The Adventures of ARACHNE:
emissions from real cooking fires in Central America

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Trees, Water and People

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AHDESA

ETHOS Conference
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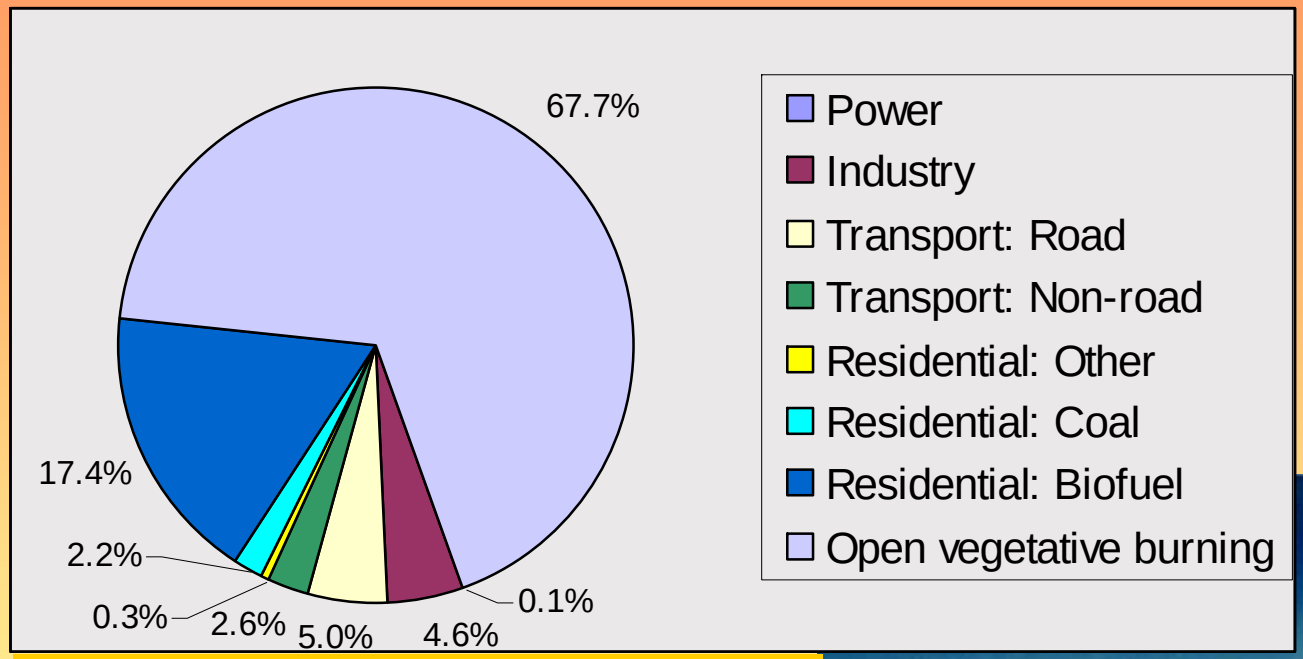
the global picture



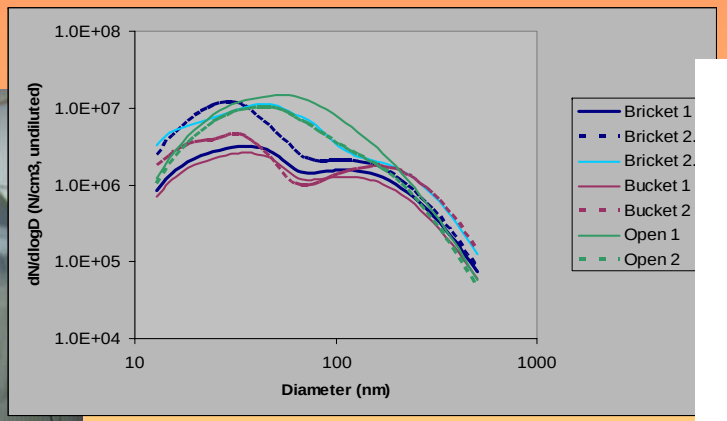
Carbon particles emitted globally

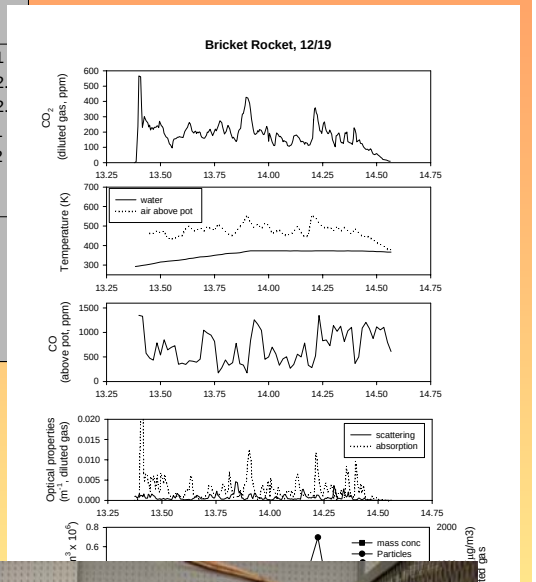
Bond et al., Journal of Geophysical Research, 2004

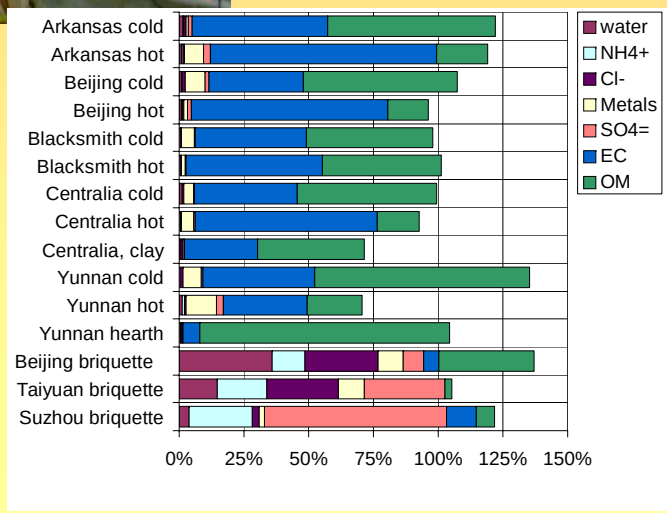
Human effects on Earth's radiative balance

