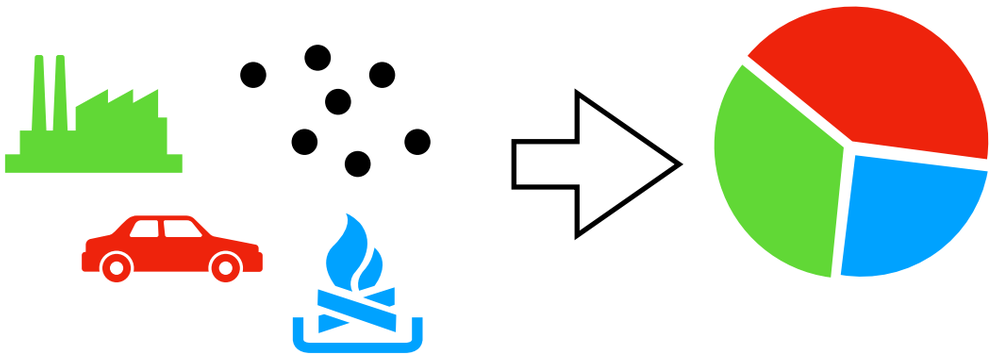

A dummy's guide to receptor modelling

CT1 - Source apportionment

Véronique Riffault, Stefania Gilardoni, Vorne Gianelle, Guido Pirovano, Alain Clapier, Philippe Thunis

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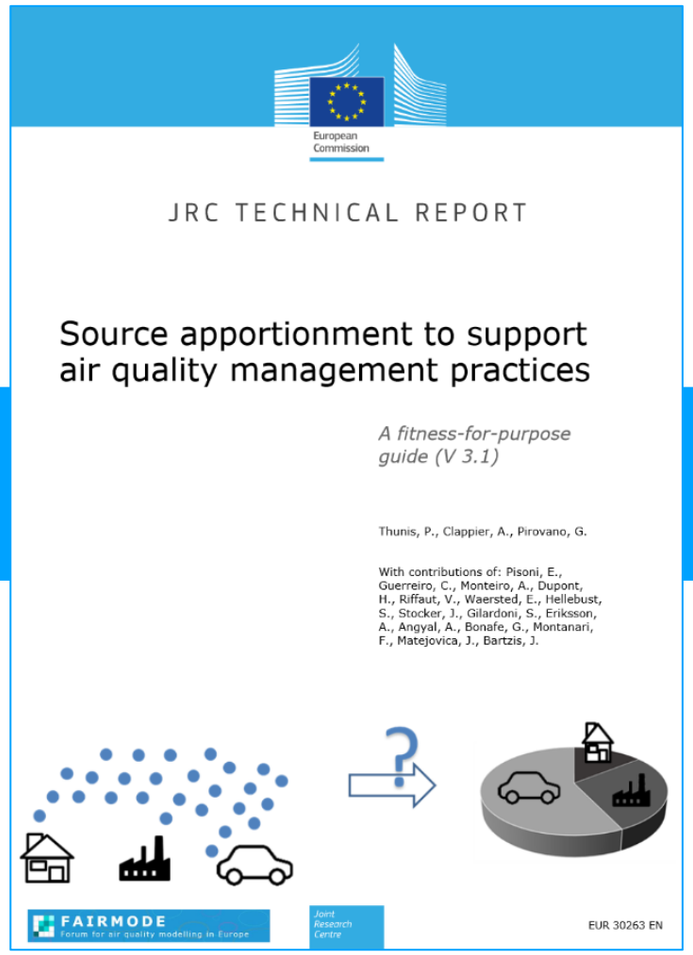
FAIRMODE
Forum for air quality modelling in Europe

