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Applied Systems Analysis
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science for global insight

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

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Air Quality and Greenhouse Gases Program

IIASA

Laxenburg, Austria


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IIASA, International Institute for Applied Systems Analysis

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


**Service Contract on
Monitoring and Assessment
of Sectoral Implementation Actions
070307/2011/599257/SER/G3**

**Urban PM_{2.5} levels
under the
EU Clean Air
Policy Package**

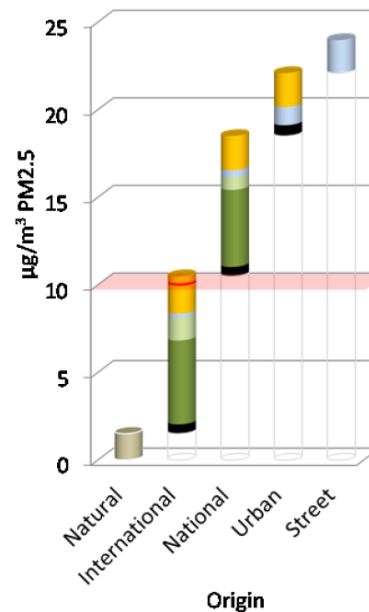
**TSAP Report #12
Version 1.0**

**Gregor Kiesewetter and Markus Amann
International Institute for Applied Systems Analysis IIASA**

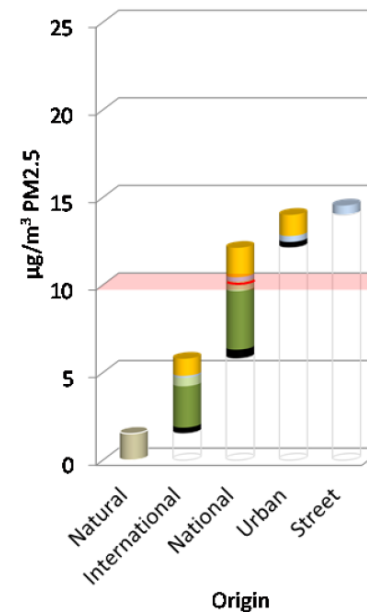
October 2014

Czech Republic (33 stations)

A. 2009



B. 2030 Commission Proposal



- Households
- Primary PM: Traffic
- Sec. PM: Traffic + agri.
- Sec. PM: Industry + agri
- Primary PM: Industry
- Natural

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 $0.25^\circ \times 0.5^\circ$ + “7km” downscaling based on CHIMERE
- Resolution outside Europe: 0.5° + downscaling 0.1°
- Methodology: Perturbation simulations (brute-force) with EMEP global CTM
- EMEP model simulations:
 - Base case simulation 0.5°
 - 15% reduction for each precursor pollutant of $PM_{2.5}$ and source region 0.5°
 - 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 0.1° with refined residential emission gridding pattern
 - Urban 30% reduction simulation (all pollutants) 0.1° with refined residential emission gridding pattern

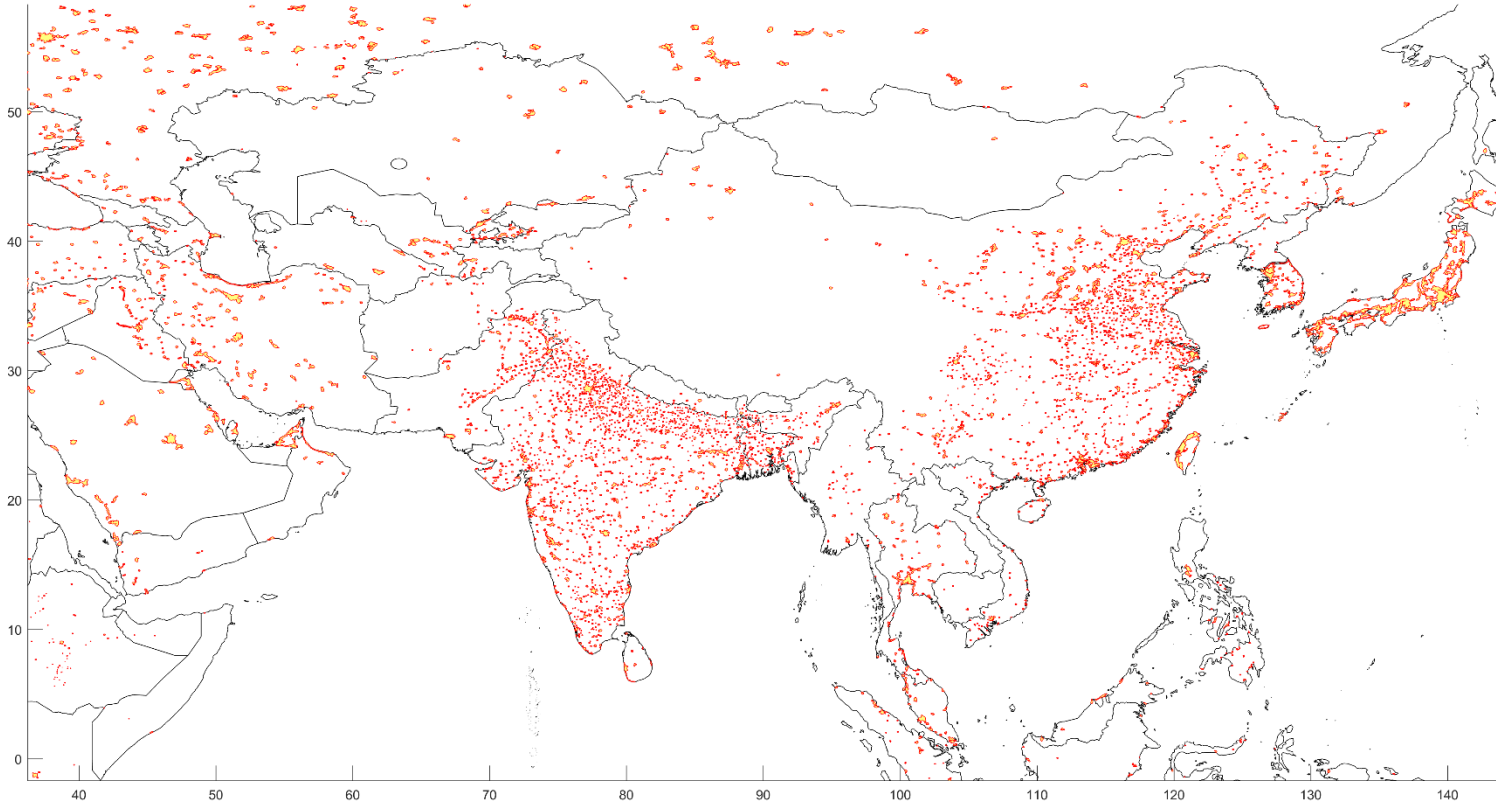
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- Methodology: Perturbation simulations (brute-force) with EMEP global CTM
- EMEP model simulations:
 - Base case simulation ⇒ Source-receptor coefficients for ambient $PM_{2.5}$ from:
 - 15% reduction in residential emission PPM_{2.5} urban low-level / rural low-level / other region 0.5°
 - 15% reduction in residential emission SO₂ urban low-level / other region, to take account of the sources
 - Base case simulation NH₃ gridding pattern
 - Urban 30% reduction in residential emission NMVOC gridding pattern
 - From each GAINS region to $0.1^\circ / 0.5^\circ$ grid residential emission

