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Comparison of inventory maps with independent emission assessments, both for Poland and Ukraine. Steps towards assessment of significance of various activity sources, and validation of emission factors

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GESAPU

Geoinformation technologies, spatio-temporal approaches, and full carbon account for improving accuracy of GHG inventories

Deliverable 3.3. Comparison of inventory maps with independent emission assessments, both for Poland and Ukraine. Steps towards assessment of significance of various activity sources, and validation of emission factors

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Work package 3. Improving accuracy of inventories by means of spatio-temporal statistical methods

<u>Deliverable 3.3.</u> Comparison of inventory maps with independent emission assessments, both for Poland and Ukraine. Steps towards assessment of significance of various activity sources, and validation of emission factors.

Content

List of figures

List of tables

2. Comparison of the developed inventory map with independent emission assessments: nighttime lights

2.1 ODIAC and GESAPU emission assessments

Below we present a comparison of the developed GHG spatial inventory with an independent assessment, that was obtained by combining a worldwide point source database and satellite observations of the global nightlight distribution; for details see Oda & Maksyutov, 2011. The ODIAC (Open source Data Inventory of Antropogenic CO_2 emissions) data set has been compiled for the whole globe, and Figure 1 presents the map for Poland. It provides a 1km × 1km annual fossil fuel CO_2 emission inventory, where source regions corresponding to human settlements and land transportation are well articulated.

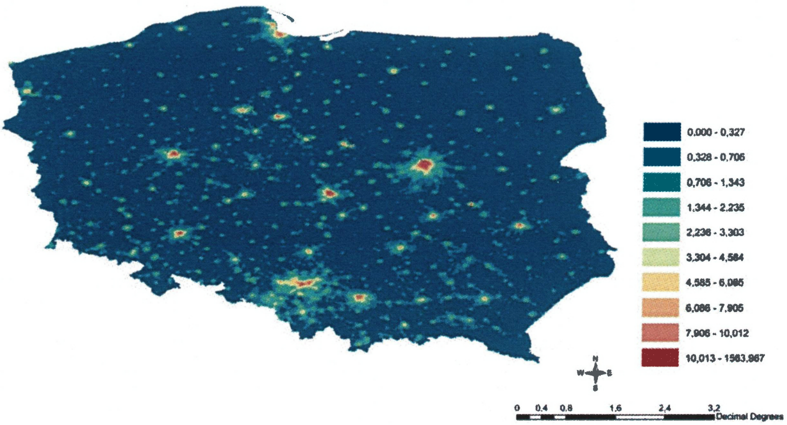


Figure 1. ODIAC assessment of fossil fuel CO_2 emissions at the territory of Poland in the original 1km × 1km grid [Gg CO_2]

For comparison, a relevant inventory part of GESAPU assessment comprises Energy sector, see Figure 2. It should be noted that this emission inventory is prepared for the year 2010, while the presented ODIAC results were compiled for the year 2013.

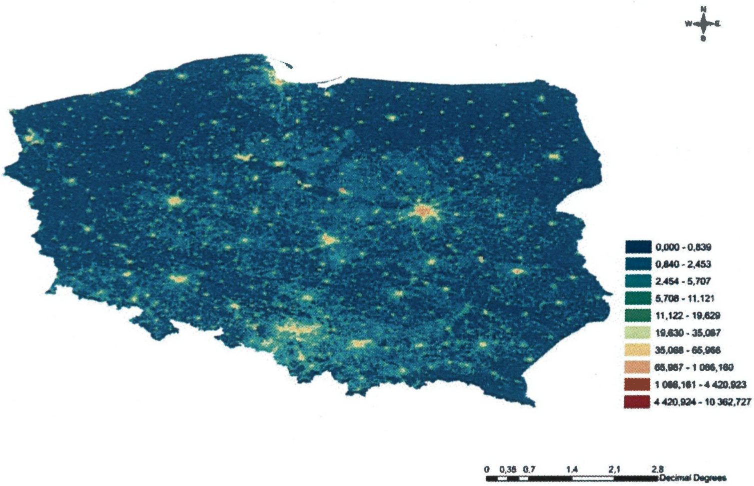


Figure 2. GESAPU assessment of fossil fuel CO_2 emissions at the territory of Poland in 2km × 2km grid [Gg CO_2]

