Status of WG3

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RSE SpA

Fairmode Plenary meeting
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Outline

- Activities of WG3 in 2014-2016
- Lessons learned from the intercomparision exercise
- Road map for WG3 in 2017-2019
Activities carried out in the cycle 2014-2016

• Publications about the methodology for performance evaluation and RMIE results
• Organisation and evaluation of an ambitious IE for RM and CTM
• Developed recommendations to the e-reporting community (report feb/2016)
• Contribute to the creation the TC264 WG44 on the SA applications performance evaluation
• Development of an online database for chemical source profiles of PM SPECIEUROPE (http://source-apportionment.jrc.ec.europa.eu/Specieurope/index.aspx)
• Training activities in collaboration with IAEA
First intercomparison for Receptor (RM) and Chemical Transport models (CTM).

The intercomparison was useful for:

- Evaluating the overall source apportionment model performance on the basis of pre-established criteria,
  - for the purposes of air quality management (AQM)
- Obtaining an indirect measure of the overall output uncertainty,
- Cross-validating results (to overcome the lack of SA observed data)
- Providing insights to understand the behavior of models:
  - influence of specific factors (e.g. type of site, type of source, spatial resolution, vertical dispersion, etc...)
  - sensitivity to modelling approaches (e.g. RMs vs CTMs; brute force vs tagged)
- Generating reference datasets for future tests (a posteriori)
## Participants

### RM: 33 participants – 38 results

<table>
<thead>
<tr>
<th>AGH-UST</th>
<th>ISAC LE</th>
<th>RIVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPATN</td>
<td>FMI</td>
<td>SAGE</td>
</tr>
<tr>
<td>ARPA ER</td>
<td>IDAEA_T</td>
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<td>ISAC BO</td>
<td>PUC</td>
<td>WUT</td>
</tr>
</tbody>
</table>

### CTM: 7 participants – 11 results

<table>
<thead>
<tr>
<th>ENEA /ARIANET/ARPA PIEMONTE</th>
<th>joint result</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIEMAT/LISA CNRS</td>
<td>joint result</td>
</tr>
<tr>
<td>RIER- UNI KOLN</td>
<td>independent result</td>
</tr>
<tr>
<td>TNO</td>
<td>independent result</td>
</tr>
<tr>
<td>ARPAV</td>
<td>coordinated result</td>
</tr>
<tr>
<td>RSE</td>
<td>coordinated results</td>
</tr>
<tr>
<td>UNIAVE</td>
<td>coordinated results</td>
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</tbody>
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**Special thanks to:** M.T. Pay (BSC), M. Rezler (WTU), O. Favez (INERIS), J.L. Jaffrezo (LGGE), J. Kuenen and H. Denier van Der Gon (TNO)
Domains and Receptors

Special thanks to: M.T. Pay (BSC), M. Rezler (WTU), O. Favez (INERIS), J.L. Jaffrezo (LGGE), J. Kuenen and H. Denier van Der Gon (TNO)
Source Contributions

RM LENS

CTM mdt LENS

CTM opt LENS
SA performance

z-score (overall average)  Target plot (time series)  total mass test

Mainly model PMF5

RMs

CTMs

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CTM percentage of successful scores (crsme) in different sites
CTMs vs RMs Lens

z-score (overall average)

The comparability between RMs and CTMs varies among sources
Sensitivity tests

The goal of the sensitivity test was to evaluate the influence of the reduced horizontal resolution on the CAMX output. To that end, CAMx run 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 PM10 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 contributions to PM2.5 from agriculture, a complex source, were analysed more into detail. CAMx presents the highest contributions on average. The time trends of CAMx and LOTOS E were the most correlated among each other. FARM presents the highest levels in summer while LOTOS E shows the highest ones in winter. The chemical components associated with this source provide evidence about the underlying assumptions of the different types of models.
## Different CTM SA approaches

