Sulfate and soot panel

"Can reduced soot emissions counteract the warming effects of reducing sulfates?"

(Ellie's opinions and Tami's thoughts)

Implies two questions:

- Can we quantify the climatic impacts of reduced sulfate emissions?
- Can we quantify the climatic impacts of reducing carbonaceous aerosol emissions?

Progress since Workshop 1?

"Can we decrease BC aerosols enough to alleviate the global warming "bounce" that will accompany "clear sky" initiatives that are expected to reduce reflecting aerosols in places such as the United States and China?"

But the good news is that:

- **Estimates of climate effect have generally become more quantitative (thanks to new emission inventories, systematic evaluation of AERONET and field campaign data, GCM development)**

"Real knowledge is to know the extent of one's ignorance"
(Confucius)

1. Can we quantify the climate impact of reducing sulfate emissions?

a. Comment (obvious)

- Reducing sulfate is just as (or more!) fundamental to economic progress/development as the energy consumption that produces CO_2.
- Climate warming by reducing sulfates belongs in the list of environmental impacts that we accept as a cause of economic improvement.
- Climate considerations do not and should not play into question of reducing sulfate emissions.

  Watch ethics!

1. Can we quantify the climate impact of reducing sulfate emissions?

b. Direct forcing - Yes, with uncertainty

- Has been quantified in TAR
- Uncertainties in humidity response, size distribution
- Somewhat nonlinear (oxidant limited)– initial reductions require lower "offsets" (+ nitrates issue)?
- Question needing consensus–

Are we going to address regional specificity?

1. Can we quantify the climate impact of reducing sulfate emissions?

c. Elephant One

"Elephant in the room" (thanks to Tony Clarke)

- Indirect effect
  - Impact on clouds, almost certainly in this direction:

    aerosol reductions ◊ reduced cloud effect◊ warming
  - Implication: Sulfate bigger "knob" than represented by direct alone

1. Can we quantify the climate impact of reducing sulfate emissions?

c. Elephant Two

Discussion on this has been limited

- Regional climate change
  - Possibly in this direction:

    aerosol reductions ◊ reduced regional changes ◊ less "interference"
  - warming/cooling are improper metrics, but reducing aerosols is correct direction!

1. Can we quantify the climate impact of reducing sulfate emissions?

c. Ellie's extra elephant

- Radiative forcing or climate response
  - Is forcing enough as a comparative measure when we really want temperature or precipitation or …?
  - Probably not a huge deal for sulphates as the forcing response relationship appears well constrained. (but watch this space for BC)

