EMEP MSC-E activities:

Progress and plans

Oleg Travnikov, Jan Gačnik,
Igor Živković, Saeed Waqar Ali,
Tina Kosjek, Nives Ogrinc,
Milena Horvat

Jožef Stefan Institute
Ljubljana, Slovenia

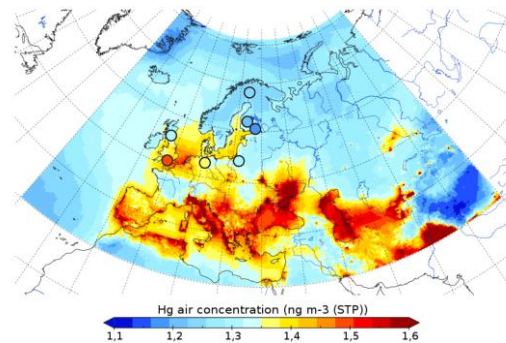# On-going research and development activities

- Preparatory work for EMEP operational modeling of HMs and POPs

- GLEMOS model update and improvements – Hg
  - New Hg chemical scheme
  - Update and evaluation of Hg^0 vegetation uptake
  - Refinement of air-water Hg exchange

- Multi-Compartment Hg Modeling and Analysis Project (MCHgMAP)

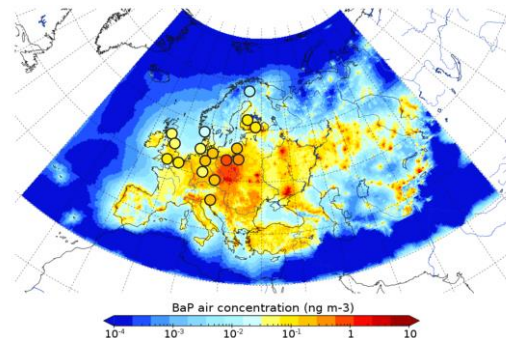- Country-scale study of PAHs pollution in Balkan countries

Preparatory work for operational modelling

- Arranging computational resources for modeling (NSC, ARNES clusters)

- Installing the modelling tools:
  - GLEMOS (v2.2.2a) – heavy metals and POPs
  - WRF (v3.7.1) – meteorological preprocessor
  - GEOS-Chem (v14.2.0) – chemical reactants

- Adapting and upgrading the GLEMOS model

- Generating input data (meteorology, reactants)

- Pilot simulations – full cycle of annual runs for Hg and B(a)P for 2022

Hg concentration (2022)

Hg air concentration (ng m-3 (STP))
1,1   1,2   1,3   1,4   1,5   1,6

B(a)P concentration (2022)

BaP air concentration (ng m-3)
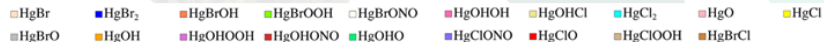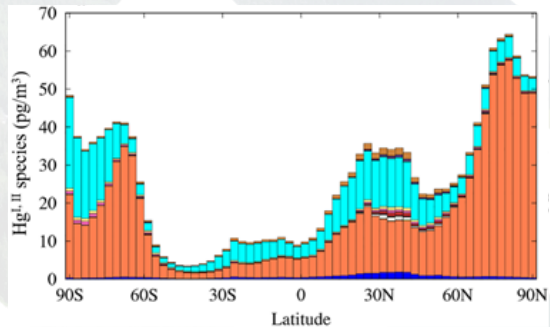10⁻⁴   10⁻³   10⁻²   10⁻¹   1   10
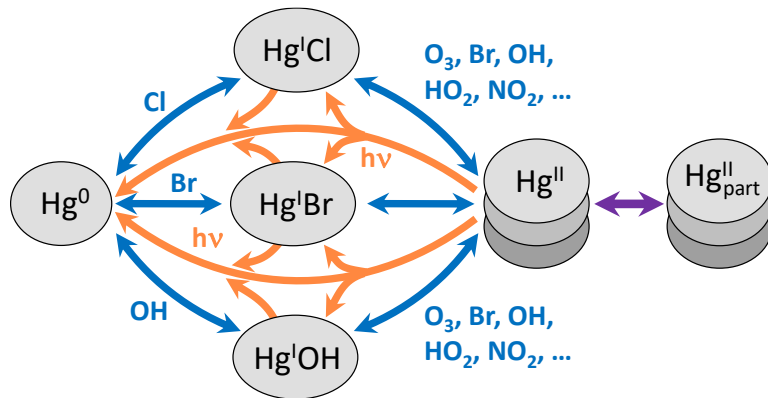
Hg atmospheric chemistry