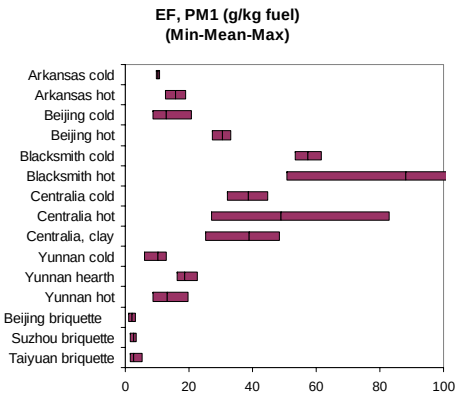
Photo: NASA (via Robert Charlson)

background lab work (2001-2002)
wood and coal burning

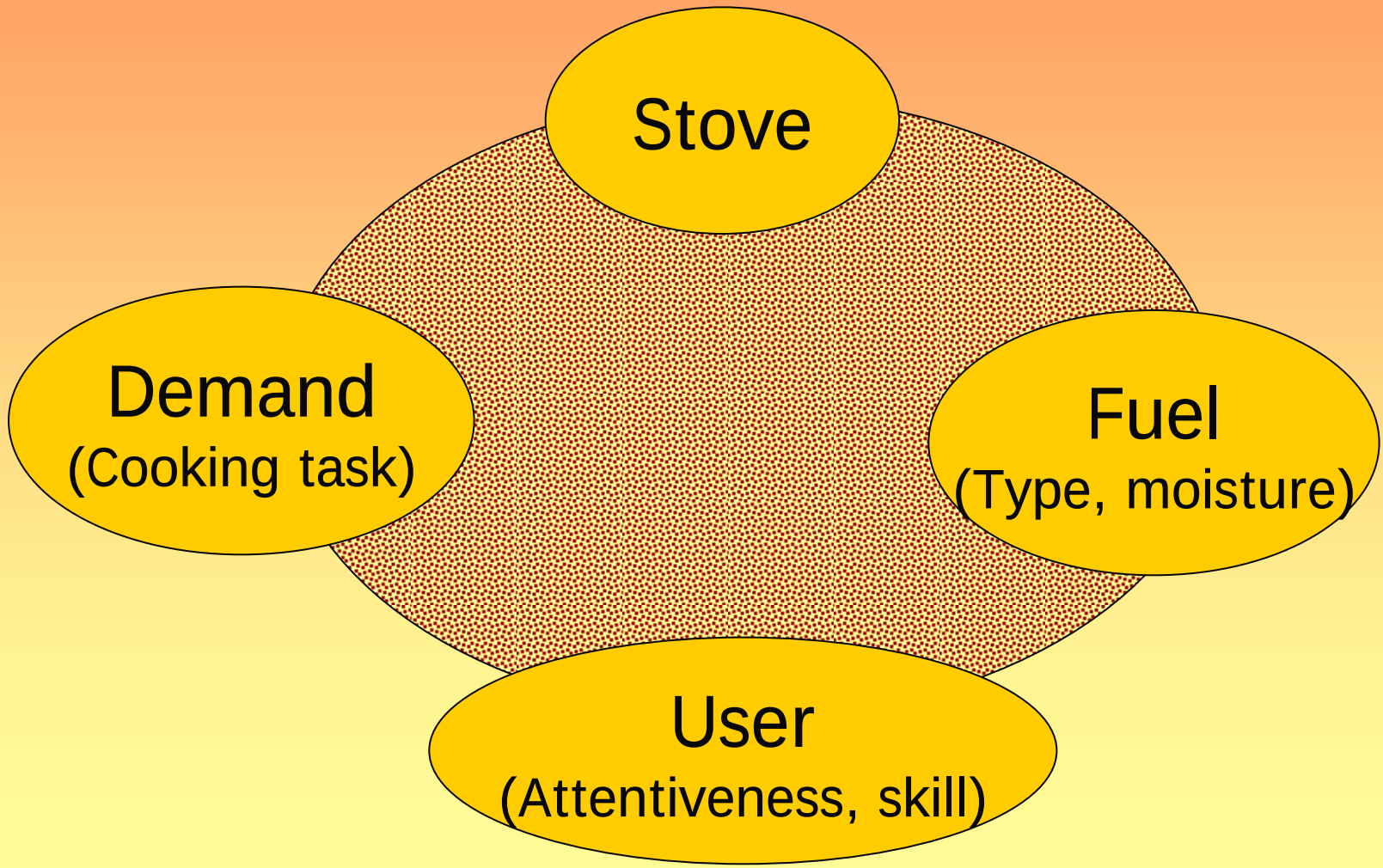




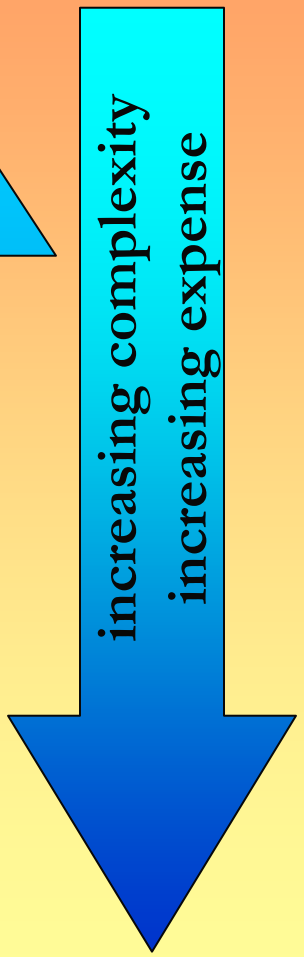




Emissions are the result of a system



Proposal for monitoring hierarchy (2003)



