

US EPA ARCHIVE DOCUMENT

CSU

Global modeling and climate effects

Jack Kodros, Jeff Pierce, and the CSU team



Goal

While the data suggest that improving biofuel combustion devices will benefit health, what is the effect on climate?

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Uncertainties in aerosol emissions/properties →
Uncertainties in aerosol climate forcings

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Current project:

Uncertainties in aerosol emissions/properties →
Uncertainties in aerosol climate forcings

e.g. where do we need help?!

Biofuel vs. cookstoves

- We focus here on biofuel (mostly) due to current emissions inventories
- Biofuel for as other energy sources (e.g. heating/lighting) is included here
- Coal as cookstove fuel is not included as biofuel
 - We perform one sensitivity simulation to test this over Asia

Biofuel Climate Effects

- GHGs: CO₂, CH₄, VOCs
- Aerosol direct effect (scatter/absorb sunlight) (?)
- Aerosol indirect and semi-direct effect (affect cloud albedo/lifetime/amount) (??)
- Black carbon on snow (?)
- Aerosol driven circulation changes (???)

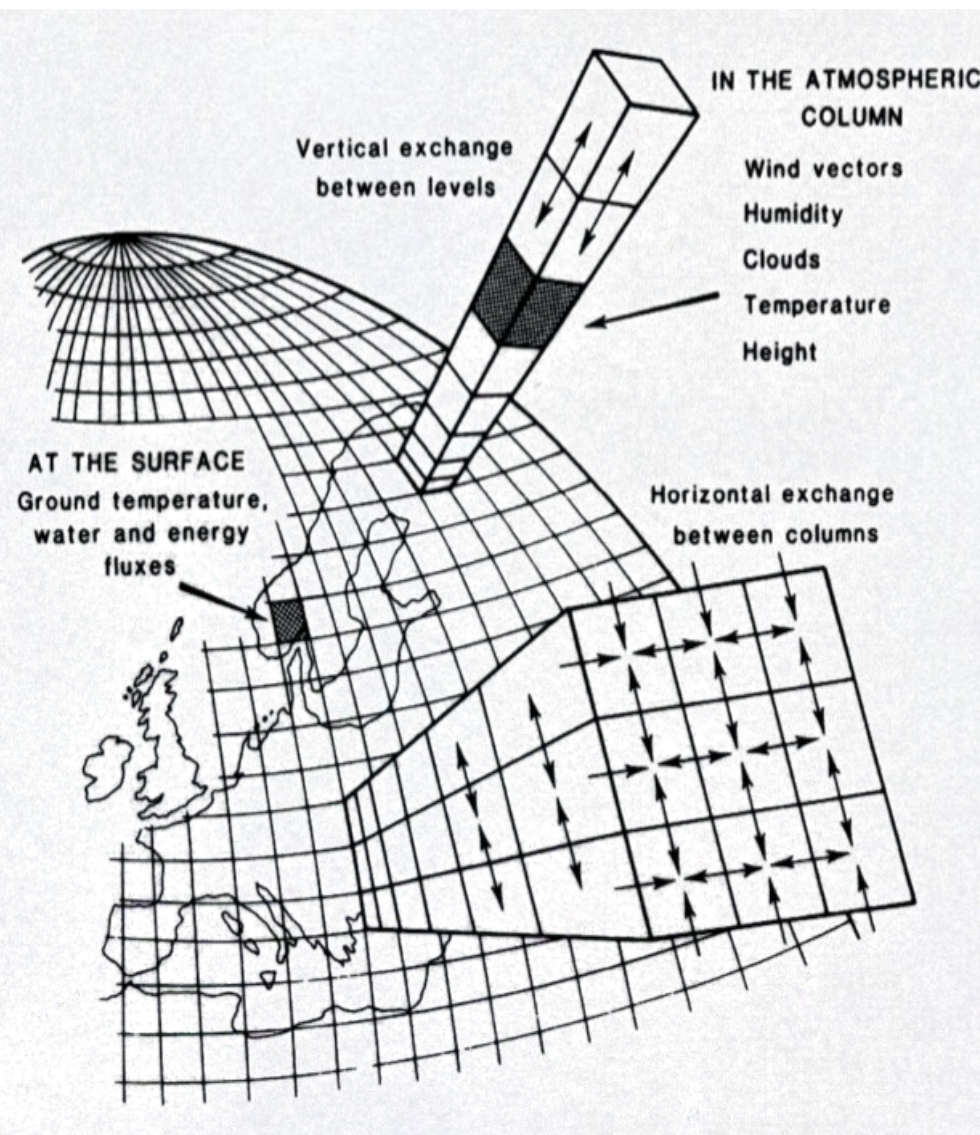
??? - level of uncertainty in magnitude

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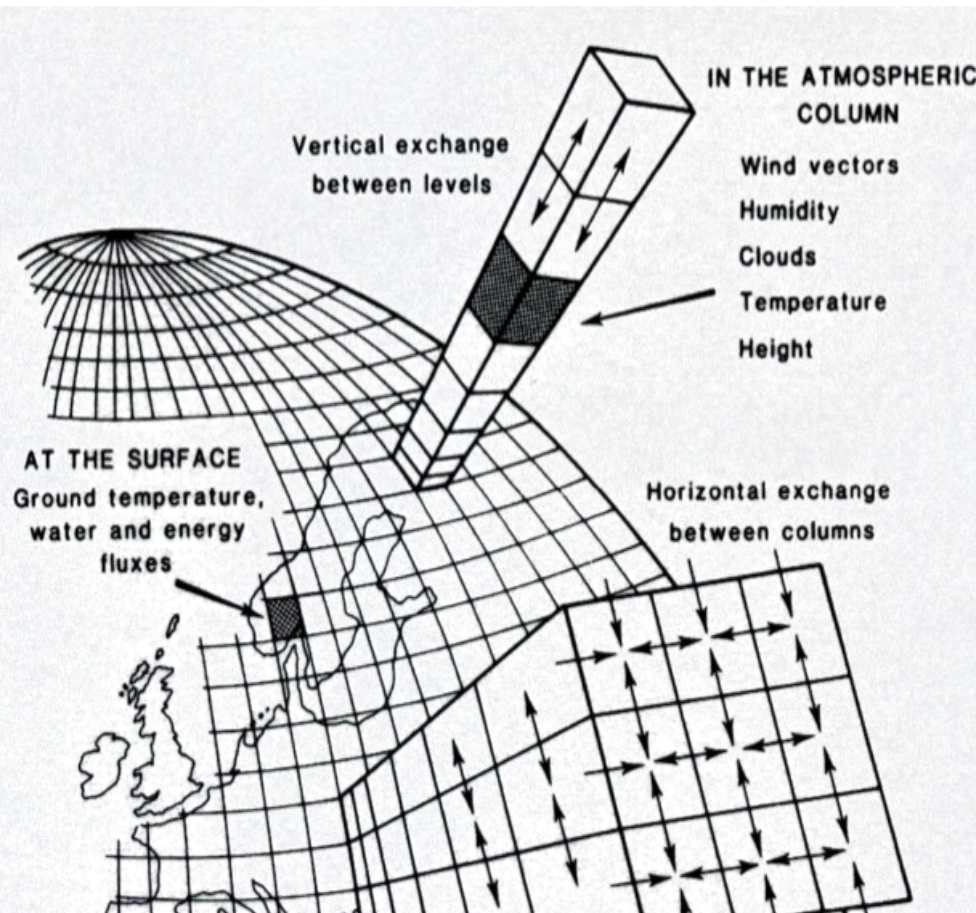
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GEOS-Chem-TOMAS



- GEOS-Chem version 9.02
 - 4 x 5° horizontal resolution
 - 47 vertical layers
 - GEOS-5 met fields
- TOMAS
 - Aerosol microphysics
 - 15 size sections: 3nm – 10 μm
 - Species: sulfate, sea-salt, OA, BC, dust

GEOS-Chem-TOMAS



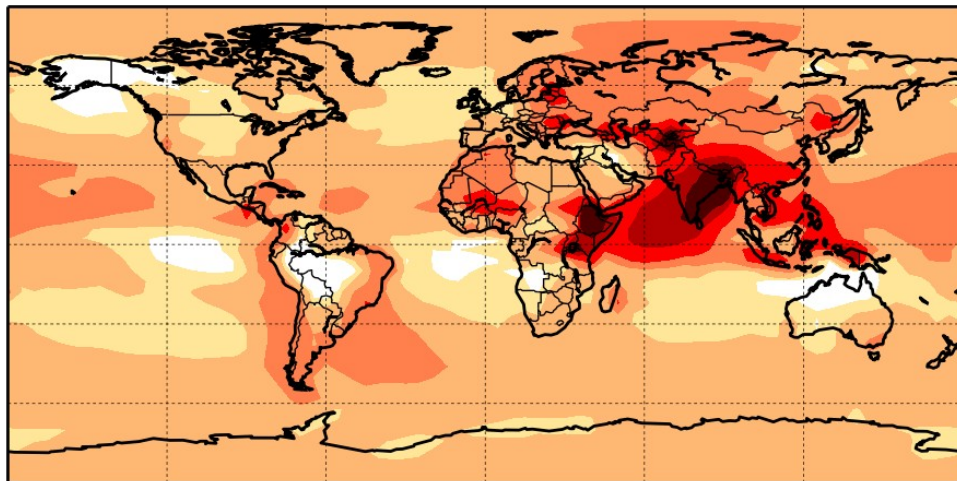
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BASE EMISSIONS DETAILS

