International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Interactions between urban and rural air pollution in Asia

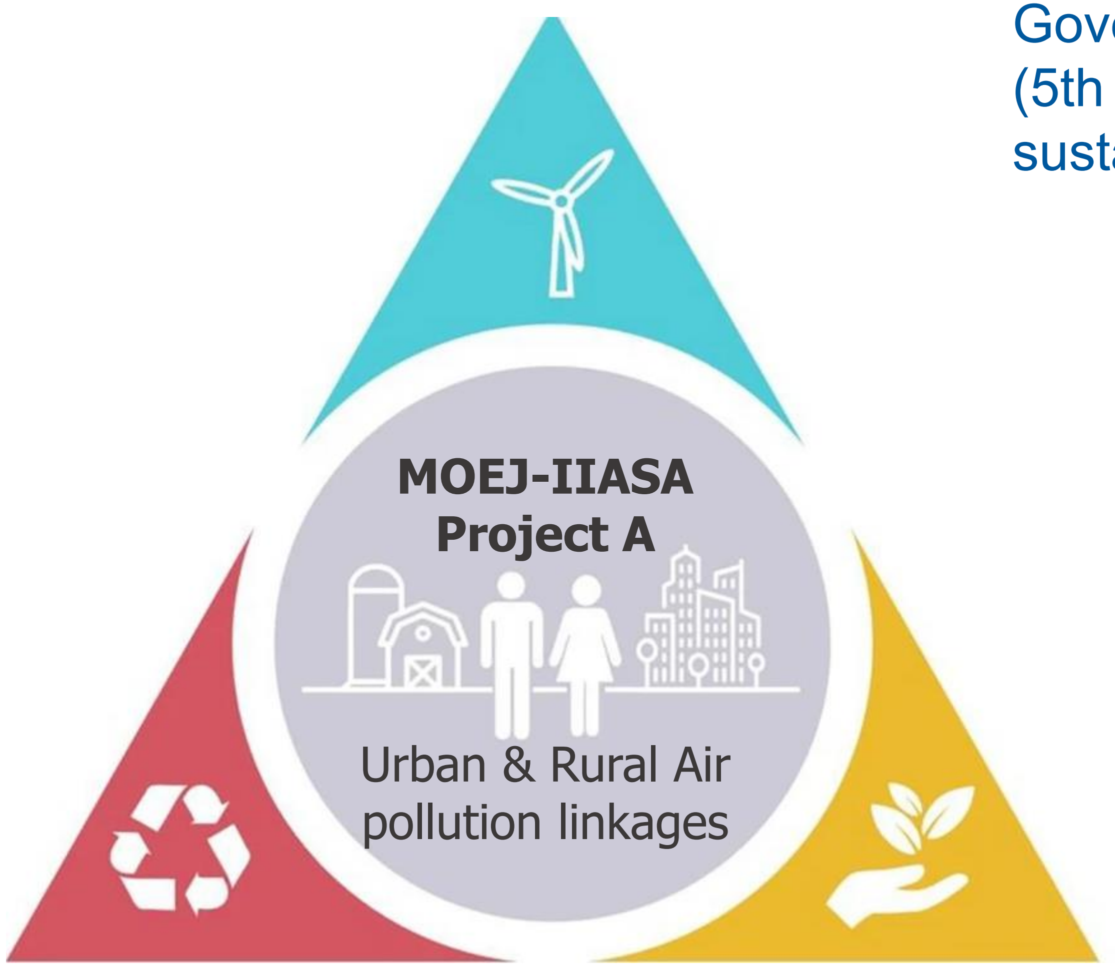
Zbigniew Klimont[1], Gregor Kiesewetter[1], Shinichiro Fujimori[2]

[1] Energy, Climate and Environment program, IIASA, Austria
[2] Kyoto University and NIES, Japan

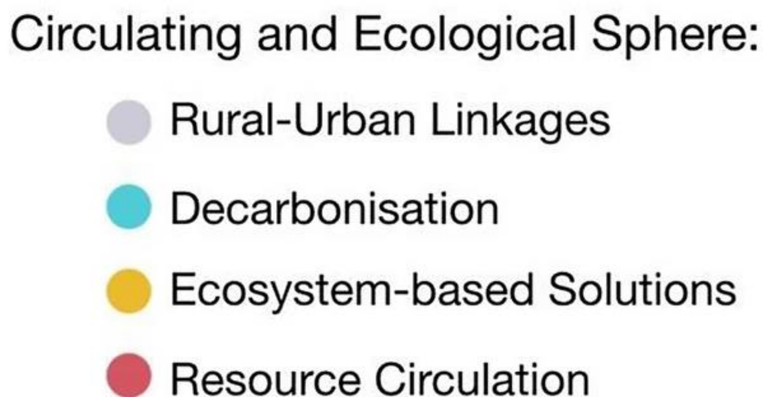
BAQ Conference, Manila, November 15-17, 2022

National Institute for Environmental Studies, Japan

Japan's Circulating and Ecological Sphere (CES)

