# Trends of Atmospheric Mercury

Franz Slemr, Max-Planck-Institute for Chemistry, Mainz, Germany, with help of teams operating Mace Head, Cape Point, Amsterdam Island, Mount Bachelor, and Cape Hedo stations

# Used data

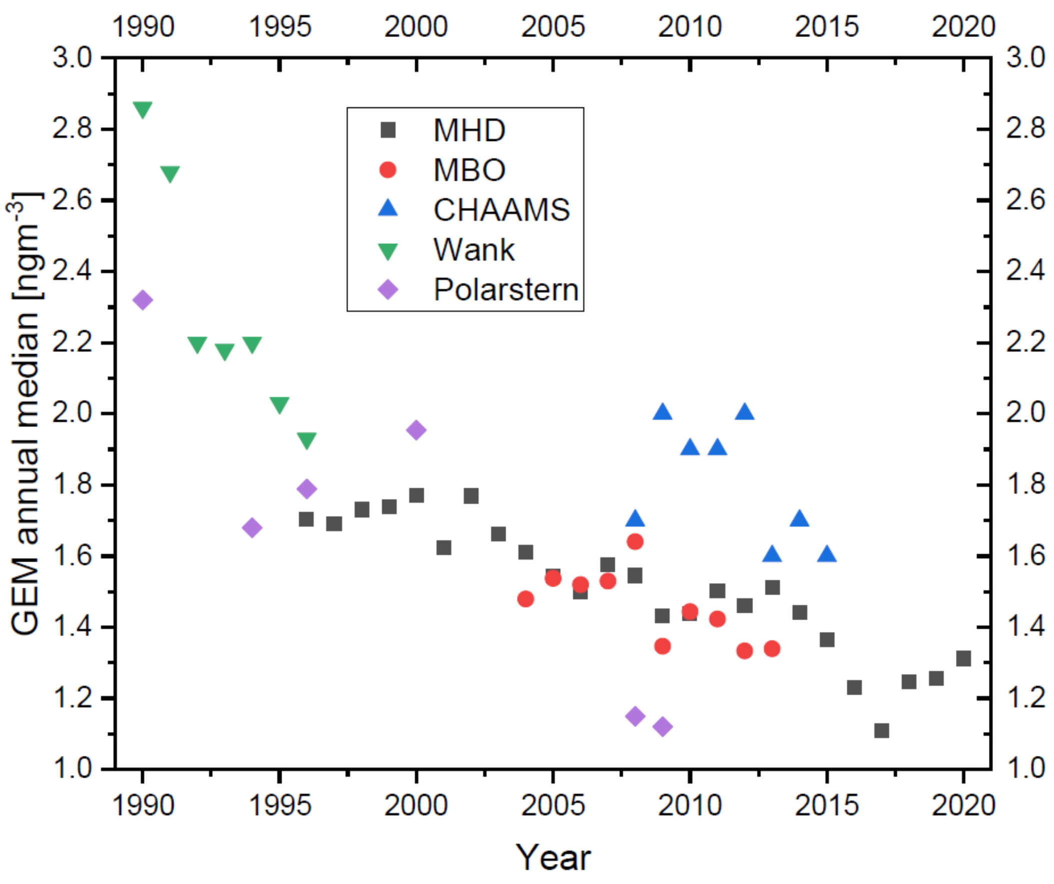
- Mace Head (MHD), Ireland, coastal, 53.33°N, 9.40°W, GEM, Tekran, 1996-2020
- Mount Bachelor (MBO), Oregon, USA, 43.98°N, 121.69°W, mountain 2700 m a.s.l., GEM, Tekran, 2004-2008 and 2010-2013*
- Cape Hedo (CHAAMS), Okinawa, Japan, coastal, 26.87°N, 128.26°E, GEM, Tekran, 2008-2015*
- Cape Point (CPT), South Africa, coastal, 34.35°S, 18.48°E, GEM, manual technique, 1996 and 1999-2004, Tekran, 2007-2017
- Amsterdam Island (AMS), France, coastal, 37.80°S, 77.57°E, GEM, Tekran, 2012-2019
- Wank, Germany, 47.51°N, 11.11°E, mountain, 1780 m a.s.l., 1990-1996
- Ships, Atlantic cruises, 50°S – 54°N, 1977-1994 manual, 1996-2009 Tekran, seasonal snapshots, different latitude ranges

* annual values of 2007 at CHAAMS and 2009 at MBO eliminated because less than 1000 hourly values

