



CLIMATE
SOLUTIONS
CONSULTING

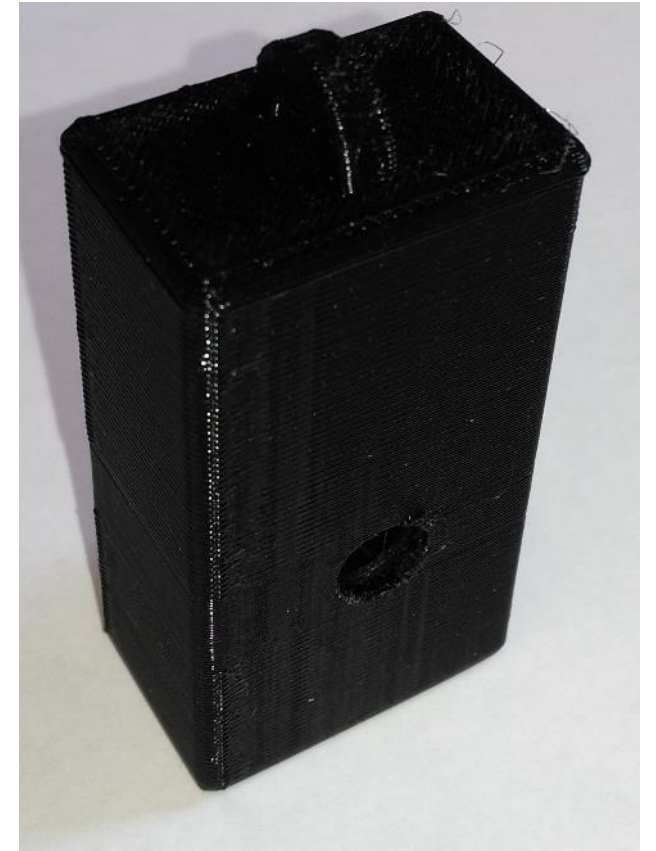
HAPEX

A low cost PM sensor to
measure exposure from solid
fuels

I) PRESENTATION

Specifications

- **PM range:** 10ug/m³ to 50,000 ug/m³
- **Size:** 2.5"*1"*1.3" (1.4 oz)
- **Passive:** rely on natural convection/diffusion
- **GP2Y1010** (IR 950nm, 60^o scattering)
- **Accelerometer:** compliance
- **Battery Life:** 5 years (2.6 millions sample)
- **Low Cost:** US\$120

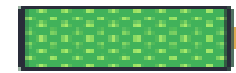


User Interface

- Simple
- Wireless
- Touchscreen



v5.8



2018-09-02 10:28:35

START

DOWNLOAD

SETTINGS

CALIBRATION

UPDATE

User Interface

- Simple
- Wireless
- Touchscreen
- Real Time streaming
- Up to 20 sensors simultaneously

Version 4.6

STATUS REAL TIME SUMMARY

cook
HAPEX
SN#: 177

Biogas
EXACT
SN#: 227

PM: 50
Compliance: 1

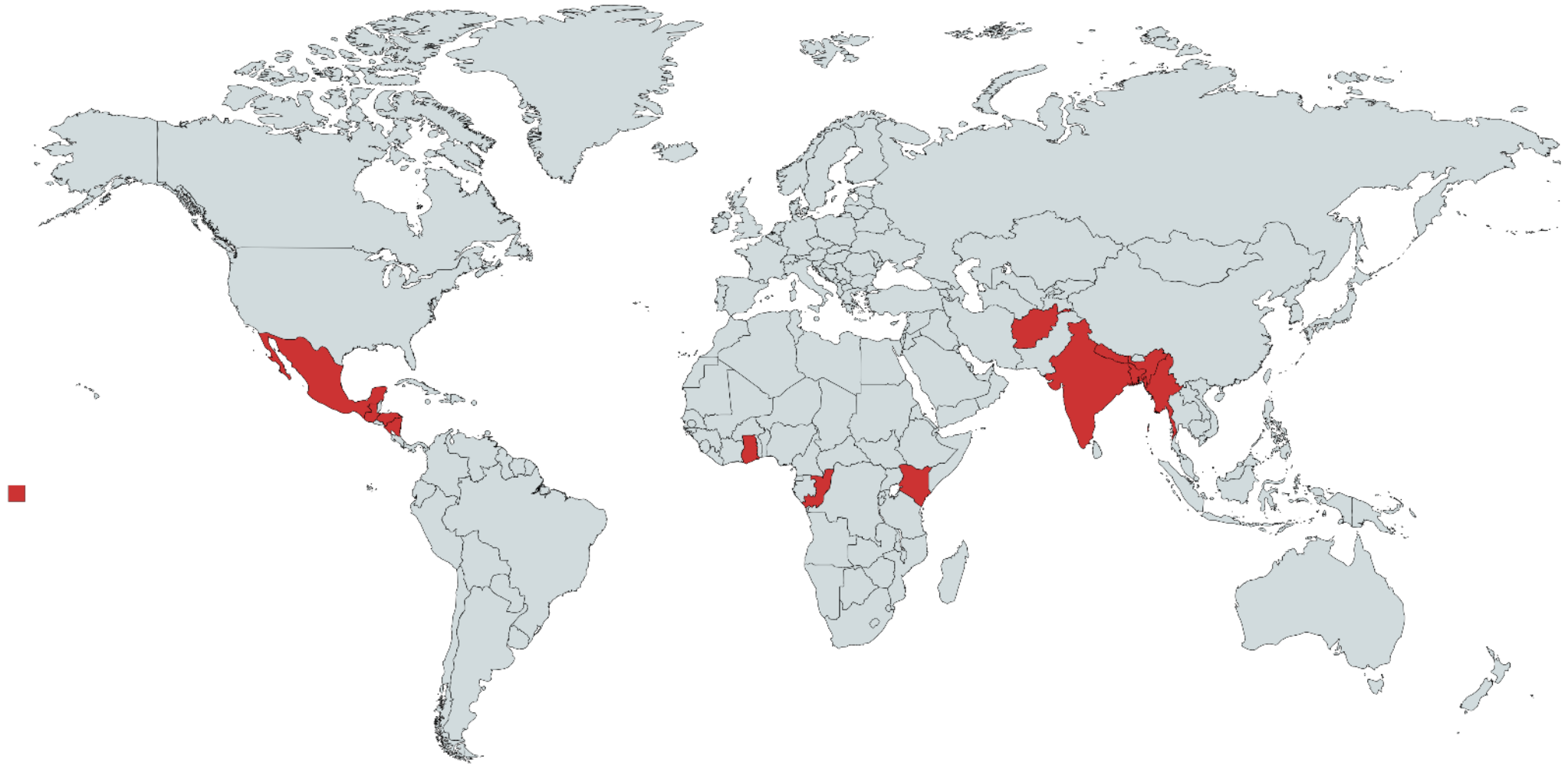
Temperature: 0
Cooking: 0

All sensors were started successfully!

