Mercury monitoring in Australia

14th Annual APMMN Partners meeting

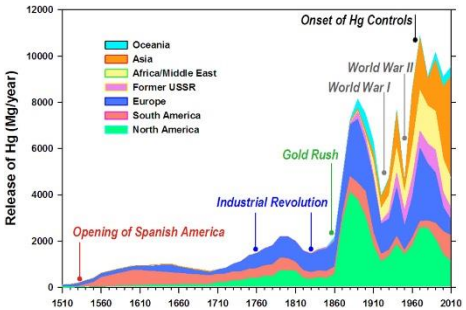
Jennifer Powell | 9 December 2025

Australian mercury monitoring update

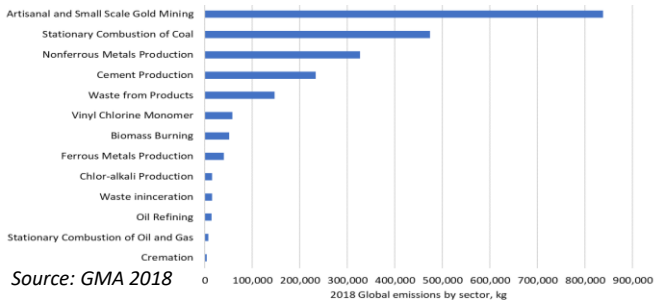
- Wet deposition sampling in the Asia Pacific Mercury Monitoring network
- Gaseous elemental sampling with the MOEJ Kit
- Long term active GEM measurements at two Australian sites
- Participation in the global passive network
- Submission of data and participation in the Minamata Effectiveness Evaluation Process
- Future goals

Global, hemispheric, regional emissions

- Composition of annual emissions to air: 60% legacy emissions, 30% primary anthropogenic, 10% natural sources
- 2220 tones emitted to air in 2015 (20% increase since 2010)

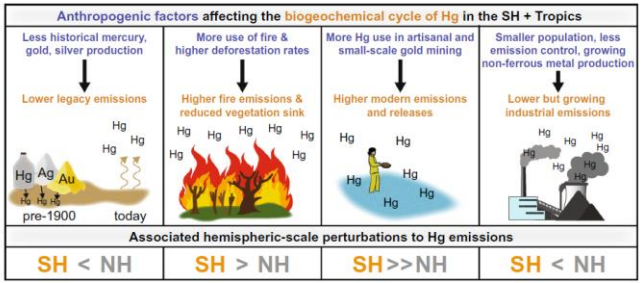


Source: Streets et al 2019



Source: GMA 2018

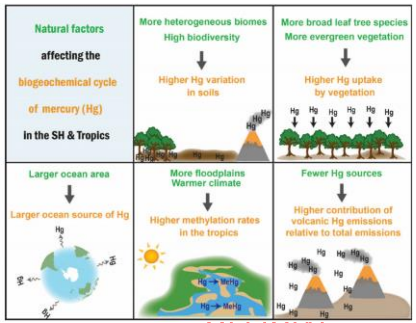
SH anthropogenic: lower legacy, lower industrial, higher ASGM, higher fires



Source: Fisher et al 2023

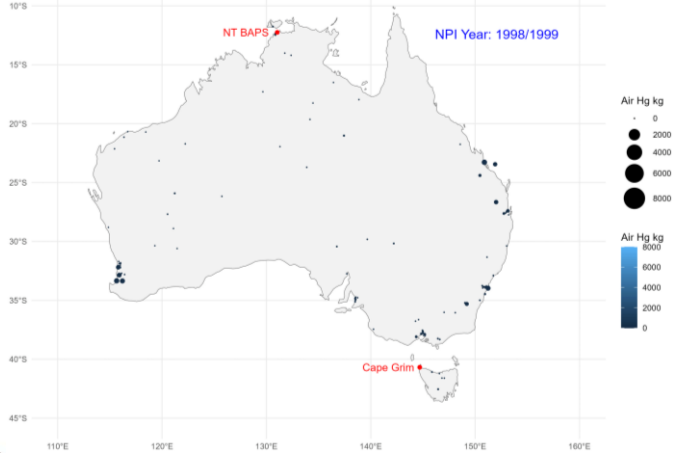
Levels in the atmosphere are currently 450% above natural levels.

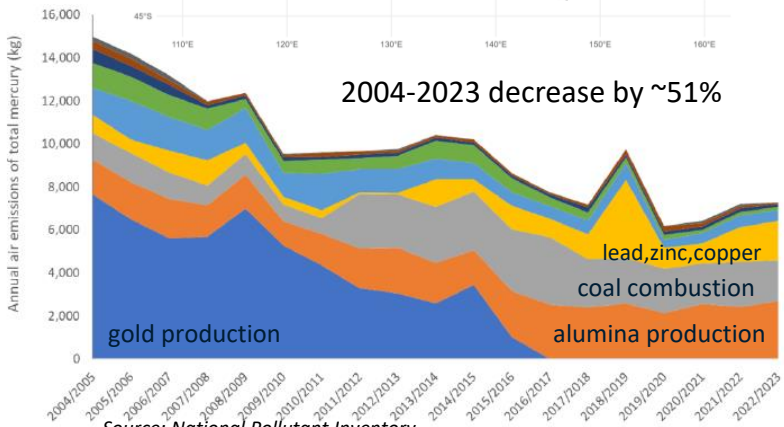
SH natural: larger ocean source, greater uptake by vegetation



