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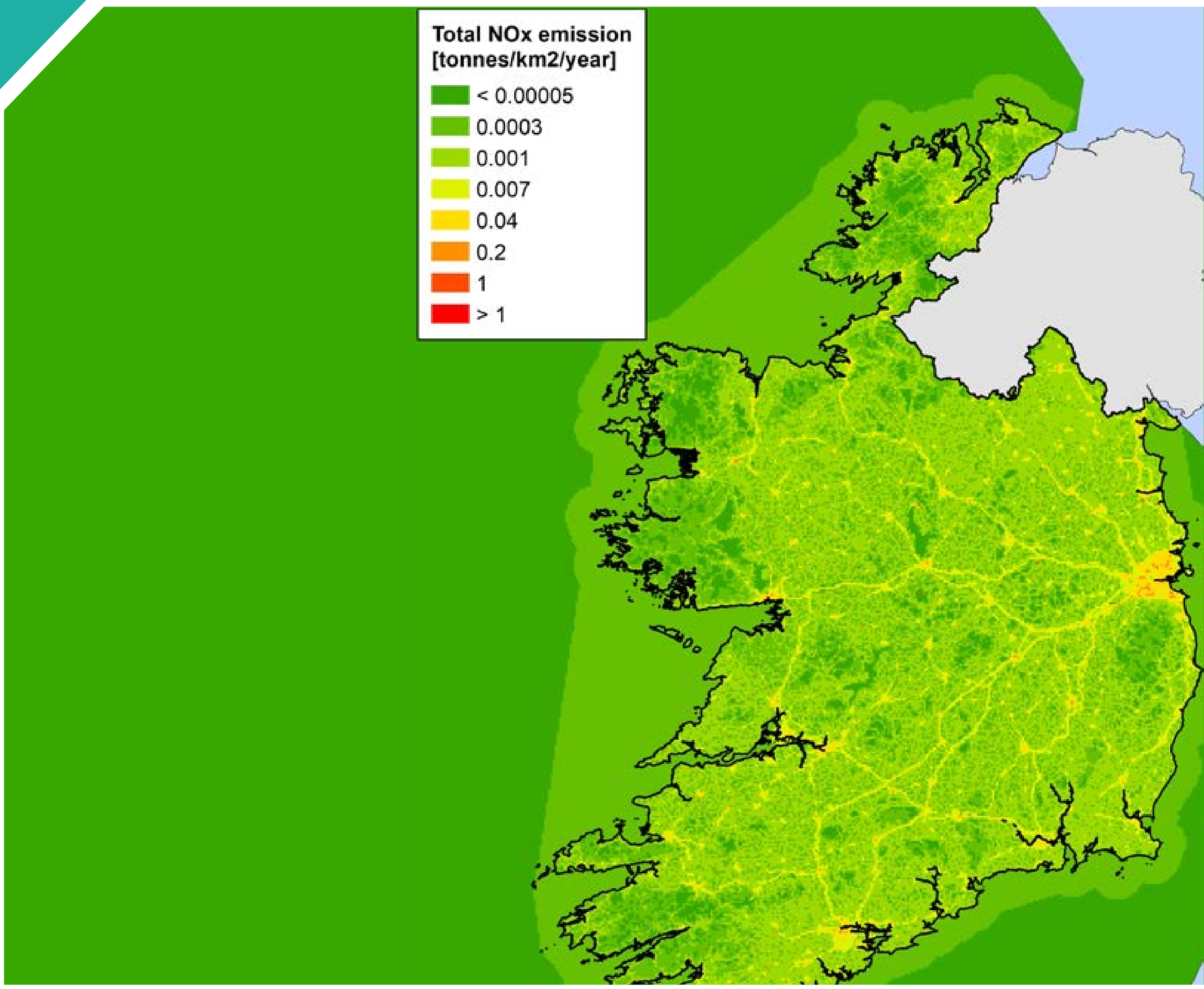
MapEIre: National Mapping of Greenhouse Gas and Non-greenhouse Gas Emissions Sources Project

Authors: Ole-Kenneth Nielsen, Marlene S. Plejdrup, Henrik G. Bruun, Steen Gyldenkærne and Jesper H. Christensen



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ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

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- intensive agriculture *(e.g. pigs, poultry)*;
- the contained use and controlled release of Genetically Modified Organisms *(GMOs)*;
- sources of ionising radiation *(e.g. x-ray and radiotherapy equipment, industrial sources)*;
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- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

EPA RESEARCH PROGRAMME 2014–2020

MapEIre: National Mapping of Greenhouse Gas and Non-greenhouse Gas Emissions Sources Project

(2015-CCRP-MS.26)

EPA Research Report

Prepared for the Environmental Protection Agency

by

Aarhus University

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Executive Summary

This report documents the spatial emission model (MapEIre) created for Ireland under the "National mapping of greenhouse gas and non-greenhouse gas emissions sources" project funded by Ireland's Environmental Protection Agency (EPA). The report describes the work carried out in the project, including the preliminary literature study, the technical specifications of the spatial and the temporal model, and the spatial and temporal distribution keys (GeoKeys and TKeys, respectively) developed and used in the model. Model results are presented in spatial emission maps for Ireland. Extended technical documentation is available in the technical documentation report available on the project web page (www.mapeire.dk), and is intended to serve as guidance for experts installing and implementing the model as well as a thorough documentation of the GeoKeys used in the model. Further, a user manual was prepared to guide users of the model through the basic functions in the model system.

The EPA is obligated to report on emissions of a wide range of pollutants that come under the scope of the Clean Air For Europe (CAFE) Directive (2008/50/EC), the Convention on Long-range Transboundary Air Pollution (CLRTAP) and the United Nations Framework Convention on Climate Change (UNFCCC). The scope of the MapEIre project is to develop a model system to provide emissions for all activities and of all pollutants included in the aforementioned legal agreements with a temporal and a spatial resolution.

Reporting of spatial emissions is a requirement under CLRTAP, and priority was given to the pollutants and the activities included in the Convention. Separate spatial distributions are created for each source category based on the best available digital spatial and statistical data, following the guidance under the relevant legal agreements. The spatial distribution is consistent with the European Monitoring and Evaluation Programme (EMEP) grid. Temporal variations were agreed for the source activities at an appropriate resolution, following the format of the EMEP standard temporal distributions.

The MapEIre project has developed high-resolution spatial and temporal mapping of the national Irish emission inventory. The work is state-of-the-art and combines a large number of statistical data with detailed spatial information to allow for complete spatial emission mapping at a 1 km × 1 km resolution for the Irish Exclusive Economic Zone. The results from the spatial model can be combined with sector-specific temporal profiles to generate a spatio-temporal emission inventory with a temporal resolution of 1 hour. The temporal distribution is based on three levels of temporal profile: hourly (24 hours), daily (7 days) and monthly (12 months).The MapEIre model was developed as an integrated database system focusing on performance optimisation.

The results from the spatial and temporal models can be used by all stakeholders to obtain an impression of where and when the highest levels of emissions occur. This knowledge can be used as input for policymakers with regard to the implementation of environmental policies and measures, and data at this highly detailed level can be used to quantify pressures on vulnerable nature, e.g. Natura 2000 areas.

1 Introduction

This report serves as the final report for the “National mapping of greenhouse gas and non-greenhouse gas emissions sources project” (MapEIre). The project was funded by the Irish Environmental Protection Agency (EPA) and is part of the EPA Research Call 2015 on Climate – Air Science under the EPA Research Programme 2014–2020. The project duration was 24 months plus an extension of 12 months starting in January 2016.

The project was carried out by the Department of Environmental Science at Aarhus University, Denmark, in co-operation with the EPA, in particular the Irish emission inventory team. The project team also liaised with other organisations with relevant data.

The EPA is obligated to report on emissions of a wide range of pollutants that come under the scope of the Clean Air For Europe (CAFE) Directive (2008/50/EC), the Convention on Long-range Transboundary Air Pollution (CLRTAP) and the United Nations Framework Convention on Climate Change (UNFCCC). The scope of the MapEIre project was to develop a model system to provide emissions for all activities and of all pollutants included in these legal agreements with a temporal and a spatial resolution.

Reporting of spatial emissions is a requirement under CLRTAP, with priority given to the pollutants and the activities included in the Convention. Separate spatial distributions were created for each source category based on the best available digital spatial and statistical data, following the guidance under the relevant legal agreements. The spatial distribution is consistent with the European Monitoring and Evaluation Programme (EMEP) grid. Temporal variations were agreed for the source activities at an appropriate resolution, following the format of the EMEP standard temporal distributions.

The spatial and temporal models are based on input data from the current inventories to ensure consistency between the national total emissions in the national emission inventory, the spatial model and the temporal model. Input and output data are in a format that facilitates the input of emissions from the national inventory and further analysis of the outputs.

