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Kerneels Jaars

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Statistically evaluating the performance of mercury passive air sampler at a regional background site in South Africa

Mercury Emissions and Monitoring in South Africa

- **Significant Emissions:** South Africa is a top **global mercury emitter**, primarily from **coal-fired power plants**, posing **serious health and environmental risks**

- **Global Treaty Commitment:** Signed the **Minamata Convention** in 2013 to reduce mercury emissions; monitoring atmospheric mercury is crucial for compliance and health.

- **Monitoring Gaps:** Existing global networks have **limited coverage in Africa**, highlighting the need for expanded atmospheric mercury measurements

- **Solution:** Mercury Passive Air Samplers (***Mer*PAS®**) offer a **cost-effective** and scalable method to enhance monitoring in Africa, despite some limitations

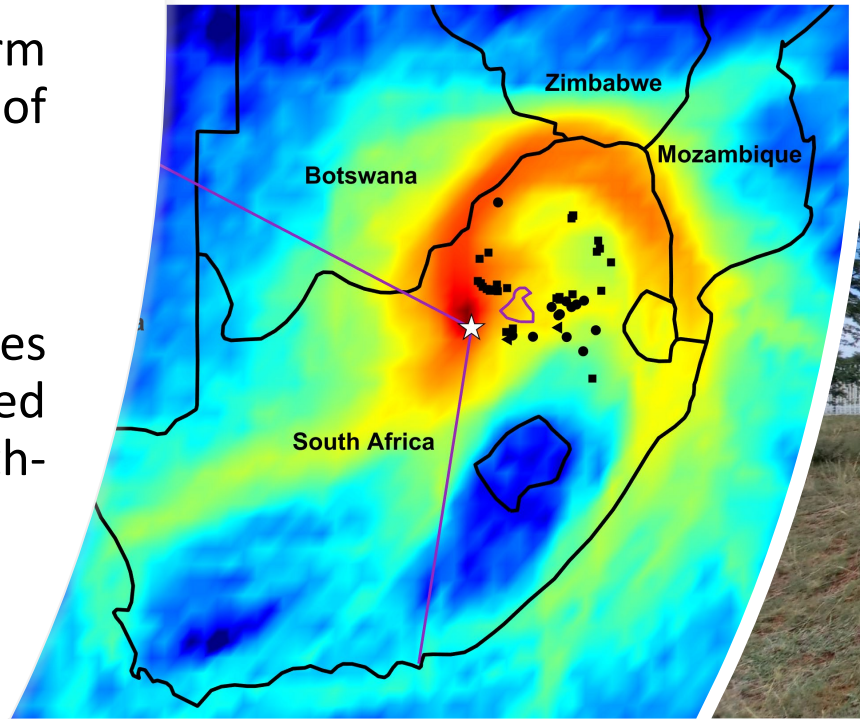
- **Research Focus:** This study evaluated *Mer*PAS® performance in South Africa through the **South African Mercury Network** (SAMNet)

