16th ICMGP Cape Town 2024

MINAMATA CONVENTION ON MERCURY

Science to Policy:

For the Minamata Convention Effectiveness Evaluation

International Conference on Mercury as a Global Pollutant 2024

Plenary speakers

In order of speaking:

- Celia Chen, Dartmouth College
- Dominique Bally Kpokro, Co-Chair OESG, Côte d’Ivoire & Togo
- Mark Burton, Biodiversity Research Institute
- Sandy Steffen, Environment and Climate Change Canada, Canada
- Karina Miglioranza, Mar del Plata University, Argentina
- Milena Horvat, Jozef Stefan Institute, Slovenia
- Svetoslava Todorova, Syracuse University, US, OESG- Bulgaria
- Ashu Dastoor, Environment and Climate Change Canada, Canada

What is the Minamata Convention?

Global Agreement: 148 Parties (countries that have ratified) to date

Main Obligations:

- Ban on new mercury mines and phase out of existing mines
- Phase out and phase down of mercury use in products and processes
- Control measures on emissions and releases
- Regulation of Artisanal and Small-scale Gold Mining (ASGM)

Entered into Force: 16 August 2017

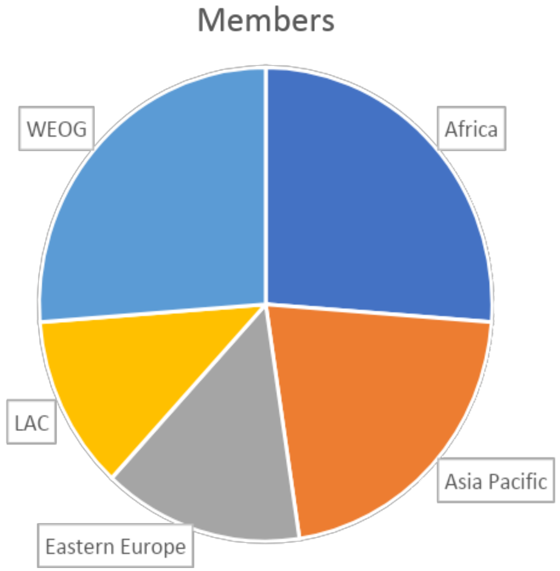
Article 22: Requires the Conference of the Parties (COP) to periodically evaluate the effectiveness of the Convention, beginning no later than 6 years after entry into force, based on available scientific, environmental, technical, financial and economic data.

Who is involved in the Effectiveness Evaluation?

- **Conference of the Parties (COP):** Countries that have ratified the agreement make up the main decision-making body of the Convention, meets every 2 years. Each Party has a National Focal Point.
- **Secretariat:** Administrative, technical, and legal support staff for the Convention, hosted by UNEP in Geneva.
- **Effectiveness Evaluation Group (EEG):** Group of 25 experts (5 per each UN region) nominated by Parties and charged with drafting an Effectiveness Evaluation Report to COP7 (planned for 2027).
- **Open Ended Science Group (OESG):** Group of experts nominated by Parties, open to one expert per country, charged with writing a Scientific Report to inform the work of the EEG.
- **Roster of Experts:** Group of relevant experts, open to nominations by Parties, observers, and other organizations, who participate in and contribute to the activities of the OESG.
- **Data Providers:** Anyone with relevant data can provide information to the OESG for consideration in the development of the Scientific Report. National Focal Points will be informed of data that has been submitted relevant to their geographic region.
- **Report Reviewers:** The OESG's plans and draft reports must be circulated to Parties and observers for comment. Interested experts can contribute to the review by submitting comments to the Secretariat.

Open-Ended Scientific Group

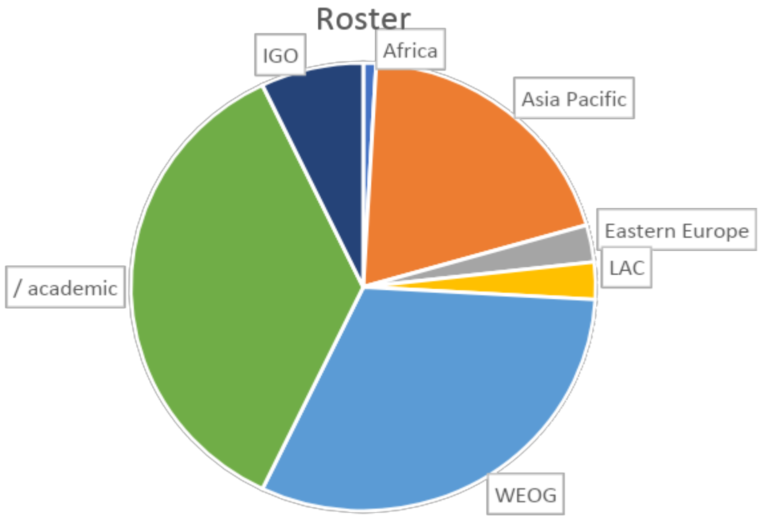
- OESG members – one expert nominated by each Party
- Parties and observers may nominate experts to a roster, who contribute to the work of OESG
- Met online 13 times by July 2024, 1st face-to-face meeting in March 2023, 2nd face-to-face meeting planned for March 2025



42 OESG Members

112 Experts on Roster

(As of 31 May 2024)



What does the Effectiveness Evaluation and Scientific Report address?

Policy Questions for the Effectiveness Evaluation (MC/COP.3/14)

- Have the parties taken actions to implement the Minamata Convention?
- Have the actions taken resulted in changes in mercury supply, use, emissions and releases into the environment?
- Have those changes resulted in changes in levels of mercury in the environment, biota, and vulnerable human populations that can be attributed to the Minamata Convention?
- To what extent are existing measures under the Minamata Convention meeting the objective of protecting human health and the environment from mercury?

Lessons Available to be Learned for Future Effectiveness Evaluations

- Where are the gaps in our knowledge or capabilities that are barriers to answering the policy questions above?
- What actions could be taken to address these gaps or barriers?

OESG team structure: where the work gets done

Role	OESG Member	Country
Co-Chairs	Dominique Bally Kpokro	Côte d'Ivoire
	Terry Keating	United States
Emissions Lead	Lynwill Martin	South Africa
Releases Lead	Ronnie Frazer-Williams	Sierra Leone
Air Lead	Sandy Steffen	Canada
Biota Lead	Karina Miglioranza	Argentina
Other Media Lead (Soil, Water, …)	Adrien Mestrot	Switzerland
Humans Lead	Janja Snoj Tratnik	Slovenia
Integrated Analysis Lead	Noriyuki Suzuki	Japan
Secretariat	Eisaku Toda (UNEP) with support of Biodiversity Research Institute	

OESG data analysis questions

1. Current Levels

- What are the current levels of Hg emissions and releases and levels of Hg observed in air, biota, humans, and other media in sites that are
  - remote from anthropogenic sources?
  - affected by local anthropogenic sources?

2. Temporal Trends

- How have levels of Hg emissions and releases and Hg observed in air, biota, humans, and other media changed over the available record?
- How do those changes compare to the timeline of the Minamata Convention?
- What specific mitigation measures have contributed to changes in emissions and releases?
- How are levels of Hg emissions and releases and Hg observed in air, biota, humans and other media expected to change in the future?

3. Spatial Patterns

- How do current levels and temporal trends vary geographically at the global scale?

OESG data analysis questions

4. Source or Process Attribution

- What is the fractional contribution of contemporary anthropogenic emissions and releases to current Hg levels observed in air, biota, humans, and other media?
- How have these contribution levels changed over the timeline of the Minamata Convention?
- How do the contribution levels and their trends vary geographically at the global scale?
- How have drivers other than changes in emissions and releases contributed to the trend in observed Hg levels?

5. Exposure and Adverse Impacts

- How do current levels of Hg observed in air, biota, humans, and other media compare to levels in established guidelines, as well as to observed and projected thresholds for effects to humans, other living organisms and biodiversity based on recent research and knowledge?
- How do changes in Hg levels over the timeline of the Minamata Convention compare to those guideline levels and effect thresholds?

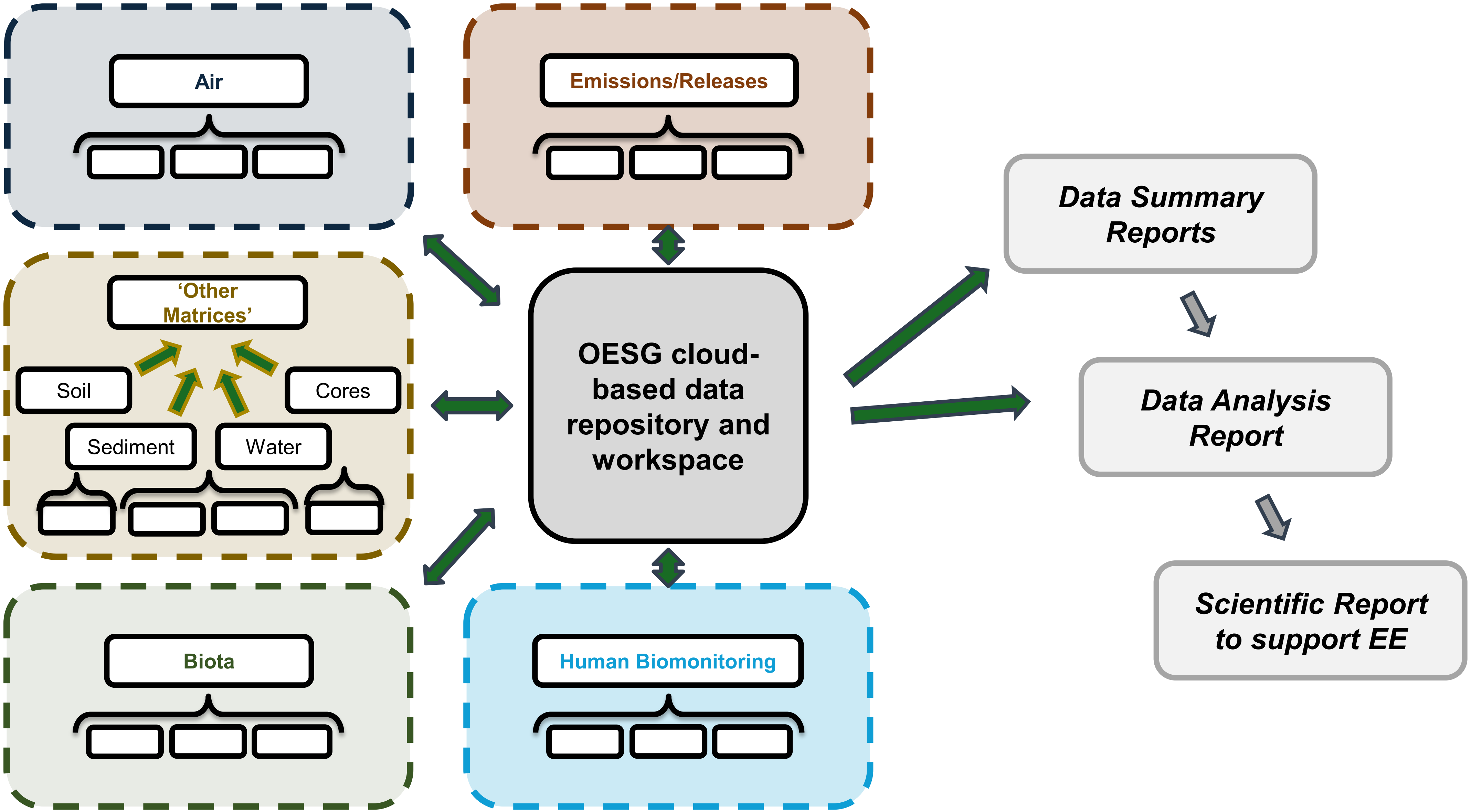
6. Process Understanding

- How consistent are current levels, temporal trends, and spatial patterns of Hg emissions and releases and Hg levels in air, biota, humans, and other media with estimates from current mechanistic models?

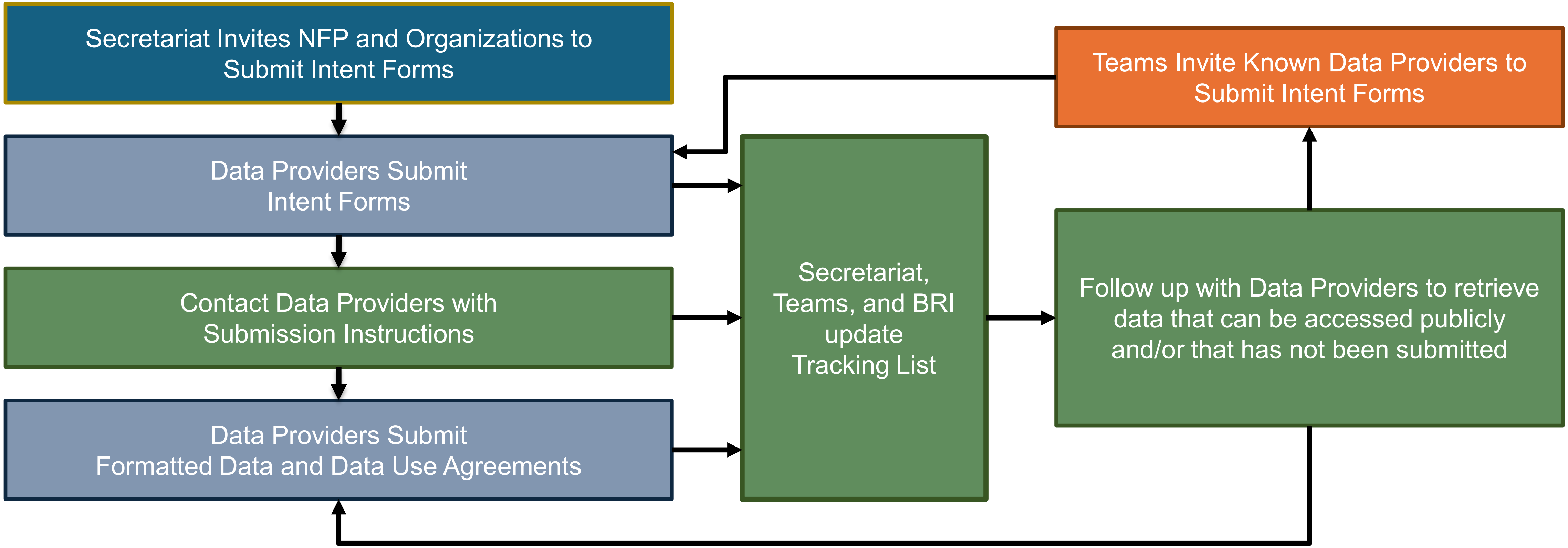
Open-Ended Scientific Group products

Plans	
Emissions and Releases Data Collection Plan	Presented at COP5 (2024) Document INF/24
Observational Data Collection Plan	
Data Analysis Plan	
Draft Reports for Review	
Summary of Available Data (Emissions/Releases, Observations)	January 2025
Data Analysis	October 2025
Gaps and Recommendations	October 2025
Revised Draft Reports	
Scientific Report (Available Data and Analysis)	June 2026
Lessons Learned: Gaps and Recommendations Report	June 2026

Data collection process



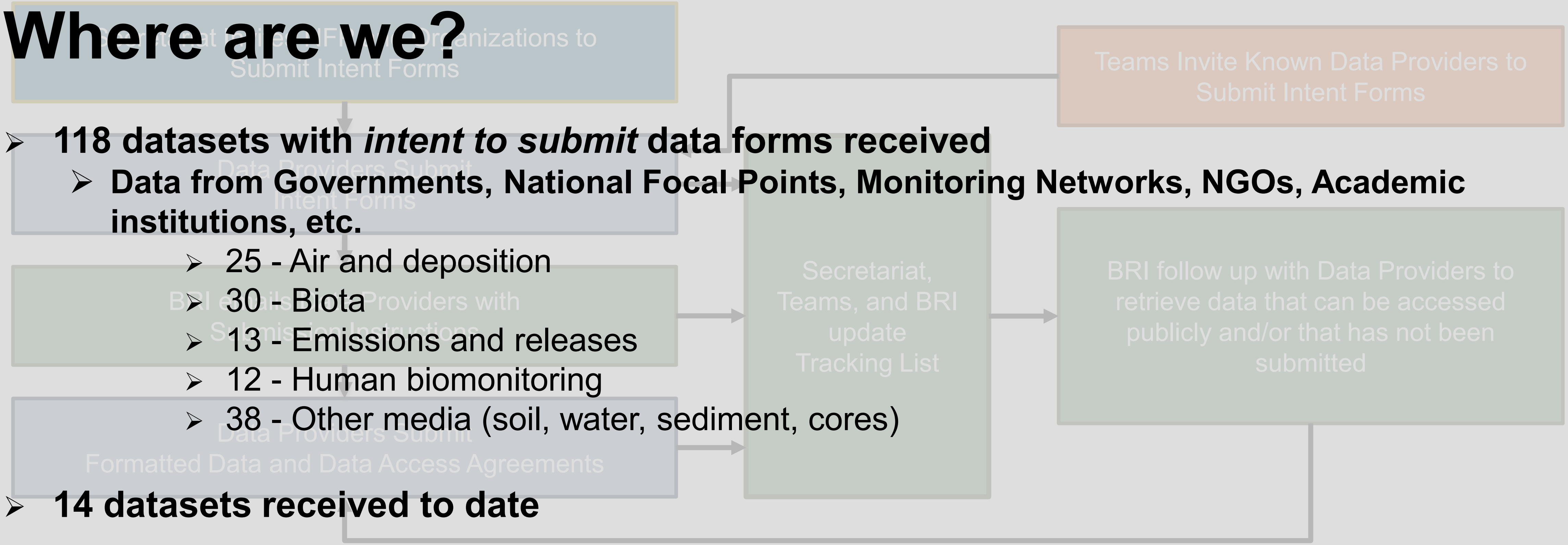
Data collection process



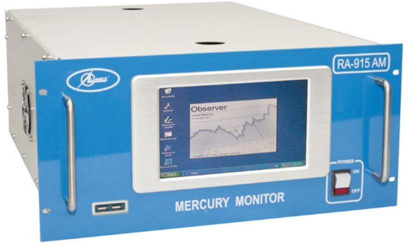
Data collection process

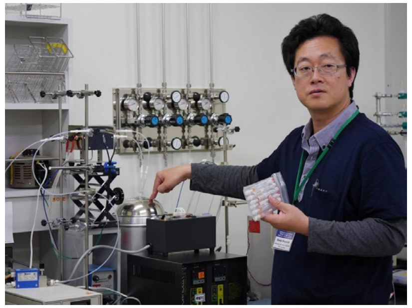
Where are we?

