Category		Title
GG		General guidance
		Spatial emissions mapping
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1 Introduction

Sub-national spatial emissions are increasingly important because:

- reported spatial emissions data are an important input for models used to assess atmospheric concentrations and deposition, as the spatial location of emissions determine to a great extent their atmospheric dispersion patterns and impact area. The results of model assessments inform national and international policies used to improve the environment and human health;
- regular reporting of spatial emissions is required under the Emissions Reporting Guidelines (ECE/EB.AIR/97) for Parties to the LRTAP Convention.

This chapter, developed by the European Environment Agency's European Topic Centre on Air and Climate Change (EEA's ETC/ACC), provides guidance on compiling spatial emissions datasets. It focuses on methods suitable for reporting spatial data required under the Long-Range Transboundary Air Pollution (LRTAP) Convention and on generating spatial data that is consistent with nationally-reported inventories under the LRTAP Convention.

This chapter starts with the definition of terms used when dealing with spatial datasets. It then establishes a generic set of methodologies for deriving spatial datasets from national emissions inventories with an elaboration on sector-specific issues and an outline tiered approach for estimating spatial emissions by sector. These methods will rely on the identification and use of important spatial datasets, so generic data sources for this type of data are outlined in Section 4, Finding key spatial data sources, of this chapter. Finally, approaches to combining spatial datasets are presented to enable the inventory compiler to derive an aggregated spatial dataset combining sectoral emissions into a unified gridded dataset like that needed for European Monitoring and Evaluation Programme (EMEP) reporting.

When preparing spatial data for reporting under EMEP, this chapter should be used in conjunction with the EMEP Reporting Guidelines (United Nations Economic Commission for Europe (UNECE) 2009). These guidelines define the reporting requirements for spatially resolved data. Reporting is also required for large point sources represented by latitude and longitude references for the location of the point source, and for gridded sources using the EMEP 50x50 km^2 represented by x,y values for the centre of the grid.

The Guidelines give guidance on:

- the EMEP 50x50 km grid;
- the sectoral definitions for gridded and large point sources;
- additional large point source information requirements, e.g. height class;
- the required pollutants (main pollutants, PM, Pb, Cd, Hg, PAHs, HCB, dioxins/furans);
- years for reporting.

2 Terminology

2.1 General terms

Focal mean: a focal mean is a geographic information system (GIS) function that finds the mean value within a specified focal radius.

EMEP grid: the EMEP grid is the geographical extent covering the EMEP area made up of 50x50 km grid squares. Annex 6 provides more details.

E-PRTR: E-PRTR is the European Pollutant Release and Transfer Register, Regulation 166/2006/EC, which entered into force in February 2006. It is based on Regulation (EC) No 166/2006 and is intended to fully implement the obligations of the UNECE PRTR Protocol. The obligations under the E-PRTR Regulation extend beyond the scope of the earlier European Pollutant and Emission Register (EPER) mainly in terms of inclusion of more facilities, more substances to report, additional coverage of releases to land, off-site transfers of waste and releases from diffuse sources, public participation and annual instead of triennial reporting.

GIS: Geographical Information Systems.

IPPC: Integrated Pollution Prevention and Control. This Directive (the 'IPPC Directive') imposes a requirement for industrial and agricultural activities with a high pollution potential to have a permit which can only be issued if certain environmental conditions are met, so that the companies themselves bear responsibility for preventing and reducing any pollution they may cause. Integrated pollution prevention and control concerns highly polluting new or existing industrial and agricultural activities, as defined in Annex I to the Directive (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, livestock farming, etc.).

HDV: Heavy Duty Vehicles are vehicles with a gross vehicle weight of > 3 500 kg.

LCPD: Large Combustion Plant Directive: Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants.

LDV: Light Duty Vehicles are vehicles with a gross vehicle weight of ≤ 3 500 kg.

NUTS: Nomenclature of Units for Territorial Statistics, which is a hierarchical classification of administrative boundaries developed by Eurostat. The idea behind NUTS is to provide a common designation for different levels of administrative geographic boundaries across the EU regardless of local language and naming conventions.

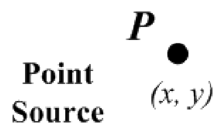
SNAP: Selected Nomenclature for sources of Air Pollution — developed as part of the CORINAIR project for distinguishing emission source sectors, sub-sectors and activities.

Surrogate spatial dataset: a geographically resolved dataset of statistics by grid, link, point or boundary such as land use coverage percentage by grid, vehicle flow by road link, employers number by industrial point, population by administrative boundary.

2.2 Geographic features

Geographical features will be used to represent emission sources. These features will define the geographical structure of the spatial dataset.

Point sources: a point source can be any emission represented by x and y coordinates. This should represent the main point of emission (i.e. a stack on an industrial site).

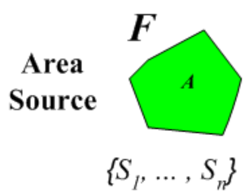


A point source is an emission source at a known location such as an industrial plant or a power station. Emissions from point sources represent sectors of a national inventory either fully (e.g. often for power stations where the sector is made up of only large sites for which emissions reporting is mandatory) or in part (e.g. such as combustion in industry, for which only the large sites within the sector are typically required to report emissions). In the latter case, the remainder of the emissions for the sector are mapped as an area source.

Large point sources (LPS): LPS are defined in the UNECE reporting guidelines (UNECE 2009) as facilities whose combined emissions, within the limited identifiable area of the site premises, exceed certain pollutant emission thresholds. *Note: although stack height is an important parameter for modelling emissions, it is not a criterion used for selecting LPS.*

Area sources: this is a description given to a source that exhibits diffuse characteristics. For example, sources that are too numerous or small to be individually identified as point sources or from which emissions arise over a large area. This could include forests, residential areas and administrative/commercial activities within urban areas.

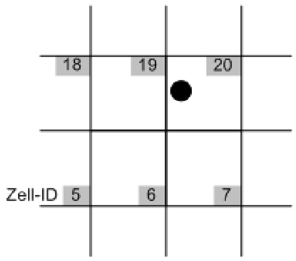
Area sources as polygons: area polygons are often used to represent data attributed to administrative or other types of boundaries (data collection boundaries, site boundaries and other non-linear or regular geographical features).



Residential fuel combustion is an example of a sector that can be represented in this way, using population census data mapped using the polygons defining the data collection boundaries. In some cases road transport data can also be represented as polygon datasets with statistics collected for a particular administrative boundary.

Polygons, whether regular (gridded or irregular) are vector- (line-) based features and are characterised by multiple x,y coordinates for each line defining an area.

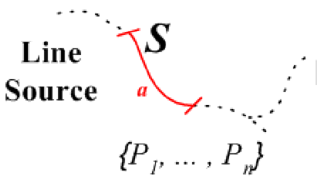
Area sources as grids: area sources can be represented in a regular grid of identically-sized cells (either as polygons or in a raster dataset). The spatial aspects of grids are usually characterised by geographical coordinates for the centre or corner of the grid and a definition of the size of each cell.



Agricultural and natural emissions sectors can be represented using land-use data derived from satellite images in raster format. In addition, road transport data can be represented as a grid rather than a line source.

Grids are often used to harmonise datasets as point, line and polygon features can be converted to grids and then several different layers of information (emission sources) can easily be aggregated together (see Combining different spatial features below). The EMEP grid is a defined grid for reporting spatial emissions under the LRTAP Convention. For technical details of this grid, please refer to www.emep.int/grid/index.html and Appendix G of this chapter.

Line source: a description given to a source that exhibits a line type of geography, e.g. a road, railway, pipeline or shipping lane, etc. Line sources are represented by vectors with a starting node and an end node specifying an x,y location for each. Line source features can also contain vertices that define curves between the start and end reference points.



3 Methods for compiling a spatial inventory

This section provides general guidance on the approaches to deriving spatially resolved (e.g. sub-national) datasets. It is advisable to consider the resolution (spatial detail) required in order to meet any wider national or international uses. Aggregation to the present EMEP 50x50 km grid could be done, for example, from more detailed spatial resolutions that might be more useful in a national context.

Most nationally reported emissions datasets are based on national statistics and are not resolved spatially in a manner that could be readily disaggregated to the required 50x50 km EMEP grid. Possible exceptions in some countries are detailed road transport networks and reported point source emissions data. Where Parties' inventories are compiled at a sub-national level, these areas are usually too large to aggregate adequately to the EMEP 50x50 km grids.

It is good practice to consider the elements below when defining an efficient spatial distribution project.

1. Use key category analysis (see Chapter 2, Key category analysis and methodological choice) to identify the most important sources and give the most time to these.
2. To make use of existing spatial datasets and carefully consider the merits vs. costs of extensive new surveying or data processing to derive new spatial datasets. It is often more important to generate a timely dataset for a lower Tier than a perfect dataset that means reporting deadlines are missed or all resources are consumed.
3. Make use of GIS tools and skills to improve the usefulness of available data. This will mean understanding the general types of spatial features and possibly bringing in skills from outside the existing inventory team for the production/manipulation of spatial datasets.
4. It is recommended to select the surrogate data that is judged to most closely represent the spatial emissions patterns and intensity, e.g. for combustion sources, surrogate spatial datasets that most closely match the spatial patterns of fuel consumed by type should be chosen. In some cases specialized surrogate statistics can be derived from a number of different spatial surrogate datasets (e.g. Example 1, page 10).
5. Surrogate spatial datasets that are complete (cover the whole national area) should be preferred.
6. To use, when possible and when no other more accurate data is available, the spatial surrogate that was used for spatial mapping in previous years. This is to guarantee consistency.

Issues relating to non-disclosure may be encountered (at a sectoral or spatial level) that may impose barriers to acquiring data (e.g. population, agriculture, employment data). As only highly aggregated output data is needed for reporting, signing of non-disclosure or confidentiality agreements or asking the data supplier to derive aggregated datasets may improve the accessibility of this data. It is important that issues relating to this are identified and dealt with in consultation with the national statistical authority.