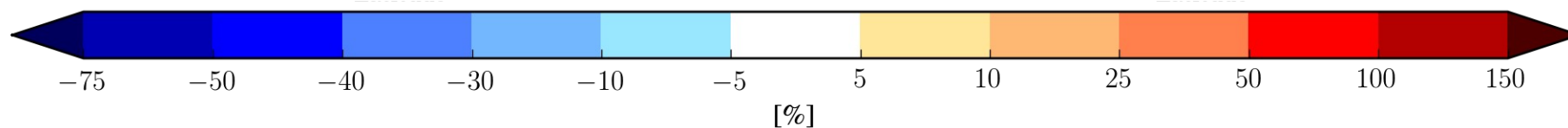
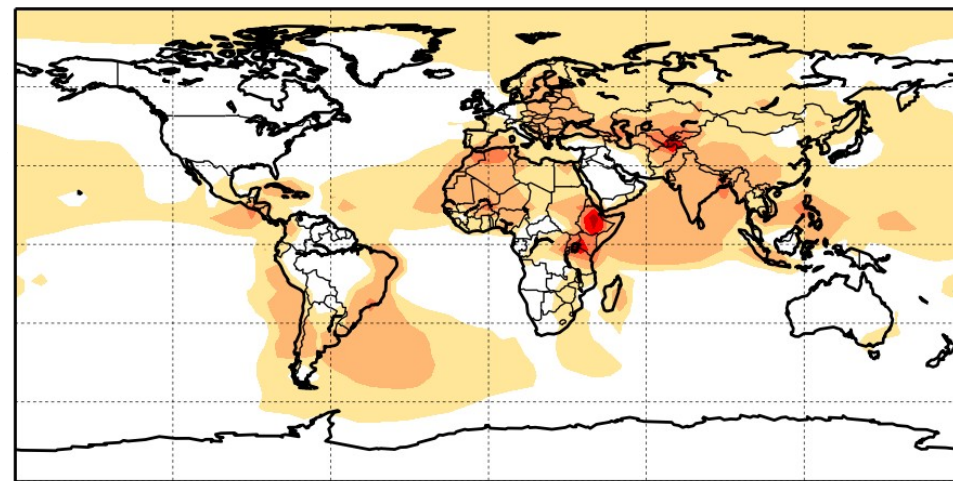
- BC and OA emission mass from Bond et al. (2007) (biofuel only)
- Lognormal size distribution with median $D_p=100$ nm and $\sigma=2.0$

BC and OA Mass increases due to biofuel

BC Boundary Layer % Change
Global Mean: 30%



OA Boundary Layer % Change
Global Mean: 8%

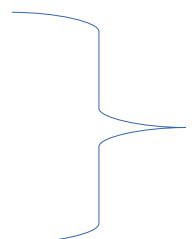


Key uncertainties to test

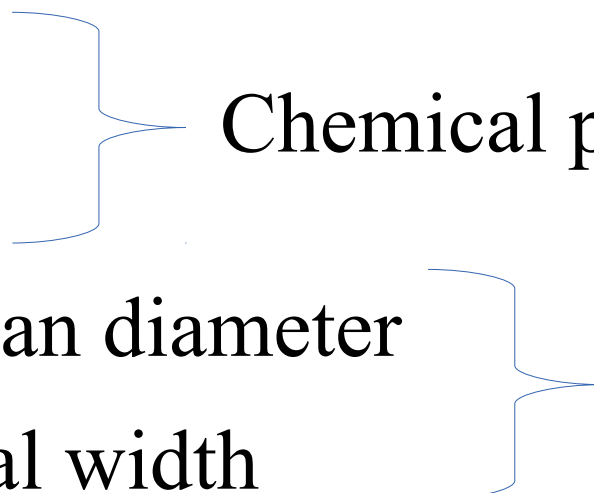
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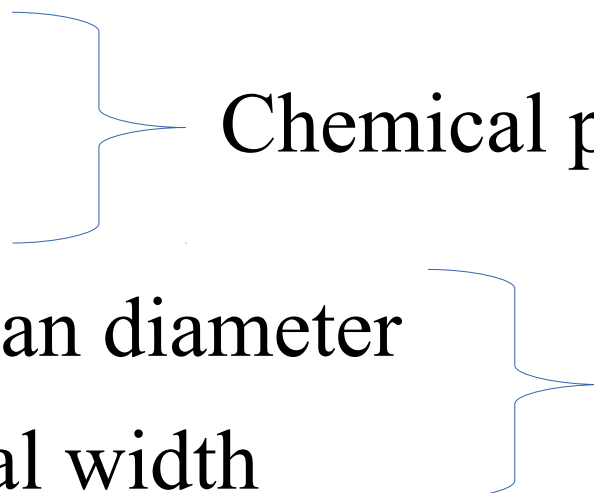
Key uncertainties to test

- Total mass emissions
 - BC:OA ratio
 - Hygroscopicity
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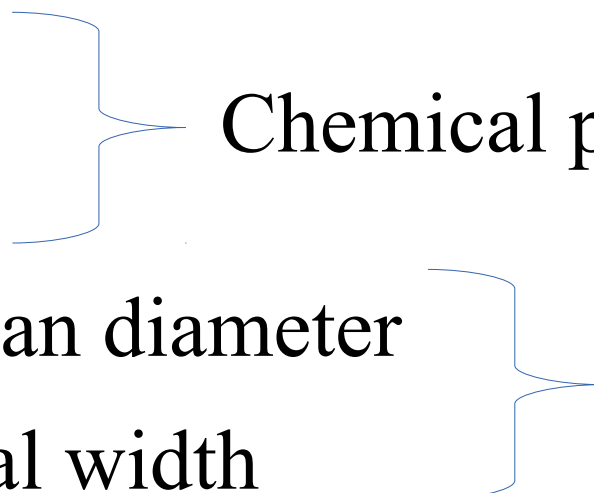
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 - Emissions modal width
- Chemical properties
- “Aged” particle size
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- Total mass emissions
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 - Residential coal (not included in base inventory)
- Chemical properties
- “Aged” particle size
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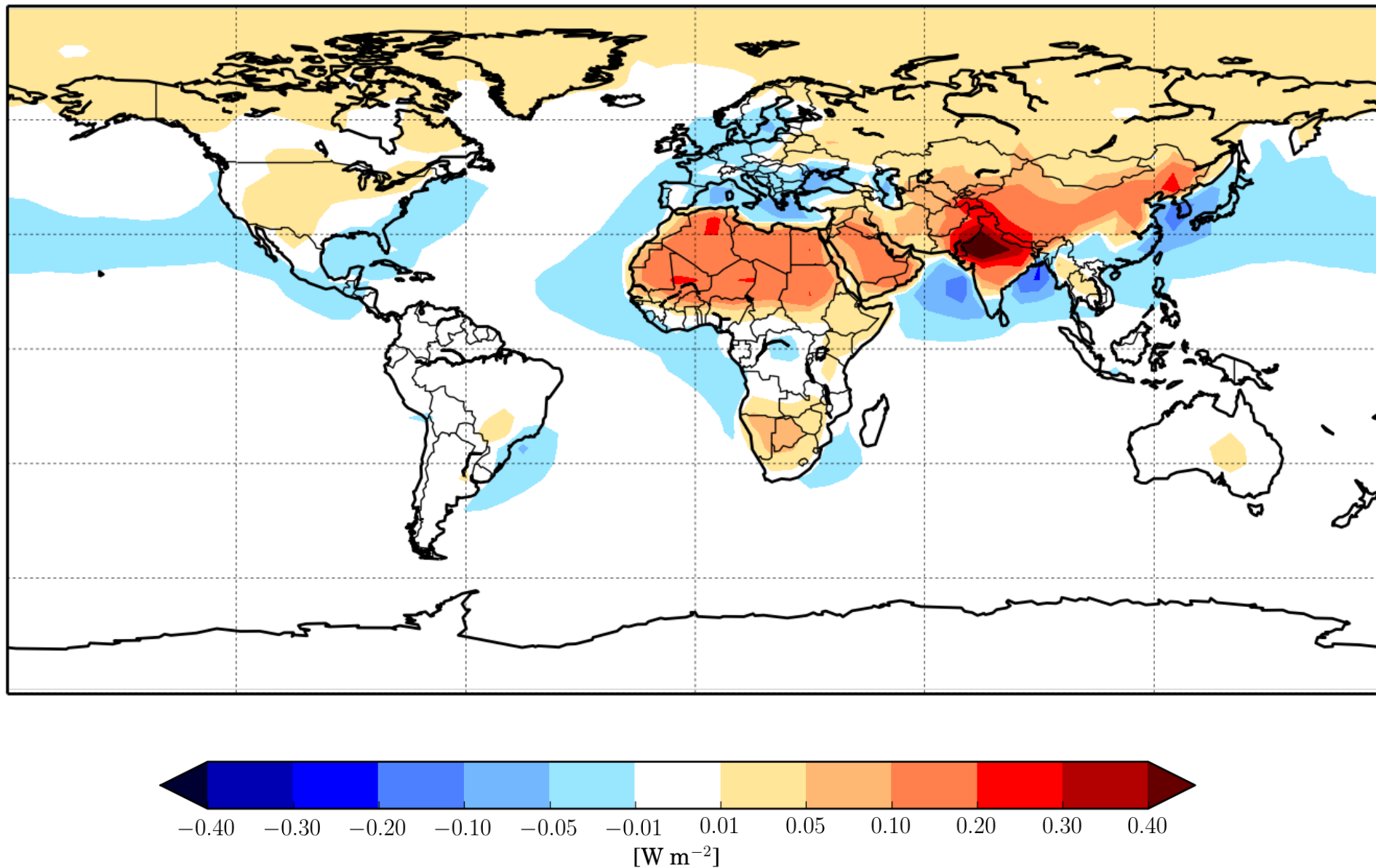
Key uncertainties to test

- Total mass emissions
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 - Hygroscopicity
 - Emissions median diameter
 - Emissions modal width
 - Optics
 - Residential coal (not included in base inventory)
 - Background SOA
 - Nucleation
- Chemical properties
- “Aged” particle size
- Non-biofuel model parameters

Direct Radiative Effect Uncertainties due to optics only

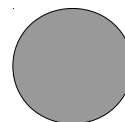
DRE – Core-Shell

Global Mean: $+0.007 \text{ W m}^{-2}$

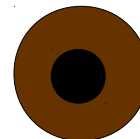


Assumptions for optics calculations

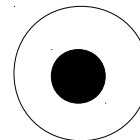
Internal



Core-Shell (absorptive OA)



Core-Shell

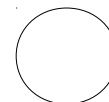


Ext*1.5 (absorptive OA)



