Study by the JRC on the impact of emission precursors on air quality in the Po Basin

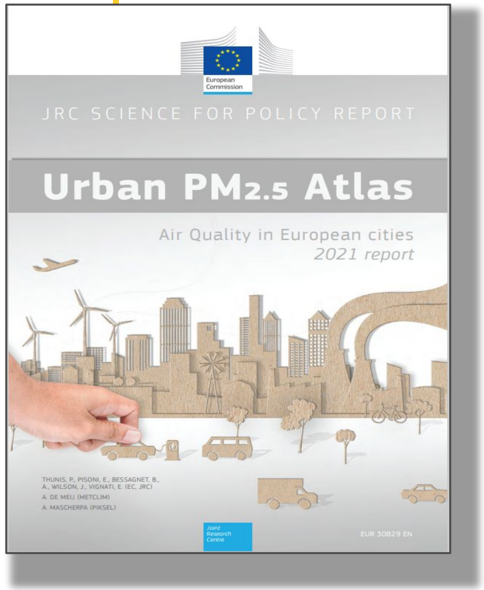
A. de Meij, P. Thunis

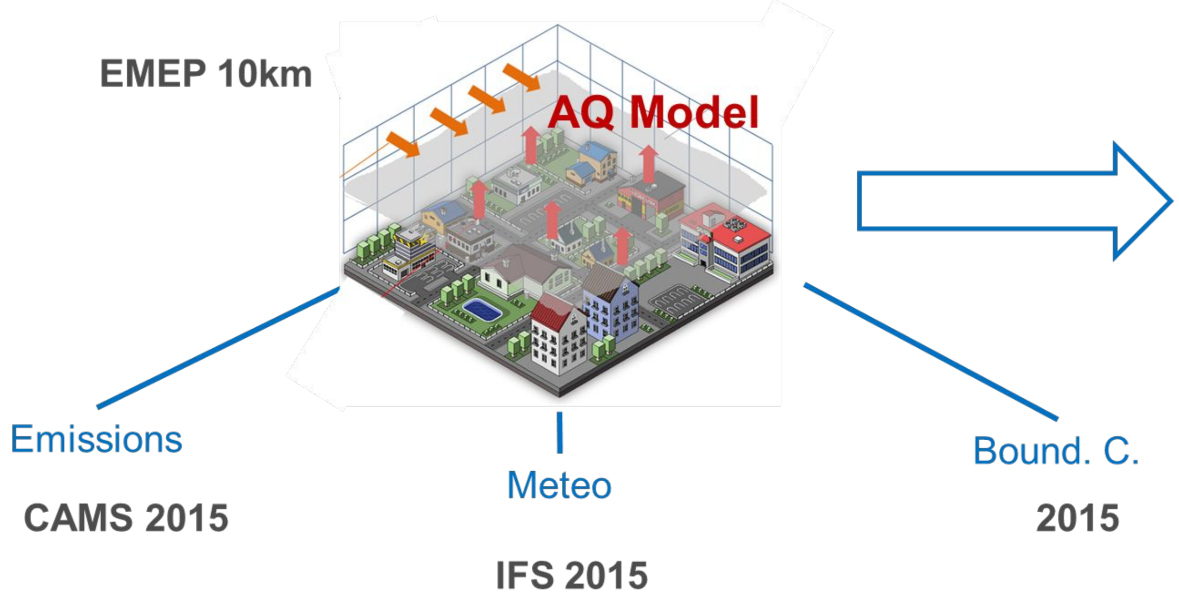
PrePair meeting, May 5th 2022

Impact of agriculture emissions: a complex issue

European Commission

Sectorial contributions to $PM_{2.5}$ for 150 EU cities





SHERPA

Receptor: - "hot-spot" model grid cell concentration in each city
- Yearly average

Source: - 7 sectors among which agriculture
- 3 main spatial scales (city, country, EU)

