Technical meeting, Zagreb, 27-29 June 2016

WG3 – Source apportionment intercomparison exercise with FARM CTM

S. Bande[1], G. Calori[2], M.P. Costa[2], M. Mircea[3], C. Silibello[2]

[1] ARPA Piemonte, via Pio VII, 9, Torino, Italy

[2] ARIANET s.r.l., via Gilino 9, Milano, Italy

[3] ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, via Martiri di Monte Sole 4, 40129 Bologna, Italy

Modelling system

Based on **FARM Eulerian grid model**

Originally derived from **STEM** (G.R. Carmichael *et al.*, CGRER - Center for Global and Regional Environmental Research, U. of Iowa)

Now shared by ARIANET, ENEA, ARPA-P and other ARPAs, code repository at CINECA HPC-Forge

Configuration used for SA intercomparison exercise**:**

- 3D gridded **emissions** (dynamic plume rise for point sources: here not used)
- **3D dispersion** by advection and turbulent diffusion (Yamartino, 1993 scheme)
- **gas phase: SAPRC99** chemical mechanism (Carter, 2000)
- **aerosol**: 3-modes AERO3 (Binkowski,1999) with coagulation/condensation/nucleation, ISORROPIA v1.7 (Nenes *et al.*, 1998) for SIA equilibrium, MADE (Schell *et al*., 2001) for SOA formation
- **aqueous** SO_2 chemistry (Seinfeld and Pandis, 1998)
- **dry & wet** (in-cloud and sub-cloud scavenging coefficients: EMEP, 2003) **deposition**
- two-way on-line **nesting** on EU and Lens domains
- no data assimilation used here

Input data – Meteorology & BC

- Reference **meteorology**: distributed **WRF** fields

- Through SURF*PRO* pre-processor, complemented with:
  - **micro-meteorology**: similarity theory, Holtslag and van Ulden (1983) Venkatram (1980) over land, Hanna *et al*. (1985) over water
  - daytime convective **mixing height**: Maul (1980) version of Carson (1973) heat conservation algorithm; mechanical: Venkatram (1980); nighttime: the Bulk Richardson number method (Sorensen, 1998)
  - turbulent **diffusivities** (K-theory): Lange (1989) for vertical, Smagorinsky (1963) and depending on local stability class and wind speed for horizontal
  - **deposition velocities**: resistance model (Walcek and Taylor,1986; Wesely, 1989)

  … fed by WRF data and CORINE Land Cover (2006)

Boundary conditions: distributed, from MACC global model

Input data - Emissions

Prescribed **anthropogenic emissions** (TNO):

- already gridded
- height distribution
- time profiles
- chemical speciation (PM, NOx, SOx); NMVOC: Passant (2012)

(further cause of inter-model differences)

"Free" **natural sources**:

- **dust emissions** from local erosion and particle resuspension (Vautard *et al.*, 2005) with attenuation in the presence of vegetation from Zender *et al.* (2003)
- **sea salt**: Zhang *et al*. (2005) parameterization
- **bio VOC**: MEGAN 2.04 model (Guenther *et al.*, 2006, 2012)

Source apportionment method (1/2)

Brute Force Method (BFM) / 3D sensitivity runs

Michael J. Burr, Yang Zhang, Source apportionment of fine particulate matter over the Eastern U.S. Part I: source sensitivity simulations using CMAQ with the Brute Force method, *Atmospheric Pollution Research* **2** (2011) 300-317, and Part II: source apportionment simulations using CAMx/PSAT and comparisons with CMAQ source sensitivity simulations, *Atmospheric Pollution Research* **2** (2011) 318-336

- Multiple simulations with an air quality model, each one of them made using the same input data, except for the **emissions** from the *set of sources* that need to be investigated, that are **cyclically perturbed** by a given percentage
- The resulting ambient concentrations from the perturbed runs are then compared against the ones from the reference run, made with unperturbed emissions, providing a **first-order estimate of the contributions** from the chosen set of sources:

$SCE = 100 \cdot \Delta_i / \sum_{i=1}^{n} \Delta_i$ *source contribution estimate*

