Proposal for emission benchmarking indicators

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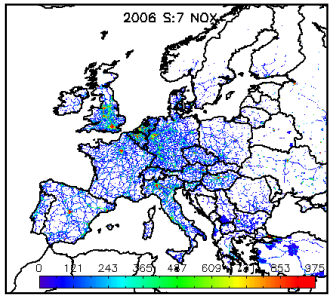
Objectives

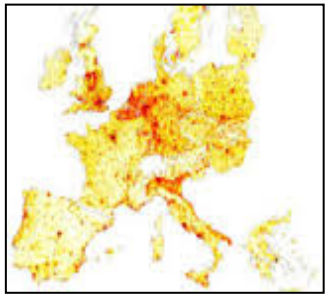
- *These indicators are meant to be used as screening to identify inconsistencies between top-down (TD) and bottom-up (BU) emission inventories in terms of:*
  - **Geographical areas**
  - **Sectors and/or sub-sectors**
  - **Pollutants**

- *Designed for cities (?) and regions/countries*

What we need



MACC 7km sector/pollutant maps

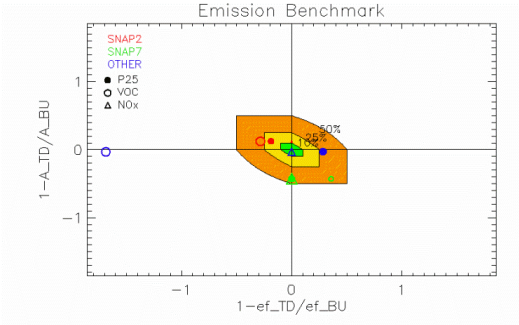


Population map

Macrosector – Emission Info Table			
Reference year			
Domain (4 corners lat-lon coord) or administrative boundaries (city, region)			
Precursor	Macrosectors (yours)	CORINAIR conversion	Total emitted (kT/ y)
Nox	Traffic	S7	XX1
Nox	Domestic	S2	XX2
Nox	Point sources	0.5*S3+S1	XX3
NOx	Other	0.5*S3+S4+S5...	XX4
VOC	Traffic	S7	YY1
VOC	Domestic	S2	YY2
VOC	Point sources	0.5*S3+S1	YY3
VOC	Other	0.5*S3+S4+S5...	YY4
...			

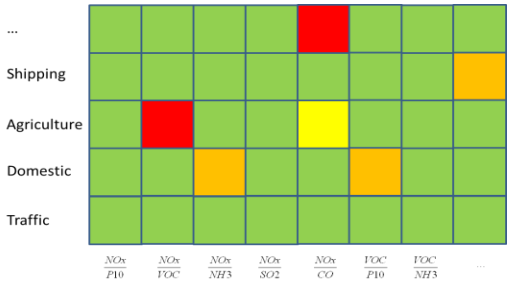
Info request to participants

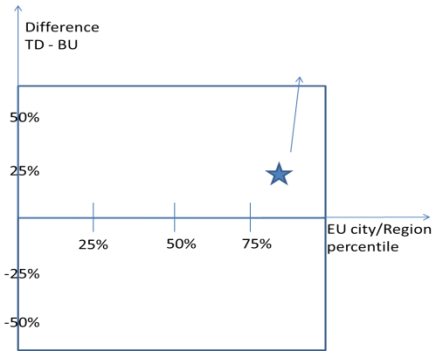
What we get



- General overview

- Precursor ratios





- Pro Capita comparisons

Info requested to participants

Shape	7			
ITA-VDA				
ITA-PMN				
ITA-LMB				
ITA-TAA				
ITA-VEN				
ITA-FVG				
ITA-ERM				
2006				
#Species	BU sectors abbreviation	BU sectors nomenclature	Correspondance with SNAP	Domain Total
NOx	DOM	Domestic	S2	29.3
NOx	TRA	Traffic	S7	184.5
NOx	OTH	Others	S1+S4+S5+S6+S3+S8+S9+S10	116.2
NOx	PASC	Passenger cars	S7.1	101
PM25	DOM	Domestic	S2	10
PM25	TRA	Traffic	S7	11
PM25	OTH	Others	S1+S4+S5+S6+S3+S8+S9+S10	12
VOC	DOM	Domestic	S2	169
VOC	TRA	Traffic	S7	83
VOC	OTH	Others	S1+S4+S5+S6+S3+S8+S9+S10	165

