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


on behalf of FAIRMODE

2019
Contents

Abstract ................................................................................................................................. 1
Acknowledgements ............................................................................................................... 2
Executive summary ............................................................................................................. 2
1 Introduction – Policy context .......................................................................................... 6
2 The FAIRMODE network: goal and structure ................................................................. 7
3 Recommendations regarding assessment using modelling ............................................. 9
   3.1 Background .................................................................................................................. 9
   3.2 Challenge / Issue ......................................................................................................... 9
   3.3 Recommendations .................................................................................................... 10
   3.4 Implications ............................................................................................................... 11
4 Recommendations regarding fine scale emissions ......................................................... 12
   4.1 Background ................................................................................................................ 12
   4.2 Challenge / Issue ......................................................................................................... 12
   4.3 Recommendations .................................................................................................... 13
   4.4 Implications ............................................................................................................... 14
5 Recommendations regarding source apportionment and planning ............................. 15
   5.1 Background ................................................................................................................ 15
   5.2 Challenge / Issue ......................................................................................................... 16
   5.3 Recommendations .................................................................................................... 16
   5.4 Implications ............................................................................................................... 17
6 Implications of the FAIRMODE recommendations ..................................................... 18
   6.1 Implications for legislation ......................................................................................... 18
   6.2 Implications for Members States .............................................................................. 18
   6.3 Implications for FAIRMODE activities .................................................................... 19
List of abbreviations and definitions ................................................................................. 20
List of boxes ........................................................................................................................ 21
List of figures ....................................................................................................................... 22
Abstract

The Forum for Air Quality Modelling (FAIRMODE) is a European network to exchange experiences and competence on the use of air quality models in the context of the Ambient Air Quality Directives. Its purpose is to identify and promote the use of good practices for air quality modelling and to propose harmonized ways to assess the quality of model-based air quality applications by EU Member States.

The recommendations in this document are part of FAIRMODE’s contribution to the ongoing fitness check of the two EU Ambient Air Quality Directives (Directives 2008/50/EC and 2004/107/EC) initiated by the European Commission.

This document provides technical recommendations where the scientific consensus within FAIRMODE indicates that robust conclusions can be drawn, and identifies follow up actions. These recommendations might potentially affect the work of Member States in case they may be requested to be implemented. They may also be relevant to the outcome and follow-up to the fitness check of the Air Quality Directives. Finally, they have implications for the work of the FAIRMODE network itself, and guide future technical discussions.
Acknowledgements

This report would not have been possible without the involvement and participation of the FAIRMODE network. The authors would like to acknowledge the FAIRMODE national contact points for their input to the review of the document as well as all the participants of the FAIRMODE network who carried out the technical work and associated analysis that underpin these recommendations.

Authors

P. Thunis, European Commission (EC), Joint Research Centre (JRC), Italy
S. Janssen, VITO, Belgium
J. Wesseling, National Institute for Public Health and the Environment (RIVM), The Netherlands
C. A. Belis, European Commission (EC), Joint Research Centre (JRC), Italy
G. Pirovano, Ricerca sul Sistema Energetico - RSE S.p.A., Italy
L. Tarrasón, Norwegian Institute for Air Research (NILU), Norway
M. Guevara, Barcelona Supercomputing Centre (BSC), Spain
A. Monteiro, University of Aveiro, Portugal
A. Clappier, University of Strasbourg, France
E. Pisoni, European Commission (EC), Joint Research Centre (JRC), Italy
C. Guerreiro, Norwegian Institute for Air Research (NILU), Norway
A. González Ortiz, European Environment Agency (EEA), Denmark
Executive summary

Policy context

The Forum for Air Quality Modelling (FAIRMODE\(^1\)) is a European network to exchange experiences and competence on the use of air quality models in the context of the Ambient Air Quality (AAQ) Directives. Its purpose is to identify and promote the use of good practices for air quality modelling and to propose harmonized ways to assess the quality of model-based air quality applications by EU Member States (MS).

The recommendations in this document are part of FAIRMODE’s contribution to the ongoing fitness check of the two EU AAQ Directives (Directives 2008/50/EC and 2004/107/EC) initiated by the European Commission. The fitness check also covers Implementing Decision 2011/850/EC on the reciprocal exchange of information and reporting on ambient air quality (also known as IPR, the acronym for Implementing Provisions on Reporting) and Commission Directive EU/2015/1480 amending several annexes to Directives 2004/107/EC and 2008/50/EC. It examines all articles and provisions of the AAQ Directives, looking at the role they have played in meeting their objectives.

The fitness check evaluates the relevance, effectiveness, efficiency, coherence and EU added-value of these AAQ Directives.

In particular, the fitness check addresses to what extent the AAQ Directives have successfully defined methods to monitor and assess air quality to ensure that representative and high quality assessment regimes are in place in all Member States. These activities fall within the scope of FAIRMODE and have been addressed by the network.

