Household/Outdoor Pollution in India: EPA STAR Grant

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UC Berkeley

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

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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

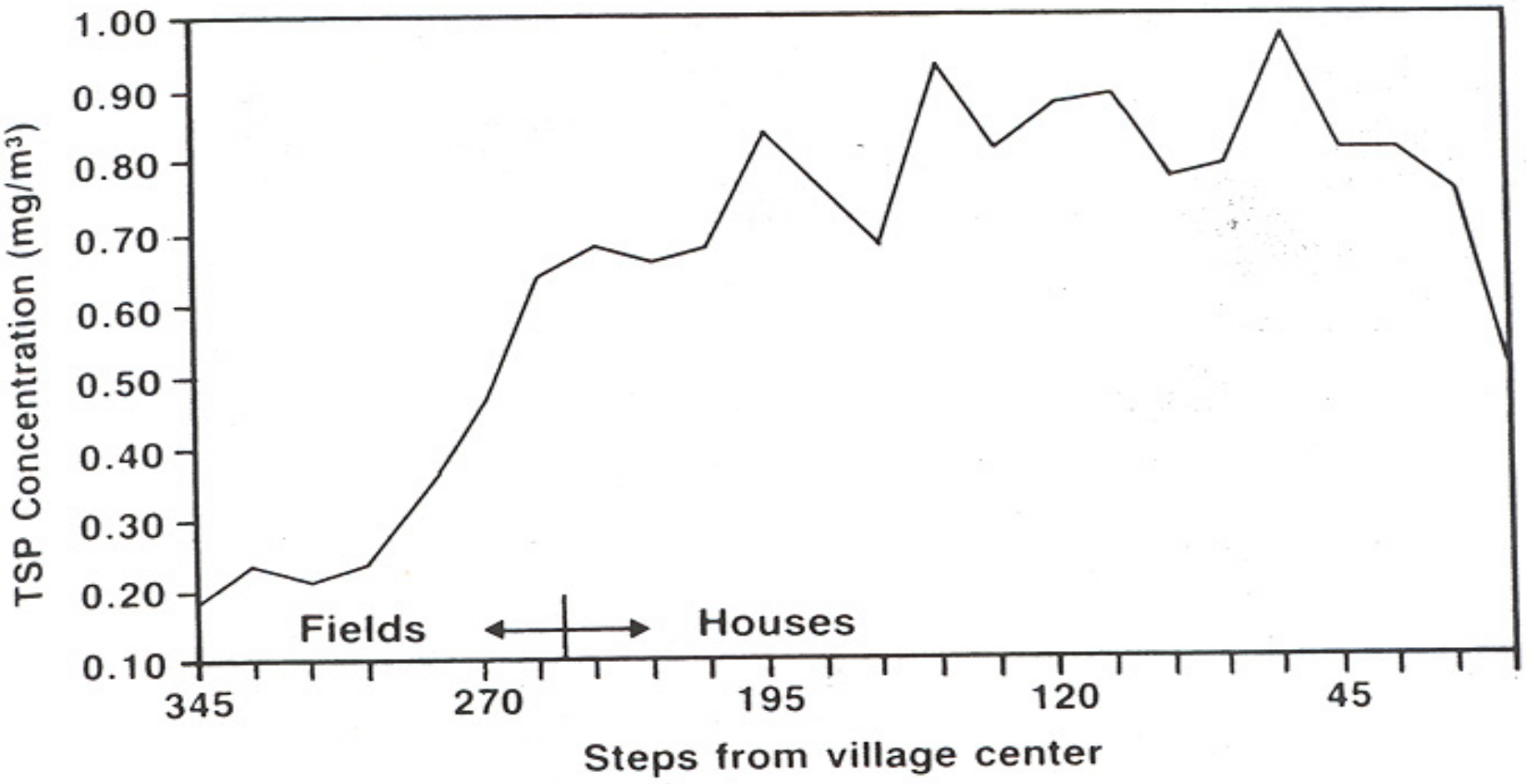
Table 5. TSP and BaP measurements: ambient levels

Village	Height (m)	Time at start	Duration (minutes)	TSP 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.

Smith, et al., 1983

Neighborhood Pollution in an Indian Village



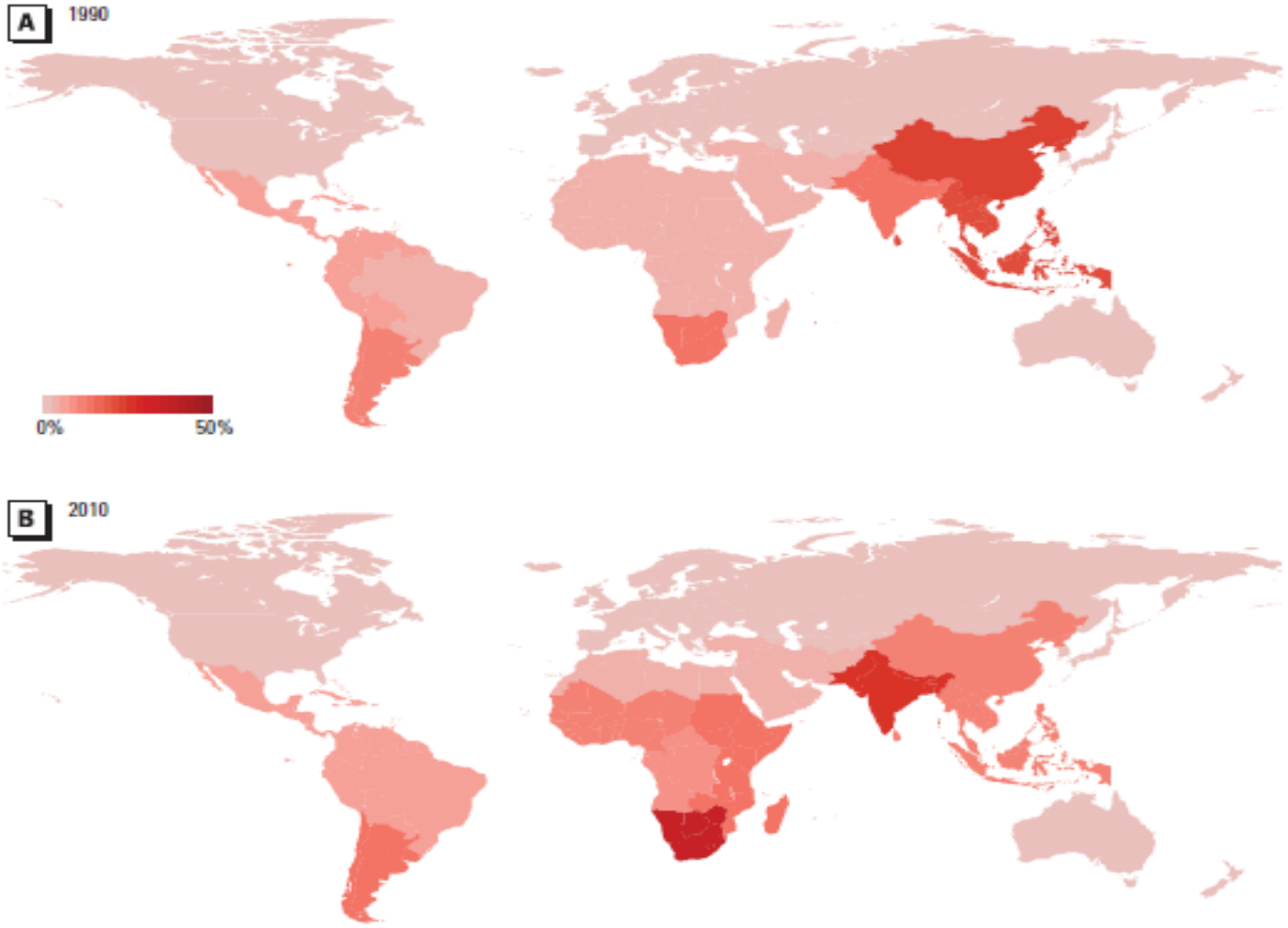


Figure 1. Percentage of population-weighted ambient $PM_{2.5}$ attributable to household cooking with solid fuels, 1990 (*A*) and 2010 (*B*).

