Low-cost Methods for Measurement of $PM_{2.5}$ Composition at African Cities by Exploiting Existing Beta Attenuation Monitors

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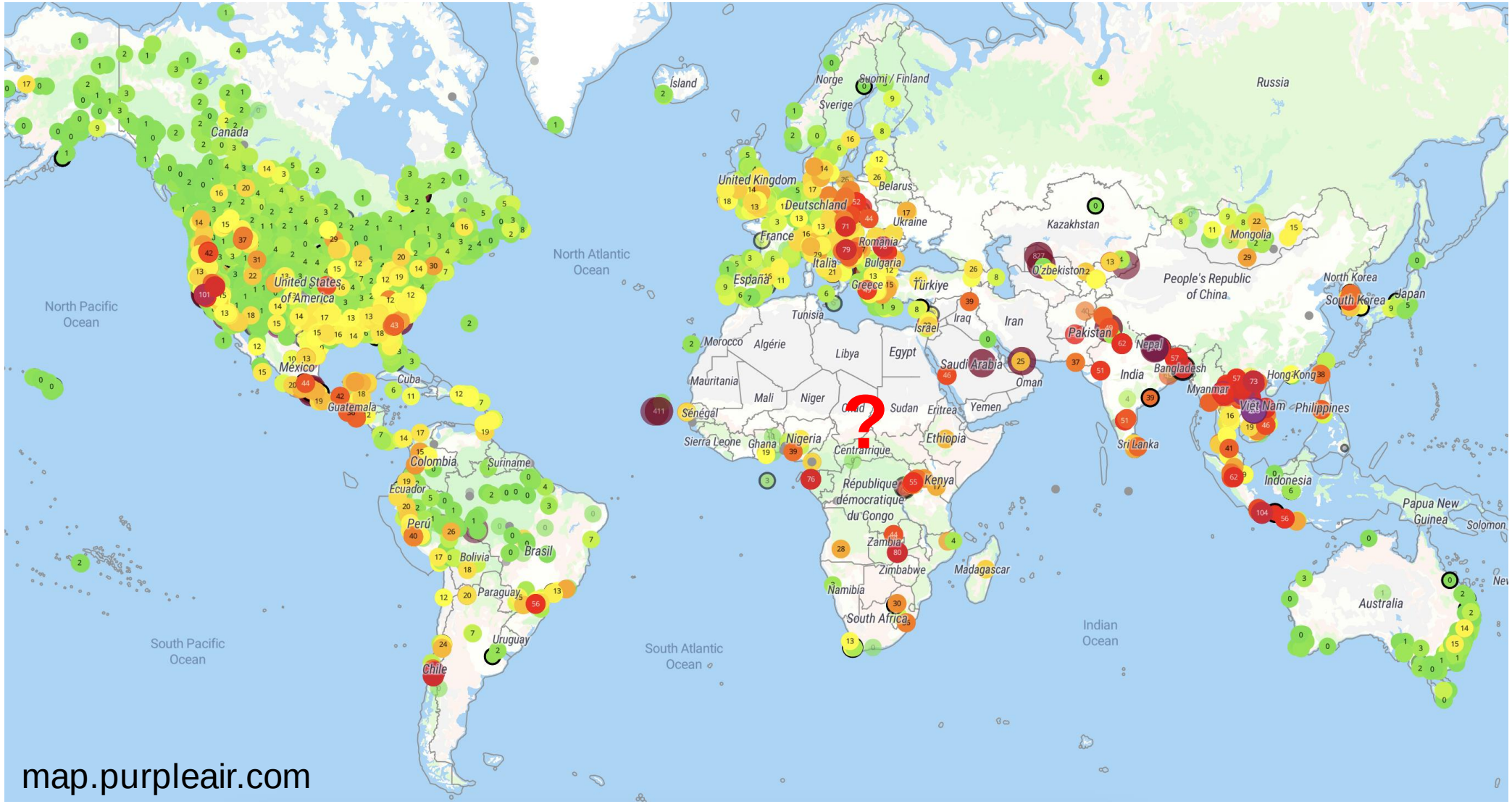
Disparity in ground-based monitors



map.purpleair.com

We are measuring black carbon

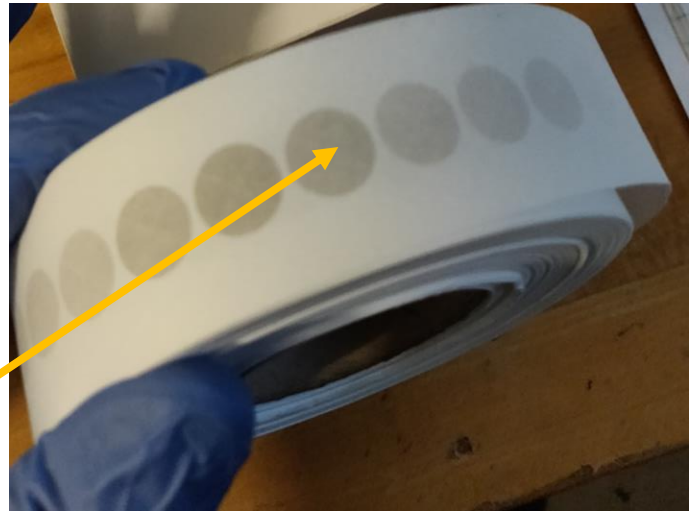
- Subset of fine particulate matter
- Formed by incomplete combustion of fossil fuels, biofuel, or biomass
- Tracer for combustion sources.

(EPA, 2011)

