The European Commission's science and knowledge service

Joint Research Centre

Source apportionment inter-comparison exercise 2015-2016 part 2 CTM

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Fairmode Technical meeting
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European Commission

Contributors

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Schedule of the IE

Applications: 79

Withrawed: 39

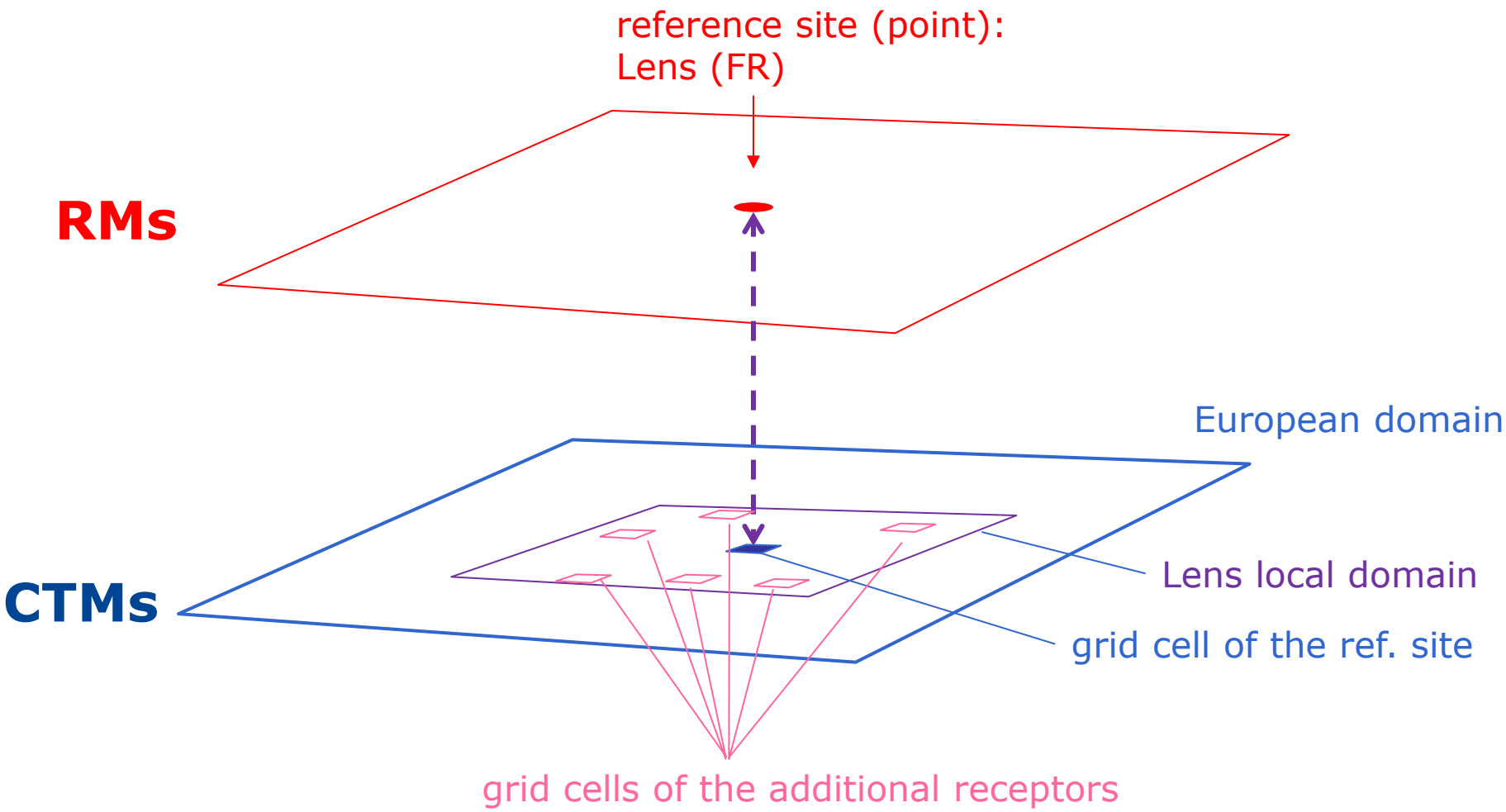
delivered: 40 teams (33 RM, 7 CTM)

- Data distributed in July 2015
- Update in November 2015
- Receptors for CTM in January 2016
- RM results reported 33 teams
- Questionnaire for RMs in first quarter 2016
- CTM results reported by 7 teams
- Requests of clarifications and correction of inconsistencies needed
- Questionnaire for CTMs in spring 2017

CTM CONSORTIA

ENEA /ARIANET/ ARPA PIEMONTE	joint result
CIEMAT/LISA -CNRS	jont result
RIER- UNI KOLN	independent result
TNO	independent result
ARPAV	coodinated result
RSE	coordinated results
UNI AVEIRO	cordinated results

Domains and receptors



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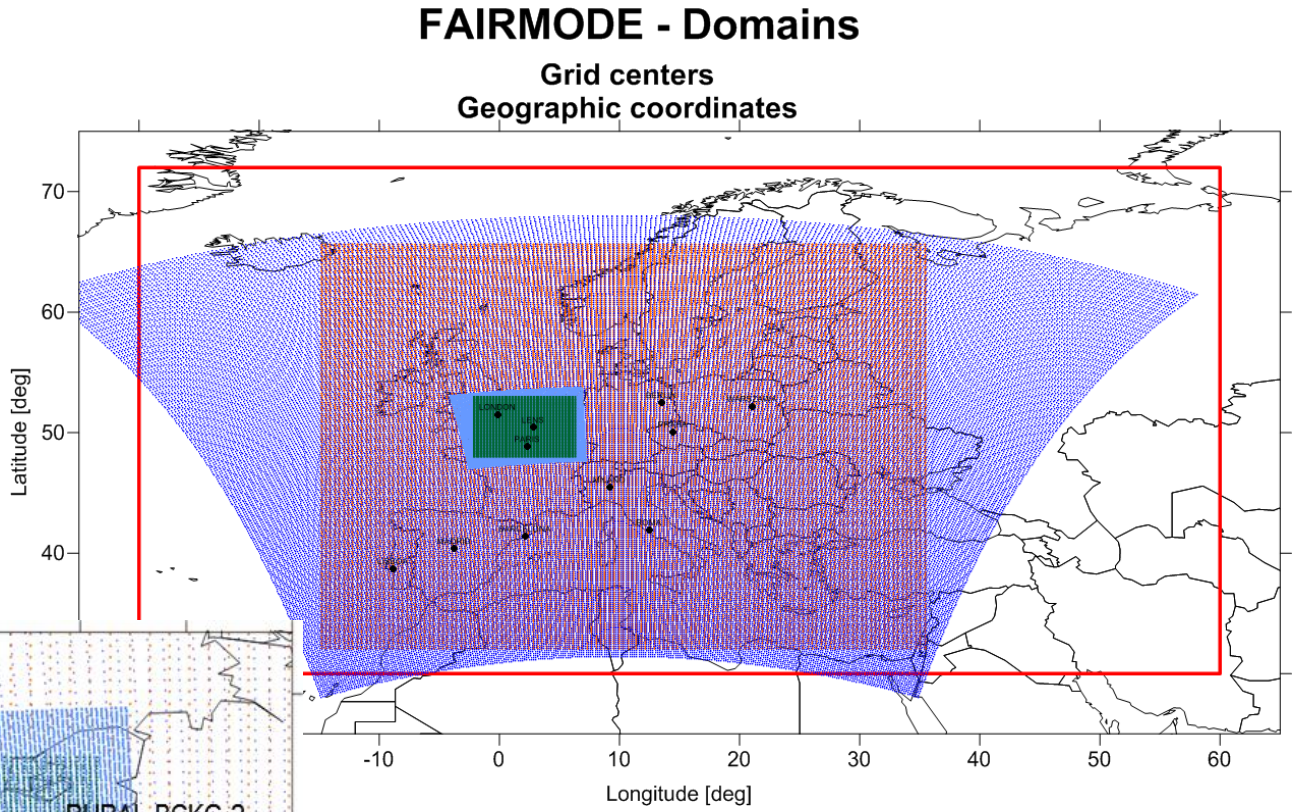
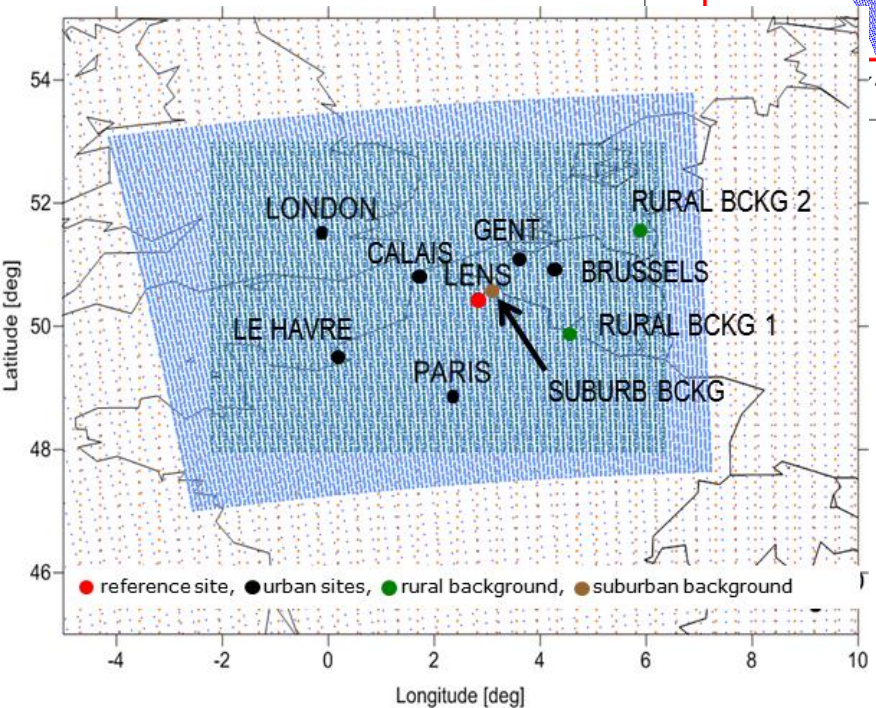
Intercomparison outline – Source oriented models (CTM)





