International Institute for Applied Systems Analysis
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Improving $PM_{2.5}$ source apportionment in GAINS

Some lessons from South Asia

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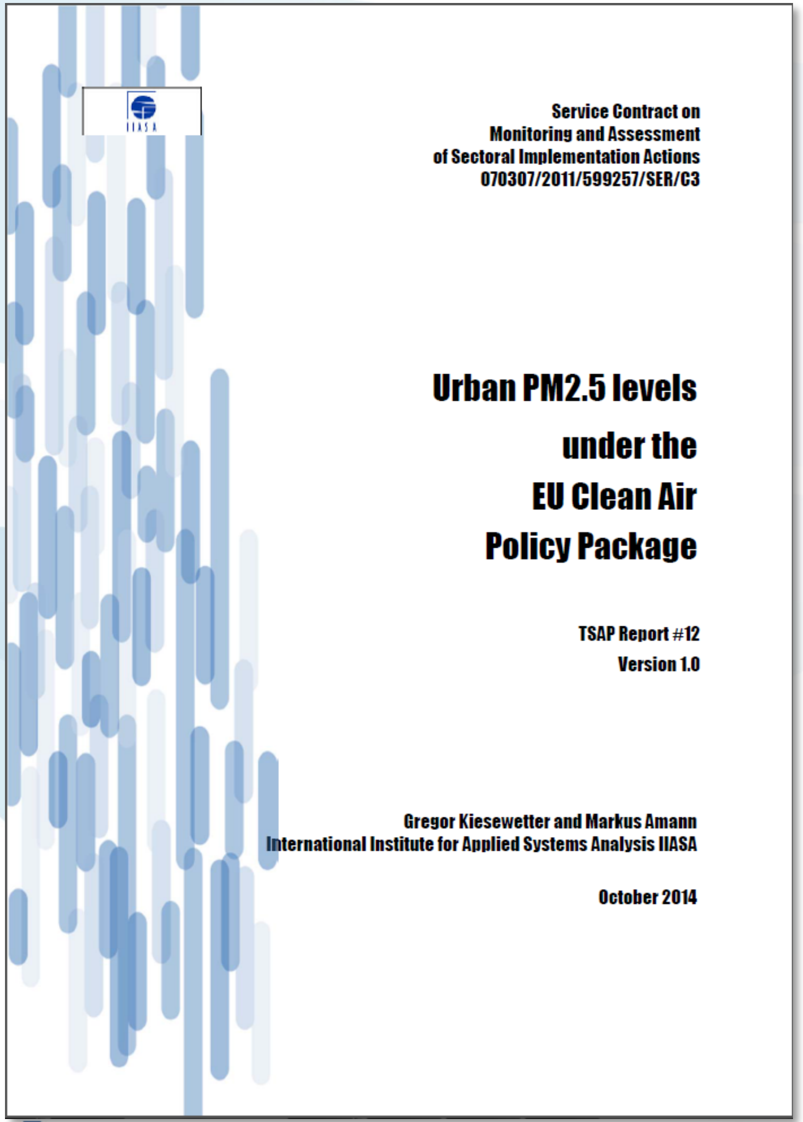
TFIAM Expert Panel on Clean Air in Cities
Online meeting 29 Sep 2020

science for global insight

Source apportionment in GAINS-Europe



Service Contract on
Monitoring and Assessment
of Sectoral Implementation Actions
070307/2011/599257/SER/C3

Urban PM2.5 levels under the EU Clean Air Policy Package

TSAP Report #12
Version 1.0

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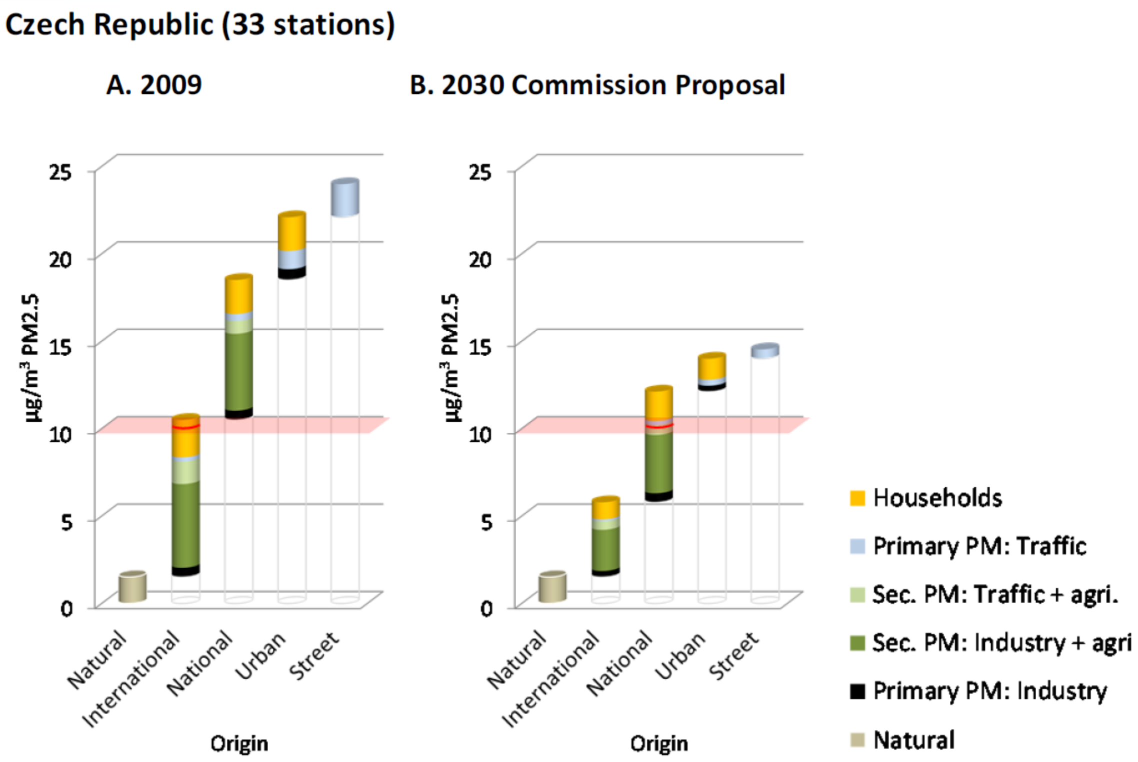
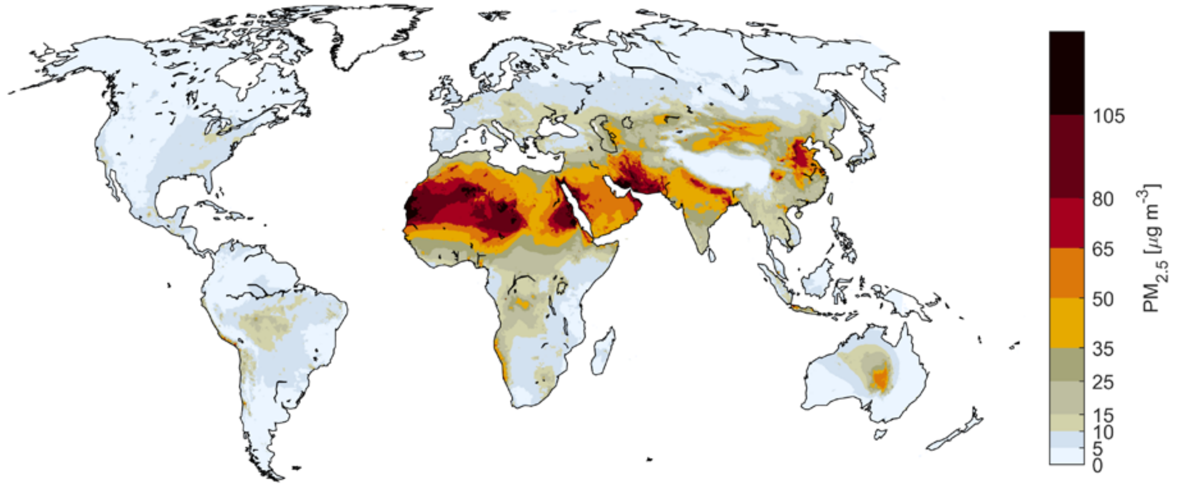
- Fusion approach combining model and observations, mainly following the Lenschow approach
- Source attribution covers ~1900 AirBase stations
- Data heavy – not feasible in other world regions



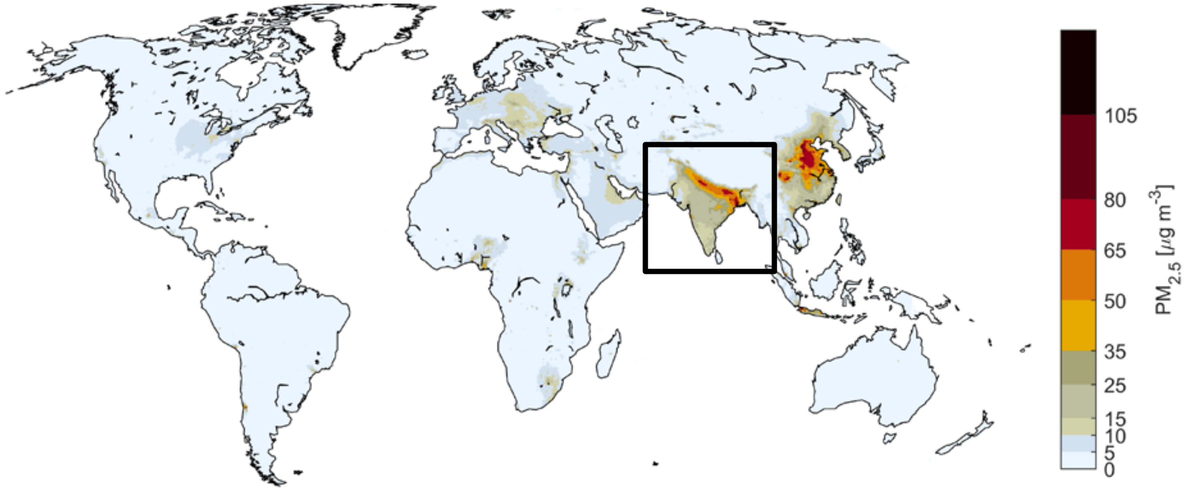
Introduction

- South Asian cities are among the highest polluted in the world
- Objective: Develop sectoral and spatial source apportionments for $PM_{2.5}$ in South Asia, for States and major cities