Our approach uses BAM tapes from US embassies

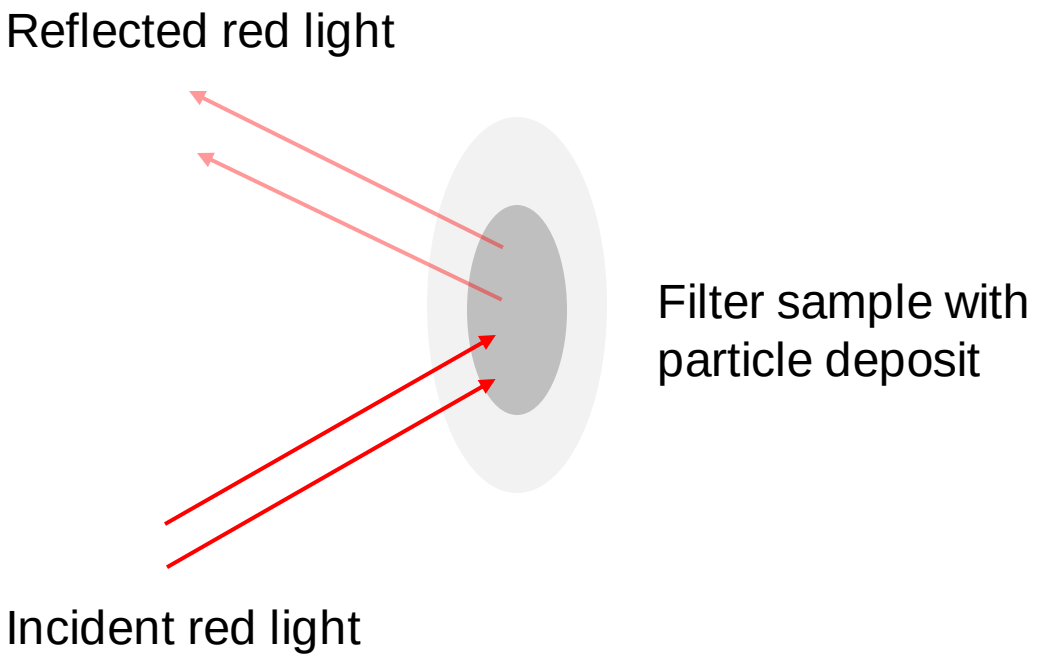
BAMs

Hourly spots



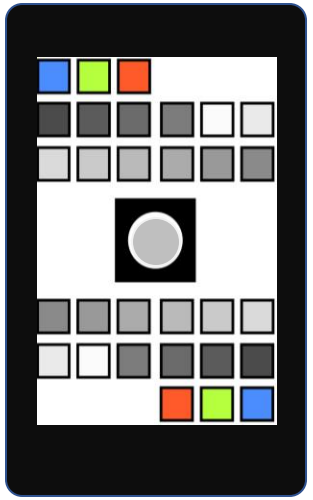
BAM: Beta Attenuation Monitor

BC loading is correlated to intensity of reflected red light



Workflow

Paper Available!



Sampled particulates on filters

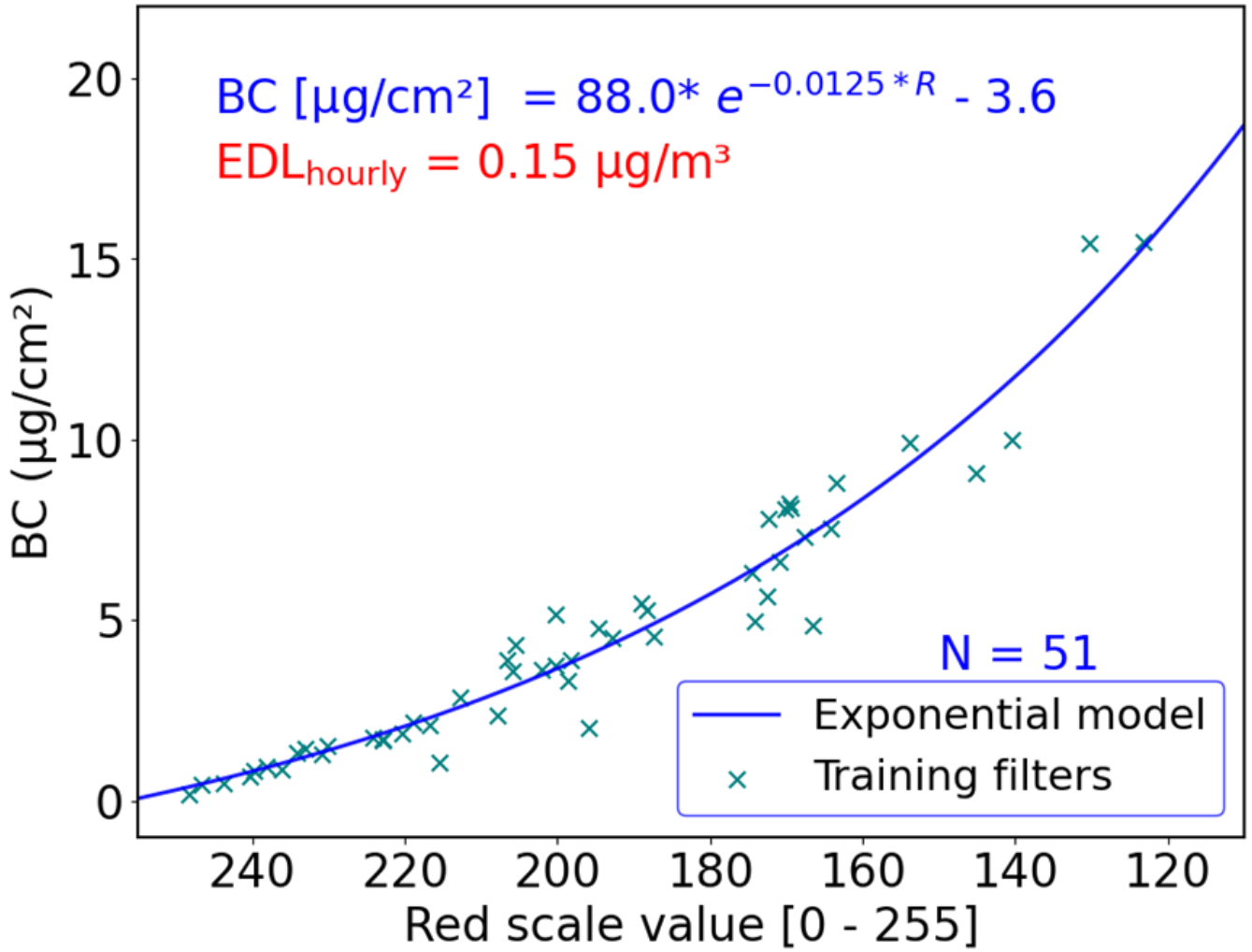
Images captured (filter + reference card)

Image processing to estimate optical BC

Correlated with references (BC)

