Controlling Household SLCF Emissions: An overview

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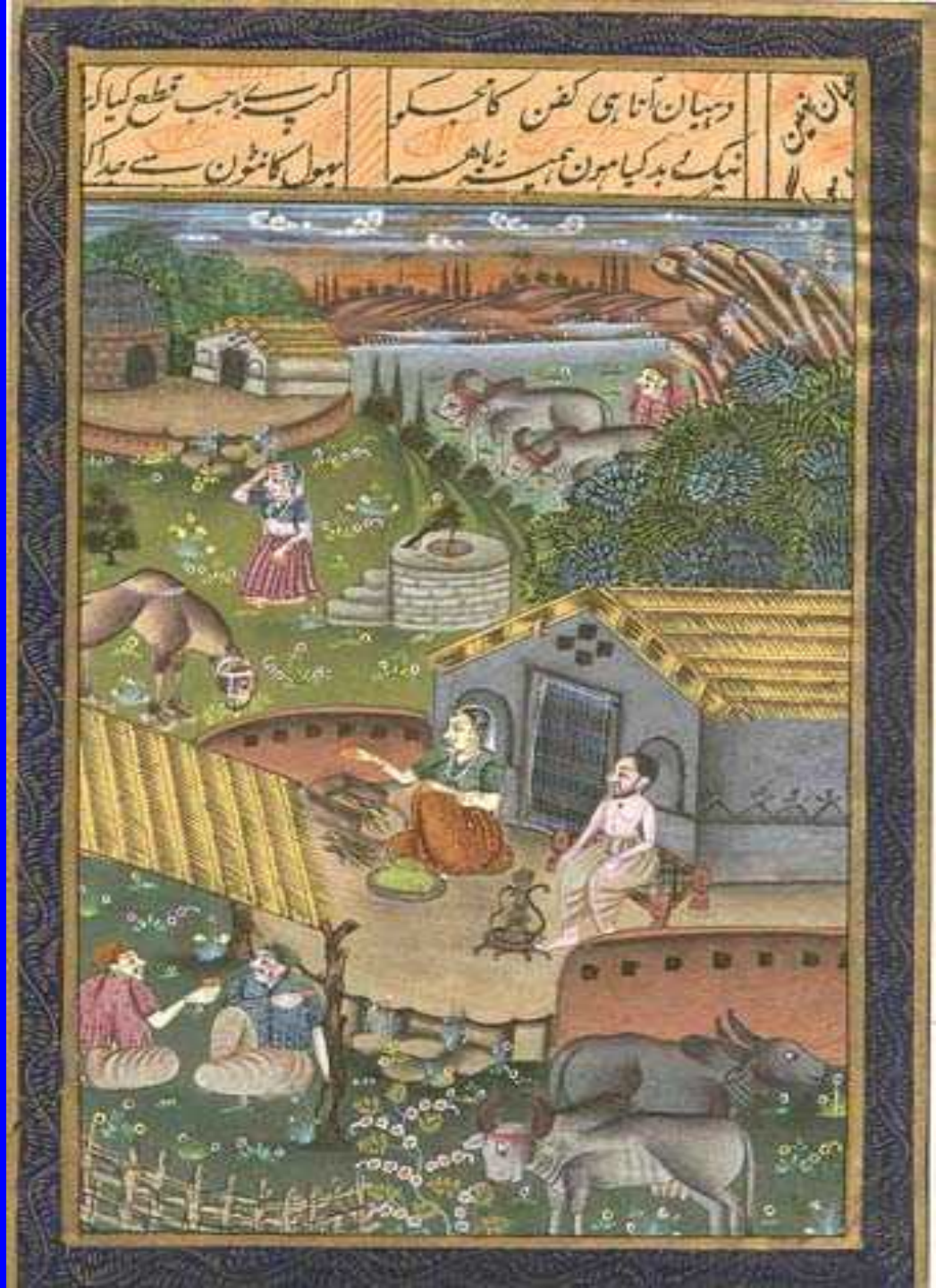
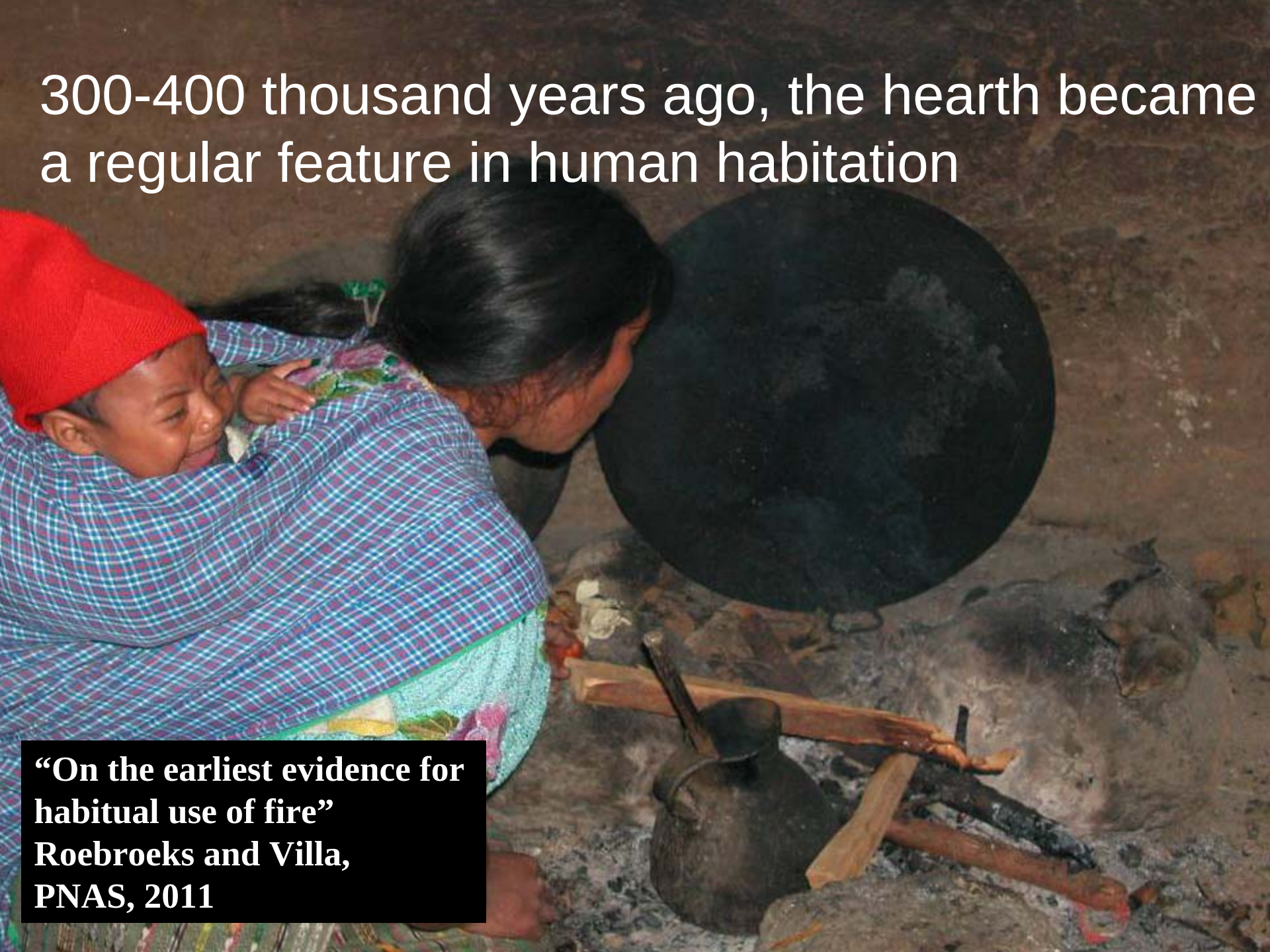


Road Map

- Brief global history of household fuel use
- Why is it a concern for climate and health?
- What is current thinking about its influence globally?
- What needs to be done?
- What do we need to know to do so?
- A little on fixing terminology

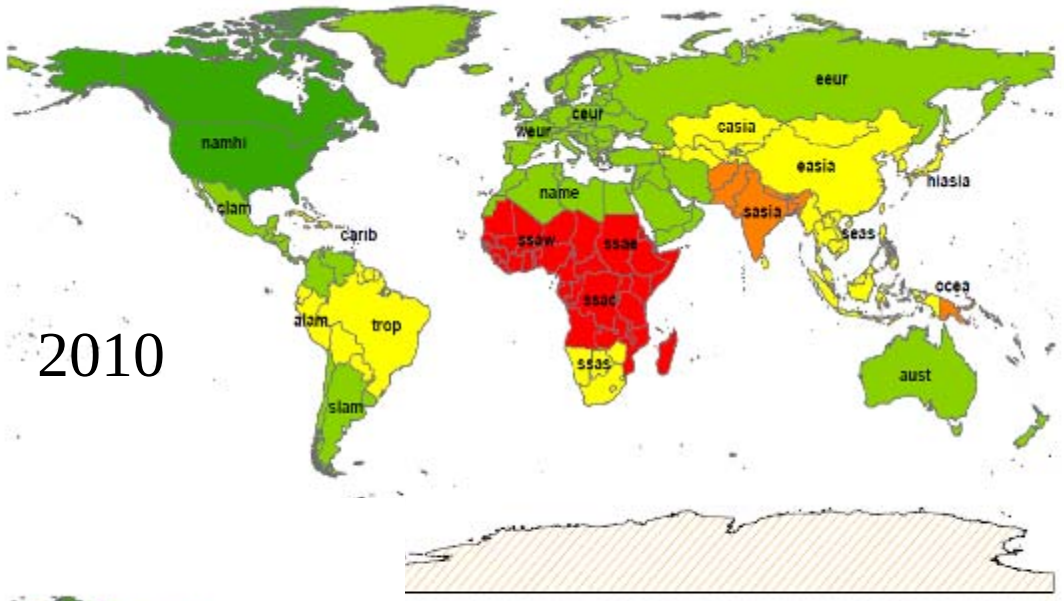
300-400 thousand years ago, the hearth became a regular feature in human habitation

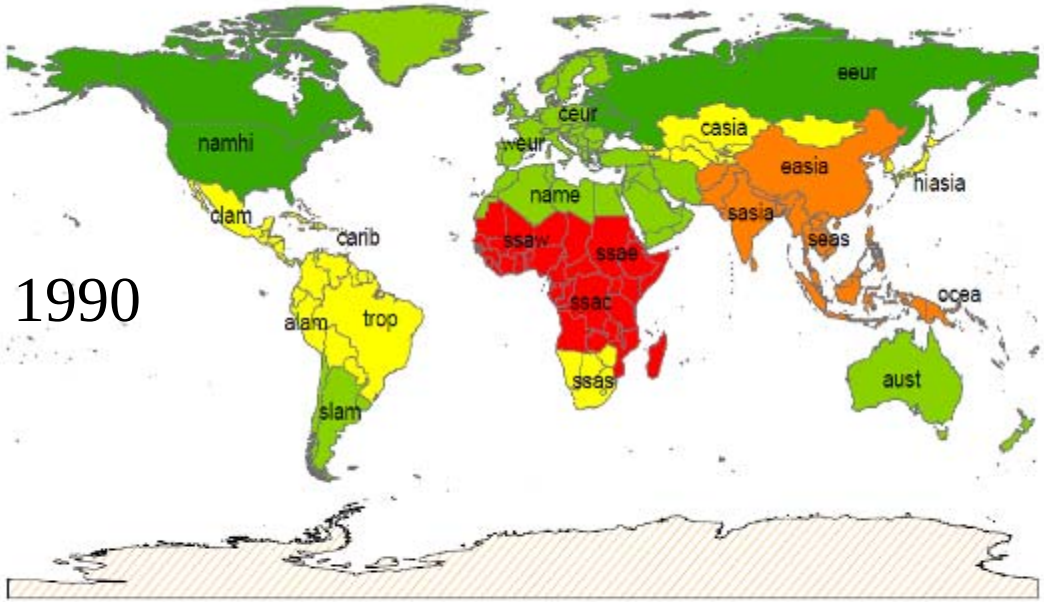


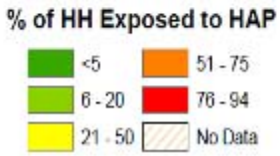
“On the earliest evidence for habitual use of fire”
Roebroeks and Villa, PNAS, 2011


