



Role of black carbon in global climate systems

Ellen Baum, Climate and Health Research Network

Tami Bond, University of Illinois

March 11, 2015

2000: Focus on role of black carbon and short-lived climate pollutants

Global warming in the twenty-first century: An alternative scenario

James Hansen^{**}, Makiko Sato^{**}, Reto Ruedy^{*}, Andrew Lacis^{*}, and Valdar Oinas^{**}

PNAS | August 29, 2000 | vol. 97 | no. 18 | 9875–9880

If sources of CH₄ and O₃ precursors were reduced in the future, the change in climate forcing by non-CO₂ GHGs in the next 50 years could be near zero.

Combined with a reduction of black carbon emissions and plausible success in slowing CO₂ emissions, this reduction of non-CO₂ GHGs could lead to a decline in the rate of global warming, reducing the danger of dramatic climate change.

Another milestone. Tami Bond completed her dissertation: *Light absorption by primary particles from fossil-fuel combustion: Implications for radiative forcing.*

Fast forward to 2013: The paper known as “Bounding-BC”

JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES, VOL. 118, 1–173, doi:10.1002/jgrd.50171, 2013

Bounding the role of black carbon in the climate system: A scientific assessment

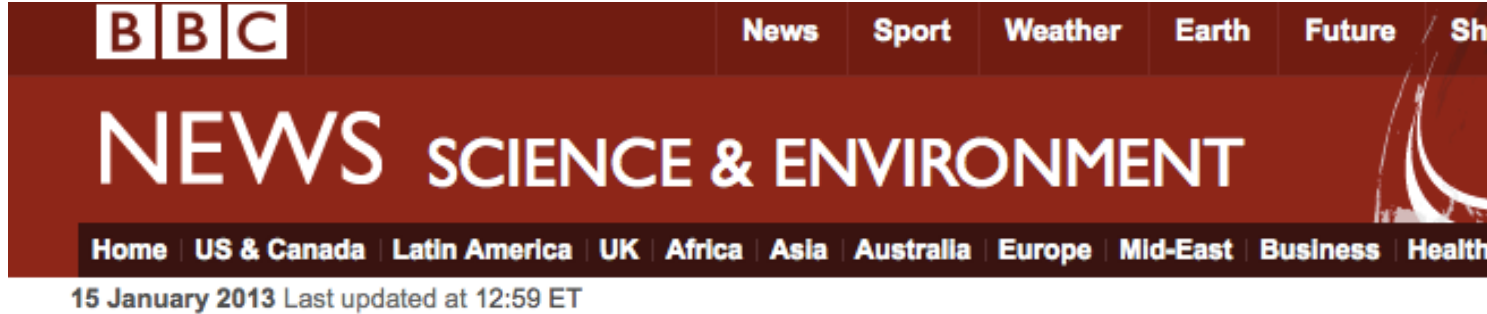
T. C. Bond,¹ S. J. Doherty,² D. W. Fahey,³ P. M. Forster,⁴ T. Berntsen,⁵ B. J. DeAngelo,⁶ M. G. Flanner,⁷ S. Ghan,⁸ B. Kärcher,⁹ D. Koch,¹⁰ S. Kinne,¹¹ Y. Kondo,¹² P. K. Quinn,¹³ M. C. Sarofim,⁶ M. G. Schultz,¹⁴ M. Schulz,¹⁵ C. Venkataraman,¹⁶ H. Zhang,¹⁷ S. Zhang,¹⁸ N. Bellouin,¹⁹ S. K. Guttikunda,²⁰ P. K. Hopke,²¹ M. Z. Jacobson,²² J. W. Kaiser,²³ Z. Klimont,²⁴ U. Lohmann,²⁵ J. P. Schwarz,³ D. Shindell,²⁶ T. Storelvmo,²⁷ S. G. Warren,²⁸ and C. S. Zender²⁹

Received 26 March 2012; revised 6 December 2012; accepted 4 January 2013.

173 pages – 31 authors – 4 years

Supported by International Global Atmospheric Chemistry (IGAC)

Biggest press headline from Bounding-BC



Climate change: Soot's role underestimated, says study



By Matt McGrath
Environment correspondent



The burning of wood is a major source of black carbon the world over.