https://publications.jrc.ec.europa.eu/repository/handle/JRC126221

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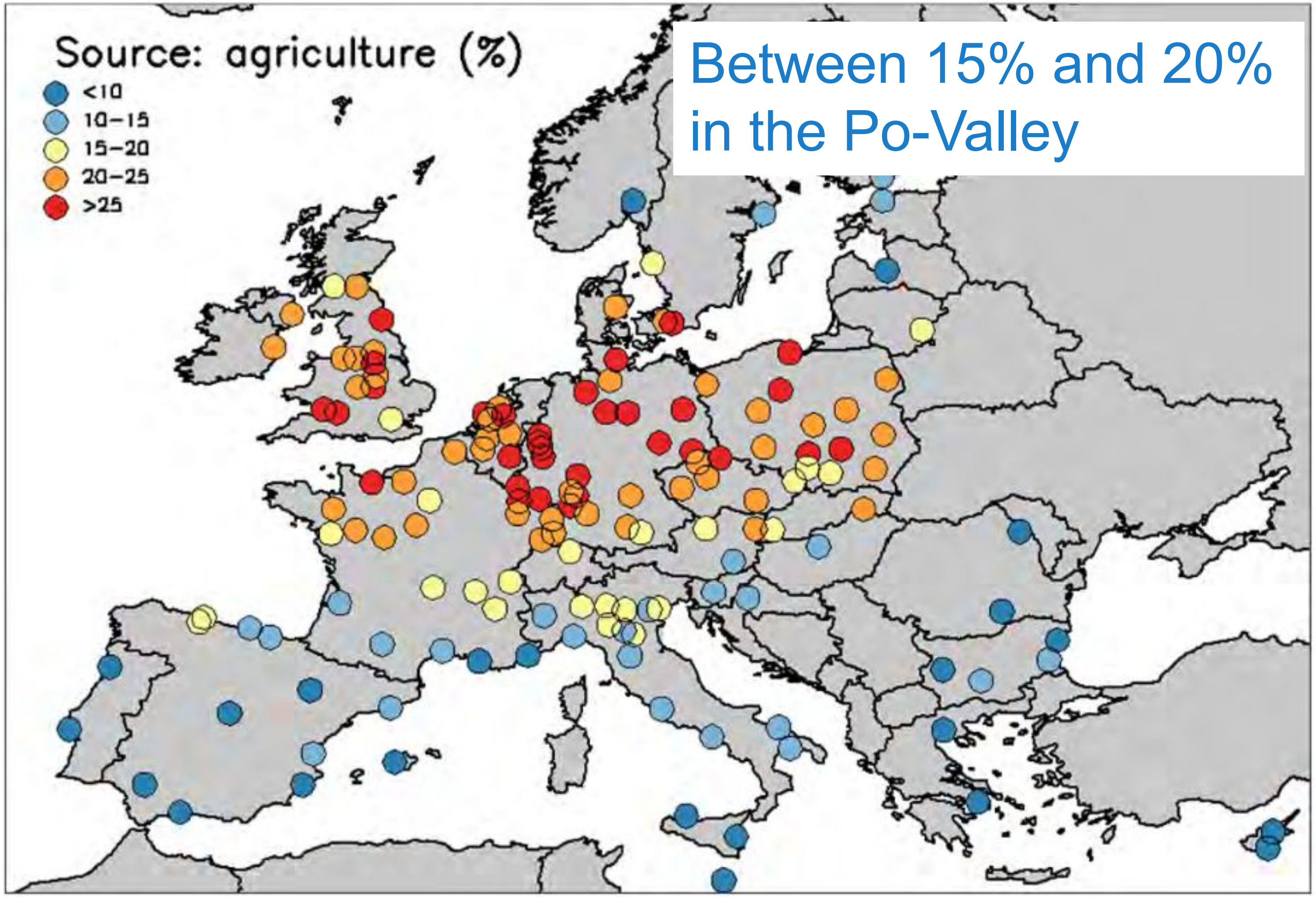
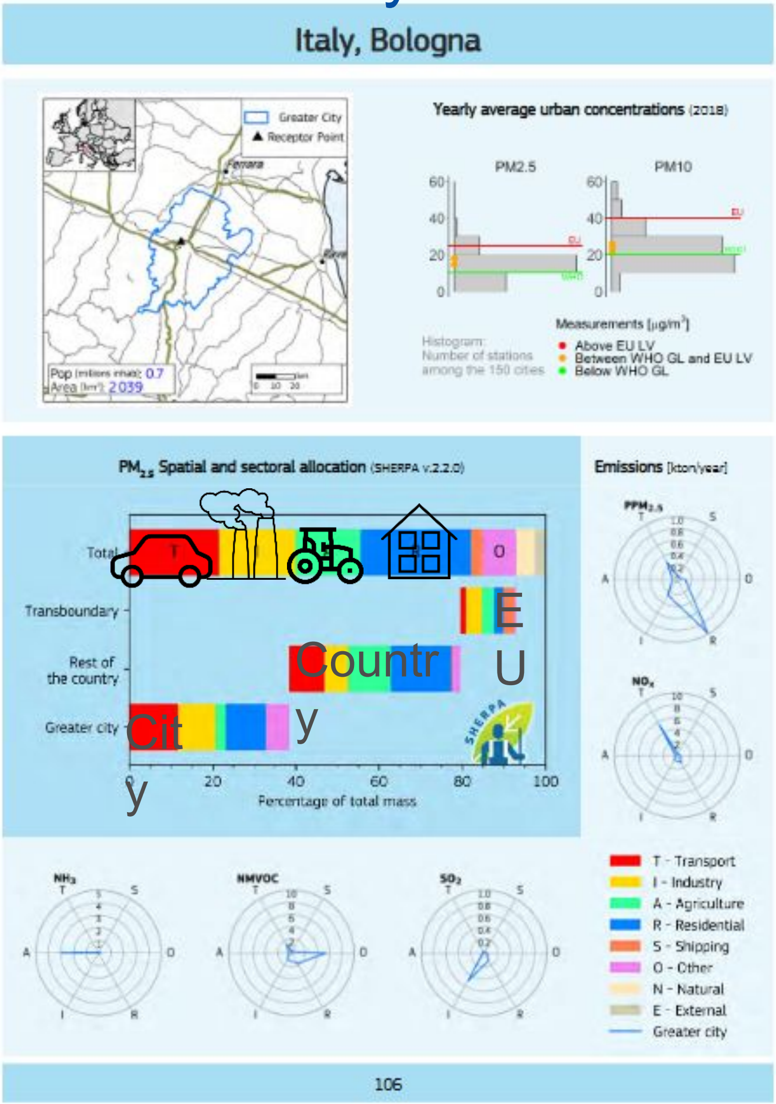
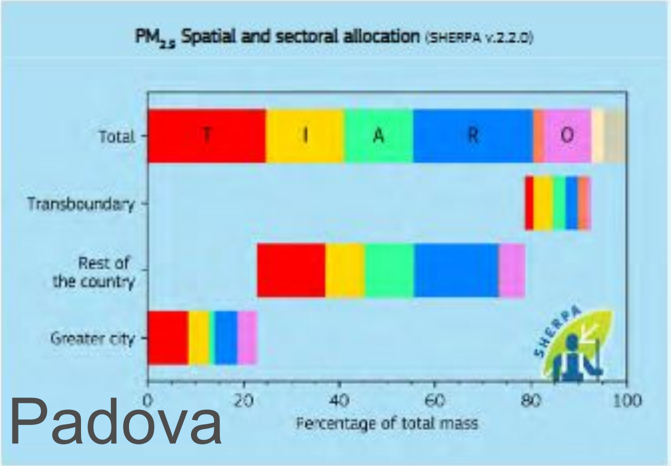
Average contribution from agriculture