Three main types of household solid fuel

Households using biomass or coal to cook today

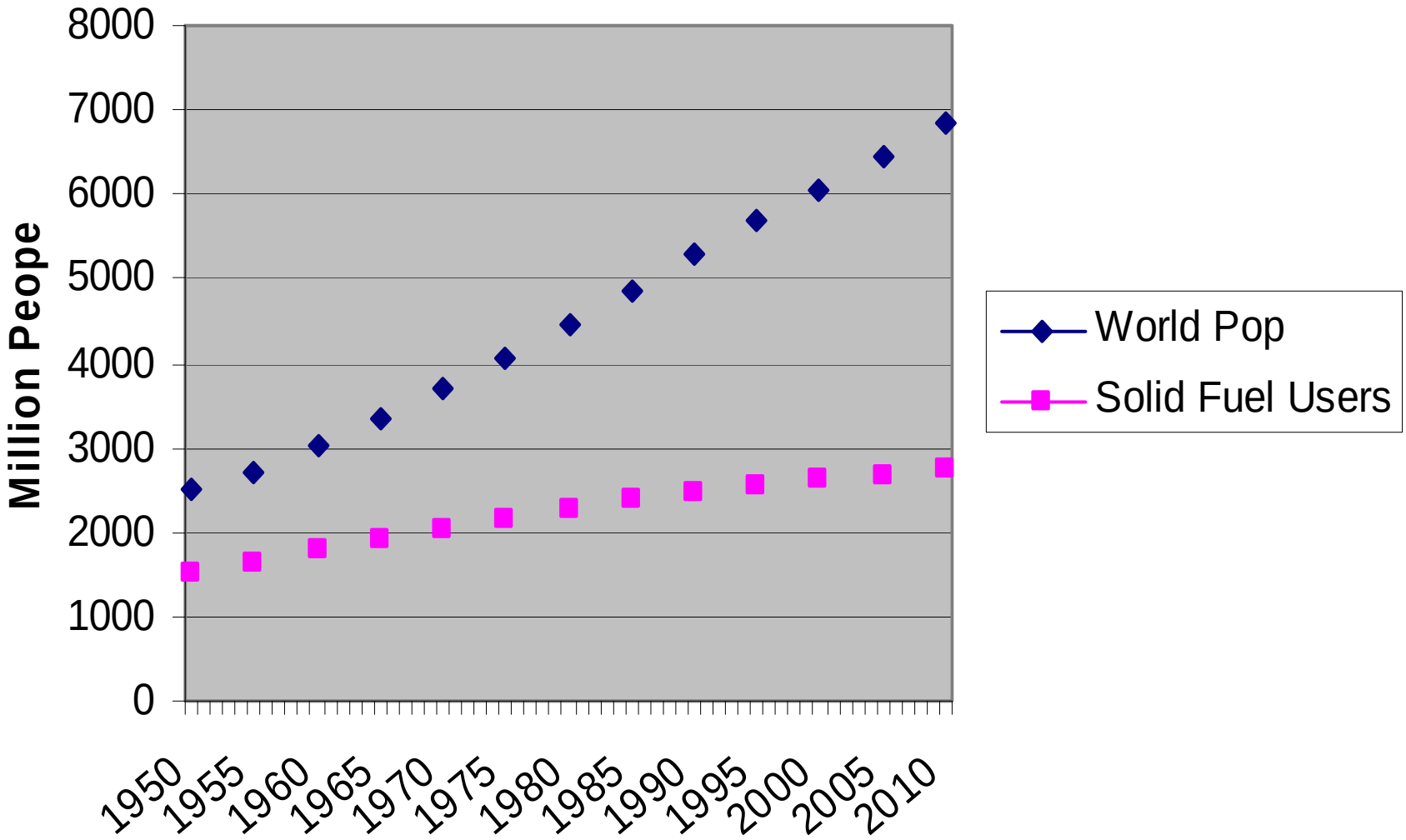






Comparative Risk Assessment (CRA) 2011- preliminary,

World Population Using Solid Fuels



Biomass Cooking in History

- **Today, ~40% use solid fuels, about 2.7 billion people**
- **Although the percentage is dropping, the absolute number is still rising.**
- **Indeed, there are more people using solid fuels today for cooking than the total world population in 1950**
- **Or any year previously**
- **Note, however, that if household biomass use is a major source of climate forcers, then it changes the political and historical narrative about climate change.**

Woodsmoke is natural – how can it hurt you?

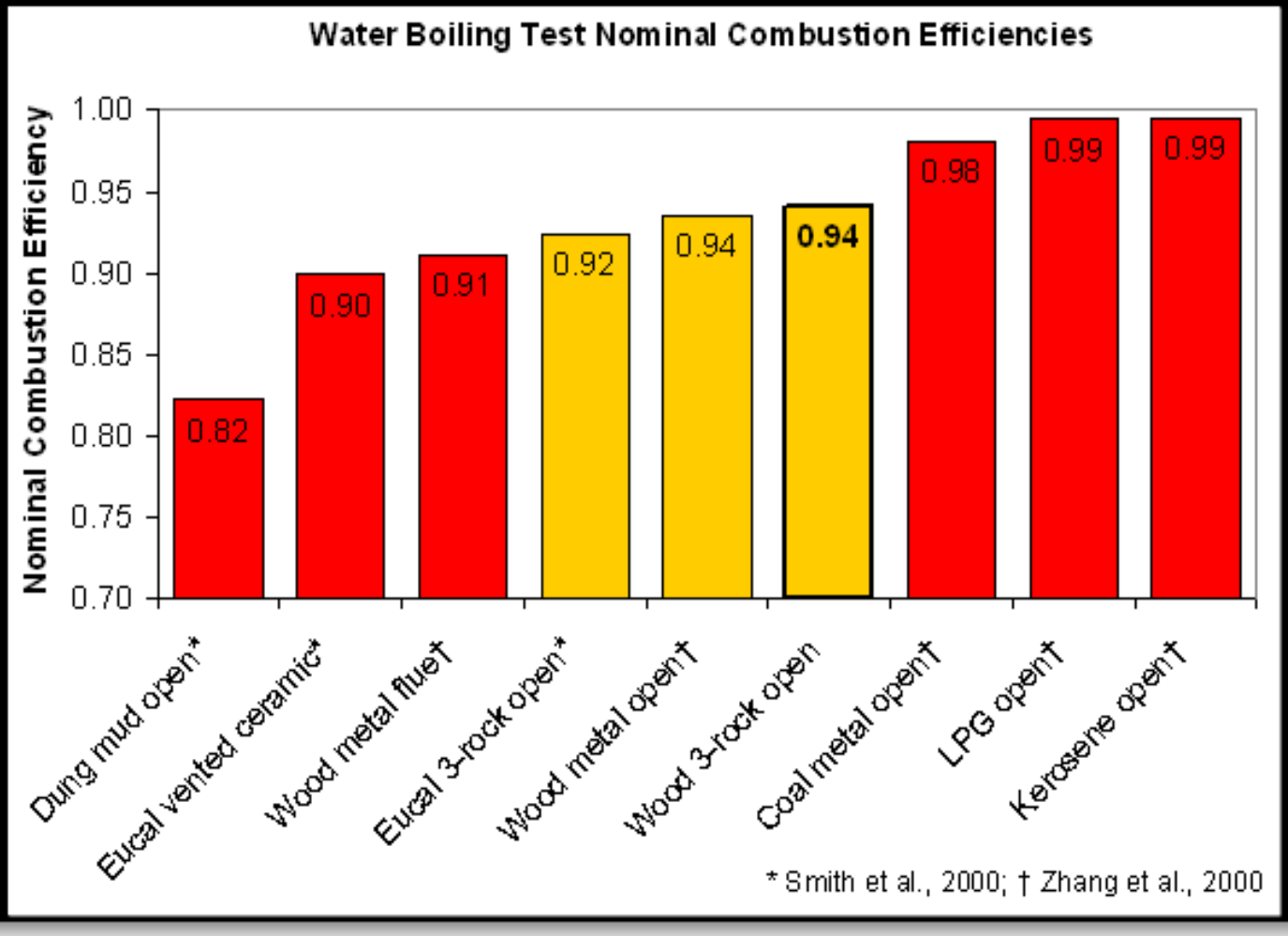
Or, since wood is mainly just carbon, hydrogen, and oxygen, doesn't it just change to CO_2 and H_2O when it is combined with oxygen (burned)?

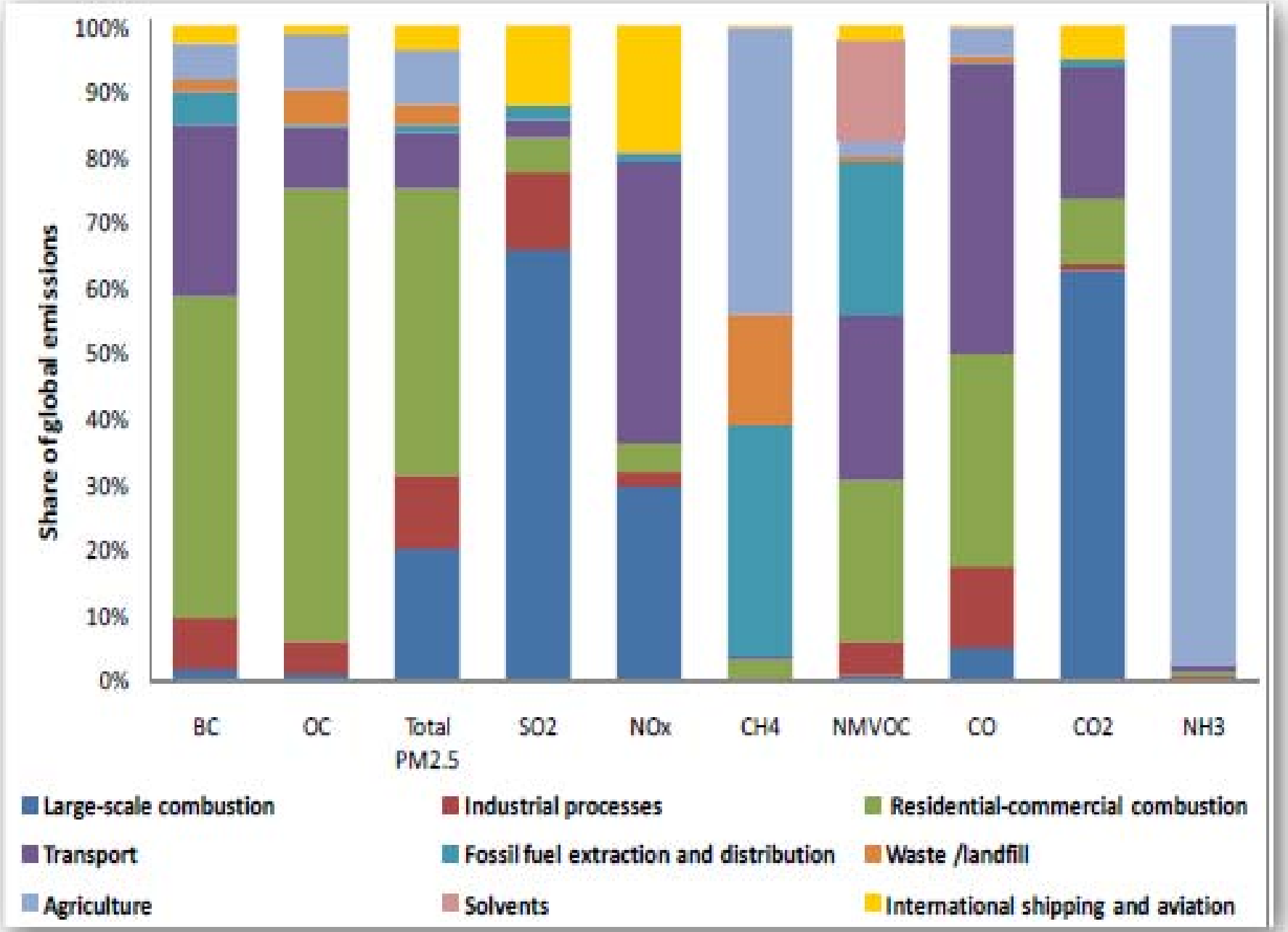
Reason: the combustion efficiency is far less than 100%