National stakeholders and inventory experts were involved in the project in order to include knowledge on spatial properties for the activities concerned. Further, the national experts were introduced to the final model system and trained in using it to ensure that the model system is useful to the national emission inventory system.

2 Objectives

The overall objective of the project was to develop models to enable high spatial and temporal resolution of Irish air emission inventories.

A main outcome was the preparation of the official Irish submission of spatial emissions to the United Nations Economic Commission for Europe (UNECE), which was due by 1 May 2017. Additionally, the project aimed to go beyond the official requirements, e.g. by using finer sectoral disaggregation.

The project was divided into the following work packages (WPs) to achieve its objectives:

- WP1: development of specifications for the spatial and temporal models;
- WP2: assessment and selection of geographic data for the spatial model;
- WP3: development of the model for spatial distribution of emissions;
- WP4: development of the model for temporal distribution of emissions;
- WP5: project management and communication.

Additionally, the following WPs were added as part of the project extension:

- WP6: development of a bottom-up inventory for Dublin;
- WP7: updating the spatial model.

In addition to fulfilling the official requirements for reporting under the UNECE, an important objective was to develop a model that could produce high-quality inputs to air quality modelling. This meant a need for high spatial resolution, high temporal resolution and high sectoral disaggregation.

3 Project Results

3.1 Identification of Available Spatial Data

Through a survey of the Irish national emission inventory data and calculation system, the project team identified the relevant sectors and sources and the methodology used in the previous spatial emission mapping. A list was elaborated including spatial data that could be used in the present mapping, at both a detailed level and a more aggregated level. In the first step, the main focus was to prepare a list of spatial data that could be useful, without excluding any data. The number of data sets then decreased as some data turned out to be non-existent or were not available, the quality of some data was too poor and/or for some data more data processing was necessary than could be justified by the benefit of including the data. For example, it is not beneficial to apply very extensive methodologies for minor emission sources. The level of detail to be applied to the mapping methodology was decided after review of the data obtained.

The data survey focused on spatial data covering the entire country with relevance for emission mapping. Both general data, such as on national borders (land and sea area), buildings, population density and land use, and sector-specific data, such as on road networks, including mileage, agricultural areas, including animal numbers, and ferry routes were covered. These data were all used to map emissions from area sources, and the features in the layers were used as proxy data to determine the share of the national total emissions to be allocated to the individual cells in the 1 km x 1 km grid covering Ireland. The resulting tables including shares of national emissions by grid cell were referred to as GeoKeys. For some area sources, there were no closely related spatial data available to use as a proxy for emission mapping, e.g. emissions from domestic solvent use were allocated according to population density, as no data were available to indicate in more detail where product use takes place. For other emission sources, more closely related spatial data were available, e.g. emissions from road transport were allocated to the road network, taking into account information on mileage where available.

The most accurate emission mapping can be carried out for sources that are handled as point sources in the national emission inventory. This was the case, for example, for power plants and large industrial plants, for which annual emissions are available for the individual plants based on Emissions Trading System (ETS) reporting or other plant-specific data. In these cases, emissions were allocated to the exact position (XY co-ordinates) of the plants. For other point sources, emissions are not calculated annually on an individual level, but instead are based on plant-specific data for 1 year or a few years or are provided as a sum for all sources based on aggregated activity data. This was the case for emissions from wastewater treatment plants and solid waste disposal sites, among others.

The first step in identification of the spatial data set was a search for online geodata. The project team analysed relevant institutions' websites to identify which institutions provide publicly available spatial data and to what extent the data can be downloaded. Among the Irish institutions surveyed were Ordnance Survey Ireland (OSi), the GeoDirectory, the Geoportal, Transport Infrastructure Ireland and the Irish Organisation for Geographic Information (IRLOGI). In addition, census data provided by, for example, the Central Statistics Office (CSO), the National Road Authority and Transport Infrastructure Ireland were explored.

The second step was to contact institutions that presented relevant data when these were not publicly available. This included input from meetings with the steering committee, as well as input received during the stakeholder workshop. In all cases, the institutions were very positive and co-operative and, in most cases, it was possible to obtain the relevant data and explanations, in some cases in an aggregated form to comply with confidentiality conditions. See Nielsen and Plejdrup (2017) for more information.

3.1.1 Review and selection of the spatial data sets

Based on the analysis of the available spatial data sets, the best data set for each category was selected. Many factors were considered when selecting the best spatial data set, e.g. whether or not the coverage was sufficient, if the spatial uncertainty was acceptable and if the data format was suitable.

An extended description of the selected geodata and the GeoKey(s) for each of the source/sink categories currently included in the national Irish emission inventories is available in the technical documentation report (Plejdrup *et al*., 2019a) available on the project web page (www.MapEIre.dk). The report includes tables listing the source categories in each sector, with a short description when relevant, and the geodata and methodology used to generate GeoKeys. Further, information is provided on whether the categories cover point sources (P), area sources (A) or both point and area sources (P/A). In some cases, GeoKeys were defined for a group of pollutants when the pollutants have a similar distribution, e.g. across fuels. This was because it is not practicable to have more than 25 different GeoKeys for a sector, with only minor differences between most of the GeoKeys.

The categories that were reported as not estimated in the Irish inventory are included in Plejdrup *et al*. (2019a) to ensure completeness. Where possible, a suggested source of geodata is provided and GeoKeys were developed to the extent that resources allow.

3.2 Model Description

The MapEIre project has developed high-resolution spatial and temporal mapping of the national Irish emission inventory. The work is state-of-the-art and combines a large number of statistical data with detailed spatial information to allow for complete spatial emission mapping at a 1 km × 1 km resolution for the Irish Exclusive Economic Zone (EEZ). The results from the spatial model can be combined with sector-specific temporal profiles to generate a spatio-temporal emission inventory with a temporal resolution of 1 hour. The MapEIre model was developed as an integrated database system focusing on performance optimisation.

The MapEIre model includes all sectors ($n = 138$) and pollutants ($n = 32$) in the national inventories of greenhouse gas (GHG) and non-GHG emissions (Figure 3.1). The MapEIre model enables spatial emission mapping on three sectoral levels – nomenclature for reporting (NFR), gridded nomenclature for reporting (GNFR) and a national total for all sectors – and on two spatial resolution levels: 1 km × 1 km and 0.1 degree × 0.1 degree.

Further, the MapEIre model includes a module that adds a temporal component and calculates spatio-temporal emissions at a spatial resolution of 1 km × 1 km and a temporal resolution of 1 hour. The temporal distribution is based on three levels of temporal profile: hourly (24 hours), daily (7 days) and monthly (12 months) (Figure 3.2).

The MapEIre model is based on the most detailed data available regarding both emissions and spatial and temporal conditions.

3.2.1 *Specifications of the spatial model*

The main purpose of creating a spatial model for the Irish emission inventories was for Ireland to be able to fulfil the requirement under the CLRTAP to report gridded emissions in the agreed reporting format. Therefore, the spatial emission model for Ireland was prepared in agreement with the methodologies in the EMEP/European Environment Agency (EEA) guidebook (EEA, 2016) and the model was designed to fulfil the 2017 requirements for reporting of gridded emissions for the year 2015 in agreement with the guidelines for reporting under the CLRTAP (UNECE, 2014). Further, spatial emissions can serve

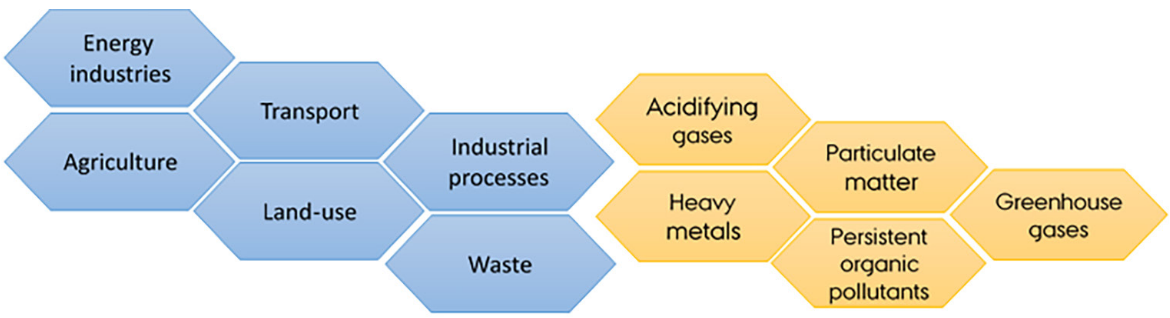


Figure 3.1. Main sectors and pollutant groups included in the MapEIre model.

as valuable inputs to air quality models, but this requires a rather high spatial resolution. Therefore, the spatial emission model for Ireland was prepared on a higher spatial resolution than required for reporting to the CLRTAP.

