Minamata Convention: Initial Assesment of Turkey

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Inventory Mercury Training Meeting

29 – 31/01/2018, Hilton Garden Inn Eskişehir

Lecture 2

Mercury and Environmental / Health Issues – properties, fate, behaviour, health and environmental impacts and risks

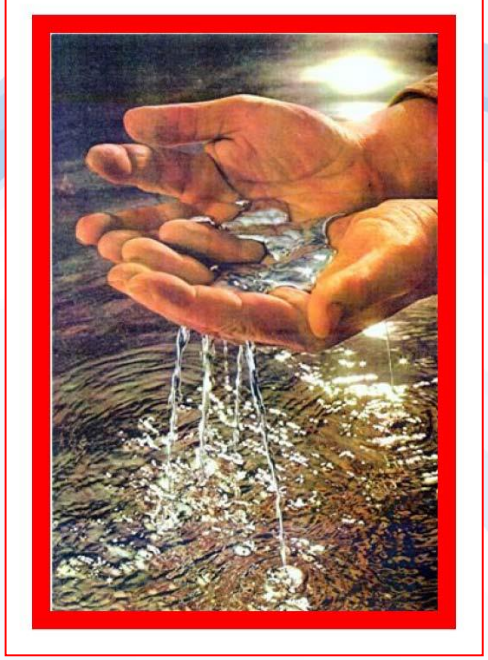
Mercury (Hg)

Metal with very specific properties and behaviour – white silver liquid metal:

- The lowest value of melting and boiling points from all metals (-38,87 °C; 358,53 °C)
- Good potential to dissolve metals and form alloys (amalgames)
- Organometallic form – higher toxicity

Mercury (Hg)

Heimaey, Iceland



Elemental Hg, hydrothermal spreading centre, New Zealand

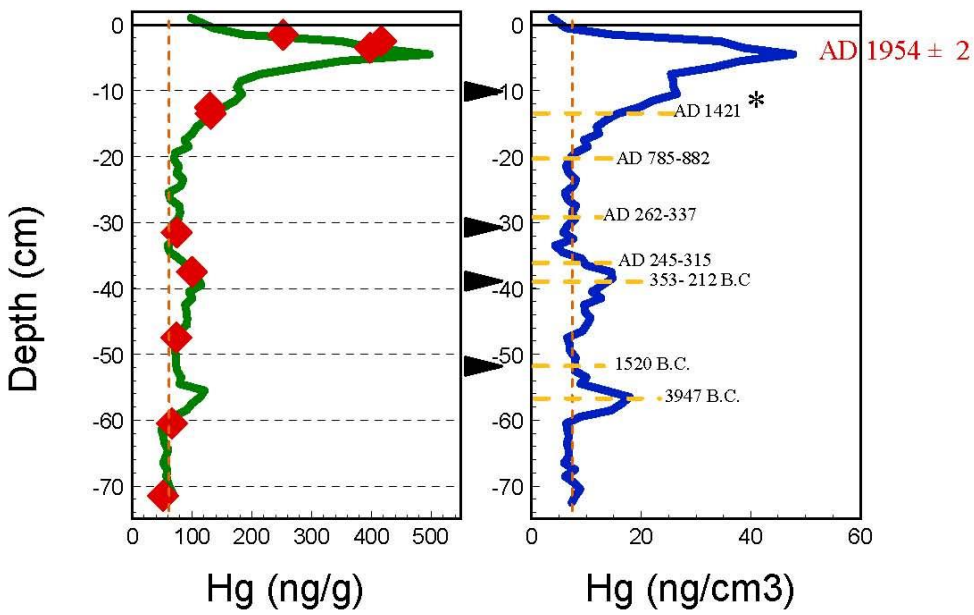
Mercury (Hg)

Myrarnar, Faroe Islands

Natural Hg ?

AnthropogennicHg ?

Concentration profile Hg, Faroe Islands



GREEN SOLID LINE
Hg concentrations measured in whole, air-dried bulk peat samples by Nicolas Givelet using the LECO AMA

RED DIAMONDS
Hg concentrations measured in acid digests of peat samples by Stephen Norton using atomic fluorescence spectroscopy

BLACK ARROWS
tephra layers identified using Zr concentrations

* fine fraction of peat was age dated because no macrofossil could be found

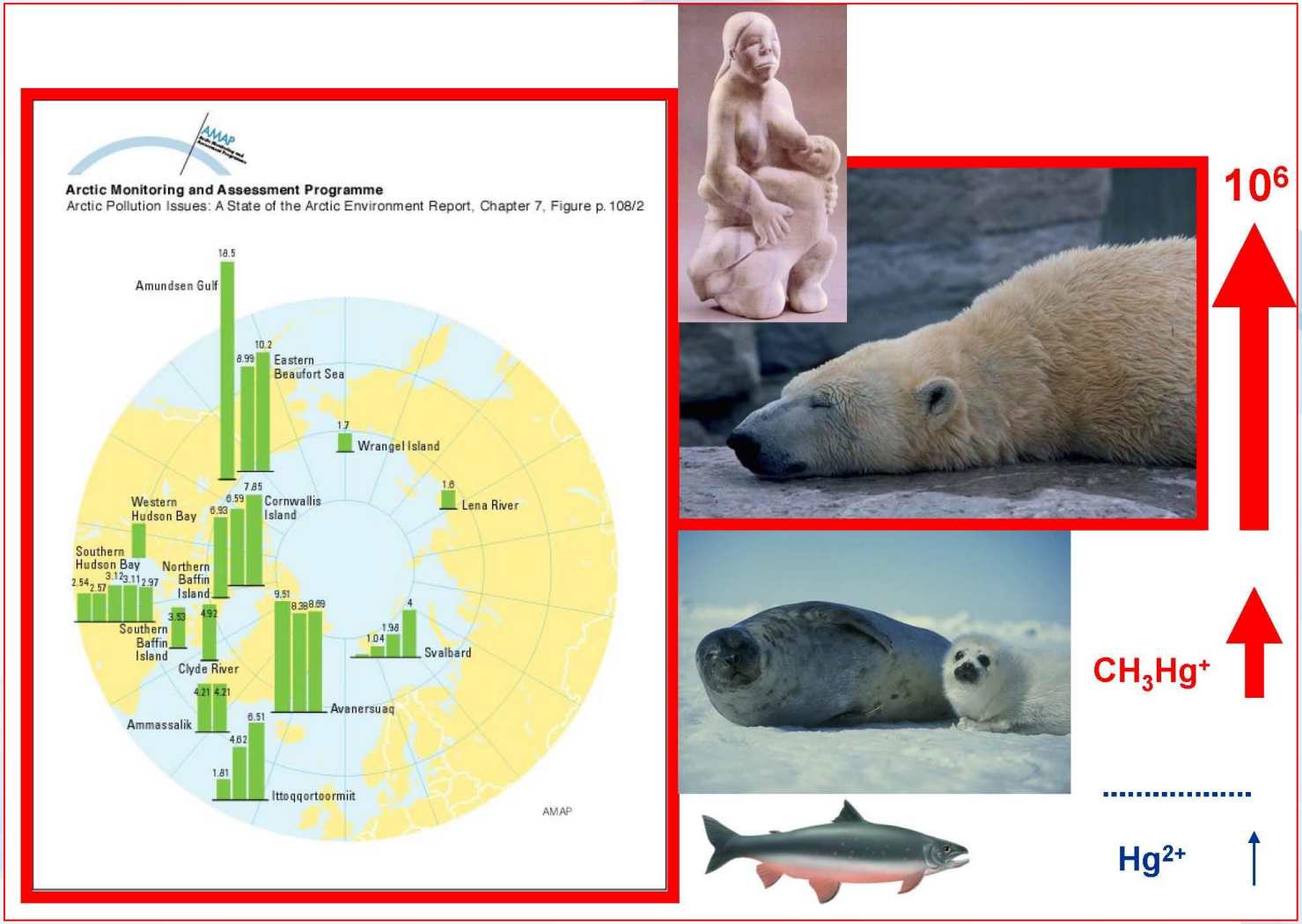
HORIZONTAL GOLD LINES
macrofossils from this depth were age dated using 14C AMS

Mercury in Arctic

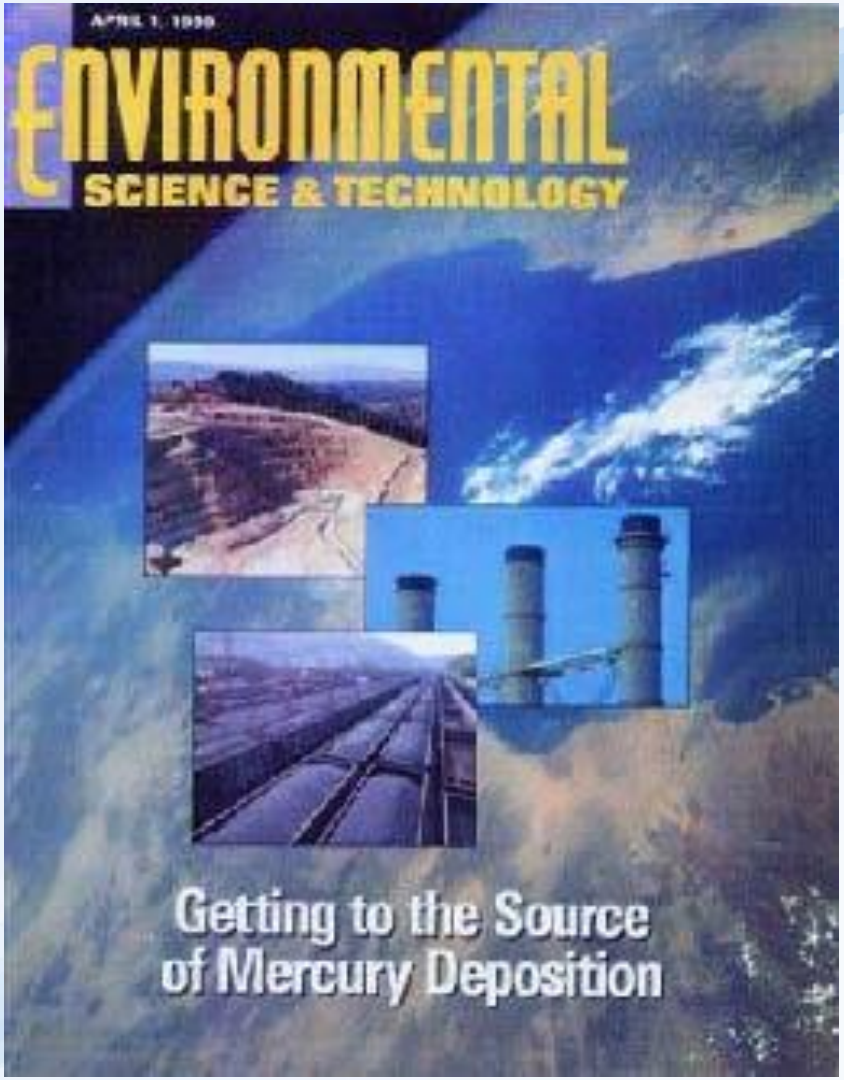
"Up to half of Inuit women in the Canadian Arctic are consuming toxic pollutants at levels exceeding international safety limits. The fish, seals, and whales they eat are contaminated with pesticides, heavy metals, and PCBs from the developed world "

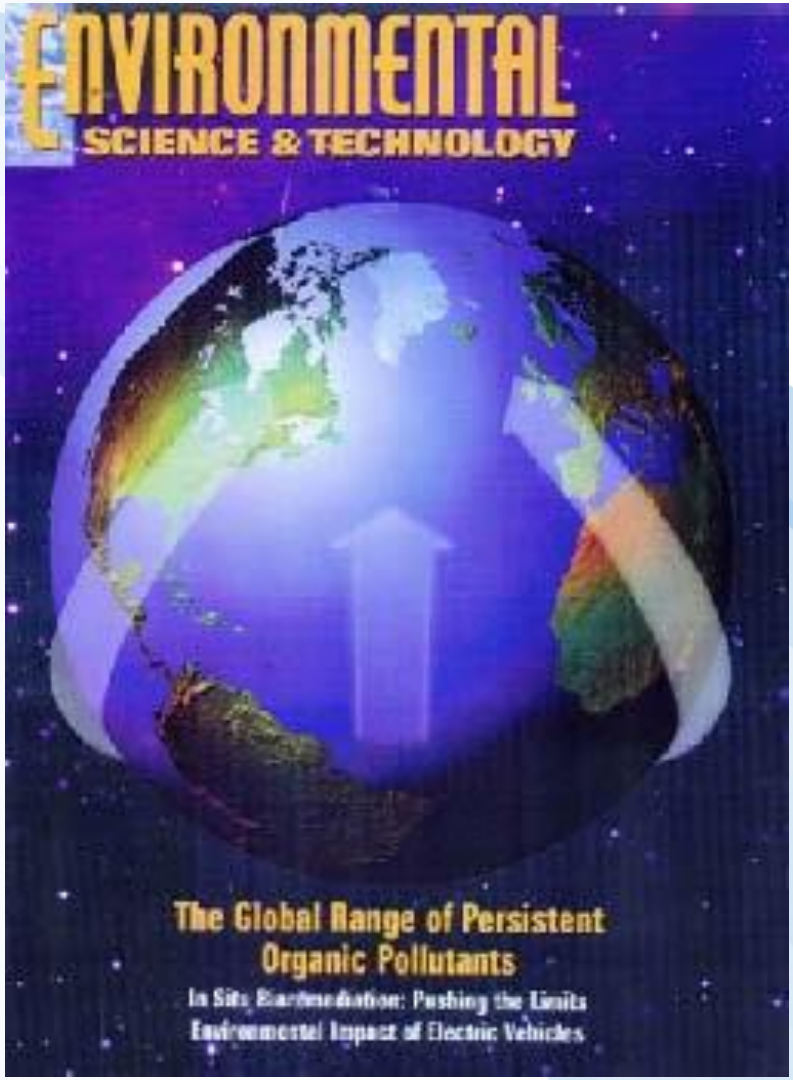
Arctic Monitoring and Assessment Program (AMAP)

