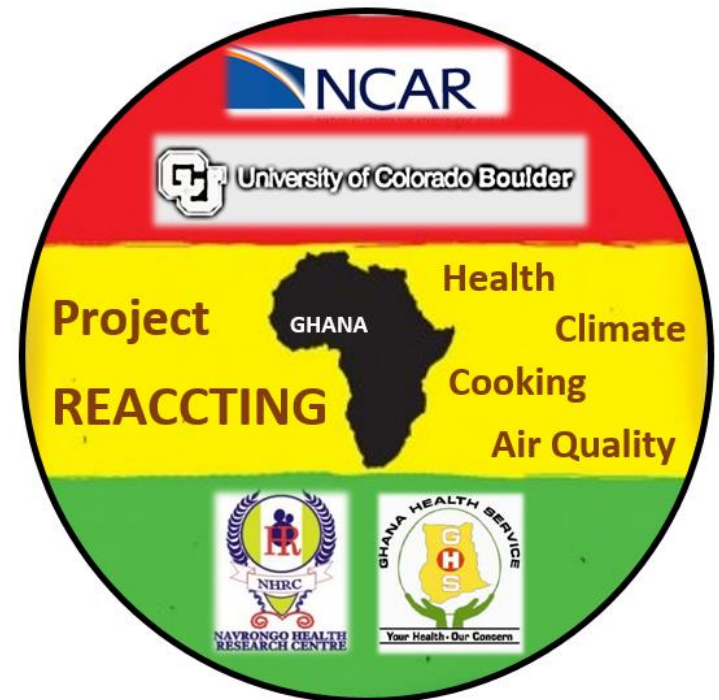


US EPA ARCHIVE DOCUMENT

REACCTING

RESEARCH ON EMISSIONS AIR QUALITY, CLIMATE,
AND COOKING TECHNOLOGY IN NORTHERN GHANA



Dickinson et al., BMC Public Health (2015) 15:126
DOI 10.1186/s12889-015-1414-1

Investigators



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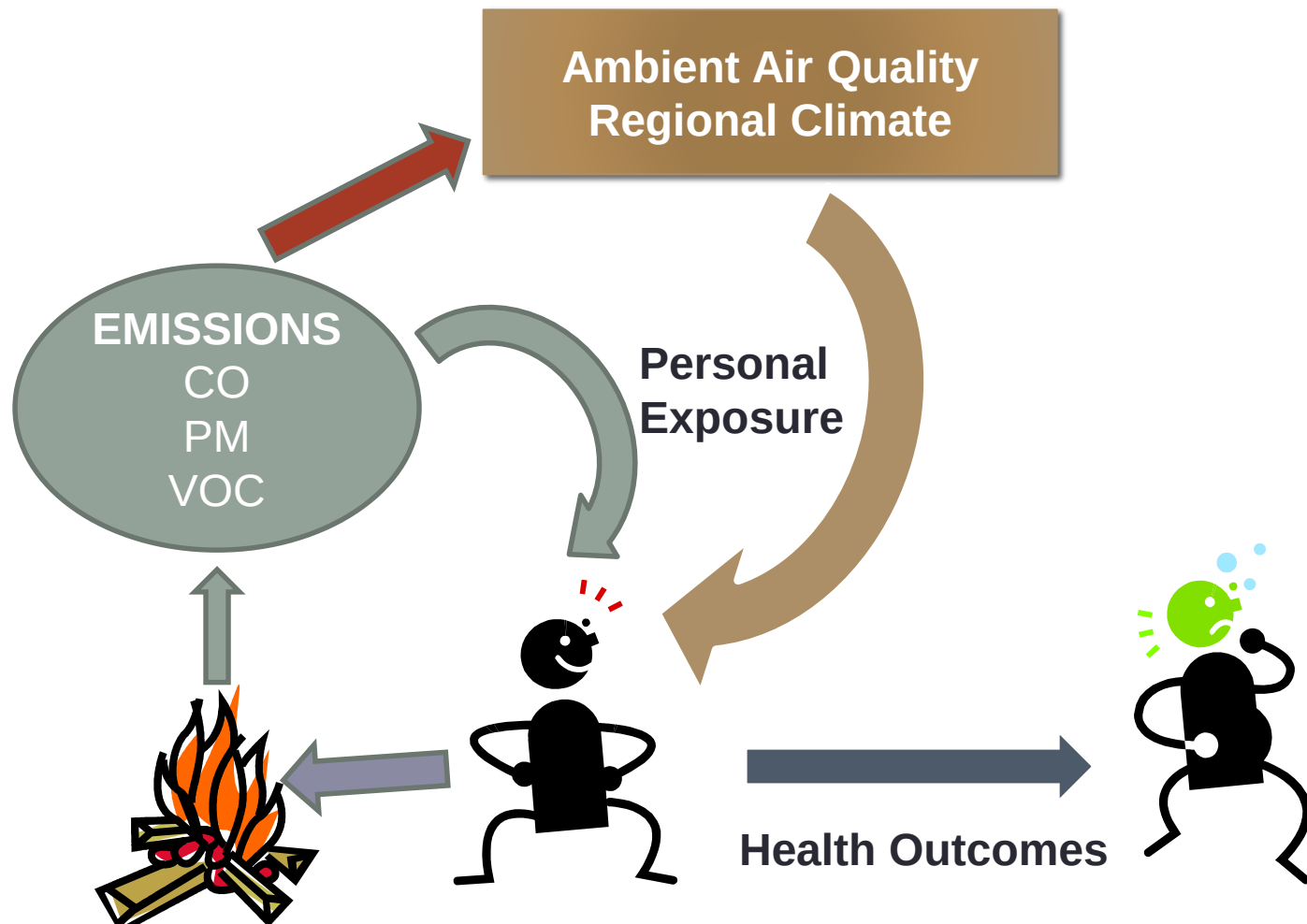
Relief International/Gyapa Enterprises

- MacKenzie Dove, Atsu Titiati



REACCTING

Research of Emissions, Air Quality, Climate, and Cooking Technologies in Northern Ghana



Why Ghana?

- Strong ties with Navrongo Health Research Center (NHRC) from prior research
- Poverty affects the Northeast region
- Mostly cook with biomass
- Safe and stable work environment

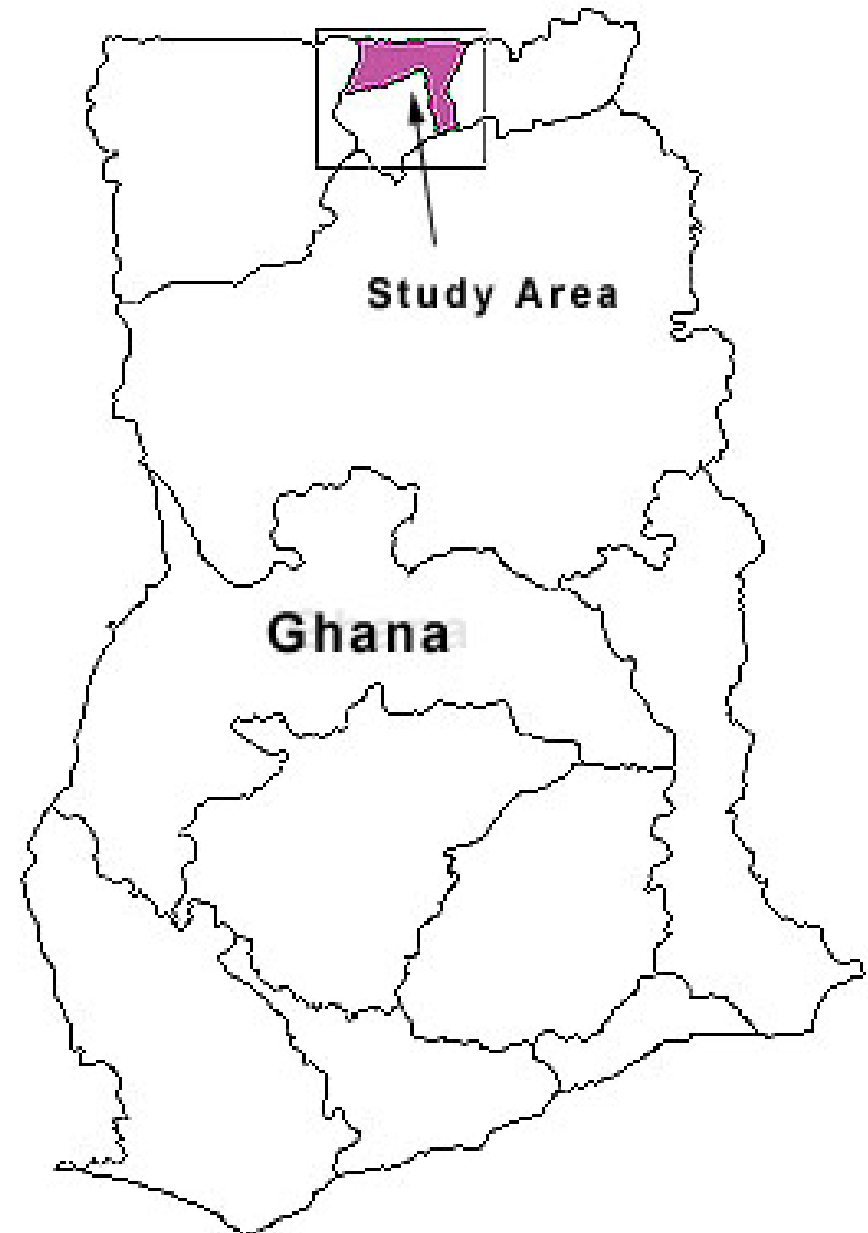


Study Area

Region: Upper East

District: K-N

Town: Navrongo



Traditional Cooking

- 3-stone stove
- Biomass for fuel





REACTING

Intervention Study



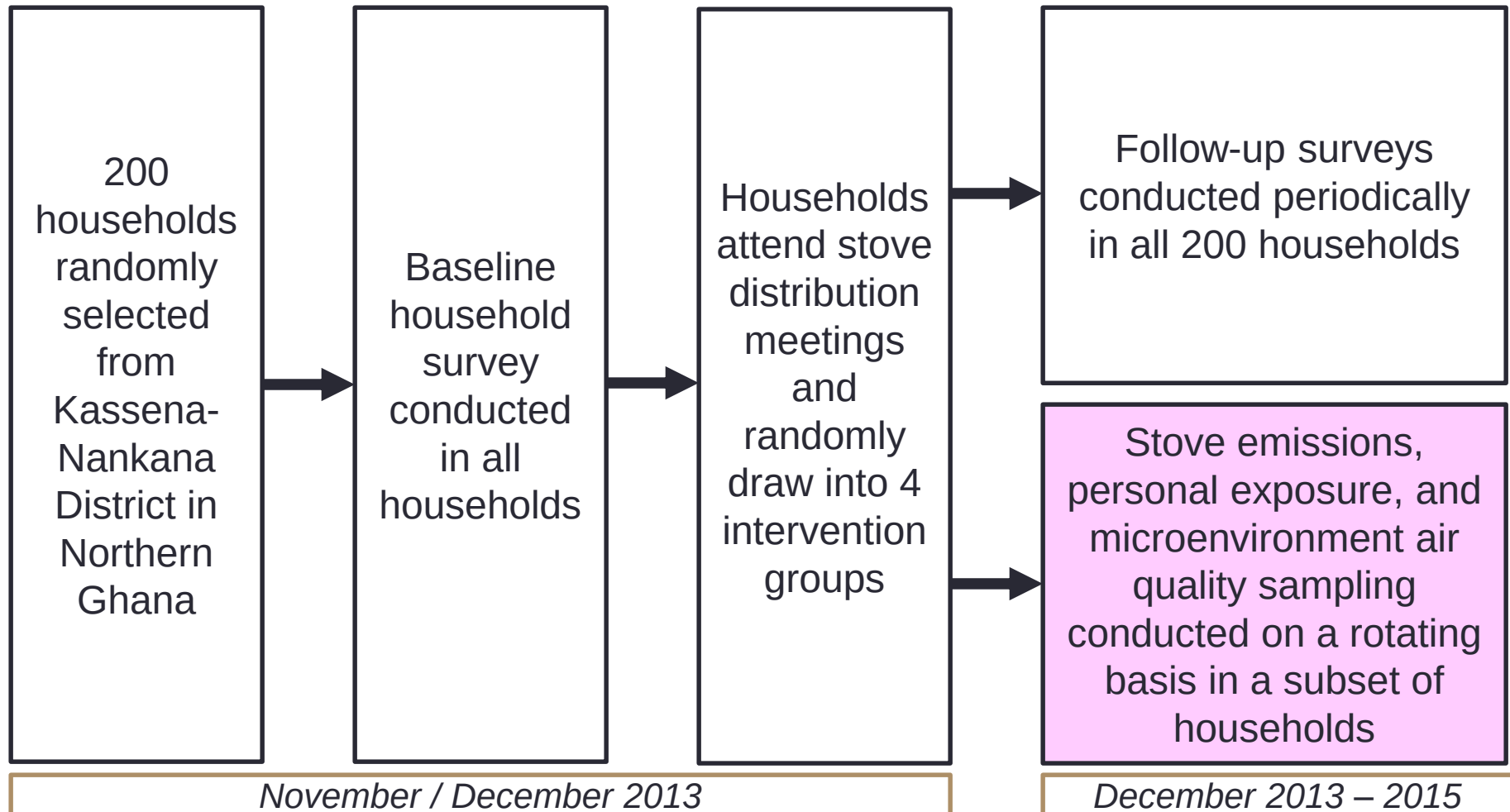
rural households (200)