Source: Schneider et al 2023

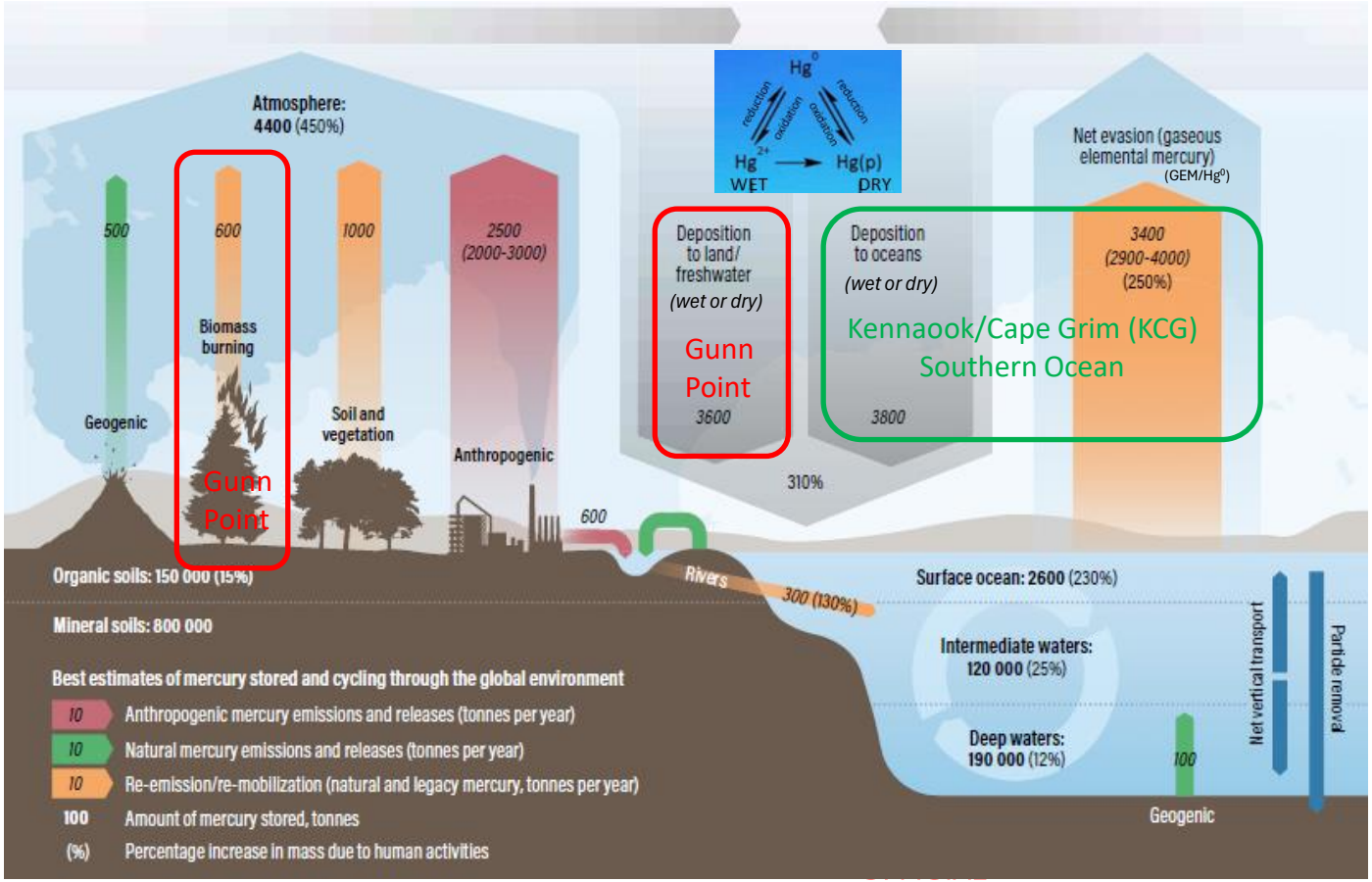
Australia: 72% of emissions from vegetation and soil, 21% from fires and 7% from primary and legacy anthropogenic sources (Nelson 2012)





Source: National Pollutant Inventory

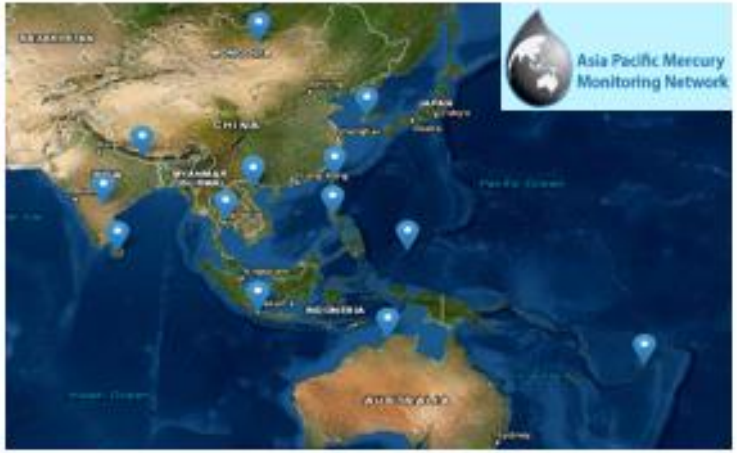
What impact can Australian observations have?



- Long term monitoring sites in Southern Hemisphere are scarce; needed for effectiveness evaluation
- Mercury cycling in SH tropics:
- Wet season interhemispheric mixing with SE Asian region – fate and deposition
- Dry season savanna emissions
- Mercury cycling in Southern Ocean:
- Net source or sink? (evasion vs deposition)

Northern Australia mercury monitoring

Submission of NTBAPS 2014-2023 GEM for Effectiveness Evaluation

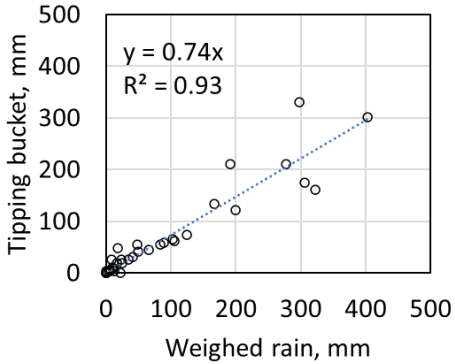


APMMN Darwin site, wet deposition sampling, 2022 to present; visit our blog about the APMMN site www.mercury-australia.com.au/

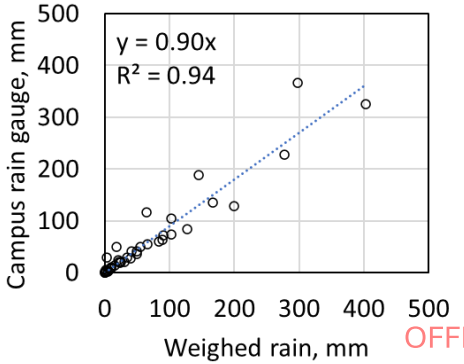
APMMN sampling update

- 92% successful samples taken from 2022-2025
- Sample weighing matches nearby rain gauges (closest gauges most accurate)
- No measurements for CDU BOM rain gauge available after May 2024
- Bias of 25% with co-located tipping bucket- too close to sampler or intensity too high for tipping bucket?
- Reasonable correlation in rain at Gunn Point

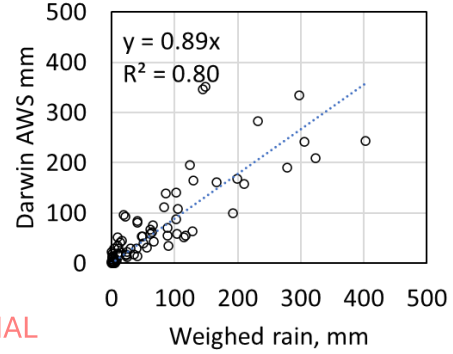
Tipping bucket co-located (0 m away)



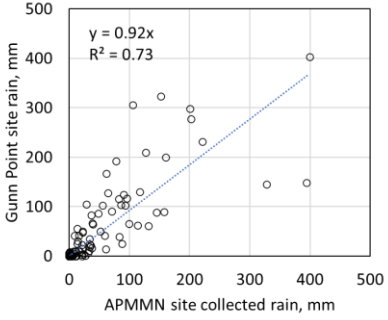
CDU manual rain gauge (400 m away)