Step 1 **Step 2** **Step 3** **Step 4**

BC is exponentially correlated to R

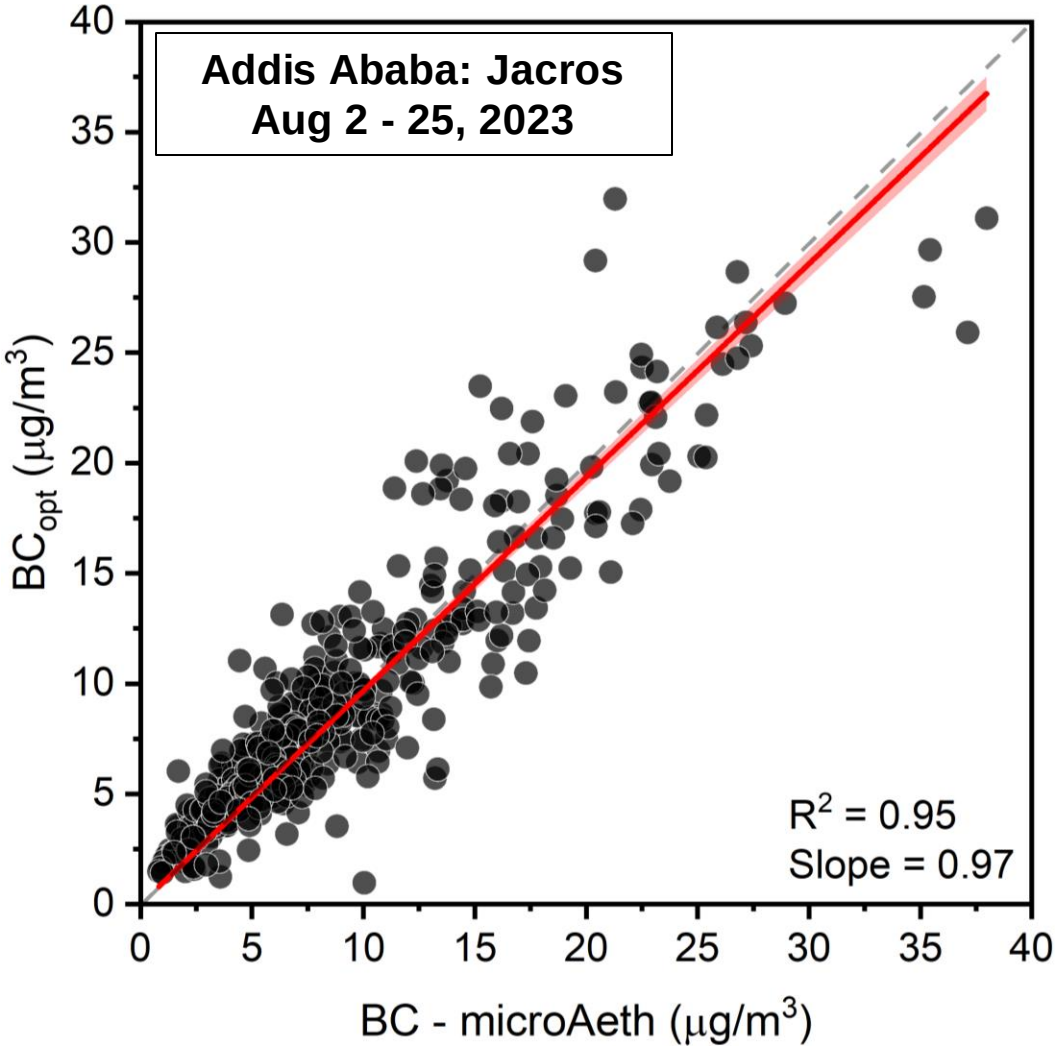


EDL: effective detection limit

Anand et al (2023)

Measured BC at cities in Africa

Our BC is highly correlated with microAeth



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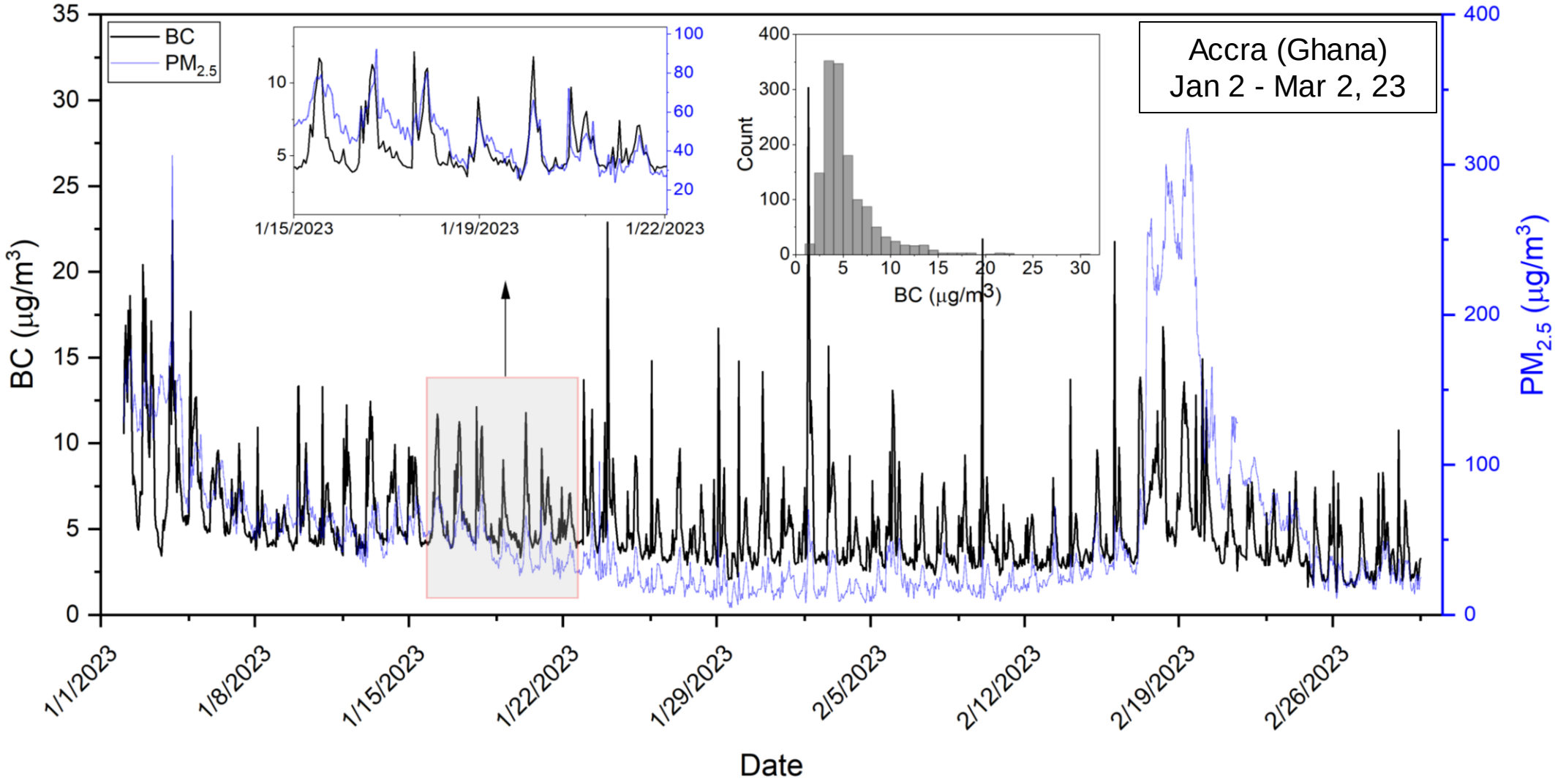
Hourly BC and $PM_{2.5}$ shows a strong correlation



