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Long-term monitoring of atmospheric mercury and its source contributions at Kennaook/Cape Grim (KCG), Australia

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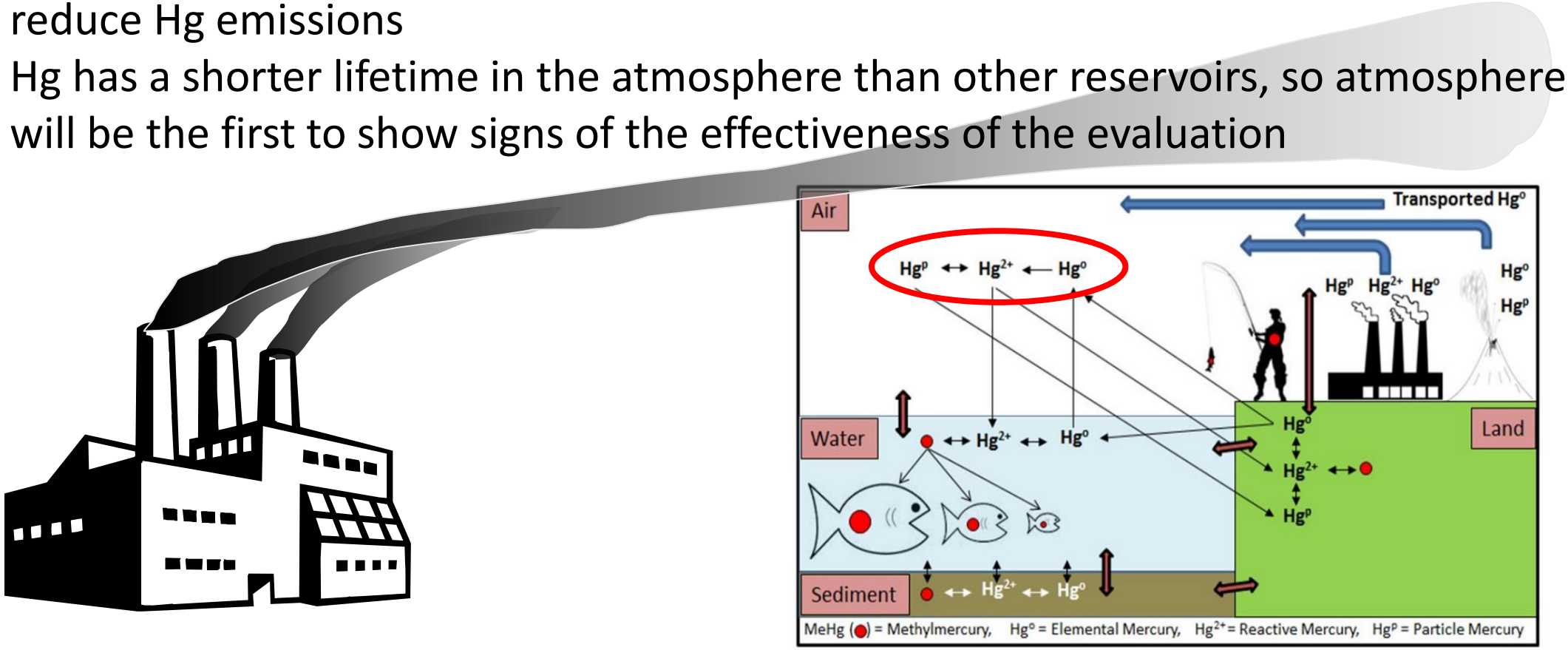
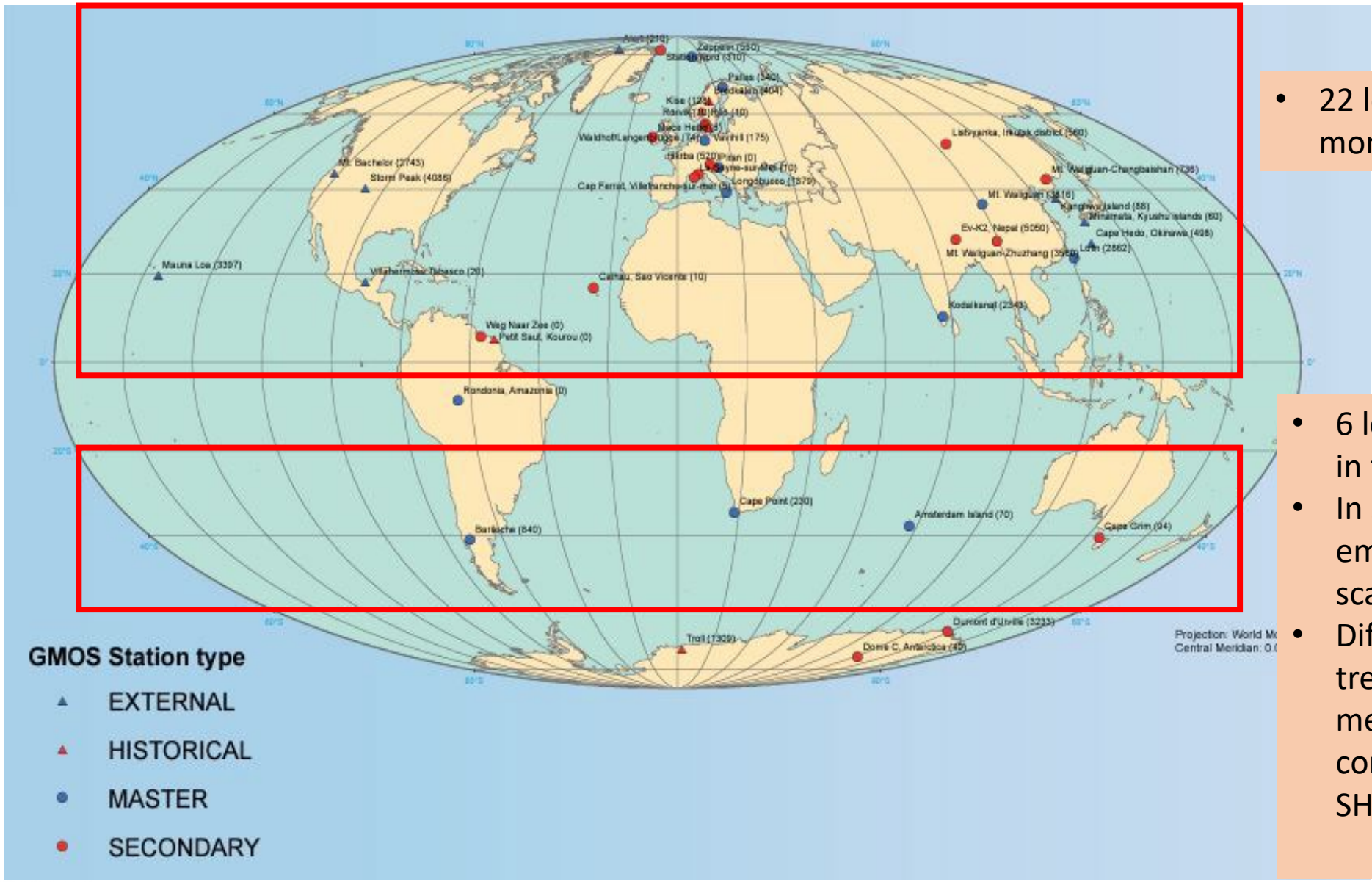
Why atmospheric mercury (Hg^0)