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Intercomparison set up

- **Common input dataset**
  ECMWF meteorology
  TNO emissions with fuel detail
  MACC chemical fields
- **MPE using ca. 200 Airbase stations (centralised by RSE)**

Study Periods

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

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

Receptors for SA results ------>

Station Code	Station Name	Region	Station Type	Area Type
LENS_SA	Lens-CARA	FRANCE	Background	urban
CALAIS_SA	Sangatte	FRANCE	Background	suburban
LE_HAVRE_SA	Le Havre Henri Fabre	FRANCE	Background	urban
PARIS_SA	PARIS 6eme	FRANCE	Background	urban
LONDON_SA	LONDON N. KENSINGTON	UNITED KINGDOM	Background	urban
BRUXELLES_SA	41R012 - UCCLE	BELGIUM	Background	suburban
GENT_SA	Gent	BELGIUM	Background	urban
SUBU_BKGD_SA	40MN01 - MENEN	BELGIUM	Background	suburban
RUR_BKGD1_SA	REVIN	FRANCE	Background	rural
RUR_BKGD2_SA	Vredepeel-Vredeweg	NETHERLANDS	Background	rural

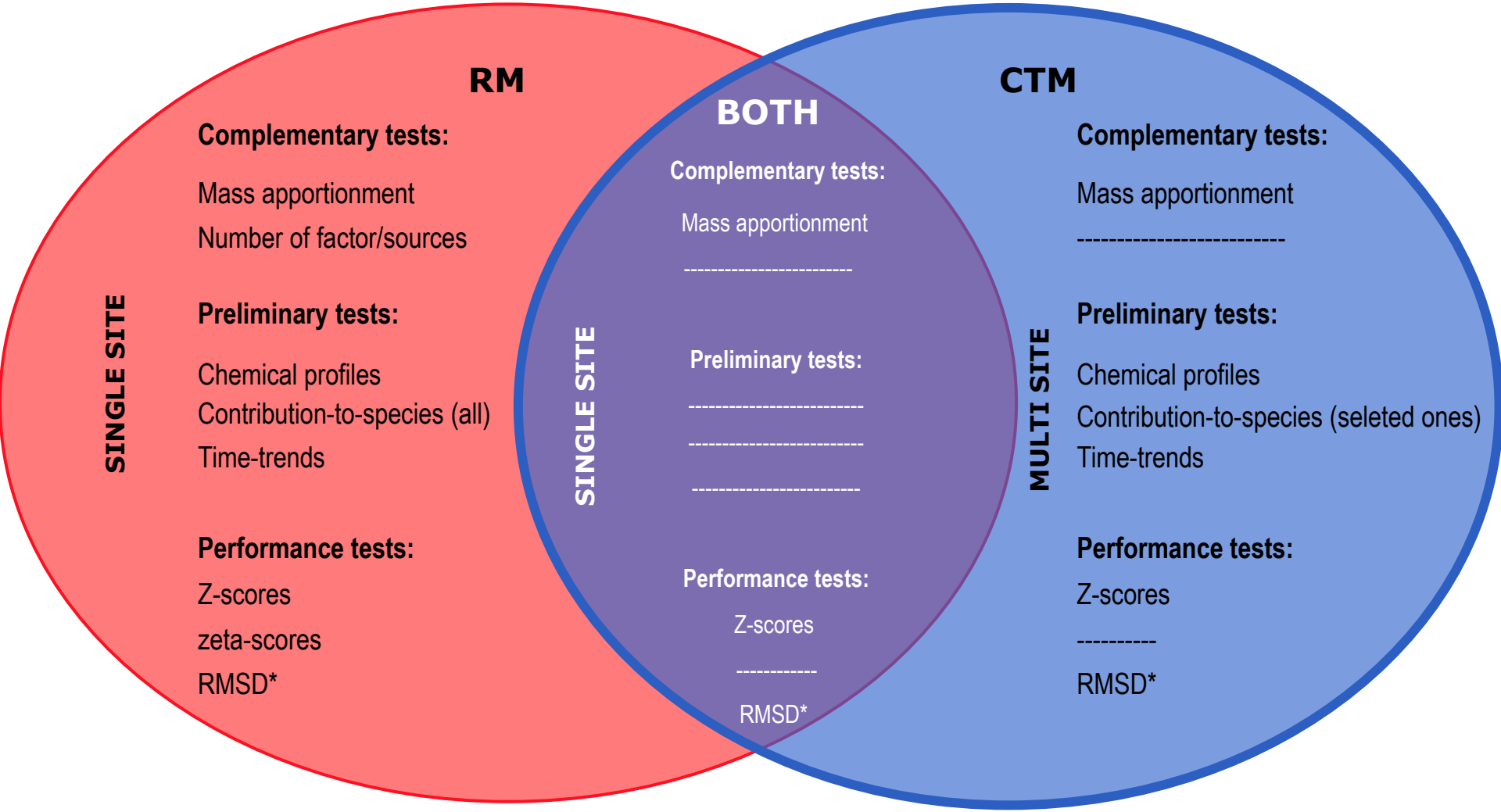
Definition of sources

SNAP		Mandatory 8 sources	Optional 14 sources
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

Evaluation in this IE



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CTM RESULTS

id	model	method	MANDATORY	OPTIONAL
cA	CAMx	CTM	selected for reference	
cAo	CAMx	CTM		selected for reference
cAs	CAMx	CTM	sensitivity run	sensitivity run
cAso	CAMx	CTM	sensitivity run	sensitivity run
cAs2	CAMx	CTM	sensitivity run	sensitivity run
cB	FARM	CTM	selected for reference*	
cBo	FARM	CTM		selected for reference*
cD	LOTOS	CTM	selected for reference	
cDo	LOTOS	CTM		selected for reference
cE	EURAD	CTM	selected for reference*	
cF	CHIMERE	CTM	NH_4 and NO_3 not reported	NH_4 and NO_3 not reported

Mandatory: few sources, all participants
Optional: many sources, few participants

CTM results indicated with letters from A to F preceded by c (low case).
o: optional; s: sensitivity run

Green background indicates results used to calculate the reference for mandatory and optional respectively. Sensitivity runs not used for reference.