Emission re-gridding

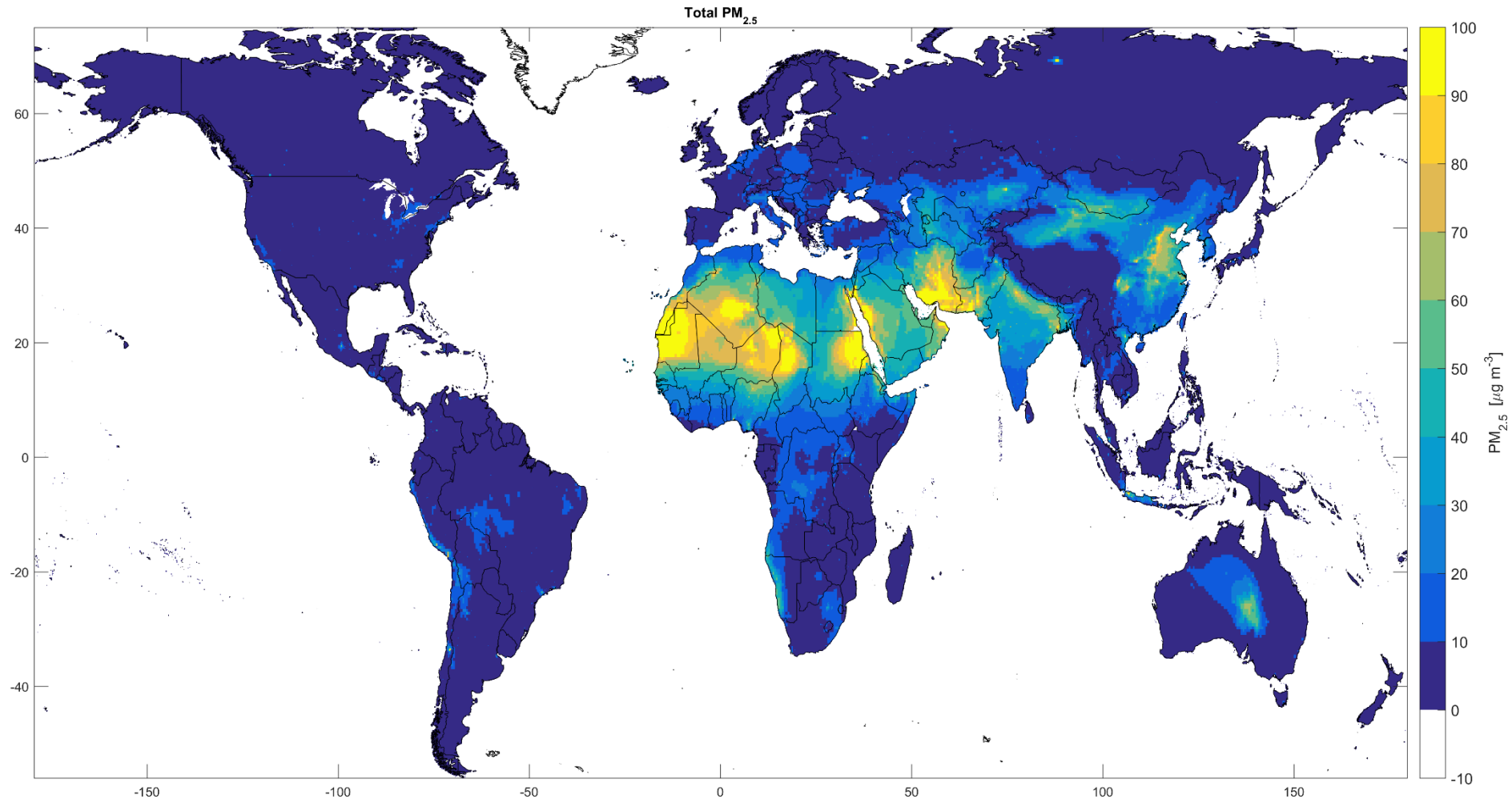
- Global gridded emissions from GAINS usually at 0.5° resolution
- For finer resolution modelling, gridded emissions are needed at higher resolution, which are not necessarily available everywhere
- Mainly of interest for higher resolution: low-level emissions (residential combustion, traffic, waste 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 $\sim 5,000$ 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

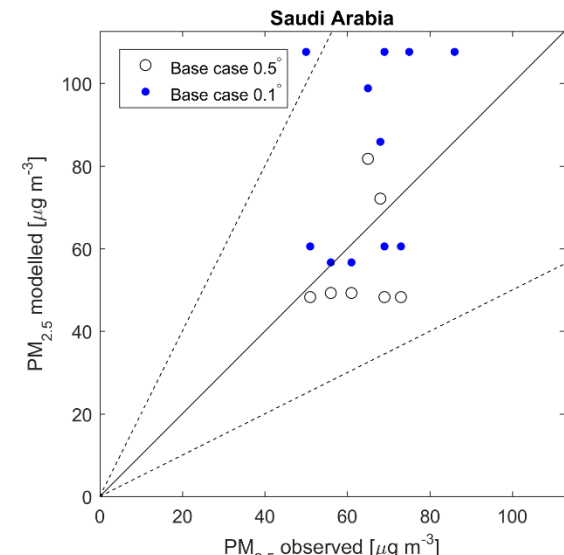
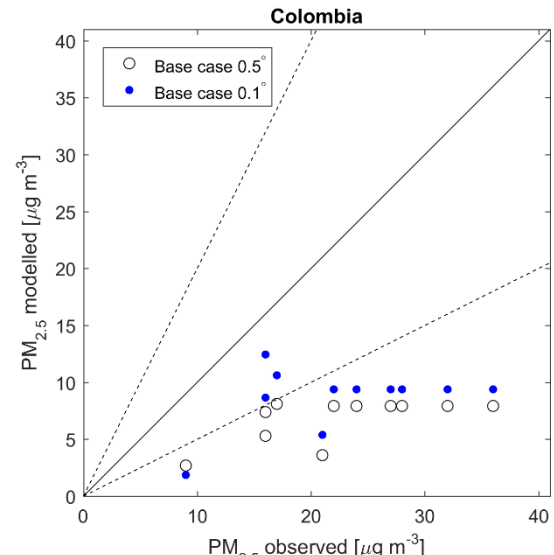
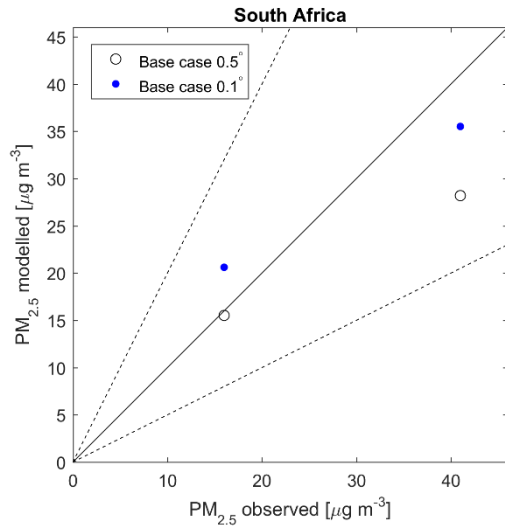
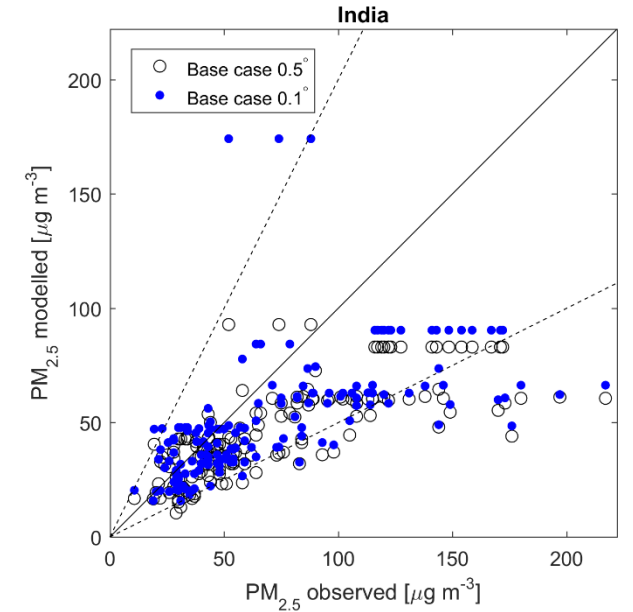
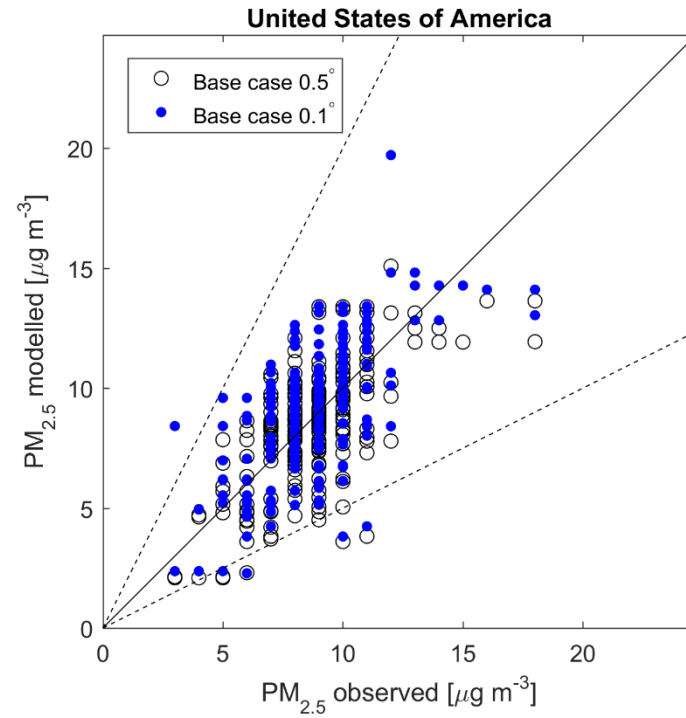
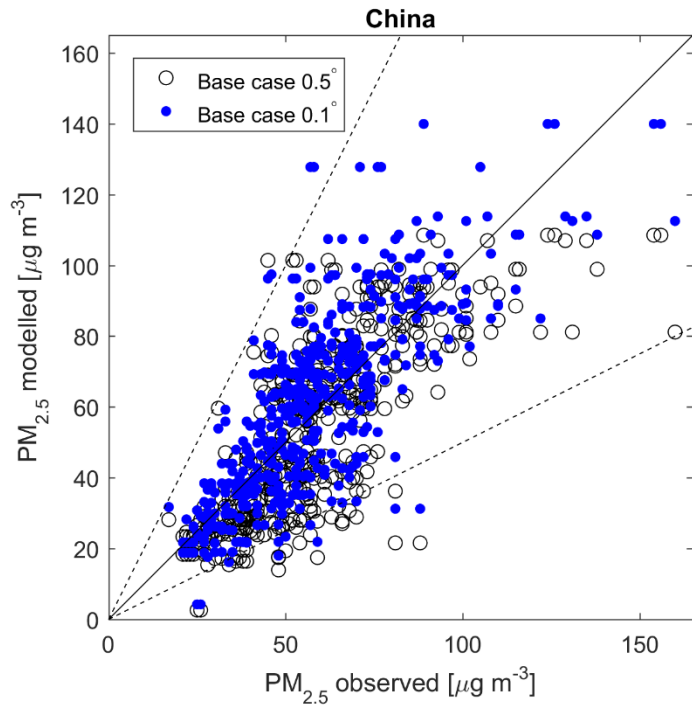


