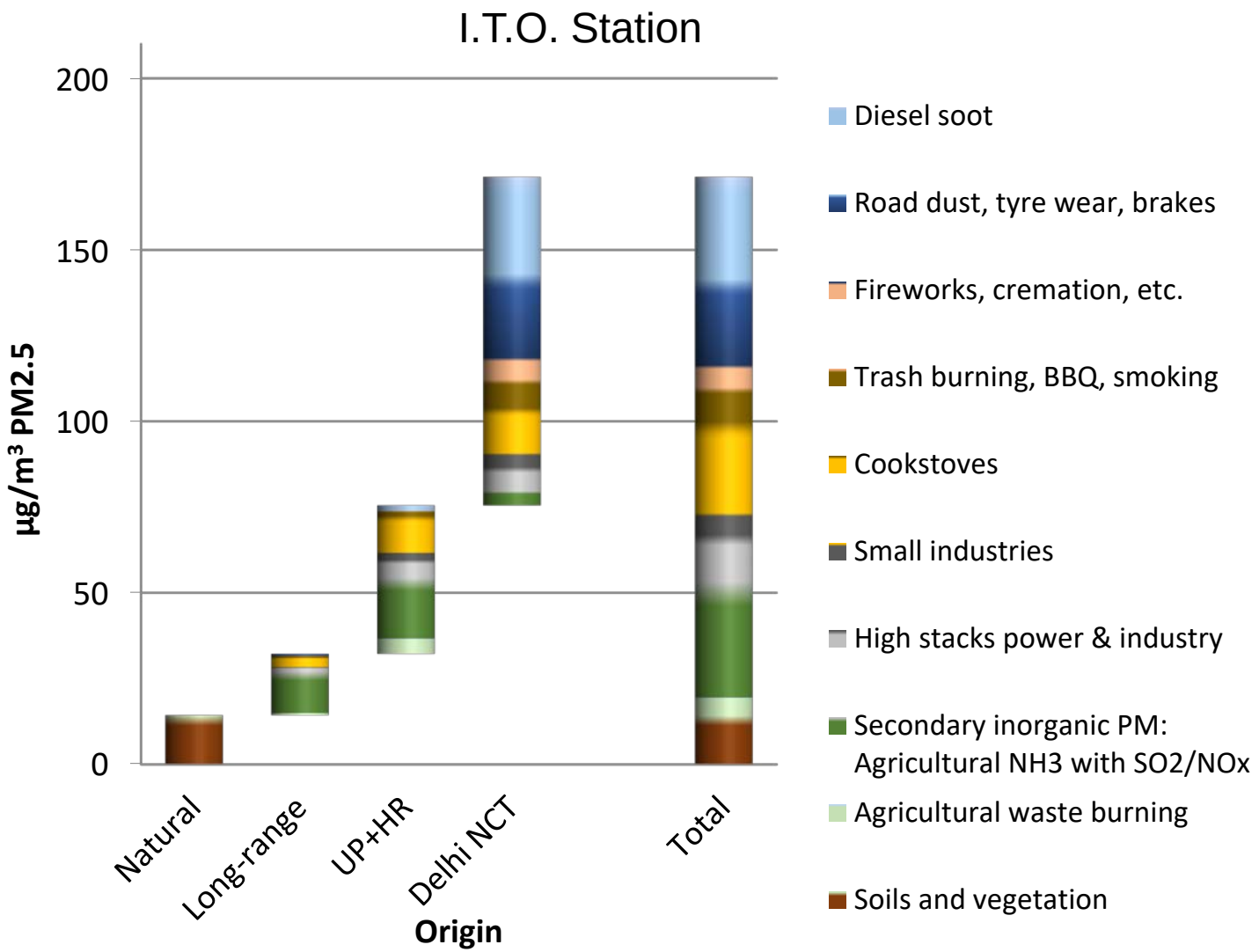
Validation of the dispersion calculations for Delhi 2015