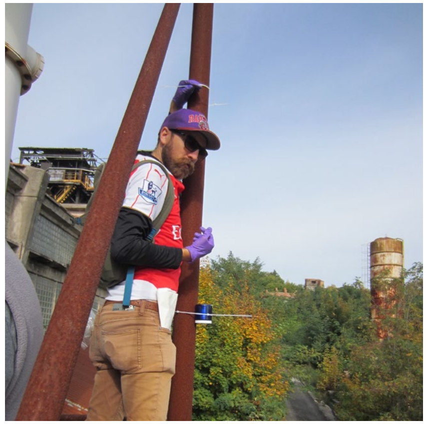
- **118 datasets with *intent to submit* data forms received**
  - **Data from Governments, National Focal Points, Monitoring Networks, NGOs, Academic institutions, etc.**
    - 25 - Air and deposition
    - 30 - Biota
    - 13 - Emissions and releases
    - 12 - Human biomonitoring
    - 38 - Other media (soil, water, sediment, cores)
- **14 datasets received to date**
- **373 additional datasets have been identified**



Atmospheric Mercury





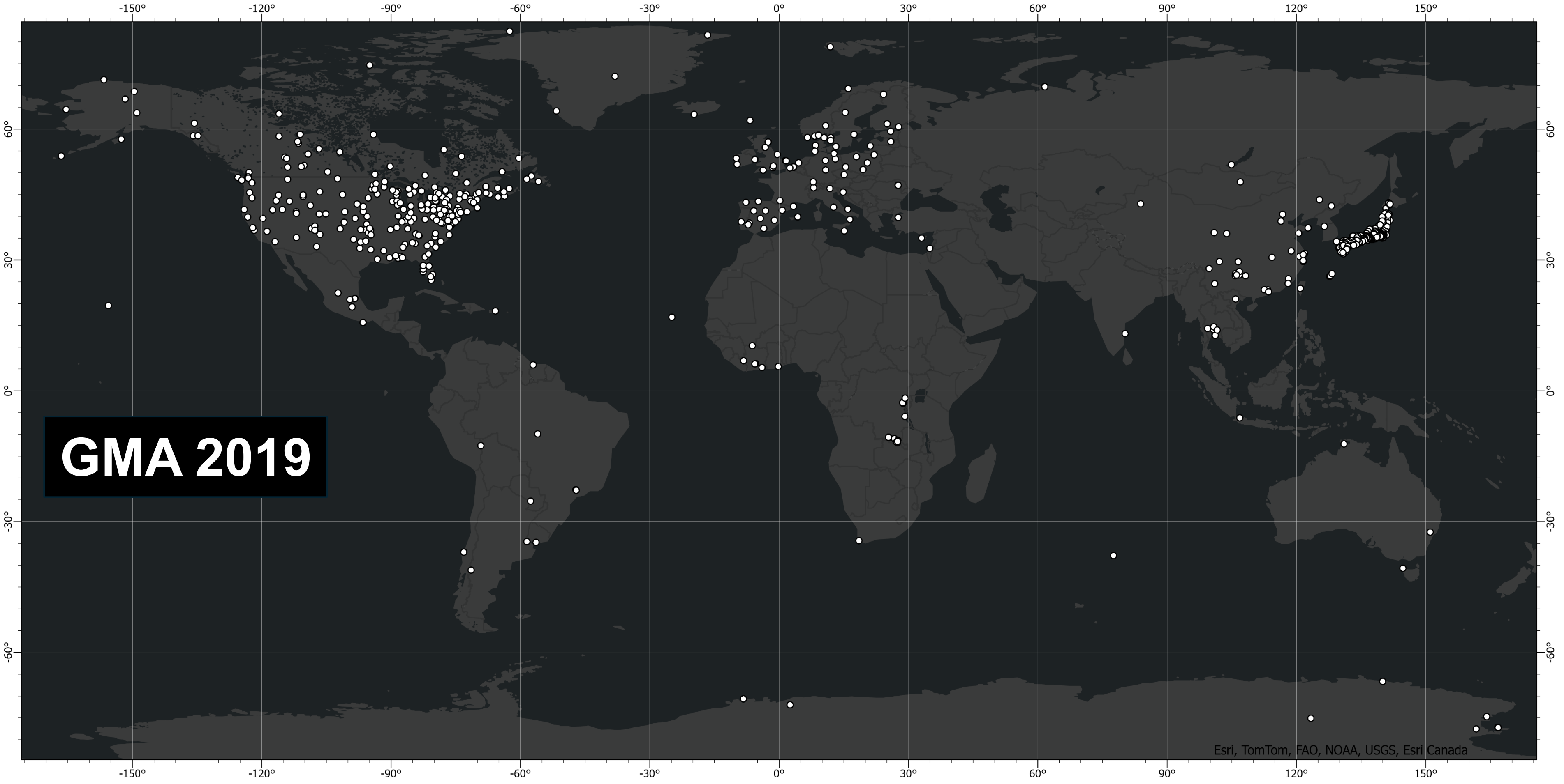


Evaluation of atmospheric mercury on a global scale

- Active continuous (hourly, weekly)
- Wet deposition (weekly)
- Passive (quarterly, monthly)

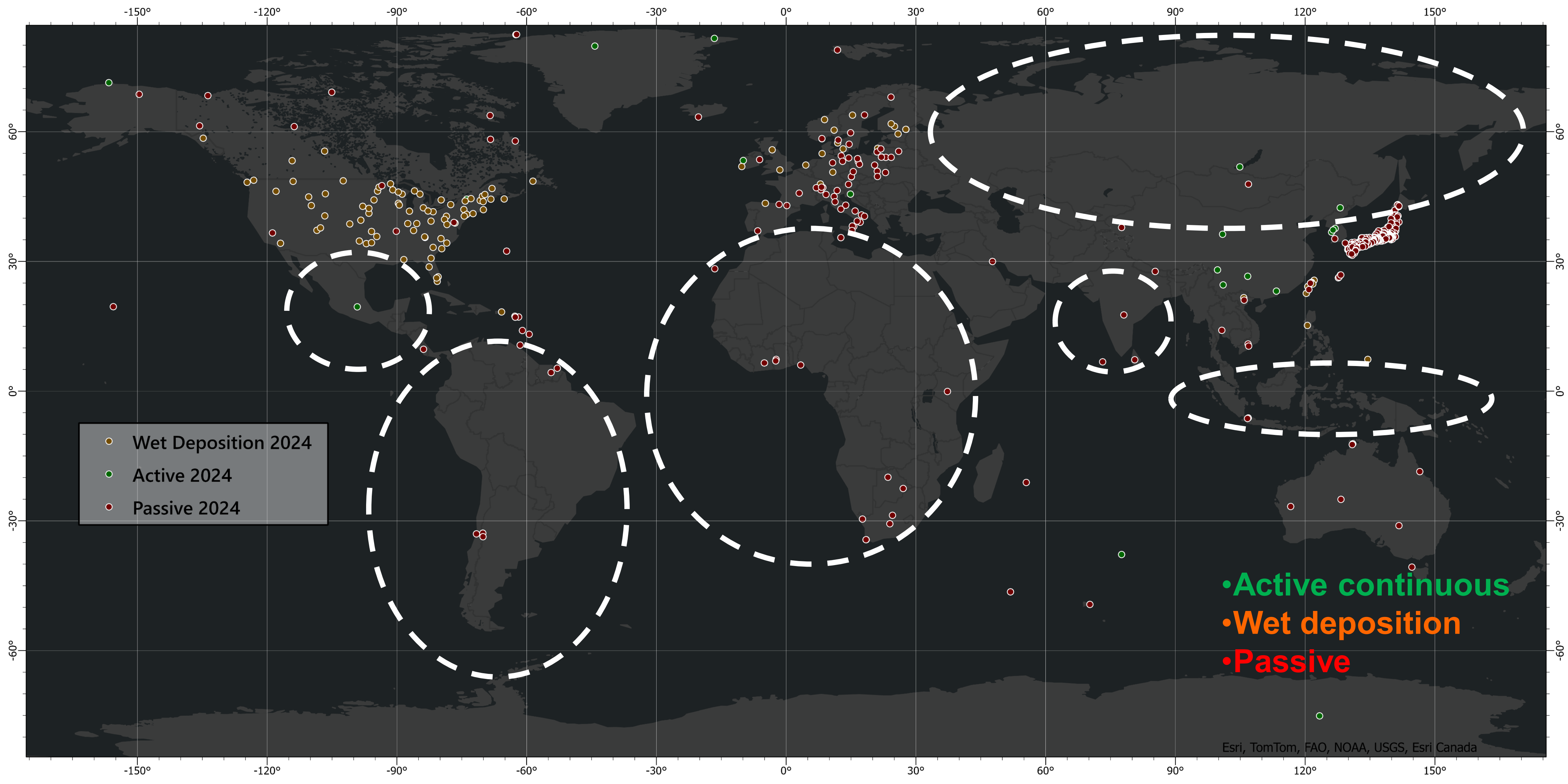
Expectations for the 1st cycle of the EE

- Simple
- Straight forward
- Starting point
- Inclusive
- Identify gaps
- Propose solutions

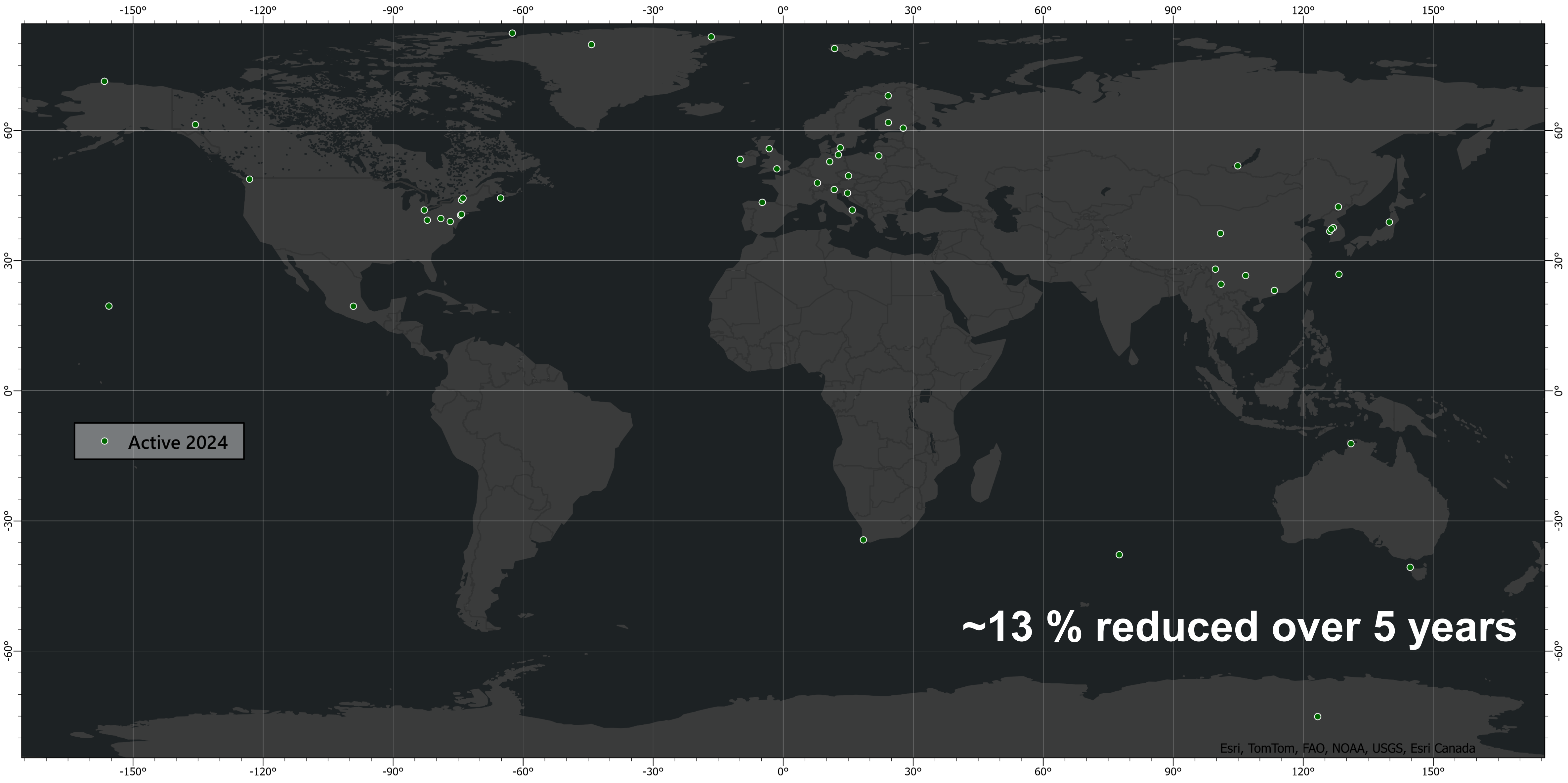


Where are the air data?

