The European Commission's science and knowledge service

Joint Research Centre

Source apportionment inter-comparison exercise 2015-2016 part 3 RM and CTM

C.A. Belis , D. Pernigotti EC-JRC

G. Pirovano RSE SpA

Fairmode Technical meeting
Athens, 19-21 June 2017

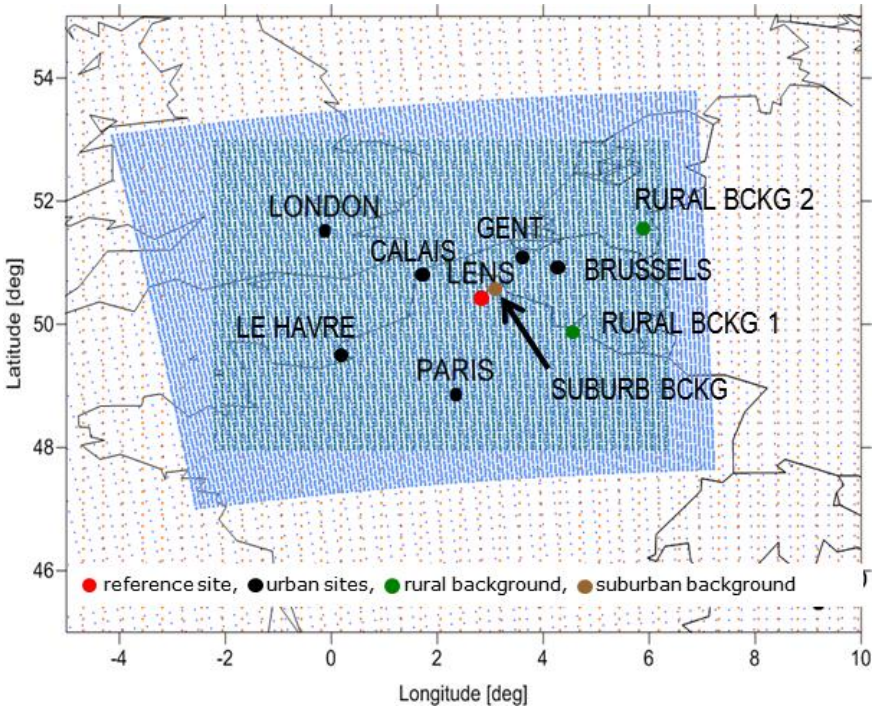
European Commission

Contributors

O. Favez, J.L. Jaffrezo, J. Kuenen, H. Denier van Der Gon, M. Rezler, M.T. Pay, M. Almeida, F. Amato, A. Aniko, I. Beslic, M. Bove, G. Calori, D. Cesari, C. Colombi, D. Contini, G. De Gennaro, A. Di Gilio, I. El Haddad, H. Elbern, K. Eleftheriadis, G. Foret, M. Garcia Vivanco, S. Gilardoni, M. Grosa, S. Hellebust, R. Hoogerbrugge, P. Hopke, Y. Izadmanesh, H. Jorquera, A. Karppinen, Z. Kertesz, T. Kolesa, P. Lazzeri, F. Lenartz, F. Lucarelli, A. Manders, H. Martins, M. Mircea, D. Mooibroek, S. Nava, D. Oliveira, P. Paatero, M. Paglione, M. Perrone, E. Petralia, A. Pietrodangelo, S. Pilion, P. Pokorna, P. Prati, M. Reizer, V. Riffault, C. Samara, L. Samek, S. Sauvage, F. Scotto, K. Sega, G. Siour, R. Tauler, R. Vecchi, E. Venturini, M. Vestenius, E. Yubero

Intercomparison outline – Source oriented models (CTM)

- **Common input dataset**
  - ECMWF meteorology
  - TNO emissions
  - MACC chemical fields
- **Centralized MPE (by RSE)**
  - LENS dataset
  - ca. 200 AIRBASE sites
  - Local networks
- **Set of receptors (10)**
  - Lens
  - Urban sites
  - Coastal sites
  - Background sites



