Mercury atmospheric modeling to support policy decisions

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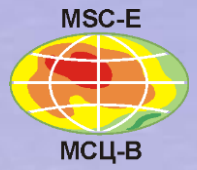
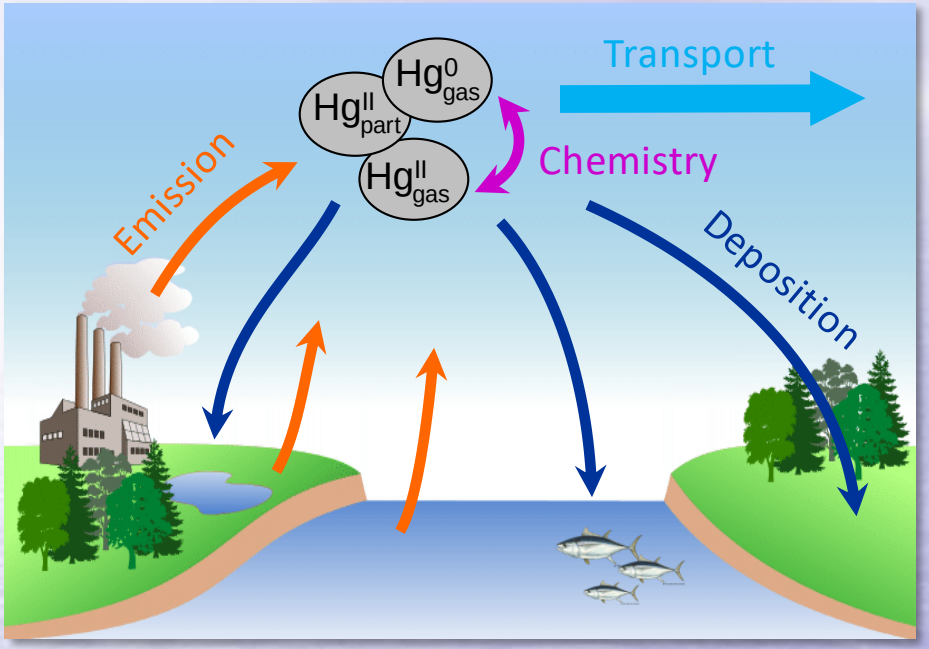


Minamata Online Session, 17 November 2020

Chemical transport models (CTMs)



Environmental media:

- Atmosphere
- Ocean (water, ice, sediments)
- Land (soil, snow, freshwater, vegetation)

Main processes:

- Anthropogenic and natural/legacy emissions
- Transport in the atmosphere (ocean, freshwater, etc.)
- Chemical transformations in air (water, soil, snow, etc.)
- Deposition to the ground, air/surface exchange

Chemical transport models (CTMs)

List of contemporary CTMs used for mercury modeling (*incomplete*)

Model	Institution (user)	Scale	Type
GEM-MACH-Hg	Environment and Climate Change Canada (Canada)	Global	Atmospheric
GEOS-Chem	Harvard Univ., MIT (USA)	Global	Multi-media
GLEMOS	EMEP/MSC-E	Global	Atmospheric
ECHMERIT	CNR-IIA (Italy)	Global	Atmospheric
CAM-Chem	Univ. of Illinois (USA)	Global	Atmospheric
HYSPLIT	NOAA (USA)	Global	Atmospheric
DEHM	Aarhus Univ. (Denmark)	Regional	Atmospheric
CMAQ-Hg	Lamar Univ. (USA), HZG (Germany)	Regional	Atmospheric
WRF-Chem	CNR-IIA (Italy)	Regional	Atmospheric
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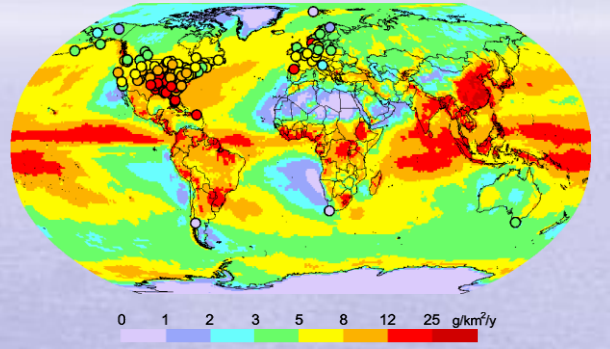
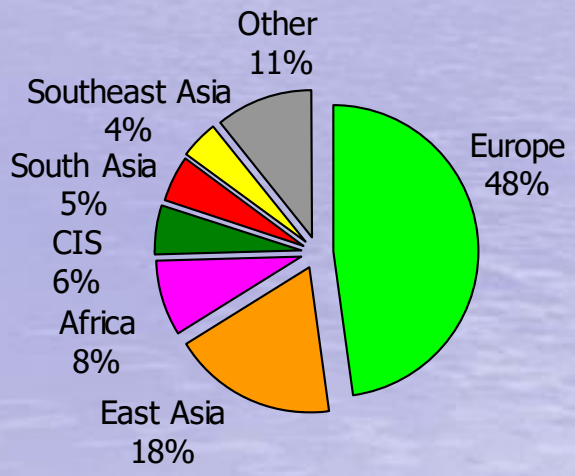
What are mercury CTMs used for?

