ČESKÝ
HYDROMETEOROLOGICKÝ
ÚSTAV

Action 6 – Inter-regional Air Quality Modelling in the Małopolska Region, Slovakia and the Czech Republic

Krakow, 21st November 2018

ČHMÚ: Benešová, Honzáková, Modlík, Vlček, vlcek@chmi.cz
SHMÚ: Krajčovičová, Matějovičová, Štefánik
VITO: Vranckx, Blyth et al.

MAŁOPOLSKA
IN A HEALTHY ATMOSPHERE

AIMS

Task 1: Residential Emission Inventory

(Lead: VITO, Partners: MZP, SHMU, Malopolska)

Task 2: Trans-boundary Emission Data Base

(Lead: MZP, Partners: VITO, SHMU, Malopolska)

Task 3: Inter-regional Air Quality Modelling

(Lead: MZP, Partners: VITO, SHMU, Malopolska)

AIMS

Task 2: Trans-boundary Emission Data Base

- Development of **regional benzo[a]pyrene emissions**
- Integration of bottom-up and top-down emissions for a **reference year, 2015**
- Integration of bottom-up and top-down emissions for **emission reduction scenarios**

AIMS

Task 3: Inter-regional Air Quality Modelling (Lead: MZP, Partners: VITO, SHMU, Malopolska)

- ~~**Implementation of BaP chemistry module to regional chemical transport model**~~
- **Setting up and running CAMx *& CMAQ* (CTM)**
- **Setting up measurement-based land-use regresion model RIO** for near real time and historic air quality assessments
- **Intercomparison of CTM and RIO model results**
- **Combination of CTM and RIO tools** for the evaluation of the emission reduction scenarios

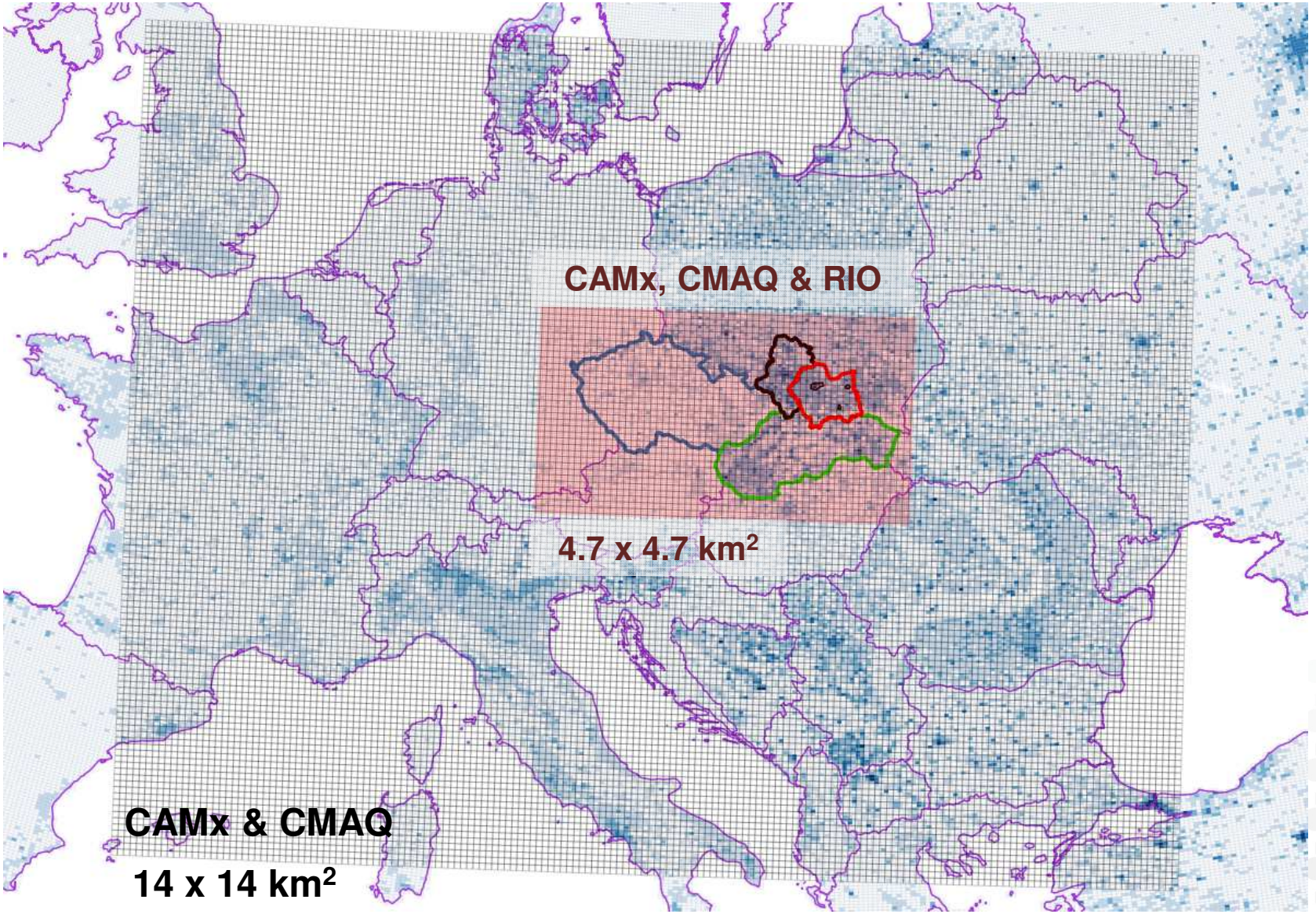
AIMS SUMMARY

- Reliable **measurement-based** model for the description of current air quality in transboundary region → RIO
- CTM model for evaluation of **scenarios**
- **Detailed (harmonized) emissions** as input for CTMs
- Use **CTM and RIO in combination to evaluate** expected improvements of air quality according to **scenarios**

APPROACH

$$CONC_{SCENARIO} = CONC_{REF} \cdot \frac{CTM_{SCENARIO}}{CTM_{REF}}$$

Modelling domains



Transboundary emission inventory

- **Europe** outside of Czech Republic, Silesia, Małopolska, and Slovakia:
  - TNO MACC-III for 2011
  - **B(a)P** for 2015: J. Bieser from Hamburg University

- **Małopolska and Silesia** Regions
  - Hi-res emission inventories for 2015 by the ATMOTERM.
    MEGAN model was used to calculate biogenic emissions instead of natural emission provided by ATMOTERM.

- **Czech Republic**
  - Detailed national inventory REZZO for, road and off-road transport emissions for 2016

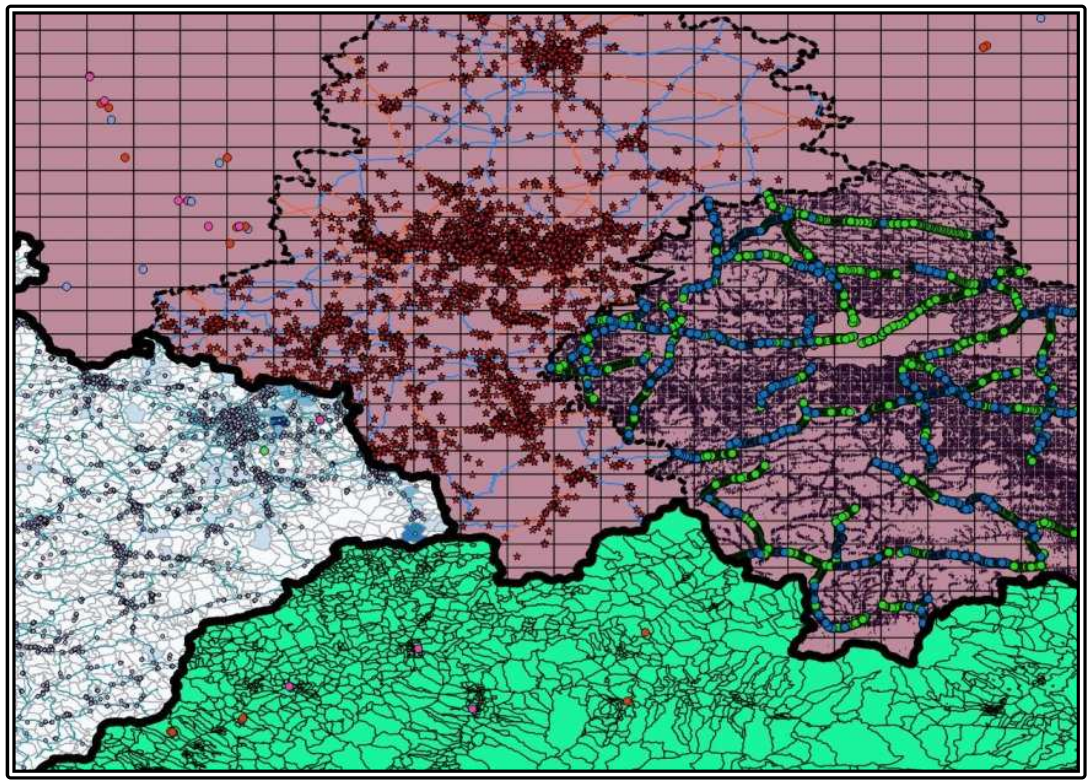
Transboundary emission inventory

- **Slovakia**
  - Detailed residential heating emissions and point sources that belong to SNAP 2. The rest of emissions: TNO MACC-III 2011.

- **Biogenic emissions**
  - Biogenic emissions were calculated by the MEGAN (Guenther, 2012) model based on the meteorology given by the weather prediction model ALADIN.

