FAIRMODE joint mapping benchmark exercise WG2 & WG7: Composite mapping of MQI and underlying emissions

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Introduction

Spatially disaggregated information on air pollutant concentrations and emissions is currently available for benchmarking activities by air quality experts via the 'Composite Mapping' (CM) platform developed under the umbrella of FAIRMODE. The CM platform was launched in 2015, to collect air quality and emission maps produced at national, regional or local level in support of the implementation of the AAQD. Today, the CM platform is populated by a diversity of results covering most of Europe and offers a unique view on current practices in air quality and emission modelling in support of policy implementation. In this document we propose to proceed further with the CM platform with the creation of a benchmark composite map for further evaluation of the model results on the basis of model quality indicators through a "MQI map" based on best available maps at NUTS3 level. This exercise is foreseen to be updated at a 2 years frequency cycle**.**

The MQI composite map (WG2)

The FAIRMODE composite platform acts as a repository for a series of modelling results on annual air concentrations over Europe. In this exercise, different areas in Europe will be classified following Eurostat's nomenclature of territorial units for statistics (NUTS) so that maps with annual air concentrations can be created. All modelling gridded results (annual concentrations) available for a given NUTS2/NUTS3[1] area will be compared in terms of their MQI and the best performing map will be selected for that area. The MQI comparison will be based on all monitoring stations in the NUTS3 area, regardless of their type (urban or rural background, traffic or industrial) will be considered for the MQI calculation. A collation of the best MQI performing modelling results for a specific year will be then presented in the CM platform. This collation is what we denominate the "MQI composite map", where each NUTS3 gridded concentration maps are set by its MQI.

In addition to the concentration composite map, MQI maps (i.e. maps indicating the best MQI per area) aggregated at different NUTS level (NUTS0, NUTS2 and NUTS3) will be produced with the aim of:

(1) Monitoring the status of modelling accuracy in terms of MQI (from one exercise to the next)

(2) Identifying areas that require improvements in terms of modelling and steer discussions towards areas requiring priority improvements.

(3) Support the further testing of some QA/QC performance indicators (e.g. representation of spatial gradients)

(4) A user-flexible interface will be developed to allow testing the sensitivity of the MQI calculations to specific parameters: type and number of stations, spatial coverage (from NUTS to air quality zones to country)

[1] The choice between NUTS3 or NUTS2 will depend on availability of monitoring data

(5) Assess differences between data-assimilated and non-assimilated results

Details about the requested concentration maps for interested participants in this exercise are summarized in the table below.

Requested data

Note that participants are required to run a QA/QC procedure before uploading the concentration maps. This QA/QC procedure is essential to guarantee a smooth processing of the data. More information about this quality checks and the upload procedure can be found on the FAIRMODE CM website: https://aqm.jrc.ec.europa.eu/ecmaps/

Pollutants considered	NO_2, PM10, PM2.5, O3
Temporal	Annual averaged concentrations (based on hourly, daily, daily for NO_2, PM10, PM2.5 respectively. For O_3, the indicator to report is the yearly highest six monthly average of daily maximum 8h mean concentration.
Year considered	Y-4 (i.e. 2019 for data delivered in 2023)
Data format	Gridded. See current composite mapping platform instructions & templates (https://aqm.jrc.ec.europa.eu/ecmaps/) If gridded (regular grid) data cannot be provided, one can also upload: a) Vector data containing all model results (i.e. irregular grid/points with model results). This will be used for visualization and MQI computation; b) Vector data containing the model results at station locations only: This will not be visualized, but used to compute MQI.

Table 1: Requested data for gridded concentrations

Requested meta-data

The following meta-data are requested when uploading your data via the CM platform interface.

Basic information	Model code (visualisation name)
	Model name (e.g. EMEP, CAMx…)
	Model version
	Reference Year
	Model type

	Country covered
	Area covered (optional)
	EPSG map projection
Other information[2]	Contact information
	Model domain/ spatial coverage
	Temporal resolution
	Spatial resolution
	Underlying emissions (inventory name and reference year)
	Input meteorology
	Initial & boundary conditions
	Data assimilation / fusion
Model documentation[2]	

Table 2: Meta-data for gridded concentrations

Comparison of the underlying emission data (WG7)

