Comparison of Aerosol Absorption AOD with AERONET ground data

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Introduction

- Absorbing aerosols increase atmospheric absorption and reduce solar radiation reaching the surface. They can have impacts on both the global and regional climate.
- *Sato et al.* [2003] compared the absorbing AOD in the GISS and GOCART model with the AERONET data. The results suggested that both model underestimated the absorption AOD by factor of 4-2.

Model data

- Monthly average aerosol column burden in 1° x 1° for Experiment A ("as it is").
- Model data only provide total black carbon, total organic carbon and lumped dust masses.
- Refractive indices at 440, 670, 870 and 1020 nm, and aerosol density for each species were provided by each model.
- Absorption AOD were computed for black carbon, organic matter and dust.

AERONET ground data

- Monthly average AERONET absorption AOD from January 1993 to June 2004 at 440, 670, 870 and 1020 nm were used.
- Data points with monthly average absorption AOD > 0.01 were selected. Seasonal and annual average at each site were derived based on available months.
- Model data were selected only if the AERONET data were selected.

Experiment I

	r_g μm	σ	r_{eff} μm	ρ g m^{-3}	N 440 nm	N 1020 nm
BC	0.012	2.0	0.040	1.0	1.75-0.46i	1.75-0.44i
OM	0.021	2.2	0.10	1.8	1.53-0.005i	1.52-0.016i
Dust	0.01	1.4	0.013	2.6	1.53-0.003i	1.53-0.001i
	0.045	1.6	0.078	2.6	1.53-0.003i	1.53-0.001i
	0.275	2.5	2.24	2.6	1.53-0.003i	1.53-0.001i

BC and OM refractive indices and sizes are from GADS data set.

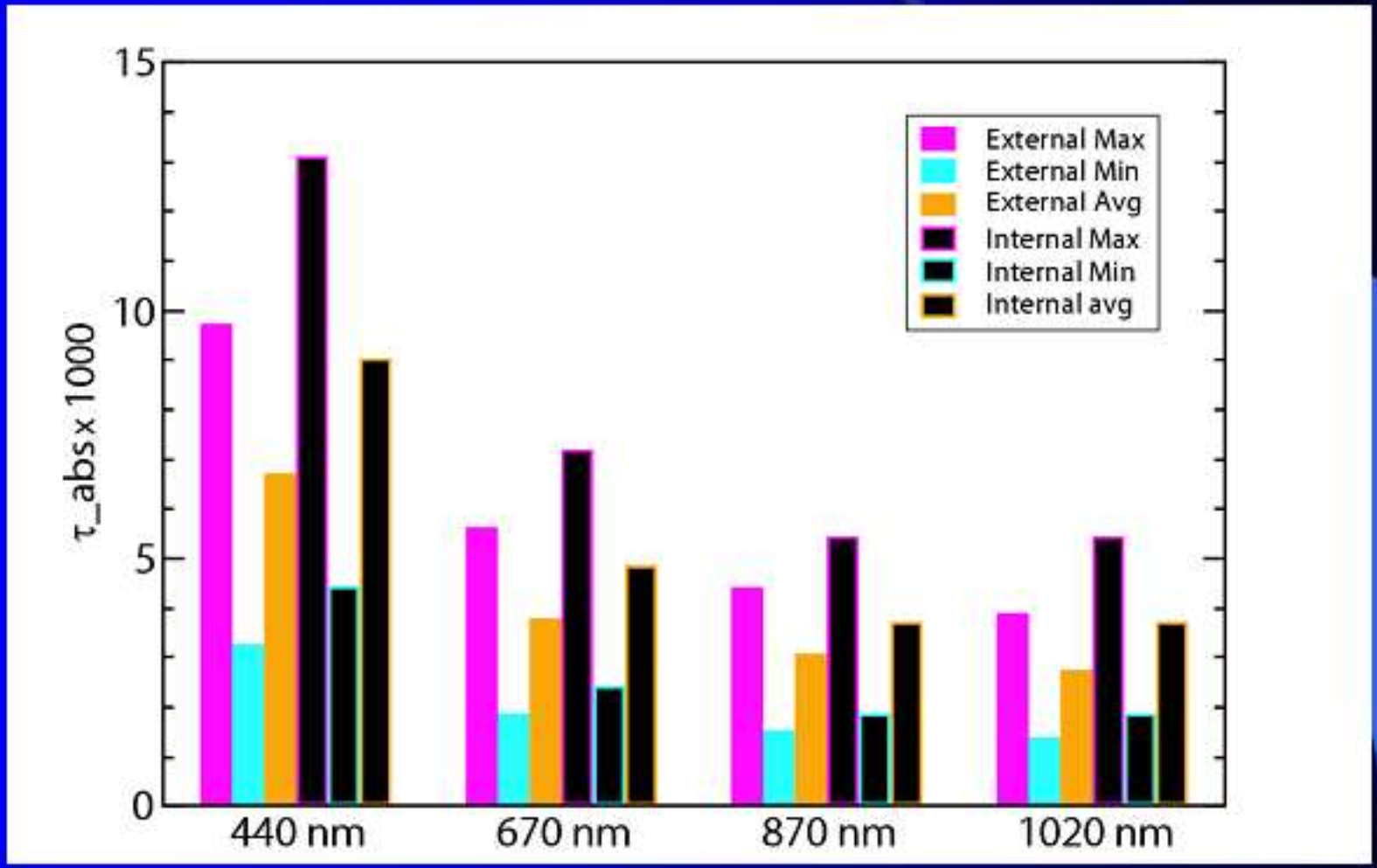
Dust size distribution are from de Reus et al. 2000.