Different tiered methods for compiling spatially resolved estimates can be used depending on the data available. A general decision tree for prioritising approaches for each sector is presented below in Figure 3-1.

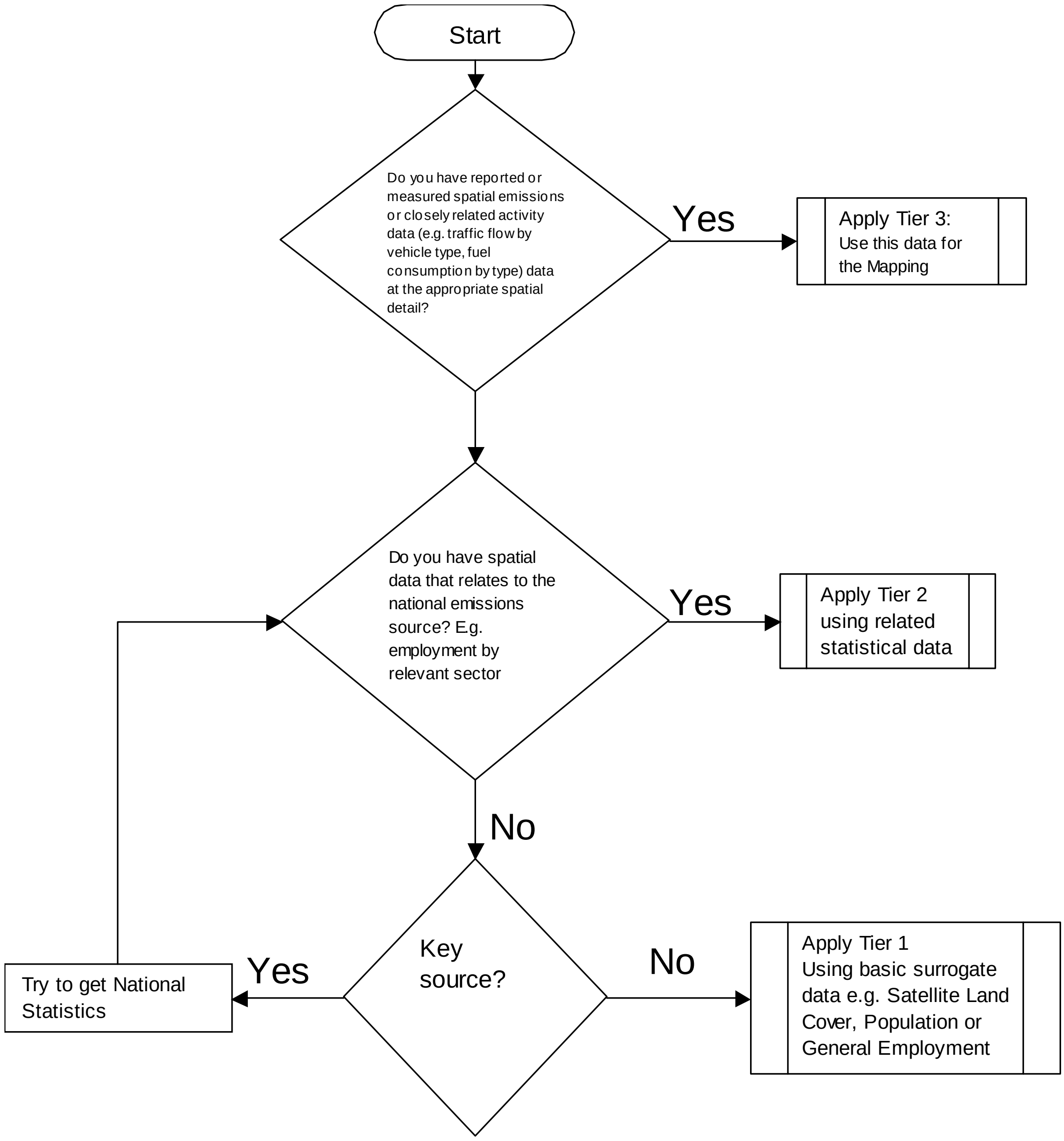


Figure 3-1 General decision tree for emissions mapping

Tier 3 methods will include the use of point source data from regulated process or from industry and estimates that are based on closely related spatial activity statistics, e.g. road traffic flows by vehicle type, spatial fuel consumption data by sector (e.g. boiler use data).

Tier 2 methods will be based on the use of surrogate statistics. However, for Tier 2, these statistics need to relate to the sector and could include detailed sector specific employment, population or household size and number (for domestic emissions).

Tier 1 methods will include the use of loosely related surrogate statistics such as urban rural land cover data, population (for non domestic sources).

These principals apply to the general methods described below for estimating spatial emissions. Detailed methods are provided for each sector in Annex 1.

3.1 Working with point source data

Emissions for point sources can be compiled using a number of different data sources and techniques. Generally, the use of point source data can be considered a Tier 3 method. Where point sources are reported (either through a formalised regulation based reporting system or through voluntary reporting) these need to be classified into process or Nomenclature For Reporting (NFR) categories so that they can be reconciled with the National Totals. Where only partial reporting is available for a sector, these estimates should be used and methods outlined below used to assign the remaining emissions spatially as appropriate to provide a lower-tiered method. For convenience, the point source data can be divided into three groups.

1. Regulated point sources such as those regulated under the Integrated Pollution Prevention and Control (IPPC) Directive regulatory regime and/or where there is a requirement for centralized annual emissions reporting (e.g. for E-PRTR/the Large Combustion Plant (LCP) Directive); these data can be used directly but will need to be reconciled with the National Totals in the inventory.
2. Point sources that are regulated but for which there are no annual emissions reporting requirements (this is often smaller plants). For these, sources emissions can often be estimated based on centralised data on process type and/or registered capacities and initialisation reports associated with the original application for emission permits for a Tier 2 method.
3. Point sources for sites or pollutants not reported or regulated. Emissions can be modelled by distributing national emission estimates over the known sources on the basis of capacity, pollutant correlations with reported data (e.g. particulate to PM_{10}/$PM_{2.5}$) or some other 'surrogate' statistic, such as employment. These methods would be considered as lower Tier methods (e.g. Tier 2 or 1) as there is not a close relationship between the real emissions and the statistic used to estimate the emissions for the point source. The following box (Example 1) provides some examples of approaches used to derive emissions for point sources in the absence of reported data.

EXAMPLE 1: ESTIMATING POINT SOURCE EMISSIONS FOR SOURCES/POLLUTANTS THAT ARE NOT REPORTED

Point source data are often not available for all processes even if the location of the emissions is known. For example, sources may not need to report emissions if these are below a specified reporting threshold or reporting is not required for the specific activity undertaken at a facility. In some cases, datasets are not complete. Furthermore, some point sources are not regulated. In these cases, point source data is generated using national emission factors and some ‘surrogate’ activity statistic. Examples of approaches used are given below.

- Estimates of plant capacity can be used to allocate the national emission estimate. This approach can be used, for example, for bread bakeries where estimates of the capacity of large mechanised bakeries can be made or gathered from national statistics or trade associations.
- Emission estimates for one (reported) pollutant can be used to provide a weighted estimate of the national emission estimate of another pollutant. For example, emissions of PM_{10} from certain coating processes can be estimated by allocating the national total to sites based on their share of the national VOC emission.
- Deriving point source estimates based on pollutant ratios can be used to fill gaps in reported emissions data. In some cases known $PM_{10}/PM_{2.5}$ ratios can be established to estimate emissions for PM_{10} and $PM_{2.5}$ for similar processes. Where no other data is available, other pollutants, such as NO_x and SO_2, can be used to distribute other pollutant emissions.
- Assuming that all plants in a given sector have equal emissions: in a few cases where there are relatively few plants in a sector but no activity data can be derived, emissions can be assumed to be equal at all of the sites.

With the possible exception of using plant capacity, many of the approaches listed above will yield emission estimates that are subject to significant uncertainty. However, most of the emission estimates generated using these methods are, individually, relatively small and the generation of point source data by these means is judged better than mapping the emissions as area sources.

The derived point source dataset should be structured such that it is possible to differentiate point source emissions into the relevant reporting sectors so that emissions can be reconciled with national totals for these sectors.

3.2 Working with line sources

In some cases emissions can be estimates for individual line sources calculations of emissions using the traffic flow, details of the type and fuel consumption characteristics of the sources. Major roads, shipping routes and railways can be calculated in this way if appropriate data is available to provide Tier 3 estimates. Parts of the sector that are excluded from such a dataset (such as minor roads and ports) must be considered and calculated separately using the methods described below in subsection 3.3 of the present chapter.

3.3 Distributing national emissions

There will be many cases where emissions cannot be calculated at a suitably small spatial scale or estimates are inconsistent with national estimates and statistics. Hence, national emission estimates will need to be distributed across the national spatial area using a surrogate spatial dataset. The methods used can range in quality from Tier 3 to Tier 1 depending on the appropriateness of the spatial activity data being used.

3.3.1 Basic Principals

The basic principle of distributing emissions is presented in the formula below using a surrogate spatial dataset x:

$$emission_{ix} = emission_t \times \frac{value_{ix}}{\sum_{jx}^{ix} value}$$

Where:

i	:	is a specific geographic feature;
emission$_{ix}$	:	is the emissions attributed to a specific geographical feature (e.g. a grid, line, point or administrative boundary) within the spatial surrogate dataset x;
emission$_t$	:	is the total national emission for a sector to be distributed across the national area using the (x) surrogate spatial dataset;
value$_{ix-jx}$	:	are the surrogate data values of each of the specific geographical features within the spatial surrogate dataset x.

The following steps should be followed:

1. determine the emission total to be distributed (**emission$_t$**) (either national total for sector or where a sector is represented by some large point sources; national total — sum of point sources);
2. distribute that emission using the basic principals above using a suitable surrogate statistic (according to the detailed guidance by sector below).

