Satellite Data and Model Integration of Global Distribution of Aerosols to Estimate the Aerosol Radiative Effect

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Motivation & Objective

- IPCC report summarizes that the uncertainty for the aerosol direct forcing is about a factor of 2-3, based largely on model simulations.

- In recent years, a great deal of effort has gone into improving measurements and data sets.

- It is feasible to shift the estimates of direct effect from largely model-based to increasingly measurement-based.

- Observations can also be used to improve and constrain model simulations through synthesis and integration.

Integrated Study of Global Aerosols and Direct Effect

GOCART

Optimum Interpolation (OI)

$\sigma^2 = \varepsilon^2 + (f)^2$

SSA, g

Integrated AOT

Radiative Transfer Model

MODIS
surface albedo

Aerosol Direct Radiative Effect (clear-sky)

Inter-comparisons

- AERONET
- MODIS *(Remer)*
- CERES *(Loeb)*

Data and Model

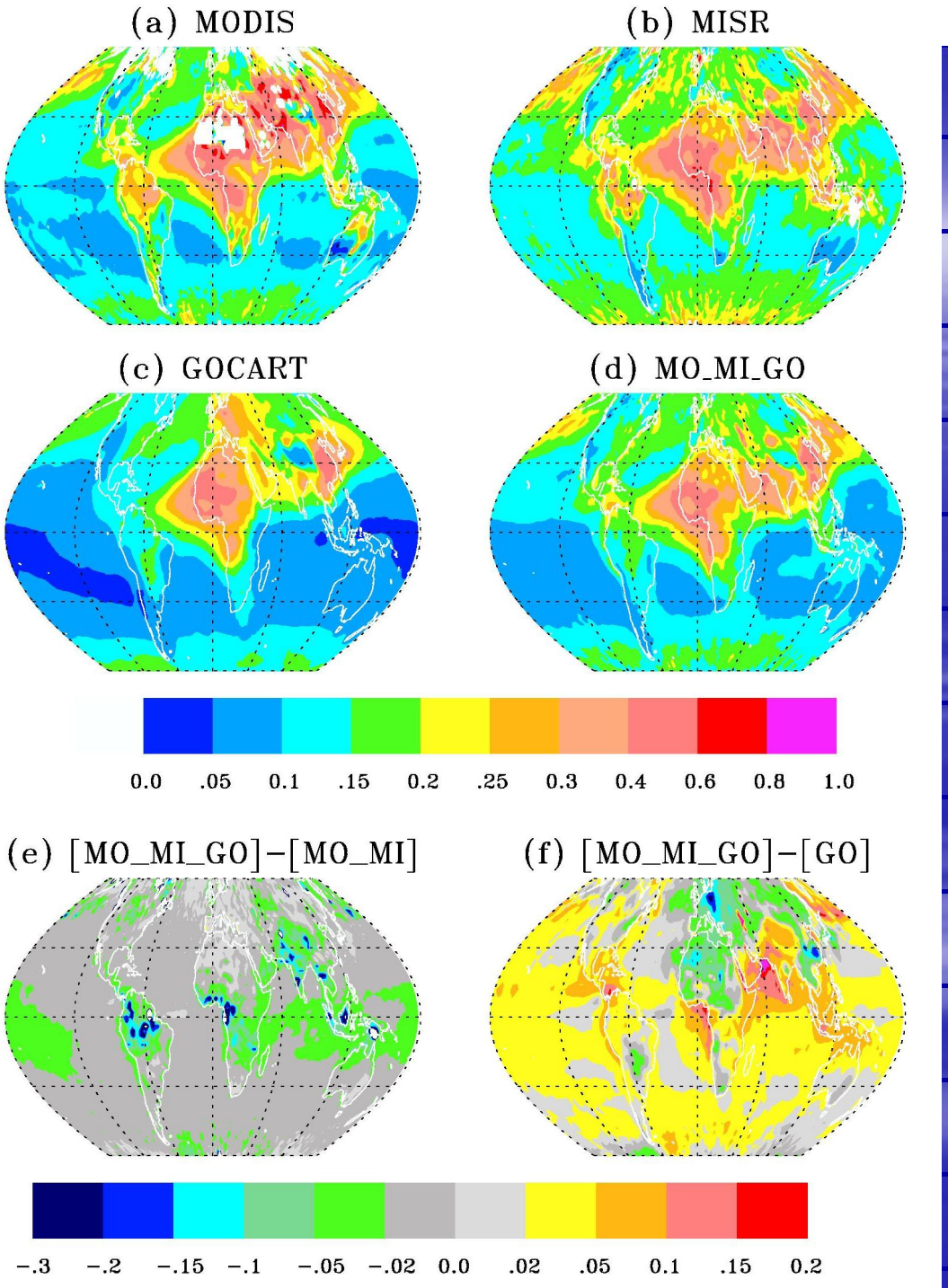
- **MODIS**
  - ±0.03 ± 0.05 (Ocean) √
  - ±0.05 ± 0.20 (Land), gaps over deserts
- **MISR**
  - +0.038 (Ocean)
  - ±0.20 or ±0.05 (Land) √
- **GOCART:** Goddard Global Ozone Chemistry Aerosol Radiation & Transport
  - Sulfate, OC, BC, dust, Sea-salt
  - driven by the assimilated metorology
  - 30 layers, 2.5°x2° *[1.25°x1° ongoing]*
  - ±0.01 ± 0.46 (Ocean), ±0.04 ± 0.31 (Land) √

