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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)

Poland → $E = \begin{cases} \text{Category 1} \\ \text{Category 2} \\ \text{......} \\ \text{Category n} \end{cases}$

New task: spatial inventory (spatial distribution of emissions)

Poland – 300,000 km^2
Ukraine – 600,000 km^2

= $\begin{cases} \text{Category 1} \\ \text{Category 2} \\ \dots \\ \text{Category n} \end{cases}$

Category 1

Category 2

...

Category n

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

Emission sources

Categories of anthropogenic activity covered by IPCC Guidelines





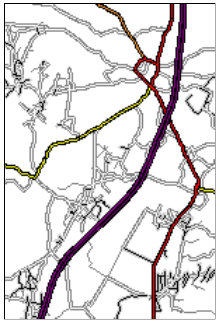


Classification:

1. Point-type sources:

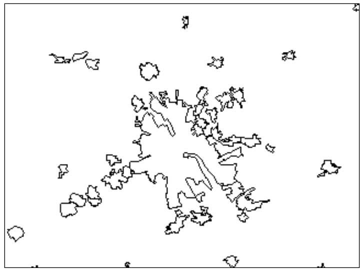

2. Line-type sources:





3. Area-type sources/sinks:






Maps of emission sources

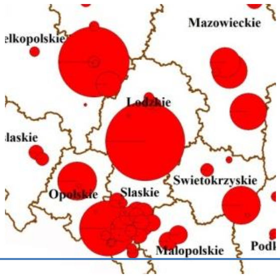
What is spatial resolution?

Multi stacks ?

1. Point-type sources:

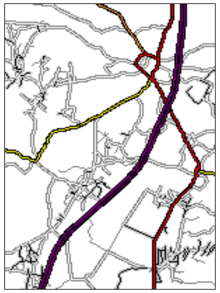
Power plants, cement plants, production of glass, ammonia, iron and steel, pulp and paper, petroleum refining, underground mining etc.

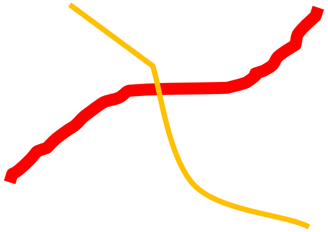
Presentation of results

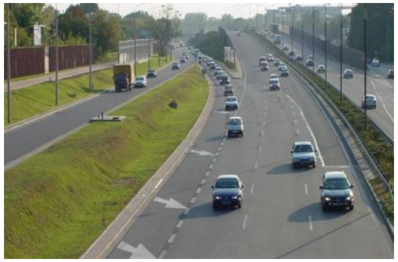


2. Line-type sources:

Roads and railways

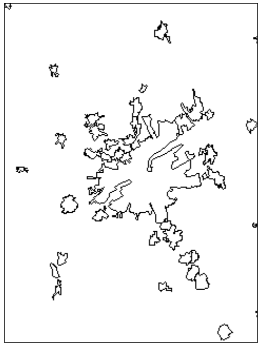


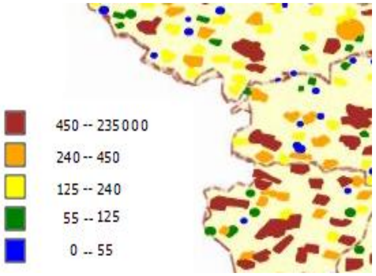




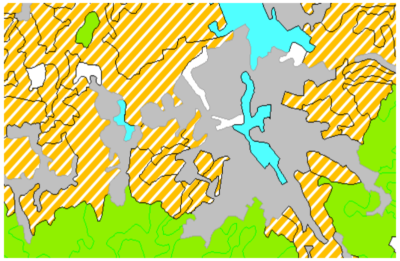
3. Area-type sources/sinks:

Croplands, settlements, industrial areas, forests etc.





CLC map, 100 m



Emissions calculation

Administrative structure:

Regions (voivodeships)
N – 16

Districts (powiaty)
N = 379

Municipalities (gminy)
N = 3081

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)

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

GHGs:
CO_2, CH_4, N_2O
1 25 298
SF_6, NMVOC
22,800
CO_2-equivalent

?

