Atmospheric mercury monitoring at Auchencorth Moss – trends, patterns and a source analysis.

John Kentisbeer, Sarah Leeson, Heath Malcolm, Ian Leith and J. Neil Cape

Centre for Ecology & Hydrology NERC, Edinburgh, Scotland

Location and Method

Figure 1: Location of the Auchencorth Moss Field Site as seen on Google Earth.

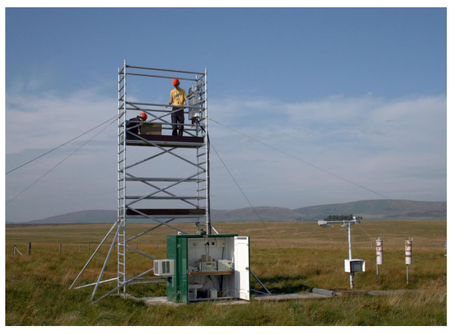

Figure 2: Tekran Instruments on scaffold

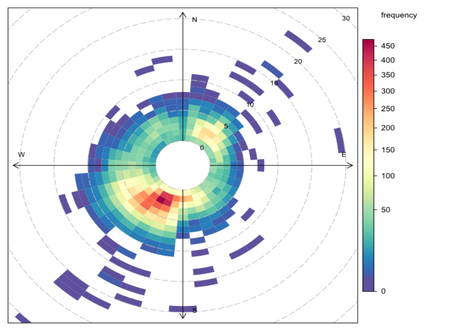

Figure 3: Wind direction and frequency (2009-11)

- The Auchencorth Moss field site was established in 1995 and is located about 20 km south-west of Edinburgh in the county of Midlothian. It is a remote, rural, sheep-grazed, upland peat bog site with a large uniform fetch. The surrounding land is also grazed and has some small wooded areas [Figure 1.]
- Atmospheric mercury species: (elemental (Hg^0) particulate bound (PBM) & gaseous oxidised (GOM)) are measured using the Tekran Speciation System (2537A/1130/1135), which uses Cold Vapour Atomic Fluorescence Spectroscopy (CVAFS) to detect elemental mercury.
- Measurements of atmospheric mercury have been made at the site since 2004 on behalf of the UK government's Department for Food and Rural Affairs and the devolved administrations.
- The site is one of the two UK EMEP Supersites, operated at Level III and is now part of the Global Mercury Observation System (GMOS).
- System relocated from 0.9 m high inlet to 4 m high inlet in spring 2011, but due to technical problems, there is no speciated data for 2011 [Figure 2.]

Results

ng m^{-3}	Spring	Summer	Autumn	Winter	Annual Mean
2009					
Hg^0	1.445	1.331	1.262	1.416	**1.359**
PBM	0.008	0.002	0.000	0.004	**0.004**
GOM	0.000	0.000	0.000	0.000	**0.000**
2010					
Hg^0	1.486	1.393	1.380	1.511	**1.445**
PBM	0.001			0.000	**0.001**
GOM	0.001	0.000	0.000	0.001	**0.001**
2011					
Hg^0		1.453	1.326	1.386	**1.375**
PBM					
GOM					
Seasonal Mean					
Hg^0	**1.467**	**1.388**	**1.317**	**1.451**	
PBM	**0.006**	**0.002**	**0.000**	**0.003**	
GOM	**0.001**	**0.000**	**0.000**	**0.000**	

Table 1: Annual and Seasonal Means concentrations of Hg species

- Annual mean concentrations of Hg^0 observed were: 2009 1.359 ± 0.144ng m^{-3}, 2010 1.445 ± 0.131 ng m^{-3} and 2011 1.375 ± 0.180 ng m^{-3}, slightly lower than other observations in the northern hemisphere, between 1.5 and 1.7 ng m^{-3}.
- Levels of PBM and GOM observed are typically very low, or below detection limit.
- Seasonal variations are consistent with other studies in the northern hemisphere.
- Maximum values of Hg^0 observed are in the order of 2.5 – 2.7 ng m^{-3} and are episodic in nature.

