Assessment of transboundary pollution with heavy metals and POPs

MSC-E: Oleg Travnikov, Jan Gačnik, Saeed Waqar Ali, Tina Kosjek, Nives Ogrinc, Milena Horvat (*Jožef Stefan Institute, Slovenia*)

CEIP: Stephan Poupa, Ullrich Bernhard, Robert Wankmüller, Sabine Schindlbacher, Oscar Redeyoff (*Umweltbundesamt GmbH, Austria*)

CCC: Wenche Aas, Helene Lunder Halvorsen, Katrine Aspmo Pfaffhuber (*NILU, Norway*)

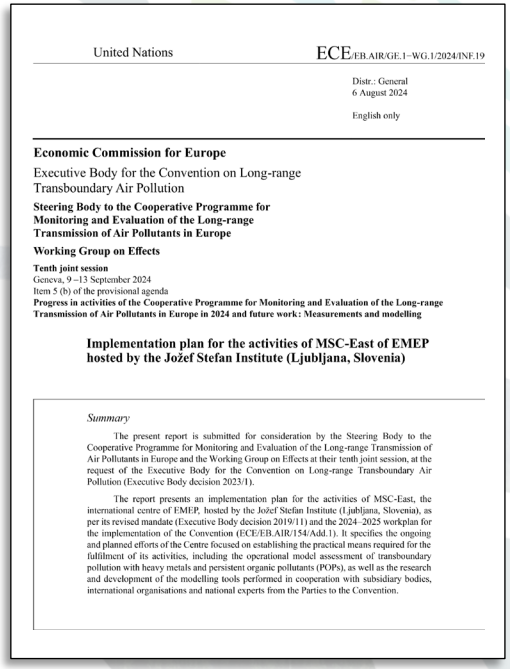
Meteorological Synthesizing Centre /East

CEIP umweltbundesamt

nilu

MSC-E implementation plan

ECE/EB.AIR/GE.1–WG.1/2024/INF.19



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Economic Commission for Europe

Executive Body for the Convention on Long-range Transboundary Air Pollution

Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

Working Group on Effects

Tenth joint session
Geneva, 9–13 September 2024
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Implementation plan for the activities of MSC-East of EMEP hosted by the Jožef Stefan Institute (Ljubljana, Slovenia)

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MSC-E activities according to the Mandate (*ECE/EB.AIR/144/Add.1*) and 2024-2025 workplan (*ECE/EB.AIR/154/Add.1*):

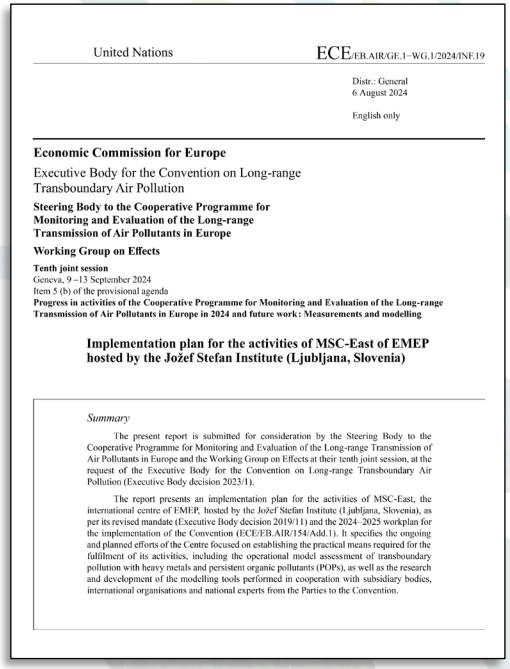
1.1.1.2	Investigate monitoring of chemicalsof emerging concern. Follow up conclusions and guidelines from workshop in autumn 2023	Report from workshopin 2024. Follow up results in EMEP report 2025	TFMM, CCC, MSC-E	EMEP budget
1.1.1.8	Finalize Eurodelta-BaP model intercomparison. Assess BaP-related health effects	Peer-reviewed publication	TFMM, MSC-E	Additional resources required
1.1.4.3	Organize new global Hg model simulations	2010–2020 baseline simulations (2024); additional sensitivity analyses (2025)	TFHTAP, MSC-E	Parties' in-kind contributions
1.1.4.4	Design multi-model intercomparison of multi-pollutant(PM, POPs, metals, O3) impacts offires	Options paper (2024)	TFHTAP, MSC-E	Additional resources required
1.3.3	Support Stockholm Convention in relation to atmospheric observations and data management	Report to annual jointsessions of Steering Body to EMEP and WGE	CCC, MSC-E	
1.3.4	Support Minamata Convention in relation to atmospheric observations and data management Contribute to Minamata Convention's effectivenessevaluation	Report to annual jointsessions of Steering Body to EMEP and WGE	CCC, TFHTAP, MSC-E	

