

Radiative forcing and climate response in CESM/MARC coupled simulations

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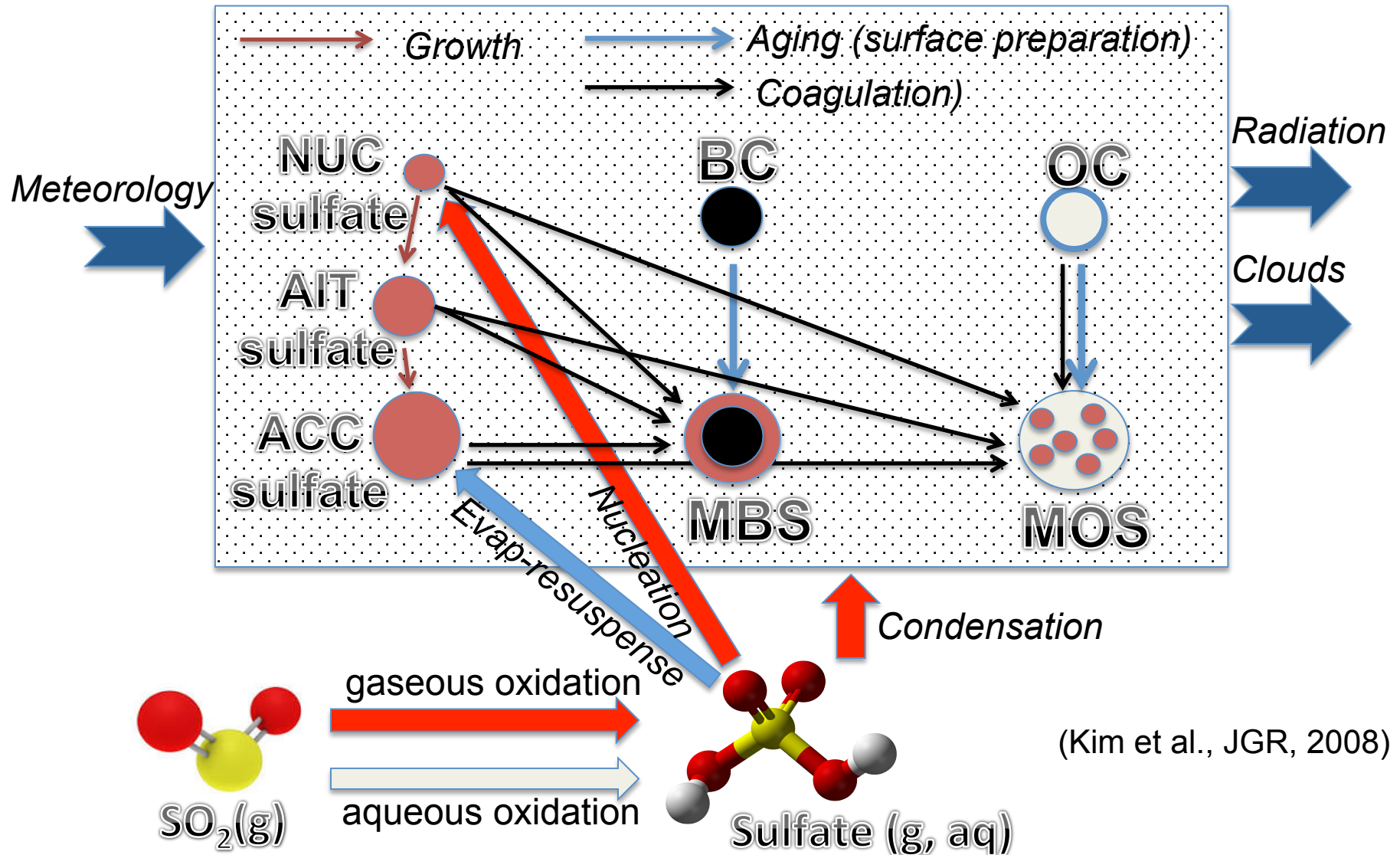
³Singapore-MIT Alliance for Research and Technology

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CESM AMWG/CMWG Meeting

MARC = a Multimode, 2Moment, and Mixing-resolving Model of Aerosols for Research of Climate

Log-normal distribution, 2 prognostic moments (Q, N) + BIM & OIM, prescribed σ



MARC

- 7 aerosol modes
 - external: NUC, AIT and ACC sulfate; BC and OC
 - Internal
 - MBS - BC core coated with sulfate shell
 - MOS - uniform mixture of OC shell
- 2 moment scheme – mass and number predicted; mixing state of MBS and MOS
- Why doing it again?
 - CAM3 -> CAM5
 - some improvements, mainly in the coupling
 - completely new code
 - add sea-salt and dust (borrowed from BAM)

Coupling to CAM

- CAM sulfur chemistry module – SO_4 oxidation
- sedimentation and dry deposition – Wang (2004) + “resistance” model adopted from the dust model
- impaction scavenging – function of rain/snow m_r , Wang (2004)
- nucleation scavenging – explicit in stratiform clouds, fixed for shallow and deep convection; aqueous SO_4 release to ACC by cloud droplet/rain evaporation

- cloud droplet activation – all but BC allowed to activate as CCN
- aerosol optical properties – k , ω , g to RRTMG