2. Can we quantify the climate impact of reducing carbonaceous aerosol emissions?

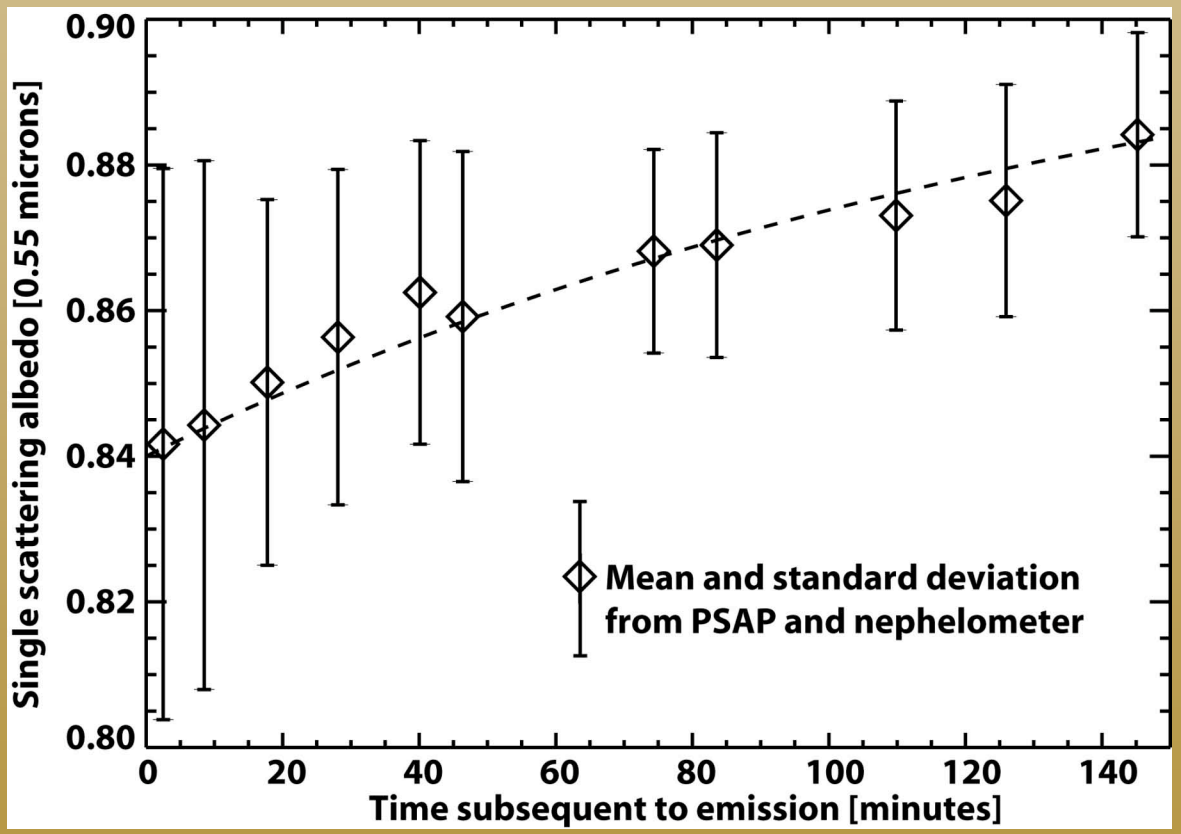
a. Direct effect? Yes, with uncertainty (Tami)

Possibly (Ellie)

Uncertainty	Constraint
v Emission factors	*Measurements/ concentration*
v Lifetimes	*Burden (even if measurements uncertain)*
v Optical properties	*Absorption/scattering per mass; closure experiments*
v BC/OC ratios	*Ratios at emission & in atmosphere*
v "Secondary" organic aerosol (gas ↔ particle conversion)	*Atmospheric ratios*

Reason for caution 1:

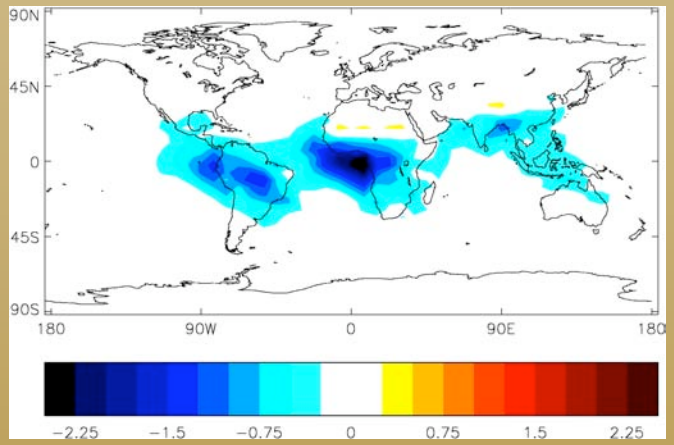
Emissions to atmosphere changes of BC/OC



- BC aerosol from biomass burning changes optical properties substantially within a few hours.
- Is this true for other burning emissions
- Does this affect emission factors (c.f. discussion yesterday afternoon)?