Sources and Exposure Characterization



urban and rural regions
(50 households)

Intervention Study Design



Intervention Groups

- 200 households, each with one woman aged 18-55, one child aged 0-5

Group A:



Group B:



Group C:



Group D:



Kassena-Nankana District Snapshot

Variable	K-N District (N, E, S, W Regions)	Intervention Study Sample	P-value
# households	25,458	200	
Ethnicity: Kasem	51.5%	50.0%	0.68
Ethnicity: Nankam	44.5%	45.5%	0.79
Cooking fuel: Biomass	84.3%	100%	0.000***
Location: Rural	90.0%	100%	0.000***
Water source: Borehole	86.4%	100%	0.000***
Sanitation: No facility	95.5%	96.5%	0.32
Has Electricity	13.1%	6.0%	0.003***
Owns Motorcycle	14.9%	10.0%	0.049**
Owns Bike	77.5%	87.0%	0.001***
Owns Mobile phone	69.0%	81.0%	0.000***
# Livestock	7.07	10.9	0.000***

Measurement Approach

- Surveys
 - Cooking behavior
 - Health burden
- Emission
 - Field Portable Emission Monitor for cookstoves
 - Other sources
- Ambient
 - Regional low-cost monitors
 - Reference monitors at NHRC
- Household
 - Air (CO and PM2.5)
 - Stove use
- Personal
 - Air (CO and PM2.5)
 - Location

UPOD
(yoo-päd)

*An open source platform
for mobile air quality monitoring*



<http://mobilesensingtechnology.com/>

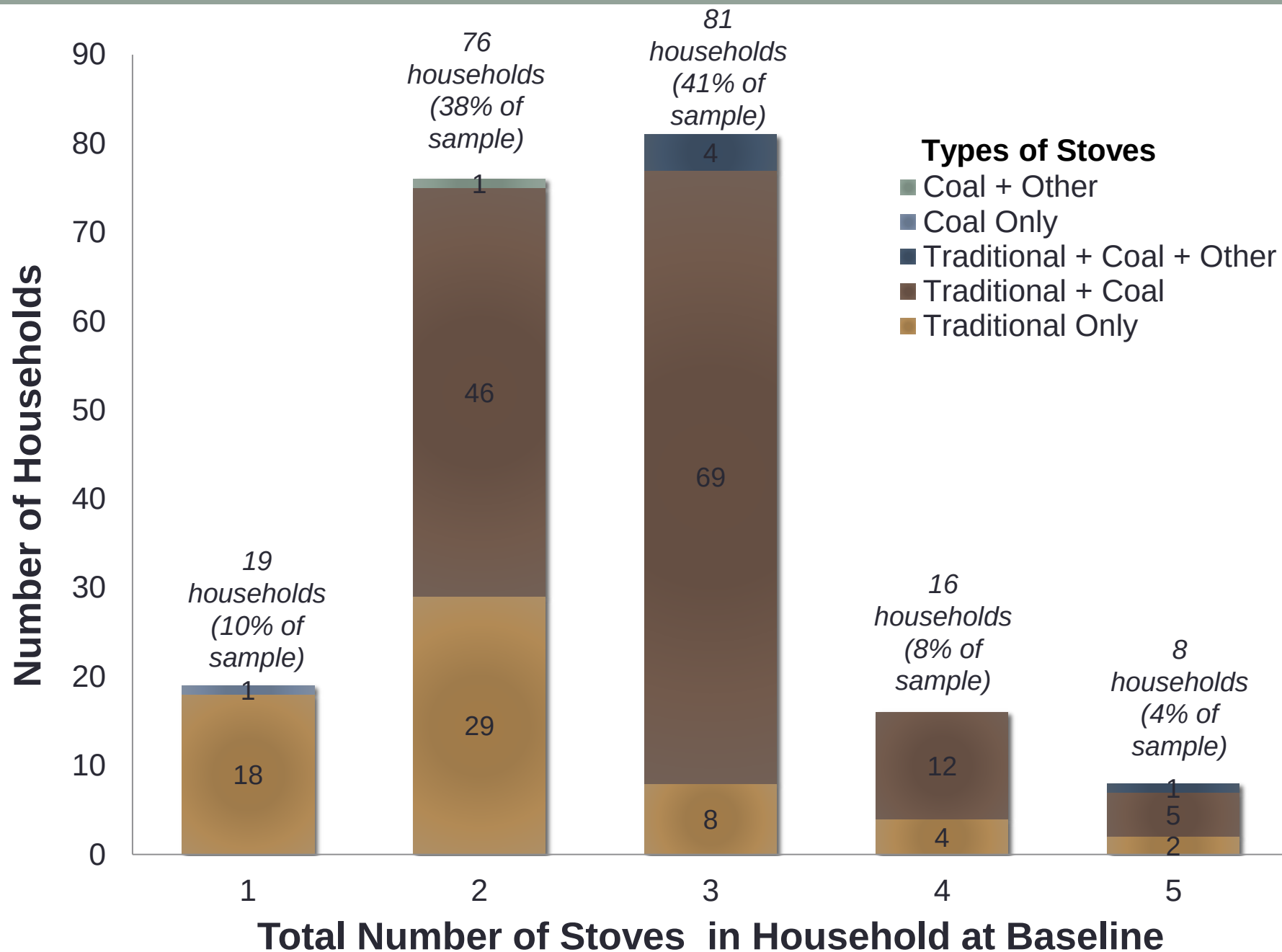


Fourth survey pretest: Dominic (Nankai)

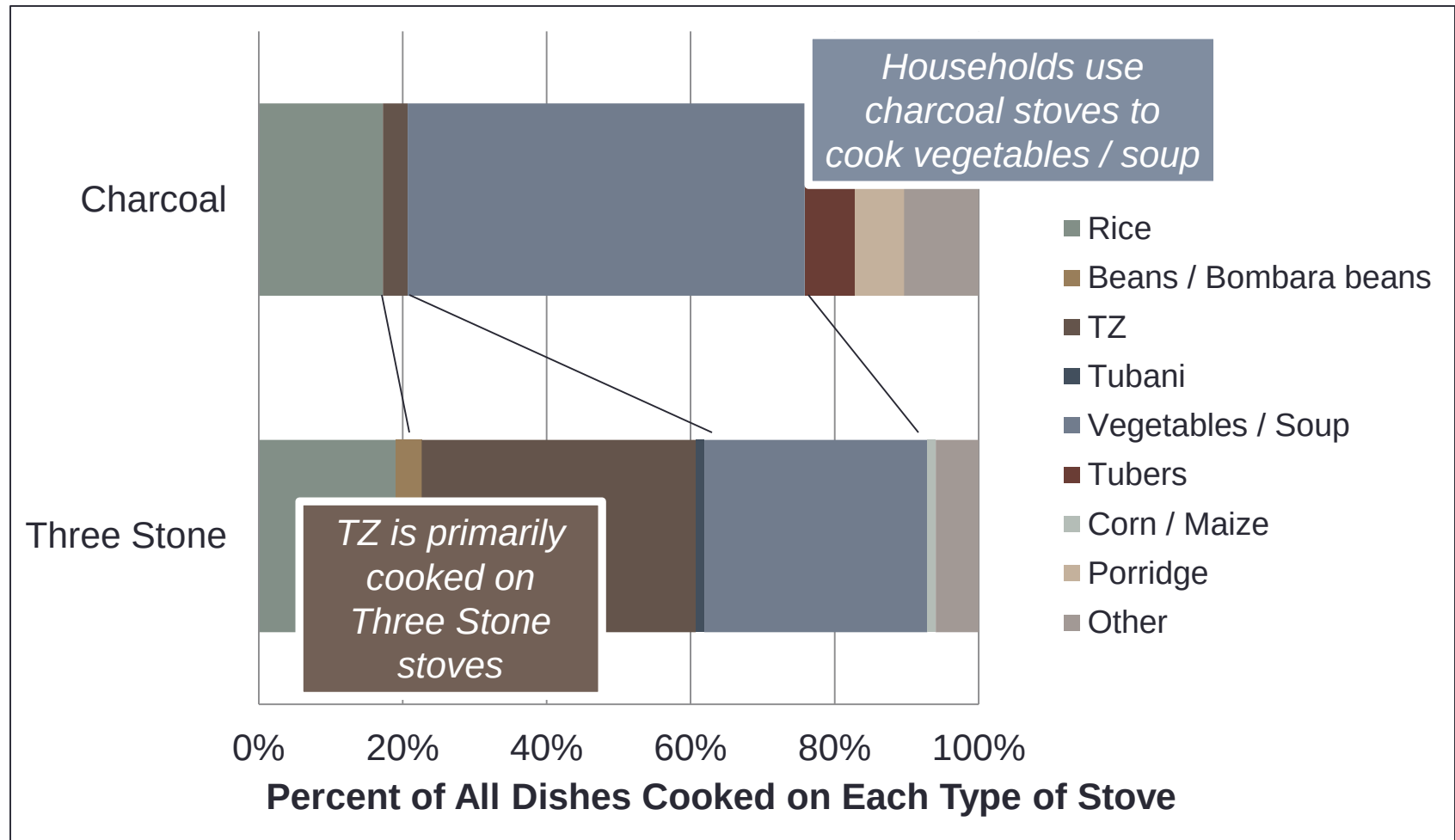
Behavioral Surveys

	STOVE A	STOVE B
SMOKE		
FUEL USE		
TIME TO COOK RICE	30 MINUTES	60 MINUTES
WHERE WAS THE STOVE MADE?	GHANA	GHANA
COST	15 Cedis	30 Cedis

	STOVE A	STOVE B
SMOKE		
FUEL USE		
TIME TO COOK RICE	60 MINUTES	60 MINUTES
WHERE WAS THE STOVE MADE?	GHANA	GHANA
COST	15 Cedis	30 Cedis



What dishes were cooked yesterday on each stove?



