URBAN EMISSIONS AND PROJECTIONS

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OUTLINE

1. Introduction
2. Methodology
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1. Introduction

FAIRMODE flowchart as agreed on 2nd plenary meeting (Nov. 2009)

- SG(2) + SG(1)
  Combination of monitoring and modelling (data assimilation)
- SG(5)
  Contribution of natural sources and Source apportionment
- SG (3)
  Emission inventories and scenarios
- Benchmarking SG (4)
  Protocols and Tools for benchmarking of AQ models
  Urban Agglomeration
- Best practice guidelines
  WG1
SG(3) on urban emissions and projections

- Background document on the emission needs at local scale
- Needs for guidance on emission compilation at urban level
  - Consistency with national inventories
  - Top down vs bottom up approaches
  - Use of GIS tools
- Urban emission compilation is a key issue at European level
- Both guidance and relevant exchange fora are needed
- Next step:
  - Proposal for a framework for the development of emission inventories at local scale

- Links to TFEIP/EIONET, NIAM, GEIA, JRC-EDGAR
Air Quality Modelling in the AQD

- Assessment of ambient air quality
- Planning and mitigation strategies
- Assessment of the contribution of natural sources, road dust and sea salt
- Short-term forecast for threshold exceedances

- Uncertainties for Air Quality Models (AQMs)
  - Meteorology
  - Modelling system
  - Boundary and Initial conditions
  - Emission input

- Uncertainties from emission inputs → emission inventories:
  - Emission data accuracy
  - Temporal disaggregation
  - Spatial resolution and emission allocation
  - Chemical speciation and mass distribution

Consistent emission estimates across the scales, inventory harmonization. Criteria for local scale EI development.
1) Emission data accuracy (Cho et al., 2009)

2) Temporal disaggregation (Wang et al., 2010, Kühlwein et al., 2002)

3) Spatial resolution and emission allocation (Mensink et al., 2008, Cheng et al., 2008, Pisoni et al., 2010)
2. Methodology

• To analyse two approaches for different scale emission inventory compilation for an inland city and surroundings:
  – National calculation using country statistics and some regional data with spatial disaggregation afterwards
  – Regional calculation using regional data

• Compare AQM results (whole year, 1-h resolution) with monitoring data

• Select and analyse a number of representative stations where the alternative inventories produce important discrepancies in AQM results

Relate these differences with emission compilation methods for the dominant source in the grid cell

Understand reasons for discrepancies, get an idea about emission accuracy, and identify options for multi-scale emission inventory harmonization
• AQM domain including AQ monitoring stations

• Same BC and individual profiles for temporal and chemical speciation. Differences in model performance due to:

  • Emission data accuracy (total figures and sectoral figures)
  • Emission allocation (source apportionment at grid cell level)
3. Results

- Emission inventory aggregated comparison (INV1 – INV2)

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• Emission allocation (Gridded total NOx emissions according to the inventories considered)

• Largest discrepancies related to road transport and domestic/commercial/institutional heating

• Some differences in industry-related combustion processes and off-road mobile sources

• Different spatial allocation patterns
• Emission allocation: a) Source apportionment at grid cell level: SNAP 02

INV1

SNAP 02 contribution to NO\textsubscript{X} emissions at grid cell level (%)

0 - 0.5
0.5 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 50
50 - 60
60 - 80
80 - 100

INV2

• Differences:
  • statistical basis used for activity rates estimation
  • population as spatial surrogate (uniform emission distribution across a given municipal urban area vs. CORINE land cover population density)
• Emission allocation: b) Source apportionment at grid cell level: SNAP 07

SNAP 07 contribution to NOx emissions at grid cell level (%)

- Differences:
  - discrepancies regarding driving patterns and road classification
  - differences in mileage estimation per vehicle (daily average intensities and road length vs. prescribed total mileage values depending on vehicle type)
  - road maps considered
• AQM results:
  a) NO$_2$
  annual mean

• AQM results:
  b) NO$_2$ 99.8$^{th}$
  1-h percentile
• AQM results: c) NO$_2$ Mean Bias (ppb) at station level

Monitoring stations:
A – traffic
B – urban background
C – industrial
• Station A (traffic)

- INV1 more than double NOx emissions in the corresponding grid cell
- SNAP 07 (road traffic) is the predominant source (consistent with station label)
- INV2 considers a significant contribution from other sources

- NO$_2$ underestimated with INV2 and overestimated with INV1 similarly
- Absolute mean errors (ME) and the correlation coefficient are similar

- SNAP 07 emissions largely overestimated in INV1 (excessive contribution of heavy duty vehicles in highway driving pattern), although activity ratios are more specific.
- Inaccurate secondary EF
• Station B (urban background)

- INV1 more than double NOx emissions in the corresponding grid cell
- Source apportionment resulting in this grid cell is more balanced for INV2
- Non-LPS allocated using covers (INV2) and area-to-point algorithm (INV1)
  - NO$_2$ slightly underestimated with INV2 and overestimated with INV1
  - Better statistics for INV2

✓ SNAP 07 emissions overestimated in INV1 (dominating source in urban background)
✓ Not enough information to support and area-to-point allocation strategy (spatial surrogates provide a more reasonable picture)
• Station C (industrial)

![Graph showing emissions for Station C – INV1 and INV2](image)

- INV1 more than triple NOx emissions in the corresponding grid cell
- Road traffic emissions are in relatively good agreement
- INV2 considers larger industrial emissions
  - NO\textsubscript{2} overestimated with INV1 (MB = 14.8 ppb, ME = 20.3 ppb)
  - NO\textsubscript{2} less underestimated with INV2 (MB = -3.6 ppb, ME = 12.6 ppb)

✔ Apparently, an excessive emission allocation from industry in INV1 in general terms
• Station C (industrial)

- r coefficients similar
- Important seasonal differences
- Better agreement with observations during most of the year for INV2, except for particular periods concentrated in August-November

✓ No significant differences in temporal patterns in those periods ⇒
  ✓ misrepresentations of the chemical split of NOx and VOCs for particular industrial activities
  ✓ (most likely) high NO$_2$ levels due to non-local contributions
4. Conclusions

• There is an increasing demand for high-resolution, fine-scale emission inventories for air quality modelling activities

• It was agreed within FAIRMODE that this need is the most relevant emission-related issue for the application of the AQD

• A reliable air quality model may be useful to discriminate the uncertainty of emission inventories

• AQ monitoring sites should be carefully selected to guarantee the correctness and representativeness of the observational data considering the spatial and temporal resolution of the model

• It is essential that the methodology used at different scales is known and transparent for all the inventories involved
• Emissions from the road traffic are the key issue in an urban-scale inventory. Traffic flow measurements and accurate fleet characterization are crucial to get a reasonable estimate of traffic emissions. However, energy balances, computation methods and underlying hypotheses are, at least, equally important.

• A previous analysis of main statistics used to derived activity rates at different scales is needed.

• The bottom-up approach is preferred when there is information enough to support a very detailed emission estimation, but a top-down approach in combination with an updated high-resolution land use/population cover may provide a more accurate picture of general emission distribution pattern.

• If basic reference statistics are properly harmonised, both approaches should lead to quite similar results, being the differences due to the use of more specific information available only at finer scales.
THANK YOU FOR YOUR ATTENTION!