Diagram 1

General Overview
Activities, emission factors, total emissions

Starting point: total emissions per sector/pollutant

$E_{TD}^{m,p}$ Total top-down emissions for precursor “p” and macrosector “m”

$E_{BU}^{m,p}$ Total bottom-up emissions for precursor “p” and macrosector “m”

$$E_{BU}^{m,p} = ef_{BU}^{m,p} * A_{BU}^{m}$$

$$E_{TD}^{m,p} = ef_{TD}^{m,p} * A_{TD}^{m}$$

Aiming to get the ratios: $\frac{ef_{BU}^{m,p}}{ef_{TD}^{m,p}}, \forall \mathrm{m,p}$ and $\frac{A_{BU}^{m}}{A_{TD}^{m}}, \forall \mathrm{m}$

From our input data, the emission totals $E_{BU}^{m,p}$ $E_{TD}^{m,p}$

Assumption made:

For each macrosector “m” we assume that the ratio (alpha) between the top-down and bottom-up emission factor for one precursor (p*) is unity

$$\forall m, \quad \exists \mathrm{p}^* \Rightarrow ef_{BU}^{m,p^*} = ef_{TD}^{m,p^*}$$

From the basic relation: $$\frac{E_{BU}^{m,p}}{E_{TD}^{m,p}} = \frac{A_{BU}^{m} * ef_{BU}^{m,p}}{A_{TD}^{m} * ef_{TD}^{m,p}}$$

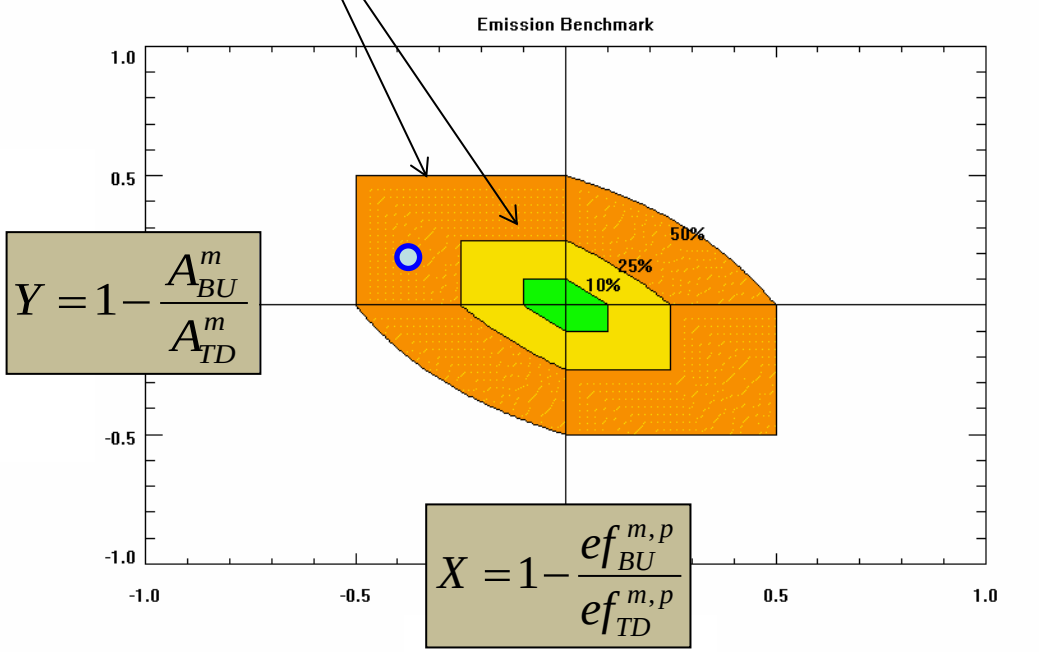
Using $$ef_{BU}^{m,p^*} = ef_{TD}^{m,p^*}$$

we deduce the requested ratios: $$\frac{A_{BU}^{m}}{A_{TD}^{m}} = \frac{E_{BU}^{m,p^*}}{E_{TD}^{m,p^*}}$$

$$\frac{ef_{BU}^{m,p}}{ef_{TD}^{m,p}} = \frac{E_{BU}^{m,p}}{E_{TD}^{m,p}} * \frac{A_{TD}^{m}}{A_{BU}^{m}} = \frac{E_{BU}^{m,p}}{E_{TD}^{m,p}} * \frac{E_{TD}^{m,p^*}}{E_{BU}^{m,p^*}}$$