This document provides technical recommendations where the scientific consensus within FAIRMODE indicates that robust conclusions can be drawn, and identifies follow up actions. These recommendations might potentially affect the work of Member States in case they may be requested (by the IPR or similar) to be implemented. They may also be relevant to the outcome and follow-up to the fitness check of the AAQ Directives. Finally, they have implications for the work of the FAIRMODE network itself, and guide future technical discussions.

Key conclusions

The recommendations follow the FAIRMODE structure and are organised around the assessment, emission, source apportionment and planning activities, intended as follows:

- **Assessment:** Assessment of air quality levels, estimation of the extent of exceedances and of the population exposure
- **Source apportionment:** Modelling approaches to determine air pollution sources and provide a knowledge basis for planning strategies
- **Planning:** Development and assessment of plans and measures to control air quality
- **Emissions:** provide support to the three other activities, as they highly depend on the quality and scale of the emission input data

**Recommendations regarding assessment using modelling:**

1. **On the use of the Modelling Quality Objective (MQO):** FAIRMODE proposes to use the MQO\(^2\) as a quality control mechanism to determine whether an assessment is “good enough” for application in the context of the AAQ Directives.

---


2. **On the link with e-Reporting:** FAIRMODE proposes to use the MQO and related summary statistics as modelling quality control information under the IPR.

3. **On the fitness-for-purpose criteria related to spatial resolution:** FAIRMODE proposes, as a general guidance, for the spatial scale(s) of the modelling system to be such that all observations of concentration levels within the scope of the application can be reproduced with acceptable quality. This recommendation is further refined according to the various modelling application purposes: modelling data as complementary information to observations, modelling for the calculation of specific exceedance indicators, modelling to provide understanding of the current situation, modelling assessment to serve as starting point for air quality planning and modelling for forecast.

**Recommendations regarding emissions for local/urban applications**

1. **On fine scale emission requirements:** FAIRMODE proposes to specify the requirements for compiling fit-for-purpose fine scale emission data to be used as input for local/urban air quality assessments and air quality planning under the AAQ Directives. FAIRMODE can assist in the specification of such fine scale emission data requirements.

2. **On guidance to compile fine scale emissions:** FAIRMODE proposes to expand the existing emission guidance document or create a new one to include guidance on local/urban emission inventory compilation. FAIRMODE can host a process to secure the development of user-checked guidance for local/urban emission inventory compilation.

3. **On the use of benchmarking for quality assessment of emissions:** FAIRMODE proposes to introduce benchmarking activities to establish the validity of the fine scale emission data used for local/urban air quality assessments and air quality planning.

4. **On the nomenclature for classifying fine scale emission sources:** FAIRMODE recommends adopting the nomenclature used under the National Emissions Ceilings (NEC) Directive for reporting fine scale emissions by sector, as basis for the local/urban air quality assessments and source allocation activities under the AAQ Directives.

**Recommendations regarding source apportionment and air quality planning**

1. **On the use of benchmarking tools:** FAIRMODE recommends applying proven benchmarking methodologies to ensure fit-for-purpose and reliable quality when performing source apportionment and air quality planning applications.

2. **On the nomenclature for classifying emission sources:** Following the recommendations from emissions, FAIRMODE recommends adopting the nomenclature used under the NEC Directive for reporting emissions as basis for the source apportionment activities under the AAQ Directive.

3. **On the use and limitations of source apportionment methods:** For the specific purpose of providing information of direct relevance to support the design of air quality plans and assess their potential benefits: (1) The incremental approach is not recommended for air quality planning applications; (2) Methods based on mass-transfer precursor mass-ratios are suited for linear pollutants but not for non-linear pollutants; (3) Brute-force based approaches are recommended for air quality planning applications.

---

Quick guide

- The FAIRMODE recommendations summarize the findings where the Forum is confident that robust conclusions can be drawn and identify actions for follow-up.
- FAIRMODE proposes a series of recommendations addressing assessment, emissions, source apportionment and planning in the context of air quality modelling applications related to the Ambient Air Quality Directives.
- FAIRMODE recommendations focus on fitness-for-purpose, quality control and necessary guidance to cover these aspects.
- Adopting the FAIRMODE recommendations would have implications on legislation, Member States and on the Forum itself.
1 Introduction – Policy context

The Forum for Air Quality Modelling (FAIRMODE) is a European network of air quality experts aimed at exchanging experiences and competence on the use of air quality models in the context of the application of the Ambient Air Quality (AAQ) Directives. Its purpose is to identify and promote the use of good practices for air quality modelling and to propose harmonized ways to assess the quality of model-based air quality applications by EU Member States (MS). Member States can designate one or more experts in the use and/or development of air quality models to be their representatives to FAIRMODE and contribute to the work plan of the Forum. FAIRMODE works by consensus, with the aim of strengthening and better focusing guidance to the use of modelling in the context of the AAQ Directives. The Ambient Air Quality Expert Group\(^5\) approves the FAIRMODE work plan and supports the participation of relevant national/regional representatives to achieve the goals from the work plan. The FAIRMODE network is presented in more detail in chapter 2.