<table>
<thead>
<tr>
<th>Tagged</th>
<th>Brute force</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Tagged species are used to track the contributions of sources in every grid cell by mass balance. Conc. = (emission + import + formation) – (export + degradation + deposition)</td>
</tr>
<tr>
<td><strong>Kind of approach</strong></td>
<td>Static</td>
</tr>
<tr>
<td></td>
<td>Depicts the situation corresponding to the input dataset</td>
</tr>
<tr>
<td><strong>Underlying question</strong></td>
<td>What is the actual contribution of sources in the studied area/time window?</td>
</tr>
<tr>
<td><strong>Runs</strong></td>
<td>Accomplishes the apportionment in one single run</td>
</tr>
<tr>
<td><strong>Mass conservation</strong></td>
<td>The total mass is conserved</td>
</tr>
<tr>
<td><strong>Uncertainties</strong></td>
<td>Uncertainties of the model (e.g. processes, ), uncertainties of the input data (EIs, meteo data, BC)</td>
</tr>
<tr>
<td><strong>Advantages</strong></td>
<td>Reflects the current situation</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>The actual contribution of source is not necessarily what can be abated</td>
</tr>
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</table>
Conclusions of the IE (1)

GENERAL
- In general models show better performances in estimating the average source contribution for the entire period than the contributions for single time steps (time series).

RMS
- RM5s present comparable results which are also coherent with measured PM.
- There is a convergence towards one particular model: PMF5.
- Industry source category in RM needs better definition because too generic.
- Care is required in defining the conditions for the comparison between RM5s and CTMs.
- The comparability between RM5s and CTMs varies for the different sources.
Conclusions of the IE (2)

CTMs

• CTMs show good performances when tested using an ensemble reference.
• No significant differences in performance between source categories.
• The sensitivity analysis for CTM demonstrates the influence of the spatial resolution on the SA performance of model in densely populated areas.
• More effort is needed to improve the estimation of soil and road dust sources, in particular in the emission inventories.
• More work is needed to understand the implications of the different CTM approaches (tagged, brute force) and the information about the sources they provide.
Road Map 2017-2019 (1)

- Develop comprehensive **guidelines** for RM and CTM approaches on the basis on the inter-comparison exercise and other scientific evidence.
- Develop methodologies to support the evaluation of CTM models, with a particular focus on **spatial issues**.
- Promote the **integration** between RM and CTM in order to take advantages of the strengths of both approaches.
- Support to the **e-reporting** process (built-in SHERPA report facility)
- Support **pilot regions/cities** in their source-apportionment estimates (first stage of an air quality plan)
Road Map 2017-2019 (2)

- Interact with **CEN** to take advantage of synergies and contribute to standardization
- Continue improving the **DeltaSA** on line tool for testing SA applications
- Extend the activities to pollutants for which there are already available tools (**ozone**, **nitrogen oxides**, etc.)
- Perform **training** activities to disseminate harmonized best practices

In collaboration with IAEA regional projects on source apportionment and the newly created Task Force on Air Quality of the EU Strategy on Danube Region.
Thank you for your attention!
Intercomparison exercise: what’s next

- Extend evaluation to identification of geographical origin of pollutants
- Better understanding of the differences between brute force and tagged approaches
- More work in needed to improve estimation of critical sources (involving complex processes: i.e. secondary) such as agriculture
- Verification if the acceptability thresholds are appropriate
- Evaluation of other pollutants (specific PM components: BC, PAHs)
- On the basis of the performance of the different models develop a strategy combining RM and CTM to take advantage of the advantages of both
- Continue development of state-of-the-art SA CTM models and use RM for validation purposes
Guidance on the use of air quality models for estimating particulate matter source contributions (thanks to M. Mircea – ENEA)

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1.3 Why use an air quality (AQ)/chemical transport model (CTM)?