⇒ **MO_MI_GO**

Annual ave. AOT, 2001

60°S ~ 60°N

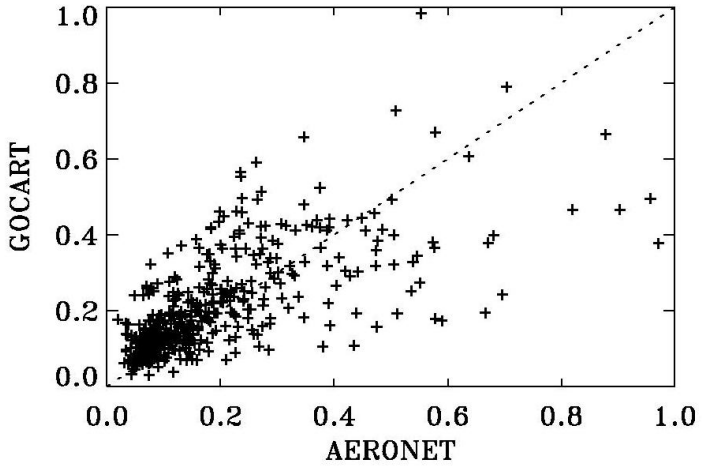
MODIS	0.188
MISR	0.199
MO_MI_GO	0.151
GOCART	0.134