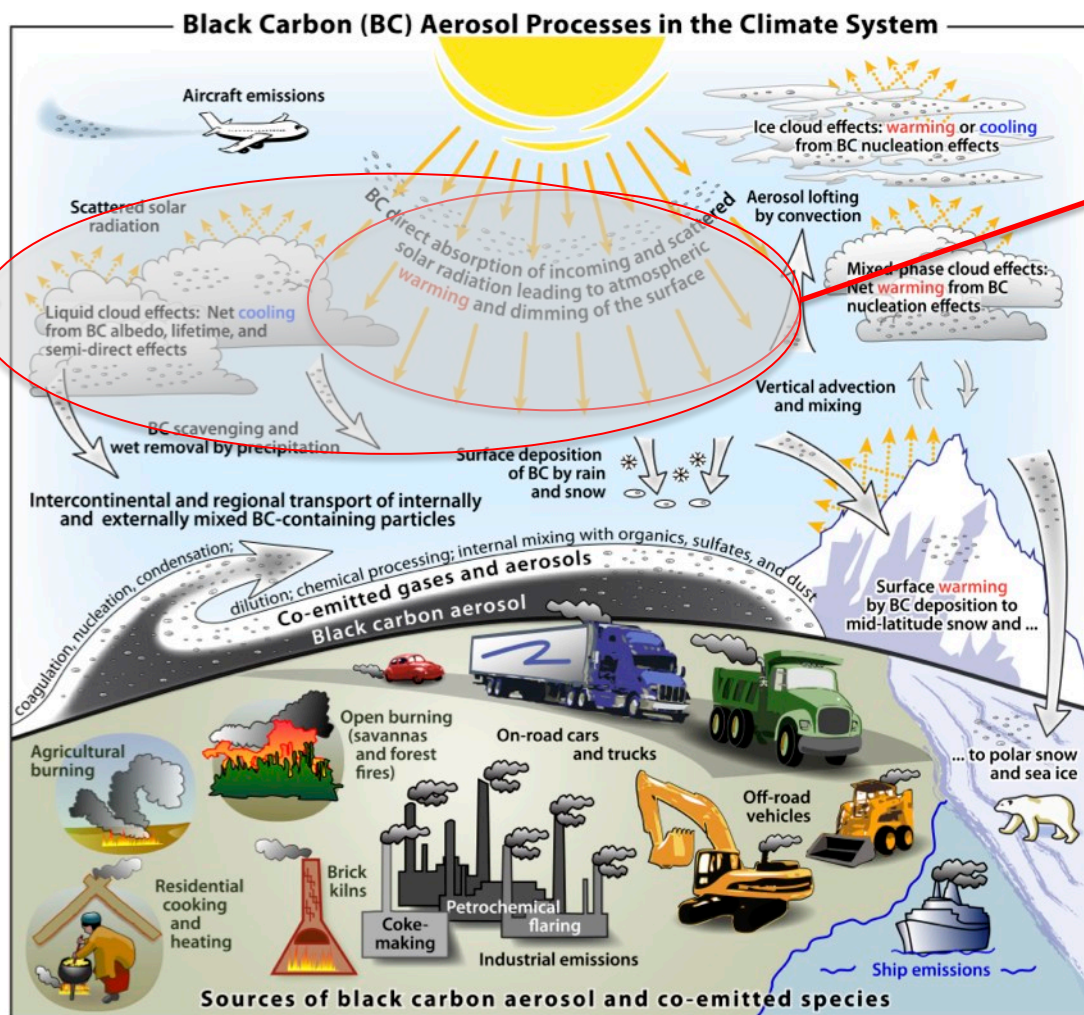
Black carbon, or soot, is making a much larger contribution to global warming than previously recognised, according to research.