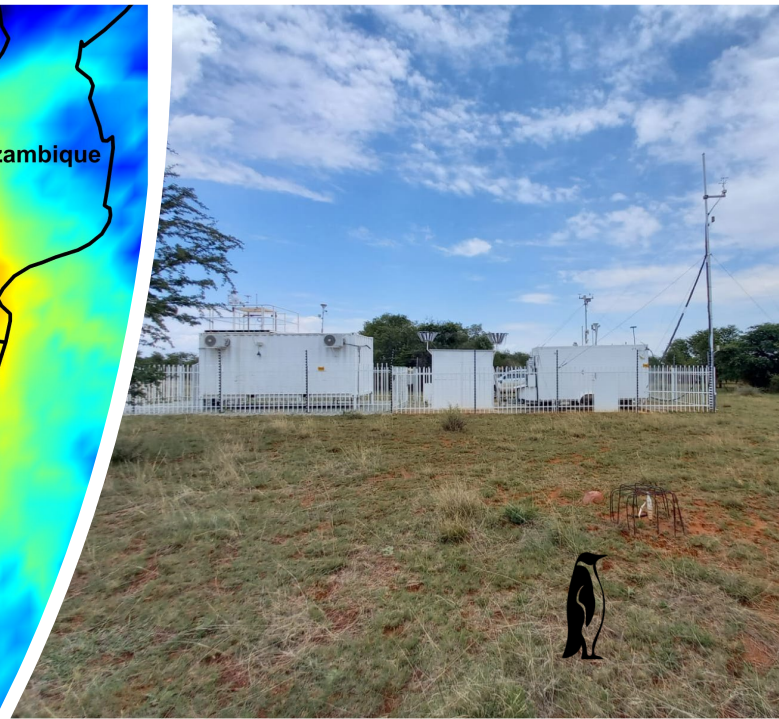
Measurement site

- Measurements were conducted at the Welgegund Atmospheric Measurement Station from June 2021 to September 2022

- The site is located on a commercial farm approximately 100 km southwest of Johannesburg

- Although no large pollution point sources are near Welgegund, the site is impacted by the major source regions in the north-eastern South African interior

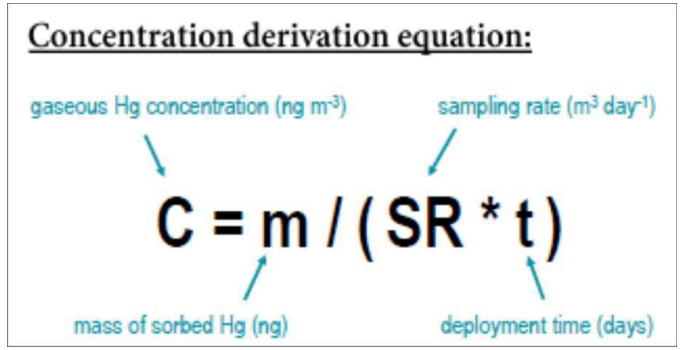




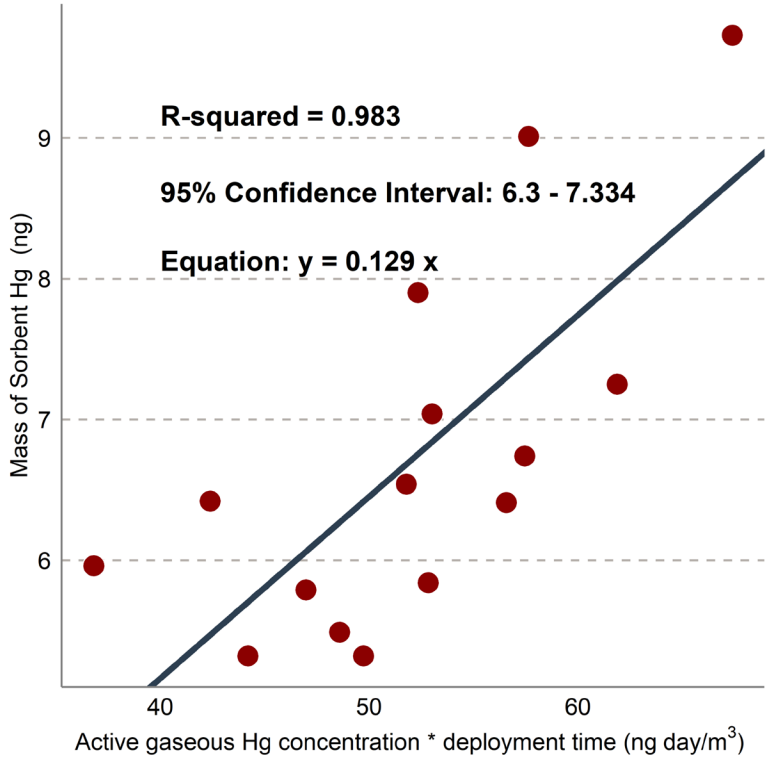
Data quality and calculations

Hg concentrations measured with *Mer*PAS® were calculated from the blank-corrected Hg mass