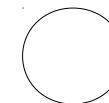
*1.5

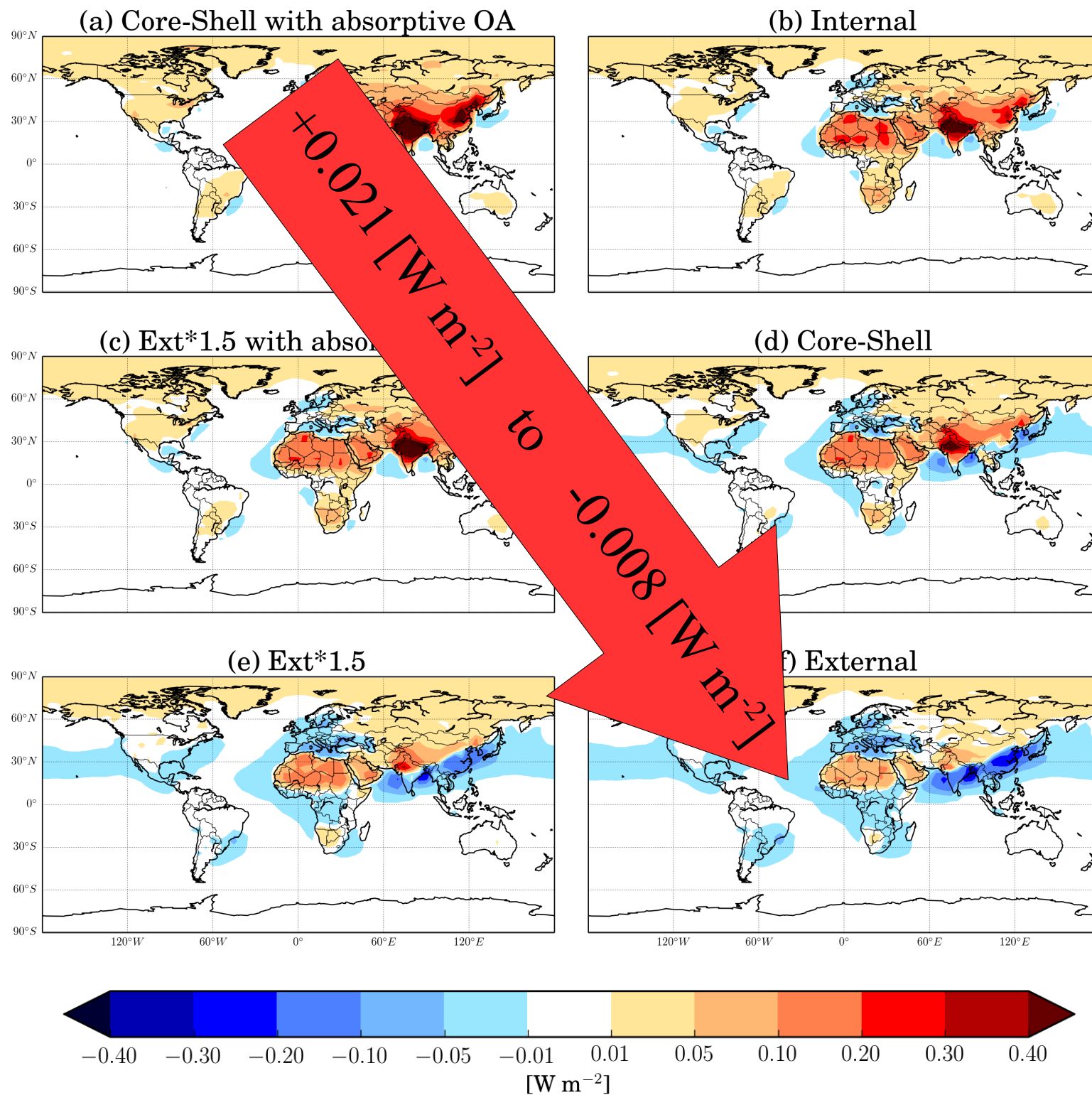
Ext*1.5



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External

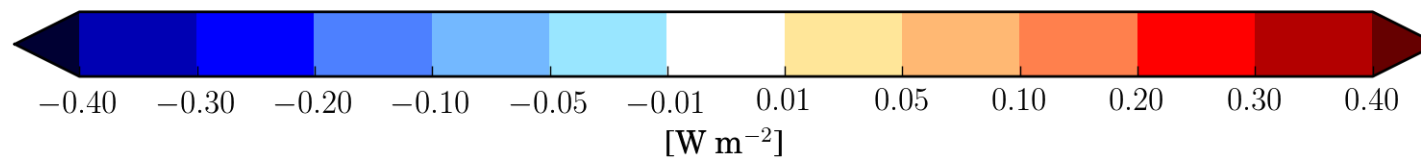
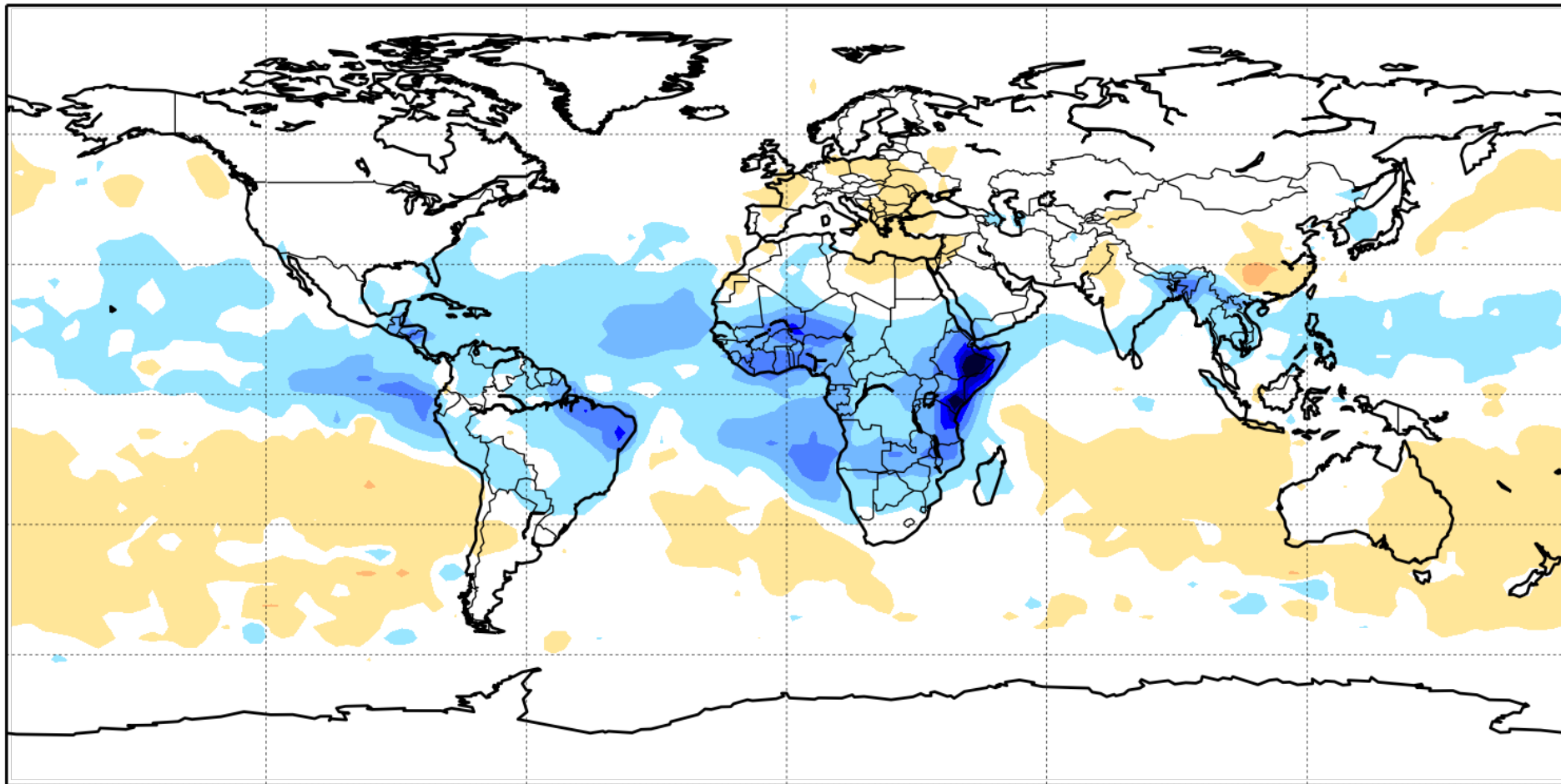