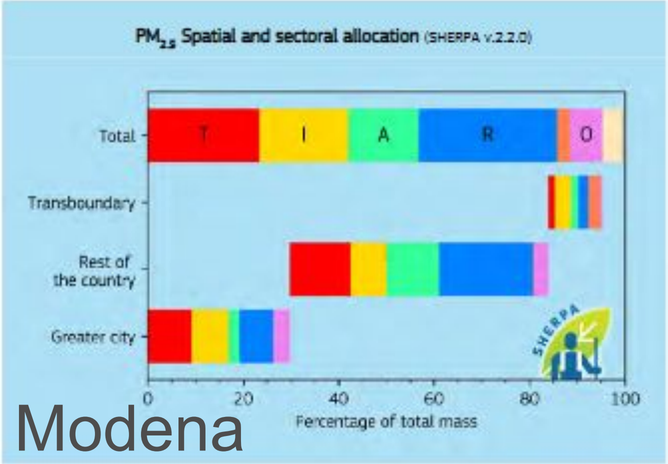


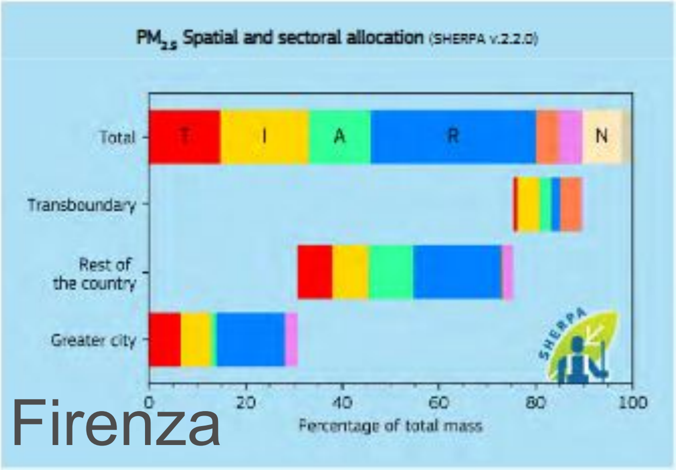
Between 15% and 20% in the Po-Valley

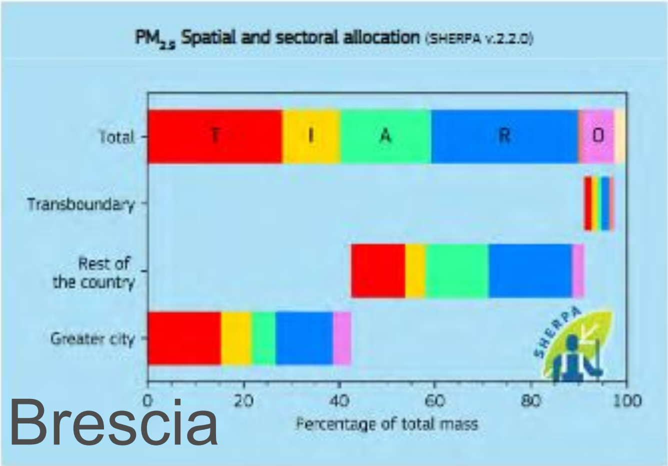
150 City fiches

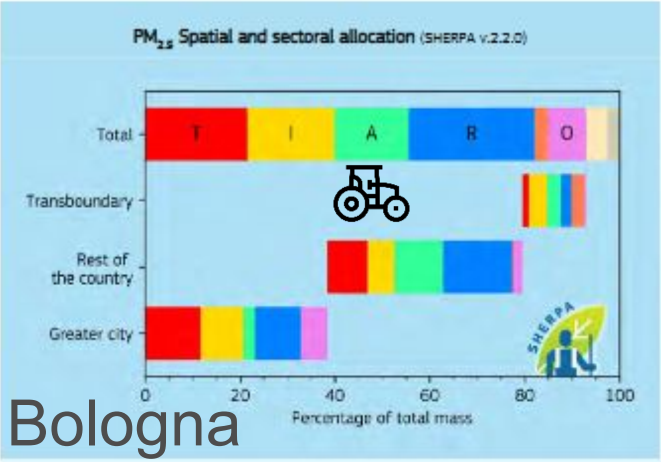


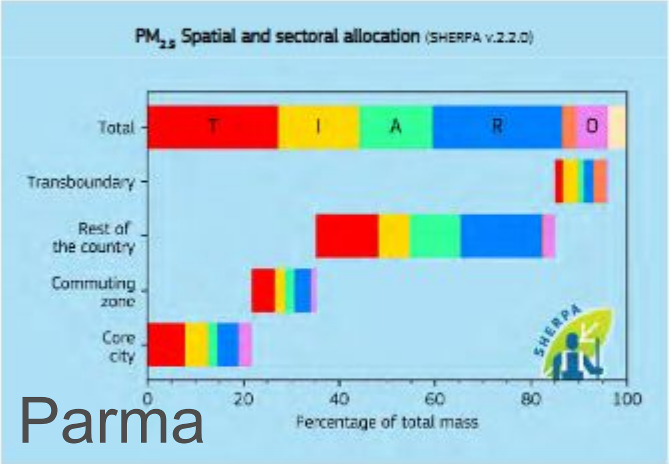


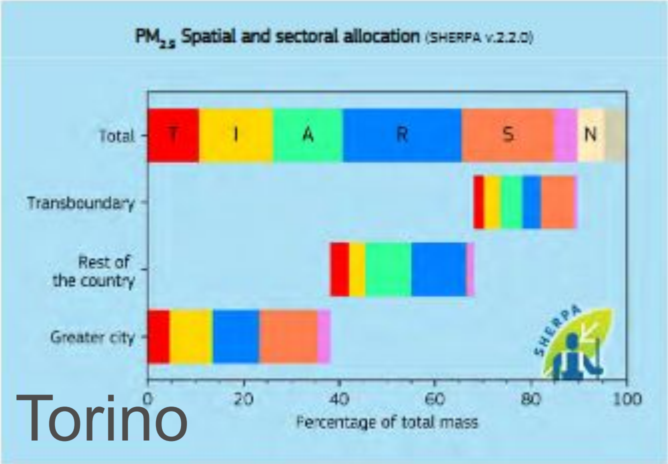


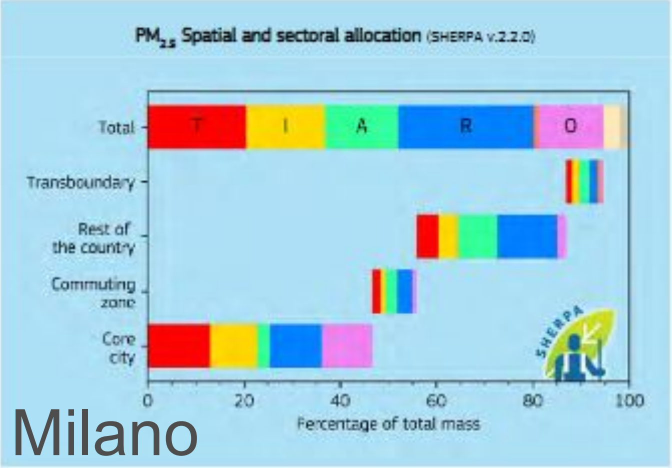


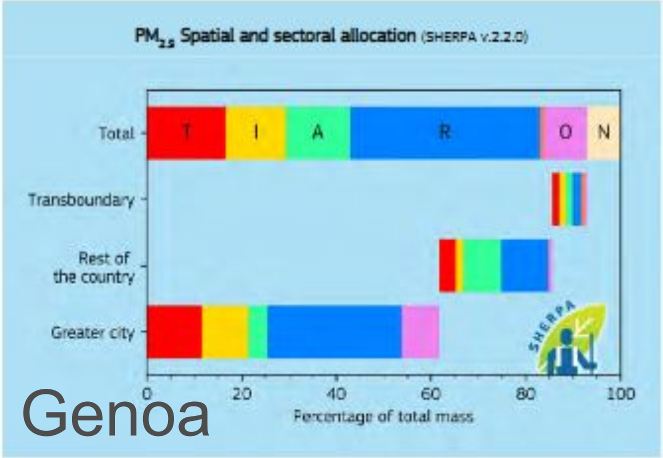












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$PM_{2.5}$ Atlas main conclusions

1. Target or key sectors and scales to abate air pollution are city specific
2. For many cities, sectoral measures addressing agriculture at country or EU scale would have a clear benefit on urban air quality. Agriculture contributes to more than 25% of the air pollution in about 20% of the cities and to more than 20% in 50% of them.
3. For many cities, local actions at the city scale are an effective means of improving air quality. About 30% of the cities contribute to at least 40% of their pollution and about 50% contribute to more than 30% of their pollution.
4. Because of methodological choices and assumptions, the responsibility of a city in generating its air pollution is often underestimated.

Why is the city's responsibility for its air pollution often underestimated? A focus on PM2.5.
Thunis P., Clappier A., de Meij A., Pisoni E., Bessagnet B., Tarrason L., ACP 2021

Impacts of NH_3/NO_x emissions on $PM_{2.5}$ and associated non-linearities

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Environment International
Volume 156, November 2021, 106699

Impact of SO_x, NO_x and NH_3 emission reductions on $PM_{2.5}$ concentrations across Europe: Hints for future measure development

A. Clappier [a], P. Thunis [b], M. Beekmann [c], J.P. Putaud [b], A. de Meij [d]

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Non-linear response of $PM_{2.5}$ to changes in NO_x and NH_3 emissions in the Po basin (Italy): consequences for air quality plans