Dust refractive indices are base on AERONET retrievals.

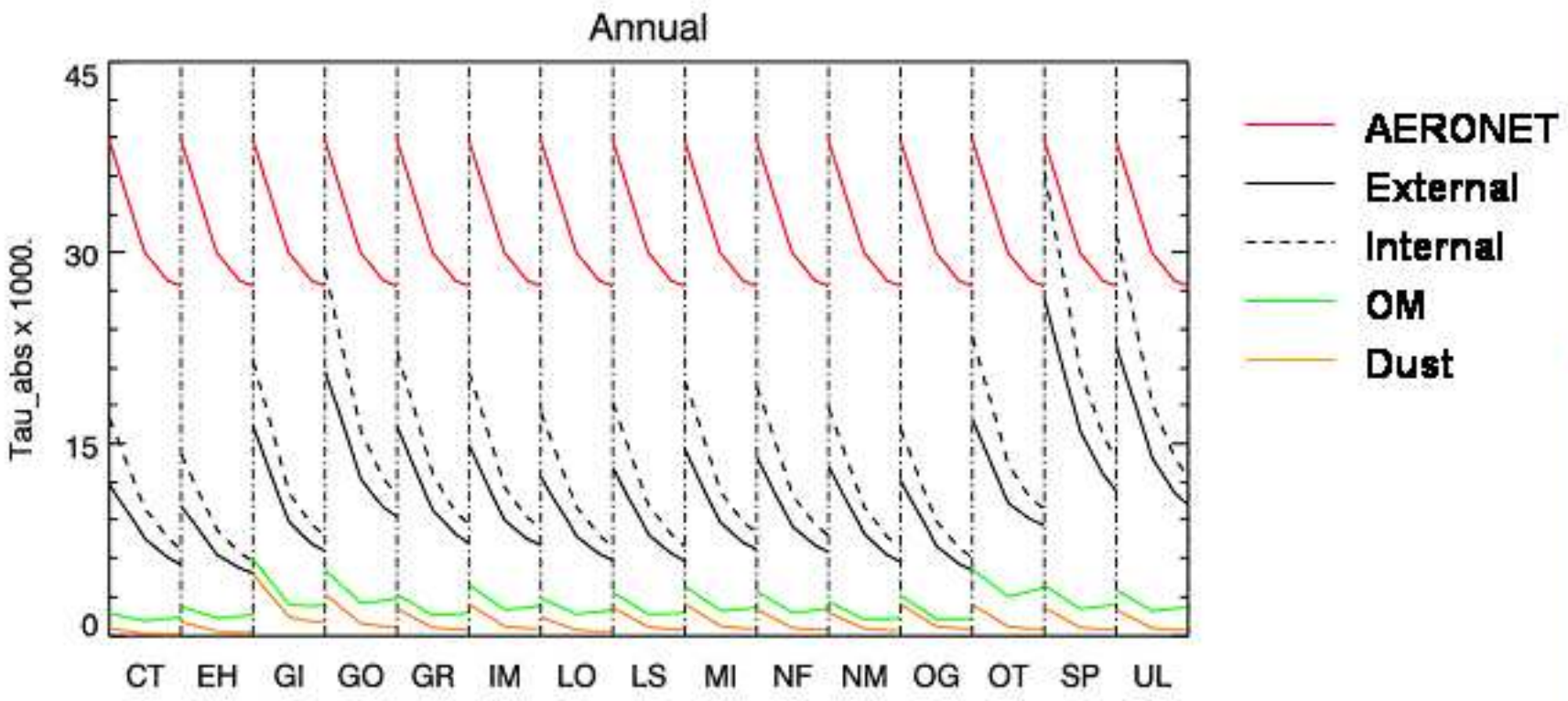
Experiment I (cont)

