Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

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

EPA Research Programme 2014-2020

Climate 2015 Call – Project 15
National mapping of GHG and non-GHG emissions sources

Section A1: Literature Review

Spatial distribution of emissions is a key element in assessing human exposure to air pollution through the use of dispersion modelling. The quality of the spatial and temporal distribution of emissions is crucial for the quality, applicability and reliability of the modelled air pollution levels, the estimated human exposure, incurred health effects and related costs; all issues that are very important information for policy makers in decisions of implementation of environmental policies and measures.

In addition to the importance of spatial and temporal resolution of emissions to air quality modelling there is also international requirements regarding the reporting of spatially distributed emissions. Under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) there is a requirement to report spatially distributed emissions every four years (ECE/EB.AIR/125). The reporting guidelines under CLRTAP specifies the coverage of pollutants, and emission sources and sectors to be covered as well as setting out requirements to the grid used and the deadline for reporting. The reporting by Parties is used in the European Monitoring and Evaluation Programme (EMEP) modelling[1]. The EMEP model calculations have been supporting the decision making within CLRTAP for more than 30 years. Since the 1990s the EMEP models have been the reference tools for atmospheric dispersion calculations as input to the Integrated Assessment Modelling, which supports the development of air quality polices in the European Union.

Another important issue, for which there are currently no international obligations, is the temporal distribution of emissions. While emission inventories have been subject to significant improvements over the last decades and efforts to both quantify and reduce the uncertainties of inventory datasets, both the sensitivity to and the processing of emission input data in currently applied atmospheric transport models has not been investigated in sufficient depth. This is in particular the case for the temporal resolution of emissions, which may have a significant impact on the match between modelled and measured air pollution levels in particular when applying atmospheric transport models with exceptionally high spatial resolution on a national or smaller scale (Reis et al., 2009). The temporal factor has a large impact on the dispersion, due to variations in climatic parameters like wind speed, wind direction, temperature, and precipitation, and thereby on the human exposure (Ramsdell and Rishel, 2006).
Regarding environmental policy decisions, information on temporal distribution can allow policy makers to adapt environmental initiatives both on a geographical and a temporal level to optimise the effect and minimise the costs.

In the EMEP/EEA Guidebook (EEA, 2013), there is provided technical guidance for the spatial distribution of emissions. The Guidebook is mandatory to use as a minimum standard in preparing and reporting data under CLRTAP. The Guidebook contains guidance on the selection of spatial data sets, both related to possible nationally available data and internationally available datasets (such as CORINE or Eurostat data) that can be used, if no national data are available.

Many studies have been published regarding spatial distribution and to a lesser extent

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[1] https://wiki.met.no/emep/page1/emepmscw_opensource#model_description

temporal distribution of emissions. Several studies have endeavoured to make a spatial distribution for the whole of Europe. These include the EDGAR[2] system developed by the European Commission Joint Research Centre and the system developed by TNO (Denier van der Gon et al., 2010). In general both of these projects used point source information where it was available. This information came from international databases such as EPER (European Pollutant Emission Register) and the World Electric Power Plants Database. For the area sources both studies used very crude spatial proxies to distribute emissions, such as population density, FAO data on distribution of livestock, and CORINE (Coordination of Information on the Environment) land cover. With thorough research at the country level, it is possible to significantly improve the spatial distribution compared to these models attempting to cover the entire European continent.

Most of the published studies have focussed on single pollutants (Bo et al., 2008; Sahu et al., 2011; Dalvi et al., 2006) or single sectors (Skjøth et al., 2011; Hellsten et al., 2008; Puliafito et al., 2015). In addition, many studies have not been at the national level but at a city or regional level (Sahu et al., 2011; Guttikunda & Calori, 2013; Tian et al., 2004). A few studies have focused on spatial distribution for a range of pollutants at the national level for all emission sectors (Plejdrup & Gyldenkærne, 2009; Tsilingiridis et al., 2010; Tsagatakis et al., 2013; Kannari et al., 2007).

In Denmark, the SPREAD model has been developed for high resolution (1 km x 1 km) spatial distribution of all sources and all pollutants included in the national emission inventories (Plejdrup & Gyldenkærne, 2009). Spatial distribution is carried out on highly disaggregated emission source level, and resulting spatial emissions corresponds to the emissions in the national inventories. SPREAD is based on detailed national spatial data, e.g. the Danish Building and Dwelling Register, the Civil Registration Register, the national GIS-based road and traffic data base, and the Central Husbandry Register. Spatial data are analysed in a Geographical Information System (GIS) and through geoprocessing converted to spatial distribution keys to be included in the integrated database system.

For Ireland a study was published in 2001 on the modelling of the spatial distribution of SO_2 and NO_x emissions in Ireland (Kluizenaar et al., 2001). This study provides more detail than the first study reporting spatially distributed emissions in Ireland (McGettigan & O'Donnell, 1995). Kluizenaar et al. (2001) spatially distributed emissions of SO_2 and NO_x at a 1 km x 1 km resolution. The study relied on data from e.g. population census, land cover data from CORINE, road travel statistics, and county based residential fuel consumption. The study lists several areas where the methodologies used could be improved. Since the study only focusses on SO_2 and NO_x, it does not include the agricultural sector and the land use sector. The agricultural sector is a main source of emissions of other pollutants, e.g. methane and ammonia, and will hence need to be given careful consideration.