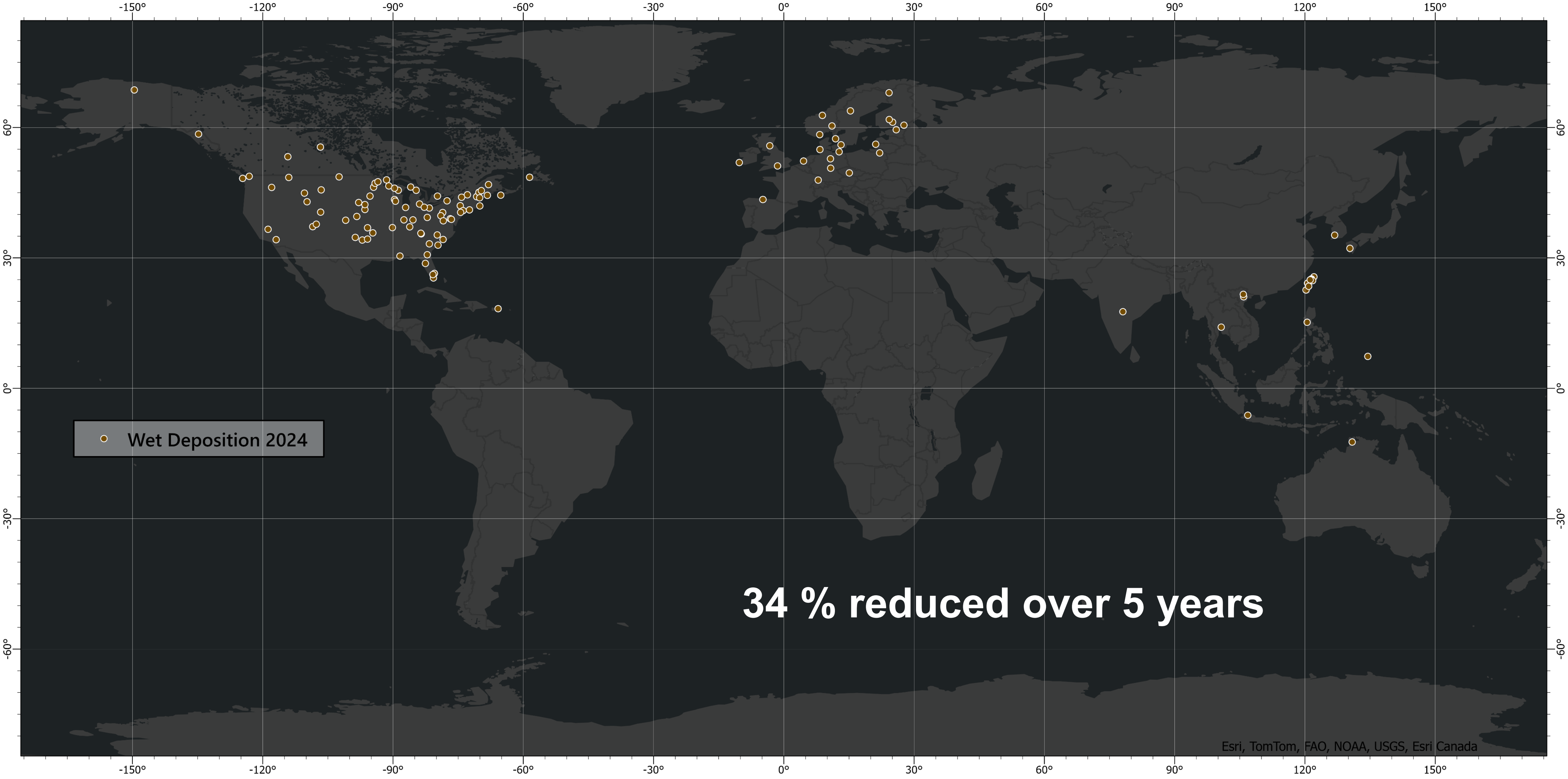
- GMA 2019 (earlier data)
- Updated in 2019
- Updated 2024



Active air


-150°
-120°
-90°
-60°
-30°
0°
30°
60°
90°
120°
150°
60°
30°
0°
-30°
-60°
Active 2024
~13 % reduced over 5 years
Esri, TomTom, FAO, NOAA, USGS, Esri Canada

Wet Deposition



34 % reduced over 5 years

Passive sampling

What is this telling us?

- ➢ Not enough monitoring
- ➢ Shifting down from active and wet deposition
- ➢ Shifting up to passive air monitoring
- ➢ Resources in monitoring are declining
- ➢ Impacts results produced and conclusions to be made

Approach for global air analysis

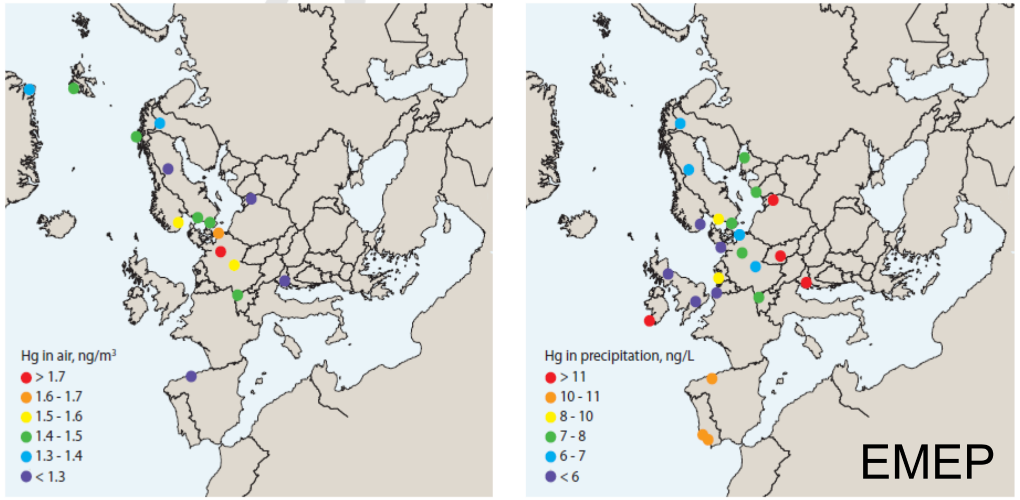
Past approach

Based on measurements

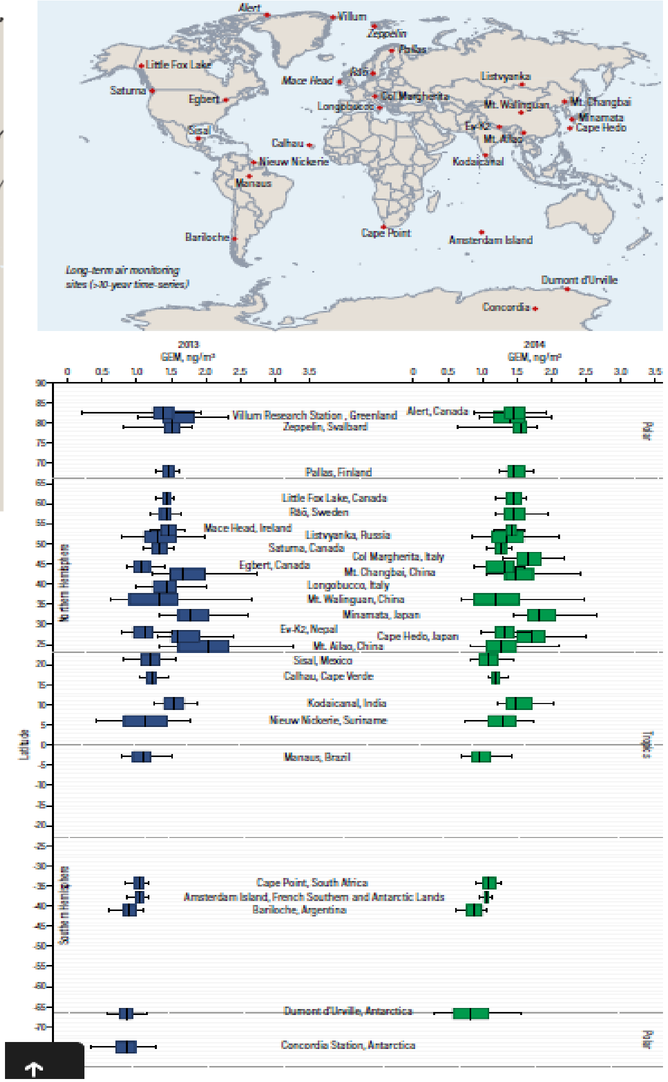
... National

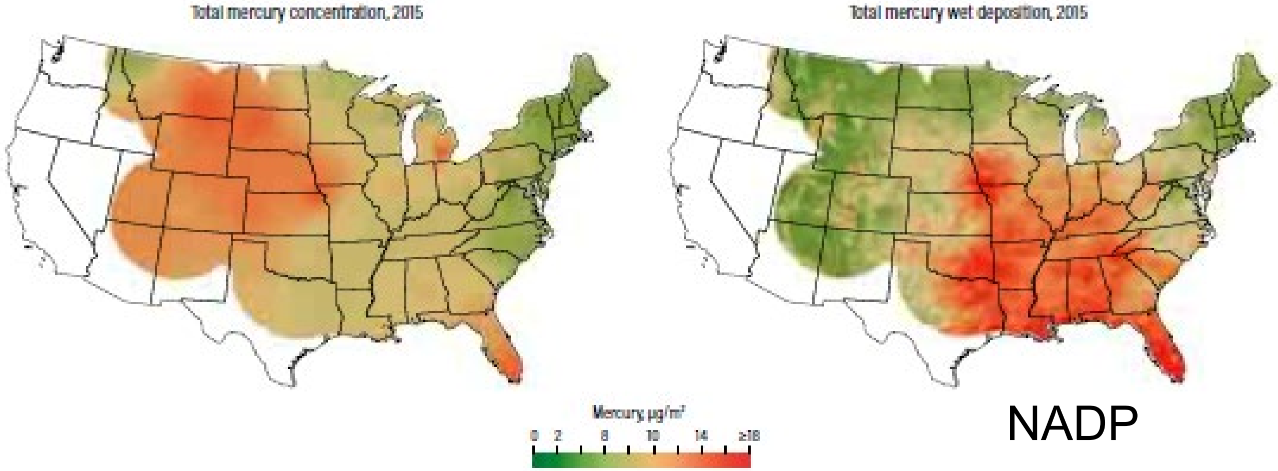
... Regional

... As global as we could get



EMEP





NADP

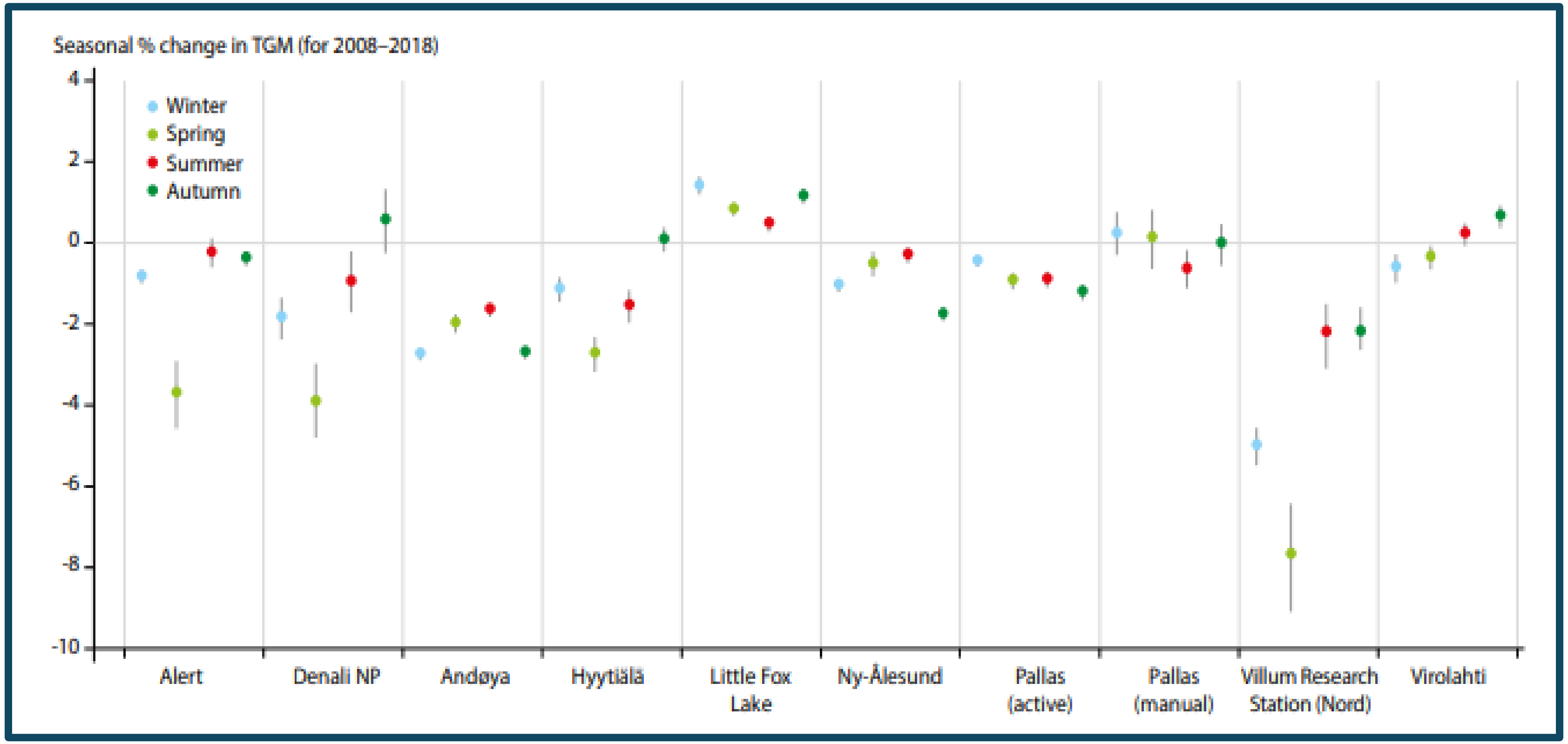
GMOS

A global approach with comparable data

Collect data for same analysis

- Temporal variation
- Spatial variation
- Trend analysis
- Statistics
- Regional analysis
- Model validation

AMAP 2021



Final thoughts

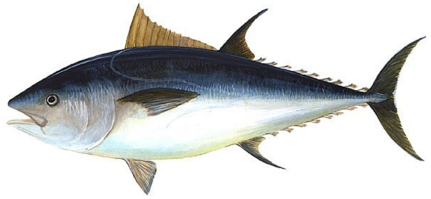
- Air is relatively easier than other media *but not easy*
- Data intake template is key for data management
- Lessons learned so far
  - The disconnect between the COP and those doing the work is a challenge
  - Need global monitoring program
  - Need one common spot to put the data
  - Politics are tricky to navigate with science
  - Set expectations with everyone early on

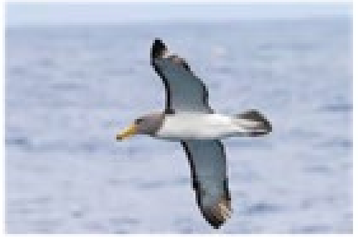
Biota

Policy Questions for the Effectiveness Evaluation (MC/COP.3/14)

- Have those changes **resulted in changes in levels of mercury** in the environment, **biota**, and vulnerable human populations that can be attributed to the Minamata Convention?

The OESG Biota group will use the information to analyze and synthesize comparable mercury monitoring data and seek answers on the following questions






Biota

1. What is known about **current levels of mercury** in **BIOTA** (invertebrates, fish, amphibians, reptiles, birds, mammals) for continents and oceans?