- OM=1.4*OC
- RH=75%
- A dust size distribution is forced on the lumped dust mass. Using bin segregated dust mass and optical properties results in a difference of 5-20% globally for the GISS model.
- Experiment I.a assumes externally mixed BC, OM and dust.
- Experiment I.b assumes internally mixed BC and OM, and externally mixed dust.

Global Annual Average τ_abs*1000



Annual Average τ_abs*1000 at AERONET sites.

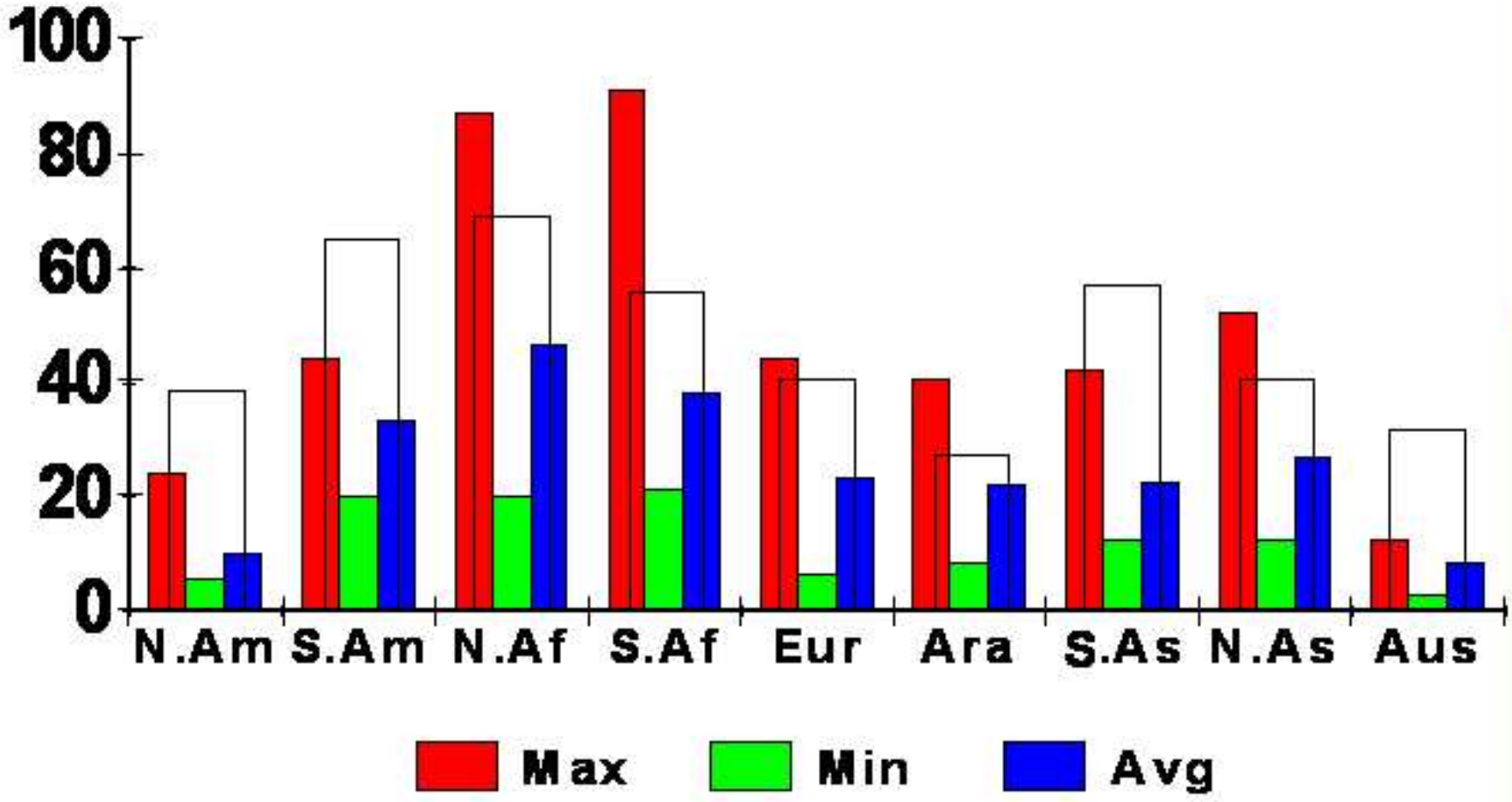


CT:ARQM EH:ECHAM5 GI:GISS GO:GOCART GR:GRANTOUR

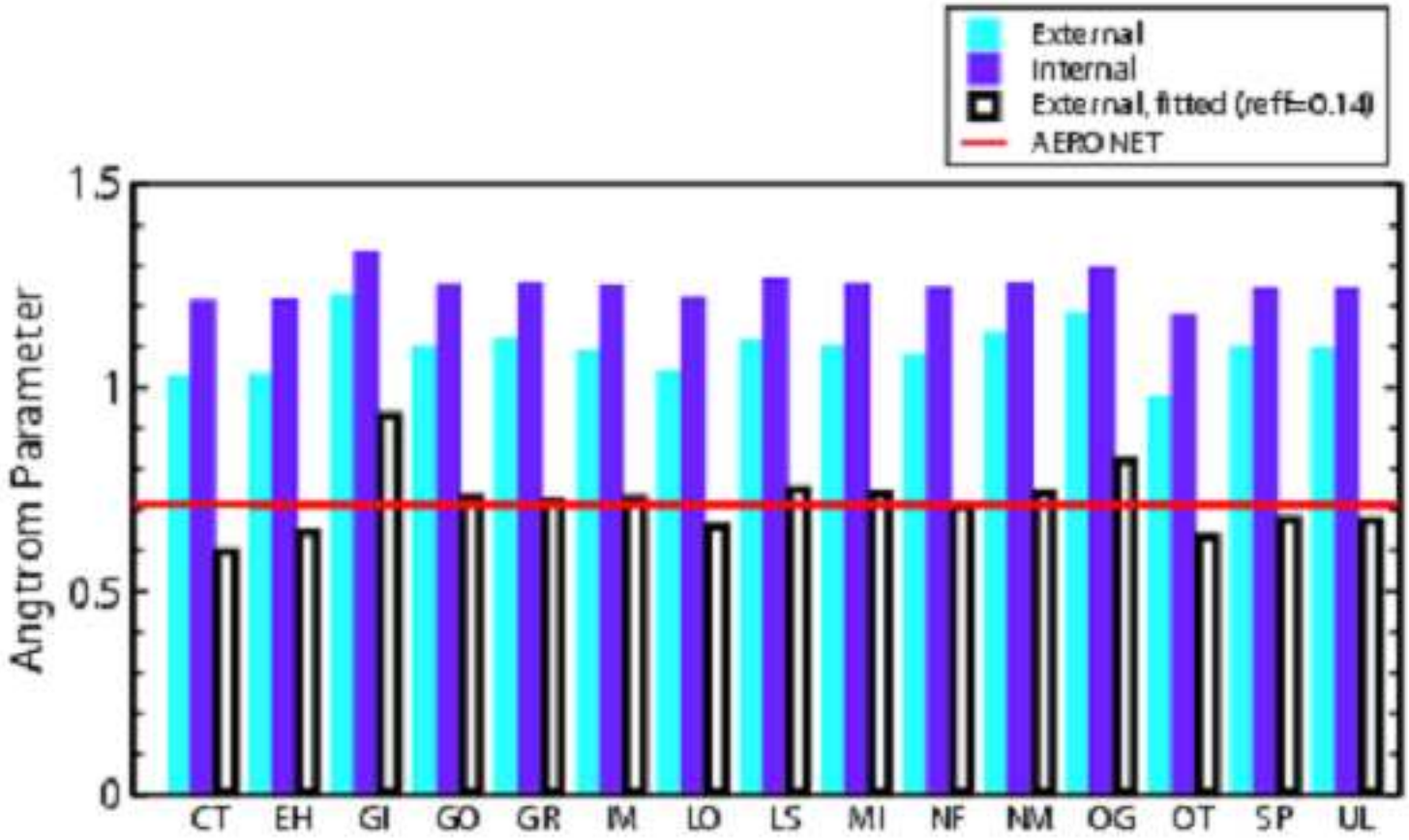
IM:IMPACT LO:LOA LS:LSCE MI:MIRAGE NF:NCAR_MATCH