Hynes et al. (2009) published a spatial micro-simulation analysis of methane emissions from Irish agriculture. This study used data from the National Farm Survey and the Census of Irish Agriculture, in particular data for the number of cattle and sheep at each farm spatially aggregated to Electoral Division level. The data from National Farm Survey and the Census of Irish Agriculture used by Hynes et al. (2009) could form the basis for a spatial distribution methodology for the agriculture sector.

References

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Denier van der Gon et al., 2010: A high resolution European emission data base for the year 2005. Umweltbundesamt, Germany

ECE/EB.AIR/125: Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution

EEA, 2013: EMEP/EEA air pollutant emission inventory guidebook 2013. Technical guidance to prepare national emission

[2] http://edgar.jrc.ec.europa.eu/index.php

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Guttikunda & Calori, 2013: A GIS based emissions inventory at 1 km x 1 km spatial resolution for air pollution analysis in Delhi, India. Atmospheric Environment 67 (2013) 101-111

Hellsten et al., 2008: Modelling the spatial distribution of ammonia emissions in the UK. Environmental Pollution 154, 370-379.

Hynes et al., 2009: A spatial micro-simulation analysis of methane emissions from Irish agriculture. Ecological Complexity 6 (2009) 135–146.

Kannari et al., 2007: Development of multiple-species 1 km x 1 km resolution hourly basis emissions inventory for Japan. Atmospheric Environment 41, 3428-3439.

Kluizenaar et al., 2001: Modelling the spatial distribution of SO2 and NOx emissions in Ireland. Environmental Pollution 112 (2001) 171-182

McGettigan & O'Donnell, 1995: AIR POLLUTANTS IN IRELAND - Emissions, Depositions and Concentrations 1984-1994. Environmental Protection Agency, Ireland

Plejdrup & Gyldenkærne, 2011: Spatial distribution of emissions to air – the SPREAD model. Aarhus University, Denmark. NERI Technical Report no. FR823

Puliafito et al., 2015: High resolution inventory of GHG emissions of the road transport sector in Argentina. Atmospheric Environment 101 (2015) 303e311

Ramsdell and Rishel, 2006: Regional Atmospheric Transport Code for Hanford Emission Tracking, Version 2 (RATCHET2). Department of Energy, United States of America.

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Sahu et al., 2011: Emissions inventory of anthropogenic PM2.5 and PM10 in Delhi during Commonwealth Games 2010. Atmospheric Environment 45 (2011) 6180-6190

Skjøth et al., 2011: Spatial and temporal variations in ammonia emissions – a freely accessible model code for Europe. Atmospheric Chemistry and Physics 11, 5221–5236.

Tian et al., 2004: Model development for spatial variation of PM2.5 emissions from residential wood burning. Atmospheric Environment 38 833–843

Tsagatakis et al., 2013: UK Emission Mapping Methodology 2011. Ricardo-AEA/R/3376 ED57422104.

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Section A2: Pressures, Policy and Solutions

Mapping of emissions is an important first step to quantify pressures in the form of deposition of harmful substances to the environment and human exposure to air pollution. Human exposure to air pollution is a significant challenge. WHO estimates that there were 3.7 million premature deaths in 2012 from urban and rural sources worldwide due to outdoor air pollution[3]. Recent results (Brandt et al., 2013a) show that outdoor air pollution caused a total number of 570.000 premature deaths in the year 2011 in Europe. While emissions in Europe are generally decreasing (EEA, 2015) there are still challenges at the local and regional scale that can only be quantified using high resolution spatial models.

The impacts from air pollution are not equally distributed, but depend on geography, socio-demographic and socio-economic factors, including residence address, age, gender, social status, and level of income. Including detailed spatial and temporal distributed emissions improve air quality modelling and contribute to understand the link between air pollution and distribution of related health impacts by adding knowledge that influences modelling of human exposure levels.

Air pollution, in general, is a transboundary and scale dependent challenge with global, regional, national and local sources giving rise to large geographic variability and thereby large differences in the geographical distribution of human exposure to air pollution. Therefore, the life time exposure and personal risk factors for mortality and morbidity outcomes due to air pollution, and thereby their welfare, is very dependent on the individuals possibilities to live in a clean environment.

[3] http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/

For larger geographical areas, e.g. Europe, there are large differences in the exposure risks and living conditions due to regional differences in air pollution levels caused by long range transport of polluted air masses especially from the south and east as well as the degree of urbanisation and geography in densely populated areas. There are also local differences depending on wind direction and distance from local emission sources such as road transport, power plants and industry (Brandt et al., 2013b). Due to considerable impacts of near-by sources, emission inventories with high spatial resolution are crucial for reliable health impact assessment. Further, implementation of high resolution spatial and temporal emissions contribute to efficient regulation of emission sources to air pollution and to decrease the related health effects and impacts on society.