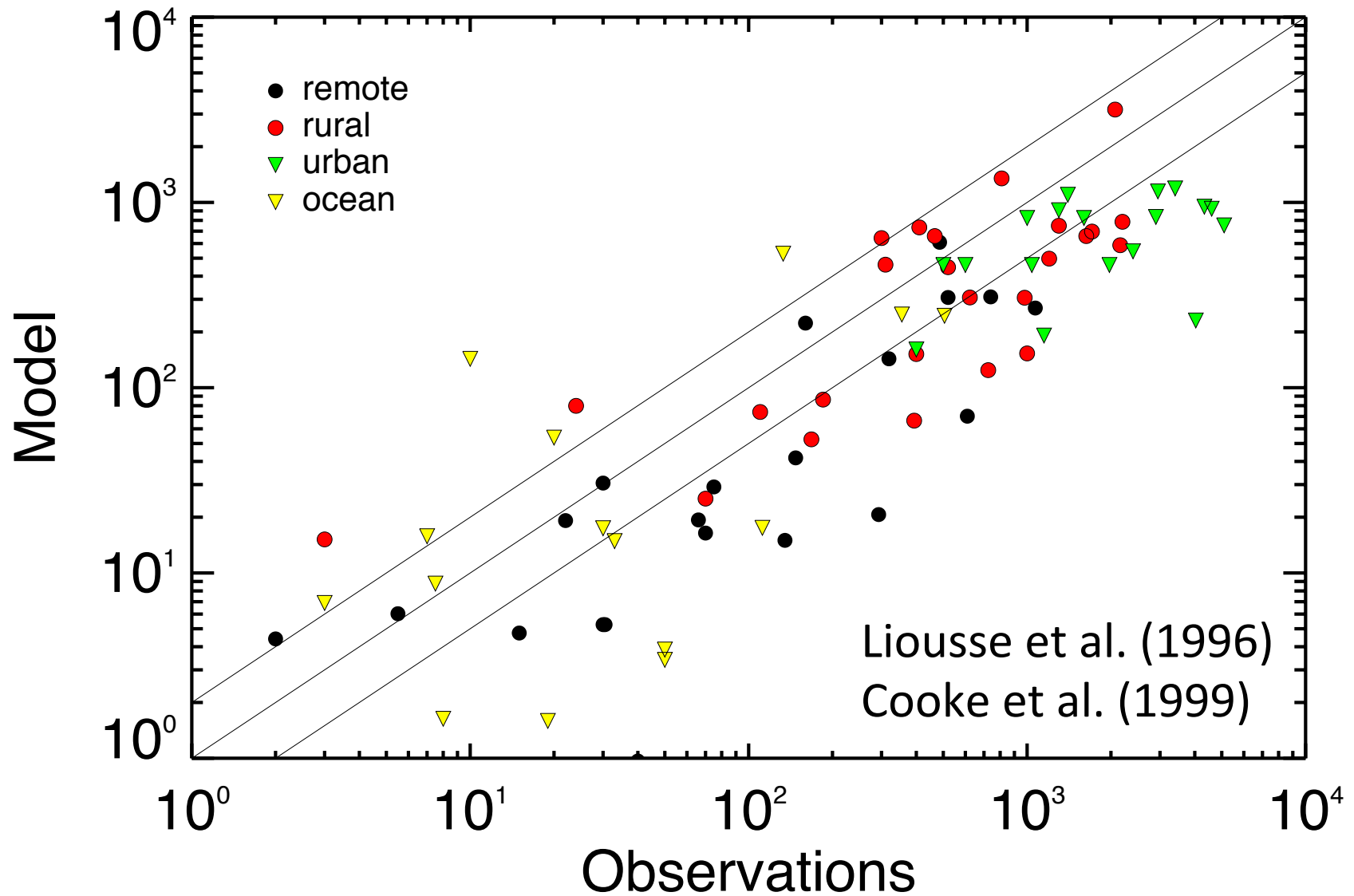
- 28 advected scalars – “heavier” than MAM3
 - 4 sea salt and 4 dust modes BAM
 - 4 gas-chemistry module
 - 16 MARC – m , N of 7 modes + 2 mixing-state variables

Simulation Setup

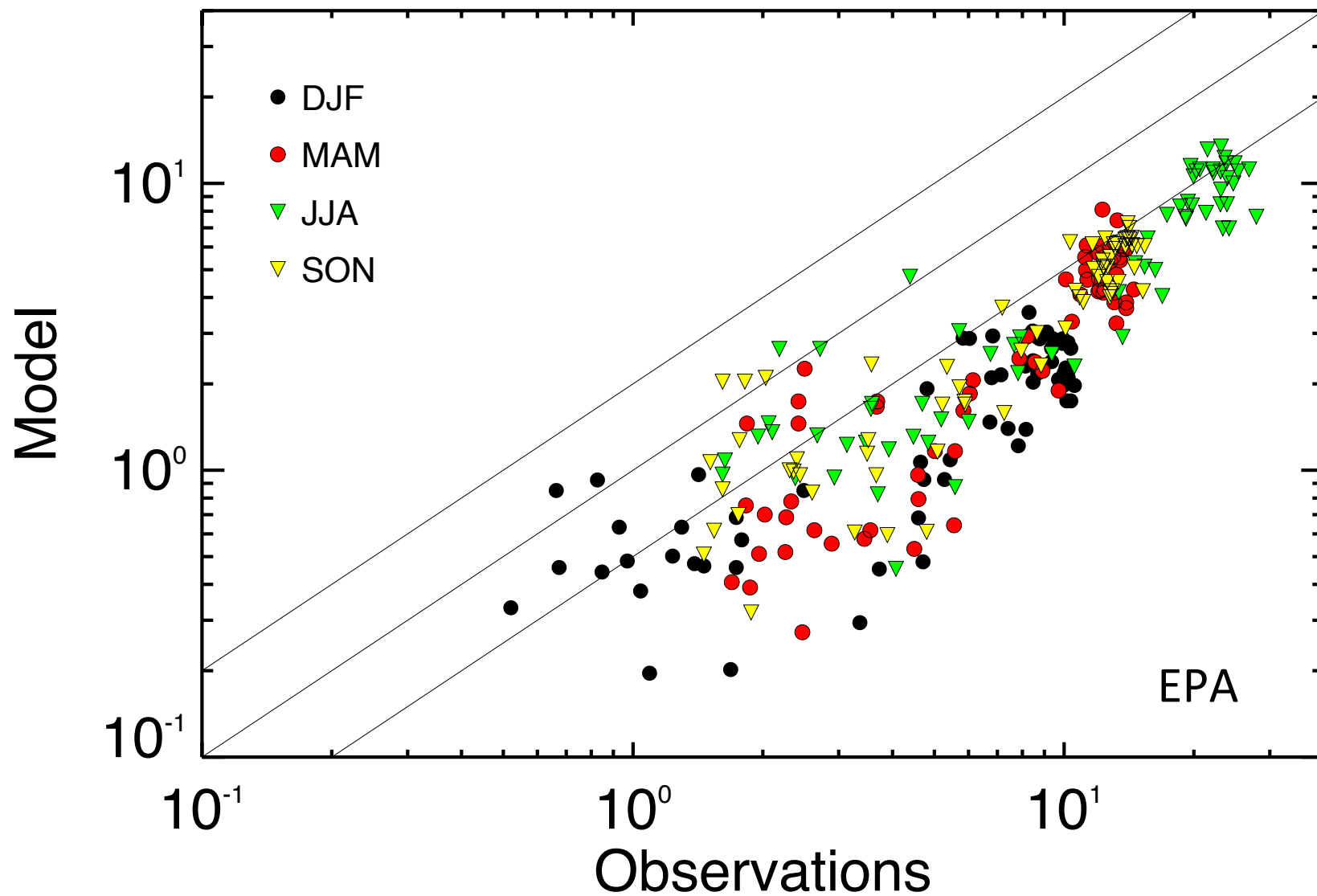
- Test case – what is the RF and how does it depend on the aerosol mixing state
- CESM 1.0.5
 - 5 years long simulations, with and without mixing
 - F configuration: prescribed SST and sea ice
 - emissions 1850, 2000
- Surface emissions – BC, OC, biogenic VOCs, SO₂ and SO₄

