CityZen

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Report on the assessment of the consistency of the emissions inventories used in the CITYZEN models

Outline

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1. Introduction

The simulations and analysis of observations performed within CityZen use different sets of anthropogenic, biomass burning and natural emissions. This report provides information on the work performed as part of workpackages 3.1 and 3.2, which concern the development and evaluation of surface emission inventories.

Most of the work performed during the first 18 months of the project focused on the preparation of the emissions used in the global and regional simulations. A systematic evaluation of the emissions used in CityZen and other projects started at the beginning of 2010. Preliminary results of this work are being given in this report.

It should be noted that, as planned in workpackage 4.6, contacts have been taken with groups working in other European projects, such as the TNO laboratory in the Netherlands, who is developing emissions for Europe within the MACC and MEGAPOLI projects. As also planned in workpackage 4.6, we are developing contacts with other international groups working on emissions, through GEIA (Global Emissions Inventory Activity), a sub-project of the IGAC, AIMES and iLEAPS projects of the International Geosphere-Biosphere Program (IGBP).

Section 2 describes the regional European emissions used in the first 18 months of the project, Section 3 gives details about the global emissions inventories which has been developed. Section 4 deals with biomass burning emissions and natural emissions, Section 5 gives first results of the on-going intercomparison of emissions, and section 6 provides information on the work planned for the next months.

Both the regional and global CityZen datasets discussed in this report are available on the CityZen web site, at https://wiki.met.no/cityzen/emissions.

1. European anthropogenic emissions for the 1998-2007 period: The INERIS-EMEP European inventory developed within CITYZEN

Emissions for Europe for the 1998-2007 period have been developed for the CITYZEN project by the INERIS group (Bertrand Bessagnet, Guillaume Siour, and co-workers). These emissions are based on the emissions provided by the EMEP programme (European Monitoring and Evaluation Programme) (http://www.emep.int). The emissions are provided for the following species: carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO2), total non-methane volatile organic compounds (NMVOCs) , ammonia (NH3) and particulate matter (PM2.5 and PM10).

The emissions are provided by EMEP at a 0.5x0.5 degree resolution. They have been regridded at a 0.1x0.1 degree resolution in latitude and longitude, using the fine scale global land cover database GlobCover (http://ionia1.esrin.esa.int). The emissions are given as an annual total per grid cell (in Mg/cell), and for different emissions sectors, as defined in the EMEP program, i.e. the so-called SNAP sectors. The definition of the SNAP sectors is provided in the table below; more details can be found at http://www.eea.europa.eu/publications/EMEPCORINAIR5/.

Sector number	Definition of sector
1	Combustion in energy and transformation industries
2	Non industrial combustion plants
3	Combustion in manufacturing industry
4	Production processes
5	Extraction and distribution of fossil fuels and geothermal energy
6	Solvents and other product use
7	Road Transport
8	Other mobile sources and machinery
9	Waste Treatment and disposal
10	Agriculture
11	Other sources and sinks

Table 1: Definition of the SNAP sectors

A few emission files were amended in January 2010 to account for an inconsistency in the way PM emissions are reported:

- There are no PM (2.5 and coarse) emissions in North Africa before 2007. Therefore, for the CITYZEN studies which are analyzing trends, it was decided to switch off PM emissions in North Africa for the full period of the study.
- There are no PM (2.5 and coarse) emissions over the sea areas in 1999. It was decided to copy over sea PM emissions from year 2000 to 1999.
- There are no PM (2.5 and coarse) emissions reported in 1998. It was decided to copy over PM emissions from year 1999 to year 1998.

Figures 1 and 2 show the distribution of the total anthropogenic emissions of CO and NOx for the year 2000.