The recommendations in this document are FAIRMODE’s contribution to the on-going fitness check\(^6\) of the two EU Ambient Air Quality (AAQ) Directives (Directives 2008/50/EC and 2004/107/EC) initiated by the European Commission in 2018. These Directives set air quality standards and requirements to ensure that Member States monitor and/or assess air quality in their territory, in a harmonised and comparable manner. The fitness check also covers the corresponding Implementing Decision 2011/850/EC (IPR) and Commission Directive EU/2015/1480 amending several annexes to Directives 2004/107/EC and 2008/50/EC. It examines all articles and provisions of the two Directives, looking at the role they have played in meeting their objectives. The fitness check evaluates the relevance, effectiveness, efficiency, coherence and EU added-value of the AAQ Directives. In particular, the fitness check addresses to what extent the AAQ Directives have successfully defined methods to monitor and assess air quality to ensure that representative and high quality assessment regimes are in place in all Member States. All these activities fall within the scope of FAIRMODE, and have been addressed by the network.

The present recommendations (chapters 3 to 5) draw from the experience of all Member States participating in FAIRMODE. They have been discussed in three plenary and technical meetings in 2017 and 2018, and have been adopted on the base of a wide scientific consensus within the FAIRMODE community. Follow-up actions have also been identified. The topics considered include assessment, emissions, source apportionment and planning activities, following the current priority areas and the organisation of work in FAIRMODE. The implications of adopting the FAIRMODE recommendations for legislation, for Member States and for the future work of the network are summarised in chapter 6.

\(^{5}\) http://ec.europa.eu/transparency/regexpert
\(^{6}\) http://ec.europa.eu/environment/air/quality/aqd_fitness_check_en.htm
2 The FAIRMODE network: goal and structure

FAIRMODE (Forum for Air Quality Modelling) was initiated by the Joint Research Centre (JRC) and the European Environment Agency (EEA) in 2007 for exchanging experience and results from air quality modelling in the context of the Ambient Air Quality Directives and for promoting the use of modelling for air quality assessment and management in a harmonized manner by Member States. Its main objectives are:

- To provide a permanent European Forum for air quality modellers, particularly addressing modelling uses;
- To study and set up a system (protocols and tools) for the quality assurance and continuous improvement of air quality models and input data operating at different spatial scales, from national to urban and local;
- To provide guidance, support the standardization and evaluate the fitness-for-purpose of air quality models and input data used for assessing current and future air quality in application of the EU Ambient Air Quality Directives;
- To support air quality management (at the national, regional and local/urban level) in developing and implementing air quality plans and measures through the use of efficient modelling tools;
- To promote capacity building activities to ensure an optimum use of the proposed common methodologies and guidance, and to promote best practices among the EU Member States;
- To make recommendations on future priorities, research activities and other relevant initiatives to secure air quality improvements.

The current structure of FAIRMODE reflects the main applications on the use of models identified by the forum already back in 2011 as essential to air quality applications under the AAQ Directives, namely: assessment, forecasting, source apportionment and planning. The Forum published a series of technical guides in relation to these topics (see Box 1 below).

**BOX 1: FAIRMODE GUIDANCE DOCUMENTS RELATED TO MODELLING**

FAIRMODE has issued guidance to support the use of modelling (all available on the [FAIRMODE web pages](#)):

- Guide on modelling Nitrogen Dioxide (NO₂) for air quality assessment and planning relevant to the European Air Quality Directive. ETC/ACM Technical Paper 2011/15
- European guide on air pollution source apportionment with receptor models, Report EUR 26080 EN, 2014
- How to start with PM modelling for air quality assessment and planning relevant to the Air Quality Directive. ETC/ACM Technical Paper 2013/11
- FAIRMODE Contribution to the e-reporting implementation
Since 2011, the work has been organized around four main working groups (WGs). Three WGs follow three of the above identified applications: assessment (including forecasting), source apportionment and planning. The role of the WG on emissions is meant to provide support to all other WGs as they highly depend on the quality of the emission input data.

The current FAIRMODE working groups have the following objectives:

- **Assessment**: Assessment of air quality levels, estimation of the extent of exceedances and of the population exposure
- **Emissions**: provide support to the three other WGs, as they highly depend on the quality of the emission input data
- **Source apportionment**: Modelling approaches to determine air pollution sources and provide a knowledge basis for planning strategies
- **Planning**: Development and assessment of plans and measures to control air quality

In addition, in 2017, the Air Quality Management Pilot Exercise was initiated as cross-cutting activity aimed at fostering interactions across WGs, with the objective of improving air quality management modelling practices. This activity was organised in FAIRMODE as a fifth WG. The current FAIRMODE organisation structure is shown in Figure 1.

Figure 1: Schematic overview of the structure of FAIRMODE activities in four working groups. The Pilot Exercise, in which a series of cities and regions are involved, is a cross-cutting activity that aims at improving air quality management practices

The recommendations presented below follow the FAIRMODE structure and are organised around the assessment, emission, source apportionment and planning activities.
3 Recommendations regarding assessment using modelling

3.1 Background

Under the AAQ Directives, EU Member States have obligations to assess and manage ambient air quality and report the results of those assessments and management on a regular basis. The data sharing obligations are thoroughly defined in the IPR Decision (2011/850/EU). The EEA assists the Commission in establishing and operating the mechanism for sharing air quality information (e-Reporting).