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)

Hg chemical mechanism

Speciation of Hg^{II} in surface air

Hg uptake by vegetation

Update of Hg dry deposition scheme:

- Refinement of Hg^0 gaseous uptake by forest foliage in GLEMOS

- Evaluation against Hg measurements from ICP-Forests

- Hg concentrations in foliage (>2000 samples) and bottom-up estimates of Hg foliage uptake flux

- Sensitivity analysis of different deposition schemes

ICP-Forest Hg sampling plots

- ash
- beech
- Douglas fir
- fir
- hornbeam
- larch
- oak
- pine
- spruce
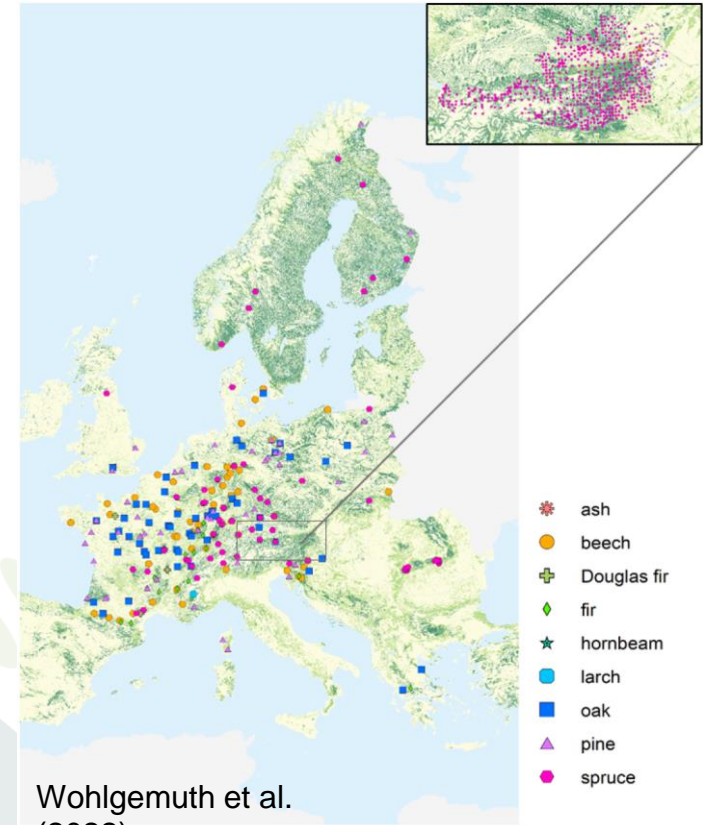
Wohlgemuth et al. (2022)

Hg air-water exchange

Update of Hg air-water exchange:
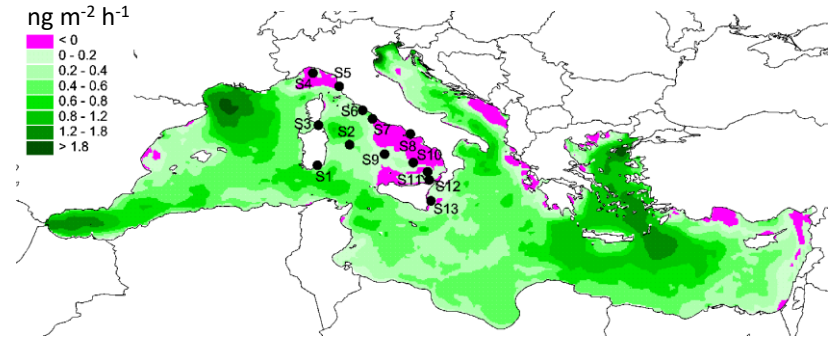
- Implementation of improved air-water exchange scheme for Hg^0