- Reporting and dissemination of the assessment results

CEIP nilu

MSC-E implementation plan

ECE/EB.AIR/GE.1–WG.1/2024/INF.19



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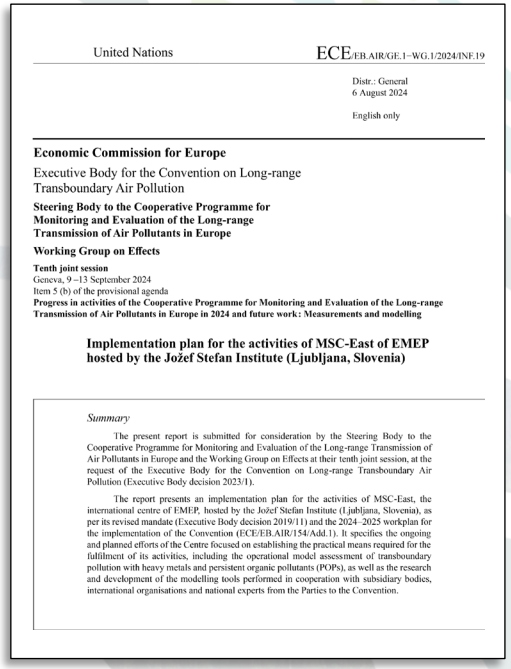
Activities implemented in 2024:

- Preparing for operational modelling:
  - Arranging computer resources (HPC clusters)
  - Installing and updating the modelling tools
  - Engaging scientific staff
- Operational simulations of transboundary pollution with heavy metals (Pb, Cd, Hg) and selected POPs (PAHs – B(a)P, B(b)F, B(k)F, IP) in 2022
- Research and development aimed at improving model performance (Hg processes, PAH pilot study, etc.)
- Resumed co-operation with TFMM, TF HTAP, HELCOM, OSPAR
- Initiated development of the website (www.msc-east.org)

CEIP nilu

MSC-E implementation plan

ECE/EB.AIR/GE.1–WG.1/2024/INF.19



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Activities to be implemented in 2025:

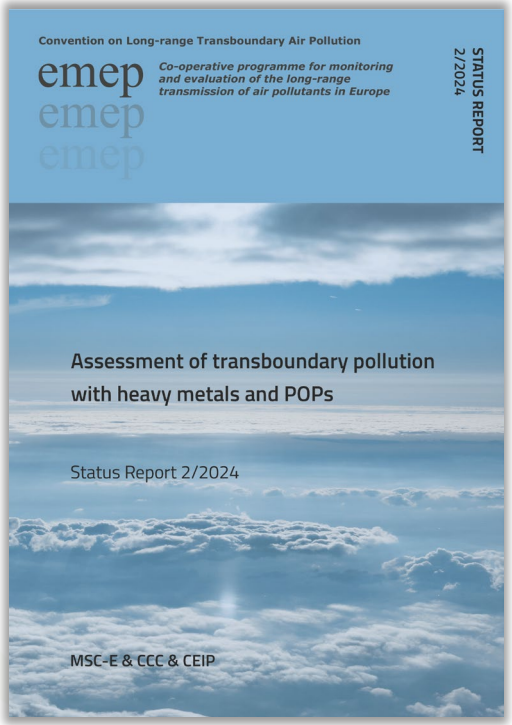
- Extend operational model assessment to include other priority POPs (PCBs, PCDD/Fs, HCB)
- Further update the GLEMOS model with a focus on key transport and multi-media exchange processes
- Continue co-operation with TFMM (*1.1.1.2*, *1.1.1.8*) and TF HTAP (*1.1.4.3*, *1.1.4.4*)
- Proceed with country-scale pollution studies in co-operation with national experts (PAH pollution in the Balkan countries)
- Renew collaboration with ICP-Vegetation (WGE) on joint pollution analysis involving moss measurements
- Co-operate with other international bodies (HELCOM, OSPAR, Minamata and Stockholm Conventions, *1.3.3*, *1.3.4*)

CEIP nilu

EMEP Status Report 2/2024

Main topics:

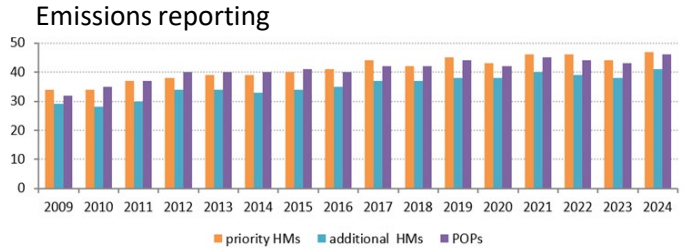
- Reporting of heavy metal and POP emissions (CEIP)
- Monitoring of heavy metals and POPs (CCC)
- Status of HM and POP air pollution in 2022 (MSC-E)
- Research and developments (MSC-E)
  - Refinement of Hg atmospheric chemistry
  - Evaluation of Hg air-vegetation exchange
  - Country-scale study of PAH pollution
- Cooperation
- Future directions