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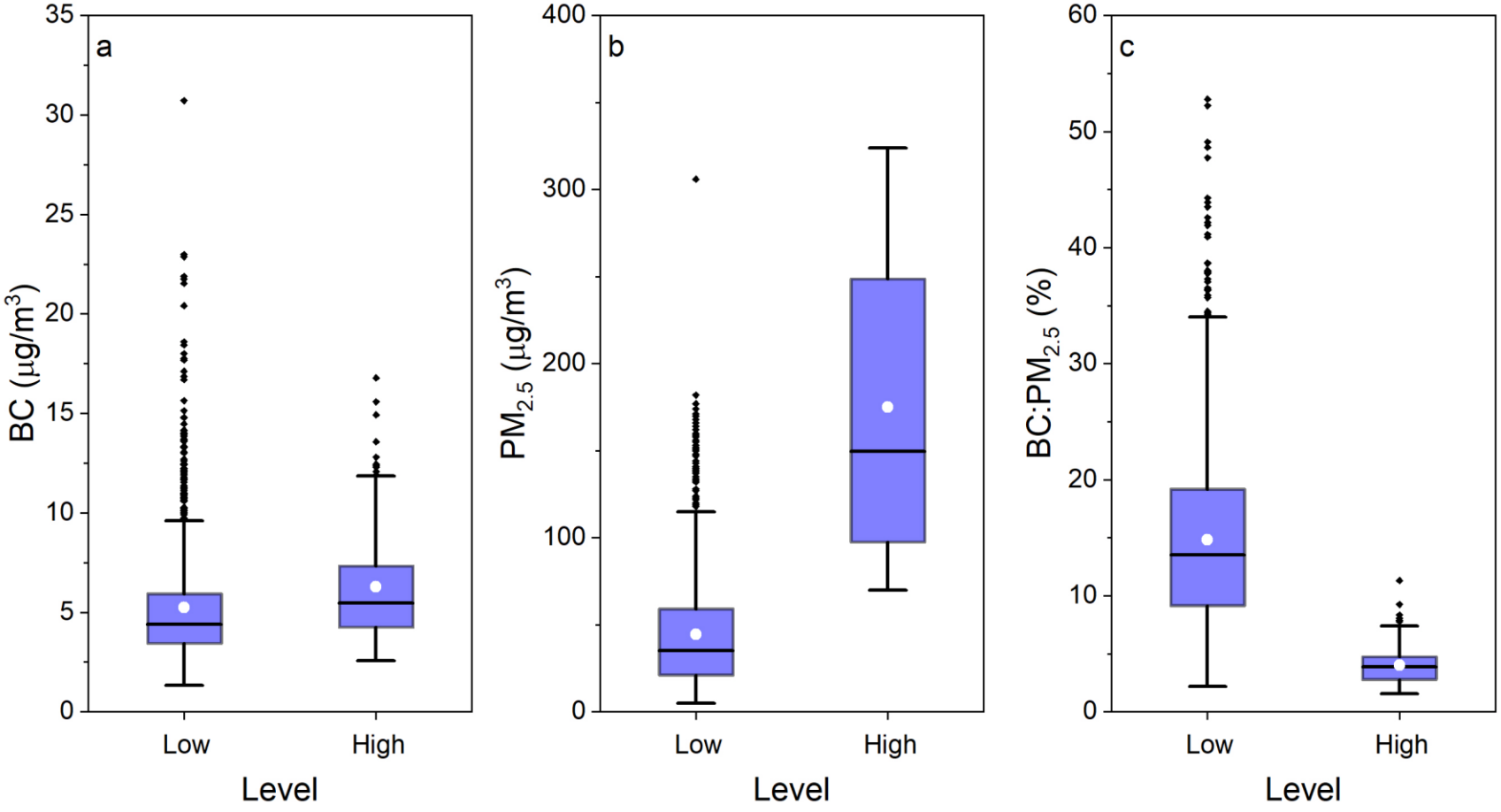
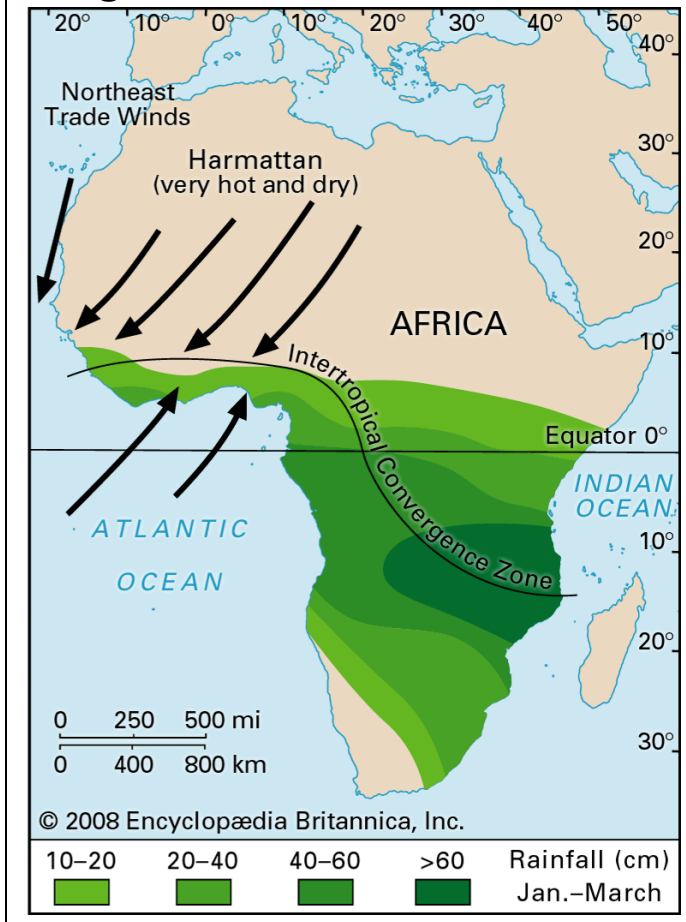
Accra: High PM period



