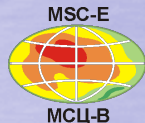


Heavy metal pollution assessment: emissions, monitoring and modelling

O. Travnikov, I. Ilyin, M. Kleimenov, O. Rozovskaya, I. Strijkina (**MSC-E**)

W. Aas, K. Breivik, H.L. Halvorsen, P.B. Nizzetto, K.A. Pfaffhuber (**CCC**)

K. Mareckova, S. Poupa, R. Wankmueller, B. Ullrich (**CEIP**)



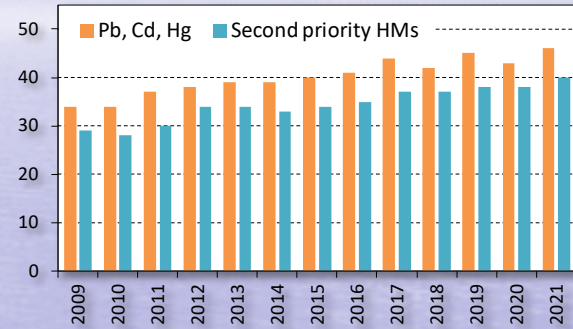
Heavy metal emissions (CEIP)

Main activities:

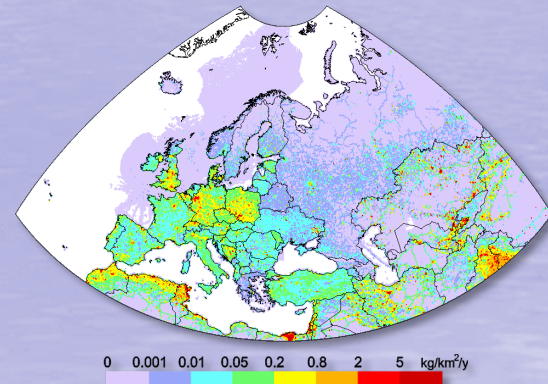
- Collection, check, and analysis of emissions reporting by countries (CEIP)
- Gaps filling and preparation of gridded emissions for modelling (CEIP)
- Preparation of additional emissions parameters (*vertical distribution, seasonal variation, speciation*) (MSC-E)
- Collection of global emissions data (MSC-E)

Note: *Long-term time series of heavy metal gridded emissions are not prepared*

Number of countries reported HM emissions

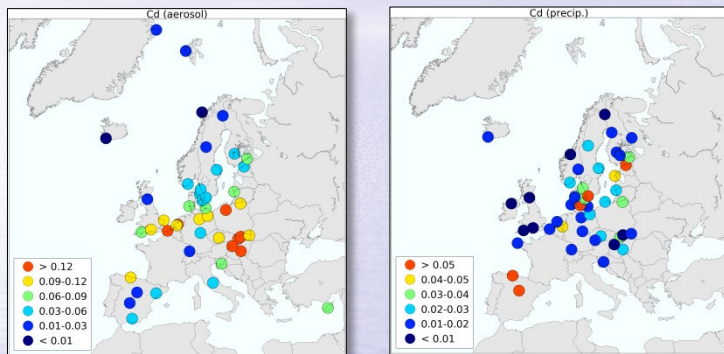


Pb anthropogenic emissions in 2019

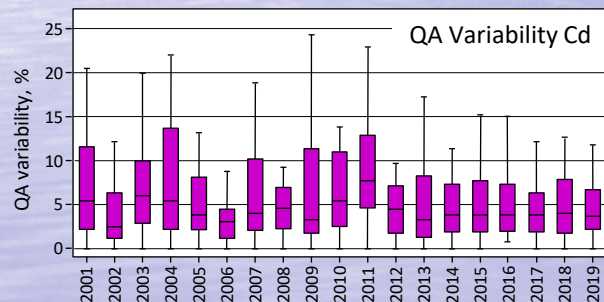


Monitoring of heavy metals (CCC)

Measurements of Cd in air and precipitation (2019)



QA variability of Cd measurements



Main activities:

- Support, co-ordination, and collection of heavy metal measurements (CCC)
- Checking and storing data in the EBAS database (CCC)
- Collection of auxiliary measurements (MSC-E)
- Regular EMEP laboratory intercomparisons for QA of wet deposition measurements (CCC, countries)