Considerations: migratory range, trophic levels, diet, tissue types, biodiversity indicators – threatened species (follow IUCN listings), sensitive ecosystems (terrestrial/freshwater and coastal/marine, accessibility)

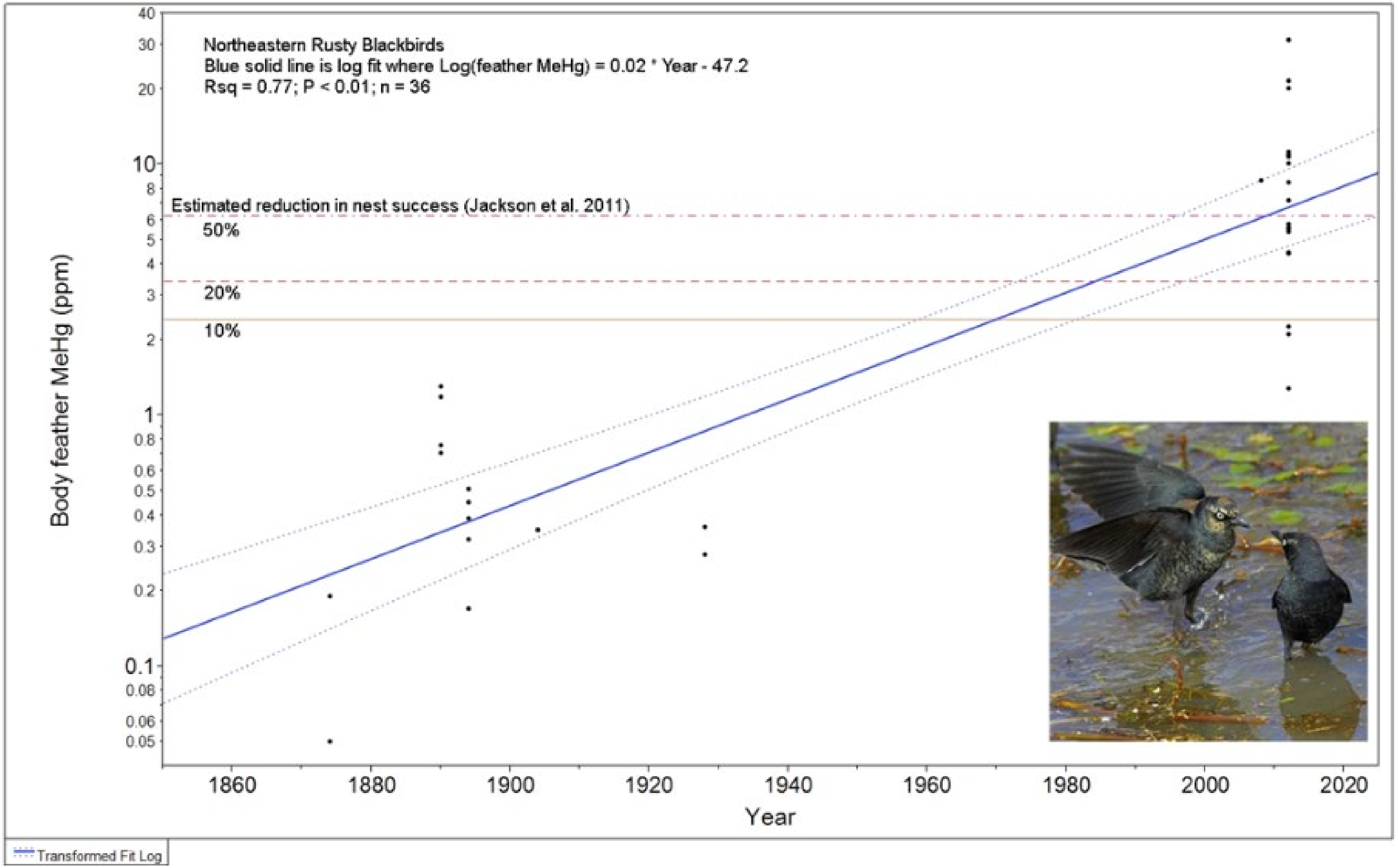
	Fish	Sea Turtles	Birds	Marine mammals	Subtotal
Continental**					
Africa	6,126	N/A	192	N/A	6,318
Antarctica	0	N/A	0	N/A	0
Asia	14,093	N/A	3,794	567*	18,454
Australia	323	N/A	3	N/A	326
Europe	62,321	N/A	7,712	220*	70,253
North America	191,346	N/A	50,449	N/A	241,795
South America	38,126	N/A	356	95*	38,577
Subtotal	312,335	N/A	62,506	882	375,723
Oceanic					
Antarctic	1,228	N/A	6,305	1,738	9,271
Arctic	1,808	N/A	7,498	8,730	18,036
Gulf of Mexico-Caribbean	8,480	557	467	818	10,332
Indian	9,662	397	1,851	487	12,397
Mediterranean	13,720	773	2,054	2,600	19,147
North Atlantic	26,504	1,438	13,951	6,698	48,591
North Pacific	24,049	1,077	33,933	6,996	66,055
South Atlantic	12,428	714	2,808	1,398	17,348
South Pacific	8,152	51	3,054	351	11,608
Subtotal	106,031	5,007	71,921	29,816	212,775
Total	**418,366**	**5,007**	**134,427**	**30,698**	**588,498**

Biota

2. How have **levels of mercury species changed** in **BIOTA over recent decades** and in between specified time periods?

A challenging question!!

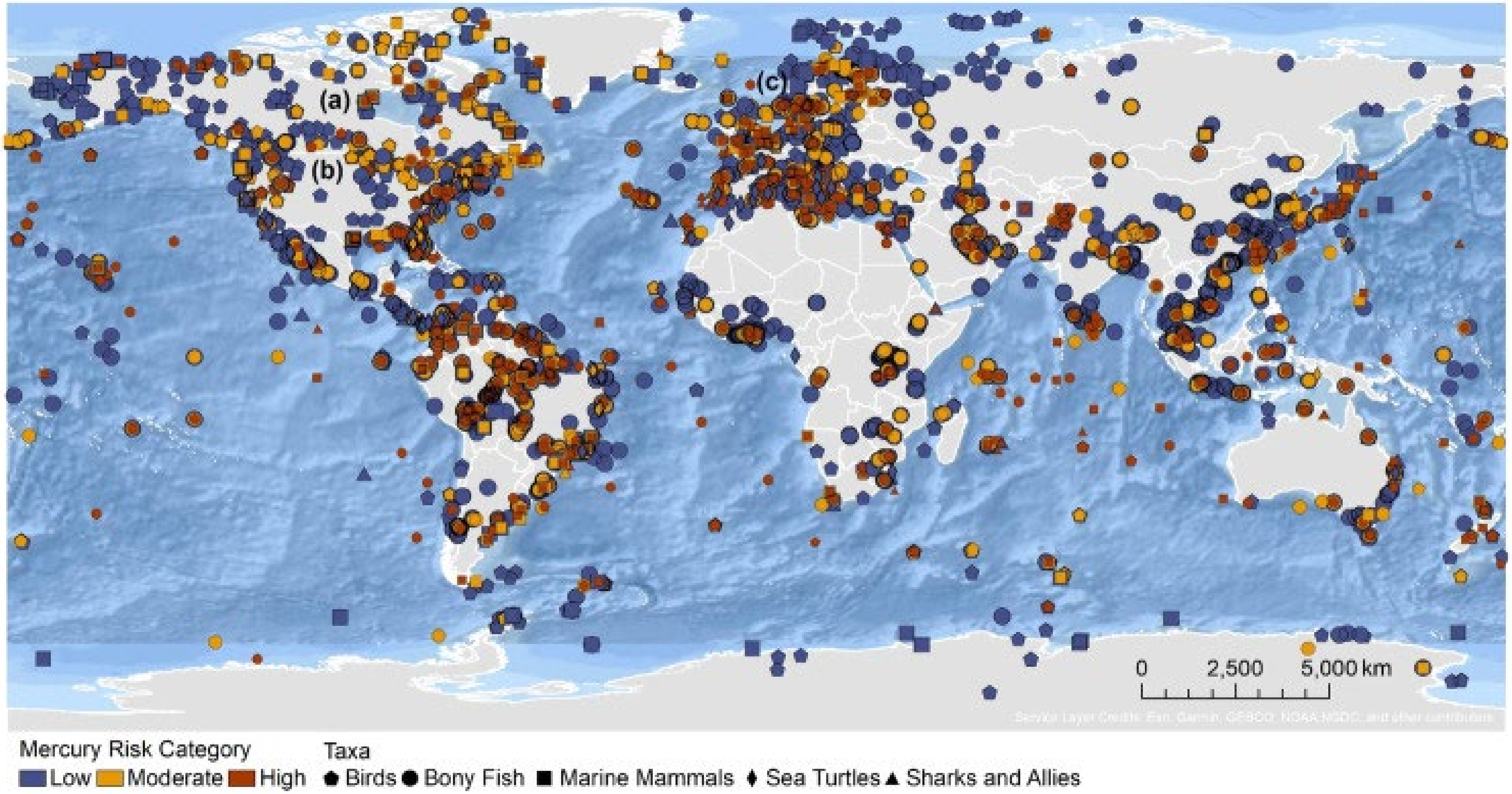
Rusty blackbirds have declined by over 90% the past few decades



Edmonds, S.T., **D.C. Evers**, N.I. O'Driscoll, C. Mettke-Hoffman, L. Powell, D. Cristol, A.J. McGann, J.W. Armiger, O. Lane, D.F. Tessler, and P. Newell. 2010. Geographic and seasonal variation in mercury exposure of the declining Rusty Blackbird. Condor 112:789-799

Biota

3. How do **current levels of mercury** in **BIOTA vary spatially** (by world region)?



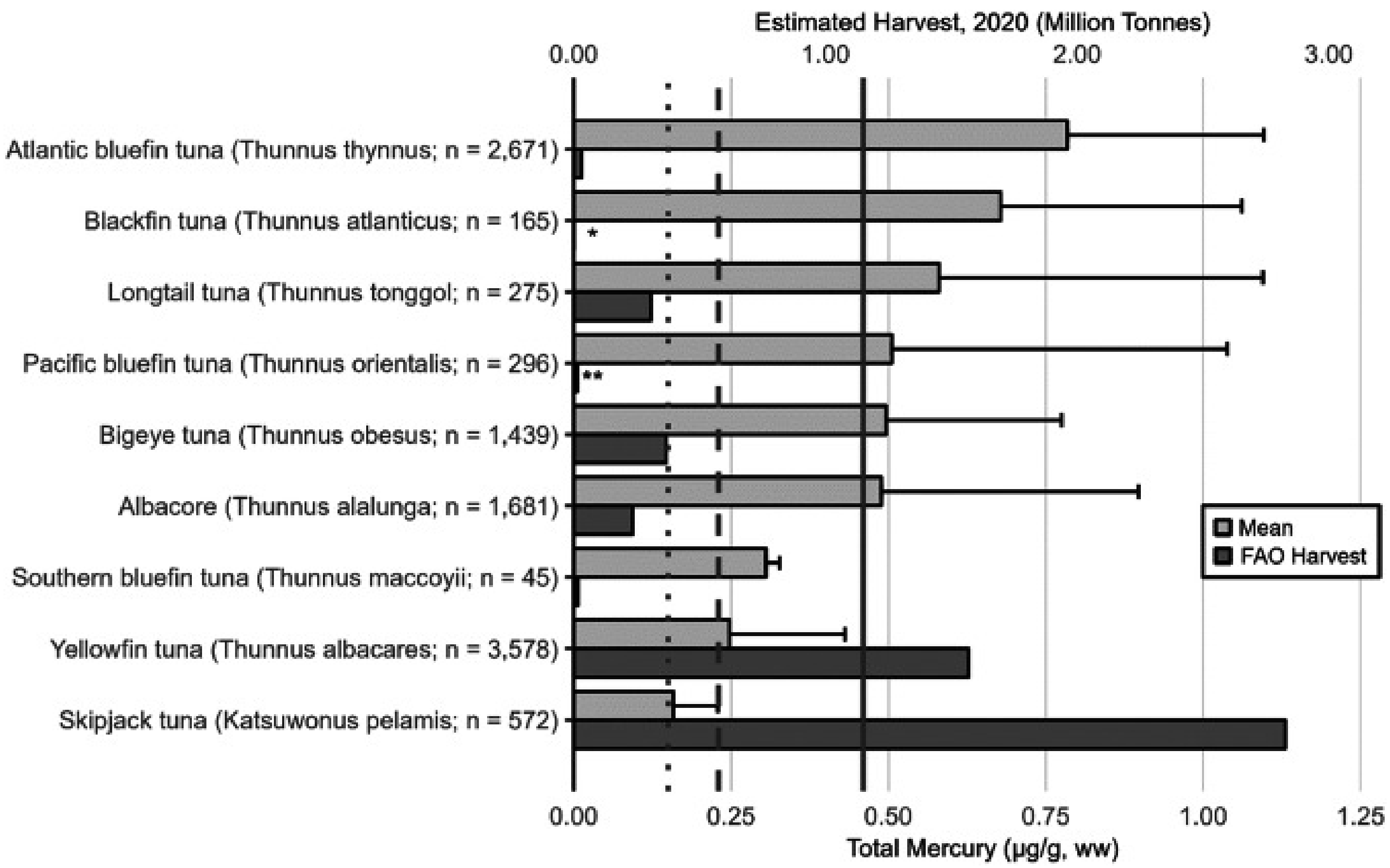
Evers et al. 2024. Global mercury concentrations in biota: Their use as a basis for a global biomonitoring framework. Ecotoxicology 33:325-396

Biota

4. How do **current levels of mercury** observed in **BIOTA compare to established national and international benchmark levels** associated with adverse effects on human health, wildlife health, and environmental sustainability?

Tuna fish example

Guideline or criterion by agency	Mercury in fish (µg/ww)	Fish consumption guideline
U.S. Environmental Protection Agency (USEPA) – U.S. Food and Drug Administration (FDA) fish advice	< 0.15	Best choices; 2-3 meals/week
	< 0.23	Good choices; 2 meals/week
	< 0.46	Good choices; 1 meal/week
	> 0.46	Choices to avoid: 0 meals/week



Evers et al., 2024. Global mercury concentrations in biota: Their use as a basis for global biomonitoring framework. Ecotoxicology 33:325-396

Biota

On the basis of previous studies…

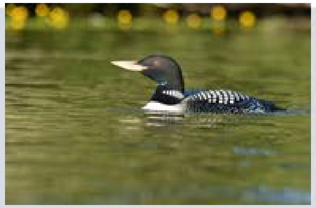
5. What are the **best bioindicators** by biome and oceanic region for the major taxa of interest by the **Minamata Convention**?

Consider:

- Habitat
- Migratory range
- Geographic region
- Diet
- Trophic level

Examples of **birds** for freshwater/terrestrial and marine ecosystems…

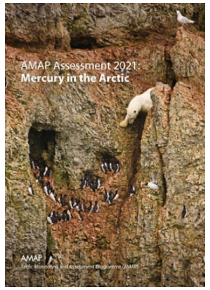
Freshwater bird species of interest for mercury monitoring

Arctic Tundra	**Loons**   
Boreal Forest and Taiga	**Loons, Eagles, Osprey, Songbirds (Warblers, Flycatchers, Blackbirds)**   
Temperate Broadleaf and Mixed Forest	**Loons, Grebes, Egrets, Herons, Osprey, Terns, Songbirds (Warblers, Flycatchers, Wrens, Blackbirds, Sparrows)**    
Tropical Rainforest	**Egrets, Herons, Kingfishers, Songbirds (Wrens, Thrushes, Flycatchers)**   

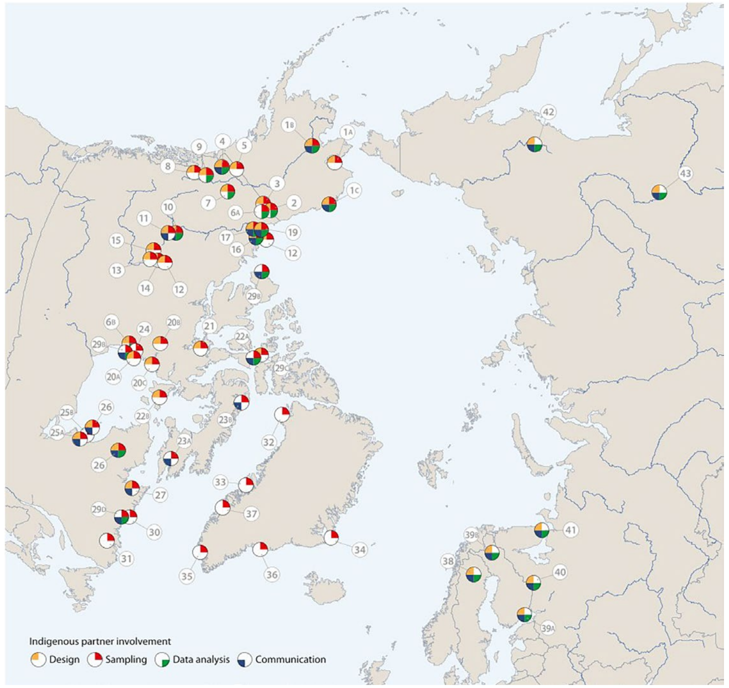
Marine bird species of interest for mercury monitoring

Arctic Tundra	**Fulmars, Murres**	 
Boreal Forest and Taiga	**Osprey, Petrels**	 
Temperate Broadleaf and Mixed Forest	**Cormorants, Osprey, Terns**	  
Tropical Rainforest	**Albatrosses, Noddy, Shearwaters, Terns, Tropicbirds**	   

Contributions of **Indigenous Peoples** to the study of mercury in the circumpolar Arctic



