

Convention on Long-range Transboundary Air Pollution

emep

*Co-operative programme for monitoring
and evaluation of the long-range
transmission of air pollutants in Europe*

EMEP case studies on HMs and POPs (2010-2018)

Pollution Assessment
on a Country Scale

MSC-East

Objectives

Currently produced information on pollution levels in the EMEP domain can be significantly extended by assessment performed on a country scale. A number of country-specific case studies have been conducted by Meteorological Synthesizing Centre – East (MSC-E) with support of Task Force on Measurement and Modelling (TFMM).

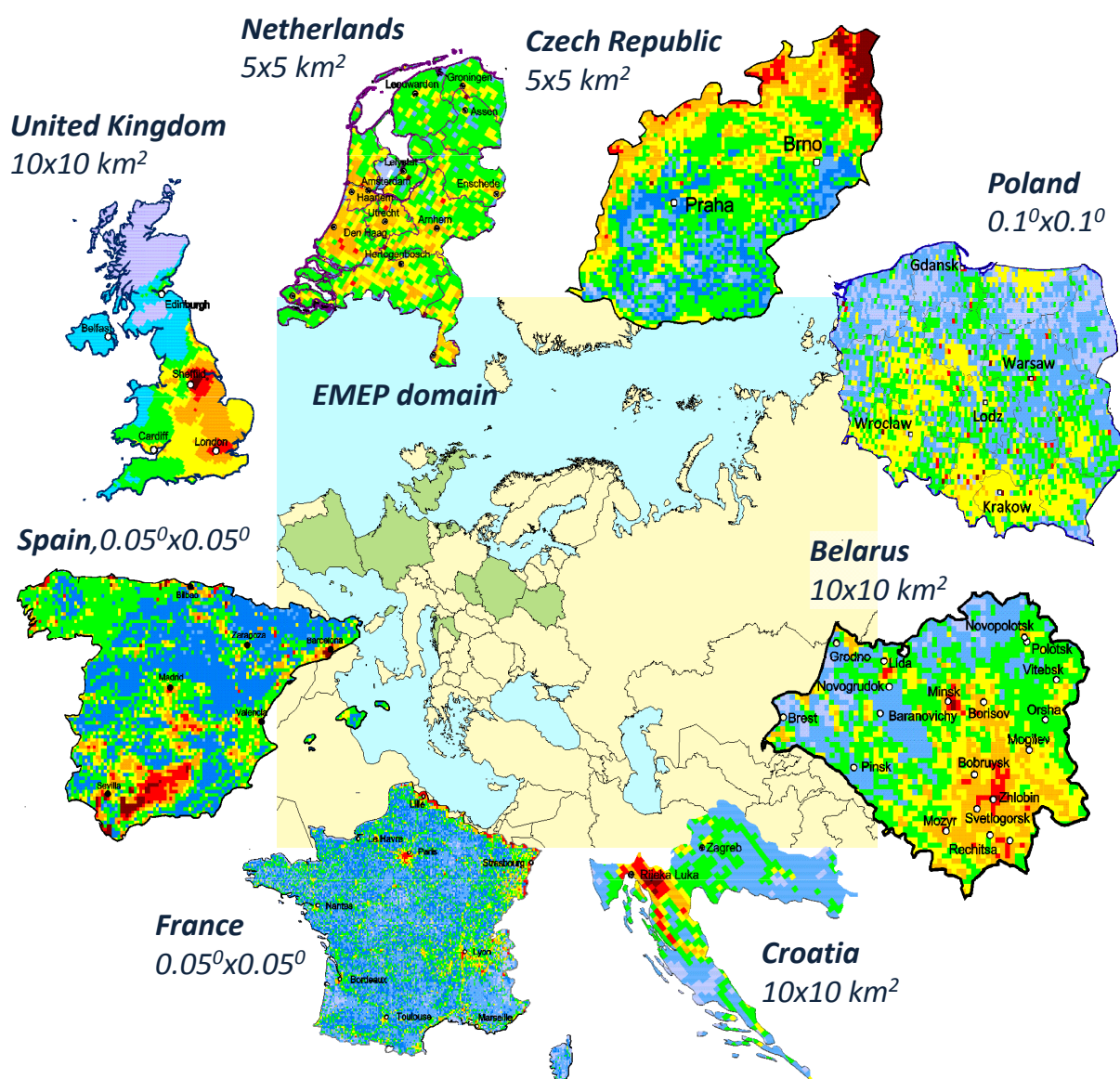
A particular benefit of such studies is achieved by close co-operation between EMEP and national experts. At current stage Croatia, the Czech Republic, the Netherlands, the United Kingdom, Belarus, Spain, Poland and France participate in the study.

Originally the main goal of the case study is investigation of the effects caused by transition from coarse to fine modelling resolution, taking into account detailed national-scale information on emissions, measurements, meteorological and geophysical data. It is assumed that the experience gained in the national-scale studies could be applied for model assessment over the entire EMEP domain.

Another objective of the study is to provide the countries with detailed information on pollution levels in addition to the regular information generated within EMEP. The countries receive detailed data on pollution levels with fine spatial resolution, source apportionment of pollution for provinces and cities, contribution of emission sectors and large point sources etc. MSC-E modelling tool is under preparation for use by national experts.

Country-scale assessment: an approach

Model assessment was carried out for seven countries (Croatia, the Czech Republic, the Netherlands, Belarus, Spain, Poland, France, UK) located in different parts of Europe and characterized by different environmental conditions. Results of the research were jointly analyzed by national experts in close cooperation with MSC-E at bi-lateral and TFMM meetings, and reported at the EMEP Steering Body sessions.



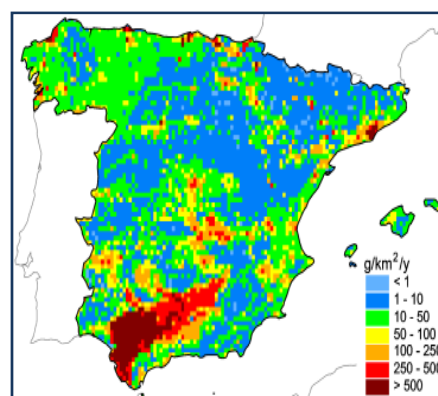
Research domains. Pollution levels with fine spatial resolution.