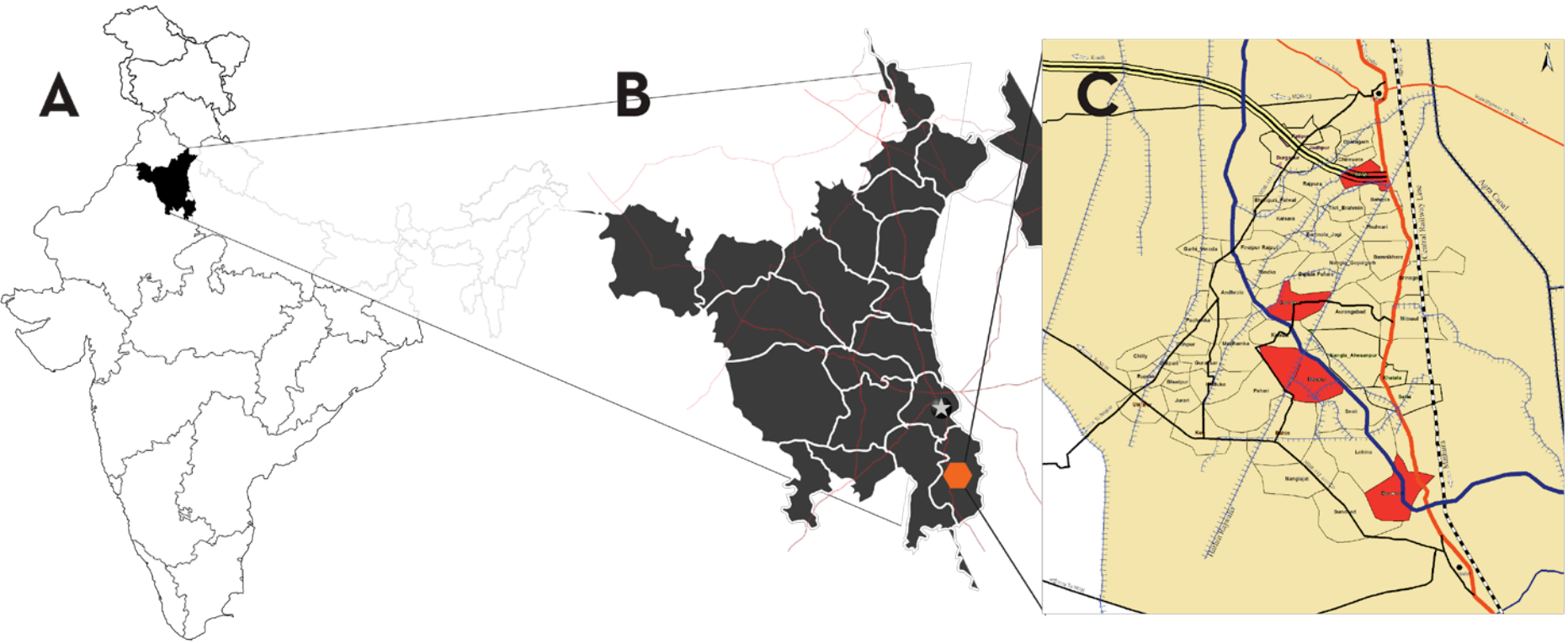
Chafe et al.

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



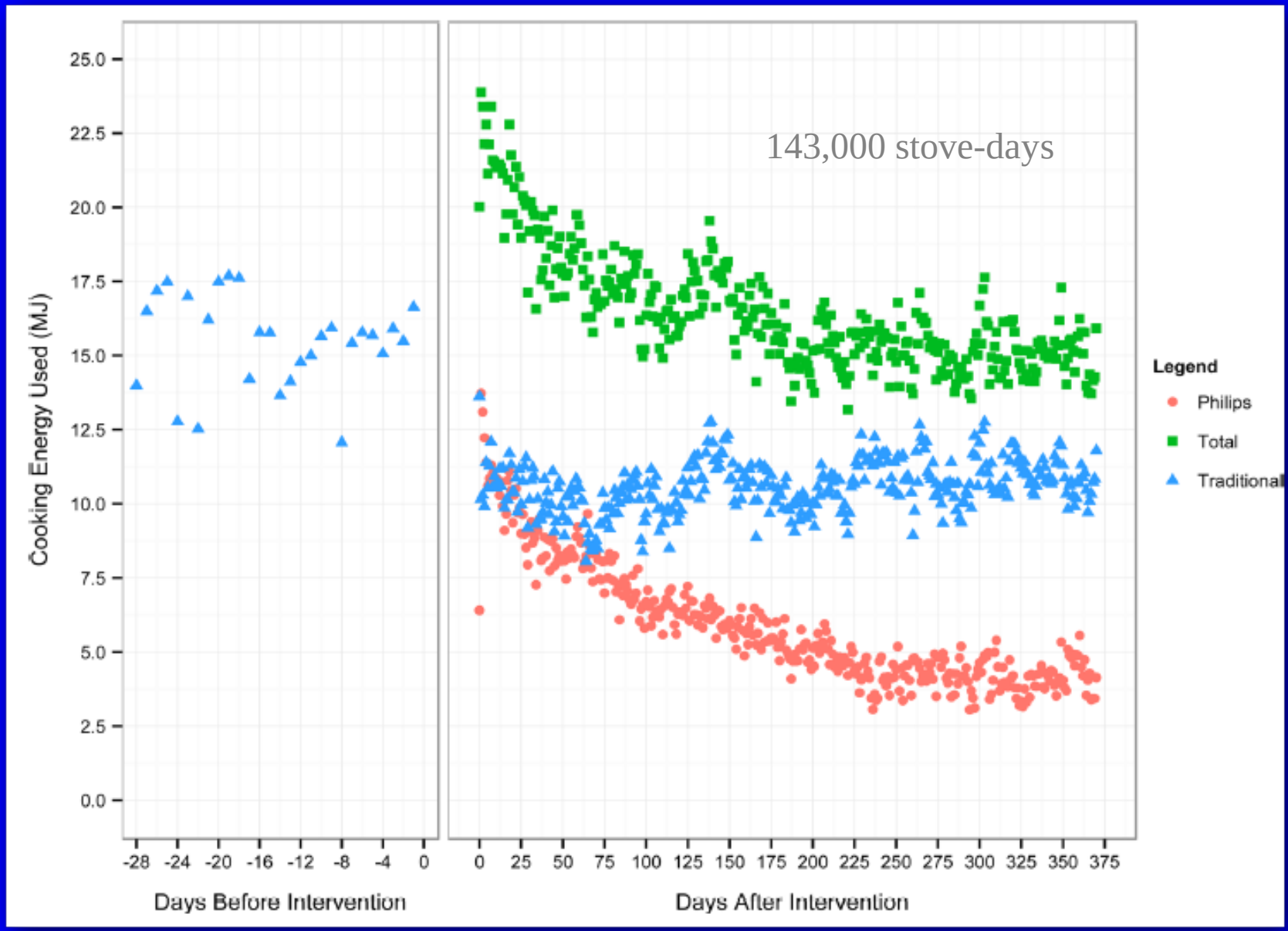
International Clinical Epidemiology Network (INCLEN)