Abel, Haywood and Highwood, GRL, 2003

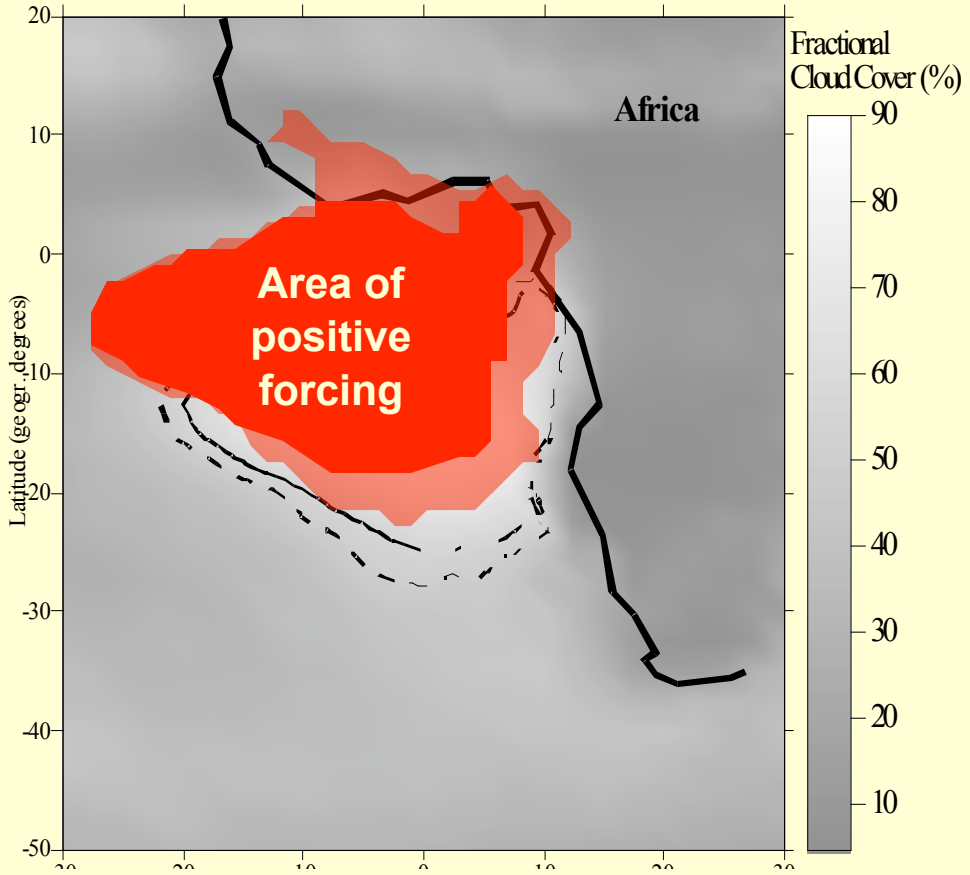
Reason for caution 2: Unless we get the vertical profile and clouds right, the sign of direct forcing in some regions can be wrong – it remains to be seen whether this affects the sign of the global forcing.



Penner et al, as in IPCC 2001

Strong negative forcing, and negative global mean

Keil and Haywood (2002) for biomass, but other BC from Asia gets lofted high too.

