



## WG3 Source Apportionment

27-29 June 2016

### CAMx Base Configuration - Model Performance Evaluation

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Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto



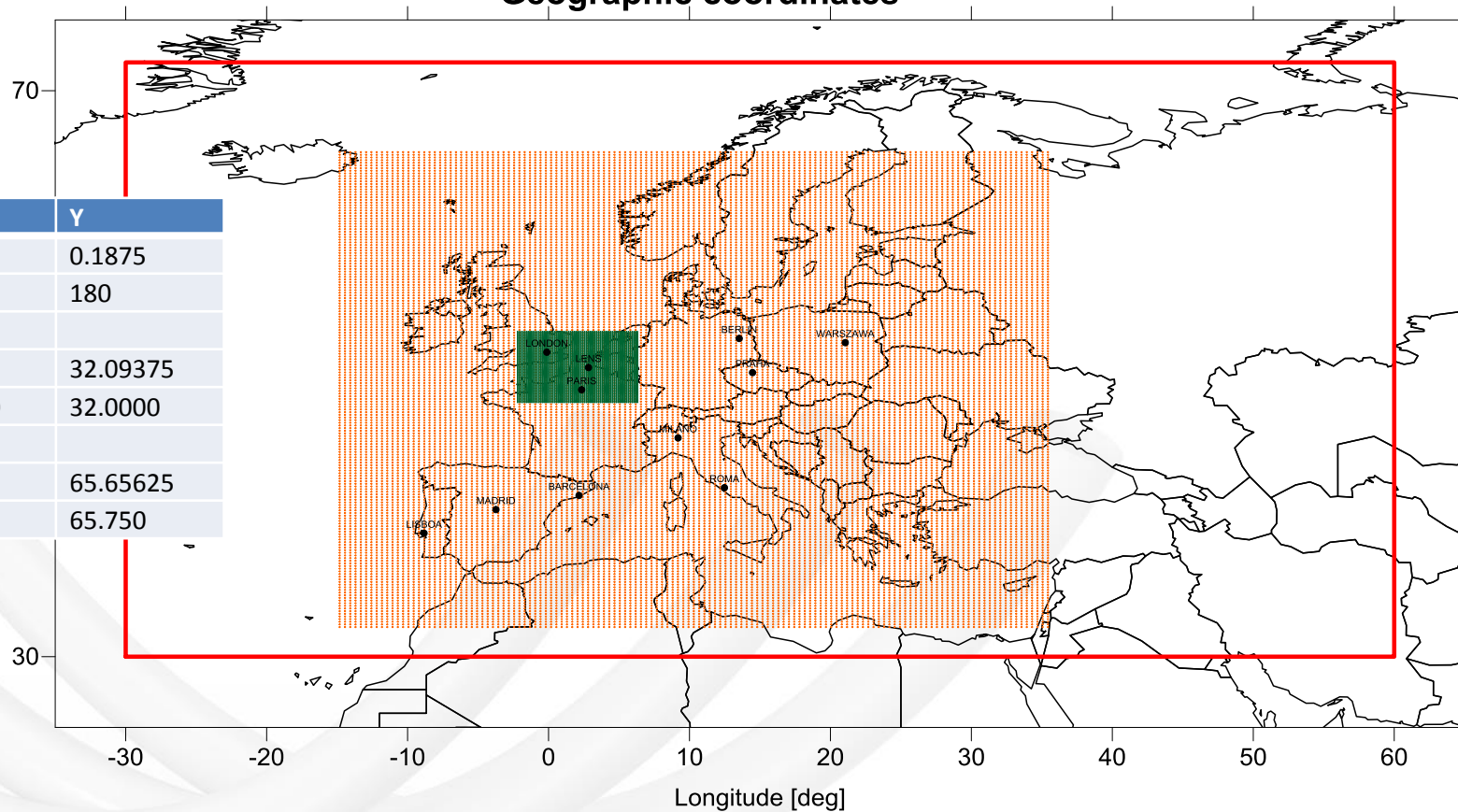
ARISTOTLE UNIVERSITY OF THESSALONIKI



# FAIRMODE Domains

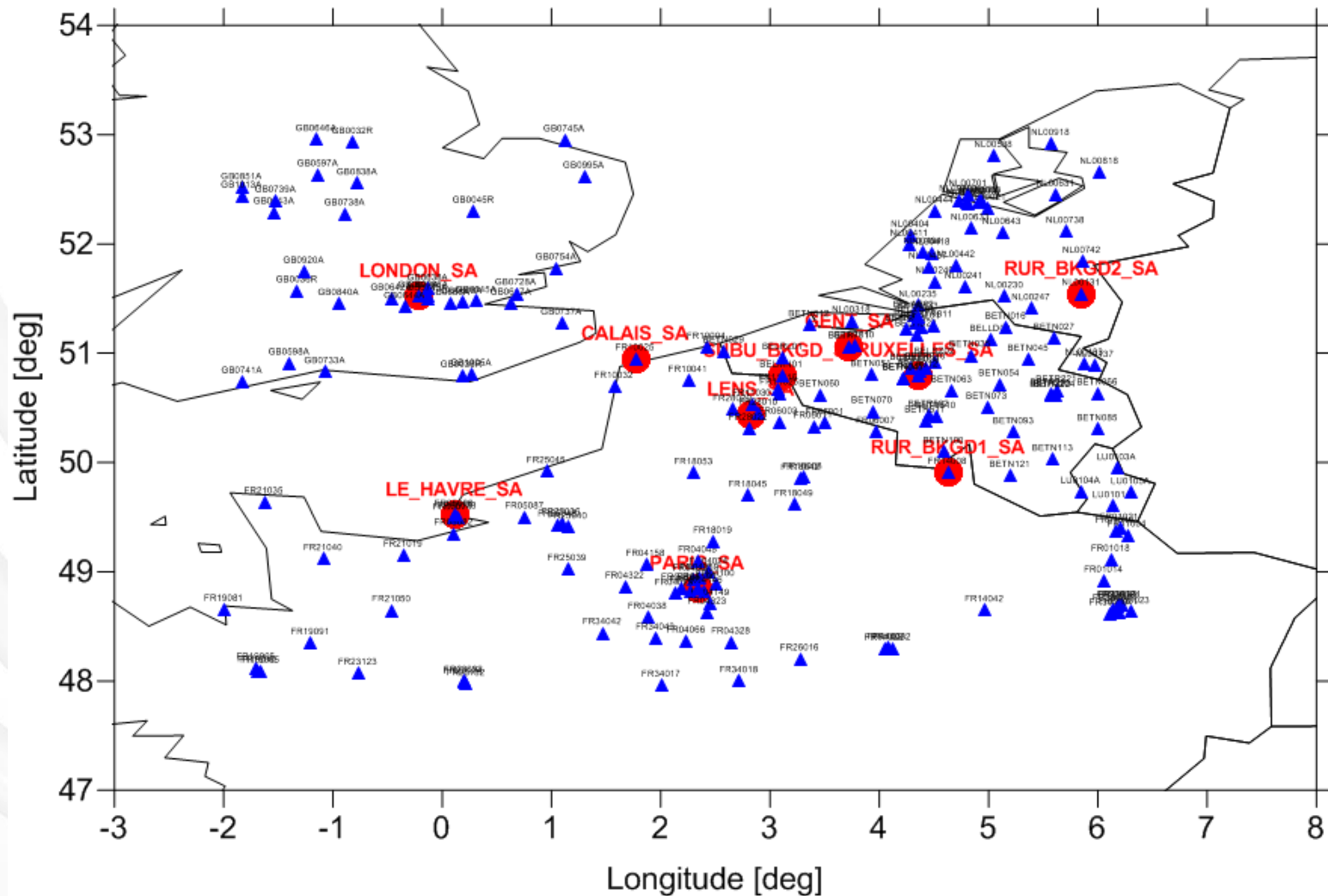
## FAIRMODE - Domains

Grid centers  
Geographic coordinates

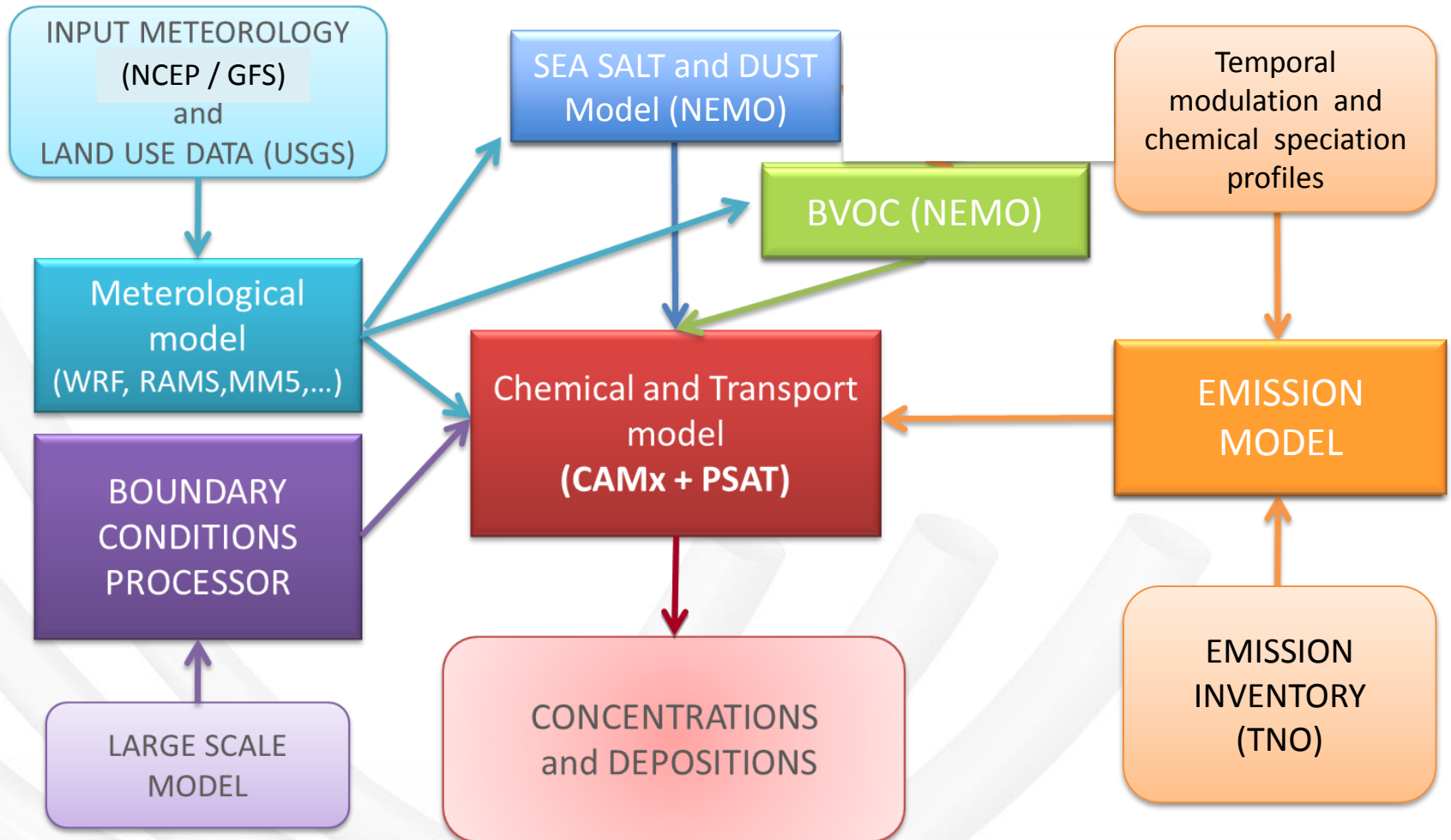


	X	Y
D	0.375	0.1875
N	135	180
SW_centre	-14.8125	32.09375
SW_corner	-15.0000	32.0000
NE_centre	35.4375	65.65625
NE_corner	35.625	65.750

# Measurement and SA sites



# CAMx setup



# Natural Emissions Model (NEMO)

➤ Developed in Laboratory of Atmospheric Physics of Aristotle University of Thessaloniki  
(Liora et al., 2015; Liora et al., 2016)

✓ **4 major subroutines** : totally coded in Fortran90

✓ **Meteorology** → **Weather Research Forecasting (WRF)**

✓ **Emission sources:**

a) **Biogenic VOCs (isoprene, monoterpenes, OVOCs)**

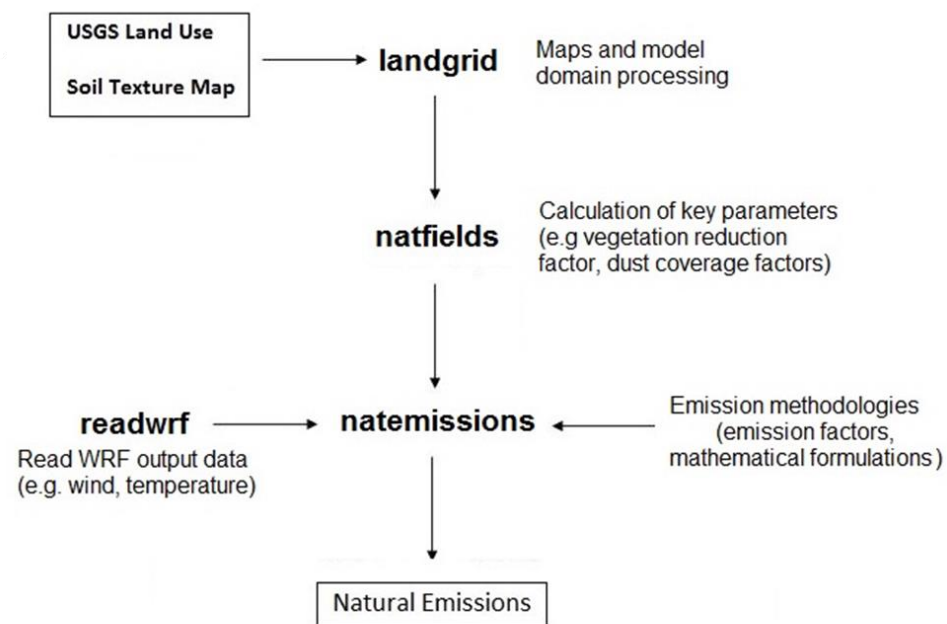
b) **Windblown dust (PM<sub>10</sub>, PM<sub>2.5</sub>)**

c) **Sea Salt Aerosols (PM<sub>10</sub>, PM<sub>2.5</sub>)**

d) **Primary Biological Aerosol Particles (PBAPs) (PM<sub>10</sub>)**

✓ **Spatially** resolved emissions (Geographical coverage: European continent)

✓ **Temporally** resolved emissions (resolution depending on the meteorological model results)





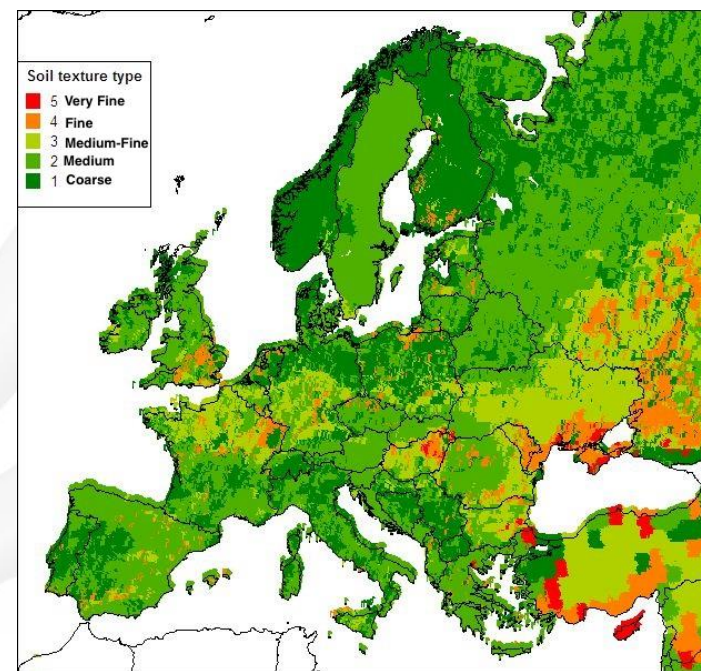
# NEMO - Input Databases

❖ **Land Use** → Eurasia Land Cover Characteristics database (version 2) (U.S. Geological Survey (USGS))

- 1km<sup>2</sup> spatial resolution
- 253 classifications of Land Use and Land Cover (LULC)
- dust producing LULC → barren land, grassland, cropland and agricultural land (156 in total)

❖ **Soil Texture** → European Soil Map database (ESDB) version 2.0 + Global Soil Map Oak Ridge National Laboratory (ORNL)

- 6km resolution database
- 5 texture types: Coarse, Medium, Medium Fine, Fine, Very fine



# Anthropogenic emissions

## Spatial disaggregation

- Lat/Lon regular grid
- Two datasets considered for EU and Lens domain

## Temporal disaggregation

- Temporal profiles for  $\text{NO}_x$ ,  $\text{NH}_3$ , CO, NMVOC, PMfine, PMcoarse,  $\text{SO}_2$ ,  $\text{CH}_4$
- 20 sectors considered
- Monthly, daily and hourly temporal profiles introduced for each sector

## Chemical speciation

- Gaseous pollutants (CB05/CB06 mechanism considered):
  - $\text{NO}_x \rightarrow \text{NO}, \text{NO}_2$
  - $\text{SO}_x \rightarrow \text{SO}, \text{SO}_2$
  - NMVOCs  $\rightarrow$  TRP, TERP, SQT, IOLE, OLE, PAR, TOL, TOLA, XYL, XYLA, FORM, ALD2, ALDX, ETH, ETHA, MEOH, ETOH, ISOP, ISP, CG1, CG3, CG6
- PM
  - Coarse/fine fraction profiles obtained averaging country profiles (averaged weighting the contribution to the total mass)
  - SOAP and VBS aerosol mechanisms available

# WRF-ARW fields preprocessing

CAMx v6 meteorological input files from WRF-ARW core output files keeping original WRF fields were generated considering several improvements:

- Kv computation by means of YSU scheme
- Subgrid convection: sub-grid clouds diagnostic from gridded met fields
- Stratiform scheme: sub-grid stratiform cloudiness diagnostic
- Enhancement of vertical mixing via vertical diffusivity
  - Landuse-based patch to enhance mixing over urban areas.
  - Expansion of the daytime PBL Kv profile through capping cloud tops as a means to prohibit artificial collapse of the boundary layer when convection develops and to include convective venting to the free troposphere.