This approach effectively shares out the national emissions according to the intensity of a chosen or derived spatially resolved statistic.

EXAMPLE 2: DISTRIBUTION OF NATIONAL EMISSIONS

SO_2 emissions from residential combustion may be allocated based on a gridded or administrative boundary (e.g. NUTS) spatial dataset of population density. However, emissions of SO_2 may not correlate very well to population density in countries where a variety of different fuels are burned (e.g. city centres may burn predominantly gas and therefore produce very low SO_2 emissions per head of population). Additional survey information and or energy supply data (e.g. metered gas supply) could be used to enhance the population-based surrogate for residential emissions and achieve a better spatial correlation to 'real' emissions.

National transport emissions may be allocated to road links (road line maps) based on measured or modelled traffic flow, road type or road width information for each of the road links. Again, the closer the distribution attributes for each road link correlate to the actual emissions, the better. For example, road width and road type only loosely relate to traffic emissions and provide a poor distribution method. Being able to distinguish between the numbers of heavy goods vehicles and cars using different road links each year, and the average speeds of traffic on these links, will improve the compiler's ability to accurately allocate emissions.

In many cases the combination of more than one spatial dataset will provide the best results for distributing emissions. For example, where traffic count/density information is not available, basic road link information can be combined with population data to derive appropriate emission distribution datasets to provide a Tier 1 methodology.

Following the emission-distribution process, emissions at this stage are likely to be in a number of different spatial forms including different sizes of grids, polygons, lines and even point sources (where emissions are derived by allocating national estimates according to published capacity or employment information) each determined by the spatial characteristics of the source data. There is then a need to combine these together into a unifying format. This is usually a regular grid at a resolution appropriate to the spatial accuracy of the data inputs (see Section 5 of the present chapter).

4 Finding key spatial data sources

There are a number of different sources of spatial data. The first place to look should be national statistical centres such as demographic, economic, transport, regulatory, energy, regulating bodies and trade associations, as these data are likely to be most up-to-date.

4.1 General

4.1.1 *Administrative boundaries*

Statistics may be collected and stored with reference to regional or local government names while the information that defines the spatial boundaries of these areas (geographies) could be maintained in separate mapping datasets. Often a national mapping body is responsible for the boundary datasets while specific statistics attributable to these boundaries can be available from elsewhere. In these cases the statistics will need to be joined to the boundary dataset using lookups between the statistical dataset and the spatial structure dataset (e.g. area Ids or names). A number of common national datasets are listed below and give a starting point for data collection activities.

4.1.2 *Geo-referenced data*

Some data will be available with grid reference attributes, whereas other data may have postal address details. A grid reference lookup will be required to place the latter on a map.

Where national data is unavailable or too time consuming to collect, a number of international datasets can be used (see subsection 4.3 of the present chapter).

4.2 National datasets

4.2.1 *Population and employment*

Most countries will have spatial population and employment datasets based on administrative boundaries that can be used/combined to derive specific distributions or used as general default distributions where other methods are not feasible. This is a good basic dataset that can be used in many ways for distributing emissions from different sources.

4.2.2 *Gas distribution networks*

Information on gas supply by region or on a GIS basis is often available from energy departments, gas suppliers or from national statistical centres. Even national information on the number of households with/without gas supply can be useful when combined with population to estimate a distribution network.

4.2.3 Agricultural data

Most countries have agricultural census or survey data collected (e.g. livestock numbers, crop production, fertilizer use) at a detailed spatial scale at administrative boundary level.

4.2.4 Road network information

It is likely that many countries will hold national or commercial road network datasets that includes the road geography. These can be used to help distribute road traffic emissions in combination with traffic intensity statistics for administrative boundaries or specific count points.

4.2.5 Rail

Rail networks can be relatively easy to identify and datasets of the network are usually held by national mapping departments or organisations. Rail activity data is more difficult to obtain but can be part of national statistics or generated from detailed timetable information.

4.2.6 Airport activity data

Many countries have detailed aircraft movement datasets as part of their national statistics. These can be used to distribute emissions from Landing and Take-Off (LTO) and from airside support vehicles to airport areas.

4.2.7 Aviation

National aviation authorities will have detailed databases of aircraft movements, the aircraft type, origin and destination by airport. These data can be used to distribute the nationally estimated emissions for Landing and Take-Off for domestic and international aviation and allocate these emissions to the appropriate grid square.

4.2.8 National shipping

National shipping data is usually in the form of port arrival and departure statistics and available from the national statistical authority. These will need to separate national and international shipping but can be used to provide an indication of port activity for attributing national emissions.

4.2.9 Point source information

Regulation of large point sources is common in most countries and public reporting of regulated emissions occurs under the requirements of the Aarhus Convention PRTR Protocol, LCPD and E-PRTR, all of which have established a requirement for regular point source emissions reporting. Regulators within countries that are parties to these protocols and directives will have publicly available records of reported emissions data. Alternative large point source information sources can include:

- trade associations
- operators
- statistical energy and productivity publications (capacity).

4.2.10 Local inventory data

In some cases local inventory data can be used to improve the spatial distribution of emissions for transport and stationary sources by providing smaller process emissions by point source and traffic information. However, integration of this data with the nationally reported data and resolving emissions allocated to other areas can be time consuming and difficult to document.

4.3 International datasets

There are a number of different international datasets that can be used to help derive the spatial emissions of a country.

4.3.1 INSPIRE

In the future the EU intends to provide access to spatial datasets through the INSPIRE programme www.inspire-geoportal.eu/. A number of different geographical datasets will be available under this European initiative.

4.3.2 EDGAR model

The EDGAR model, jointly developed by the European Commission Joint Research Centre (JRC) and the Netherland's PBL, provides gridded emissions at a global resolution of $0.1^{o}x0.1^{o}$ (approximately 10 x 10 km) for a range of air pollutants and greenhouse gases. Data including gridded emissions by individual NFR/CRF source categories are available for download from the EDGAR website http://edgar.jrc.ec.europe.eu.

4.3.3 APMOSPHERE

This study for the European Commission (Briggs 2005) presents a methodology and dataset for emission mapping at 1x1 km. Details can be found at www.apmosphere.org/.

4.3.4 CORINE

The CORINE ([1]) dataset provides processed satellite images showing different land cover classes that can be used to distribute emissions for different sectors. This data can be accessed from: http://dataservice.eea.europa.eu/dataservice/.

Among the 43 different land covers provided, CORINE provides the following datasets of relevance to emissions mapping:

- continuous urban fabric
- discontinuous urban fabric
- industrial or commercial units
- road and rail networks and associated land
- port areas
- airports
- mineral extraction sites
- dump sites
- construction sites
- green urban areas
- arable land
- sport and leisure facilities.

([1]) The framework, objectives and methodology for the CORINE Land Cover project can be found on http://reports.eea.europa.eu/COR0-part1/en (Commission of the European Communities, 1995a).

A number of these CORINE datasets can be used individually or in combination to generate spatial distributions for sectoral emissions. Part Two Nomenclature: illustrations located on www.eea.europa.eu/publications/COR0-part2/land_coverPart2.1.pdf are a useful illustration of the application of the datasets (Commission of the European Communities, 1995). Technical guidelines concerning the latest available CORINE dataset is available here: www.eea.europa.eu/publications/technical_report_2007_17

Where CORINE or similar data is not available, satellite-based land cover data can often be derived from raw images using the CORINE methodology. Expertise to support this can be found from www.temis.nl European Space Agency (2004).

4.3.5 ICAO

Airport statistics for major airports can be obtained from the International Civil Aviation Organisation (ICAO) website if country-specific data are not available. See www.icaodata.com/Trial/WhatIsICAO.aspx. These can be used to distribute nationally calculated emissions to different airports to estimate LTO emissions for each.

4.3.6 Eurostat

Employment data is available from Eurostat at NUTS 3 level, split into three categories: services, industry and agriculture. Employment statistics are reported using the NACE classification system. See details concerning NACE at http://ec.europa.eu/eurostat/ramon/

Eurostat also has several useful agricultural datasets such as the Farm Structural Survey.

4.3.7 Shipping: Lloyds Register

The Lloyds Register contains detailed ship movements data that can be used to distribute emissions from shipping.

See www.lr.org/Industries/Marine/Services/Shipping+information/.

4.3.8 European Shipping Studies

There are a number of European shipping studies (carried out by consultants) that provide spatial emissions estimates for international shipping.

4.3.9 Natural emissions: NatAir

A detailed set of methods and data sources for estimating biogenic sources and forest fire emissions are presented in the NatAir project (Friedrich, 2007). The following natural sources have been taken into account:

- natural and semi-natural vegetation (NMVOC)
- wind-blown dust (PM)
- volcanoes (SO_x, NO_x, PM)
- biomass burning and forest fires (NO_x, PM, CO, VOC)
- NO from soils (natural and agricultural) (NO)
- lightning (NO)
- primary biological aerosol particles (PM)
- coastal zones, seas and lakes (DMS)
- sea salt (PM)

- wild animals (CH_4, NH_3)
- anoxic soil processes (wetlands) (CH_4)
- geological seepages (CH_4)

The project aimed at the improvement of methods for the calculation of natural and biogenic emissions from various sources, the application of these methods to provide emission data for 2000 and 2010 and the assessment of impacts on air quality policy implementation. These data and methods can be used to estimate or distribute national emissions of biogenic sources and forest fires.

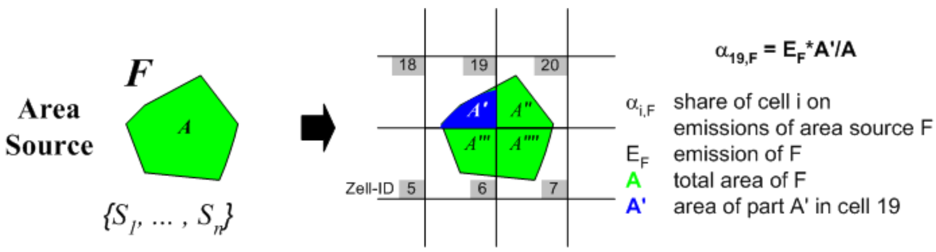
5 Combining different spatial features

Spatial emission data will need to be combined to form emission maps and in order to derive the EMEP 50x50 km grids (for details of this grid please refer to www.emep.int/grid/index.html and Appendix G).