SOMAARTH surveillance site

Palwal District • 51 villages • 200,000+ people

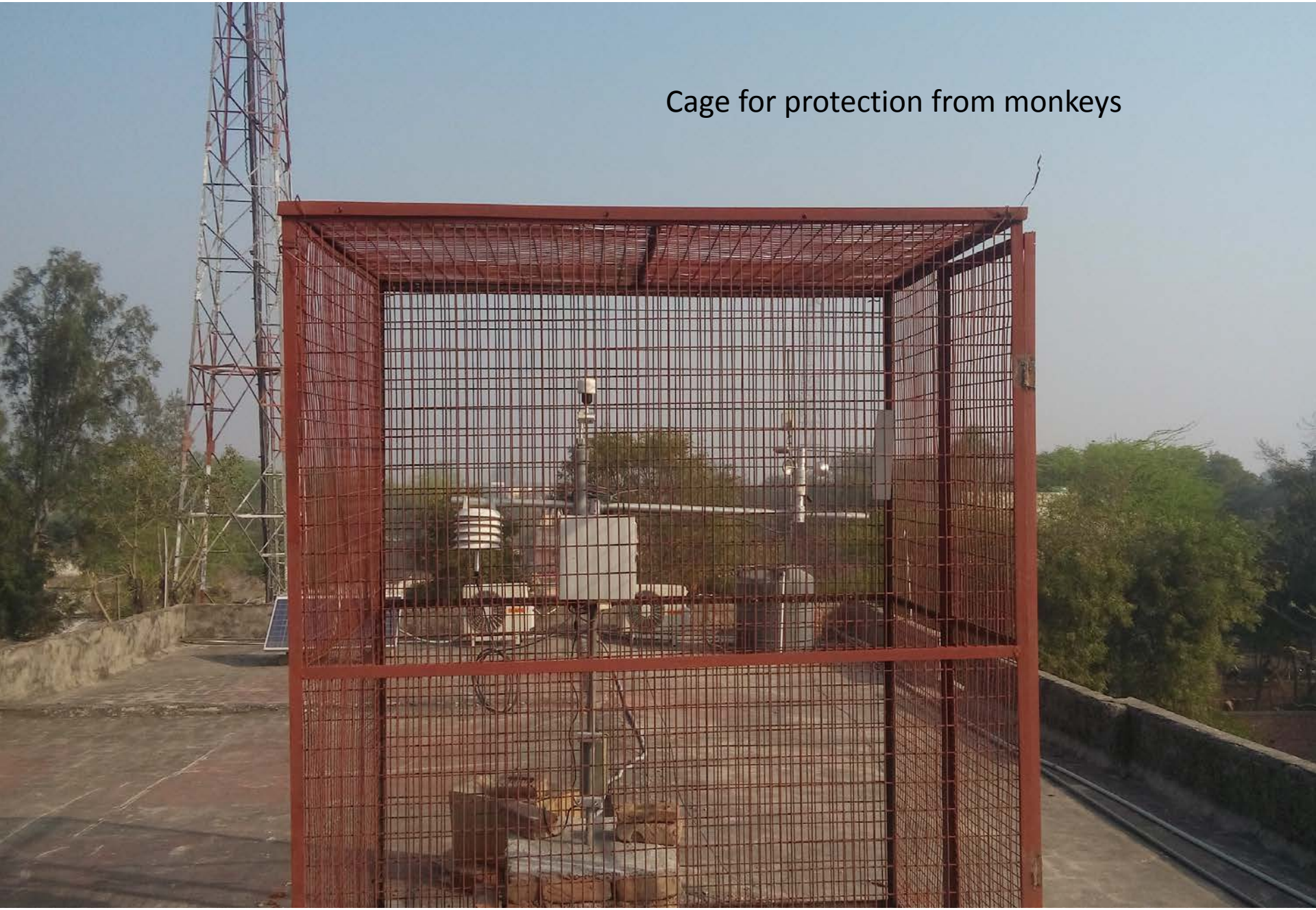
77% use biomass • 94% gather fuel

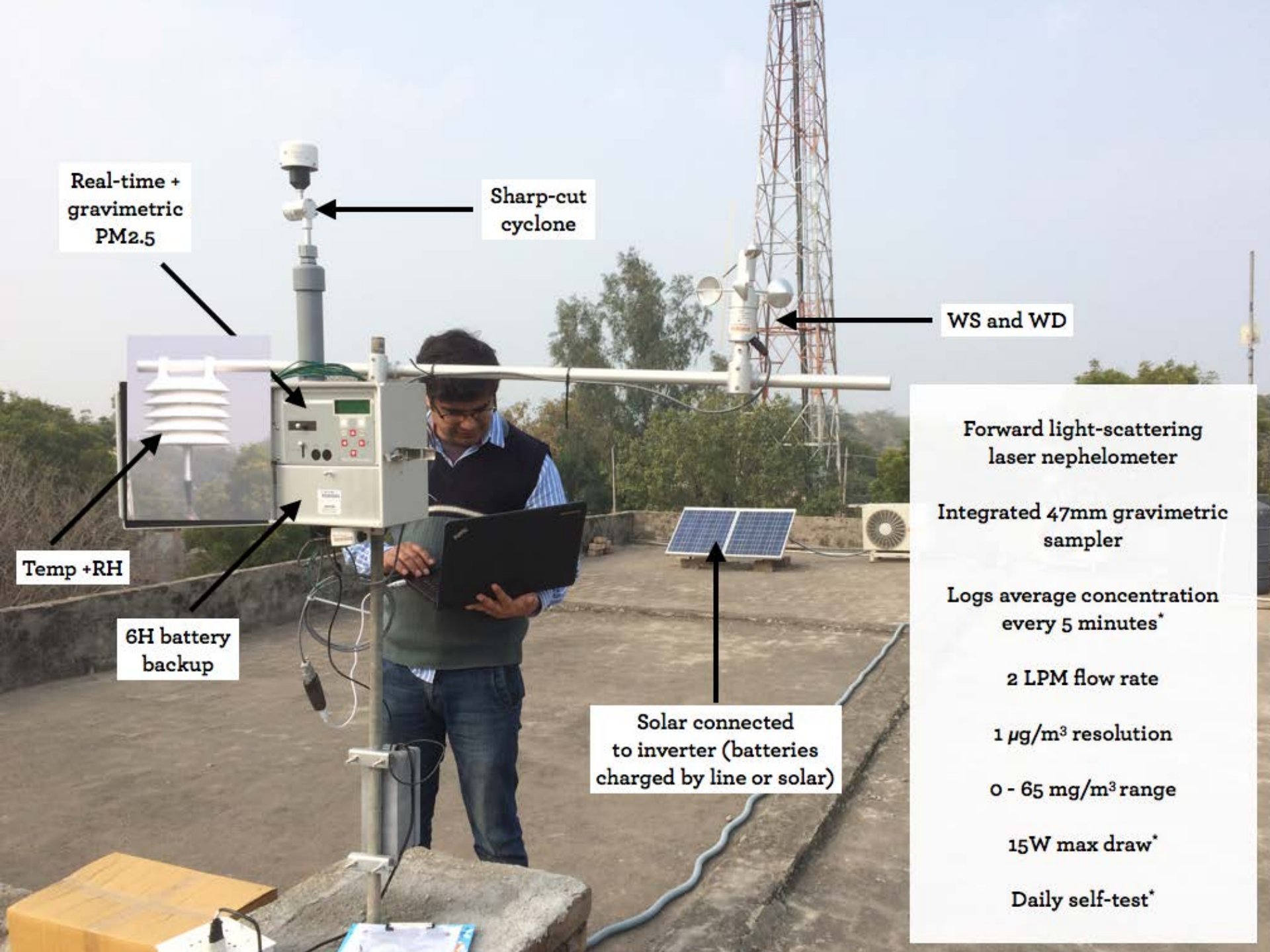
Nearly universal outdoor cooking

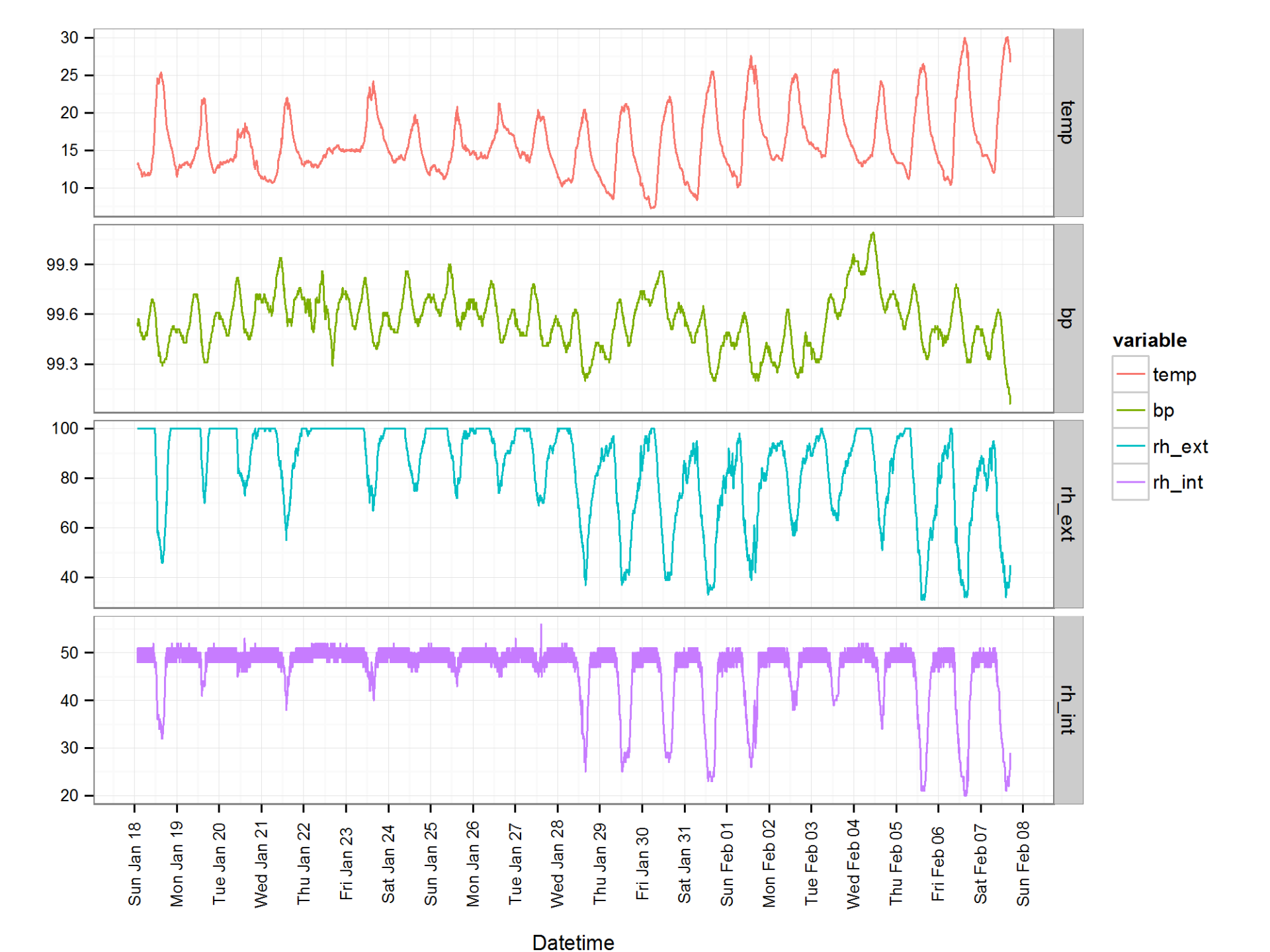


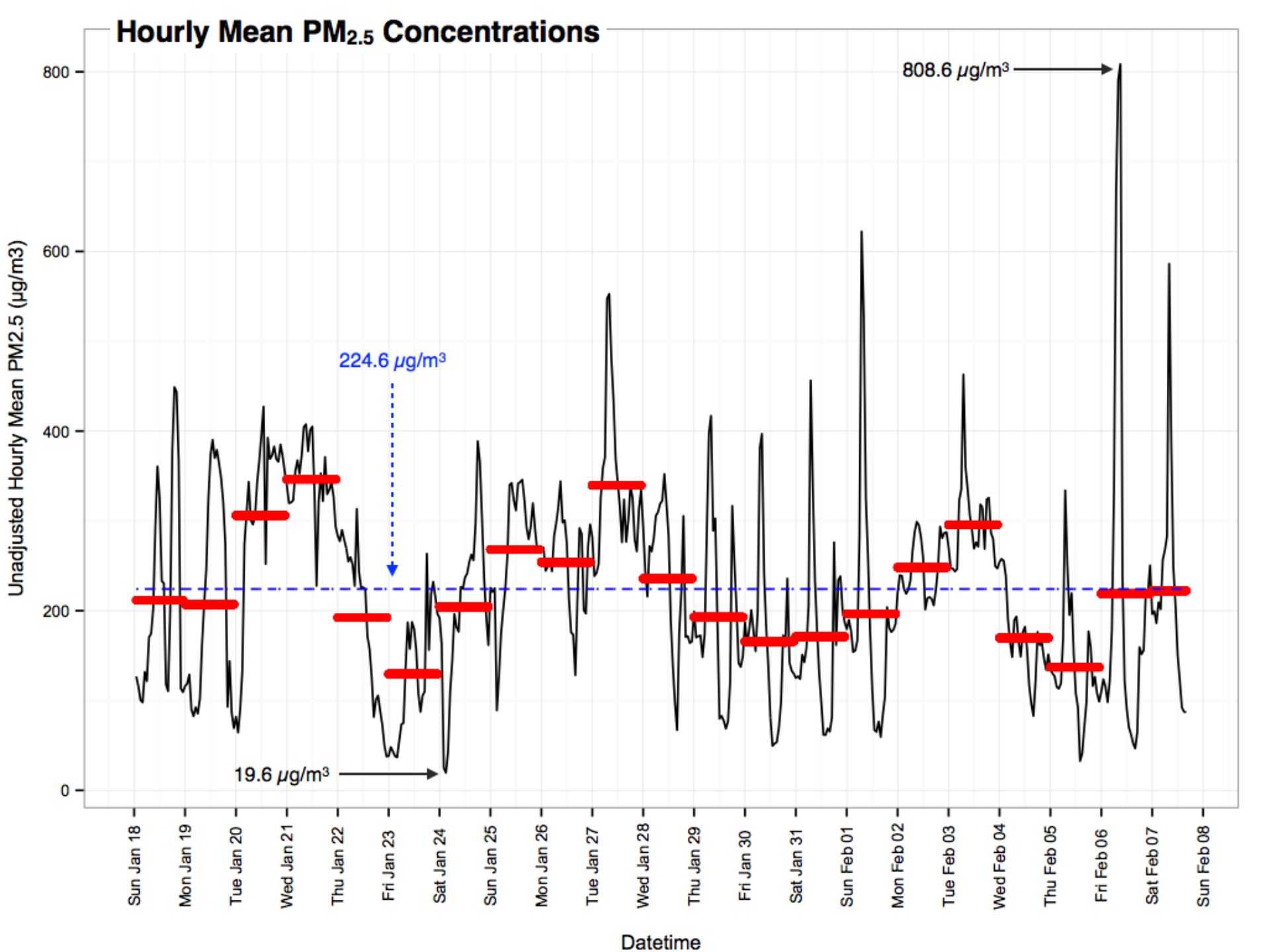
Pillarisetti, et al., EST, 2104


INCLEN HQ


Cage for protection from monkeys


Real-time + gravimetric PM2.5
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 μg/m³ resolution
0 - 65 mg/m³ range
15W max draw*
Daily self-test*


temp
bp
rh_ext
rh_int
30
25
20
15
10
99.9
99.6
99.3
100
80
60
40
50
40
30
20
Sun Jan 18
Mon Jan 19
Tue Jan 20
Wed Jan 21
Thu Jan 22
Fri Jan 23
Sat Jan 24
Sun Jan 25
Mon Jan 26
Tue Jan 27
Wed Jan 28
Thu Jan 29
Fri Jan 30
Sat Jan 31
Sun Feb 01
Mon Feb 02
Tue Feb 03
Wed Feb 04
Thu Feb 05
Fri Feb 06
Sat Feb 07
Sun Feb 08
Datetime
variable
temp
bp
rh_ext
rh_int


Hourly Mean PM2.5 Concentrations
808.6 µg/m3
224.6 µg/m3
19.6 µg/m3
Unadjusted Hourly Mean PM2.5 (µg/m3)
0
200
400
600
800
Sun Jan 18
Mon Jan 19
Tue Jan 20
Wed Jan 21
Thu Jan 22
Fri Jan 23
Sat Jan 24
Sun Jan 25
Mon Jan 26
Tue Jan 27
Wed Jan 28
Thu Jan 29
Fri Jan 30
Sat Jan 31
Sun Feb 01
Mon Feb 02
Tue Feb 03
Wed Feb 04
Thu Feb 05
Fri Feb 06
Sat Feb 07
Sun Feb 08
Datetime