NM:NCAR_MOZART OG:OSLO_GCM OT:OSLO_CTM SP:SPRINT UL:ULAQ

Annual Average τ_abs*1000 at 440 nm in nine different regions.



Angstrom Parameter for τ_{abs}



Experiment II

- OM=1.4*OC
- RH=75%
- Optical properties were computed using the refractive indices, aerosol density provided by each model.
- Size distributions for each aerosol species are the same as in Experiment I.
- Assuming external mixing for all aerosol species.

Refractive Indices at 500 nm

CT	EH	GI	GO	GR	IM	LO	LS	MI	NF	NM	OG	OT	SP	UL
Black Carbon														
1.75	1.75	1.56	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	2.0	1.75*	1.75	2.07
.44	.45	.50	.45	.45	.45	.45	.45	.45	.45	.45	1.0	.45*	.45	.6
Organic Carbon														
1.53	1.53	1.56	1.53	1.53	1.53	1.53	1.53	1.55	1.53	1.53	1.53	1.53*	1.38	1.6
.006	.0055	.04#	.005	.005	.005	.005	.005	0.0	.005	.005	.005	0.0*	.003	.0035
Dust														
1.53	1.52	1.56	1.53	1.53	1.53	1.48	1.48	1.5	1.56	1.53	1.53	1.48	1.53	1.56
.0055	.0012	.0018	.0019	.0014	.0014	.0016	.0033	.002	.0014	.0028	.0078	.0013	.002	.006

CT: CANADA_ARQM EH: ECHAM5 GI: GISS GO: GOCART
GR: UM_Grantour IM: UM_IMPACT LO: LMDzT-LOA LS: LSCE
MI: PNNL_MIRAGE NF: NCAR_Match NM: NCAR/GFDL_Mozart
OG: OSLO_GCM OT: OSLO_CTM SP: SPRINT UL: ULAQ

Aerosol density (g/m^3)

CT	EH	GI	GO	GR	IM	LO	LS	MI	NF	NM	OG	OT	SP	UL
Black Carbon														
1.5	1.	1.3	1.	1.	1.	1.	1.55	1.	1.	1.	2.0	1.0*	1.25	1.
Organic Carbon														
1.3	1.8	1.5	1.8	1	1	1.8	1.5	1.7	1.8	1.4	1.8	1.3*	1.47	2.
Dust														
2.65	2.6	2.	2.6	2.5	2.5	2.6	2.65	2.65	2.6	2.6	2.6	2.6	2.6	2.5

* Fossil Fuel BC or OC only; assuming1.35 g/m^3 for biomass smoke.