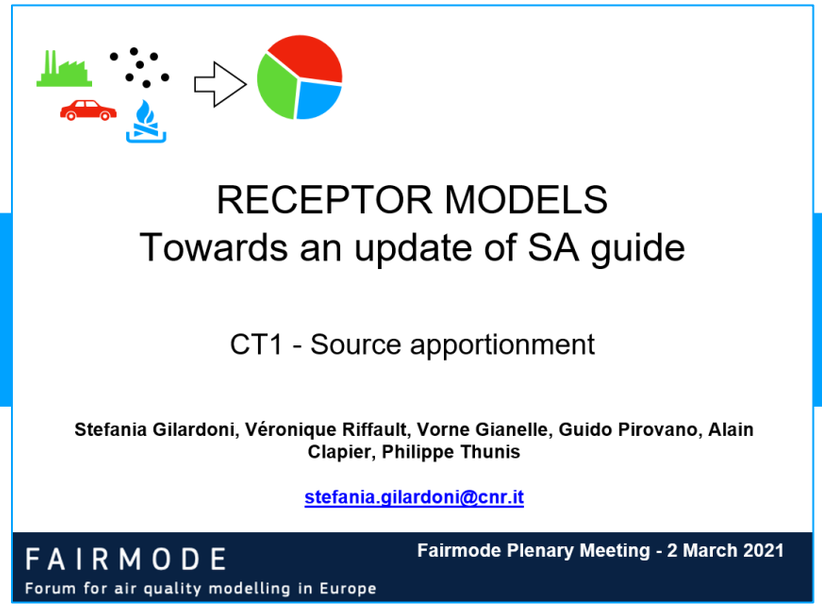
Technical Meeting – 6-8 October 2021

MOTIVATION

Need to update the latest JRC guide with more details on receptor models, with a framework similar to the one used for source-oriented models



Thunis, Clappier, Pirovano et al.
June 2020



Gilardoni et al.
March 2021

RECEPTOR MODELS: PRINCIPLES

"Receptor models use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations." *(US EPA)*

Based on 3 fundamental assumptions:

❶ A source emission has a **constant composition** over time

❷ The species do not react with each other but add linearly

❸ A number of *p* user-defined sources contribute to the receptor observations

If these assumptions are met:

$$C = a \times E \times D$$

- C: **Concentration matrix**
- a: **Fractional amount in the emission**
- E: **Emission rates**
- D: **Atmospheric dispersion**

J. G. Watson (1984) Overview of Receptor Model Principles, Journal of the Air Pollution Control Association, 34:6, 619-623, DOI: 10.1080/00022470.1984.10465780

RECEPTOR MODELS: PRINCIPLES

$$C = a \times E \times D$$

C — **Concentration matrix**

a — **Fractional amount in the emission**

E — **Emission rates**

D — **Atmospheric dispersion**

In a source model:

- C is **calculated**
- a × E is known
- D is known

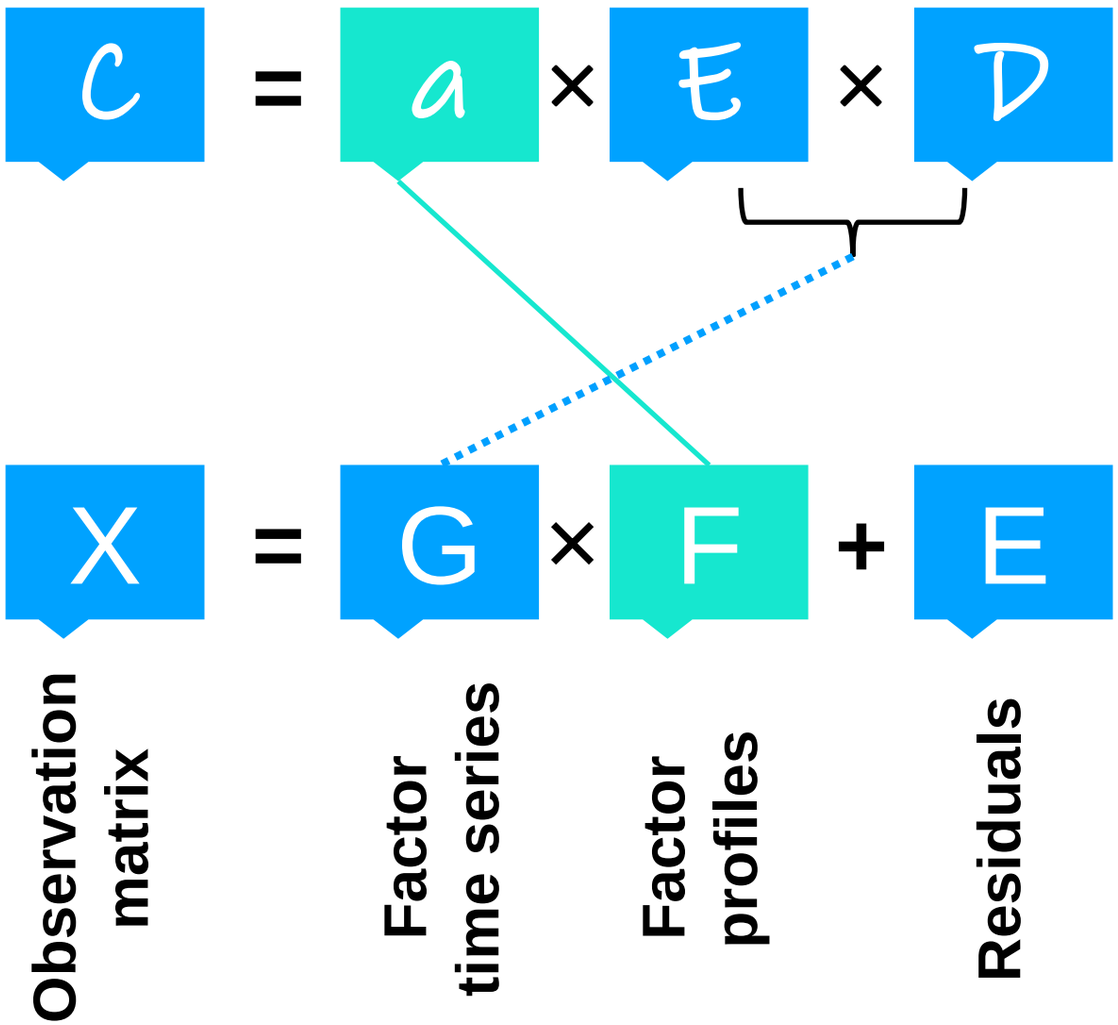
In a receptor model:

- C is known
- a is known (*)
- E × D is **calculated**

(*) qualitatively or quantitatively

J. G. Watson (1984) Overview of Receptor Model Principles, Journal of the Air Pollution Control Association, 34:6, 619-623, DOI: 10.1080/00022470.1984.10465780

RECEPTOR MODELS: PRINCIPLES



Mass balance equation

$$x_{ij} = \sum_{k=1}^{p} g_{ik} f_{kj} + e_{ij}$$

Where

i = 1,..., n samples

j = 1,..., m species

k = 1,..., p factors

Can be solved by a linear least-square fit

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New assumptions arise to solve this equation:

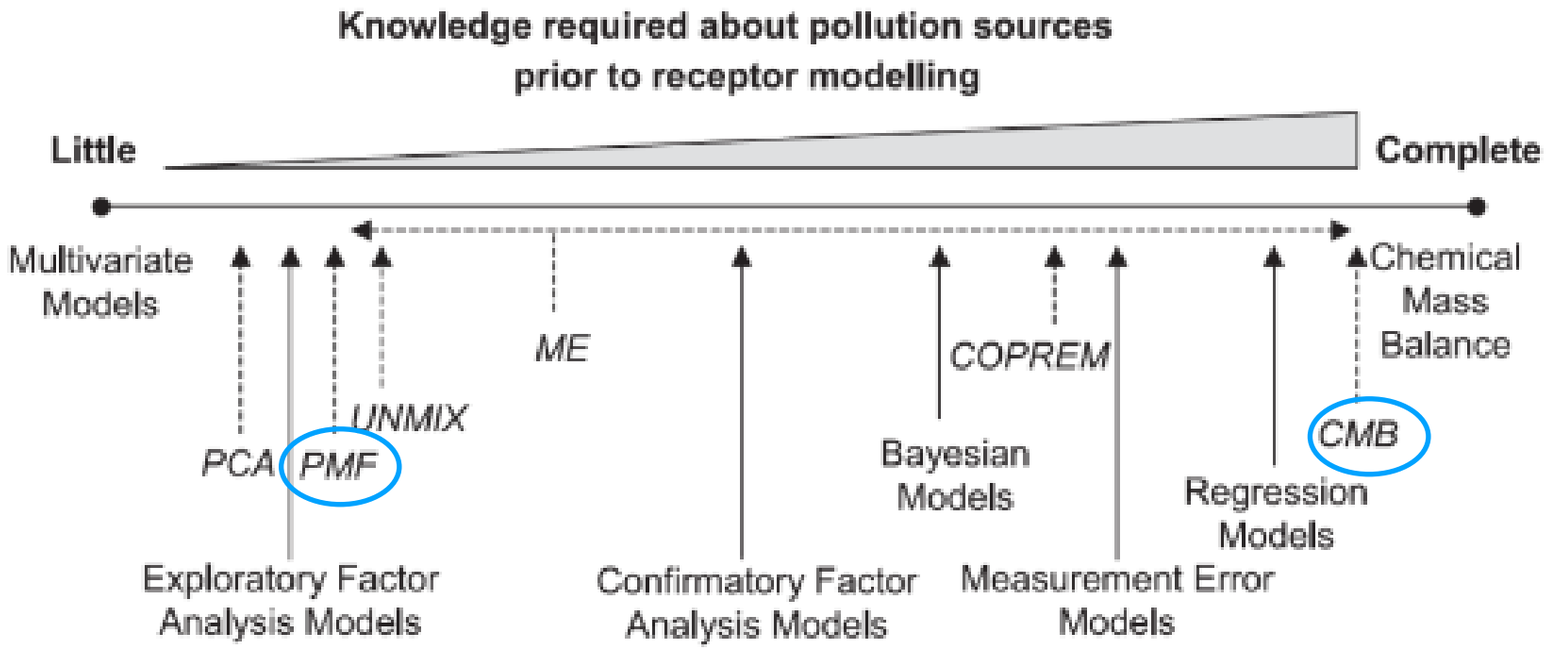
❹ *p*, the number of sources (factors), ≤ *m*, the number of species

❺ Source compositions are linearly independent from each other

J. G. Watson (1984) Overview of Receptor Model Principles, Journal of the Air Pollution Control Association, 34:6, 619-623, DOI: 10.1080/00022470.1984.10465780

RECEPTOR MODELS: TYPES of MODELS

What knowledge of the sources **at the receptor site**?



Viana et al. (2008) Source apportionment of particulate matter in Europe: A review of methods and results, Journal of the Aerosol Science, 39, 827-849, DOI: 10.1016/j.jaerosci.2008.05.007

Positive Matrix Factorization (PMF)

- Number of sources (*p*) explored by the user
- Computed source profiles (f_{kj})
- Computed source contributions (g_{ik})
- Equations solved numerically

Chemical Mass Balance (CMB)

- Known number of sources (*p*)
- Known source profiles (f_{kj})
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RECEPTOR MODELS: TYPES of MODELS

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Technical requirements

Number of samples?

$$N_t \geq \frac{N_{sp} \times N_{sr}}{N_{sp} - N_{sr}}$$

N_t = 1 sample is enough to solve the equation

Use of uncertainties?

Minimization of:

$$Q = \sum_{sp} \sum_{t} \left(\frac{C^{sp}(t) - \sum_{sr} C_{sr}^{sp}(t) f_{sr}^{sp}}{U^{sp}(t)} \right)^2$$

Variables are weighted in the least-square solution so that less precise measurements have less influence than more precise ones

RECEPTOR MODELS: TYPES of MODELS

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Results

Unicity of the solution?

No — Can appear as 1 or 2 factors

~Yes — Should stay negligible

Background?

How to choose **the best solution** with PMF?

Results need to make sense environmentally.
No structure left in the residuals.

SUMMARY of POSSIBLE CASES? (ongoing discussion …)

Type of pollutant	Spatial variability (from source to receptor)	Temporal variability (at the receptor site)	Example of identified factors	Example of identified sources
Primary	Profile constant	Profile constant	Hydrocarbon-like organic aerosol (HOA)	Primary traffic exhaust emissions
			Fresh marine aerosols	Sea spray emissions
Primary	Profile not constant	Profile constant	Aged marine aerosol	Sea spray emissions + other(s)
Secondary	Profile not constant	Profile can be assumed constant over time (diffuse sources)	Secondary organic aerosol (SOA) Secondary inorganic aerosol (SIA)	Sources are precursor gases
Secondary	Profile not constant	Profile changes over time	IEPOX-SOA	Biogenic SOA

Factor = source = emission profile

Thank you for your attention

Any questions/comments?