- AMAP Mercury in the Arctic 2021
- STOTEN 2022
- 40 mercury projects featured



ELSEVIER
Science of The Total Environment
Volume 841, 1 October 2022, 156566

Contributions and perspectives of Indigenous Peoples to the study of mercury in the Arctic

Magali Houde [a 1], Eva M. Krümmel [b 1], Tero Mustonen [c], Jeremy Brammer [d e], Tanya M. Brown [f], John Chételat [e], Parnuna Egede Dahl [g], Rune Dietz [h], Marlene Evans [i],

ID	Species/ matrices studied
1A	Seals, fish, caribou
1B	Water, sediment, permafrost
1C	Bowhead whales, seals, walrus, polar bears, beluga
2	Muskrats
3	Fish
4	Fish
5	Fish
6	Caribou (Qamanirjuaq and Porcupine herds)
7	Moose, fish
8	Moose, fish
9	Fish
10	Humans (hair, blood, urine)
11	Water, sediment, zooplankton, benthic invertebrates, fish
12	Invertebrates, fish
13	Fish, water, sediments
14	Fish
15	Fish

ID	Species/ matrices studied
16	Fur bearers
17	Burbot
18	Beluga
19	Husky Lakes, Canada; 2011, 2012; water, sediment, aquatic food web (zooplankton, fish)
20	Lichens, mushrooms, seaweed
21	Fish
22	Seabirds (eggs, tissues)
23	Ringed seals
24	Polar bears
25	Blue mussels, sea urchins, plankton, marine fish, common eiders, ringed seals
26	Marine, freshwater, terrestrial assessments
27	Water, sediment, lichen, fish, birds, seals
28	Humans (blood, urine, hair, blood) and country foods
29	Ringed seals
30	Ringed seals and prey
31	Water, invertebrates, fish, ringed seals

ID	Species/ matrices studied
32	Polar bears, ringed seals, black guillemots, sculpins
33	Ringed seals, black guillemots, sculpins
34	Polar bears, ringed seals, black guillemots, sculpin
35	Caribou, Arctic char
36	White-sided dolphins, pilot whales, killer whales
37	Harbor porpoises
38	Freshwater, northern pike, reindeers
39	Northern pike, burbot, sea eagles and other apex predators
40	Northern pike, perch, burbot, human health, other apex predators
41	Ponoi river
42	Kolyma fish
43	Water quality, fish, human health

Houde M, Krümmel, E.M., 34 co-authors (2022)

Specific examples of Indigenous contributions

- Indigenous Knowledge (IK) explaining lower Hg levels due to fish migration
- Feeding behavior of caribou
- IK on fish types, appearance, habitat, and feeding ecology, which were found to cause different Hg levels
- Concerns about fish health leading to contaminant study
- Selenoneine concentrations in beluga and humans – why women in Nunavik have higher selenoneine levels?

Co-producing mercury monitoring/research

Indigenous Knowledge ⟷ **Science**

Mercury Research

Policy Development, Management, Regulations

Decreasing Mercury Levels in the Environment

Biota: Challenges

- More data are needed for establishing temporal trends
- Data gaps for some biota groups and areas

Summary of sampling strength of available biotic Hg data (i.e., [(number of individuals/sq. km) x 1,000]) by priority taxonomic group identified by the Minamata Convention across oceanic and continental geographies

Global averages are used to categorize **relative sampling intensity** as:

- very high (> 4x above global average in blue)
- high (2x above global average in green)
- medium (global average in gray)
- low (2x below global average in orange)
- very low (> 4x below global average in red)

	Fish	Sea Turtles	Birds	Marine mammals	Subtotal
Continents					
Africa	0.20	N/A	0.01	0.00	0.21
Antarctica	0.00	N/A	0.00	0.00	0.00
Asia	0.32	N/A	0.09	0.01	0.41
Australia	0.04	N/A	0.00	0.00	0.04
Europe	6.30	N/A	0.78	0.02	7.10
North America	7.90	N/A	2.08	0.00	9.99
South America	2.14	N/A	0.02	0.01	2.16
Global coefficient	2.13	N/A	0.43	0.01	2.56
Ocean Basins					
Antarctic	0.06	N/A	0.31	0.09	0.46
Arctic	0.13	N/A	0.54	0.62	1.29
Gulf of Mexico-Caribbean	1.95	0.13	0.11	0.19	2.37
Indian	0.14	0.01	0.03	0.01	0.18
Mediterranean	5.97	0.34	0.89	1.13	8.32
North Atlantic	0.64	0.03	0.34	0.16	1.17
North Pacific	0.31	0.01	0.44	0.09	0.86
South Atlantic	0.31	0.02	0.07	0.03	0.43
South Pacific	0.10	0.00	0.04	0.00	0.14
Global coefficient	0.30	0.01	0.20	0.09	0.60
Total	0.84	0.01	0.27	0.06	1.18

Evers et al. 2024. Global mercury concentrations in biota: Their use as a basis for a global biomonitoring framework. Ecotoxicology 33:325-396

Human biomonitoring (HBM)

Mercury global monitoring programme

Proposed framework for using HBM for effectiveness evaluation:

Government-led national biomonitoring programmes, regional initiatives and/or academic-led studies

A harmonized approach so that programmes are purposefully designed to fill data gaps, build capacities and support the effectiveness evaluation

Target population: general population as well as vulnerable groups

Biomarkers: urine, blood, hair
(depending on the form of Hg and other factors)

Survey protocol

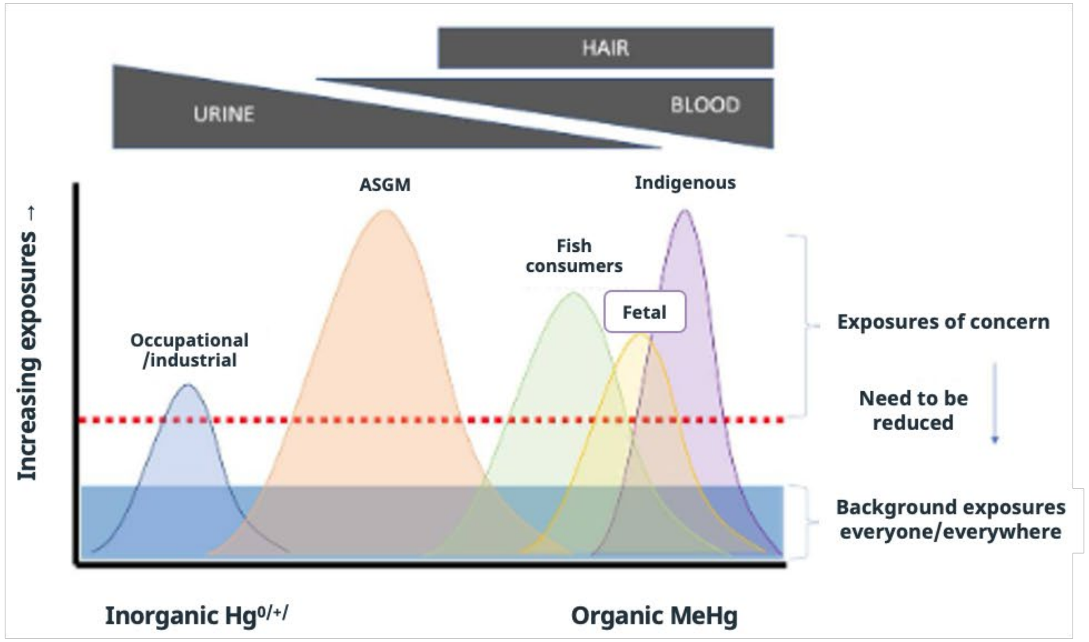


Diagram of accepted Hg biomarkers (at top) in relation to the different chemical forms of Hg that these biomarkers represent exposure to (at bottom)

Key population groups identified to be of concern from the Global Mercury Assessment 2018 are outlined in the middle of the figure, along with a horizontal band along the bottom that represents the general population

Basu et al., 2023

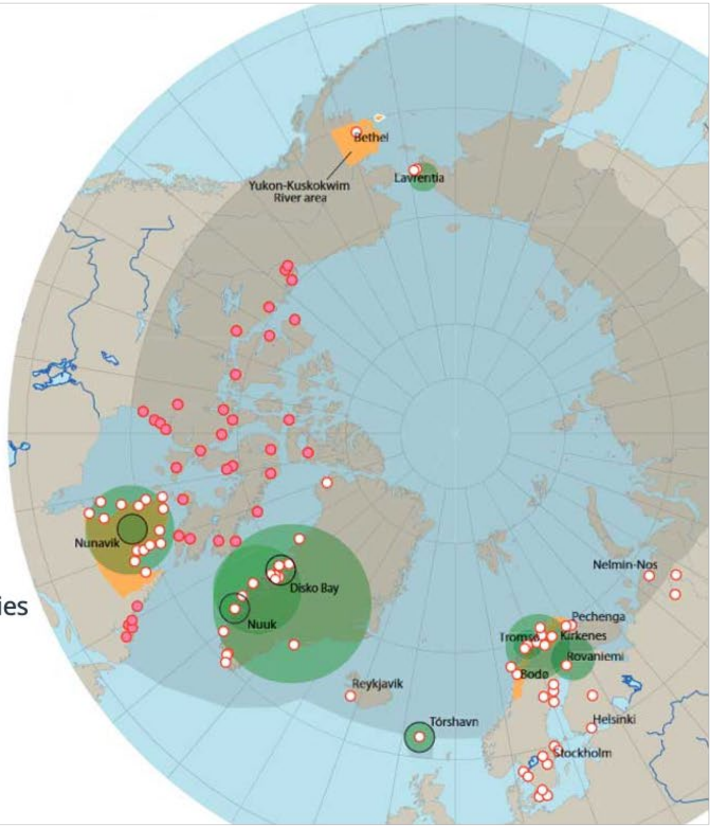
HBM – Regional efforts

Arctic Monitoring and Assessment Programme (AMAP)

to advise the governments of the eight Arctic countries (Canada, Denmark/Greenland, Finland, Iceland, Norway, the Russian Federation, Sweden and the United States) on matters relating to threats to the Arctic region from pollution

to publish results in AMAP reports (1998, 2002, 2009, 2015) prepared for ministerial meetings

Location of recent and ongoing blood monitoring, temporal trend and human health cohort studies around the Arctic



- Area-wide community studies
- Blood monitoring
- Inuit Health Survey
- Cohort studies
- Temporal trends

AMAP, 2015

HBM – WHO and EU supported initiatives

https://www.who.int/europe/publications/i/item/9789289060097

https://iris.who.int/handle/10665/332161

ESBIO
Expert team to Support BIOmonitoring in Europe

(2004–2008)

COPHES
DEMOCOPHES

(2009–2012)

HBM4EU
European Human Biomonitoring Initiative

(2017–2022)

PARC
Partnership for the Assessment of Risks from Chemicals

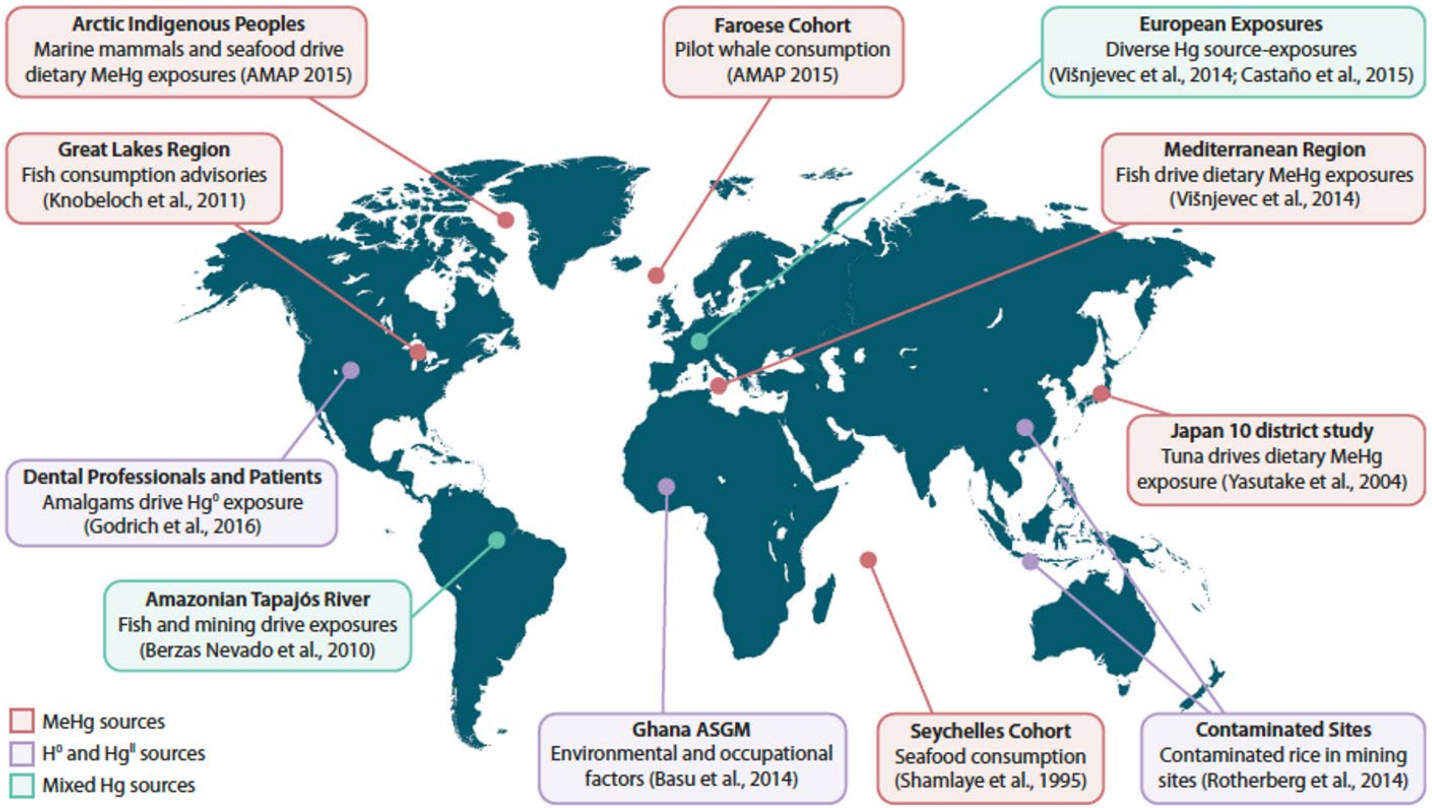
(2022–2029)

HBM – GMA report 2017 (Basu et al, 2018)

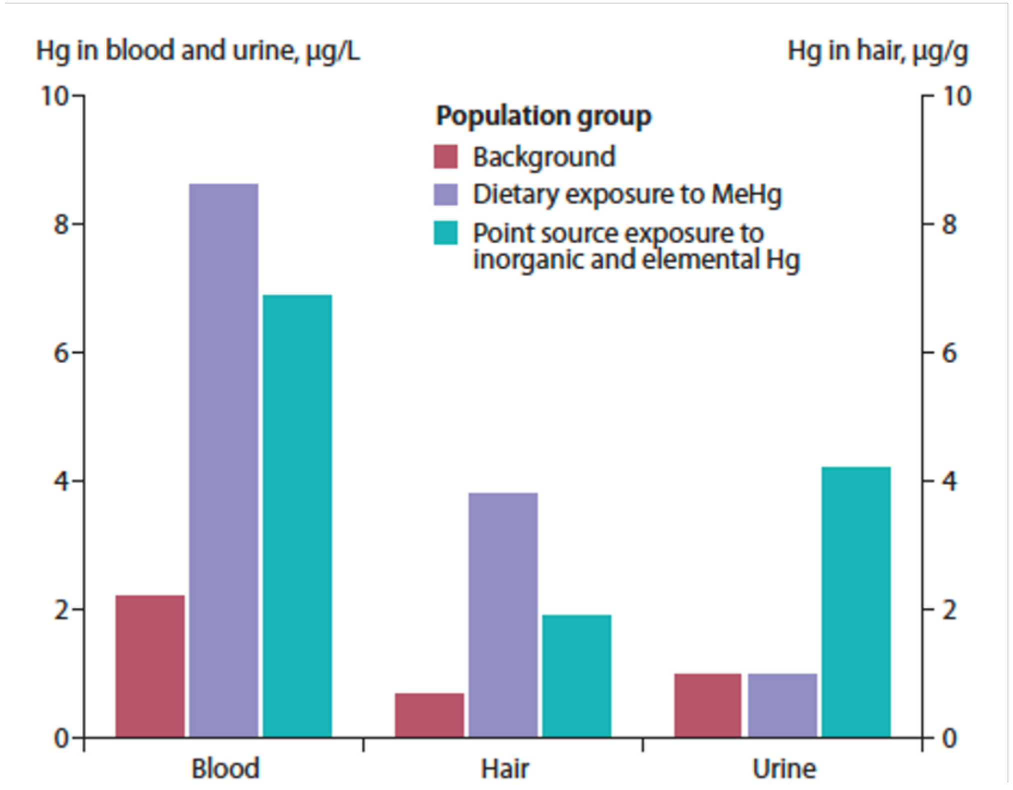
- *A-National human biomonitoring programs*
- *B-Longitudinal birth cohort studies*
- *C-Cross-sectional studies*