RETRY DOWNLAOD ONLY STOP & DOWNLOAD

II) APPLICATIONS

HAPEx field deployment location



Created with mapchart.net ©

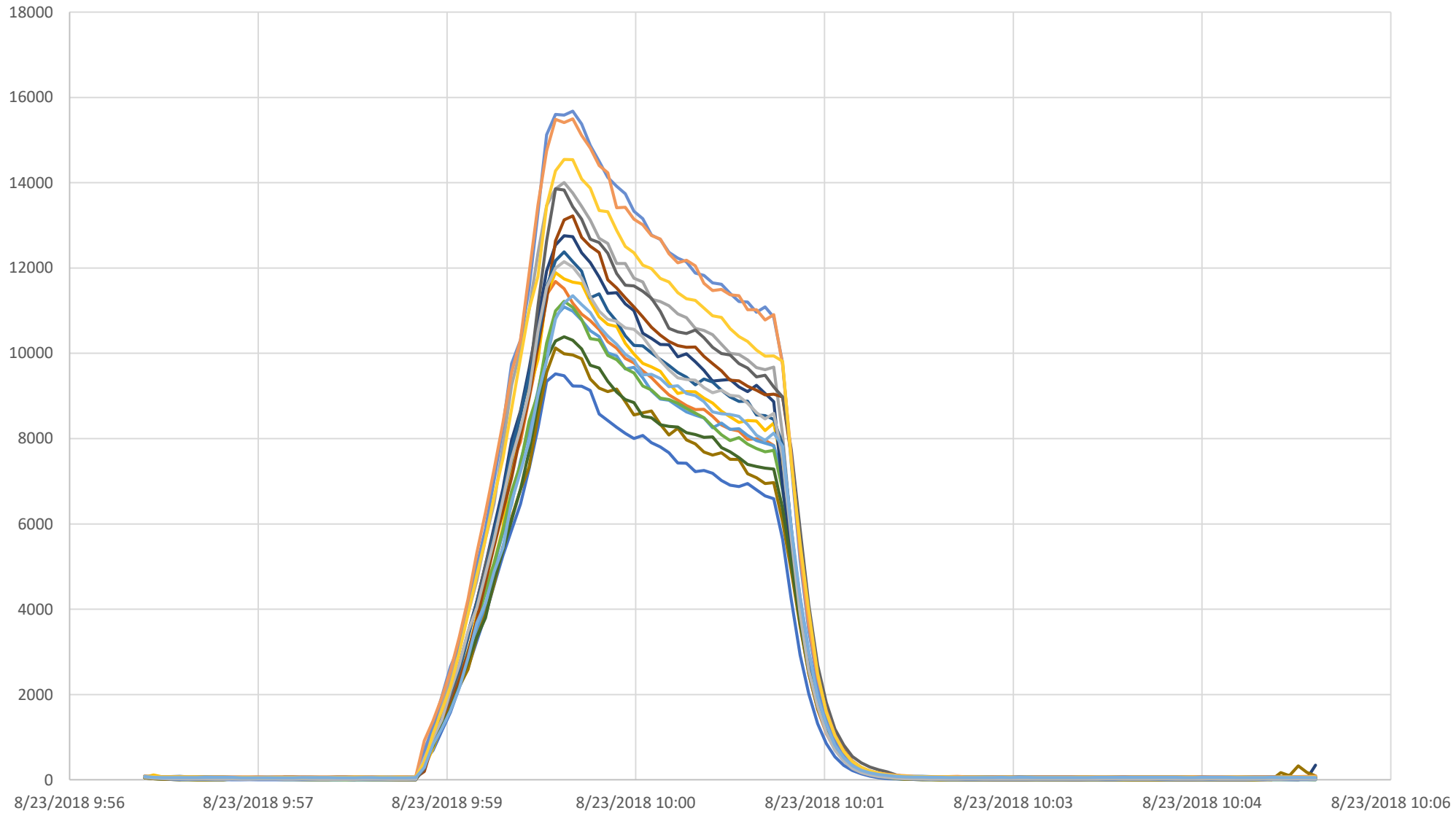
Measurement in 12 countries: 1,000+ households

Kitchen's PM distribution Study

- Aprovecho Research Center & Oregon State University
- Distribution of PM cookstove emissions in a test kitchen
- 33 HAPEx – 1 per m³

