

# Household/Outdoor Pollution in India: EPA STAR Grant

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- INCLEN/SOMAARTH, India
- UC Irvine
- CalTech
- University of Illinois

# AIR POLLUTION AND RURAL BIOMASS FUELS IN DEVELOPING COUNTRIES: A PILOT VILLAGE STUDY IN INDIA AND IMPLICATIONS FOR RESEARCH AND POLICY

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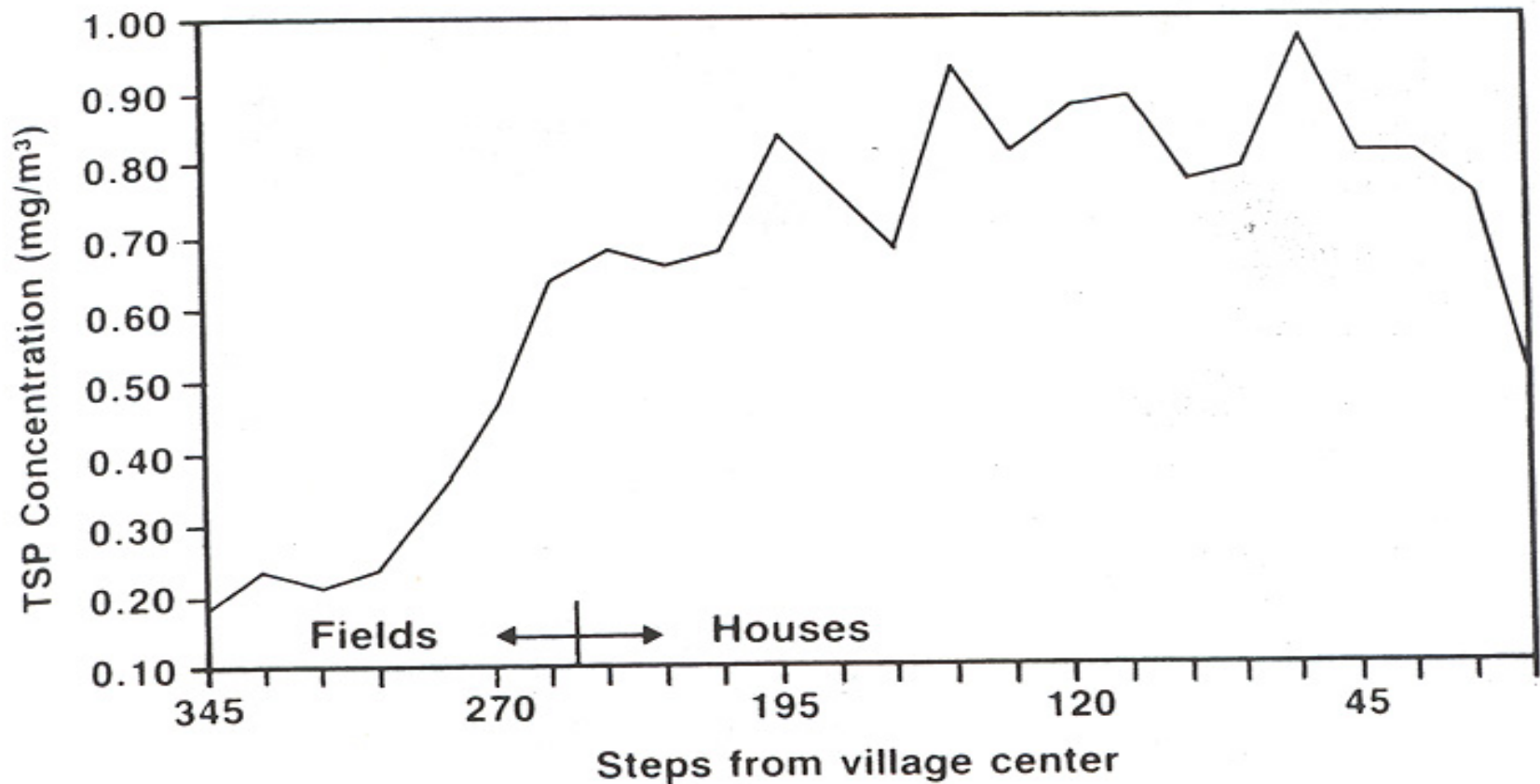
# Measurement of Neighborhood Pollution

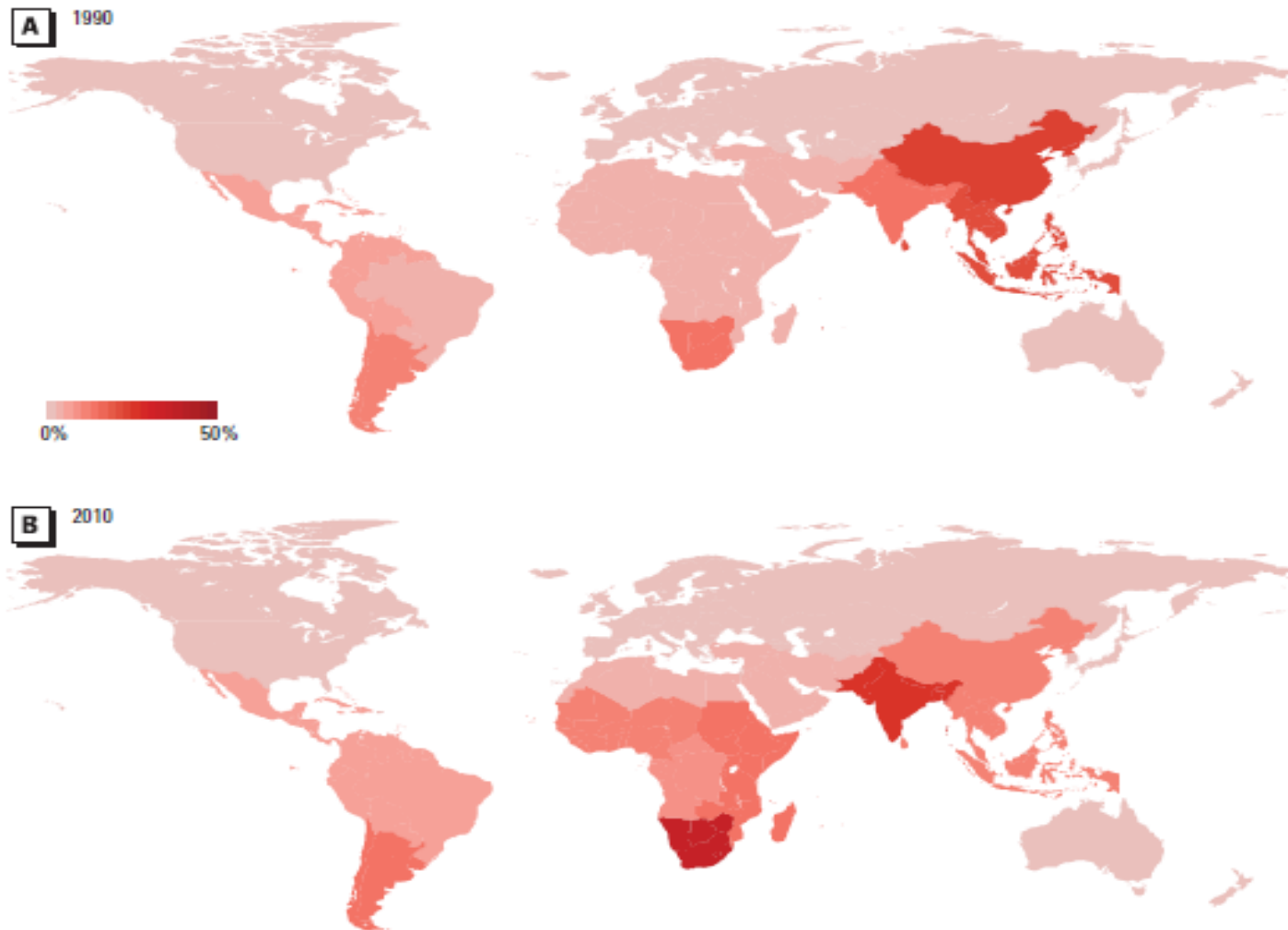
Table 5. TSP and BaP measurements: ambient levels