- **Residential heating – boiler operation conditions 85/15:**
  - 15% time nominal heat output
  - 85% time lower heat output

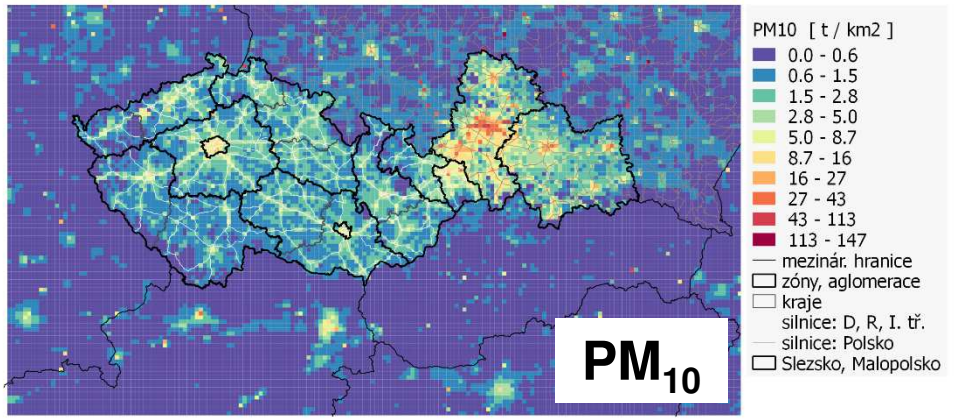
Transboundary emission inventory

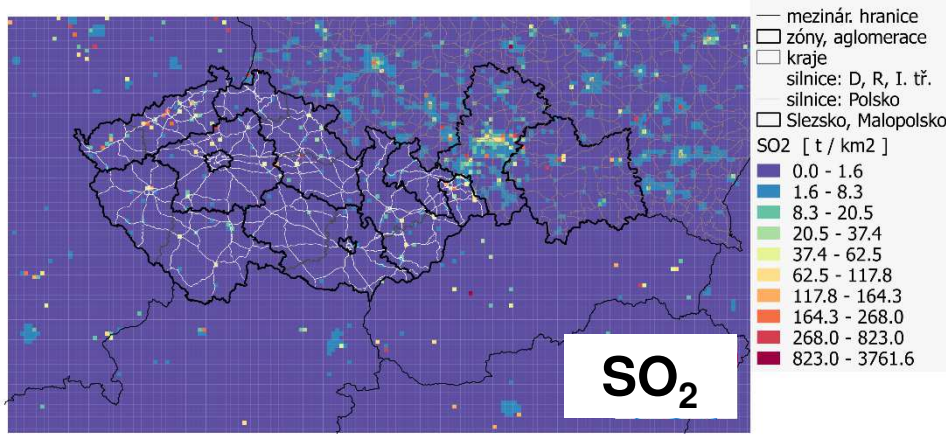


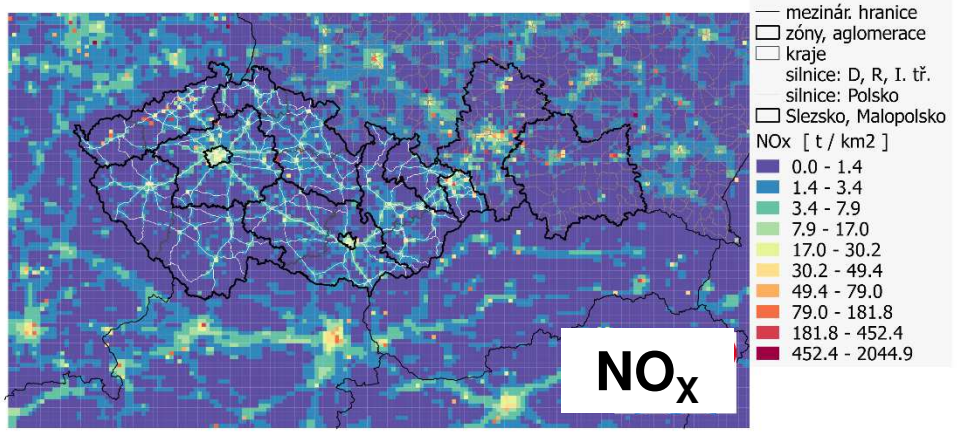
Emission processor FUME http://fume-ep.org/

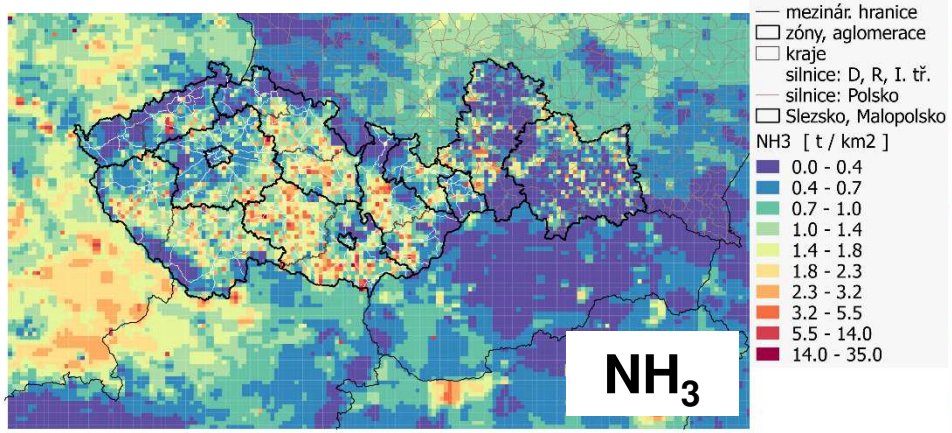
- Spatial and time disaggregation
- Chemical speciation