Model-obs comparisons

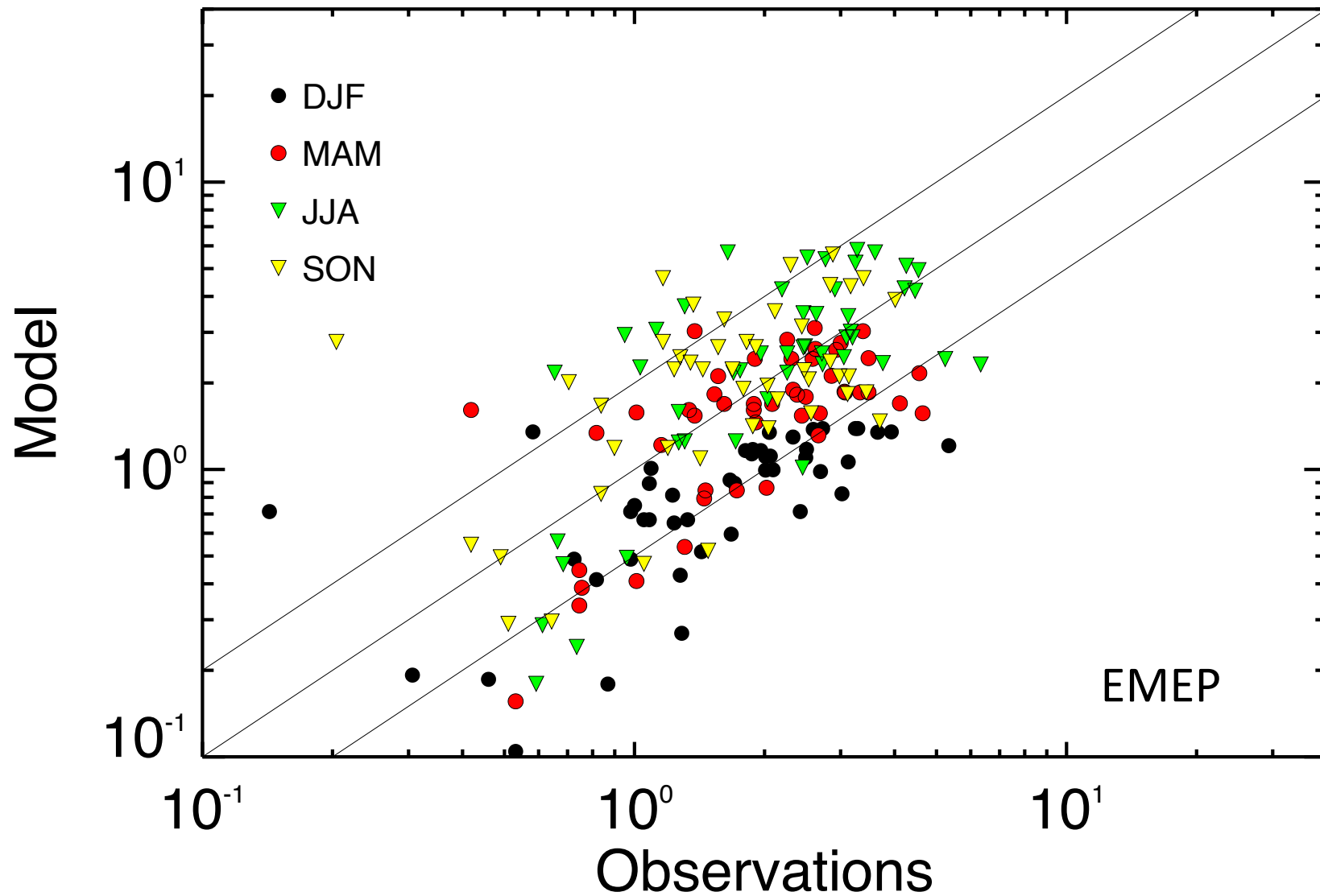
Surface BC [ng/m³]



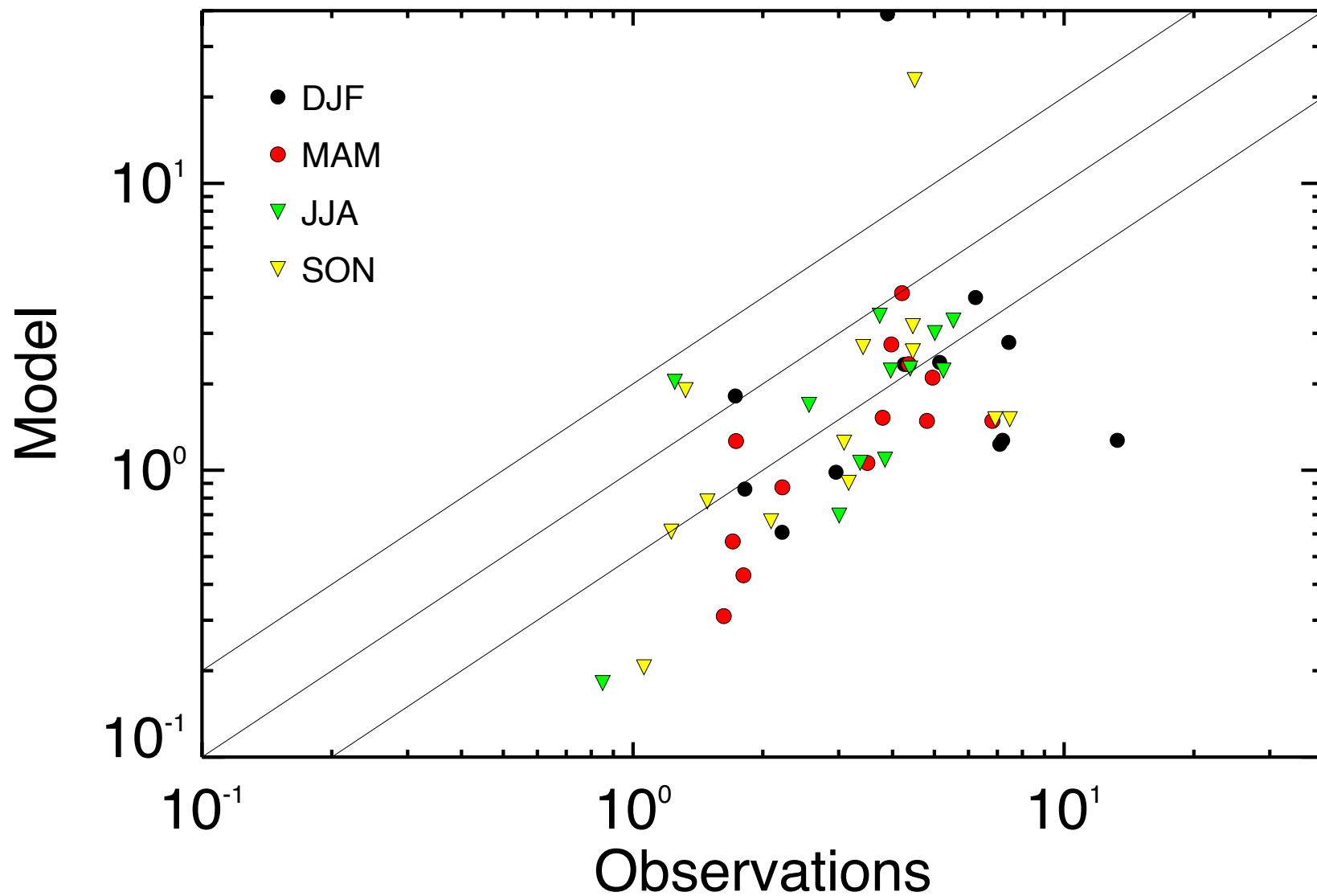
Surface SO_4 [$\mu\text{g}/\text{m}^3$]: US