Total $PM_{2.5}$ (2015, GAINS)



Anthropogenic $PM_{2.5}$ (2015, GAINS)



Introduction

- South Asian cities are among the highest polluted in the world
- Objective: Develop sectoral and spatial source apportionments for $PM_{2.5}$ in South Asia, for States and major cities
- Quantify the local and imported shares of $PM_{2.5}$ for states and for major cities
- Develop and test a methodology which can be applied elsewhere in the GAINS model framework

Methodology

- GAINS global transfer coefficients: linear approximation of EMEP CTM
  - 180 source regions globally (state level in India), region to grid, based on 15% reduction
  - high stack PPM and secondary PM precursors SO_2, NO_x, NH_3, VOC: 0.5º x 0.5º
  - Low level sources PPM, SO_2, NO_x: 0.1º resolution (with urban/rural source distinction)

- Grid to grid tracking ("local fraction") of PPM with EMEP CTM at 0.1º, monthly results, 2015 (/ 2018), within $\pm$8º of each receptor grid

=> sectoral transfer coefficients for PPM:

$$T_{r,s,g} = \frac{1}{12} \cdot \sum_{m=1}^{12} \sum_{g'} \gamma(r,s,g')\, \tau(s,g',m)\, G(g',g,m)$$

r... source region, s... source sector, g... receptor grid cell (0.1^0), g'... emission grid cell (0.1^0)

$\gamma(r,s,g)$ … spatial emission distribution

$\tau(s,g,m)$ … temporal (monthly) emission share

$G(g',g,m)$… grid-to-grid transfer coefficient from g' to g in month m

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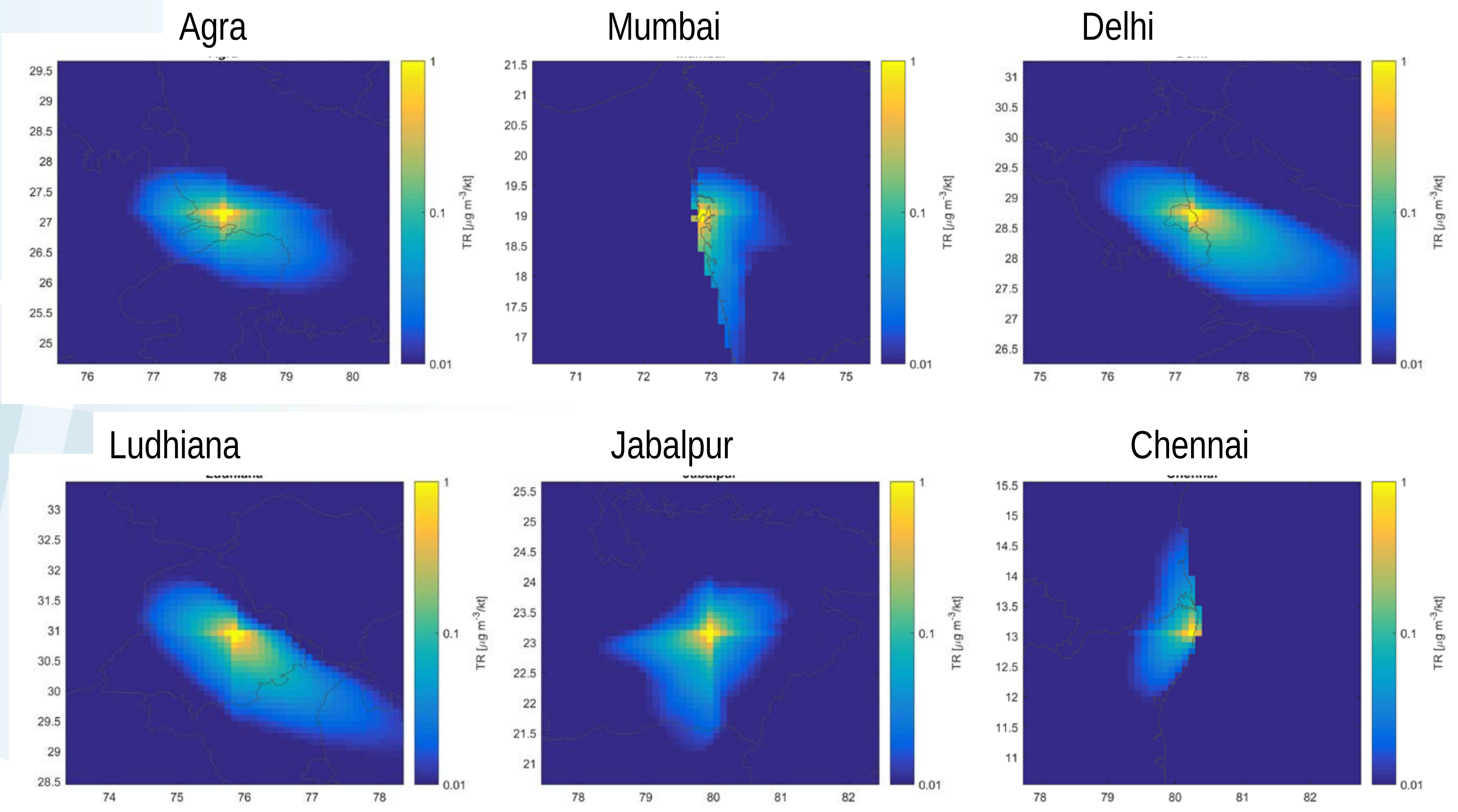
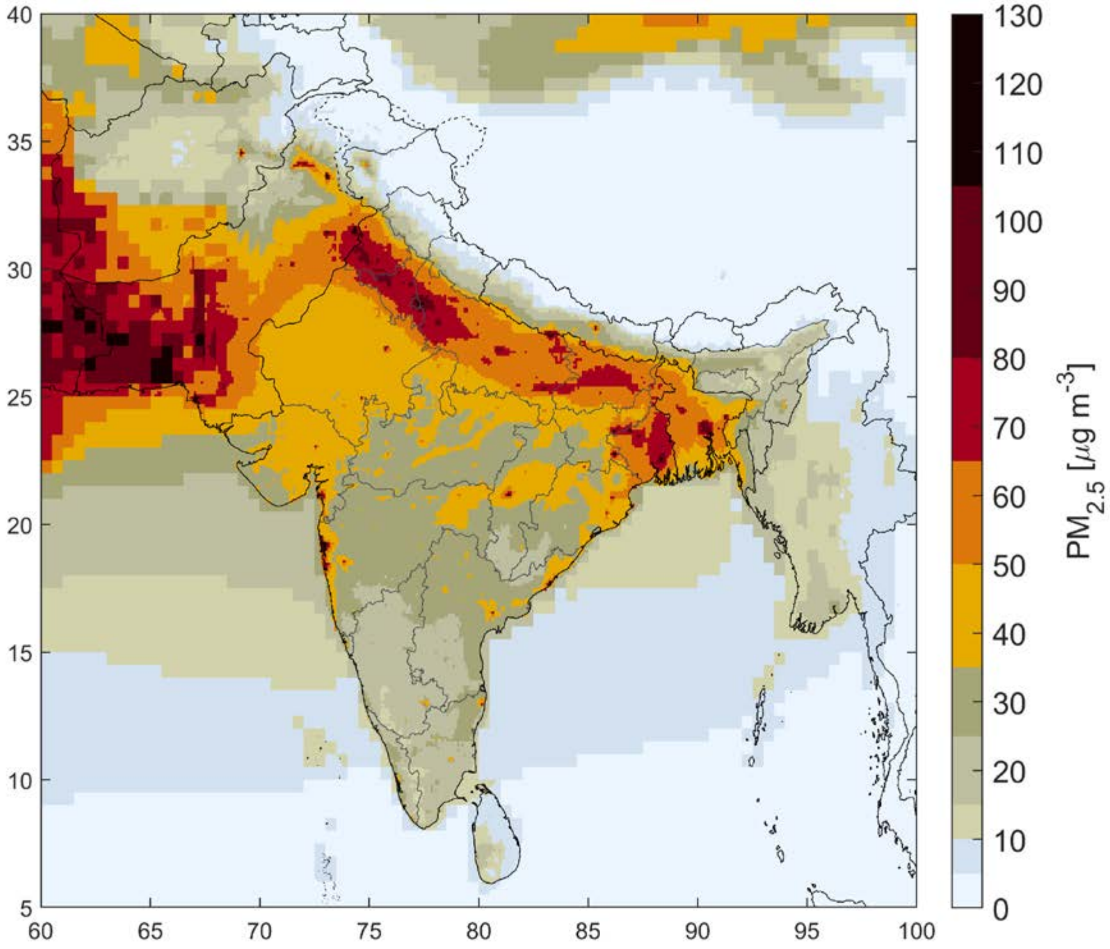
Fine-scale dispersion of low-level PPM emissions