Δ_i = concentration variation at given point, respect to reference run

n = number of sets

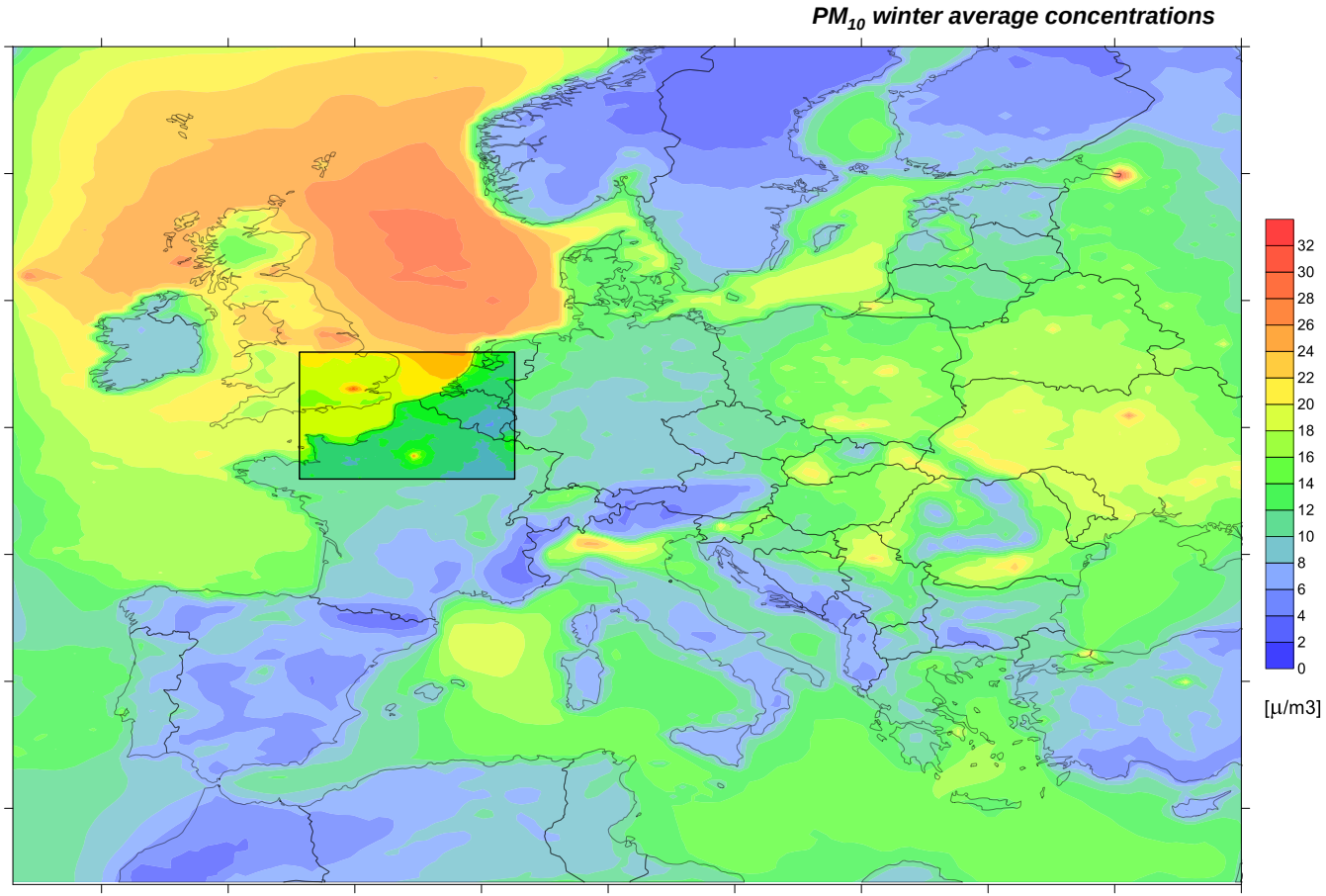
Source apportionment method (2/2)

- **Set of sources**: groups of sectors / specific sources / geographic areas, according to interest and detail in underlying emission inventory
- The chosen **normalization** implies that the sum of sources sets must corresponds to all sources in the inventory; use of a *"rest"* source set, if needed
- In principle, any **target pollutant** of interest

- Embedded in **FARM/BFM** automated procedure to manage the calculations, starting from a pre-configured "base case"

