European Commission

On the validity of the incremental approach to calculate the impact of cities on air quality

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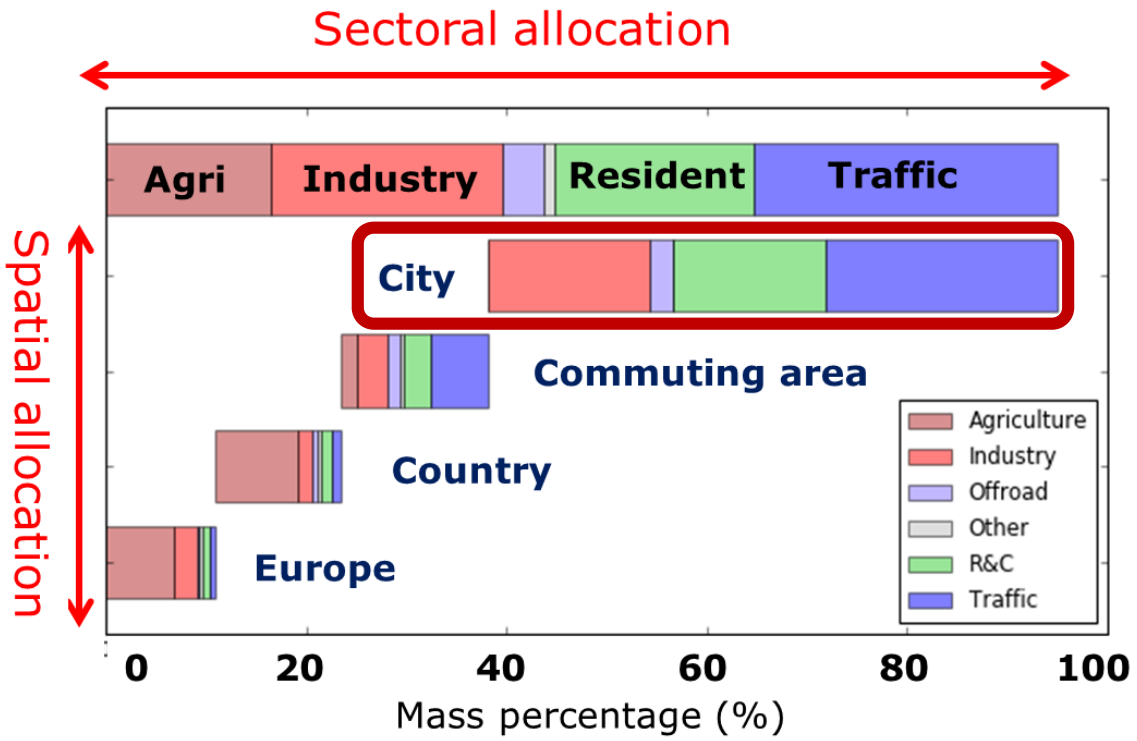
Joint Research Centre

Motivations

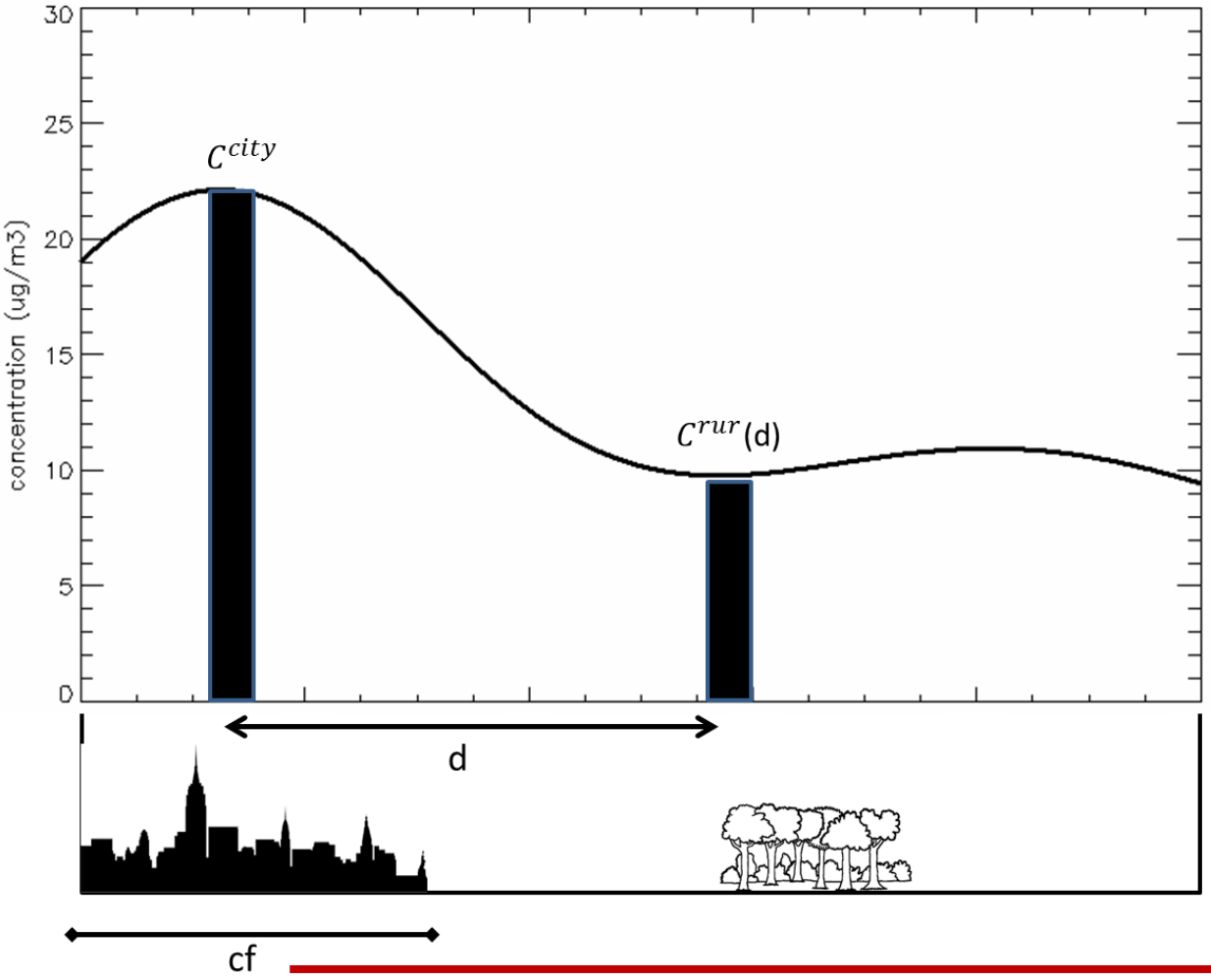
- Determine at which level/scale air quality measures should be taken to abate air pollution in the most efficient manner.

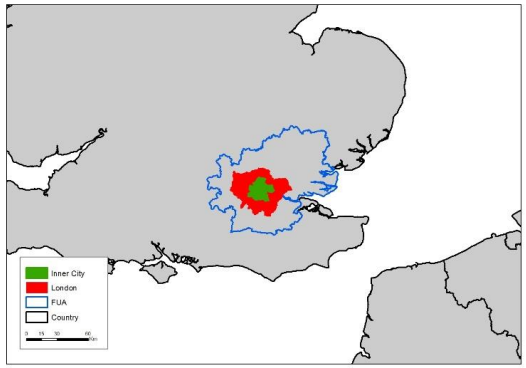
- How can we quantify the contribution of city emissions on its own air pollution?