- Pilot simulations of Hg air-water exchange over the Mediterranean Sea (*co-operation with OGS, Italy*)

- Evaluation vs. cruise measurements (Minerva 2015)

- Estimates of the Hg atmosphere/sea exchange budget for the Mediterranean sea

Annual Hg net exchange flux (2015)

ng m^{-2} h^{-1}
- < 0
- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.2
- 1.2 - 1.8
- > 1.8

Hg atmosphere/sea exchange budget for the Mediterranean Sea
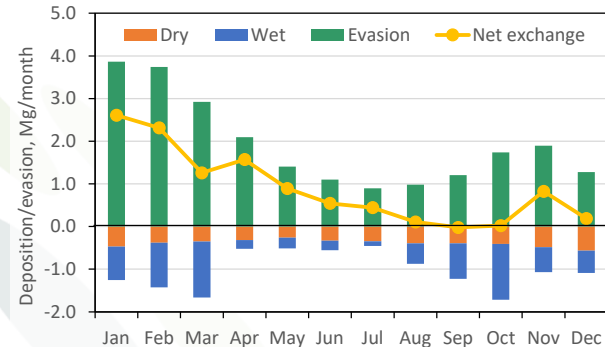
Multi-Compartment Hg Modeling and Analysis Project (MCHgMAP)

Co-operation with TF HTAP and Minamata Convention

- Focused on analysis of Hg pollution trends, source attribution, and evaluation of future scenarios

- Aimed at informing the effectiveness evaluation of CLRTAP (HM Protocol) and Minamata Convention

- Bringing together Hg emissions, monitoring and modeling communities

- Engaging Hg atmospheric, ocean and mass balance models

Coupled multi-model simulation approach
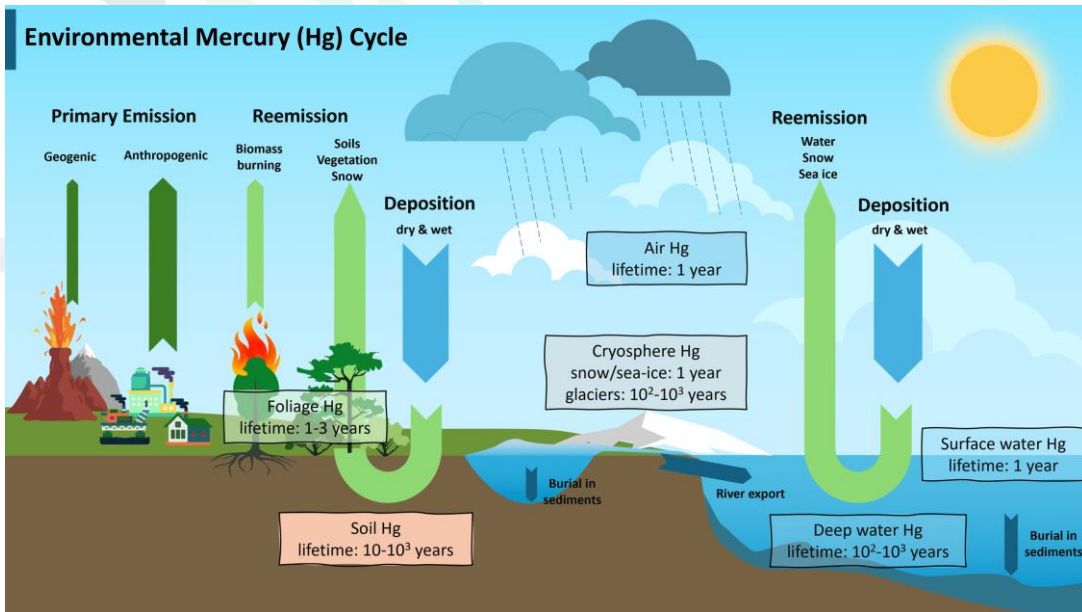
Atmosphere-ocean coupling:

- Iterative simulations (3 cycles) with off-line inter-media exchange of simulated parameters

Mass balance modeling:

- Adjusted legacy emissions from land and seawater concentration

Terrestrial modeling:

- Estimates of Hg air-surface exchange with terrestrial surfaces

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	
Global Biogeochemical Box Model (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)

Coordinated multi-model simulations (2024)

Off-line coupling atmospheric, ocean and mass balance models

- Simulated period: 2010-2020
- Main simulations: **Baseline**, **'Nature'** (fixed anthropogenic emissions)
- Optional simulations: Sensitivity runs with alternative parameterizations
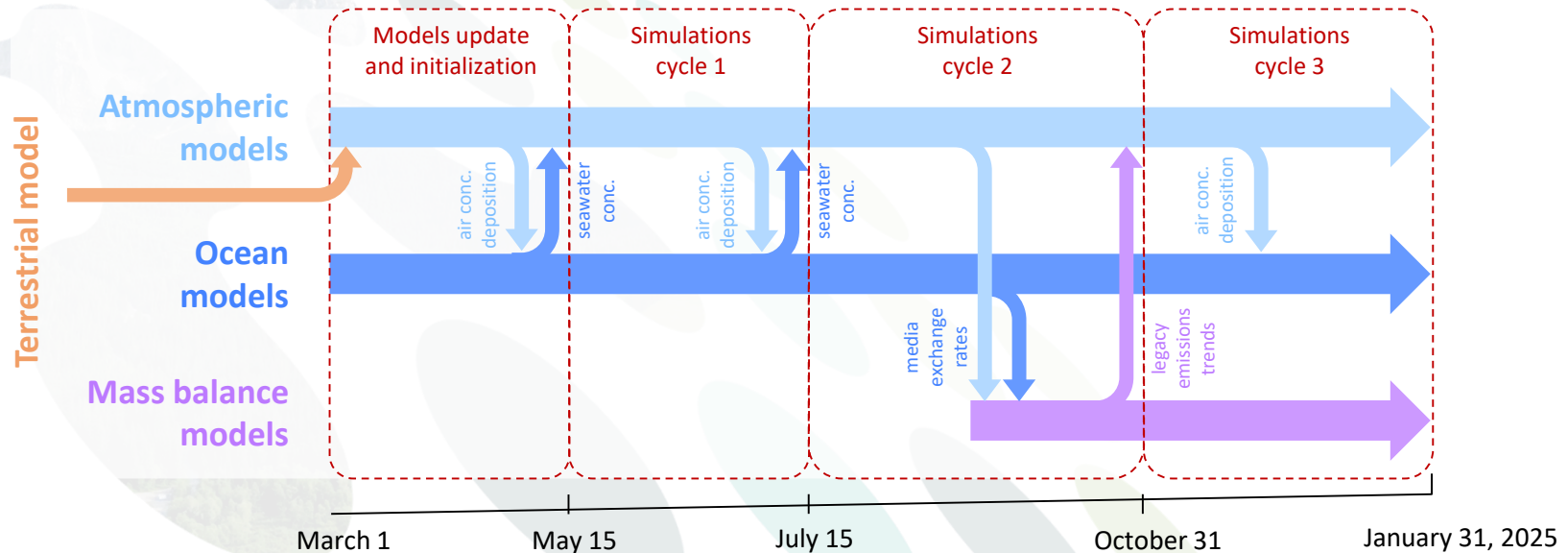
EMEP country-scale studies (2010-2020)

Countries:

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

Objectives:

- Detailed assessment of HM and POP pollution on a country scale

- Evaluation and refinement of national emission inventories

- Improvement of the modeling tools

Pollutants:

Lead (Pb), cadmium (Cd), mercury (Hg), benzo(a)pyrene (B(a)P)

New pilot study for Balkan countries

Countries:

Slovenia, Croatia, Montenegro, Serbia, Bosnia & Herzegovina, North Macedonia, Albania

Pollutants:

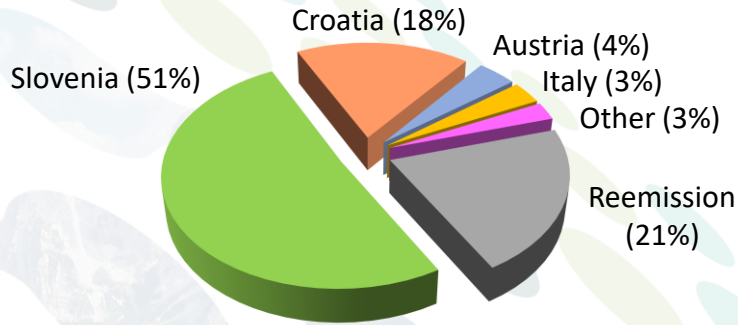PAHs (B(a)P, B(b)F, B(k)F, I(cd)P), metals (Hg, Pb, Cd)

Phase I (2025-2026):

- Slovenia: Country-scale assessment of PAHs pollution

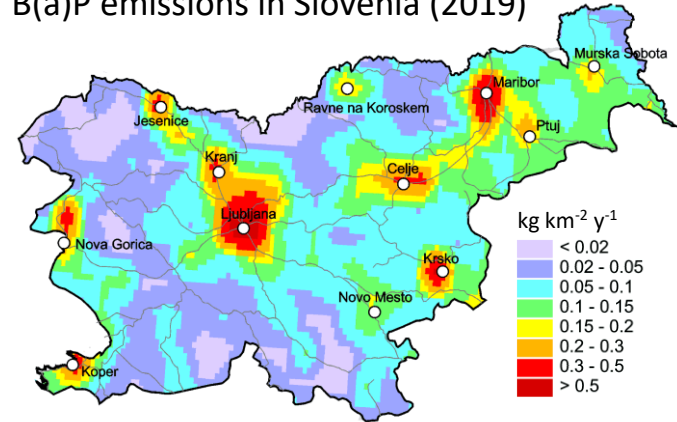- Exploring possibility to extent the study to other Balkan countries

PAH pollution in Slovenia (EMEP data)

B(a)P deposition to Slovenia (2019)

Croatia (18%)
Austria (4%)
Slovenia (51%)
Italy (3%)
Other (3%)
Reemission (21%)

B(a)P emissions in Slovenia (2019)

$kg\ km^{-2}\ y^{-1}$

< 0.02
0.02 - 0.05
0.05 - 0.1
0.1 - 0.15
0.15 - 0.2
0.2 - 0.3
0.3 - 0.5
> 0.5

- 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
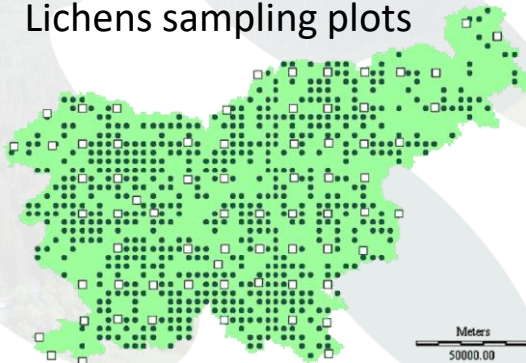
Sectoral composition of B(a)P emissions

Residential combustion (91%)

Industry (7%)

Road transport (1.5%)