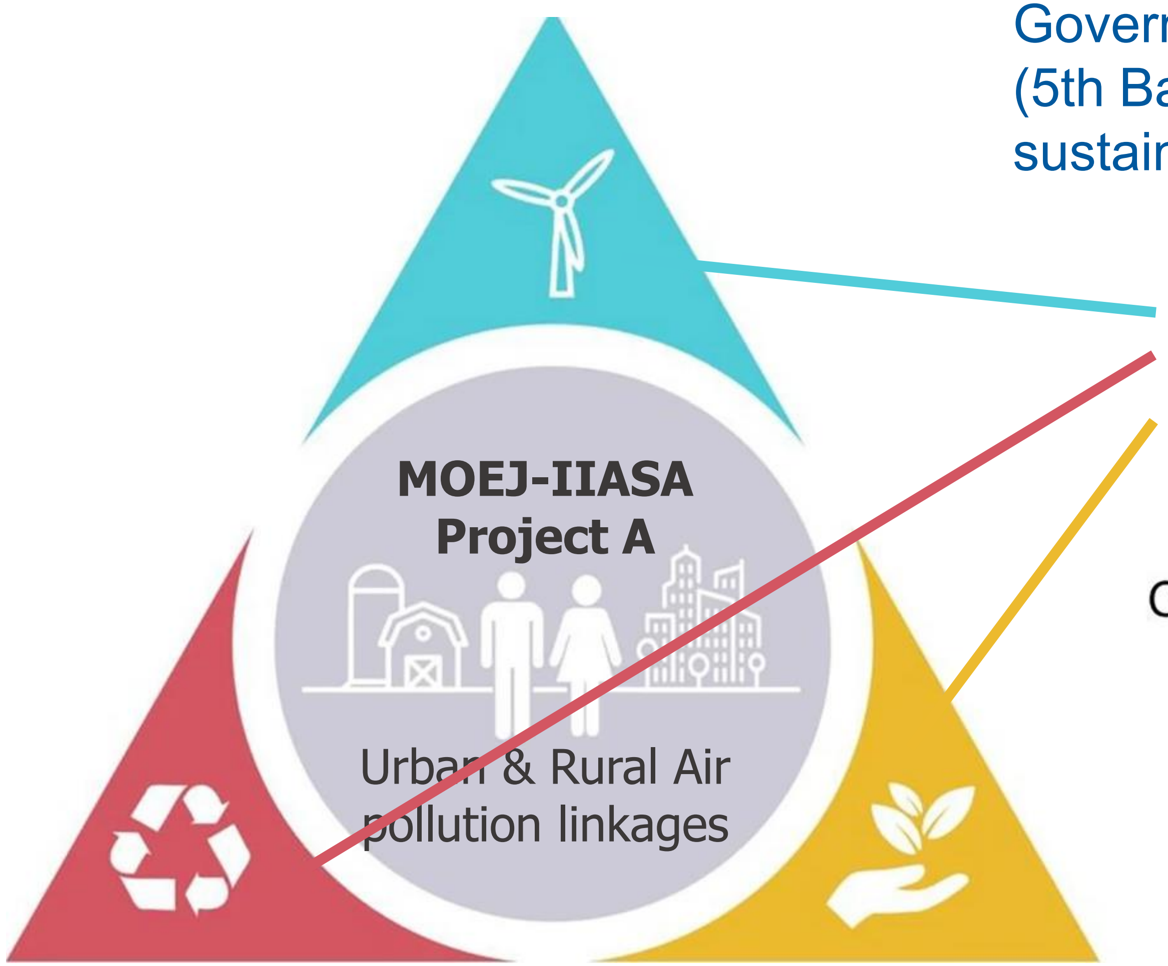


Government of Japan proposed CES concept (5th Basic Environmental Plan) to guide sustainable transition in light of the SDGs



Japan's Circulating and Ecological Sphere (CES)