Low: Non-Harmattan Period
High: Harmattan Period



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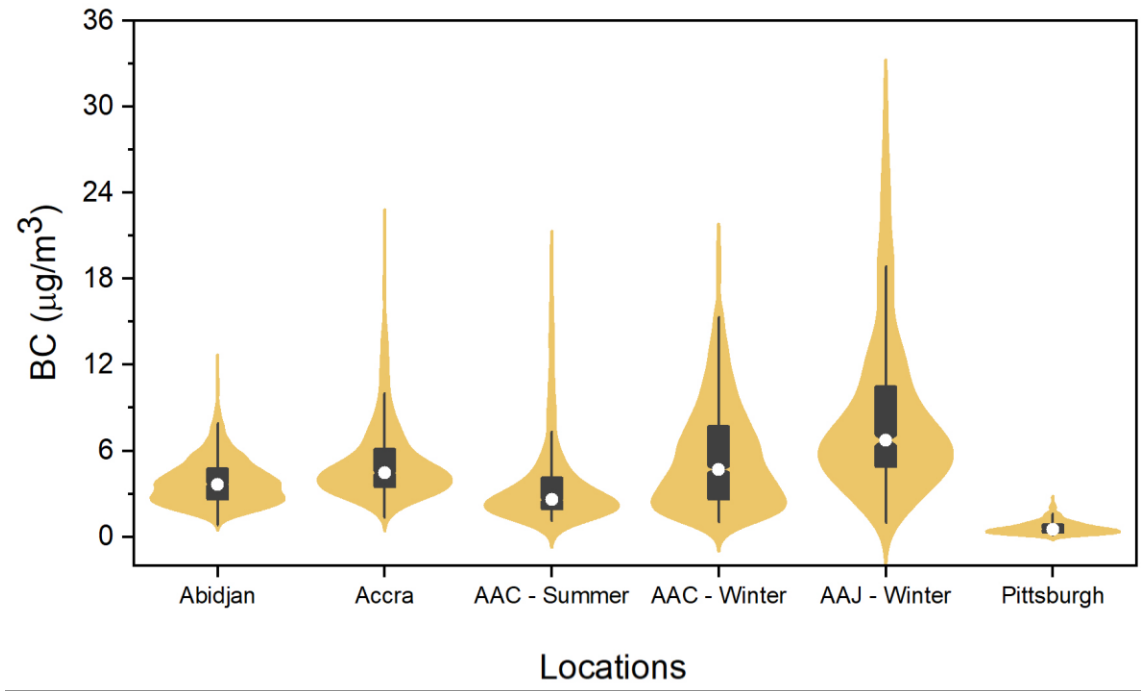
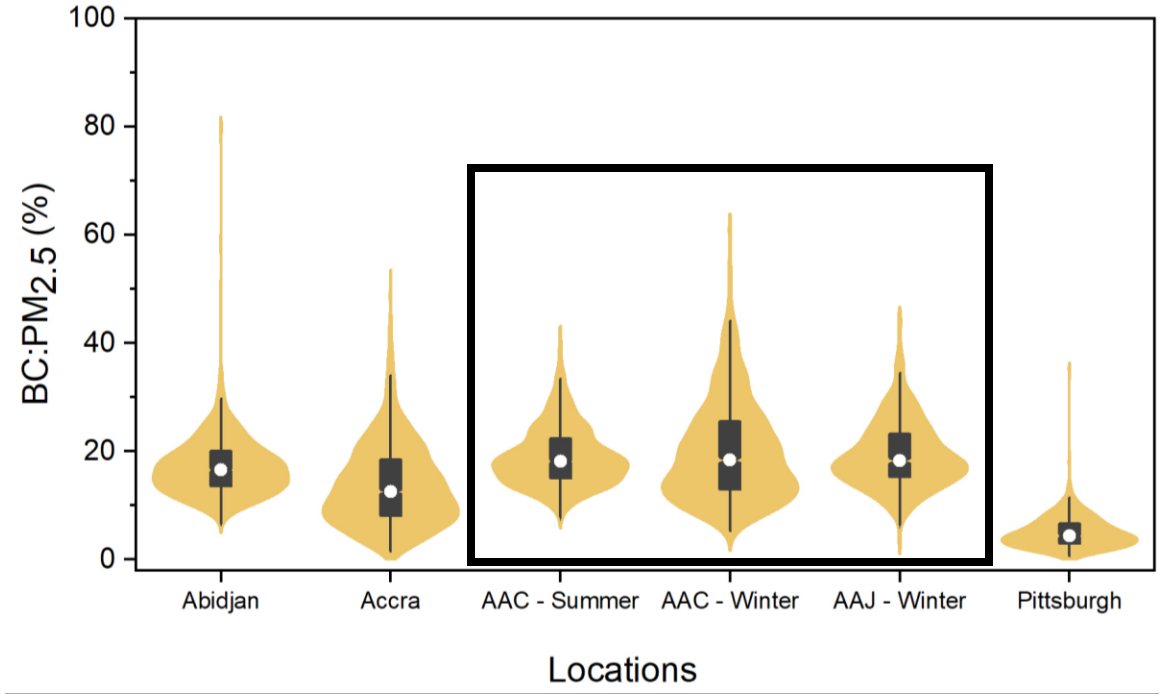
BC and BC/$PM_{2.5}$ in SSA cities are significantly higher than Pittsburgh





AAC: Addis Ababa - Central site
AAJ: Addis Ababa - Jacros site

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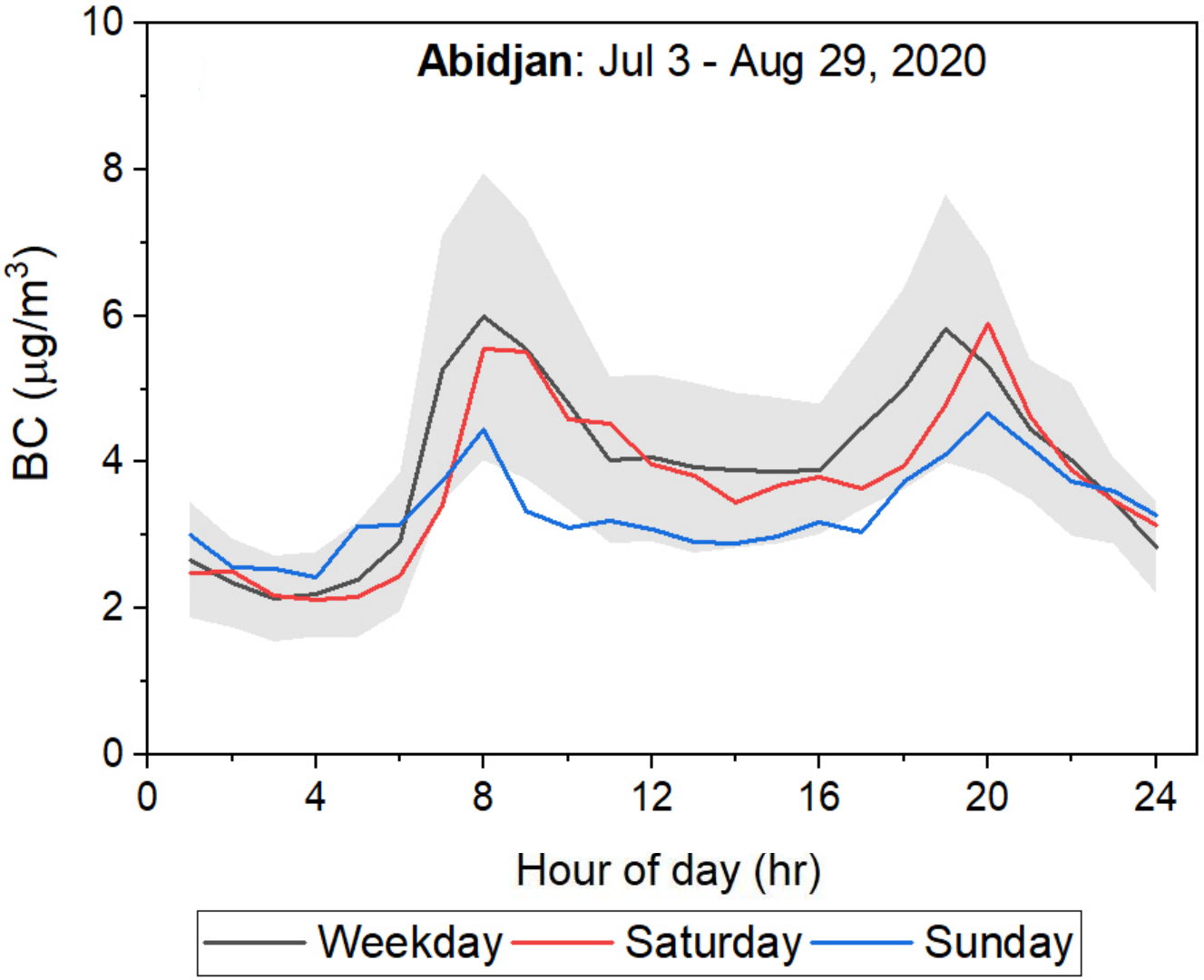
Hourly BC allows a weekday-weekend comparison for diurnal BC