This is generally done by resolving the different spatial forms to a common grid so that different sectors/sources can be aggregated. The common grid can either be the EMEP 50x50 km grid or another grid based on national coordinates and or smaller cell sizes. The methodologies for converting the different forms to a common grid are outlined below. For line and area conversion to grids an intersect operation is needed. This intersects the boundaries of the polygon or the length of the line with the boundaries of the grid and creates a new set of features cut to the extent of each grid cell.

5.1 Area source (polygons) to grids

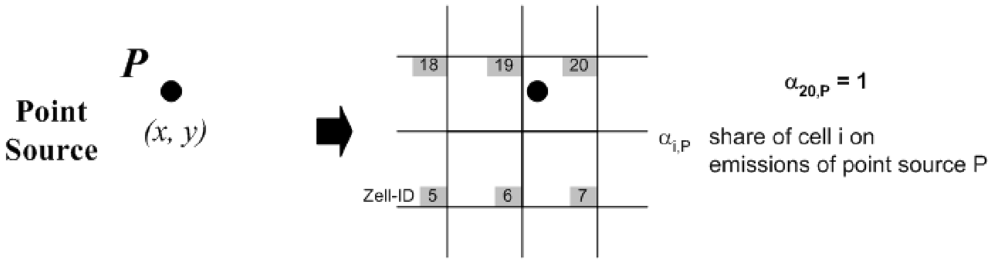
Intersecting the polygon with the grid will produce a dataset of polygons contained within each grid.



The fraction of the area of the new polygons can be used to distribute the emissions/surrogate statistics from the original polygon to the grid cells. Alternatively, an emission rate/area can be applied to the new polygon area and that emission/surrogate statistic assigned to the grid cell.

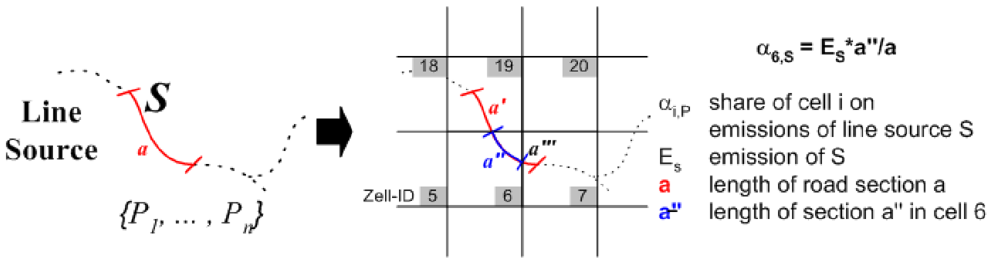
5.2 Point sources to grids

Point sources can be allocated directly to the grid within which they are contained by converting (rounding) the x,y values to that of the coordinates used to geo-reference the grid or by intersecting the point with the grid.



5.3 Line sources to grids

Intersecting the line features with the grid will produce a dataset of shorter line lengths contained within each grid. The fraction of the original line length of the new line can be used to distribute the emissions/surrogate statistics from the original line to the grid cells. Alternatively, an emission rate/unit of length can be applied to the new line length and that emission/surrogate statistic assigned to the grid cell.



5.4 Converting between different spatial projections (e.g. GIS to EMEP)

In a number of cases, an inventory compiler may need to combine data from different spatial datasets and extents to eventually derive the 50x50 km EMEP grid. Appendix G presents the definition of the EMEP grid.

The Open Geospatial Consortium Inc. provides guidance and standards for coordinate transformation (see www.opengeospatial.org/standards/ct).

5.5 Aggregating to the UNECE GNFR

The aggregated sectors 'gridded NFR' (GNFR) for reporting are defined in Table I of Annex IV to the Guidelines for reporting emission data under the Convention on Long-range Transboundary Air Pollution (UNECE 2009). These aggregations can be achieved through the aggregation of the spatially resolved (mapped) detailed NFR sectors (or sector groups). Aggregation of NFR to GNFR prior to mapping is not recommended as it may result in reduced accuracy in the placement of emissions.

6 References

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7 Point of enquiry

Enquiries concerning this chapter should be directed to the co-chairs of the Task Force on Emission Inventories and Projections (TFEIP). Please refer to the TFEIP website (www.tfeip-secretariat.org/) for the contact details of the current co-chairs.

Appendix A Sectoral guidance for spatial emissions distribution

The table below presents general guidance for the tiered mapping of emissions for different sectors.

Table 1: General tiered guidance for the spatial distribution of emissions by sector

	Best -- Worst			
NFR Sector	**Tier 3**	**Tier 2**	**Tier 1**	**Notes**
1.A.1	*Reported point source data or national totals distributed using plant-specific capacity or other activity statistics*	*Employment data. See Annexes 3 and 5*	*Land cover. See Annex 2*	A combination of tiered approaches might be needed depending on the availability of a complete dataset of point sources. Where only partial datasets are available for point sources use Example 1 to make best use of point source data whilst maintaining consistency with national emissions estimates
1.A.2	*Reported point source data or national totals distributed using plant-specific capacity or other activity statistics*	*Employment data. See Annexes 3 and 5*	*Population or land cover. See Annex 2*	A combination of tiered approaches might be needed depending on the availability of a complete dataset of point sources
1.A.3.a.ii.(i) (Landing and Take-Off)	*Estimated detailed emissions by airport for Landing and Take-Off by type of aircraft*	*Allocate national emissions estimates to each airport based on takeoff and landing statistics*	*Land cover. See Annex 2*	Emissions from domestic cruise and from international aircraft flights should be excluded from the mapping as these are estimated centrally by EMEP. Where possible, additional weightings to take account of the average size of aircraft at each airport should be used (e.g. emission factor to aircraft size ratios)
1.A.3.b	*Traffic flows and types of vehicles ([2])*	*Using road network information and population based traffic intensity. See Annex 6*	*Population and land cover. See Annex 6*	Different tiered approached will usually be needed for different road types. Major roads will often have traffic counts or modelled flows, while minor roads will not. Countries that have traffic count/flow information will usually need to apply a Tier 2 method for minor roads
1.A.3.c	*Diesel rail traffic on the rail network reconciled with national mobile locomotive consumption data*	*Rail network and population-based traffic weightings*	*Population-weighted distributions of land cover class for rail*	Rail networks that have been electrified should be excluded from the distributions where possible. This may only be important if large areas are all electrified (e.g. cities)
1.A.3.d.ii	*Route-specific ship movement data and details of fuel quality by region, consumption and emission factors by type of ship & fuel*	*Port arrival & destination statistics used to weight port and coastal shipping areas*	*Assign national emissions to Land cover classes for ports and coastal shipping areas*	Tier 1 & 2 methods will need to make assumptions about the weighting of in-port vs. In-transit emissions. Tier 3 methods will need to use ship movement data from centralized databases and account for in port emissions for loading and unloading of ships. Harbourmaster or coast guard data can sometimes provide details of ship time in ports and operations. Emissions will need to be broken down into national and international

([2]) Spatial traffic flow statistics that have a basic vehicle type split should be used in order to enable appropriate emissions allocation for the key NFR reporting categories. Where traffic composition data (flows by vehicle type) are unavailable, averaged composition % can be applied to total flow by road type based on national survey data or on data available on the COPERT4/FLEETS webpages Gkatzoflias et al (2007), or from the European MEET (Methodologies to Estimate Emissions from Transport), a European Commission (DG VII) sponsored project in the framework of the 4th Framework Programme in the area of Transport project.

	Best -- Worst			
NFR Sector	Tier 3	Tier 2	Tier 1	Notes
				data. Useful information for the mapping of shipping data can be obtained from Entec UK (2002) and Entec UK (2005)
1.A.4.a	*Reported/collected point source data, boiler census or surveys*	*Employment for public and commercial services. See Annexes 3 and 5*		Large point source data is likely to be minimal unless there are large district heating or commercial/institutional heating plant included in the national inventory under sectoral 1A4a
1.A.4.b	*Detailed fuel deliveries for key fuels (e.g.gas) and modelled estimates for other fuels using data on population density and/or household numbers and types. See Annex 3*	*Population or household density combined with land cover data if smoke control areas exist in cities.*	*Land cover. See Annex 2*	Tier 1 & 2 methods assume that a linear relationship between emissions and population density or land cover exists. This assumption will be most realistic if a country has a uniform distribution of fuel use by type. Where there is a broad variation of fuel type use in different areas, the accuracy of the simple method will be much lower
1.A.4.c (Stationary)	*Detailed fuel deliveries for key fuels (e.g. gas) and modelled estimates for other fuels using employment data*	*Employment data for the agricultural and forestry sectors Annexes 3 and 5*	*Land cover. See Annex 2*	Where land cover is used, emissions for agriculture and forestry should be split and distributed according to the relevant classes. Where this is not possible, emissions should be distributed according to a combined land cover class for agriculture and forests or allocated to the dominant class e.g. 'arable land' for countries where emissions from agricultural combustion dominate. Where employment data is used, care should be taken to ensure that the employment classes are representative of the national sector for Agriculture and Forestry. Employment statistics will often include the financial and administrative head offices (often located in cities) while energy statistics based national emissions from these 'head offices' may be included under 1.A.4.a.i Commercial / Institutional: Stationary. Care should be taken to ensure that the emissions are located where they occur. The use of employment data will locate emissions at registered places or regions of work and may tend to focus emissions inappropriately to urbanized areas
1.A.4.c.iii	*Allocation of emissions to ports on fish landings and to geographic areas of fishing grounds*	*Allocation of emissions to ports on fish landings*	*Assign national emissions to Land cover classes for ports.*	Emissions from fishing are likely to be associated with fishing grounds rather than port activities. Tier 3 methods will need to allocate emissions to ports and fishing grounds
1.B.1	*Reported point source data or using plant-specific capacity or other activity statistics*	*Locate point sources and use employment data for specific sectors to allocate emissions. See Annexes 3 (3) and 5*	*Total employment for the mining and transformation industry as a whole*	Mines, fuel transformation plant, depots and distribution centres are likely to be regulated and significant national industrial sites. In these cases site-specific information can be collected and used to distribute national emission estimates over a number of point sources or grids

(3) For some sectors information on the distribution systems and storage depots might be more appropriate if available (e.g. Natural Gas distribution networks).