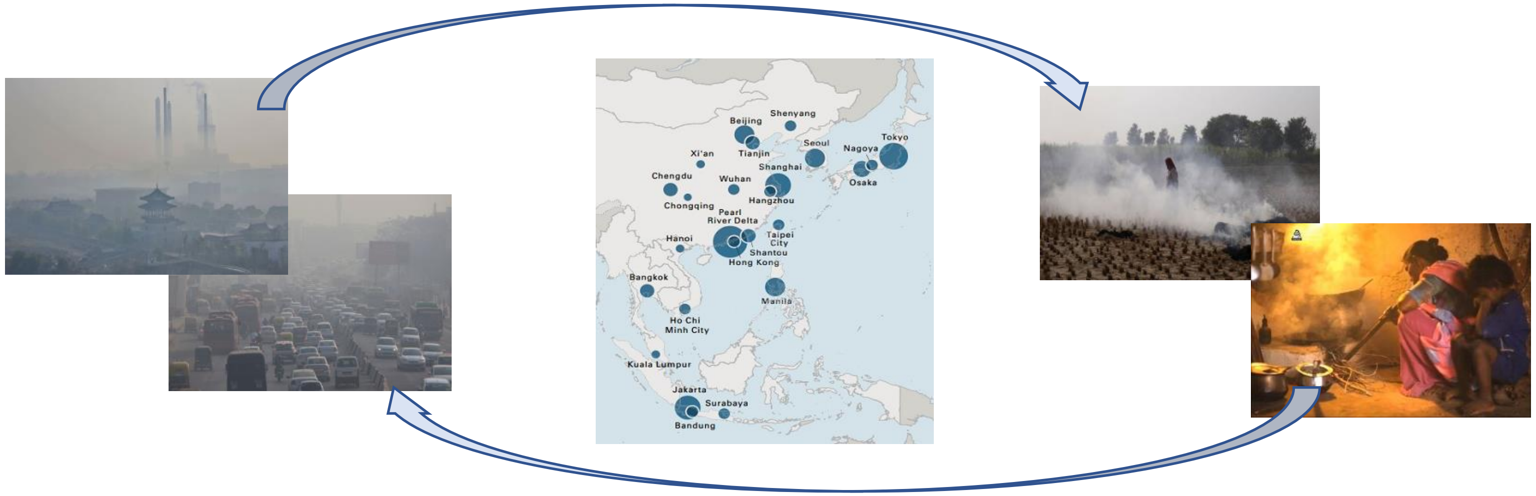
Government of Japan proposed CES concept (5th Basic Environmental Plan) to guide sustainable transition in light of the SDGs



MOEJ-IIASA Project B
Climate resource / air pollution link
Climate / biodiveristy links in Asia

Circulating and Ecological Sphere:

- Rural-Urban Linkages
- Decarbonisation
- Ecosystem-based Solutions
- Resource Circulation



Air pollution in Asia is mainly perceived as an urban issue, because largest pollution levels are typically measured within cities. However, it is found that **in most cities a large share of $PM_{2.5}$ originates from sources outside the cities**. Coordination and cooperation among authorities beyond city boundaries is indispensable.

This work identifies and assesses interdependencies between urban and rural air pollution in Asia and highlights the air quality benefits from regionally and internationally coordinated response action

Collaboration and exchange with scientific institutions/programs in Japan (IGES, NIES, ACAP, JTCAP, EANET, Kyoto University)

Update of the atmospheric calculation in GAINS* model

Dispersion modelling method for this project

- Linear approximations of responses of ambient PM2.5 to changes in precursor emissions; computed with the EMEP CTM of the Norwegian Meteorological Institute
- 100 source regions in Asia, region to grid, based on 15% reduction runs
- Meteorological year: 2018

❑ For secondary PM precursors (SO_2, NO_x, NH_3, VOC):

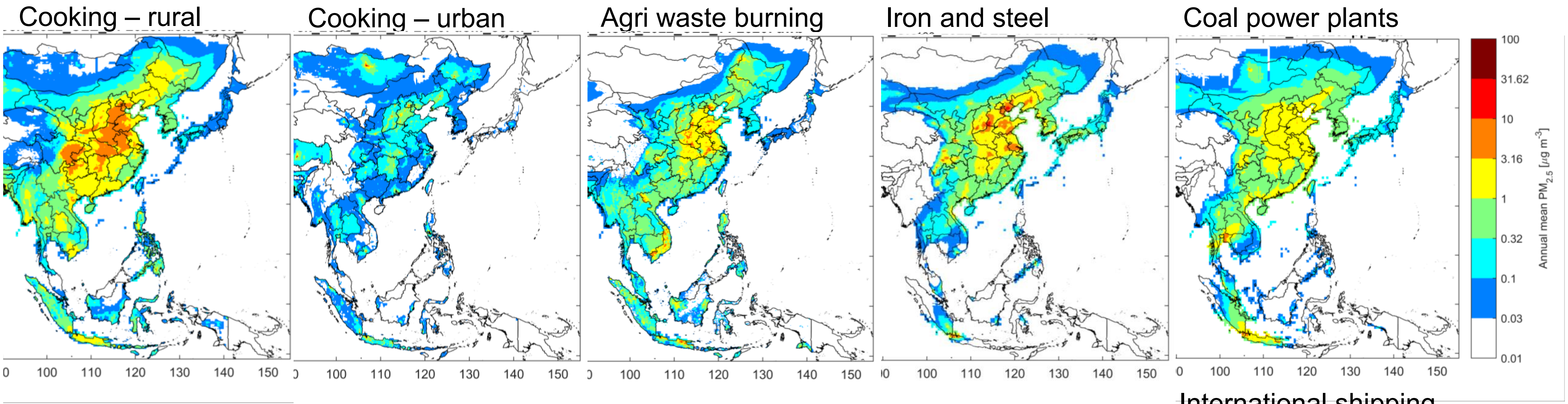
  Spatial resolution 0.5^o x 0.5^o

❑ For primary PM2.5: Grid to grid tracking ("local fraction")