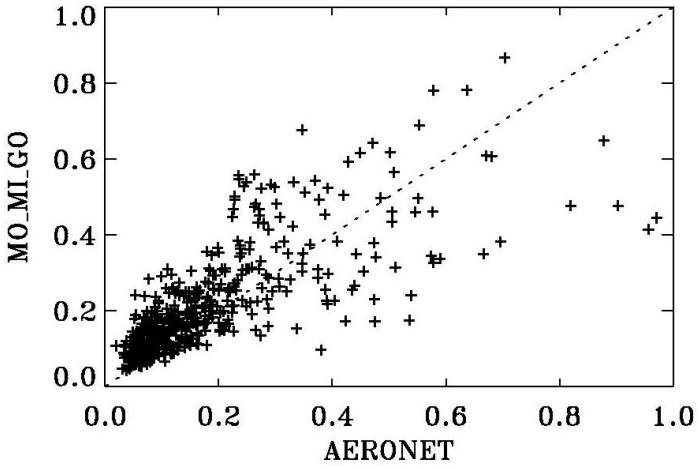


Before Integration

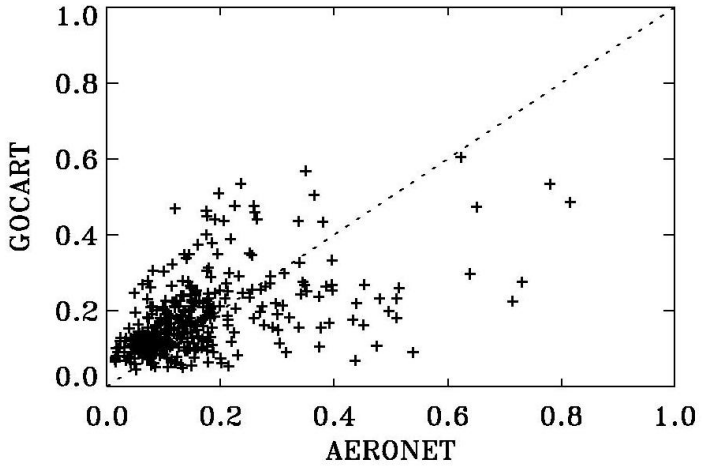
After Integration

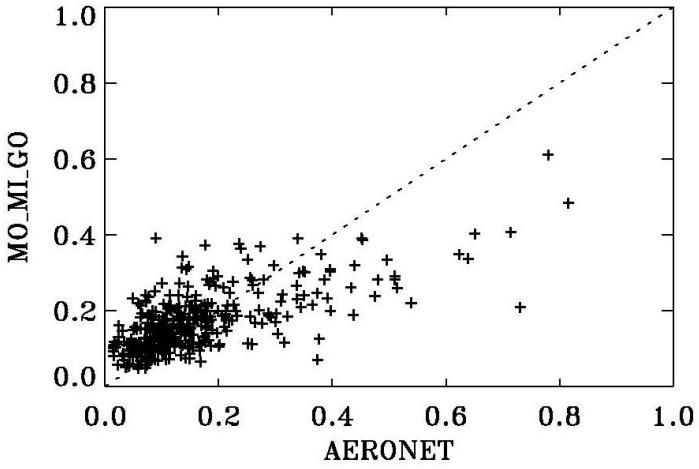
Angstrom exponent < 1.5





Angstrom exponent > 1.5





Comparisons with AERONET measurements

Clear-sky Aerosol Direct Effect

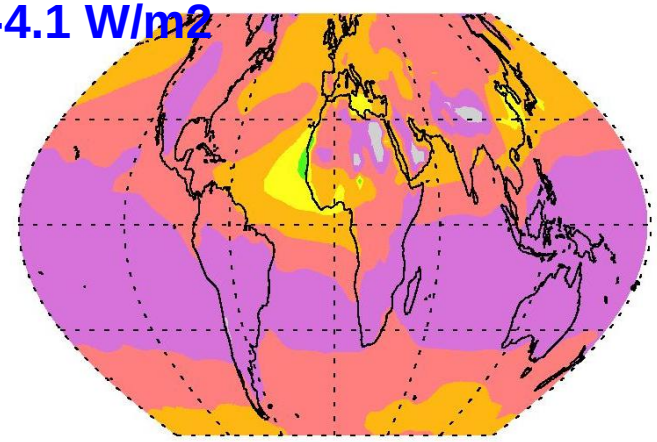
MO_MI_GO - GOCART

TOA SURFACE

GOCART

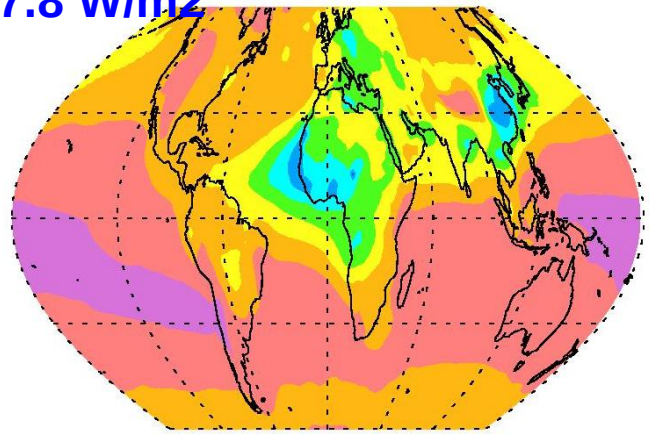
(c) DF_{TOA}

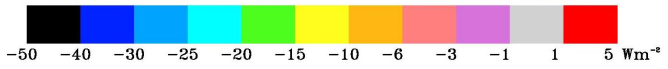
-4.1 W/m2



(d) DF_{SFC}

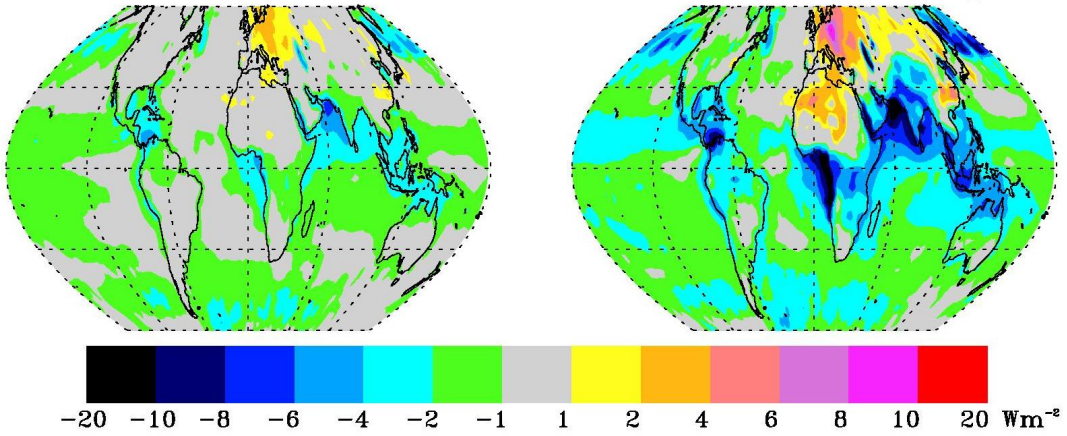
-7.8 W/m2





(e) ΔDF_{TOA} [a − c]

(f) ΔDF_{SFC} [b − d]

