ATMOSPHERIC MERCURY ACROSS THE AUSTRALIAN CONTINENT

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Introduction

Mercury is ubiquitous in the environment and large-scale transport of this toxic element occurs via gas phase movement within the atmosphere (Driscoll et al., 2013). Our understanding of the fate and transport of atmospheric mercury in the Southern Hemisphere (SH) has been hampered by the limited temporal and spatial distribution of monitoring networks. The background gaseous elemental mercury (GEM) concentration in the SH, based on sparse data, is currently taken as 1.1 to 1.3 ng m^{-3}, however a recent analysis of long-term measurements from four stations across the SH taken between 2007 and 2013 have shown GEM concentrations are lower and more spatially uniform than previously thought, lying between 0.85 and 1.05 ng m^{-3} (Slemr et al., 2015). As part of an effort to understand the natural cycling of mercury, and achieve the monitoring goals of the recent Minamata Convention on Mercury, long-term atmospheric mercury monitoring programmes have been implemented on the Australian continent, with measurements currently being undertaken in temperate marine and tropical environments.

Methods

Long-term GEM monitoring has been taking place at the Cape Grim Baseline Atmospheric Pollution Station (CGBAPS) in Tasmania, Australia since September 2011. More recently, since June 2014, such a programme has been implemented at the Australian Tropical Atmospheric Research Station (ATARS), located on the Gunn Point peninsula in northern Australia. GEM is measured at these sites using Tekran 2537 analysers that quantify gaseous mercury using gold pre-concentration and cold vapour atomic fluorescence spectroscopy. Both stations collect standard meteorological measurements (wind velocity, atmospheric pressure, precipitation), as well as radon-222 (radon), for wind sector and fetch analysis.

Results

Measurements across the period December 2014 – November 2015 show varying median background concentrations along a latitudinal gradient, ranging from 0.83 ng m^{-3} at CGBAPS to 0.94 ng m^{-3} at ATARS. These values are in line with findings from Slemr et al. (2015) that showed GEM concentrations in the SH to be around 30% lower than previously believed. The data also show some seasonal influence at both these sites, with lowest mean concentrations occurring in autumn (Table 1). The highest mean seasonal values at CGBAPS occurred during winter, whereas these were seen during spring at ATARS. This may be linked to frequent biomass burning that takes place during the dry winter and early spring months, before the onset of a monsoon season that runs from November until April.

Table 1. Seasonal GEM concentrations (mean ± standard deviation) for the period December 2014 –November 2015

Site	Summer (DJF) ng m^{-3}	Autumn (MAM) ng m^{-3}	Winter (JJA) ng m^{-3}	Spring (SON) ng m^{-3}
CGBAPS	0.81 ± 0.07	0.71 ± 0.09	0.92 ± 0.10	0.88 ± 0.07
ATARS	0.90 ± 0.11	0.85 ± 0.13	0.96 ± 0.09	1.00 ± 0.12

Variability in GEM concentrations was also larger at ATARS than at CGBAPS, as evidenced by larger standard deviations. This is likely due to greater fetch variability at ATARS that experiences regular sea- and land-breeze circulations, whilst CGBAPS is more heavily influenced by the large, homogeneous fetch of the Southern Ocean. Nocturnal depletion events are also often witnessed at ATARS, with GEM concentrations dropping overnight by up to 60% (Figure 1). Preliminary results from radon analysis suggest these are linked to local dry deposition under stable nocturnal boundary layers. Drops in GEM concentration are also seen at CGBAPS (not shown), though these events are less frequent, less pronounced and likely due to transport of GEM-depleted air masses as suggested by back trajectory analysis. Back trajectory analysis at ATARS also suggests influences from the Northern Hemisphere as the inter-tropical convergence zone shifts southwards during the monsoon season. An example of this can be seen in Figure 1 when GEM concentrations spiked to 1.4 ng m^{-3} on the 25th February, possibly in relation to GEM emission from biomass burning on the Indonesian archipelago.

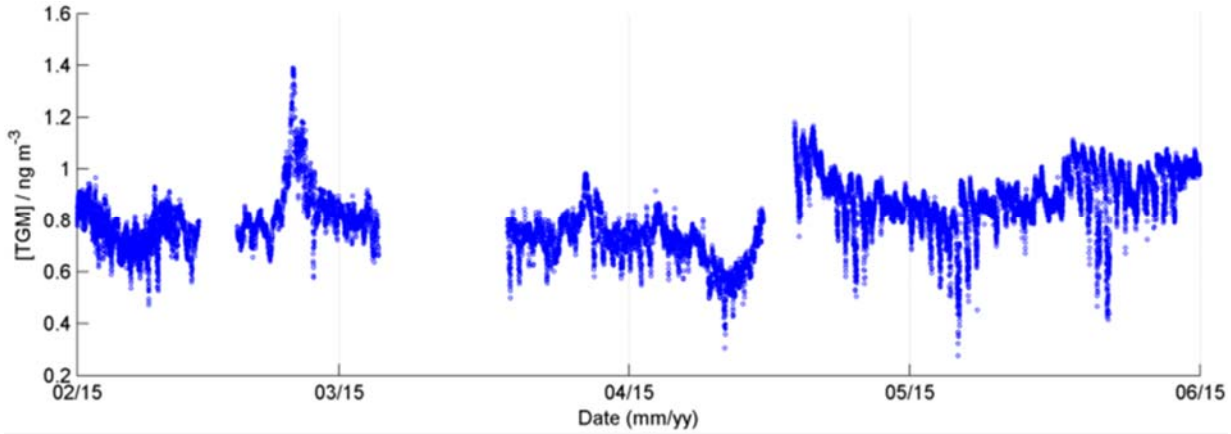

Figure 1. Close up of four months' data from ATARS, showing possible influence from Indonesian biomass burning (25th February), as well as nocturnal depletion events throughout late April and May.

Conclusion

In addition to supporting recently published results regarding the concentration of GEM in the Southern Hemisphere, the high temporal resolution of the current atmospheric mercury monitoring techniques enables fetch analysis techniques that can improve our understanding of the natural cycling of mercury in the environment. By investigating biomass burning events witnessed at both ATARS and CGBAPS we can work to constrain estimates of mercury release from fire across the Australian continent, currently taken to be between 21 and 63 Mg $year^{-1}$ (Nelson et al., 2012). Additionally, the depletion events witnessed at both sites can provide insights into delivery of mercury to the environment from the atmosphere, an important consideration when assessing the impact of anthropogenic mercury pollution on human and ecosystem health.

References

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