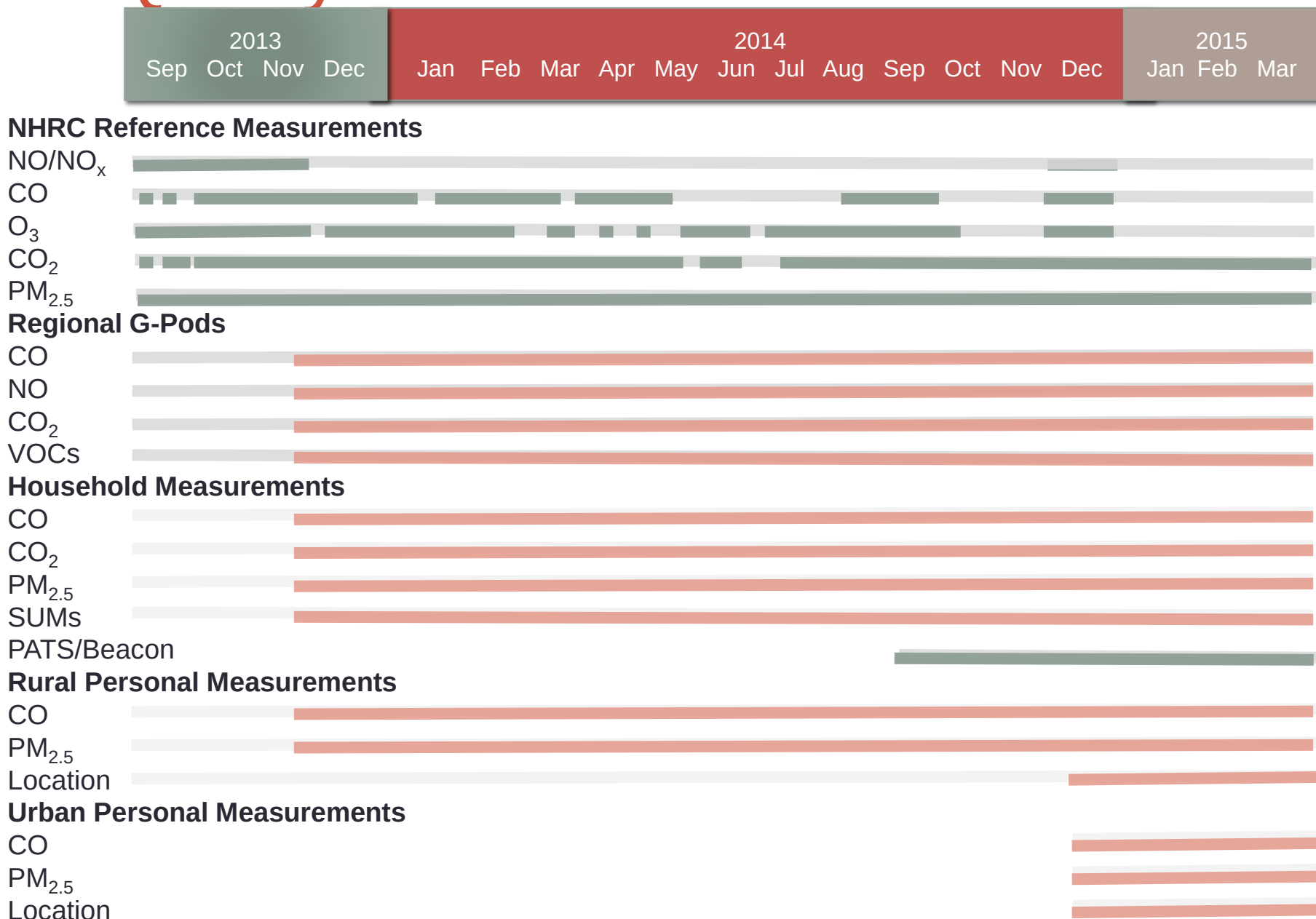
Health Measures

For Respondent and Children Under Five

- Self-Reported Illness
- Blood Spots
- Anthropometrics:
 - Height
 - Weight
 - Arm circumference



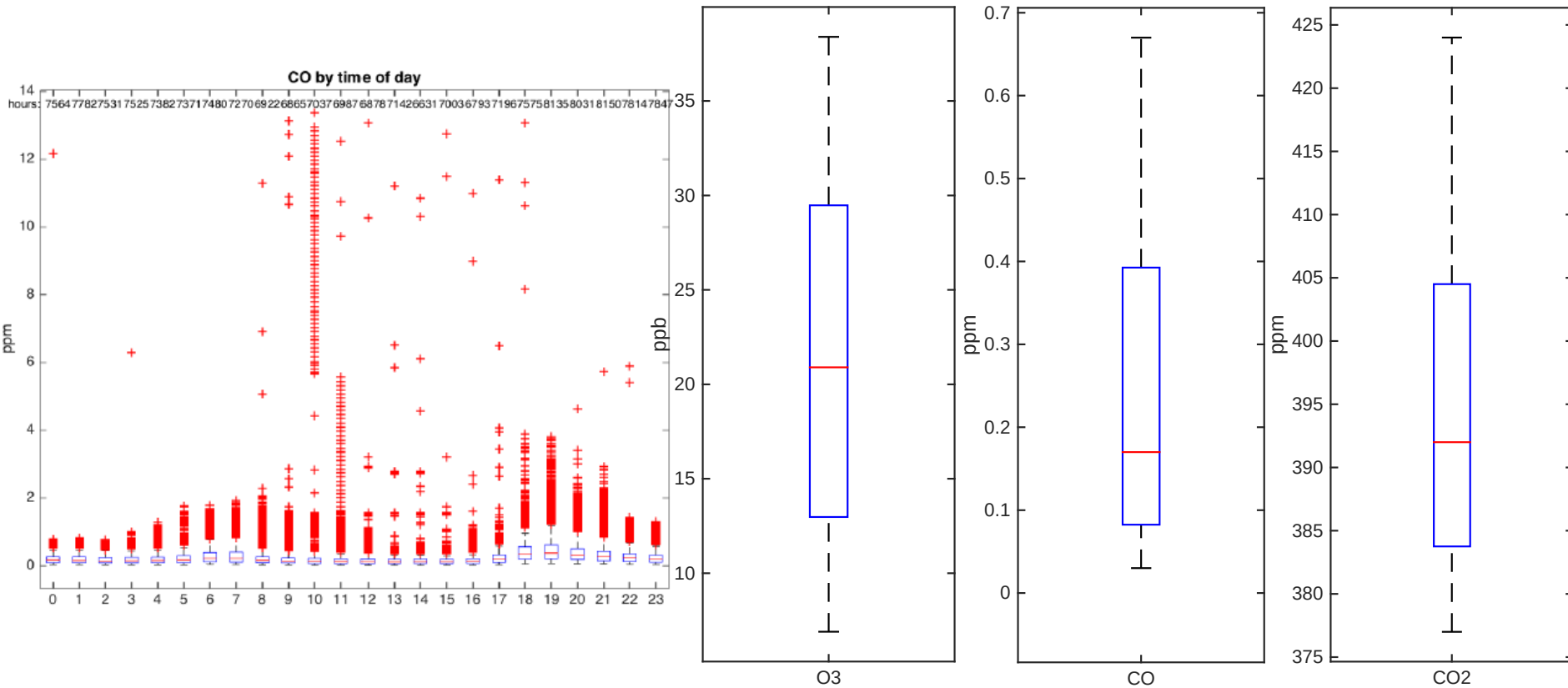
Air Quality Measurement Timeline



NHRC Reference Measurements



Ambient Air Quality at NHRC

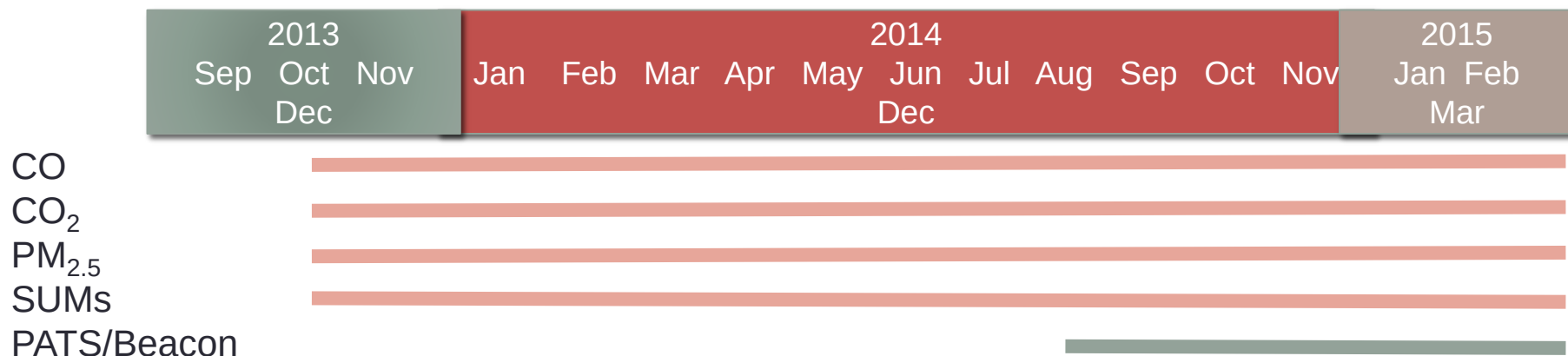


Regional G-Pods



Household Measurements

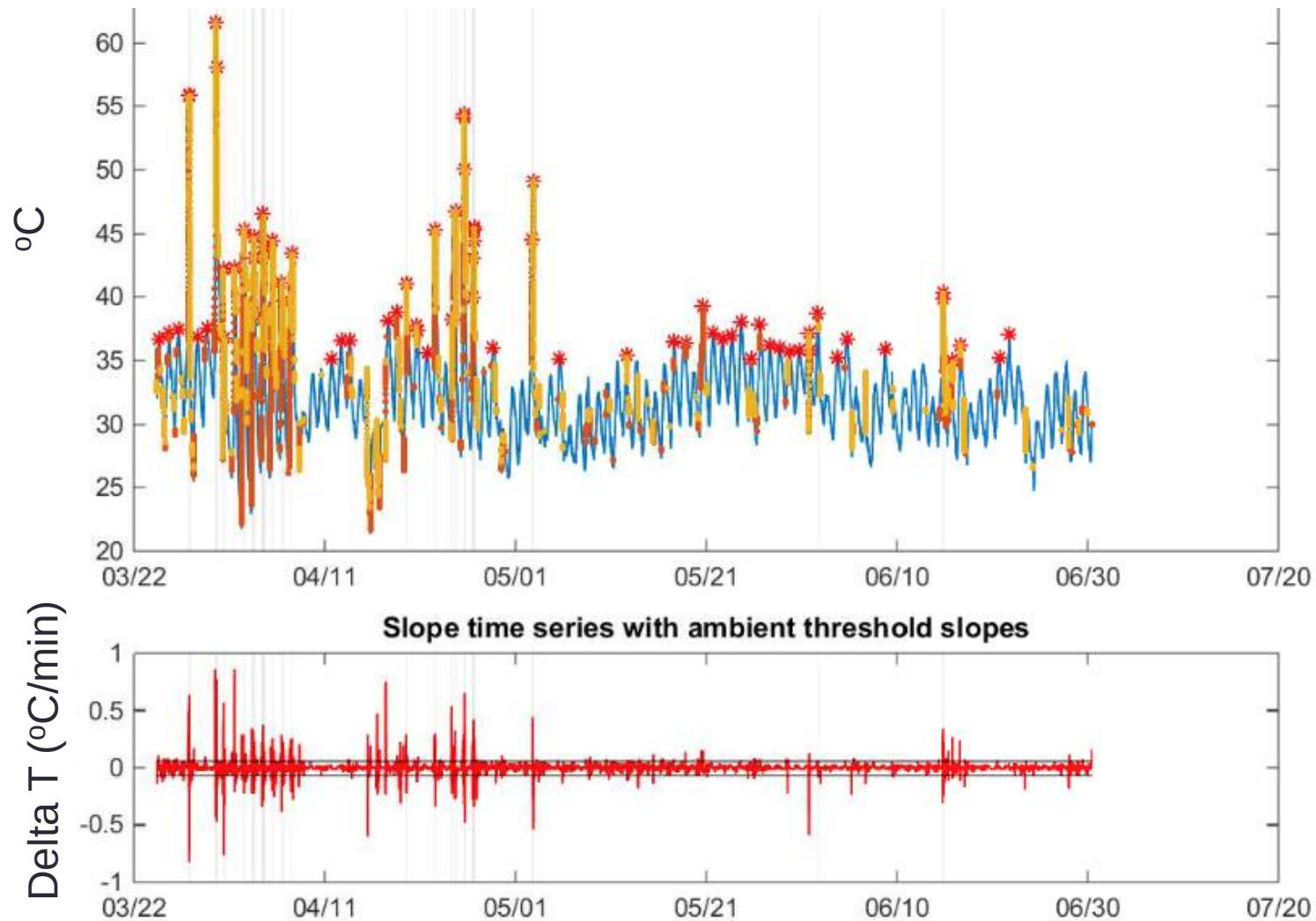
- Stove usage monitors (SUMs)
 - 110 SUMs over 35 households
 - CRECER/RESPIRE studies
 - Proposed standard methods and algorithms for SUMs in Ruiz-Mercado et al., 2012
- Microenvironment monitoring
 - CO, PM_{2.5}, CO₂