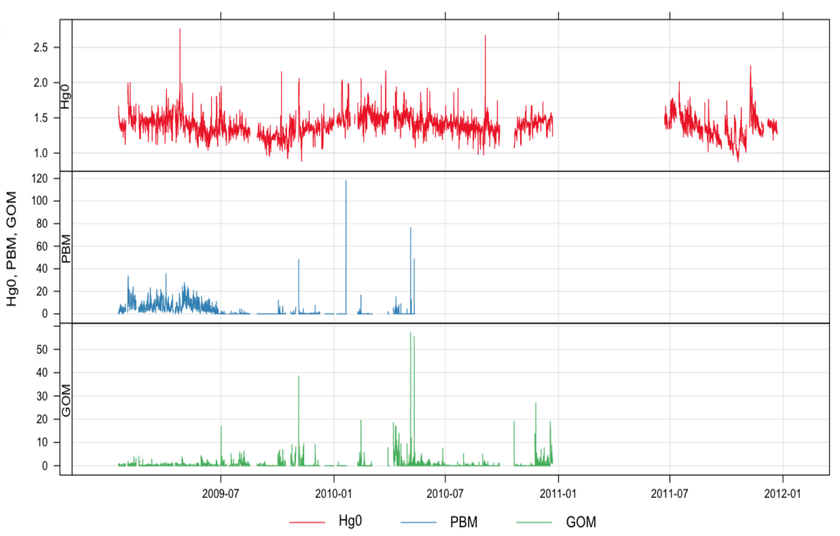

Figure 4: Temporal plot of mercury species data

Elemental Mercury: Trends & Patterns

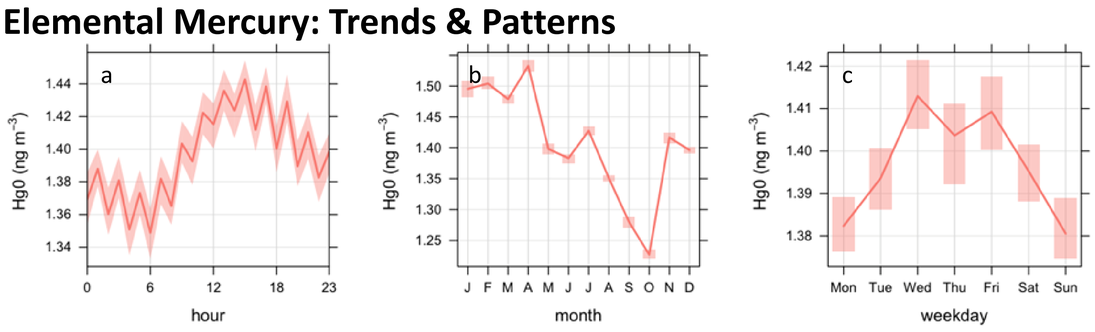

Figure 5: Hg^0 a) Diurnal cycle, b) Seasonal cycle, c) Weekday cycle (2009-11)

- Consistent with other studies[1] Hg^0 shows a clear diurnal cycle reaching a minima in the early hours of the morning, and a maxima in the middle of the afternoon [Figure 5a].
- Concentrations are highest in the winter and spring and lowest in the summer and autumn, similar to other sites and probably due in part to increased emissions during winter from coal combustion, but also photochemical oxidation of Hg^0 to reactive species during the summer [Figure 5b].

- Air mass back trajectories, calculated at 3 hour intervals using the NOAA HYSPLIT trajectory model[2] can be imported into Openair[3,4], a package for statistical analysis of atmospheric pollutant data in R.
- The package associates concentrations of Hg^0 for each point on the back trajectory based on the arrival time concentration. This can reveal geographic origins of air masses associated with high Hg^0 concentration.
- Figure 6 shows all data for 2009-2011 showing the influence of Europe's industrial heartland on Hg^0 levels seen in the UK.
- Figure 7 shows the same data by season, showing greatest contributions from continental Europe during winter, likely due to increased fossil fuel burning.

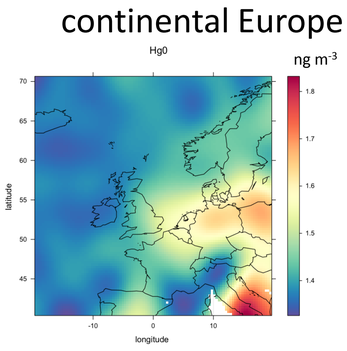

Figure 6: Contribution of Hg^0 to Auchencorth Moss by direction (2009-11)

