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An IPCC Perspective on Absorption

Steve Ghan

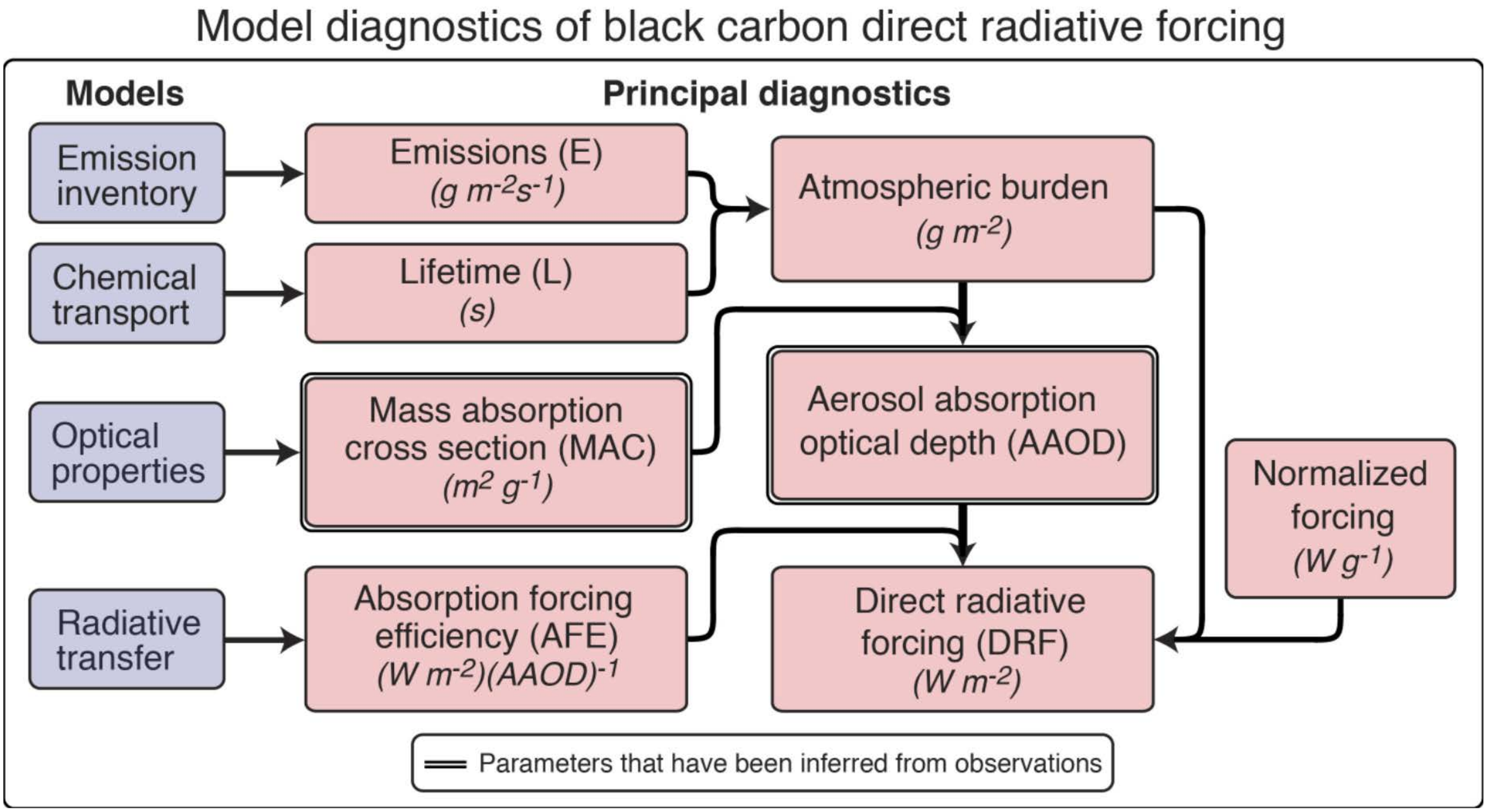
Direct Radiative Forcing by Black Carbon

$$F = \underbrace{\overbrace{E \times L}^{B} \times MAC}_{\tau_{aBC}} \times AFE$$

where
F = global mean anthropogenic BC direct radiative forcing
E = global mean anthropogenic BC emissions
L = global mean lifetime = global mean anthropogenic BC burden B / E
MAC = global mean BC mass absorption cross section
= global mean anthropogenic BC absorption optical depth τ_{aBC} / B
AFE = anthropogenic BC absorption forcing efficiency = F / τ_{aBC} (from models)

