Application of EMEP4PL for BaP concentrations modelling for Poland

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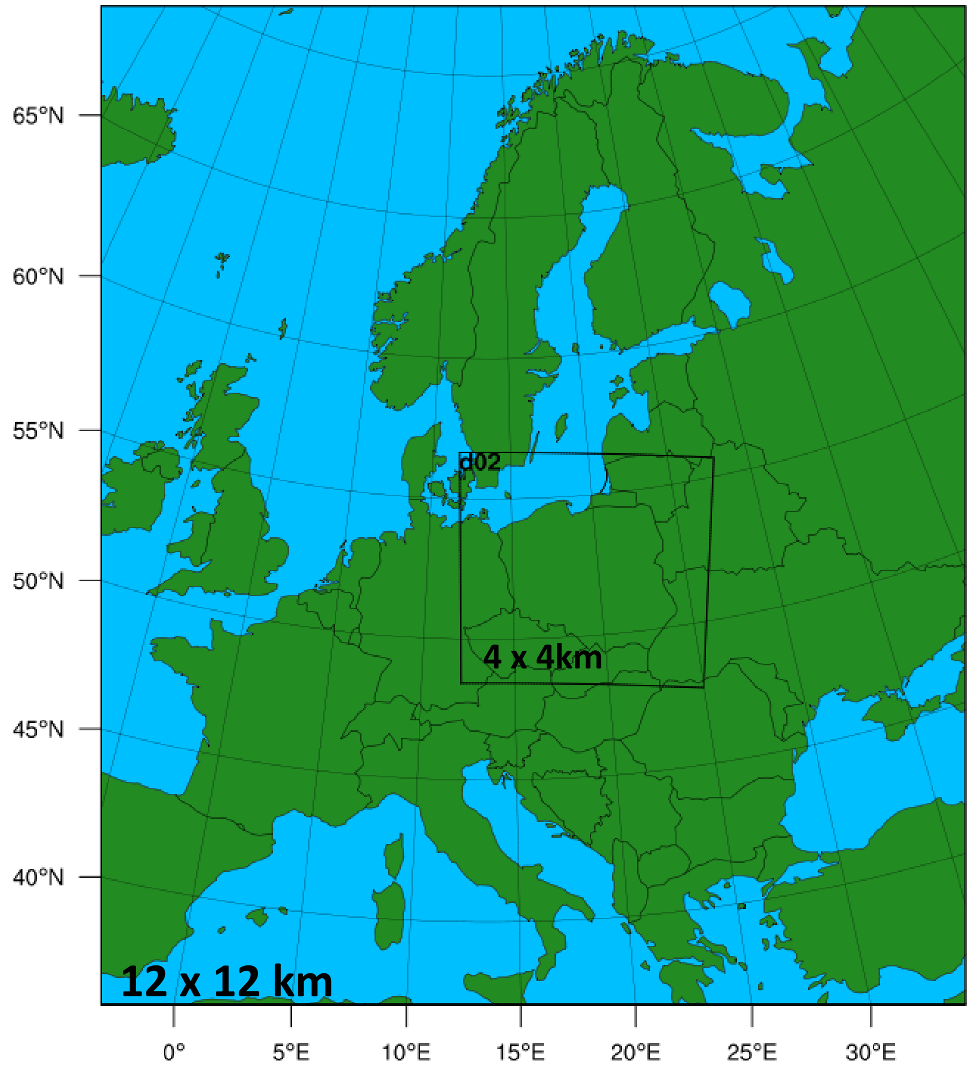
The study aims

- Calculate BaP concentrations for Poland (with EMEP4PL) for selected years to show:
  - Impact of winter severity on BaP concentrations and exceedances of the target value (1 ng/m3)
  - Population exposure to BaP concentrations in Poland
  - The health effects of exposure to BaP in Poland

Methods – modelling framework

- Chemical transport model: EMEP4PL
  - Version: 4_34
  - Met data: WRF (v. 3.9) with observational nudging
- Emissions:
  - EMEP 0.1° x 0.1° for Europe
  - KOBIZE (National Centre for Emission Management) 1km x 1km for Poland