Spatial inventory ⇔ **National inventory (NIR)**

$$\Sigma E_i \approx \neq E_{NIR}$$

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

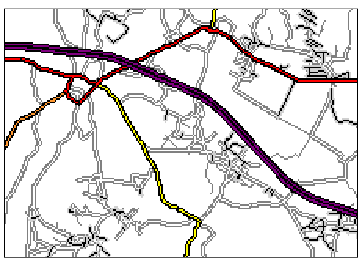
Regional scale

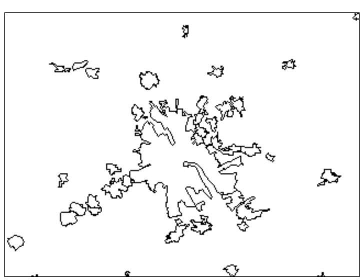
District scale

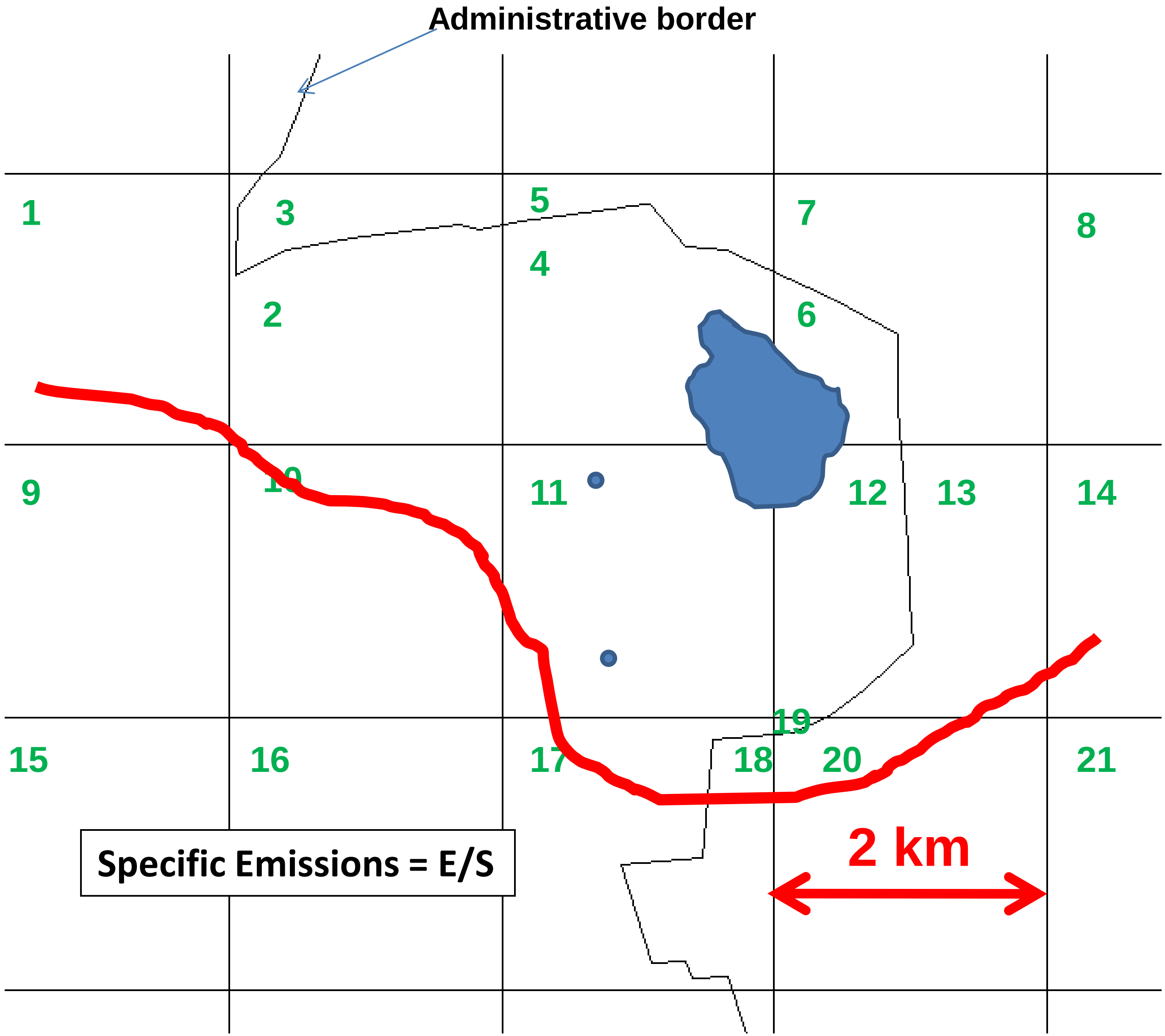