# Stations

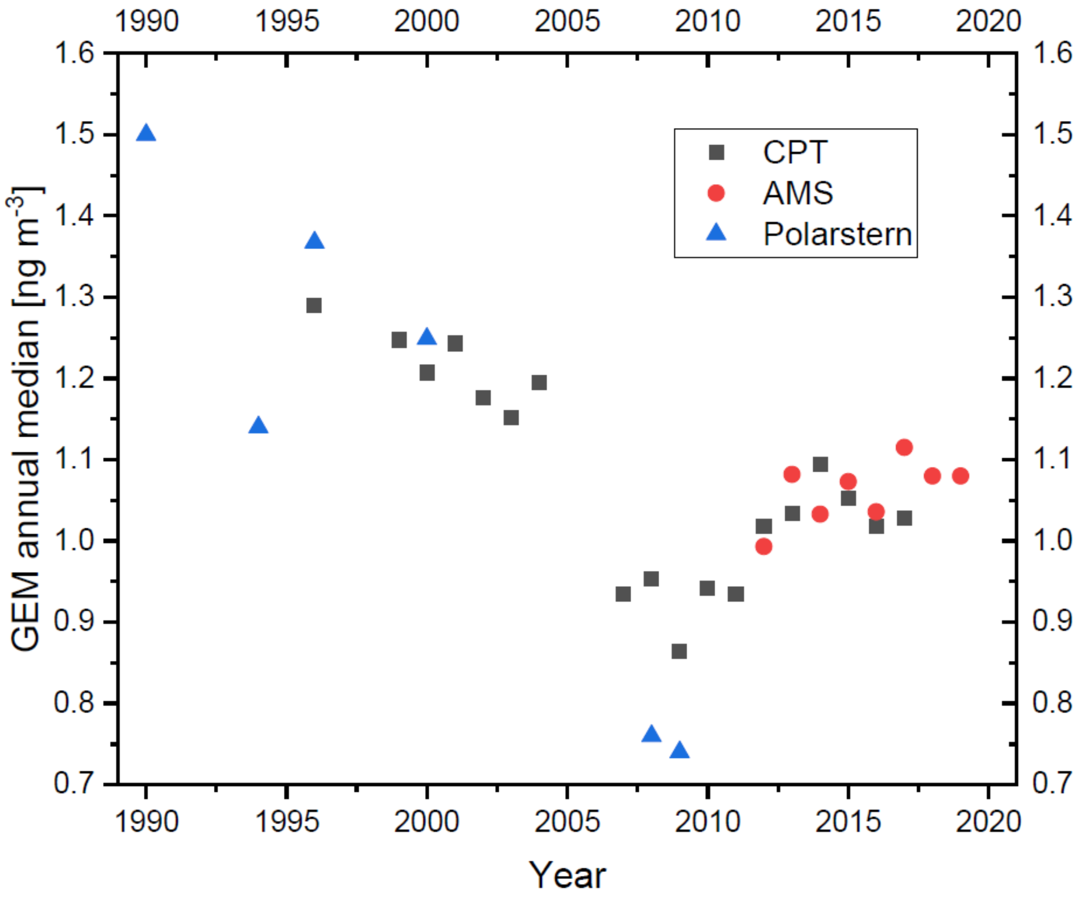
Arctic Ocean
Beaufort Sea
Greenland Sea
Barents Sea
Kara Sea
Laptev Sea
East Siberian Sea
Norwegian Sea
Labrador Sea
Bering Sea
North Pacific Ocean
North Atlantic Ocean
South Atlantic Ocean
Indian Ocean
South Pacific Ocean