So $$F = \tau_{a_{BC}} \times AFE$$

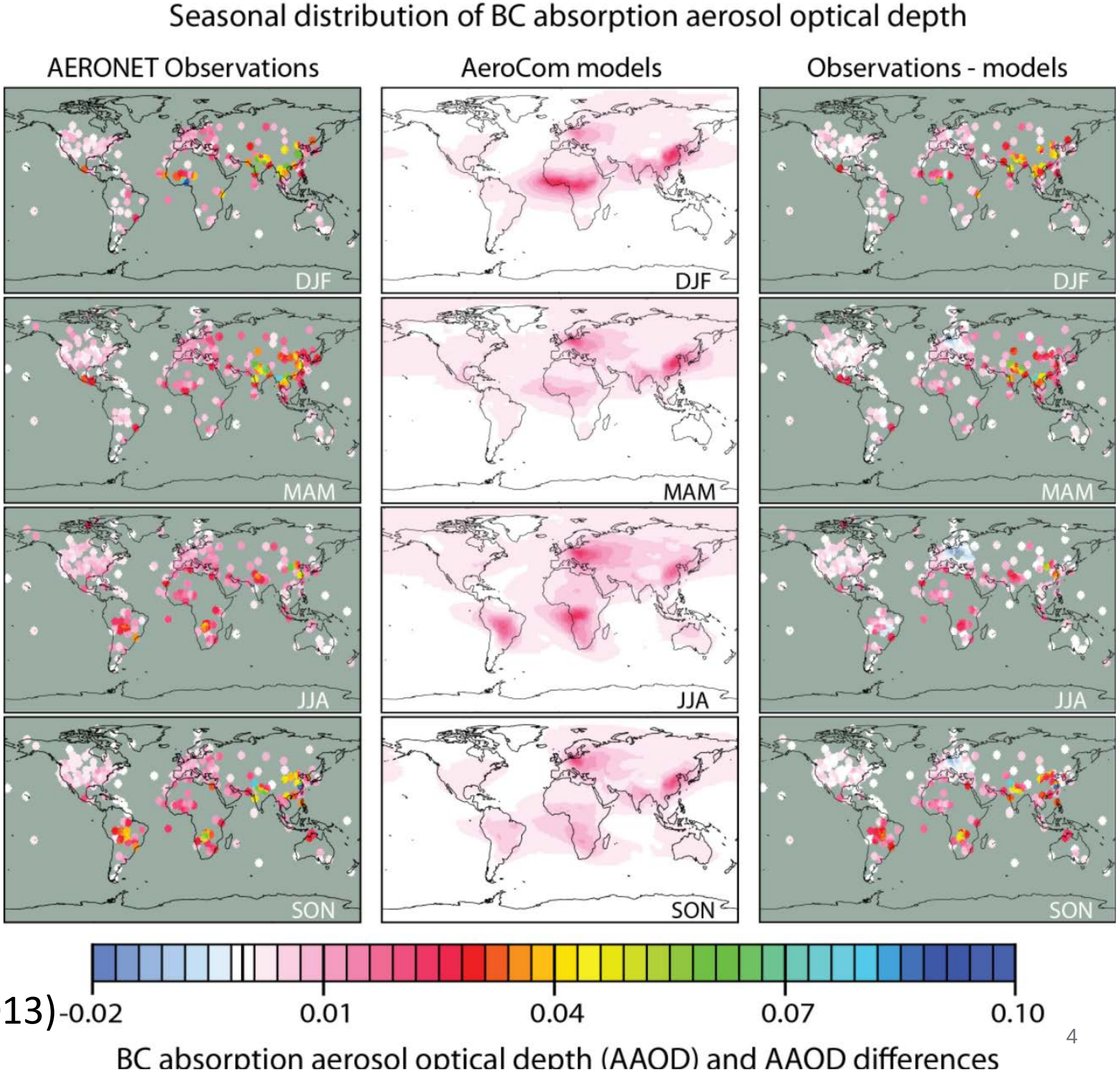
Estimating DRF



Bond et al. (2013)

Why use observed rather than simulated τ_{aBC}?

- AeroCom models underestimate τ_{aBC} in all seasons, particularly in Asia



Bond et al. (2013)

But how is τ_{aBC} determined from AERONET retrievals?