Municipal scale

Elementary emission sources

Summing up the results



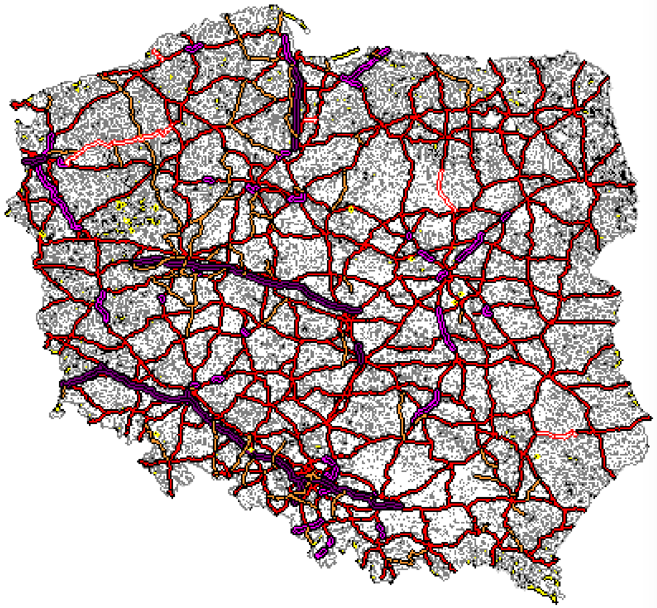




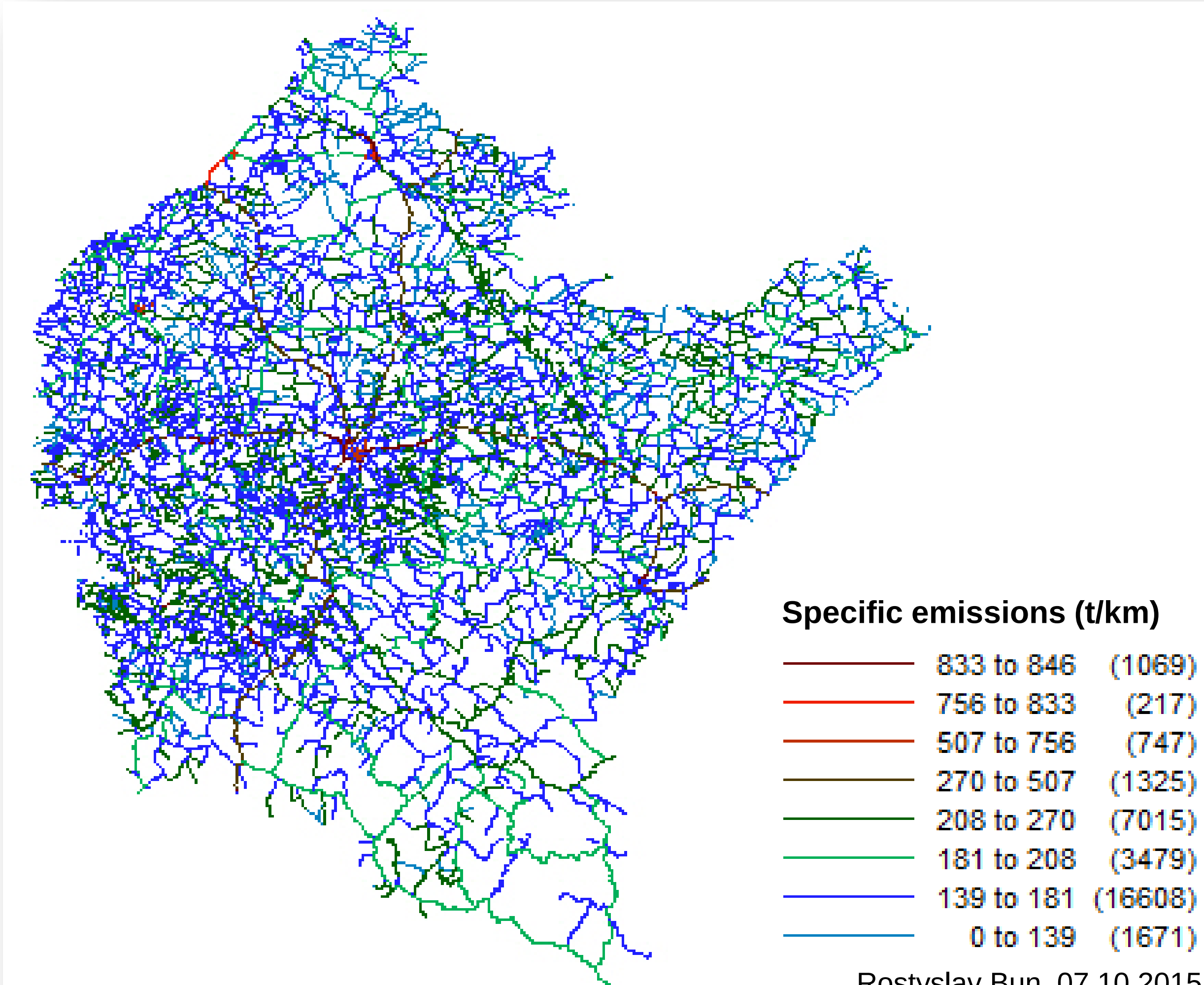
Transport sector in Poland

Input data

- **Statistical data**
  - GUS, BDL
- **Emission factors**