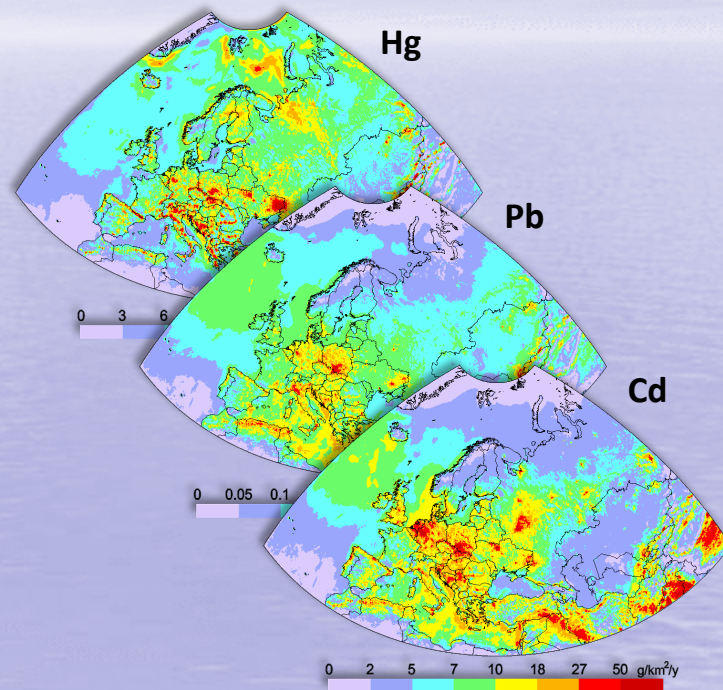
Note: *Hg data are not included to the QA process. A new field intercomparison is proposed (CCC).*

Heavy metal pollution assessment (MSC-E)

Main activities:

- Modelling heavy metal (**Cd**, **Pb**, **Hg**) pollution on regional and global scales
- Preparation of **country-specific information** on heavy metal pollution (website)
- Evaluation of **ecosystem-specific deposition** for exposure assessment
- **Update** and **improvement** of the modelling tools in co-operation with scientific community

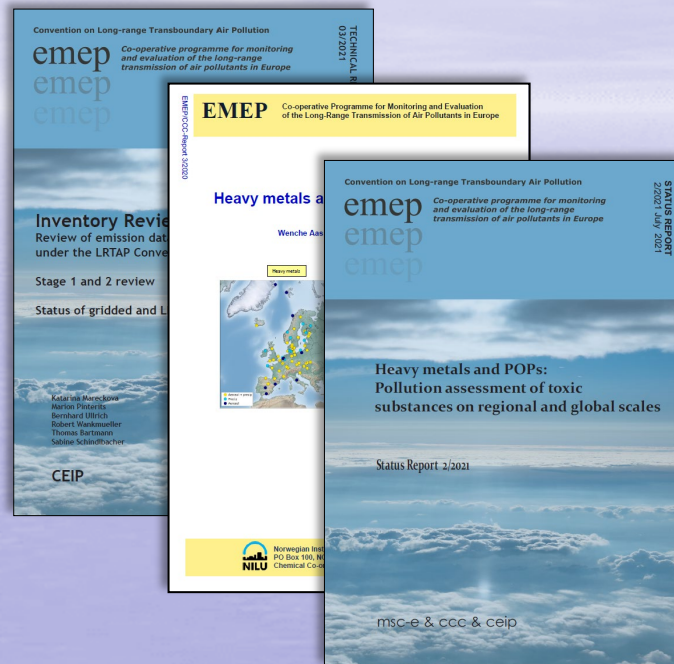
Heavy metal deposition (2019)



Heavy metal pollution assessment (MSC-E)

Main activities:

- Modelling heavy metal (**Cd**, **Pb**, **Hg**) pollution on regional and global scales
- Preparation of **country-specific information** on heavy metal pollution (website)
- Evaluation of **ecosystem-specific deposition** for exposure assessment
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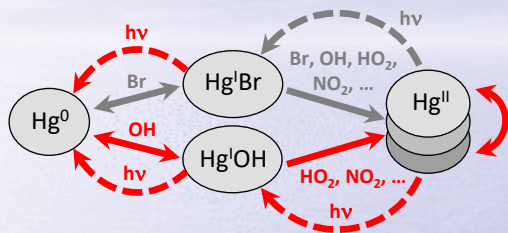
CEIP: www.ceip.at