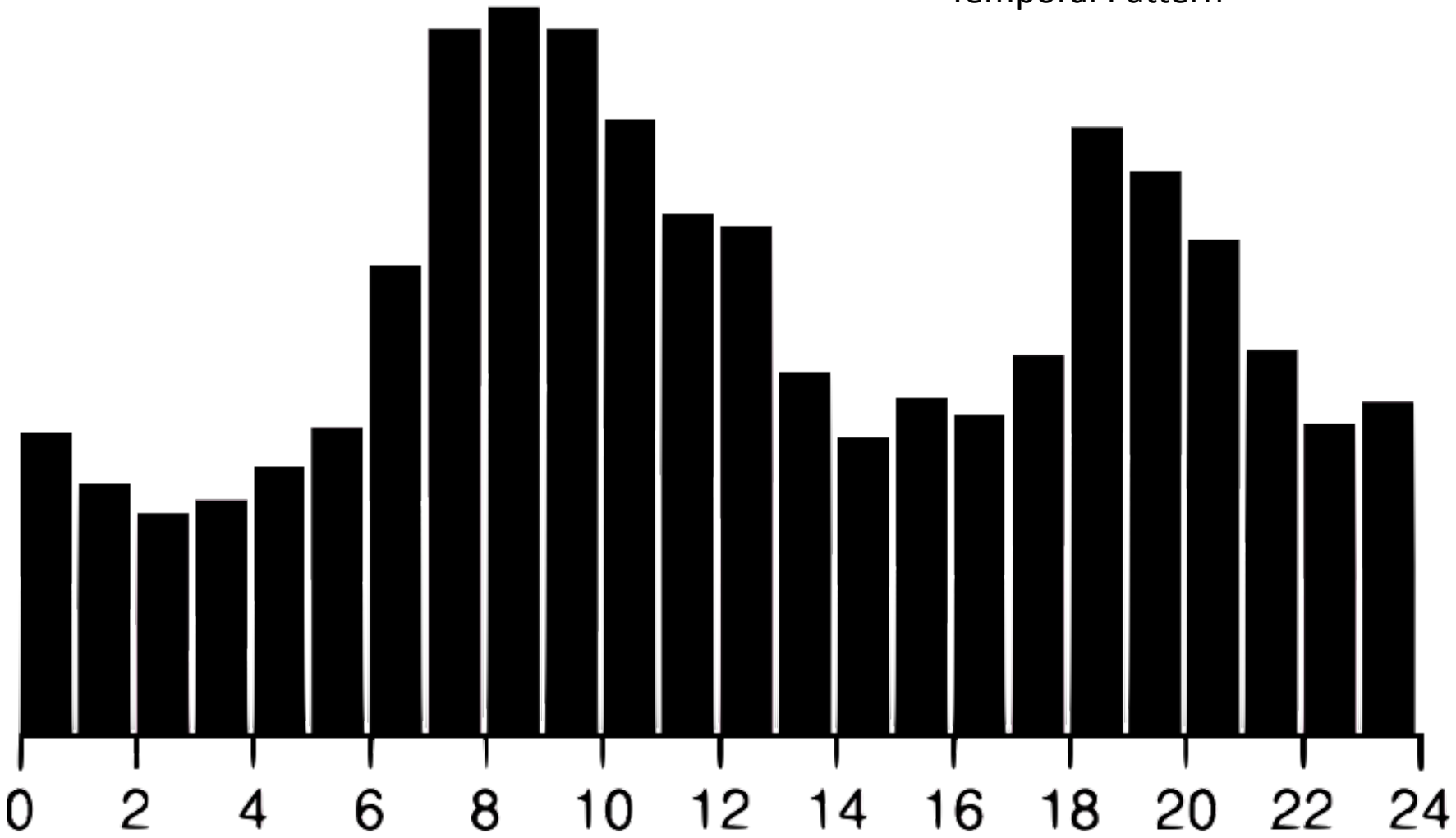
Daily $PM_{2.5}$ Summary Statistics

Date	Min	Median	Mean	SD	Max
			$\mu g/m^3$		
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