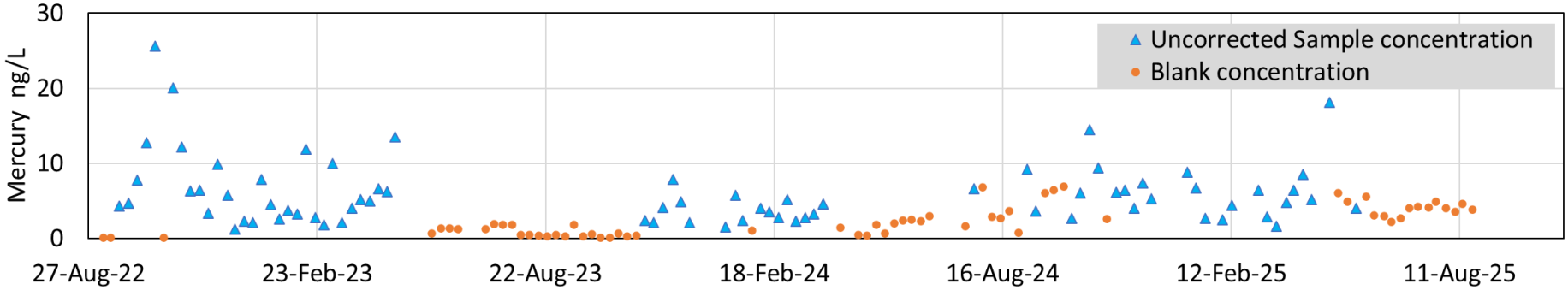
Darwin airport AWS (6 km away)

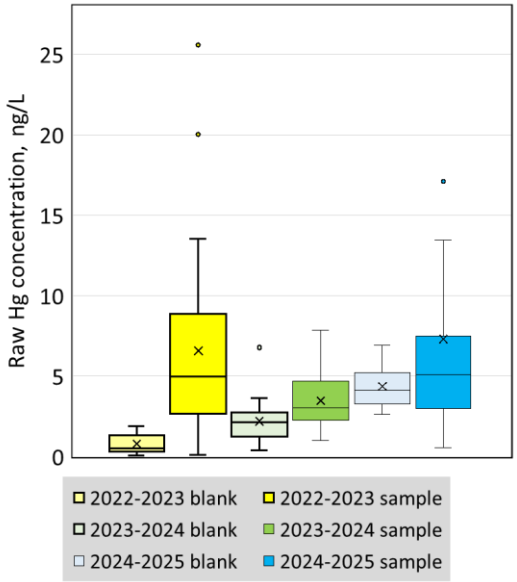


Gunn Point AWS (30 km away)



Challenges: increase in blanks





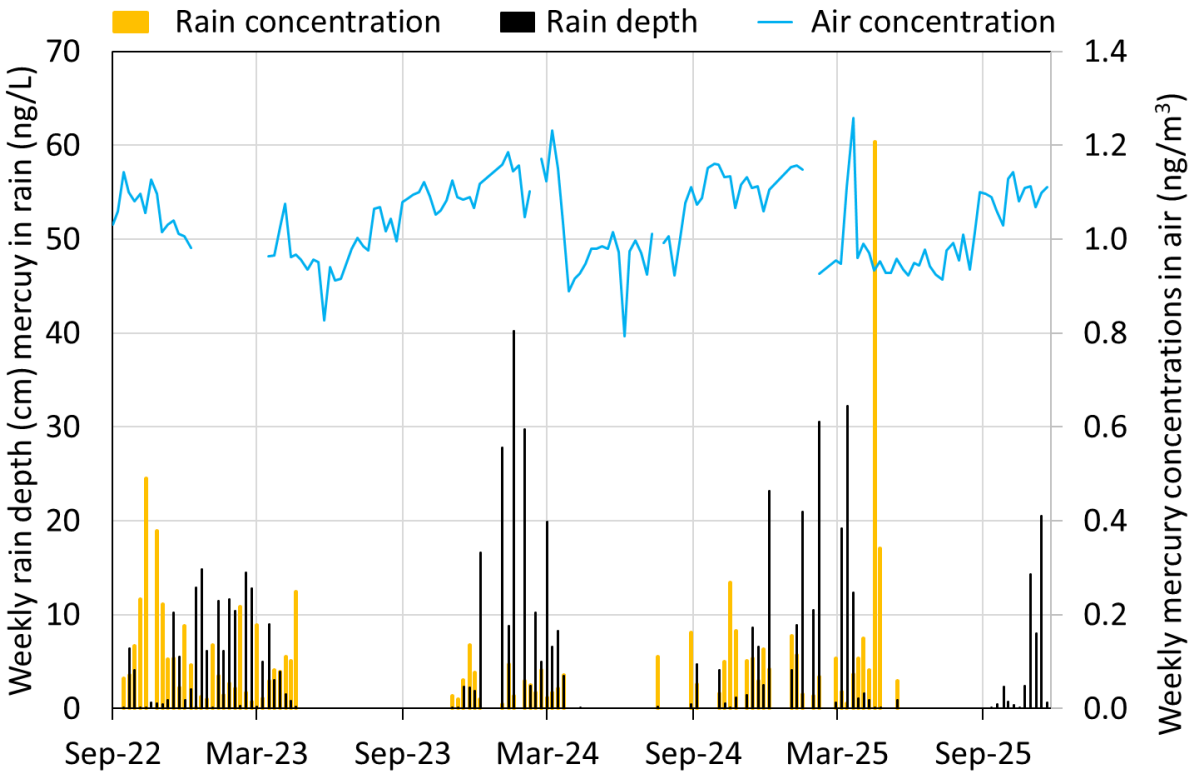
Why have blanks increased?

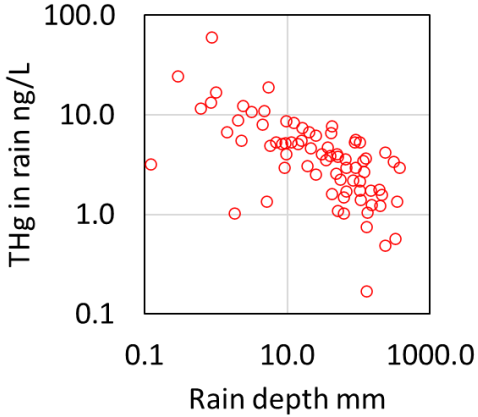
- Bench air drying?
- Difficulty cleaning airlocks?
- Laboratory DI water issues? (some reported)

