

Source apportionment to support air quality management practices

A fitness-for-purposes guide

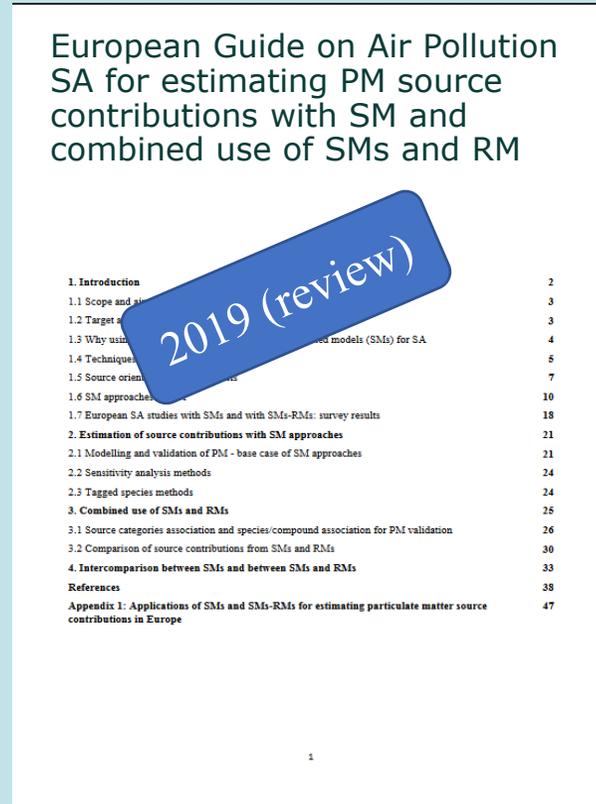
P. Thunis, A Clappier, G. Pirovano

Madrid, October 2019

Agenda: SA session 2

| Time | Title | Slides | Chair(s) |
|---------------------|-----------------------------|--------|-----------|
| 16:00 – 16:20 (20') | Introduction | 1-14 | P & A |
| 16:20 – 16:50 (20') | Group exercises | 15-19 | G |
| 16:50 – 17:20 (30') | Solutions & Discussion | 20-25 | G |
| 17:20 – 17:40 (20') | Content of the guide | 26-35 | P |
| 17:40 – 18:00 (20') | Group discussion | 36-40 | G |
| 18:00 – 18:30 (30') | Group reports & Conclusions | | P & A & G |

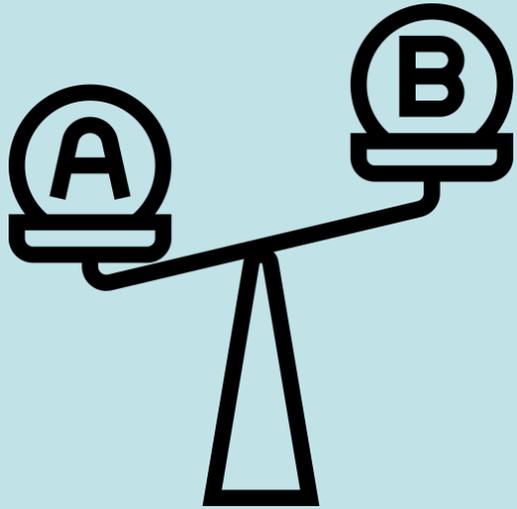
Background



Two guides mostly dedicated to:

1. the description of available methodologies and
2. the definition of a protocol for quality assurance

Background



Inter-comparison exercise

Atmospheric Environment 173 (2018) 210–222

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

On the validity of the incremental approach to estimate the impact of cities on air quality

Phil
Europe

Geosci. Model Dev., 10, 4245–4256, 2017
<https://doi.org/10.5194/gmd-10-4245-2017>
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Geoscientific Model Development EGU

Source apportionment and sensitivity analysis: two methodologies with two different purposes

Alain Clappier¹, Claudio A. Belis², Denise Pernigotti², and Philippe Thunis²

¹Université de Strasbourg, Laboratoire Image Ville Environnement, Strasbourg, France
²Europe

Corresp
Receives
Revised:

Environment International 130 (2019) 104825

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Source apportionment to support air quality planning: Strengths and weaknesses of existing approaches

P. Thunis^{a,*}, A. Clappier^b, L. Tarrason^c, C. Cuvelier^d, A. Monteiro^e, E. Pisoni^f, J. Wesseling^g, C.A. Belis^h, G. Pirovanoⁱ, S. Janssen^j, C. Guerreiro^k, E. Peduzzi^l

^a European Commission, Joint Research Centre, Ispra, Italy
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^c NILU – Norwegian Institute for Air Research, Kjeller, Norway
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^f RIVM, National Institute for Public Health and the Environment, Bilthoven, the Netherlands
^g ISPRA, Milan, Italy
^h VITO, Boxtang, 200, 2400 Melle, Belgium

European Commission

JRC SCIENCE FOR POLICY REPORT

Recommendations regarding modelling applications within the scope of the ambient air quality directives

Thunis P., Janssen S., Wesseling J., Belis C. A., Pirovano G., Tarrason L., Guevara M., Monteiro A., Clappier A., Pisoni E., Guerreiro C., González Ortiz A. on behalf of FAIRMODE

2019

Starting addressing fitness for purpose with focus on air quality planning

Background

Source apportionment to support air quality management practices

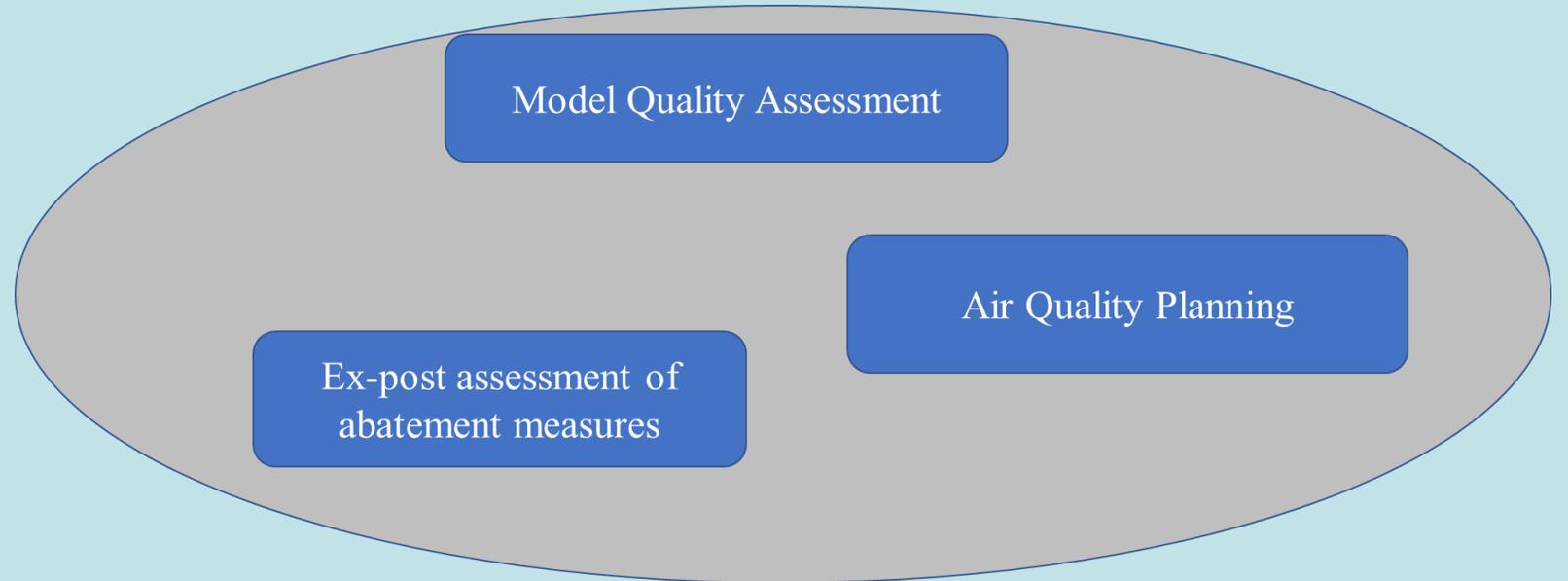
A fitness-for-purposes guide

Authors: P. Thunis, A. Clappier

Contributors: G. Pirovano, E. Pisoni, C. Gueirreiro, A. Monteiro, H. Dupont

7/11/2019

Aim: Address fitness for purpose issues within an air quality management perspective



Background

High priority according to FAIRMODE survey

SA to support AQ manag.



■ Highly Rel ■ Relevant ■ Not relevant ■ Unclear

- First circulated to SG, WG3, WG4 & WG5
- Currently a draft. Your contributions are not only welcome but necessary!
- Many issues likely to be solved on current expertise but some will require additional testing
- Intended as a living document (ref MQO guide) to support technical discussions within FAIRMODE
- Didactic aim
- Support to the next stage of CEN TC264 WG44?



A brief survey before starting...