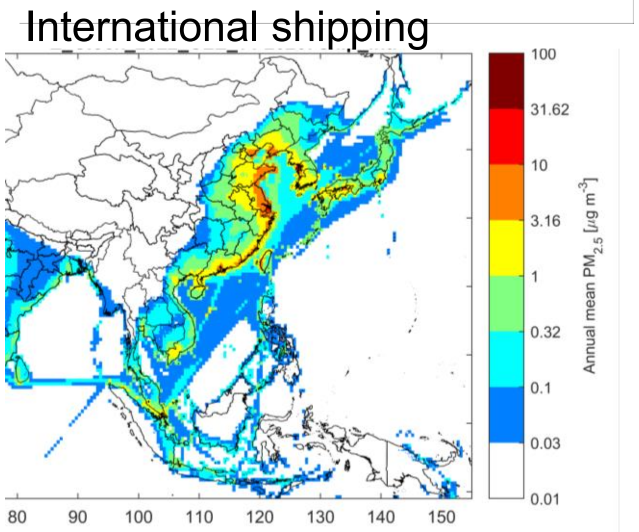
  Spatial resolution 0.1^o x 0.1^o
  Monthly results
  For 4 different source sectors / vertical layers (can be mixed as needed)

* GAINS – Greenhouse gas and Air pollution INteractions and Synergies model (https://gains.iiasa.ac.at/models/gains_models4.html)

Selected examples of source contributions to ambient $PM_{2.5}$

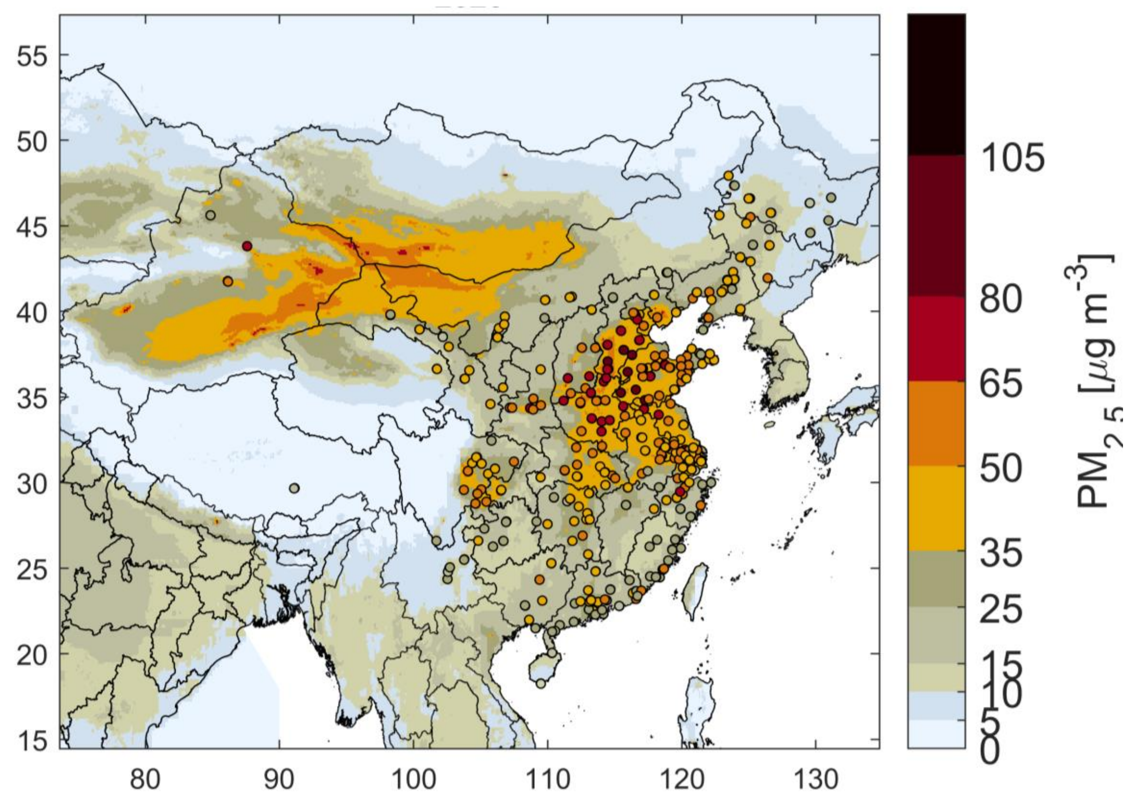


Development of source specific contributions across East Asia served evaluation of data and model validation, also at the city level. The model considers about 50 emission/source layers and contributions are calculated including both primary and secondary particulate matter.