Whilst previous directives have based assessment and reporting largely on measured data, Directive 2008/50/EC encourages the use of modelling in combination with monitoring in a range of applications. The AAQ Directives (and their related IPR) define a range of situations where modelling can be applied for assessment instead of — or in combination with — fixed measurements, as follows:

a) Use of modelled data as complementary information to observations;

b) Use of a model for the calculation of specific exceedance indicators (area of exceedance, length of road in exceedance, population in the exceedance area) as described in the IPR;

c) Use of a model to provide a comprehensive understanding of the current situation of the ambient atmosphere in an air quality zone. This assessment can serve as starting point (baseline) for air quality planning under the AAQ Directives;

d) Use of a model to forecast for the following hours/day(s) geographical area of expected exceedances of standards and/or thresholds, expected changes in pollution and the reasons for those changes.

In all cases (except for d), modelled data or related indicators are to be reported to the European Commission via the e-Reporting mechanism.

Modelling quality objectives are described in Annex I of the AAQ Directives along with the monitoring quality objectives. However, the guidance documents associated to the AAQ Directives and their related IPR are significantly vague with respect to the definition and quality objectives of the modelling methods that are to be used in air quality assessments.

Two questions thus arise: 1) when is a modelling application fit-for-purpose? and 2) when can it be applied for each of the situations listed above?

3.2 Challenge / Issue

In order to be fit-for-purpose, a modelling application should be able to capture both the spatial and temporal variability of the environmental indicator under investigation. This ability is assessed by quantitatively comparing the model output to observations. FAIRMODE proposes a standardized Modelling Quality Objective (MQO, see Box 2), which can be used to evaluate the quality of a given modelling application.

While the temporal resolution of indicators is set by the requirements in the AAQ Directives (specific annual averaged values or percentiles have to be reported), the spatial resolution of the indicator has not been discussed very much. However, this spatial variability has major implications on the minimum spatial resolution that should be covered by the modelling system.

Clearly, when results have to be reported at a spatially detailed level (e.g., at road level), the type of modelling has to be fit-for-purpose, and should match the requested level of detail. Up to now, very little guidance exists on how to define the fit-for-purpose resolution or spatial scale of a modelling system in order to match the level of detail required by the application. The present recommendations aim to provide some guidance.

3.3 Recommendations

1. **On the use of the MQO**: The standardized Modelling Quality Objective (MQO), as defined by FAIRMODE, should be used as a quality control mechanism to assess whether a modelling based assessment is fit-for-purpose (i.e., “good enough”) for application in the context of the AAQ Directives. The MQO determines how well the results from a modelling application are in agreement with observations. The DELTA tool (or an equivalent software package) should be used to establish the MQO of any particular assessment.

2. **On the link with e-Reporting**: The Modelling Quality Indicator (MQI) and related summary statistics as available in the DELTA Summary Report (or equivalent software packages) should be used as modelling Quality Control information to be reported under the IPR. Special support is provided by the e-Reporting data flows to accommodate this process. The e-Reporting community should be further informed about this link.

3. **On the fitness-for-purpose criteria related to spatial resolution**: To reduce the ambiguity of the spatial scale in the fitness-for-purpose definition, FAIRMODE proposes, as a general guidance, that the spatial scale(s) of the modelling system should be such that all observations of pollutant concentration levels within the scope of the application can be reproduced:

   a. A modelling application which produces data used as complementary information to observations should be consistent with the type of station and pollutant that is complemented. This means that, for rural stations, (coarser) regional scale model results can be sufficient, whereas for traffic stations more detailed street level models have to be applied. The MQO should be evaluated

---

by making use of all observations from monitoring stations that are complemented by the modelling application.

b. A modelling application that is used to assess exceedance indicators (area of exceedance, length of road in exceedance, population in the exceedance area), should be able to describe all available observations in the area or air quality zone of interest.

c. When assessment using modelling is performed as a starting point for planning under the AAQ Directives, the ambition should be to reproduce what is observed in the atmosphere within the air quality zone under investigation. Therefore, it is recommended that all observations in the air quality zone are used in the MQO evaluation of the assessment results. This will ensure that the starting point of the plan reproduces (most of) the complex structures and gradients as described by observations.

3.4 Implications

The adoption of the proposed recommendations would have some (non-trivial) consequences:

As the MQO makes it possible to meaningfully compare the performance of modelling results all over Europe, and its definition is likely to be embedded in a CEN standard, it is important to select a set of parameters in the MQO that are supported by the whole air quality community.