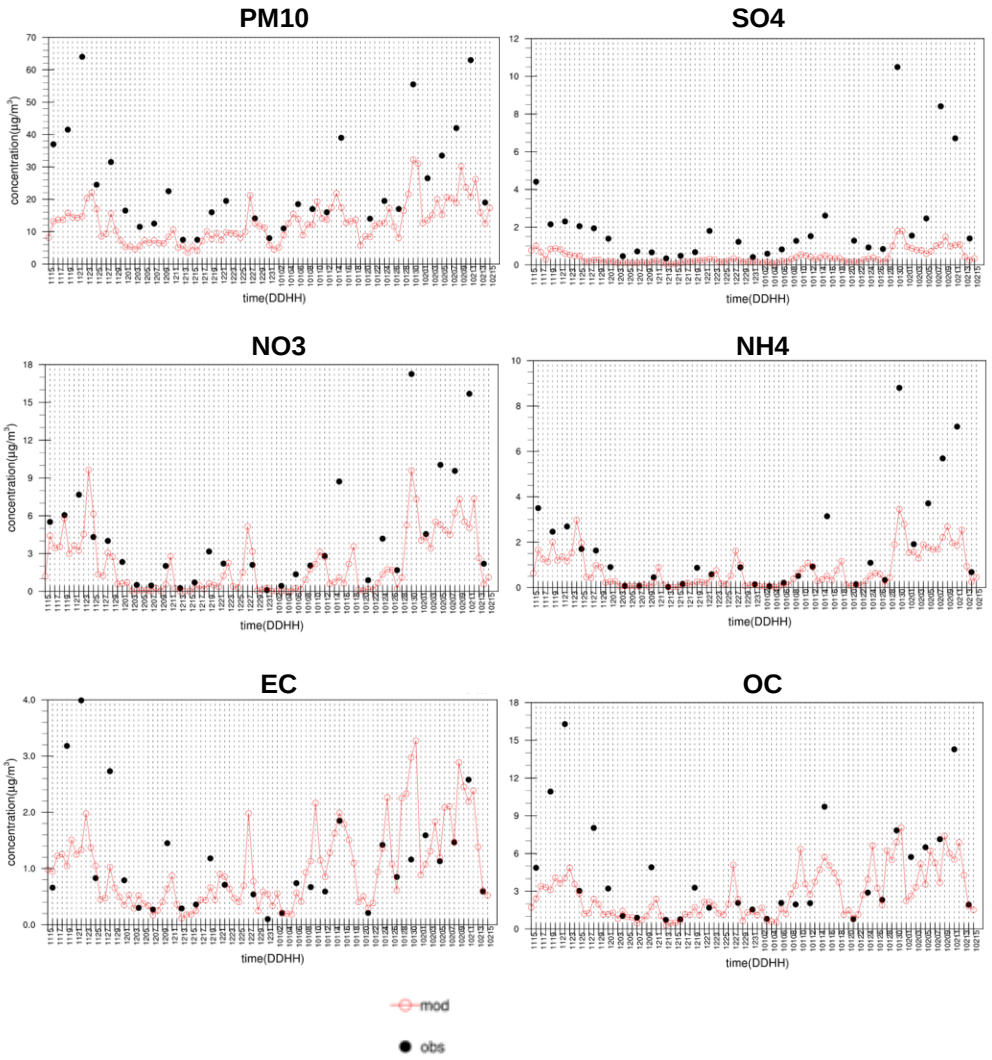
Setup for SA exercise

- In **FAIRMODE SA exercise**:
  - **base case** run on two nested grids (EU and Lens)
  - winter (15 Nov 2011 – 15 Feb 2012) and summer (1 Jun – 31 Aug 2011)
  - then **SA** with FARM/BFM run on inner grid
  - sources sets: as defined in "optional" category tracking
    - Energy industry
    - R&C combustion, other fuels
    - R&C combustion, solid biomass (wood)
    - Industry (combustion & processes)
    - Road transport, exhaust, gasoline
    - Road transport, exhaust, diesel
    - Road transport, other
    - Road transport, non-exhaust, wear
    - International shipping
    - Agriculture
    - Other anthropogenic sources
    - Dust
    - Sea salt
    - Biogenic SOA