Mercury in Arctic



Global occurrence of Hg

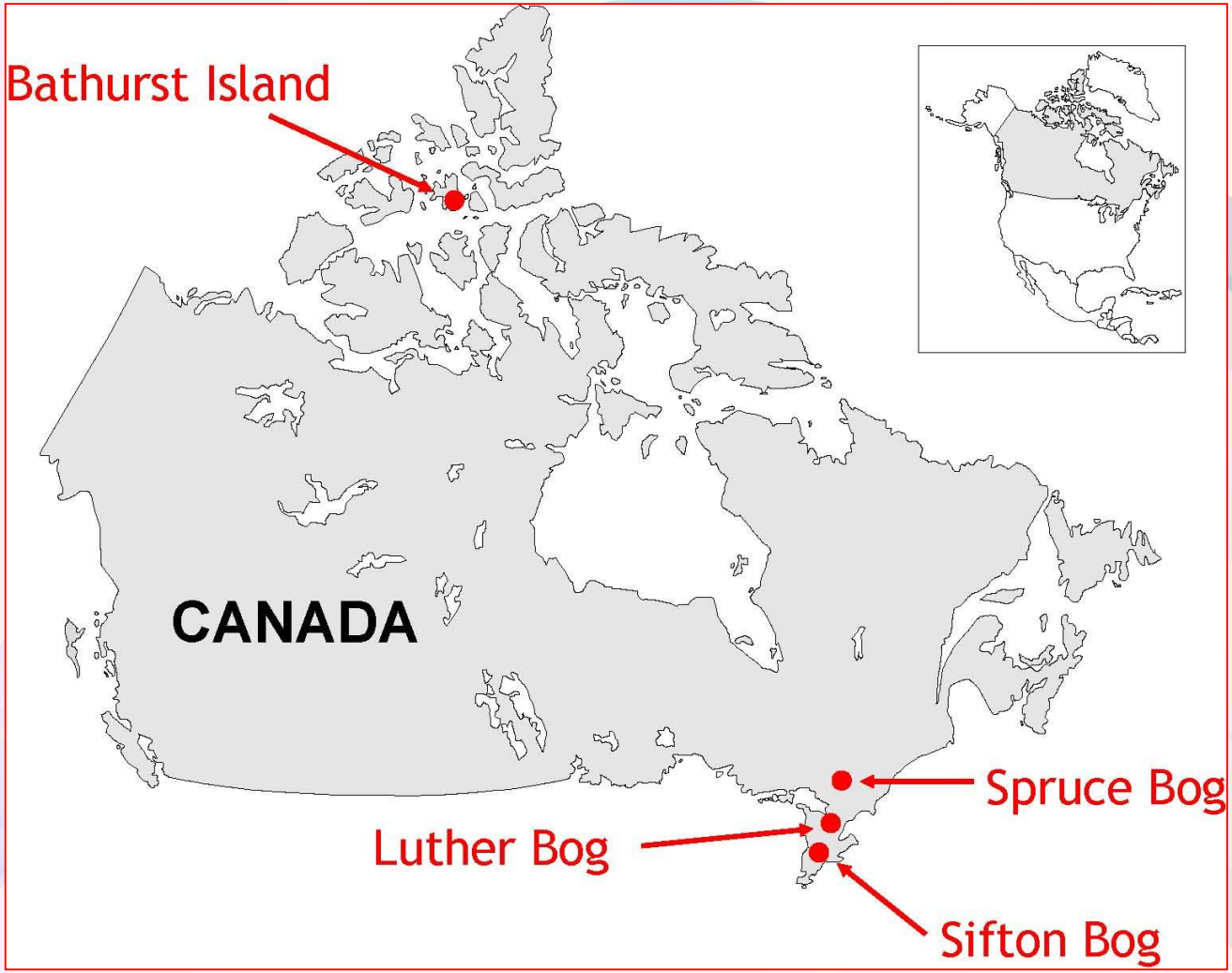




Lack of temporal trends

"The most significant gap in our knowledge at the present time is the lack of temporal trend data for most contaminants"

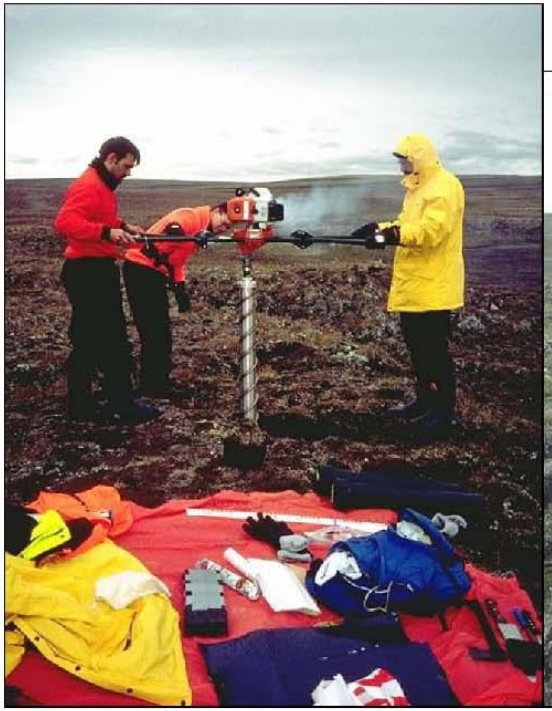
Lack of temporal trends



Lack of temporal trends

Bathurst Island, Nunavut (75 °N)

Bracebridge Inlet Sampling site
July 2000



Lack of temporal trends

Bathurst Island,
Nunavut,
Canada,
Summer 2000

Peat accumulation from
4000 B.C. to 1000 A.D.

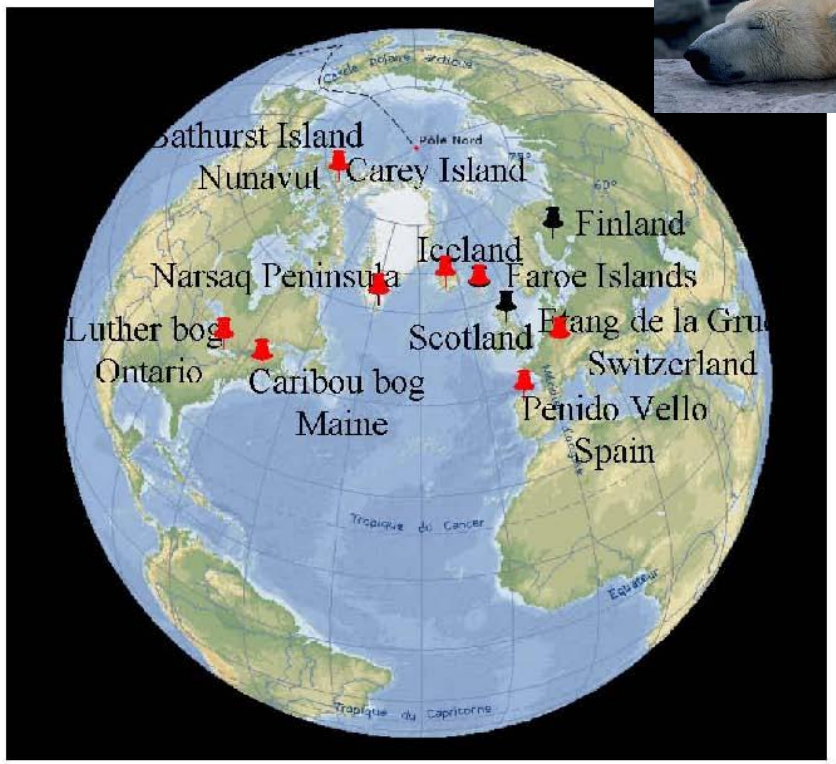
Natural rates of atmospheric Hg accumulation
Arctic =
Switzerland =
Faroe Islands =
Southern Greenland =
southern Ontario = 1 µg/m²/yr

Spatial trends

Comparison with other locations

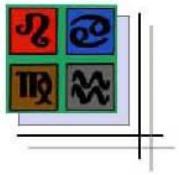
Natural background net deposition rate:

0.5 - 1.5 µg Hg m^{-2} yr^{-1}



⇒ No evidence that the Arctic was an important natural sink for mercury in the global cycle

Global cycle of Hg



Implication for the global Hg cycle

Estimated pre-anthropogenic global atmospheric mercury
Flux: 450 t/yr (peat records)

Estimated pre-anthropogenic global atmospheric mercury
Flux: 2500 t/yr (Nriagu, 1989)

Estimated global anthropogenic atmospheric mercury
Flux: 1900 t/yr (Pacyna & Pacyna, 2002)

⇒ **True impact of anthropogenic emissions of mercury to global atmosphere underestimated by a factor 5?**

Visible metallic mercury in alluvial sediments

Mongolia: Technical and Technological Support for Ecological Burden Remediation Caused by Illegal Mining in Central Part of Mongolia, GEOMIN Company;

Mercury – sources and use

Natural sources: as compounds – igneous rocks, sedimented sulphidic minerals, elemental form - rare.

Anthropogennic sources:

- Some fungicides for pulp bleaching
- Production of chlorinated hydrocarbons
- Destillation of oils nd coals
- Production of electric contacts
- Agricultural stains
- Ore processing
- Amalgamation
- Electrochemical production
- Regulation technics
- Medicine - active components of different diuretics, antiseptics, dermal drugs, tooth amalgames
- Laboratory colorants

Environmental chemistry of Hg

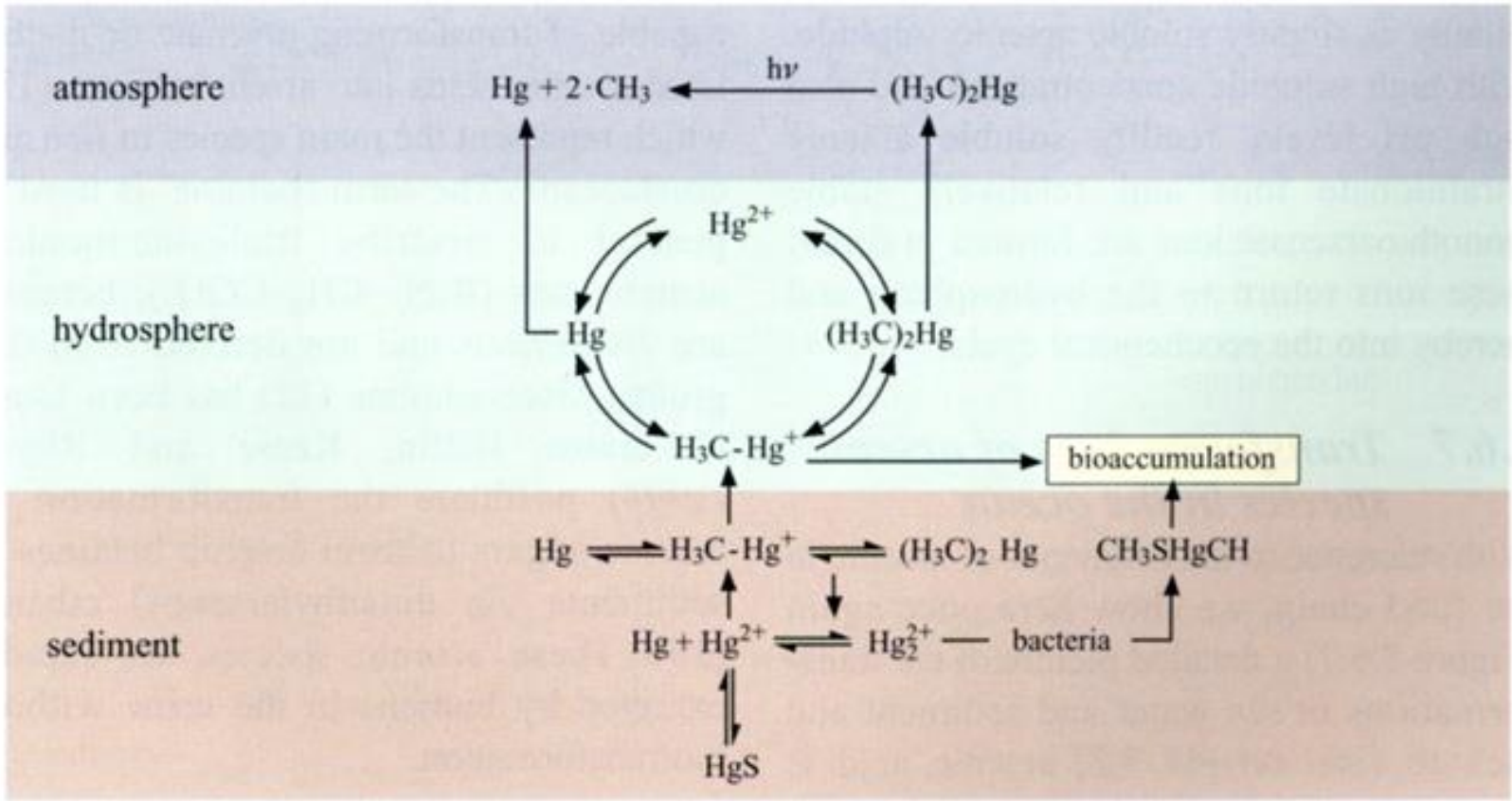
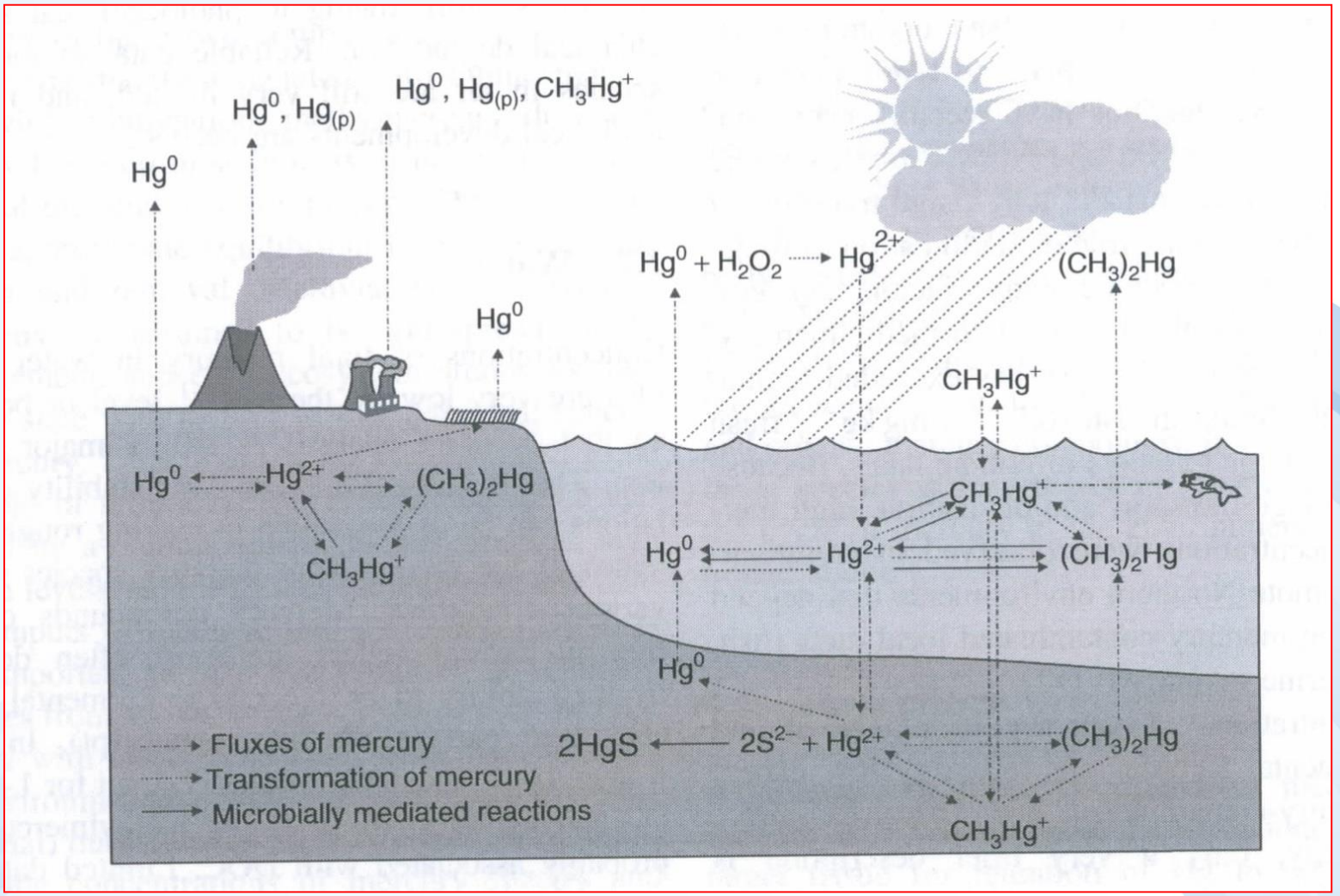
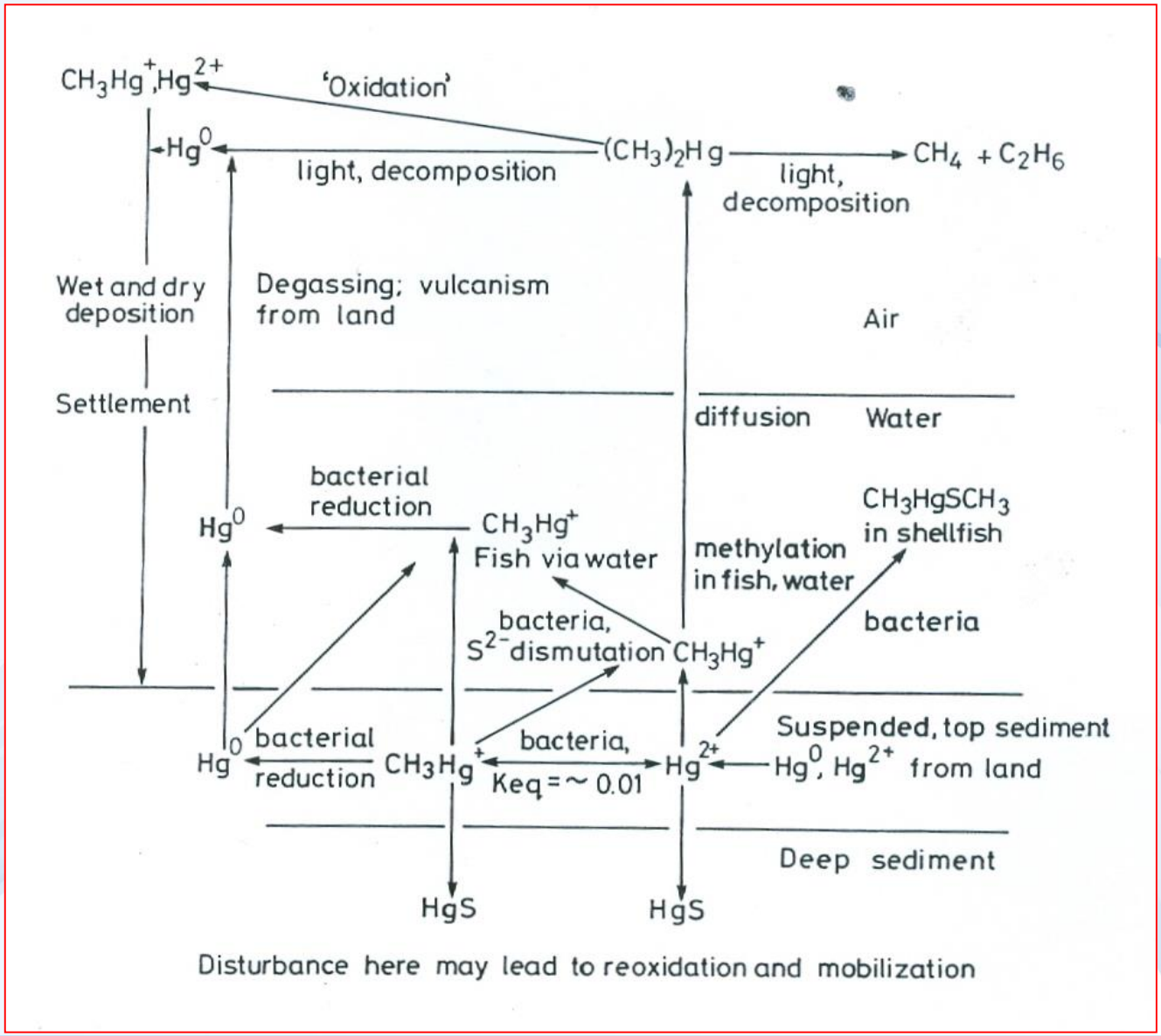