2.2 Basic assumptions underlying the two approaches for spatial emission assessment

Below we compare the basic assumptions used for modelling emissions by the ODIAC method (Oda & Maksyutov, 2011) and the method used in the GESAPU project.

Table 1. Methodological assumptions: ODIAC versus GESAPU emission data sets

ODIAC	GESAPU
National emission data: • Estimates of annual national CO_2 emissions based on worldwide energy statistics compiled by the energy company BP p.l.c., which includes the consumption of commercially traded primary fuels (e.g. oil, coal, natural gas) • The CO_2 emissions estimated by calculating the carbon content of the consumed fuels according to the methodology specified in the IPPC 1996 guidelines	**National emission data**: • Estimates of annual GHG (CO_2, CH_4, N_2O, SF_6, NMVOC) emissions at the level of point-, line- and area-type sources, using national statistical data about fossil fuel consumption in the Energy sector as well as activity data in the Industry, Agriculture, Waste and LULUCF sectors at the national, regional levels, and the level of municipalities • The GHG emissions estimated using emission factors in all sectors, and net

• Conversion factors adopted from the statistics report prepared by IEA (2007)	calorific values in the Energy sector (national or for point-type sources – where possible) according to the methodology specified in the IPPC 2007 guidelines
Point sources (power plants): • Data (localization, emissions) from the database CARMA (Carbon Monitoring and Action, http://carma.org) • Emissions from cement production not considered • Non-land fossil fuel CO_2 emissions (marine and aviation) included in the land emission estimates	**Point sources** (power plants, metallurgy, chemicals, cement production, mining etc.): • Localization of point emission sources using GoogleEarth; activity data using disaggregation algorithms from the lowest as possible level of statistical data (plant, municipality, region, national scale) • Emissions from cement production are considered • Non-land fossil fuel CO_2 emissions (marine and aviation) are not included in the emission estimates
Non-point sources (industrial, residential, commercial sections, and daily transportati • National emissions approximated by subtracting the emissions of point sources from the national total emissions • The spatial distribution determined using d from the satellite nightlight observations obtained from the US Air Force Defense Meteorological Satellite Project Operationa Linescan System (DMSP-OSL) satellites	**Non-point sources** (area-type sources for industrial, residential, commercial, city transport, agriculture, waste, LULUCF sect line-type sources for road and railway transportation): • Activity data (and emissions) for each secto (category of economic activity) are calcula using disaggregation algorithms from the lowest as possible level of statistical data (municipality, region, national scale), and subtracting the data of point sources; • Additional specific regional data are used i disaggregation algorithms, for example, energy demand for cooking, water and spac heating in households for disaggregation fo fuels in the residential sector • Borders of area sources are defined using population density map (Gallego, 2010), an land cover map (Corine, 2006); line source are estimated using national road and railw maps
Final data integration: • Point sources emissions were placed directly at exact locations using coordinate information available in the CARMA database • Total emissions from non-point sources were distributed to 1 km × 1 km pixels	**Final data integration**: • Emissions assigned to point sources and segments of line sources are placed directly at exact locations using coordinates from GoogleEarth and national road maps • Emissions from area-type sources are

according to the distribution of nightlight radiance	placed at corresponding polygons with spatial resolution 100m, using land cover map • Spatially resolved total greenhouse gas emissions point-, line-, and area-type sources are obtained for the 2 km x 2 km grid. Each cell contains information about emissions from all sectors/subsectors as well as total emissions, separately for each greenhouse gas as well as total in CO_2-equivalent

