Progress in development of GLobal EMEP MOdelling System (GLEMOS) for HMs and POPs

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Meteorological Synthesizing Centre East

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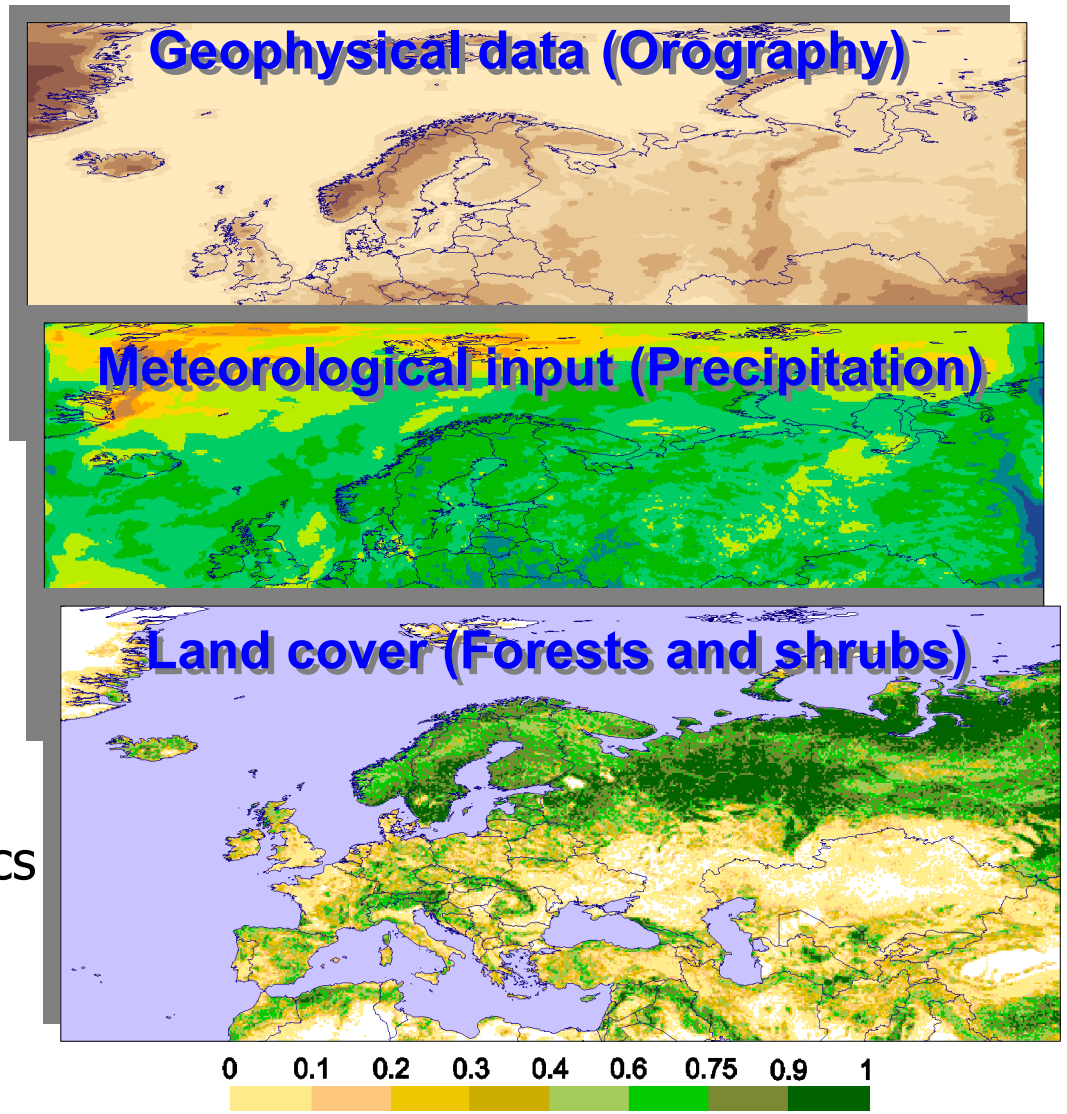
Current activities on implementation of the new EMEP grid (latitude/longitude)

- Preparation of input information for the new EMEP domain (meteorological and geophysical data, emissions)
- Global modelling using GLEMOS
- Adaptation of GLEMOS for regional simulations in the new grid
- Pilot simulations in the new grid with high spatial resolution and their evaluation
- Refinement of GLEMOS parameterizations
- Directions of further work

Current and New EMEP domains

Preparation of model input data for the new EMEP domain

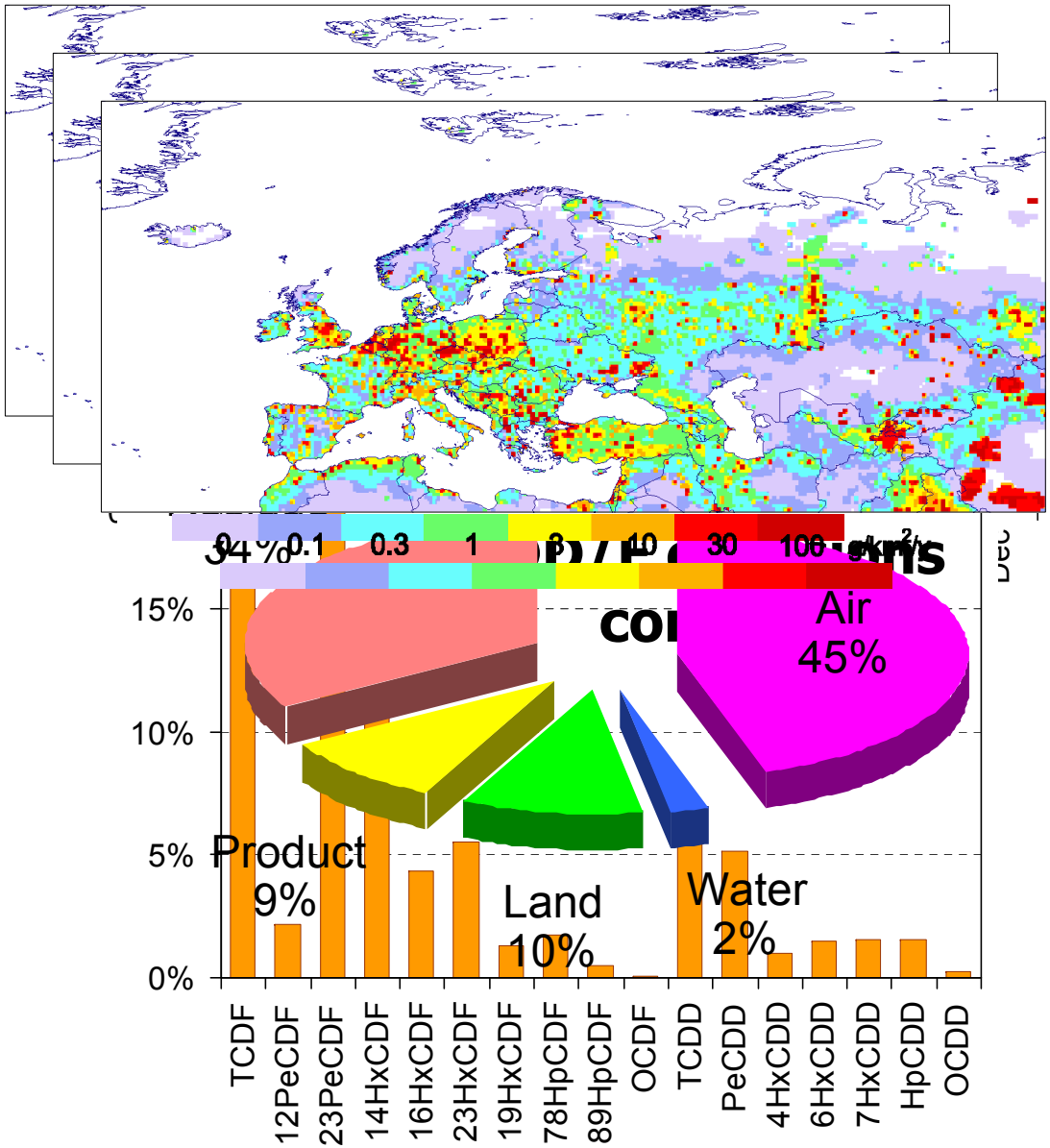
- New EMEP domain peculiarities (e.g. complex orography of Himalayas)
- Generation of meteorological input
- Land use/land cover information (consistency between EMEP Centres and WGE)
- Data on reactants and aerosols in the atmosphere
- Generation of data on sea currents
- Data on underlying surface characteristics and vegetation (LAI, OM content, …)