- Atmosphere is the dominant pathway for re-distribution of Hg from emission source to the ecosystem
- Many countries have ratified the Minamata Convention, and have made efforts to reduce Hg emissions
- Hg has a shorter lifetime in the atmosphere than other reservoirs, so atmosphere will be the first to show signs of the effectiveness of the evaluation



Motivation



- 22 long-term (>10 years) monitoring stations in the NH

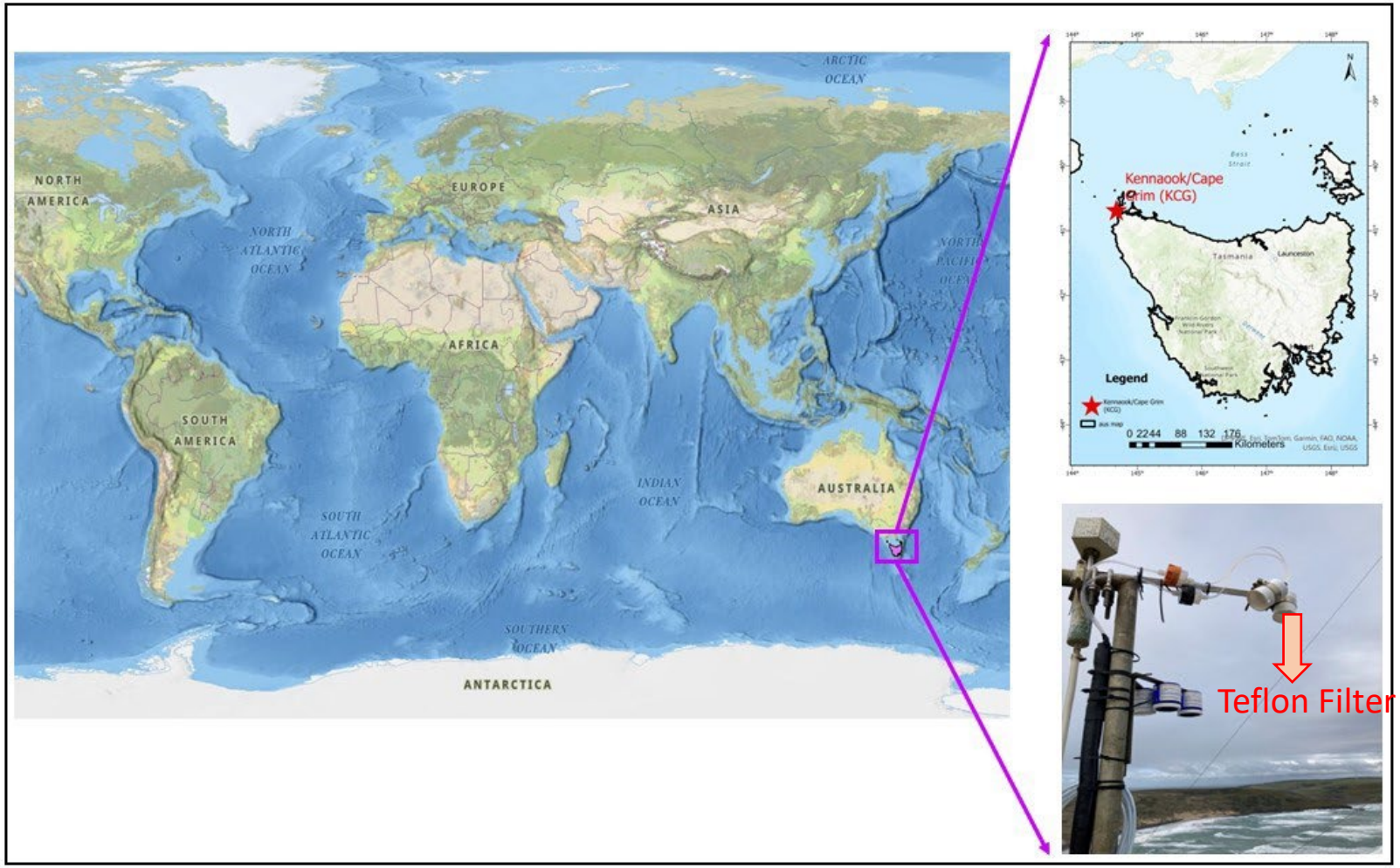
- 6 long-term monitoring stations in the SH *(UNEP, 2019*)
- In SH, large variability of emission sources from artisanal scale gold mining (ASGM)
- Difficult to capture ASGM trends from existing measurement network but they contribute to the trends in the SH background

