European Commission

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Global emission inventories in the Emission Database for Global Atmospheric Research (EDGAR) – Manual (I)

I. Gridding: EDGAR emissions distribution on global gridmaps

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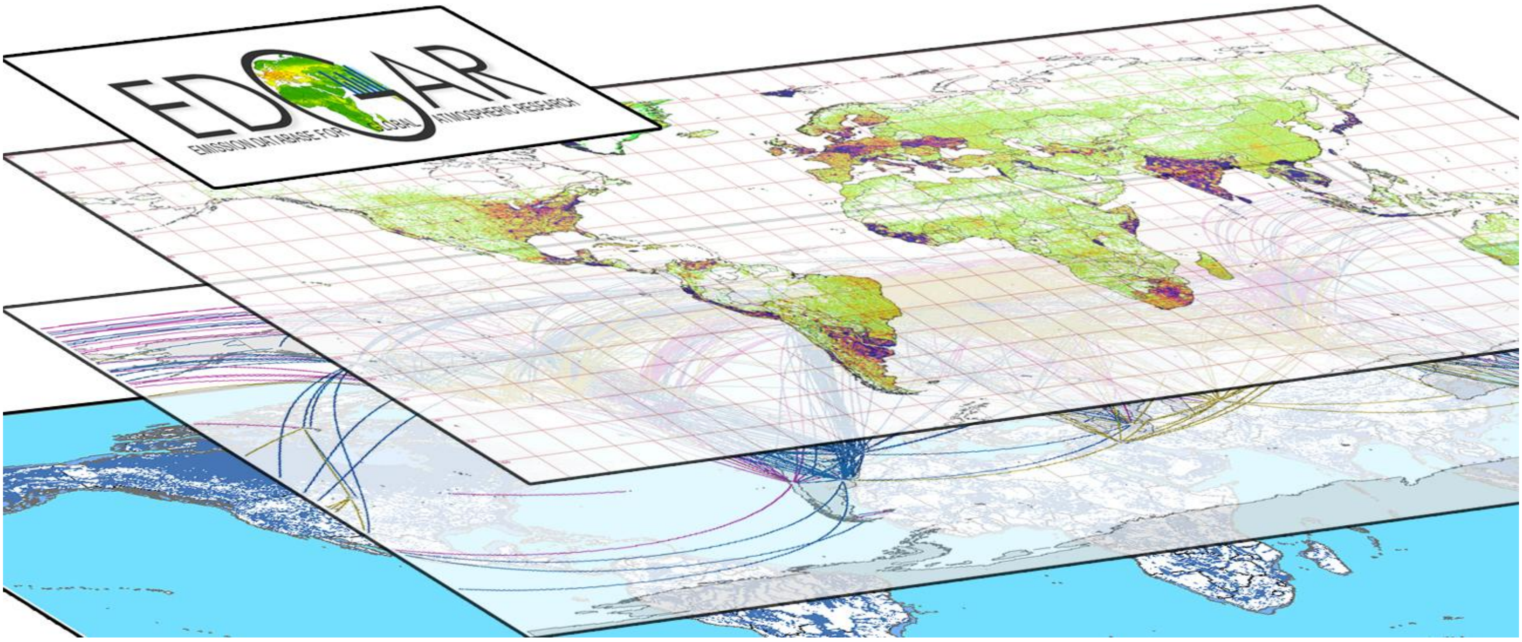

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Contents

I. Introduction

The Emission Database for Global Atmospheric Research version 4 (EDGAR v4), a product of the Joint Research Centre and the PBL Netherlands Assessment Agency, contains global emission inventories for greenhouse gases and air pollutants. These emissions are calculated as total by country and sector from 1970-2008, and distributed on the grid using proxy data. The global emissions for all countries are spatially allocated on 0.1°x0.1° resolution grids over the globe. The emissions distributed on gridmaps using Geographical Coordinate System (lon, lat) have been prepared and can be downloaded in “txt” and “netcdf” formats from EDGAR WEB site
(http://edgar.jrc.ec.europa.eu/overview.php?v=42).

The classification of emitting sources in EDGAR v4 is that developed under the IPCC National Greenhouse Gas Inventories Programme (Reporting guidelines in the revised 1996 IPCC guidelines) having as main sectors: 1.Energy (including biofuel combustion and gas leakage, venting and flaring); 2.Industrial processes (non-fuel combustion sources, incl. F-gas use); 3.Solvents and other product use; 4.Agriculture (including savannah fires); 5.Land-Use Change and Forestry (including post-burn decay and drained peatlands); 6.Waste; 7.Other. The emissions are calculated for the following substances: 1.Direct greenhouse gases, 2.Ozone precursor gases, 3.Acidifying gases and 4.Stratospheric Ozone Depleting Substances.

Total emissions by country are allocated on spatial grids, using proxy data, to provide gridded emissions datasets for atmospheric modeling. The methodology on emissions distribution is described in chapter II and information about the proxy data used in EDGARv4 is given in chapter III. The EDGAR approach on developing derived proxy data (in-house) to enhance emissions distribution capability for some specific sectors (e.g. different emissions distribution heights used in aviation sector) is presented in the last chapter.

II. Methodology

The emissions from area (diffuse), line (road, rail, water and air ways) and point (stacks) sources in EDGAR are calculated as country totals and are distributed on $0.1^0 x 0.1^0$ resolution gridmaps. Regarding the point sources, in most of the cases the emissions are distributed in the grid cells where they are located using the coordinates of each facility. For area, line (Theloke et al., 2011) and some of the point sources the emission distribution of a given substance on a grid covering the country is performed using the coupling “EDGAR activities - Proxy data”, as presented in Tables III.1-III.4, and applying the following formula:

$$EM_{cell,p_i} = EM_{country,P_i} * \frac{PROXY_{cell\_P_i}}{PROXY_{country\_P_i}} \qquad \text{(II.1)}$$

Where:

EM_{cell,p_i} - pollutant p_i, emission inside the cell

$EM_{country,P_i}$ - pollutant p_i, emission as total by country

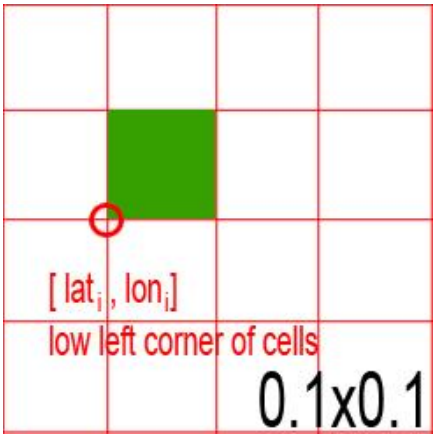
$PROXY_{cell\_pi}$ – proxy associated to the pollutant p_i, inside the cell (e.g. population)

$PROXY_{country\_pi}$ - proxy associated to the pollutant p_i, as total by country

The emissions distribution is based on existing reference grids used as proxies (Tables III.1.1-III.1.4, column EDGAR proxy data) to assign values to each activity in EDGAR e.g. the emissions of p_1, p_2, ….,p_i, … pollutants from combustion in fishing activities "RCO.FSH" are distributed using as associated proxy "Fishing" (see chapter IV.4 EDGAR derived proxy data for costal fishing).

The EDGAR grid is bottom left corner type as it is illustrated in the Figure II.1. The emission assigned to the (lat_i, lon_i) point is the emission distributed in the cell in green.

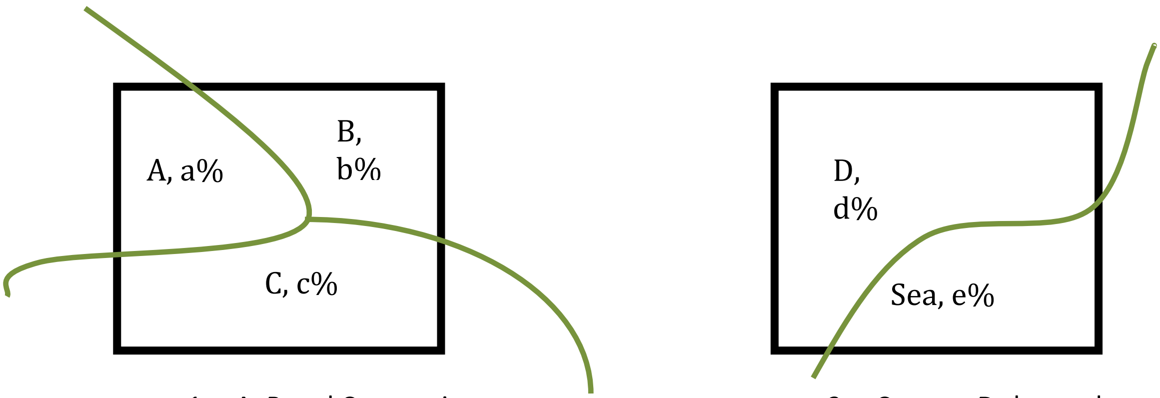
Figure II.1 EDGAR grid – bottom left corner of cells



Emissions distribution in the cells with country borders

In EDGAR, if a cell belongs 100% to one country, the equation (II.1) is used to distribute the emission in that specific cell. In some particular cases when a cell belongs to many countries, a percentage will be assigned to each of those countries. In the Figure II.2 (1) there is an example of a cell with country borders where a%, b% and c% are assigned to $A_{country}$, $B_{country}$, and $C_{country}$ respectively. When the sea area is part of the cell as illustrated in Figure II.2 (2) the entire emission in the cell will be allocated to the country (D, 100%) - except for costal fishing fuels combustion, where the maritime boundaries have been considered.

Figure II.2 Emissions distribution in the cells with country borders



1. A, B and C countries share the same cell
2. Country D shares the cell with sea area

III. Proxy data for emissions distribution on gridmaps

III.1 Proxy data used in EDGAR v4

The emissions generated by area and line sources are distributed based on national spatial data on global maps such as urban and rural population, road network, animal density, landuse (e.g. grassland, arable land), inland waterways, and aviation and international shipping trajectories. For emissions distribution of point sources are used maps with individual plants and industrial activity locations, such as power plants, iron and steel plants, cement production facilities, but also locations of coal mines and oil and gas production sites. The EDGAR activities and proxy data couplings used for country emissions distribution are presented in Tables III.1.1-III.1.4.

The country total emissions for each year are distributed using the most appropriate proxy in the EDGAR proxy data library. The EDGAR proxy data library is periodically updated with information released by different organizations. When for a specific activity there is no proxy for a specific year, by default the system will choose the most appropriate year (close to the year for which the distribution is performed).

Table III.1.1 Proxy data used in EDGAR for emissions distribution – energy sector

Sector	Subsector	EDGAR code	EDGAR proxy data	Reference
Energy	Energy industry	ENE	CARMA maps	http://carma.org/plant
	Combustion in manufacturing industry	IND	Population Urban population, Rural population Steel production (all processes)	http://sedac.ciesin.columbia.edu/ In-house EDGAR proxy TNO EDGARv32
	Fuel production/ transmission	PRO	Lignite and bituminous coal (surface and underground) Gas and oil production Venting and flaring Roads Ships , Tanker Population Urban population, Rural population	U.S. Geographical Survey (2000) Oil & Gas Worldwide Refining Survey (2006) PBL GRIP (2008) http://coast.cms.udel.edu/GlobalShipEmissions/Inventories/ http://sedac.ciesin.columbia.edu/ In-house EDGAR proxy
	Residential	RCO	Population Urban population, Rural population Fishing	http://sedac.ciesin.columbia.edu/ In-house EDGAR proxy Bathymetry map and Maritime Boundaries Geodatabase
	Oil refineries	REF	Refineries	TNO EDGAR32
	Non-road transport	TNR	Domestic and International aviation Inland waterways Ships Roads Railways Population Urban population	Airline Route Mapper (2011) Lehner et al. (2004) http://coast.cms.udel.edu/GlobalShipEmissions/Inventories/ PBL GRIP (2008) Mapcruzin, ArcGIS http://sedac.ciesin.columbia.edu/ In-house EDGAR proxy
	Transformation industry	TRF	Blast furnaces and Coke production Population, Urban population, Rural population	TNO EDGAR32 http://sedac.ciesin.columbia.edu/ In-house EDGAR proxy
	Road transport	TRO	Roads&population Roads	In-house EDGAR proxy PBL GRIP (2008)

Table III.1.2 Proxy data used in EDGAR for emissions distribution – industrial processes and solvents

Sector	Subsector	EDGAR code	EDGAR proxy data	Reference
Industrial processes	Production of chemicals	CHE	Adipic acid Ammonia, and Nitric and Sulfuric acids Caprolactam Chlor-alkali Urban population	ICIS Chem. Bus. (2007)& EPRTR (2011) RIVM Hyde& EPRTR (2011) SRI consulting (2003)& EPRTR (2011) In-house EDGAR proxy In-house EDGAR proxy
	Production of foods	FOO	Urban population	In-house EDGAR proxy
	Production of iron and steel	IRO	Pig iron and Sinter production Steel making (OHF, EAF, BOF tech.) Population	TNO EDGARv32 TNO EDGARv32 http://sedac.ciesin.columbia.edu/
	Production of non-ferrous metals	NFE	Al (Prebake and Soderberg processes) Zn (pri, sec); Cu (pri, sec); Gold and Mercury mines Urban population	Aluminium Verlang (1998) U.S. Geographical Survey (2011) In-house EDGAR proxy
	Production of non-metallic minerals	NMM	Cement and Lime production Urban population	U.S. Geographical Survey (2011)& EPRTR (2011)&CEC.ORG In-house EDGAR proxy
	Production of pulp and paper	PAP	Urban population	In-house EDGAR proxy
	Production and use of other products	PRU	Flat panel display, Semiconductor and PV solar cells production Urban population	PBL EDGARv4.0 In-house EDGAR proxy
Solvents	Application of solvents	SOL	Urban population	In-house EDGAR proxy

Recent updates of EDGAR proxy data include the population and power plant locations. The population grid GPWv3 from CIESIN, with a grid map of 2.5 minutes resolution, has been replaced by GRUMPv1 with a grid map of 30 seconds resolution, which brings additional information for some countries such as Turkey, ex-Yugoslavia, Middle-East, Central Africa, Germany etc. (Figure IV.2.7) and also leads to a better assessment of urban and rural population using EDGAR approach (see chapter IV.2). Moreover, the available datasets of CIESIN for 1990, 1995, 2000, 2005, and 2010 have been used to create the population EDGAR proxy data library that includes also urban and rural population for these years. Further, the 2005 and 2010 datasets have been interpolated to calculate the population for the 2008.

Regarding power plant locations the new updated version 3.0 of CARMA is used in EDGAR v4.2. The fuel allocation (consisting in three fuel classes) to each “substantial size” point source was performed based on the information provided by this data source, resulting in a number of 7965 coal, 4914 gas and 5301 oil power plants at global level.

Table III.1.3 Proxy data used in EDGAR for emissions distribution – agriculture and LULUCF

Sector	Subsector	EDGAR code	EDGAR proxy data	Reference
Agriculture	Agricultural soil	AGS	Animal density (buffalo, cattle, goats, pigs, poultry, sheep) Grassland Rice Cropland Maps with combination of soil type (histosols), land use, climate zone, soil acidity, etc.	FAOSTAT (2000) – animal density Global Land Cover map JRC (2000) http://www.sage.wisc.edu:16080/iamdata/ FAO Geonetwork (2007) In-house EDGAR proxy
	Agricultural waste burning	AWB	Arable land	FAO Geonetwork (2007)
	Enteric fermentation	ENF	Animal density (buffalo, cattle, goats, pigs, sheep) Grassland	FAOSTAT (2000) – animal density Global Land Cover map JRC (2000)
	Manure management	MNM	Animal density (buffalo, cattle, goats, pigs, poultry, sheep) Grassland	FAOSTAT (2000) – animal density Global Land Cover map JRC (2000)
LUCF	Large scale biomass burning	BMB	Burnt areas Post burn areas Peat fires Combination of soil type (histosols), land use, climate zone	Global Fire DATA: http://www.globalfiredata.org/Data/index.html In-house EDGAR proxy
	Forest land	CSC	Forest land remaining forest land	Global Land Cover map JRC (2000)
	Change of land management	CLM	Population	http://sedac.ciesin.columbia.edu/

For the EDGAR histosols, the digital soils map of the world from FAO (http://www.fao.org/geonetwork/) has been used to select soil sub- classes and to assign to each class a "weighted value" based on the soil type e.g. the maximum weight was given to histosols classes. The main soil classes considered in EDGAR are histosols, gleysols, podzols and podzoluvisols, and other areas from secondary classes. Further, for countries with no information on the main soil classes such as Russia, Estonia, Latvia, Lithuania, Finland, Sweden, Norway, additional data has been extracted from "the percentage organic soils map", which is an elaboration soil map from Harmonized World Soil database of IIASA (http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/SoilQuality.html?sb=10).