The development of a high resolution spatial and temporal model for Ireland will allow for a more detailed regulation implementing measures targeting areas where the emissions are highest allowing for more cost-effective initiatives. Development of a national spatial emission model covering the entire country allows for assessment of effects of measures on local, regional and national scale.

In development of a spatial distribution model it is advantageous to link directly to the official Irish air emission inventories produced by the Irish Environmental Protection Agency and to design the model to comply with the international reporting requirements under CLRTAP. Additionally, the national model for spatial distribution can be used to evaluate future trends, by adding a geographical component to emission projections prepared frequently by the Irish EPA, which is a valued tool for environmental policy makers.

References

Brandt et al., 2013a: Assessment of past, present and future health-cost externalities of air pollution in Europe and the contribution from international ship traffic using the EVA model system. Atmospheric Chemistry and Physics, 13(15), 7747-7764. 10.5194/acp-13-7747-2013

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Section B: Objectives and targets, detailed work-packages, risk and contingencies

The overall objective of the project is to develop models to enable a high spatial and temporal resolution of the Irish air emission inventories.
A main outcome is the preparation of the official Irish submission of spatial emissions to the UNECE due by May 1 2017. Additionally, the project aims to go beyond the official requirements, e.g. by using a finer sectoral disaggregation.

As discussed in Section A, there are few studies published at the national level that describes methodologies for spatial and temporal high resolution inventories. The development of an integrated spatial and temporal model for Ireland would be the first of its kind. While several papers have been published documenting methodologies for single pollutants, single sectors and/or smaller geographical areas, an integrated model covering a whole country is not currently available. This project will draw upon all literature available in assessing the best possible methodologies to implement in the Irish model. However, since the appropriate methodologies are to a high extent country-specific it will be necessary with significant independent research to achieve the best possible result in the Irish context.

The following work packages (WPs) are planned to ensure the organisation and implementation of the project.
WP1: Development of specifications for the spatial and temporal model
WP2: Assessment and selection of geographical 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

The work packages are described in more detail in the templates below.

There are limited risks associated with the project. The project team has a large experience with both emission inventories and spatial distribution and are very familiar with the international requirements for the preparation of spatial distributed emissions. One element that can present a challenge is whether relevant spatial datasets are available to the project through the Irish EPA. In this project, it is assumed that all spatial datasets to be used within the project are available free of charge.

Work Package Title	Development of specifications for the spatial and temporal model				
Work Package No.: WP1	**Start Month:** 01/01/2016		**End Month:** 01/07/2016		
Work Package Leader Name/Organisation	Ole-Kenneth Nielsen, Department of Environmental Science, Aarhus University				
Other Participant Name/Organisation with major involvement	Marlene S. Plejdrup, Department of Environmental Science, Aarhus University				
Participant:	Ole-Kenneth Nielsen	Marlene S. Plejdrup			
Person-months per participant	1.21	1.21			
Objectives. The objectives of this work package are to define the specifications for the spatial and temporal model including coverage, resolution and data system.					

Description of Work.
This WP will consist of a number of tasks:
WP1.1 Literature review
WP1.2 Specifications of the spatial model
WP1.3 Specifications of the temporal model

WP1.1. The literature review will include relevant scientific publications both peer-reviewed articles and scientific reports. Additionally, this task will include an overview of the requirements for compliance with the international obligations and guidance. The literature review will uncover examples of spatial datasets used and will provide important input in terms of examples of best practice. Furthermore, the review will provide input to the specifications of the spatial and the temporal model.

WP1.2. The specifications for the spatial model will be developed taking into account the outcome of WP1.1 and in close dialogue with the EPA concerning specific requests. As a minimum the specifications will be compliant with the requirements for reporting under CLRTAP. Issues that need to be addressed are the coverage of pollutants, the level of detail in the sectoral breakdown (i.e. GNFR level, NFR level or a more detailed sectoral level), the spatial resolution (i.e. the EMEP grid of 0.1° x 0.1° or a higher spatial resolution) and the available spatial datasets within Ireland. Part of the specifications will also be to determine the current data system in place at the inventory team to ensure that the spatial and temporal model will be easily compatible with the inventory system.

WP1.3. The specifications for the temporal model will be developed taking into account the outcome of WP1.1 and in close dialogue with the EPA concerning specific requests. The specifications will also take into account the temporal profiles currently used in the EMEP model. The applicability of the default EMEP temporal resolution will be assessed as part of developing the specifications particular to Ireland.

At the start of WP1, it is important to have a steering committee meeting between members of the project team and the EPA. The purpose of this meeting will be to agree on a detailed work plan for the entire project.

As part of WP1.2 and WP1.3, it will be necessary for the project team to be in Ireland to liaise with the EPA inventory team as well as with other parts of the EPA and other organisations related to the availability of spatial datasets. It is envisaged that one or two visits will be required during the first 5 months of 2016. The work of WP1 will be described in a short report, synthesising the outcome of the literature review as well as the detailed specifications agreed upon. A draft of this report will be prepared and discussed at a meeting with the EPA before finalisation. This meeting would tentatively be placed in the period from mid-May to mid-June.