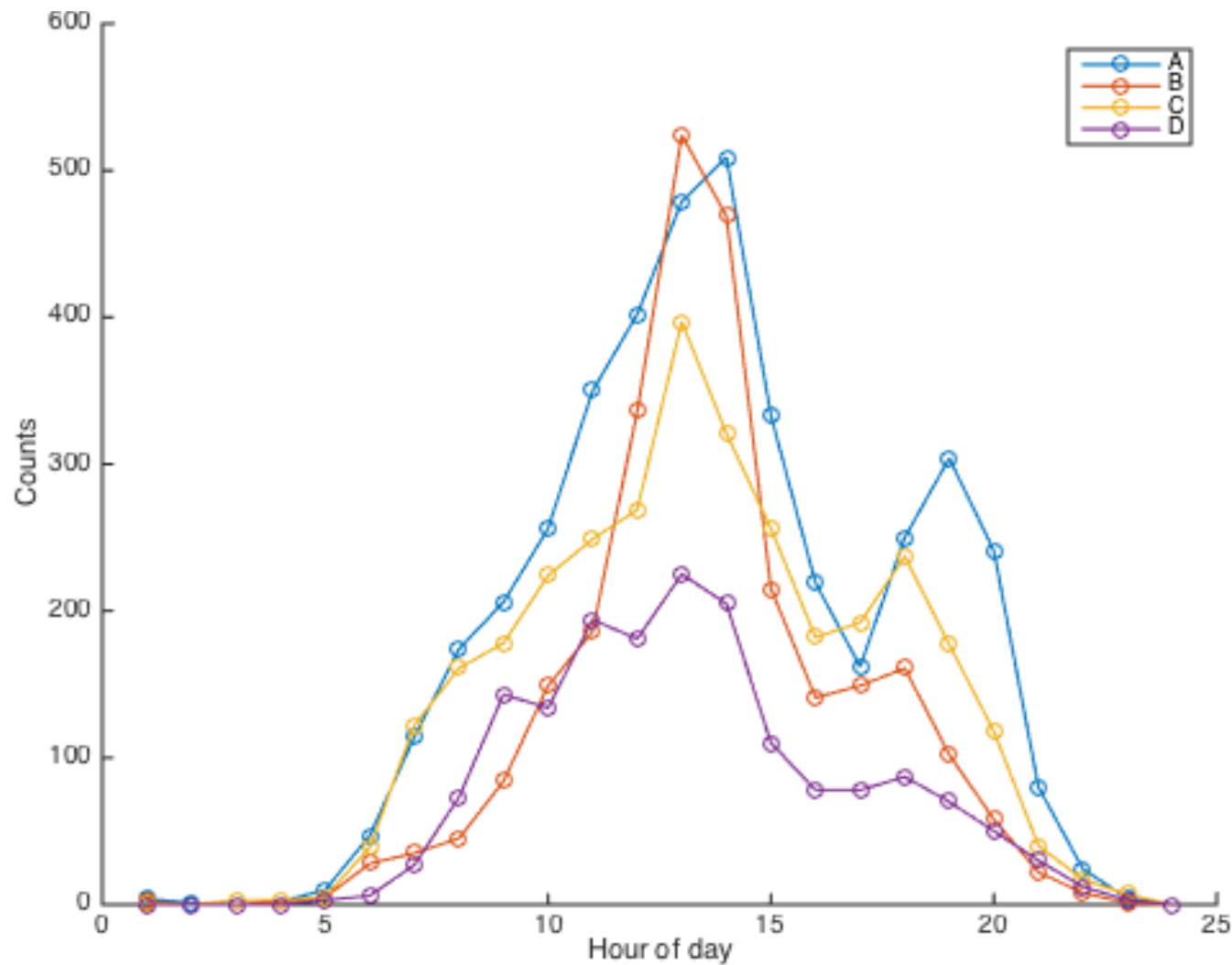
Household Measurements



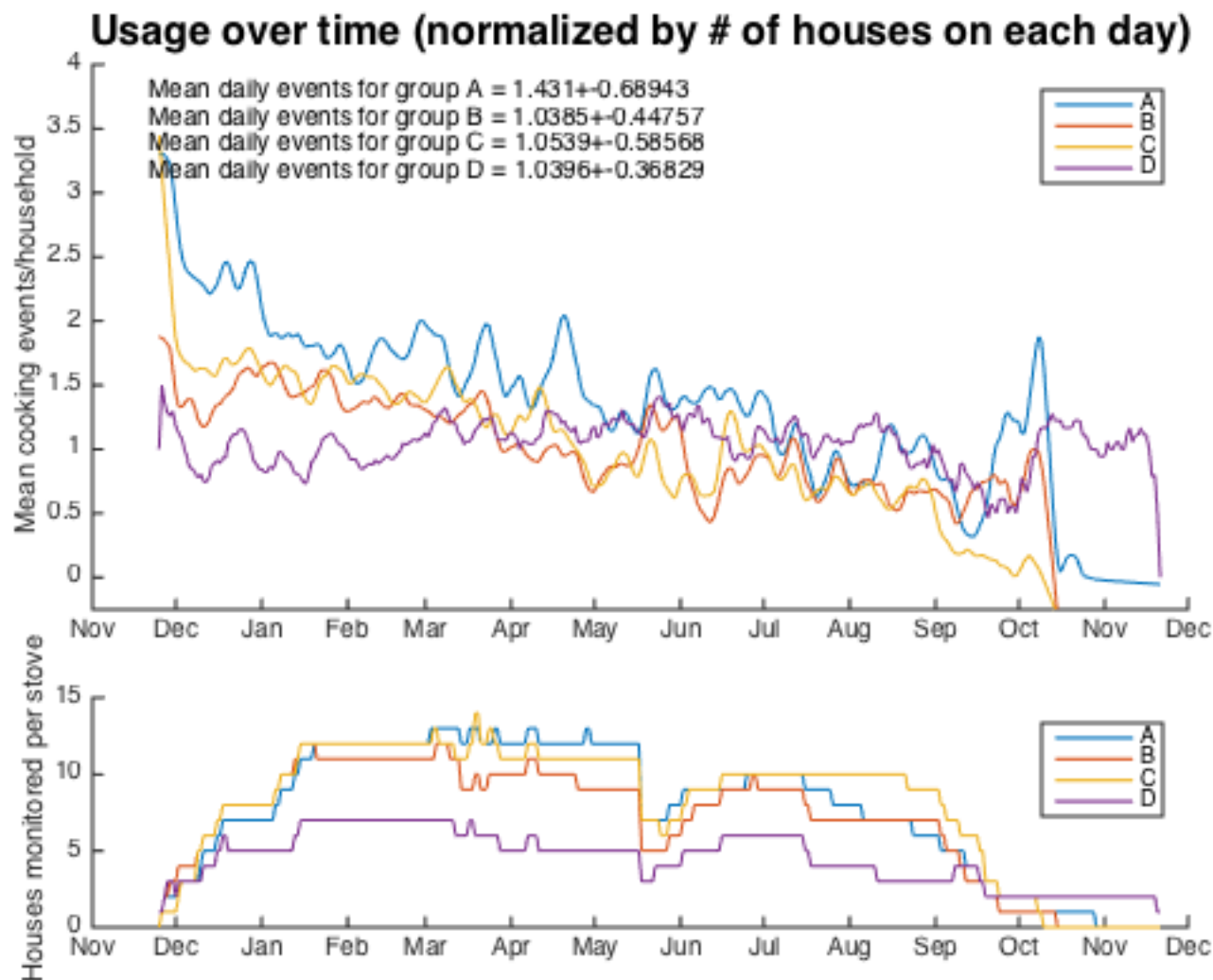
Example SUMs Data



Peak cooking time distribution by study arm

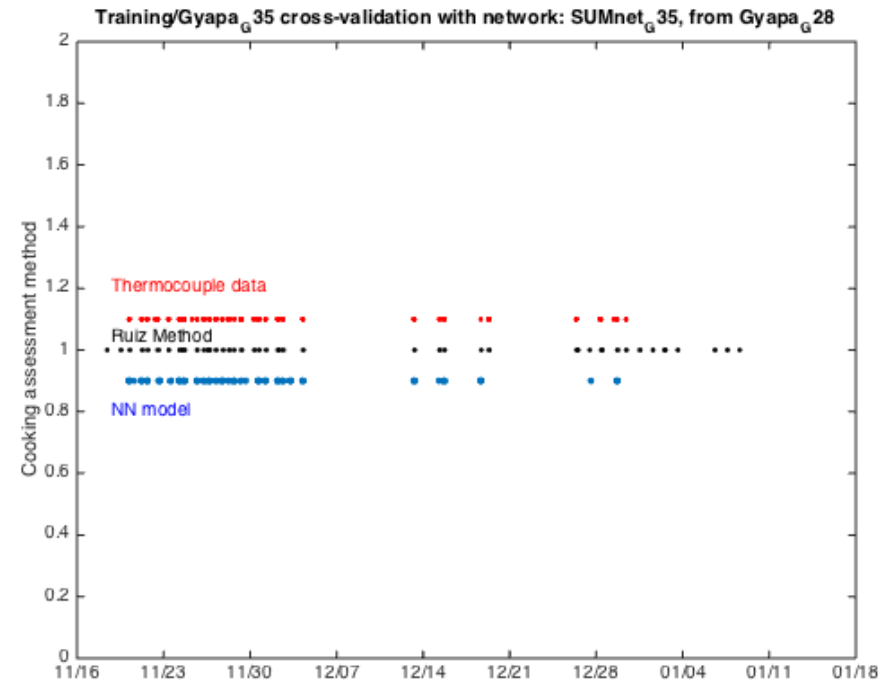
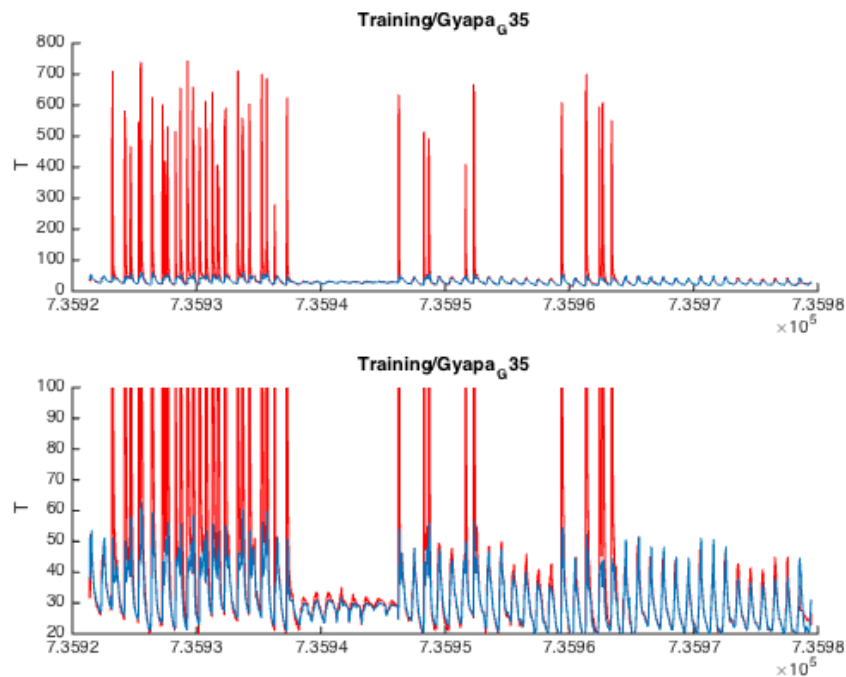