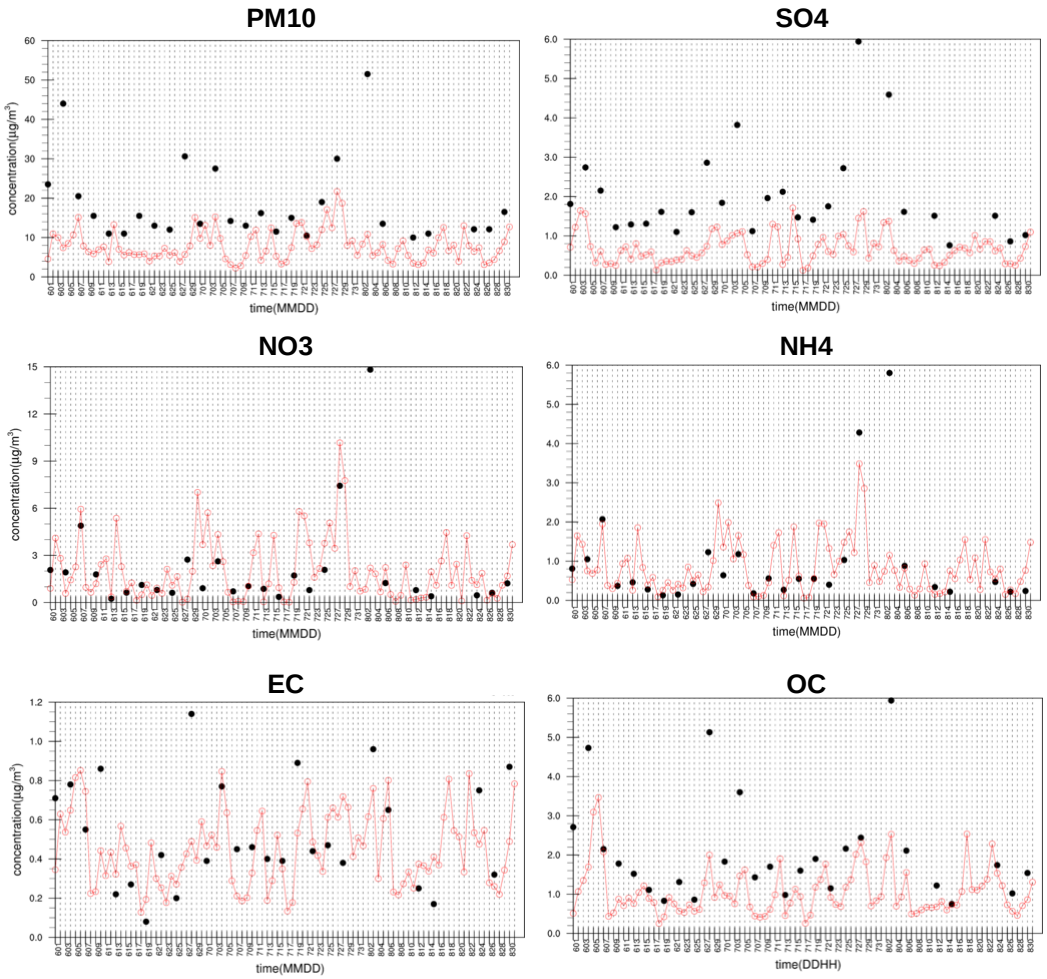


PM components at Lens (base case)

Winter



Summer



(full base case MPE: centralized)

Emissions & contributions by set, Lens domain - Examples

Average PPM emissions
(yealy totals by cell, all levels)