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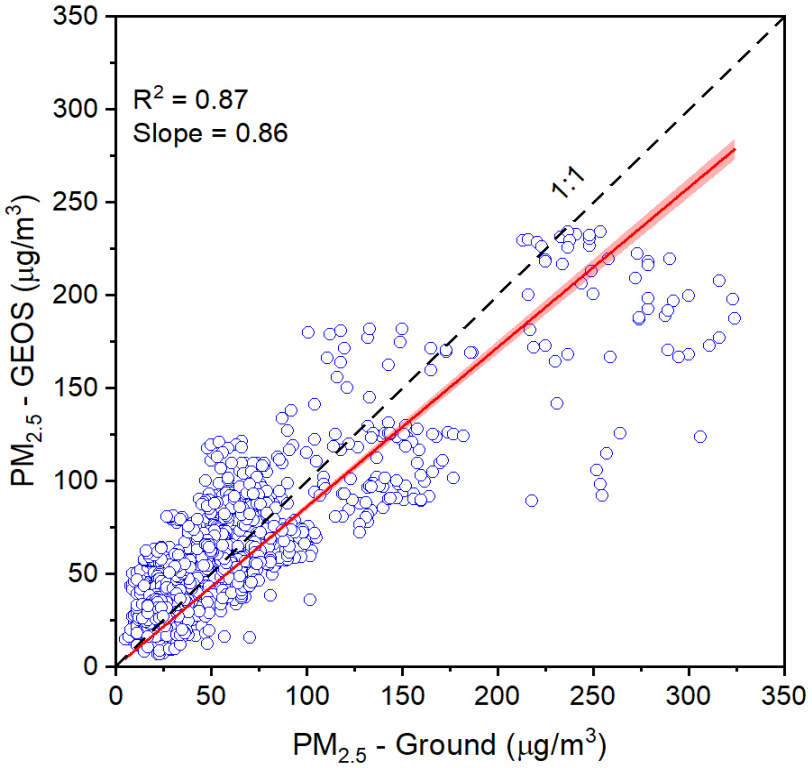
Ground BC could help improve model performance

- Goddard Earth Observing System Composition Forecast (GEOS-CF)
- A forecast model that uses GEOS-Chem chemistry model
- A 5-day forecast is generated daily
  - Spatial resolution: 25 km x 25 km
  - Temporal resolution: 1 hour

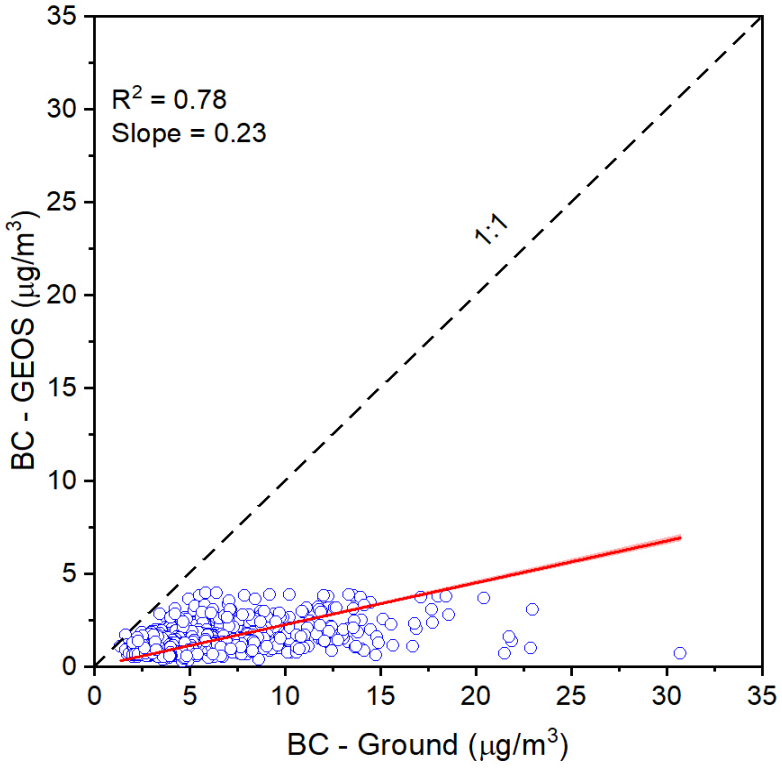
Keller et al (2021)