# CAMx - Sensitivity analysis

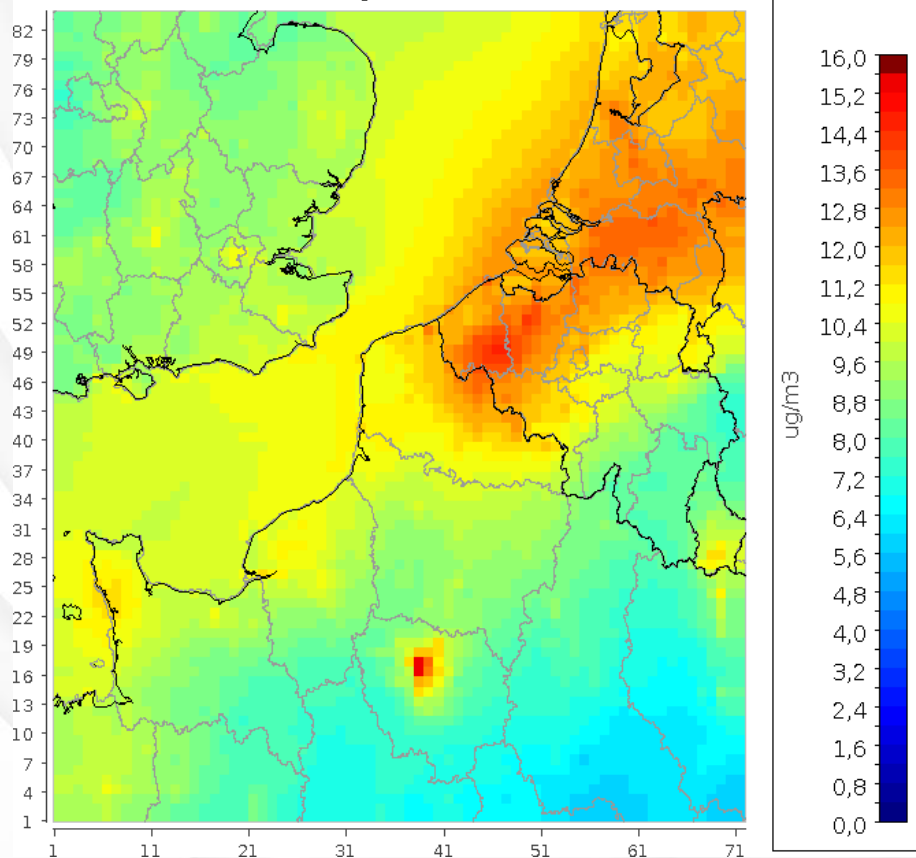
- **Base case** configuration (RSE) *[today and tomorrow...]*
- **KV** scheme changed in WRFCAMx (from YSU to CMAQ) (ARPAV) *[tomorrow...]*
- **nested domain switched off** (influence of resolution on SA results) (UAVR) *[tomorrow...]*
- evaluate **Organic aerosol trough VBS** instead of SOAP (RE) *[coming soon...]*

# Summer Episode - $PM_{10}$ / $PM_{2.5}$

## Base case configuration - Summer mean

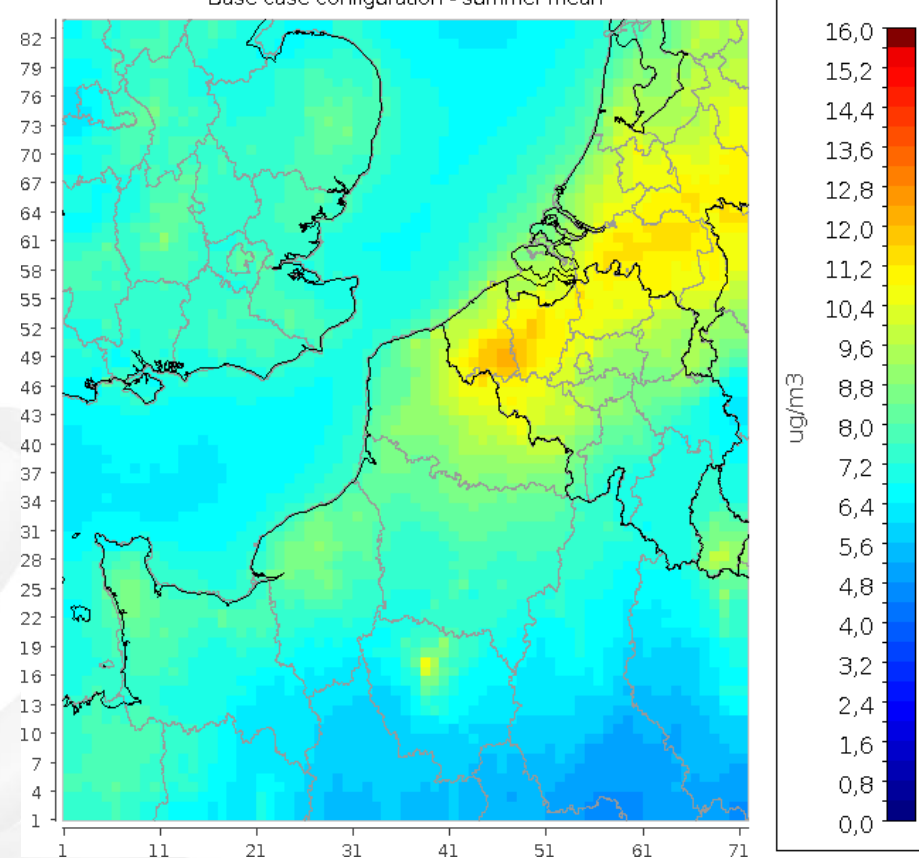
### PM10 - Lens Domain

Base case configuration - summer mean



### PM2.5 - Lens Domain

Base case configuration - summer mean

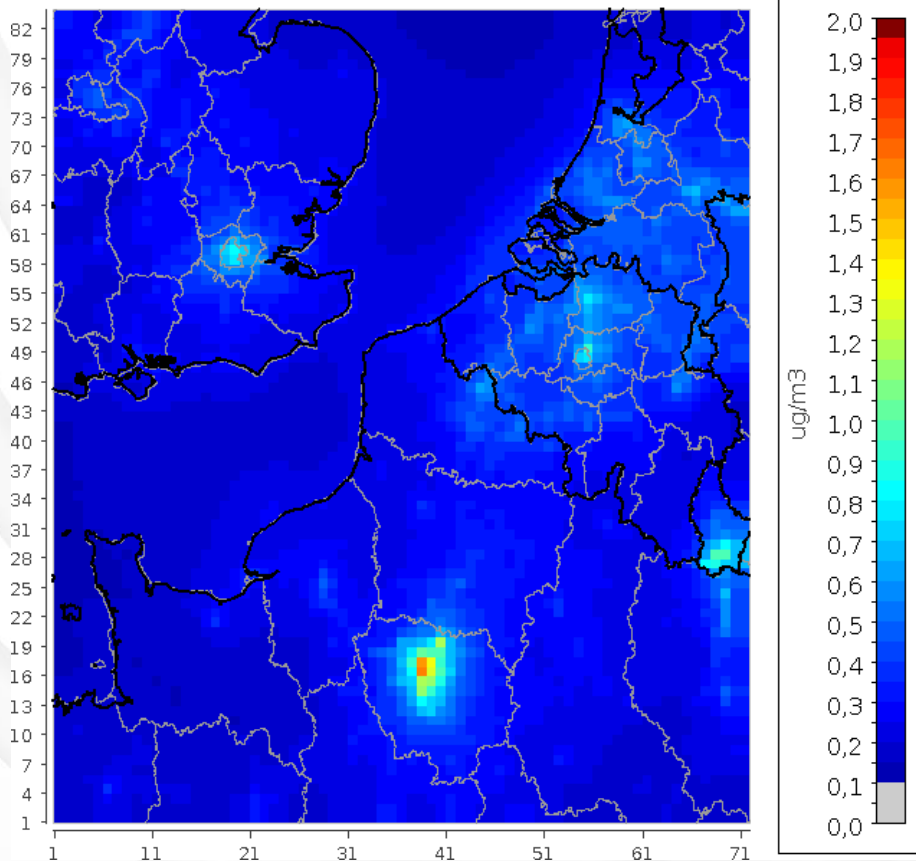


# Summer Episode - EC / OM

## Base case configuration - Summer mean

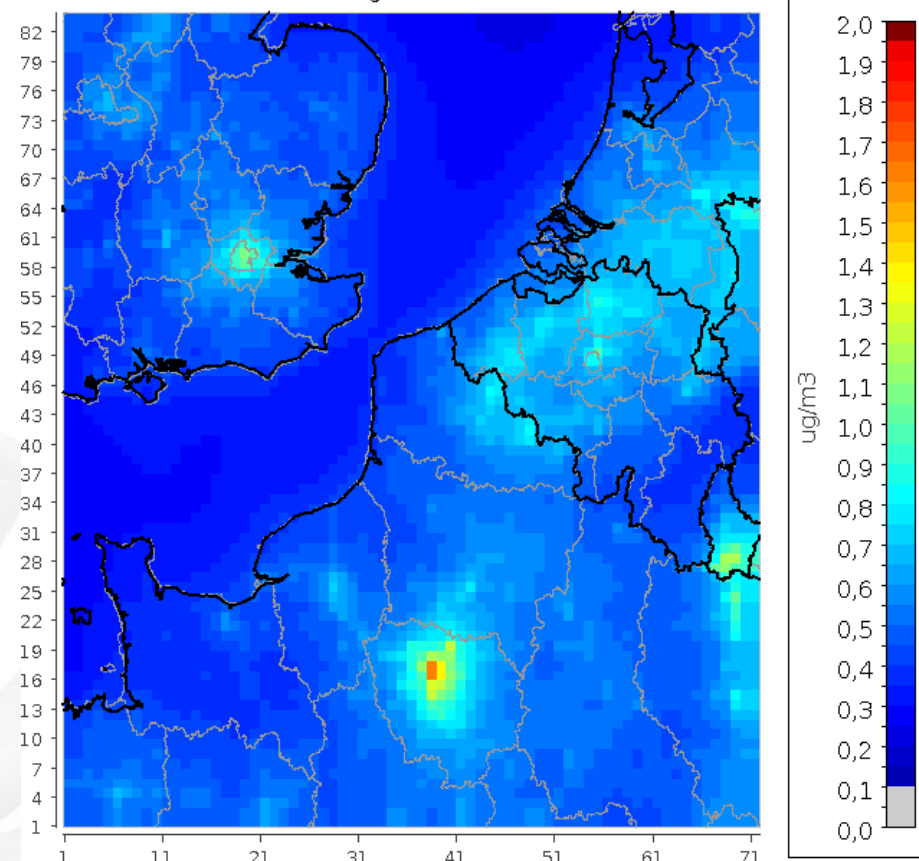
### EC - Lens Domain

Base case configuration - summer mean



### OM - Lens Domain

Base case configuration - summer mean

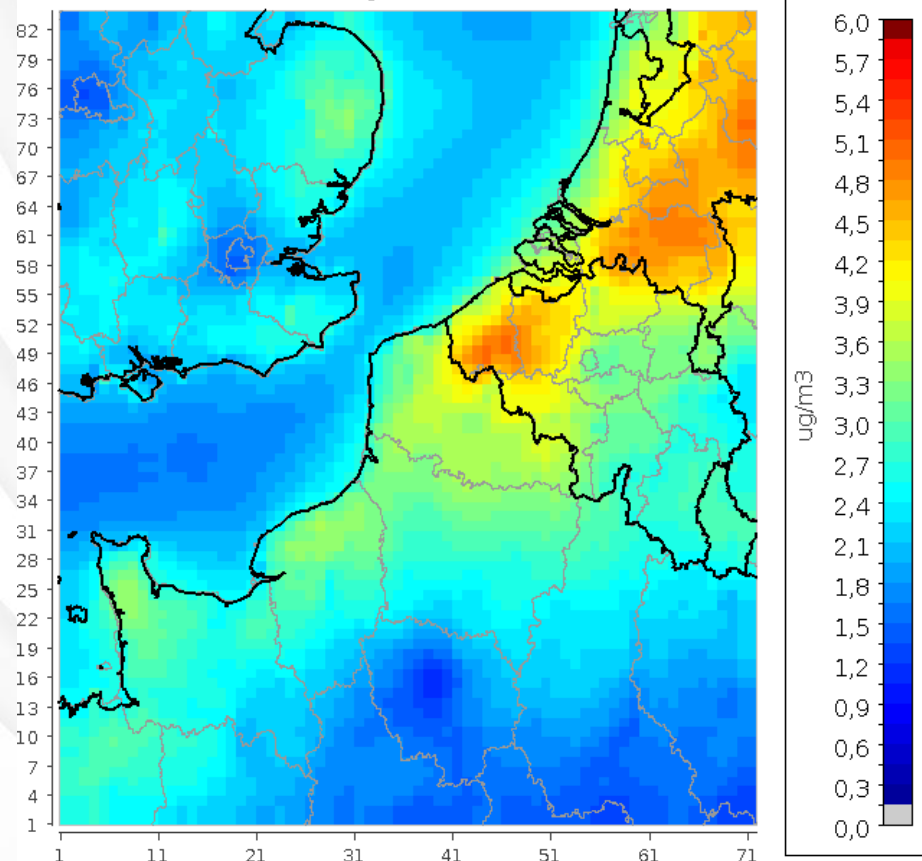


# Summer Episode - Inorganic

## Base case configuration - Summer mean

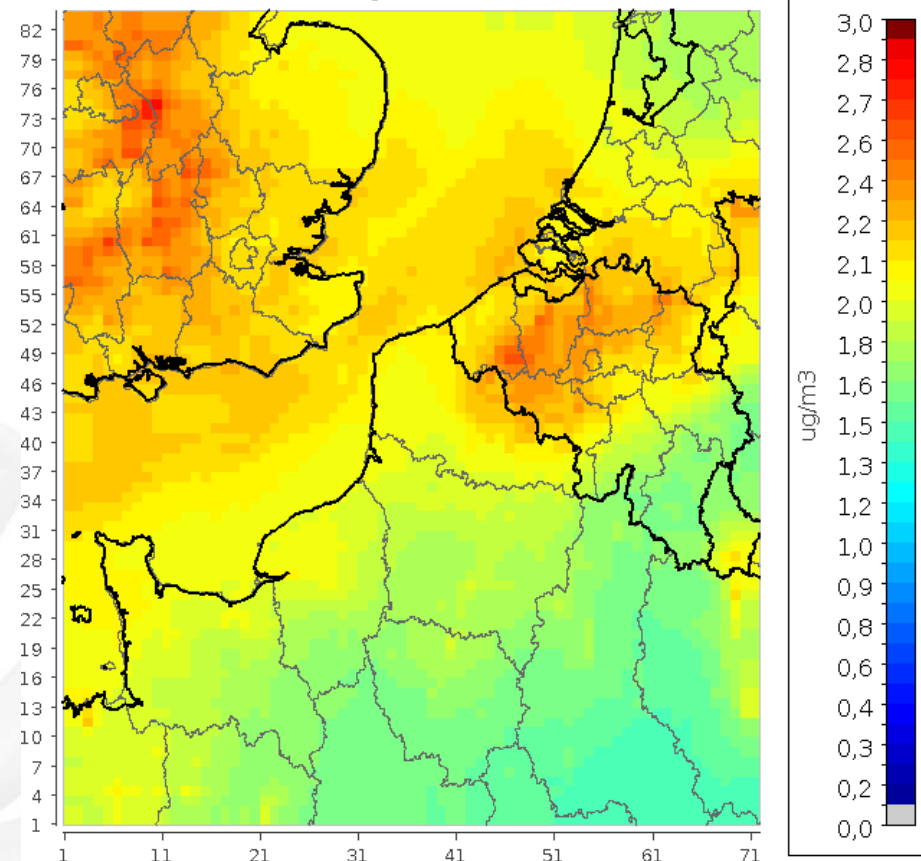
### NO<sub>3</sub>- - Lens Domain

Base case configuration - summer mean



### SO<sub>4</sub>= - Lens Domain

Base case configuration - summer mean

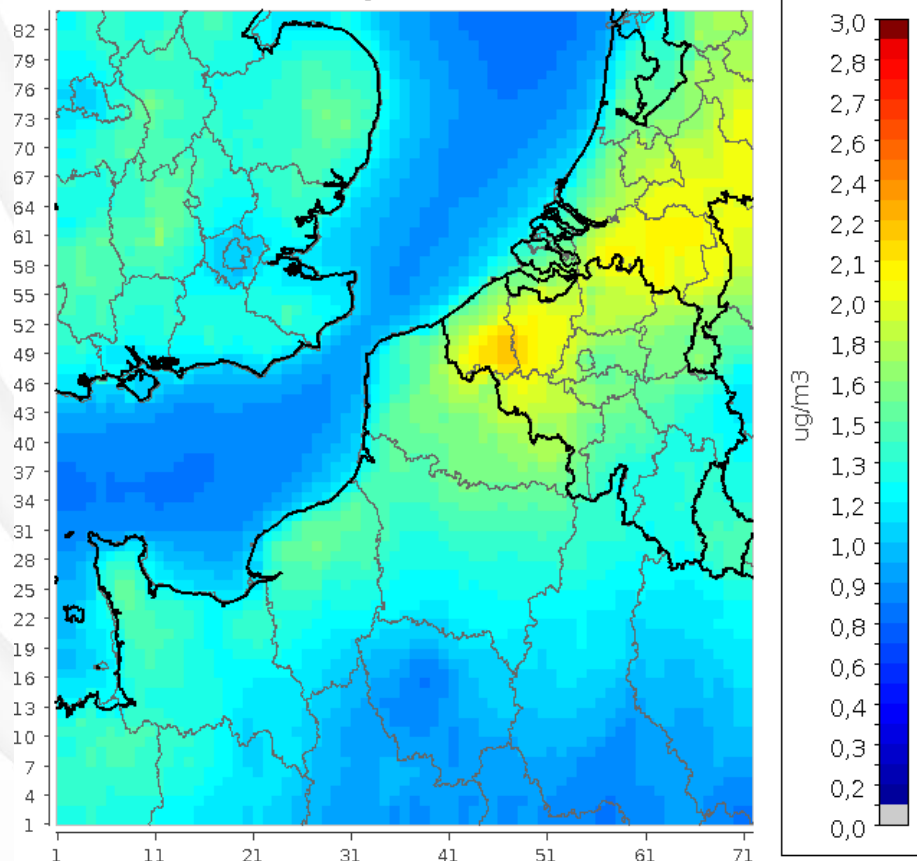


# Summer Episode - Inorganic

## Base case configuration - Summer mean

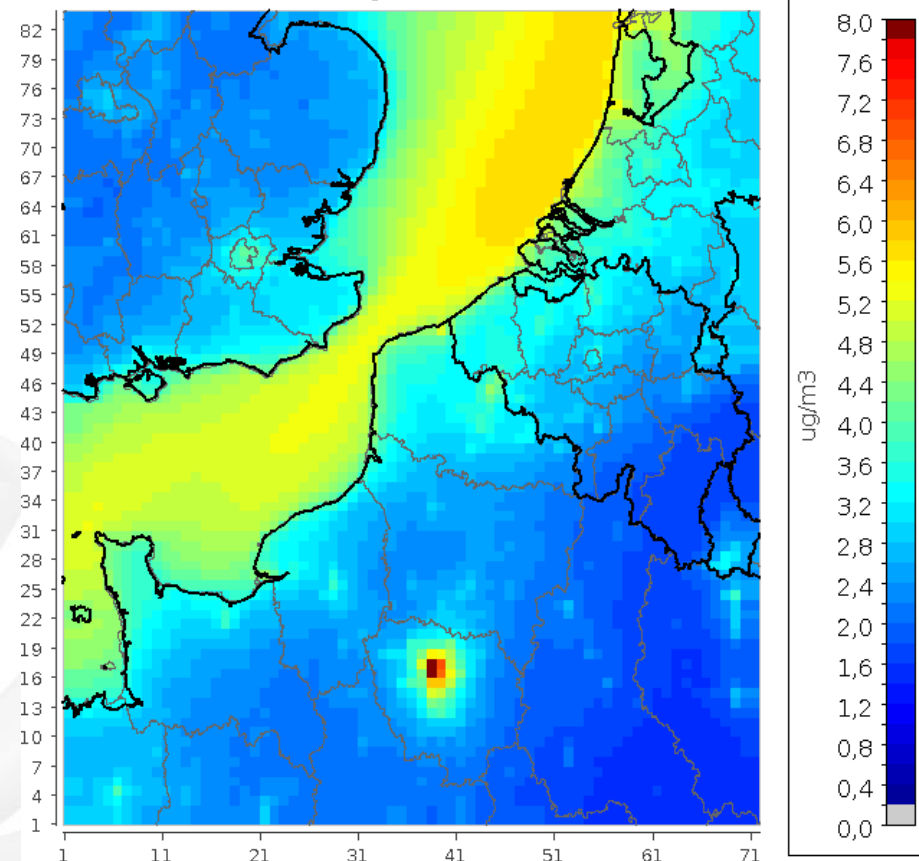
### NH<sub>4</sub><sup>+</sup> - Lens Domain

Base case configuration - summer mean



### Other PM<sub>10</sub> - Lens Domain

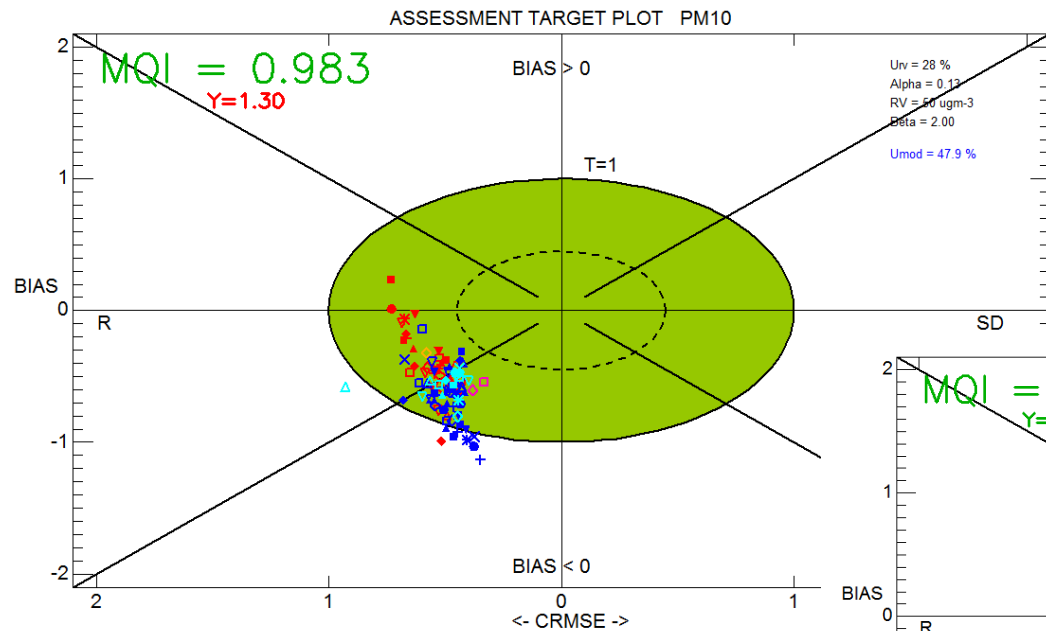
Base case configuration - summer mean



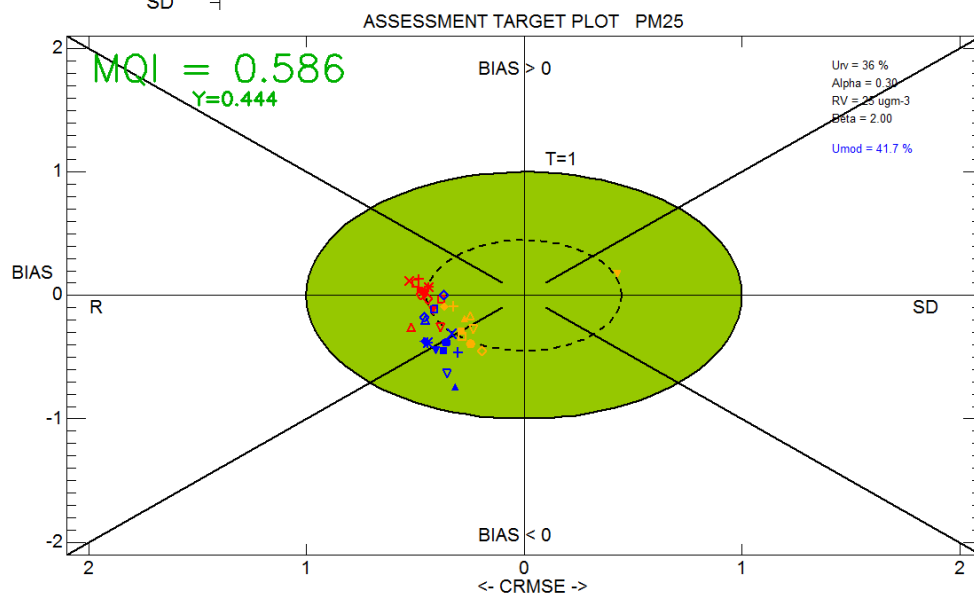


# Summer Episode - PM<sub>10</sub> / PM<sub>2.5</sub>

## Target Diagram – Airbase (All sites) – Daily mean



◊ BELAB01	◊ BETN012	◊ BETN073	◊ BETR502	◊ FR04002
◊ BELAB02	◊ BETN016	◊ BETN085	◊ BETR510	◊ FR04024
◊ BELAL01	◊ BETN029	◊ BETN093	◊ BETR511	◊ FR04066
◊ BELHB23	◊ BETN035	◊ BETN100	◊ BETR701	◊ FR04158
◊ BELMN01	◊ BETN045	◊ BETN121	◊ BETR710	◊ FR04322
◊ BELRL01	◊ BETN054	◊ BETR012	◊ BETR811	◊ FR04328
◊ BELSZ02	◊ BETN060	◊ BETR201	◊ BETR833	◊ FR05074
◊ BETB011	◊ BETN063	◊ BETR221	◊ FR05086	◊ FR01019
◊ BETM204	◊ BETN070	◊ BETR222	◊ FR04001	◊ FR06001