Information from countries

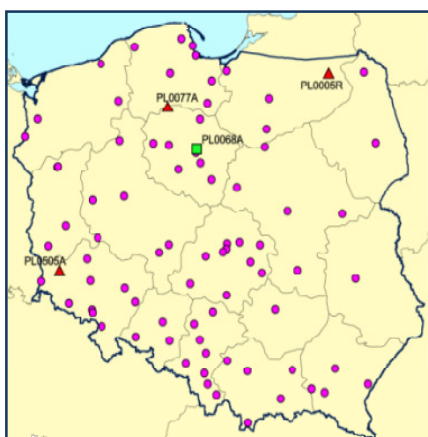
In addition to available EMEP data, national experts submit various country-specific data on emissions, monitoring, meteorological observations, concentrations in media etc.

Emissions

The countries provide gridded emission data with fine spatial resolution, including information on source categories and large point sources.



*Official emissions B(a)P of Spain
in 2015, 0.05°x0.05°*



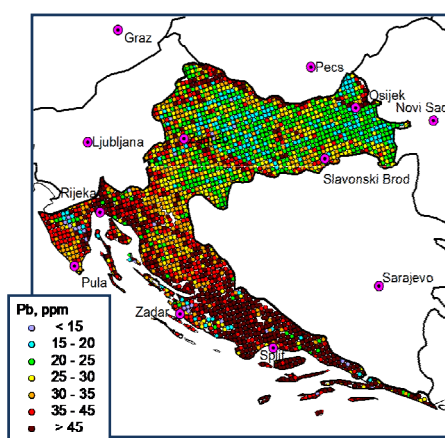
*Polish national monitoring
network*

Supporting information

Supporting information including orography and meteorological data, etc.

Measurements

Measurements from national monitoring programmes. For example, cadmium concentrations in air in 2014 are available from 84 stations of national monitoring network of Poland.



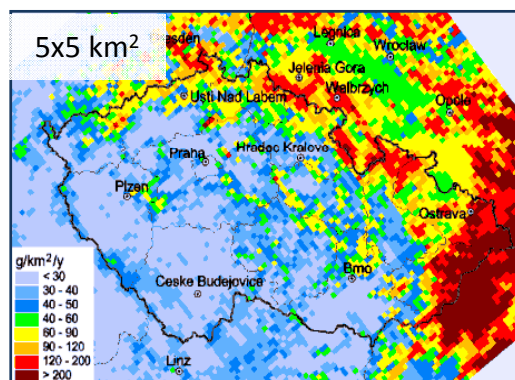
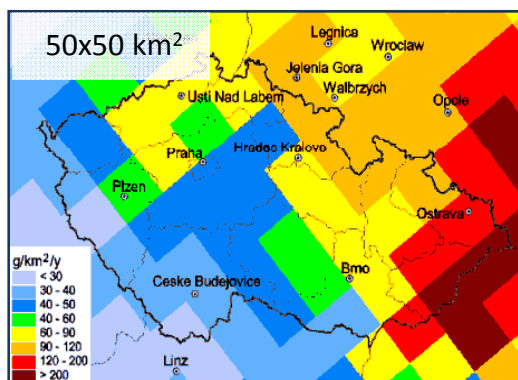
*Pb concentrations in soils in Croatia,
5x5 km²*

Assessment with fine resolution

Provides countries with detailed country-specific information, such as:

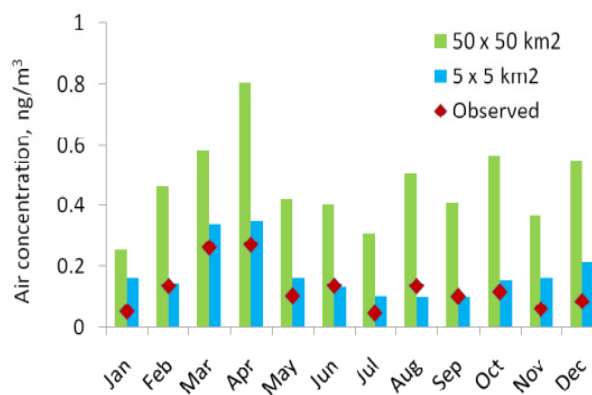
- Spatial distribution of pollution levels with high resolution (concentrations, deposition, contributions of national and external sources, etc...).
- Pollution levels caused by different emission source categories.
- Contamination from large point sources (LPS).
- Transboundary transport of pollution between country's provinces.

Modelling with fine spatial resolution leads to the improvement of the evaluation of pollution levels and agreement between modelled and observed values.



