

Answers to Policy-Relevant Science Questions

➤ How does the intercontinental or hemispheric transport affect deposition patterns in the NH ?

✓ Is it possible to identify regions that are most sensitive ?

The Arctic is only affected by intercontinental transport (no local sources). Mercury Depletion Events in spring provides a large input of Hg to the ecosystem. The Hg originates from intercontinental transport. Also remote terrestrial and marine ecosystems.

✓ What is the relative contribution of intercontinental transport on Hg accumulation in terrestrial, marine or freshwaters ecosystems ?

Modelling results suggest a significant contribution of global Hg cycling to deposition fluxes to aquatic and terrestrial ecosystems. There is measurement evidence of episodic transport of atmospheric Hg from Asia to North America. The main contribution however, comes from the "global pool" of Hg which consists of a mixture of recently emitted, re-emitted anthropogenic Hg and natural Hg. In parts of Europe and North America far from local sources, the "global pool" is the dominant source of total Hg deposition. To assess the response of emission changes on intercontinental transport, this "global pool" needs to be better characterised in terms of contributing sources, transport pathways and residence time of Hg species.

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- **How well are understood major chemical and physical processes affecting Hg deposition patterns ?**
 - ✓ **Important progress has been made in recent years to identify and characterise the main chemical transformations (*add more info ..*) of atmospheric Hg. However, significant uncertainties still remain regarding some key reaction rate constants and reaction products;**
 - ✓ **Mechanisms of dry deposition to vegetation are poorly understood and models are generally unable to predict total deposition as measured in litterfall;**
 - ✓ **There is growing experimental evidence of a rapid cycling of Hg in the MBL with oxidation → deposition → re-emission.**
 - ✓ **This air-water exchange influences the global cycling and is not explicitly included in current atmospheric models.**

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- Is it possible to characterize source-receptor relationship taking into account the various mechanisms affecting its cycle (emission-chemistry-deposition-reemission) and the spatial scale (local-to-regional-to-global) ?

Regional and hemispherical models are capable of reproducing measurement results of annual total wet deposition within $\pm 50\%$. For short term predictions at individual sites, the accuracy is much lower. Measurement data on dry deposition of Hg is only available as long-term values for deposition to vegetation (forests) which are of limited value for testing and evaluation of model parameterisation.

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➤ Are emission inventories consistent with observations ?

Emission inventories for mercury (point sources and area sources) are available on global scale including information on speciation. The inventory is believed to be reasonably accurate, based on the current state of knowledge on sources and emission factors, with the exception of the waste handling category where the uncertainties are significant. Some measurement results also indicate that emissions from China may be underestimated. In addition, emission inventories for regions (Europe, Arctic states) and individual countries are also available.

Prioritised topics for further work are:

- ✓ **Verification and updating (measurements) of global and national emission inventories.**
- ✓ **More information on emissions from waste (waste incineration, landfills etc) are needed. It is important to follow fate of Hg in products to estimate emissions from household waste.**

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- ✓ **Better estimates of emissions from natural surfaces. Special attention should be addressed to:**
 - Emissions from contaminated sites;
 - Re-emissions from oceans, soil and vegetation;
 - Seasonal variations.

- ✓ **Quantification of mercury emissions from artisanal gold mining and other activities where mercury is used.**

- ✓ **For relevant future scenarios: Information of effects on Hg emissions of planned control measures to reduce particles, SO₂, NO_x.**

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➤ Is the contribution of natural sources well characterized ?

No.

➤ What about the temporal variation of the residence time of different Hg compounds ?

- ✓ Depending on the origin and composition of air masses (i.e., continental, marine, urban, desert) and meteorological and solar irradiation patterns the life time of Hg⁰ may vary between few weeks to several months.
- ✓ The life time of oxidised Hg is quite short, days to weeks.
- ✓ The life time of Hg(p) depends on its particle size distribution, however it is removed by dry deposition and efficiently scavenged by precipitation events.

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- **Besides speciated Hg measurements, what other key measurements do we need to improve our models capabilities ?**
 - ✓ **Fluxes from terrestrial and marine surfaces (re-emissions and natural emission);**
 - ✓ **Estimation of Hg emissions from forest fires and biomass burning;**
 - ✓ **Dry deposition measurement network;**
 - ✓ **Establish a small number of new sites around the globe to provide long-term measurements and vertical profiles of reactive compounds, aerosols and speciated Hg that will allow meaningful examination of long-range transport and trends in background concentrations;**
 - ✓ **Develop uniform and traceable standards on a global basis for calibration of both gas-phase and aerosol Hg measurements;**
 - ✓ **Promote observational programs specifically designed to address chemical and meteorological data requirements for the improvement and validation of models.**

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- ✓ **How deposition loads would change in the next 20-50 years if a 50% reduction will occur in Hg emissions ?**
 - **Examples of emissions reductions resulting in decreased deposition are available from Europe and North America. On a global scale, re-emissions from terrestrial and ocean Hg pool may lead to significant time delays in the response.**
 - **Further development of global/hemispherical models are needed to assess this relationships between emission changes and resulting changes in deposition.**

- ✓ **How future changes in ozone and aerosol concentrations will affect Hg fate and transport ?**
 - **Reductions in ozone and other atmospheric oxidants would reduce the oxidation rate of Hg and thus increase the residence time of Hg in the atmosphere.**
 - **Gas-particle interactions of Hg species are complex and poorly understood but important for determining total deposition.**
 - **Changes in aerosol composition and/or concentrations will likely affect the deposition rate of atmospheric Hg.**