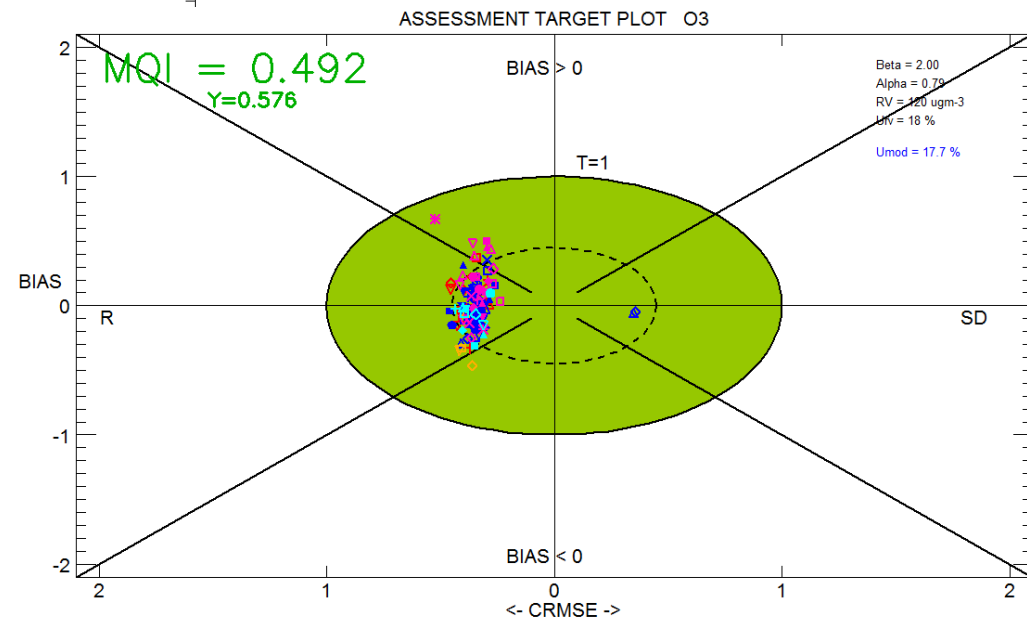
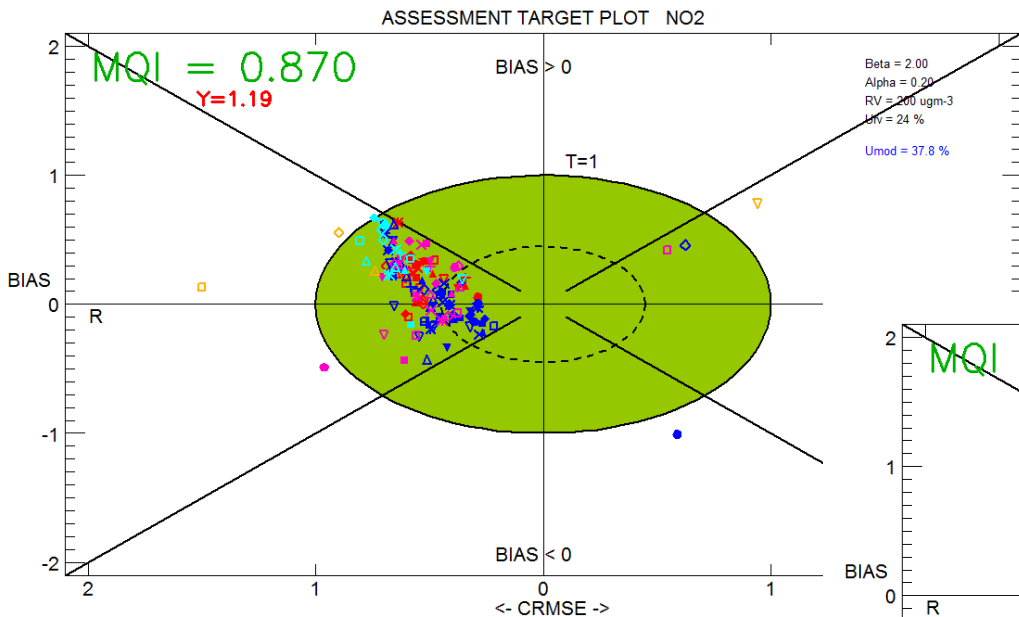


◊ BETB011	◊ BETR502	◊ FR14042	◊ GB0608A
◊ BETM204	◊ BETR701	◊ FR18042	◊ GB0620A
◊ BETN029	◊ BETR833	◊ FR18053	◊ GB0646A
◊ BETN045	◊ FR04002	◊ FR21182	◊ GB0733A
◊ BETN063	◊ FR05087	◊ FR25036	◊ GB0840A
◊ BETR012	◊ FR06001	◊ FR25048	◊ GB0920A
◊ BETR201	◊ FR06003	◊ FR30034	◊ GB0995A
◊ BETR221	◊ FR11025	◊ GB0586A	◊ GB0995A
◊ BETR222	◊ FR14008	◊ GB0597A	◊ GB1005A

Str/End Ind: 3625-5832  
 Model (s): CAMXRSE  
 Parameter: PM25  
 Scen: 2011  
 Extra Values: No  
 Season: Year  
 Day hours: All 24h  
 Time Average: Preserved  
 Daily stats: Mean

# Summer Episode - NO<sub>2</sub> / O<sub>3</sub>

## Target Diagram – Airbase (All sites) – Hourly/8-hourly mean

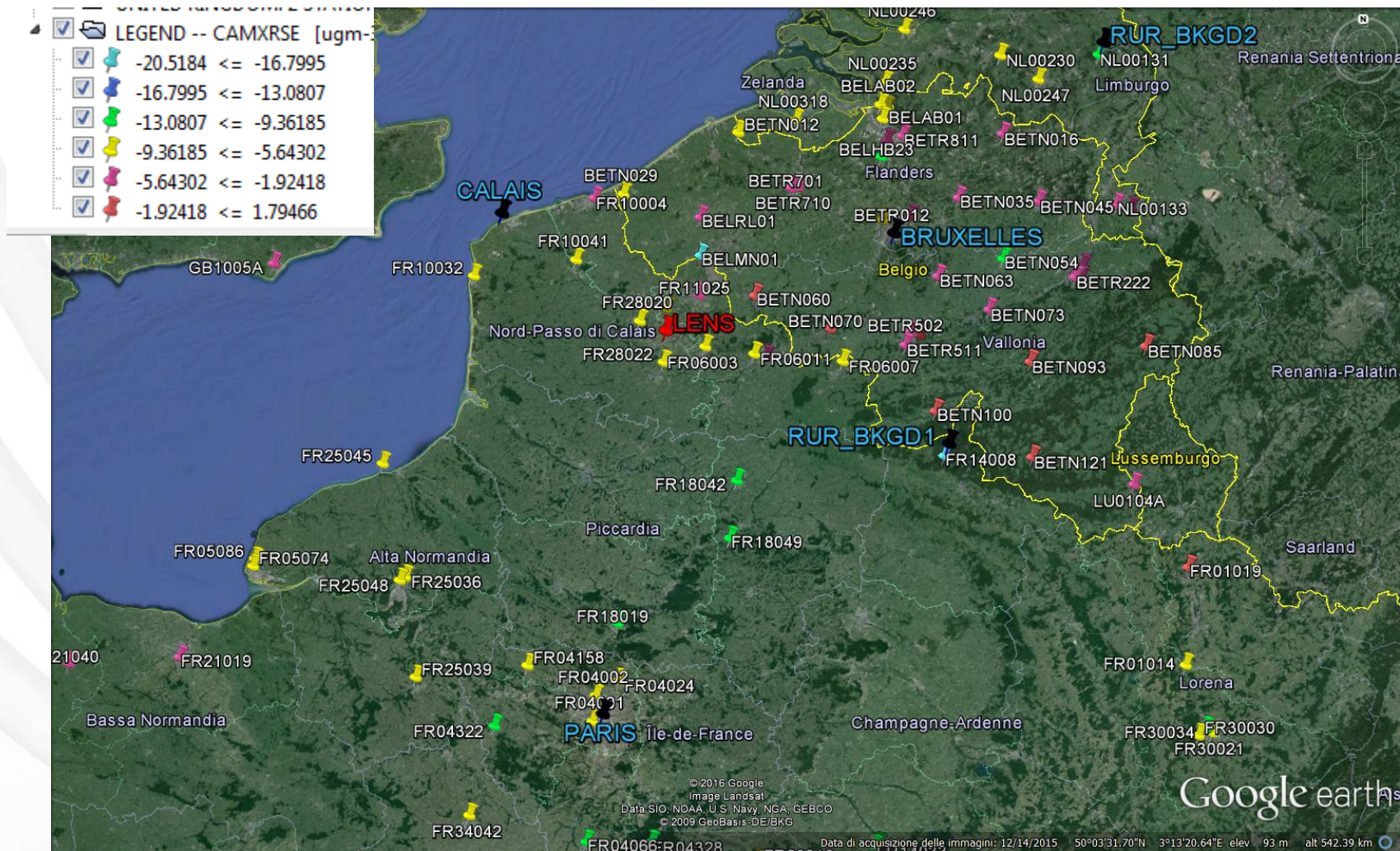


◇ BELHB23	● BETN040	▲ BETN085	▽ BETR701	■ FR04001	Strl
◇ BELLD02	● BETN045	▲ BETN093	▽ BETR710	■ FR04002	Mod
◇ BELSZ02	● BETN051	▲ BETN100	▽ BETR811	■ FR04024	Par
◇ BETB006	● BETN054	▲ BETN121	▽ BETR821	■ FR04029	Sc
◇ BETB011	● BETN060	▲ BETR010	▽ FR01004	■ FR04038	Extr
◇ BETN016	● BETN063	▲ BETR012	▽ FR01014	■ FR04059	Sea
◇ BETN027	● BETN066	▲ BETR201	▽ FR01018	■ FR04145	Day
◇ BETN029	● BETN070	▲ BETR222	▽ FR01019	■ FR04146	Tim
◇ BETN035	● BETN073	▲ BETR502	▽ FR01021	■ FR04149	Dail

◇ BETB006	● BETN045	▲ BETN100	▽ BETR811	■ FR04100	Strl/end ind: 3625-5832
◇ BETB011	● BETN051	▲ BETN113	▽ FR01004	■ FR04145	Model (s): CAMXRSE
◇ BETN012	● BETN054	▲ BETN121	▽ FR01014	■ FR04149	Parameter: O3
◇ BETN016	● BETN060	▲ BETR012	▽ FR01018	■ FR04158	Scen: 2011
◇ BETN027	● BETN063	▲ BETR201	▽ FR01019	■ FR04322	Extra Values: No
◇ BETN029	● BETN066	▲ BETR222	▽ FR01021	■ FR04328	Season: Year
◇ BETN035	● BETN073	▲ BETR502	▽ FR04038	■ FR05074	Day hours: All 24h
◇ BETN040	● BETN085	▲ BETR701	▽ FR04048	■ FR05082	Time Average: 8h
◇ BETN041	● BETN093	▲ BETR710	▽ FR04066	■ FR05086	Daily stats: Max

# Summer Episode - PM<sub>10</sub>

## Mean Bias – Airbase (All sites) – Hourly mean values

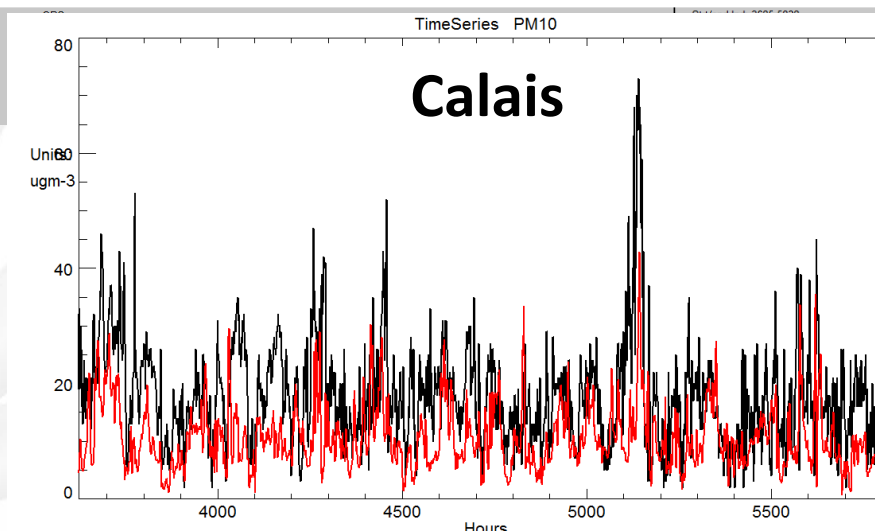
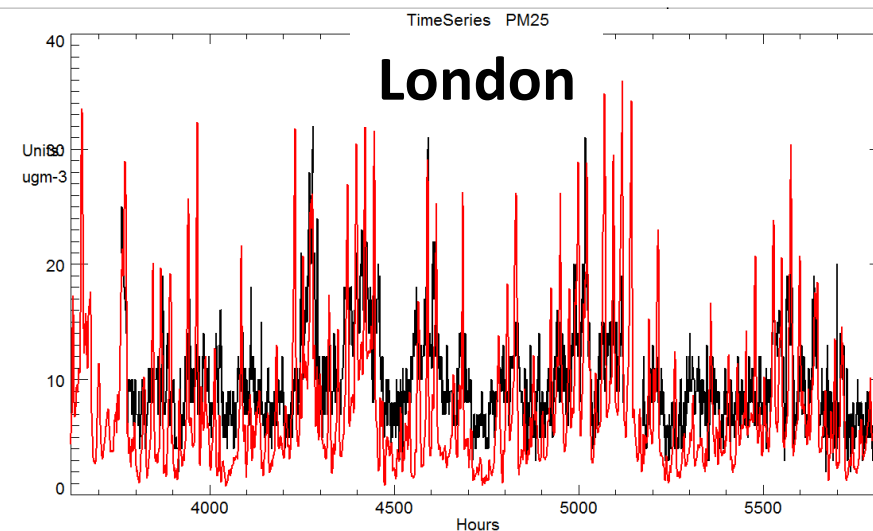
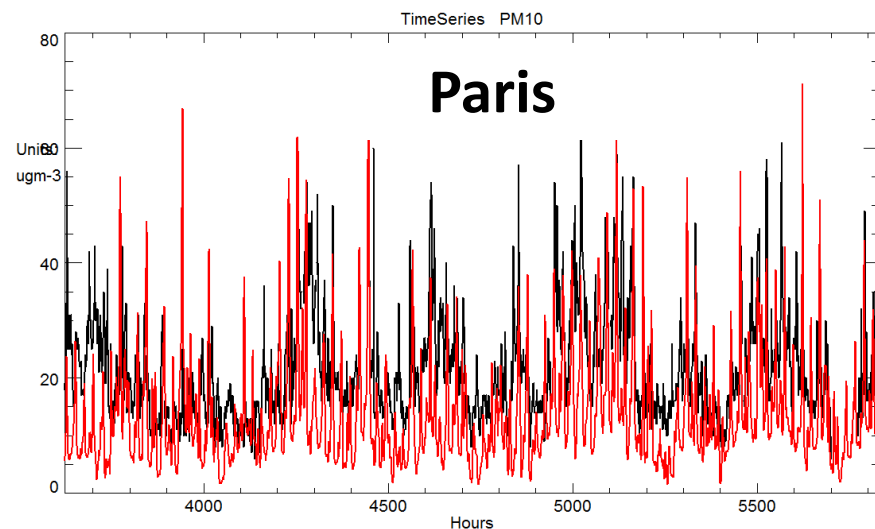
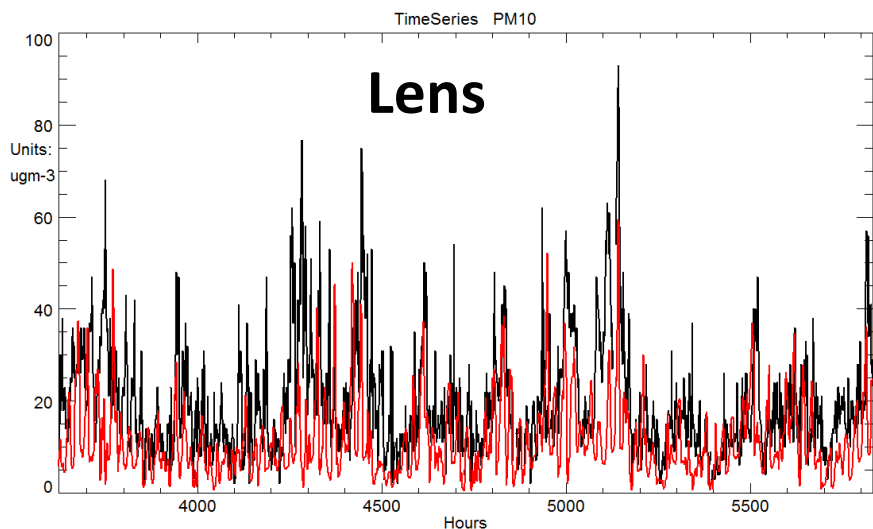