Total deposition of Cd in the Czech Republic

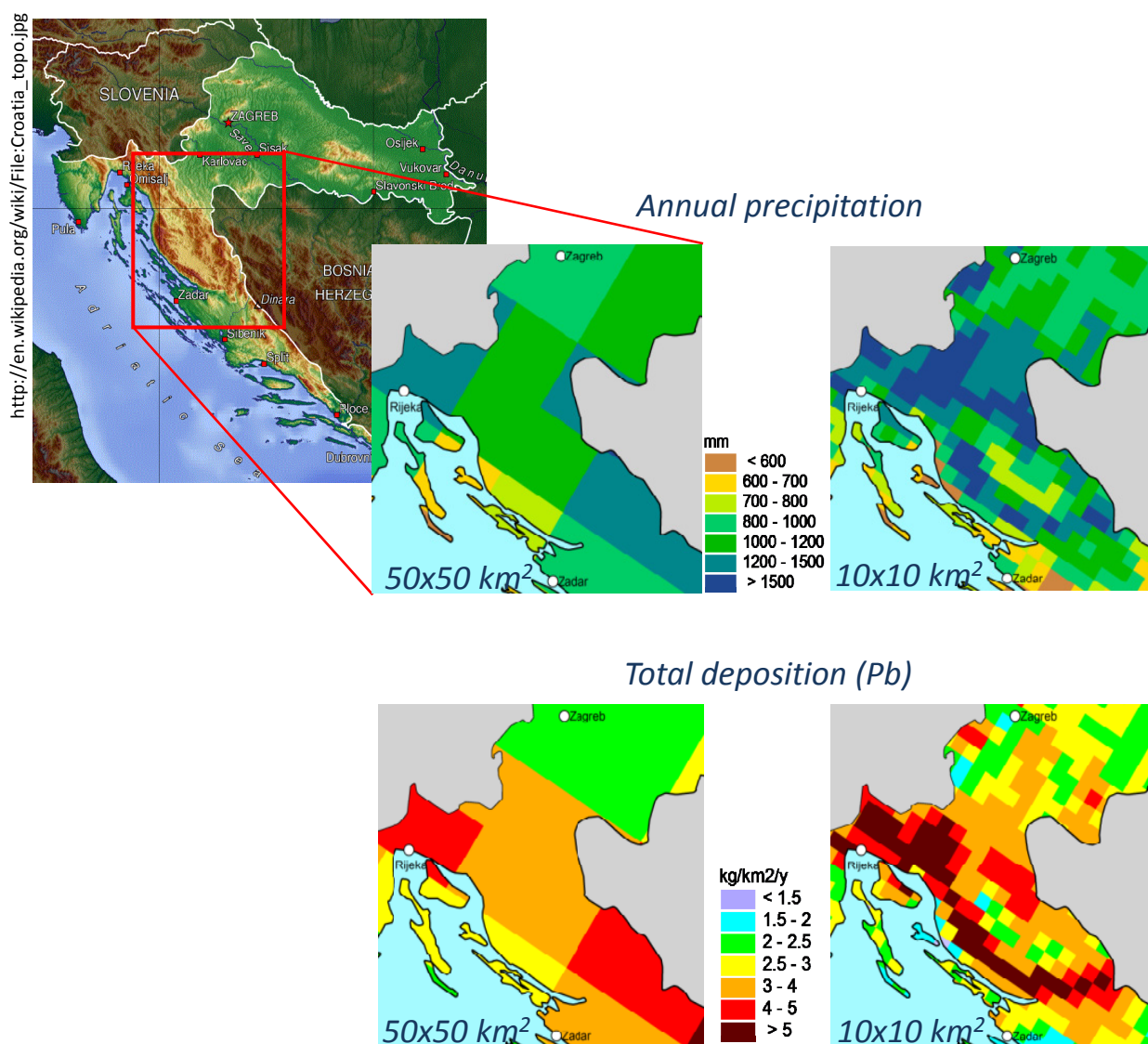
Quality of the country-scale assessment is determined to great extent by various factors including peculiarities of local conditions (orography and meteorology), national monitoring data and emission data, adequacy of model parameterizations etc.



Modelled and observed Cd air concentrations at station Rudolice v Horah (the Czech Republic)

Effect of fine-scale orography and meteorology

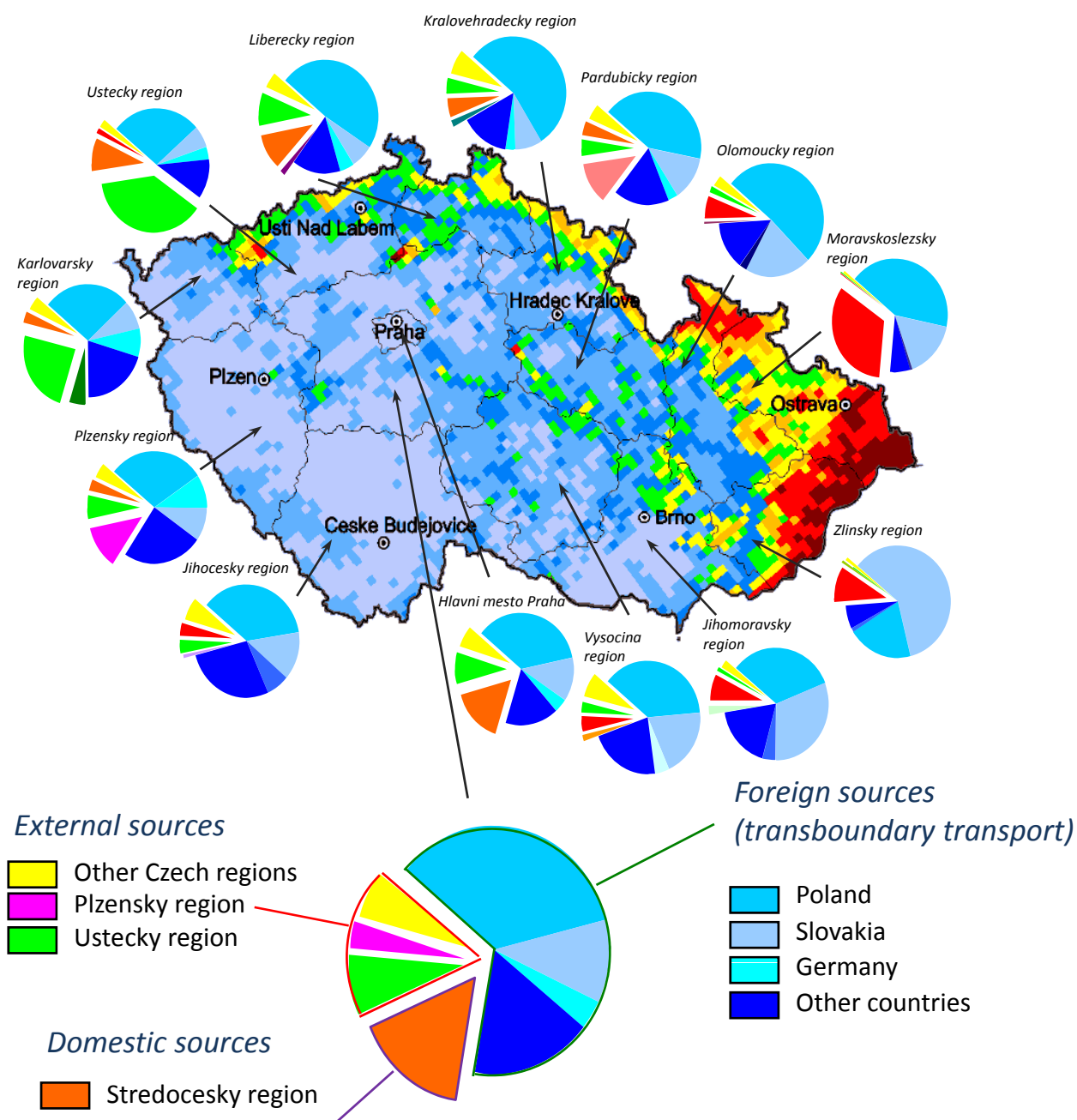
Transition to fine resolution allows capturing small-scale country-specific peculiarities. For example, modelling with fine resolution reproduces orographic precipitation along mountainous regions and associated increased deposition.