Ground BC could help improve model performance

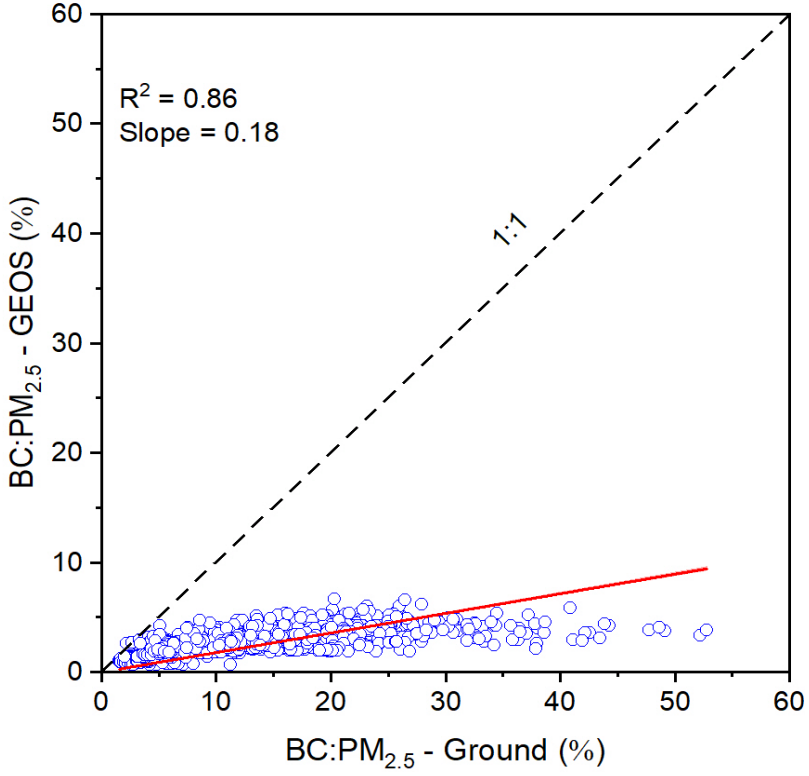
$PM_{2.5}$



BC



$BC/PM_{2.5}$



Adding more ground data could help improve emission inventory and hence calibrate CTMs!

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Conclusion

- ❑ The method can measure hourly BC at existing BAM locations.
- ❑ We are able to capture diurnal trends and differentiate between weekday and weekend trends.
- ❑ Ground-level BC measurements could help in evaluating CTM outputs.

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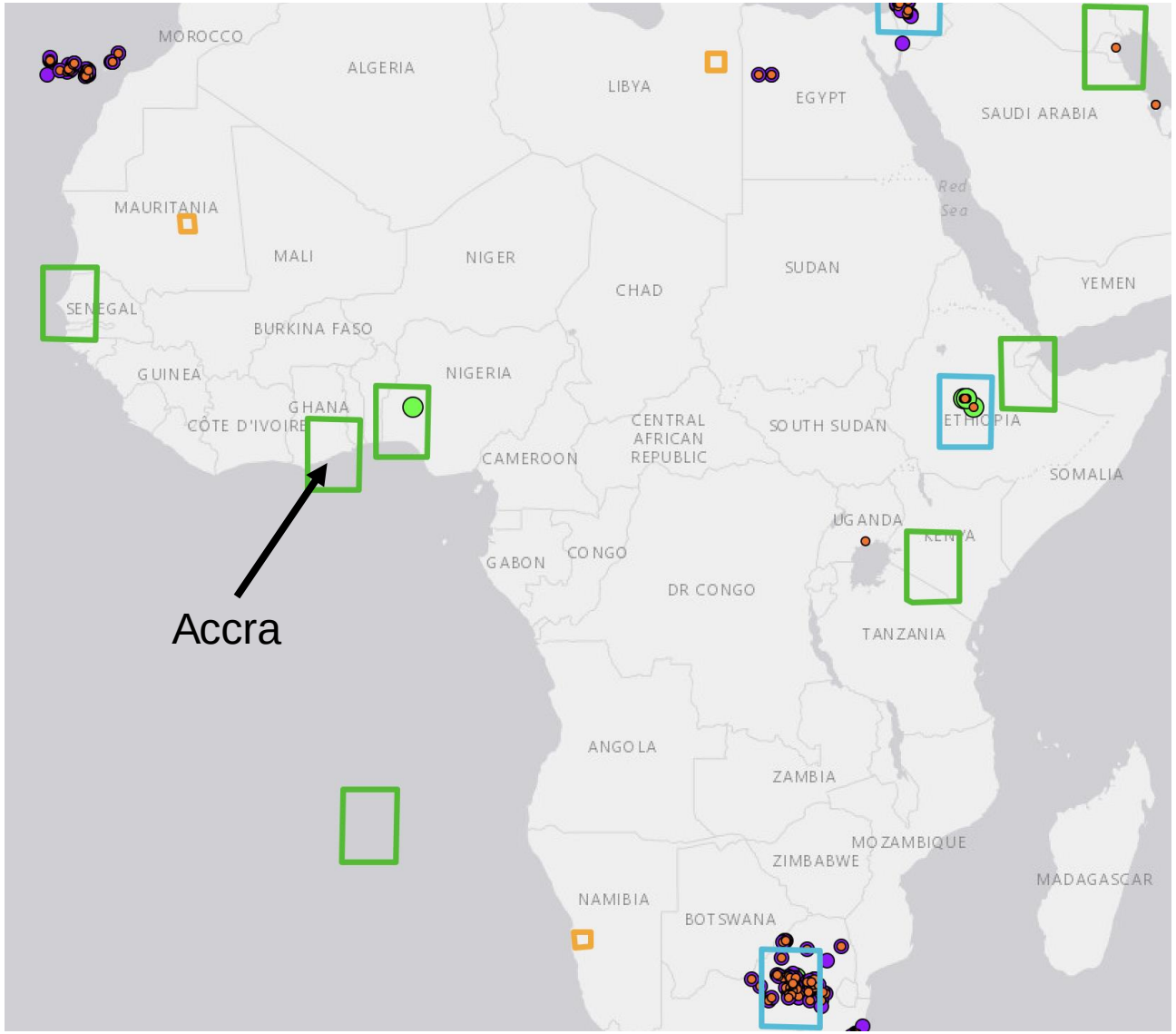
Preprint available at ChemRxiv!

Can help improve satellite-derived composition



Imparting the technique to local collaborators

BAMs at multiple locations in East Africa

- Addis Ababa, Ethiopia
- Kampala, Uganda
- Nairobi, Kenya
- Kigali, Rwanda

geohealth-hub.org

Thank you…

- Prof. Albert Presto
- Our collaborators in Africa, CMU Africa, NASA JPL
- Presto group
- Centre for Atmospheric Particle Studies

Paper 1

Anand et al (Under review)

Preprint available at ChemRxiv!