CCC: projects.nilu.no/ccc/

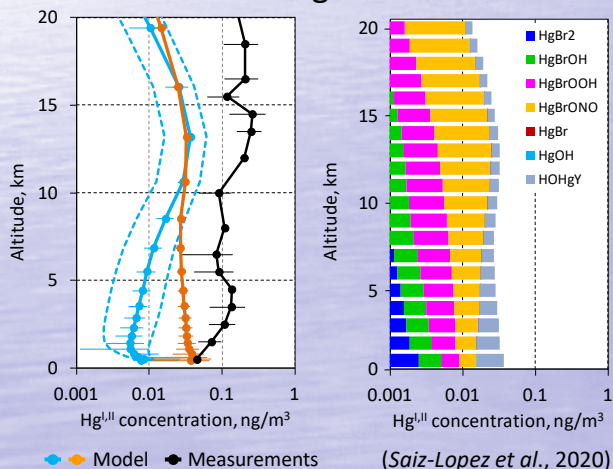
MSC-E: www.msceast.org

Model study of Hg atmospheric chemistry

General scheme of Hg redox chemistry



Simulated Hg^{II} concentration



Objectives:

- Improvement of understanding of Hg dispersion in the atmosphere
- Evaluation of new Hg oxidation/reduction mechanisms

Expert group: CSIC (Spain), MSC-E, CNRS (France), Harvard (USA), Leeds (UK), HZG (Germany)

Research activities:

- New photo-reduction schemes were developed and tested (*results published in PNAS, Saiz-Lopez et al., 2020*)
- The study is continued with research of Hg^0 heterogenic oxidation mechanisms

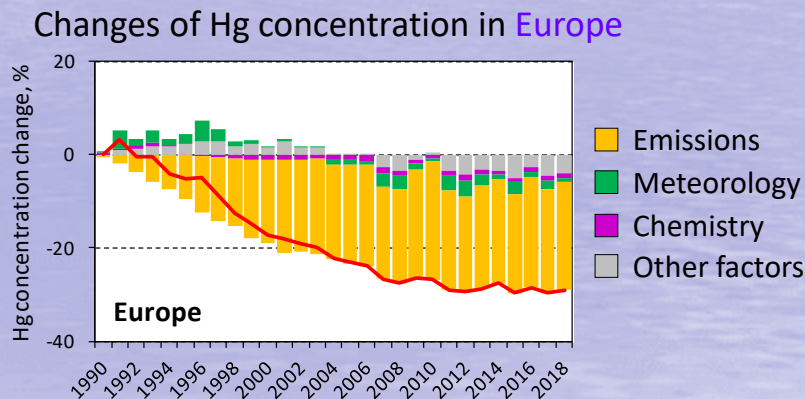
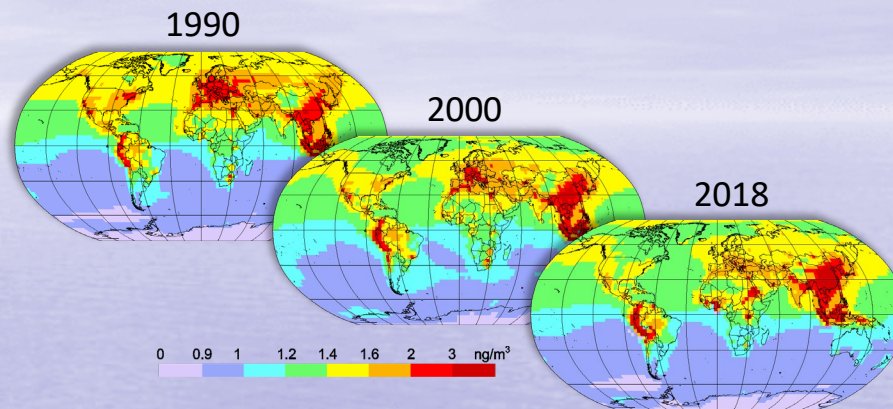
Attribution of Hg pollution trends: A pilot study

Motivation:

- Explain long-term pollution changes in the EMEP and other regions
- Isolate the effect of regional emissions reduction from other factors