Village	Height (m)	Time at start	Duration (minutes)	TSP $\text{mg m}^{-3}$
Meghva	2.5	7:00 p.m.	—	1.48
Denapura	2.5	6:40 p.m.	58	1.14
Denapura	2.5	6:40 p.m.	50	0.50
Rampura	3.5	6:23 p.m.	50	2.5
Rampura	1.5	5:50 p.m.	51	2.5
Vallabh Vidyanagar*	1.5	5:55 p.m.	150	0.6

\* Semi-urban area.

# Neighborhood Pollution in an Indian Village





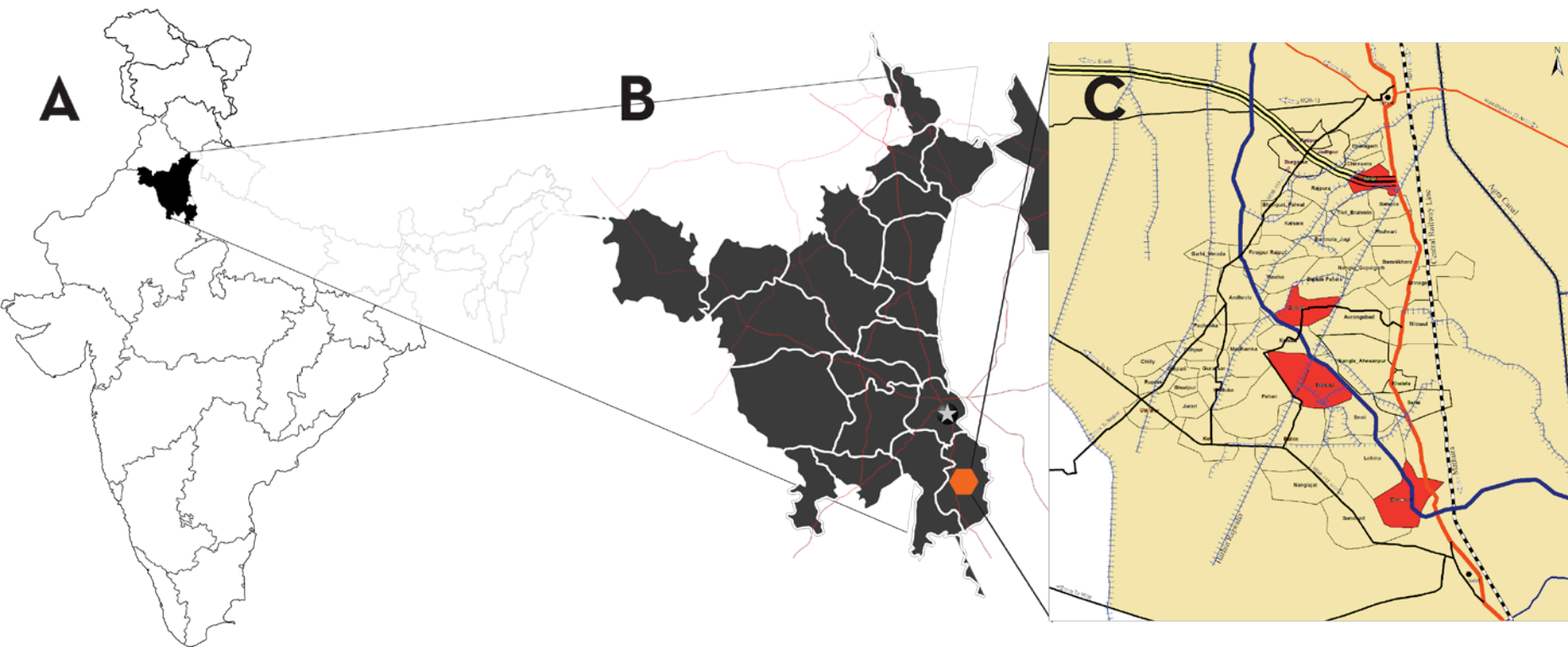
**Figure 1.** Percentage of population-weighted ambient PM<sub>2.5</sub> attributable to household cooking with solid fuels, 1990 (A) and 2010 (B).

# EPA Star Grant

1. Estimate contribution of household sources to both primary and secondary PM in North India
  - Field sampling: emissions and ambient
    - Rufus Edwards, UCI
  - Lab analysis: Donald Blake, UCI
  - Atmospheric modeling: John Seinfeld, CalTech
2. Measure village PM pollution and estimate contribution to exposures
3. Intervene with “clean village” - not EPA funded

# Longer-term Goals

- Add environmental health measurements to existing Health and Demographic Surveillance Sites (HDSS)
- Develop human capacity in India to design, conduct, analyze, publish, and policize environmental health studies
- Thus, all work in the EPA Star is in a new HDSS: SOMAARTH
- Even though capacity building is slow