Figure 5.6.5 Environmental chemistry of mercury

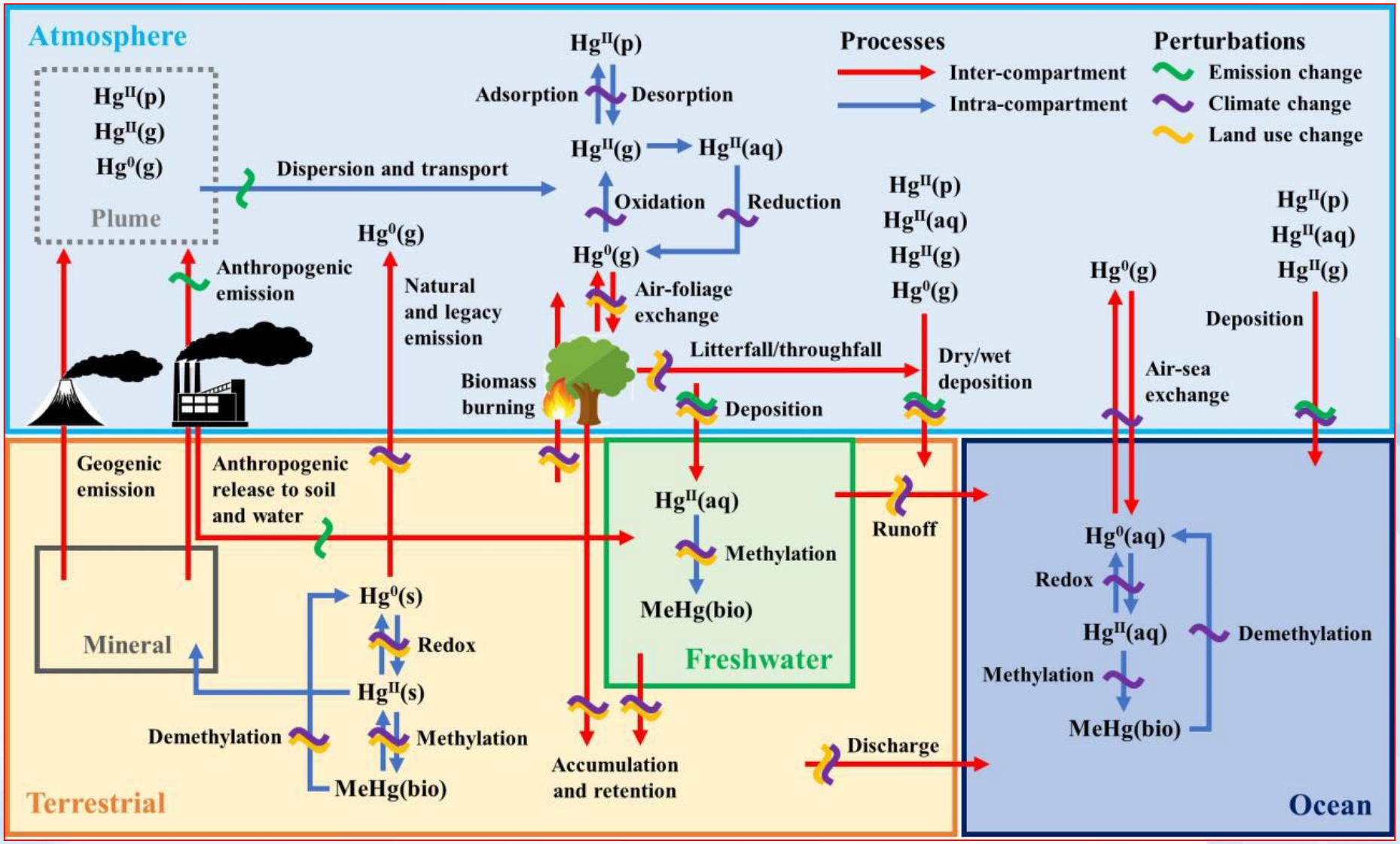
Environmental cycle of Hg



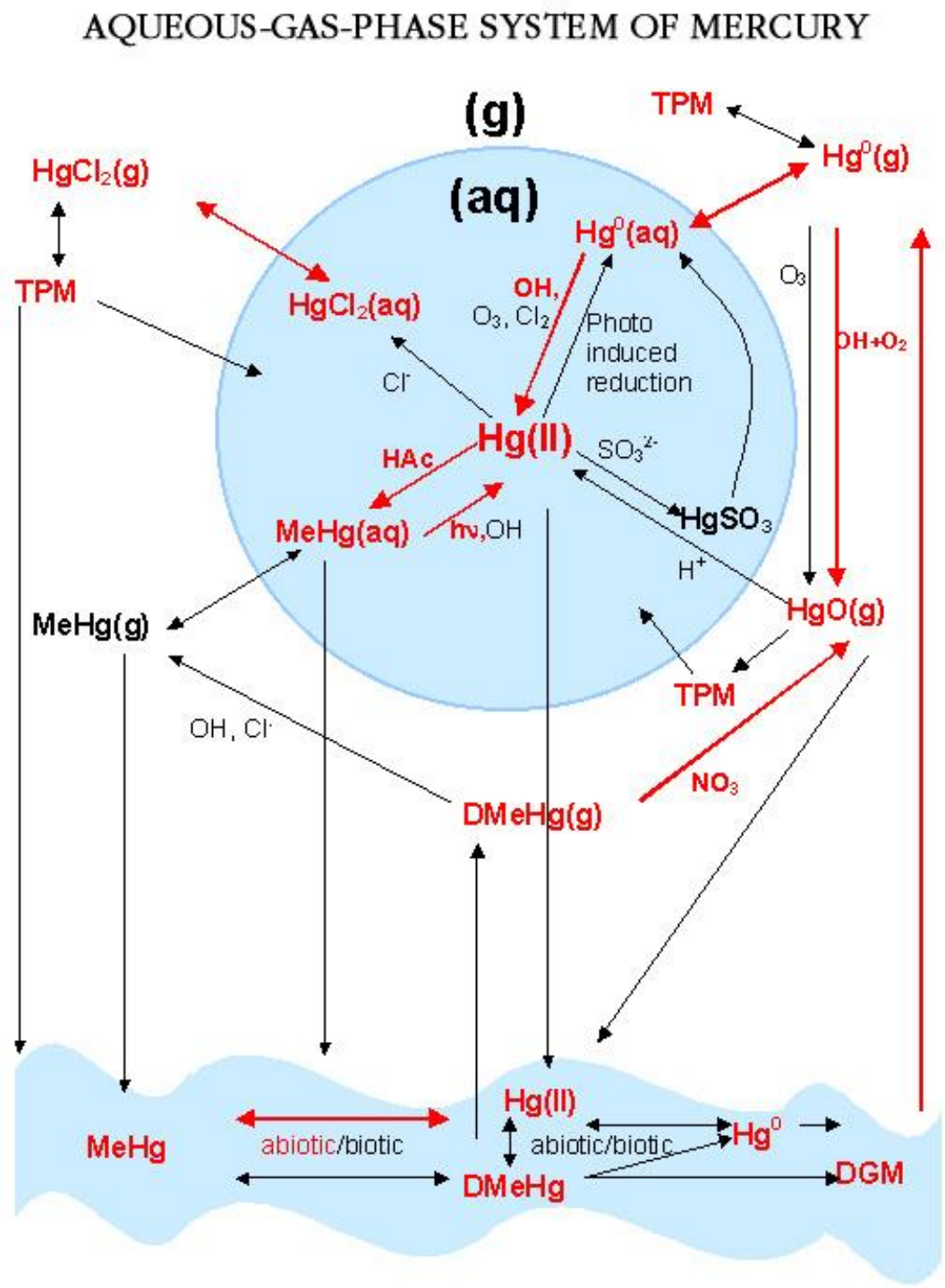
Environmental fate of Hg



Critical processes of global importance for Hg cycling



Atmospheric Hg cycle



Atmospheric forms of Hg

Mercury in the atmosphere is in three primary forms.

Gaseous elemental mercury is the most common in anthropogenic and natural emissions to the atmosphere.

Gaseous oxidized mercury and mercury bound to particulates are less common.

The transport and deposition of atmospheric mercury depend greatly on whether the mercury is elemental or oxidized.

Elemental mercury stays in the atmosphere long enough for it to be transported around the world, whereas oxidized and particulate mercury are more readily captured in existing pollution control systems or deposited relatively rapidly after their formation.

As a result, most mercury in the air is in the gaseous elemental phase.

Relatively little elemental mercury is deposited directly, but instead must first be oxidized.

Atmospheric forms of Hg

Although gaseous oxidized mercury is very important in mercury cycling between air and other environmental compartments, the process of oxidation in the air is poorly understood, with reactions and resulting compounds yet to be verified in observations.

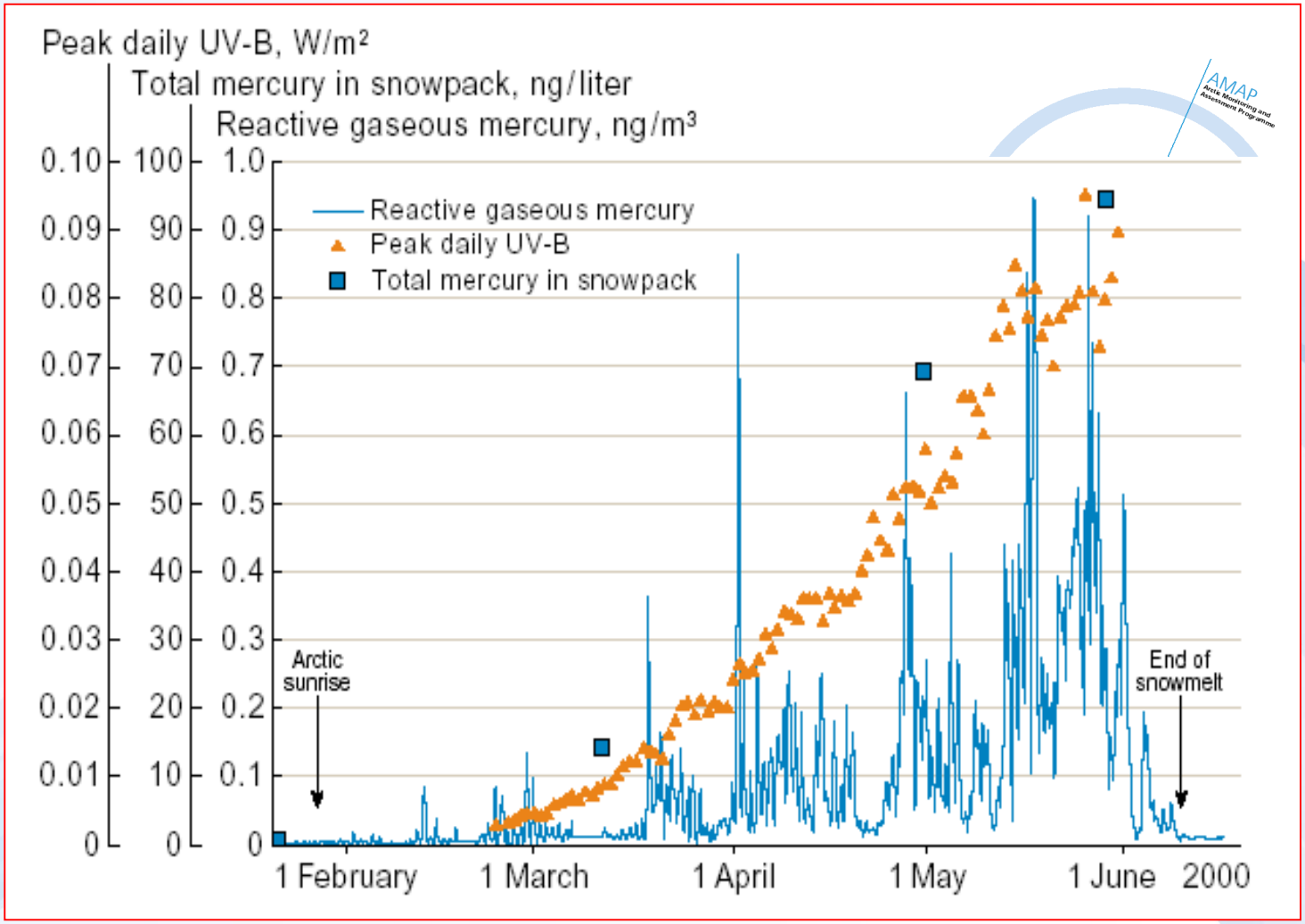
When mercury moves from air to water and land, it is generally in an oxidized gaseous or particulate form, whereas when it is re-emitted to air it has been converted back to gaseous elemental mercury.