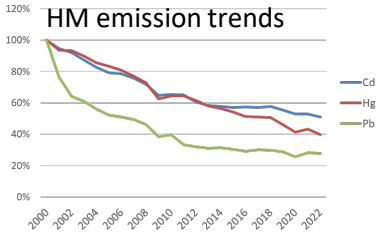


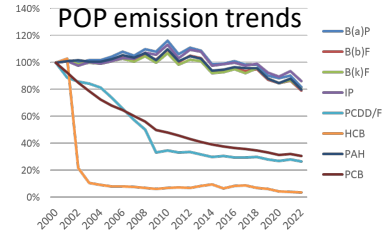
CEIP nilu

Reporting of heavy metal and POP emissions

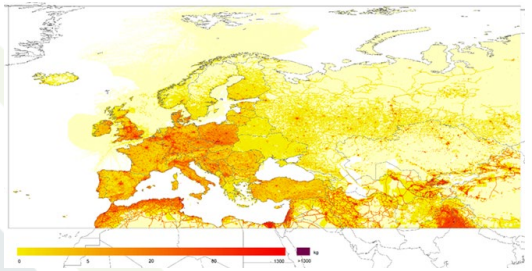
- Review of heavy metal and POP emissions reporting in 2024
- Analysis of emission trends in the western and eastern parts of the EMEP region
- Review of emissions recalculations by the Parties in 2024
- Description of emissions data for 2022 prepared for modelling





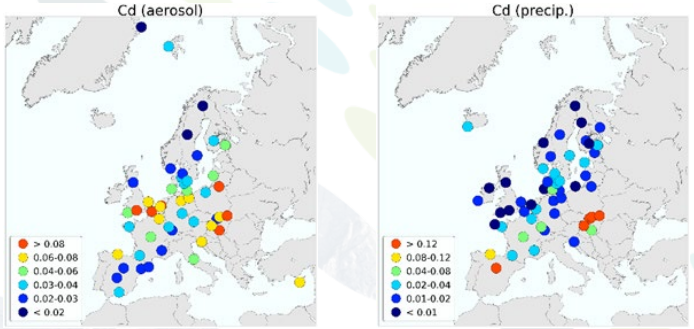


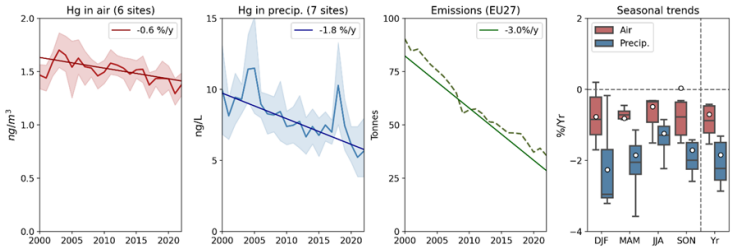
Pb emission for modelling (2022)

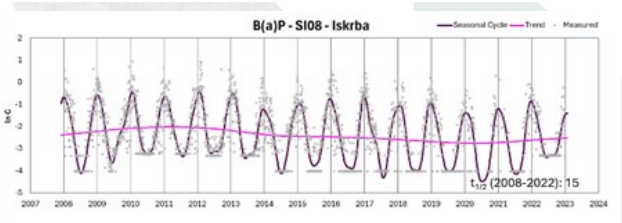


CEIP nilu

Monitoring of heavy metals and POPs







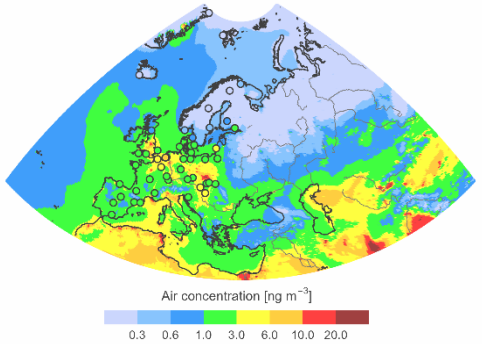
- Status of the EMEP monitoring network for heavy metals and POPs in 2022
- Analysis of measured Hg trends (2000-2020) in air and precipitation
- Long-term trends and seasonal variability of PAH concentrations
- Short overview of activities and plans on contaminants of emerging concern (CECs)

Status of HM and POP pollution (2022)

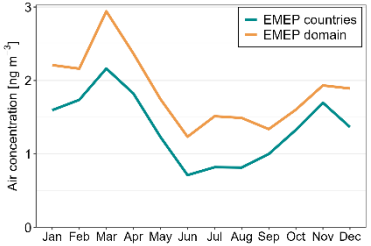
Operational model assessment:

- Full cycle of annual simulations with GLEMOS (v2.2.2, open source) for Pb, Cd, Hg, B(a)P, B(b)F, B(k)F, IP in 2022
- Spatial patterns of air concentrations, wet and total deposition
- Seasonal variation of pollution levels
- Source attribution and transboundary transport of HM and POP pollution
- Evaluation of modelling results vs. observations