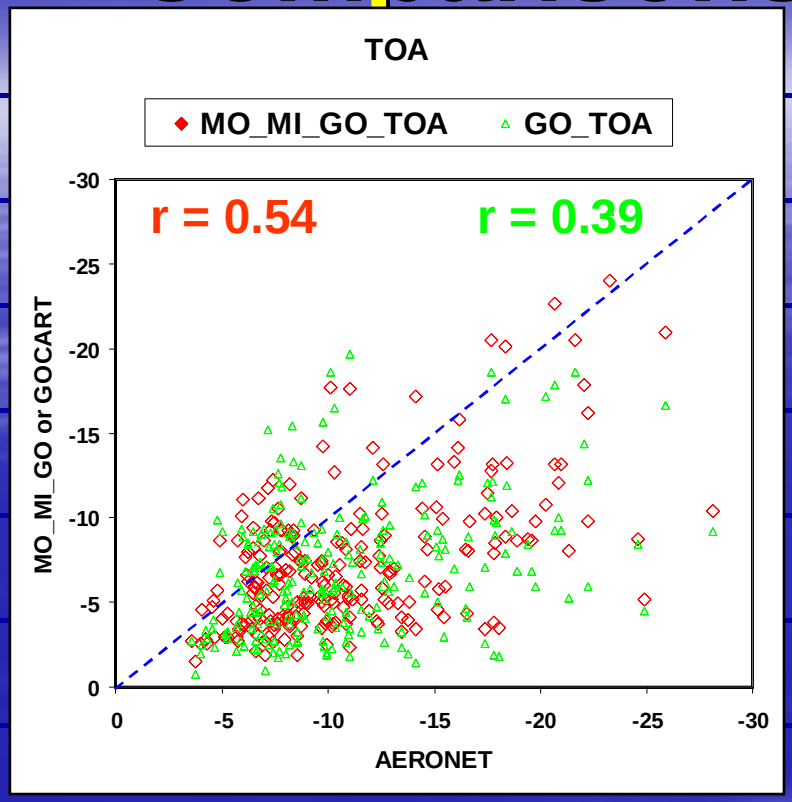


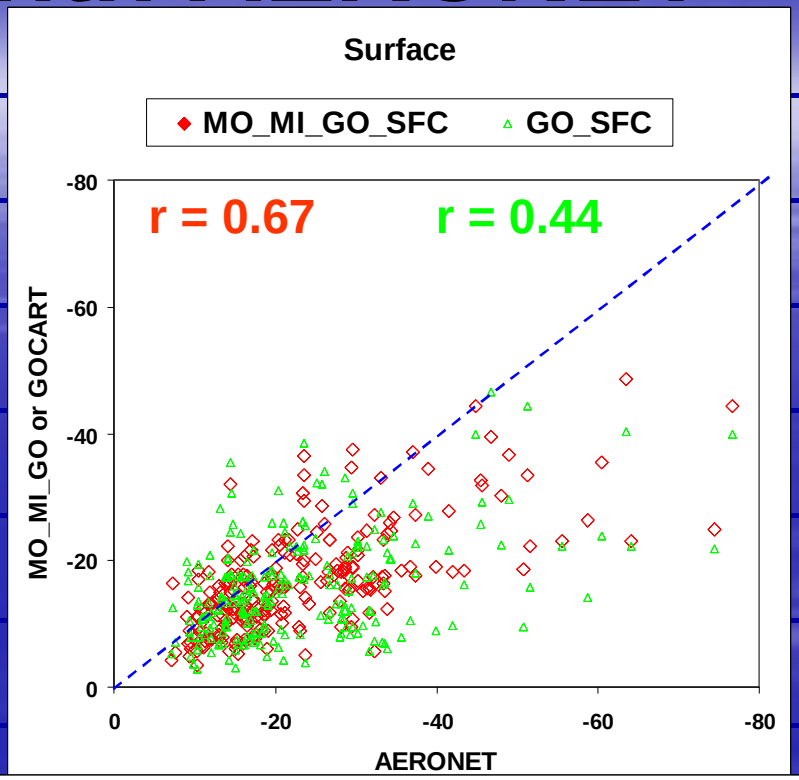
Δ = - 0.8 W/m2 (20%)

Δ = - 1.5 W/m2 (20%)