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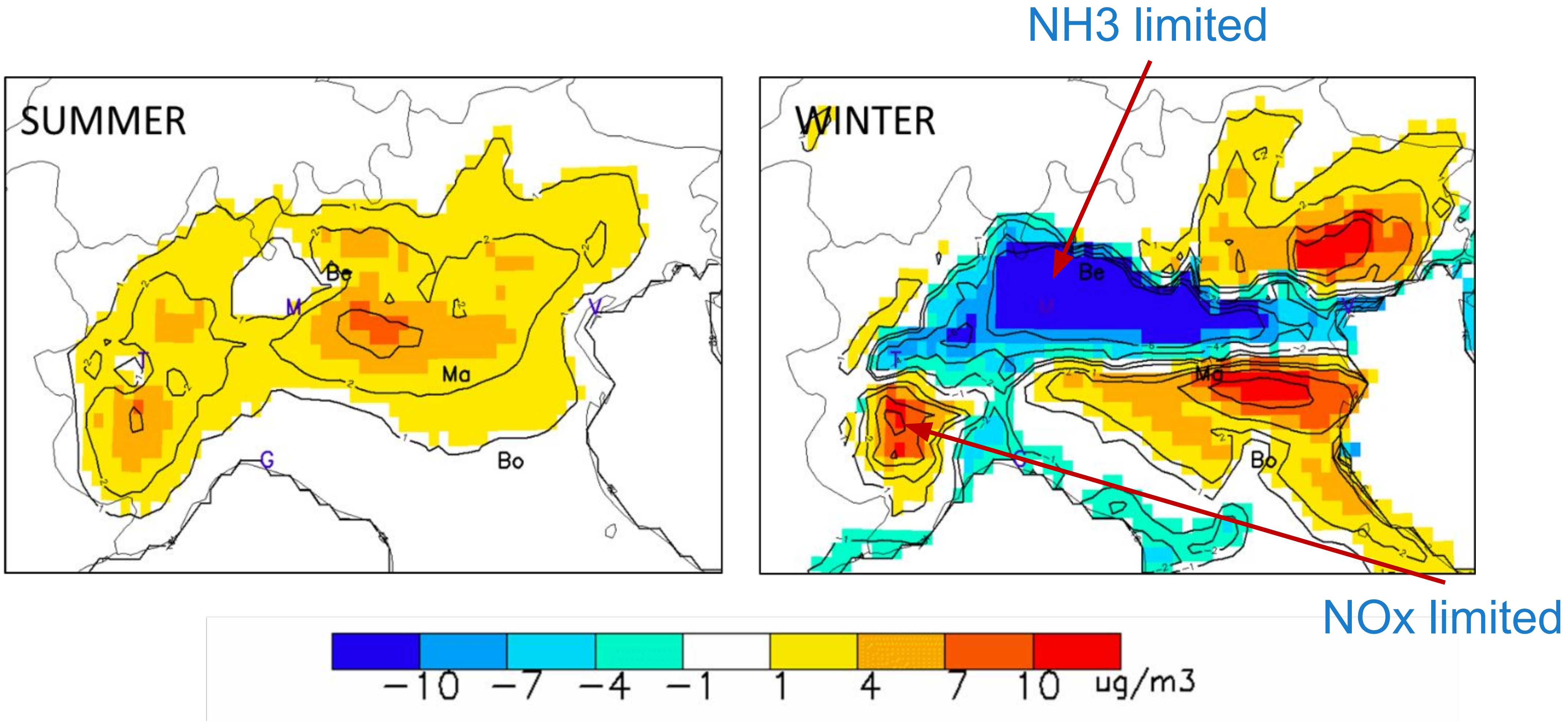
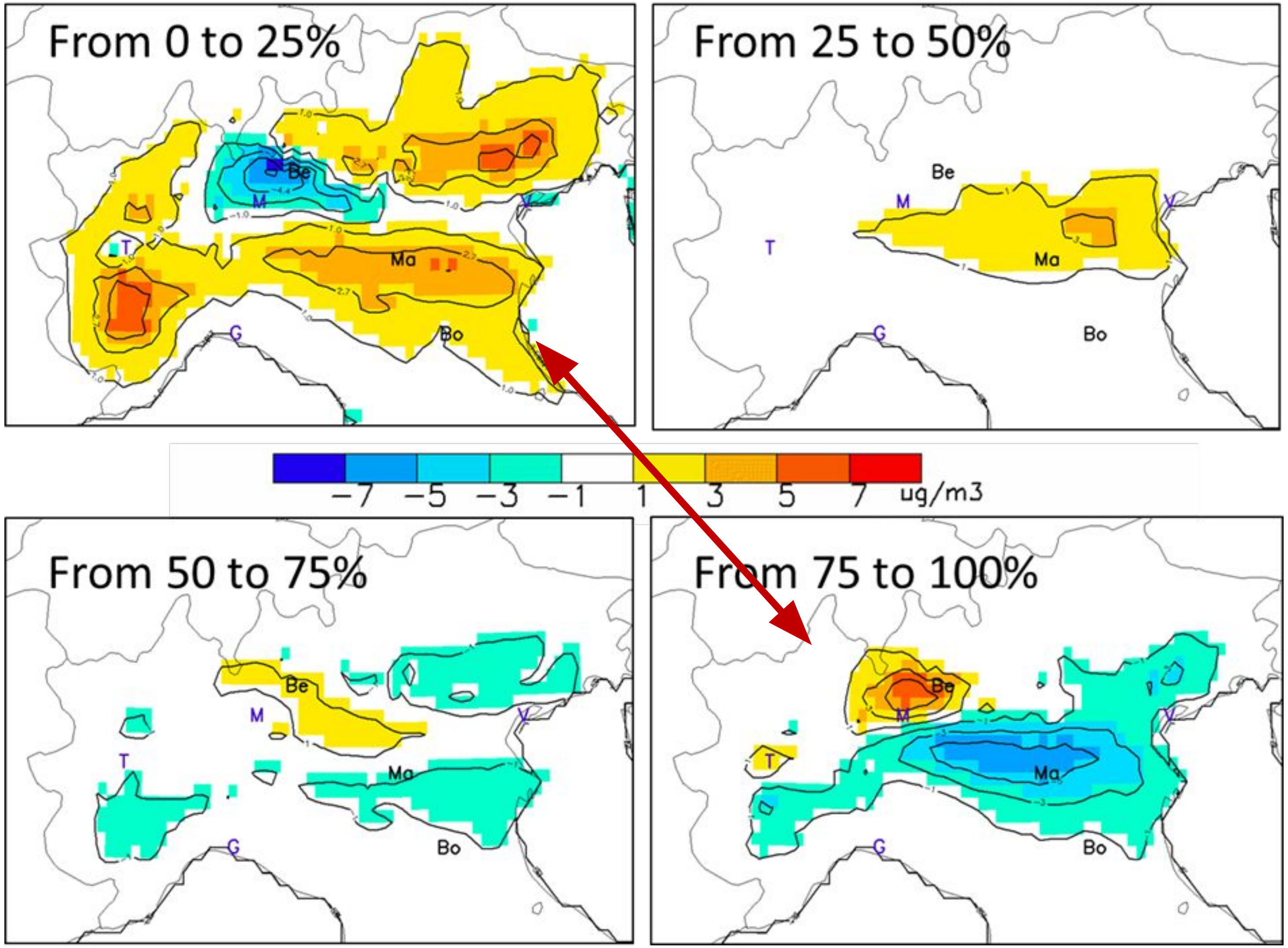
- Focus on the Po basin, a region where chemical regimes are the most complex, showing important non-linear processes, especially those related to interactions between NO_x and NH_3.
- Analyse the sensitivities of $PM_{2.5}$ to NO_x and NH_3 emissions by means of a set of EMEP simulations performed with different levels of emission reductions, from 25% up to a total switch-off of those emissions.
- Apply single and combined precursor reduction scenarios to determine the most efficient emission reduction strategies and quantify the interactions between NO_x and NH_3 emission reductions

