Confidence and key uncertainties in black carbon emissions & radiative impacts & measurements & co-emitted particles & gases & optical properties & vertical distributions & future emissions &…

Tami C. Bond
Department of Civil & Environmental Engineering
University of Illinois at Urbana-Champaign

U.S. Environmental Protection Agency, SLCF Workshop
North Carolina, USA
March 3, 2010
Source-to-Impact measures

- Forcing

Warming

+ Forcing

Cooling

Net

Aerosols: BC, OC, SO2, other precursors

VOCs, NOx, methane

Carbon dioxide (CO₂)
Strong absorption of BC causes powerful, immediate warming.

1 gram BC emitted = small heater in atmosphere for 1 week

1 kg CO$_2$ emitted = 1 small bulb for 100 years
Black Carbon Sources
Black carbon is created only in flame


Fig. 2. A representation of the methane flame with PAH-maxima and soot particle size distributions, assigned to the respective height in the flame.
Historical BC lessons

- Lots of trees here!
- We love steel (& coke) (& trains)
- Great Depression
- Energy prices ↑; Wood use ↑
- Diesel ↑; residential solid

Graph showing US/Canada emissions (ktonne/yr) from 1850 to 2000, with peaks and troughs for Residential, Transport, and Industry sectors.
Source mix differs by region

Green bars indicate relative contribution to global total.

Gray bars show how much comes from energy-related combustion.

Colored bars indicate relative contribution to global total.

(Bond et al. 2004 JGR)
Global & N American sources of BC

Global

Year 2000 estimates (Bond et al., GBC 2007 + van der Werf, 2006 + updates for IPCC AR5)

North America
Bottom-up inventory needs & major uncertainties

- Open biomass (forest+savanna) will always be uncertain

Gaps: Small fractions or small sources (stats please!)
- Activity: Vehicle superemitters
- Activity & Profiles: Residential wood
- A&P: Small industrial sources
- A&P: Crop burning, esp near ice
- A&P: Flaring

Connections: Inventory links from state-national-global levels
- Must retain flexibility & research nature
Straight talk about uncertainties

- Bottom-up inventory uncertainty = x2
  - Some sectors x5
  - If activity uncertain $\rightarrow$ Sign is known, magnitude isn’t
  - If profile uncertain $\rightarrow$ Climate forcing may be wrong
  - Measurements contribute (BC/OC division)

- Global model analysis (Koch et al., ACP, 2009)
  - Surface predictions close to models
    $\Rightarrow$ But only available in certain regions (US-Europe)
  - Column absorption higher than models
    $\Rightarrow$ Probably affected by aerosol mixing = absorption ↑
  - Large underpredictions in open biomass burning regions
Major BC sources of interest

- SPEW emissions
- Co-emissions

- Diesel engines
- Residential solid fuel
- Open burning

ktonne/yr, 2000

OC:BC ratio
SO2:BC ratio

On-road
Off-road
Industry
Wood/cooking
Wood/heating
Other solid bio
Coal
Ag fields
Forests
Savannas
Other

Other Asia
China
India
Latin America
North America
Europe
Former USSR
Middle East
Africa

Diesel engines
Residential solid fuel
Open burning

AKA: bands with a loud frontman
Bounding-BC

"Bounding the Role of Black Carbon in Climate"

Conceived Jan 2009

Due Jun 2010
Bounding-BC major goals

- Provide **best current estimate** for radiative forcing by black carbon
  - identify causes of disagreement
- Connect **individual sources** to climate impacts
  - account for co-emitted short-lived pollutants
Bounding-BC Source-to-Impact measures

Aerosols: BC, OC, SO2, other precursors
VOCs, NOx, methane
Carbon dioxide (CO₂)

Direct
Clouds (indirect)
Snow/ice

Forcing: an intermediate measure
(probably forcing per mass)

Warming
Warming?
Cooling?
Warming Melting
Impact
(probably temperature)

Bounding-BC: BC+OC+SO₂
Someday: All emitted species
THANK YOU!!

Questions?

yark@illinois.edu