Refinement of Pb deposition field in Croatia due to increased resolution of precipitation data

Refinement on pollution levels on a country scale

Source apportionment of pollution levels

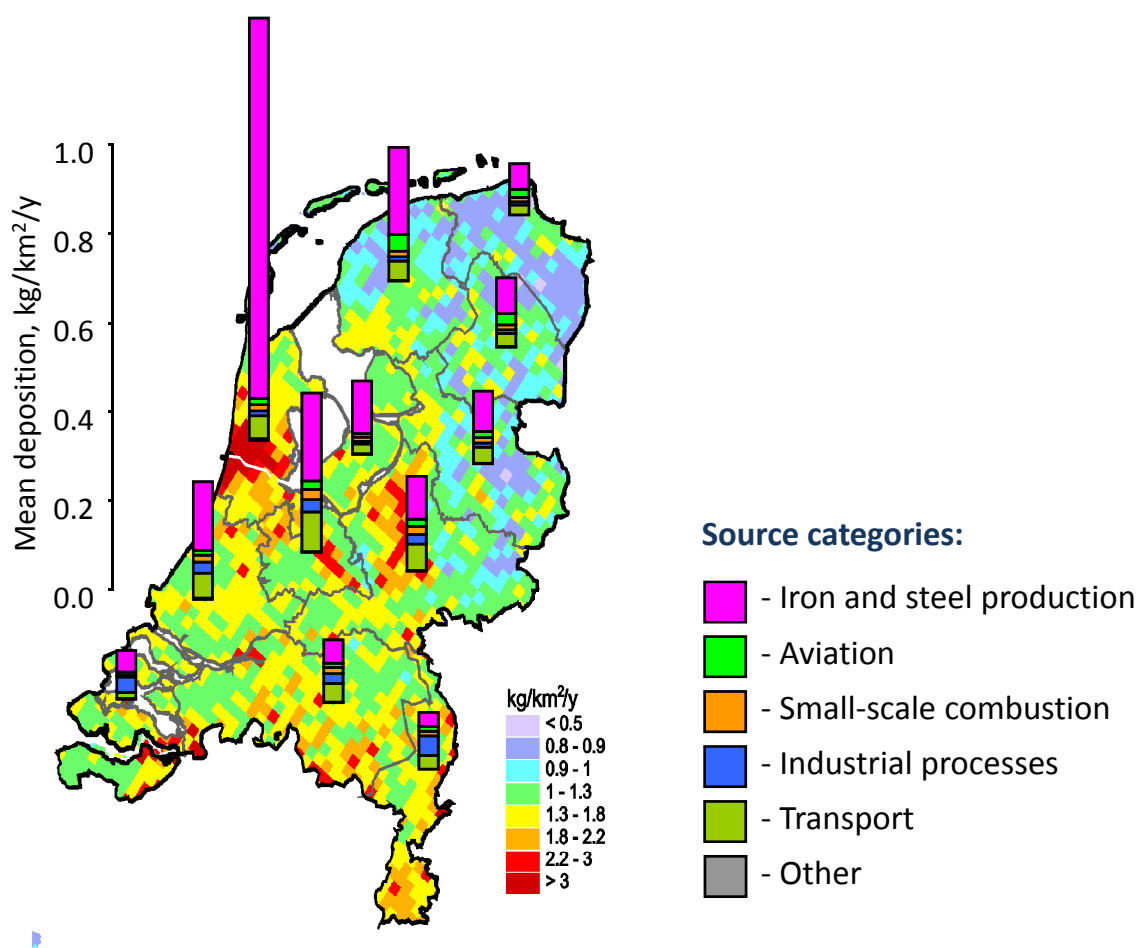


For each province of a country deposition from three types of sources are distinguished: **domestic** sources (located within a province), **external** (national sources outside a province) and **foreign** (outside national borders).

Contributions from source categories in the country

Additional information on the country scale:

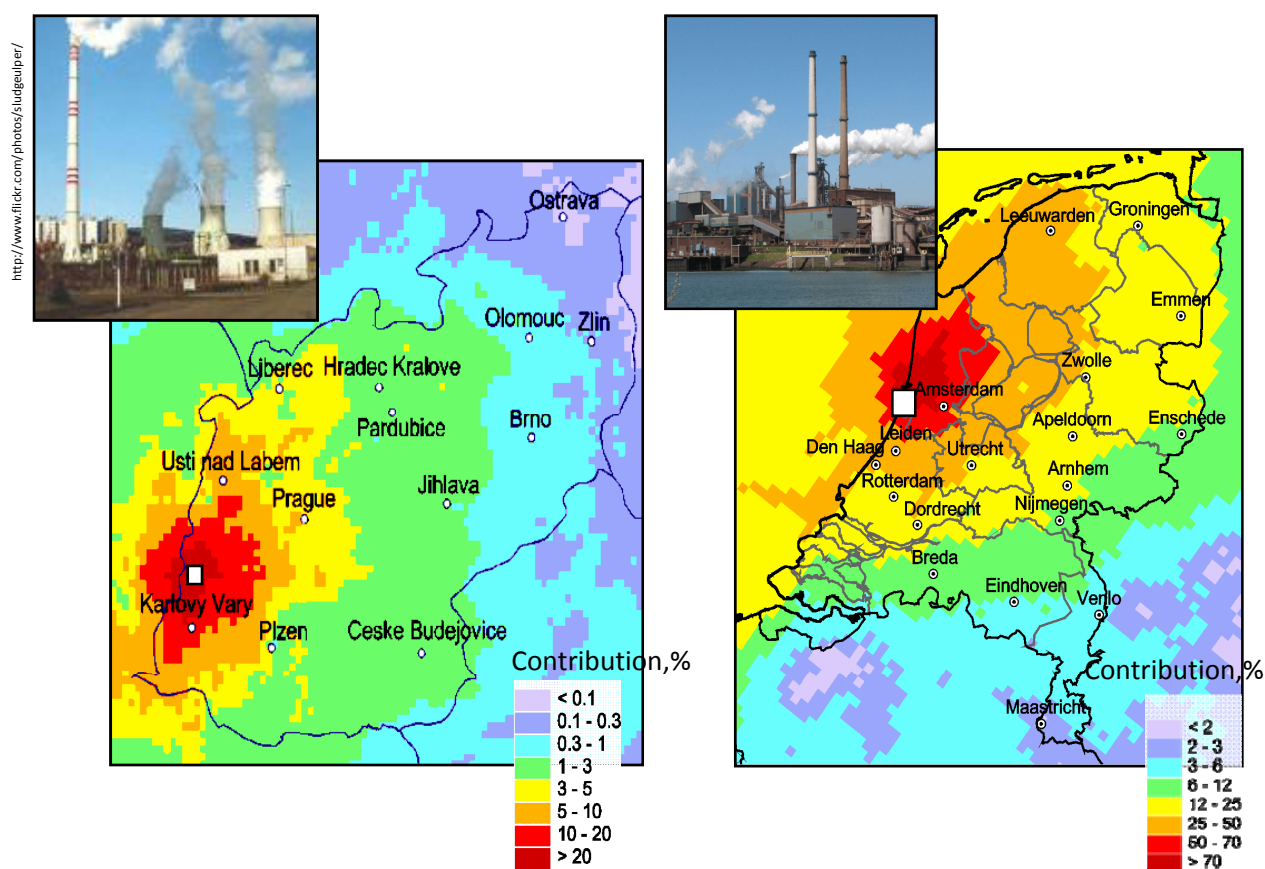
- Pollution levels with fine spatial resolution (down to 5×5 km²)
- Contamination of the country provinces
- Contribution of different emission source categories



Pb deposition from source categories in the Netherlands

Contribution of large point sources to deposition in the country

Information on contribution of large point sources to pollution levels in a country can be useful for both national regulatory organisations and experts from the industrial companies.

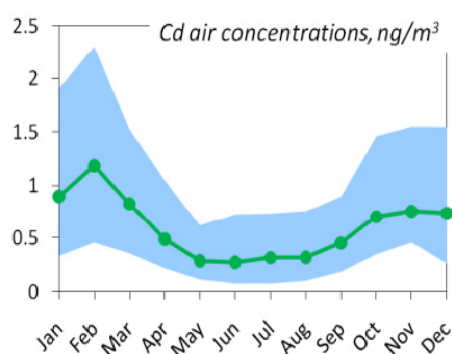
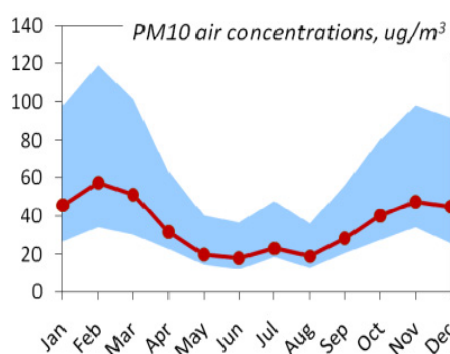


*Relative contribution of individual LPS to Cd and Pb deposition
in the Czech Republic and in the Netherlands*

Toxic species and particulate matter

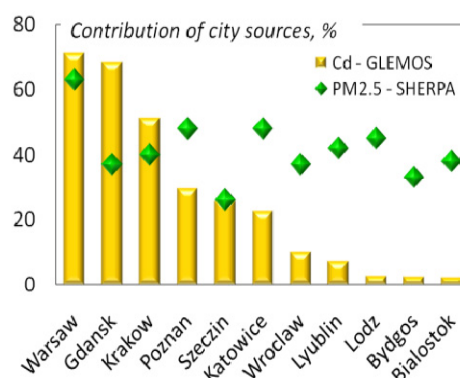
Atmospheric pollution by fine particles is one of current environmental problems considered by the Convention. At the same, a number of heavy metal and POP species are part of chemical composition of particulate matter. Therefore, health effects of the inhaled particles is enforced by presence of carcinogenic, mutagenic and reproductive toxic species.

Atmospheric behaviour of particulate toxicants is similar to that of fine particles. For example, concentrations of PM₁₀ and Cd measured at stations in Poland both demonstrate lower levels in warm period and higher- in cold period. Therefore, in country-scale studies the analysis of toxic pollutant levels can be accompanied with the analysis of PM chemical composition.



*Monthly mean concentrations observed in Poland in 2014
(averaged over 70 stations)*

Contributions of city sources (urban increments) to air concentrations of Cd and PM_{2.5} were compared for cities of Poland. Cd and PM_{2.5} urban increment are comparable in large cities (e.g., Warsaw, Krakow, Gdansk, Katowice, Poznan). However, in smaller cities the increment of Cd is much smaller than that of PM, most likely due to differences in emission sources. Further joint analysis of toxic pollutants and PM could be important for evaluation of human health and ecosystem effects.