	Best -- Worst			
NFR Sector	**Tier 3**	**Tier 2**	**Tier 1**	**Notes**
1.B.2	*Exploration and production distribution centres should be identified and emissions estimated allocated to the point locations using production activity data. Distribution emissions should be mapped using details of distribution network and leakage rates or losses along the systems*	*Location of off shore extraction installations and allocation of emissions using proxies such as employment or capacity. Distribution to be allocated evenly over the distribution network*	*Identification of large point sources and distributed evenly over locations. Use population data for distribution*	Many of the exploration, refining and storage facilities will be regulated and data available from energy ministries or regulators. Operators or regulators for distribution of fuels will often be able to provide network maps
2	*Integrate reported point source data or derive emissions using plant specific, activity, throughput, production, capacity or other activity statistics*	*Employment data for specific sectors. See Annexes 3 (4) and 5*	*Land cover. See Annex 2*	Where possible, try to use point source data as the basis for estimating process emissions. The methodology for Tier 2 relies heavily on detailed sectoral employment data for surrogate spatial distributions. However, in many cases these are not specific to the processes producing emissions, as emissions are likely to be highly specific to particular plants and processes. Employment data will also distribute emissions to locations that may have administrative or head office activities only where process emissions do not occur
3	*Integrate reported point source data or derive emissions using plant-specific, activity, throughput, production, capacity or other activity statistics*	*Employment or appropriate population data for specific sectors. See Annexes 3 and 5*	*Land cover see Annex 2*	For Tier 2 where processes are industrial and there is a good employment dataset, use this. For emissions that result from consumption of products in the home use population
4.B	*Reported emissions from regulated farms or detailed spatial farm livestock survey statistics*	*Employment statistics. See Annexes 3 and 5. Land cover and agricultural production stats may be better than employment*	*Land cover for arable land. See Annex 2*	When using these statistics care should be taken to account for possible over allocations to head/offices or market employment in urban areas that will distort the pattern of emissions and allocate too many emissions to urban areas
4.D – 4.F	*Reported emissions from regulated farms or detailed spatial farm crop/fertilizer use survey statistics*	*Employment statistics. See Annexes 3 and 5. Land cover and agricultural production stats may be better than employment*	*Land cover for arable land. See Annex 2*	For Tier 3 survey statistics for crop production can be combined with fertilizer use/stubble burning rates to estimate weightings by crop type. Farm level data is often commercially sensitive and may need to be aggregated
6.A	*Waste disposal to land statistics and landfill disposal records by site*	*Evenly distributed emissions over landfill site locations*	*Population statistics weighted with discontinuous urban fabric land cover*	Most countries with regulated land disposal will have records of landfill sites in use. It may be more difficult to identify disused sites or sites that are not regulated
6.B	*Regulated process information and data on wastewater*	*Employment statistics for wastewater*	*Population statistics*	Many countries now regulate wastewater treatment plant. Locations should be well known and activity

(4) For some particular industrial process sectors, population (e.g. for 2 F consumption of POPs and heavy metals and 2 A 5 asphalt roofing) or road related statistics (e.g. 2 A 6 road paving with asphalt) might be more appropriate.

	Best -- Worst			
NFR Sector	**Tier 3**	**Tier 2**	**Tier 1**	**Notes**
	treatment plant	*treatment location of plant and capacity or some surrogate of capacity-based on population density*		data/emissions available by site
6.C & 6.D	*Regulated process emissions by site*	*Emissions distributed over known sites based on capacity or population*	*Employment data for the specific industry or population/ farm statistics for small scale burning*	Incineration 6Ca–d is generally regulated or controlled. Regulators or trade associations will hold site location details and often records of activity. Small scale waste burning (6Ce) should be distributed using population or farm statistics depending on the dominant small scale burning sector
Biogenic emissions and forest fires (11)	*Detailed surveys of land use types and burned area combined with (Ing 2007) factors for emissions*	*National emissions distributed using land cover data and burned area data from NatAir*	*Basic land cover data*	

Appendix B Land cover data (e.g. CORINE) for Tier 1 methods

If relevant national spatial statistics are not available then a simpler and less accurate method using land cover data can be used to derive emissions from land cover data. The Impresareo project (Dore *et al.*, 2001) derived weightings to apply to elements of the CORINE land cover map to represent NFR sectors.

NFR Sector	Land cover class	Weighting
1.A.1, 1.A.2, 2 and 3	Industry	76%
	Continuous urban fabric	15%
	Discontinuous urban fabric	1%
	Ports	4%
	Airports	4%
1.A.3.d.ii	Ports	100%
1.A.3.a.ii.(i)	Airports	100%
1.A.4.a	Continuous urban fabric	50%
	Discontinuous urban fabric	50%
4	Arable land	100%
6.A	Discontinuous urban fabric	100%

Appendix C Using employment data

A simple map of employment numbers can be applied to distribute national total emissions (possible allocations of NFR codes to employment datasets are presented in Appendix E). Where possible, weightings (based on energy use) should be applied at the highest level of sectoral detail available from the employment and the emissions data and then aggregated.

A more complex (Tier 2) approach combining different datasets can be used where time and resources permit for energy use emissions. In Example 3 below, national energy statistics by industry type have been used to apply specific energy intensity weightings to spatial employment datasets in order to derive a more realistic emissions distribution dataset.

EXAMPLE 3: DERIVING SECTOR SPECIFIC SURROGATE DATASETS

In the UK the following data sets are used to develop emissions distribution maps for other industrial combustion, miscellaneous industrial/commercial combustion, public sector combustion and agriculture stationary combustion:

- Office of National Statistics Inter-Departmental Business Register which provides detailed spatial data on employment at business unit level by Standard Industrial Classification (SIC) code; and
- DTI Energy Consumption in the UK data on industrial and commercial sector fuel usage for coal, solid smokeless fuel (SSF), oil and gas for 2002. (DTI, 2002: Tables 4.6, 5.2 and 5.5)

The SIC codes in the IDBR database were aggregated and matched with the DTI energy datasets in order to calculate total employment by DTI energy sector and then used to derive UK average fuel intensity per employee by fuel type and industry type. These intensities could then be applied to employment distributions across the UK to make maps of implied fuel use by industry type and aggregated for the different emissions reporting sectors.

Additional data such as gas supply, smoke control areas or other fuel supply information could be used to enhance the employment dataset to differentiate between different priority fuels in different areas. These datasets should be combined using GIS methods to derive a weighted spatial surrogate dataset.

As with other combustion, process emissions representing the allocation of different fuels used can make an important difference to the distributions. Therefore the integration of additional spatial data (e.g. gas distribution, known areas of fuel/smoke control), which helps to highlight any different spatial patterns for different fuel consumption, will help to improve the distribution dataset. Employment statistics can be used for the distribution of off-road mobile emissions where other more specific data is not available.

Pollutants that are dependant on the differentiation between different fuels will show high uncertainties for distributions based on data (e.g. employment) that cannot reflect different spatial patterns of different fuel use, e.g. spatial emissions of SO_2 and PM_{10} from stationary combustion will not be well reflected if there is a diversity of fuel (e.g. coal and gas) used in different areas if the surrogate spatial datasets cannot show this differentiation.

Some countries have also used surveys of boiler insurance documents in industry to build an accurate snapshot of combustion emissions by fuel type and size. However, undertaking suitable surveys can be resource intensive and can become quickly outdated.

Distributing non-road mobile sources (1.A.4.a.ii Commercial / Institutional: Mobile) will be highly uncertain as emissions often occur in different places to employment. Emissions will be dependant on construction and maintenance activities that can be highly transient.

Improvement in national spatial statistics on gas supply to residential and commercial meters available nationally or reported internationally could improve the spatial distribution of fuel combustion for many non-point source sectors.

Appendix D Detailed domestic spatial mapping

Development of maps that show the spatial variation of different fuel types using gas network information will improve the emissions distributions for countries that have geographical diversity in gas and solid/liquid residential fuels use. This methodology is only appropriate for countries that have a significant variation in fuel use for residential heating and cooking.

Integrating gas supply with population data:

Where geographic gas supply data is available this should be used and will deliver a Tier 3 methodology:

- to distribute emissions from gas consumption;
- to help remove emissions from other fuels allocated to areas with gas supply and allocate to areas where gas supply is low or zero.

Where no specific spatial gas supply data is available an approach highlighted by Dore *et al.* (2001) can be used to estimate gas supply distributions based on national statistics on the number of domestic connections to the gas network relative to the total number of households (see Table 2 below).

Table 2: Domestic connections to the gas network

Country	Households	Year	Households connected	Year	Proportion connected	% in NG supply area	Comments
Austria	3,248,489	1998	1,207,000	1998	0.345	0.69	
Belgium	4,185,202	1998	2,303,000	1998	0.55	0.92	
Denmark	2,423,208	1999	289,000	1998	0.12	0.5	
Finland	2,340,000	1999	35,000	1997	0.15	0.33	Network only in south / south east
France	23,900,000	1998	9,590,000	1998	0.41	0.72	
Germany	37,532,000	1998	14,720,000	1998	0.42	0.93	
Greece	4,000,000	1999	8000	1999	0.2	0.5 (in 2006)	Only in Athens
Ireland	1,191,900	1997	322,000	1997	0.27	0.41	
Italy	21,642,350	1997	15,200,000	1998	0.696	0.86	
Luxembourg	144,300	1995					
Netherlands	6,692,000	1998	6,491,000	1997	0.97	0.99	
Portugal	3,083,000	1991	74,000	1998	0.026		
Spain	11,736,376	1991	3,271,000	1998	0.26	0.55	
Sweden	4,139,631	1996	52,000	1998	0.012		
UK	24,484,000	1999	19,897,000	1998	0.819	0.87	

Source: Griffin and Fawcett (2000).