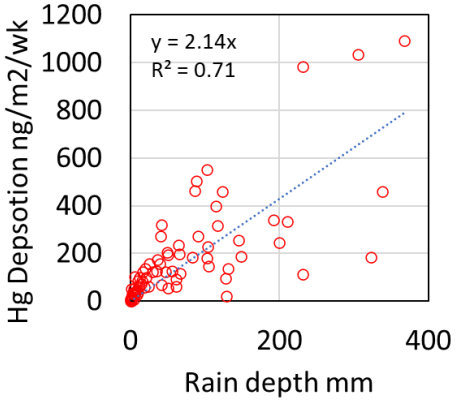
Solutions:

- New HCl soaking solution
- Drying in containers; not benchtop
- Wet season laboratory and field every four weeks
  - DI water directly into sample bottle
  - DI water via cleaned sample-train

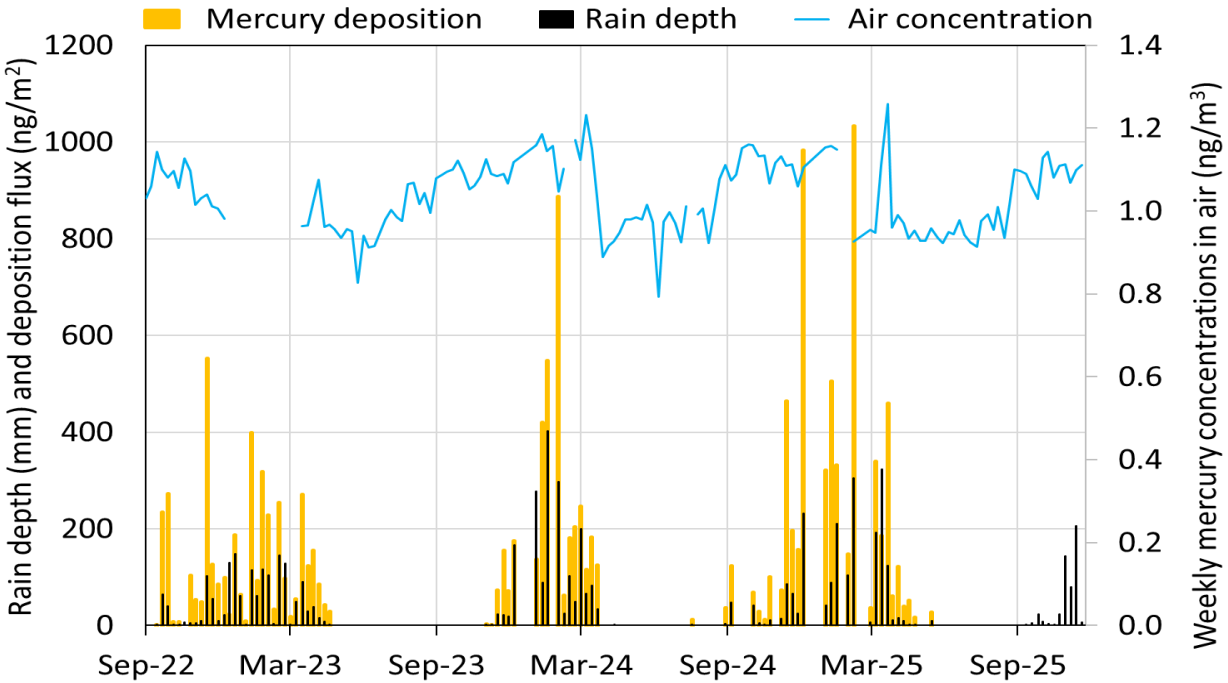
Mercury water concentrations, 2022-2025







Wet deposition fluxes, 2022-2025

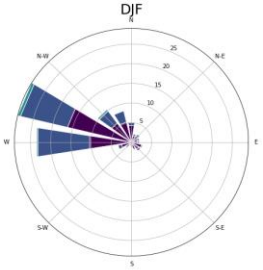


- For comparison Cape Grim bulk deposition fluxes in 2014-2015 were 3.1–3.8 µg/m2/yr (Sprovieri et al 2017)
- Blank levels can really affect deposition estimates: a 1 ng/L correction reduces fluxes by 30%

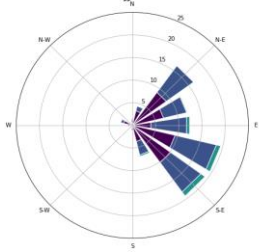
Wet season	Wet season onset	Monsoon arrival	Duration	Site Rainfall	Wet deposition flux
2022/2023	27-Sep-2022	22-Dec-2022	217 days	1568 mm	4.07 µg/m^2/yr
2023/2024	30-Nov-2023	10-Jan-2024	161 days	1763 mm	3.49 µg/m^2/yr
2024/2025	17-Sep-2024	07-Feb-2025	245 days	1980 mm	5.89 µg/m^2/yr

Northern Australia wet and dry seasons

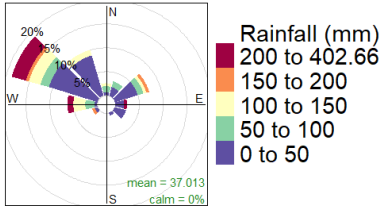
Wet season marine



Dry season – biomass burning; dry deposition

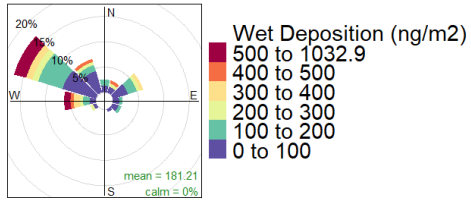


Weekly Rainfall



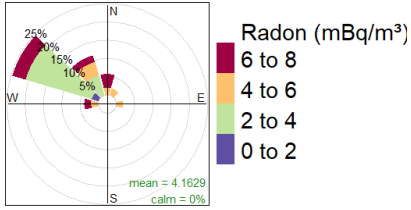
Frequency of counts by wind direction (%)

Weekly wet deposition



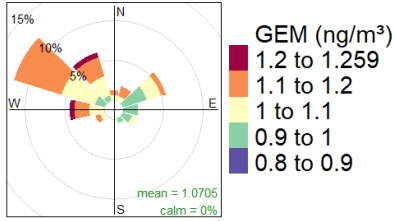
Frequency of counts by wind direction (%)

Radon concentration — Wet Season



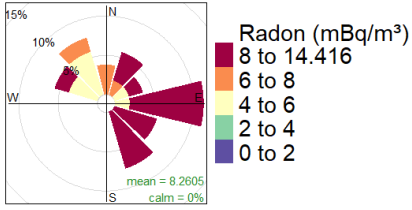
Frequency of counts by wind direction (%)

GEM concentration — Wet Season



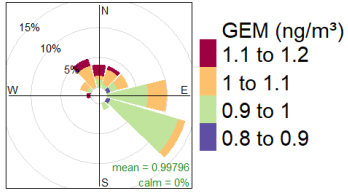
Frequency of counts by wind direction (%)