Factors analyzed :

- Emissions changes in the EMEP countries
- Long-range transport from other regions
- Variation of meteorological and surface conditions
- Changes in atmospheric chemistry



Scientific co-operation on Hg pollution assessment

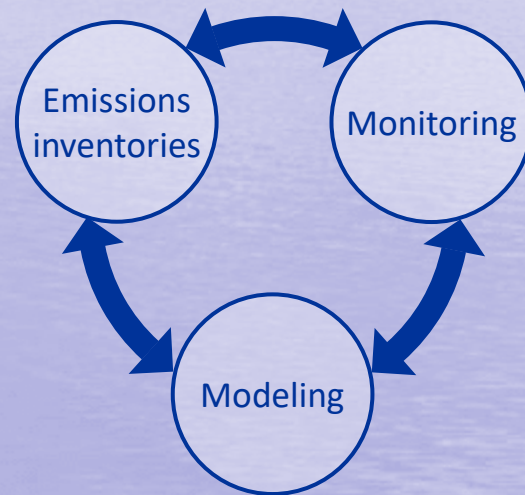
TF HTAP/MSC-E **Workshop on Hg** (April 13, 2021)

Objectives:

- **Review progress** made and identify **needs** of CLRTAP and other international forums for of Hg pollution assessment
- Formulate **short term** (2 years) and **longer term plans** for cooperative activities on Hg under TF HTAP

Participation: **85 experts** (incl. UNEP, Minamata Conv., AMAP, GOS⁴M, GMOS-Train, countries)

Discussions: Needs and opportunities for Hg **emissions inventories**, **monitoring** and **modeling**



Scientific co-operation on Hg pollution assessment

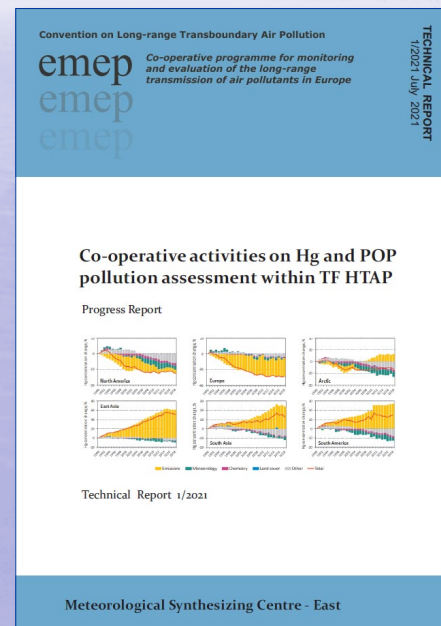
TF HTAP/MSC-E **Workshop on Hg** (April 13, 2021)

Long-term goal:

- Co-operative analysis and attribution of **long-term trends** and projection of **future levels** of Hg pollution in the EMEP and other regions

Short-term activities (2022-2023):

- Development/update of **global Hg emissions** inventory and **future scenarios** (TF HTAP, CEIP, CIAM, AMAP, JRC)
- **Multi-model study** of Hg cycling on a global scale with focus on **air-surface exchange** and **secondary emissions** (MSC-E, national experts)



Assessment of the Arctic pollution with Hg

EMEP/MSC-E contribution to the *AMAP Hg Assessment 2021*

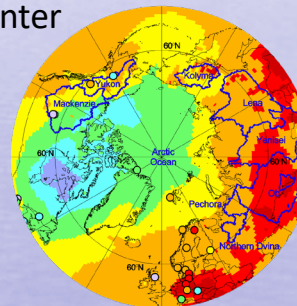
Model assessment:

- Multi-model study by international research group (MSC-E, Canada, USA, Denmark)
- Model estimates of Hg concentration, deposition and source apportionment over the Arctic and large rivers watersheds
- Balance estimates of Hg transport and accumulation in the Arctic

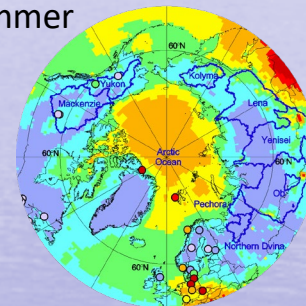
Results are under review in Nature Reviews Earth & Environment

