Characteristics and Climate Implications of Particles Generated by Traditional Wood Burning Cookstoves

Christoph Roden

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Outline

- Biofuel
- Influences that Aerosols have on climate
- Sampling Cart
- Real-time data
- Emission Factor – ours / comparison
- Conclusion

Biofuel

- What is Biofuel?
- 2.4 billion people use biofuel for heating and cooking.
- Indoor air pollution from burning of solid fuel kills 1.6 million people per year.

World Health Organization (www.who.int)
http://www.itdg.org/?id=smoke_index

- Particulate emissions from biofuel are poorly characterized.
- Emissions from the burning of biofuel have climatic effect.

http://www.itdg.org/?id=smoke_index

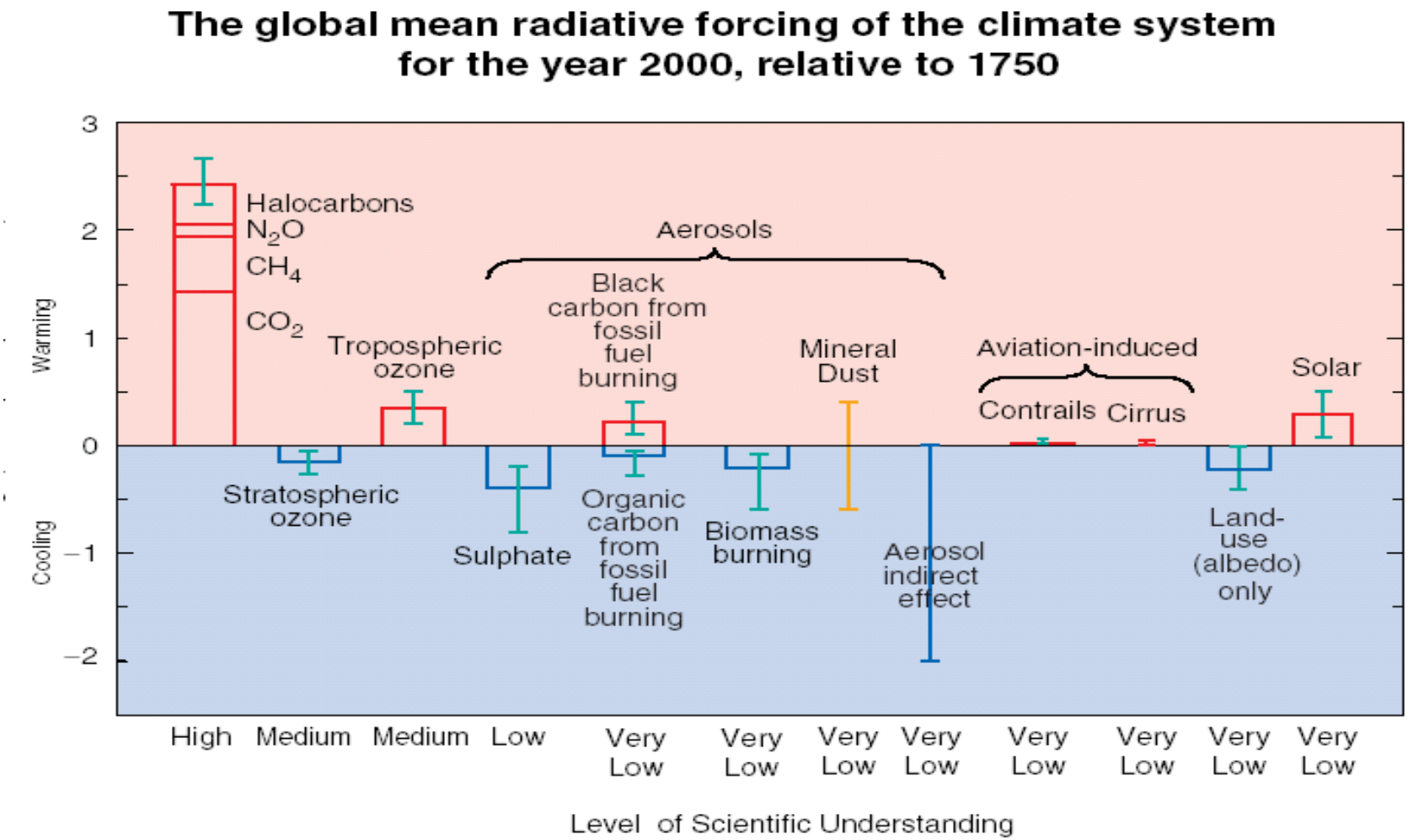
http://www.trekearth.com/gallery/Central_America/Nicaragua/photo101920.htm

http://www.geocities.com/dieret/re/Biomass/biomass.html

Emissions from Biofuel Combustion

- **CO_2 –** Green House Gas
- **CO –** Health concerns
- **NO_x -** Ozone precursor
- **VOC –** Health concerns & Ozone precursor
- **Carbonaceous Particles –** Health concerns
  - **Black Carbon (BC)**
  - **Organic Carbon (OC)**

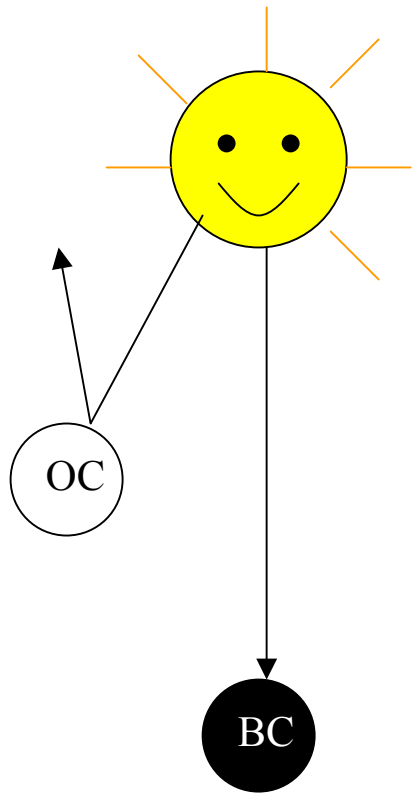
Contributions to Climate change



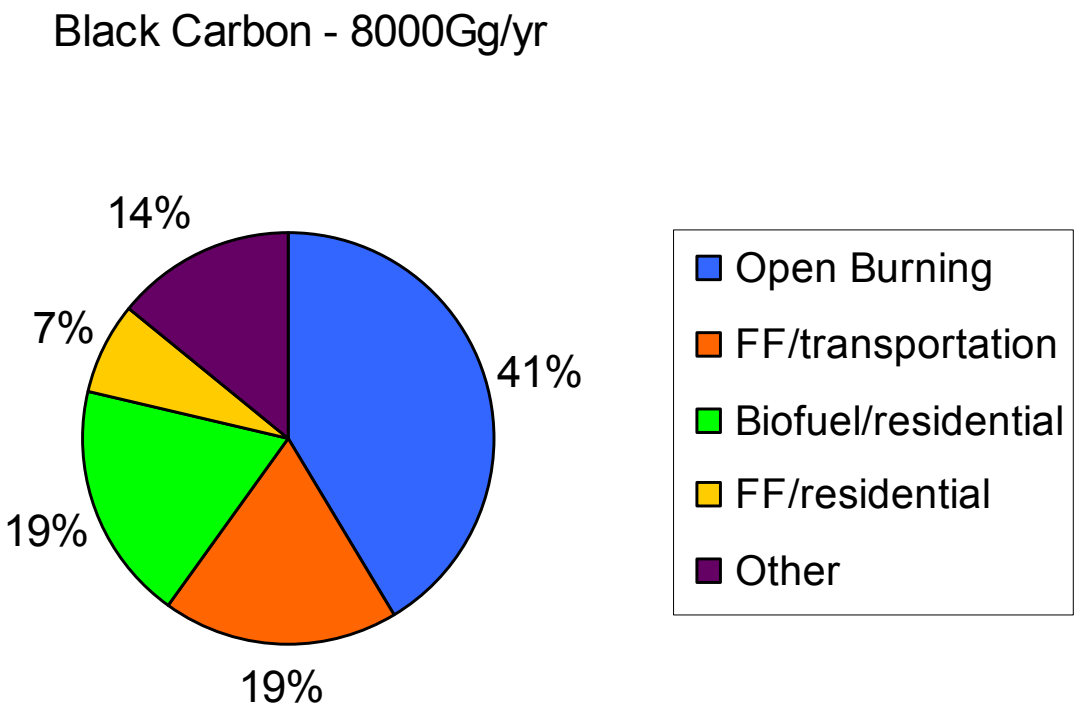
IPCC summary for PM p.8

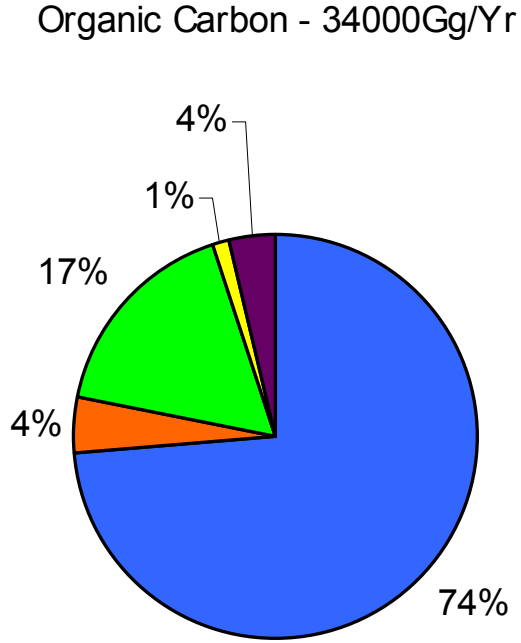
Particles' effects on Climate

- Carbonaceous aerosols are classified as either Black Carbon (BC) or Organic Carbon (OC).
  - BC is an excellent light absorber in the visible range – considered warming.
  - OC Scatters sun's radiation – considered cooling
- Both BC and OC are emitted together by incomplete combustion processes.
- Both usually small particles (1um or less in diameter)



BC and OC sources



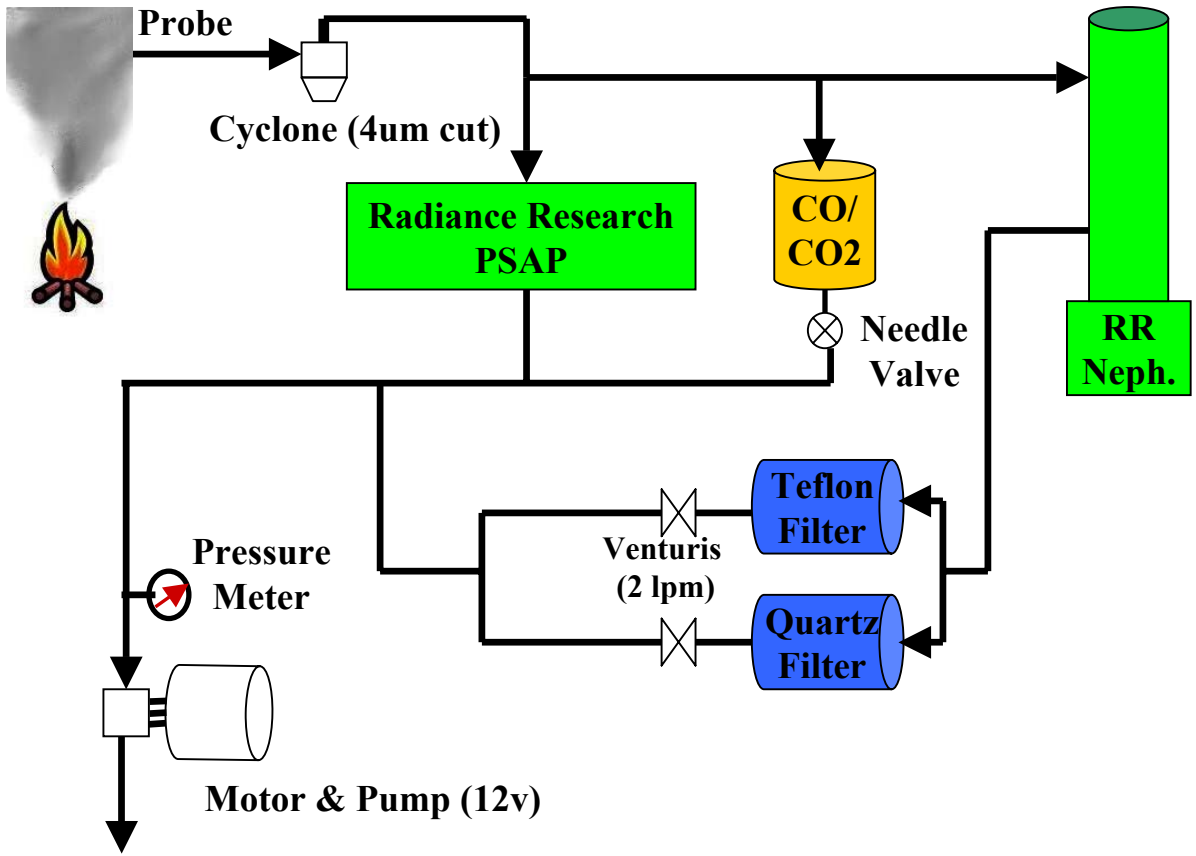


Bond – JGR 2004

Sampling Cart Measurements

Real Time Measurements:
- Light Absorption by Particles
- Light Scattering by Particles
- CO and CO2 concentrations

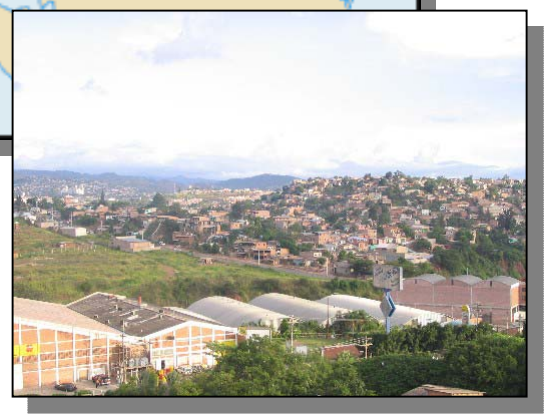
Integrated Measurements:
- Total Mass concentration
  - Teflon filter
- Total Carbon and EC/OC split
  - Quartz filter with back-up.



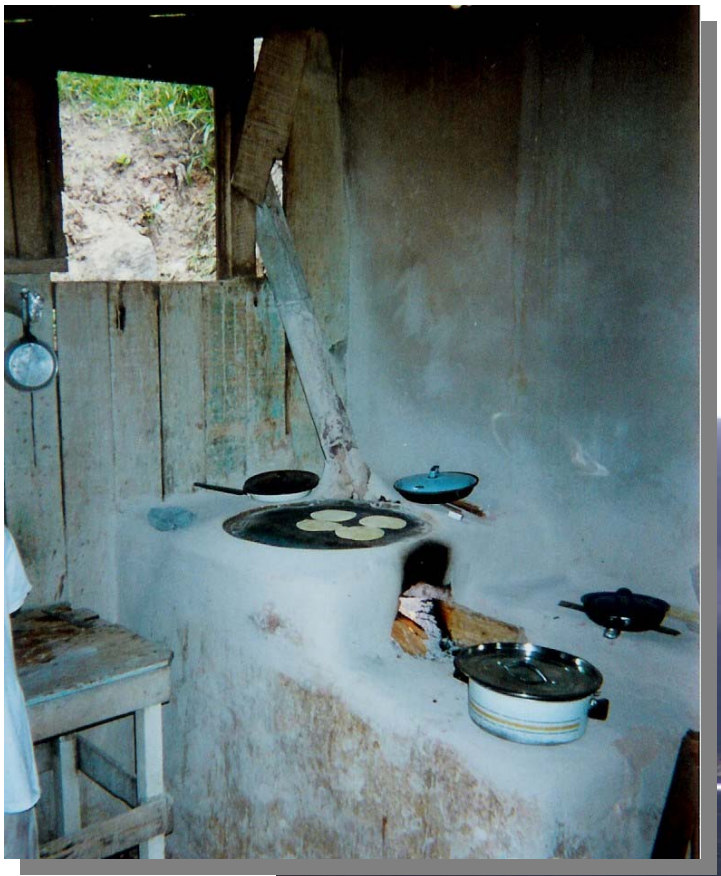
Honduras

http://www.cia.gov/

- Population ~7,000,000
- Capital is Tegucigalpa which sits at 1000 m
- Climate – temperate mountains



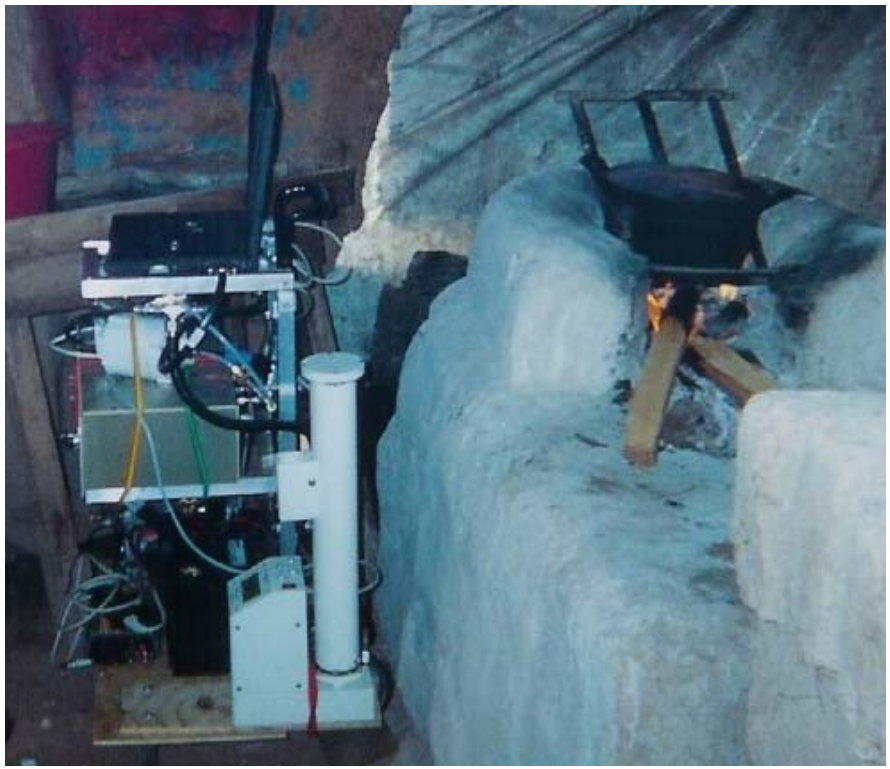
Typical Honduran Cookstoves and Kitchens



Emission Sampling Cart

Portability

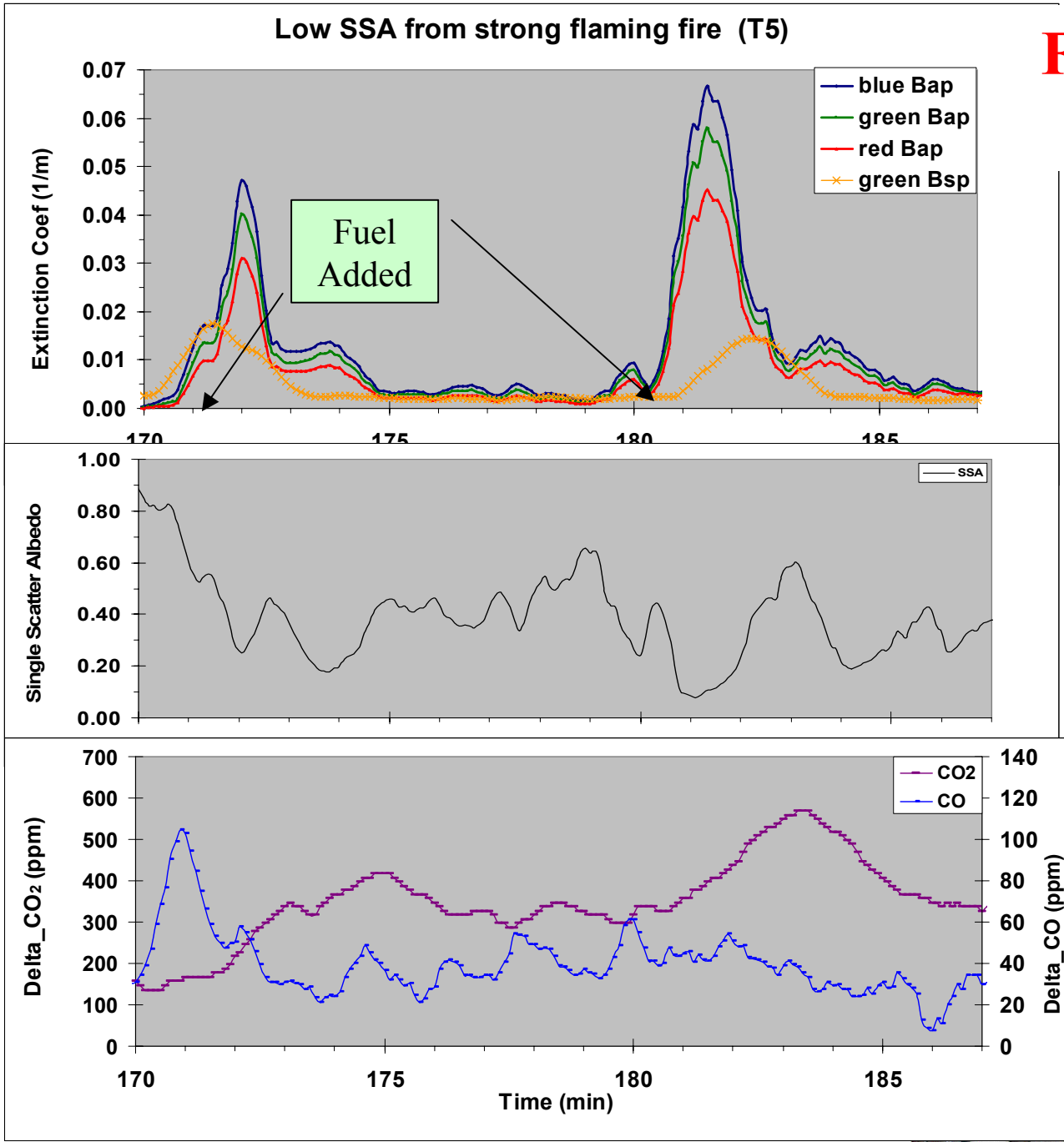
- Size: 24” x 36” x 19” (W x H x D)
- Power: 12v car battery 100W total power
- Runtime: approximately 5 hours



Testing

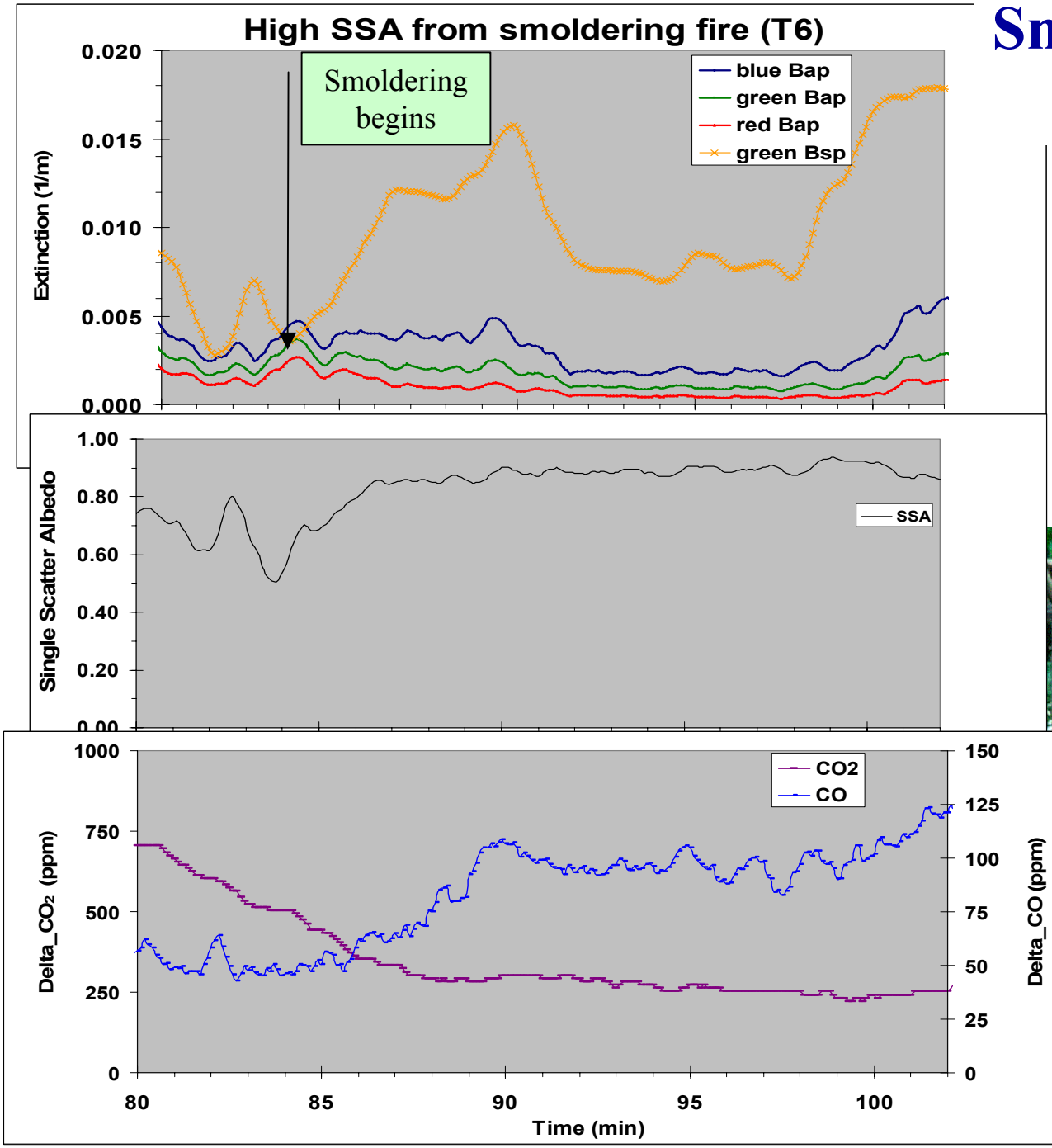
- Conducted a total of 12 tests.
- Typical test included:
  - 10 minute pre-cooking ambient conditions
  - 1.5 to 3 hours of measurement during cooking
  - 10 minutes of post cooking measurements

Flaming Emission Characteristics



- Large Visible Flames
- Strong absorption and scattering
- Occurs while volatile matter is being rapidly released from wood
- Lower SSA
- Often large EC fraction
- Higher Emission Factors

Smoldering Emission Characteristics

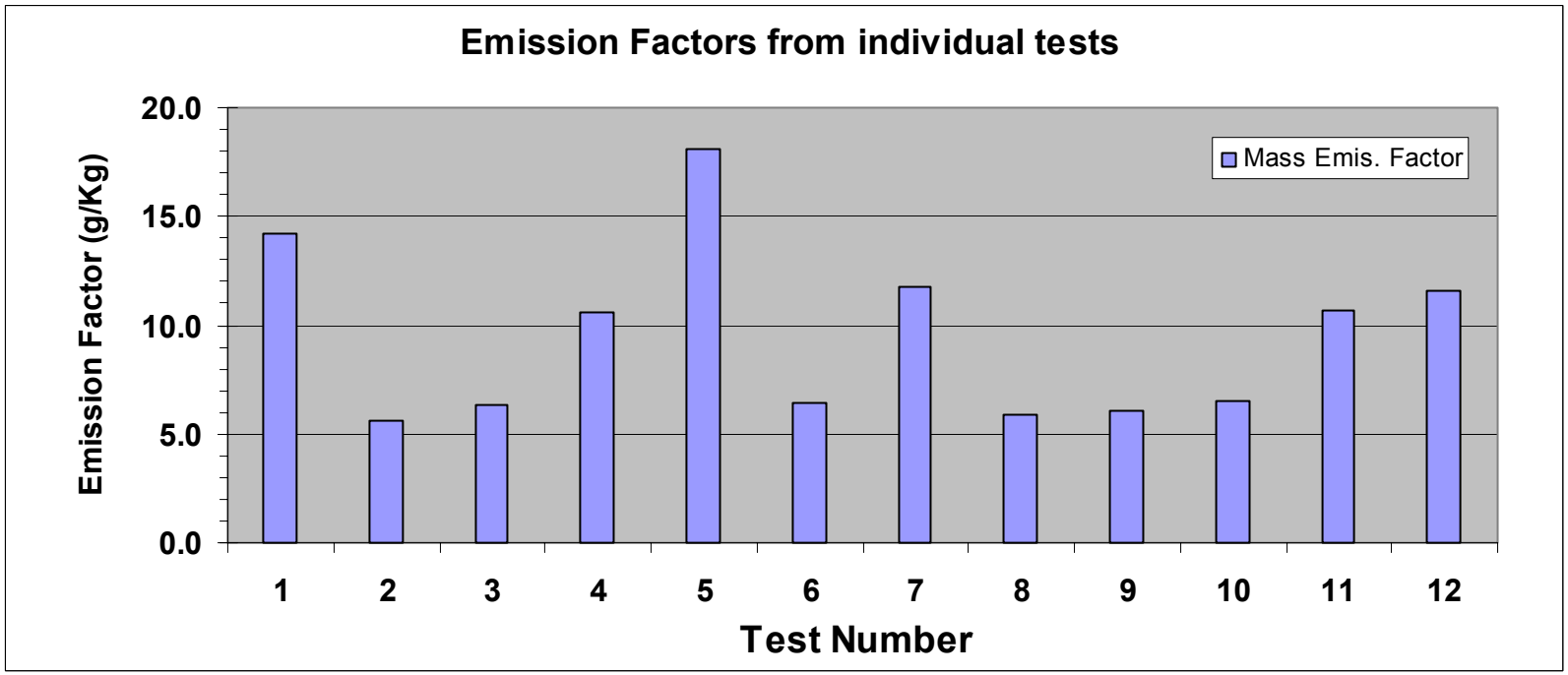


- No flame, mostly white smoke
- Strong Scattering.
- Very low absorption
- Generally high CO emission
- High SSA
- Probably mostly OC

Emission Factors

- Emission Factor – mass of particulates emitted per mass of fuel combusted

$$EF\left(\frac{g}{Kg\_wood}\right)=\left(\frac{Filter\_mass}{Volume\_sampled}\right)\times\left(\frac{1}{\Delta\_CO_2+\Delta\_CO}\right)\times\left(\frac{m\text{^}3\_CO_2}{0.473Kg\_C}\right)\times\left(\frac{1Kg\_C}{2Kg\_wood}\right)$$



EF Comparison with Previous Work

•Our field emission factors are significantly larger than previous lab measurements.

•Lab measurements and procedures do vary from real world cooking fires

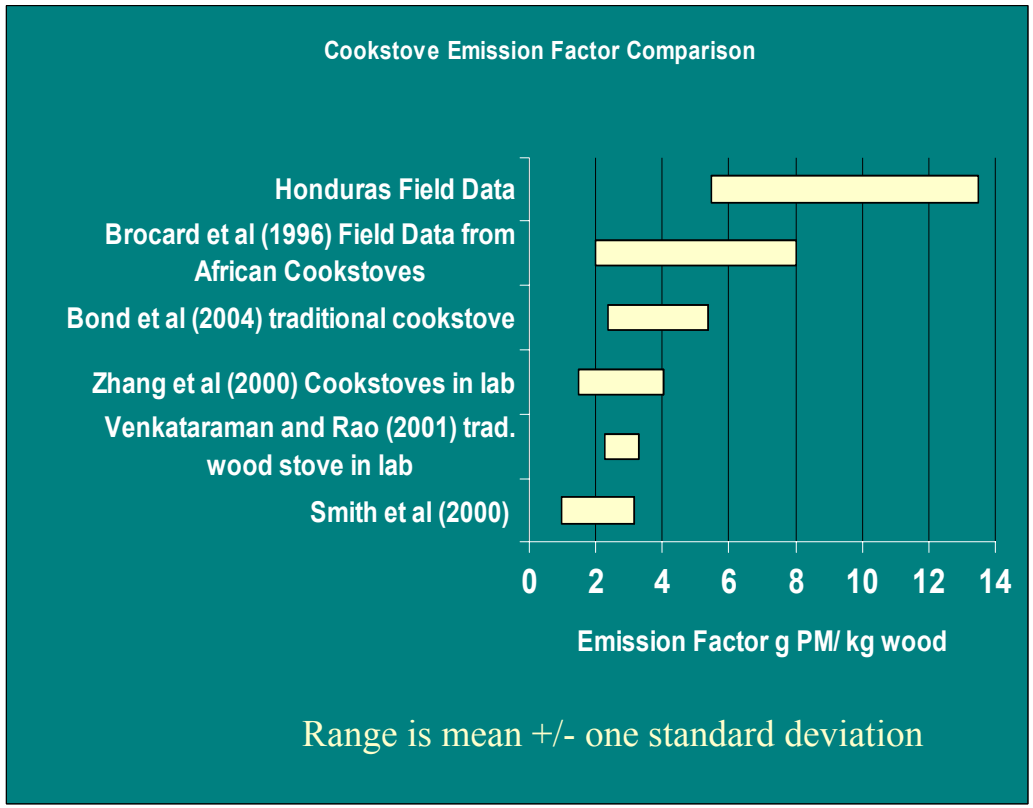
✓ Wood is sometimes added at uniform intervals.