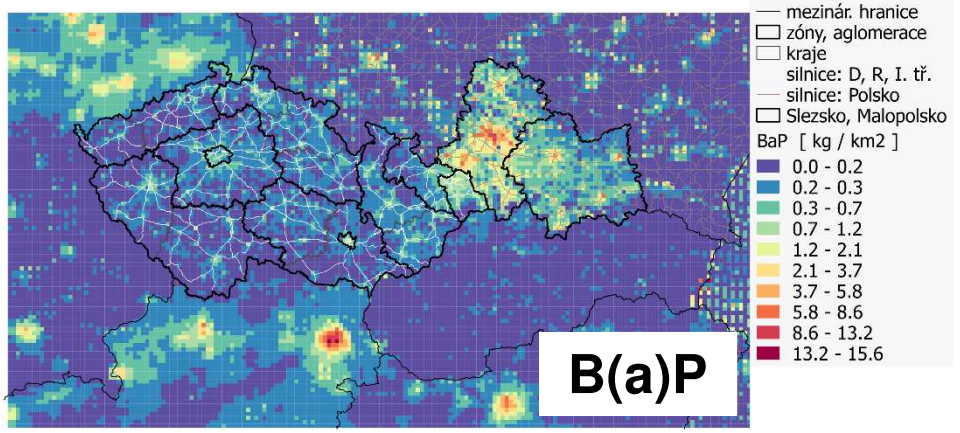
Transboundary emission inventory



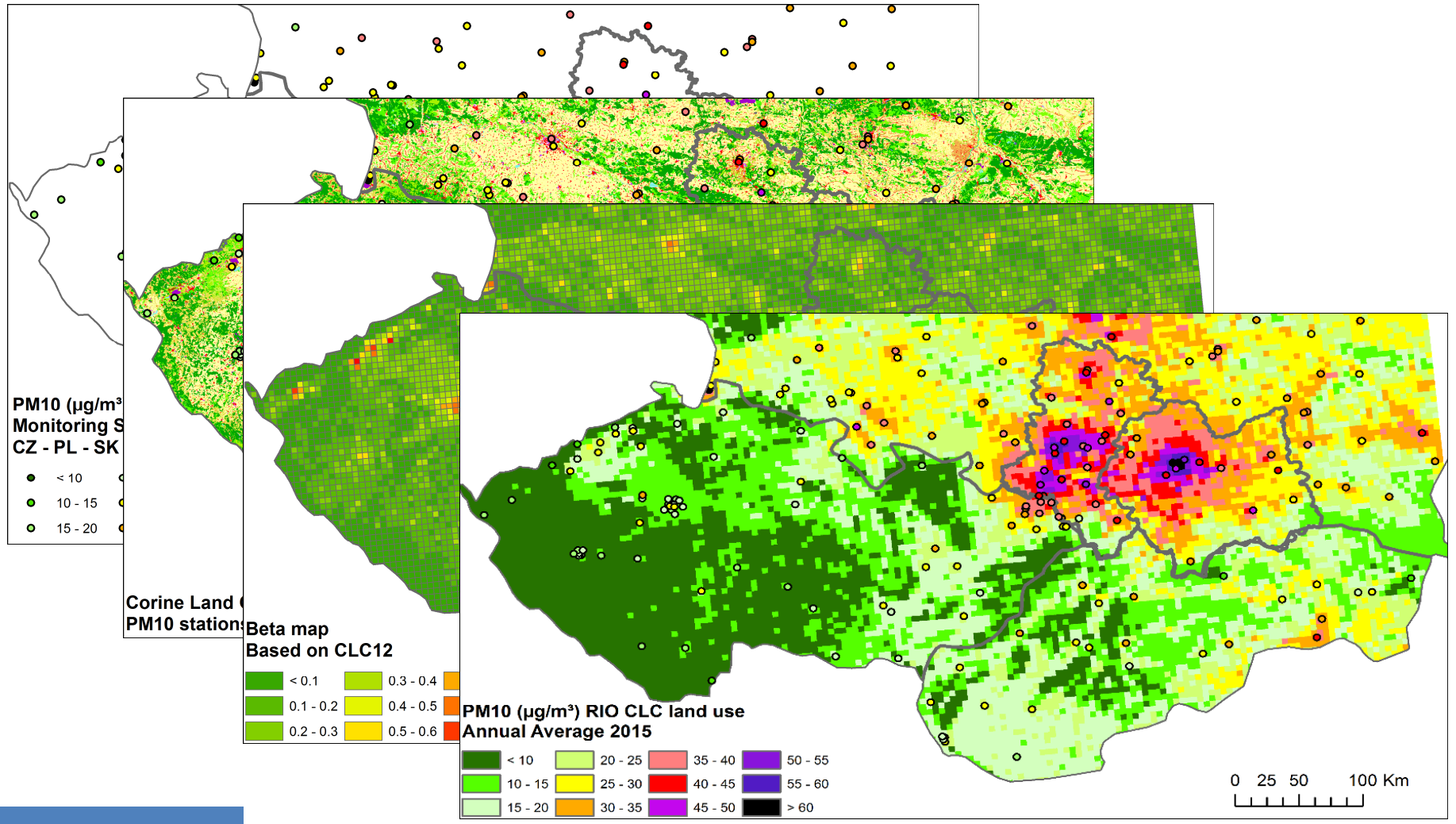




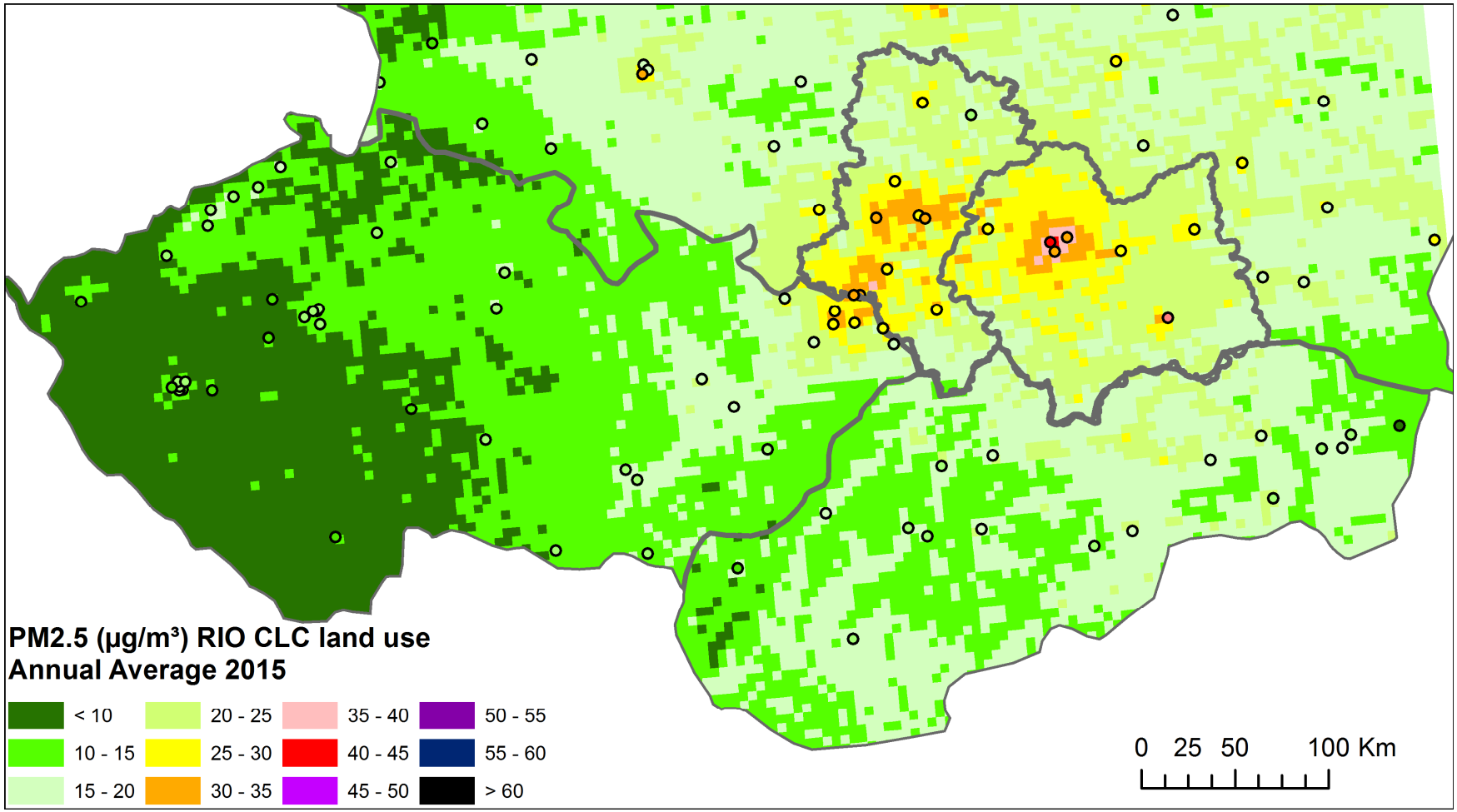




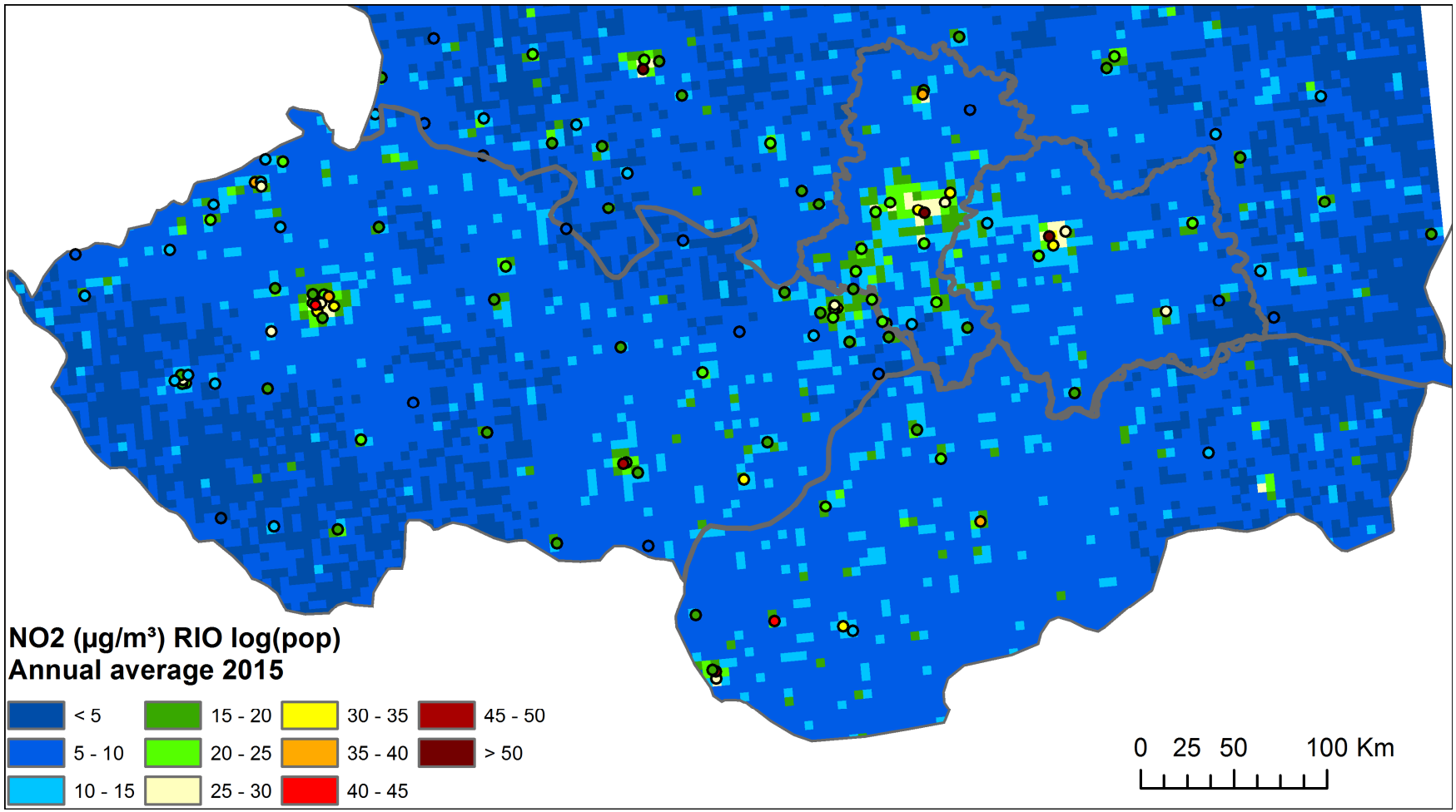
From monitoring data to air quality maps