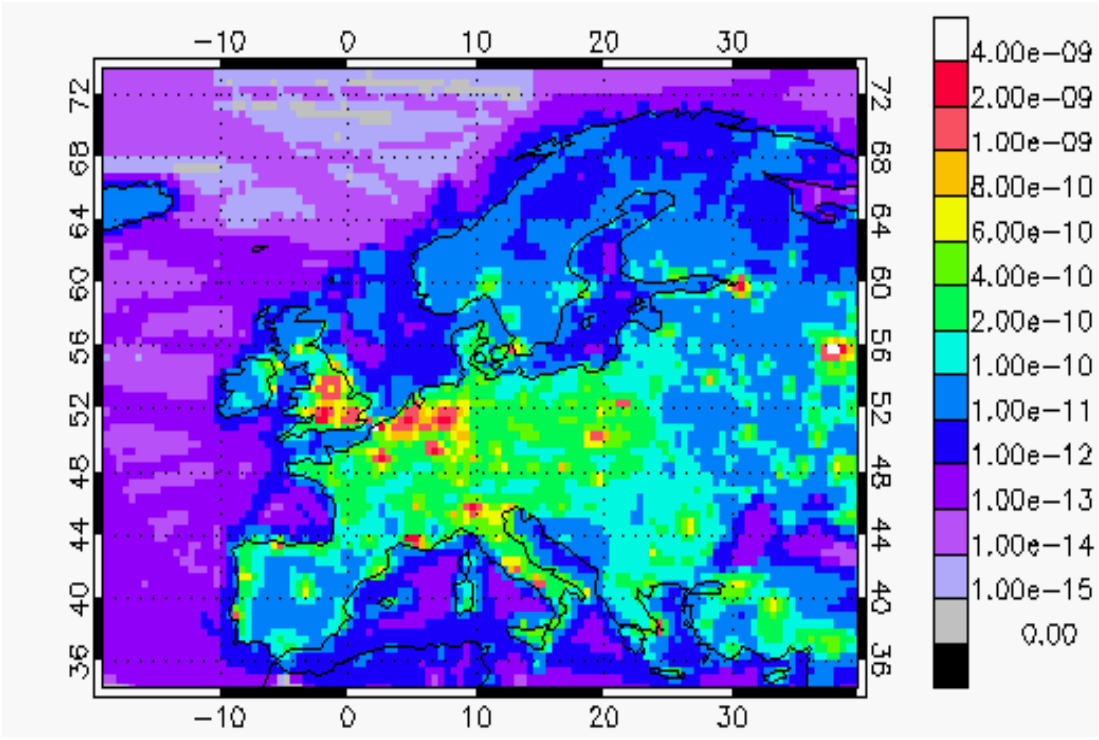

Figure 1: CO anthropogenic emissions from the INERIS-EMEP inventory in 2000.

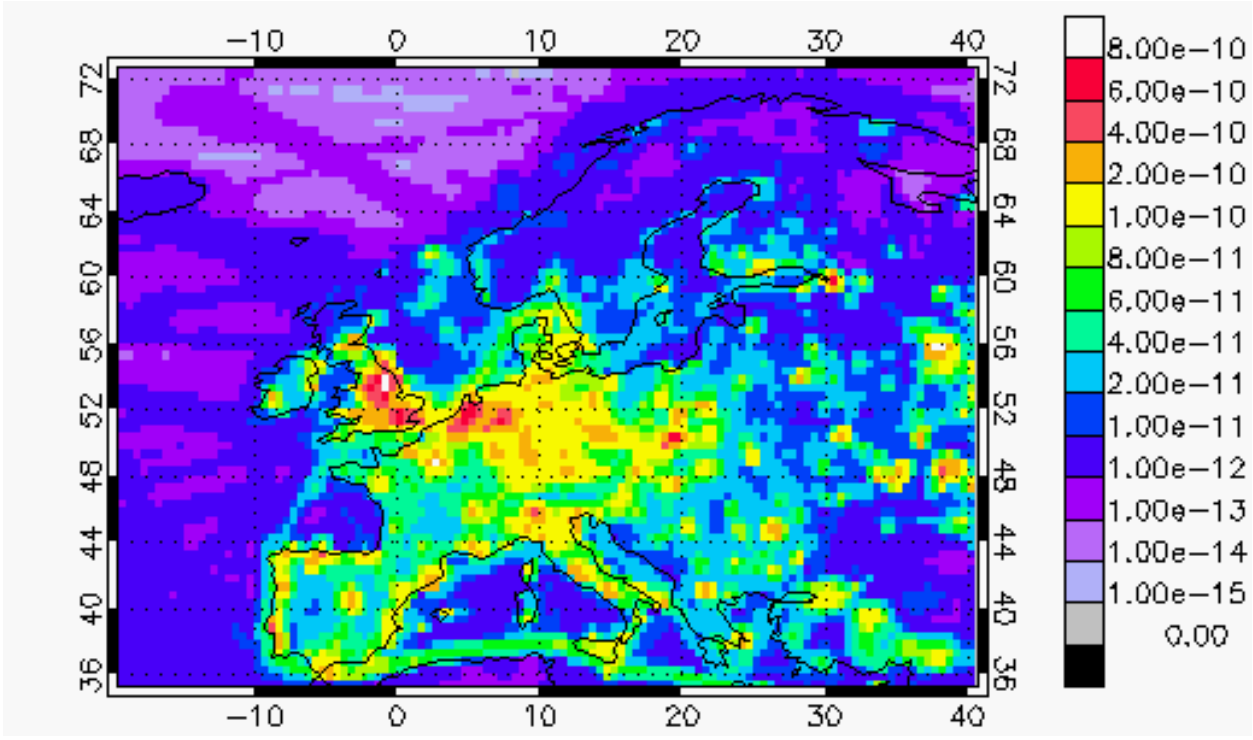

Figure 2: NOx anthropogenic emissions from the INERIS-EMEP inventory in 2000.

2. Global anthropogenic emissions for the 1997-2008 period

A global anthropogenic emissions dataset covering the 1997-2000 period has been developed for the CITYZEN project by the CNRS group (Claire Granier, Fahim Khokhar, Ariela D'Angiola, Aude Mieville). It has been constructed from two datasets: a new global inventory which has been developed in the framework of the next Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR5), as well as the regional inventory for Europe described above.