Long-term monitoring of Hg sites in Australia

Gunn Point: Hg monitoring started in **2014**

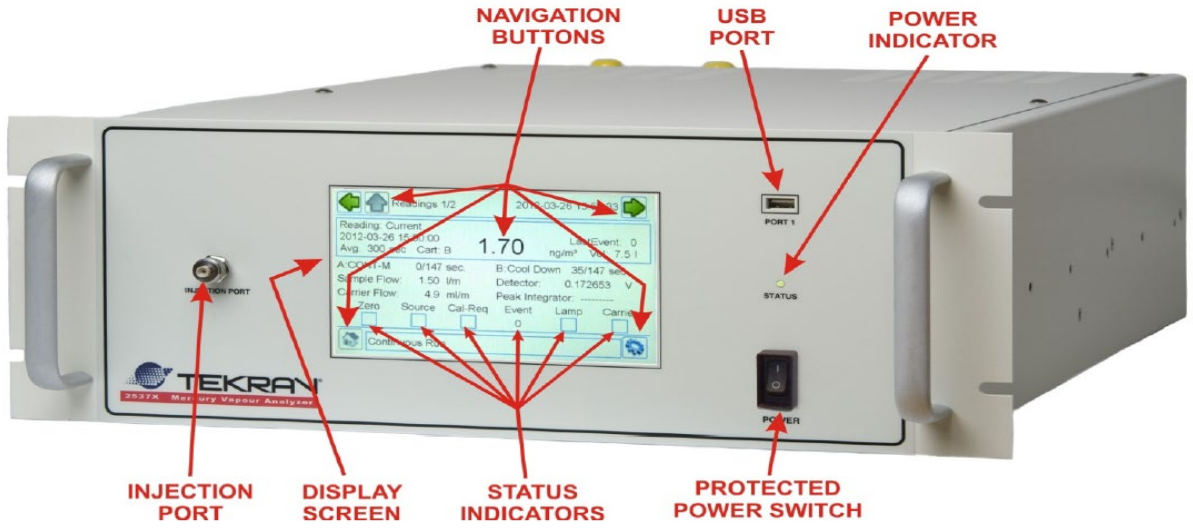
Kennaook/Cape Grim (KCG): Hg monitoring began in **2011**

Why Kennaook/Cape Grim?



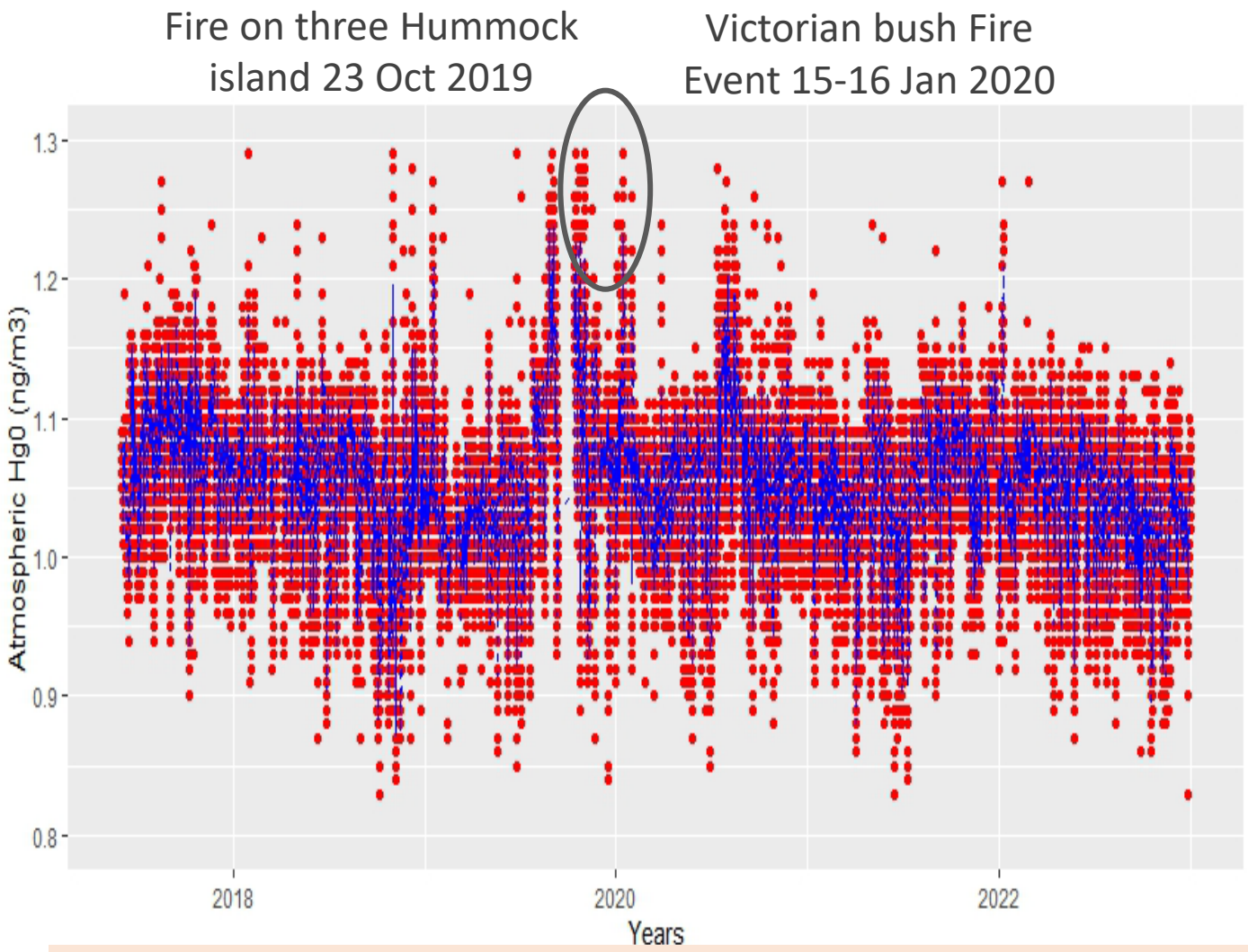
- Ideal site for measuring atmospheric composition of the background Southern Hemisphere
- Less impacted by anthropogenic influence
- Proximity to the Southern Ocean