For assessment specifically aiming at urbanized environments, modelling systems down to street level have to be applied (although some exceptions may apply to secondary pollutants, e.g. ozone; part of PM). In that situation, regional scale models will most probably be insufficient to capture the observed spatial gradients, and consequently they are not fit-for-purpose in local/urban environments. If the modelling assessment is not able to sufficiently reproduce the fine scale concentration patterns of a pollutant from the ambient atmosphere observations, it simply means that the modelling system is not 'fit-for-purpose' for assessment of that pollutant in that location and at that scale, and more elements should be added to the modelling system to capture the observed variations. It should be noted that a mismatch could also be related to insufficient quality of the input data (emissions, meteorology, boundary conditions, etc.), and not necessarily to the type of model used in the application.

Various (sub)models in a modelling chain still need validation, but most probably the concept of the (IPR) “station type/classification” should be sufficient to select appropriate stations for such a partial validation of the modelling chain.

In exceptional situations, stations can be left out in the evaluation of the model application when the situation is too complex to be captured in a model. However, in reporting the results of the assessment, the regions/situations where the modelling system (including input data such as meteorology, terrain data or emissions) may not be ‘fit-for-purpose’ should be clearly described. No formal assessment in the context of the AAQ Directives/IPR is possible in this region/situation with such a modelling system.
4 Recommendations regarding fine scale emissions

4.1 Background

The methods to monitor and assess air quality with the help of air quality models require good quality input data on emissions, boundary conditions and meteorology. In order to ensure the representativeness and the quality of the assessment results required by the AAQ Directives, further focus is to be placed on the compilation of high-quality input data. This includes, in particular, fine scale emission data.

However, neither the AAQ Directives nor the IPR guidance documents provide any identification of the methods to be applied in the compilation of emission data to be used as basis for modelling air quality assessments. Also, no reference is made to how the quality of emission data is to be assessed.

4.2 Challenge / Issue

National emission data reporting is addressed in the National Emission Ceilings (NEC) Directive (2016/2284/EU). Reporting under the NEC Directive is harmonized with EMEP emission reporting under the LRTAP Convention. The EEA is responsible for the reporting of the EU inventory under the CLRTAP. The methods mandated for the compilation of the EMEP and NECD emission data are specified in the EMEP/EEA emission inventory Guidebook (2016). The EMEP/EEA guidance on methods for emission compilation is organized by three different levels or tiers (1 to 3), and includes also guidance on the spatial disaggregation of emissions down to the new resolution requested for the reporting of the official EMEP emissions (0.1° x 0.1° long-lat, ECE/Ab.AIR/122/Add.1, decision 2013/4).

Since the focus of the NEC Directive is on national emission totals, its emission data compilation requirements do not take into account the needs for fine scale emission data in air quality modelling applications under the AAQ Directives: the requirements on emission data from NEC Directive and the guidance under EMEP/EEA are too coarse—both spatially and temporally, and also in terms of technology disaggregation—to respond to the needs of highly resolved fine scale emission data needed to fulfil assessment requirements under the AAQ Directives. The experience gained in FAIRMODE with emission benchmarking and understanding of urban emissions and in the context of the EEA’s Air Implementation Pilot revealed the existence of a large gap between national and local/urban inventories. A higher level of disaggregation of emission information is necessary for urban scale air quality applications, and this requirement is not solved by simply downscaling to fine scale from highly aggregated data. Greater consistency and coherence between local and regional inventories compilation practices needs to be ensured (taking account of the different scales), as well as an alignment of nomenclatures. Box 3 provides an overview of the different emission inventories currently available. While the European scale emissions (either official or expert estimates) are too coarse to support air quality modelling applications under the AAQ Directives, expert estimates at local scale do not consistently cover the whole of Europe.

(9) https://www.unece.org/env/lrtap/welcome.html.html
### Recommendation

1. **On fine scale emission requirements**: Specify the requirements on the fine scale (local/urban) emission data to be used as input for air quality assessments under the AAQ Directives. The current practice to compile and report national emission data is not appropriate to ensure the highly spatially and temporally disaggregated air quality assessments required under the AAQ Directive. Some emission processes are currently missing in the national data. For instance, Member States are not requested to include particle resuspension sources (traffic-related) in their official national emission inventories, even though these could dominate local/urban PM emissions in some countries. An alignment between NEC and AAQ Directives in some key areas (notably nomenclature) should be attained. FAIRMODE can assist in the specification of fine scale emission data requirements.

2. **On guidance to compile fine scale emissions**: Expand the existing emission guidance document or create a new one to include guidance on local/urban emission compilation. The current EMEP/EEA emission inventory Guidebook provides guidance for the spatial disaggregation of emission data, but the methodologies proposed do not always ensure appropriate results for local/urban emission assessments. For example, spatial proxies used to generate the gridding of residential wood combustion emissions may largely vary between countries due to local factors (e.g. legal restrictions, social customs) and subsequently urban and rural population distribution maps cannot be applied in a generalized way. FAIRMODE can contribute to the development of guidance for the compilation of fine scale emission inventories.

3. **On the use of benchmarking for quality assessment of emissions**: Introduce benchmarking activities (analogous to those carried out within FAIRMODE) as a system to evaluate the quality of emission data used for air quality assessments. The benchmarking of emission inventories in selected cities that has been performed in the framework of FAIRMODE during the past years has highlighted large inconsistencies between local bottom-up urban emission inventories and regional emission inventories, and contributed to the improvement of both types of emission inventories. It is recommended to promote the use of the Emission Delta-tool and the emission composite mapping tool, to reduce the gaps between local and regional emission inventories, to spot the main inconsistencies and to evaluate the quality of emission data.