[Related Stories](#)

Behind the headline: Big message from Bounding-BC

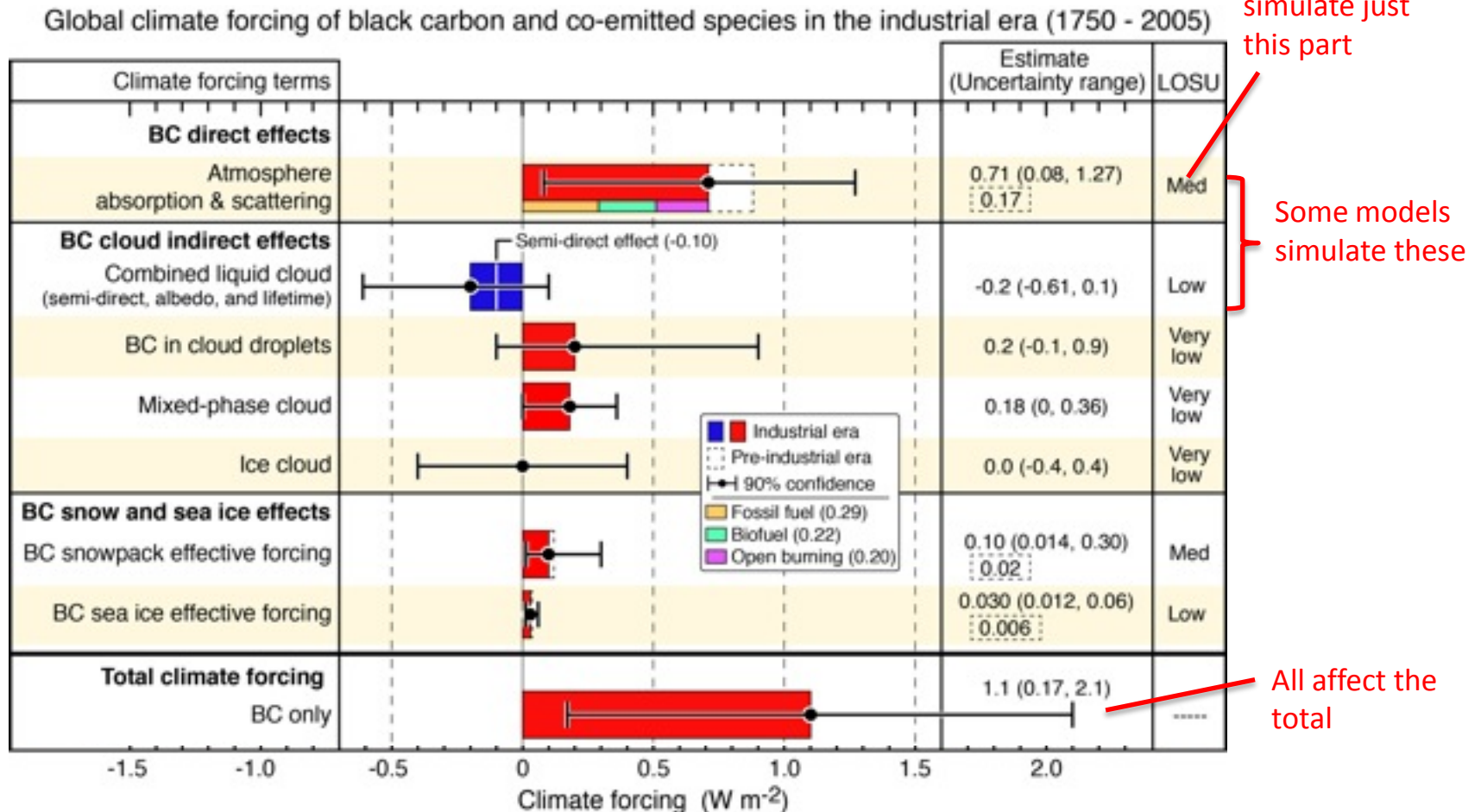
Comprehensiveness: When you change emissions of black carbon, you change all its effects in the Earth system.