8 - 14 source categories

3 + 3 summer/winter months

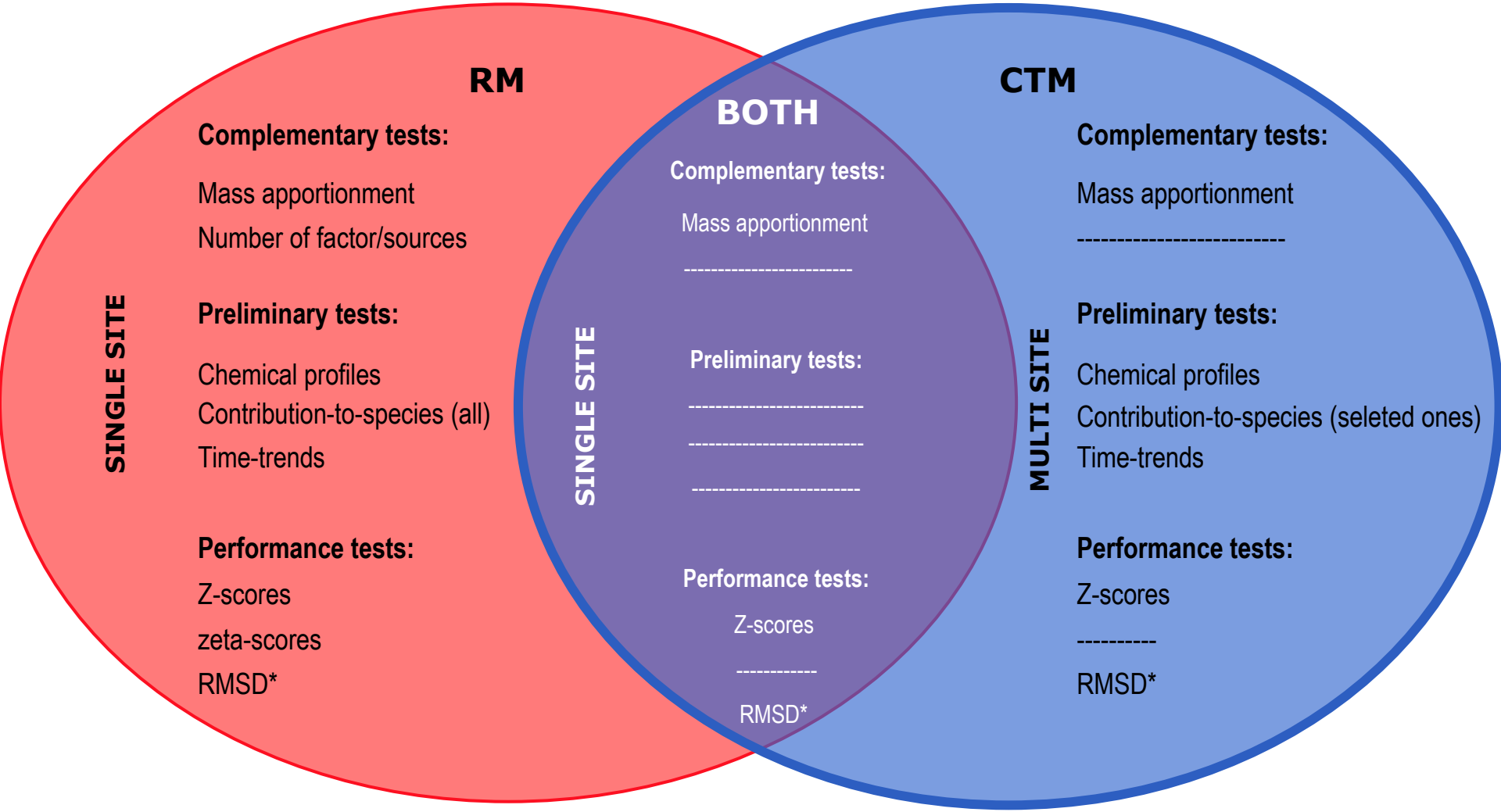
Hourly concentrations

Primary and secondary PM

PM precursors

European Commission

Evaluation in this IE



European Commission

Intercomparison differences in RM and CTM set up

RM

09/03/2011 to 06/03/2012

every 3 days

24 hours mean

116 samples

PM_{10}

98 chemical species

CTM

Summer: 1/6/2011 to 1/08/2011

Winter: 15/11/2011 to 5/2/2012

Hourly data

c.a 4300 time steps

PM_{10} and $PM_{2.5}$

7 chemical species

	RMs	CTMs
IONS	8 species	nitrate (NO3), sulphate (SO4), ammonium (NH4),
carbonaceous fraction	EC/OC 2 species	elemental carbon (EC), organic carbon x *k* = (POA+SOA)
TRACE ELEMENTS	25 species	other primary aerosol (OPA)
PAHs	15 species	POA+SOA
LEVO/MANN	3 species	
HOPANES	10 species	
N-ALKANES	29 species	
CHOLESTEROL		
POA MARKERS	4 species	primary organic aerosol (POA),
OTHER	Pristane, Phytane, Glucose	
		secondary organic aerosol (SOA),
TOTAL	98	7

Definition of sources in CTMs

SNAP		Mandatory 8	Optional 14
1	Energy industry	01_ENI	01_ENI
21	R & C combustion, coal	99_OTH	**02_OTH**
22	R & C combustion, light liquid fuel	99_OTH	**02_OTH**
23	R & C combustion, medium liquid fuel	99_OTH	**02_OTH**
24	R & C combustion, heavy liquid fuel	99_OTH	**02_OTH**
25	R & C combustion, gas	99_OTH	**02_OTH**
26	R & C combustion, solid biomass (wood)	02_BIO	02_BIO
34	Industry (combustion & processes)	34_IND	34_IND
5	Fugitive emissions from fuels	99_OTH	99_OTH
6	Product use including solvents	99_OTH	99_OTH
71	Road transport, exhaust, gasoline	07_RTR	**71_RTG**
72	Road transport, exhaust, diesel	07_RTR	**72_RTD**
73	Road transport, exhaust, LPG/natural gas	07_RTR	07_RTR
74	Road transport, non-exhaust, evaporation	07_RTR	07_RTR
75	Road transport, non-exhaust, wear	07_RTR	**75_RTW**
8	Non-road transport	99_OTH	99_OTH
81	International shipping, marine diesel oil	08_SHP	08_SHP
82	International shipping, heavy fuel oil	08_SHP	08_SHP
9	Waste treatment	99_OTH	99_OTH
10	Agriculture	10_AGR	10_AGR
11P	Dust	11_DST	11_DST
11	Sea Salt	99_OTH	**11_SLT**
11	Biogenic SOA	99_OTH	**11_BSO**

8 - 14 source categories defined for comparability with RM source categories (SPECIEUROPE used as reference)
The optional set with higher detail on domestic, traffic and primary inorganic aerosol (dust/salt)