- Two main approaches:
  - ✓ Incremental
  - ✓ CTM scenarios



Urban impact &urban increment





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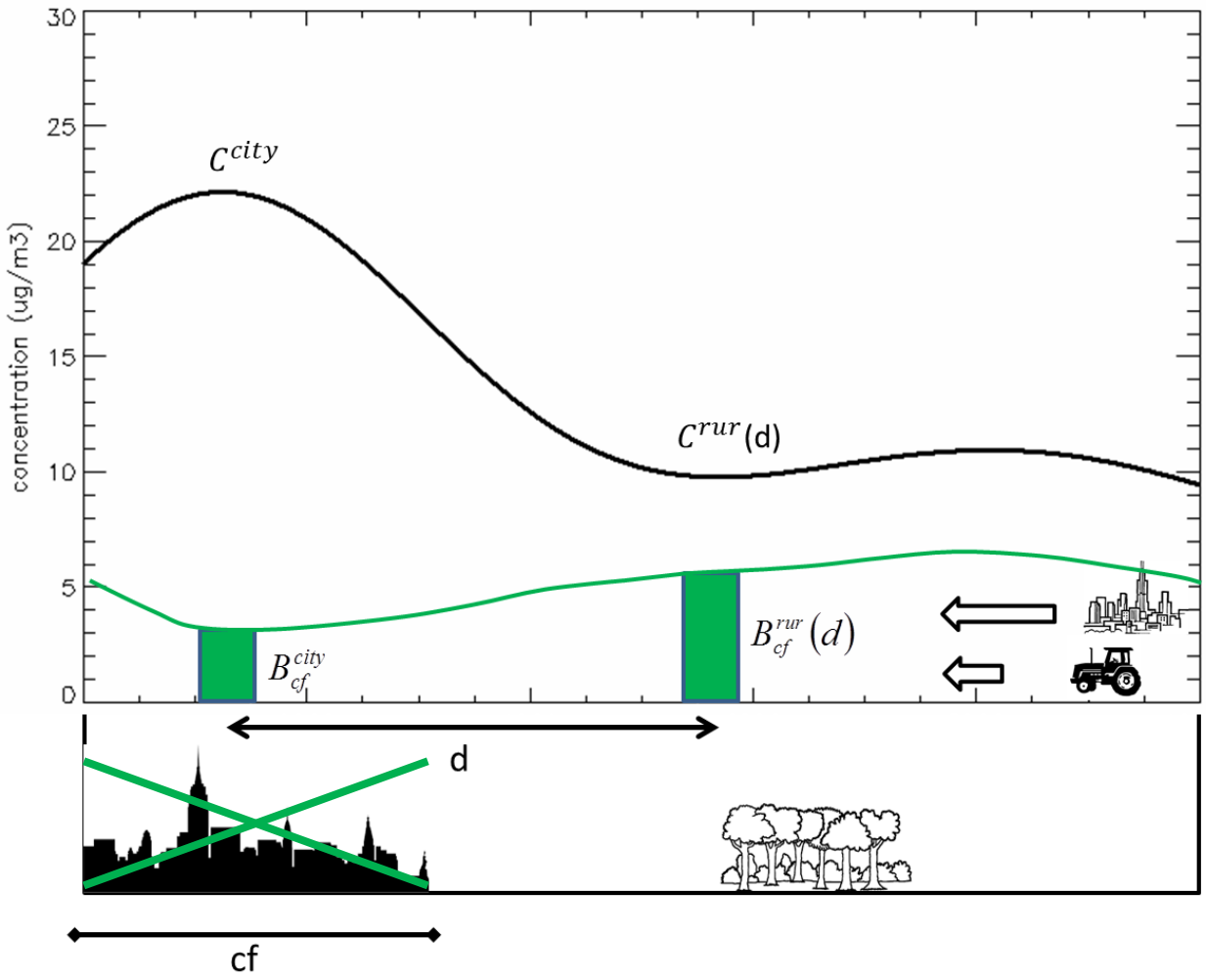

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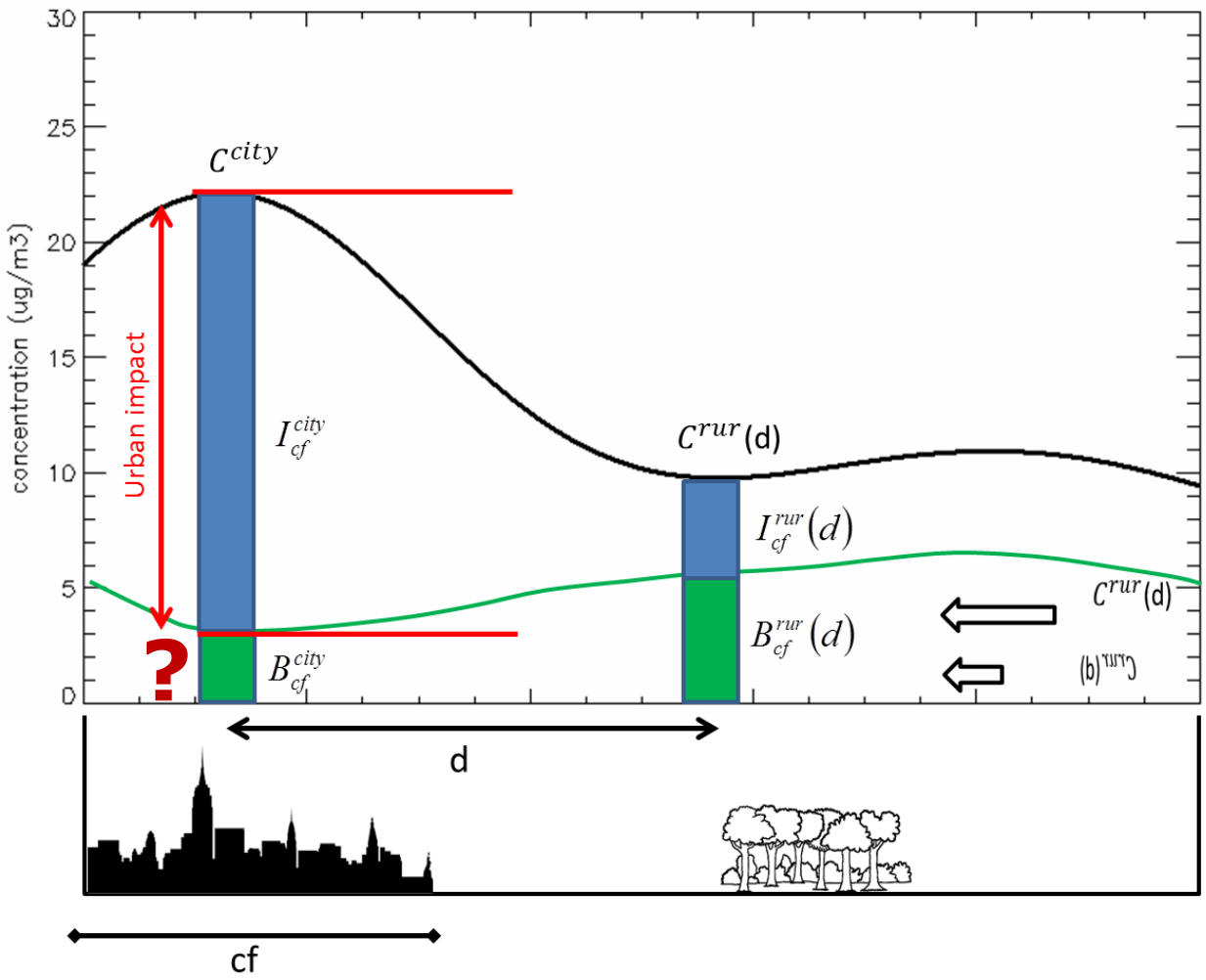