Analytical Instrument

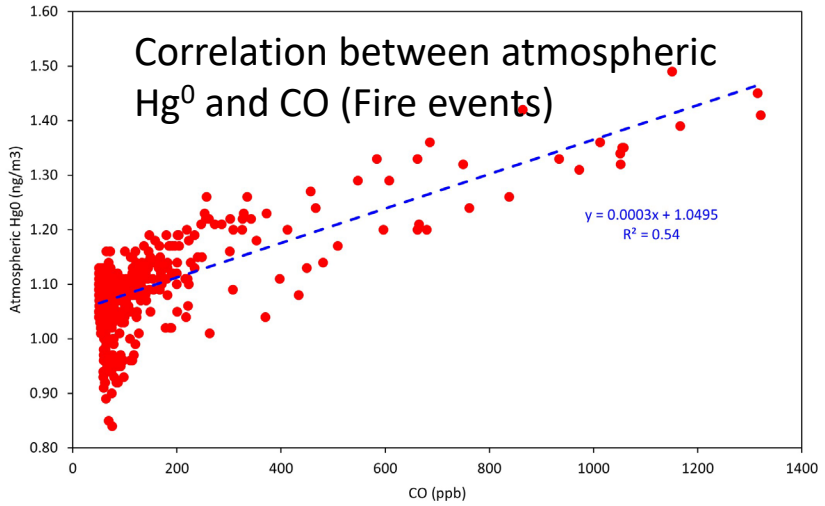


- Data retrieved from 2 June 2017- 31 Dec 2022
- Sampling flow rate was 1 L min^{-1} with a sampling interval of 5 min.
- The 5 min atmospheric Hg^0 data was averaged hourly
- Auto-calibrated every 24 hours
- QA/QC based on the GMOS protocol (Sprovieri et al., 2016)

Atmospheric Hg^0 at KCG similar to other SH sites

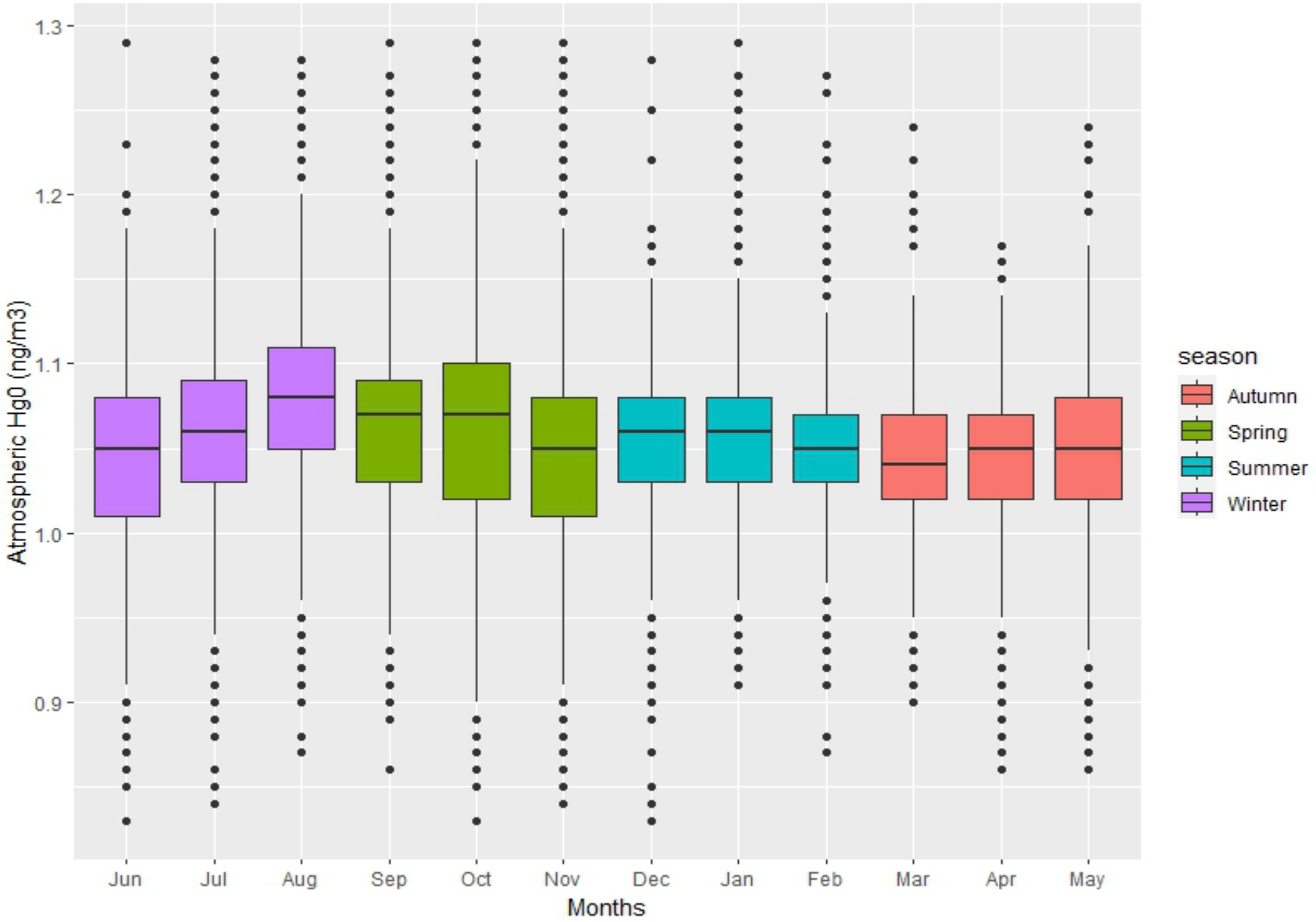


Red dot indicate the hourly atmospheric Hg^0, and blue line represents the moving average of Hg^0 at KCG