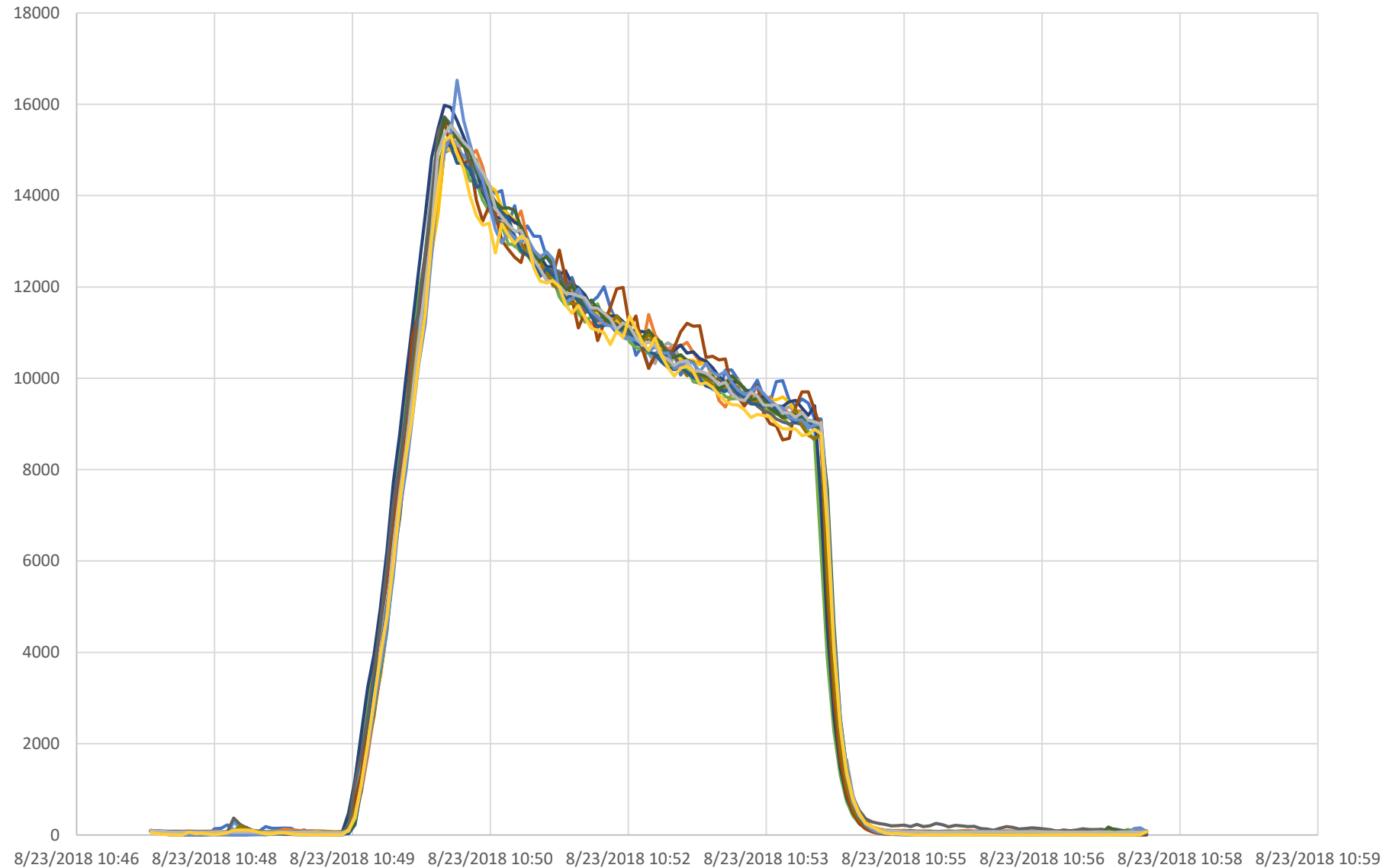
III) PERFORMANCE

Inter Device variability: before calibration



+ -50%

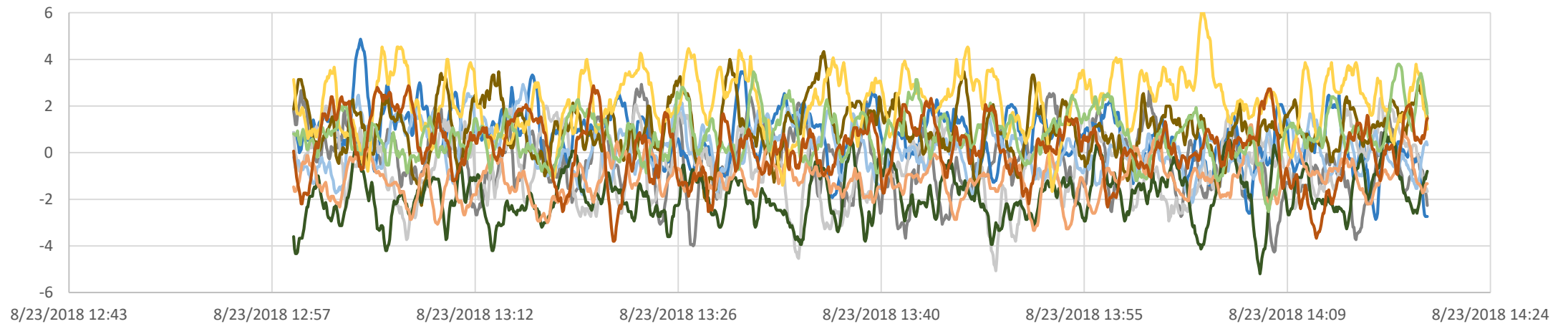
Inter Device variability: after calibration



+ -5%

Limit of detection

Noise in clean air (1 min average 4s sampling rate)



SD (raw unit)