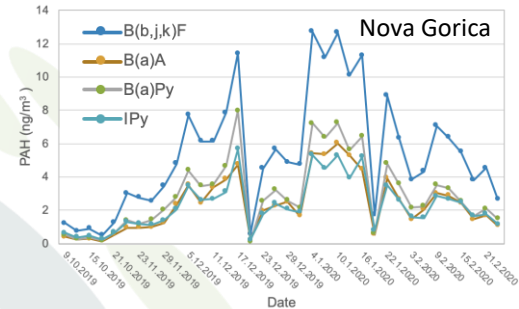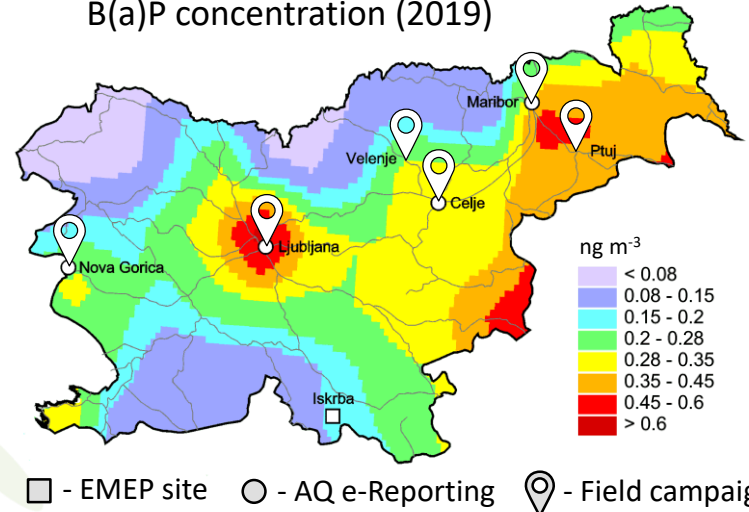Other (0.5%)
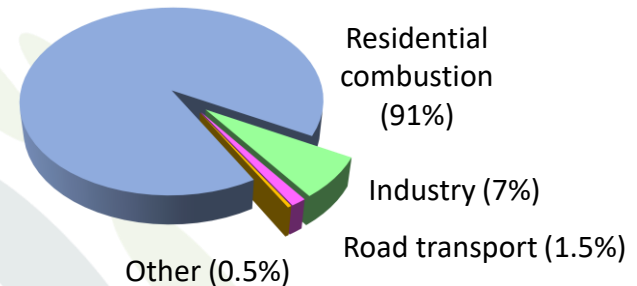
PAH observations in Slovenia

Available PAH measurements:

- EMEP measurements (Iskrba)

- Urban measurements (AQ e-Reporting)

- Measurement campaign (2019-2020) – **stable isotope** composition of PAHs

- Lichen and moss archives (collaboration with ICP-Vegetation)

B(a)P concentration (2019)

ng m^{-3}

- < 0.08
- 0.08 - 0.15
- 0.15 - 0.2
- 0.2 - 0.28
- 0.28 - 0.35
- 0.35 - 0.45
- 0.45 - 0.6
- > 0.6

☐ - EMEP site   ◯ - AQ e-Reporting   ⊙ - Field campaign

Lichens sampling plots

Meters
50000.00

Country-scale 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

Plans for 2024

Operational modelling

- Pollution levels and transboundary transport of heavy metals (Cd, Pb, Hg) and PAHs (B(a)P, B(b)F, B(k)F, I(cd)P) in 2022

Research and development activities

- GLEMOS model updates (Hg chemistry, multi-media processes for PCBs, PCDD/Fs, HCB)

- TF HTAP: Participation in MCHgMAP project (item 1.1.4.3)

- TF HTAP: Contribution to multi-pollutant multi-effects study of wildfires (item 1.1.4.4)

Plans for 2024

Research and development activities (cont.)

- TFMM: Country-scale study of PAH pollution in Slovenia and other Balkan countries

- TFMM: Contribution to cooperative activities on contaminants of emerging concern (CECs) (item 1.1.1.2)

Co-operation and outreach activities

- Collaboration with the Open-Ended Science Group (OESG) of the Minamata Convention (item 1.3.4)