European Commission

$$Z = X + Y - XY = 1 - \frac{E_{BU}^{m,p}}{E_{TD}^{m,p}}$$



$$Y = 1 - \frac{A_{BU}^{m}}{A_{TD}^{m}}$$

$$X = 1 - \frac{ef_{BU}^{m,p}}{ef_{TD}^{m,p}}$$

Emission magnitude

macro-sector

pollutant

An example : POMI (BU) vs. EMEP (TP)

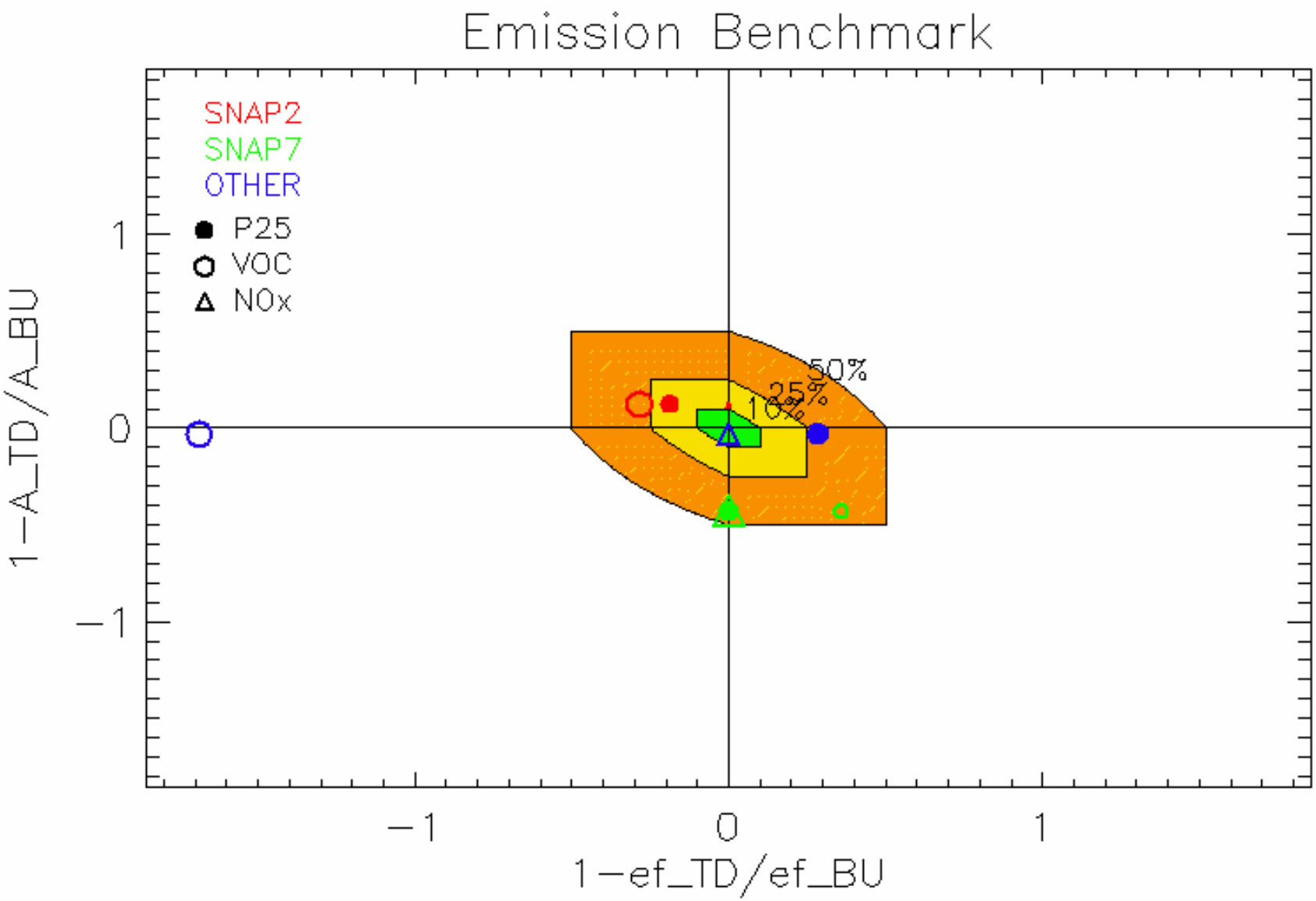


Diagram 1: Considerations

- *Top-down data to be generalized in terms of sources (MACC, EMEP…) and reference years*
- *The method can also be downscaled to sub-sectors*
- *The limitations from grid resolution should be kept in mind, especially when comparing city scale inventories.*

Diagram 2

Precursor ratios

European Commission

Calculate for each macro-sector all possible emission precursor ratios, i.e.

$$\forall m \rightarrow \left\{ \frac{E_{R,TD}^{m,p_j}}{E_{R,TD}^{m,p_i}} \right\}$$

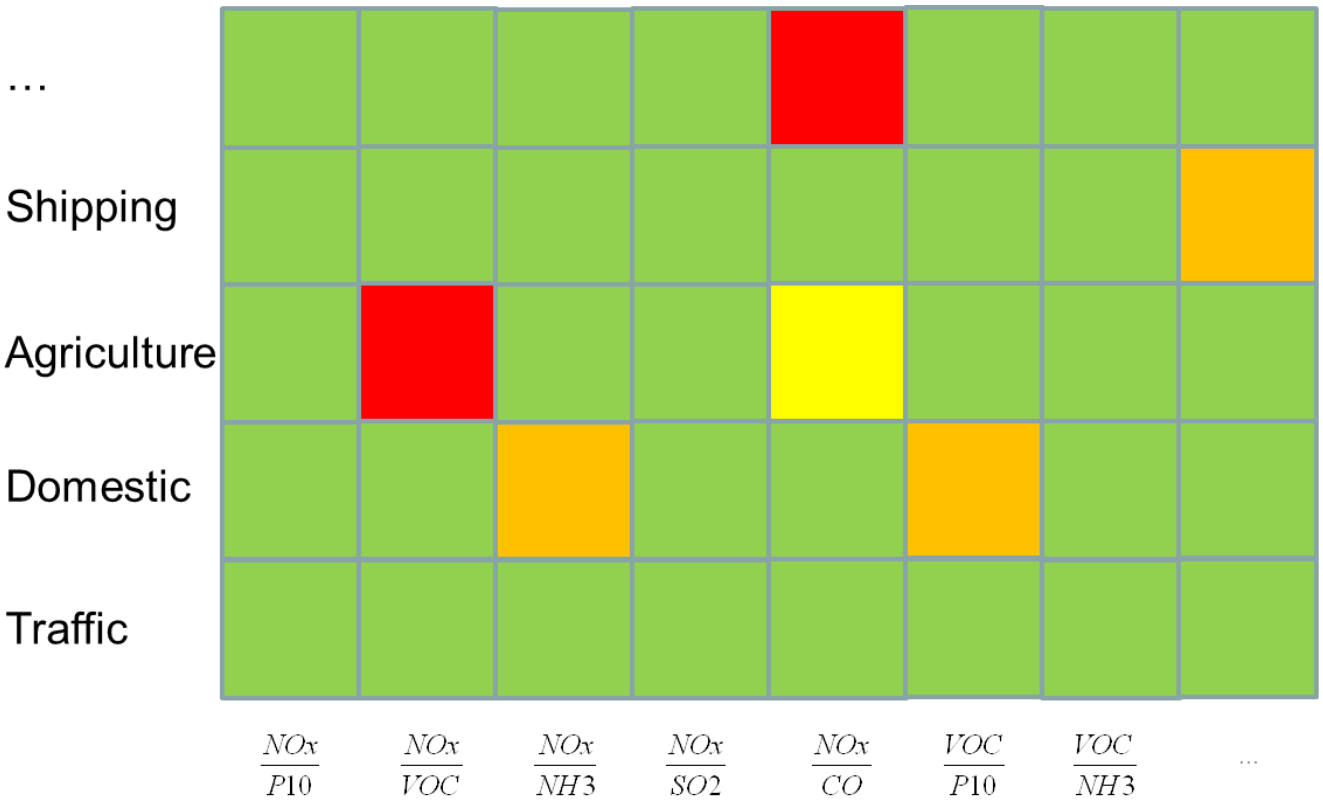
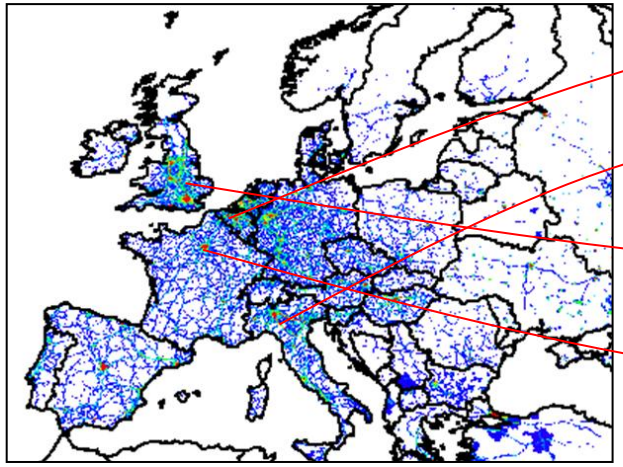


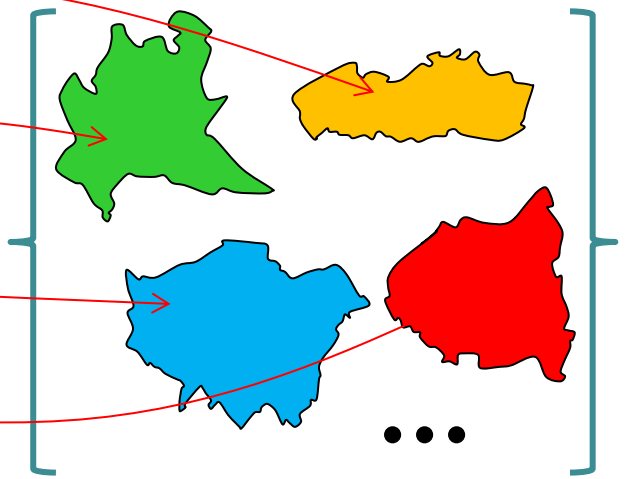
Diagram 3

Per capita emissions
EU ranking

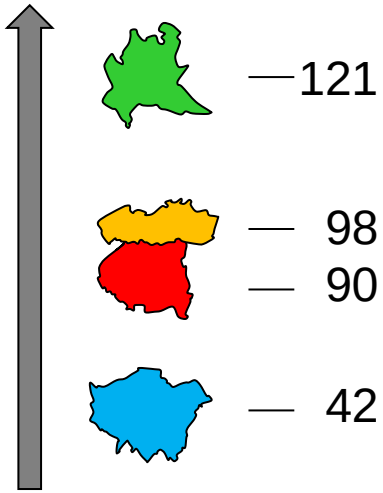
Top-down Sector/Pollutant emissions



All NUTS2



Extraction
Per-capita
emissions

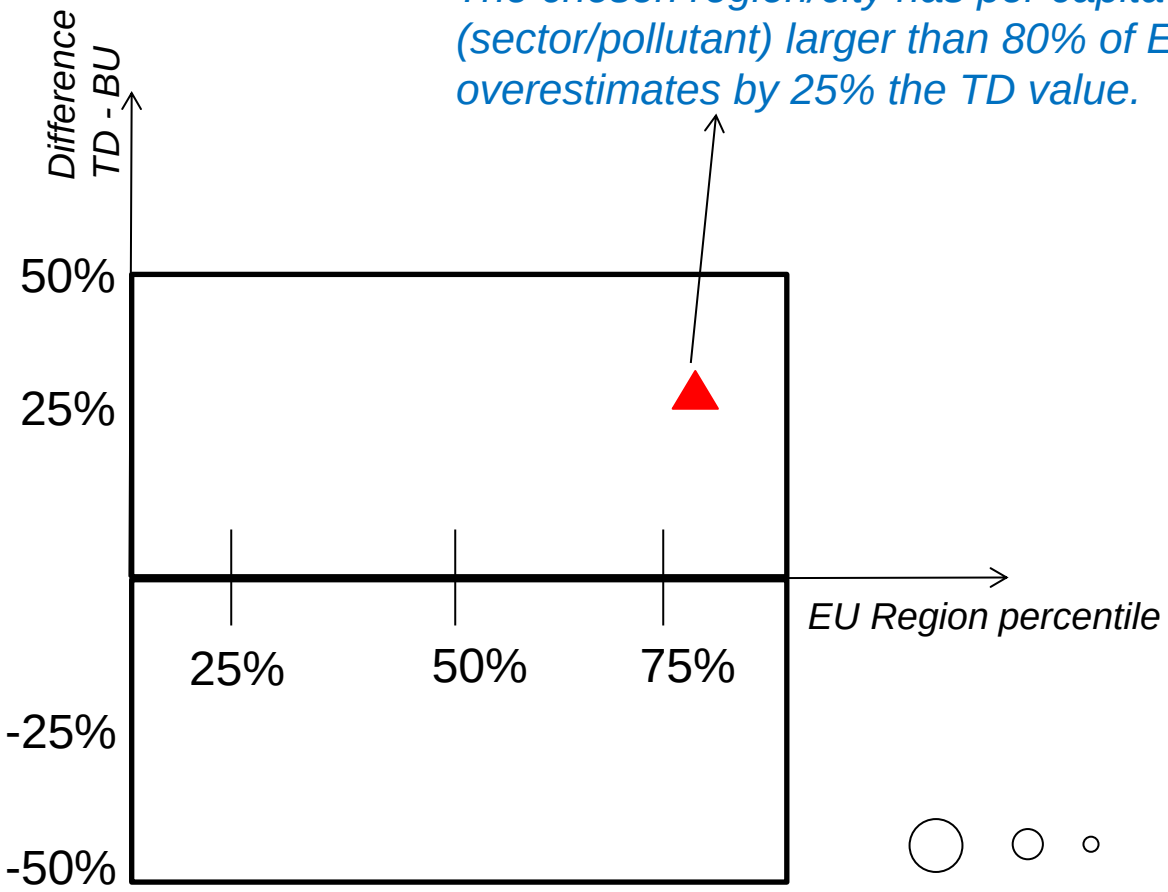


Same approach possible for large cities

Top-down ranking

Bottom-up ranking

The chosen region/city has per capita emission (sector/pollutant) larger than 80% of EU cities and overestimates by 25% the TD value.



Emission magnitude

macro-sector

pollutant

Conclusions

- *These three diagrams could be used as a first stage in the benchmarking process to identify and hierarchize problems in terms of regions, pollutants and sectors.*

- *These diagrams are currently available in a beta-version IDL tool in which any Bottom-up inventory (city/region) can be tested → Kees.*

Indicator screening

Explain differences!!

ANNEXES

Step1: Top-down pre-calculation

- *For each region (Ri) sum-up emissions over shape per precursor and pollutant :*

$$\forall i \rightarrow E^{m,p}_{R_i,TD}$$

- *For each city (Ci) sum-up emissions over shape: (400 Citydelta cities) per precursor and pollutant:*

$$\forall i \rightarrow E^{m,p}_{C_i,TD}$$

Step1: Converting to user-defined sectors

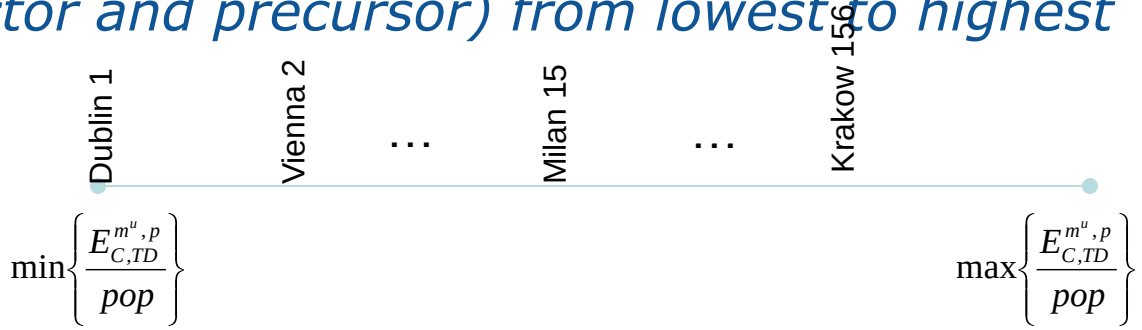
- *For each region (Ri) convert emissions into user-defined (subscript u) categories per pollutant :*

$$\forall p \text{ and } R_i : E^{m,p}_{R_i,TD} \rightarrow E^{m^u,p}_{R_i,TD}$$

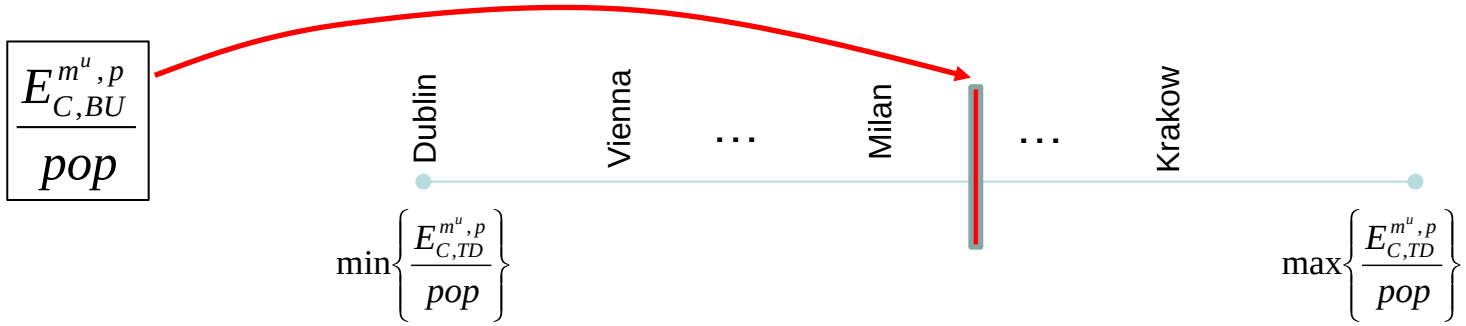
- *For each city (Ci) sum-up emissions over shape: (from Artur – 400 cities in Citydelta) per precursor and pollutant:*

$$\forall p \text{ and } C_i : E^{m,p}_{C_i,TD} \rightarrow E^{m^u,p}_{C_i,TD}$$

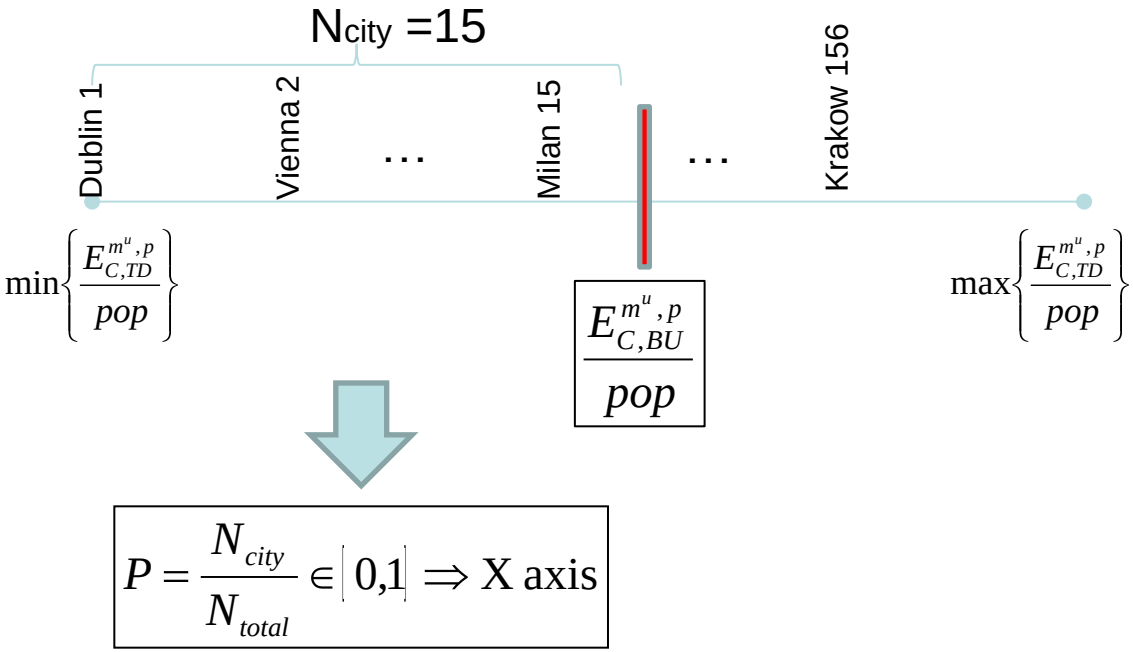
1. *Rank the top-down per-capita emission density (for one user-defined sector and precursor) from lowest to highest values*



2. *Position the bottom-up per-capita emission density in the scale*



3. *Count the percentage of top-down city emission densities (P) below the bottom-up density among the available number of cities: N_{total}.*



$$P = \frac{N_{city}}{N_{total}} \in \left|0,1\right| \Rightarrow \text{X axis}$$

4. *Same reasoning with Regions.*

Inconsistency

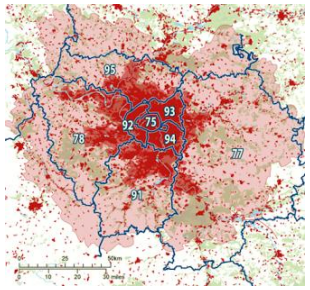
- *Calculate the difference between bottom-up and top-down pro-capita emission density per pollutant and macro-sector*

$$\forall p, s \text{ and } R_i \rightarrow \frac{E^{m^u, p}_{R_i, BU}}{E^{m^u, p}_{R_i, TD}}$$

$$\forall p, s \text{ and } C_i \rightarrow \frac{E^{m^u, p}_{C_i, BU}}{E^{m^u, p}_{C_i, TD}}$$

City

Region

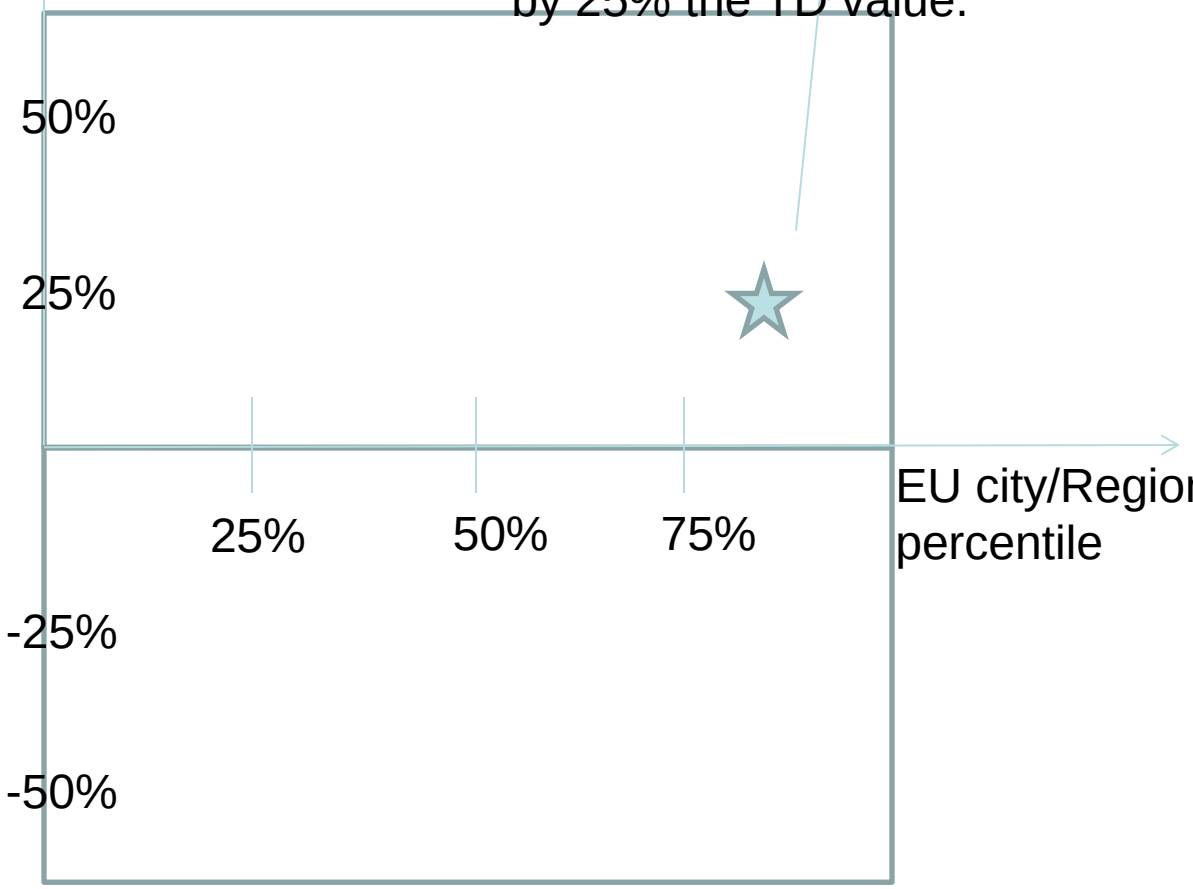


$$\frac{E_{TD}^{m^u,p}}{pop}$$

$$\frac{E_{TD}^{m^u,p}}{pop}$$

Difference TD - BU

The chosen city has per capita Emission larger than 80% of EU cities and overestimates by 25% the TD value.



Again symbol can be made color (sector) and shape (pollutant) specific