1.08

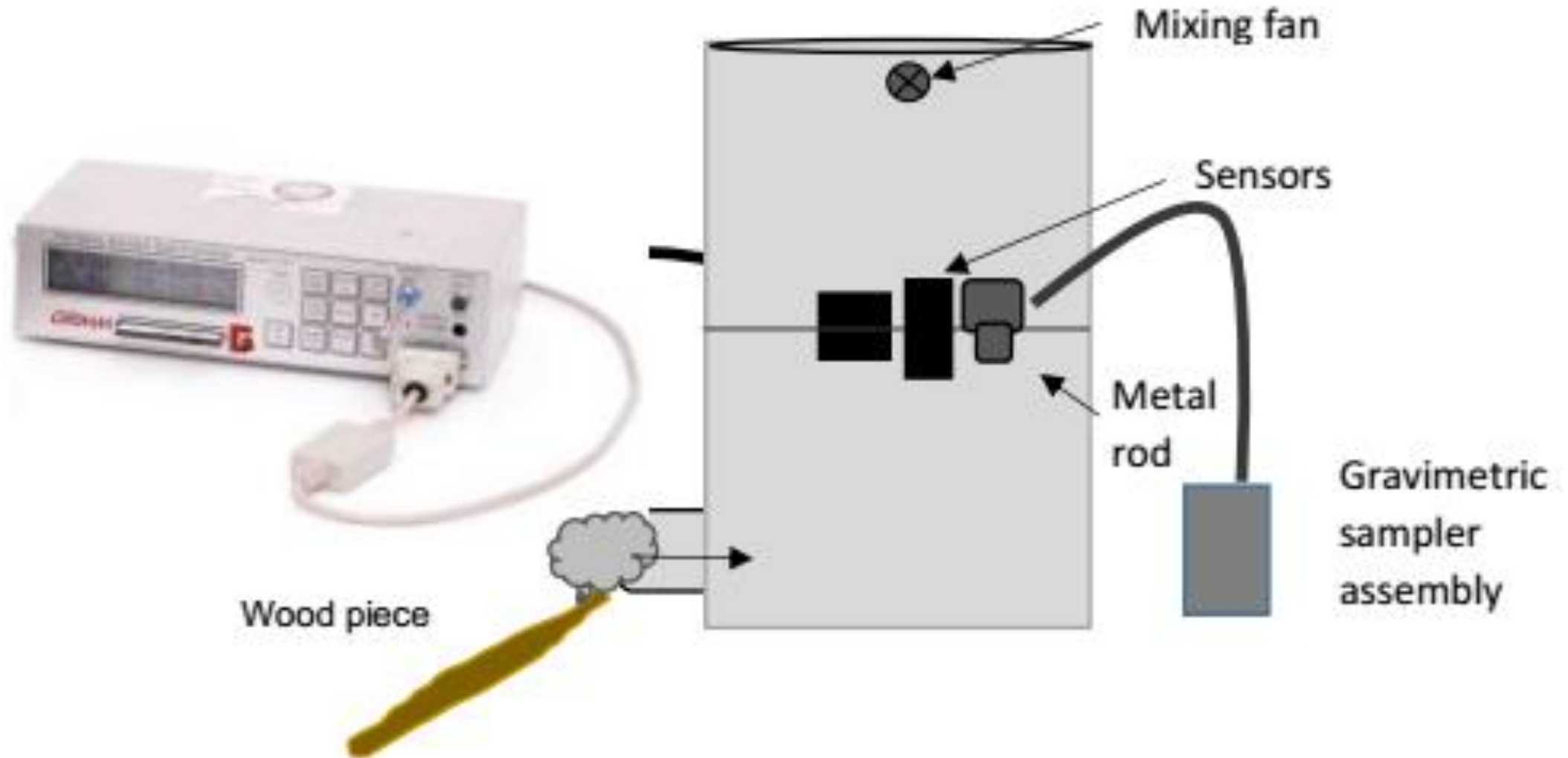
Wood PC (ug/m3/raw unit)

1.8

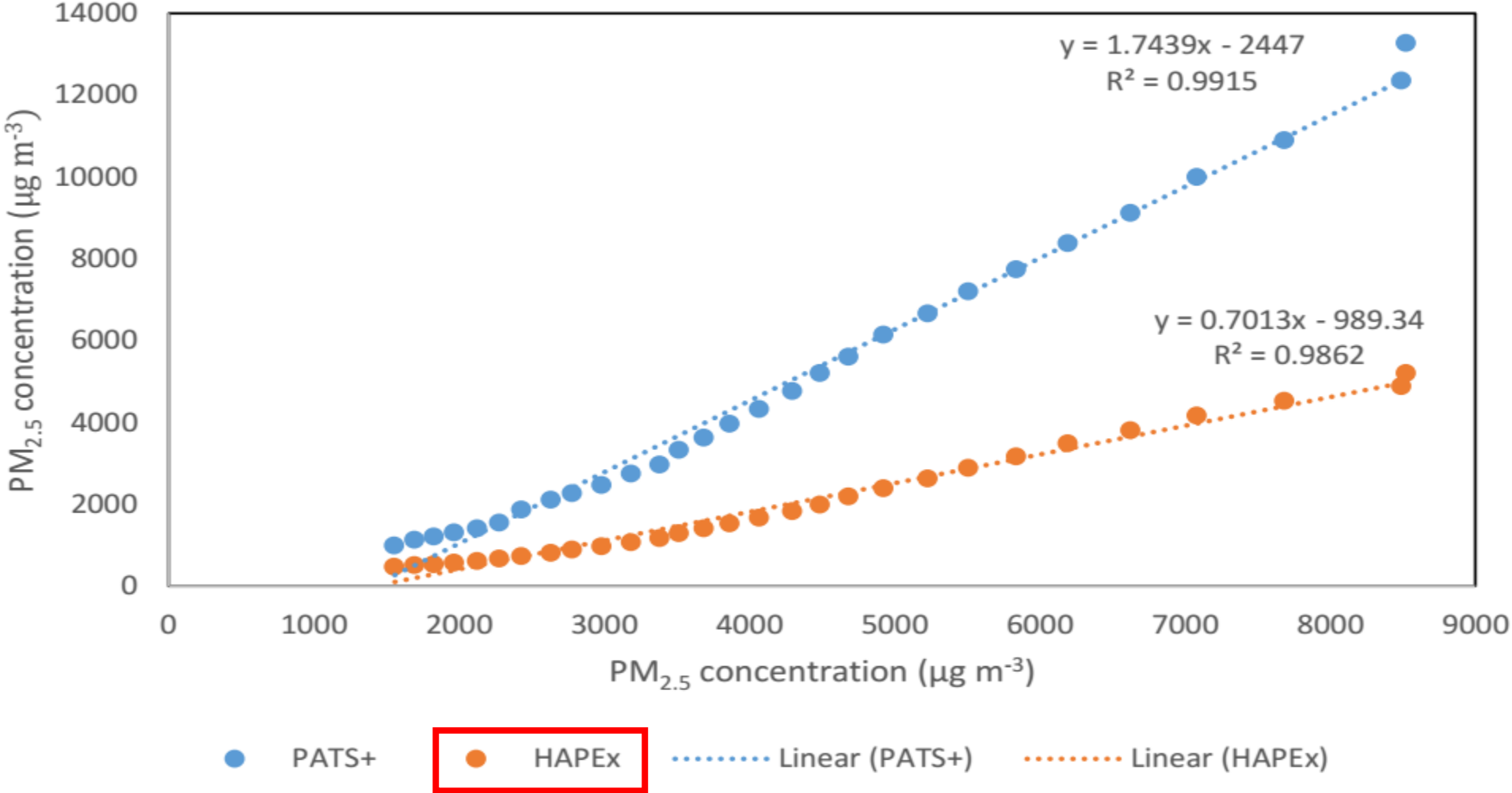
LOD = 3 SD*PC (ug/m3)