  - NIR, IPCC
- **Digital maps**
  - road map
  - administrative map
- **Indicators**
  - car numbers
  - road categories etc.



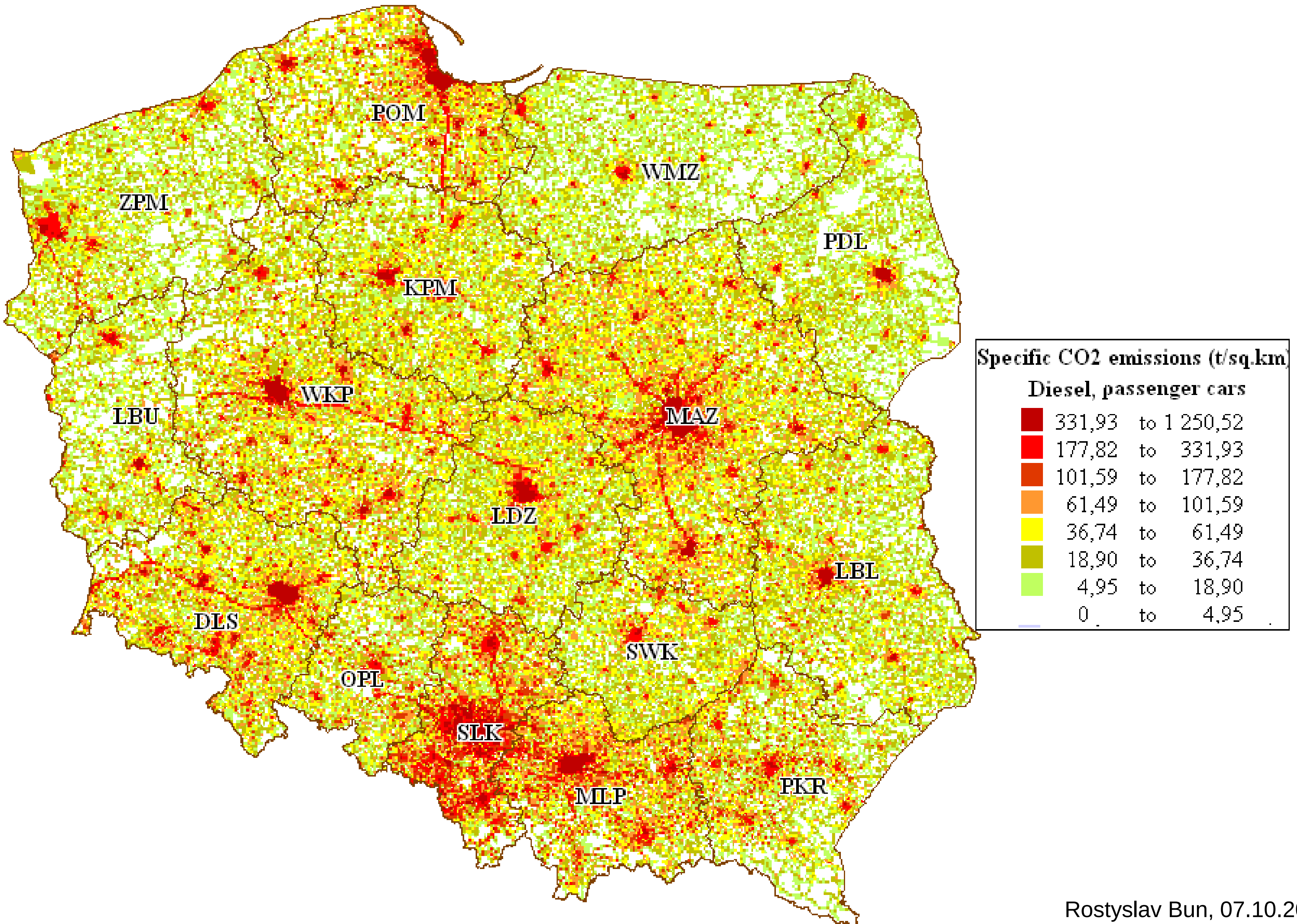
Results: total specific GHG emissions in transport sector (Subcarpathian region, CO_2-equivalent, 2012)



