Accounting metrics for climate impacts... black carbon, methane...

A deeper look

Stop looking so deep

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Two (nearly separate) systems: atmospheric reactor and energy balance

Emissions:
Our challenge

Atmosphere

absorption/scattering

removal

mass balance

energy balance

Characteristic times ($\tau$) in years:
0.02; 0.3; 4; 12; 400

8; 400
$\tau = 4 \text{ months}$  \hspace{1cm} $\tau = 9 \text{ years}$ \hspace{1cm} decay like CO$_2$

**Emission (arbitrary units)**

**Global avg forcing (W m$^{-2}$)**

**Temp response (K)**

*Bond et al. ACP 2011*
There are two kinds of forcers in the world...

This one goes on for (almost) ever

CO$_2$ is the sum of these

These have their primary impacts within 1-1.5 generations
Peak temp. is proportional to cumulative carbon because of the long-lived portion.

IPCC AR5 Fig SPM.10
Based on work since 2009 & since
See Allen et al, Nature 458, 1163;
Matthews et al, Nature 459, 829;
Zickfeld et al, PNAS 106, 16129
Average T change after emission of pulse CO$_2$ and BC

Picture changes a bit (but not much) for 10yr $\tau$

_Hade & Bond, really close to submission..._
Dual roles for LLCF & SLCF (not news)

constant T commitment; stabilization

current forcing; management

Hade & Bond, really close to submission...
What current emission metrics provide

- Global Warming Potential: How much forcing is done?
  - Good: Integrated measure; well-accepted
  - Bad: Doesn’t communicate what we care about

- Global Temperature Potential: Will we have an effect on temperature in year N?
  - Good: (More) relevant to what people care about
  - Bad: What about all the other years?
Important use of emission metrics: Answer the questions “Should we care? Should we worry”?

Do SLCF considerations alter mitigation choices? Are they worth thinking about?
Use same units (equivalence) for comparison only

1:1 line
“Should we worry?”

Effect of 1 year’s emissions

Short+Medium-(TW-yr)-

LongTerm-Forcing-(TW-yr)-

10#
8#
6#
4#
2#
0#

Simple lamp to solar LED

kerosene lamps

kiln
upgrades

Bull’s Trench to Zigzag

Traditional to VSBK

Basically AGWP

Next, add the units that communicate.

Mtonne CO$_2$
LLCF, tonne CO$_2$: mass – no timeframe – persistent
Mtonne CO$_2$

SLCF, W/m$^2$: forcing – instant = current-generation

Short+Medium-(TW-yr)-
Long6Term-Forcing-(TW-yr)-

kerosene lamps
Simple lamp to solar LED
kiln upgrades
Bull’s Trench to Zigzag
Traditional to VSBK
We have much bigger problems than determining “equivalence”

SLCF reductions won’t help climate unless they are constant into the future.

We may be able to quantify the benefit but we have no way to enforce persistence.

→ Do something simple for guidance, move on, start worrying about the hard stuff
Persistent uncertainty in the responses that people care about most will remain until it’s “too late”

Regional temp, precip, circulation change, extreme events…
20 years later, we have general ideas of the direction, little idea of the magnitude

“Too late”: Achieving persistent change requires investment in infrastructure & governance -- must start NOW for results in 2-3 decades
We have much bigger problems than determining “equivalence”

Only brief discussion of disbenefits. Examples:
- sulfate reductions
- organic carbon/cloud effects
- NOx on O₃ (good), methane (bad)

We are changing the atmosphere and its systems in ways that will take many years to characterize

→ Do something simple for guidance, move on, set a “good-enough” course
Use equivalence metrics for guidance and direction-setting ONLY.

We’ll need something completely new to make sure mitigation efforts stay on course.