Cloud Albedo Indirect Effect

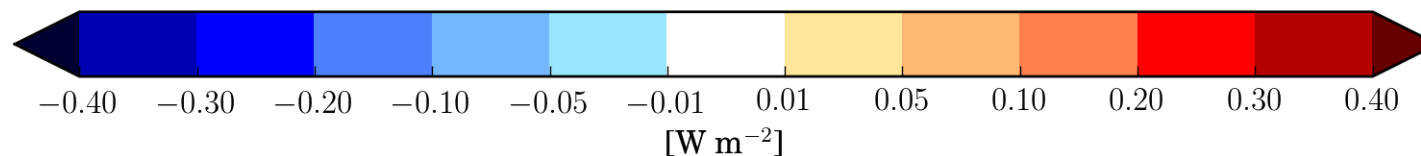
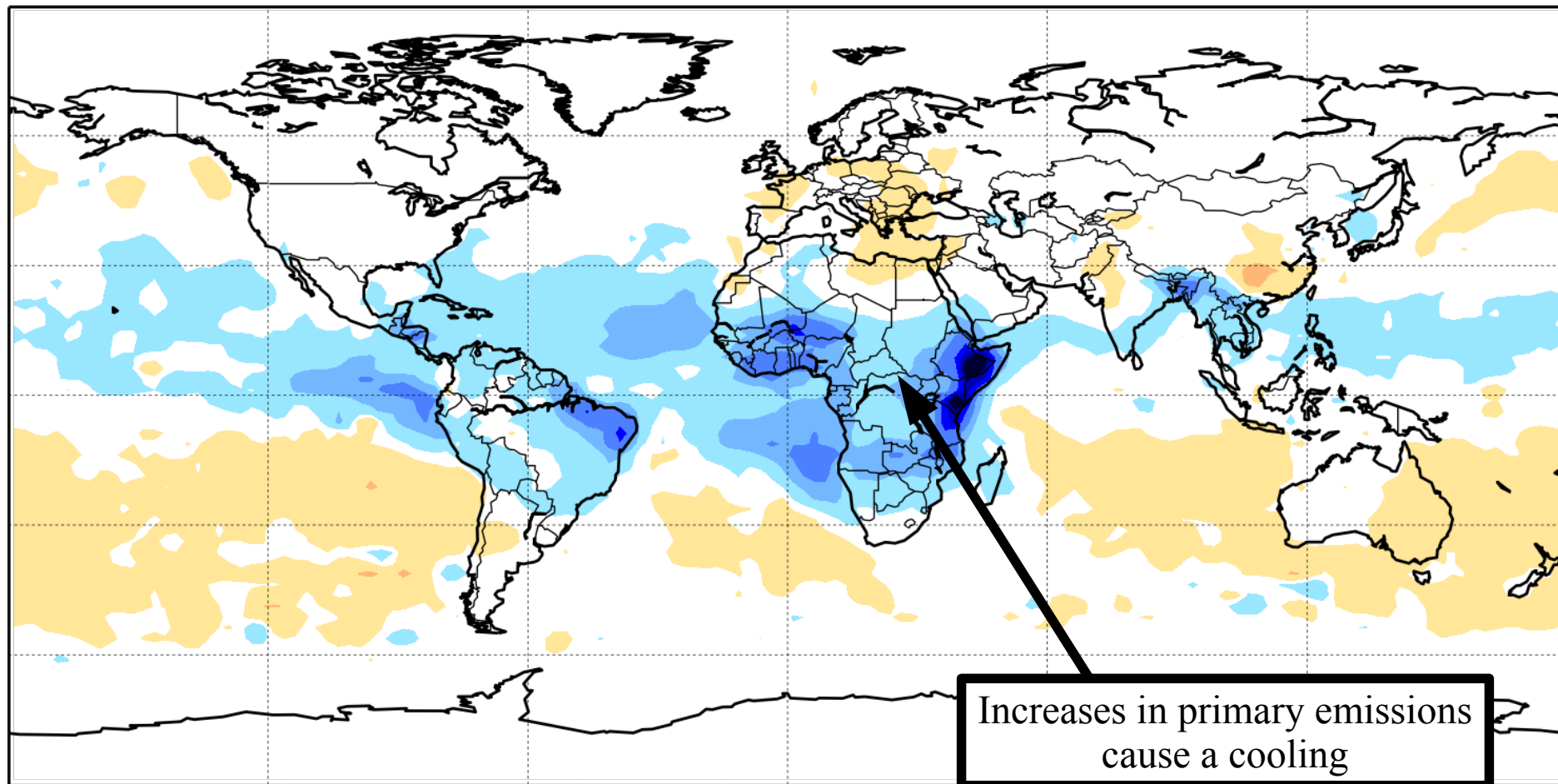
Cloud Albedo Indirect Effect

Global Mean: -0.006 W m^{-2}



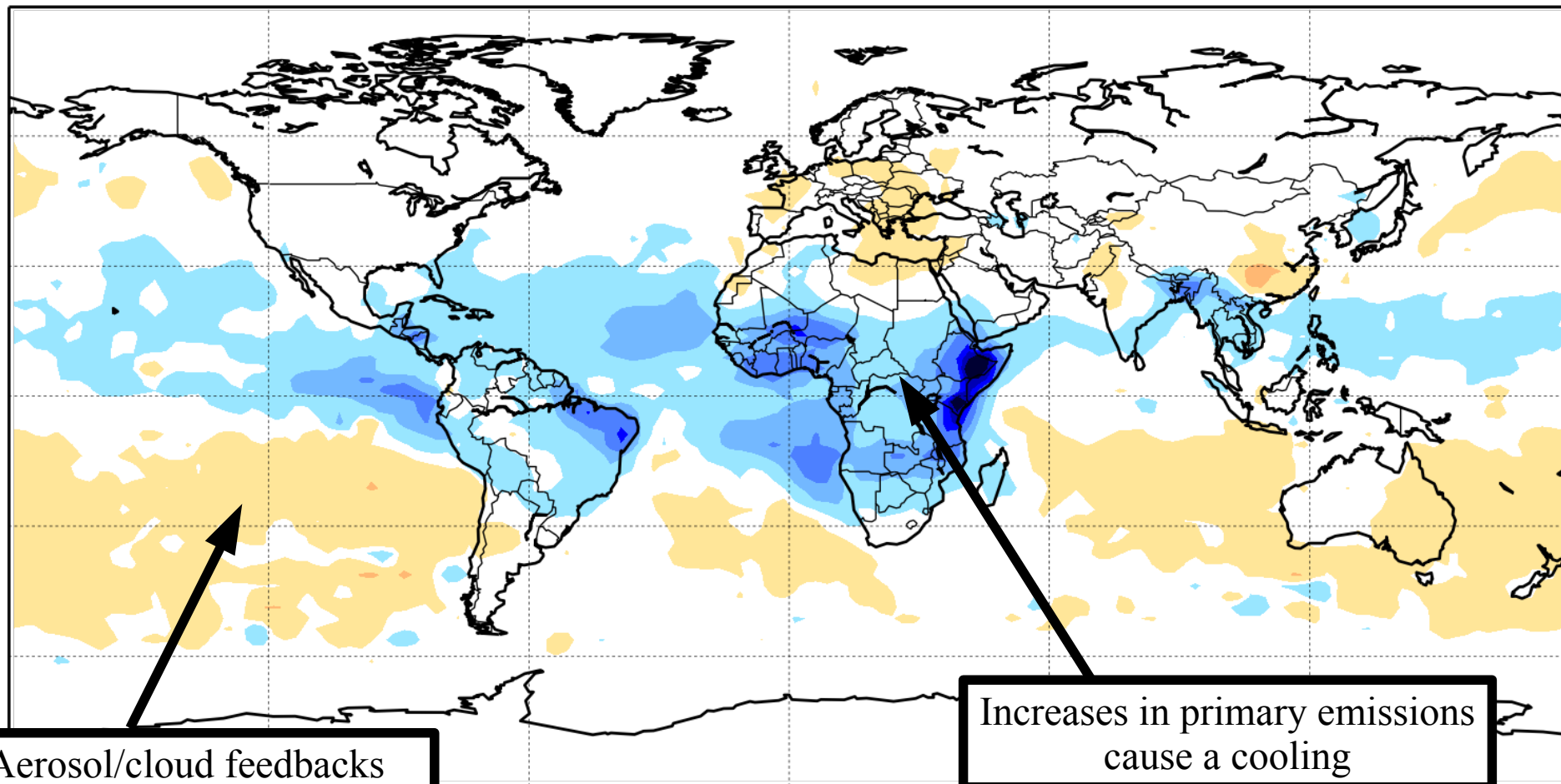
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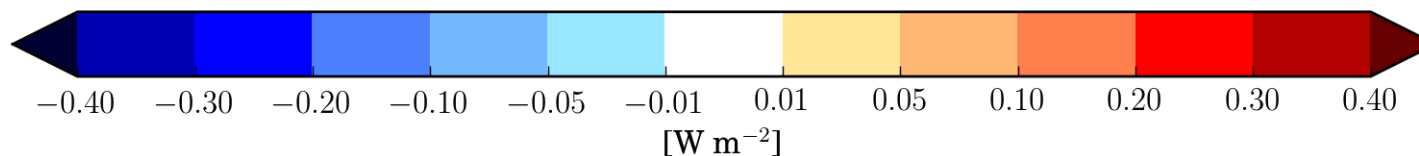
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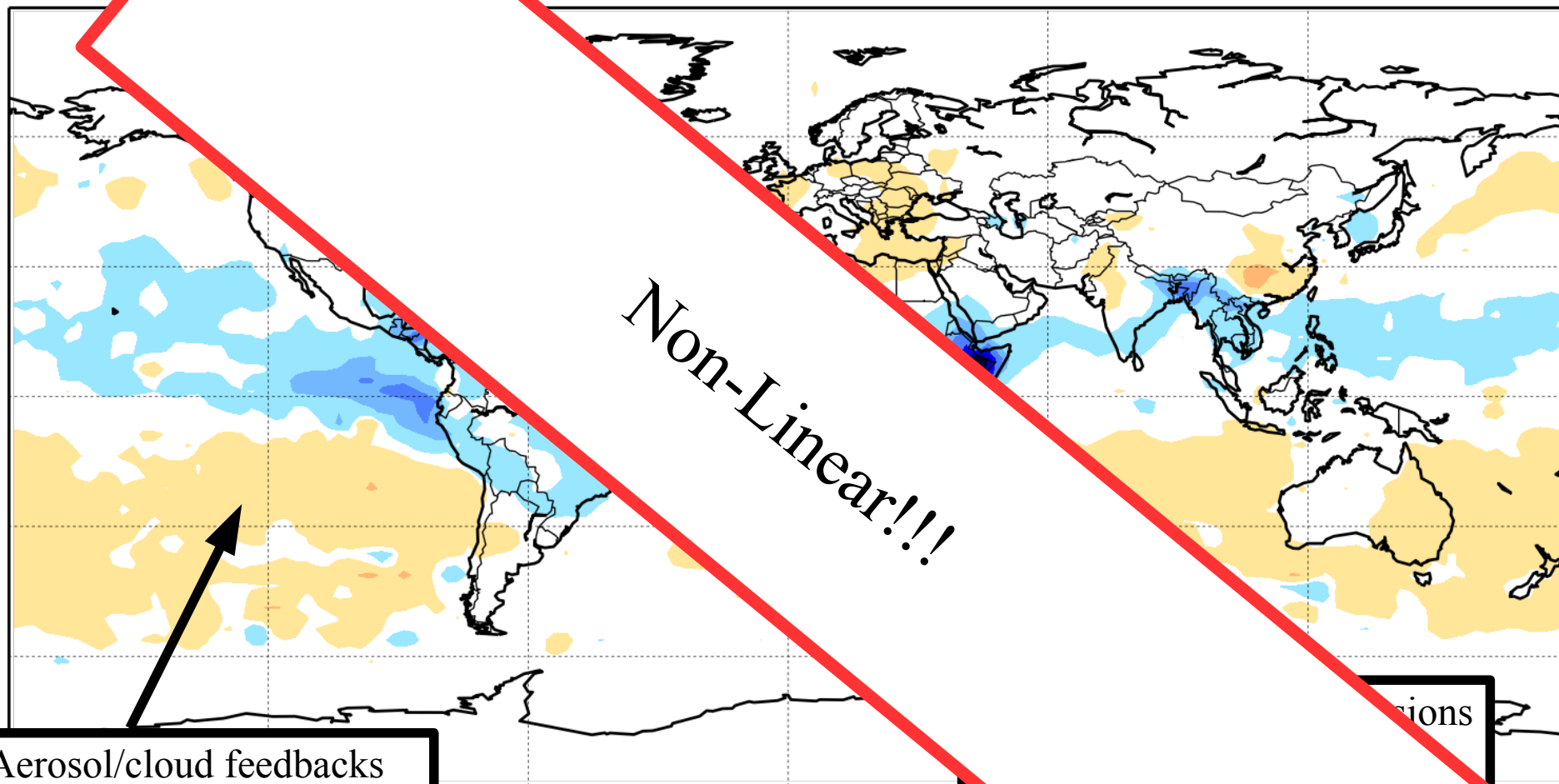
Aerosol/cloud feedbacks
cause a warming