*not considered when only tagged species approach used for reference

Overview of SA methods commonly used in Europe

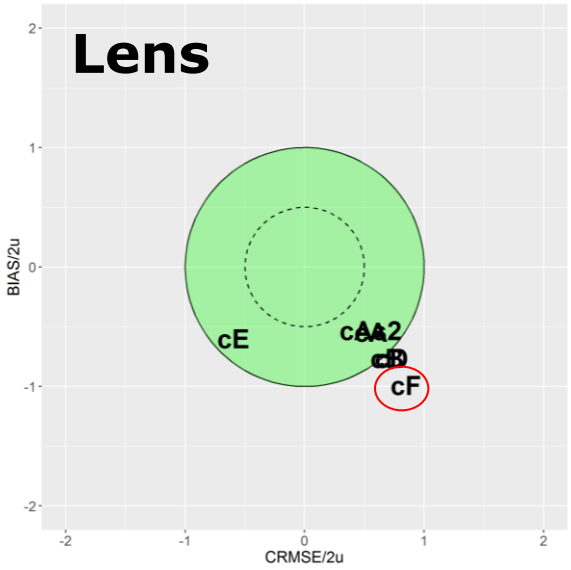
Different CTM approaches used for SA

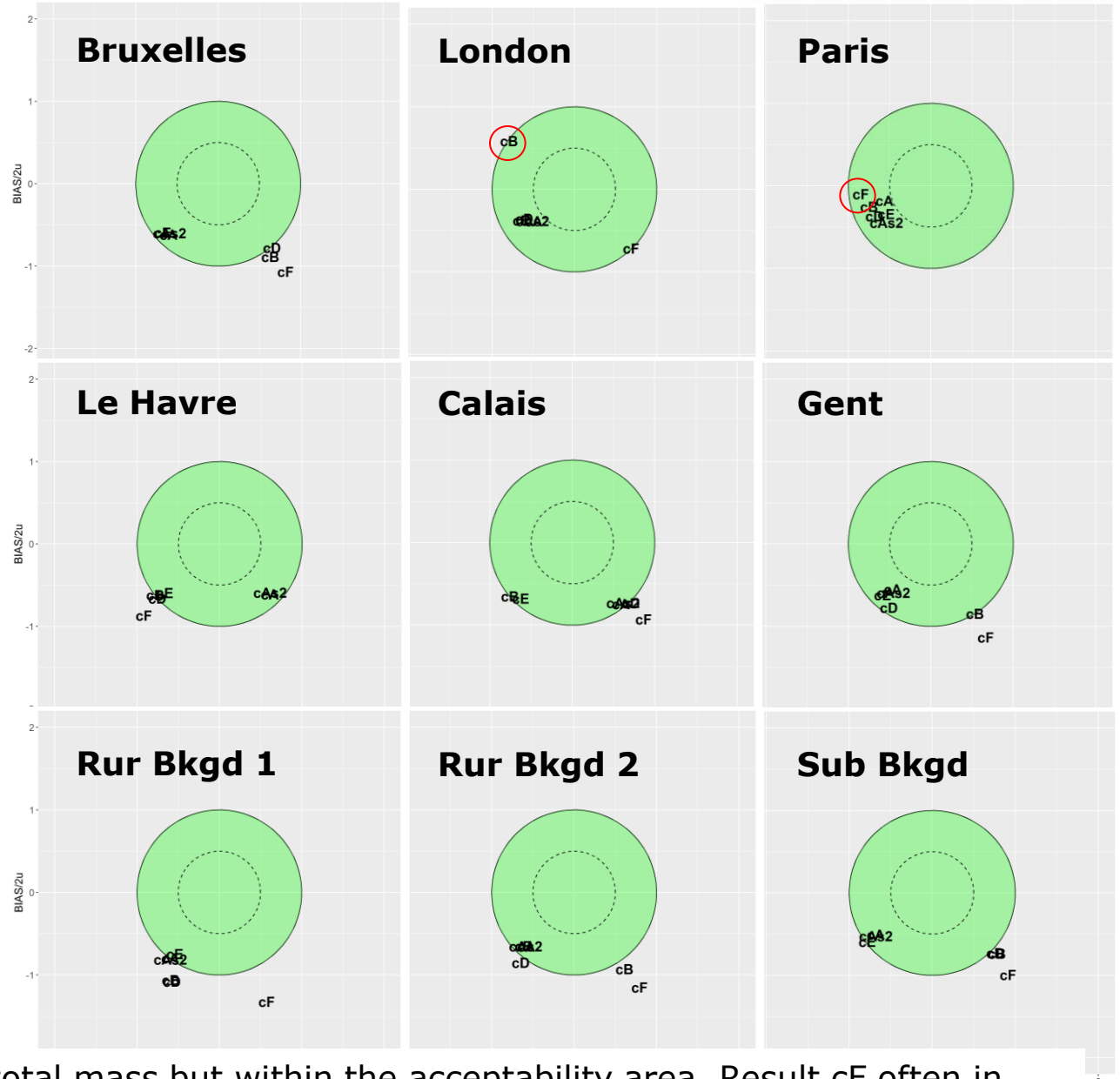
	Tagged species	Brute force (top down)
Description	Tagged species are used to track the contributions of sources in every grid cell by mass balance. Conc. = (emission+ import+ formation) – (export+ degradation+ deposition)	Estimate the contribution of sources by comparing the BC with a run where the source of interest has been reduced by a given % over the whole domain.
Underlying question	What is the actual contribution of sources in the studied area/time window?	What would be the reduction in concentrations corresponding to a given reduction in emissions?
Mass apportionment	Coherence between sum of sources and total pollutant mass	The total mass of the different sources is obtained from independent runs. The sum of the sources maybe not coherent with the base case. Post processing would be needed to re-normalise the source contributions.
Advantages	Accomplishes the apportionment in one single run Reflects the situation that caused the exceedance	Respond to the question of interest for the policy maker (air quality manager)
Disadvantages	The actual contribution of a source is not necessarily what can be actually abated with a measure	Requires many runs Distortion may be caused by normalising source contributions to match the base case

Evaluation of CTM SA applications

Evaluation of base case and sensitivity runs…

Mass Apportionment (mandatory)