Stove Use Over Time



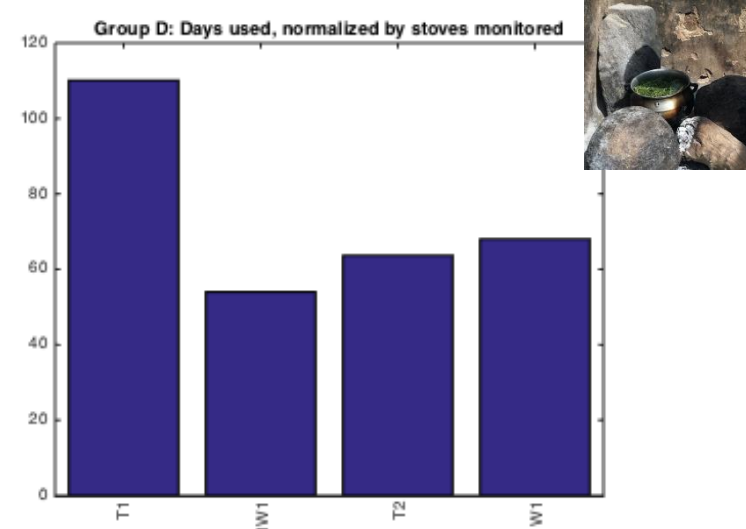
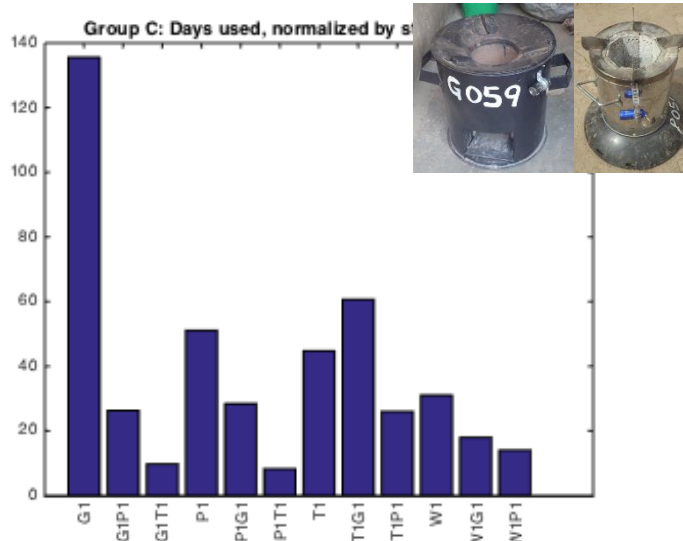
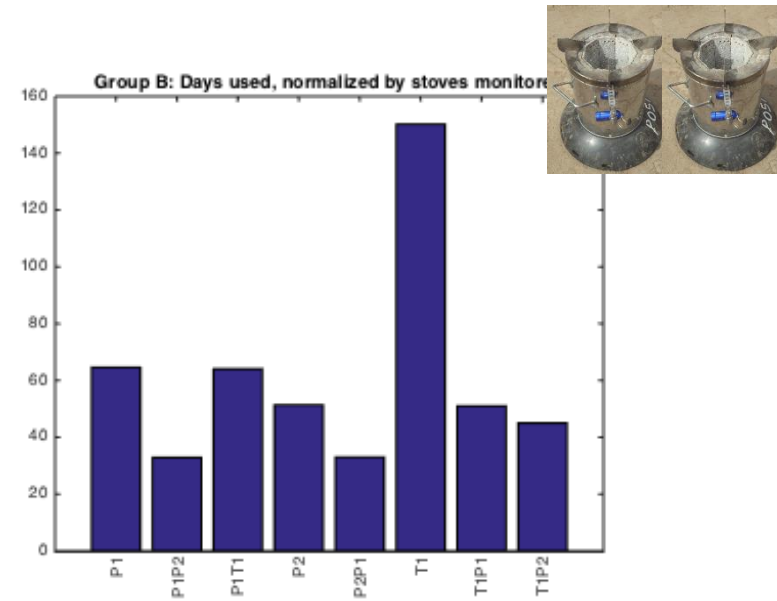
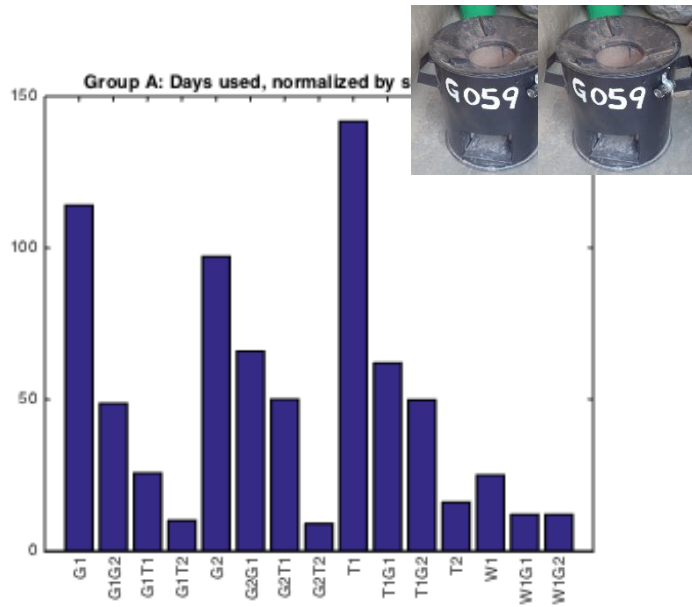
Assessing cooking event detection algorithm

- Develop a test data set to assess cooking event detection
- 8+ week of thermocouple in fire box + SUMs on 5-7 stoves

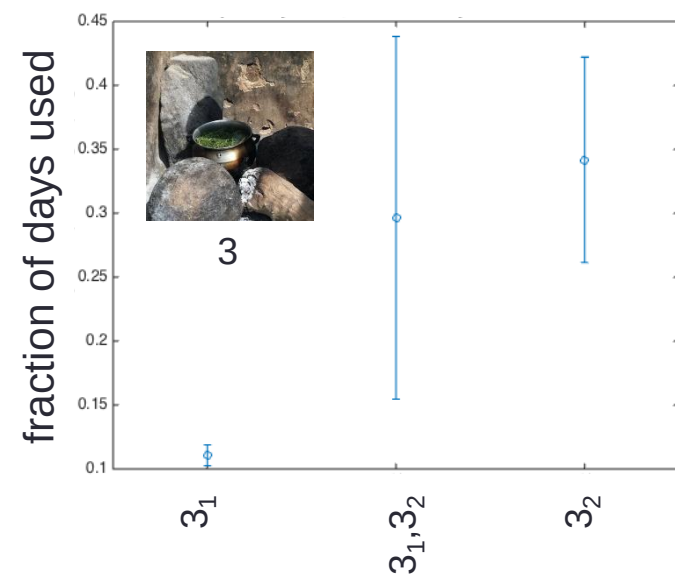
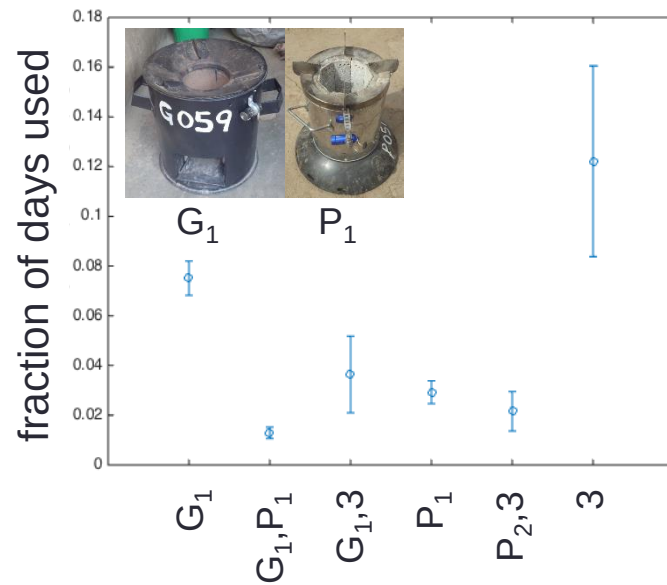
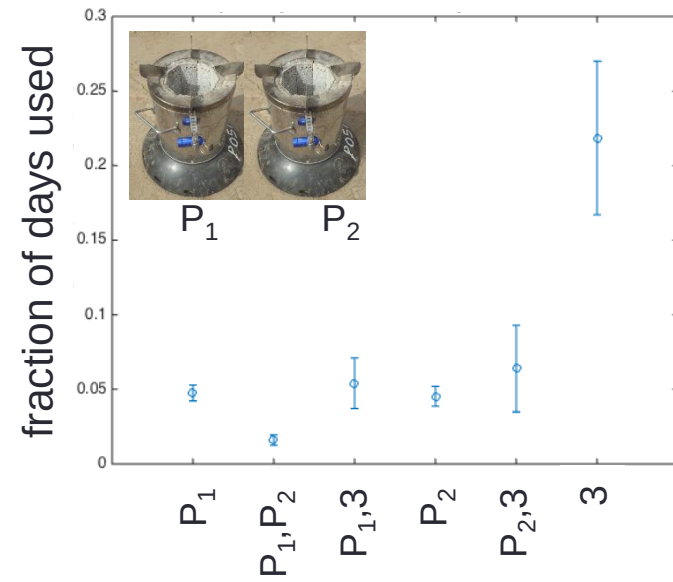
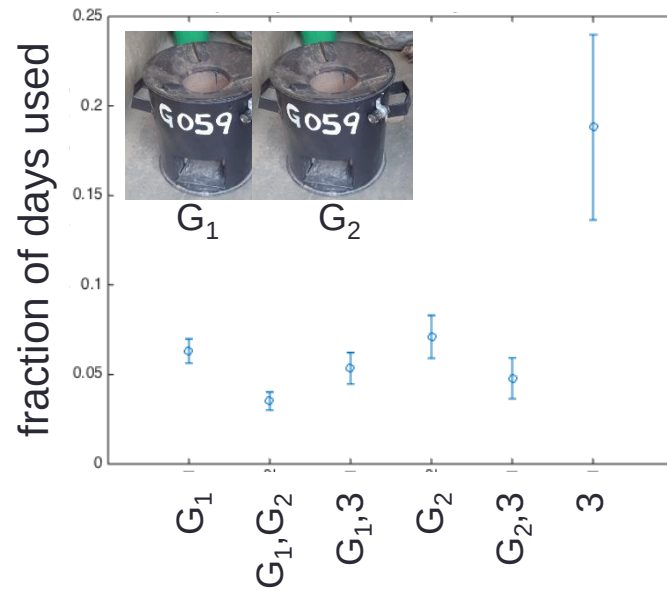


SUMs Stacking Results

G = Gyapa
T = 3-stone
P = Philips



SUMs Stacking Results



Personal Measurements

- 48-hr personal exposure monitoring periods rotating through study households
- 4 families/households monitored from each study arm per deployment period
- 2 deployment periods per week
 - Mon-Wed, Wed-Fri



- Monitoring
 - cooks
 - school children
 - children under 5
 - available males

Personal Measurements



Carbon monoxide (CO)

- Real-time CO loggers worn by participants
 - Around necks or in “child-proof” pockets
- Lascar EL-USB (electrolytic)
 - 1-minute logging interval
 - Range: 0-300 ppm
 - 0.5 ppm resolution