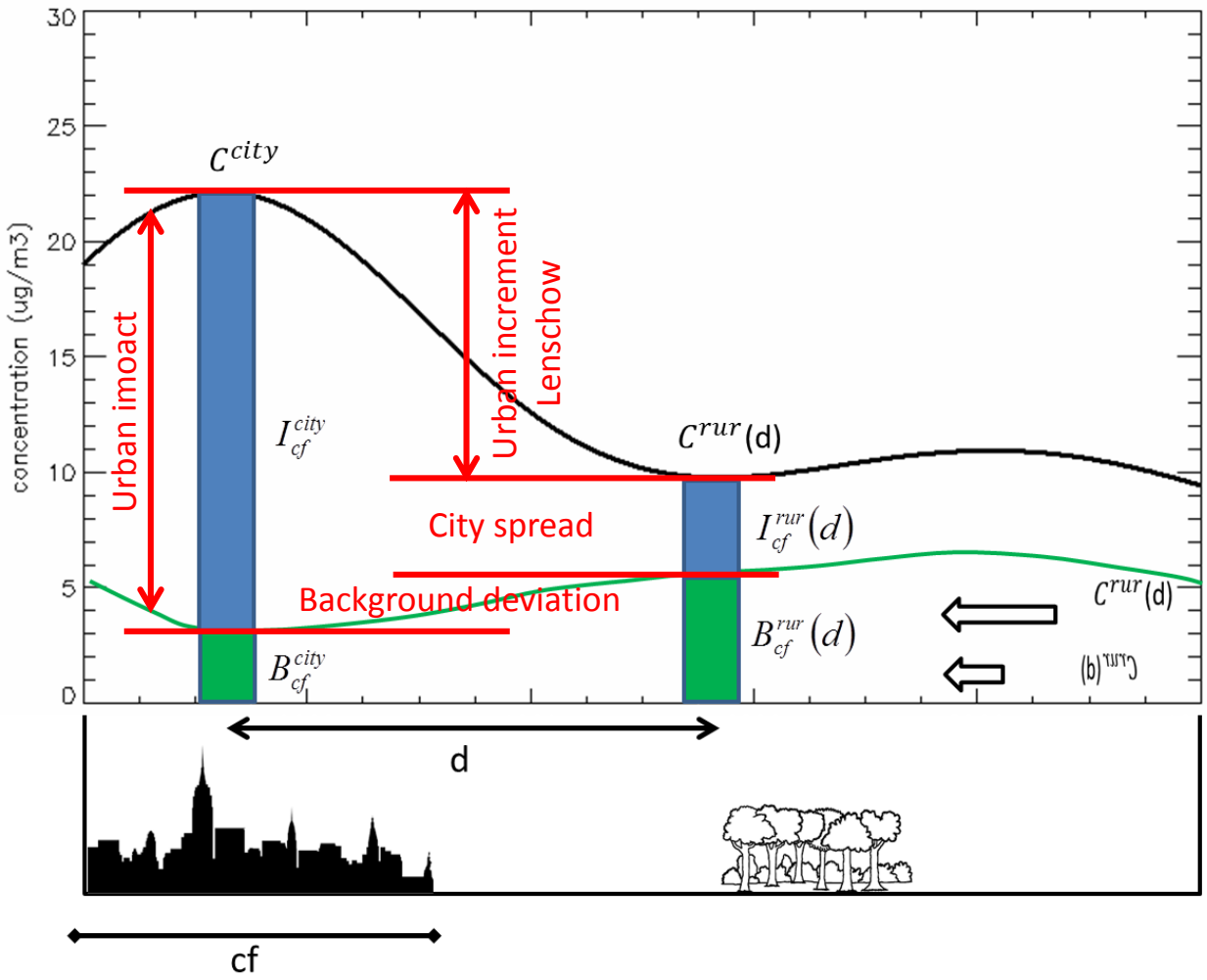
1. CTM-scenario

$$B_{cf}^{city} \cong B_{cf}^{city}(\mathrm{CTM})$$

2. Lenschow

$$B_{cf}^{city} \cong C^{rur}(d)$$

Urban impact &urban increment

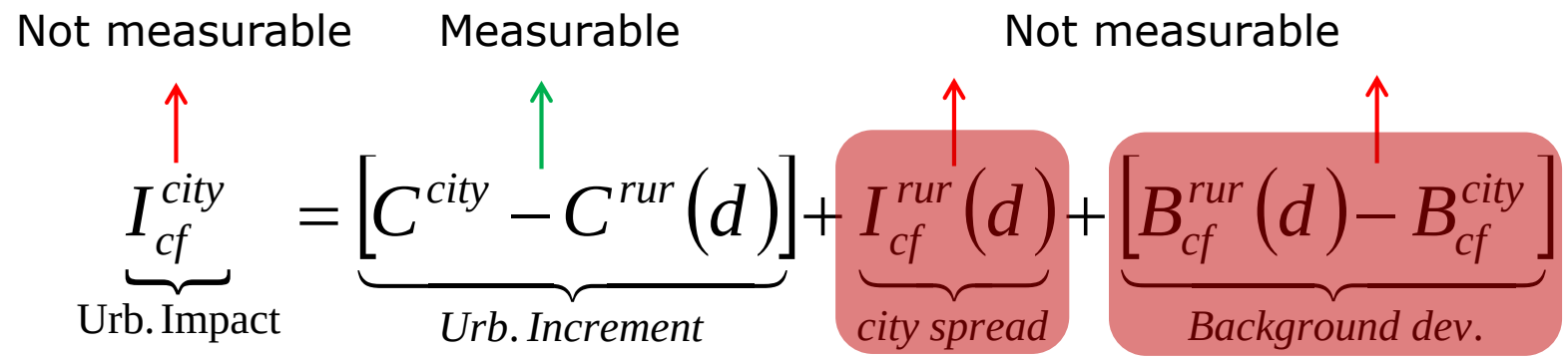


$$C^{city} = B_{cf}^{city} + I_{cf}^{city}$$

$$C^{rur}(d) = B_{cf}^{rur}(d) + I_{cf}^{rur}(d)$$

$$I_{cf}^{city} = \left[C^{city} - C^{rur}(d)\right] + I_{cf}^{rur}(d) + \left[B_{cf}^{rur}(d) - B_{cf}^{city}\right]$$

Urban impact &urban increment



Assumption I: the city spread is negligible $I_{cf}^{rur}(d) \cong 0$

The rural background location is far enough from the city not to feel its influence

Assumption II: the background is homogeneous $B_{cf}^{rur}(d) \cong B_{cf}^{city}$