Radon concentration — Dry Season



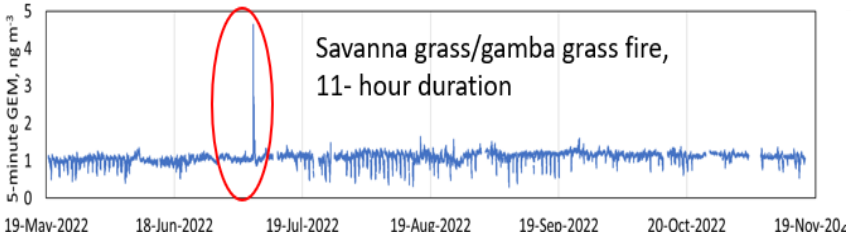
Frequency of counts by wind direction (%)

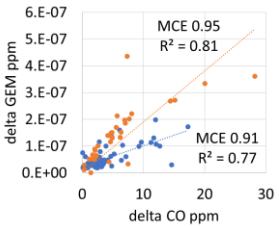
GEM concentration — Dry Season

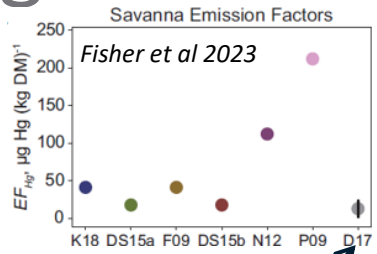


Frequency of counts by wind direction (%)

Measured biomass burning emission factors

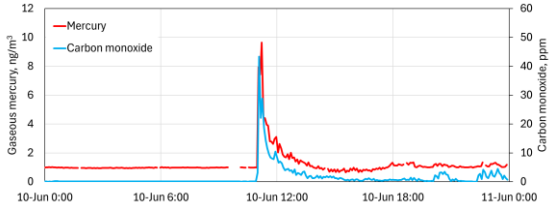


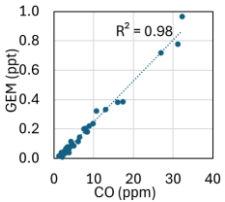




Australian savanna lower EFs

vegetation type? gamba grass?





Year	2014*	2022	2023	2025
Hg Emission factor µg kg^{-1} dry fuel	10 ± 2	6.2 – 9.8	13.3	13.0
Combustion efficiency	0.86 – 0.93	0.91 – 0.95	0.97	0.98

**Desservettaz et al 2017*

Emission ratios converted to emission factors using 65 ± 20 g CO kg^{-1} Dry Mass burned (Andreae and Merlet 2001)

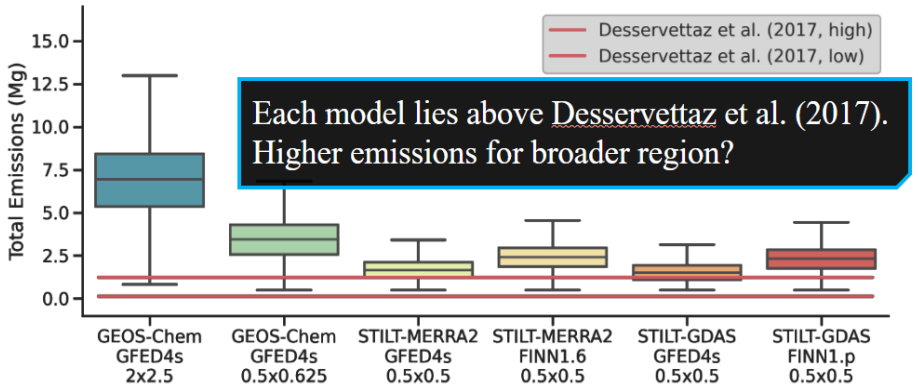
Photos courtesy of James Harnwell and Jason Ward

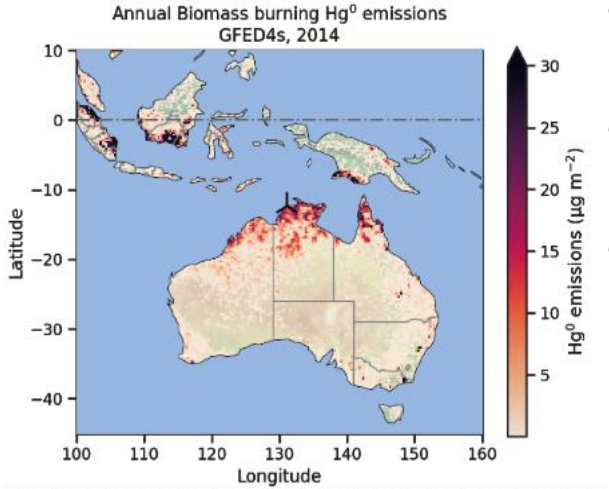
Modelled emissions

Using the unused data:
Top-down constraints on mercury exchange from diffuse processes

Eric Roy

Aryeh Feinberg, Jenny A. Fisher, Jennifer Powell, Jason Ward, James Harnwell, Thandolwethu Dlamini, Noelle E. Selin





- Inverse modelling using 2014 -15 Gunn Point concentrations
- Various models and met schemes run to determine the optimal fluxes that explain the concentrations
- Higher optimal emissions than GFED4s and FINN biomass burning inventories
- Optimal emissions much higher than measured emission factors– are Gunn Point emission factors representative of grass rather than savanna emissions?
  - Grass (7) + grassland soil (9) = 17 μg kg^{-1}
  - Tree litter (21) + forest canopy soil (26) = 47 μg kg^{-1}

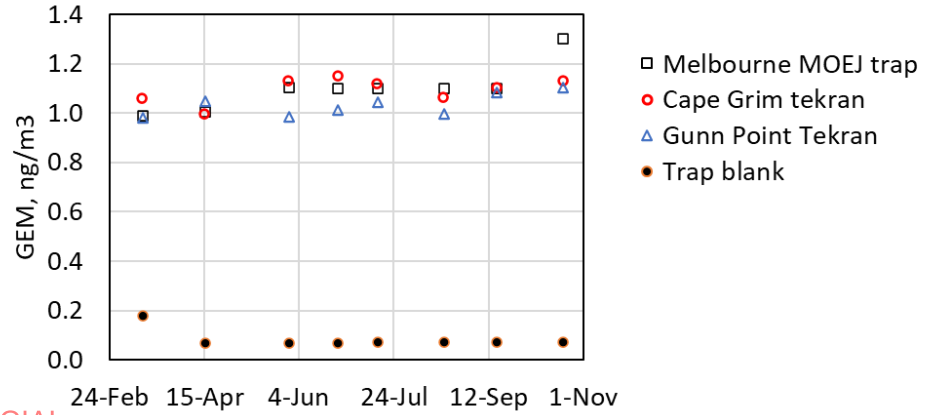
*Edwards & Howard 2013

Active sampling with the MOEJ kit

- Tubes baked for 1 hour @ 700 °C
- Soda lime baked for 1 hour @ 110 °C
- Flow calibrated under load w soap bubble meter
- Kit can withstand 50 kph winds and rain!