## **International Clinical Epidemiology Network (INCLIN)**

SOMAARTH surveillance site

Palwal District • 51 villages • 200,000+ people

77% use biomass • 94% gather fuel

Nearly universal outdoor cooking











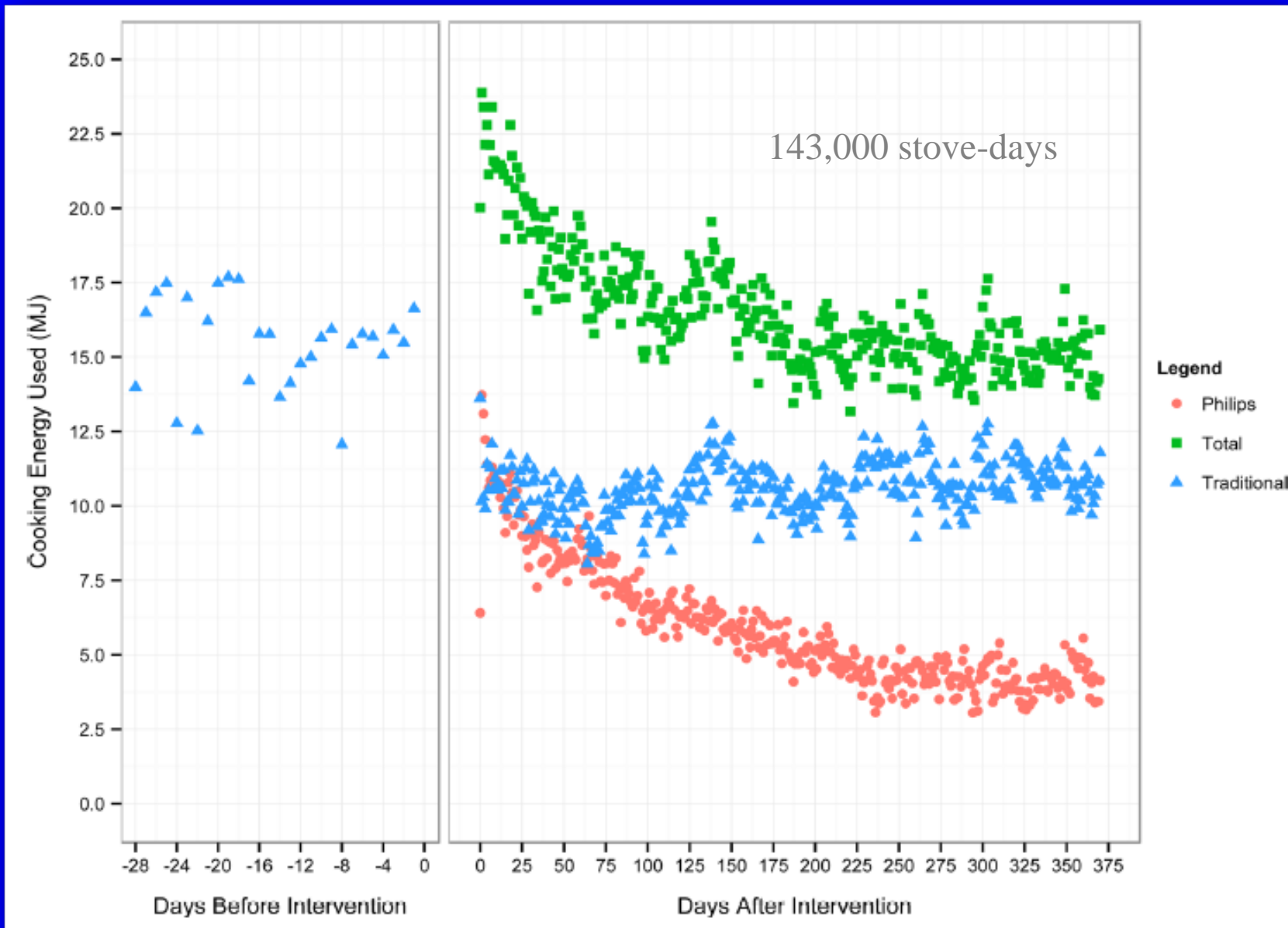


18

GOLD ZINNE

**Warning!** **Brand!** **Logo!**

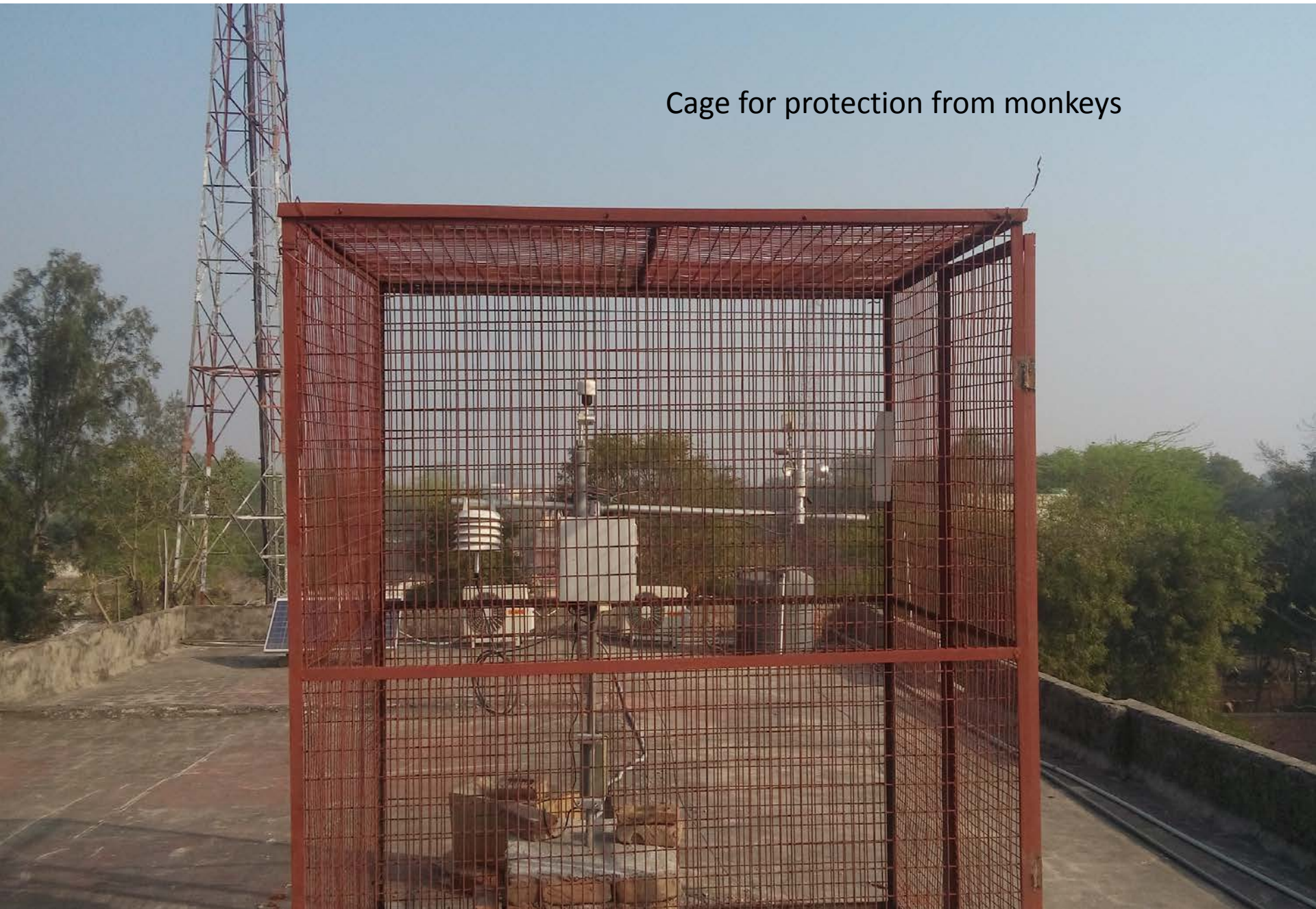
Use in accordance with  
instructions for correct operation.  
Use only with parts & app. approved by  
the manufacturer. **Do not** use for  
any other purpose. **Do not** use for  
any other purpose. **Do not** use for  
any other purpose.