5.8

HAPEx Lab Testing



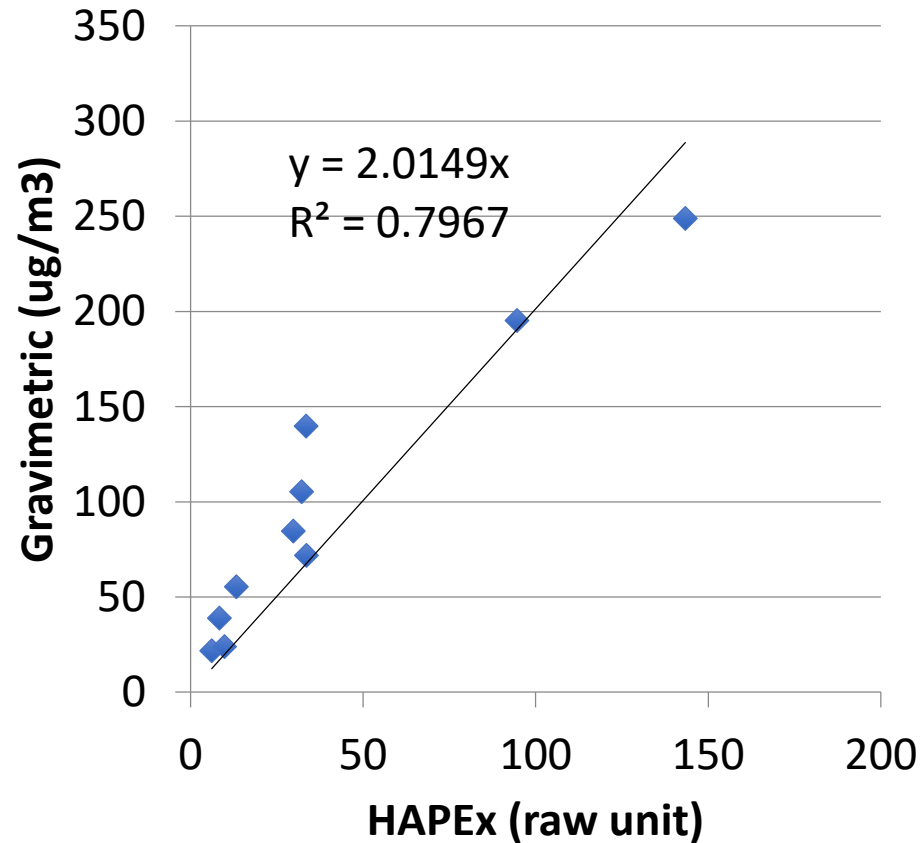
Lab Correlation with GRIMM OPC



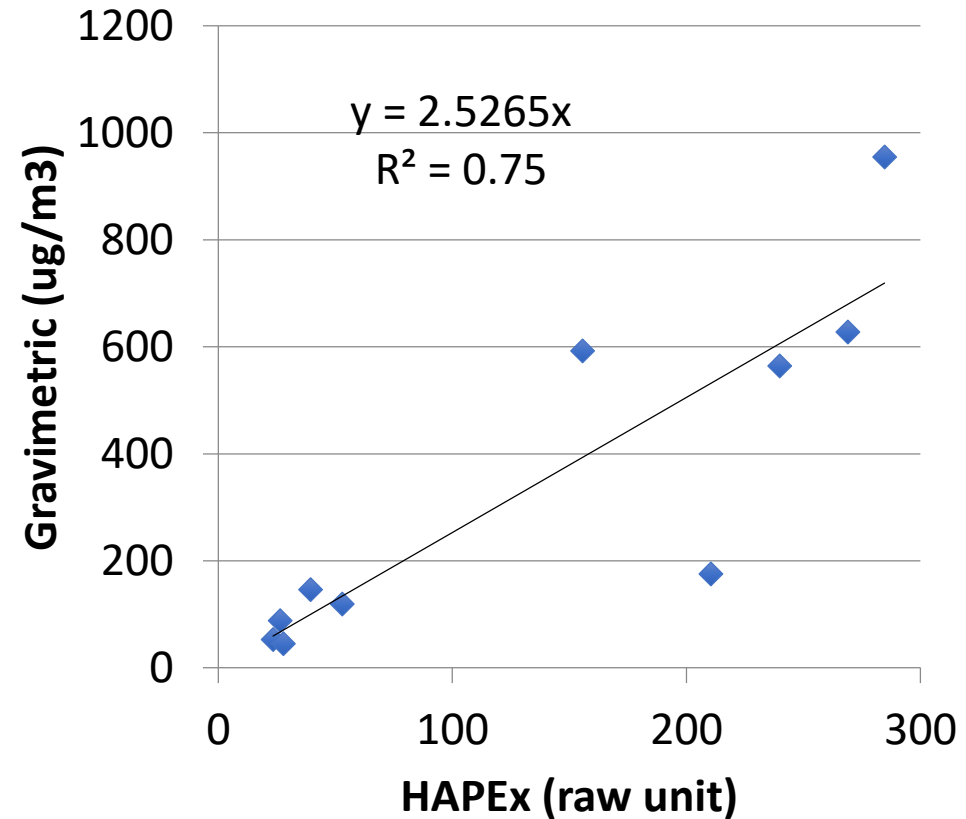
Source: **Transparent Climate and Health Metrics: An open Data Dashboard and Wireless Platform for Cookstove Monitoring**, Nexleaf, 2017