4. **On the nomenclature for classifying emission sources**: We recommend adopting the nomenclature used under the NEC Directive for reporting emissions by sector, as
basis for the urban emission assessment and source allocation activities under the AAQ Directive. This nomenclature is the NFR-UNECE aggregation for gridding (GNFR – Gridded Nomenclature For Reporting)\(^{10}\).

### 4.4 Implications

The adoption of these recommendations would have significant implications for the compilation and quality control of emission data, and for the resources used for emission data compilation.

- Member States would need to include detailed information on the geographical and temporal distribution of fine scale emissions in their reporting under AAQ Directive and the e-Reporting chain.

- It is advised to co-ordinate efforts at national level on urban scale emission compilation and put more focus on the compilation of fine scale emission data following bottom-up approaches.

- The IPR and e-Reporting guidelines would need to adopt the nomenclature for reporting emission by sector consistently across the AAQ and NEC Directives, so that the request to report urban emissions adopts the GNFR nomenclature used in the NEC Directive.

- Guidance documents for the compilation of disaggregated fine scale emissions will need to be elaborated, preferably linked to the EMEP/EEA emission inventory guidebook.

5 Recommendations regarding source apportionment and planning

5.1 Background

Reliable and quantitative information on the origin of pollution and on pollution sources is required by the AAQ Directive (Annex XV), as well as in the IPR guidance documents, with a view of supporting the design of air quality plans and explaining the origin of exceedances. This information regarding the quantification of the sources of air pollution, both in terms of their sectorial and spatial origins, constitutes an essential step of the air quality management process. Air quality planning involves, among others, the following tasks: (1) identify and quantify the sources that contribute most to pollution; (2) inform on the efficiency of mitigation strategies; (3) identify possible mitigation measures to be applied to each of these sources and/or (4) evaluate the effectiveness of mitigation strategies. Source apportionment methods can support air quality planning activities, among others — especially for tasks (1) and (2) — by providing information on the relationship between air pollution sources and their concentrations.

Different approaches (see Box 4) are available to provide this information, but not all methods are suited to support air quality planning. Therefore, the limitations and range of applicability of each approach should be properly defined. Although FAIRMODE provided support on specific aspects, guidelines are generally lacking.

BOX 4: WHAT IS SOURCE APPORTIONMENT?

Source apportionment is defined as the practice of deriving information about the influence of emission sources on ambient air pollution levels. It includes among others:

- Incremental methods (or “Lenschow” approaches) based on spatial gradients of concentration, calculated as the difference between concentrations at two specific locations. They are based on the assumption that source contributions can be derived from the difference between the concentrations. This approach is based on the assumptions that: a) the regional contribution is constant outside and inside the urban area, and b) the city does not contribute to the regional background. This approach is only applicable to determine contributions from different spatial sources (e.g. city vs regional background) to concentrations.

- Mass-transfer methods designed to estimate the mass of a pollutant transferred from the emission sources to the ambient concentrations (receptor or source-oriented tagging models). It is applicable to determine sectoral (receptor and source-oriented models) and spatial (source-oriented models) contributions to concentrations.

- Brute-force methods where source contributions are obtained by differencing two source oriented model simulations performed with the full and a reduced emission source. This approach is applied to determine the contribution from both sectorial and spatial sources.

5.2 Challenge / Issue

The European Court of Auditors recently raised the issue\footnote{https://www.eca.europa.eu/Lists/ECADocuments/SR18_23/SR_AIR_QUALITY_EN.pdf} that air quality plans were not designed as “effective monitoring tools” because their measures were poorly targeted and could not be implemented quickly for the areas where the highest concentrations were measured. Part of the issue may arise from the fact that different source apportionment approaches lead to results that generally differ among themselves, and can subsequently lead to inadequate conclusions about the responsibility of certain sectors and raise misleading prospects about the efficiency of mitigation strategies. The lack of guidance on what methods to use to support air quality planning and under which circumstances these can be used is a main challenge that FAIRMODE has been addressing. Specifically, the following issues were explored:

- Technical guides and QA/QC steps are not always applied in source apportionment studies.
- The validity of the assumptions underpinning the incremental or Lenschow approach\footnote{Lenschow P., H.-J. Abraham, K. Kutzner, M. Lutz, J.-D. Preu, W. Reichenbacher (2001) Some ideas about the sources of PM10, Atmospheric Environment 35 Supplement No. 1 23–33.} is difficult to assess. Experience shows that this approach lacks robustness and often leads to important under- or overestimation of the contributions from different sources.
- The nomenclatures of the emission sources used in different source apportionment studies, both with receptor and source-oriented models are not always consistent.
- Information about the range of applicability of a given source apportionment approach is generally lacking.

