

US EPA ARCHIVE DOCUMENT

Quantifying the climate, air quality, and health benefits of improved cookstoves:

an integrated laboratory, field and modeling study

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**CENTER FOR ENERGY
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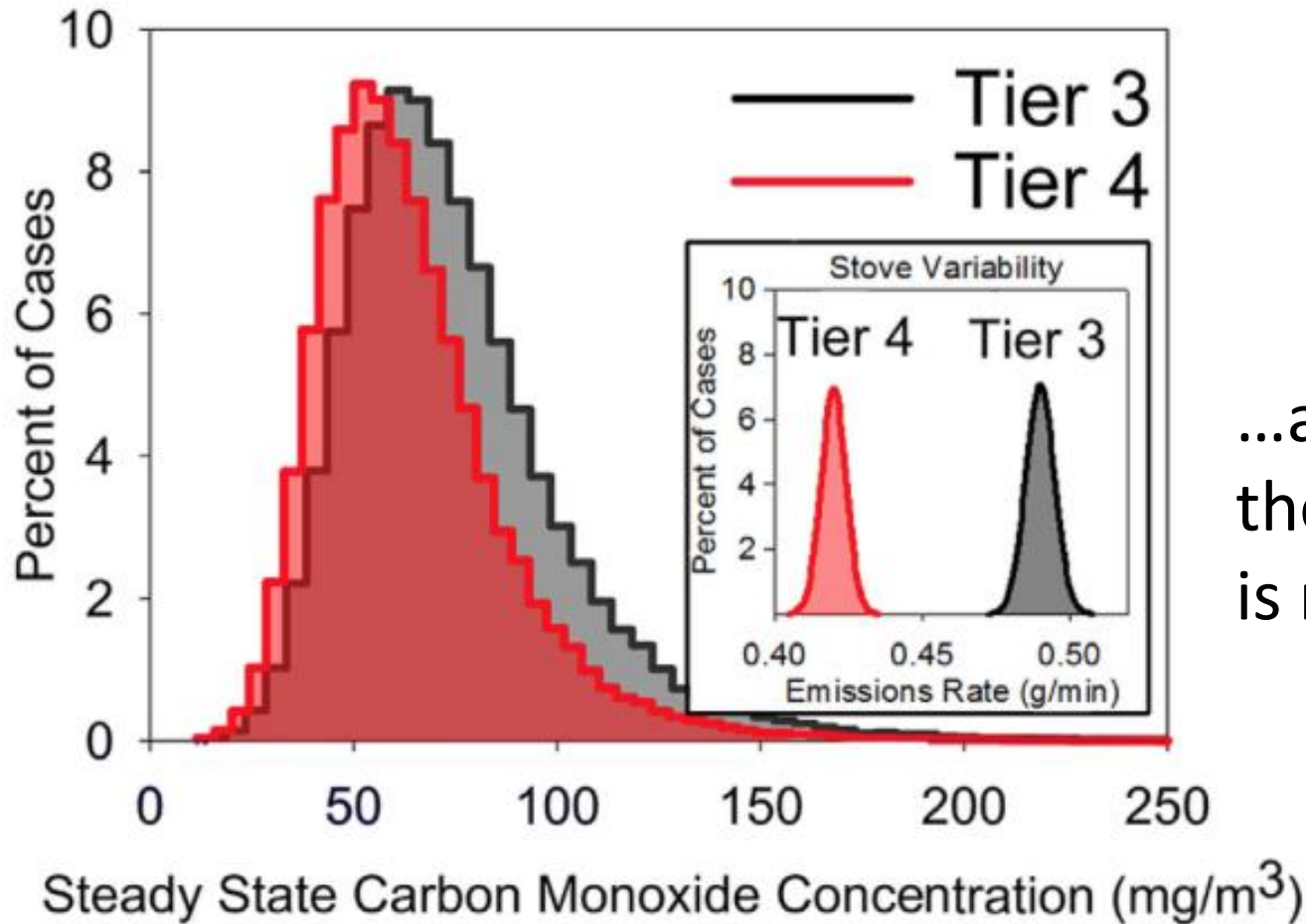
Big Picture Questions

- How much air pollution is emitted by all the residential solid fuel combustion on the planet?
- What would happen to climate, air quality, and health if everyone who burns solid fuels could move up 'one rung' on the energy ladder?
- Why doesn't our laboratory-generated data on emissions agree field observations?

The Challenge of Field Studies

- Between 2009 and 2010, CSU and Berkeley Air conducted approximately 260 field tests in India to evaluate stove performance.
 - “no significant difference was found in IAP concentrations”*
 - “there was no statistical difference between the stove types”*
 - “no statistically significant difference in black carbon”*
- Why would a stove that showed marked improvement in the lab show minimal improvement in the field?