Total base case PM_{2.5} (0.1° resolution)

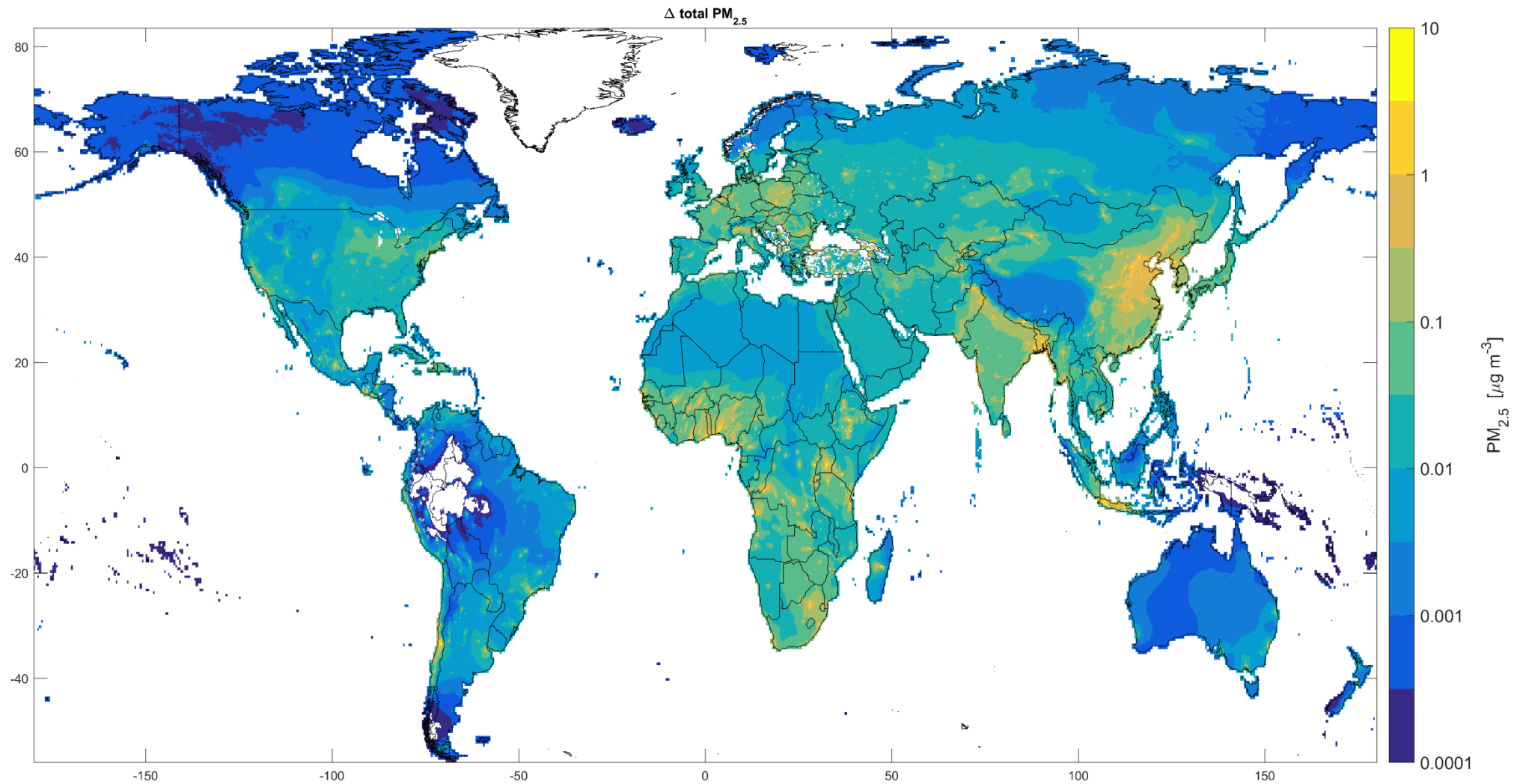
Annual mean, 2015 emissions & meteorology