The spatial emission model is based on various Irish spatial data sets and, for ease of use, the common Irish projection TM65 (EPSG 29902) was applied in the model instead of the geographic co-ordinate system (WGS84) used by EMEP. The CLRTAP requirement is a spatial resolution of 0.1 degree × 0.1 degree, which corresponds to approximately 7 km × 11 km. However, the model was prepared with a spatial resolution of 1 km × 1 km to increase the level of detail. The higher spatial resolution was agreed as more spatial data sets were available at a higher resolution and as the higher spatial resolution means that the spatial emission inventory is applicable as an input to air quality modelling at the national level. Further, it was convenient to have a grid with orthogonal cells of the same scale all over the grid, in this case 1 km both longitudinally and latitudinally, as emissions do not have to be normalised in order to generate easily understandable maps, as output from the spatial emission model will be emissions per km^2. As both the projection and the spatial resolution of the grid differ from the CLRTAP reporting requirements, a module was included in the spatial model to convert from the 1 km × 1 km Irish grid to the 0.1 degree × 0.1 degree EMEP grid (Table 3.1).

Gridded emissions reported to the CLRTAP are aggregated at a sectoral level defined by the GNFR sectors. The sectoral split in the spatial emission model for Ireland is, for the main part, more

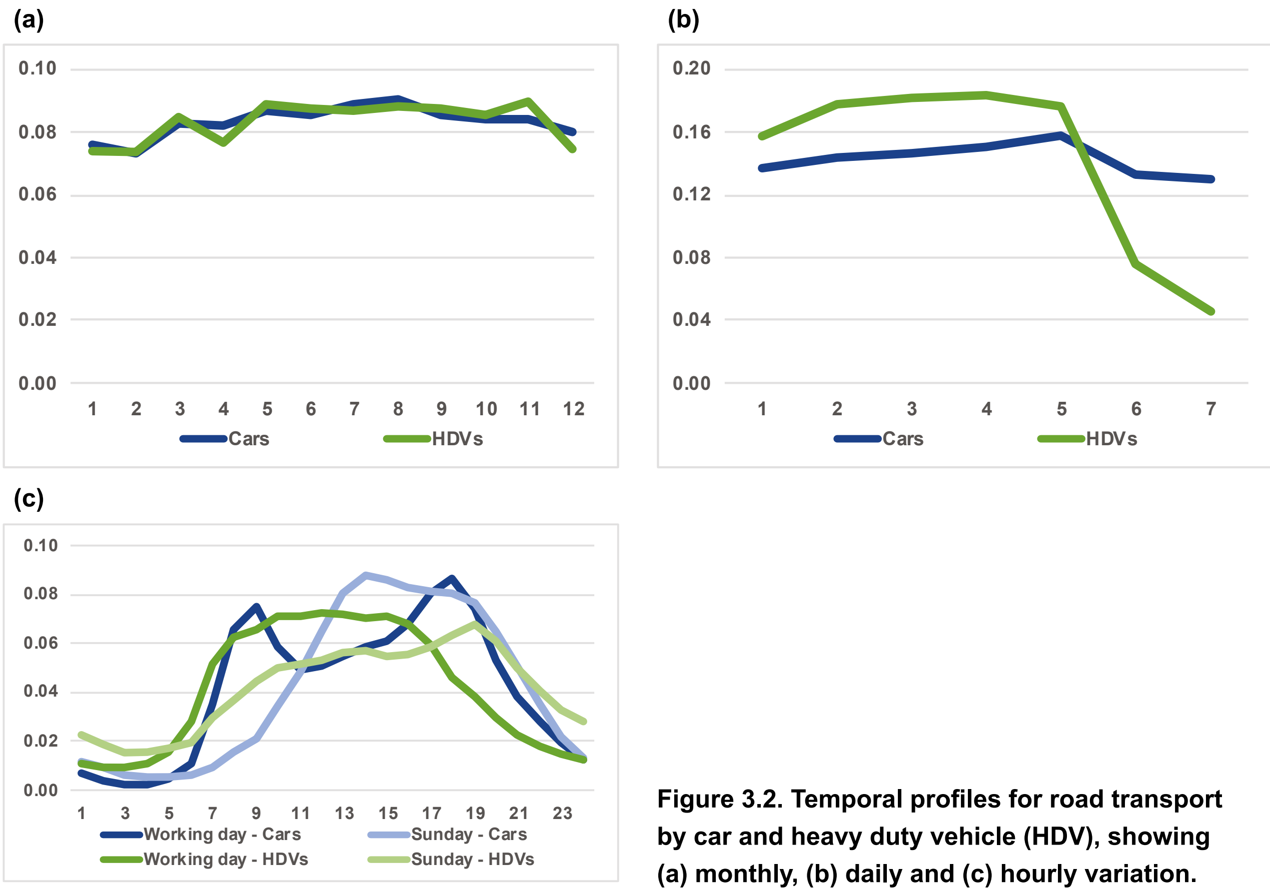


Figure 3.2. Temporal profiles for road transport by car and heavy duty vehicle (HDV), showing (a) monthly, (b) daily and (c) hourly variation.

Table 3.1. Comparison between the requirements under the CLRTAP and the spatial model

	Resolution	Projection	Sectoral level
CLRTAP	0.1 degree × 0.1 degree	Geographic co-ordinate system, WGS84 (EPSG 4326)	GNFR
Irish model	1 km × 1 km	Projected co-ordinate system, TM65 (EPSG 29902)	NFR, with disaggregation for selected sectors

disaggregated than the GNFR level. The details of the available spatial data were the determining factor in selection of the sectoral disaggregation level. In a number of cases it was appropriate to use the sectoral level defined by the NFR categories, which are used for reporting national emission to the CLRTAP. For some sources it was advantageous to disaggregate the emissions further to create the most accurate spatial distribution, again depending on the availability of detailed spatial data. This was the case for residential heating, for which it was found to be beneficial to make different GeoKeys depending on the type of fuel. The NFR format is prepared for reporting emissions of air pollutants. As the spatial emission model for Ireland covers both air pollution and GHGs, not all sources are included in the NFR categories. This is the case for the land use, land use change and forestry (LULUCF) sector, several categories within agriculture, i.e. enteric fermentation, liming and urea application, and categories related to emissions of fluorinated gases. These categories were added to the spatial model to ensure complete coverage of all anthropogenic emissions. As the sectoral level in the spatial model differs from the CLRTAP reporting requirements, a module was included in the spatial model to aggregate the spatial emissions according to GNFR level.

As UNECE (2014) does not include guidance on national sea territory, the EEZ was used as the outer border for the spatial emission model for Ireland. For more information, see Nielsen and Plejdrup (2016).

Choice of data for the EEZ, coastline and national border

Outer borders for the land area and sea area included in the spatial model were defined, and appropriate spatial data sets were chosen for use in creating spatial distribution keys (GeoKeys). The included land area was defined by the coastline and the national border between the Republic of Ireland and Northern Ireland (UK), which are both available in different versions and from different data providers. The coastline chosen was that provided by the EPA in the spatial data set “ADMIN_CoastPolyline”. The border with Northern Ireland included in the spatial model was based on the 2011 census by the CSO at constituency level, included in the spatial data set “Census2011_Constituencies_2013.shp”, following advice from the EPA, as small discrepancies are detected between spatial census data sets at different levels, e.g. small areas, garda districts and constituencies. International guidelines on emission inventories and gridded emissions do not include guidance on definitions of the national sea area, so this must be decided individually by different countries. The EEZ was chosen as the outer border for the spatial model, and the version provided by the Department of Communications, Energy and Natural Resources (DCENR) was applied. This version deviates from the version available from MarineRegions.org.

A 1 km × 1 km grid was developed for the spatial emission model, using the standard tool “Create Fishnet” in ArcMap, using the projection TM65 (EPSG 29902). The fishnet was created so that the corners of the grid cells follow the 1000-m *x*-axis and *y*-axis. The extent and resolution of the fishnet are defined by the parameters included in Table 3.2.

Using the calculate geometry tool in ArcMap, X and Y co-ordinates were applied to each grid cell for the centrepoint (Xc and Yc). The grid cells were named according to the location of the lower left corner and the grid resolution, IE_1km_±Y_±X, where ±Y and ±X are the Y and X co-ordinates rounded down to the nearest full kilometre [e.g. the point (–296 713.384, 158 922.683) was given the grid identifier 1km_158_–297]. By using a name convention based on the X and Y co-ordinates, it is easy to apply grid cell names to point sources, which are defined by their exact location (X,Y), and then to summarise emissions from point sources and area sources per grid cell without using a geographic information system (GIS).

It was very important that the models developed within this project were easily compatible with the data systems used by the emission inventory team at the EPA. Currently, the calculation of emissions is based on a series of Microsoft Excel spreadsheets covering

Table 3.2. Fishnet parameters

Extent	Bottom: −345,000 m
	Top: 630,000 m
	Left: −360,000 m
	Right: 385,000 m
Resolution	Width: 1000 m
	Height: 1000 m
Size	Number of rows: 975
	Number of columns: 745

different pollutants, sectors or both. In addition, the final reporting formats are available, i.e. the NFR and the common reporting format (CRF) tables.