RIO 2015 $PM_{2.5}$

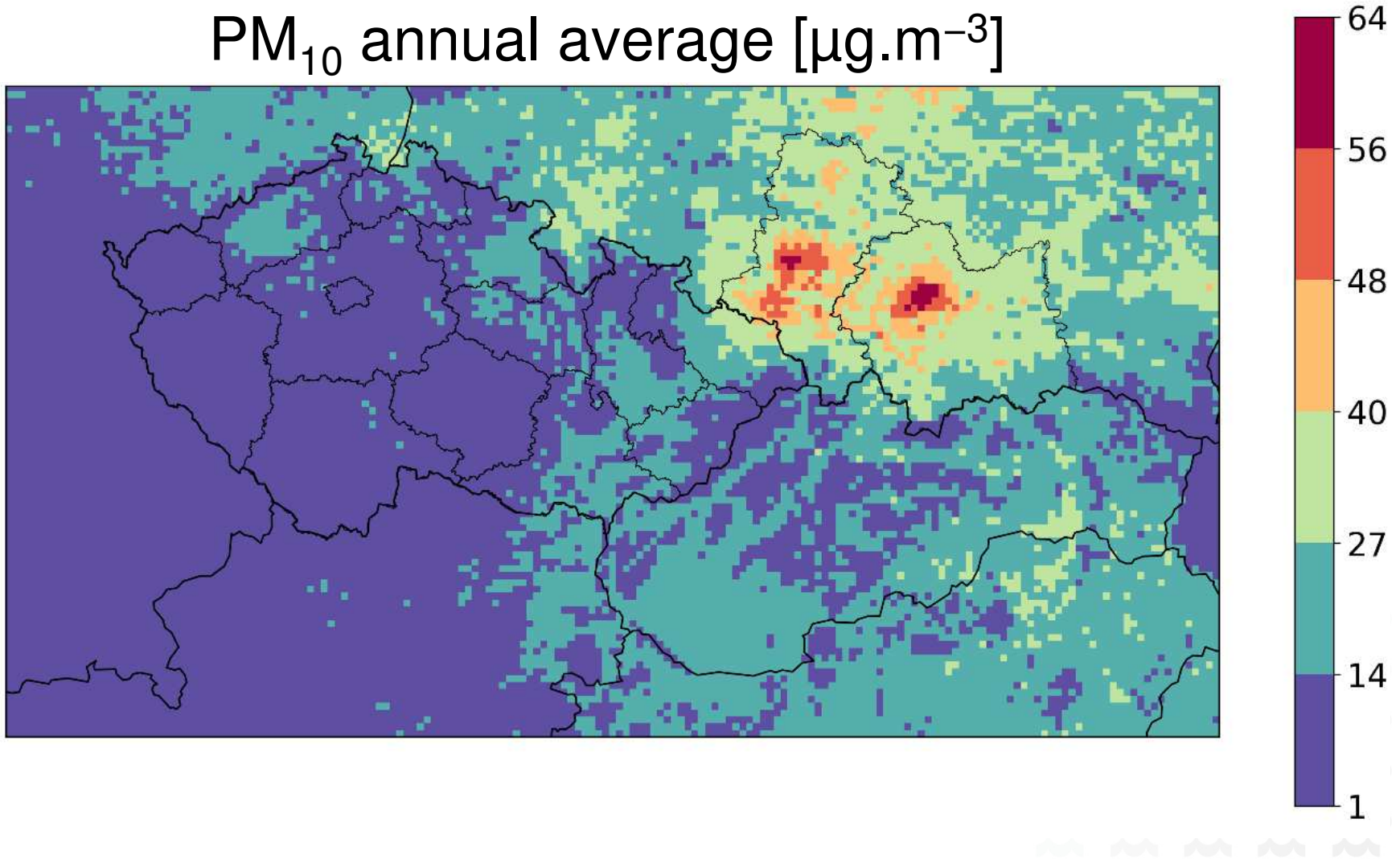


RIO 2015 NO_2



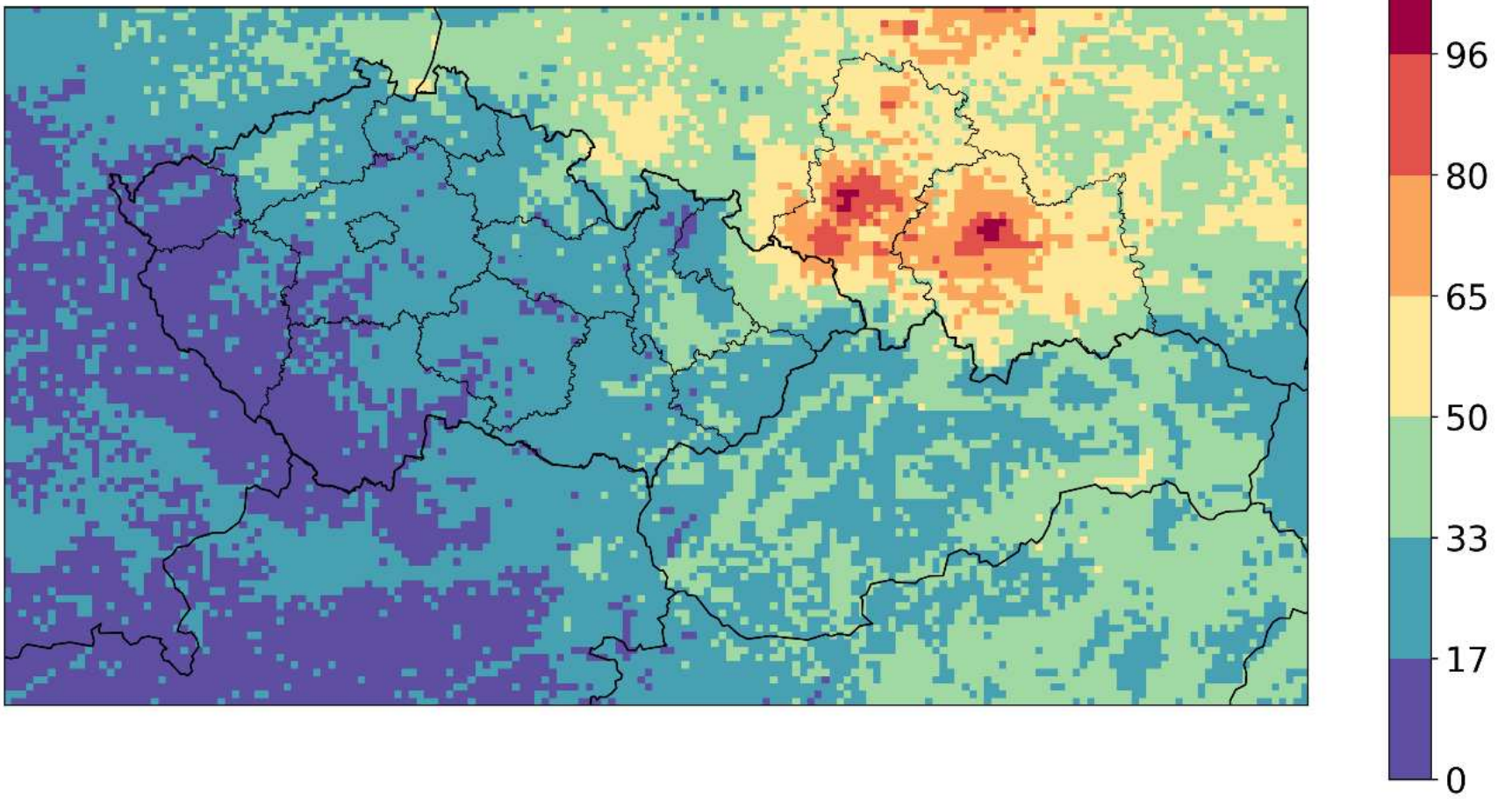
AQ for reference year – RIO model

PM_{10} annual average [$\mu g.m^{-3}$]



AQ for reference year – RIO model

PM_{10} 36th highest daily average [µg.m^{-3}]



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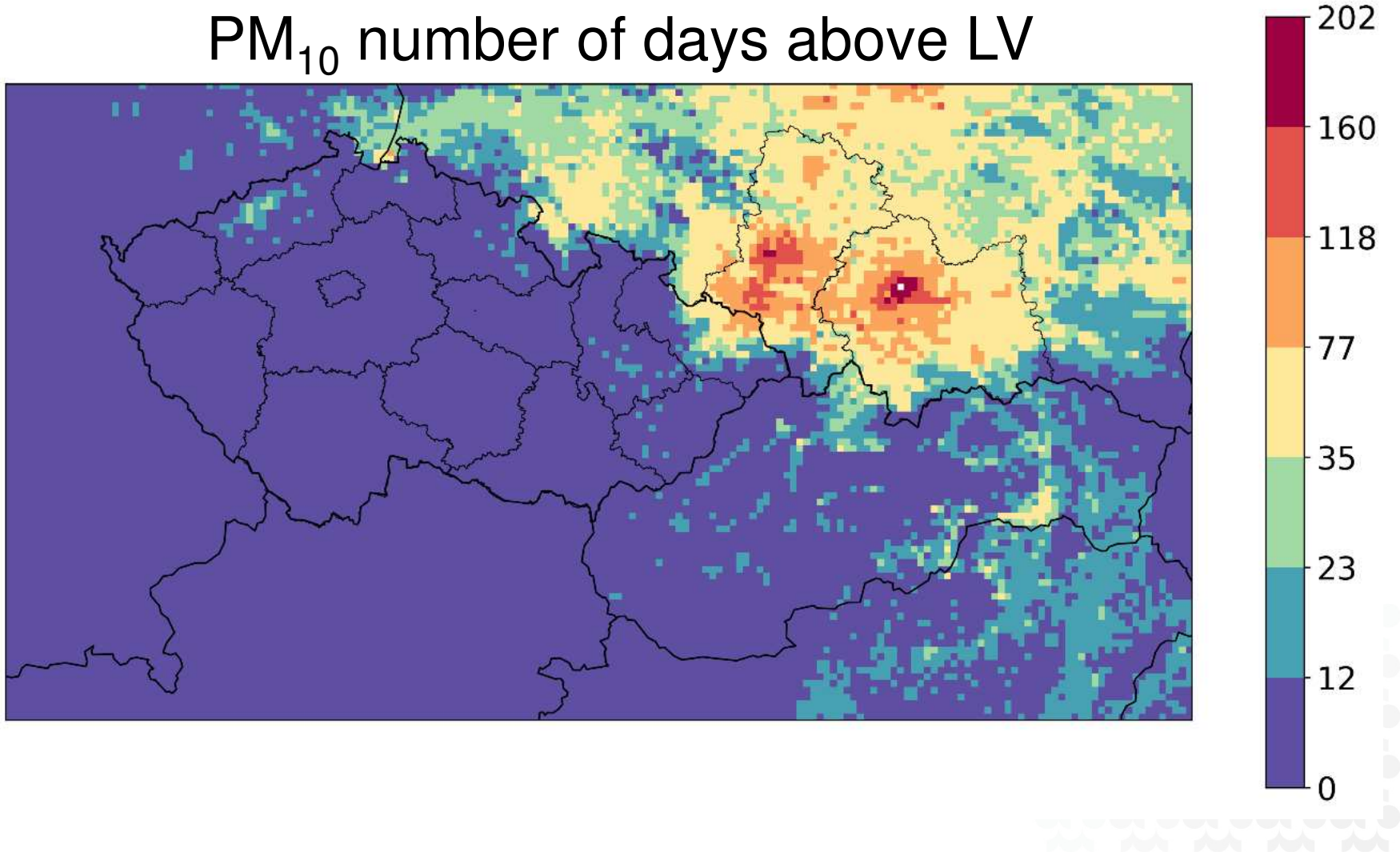
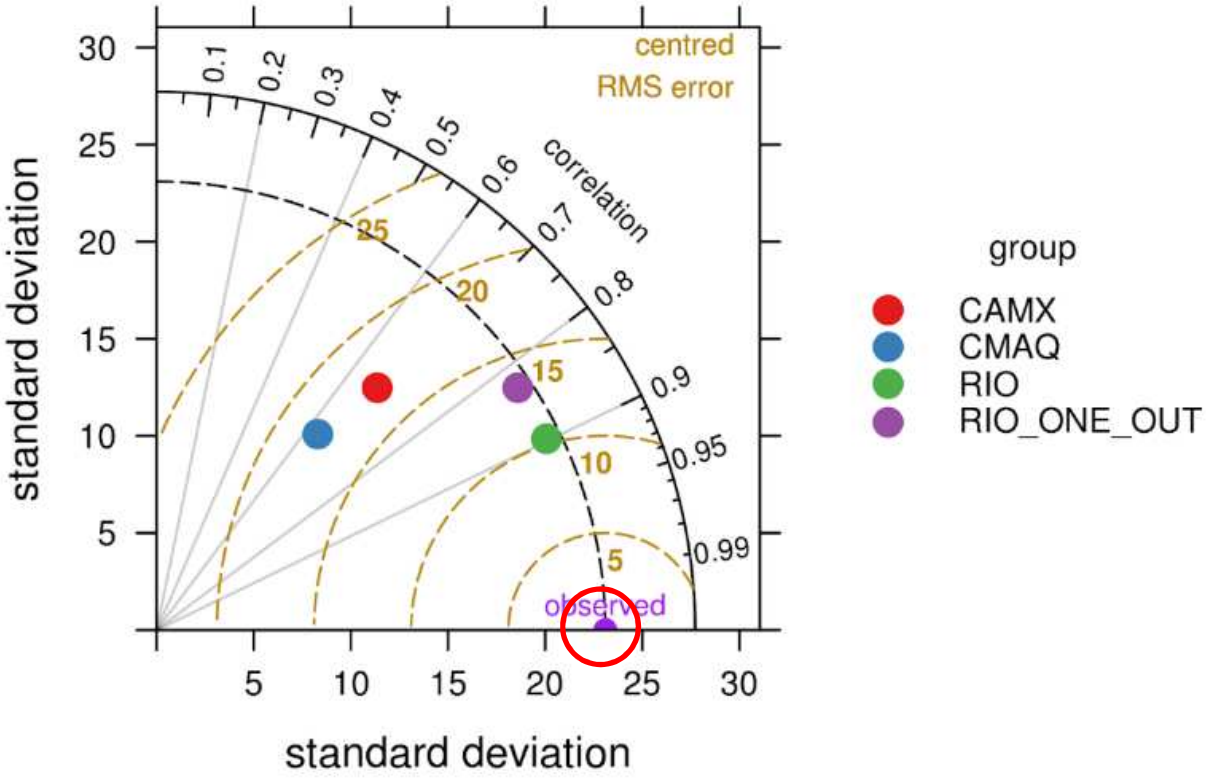
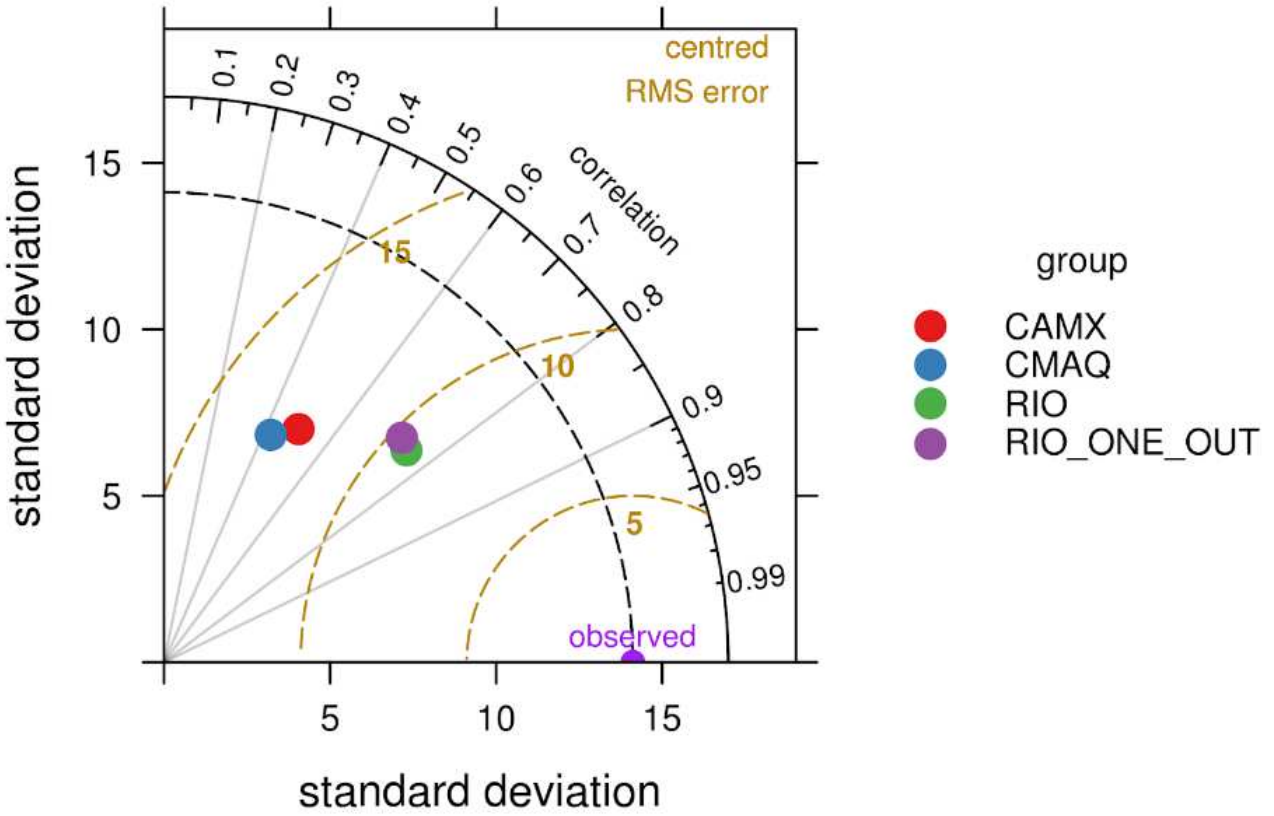