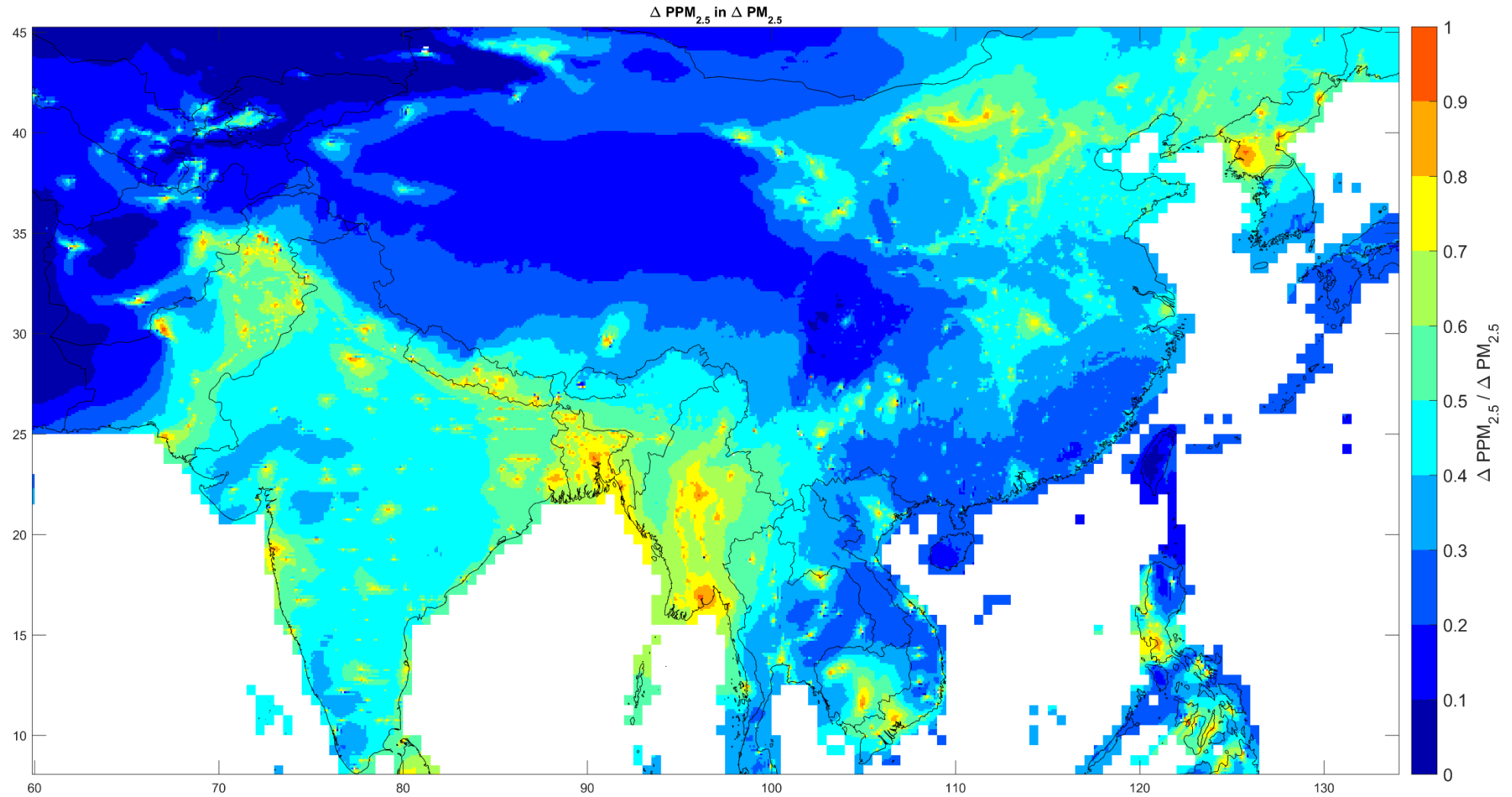
Validation (not really)



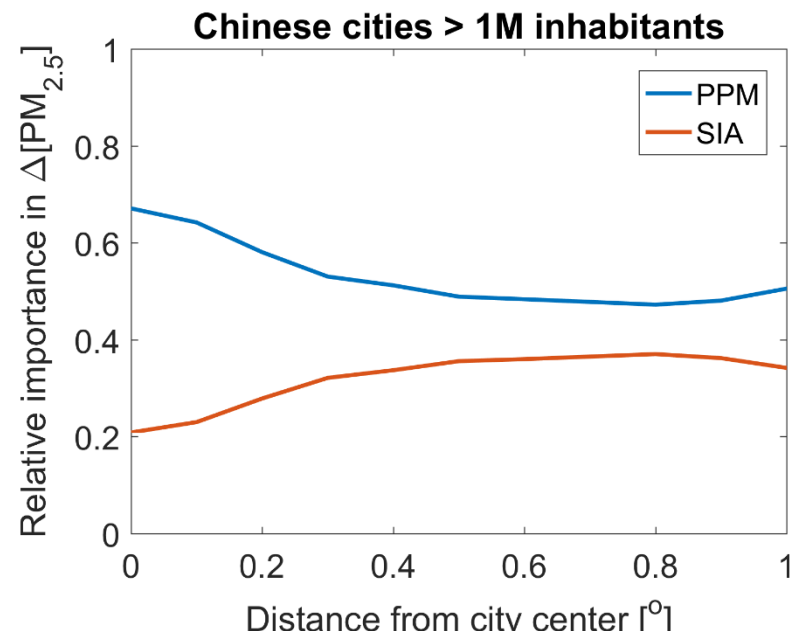
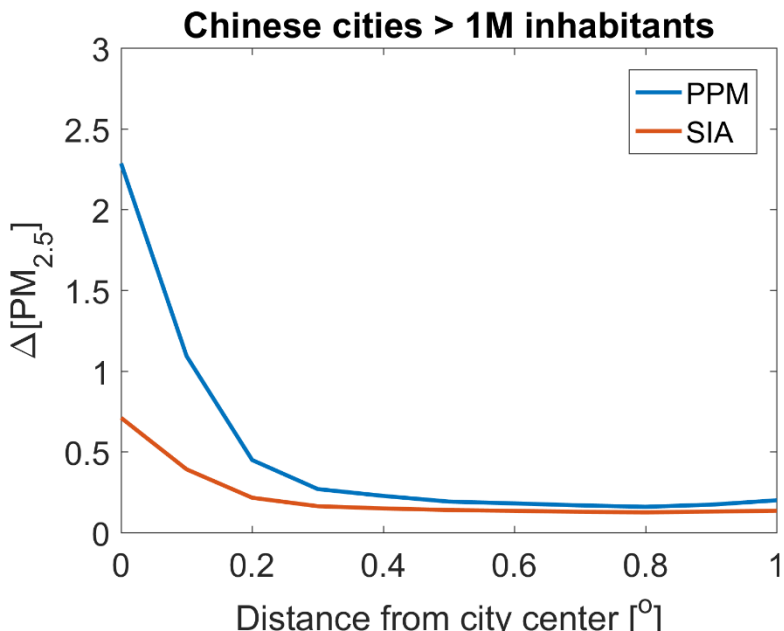
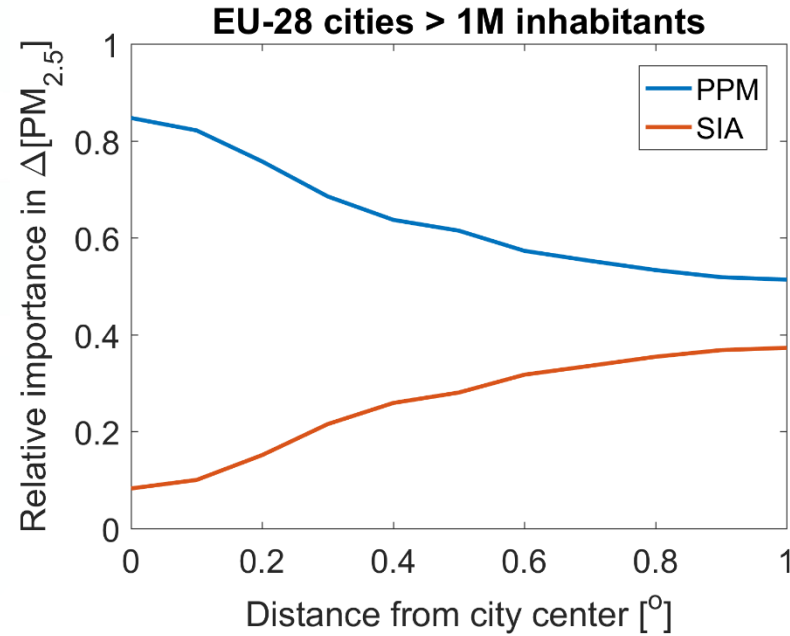
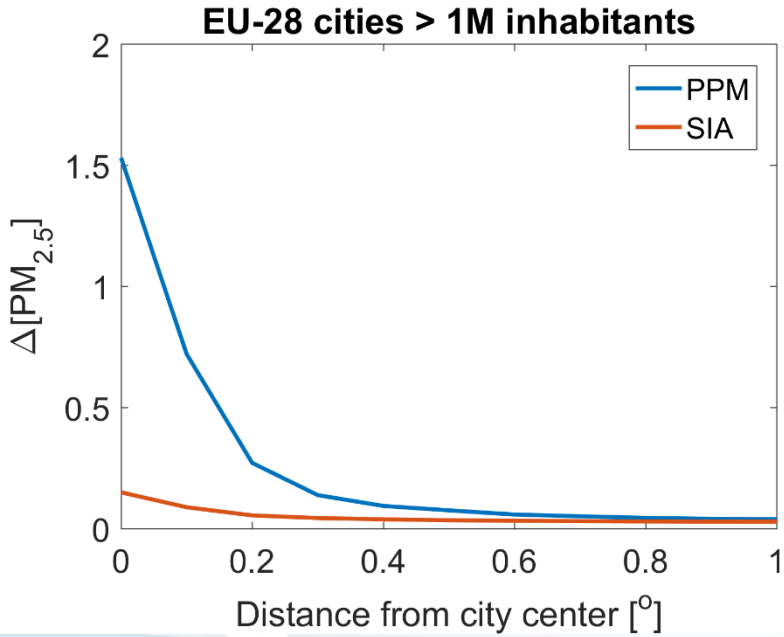
Delta from urban 30% reduction