Field correlation with 48h Gravimetric

Hapex field calibration from Gasifier Stove



Hapex field calibration from Open Fire

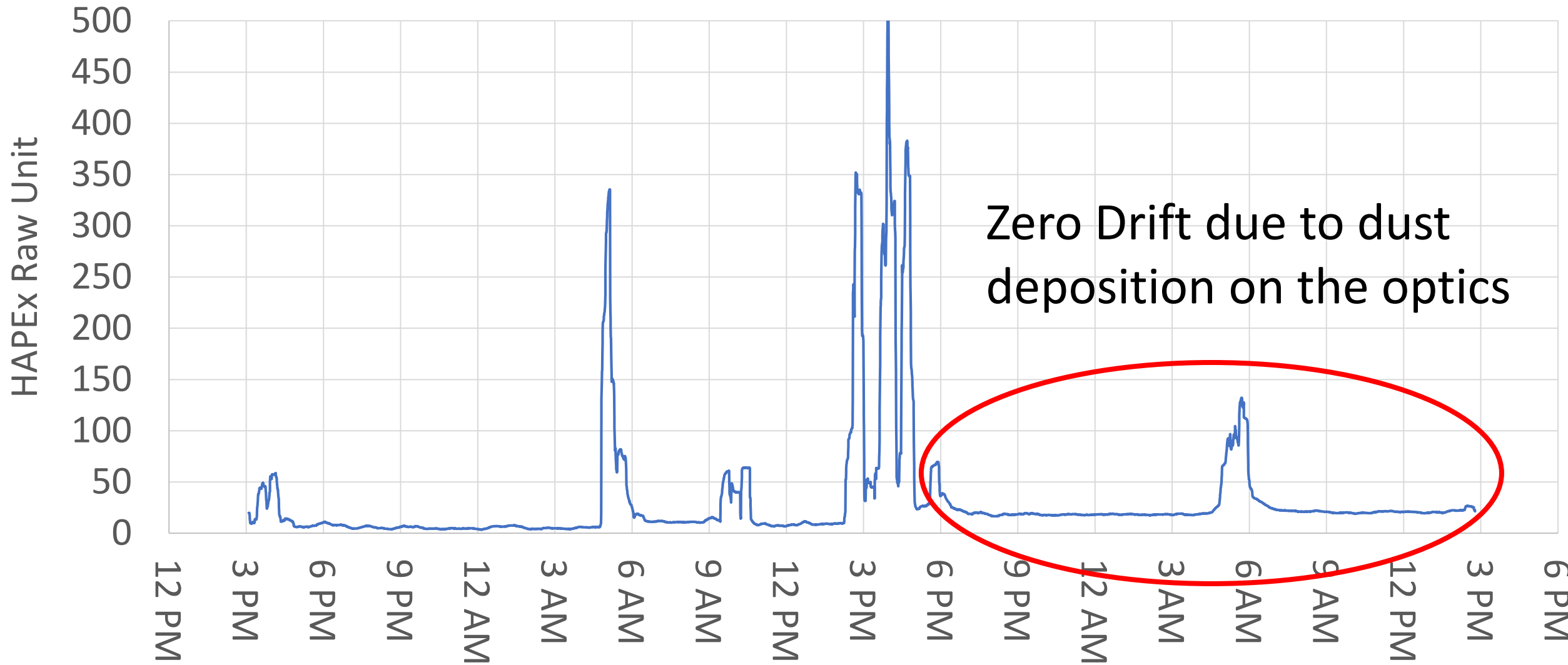


IV) LIMITS

Influence of Environmental parameters

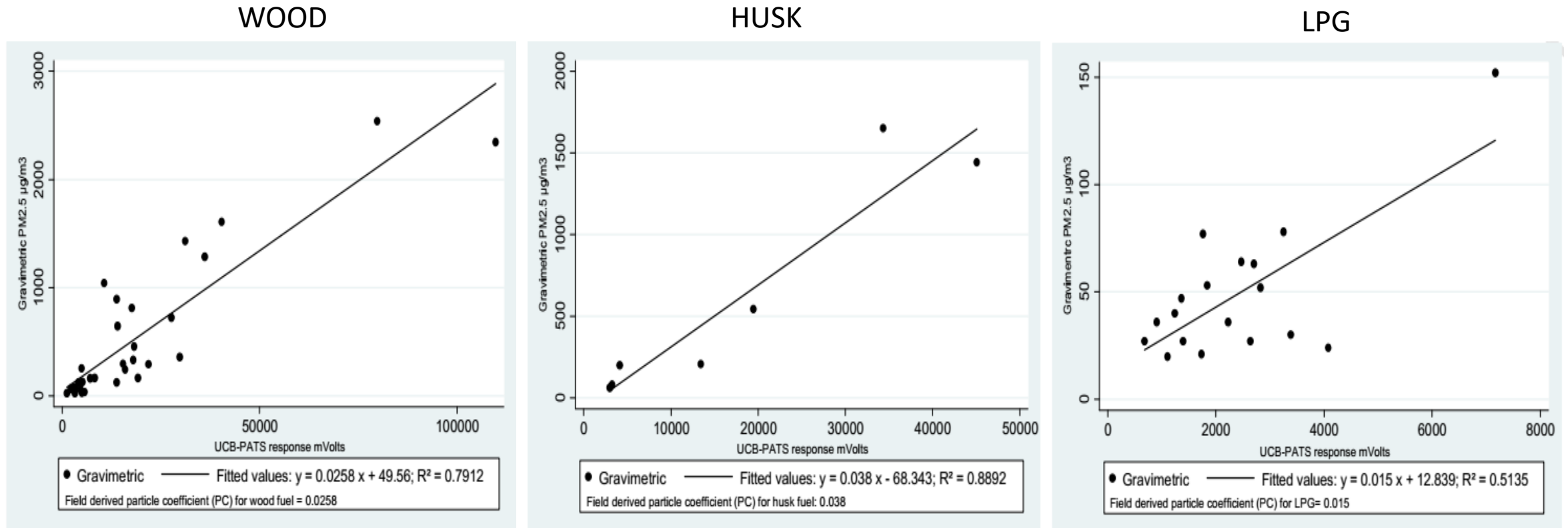
- Influence of RH is strong above 60%
- Dust (larger than 2.5 μ m)