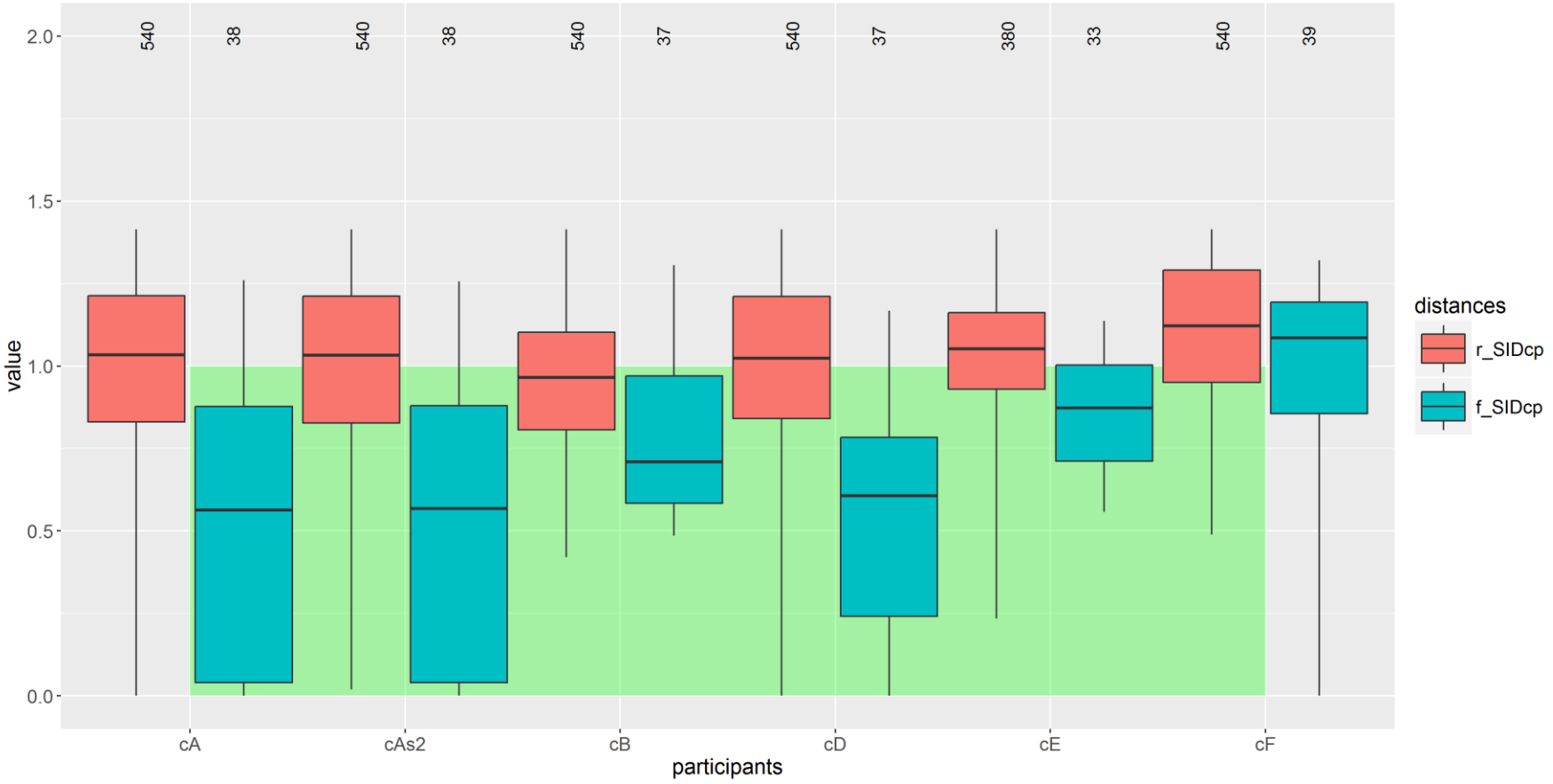


Sum of sources compared with gravimentric mass

Sum of sources below the total mass but within the acceptability area. Result cF often in rejection area with the exeption of Paris and cB overstimates only in London

SID by participants (mandatory set)

Lens Comparison between the chemical profiles of the sources (i.e. the mass attributed to the chemical species)



r = distances to the reference chemical profiles (cp) in SPECIATE/SPECIEUROPE

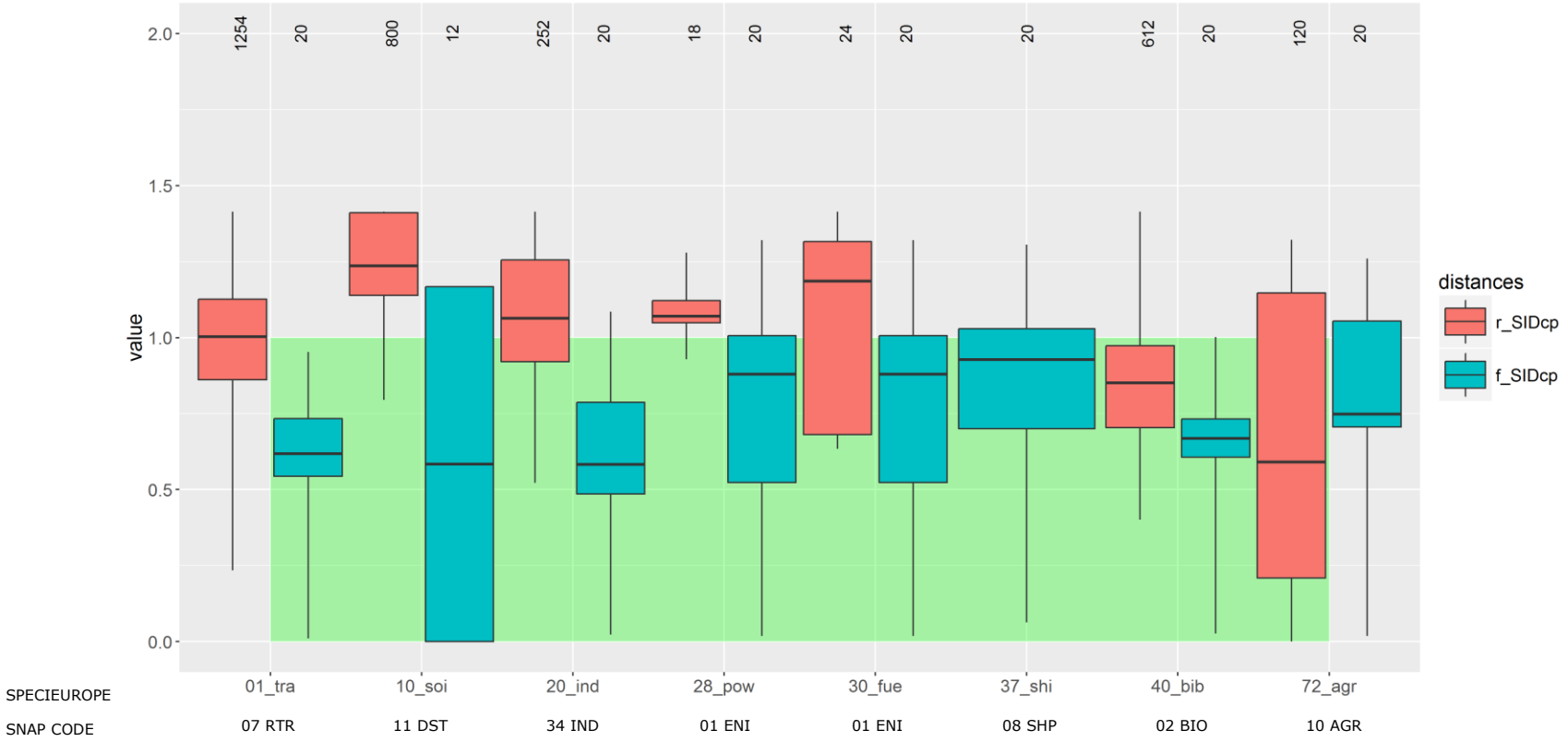
f = distances among the candidate sources

top = number of distances, green = acceptability area

Candidate sources comparable among each other but no with the reference cp. There are no significant differences between results with mandatory and optional set of sources. cF is not similar to the other results.

SID by sources (mandatory set)

Lens Comparison between the chemical profiles of the sources (i.e. the mass attributed to the chemical species)



r = distances to the reference chemical profiles (cp) in SPECIATE and SPECIEUROPE

f = distances among the candidate sources

top = number of distances, green = acceptability area

Candidate sources comparable among each other. Traffic, soil, industry and power plant, not comparable with the reference.