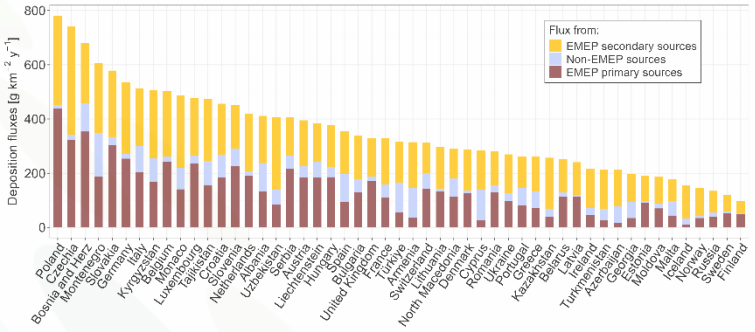
Pb air concentration (2022)



Seasonal variation of Pb concentration



Source attribution of Pb deposition



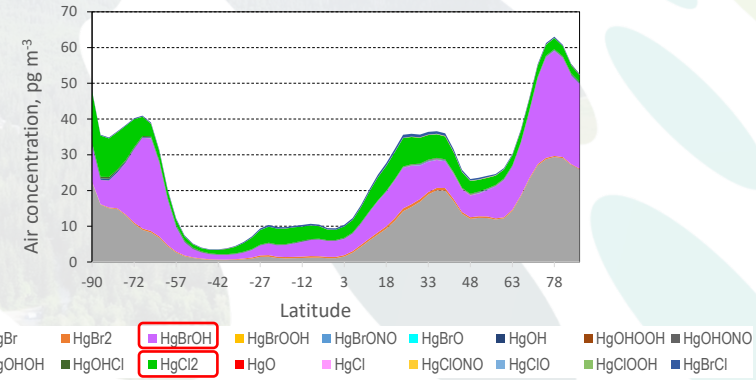
CEIP nilu

Research: Hg atmospheric chemistry

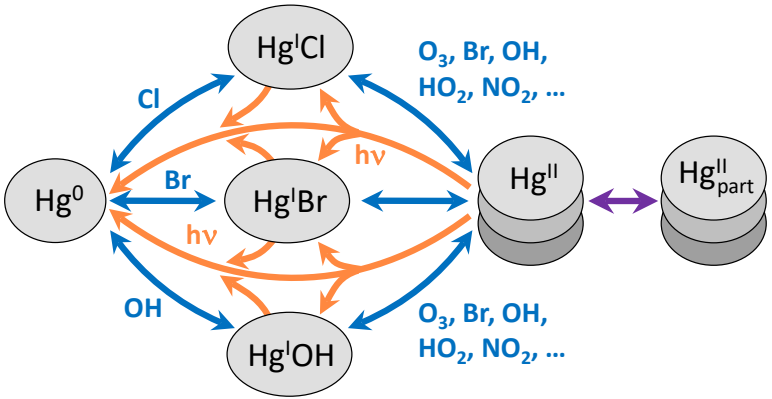
New Hg chemical mechanism (GLEMOS, v2.3):

- Br, OH, Cl induced oxidation, photo reduction, gas-particle partitioning of Hg^{II}
- 20 Hg species (Hg^0, BrHg, $HgBr_2$, BrHgOH, BrHgCl, BrHgOOH, BrHgONO, BrHgO, HOHg, HOHgOOH, HOHgONO, HOHgO, HOHgOH, HOHgCl, ClHg, $HgCl_2$, ClHgO, ClHgONO, ClHgOOH, HgO)

Speciation of Hg^{II} in surface air



Hg chemical mechanism



PNAS RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

Anthropogenic short-lived halogens increase human exposure to mercury contamination due to enhanced mercury oxidation over continents

Xiao Fu[a,1,2], Xianyi Sun[a,1], Oleg Travnikov[b,1], Qinyi Li[c,d,e,1], Chuang Qin[a], Carlos A. Cuevas[c], Rafael P. Fernandez[f], Anoop S. Mahajan[g], Shuxiao Wang[h], Tao Wang[d], and Alfonso Saiz-Lopez[c,2]

Edited by Joel Blum, University of Michigan; received August 31, 2023; accepted February 6, 2024

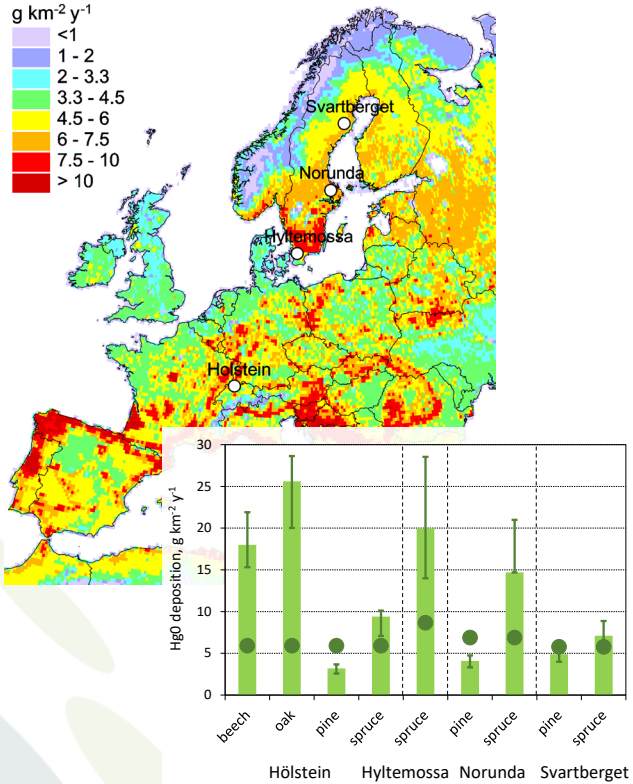
Fu et al., *Proc. Natl. Acad. Sci.*, 2024