Some models simulate these



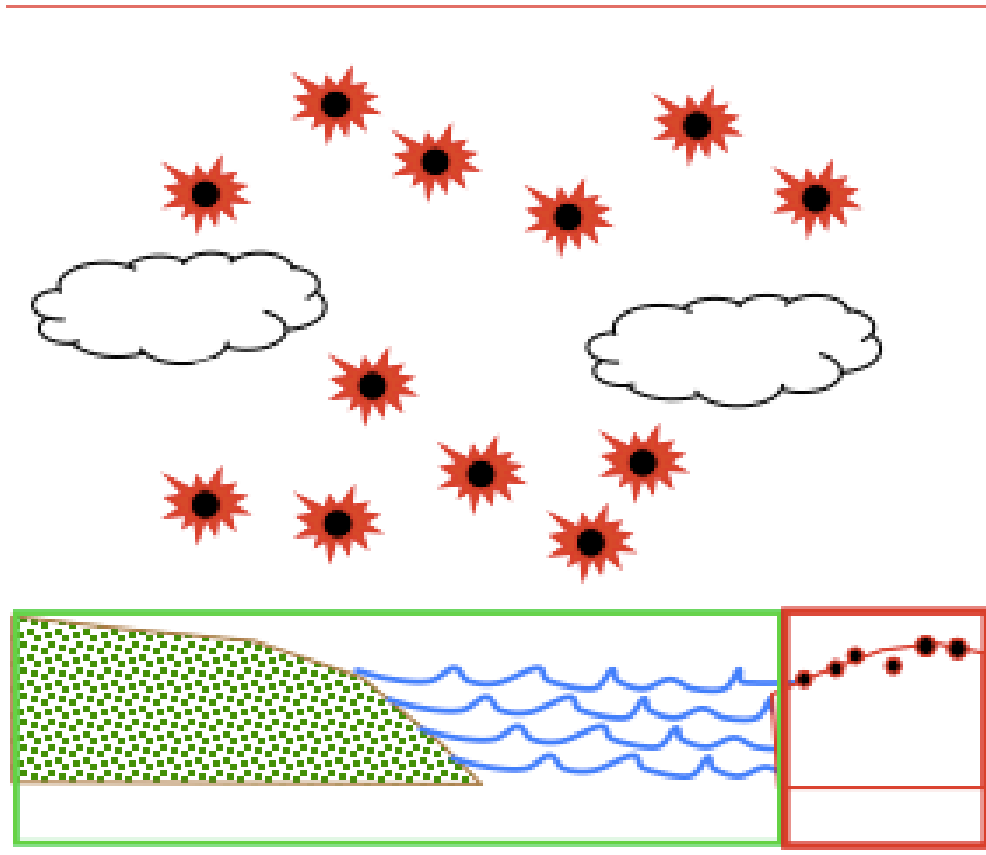
Many models simulate just this part

Comprehensiveness: When you change emissions of black carbon, you change all its effects in the Earth system



The goal of Bounding-BC was to set up a framework that accounts for each of these pieces. We expect that the estimate will change.