Global anthropogenic emissions are provided for CO, NOx, ammonia (NH3), black carbon (BC), organic carbon (OC), and 13 different hydrocarbons: ethane (C2H6), propane (C3H8), other alkanes (C4H10 and higher), ethene (C2H4), propene (C3H6), other alkenes (C4H8 and higher), formaldehyde (CH2O), other aldehydes (acetaldehyde and other aldehydes), methanol (CH3OH), other alcohols (ethanol andother alcohols), acetone (CH3COCH3), other ketones (methyl-vinyl ketone and other ketones), toluene (and other aromatics).

The emissions are provided for the 1997-2008 period. The spatial resolution of the emissions is 0.5x0.5 degree in latitude and longitude.

The IPCC emission dataset provides emissions for each decade from 1850 to 2000. This dataset is described in a paper submitted for publication in Atmos. Chem. Phys. (Lamarque et al., ACPD, 2010). The anthropogenic emissions are provided for the following activity sectors:

AGR : agriculture
AWB : agricultural waste burning
DOM : domestic
ENE : energy production
IND : industrial processes and combustion
SLV : solvent
TRA : transport
WST : waste

The anthropogenic emissions for the years 1997-2000 were obtained through a linear interpolation of the IPCC emissions in 1990 and 2000. At the present time, no publicly available inventories provide global anthropogenic emissions beyond 2000. It was therefore decided to determine the emissions for years 2001 and beyond using the so-called Representative Concentration Pathways (RCPs) developed in the IPCC framework for the definition of the 2005-2100 emissions. Information about the RCPs and the scenario development process for the IPCC AR5 can be found in the IPCC Expert Meeting Report on New Scenarios, which can be found at: http://www.ipcc.ch/workshops-experts-meetings-ar5-scoping.htm.

We have used the RCP 8.5 scenario, which was the only scenario available in the fall of 2009. The global emissions for each year between 2001 and 2008 were obtained through a linear interpolation of the IPCC 2000 emissions and the 2005 and 2010 emissions provided by the RCP 8.5 scenario. The INERIS-EMEP European emissions were then regridded at a spatial resolution of 0.5x0.5 degree, and merged into the global IPCC emissions dataset. The INERIS-EMEP European inventory provides total NMVOCs emissions. The speciated VOCs emissions (mentioned above) have been estimated from the spatial distribution of IPCC VOCs emissions, and thus from the spatial distribution of the emission sectors in IPCC emissions, as following:

for each grid point, the ratios of each VOC emissions over the total NMVOC emissions from the IPCC 2000 dataset are applied on the INERIS-EMEP total NMVOC emissions over Europe.

All the emissions are provided in the NetCDF format, where the latitude and longitude coordinates correspond to the central point of each cell.

Figure 3 shows the evolution from 1998 to 2007 of the total emissions of SO2 (3a) and nitrogen oxides (3b) at the global scale as well as in four different regions, Western Europe, Eastern Europe, USA and China. These figures show clearly the decrease in NOx emissions in regions such as Western Europe, Eastern Europe and the USA, and the strong increase in emissions in China.