The reporting formats are believed to be very stable and hence it was beneficial to base the input to the spatial model on the reporting formats as far as possible. Therefore, the aim was to base the input on the official reporting formats and to include any spatial variations within the reporting categories in the development of the GeoKeys. For further information see Nielsen and Plejdrup (2016).

3.2.2 Specifications of the temporal model

Currently, temporal distribution in the EMEP model is carried out at a very coarse level, e.g. considering all non-road transport and mobile machinery as one source with the same temporal profile. This is deemed to be insufficient and therefore temporal profiles were defined at the emission reporting level, e.g. separately for railways, aviation, navigation and machinery, in different sectors.

Temporal profiles were developed at three levels, as in the current set-up in the EMEP model, i.e. monthly, weekly and daily variations. For further information see Nielsen and Plejdrup (2016).

3.2.3 GeoKeys

The spatial distribution of emissions was based on a large number of GeoKeys, which are tables including information on the part of a national emission that should be allocated to the individual grid cells. The GeoKeys are normalised tables in which emission shares sum to 1. GeoKeys were prepared either from statistical data in spreadsheets or in a GIS based on digital spatial data. Among the data used in the MapEIre model are official statistics, such as the Irish emission inventory and censuses of population, housing and agriculture. Spatial data sets as diverse as land cover, road networks, building use and heat demand were used to prepare the GeoKeys.

Data integration

Integration of spatial data sets can improve spatial distribution and was used to a wide degree in creating the MapEIre model (Plejdrup *et al.*, 2018). Using data integration makes it possible to include detailed data covering only part of an emission sector, to prepare combined GeoKeys, e.g. for sectors with both point and area sources, and to combine information from different types of data, such as regional statistics and spatial maps, in GeoKey, e.g. mileage data for a part of the road network was integrated with a simple road network covering the entire domain to generate GeoKeys for road transport. Another example is identification of cultivated organic soils through integration of the Land Parcel Identification System (LPIS) and a soil map including organic soils.

GeoKeys were prepared from the most detailed, complete and accurate data available, with the best data being data on source level. Pollutant- and/or year-specific GeoKeys were prepared for sectors if detailed emissions or activity data were available, e.g. data from Pollutant Release and Transfer Register (PRTR) reporting or information provided by individual plants, facilities or companies. If less detailed data were available, the sectoral GeoKeys were used for all pollutants and/or for all years, resulting in similar spatial emission patterns for the sector for all pollutants and/or all years included in the model. This is probably not the case but is a necessary assumption in the spatial emission model because of data limitations.

A number of GeoKeys are a combination of two or more sub-sector keys. When a NFR sector covered both point sources and area sources, e.g. non-ferrous metals (NFR category 1A2b), for which 85% of the emissions were covered by point sources, a GeoKey was prepared from the point source data. The remaining emissions from the sector were allocated using a spatial distribution based on more general data, e.g. heat demand for industrial buildings. The sectoral GeoKey was calculated as an average of the two spatial distributions, weighted by the share of emissions from point sources and area sources, respectively (Plejdrup *et al.*, 2018).

If source-specific data were not available, spatial proxy data were used to prepare the GeoKeys, preferably at a sector level; however, in cases in which no spatial sector-specific data exist or in which no data were available, the GeoKeys were based on general spatial data, e.g. buildings, heat demand or population. Even if general GeoKeys were prepared from detailed, complete and accurate spatial data, their appropriateness as a proxy for a given emission sector might be poor, which is often the case when population density is used as a proxy.

In other cases, GeoKeys were based on spatial data that served as a good proxy, but that were poor regarding accuracy or spatial resolution or that were out of date, an example being the use of catching statistics by International Council for the Exploration of the Sea (ICES) areas as a proxy for emissions from fishing, because of the low spatial resolution of the spatial data. Another example is the use of CORINE land cover maps to prepare GeoKeys for the LULUCF sector. These satellite-based pan-European maps have considerable uncertainties when applied on a national scale regarding the geographic demarcation of features and assigned land use category.

All GeoKeys are documented in the technical documentation report (Plejdrup *et al*., 2019a). An example of the documentation of the GeoKeys is provided for railways in Table 3.3.

3.2.4 TKeys

The temporal distribution of emissions is based on a large number of temporal distribution keys (TKeys), which are tables including information on the parts of national emissions that should be allocated to the individual time intervals. The TKeys are normalised tables in which emission shares sum to 1.

Temporal variations in emissions occur on a monthly, daily and hourly basis, based on, for example, production, use and transport patterns. The time factors are highly variable from emission source to emission source, and variability is expected between pollutants.

The temporal model includes temporal distribution profiles at monthly, daily and hourly levels. The emission source aggregation level in the temporal model depends on the availability of statistical data with a temporal component. A number of statistics were available on a monthly basis, but temporal data at the daily and hourly levels were generally scarce, so it was necessary to use data for smaller areas, use proxy data from other countries or base the temporal profiles on expert judgement, in order to prepare TKeys for all sectors.

Three temporal profiles were prepared for each emission source category in the spatial model describing the monthly, daily and hourly distributions. For selected emission sources, separate hourly TKeys were prepared for different days of the week, where weekday 1 refers to Monday. An example is road transport, for which separate hourly TKeys were prepared for Monday (weekday 1), Tuesday–Thursday (weekdays 2–4), Friday (weekday 5), Saturday (weekday 6) and Sunday (weekday 7) (Plejdrup *et al*., 2020). In other cases, separate TKeys were prepared for different pollutants for an emission source category, as the emissions were related to different activities or processes. This was the case for domestic wastewater handling, for which two separate TKeys were prepared for N_2O and for the remaining pollutants.

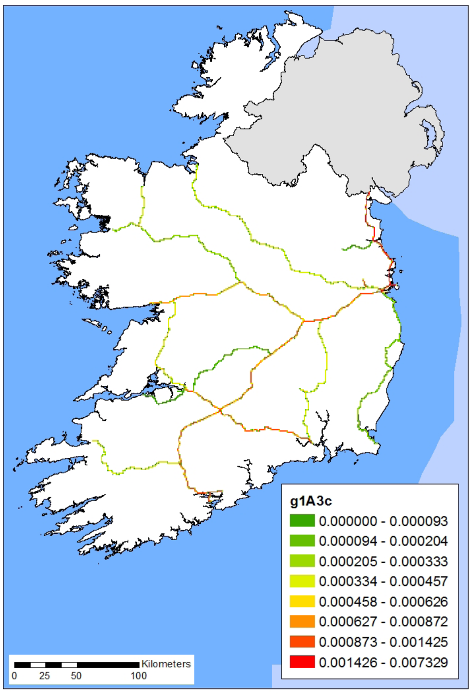
TKeys were developed to reflect the distribution of emissions from a source on a given temporal level (months, days or hours). The temporal distribution was based on different kinds of temporal data and information, e.g. monthly electricity output, hourly traffic counts, and assumptions such as shutdown or reduced activity levels at weekends for specific industries. Some of the temporal input data were closely related to the emissions, e.g. electricity output, as fuel consumption, and to a certain degree also emissions, were correlated with electricity production. Others are poorer proxies, e.g. number of trains by route determined from timetables, as the trains might be of different types. Further, neither activities at service and shunting areas nor freight trains were covered in the timetables, but they contribute significantly to emissions.

To improve the quality of the temporal distribution, TKeys should be prepared at a disaggregated sectoral level, so the sectoral properties can be reflected in as detailed a manner as possible. For example, separate TKeys should be prepared for different animal types in the agricultural sector and for different vehicle types for road transport. In some cases, it could be of benefit to prepare separate TKeys for different pollutants for a sector, as pollutants might result from different activities or processes. This is, for example, the case for domestic wastewater handling, where N_2O shows a seasonal variation with water temperature, whereas the same correlation is not found for CH_4.

The temporal model uses the TKeys for the entire Irish domain and it is therefore not possible to reflect regional differences using the temporal emission distribution. Including a spatial parameter in the temporal model would increase the number of data significantly and, for many sectors, it would be of no or little relevance, as the TKeys are based on proxies for national characteristics. A few sources could benefit from including a spatial parameter in the temporal

Table 3.3. Documentation of the GeoKey for railways

Source data	IR Network and 2016 Traffic ((2016 05 24)(RevA).pdf)
	IR_Rail_Network_LineNames_20161219
Data provider	Irish Rail
File location	\\MapEIre\DataLibrary\Rail\IR Network and 2016 Traffic (2016 05 24)(RevA).pdf
	\\MapEIre\DataLibrary\Rail\Rail.mdb
Projection	ING-75 (Authority: Custom) (corresponds to TM75_Irish_Grid, EPSG: 29903)
Data description	Annual train passages on different sections of the network for 2011 and 2016
	Centre lines for the Irish Rail track network
Workflow	The rail network layer is modified by deleting the coastline segments and adding the length of the rail network by route
	Annual train passages in 2016 [ATP_2016] are added to the routes in the rail network layer. Only one ATP is applied for each route, and for routes where more ATP values are available the selection of ATP will be based on expert judgement, but, in general, the highest ATP value will be applied
	Annual train kilometres are calculated by route ([ATP_2016]*[Length]) and the share of total train kilometres is calculated by route ([ShrATP16xL])
	Add field "ATPxLen16" and calculate value as [ATP_2016]*[Length]
	Add field "ShrATP16xL" and calculate values as [ATPxLen16]/SumOf[ATPxLen16], with the latter calculated using the statistics tool
	The share of the total rail network length is calculated by grid cell ([LenPrRoute])
	The GeoKey shares are calculated as [ShrATP16xL]*[LenPrRoute]
GeoKey	1A3c
NFR/CRF sector	1A3c – Railways



model, e.g. agricultural soils, for which different practices occur in different parts of the country, and road transport, for which the temporal pattern is different in large cities, along commuting routes and in rural areas.

More documentation on the development of TKeys is provided in Plejdrup *et al*. (2019a). An example of the documentation for public electricity production is provided in Table 3.4.

Table 3.4. Documentation of the TKey for public electricity production

GNFR	A		
NFR/CRF	1A1a		
Pollutant	All		
Temporal resolution	Monthly	Daily	Hourly
Weekday			Monday–Saturday
			Sunday
Input data	MSM01: Electricity Output by State, Month and Statistic	Electricity generation excluding wind	Electricity generation excluding wind
	Net electricity output (GWh)	Hourly actual electricity generation (MW)	Hourly actual electricity generation (MW)
Data provider	CSO	EirGrid	EirGrid
Data source	https://www.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?maintable=MSM01&PLanguage=0	http://smartgriddashboard.eirgrid.com/	http://smartgriddashboard.eirgrid.com/
Description	Average monthly net electricity output for the years 2010–2017	Average electricity generation excluding wind by weekday	Average electricity generation excluding wind by hour for Monday–Saturday and Sunday

3.2.5 Dublin

As part of the extension of the MapEIre project, a detailed case study was made for Dublin. The spatial model was extended with a module for Dublin, in which the spatial resolution was increased to 100 m × 100 m. The Dublin model covers the following pollutants: nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), SO_2 and particulate matter (PM_{10}). The higher spatial resolution improves the applicability of the spatial emissions as a basis for air quality modelling. Further, the Dublin data provide a better opportunity for comparison with measurements of air quality for verification of the model.

The Dublin case model was designed in a similar format to the national model, and the model set-up allows an easy extension of the model to include gridding of all pollutants in the Irish emission inventories. All GeoKeys were recalculated, based on the original spatial data sets used in the national model, to ensure the highest level of spatial details possible. The best available spatial data were used in the national model, e.g. detailed point source data for large point sources, and therefore the Dublin case model is based on the same spatial data as the national model.

3.3 Main Outputs

Detailed spatial emission inventories on a resolution of 1 km × 1 km were developed for all major pollutants. The detailed sectorial breakdown in the model set-up enables implementation of detailed GeoKeys, and estimates of the emission patterns have the potential to enable emission hotspots and peak hours to be identified.

3.3.1 Spatial

The output from the spatial model was aggregated to the national total emissions as well as to the main sectoral emissions following the EMEP classification. The output is available on the project website both as images and as data files for further processing in a GIS (http://projects.au.dk/mapeire/spatial-results/download/). Maps showing the national total emissions of selected pollutants are provided in Figure 3.3.

The largest sources of emissions of $PM_{2.5}$ are residential plants, agriculture and road transport; they are clearly visible on the map in large urban areas and, to a lesser degree, along the major roads.

The largest sources of emissions of CO_2 are power plants, road transport and residential combustion, and hence the map is dominated by point sources, the road network and urban areas. Both CO_2 emissions and removals are included in the national total. The major part of removals occurs in forest areas, which are also visible on the map.

National total NO_x emissions are dominated by road transport, power plants, industry and shipping, which

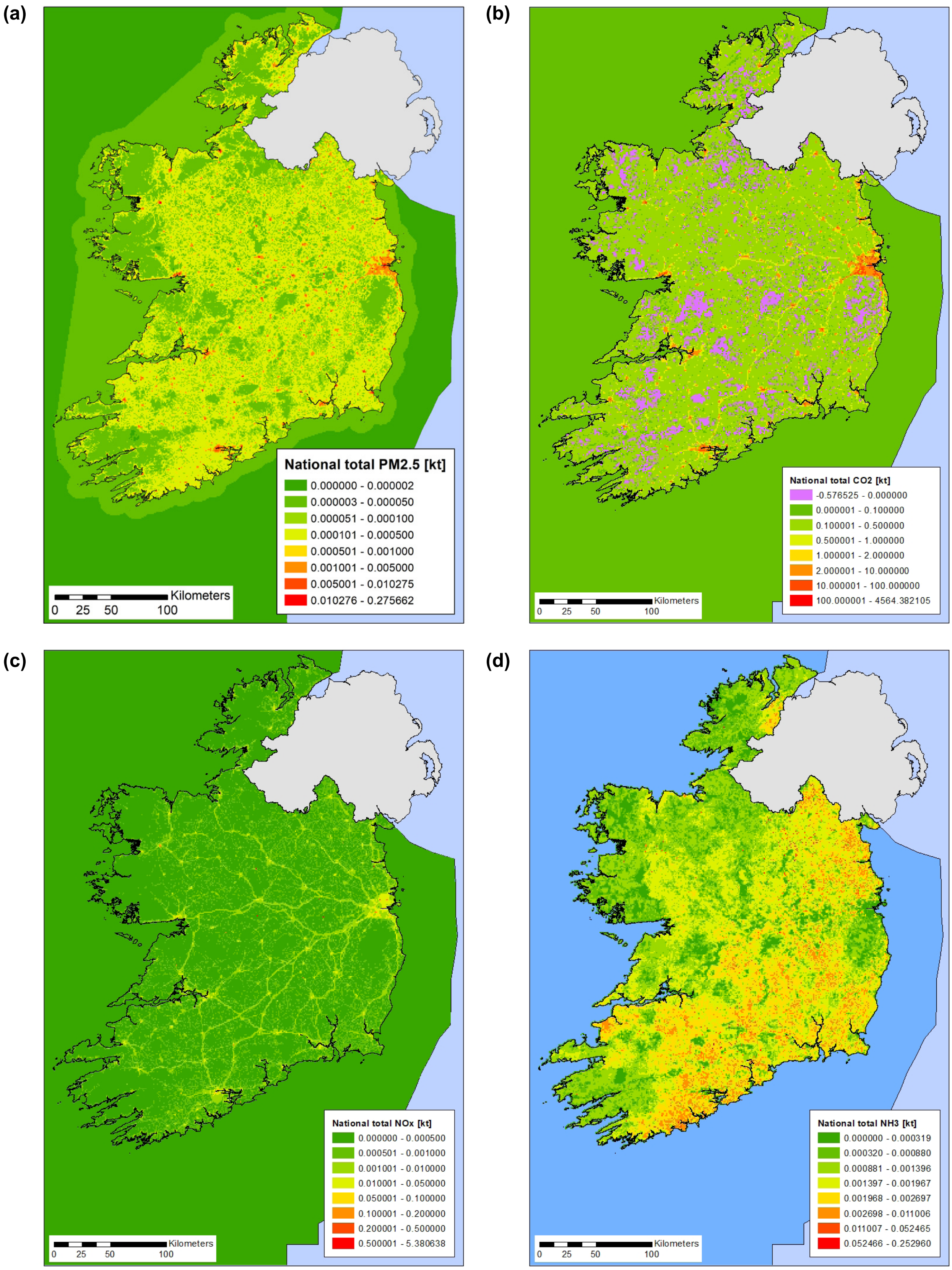


Figure 3.3. Spatial emission maps for national total emissions of (a) $PM_{2.5}$, (b) CO_2, (c) NO_x and (d) NH_3.

is reflected in the emission map, which shows high emission levels along major roads and in densely populated areas. Emissions from power plants are allocated to point source locations and, because of the high spatial resolution of the emission model, are not clearly visible on the map.

Emissions of NH_3 mainly come from the agricultural sector. The largest sources are cattle, manure applied to soils, grazing animals and mineral fertiliser. The pattern on the map basically reflects animal density and agricultural areas. No NH_3 emissions occur from water-based sources.

The map of CO_2 emissions from road transport reflects the major roads in the road network (Figure 3.4). The railway network is visible on the map of NO_x from off-road mobile sources, as this source makes a significant contribution to the sectoral emission, and as the emission levels are high because of allocation to a relatively small area. NH_3 emissions from agricultural livestock mainly come from manure management of cattle and the spatial distribution is based on animal numbers by electoral district and the areas with agricultural fields.

Previously published projects on the spatial distribution of emissions in Ireland were carried out at a resolution of 10 km × 10 km (de Kluizenaar *et al.*, 2001; AEA, 2012) and the official submissions were carried out at a resolution of 50 km × 50 km. The MapEIre project increased the resolution to 1 km × 1 km to improve usability for air quality modelling and to allow for more detailed regulations implementing measures targeting areas where the emissions are highest, resulting in more cost-effective initiatives. Development of a national spatial emission model covering the entire country allows assessment of the effects of measures at local, regional and national scales. The MapEIre project has made comparisons between the previous Irish spatial emissions and the new higher resolution emissions to illustrate the increased accuracy that can be gained by changing to a higher resolution.

Using data at a more disaggregated level and a higher spatial resolution results in a more detailed spatial emission mapping with higher accuracy, when based on appropriate background data. The improvements from the coarse 50 km × 50 km resolution spatial inventory to both the 10 km × 10 km and the 1 km × 1 km resolution spatial inventories are significant, especially for NO_x, SO_2 and $PM_{2.5}$. See Plejdrup *et al.* (2019b) for further information.

3.3.2 Temporal

For each of the sectors and pollutants covered by the spatial model, temporal profiles were developed. The temporal profiles were made at three levels: monthly, daily and hourly. To reflect as many details as possible, the temporal profiles were prepared at the sector level and, when relevant, separate profiles were prepared for different pollutants or weekdays, e.g. for wastewater and for road transport, respectively.

The TKeys are available for download on the project web page (http://projects.au.dk/mapeire/temporal-results/temporal-profiles/).

Calculation of the entire Irish emission inventory at high spatial and temporal resolution would result in a very large number of data, which would be difficult to handle by the common user. To solve this issue and to ensure good model performance, the temporal model was set up to run the calculation for a user-defined time period, emission sector and pollutant, e.g. $PM_{2.5}$ from residential combustion in March 2016.

An appropriate way to visualise the temporal emissions is by using videos. The temporal model was set up to generate output in a format that can be used in a GIS (ArcMap) to make hourly emission maps, which can be processed into a video. Examples of videos are available for download on the project web page (http://projects.au.dk/mapeire/temporal-results/).

3.3.3 Dublin

The Dublin case study is methodologically very similar to the national model but, because of the improved spatial resolution, the emission maps show different patterns. Further, the sectoral contributions to the total emissions are different for Dublin and for Ireland, as shown in Figure 3.5. The contribution to NO_x emissions from road transport and other stationary combustion (mainly residential combustion) is larger in Dublin than in Ireland, whereas the contribution from navigation and agriculture is smaller. Industry and road transport make larger contributions to the total PM_{10} emissions in Dublin than in Ireland. Emissions from shipping, which make up a significant share of the national PM_{10} emissions, do not occur in the Dublin model, as the coverage is of the land area. Solvent use is the dominating sector in the Dublin NMVOC emissions, whereas livestock dominates the national total NMVOC emissions. In both the national model and the Dublin model, emissions from industry contribute significantly, and part of the emissions are allocated to specific point source locations, in this

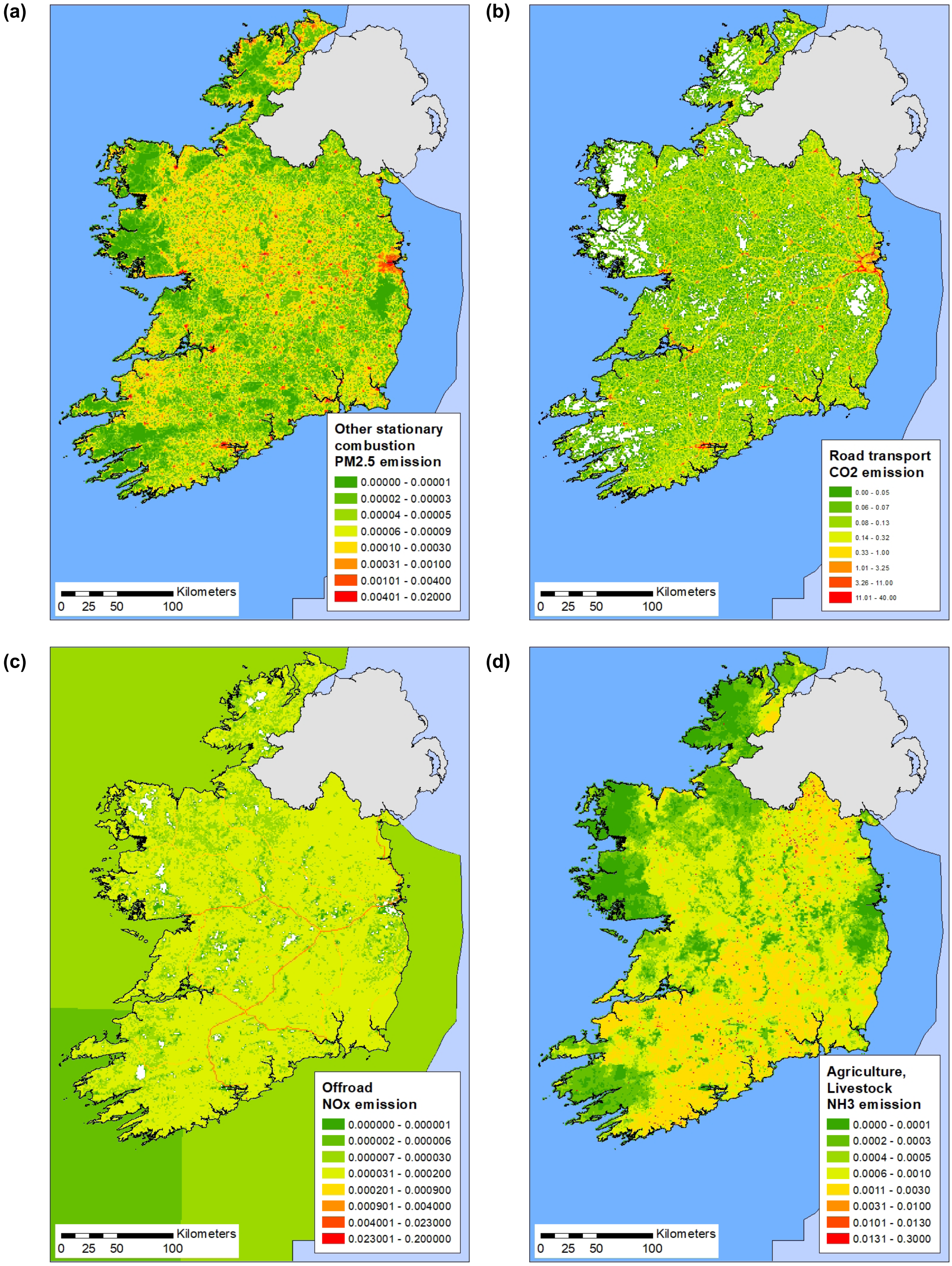


Figure 3.4. Spatial emission maps for (a) $PM_{2.5}$ from residential combustion, (b) CO_2 from road transport, (c) NO_x from off-road mobile sources and (d) NH_3 from agricultural livestock.

case among six industrial plants in Dublin. Other stationary combustion (mainly residential) is a large source of SO_2 emissions both at the national level and in Dublin. At the national level, power plants and fugitive emissions also make up large sources, which is not the case in Dublin.