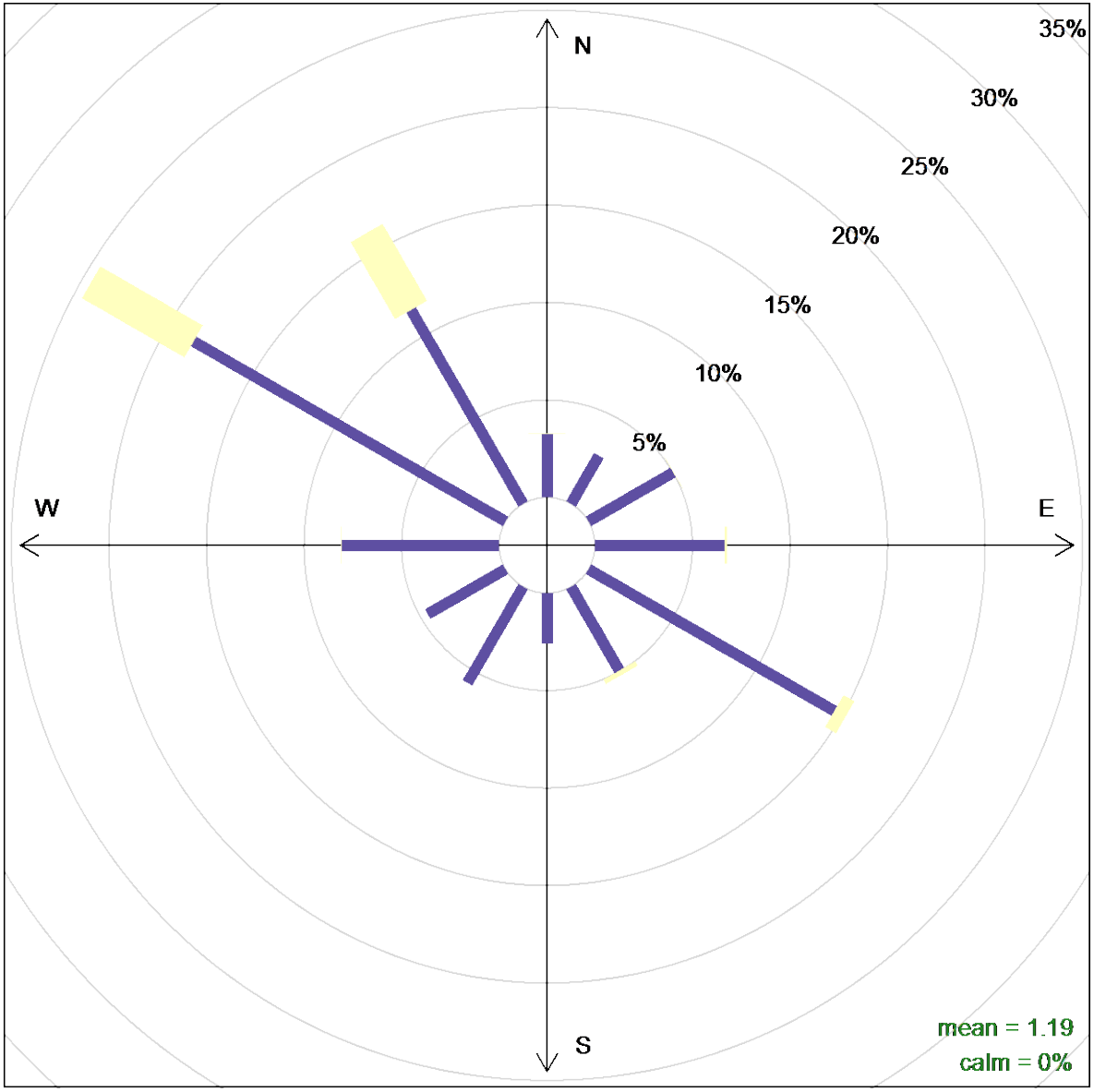
Ambient $PM_{2.5}$ Concentrations

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

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

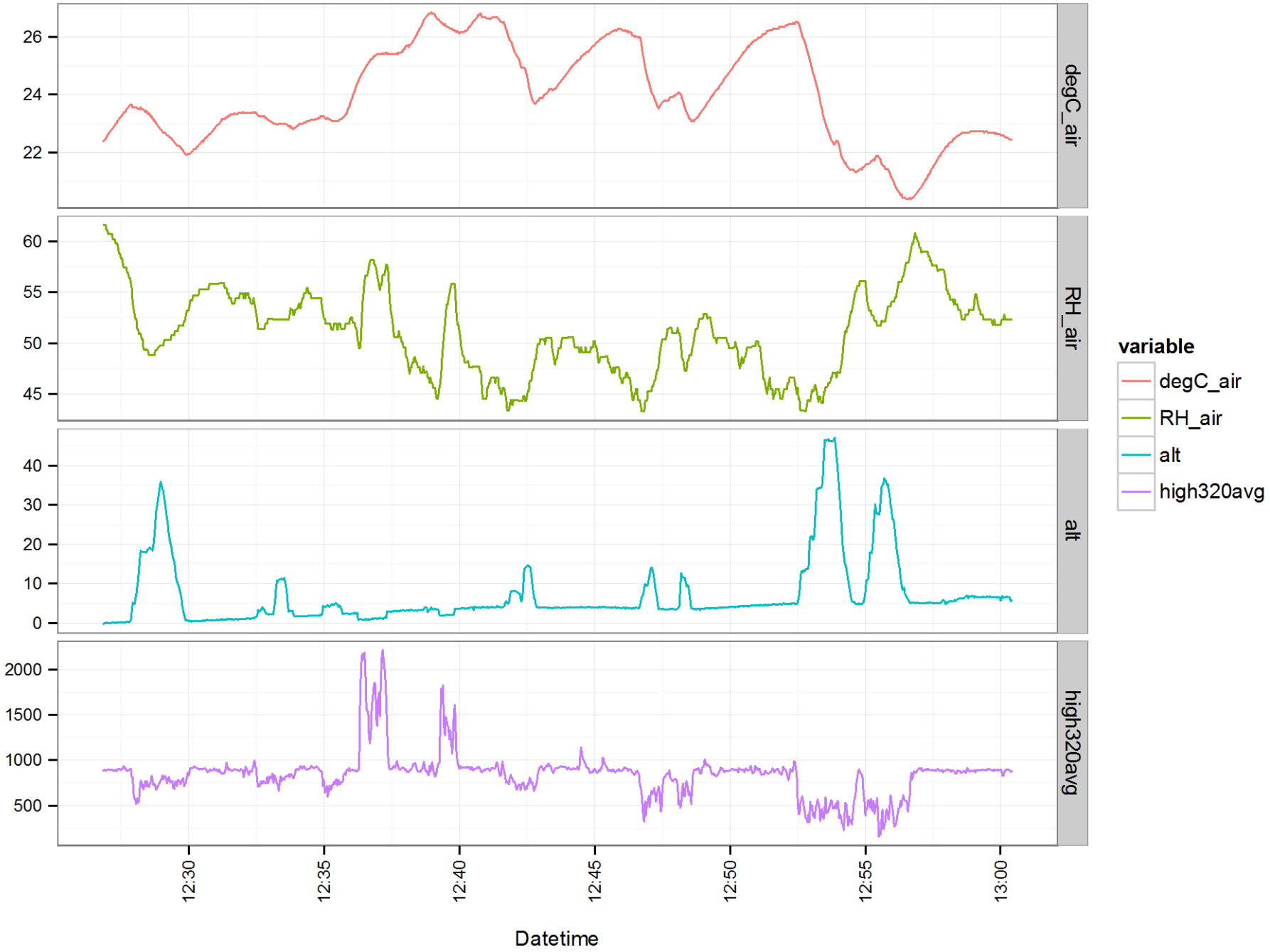
GPS + Compass

Built in flight-controller with gyroscope

~500 USD

7 minute flight time

Auto home feature


26
24
22
degC_air
60
55
50
45
RH_air
40
30
20
10
0
alt
2000
1500
1000
500
high320avg
12:30
12:35
12:40
12:45
12:50
12:55
13:00
Datetime
variable
degC_air
RH_air
alt
high320avg

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 ug/m3 to 65 mg/m3; baseline more stable