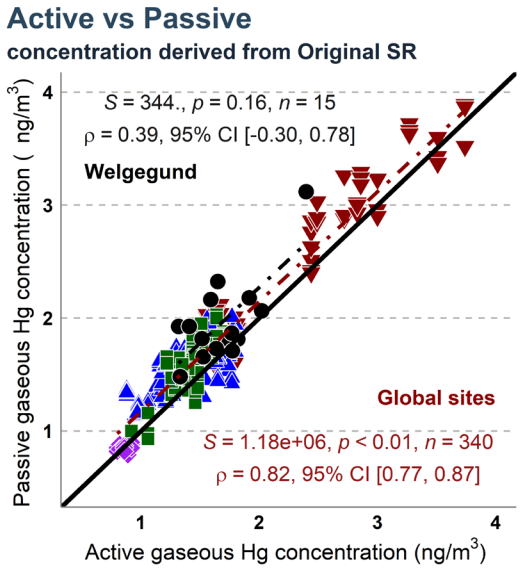
- ***original SR*** (OSR) provided by Tekran;
- ***adjusted original SR*** (AOSR) where the sampling rate provided by Tekran was adjusted according to mean temperature (T_{exp}) and wind speed (WS_{exp})
- ***recalibrated SR***s (RSR) determined from the slope of a plot of the Hg *m* determined with the *Mer*PAS® against the monthly average GEM concentration measured with an active sampler multiplied with the deployment time
- ***adjusted recalibrated SR***

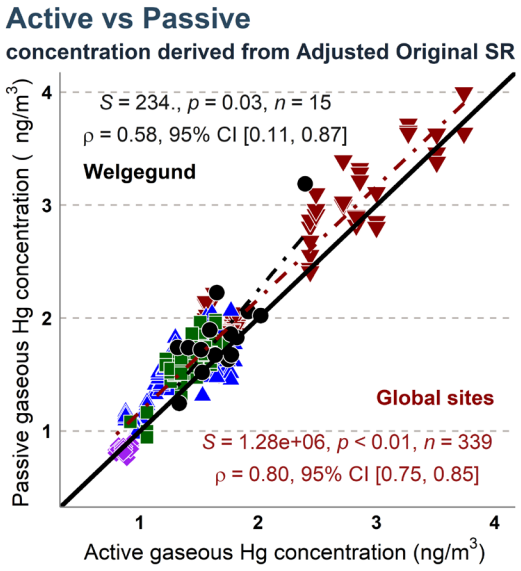


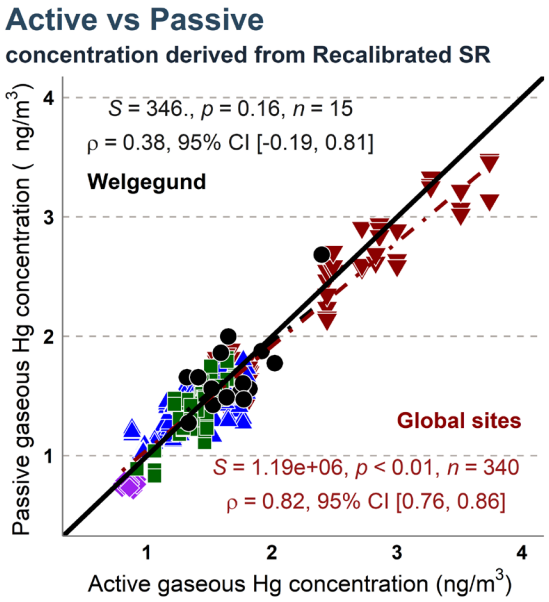
$$SR_{adj} = SR + \left(T_{exp} - 9.89°\text{C}\right) \times 0.0009 \frac{m^3}{day\ °\text{C}} + \left(WS_{exp} - 3.41 \frac{m}{s}\right) \times 0.003 \frac{m^2\ s}{day}$$