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- Method A (Bond et al., JGR 2013)
  - Use AERONET retrieved size distribution and τ_a
  - Assume all absorption by particles with diameter d>1 micron is by dust, all absorption by particles with d< 1 micron is by BC
  - Estimate τ_{aD} from retrieved size distribution (d>1 micron) and prescribed dust refractive index
  - $\tau_{aBC} = \tau_a - \tau_{aD}$
- Method B: as in Method A, but
  - Estimate τ_{aBC} from retrieved size distribution (d<1 micron) and retrieved refractive index

Size Resolved Chemical Composition

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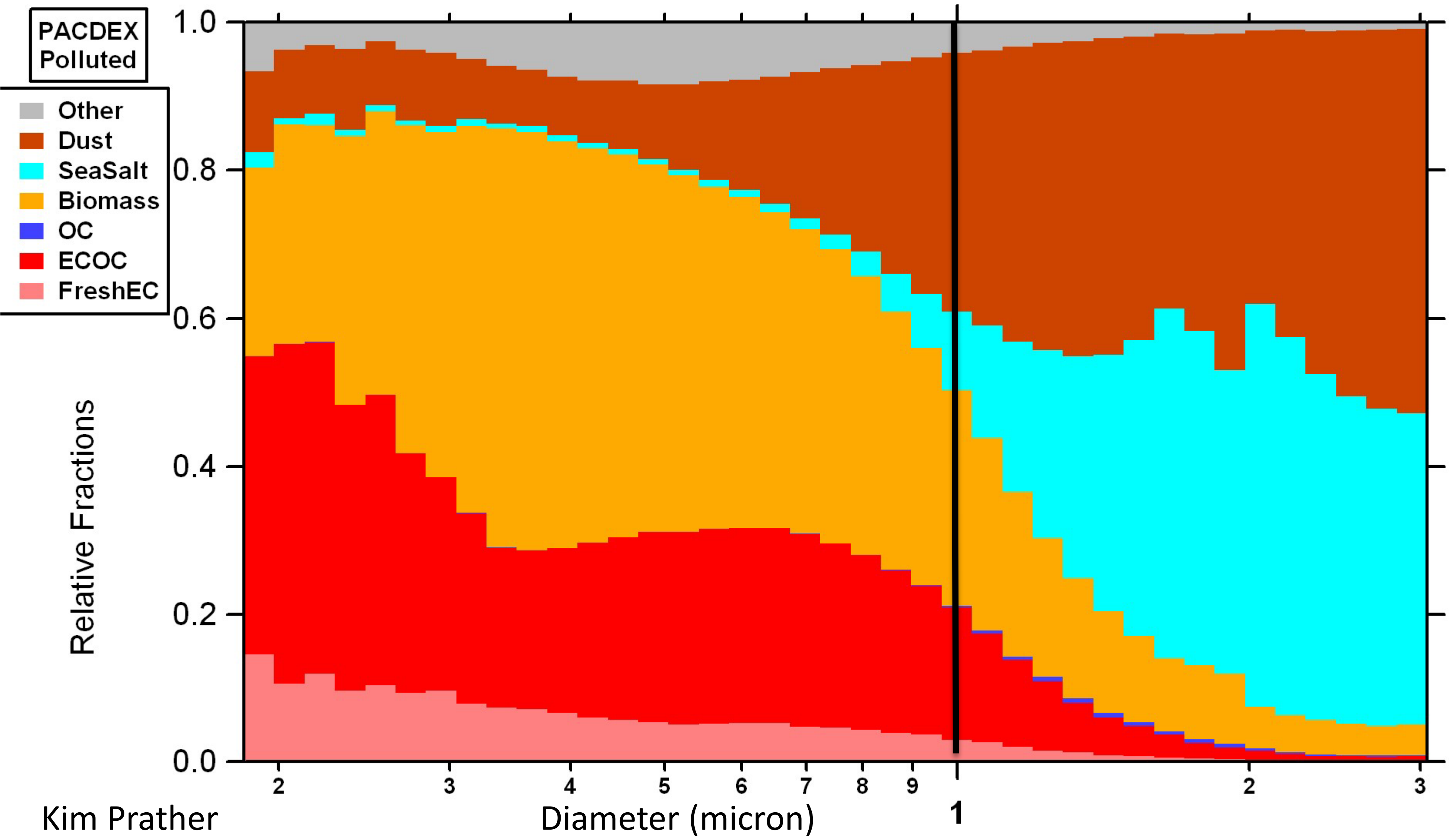
Gosan, South Korea, polluted conditions



Kim Prather

But how is τ_{aBC} determined from AERONET retrievals?