Preparation of emissions for HMs and POPs

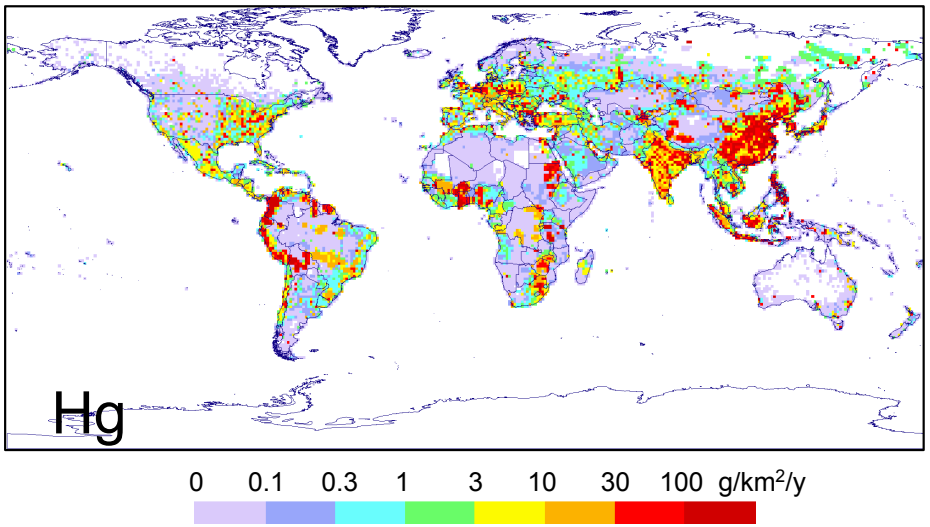
Emission data for regional modelling:

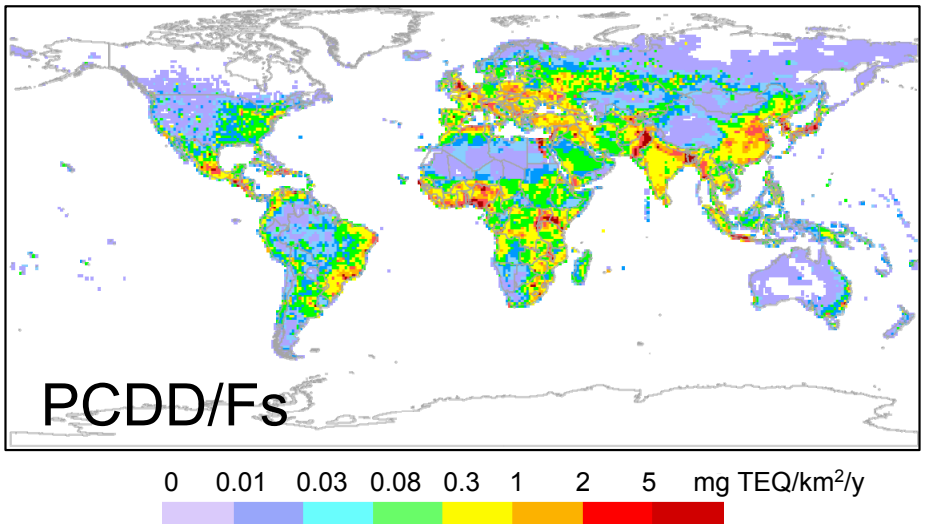
- Time-series of gridded annual emissions
- Intra-annual variations of emissions
- Emissions to other environmental media
- Speciation for Hg, congener composition for POPs
- Vertical distribution
- Secondary sources (re-suspension, re-volatilization)
- Natural emissions



Preparation of emissions for HMs and POPs

- **Global emission inventories:**
- Global Hg emissions inventory for 2010 (AMAP/UNEP, 2013)
- Global PCB emissions inventory for 1930-2100 (Breivick, 2007)
- Global PCDD/F emissions inventory based on UNEP Toolkit, 1999-2009 (Fiedler et al., 2007, 2012)
- Scenario of global HCB emissions 1945-2012 (MSC-E)



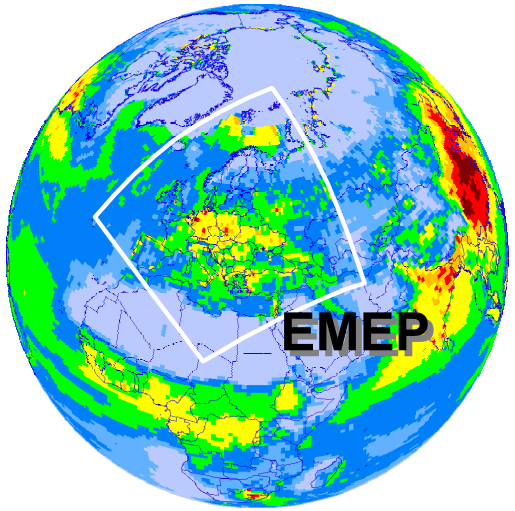


Pollution of EMEP domain by global sources

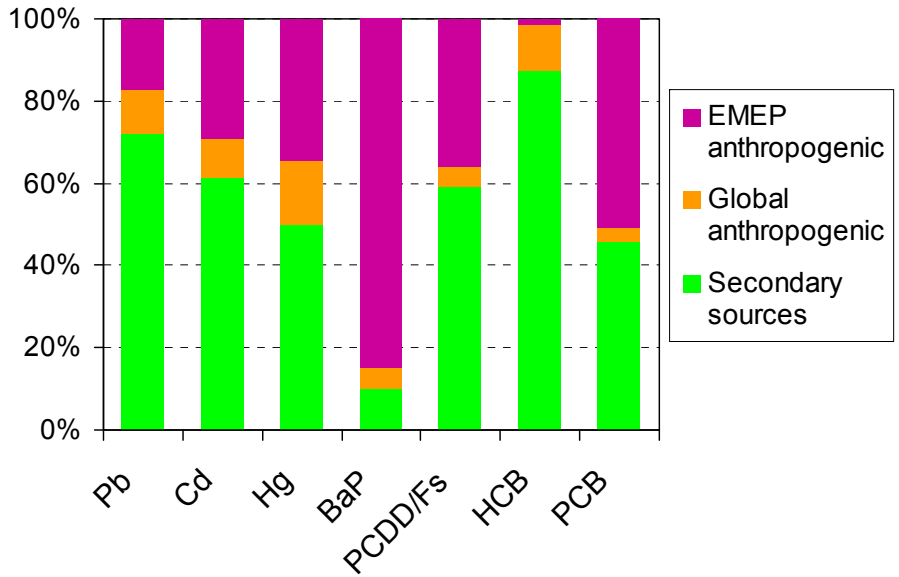
Global scale modelling provides:

- Boundary conditions for EMEP domain
- Initial concentrations in media within EMEP domain
- Contributions of non-EMEP anthropogenic and secondary emissions
- Influence of EMEP emissions on other regions (e.g. Arctic)

Hg deposition (2010)