PM_{10} winter average concentrations

Δ_i variation

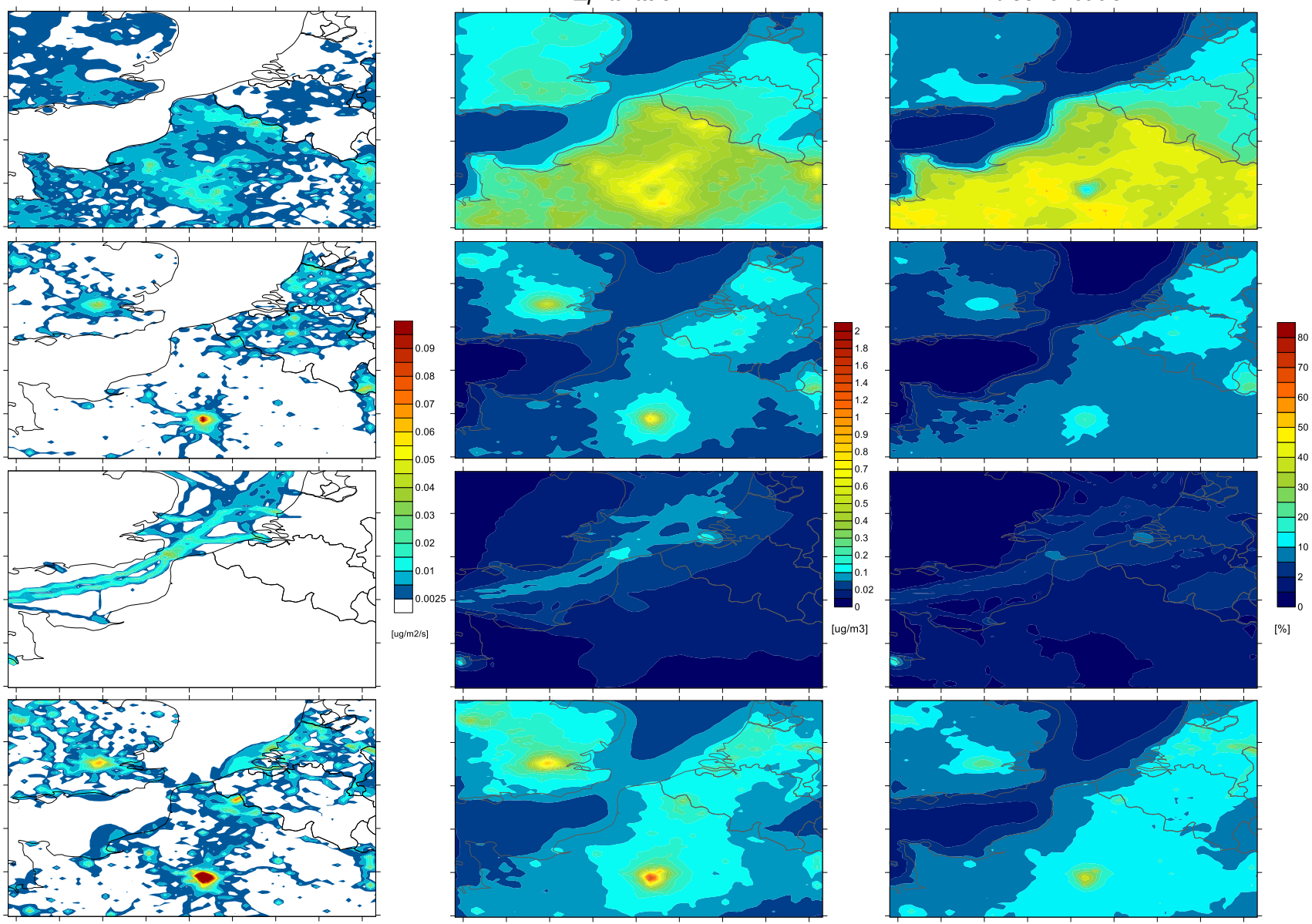
% contribution

R & C combustion, solid biomass (wood)