--Better software and data management

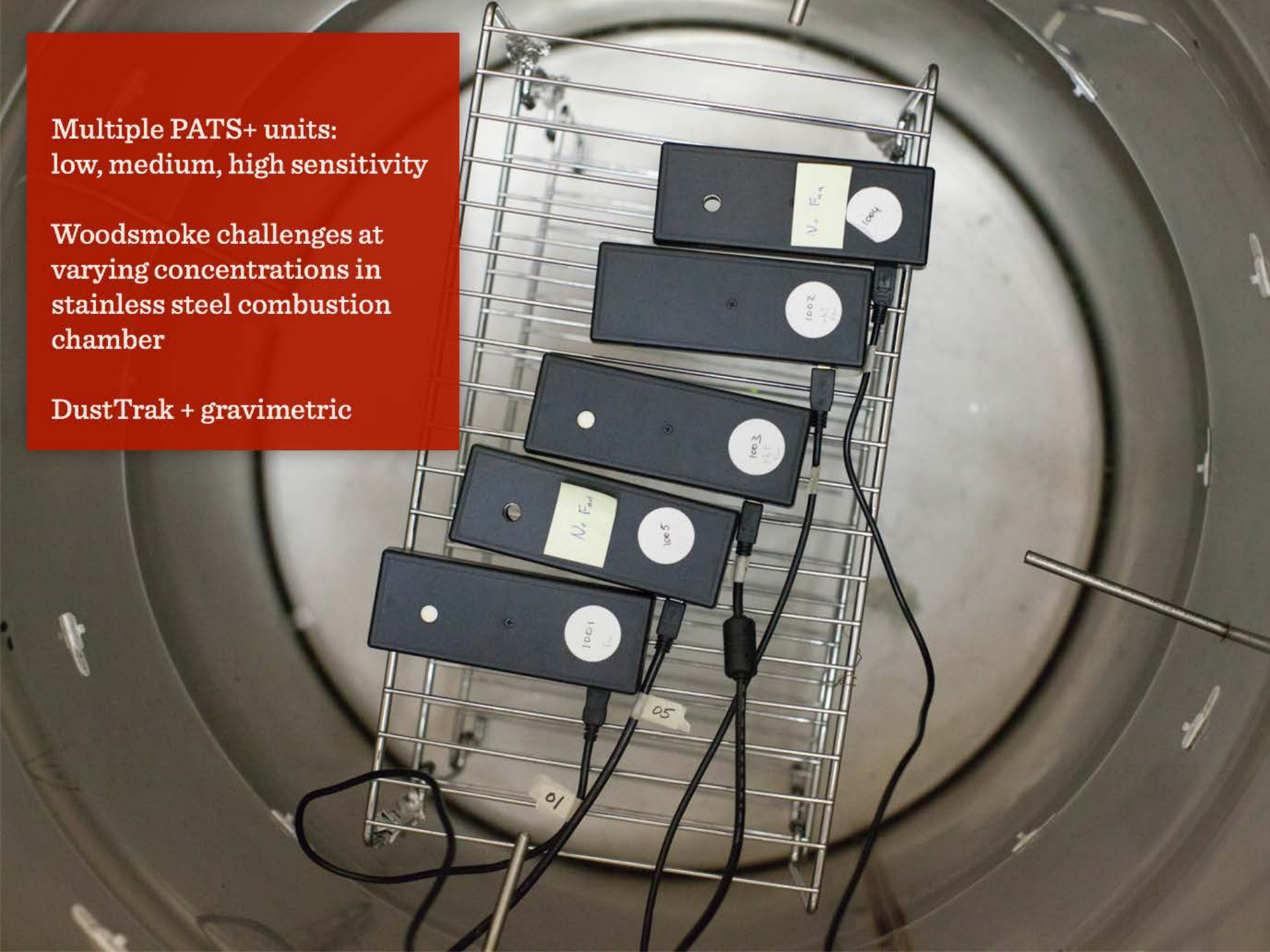
--Better power management

--Smaller

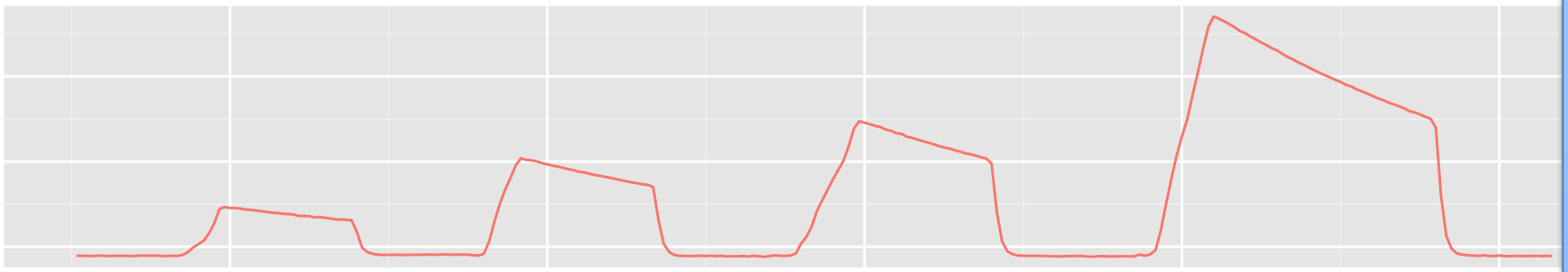
--Price not yet determined

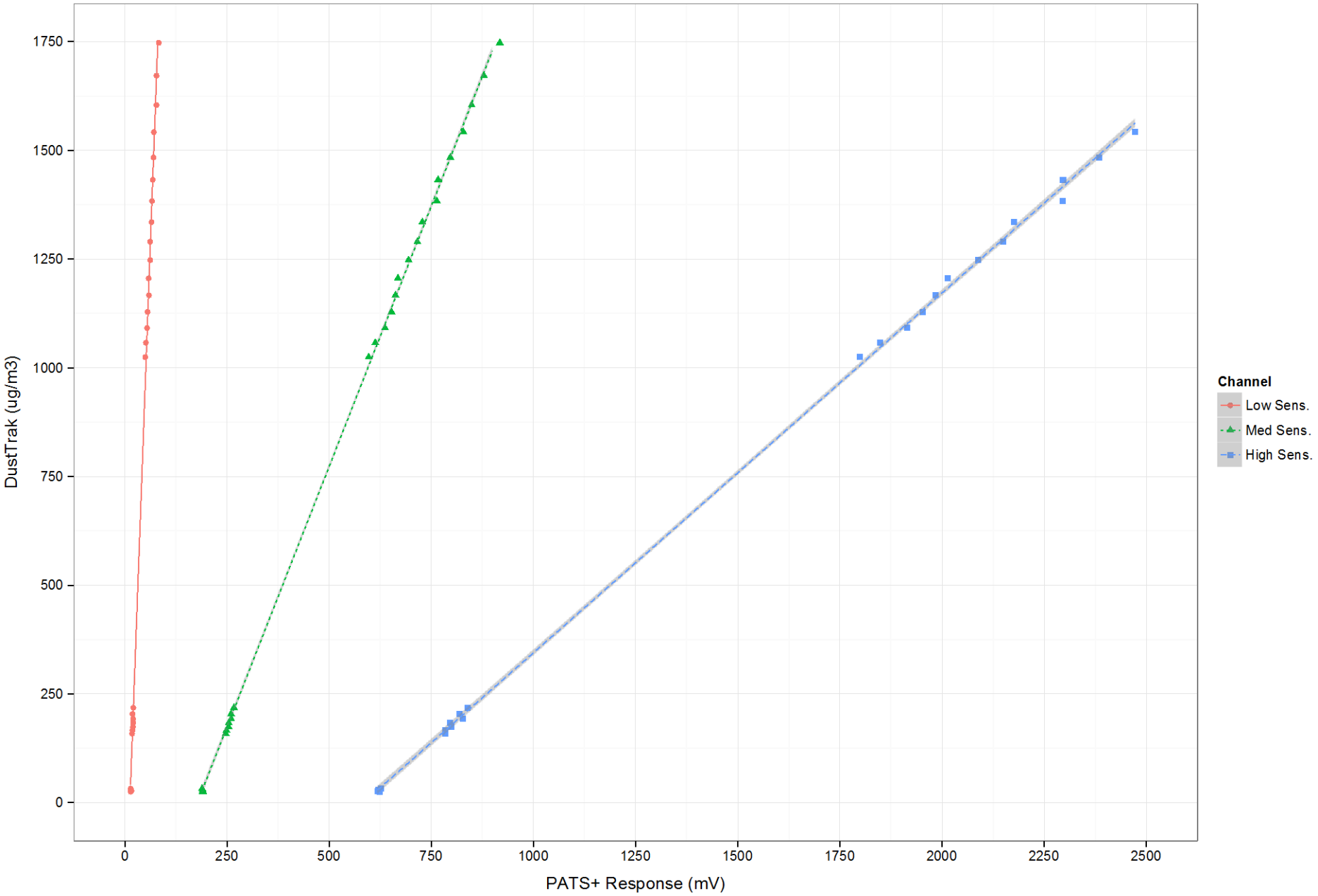
Power options: Li-ion, AA, AAA

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




DustTrak (ug/m3)
1750
1500
1250
1000
750
500
250
0
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
PATS+ Response (mV)
Channel
Low Sens.
Med Sens.
High Sens.

$PM_{2.5}$ Mass Coefficients (mg/m³)/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

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

Ajay Pillarisetti,*,† Mayur Vaswani,‡ Darby Jack,§ Kalpana Balakrishnan,∥ Michael N. Bates,† Narendra K. Arora,‡ and Kirk R. Smith†