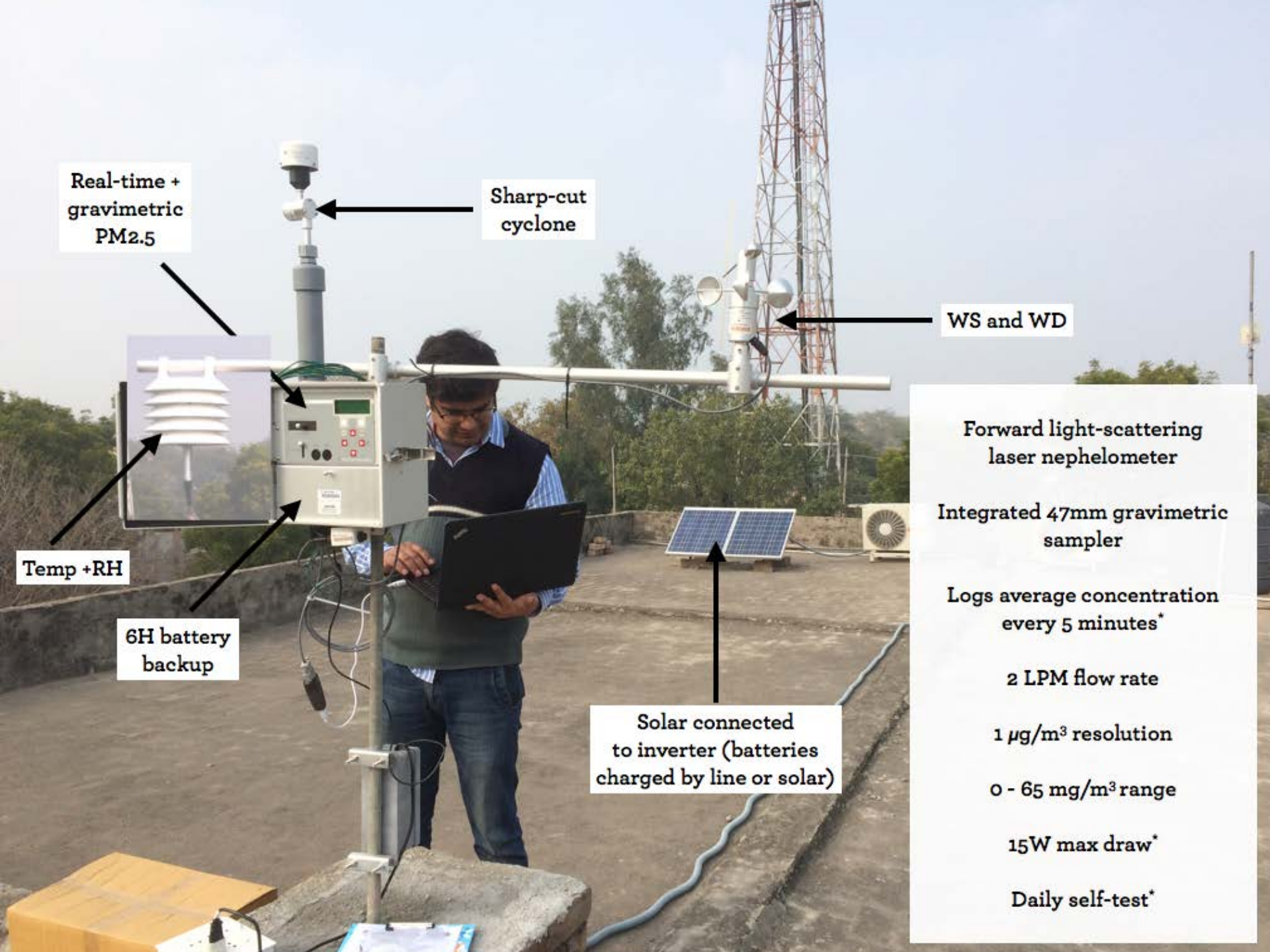
# INCLEN HQ



Cage for protection from monkeys







Real-time +  
gravimetric  
PM<sub>2.5</sub>

Sharp-cut  
cyclone

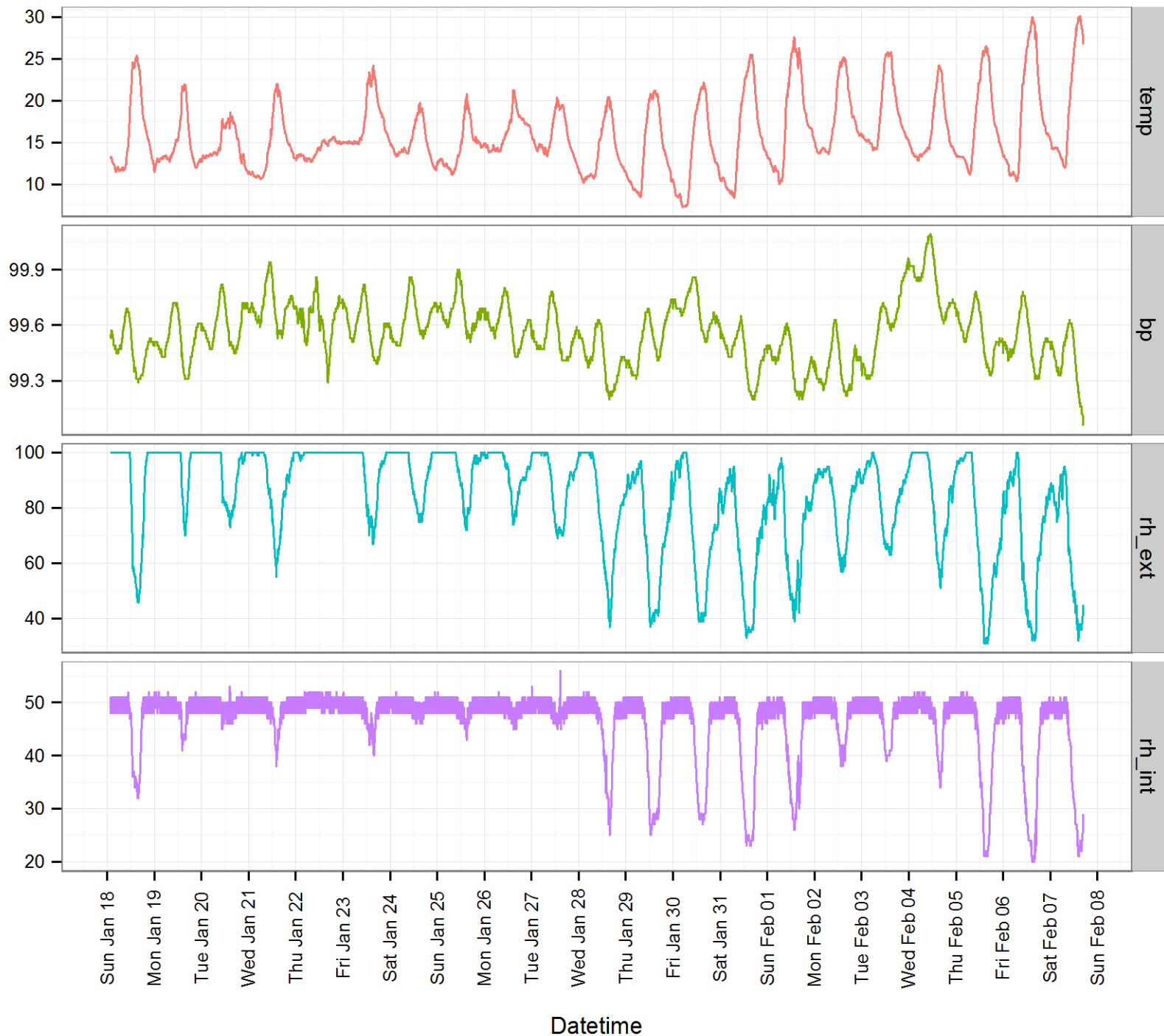
WS and WD

Temp +RH

6H battery  
backup

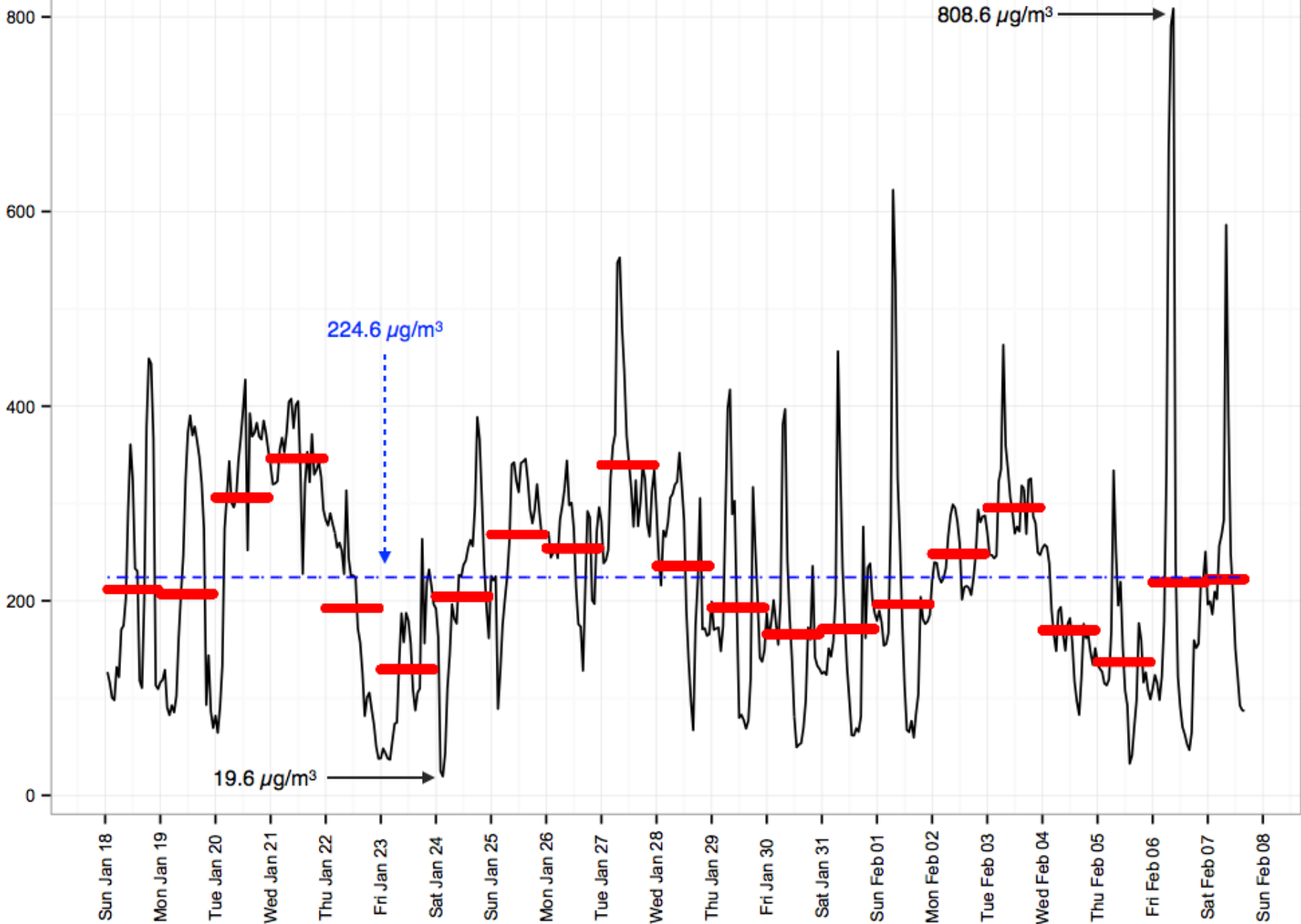
Solar connected  
to inverter (batteries  
charged by line or solar)

- Forward light-scattering  
laser nephelometer
- Integrated 47mm gravimetric  
sampler
- Logs average concentration  
every 5 minutes\*
- 2 LPM flow rate
- 1  $\mu\text{g}/\text{m}^3$  resolution
- 0 - 65  $\text{mg}/\text{m}^3$  range
- 15W max draw\*
- Daily self-test\*



# Hourly Mean PM<sub>2.5</sub> Concentrations

Unadjusted Hourly Mean PM<sub>2.5</sub> ( $\mu\text{g}/\text{m}^3$ )