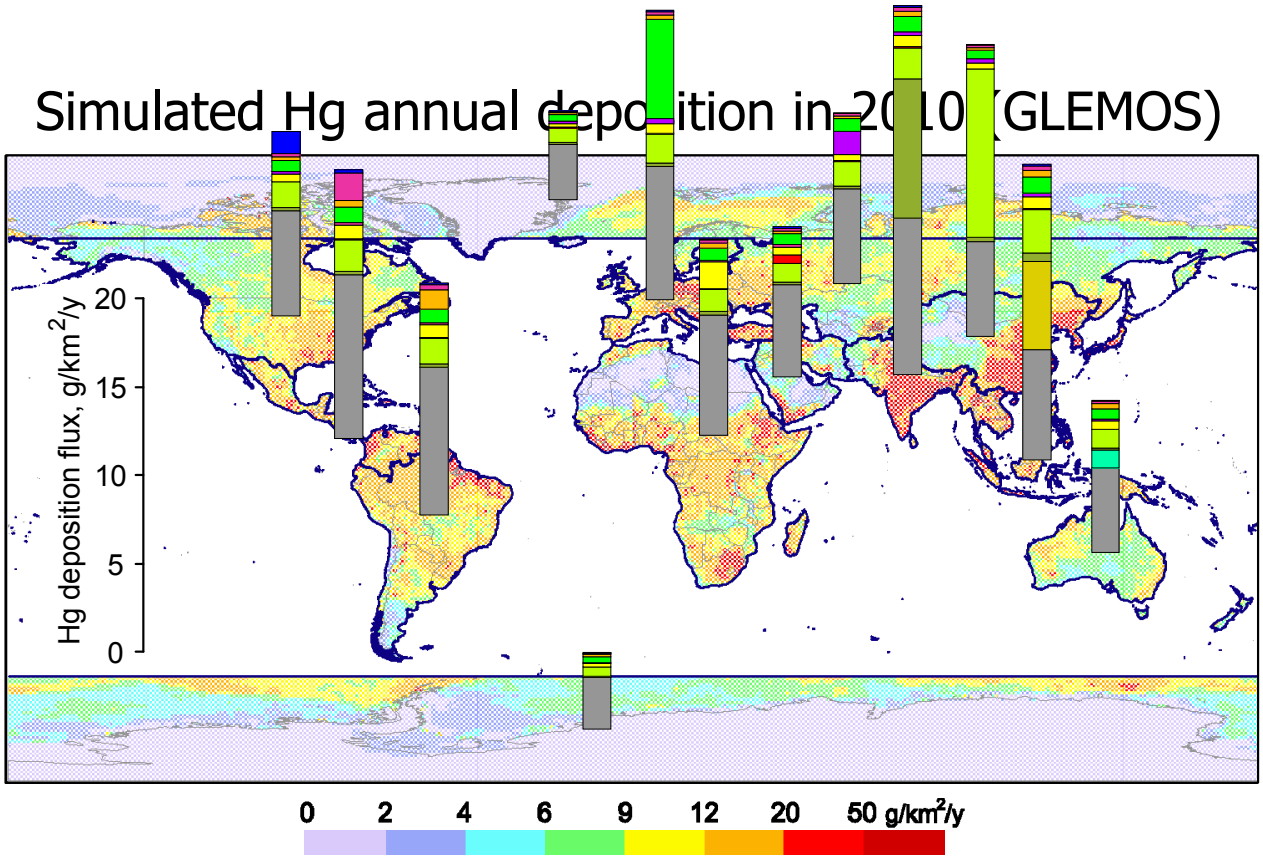


EMEP pollution by different sources types

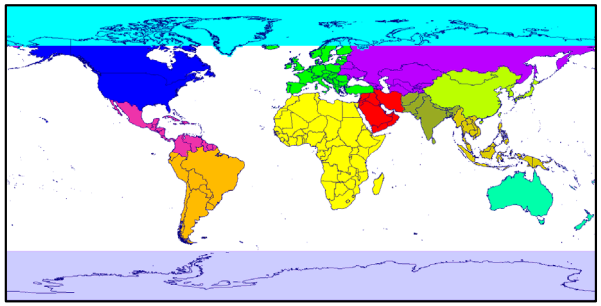


Intercontinental transport of Hg

Source-receptor modelling experiments (TF HTAP)



Source regions



Source/receptor regions:

- North America
- Mexico & Central America
- South America
- Europe
- CIS countries
- Africa
- Middle East
- East Asia
- South Asia
- South East Asia
- Australia and New Zealand
- Arctic
- Antarctica
- Natural and legacy sources

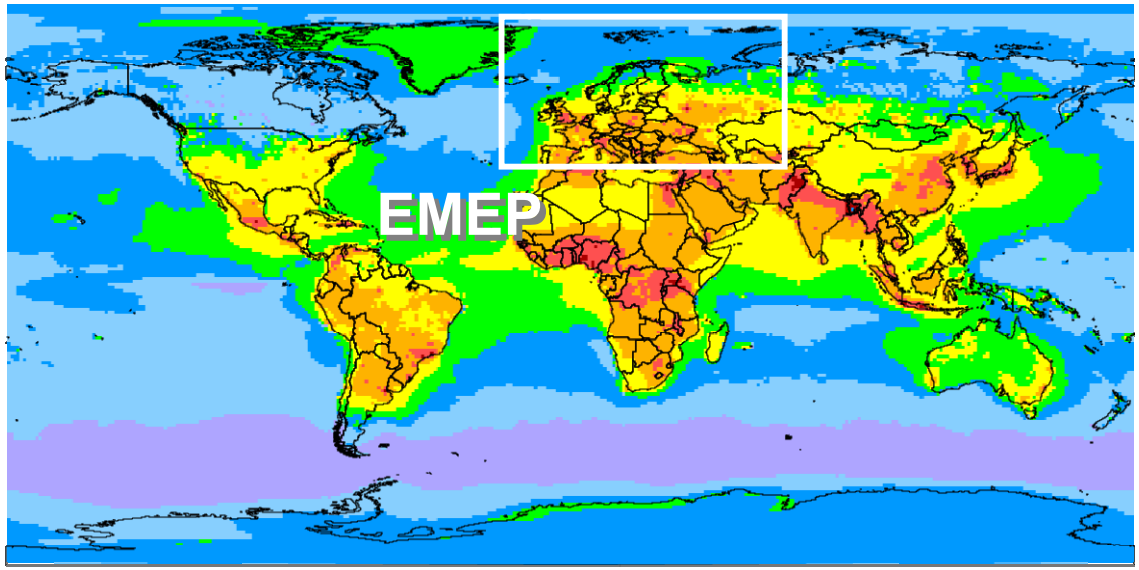
Source apportionment of Hg deposition (2010)

EMEP pollution by PCDD/F global sources

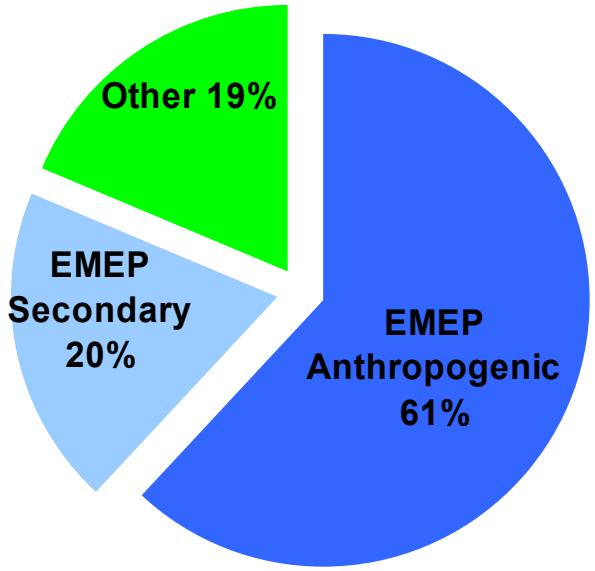
Experimental modelling (in lat/lon projection) using UNEP Stockholm Convention data on PCDD/F emissions

- National inventories of PCDD/F emissions of 68 countries (PCDD/F Toolkit)
- Expert estimates for other countries using regression analysis
- Emission inventories cover the period ~1999-2009
- Scenario of emissions includes PCDD/F releases to air and soil