Sunlight appears to play a large role in both oxidation and reduction of mercury, but temperature and biological interactions are also likely to be involved to some degree.

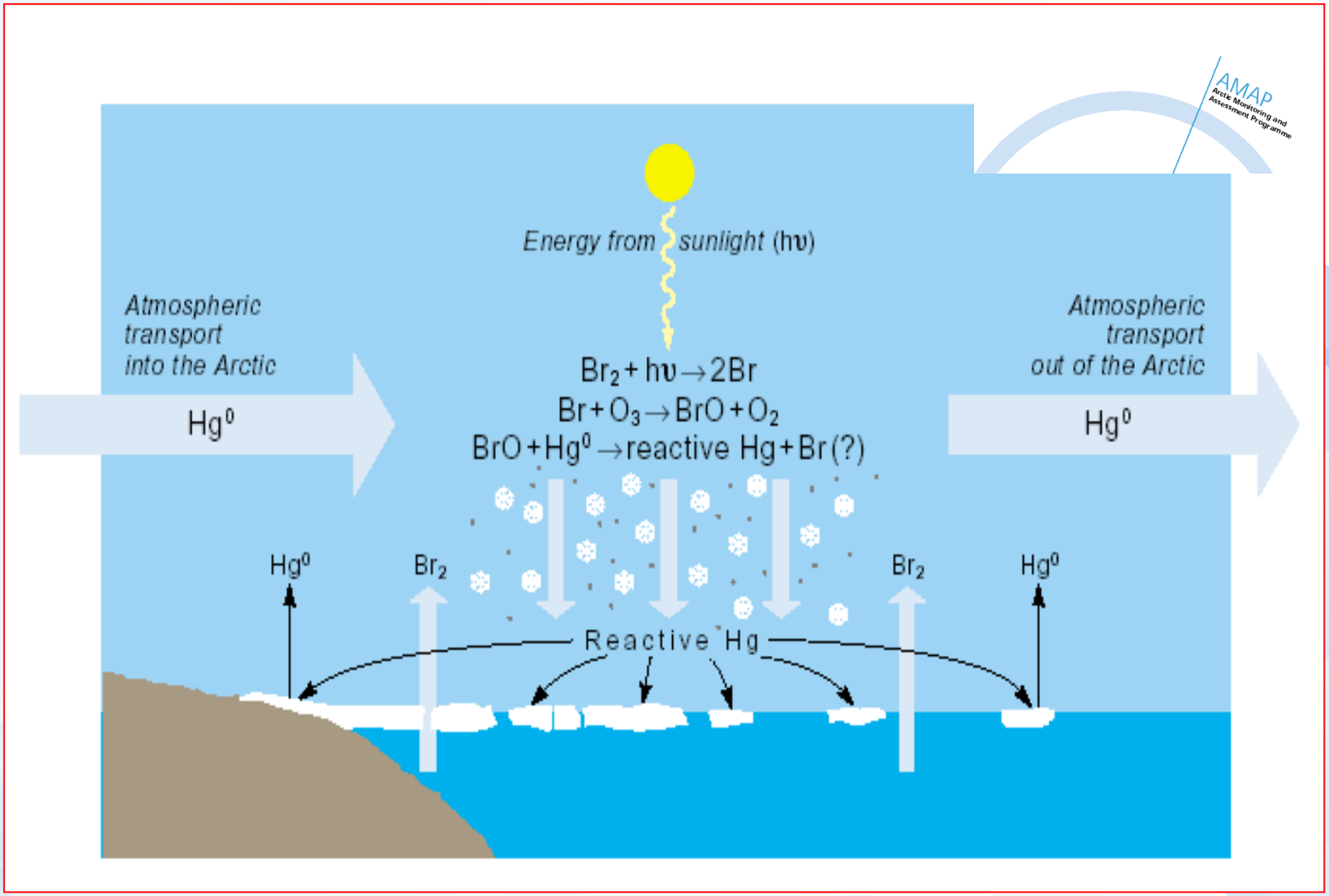
Here, too, much uncertainty remains.

Nonetheless, the reactions are important in determining net deposition and fate of mercury.

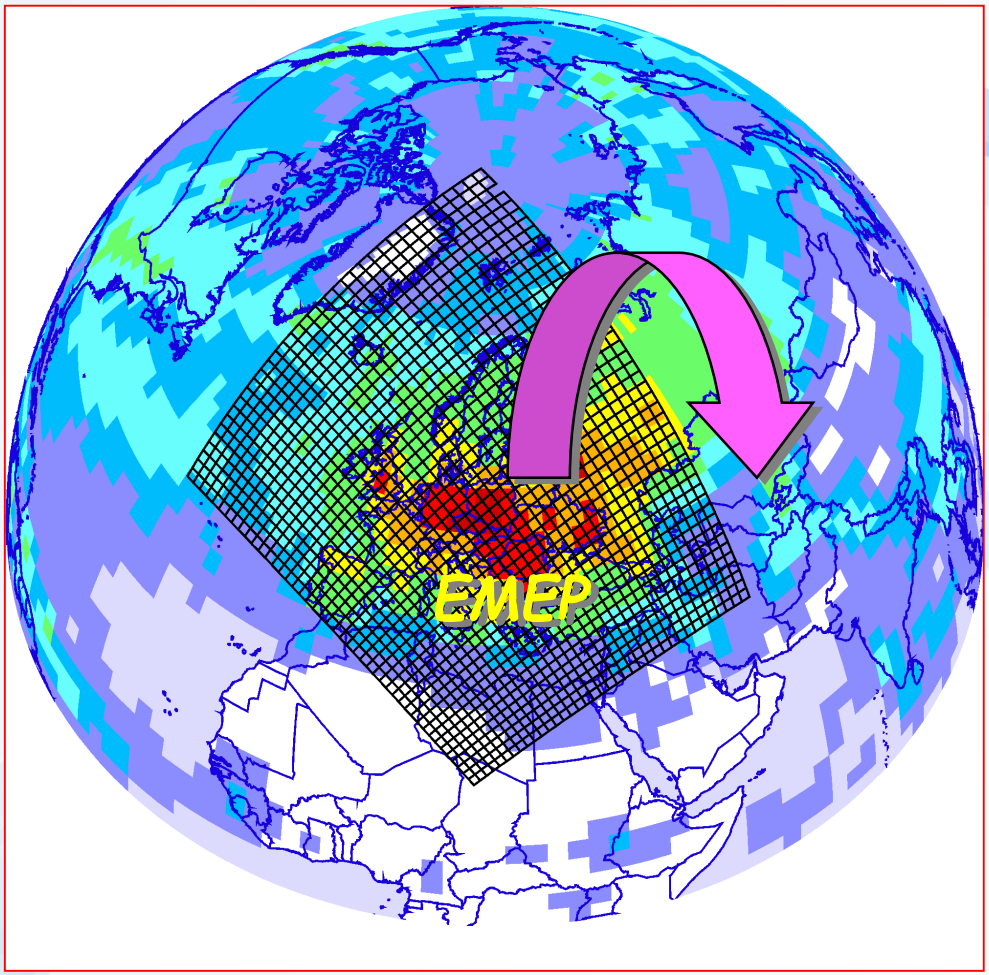
Relationship between UV radiation and Hg