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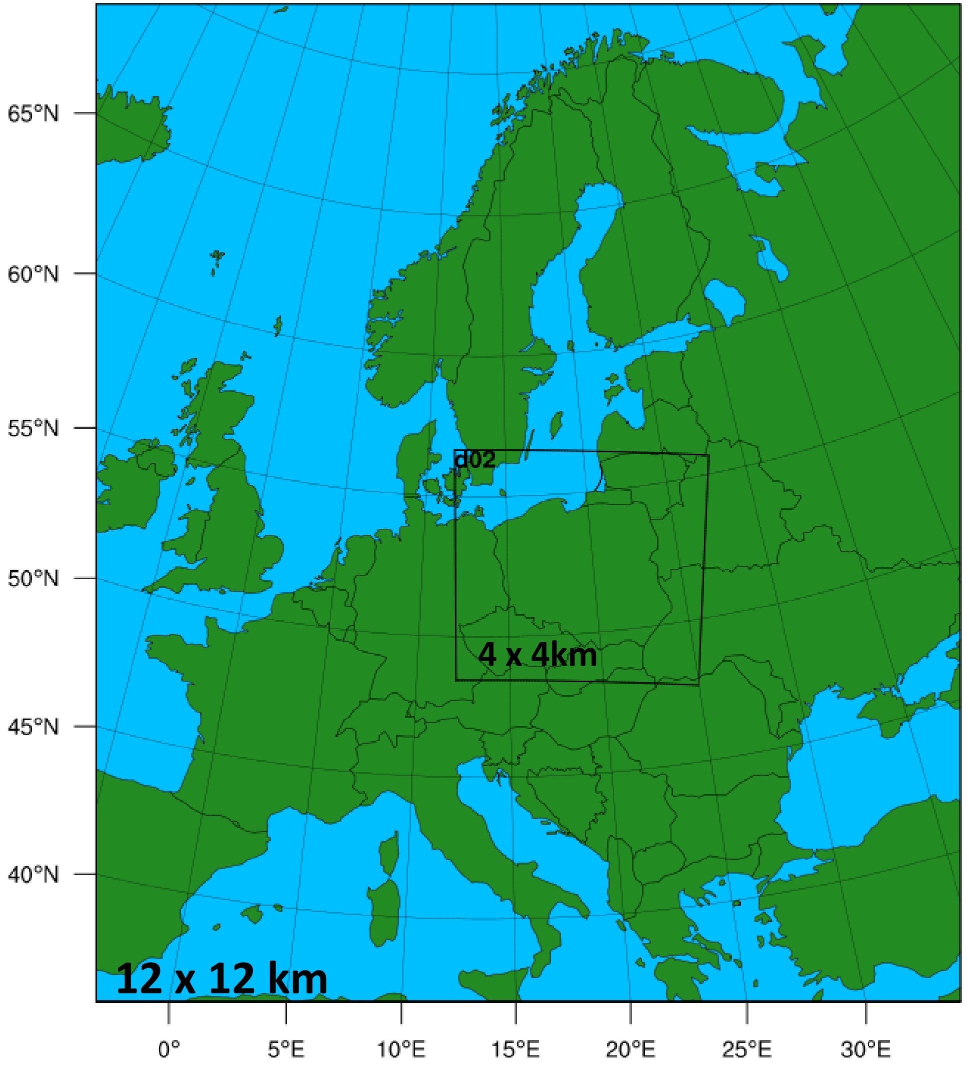
- Health effects: AlphaRisk
  - Number of additional lung cancer cases (ALCC)



Methods – study design

- EMEP4PL run for 3 years
  - **average (BASE)**: 2018, meteorology **2018**, emissions **2018**
  - **cold**: 2010, meteorology **2010**, emissions **2018**
  - **warm**: 2020, meteorology **2020**, emission **2018**

- Modelled results compared with obs. for 2018

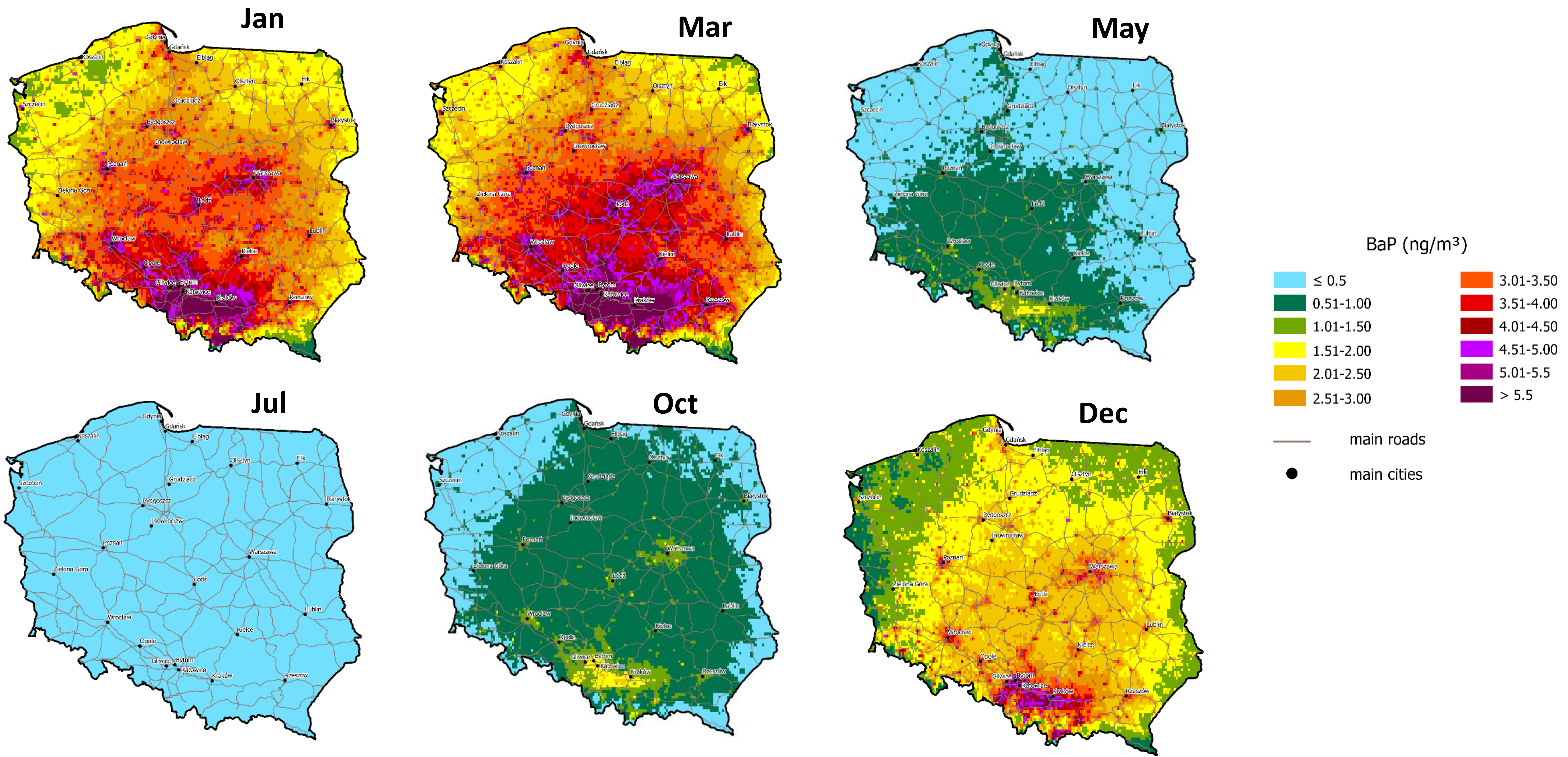
- Differences between the years were analysed
  - Concentrations
  - Population exposure
  - Health effects