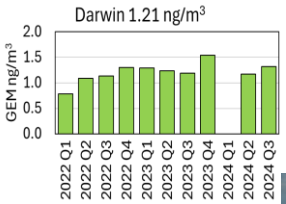
Ministry Of Environment Japan monitoring

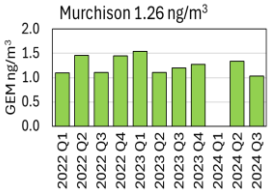
- MOEJ Nippon sampling kit: pumps, gold traps for integrated sampling; logger for .
- Participation of 1 day in month sampling across Asia Pacific; 8 samples so far
- Plan to across a range of Australian locations to build a spatial map (including near/far sources)
- Use for real-world biomass burning emission factors

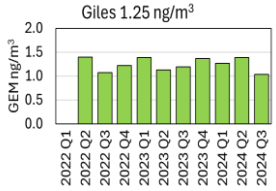


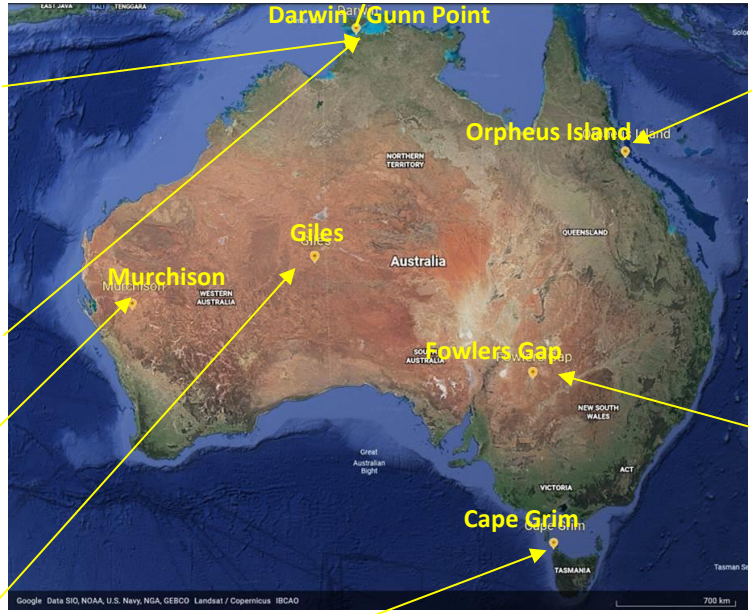
AUSHG passive sampling network

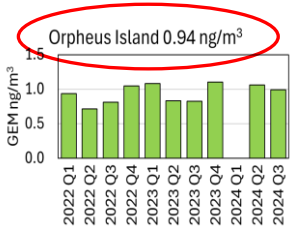
Lowest in world!