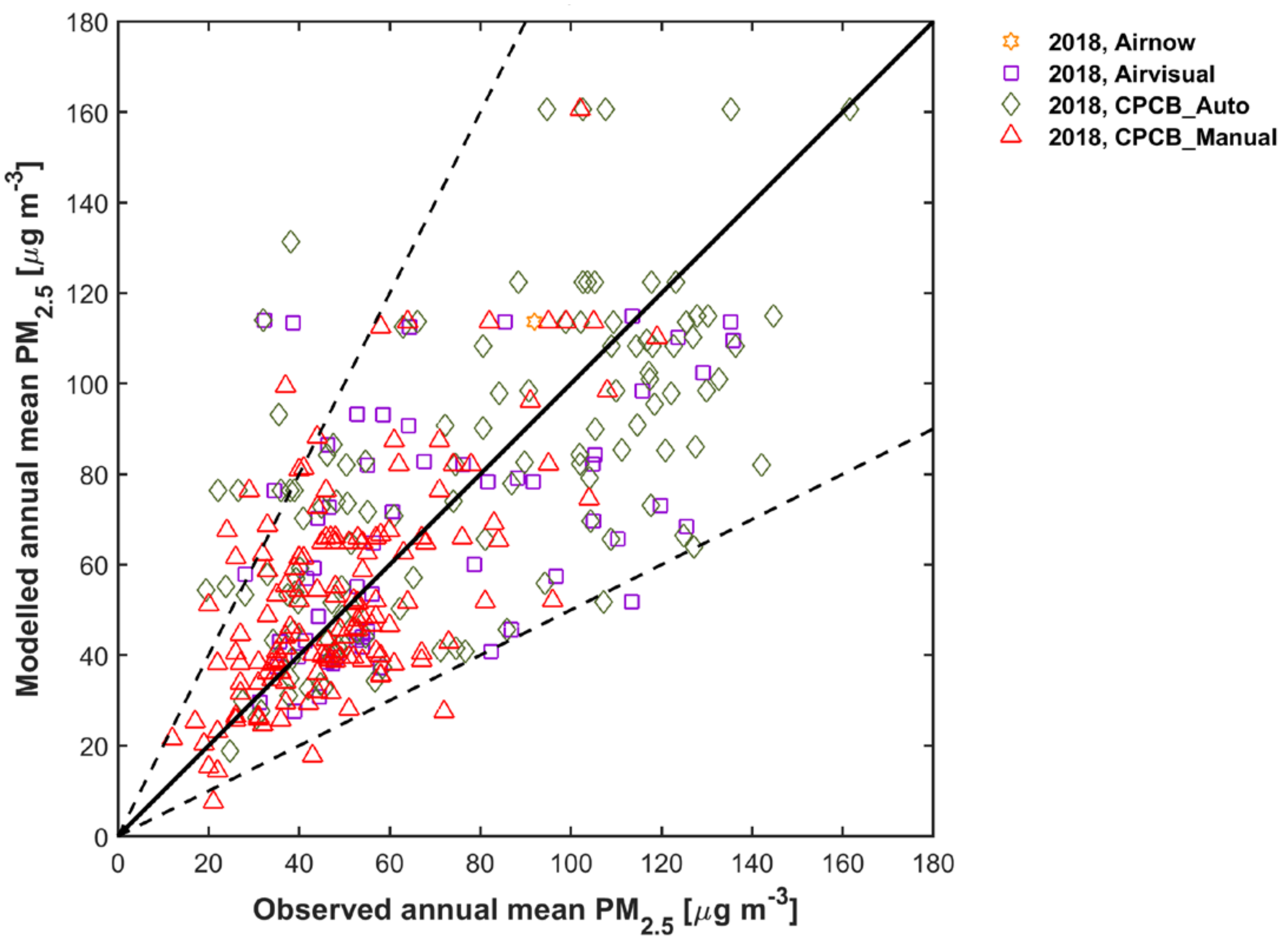
- Examples of dispersion patterns of low-level PPM emissions from cities



This enables analyses for individual cities!

Modelled $PM_{2.5}$ and validation - 2018



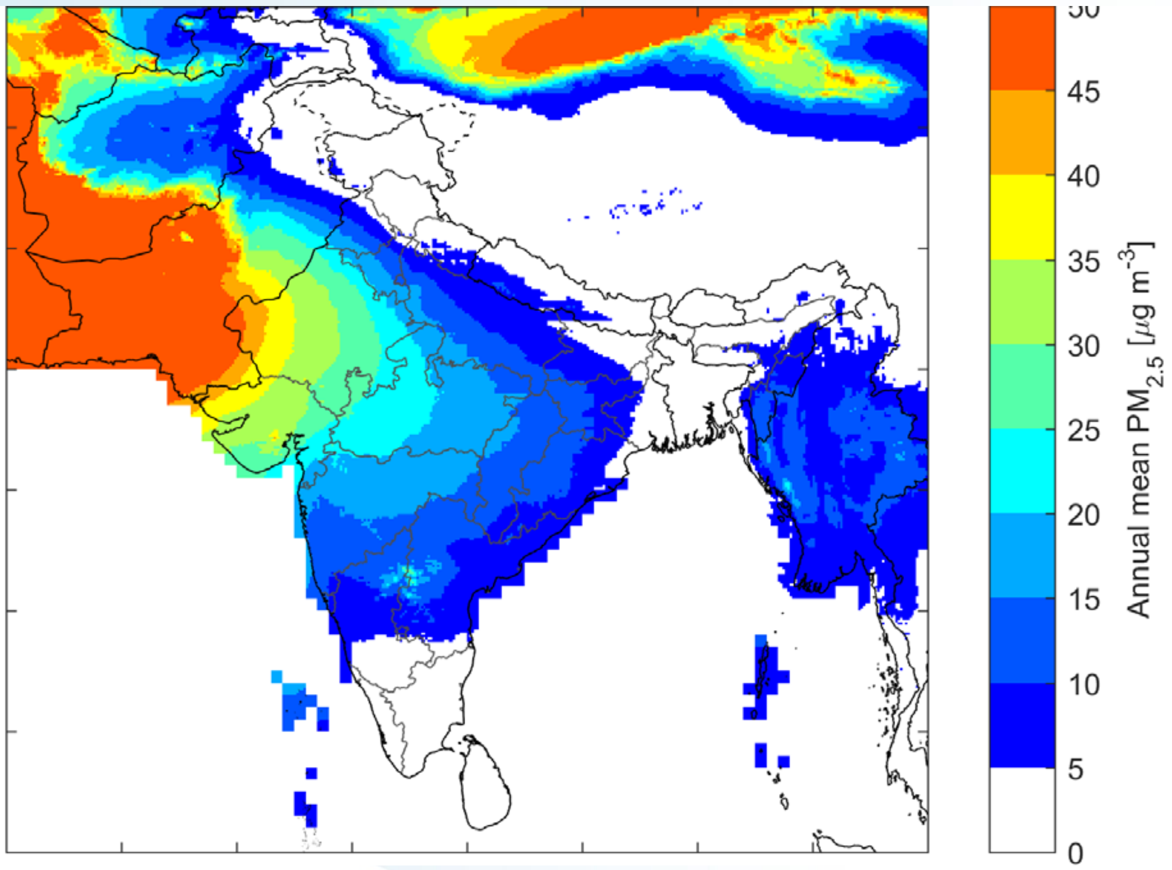


Sectoral contributions to $PM_{2.5}$

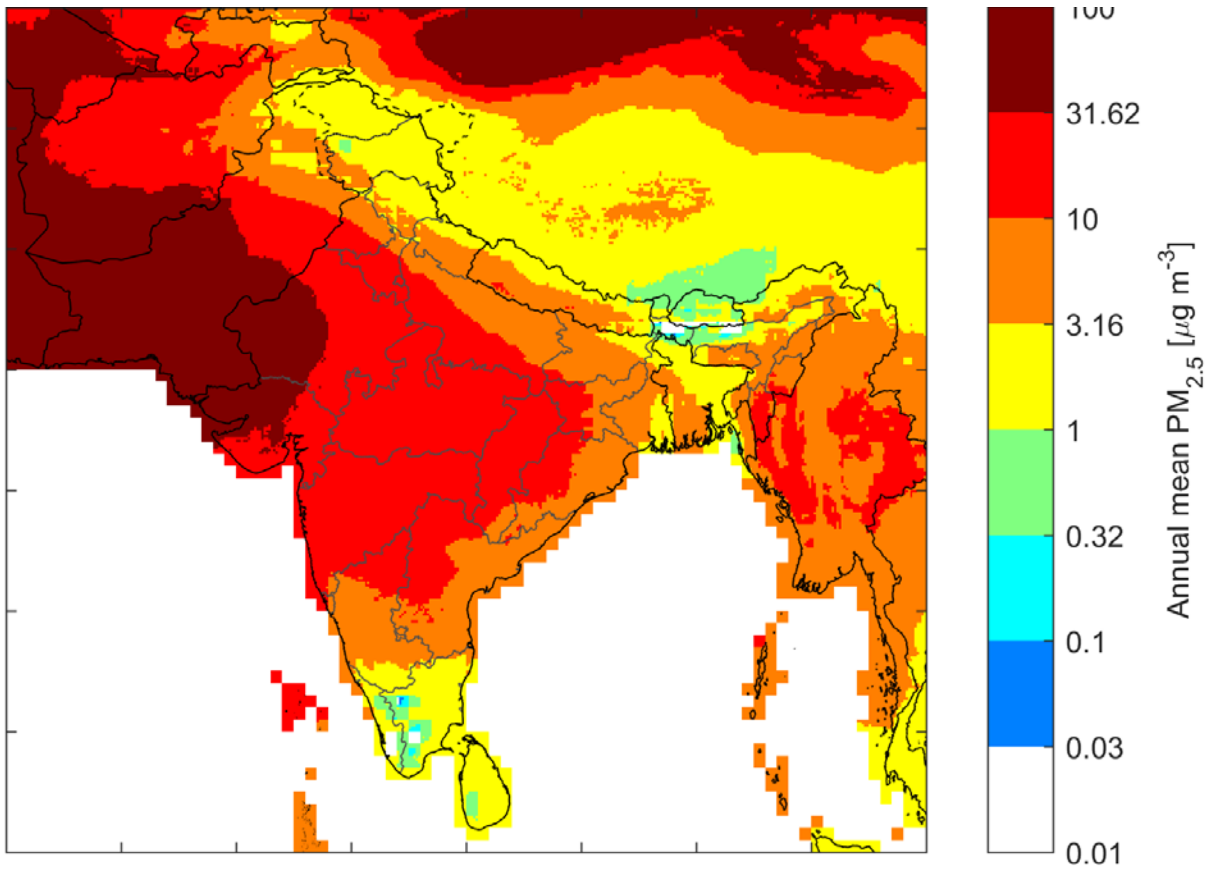
(examples for a few sectors)