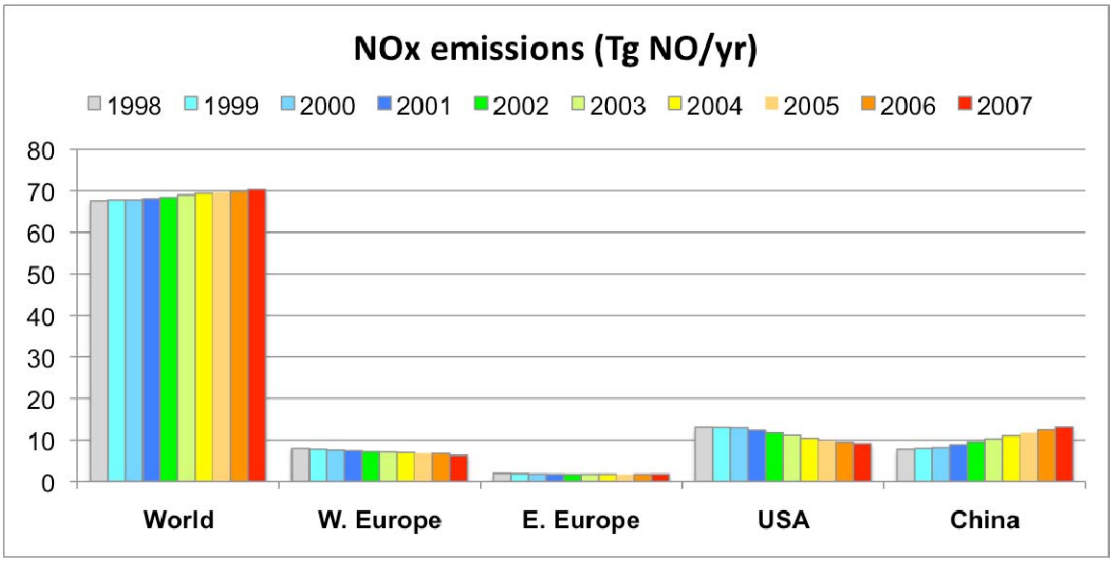

Figure 3a: Change in NOx emissions from 1998 to 2007

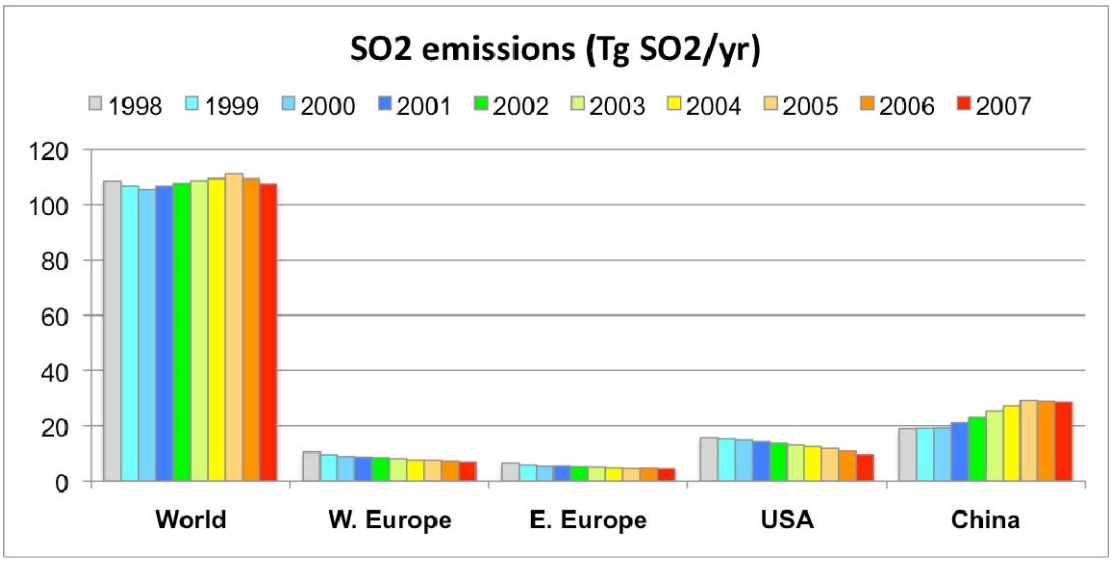

Figure 3b: Change in SO2 emissions from 1998 to 2007

Figures 4a, 4b and 5a and 5b give more information on the distribution of the changes during the 1998-2007 period for the emissions of nitrogen oxides. The differences (in kg/m2/s) shown in Figure 5a and 5b show that surface emissions of NOx have significantly decreased, mostly in the industrialized areas of Europe, and the Eastern part of the USA. Large increases in NOx emissions can be noticed in India and China. Figure 5b provides a zoom for Europe of the differences shown in Figure 5a: it shows that, even if NOx emissions have decreased in most areas in Europe, there are still increases in emissions in several areas close to the coasts, as well as a significant increase in ship emissions.

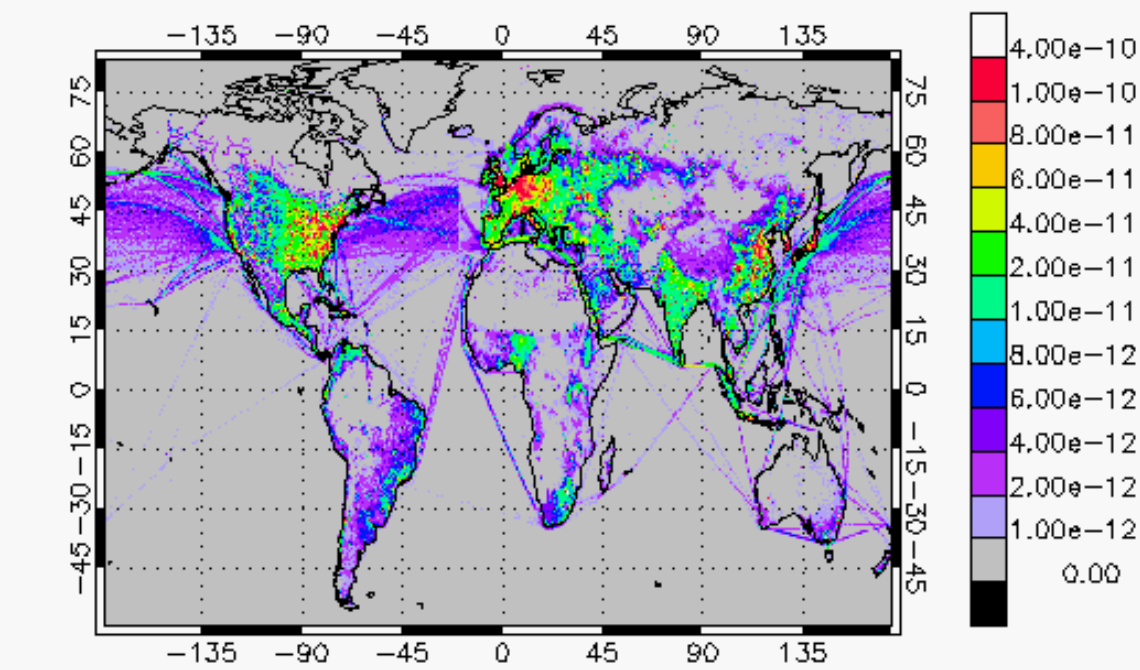

Figure 4a: Anthropogenic NOx emissions (in kg/m2/s) in 1998.