Reference year - model validation



Taylor diagram for comparison CAMX and CMAQ, RIO and RIO_out for **PM_{10}** with daily measured data from all Czech, Poland and Slovak monitoring stations in 2015

Reference year - model validation



Taylor diagram for comparison CAMX and CMAQ, RIO and RIO_out for **NO_2** with daily measured data from all Czech, Poland and Slovak monitoring stations in 2015

Reference year - model validation

Model	FAC2	MB	NMB	r
CAMX	0.36	-2.26	-0.47	0.49
CMAQ	0.13	-4.32	-0.89	0.38

Comparison the CAMX and CMAQ,with daily measured data of **benzo(a)pyrene** from rural background Czech, Poland, Austria, Hungary and Slovak monitoring stations in 2015

2023 scenarios

Czech Rep. business as usual (BAU)

- No changes in the total number of apartments heated by solid fuels
- Thermal insulation measures:
  - the number of insulated family houses + 5 %
  - the number of insulated apartment buildings + 10 %
- Replacement of 100 000 (cca 25-30% wrt 2015) of over-fire and under-fire boilers with automatic and gasification boilers

2023 scenarios

Czech Rep. “the most optimistic”

- 15 % of apartments in family houses currently using solid fuels will switch to non-emission sources; all municipalities; ratio between coal and wood remained unchanged
- Part of apartments in family houses currently using solid fuels will switch to natural gas; replacement only in the basic settlement unit (ZSJ) located in basic territorial unit (ZUJ) with more than 10 apartments heated by natural gas; ratio between coal and wood remained unchanged
  - municipalities < 10 000 inhabitants 10 % of apartments
  - municipalities > 10 000 inhabitants 20 % of apartments

2023 scenarios

Czech Rep. "the most optimistic"

- Building thermal insulation measures:
  - the number of insulated family houses + 10 %
  - the number of insulated apartment buildings + 20 %
- Replacement of 100 000 (cca 25-30% wrt 2015) of over-fire and under-fire boilers with automatic and gasification boilers

2023 scenarios

Małopolska business as usual (BAU) – changes wrt 2015

- changes in the amount of heat demand resulting from thermal modernization and new building development (0.95)

- change in the use of wood in connection with the replacement of heat sources and other activities and restrictions in 2023:
  - Cities – 0.6
  - Krakow – 0
  - Nowy Sącz – 0.4
  - Tarnów – 0.3
  - the rest of the region – 0.75

Other details described in ATMOTERM" report

2023 scenarios

Małopolska “the most optimistic”

Area covered by the resolution		Ecodesign (class 5)	
solid fuel furnaces		date of entry into force	
	obligatory furnace class	Ecodesign	
	users of solid fuels furnaces	owner of an old furnace	2023
		owner of a new non-class device	2023
		owner of a new device, class 3/4	2027
		buyers of a new furnace after the resolution comes into force	June 2017
fireplaces	Requirements	Ecodesign, efficiency> 80%, solid particle filter	
	fireplace users	Existing devices	2023
		New devices	2019 or June 2017
solid fuels	Introduction of restrictions	YES	
	fuel quality	Coal	No muds and fleets, no fuels with a grain size of 0-1 mm
		Biomass	with moisture above 20%

2023 scenarios

Małopolska

	TSP	PM_{10}	$PM_{2.5}$	B(a)P	SO_2	NO_X	NO_2	CO
2023 BAU [t]	11 792	10 826	10 564	6.214	10 536	4 408	441	121 254
2023 "the most optimistic" [t]	1 315	1 094	1 075	1.073	106	6 248	625	14 426

The Czech Republic

	TSP	PM_{10}	$PM_{2.5}$	B(a)P	SO_2	NO_X	NO_2	CO
2023 BAU [t]	55 506	51 415	50 391	12.668	15 428	8 411	422	598 348
2023 "the most optimistic" [t]	46 454	43 088	42 216	10.881	13 210	7 914	397	512 702

Quality check revealed, that emission scenarios for Małopolska are nor compatible wit ref year emissions (85/15 assumption)