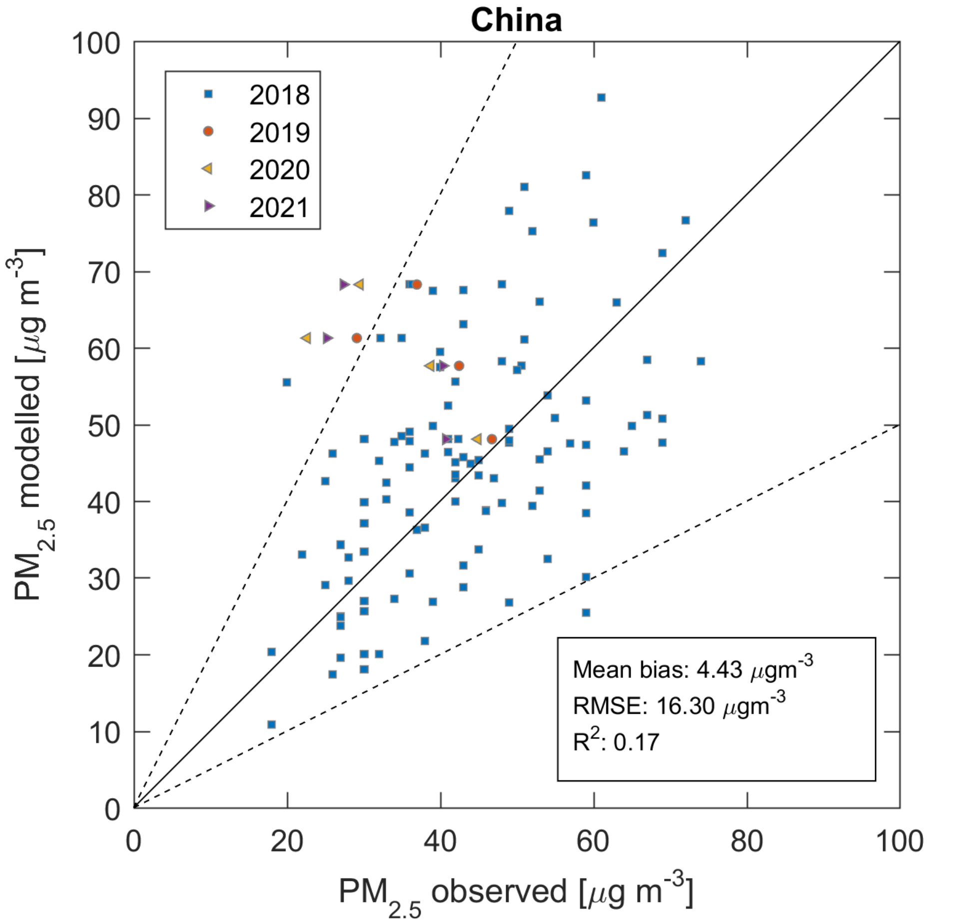


Source: GAINS model (IIASA)

Validation: Ambient $PM_{2.5}$ for 2019



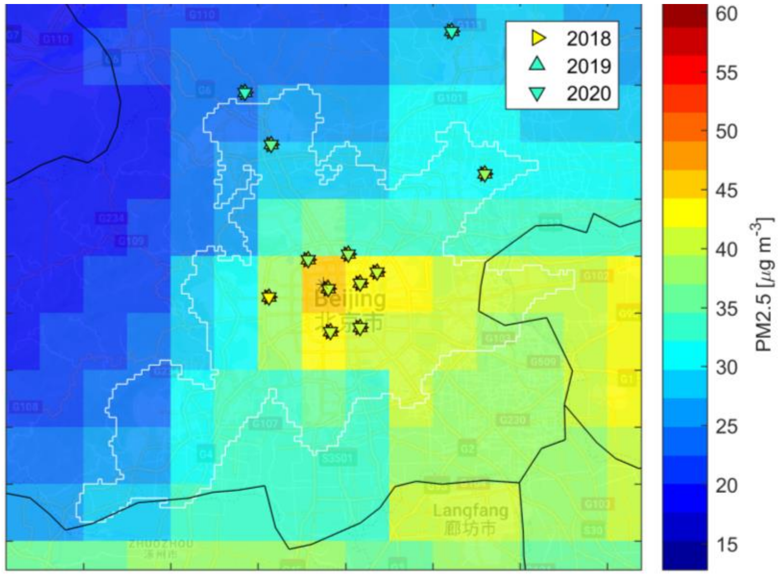
Comparison to observations for China (statistical yearbook)



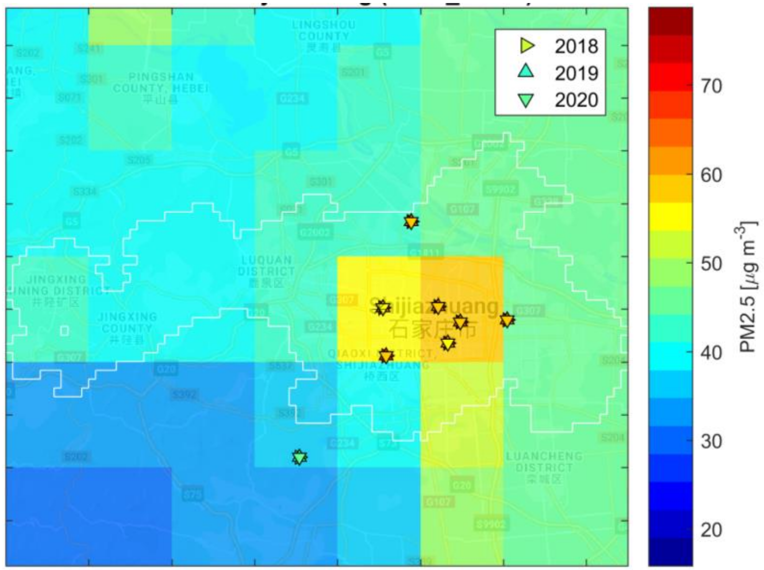
Source: GAINS model (IIASA)