A 15-20% Improvement in the Lab is Difficult to Detect in the Field



...and reliability of the measurements is not the problem

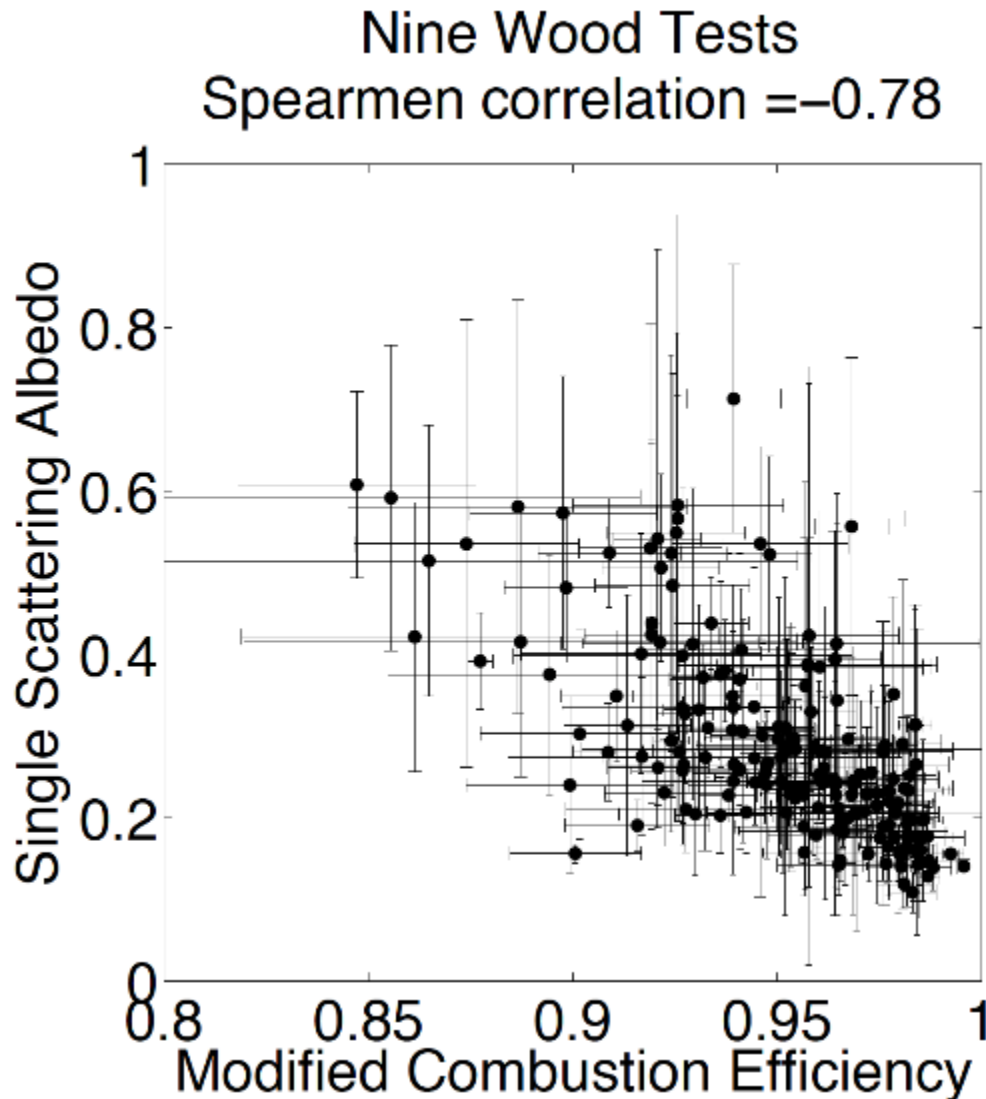
Stove 'performance' can vary for many reasons

We must understand what governs stove performance if we are to rely on laboratory data to predict performance in the field

...and there are good reasons why we would want to do this.

We want to predict stove performance in the field so that intervention programs produce impact as planned: *on health, on climate, on economics*

Modified Combustion Efficiency (MCE):
Helpful? *Yes*. Perfect? *No*. Practical? *Not really*.