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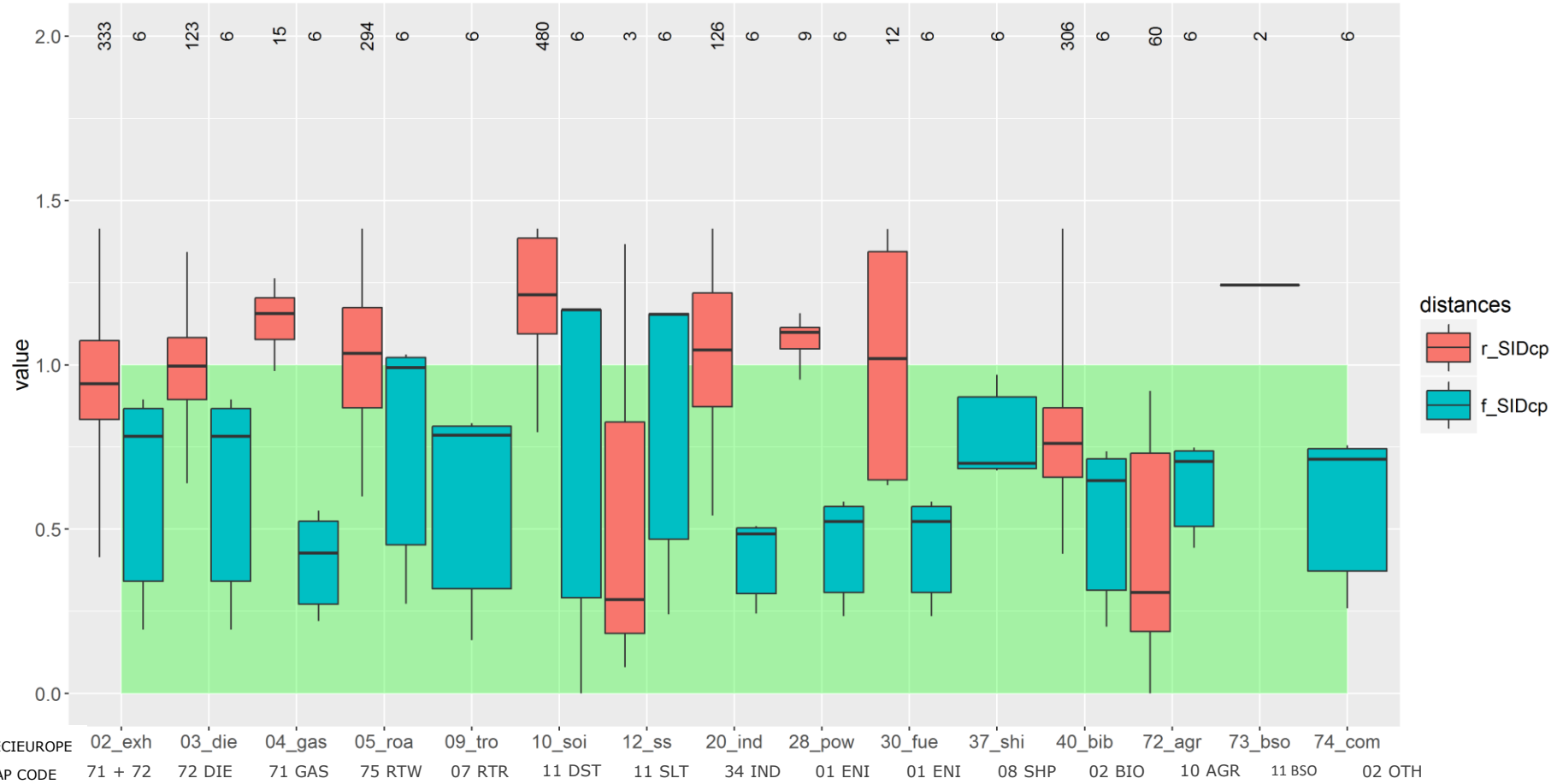
SID by sources (optional set)

Lens Comparison between the chemical profiles of the sources (i.e. the mass attributed to the chemical species)



r = distances to the reference chemical profiles (cp) in SPECIATE and SPECIEUROPE

f = distances among the candidate sources

top = number of distances, green = acceptability area

Sea salt most comparable with the reference but variable scores between participants. Gasoline, road dust and power plant not comparable with the reference. Soil cps are not comparable both with reference and among results.

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CTM performance tests

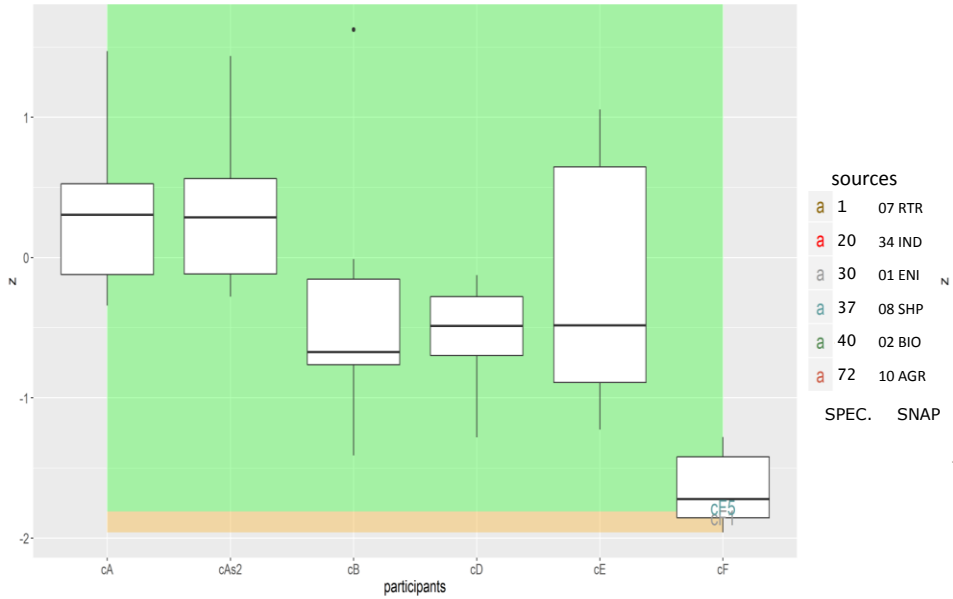
Performance CTMs z-score (overall sce)

Reference = all models

Lens

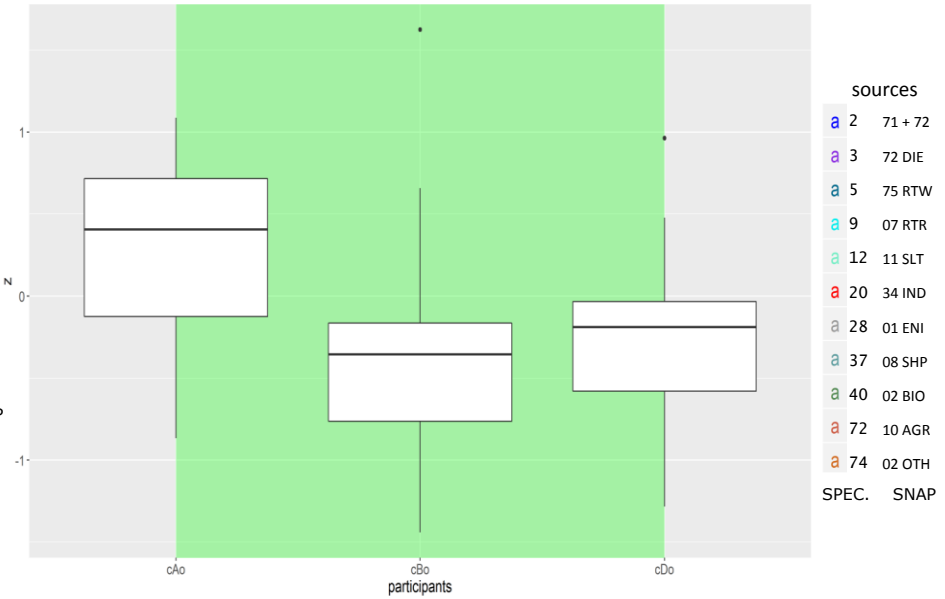
sce = source contribution estimate

mandatory



successful candidates: 93%

optional



successful candidates: all

Ship and power plants understimated in cF likely due to role of nitrate and ammonia in these sources

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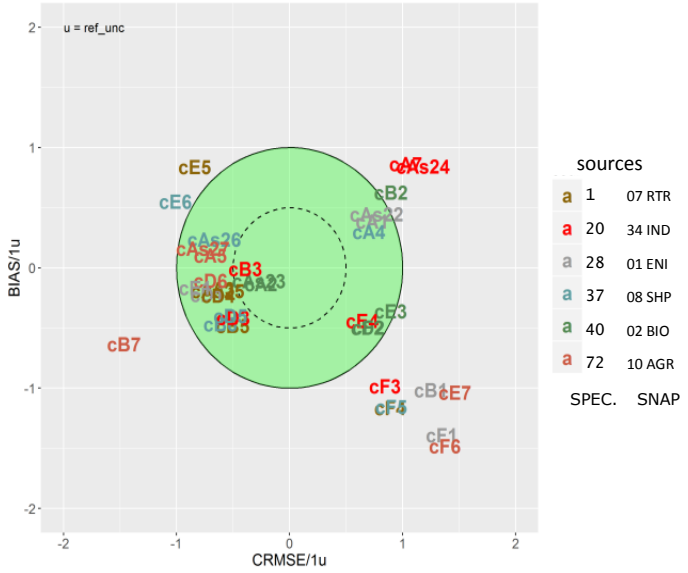
Performance RMs Target plot (sce time series)