Annual Average, 2001

Comparisons with AERONET

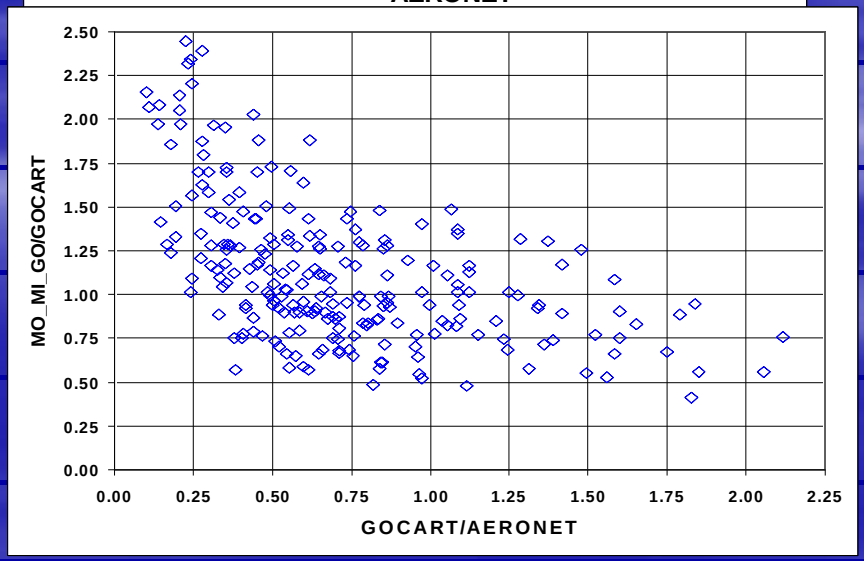




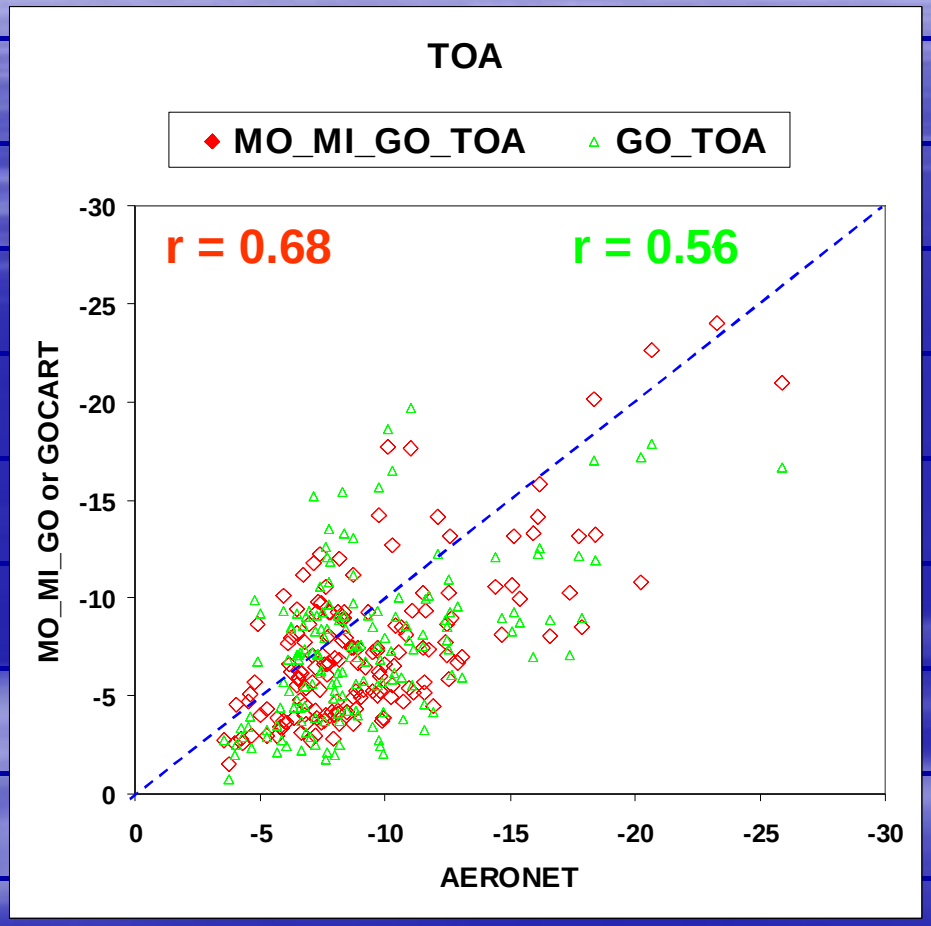
* Integration increases correlation;