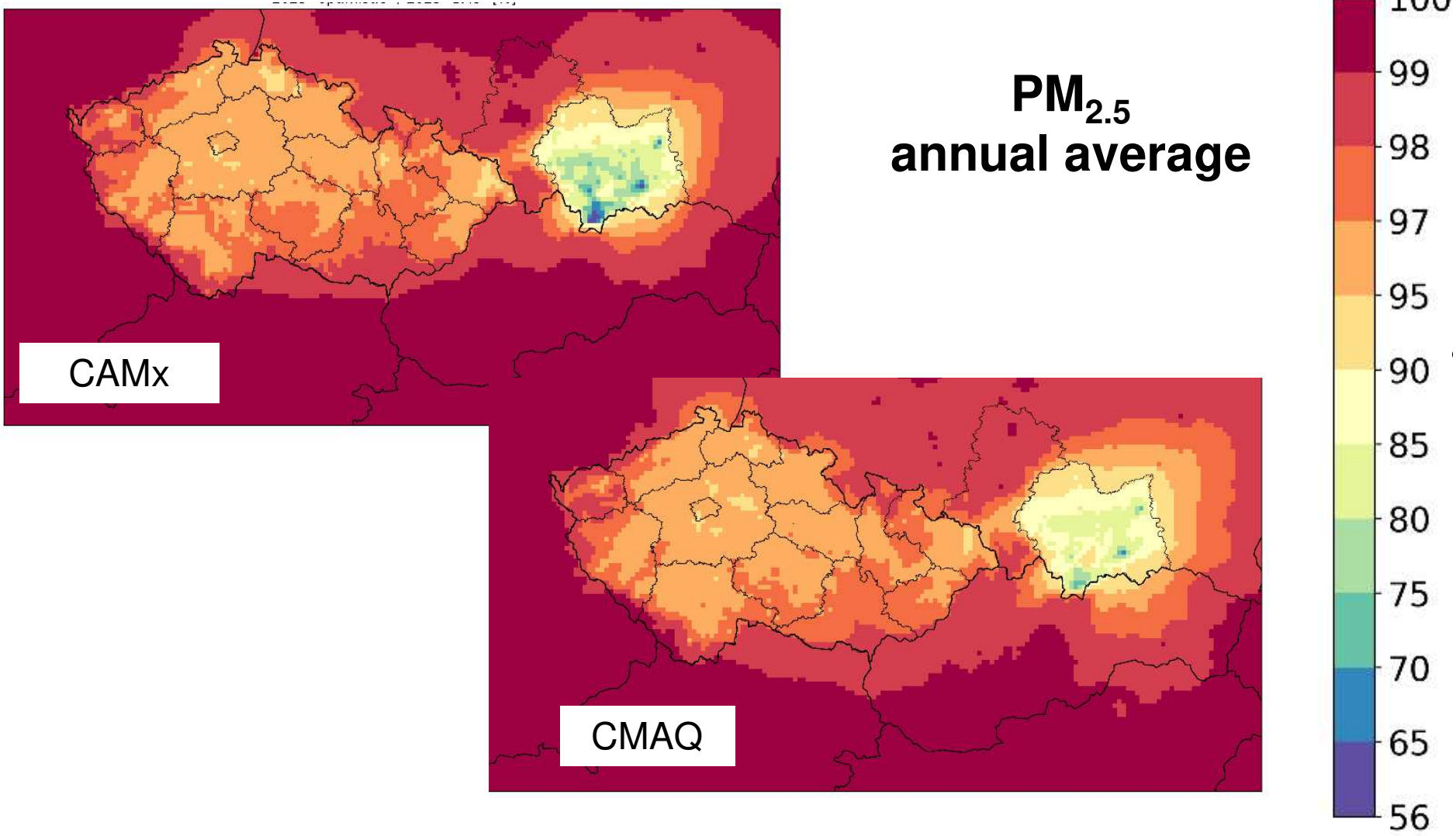
2023 scenarios

$$CONC_{SCENARIO} = CONC_{REF} \cdot \frac{CTM_{SCENARIO}}{\cancel{CTM_{REF}}}$$

Cannot be used for Małopolska
(not comparable with scenario)

- For Małopolska only relative (%) changes can be evaluated right now ☹
- Absolute changes (μg.m^{-3}) could be evaluated for Czech Republic → update of Air Quality Improvement Plans ☺

Comparison of results for scenarios: 2023 W1 „optimistic“ / W0 (BAU)



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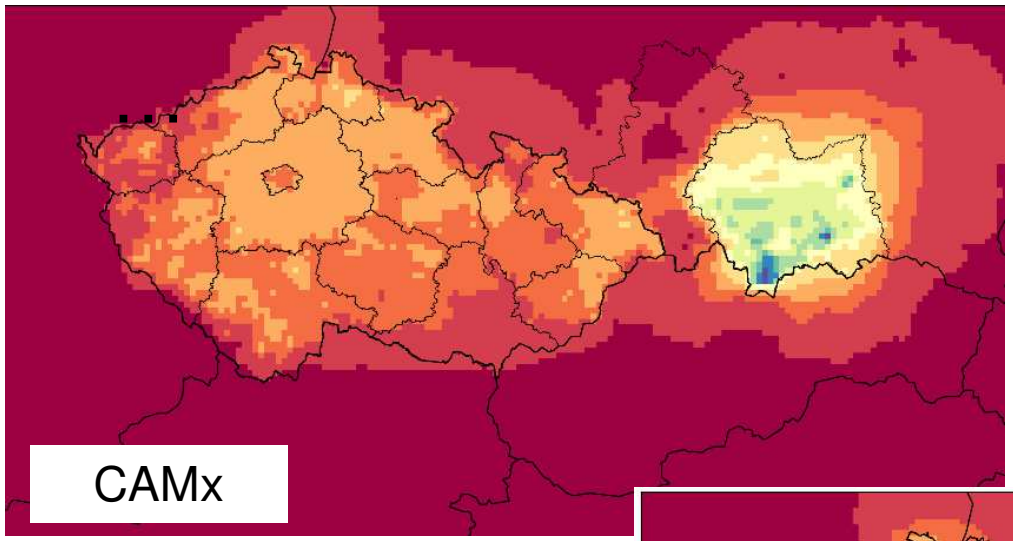
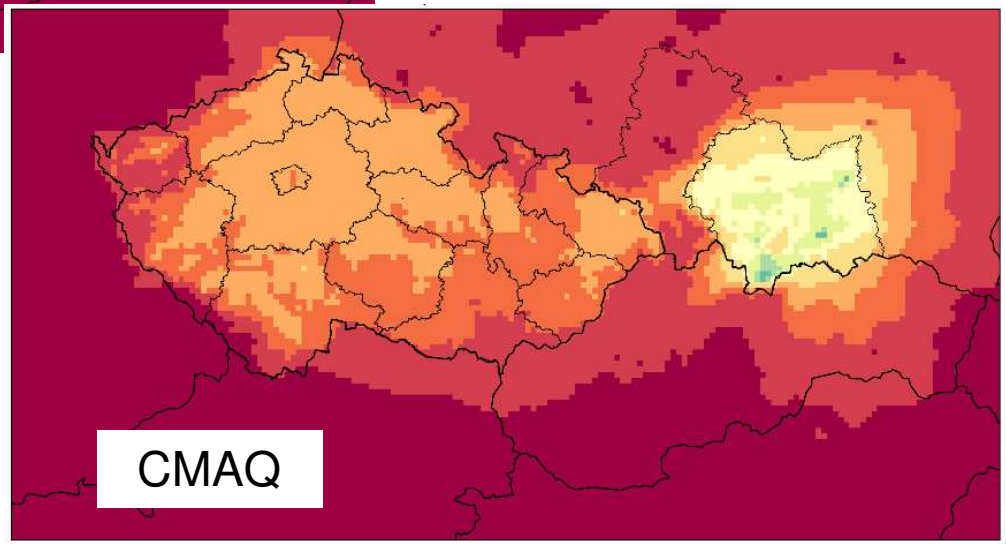
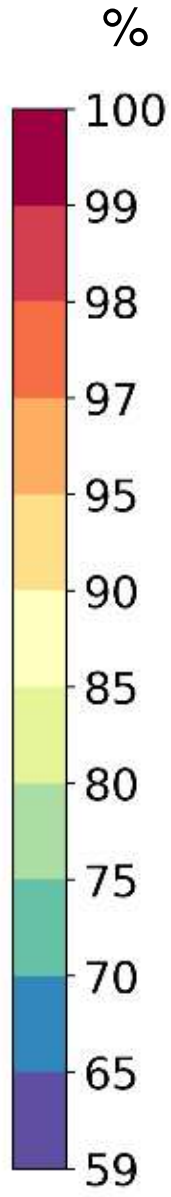




PM_{10} annual average



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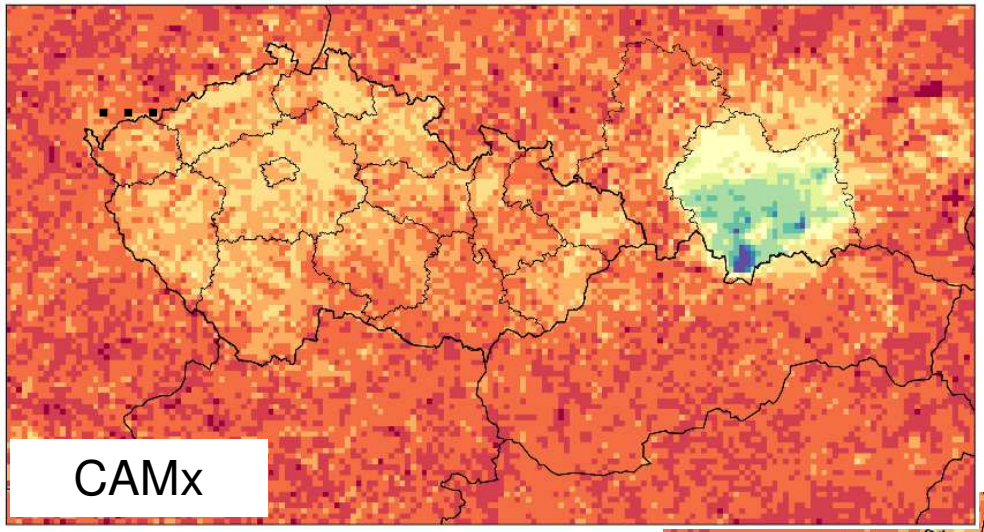
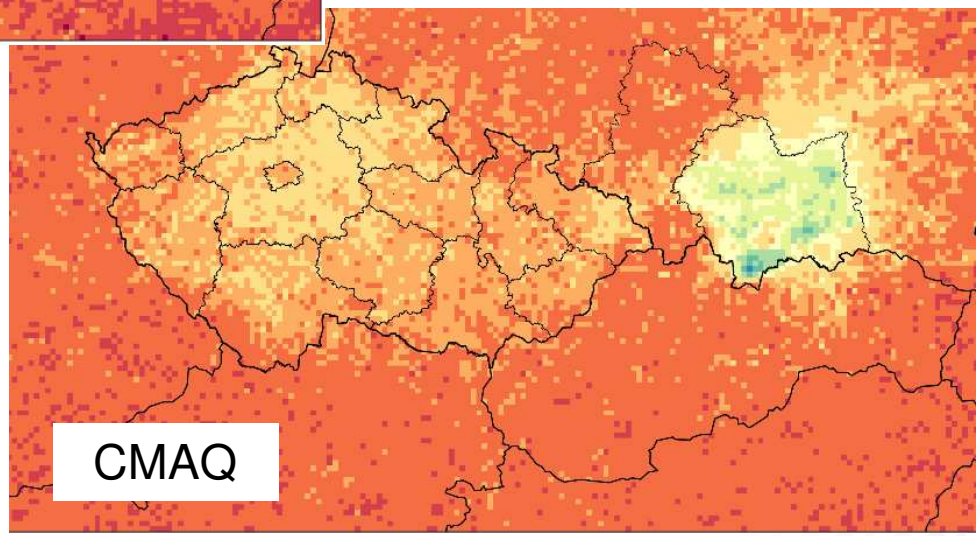
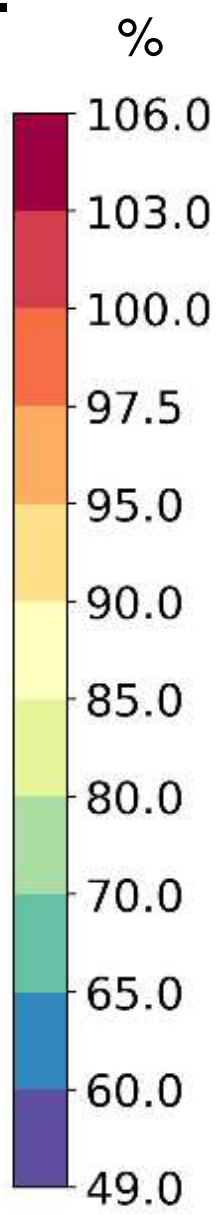