Nominal combustion efficiency

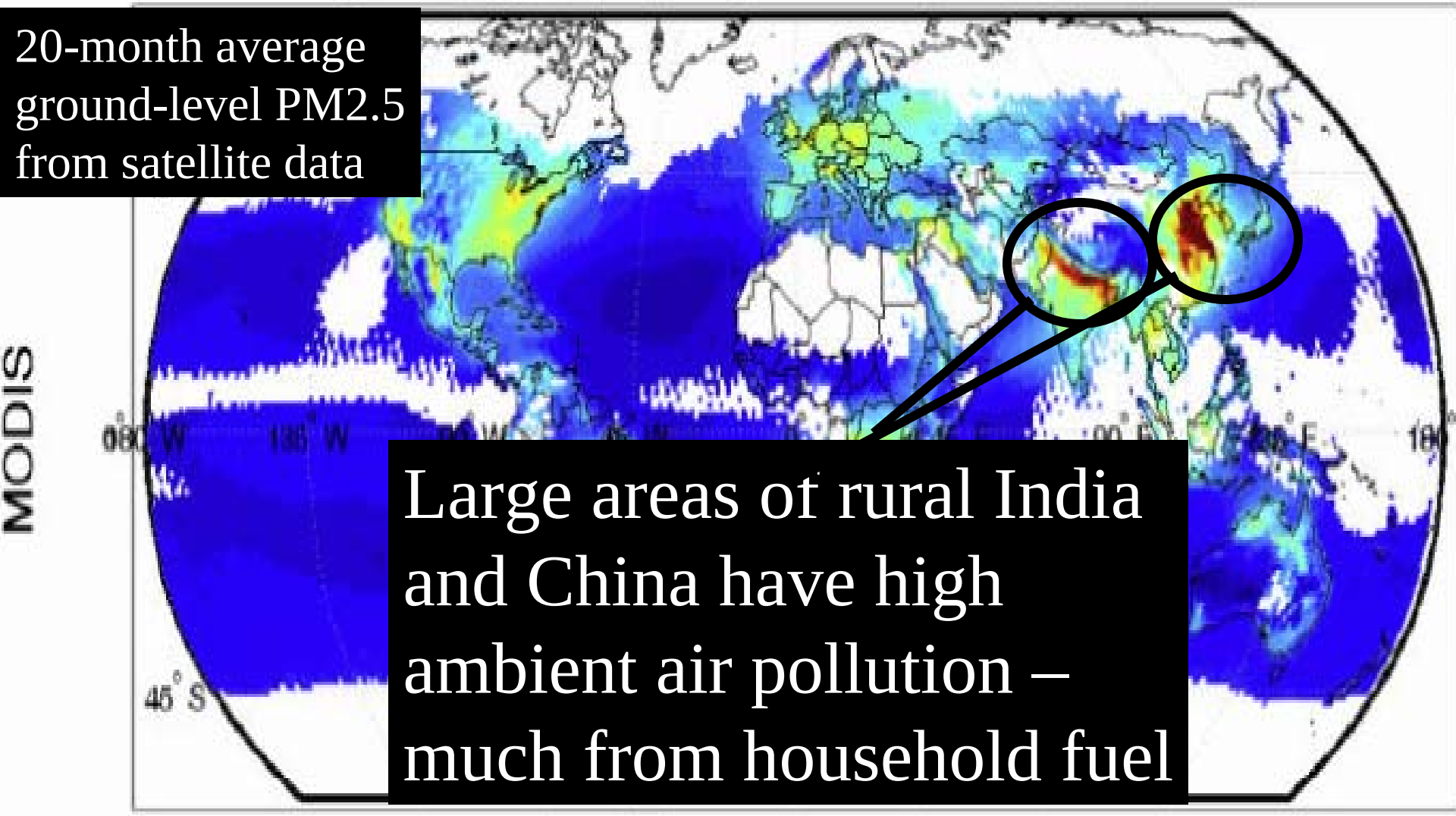
$C_xH_x + O_2 \rightarrow \text{Energy} + H_2O + CO_2$

$$NCE = \frac{CO_2}{CO_2 + CO + CH_4 + TNMHC + TSP}$$

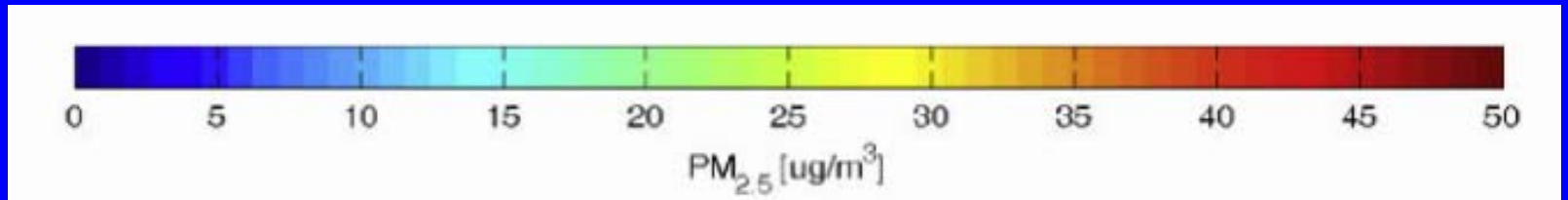



Share of global emissions
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
BC
OC
Total PM2.5
SO2
NOx
CH4
NMVOC
CO
CO2
NH3
Large-scale combustion
Industrial processes
Residential-commercial combustion
Transport
Fossil fuel extraction and distribution
Waste /landfill
Agriculture
Solvents
International shipping and aviation

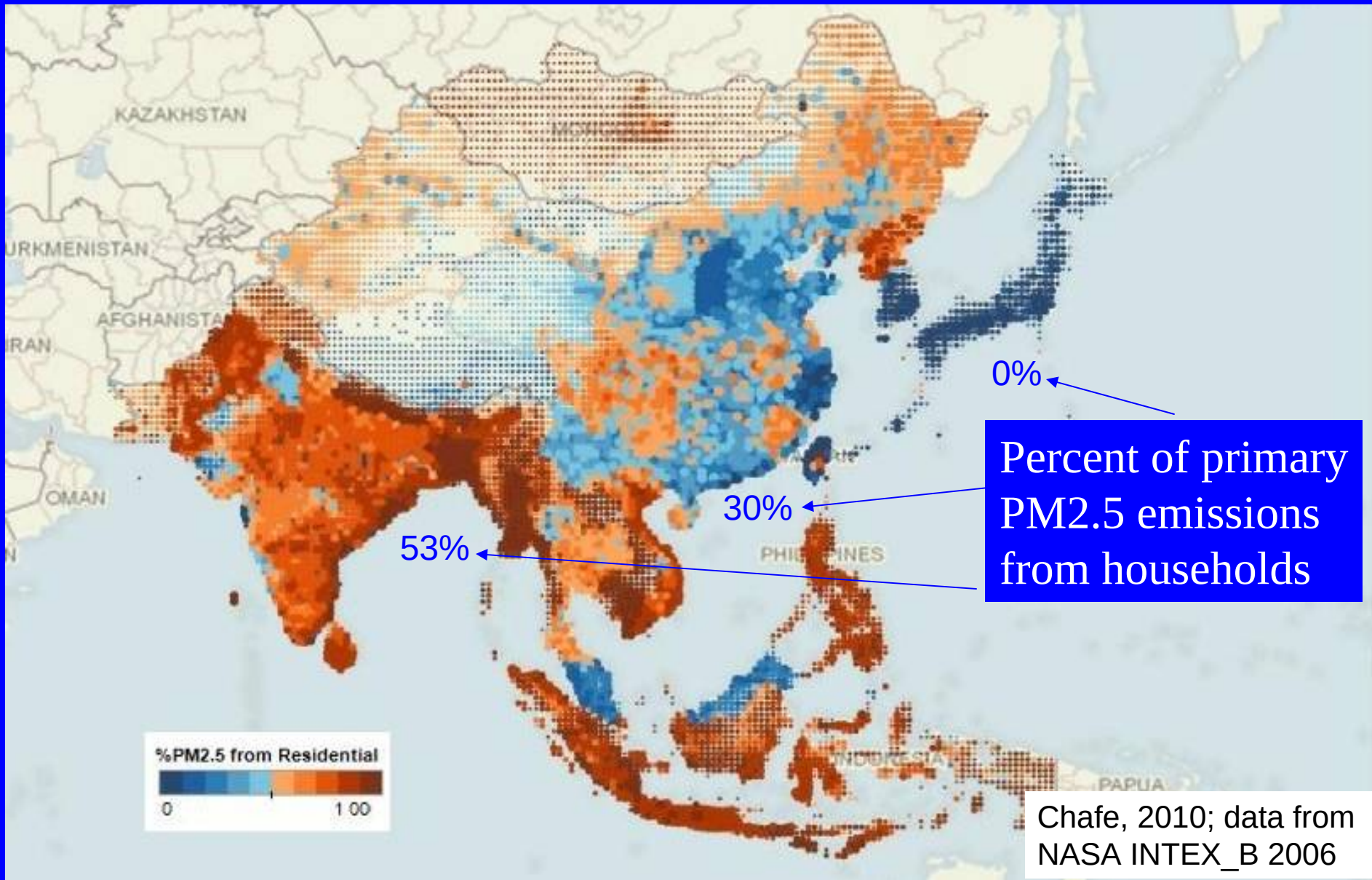
20-month average ground-level PM2.5 from satellite data