Hg⁰ air concentration in the Arctic

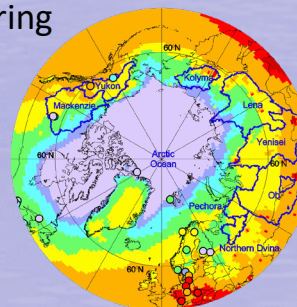
Winter



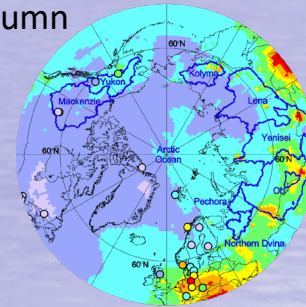
Summer



Spring



Autumn



0 1.3 1.35 1.4 1.45 1.5 1.6 1.7 ng/m³

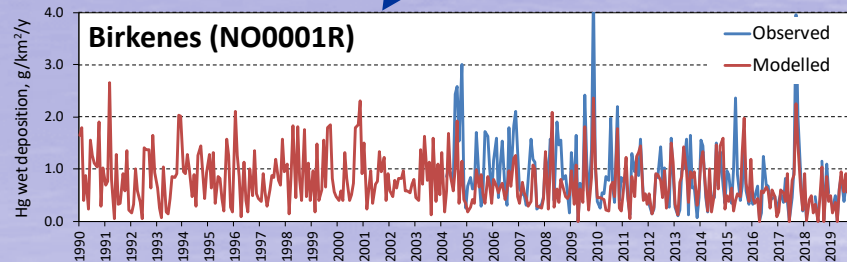
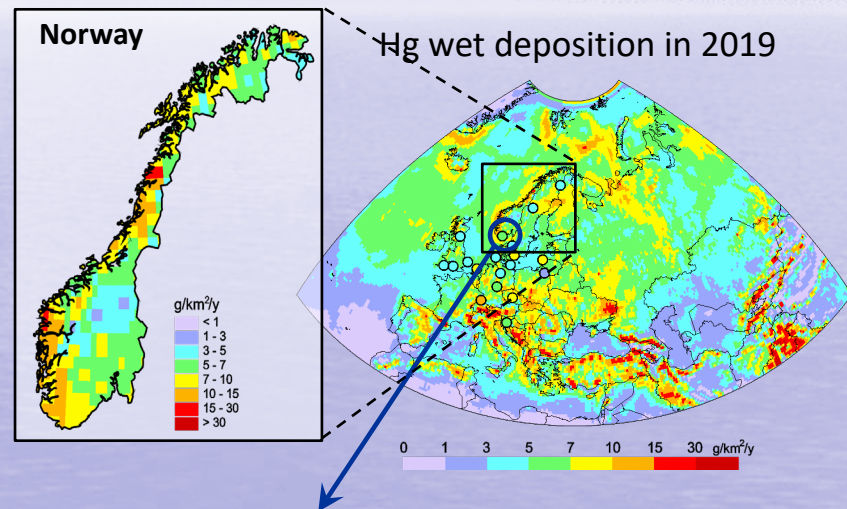
Hg pollution in Norway: A case study

Country-scale assessment in co-operation with national experts (TFMM)

EMEP/MSC-E contribution to Norwegian Hg assessment (2021-2022)

Expected model outcome:

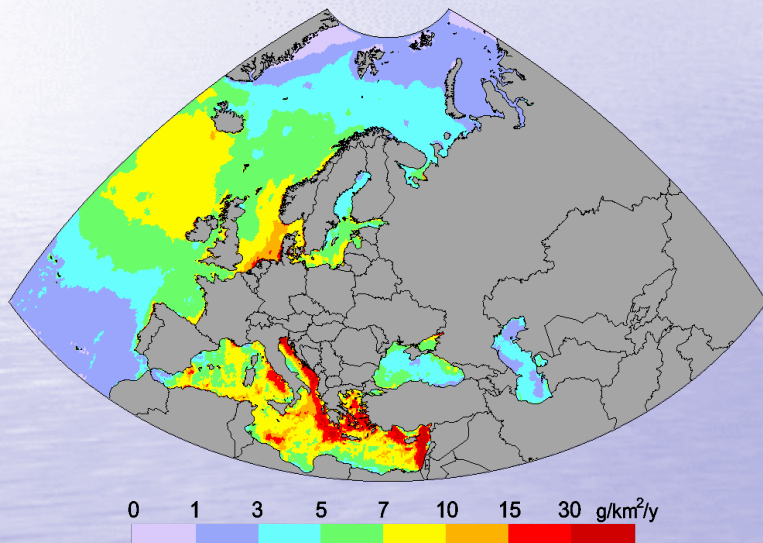
- Long-term time series of Hg concentration and deposition in the country
- Country-scale simulations of Hg levels with fine spatial resolution
- Comparison with national observations
- Ecosystem-specific Hg deposition for exposure analysis