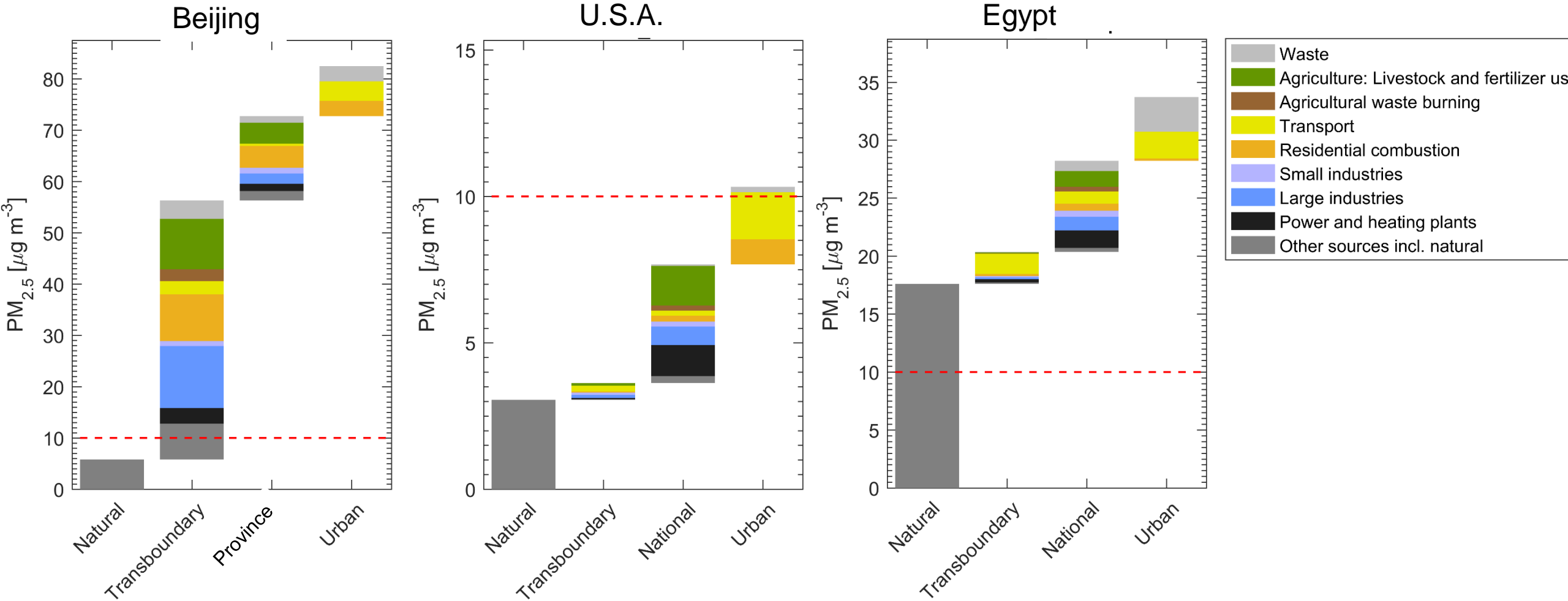
Delta from urban 30% reduction: PPM share



Delta from urban 30% reduction: PPM vs SIA

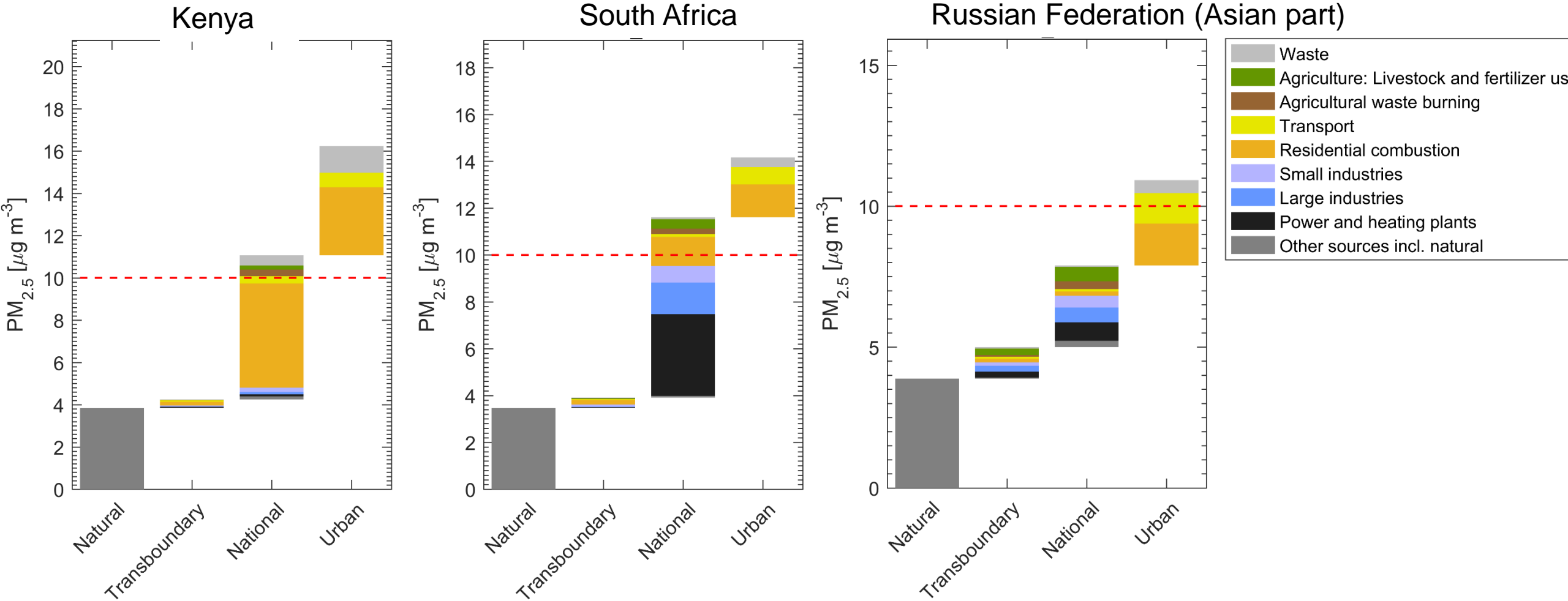


Source apportionment for cities (preliminary!)