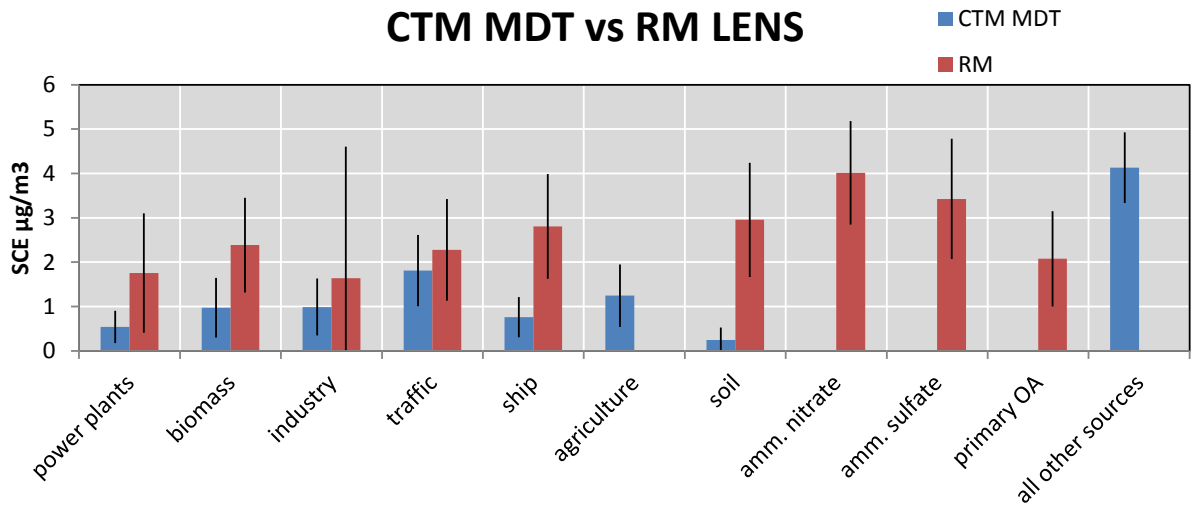
3 + 3 summer/winter months
Hourly concentrations (current evaluation for daily averages)
Primary and secondary PM
PM precursors

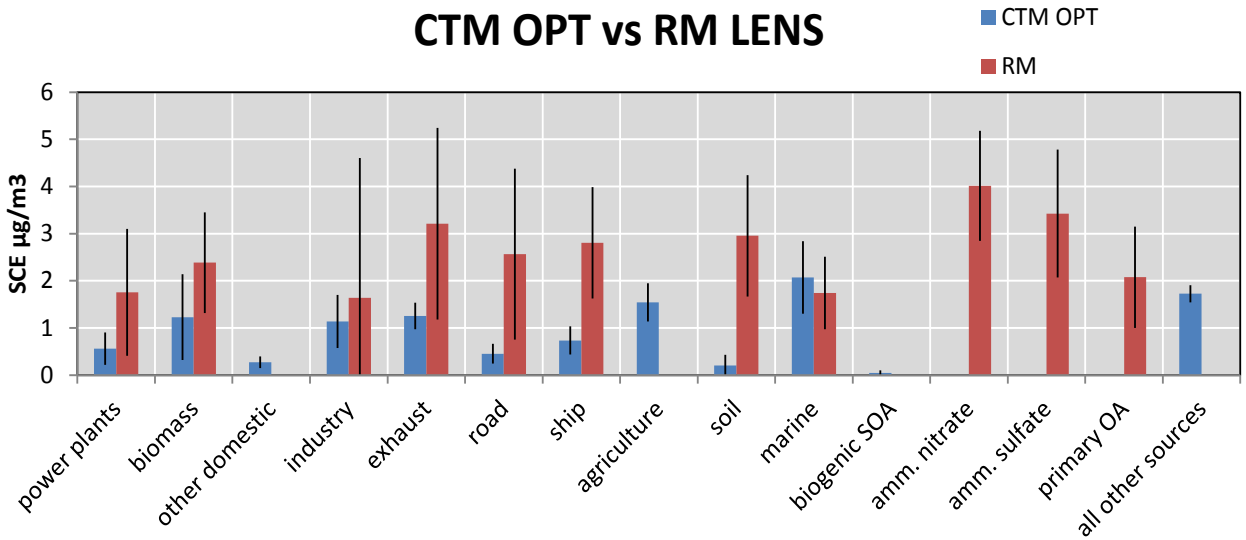
Comparability of sources between RMs and CTMs

CTM	RM corresp.	CTM	RM corresp.
Mandatory		**Optional**	
01_ENI	30 fuel oil	01_ENI	30 fuel oil
99_OTH		**02_OTH**	
99_OTH			
99_OTH			
99_OTH			
99_OTH			
02_BIO	40 biomass burn.	02_BIO	40 biomass burn.
34_IND	20 industry	34_IND	20 industry
99_OTH		99_OTH	
99_OTH		99_OTH	
07_RTR	1 traffic	**71_RTG**	2 exhaust
		72_RTD	
		07_RTR (OTH)	
		07_RTR (OTH)	
		75_RTW	5 road dust
99_OTH		99_OTH	
08_SHP	37 ship, 30 fuel oil	08_SHP	37 ship
99_OTH		99_OTH	
10_AGR		10_AGR	
11_DST	10 dust	11_DST	10 dust
99_OTH		**11_SLT**	12 marine, 71 aged sea salt
99_OTH		**11_BSO**	
$NH_4+NO_3+SO_4$	60 SIA	$NH_4+NO_3+SO_4$	60 SIA