Validation of GAINS model against measurements; few examples

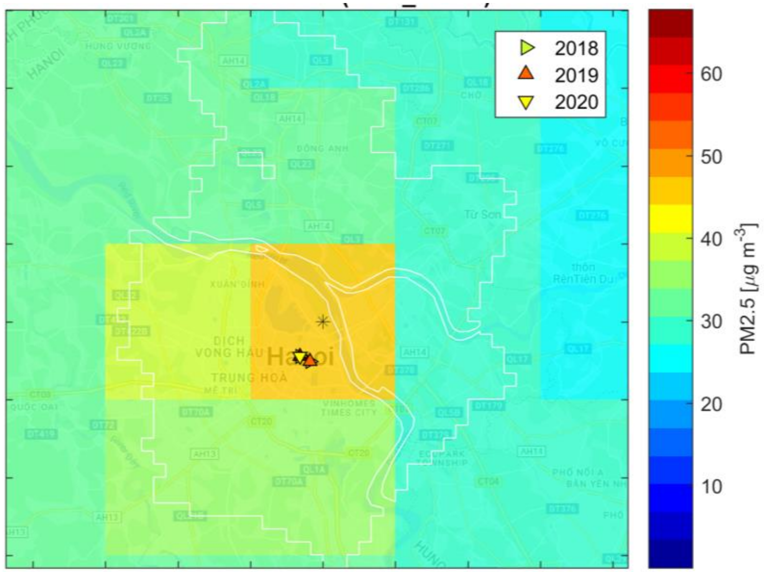
Beijing, China



Shijiazhuang (Hebei), China



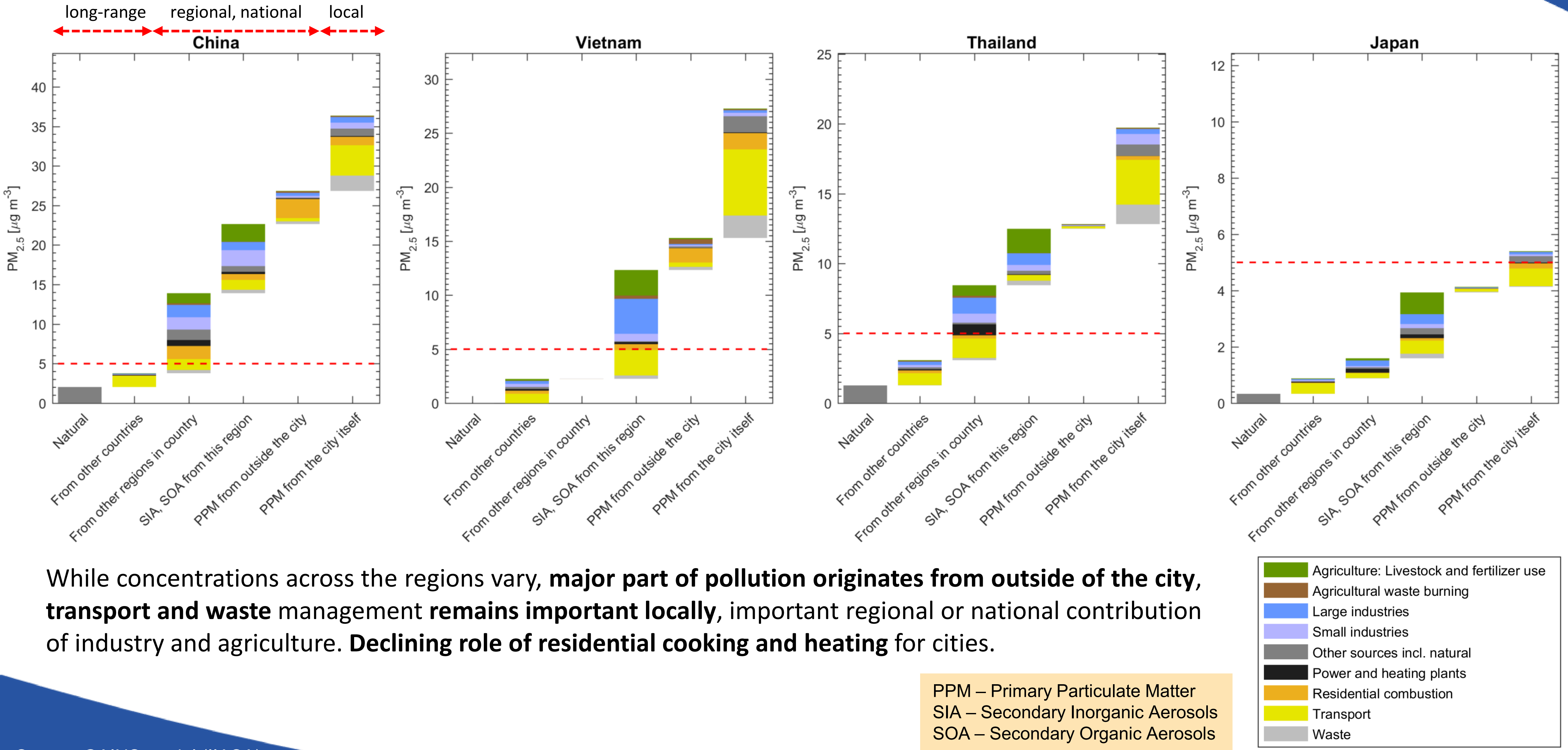
Hanoi, Vietnam



Such comparisons have been done for all cities >100,000 inhabitants where measurement data exists, i.e., is publicly accessible. These are GAINS grid averages calculated for 2020 compared to station values for given years. Obviously, not all comparisons look perfect, but the model allows for work on specific input data analyzing inputs and policy assumptions as well as spatial distribution to improve the match.