Road transport, exhaust, diesel

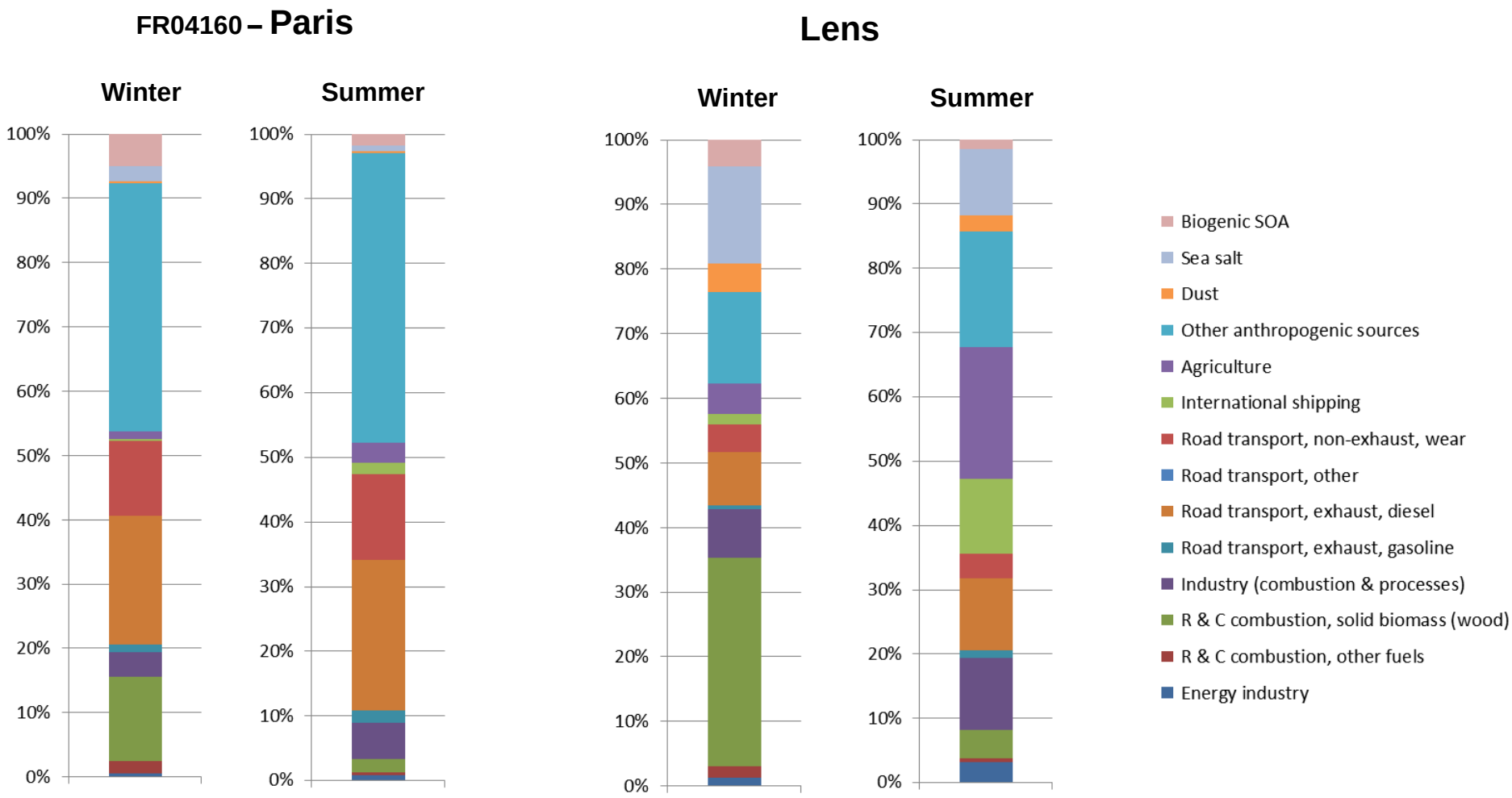
International shipping

Other anthropic



Contributions extracts at receptors

Average contributions to PM_{10}