Computed $PM_{2.5}$ concentrations: Natural sources, 2015

Linear scale

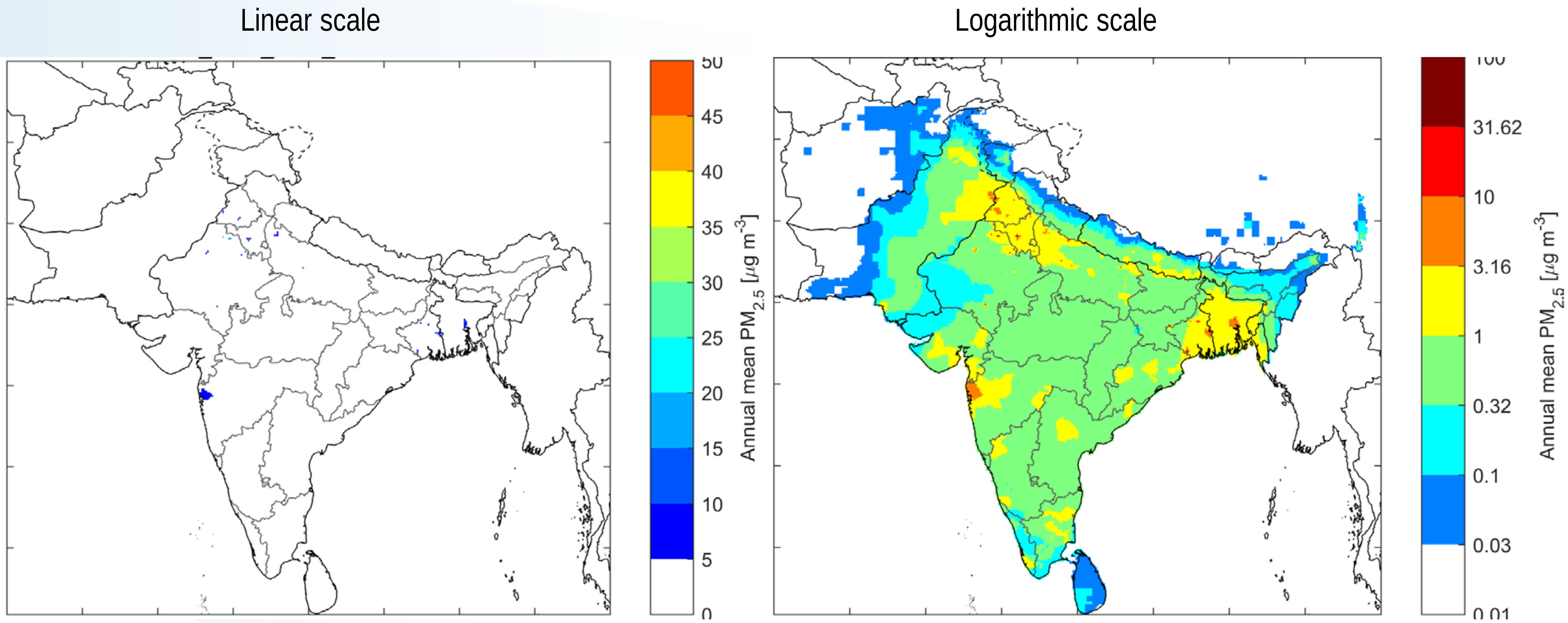


Logarithmic scale



Preliminary results!

Computed $PM_{2.5}$ concentrations: Brick kilns, 2015

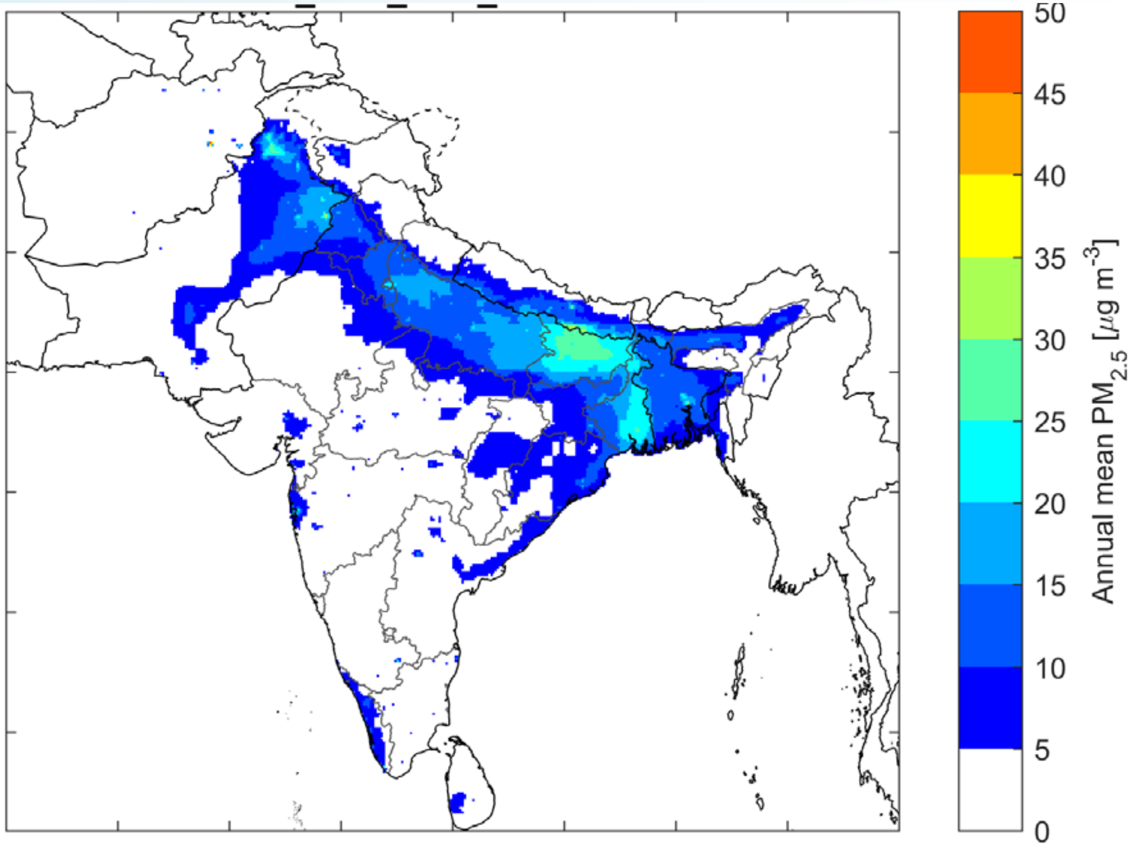


Mainly local contributions around brick production clusters in Northern states

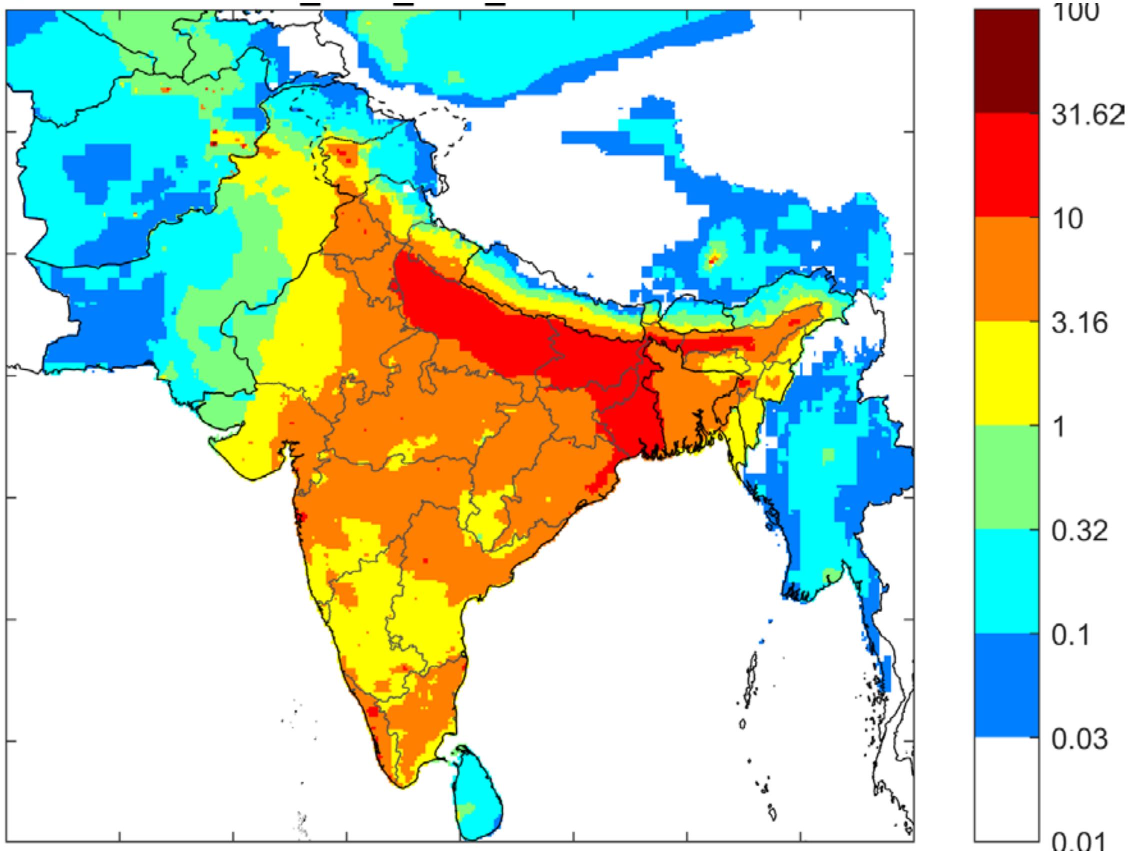
Preliminary results!