Polar sunrise and Hg discharge

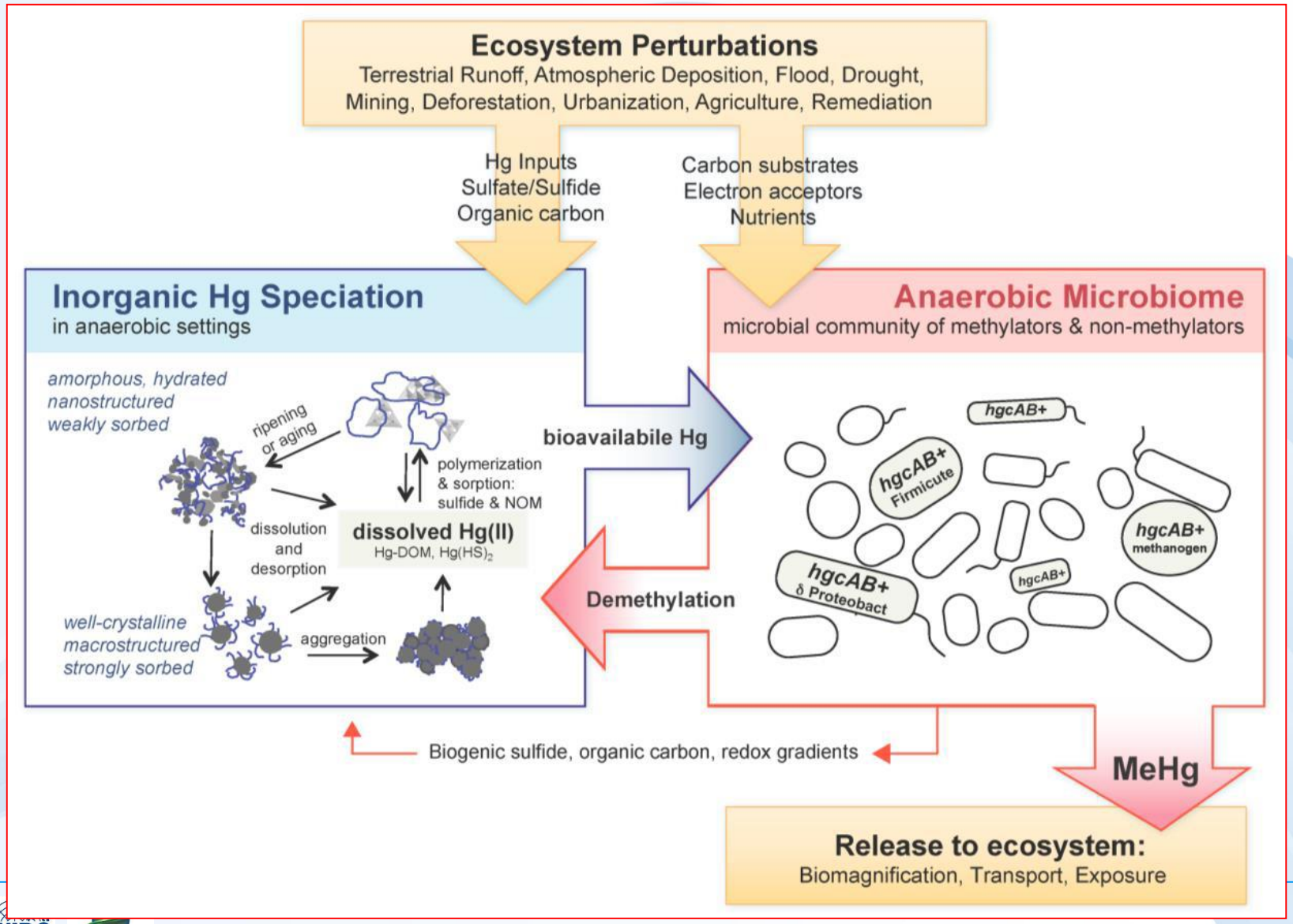


Transport of Hg outside EMEP region

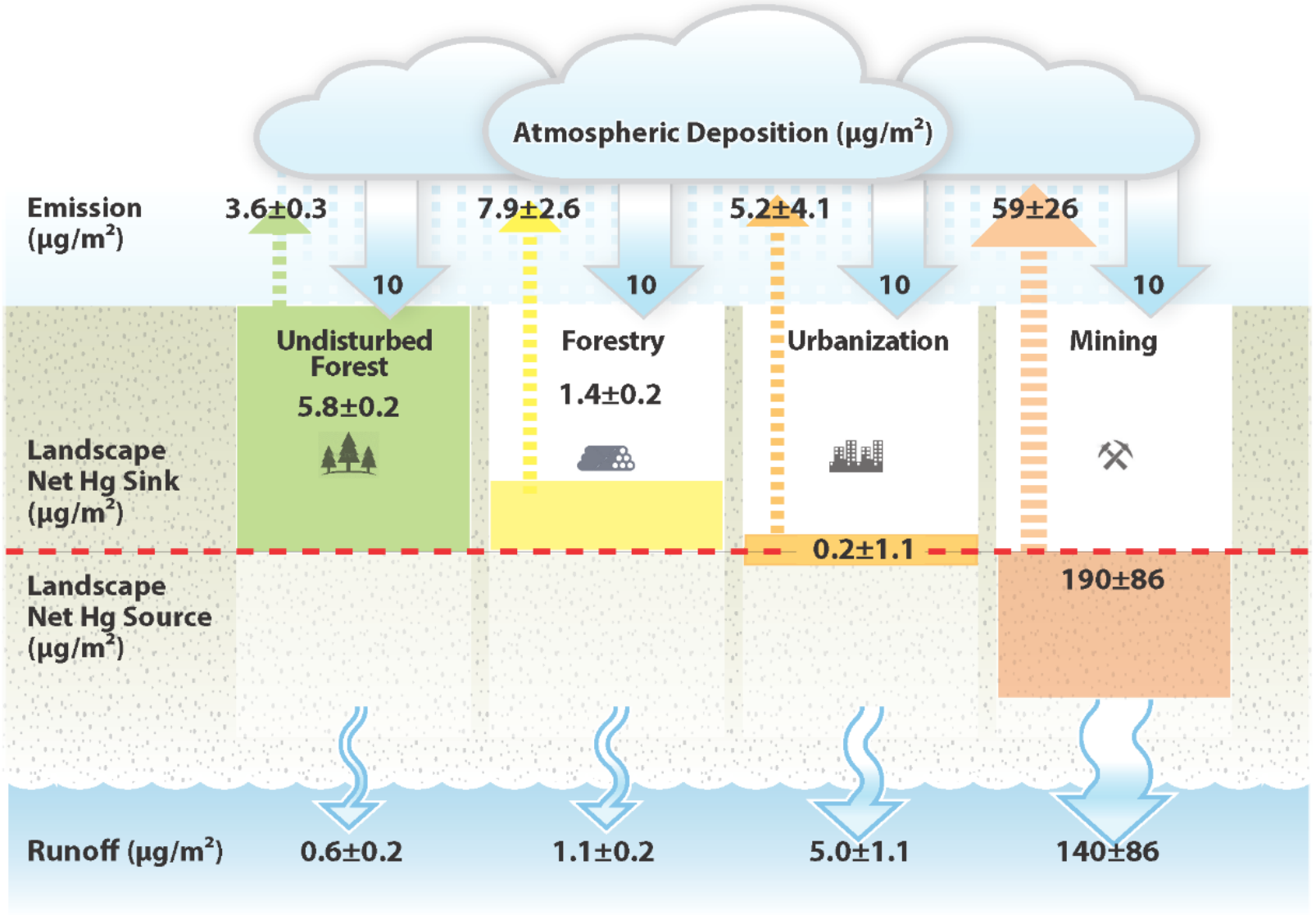


~ 60% anthropogennic emissions Hg

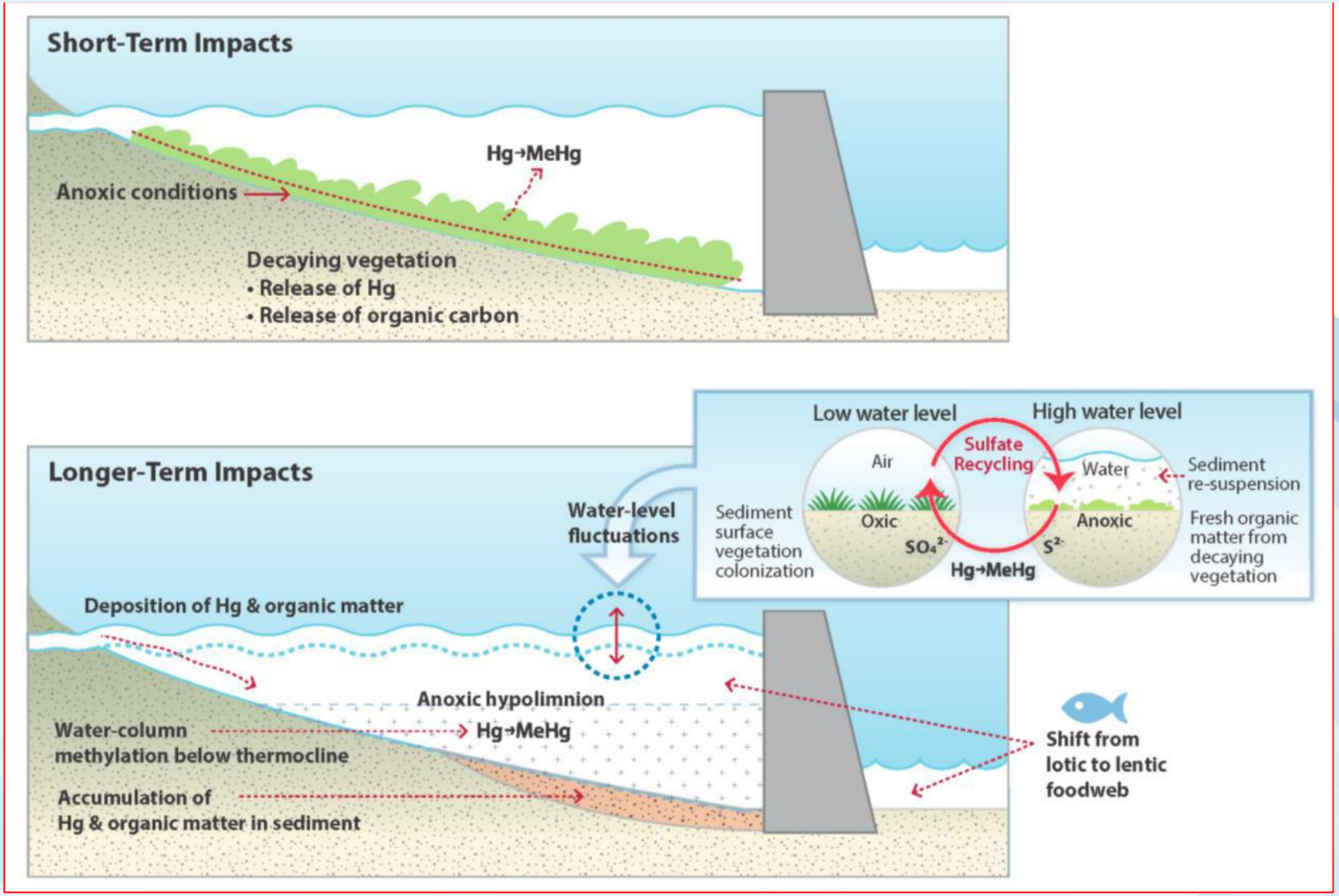
Perturbations to ecosystems - the contribution to the production of MeHg in the aquatic environment



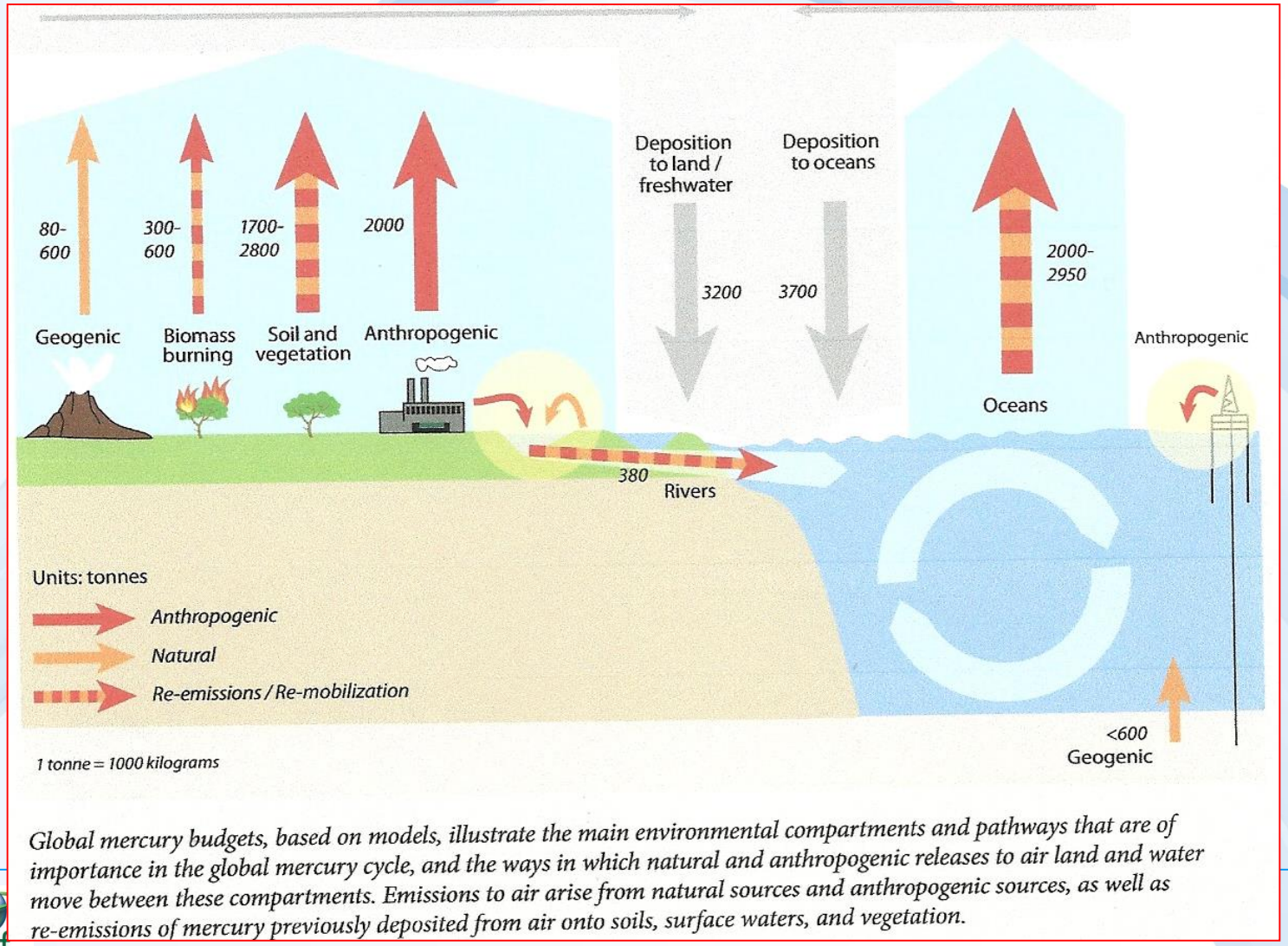
The influence of different landscape perturbations for Hg accumulation within catchments and Hg exports via runoff and emission



Conceptual diagram showing the short-term and longer-term impacts of reservoir creation on MeHg cycling and bioaccumulation



Estimation of the the global Hg cycle

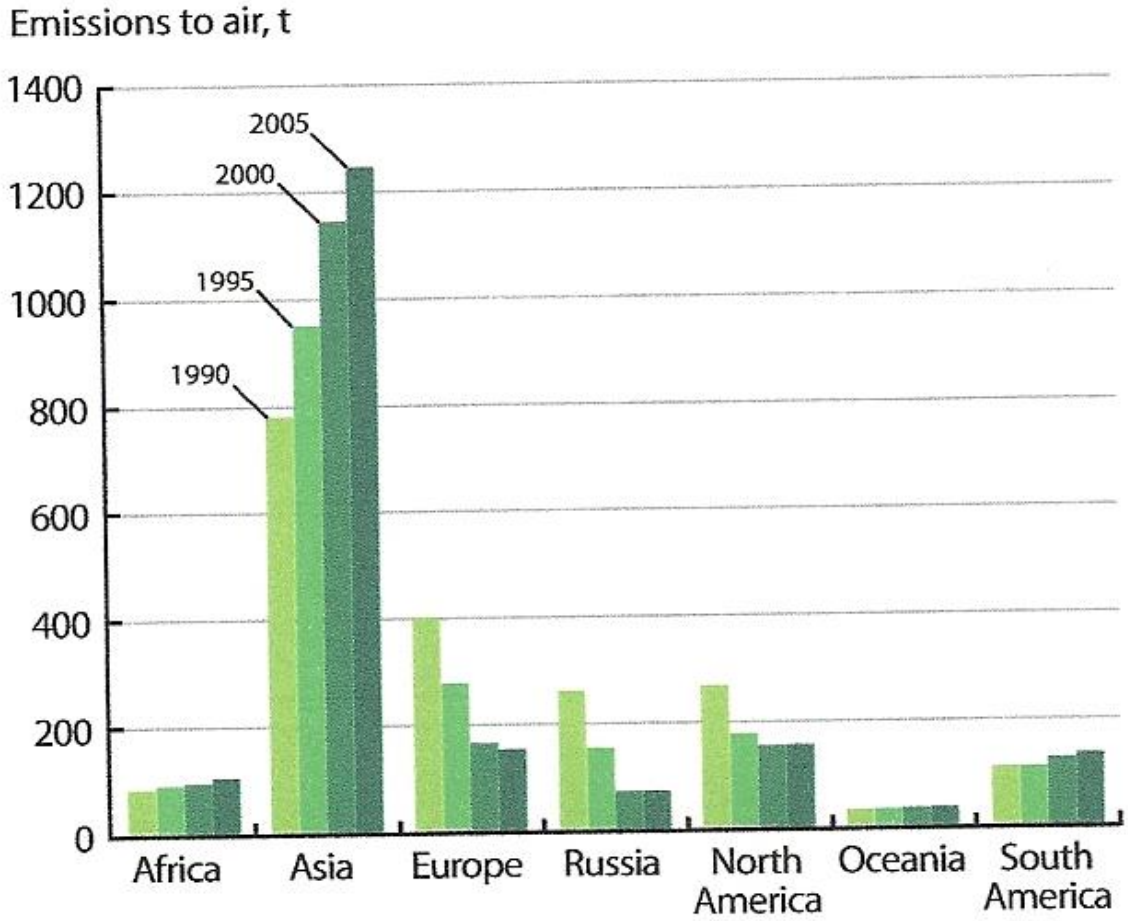


Global mercury budgets, based on models, illustrate the main environmental compartments and pathways that are of importance in the global mercury cycle, and the ways in which natural and anthropogenic releases to air land and water move between these compartments. Emissions to air arise from natural sources and anthropogenic sources, as well as re-emissions of mercury previously deposited from air onto soils, surface waters, and vegetation.

Global distribution of anthropogenic Hg emissions - 2010

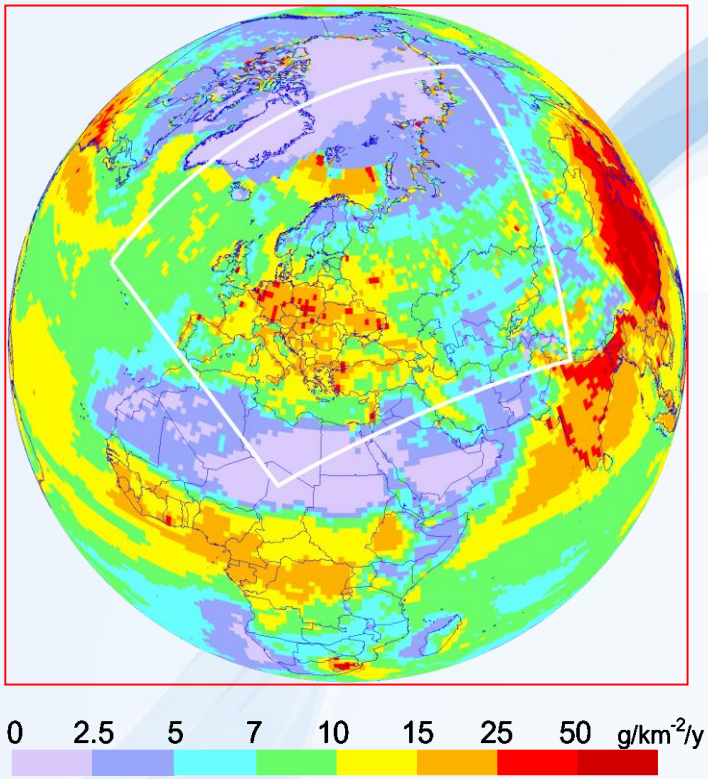
Global distribution of anthropogenic mercury emissions to air in 2010.

Estimation of annual anthropogenic Hg emissions

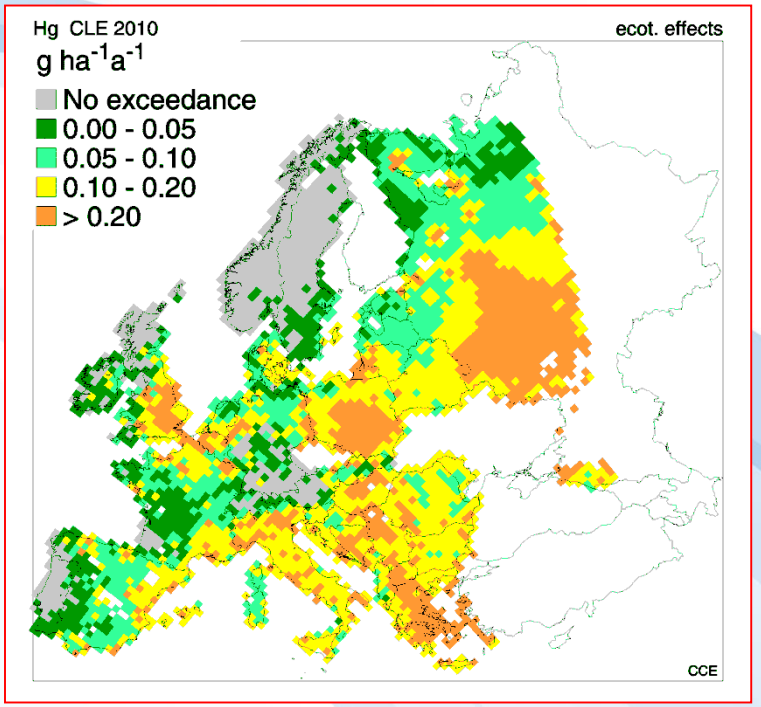


Estimates of annual anthropogenic mercury emissions from different continents/regions, 1990-2005.