- Reconstruction of spatial patterns and temporal trends
- Interpretation of observations
- Studies of Hg physical and chemical processes
- Source apportionment (source-receptor relationships)
- Hindcasting and forecasting

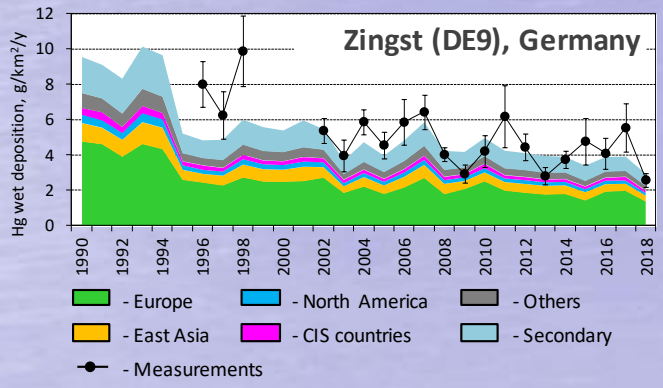
Global pattern of Hg wet deposition



Source apportionment of Hg deposition in Europe



Long-term trends of Hg wet deposition



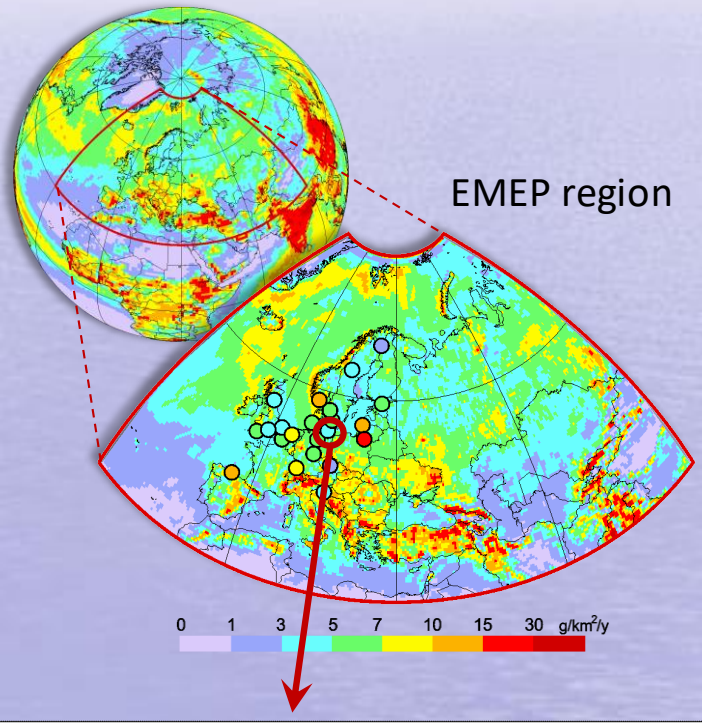
Modeling to support policy: Regional

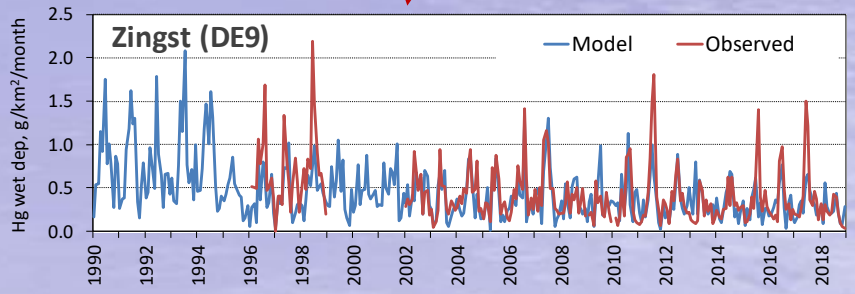
UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP)

Modeling activities:

- Multi-scale modeling of Hg transport and deposition (GLEMOS)
- Joint model-measurement analysis of spatial patterns and long-term trends
- Assessment of Hg transport between countries (S-R relationships)
- Evaluation of critical loads exeedances for Hg deposition

Hg wet deposition in 2015





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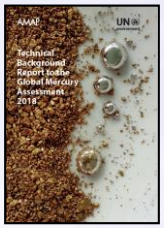
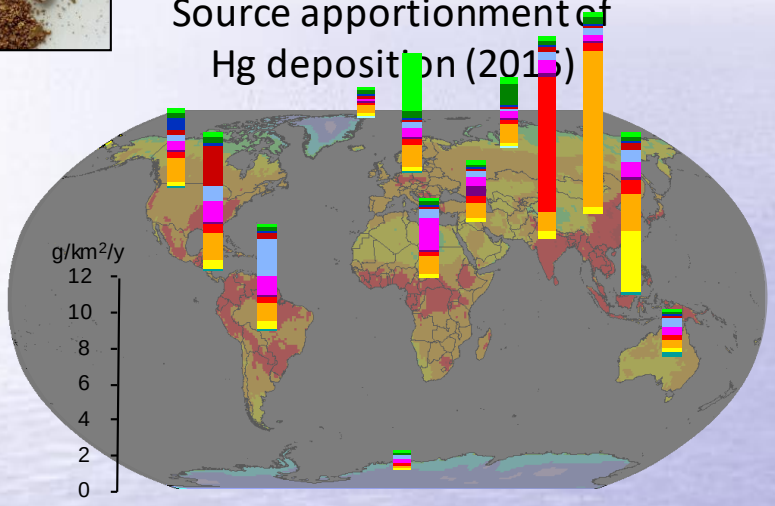
Clean Air 40 YEARS

Modeling to support policy: Global



UN Environment Global Mercury Assessment 2018 (GMA 2018)

Source apportionment of Hg deposition (2015)



Modelling groups:

Model	*Institution*
GEM-MACH-Hg	Environment Canada
GEOS-Chem	MIT (USA)
GLEMOS	EMEP/MSC-E
ECHMERIT	CNR-IIA (Italy)

Lessons learned:

- Better performance of multi-model simulations vs. single models
- Dry deposition estimates are more uncertain than wet deposition
- Good agreement among the models on estimates of Hg deposition from anthropogenic sources
- Large (65-80%) and very uncertain contribution of natural and legacy sources

UN environment

Key uncertainties and limitations

Uncertainties:

- Atmospheric Hg oxidation and reduction chemistry
- Anthropogenic emissions (chemical speciation, ASGM)
- Natural and legacy emissions from soil and the ocean
- Air-surface exchange (with vegetation, snow, seawater, etc.)

Limitations (atmospheric models):

- Unable to make long-term projections (decades/centuries) (no delayed response of other media)
- Cannot be directly used for exposure analysis (no link to biota)

Further steps needed

- Development of multi-media abilities of Hg chemical transport models
- Development and improvement of monitoring networks (global, speciated, multi-media)
- Updates of emissions (speciation) and projections
- Continued process studies (chemistry, air-surface exchange)

Thank you!

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MSC-E

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