PCDD/F air concentrations for 2012

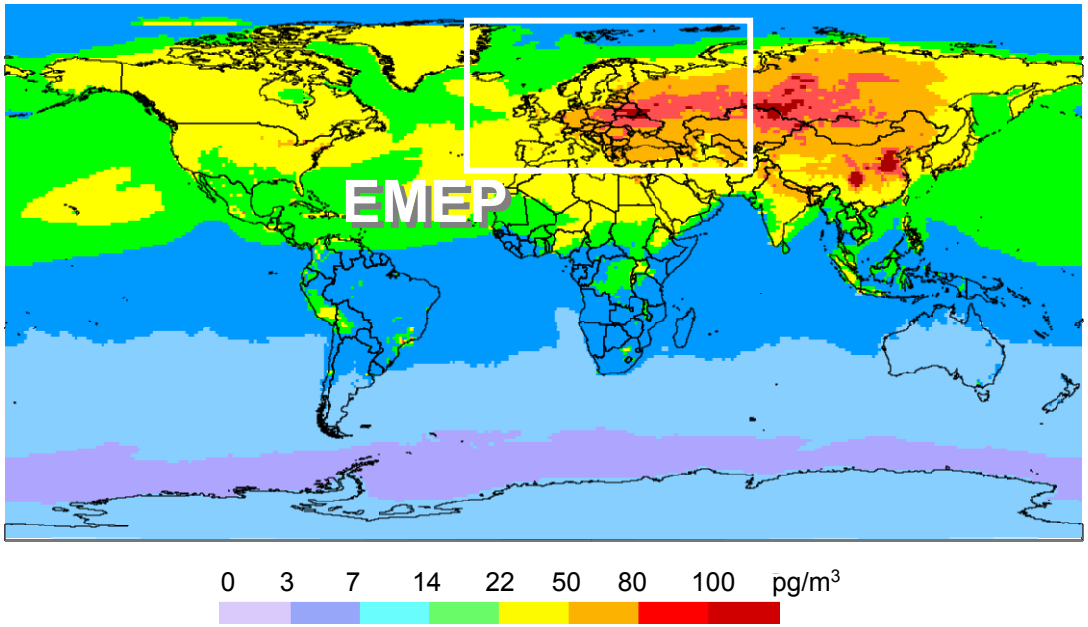


Contributions of EMEP and other sources

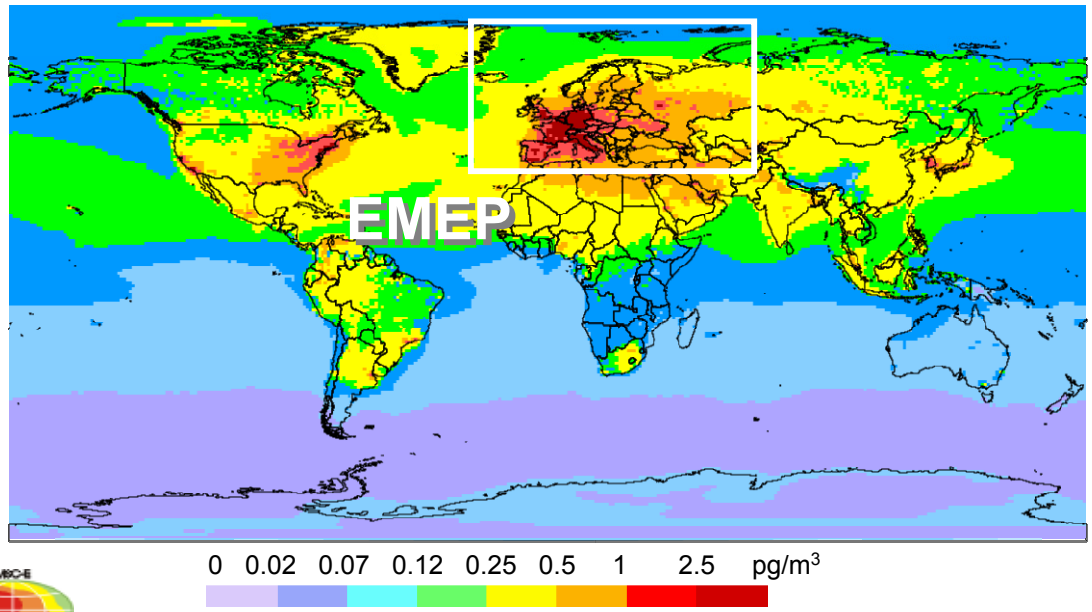


EMEP pollution by global PCB and HCB sources

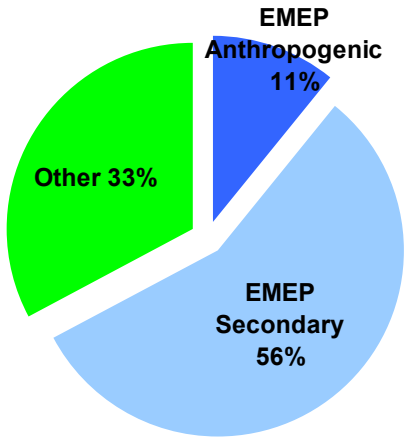
HCB air concentrations for 2012



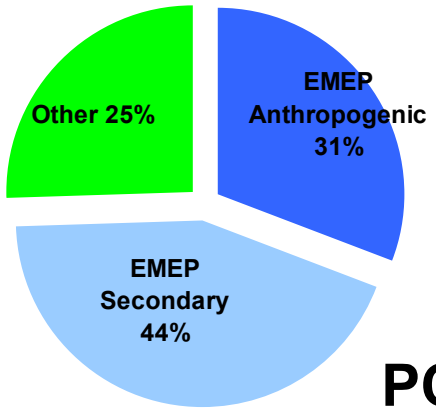
PCB-153 air concentrations for 2012



Contributions of EMEP and other sources



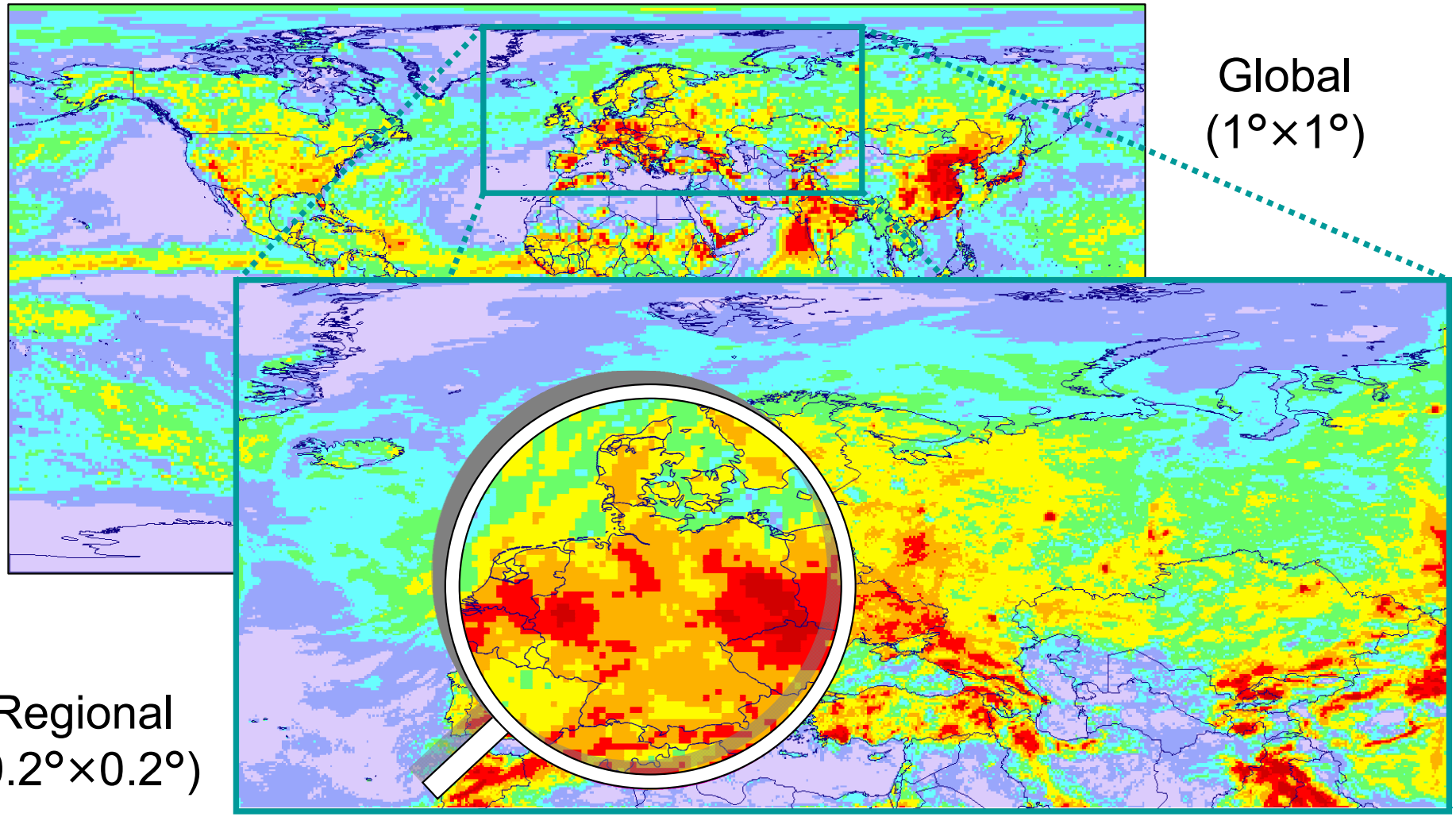
HCB



PCB-153

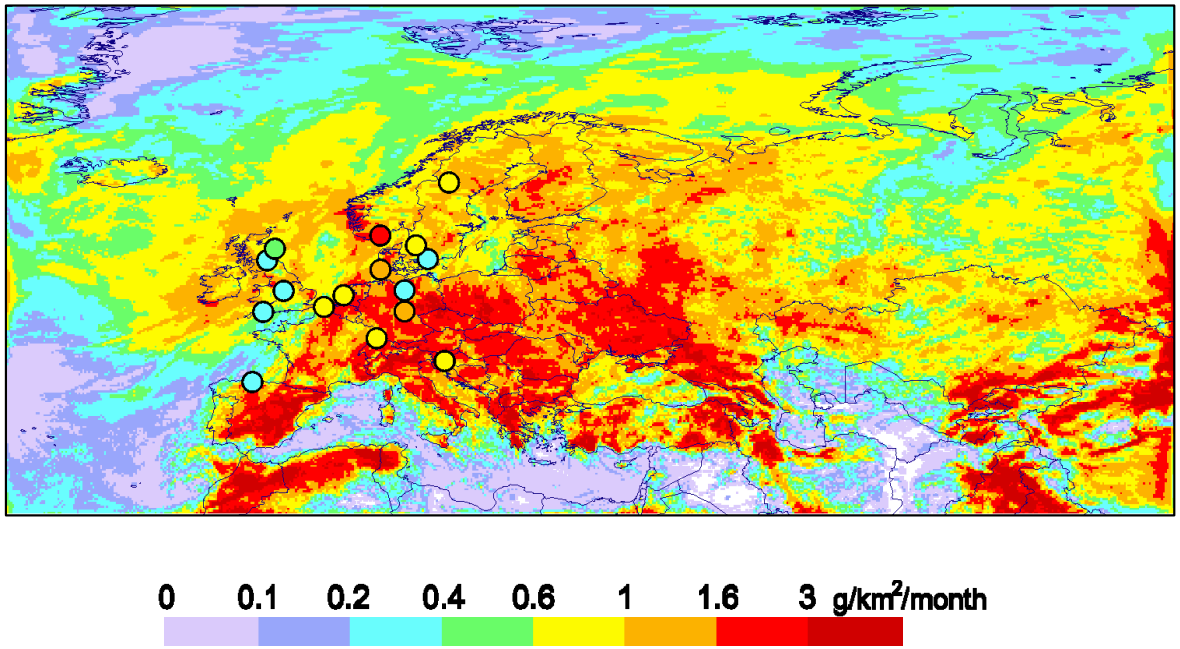
Pilot model simulations for Hg in the new EMEP grid

Simulated annual Hg deposition flux (July 2010)