Work Package Title	Assessment and selection of geographical data for the spatial model				
Work Package No.: WP2	**Start Month:** 01/04/2016		**End Month:** 01/01/2017		
Work Package Leader Name/Organisation	Marlene S. Plejdrup, Department of Environmental Science, Aarhus University				
Other Participant Name/Organisation with major involvement	Ole-Kenneth Nielsen, Department of Environmental Science, Aarhus University				
Participant:	Marlene S. Plejdrup	Ole-Kenneth Nielsen	Steen Gyldenkærne		
Person-months per participant	1.81	1.01	0.81		

Objectives. The objectives of this work package are to identify available spatial data, and, based on an assessment of these data sets, select the most appropriate spatial data for use in the spatial distribution model.

Description of Work.
This WP will consist of a number of tasks:
WP2.1 Identification of available spatial data
WP2.2 Review of the spatial data sets
WP2.3 Selection of the spatial data

WP2.1. This task will focus on identifying spatial data sets covering the entire Ireland. Data providers will be identified and contacted, if necessary, in order to obtain access to spatial data and associated metadata, holding important details on e.g. coverage, projection and date of compilation. Spatial data for a number of themes will serve as input to the spatial distribution model, and will be selected among the available data sets taking into consideration, which data are the better proxy for an emission source or sector, and which data are of higher detail. Relevant data sets include road network preferably including mileage and road types, population density on high spatial resolution, building theme including information on building use and land use map including e.g. forest, agriculture and industrial areas. More data sources and geo-data catalogues have been identified, and will be further assessed during the project, here among the Ordnance Survey Ireland (OSi), the GeoDirectory, the Geoportal, and IRLOGI. Also, it is relevant to further explore census data provided by e.g. the Central Statistics Office, Teagasc and the National Road Authority. It is expected that spatial data from public authorities are available to the project by no cost.
If national data are not available or applicable, international data sets will be used to set up the model, e.g. CORINE (Coordination of Information on the Environment) land cover maps could be applied for the agricultural sector, OpenStreetMap for mobile sources, and LandScan population data for residential combustion. It must be noticed that national data are preferred and that international data, that are often less detailed, will only be used in the absence of applicable national data.

WP2.2. A review will be carried out of the collected spatial data e.g. regarding resolution, coverage, age, quality, cost, update frequency, and applicability for the purpose of creating the spatial distribution model. During the review it will be assessed which spatial data are the better proxy for the emission sectors in the national emission inventory, and the number of distribution keys will be decided.
In the process of reviewing the spatial data, it might in some cases turn out that very detailed

data are available and found to be the best proxy for minor emission sources, but also that applying these data and converting them into spatial distribution keys will be very demanding, labour-intensive and/or costly. In these cases an individual assessment will determine if the detailed methodology will benefit the resulting spatial emissions to an extent that justify the effort, or if a more simple methodology is preferred. The emphasis will be to achieve the highest possible accuracy within the resources available and to be conscious of the fact that the models shall remain operational after the end of the project period. During this phase it will be necessary to have 1-2 meetings with relevant stakeholders that have access to the spatial datasets. WP2.3. Based on the review, the most appropriate spatial data will be selected for the model development. Many factors are of importance when selecting spatial data and it is not necessarily the most detailed or the newest data set that will be selected. This might be the case e.g. if the coverage is insufficient, the spatial uncertainty is too large or the data format is unsuitable. The selection of spatial data will be carried out in close dialogue with the EPA concerning specific requests. The work of WP2 will be described in a short report, synthesising the outcome of the data review as well as the selected spatial data. A draft of this report will be prepared and discussed at a project meeting with the EPA before finalisation. This meeting would tentatively be placed in the autumn of 2016.

Work Package Title	Development of the model for spatial distribution of emissions				
Work Package No.: WP3	**Start Month:** 01/07/2016		**End Month:** 01/06/2017		
Work Package Leader Name/Organisation	Marlene S. Plejdrup, Department of Environmental Science, Aarhus University				
Other Participant Name/Organisation with major involvement	Ole-Kenneth Nielsen, Department of Environmental Science, Aarhus University		Henrik G. Bruun, Department of Environmental Science, Aarhus University		
Participant:	Marlene S. Plejdrup	Ole-Kenneth Nielsen	Henrik G. Bruun		
Person-months per participant	2.62	2.42	2.21		
Objectives. The main objective of this WP is to transform the specifications developed in WP1.2 and WP2.3 to an operational model for the spatial distribution of emissions.					
Description of Work. This WP will consist of a number of tasks: WP3.1 Design of the spatial model. WP3.2 Building the spatial distribution model. WP3.3 Consistency with the national emission inventory WP3.1. The spatial model and the interrelationship between the input parameters, according to the decided output details and formats will be designed. A correspondence list of distribution keys and emission sectors will be compiled, which can serve both as an overview and as input for future improvements of the distribution model. The spatial model will be built as an integrated database system, which will be designed in this WP. WP3.2. During this task, the project team will keep close contact with the EPA to ensure that the model will be optimised for future use. It will be endeavoured to deliver an output format that enable the spatial emissions to be included as part of the WebGIS on the homepage of the Irish EPA[4]. Based on the spatial data selected in WP2.3, distribution keys will be prepared in a Geographical Information System (GIS) using overlay analysis and data management functionality. The resulting distribution keys will include two parameters; grid cell ID and the share of total emissions to be allocated to the grid cell. The distribution keys will be included in a separate database in the integrated database system, which will also include a database for					

[4] http://gis.epa.ie/Envision

output of resulting spatial emissions at appropriate aggregation levels. The spatial emission model will be prepared to deliver output data that are applicable for visualisation in GIS, and maps for all pollutants will be prepared.