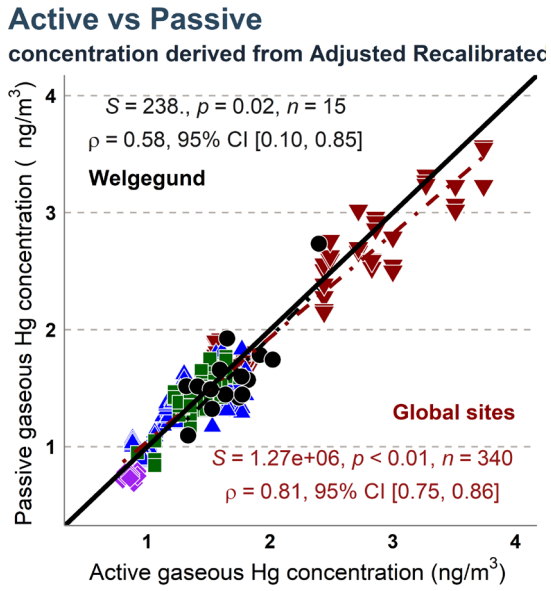


Comparative Analysis of *In Situ* Measurements and PAS-Derived Hg Concentrations









Urban sites; Rural sites; High-altitude sites; Northern/Arctic sites; Welgegund

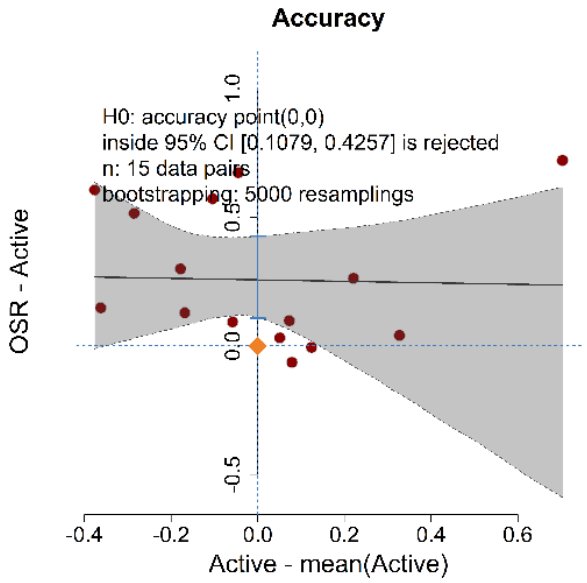
Mclagan et al. 2018

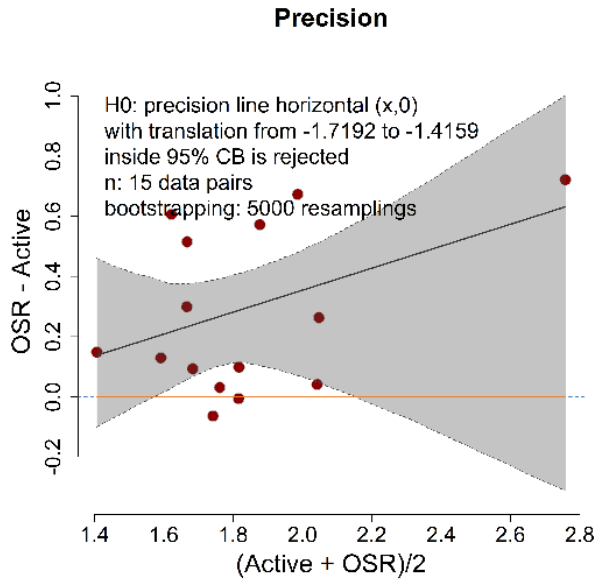
- For **OSR and AOSR**, the data points are positioned **above the 1:1** line, suggesting that Hg concentrations tend to be **overestimated**
- For **RSR and ARSR**, the data points are **below the 1:1 line**, indicating **underestimation**

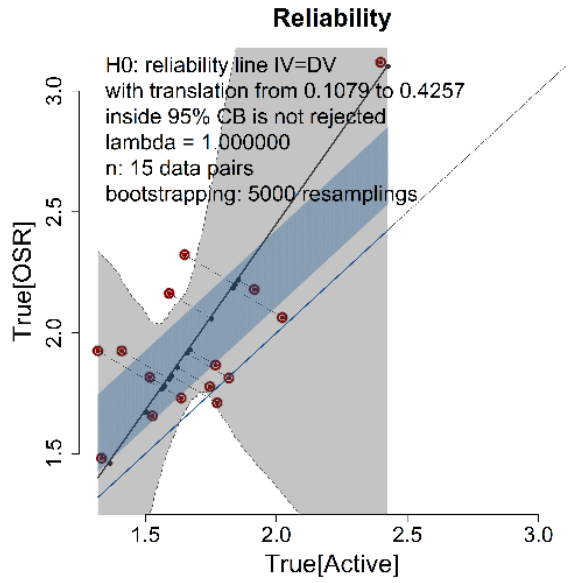
Bland-Altman Analysis of *In Situ* Measurements and PAS-Derived Hg Concentrations