I. In-field monitoring

- confirm improvements
- rapid feedback to stove artisans

II. Stove design lab

- evaluate design choices
- demonstrate emission improvements

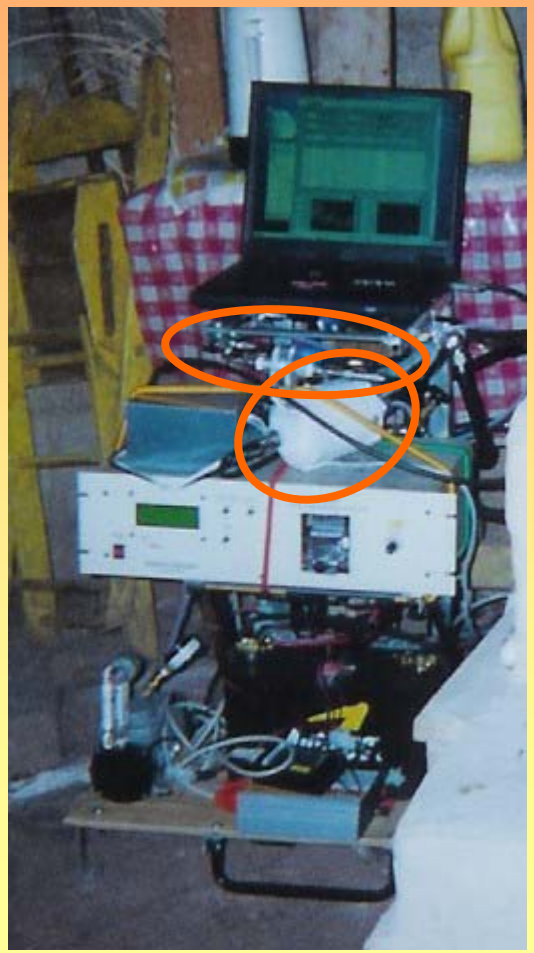
III. High-end (university) testing

- validate less-expensive measurements
- understand nature of emissions

ARACHNE

***A**mbulatory **R**eal-Time **A**nalyzer for*
***C**limate and **H**ealth-Related **N**oxious **E**missions*

Christoph Roden, PhD student



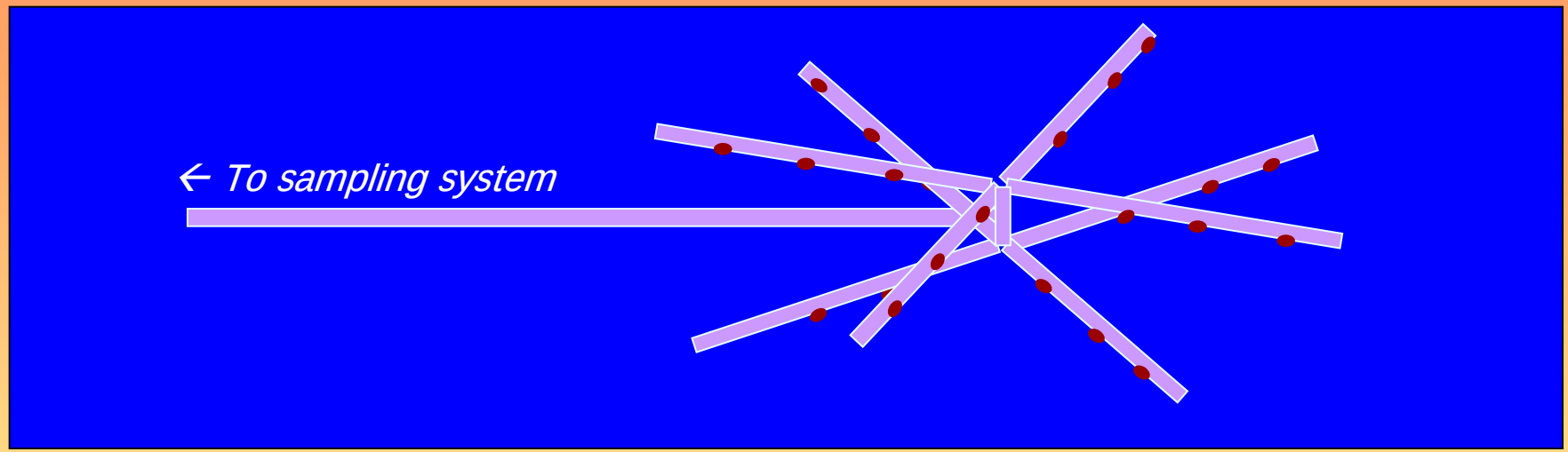
Size: 24” x 36” x 19”
Power: 12v car battery
Runtime: approximately 5 hours
Cost: About $14k

Measurements:

Similar to Aprovecho, with some additions

- Real-time CO and CO_2
- Real-time optics
  - nephelometer (approximately particle mass)
  - absorption meter (particle color/type)
- Particles also collected on filters for later chemical analysis

Araña– cross between hood & probe



- Samples at 24 points representing equal area
- Placed high in plume so initial dilution is natural
- Doesn't disturb combustion or exhaust flow; thus, we can measure IAQ simultaneously
- Not isokinetic (but sampling efficiency estimated as ~94%)
- Relies on ratio method for calculating emission factors

TWP/AHDESA project

umbrella:
Trees, Water, & People

- Stove Improvement
  AHDESA & Aprovecho
- Dissemination
  AHDESA & TWP
  (Stuart Conway's talk)
- Monitoring
  UIUC & AHDESA

funded by PCIA
UIUC participation:
travel by PCIA
remainder by NSF & U of Illinois