All cities within the respective GAINS region (province/country) averaged
 Emissions: 2015 – latest GAINS global scenario (Eclipse v6a, March 2019)

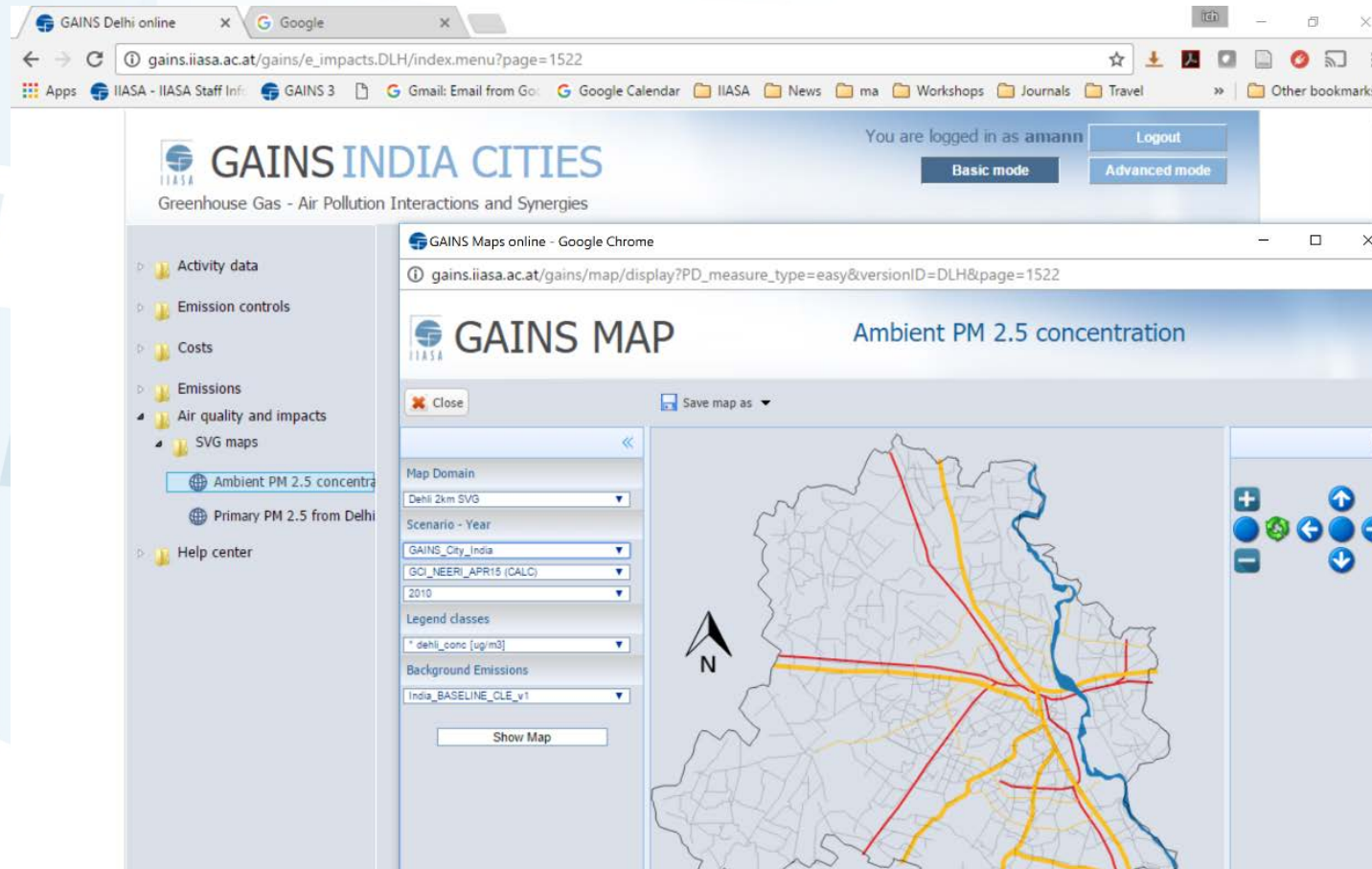
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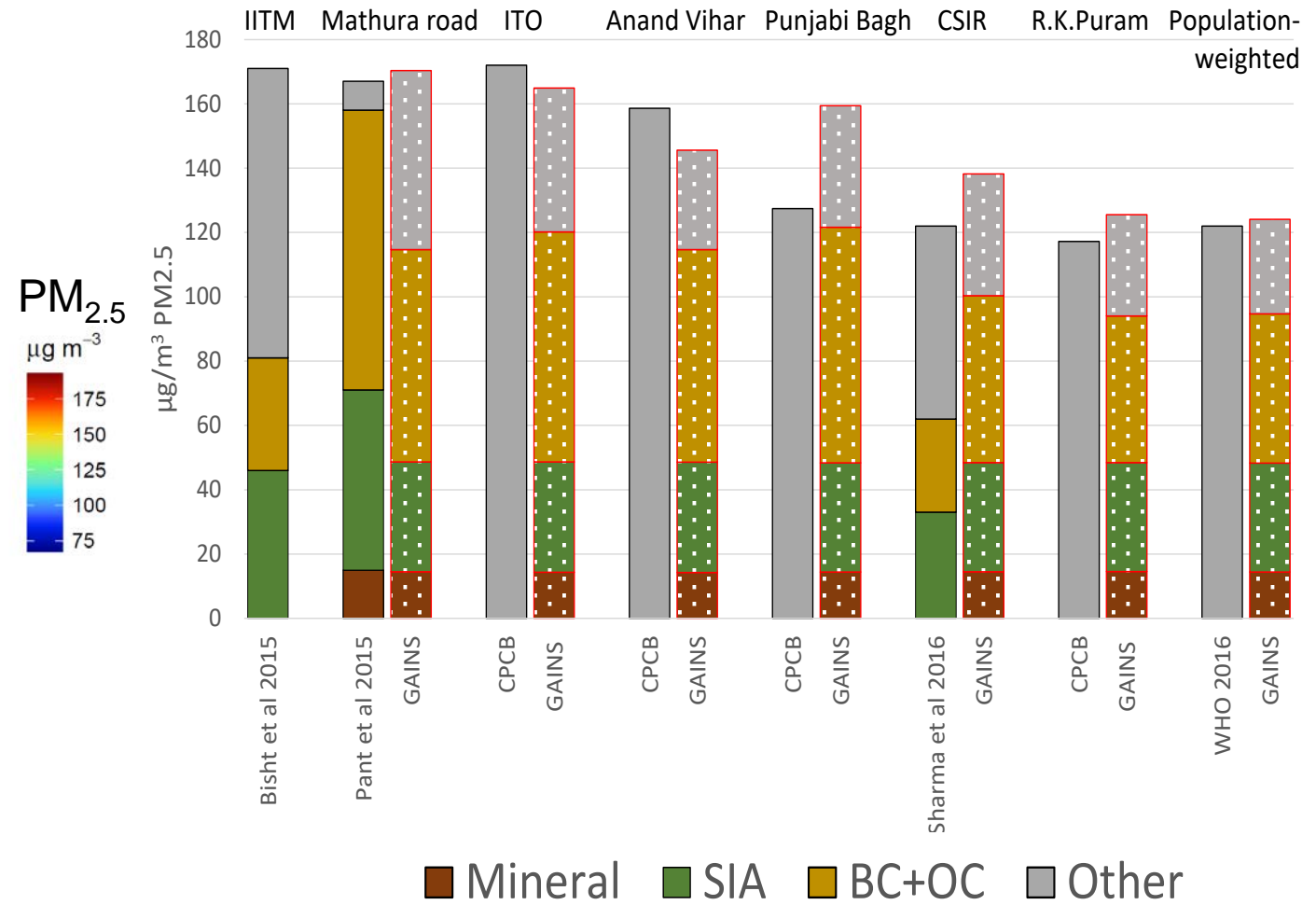
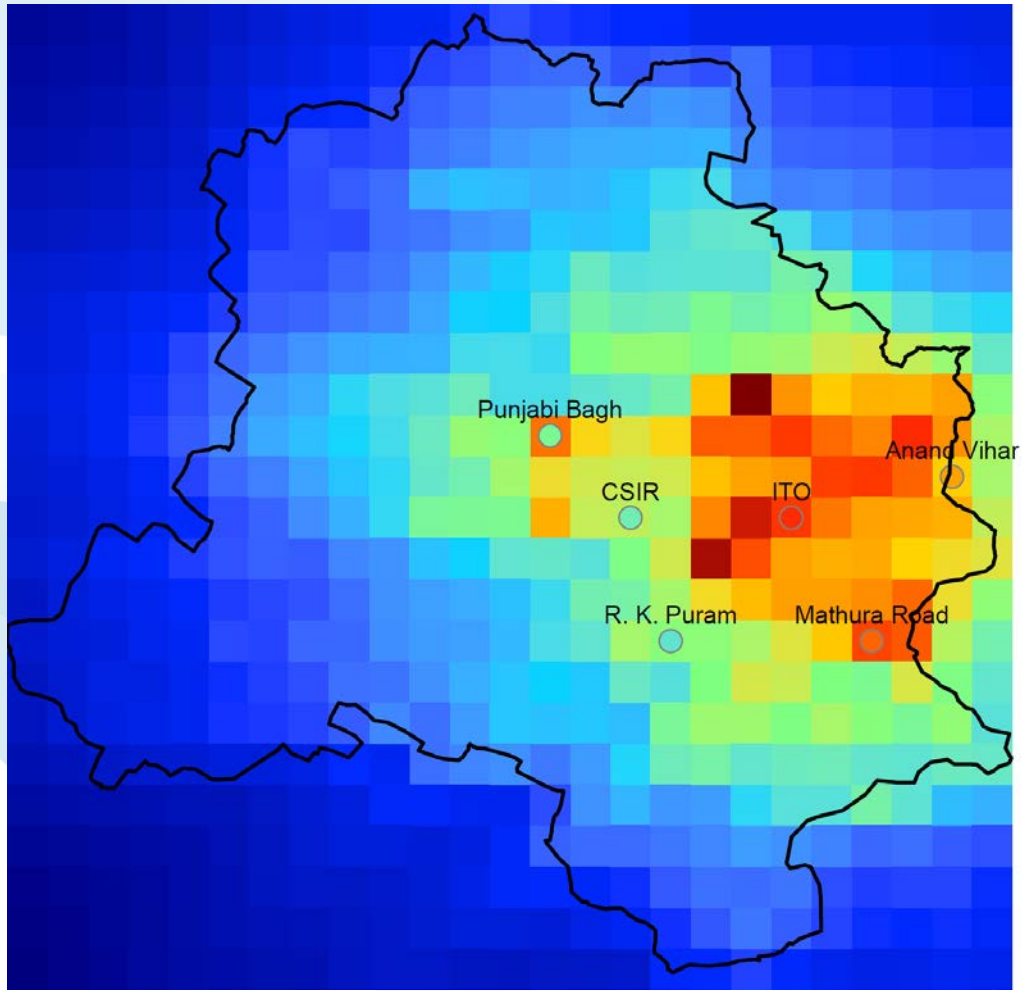
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From global to local II: High-resolution model for Delhi