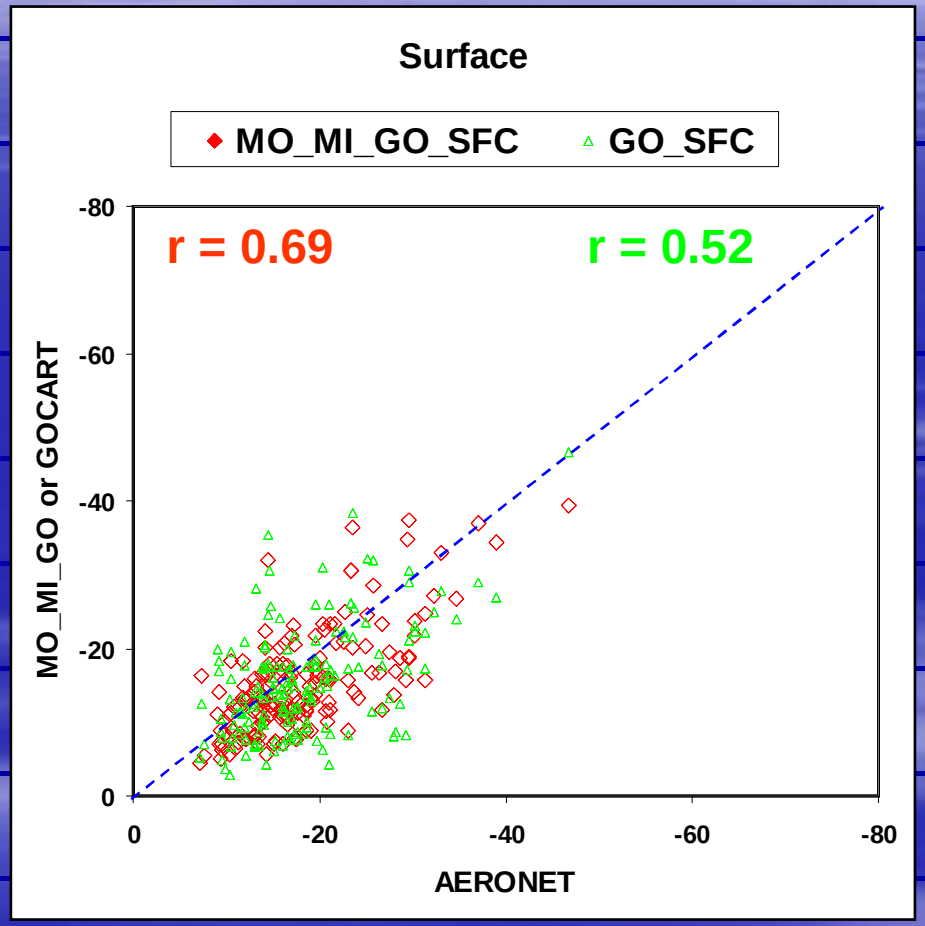
* Integration overall brings the direct effect estimates closer to AERONET measurements;

* Significant low biases. Part of them could result from mismatching between points and 2.5°x2° grids.