2.3 Quantitative comparison of emission maps

In order to perform a quantitative comparison, the ODIAC 1 km × 1 km map has been adjusted to the 2km grid used in GESAPU calculations. The considered 2km grid for the territory of Poland comprises 79 098 grid cells. The resulting differences between the two assessments are presented in Figure 3, and further analyzed in a histogram and a boxplot in Figure 4. The maps showed good agreement, with the majority of differences (over 70 000) being close to 0. From the histogram it can be noticed that there are more differences below 0 (over 50 000) than above 0 (over 20 000), meaning that the ODIAC assessment tends to report slightly higher values.

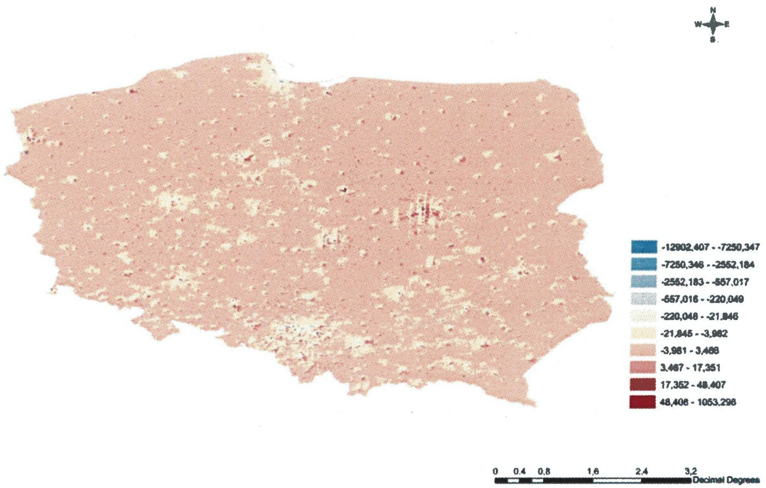


Figure 3. The difference between GESAPU and ODIAC CO_2 emissions [Gg CO_2]

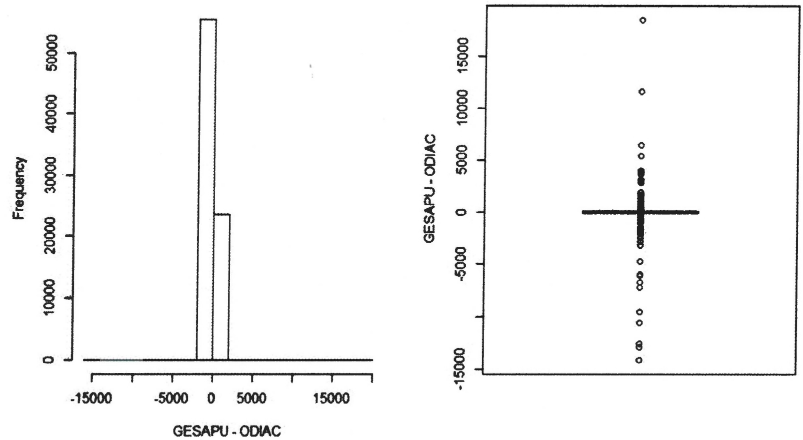
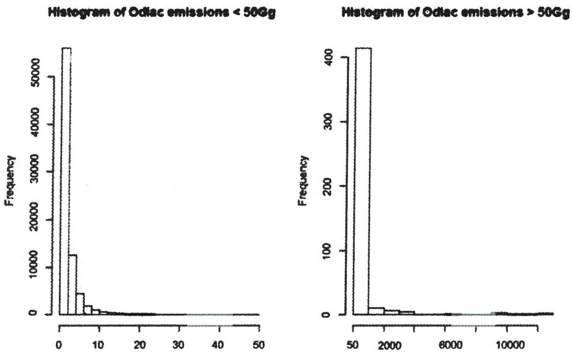