Increases in primary emissions
cause a cooling

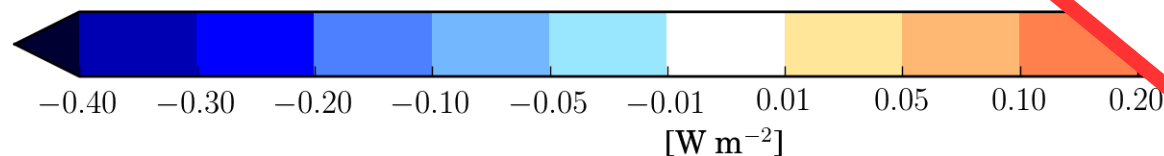


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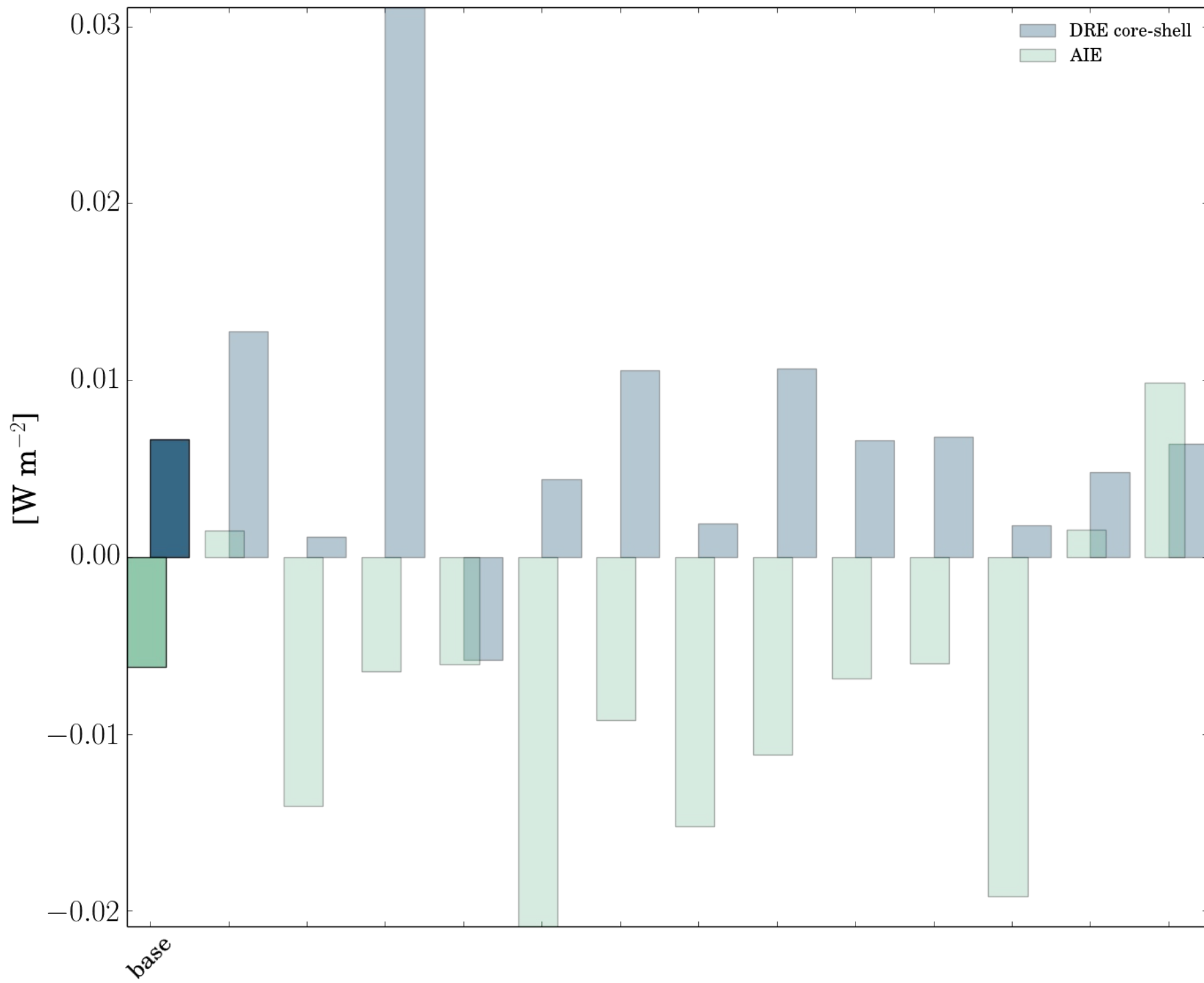


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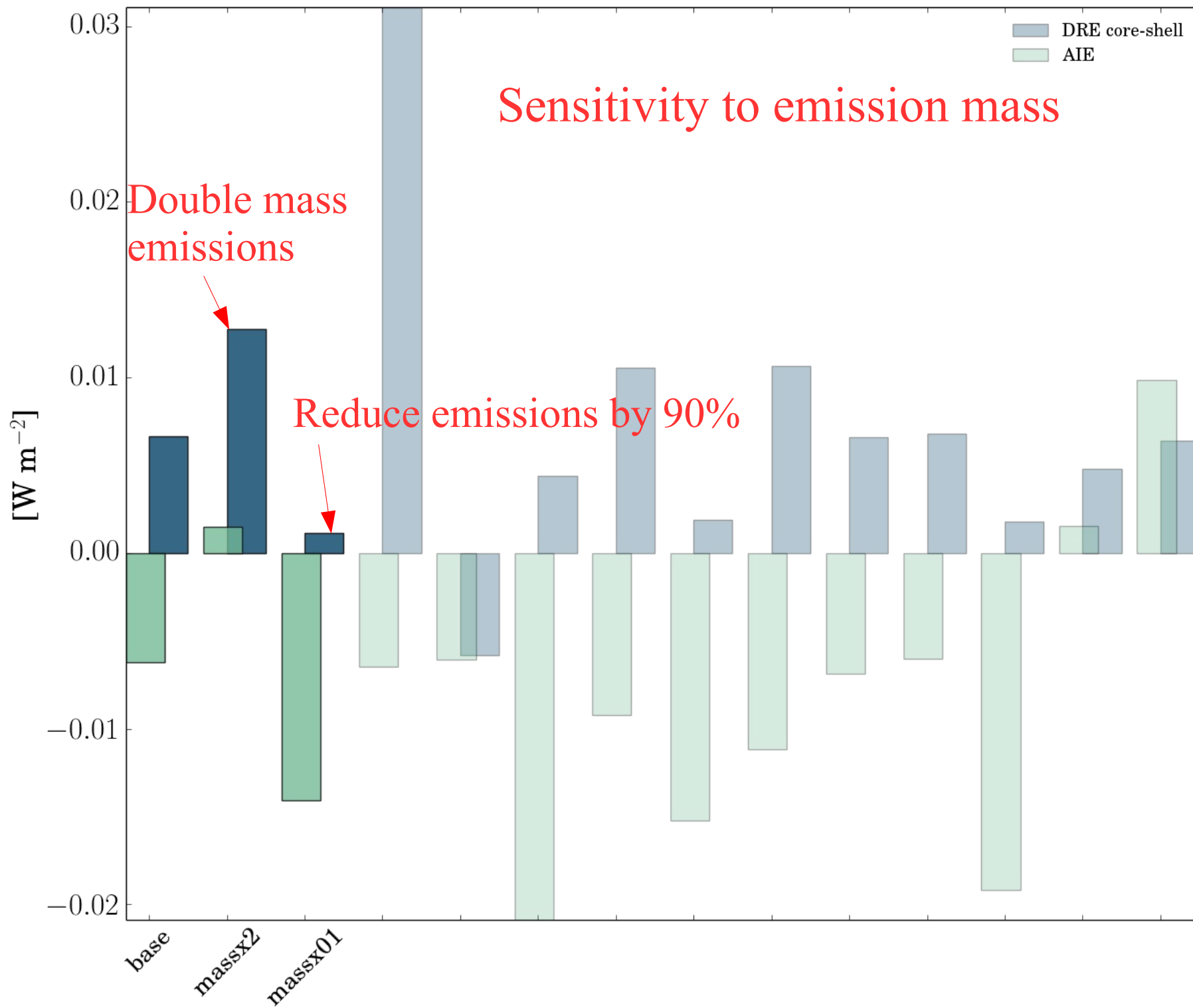