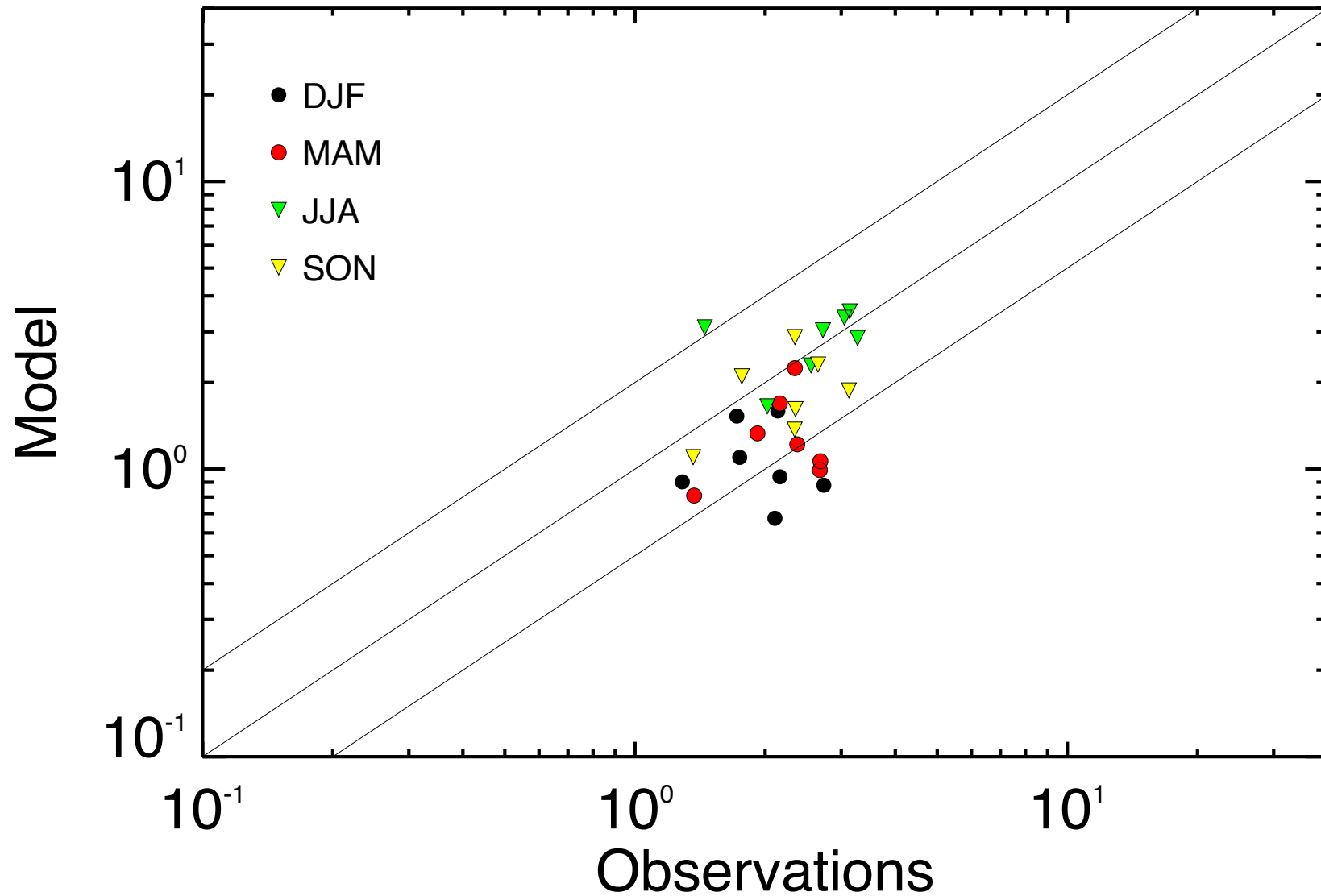
Surface SO₄ [$\mu\text{g}/\text{m}^3$] Europe