Figure 4. Histogram (left) and boxplot (right) of differences



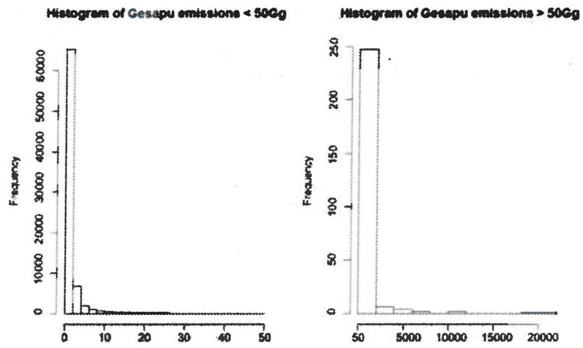


Figure 5. Histogram of CO_2 emissions in both inventories

The histograms in Figure 5 reveal that huge amount of observations (over 60 000) is below 50Gg, and only the remainder (approx. 400 for ODIAC and 250 for GESAPU) represent high values up to 20 000Gg, apparently corresponding to point emission sources. From the scatterplots in Figure 6, particularly the right one of values up to 100Gg, it can be seen that the agreement among the two inventories is somehow limited. One can partly attribute this fact to the issue of transformation of ODIAC map from 1km to 2km resolution. This can be seen in maps for Warsaw agglomeration (Figure 7) and the Silesia region (Figure 8), where the agreement of the GESAPU results with the original 1km ODIAC map is visibly much better than with the adjusted 2km map. Also, note the misallocation of point emission sources in the Warsaw map of ODIAC database. In terms of precise location of power and electricity stations, the GESAPU study seems to provide more reliable information.

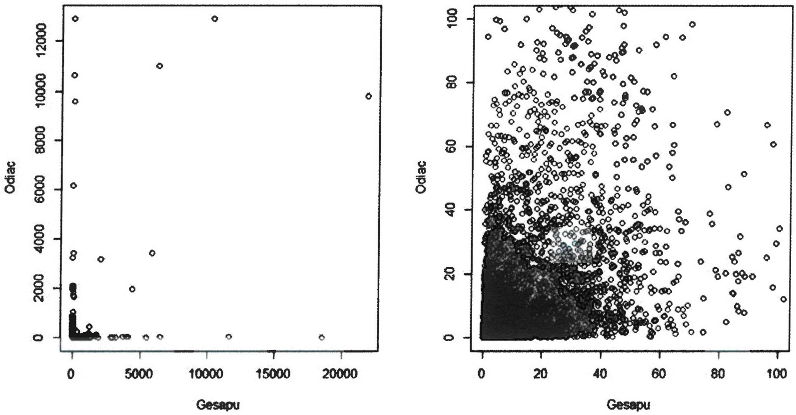


Figure 6. Scatterplot of CO_2 emission values [Gg CO_2]