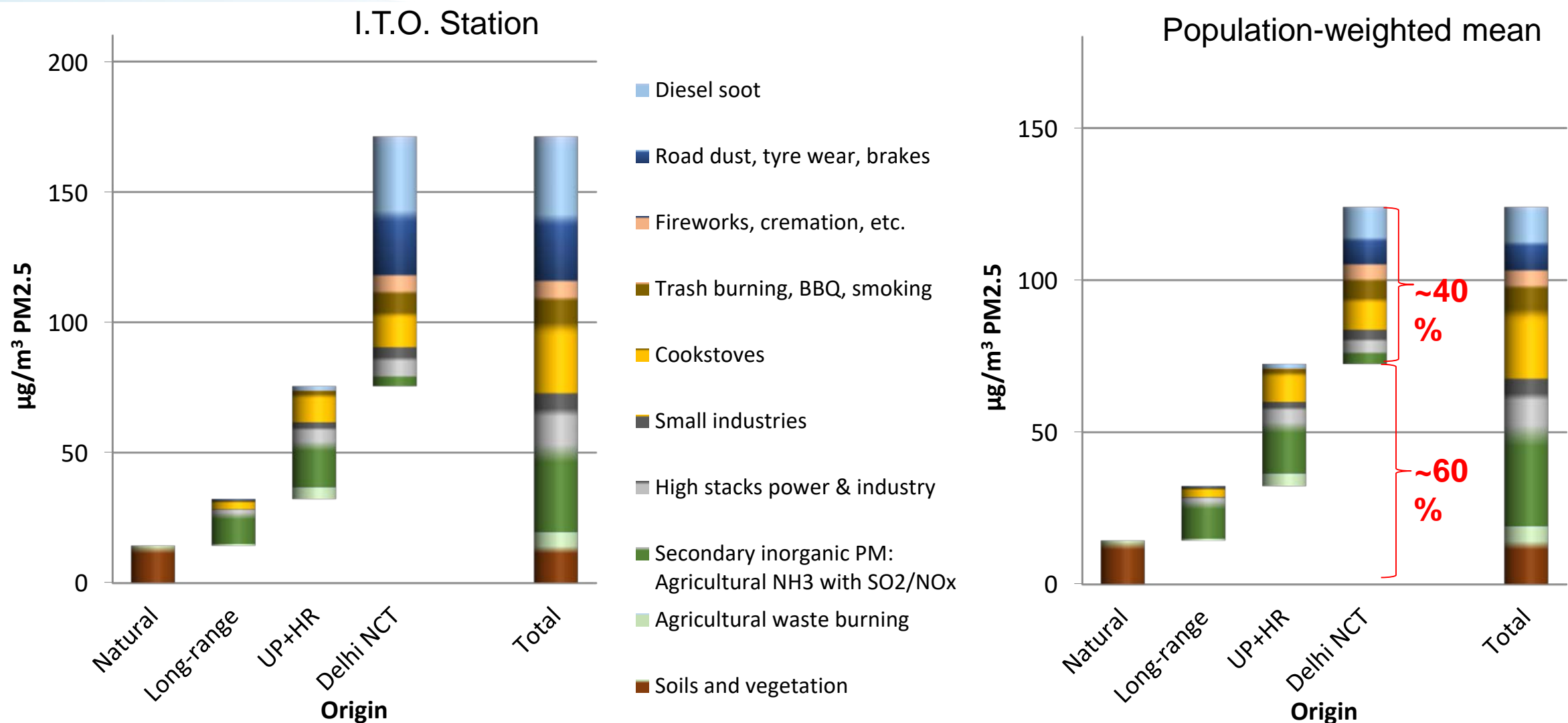
- Study for Delhi with local partners
- Local high-resolution sectoral transfer coefficients for PPM: AERMOD dispersion model
- Fully functioning “classical” GAINS model for Delhi:



Validation of the dispersion calculations for Delhi 2015



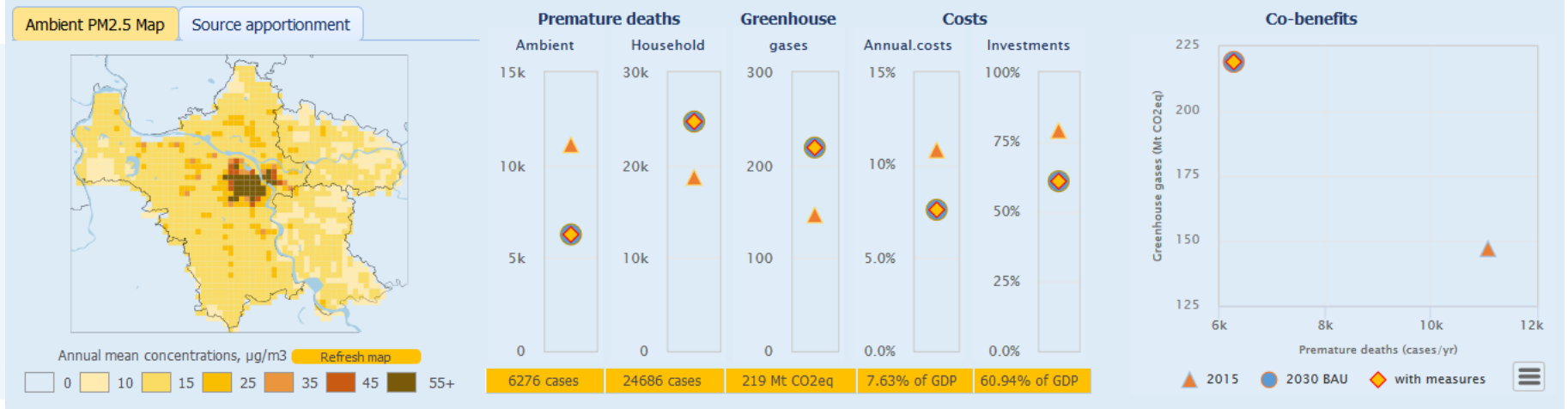
Source apportionment of PM_{2.5} in Delhi 2015



Global to local III: Integrated city tool for Hanoi

- weblink

Under development!