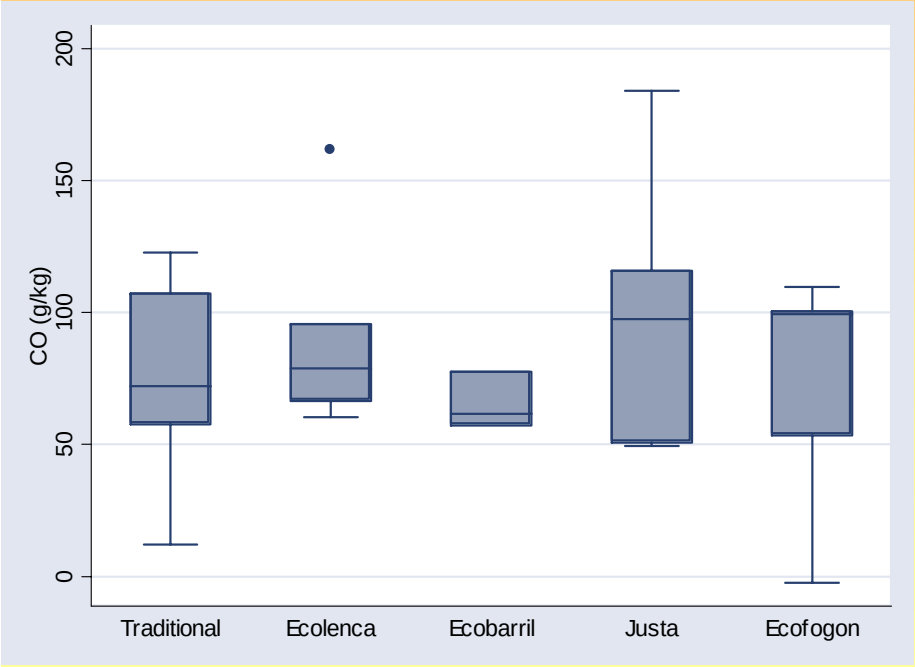
- Measure emissions & room concentration simultaneously
- Gather in-field measurements of emission rates
- Train AHDESA in monitoring
- Gather information for other projects

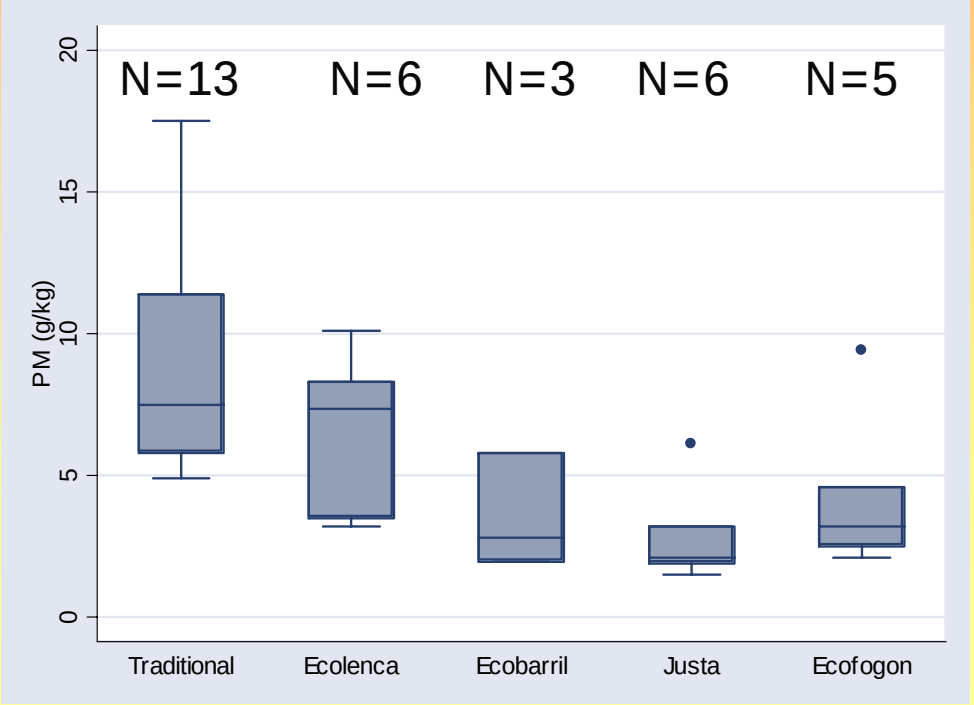
Do chimneys make a difference?

Or do they just dump the pollution outside for the neighbors to breathe?

Yes, they help, when they are not clogged.

They improve combustion by increasing draft, and reduce PM emission factor (but, apparently, not CO emission factor).





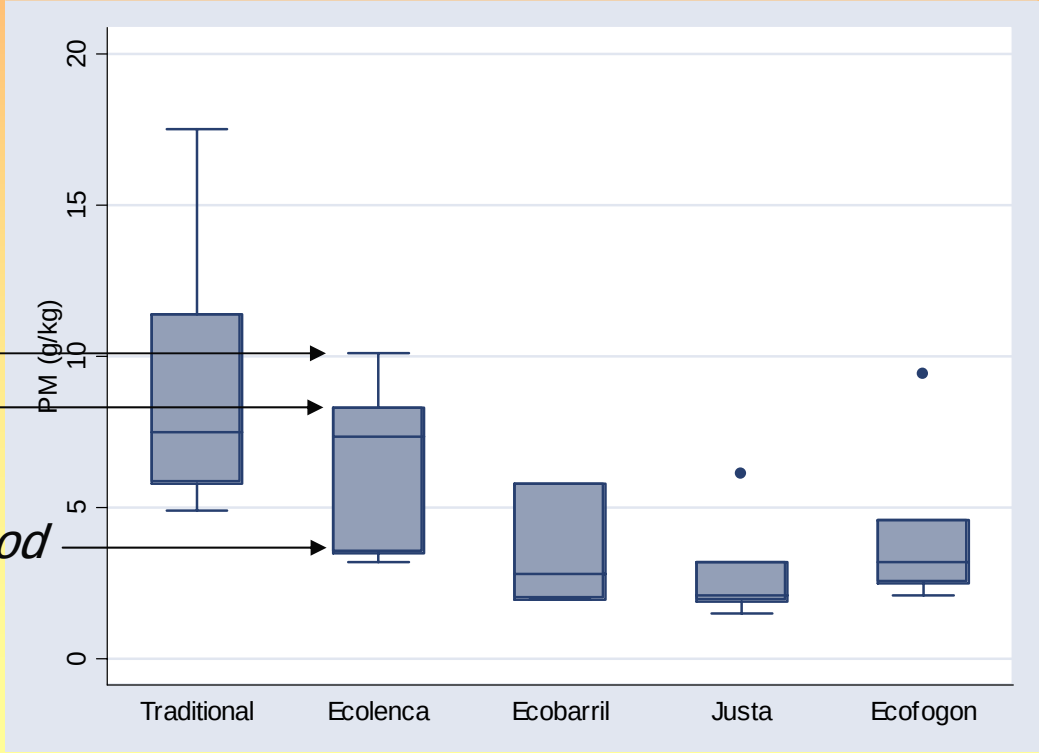
Are stoves that are better in the lab also better in homes?