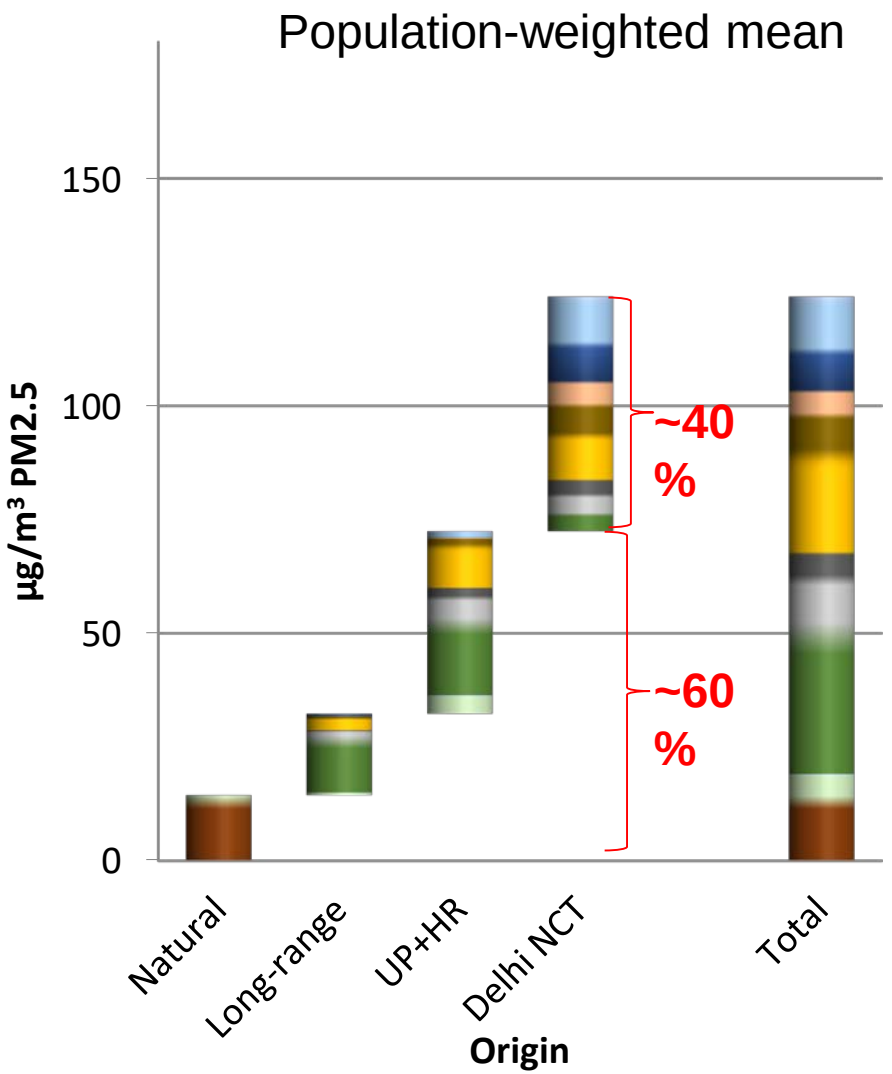




Amann et al., Atmos Environ (2017)

Source apportionment of $PM_{2.5}$ in Delhi 2015





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Global to local III: Integrated city tool for Hanoi