Computed $PM_{2.5}$ concentrations: Residential & commercial, 2015

Linear scale



Logarithmic scale

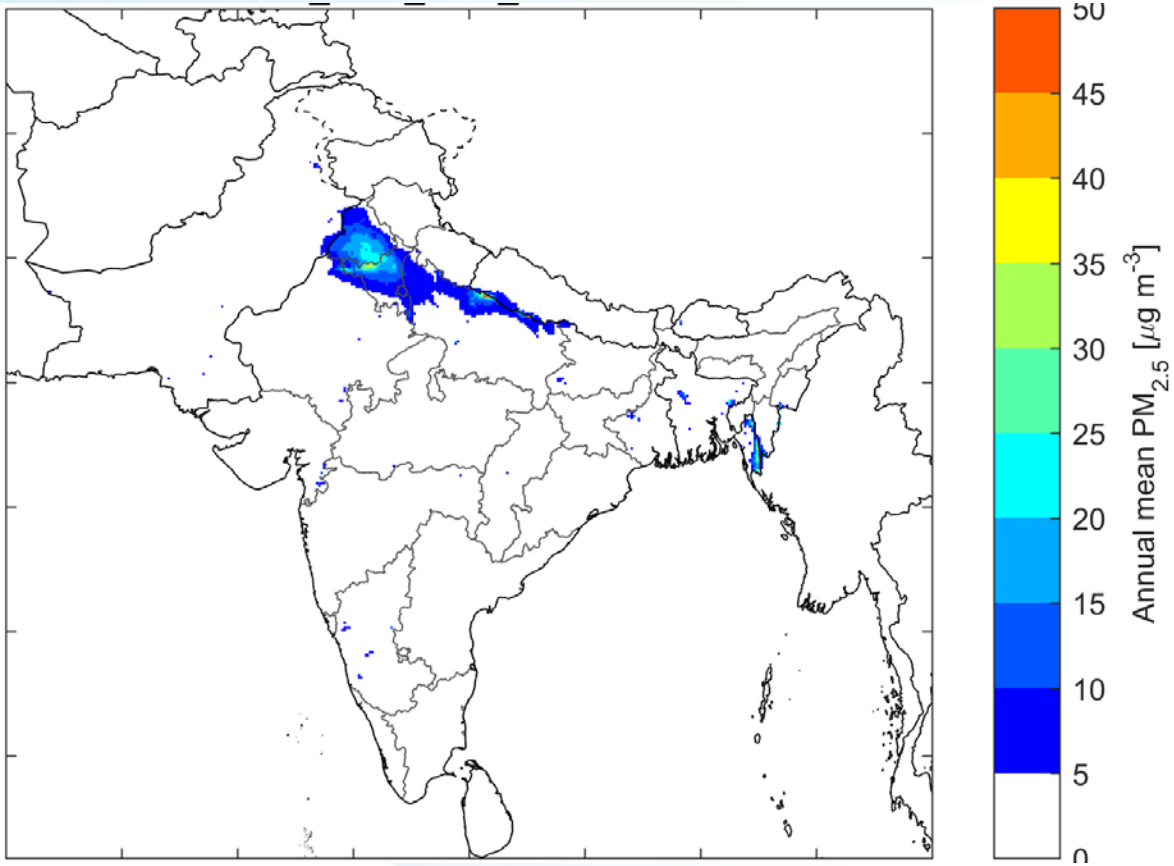


Mainly relevant in Gangetic Plain (Uttar Pradesh, Bihar…)

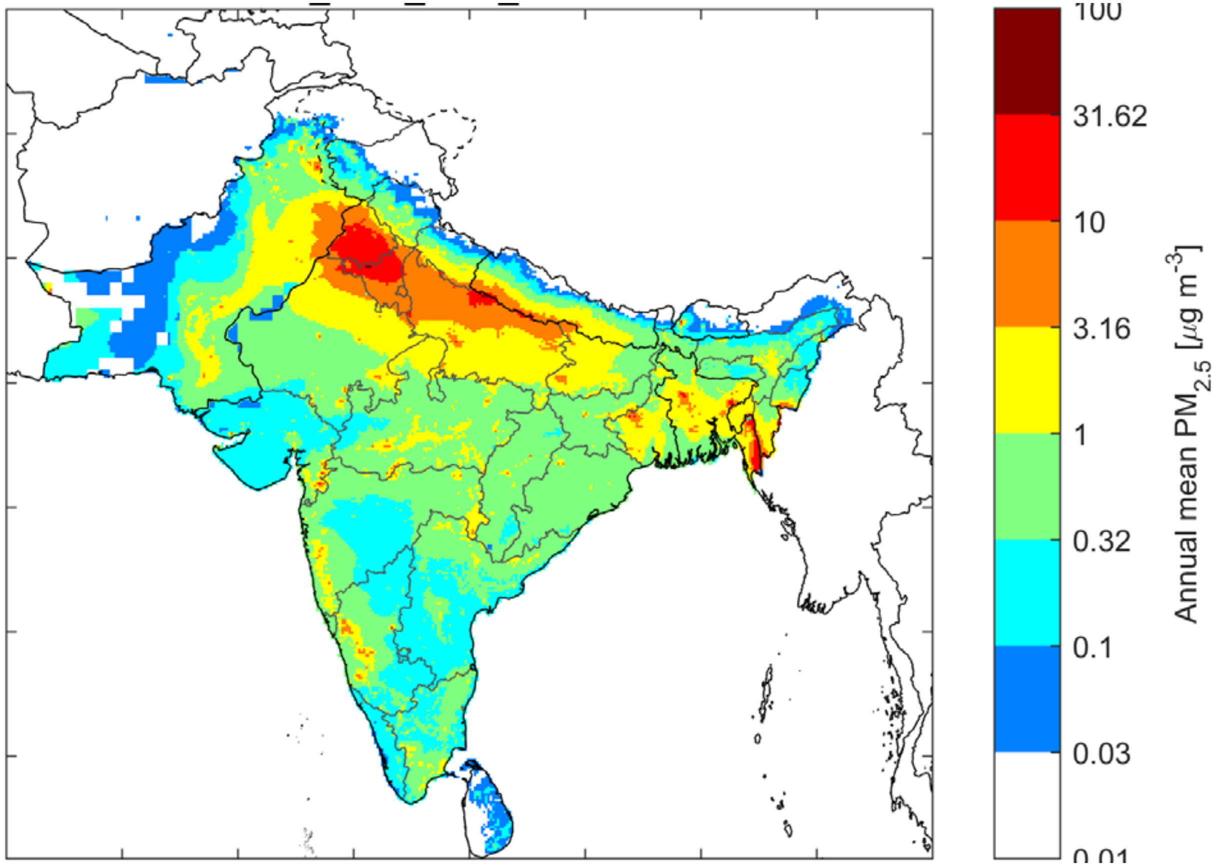
Preliminary results!