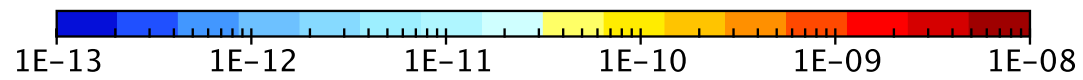
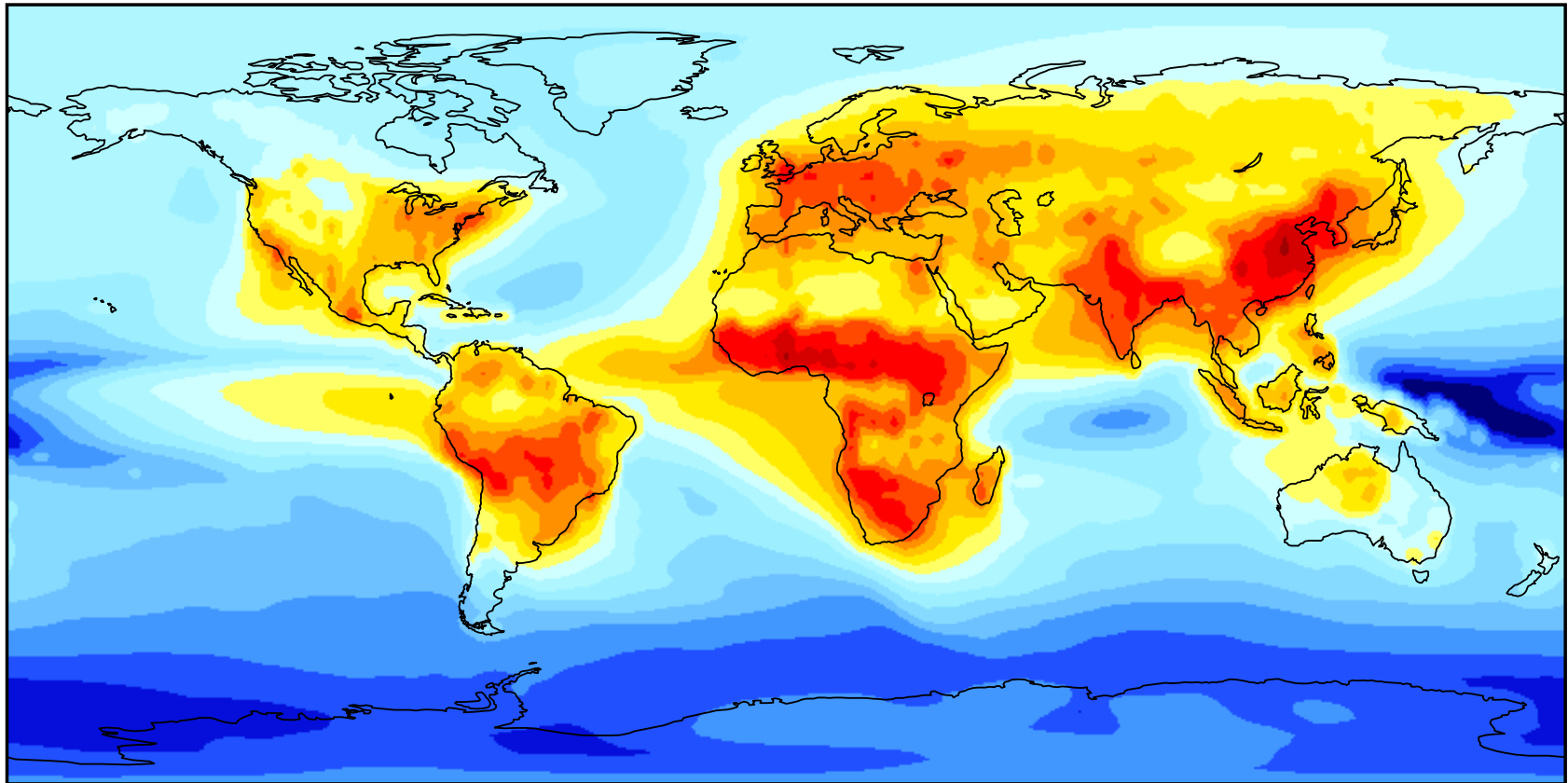
Surface OC [$\mu\text{g}/\text{m}^3$]: Europe



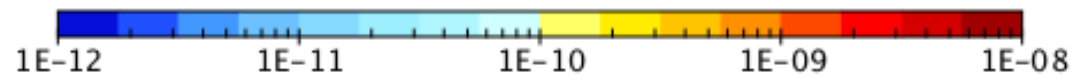
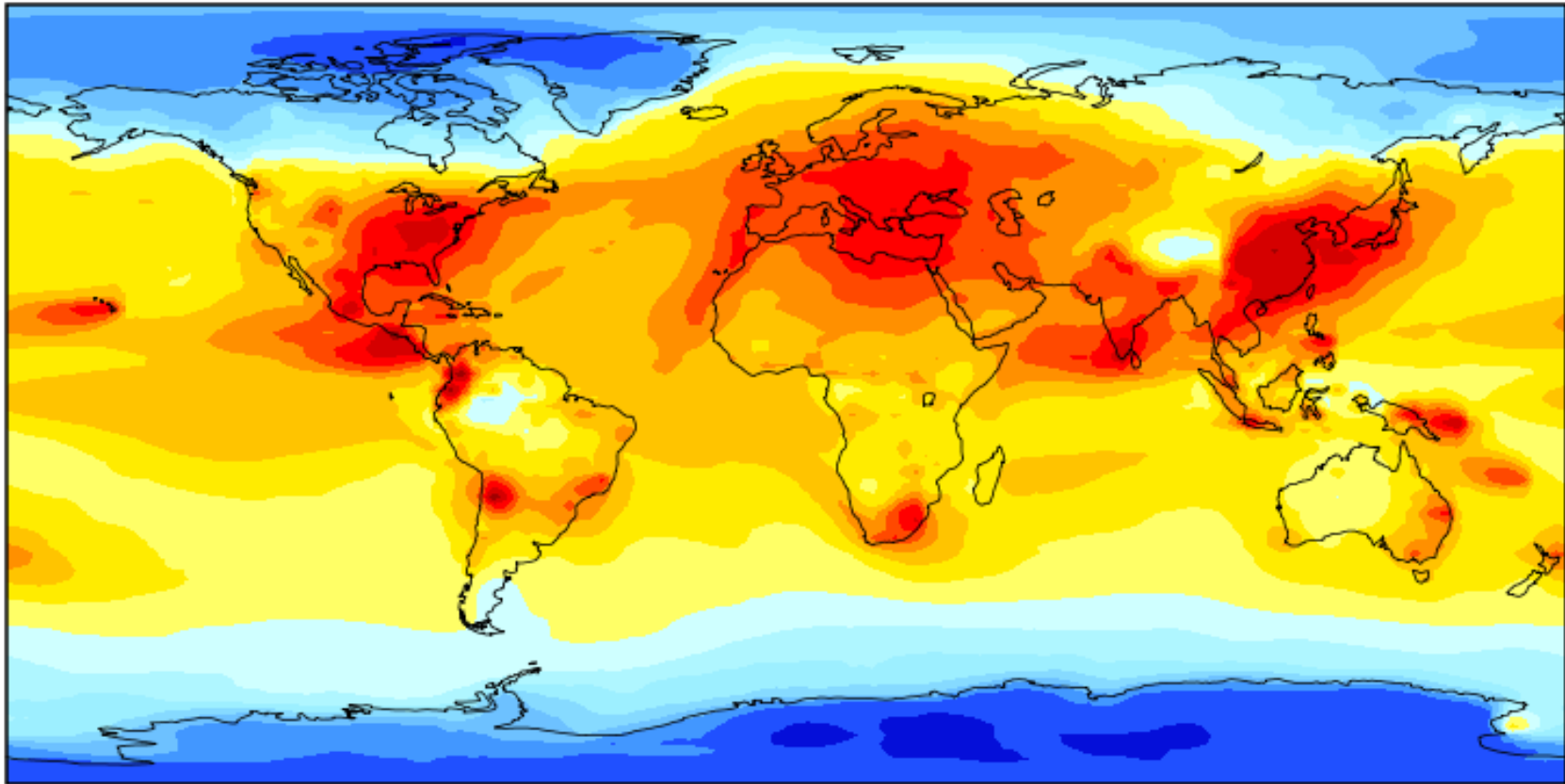
Surface OC [$\mu\text{g}/\text{m}^3$]: US