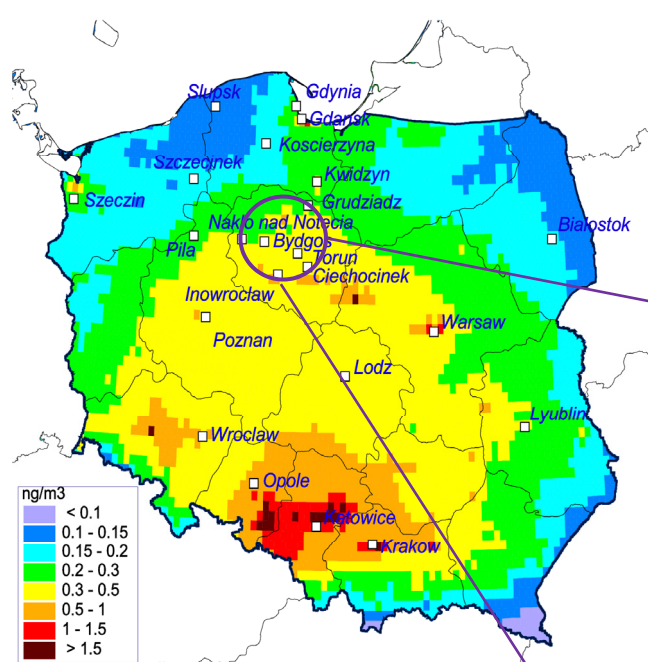


*Contribution of city sources to
mean annual cadmium air
concentrations*

Pollution of cities

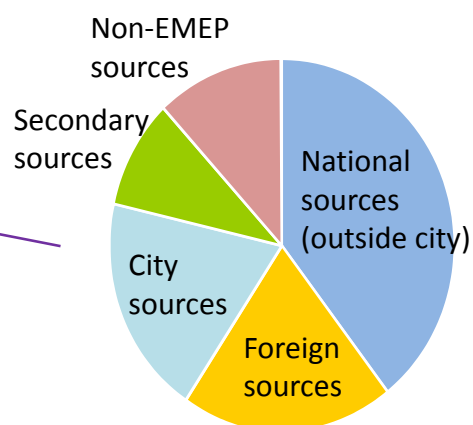
Modelling with fine spatial resolution allows (with certain restrictions) to evaluate levels of exposure in densely populated areas such as cities.

In the framework of the studies contributions of different sources for the selected cities is evaluated.



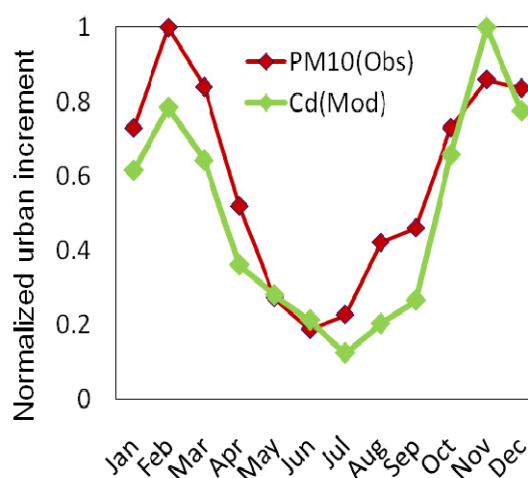
Data on HMs and POPs complement the information on composition of particulate matter. Consequently, their levels are analyzed along with the levels of particles. In particular, seasonal changes of Cd urban increments are similar to that of PM₁₀ in a number of Polish cities

Koscierzyna, Poland



Main sources of Cd in air

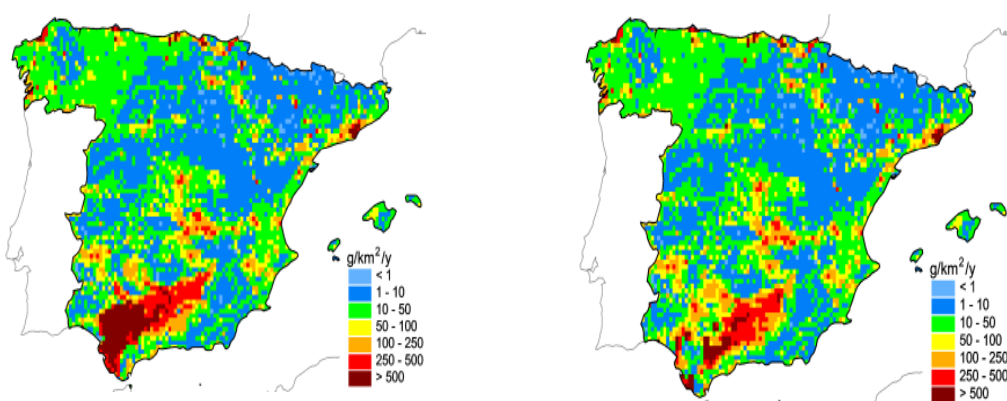
Koscierzyna, Poland



Cd and PM₁₀ urban increments

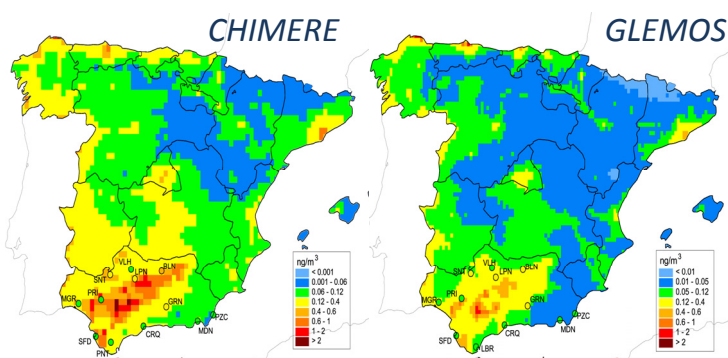
Model evaluation of national emissions: Agricultural sector

Analysis of B(a)P levels in Spain revealed significant overestimation of modelled air concentrations in the southern part of the country. The discrepancy between the modelling results and measurements was attributed to possible uncertainties in the reported national PAH emissions from agricultural sector. National experts from Spain have developed scenario with smaller emission from this sector.