# Northern Hemisphere



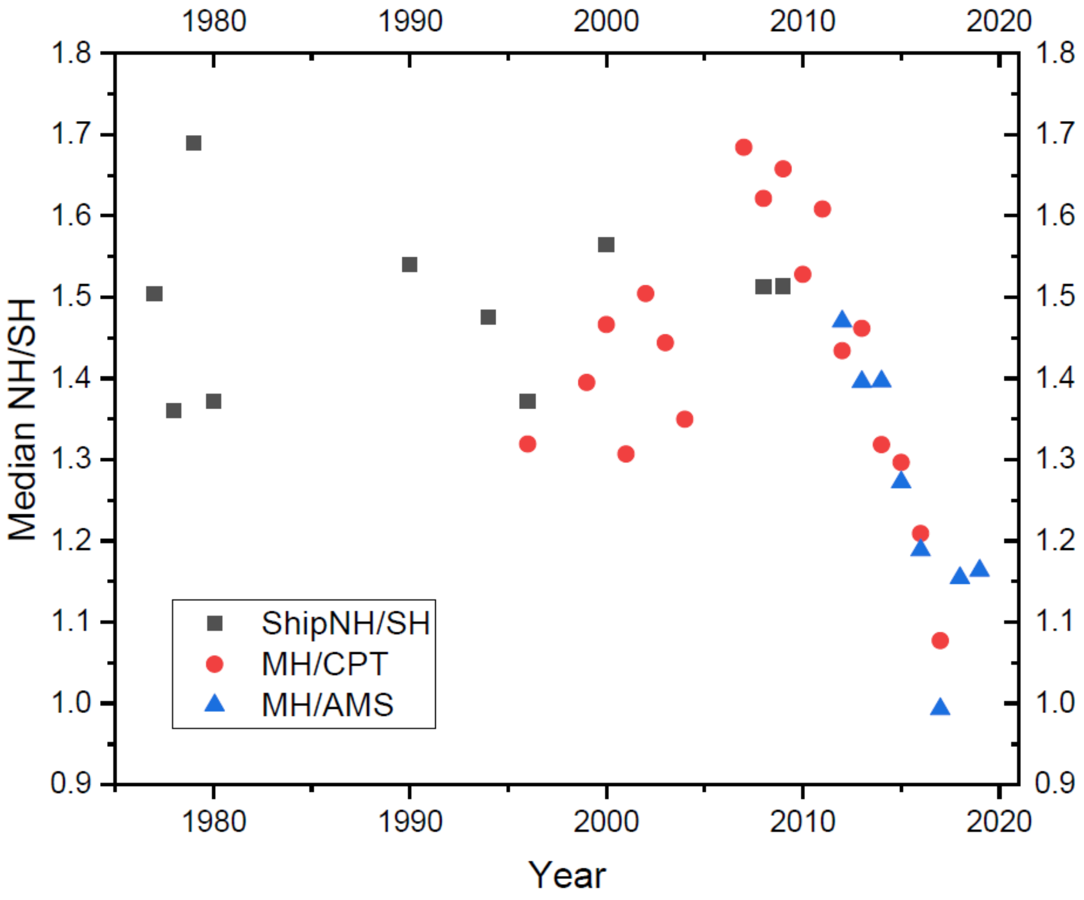

- MHD and MBO comparable, Wank and CHAAMS elevated because of regional emissions
- NH from Atlantic cruises more variable - partly because of different seasons and different latitude ranges
- overall downward trend since 1990
- MHD Sen´s slope of annual medians: -21.4 (-26.7 to -18.0 at 95% confidence) pg $m^{-3}$ $yr^{-1}$ for 1996-2020 – corresponding to -1.4% $yr^{-1}$
- CHAAMS LSQF of monthly averages: -38.3 ± 6.5 pg $m^{-3}$ $yr^{-1}$ for 2008-2019, corresponding to -2.1% (Marumoto et al., Atmosphere, 10, doi: 10.3390/atmos10070362, 2019) – trend larger than at Mace Head possibly because of faster reduction East Asian emissions

# Southern Hemisphere




- Polarstern more variable because of different seasons and different latitude ranges
- Polarstern roughly in line with CPT 1996 – 2009 data => downward trend in 1990 - 2009
- CPT and AMS data comparable – no trend in 2012-2019
- CPT and AMS data – influence of ocean emissions dominating (Bieser et al., ACP, 20, 10427-10439, 2020; Slemr et al., ACP, 20, 7683-7692, 2020)
- terrestrial surface of southern Africa – correlations with $^{222}Rn$ point to weak Hg sink (Slemr et al., ACP, 13, 6421-6428, 2013)

# NH/SH Ratio




NH/SH ratio shows two different regimes:

- Regime A: 1977 – 2007 - NH/SN ratio of ~1.45, roughly constant

- Regime B: since 2007 - decreasing from ~1.65 in 2007 to almost a parity in 2017 – 2019

# Tentative explanation of regimes A and B

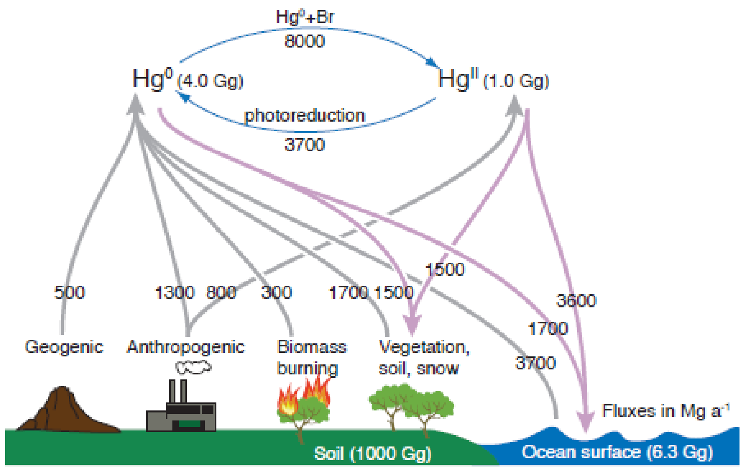



**Fig. 1.** Global budget of atmospheric mercury derived from this work. $Hg^{II}$ here includes gaseous and particulate forms, plus a negligible contribution (1 Mg) from inert particulate mercury.

Holmes et al., ACP, 10, 12037-20157, 2010

- oceanic emissions with 3700 Mg $yr^{-1}$ comparable to the terrestrial ones with 3800 Mg yr-1 (without emissions of $Hg^{2+}$ which are only of regional importance) – terrestrial emissions located predominantly in NH
- oceanic emissions will react with a long delay to the decrease in terrestrial ones
- regime A: terrestrial emissions substantially larger than oceanic – SH follows NH – nearly constant ratio given by the NH/SH emission ratio and the NH->SH transport (hemispheric air exchange time of ~1 yr)
- regime B: terrestrial emissions decreasing and smaller than oceanic – NH/SH distribution would slowly approach towards a ratio given by the hemispheric distribution of oceanic surface areas and the SH->NH transport – resulting finally in somewhat higher SH than NH concentrations