Or are factors besides combustion more important?

Sometimes. Training and fuel quality also play major roles.

Untrained user
Wet wood

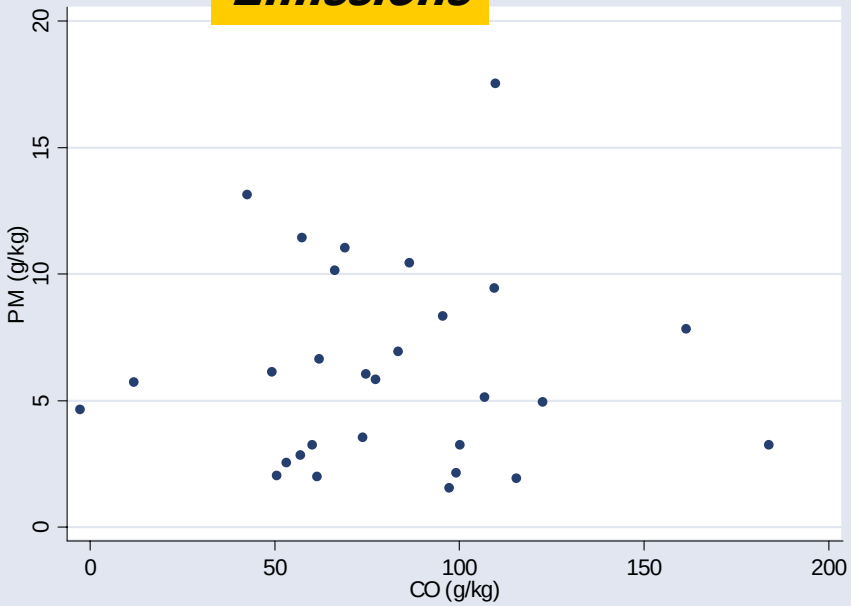
Same stove, warmed up & dry wood



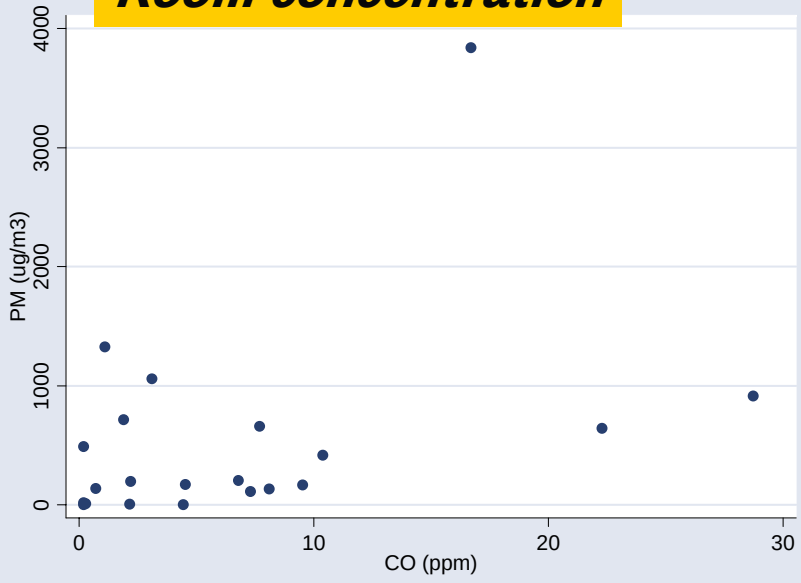
Are PM and CO emissions related for similar fuels?

No. There is no correlation for the emission data, and correlation for room data (r=0.4) is dominated by bimodality of data.