Reference = all models

Lens

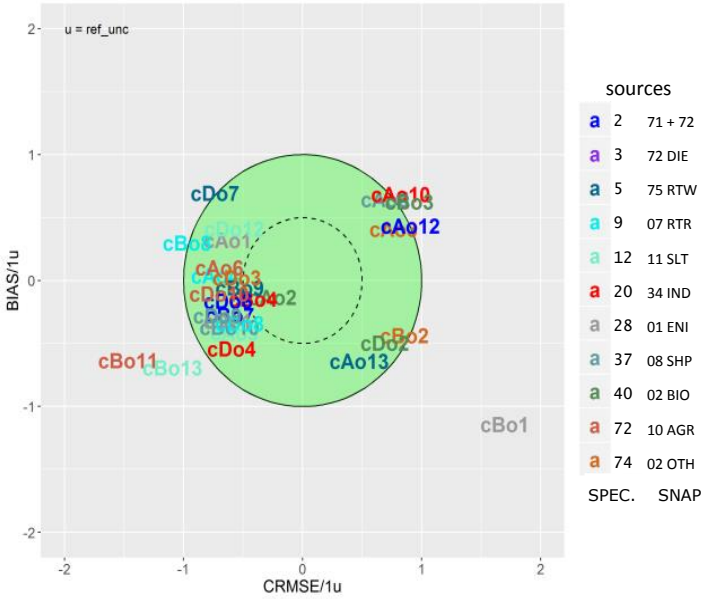
sce = source contribution estimate

mandatory



successful candidates: 60%

optional



successful candidates: 73%

Mandatory: industy often scoring out of the acceptability area. cF only pass biomass burning

Optional: cBo highest number of rejected RMSEu.

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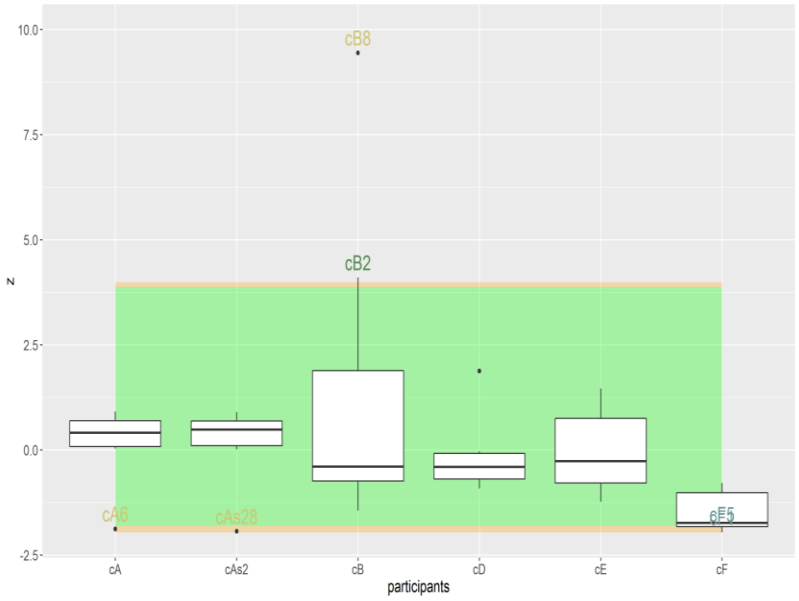
Performance CTMs z-score (overall sce)

Reference = in this case only tagged species were used in the reference to test if there are measurable differences between the two CTM approaches

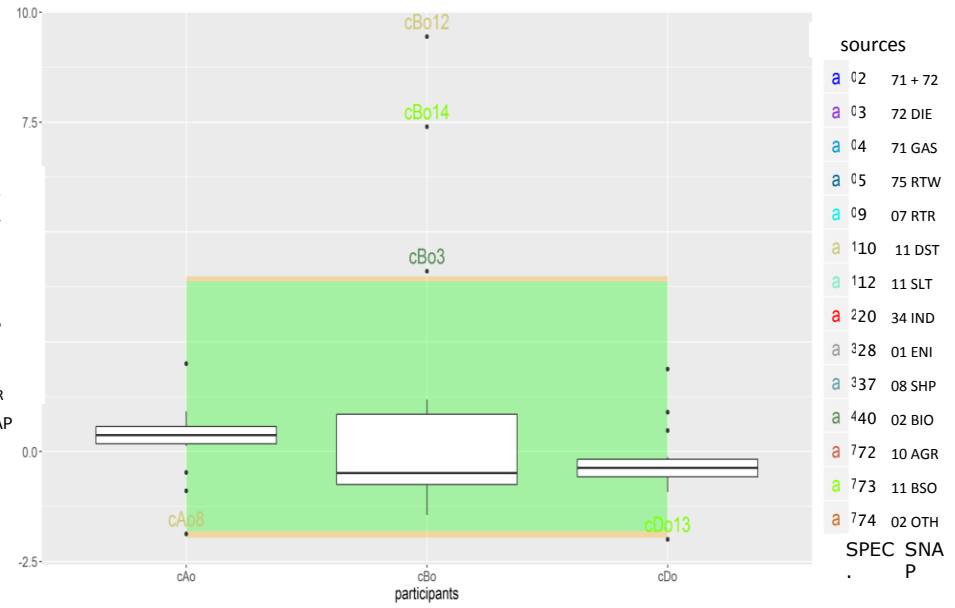
Lens

sce = source contribution estimate

mandatory



optional



successful candidates: 80%

successful candidates: 87%

Mandatory: soil and biomass burning overestimated in cB, soil understimated in cA while cF underestimates power plant and ship.

Optional: cB overestimates soil, biomass burn. and biogenic, cA underestimates soil and cD underestimates biogenic.

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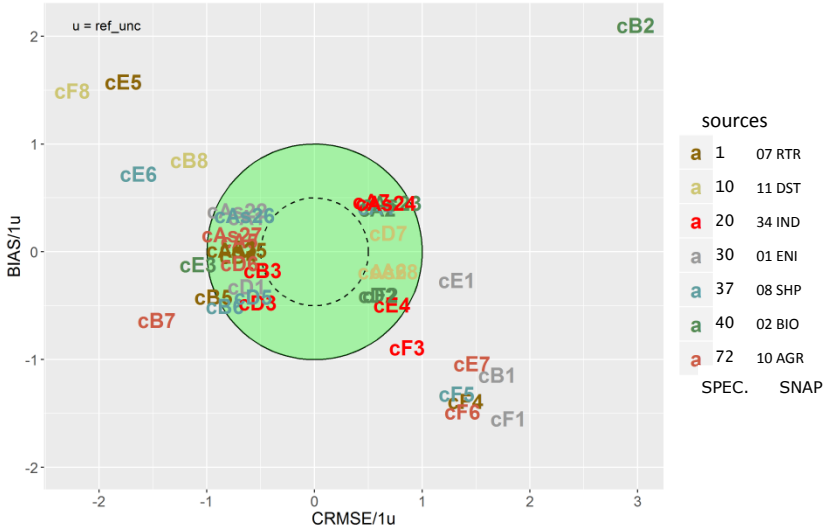
Performance RMs Target plot (sce time series)

Reference = in this case only tagged species were used in the reference to test if there are measurable differences between the two CTM approaches

sce = source contribution estimate

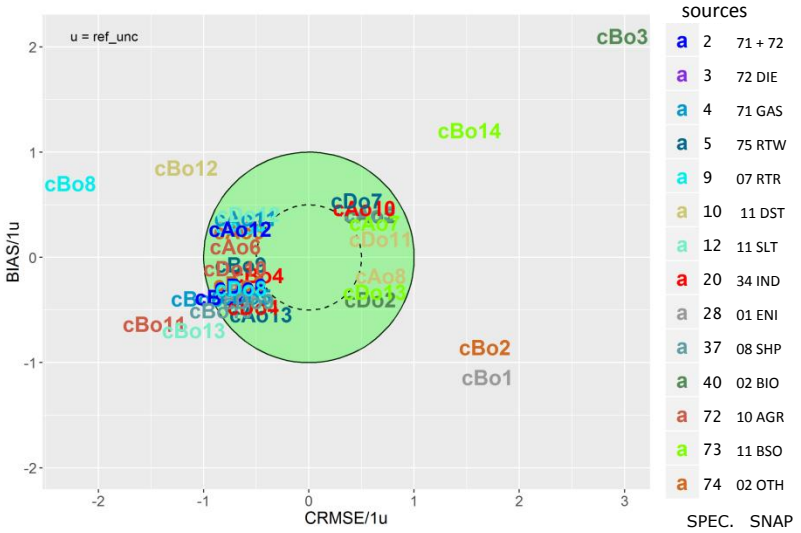
Lens

mandatory



successful candidates: 51%

optional



successful candidates: 77%

Mandatory: cB,cD and cF not comparable with the reference for agriculture, power plant, soil and traffic.

cB and cE problems with biomass burning (overstimation or lack of correlation). cF passes only biomass burning.