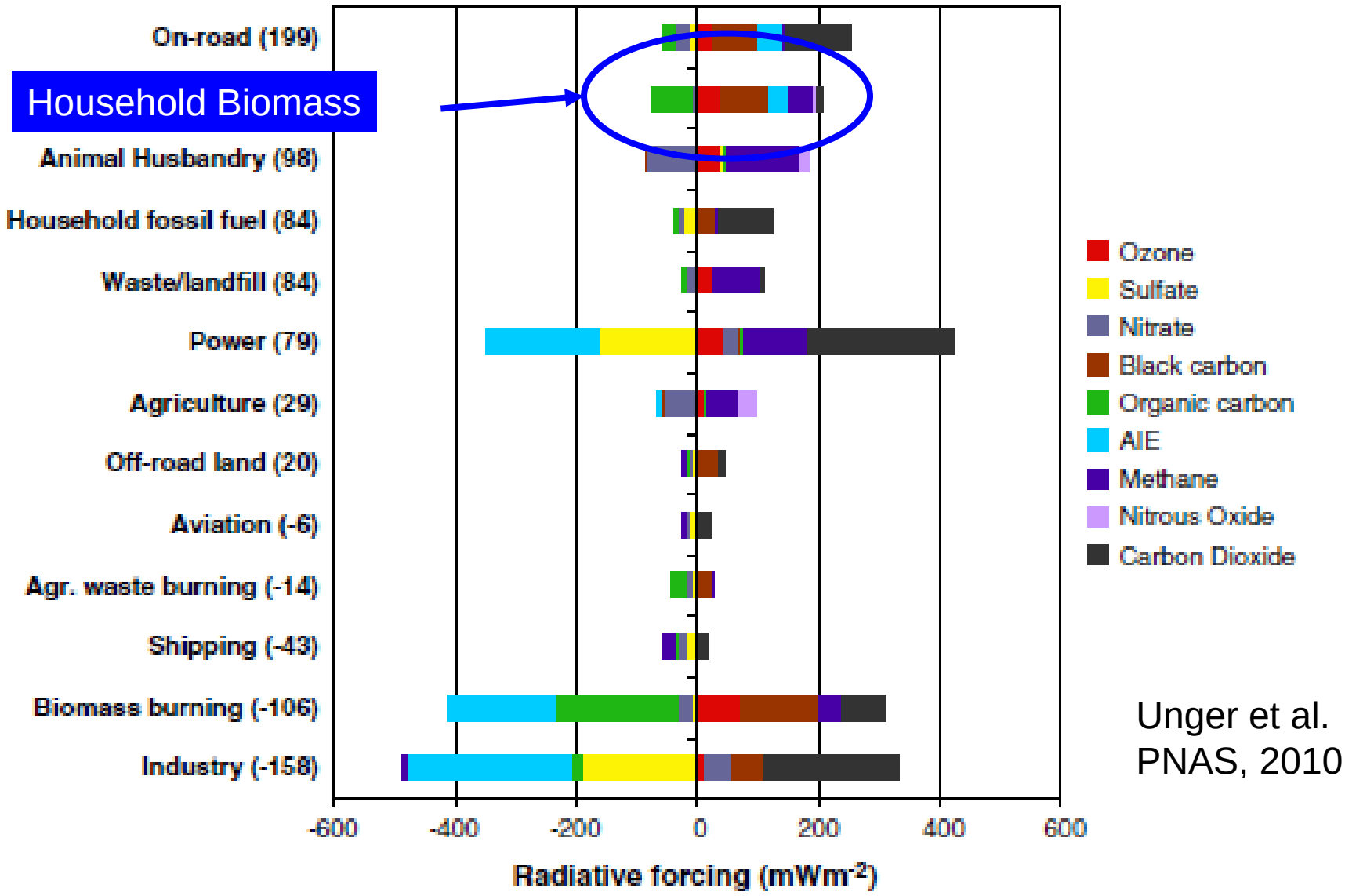
Large areas of rural India and China have high ambient air pollution – much from household fuel



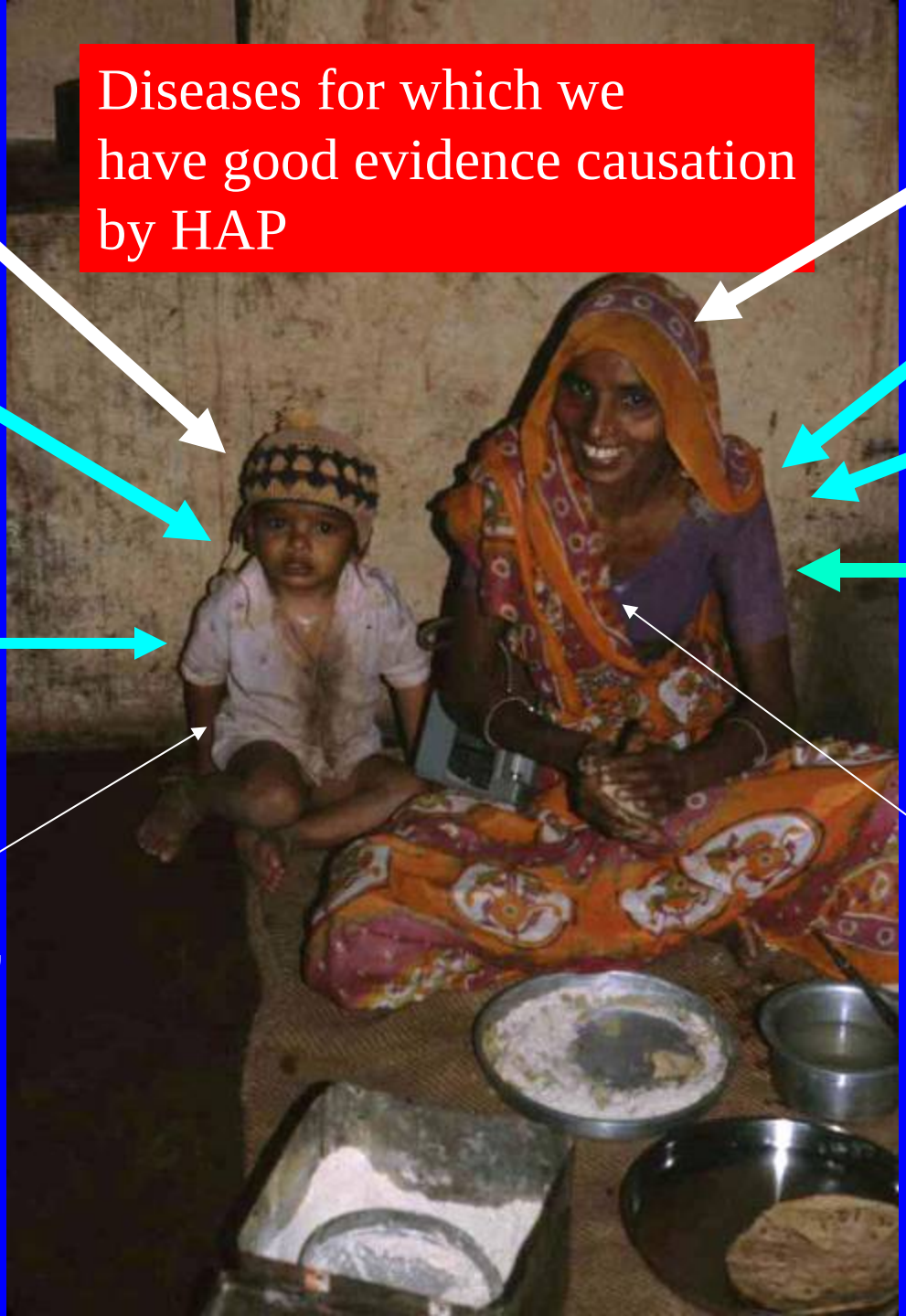
NASA INTEX_B Database
Percent $PM_{2.5}$ emissions from households



Climate Warming in 2020 Under Present Trends



Unger et al.
PNAS, 2010



Diseases for which we have good evidence causation by HAP

ALRI/ Pneumonia

Low birth weight

Stillbirth

Cognitive Impacts – "IQ"

Chronic Lung Disease

Lung cancer

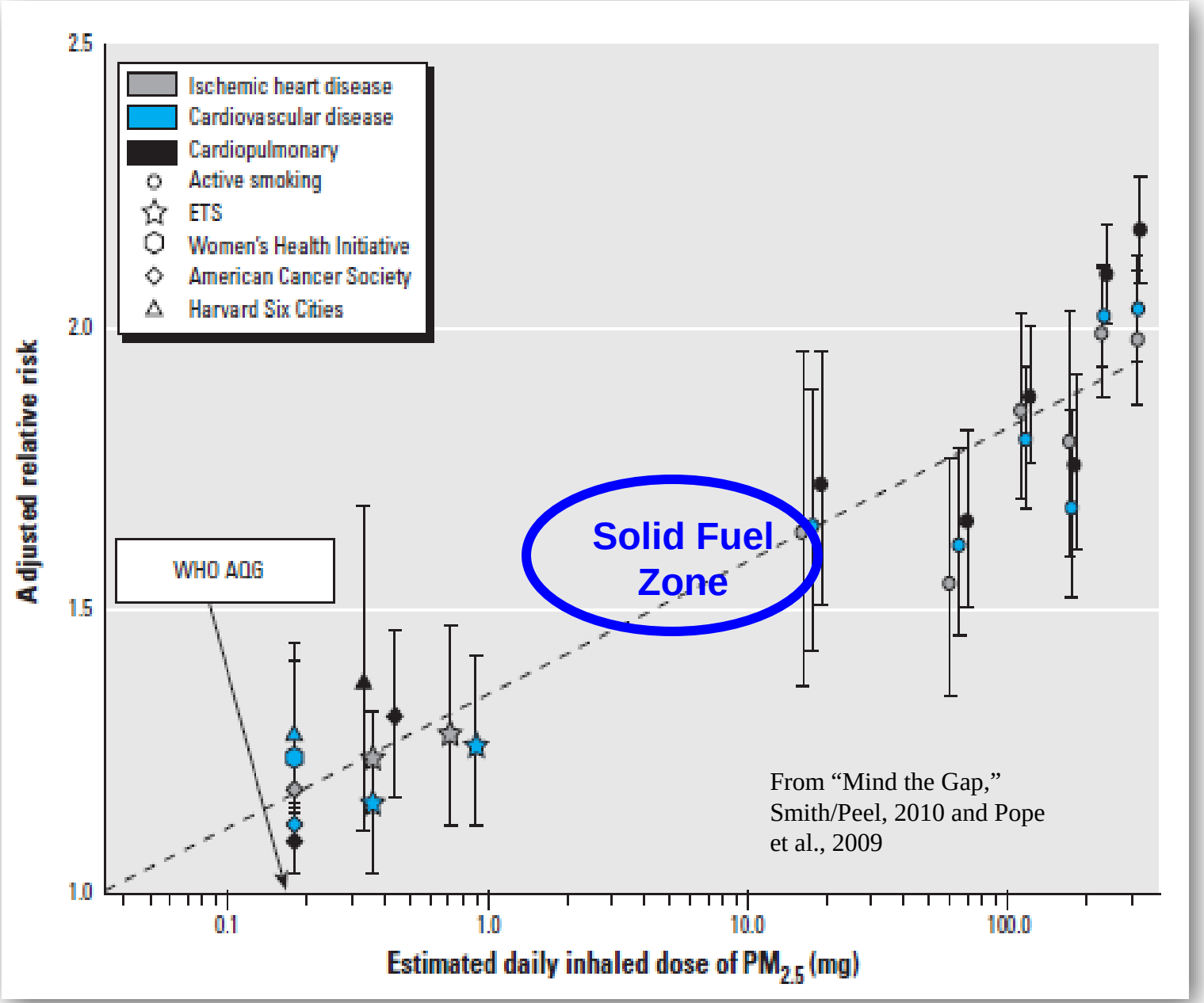
Blindness (cataracts, opacity)