Zero Drift



Source dependent Sensitivity

Example of UCB PATS in Nepal



$$y = 0.0258x + 49.56$$

$$y = 0.038x - 68.3$$

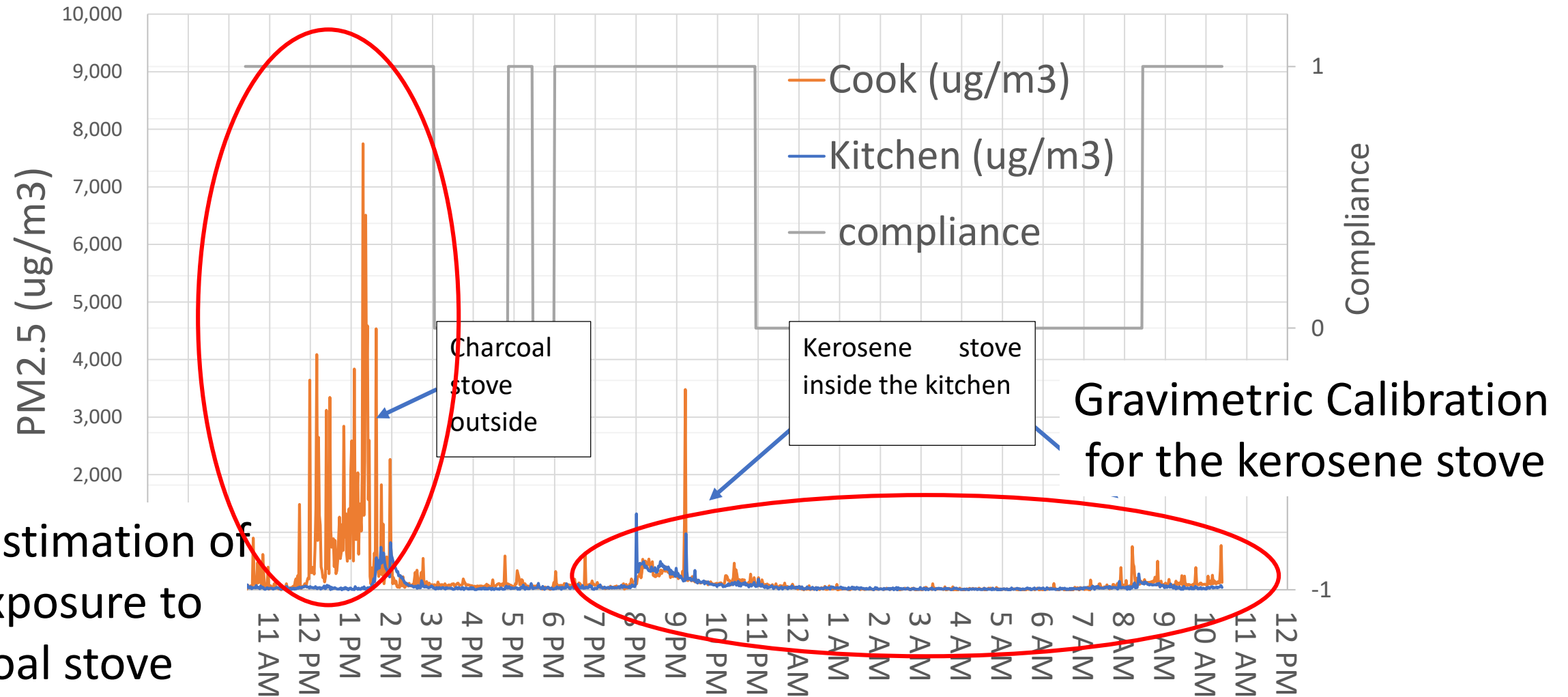
$$y = 0.015x + 12.89$$

Source: Pokhrel, et al. PM2.5 in household kitchens of Bhaktapur, Nepal, using four different cooking fuels, *Atmospheric Environment* (2015), doi: 10.1016/j.atmosenv.2015.04.060

Kitchen Air Pollution vs Cook Exposure (Kenya)