Sensitivity Simulations

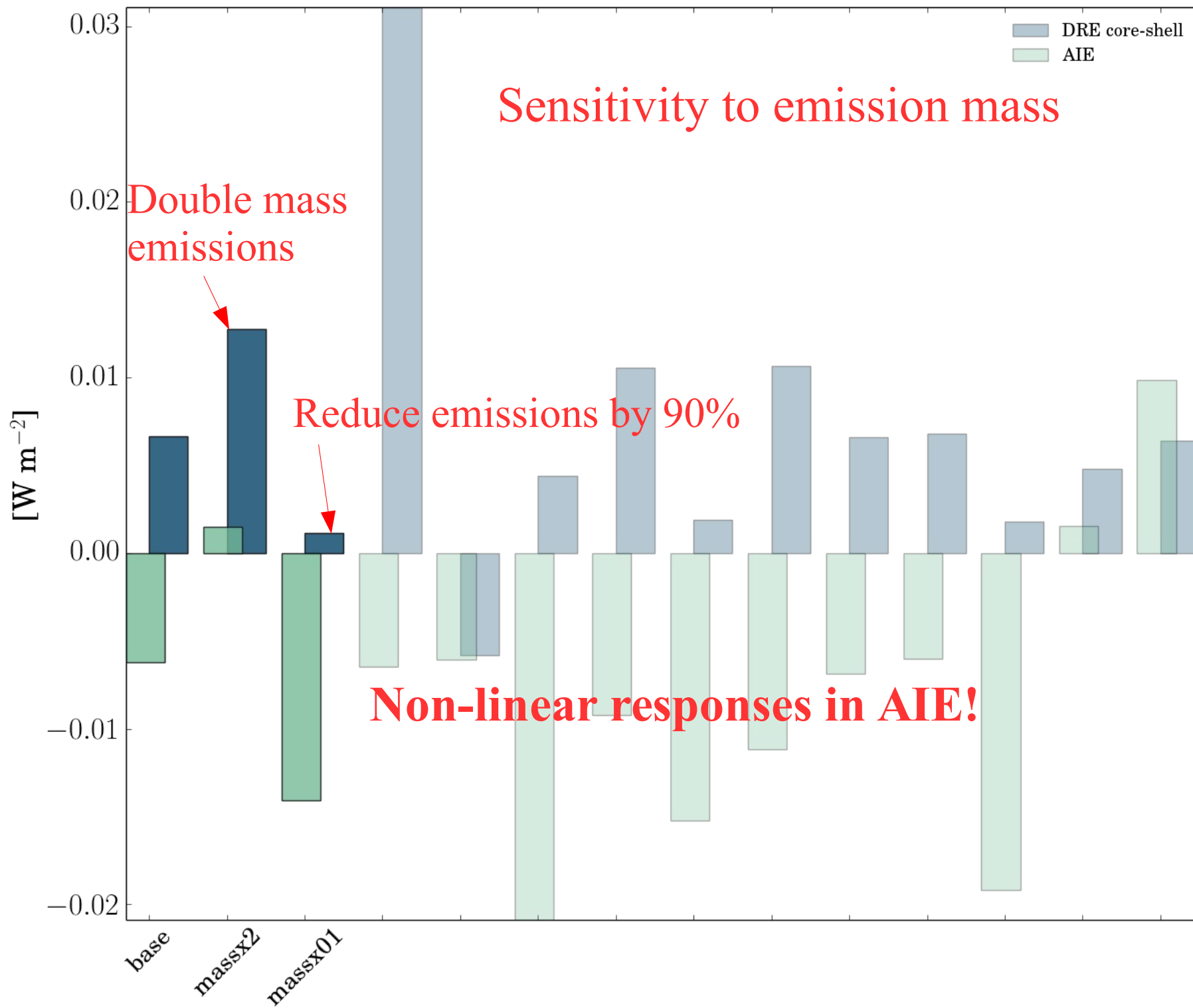
Global-mean direct and indirect effects



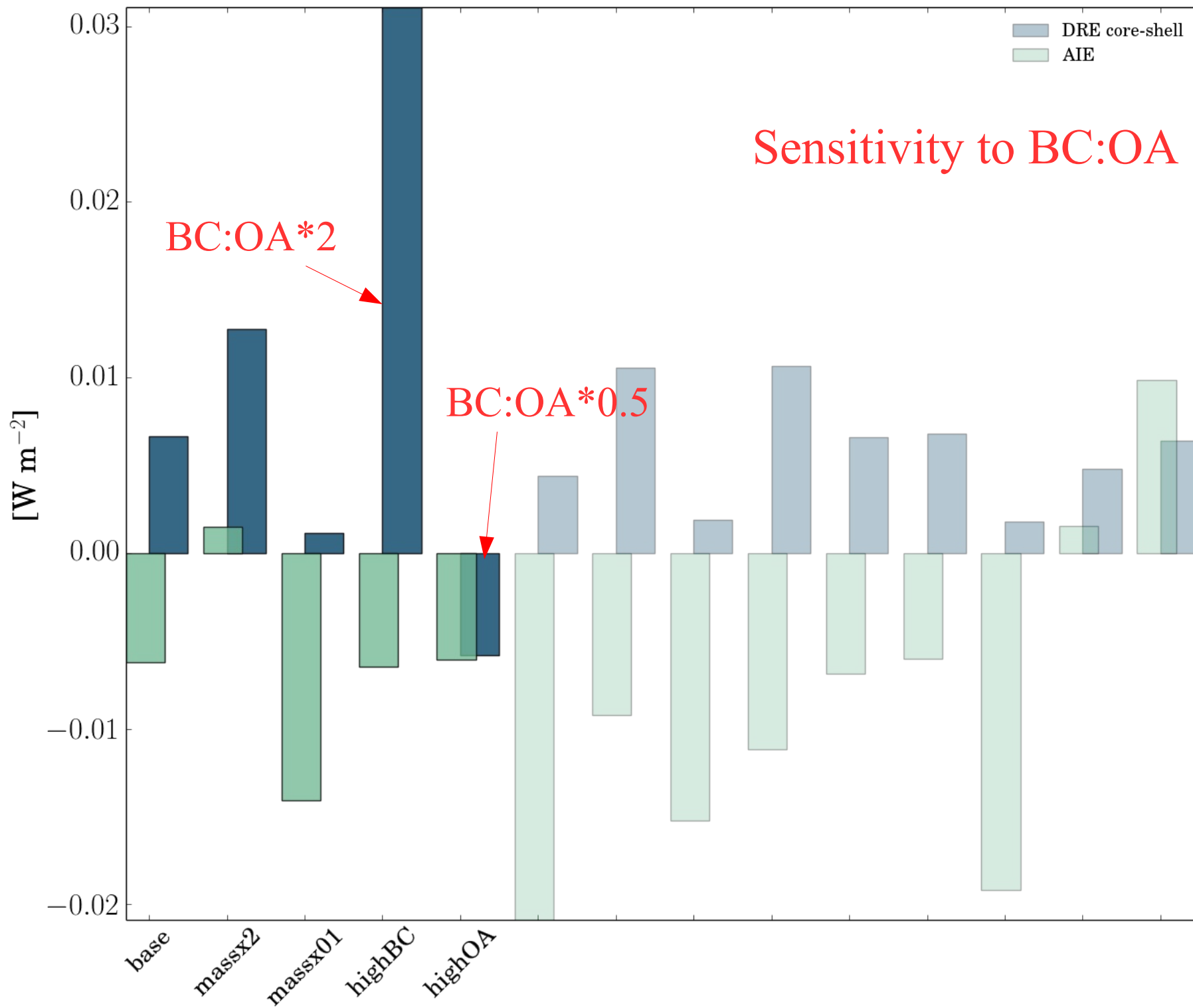
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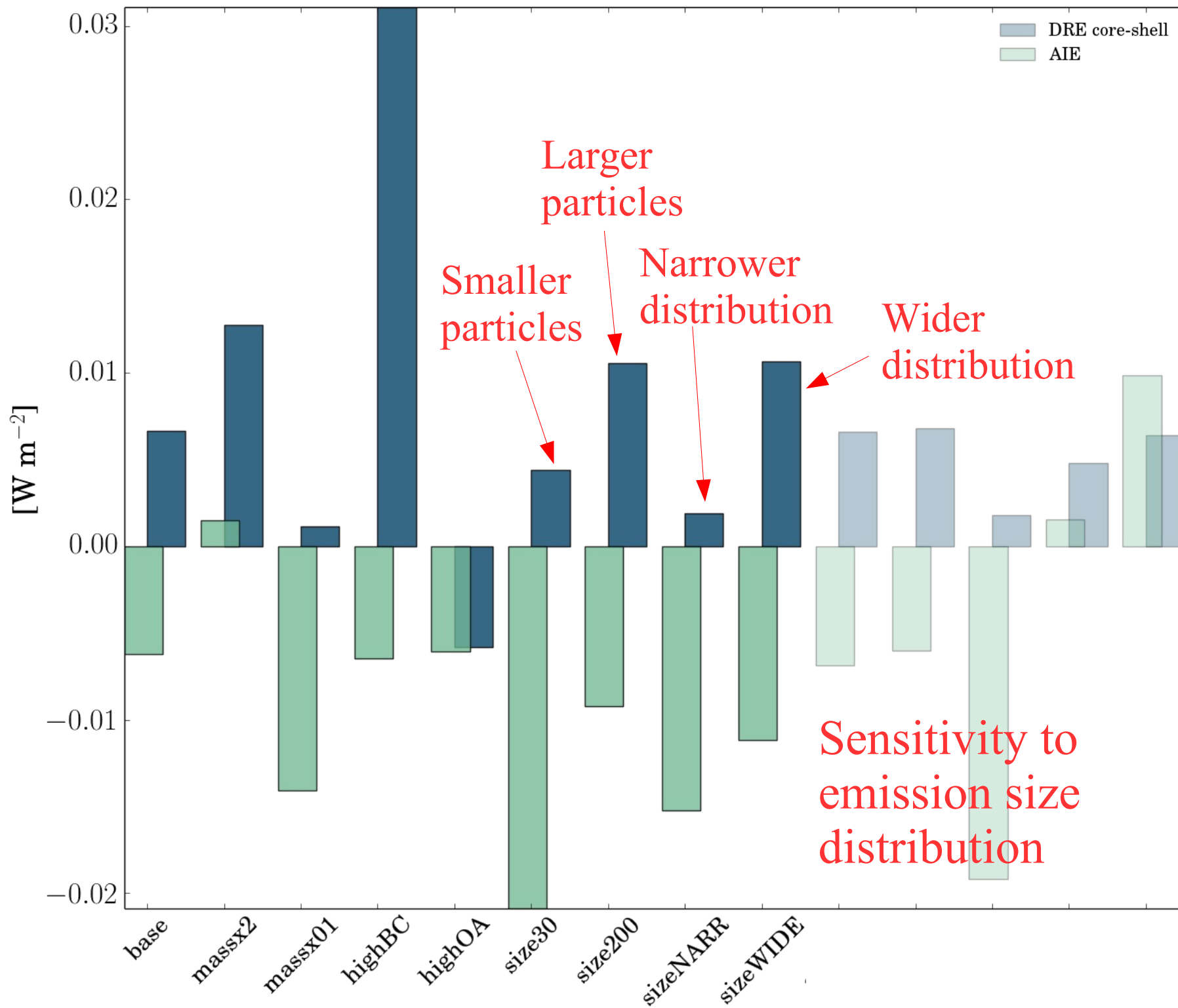
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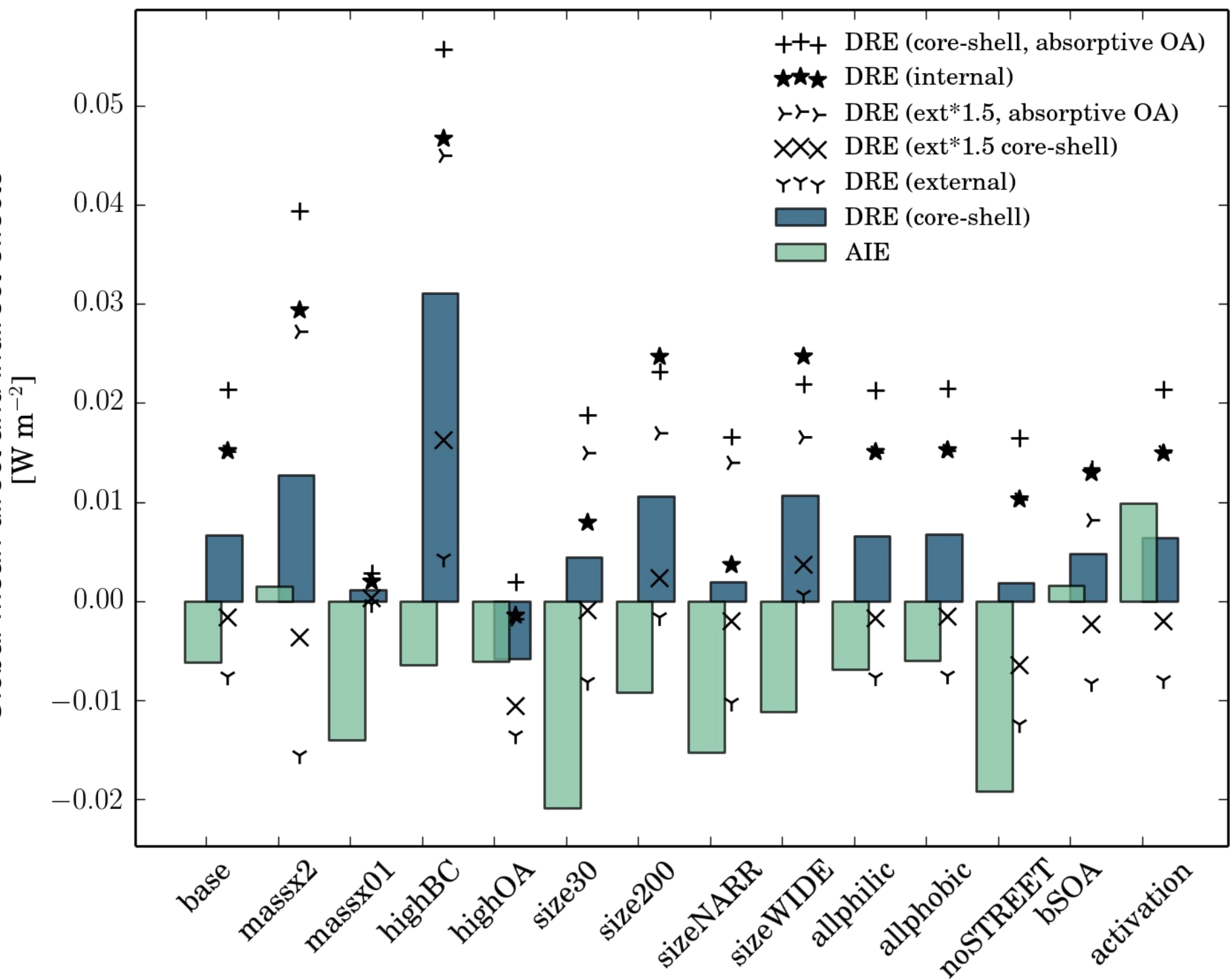