$$\text{MCE} = \frac{\Delta CO_2}{\Delta CO + \Delta CO_2}$$

All stoves have a working range of power output

Low Power

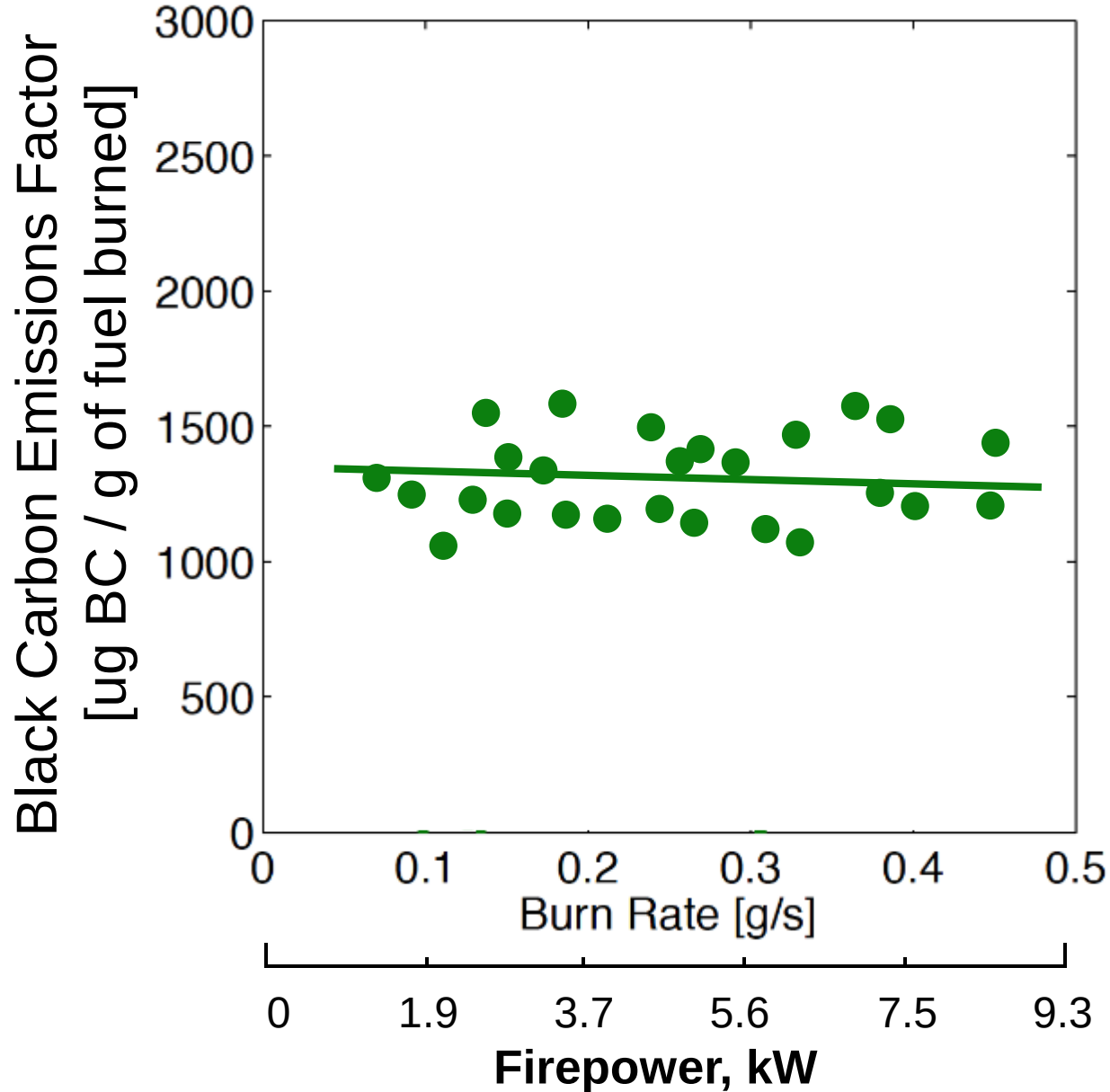


High Power

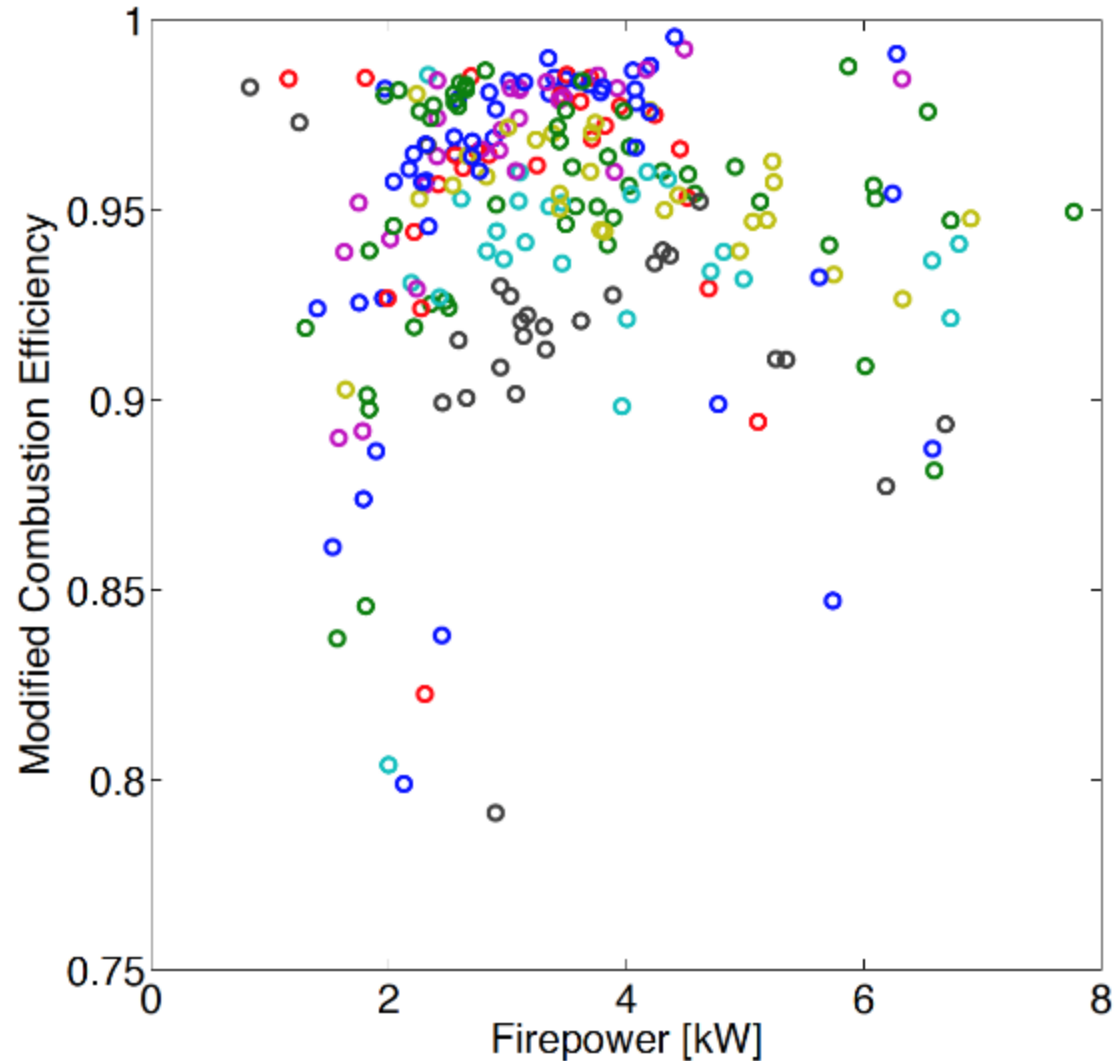


$$\text{Firepower(kW)} = \frac{\text{Stove Energy Output (kJ)}}{\text{Time (s)}}$$