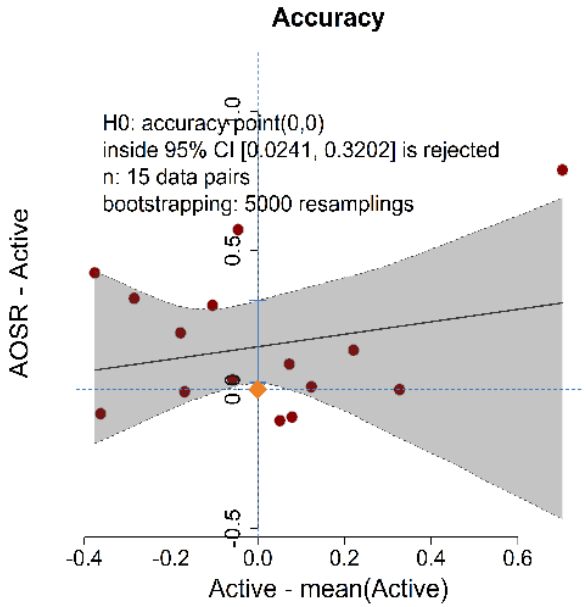
- Correlation analysis identifies patterns but not agreement
- Bland-Altman detects systematic differences between methods
- Three-step approach (eirasagree package in R, by Silveira et al. 2024):
  - Step 1: Equivalence of structural means (accuracy)
  - Step 2: Equivalence of structural variances (precision)
  - Step 3: Agreement with structural bisector line (same subject)
- Full equivalence assumed when no tests rejected equivalence

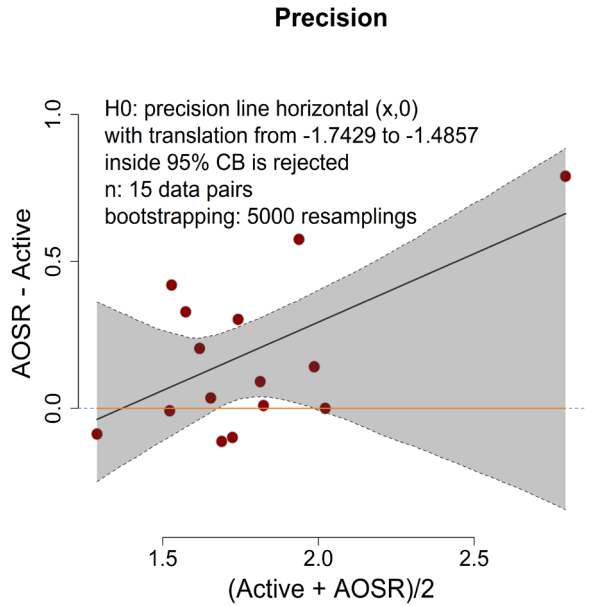
Active *In Situ* vs *Mer*PAS® OSR and AOSR: Comparative Analysis of Accuracy, Precision, and Reliability