Table III.1.4 Proxy data used in EDGAR for emissions distribution – waste and others

Sector	Subsector	EDGAR code	EDGAR proxy data	Reference
Waste	Solid waste disposal	SWD	Urban population Combination of Urban Population for Dev. countries and Rural population for Ind. countries	In-house EDGAR proxy& EPRTR (2011)&CEC.ORG
	Waste water	WWT	Population Urban and Rural population	http://sedac.ciesin.columbia.edu/ In-house EDGAR proxy
Others	Fossil fuel fire	FFF	Coal fires, Oil production	Coal_fires PBL July 2010; Oil & Gas Worldwide Refining Survey (2006)
	Indirect emissions	IDE, N2O	Nitrogen deposition map Arable land Cropland/grassland map Animal density (cattle)	Dentener N-deposition map, (2006) FAO Geonetwork (2007) FAO Geonetwork (2007) /Global Land Cover map JRC (2000) FAOSTAT (2000) – animal density

III.2 New and updated proxy data in EDGARv4.2

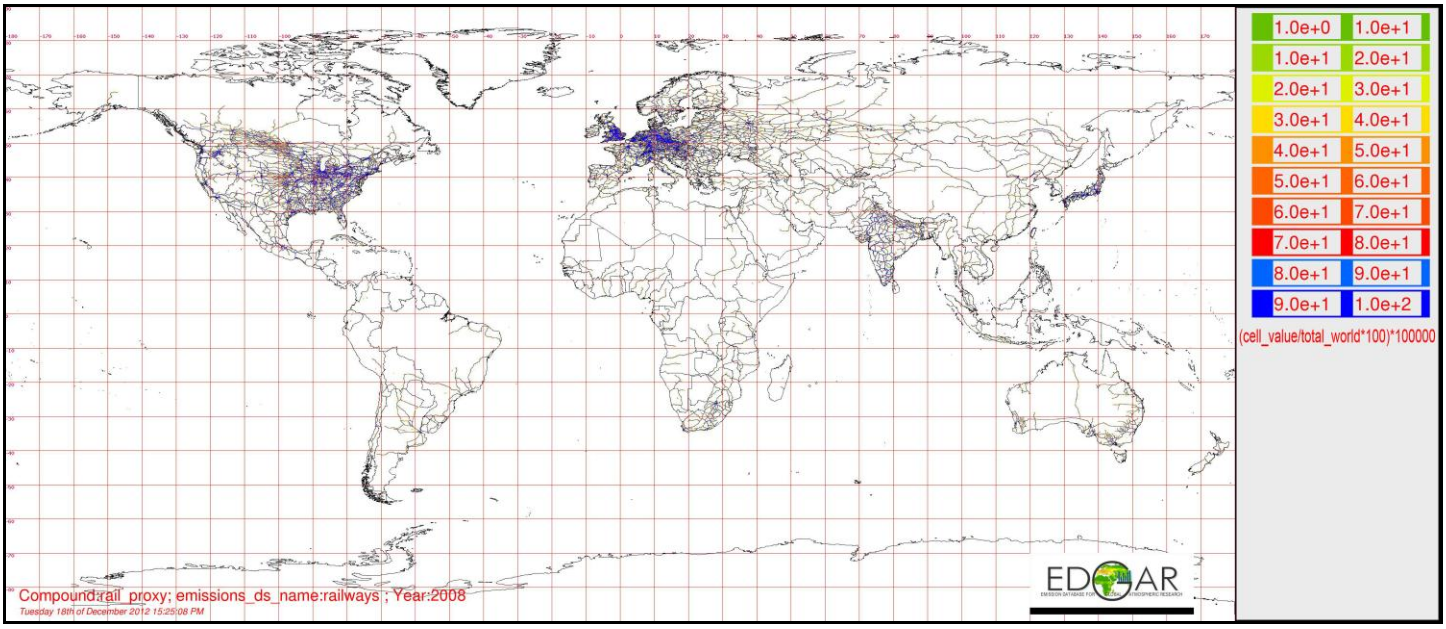
The EDGAR database is evolving from one version to another version by increasing the number of pollutants and consequently by including new activity data and emission factors. These developments lead to considering also new proxy data. Therefore, new proxies have been inserted in the EDGAR proxy data library and also other proxies have been updated. The lists of the new and updated proxy data in EDGAR are in the Table III.2.

Table III.2 New and updated proxy data in EDGAR

New proxy data	Updated proxy data
Fishing	Dom. aviation - climb, desc, cruise, takeoff, landing
Inland waterways	Int. aviation - climb, desc, cruise, takeoff, landing
Railways	Zn (pri, sec)
Peat fire	Cu (pri, sec)
Post burn area	Cement
Burnt areas	
Forest land remaining forest land	
Gold mines (v4.3)	
Mercury mines (v4.3)	
Chlor-alkali, mercury cell technology (v4.3)	

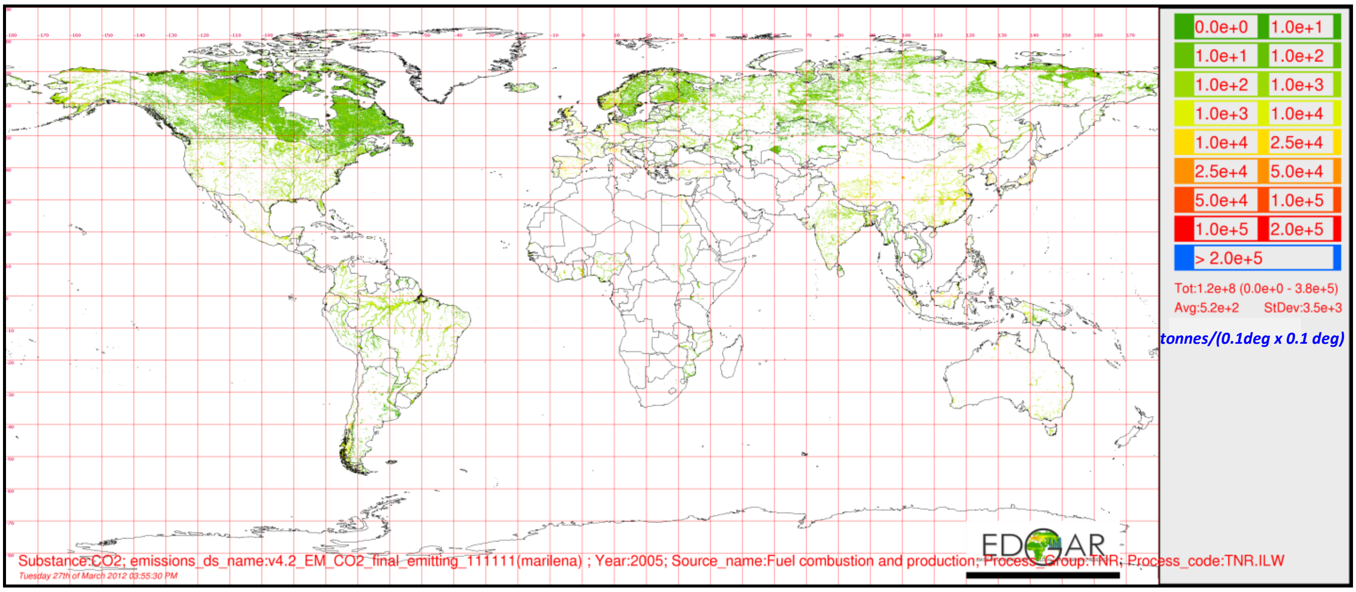
An example of a new proxy data implemented in EDGAR and used for distributing the emissions from fuels combustion in non-road transport, railways subsector, is given in Figure III.2.1.

Figure III.2.1 New proxy data in EDGAR e.g. – Railways



Emissions on the grid are presented in the Figures III.2.2-III.2.3 by showing CO_2 emissions distribution for inland waterways, and international and domestic aviation subsectors using appropriate proxy data and derived proxy for these activities.

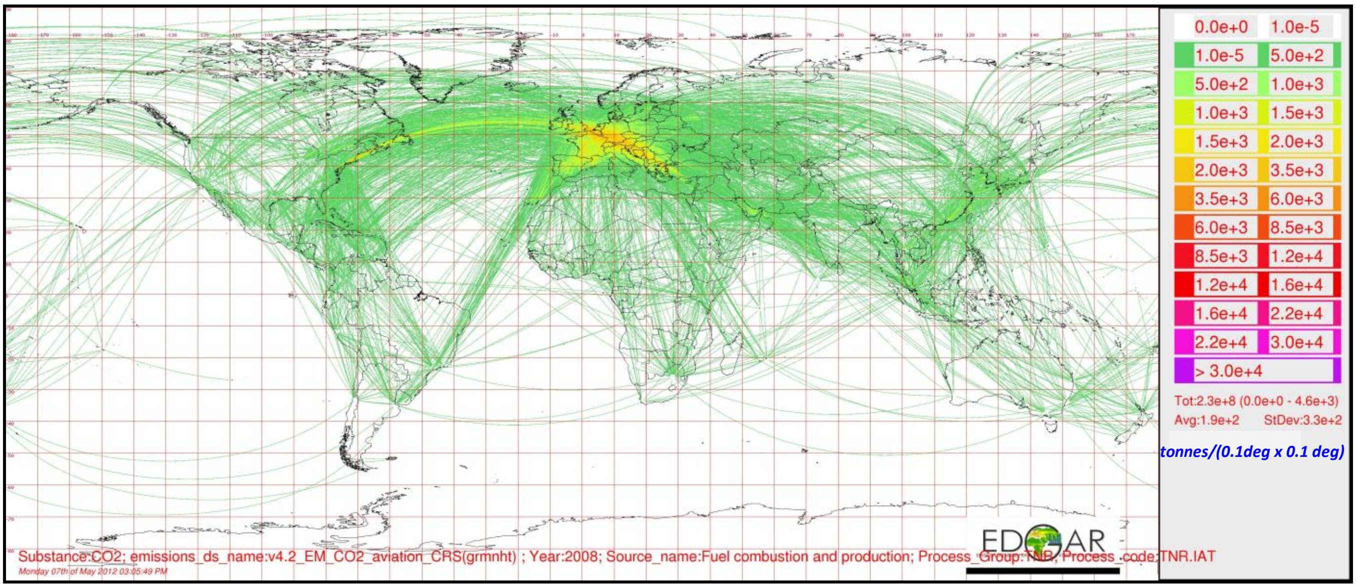
Figure III.2.2 New proxy data in EDGAR e.g. – CO2 gridded emission for inland waterways



A significant progress has been made in aviation sector by updating the flight trajectories based on recent information, and by allocating the emissions generated by this activity to different heights, taking into account different flight phases (see chapter IV.3). Moreover, the 0.1x0.1 degree resolution of the new map avoids further re-gridding, which improves the emissions distribution compared to the old distribution map. Figure III.2.4 illustrates the difference between the emissions distribution using the 1x1 degree resolution old proxy and the 0.1x0.1 degree resolution new EDGAR proxy.

Figure III.2.3 Updated proxy data in EDGAR e.g. – CO_2 gridded emission for aviation, cruise phase

a). International aviation CO2 emissions, cruise (height > 9km), [kg /m^2 /s], 2008



b). Domestic aviation CO2 emissions, cruise (height > 9km), [kg /m^2 /s], 2008

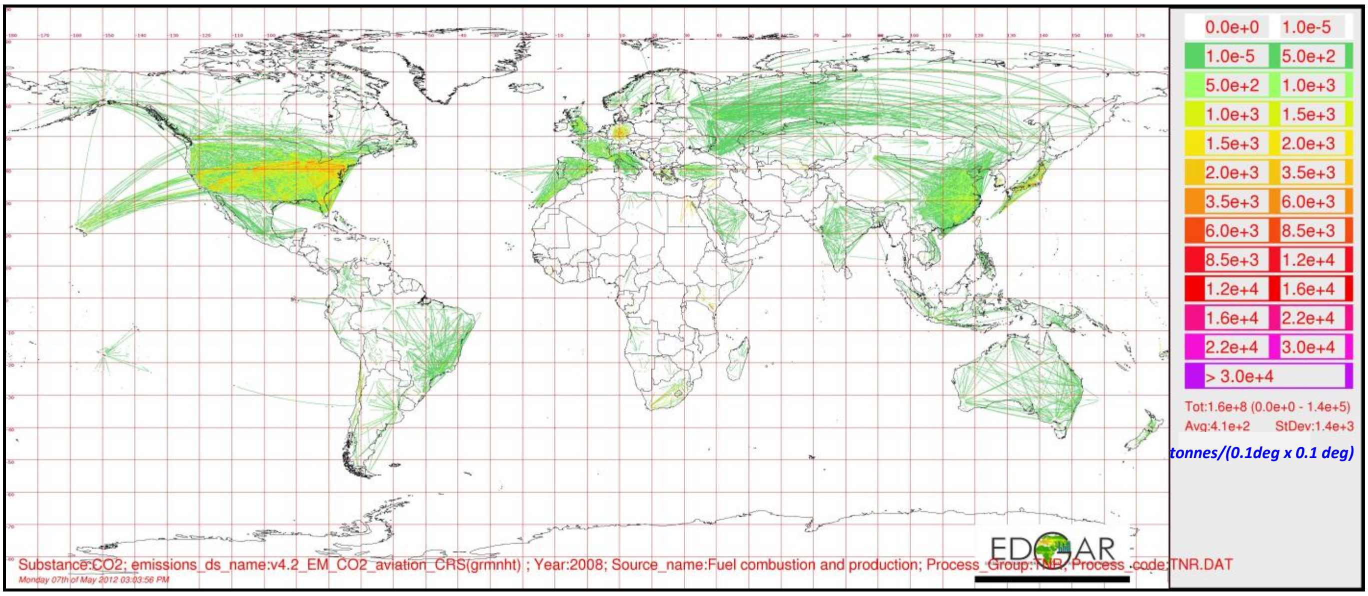
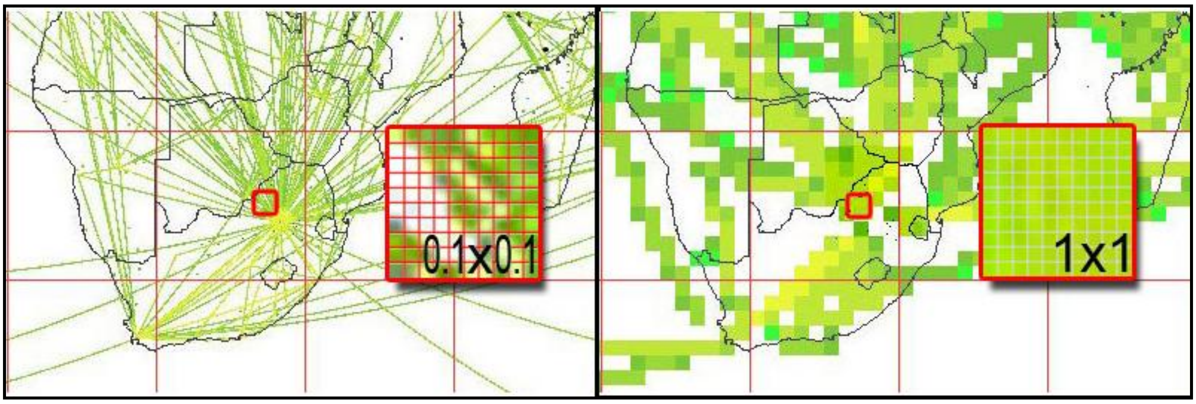


Figure III.2.4 Aviation, emission distribution comparison when using 1x1 and 0.1x0.1 degree resolution EDGAR proxies



IV. EDGAR derived proxy data (in-house)

Emissions distribution on gridmaps has been improved not only by updating and implementing new proxy data but also by creating EDGAR derived proxy data (in-house).