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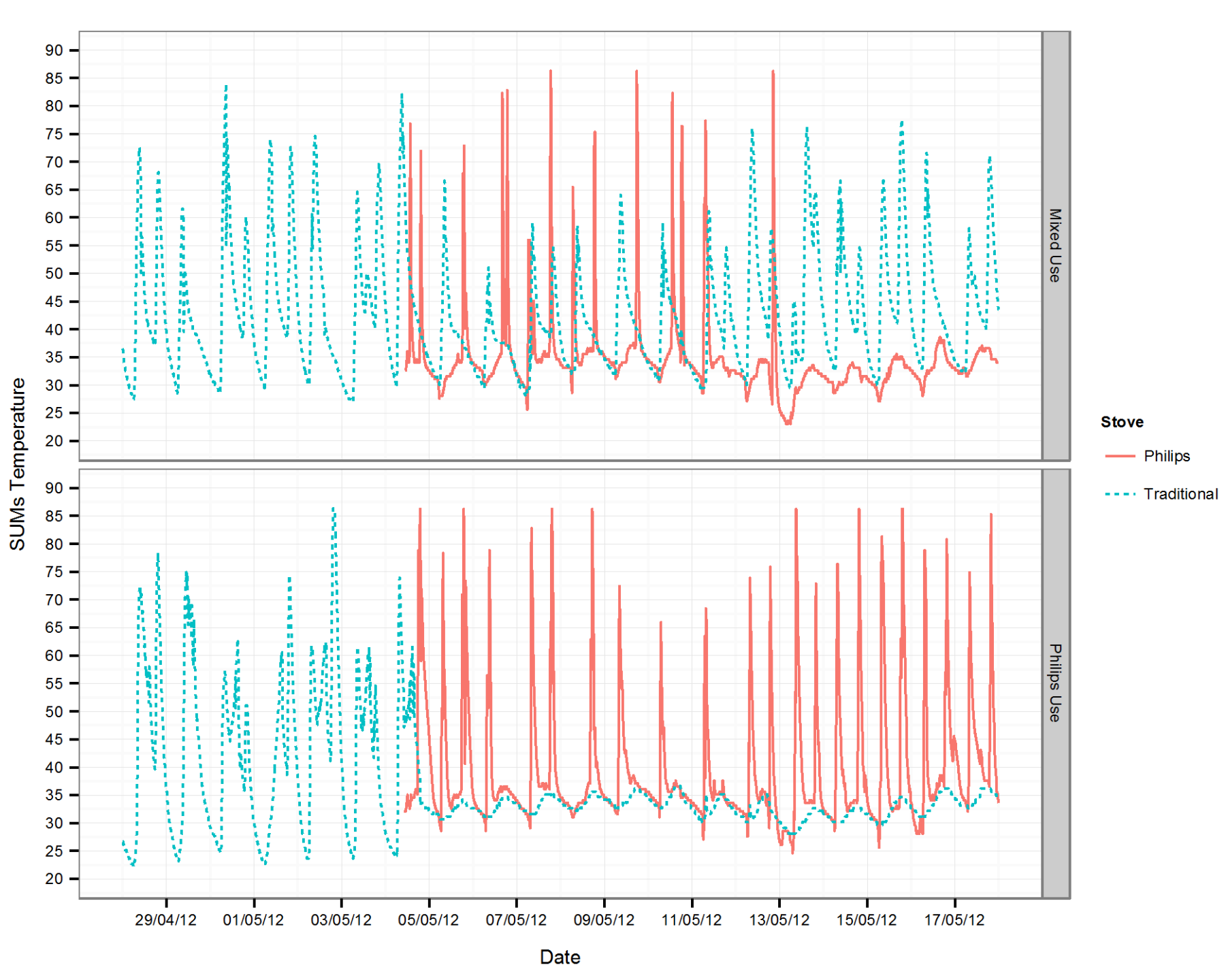
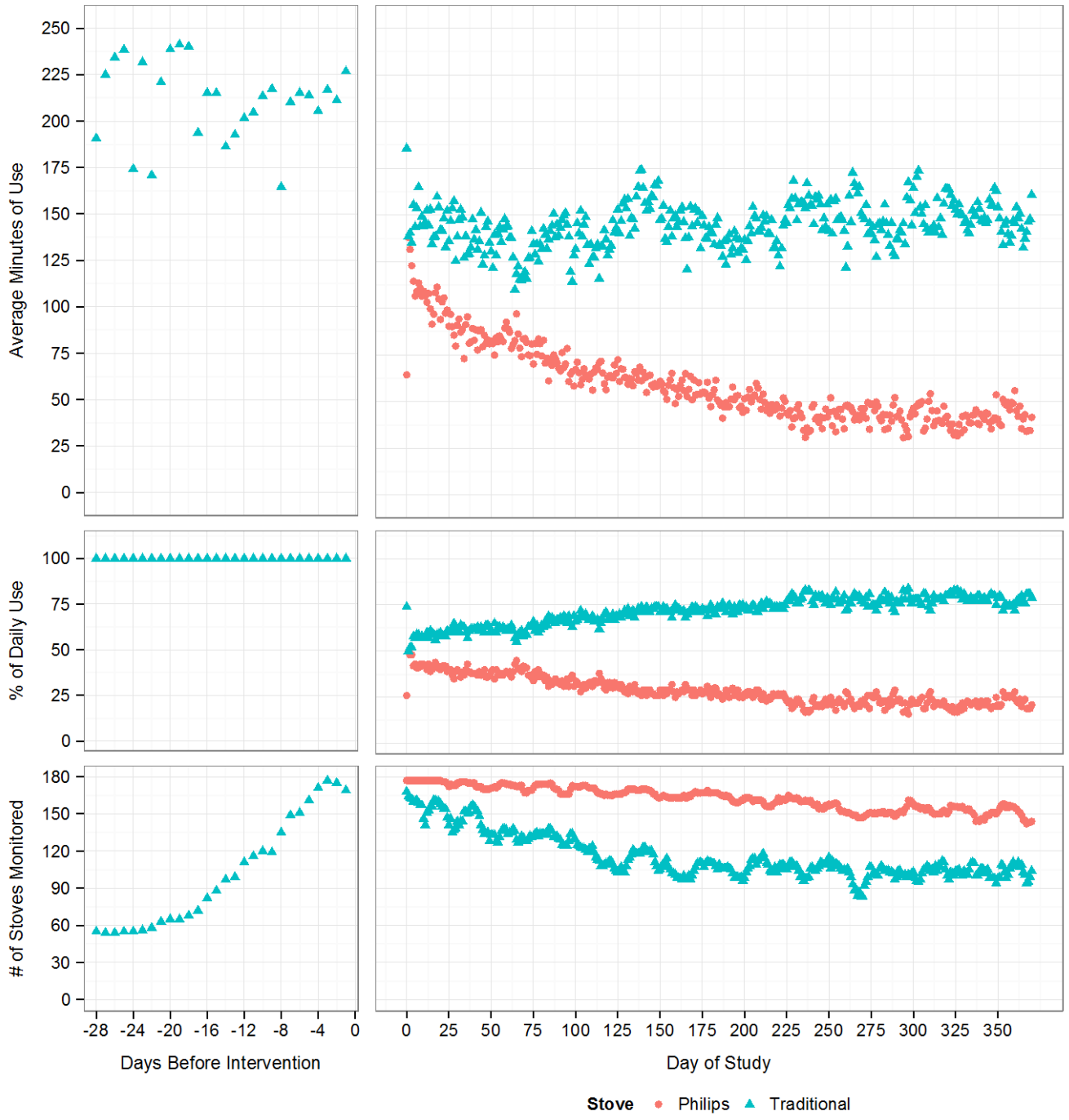
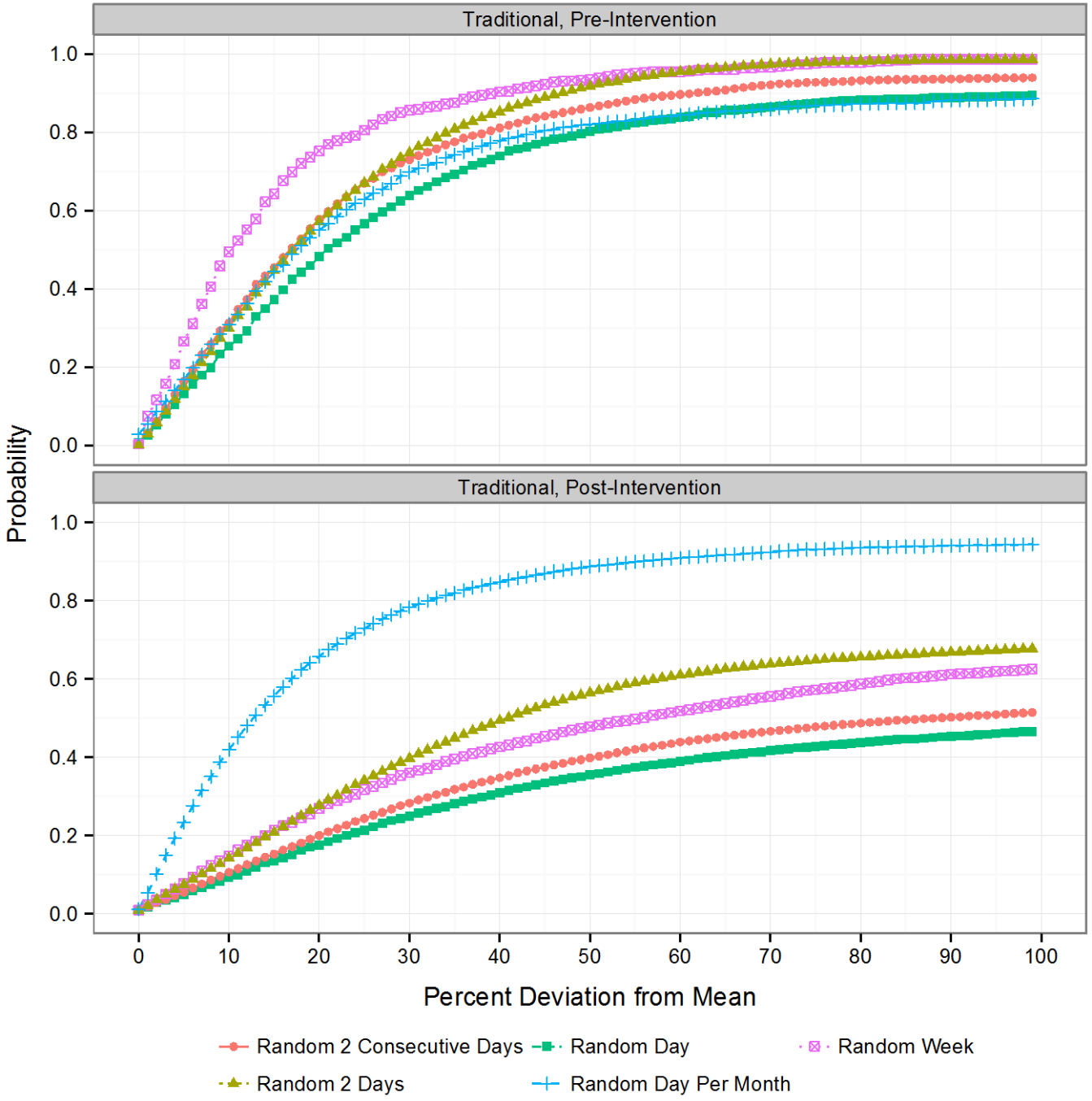

SUMs Temperature
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
Mixed Use
Philips Use
29/04/12
01/05/12
03/05/12
05/05/12
07/05/12
09/05/12
11/05/12
13/05/12
15/05/12
17/05/12
Date
Stove
Philips
Traditional


Average Minutes of Use
250
225
200
175
150
125
100
75
50
25
0
% of Daily Use
100
75
50
25
0
# of Stoves Monitored
180
150
120
90
60
30
0
-28 -24 -20 -16 -12 -8 -4 0
Days Before Intervention
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350
Day of Study
Stove
Philips
Traditional


Traditional, Pre-Intervention
Traditional, Post-Intervention
Probability
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
70
80
90
100
Percent Deviation from Mean
Random 2 Consecutive Days
Random Day
Random Week
Random 2 Days
Random Day Per Month