The city and rural background locations should not be too far from each other

SHERPA assessment in 4 cities

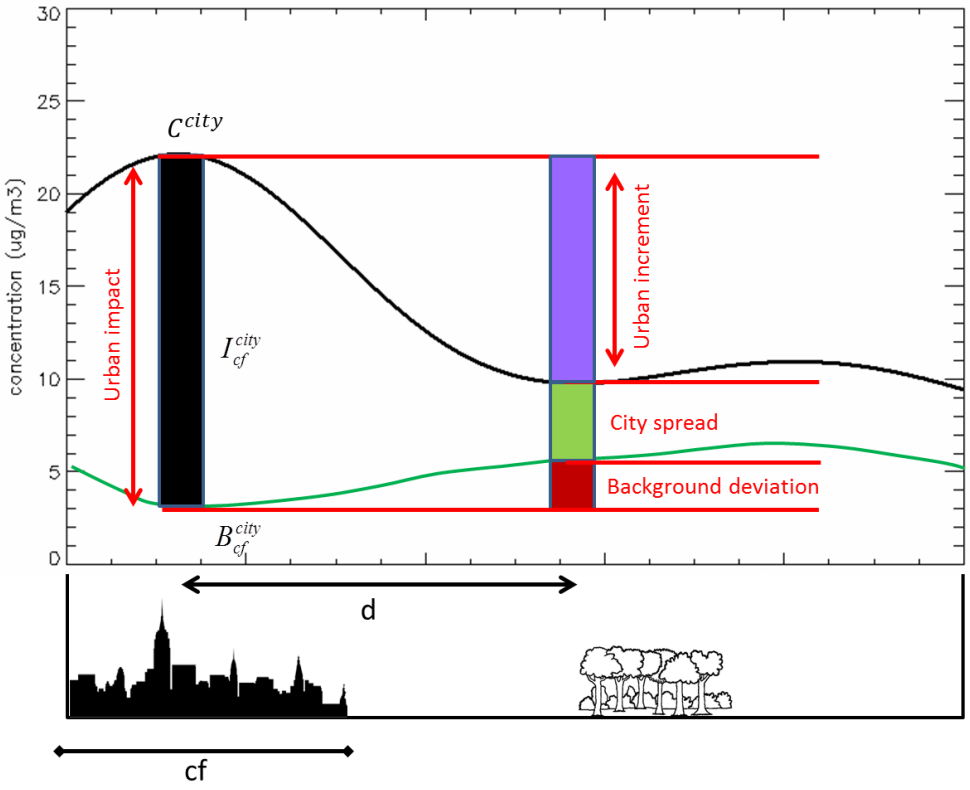
European Commission

$$\underbrace{I_{cf}^{city}}_{\text{Urb. Impact}} = \underbrace{\left[C^{city} - C^{rur}(d)\right]}_{\text{Urb. Increment}} + \underbrace{I_{cf}^{rur}(d)}_{\text{city spread}} + \underbrace{\left[B_{cf}^{rur}(d) - B_{cf}^{city}\right]}_{\text{Backgrounddev.}}$$

SHERPA

How do these components vary

- with distance (d)
- With city fraction (cf)
- With city: Berlin, Paris, London, Bruxelles
- With pollutant: $PM_{2.5}$ and NO_2



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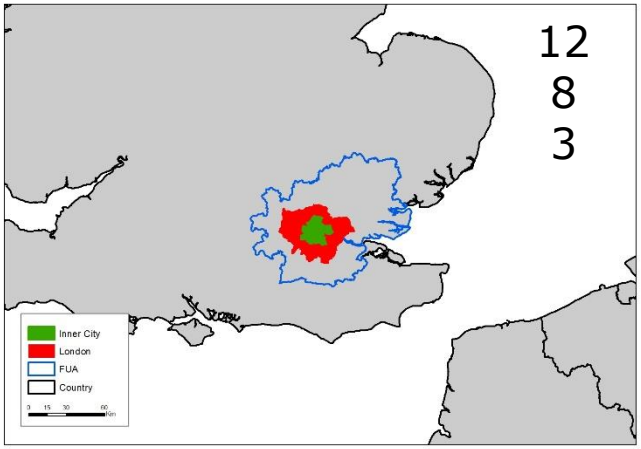
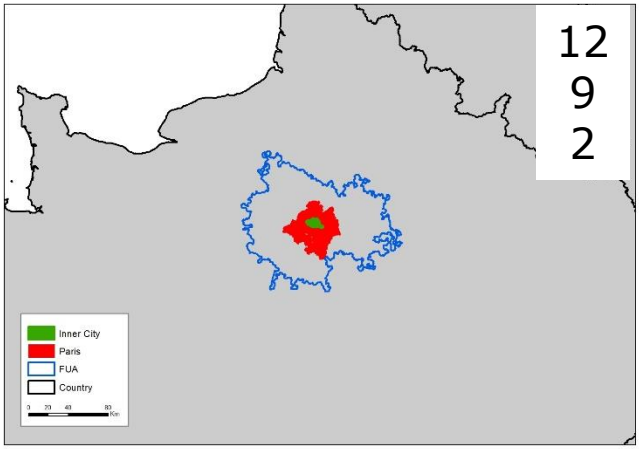
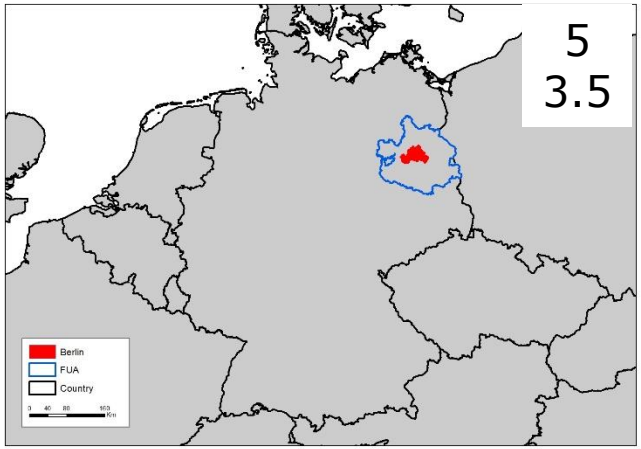
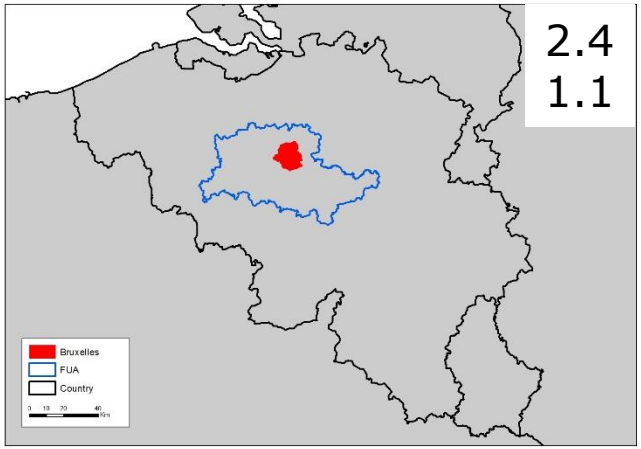
SHERPA assessment in 4 cities









