Institute of Energy Economics and the Rational Use of Energy
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Temporal and Spatial resolution of Greenhouse Gas Emissions in Europe

Selected results from the CarboEurope GHG & IP projects

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Aims & Objectives

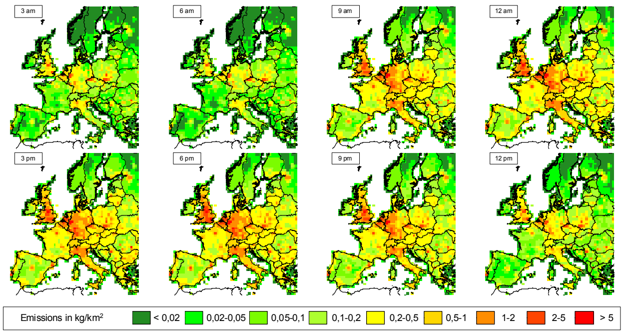
Until recently, the main questions related to the emissions of greenhouse gases were total amounts of CO_2 or CO_2 equivalents emitted, without any regard of spatial and temporal patterns. However, with the issue of compliance with emission targets emerging due to the Kyoto protocol and at the same time intensive measurement campaigns are conducted to quantify regional and global Carbon budgets (e.g. in the CarboEurope project cluster), the need for more detailed greenhouse gas (GHG) emission inventories becomes evident. If, for instance, ground based observations or satelite measurements are to be compared to calculated emission rates, both the anthropogenic and biogenic emissions need to be known as to when and where exactly they occur, else a verification of calculated emissions by measurements, or vice versa, is impossible.

A lot of work in the field of spatial and temporal emission resolution has already been conducted for other trace gases, e.g. in the EUROTRAC subproject GENEMIS (http://genemis.ier.uni-stuttgart.de, *see Fig. 1*). The status quo of GHG emission resolution corresponds to the annual national communications of parties to the UNFCC (typically national & sectoral total emissions). For modelling purposes however, any resolution better than annual and national would improve the calculation of dispersion and resulting concentrations of GHGs.

The work described here aims at obtaining **hourly** emission data on a **10 km * 10 km grid** for CO_2, CH_4 and N_2O.

In most cases, the disaggregation methodology developed for 'classic' air pollutants (NO_x, NMVOC, SO_2, CO etc.) can be applied for greenhouse gases as well because they depend on the same activities of emission sources. However, in some cases greenhouse gas emissions follow distinct time curves. Concerning agriculture, for example, studies about the temporal distribution of NH_3 emissions have been conducted, but those time curves are not necessarily applicable for emissions of CH_4 or CO_2. In order to account for greenhouse gas budgets, the developed methodology needs to be improved and adapted to be applicable to GHG emissions. Adaptation is also necessary regarding classification of emission source groups. Within GENEMIS, emission sources were grouped with respect to CORINAIR "Selected Nomenclature for Air Pollution". National greenhouse gas emission inventories are in most cases based on the Intergovernmental Panel on Climate Change (IPCC) guidelines and emission sources are thus categorised pursuant to the IPCC Common Reporting Format (CRF) since 2000. Correlation between SNAP and CRF was established during the development of the new *Nomenclature for Reporting* to EMEP (NRF).

Based on the approaches developed in the context of GENEMIS, methods of spatial and temporal disaggregation are proposed for emission source groups comprising sources with similar temporal activity.



Sources: CORINAIR/SANA/LOTOS

Fig. 1: Example of the spatial and temporal distribution of NO_x- Emissions in Europe on Monday, July, 25th 1994 in 3-hourly resolution

Temporal Resolution

There are a number of factors influencing the temporal pattern of anthropogenic emissions, both of air pollutants and of greenhouse gases. In most cases, combustion of fossil fuels is the driving force for these emissions, as the following overview table illustrates:

Power plants	fuel use	load curves	load curves
Industrial combustion	fuel use, temperature, degree days, production	working times, holidays	working times
Commercial, institutional and residential combustion	fuel use, degree days	user behaviour	user behaviour
Refineries	oil troughput, fuel use	working times, holidays	working times, shift times
Industrial processes	production	working times, holidays	working times, shift times
Solvent use	production	working times, holidays	working times, shift times, user behaviour
Road traffic	traffic counts	traffic counts	hourly traffic counts
Air traffic	LTO cycles, number of passengers and freight	LTO cycles, number of passengers and freight	LTO cycles, number of passengers and freight

Table 1: Socio-economic data describing temporal activity variation of selected emission sources

By analysing these patterns along with statistical information on production cycles, meteorolocial information (temperature curves etc.) and other data, distinct time curves can be derived for individual plants, types of sources and whole source categories. The following *Fig. 2a* displays exemplary time curves for different types of public power plants, *Fig. 2b* illustrates the temporal behaviour of road transport sources.