Marine pollution assessment

Model study of heavy metal atmospheric loads to the regional seas

Cd deposition to aquatic regions (2019)



Motivation:

- **Regional seas** (Baltic, Northern, Mediterranean, etc.) are significant part of the EMEP domain
- Focus of regional **marine conventions** (HELCOM, OSPAR, ...), EU Marine Strategy Framework Directive
- **Ad-hoc group** on marine pollution (Bureau meeting, March, 2021)

Marine pollution assessment

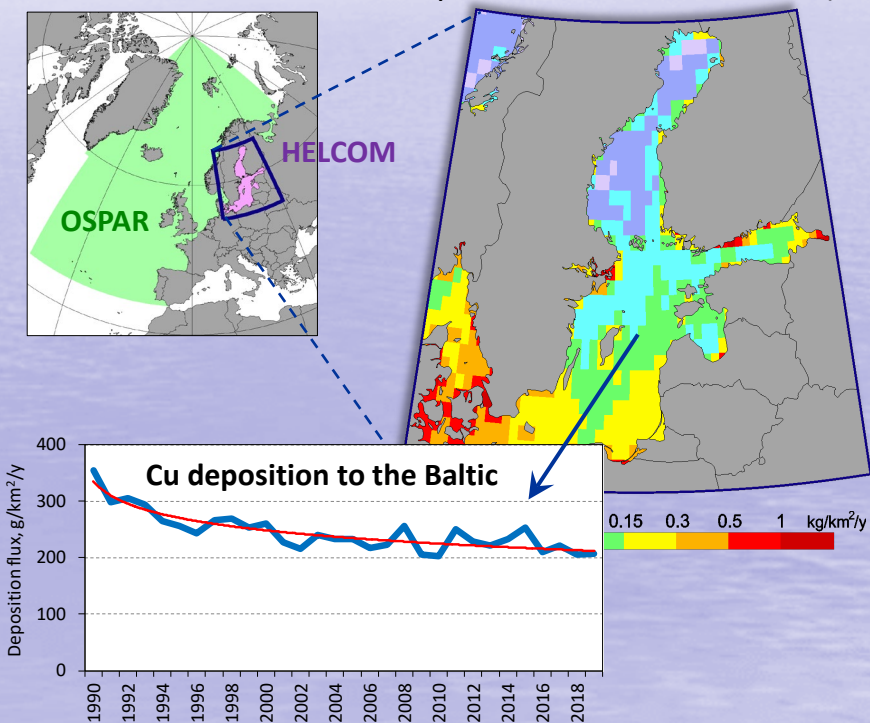
Model study of heavy metal atmospheric loads to the regional seas

Co-operation with HELCOM and OSPAR:

- Model assessment of **long-term trends** of HM deposition to the Baltic and North Seas, and the Northern Atlantic
- **Source apportionment** of HM deposition
- Considered pollutants – Cd, Pb, Hg, other metals (**Cu**)

The projects are funded by the marine conventions (HELCOM, OSPAR)

Cu deposition to the Baltic Sea (2019)



Main future research activities

(Proposals for work plan 2022-2023)

- Multi-model study of Hg cycling on a global scale with focus on **air-surface exchange** and **secondary emissions** (co-operation with TF HTAP)
- Country-scale pollution assessment: **A case study of Hg pollution in Norway** (co-operation with TFMM, national experts)
- Co-operation with the **effect community** on assessment of heavy metal pollution and trends (WGE, ICP Vegetation, ICP Integrated Monitoring)
- Research of heavy metal pollution of the **marine environment** (co-operation with HELCOM and OSPAR)
- Co-operation with other **international bodies** (UNEP, Minamata Convention, AMAP, etc.) on Hg pollution assessment