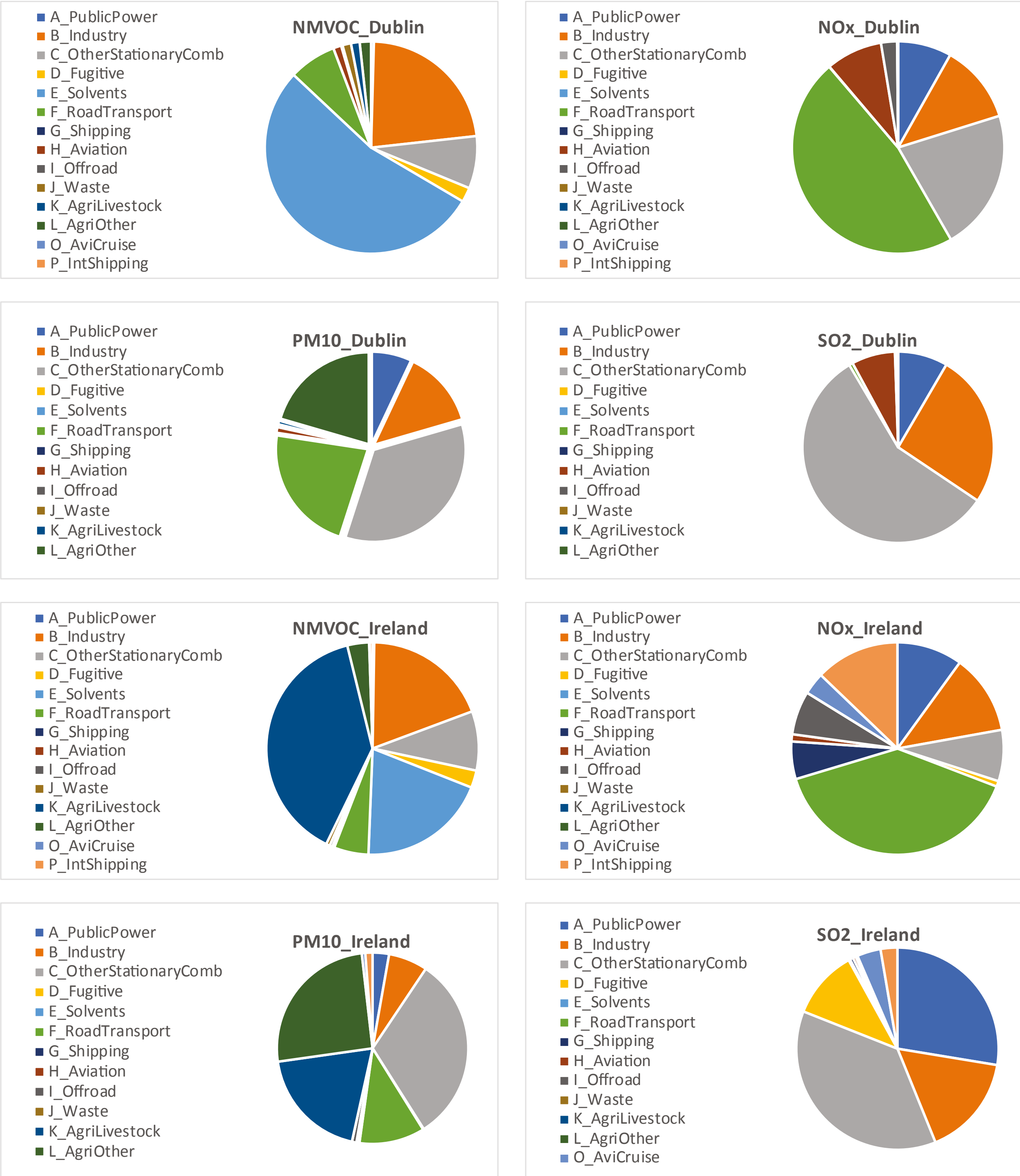


Figure 3.5. Sectoral contributions to the total emissions for Dublin and for Ireland for the pollutants NMVOCs, NO_x, PM_{10} and SO_2.

Figure 3.6 shows maps of total emissions in Dublin for selected pollutants. The road network is identifiable on the NO_x map, as road transport is a dominant sector for NO_x emissions. The NMVOC map shows that emissions are highest in densely populated areas and in industrial areas.

Using the 100 m × 100 m grid in the Dublin model left many grid cells without emissions, as these areas have no emission activity for a given sector. This was apparent on both maps showing sectoral emission results from the Dublin model (Figure 3.7), in which large areas are visible with no emissions from road transport and industry.

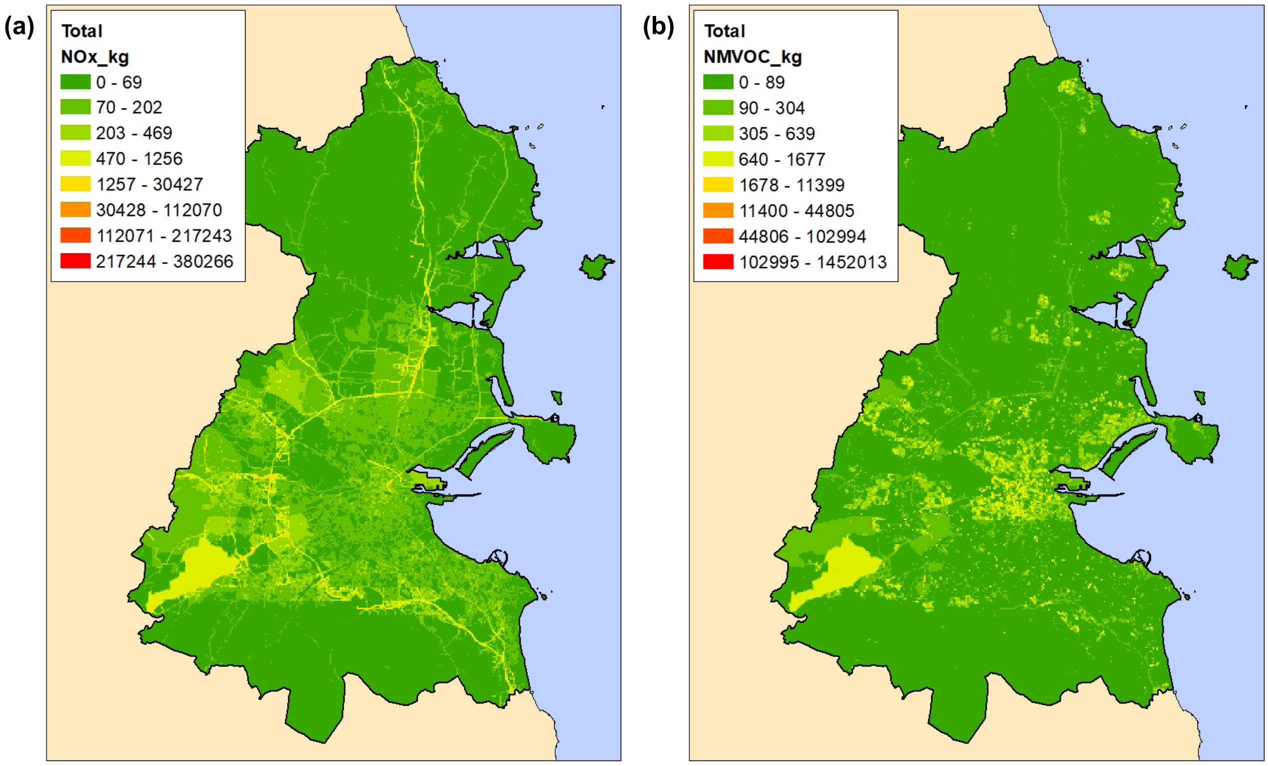


Figure 3.6. Spatial emission maps for Dublin for (a) NO_x and (b) NMVOCs.

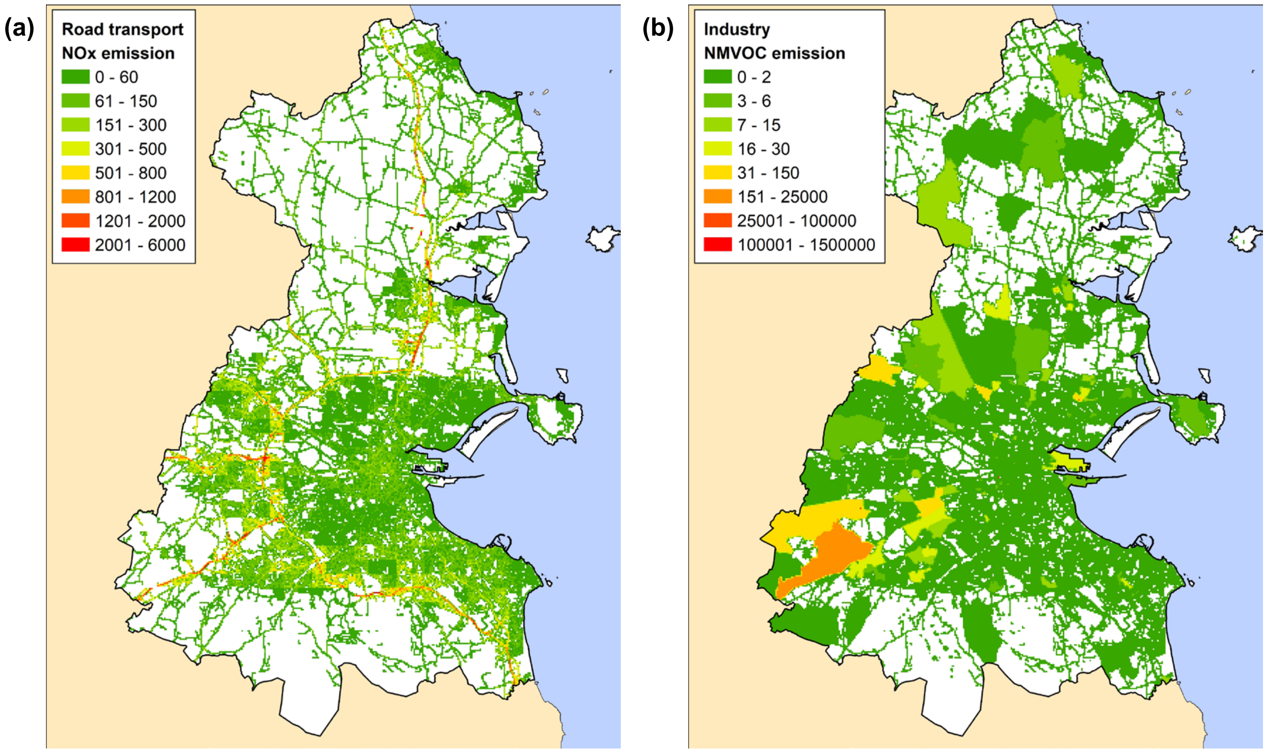


Figure 3.7. Spatial emission maps for Dublin for (a) NO_x from road transport and (b) NMVOCs from industry.