Bounding-BC forcing estimate was high for two reasons



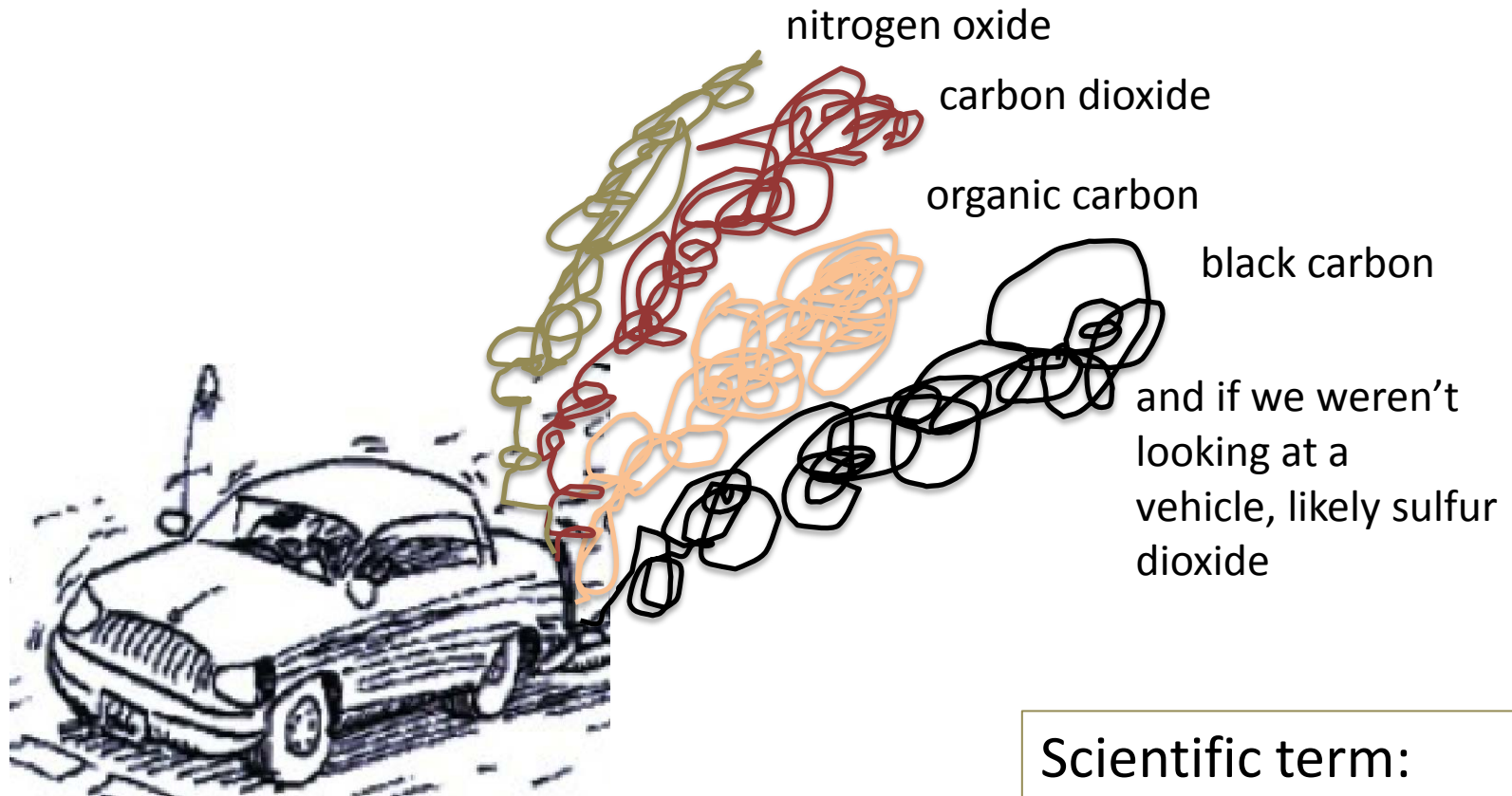
1. **Larger amount** of black carbon in the atmosphere than in some other studies.

(Used observations to adjust models)

2. **More forcing by each gram** of black carbon than in most other studies.

(Included many atmospheric changes, including some cloud effects)

Comprehensiveness: When you change a single source, you also change all pollutants that are emitted



Scientific term:
“Co-emitted species”