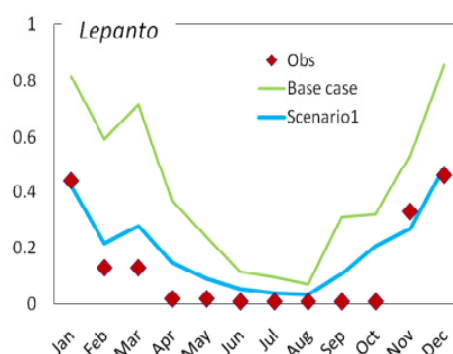


Official (left) and scenario-based (right) emissions of B(a)P in Spain in 2015

Model simulations of B(a)P pollution levels were carried out by models GLEMOS (MSC-E) and CHIMERE (CIEMAT) using official and scenario emissions. The usage of scenario emissions in Spain favoured improvement of the agreement between modelled and observed B(a)P levels.



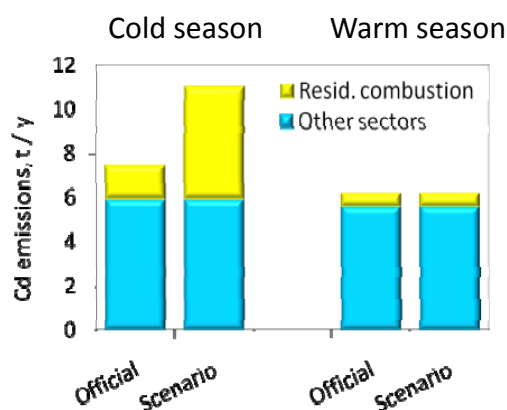
Concentrations of B(a)P in air based on emission scenario for agricultural sector in 2015



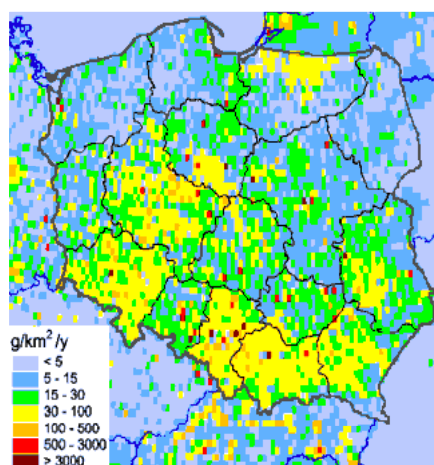
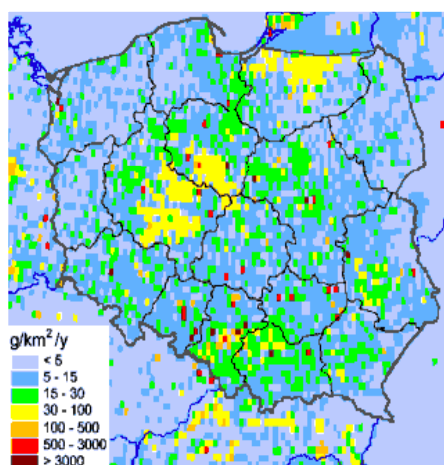
Modelling results of GLEMOS model with base case and scenario emissions

Model evaluation of national emissions: Residential combustion sector

In order to improve agreement between modelling and measurements data (Poland), scenario of Cd emission was developed. The scenario assumes correction of Cd official emissions from sector 'Residential Combustion'. According to the scenario, the the most significant changes are noted in the southern and south-western parts of the country in the cold season.

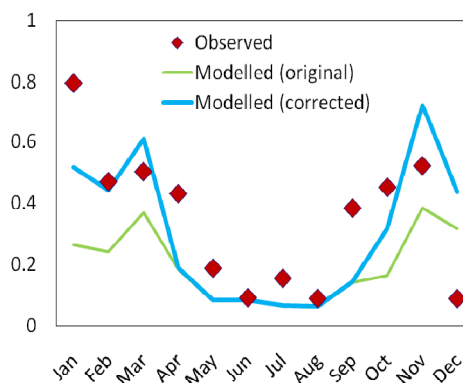


Cd emissions in Poland in 2014



Maps of the original (left) and scenario (right) emissions of Cd in Poland in 2014

Application of the emission scenario resulted in the improvement of agreement between modelled and observed concentrations in air both in Poland and in neighbouring countries.



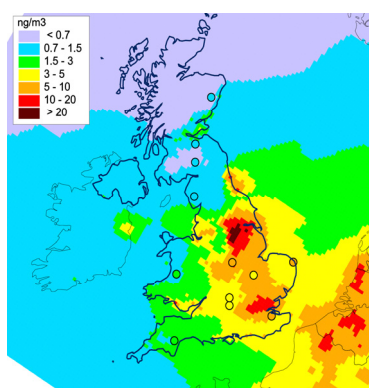
Modelled and observed concentrations in air at Polish station (PL0505)

Cooperation with national experts: comparison of modelling results

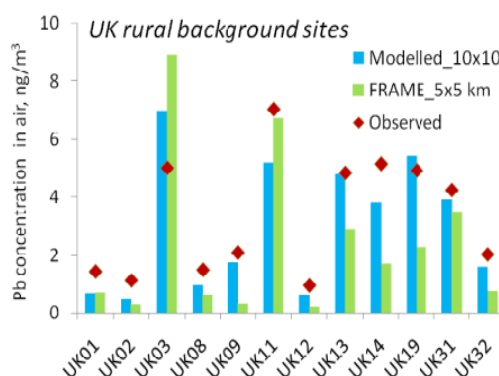
In a number of country-specific studies the results simulated by MSC-E are compared with the results produced by national models.

The United Kingdom

Air concentrations of lead simulated for the UK were compared with the results of national FRAME model. The indicated differences were attributed to peculiarities of parameterization of re-suspension used in these models.