Emissions



Room concentration

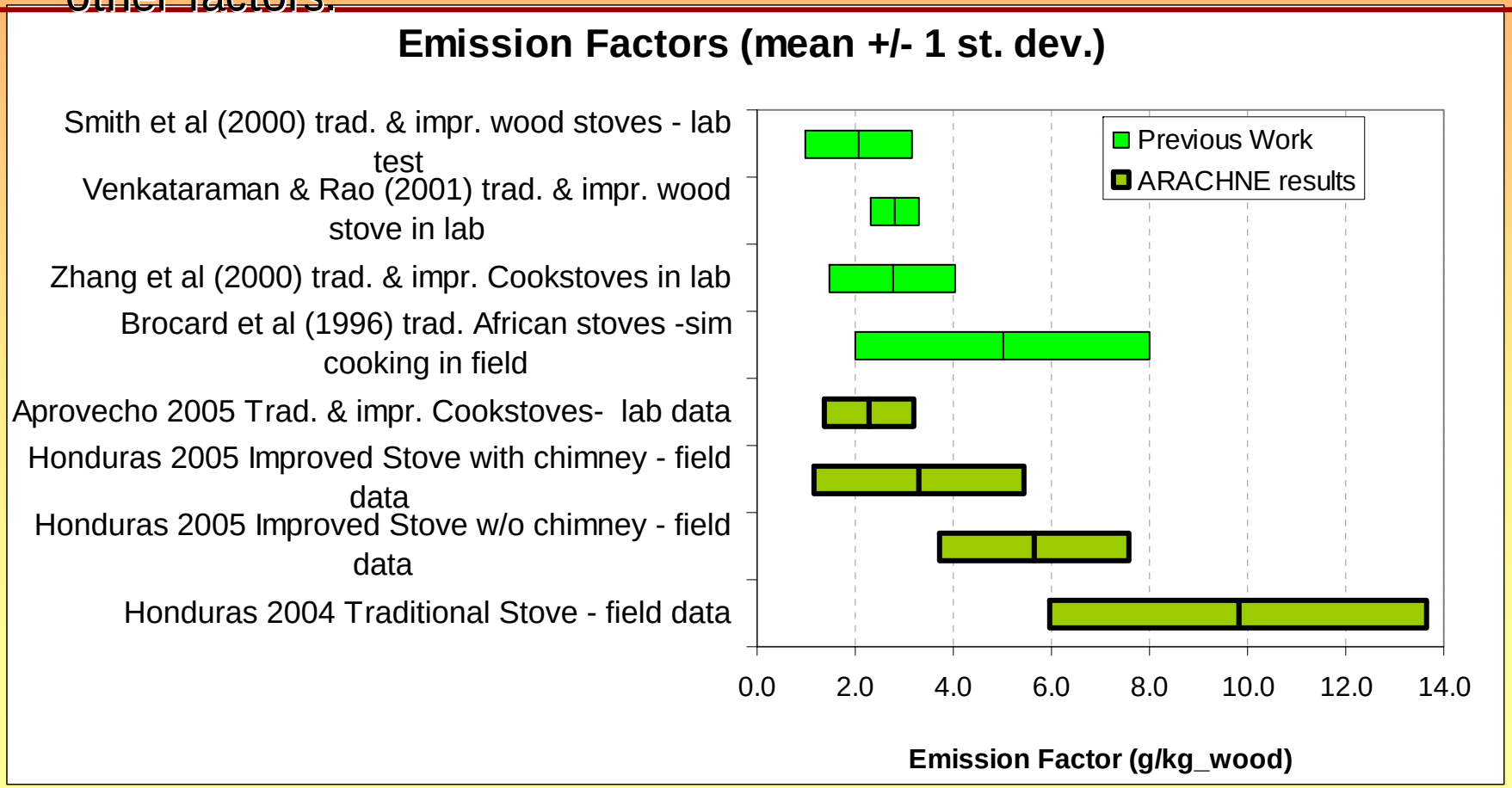


Do stoves measured in the field perform differently?

Or can we rely on lab measurements to predict real behavior?

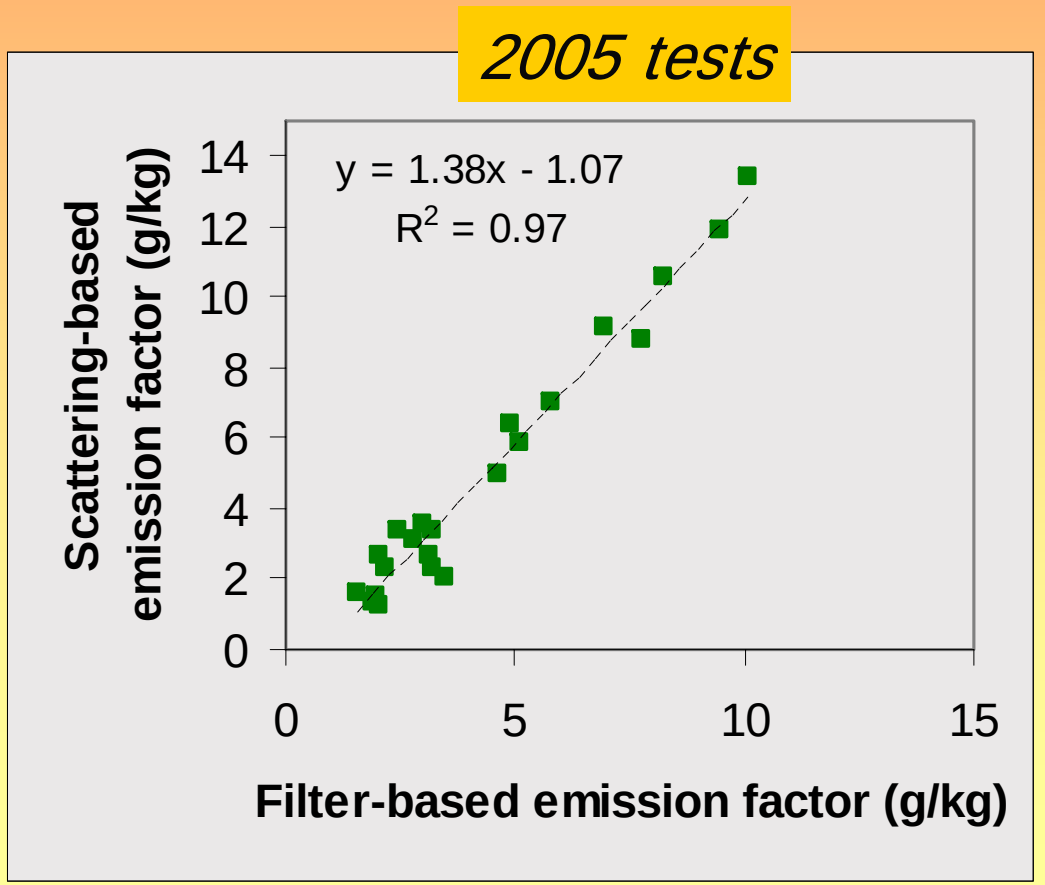
Yes, there is a big difference between lab and field measurements.

We are considering wood type & moisture as explanations, but there are other factors.