Methods – measurements data

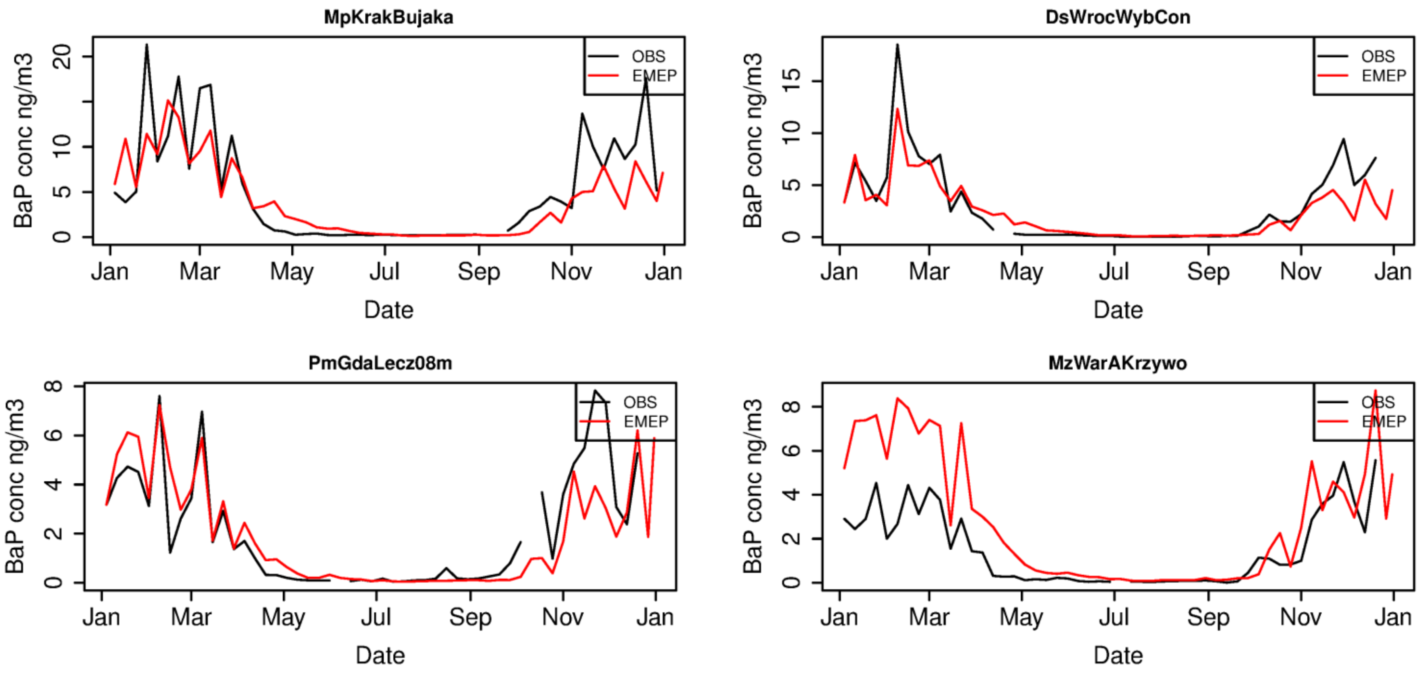
- Meteorological:
  - Hourly T_2 for the winter seasons from Institute of Meteorology and Water Management used to chose average, cold and warm years (2010-2020)
- BaP concentrations
  - Weekly data from GIOŚ for the year 2018, around 120 stations
  - Used to validate te modelling results
- Population data from JRC (Joint Research Centre)