IV.1 Emissions distribution improvement for road transport sector

"Population & Roads" is a derived proxy data created to distribute better the emissions from road transport. In this approach, the emissions generated by fuels combustion in road transport sector are distributed using improved proxy "population x road length" - except for heavy duty vehicles for which only roads proxy data has been used.

The EDGAR gridding improvement has been analyzed in a case study on sensitivity emissions distribution to proxy data in Europe (Muntean et al., 2011). In this application, the same NOx emission from road transport has been distributed using two different proxy data. Comparing the EDGAR NOx gridded emission map with the E-PRTR map produced using advanced proxy (traffic volume) we can conclude that EDGAR proxy increases the gradient between city and intercity transport and represent well the traffic volume. Figures IV.1.1 and IV.1.2 illustrate the difference between the two approaches.

Figure IV.1.1. EDGAR proxy - population x road length

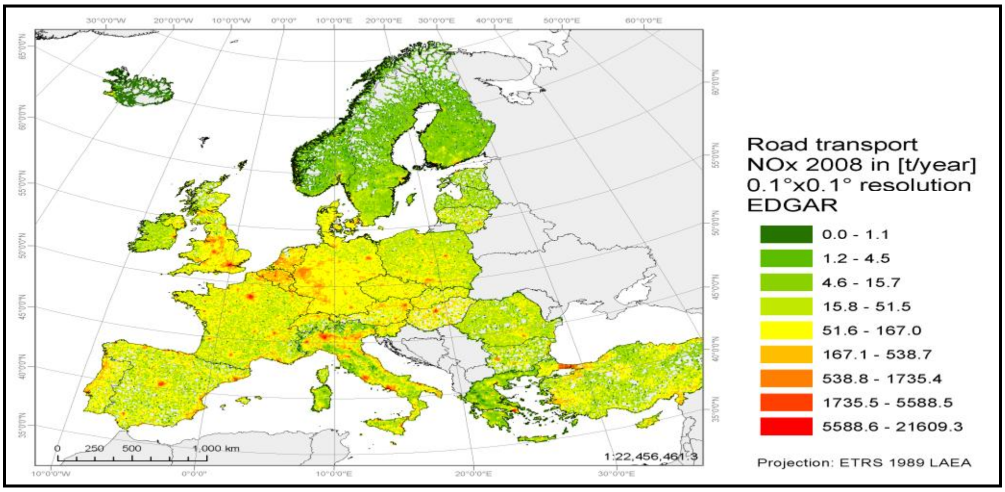
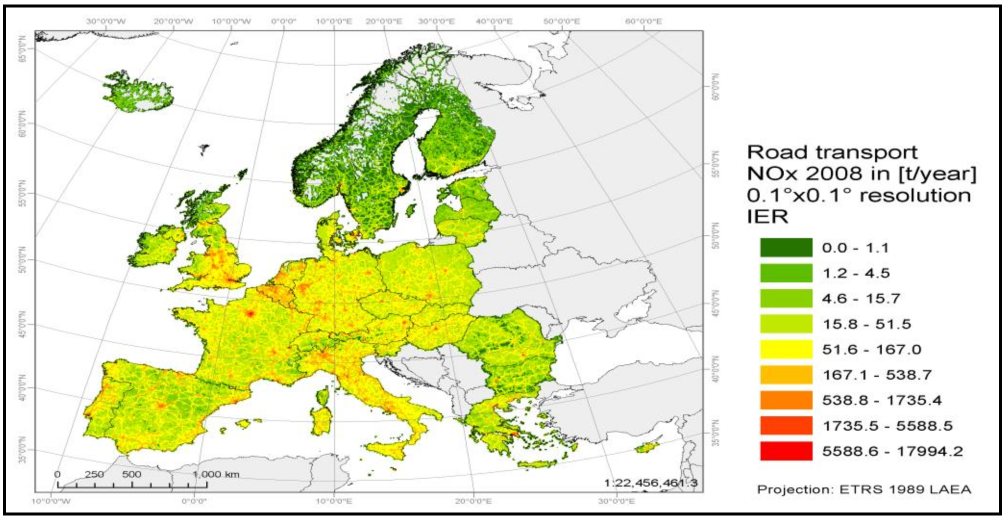


Figure IV.1.2 E-PRTR proxy – advanced proxy, traffic volume (Trans-Tools)



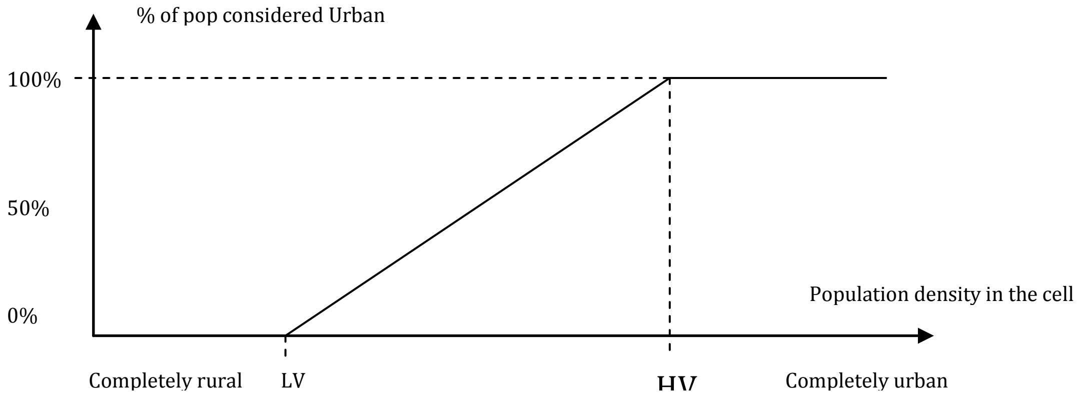
IV.2 Assessment of the rural and urban world population

The urban and rural population proxies are needed to distribute emissions generated by some specific activities such as combustion in manufacturing industries, fuel production and transmission, fuel combustion in residential sector, production of pulp and paper, solid waste incineration etc. (Tables III.1.1-III.1.4). Based on CIESIN data, an in-house methodology has been developed in order to obtain these derived proxies. The EDGAR approach is presented in this chapter together with the input data and the results.

Data available: Population data from CIESIN: http://sedac.ciesin.columbia.edu/gpw/global.jsp . The site provides Population grids from 1990 to 2015 (5 years step) at different resolutions. For our purposes the resolution 2.5' (minutes) has been chosen. The re-gridding to 0.1^{o} (degrees) has been performed using ArcMap and ad-hoc PHP programs. The site also provides a **Settlements Points** grid at a resolution of 30'' (seconds). This grid is the reference for the computation of urban/rural population coefficients and further creating derived maps.

Approach: The method is based on the assumption that the quota of population to be considered as Urban depends upon the population density in grid cells following a linear function for densities between specific ranges until a defined saturation point after which the population of the cell is considered completely Urban, while before the low value of the range the population is considered completely rural (Figure IV.2.1).

Figure IV.2.1 Urban and Rural population allocation (%) in grid cells – approach

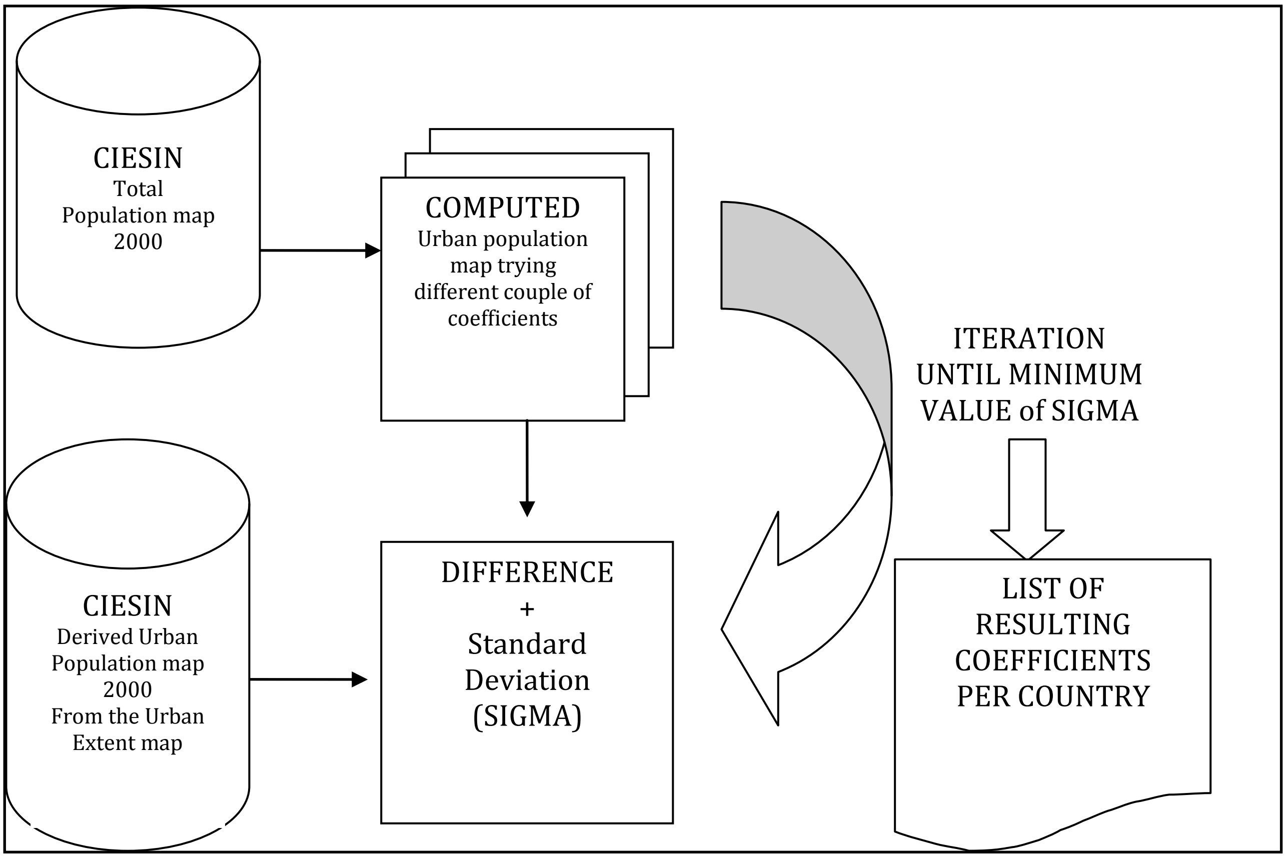


The low_value (LV) and high_value (HV) are evaluated country by country using the Urban Extent map for the year 2000 provides by CIESIN. Those HV and LV values give indication of the level of adaptability of the population of a country, i.e. when a cell is assigned an Urban qualifier with a low HV density (say 800 to 1200) then it is normally an industrialized country that provides urban infrastructures even for a scarce population.

The Urban Extent map provided by CIESIN (Settlements Points) is a set of small cells (30'') indicating the presence or not (0/1) of settlements in the cell. Using ArcGis this map has been resampled to 0.01^{o} - to be a multiple of our population maps, then mapping 100 settlement cells per each population cell (0.1^{o}) the total number of 'settled' cells gives the percentage of urbanization of the 0.1^{o} population cell.

After these operations we have a single urbanization map for the year 2000 that leads to an Urban Population and a Rural Population maps for the year 2000.

Figure IV.2.2 Methodology to derive urban and rural population



The method consists in deriving the two function coefficients (LV and HV) for each country to be applied to all years before and after 2000, allowing to assess the sharing between rural and urban population given the total population and the area of the cell (Figure IV.2.2).

The coefficients are derived by computing the urban population for the year 2000 iterating different combinations of coefficients, until the couple of coefficients leads to the minimum Standard Deviation of the difference between the computed urban population and the urban population obtained from the Urban Extent map.

The iteration values for LV are 10 to 600 stepping by 10, while for HV are 500 to 1900 stepping by 50 (unit is heads/Km^2).

The graphs below show the trends of the Standard Deviation of the difference for developed and under development countries computed for three Low_values (LV): 10, 200, 390 and different High_values (HV). The minimum sigma occurs for LV=390 and HV=1300 heads/Km^2: actually it's about a country under development (CHN). The results of the computation are presented in Figure IV.2.3 for a under development country while the Figure IV.2.4 shows minimum sigma at LV=10 as it's a developed country (USA).

In order to avoid divergence in the minimization process, the point exciding 2*Sigma are eliminated from the process. The coefficients (LV and HV) have been calculated for each country. Using this methodology with correction for small countries and large countries with big deserts, the Urban and Rural population maps were produced for 1990, 1995, 2000, 2005, 2010, 2015 to better distribute country total emissions.

Figure IV.2.3 LV and HV coefficients – e.g. country under development

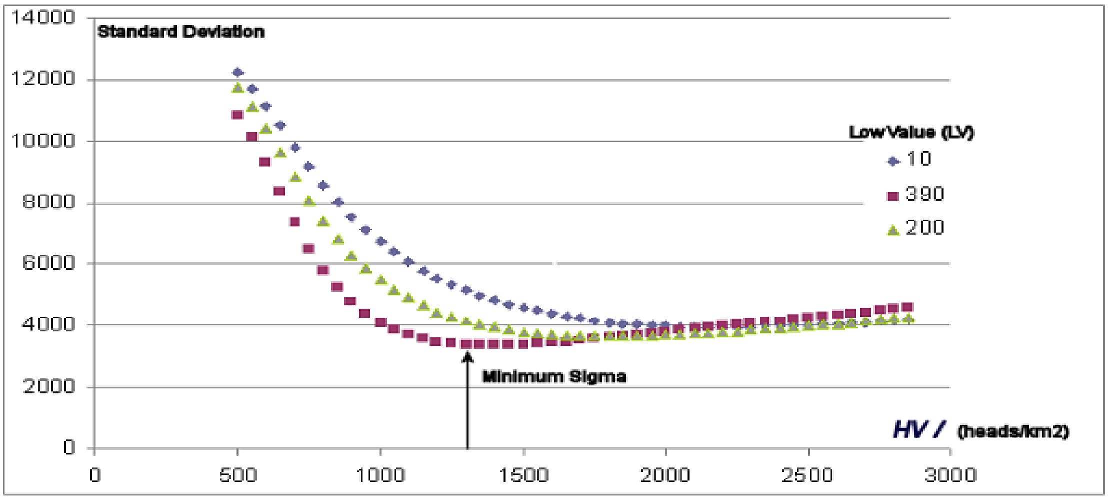
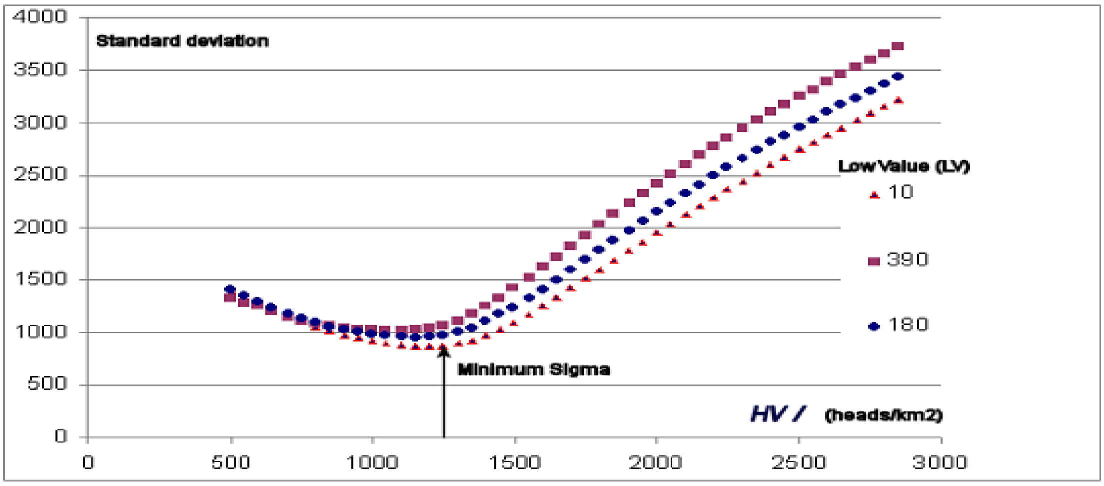


Figure IV.2.4 LV and HV coefficients – e.g. developed country



The year 2008 was computed by linear interpolation between population 2005 and population 2010 using the same method. In Figures IV.2.5 and IV.2.6 are two examples of the urban population maps produced by applying this method. The urbanization process can be noticed in northern India and Pakistan.

Figure IV.2.5 Urban Population in India and China in 1990

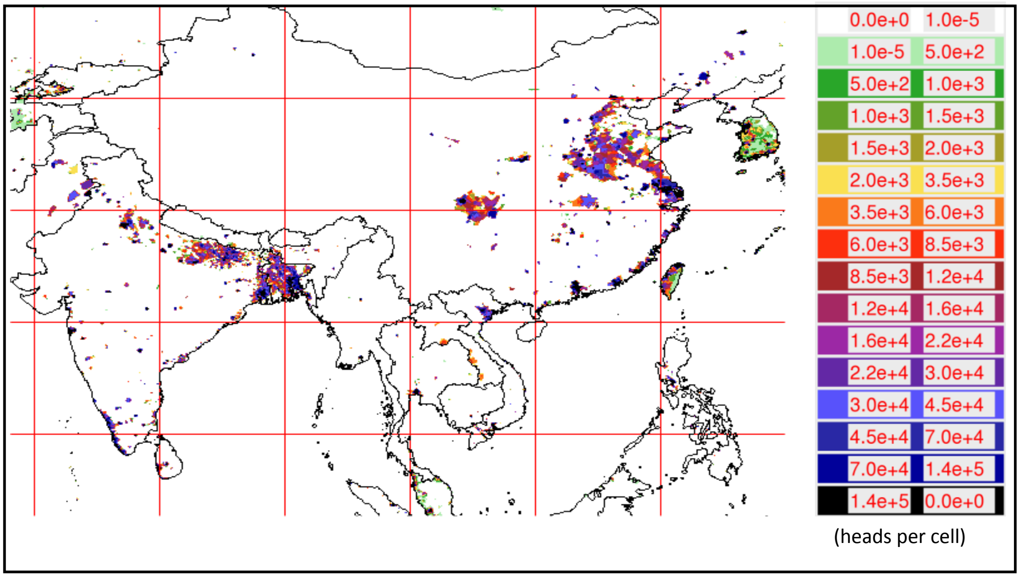
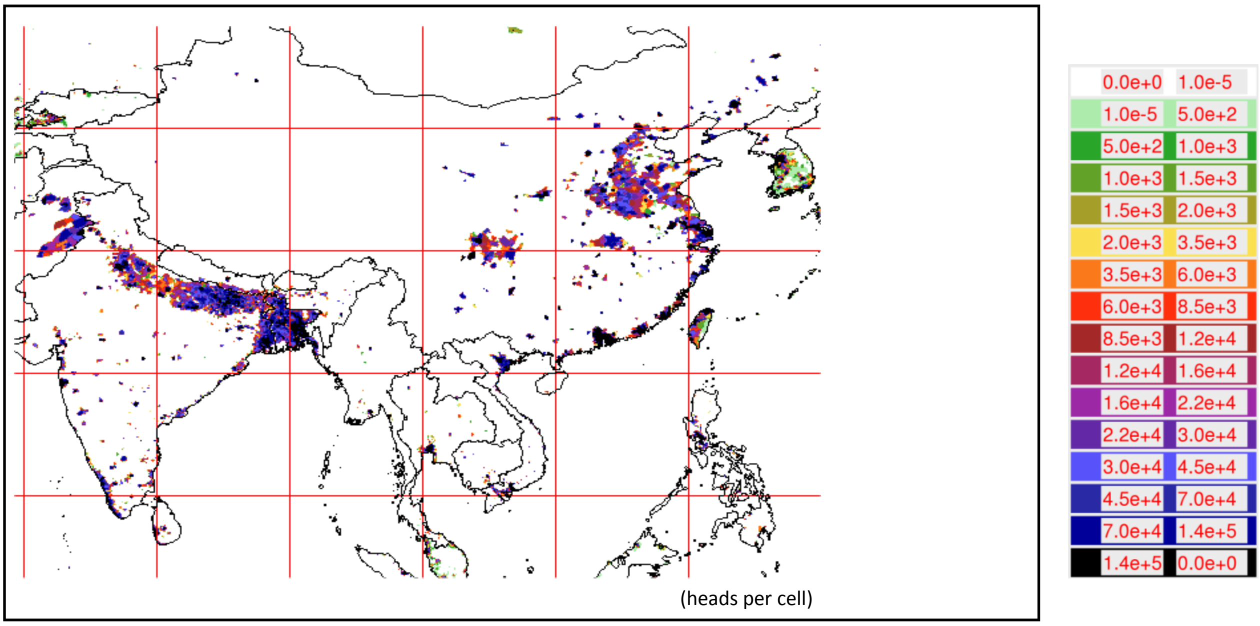


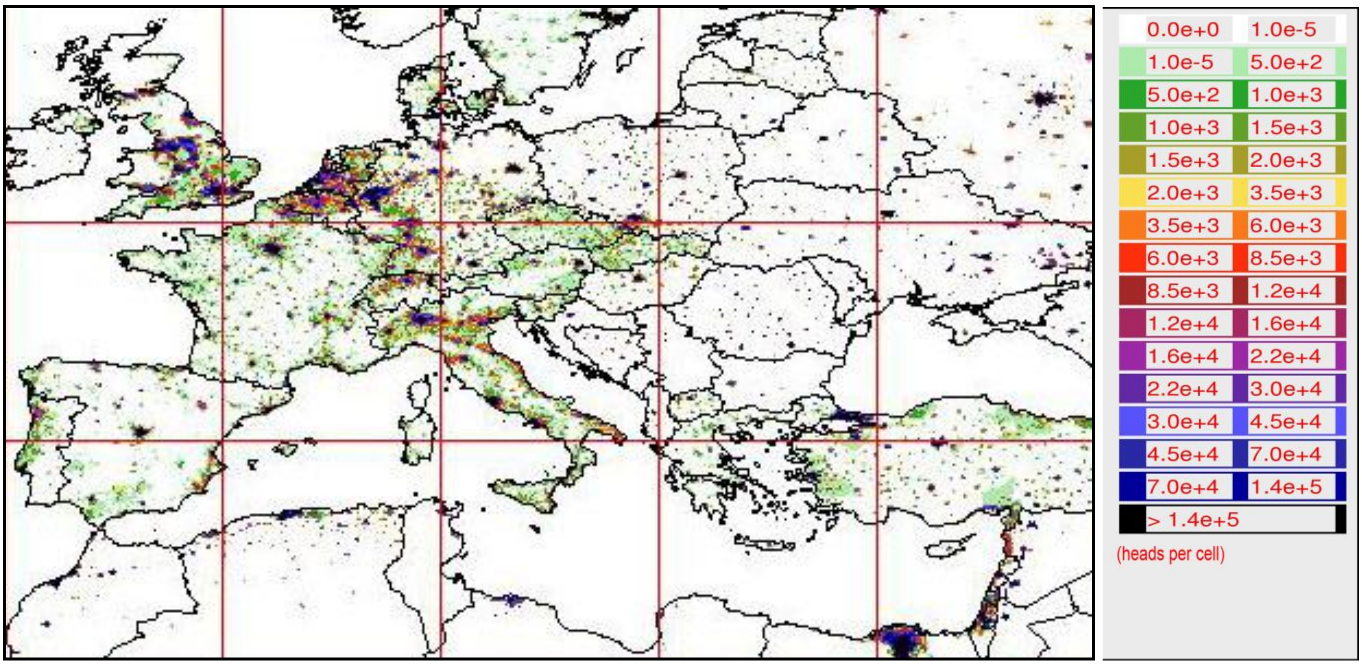
Figure IV.2.6 Urban Population in India and China in 2015



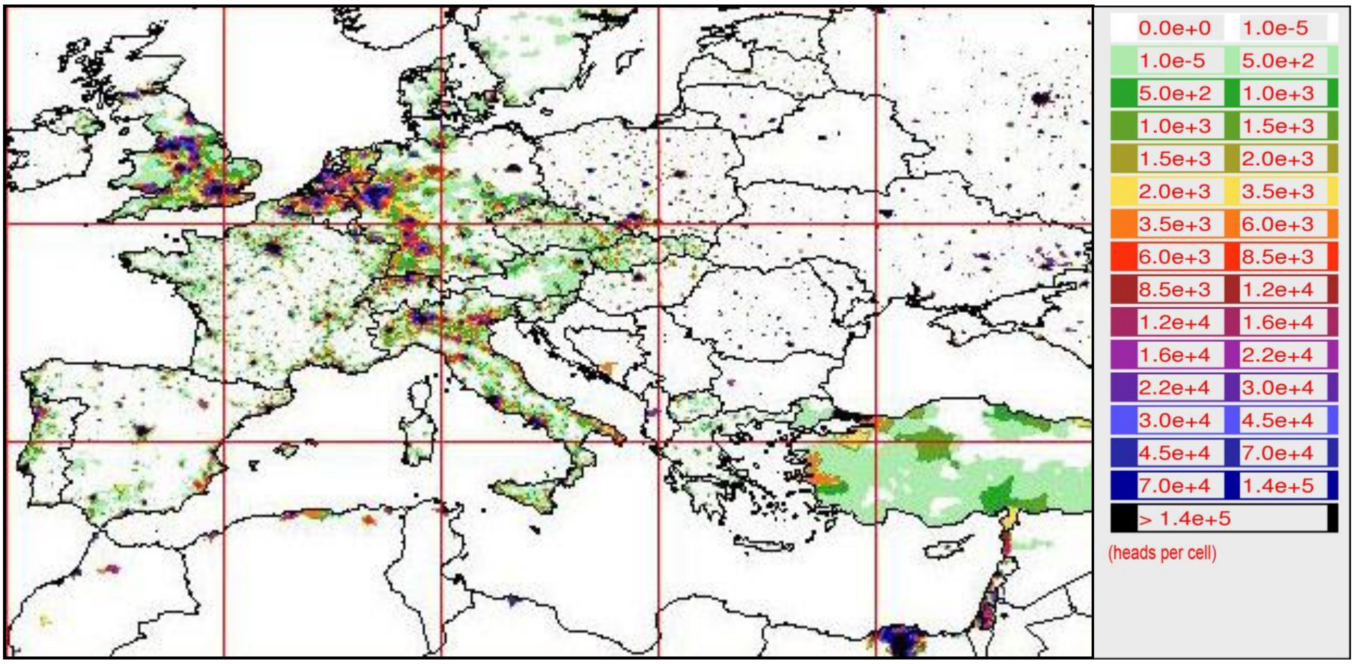
With the new GRUMPv1 population grid from CIESIN (http://sedac.ciesin.columbia.edu/gpw/global.jsp), which is a grid map of 30 seconds resolution, as input we notice also better results for urban population map. The two maps in Figure IV.2.7 illustrate the added values brought by implementation of the new version of population grid from CIESIN. The cities are better represented when using GRUMPv1 population grid, for example the urban areas in Turkey were not very well represented in the previous version the (b) whereas the new proxy population emphases better the location of the cities (a).

Figure IV.2.7 Urban population – EDGAR approach

a). Urban population calculate using GRUMPv1



b). Urban population calculate using GPWv3

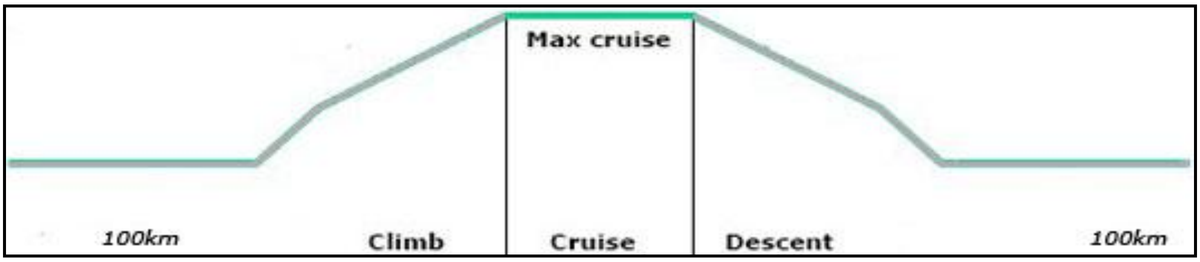


IV.3 EDGAR derived proxy data for international and domestic aviation

The emissions in aviation sector occur at different heights depending of the flight phase that generates them. As for modeling purposes is necessary to know where the pollutants are injected into the atmosphere, an in-house approach has been developed to distribute the emissions from this sector for three flight phases: takeoff/landing, climb-out/descending and cruise.

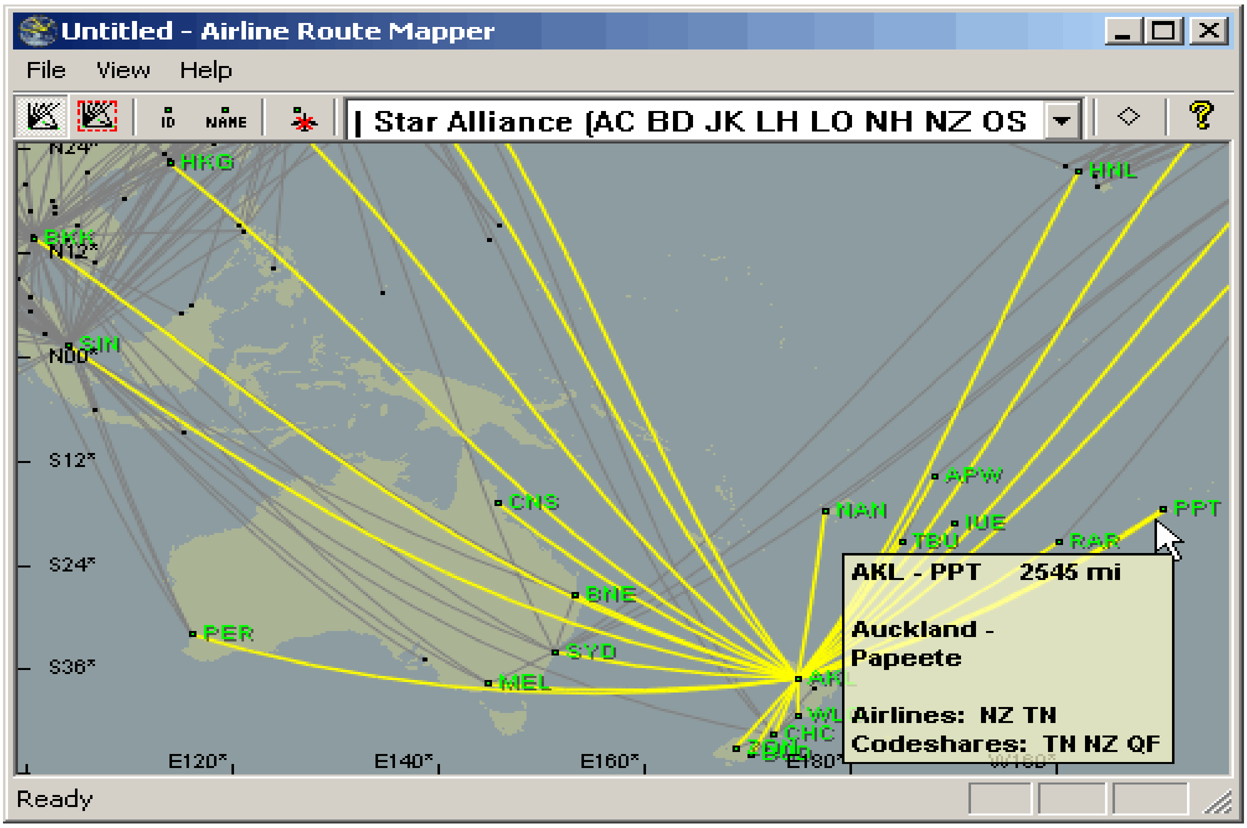
Methodology: The EDGAR gridding methodology for aviation is based on the information regarding International Civil Aviation Organization (ICAO) landing/take-off cycle and the ATR 72-500 "trip pattern" considering the first and the last 100km of a flight as CLIMB-OUT/DESCENDING phase. The remaining part in the middle, from the 101 km to last 101km, is considered as CRUISE phase. The trip pattern used for aviation emissions distribution in EDGAR is illustrated in Figure IV.3.1.

Figure IV.3.1 EDGAR approach to distribute emissions from aviation at different heights



The input data regarding airports and routes used in this approach has been downloaded from "Airline Route Mapper" (http://arm.64hosts.com/), as airports.dat and routes.dat data tables (Figure IV.3.2).

Figure IV.3.2 Airline Route Mapper



The information on airports and routes such as AIRPORT_ID, LATITUDE, LONGITUDE, AIRPORT_NAME, COUNTRY_NAME, COUNTRY_CODE, AIRLINE, AIRPORT_FROM, AIRPORT_TO etc. have been used in this approach i.e. to derive the routes for domestic and international aviation.

The routes in domestic aviation are those for which the AIRPORT_FROM, AIRPORT_TO are in the same country whereas for international aviation the AIRPORT_FROM, AIRPORT_TO are located in different countries.

LTO (Takeoff/Landing) emissions are distibuted on TakeOff-Landing proxy as:

$$\frac{n * EmissionTotal\ (per\ country)}{N}$$

Where:

n = Number of routes from and to each airport in the cell.
N = Number of routes for all airports of the country.

CDS (Climb-out/Descending) emissions are distributed on Climb-out/Descending proxy and **CRS** (Cruise) emissions are distributed on Cruise proxy as:

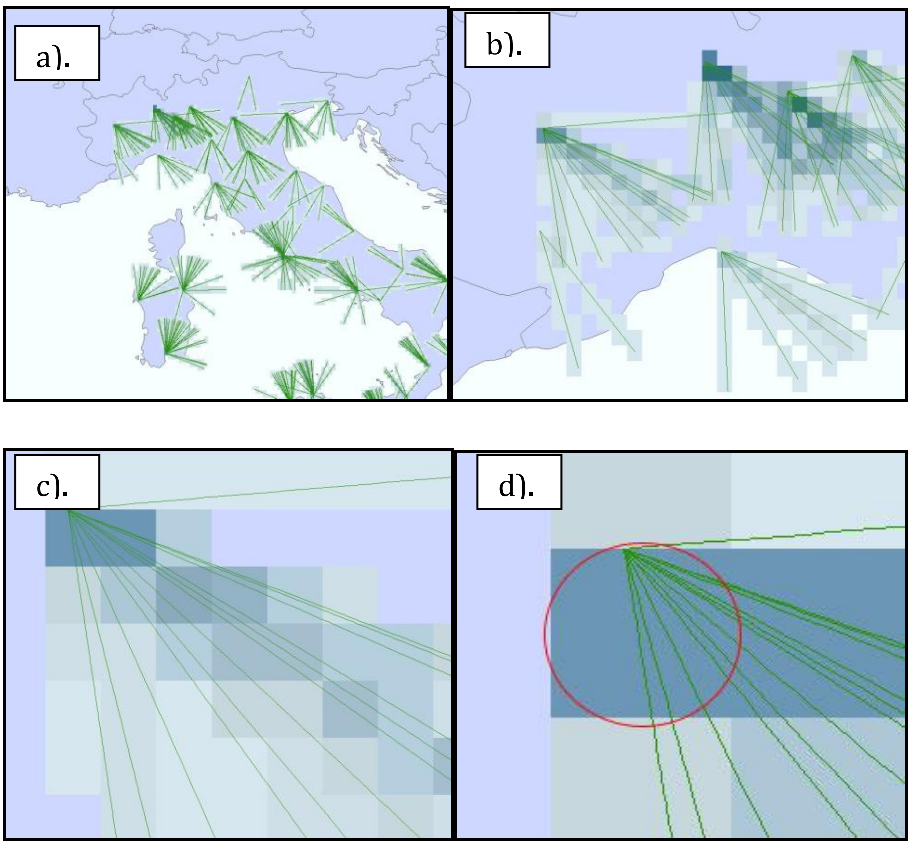
$$\frac{ld * EmissionTotal\ (per\ country)}{LD}$$

Where:

ld = Line Density in the cell.
LD = Sum of Line Density of the country.

Line density is the magnitude per unit area from polyline features that fall within a radius of 0.06 around each 01x01. In Figure IV.3.3 the line density is represented at different scales including cell level (Figure IV.3.3 .d).

Figure IV.3.3 Line density at different scales



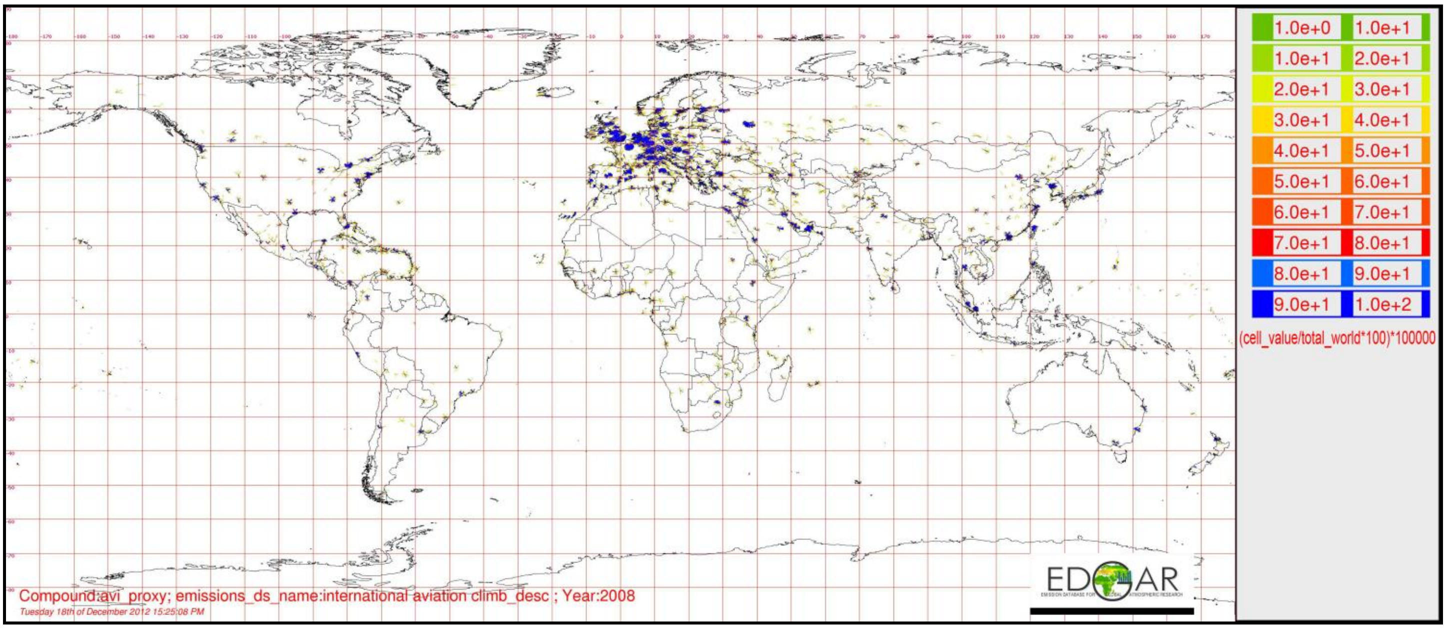
In this approach, a proxy is associated to each flight phase (Muntean et al. 2012). Therefore, in EDGAR there are six proxies for both international and domestic aviation activities.

Emissions distribution – international aviation.

For international flights, three different proxies have been created:

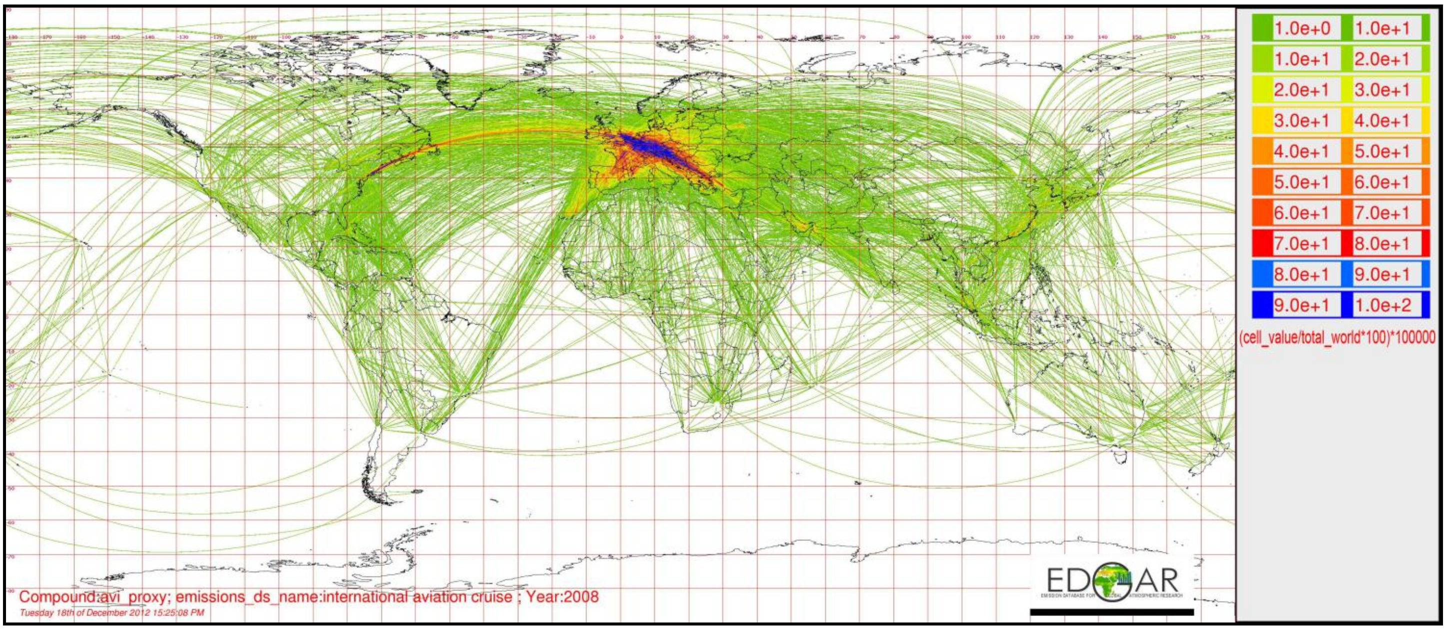
- TAKEOFF/LANDING: point source map, for each airport. A value has been assigned to each airport, which represents the number of routes from and to the airport. This allows to distinguish between small and big airports.
- CLIMB-OUT/DESCENDING: using the XYToLine function of arcmap the first and the last 100km of each route have been identified. On this map, for crowded routes, we can have more than one flight between two airports. By counting the number of routes for each 01x01 degrees cell, different weights have been calculated based on number of flight per route (Figure IV.3.4).

Figure IV.3.4 EDGAR proxy data, international aviation, climbing & descend (1km < height < 9km)



- CRUISE: for each route, the first and the last 100km of the route were cut. On this map, for crowded routes, we can have more than one flight between two airports. By counting the number of routes for each 01x01 degrees cell, different weights have been calculated based on number of flight per route (Figure IV.3.5).

Figure IV.3.5 EDGAR proxy data, international aviation, cruise (height > 9km)

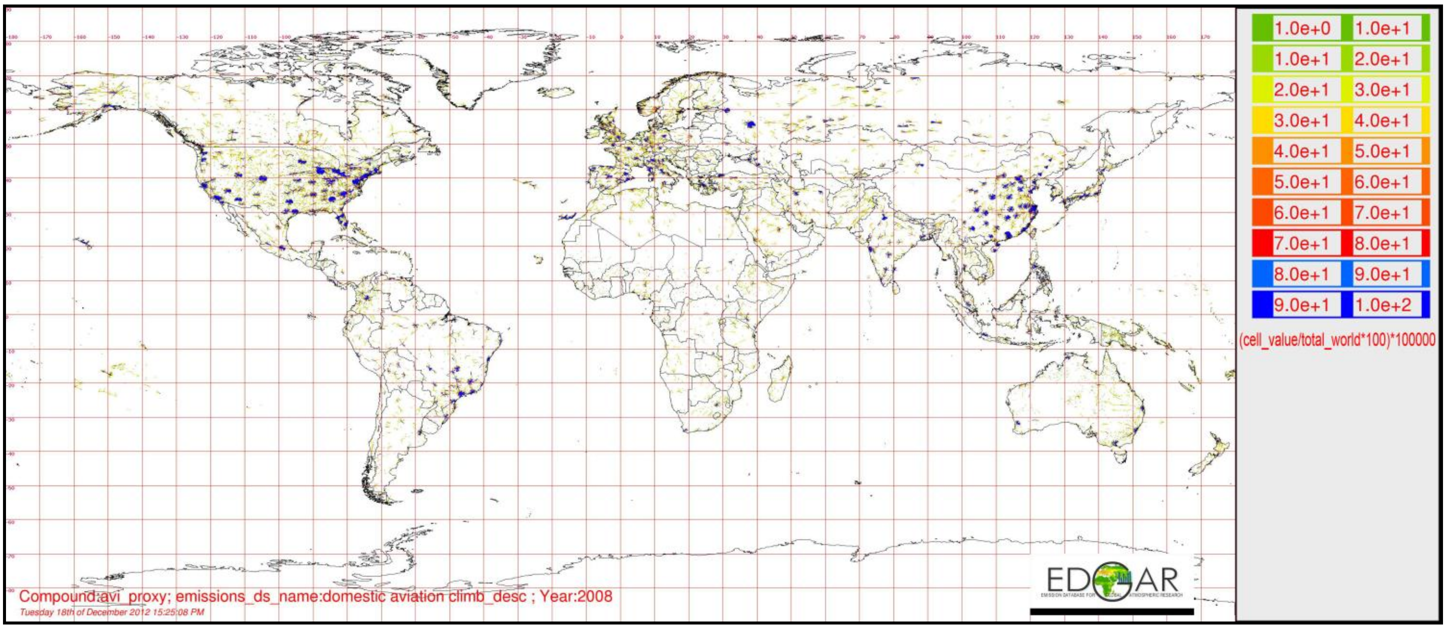


Emissions distribution – domestic aviation

For small countries with no domestic routes in "Airline Route Mapper", additional source of information that contains also small airports has been used (http://www.partow.net/miscellaneous/airportdatabase/) to complete proxy for domestic aviation.