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- Method C (Chung et al., PNAS 2012)
  - Use spectral information about τ_a from AERONET
  - Assume Angstrom dependence on wavelength λ

$$\tau_a(\lambda_{550})\left(\lambda/\lambda_{550}\right)^{\beta} = \tau_{a_{CA}}(\lambda_{550})\left(\lambda/\lambda_{550}\right)^{\beta_{CA}} + \tau_{a_D}(\lambda_{550})\left(\lambda/\lambda_{550}\right)^{\beta_D}$$

Apply at $\lambda=\lambda_{550}$ and $\lambda=\lambda_{675}$ using retrieved τ_a and prescribed $\beta_{CA}=1$ and $\beta_D=2.4$ to solve for τ_{aCA} and τ_{aD} at $\lambda=\lambda_{550}$

Use same method to partition τ_{aCA} into τ_{aBC} and τ_{aOC}

All τ_{aBC} retrievals exceed simulations, but some much more than others

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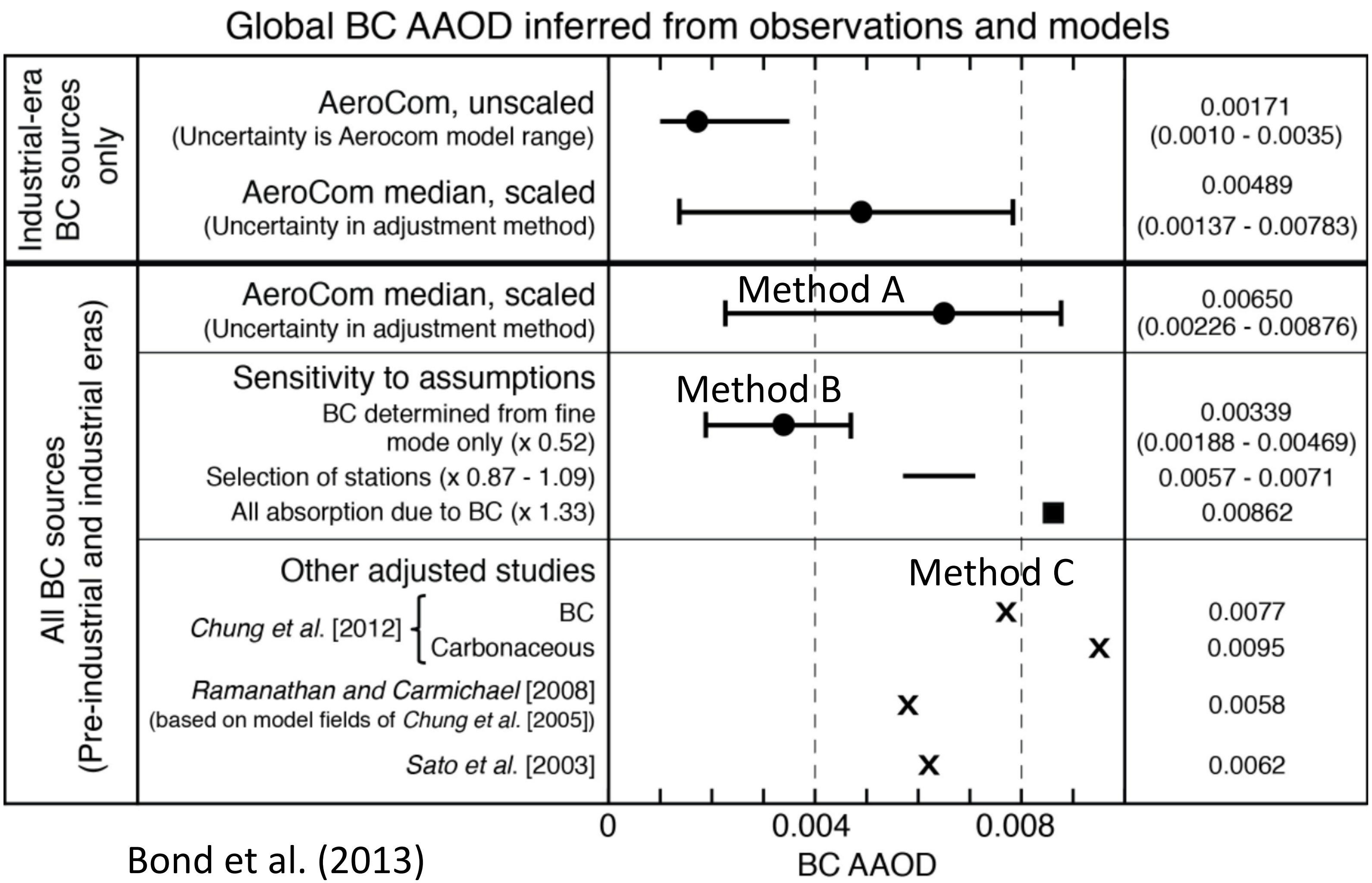

Bond et al. (2013)

How ASR Can Help Resolve Retrieval Differences

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- Focus on conditions with mixtures of dust and carbonaceous aerosol
- Column τ_a retrieval at multiple wavelengths
- Surface and aircraft measurements of
  - aerosol absorption at multiple wavelengths
  - size-resolved aerosol number and composition
- Constrain partitioning of retrieved τ_a into contributions from BC, OC, dust
- Constrain partitioning of local aerosol absorption into contributions from BC, OC, dust
- Test different partitioning methods