	SOURCE CATEGS, (SPECIEUROPE)
1	traffic
2	exhaust
10	soil
12	marine (fresh sea salt)
20	industry
30	fuel oil
31	coal
37	ship
40	biomass burning
41	wood burning
5	road dust
60	SIA
61	ammonium nitrate
62	ammonium sulphate
66	deicing salt
70	POA
71	aged sea salt
74	combustion

Averaged reported contributions





Error bar: standard deviation

European Commission

Mass apportionment

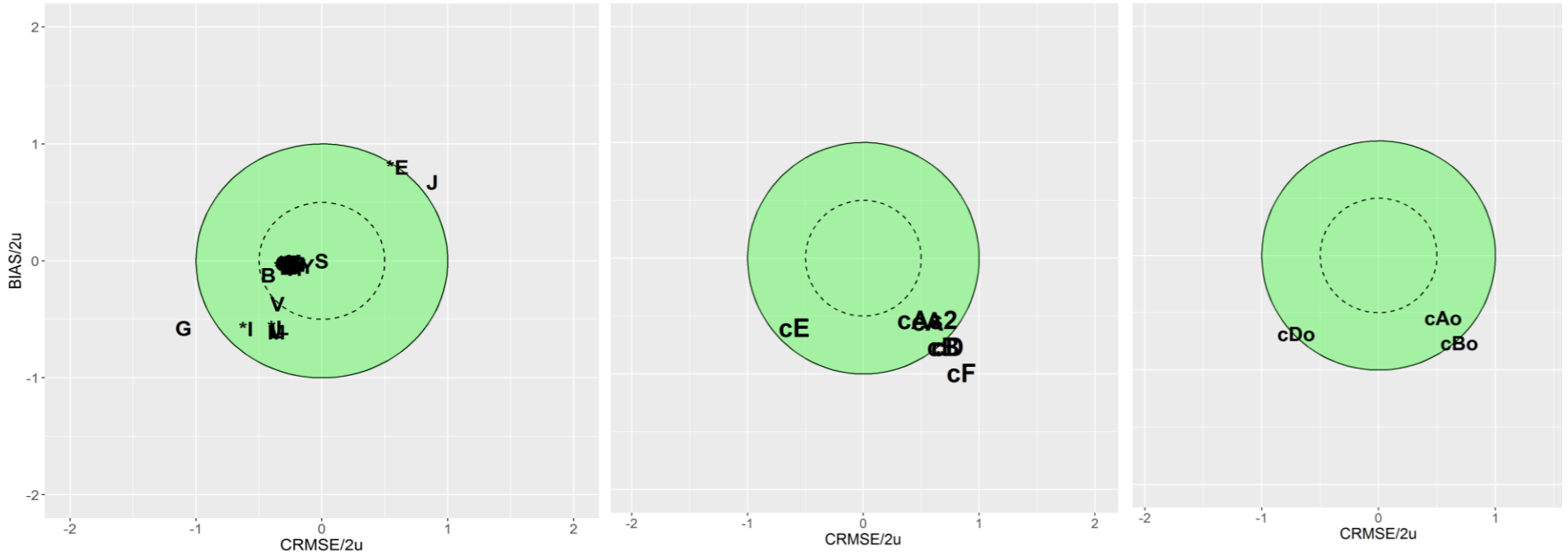
Lens

Receptor Models

Chemical Transport Models

Mandatory

Optional



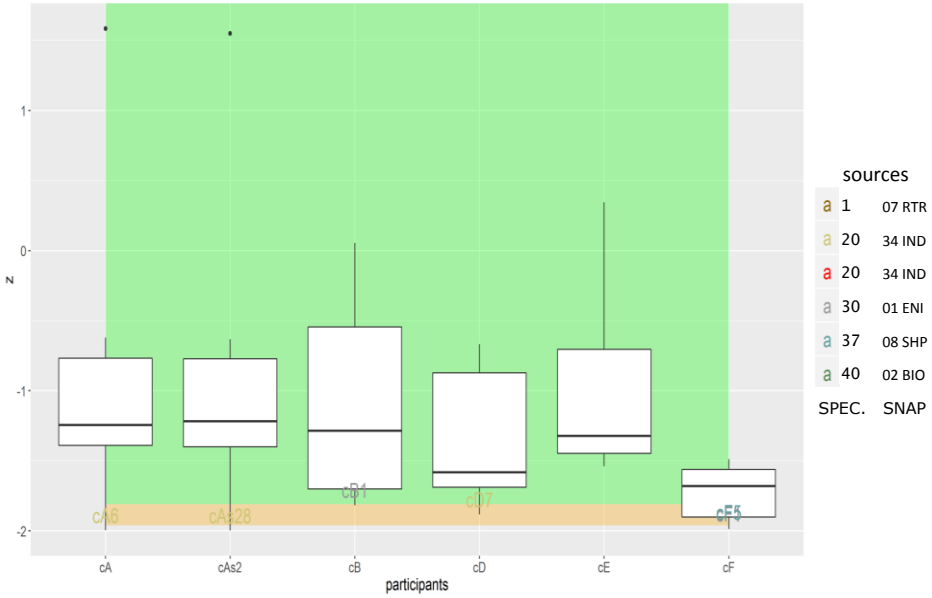
European Commission

CTM performance tests using the RMs as reference

Performance RM CTMs z-score (overall sce)