- Battery operated
- Calibrated weekly at NHRC



Personal Measurements and Methods



Particulate Matter (PM_{2.5}) Sampling

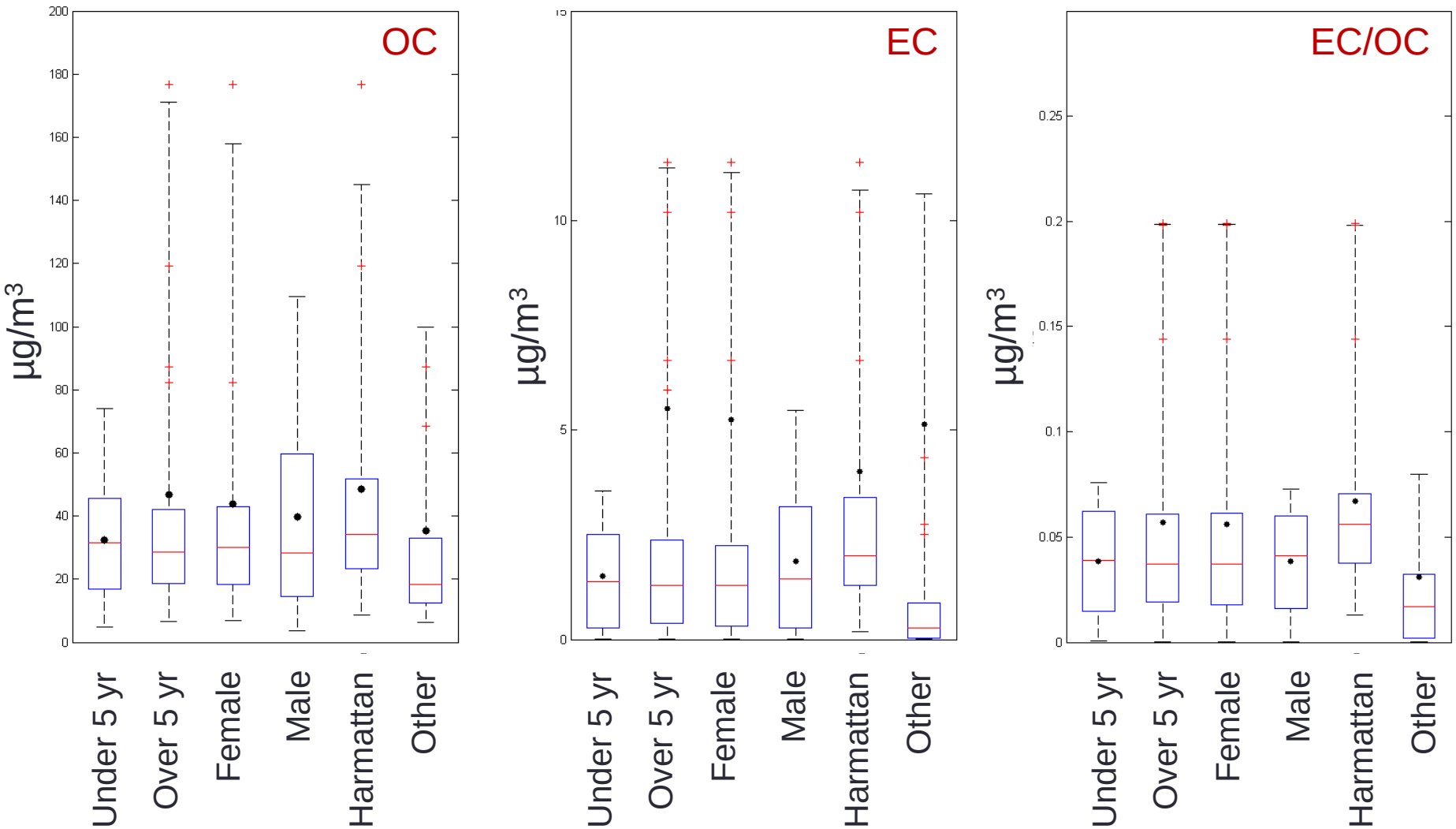
- Monitors worn in small backpacks or fanny packs
- SKC pump running at 2 LPM
 - Calibrated biweekly
- 25mm quartz filters with URG impactor upstream
- Battery powered to last over 48 hours
- Filters returned to US for EC/OC analysis



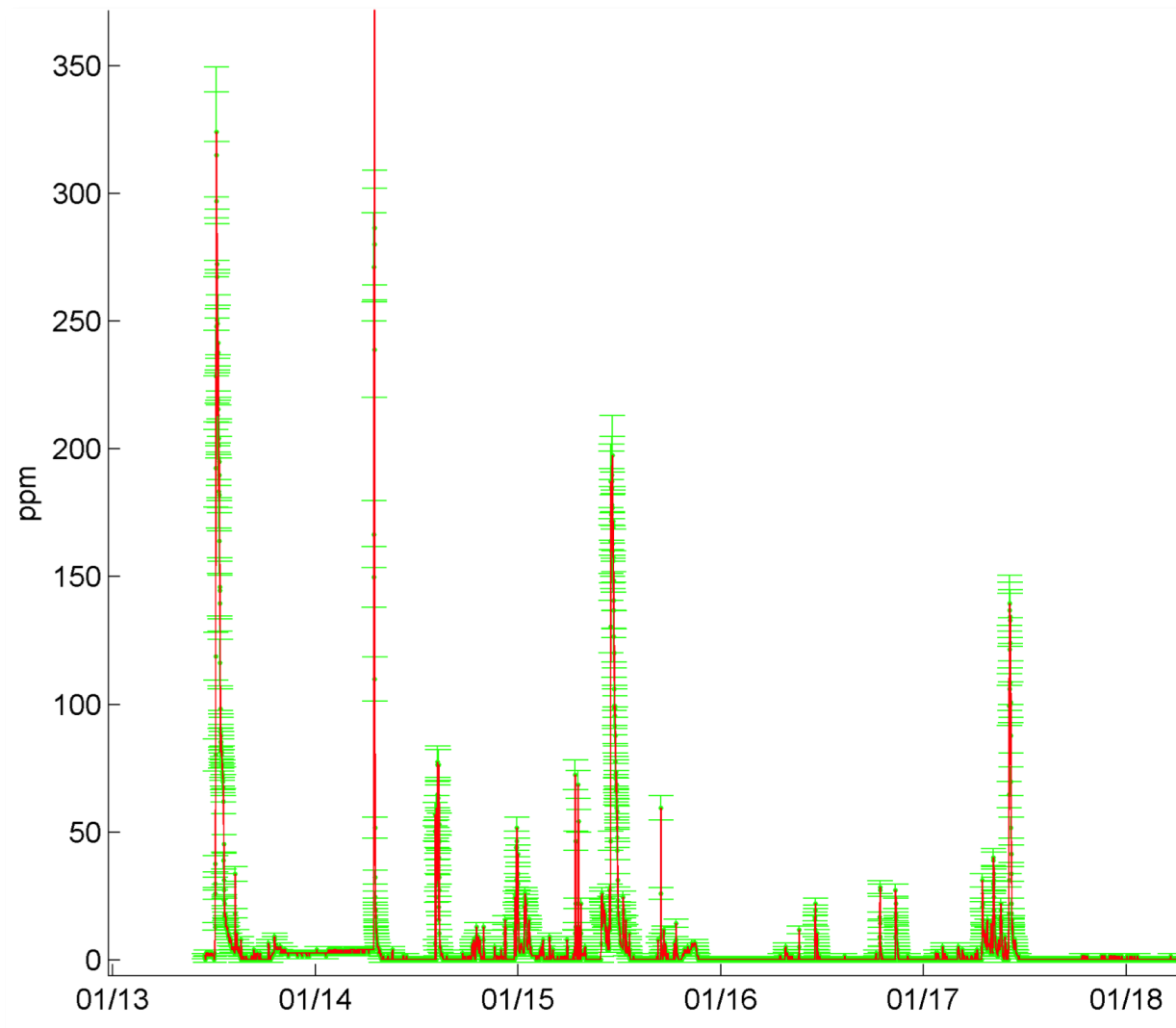
Measurements Stats

	Personal PM	Personal CO
Analyzed Sampling Interval	Nov 2013 – May 2014	Nov 2013 – July 2014
N Individuals	70 total 18 children 16 males	266 adults 112 children from 118 households (over 1.2 million minutes)
Analysis Type	EC/OC Sunset Analyzer	Matlab code
Future	Over 100 more to analyze	Over 500,000 more minutes to analyze