More up-to-date data may be available from Eurostat or the International Energy Agency (IEA).

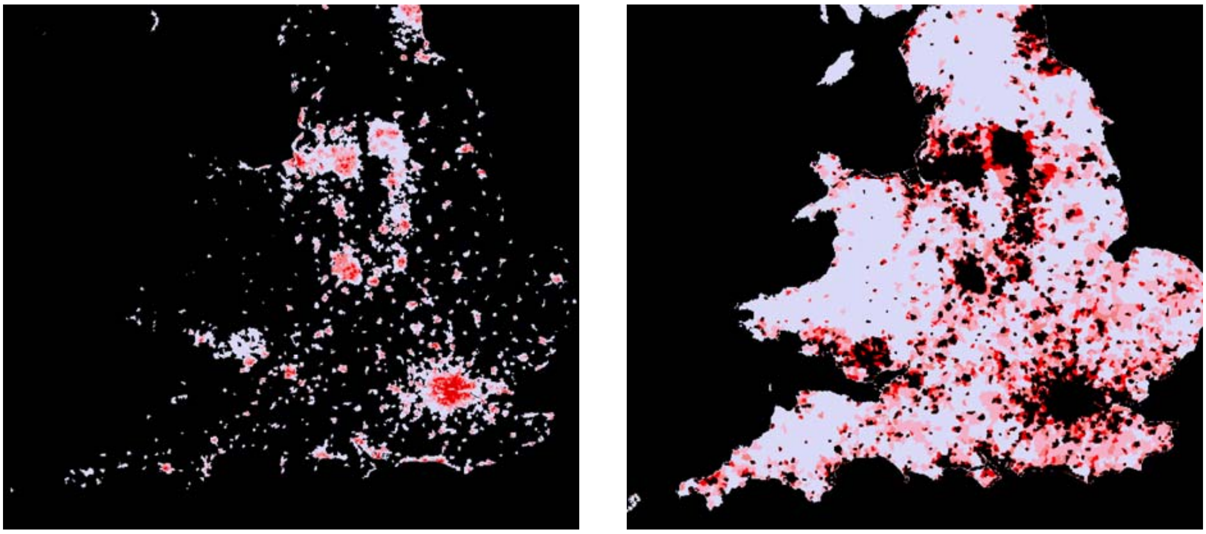
A distribution of gas supply can be derived based on the assumption that in areas of highest population densities, the share of gas use is highest and hence the use of other fuels is reduced or excluded. This methodology assumes that gas networks (for the residential sector) will tend to be located in the most densely populated urban areas first. Obvious area restrictions should also be applied (e.g. from Table 2 above 'Only in Athens' indicates additional limitations to the spatial coverage of gas supply).

The grid cells with the highest densities that cumulatively equate to the percentage of the population with gas supply (e.g. for UK, the proportion connected is 81.9 %) are considered to have the potential to use gas. Therefore, a grid can be developed based on population densities where we can identify the population that might potentially be using gas, and a grid showing population not using gas.

The general objective should be to map different fuel uses separately and to derive the following surrogate spatial datasets to achieve a basic fuel differentiated map for the residential sector. For example:

- areas of gas supply or high population density assumed to be using gas;
- areas of low population density (in countries with gas supply) to distribute emissions from consumption of solid fuels;
- all population densities — to distribute emissions from consumption of oil and other fuels.

(a) and (b) in Figure D.1 below are taken from the detailed APMOSPHERE report and show how the allocation for gas (Figure (a)) and other fuels (Figure (b)) might be assigned in the case of the UK.



(a) (b)

Figure D-1 (a) Highest density grid cells representing 82 % of population, and (b) remaining grid cells (representing 18 %)

The need for energy balance data for the domestic sector is crucial in order to calculate the relative emission contributions from different types of fuel. It is worth noting in this analysis that derived heat and electricity are not included in the energy balance, as emissions from the use of such energy types are not directly attributable to the use of this energy. However, the spatial location of households using such energy is important as it indicates that other fuel types are not being used.

As previously noted, population density does not always correlate with emission density. Therefore, the integration of additional spatial data that helps to highlight any different spatial patterns for different fuel consumption will help to improve the distribution dataset. For SO_2 and PM in the residential sector, the identification of areas burning mainly solid and liquid fuels, as opposed to natural gas, is important.

Improved approaches to distributing the combustion of bio-fuels (e.g. wood) will be important for many countries. Improvement in national spatial statistics on gas supply to residential and commercial meters available nationally or reported internationally could also improve the spatial distribution of fuel combustion for many non-point source sectors.

This detailed methodology makes a number of assumptions about the distribution of gas supply (depending on the methods used), such as the relationship between population density and gas use that may not be appropriate. In addition, it is assumed that the consumption of other fuels is related to the consumption of gas. In reality this relationship is much more complex, especially in the combustion of bio-fuels (e.g. wood) and in areas where there is a high proportion of localized use of coal and peat fuels.

Appendix E Proposals for use of surrogate statistics by NFR

NFR sector	Description	Likelihood of point sources data	Surrogate spatial distribution
1.B.1.a Fugitive emission from solid fuels: coal mining and handling	Use surrogate spatial distribution	None	Employment (coal mining)
1.B.1.b Fugitive emission from solid fuels: solid fuel transformation	Combine point sources data with surrogate distribution	Some plant data likely to be available	Employment (mineral products)
1.B.1.c Other fugitive emissions from solid fuels	Use surrogate spatial distribution	None	Employment (mineral products)
1.B.2.a.i Exploration production, transport	Combine point sources data with surrogate distribution	Some plant data likely to be available	Employment (oil and gas employment)
1.B.2.a.iv Refining / storage	Try to collect/estimate emissions for all point sources for sector	Most plants	Employment (manufacture of refined petroleum products)
1.B.2.a.v Distribution of oil products	Combine point sources data with surrogate distribution	Some plant data likely to be available	Employment (oil employment)
1.B.2.a.vi Geothermal energy extraction	Combine point sources data with surrogate distribution	Some plant data likely to be available	Statistics on geothermal energy extraction
1.B.2.b Natural gas, and 1.B.2.c Venting and flaring	Combine point sources data with surrogate distribution	Some plant data likely to be available	Employment (oil and gas employment)
2.A.1 Cement production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of cement)
2.A.2 Lime production	Combine point sources data with surrogate distribution	Some point sources	Employment (manufacture of lime)
2.A.3 Limestone and dolomite use	Combine point sources data with surrogate distribution	Some chemical processes	Employment (chemical, processes in wood, paper pulp, food, drink and other industries)
2.A.4 Soda ash production and use	Combine point sources data with surrogate distribution	Some production processes	Employment (chemical, processes in wood, paper pulp, food, drink and other industries)
2.A.5 Asphalt roofing	Use surrogate spatial distribution	None	Population density
2.A.6 Road paving with asphalt	Use surrogate spatial distribution	None	New or total road lengths
2.A.7.a Quarrying and mining of minerals other than coal	Use surrogate spatial distribution	None	Employment (non-coal mining and quarrying)
2.A.7.b Construction and demolition	Use surrogate spatial distribution	None	Employment (construction)
2.A.7.c Storage, handling	Use surrogate spatial	None	Employment (mineral products)

NFR sector	Description	Likelihood of point sources data	Surrogate spatial distribution
and transport	distribution		
2.A.7.d Other mineral products	Use surrogate spatial distribution	None	Employment (mineral products)
2.B.5.a Other chemical industry	Combine point sources data with surrogate distribution	Some production processes	Employment (mineral products)
2.B.5.b Storage, handling and transport	Combine point sources data with surrogate distribution	Identification of some large production processes	Employment (mineral products)
2.B.1 Ammonia production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of fertilizers and nitrogen compounds)
2.B.2 Nitric acid production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of other inorganic basic chemicals)
2.B.3 Adipic acid production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of other inorganic basic chemicals)
2.B.4 Carbide production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of other inorganic basic chemicals)
2.C.1 Iron and steel production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of iron and steel)
2.C.2 Ferroalloys production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of ferroalloys)
2.C.3 Aluminium production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of aluminium)
2.C.5.a Copper production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of aluminium)
2.C.5.b Lead production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of lead)
2.C.5.c Nickel production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of nickel)
2.C.5.d Zinc production	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of zinc)
2.C.5.e Other metal production	Combine point sources data with	Some plant	Employment (other metals manufacture)