- **24,882** Hg biomarker measurements
- **336,015** individuals
- **312** articles
- **75** countries

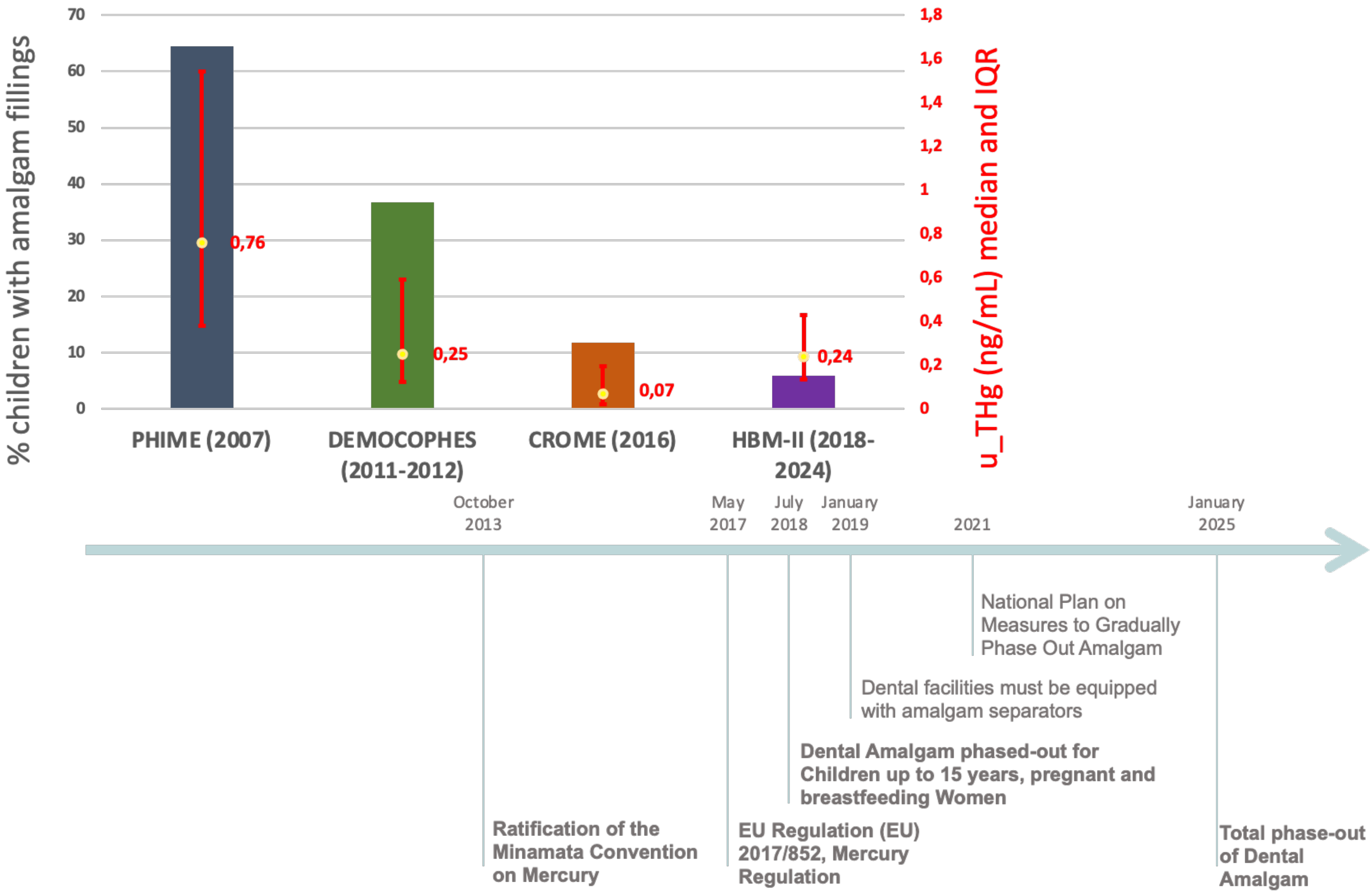
Selected studies worldwide: evidence of Hg source-exposure relationships



Cross-sectional studies



HBM – Case study in Slovenia: amalgam use in children and Hg in urine

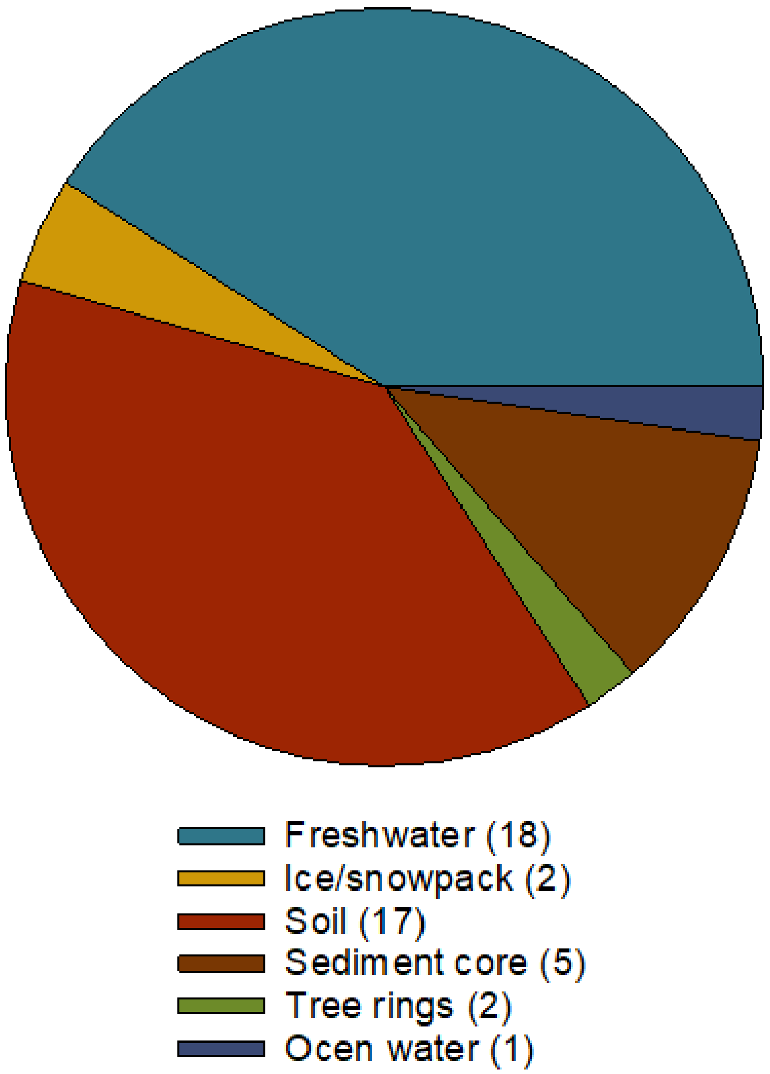


HBM - Challenges

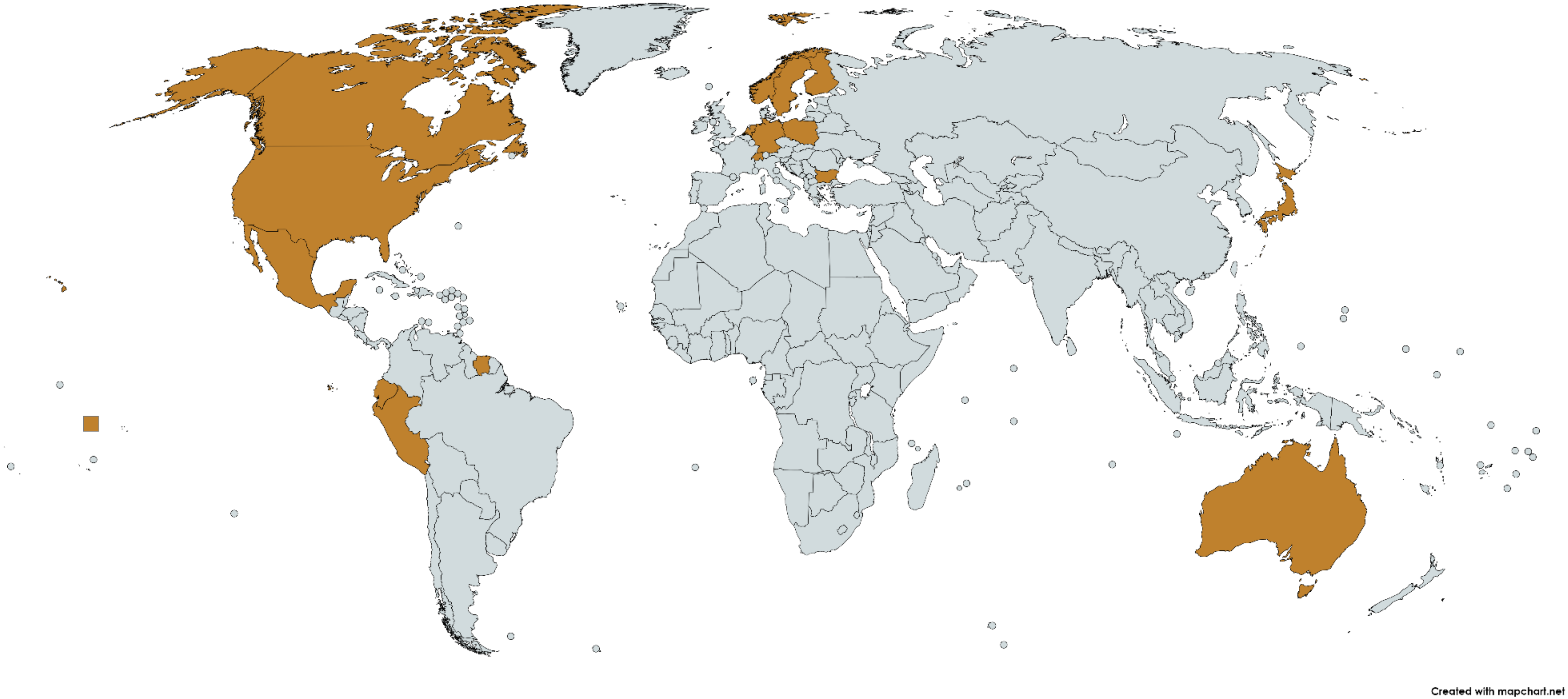
- **Unstructured HBM Data**: HBM data often lack structure, quality control, and metadata, complicating comparison and integration. Adopting FAIR principles (Findable, Accessible, Interoperable, Reusable) is essential.
- **Regulatory Gaps**: Current laws don't sufficiently mandate HBM data use, leading to inconsistent enforcement.
- **Limited Long-Term Programs**: Few countries have consistent HBM programs, limiting regular use in regulations.
- **Improvement in Methodologies**: Better standardization and integration of HBM data into policies are needed. This involves enhancing processes connecting HBM studies with policy decisions.
- **Exposure Sources and Global Variability**: Major sources include dietary (fish, shellfish), occupational, and environmental exposures. Significant variability exists, with higher exposure in vulnerable groups like fetuses, Arctic and tropical populations, indigenous and mining communities.
- **Effective Biomarkers**: Blood, hair, and urine measurements are key for assessing mercury exposure. Hair and urine are particularly suitable due to their non-invasive nature and cost-effectiveness.
- **Holistic Future Studies**: Future studies should consider both genetic and exposure factors. Combining HBM data with environmental data is vital for a comprehensive risk assessment.

Other matrices

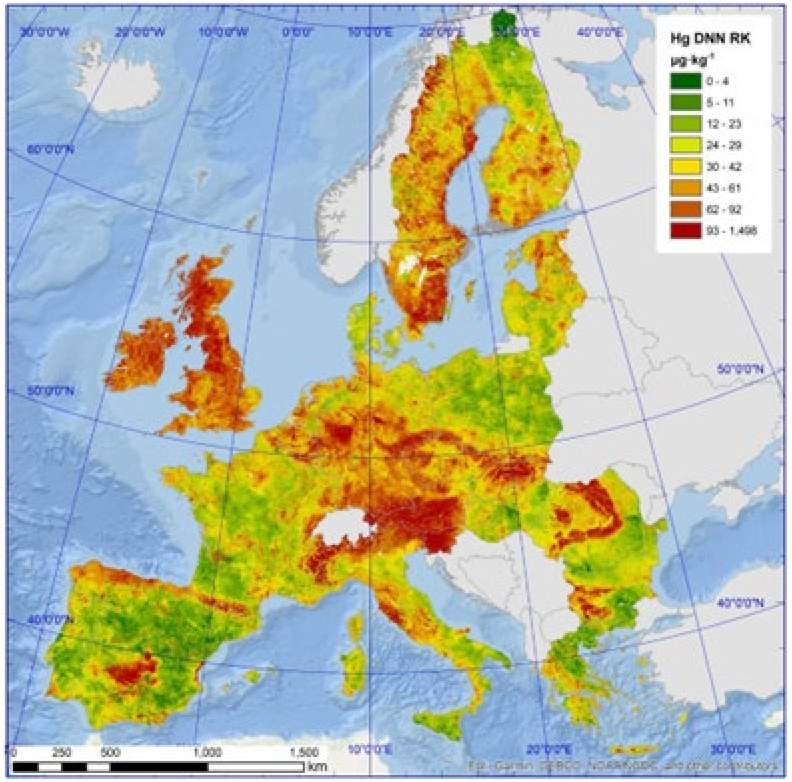
- Freshwater
- Ocean water
- Soil
- Sediment cores
- Ice/snowpack
- Tree rings