# Summer Episode - PM<sub>10</sub>

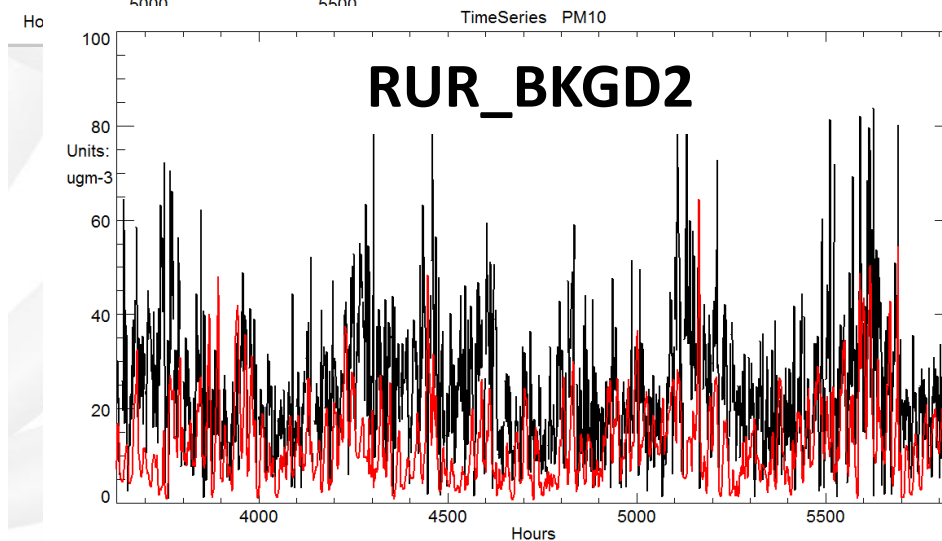
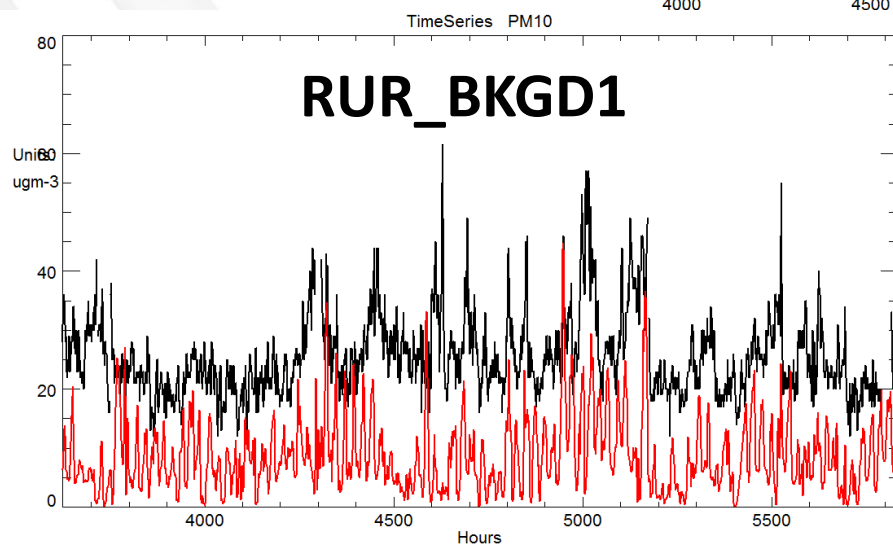
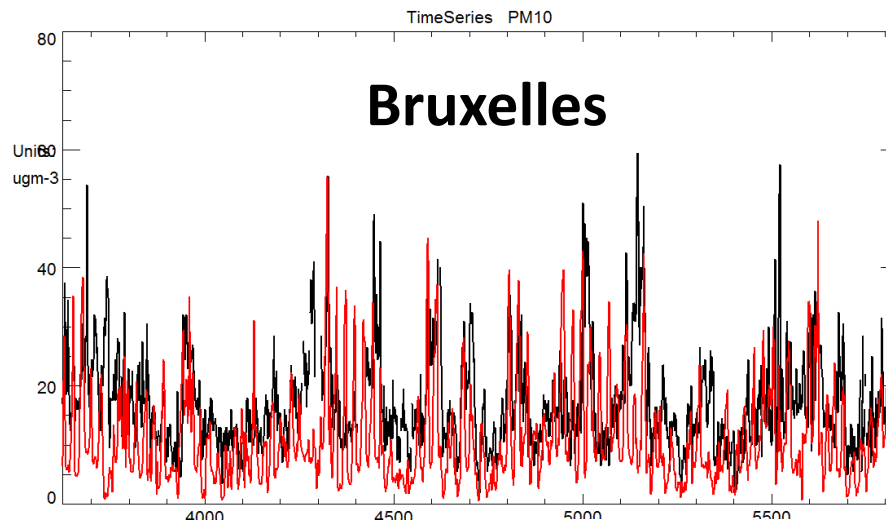
Time series – **SA sites** – hourly mean values





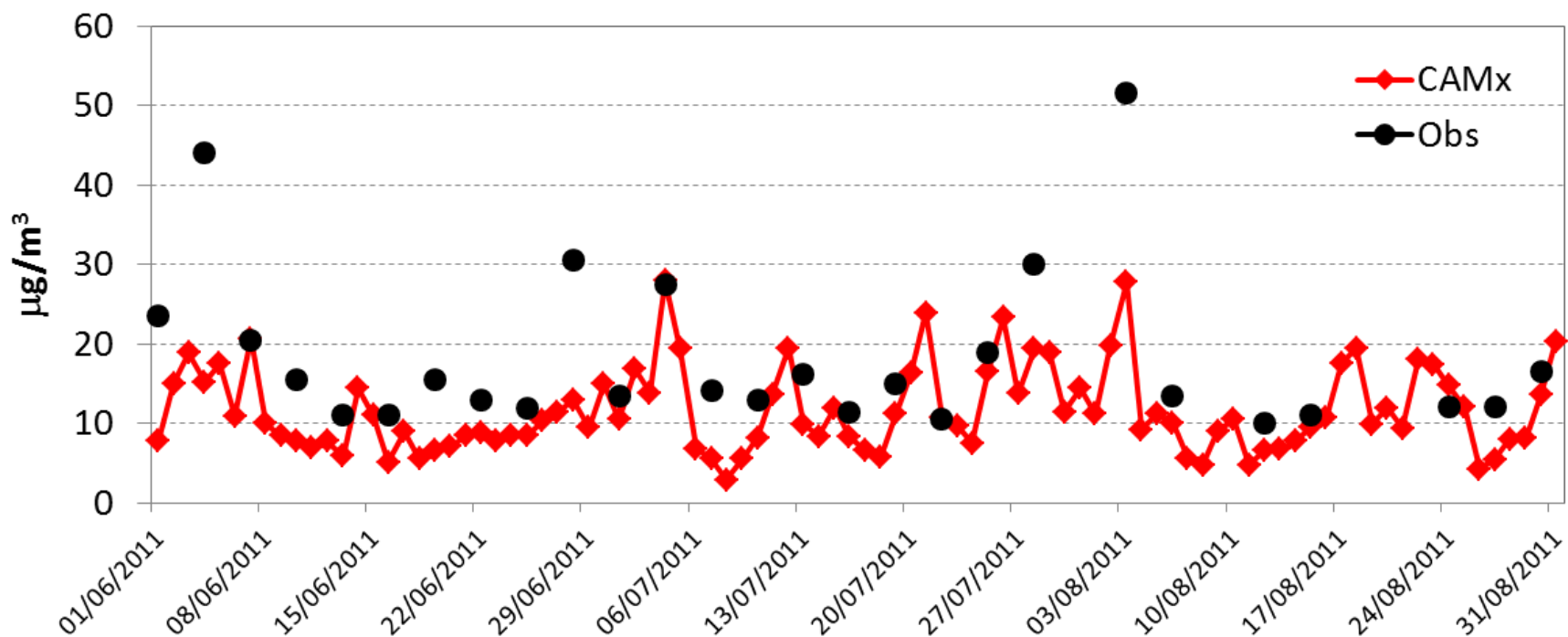
# Summer Episode - PM<sub>10</sub>

Time series – **SA sites** – hourly mean values



# Summer Episode - PM<sub>10</sub>

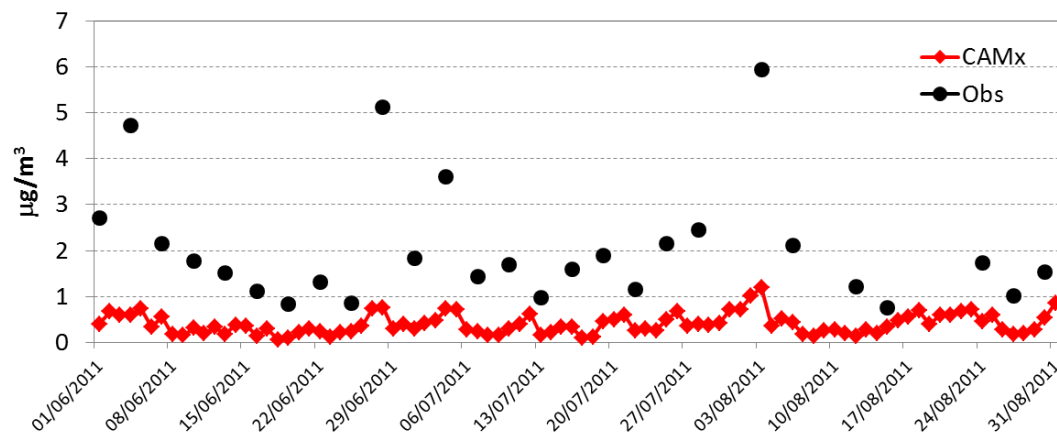
Time series – **Lens** – Daily mean values



Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
18.285	11.624	-6.580	-36.0%	9.705	0.7203

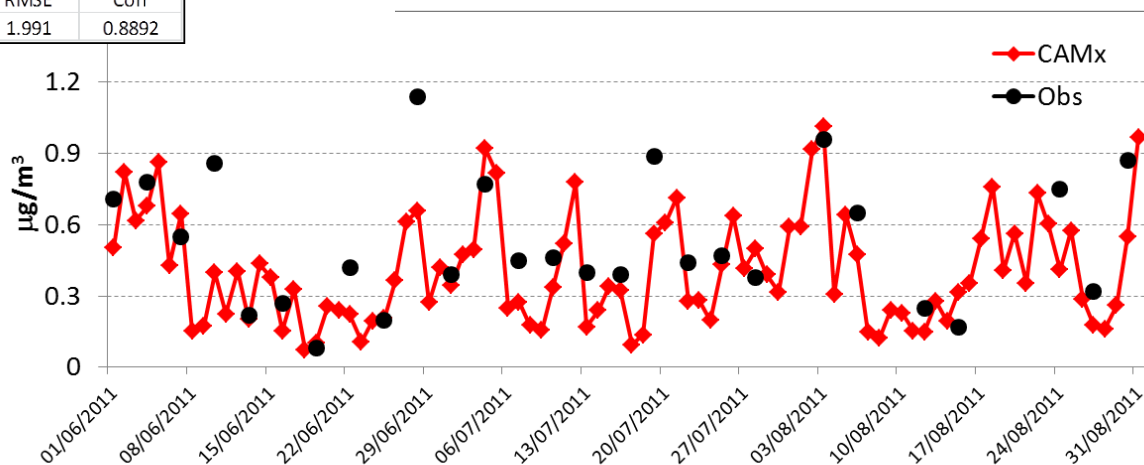
# Summer Episode - OC / EC

Time series – **Lens** – Daily mean values



OC

Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
2.046	0.396	-1.658	-81.0%	1.991	0.8892



EC

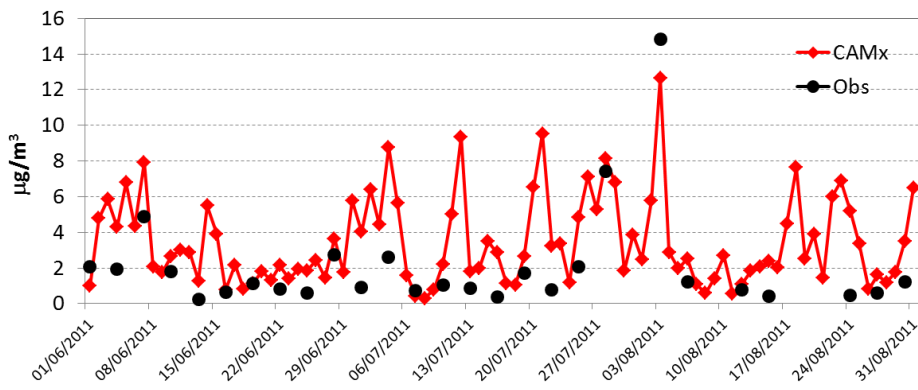
Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
0.527	0.406	-0.120	-22.8%	0.206	0.7879

# Summer Episode - SIA

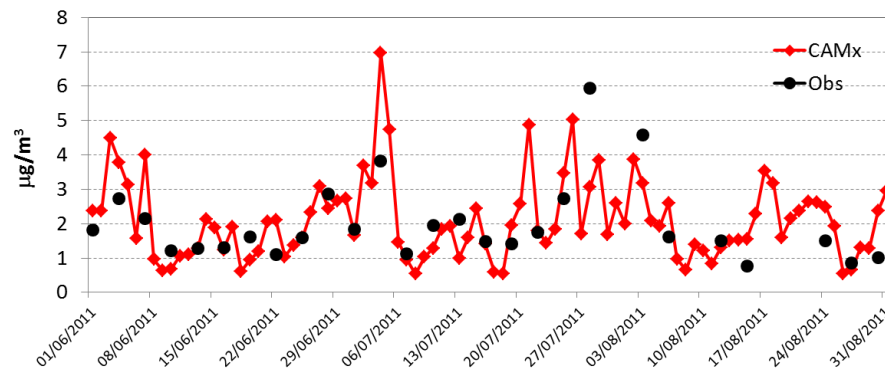
Time series – **Lens** – Daily mean values

**NO<sub>3</sub><sup>-</sup>**

**SO<sub>4</sub><sup>=</sup>**

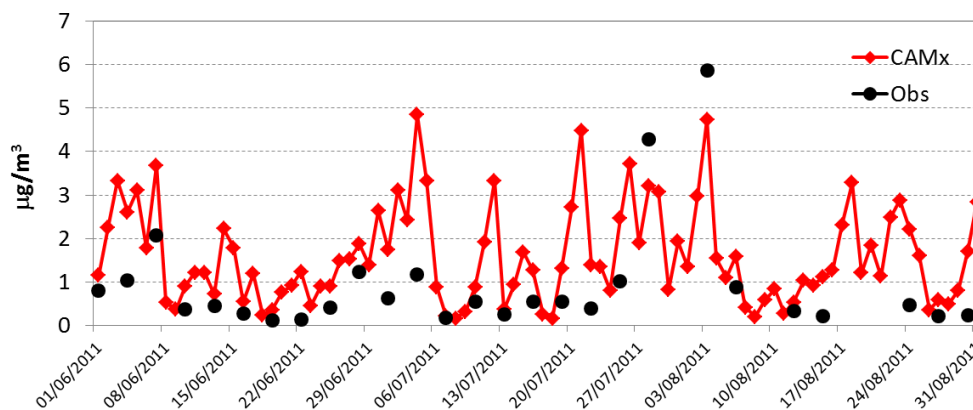


Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
2.033	3.422	1.469	72.3%	2.210	0.8353



Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
1.989	2.087	0.164	8.2%	1.120	0.6039

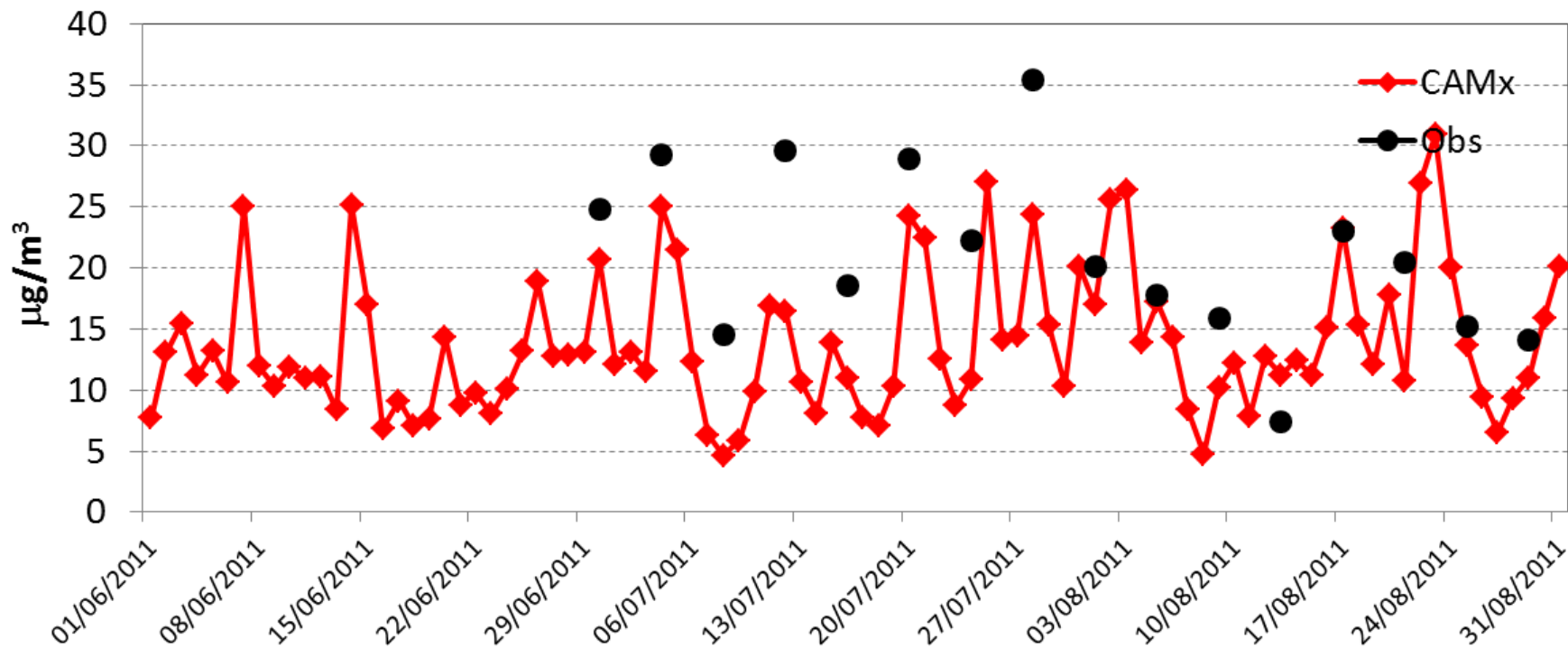
**NH<sub>4</sub><sup>+</sup>**



Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
0.920	1.597	0.719	78.2%	1.147	0.7441

# Summer Episode - PM<sub>10</sub>

Time series – **Gent** – Daily mean values

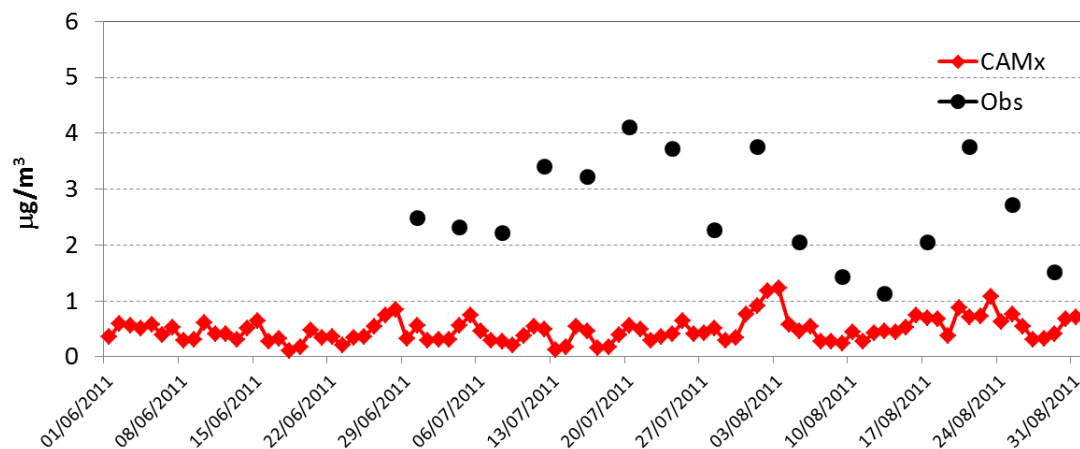


Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
21.080	13.789	-5.361	-25.4%	7.067	0.7596



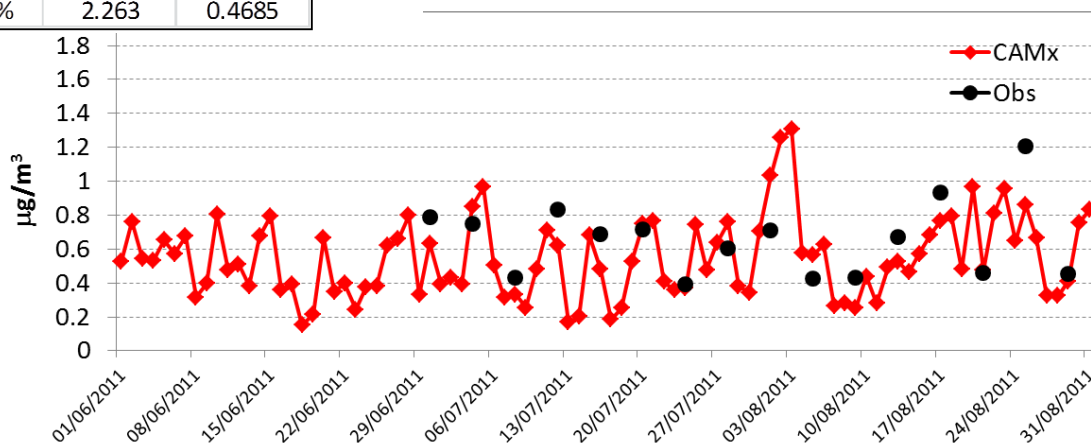
# Summer Episode - OC / EC

Time series – **Gent** – Daily mean values



OC

Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
2.631	0.476	-2.104	-80.0%	2.263	0.4685



EC

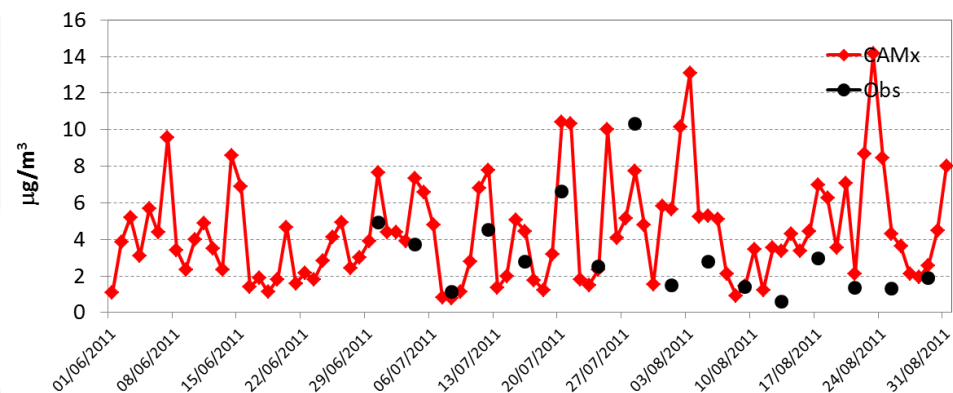
Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
0.656	0.547	-0.051	-7.7%	0.174	0.6977