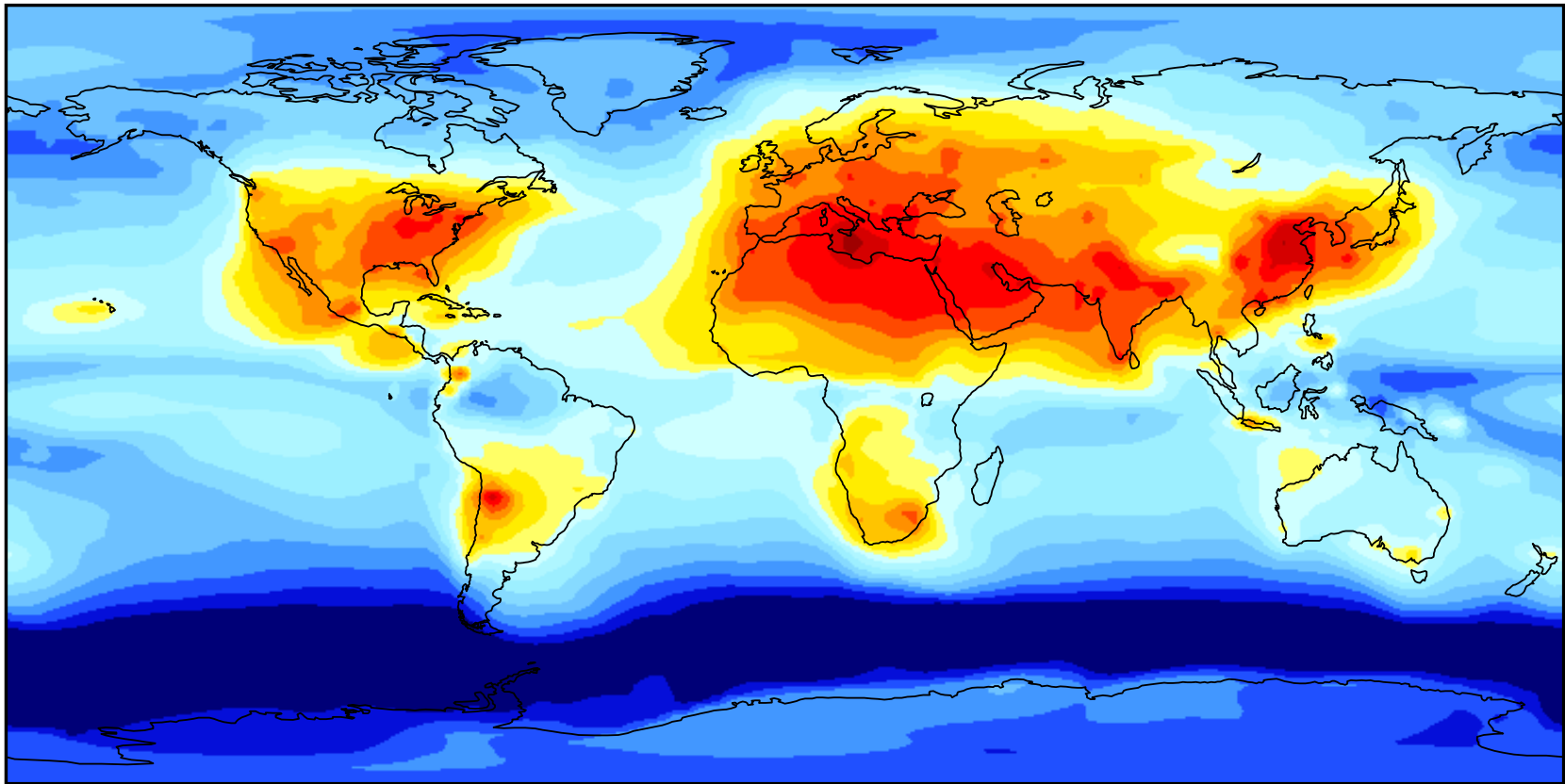
Surface BC [kg/kg]



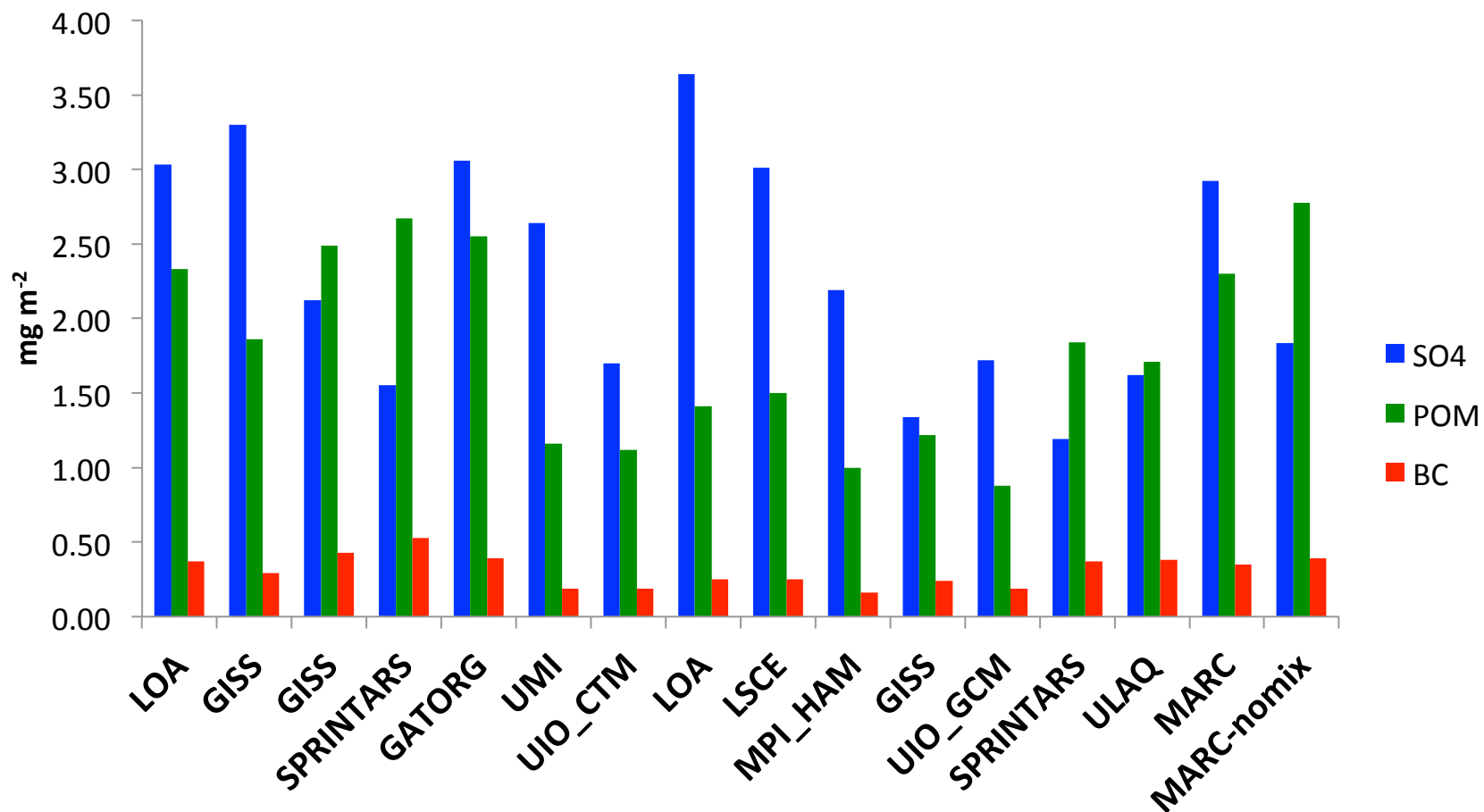
Surface SO_4 [kg/kg]