Research: Hg air-vegetation exchange

Update of GLEMOS dry deposition scheme:

- Refinement of Hg^0 gaseous uptake by forest foliage
- Model evaluation vs. Hg measurements from ICP-Forests (*Wohlgemuth et al.*, 2022; 2023)
- Hg concentrations in foliage (>2000 samples) and bottom-up estimates of Hg foliage uptake flux
- Testing and uncertainty analysis of Hg air-vegetation exchange

Hg^0 deposition to forests (2022)



CEIP nilu

Country-scale pilot studies

Previous studies (2010-2020) for EMEP countries:

Czech Republic, Croatia, Netherlands, Belarus, UK, Poland, Spain, France, Germany, Norway

CEIP nilu

Country-scale pilot studies

Previous studies (2010-2020) for EMEP countries:

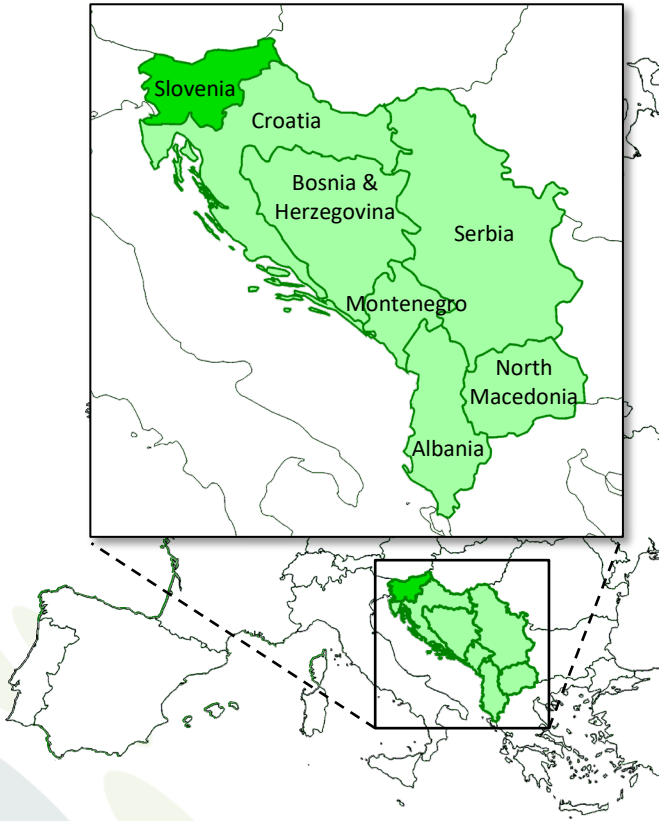
Czech Republic, Croatia, Netherlands, Belarus, UK, Poland, Spain, France, Germany, Norway

New study for the Balkan countries:

Pollutants – PAHs, heavy metals (Hg, Pb, Cd)

Phase I (2025-2026):

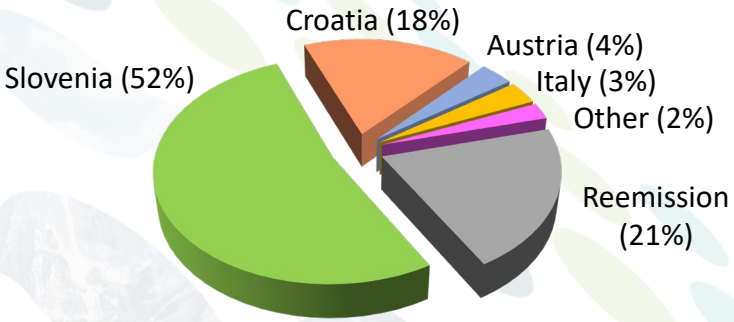
- Detailed assessment of PAH pollution in Slovenia
- Exploring possibility to extent the study to other Balkan countries and other pollutants



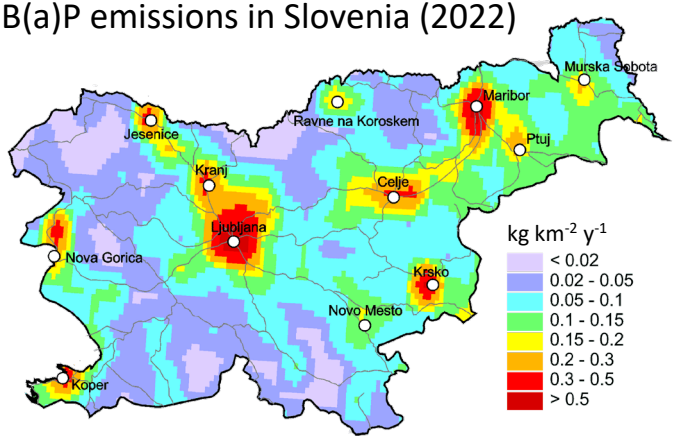
CEIP nilu

PAH pollution in Slovenia (EMEP data)