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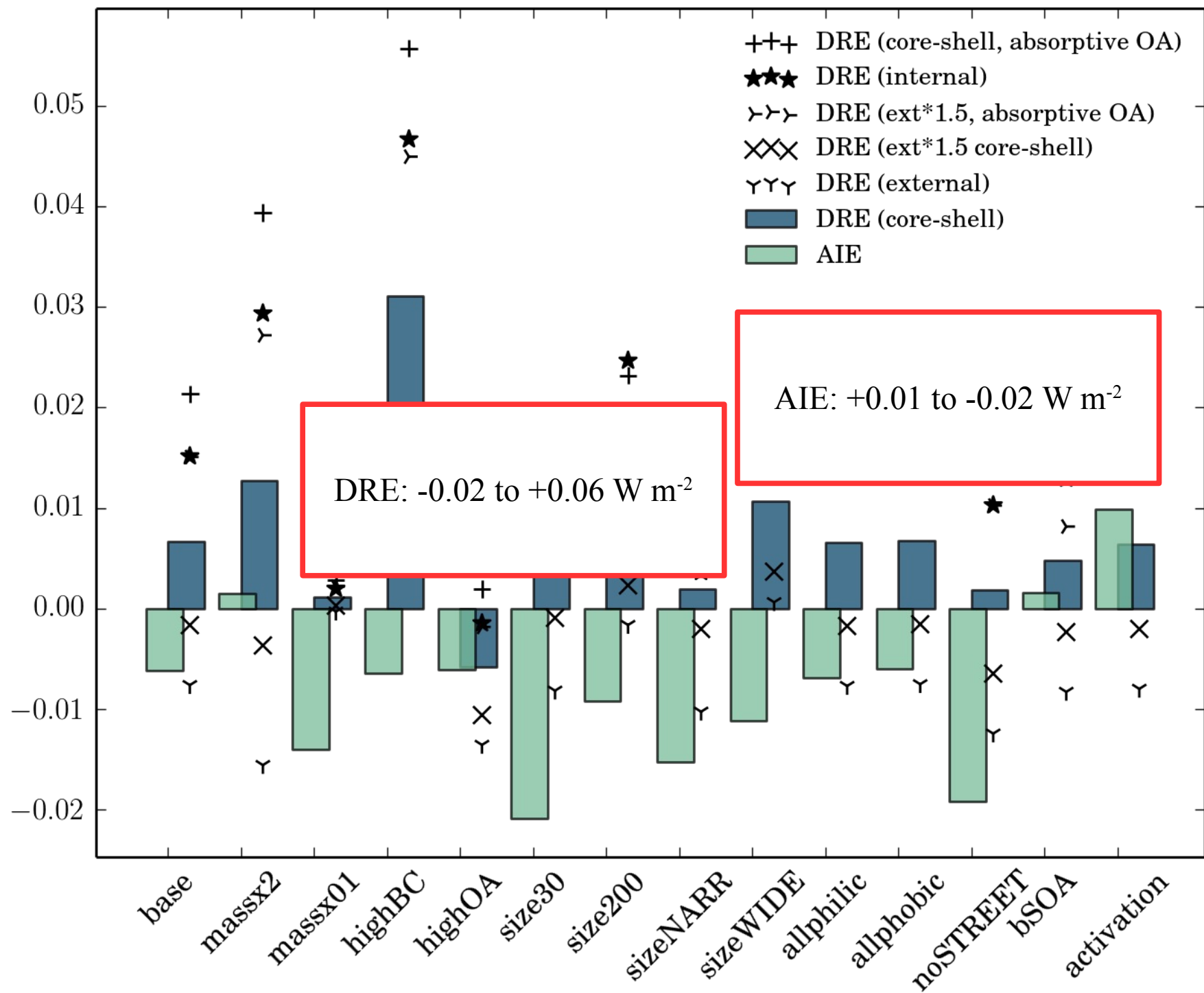
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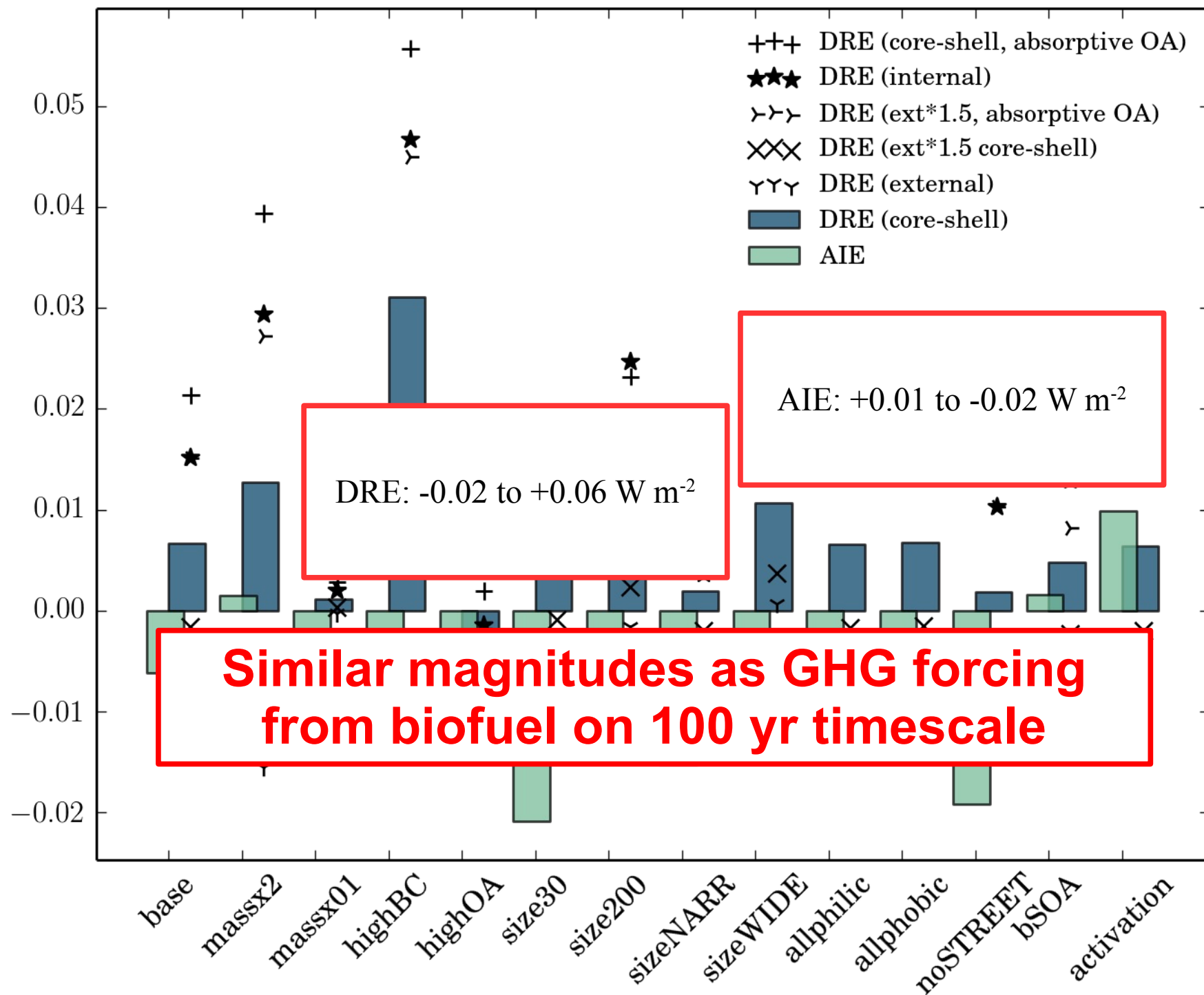
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Global-mean direct and indirect effects
[W m⁻²]