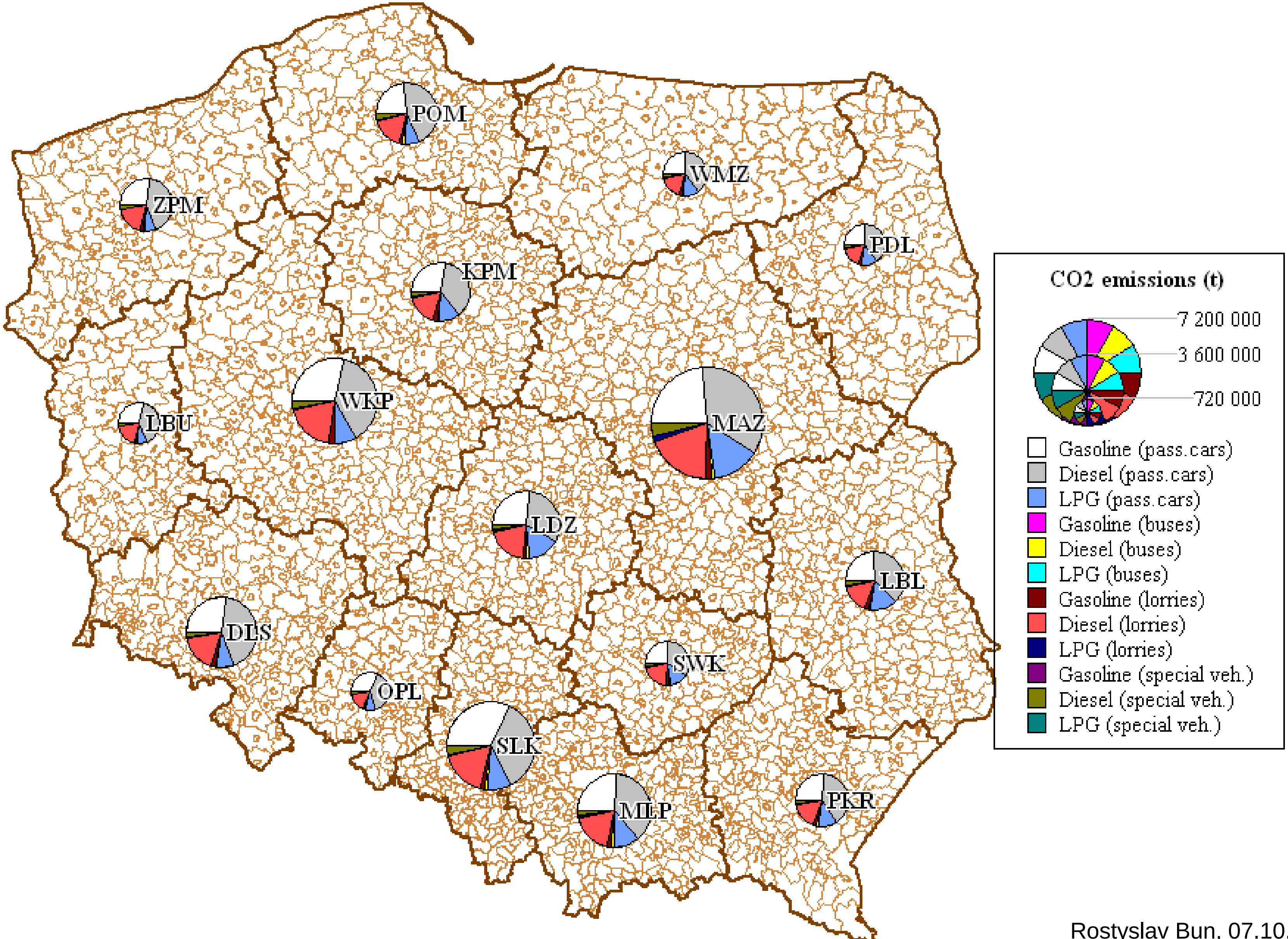
Emissions: GHGs, categories, fuels

Vehicle category	**Fuel**		
	gasoline	**diesel**	**LPG**
Passenger cars	CO_2	$\boxed{CO_2}$	CO_2
	CH_4	CH_4	CH_4
	N_2O	N_2O	N_2O
Buses	CO_2	CO_2	CO_2
	CH_4	CH_4	CH_4
	N_2O	N_2O	N_2O
Lorries	CO_2	CO_2	CO_2
	CH_4	CH_4	CH_4
	N_2O	N_2O	N_2O
Special vehicles	CO_2	CO_2	CO_2
	CH_4	CH_4	CH_4
	N_2O	N_2O	N_2O

Specific CO_2 emissions from diesel combustion by passenger cars in Poland (2 km x 2 km; t/km^2; 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.)

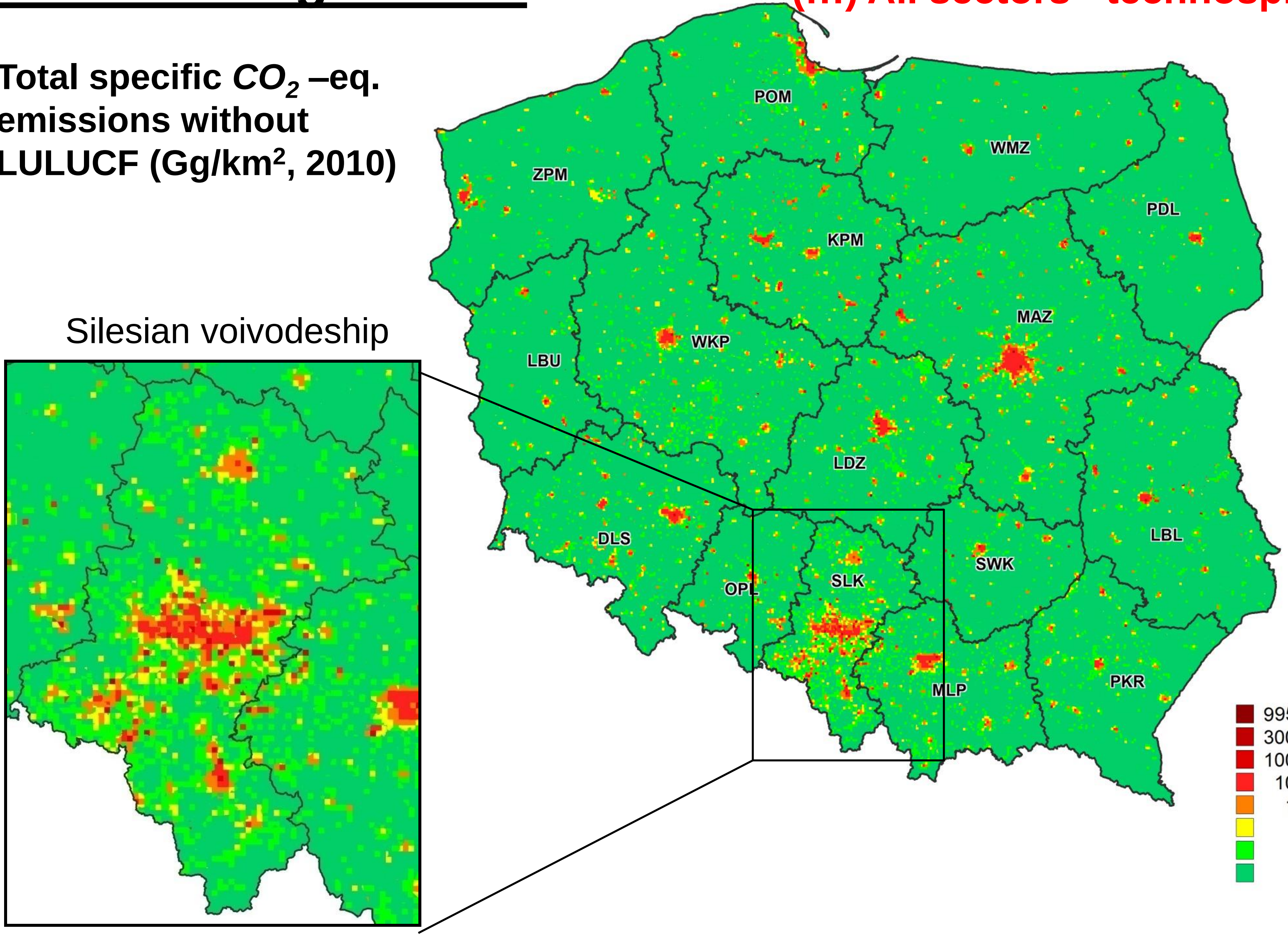
Residential sector
(Olha Danylo et al.)