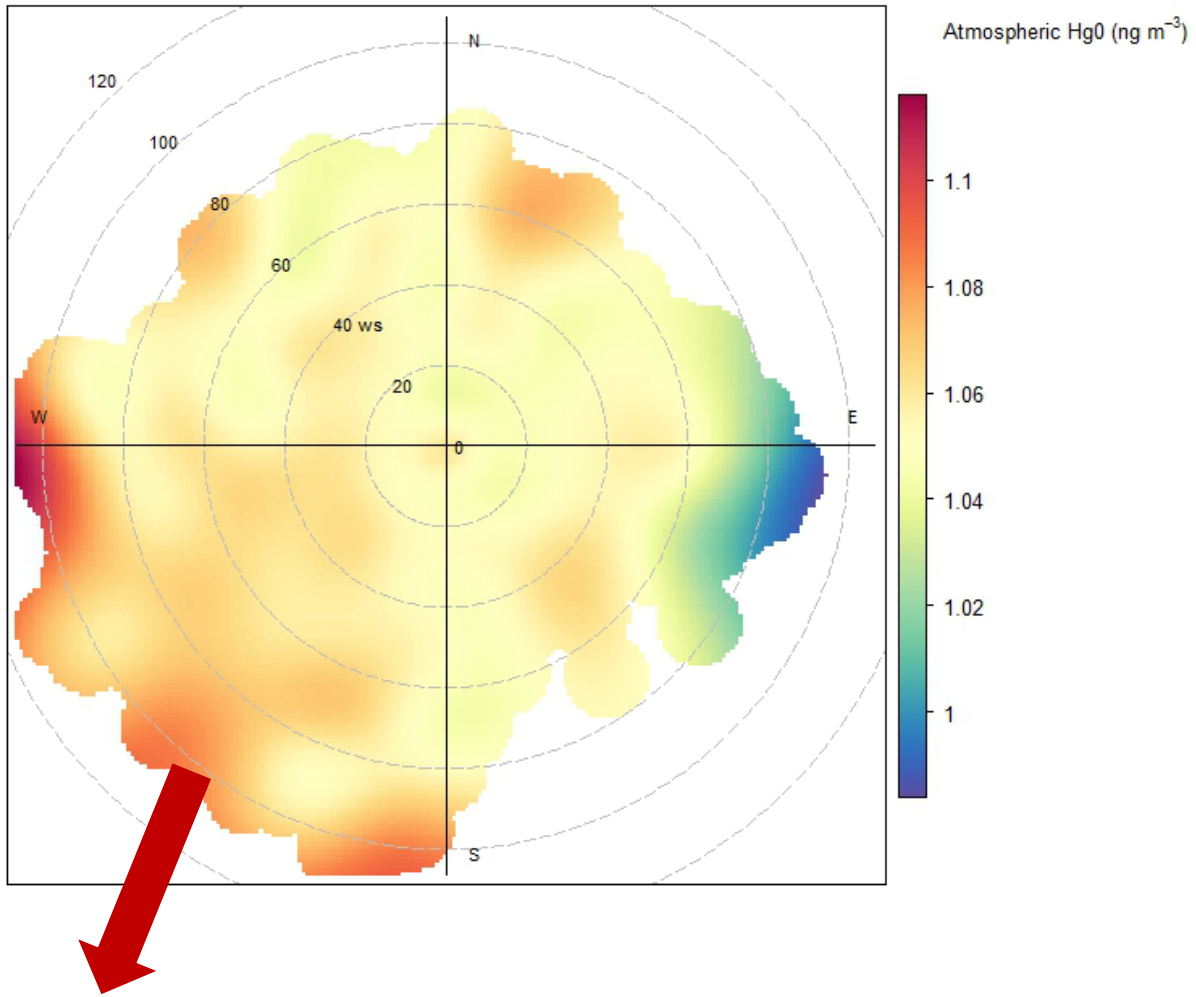


- Mean Hg^0 = 1.05 ± 0.04 ng m^{-3}
- Range : 0.83 - 1.29 ng m^{-3}
- Mean Hg^0 is lower compared to NH but in the range of SH mid-latitude sites

No seasonality



Southern Ocean the largest contributing Source?



Southern Ocean Influence

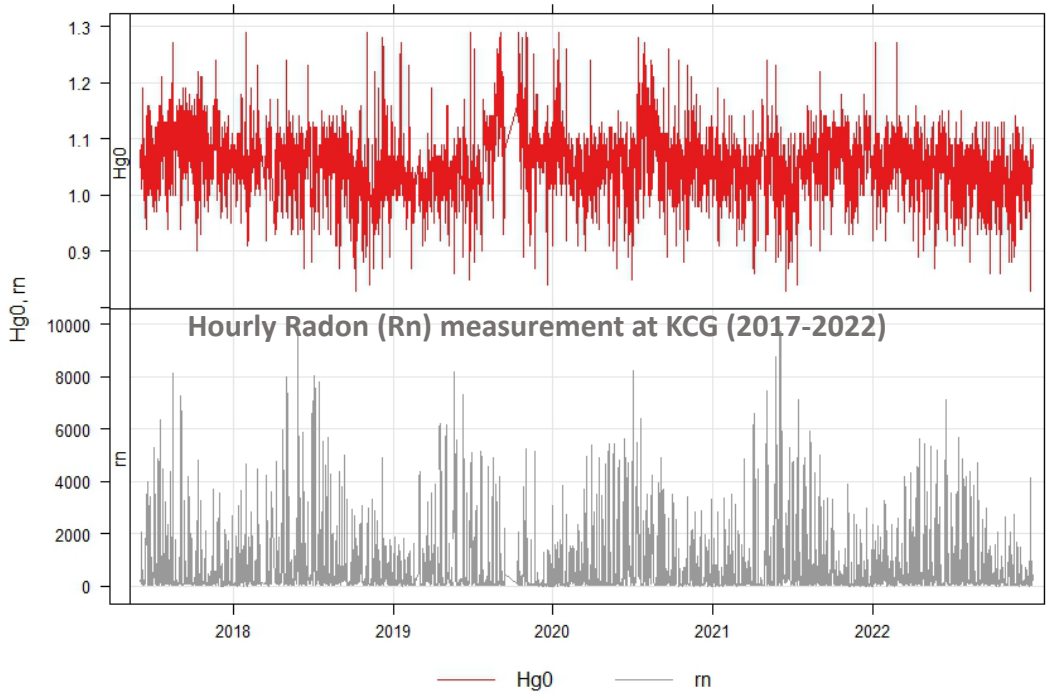
- Bivariate Polar analysis shows the relationship between atmospheric Hg^0 with wind speed and wind direction
- Airmasses from the southwest bring higher atmospheric Hg^0 concentration at KCG, attributed to the Southern Ocean