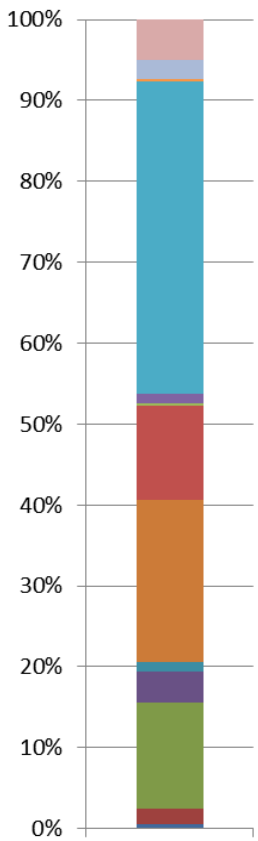


Contributions extracts at receptors

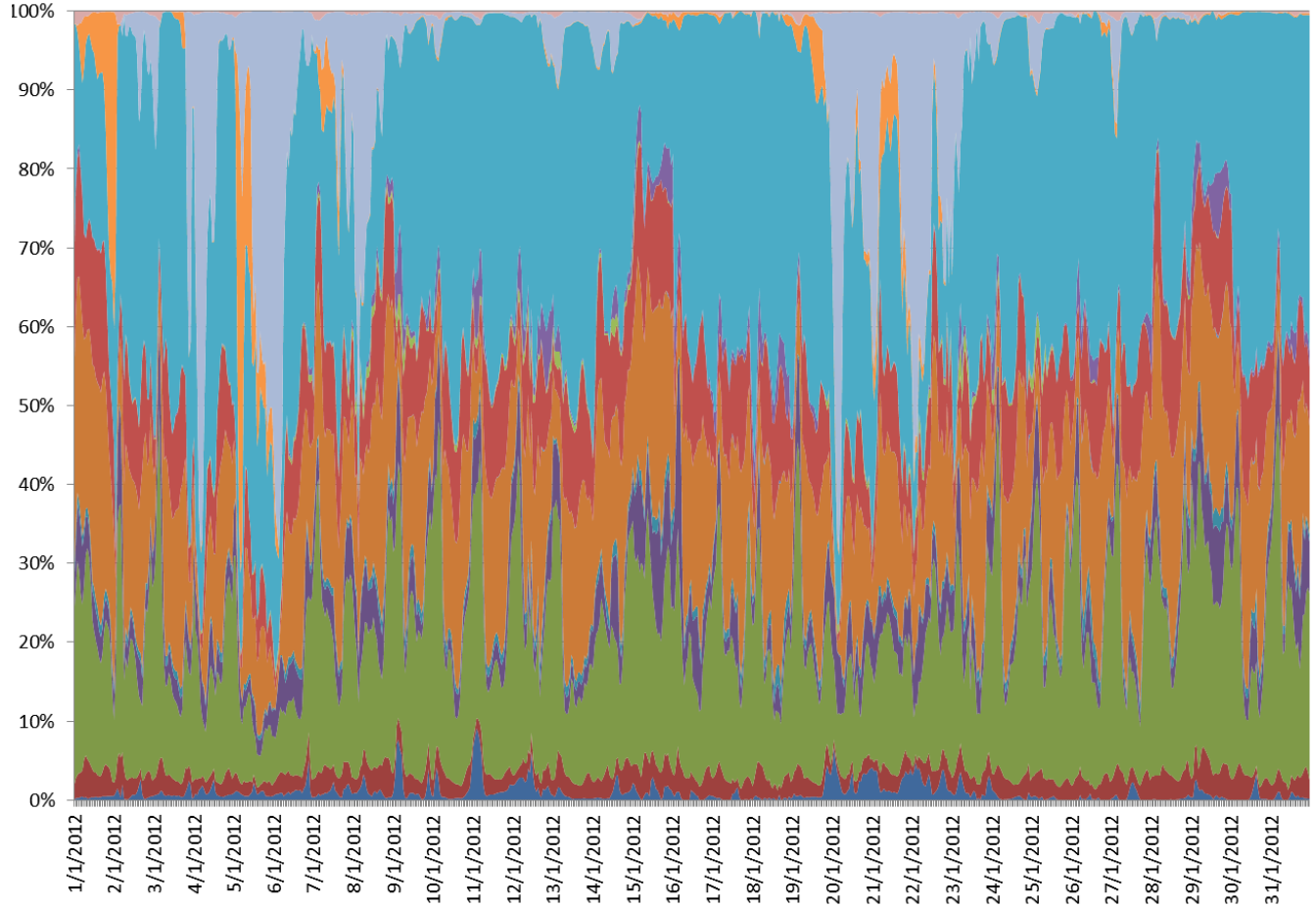
FR04160 – Paris

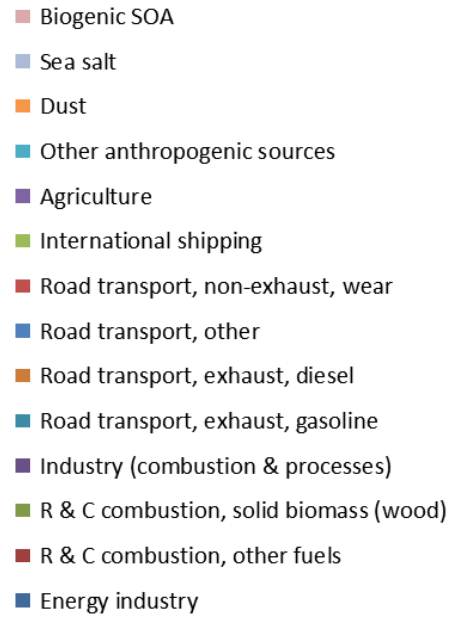
Contributions to PM_{10}, winter

Winter avg.