WP3.3. The spatial distribution model will be created to achieve consistency with the national emission inventory, ensuring that the output from the spatial distribution model meets the requirements for reporting of gridded emissions to the LRTAP convention. Resulting spatial emissions will match emissions in the national inventory on the aggregation level in the reporting tables for gridded emissions to the LRTAP convention (gridded nomenclature for reporting, GNFR).

The work of WP3 will be published in a peer-reviewed journal, documenting the methodology of the spatial model. Furthermore, a quick guide to the model will be completed for the end users.

Work Package Title	Development of the model for temporal distribution of emissions				
Work Package No.: WP4	**Start Month:** 01/02/2017		**End Month:** 01/10/2017		
Work Package Leader Name/Organisation	Ole-Kenneth Nielsen, Department of Environmental Science, Aarhus University				
Other Participant Name/Organisation with major involvement	Marlene S. Plejdrup, Department of Environmental Science, Aarhus University		Jesper H. Christensen, Department of Environmental Science, Aarhus University		
Participant:	Ole-Kenneth Nielsen	Marlene S. Plejdrup	Jesper H. Christensen	Steen Gyldenkærne	Henrik G. Bruun
Person-months per participant	1.41	1.21	1.01	0.40	1.61

Objectives. The objective of this work package is to build a temporal model to be applied together with the spatial model developed in WP3.

Description of Work.
This WP will consist of a number of tasks:
WP4.1 Design of the temporal model
WP4.2 Integration with the spatial distribution model.
WP4.3 Building the temporal distribution model.

WP4.1. Based on the literature review carried out in WP1.1 and the specifications agreed upon in WP1.3 the temporal model will be designed. In the design of the model, it will be ensured that the design is compatible with the design of the temporal profiles used in the EMEP model and any design currently being used for official air pollution modelling in Ireland. The model will include temporal distribution profiles on monthly, daily and hourly level. The emission source aggregation level in the temporal model will depend on the availability of statistical data with a temporal component. Due to reporting obligations to EUROSTAT, national energy statistics are available on a monthly level, and this information will be taken into account in the design of the temporal model. National data on daily and hourly level are generally scarcer, and it might be necessary to use data for either smaller areas or from other countries.

WP4.2. The format of the temporal distribution model will depend on the outcome of WP3 regarding the format of the spatial model. To achieve the objective of an integrated model, it is important to ensure that the temporal distribution model is compatible with the spatial distribution model. Still it is important to design the spatial and the temporal models so that they are operational separately, as different uses of the output emissions might have different requirements to the format, e.g. the temporal component must be omitted when preparing spatial emissions for reporting to CLRTAP.

WP4.3. The temporal distribution model will be built based on the design requirements as per WP4.1 taking into account the outcome of WP4.2. During this task, the project team will keep close contact with the EPA to ensure that the model will be optimised for future use, here among implementation in air pollution models. An output of WP4.3 will be animations showing the emission of selected pollutants at the spatial and temporal scale set out in the specifications defined in WP1.

The work of WP4 will be published in a peer-reviewed journal, documenting the methodology of the temporal model. Furthermore, a quick guide to the model will be completed for the end users and examples of output from the spatio-temporal model system will be presented in animations for selected pollutants.

Work Package Title	Project management and communication				
Work Package No.: WP5	**Start Month:** 01/01/2016		**End Month:** 01/01/2018		
Work Package Leader Name/Organisation	Ole-Kenneth Nielsen, Department of Environmental Science, Aarhus University				
Other Participant Name/Organisation with major involvement	Marlene S. Plejdrup, Department of Environmental Science, Aarhus University				
Participant:	Ole-Kenneth Nielsen	Marlene S. Plejdrup			
Person-months per participant	0.81	0.81			

Objectives. The objective is to ensure the smooth implementation of the project, ensuring the continuous progress towards the overall objectives, and to communicate the progress and results.

Description of Work.
There is planned for four steering committee meetings. These meetings will to the extent possible be held back-to-back with other meetings within the project in order to limit travel expenses. Technical progress reports (TPR) will be prepared every 6 months together with a cost statement. Part of this WP will be the launch of a project website that will contain details on the project, the progress, and the results. At the first meeting of the steering committee, the scope of the project website will be further discussed.

It is envisaged that two workshops will be organised, hosted at the EPA. The workshops will be aimed at stakeholders both in terms of other government agencies but also other stakeholders, e.g. research communities involved with environmental geography, air pollution modelling, etc. Tentatively these workshops would be planned for the third quarter of 2016 and the last quarter of 2017. Additionally, there are plans for a separate workshop with the end-users at the EPA at the end of 2017 to ensure that the transfer of the models occurs smoothly and that the end-users can operate the models without problems.
At the conclusion of the project a 2 pager project summary will be prepared and the EPQ (End of Project Questionnaire) will be completed.
For more information on the details of the communication activities, please refer to Section C. The scheduling of meetings, workshops and deliverables is presented in the Gantt chart.