Datetime

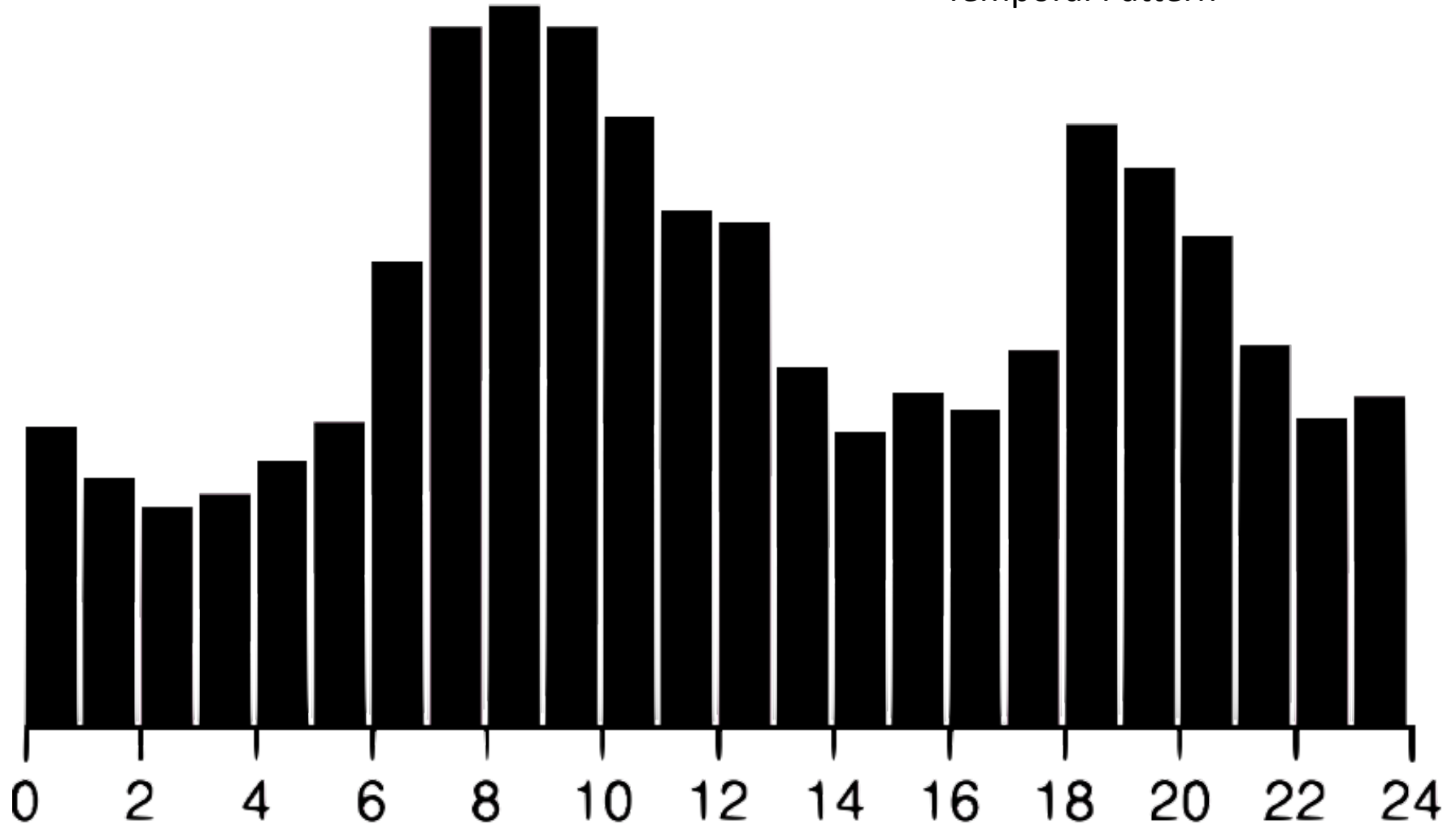
## Daily PM<sub>2.5</sub> Summary Statistics

Date	Min	Median	Mean	SD	Max
	$\mu\text{g}/\text{m}^3$				
2015-01-17	40	166	217.1	122.3	564
2015-01-18	77	157	211.7	121.6	543
2015-01-19	61	153	207	123.7	458
2015-01-20	53	343.5	310.4	111.3	482
2015-01-21	96	345	347.5	46.9	485
2015-01-22	27	220	192.4	87.8	440
2015-01-23	21	112	129.5	81.8	710
2015-01-24	11	206	204.3	95.6	491
2015-01-25	60	281.5	268.2	74.5	416
2015-01-26	107	260	254	58.8	429
2015-01-27	104	319	340.7	91.4	650
2015-01-28	18	243	236.6	83.3	394
2015-01-29	62	166.5	192.8	104.7	582
2015-01-30	43	155	165.8	93.2	514
2015-01-31	53	148	171	100.7	628
2015-02-01	52	167	196.4	156.5	1025
2015-02-02	176	247	248.2	37.8	341
2015-02-03	216	276	295.8	61.4	582
2015-02-04	74	164	169.8	50.4	301
2015-02-05	22	121	137.1	72.8	692
2015-02-06	29	131.5	220.4	234.6	1168
2015-02-07	73	203	222.2	127.9	772

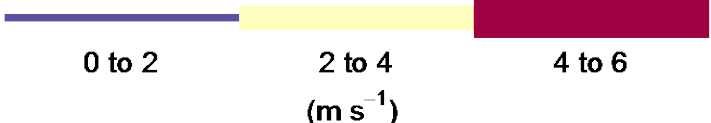
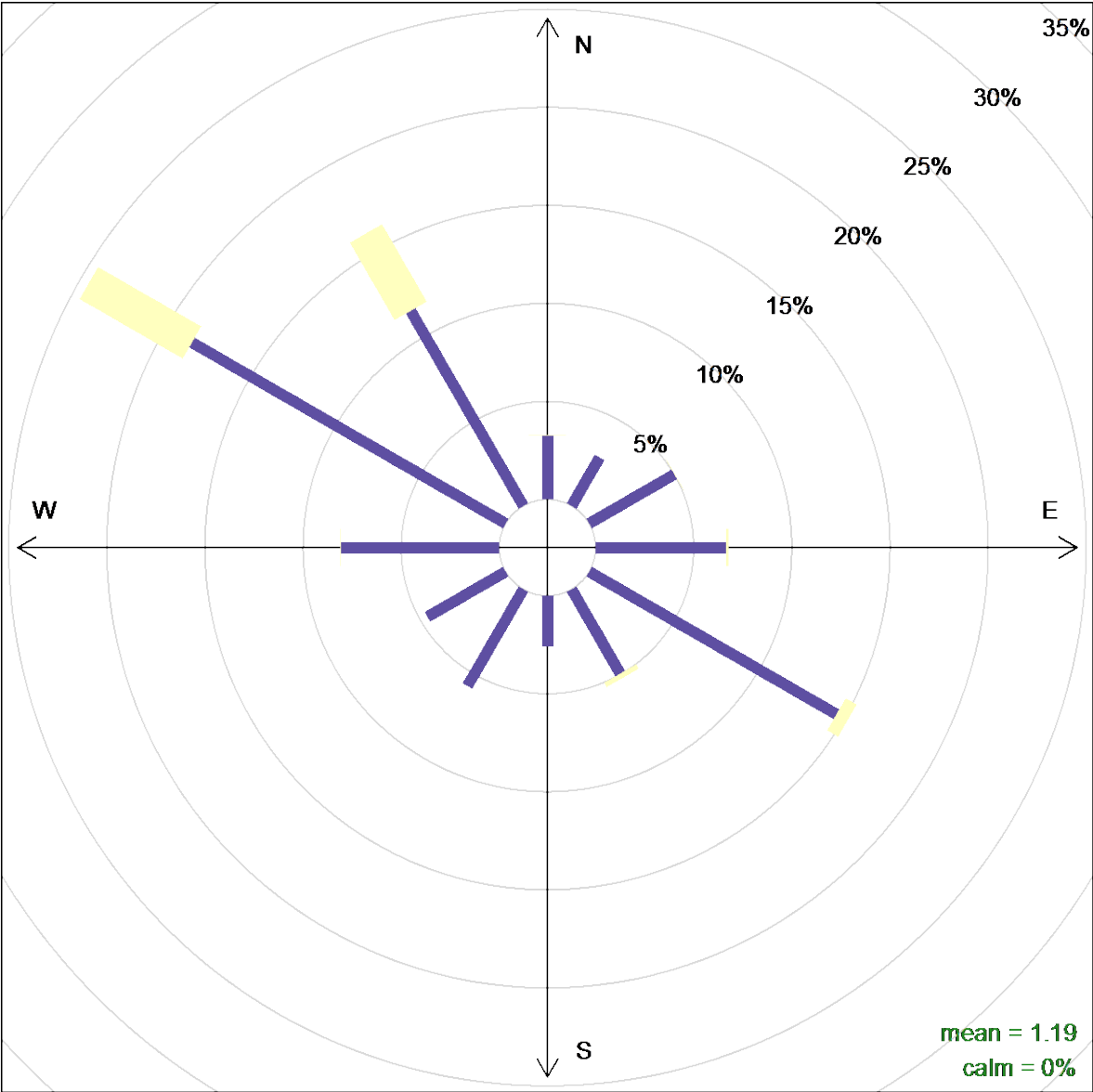
# Ambient PM<sub>2.5</sub> Concentrations