Comparing two kinds of particles

Black carbon

Made in flames



1 gram absorbs as much sunlight
as ~10 black umbrellas

Absorption makes the Earth **hotter**

Organic carbon

Often unburned fuel



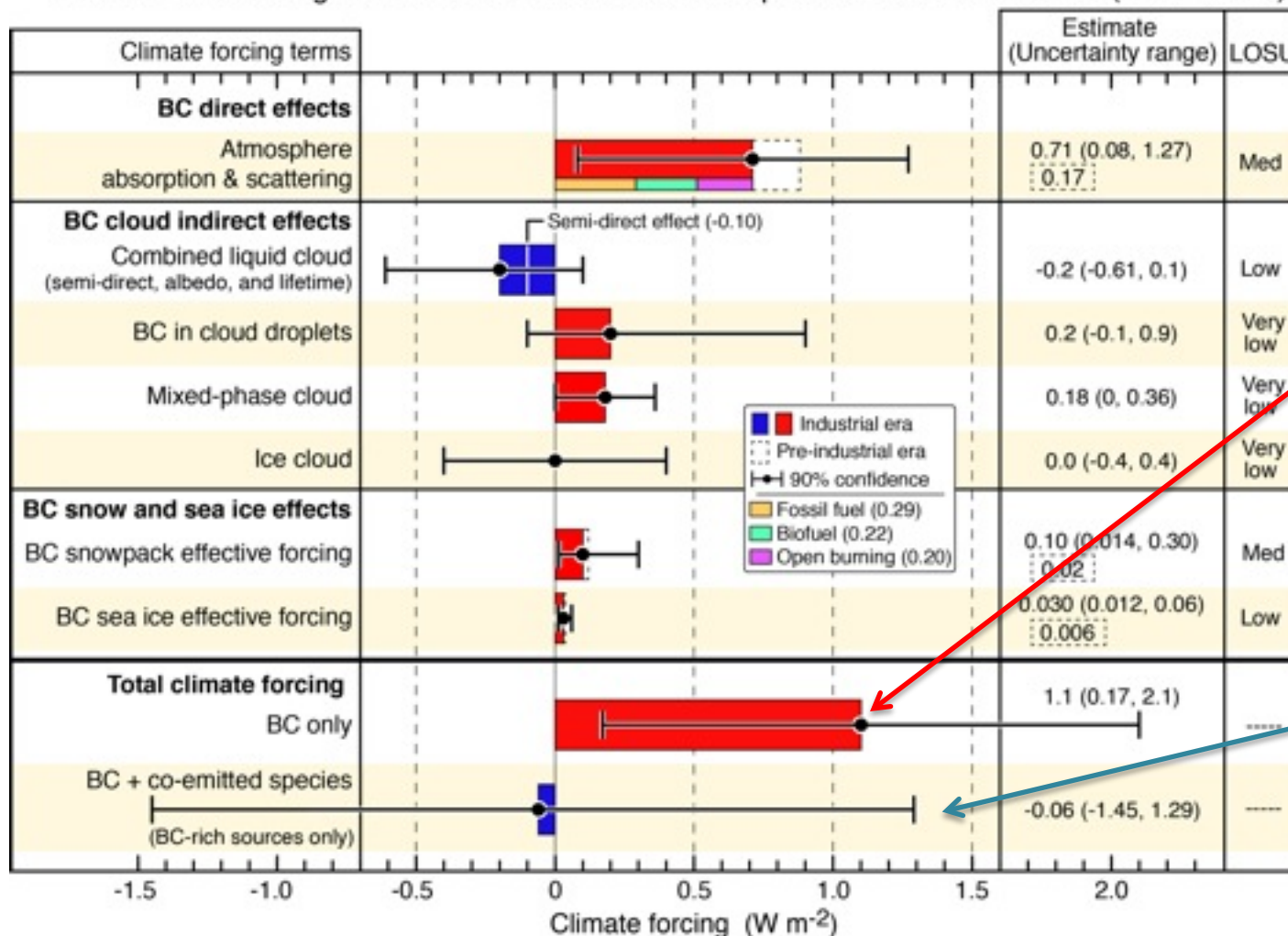
1 gram reflects as much sunlight
as ~3 white umbrellas

Reflection makes the Earth **cooler**

Remember comprehensiveness – Both alter clouds, too

Comprehensiveness: When you change emissions of black carbon and co-emitted species, you change all the effects in the Earth system

Global climate forcing of black carbon and co-emitted species in the industrial era (1750 - 2005)