Baseline characterization of atmospheric Hg^0

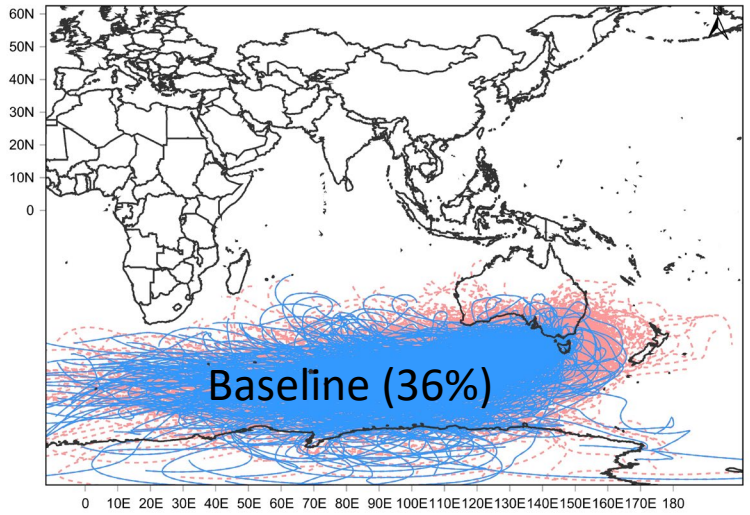
- Radon (Rn) is a naturally occurring radioactive trace element emitted by land but not by the ocean
- Terrestrial air masses associated with high Rn
- Ocean air masses associated with very low Rn

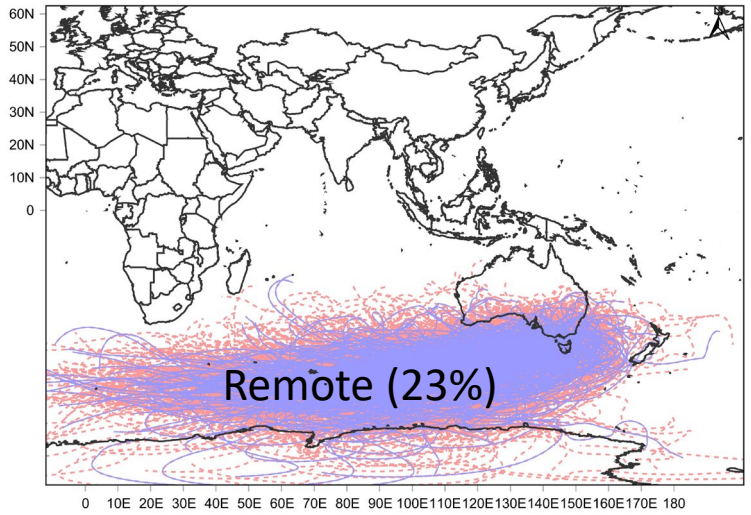
Criteria for air mass origin

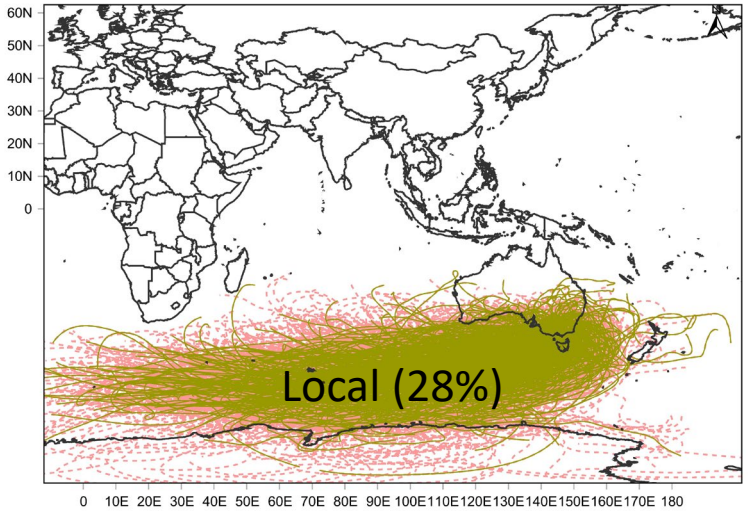
- Rn between 30-90 mBq m^{-3} (Oceanic baseline)
- Rn between 90-250 mBq m^{-3} (Remote terrestrial influence)
- Rn between 250-1500 mBq m^{-3} (Local Influence)
- Rn > 1500 mBq m^{-3} (Mainland terrestrial Influence)