Chemical regimes for moderate (25%) emission reductions

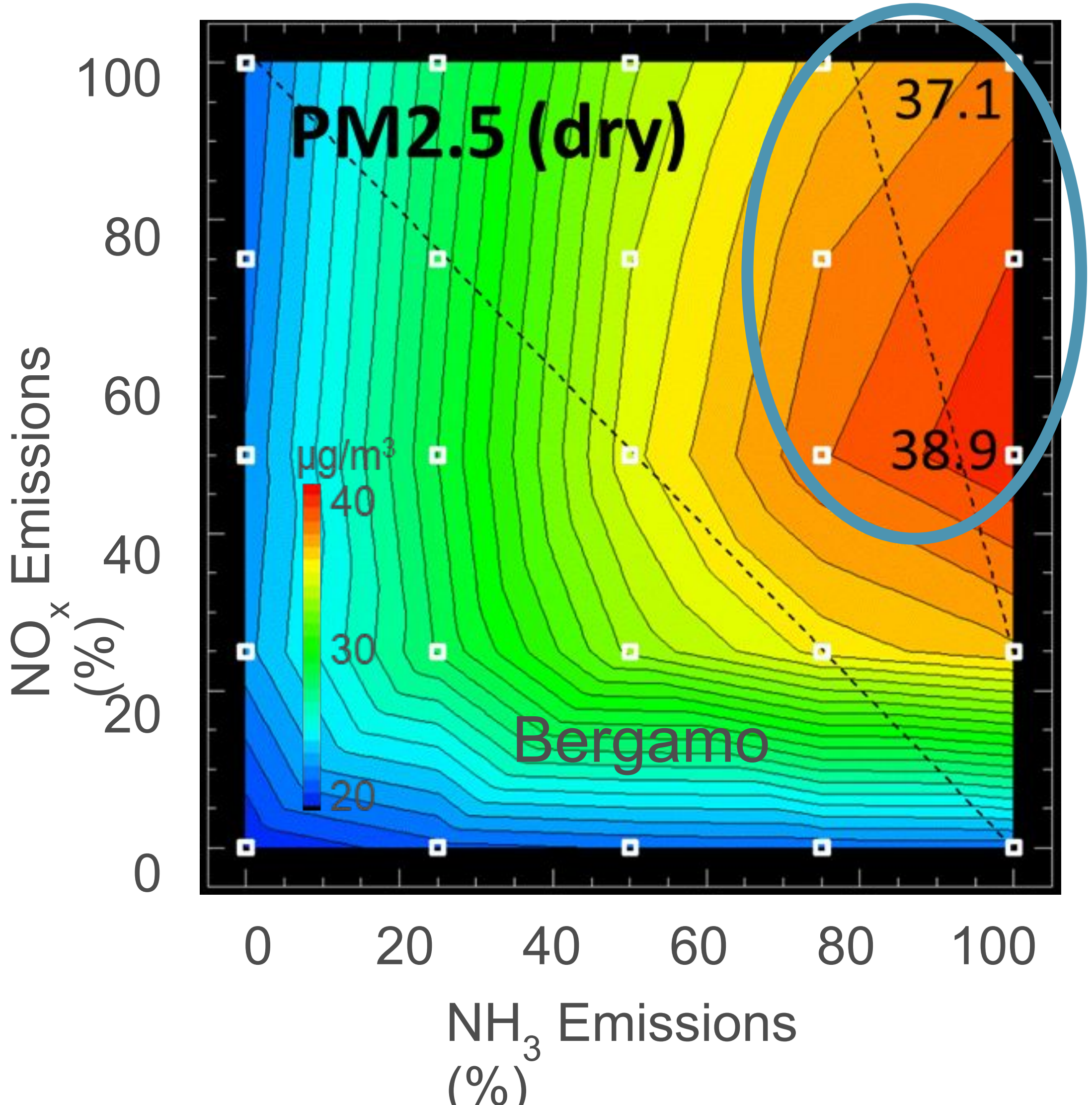


Chemical regimes for larger emission reductions



Note: Inversion of regimes according to the emission reduction strength

Moderate NO_x emission reductions may lead to increased $PM_{2.5}$ concentrations



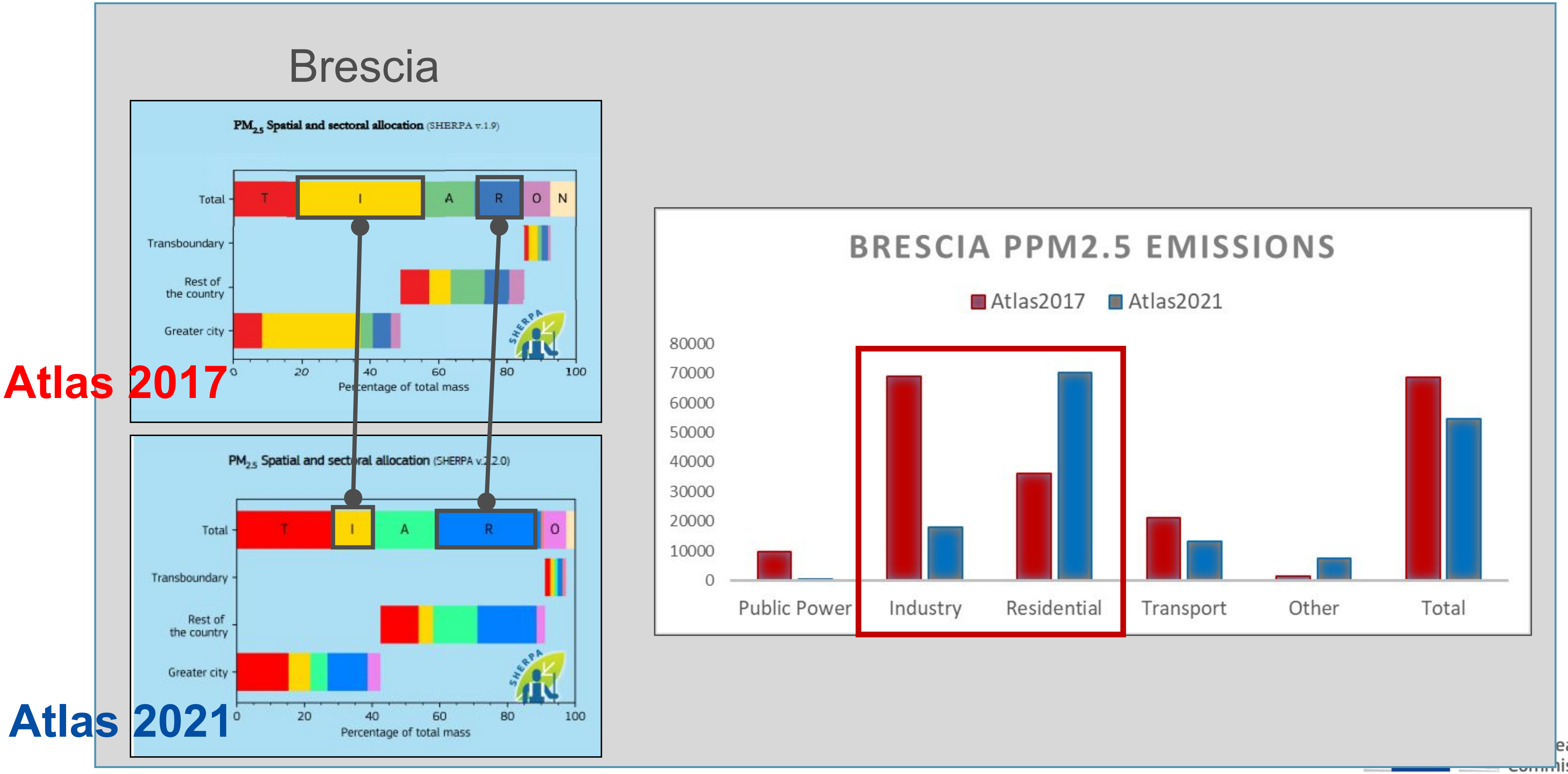
- ✔ The increased oxidative capacity of the atmosphere is the cause of the increase of $PM_{2.5}$ induced by a reduction in NOx emission.
- ✔ This process can have contributed to the absence of significant $PM_{2.5}$ concentration decrease during the COVID-19 lockdowns in many European cities.
- ✔ It is important to account for this process when designing air quality plans, since it could well lead to transitionary increases in $PM_{2.5}$ at some locations in winter as NO_x emission reduction measures are gradually implemented.