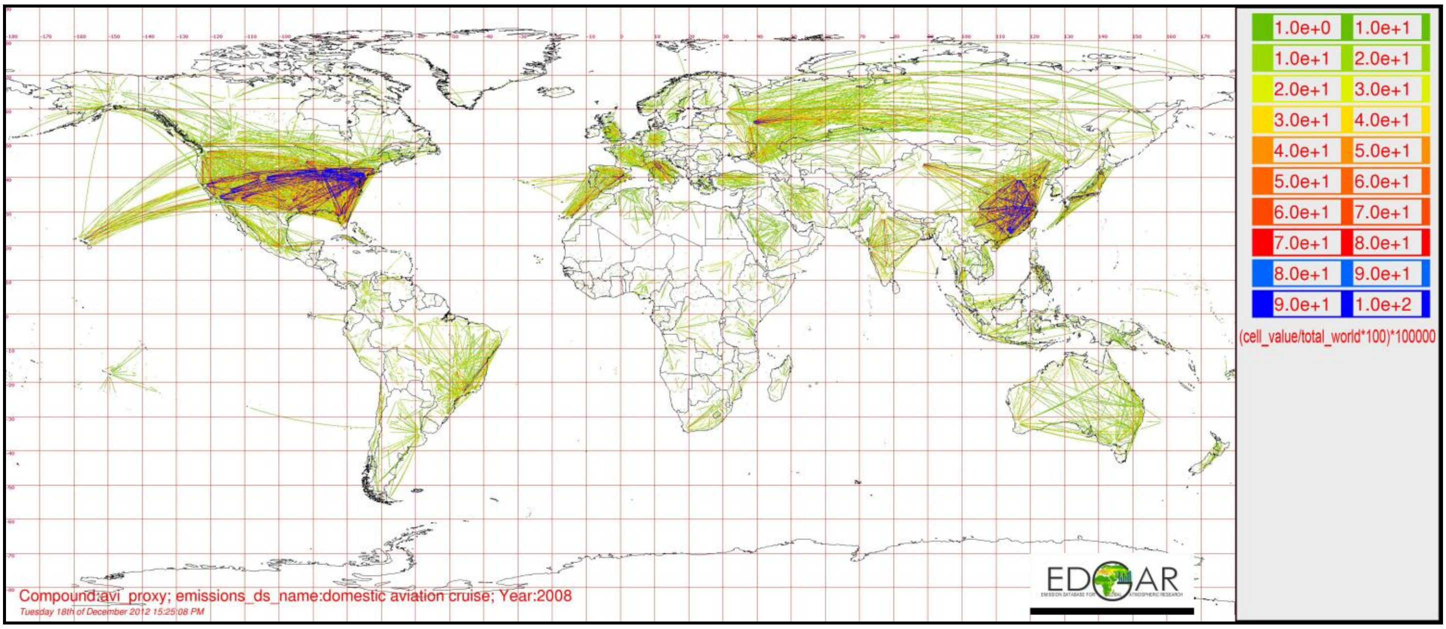
For domestic aviation, using the same assumption as for international aviation and adding also the touristic flights, three different proxies have been created for: 1. TAKEOFF/LANDING; 2.CLIMB-OUT/DESCENDING: and 3. CRUISE (Figure IV.3.6, Figure IV.3.7)

Figure IV.3.6 EDGAR proxy data, domestic aviation, climbing & descend (1km < height < 9km)



From small airports database, a buffer of 10km has been shaped around each airport to simulate touristic flights possible routes, we added low values to climb-out/descending map.

Figure IV.3.7 EDGAR proxy data, domestic aviation, cruise (height > 9km)

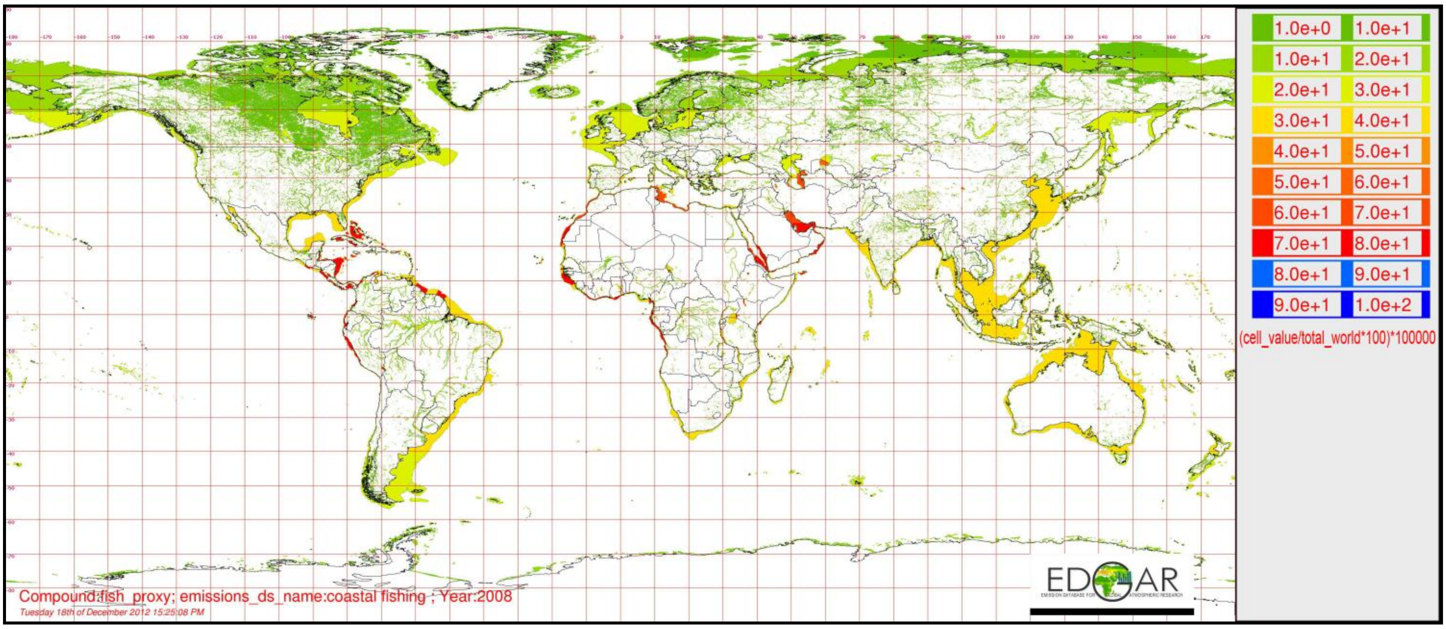


Quality control: A quality control has been done on input airports data by overlaying global country map with point source map of airport. For each country all airports not within country borders have been checked on http://www.flightstats.com/go/Airport/airportDetails.do. In some case we found errors in airports coordinates.

IV.4 EDGAR derived proxy data for costal fishing

The emissions generated by fuel combustion in fishing activities (EDGAR code RCO.FSH, IEA code FISHING) are distributed in EDGAR considering both inland waterways and sea fishing areas.

Figure IV.4.1 EDGAR derived proxy data for costal fishing



The derived proxy data for costal fishing has been created based on the information from bathymetry map and inland waterways map considering the water depth in the range of 0-200m (http://en.wikipedia.org/wiki/Coastal_fish). Therefore, the emissions from this sector are distributed in areas that cover mainly the continental shelf as illustrated in Figure IV.4.1.

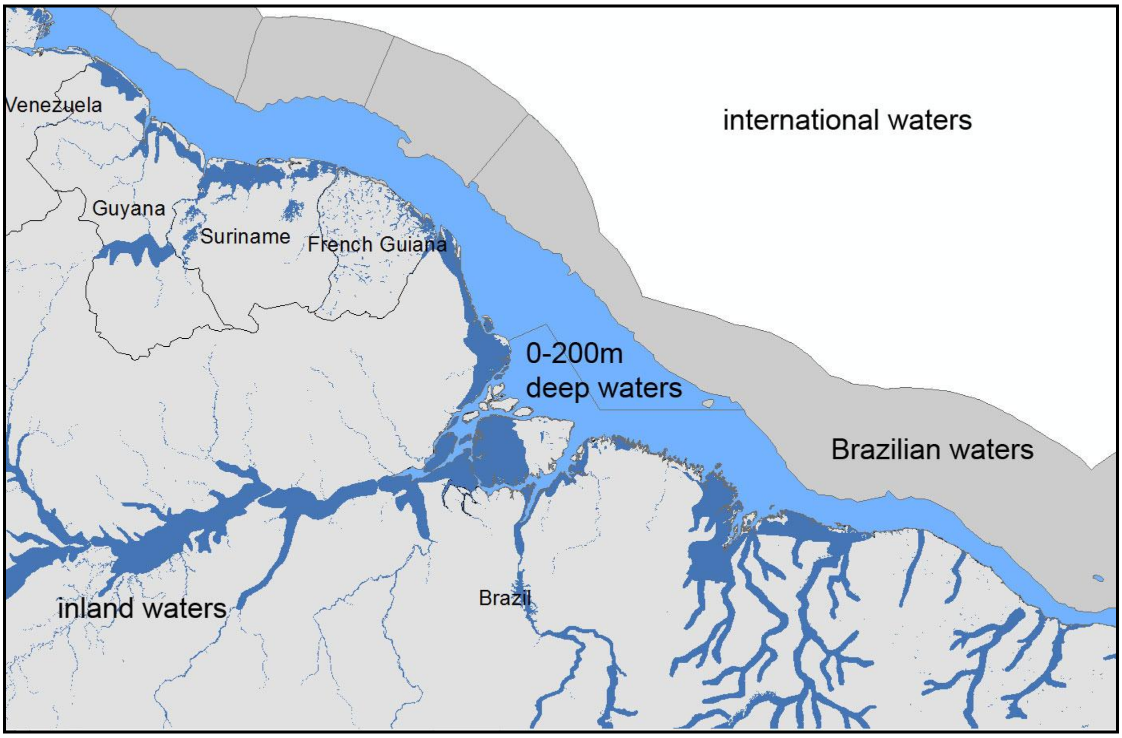
The final proxy is obtained by intersecting bathymetry map and marine boundaries map, which is unified with EDGAR's inland waterways map. The value in each cell has been multiplied by the cell area using the following formula:

A_{cell}= round(61960094.64*(cos(RADIANS([lat]))+cos(RADIANS([lat]+0.1)))/1000000,2)

where A_{cell} is the area of the cell in km^2. This operation has been performed to calculate the right weights for the territories located at lower and higher latitudes e.g. Russian territories.

The EDGAR emissions from fuel combustion in fishing activities are calculated as country totals and have to be distributed in the areas within the country. Therefore, the information on maritime boundaries from Maritime Boundaries Geodatabase is taken into account to establish the country maritime boundaries. Figure IV.4.2 shows the extension of the emissions distribution areas (in blue) for Brazil.

Figure IV.4.2 Example of proxy data used for emissions distribution in fishing activities (the area in blue), Brazil



V. Conclusions

The set of a hundred proxy datasets are used as geospatial surrogate for gridding the sector- and country-specific emission totals with a standard resolution of 0.1degx0.1deg (see examples in the Annex). For the aviation, there are three layers at different heights foreseen in the third dimension. The other emissions data are upon request split into two height layers, one at stack height, one at ground level, based on the type of activity.

These proxy datasets are applied not only to version v4 of the Emissions Database of Global Atmospheric Research (EDGAR), but also to emissions datasets of the project for Hemispheric Transport for Air Pollution (HTAP), and the emissions scenarios of the UNEP black carbon study. The proxy datasets are also requested by e.g. EMEP countries or by scientists for gridding their emission inventory.

The gridding with the proxy datasets is a distribution with geospatial surrogates and therefore aims at a first visualisation, and not an accurate allocation of the emission source. The spatial uncertainty remains very large and it can not be expected that with these surrogates each single point source is represented with its emission as accurately as in those databases which trace locally the emission sources such as E-PRTR.

Nevertheless, the global coverage and geospatial consistency allow to provide a consistent input to the atmospheric chemistry. In particular multipollutant sources are represented as one single point source. As such the chemical models are correctly receiving the combination of substances and can model the chemical interactions between the substances that should take place. It is expected that this input is appropriate of regional and global climate models and chemical transport models with a spatial resolution up to 0.1 deg x 0.1 deg.

References:

1. References for proxy data:

- Global Fire DATA: http://www.globalfiredata.org/Data/index.html) – burnt and post burn areas
- http://carma.org/plant : CARMA maps - for power plants
- U.S. Geographical Survey (USGS, 2011) – for Zn, Cu and Pb smelters and for gold and mercury mining
- U.S. Geographical Survey (2011)& EPRTR (2011)&CEC.ORG - for cement and lime production
- Airline Route Mapper (2011) with AERO2K for height profiles – for domestic and international aviation; http://arm.64hosts.com/; http://www.partow.net/miscellaneous/airportdatabase/

- http://sedac.ciesin.columbia.edu/; Center for International Earth Science Information Network (CIESIN, 2012) – for population 1990, 1995, 2000, 2005, 2010
- Oil & Gas Worldwide Refining Survey (2006)– for oil and gas production
- FAO Geonetwork (2007) – for cropland
- Global Land Cover map JRC (2000) – for grassland, histosols, forest land remaining forest land
- FAOSTAT (2000) – animal density
- PBL GRIP (2008)-roads, RIVM Hyde – for ammonia, sulfuric acid, TNO EDGARv32 - steel
- SRI consulting (2003) – caprolactam
- Aluminium Verlang (1998) – for Al
- Mapcruzin, ArcGIS– for railways
- http://coast.cms.udel.edu/GlobalShipEmissions/Inventories/ - for ships
- ICIS Chem. Bus. (2007) – for adipic acid
- Lehner, B. and Döll, P. (2004): Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296; hydrological map – for waterways
- Computation N-deposition map (Dentener, 2006) – for N_2O indirect emissions
- Bathymetry map: http://www.naturalearthdata.com/downloads/10m-physical-vectors/ http://www.naturalearthdata.com/; http//www.naturalearthdata.com/download/10m/physical/10m-bathymetry-all.zip – for costal fishing

- Maritime Boundaries Geodatabase: http://www.vliz.be/vmdcdata/marbound./download.php – for costal fishing

- http://prtr.ec.europa.eu/IndustialActivity.aspx (E-PRTR) – for Adipic, Nitric, Sulfuric acids, Ammonia , Caprolactam, Cement, Lime and Solid Waste Incineration in Europe

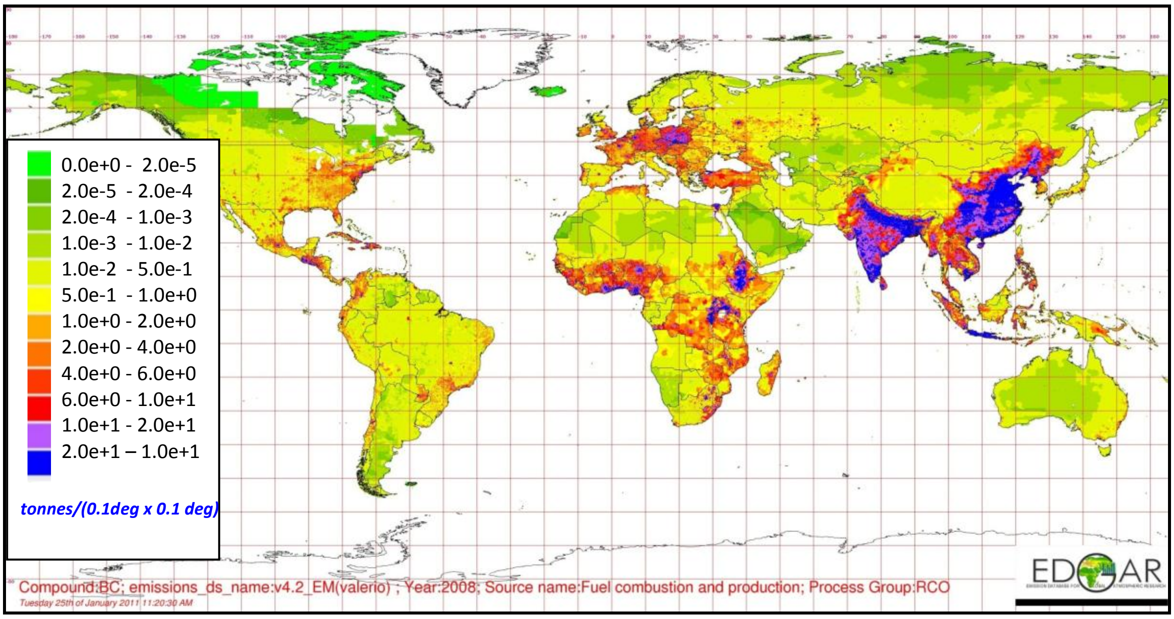
- http://www.sage.wisc.edu:16080/iamdata/ - for rice

2. Theloke, J., Thiruchittampalam, B., Orlikova, S., Uzbasich, M., Thomas Gauger, T., 2011, Methodology development for the spatial distribution of the diffuse emissions in Europe, Report for the European Commission, 070307/2009/548773/SER/C4 http://circa.europa.eu/Public/irc/env/e_prtr/library?l=/diffuse_releases_e-prtr/methodology_2011/_EN_1.0_&a=d

3. Muntean, M., Pagliari, V., Janssens-Maenhout , G., Guizzardi, D., Petrescu, R., Olivier, J., Thiruchittampalam, B., Uzbasich, M., Theloke, J., van Aardenne, J., 2011. On the Gridding Emissions Globally, CLRTAP/EMEP/TFEIP meeting, Stockholm May 2011.