# Summer Episode - SIA

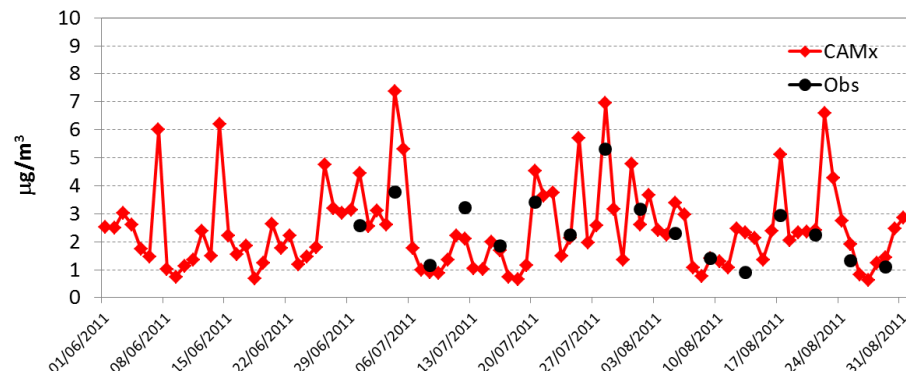
Time series – **Gent** – Daily mean values

**NO<sub>3</sub><sup>-</sup>**

**SO<sub>4</sub><sup>=</sup>**

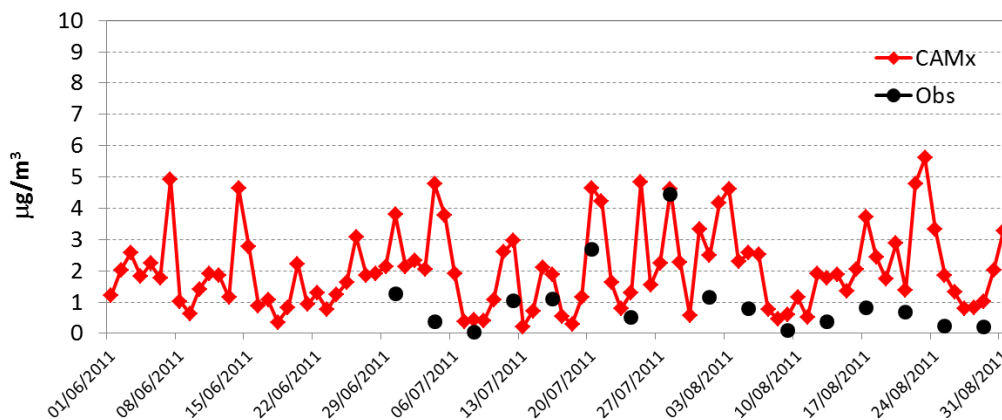


Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
3.144	4.423	1.868	59.4%	2.653	0.7346



Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
2.431	2.451	0.739	30.4%	1.381	0.8214

**NH<sub>4</sub><sup>+</sup>**



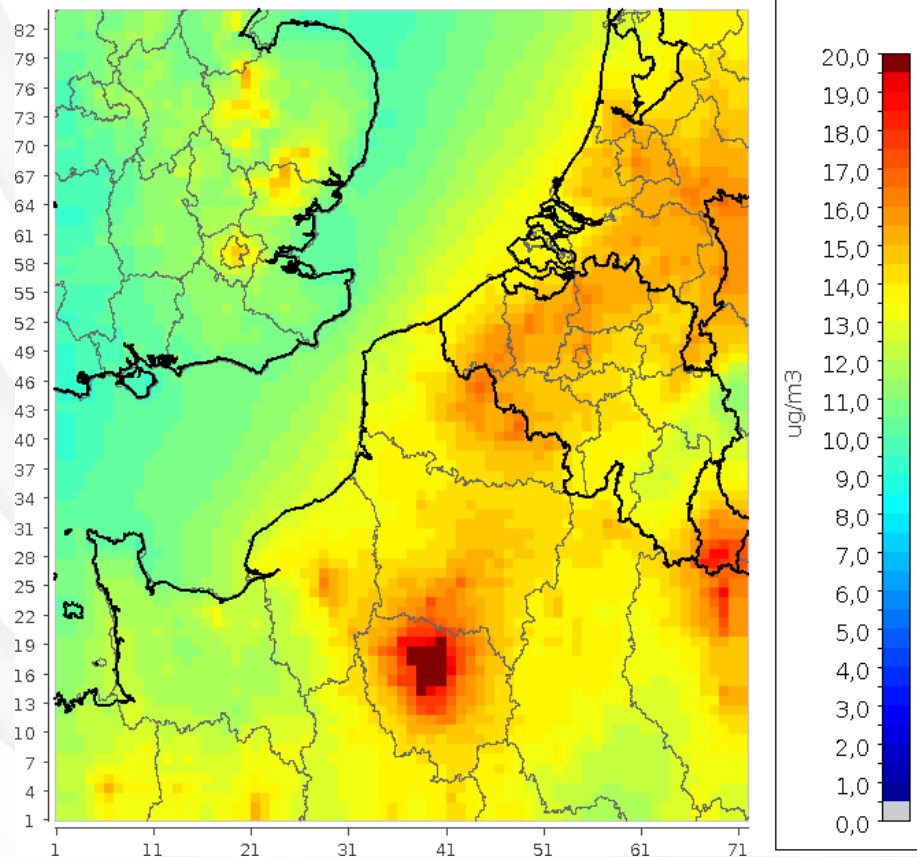
Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
0.989	2.039	1.498	151.5%	1.837	0.6642

# Winter Episode - $PM_{10}$ / $PM_{2.5}$

## Base case configuration - Winter mean

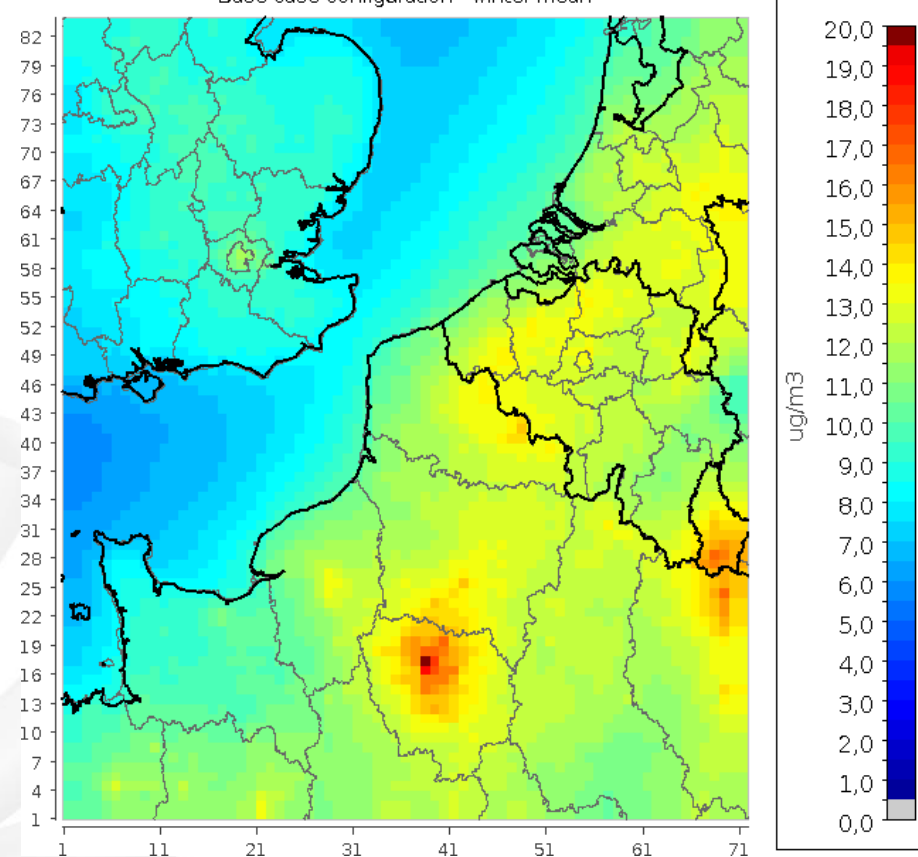
### PM10 - Lens Domain

Base case configuration - winter mean



### PM2.5 - Lens Domain

Base case configuration - winter mean

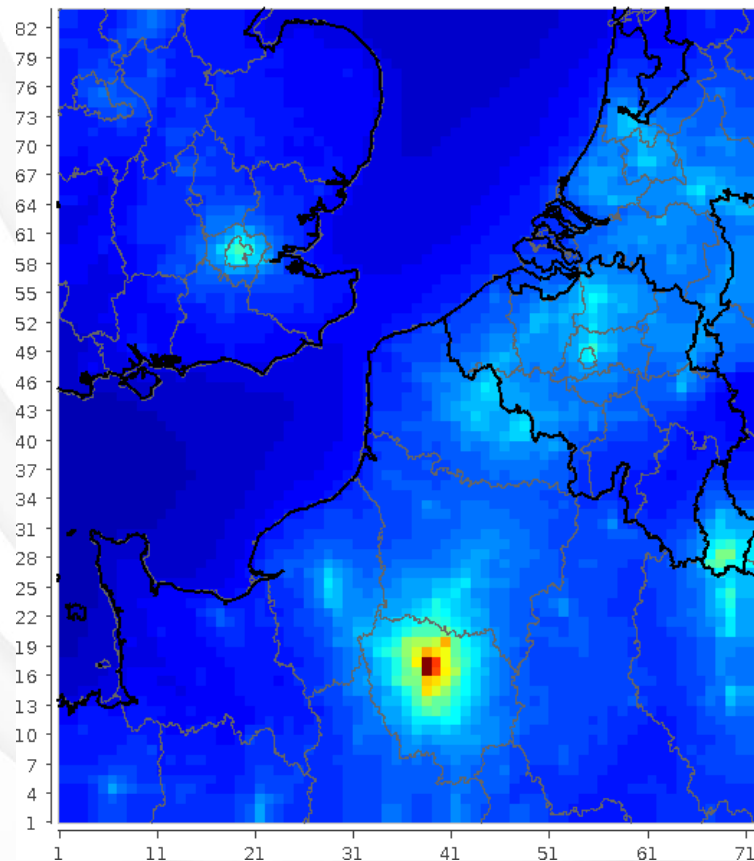


# Winter Episode - EC / OM

## Base case configuration - Winter mean

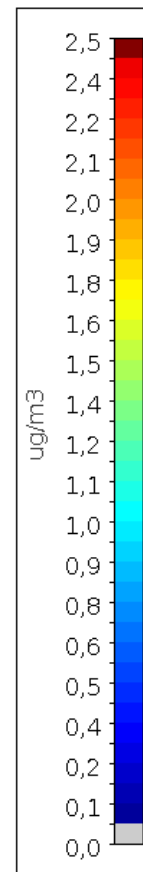
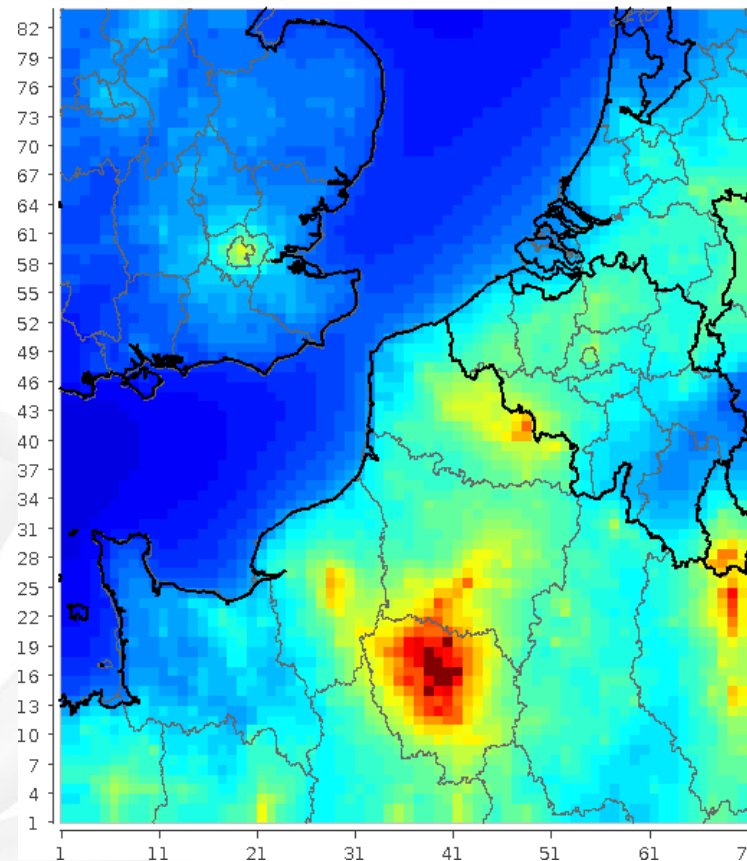
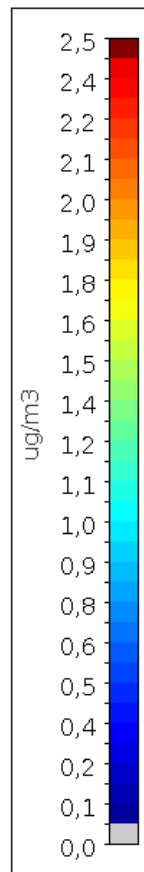
### EC - Lens Domain