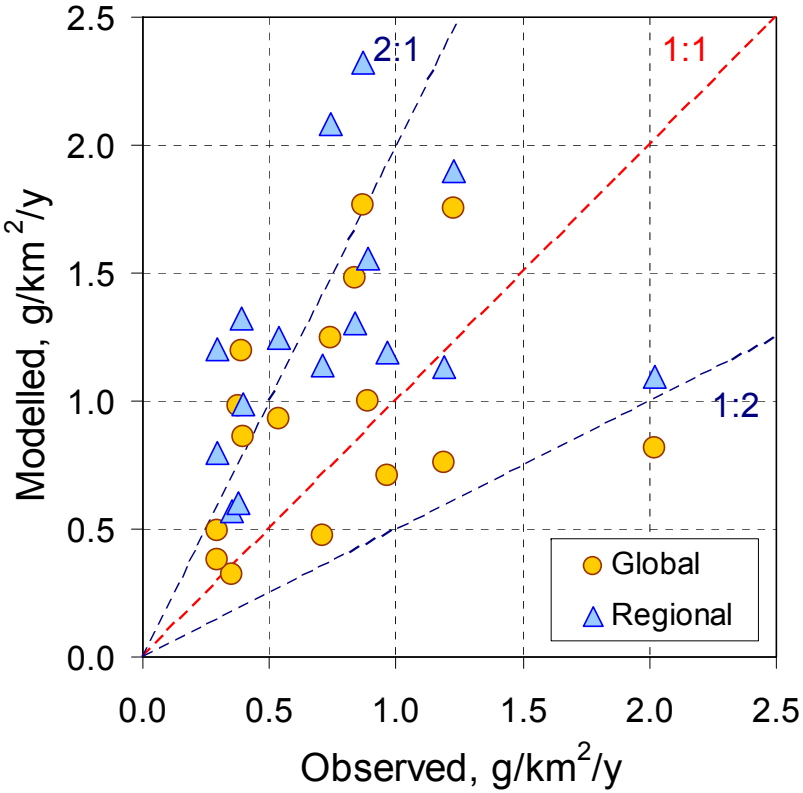


Evaluation of pilot modelling results

Map of simulated Hg wet deposition and comparison with EMEP measurements (July 2010)



Hg wet deposition (0.2°×0.2°) and locations of EMEP monitoring sites



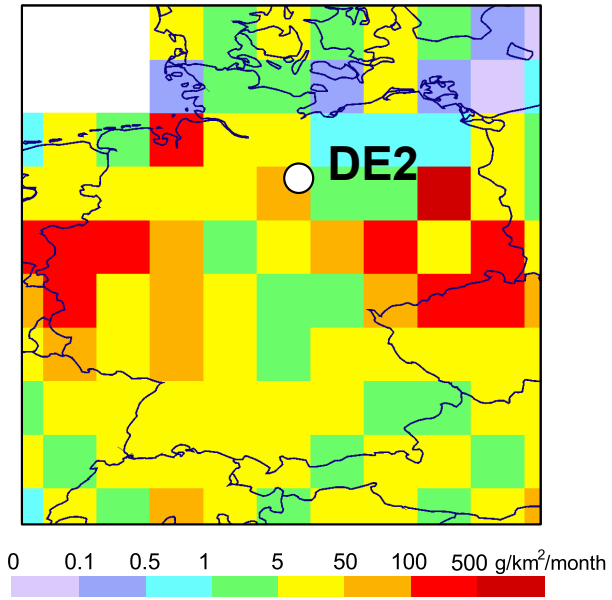
There is ongoing work on the comparison with modelling results for currently used EMEP domain

Global (1°x1°) and regional (0.2°x0.2°) Hg wet deposition vs. EMEP measurements

Evaluation of pilot modelling results

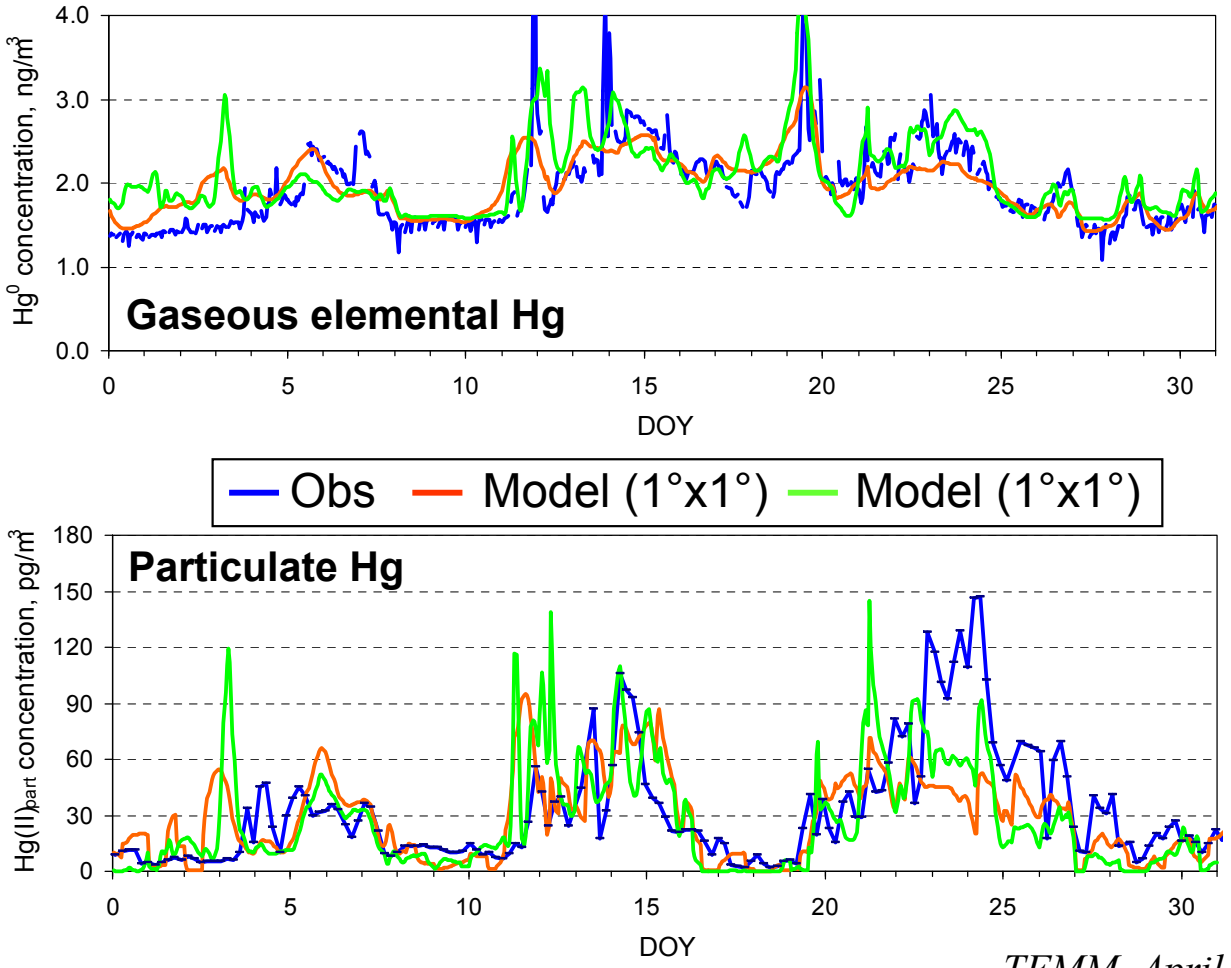
Hg modelled concentration vs. measurements at Waldhof (DE2)