2 Air quality models -link with WG1
2.1 Primary aerosol: Gaussian steady-state and Lagrangian puff models
2.2 Primary and secondary aerosol: Eulerian photochemical grid models

3 PM source attribution in grid models
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3.2 Reactive tracer methods

4 Modelling source impacts
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4.3 Spatial and temporal resolutions of simulations
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4.4 Natural emissions
4.5 Boundary conditions
4.6 Meteorology
4.7 Model evaluation -MQO -link with WG1
4.8 Estimate modelled source contributions

5 Evaluation of estimated source contributions
5.1 Impact of input data uncertainties on source contributions from AQ/CTM
5.2 Comparison of source contributions from AQ/CTM and receptor modelling (RM) approaches -link with previous work in WG3
5.2 Combined use of AQ/CTM and RM source contributions: hybrid approaches -link with previous work in WG3

References

Appendix 1: Applications of AQ models for estimating particulate matter source contributions in Europe
Geographical Source Apportionment
(Contribution Estimate from Source Regions)

PM$_{2.5}$

(Emission sectors – Po valley vs Lombardy)
Geographical Source Apportionment
(Contribution Estimate from Source Regions)

Milan Receptor

PM2.5 - Duomo (CAMx)

PM2.5 - Traffico (CAMx-HMS)

NO2 - Duomo (CAMx)

EC - Traffico (CAMx-HMS)

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Consider an ideal situation with only two sectors: Transport and Agriculture

Suppose Transport emits just NO\textsubscript{x} and Agriculture just NH\textsubscript{3} ...
suppose also they emit the same rate and there are no limiting effects.

Therefore the same amount of NO\textsubscript{x} moves to NO\textsubscript{3}\textsuperscript{-} and NH\textsubscript{3} to NH\textsubscript{4}\textsuperscript{+}

**Brute Force (BF)** computes source contribution removing it:
If I remove agriculture I remove NH\textsubscript{4}\textsuperscript{+} but also NO\textsubscript{3}\textsuperscript{-} -> \(\Delta PM_{AG} = PM_{tot}\)
If I remove Transport I remove NO\textsubscript{3}\textsuperscript{-} but also NH\textsubscript{4}\textsuperscript{+} -> \(\Delta PM_{RT} = PM_{tot}\)

...? \(\Delta PM = 2*PM_{tot}??\)
After normalization...
\[
PM_{RT} = NO\textsubscript{3}\textsuperscript{-}/2 + NH\textsubscript{4}\textsuperscript{+}/2 = PM_{AG} = NO\textsubscript{3}\textsuperscript{-}/2 + NH\textsubscript{4}\textsuperscript{+}/2 = PM_{tot}/2
\]
(Apportionment of Source Effects)

**Tagged (TAG)** computes source contribution according to precursors:
Agriculture emits just NH\textsubscript{3} -> \(PM_{AG} = NH\textsubscript{4}\textsuperscript{+}\)
Transport emits just NO\textsubscript{x} -> \(PM_{RT} = NO\textsubscript{3}\textsuperscript{-}\)
\[
PM_{RT} = PM_{AG} = PM_{tot}/2
\]
(Apportionment of Source Precursors)

**Scenario Analysis**
If I remove agriculture I remove NH\textsubscript{4}\textsuperscript{+} but also NO\textsubscript{3}\textsuperscript{-} -> \(\Delta PM_{AG} = PM_{tot}\)
If I remove Transport I remove NO\textsubscript{3}\textsuperscript{-} but also NH\textsubscript{4}\textsuperscript{+} -> \(\Delta PM_{RT} = PM_{tot}\)

\[
\Delta PM_{AG} = \Delta PM_{RT} = PM_{tot} = 2*PM_{RT} = 2*PM_{AG}
\]
On-line Delta SA tool

New on-line tool to test SA model performance using existing testing datasets developed by JRC.
WG3 topics for future activity

**Guidelines:** development of CTM area and update the RM existing document (M. Mircea coordinator, G. Pirovano, G. Calori, O. Favez, I. El Haddad.)

**E-reporting:** creation of dedicated task force inter WGs to address the different aspects. In particular, propose sensible and robust SA approach

**Standardization:** continue collaboration for the Technical Specification, comments to the method are welcome, take advantage of the intercomparison, use the Delta SA tool

**Specific pollutants** put an emphasis on the apportionment of key pollutants like BC and PAHs

**Delta SA tool** test and implementation for online model evaluation (D. Salameh, E. Venturini, Z. Kertesz test users)