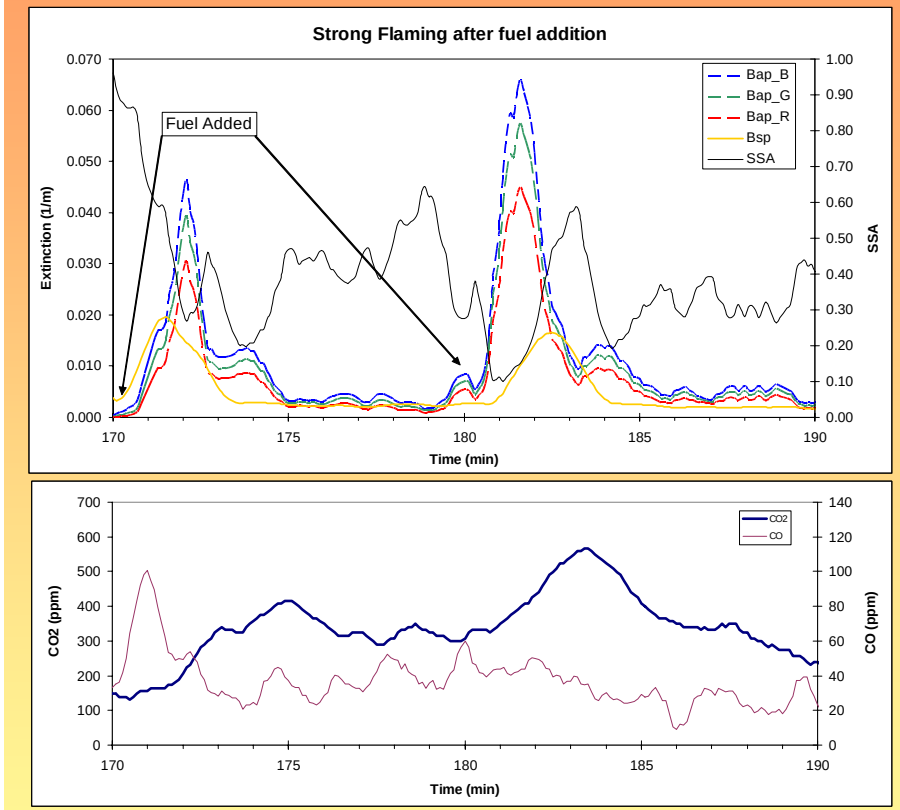


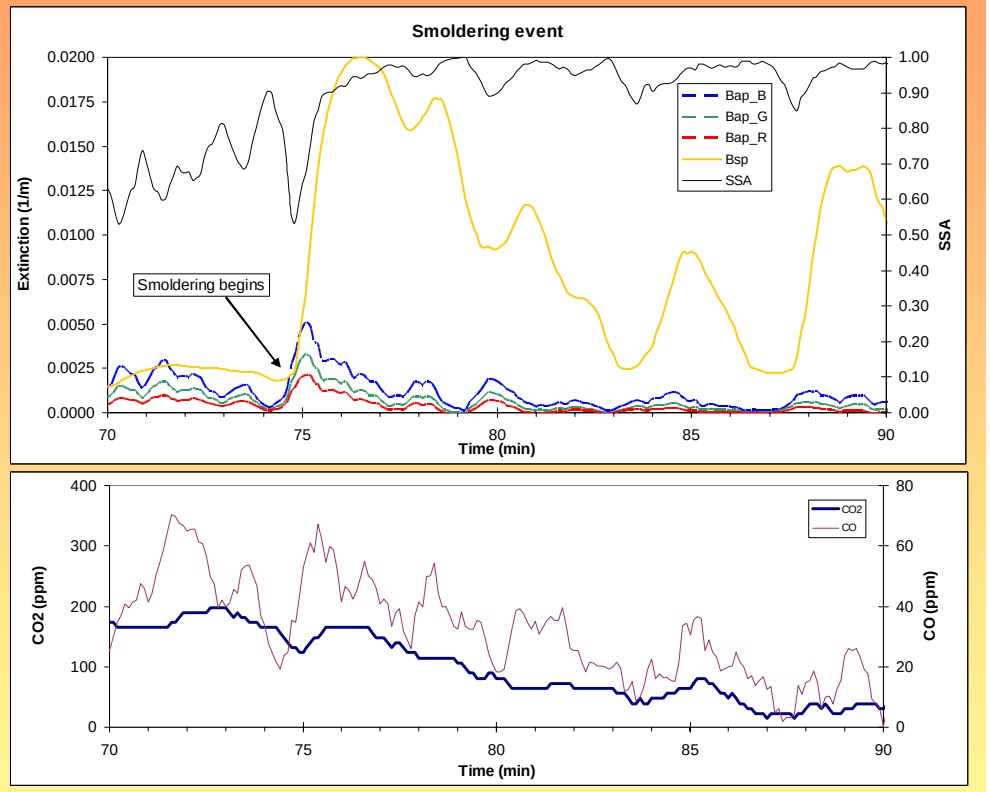
How do our "compromise" PM methods compare with accepted measurements?

- Optical measurements (light scattering) have variable relationship with particle mass.
- However, these particles are all from combustion and are similar in nature.