Results

BaP concentrations, monthly, 2018



BaP verification, 2018

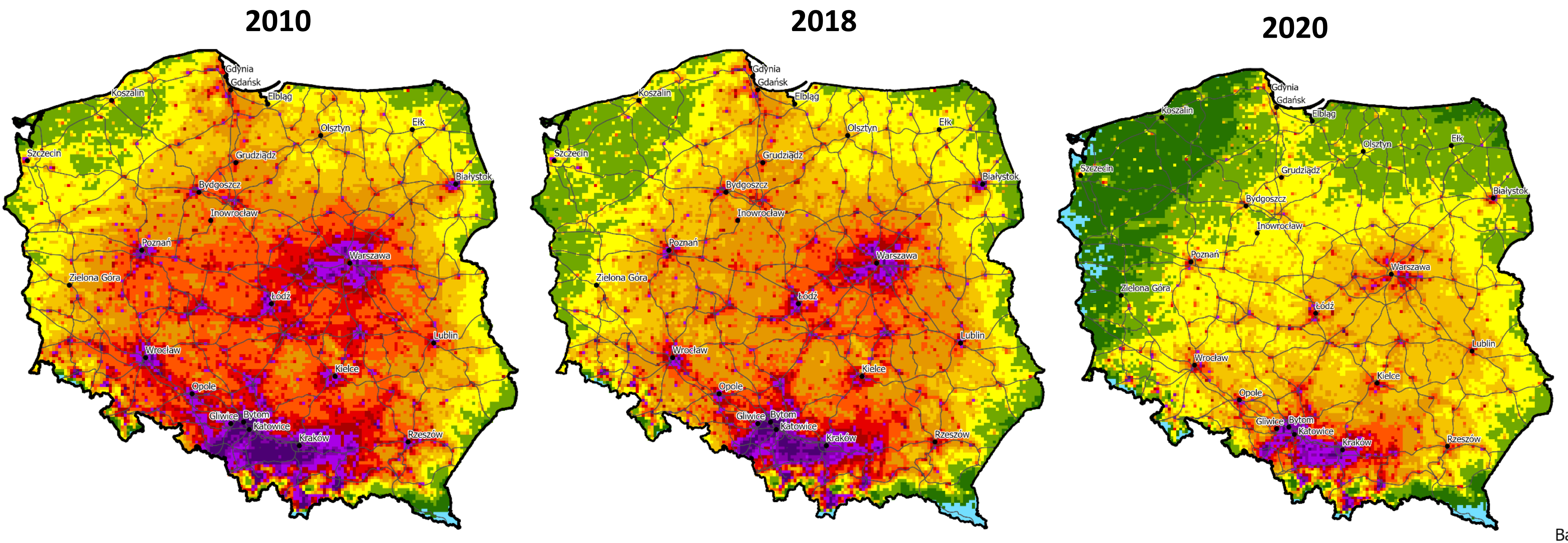


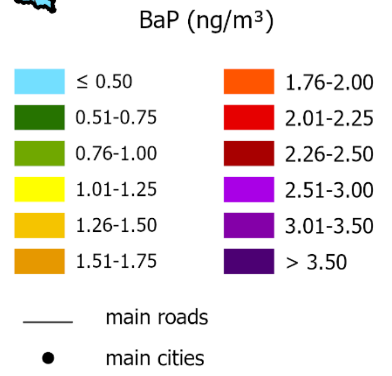
Time series of modelled and observed BaP concentrations in 2018 in Krakow, Wroclaw, Gdańsk, Warszawa.

MB	MGE	NMB	NMGE	RMSE	R	IOA
-2,22	2,66	-0,52	0,62	5,51	0,67	0,69

Statistical measures for model-measurements comparison for 7-days mean BaP concentrations for Poland (120 stations).