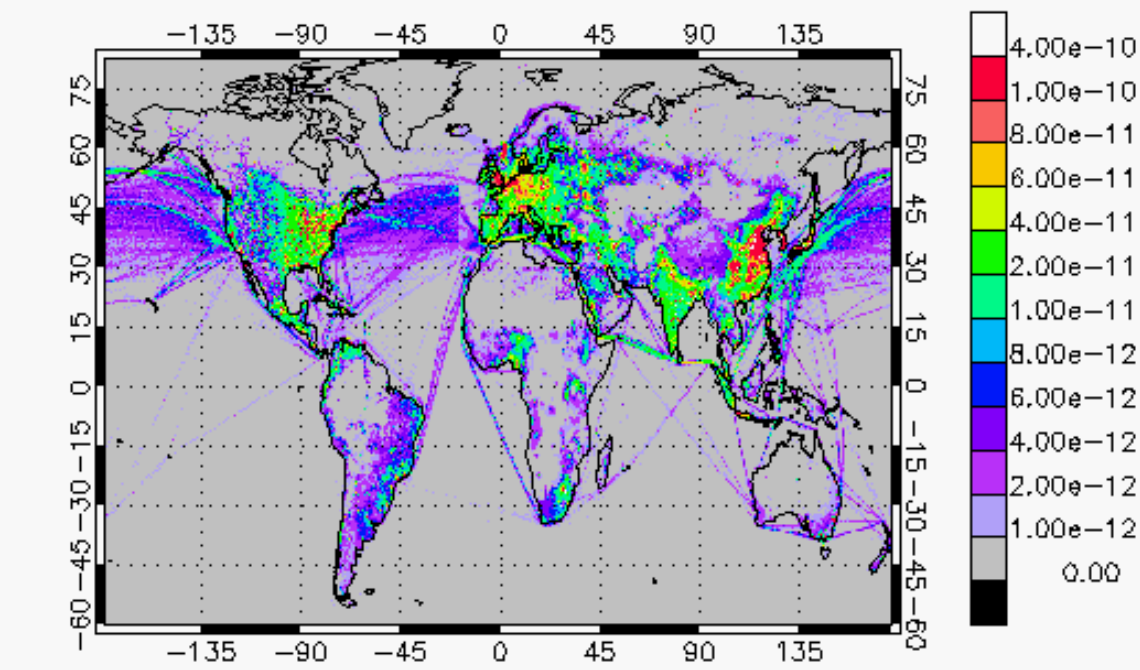

Figure 4b: Anthropogenic NOx emissions (in kg/m2/s) in 2007.