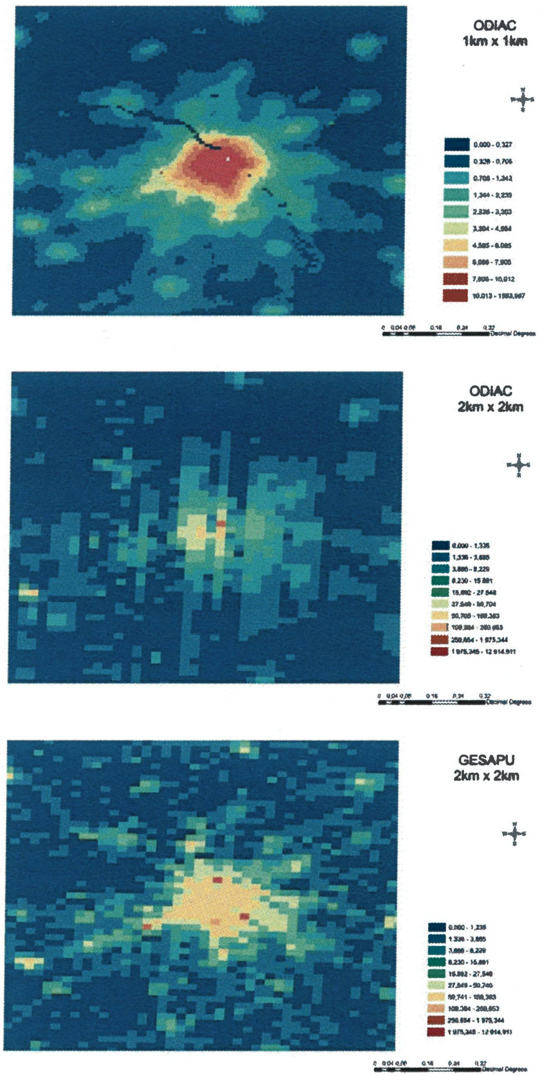


Figure 7. Fossil fuel CO_2 emissions in Warsaw agglomeration and its surroundings

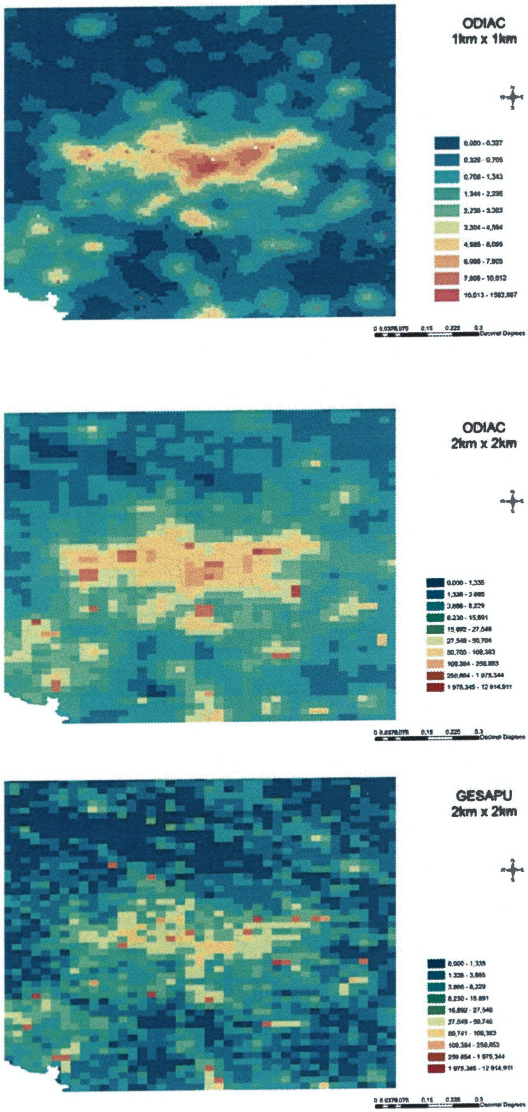


Figure 8. Fossil fuel CO_2 emissions in the Silesia region

3. Concluding remarks

A review of available approaches to assimilation of independent emission assessments has been provided. Four groups of methods have been identified, and their basic paradigms and principles have been reviewed. These are: the satellite observations of nighttime lights, the observations of $^{14}CO_2$ mixing ratios, the inversion of atmospheric measurements, and the flux tower observations. An analysis of independent sources of information revealed that, at the present state of availability of observations, only satellite observations of nighttime lights can be readily used for an independent emission assessment of very high resolution inventory, like the one developed for Poland within the GESAPU project. Such data has been received from the ODIAC project. They have been used for a comparison, both in a qualitative and quantitative manner. Regardless of many identified differences in assumptions taken in both methods, a good match was obtained for about 90% of around 80 000 grid cells. The major differences were mainly due to misallocation of some high point sources in the ODIAC data, and due to errors caused by a mismatch in overlay of both maps.

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