5.3 Recommendations

1. **On the use of benchmarking tools**: To perform source apportionment and air quality planning applications, we need to select an approach that is fit-for-purpose and of reliable quality concerning: a) the source apportionment (SA) method (incremental, mass-transfer or brute-force), b) the Chemistry Transport Model, (CTM) used for the scenario runs and c) the emission scenario development methodology. In order to check a) the SA method and b) the CTM model selection, we recommend applying the FAIRMODE source apportionment benchmarking technical guides and to promote the use of methodologies that have been tested with the FAIRMODE performance assessment methods for this type of applications (e.g. DeltaSA, see box-below).

**BOX 5: DELTA SA**

The DeltaSA (Delta Source apportionment) tool is an R-package and a Java on-line tool developed at the EC-JRC to support and benchmark source apportionment applications. Its key functionalities support two critical tasks: the assignment of a factor to a source in factor analytical models (source identification) and the model performance evaluation. The source identification is based on the similarity between a given factor and source chemical profiles from public databases. The model performance evaluation is based on statistical indicators used to compare model output with reference values generated in inter-comparison exercises.
2. On the nomenclature for classifying emission sources: Following the recommendations from emissions, we recommend to adopt the nomenclature used under the NEC Directive for reporting emissions as basis for the source apportionment activities under the AAQ Directive. In this way, better consistency between the different Directives and higher level of transparency would be ensured, harmonising with the classification of emission sources at macro sector level given as the GNFR.

3. On the use and limitations of source apportionment methods: For the specific purpose of providing information of direct relevance to support the design of air quality plans and assess their potential impacts:
   
a) The incremental approach is not recommended for air quality planning applications, unless the validity of the underlying assumptions has been verified.
   
b) Methods based on mass-transfer precursor mass-ratios (e.g., tagging species algorithms built into CTM, receptor models) are suited for linear pollutants, that is, those characterised by a linear relationship between emission and concentration changes, but not for non-linear pollutants, such as some secondary PM species or O3.
   
c) Brute-force approaches are recommended for air quality planning applications, but an assessment of the associated non-linearities is necessary to provide information on their range of applicability.

5.4 Implications

The implications of adopting the general source apportionment and planning recommendations would be as follows:

1. With respect to source apportionment, MS should report the contribution of every source at a given site with the most suitable approach without an “a priori” imposition of the Lenschow approach, which lacks general validity (see recommendation 3a).

2. Member States should be free to choose the source apportionment methodology most suitable for their situation, provided their performances and uncertainties have been tested (using benchmarking tools), the FAIRMODE technical protocols are applied (recommendation 1) and the validity of the approach for the given purpose has been assessed (recommendation 3).

3. The classification of sources should be adapted according to recommendation 2.

4. Additional information is to be provided with the SA output to ensure that the adequate SA methodology is used for the desired scope. Additional metadata (type of approach used, range of applicability, etc.) might be useful in this context to increase the relevance and comparability of the reported information.
6 Implications of the FAIRMODE recommendations

The recommendations in the previous chapters reflect a consensus within the FAIRMODE network that has been consolidated through extensive discussions at plenary and technical meetings since 2017. The recommendations will also potentially affect the work of Member States where they might be requested (by the IPR or similar) to implement them. Finally, the recommendations have also implications for the work of the FAIRMODE network itself and guide the future technical discussions in the expert network. All these implications are specified in more detail in the following:

6.1 Implications for legislation

Adopting the recommendations from FAIRMODE would have implications on the revision and extension of the Implementing provisions under the IPR and the e-Reporting mechanism and would require in particular streamlining nomenclatures with those used under the National Emission Ceilings (NEC) Directive. FAIRMODE is an advisory network, and thus it is not responsible for implementing the advice and has no authority to determine whether a recommendation should be mandatory or voluntary. For the recommendations from FAIRMODE to become effective, the following steps should be considered:

- The recommendation on the use of the FAIRMODE Modelling Quality Indicator (MQI) and Modelling Quality Objective (MQO) and its links to e-Reporting would need to be adopted in the IPR decision and in the IPR guidance documents in order to be effective. This recommendation is currently under evaluation by CEN and it is expected that the MQO in the AAQ Directive in the future would be aligned with the MQO practices recommended by FAIRMODE.

- The recommendation to consider including fine scale emission reporting requirements would have serious implications for the AAQ Directive and would need to link with the NEC Directive. The focus on fine scale emissions is essential to the success of air quality control strategies. The recommendation is to request reporting urban emission under the e-Reporting chain and to report fine scale emissions following the same nomenclature for reporting emission by sector as prescribed by the NEC Directive (GNFR nomenclature). Any fine scale emission reporting requirement would need to be supported with the elaboration of adequate guidance and to be linked to the EMEP/EEA emission inventory guidebook.

- The recommendation on the use of benchmarking tools for assessment, emission and source allocation purposes would also need to be adopted in the IPR document and in the e-Reporting guidance activities in order to be effective. In particular, the IPR for source apportionment would need to be revised to adopt the GNFR nomenclature for emission sources, and for a more flexible reporting of source contributions.