4 Communication Activities

The MapEIre project activities and results have been documented in a number of papers, reports and presentations. The main communications are listed in the following sections and are available for download from the project web page (http://projects.au.dk/mapeire/publications/).

4.1 Papers

- Plejdrup, M.S., Nielsen, O.-K. and Bruun, H.G., 2018. Spatial high-resolution mapping of national emissions. *WIT Transactions on Ecology and the Environment: Air Pollution XXVI* 230: 399–408.
- Plejdrup, M.S., Nielsen, O.-K. and Bruun, H.G., 2019. Influence of improved methodology and increased spatial resolution on gridded emissions. *International Journal of Environmental Impacts* 2: 161–173.
- Plejdrup, M.S., Nielsen, O.-K., Bruun, H.G. and Christensen, J.H. Temporal variations in road transport emissions as input to air quality modelling. *Atmospheric Environment*. Submitted.

4.2 Abstract

- Abstract presented at the European Forum for Geography and Statistics (EFGS) Conference in Dublin, 2–3 November 2017.

4.3 Reports

- Two-page summary report.
- Technical documentation report.
- User manual.
- WP1 synthesis report.
- WP2 synthesis report.

4.4 Presentations

- 10th EFGS Conference, Dublin, 2–3 November 2017.
- 11th FAIRMODE Plenary Meeting, Baveno, Italy, 2018.
- 26th International Conference on Modelling, Monitoring and Management of Air Pollution, Naples, Italy, 2018.
- First stakeholder workshop, Dublin, 2016.
- Second stakeholder workshop, Dublin, 2018. Presentation of the project
- Second stakeholder workshop, Dublin, 2018. Presentation of the spatial model, the temporal model, and data availability and future applications

4.5 Other Publications

- Pamphlet, November 2017.

5 Recommendations

The MapEIre model is state-of-the-art; it leaves room for improvement by the application of new spatial and temporal data and by further development and refinement of the model set-up. Both the spatial and the temporal model can be improved by developing more detailed distribution keys. The spatial model can be improved by including time series for more GeoKeys, whereas the temporal model can be improved by use of more detailed profiles for the sectors for which the present TKeys are based on expert assumptions. If data availability allows, it could be relevant to evaluate if pollutant-specific TKeys should be made for more sectors, and if more sectors should have different hourly profiles for different days of the week.

In future work, the emphasis should be on refining methodologies as a further increase in resolution is unlikely to improve the accuracy of the spatial inventory, as very few data sets are available to support a resolution of, for example, 100 m × 100 m.

The results from the spatial and temporal models can be used by all stakeholders to provide an impression of where and when the highest emissions occur. This knowledge can be used as input for policymakers in decisions around implementation of environmental policies and measures, and data at this highly detailed level can be used to quantify pressures on vulnerable natural resources, e.g. Natura 2000 areas.

References

AEA Technology, 2012. *Mapping Methods for Gridded Data*. Unpublished.

de Kluizenaar, Y., Aherne, J. and Farrell, E.P., 2001. Modelling the spatial distribution of SO_2 and NO_x emissions in Ireland. *Environmental Pollution* 112: 171–182. https://doi.org/10.1016/S0269-7491(00)00120-2

EEA (European Environment Agency), 2016. *EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016*. Available online: https://www.eea.europa.eu/publications/emep-eea-guidebook-2016 (accessed 6 March 2020).

Nielsen, O.-K. and Plejdrup, M.S., 2016. *National Mapping of GHG and Non-GHG Emissions Sources – Synthesis Report for Work Package 1*. Department of Environmental Science, Aarhus University, Aarhus, Denmark.

Nielsen, O.-K. and Plejdrup, M.S., 2017. *National Mapping of GHG and Non-GHG Emissions Sources – Synthesis Report for Work Package 2*. Department of Environmental Science, Aarhus University, Aarhus, Denmark.

Plejdrup, M.S., Nielsen, O.-K. and Bruun, H.G., 2018. Spatial high-resolution mapping of national emissions. *WIT Transactions on Ecology and the Environment: Air Pollution XXVI* 230: 399–408.

Plejdrup, M.S., Bruun, H.G., Nielsen, O.-K. and Gyldenkærne, S., 2019a. *National Mapping of GHG and Non-GHG Emissions Sources – Documentation of the Spatial and Temporal Emission Model for Ireland. Technical Documentation Report*. Department of Environmental Science, Aarhus University, Aarhus, Denmark.

Plejdrup, M.S., Nielsen, O.-K. and Bruun, H.G., 2019b. Influence of improved methodology and increased spatial resolution on gridded emissions. *International Journal of Environmental Impacts* 2: 161–173.

Plejdrup, M.S., Nielsen, O.-K., Bruun, H.G. and Christensen, J.H., 2020. Temporal variations in emission from road transport. Submitted.

UNECE (United Nations Economic Commission for Europe), 2014. *Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution*. ECE/EB.AIR/125. United Nations, Geneva, Switzerland.

Abbreviations

CLRTAP	Convention on Long-range Transboundary Air Pollution
CRF	Common reporting format
CSO	Central Statistics Office
EEZ	Exclusive Economic Zone
EFGS	European Forum for Geography and Statistics
EMEP	European Monitoring and Evaluation Programme
EPA	Environmental Protection Agency
GeoKey	Spatial distribution key
GHG	Greenhouse gas
GIS	Geographic information system
GNFR	Gridded nomenclature for reporting
LULUCF	Land use, land use change and forestry
NFR	Nomenclature for reporting
NMVOC	Non-methane volatile organic compound
NO_x	Nitrogen oxides
$PM_{2.5/10}$	Particulate matter
TKey	Temporal distribution key
UNECE	United Nations Economic Commission for Europe
WP	Work package

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d’earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d’Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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MapEIre: National Mapping of Greenhouse Gas and Non-greenhouse Gas Emissions Sources Project

epa Research
Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

Authors: Ole-Kenneth Nielsen, Marlene S. Plejdrup, Henrik G. Bruun, Steen Gyldenkærne and Jesper H. Christensen

This research developed a state-of-the-art integrated model system to map emissions for Ireland's emission inventories of air pollutants and greenhouse gases. Based on a variety of spatial and statistical data, the MapEIre model produced detailed spatial emissions at a resolution of 1 km × 1 km. The MapEIre model also includes a temporal module that enables the addition of a temporal parameter with a resolution of 1 hour. The detailed sectoral breakdown in the MapEIre model facilitates the identification of emission hotspots and peak hours.

Identifying Pressures

Emissions of air pollutants and greenhouse gases influence the local air quality and the global climate, both of which affect the public. It is crucial to be able to identify the largest emission sources, hotspot locations and peak hours to be able to identify proportions of pressures. This research has produced the first spatial and temporal high-resolution data to allow for a better understanding of exposure to air pollution.

Informing Policy

Regulation of local and national emissions is important to improve air quality and reduce effects on the climate. Spatio-temporal emission mapping is an important tool for targeting measures and documenting improvements over time. Identifying emission hotspots and peak hours allows policymakers to target the regulations and thereby optimise the cost–benefit of measures. The results of this project can help to inform the work on Ireland's Clean Air Strategy.

Developing Solutions

Developing cost-effective policies and measures depends on the existence of detailed data on spatial and temporal emissions. Knowledge of national and local circumstances is crucial for the preparation of accurate spatio-temporal emissions, which favour the use of national or local models rather than existing regional or global models. Detailed spatial and statistical data should be used as the basis for models to provide the most accurate picture of national and local conditions. Basing policies on less detailed general models constitutes a risk that the measures are not being targeted optimally.

The MapEIre model set-up focuses on user-friendliness, being easy to update as new data become available, such as emissions data, spatial data or temporal data, and thereby provides a useful tool for policymakers. The findings from this research suggest the need to:

- target mitigation actions at areas with significant emissions;
- continuously improve the emission inventories, as well as the spatial and temporal models, to ensure a good basis for developing policies and measures;
- further develop an integrated system in Ireland using the results of this project for air quality modelling and exposure modelling.

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