Conclusions

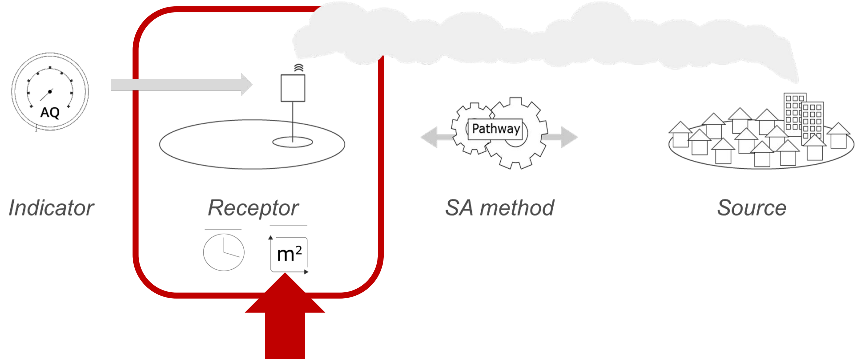
- This work confirms the peculiarity of secondary $PM_{2.5}$ formation in the Po basin, characterised by contrasting chemical regimes within distances of few (hundreds of) kilometres, as well as strong non-linear responses to emission reductions during wintertime.
- One striking result is the increase of the $PM_{2.5}$ concentration levels when NO_x emission reductions are applied in NOx-rich areas, such as the surroundings of Bergamo.
- While PM2.5 responses to NO_x and NH_3 emission reduction show large variations seasonally and spatially, these responses remain close to linear, at least up to -50%.
- It would be important to compare these results with similar results obtained from other models. With its complex setting, the Po basin represents a good test case for such inter-comparisons.

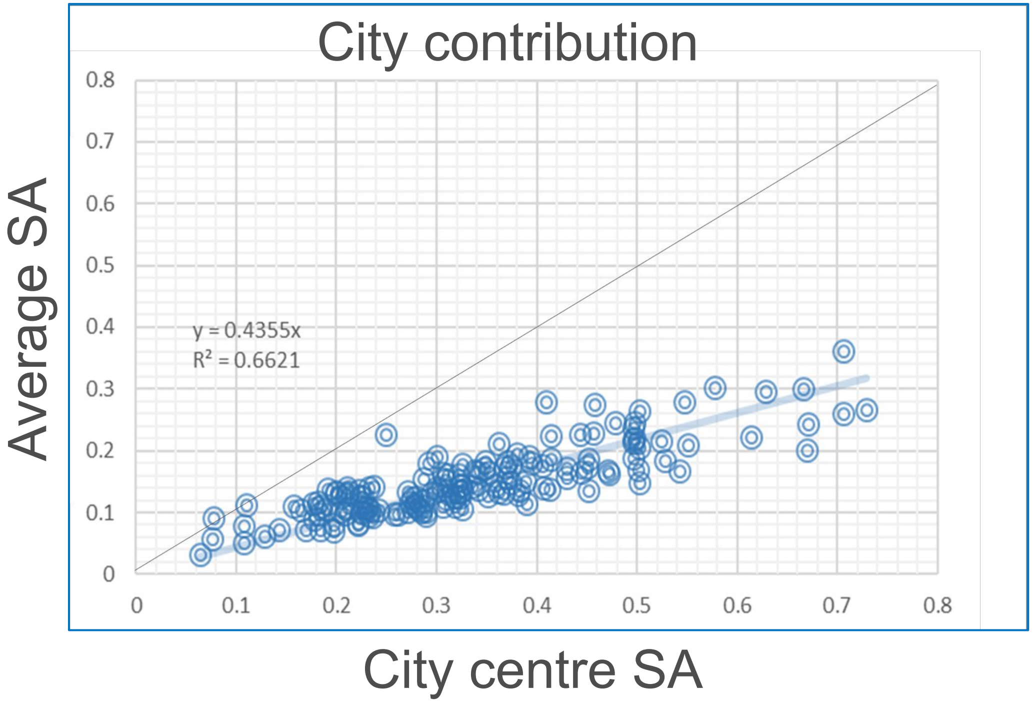
Appendix

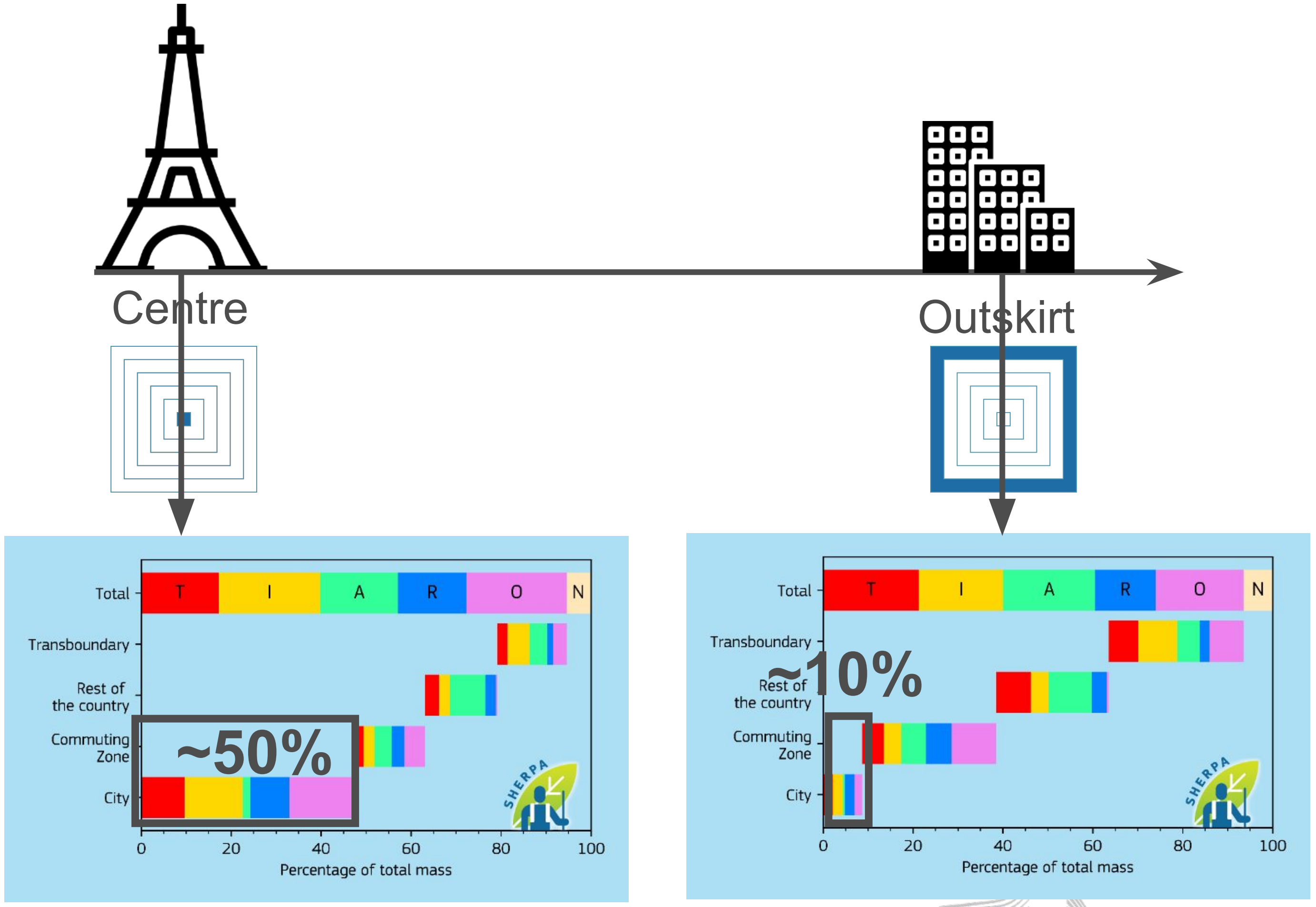
Emission differences: implications for source apportionment