Heart disease
Blood pressure
ST-segment

Tuberculosis

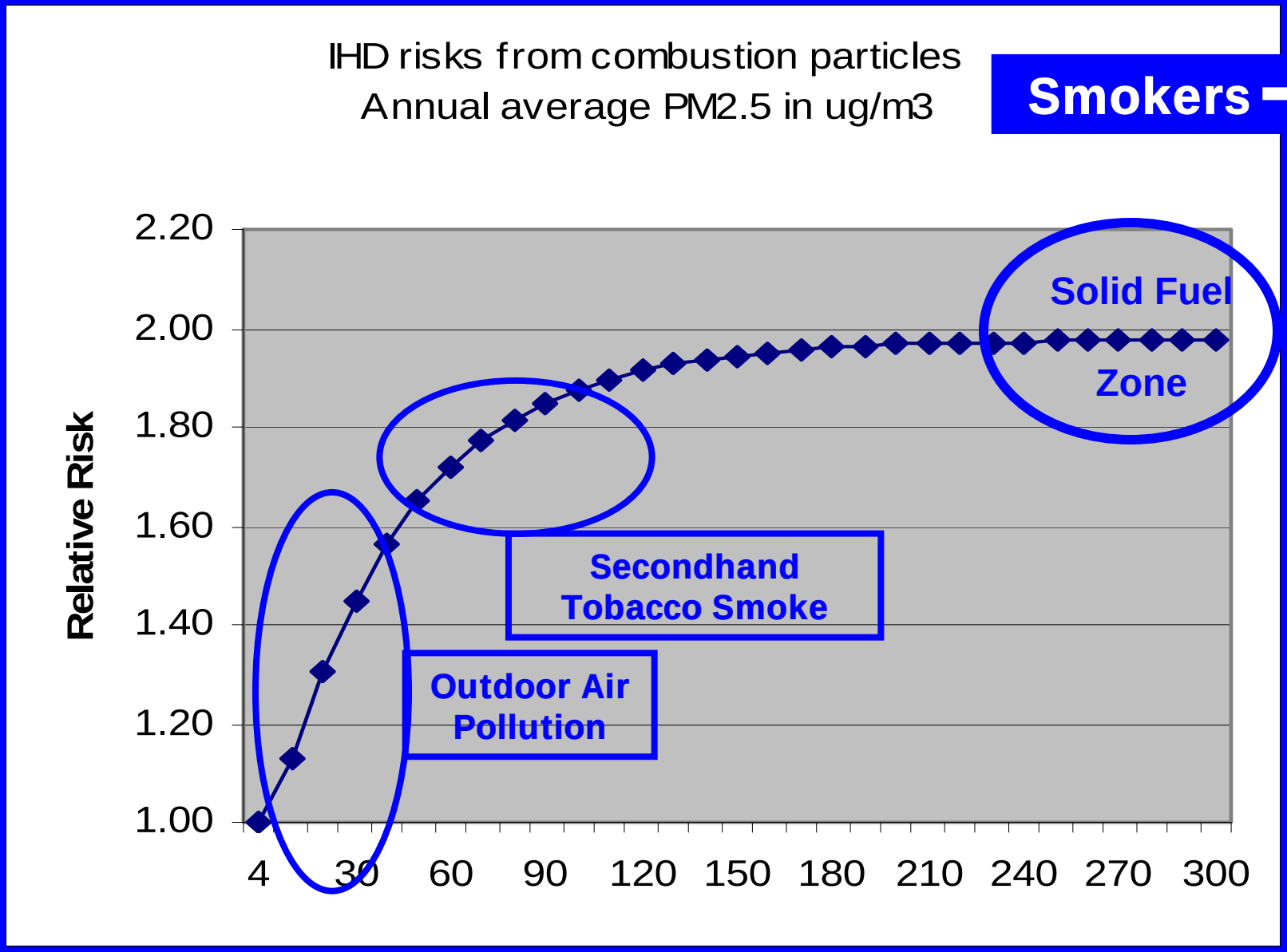
GBD / CRA 2011

Heart Disease and Combustion Particle Doses



From "Mind the Gap," Smith/Peel, 2010 and Pope et al., 2009

Generalized Exposure-Response: Outdoor Air, SHS, and Smoking



CRA, 2011

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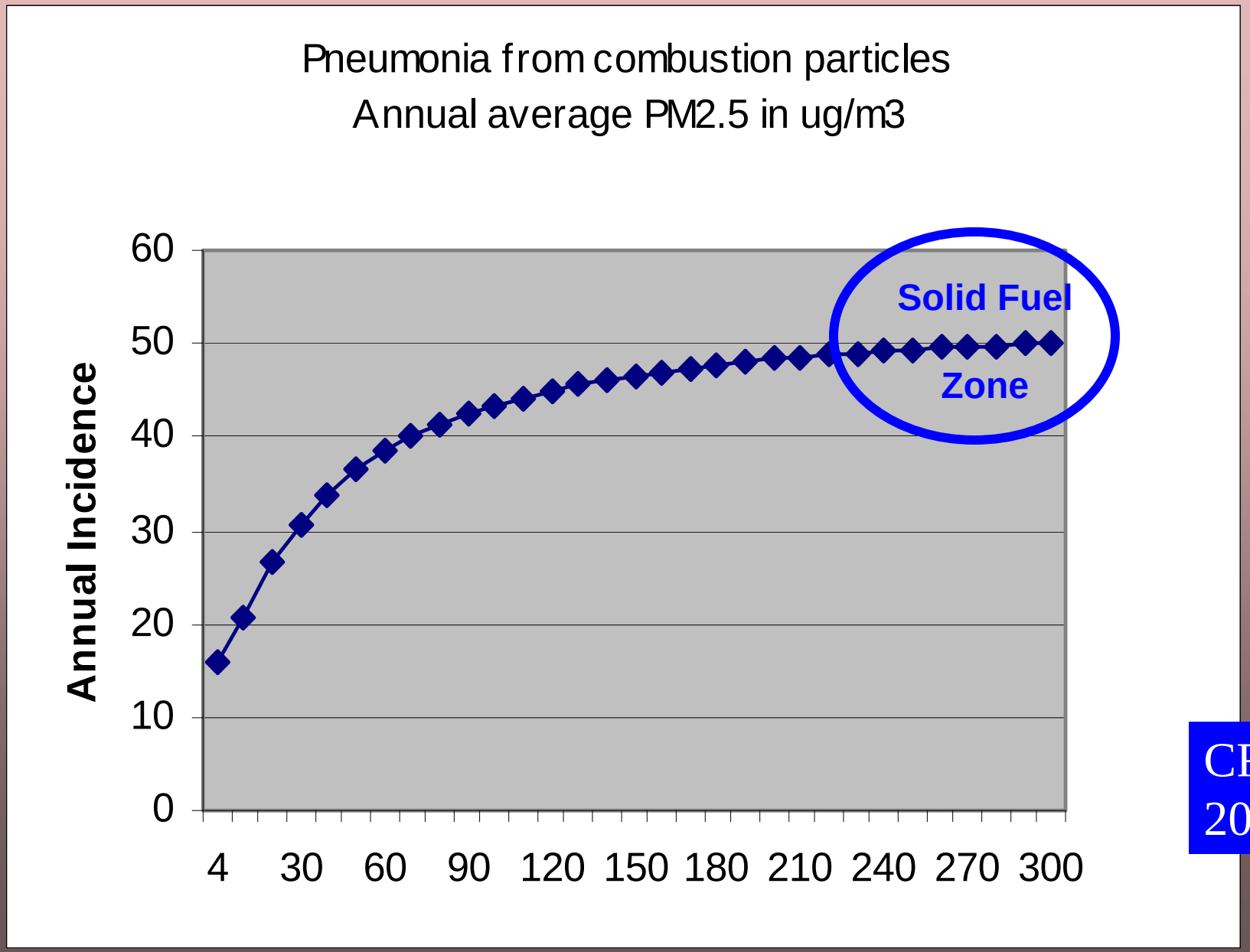
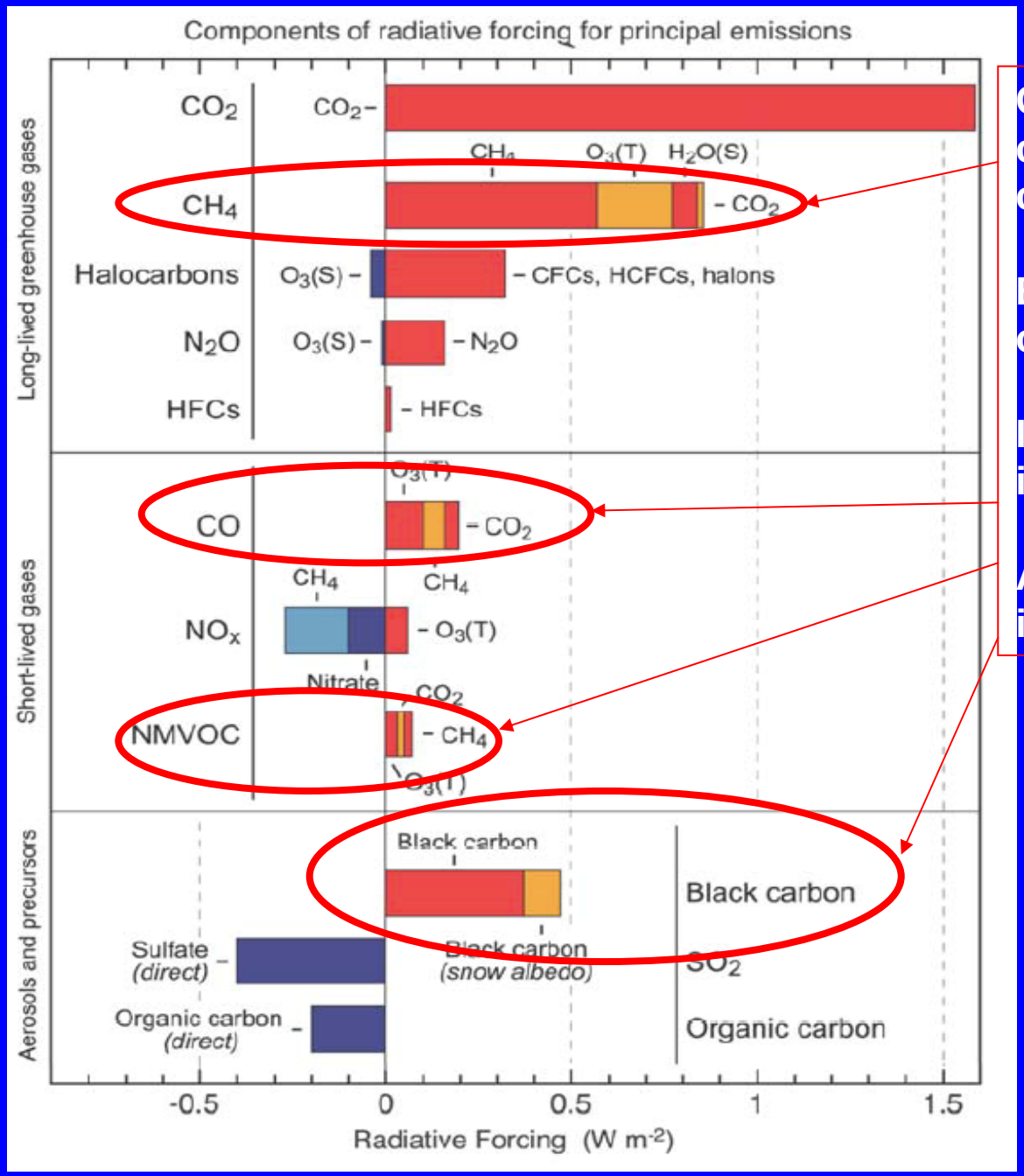