PM_{10}
36th highest daily average



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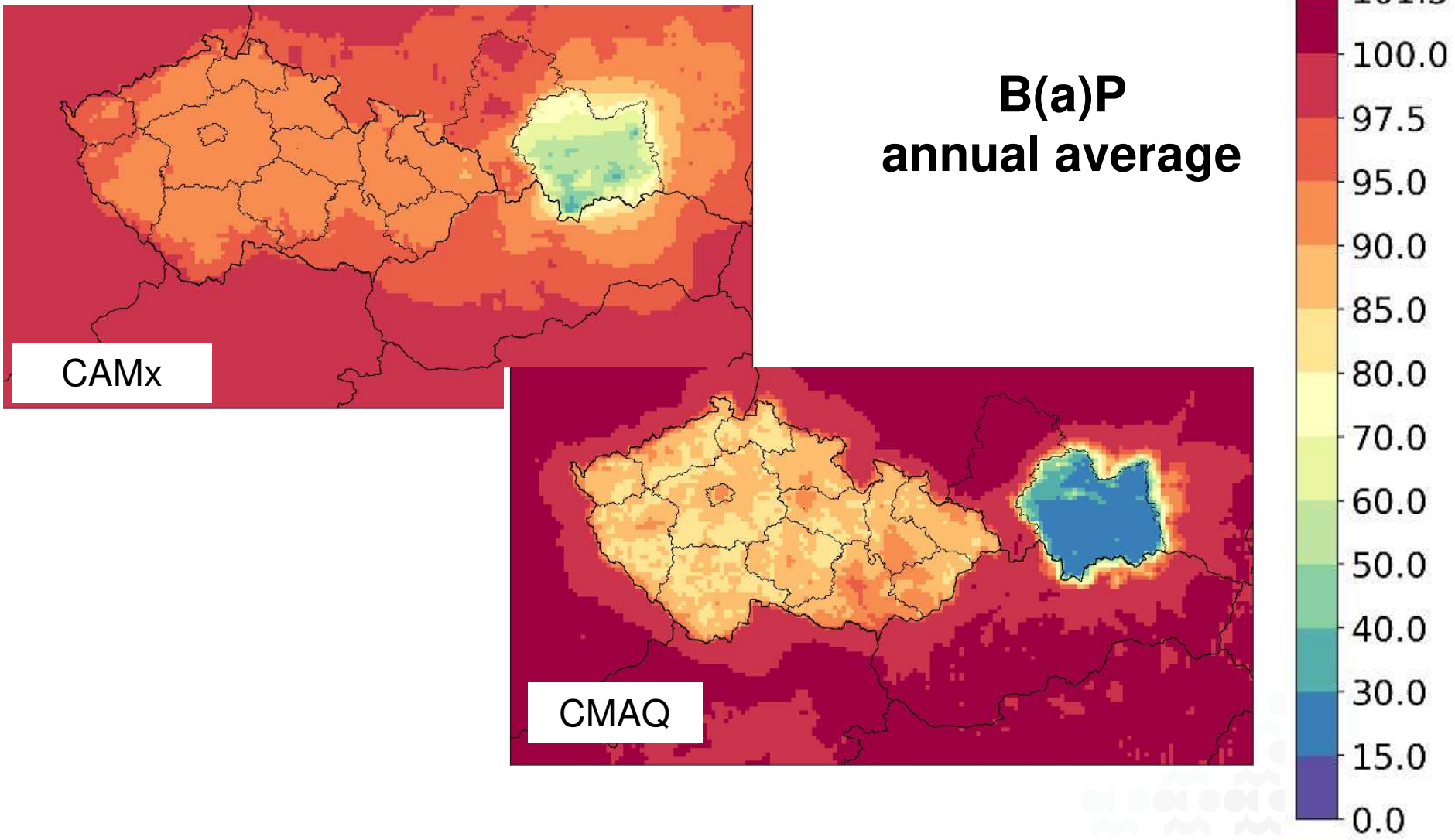

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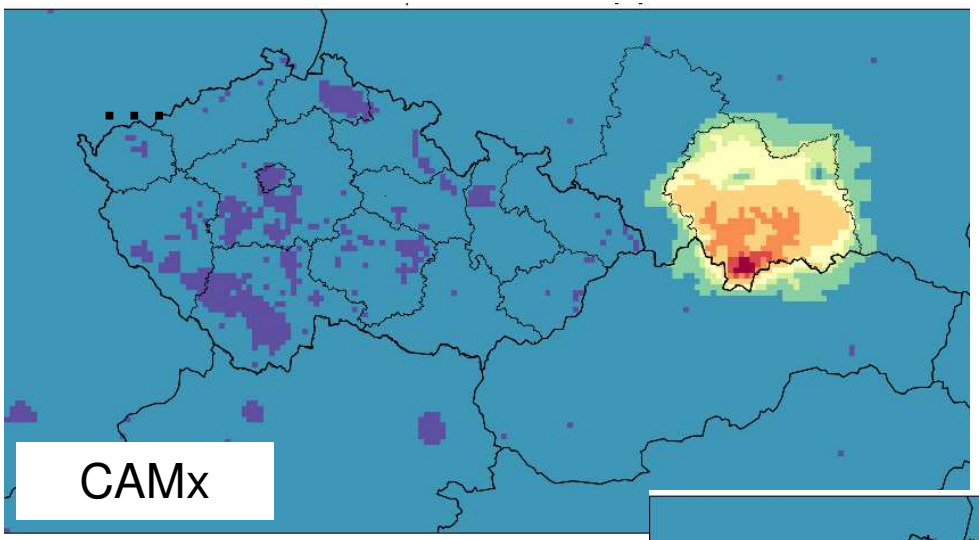
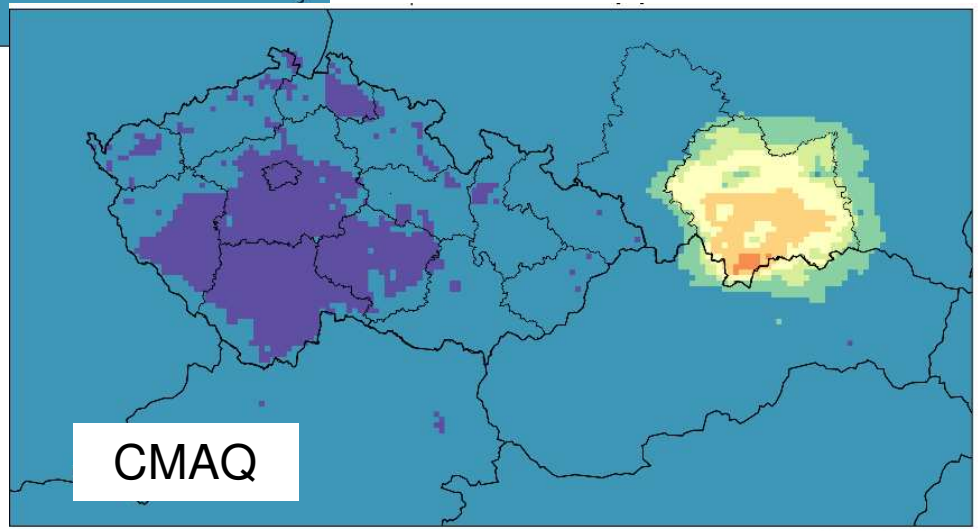
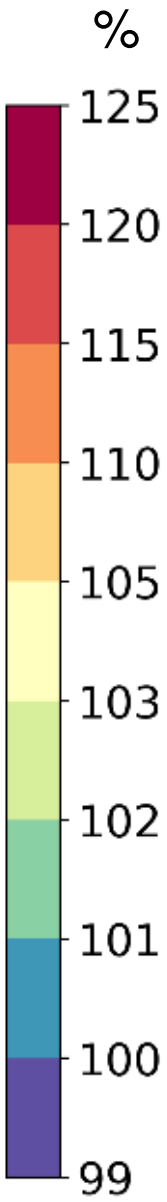




NO_2
annual average



Scenarios

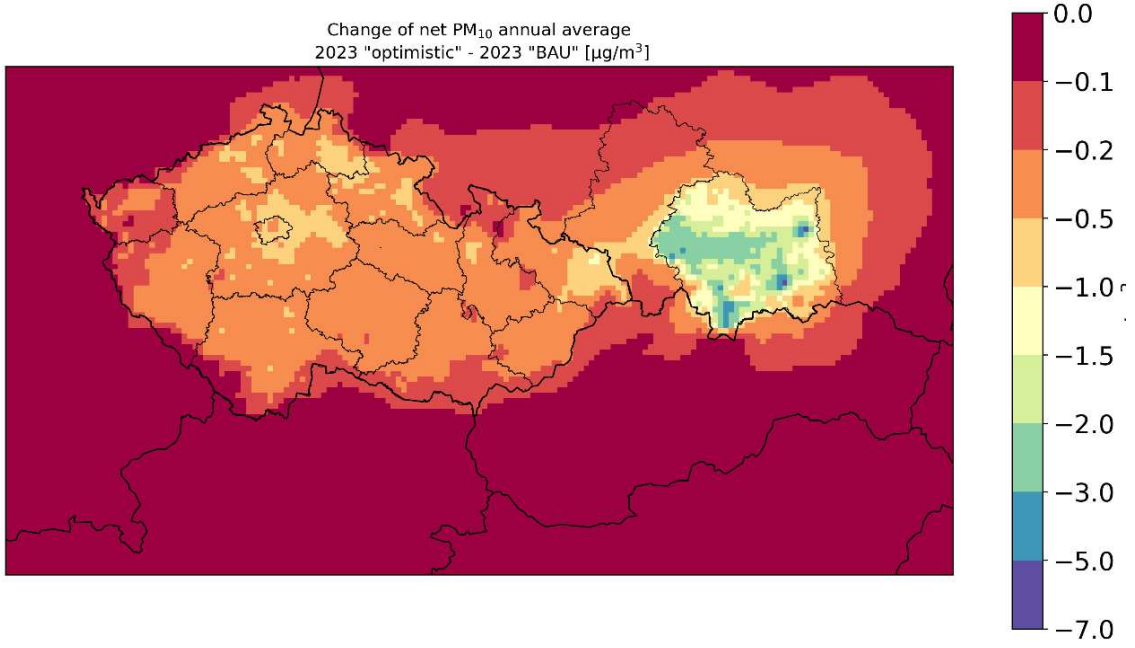
What is more important – decrease of primary or secondary particles?