In addition to annual gridded concentrations, we aim at assessing and comparing the underlying emissions. To this end, annual emissions aggregated over pre-defined spatial areas will be required for a series of precursors and sectors. The spatial aggregation will be performed (1) at NUTS3 level that are covered entirely by the modelling domain as well as (2) over a series of predefined local areas (Functional Urban Areas - FUA), defined via shape files (prepared by the JRC). These local areas (about 150 over Europe) will consist mostly of urban areas. Spatially aggregated emission data will then be compared with the EU wide inventory estimates (see below). The screening methodology will follow Thunis et al. (2021) to flag the main inconsistencies in terms of pollutants, sectors and type (large scale totals, sector totals or urban spatialisation). Note that for the emissions, in contrast to previous CM exercises, no gridded maps will be requested. **However all precursors and sectors (indicated in table 3) need to be provided for the screening**. In case of non-available sector, a -999 value must be inserted whereas a note should be added in the metadata (other information field)

Precursor considered	NOX, NMVOC, NH_3, SO_2, PM25, PM10. The naming of the pollutants when reporting must match exactly with the naming in this list.
Temporal	Annual totals
Year considered	Year used as basis for assessment

[2] These metadata fields do not appear explicitly in the interface and should be added in the "other information" field

Sector considered	Traffic (GNFR F), commercial and residential (GNFR C), agriculture (GNFR K + L), industry (GNFR A + B), shipping (GNFR G), Solvents (GNFR E), Fugitive (GNFR D), Off-road (GNFR I + H), Waste (GNFR J)
Spatial aggregation	(1) Emissions aggregated to NUTS3 covered by the modelling domain. (2) AND emissions over a series of smaller areas (FUA) defined by specific shape files. A pre-processing programme is made available by the JRC to aggregate emissions over the different areas starting from gridded data. Note that emissions MUST be aggregated in the NUTS/FUA shapes provided in the pre-processing programme.
Data format	Spatially aggregated: 2 excel files (output of the JRC pre-processor): 1 for the NUTS3 entirely covered by the modelling domain, the second for all local areas (FUA). A template and additional information is provided in the annex of this document
Missing data	-999
FUA/NUTS ID	NUTS/FUA ID should be as specified in the pre-processor: NUTS: https://github.com/enricopisoni/FAIRMODE-compute_emissions_by_polygon/tree/master/data/polygons/NUTS_RG_01M_2016_4326 NUTS_ID FUA : https://github.com/enricopisoni/FAIRMODE-compute_emissions_by_polygon/tree/master/data/polygons/URAU_RG_100K_2020_4326_FUA URAU_CODE

Table 3: Requested data for spatially aggregated emissions

Requested meta-data

The following meta-data are requested when uploading your data via the CM platform interface.

Basic information	Inventory code (visualisation name)
	Inventory name (e.g. CAMS-REG)
	Inventory version
	Reference year
	Country (main country covered)
	Area (sub-national area – optional)

Table 4: Meta-data for spatially aggregated emissions

Emission dashboard (WG7)

An emission dashboard will be developed within WG7 with the aim of assessing and monitoring the level of consistency among EU top-down inventory. The three main inventories at that scale (EDGAR, EMEP and CAMS-REG) will be compared to their median (ensemble) with the same screening approach as in Section 3. The screening will be repeated at a frequency determined by the release frequency of these three inventories. In addition to an overall indicator measuring consistency, differences will be detailed in terms of pollutants, sectors and type (national totals, sector totals or urban spatialisation), at different spatial zooms (from country to NUTS3). These inventories will serve as basis for the comparison with the emissions underlying the MQI map.

Annex: Additional information regarding the upload of spatially aggregated emissions

The template for reporting emissions (either over NUTS3 or over FUA) is shown below. The output to be uploaded in the composite mapping platform should be one unique csv file (one for NUTS3 and one for FUA) containing emissions (expressed in kTons) for all sectors and pollutants mentioned in Table 3. It is important to use the following naming nomenclature:

Pollutants: PM25, PM10, NOX, NMVOC, SO2, NH3

Sectors: GNFRAB, GNFRC, GNFRD, GNFRE, GNFRG, GNFRHI, GNFRJ, GNFRKL

NUTS_ID/FUA_ID (*)	CNTR_CODE	NAME_LATN	POLLUTANT	YEAR	SECTOR	EMIS(kTons)
DE249	DE	Hof, Landkreis	NOX	2017	GNFRF	21586.23
AT311	AT	Innviertel	PM25	2017	GNFRIH	18000.01

(*) NUTS_ID for the NUTS3 csv file and FUA_ID for the FUA csv file

To produce the above precursor/sector csv file, a JRC pre-processor is available. It is possible to use this pre-processor in two ways:

1. Use the pre-processor full capabilities starting from your gridded input files (either in ASCII, NetCDF or geoTIFF) to create the unique csv output to be uploaded via the CM interface
2. Download the FUA or/and NUTS3 shape files in the pre-processor's library and develop own processing program

More information on the pre-processor are available at:

https://github.com/enricopisoni/FAIRMODE-compute_emissions_by_polygon