Source: GAINS model (IIASA)

$PM_{2.5}$ Source apportionment for cities > 500,000 inhabitants in selected countries; calculation for 2020



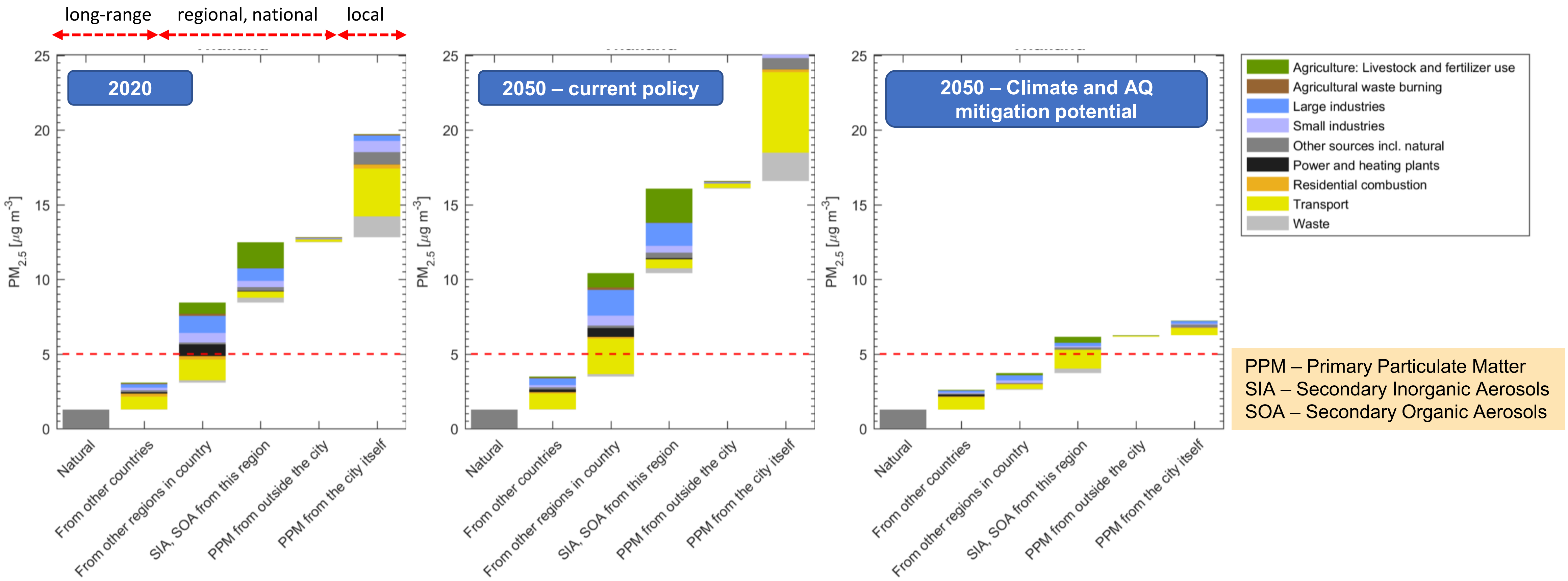
While concentrations across the regions vary, **major part of pollution originates from outside of the city**, **transport and waste** management **remains important locally**, important regional or national contribution of industry and agriculture. **Declining role of residential cooking and heating** for cities.