Section C: Communication

Communication plan
Relevance to Research Priorities:

- The spatial and temporal distribution models will provide improved knowledge on emission and air pollution levels on both national and local scale.
- Development of a model for high spatial and temporal resolution emissions provide important knowledge to the modelling community, and is expected to improve the agreement between measured and modelled concentrations of air pollutants.
- Detailed emissions and air pollution levels can be used by policy makers in decision making and prioritising of environmental measures, and improve the reasoning for environmental regulation when used as input to e.g. health effect studies.

Target audience:

- National emission inventory compilers, responsible for reporting of spatial emissions to UNECE-CLRTAP can use the models as part of the national system to fulfil reporting obligations.
- Modellers and researchers working with air pollution, air quality and related fields can benefit from using output from the model due to the high spatial and temporal distribution.
- Policy makers can include spatial and/or temporal emissions in the process of assessing and deciding on environmental measures, e.g. combined with emission projections to consider long-term effects of local and national planning.

Expected output of the project include the following products:

- Final report. The final report will summarise the work carried out during the whole project. As part of the final report, the written outputs prepared during the WPs will be annexed. These outputs include:
  - The work of WP1 will be described in a short report, synthesising the outcome of the literature review as well as the detailed specifications agreed upon.
  - The work of WP2 will be described in a short report, synthesising the outcome of the data review as well as the selected spatial data.
  - The work of WP3 will be published in a peer-reviewed journal, documenting the methodology of the spatial model. Furthermore, a quick guide to the model will be completed for the end users
  - The work of WP4 will be published in a peer-reviewed journal, documenting the methodology of the temporal model. Furthermore, a quick guide to the model will be completed for the end users and examples of output from the spatio-temporal model system will be presented in animations for selected pollutants.
- Synthesis report providing a clear non-technical summary of the research project.
- Two papers regarding the developed models for spatial and temporal resolution will be submitted to peer-reviewed journals. Tentatively, the papers are planned to be submitted to Atmospheric Environment. When submitting the papers it will be with open access in accordance with EPA's policy. The fees for ensuring open access have been included in the budget.
- A 2-page summary report, at the end of the project, for inclusion on the EPA website.
- Maps of spatial emissions for all pollutants will be prepared.
- Animations of temporal emissions will be prepared for selected pollutants.
- A project webpage will be created and maintained during the project. The webpage will provide information on the objectives of the project, updates on the progress and the results as they become available. The webpage will also include links to all reports and papers produced as part of the project. The webpage will be updated continuously at least once every 3 month during the project period.
- A quick guide to the integrated model targeted at end-users will be prepared. The guide will build on the separate end-user guides prepared under WP3 and WP4.
- An oral or poster presentation of the work at a relevant conference, e.g. during the annual meeting of the Task Force on Emission Inventories and Projections (TFEIP) under EMEP.
- Two workshops for stakeholders will be organised. One to present and discuss the available spatial data and one to present and discuss the models and the results.
- A one-day workshop for end-users to be introduced to the models and guided through features regarding use, updating and future improvements.
- The integrated model system for spatial and temporal distribution including the associated databases, geographical datasets and spatial distribution keys.

Communication of project activities and outputs:

The outputs and the work carried out through the project will be communicated in a number of different ways:

- A project website will be created and continuously maintained throughout the project.
- All reports, presentations, status updates, and maps will be uploaded to the project webpage.
- Close contact with the EPA during the entire project period.

- Workshops and meetings with stakeholders during the project.
- Publication of results in peer-reviewed journals.
- Presenting the work at international conferences.
- Documentation report for the spatial model.
- Documentation report for the temporal model.
- Quick guides for users.
- Press release and/or newsletter will be prepared for publishing on e.g. epa.ie.
- Final newsletter to all involved stakeholders at the end of the project summarising the results.

Section D: Project management and project team

The project will be carried out by the Department of Environmental Science (ENVS) at Aarhus University (AU), Denmark. ENVS has extensive experience with project management both with research projects and large monitoring and consultancy tasks carried out for the Danish Ministry of Environment and the Danish Ministry of Climate, Energy and Building. Among these tasks are the responsibility to annually prepare the official Danish emission inventories for greenhouse gases (GHGs) and non-GHGs for reporting to international conventions, the responsibility to prepare the official spatial distribution of emissions in accordance with the EMEP/EEA Guidebook, the responsibility for the Danish air quality monitoring programme of air pollution and the official modelling of air pollution in Denmark. Through these tasks ENVS has a unique position to successfully achieve the objectives of the project of developing a model for the spatial and temporal distribution of emissions in Ireland.

The project team will have to have a strong cooperation with the EPA to ensure the successful completion of the project. In particular close cooperation is needed with the Irish emission inventory team, but it will also be crucial with cooperation with the EPA GIS team responsible for the EPA GeoPortal. The project team will also liaise with other organisations with relevant spatial data; it will encompass the organisations that are part of the Irish Spatial Data Exchange (ISDE). If relevant spatial data are available from other Irish or international organisations, it will be included in the work.