Summarizing results

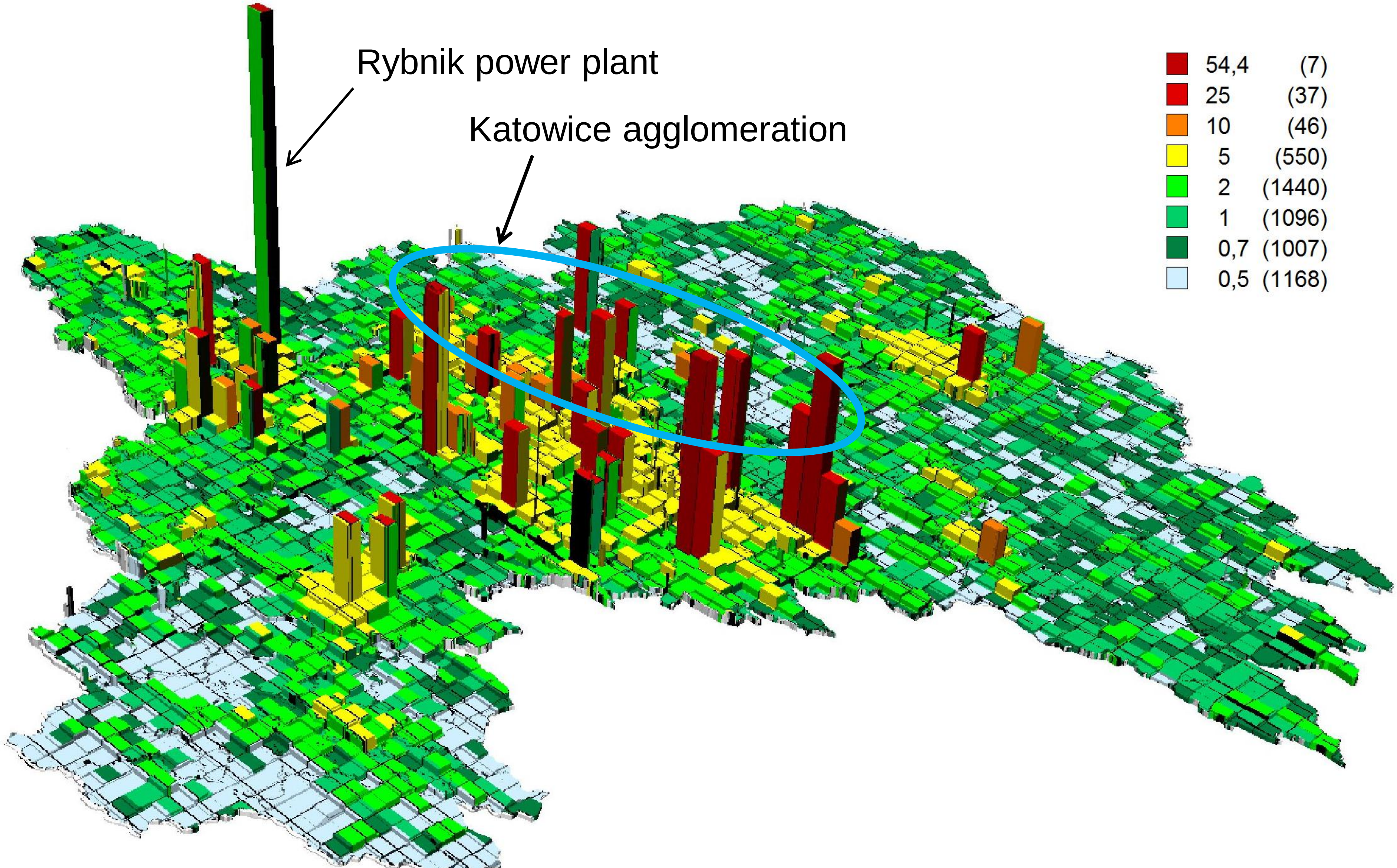
(!!!) All sectors - technosphere

Total specific CO_2 –eq. emissions without LULUCF (Gg/km², 2010)