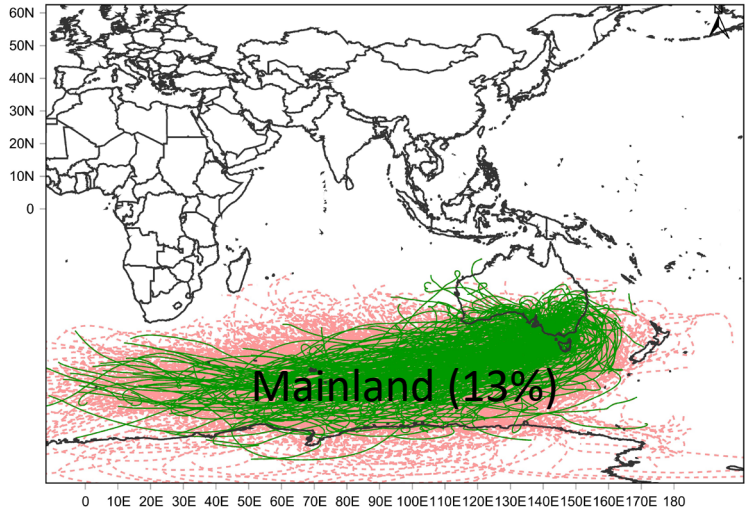


Implication of backward trajectory



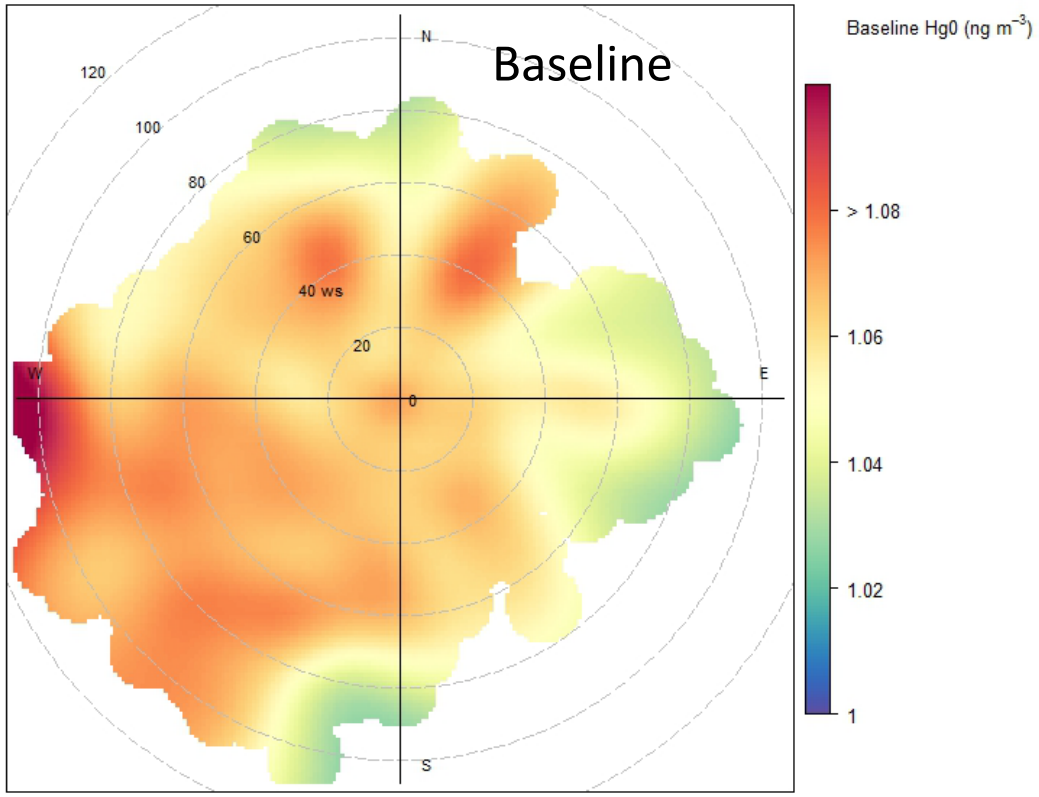




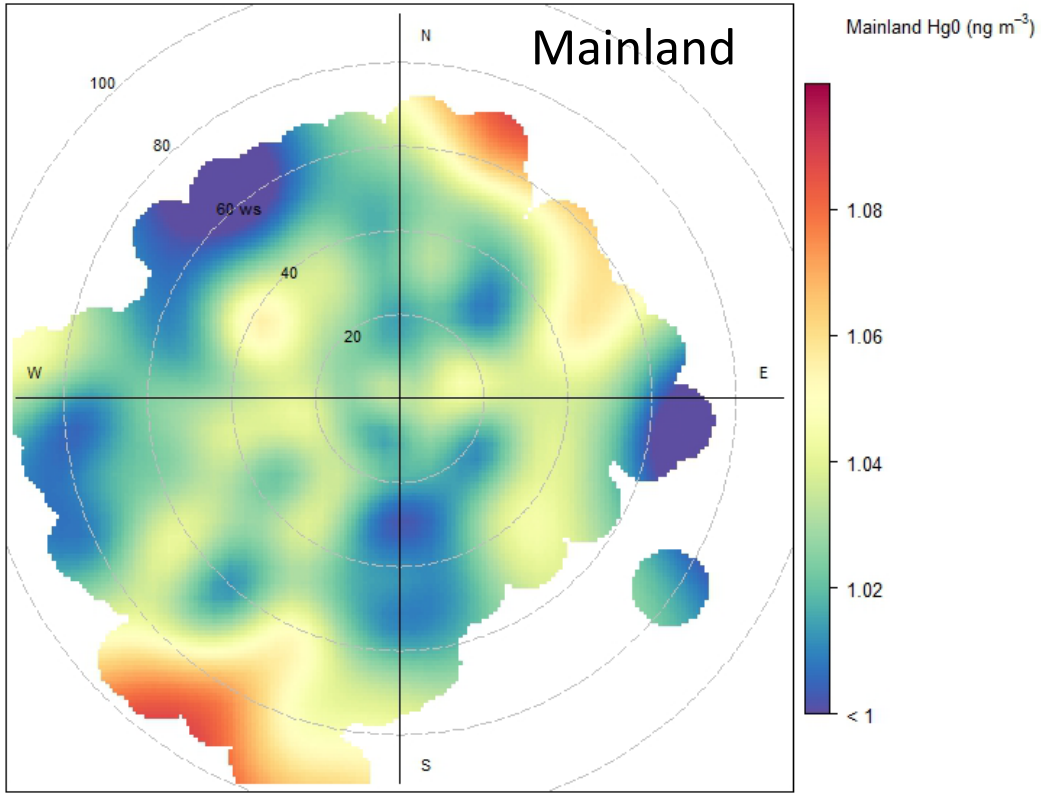


- Baseline: All the air masses originated from southern ocean with a few from Antarctica
- Remote and Local had mixed ocean and terrestrial influence
- Mainland: air masses spend more time over Australia