Location of Waldhof site



Underlying map – Hg anthropogenic emissions (1°x1°)

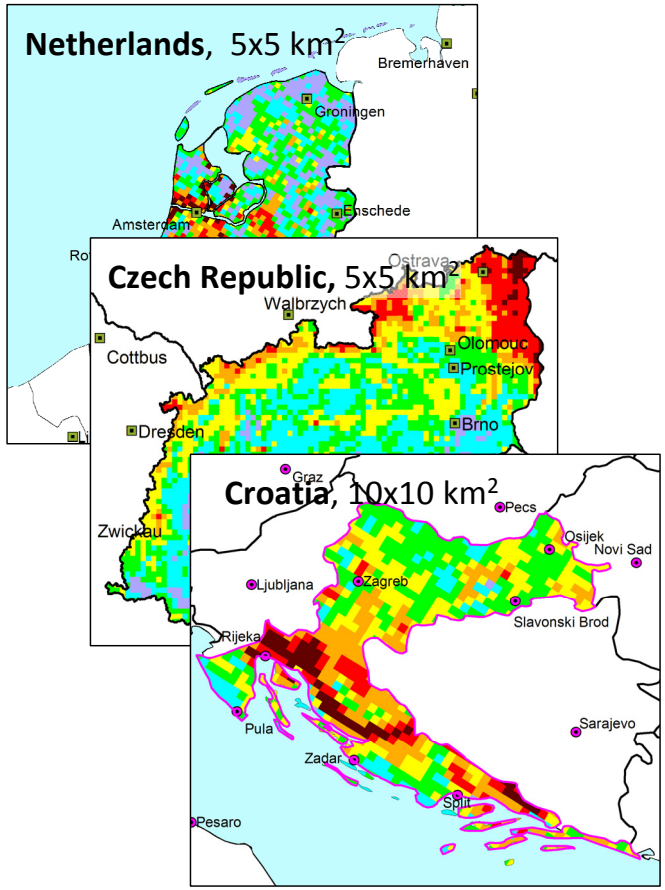
Comparison of hourly Hg concentration, January 2010



Fine resolution modelling of HMs

Country-specific case studies:

- Preparation of fine scale model input data
- Nesting from regional to local scale
- Comparison of modelling results with fine resolution national measurements
- Application of inverse modelling for the analysis of discrepancies
- Improvement of model parameterizations when modelling with fine resolution



Pb, Cd deposition in the Netherlands, Croatia, and the Czech Republic

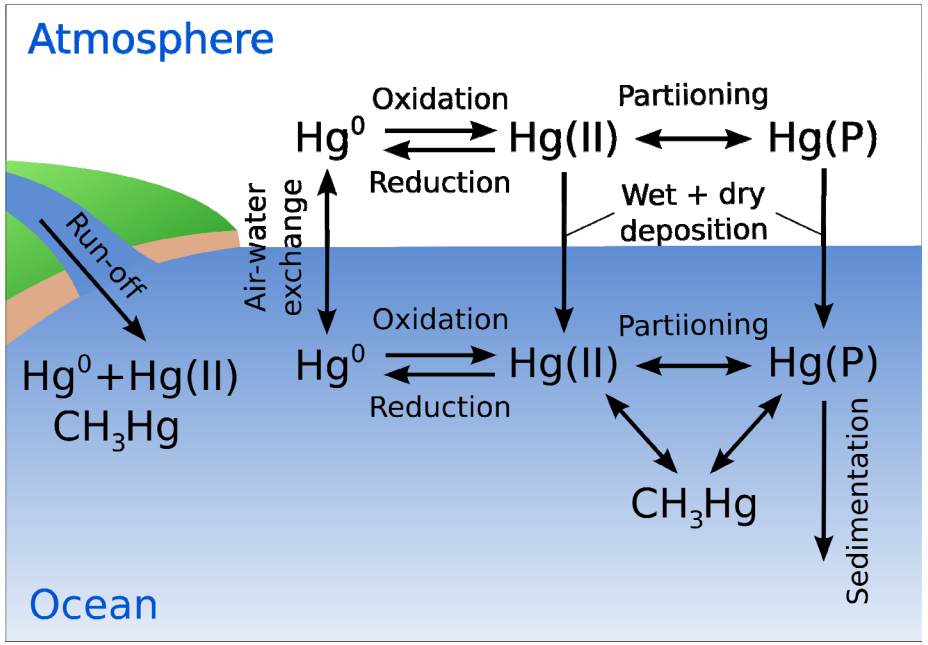
Further development of GLEMOS

Elaboration of multi-media model approach for Hg

Development of model parameterizations:

- Air-water exchange of Hg between the atmosphere and the ocean
- Hg oxidation and reduction under solar and dark conditions
- Hg adsorption by suspended particulate matter and colloids
- Methylation and demethylation (biotic and abiotic)

General cycling of Hg in the ocean



Literature survey of Hg processes in seawater is in press in *Ocean Science Discussion* (Batrakova et al., 2014)

Further development of GLEMOS

Sub-grid vertical distribution of air concentration

Motivation:

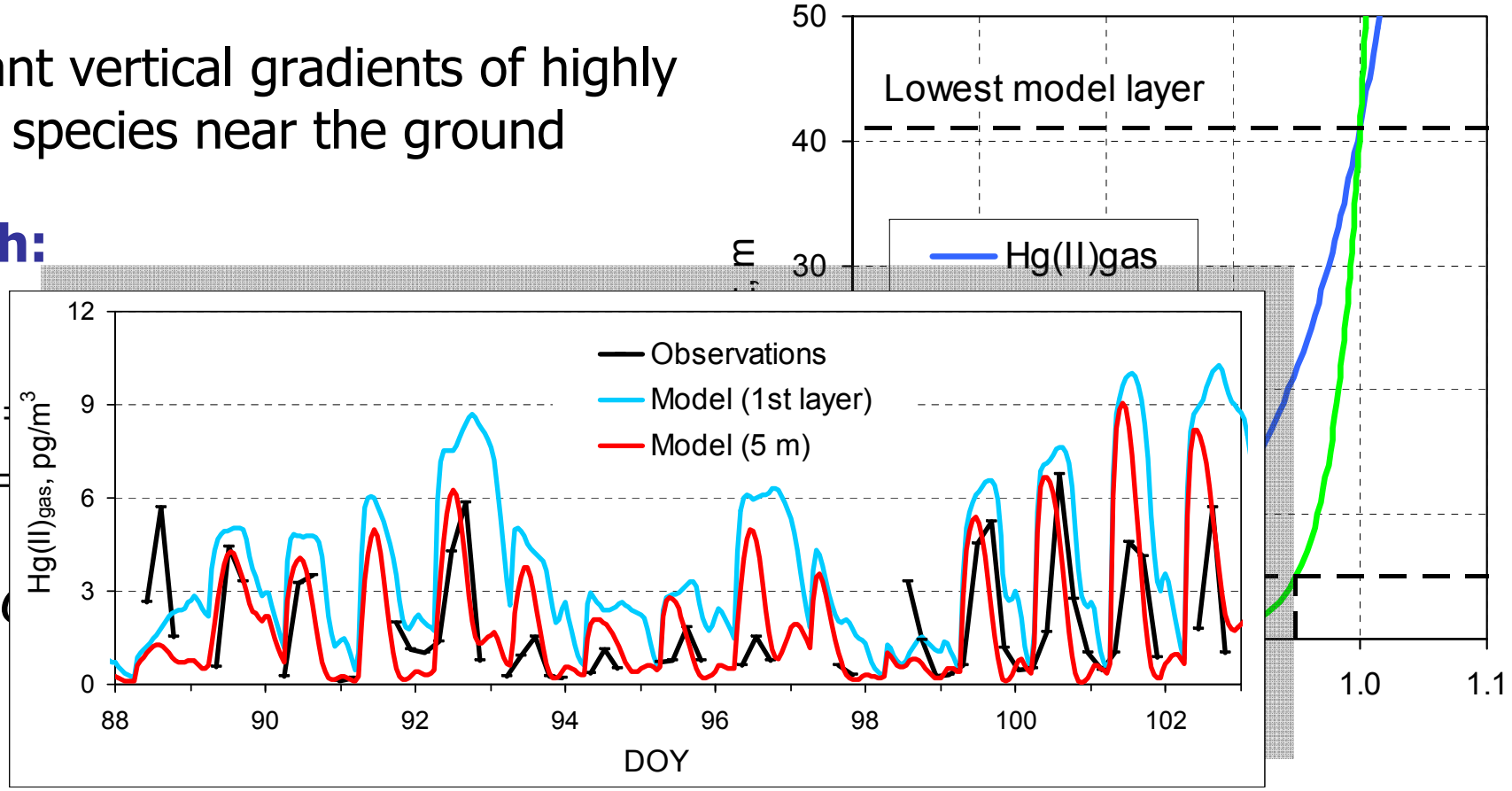
Significant vertical gradients of highly reactive species near the ground