B(a)P deposition to Slovenia (2022)

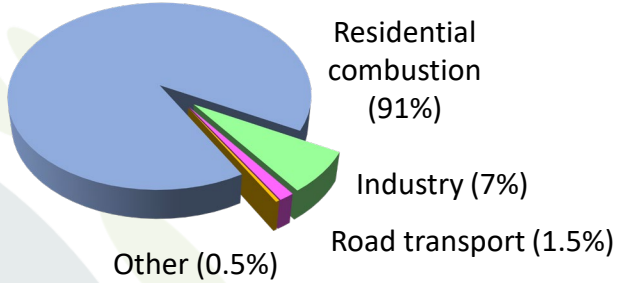


B(a)P emissions in Slovenia (2022)



- About a half of B(a)P deposition to Slovenia originates from national sources
- Most B(a)P emissions are localized around cities
- *Residential combustion* contributes >90% of total B(a)P emissions in the country

Sectoral composition of B(a)P emissions



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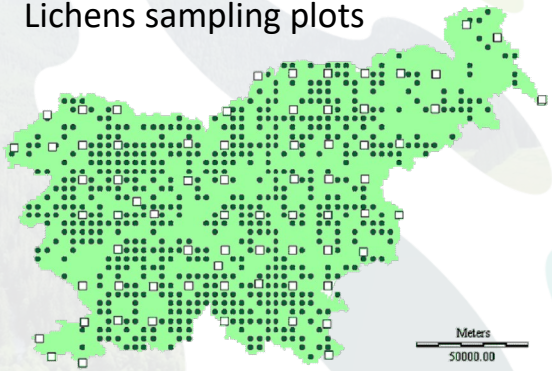
PAH observations in Slovenia

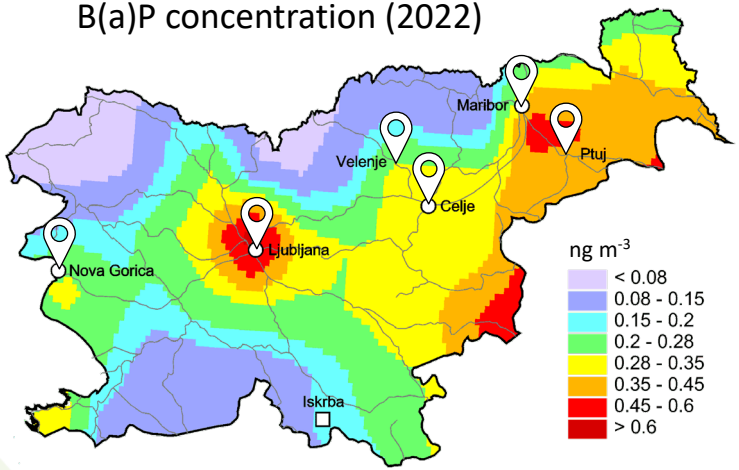
Available PAH measurements:

- EMEP measurements (Iskrba)
- Urban measurements (AQ e-Reporting)
- Measurement campaign (2019-2020) – **stable isotope** composition of PAHs
- Lichen and moss archives

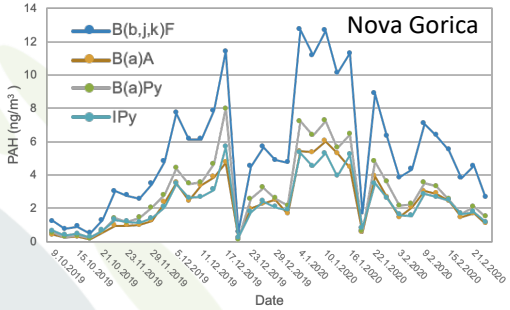
Lichens sampling plots



B(a)P concentration (2022)



□ - EMEP site ○ - AQ e-Reporting - Field campaign



CEIP nilu

Pilot study for Slovenia (2025-2026)

Program of the study:

- Pollutants – PAHs (B(a)P, B(b)F, B(k)F, I(cd)P)
- Collection of national emissions and monitoring data
- Fine-resolution simulations of PAH levels in the country
- Evaluation of modeling results vs. variety of observations
- Analysis of spatial patterns of PAH pollution involving simulations and lichen/moss archives
- Source attribution of PAH levels using SR modeling and stable isotopes analysis
- Evaluation/refinement of national PAH emissions inventory