Primary – directly emitted

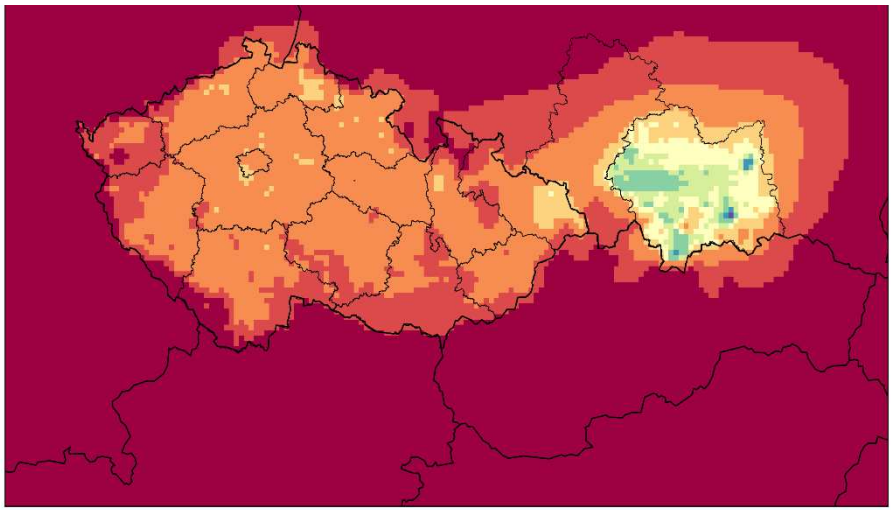
Secondary – formed in air from SO_2, NO_X, NH_3, etc.

2023 W1 „optimistic“ – W0 (BAU) raw CAMx

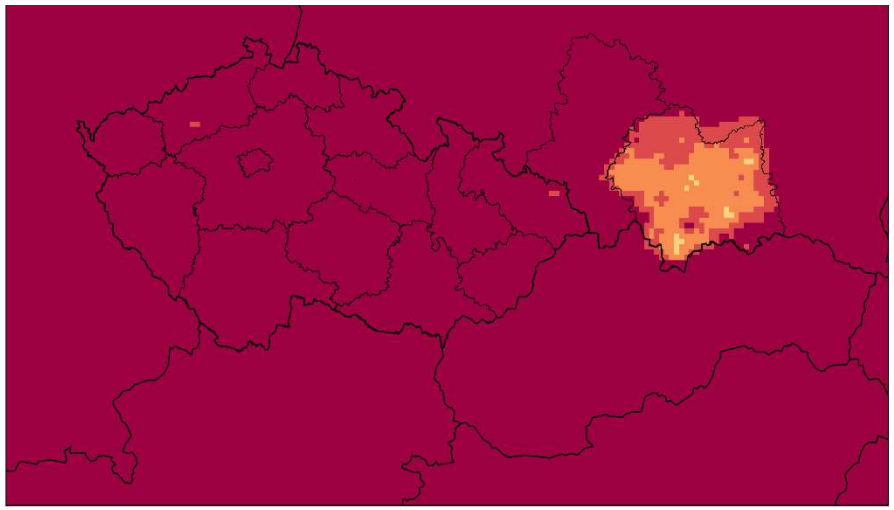
Total PM_{10}



Primary PM_{10}

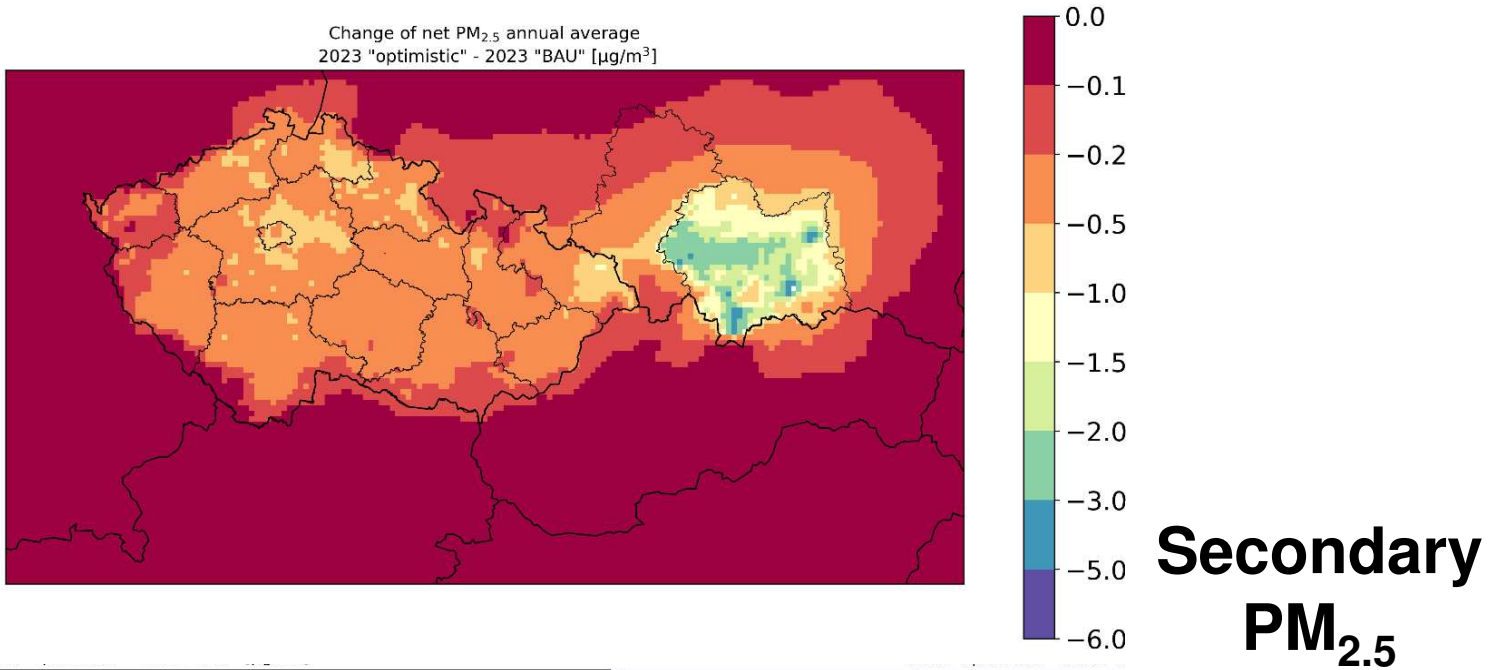


Secondary PM_{10}

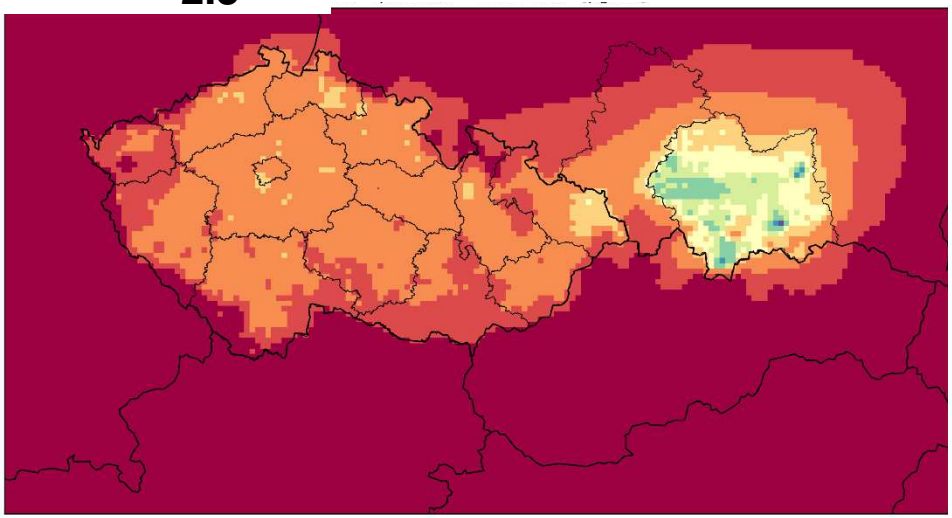


2023 W1 „optimistic“– W0 (BAU) raw CAMx

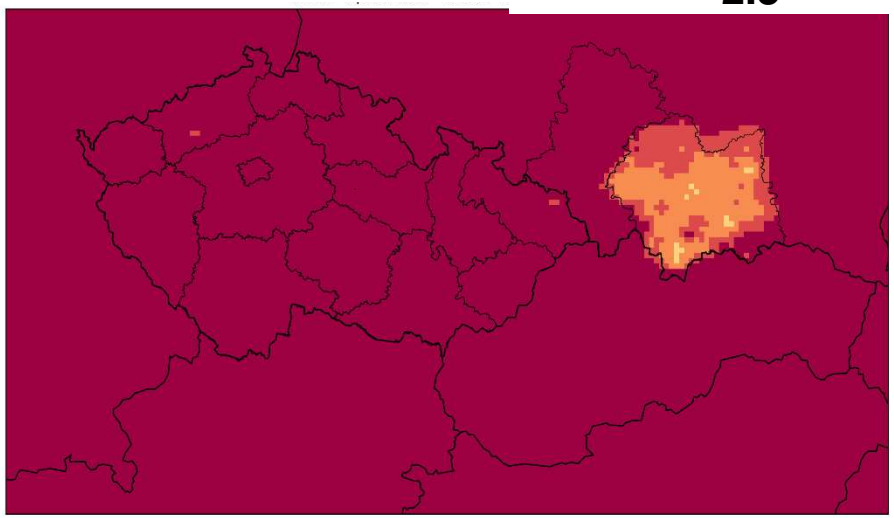
Total $PM_{2.5}$



Primary $PM_{2.5}$



Secondary $PM_{2.5}$



Outlook

- Recalculate reference year with emissions compatible with scenarios
- Evaluate scenarios (CTM-RIO)
- End of June 2019

Direct impact on the Czech Rep.

- Recalculate scenarios (include newly available Silesian and Slovak scenarios)
- Evaluate scenarios (CTM-RIO)
- End of November 2019

Presentation of results