(PM > 250  $\mu\text{g}/\text{m}^3$ )

Temporal Pattern



~ 6000 datapoints



Frequency of counts by wind direction (%)



**Primary Village**



# Secondary Village









# Aerial Particle and Temperature Sensor

- (Drone plus PATS+)
- Aerial PATS+ or aPATS



DJI Phantom 1.1.1

~500 USD

GPS + Compass

7 minute flight time

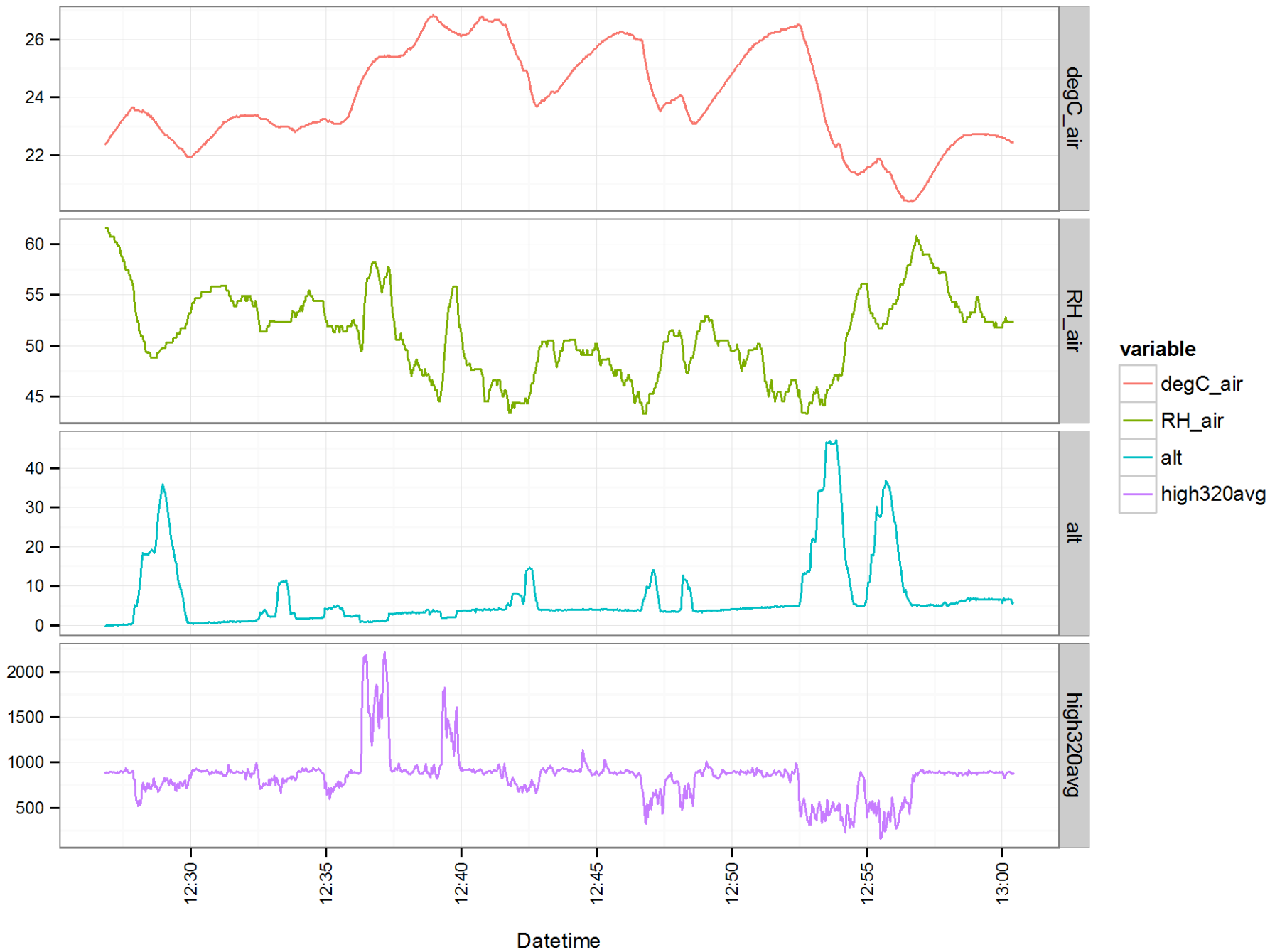
Built in flight-controller  
with gyroscope

Auto home feature











# PATS+

- Second major low-cost portable particle monitor for HAP developed in 15 years in Berkeley among several groups:
  - School of Public Health,
  - Electronically Monitored Ecosystems,
  - Berkeley Air Monitoring Group
- With funding from several sources, but most recently from SBIR-DOE
- Lab assessment completed successfully, field validation just finished in Laos