Base case configuration - winter mean



### OM - Lens Domain

Base case configuration - winter mean

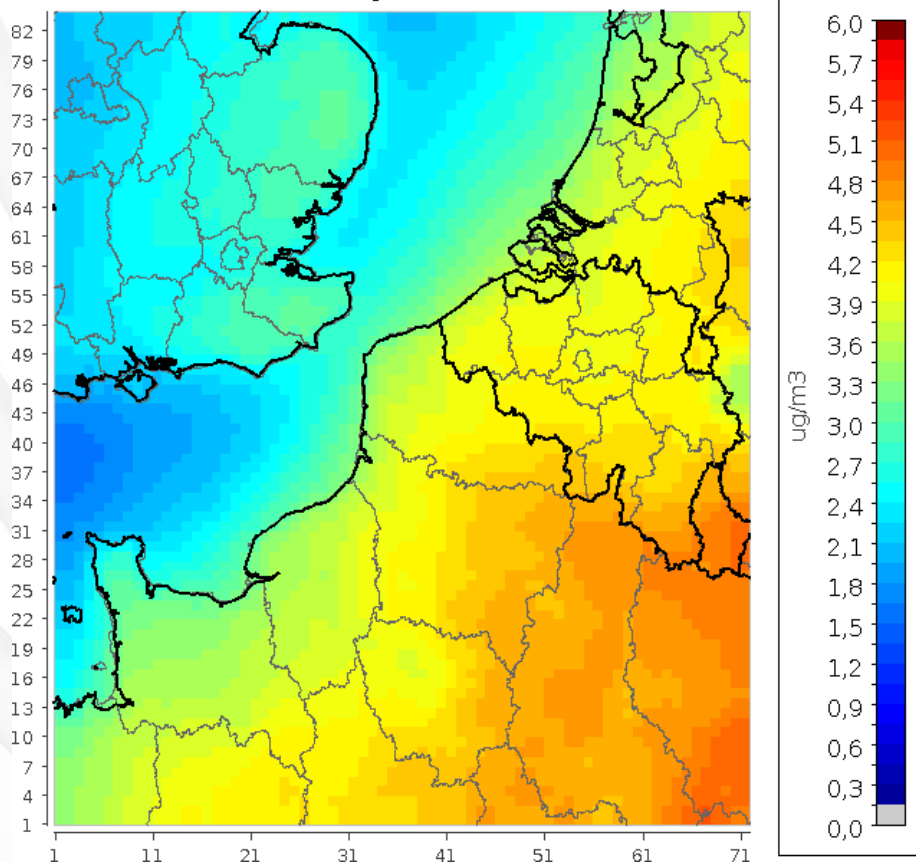


# Winter Episode - Inorganic

## Base case configuration - Winter mean

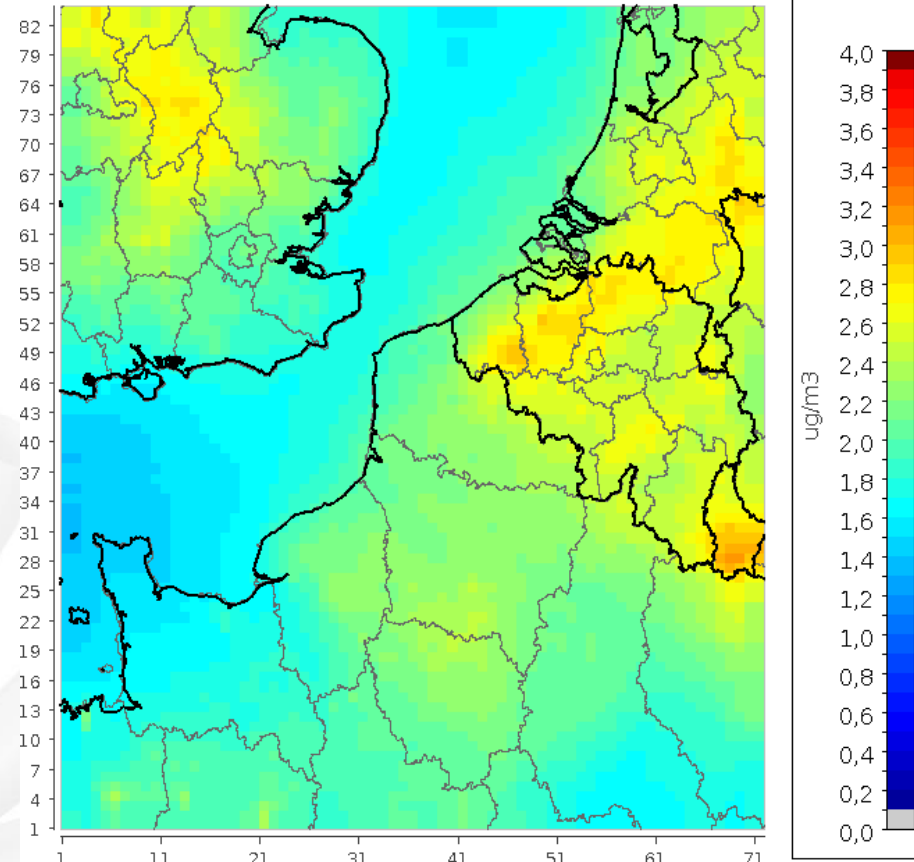
### NO3 - Lens Domain

Base case configuration - winter mean



### SO4 - Lens Domain

Base case configuration - winter mean

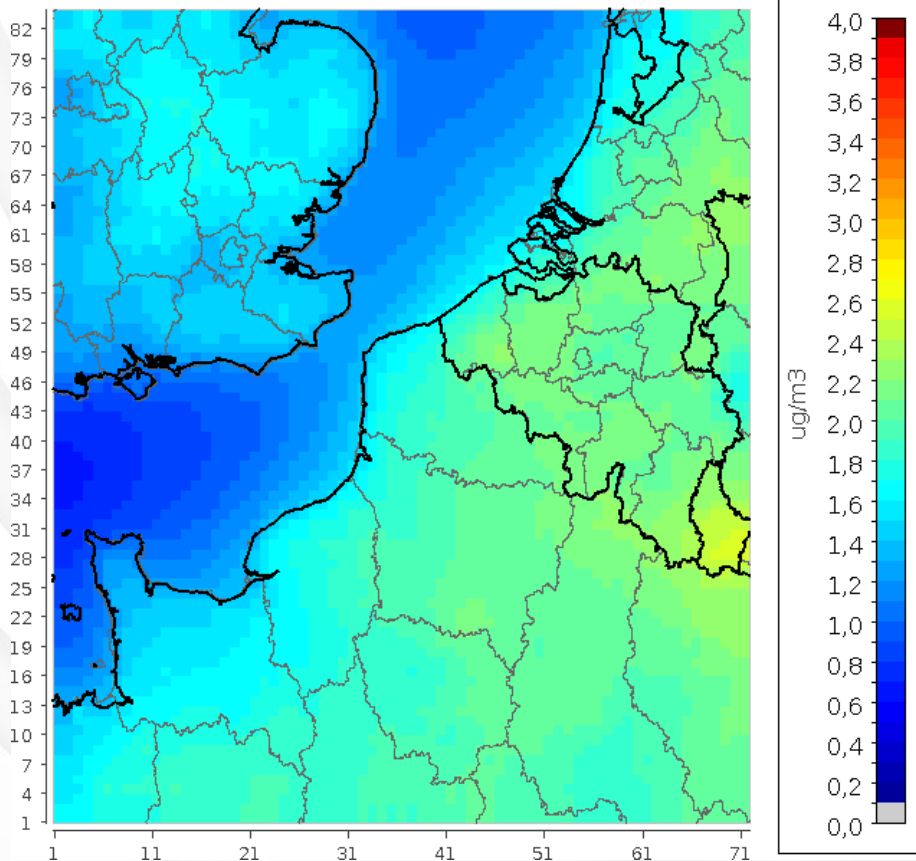


# Winter Episode - Inorganic

## Base case configuration - Winter mean

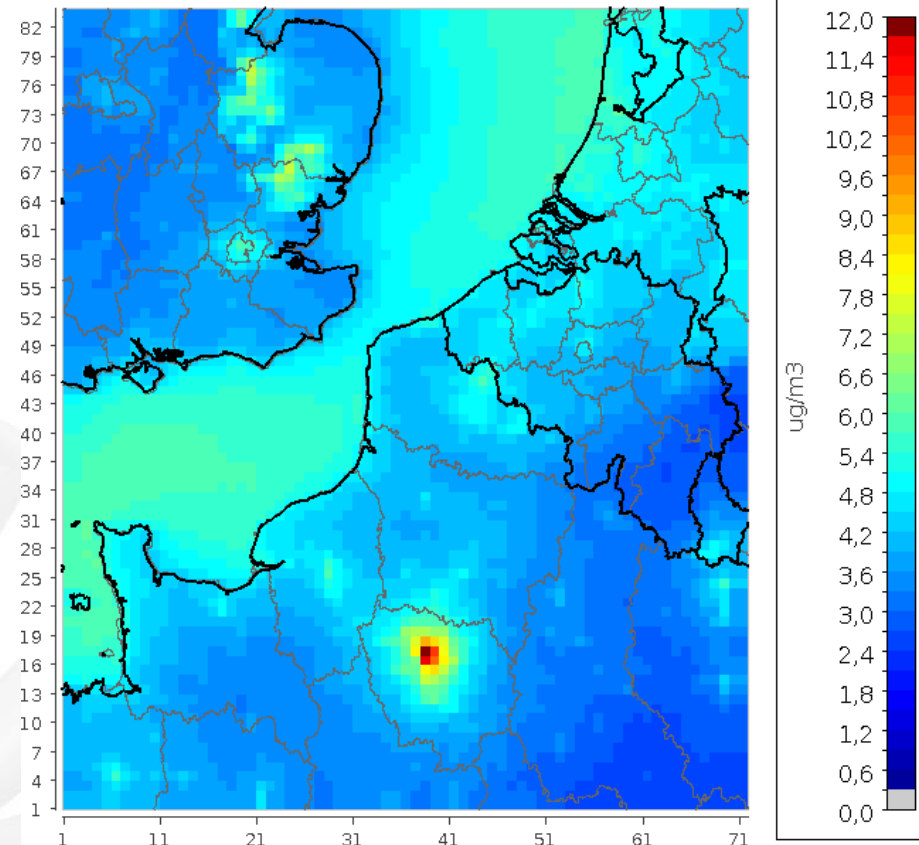
### NH4 - Lens Domain

Base case configuration - winter mean



### Oth PM10 - Lens Domain

Base case configuration - winter mean

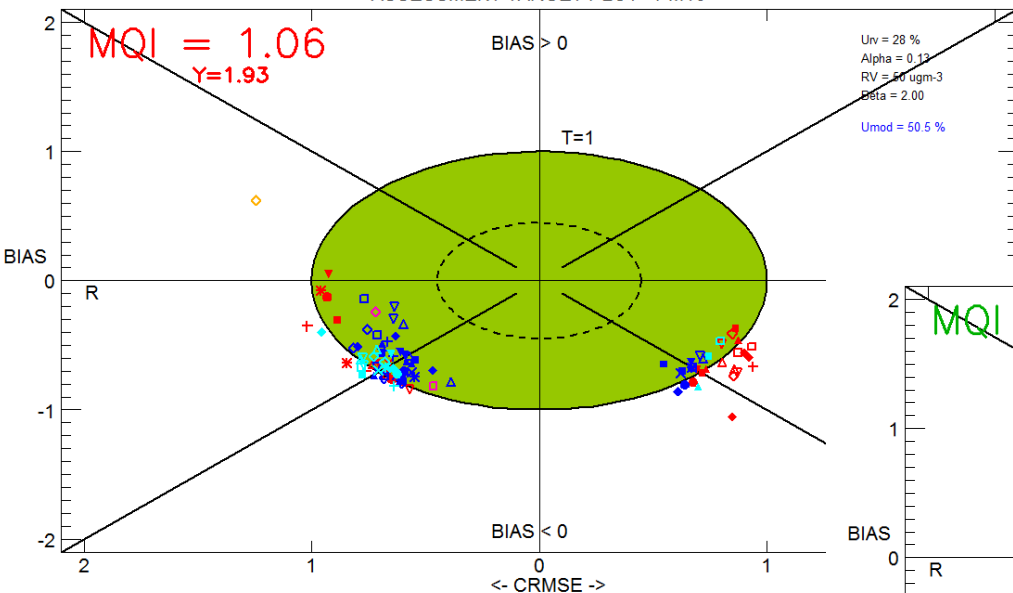




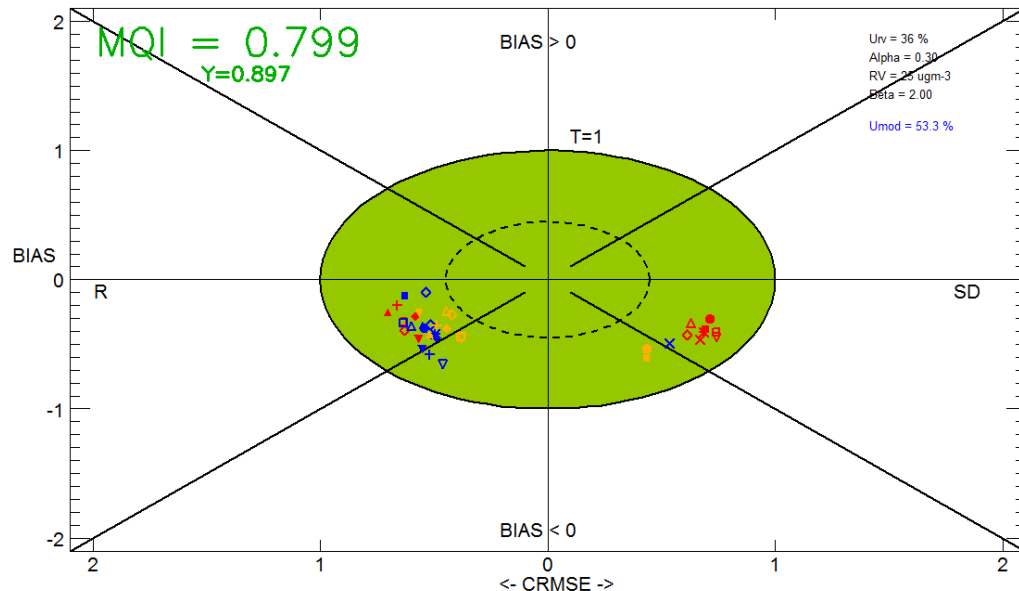
# Winter Episode - $PM_{10}$ / $PM_{2.5}$

## Target Diagram – Airbase (All sites) – Daily mean

ASSESSMENT TARGET PLOT  $PM_{10}$



ASSESSMENT TARGET PLOT  $PM_{25}$

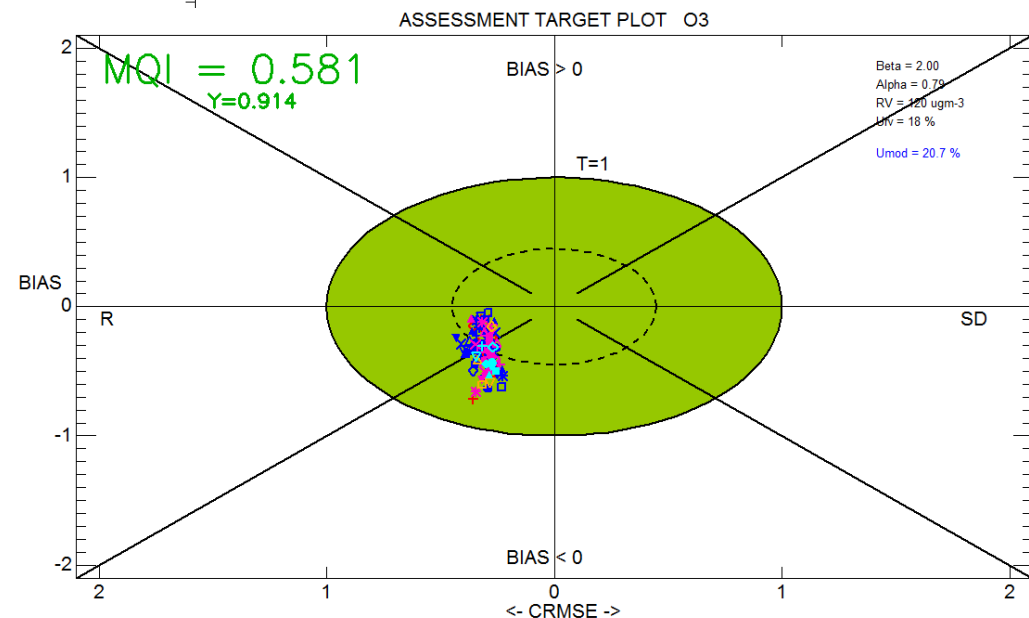
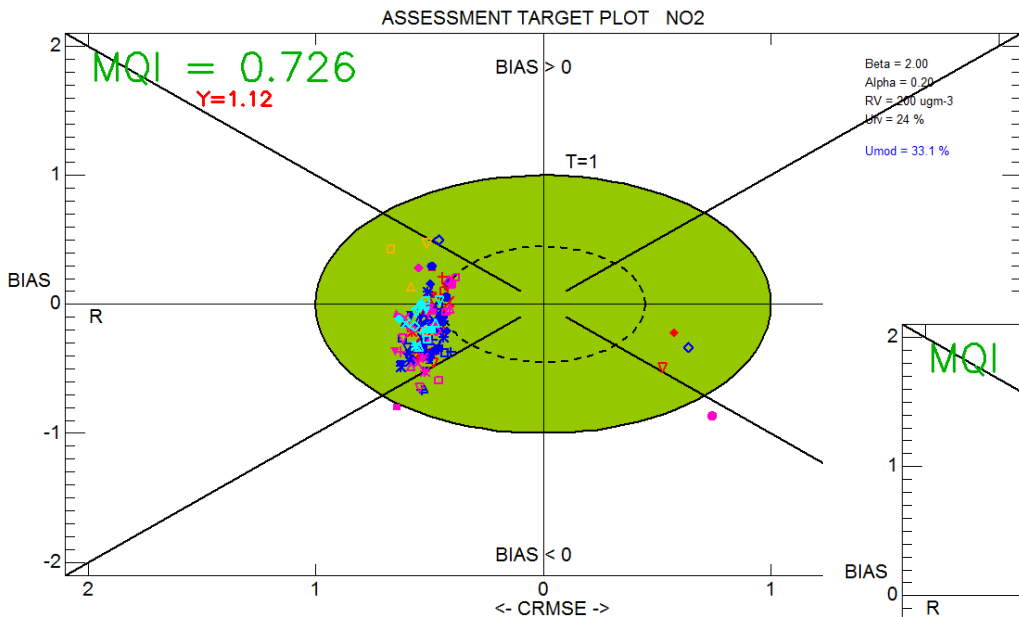


○ BELAB01	● BETN012	△ BETN073	▽ BETR502	▲ FR04001	Str/End
○ BELAB02	● BETN016	△ BETN085	▽ BETR510	▲ FR04002	Mode
○ BELAL01	● BETN029	△ BETN093	▽ BETR511	▲ FR04024	Param
○ BELHB23	● BETN035	△ BETN100	▽ BETR701	▲ FR04066	Scen
○ BELMN01	● BETN045	△ BETN121	▽ BETR710	▲ FR04158	Extra
○ BELRL01	● BETN054	△ BETR012	▽ BETR811	▲ FR04322	Seas
○ BELSZ02	● BETN060	△ BETR201	▽ BETR833	▲ FR04328	Day h
○ BETB011	● BETN063	△ BETR221	▽ FR01014	▲ FR05074	Time
○ BETM204	● BETN070	△ BETR222	▽ FR01019	▲ FR05086	Daily

○ BETB011	● BETR221	▲ FR11025	○ GB0586A	● GB1005A	Str/End Ind: 6553-8760
○ BETM204	● BETR222	▲ FR14008	○ GB0597A	● GB0608A	Model (s): CAMRSE
○ BETN029	● BETR502	▲ FR14042	○ GB0620A	● GB0646A	Parameter: PM25
○ BETN045	● BETR701	▲ FR18042	○ GB0733A	● GB0840A	Scen: 2011
○ BETN060	● BETR833	▲ FR18053	○ GB0840A	● GB0920A	Extra Values: No
○ BETN063	● FR04002	▲ FR23182	○ GB0920A	● GB0995A	Season: Year
○ BETN073	● FR05087	▲ FR25036	○ GB0995A		Day hours: All 24h
○ BETR012	● FR06001	▲ FR25048			Time Average: Preserved
○ BETR201	● FR06003	▲ FR30034			Daily stats: Mean

# Winter Episode - NO<sub>2</sub> / O<sub>3</sub>

## Target Diagram – Airbase (All sites) – Hourly/8-hourly mean



◇ BELHB23	◇ BETN040	◇ BETN085	◇ BETR701	◇ FR04001	Strl
◇ BELLD02	◇ BETN045	◇ BETN093	◇ BETR710	◇ FR04002	Mod
◇ BELSZ02	◇ BETN051	◇ BETN100	◇ BETR811	◇ FR04024	Par
◇ BETB006	◇ BETN054	◇ BETN121	◇ BETR821	◇ FR04029	Scn
◇ BETB011	◇ BETN060	◇ BETR010	◇ FR01004	◇ FR04038	Extr
◇ BETN016	◇ BETN063	◇ BETR012	◇ FR01014	◇ FR04059	Sea
◇ BETN027	◇ BETN066	◇ BETR201	◇ FR01018	◇ FR04145	Day
◇ BETN029	◇ BETN070	◇ BETR222	◇ FR01019	◇ FR04146	Time
◇ BETN035	◇ BETN073	◇ BETR502	◇ FR01021	◇ FR04149	Dail

◇ BETB006	◇ BETN051	◇ BETN113	◇ FR01014	◇ FR04149	Strl/end ind: 6553-0760 Model (s): CAMXRSE Parameter: O3 Scn: 2011 Extra Values: No Season: Year Day hours: All 24h Time Average: 8h Daily stats: Max
◇ BETB011	◇ BETN054	◇ BETN121	◇ FR01018	◇ FR04150	
◇ BETN012	◇ BETN060	◇ BETR012	◇ FR01019	◇ FR04322	
◇ BETN027	◇ BETN063	◇ BETR201	◇ FR01021	◇ FR04328	
◇ BETN029	◇ BETN066	◇ BETR222	◇ FR04038	◇ FR05074	
◇ BETN035	◇ BETN073	◇ BETR701	◇ FR04048	◇ FR05082	
◇ BETN040	◇ BETN085	◇ BETR710	◇ FR04066	◇ FR05087	
◇ BETN041	◇ BETN093	◇ BETR811	◇ FR04100	◇ FR06003	
◇ BETN045	◇ BETN100	◇ FR01004	◇ FR04145	◇ FR06007	

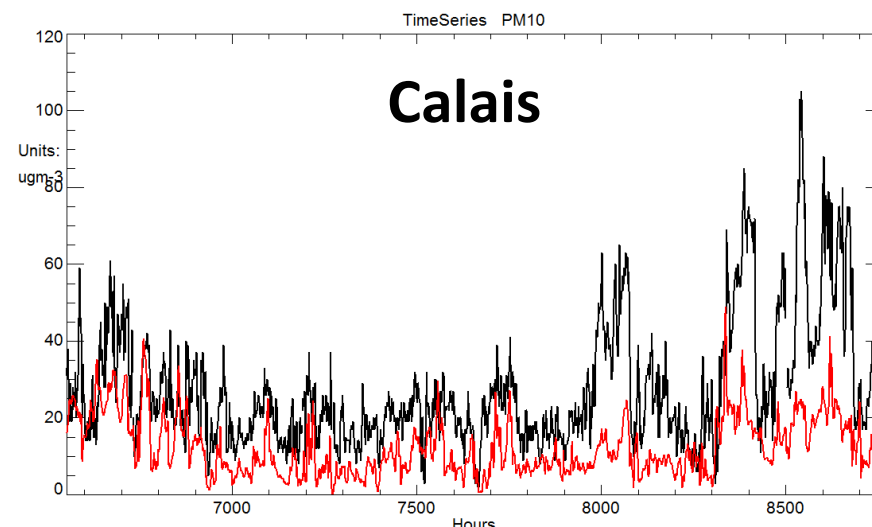
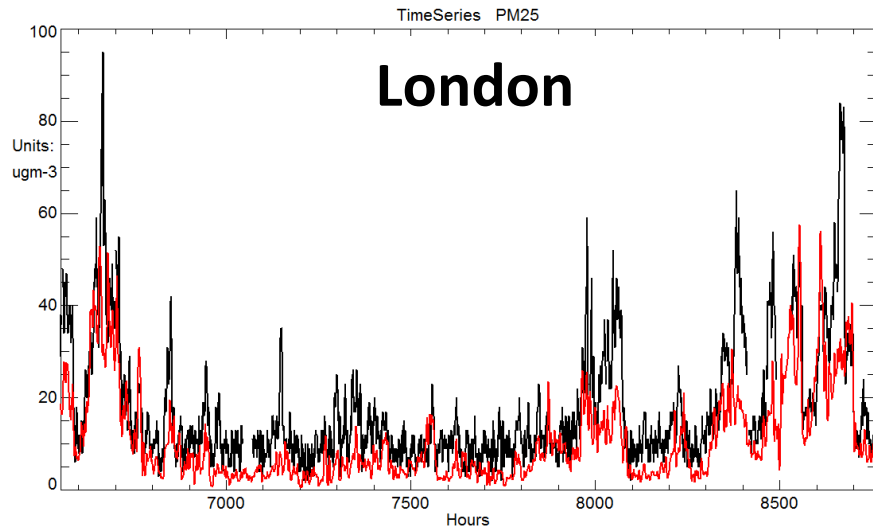
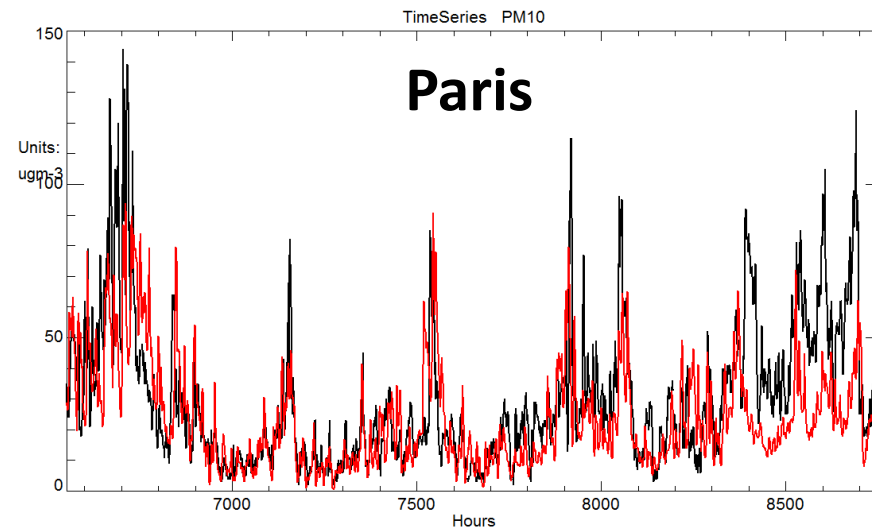
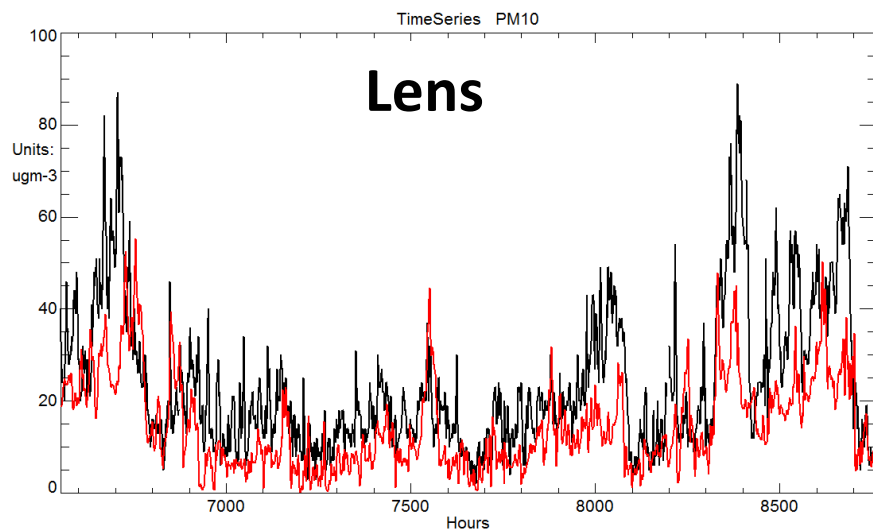