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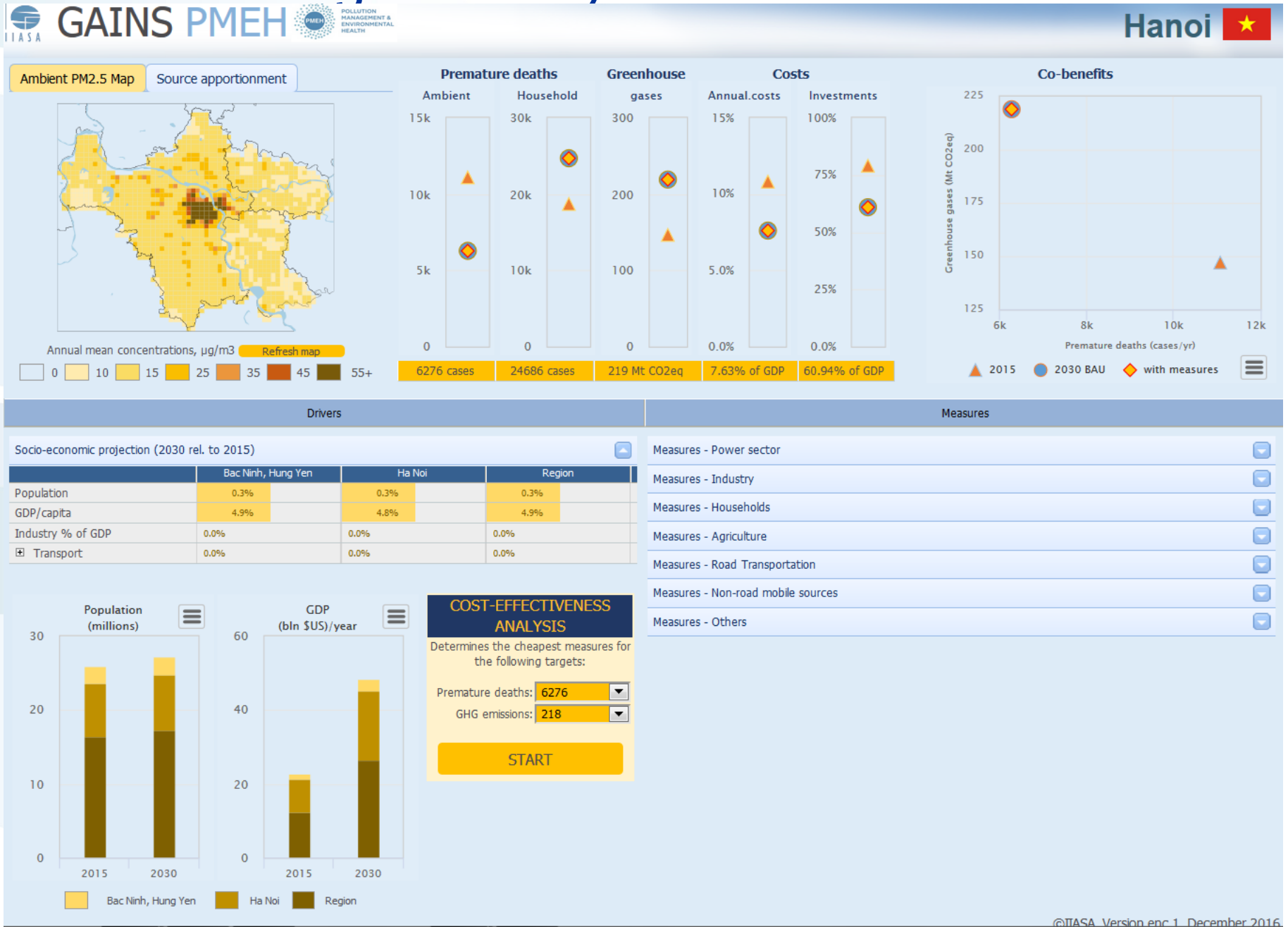
Under development!