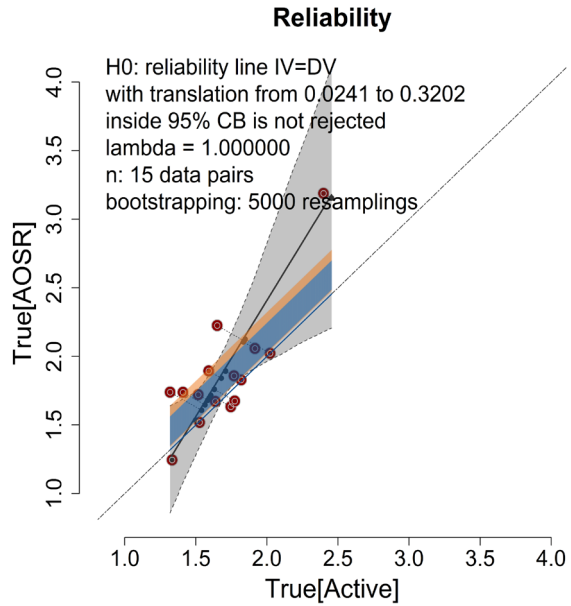






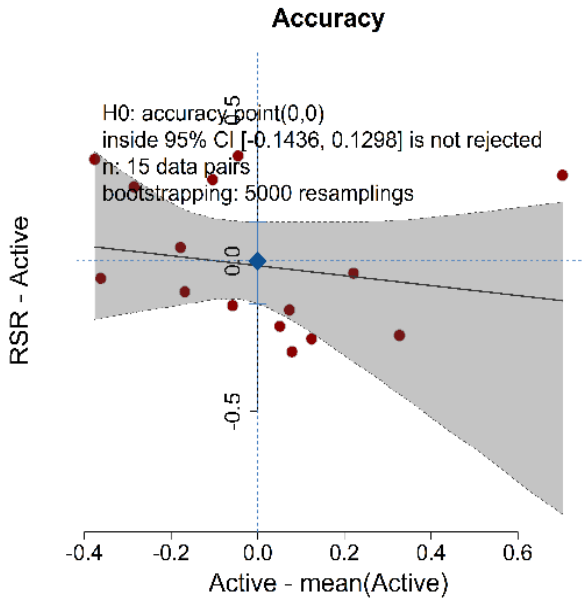


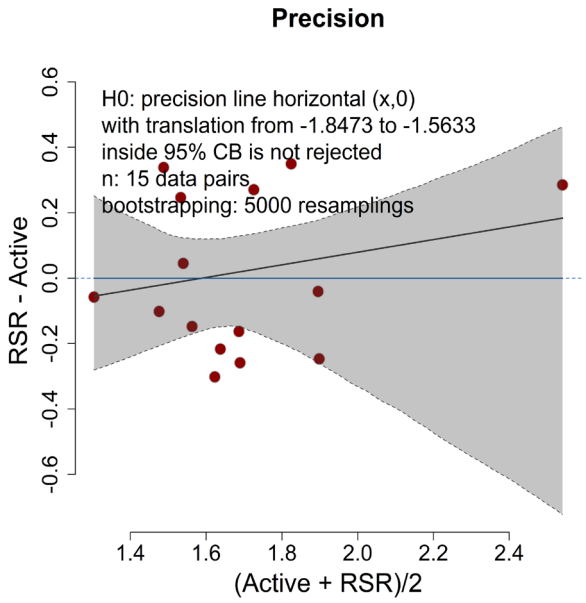


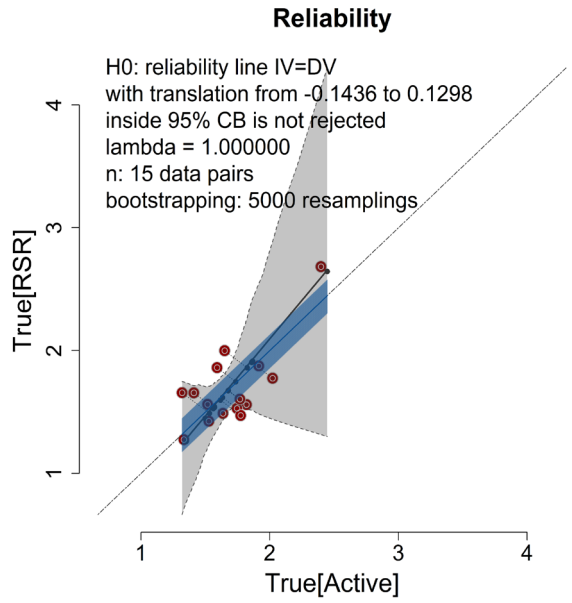


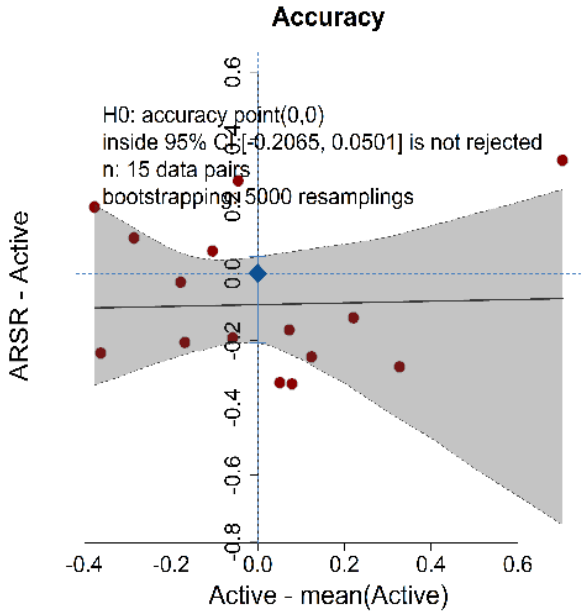
- ❑ Accuracy: positive biases
- ❑ Precision: Not comparable
- ❑ Reliability: Acceptable
- ❑ Two tests showed rejection of equivalence

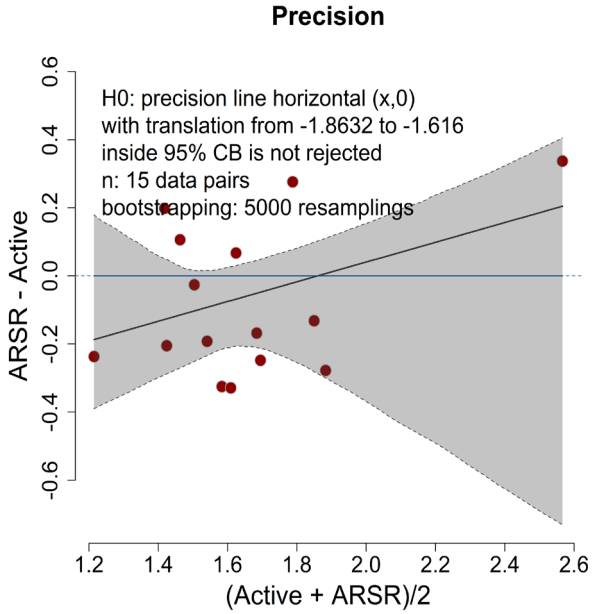
Active *In Situ* vs *Mer*PAS® RSR and ARSR: Comparative Analysis of Accuracy, Precision, and Reliability

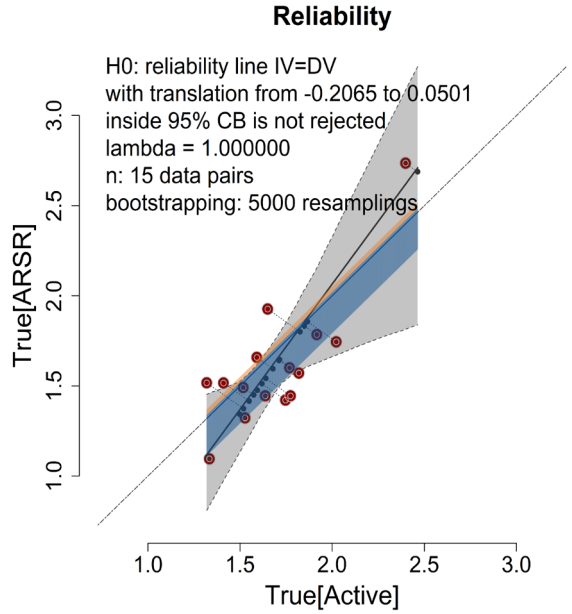












- ❑ Accuracy: no statistically significant positive biases
- ❑ Precision: statistically equivalent
- ❑ Reliability: Acceptable
- ❑ Three tests showed non-rejection of equivalence

Conclusions

- Study Overview:
  - Compared Hg concentrations: *Mer*PAS® vs. *in situ*.
  - Four *Mer*PAS® sampling rates: OSR, AOSR, RSR, ARSR.
- Key Findings:
  - OSR/AOSR: Higher Hg than *in situ*.
  - RSR/ARSR: Closer to *in situ*.
- Recommendations:
  - Use AOSR for southern Africa.
  - More research on seasonal variations needed

Acknowledgements

science & innovation
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REPUBLIC OF SOUTH AFRICA

SAMNet
South African
Mercury Network

BIOGRIP
Biogeochemistry Research Infrastructure Platform

South African
Weather Service

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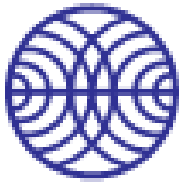

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