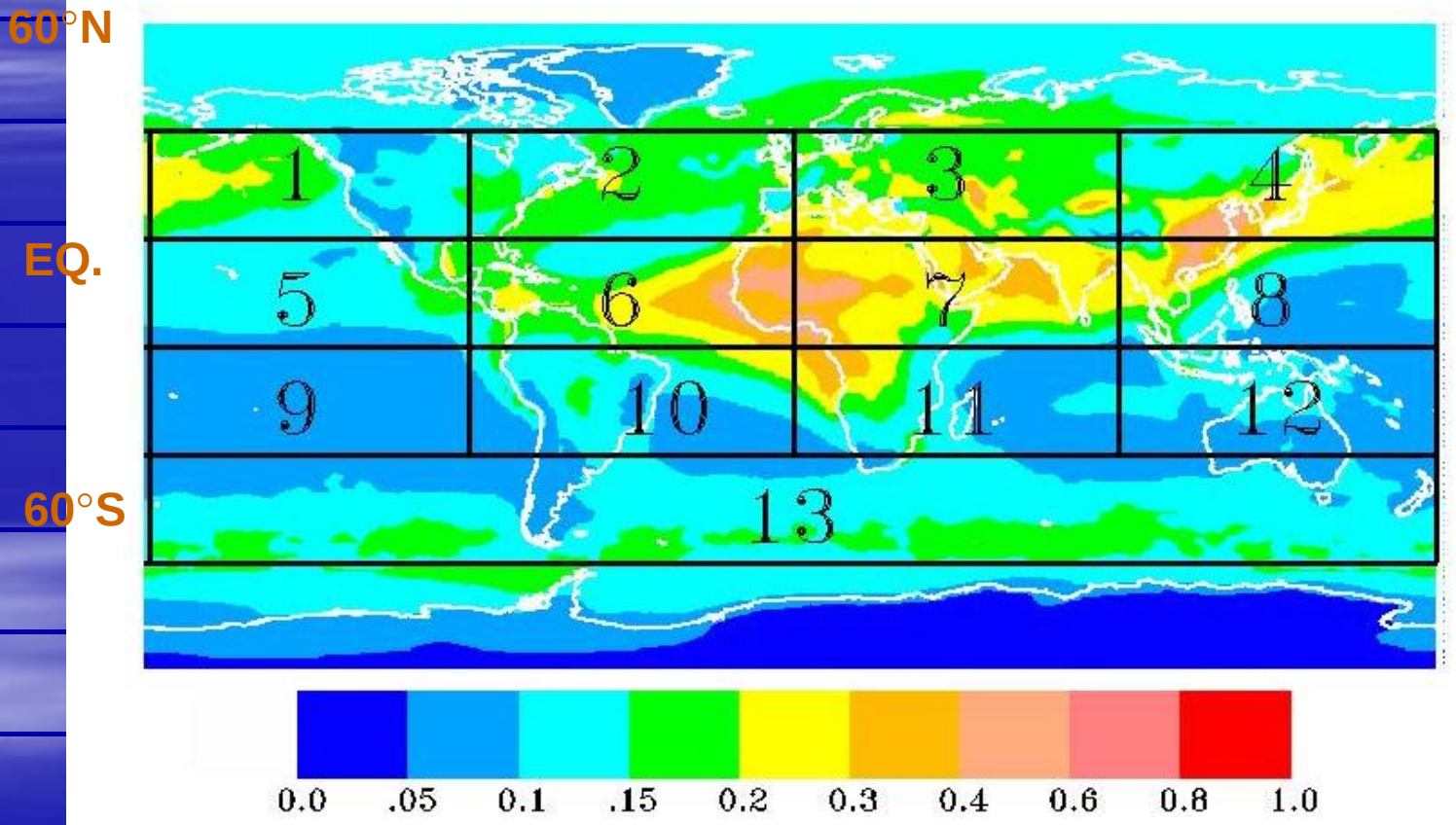


AOD < 0.4

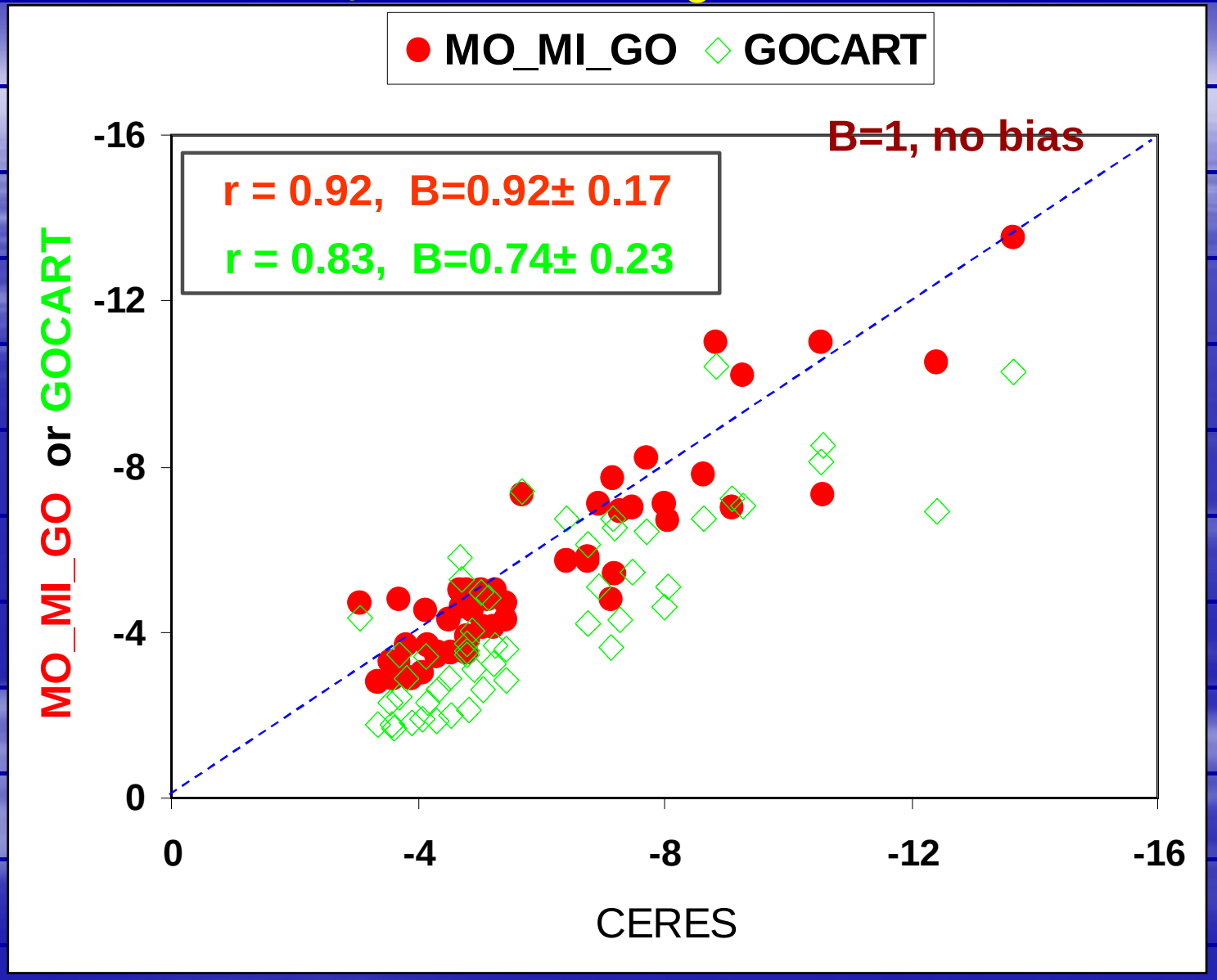

TOA
MO_MI_GO_TOA
GO_TOA
r = 0.68
r = 0.56
MO_MI_GO or GOCART
AERONET
-30
-25
-20
-15
-10
-5
0


Surface
MO_MI_GO_SFC
GO_SFC
r = 0.69
r = 0.52
MO_MI_GO or GOCART
AERONET
-80
-60
-40
-20
0