Mercury – a global pollutant

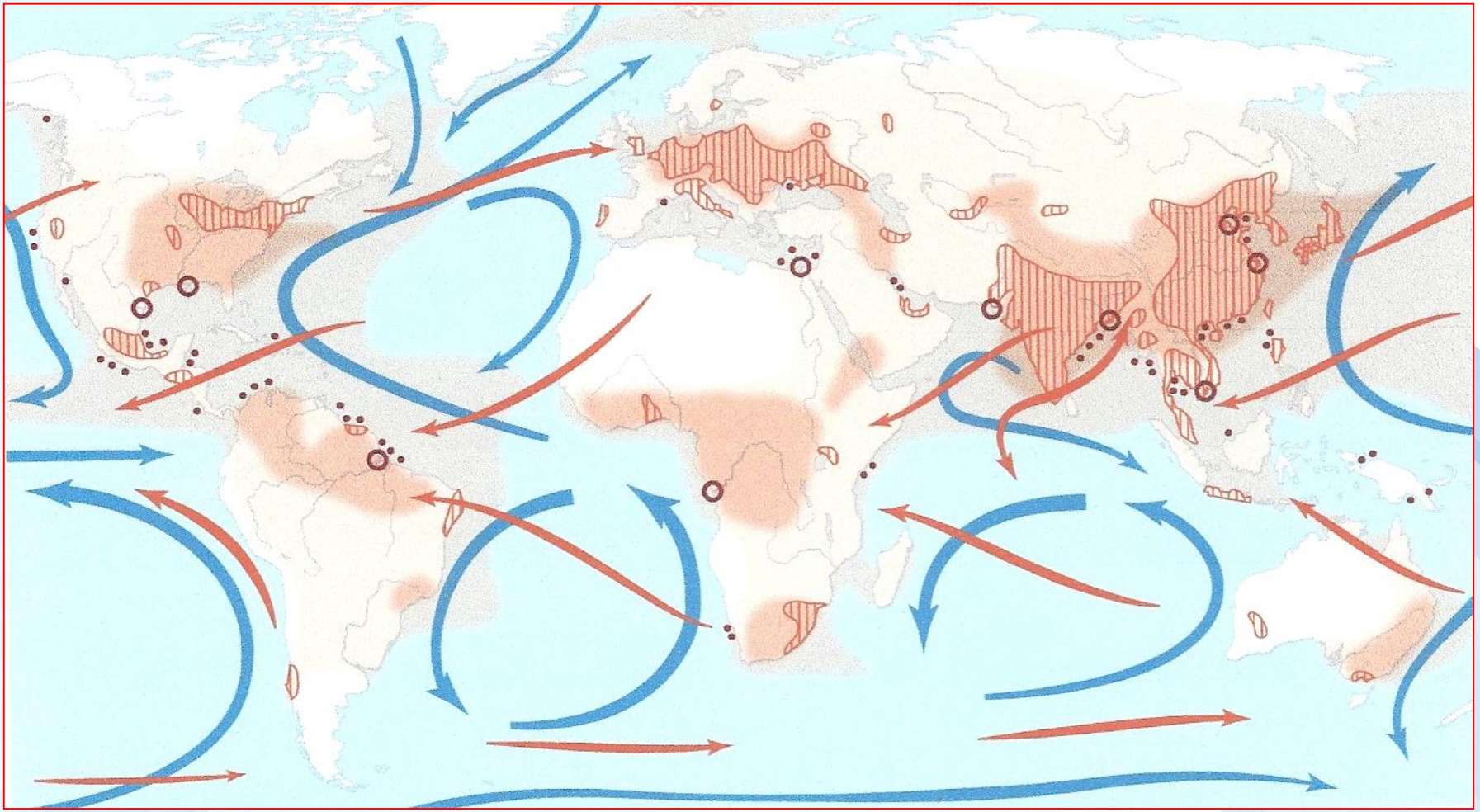


Global deposition and Europe situation



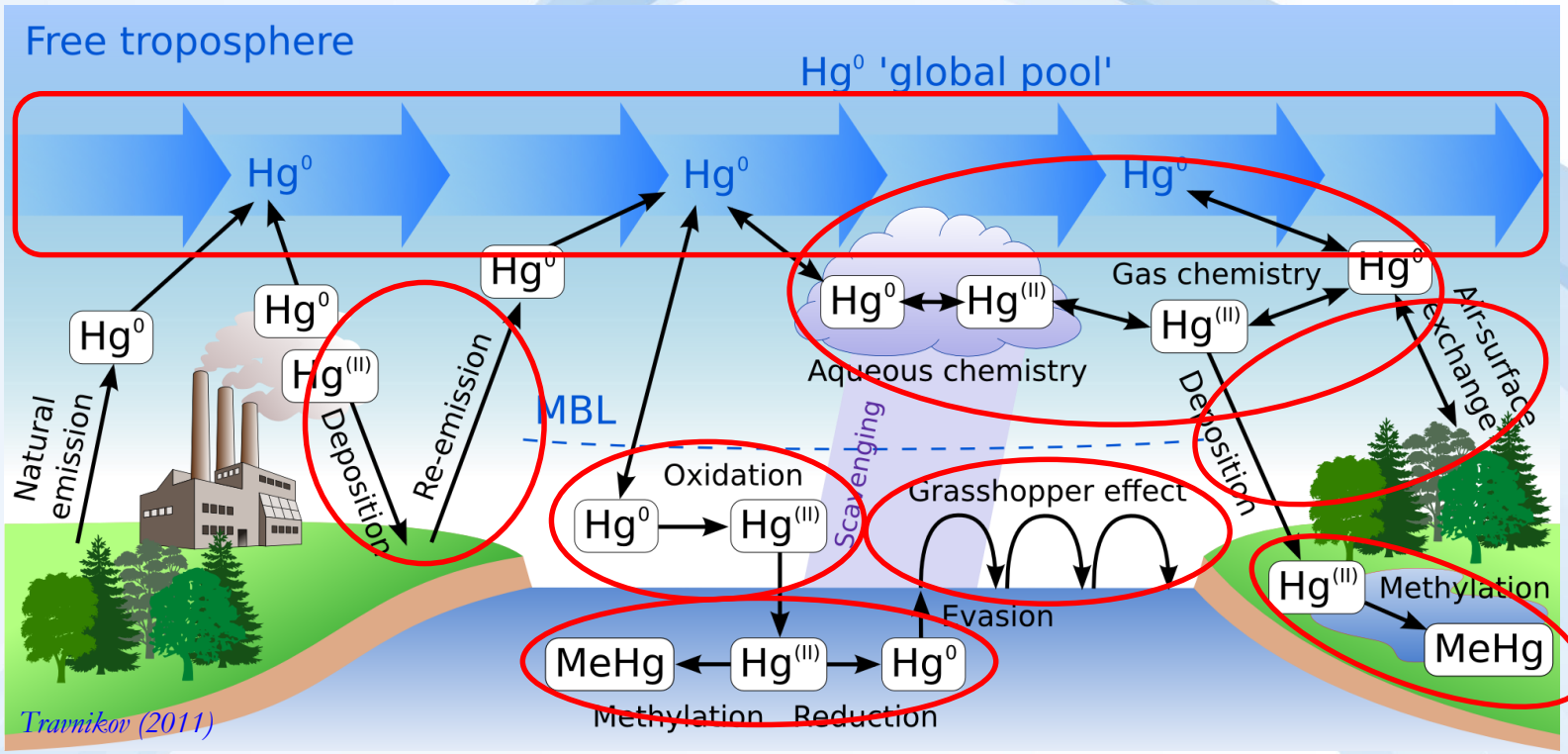
„Critical load“

Long-range mercury transport

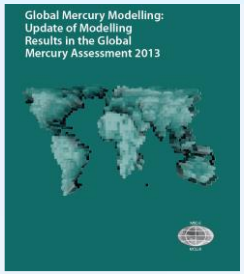


Mercury dispersion in the environment and intercontinental transpot

General scheme of Hg cycling



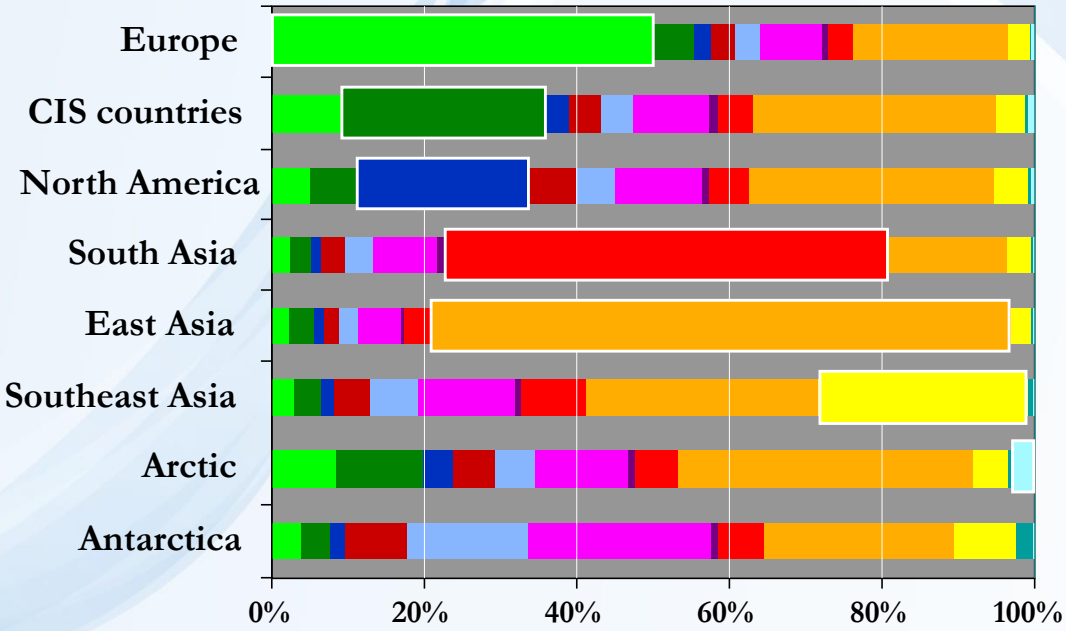
Mercury intercontinental transport



UNEP Global Mercury Assessment 2013

(with EMEP contribution to model assessment)

Source apportionment of Hg deposition from anthropogenic sources



Source/receptor regions

Mercury intercontinental transport

UNEP Global Mercury Assessment 2018

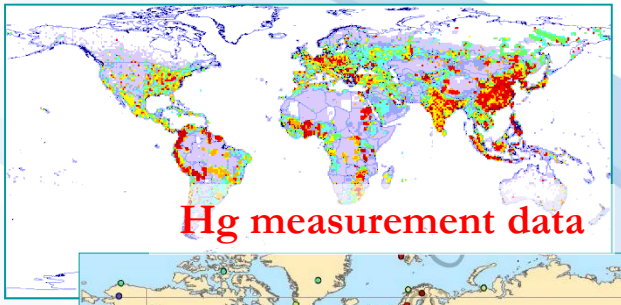
Main topics:

- Global Hg emissions inventory (2015)
- Measurements of Hg in the atmosphere
- Model assessment of Hg transport and fate
- Hg releases to the aquatic environment
- Hg levels and trends in human populations and biota

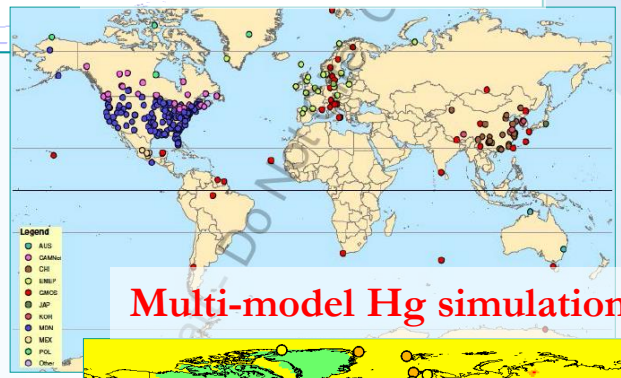
EMEP contribution

GMA 2018 draft is available for comments at www.unep.org/chemicalsandwaste/gma-2018-comments