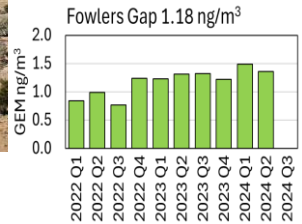


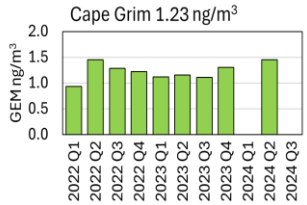


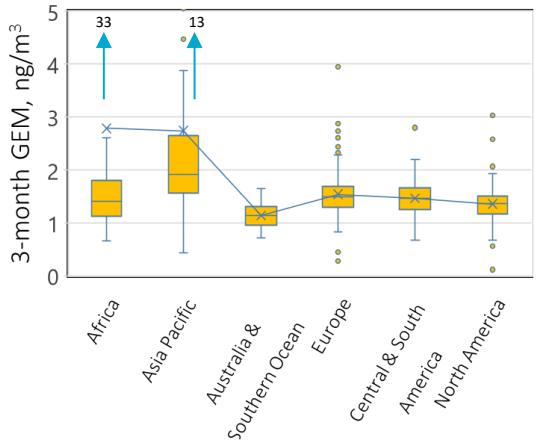












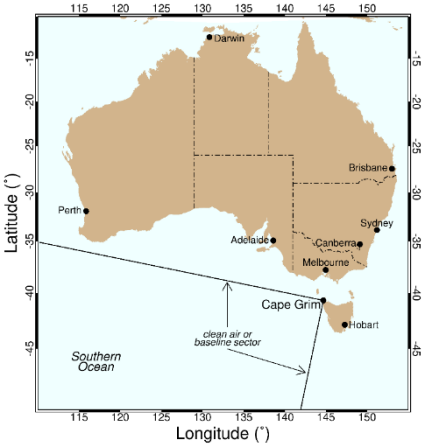
Sponsored by Environment Canada

Government of Canada

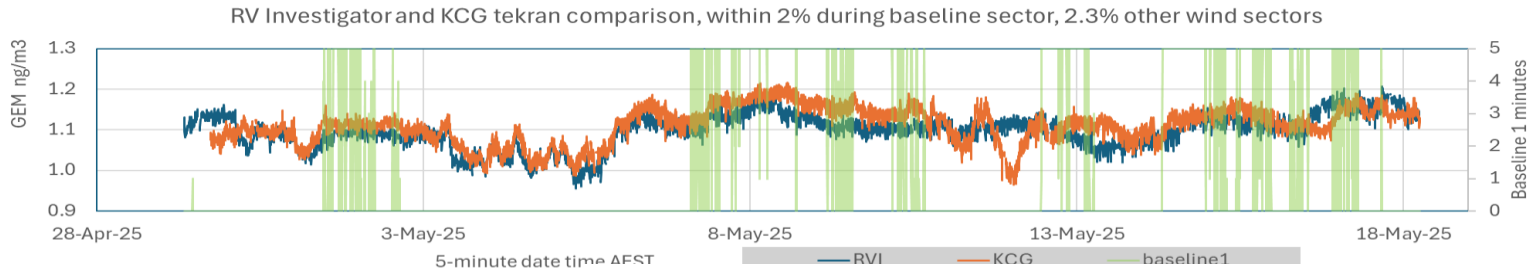
3-month sample periods, 2022-2024

Kennaook/Cape Grim monitoring

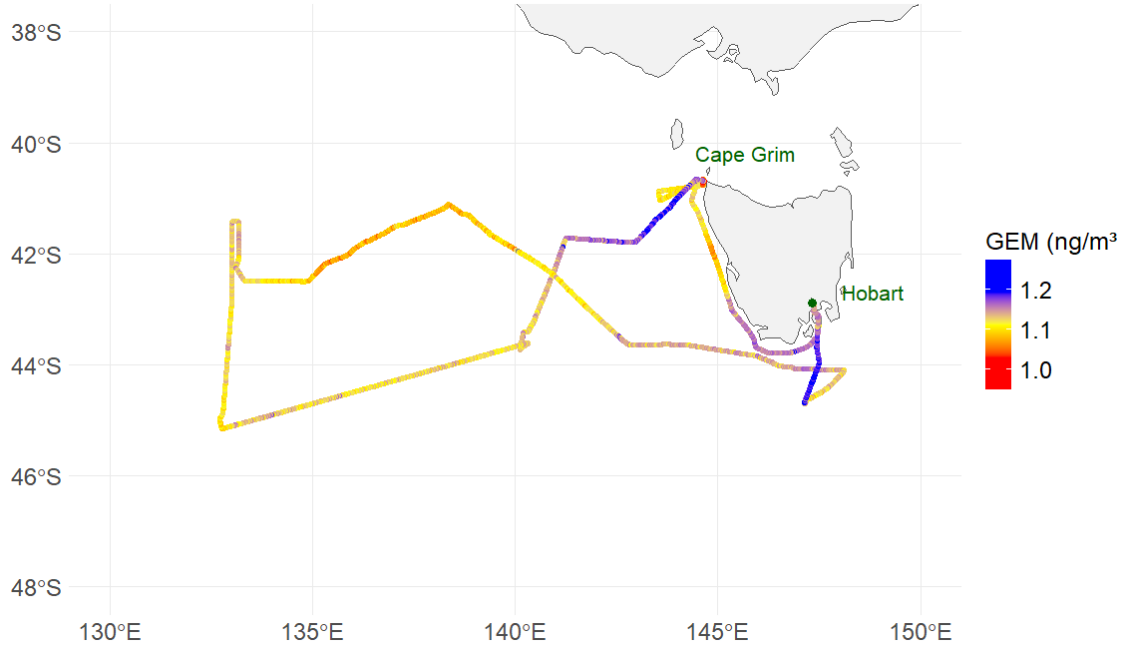
- 2013 – 2023 GEM data submitted for Minamata Effectiveness Evaluation
- Quantifying wet deposition for the Southern Ocean is important to understand whether it is a source or sink: NCON wet deposition sampler installed; sampling to beginning in January 2026
- *How representative is Cape Grim of concentrations over the Southern Ocean?*
- GEM CoastK intercomparison voyage (IN2025_V03) 28 April to 17 May 2025.



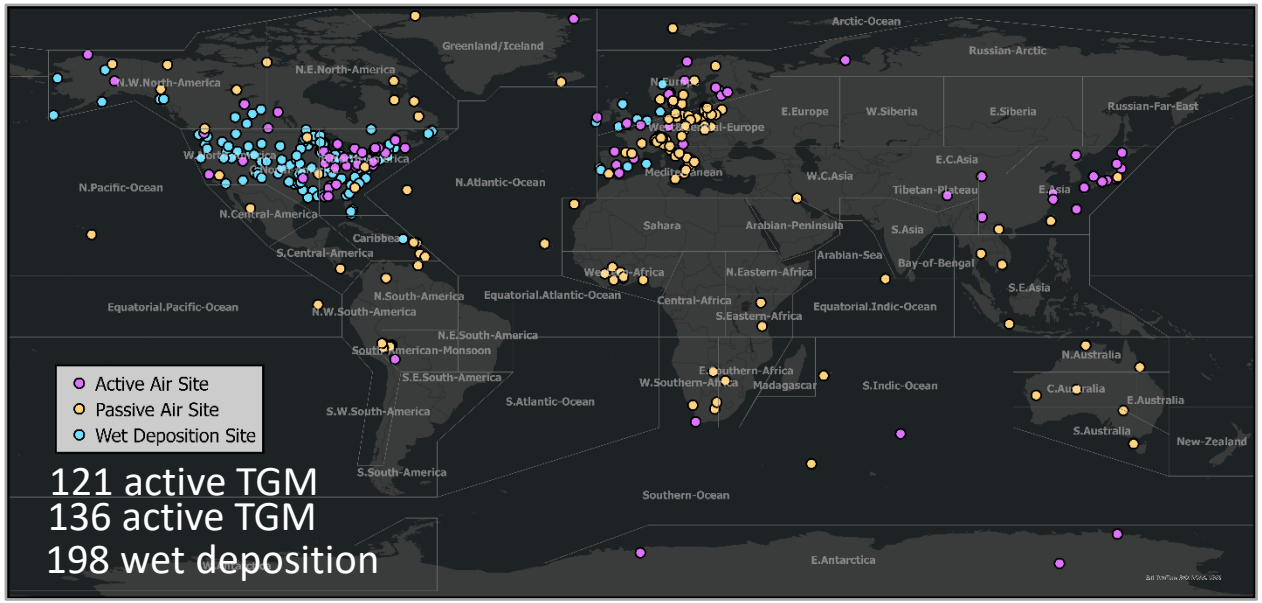
Coast K voyage intercomparison



- Duplicate analysers on RVI and at Cape Grim
- During baseline conditions agreement between RVI and Cape Grim of 2%
- Intercomparison of 4 analysers at Cape Grim after voyage with 2%



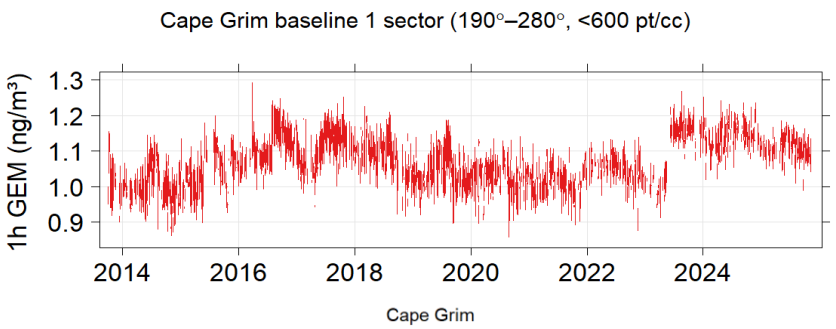
Air data submitted for Minamata EE

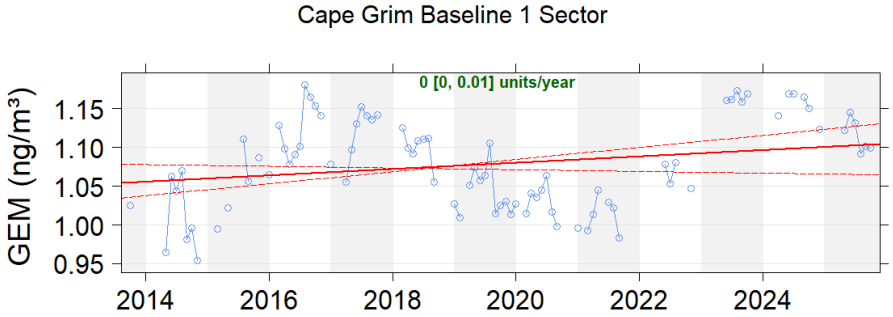


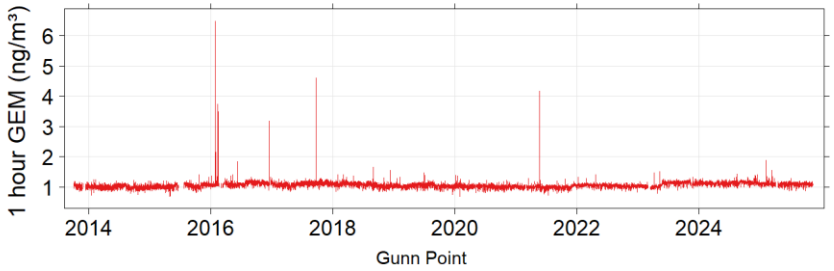
- Focus 2010 onwards
- Temporal variation
- Spatial variation
- Trend analysis
- Statistics
- Regional analysis
- Near/far source
- Model validation