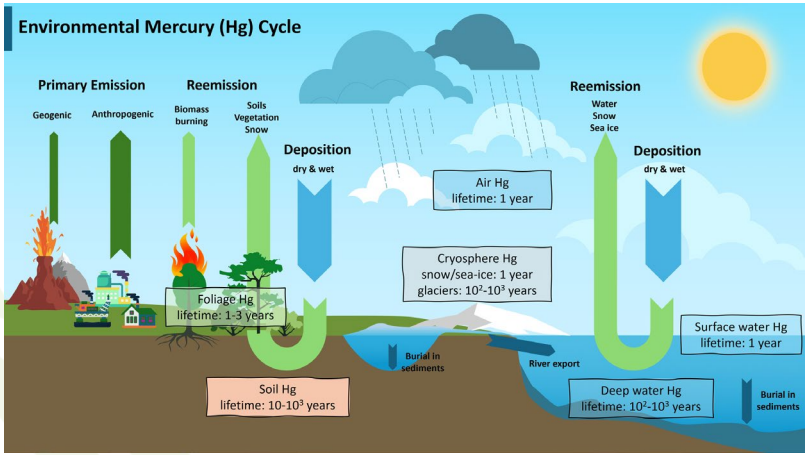
CEIP nilu

Co-operation: MCHgMAP project

Multi-Compartment Hg Modeling and Analysis Project

- Organized under the TF HTAP agenda (1.1.4.3) in co-operation with Minamata Convention (1.3.4)
- Focused on analysis of Hg pollution trends, source attribution, and evaluation of future scenarios
- Bringing together Hg emissions, monitoring and modeling communities
- Engaging Hg atmospheric, ocean and mass balance models

Environmental Hg cycle



Dastoor et al., *Geoscientific Model Development*, under review

CEIP nilu

Multi-model ensemble

Model	*Institution*
Atmospheric models	
GEM-MACH-Hg	Environment and Climate Change Canada (Canada)
GEOS-Chem	Massachusetts Institute of Technology (USA)
GLEMOS	Jožef Stefan Institute (Slovenia)
WACCM	Institute of Physical Chemistry Blas Cabrera (Spain)
Ocean models	
MERCY	HEREON (Germany)
MITgcm	Nanjing University (China)
Multi-media mass balance models	
GBBM	Harvard University (USA), University Grenoble Alpes, CNRS (France)
WorM^3	Indian Institute of Technology Hyderabad (India)
Terrestrial model	
2D air-land Hg exchange model	Lamar University (USA), Institute of Geochemistry, CAS (China)

CEIP nilu

Coordinated multi-model simulations (2024)

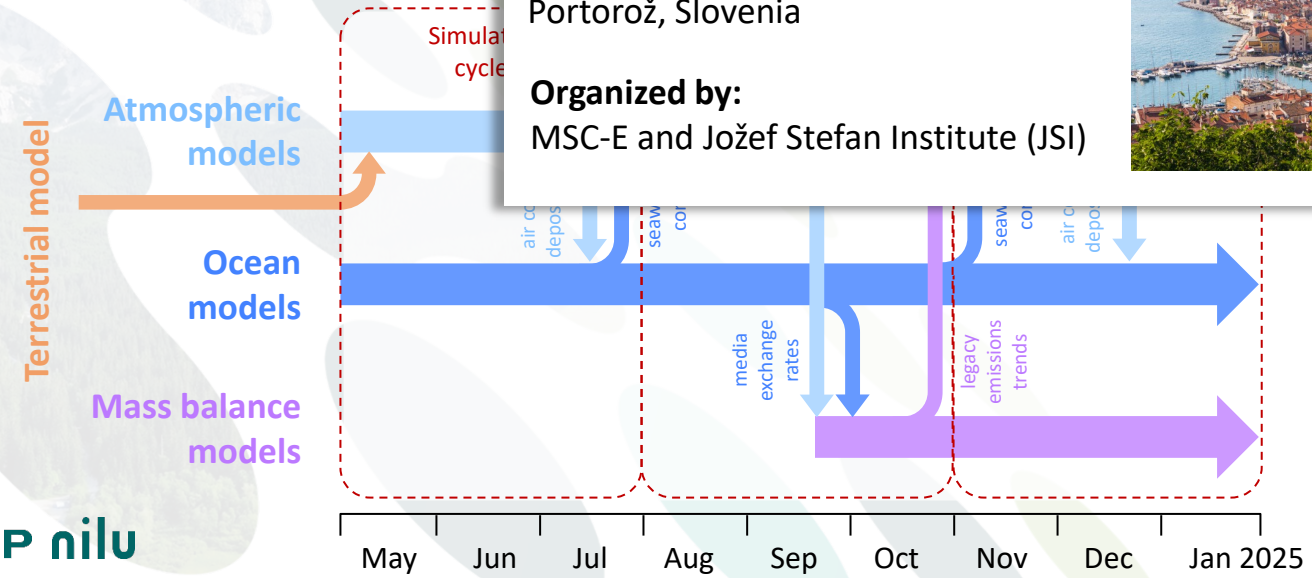
Simulations program:

- Simulated period: 2010-2020
- Off-line coupling atr
- Series of simulation
  between the model

MCHgMAP project workshop

October 9-11, 2024
Portorož, Slovenia

Organized by:
MSC-E and Jožef Stefan Institute (JSI)