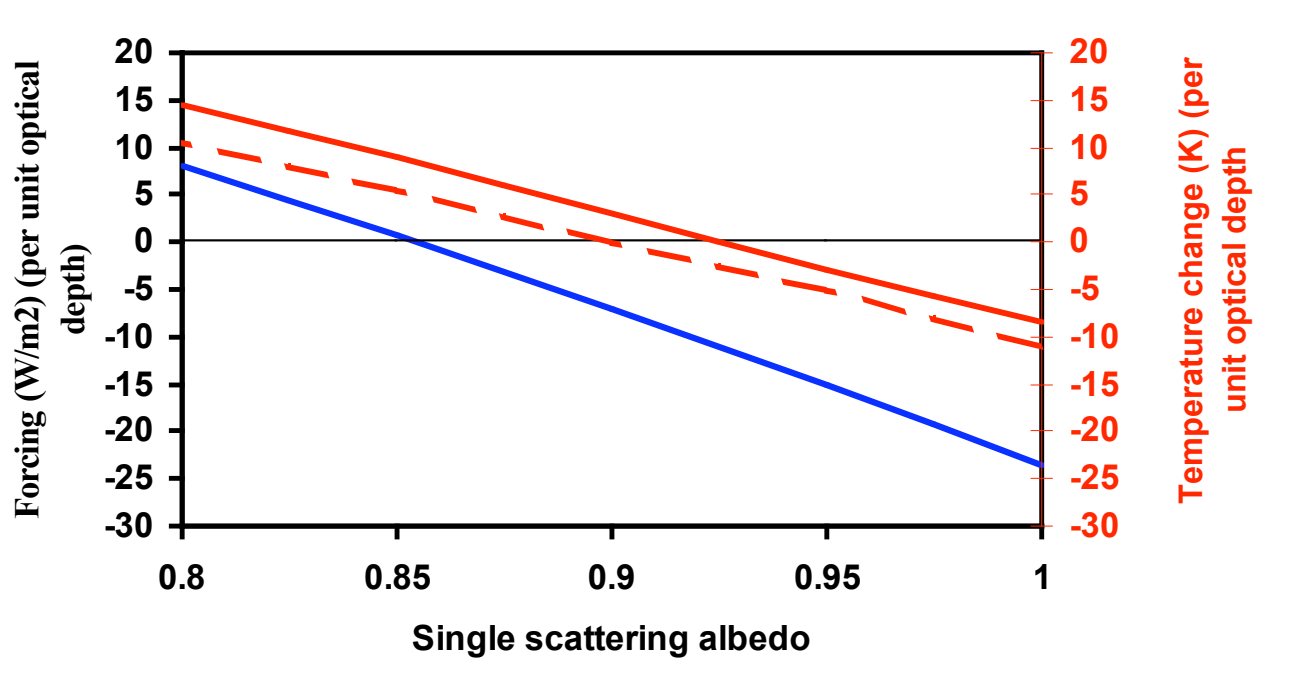


2. Can we quantify the climate impact of reducing carbonaceous aerosol emissions?

b. Same elephants!

- Indirect effect
  - We don't really know, but *probably* negative (i.e. reduction leads to warming).
  - Implication: Even if direct forcing is net positive, total forcing may be net negative (??).
- Regional climate
  - *Still* no good metrics– can only say that reducing aerosol concentrations reduces "interference"
- Forcing response
  - Weird non-linear interactions involving clouds (semi-direct effect) start happening with absorbing aerosols. Forcing is not always a good indicator of even the sign of the temperature change

Reason for caution 3:



Cook and Highwood (2004) Semi-direct effect (originally Hansen et al, 1997)?

Absorbing aerosol can warm climate, even if radiative forcing is negative.

Efficacy is a key concept? More or less than CO_2 or SO_4?. Model and distribution dependent?

Safe (?) “Messages”

Reducing BC emissions would improve air quality, and therefore have a positive influence on human health, whether or not it could balance out the “sulfate” bounce. (And is this the more appropriate question c.f. Ben’s presentation)

It seems likely that any reduction in BC (such as diesel PM10 filters or changes in cooking methods) would result in a reduced global warming impact (unless the indirect effect of BC is large and negative, or unless associated and unavoidable decreases in OC give a larger warming)

The cautious persons (or modeller's?) action list (for Hawaii 2008)

- Quantify the impact of new emissions inventories on climate simulations, and find a way to cost the impact on climate
- Quantify the BC/OC/SO_4 relationship for different sectors and technologies
- Find a more reliable way of measuring BC / EC in the atmosphere so that we can develop and validate satellite retrievals and models
- Include (even if only crudely) carbonaceous aerosols – cloud interactions
- Determine if "efficacy" (Hansen et al, 2005) is model dependent (and establish whether we need to work through to climate response to compare mitigation stategies)
- Consider how much we need to know about speciation and whether we can actually use what is out there.
- Identify if there are ways in which routine monitoring for Air Quality could be adapted to provide climate useful information, and vice versa

Over to Tami for some quantification and links to sector changes…