Computed $PM_{2.5}$ concentrations: Agricultural residue burning, 2015

Linear scale



Logarithmic scale

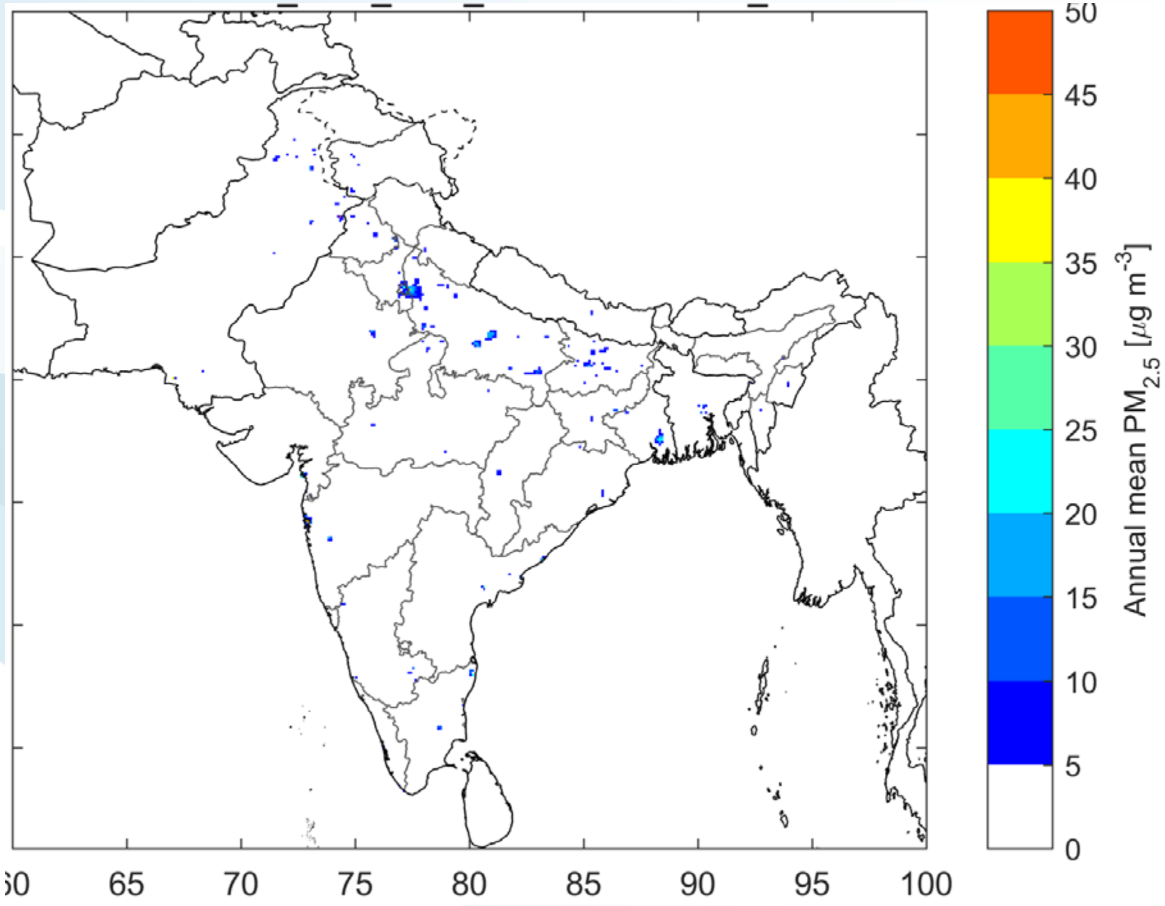


Mainly relevant in NW India, only during limited periods

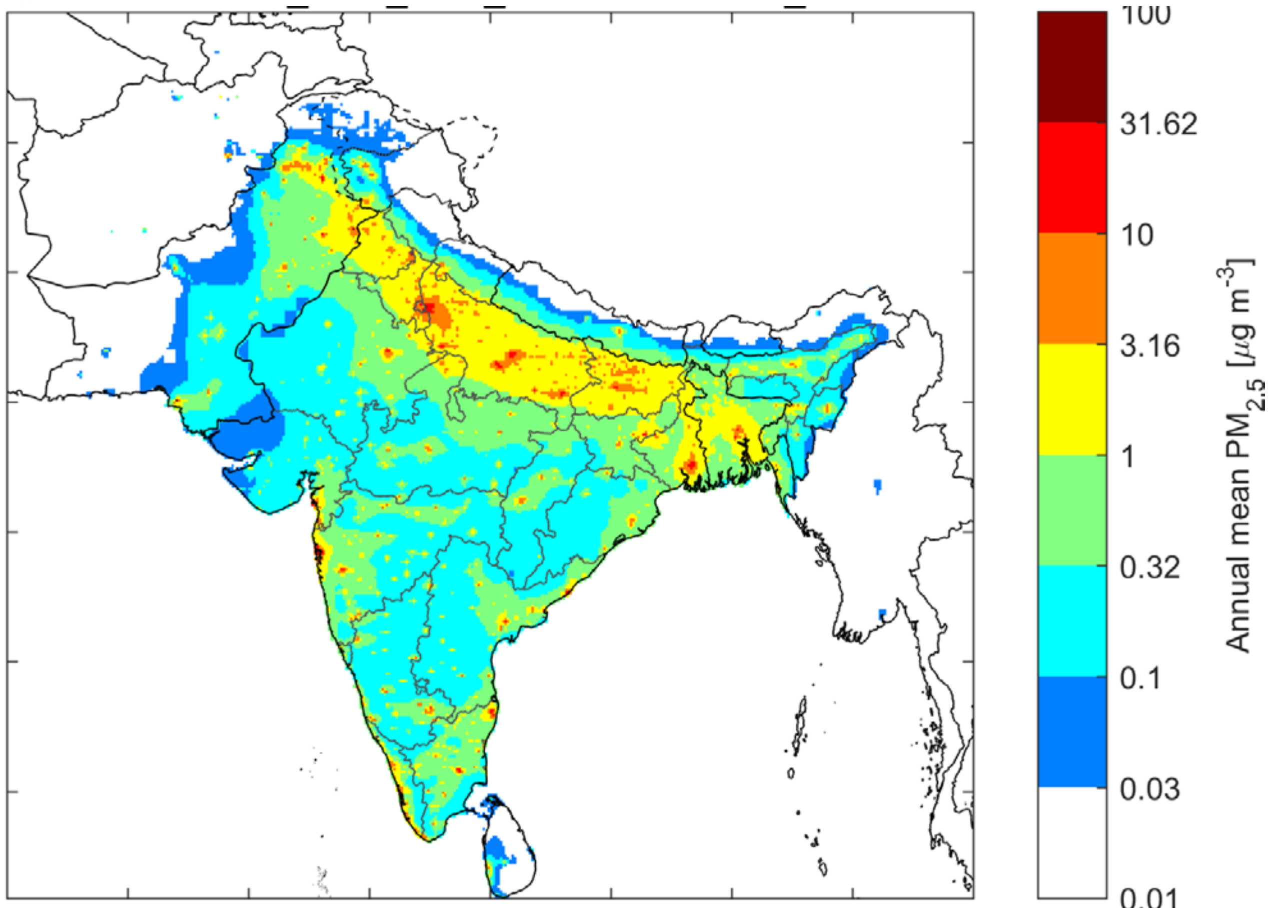
Preliminary results!

Computed $PM_{2.5}$ concentrations: Waste burning in cities, 2015

Linear scale



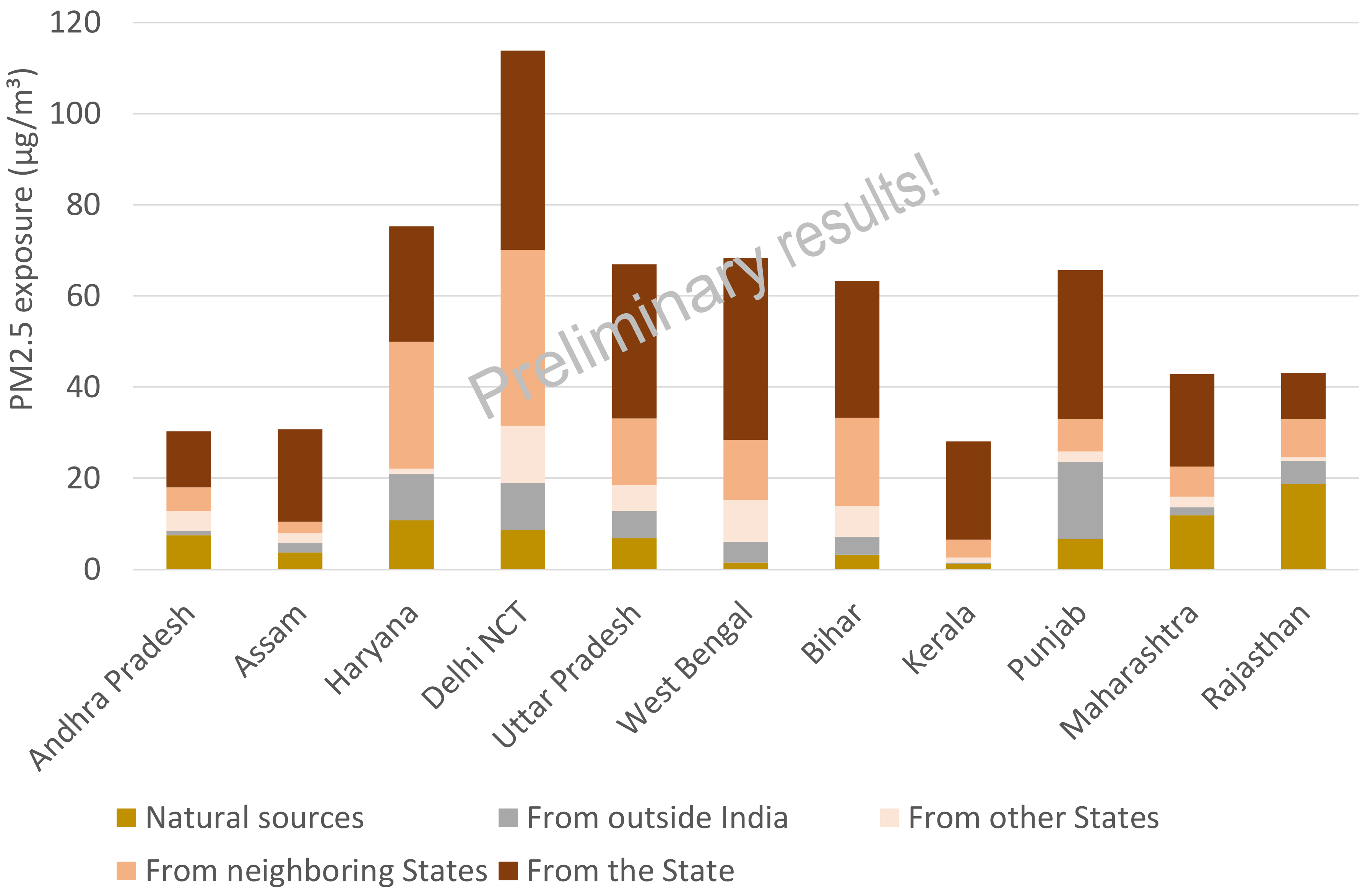
Logarithmic scale



Significant local contributions…

Preliminary results!