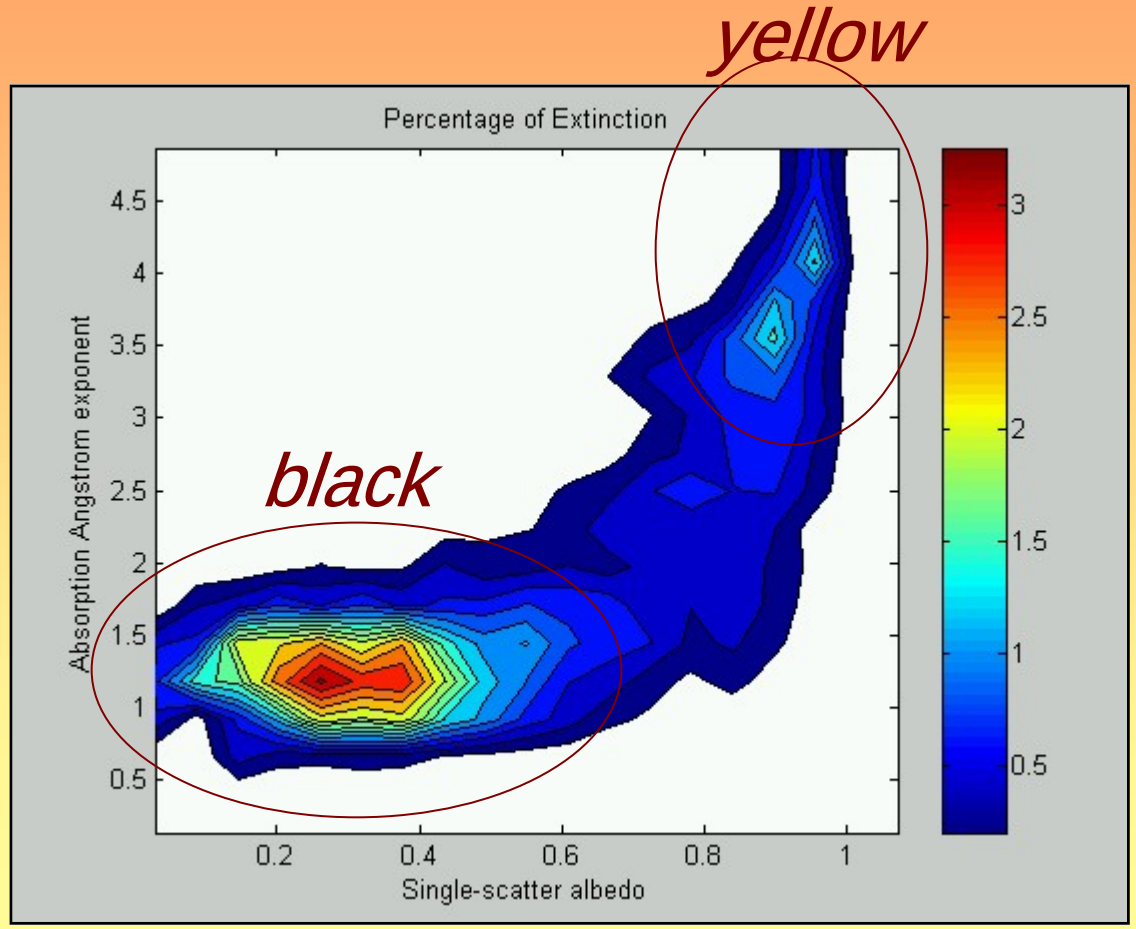
Examples of real-time data





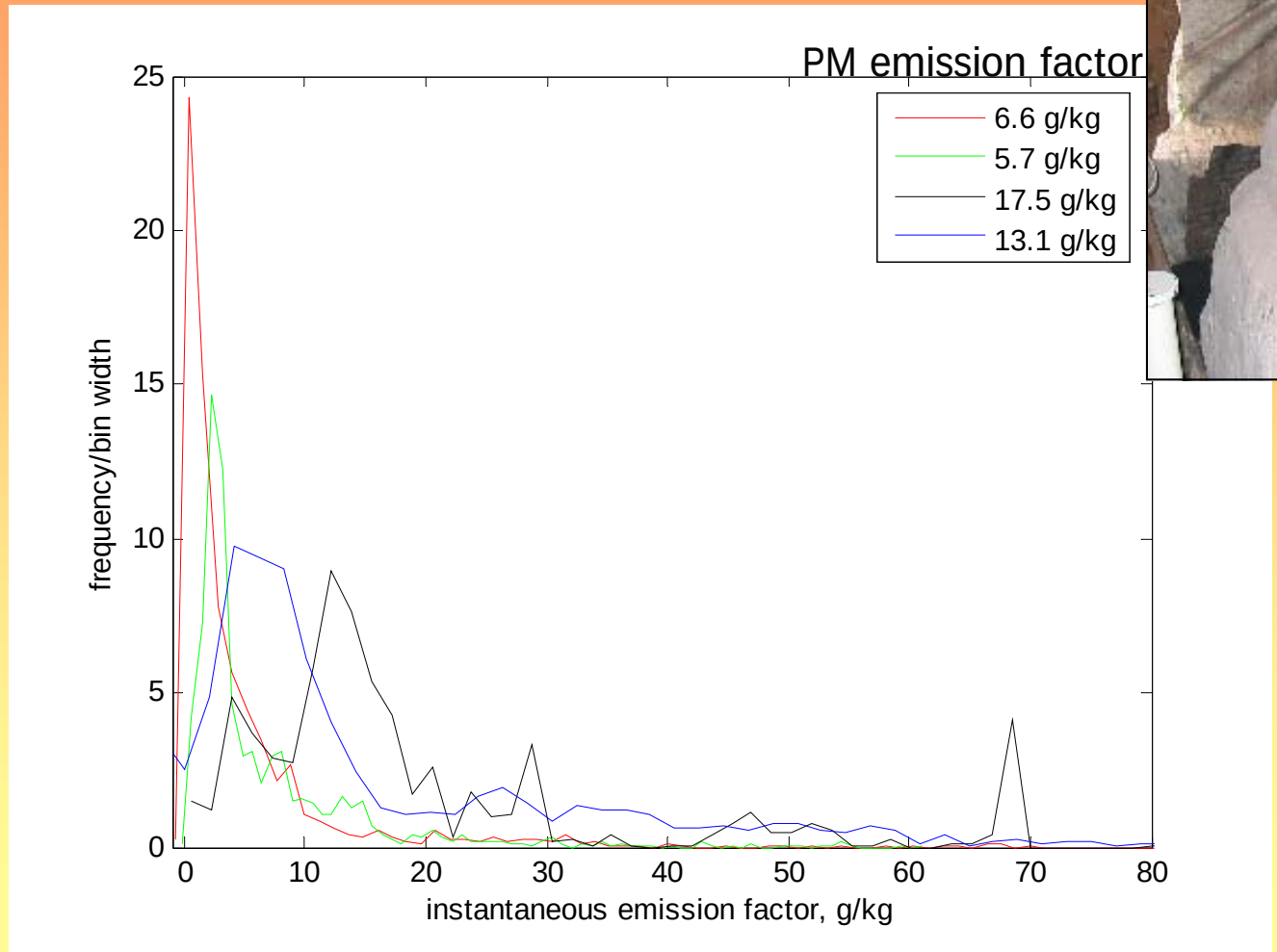
Two kinds of particles are emitted, and not much in between

Compared with open burning and fireplace combustion, more of the emitted particles are black—formed in the flame, not escaping from wood ends.



traditional stoves

High emissions are partly caused by large puffs, partly by sustained periods.



Take-home messages

- Cooking emissions result from the stove-fuel-user-cooking *system*
- Improved stoves can make a difference in *both* emissions and indoor air quality
- In-field emission factors can be very different from lab emission factors (usually higher)