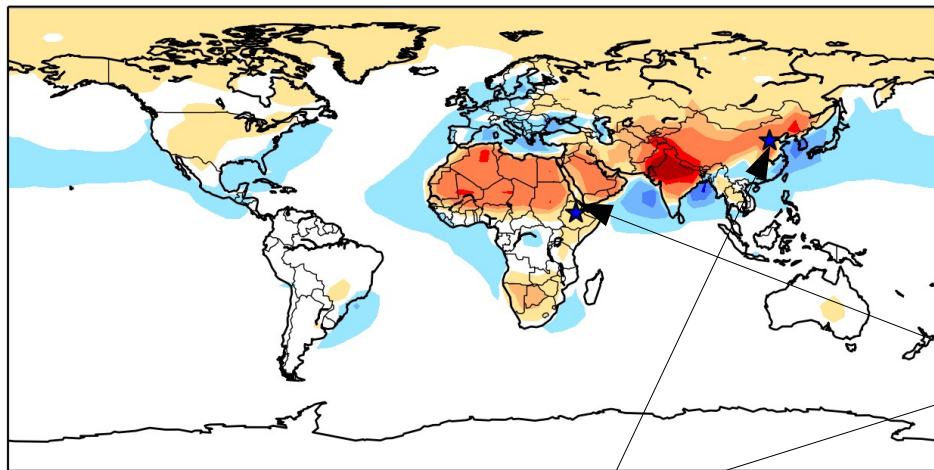


Global-mean direct and indirect effects
[W m⁻²]

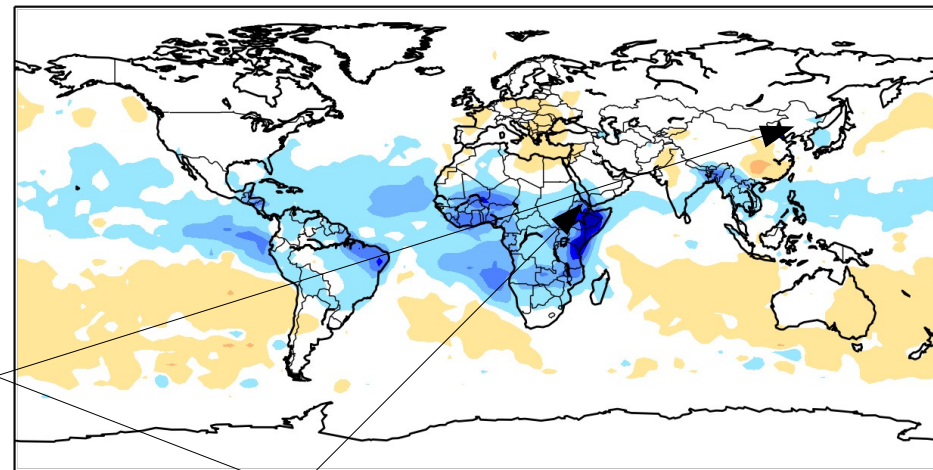


Strong regional effects/uncertainties!

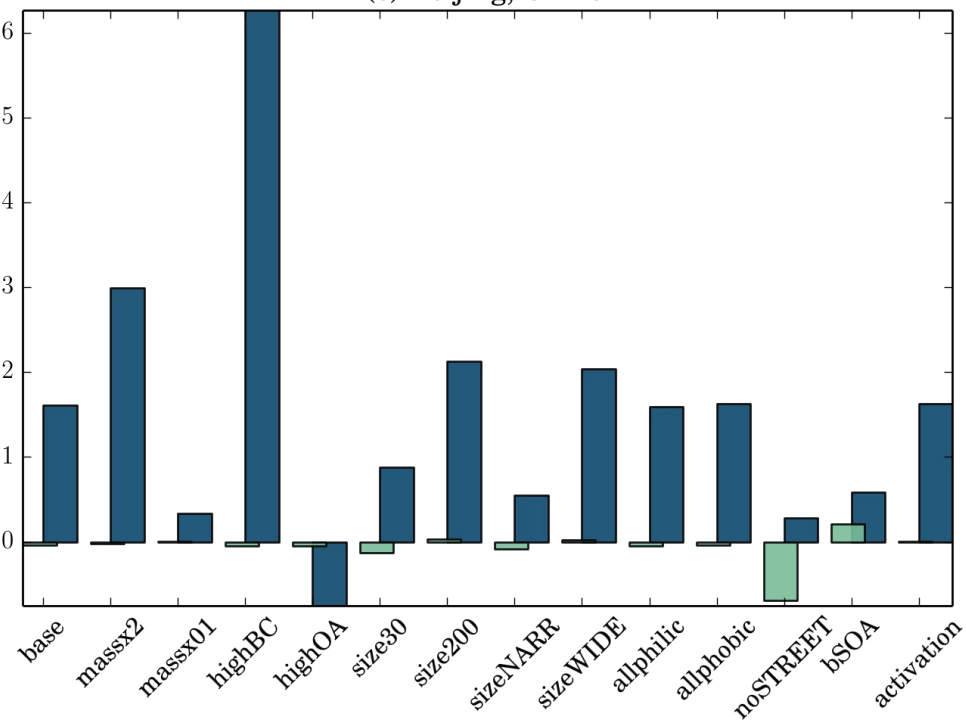
DRE (base-nobiof)



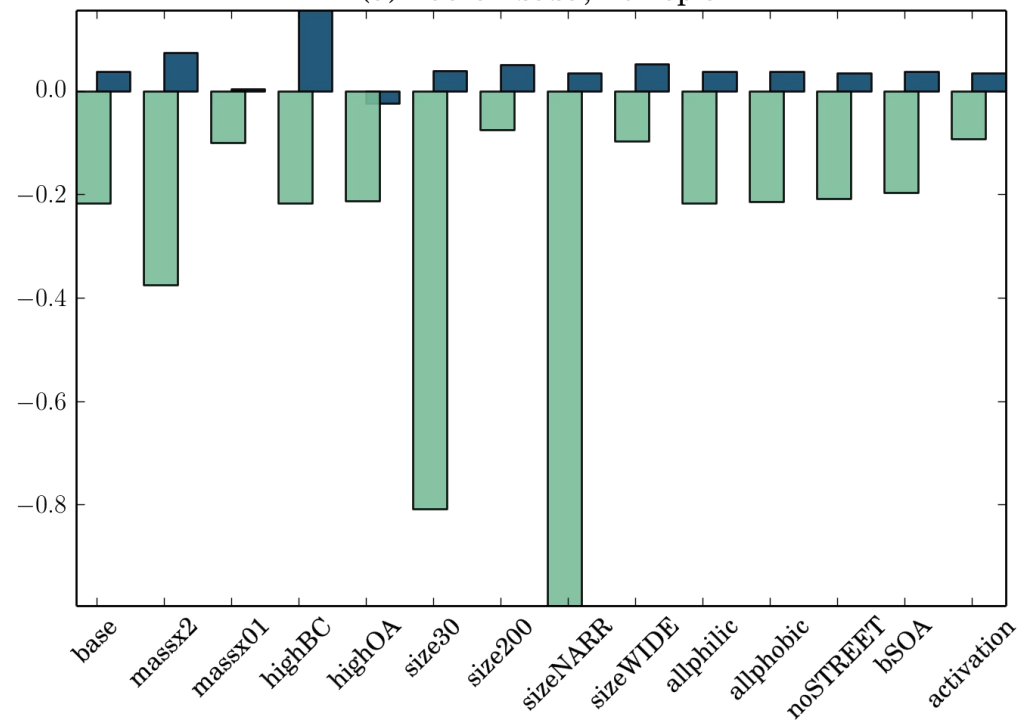
AIE (base-nobiof)



(c) Beijing, China



(d) Addis Ababa, Ethiopia



If you remember 1 thing from this presentation

- Uncertainties in aerosol-climate effects trump signal
- We don't even know the overall sign

Semi-related rant!

- Uncertainties in aerosol-climate effects trump signal
- We don't even know the overall sign
- Folks promoting BC controls as means of cooling climate are overconfident, in my opinion
 - (Unless can control BC w/o changing OC and size distributions)

Semi-related rant!

- Uncertainties in aerosol-climate effects trump signal
- We can't control climate without improving health
- Folk who think "improving health while improving climate are overconfident, in my opinion"
 - (Unless can control BC w/o changing OC and size distributions)

Improve for health → Win

Improve for climate → Uncertain

Where modelers need help!

- Direct effect:
 - Total mass emissions
 - “Aged” optical properties (mixing, lensing, BrC)
 - BC:OC ratio
 - “Aged” size distributions
- Indirect effect
 - Total mass emissions
 - “Aged” size distributions