Optional: cBo highest number of rejected RMSEu. OK for diesel, industry, road dust and ship.

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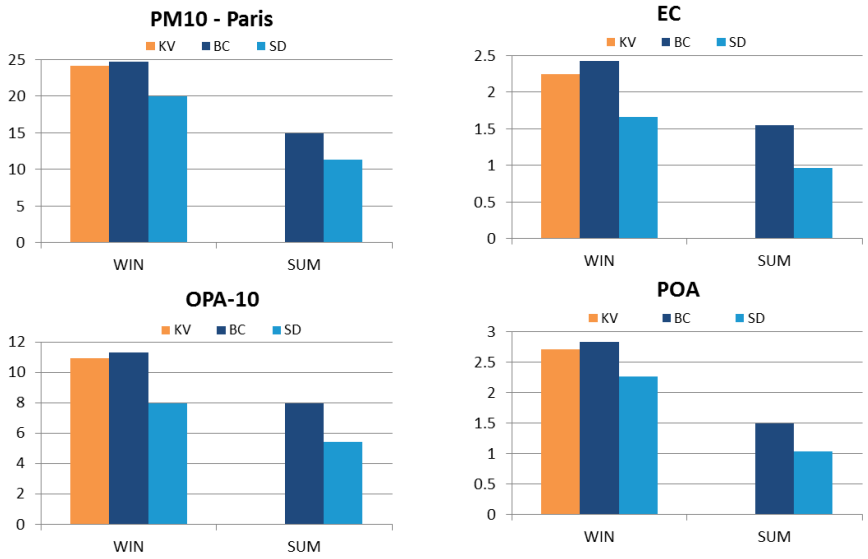
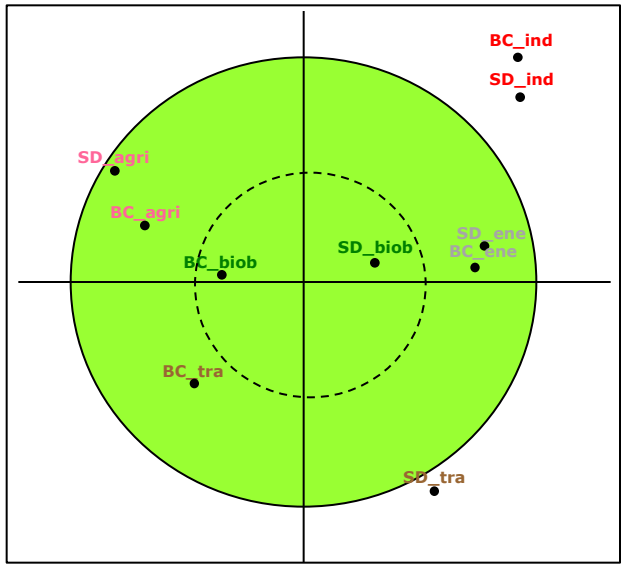
Sensitivity tests

Thanks to J. Ferreira (Univ. Aveiro)

The goal of the sensitivity test was to evaluate the influence of the reduced horizontal resolution on the CAMX output.
To that end, CAMx runs were performed with two different grid steps 7 km (BC) and 20 km (SD).
The reduced cell dimension in an area close to primary emissions (traffic) was expected to cause a reduction in the concentrations of pollutants associated with that source.



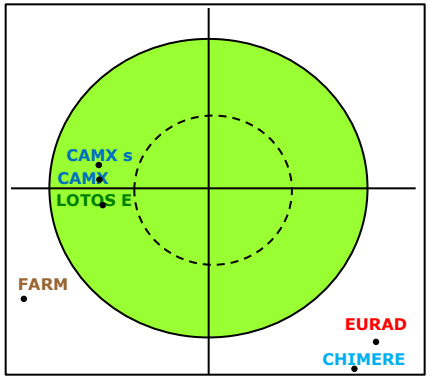


A PM_{10} concentration decrease for SD matched a decrease in elemental carbon (EC), primary organic aerosol (POA) and other primary anthropogenic aerosol (OPA-10) compared to the base case.

When comparing the performances of PSAT using two different grid steps it was also observed that the contribution of traffic was underestimated when using low spatial resolution. No significant changes were observed in the other tested sources (industry, energy production, biomass burning and agriculture).

The source chemical profiles: the case of Agriculture

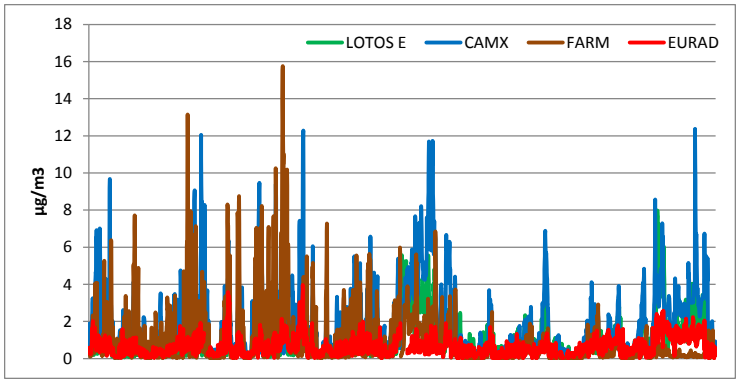
Performance of CTMs for Agriculture



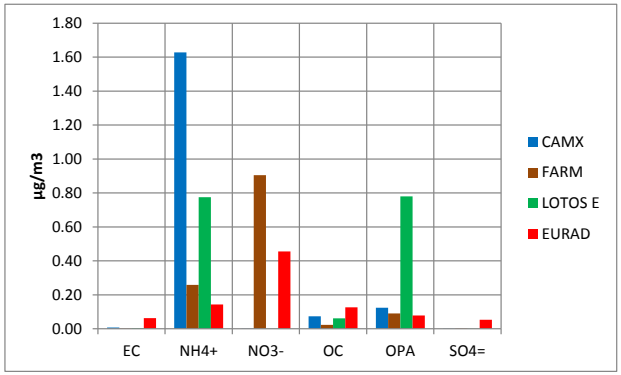
whole period	LOTOS E	CAMX	FARM	EURAD	CHIMERE
average (µg/m3)	0.91	1.78	0.95	0.64	0.04
sd (µg/m3)	1.09	1.87	1.51	0.49	0.06

R	LOTOS E	CAMX	FARM	EURAD	CHIMERE
LOTOS E	1	0.60	0.26	0.50	0.37
CAMX	0.60	1	0.42	0.52	0.49
FARM	0.26	0.42	1	0.27	0.24
EURAD	0.50	0.52	0.27	1	0.25
CHIMERE	0.37	0.49	0.24	0.25	1