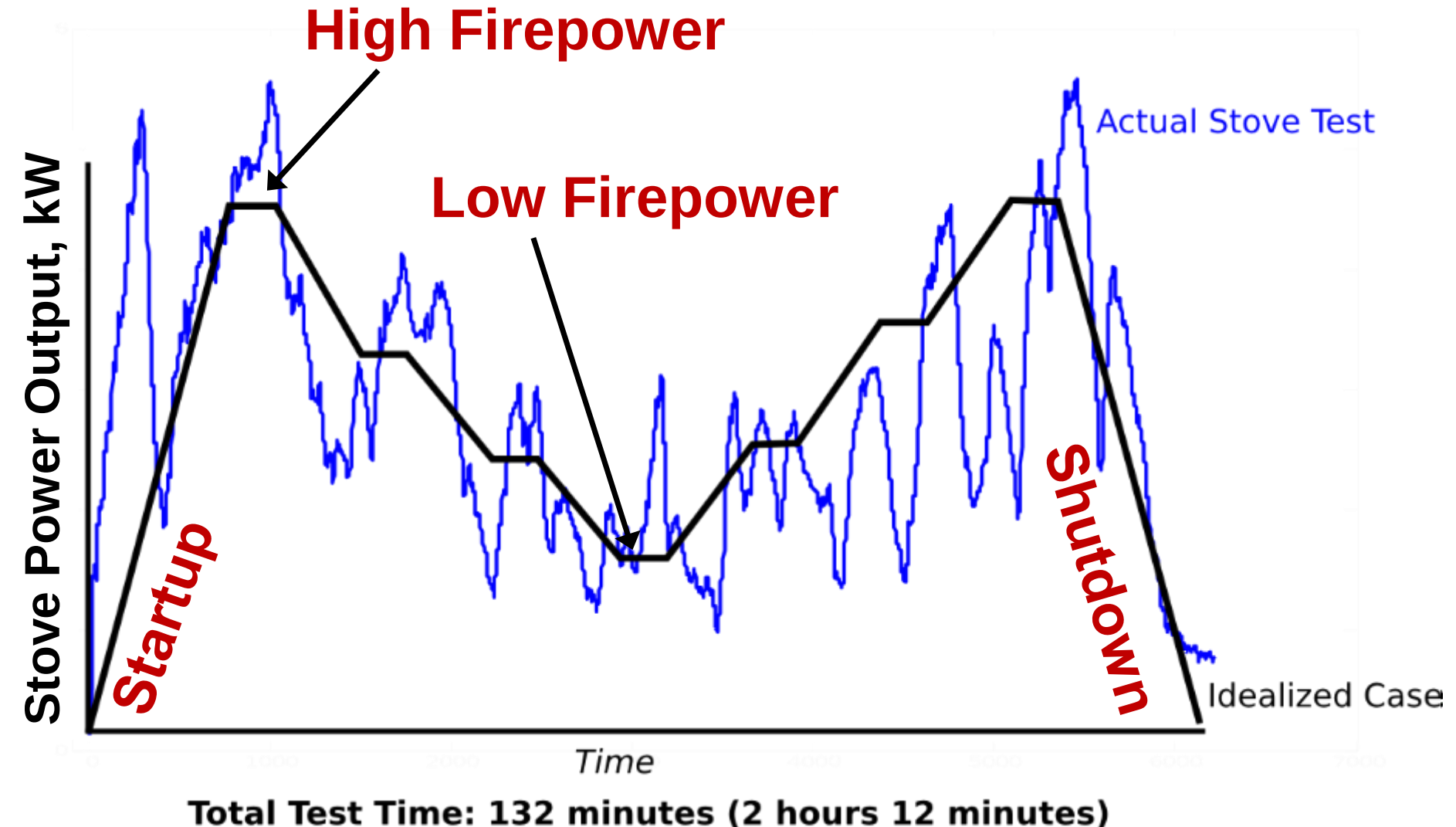
Black Carbon and Stove Firepower



Modified Combustion Efficiency vs. Firepower



The Firepower Sweep Test

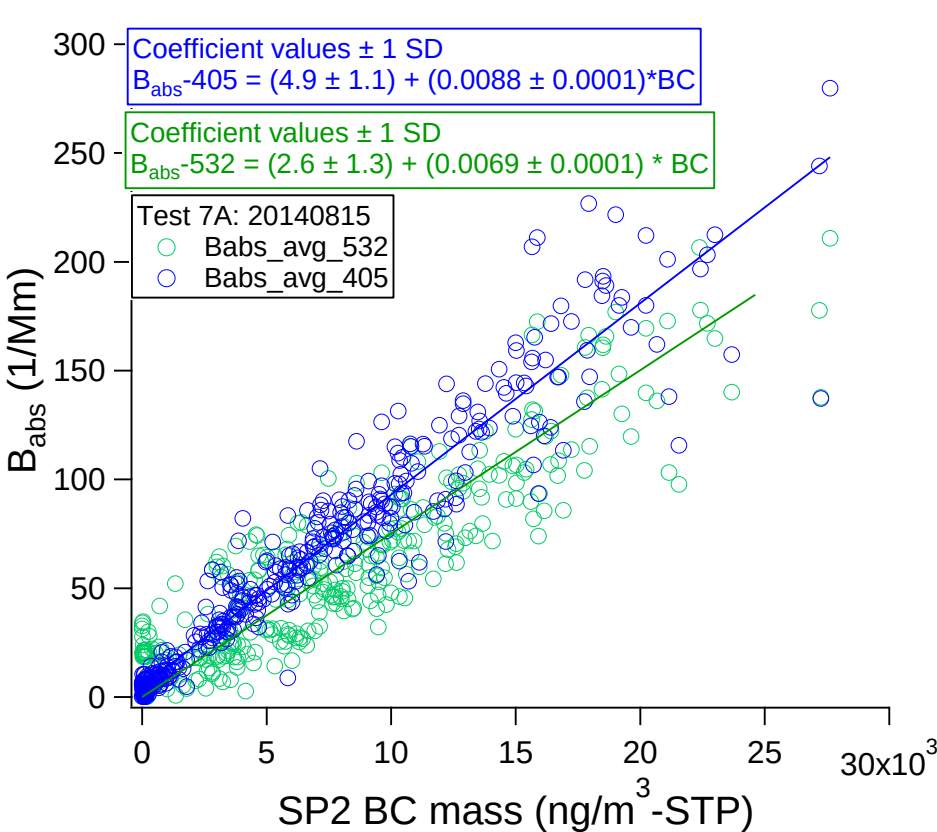


2014 Front Range Cookstove Study (FRaCs)

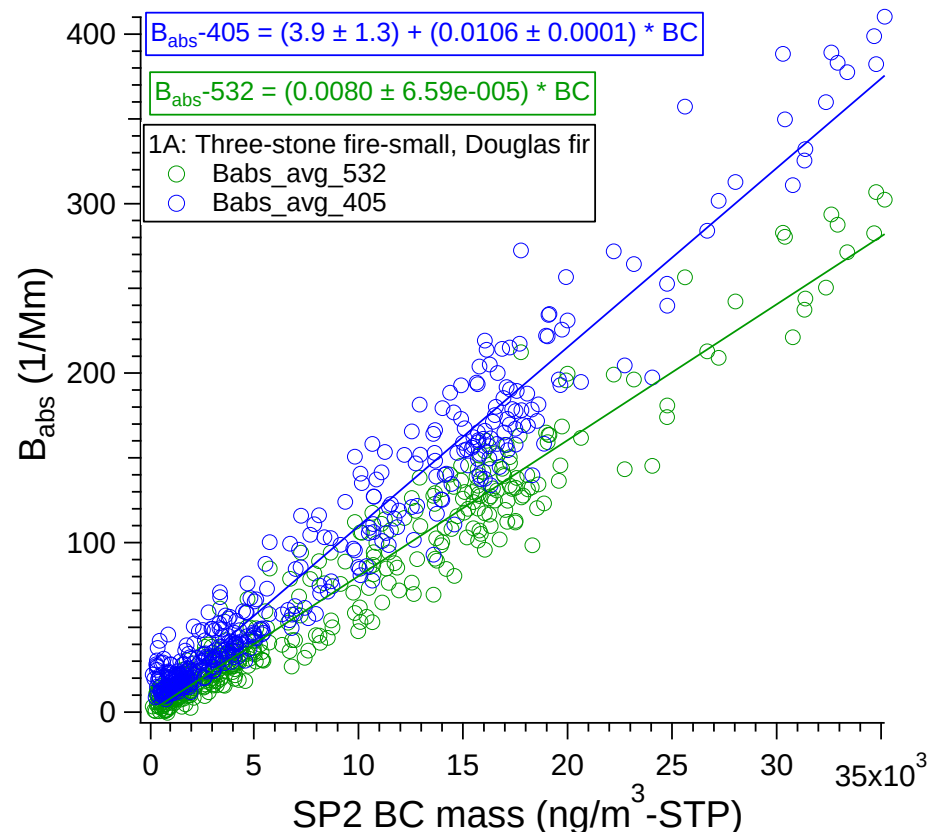
Stove Type	Versions	Fuels
Three Stone Fire	Small	Douglas Fir
		Okote
		Eucalyptus
Tradiational Built In	Justa	Douglas Fir
	Sunken Pot	Douglas Fir
		Okote
Improved Plancha	HM 5000	Douglas Fir
Ceramic Jiko	Small	Lump hardwood
		Coconut
	Large	Lump hardwood
		Coconut
Metal Jiko	Large	Lump hardwood
	Small	Lump hardwood
Improved Charcoal	BURN Design	Lump hardwood
Artisan Clay	Version 1	Douglas Fir
		Eucalyptus
Enclosed Metal	Version 1	Douglas Fir
		Eucalyptus
Rocket Elbow	Version 1	Douglas Fir
		Eucalyptus
	Version 2	Douglas Fir
Semi Gasifier	Philips	Wood Pellets
		Red Oak
	Concept Gasifier	Wood Pellets
		Red Oak

- 21 days
- 25 Stove/Fuel Combinations
- 70 tests (3hrs ea.)
- 17 participants
- 10 research groups
- 1400 person-hrs