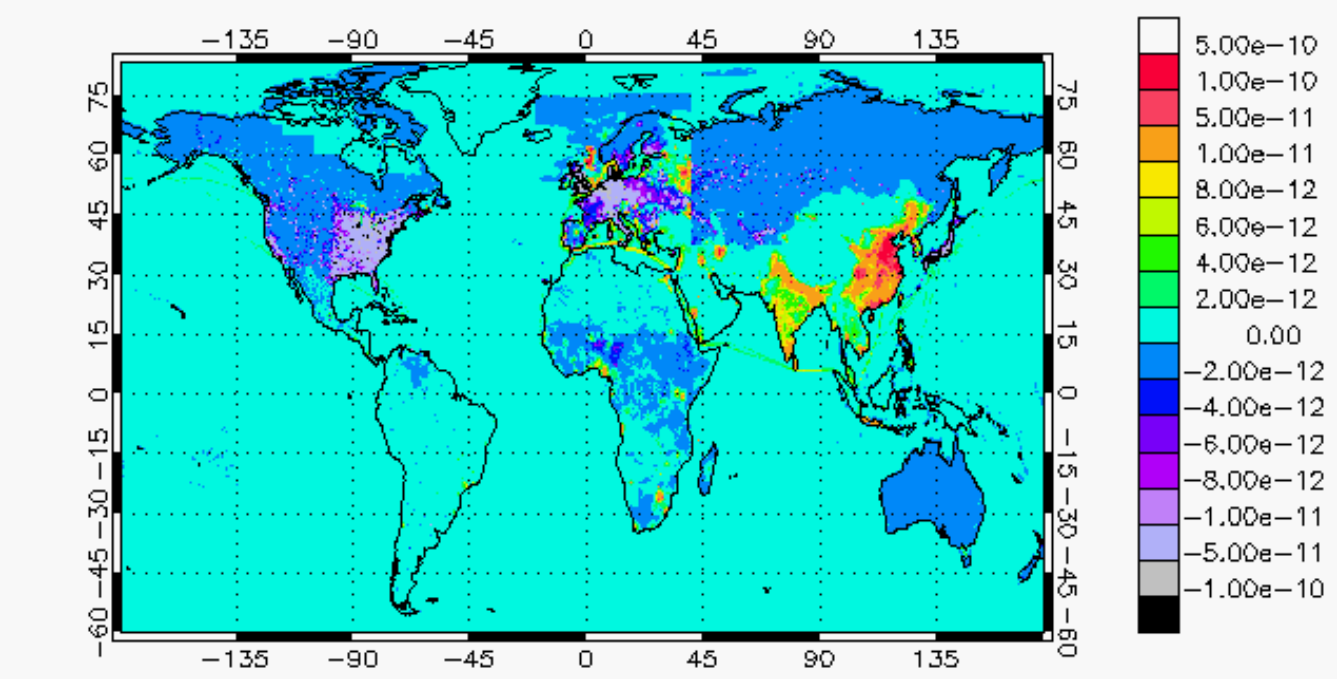

Figure 5a: Difference in anthropogenic NOx emissions (in kg/m2/s) between 2007 and 1998.

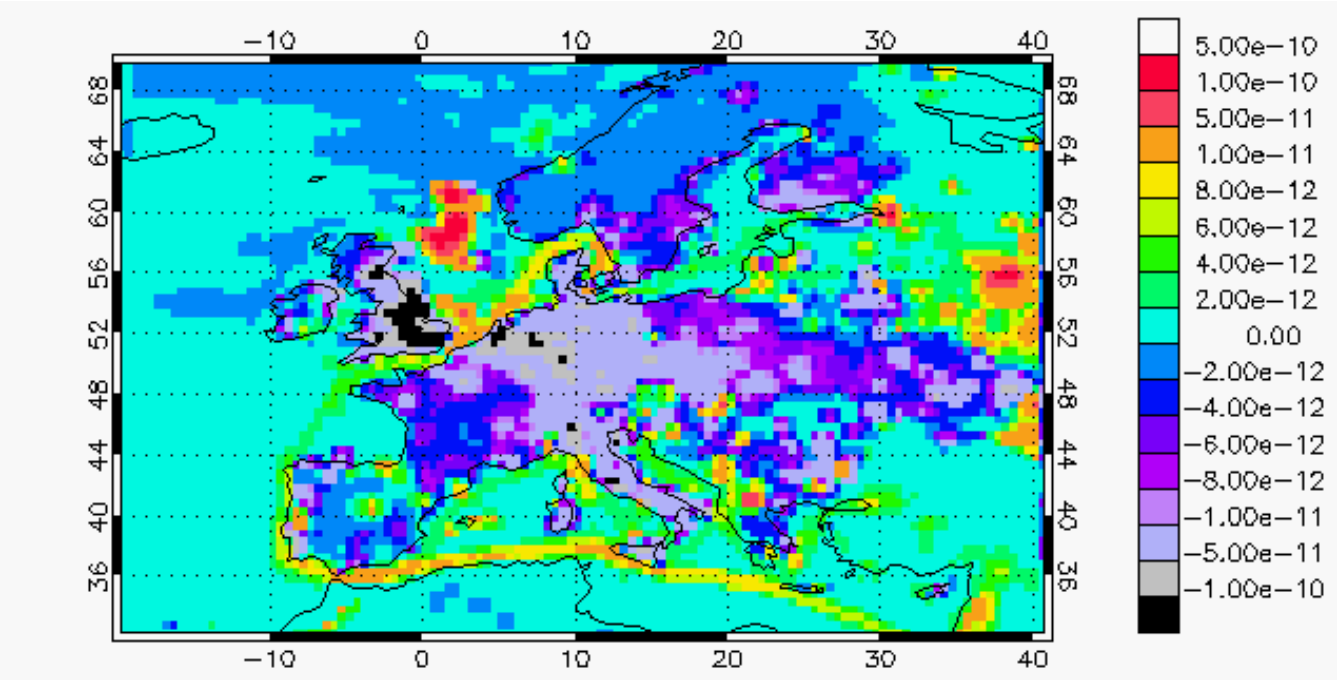

Figure 5b: Difference in anthropogenic NOx emissions (in kg/m2/s) between 2007 and 1998 over Europe.

3. Biomass burning and natural emissions

3.a Biomass burning

Biomass burning emissions on a monthly basis have been developed by the Juelich group (Angelika Heil, Martin Schultz). The emissions were calculated on the basis of the monthly GFEDv2 data, obtained as ASCII – Grid files from the following site:

http://ess1.ess.uci.edu/~j595randers/data/GFED2/. A detailed description of this dataset is provided in the papers of Randerson et al. (2005) and van der Werf et al. (2006).

The emissions of the GFEDv2 standard species, i.e. CO, CO2, CH4, H2, NOx, N2O, total particulate matter (TPM), PM2.5, OC, BC, and total NMVOCs were calculated from the carbon emission fields, the vegetation type map (VEG.txt), and vegetation type specific emission factors provided in the following site:

ftp://daac.ornl.gov/data/global_vegetation/fire_emissions_v2.1/comp/global_fire_emissions_v2_1_readme.pdf.