Hourly, January





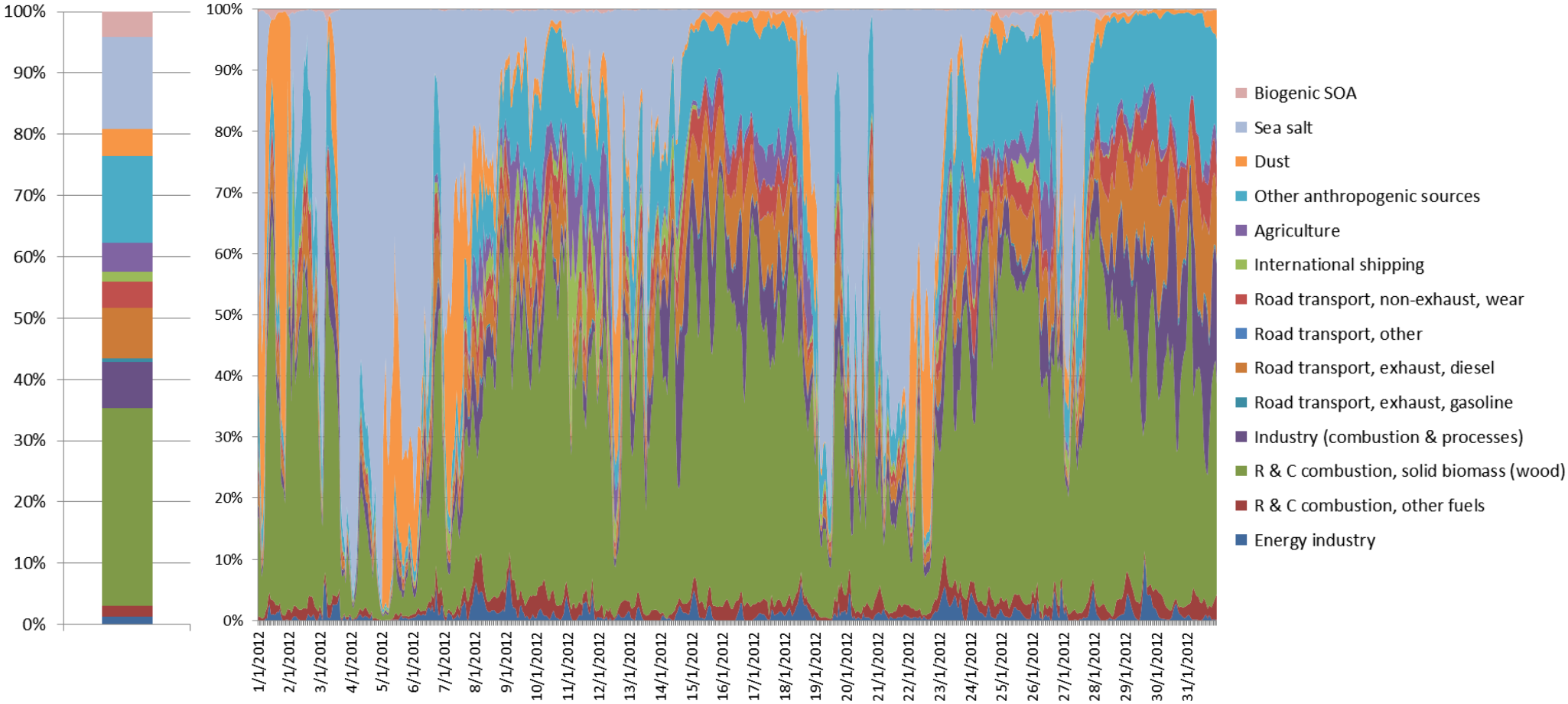
Contributions extracts at receptors

Lens

Contributions to PM_{10}, winter

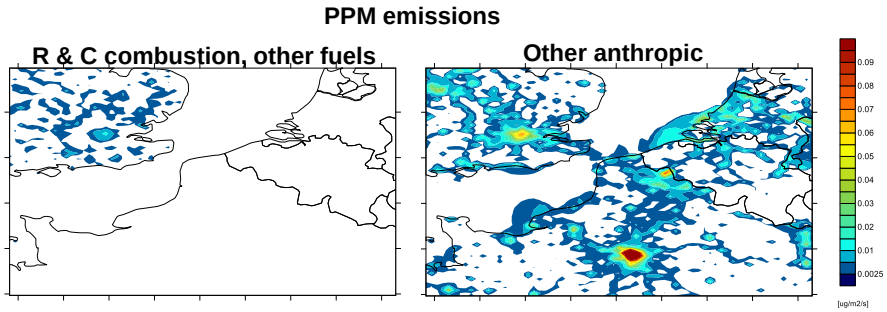
Winter avg.

Hourly, January



Open questions / work to be done …

- Sea salt



- Emissions peculiarities (countries/sectors)
- Source contribution estimates "fine" vs. "coarse" grid
- Analyses on time series of SCE (e.g. episodes)
- Outcomes of intercomparison, among CTM and with RM
- Emission areas tracking …