Time trends for Agriculture



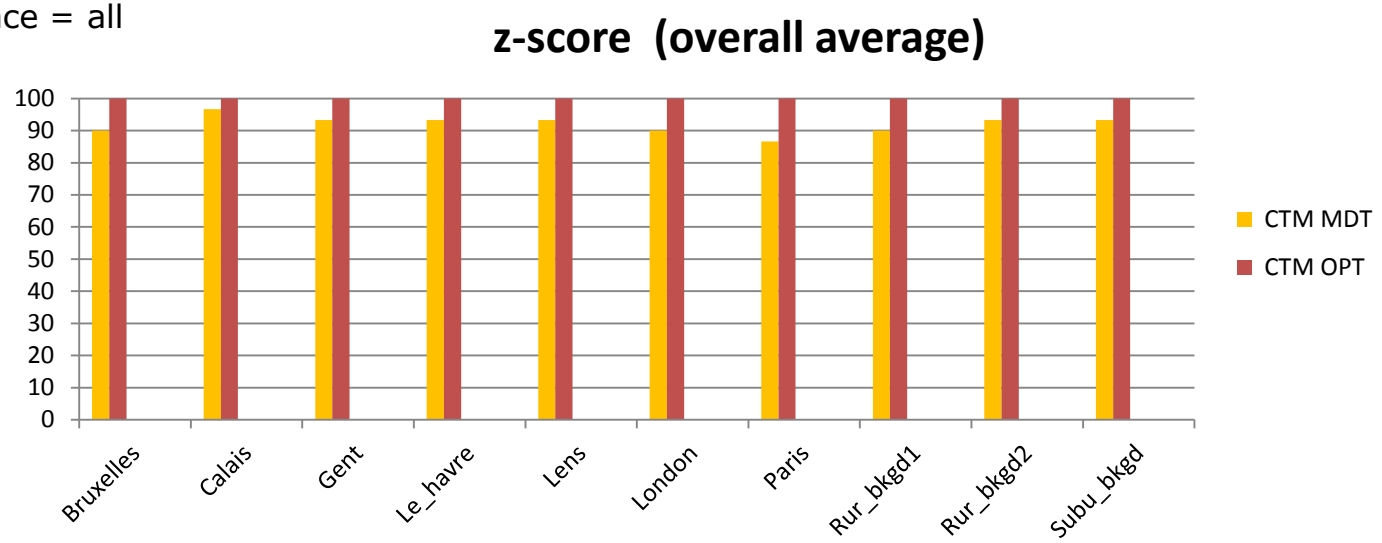
Chemical profiles for Agriculture

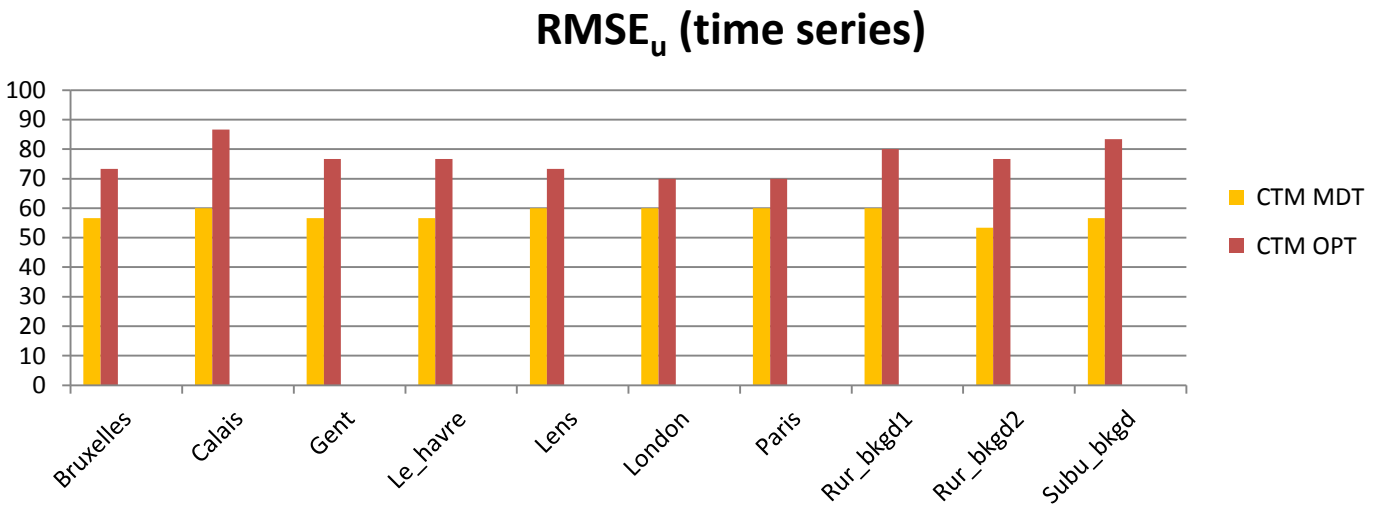


The contributions to $PM_{2.5}$ from agriculture, a complex source, were analysed more into detail.
CAMx presents the highest contributions on average.
The time trends of CAMx and LOTOS EURO where the most correlated among each other.
FARM present highest levels in summer while LOTOS EURO shows highest ones in winter.
The chemical components associated with this source provide evidence about the underlining assumptions of the different types of model approaches (tagged species or brute force).

Performance CTMs ALL RECEPTORS

Reference = all



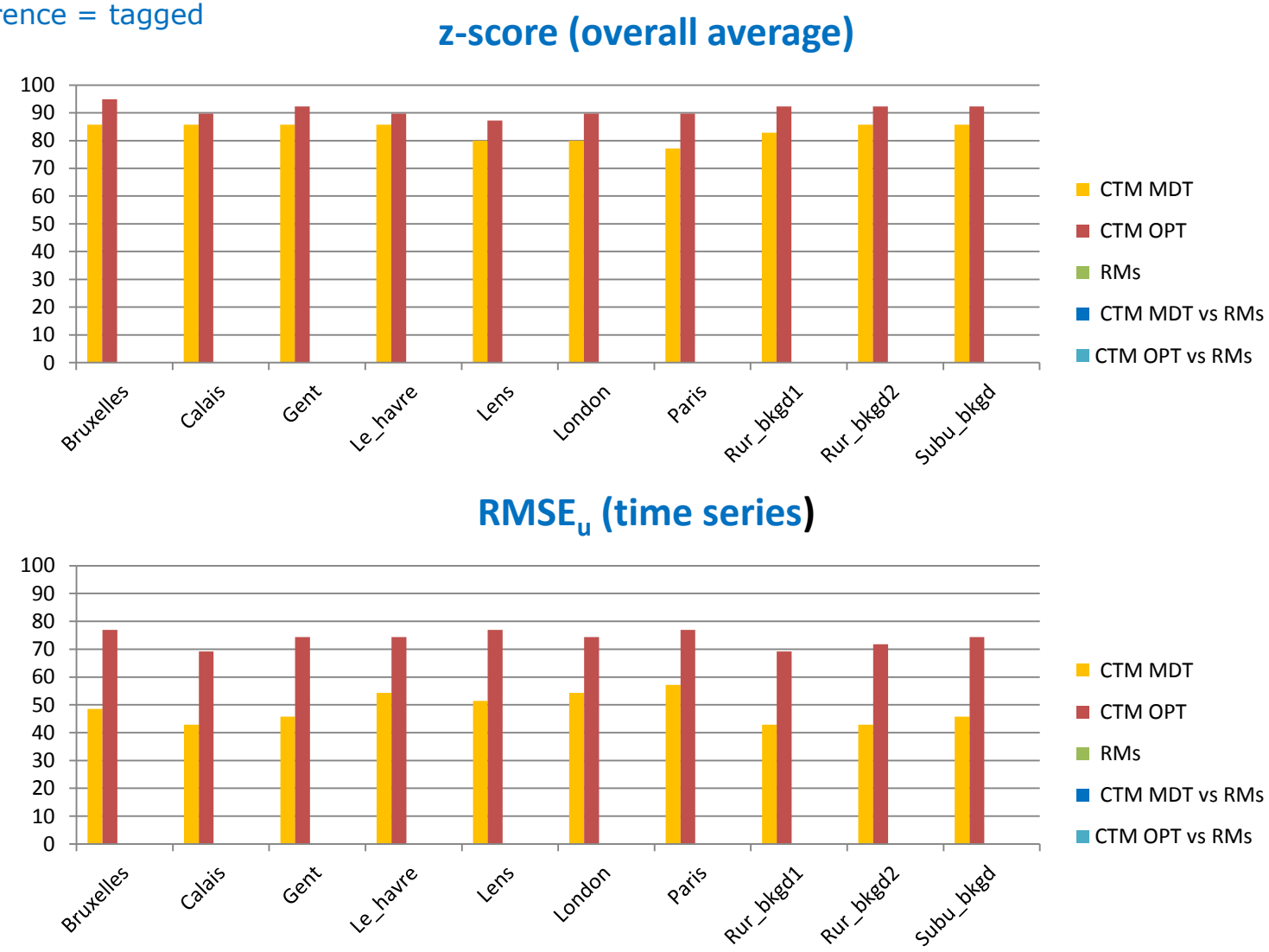


In general the geographic patterns are quite homogeneous among sites.

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

Reference = tagged



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 (2)

CTMs

- **CTMs show good performances when tested using an ensemble reference, especially z score test (overall average).**
- **No significant differences in performance between sites suggest that CTMs have a rather comparable geographical pattern likely due to same input data (EI, meteo).**
- **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.).**
- **The analysis of CTM chemical profiles was useful to detect differences between models and/or approaches**

Thank you for your attention