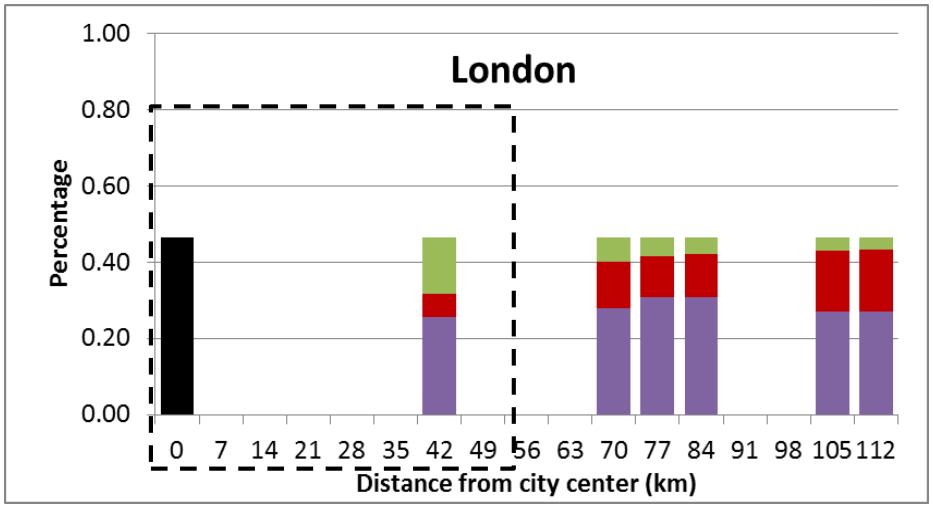
City fractions

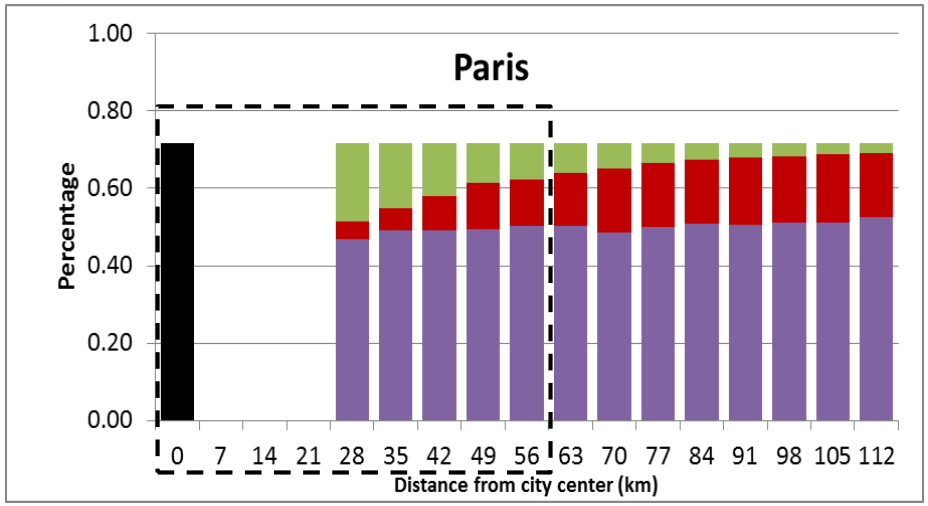
FUA

Urban core

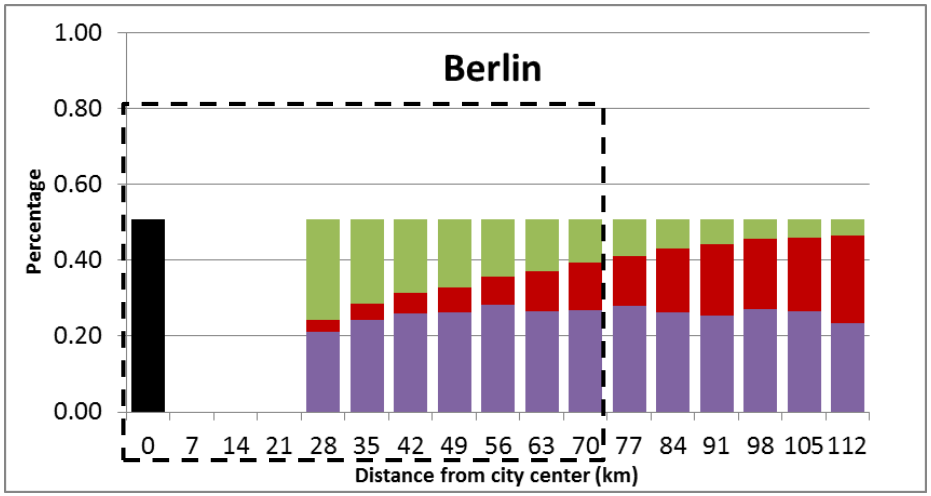
Inner city

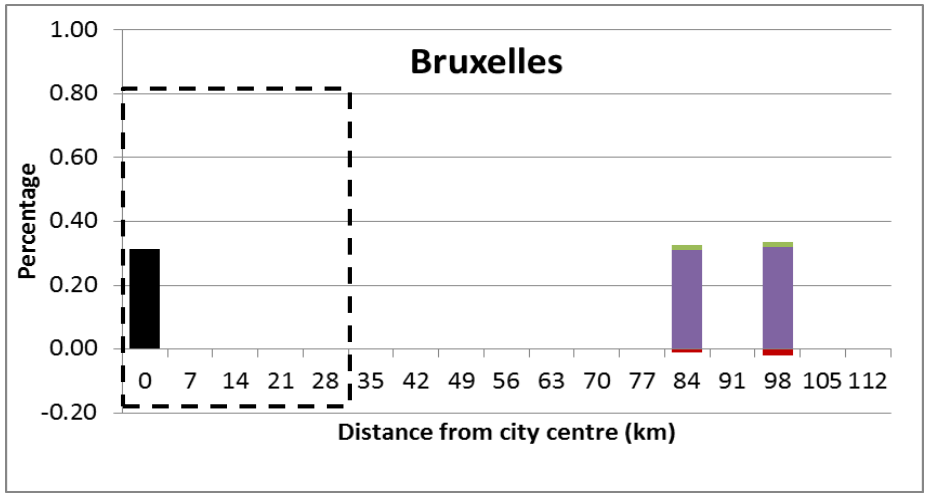
$PM_{2.5}$ for cf = FUA





Background deviation Lenschow increment City spread





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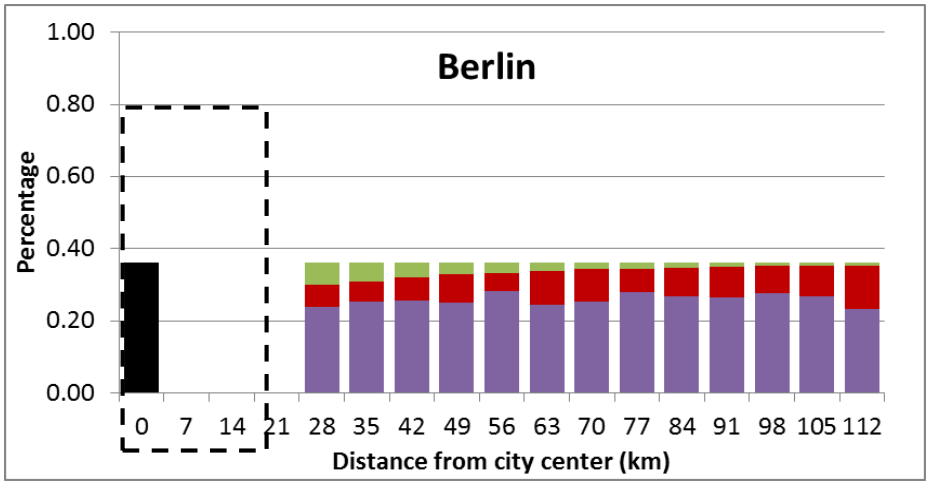
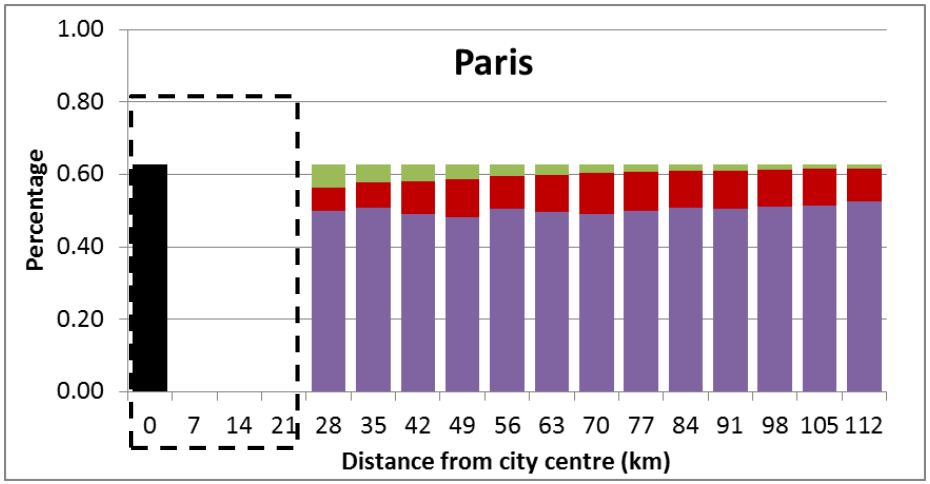
$PM_{2.5}$ for cf = urban core