# Winter Episode - PM<sub>10</sub>

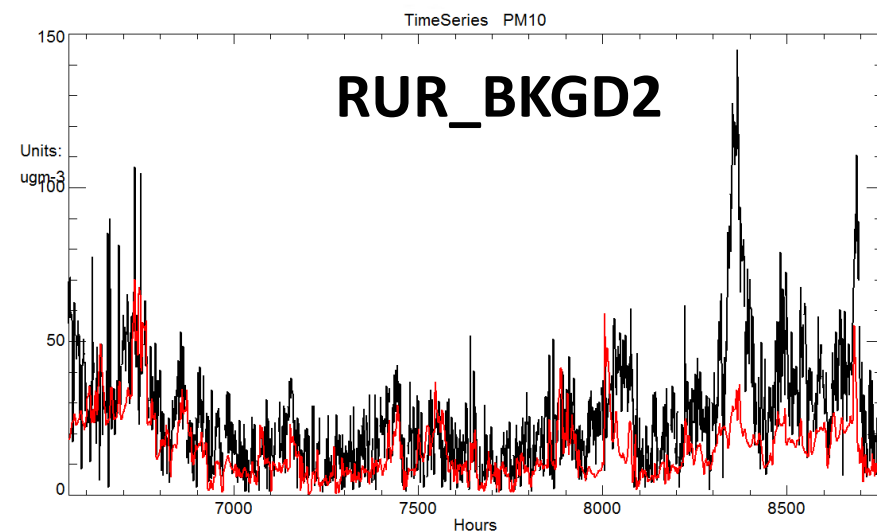
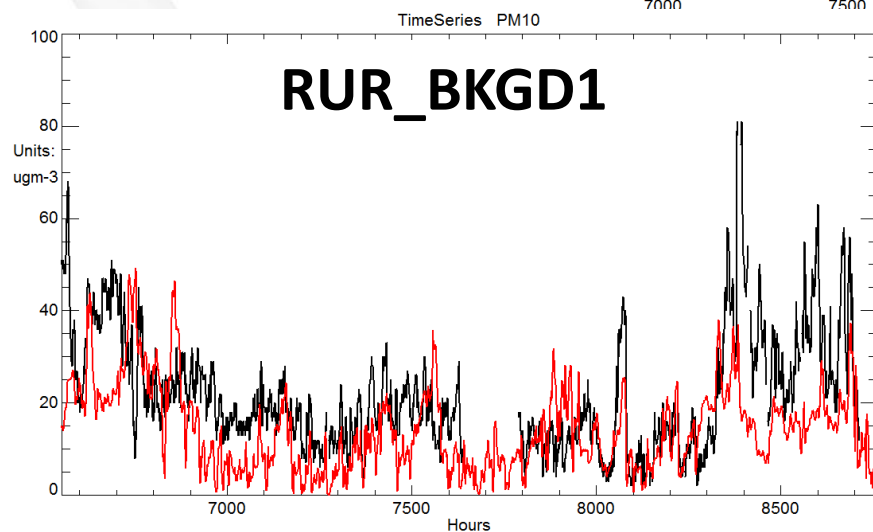
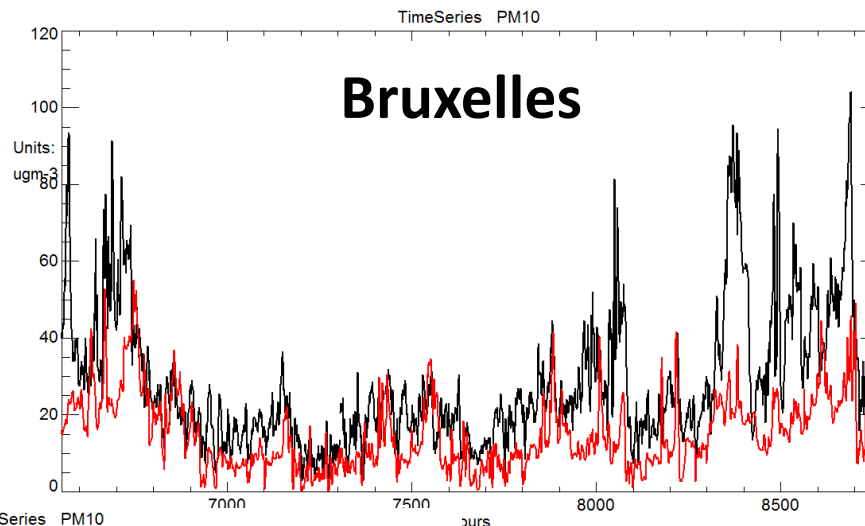
Time series – **SA sites** – hourly mean values





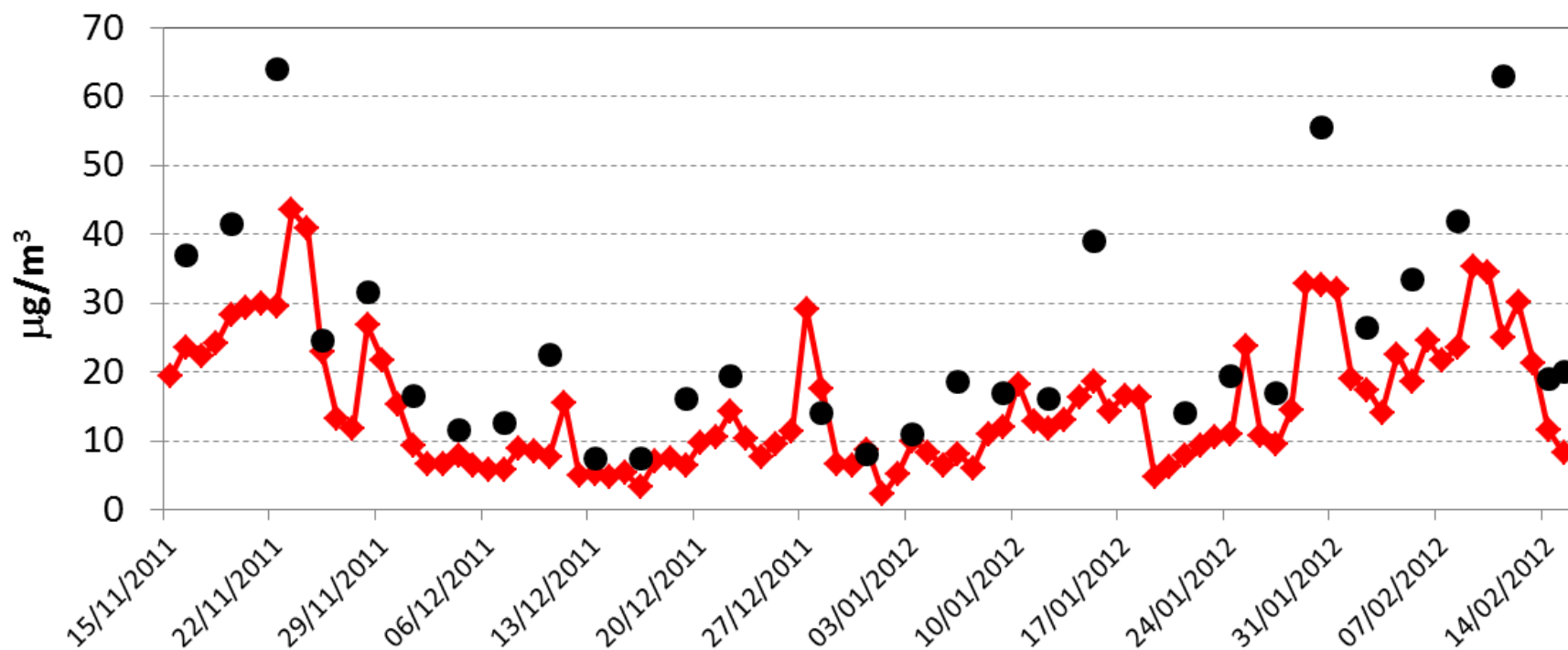
# Winter Episode - PM<sub>10</sub>

Time series – **SA sites** – hourly mean values



# Winter Episode - PM<sub>10</sub>

Time series – **Lens** – Daily mean values

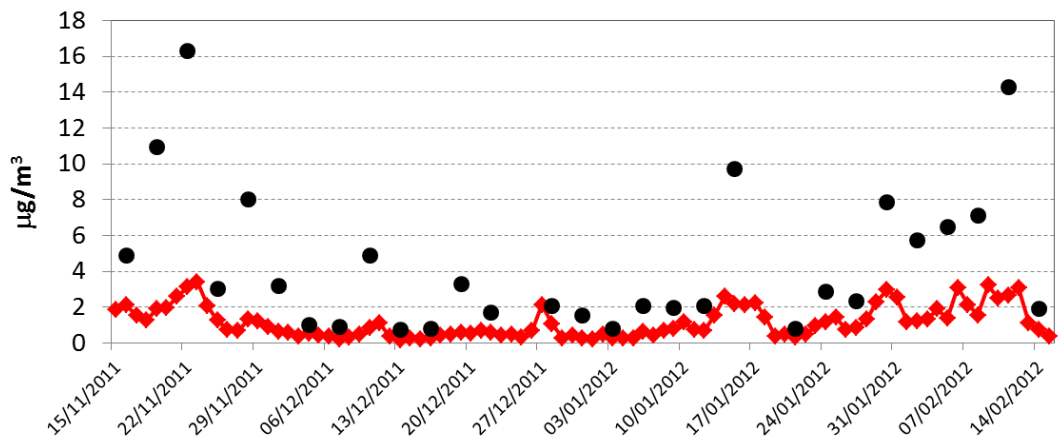


◆ CAMx  
● Obs

Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
24.853	15.230	-10.109	-40.7%	13.667	0.8717

# Winter Episode - OC / EC

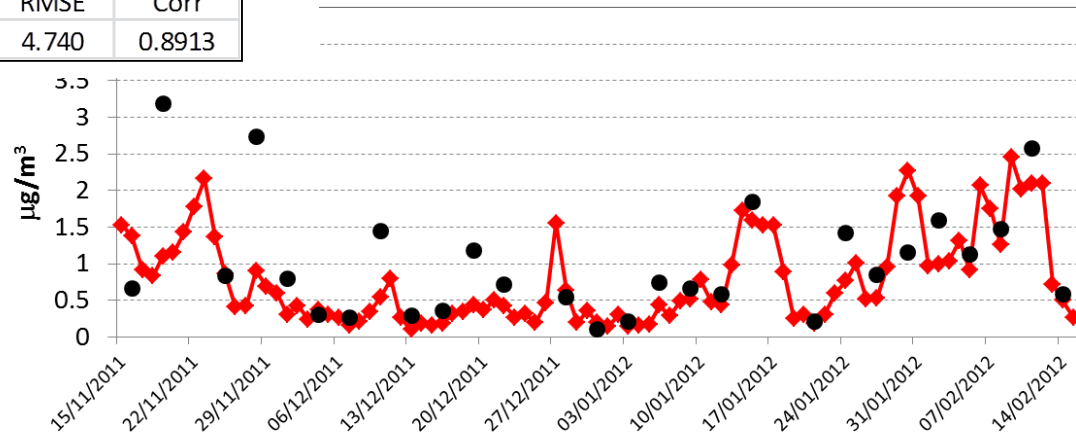
Time series – **Lens** – Daily mean values



OC

—♦— CAMx  
● Obs

Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
4.455	1.144	-3.343	-75.0%	4.740	0.8913



EC

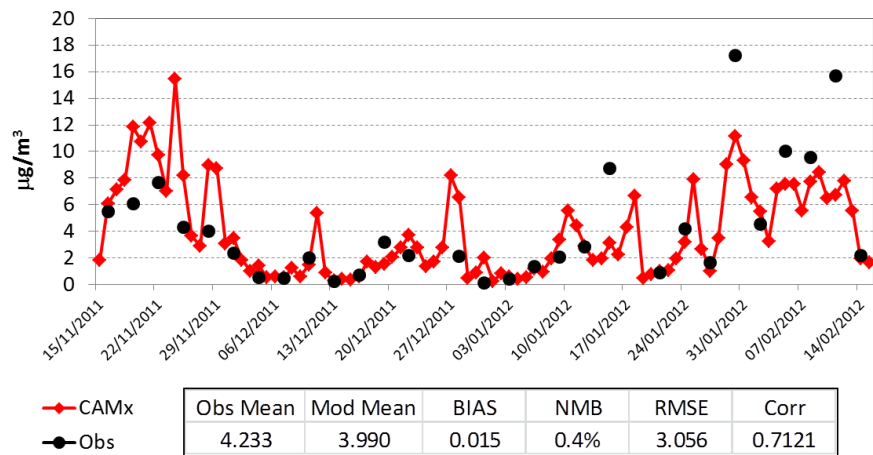
—♦— CAMx  
● Obs

Obs Mean	Mod Mean	BIAS	NMB	RMSE	Corr
1.119	0.792	-0.357	-31.9%	0.777	0.6798

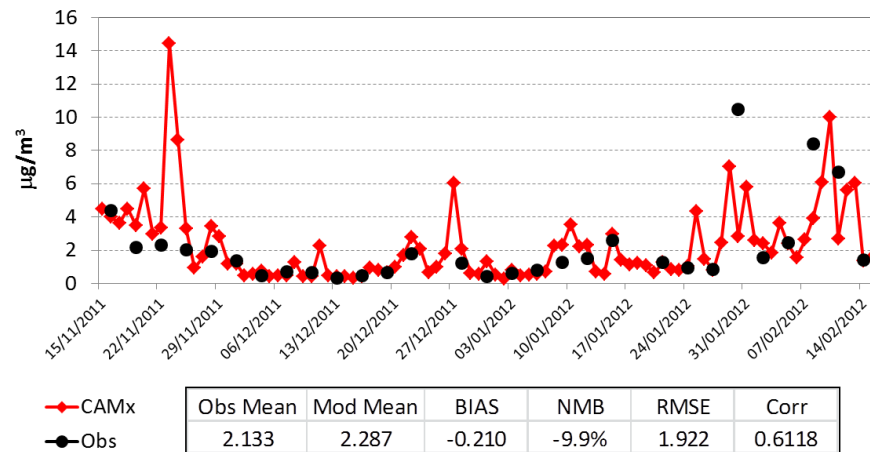
# Winter Episode - SIA

Time series – **Lens** – Daily mean values

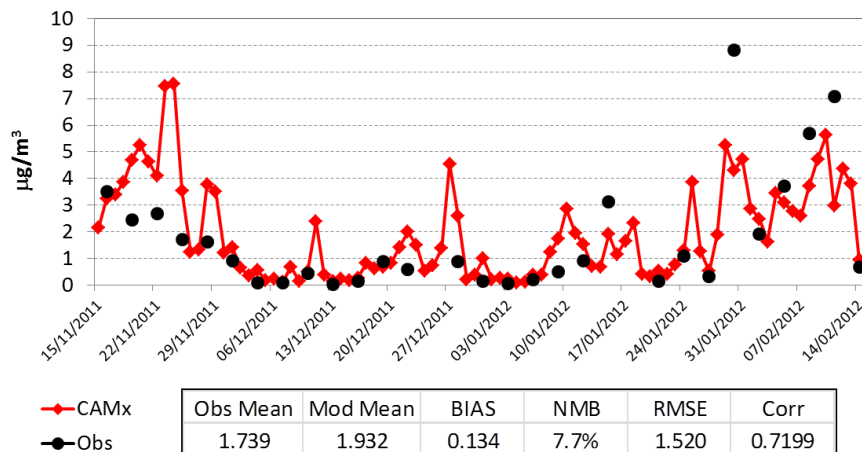
**NO<sub>3</sub><sup>-</sup>**



**SO<sub>4</sub><sup>=</sup>**

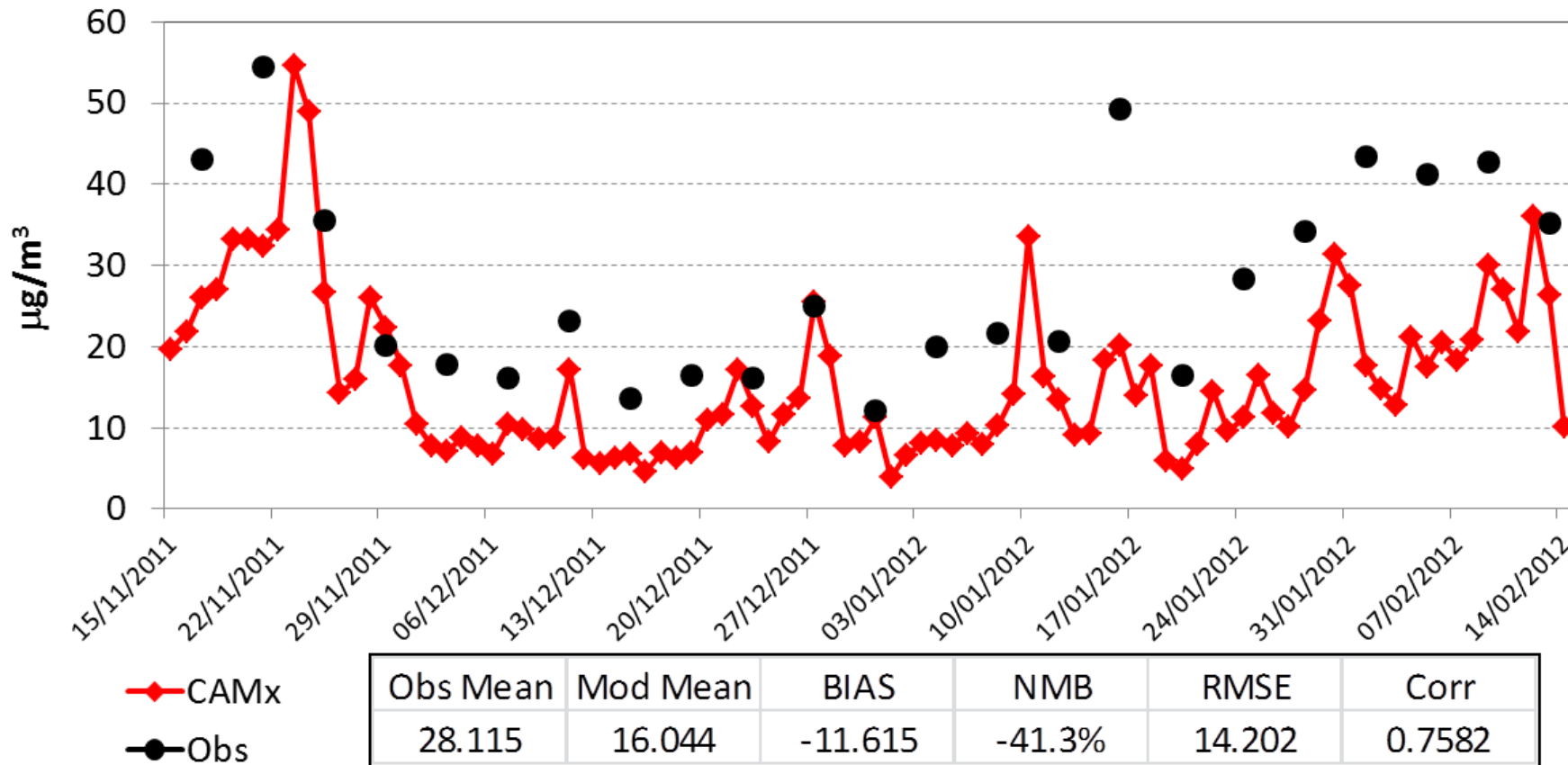


**NH<sub>4</sub><sup>+</sup>**



# Winter Episode - PM<sub>10</sub>

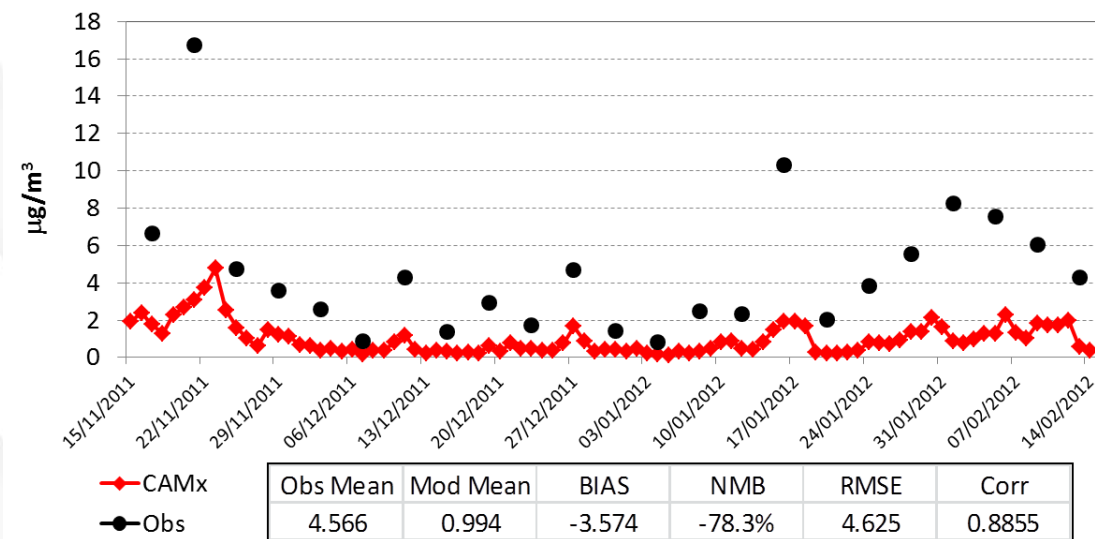
Time series – **Gent** – Daily mean values