NFR sector	Description	Likelihood of point sources data	Surrogate spatial distribution
	surrogate distribution		
2.C.5.f Storage, handling and transport	Combine point sources data with surrogate distribution	Some plant	Employment (all metals manufacture)
2.D.1 Pulp and paper	Combine point sources data with surrogate distribution	Some plant	Employment (all paper, card manufacture)
2.D.2 Food and drink	Combine point sources data with surrogate distribution	Some plant	Employment (all food manufacture)
2.D.3 Wood processing	Combine point sources data with surrogate distribution	Some plant	Employment (manufacture of wood and wood products)
2.E Production of POPs	Try to collect/ estimate emissions for all point sources for sector	Most or all plant	Employment (manufacture of other organic basic chemicals)
2.F Consumption of POPs and heavy metals	Combine point sources data with surrogate distribution	Some plant	Population density
2.G Other production, consumption, storage, transportation or handling of bulk products	Use surrogate spatial distribution	None	Employment from relevant industries
3.A.1 Decorative coating application	Use surrogate spatial distribution	None	Population density
3.A.2 Industrial coating application	Combine point sources data with surrogate distribution	Some plant data likely to be available	Employment (for coatings industries including metal packaging, vehicle refinishing, rolling mills, vehicle repair, wood coating, etc.)
3.A.3 Other coating application	Use surrogate spatial distribution	Some plant data likely to be available	Employment (for coatings in the printing and packaging industry)
3.B.1 Degreasing	Combine point sources data with surrogate distribution	Some plant data likely to be available	Employment (from relevant manufacturing industries)
3.B.2 Dry cleaning	Try to collect/ estimate emissions for all point sources for sector	Some plant data likely to be available	Employment (dry cleaning)
3.C Chemical products	Combine point sources data with surrogate distribution	Some plant data likely to be available	Employment (paint, ink, adhesive, leather, tire, rubber manufacture)
3.D.1 Printing	Use surrogate spatial distribution	None	Employment (newspaper and magazine industry)
3.D.2 Domestic solvent use including fungicides	Use surrogate spatial distribution	None	Population density
3.D.3 Other product use	Use surrogate spatial distribution	None	Population density
4.B	Use surrogate spatial distribution	Some E-PRTR sources	Livestock statistics or employment
4.D–4.G	Use surrogate spatial distribution	None	Land use (arable land)
6.A Solid waste disposal on land	Use surrogate spatial distribution	None	Where specific data on land application is not available use land cover classes for

NFR sector	Description	Likelihood of point sources data	Surrogate spatial distribution
			arable land
6.B Wastewater handling	Combine point sources data with surrogate distribution	Some wastewater treatment plant locations may be available from E-PRTR returns	Population density can be used to distribute emissions where point source data are unavailable
6.C.a Clinical waste incineration	Combine point sources data with surrogate distribution	Some clinical incineration plant locations and emissions may be available from E-PRTR or other regulated process returns. Alternative information from hospital data sources may provide additional point source datasets	Population density can be used to distribute emissions where point source data are unavailable
6.C.b Industrial waste incineration	Combine point sources data with surrogate distribution	Some industrial incineration plant locations and emissions may be available from E-PRTR or other regulated process returns	Industrial employment in the waste industry can be used to distribute emissions where point source data are unavailable
6.C.c Municipal waste incineration	Combine point sources data with surrogate distribution	Some industrial incineration plant locations and emissions may be available from E-PRTR or other regulated process returns	Industrial employment in the waste industry can be used to distribute emissions where point source data are unavailable
6.C.d Cremation	Combine point sources data with surrogate distribution	Some Cremation plant locations and emissions may be available from E-PRTR or other regulated process returns. Alternative datasets can often be obtained from trade associations	Population density can be used to distribute emissions where point source data are unavailable
6.C.e Small-scale waste burning	Use surrogate spatial distribution	None	Population density can be used to distribute emissions where point source data are unavailable. Where possible land cover urban/suburban classes data can be used

Appendix F Estimating road traffic emissions without traffic flow data

Where appropriate traffic flow data are not available, emission distributions can be generated using digital road maps and population density data using a method developed for the European APMOSPHERE project D Briggs (2005) as indicated below.

The emissions mapping approach uses a detailed European road network, which provides information on length of roads by type — motorway, A roads, B roads and minor roads. For the purposes of this methodology, B roads and minor roads are classified together as minor roads. The network must be weighted according to the contribution to emissions (i.e. vehicle type and density). The proposed approach is based on the assumption that population density is related to number of vehicles using different types of road network.

There are three steps in developing the road emission maps.

Step 1: generate weighted spatial datasets for three road type classes

Each road type is assumed to have a different relationship with the close and more distant population depending on the type of road. For the APMOSPHERE project the following assumptions were made:

- minor roads are assumed to be influenced most by densities of population (within a 5–10 km radius);
- major non-motorway/highway roads are assumed to be influenced by populations from a wider catchment (30–40 km radius);
- motorway/highway roads are assumed to be influenced by populations from an even larger catchment (40–50 km radius).

This influence of population density on road use can be modelled using a focal mean calculation using GIS tools. For each grid cell of the population grid the mean value can be determined based on the value of other grid cells in a given neighbourhood (in this case using the radius around each grid cell). So a set radius of 20 km will mean that each grid cell is calculated based on the mean value of grid cells in this given radius.

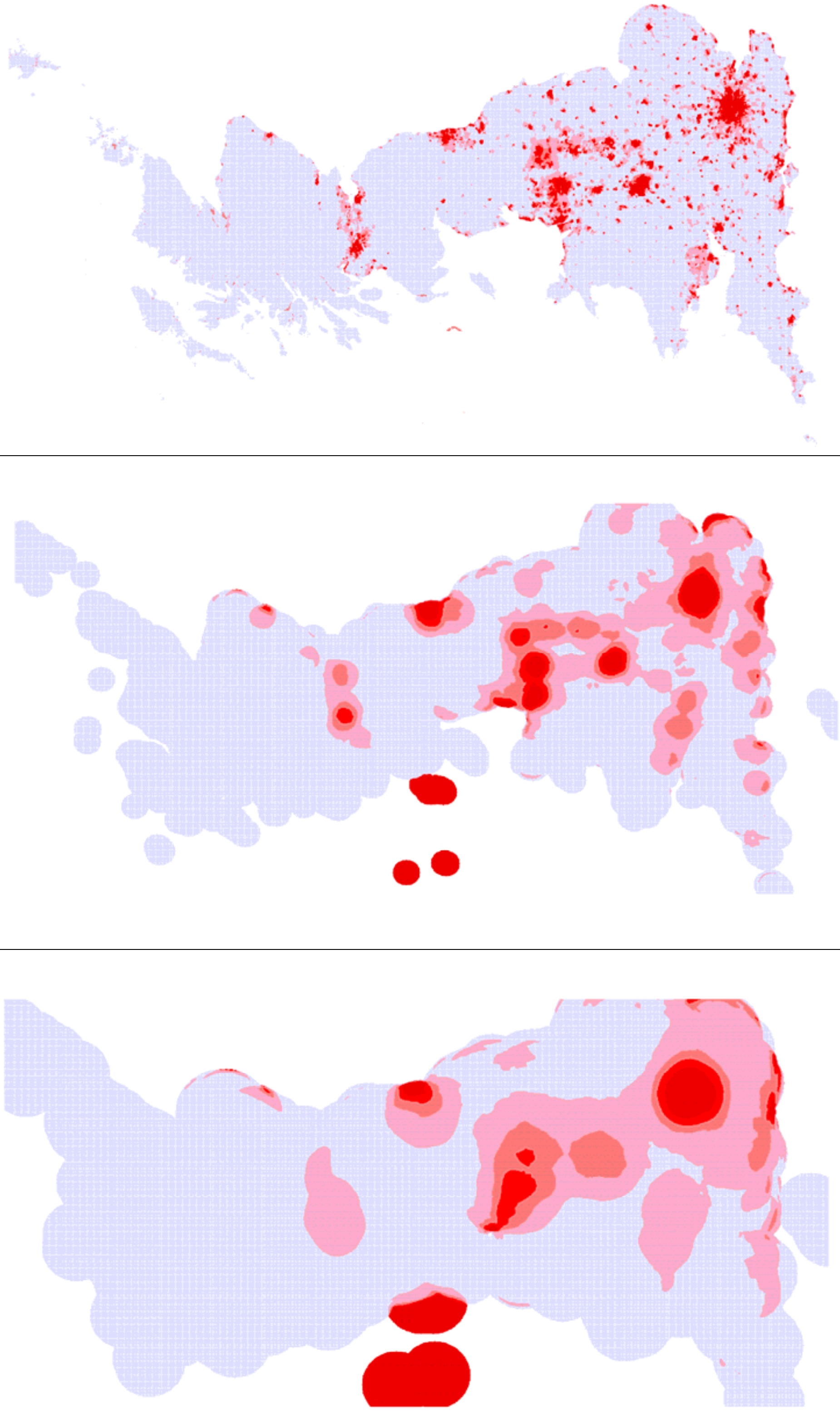
The following figures illustrate how the population density grid changes based on the use of differing neighbourhood area size. Figure G-7-2 (a) illustrates what the UK population density looks like with no focal mean applied. This grid could be used to weight the minor roads network as we assume that nearby population densities will determine road activity levels on minor roads. Figure G-7-2 (b) illustrates what the UK population density looks like using a 20 km radius. This illustrates our perceived understanding of population influence on A-road activity. Figure G-7-2 (c) illustrates the greater influence of a 50 km distance of population on motorways.

Figure G-7-2 Population density maps calculated using a) 0 km focal mean, b) focal mean of 20 km and c) focal mean of 50 km.

(a)

(b)

(c)



Furthermore, an additional base load flow of traffic on motorways can be added to account for the national base load of traffic on even very rural parts of motorway stretches. This minimum load will be irrespective of the focal mean weightings. A base load calculated for the UK has been calculated to be 36 % based on assessments of traffic flow on UK motorway roads (D Briggs, 2005).

Step 2: attributing national emissions to the different road classes

The second step is to determine the proportion of the emission totals to allocate to the different road types.

Table 3 gives an example of the UK profile and can be used where more specific COPERT III or country data is not available. This allows the percentage of emissions for each vehicle class to be allocated to each road type.

Table 3 Road transport emissions by vehicle and road type

Road type	Cars	LDVs	HDVs	Motorcycles
Motorway	12%	13%	23%	5%
A road	52%	51%	41%	59%
Minor – built	26%	25%	23%	25%
Minor - non built	10%	11%	14%	11%

Step 3: distributing emissions over the surrogate spatial datasets

Once the national total emissions have been divided into their road class components these components can be distributed across the spatial datasets prepared in step 1 using the national emissions distribution approach given in the general guidance section.