Other matrices – current intents to submit

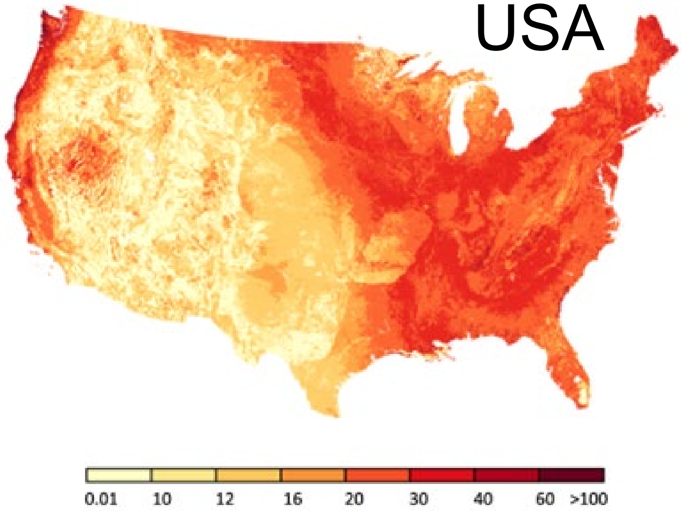


Other matrices - soil



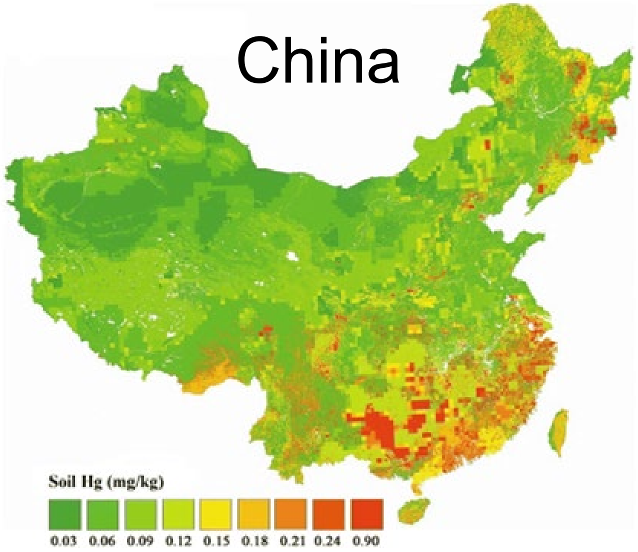
Ballabio et al. 2021

USA



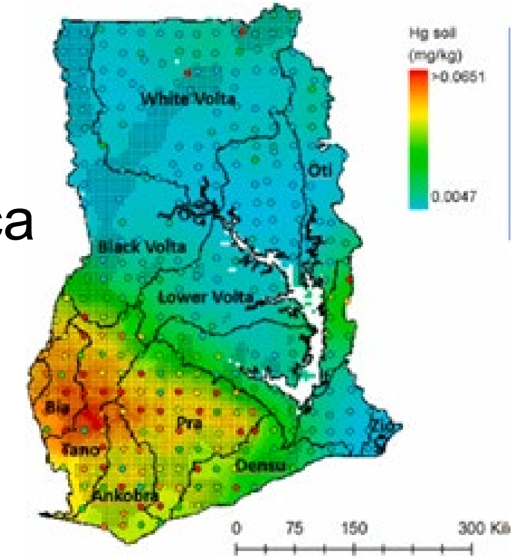
Olson et al. 2022

China



Zhang et al. 2020

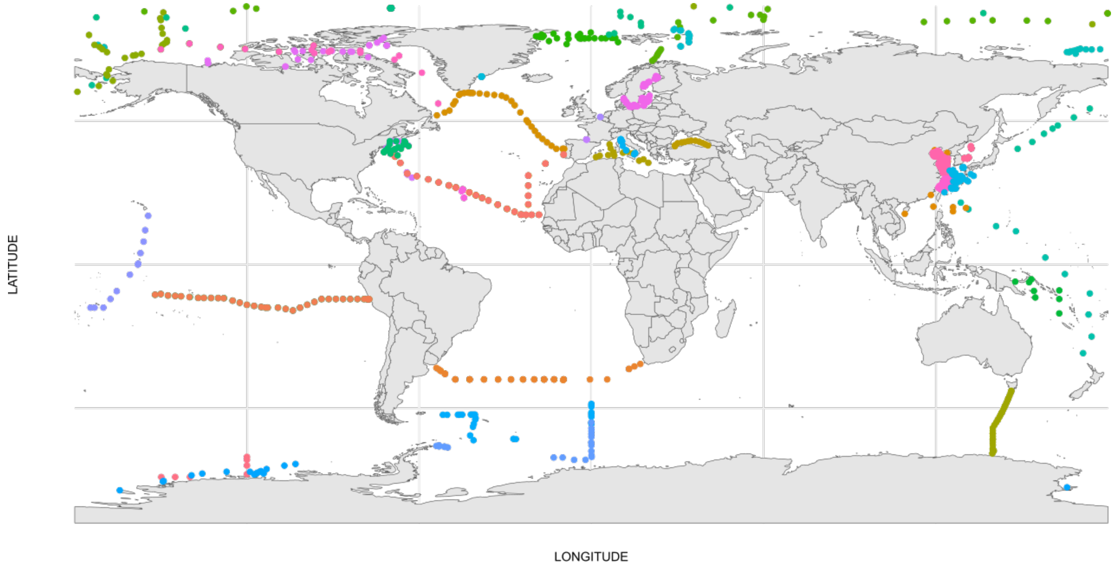
Ghana,
West Africa



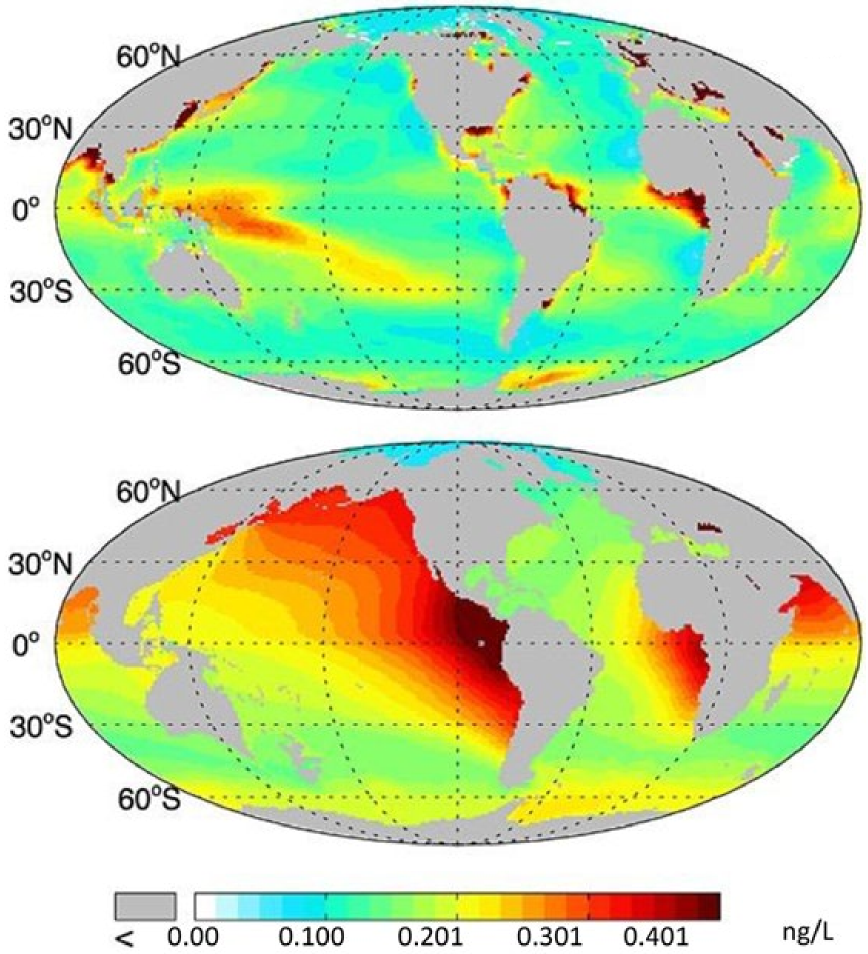
Ansah et al. 2022

Other matrices - ocean

Hg observations (2005-present)



Dastoor et al., 2024
(visit poster #215 Soerensen et al. for more info)



Zhang et al. 2014

Other matrices - challenges

- Global network for these matrices does not exist
- Current intents to submit:
  - Some national data, limited or no regional data
  - Limited temporal data
  - Large dataset owners have not responded to the call yet
  - Intercomparison of data is challenging due to lack of harmonized methodologies
- Gaps in coverage will hinder global assessment
- Members of this small group are specialists in their own matrices

Multi-compartment Hg modeling and analysis project
(MCHgMAP)

- **MCHgMAP** is a collaborative **“Mechanistic Modeling”** initiative under the **“OESG Integrated Analysis Team”** to analyze and attribute environmental Hg levels and trends observed in air, land and ocean on global scale
- The MCHgMAP multi-model ensemble approach is detailed in *Dastoor et al. 2024, The Multi Compartment Hg Modeling and Analysis Project (MCHgMAP): Mercury modeling to support international environmental policy Geosci. Model Dev. Discuss. https://doi.org/10.5194/gmd-2024-65 , 2024*

MCHgMAP (current) participants:
Ashu Dastoor[1], Hélène Angot[2], Johannes Bieser[3], Flora Brocza[4,5], Brock Edwards[6], Aryeh Feinberg[7,8], Xinbin Feng[9,10], Benjamin Geyman[11], Charikleia Gournia[12], Yipeng He[13], Ian M. Hedgecock[14], Shaojian Huang[15], Ilia Ilyin[16], Una Jermilova[17], Terry Keating[18], Jane Kirk[1], Che-Jen Lin[19], Taylor Luu[1], Igor Lehnherr[20], Robert Mason[21], David McLagan[22], Marilena Muntean[23], Asif Qureshi[24], Peter Rafaj[4], Eric M. Roy[7], Andrei Ryjkov[1], Noelle E. Selin[7], Francesco De Simone[14], Anne L. Soerensen[25], Frits Steenhuisen[26], Oleg Travnikov[27], Shuxiao Wang[28], Xun Wang[9], Simon Wilson[29], Rosa Wu[1], Qingru Wu[28], Yanxu Zhang[15], Jun Zhou[30], Wei Zhu[31], Scott Zolkos[32]

[1]Environment and Climate Change Canada (Canada), [2]Université Grenoble Alpes (France), [3]Helmholtz-Zentrum Hereon GmbH (Germany), [4]International Institute for Applied Systems Analysis (Austria), [5]University of Leeds (United Kingdom), [6]University of Manitoba (Canada), [7]Massachusetts Institute of Technology (USA), [8]Institute of Physical Chemistry Blas Cabrera (Spain), [9]Institute of Geochemistry, Chinese Academy of Sciences (China), [10]University of Chinese Academy of Sciences (China), [11]Harvard University (USA), [12]Jožef Stefan International Postgraduate School (Slovenia), [13]Florida International University (USA), [14]CNR-Institute of Atmospheric Pollution Research (Italy), [15]Nanjing University (China), [16]MSC East (Russia), [17]Trent University (Canada), [18]U.S. Environmental Protection Agency (USA), [19]Lamar University (USA), [20]University of Toronto Mississauga (Canada), [21]University of Connecticut (USA), [22]Queen’s University (Canada), [23]European Commission (Italy), [24]Indian Institute of Technology (India), [25]Swedish Museum of Natural History (Sweden), [26]University of Groningen (Netherlands), [27]Jožef Stefan Institute (Slovenia), [28]Tsinghua University (China), [29]Arctic Monitoring and Assessment Programme Secretariat (Norway), 30 Institute of Soil Science, Chinese Academy of Sciences (China), [31]Swedish University of Agricultural Sciences (Sweden), [32]Woodwell Climate Research Center (USA)

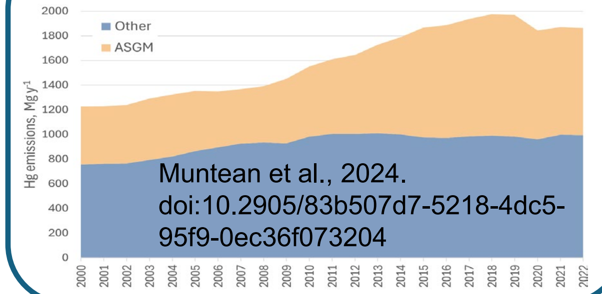
Related talks/posters at ICMGP 2024: Marilena Muntean (Session 1, Monday); Ashu Dastoor (Session 12, Tuesday) ; Johannes Bieser (Session 18, Wednesday); Aryeh Feinberg (Session 31, Friday; Poster #55); Anne Soerensen (Poster # 215)

MCHgMAP modeling focus for the Effectiveness Evaluation Cycle 1

Analysis of current environmental Hg levels and trends

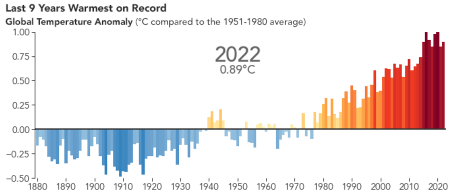
Anthropogenic Hg emissions and releases trends

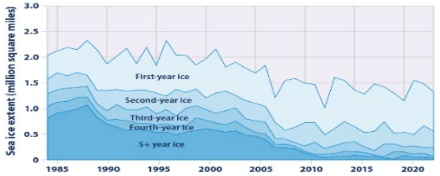
Updated EDGAR inventory



Other Global changes

Examples





https://earthobservatory.nasa.gov/world-of-change/global-temperatures
https://nsidc.org/data/nsidc-0611

Input

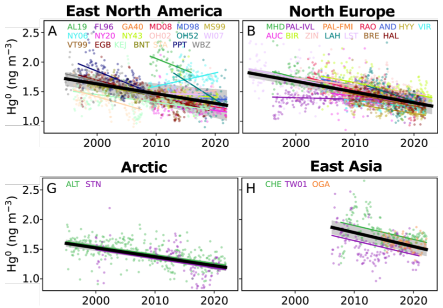
Process-based (mechanistic) Global Multi-Model Ensemble

Trend & attribution simulations

Output

Simulate/evaluate current Hg levels and trends

Air



Observed trends: Feinberg et al., 2024; doi:10.31223/X5B38K

Land

Ocean

- **Are trends in emissions consistent with trends in observed levels?**
- **How representative are the observations (levels and trends) on global scale?**

Output

Output

Attribute observed environmental Hg trends

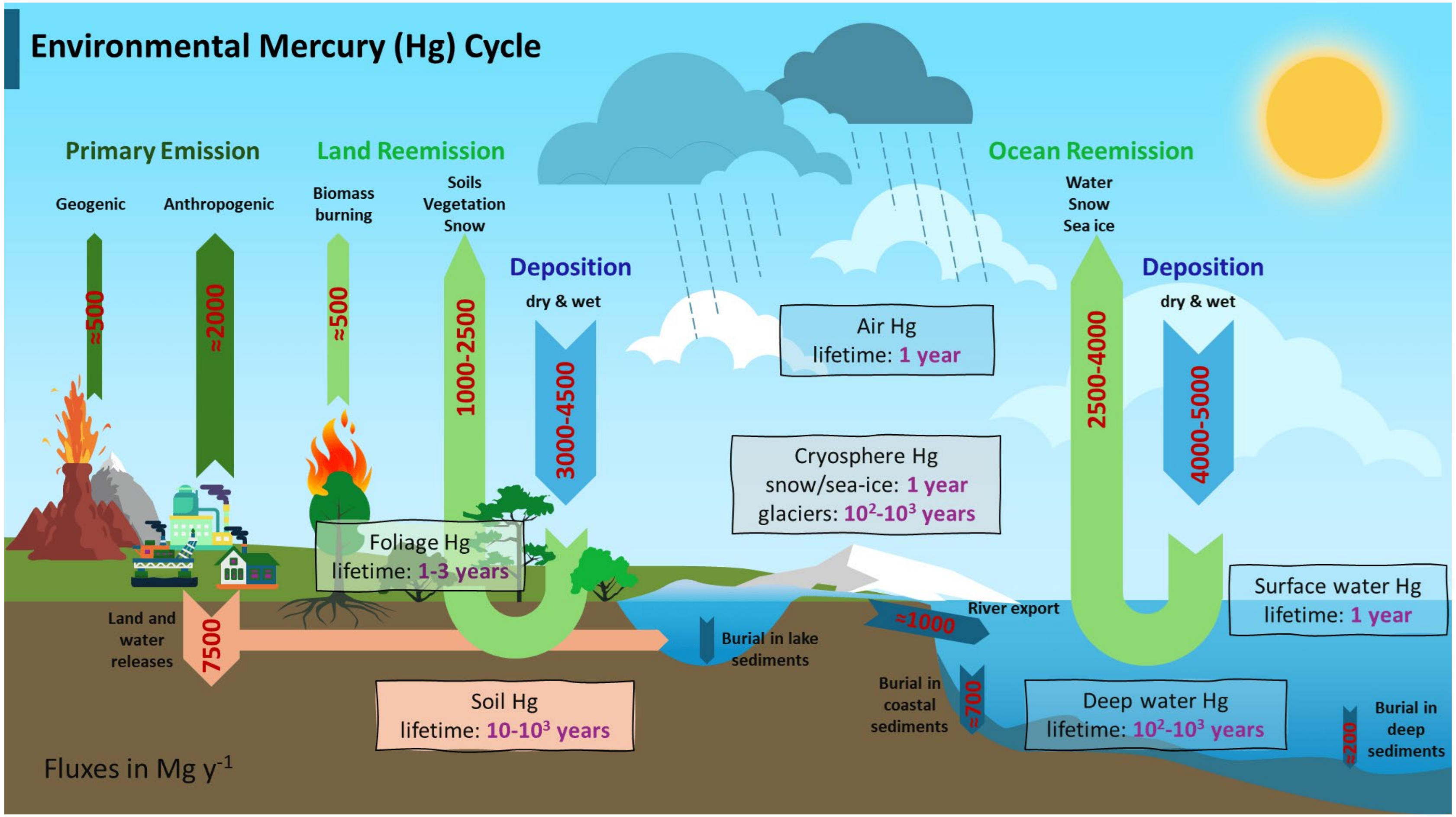
- **How have contemporary anthropogenic emissions and releases contributed to the observed trends?**