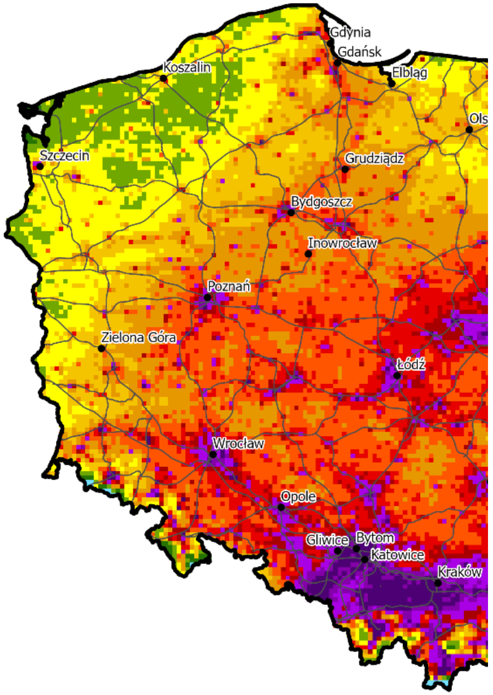
BaP annual mean, 2010, 2018, 2020

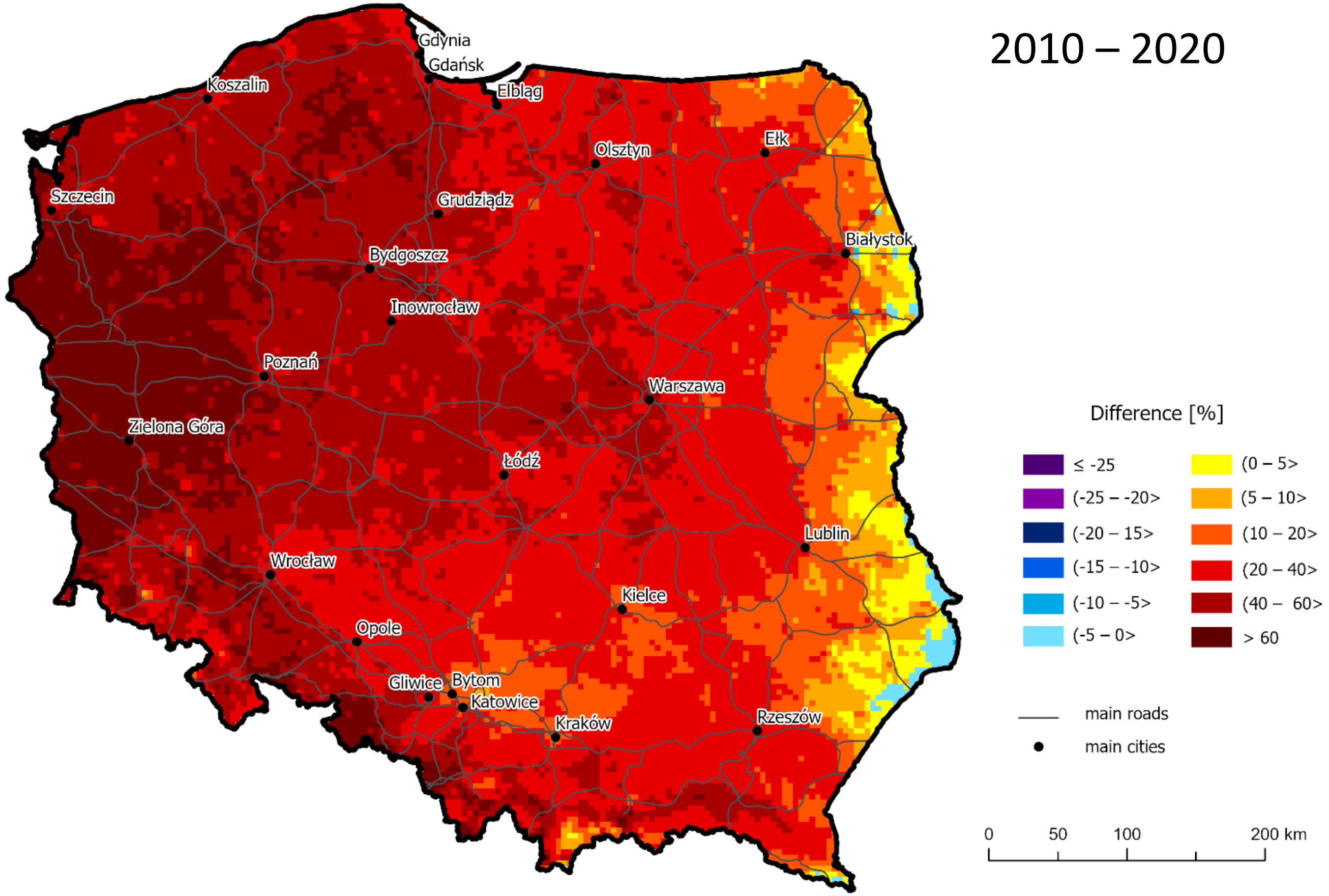


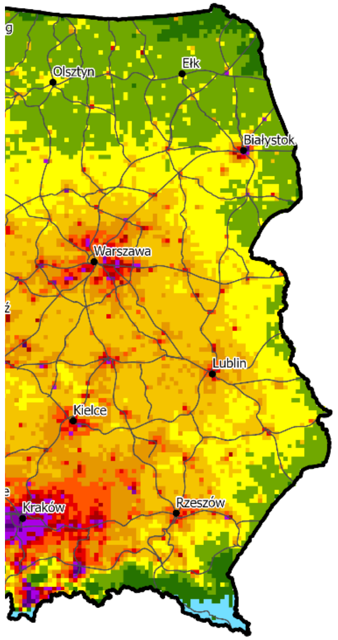


Annual TV: 1 ng/m^3

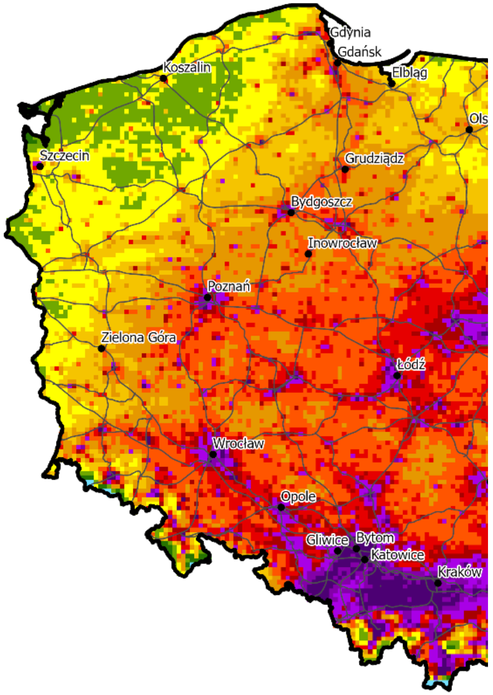
BaP annual mean, 2010, 2018, 2020

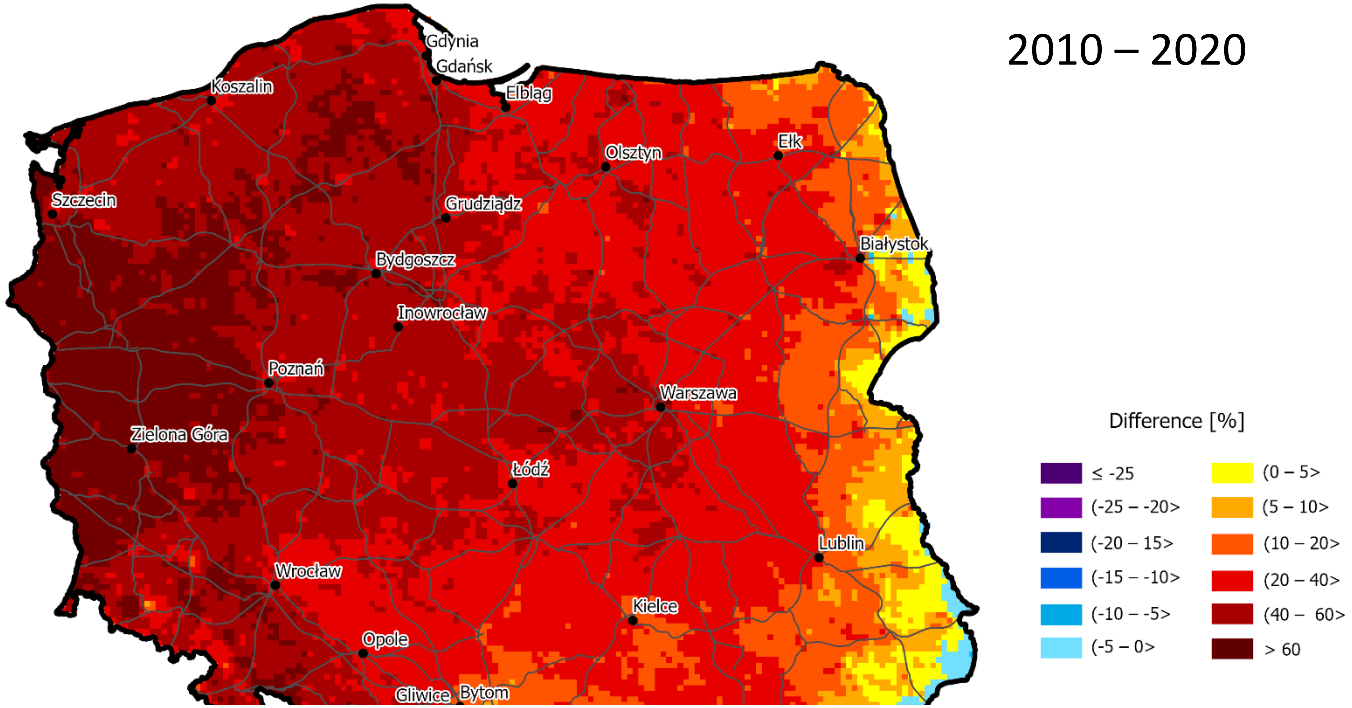


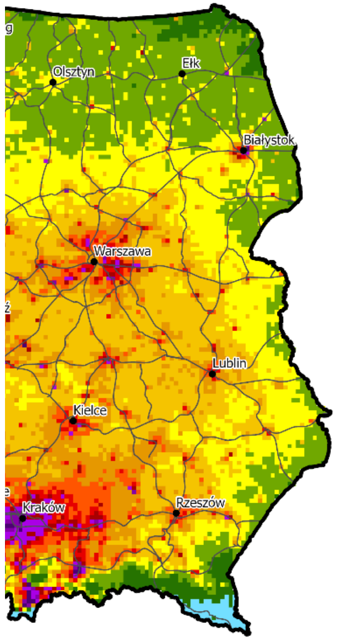




BaP annual mean, 2010, 2018, 2020







- Significant impact of meteorological conditions on BaP concnetrations
- Important for air pollution control activities and exceedances of TV

Population exposure for BaP annual mean concentrations for the year 2010, 2018 and 2020; health effects with AlphaRisk

BaP, year, annual average, exposed population (%)				
< TV		> TV		
< 0.12 ng m^{-3}	0.12 – 1 ng m^{-3}	1 – 2 ng m^{-3}	2 – 4 ng m^{-3}	> 4 ng m^{-3}
2018				