BC mass absorption cross-section: Similar to fresh combustion soot

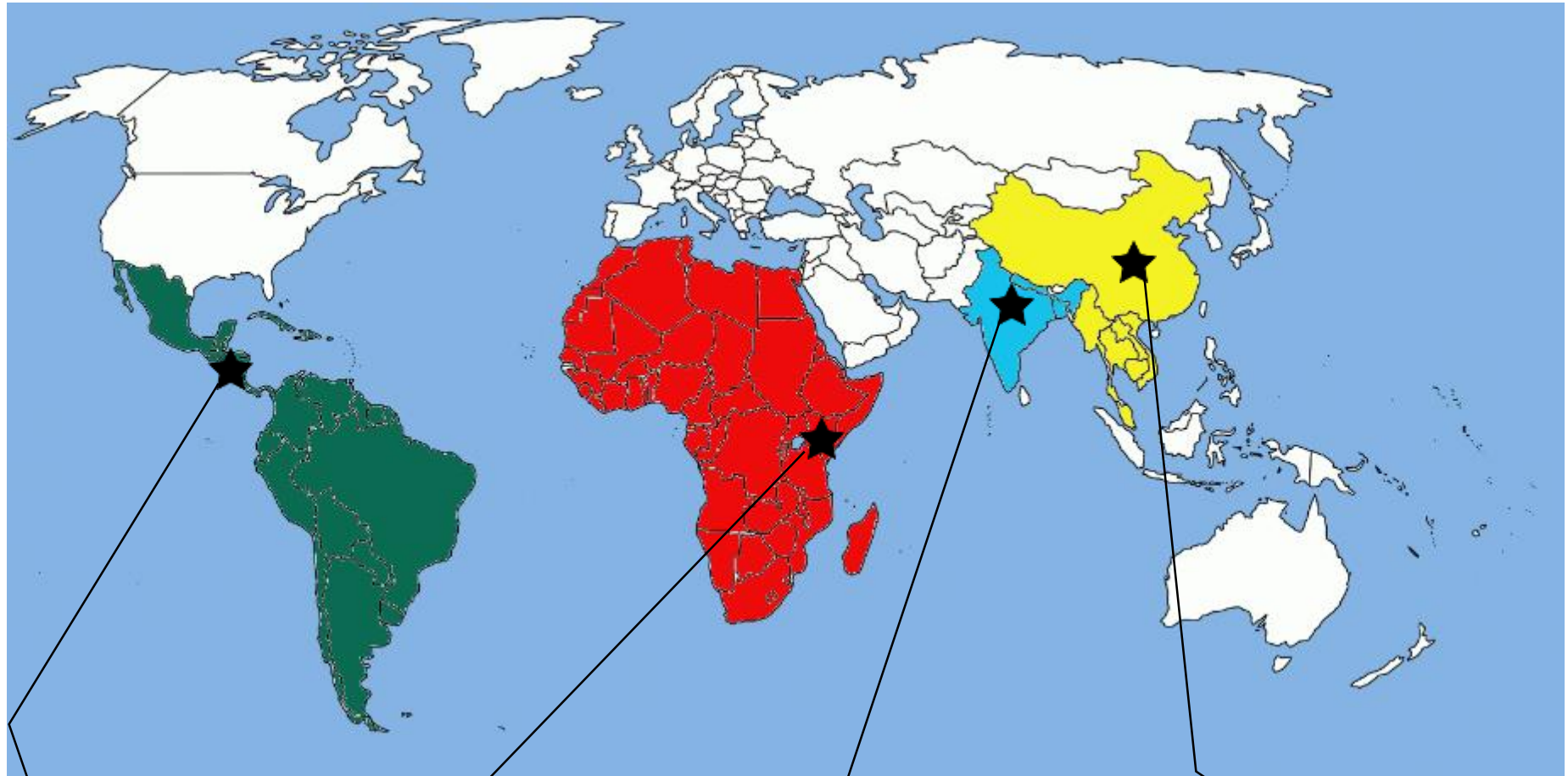


Plancha (HM5000) with Douglas fir
MAC-532 = 6.9 m²/g (Bond et al. 7.75)
MAC-405 = 8.8 m²/g (Bond et al. 10.2)



3-stone fire with Douglas fir
MAC-532 = 8 m²/g
MAC-405 = 10.6 m²/g