The original spatial resolution of the data is 1x1 degree, and the emissions were regridded for the CityZen project to a 0.5x0.5 degree resolution.

3.b Natural emissions:

Before the start of CityZen, most modelling groups were using the natural emissions (i.e. emissions from soils,vegetation and oceans) distributions available from the GEIA version 1 inventories, as well as the inventories proposed by Muller and Brasseur (1995). These inventories are available from the GEIA-ACCENT emissions portal (http://geiacenter.org), as part as the POET emissions dataset.

Concerning the emissions from soils and oceans, there has not been any updated inventories since 1995, and we are still using these 15-year or older emissions datasets.

A lot of progress has been made on the estimation of emissions of biogenic hydrocarbons by the vegetation. In CityZen, we are using the emissions provided by the MEGAN (Model of Emissions of Gases and Aerosols from Nature) model (Guenther et al., 2006). MEGAN is a modeling system for estimating the net emissions of gases and aerosols from terrestrial ecosystems into the atmosphere. Driving variables include landcover, weather and atmospheric chemical composition. MEGAN is a global model with a base resolution of about 1 kilometer.

In CityZen, we are using the distribution of 15 different hydrocarbons provided by the newest version of the MEGAN model, i.e. MEGAN version 2.1 (Guenther et al., in preparation, 2010). The MEGAN dataset has been provided by Alex Guenther (National Center for Atmospheric Research, Boulder, CO, USA), who has regridded the emissions at a 0.5x0.5 degree resolution. It provides the emissions from vegetation for the following species: carbon monoxide, methane, ethane, propane, ethane, propene, acetone, other ketones, formaldehyde, acetaldehyde, methanol, isoprene, monoterpenes, sesquiterpenes and toluene.

Figure 6 provides an example of the significant differences between the isoprene emissions in May 2000, as provided by the POET inventory (top) and as provided by the newest version of the MEGAN model used in CityZen (bottom).