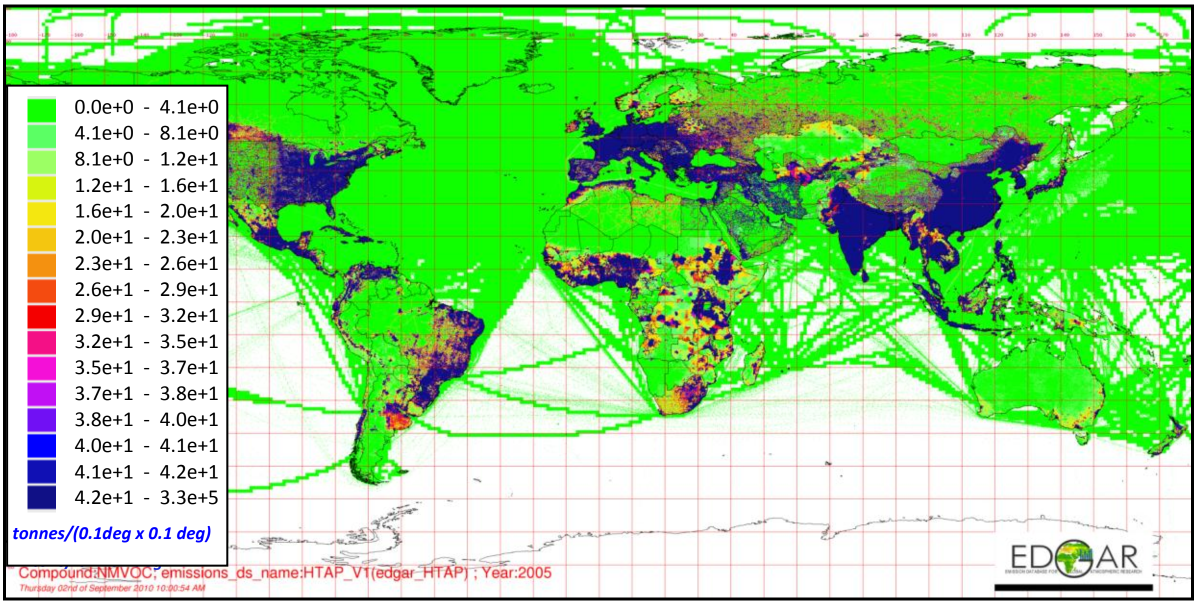
4. Muntean, M., Guizzardi, D., Pagliari, V., Janssens-Maenhout , G., 2012. On EDGAR v4.2 Aviation GHG emissions distribution and uncertainties. CARBONES FP 7th project, Stuttgart May 2012.

Annex: Gridded Emissions - Global Emissions of Air Pollutants into the Atmosphere



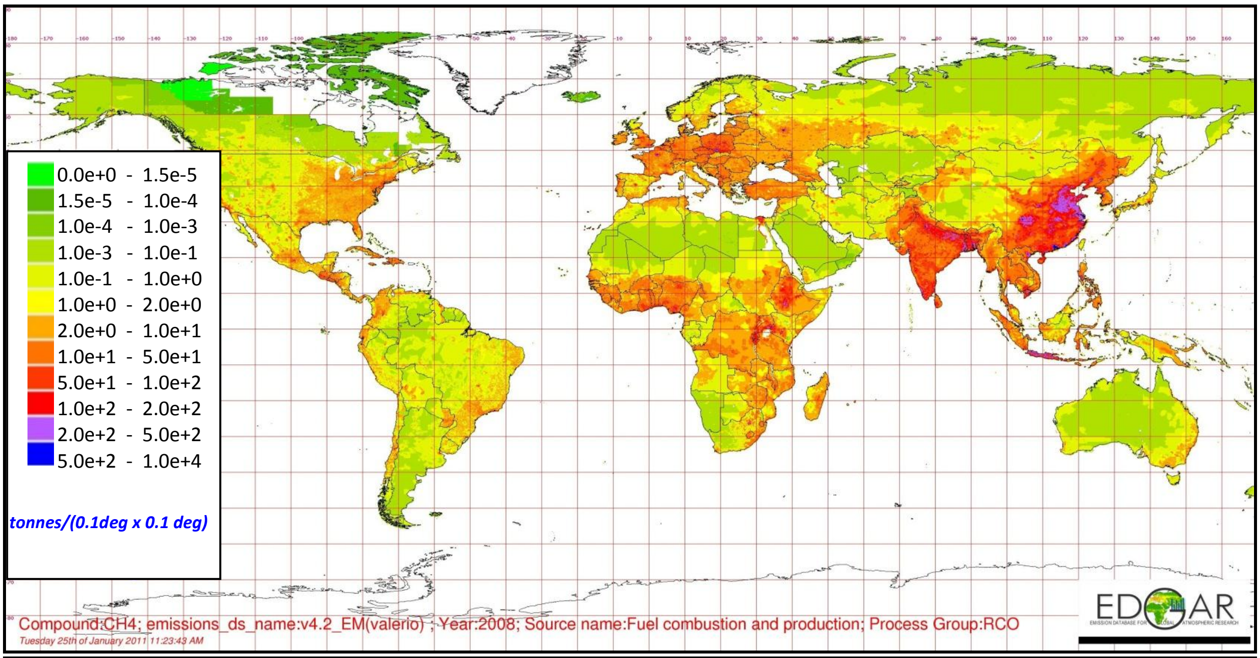
Black carbon (BC) particle emissions by households-2008

BC sources include hundreds of millions of primitive cook stoves in the developing world as well as wood stoves in the industrialized countries. Inhaling BC particles has a detrimental effect on human health. Furthermore they have a significant impact on global warming by absorbing incoming sun light and their deposition on the Greenland and Arctic ice caps and glaciers around the world leads to their faster melting.



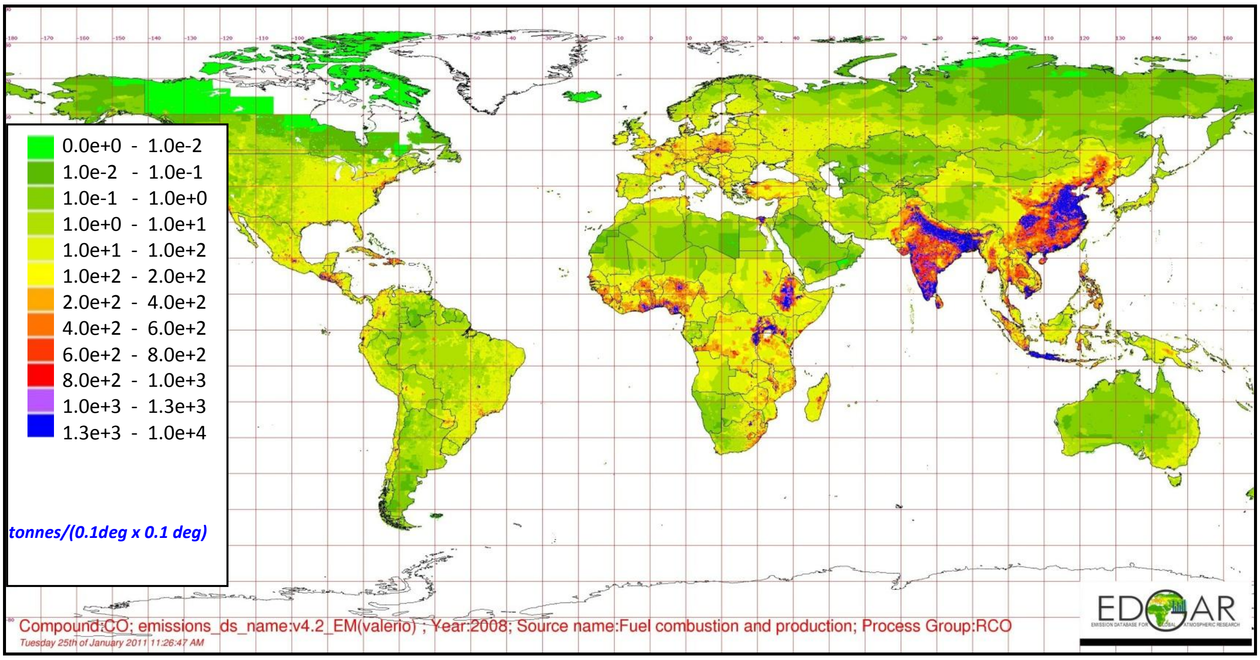
Total emissions of non-methane volatile organic compounds (NMVOC) - 2005.

Major sources of NMVOCs are both natural, such as forest and savannah fires, as well as anthropogenic, such as combustion of coal, petrol and natural gas, and use of solvents. In the atmosphere these gases lead to the production of ozone and smog in urban areas.



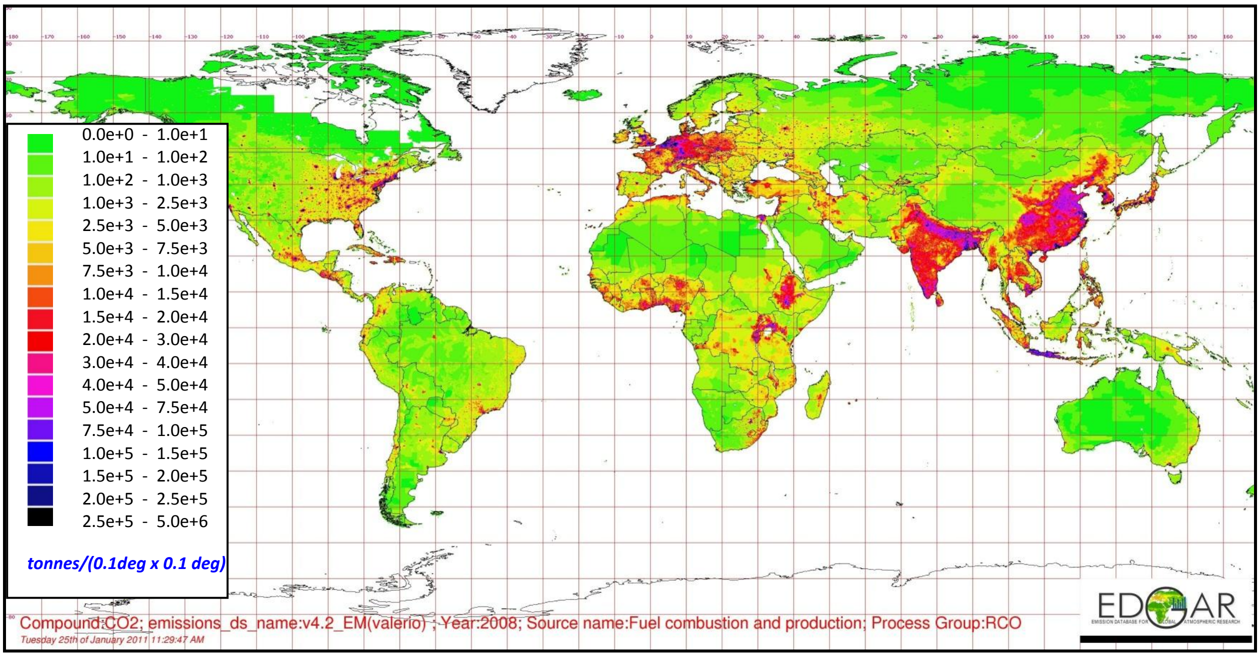
Methane emissions by households -2008

Major source of methane (CH_4) emission in households is vegetal waste and wood burning. CH_4 is an important greenhouse gas, about 20 times more effective than carbon dioxide. It also leads to the production of ozone thousands of kilometers away from its sources.



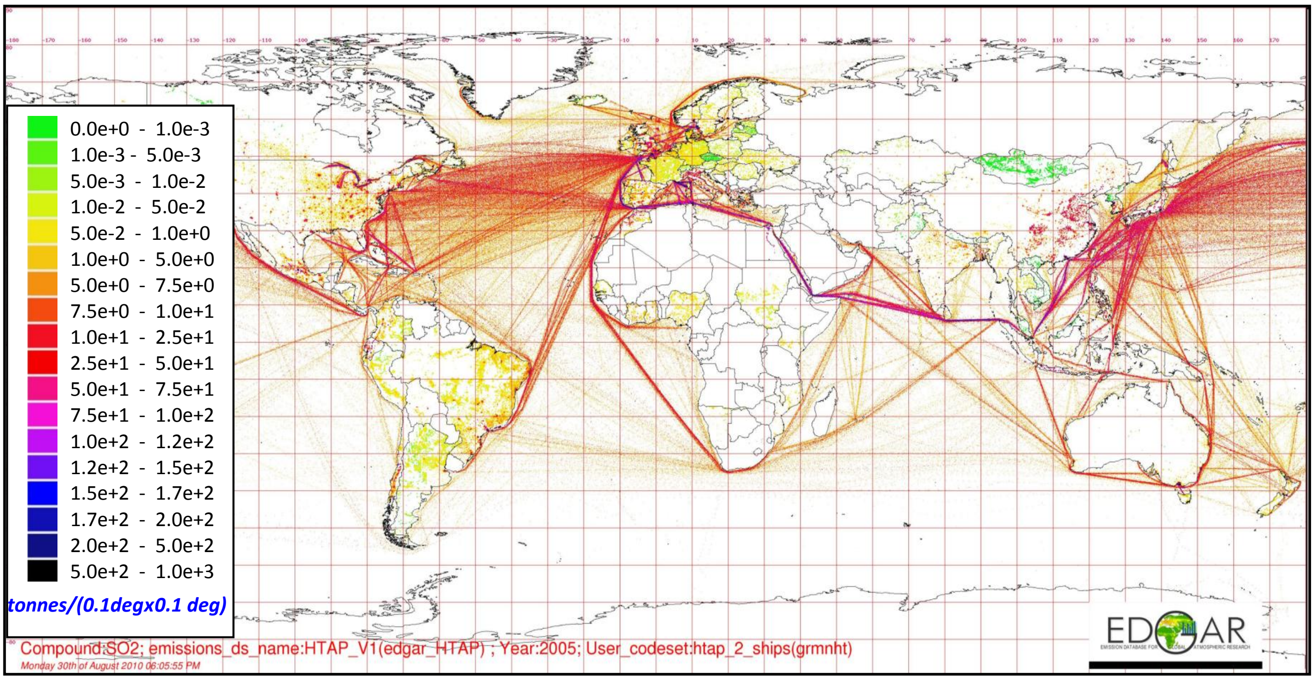
Carbon monoxide emissions by households-2008

Sources of carbon monoxide (CO) include fossil fuel and biofuel use for heating. In the atmosphere carbon monoxide leads to the production of ozone even thousands kilometers away from its sources



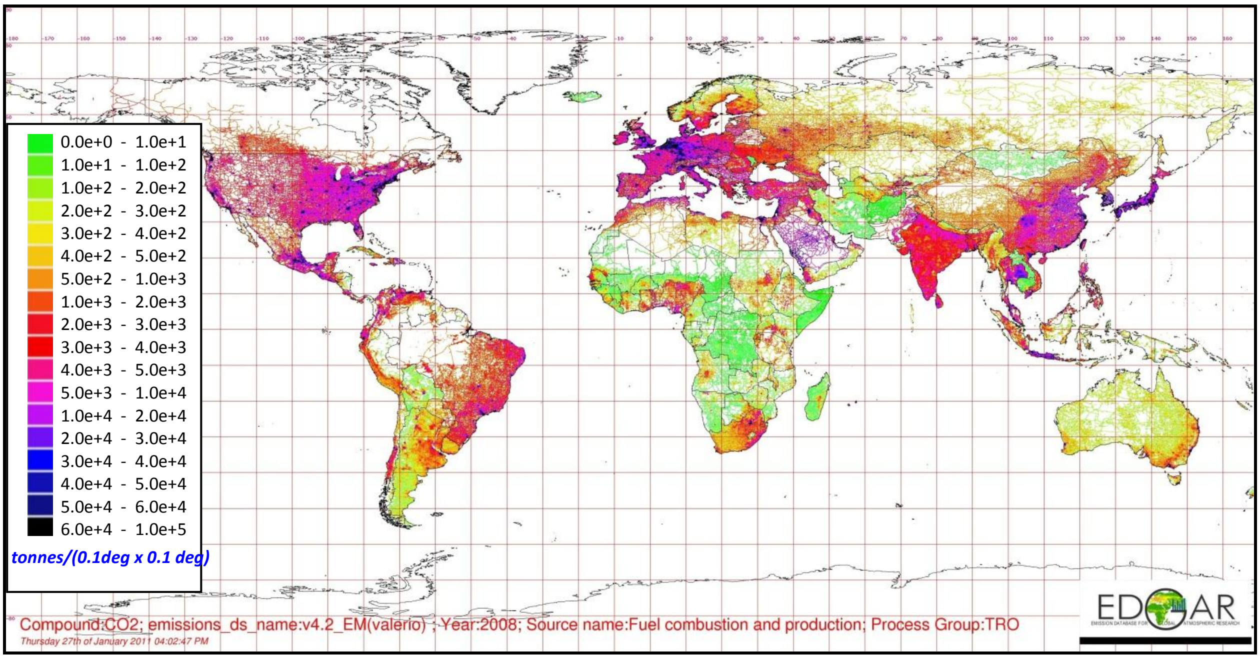
Carbon dioxide (CO_2) by households-2008

CO_2 is the greenhouse gas whose man-made emissions contribute most to global warming. Its sources in households include primarily the use of coal, petrol and natural gas for cooking and heating and air conditioning. These emissions are about 14% of the CO2 emissions from all anthropogenic activities.



