High resolution spatial inventory of GHG emissions from stationary and mobile sources in Poland: summarized results and uncertainty analysis

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Motivation and research aim

NIR: national inventory of GHG: (traditional approach)

New task: spatial inventory (spatial distribution of emissions)

Poland – 300,000 km²
Ukraine – 600,000 km²

Important: Spatial inventory (!!!) Not gridded (!!!)

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Emission sources

Classification:

1. Point-type sources:

2. Line-type sources:

3. Area-type sources/sinks:
Maps of emission sources

1. Point-type sources:
Power plants, cement plants, production of glass, ammonia, iron and steel, pulp and paper, petroleum refining, underground mining etc.

2. Line-type sources:
Roads and railways

3. Area-type sources/sinks:
Croplands, settlements, industrial areas, forests etc.

What is spatial resolution?

Presentation of results

CLC map, 100 m

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Emissions calculation

IPCC Guidelines: \( E = A * F \)

Spatial inventory: \( E_i = A_i * F_i \)
(for all elementary objects: point, line, area)

Emission coefficients
(different for each (!!!) elementary object)

GHGs:
- \( \text{CO}_2, \text{CH}_4, \text{N}_2\text{O} \)
- \( 1 \quad 25 \quad 298 \)
- \( \text{SF}_6, \text{NMVOC} \)
- \( 22,800 \)
- \( \text{CO}_2\)-equivalent

Statistical data
(disaggregated from the lowest (!!!) level)

Administrative structure:

Regions (voivodeships)
N = 16

Districts (powiaty)
N = 379

Municipalities (gminy)
N = 3081

Spatial inventory \( \Leftrightarrow \) National inventory (NIR)
\[ \sum E_i \approx \neq E_{\text{NIR}} \]
Emission structure

IPCC Guidelines → structure

Sectors
Subsectors
Categories

Positive feature

Negative feature: The same emission sources but repotted as different categories in different sectors

Industrial processes

Chemical processes
Fossil fuel using

Forestry and land use change
Energy
Transport

Approach: bottom-up vs top-down?

GHG spatial inventory

National scale
Regional scale
District scale
Municipal scale
Elementary emission sources

Disaggregation of activity data and proxy data

National scale
Regional scale
District scale
Municipal scale
Elementary emission sources

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Summing up the results

Specific Emissions = E/S

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Transport sector in Poland

Input data

- **Statistical data**
  - GUS, BDL

- **Emission factors**
  - NIR, IPCC

- **Digital maps**
  - road map
  - administrative map

- **Indicators**
  - car numbers
  - road categories etc.

**Results**: total specific GHG emissions in transport sector (Subcarpathian region, CO2-equivalent, 2012)

Specific emissions (t/km)

- 833 to 846 (1069)
- 756 to 833 (217)
- 507 to 756 (747)
- 270 to 507 (1325)
- 208 to 270 (7015)
- 181 to 208 (3479)
- 139 to 181 (16608)
- 0 to 139 (1671)
## Emissions: GHGs, categories, fuels

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<th>Vehicle category</th>
<th>Fuel</th>
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</table>
Specific CO₂ emissions from diesel combustion by passenger cars in Poland (2 km x 2 km; t/km²; 2010)
Structure of CO$_2$ emissions in road transport by vehicle types and fuels (Poland voivodships, square root scale, 2010)
Presentations:

Agriculture and waste
(Nadiia Charkovska et al.)

Electricity and heat production
(Petro Topylko et al.)

Industrial processes
(Nadiia Charkovska et al.)

Fugitive emissions and fuel processing
(Mariia Halushchak et al.)

Residential sector
(Olha Danylo et al.)
Summarizing results

Total specific $CO_2$–eq. emissions without LULUCF (Gg/km$^2$, 2010)

Silesian voivodeship

(!!!) All sectors - technosphere
Prism-map of specific GHG emissions from all anthropogenic sectors without LULUCF in the Silesia region (CO$_2$-equivalent, Gg/km$^2$, square root scale, 2 x 2 km, 2010)

Rybnik power plant

Katowice agglomeration

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Total GHG emissions structure in Poland by sector in CO$_2$-equivalent (2010)

Main sectors (Gg)

CO$_2$ Forest Sink (A5) Gg/km$^2$

- Energy
- Industry
- Agriculture
- Waste

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GHG emissions in Energy Sector in Poland by sub-sectors (Gg, CO$_2$-equivalent, 2010)

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Uncertainty of spatial inventory results

Spatial inventory:
for each category
\[ E_i = A \times D_i \times (F_{i,CO2} + GWP_{CH4} \times F_{i,CH4} + \ldots) \]

- **A** – activity data
- **D** \(_i\) – disaggregation coefficients
- **F** \(_i\) – emission factors
- **GWP** – global warming potential

Uncertainty:
\[ U = U (\text{factor}_1, \text{factor}_2, \text{factor}_3, \text{factor}_4, \text{factor}_5, \text{factor}_6, \ldots?\ldots) \]

- **factor\(_1\)** – uncertainty of sources geolocation
- **factor\(_2\)** – uncertainty of aggregated activity data
- **factor\(_3\)** – uncertainty of proxy data representation
- **factor\(_4\)** – uncertainty of proxy data values
- **factor\(_5\)** – uncertainty of proxy data geolocation
- **factor\(_6\)** – uncertainty of emission factors

Uncertainty estimation: ???

Monte-Carlo method

95% confidence intervals; symmetric and asymmetric distributions

Sensitivity analysis

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Conclusions

The presented approach:

- provides high resolution of GHG spatial inventory in Poland (>100m);
- provides spatial analysis at the level of point-, line-, and area-type emission sources/sinks without using any additional grid;
- takes into account the territorial specificity of many parameters that affect emissions or removals of GHGs;
- makes it possible to aggregate the final results even to the level of municipalities without decreasing accuracy;
- enables to display a real contribution of each even very small territory to the overall emission processes.
Thank You for Attention!