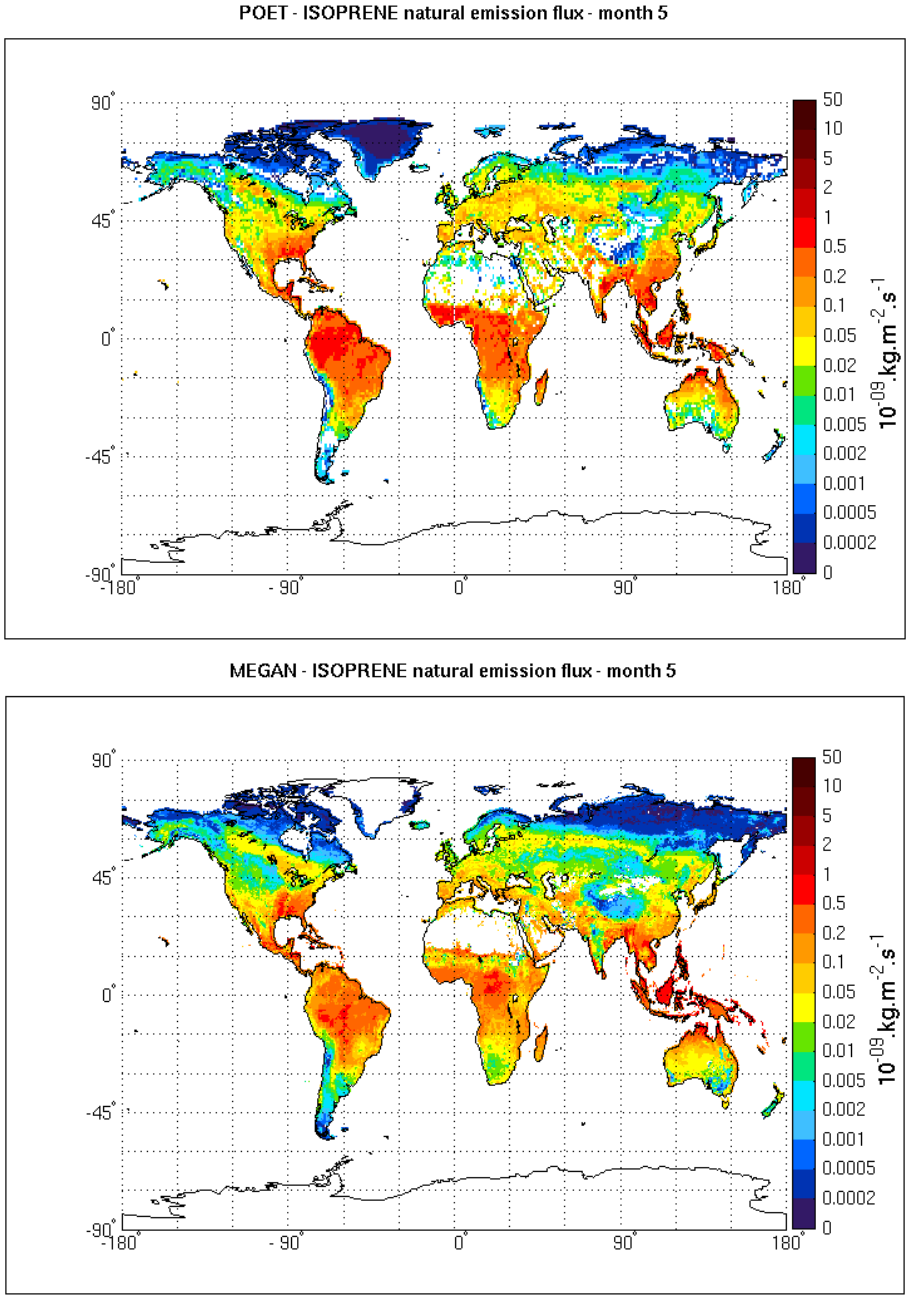

Figure 6. Distribution of isoprene emissions in May 2000, as provided by the POET inventory (left) and the new MEGAN v2.1 inventory (right)

4. First results of a systematic comparison of global and regional emission datasets

A systematic comparisons of available emissions at the global scale, as well as in different regions of the world has started at the beginning of 2010, as part of CityZen, in collaboration with colleagues working in other European projects, such as MEGAPOLI (Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation) and MACC (Monitoring Atmospheric Composition and Climate), as well as colleagues from different organizations (Laboratoire d'Aérologie, CNRS, Toulouse, France; National Oceanic and Atmospheric Administration,

Boulder, USA; National Center for Atmospheric Research, Boulder, USA; Pacific NorthWest National Laboratory, Washington, USA; University of Illinois, Urbana, USA; Frontier Research Center for Global Change, Yokohama, Japan).

The comparison focuses on the 1980-2010 period. All publicly available inventories are being gathered, and we have started to plot the different totals emitted at the global level, as well as for regions for which data are available. A preliminary result, which shows the SO2 total emissions collected until March, 2010, is shown in Figure 7.

This intercomparison has focused on NOx, CO, SO2 and BC. It will be extended to a larger set of data during the coming months.

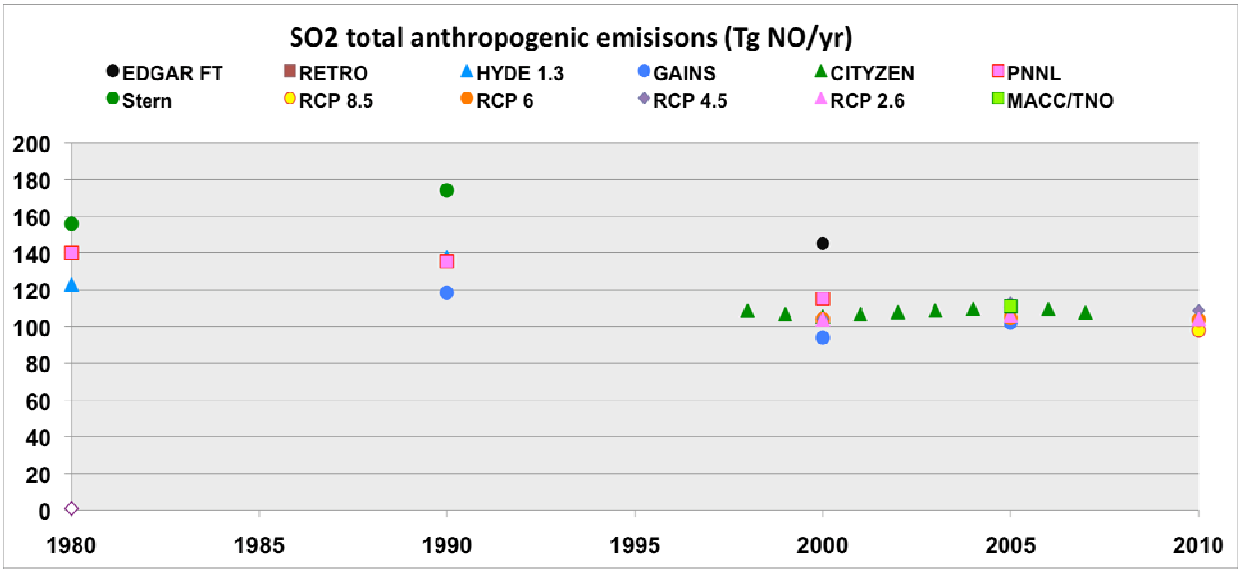

Figure 7: Comparison of total SO2 emissions from different inventories

6. Work to be performed during the next months

The work started during the first months of CityZen will continue during the next months, and will concern more particularly:

- The development of a new set of emissions using the TNO MACC/MEGAPOLI European emissions, only available at 0.5x0.5 degree resolution for 2005 at the present time.
- An evaluation of the biogenic VOCs emissions by comparing the interactive emissions calculated by regional models with the MEGAN and POET dataset
- The continuation of the systematic evaluation of emissions, and extension of the work to several hydrocarbons. The first results of the emissions intercomparison will be discussed in a meeting that will take place in Hamburg on April 27th. Colleagues working in CityZen will participate, together with colleagues from MACC and MEGAPOLI.

7. References

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