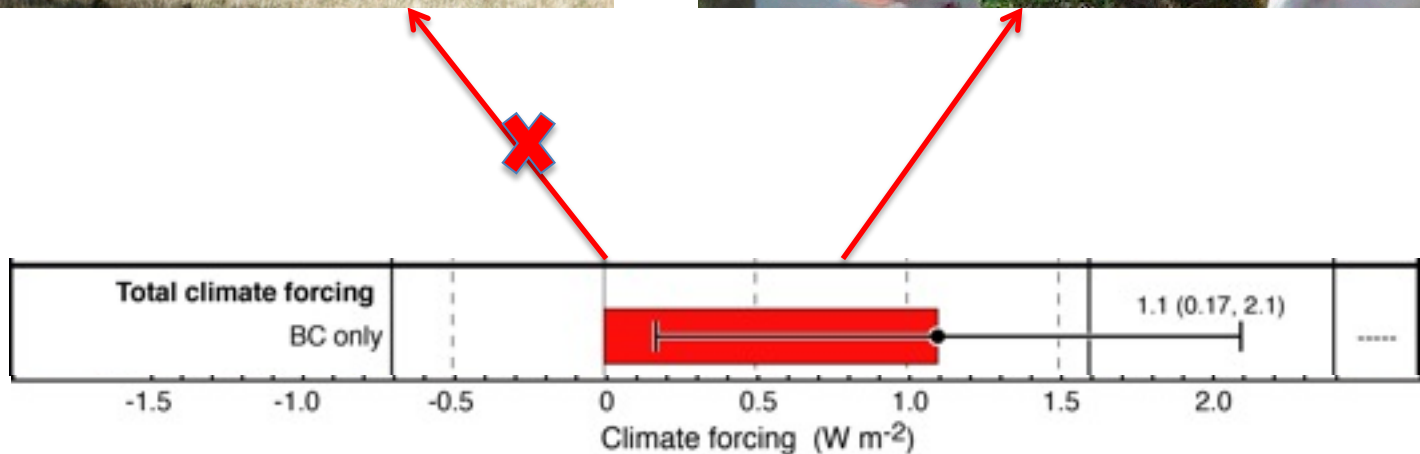


Just black carbon. **The headline**

Black carbon and everything else

Maximizing and grabbing the black carbon headline is not one big animal that you can tame...

...it's more like a flock of rabbits that you have to catch, but not all the rabbits look alike, or are even rabbits.



Each source (rabbit) has a different character

Different amounts of organic carbon and sulfur
Different location of emissions
Different ease of mitigation
And more!



Cooling

Warming

Particle heating spectrum

Coal
power
plants

Forest
burning

Cooking
with
Wood

Heating
with
Coal

Brick
kilns

Diesel
engines

This also depends on the fuel and user

We need to reduce particle emissions for health reasons.

The most climate-friendly reductions are sources with a lot of BC compared to other pollutants.

(Even if they are close to neutral on the particle heating spectrum, they are more friendly than other sources.)

Cooling

Warming

Particle heating spectrum

Coal
power
plants

Forest
burning

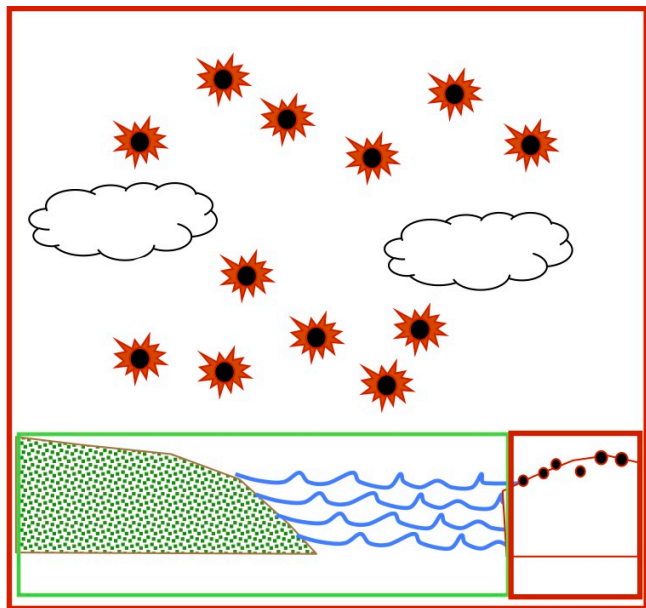
Cooking
with
Wood

Heating
with
Coal

Brick
kilns

Diesel
engines

Bounding-BC forcing estimate was high for two reasons



1. **Larger amount** of black carbon in the atmosphere than in some other studies.
(More rabbits)
2. **More forcing by each gram** of black carbon than in most other studies.
(Bigger rabbits)

- As expected, the science is evolving.
- Later studies now suggest there is *less* black carbon in the atmosphere than Bounding-BC estimated (fewer rabbits).
- This does not change the importance of each rabbit.



Take-away messages

- Black carbon on its own has a high positive forcing.

It is made up of contributions from many sources, and...

- For a number of reasons, but mostly due to co-emitted pollutants, some sources that emit black carbon warm the atmosphere, and others cool it.

Even for sources with net cooling...

- Improving human health needs particulate matter reductions;
the most climate-friendly reductions address sources with more BC.