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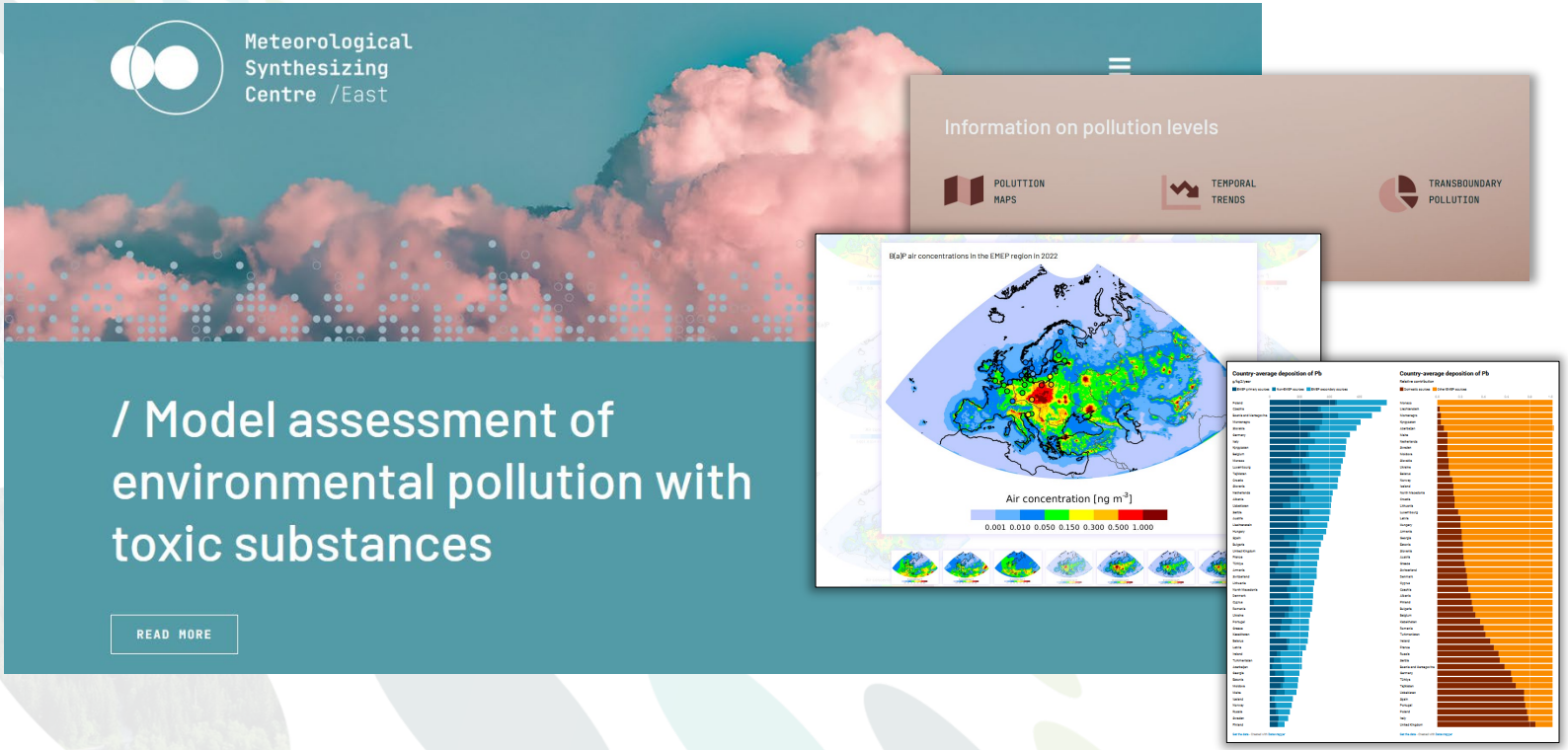
MSC-E website (www.msc-east.org)



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MSC-E plans for 2025

Operational modelling

- Pollution levels and transboundary transport of heavy metals (Cd, Pb, Hg) and POPs (PAHs, PCBs, PCDD/Fs, HCB) in 2023

Research and development activities

- GLEMOS model updates (HM processes, multi-media POP dispersion)
- TF HTAP: Participation in MCHgMAP project (1.1.4.3)
- TF HTAP: Contribution to multi-pollutant multi-effects study of wildfires (1.1.4.4)

MSC-E plans for 2025

Research and development activities (cont.)

- TFMM: Contribution to cooperative activities on contaminants of emerging concern (CECs) (1.1.1.2) and analysis of B(a)P health-related effects (1.1.1.8)
- Country-scale study of PAH pollution in Slovenia and other Balkan countries
- Further development of the Centre's website

CEIP nilu

MSC-E plans for 2025

Co-operation and outreach activities

- Renewing collaboration with ICP-Vegetation (WGE) on joint analysis of HM and POP pollution trends involving moss measurements
- Co-operation with the Marine Conventions (HELCOM and OSPAR) to assess pollution in the Baltic Sea and the Northern Atlantic
- Collaboration with the Open-Ended Science Group (OESG) of the Minamata Convention (1.3.4) and the Stockholm Convention (1.3.3)

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