✓Water boiling test is most common test: boil 2.2 kg water and then simmer for 30 minutes.

✓Lab tests use uniform sizes of wood with similar wood moisture.

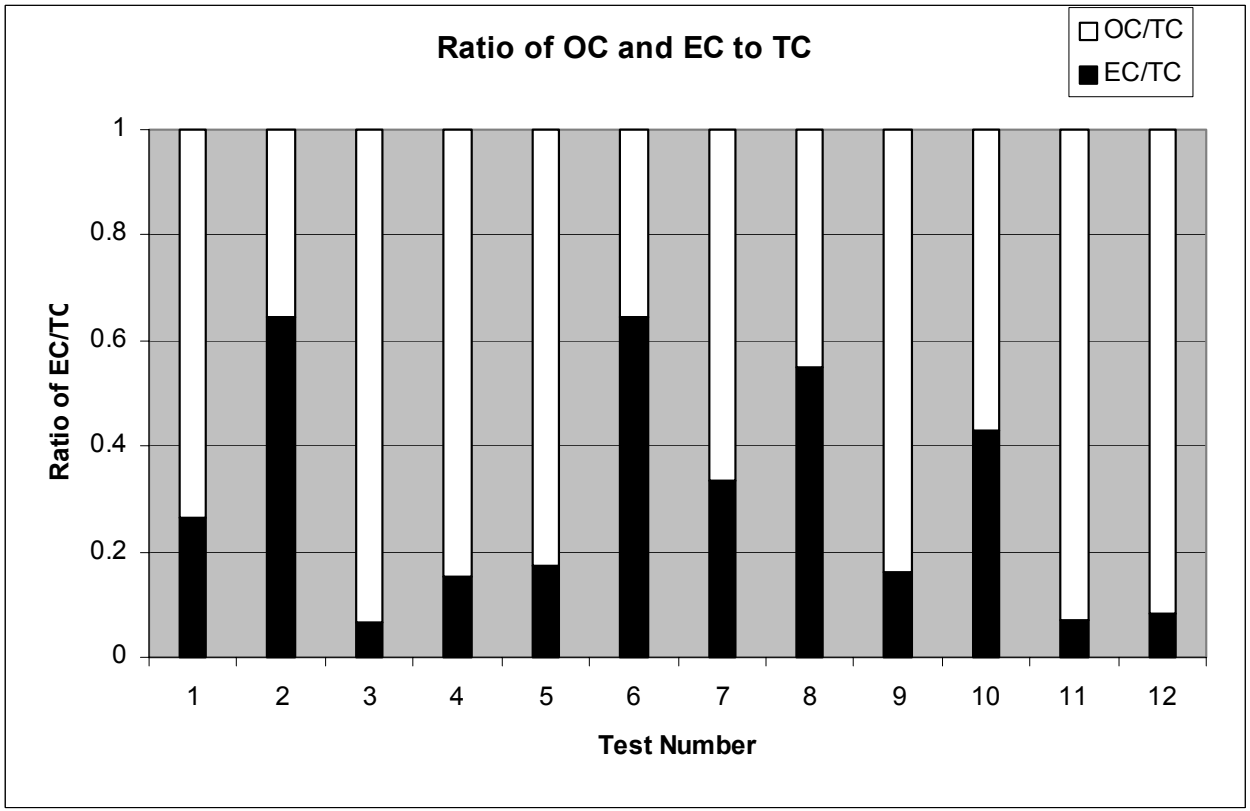
✓Lab Tests aim for uniform and consistent burning.

✓Exhaust flows vary between lab tests and field tests



Elemental Carbon vs. Organic Carbon

For climate implications, the ratio of Elemental Carbon (EC) to Total Carbon (TC) is critical in determining warming versus cooling. (TC = OC + EC).



EC/OC analysis was performed using quartz filters with backup filters to subtract positive artifacts. The filters are analyzed using the thermal method on a Sunset analyzer.

Summary

- Biofuel emissions are currently poorly represented in climate models.
- Field-based emission factors of wood cooking fires in Honduras are higher than predicted by previous lab work.
- EC/TC ratio can be highly variable for biofuel emissions from the same region.
- The SSA of particles generated from small cooking fires can be very low, with some instantaneous readings around 0.1 and the average of all tests around 0.5.

Acknowledgements

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QUESTIONS

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