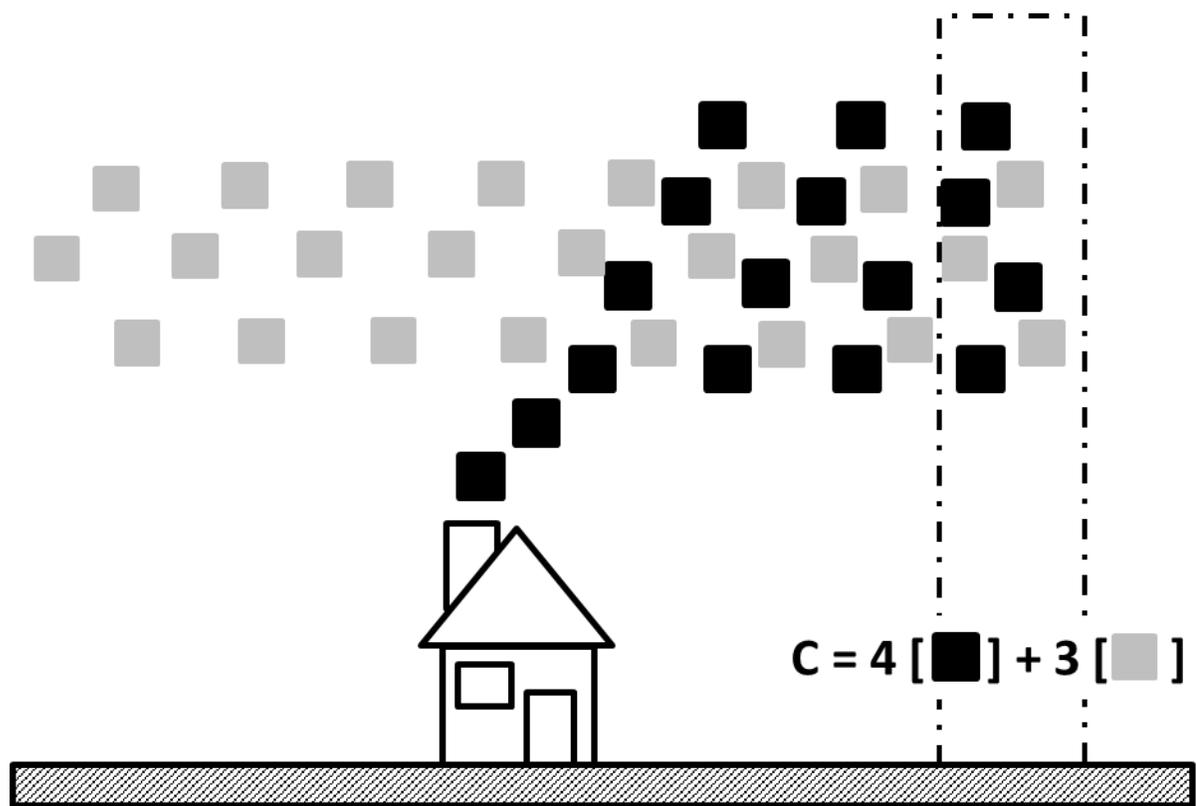
- Who read the draft version of this guide?
- Who is actively involved in source apportionment (in a broad sense to understand the role of a given source)?
- Who believes src. apportionment is an important issue?

Do we need this guide?

Let's see with simple exercises...

but first, a brief introduction to the SA methods covered in the guide

The main goal of SA

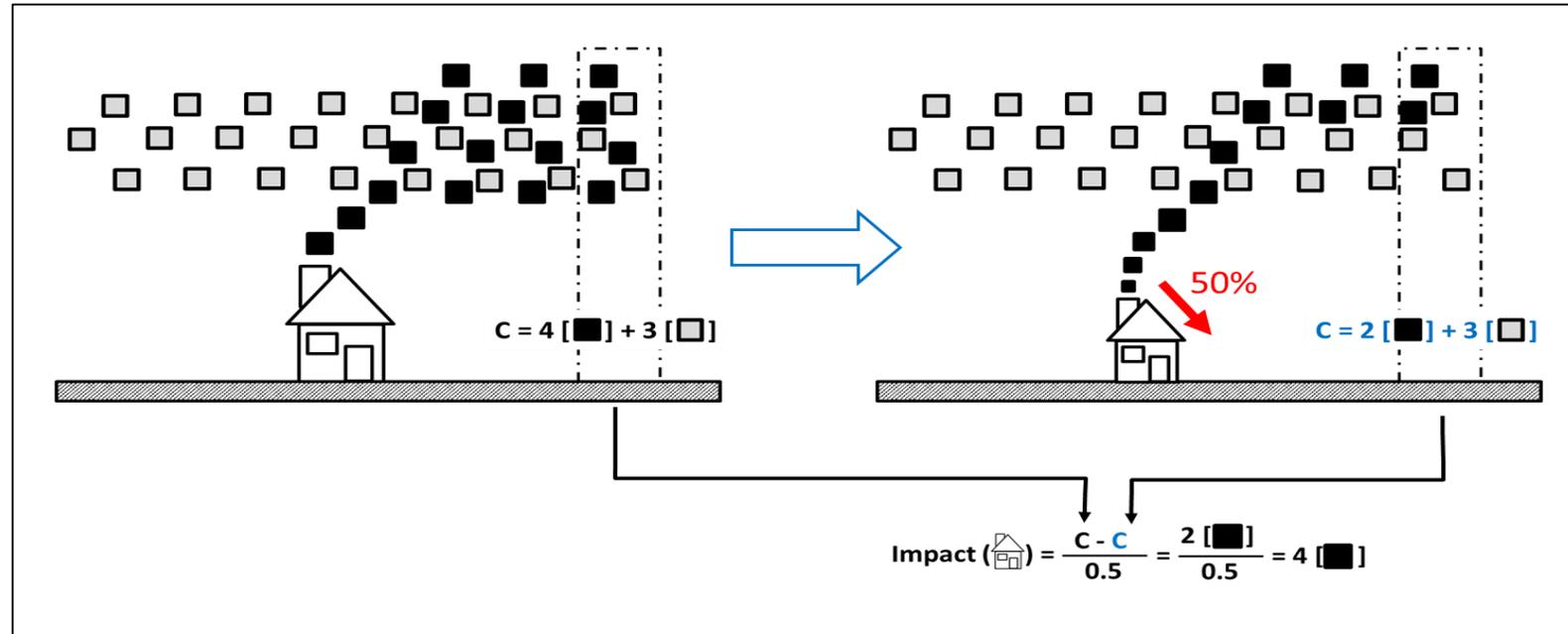


How can I estimate the contribution of the house to the air quality measured at a given location



Various approaches to Source apportionment

Partial impacts correspond to the pollutant mass obtained by differencing two air quality model (AQM) simulations performed with the full and a reduced emission sources, divided by the percentage reduction.



Only based on **model values**
Both **spatial** and **sectorial** apportionment are possible
Applied to **all types of species** (that a model can simulate!)

Impacts

Partial

Full

Contributions

Receptor

Tagging

Increments



FAIRMODE

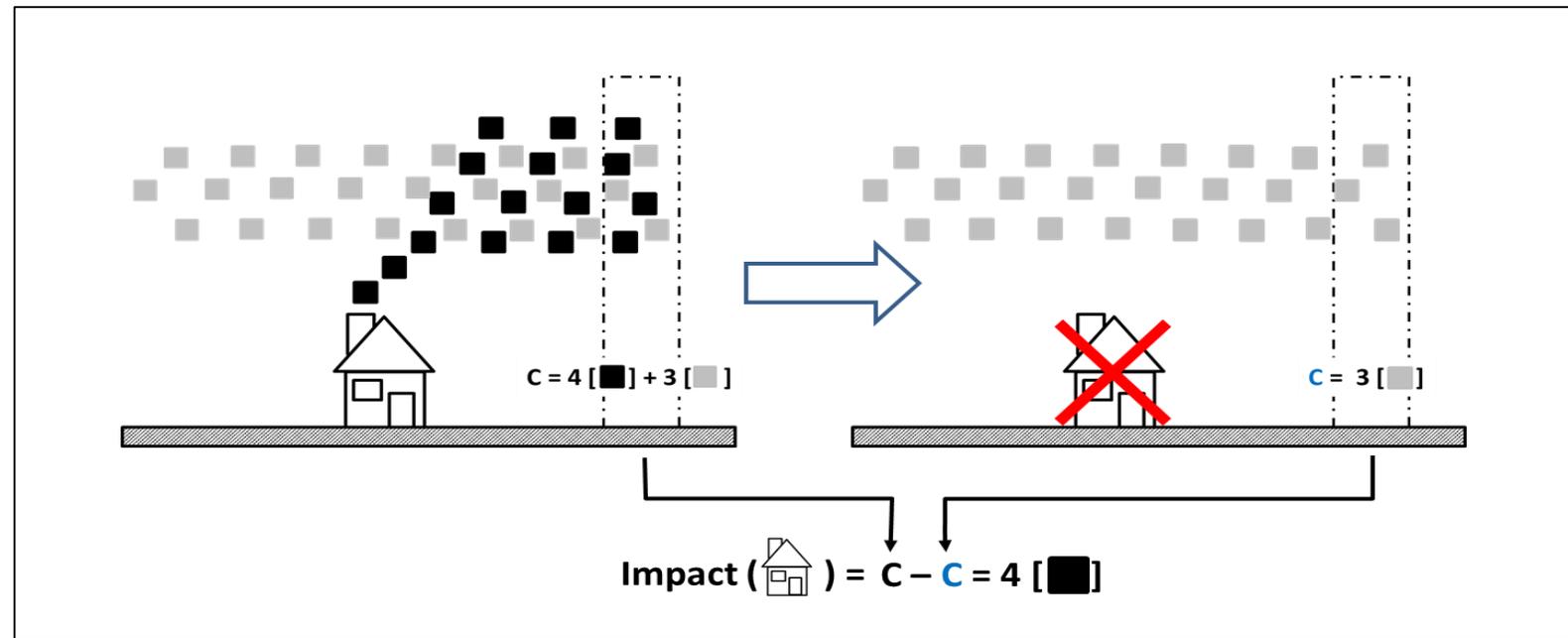
Forum for air quality modelling in Europe



European Commission

Various approaches to Source apportionment

Full impacts correspond to the pollutant mass obtained by differencing **two air quality model (AQM) simulations** performed with the full and removed emission sources.



Only based on **model values**
Both **spatial** and **sectorial** apportionment are possible
Applied to **all types of species** (that a model can simulate!)

Impacts

Partial

Full

Contributions

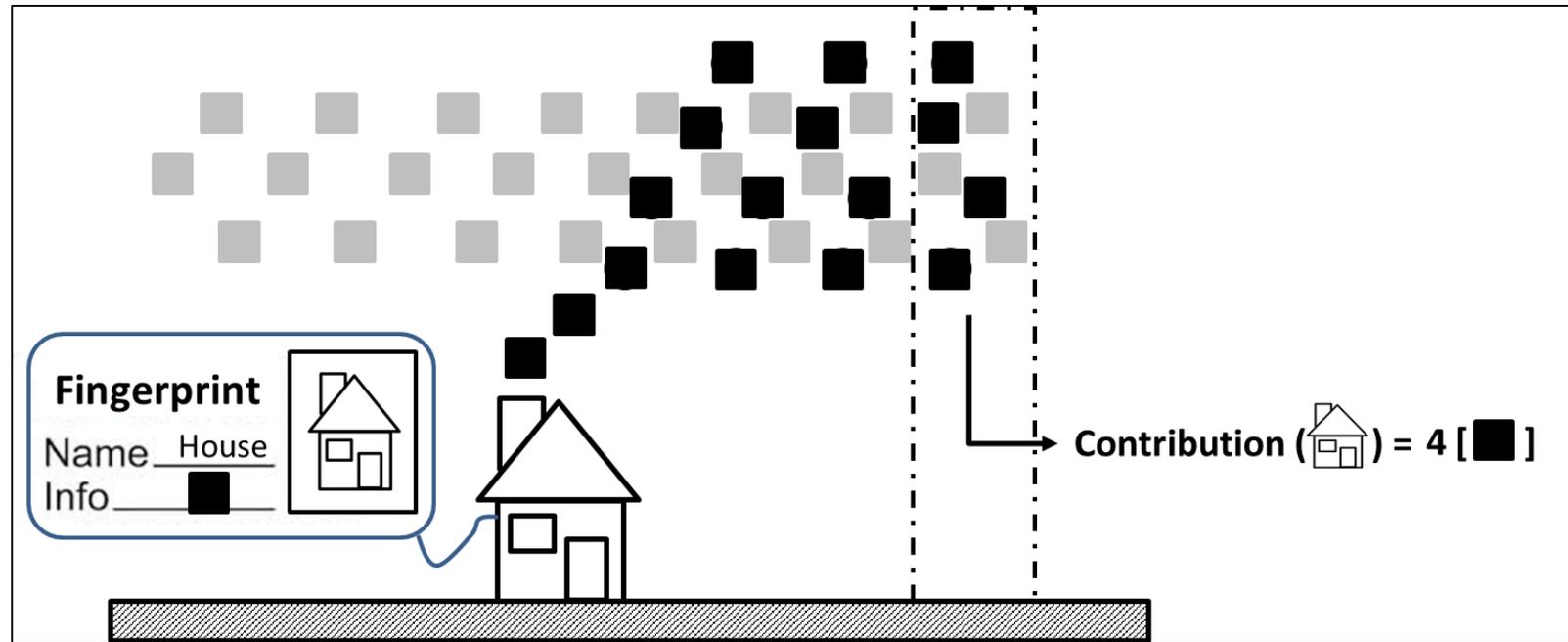
Receptor

Tagging

Increments

Various approaches to Source apportionment

Receptor contributions: correspond to the mass of a pollutant transferred from the emission sources to the ambient concentrations (based on source fingerprints).



Only based on **observations**
Only **sectorial** apportionments are possible
Only applicable to linear **species** (no transformation from source to receptor)

Impacts

Partial

Full

Contributions

Receptor

Tagging

Increments



FAIRMODE

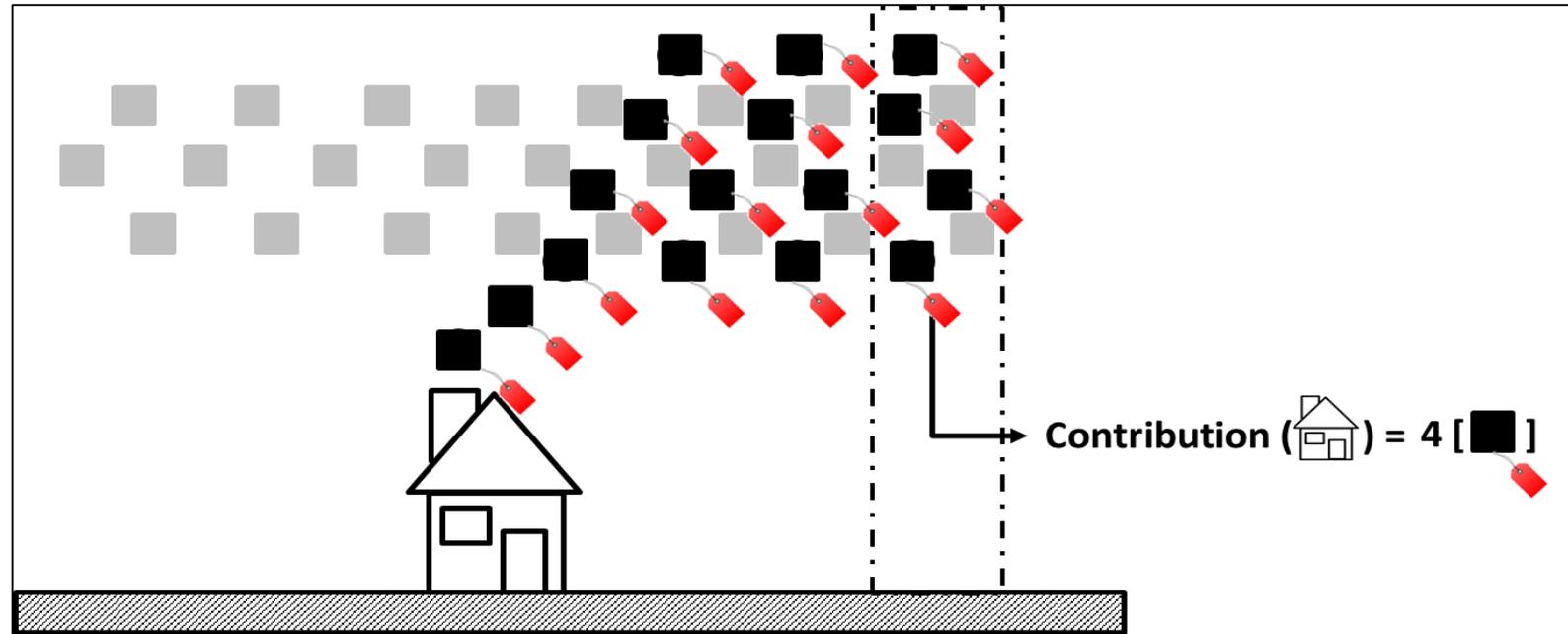
Forum for air quality modelling in Europe



European Commission

Various approaches to Source apportionment

Tagging contributions: correspond to the mass of a pollutant transferred from the emission sources to the ambient concentrations (only those with labels).



Only based on **model values**
Both a **spatial** and **sectorial** apportionments are possible
Applicable to **all type of species**

Impacts

Partial

Full

Contributions

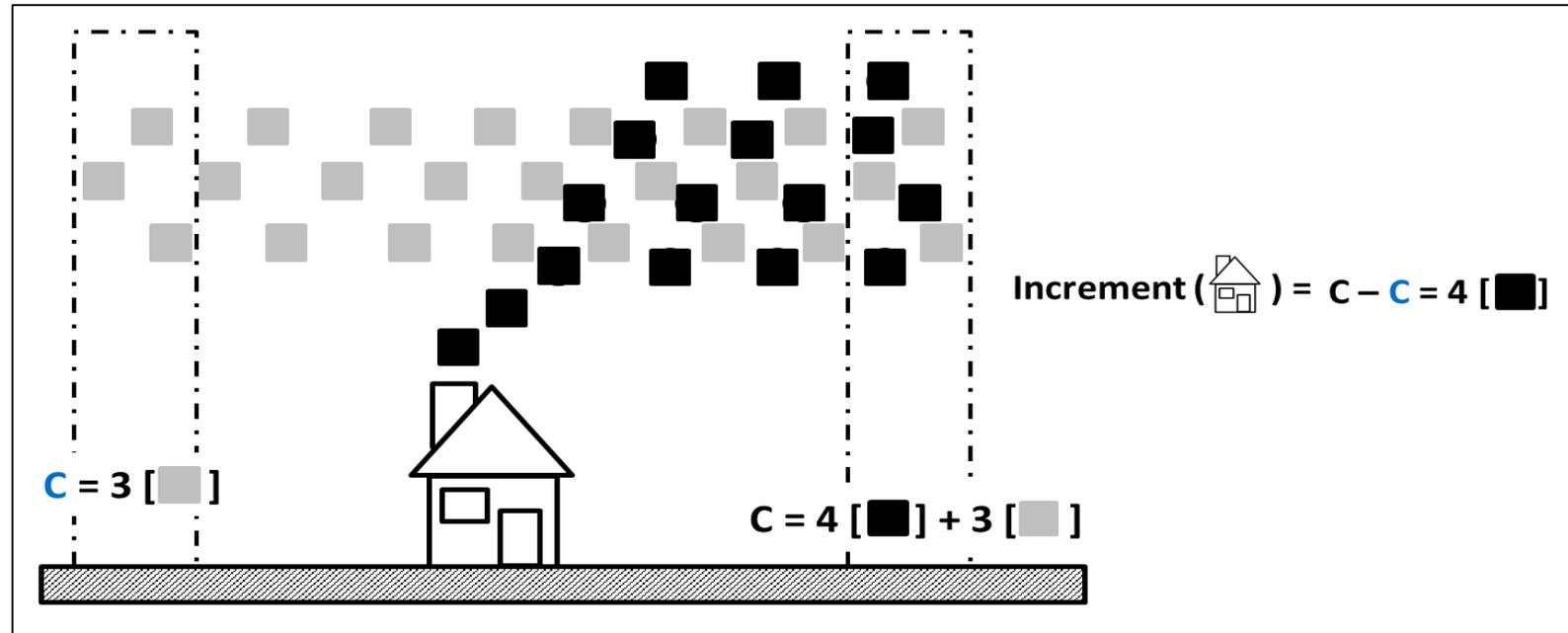
Receptor

Tagging

Increments

Various approaches to Source apportionment

Increments: are based on spatial gradients of concentration, calculated as the difference between concentrations at two specific locations (one influenced by the source, the other not).



Mostly based on **observations**
Only a **spatial** apportionment is possible
Applicable to **all type of species**

Impacts

Partial

Full

Contributions

Receptor

Tagging

Increments

A

Exercise 1

Familiarization with the Guidance approach

G



Exercise 1

Impacts

Full

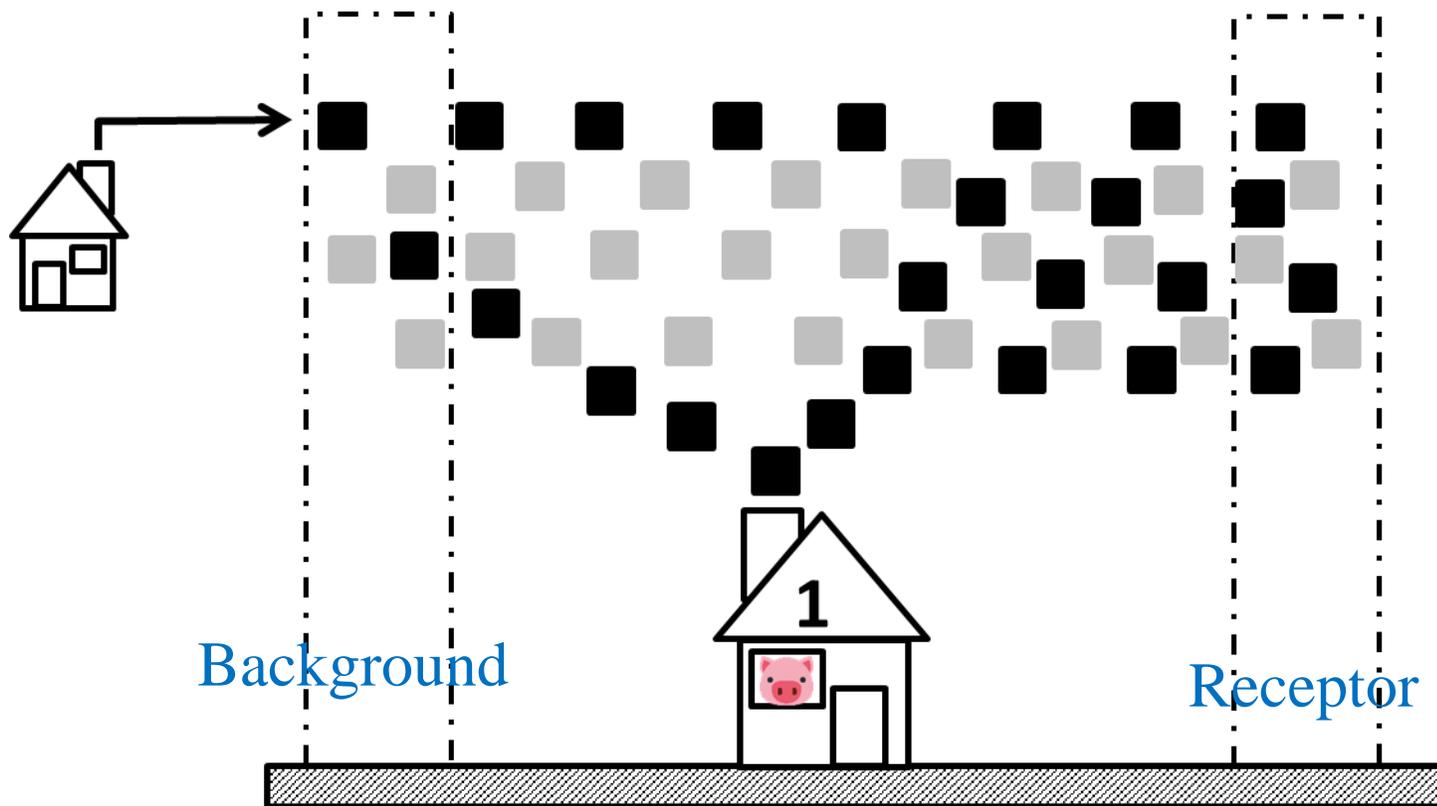
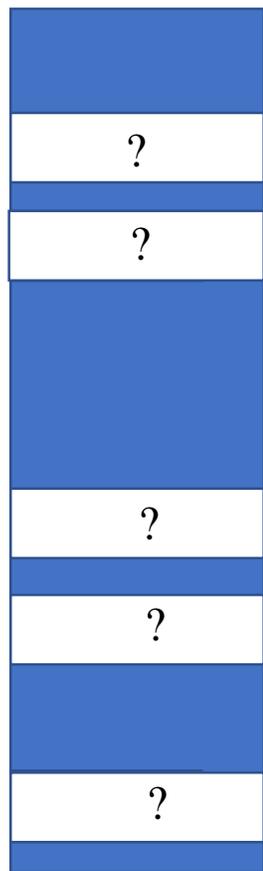
Partial 50%

Contributions

Receptor

Tagging

Increments



Fill in terms of  or  the different src. apportionment contributions/impacts/increments from the “pig” house.



Exercise 2

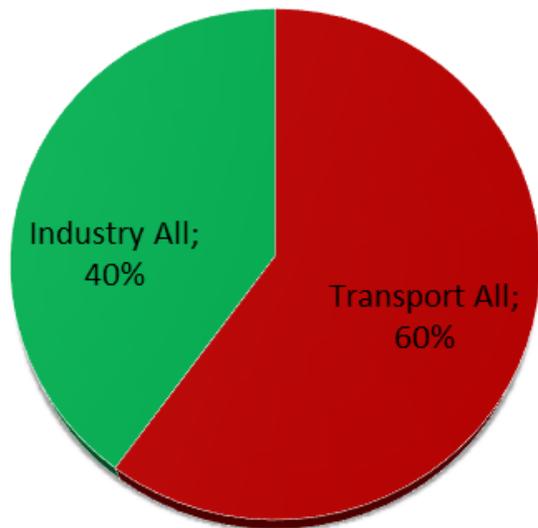
Addressing fitness for purpose

G

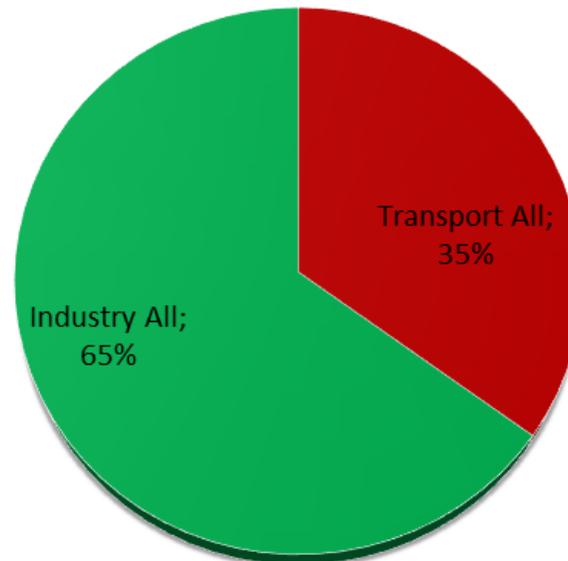
Interpretation of source apportionment pie charts to support air quality planning

In Madrid, 3 research groups used 3 different Source Apportionment methods to evaluate the source of PM2.5

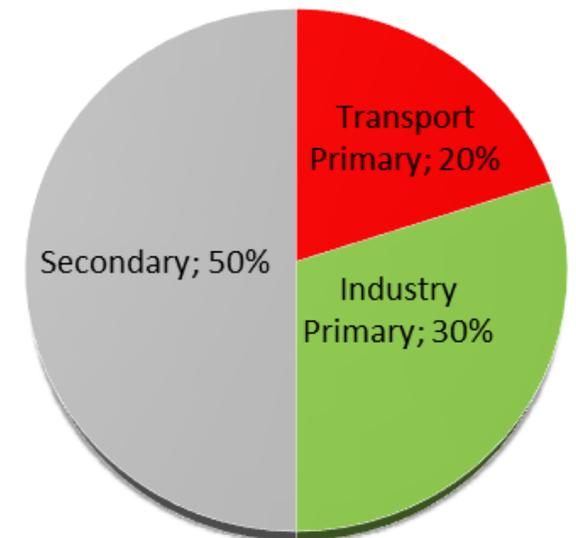
Impacts (based on 50%)



Tagging contributions



Receptor contributions



1. What is the PM2.5 concentration reduction that Madrid would achieve if transport emissions are reduced by 50% reduction with the 3 methods?
2. Same question with 75%

| | | | Solution 1 | Solution 2 | Solution 3 |
|------------|--|---------------|------------|------------|------------|
| Exercise 1 | Full Impact | | 3 BS + 1GS | 3 BS | |
| | Partial Impact | | | | |
| | Receptor contribution | | | | |
| | Tagging contribution | | | | |
| | Increment | | | | |
| | | | | | |
| Exercise 2 | Impact of a transport reduction of 50% | Impacts (50%) | | | |
| | | Tagging | 50% | | |
| | | Receptor | | | |
| | Impact of a transport reduction of 75% | Impacts (50%) | | | |
| | | Tagging | | | |
| | | Receptor | | | |

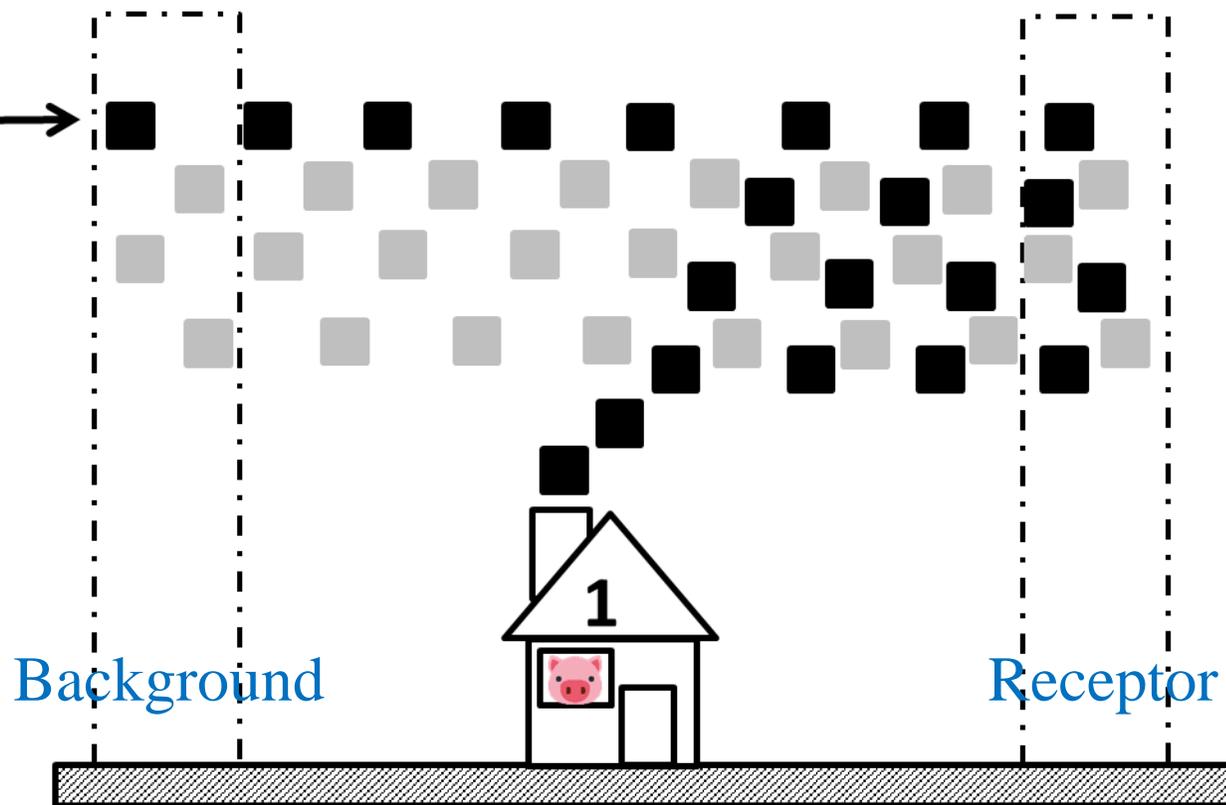
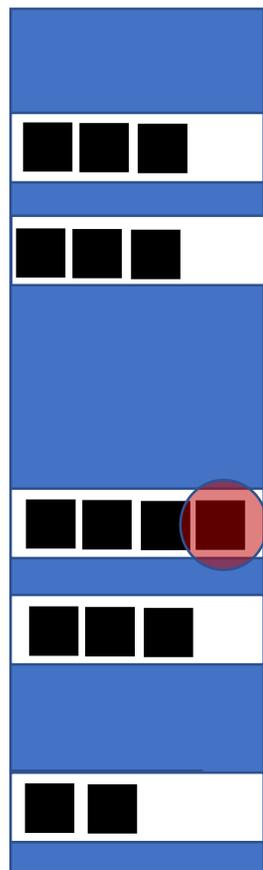
Solutions & discussion

G

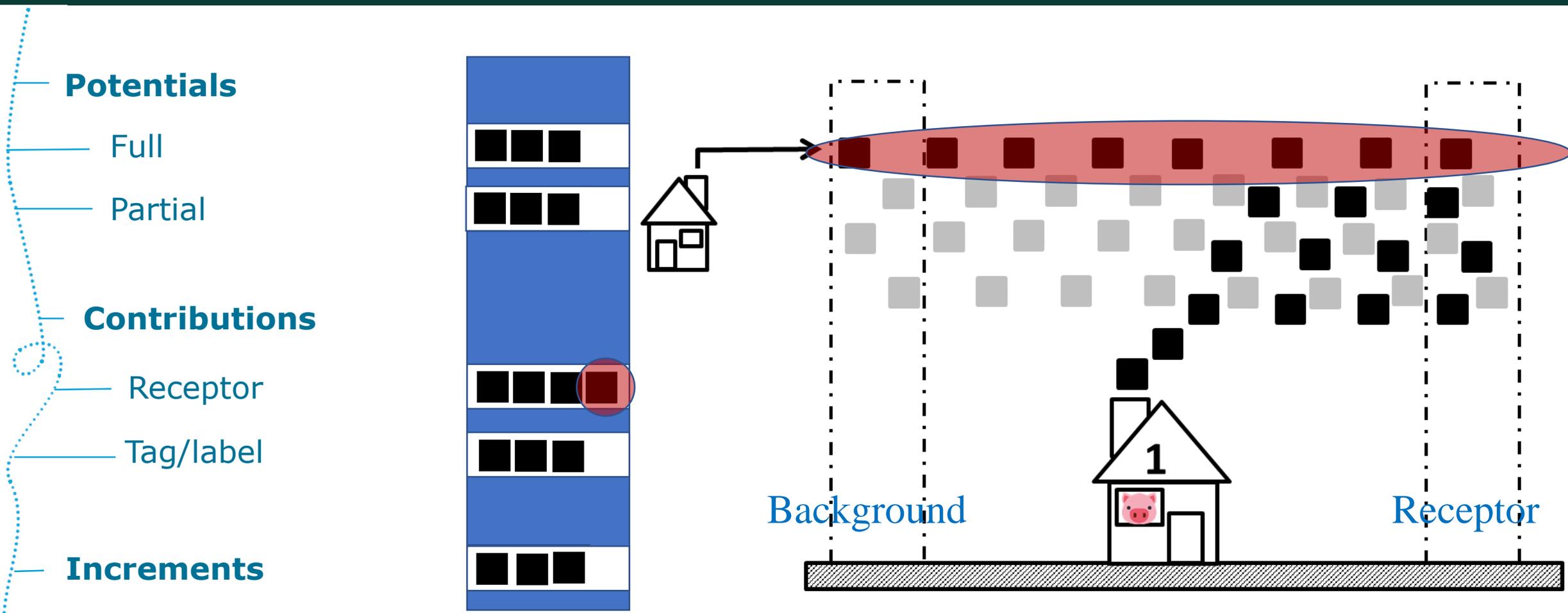


Exercise 1: solution

- Potentials
 - Full
 - Partial
- Contributions
 - Receptor
 - Tagging
- Increments



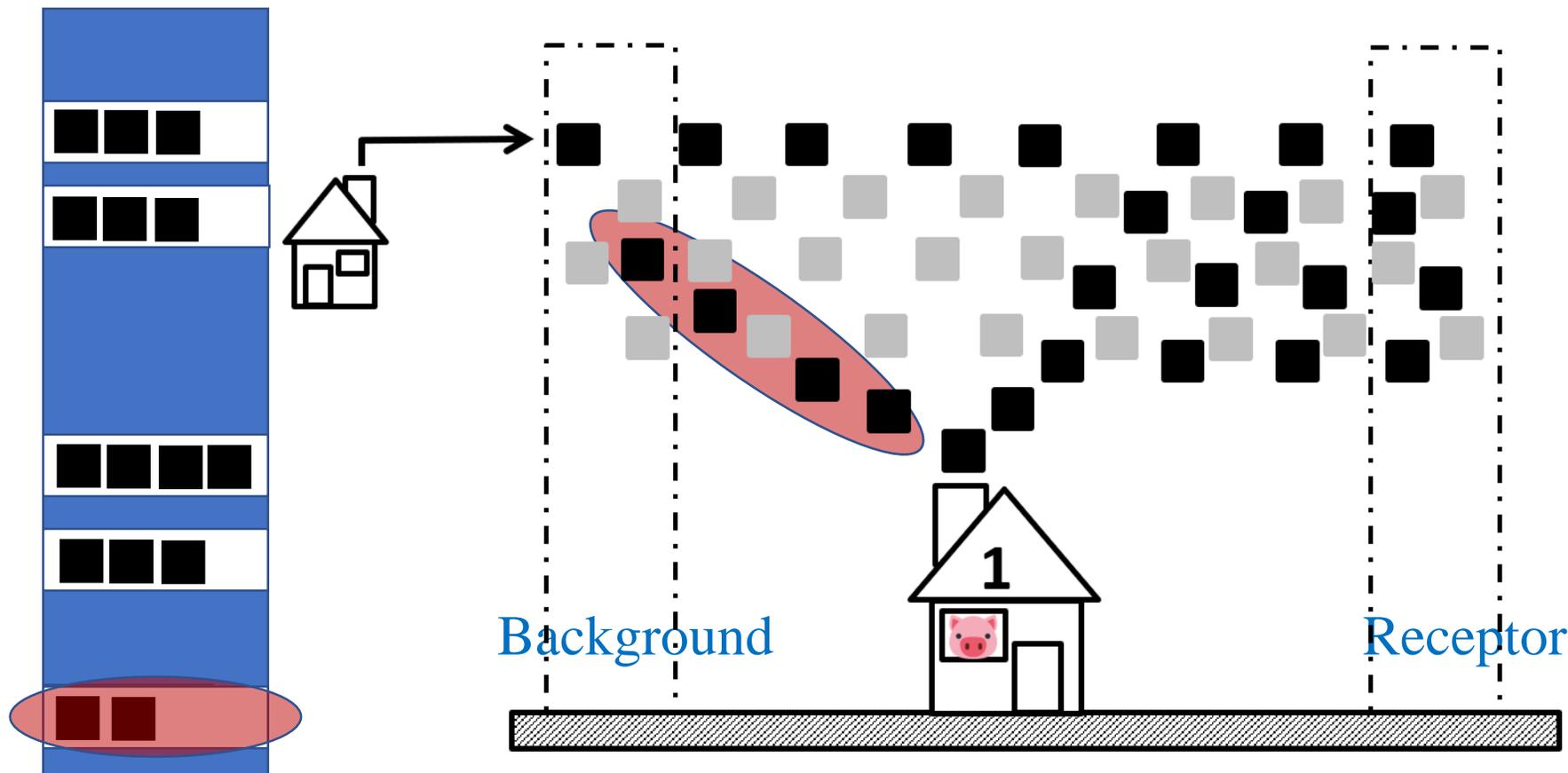
No spatial apportionment for receptor models



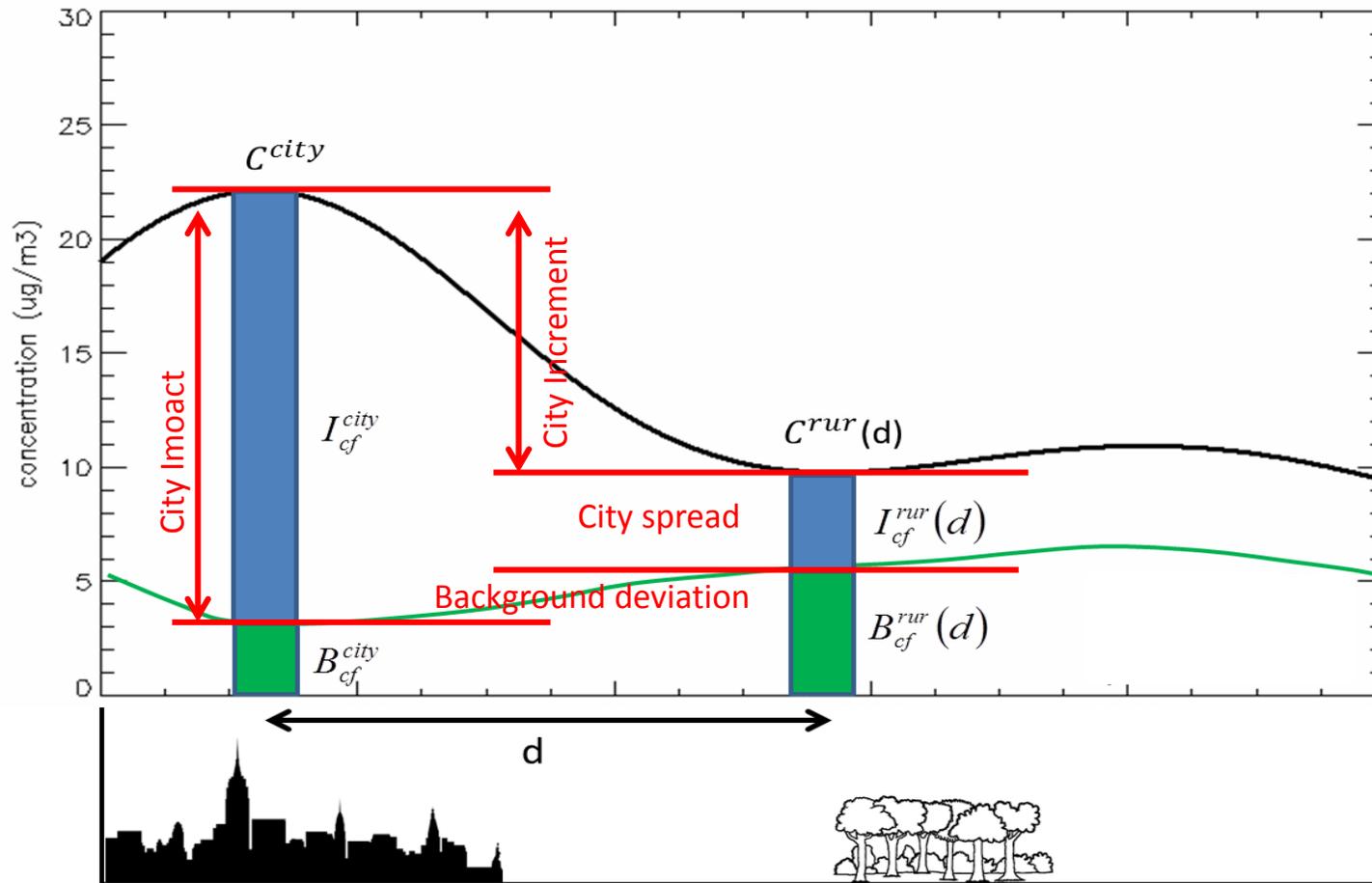


Exercise 1B: Linear pollutant (solution)

- Potentials
- Full
- Partial
- Contributions
- Receptor
- Tag/label
- Increments



Potential issues with the incremental approach



Issues are solved if:

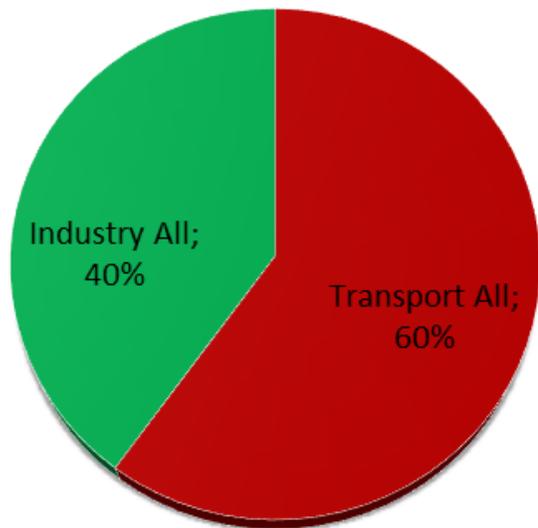
1. City spread = 0
2. Background deviation = 0
3. Robust results with “d”

The incremental approach is ambiguous because each component does not relate explicitly to one and only one source.

Interpretation of source apportionment pie charts to support air quality planning

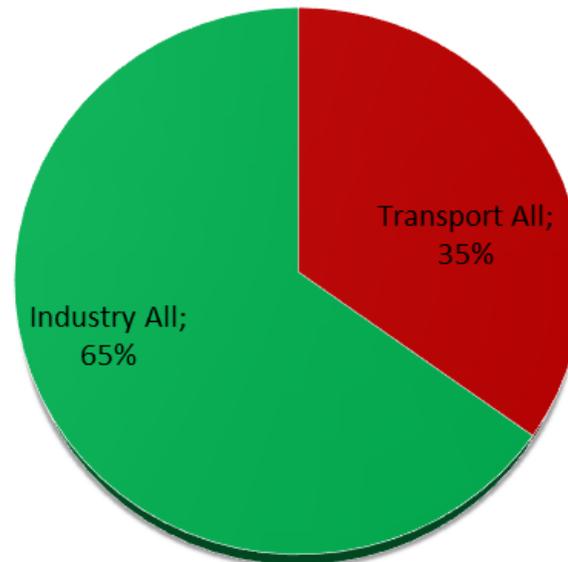
In Madrid, 3 research groups used 3 different Source Apportionment methods to evaluate the source of PM2.5

Impacts (based on 50%)



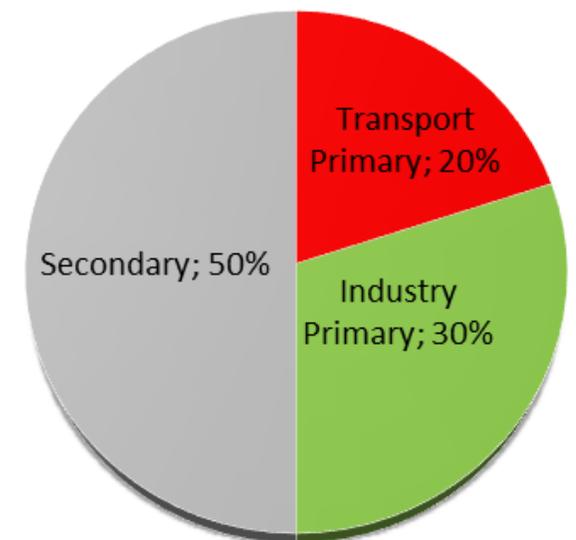
Answer 1: 30%
 Answer 2: I don't know!

Tagging contributions



I don't know!
 I don't know

Receptor contributions



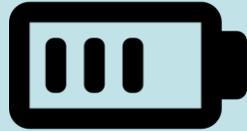
10% of primary PM
 15% of primary PM

Do we need this guide?

Answer: Yes, maybe!

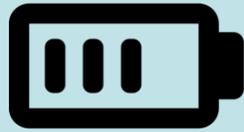
Contents of guide: three main sections

— **Methods & Concepts**



- Which method for SA
- Types of pollutants
- Properties of SA

— **An illustrative example**



- Sectorial SA
- Spatial SA

— **Which SA for which purpose**



- QA/QC
- Support to AQP
- Ex-post assessment

Methods & Concepts

Methods & Concepts

- Which method for SA
- Types of pollutants
- Properties of SA

Impacts (including source allocation)
 Contributions (receptor and tagging/labeling)
 Increments
 Combined methods

An illustrative example

- Sectorial SA
- Spatial SA

Linear vs. non-linear

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment

| | Impacts | | Contributions | | Increment |
|-------------|----------|-------------------|----------------------------------|---------|--------------------|
| | Zero-out | Source allocation | Receptor (only for sectorial) | Tagging | (only for spatial) |
| Additivity | ☹️ | 😊 | ☹️ | 😊 | 😊 |
| Dynamicity | 😊 | 😊 | ☹️ | ☹️ | 😞 |
| Linearity | ☹️ | 😊 | ☹️ | 😊 | 😞 |
| Unambiguity | 😊 | 😊 | ☹️ | 😊 | 😞 |

😊 Yes ☹️ Yes but only for linear species 😞 No ! Only valid over a limited range of reductions

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An illustrative example

Methods & Concepts

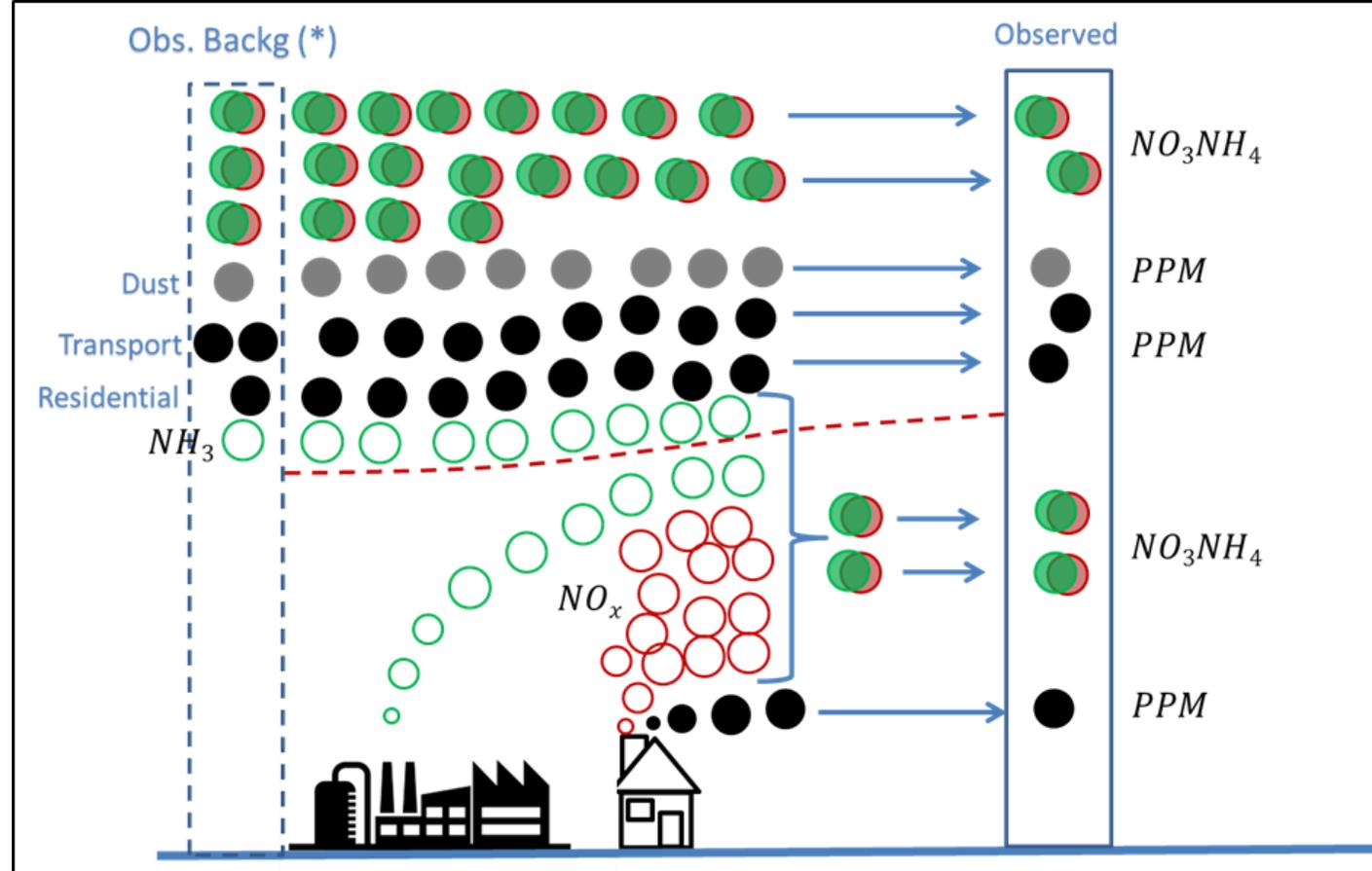
- Which method for SA
- Types of pollutants
- Properties of SA

An illustrative example

- Sectorial SA
- Spatial SA

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment



An illustrative example

Methods & Concepts

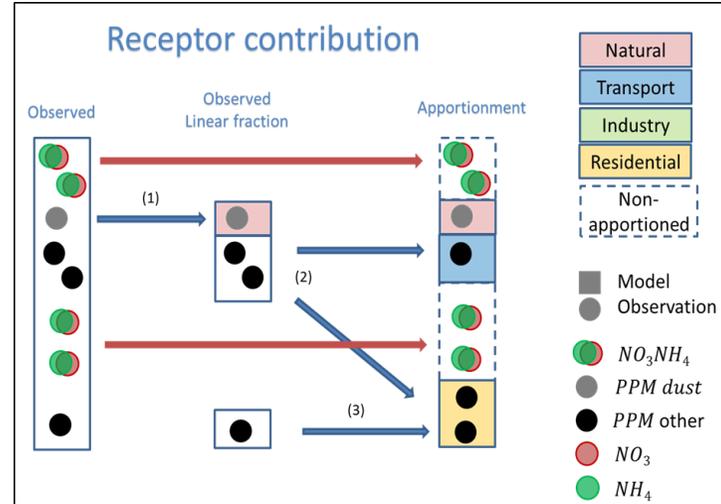
- Which method for SA
- Types of pollutants
- Properties of SA

An illustrative example

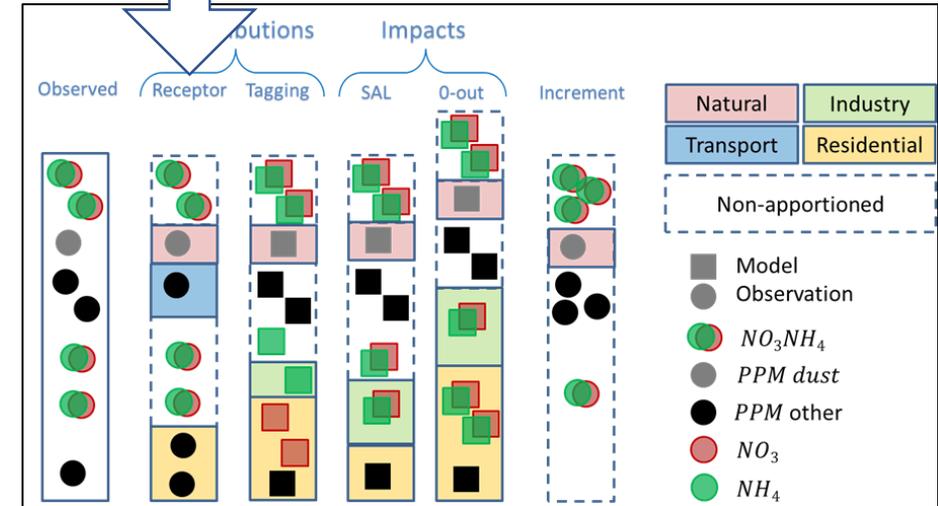
- Sectorial SA
- Spatial SA

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment



Sectorial apportionment



Which SA for which purpose?

Methods & Concepts

- Which method for SA
- Types of pollutants
- Properties of SA

An illustrative example

- Sectorial SA
- Spatial SA

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment

Purposes for source apportionment

- Explain the causes of exceedances
- Origin of pollution (e.g. transboundary)
- Assessment of specific sources (natural, winter sanding/salting)
- e-reporting

Support to AQP

Improve modelling accuracy: QA/QC

A-posteriori assessment of the efficiency of AQP

QA/QC

Methods & Concepts

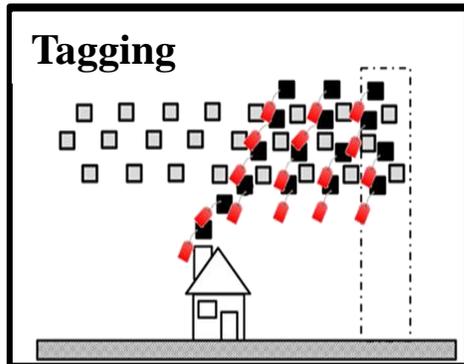
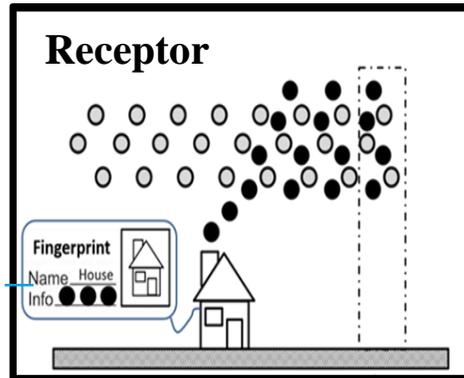
- Which method for SA
- Types of pollutants
- Properties of SA

An illustrative example

- Sectorial SA
- Spatial SA

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment



Potential issues?

- ✓ Measurements vs. model
- ✓ RM are limited to linear
- ✓ RM don't apportion spatially

Recommendation

Focus the comparison on linear species for which background sources are negligible

Which benefit ?

Model validation: comparing modeled (tagged) and measured (receptor) apportionments.

QA/QC

Methods & Concepts

- Which method for SA
- Types of pollutants
- Properties of SA

An illustrative example

- Sectorial SA
- Spatial SA

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment

What can we gain ?

| | Receptor Contribution ● ● | Tagging Contribution ■ ■ ■ | Impact ■ ■ ■ ■ | Increment ○ ○ |
|-------------------------------|---|--|--|--|
| Receptor Contribution ● ● | Model robustness | <ol style="list-style-type: none"> Measurements vs. model RM are limited to linear RM don't apportion spatially Advice: limit comparison to linear species for which background sources are negligible | | <ol style="list-style-type: none"> RM are limited to linear RM don't apportion spatially Increments to fulfill 2 assumptions prior to comparing Advice: comparison is impossible |
| Tagging Contribution ■ ■ ■ | | Model robustness | <ol style="list-style-type: none"> Direct vs. indirect effects Impacts lead to multiple apportionments Advice: limit comparison to linear species | <ol style="list-style-type: none"> Direct vs. indirect effects Increments to fulfill 2 assumptions prior to comparing Advice: comparison is often misleading |
| Impact ■ ■ ■ ■ | comparison of modeled (tagged or impacts) and measured (receptor) apportionments. | Model robustness | <ol style="list-style-type: none"> Impacts lead to multiple apportionments Model robustness Assess non-linearities | <ol style="list-style-type: none"> Increments to fulfill 2 assumptions prior to comparing Advice: comparison is often misleading |
| Increment ○ ○ | | Not recommended: The two incremental assumptions are generally not fulfilled | | Model validation compare modeled (and measured) increments. |

What should we care about?

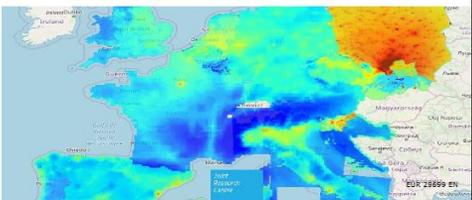
Support to air quality planning



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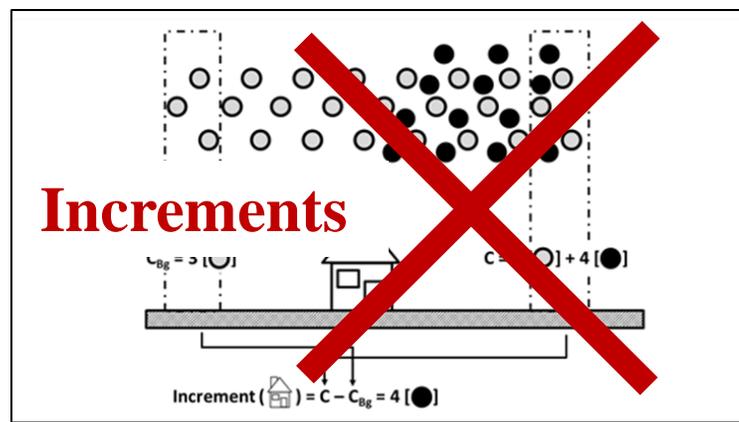
Recommendations regarding modelling applications within the scope of the ambient air quality directives

Thunis P., Janssen G., Wesseling J., Bellis C. A., Pirovano G., Tarrason L., Guevara M., Monteiro A., Clappier A., Pisoni E., Guerrero C., Gonzalez Ortiz A., on behalf of FAIRMODE
2019



Methods & Concepts

- Which method for SA
- Types of pollutants
- Properties of SA

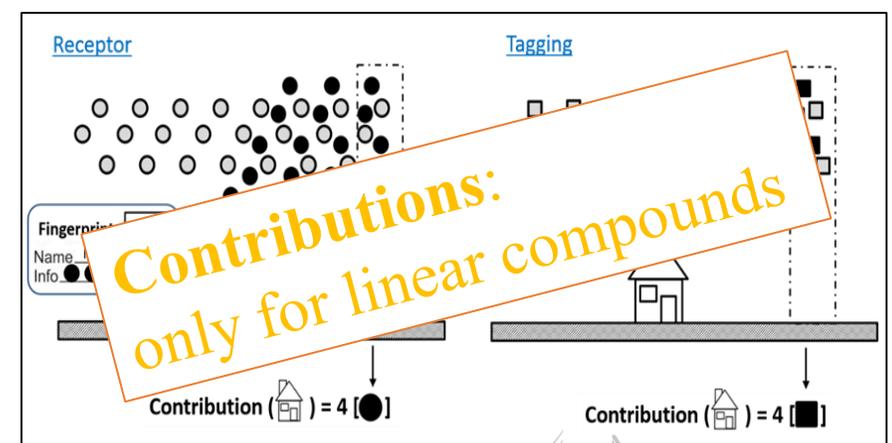
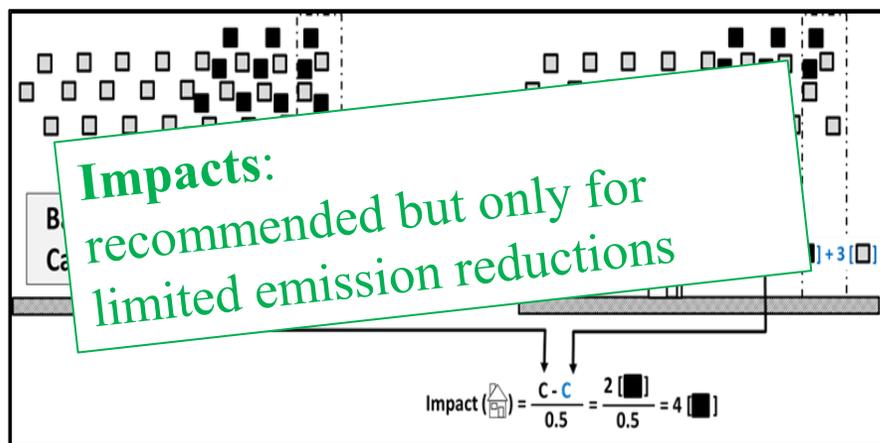


An illustrative example

- Sectorial SA
- Spatial SA

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment



Support to air quality planning (e-reporting)

Methods & Concepts

- Which method for SA
- Types of pollutants
- Properties of SA

An illustrative example

- Sectorial SA
- Spatial SA

Which SA for which purpose

- QA/QC
- Support to AQP
- Ex-post assessment

| PM | | Receptor Contributions | Tagging contributions | Impacts | Increments |
|------------|---------------|------------------------|-----------------------|---------|------------|
| Background | Transboundary | | | | |
| | Country | | | | |
| | Natural | | | | |
| Urban | Traffic | | | | |
| | Industry | | | | |
| | Agriculture | | | | |
| | Residential | | | | |
| | Shipping | | | | |
| | Off-road | | | | |
| Local | Traffic | | | | |
| | Industry | | | | |
| | Agriculture | | | | |
| | Residential | | | | |
| | Shipping | | | | |
| | Off-road | | | | |

Can tagging and other approaches be used to complement information beyond that threshold?

Ex-post assessment of AQ plans

Methods & Concepts

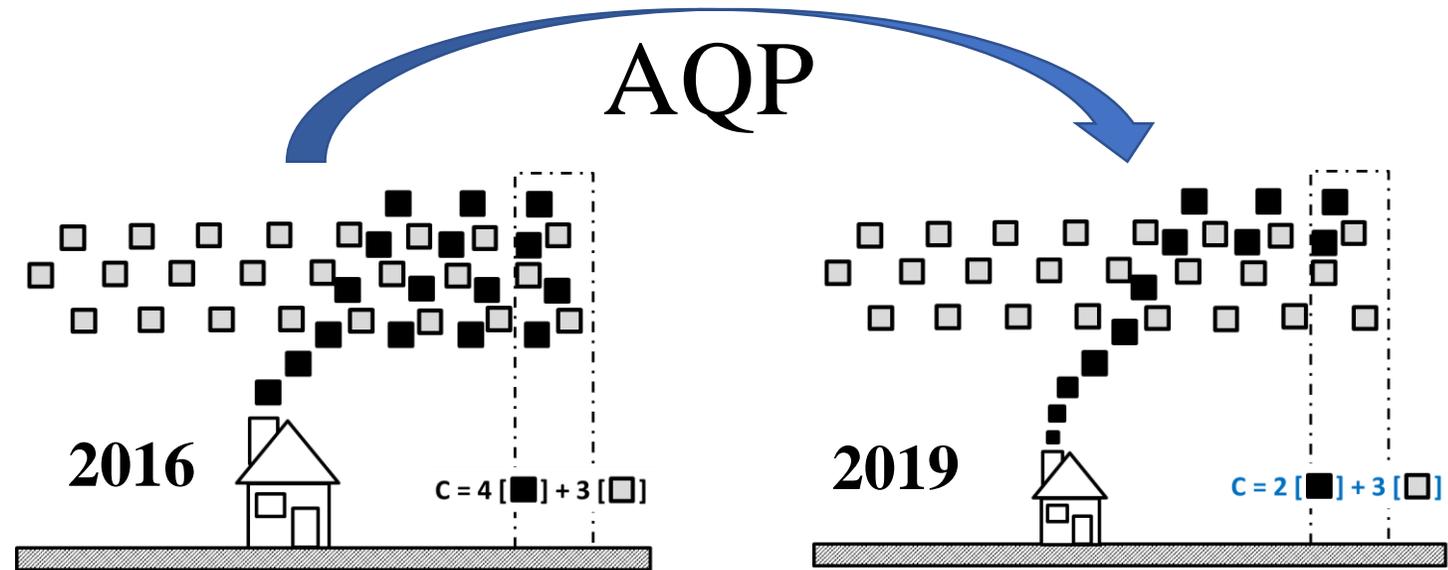
- Which method for SA
- Types of pollutants
- Properties of SA

An illustrative example

- Sectorial SA
- Spatial SA

Which SA for which purpose

- Support to AQP
- QA/QC
- Ex-post assessment



Can we retrieve information about the efficiency of the AQP by comparing src. apportionments in 2016 and 2019?

Discussion

G

Questions

1. Do you wish to be involved in the follow-up of this guide?

- a. Not at all
- b. By contributing to discussions at dedicated meetings (technical, others...)
- c. By reading & reviewing the document
- d. By contributing to the writing of specific section/topics. For example:
 - In general: extending the reasoning to O3 and/or NO2
 - For QA/QC: Provide best practice examples
 - For AQ planning: What is the potential for combined approaches (e.g. tagging and impacts), what is the difference between theoretical recommendations and practice.
- e. By performing specific tests. For example
 - testing differences between methods for specific e-reporting categories
 - Testing differences between methods for other pollutants (e.g. NO2 ad O3)

CEN TC264 / WG44 Source apportionment

Phase I: Focus on receptor modeling and its associated protocol for quality assurance. This is now finalized with the Technical Specifications sent for voting

Phase II:

- A receptor modelling approach can not be extended to source oriented models because it is too demanding and no true reference exists
- Instead, a proposal has been made to work on a checklist to ensure a proper application of SA methods. This would include: the availability of documentation, quality checks, discussion of fitness-for-purpose, ...

Questions

1. Do you wish to be involved in the follow-up of this guide?

- a. Not at all
- b. By contributing to discussions at dedicated meetings (technical, others...)
- c. By reading & reviewing the document
- d. By contributing to the writing of specific section/topics. For example:
 - In general: extending the reasoning to O3 and/or NO2
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 - For AQ planning: What is the potential for combined approaches (e.g. tagging and impacts), what is the difference between theoretical recommendations and practice.
- e. By performing specific tests. For example
 - testing differences between methods for specific e-reporting categories
 - Testing differences between methods for other pollutants (e.g. NO2 ad O3)

2. FAIRMODE and CEN/WG44

- a. Is the proposal for WG44 follow-up relevant, i.e. build a checklist to ensure a proper application of SA methods?
- b. Can this guide be used as a starting point for WG44 Phase II?
- c. Do you wish to be involved in WG44 Phase II?

| | | I wish to be involved in the Guidance on Source apportionment through: | | | | | WG44 follow-up activities | | |
|------|---------|--|---------------------------------|---------------------|--|---------------------------|---------------------------|----------------------|----|
| Name | Surname | Not at all | Discussing at dedicated meeting | Reading / reviewing | Contributing to the writing of specific sections | Performing specific tests | Good idea (Y/N) | I wish to contribute | |
| | | | | | | | | YES | NO |
| | | | | | | | | | |
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