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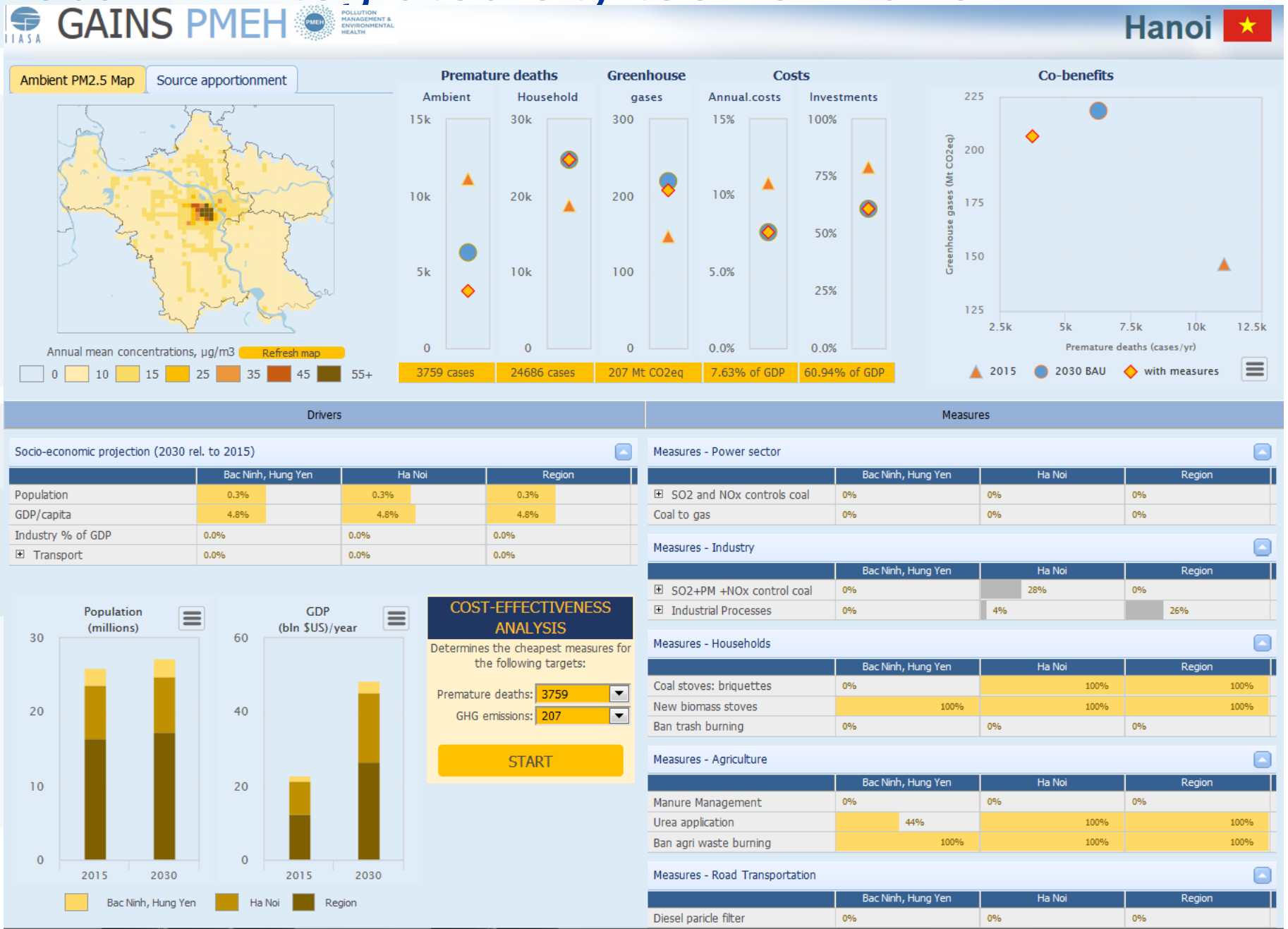

Conclusions

- GAINS atmospheric calculations outside Europe: 0.5° + urban downscaling
- Global base case & urban reduction simulation at 0.1° for splitting source-receptor coefficients into urban and rural origin for low-level sources
- Allows for generic source attribution for >4,700 cities (Preliminary!)
  - Contribution from PPM to urban increment dominant
  - Urban low-level emissions account for less than1/3 of total $PM_{2.5}$
  - Local contribution does not seem dominant in most cities.
  - Not enough local information & resolution to model individual cities!

- For policy analysis in individual cities, higher resolution is needed
- Examples:
  - full GAINS version for Delhi
  - Hanoi integrated front-end tool

} Big endavours (2 years+)!