Spatial origin of $PM_{2.5}$ in Indian States, population-weighted



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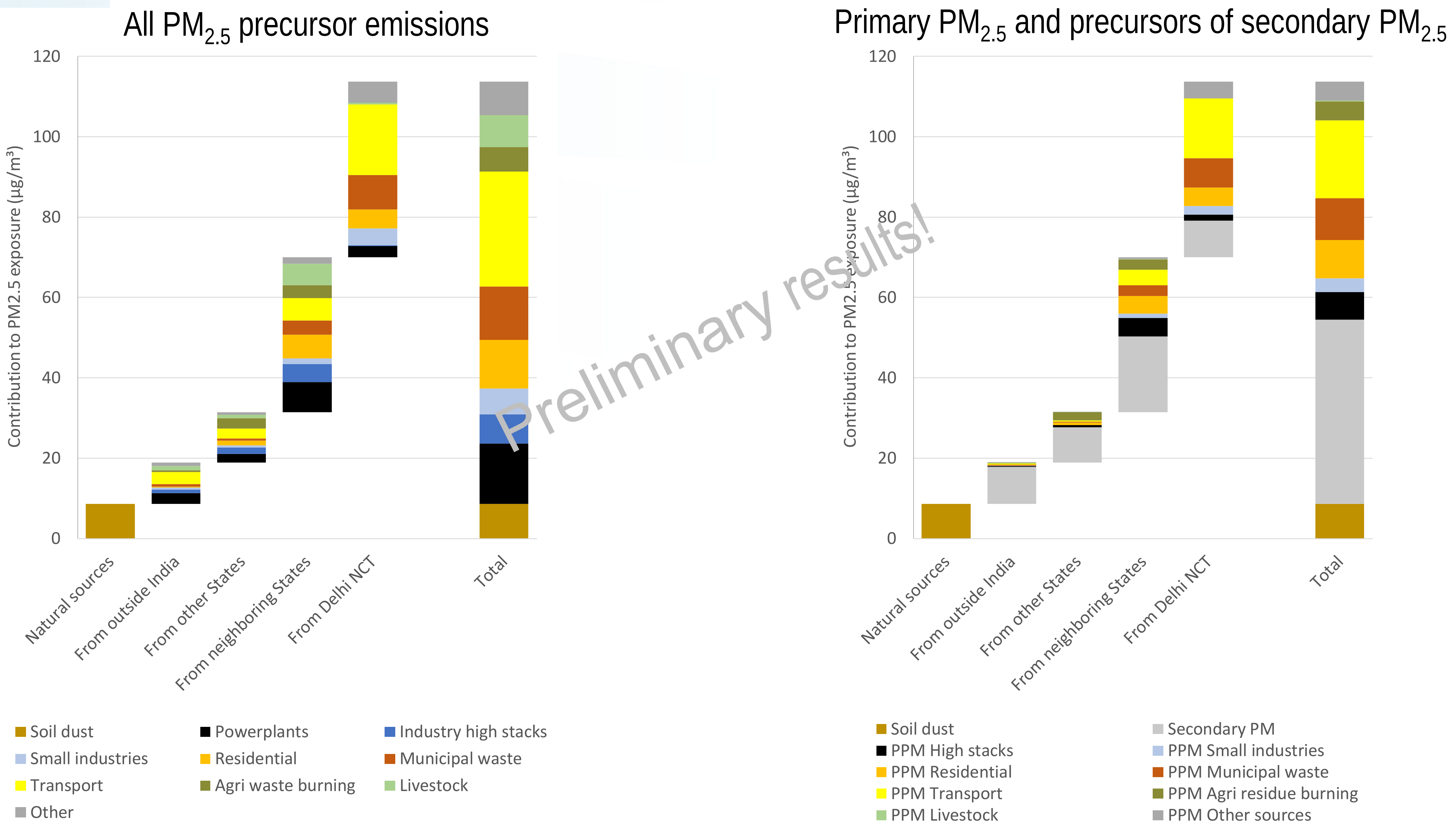
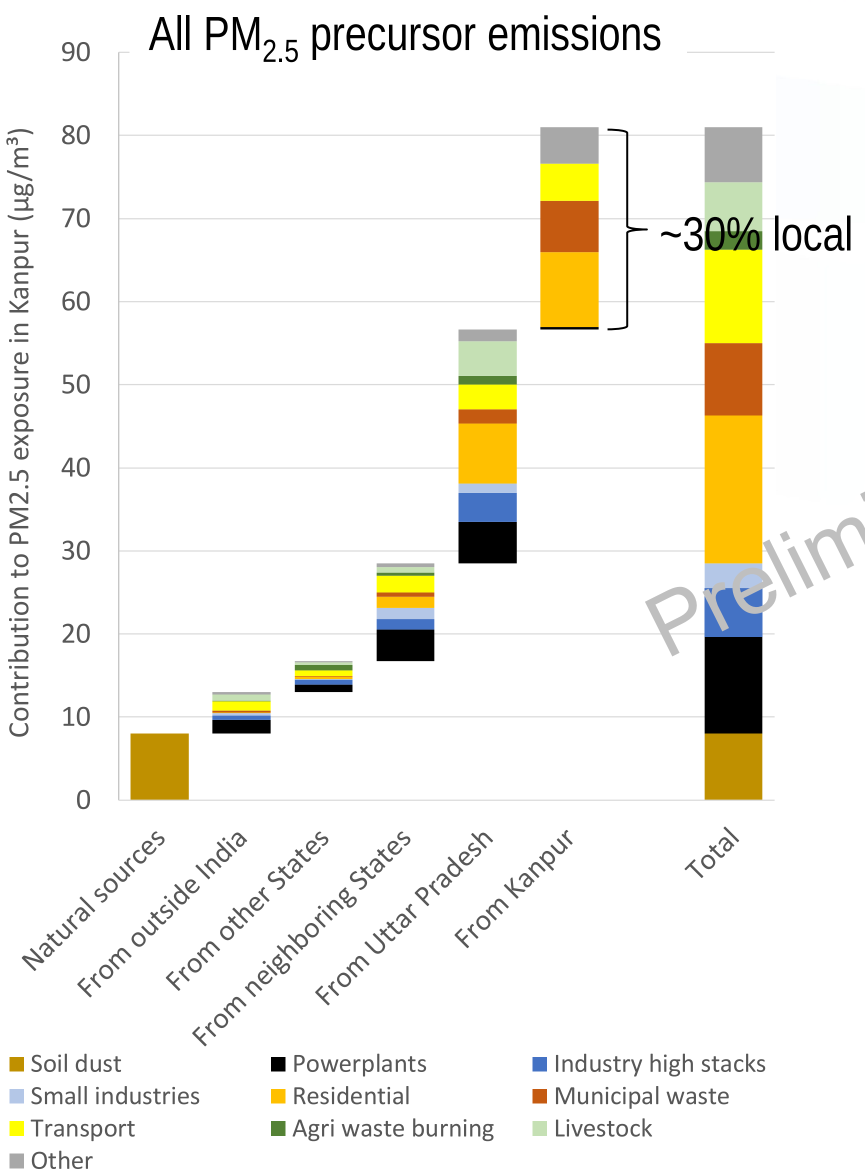
Contributions to $PM_{2.5}$ in cities