Field Work: Emissions, Exposures, Model Validation



HONDURAS:
March 2015

**Colorado
State**
University

KENYA:
July 2015

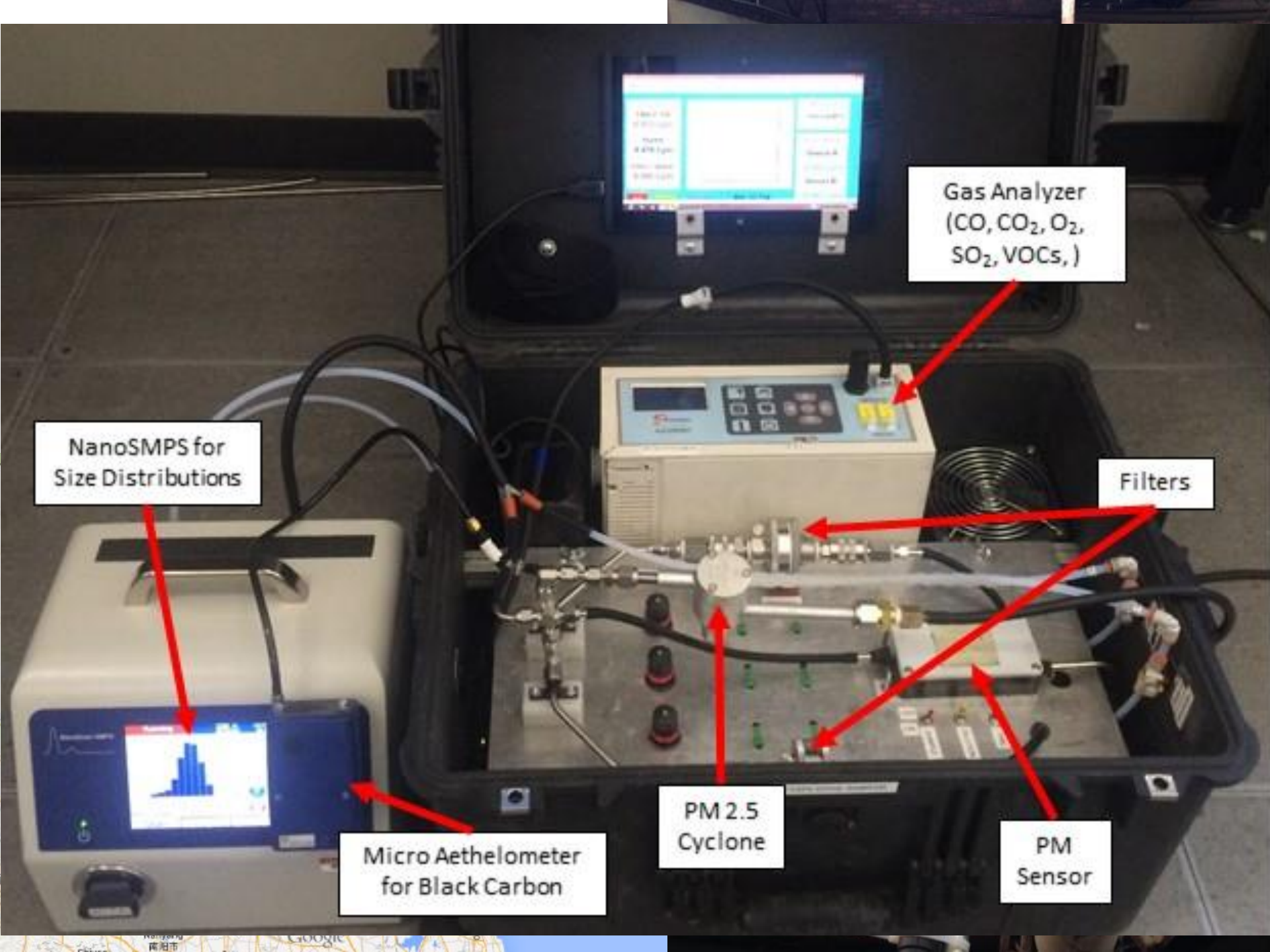
Wi
WINROCK
INTERNATIONAL

INIDA:
Winter 2016


ENVIROFIT

CHINA:
January 2015

 **清华大学**
Tsinghua University



Gas Analyzer
(CO, CO₂, O₂,
SO₂, VOCs,)