Comparison of baseline and mainland influence

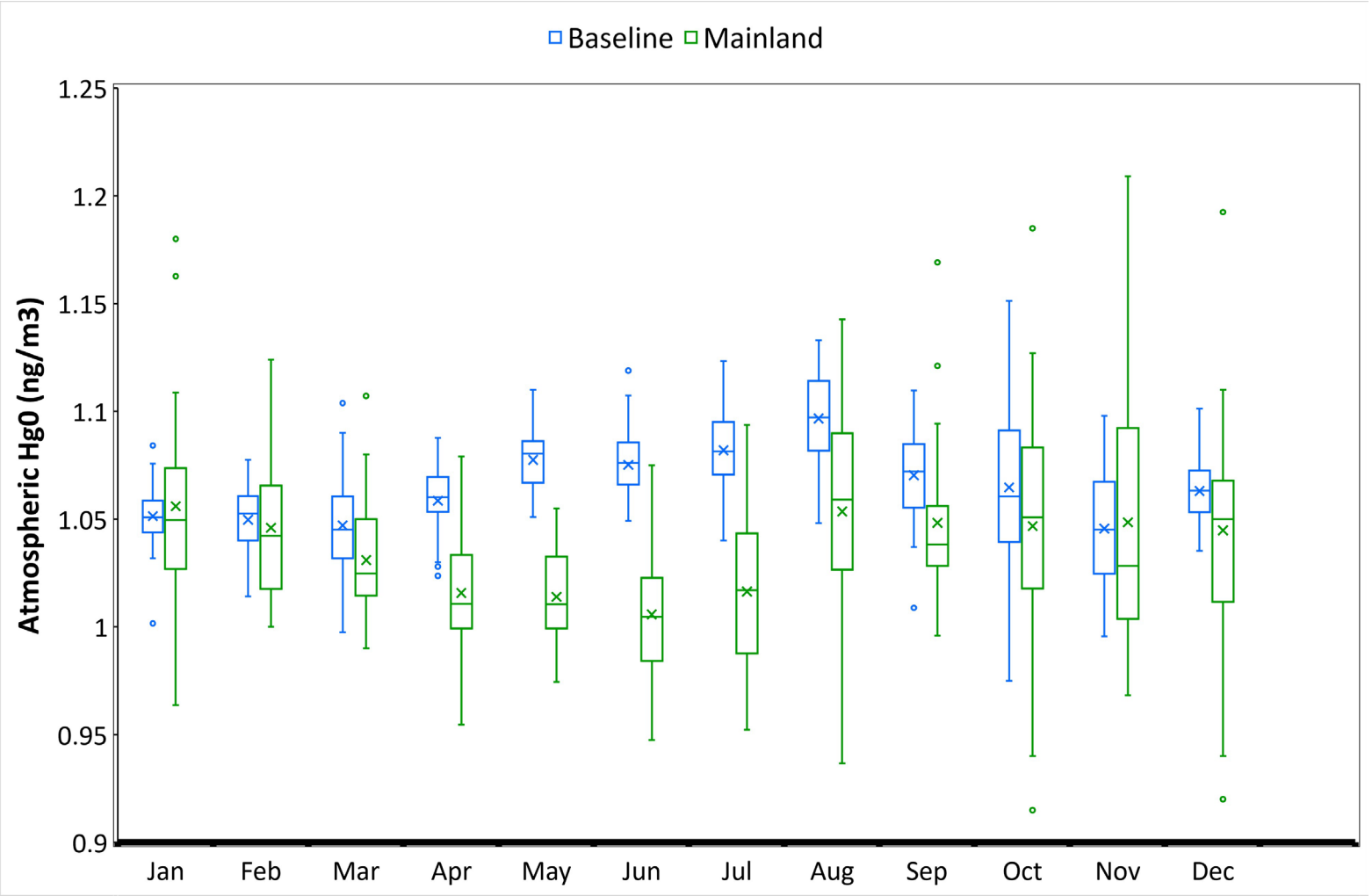


Air masses from SW direction influence atmospheric Hg^0 concentration in baseline



Air masses originated from NE (land) and SW (ocean) attributed atmospheric Hg^0 to mainland sector

Seasonality based on Rn criteria



- We observed opposite Hg^0 seasonality between baseline and mainland air masses.
- Baseline Hg^0 is higher in winter (JJA), especially in August (1.09 ng m^{-3})
- Mainland Hg^0 is higher in summer (DJF), reaching maximum in Nov (1.06 ng^{-3})

Take Home Message

- Hg^0 monitored at KCG will provide a baseline of atmospheric Hg^0 for effectiveness evaluation of Minamata Convention.
- Kennaook/Cape Grim (KCG) Hg^0 concentrations from recent measurements are consistent with reported background values at other SH mid-latitude sites
- Preliminary analysis using multiple methods suggests the Southern Ocean is a source of Hg^0 to KCG, with the highest ocean source Hg^0 in winter
- We observed inversed seasonality of the different air masses (i.e., ocean and land air masses)
- Future work will focus on identifying the drivers of the differences in Hg^0 between oceanic and terrestrial air masses.

Collaborators

CSIRO: Melita Keywood, Rob Gillett

ANSTO: Scott Chamber, Alastair Williams

Bureau of Meteorology: Sam Cleland, Nigel Somerville, Jeremy Ward, Cindy Spinks, Stuart Baly, Sarah Prior