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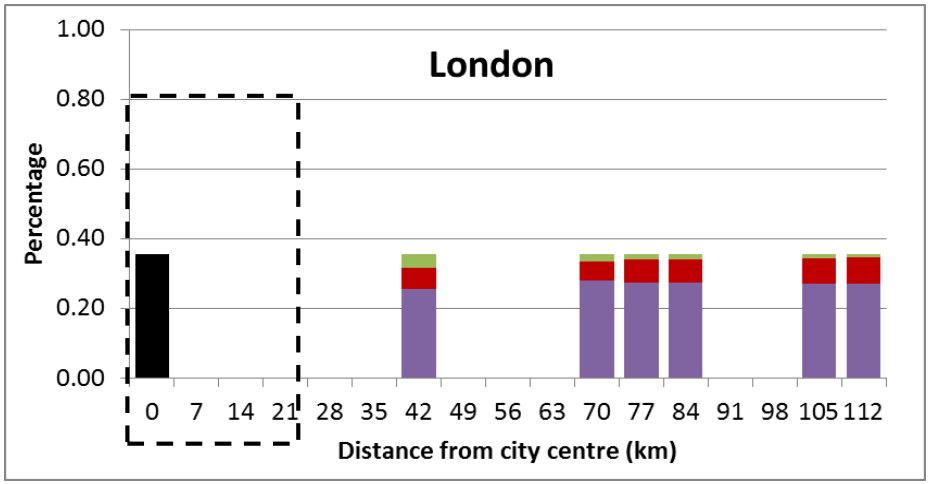

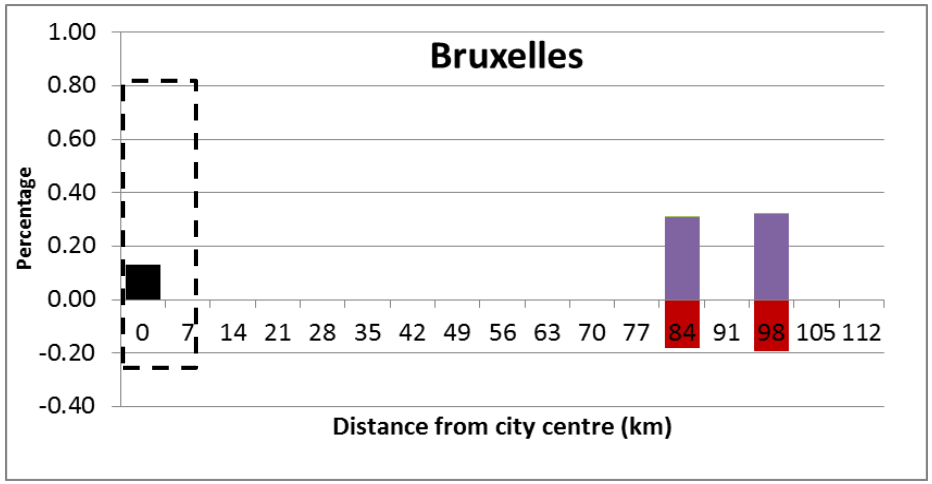

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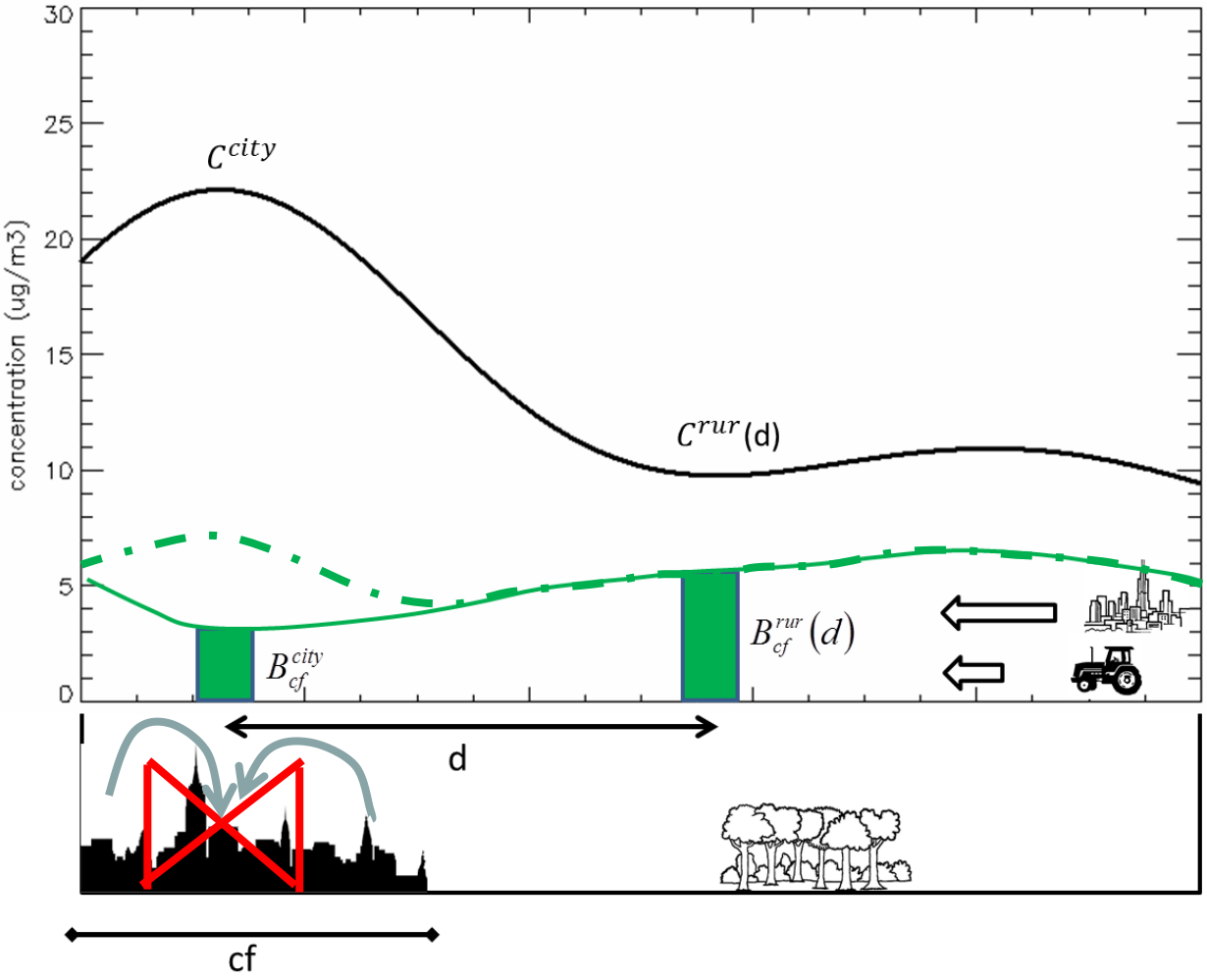
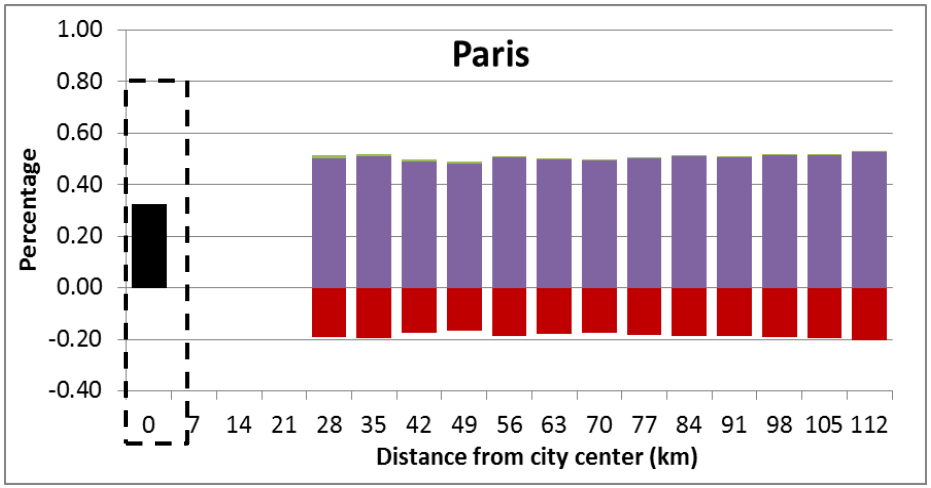
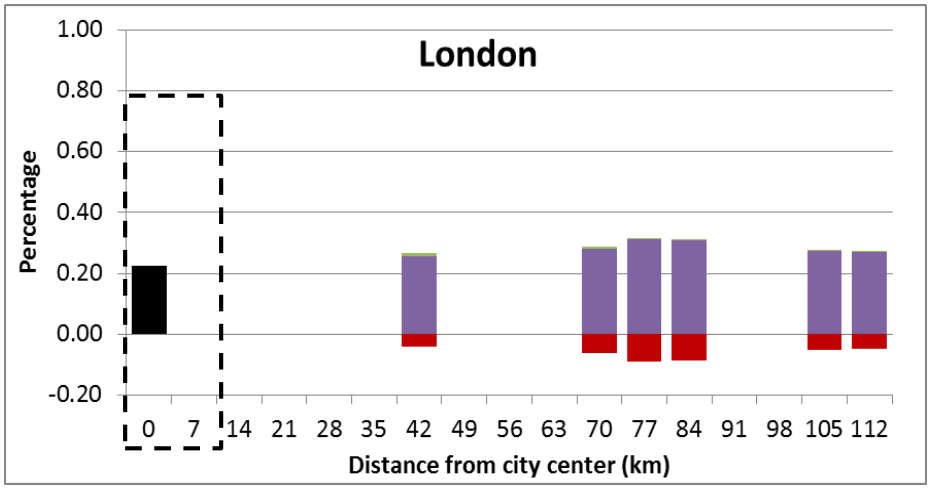
PM2.5 for cf = inner city