Sharp GP2Y1010AU0F

Commodity item

\$12 - \$20 USD

Little previous systematic  
characterization

46.0 × 30.0 × 17.6 mm

LED-based light-scattering  
chamber

Adjustments provide  
extended measurable range





Compared to UCB-Classic

New sensing unit: range now  
~10  $\mu\text{g}/\text{m}^3$  to 65  $\text{mg}/\text{m}^3$ ;

baseline more stable

--Better software and data  
management

--Better power management

--Smaller

--Price not yet determined

Power options: Li-ion, AA,  
AAA

Extensible: 2 toxic gas  
sensors, additional PM, or  
other digital sensors

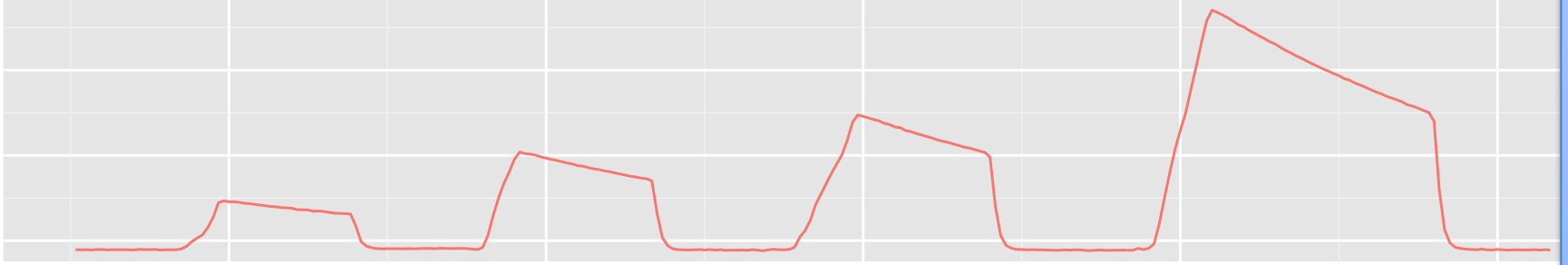
Multiple PATS+ units:  
low, medium, high sensitivity

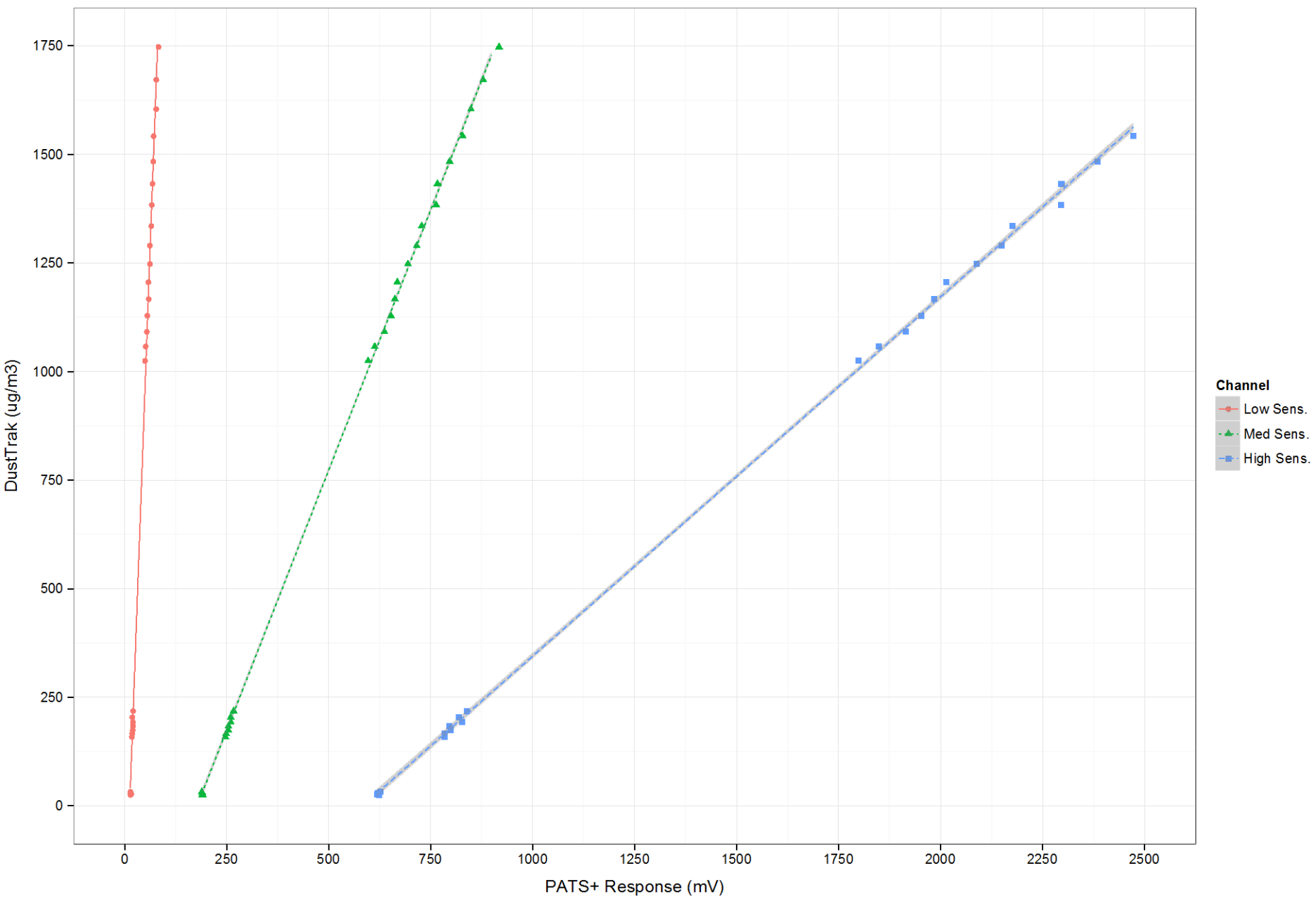
Woodsmoke challenges at  
varying concentrations in  
stainless steel combustion  
chamber

DustTrak + gravimetric



# Lab





**PM<sub>2.5</sub> Mass  
Coefficients**  
(mg/m<sup>3</sup>)/mV

3.7

5.53

# Parallel Development

- Place system of rural ambient air pollution monitors in India to inform both AAP and HAP management and studies of health impacts
- Site first in existing Health and Demographic Surveillance sites, such as SOMAARTH
- Health, economic, and demographic data already being taken routinely with data management systems in place





**HOUSEHOLD ENERGY, HEALTH, & CLIMATE RESEARCH GROUP**

UNIVERSITY OF CALIFORNIA, BERKELEY

Additional results from

**ENVIRONMENTAL**  
Science & Technology

Article

[pubs.acs.org/e](https://pubs.acs.org/e)

## Patterns of Stove Usage after Introduction of an Advanced Cookstove: The Long-Term Application of Household Sensors

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