Approach:

$$F_{dry}(z) =$$

$$V_{dry}(z) =$$

$$C(z) = C$$



Further development of GLEMOS

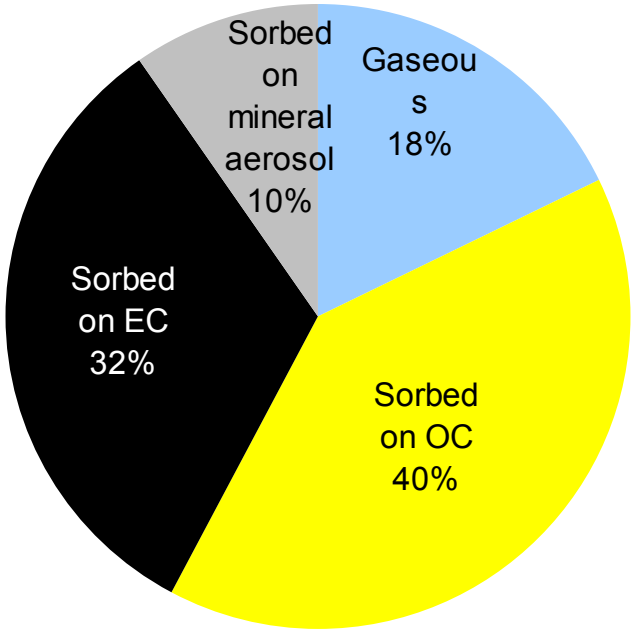
Parameterizations of POP sorption on aerosols and degradation in particulate phase

Motivation:

Differences between modelled and measured seasonal air concentrations

Modifications:

- Inclusion of POP sorption mechanisms to different components of aerosol particles (mineral part, OC, EC)
- Inclusion of POP degradation in particulate phase



Distribution of B[a]P in air between different phases at 10 ºC (background regions)

Further development of GLEMOS

Parameterizations of POP sorption on aerosols and degradation in particulate phase

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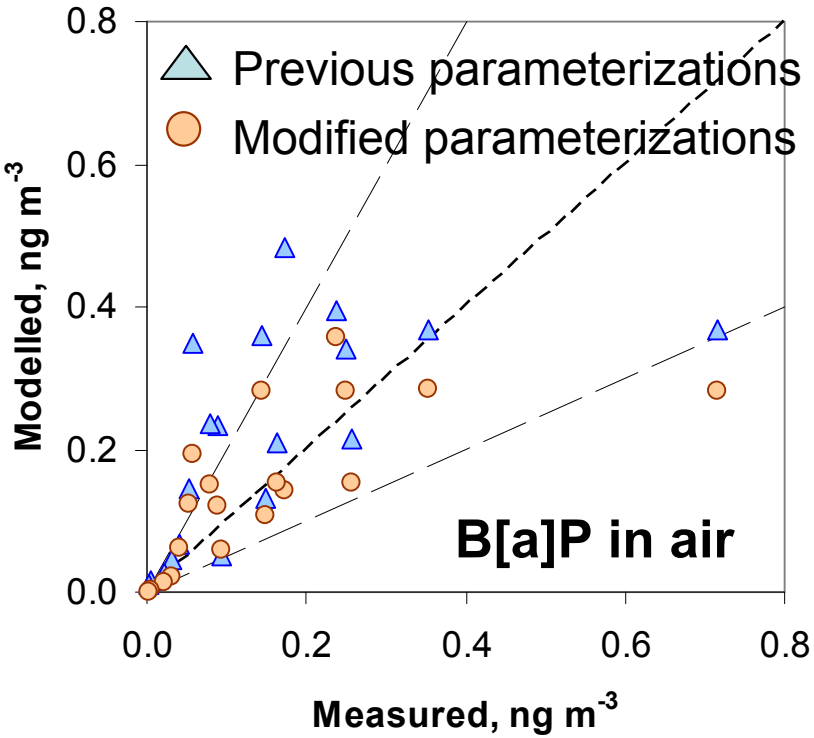


Improvement of agreement between modelled and measured B[a]P concentrations

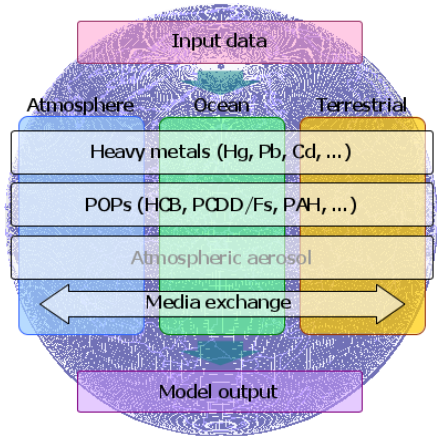
	Rel. bias	Corr
Previous	39 %	0.59
Modified	**-5 %**	**0.68**

Preparation of GLEMOS for public use

Main components of distribution:

- ✓ Free access to the model code (GPLv3)
- ✓ Model documentation and user guide
- ✓ Input data for test model runs
- ✓ Examples of the model applications (Hg and POPs)
- ✓ Web portal for support of public access and use of the model by countries

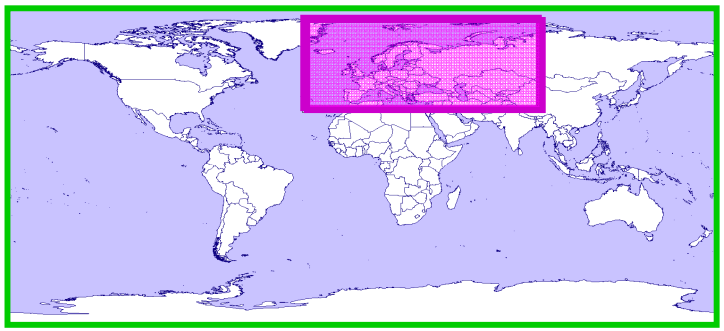
GLEMOS



GLEMOS features:

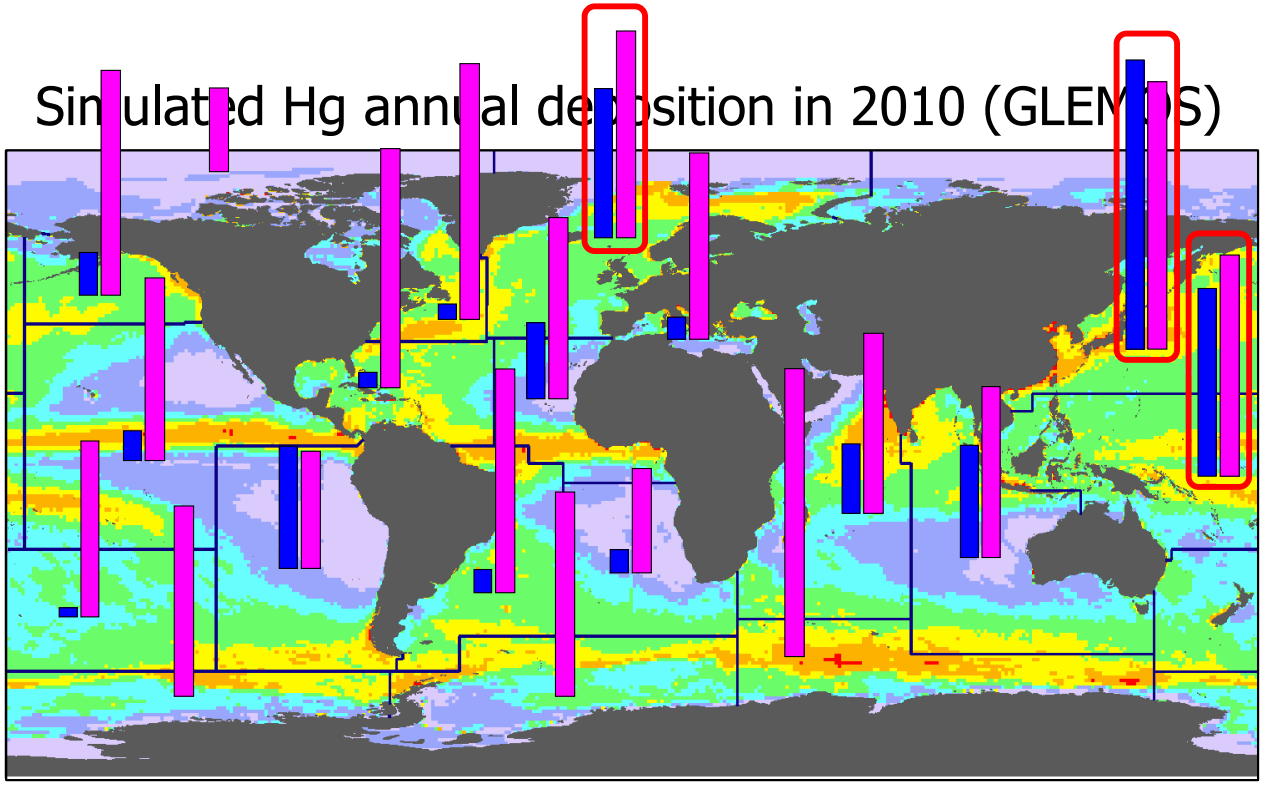
- ✓ Multi-scale consistent approach (from global to local)
- ✓ Multi-pollutant formulation (HMs, POPs, aerosol, ...)
- ✓ Multi-media model approach
- ✓ Flexible modular architecture

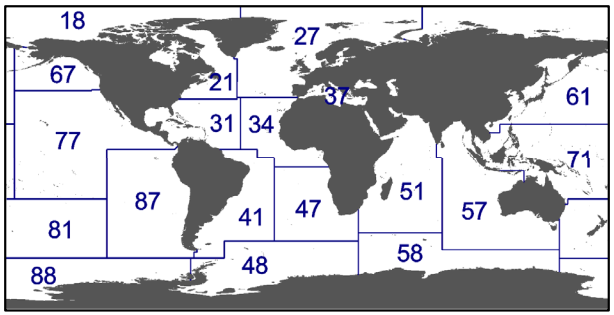
Base model domains: EMEP and global



Dissemination of results

Source attribution of Hg deposition to fishing areas (2010)

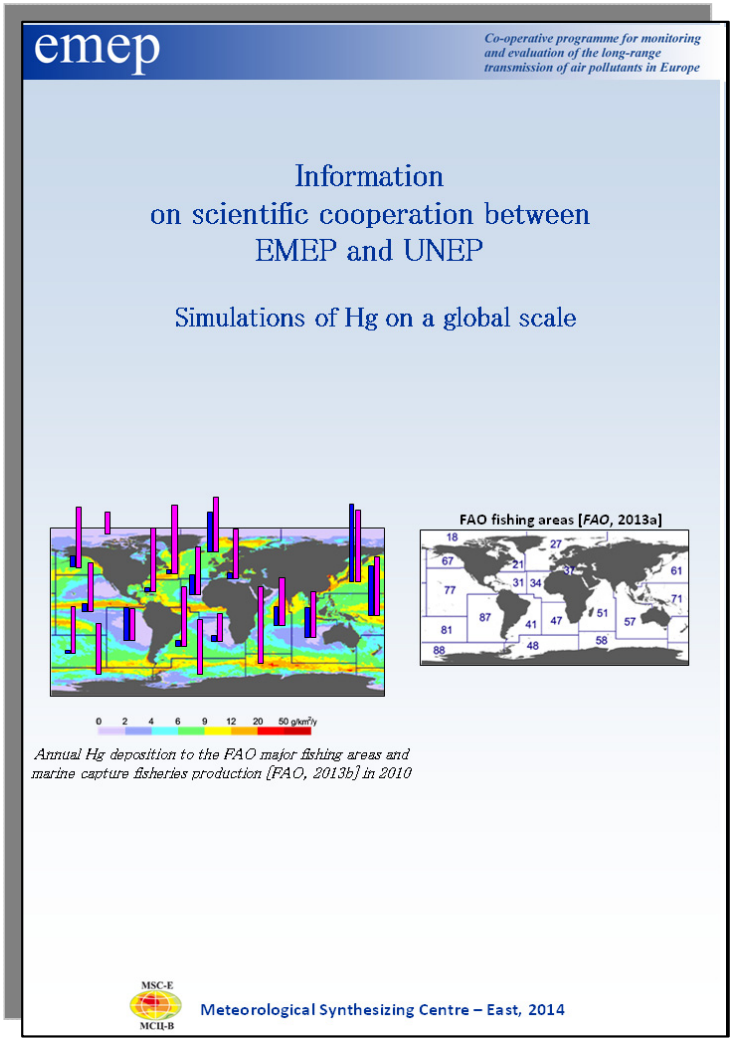


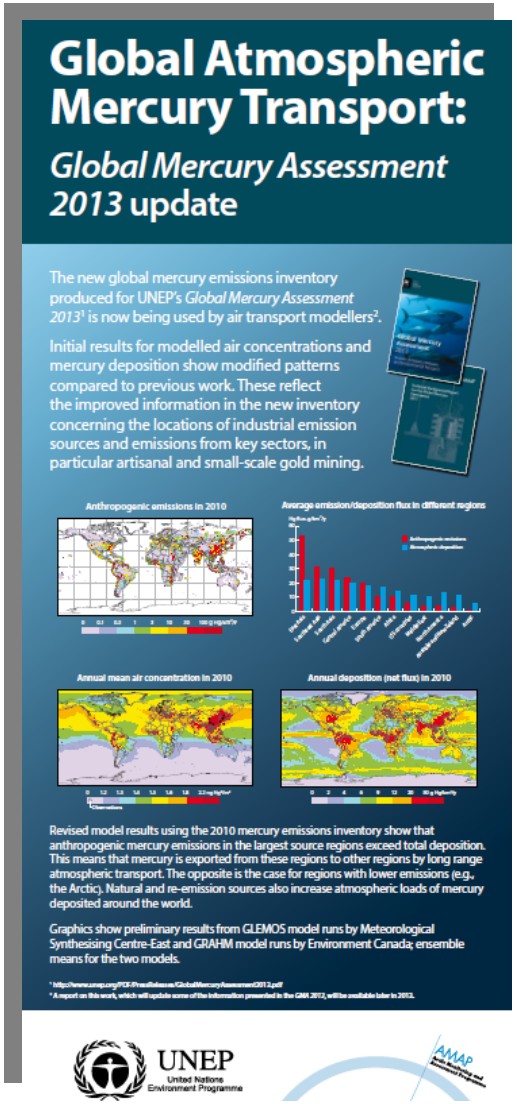


18 - Arctic Sea
21 - Northwest Atlantic
27 - Northeast Atlantic
31 - Western Central Atlantic
34 - Eastern Central Atlantic
37 - Mediterranean and Black Sea
41 - Southwest Atlantic
47 - Southeast Atlantic
48 - Antarctic Atlantic
51 - Western Indian Ocean
57 - Eastern Indian Ocean
58 - Antarctic Indian Ocean
61 - Northwest Pacific
67 - Northeast Pacific
71 - Western Central Pacific
77 - Eastern Central Pacific
81 - Southwest Pacific
87 - Southeast Pacific
88 - Antarctic Pacific

Dissemination of results

Results of Hg pollution assessment were used during preparation of UNEP Minamata Convention





Directions of further activities

- Transition to the lat/lon grid with fine resolution
- Improvement of ocean module and multi-media approach
- Source apportionment of HM and POP pollution over longer periods (tagging of accumulation and media exchange)
- Evaluation of secondary sources contributions (re-volatilization and re-suspension)
- Focus of the assessment output on evaluation of HM and POP impacts on human health and ecosystems
- Enhancement of co-operation with international organizations (UNEP Minamata and Stockholm Conventions, AMAP)