Surface MBS [kg/kg]

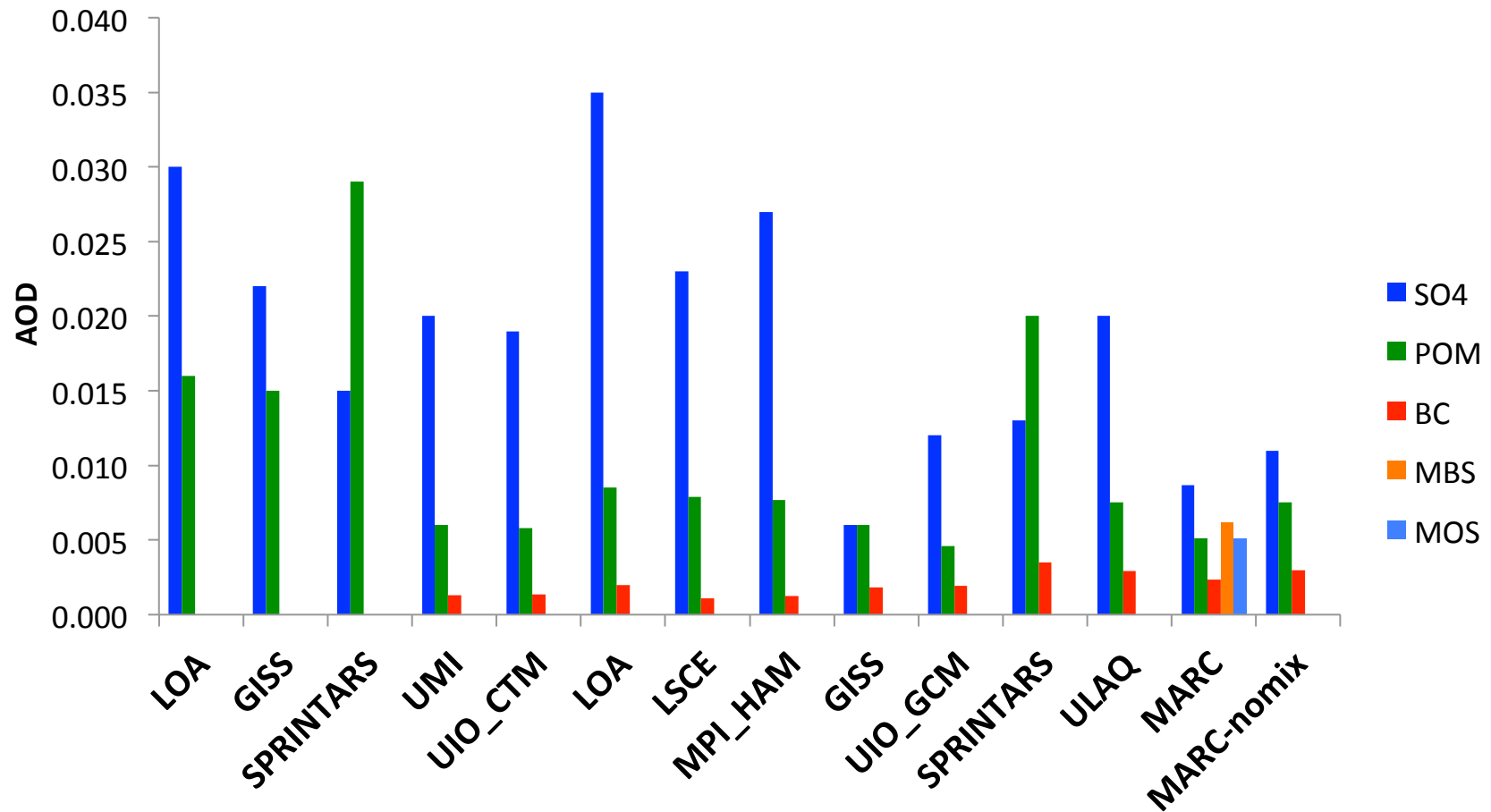


Aerosol Loading: AEROCOM models



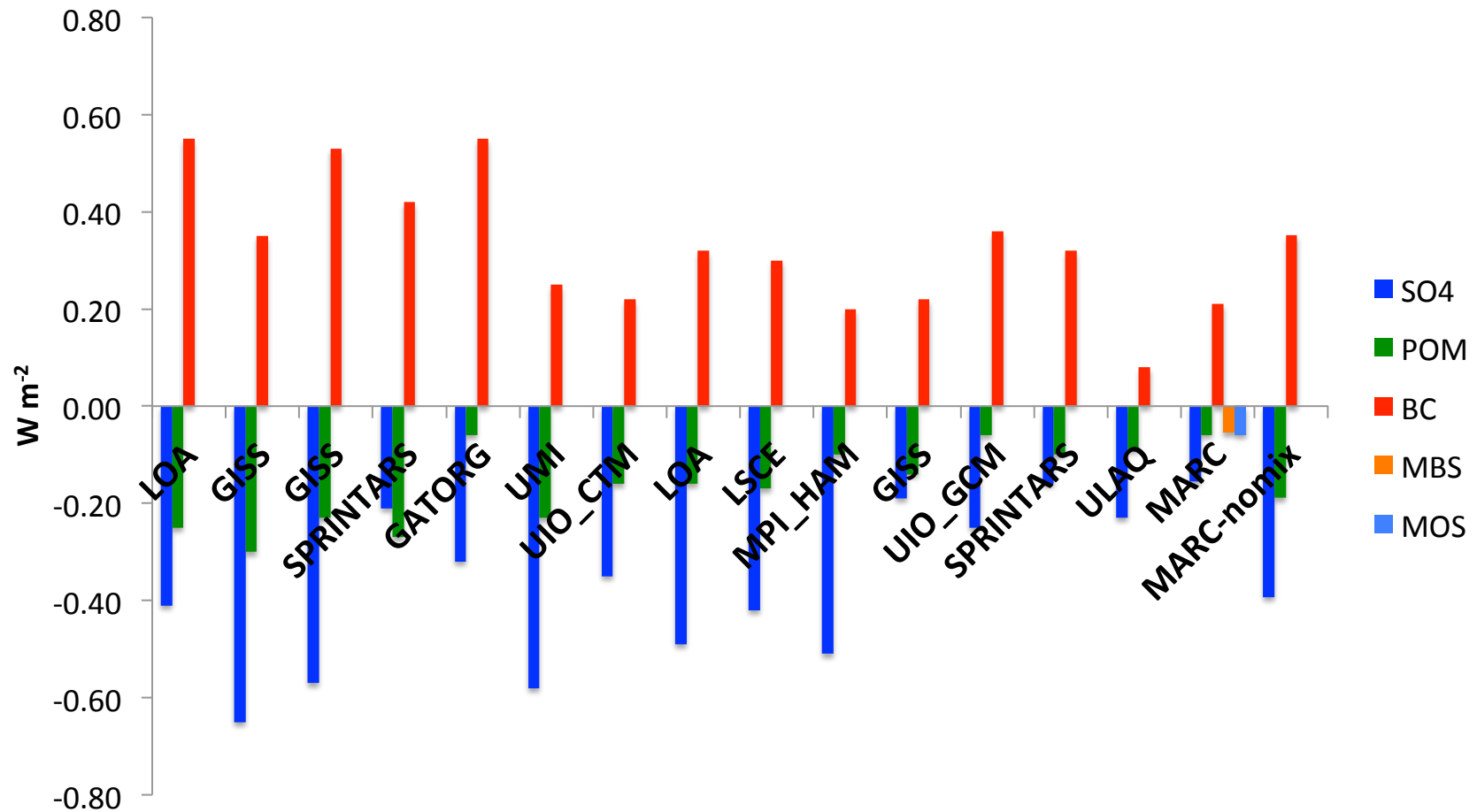
[Schulz et al., 2006]

AOD: AEROCOM models



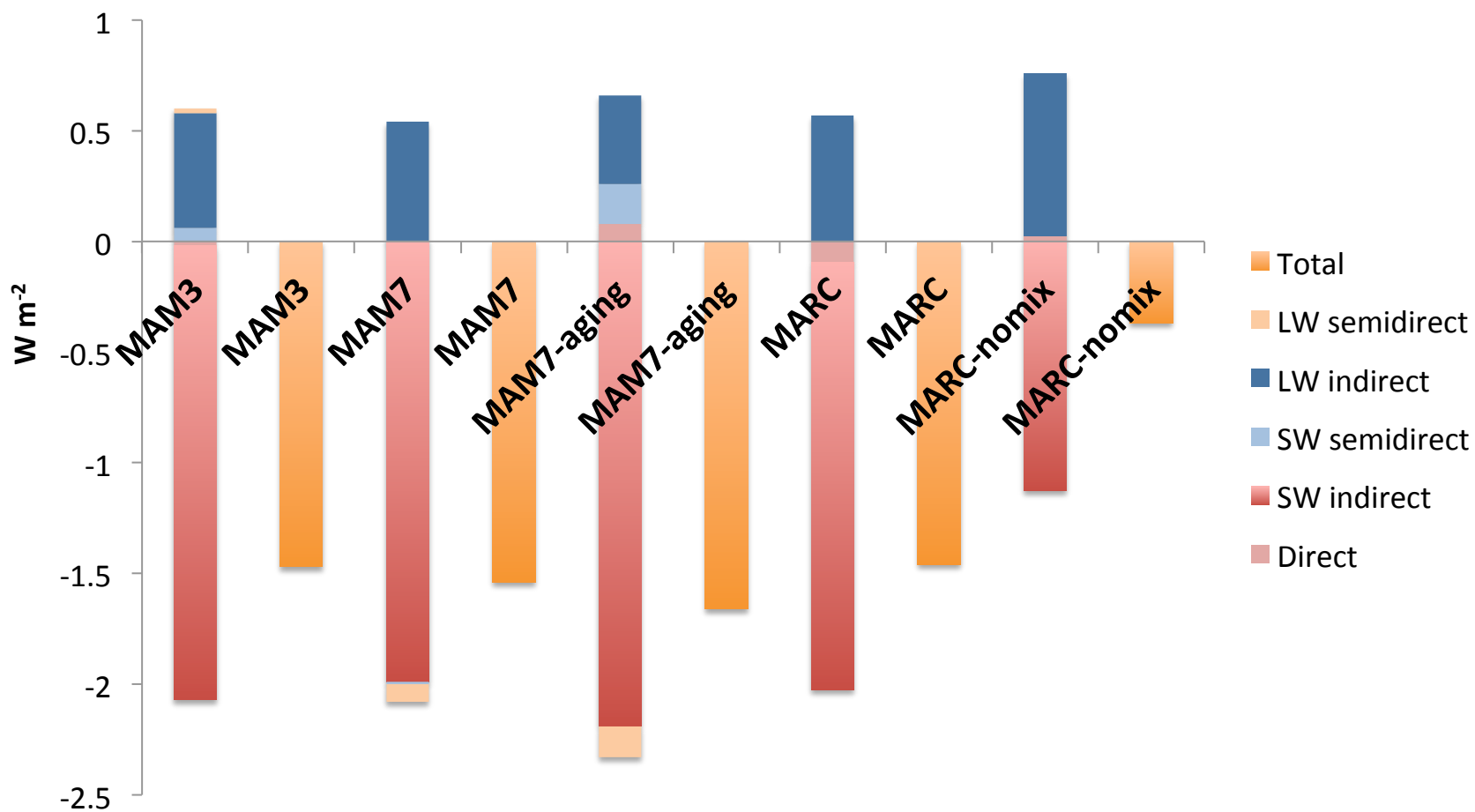
[Schulz et al., 2006]

Direct Radiative Forcing AEROCOM models



[Schulz et al., 2006]

MAMx/MARC radiative forcing



[Ghan et al., 2012]

Where do we go next?

- Coupling with CESM 1.2 – MG2, CLUBB
- Extensive evaluation of simulations, AMWG diagnostics, “tuning”?
- Droplet activation
- Ice nucleation

Acknowledgments

- Andrew Gettelman, Brian Eaton