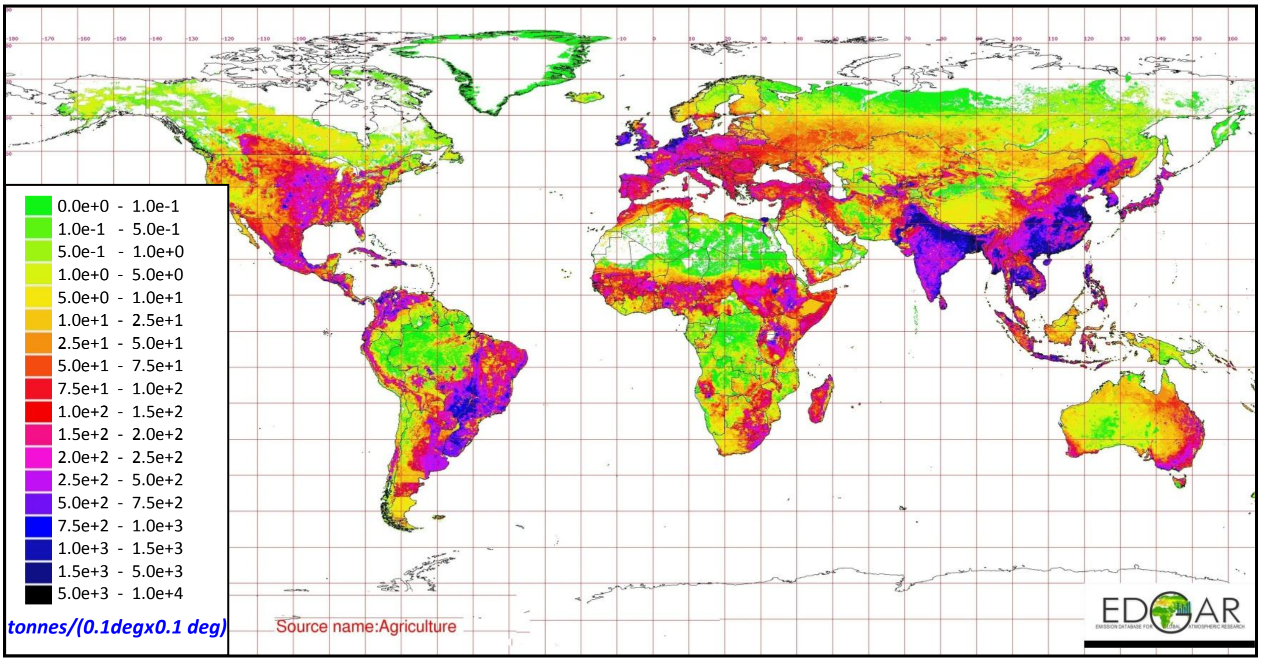
Sulfur dioxide emissions from ships-2005

Sulfur dioxide (SO_2) emissions from ships are about 15% of SO_2 emissions from power plants on land. Sulfur dioxide transforms in the atmosphere to sulfuric acid, and contributes to the problem of acid rain and to the production of particulate matter. It has a detrimental effect on ecosystems and human health.



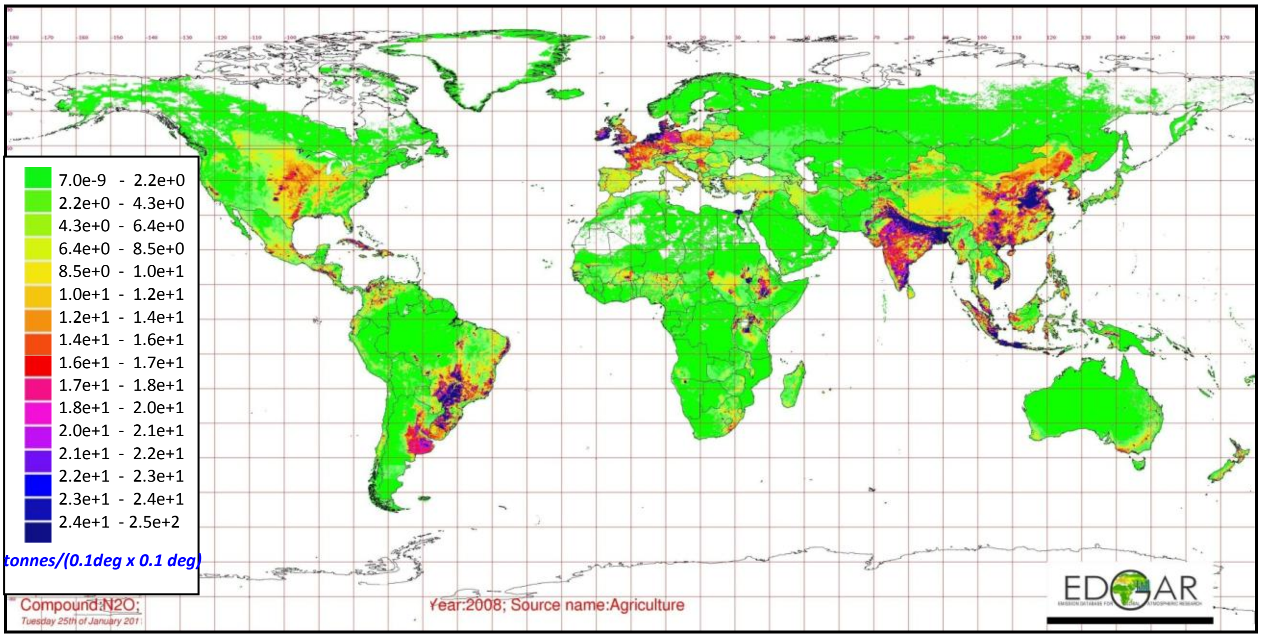
Carbon dioxide emissions from road transport-2008

Carbon Dioxide (CO_2) is the greenhouse gas which emissions contribute most to global warming. CO_2 emissions from transport are about 10% of the total CO2 emissions from all anthropogenic activities.



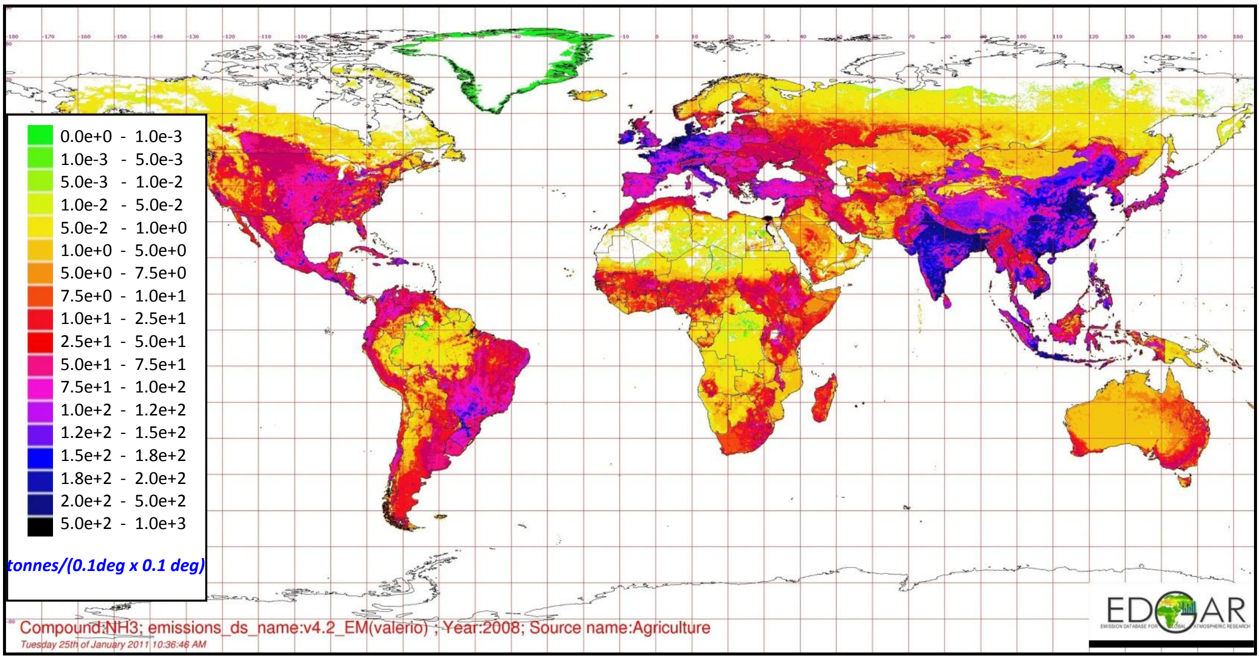
Methane (CH_4) emissions from agriculture-2008

The cultivation of rice and the raising of cattle are the main sources of anthropogenic sources of CH4. Methane is an important greenhouse gas. It also leads to the production of ozone thousands of kilometers away from its sources.



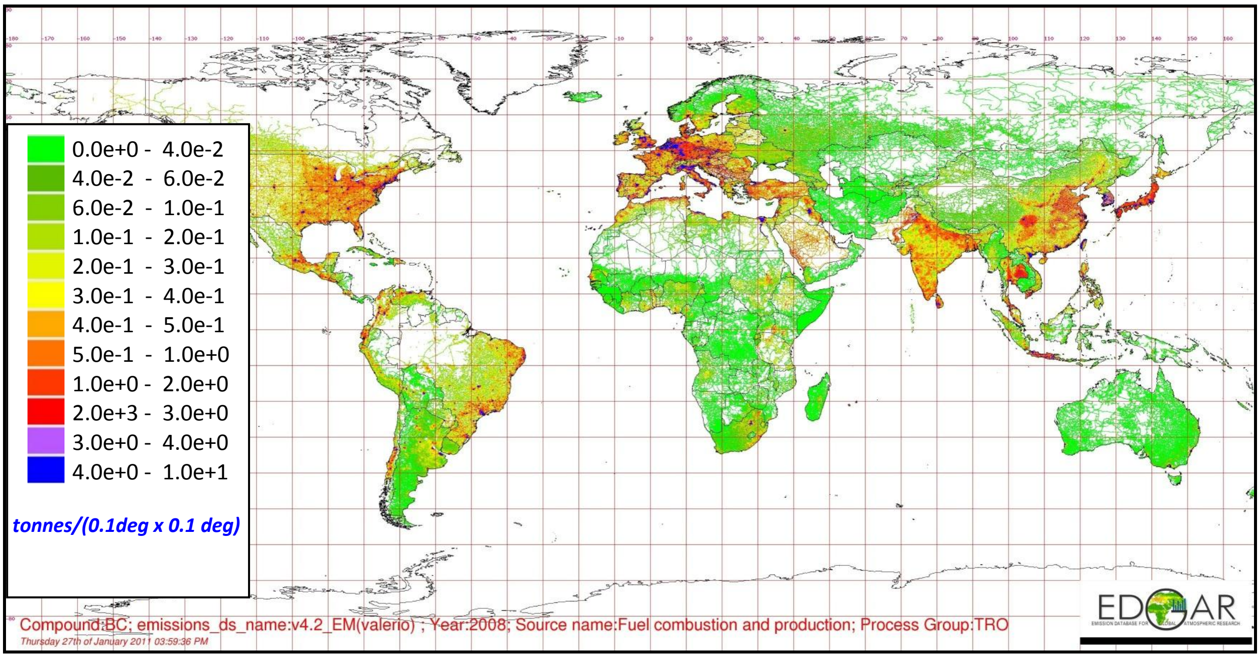
Nitrous oxide (N_2O) emissions from agriculture-2008

N_2O is an important greenhouse gas, about 300 times more effective than CO_2. Its emissions are primarily from the use of synthetic fertilizers in agriculture.



Ammonia (NH_3) emissions from agriculture -2008

NH_3 missions are primarily from the use of synthetic fertilizers in agriculture. In the atmosphere NH_3 facilitates the production of particulate matter. When it is deposits again on the Earth's surface it can lead to over fertilization with deteriorating impacts on natural ecosystems and biodiversity.



Black Carbon (BC) particle emissions from road transport-2008

Sources are primarily diesel engines. Inhaling black carbon particles has a detrimental effect on human health. Furthermore they have a significant impact on global warming by absorbing incoming sun light and their deposition on the Greenland and Arctic ice caps and glaciers around the world leads to faster ice melting.

European Commission
EUR 25785 – Joint Research Centre – Institute for Environment and Sustainability

Title: Global emission inventories in the Emission Database for Global Atmospheric Research (EDGAR) – Manual (I).
Gridding: EDGAR emissions distribution on global gridmaps.

Author(s): Greet Janssens-Maenhout, Valerio Pagliari, Diego Guizzardi, Marilena Muntean

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Abstract
The Emissions Database for Global Atmospheric Research EDGAR, version 4 is managed at a JRC-server and documented with an emipedia website. The final resulting datasets of sector-specific emission inventories for all world countries and the resulting gridmaps have been published for all greenhouse gases and air pollutants and PM10 particulate matter on edgar.jrc.ec.europa.eu. These are accompanied so far with a description online, which is then worked out in more detail in the EDGAR Manual series. A first part of the EDGAR Manual series is this report "Gridding: EDGAR emissions distribution on global gridmaps". The report documents all geospatial surrogates that were collected, mainly from publicly available information sources, which were manipulated to arrive to a full set of consistent proxy data with spatial resolution of 0.1degx0.1deg. The set of a hundred proxy datasets are applied to all EDGARv4 emissions yielding the sector-specific global emission gridmaps for all substances. Except for population and the derived urban and rural population proxy datasets, the proxy do not change over time. The population proxy, taken from CIESIN is an important default for the gridding and changes over time, reflecting the migration of people. More in particular the urban population proxy, derived in-house based on a combination of population and urban settlements, the urbanisation process over the past two decades is taken up. All spatial datasets are two-dimensional, covering the globe, except for aviation. The airline distribution occurs with three distinct layers at different heights, in order to cover a minimum third dimension. The other emissions data are upon request split into two height layers, one at stack height, one at ground level, based on the type of activity. The global coverage and geospatial consistency allow to provide a consistent input to the atmospheric chemistry. In particular multipollutant sources are represented as one single point source. The usefulness of these proxy datasets is reflected by the requests for applying it on other emission inventories, such as the UNEP emissions from IIASA or the EMEP emissions at CEIP.

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