0	3	41	52	4
2010				
0	2	37	58	4
2020				
0	10	57	32	1

Population exposure for BaP annual mean concentrations for the year 2010, 2018 and 2020; health effects with AlphaRisk

BaP, year, annual average, exposed population (%)				
< TV		> TV		
< 0.12 ng m^{-3}	0.12 – 1 ng m^{-3}	1 – 2 ng m^{-3}	2 – 4 ng m^{-3}	> 4 ng m^{-3}
2018				
0	3	41	52	4
2010				
0	2			
20				
0	10	[illegible]		

- Total number of lung cancer cases per year
  - COLD: 77
  - BASE: 73
  - WARM: 57

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Full length article

Modelling benzo(a)pyrene concentrations for different meteorological conditions – Analysis of lung cancer cases and associated economic costs

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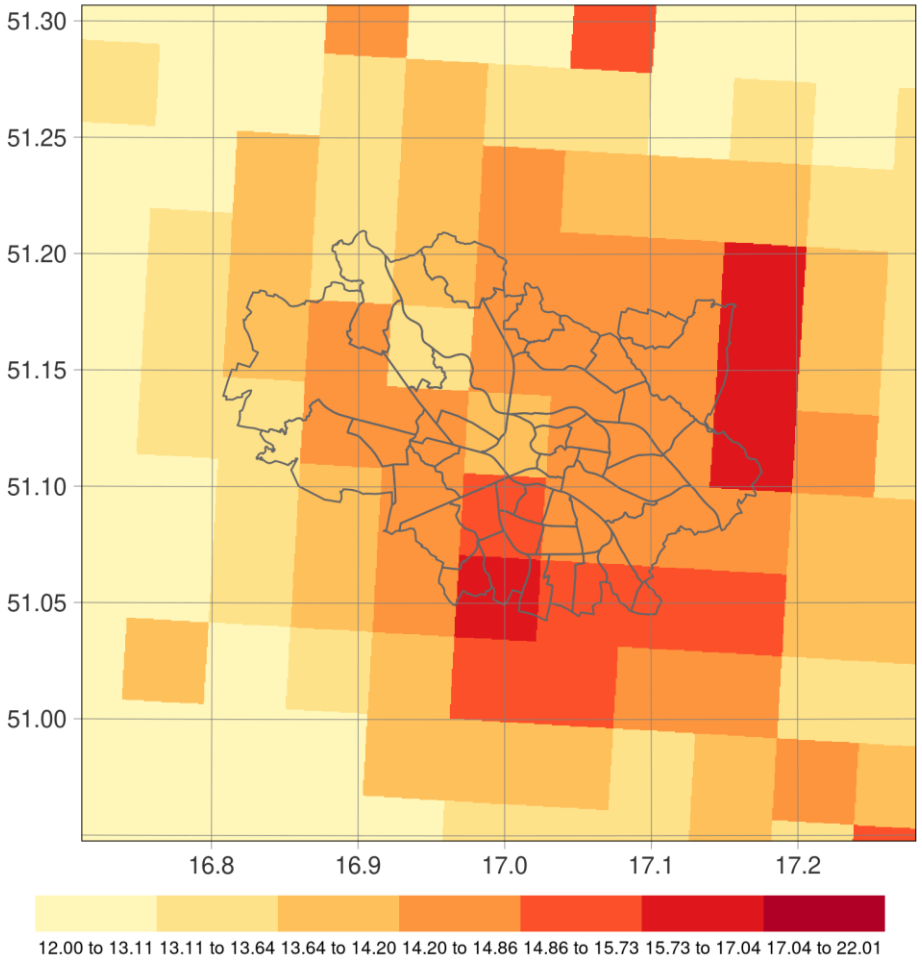
Further steps/applications