PPM – Primary Particulate Matter
SIA – Secondary Inorganic Aerosols
SOA – Secondary Organic Aerosols

Source: GAINS model (IIASA)

Example:

$PM_{2.5}$ source apportionment for Thailand cities > 500,000 inhabitants

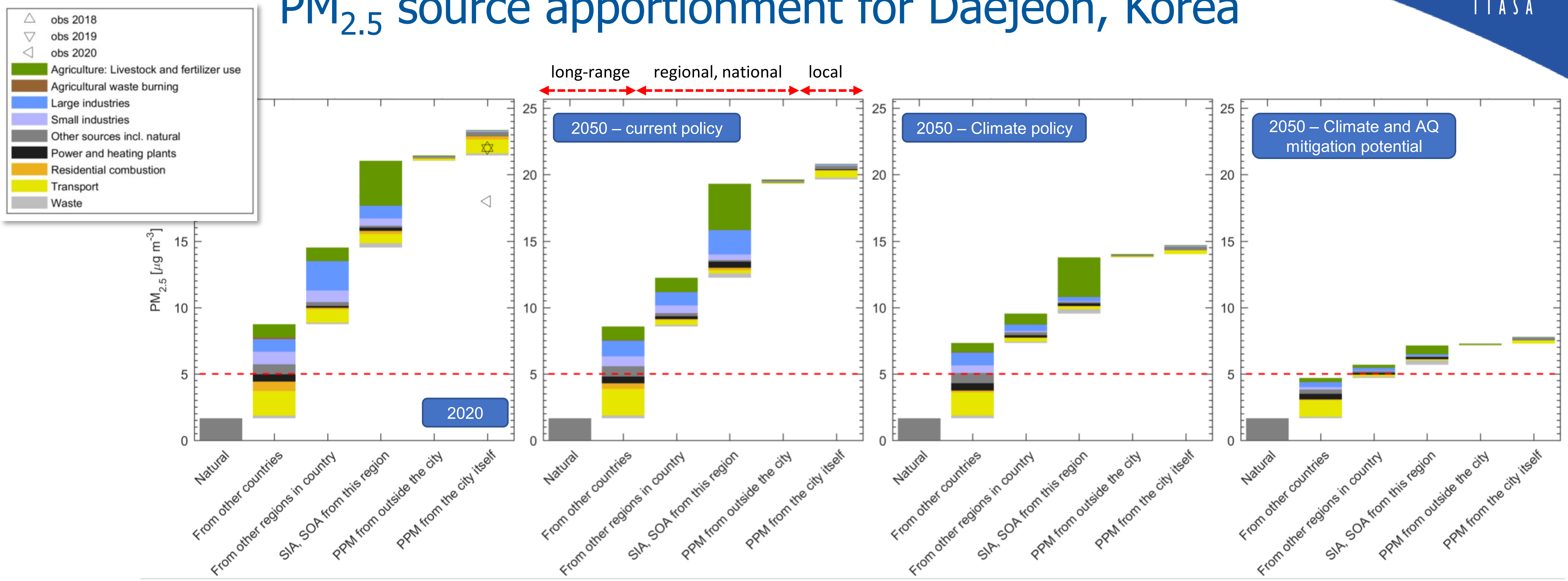


In many countries, **current policies appear often not sufficient t**o significantly, or not at all, **reduce urban PM2.5 concentrations** in the future. While role of local pollution will vary across cities and regions, sizable reduction can be only achieved in collaboration with regional and national stakeholders. Effective implementation of proven air quality measures will be typically sufficient to achieve WHO Tier I and/or national standards, while WHO guidelines would require climate policies and further structural and behavioral changes.

Source: GAINS model (IIASA)

Example:

$PM_{2.5}$ source apportionment for Daejeon, Korea



PPM – Primary Particulate Matter
SIA – Secondary Inorganic Aerosols
SOA – Secondary Organic Aerosols

Current policies provide only a small reduction of concentrations but guard against increase with economic growth. Transboundary component remains fairly constant and large; role of agriculture increases

Climate policies could bring about 25% reduction of concentrations; local potential exploited; agriculture and transboundary contribution dominates

Addressing also full air quality mitigation potential across the region, including structural and/or behavioral changes, could bring concentration close to the 2021 WHO AQG

Source: GAINS model (IIASA)

Conclusions/Recommendations

More than half of the measured ambient $PM_{2.5}$ concentrations in the city originates often from **sources outside of the cities**

Ambitious air quality, climate and development policies offer **further mitigation potential** that can be pursued **at local, regional, national and international** level

To achieve significant **reductions in urban exposure** and improve effectiveness of future policies, **cooperation and coordination across jurisdictions** will be essential, i.e., with neighboring states/provinces as well as with national governments

Effective **implementation of proven AQ measures** will be **sufficient to achieve WHO Tier I** guideline and/or national standards

Conclusions
(few more detailed observations)

The importance of local sources varies depending often on enforcement of policies, especially for transport and waste management

In many urban areas, transport sources continue playing an important role contributing typically 10-40% of PM2.5 concentrations

Many urban areas successfully reduced use of solid fuels for cooking and heating (not as widespread success for waste management yet) but in some regions rural cooking represents an important contribution to urban air pollution

For many cities, industrial sources located within the same region or country contribute an important share of concentrations, i.e., about 5-20%, but very variable for single cities

Agricultural sources are typically not representing major contribution yet, but their role increases in the future since policies are lacking

Developed modelling capacity and results of this analysis have been used in collaborative projects with partners in Asia, also exploring implementation aspects, multi-stakeholder strategies, including scope for international collaboration (e.g., study for ASEAN)