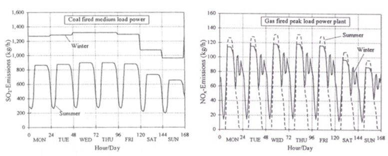


Fig. 2a: Typical Weekly Time Curves - Medium Load (left) versus Peak Load (right) Power Plant

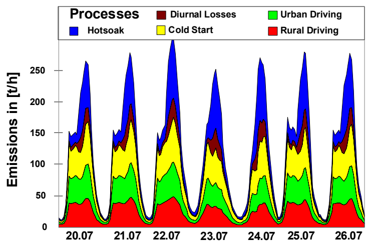
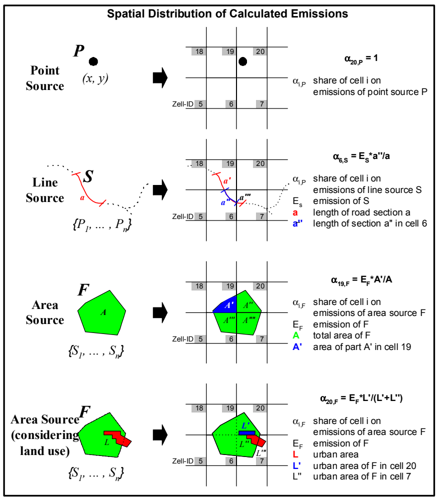


Fig. 2b: Typical Weekly Time Curves - NMVOC emissions from road transport for a typical week in July in Germany

Spatial Distribution

In order to distribute country or regional total emissions spatially, information is needed by sector, what type of source category emissions can be attributed to. Thus, by distinguishing methods for point, line and area sources (*see below*) emission data can be distributed in resolutions that are only limited by the availability and level of detail of proxy information that is used for the distribution.



A variety of data sources is needed to conduct the spatial distribution tasks which have been described in detail for each source type. The following list gives an indication of what kind of dataset is needed and currently applied at IER to achieve a high spatial resolution of emission datasets. Currently, for instance land use data are updated, and the Global Land Cover and the CORINE Landcover datasets for 2000 are expected to improve the attribution to land use changes significantly.

road transport	
highways	digital road map (Germany)
other roads	land use: urban influenced areas
urban roads	urban area
air transport	point source co-ordinates of large airports
railway transport	digitised railway maps
other mobile sources	
forestry	forest area
agriculture	agricultural land
construction	urban influenced areas
shipping	water surface
point sources	point source co-ordinates
small combustion plants, industrial area sources	land use: urban influenced areas
agriculture & animal husbandry	land use: agricultural land

Application

Fig. 3: Example for the spatial distribution of road, rail and area and large point sources in The Netherlands for test case calculation in CarboEurope and the application of data for emission inventory development (see *Fig. 4*)

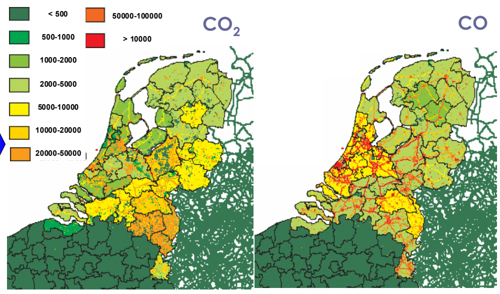


Fig. 4: Spatially resolved emissions of CO_2 and CO for The Netherlands for the year 2000 using the methodology described above and the data on road and rail networks, large point sources and area sources displayed in *Fig. 3*

Conclusions & Outlook

The work described here has lead to the development of methods for the temporal and spatial distribution of emissions of greenhouse gases, improving input data for modelling significantly. Previously established approaches for air pollutants could be extended and enhanced to provide distinct temporal and spatial patterns for GHG emissions (see *Figs. 3* and *4*). The next steps will be related to verification of these calculated anthropogenic emissions against measurements within the CarboEurope IP regional experiment, while at the same time trying to quantify uncertainty ranges for the calculated emission datasets and sensitivities of the main input factors.

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