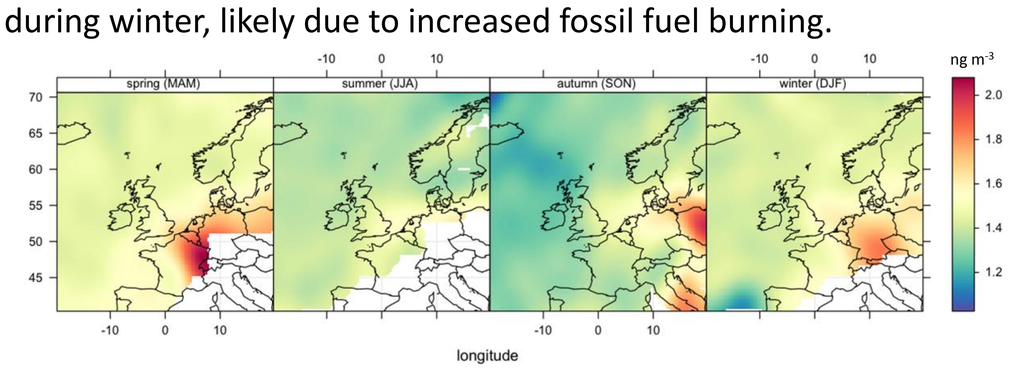

Figure 7: Seasonal contribution of Hg^0 to Auchencorth Moss by direction

PBM and GOM: Trends and Patterns

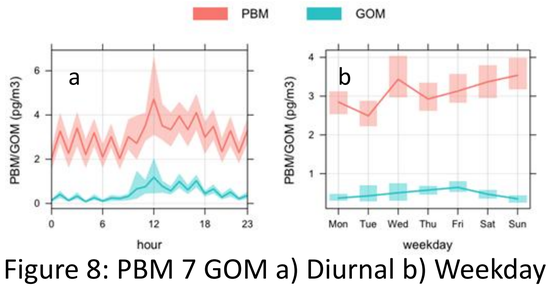

Figure 8: PBM 7 GOM a) Diurnal b) Weekday cycles (2009-11)

- Figure 8 shows the diurnal and weekday variation in both observed GOM and PBM at Auchencorth Moss.
- By associating the speciated mercury data with wind speed and direction data, we can create plots which allow us to see trends in the species origins prior to arrival at the site.
- Figure 9a shows PBM, with higher levels arriving on winds from the south-west. There are no industrial sources, however there is a peat extraction works about 1 km away and peat is a sink for mercury[5]. Therefore re-suspension may be a source of PBM, although there is limited evidence.
- Figure 9b of GOM shows no strong directional trend, possibly due to our sampling height or loss through adsorption on our infrastructure., or may not have a strong directional dependence.
- The 'spots' outwith the main data in plots 9a and b are likely to represent transport from local point sources. For example, to the north east lies Cockenzie coal fired power station

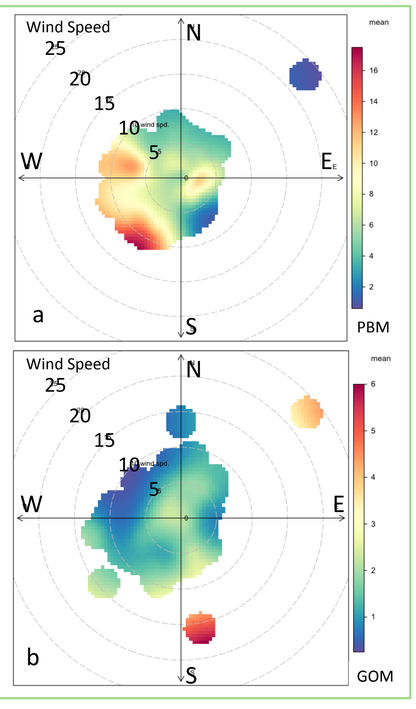

Figure 9: a) PBM & b) GOM concentration by wind speed & direction (2009-110

References:

1. U. S. Nair et al, (2012). Diurnal and seasonal variation of mercury species at a coastal-suburban, urban, and rural sites in the southeastern United States, Atmospheric Environment. 47 (2012) 499-508
2. R. R. Draxler and G. D. Rolph, HYSPLIT (HYbrid Single-Particle Lagrangian Inetgrated Trajectory) Model, http://ready.arl.noaa.gov/HYSPLIT.php, 2012.
3. Carslaw, D.C. and K. Ropkins, (2012). openair — an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61.
4. Carslaw,D.C. (2012). The openair manual—open-source tools for analysing air pollution data. Manual for version 0.6-0, King's College London.
5. Farmer JG, et al, Historical accumulation rates of mercury in four Scottish ombrotrophic peat bogs over the past 2000 years, *Sci Total Environ* (2009

jkbeer@ceh.ac.uk

www.ceh.ac.uk