6.2 Implications for Members States

Adopting the FAIRMODE recommendations would affect the work in Members States, in particular because the definition of best practices and fit-for-purpose methodologies under FAIRMODE provides a measure of quality that Member States are expected to comply with as far as possible. FAIRMODE recommendations are not mandatory until they are captured by legislation or introduced as part of the IPR. However, even though the recommendations are only advisory, they represent the consensus of what are considered best practices. Consequently,

- Members States are advised to adjust their methodologies on MQO to comply with the recommendation on the use of the FAIRMODE Modelling Quality Indicator (MQI) as modelling quality objective (MQO) and make sure they report consistently to this recommendation under e-Reporting.
• Member States are advised to select and apply modelling applications that are fit-for-purpose. FAIRMODE proposes as a general guidance that the spatial scale(s) of the modelling system should be such that all observations of concentration levels within the scope of the application can be reproduced.

• Member States are advised to coordinate efforts at national level on urban scale emission compilation and adjust the nomenclature for reporting emissions across the AAQD and the NECD. This implies to adopt GNFR sector definitions for emission and source allocation reporting and to include information on the compilation of fine scale emission data in the e-Reporting chain.

• Member States are advised to promote and support their national expert group in the use of the FAIRMODE benchmarking tools for assessment, emission and source apportionment purposes.

6.3 Implications for FAIRMODE activities

The recommendations from FAIRMODE in this report show the need for a series of guidance documents to support existing AAQ legislation. The elaboration of streamlined guidance and recommendations for the use of modelling applications in connection to air quality has implications for the organisation of work under the FAIRMODE network. Up to now, the development of benchmarking tools has focussed on particular issues separately, and the four initial working groups provided an adequate structure to carry out the work. FAIRMODE is now entering a different stage. The network has developed its benchmarking tools and reached maturity as a community so that the work of the different working groups converges. We expect that activities in the network will now develop into addressing the overall big picture as was done with the recent pilot exercise.

• FAIRMODE needs to reconsider its working group structure to secure an organisation that can effectively provide guidance to Member States on specific tasks related to the use and reporting of modelling data within the scope of the AAQD. Examples of guidance documents to be developed in the next 3 years under FAIRMODE include guidance on the official assessment and reporting of exceedance indicators, on urban assessments, on the air quality forecasting methods, on the use of SA methods and on fine scale emission compilation, among others.

• FAIRMODE needs to consider an optimal form for guidance. The practice of pilot studies has been proven a successful implementation of the “learning while doing” principle. It is necessary to consider whether the Air Quality Management Pilot Study currently designed as a temporary activity should become permanent. Pilot studies combined with publications have the advantage of promoting competence exchange and enhancing the expertise level across Member States in a more effective way than centrally managed guidance documents. However, the translation of these competence levels to recommendations and guidance in the legislation needs to be prioritized. A system to secure that the recommendations from FAIRMODE reach the IPR and e-Reporting guidance documents needs to be put in place in co-operation with the European Commission and the EEA.
### List of abbreviations and definitions

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAQD</td>
<td>Ambient Air Quality Directives</td>
</tr>
<tr>
<td>CEN</td>
<td>European Committee for Standardization</td>
</tr>
<tr>
<td>CTM</td>
<td>Chemistry Transport Model</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>EC-JRC</td>
<td>Joint Research Centre of the European Commission</td>
</tr>
<tr>
<td>EEA</td>
<td>European Environment Agency</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>GNFR</td>
<td>Gridded Nomenclature For Reporting</td>
</tr>
<tr>
<td>IPR</td>
<td>Implementing provision Rules</td>
</tr>
<tr>
<td>MQI</td>
<td>Modelling Performance Indicator</td>
</tr>
<tr>
<td>MQO</td>
<td>Modelling Quality Objective</td>
</tr>
<tr>
<td>MS</td>
<td>Member States</td>
</tr>
<tr>
<td>NECD</td>
<td>National Emission Ceiling Directive</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate matter</td>
</tr>
<tr>
<td>PPM</td>
<td>Primary Particulate Matter</td>
</tr>
<tr>
<td>RM</td>
<td>Receptor model</td>
</tr>
<tr>
<td>SA</td>
<td>Source Apportionment</td>
</tr>
<tr>
<td>WG</td>
<td>Working Group</td>
</tr>
</tbody>
</table>
List of boxes

**Box 1.** Fairmode guidance documents related to modelling  7
**Box 2.** Modelling quality objective (MQO) and model quality indicator (MQI)  10
**Box 3.** Emissions official vs. expert estimates  13
**Box 4.** What is source apportionment?  15
**Box 5.** DELTA SA  16
List of figures

Figure 1: Schematic overview of the structure of FAIRMODE activities in four working groups. The Pilot Exercise, in which a series of cities and regions are involved, is a cross-cutting activity that aims at improving air quality management practices....................... 8
GETTING IN TOUCH WITH THE EU

In person
All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email
Europe Direct is a service that answers your questions about the European Union. You can contact this service:
- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 2299696, or
- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online
Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications
You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).
The European Commission's science and knowledge service
Joint Research Centre

JRC Mission
As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.