- Scenario simulations with EMEP4PL for BaP concentrations
  - Emission reduction scenarios for residential sector
  - Task for the European Clean Air Centre

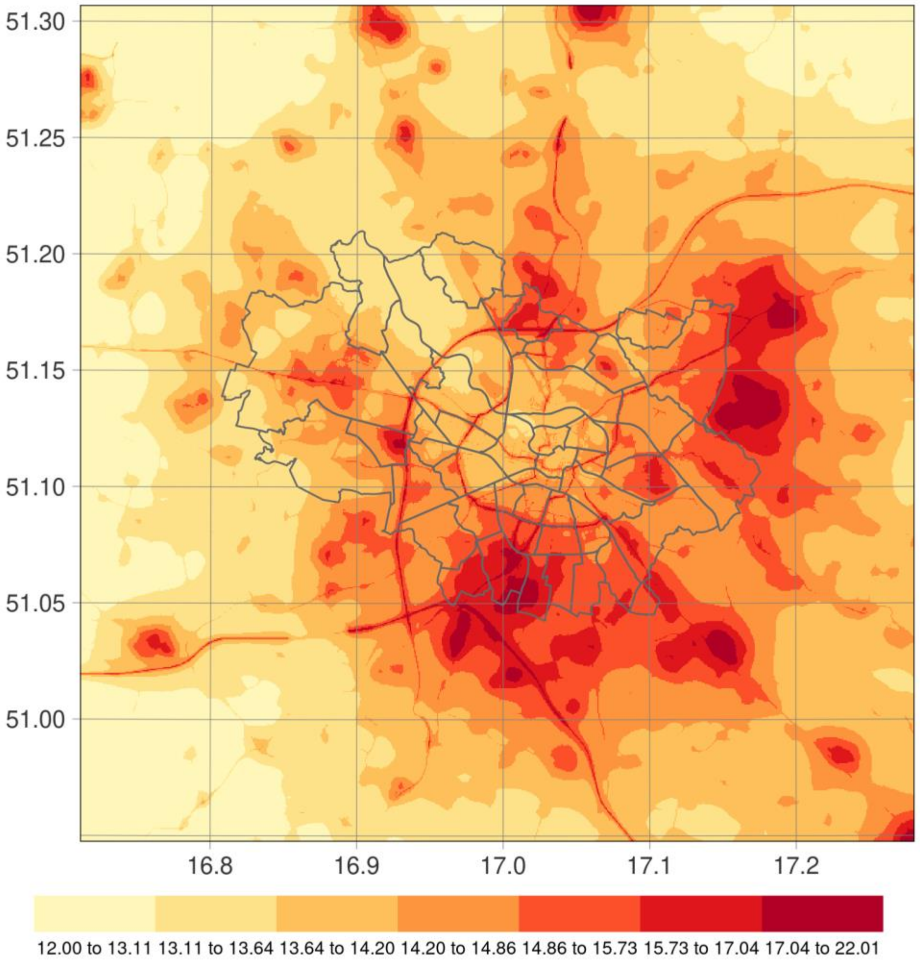
- Application of high resolution uEMEP for BaP modelling for Poland
  - Prelimnary results of appilcation of uEMEP for PM2.5 for Poland show the improvement for the model-measurements comparison (especially for the areas with high contribution of residential sector).

EEMEP4PL i uEMEP for Wrocław (SW Poland) – annual mean PM2.5 conc

„Hotspots” confirmed with the mobile measurements.