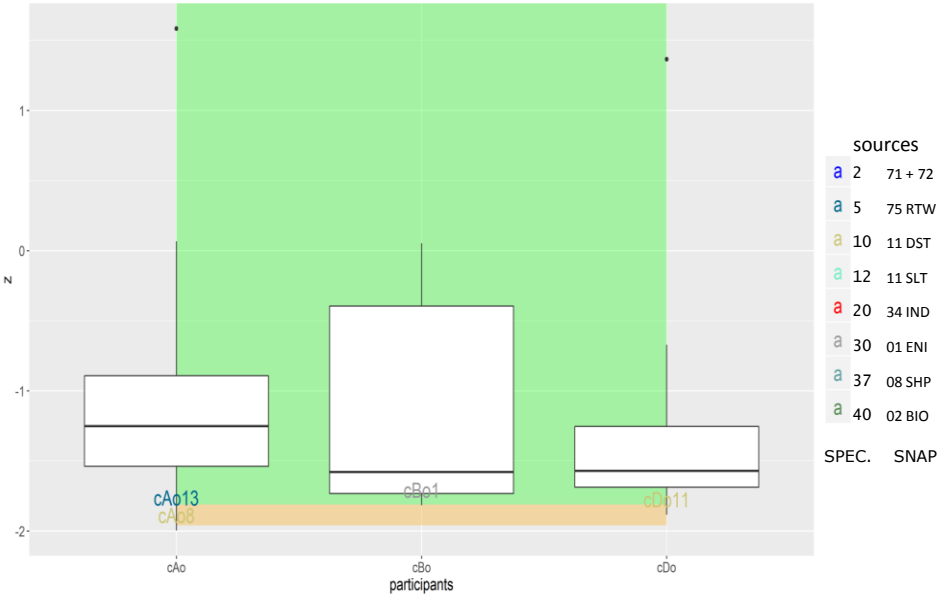
Lens

mandatory



successful candidates: 83%

optional



successful candidates: 83%

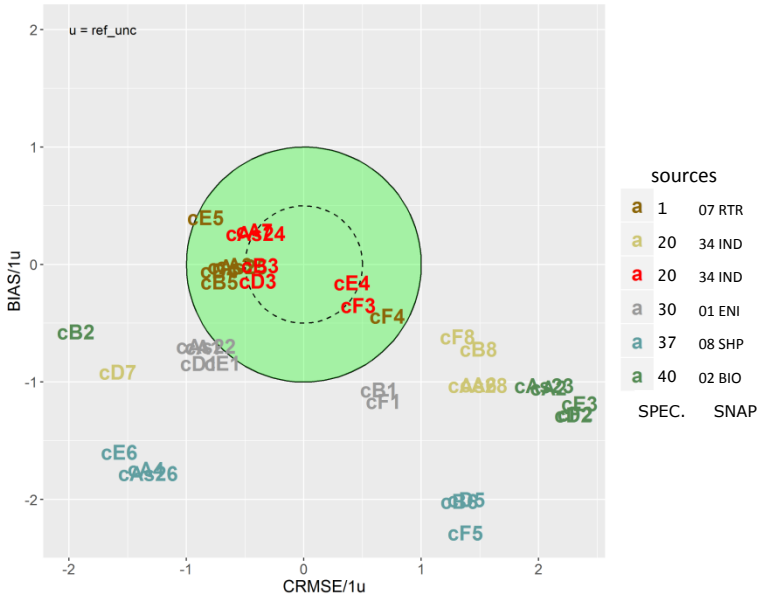
Mandatory: soil is the most critical source, only the candidate of cB is comparable with RMs, followed by power plants and ship. The scores of result cF are on average lower than the others while cB shows a contribution from power plants lower than RMs.
Optional: the most critical source is soil with two candidates (cAo and cDo) outside the acceptability area. cAo contribution is lower than RMs in road dust and the same applies to cB for power plants.

European Commission

Performance RM CTMs RMSEu (time series)