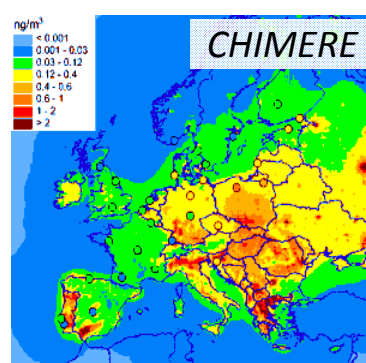
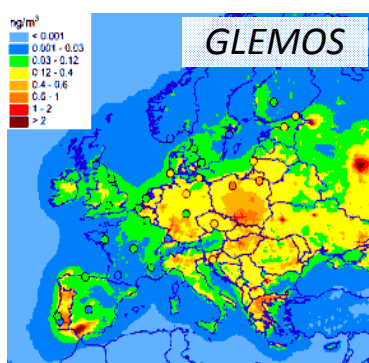
Pb air concentrations in the UK (MSC-E model)



Modelled (MSC-E and FRAME) and observed concentrations at stations in the UK

France

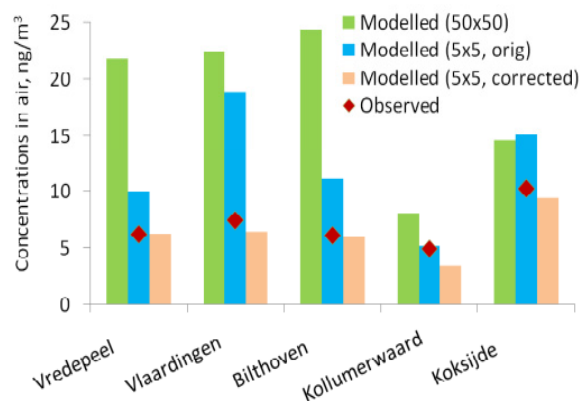
Similar levels of B(a)P concentrations in air of Europe were obtained by GLEMOS (MSC-E) and CHIMERE (INERIS) models. Some differences in spatial distributions of simulated B(a)P levels are caused by different mechanisms of gas-particulate partitioning implemented in the models.



Annual mean air concentration of B(a)P

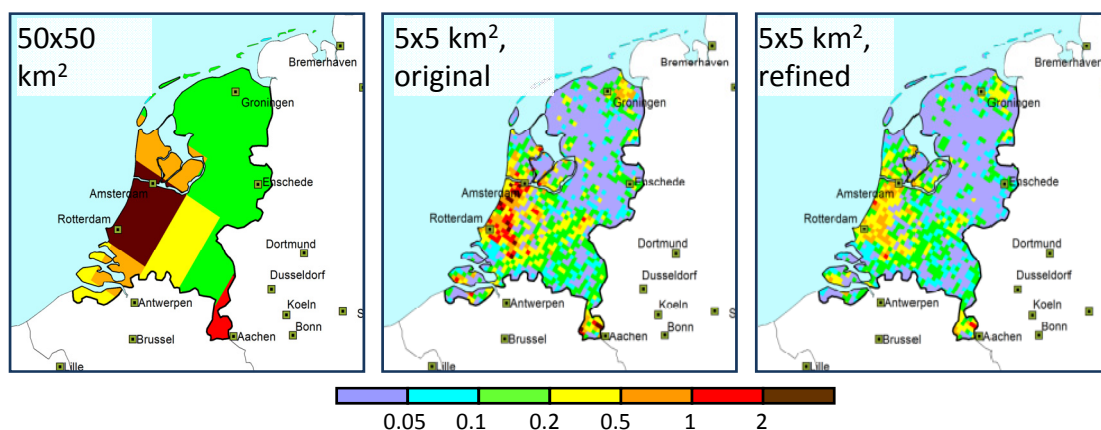
Refinement of model parameterizations

Refinement of spatial resolution does not always lead to the improvement of the assessment results. It often requires refinement of model parameterizations and supporting input information. For example, transition to finer resolution ('original') as such does not improve agreement between modelled and measured air concentrations in the Netherlands.



Modelled and observed Pb air concentrations at Dutch and Belgian stations

However, refinement of model parameterization of wind re-suspension with fine resolution ('refined') helps to significantly reduce discrepancies between the modelled and observed values. This experience can be transferred for the other EMEP countries.



Wind re-suspension of Pb in the Netherlands, kg/km²/y

GLEMOS modelling system developed by MSC-E is being prepared for distribution for public use as open-source software. Experts from different countries can use it for country-scale pollution assessment on different scales.

Concluding remarks

- Modelling with fine spatial resolution provides detailed information on pollution levels in a country and generally leads to the improvement of the pollution assessment in the EMEP domain.
- Transition to fine resolution allows taking into account influence of peculiarities of individual countries on pollution levels (e.g., relief, meteorological conditions, individual LPS, etc).
- In addition to the EMEP annual information on transboundary air pollution countries receive data on pollution levels with fine resolution, contribution of main source categories and large point sources, etc.
- Pollution of cities is of growing interest in the Convention. Development of reliable methods of city pollution assessment requires further efforts of the EMEP Centres in cooperation with national experts.
- Modelling results along with measurements can be used as an independent tool for evaluation of reported emissions. The studies showed that emission scenarios/expert estimates could be useful for generating more realistic assessment results.
- Modelling tool developed in these studies can be provided to countries in order to support air pollution assessment at a country level.
- The country scale studies will be further continued for selected EMEP countries, focusing on links between global regional and local pollution, assessment of contamination levels in cities and evaluation of adverse effects on human health and ecosystems (in co-operation with the effect community).

More detailed information is available at MSC-E website (www.msceast.org) and in the EMEP reports:

- **Persistent Organic Pollutants: assessment of transboundary pollution on global, regional, and national scales.** EMEP Status Report 3/2018
- **Detailed assessment of heavy metal and POP pollution in the EMEP countries, PART I: An overview of case studies.** MSC-E Technical Report 4/2018
- **Detailed assessment of heavy metal and POP pollution in the EMEP countries, PART II: Poland.** Joint MSC-E & IER-NRI & EGAR & CHMI Report 5/2018
- **Assessment of lead pollution levels in Belarus with fine spatial resolution (EMEP case study).** MSCE/INM Technical Report 4/2016
- **Assessment of Lead Pollution Levels in the Netherlands (EMEP case study).**
Joint MSC-E/RIVM Report 1/2014
- **Assessment of Heavy Metal Pollution Levels in the Czech Republic (EMEP case study).** Joint MSC-E/CHMI Report, 1/2012