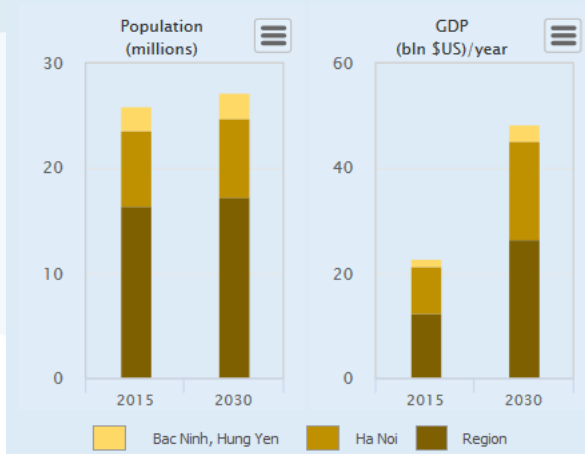


Drivers Measures

Socio-economic projection (2030 rel. to 2015)

	Bac Ninh, Hung Yen	Ha Noi	Region
Population	0.3%	0.3%	0.3%
GDP/capita	4.9%	4.8%	4.9%
Industry % of GDP	0.0%	0.0%	0.0%
Transport	0.0%	0.0%	0.0%

- Measures - Power sector
- Measures - Industry
- Measures - Households
- Measures - Agriculture
- Measures - Road Transportation
- Measures - Non-road mobile sources
- Measures - Others



COST-EFFECTIVENESS ANALYSIS

Determines the cheapest measures for the following targets:

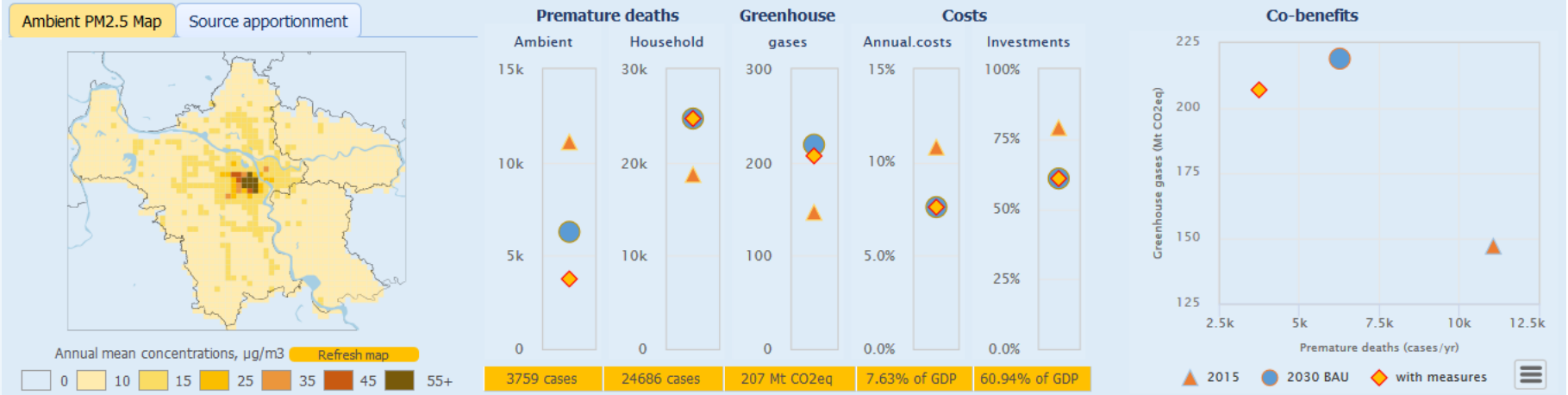
Premature deaths:

GHG emissions:

START

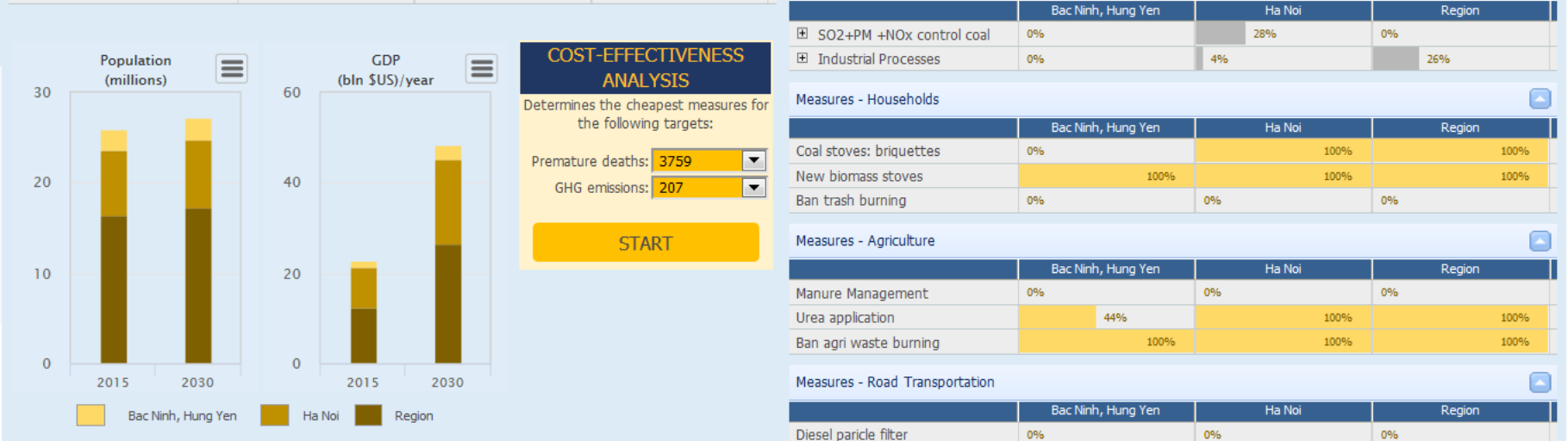
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Measures - Power sector			
	Bac Ninh, Hung Yen	Ha Noi	Region
SO ₂ and NO _x controls coal	0%	0%	0%
Coal to gas	0%	0%	0%
Measures - Industry			
	Bac Ninh, Hung Yen	Ha Noi	Region
SO ₂ +PM +NO _x control coal	0%	28%	0%
Industrial Processes	0%	4%	26%
Measures - Households			
	Bac Ninh, Hung Yen	Ha Noi	Region
Coal stoves: briquettes	0%	100%	100%
New biomass stoves	100%	100%	100%
Ban trash burning	0%	0%	0%
Measures - Agriculture			
	Bac Ninh, Hung Yen	Ha Noi	Region
Manure Management	0%	0%	0%
Urea application	44%	100%	100%
Ban agri waste burning	100%	100%	100%
Measures - Road Transportation			
	Bac Ninh, Hung Yen	Ha Noi	Region
Diesel particulate filter	0%	0%	0%



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 than 1/3 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 endeavours (2 years+)!