$$B_{cf}^{city} > B_{cf}^{rur}(d)$$

PM2.5 for cf = inner city



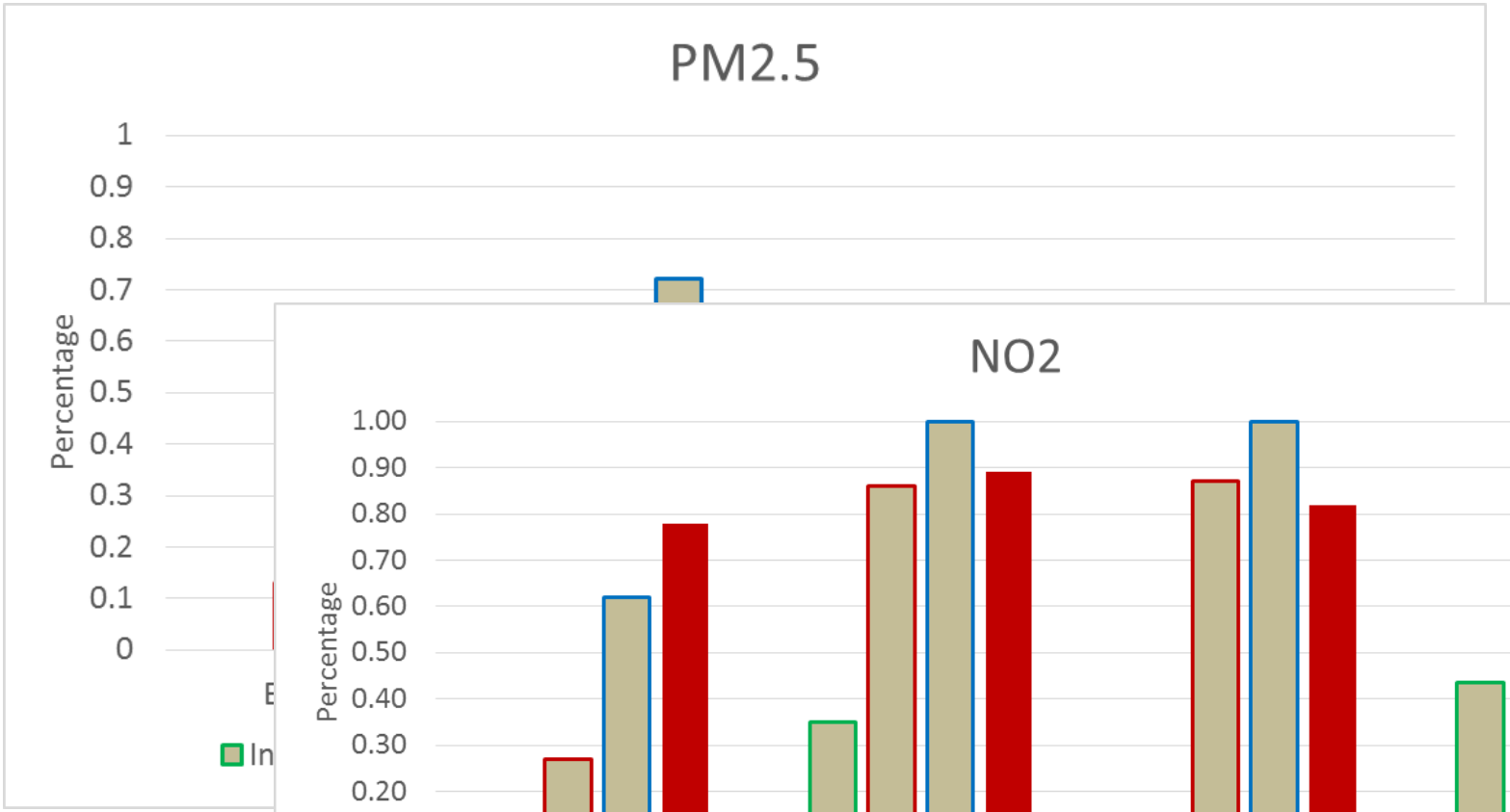


Background deviation

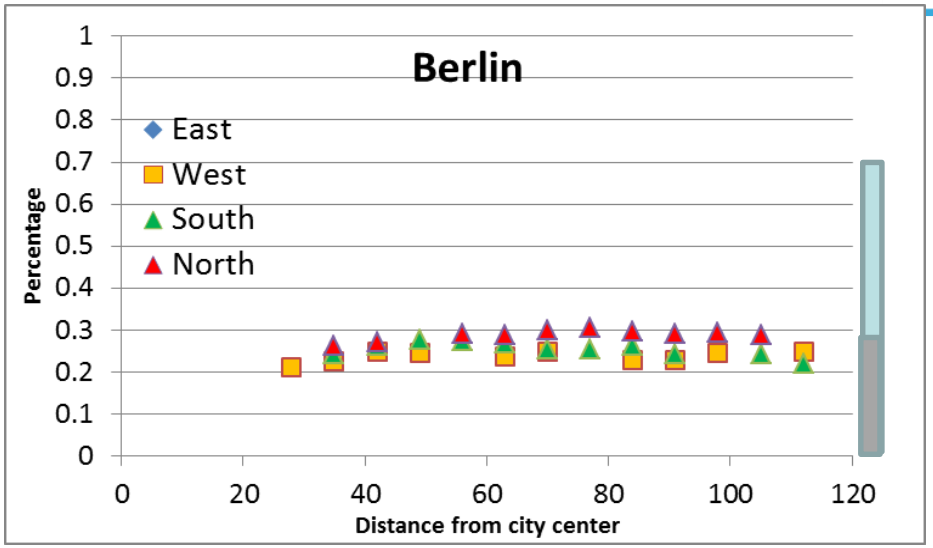
Lenschow increment

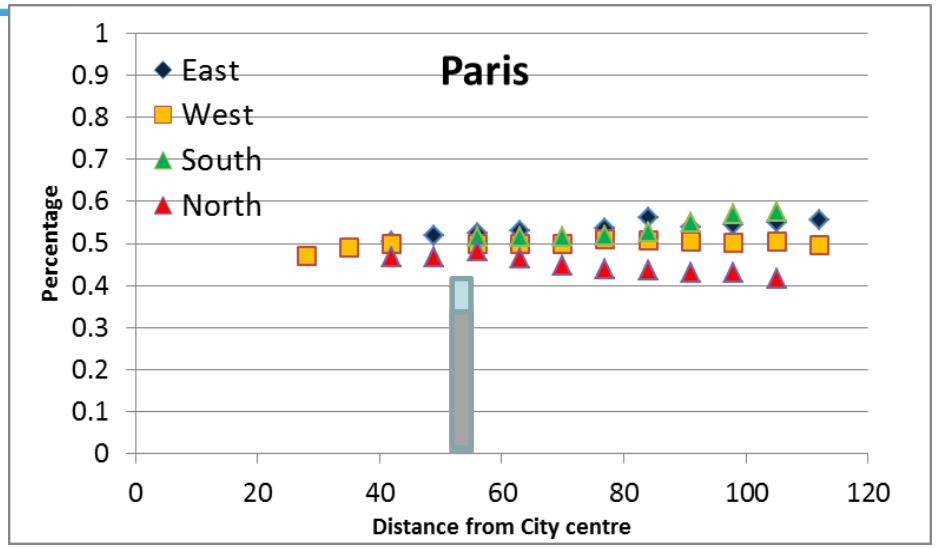
City spread

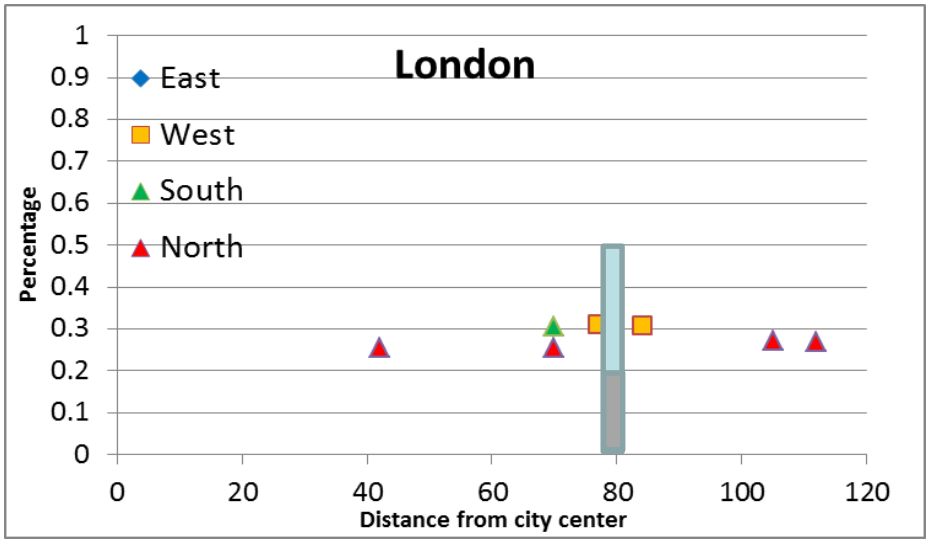
Summary overviews

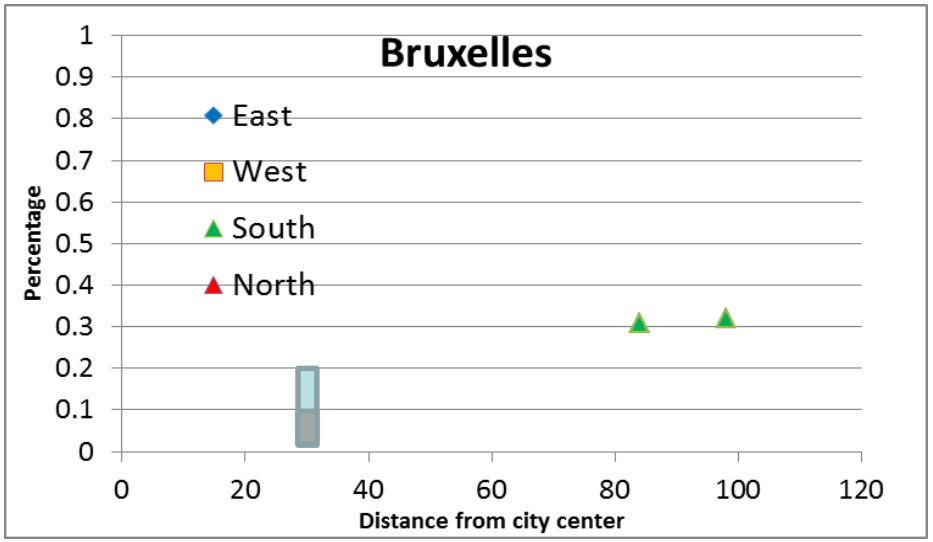


Comparison of obs. and mod. Increments ($PM_{2.5}$)









Conclusions

- The urban increment (*LUI*) is an appropriate estimate of the urban impact (*I*) only when two assumptions are fulfilled:
  - The city spread is negligible
  - The background deviation is negligible
- For $PM_{2.5}$, these two assumptions are never fulfilled for large or medium cities and the LUI underestimates the urban impact by 30 to 50%. Although it works better for NO_2 some underestimation is also found for this pollutant.

Conclusions (cont.)

- Given that:
  - The urban impact is very sensitive to the size of the city fraction
  - The urban increment is very sensitive to distance (d) and location

  the urban increment seems to be a poor proxy for estimating the urban impact.

- Studies based on the incremental approach are very likely to underestimate (heavily for $PM_{2.5}$) the impact of cities to their air pollution