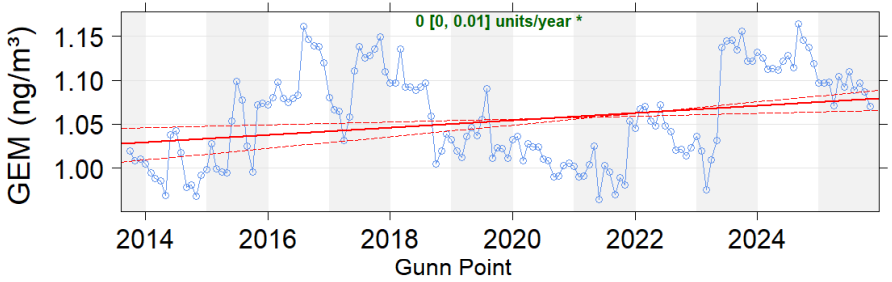
Slides from presentation of draft report by OESG Air Lead Sandy Steffen to COP6 in November www.youtube.com/watch?v=CtAefuETqCo

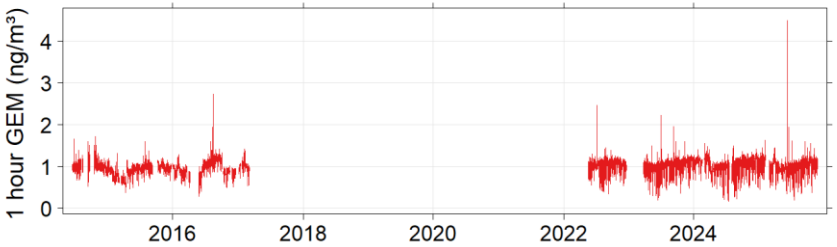
Trends at Australian sites not significant

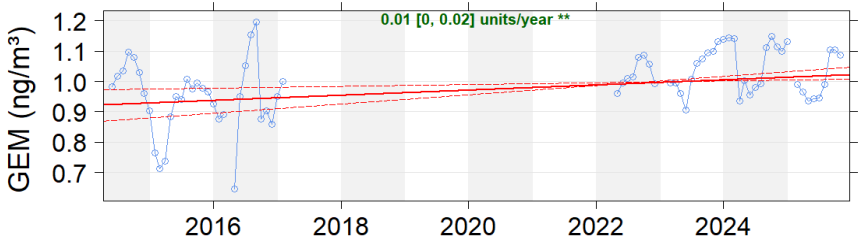








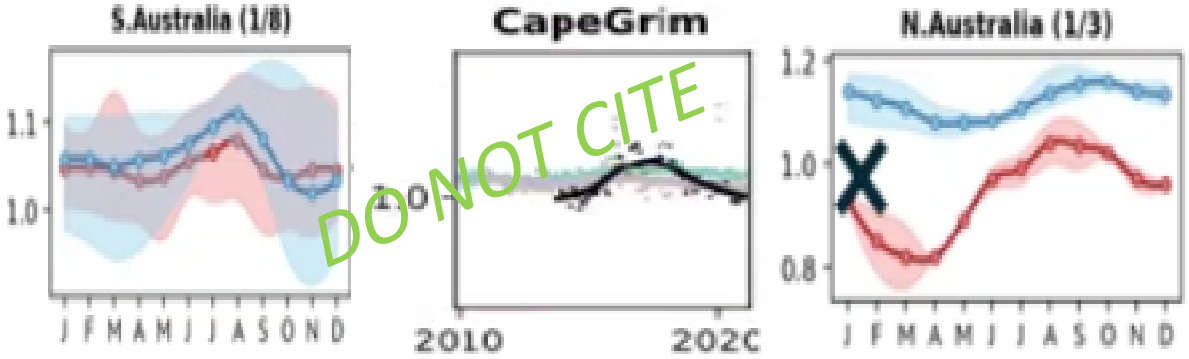




Preliminary MCHgMAP modelling

The Multi-Compartment Hg Modelling and Analysis Project (MCHgMAP) Dastoor et al 2025

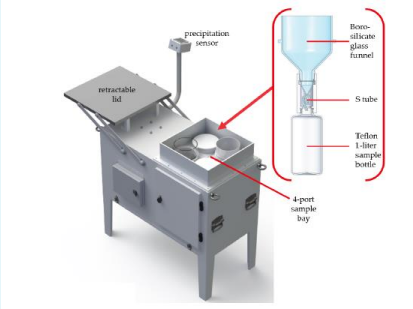
- 4 different emission scenarios to evaluate contributions to trends by natural sources, asgm sources and non asgm sources.
- 40 Northern Hemisphere and 5 Southern Hemisphere sites with sufficient data from 2010 to 2020 for trend analysis
- Modelling helps to understand how well we understand mercury cycling at Cape Grim and Gunn Point.



Going forward

- Understanding deposition and evasion of mercury in the Southern Ocean:
  - Begin wet deposition sampling at Cape Grim
  - New analyser able to be deployed on voyages to characterise air-sea exchange
- Understanding mercury cycling in Tropical Australia
  - More work to understand biomass burning emissions;
  - Changes in SOPs to reduce rainwater blanks
- Increased mercury capability – a new Tekran analyser for campaigns and voyages and a Nippon DMA to enable analysis of passive samplers and gold traps and possibly Cape Grim filter archive

Thank-you to all of our partners



Asia Pacific Mercury Monitoring Network

CHARLES DARWIN UNIVERSITY AUSTRALIA

Ministry of the Environment Government of Japan

Wet deposition sampling
- Darwin APMMN site
- Kennaook/Cape Grim WMO GAW site

Long term monitoring: Minamata Convention Effectiveness Evaluation

Mercury cycling savanna fires & monsoons

Mercury cycling Southern Ocean

Baseline monitoring of GEM at Tier 1 sites
- NT BAPS & CDU
- CG BAPS
- RV Investigator campaigns

Australian Government Bureau of Meteorology

ANSTO

MerPAS Global passive sampling network

Government of Canada