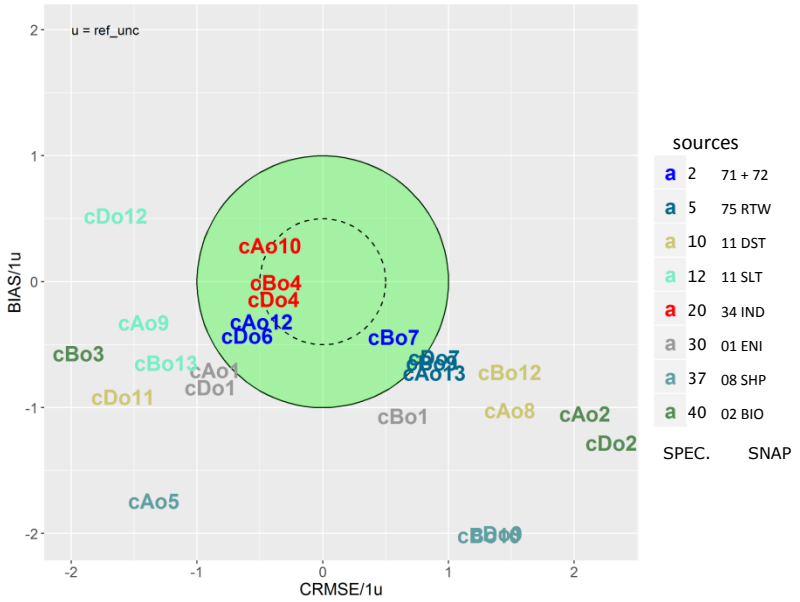
Lens

mandatory



comparable candidates: 34%

optional



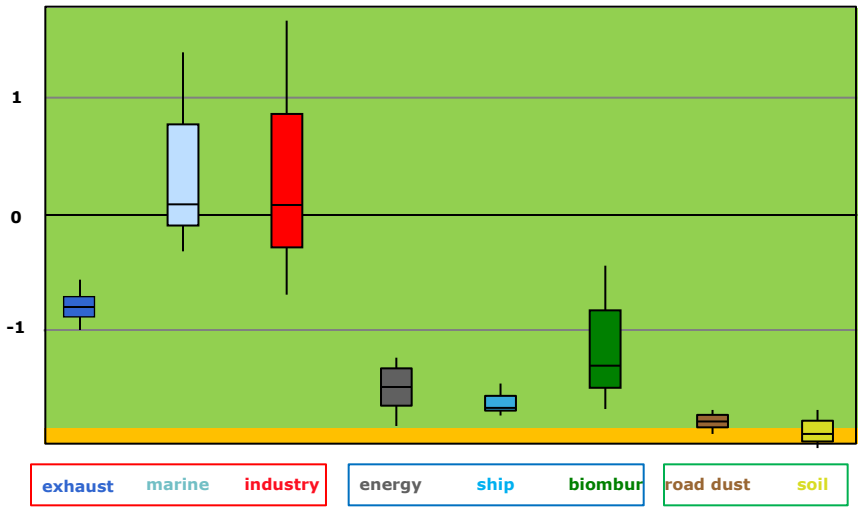
comparable candidates: 25%

Mandatory: only the candidates of the sources industry and traffic pass the RMSEu test and the same applies to sources industry and exhaust in the optional set.

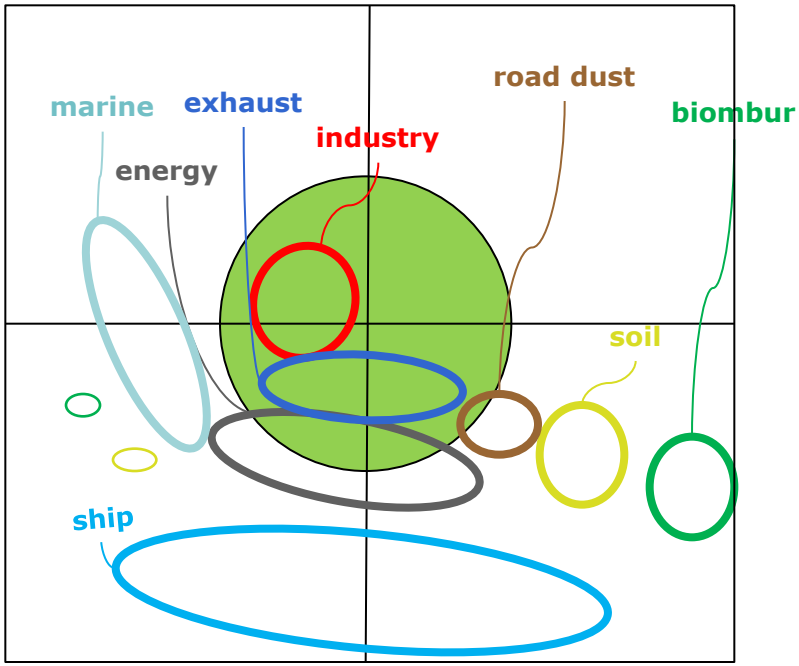
All the candidates of the other sources fall outside the acceptability area (prevailing negative bias) in both the mandatory and the optional sets

Evaluation of CTMs using RMs as reference (Lens)

z-score (overall average)



$RMSE_u$ (time series)