- **How have other drivers contributed to the observed trends?**

Environmental (air-land-ocean) Hg modeling and analysis considerations

Analysis of observed environmental Hg trends needs to address:

- Effects of Hg recycling between air, land and ocean on timescales of hours to centuries
- Current magnitudes and trends of secondary Hg emissions and releases, about 60-75% of all Hg emissions
- Sensitivity of Hg processes to global changes
- Distinguish effects of recent (small) changes in anthropogenic inputs from global change effects



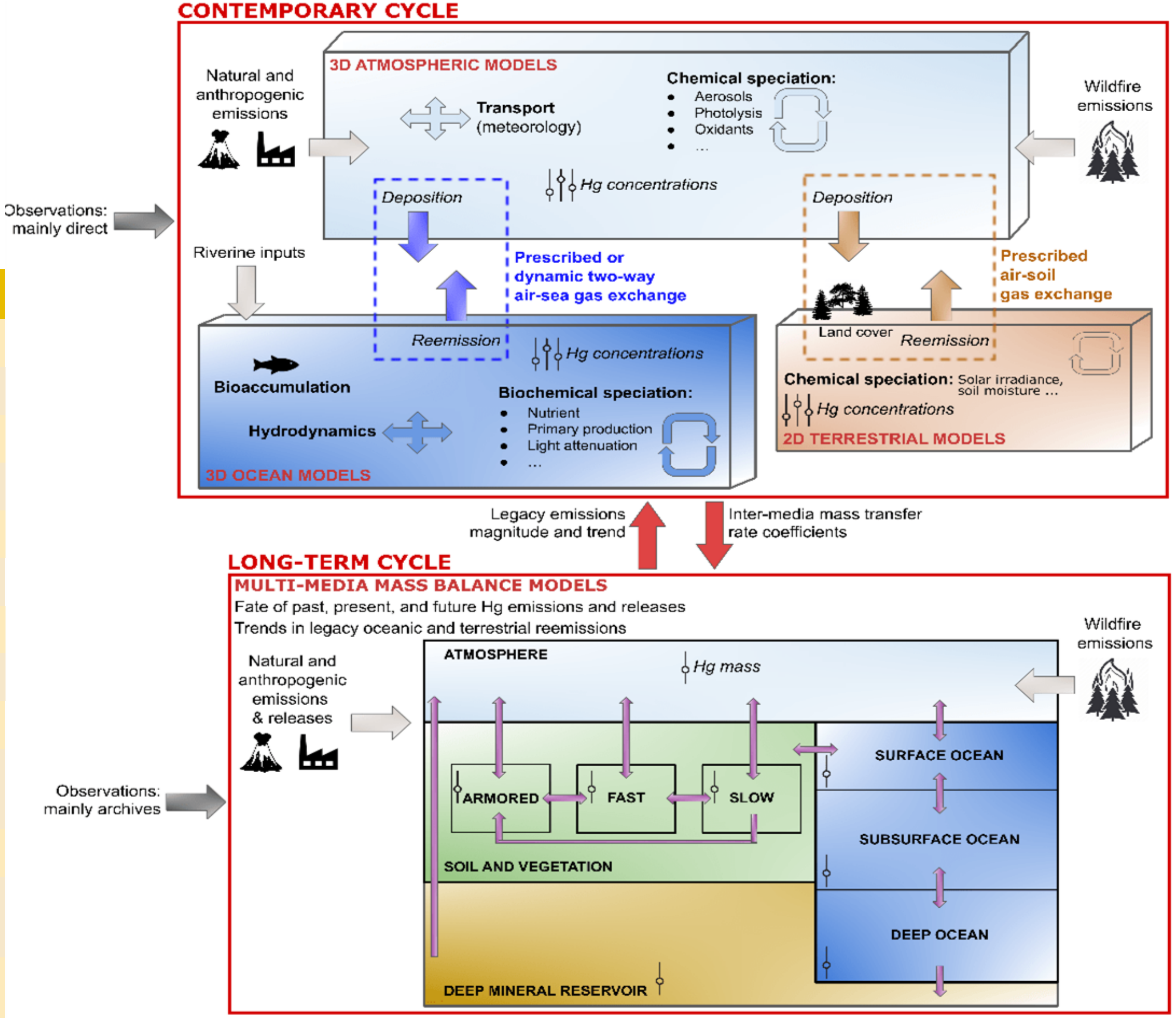
Modern-day Hg flux ranges are from recent modeling studies

MCHgMAP environmental (air-land-ocean) Hg modeling approach

- Ideally, 3D earth system modeling is required - limited availability and computational challenge
- Previous assessment efforts focused on atmospheric models only
- The OESG/MCHgMAP approach: couple **detailed** single-medium (**atmosphere, land, ocean**) and **efficient multi-media mass balance models** to account for slow and fast changes in global mercury cycling and levels

Participating Models	Institution
3D 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)
3D Ocean models	
MERCY	Helmholtz-Zentrum Hereon (Germany)
MITgcm	Nanjing University (China)
2D Terrestrial models	
Air-land Hg exchange model	Institute of Geochemistry, Chinese Academy of Sciences (China) and Lamar University (USA)
Multi-media mass balance models	
Global Biogeochemical Box Model (GBC)	Harvard University (USA) University Grenoble Alpes, CNRS (France)
$WorM^3$	Indian Institute of Technology Hyderabad (India)

Coordination of air, land, ocean and multimedia mass balance models

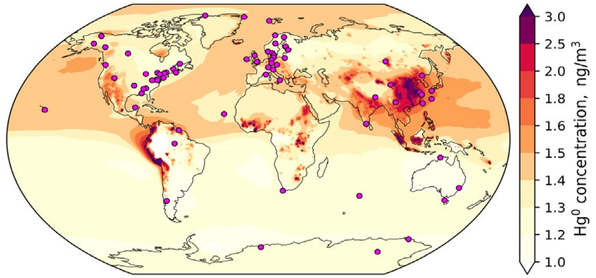


Observation data challenges for model evaluation and development

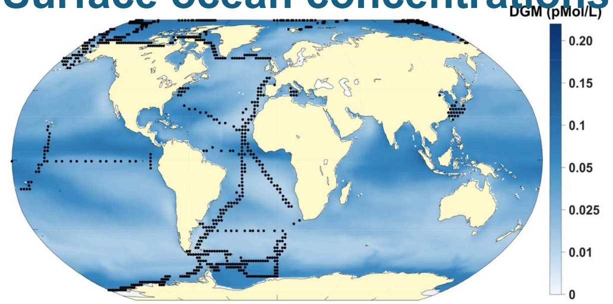
Preliminary model-simulated spatial maps for environmental Hg levels and fluxes with locations of observation sites shown

Contemporary Hg levels

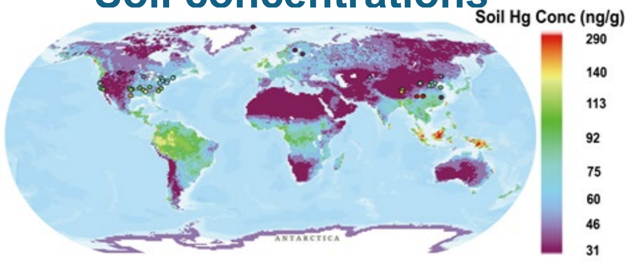
Surface air concentrations



Surface ocean concentrations



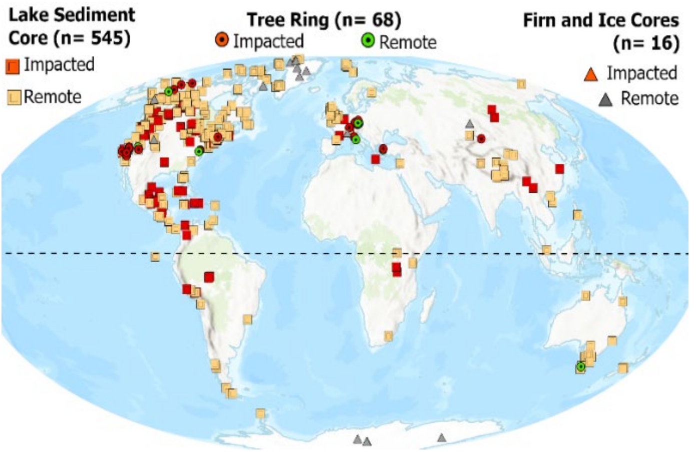
Soil concentrations



Vegetation, snow, fresh water….

- Limited media and spatial coverage
- Lack of inter-media fluxes to constrain global Hg cycling (few direct observations), critical to Hg trend simulation and analysis
- Lack of temporal trends in "other media"
- Natural archives inform all-time changes in environmental Hg levels (legacy Hg effects) but have higher uncertainties and low temporal resolution
- Multi-model approach is helpful, but data gaps need to be addressed!

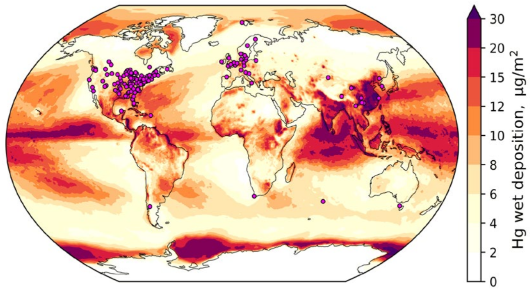
Long-term environmental Hg trends



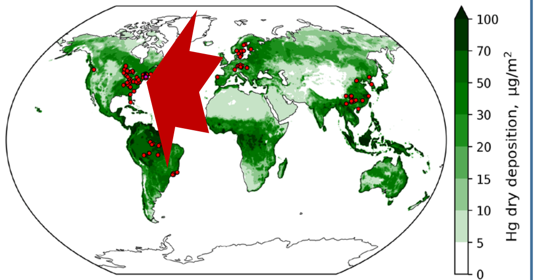
OESG "Other media" observations database in progress

Contemporary inter-media Hg fluxes

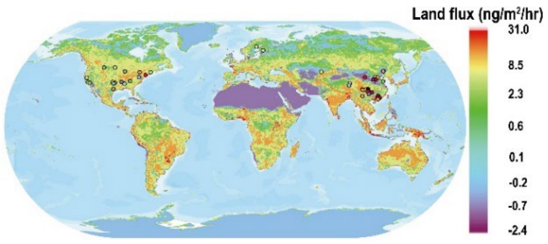
Precipitation uptake



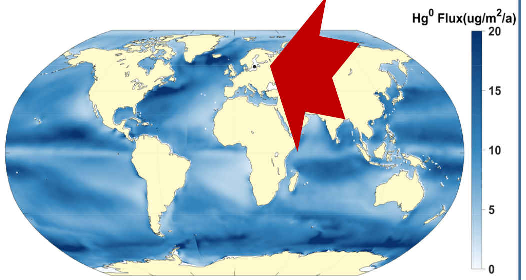
Land/vegetation uptake



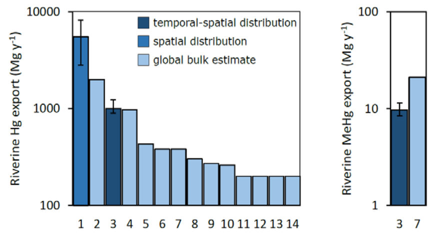
Land reemission



Ocean reemission



Global river export

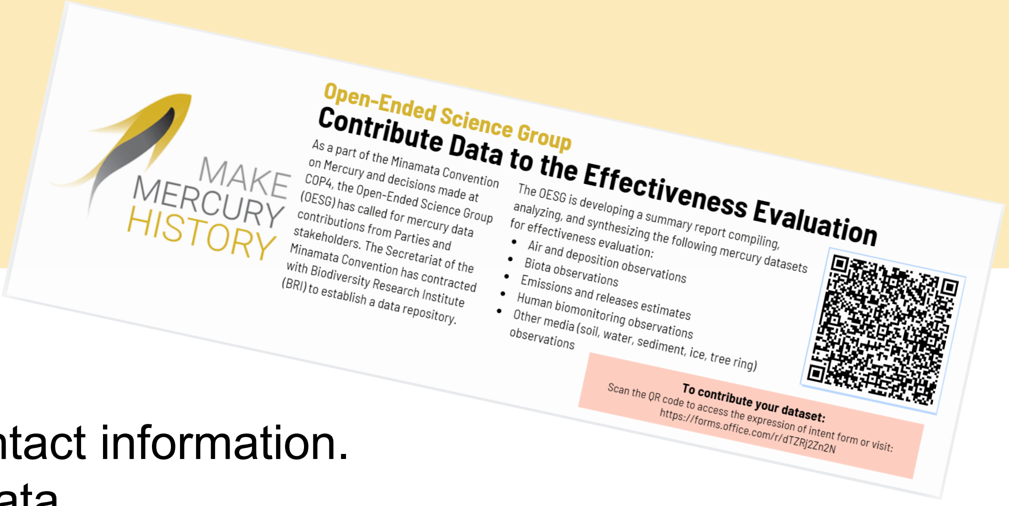


Different literature values (Dastoor et al. 2024)

Observations:
OESG "air" and "Other media" database in progress

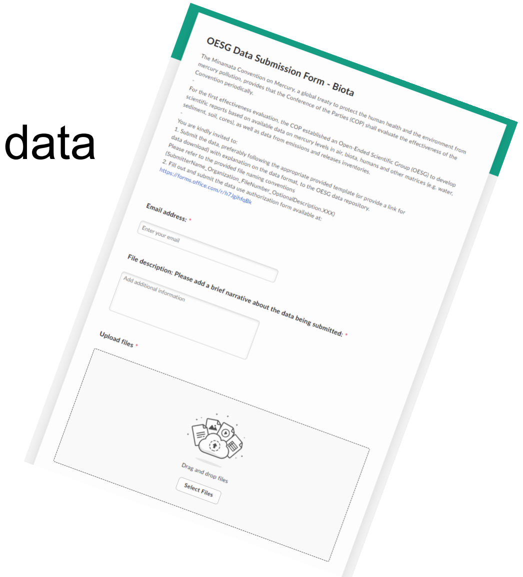
Modeling examples:
Air - GEM-MACH-Hg (ECCC, Canada)
Ocean - MITgcm (Nanjing U., China)
Land – Air-Soil model (Institute of Geochemistry, China; Lamar U., USA)

How can you contribute?



Contribute data:

- ➢ **Submit online form indicating intent**
  - ➢ Simple online form provides description of data and contact information.
  - ➢ BRI follows up with instructions specific to the type of data.
- ➢ **Format and document data**
  - ➢ OESG has developed data dictionaries and recommended formats for the different types of data from each media.
- ➢ **Data use agreement**
  - ➢ When uploading data, data providers are asked to specify an appropriate citation and identify any restrictions on the use of the data submitted.
- ➢ **Upload data to secure cloud workspace**
  - ➢ BRI has established a cloud-based workspace where data providers can upload data and OESG participants can access it for analysis.



Contribute to the analysis:

- **Get on the roster of experts and join a team**
  - Send an email to the Secretariat (Eisaku.Toda@un.org) or the Co-Chairs.
- **Participate in the Review of Drafts**
  - Contact the Secretariat or your national focal point.

Topics for discussion

MINAMATA CONVENTION ON MERCURY

- Are there datasets that you have that could be useful and submitted to the OESG?
- Are there locations for which temporal data for all matrices (abiotic and biotic) have been collected?
- What are the difficulties of this OESG process that you foresee given the data restrictions? Does that affect whether you will participate in the process?
- What are your thoughts on a global mercury monitoring program?

Scan the QR code to access the expression of intent to provide data

Topics for Discussion

- Article 19 - Research, development and monitoring
  - 1(b) modeling geographically representative monitoring of levels of mercury and mercury compounds in vulnerable populations and in **environmental media**, including biotic media such as fish, marine mammals, sea turtles and birds, as well as collaboration in collection and exchange of relevant and appropriate samples

- Article 22 - Effectiveness evaluation
  - 2 - initiate the establishment of arrangements for providing itself with comparable monitoring data on the presence and movement of mercury and mercury compounds in the environment as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations.