From Action to Forcing:
A Solution-Centered View

Tami C. Bond

University of Illinois at Urbana-Champaign

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Air Pollution as a Climate Forcing: A Second Workshop

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www.co2.org

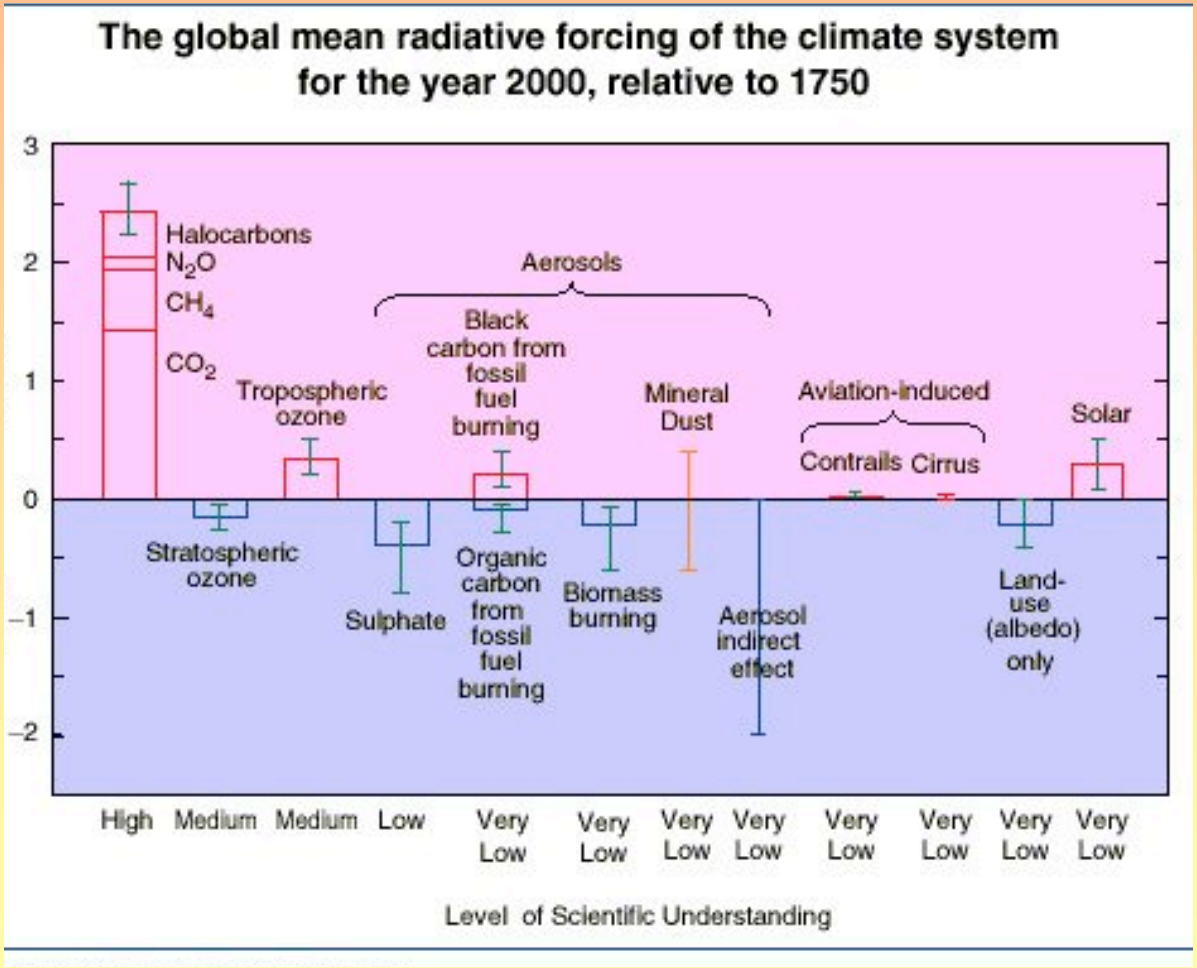
philosophy & approach

We can estimate the climatic effects of individual actions.

Uncertainty limits conclusions. It doesn't forbid them.

1. Request for an update
2. Path between action & forcing
3. Case study: black carbon
   - specific values
   - issues & thoughts
4. Here is the update!

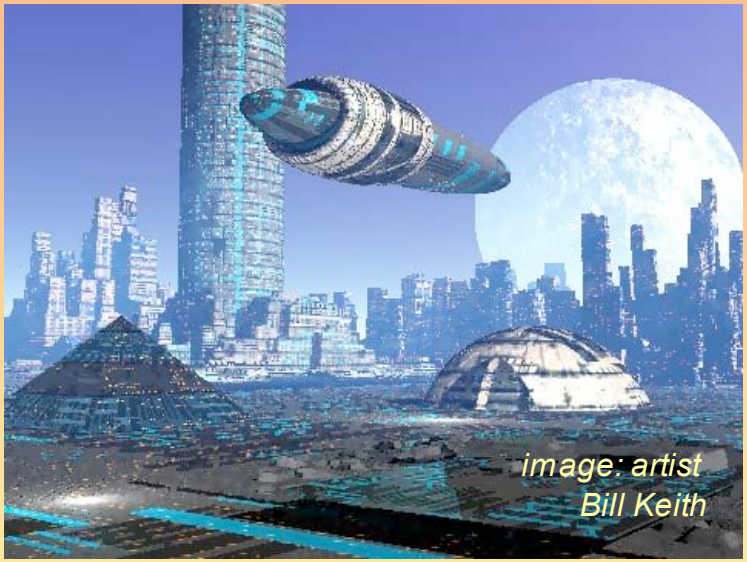
What questions are addressed by this famous chart?



- What changes have been imposed on the climate system?
- What species are primarily responsible?

1. request for an update

Forward-looking questions



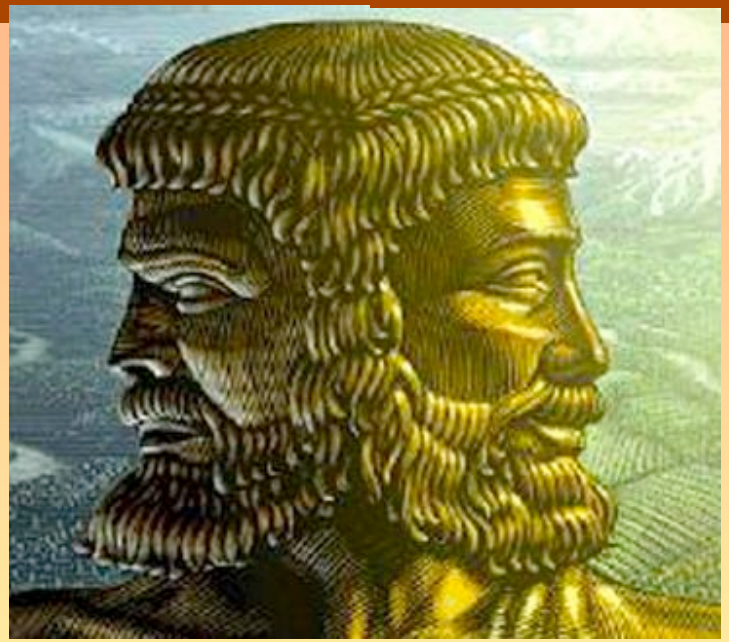
We are stuck with "abundance"… *but* we can change emissions.

Characterization examines species… *but* choices act on sources.

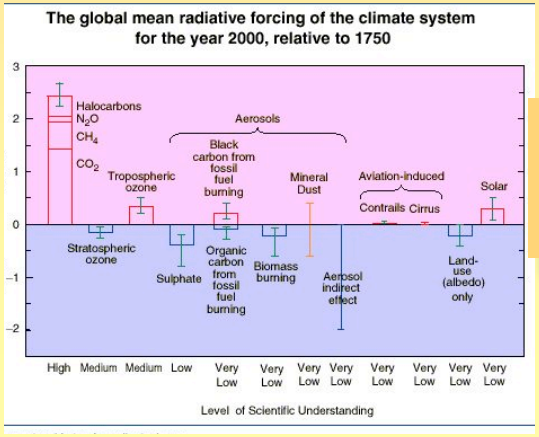
- Every year, we commit to present and future changes in the climate. How much?
- We can choose among several mitigation options. Which are most promising?
- How can we credit the benefits of actions?

“I think we can agree, the past is over…” – George W. Bush

What happened? What molecules did it?



What can we do? What are we choosing– this year? in future years?



Overdue for a partner!

1. request for an update

Linking action & impact: a recipe

Action

"Emission Factor"

Emission

"Lifetime"

atmospheric
Concentration

"Normalized Forcing"

(need metric for clouds, etc too!)

first-round
Impact

"Sensitivity/Efficacy"

climate
Response

life-system
Impact

First try: Global warming potential/commitment

forcing per mass

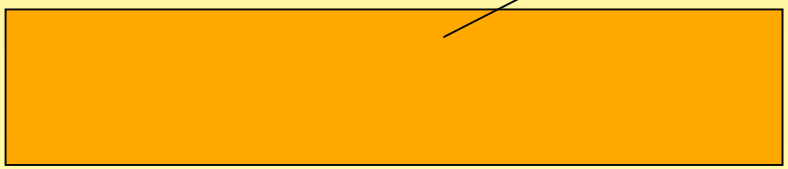
amount of original emission remaining in atmosphere

$$GWP_s = \frac{\int_0^{\tau} a_s r_s(t)\,dt}{\int_0^{\tau} a_{CO2} r_{CO2}(t)\,dt}$$

(IPCC)

time frame (20-50-100 years)

emission factor

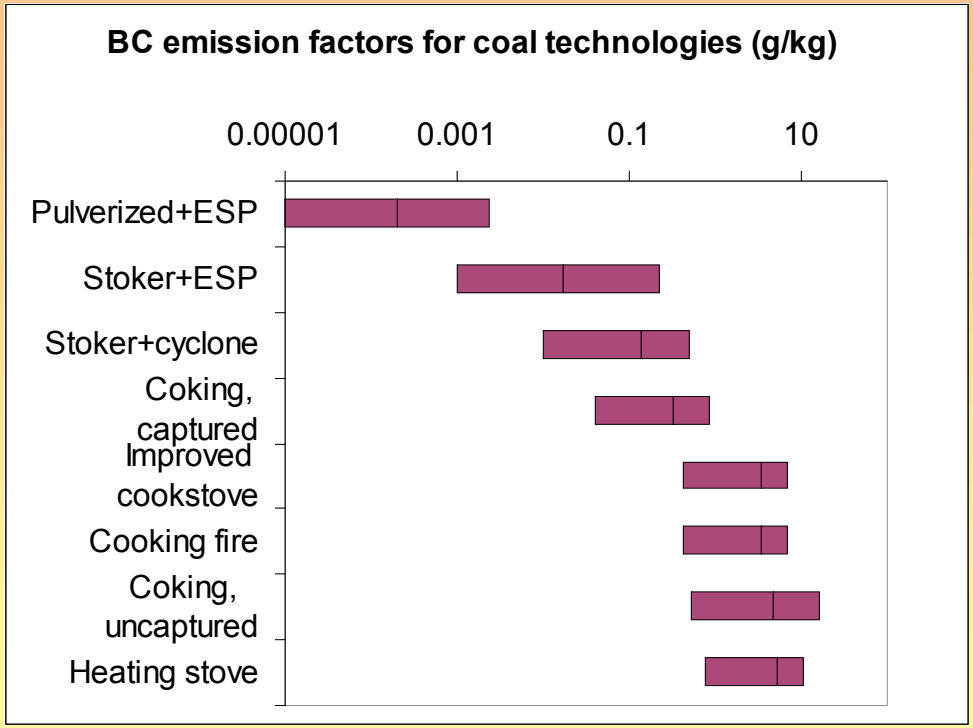


Commitment per action
(kg fuel burned, km driven, etc)

Step 1: Emission Factors

Source: Literature survey of measured emission factors

Bond *et al.*, "Technology-Based Inventory", *JGR* 2004

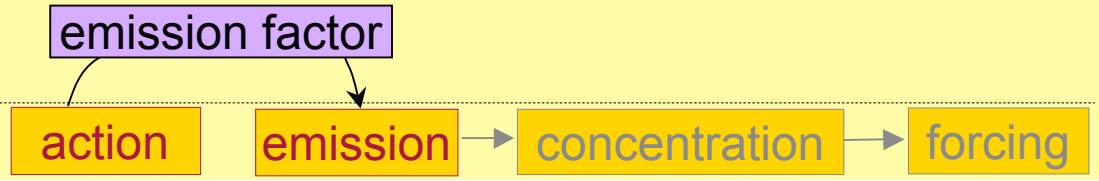


Issues:

- Varies greatly among similar sources.
- Difficult to estimate result of average action.

Comment:

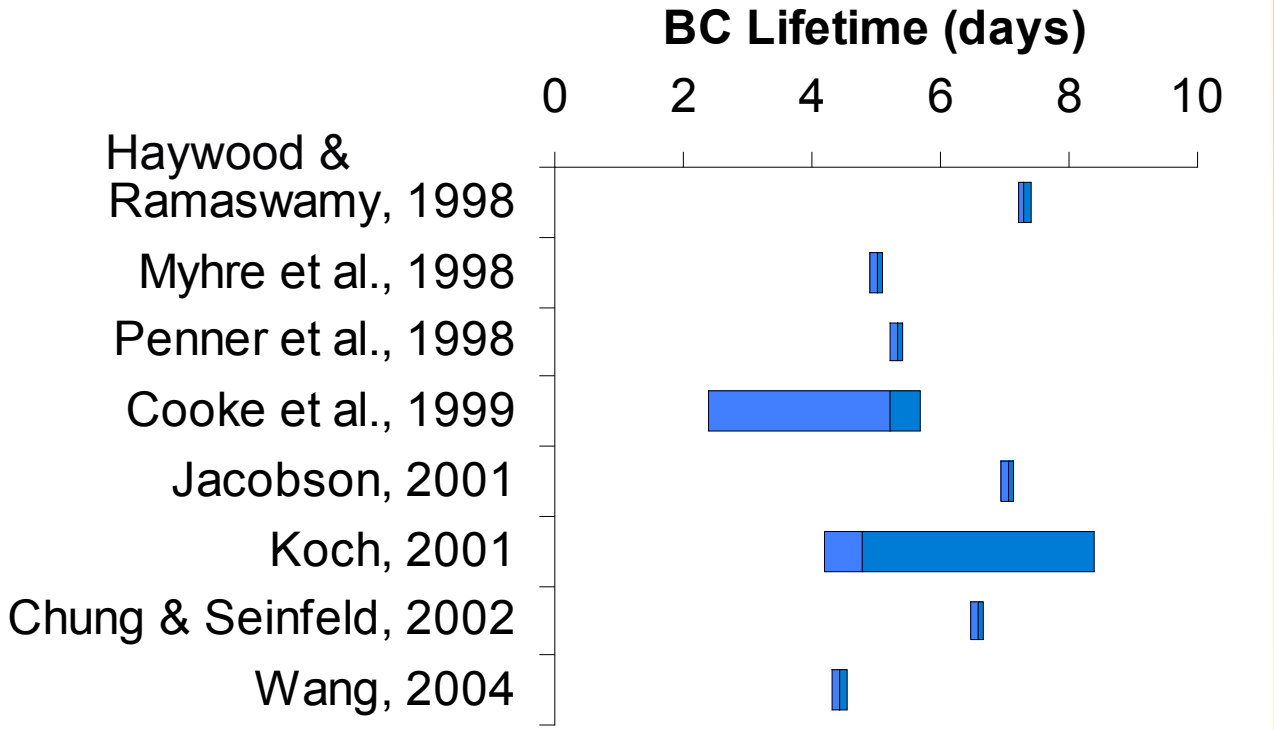
- Total emissions uncertain, but only emission *rate* needed for this purpose

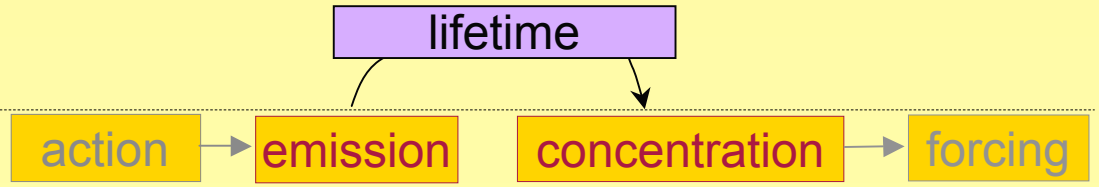


Step 2: Lifetime
Source: Compilation of model results

Issues:
Model removal processes not corroborated
Regionally specific

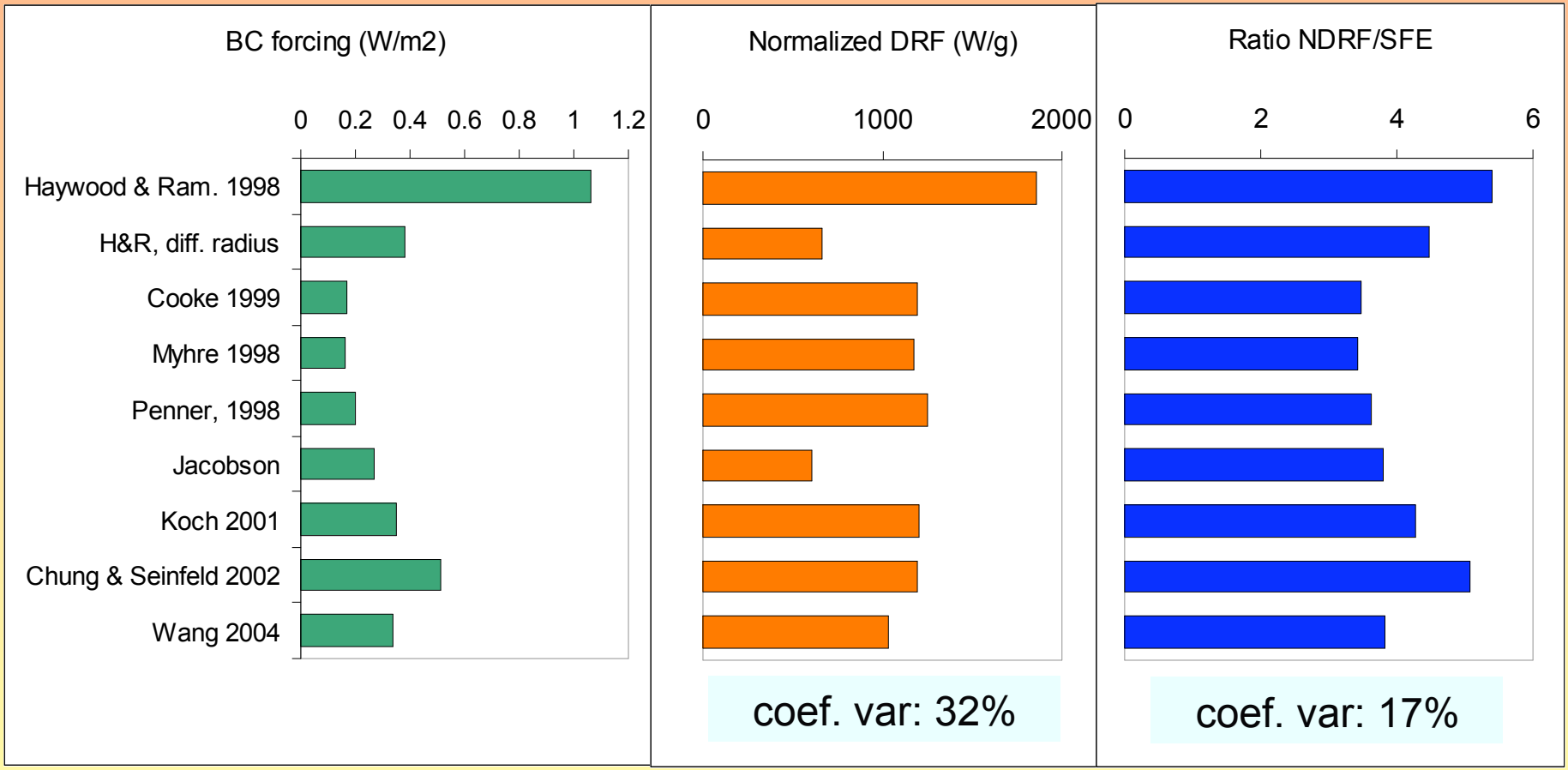
Comment:
Use of regionally-specific lifetimes politically feasible?



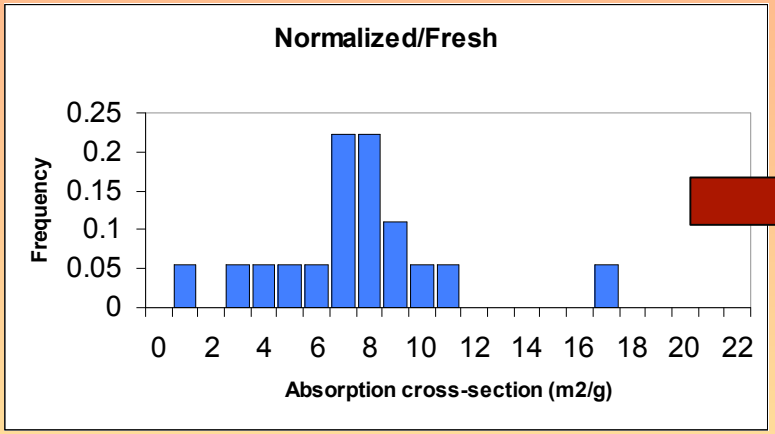


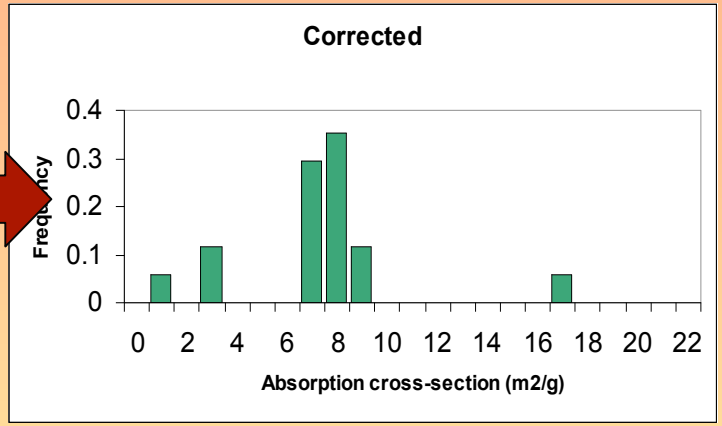
Step 3: Normalized forcing

Source: Compilation of model results +…



Step 3: Normalized forcing
Source: Model results + optics resolution





mass absorption cross-section

7.5 m^2/g

coating impact

x1.5

Normalized direct forcing

~1800 W/g

Issues:
Integrate optics over lifetime
Also regionally specific
May be source-specific

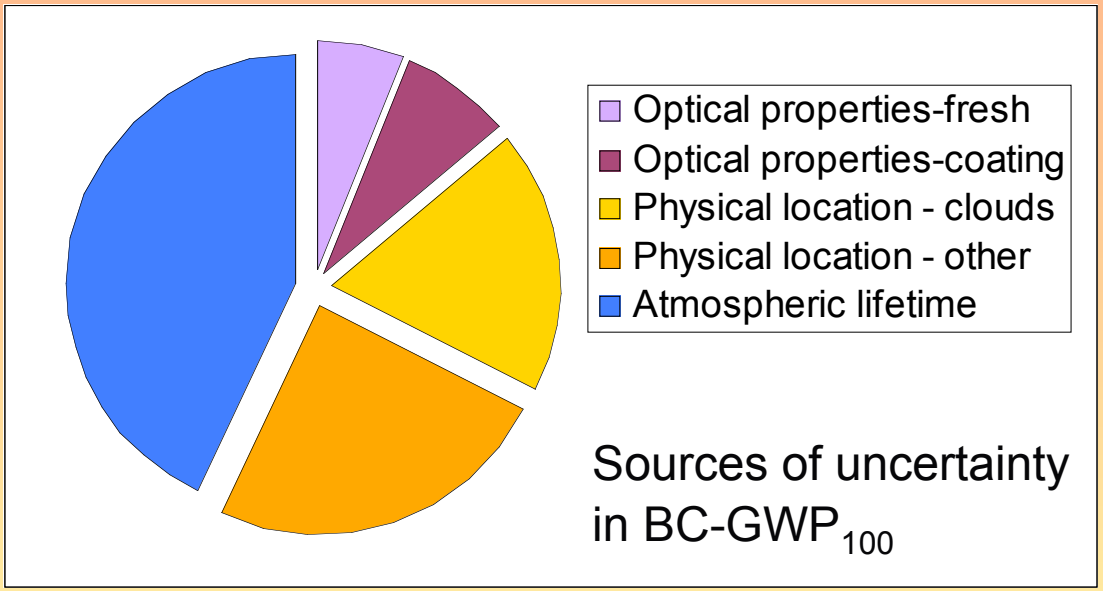
normalized forcing

3. case study: BC

action → emission → concentration → forcing

Combine, stir, mix well…

$$GWP_s = \frac{\int_0^{\tau} a_s r_s(t)\,dt}{\int_0^{\tau} a_{CO2} r_{CO2}(t)\,dt}$$



mass absorption cross-section

coating impact

Normalized direct forcing

Lifetime (model average)

5.5 days

direct global warming potential

~700

(240-1700)

Issues in the metric

- "Pulse" (GWP) vs. "sustained" (aGWP)
  - How much does it matter for short-lived species?
- What time horizon should we choose?
  - My opinion: (a) give options (20-50-100 years); (b) use discount rates *(e.g. Lashof & Ahuja, 1990)*
- "You can't do that!"
  - "Yes, but…"

We <u>can</u> (and <u>must</u>) estimate the climatic effects of individual actions

Maximum possible consensus needed as roots for metrics!

Warning: straw man coming

Estimates for other species are not as strong

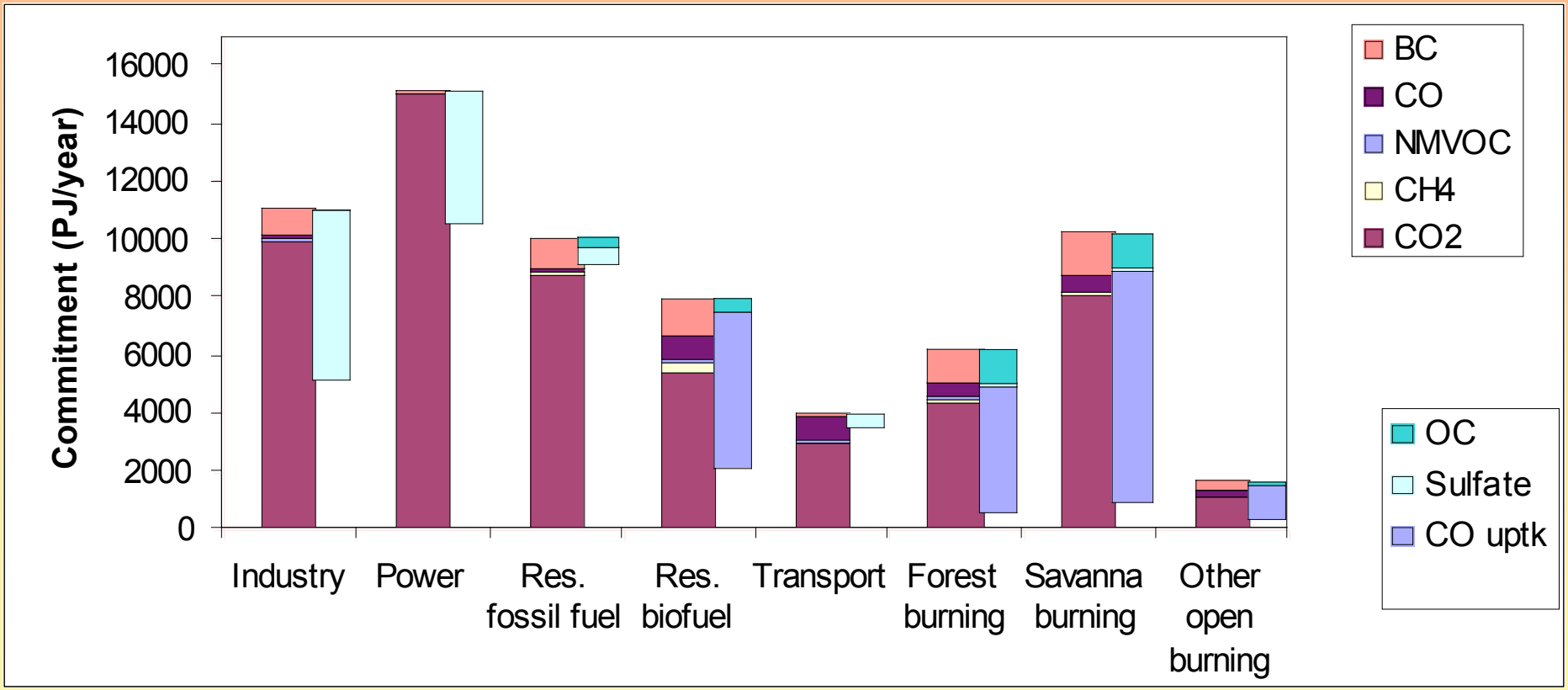
◊ Requesting help ⇓

◊ Do not quote or otherwise propagate ⇓

- Organic carbon:
  - Review models, identify critical climate-relevant properties, estimate emission rates of 4 types of OC (*Haolin Sun, UIUC*)
  - Problem: Secondary OC (not treated)
- Sulfate: Model review from IPCC TAR
  - inventory from Streets
- Methane, CO, NMVOCs
  - existing GWPs
  - inventory from EDGAR

4. here is the update!

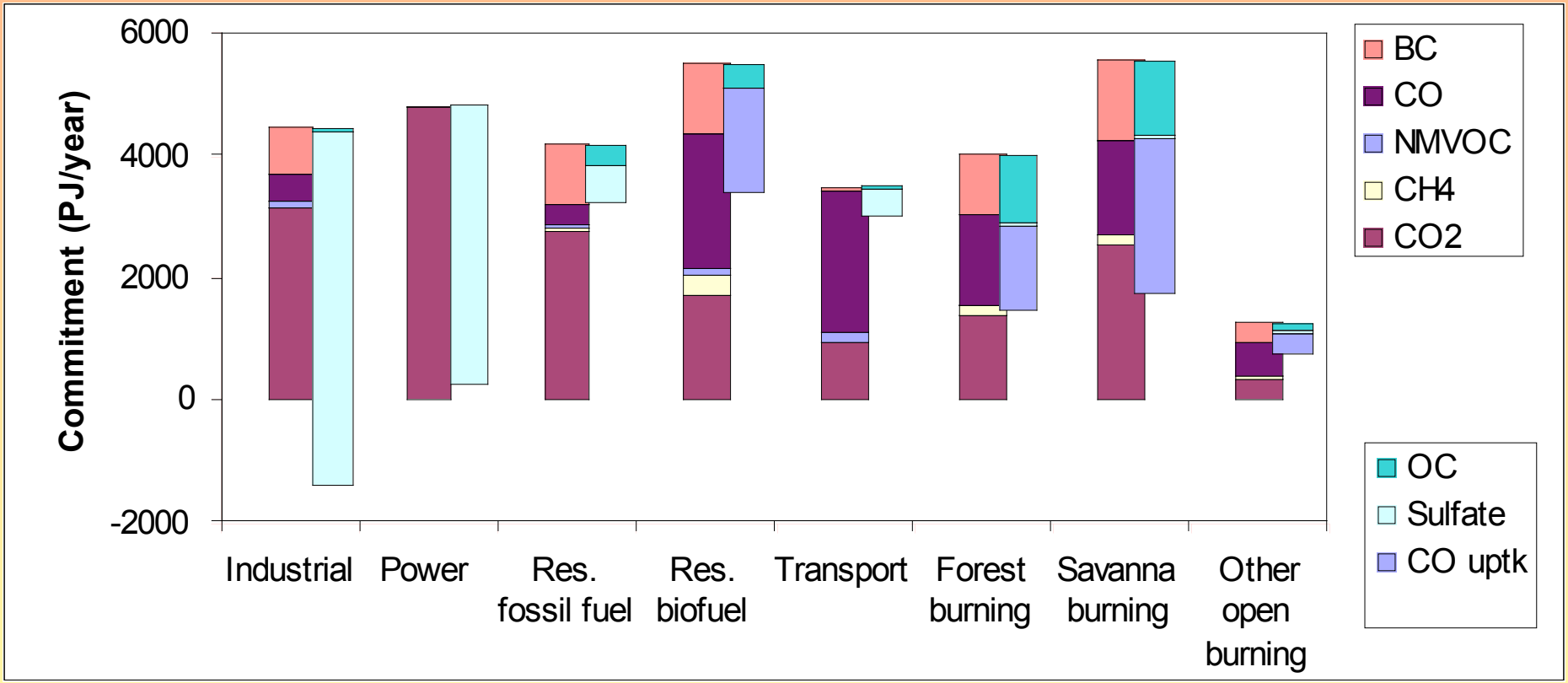
The solution-centered bar chart
100-year time frame, pulse



"Commitment"=How much energy have we agreed, this year, to add to the system over the next 100 years?

4. here is the update!

The solution-centered bar chart
20-year time frame, pulse



4. here is the update!

Summary

We <u>can</u> estimate the climatic effects of individual actions…

…by using consensus values from published literature.

Uncertainty limits conclusions. It doesn't forbid them…

…we can, and should, look at total effects of actions.