NanoSMPS for
Size Distributions

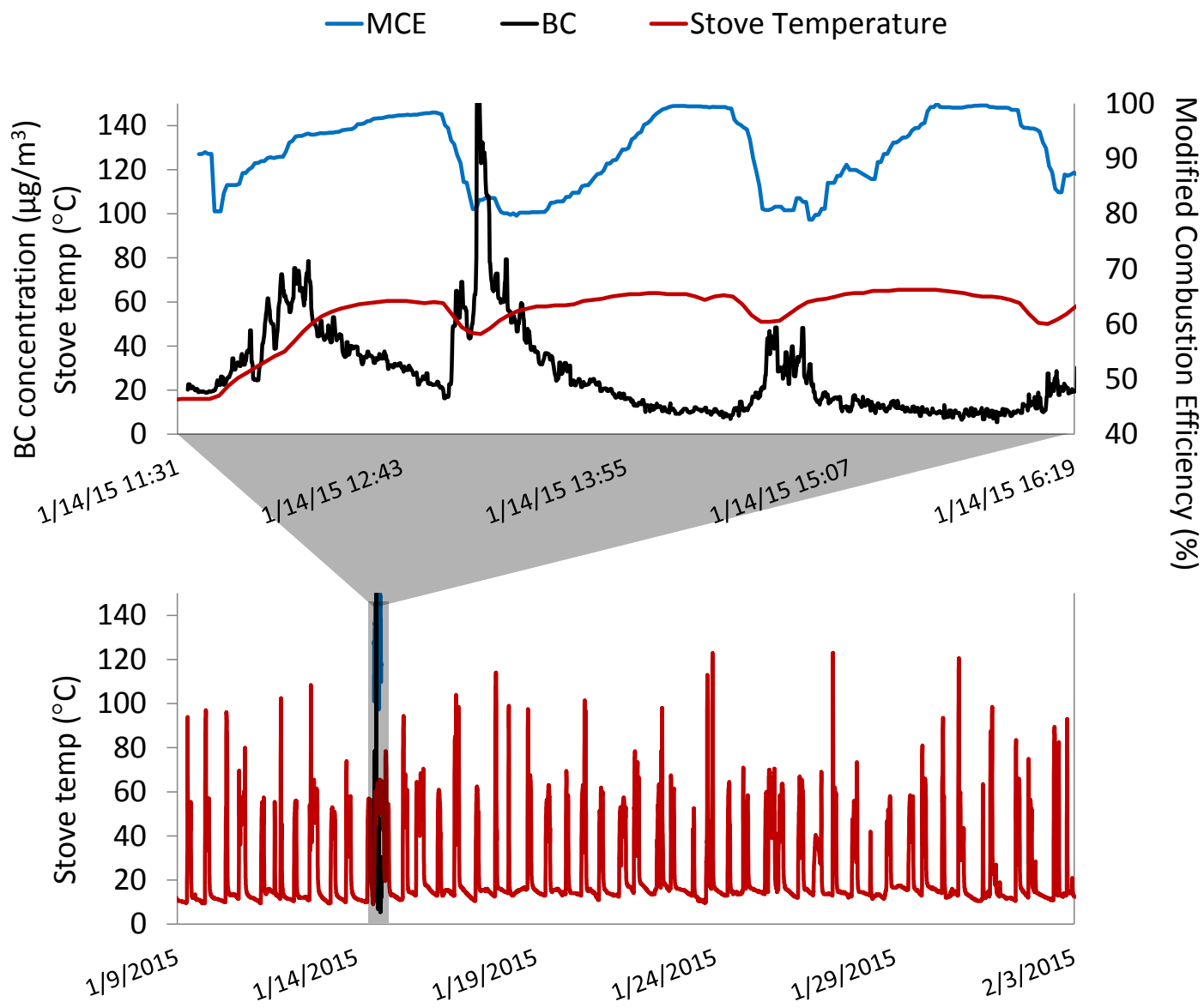
Filters

Micro Aethelometer
for Black Carbon

PM 2.5
Cyclone

PM
Sensor

Example emissions and usage data of a coal stove



BC emissions and combustion efficiency shows relationships with usage patterns

Ongoing work

- Atmospheric aging experiments
 - What happens to emissions as they are processed in the atmosphere?
- Global emissions inventory development
- Health impact and climate modeling
- Lab-to-field models