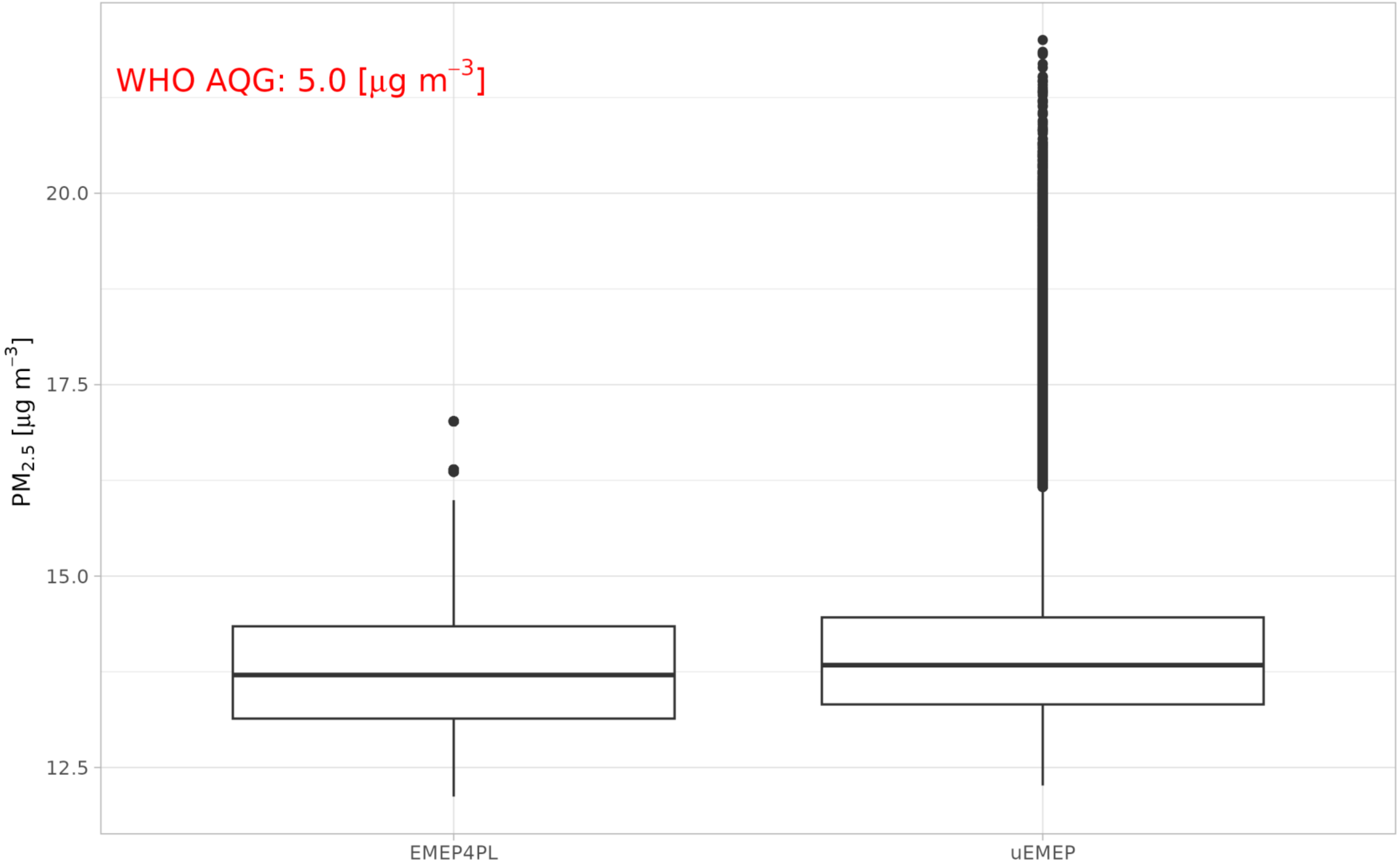


4km x 4km



50m x 50m

EMEP4PL i uEMEP for Wrocław (SW Poland) – annual mean PM2.5 conc



- uEMEP with slightly higher domain wide median value
- uEMEP with locally higher PM2.5 annual mean concetrations (marked as outliers)

Summary

- EMEP4PL model was applied to calculate BaP concetrations over Poland.
- Three full year simulations: 2010 (cold), 2018 (average), 2020 (warm).
- The temporal variability of BaP concentrations is properly represented by the model.
- A significant influence of meteorological conditions on BaP concentrations.
- Almost the entire Polish population (>90%) is exposed to BaP concentrations above the annual TV of 1 ng m^{-3}.
- Future step – application of high resolution uEMEP model for BaP modelling for Poland.

Thank you

Alpha Risk

- The number of ALCC: 8.7 x 10-5 per 1 ng/m3 (BaP),
  - which was calibrated for exposure over a 70-year lifetime.
- Therefore, the number of lung cancer cases per 1 ng/m3 per person in 1-year equates to 1.2 x 10-6.
- To determine deaths from BaP exposure, the survival rate for lung cancer was set at 19% (ECIS, 2019).

Error statistics

Name	Formula	Range of values	Expected value
Mean Bias (MB)	$MB = \frac{1}{N}\Sigma_1^N(P_i - O_i)$	[-Ō, +∞]	0
Normalized Mean Bias (NMB)	$NMB = \frac{\sum_{i=1}^N(P_i - O_i)}{\sum_{i=1}^N O_i}$	[-1, +∞]	0
Mean Gross Error (MGE)	$MGE = \frac{1}{N}\Sigma_1^N\lvert P_i - O_i\rvert$	[0, +∞]	0
Normalized Mean Gross Error (NMGE)	$NMGE = \frac{\sum_{i=1}^N \lvert P_i - O_i\rvert}{\sum_{i=1}^N O_i}$	[0, +∞]	0
Pearson Correlation Coefficient (R)	$R = \frac{\sum_{i=1}^N(M_i - \bar{M})(O_i - \bar{O})}{\{\sum_{i=1}^N(M_i - \bar{M})^2 \sum_{i=1}^N(O_i - \bar{O})^2\}^{\frac{1}{2}}}$	[-1,1]	1
Index of Agreement (IOA)	$IOA = 1 - \frac{\sum_{i=1}^N(M_i - O_i)^2}{\sum_i^N(\lvert M_i - \bar{O}\rvert + \lvert O_i - \bar{O}\rvert)^2}$	[0,1]	1

BaP conc – seasonal stats

	N	MB	MGE	NMB	NMGE	IOA
annual	5804	-2.22	2.66	-0.52	0.62	0.69
spring (MAM)	1561	-1.52	2.47	-0.41	0.66	0.70
summer (JJA)	1440	-0.07	0.16	-0.32	0.70	0.55
autumn (SON)	1476	-2.78	2.88	-0.66	0.69	0.56
winter (DJF)	1327	-4.75	5.36	-0.50	0.56	0.49