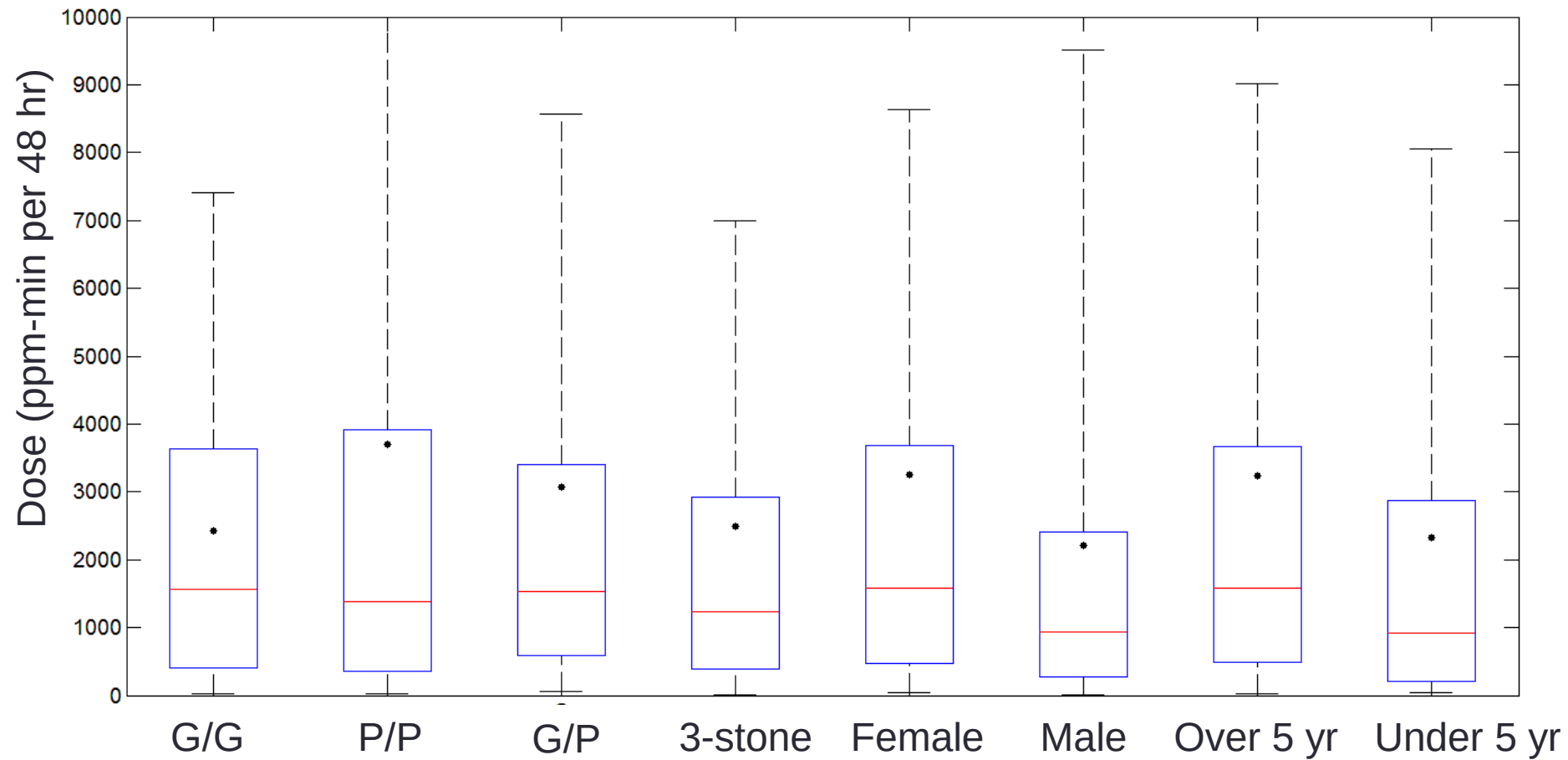
Personal EC/OC of PM_{2.5}



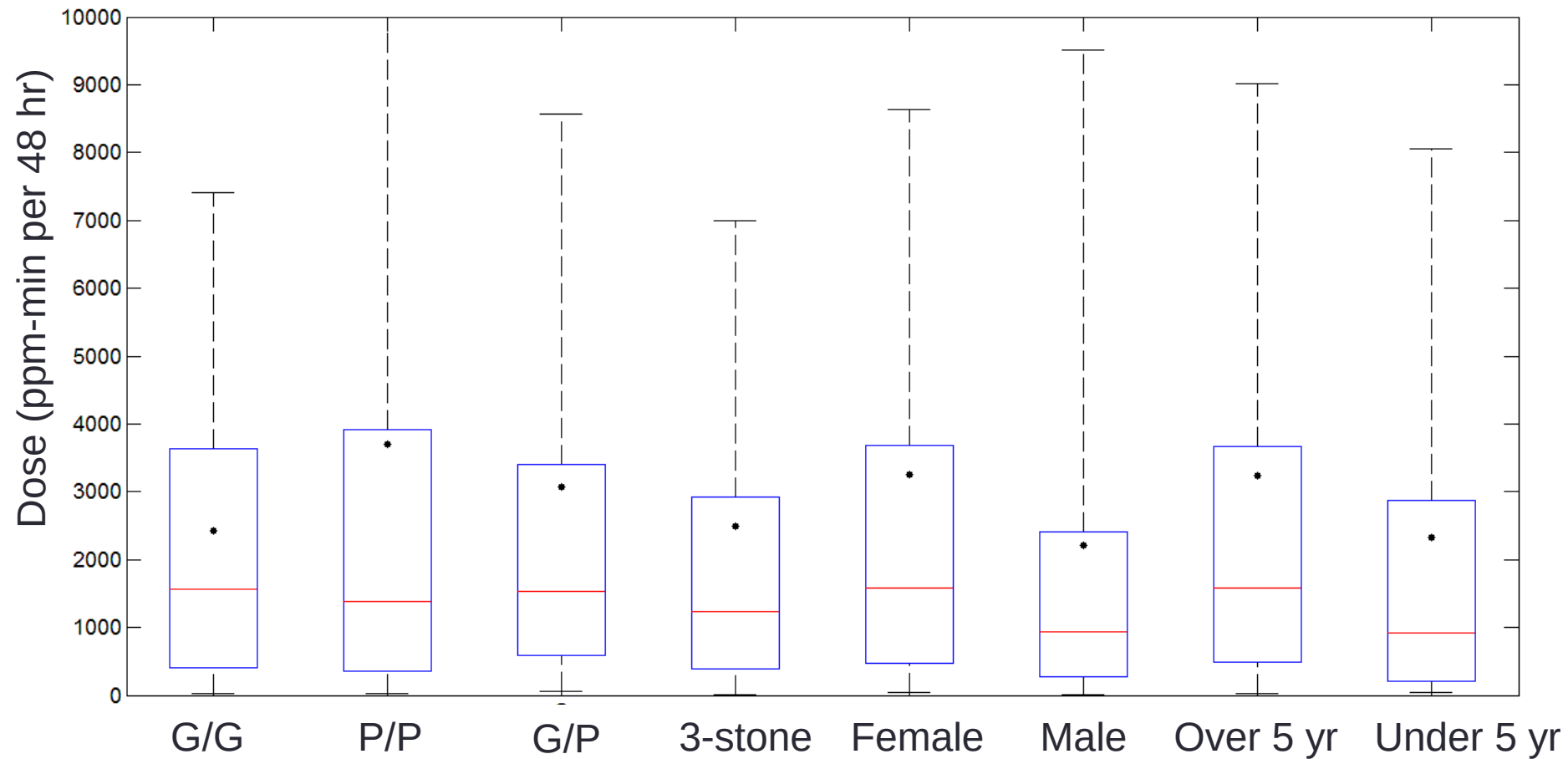
Example CO personal exposure



Personal CO Doses

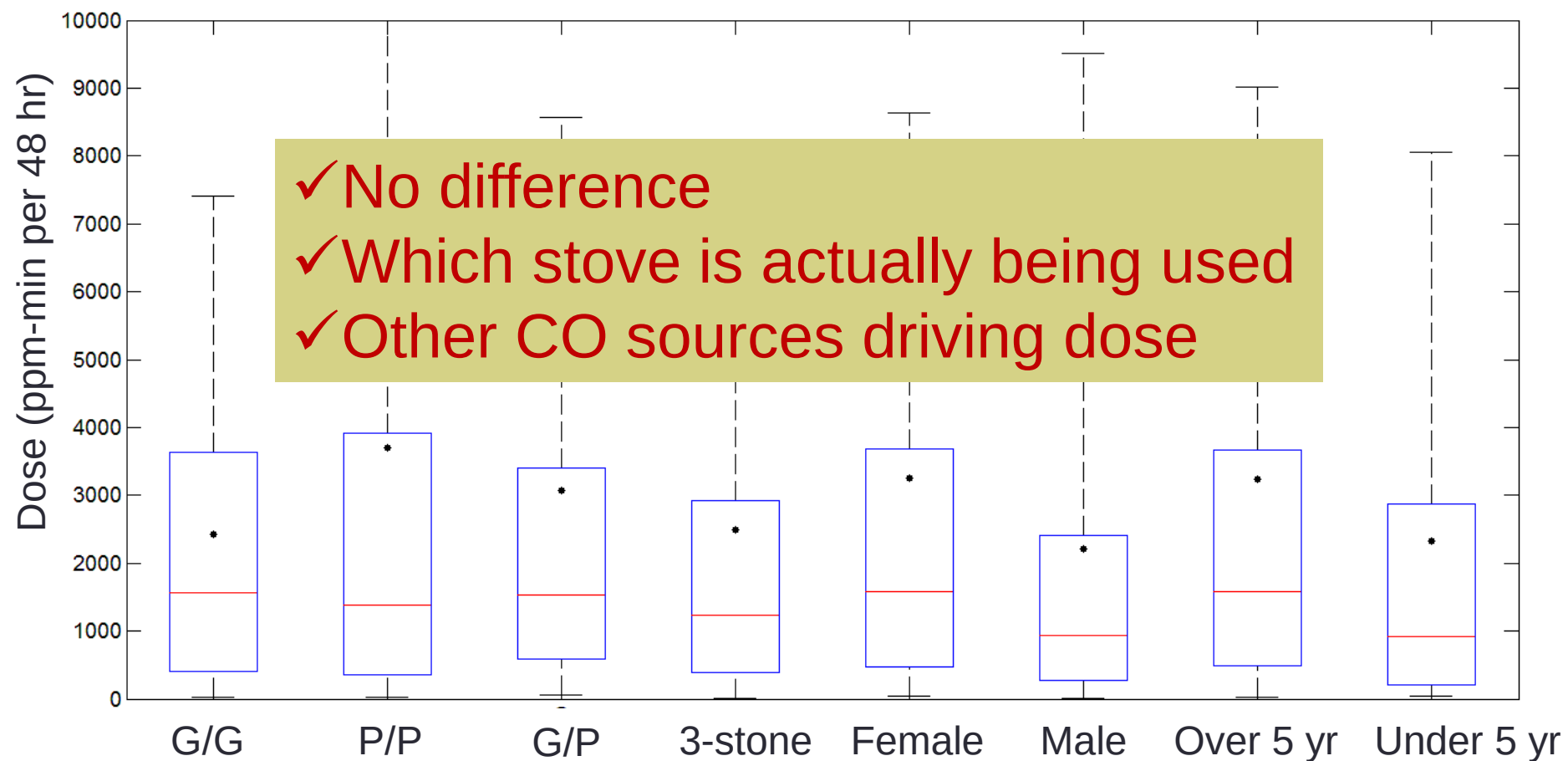


Personal CO Doses



Why aren't we seeing differences in CO exposure?

Personal CO Doses



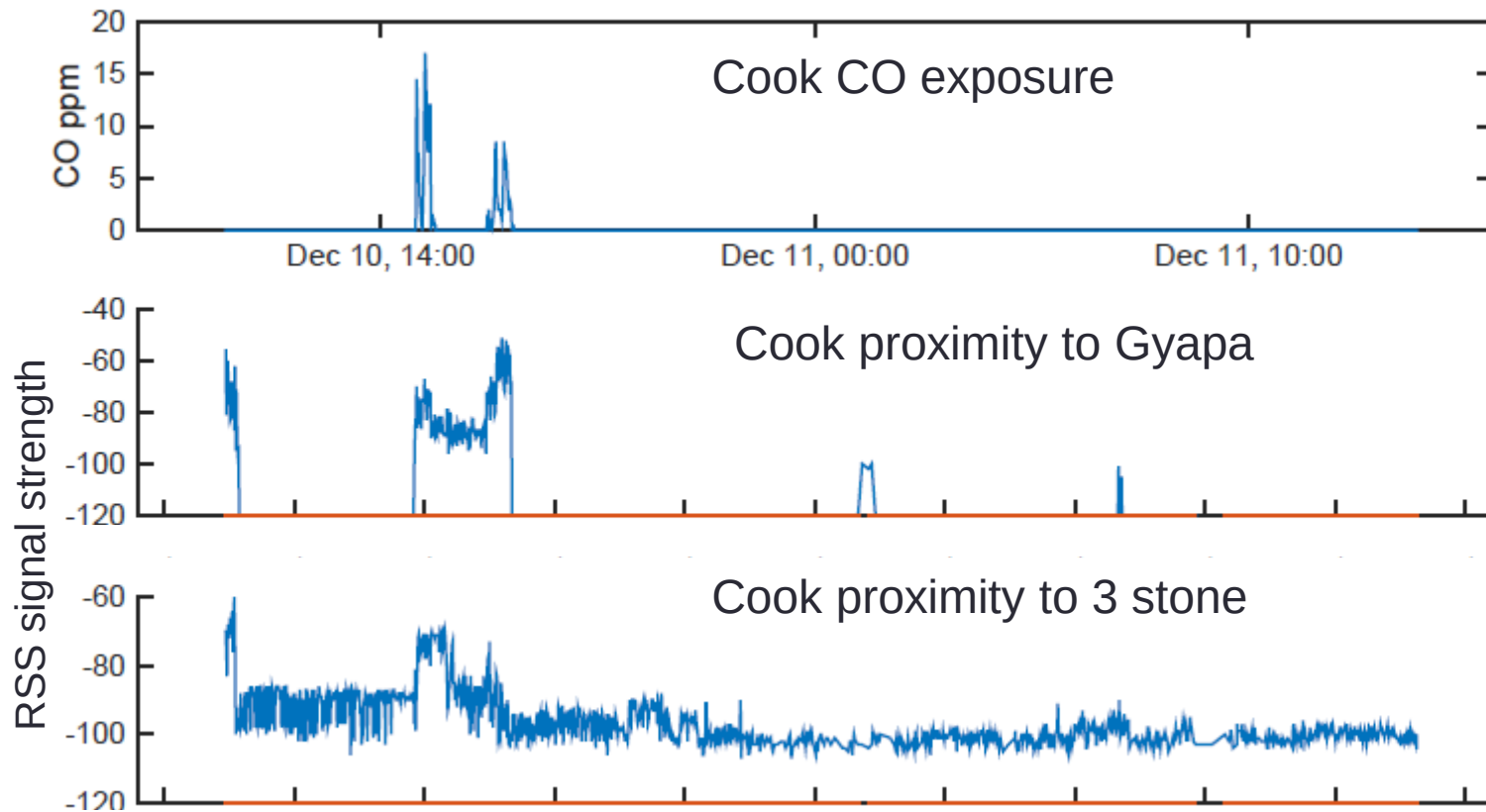
Why aren't we seeing differences in CO exposure?

Improve link between CO exposure and stove use

- Additional microenvironmental monitoring
 - UCB PATS
- Personal monitoring with iBeacons



Apportioning CO exposure



Where do we want to end up ...

Estimate ...