The project team will consist of:
Ole-Kenneth Nielsen, Special Adviser. Ole-Kenneth has a background in chemical engineering, has more than 10 years of experience within the field of air emissions, and has for the past seven years been project leader of the Danish air emission inventories. Ole-Kenneth has extensive experience within all sectors and serves as an expert reviewer under both the UNFCCC and the UNECE. Ole-Kenneth was the coordinating lead editor of the 2013 edition of the EMEP/EEA Guidebook. Ole-Kenneth will be overall project leader and be involved in the setup of both the spatial and temporal model. http://au.dk/en/okn@envs.au.dk
Marlene S. Plejdrup, Academic Associate. Marlene has a background as a physical geographer and has been responsible for developing the Danish high resolution spatial model (SPREAD) for distributing emissions. Marlene has been responsible for preparing the official Danish submission of spatial distributed emissions in adherence to the guidelines under CLRTAP. Marlene also has extensive experience in working on the Danish emission inventories and therefore has strong insight into the links between the emission inventory and the spatial modelling. Marlene will be responsible for the development of the spatial model. http://au.dk/en/msp@envs.au.dk
Steen Gyldenkærne, Senior Researcher. Steen has a background in agricultural science and has for nearly 15 years worked on the Danish air emission inventories within the agriculture and land-use sectors. Additionally, Steen has been involved in very high resolution (100 m x 100 m) mapping of emissions from agriculture in Denmark as well as research into the temporal variations of agricultural emissions. Steen will work on both the spatial and temporal model providing input and sparing based on his experience within the field. http://au.dk/en/sgy@envs.au.dk
Jesper H. Christensen, Senior Researcher. Jesper has a background in geophysics and has more than 20 years of experience within the field of atmospheric science and in particular atmospheric modelling. Jesper has been a key factor in developing the Danish Eulerian

Hemispheric Model (DEHM) and has published extensively both in peer-reviewed journals and scientific reports, and has communicated results to stakeholders and the general public. Jesper will work on the temporal model and will contribute to the visualisation of the results. http://au.dk/en/jc@envs.au.dk

Henrik G. Bruun, IT expert. Henrik has been working with environmental data for more than 20 years and has extensive experience in data processing in spreadsheets and databases. Henrik has built the national emission databases in Denmark and has implemented the Danish reporting system to fulfil obligations for reporting of NFR and CRF tables to the UNECE and UNFCCC respectively. Henrik has large experience with programming in a variety of languages and will contribute to ensure an easy workable link between the Irish emission inventory and the spatial/temporal model. http://au.dk/en/hgb@envs.au.dk

Section E: Budget justification

The project has been divided into five work packages. Most resources have been allocated to WP3 (Development of the model for spatial distribution of emissions) and WP4 (Development of the model for temporal distribution of emissions). These two WPs will yield the main outputs of the project, i.e. the final spatial and temporal models for distributing the Irish emissions.

WP1 (Development of specifications for the spatial and temporal model) and WP2 (Assessment and selection of geographical data for the spatial model) are the basis for the work in WP3 and WP4 and aims to provide a solid foundation upon which to base the spatial and temporal models.

WP1-4 accounts for more than 92 % of the personnel budget. WP5 accounts for the remaining part of the personnel costs and is for project management during the lifetime of the project including participation in steering group meetings and other administrative meetings.

In total the personnel costs are 132,922 € excluding overhead and 172,798.6 € including overhead. This covers more than 20 person-months as listed in the detailed descriptions of the WPs included in Section B above.

In addition to the personnel costs there is budgeted with travel and subsistence expenses of 18,000 € excluding overhead evenly distributed over the two years of the project. In assessing this part of the budget it is taken into account that we believe that the project will need to be carried out in close cooperation with the EPA and other Irish authorities/stakeholders. While some of the communication can take place using telephone- and videoconferencing, it is envisaged that several meetings and short work stays will be needed over the course of the project. Periodic meetings with the department of the EPA responsible for the emission inventories will be needed. The details of the planned meetings are included in the description of the WPs.

For ongoing communication costs there is budgeted with 5,000 € evenly distributed over the two years of the project. These costs will cover participation in workshops/conferences in accordance with the activities described in Section C as well as costs associated with ensuring open access publication of the results of the project.

Similarly, 2,500 € has been reserved for post completion dissemination costs to cover any expenses associated with participation in workshops/conferences and open access publication after the completion of the project.

Section F: Policy compliance

Aarhus University has a company policy that promotes among other things equal treatment, diversity and freedom of expression. A specific goal in the policy on employment is to create diversity in the staff and promote equality. A full description of the staff policy is available online[5].