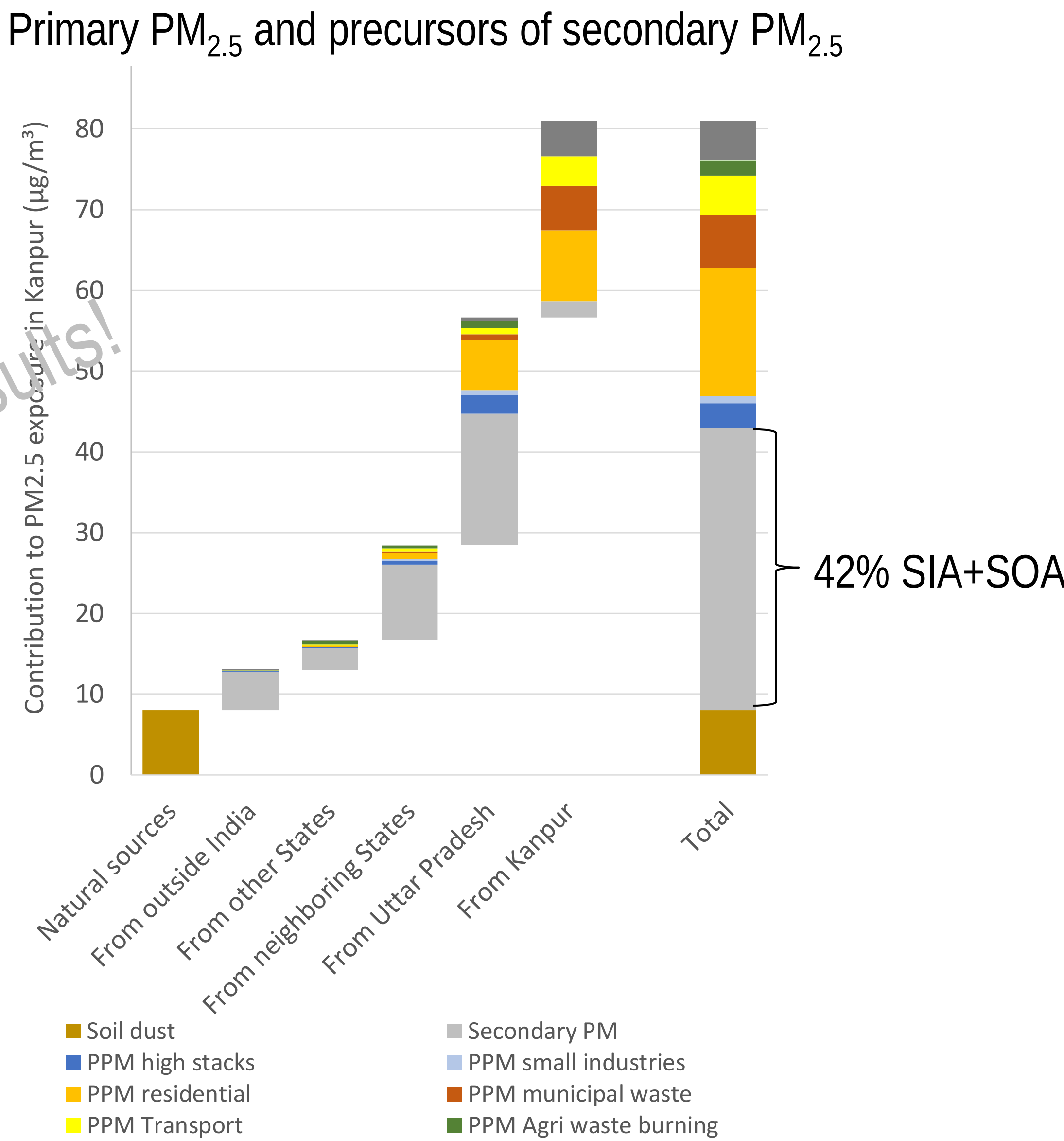
Some examples…

Contributions to $PM_{2.5}$ exposure in Delhi NCT, 2015

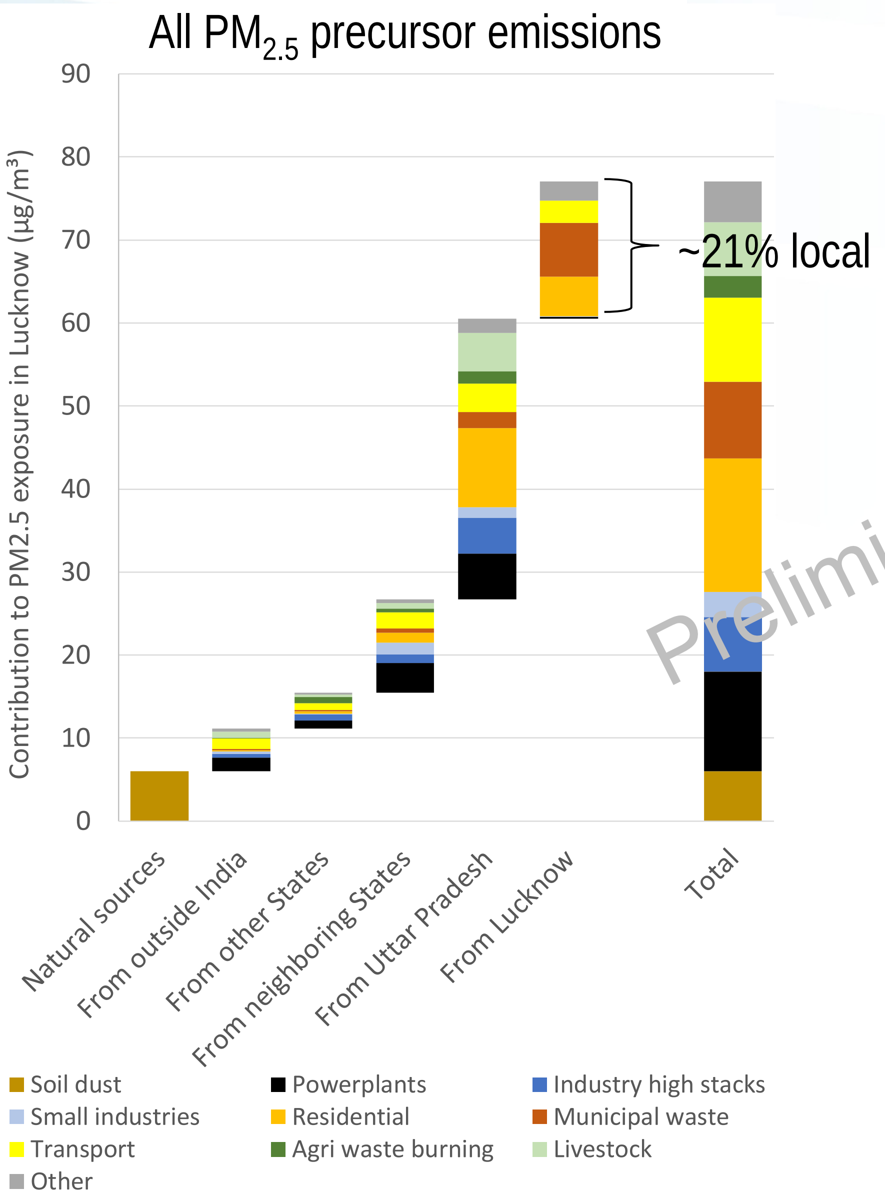


Contributions to $PM_{2.5}$ exposure in Kanpur, 2015

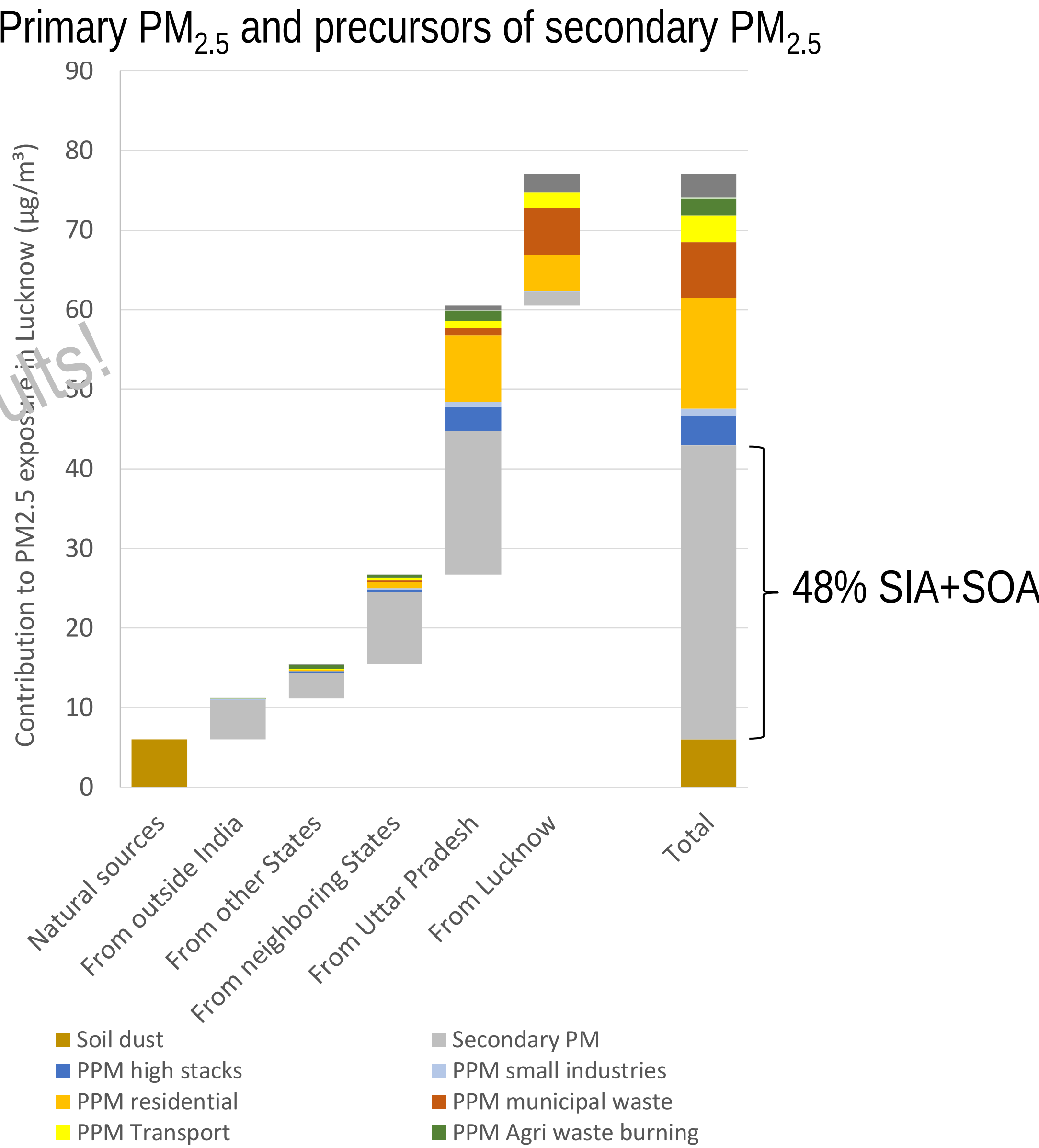




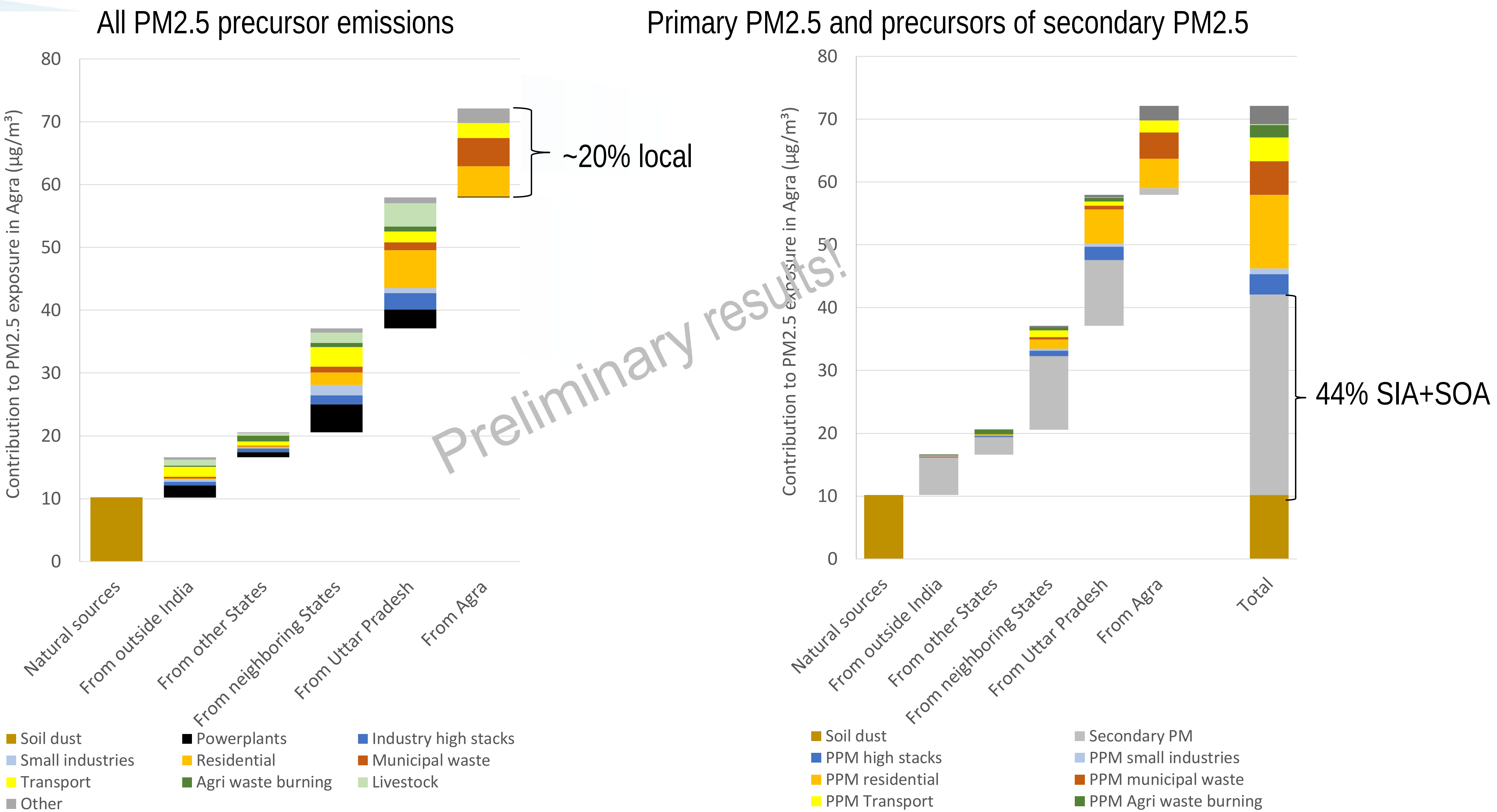
Contributions to $PM_{2.5}$ exposure in Lucknow, 2015



Preliminary results!



Contributions to $PM_{2.5}$ exposure in Agra, 2015



Some observations / (preliminary) conclusions

- Combination of traditional transfer coefficients with grid-to-grid tracking allows for improved ambient PM source apportionment in GAINS using sectoral transfer coefficients
  - Methodology developed for South Asia, could be applied elsewhere

- Individual cities cause only a limited share of their ambient $PM_{2.5}$. Transboundary contributions are important (Indian states ~ European countries!)

- Detailed emission inventories are needed. The more local we want to go, the better the inventory needs to be. Sources of local relevance need to be understood well (e.g. urban/rural differences in domestic sector fuels)

- Resolution needs to match the purpose of the modelling. Currently the resolution is 0.1° ~ urban background $PM_{2.5}$, relevant for population exposure. For local hot spots, downscaling would be needed.

- Chemically speciated monitoring data would be needed for validation!