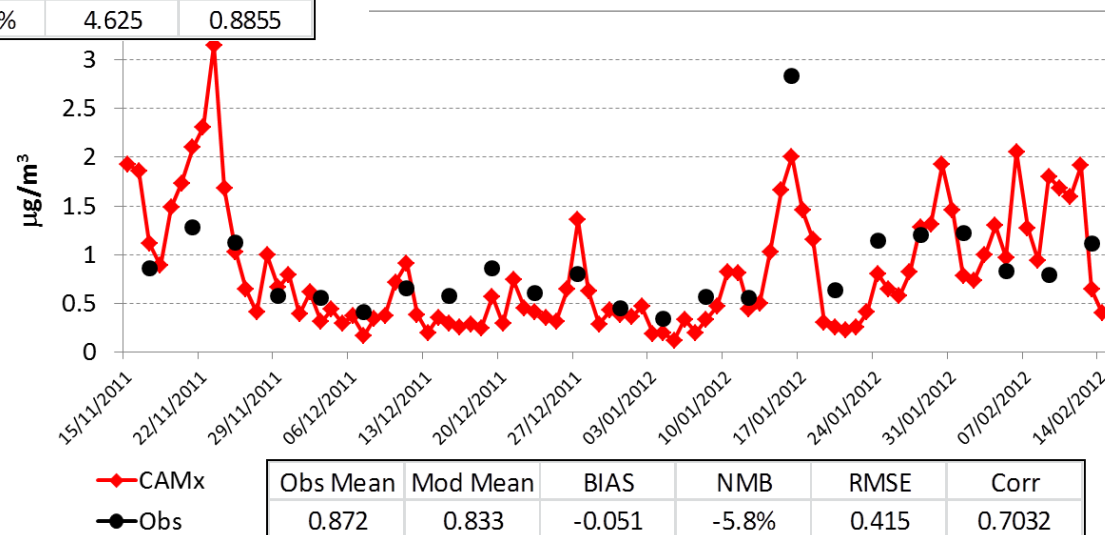


# Winter Episode - OC / EC

Time series – **Gent** – Daily mean values



OC

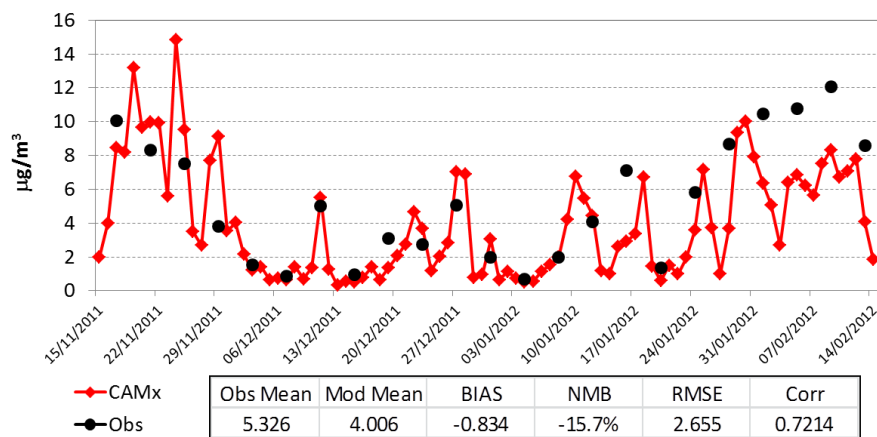


EC

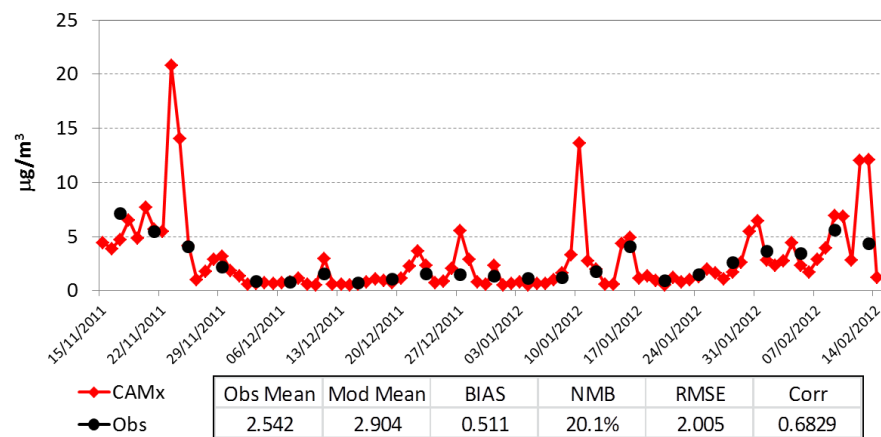
# Winter Episode - SIA

Time series – **Gent** – Daily mean values

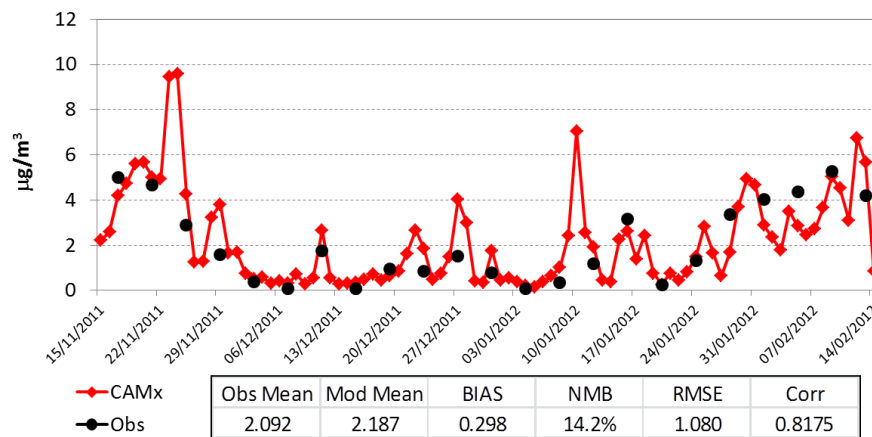
**NO<sub>3</sub><sup>-</sup>**



**SO<sub>4</sub><sup>=</sup>**

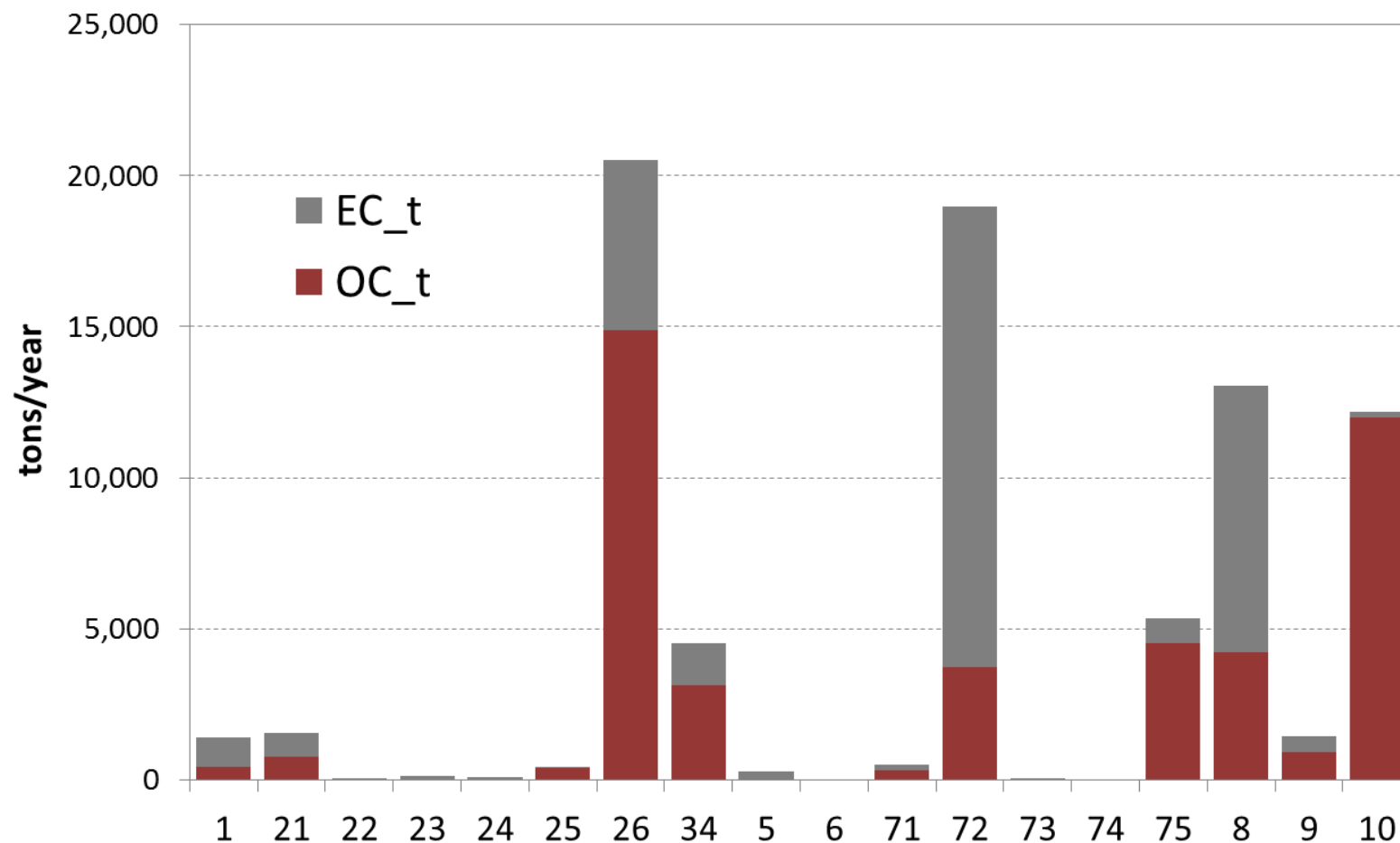


**NH<sub>4</sub><sup>+</sup>**



# EC/OC analysis

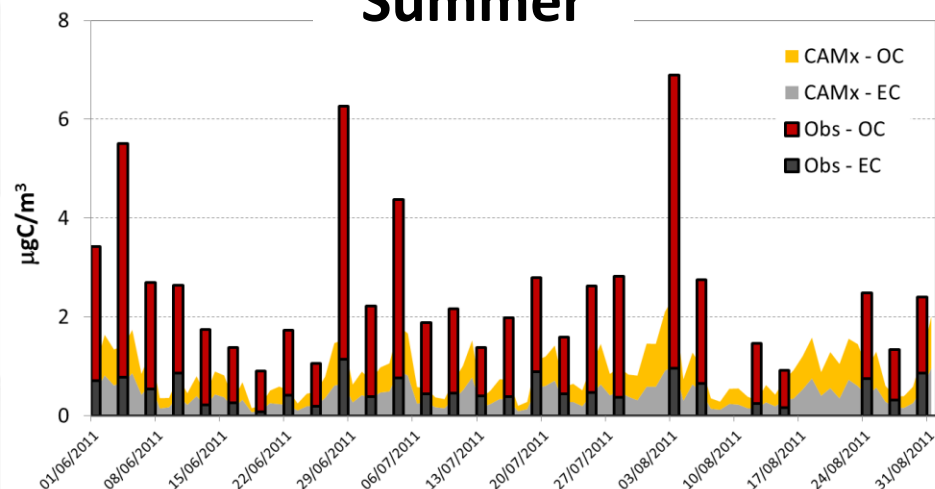
**Lens domain** – Yearly emissions by SNAP



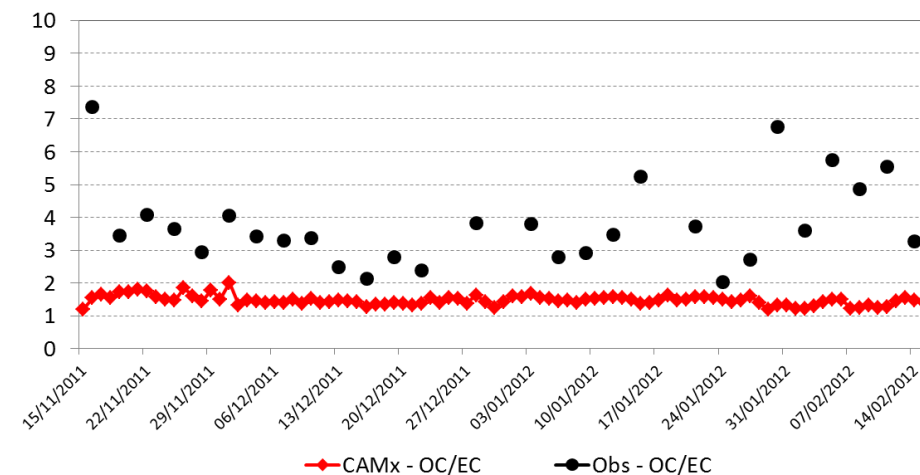
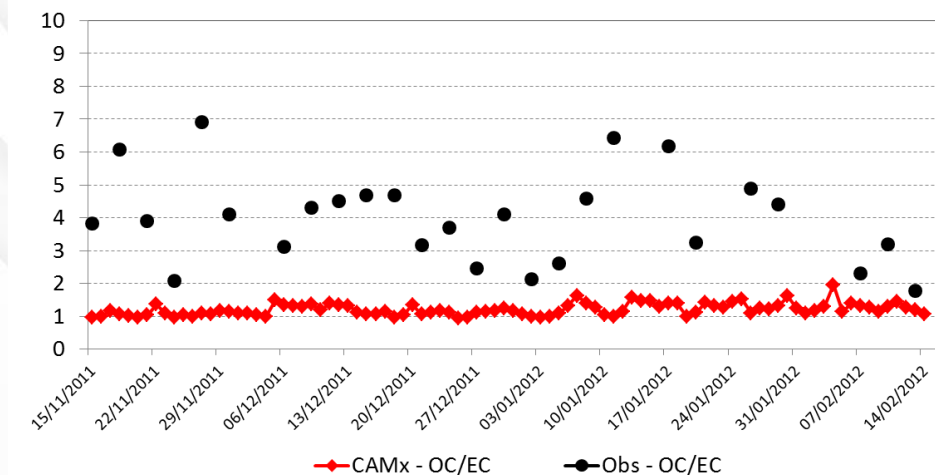
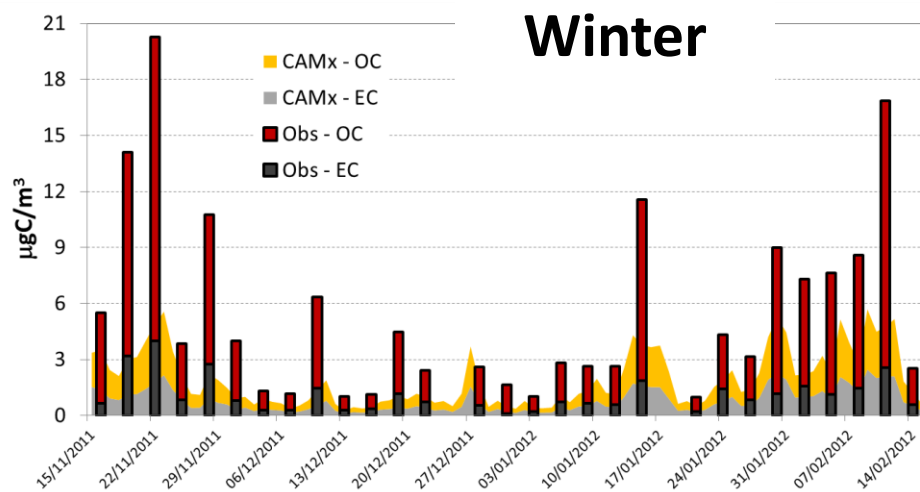
# EC/OC analysis

Time series – **Lens** – Daily mean values

## Summer



## Winter







# Methodology - Short Description



- **Biogenic Emissions (BVOCs)**

- Calculation of isoprene “synthesis” emissions (depending on both temperature and light) and monoterpene and OVOC “pool” emissions (depending on temperature only)
- leaf age, soil moisture and seasonality correction factors

- **Windblown Dust (WD)**

- Estimation of the horizontal (saltation) and the vertical (fine suspended particles) dust flux
- Parameterization of threshold wind speed as a function of soil particle size, soil moisture and drag partitioning

- **Sea Salt Aerosols (SSA)**

- The SSA production is dependent on wind speed, sea surface temperature and water salinity

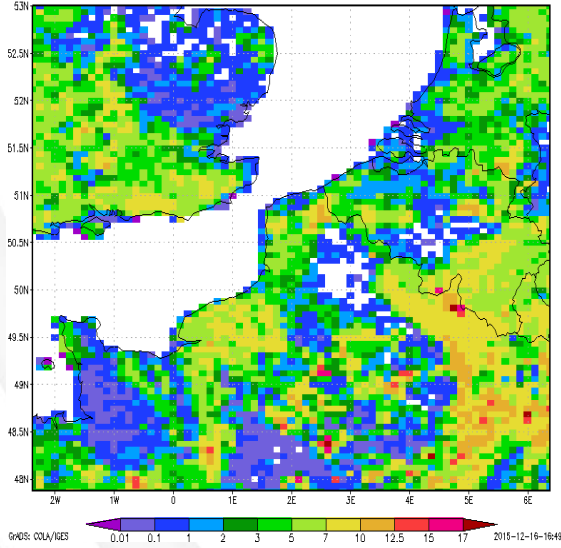
- **Primary Biological Aerosol Particles (PBAPs)**

- Emission factors for plant debris and fungal spores emissions

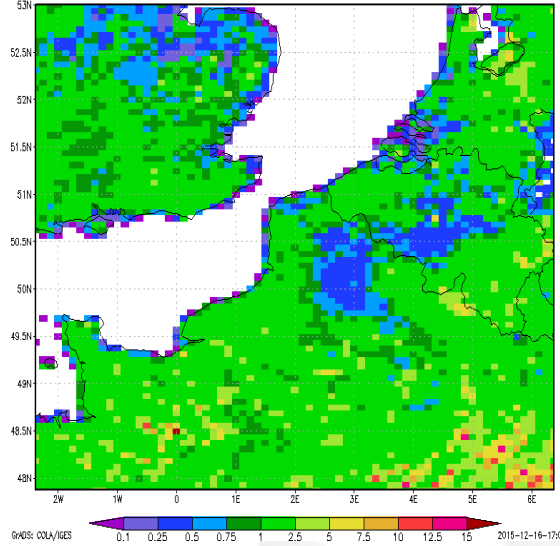
# Natural Emission Maps for LENS Domain



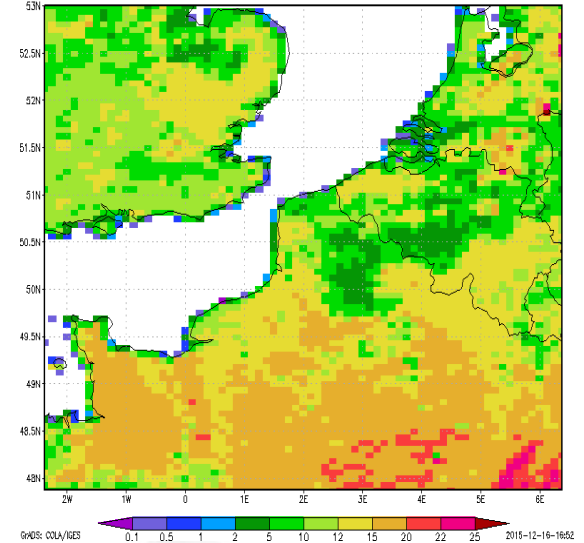
Isoprene emissions (tn/gridcell)  
Aug\_2011



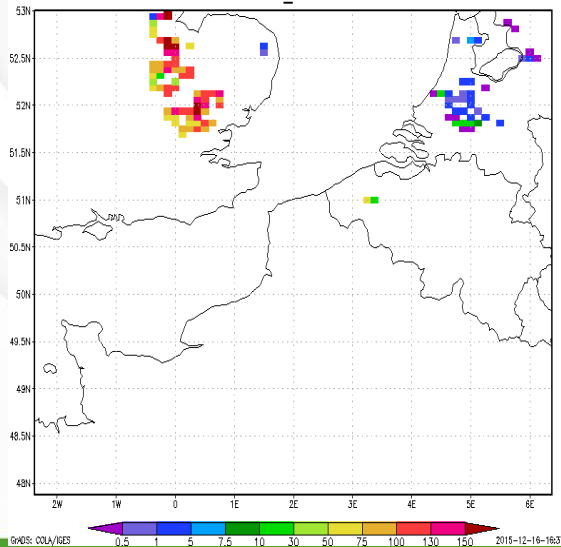
Monoterpenes emissions (tn/gridcell)  
Aug\_2011



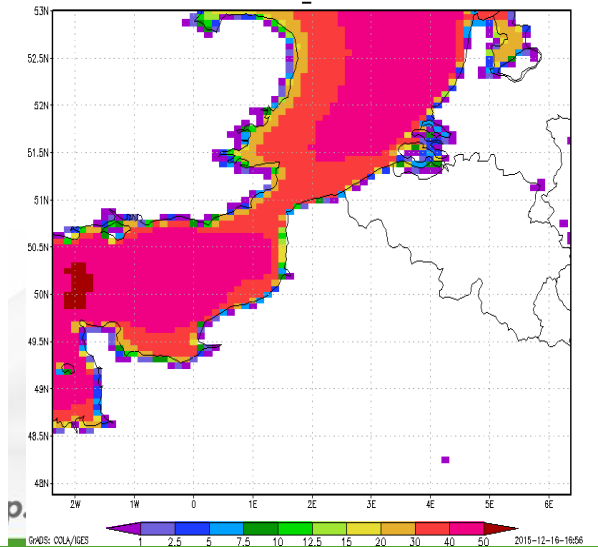
OVOcs emissions (tn/gridcell)  
Aug\_2011



Dust PM10 emissions (tn/gridcell)  
Dec\_2011



Sea Salt PM10 emissions (tn/gridcell)  
Dec\_2011



Domain wide monthly emissions maximum in:

- August 2011 for biogenic NMVOCs
- December 2011 for Wind-blown Dust and Sea Salt.