CO_{dose}

$$= \sum_i \text{function}_i(\text{stove}_i, T(t), \text{proximity to stove}_i(t)) + CO_{\text{other sources}}$$

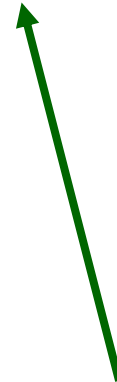
derive via regression



measure using SUMs

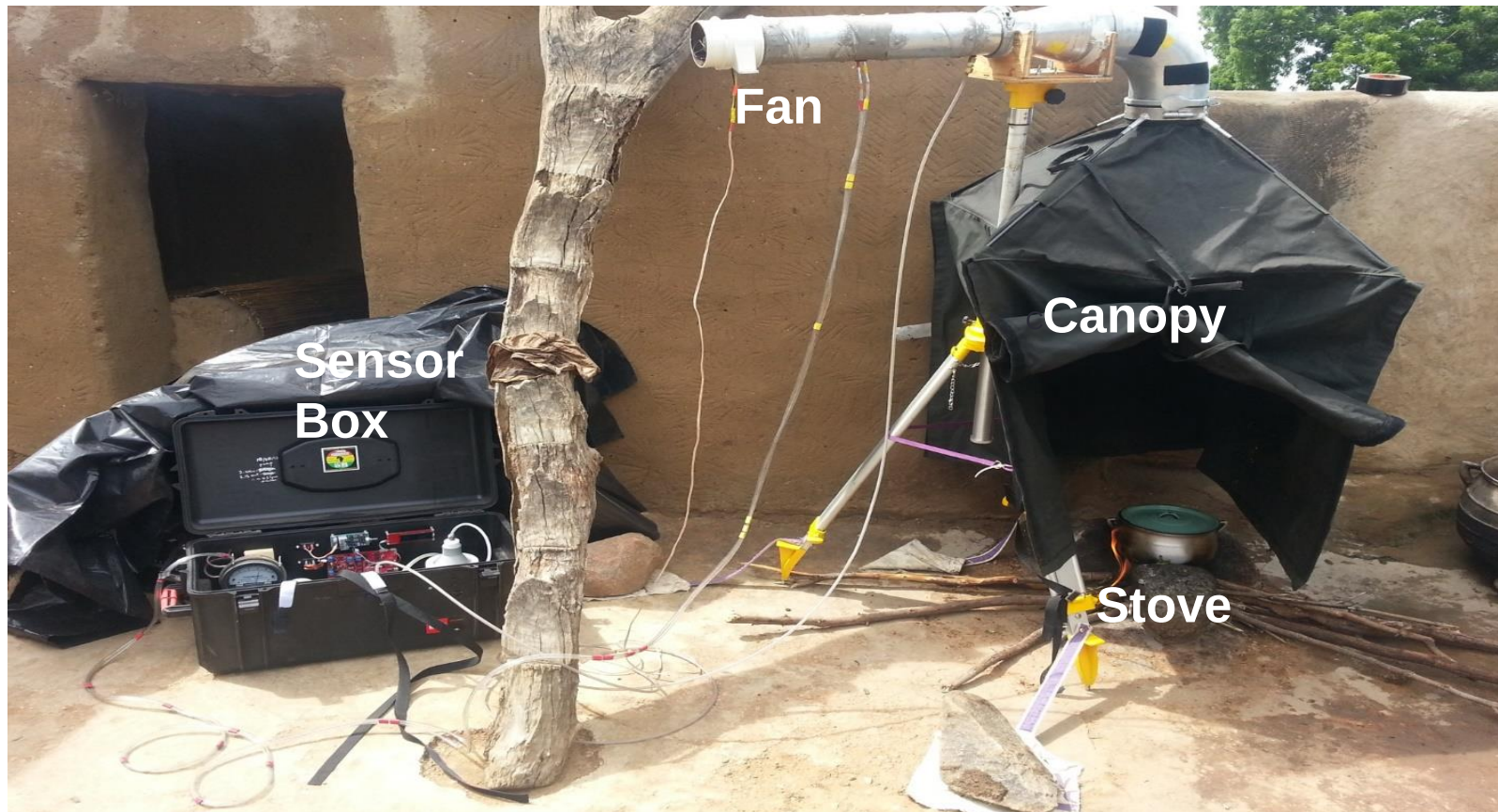


measure using beacon



PM2.5 too

Cooking Emissions Measurements

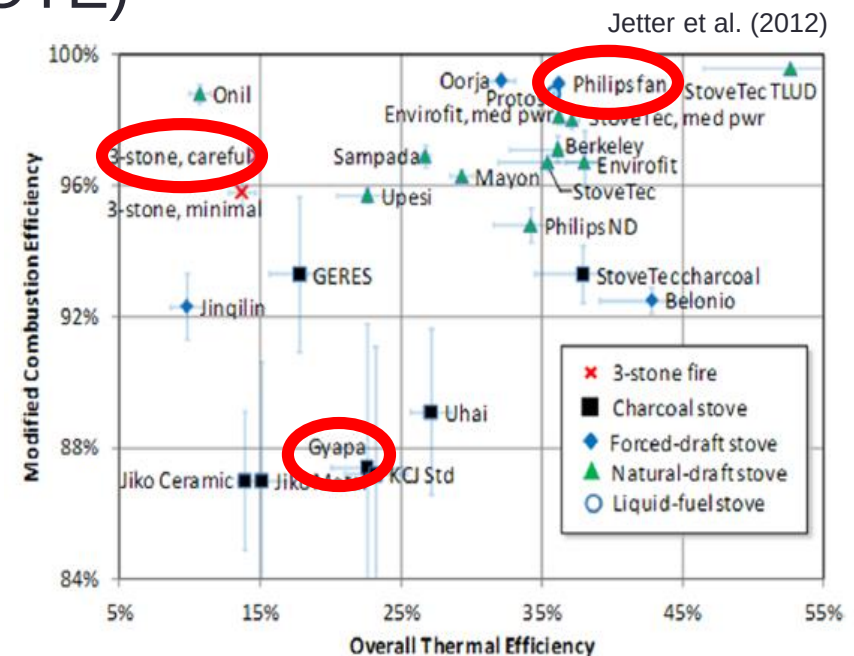


Evaluation of Stove Performance

- Using Controlled Cooking Test
- Efficiencies
 - Heat Transfer Efficiencies (HTE) and Combustion Efficiency (FCE)
 - Overall Thermal Efficiency (OTE)

- Emission Factors

- CO
- NO and NO₂
- total VOCs
- PM2.5 (cumulative)
 - speciation of PM2.5



Sampling Procedures/Techniques

- Be at household before evening cooking starts
- Let cook follow her normal practices
- Set up PEMs and measure emissions during the entire cooking period (2-4 hours)
- PM collection on 90 mm quartz-filters for integrated sample
- Gas phase emissions (CO , CO_2 , NO , NO_2 , TVOCs)
- Measure the weight of the fuel used and food cooked



Total samples collected

As of 02/22/2015

	Gyapa	Phillips	Three-Stone	Total
North	4	6	5	15
South	4	3	3	10
East	4	4	4	12
West	4	4	4	12
Residential/Total	14	15	14	49

Typical Emission Factor (mass of pollutant per mass of fuel used)

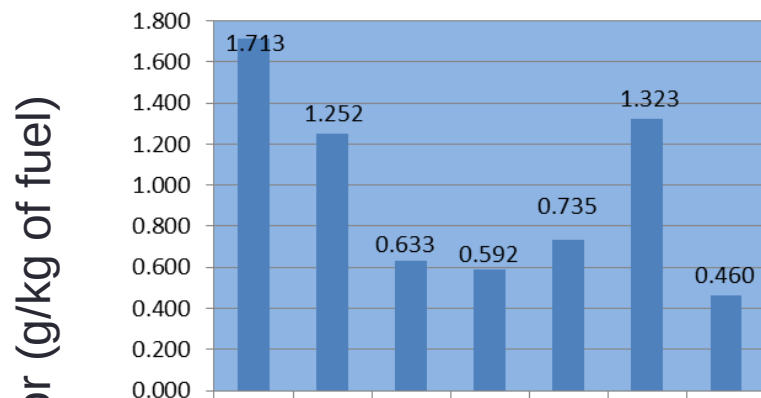
- Emissions= Function (stove type, fuel type, fuel moisture content, ambient T, food type)

Secondary analysis

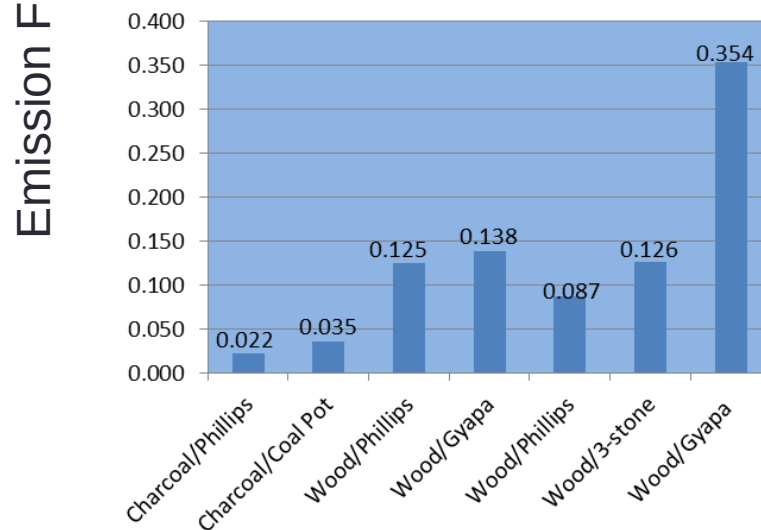
- Task based emission factors (mass of pollutant per mass of food cooked)
- Heat transfer efficiency in the field

Initial PM_{2.5} Results

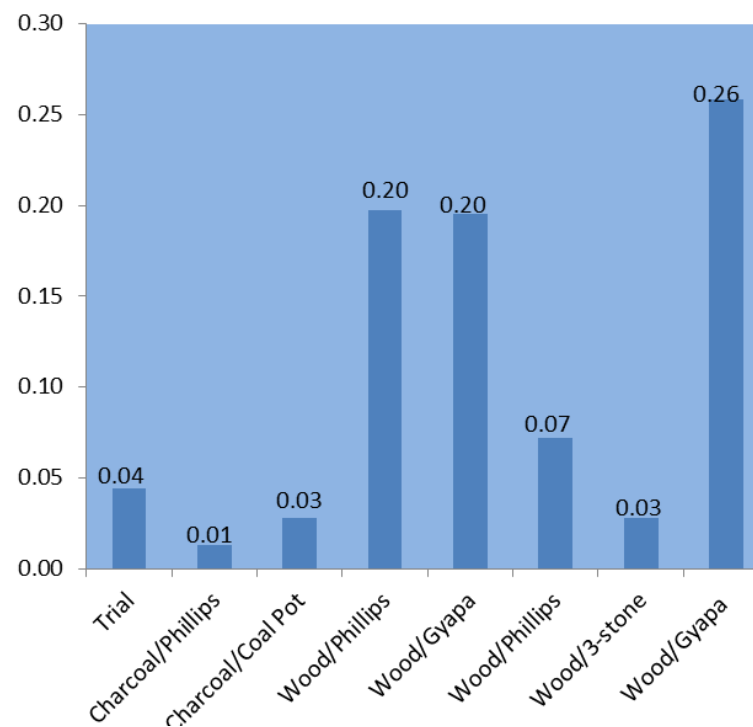
OC



EC



EC/OC ratio



Other source sampling



24 events to date
Trash burning
Traffic
Pito brewing
Commercial cooking



The Pleasures of Cookstove Assessment....

*A Norwegian an American and a Rwandan
are sitting at a campfire in the middle
of a Boulder, CO parking lot.*

*The Rwandan has two pairs of pants, one
fleece, a winter jacket and a beanie on...
while*

*The Norwegian has shorts and a light
sweater on and is asking for sunscreen...
while*

*The American is wondering what fast
food restaurant to swing by for dinner!*



Research translates to engaging class.

Questions?