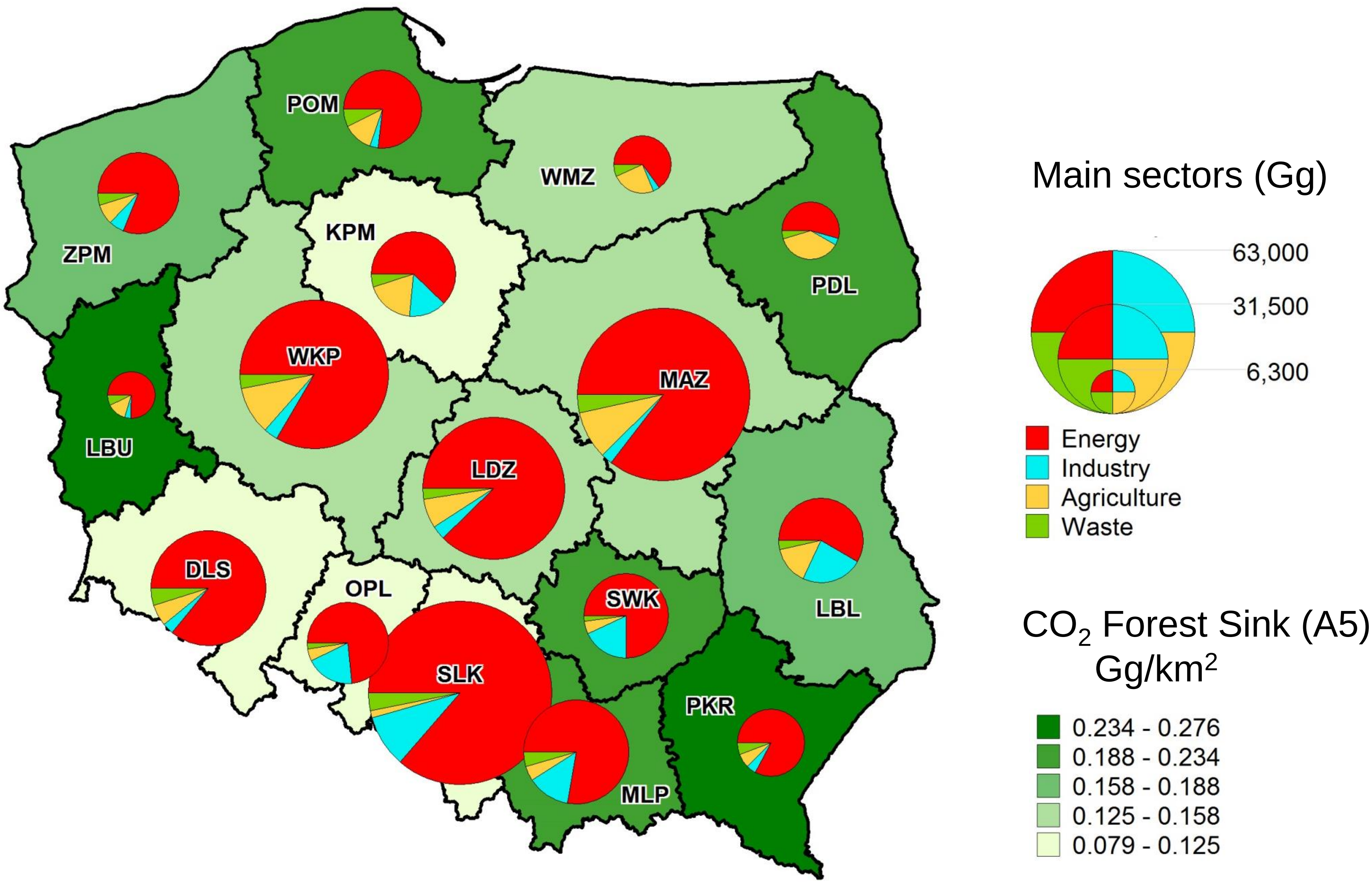
Silesian voivodeship



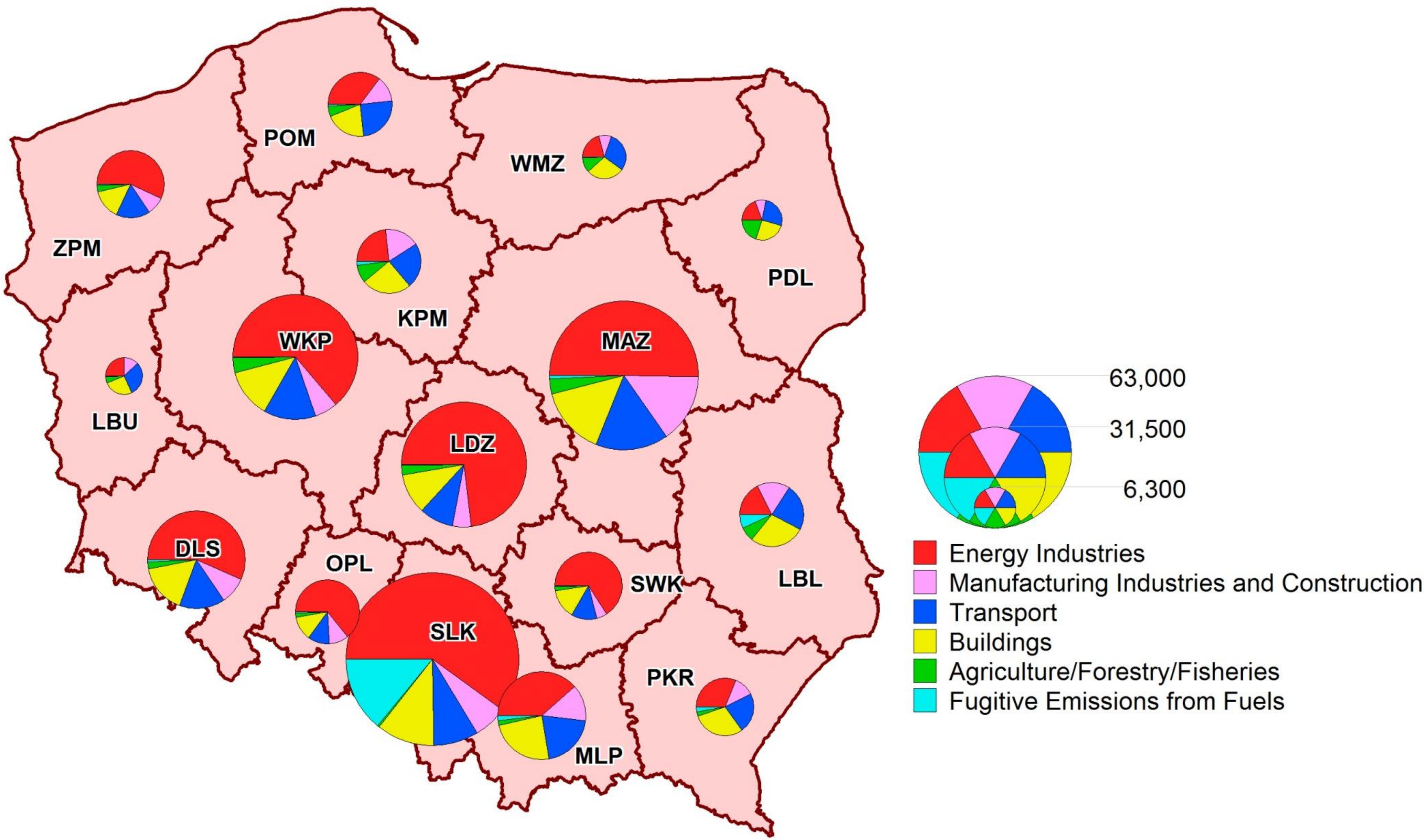
Prism-map of specific GHG emissions from all anthropogenic sectors without LULUCF in the Silesia region (CO_2-equivalent, Gg/km^2, square root scale, 2 x 2 km, 2010)