[5] http://medarbejdere.au.dk/fileadmin/www.medarbejdere.au.dk/hr/Politikker_strategier/-Politikker/STAFF_POLICY_2013_endelig_udgave.pdf

Section G: References

Reference-1

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Reference-2

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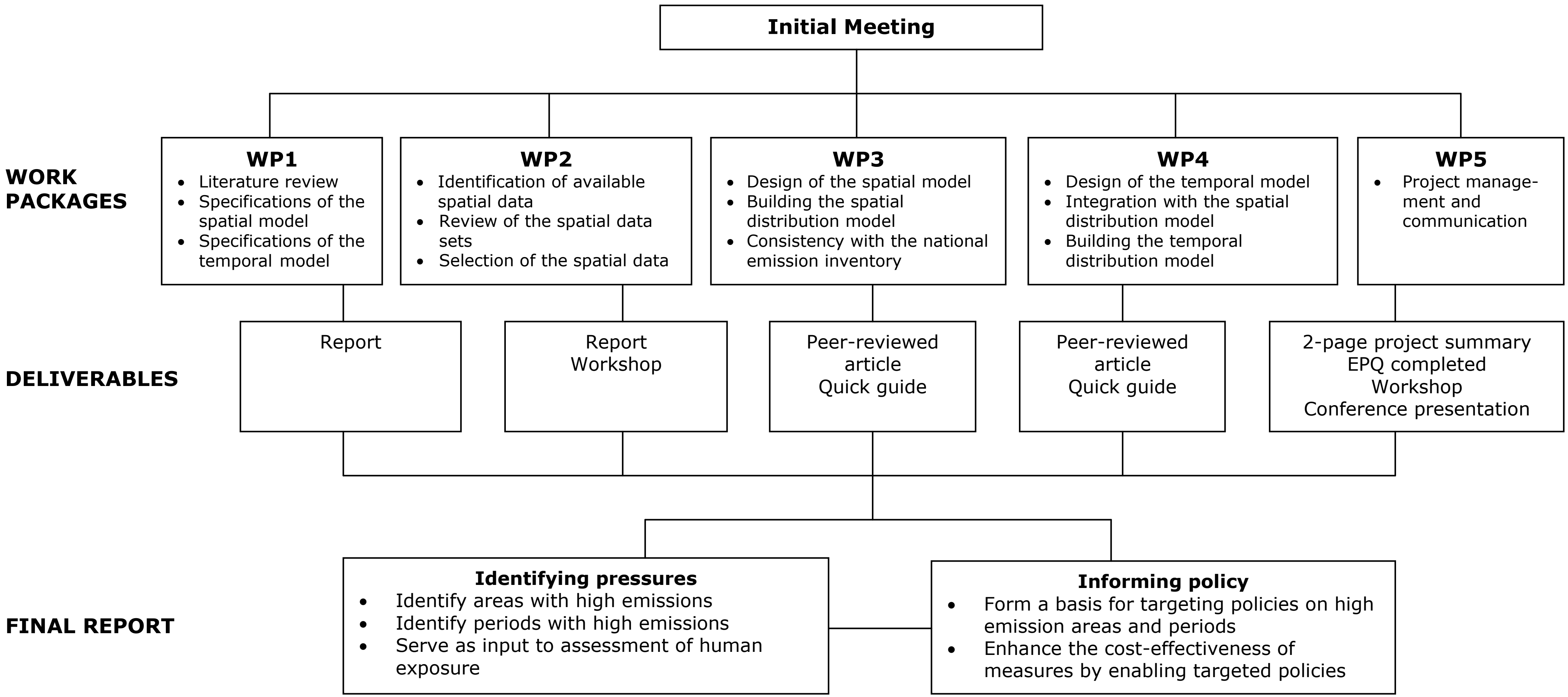
PERT CHART: Outline of Organisation and Work Plan



GANTT CHART: Project Milestones and Timetable

Task	*Month* ⇨ *Description* ⇩	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	**Development of specifications for the spatial and temporal model**																								
1.1	Literature review	■	■	■																					
1.2	Specifications of the spatial model			■	■	■	■																		
1.3	Specifications of the temporal model			■	■	■	■																		
2	**Assessment and selection of geographical data for the spatial model**																								
2.1	Identification of available spatial data				■	■	■	■																	
2.2	Review of the spatial data sets						■	■	■	■	■														
2.3	Selection of spatial data										■	■	■												
3	**Development of the model for spatial distribution of emissions**																								
3.1	Design of the spatial model							■	■	■															
3.2	Building the spatial distribution model									■	■	■	■	■	■	■	■	■							
3.3	Consistency with the national emission inventory							■	■	■	■	■	■	■	■	■	■	■							
4	**Development of the model for temporal distribution of emissions**																								
4.1	Design of the temporal model														■	■	■								
4.2	Integration with the spatial distribution model														■	■	■	■	■	■	■	■			
4.3	Building the temporal distribution model																■	■	■	■	■	■			
5	**Project management and communication**																								
5.1	Steering Committee meeting	■						■						■						■					
5.2	Technical Progress Report (TPR)	■						■						■						■					
5.3	Cost Statement							■						■						■					
5.4	Project website development		■																						
5.5	Stakeholder workshops									■													■		
5.6	End-user workshop																							■	
5.7	Final Cost statement																								■
5.8	Final Technical Progress Report (TPR)																								■
5.9	End of Project Questionnaire (EPQ) on SmartSimple																								■
5.10	2 pager project summary																								■