Appendix G Detailed description of the EMEP 50x50 km^2 grid

The following information is taken from Annex V to the UNECE EMEP Emission reporting Guidelines (UNECE, 2009). Many Parties enquire about conversion from GIS to EMEP grid basis. EMEP does not have such guidance on this issue at present — a small technical project to produce such guidance might be considered to cover this issue. However, the Open Geospatial Consortium Inc. provides guidance and standards for Coordinate Transformation; see www.opengeospatial.org/standards/ct.

According to the definition given in the Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP): *"The geographical scope of EMEP means the area within which, coordinated by the international centres of EMEP, monitoring is carried out."* This definition has been referred to in all following protocols to the Convention. Since its adoption in 1984, as Parties have ratified or acceded to the EMEP Protocol, the geographical scope of EMEP has broadened.

The EMEP grid domain is depicted in the figure below at 50x50 km^2 resolution. The technical description of the grid can be found below. In addition, the following files with relevant information are available on the EMEP web site: www.emep.int/ under the link "EMEP grid".

Trans. f: Fortran code to convert from EMEP grid coordinates to geographical (longitude-latitude) coordinates.

EMEP grid. data: ASCII file which defines the geographical coordinates and area of each EMEP grid point.

The extended EMEP grid (2008-2012)

In 2007, the Steering Body to EMEP at its 31st session agreed to a new extension of the EMEP grid in order to include EECCA countries signatories to the LRTAP Convention. The extended EMEP 50x50 km^2 domain includes 132x159 points (with x varying from 1 to 132 and y varying from 1 to 159). The 31st session of the Steering Body agreed that the present extension of the EMEP grid is an interim solution until 2012. By that time, Parties to the Convention on LRTAP will be requested to report emission data to EMEP in a different projection in a longitude-latitude grid. The technical specifications for the EMEP longitude-latitude reporting grid are to be agreed by the Steering Body before 2011.

Technical description of the EMEP grid

The EMEP grid system is based on a polar-stereographic projection with real area at latitude 60^o N. The y-axis is oriented parallel to 32^o W defined as a negative longitude if west of Greenwich. The extended EMEP 50x50 km^2 domain includes 132x159 points (with x varying from 1 to 132 and y varying from 1 to 159). In the past, the official EMEP grid included only 132x111 points, as depicted in Figure Va.

For the **extended 50x50 km^2 grid**, the latitude, ϕ, and longitude, λ, of any point (x, y) on the grid may be calculated as follows:

$$\phi = 90 - \frac{360}{\pi}\arctan\left[\frac{r}{M}\right]$$

$$\lambda = \lambda_0 + \frac{180}{\pi}\arctan\left[\frac{x - xpol}{ypol - y}\right]$$

in which:

xpol	= 8	(x coordinate of the North Pole)	
ypol	= 110	(y coordinate of the North Pole)	
d	= 50 km	(grid length at 60° N)	
ϕ_0	= 60° N = π/3	(defining latitude)	
R	= 6370 km	(radius of earth)	
M	= R/d [1 + sin (ϕ_0)] = 237.73	(Number of grid distances between the North Pole and the equator)	
r	= $\sqrt{(x - xpol)^2 + (y - ypol)^2}$		
λ_0	= -32 (32 ° W)	(rotation angle, i.e. the longitude parallel to the y-axis)	

The x and y coordinate in the EMEP grid of any given latitude and longitude can be found from:

$$x = xpol + M \tan\left[\frac{\pi}{4} - \frac{\phi}{2}\right]\sin(\lambda - \lambda_0)$$

$$y = ypol - M \tan\left[\frac{\pi}{4} - \frac{\phi}{2}\right]\cos(\lambda - \lambda_0)$$

It should be pointed out that x and y coordinates calculated with the equations above coincide with the grid-square centre. Thus, if a grid-square has its centre coordinates (x,y), the coordinates of its lower left and right corners are (x-0.5, y-0.5) and (x+0.5, y-0.5) respectively, and the coordinates (x,y) of its upper left and right corners are (x-0.5, y+0.5) and (x+0.5, y+0.5) respectively.

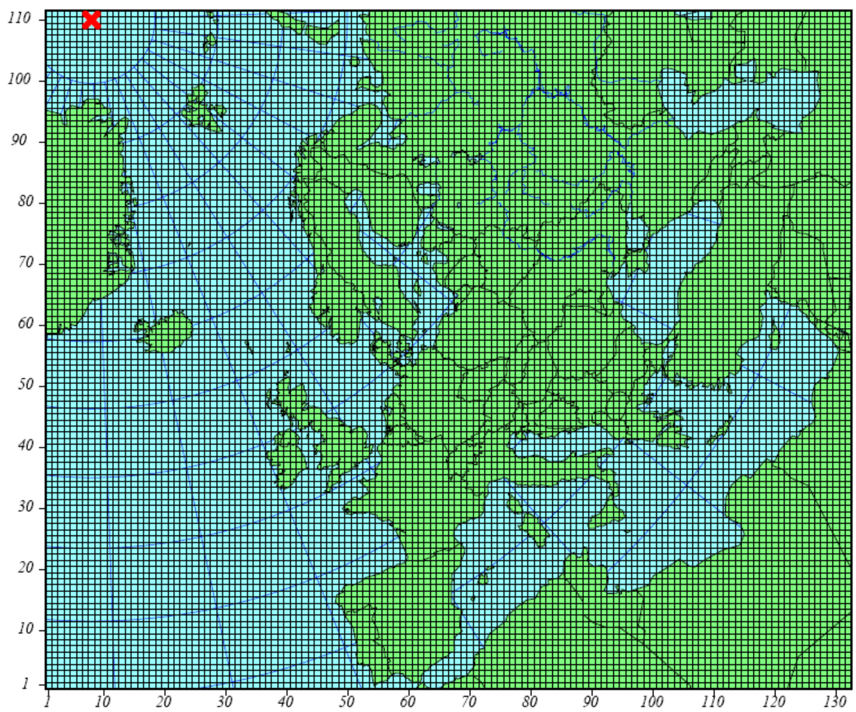


Figure G-7-3: Present extent of the EMEP 50x50 km^2 grid

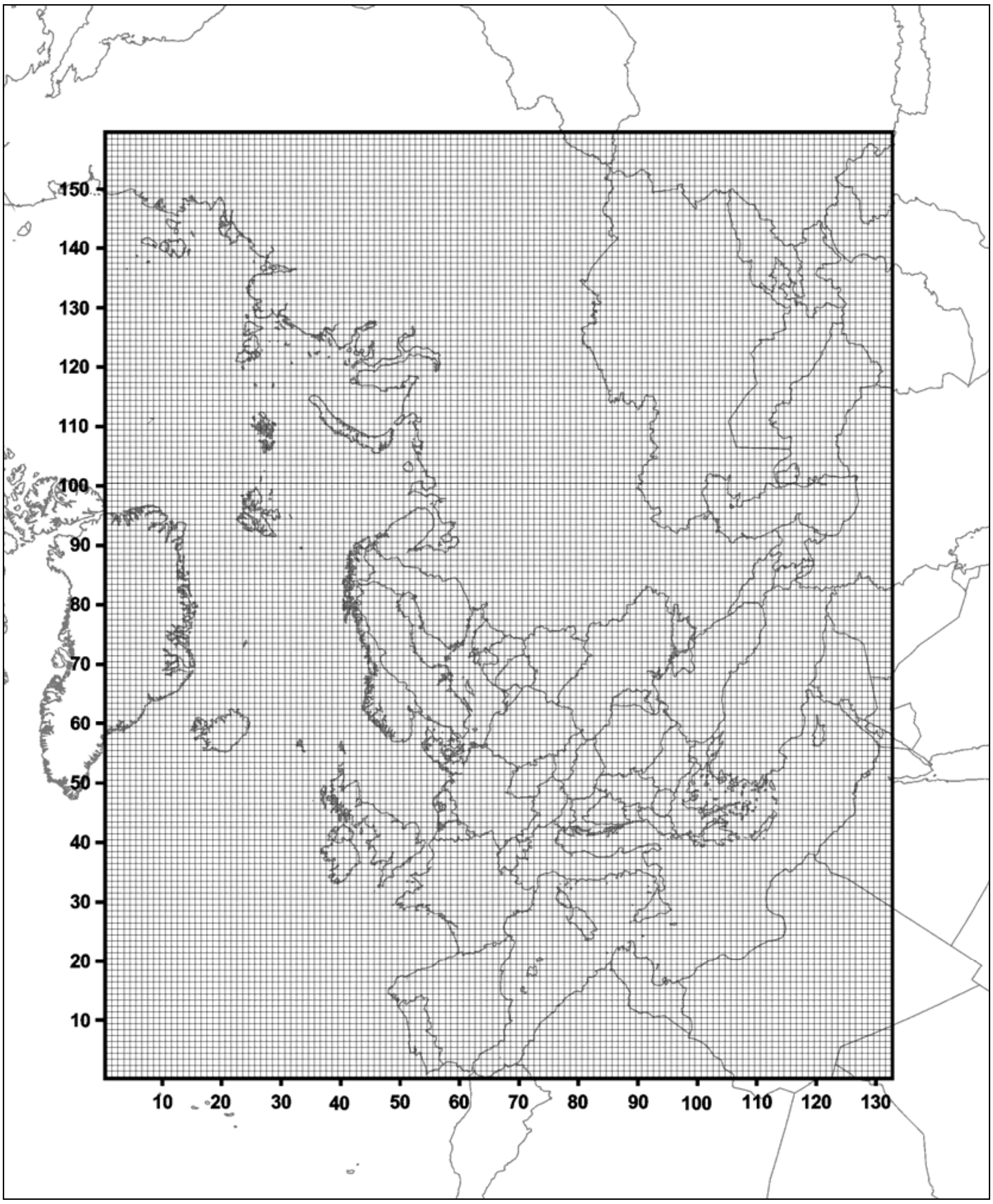


Figure G-7-4: Extended EMEP grid (132 x 159 points)

Note that the boundaries shown on the maps do not imply official endorsement or acceptance by the United Nations.

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