Q&A

Extensive air pollution monitoring is expensive

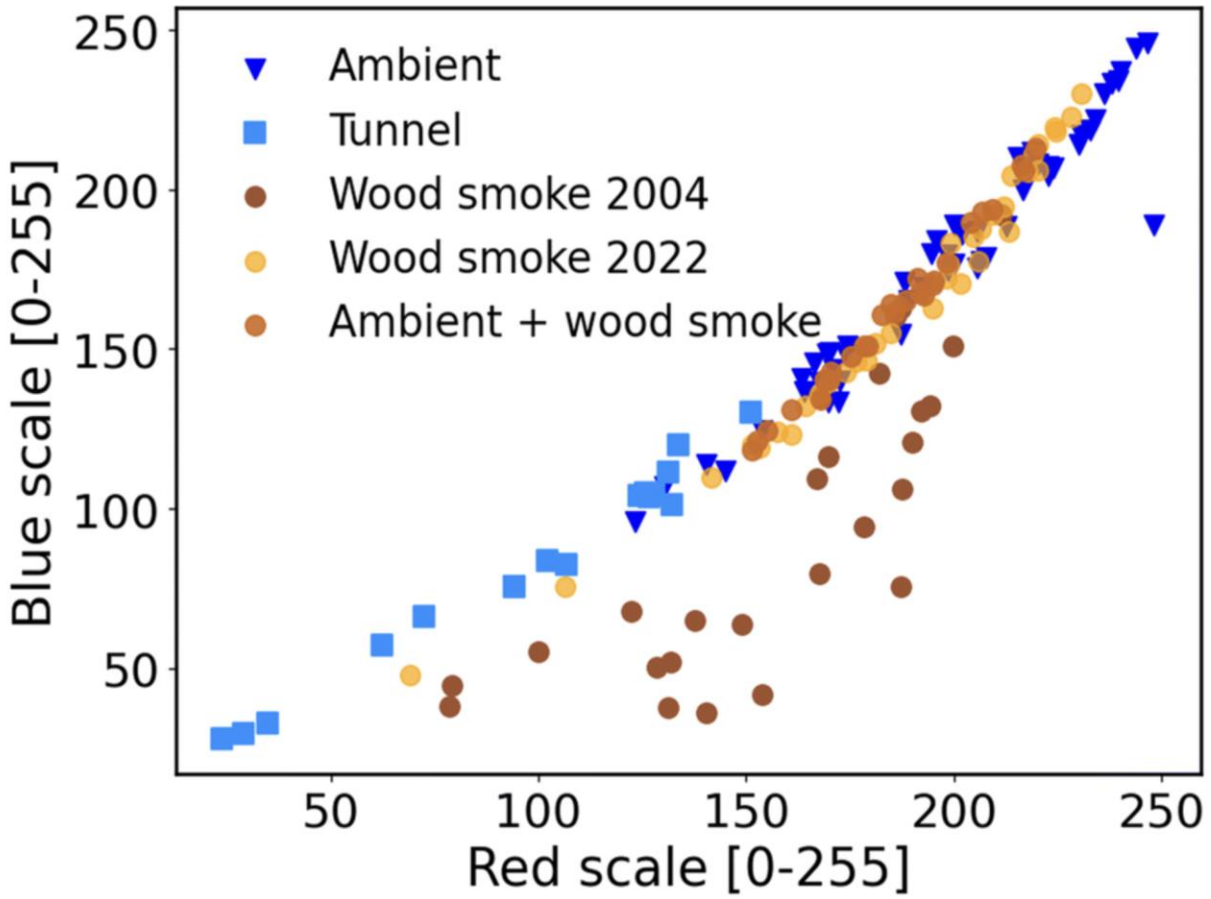
PM monitor: BAM

Black carbon monitor: Aethalometer

PM monitor: Purple Air
(Cost: ~$ 229)

BAM: Beta Attenuation Monitor

This method could help quantify woodsmoke-BC



Anand et al (2023)

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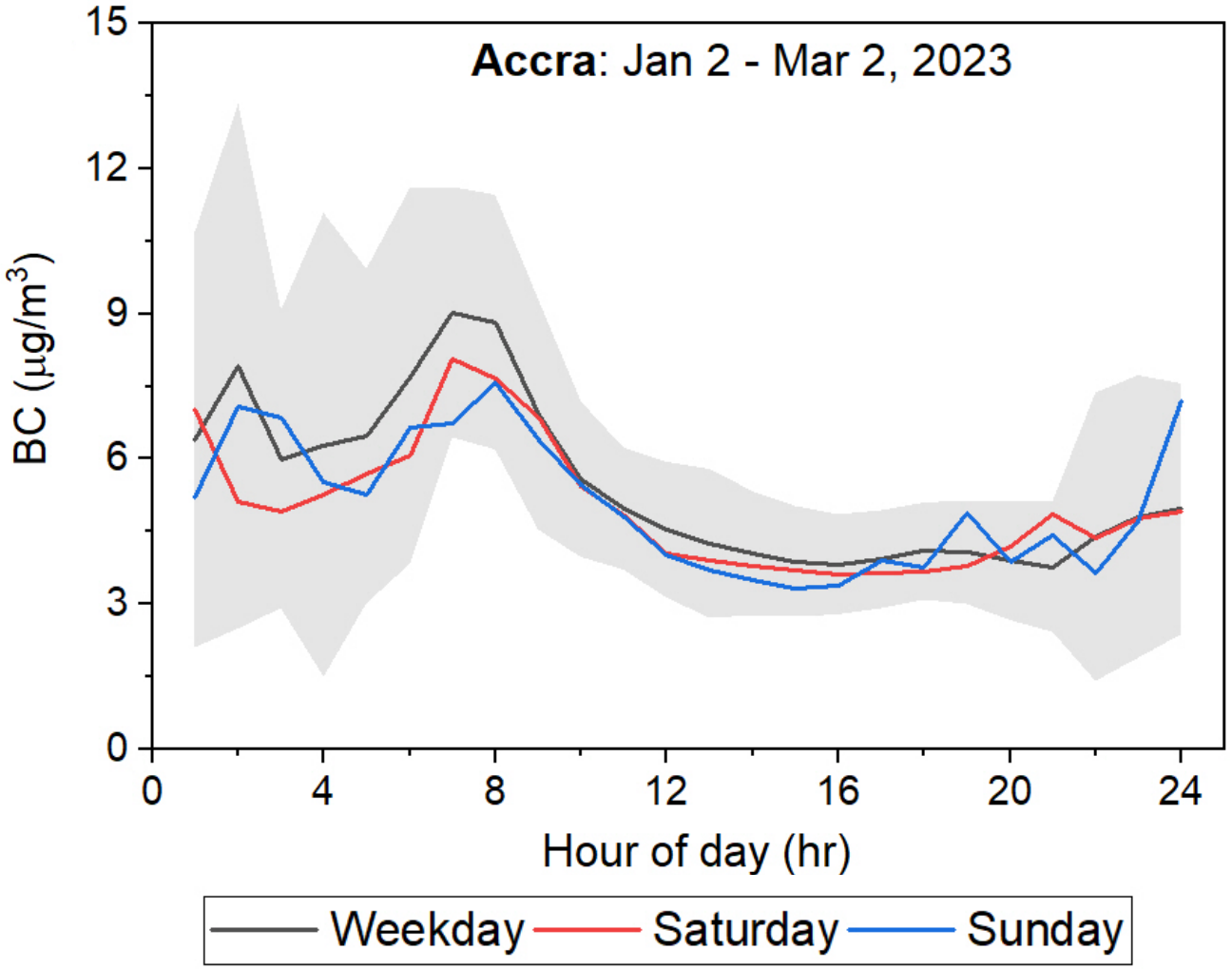

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