HAPEx worn by the cook

HAPEx in the kitchen collocated with Gravimetric Sampler

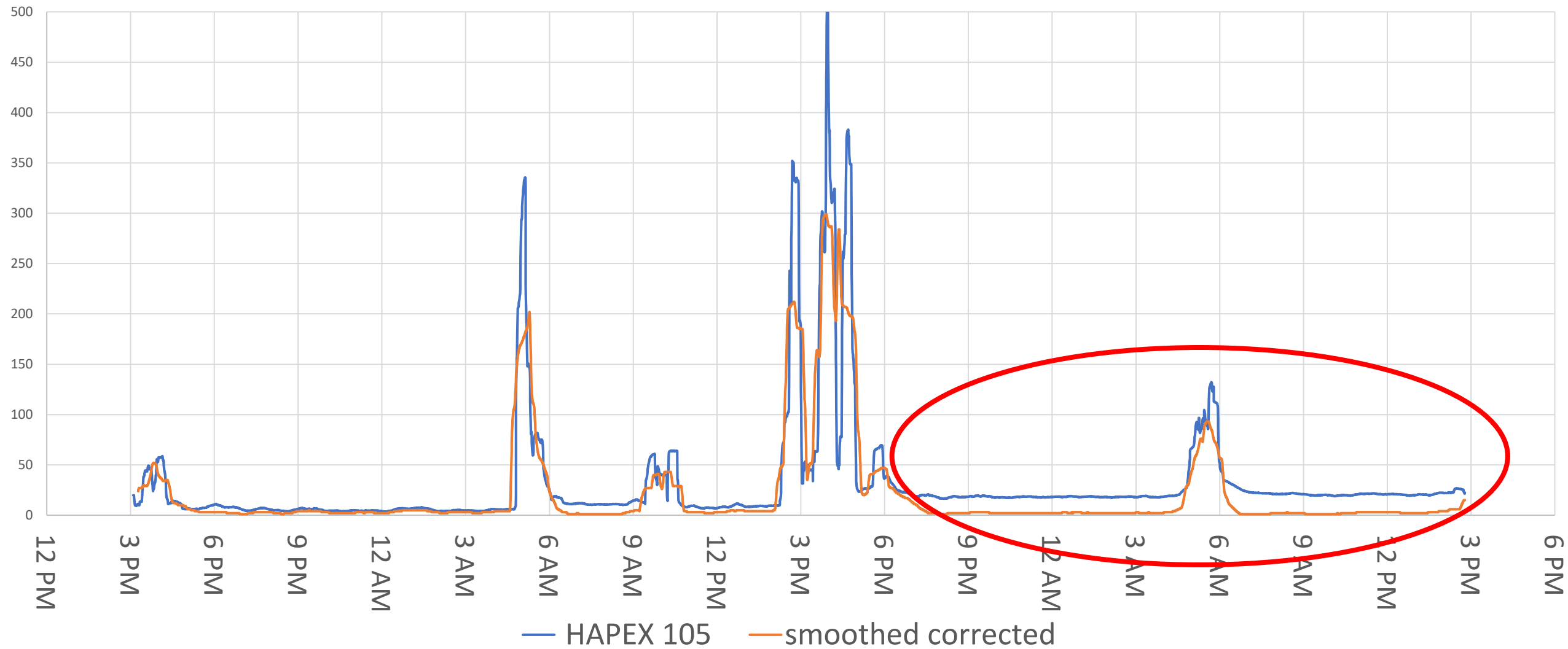


Overestimation of the exposure to charcoal stove

Gravimetric Calibration for the kerosene stove

V) SOLUTIONS

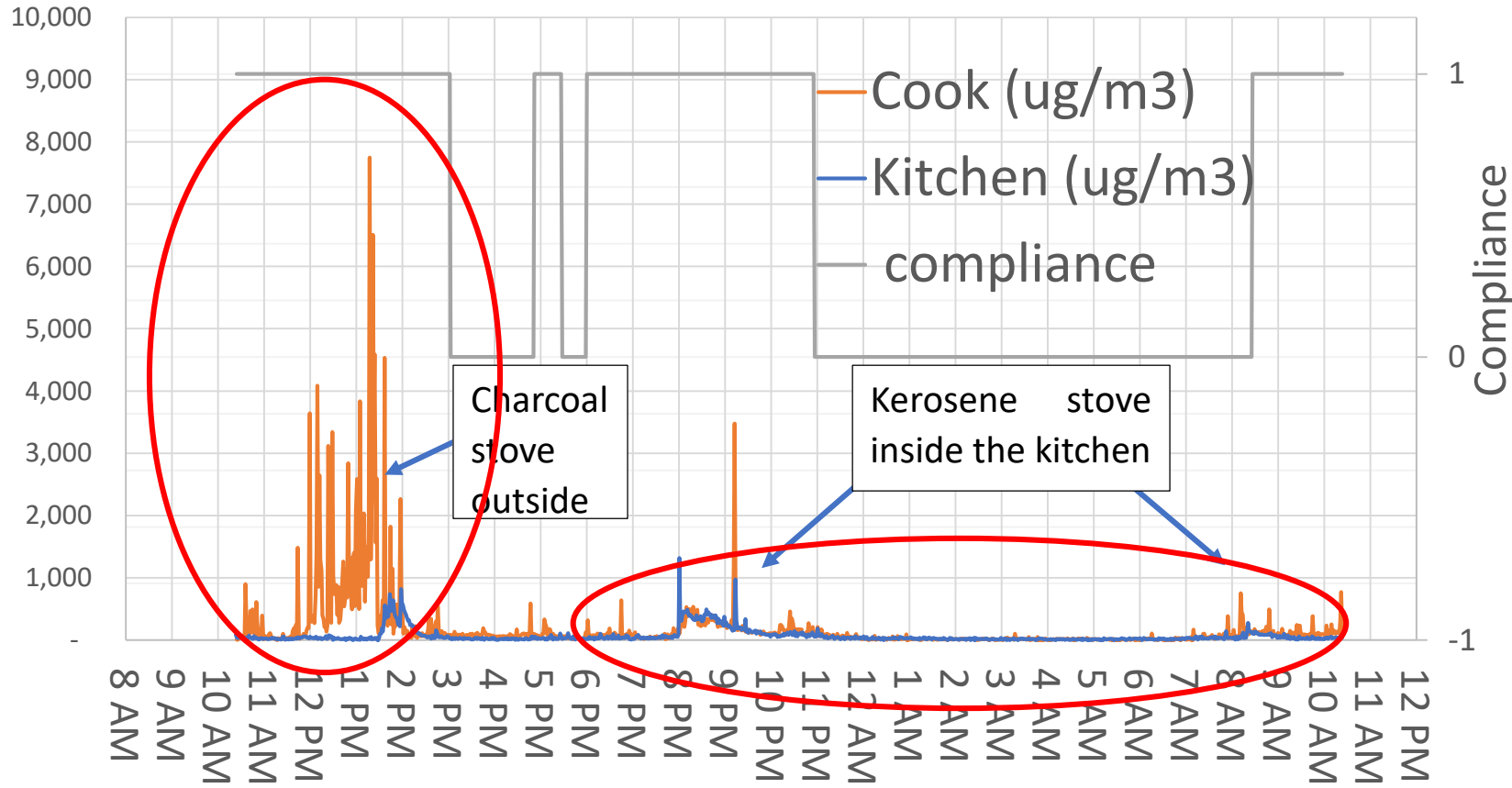
Software Drift Correction



Source Specific Calibration

HAPEx worn by the cook

HAPEx in the kitchen collocated with Gravimetric Sampler



Stove Use Monitors



Gravimetric Calibration for the Charcoal stove

Gravimetric Calibration for the kerosene stove

Hardware Solution - HAPEx “Pro”

- Active Sensor
- Size selective Inlet
- Self Zero (flush clean air)
- RH correction
- Oversampling

THANK YOU!