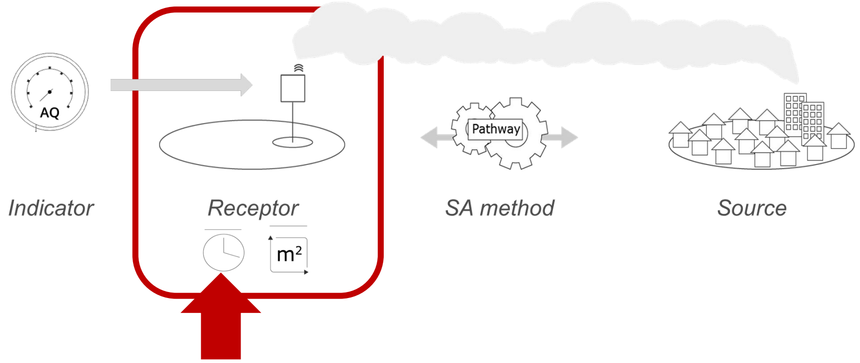
Spatial averaging at the receptor



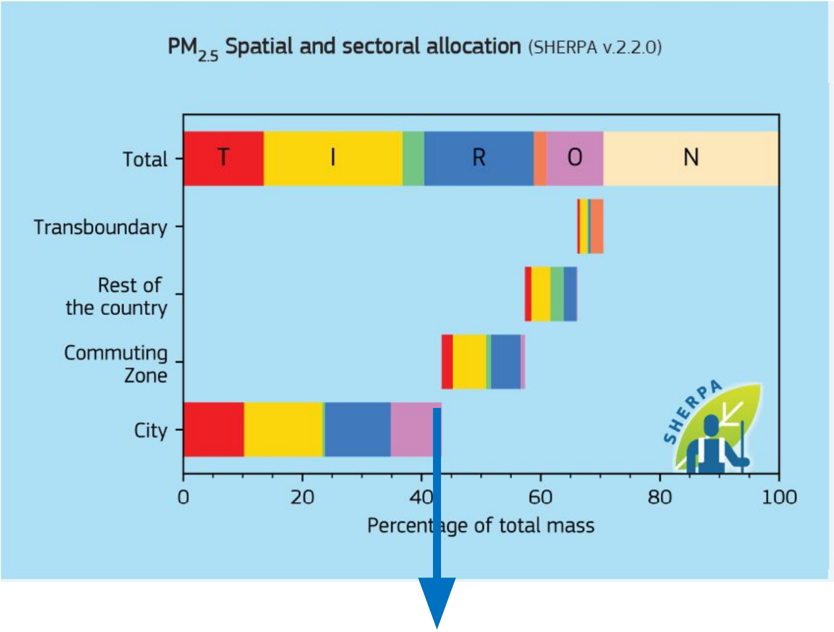




Temporal averaging at the receptor



A new methodology to evaluate the effectiveness of local policies during high PM2.5 episodes: application on 10 European cities. Pisoni, E., Thunis, P., de Meij, A., Bessagnet, B. : Submitted to Atmos. Chem. Phys., 2021



Year: 44%

Summer: 35%

Winter: 75%

Day: 90%

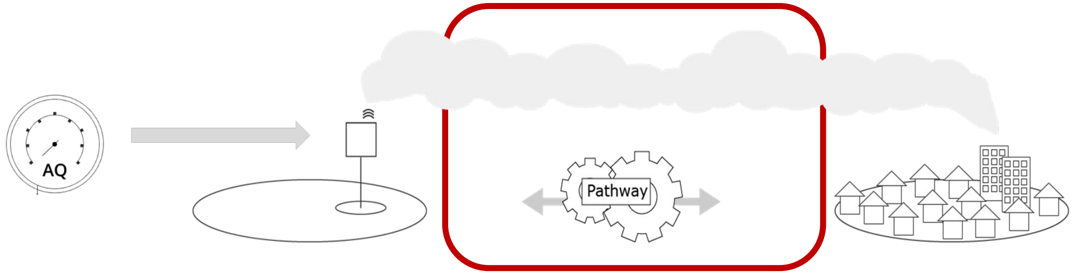
Conclusions

- The Atlas 2021 confirms the findings of 2017
  - Local actions are efficient in most cities
  - Abating agriculture emissions is an efficient way to improve urban air quality
  - City specificities must be considered when designing air quality plans
  - Methodological choices can often lead to underestimating the city responsibility on its air quality
- Emissions are the crucial input to source apportionment, but yet a very uncertain input. Hence the need to improve their robustness. (FAIRMODE QA/QC process)

Thank-you

European Commission

SA Method



EMEP 10km

SHERPA

Emissions

CAMS 2015

Meteo

IFS 2015

Bound. C.

2015