Seasonal averages over 13 zones (Land & Ocean separately)

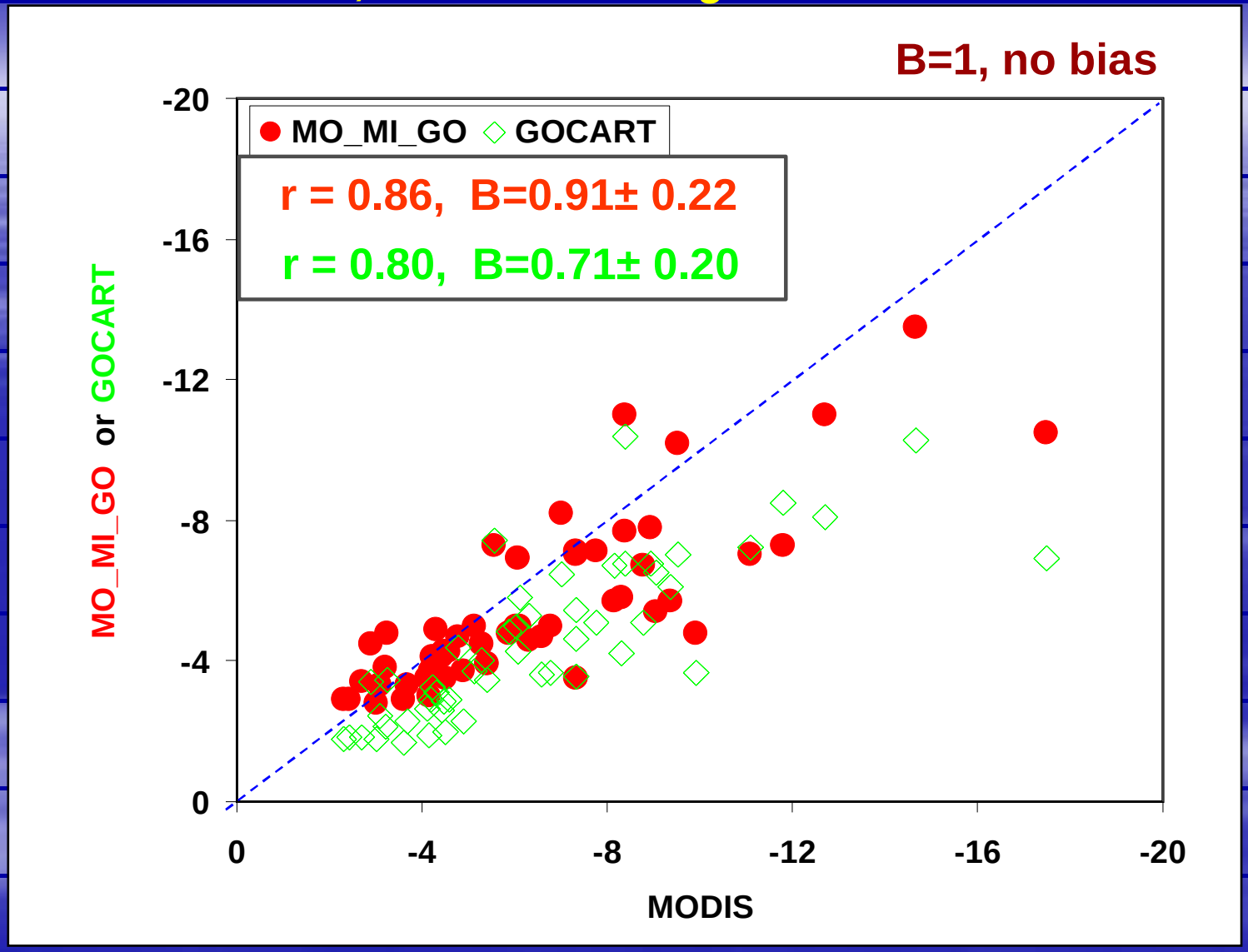


13 oceanic zones, seasonal averages of TOA aerosol effect



CERES flux + MODIS aerosol: *Loeb & Manalo-Smith, 2005*

13 oceanic zones, seasonal averages of TOA aerosol effect



MODIS AOT + MODIS aerosol models: *Remer & Kaufman, 2005*

Summary

- Integrating MODIS *(ocean)* and MISR *(land)* measurements of optical depth into GOCART simulations increases the GOCART clear-sky direct effect estimate by ~20%.

- The integration can improve the agreement with measurement-based estimates of aerosol direct effect, including AERONET, MODIS, and CERES.