CRA, 2011

Global warming in 2005 due to all human emissions since 1750



Complete combustion of fossil carbon is the biggest climate problem – net CO2

But incomplete combustion of any carbon is also serious

Indeed, per carbon atom, it is far worse for climate

And also has many other impacts on the world

IPCC, 2007

Contributions of Human Sources to BC Emissions

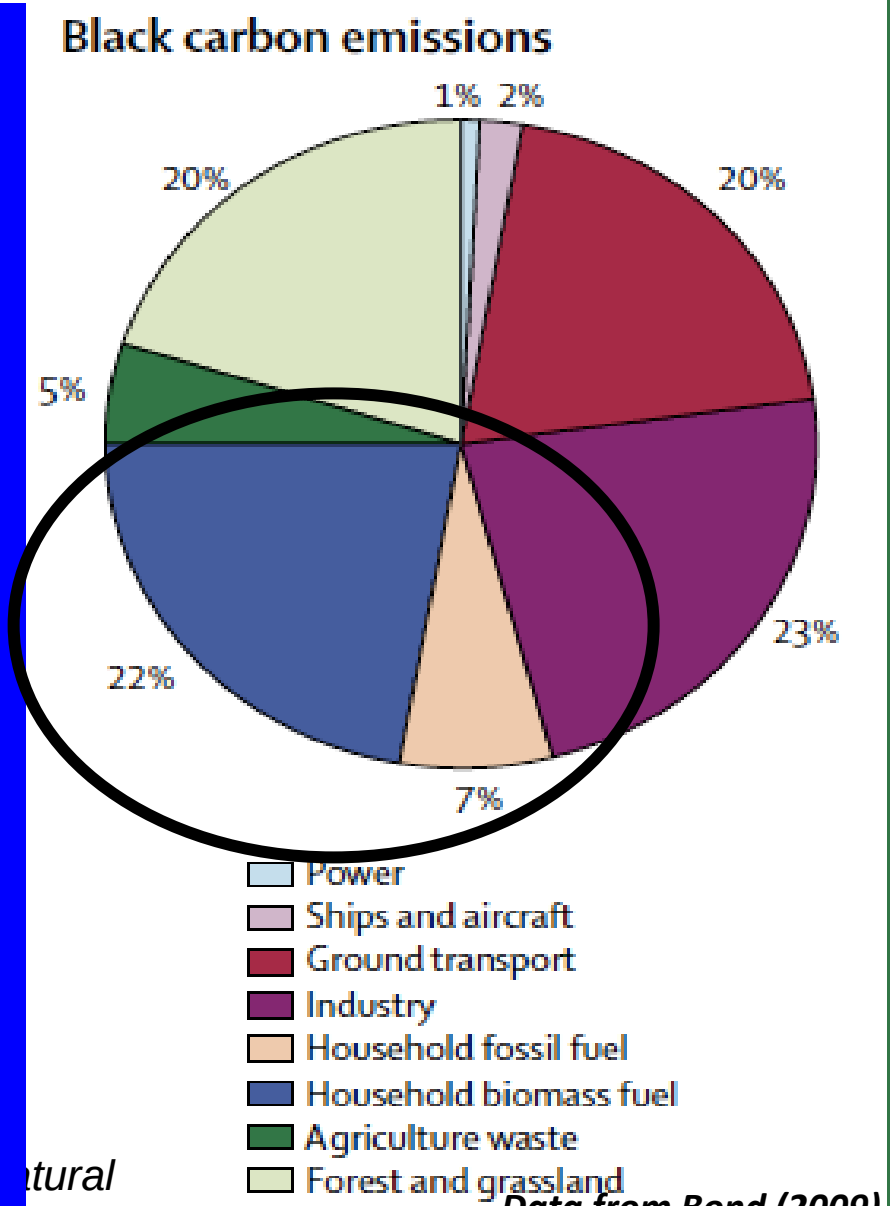
Households account for more than one-quarter of black carbon

Depending on how counted. Here “natural” sources are not included.

Smith, et al. the Lancet.2009.

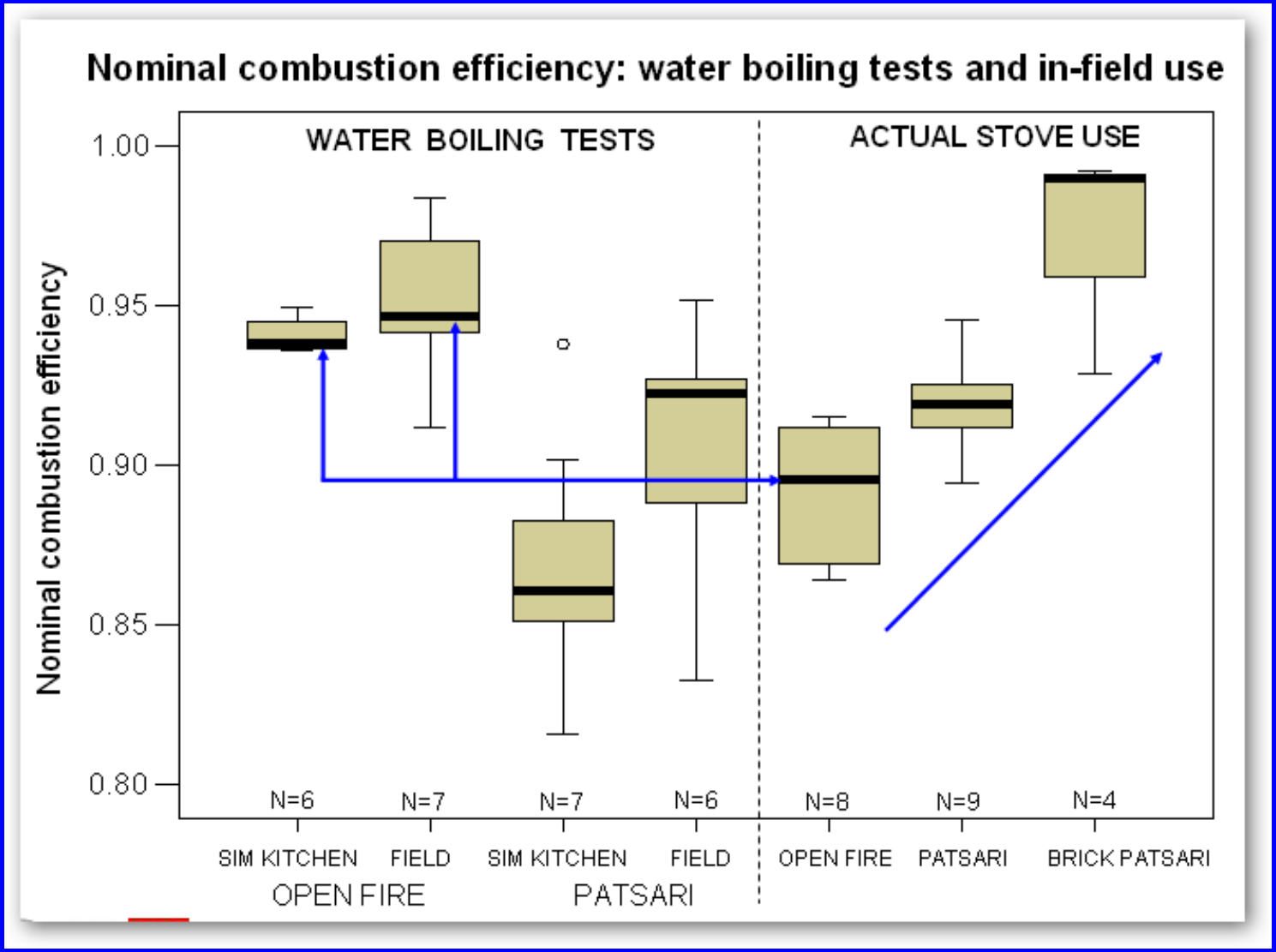
The health implications of the short-lived greenhouse pollutants,

Series on the impact on public health of strategies to reduce greenhouse gases

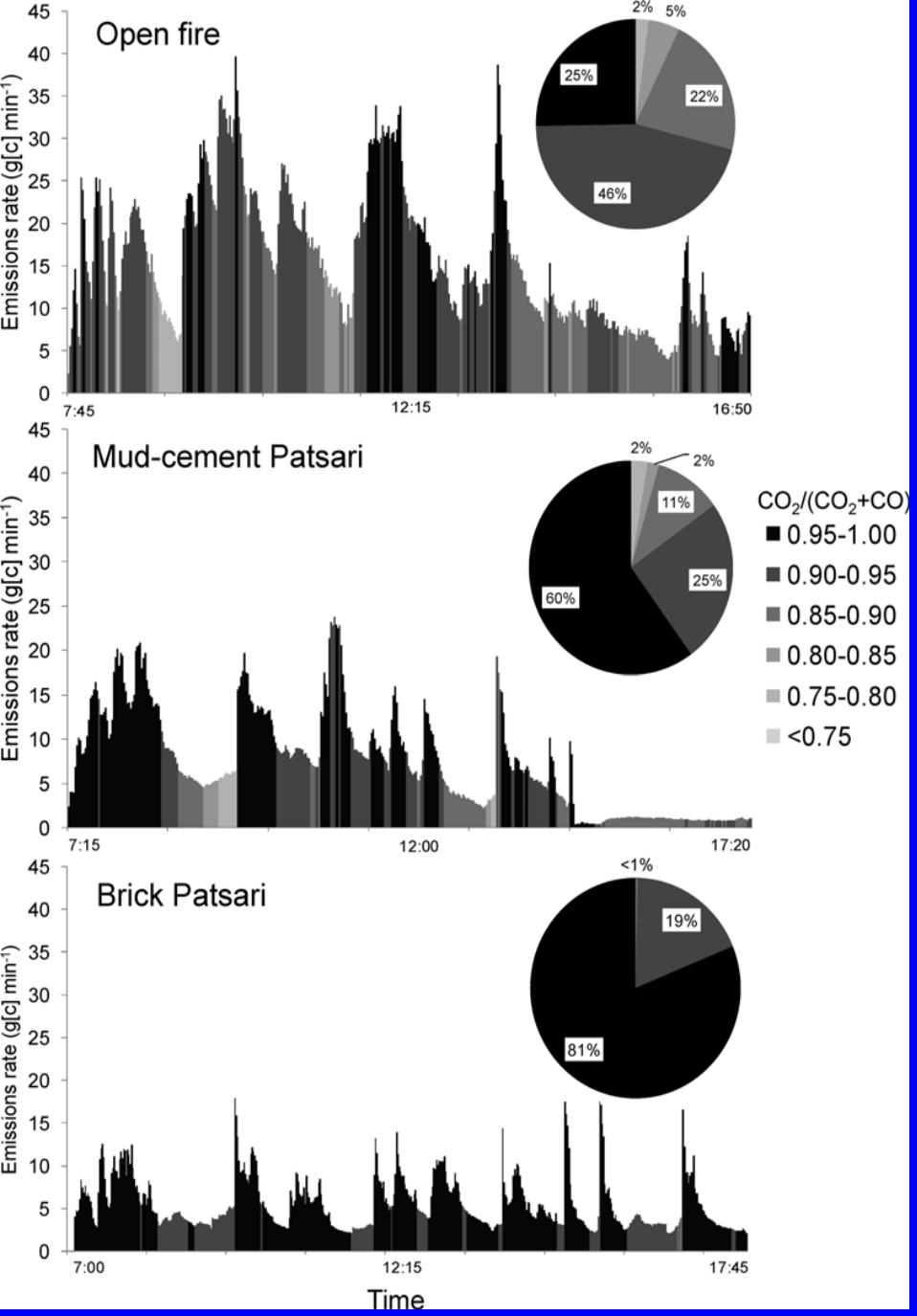


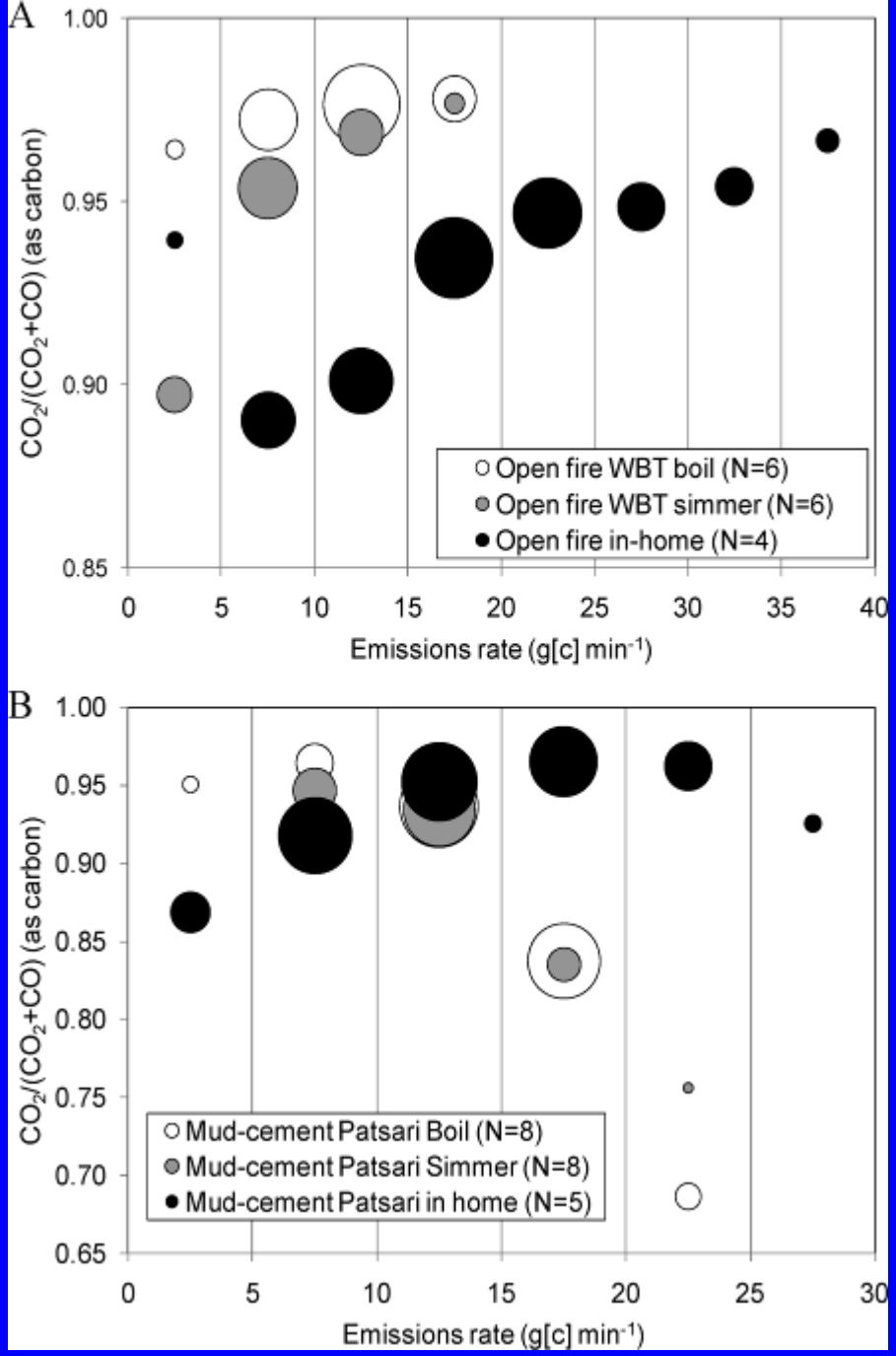
Data from Bond (2009)

Lab Tests are not Enough – Need to Measure in the Field



Johnson et al. 2008





Johnson et al. 2009

Good estimates of small (sized), large (contribution) sources are important.

Otherwise...

- Present-day emissions may be incorrect.
- Policy decisions may be inefficient, choosing wrong sources or missing opportunities.
- Future trajectories may be incorrect.

Bond, 2011

Three questions to ask when measuring & modeling emissions

- Are we representing the major causes of variability?
- What key factors would allow us to extend our estimates to another region?
- What key factors would allow us to extrapolate our estimates to the future?

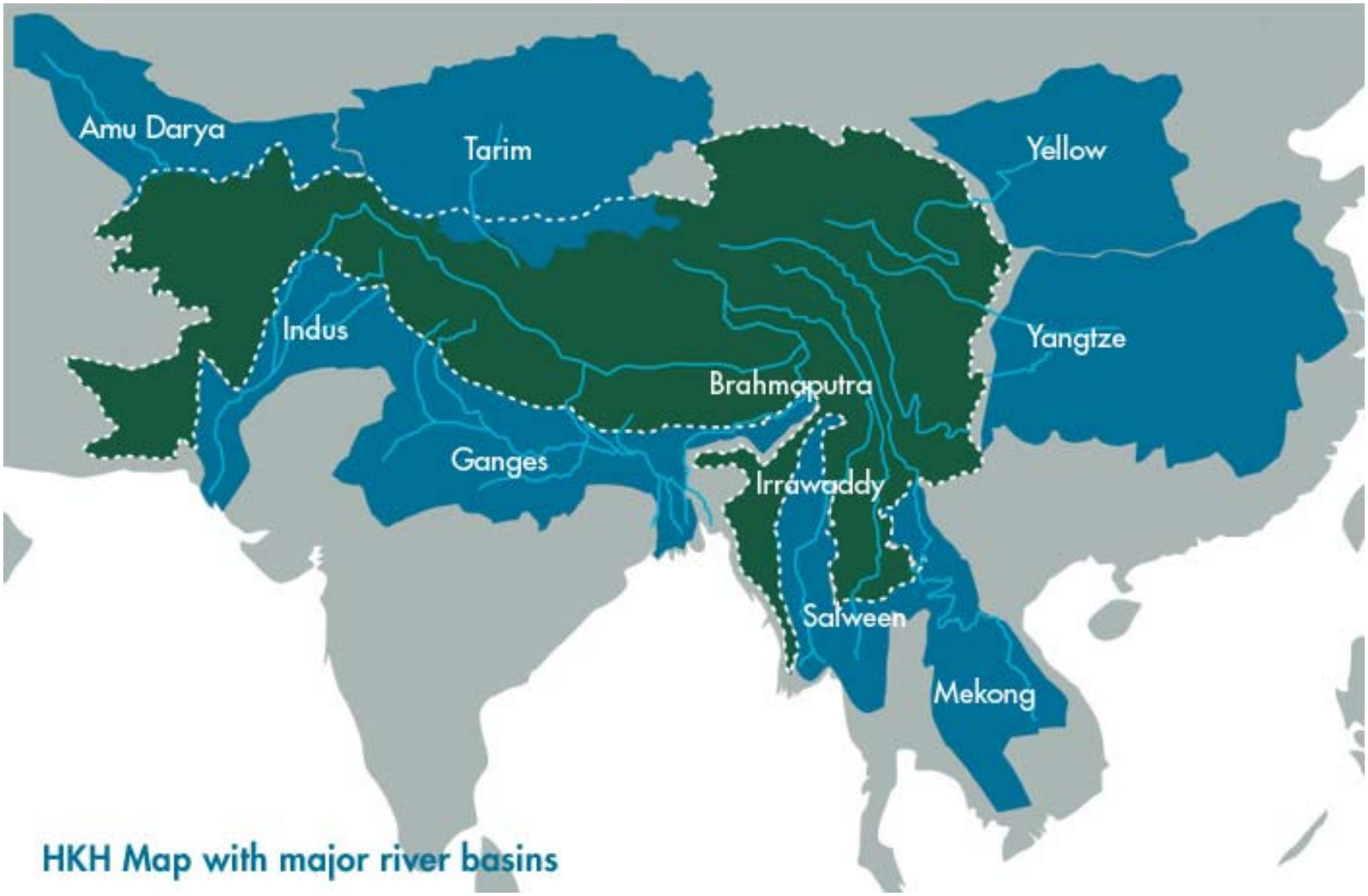
Bond, 2011

Himalayan Transect Project

- Rufus Edwards (PI), Tami Bond, and KR Smith
- Funded by USEPA, we believe
- Aim 1: Improve and standardize in-field emissions measurements from small-scale combustion: households and other sources

Himalayan Transect Project

- Aim 2: Improve emission inventories in selected sites – starting near vulnerable glaciers



HKH Map with major river basins

Himalayan Transect: Black Carbon and other Emissions from Small-Scale Combustion Sources

India Site

Nepal Site

Tibet Site

Yunnan Site

Also sites in El Salvador (very clean stoves) and Indonesia (kerosene stoves and lamps)

Seventh site in planning:
Chilean wood heating stoves near
Andean glaciers

Temuco: 90k households, 100k woodstoves

250 ug/m3 PM2.5 6 mo ambient mean. 6000 ug/m3 hourly levels

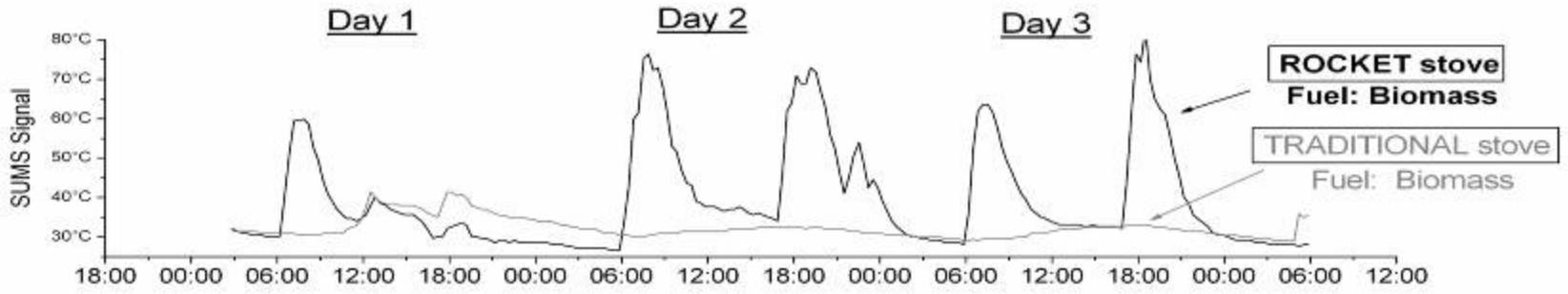
The Stove Use Monitoring System: UCB-SUMS