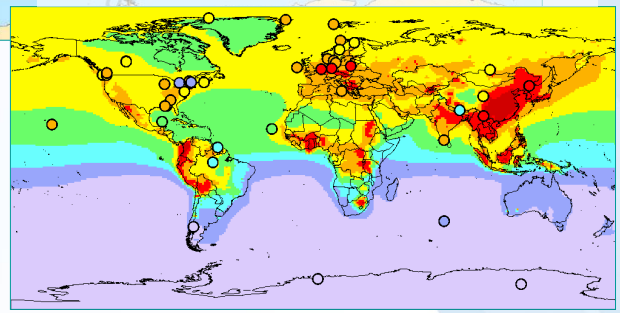
Global Hg emissions in 2015



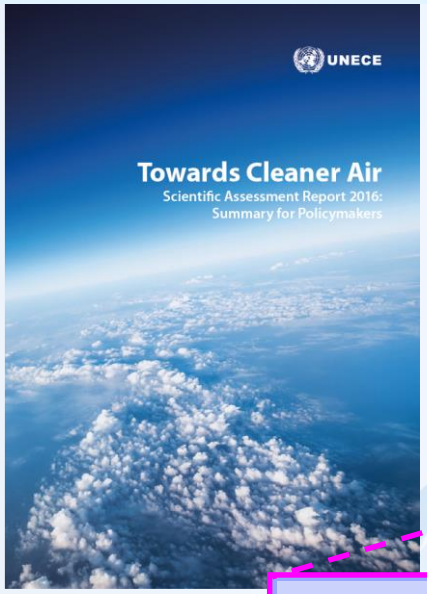
Hg measurement data



Multi-model Hg simulations

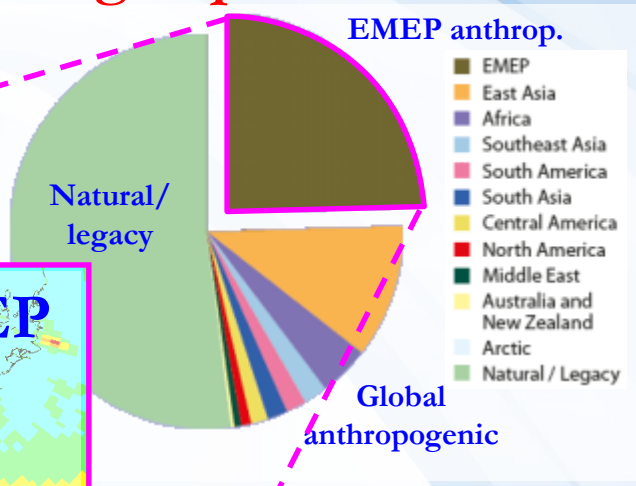


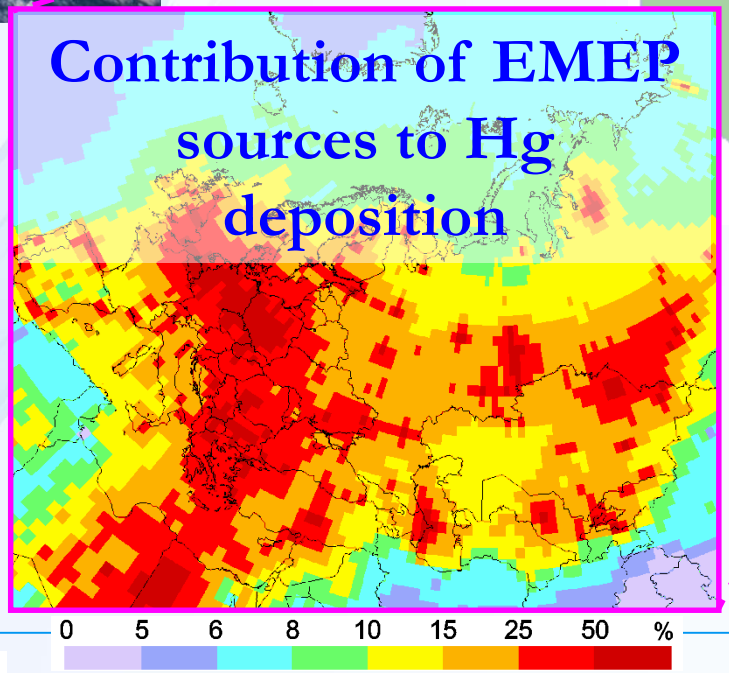
Mercury intercontinental transport



CLRTAP Assessment 2016

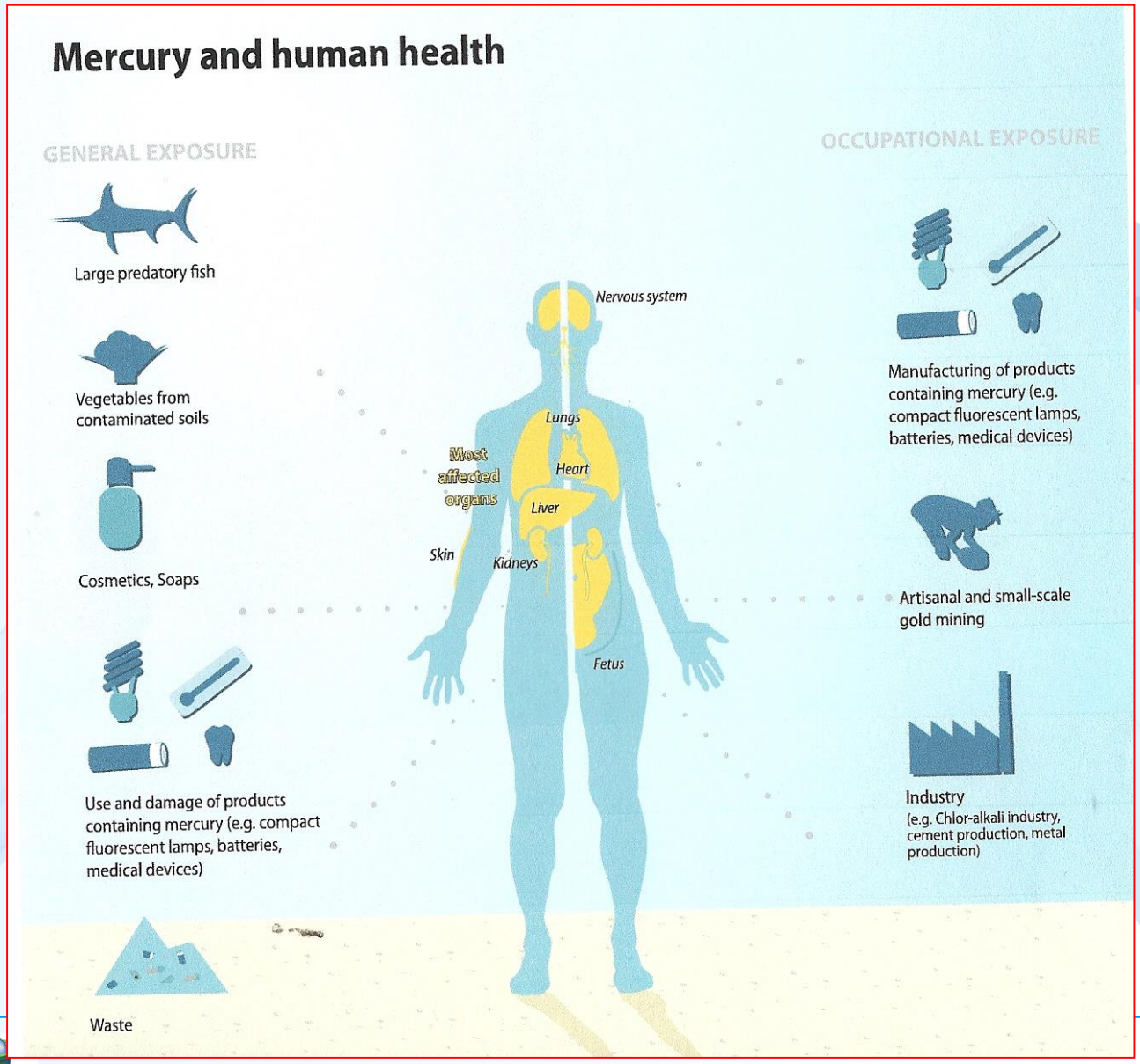
Hg deposition within EMEP



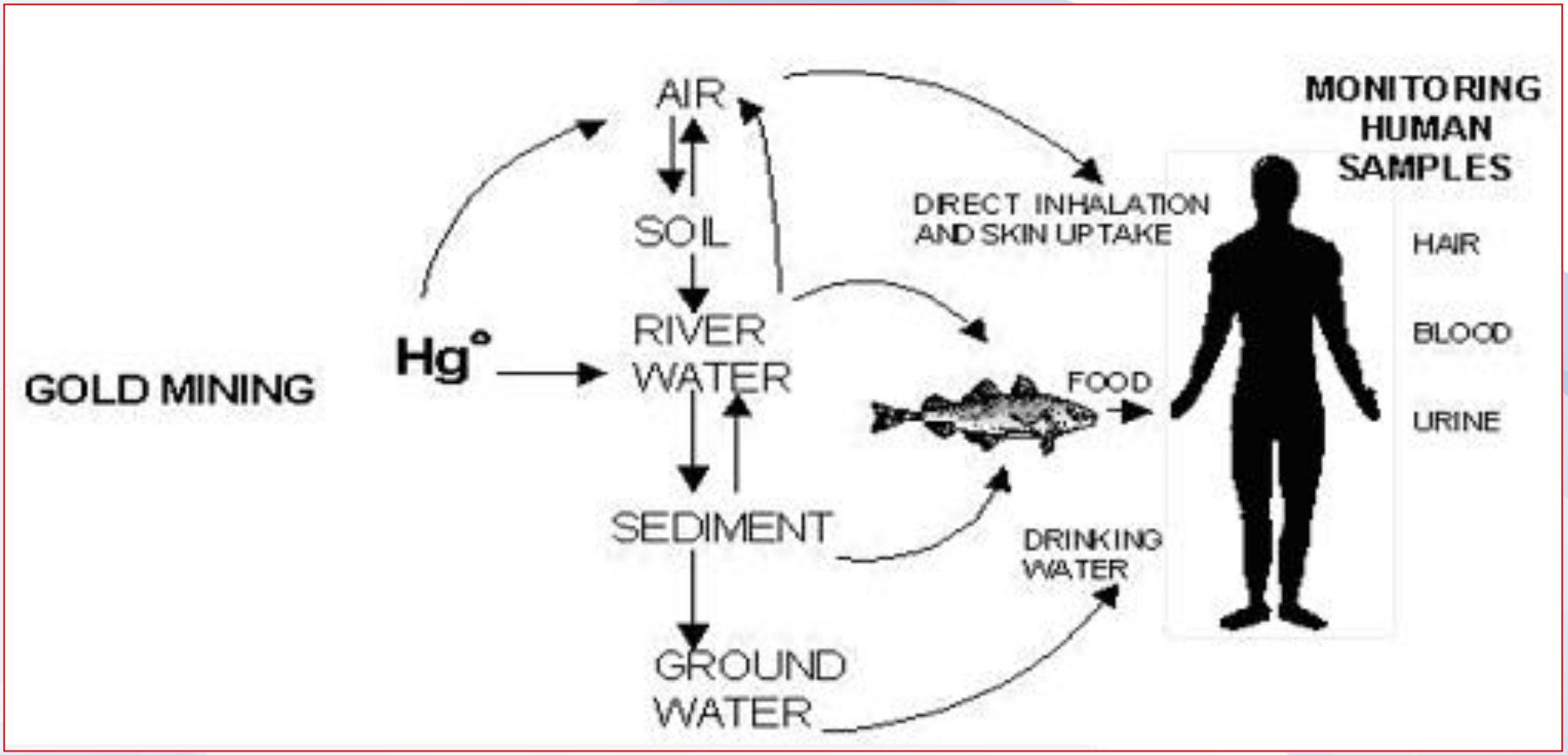


Contribution of non-EMEP sources (direct and legacy) exceeds 50% almost everywhere in the EMEP region

Mercury and human health



Input of Hg to human organism



Toxicological properties of Hg

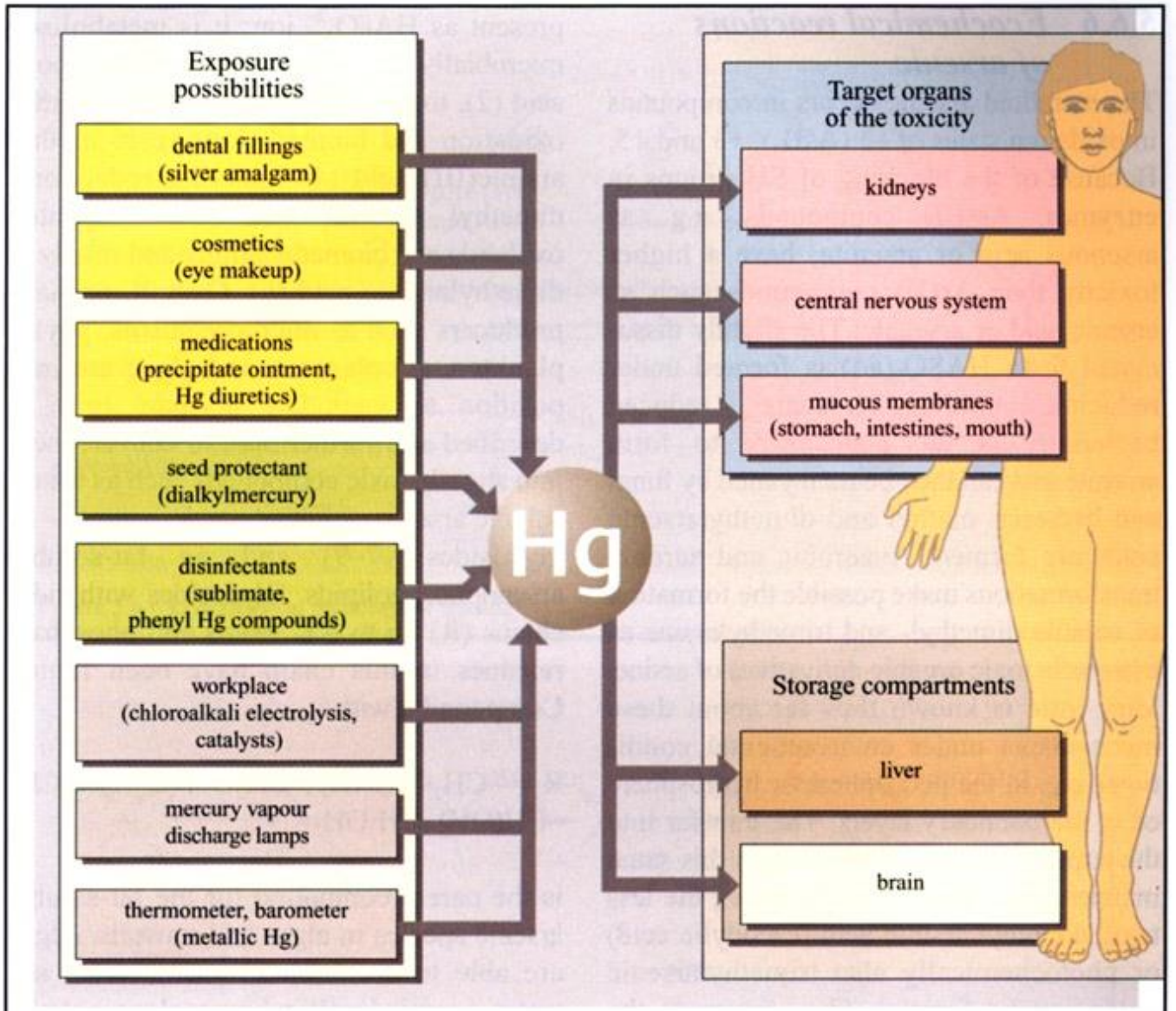


Figure 5.6.4 Mercury 'spider': applications and activity

Case Minamata (1953 – 1973), Japan

50´s and 60´s – Japan – mass poisoning by Hg and its compounds.

The first surrounding of Bay Minamata in 1953.

During the following three years was confirmed that the primary source is connected with the wastewaters from chemical company Chisso-Nippon Chemical Plant (production of acetaldehydes, vinylchlorides), which were released more than 30 years to this bay with high contents of Hg compounds , which were on water and sediments transformed to methylated form.

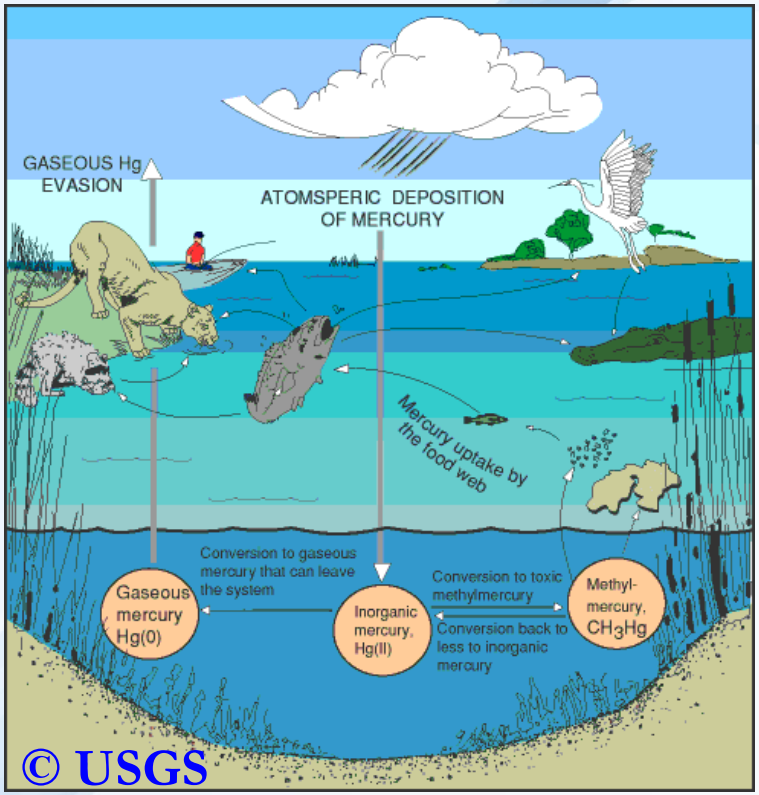
Mono- and dimethylmercury concentrated in plankton and via bioaccumulation in fish were transferred to human bodies.