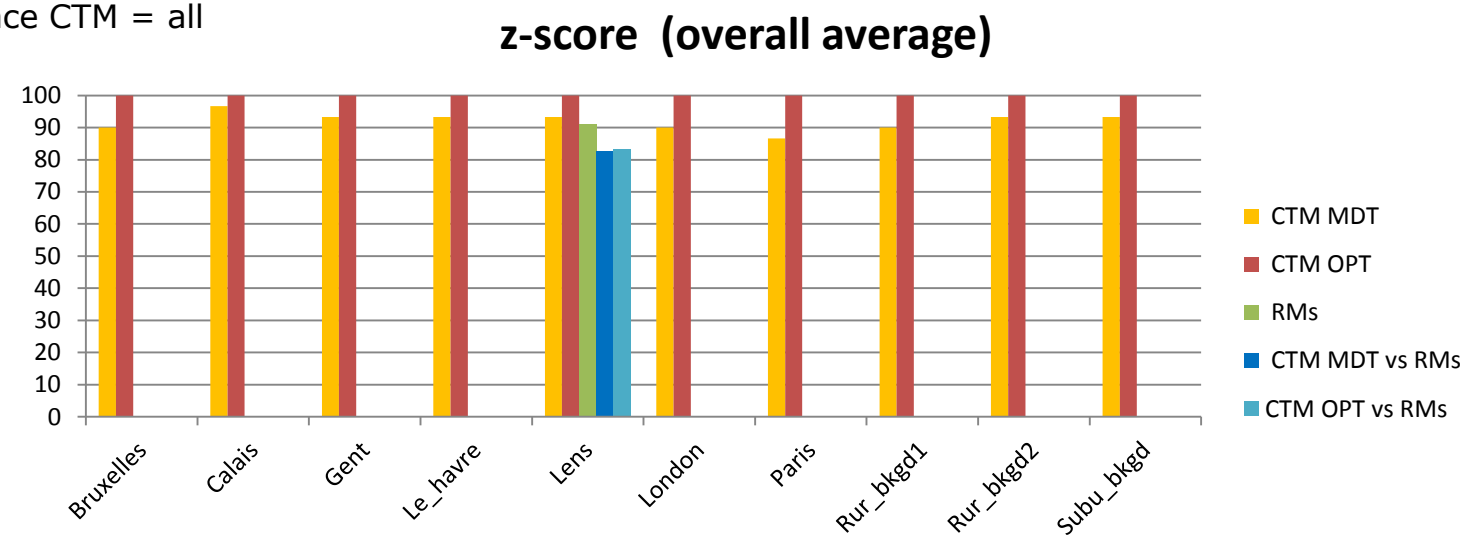


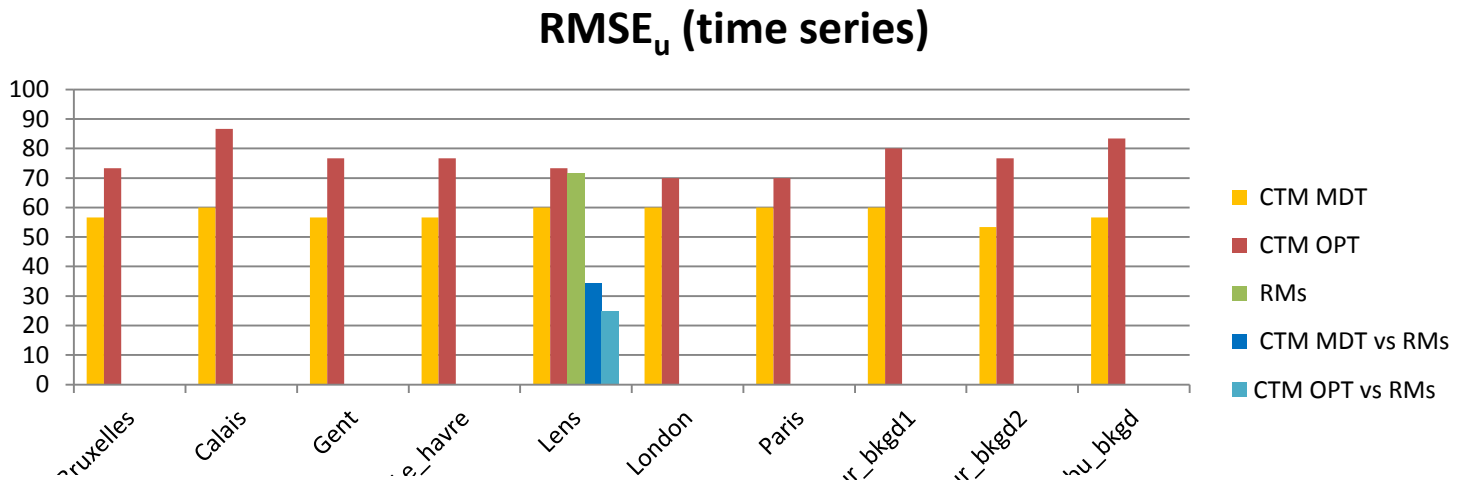
The comparability between RMs and CTMs varies from source to source

European Commission

Performance CTMs ALL RECEPTORS ALL MODELS

Reference CTM = all





MDT:7 results 180 t. steps

OPT:4 results 180 t. steps

RMs 38 results 116 time steps

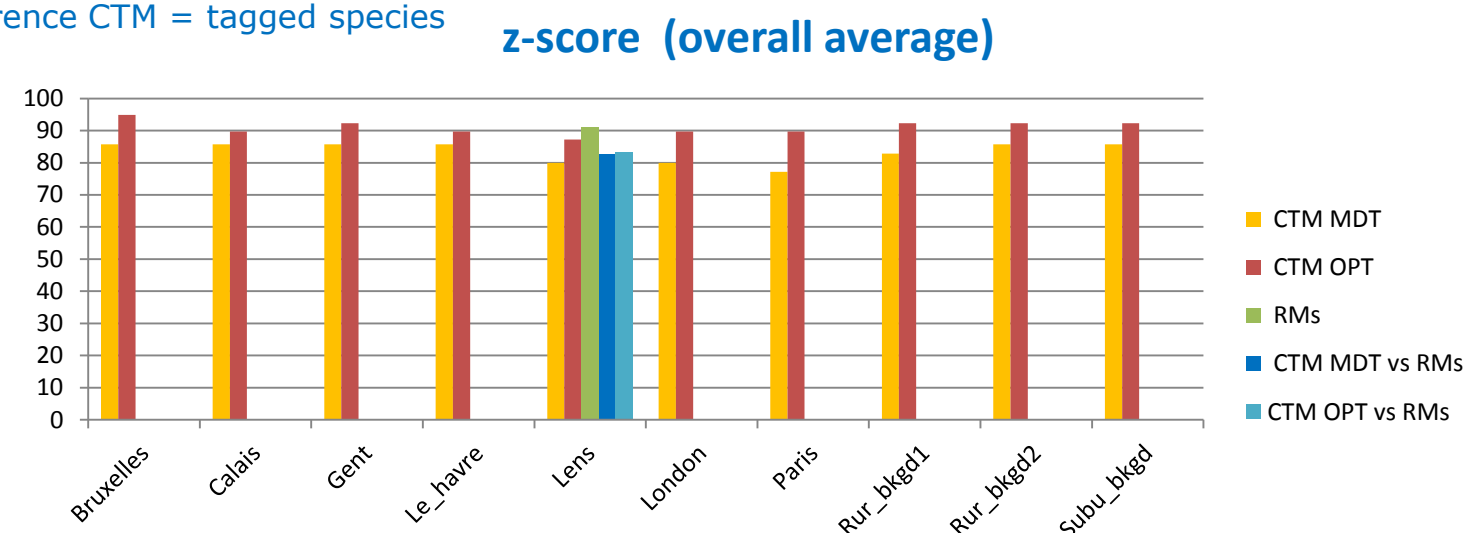
CTM vs RM 7 results 57 time steps

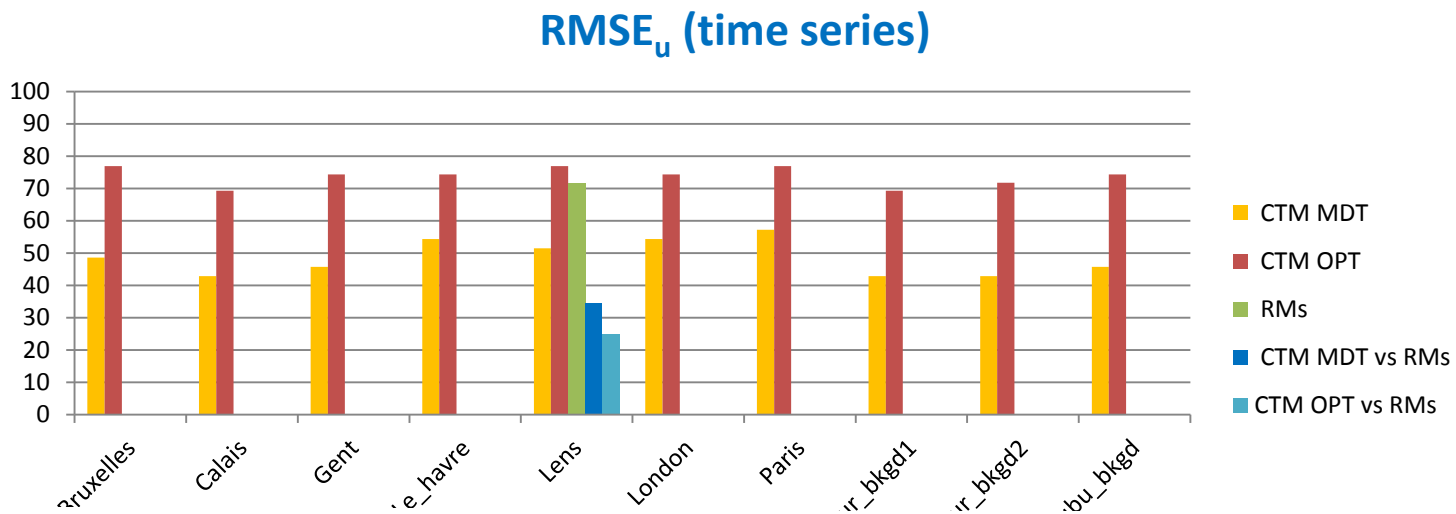
In general the geographic patterns are quite homogeneous among sites.

In z-score mandatory Paris and London slightly lower perfromance than other sites (bias problem). However these sites are among those with better perfomance in the target plots (-> good estimation of the time trends near sources).

Performance CTMs ALL RECEPTORS ALL MODELS

Reference CTM = tagged species





MDT:7 results 180 t. steps

OPT:4 results 180 t. steps

RMs 38 results 116 time steps

CTM vs RM 7 results 57 time steps

In general the geographic patterns are quite homogeneous among sites.

In z-score mandatory Paris and London slightly lower perfromance than other sites (bias problem). However these sites are among those with better perfomance in the target plots (-> good estimation of the time trends near sources).

Conclusions of the IE (1)

GENERAL

In general models show better performances in estimating the average source contribution for long time windows (in this case many months covering summer and winter) than the contributions for single time steps (time series). This is likely due to the influence of non linear processes. The comparability between RMs and CTMs changes from source to source.

RMS

- **RMs present comparable results among each other which are also coherent with measured PM.**
- **There is a convergence towards one particular model: EPA PMF5.**
- **Industry source category in RM needs better definition because often used to represent a wide variety of different sources.**
- **The experience of the practitioner influences the performance**

Conclusions of the IE (2)

CTMs

- **CTMs show good performances when tested using an ensemble reference, especially for the overall average.**
- **No significant differences in performance between sites suggest that CTM have a rather comparable geographical pattern likely due to same input data.**
- **The sensitivity analysis for CTM demonstrates the influence of the spatial resolution on the SA performance of models in densely populated areas.**
- **More effort is needed to improve and harmonise the estimation of soil and road dust sources, in particular in the emission inventories.**
- **When using tagged species as reference, differences between tagged species and brute force are mainly observed in sources involved in secondary processes (agriculture, power plants, traffic, biomass burning, etc.)**

Thank you for your attention