Fuel savings *quantification with the SUMS*

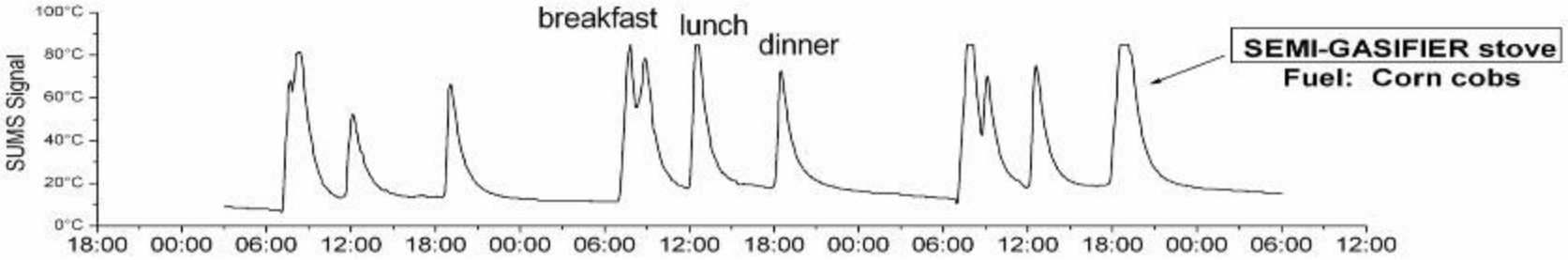
Monitoring ***drop out rates*** *and* ***patterns of use*** *with the SUMS*

Patterns of Stove Use from Around the World
captured with the UCB-SUMS

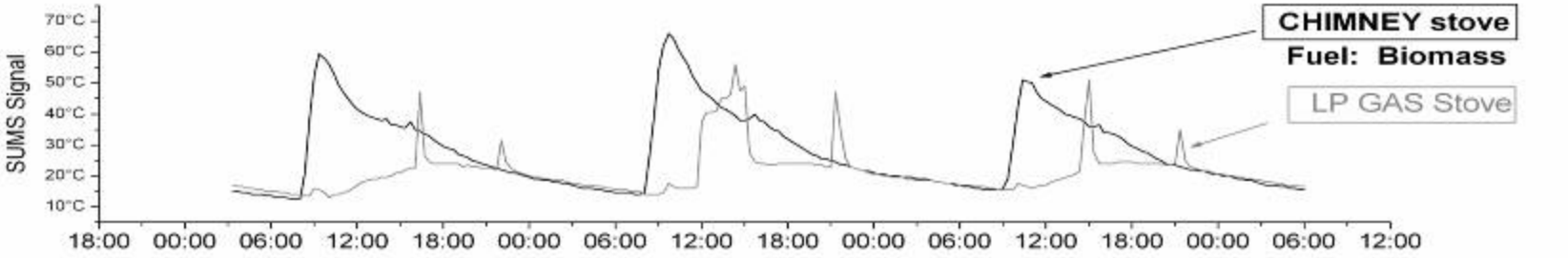
Tamil Nadu
INDIA



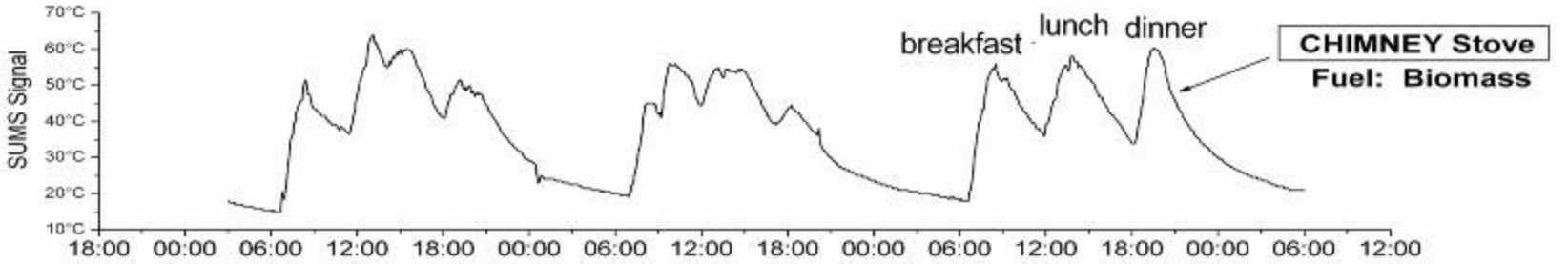
Shaanxi
CHINA



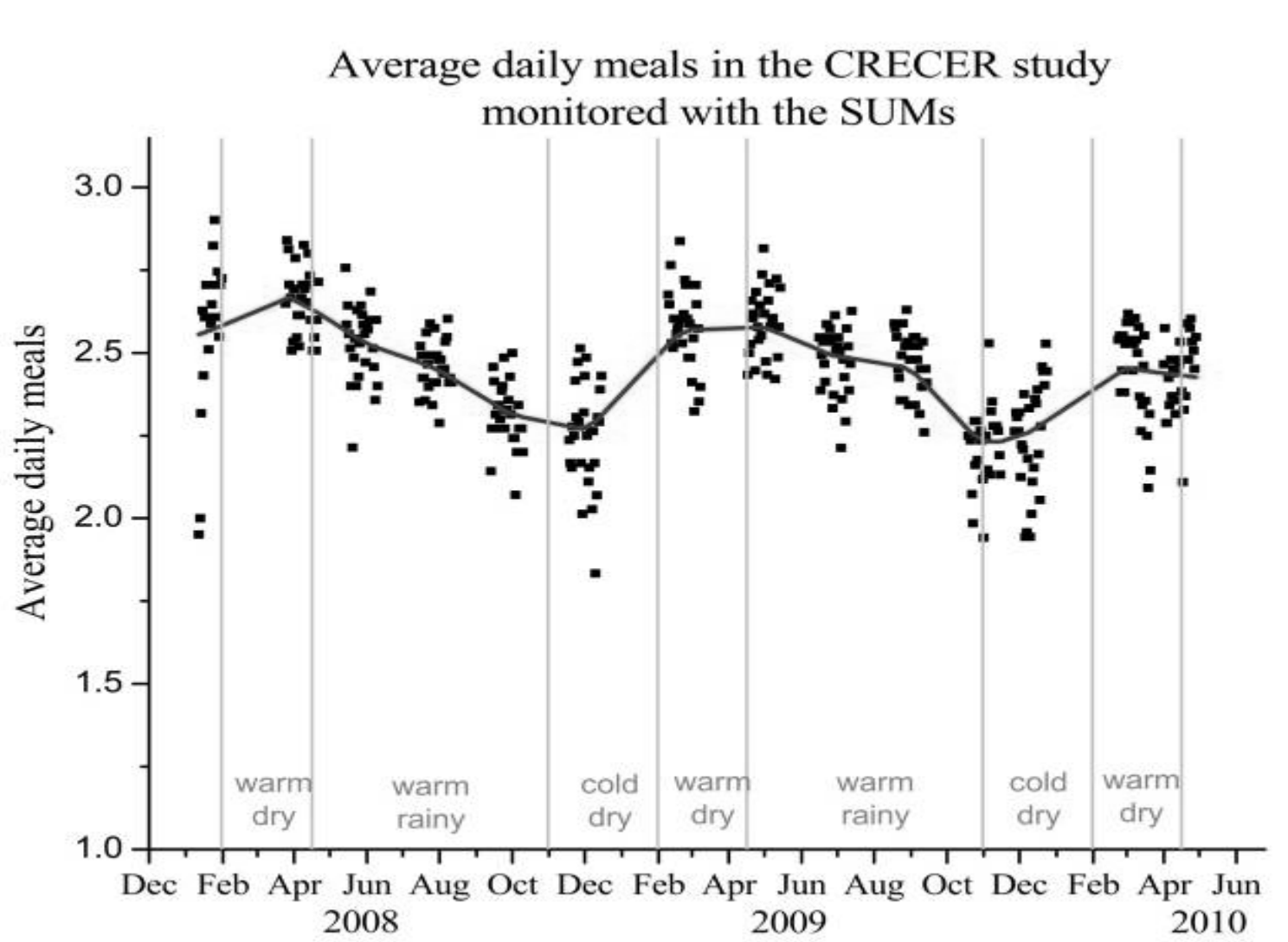
Michoacan
MEXICO



San Marcos
GUATEMALA



Long-term monitoring of stove use at the cooking event ("meal") level.



Wireless Stove Use Monitors Being Field Tested in Michoacán This Month

Recommendations from the UNEP Report

Residential	Replacing coal by coal briquettes in cooking and heating stoves
	Replacing wood burning with pellet stoves and boilers (in industrialized countries)
	Introducing clean-burning biomass stoves for cooking and heating (in developing countries)
	Substituting traditional biomass cook stoves with clean cookstoves using modern fuels (in developing countries)

Additional Needs

Replace coal in residential use
Replace kerosene in residential use

Only Gas is an Appropriate Fossil Fuel for Household Use

- **Coal** cannot be burned cleanly enough in small-scale devices unless heavily processed
- Produces CO2 plus SLCFs
- Better to process biomass: many fewer intrinsic contaminants, can be burned with higher efficiency, renewable, more widely available
- **Kerosene** has very high black carbon emissions, whether for cooking or lighting
- Combustion mixture seems to have high health impact per unit service
- Poisonous and prone to cause housefires
- Subsidies are “leaky” – people add to diesel fuel

Recommendations, cont.

Residential	Replacing coal by coal briquettes in cooking and heating stoves
	Replacing wood burning with pellet stoves and boilers (in industrialized countries)
	Introducing clean-burning biomass stoves for cooking and heating (in developing countries)
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Elaboration of cookstove issues:

Only truly clean biomass stoves have blowers

Electricity Availability is No Longer a Constraint

TEG-powered Blower Module For Stove

Generates power from the heat of the stove

Laws of Carbon-thermodynamics

I. Keep all fossil and forest carbon out of the atmosphere

II. If you cannot do so, the least-damaging form to release is carbon dioxide because all other forms are worse for climate and health.

III. Even renewable (non-fossil) carbon is damaging for climate and health if not released as carbon dioxide - avoid PIC like the plague.

Ranking of Carbon Emissions:
The Pharmaceutical Index

- Carbon dioxide is noxious if fossil or forest derived, but benign for climate if from renewable sources
- Products of incomplete combustion (PIC) such as carbon monoxide and hydrocarbons are like CO_2 on caffeine – several times worse
- Methane from any source (fossil, biologic, or incomplete combustion) is like CO_2 on steroids – dozens of times worse.
- Black carbon in particles from incomplete combustion is like CO_2 on crack – hundreds of times worse

Principles by Which to Move Forward

- "Get rid of incomplete combustion" – bad for health, climate, ecosystems, agriculture and resource efficiency
- "You don't get what you expect, but what you inspect" -- need to monitor in the field for both technical performance and usage
- "Not all stoves are equally bad" -- need to target vulnerable populations and ecosystems
- "The poor cannot afford to pay" --need to realign financing so that everyone pays, since all benefit – households, nations, globe
  - Poor will only pay for fuel savings, but many do not buy fuel and thus have little incentive
  - Cost of stoves that merely save fuel are much lower than those that are also clean -- thus sales will not bring health/climate benefits
  - Truly clean stove/fuel systems are very few in number today, and field experience even more scarce

Terminology

- We avoid the term “domestic”, but rather use household or residential. Ambiguous in international discussions.
- We try to move away from “biofuel” for “biomass fuels,” because biofuel in most of the world means liquid and gaseous fuels made from biomass. These too will have impacts and need a separate category.
- We no longer use “indoor” pollution, but household air pollution - problem is poor combustion of household fuels, but impacts occur at a number of scales
- We try not to use “improved” stoves, because it is non-specific and people read their own meanings into it. Use “fuel saving” if that is what is meant and “advanced” for stoves with high combustion efficiency: be specific
- CAPS – climate-altering pollutants being proposed by IPCC WGs I and II as the term for all species, gases and aerosols, short and long lived, direct and indirect action.

Thank You

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Just Google “Kirk R. Smith”