Case Minamata (1953 – 1973), Japan

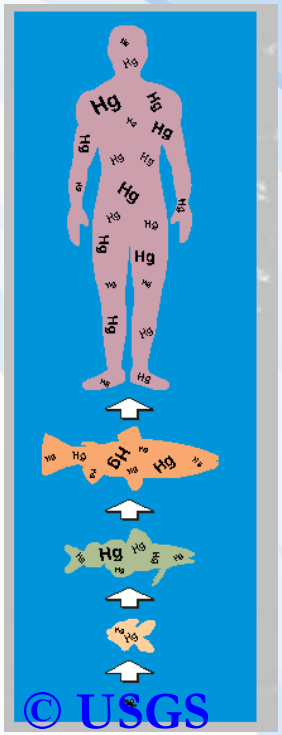
Human exposure to Hg

Major Hg exposure pathway is through fish consumption

Hg general cycle in aquatic



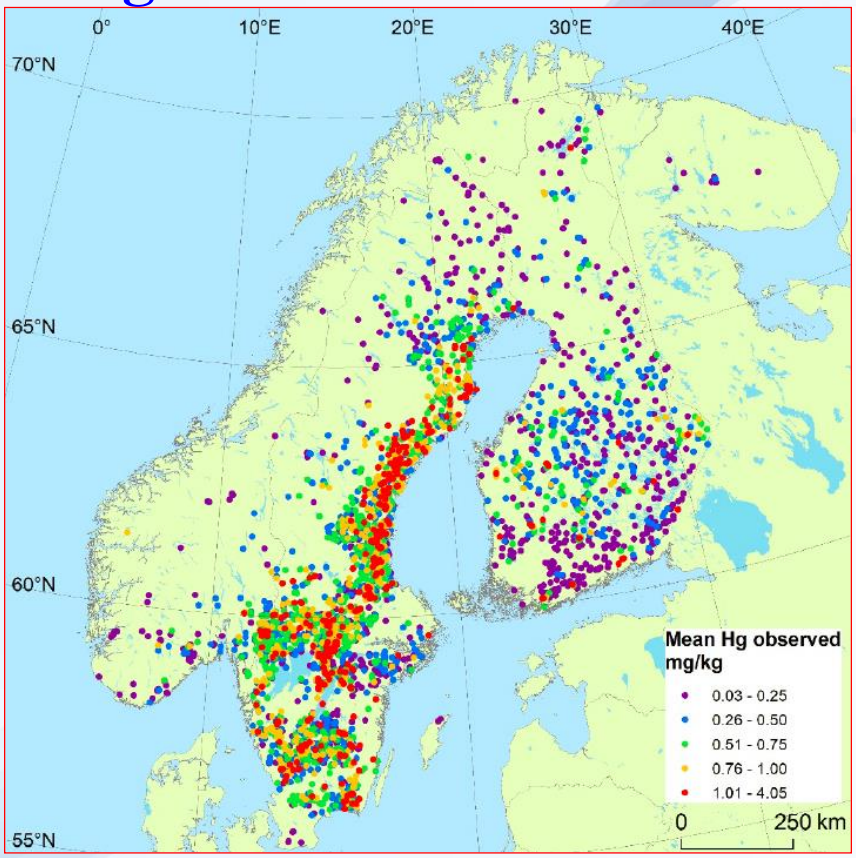
Hg accumulation in food chain



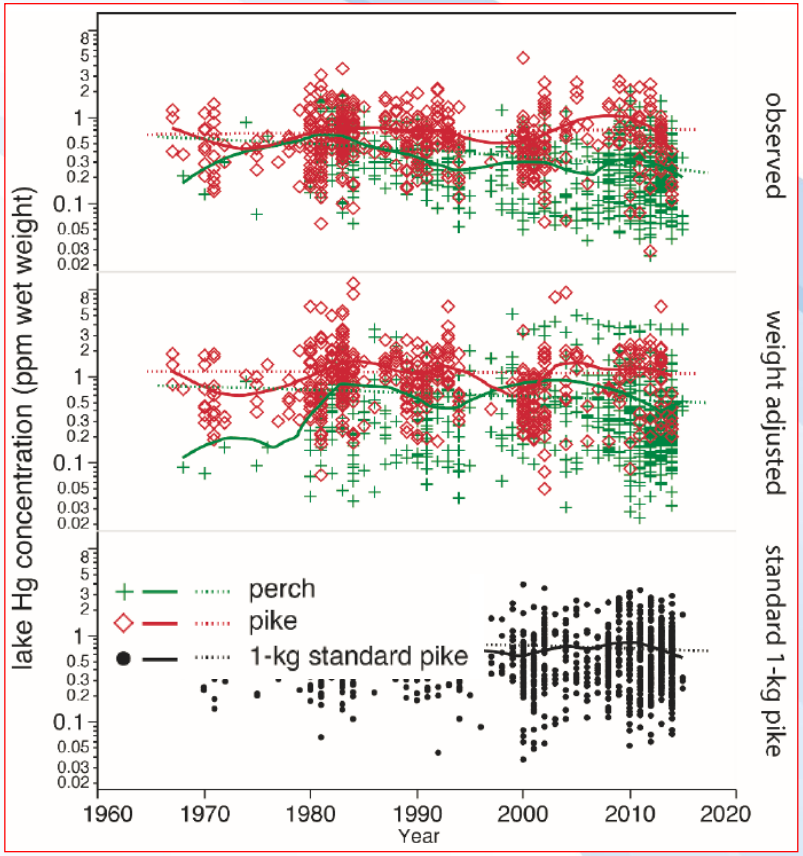
Hg in freshwater fish

Elevated levels of Hg concentration in fish of Fennoscandia (ICP Waters report 132/2017)

Hg concentration in fish



Temporal trends of Hg in fish

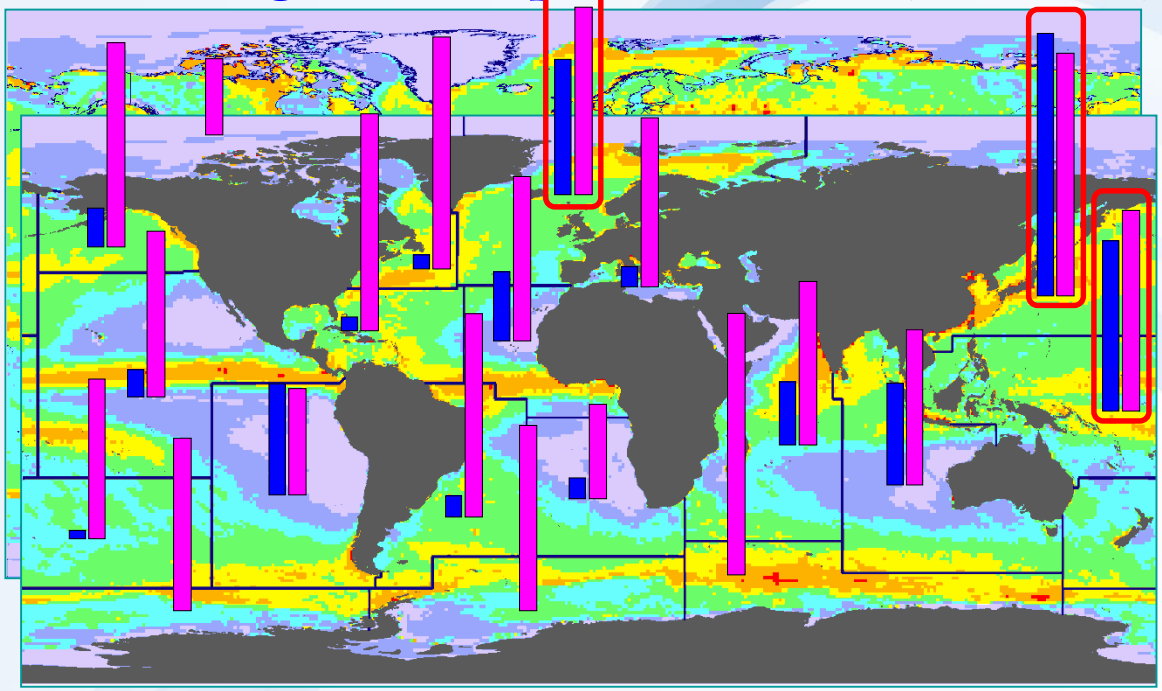


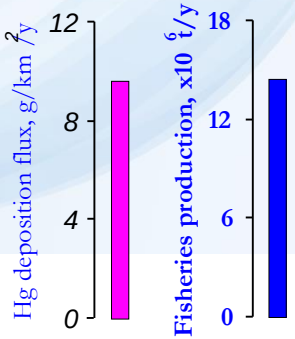
More than 40% of the almost 2 800 lakes have fish Hg levels that exceed typical environmental quality standards (0.5 mg/kg)

Hg deposition to the ocean

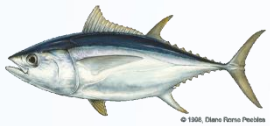
Source attribution of Hg deposition to fishing areas (2010)

Simulated Hg annual deposition in 2010 (GLEMOS)

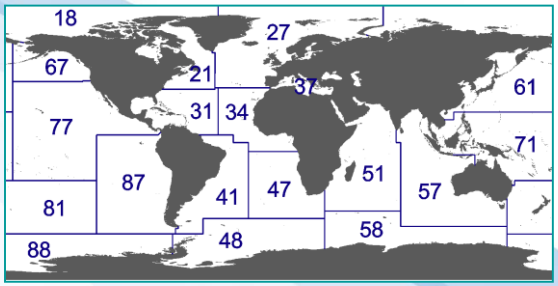




- Hg deposition flux
- Total marine capture fisheries production (FAO, 2013)



FAO fishing areas

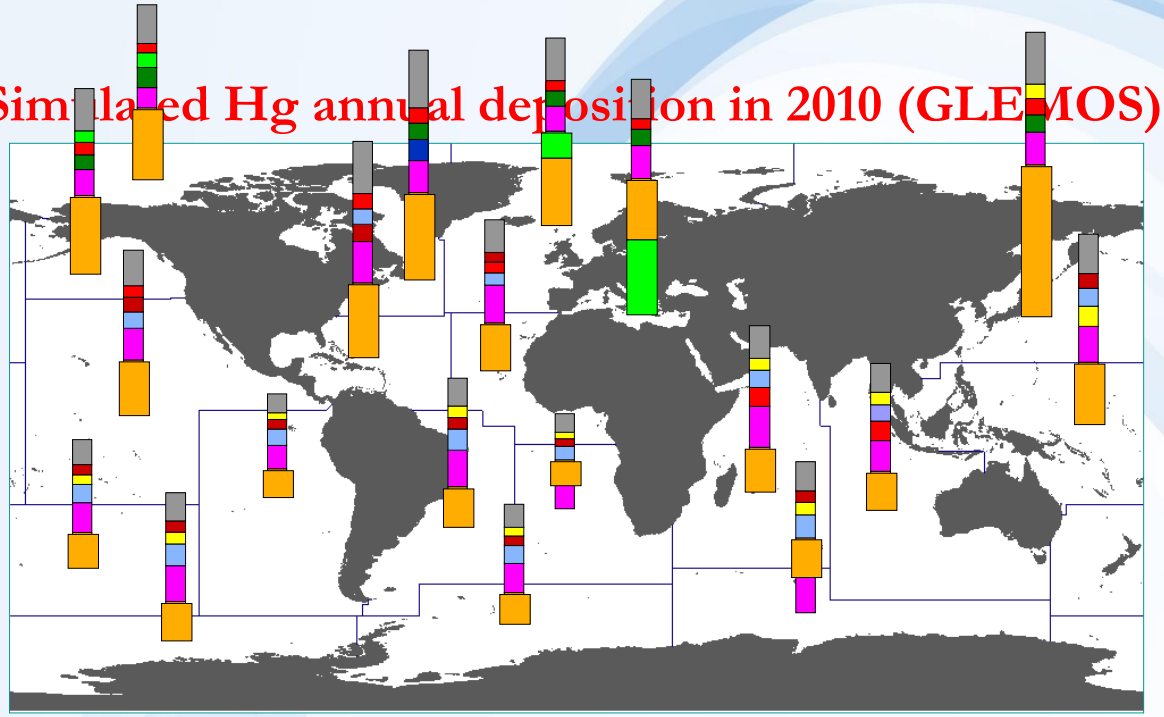


18 - Arctic Sea
21 - Northwest Atlantic
27 - Northeast Atlantic
31 - Western Central Atlantic
34 - Eastern Central Atlantic
37 - Mediterranean and Black Sea
41 - Southwest Atlantic
47 - Southeast Atlantic
48 - Antarctic Atlantic
51 - Western Indian Ocean
57 - Eastern Indian Ocean
58 - Antarctic Indian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

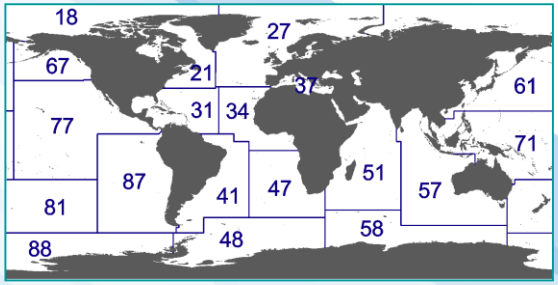
Hg deposition to the ocean

Source attribution of Hg deposition to fishing areas (2010)

Simulated Hg annual deposition in 2010 (GLEMOS)



FAO fishing areas



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
orthwest Pacific
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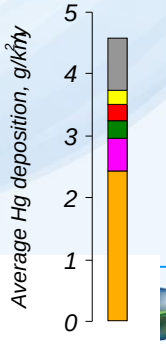
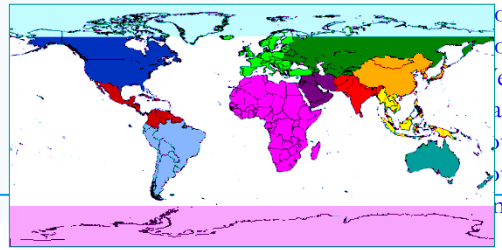
estern Central Pacific
stern Central Pacific
uthwest Pacific
utheast Pacific
ntarctic Pacific



Source regions

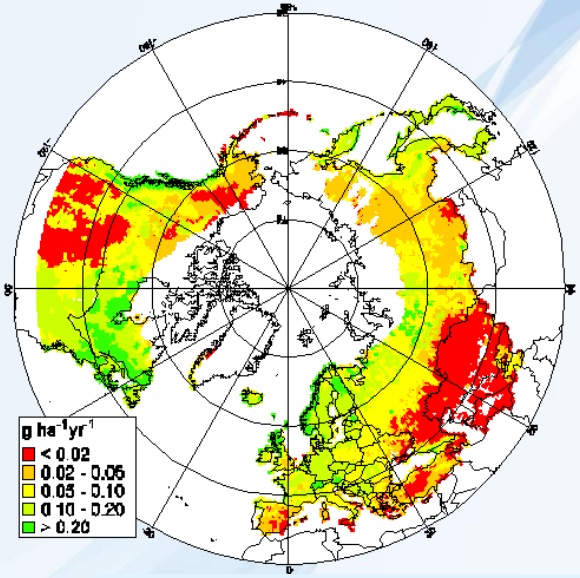
- Arctic
- Europe
- CIS countries
- North America
- Central America
- South America
- Antarctica
- Middle East
- Africa
- South Asia
- East Asia
- Southeast Asia
- Australia and NZ
- Other regions



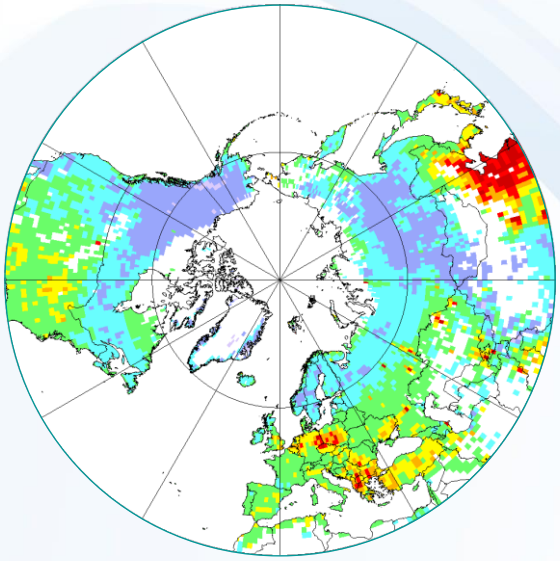
Hg adverse effects on ecosystems

Critical load exceedancies in Northern Hemisphere (preliminary results by CCE/Alterra and MSC-E)

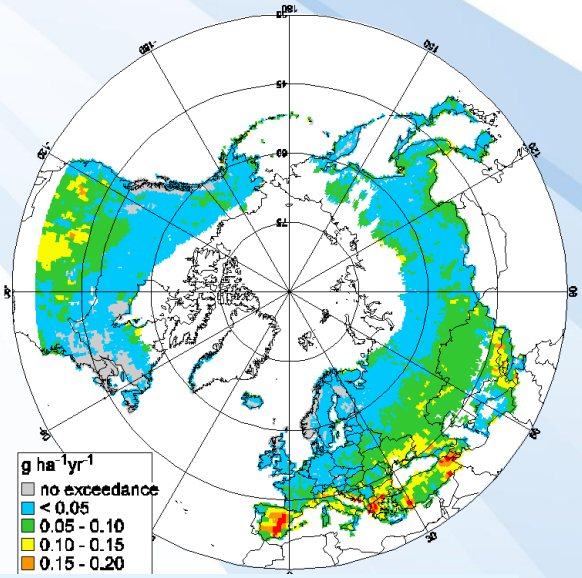
Hg critical loads for terrestrial ecosystems



Hg deposition to forests (2010)



Accumulated exceedance of Hg critical loads



These and other aspects of Hg pollution could be addressed at one of future thematic sessions of joint EMEP/WGE meetings

Teşekkür Ederim