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Forum for air quality modelling in Europe

# WG2 Emissions: Status and Roadmap

Leonor Tarrasón<sup>1</sup>, Marc Guevara<sup>2</sup>, Susana López-Aparicio<sup>1</sup>

<sup>1</sup>NILU - Norwegian Institute for Air Research, Urban Environment and Industry, Kjeller, Norway

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## cities

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About this content

## One day in the life of a suffocating planet: air pollution around the world

As Guardian Cities kicks off a week investigating air pollution, our correspondents report from the front lines of this global urban crisis

94



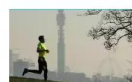
Welcome to Onitsha / The city with the world's worst air

145



'We had to sue': the five lawyers taking on China's authorities over smog

129



Commute earlier and pray for rain / What to do when there's a pollution warning

56

The war against air pollution has begun - and it will be fought in cities

Damian Carrington

262



## How bad is Delhi's air? We strapped a monitor to a rickshaw to find out

Suresh Kumar Sharma is an auto-rickshaw driver in Delhi, a city with some of the world's dirtiest air - and where many locals don't know how unhealthy the pollution really is

18

## Tippin Reveal where more!

In at least now become so bad that the danger to health of just 30 minutes of cycling outweighs the benefits of exercise altogether, according to new research

369

home UK world sport football opinion culture business lifestyle fashion environment tech

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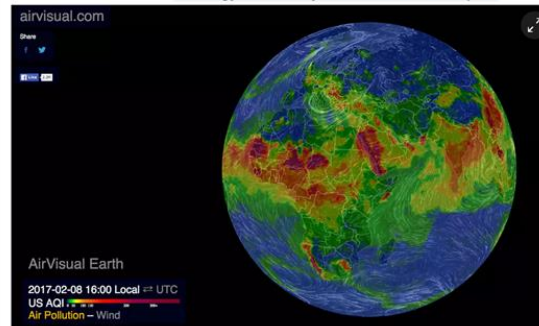
Cities

The air we breathe

## Pant by numbers: the cities with the most dangerous air - listed

We've broken down the data on dangerous PM2.5 particles, and listed them region by region - to reveal the cities with the worst air in Europe, the US, Africa, Asia and more

☛ Suffocating planet: urban air pollution around the world today - live



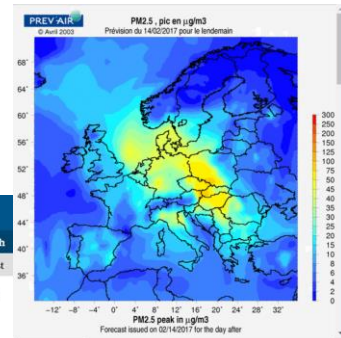
AirVisual's real-time map shows weather patterns alongside PM2.5 concentrations

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About this content

Billions of people in cities around the world are exposed to dangerous air, but pollution levels vary widely - and the fast-growing cities of Asia and Africa are the worst affected.



## Most popular in US



Michael Flynn resigns: Trump's national security adviser quits over Russia links - live



The dolphin who loved me: the NASA-funded project that went wrong



John Waters: 'A new kind of anarchy is going to happen next'



'Extraordinary' levels of pollutants found in 10km deep Mariana trench



Alabama immigration: crops not as workers vanish to avoid crackdown

☛ This article is 5 years old

All cities stories



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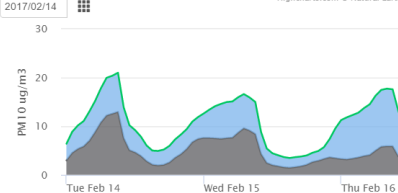
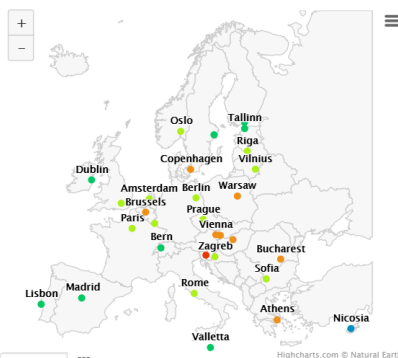
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## Regional source-receptor calculations

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Aerosols

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Forurensningsnivå » Oslo » Bygdøy Allé

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[OVERSKRIDELSER](#)

Komponent

Intervall

PM10

72 timer

[Vis/skjul tegnforklaring](#)

Bygdøy Allé



## Bygdøy Allé

Veinær stasjon på fortau utenfor Bygdøy Allé nr 77. Stasjonen måler PM10, PM2.5 og NO2. Stasjonen driftes på helårig basis.



Status: Stasjonen er i normal drift.  
Eiet av: Oslo kommune

## Detaljer

- [Se kart](#)
- [Se luftkvalitetsindikator \(Tabell\)](#)
- [Se luftkvalitetsdata \(Tabell og graf\)](#)



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### Improvement of emission data

#### Competence building

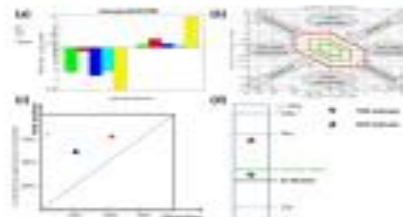
#### Benchmarking

##### Best Practices



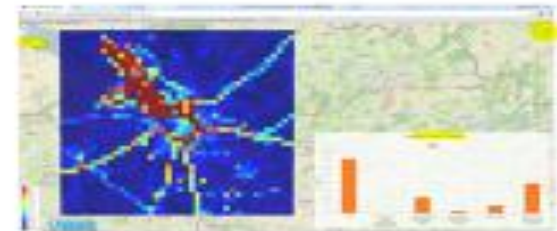
- Websurvey
- Traffic emission focus
- Publication in pipeline

##### △ Emission tool



- Training sessions
- Benchmarking exercises
- Feedback for improvement
- 3 publications 2015-2017

##### Composite Emission Map

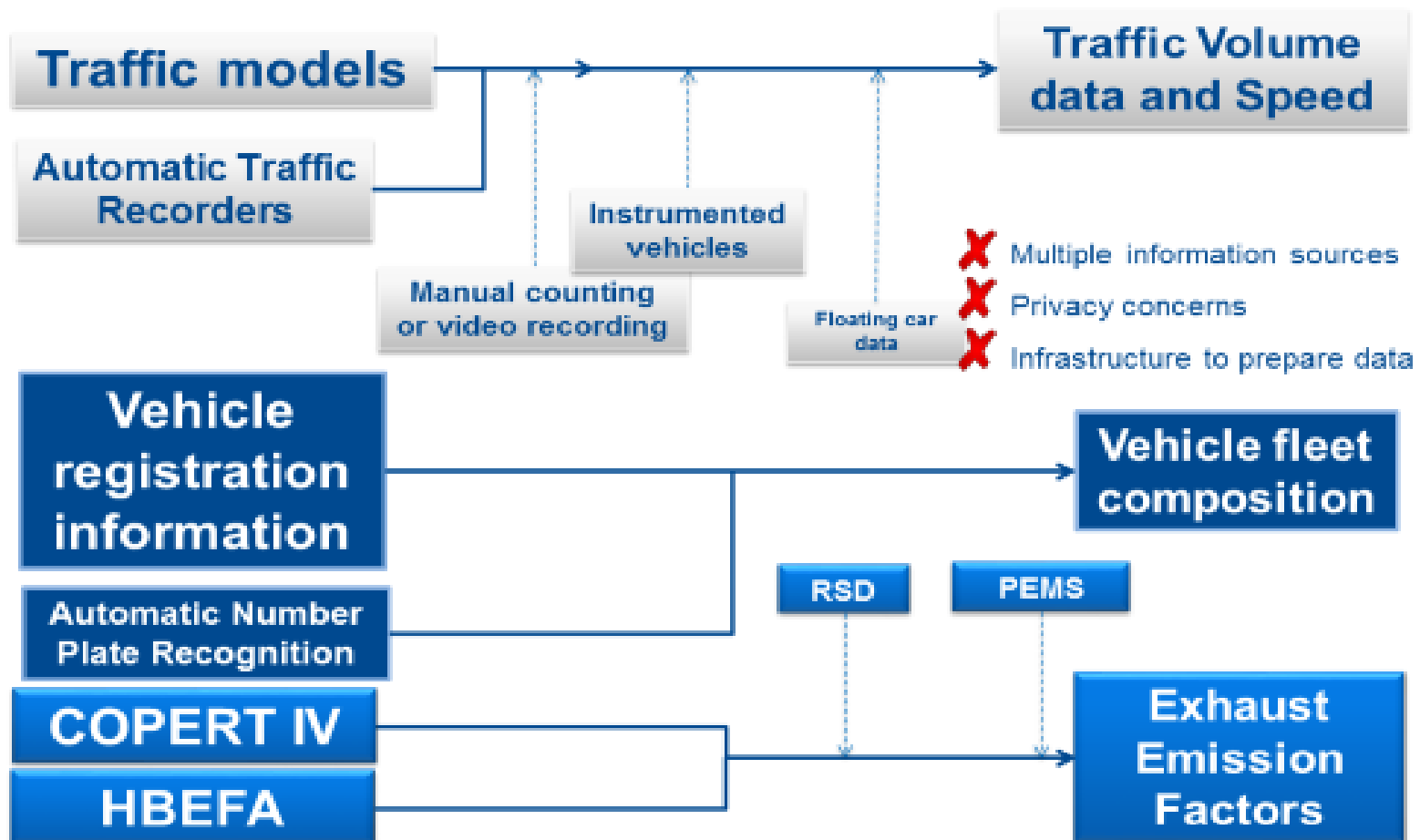


- Support AQ Assessment
- Inter-comparisons at national and local level



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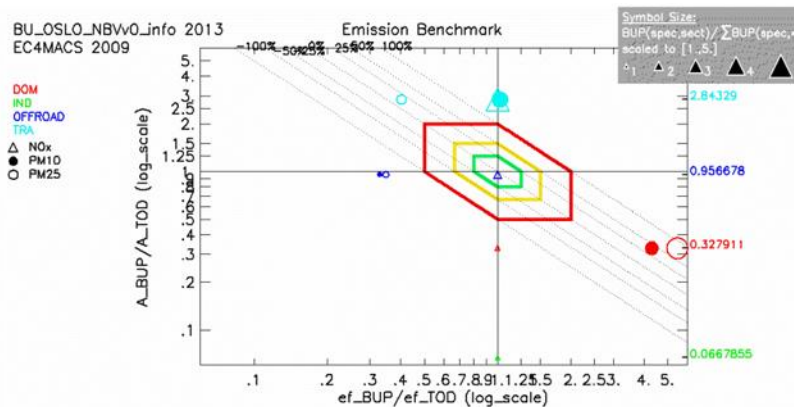


Air Qual Atmos Health (2016) 9:325–333  
DOI 10.1007/s11869-016-0402-7



## A novel approach to screen and compare emission inventories

P. Thunis<sup>1</sup> · B. Degraeuwe<sup>1</sup> · K. Cuvelier<sup>2</sup> · M. Guevara<sup>3</sup> · L. Tarrason<sup>4</sup> · A. Clappier<sup>5</sup>



## Benchmarking through Δ-tool

- Top-down vs Bottom-up
- National vs regional/local inventories
- Reducing the knowledge gap!



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Air Qual Atmos Health  
DOI 10.1007/s11869-016-0456-6

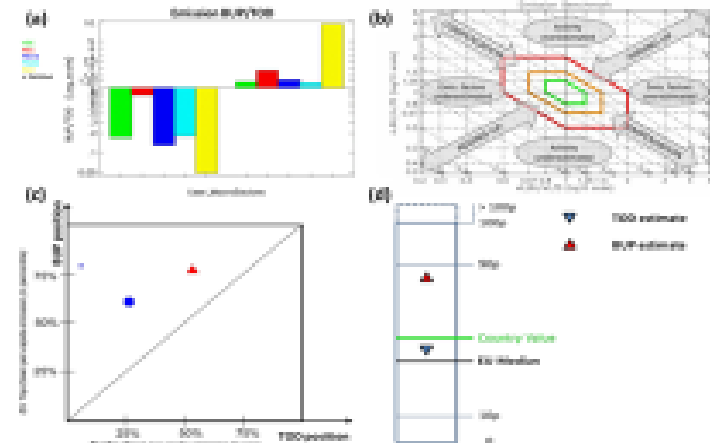


## A benchmarking tool to screen and compare bottom-up and top-down atmospheric emission inventories

M. Guevara<sup>1</sup> • S. Lopez-Aparicio<sup>2</sup> • C. Cuvelier<sup>3</sup> • L. Tarrason<sup>2</sup> • A. Clappier<sup>4</sup> • P. Thunis<sup>5</sup>



- Description of the benchmarking Methodology -  $\Delta$ -Emis tool
- Sequence of steps to perform a correct analysis of the results



# The $\Delta$ -Emis tool for emission inventories



Barcelona  
Supercomputing  
Center  
Centro Nacional de Supercomputación



Air Qual Atmos Health

DOI 10.1007/s11869-016-0456-6



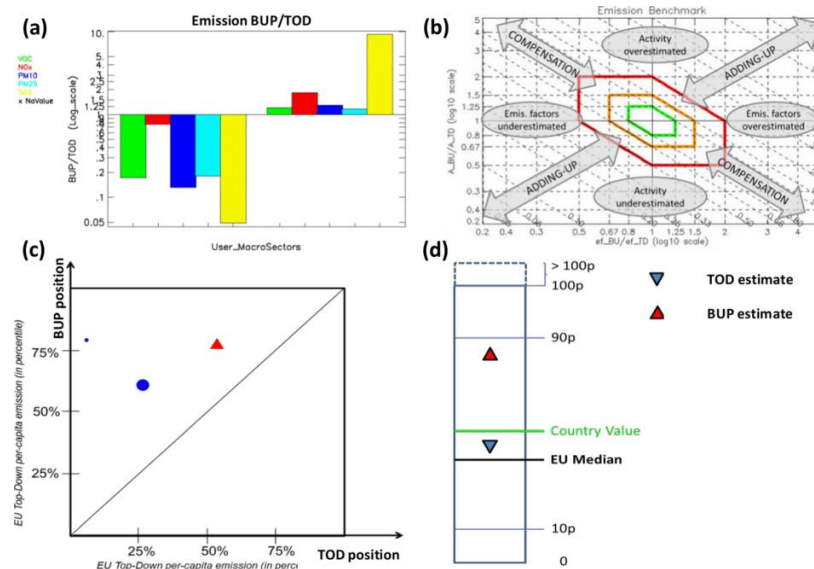
CrossMark

## A benchmarking tool to screen and compare bottom-up and top-down atmospheric emission inventories

M. Guevara<sup>1</sup> • S. Lopez-Aparicio<sup>2</sup> • C. Cuvelier<sup>3</sup> • L. Tarrason<sup>2</sup> •  
A. Clappier<sup>4</sup> • P. Thunis<sup>5</sup>



- Description of the benchmarking Methodology -  $\Delta$ -Emis tool
- Sequence of steps to perform a correct analysis of the results





## BARCELONA



On-road Traffic



Residential  
Heating





Industry

**Bottom-up local  
emission inventory  
(HERMES)**

**Downscaled regional  
emission inventory  
(TNO\_MACC-II)**

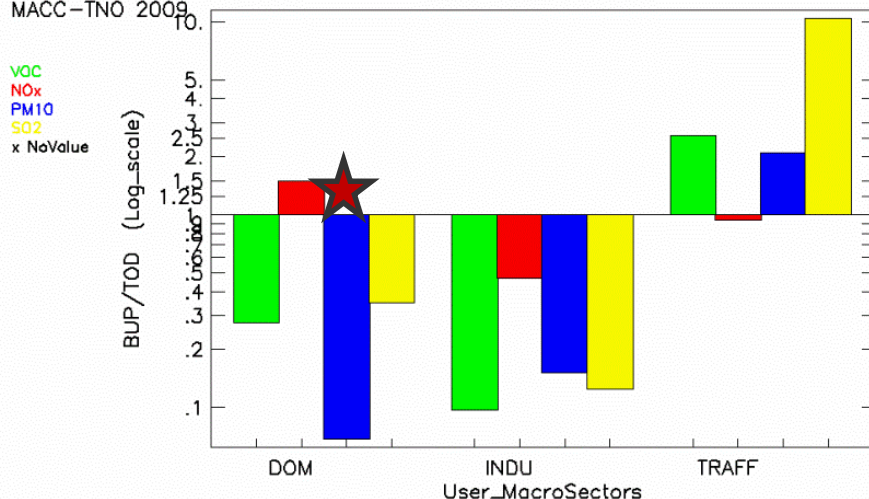
# Domestic sector



p	Bar-plot	Diamond diagram	Per-capita diagram	Pollutant ratio	Conclusions
NO <sub>x</sub>	Inconsistency with the rest of pollutants 			Large discrepancy between NO <sub>x</sub> /PPM <sub>10</sub> ratios	TOD: Activity shares for biomass and coal based fuel may be overestimated and need to be revised
VOC		Lower weighted EF partially compensated by the larger AF		BUP VOC/PPM <sub>10</sub> ratio above the EU 100p	
SO <sub>x</sub>			Large discrepancy between EU city percentiles	Large discrepancy between NO <sub>x</sub> /SO <sub>2</sub> ratios	BUP: EF for natural gas combustion may be overestimated and needs to be revised
PM <sub>10</sub>	Large discrepancy	Low contribution to total emissions (second priority)	Large discrepancy between EU city percentiles 		

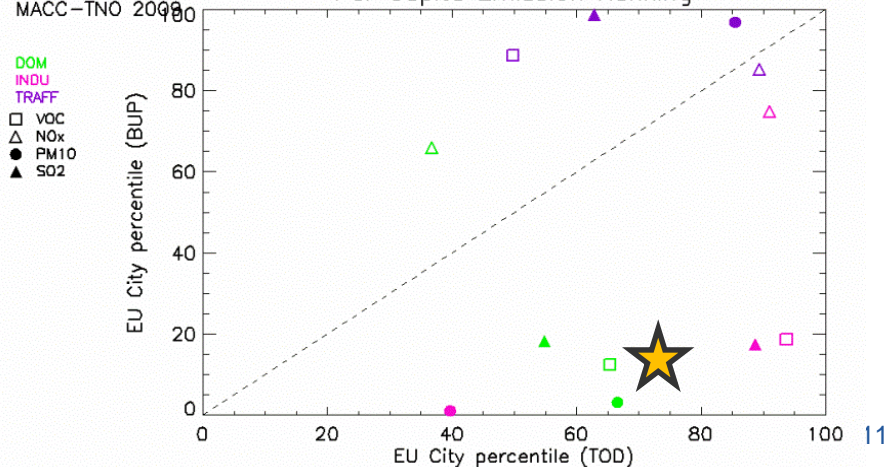
BU\_BarcelonaCityBSC 2009  
MACC-TNO 2009

Emission BUP/TOD



BU\_BarcelonaCityBSC 2009  
MACC-TNO 2009

Per Capita Emission Ranking



# Industrial sector

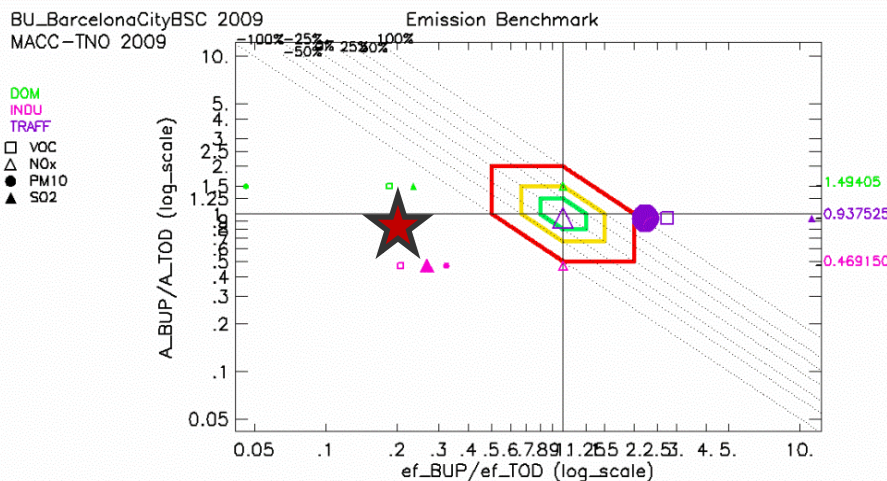


**Barcelona Supercomputing Center**  
Centro Nacional de Supercomputación

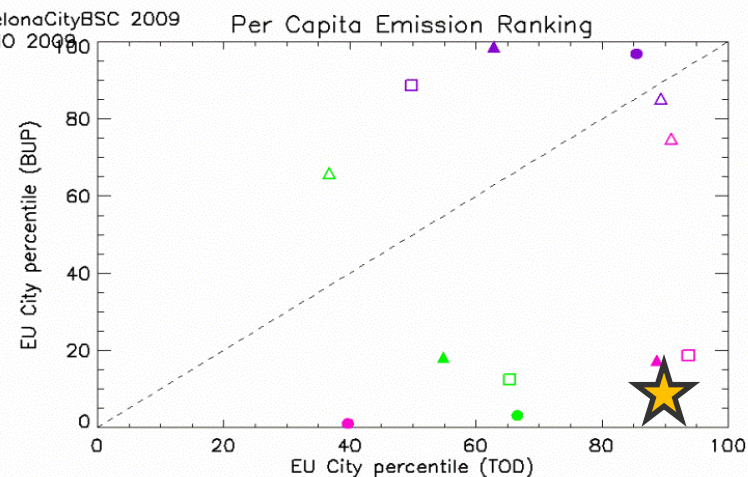
EXCELENCIA  
SEVERO  
OCHOA

p	Bar-plot	Diamond diagram	Per-capita diagram	Pollutant ratio	Hypothesis
<b>NO<sub>x</sub></b>	Low discrepancy		Close to the diagonal. High EU city percentile	BUP and TOD NO <sub>x</sub> /PPM <sub>10</sub> ratios above the EU 100p	<b>TOD: Industrial activity data may be overestimated. Activity shares related to coal and liquid based fuels may be overestimated</b>
<b>VOC</b>	Large discrepancy	Lower AF and weighted EF ★	Large discrepancy between EU city percentiles		
<b>SO<sub>x</sub></b>	Large discrepancy	High contribution to total SO <sub>x</sub> emissions	Large discrepancy between EU city percentiles ★	Large discrepancy between NO <sub>x</sub> /SO <sub>2</sub> ratios	<b>BUP: Revision of the SO<sub>2</sub> and PM<sub>10</sub> EF used in combustion processes. Possible underestimation of activity share related to industrial processes</b>
<b>PM<sub>10</sub></b>	Large discrepancy		Large discrepancy between EU city percentiles	Consistency between PPM <sub>10</sub> /SO <sub>2</sub> ratios	

BU\_BarcelonaCityBSC 2009  
MACC-TNO 2009



BU\_BarcelonaCityBSC 2009  
MACC-TNO 2009

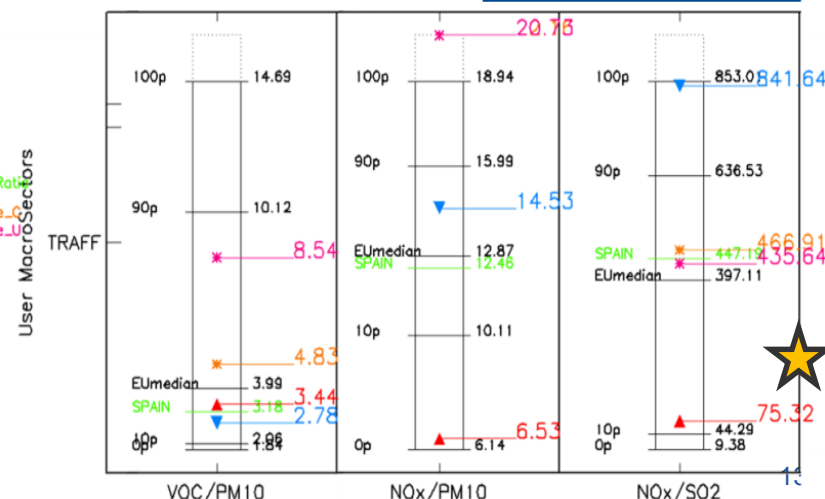
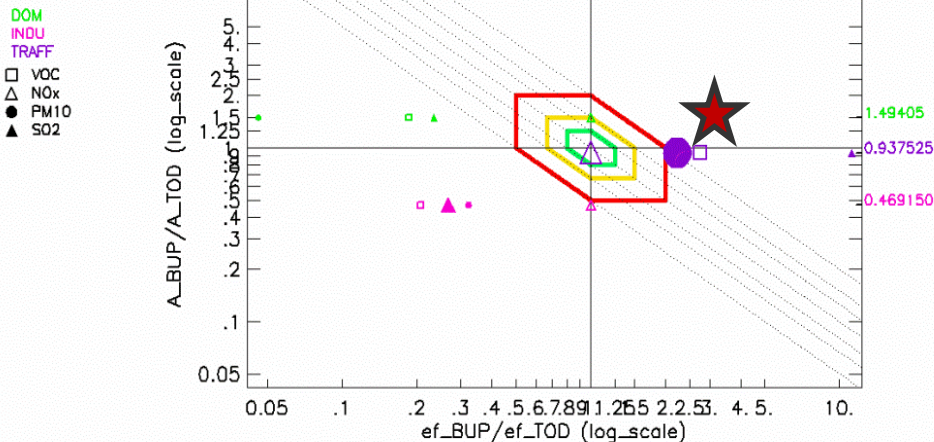


# Traffic sector



p	Bar-plot	Diamond diagram	Per-capita diagram	Pollutant ratio	Conclusions
NO <sub>x</sub>	Inconsistency with the rest of pollutants	Close to the origin. High contribution to total NO <sub>x</sub> emissions	Close to the diagonal. High EU city percentile		TOD: The inclusion of dust resuspension has a large impact
VOC		Higher weighted EF. High contribution to total emissions		Inconsistency between VOC/PPM <sub>10</sub> and NO <sub>x</sub> /PPM <sub>10</sub> BUP ratios	
SO <sub>x</sub>	Large discrepancy	Low contribution to total emissions (second priority)	Large discrepancy between EU city percentiles	Large discrepancy between NO <sub>x</sub> /SO <sub>2</sub> ratios ★	BUP: Possible overestimation of the fuel sulphur content. Revision of the methodology for estimating VOC evaporative emissions
PM <sub>10</sub>		Higher weighted EF. High contribution to total emissions ★	Close to the diagonal. High EU city percentile		

BU\_BarcelonaCityBSC 2009  
MACC-TNO 2009





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## Inventories

CTM4IAM (Ineris) 2010

EDGAR 2010

EMEP 2013

JRC 2010

MACC2 2009

MACC3 2010

## Regions



## Benchmarking through $\Delta$ -tool

- Top-down vs Bottom-up
- National vs regional/local inventories
- Reducing the knowlegde gap!

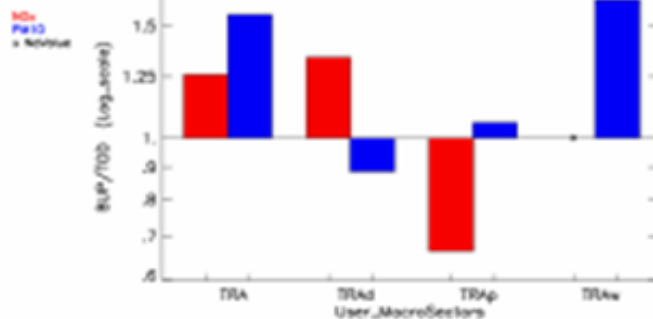


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## TOD vs BUP Traffic emissions

BU\_SWE-Region-Stockholm\_2013 2013 Emission BUP/100  
TNO-MACC3 2011

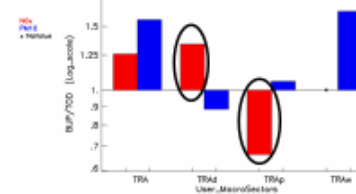


Stockholm County

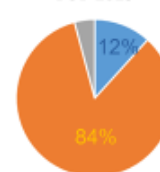
- PM10
  - BUP higher emissions of wear-particles
- NOx
  - BUP higher emissions from diesel vehicles
  - BUP lower emissions from gasoline vehicles

## NO<sub>x</sub> emissions from diesel and gasoline

BU\_SWE-Region-Stockholm\_2013 2013 Emission BUP/100  
TNO-MACC3 2011

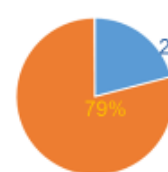


BUD 2013



■ gasoline ■ diesel ■ other

TNO-MACC3 2011



■ gasoline ■ diesel ■ other

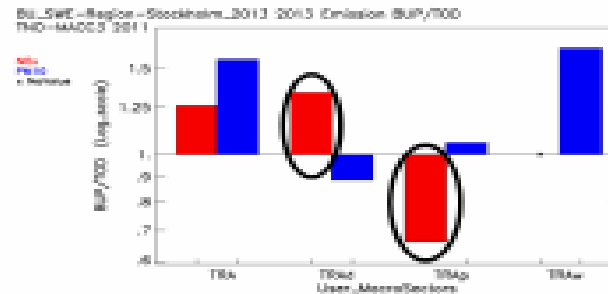
← Vehicle distribution between diesel and gasoline



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## Summary NO<sub>x</sub>



### Emissions of NO<sub>x</sub> from diesel vehicles

Time trend	Increase in share of diesel passenger cars	2011<2013	TOD<BUP
Geographical variation	The share of diesel passenger cars is higher in Stockholm compared to Sweden	Sweden<Stockholm	TOD<BUP
Methodology/EF	TOD and BUP both based on Hbefa EF		
Sum of effects	Both time-trends and spatial variation of emissions contribute to TOD is lower than BUP		<b>TOD&lt;BUP</b>

### Emissions of NO<sub>x</sub> from petrol vehicles

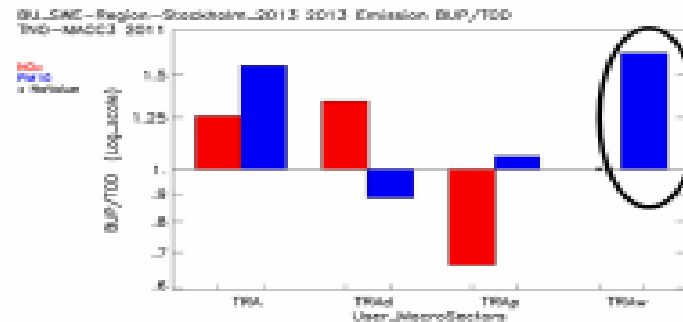
Time trend	Decrease in share of petrol passenger cars	2011>2013	TOD>BUP
Geographical variation	The share of petrol passenger cars is lower in Stockholm compared to Sweden	Sweden>Stockholm	TOD>BUP
Methodology/EF	TOD and BUP both based on Hbefa EF		
Sum of effects	Both time-trends and spatial variation of emissions contribute to TOD is higher than BUP		<b>TOD&gt;BUP</b>



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## Summary PM10



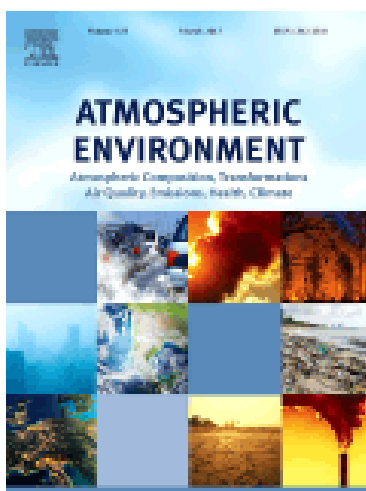
### Emissions of road wear (PM10)

Time trend	Decrease in share cars with studded tyres	2011>2013	TOD>BUP
Geographical variation	The studded tyre share is lower in Stockholm compared to Sweden	Sweden>Stockholm	TOD>BUP
Methodology/EF	TOD: EMEP/EEA, direct emissions BUP: NORTRIP, direct emissions and resuspension	Sweden<Stockholm	TOD<BUP
Sum of effects	Both time-trends and spatial variation of emissions contribute to higher emissions in TOD compared to BUP, while the difference in EF used between the two databases contribute to higher emissions in BUP compared to TOD.  The different EF gives rise to much greater differences in emissions compared to the differences in the proportion of studded tires -> TOD<BUP		<b>TOD&lt;BUP</b>



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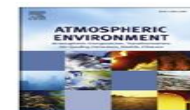
Atmospheric Environment 154 (2017) 285–296



Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: [www.elsevier.com/locate/atmosenv](http://www.elsevier.com/locate/atmosenv)



## Assessment of discrepancies between bottom-up and regional emission inventories in Norwegian urban areas

Susana López-Aparicio <sup>a,\*</sup>, Marc Guevara <sup>b</sup>, Philippe Thunis <sup>c</sup>, Kees Cuvelier <sup>d</sup>, Leonor Tarrasón <sup>a</sup>

<sup>a</sup> NILU - Norwegian Institute for Air Research, Kjeller, Norway

<sup>b</sup> Barcelona Supercomputing Center - Centro Nacional de Supercomputación, Earth Sciences Department, Barcelona, Spain

<sup>c</sup> European Commission, Institute for Environment and Sustainability, Ispra, Italy

<sup>d</sup> Ex-European Commission, Institute for Environment and Sustainability, Ispra, Italy





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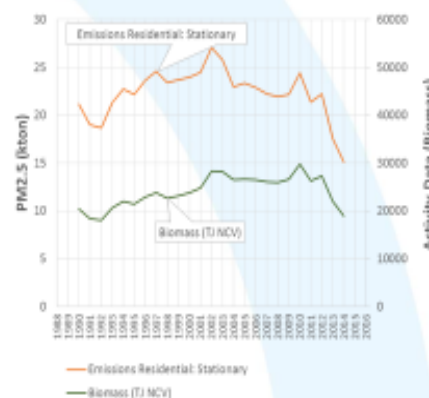
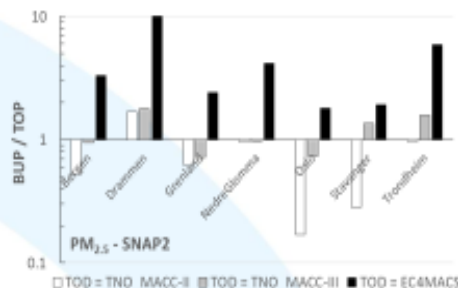
## Results \_ Residential heating (Wood burning)

PROXIES FOR SPATIAL DISTRIBUTION OF WOOD BURNING EMISSIONS:

*TNO\_MACC-II*: population density and wood availability (Wood use map; Kuenen et al., 2014)

*TNO\_MACC-III*: TNO internal estimates, population and wood availability (per. comm.).

*EC4MACS*: based on population, assuming emissions per inhabitant sharply decrease with population density (Terrenoise et al., 2015)



## Main conclusions

- **Resuspension** (not included in the National Emission Inventories)
- **Residential Combustion** (practices/spatial proxies cannot be extrapolated from one country to another)
- **Other mobile sources** (need for a more disaggregated classification)



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- How do we move from benchmarking/guidance to permanent improvements?
- How do we secure further involvement of local emission expertise in the work of FAIRMODE?

Composite mapping for emissions  
launched at the technical meeting  
in Zagreb

### Composite mapping for emissions



FAIRMODE WG2 CONTRIBUTIONS



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## Discussion

- How do we move from benchmarking/guidance to permanent improvements?
- Which use for the reported country gridded emissions within FAIRMODE?
- Composite Mapping: A necessity? ... or a nice to have?
- Which guidance for which purpose?



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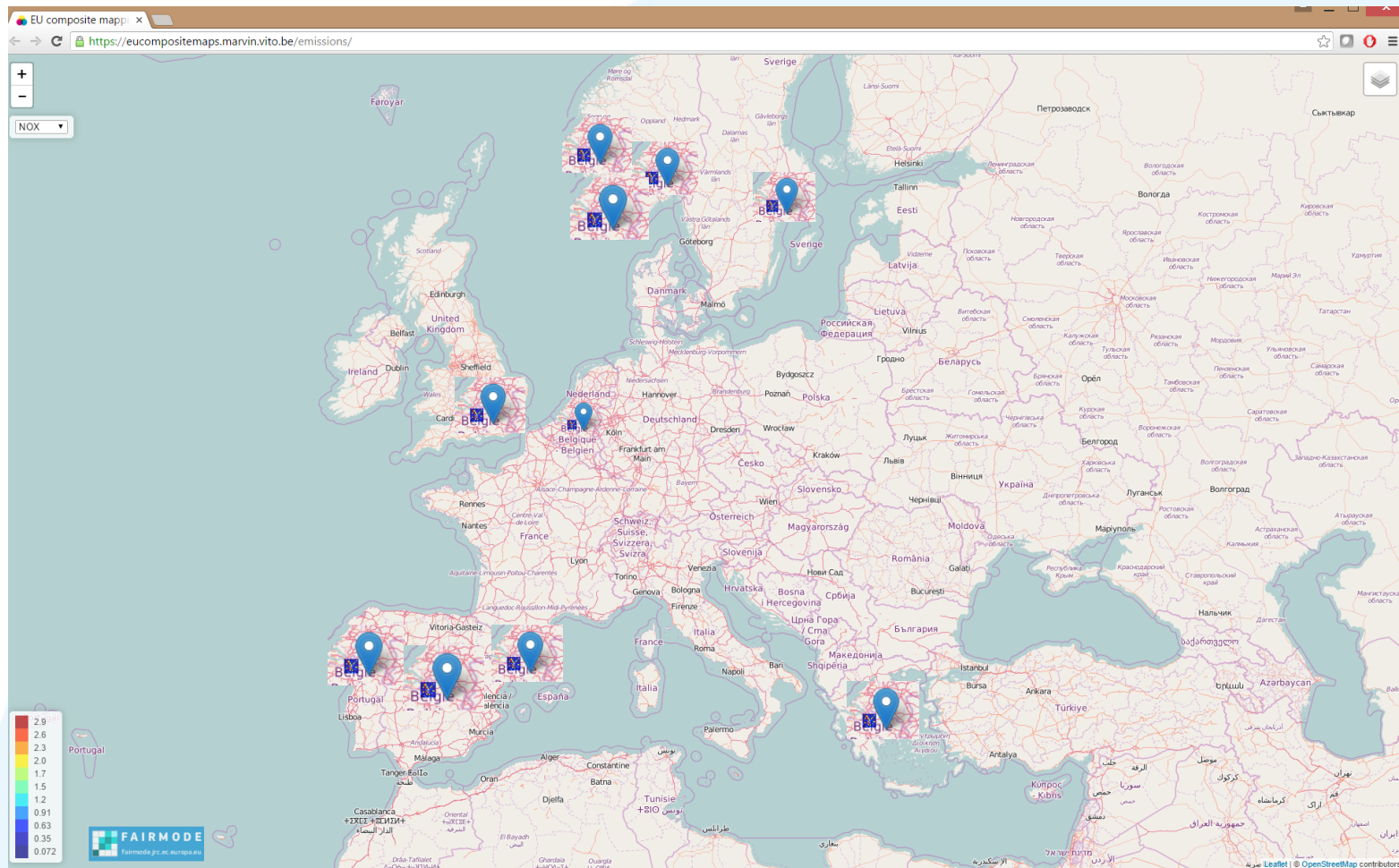
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## Central priority of WG 2 activities in 2017-2019

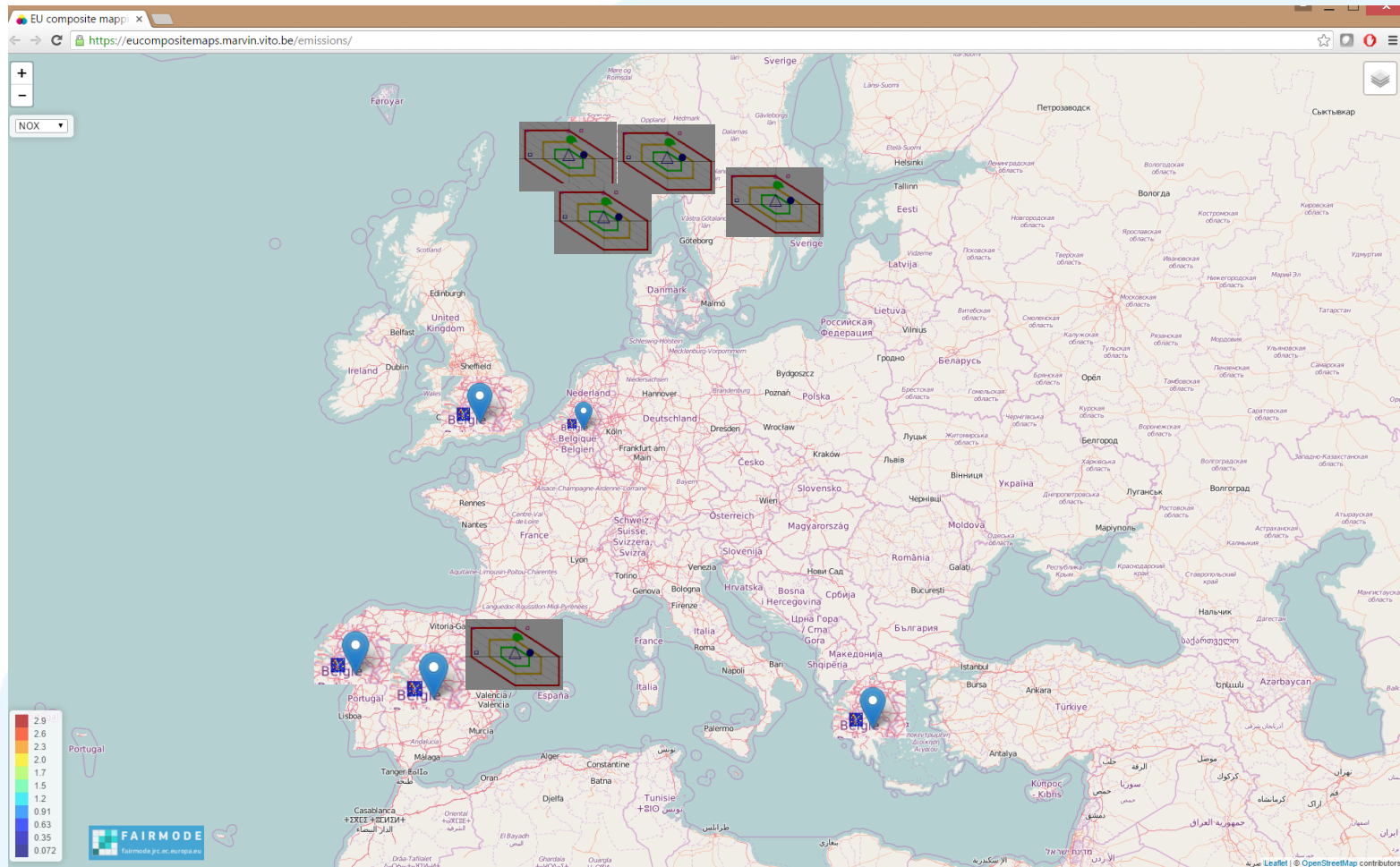
### Inter-comparison - emission composite map exercise

- Comparison of local inventories with the national and European wide inventories
- Improvement of TOD national emission inventories and of BUP local inventories – reducing the gap between them
- Better understanding of sources contributing to pollution in urban areas
- Support to WG1 assessment work; and WG3 and WG4 source allocation and measure identification work

# Composite mapping for emissions



# Composite mapping for emissions



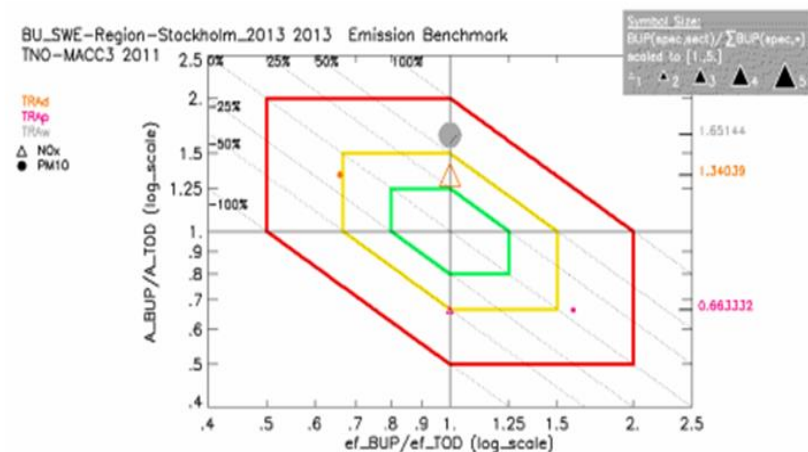


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- **WG2 goal is to provide local emission information knowledge to urban, regional, national and European assessments**
- **METHOD: Evaluation of Local inventories vs Europeanwide inventories in the  $\Delta$ -emission benchmarking tool**

**Diamondplot**





### ➤ Urban emission data compilation

BU\_StockholmCity.csv - Excel

	A	B	C	D	E	F	G	H
1	Shape	1 City		shp				
2	shape_SWE-City-Stockholm_LL							
3	2012	# Reference year						
4	#Species	BU sector: BU sectors nomenclature	Correspondance with SNAP		kton/year			
5	VOC	ENp energy_plants	S1		0.01256			
6	VOC	ENr boilers_heating	S2		0.02958			
7	VOC	INDe industrial_boilers	S3		0.20326			
8	VOC	IND industries	S4		0.06235			
9	VOC	PET petrol_stations_depots	S5		0.17383			
10	VOC	SOLV solvent_use	S6		4.362512			
11	VOC	TRA road_transport	S7		0.1587			
12	VOC	TRAp gasoline_road_transport	S7.1		0.09734			
13	VOC	TRAd diesel_road_transport	S7.2		0.04751			
14	VOC	TRAg LPG_road_transport	S7.3		0.00329			
15	VOC	TRAw road_transport_non-exhaust volatilization	S7.4		0.00894			
16	NOx	ENp energy_plants	S1		0.40427			
17	NOx	ENr boilers_heating	S2		0.06846			
18	NOx	INDe industrial_boilers	S3		0.05393			
19	NOx	IND industries	S4		0			
20	NOx	PET petrol_stations_depots	S5		0			
21	NOx	SOLV solvent_use	S6		0			
22	NOx	TRA road_transport	S7		2.33981			
23	NOx	TRAp gasoline_road_transport	S7.1		0.32164			
24	NOx	TRAd diesel_road_transport	S7.2		1.91526			
25	NOx	TRAg LPG_road_transport	S7.3		0.04236			
26	PM10	ENp energy_plants	S1		0.02377			
27	PM10	ENr boilers_heating	S2		0.02608			
28	PM10	INDe industrial_boilers	S3		0.01466			
29	PM10	IND industries	S4		0			
30	PM10	PET petrol_stations_depots	S5		0			
31	PM10	SOLV solvent_use	S6		0			
32	PM10	TRA road_transport	S7		0.7091			
33	PM10	TRAp gasoline_road_transport	S7.1		0.00304			
34	PM10	TRAd diesel_road_transport	S7.2		0.04369			
35	PM10	TRAg LPG_road_transport	S7.3		0.00033			
36	PM10	TRAw wear_road_transport	S7.5		0.66119			
37	END							
38								

#### Emissions file format for the tool:

- Total emissions per sector (.csv template):  
species; BU sector; BU sector nomenclature;  
Correspondance with SNAP; Kton/year
- Shape file

#### Emissions file format for the composite map:

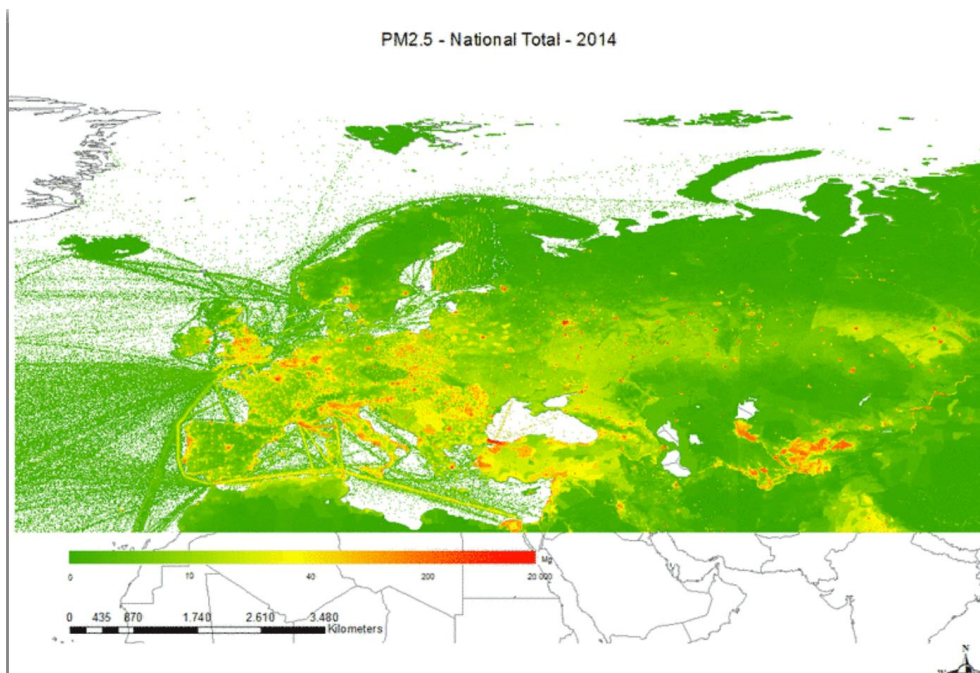
- Emission as shape file
- GRIDDED DATA



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### ➤ Urban emission data compilation comparison with EMEP 0.1x0.1



- GNFR A\_PublicPower
- GNFR B\_Industry
- GNFR C\_OtherStationaryCombustion
- GNFR D\_Fugitive
- GNFR E\_Solvents
- GNFR F\_RoadTransport
- GNFR G\_Shipping
- GNFR H\_Aviation
- GNFR I\_Offroad
- GNFR J\_Waste
- GNFR K\_AgriLivestock
- GNFR L\_AgriOther
- GNFR M\_Other
- NT National\_Total

FAIRMODE WG2 national and local estimates vs  
2014 data from CEIP and 2015 data from countries



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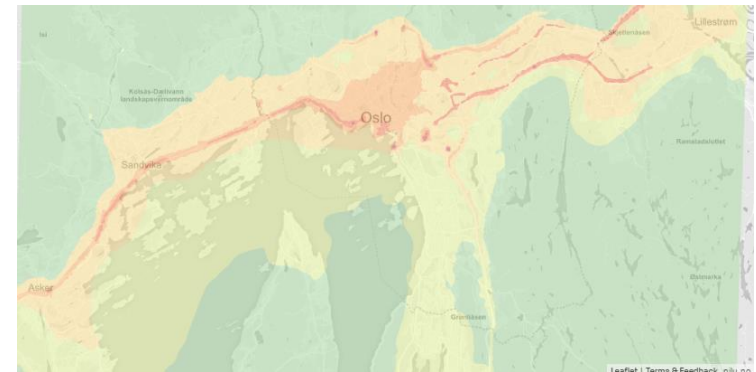
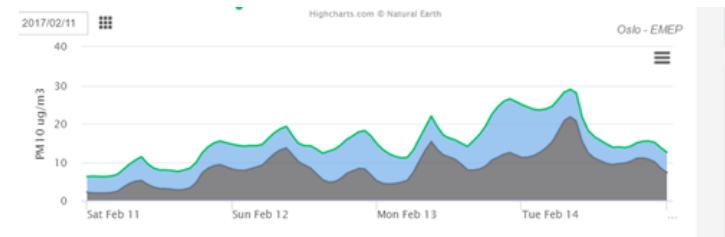
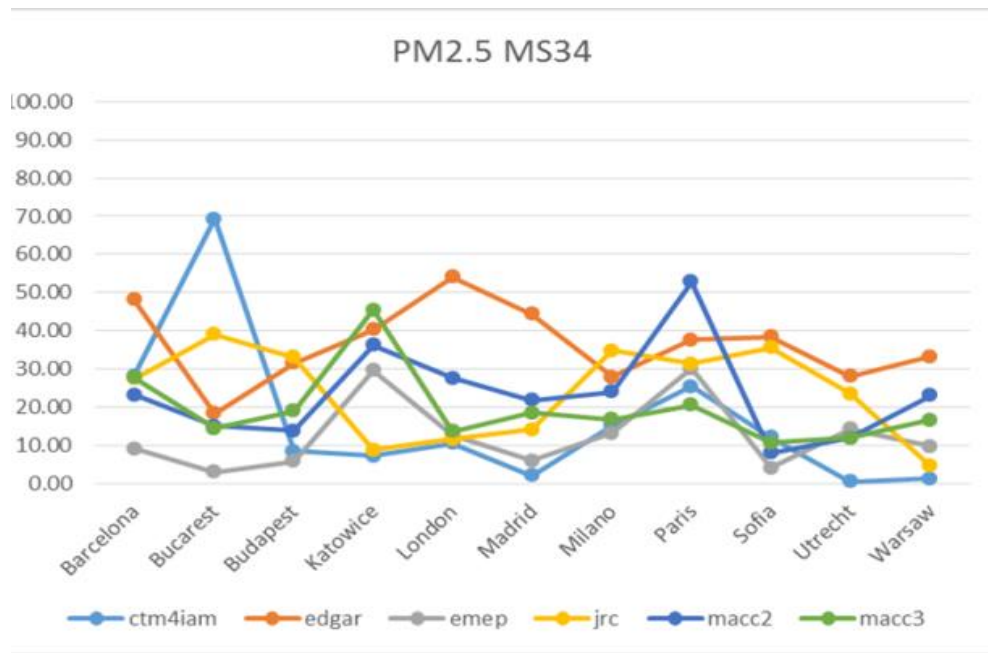
## How to carry out the composite exercise

- Send data to WG2 by 1. My 2017
- We will compile it and present it the composite mapping, run the data through the  $\Delta$ -tool and prepare questions to you for the technical meeting
- We want to understand differences between urban scale inventories and those of EMEP 01.x0.1
- Support the work with urban AQ assessment – AQ Urban partnership
- Volontaries?



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Share of the total emissions for each city coming from the residential sector. (Trombetti et al, 2017)

Share of  $PM_{10}$  from different sector are dependent on the underlying emission data and determine effectiveness of control measures



### Proposed focus for WG2 best practices in 2017-2019

- **Resuspension**
- **Residential combustion - Wood burning**
- **Small combustion and industry**
- **Agriculture**

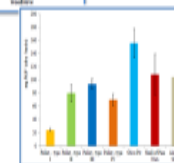
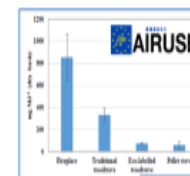
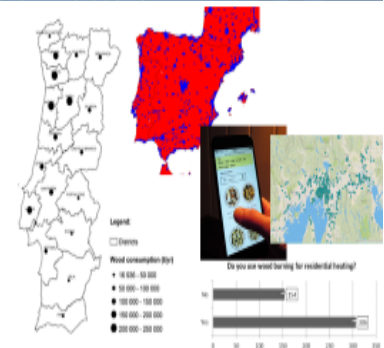
Priorities in terms of expertise or relevance to Plans&Programs and Implementation work

### Residential Combustion: Activity Data and Emission Factors



#### Activity data:

- Survey questionnaires
- Population maps (rural/urban)
- Crowdsourcing, web crawling, image recognition



#### Emission Factors:

- Type of appliance (open fireplace, traditional stove)
- Type of solid fuel (pellets, olive pit)



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## Questions for discussion

- Do you agree with the roadmap to move from benchmarking/guidance to permanent improvements?
- Do you agree on the proposed use of composite mapping to benchmark the reported country gridded emissions within FAIRMODE?
- Composite Mapping: A necessity? ... or a nice to have?
- Do you agree with the priorities for guidance?



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- Questions ?
- Comments?