Total GHG emissions structure in Poland by sector in CO_2-equivalent (2010)



GHG emissions in Energy Sector in Poland by sub-sectors
(Gg, CO_2-equivalent, 2010)



Uncertainty of spatial inventory results

Spatial inventory:

for each category

$$E_i = A * D_i * (F_{i,CO2} + GWP_{CH4} * F_{i,CH4} + \ldots)$$

A – activity data
D_i – disaggregation coefficients
F_i – emission factors
GWP – global warming potential

factor$_2$ – uncertainty of aggregated activity data

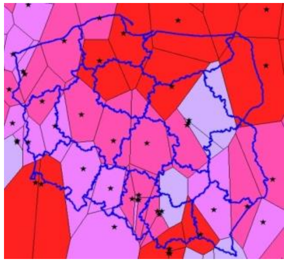
factor$_6$ – uncertainty of emission factors

factor$_3$ – uncertainty of proxy data representation

factor$_4$ – uncertainty of proxy data values

factor$_5$ – uncertainty of proxy data geolocation

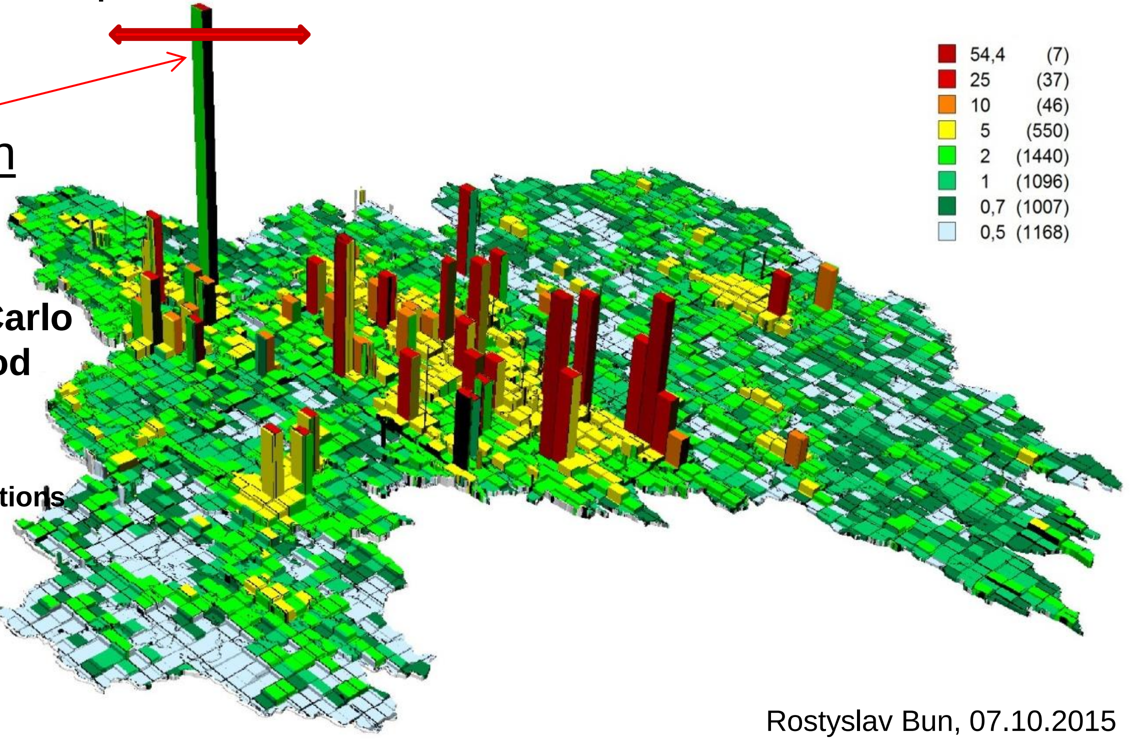
Proxy data



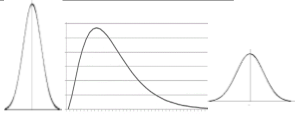
Uncertainty:

***U* = *U* (factor$_1$, factor$_2$, factor$_3$, factor$_4$, factor$_5$, factor$_6$, ...?...)**

factor$_1$ – uncertainty of sources geolocation



Uncertainty estimation: ???

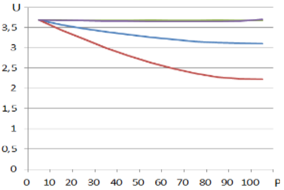


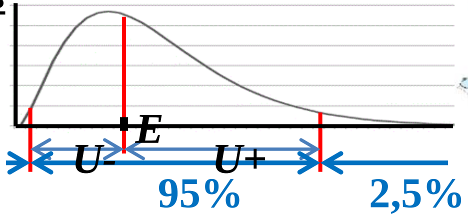
Monte-Carlo method

$Q_{En,f}\left(\xi_{En,n_p}\right), K^g_{En,f}, C_f$

95% confidence intervals;
symmetric and asymmetric distributions

Sensitivity analysis





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.

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Thank You for Attention!