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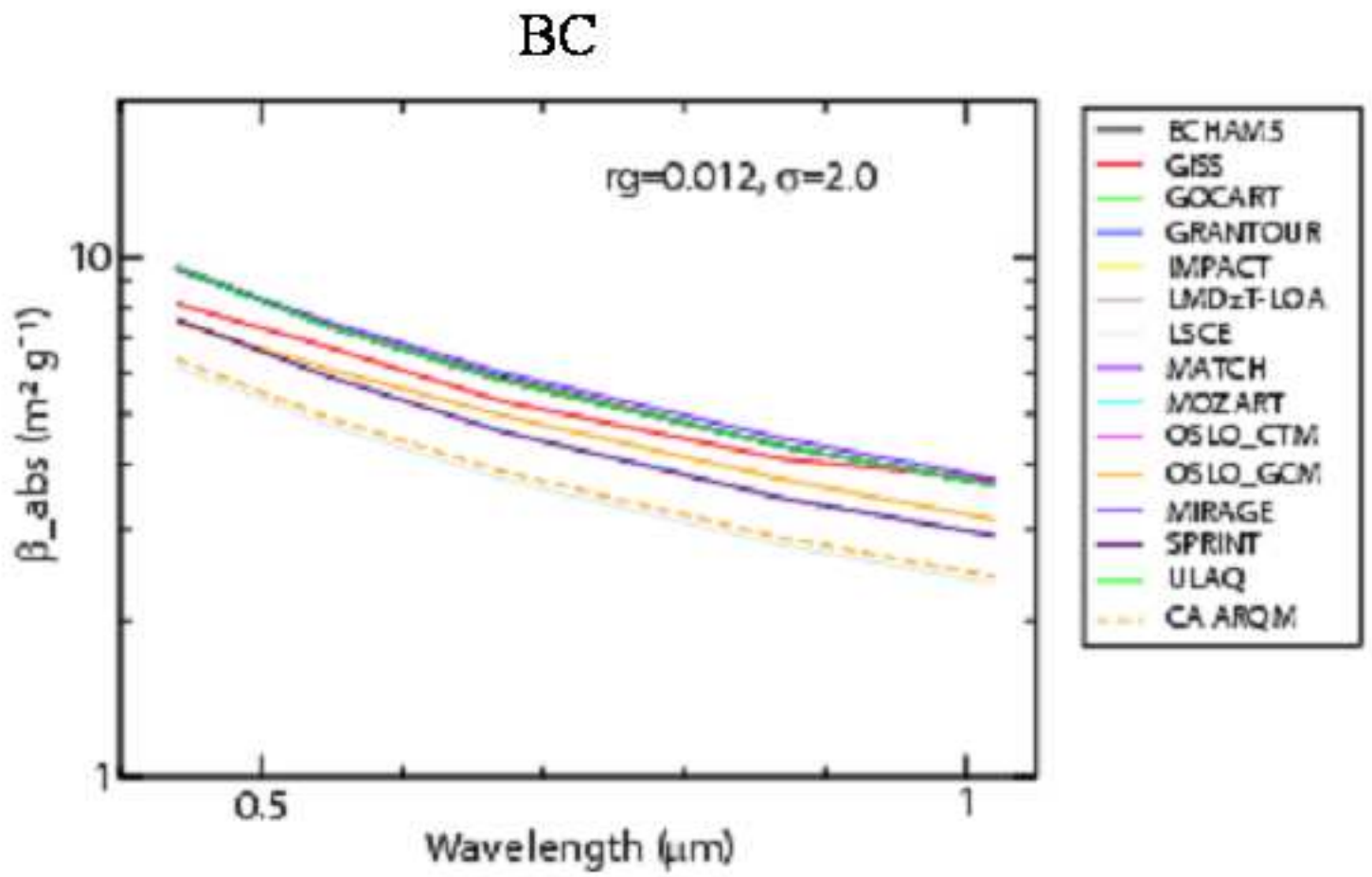
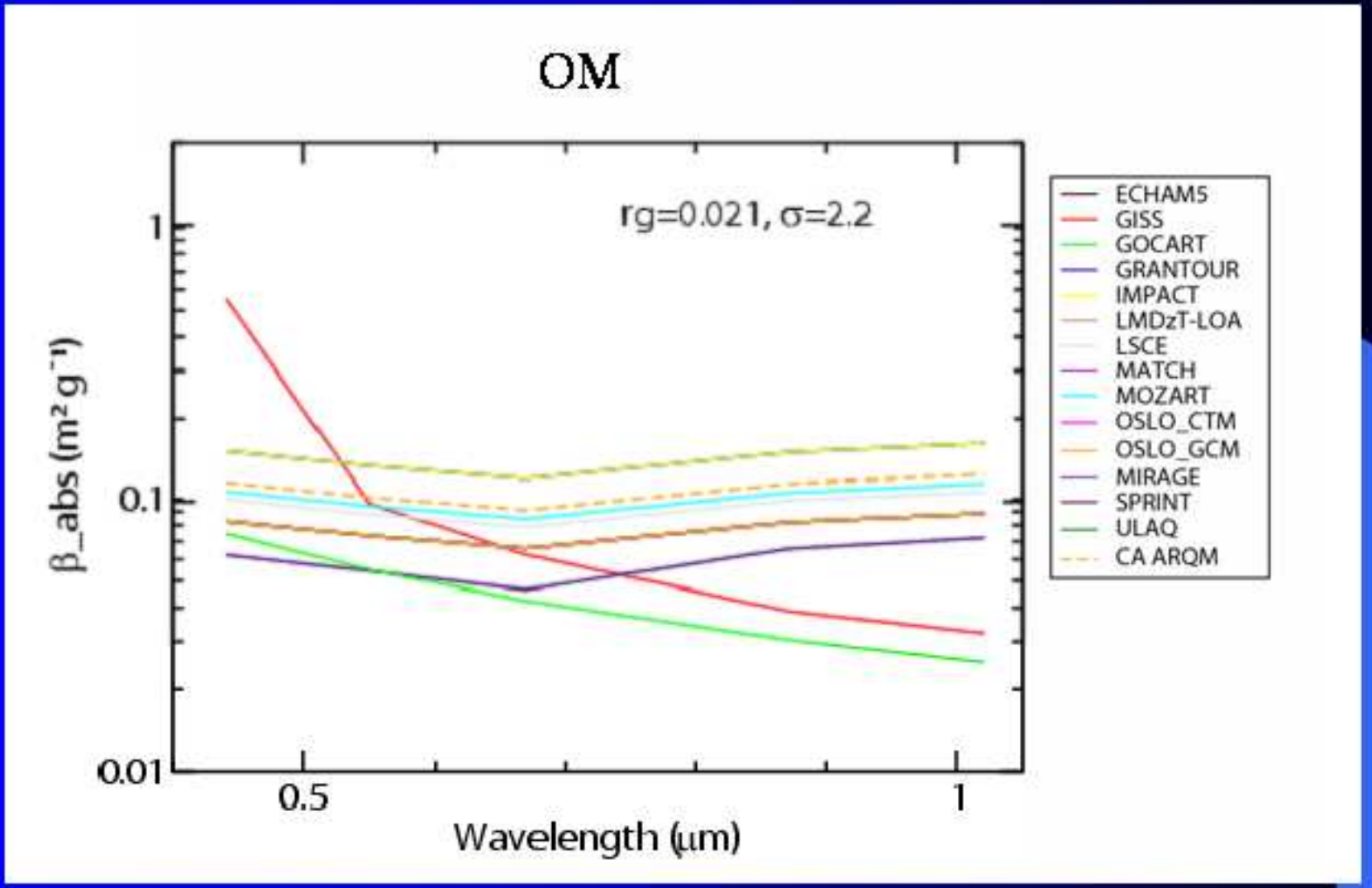
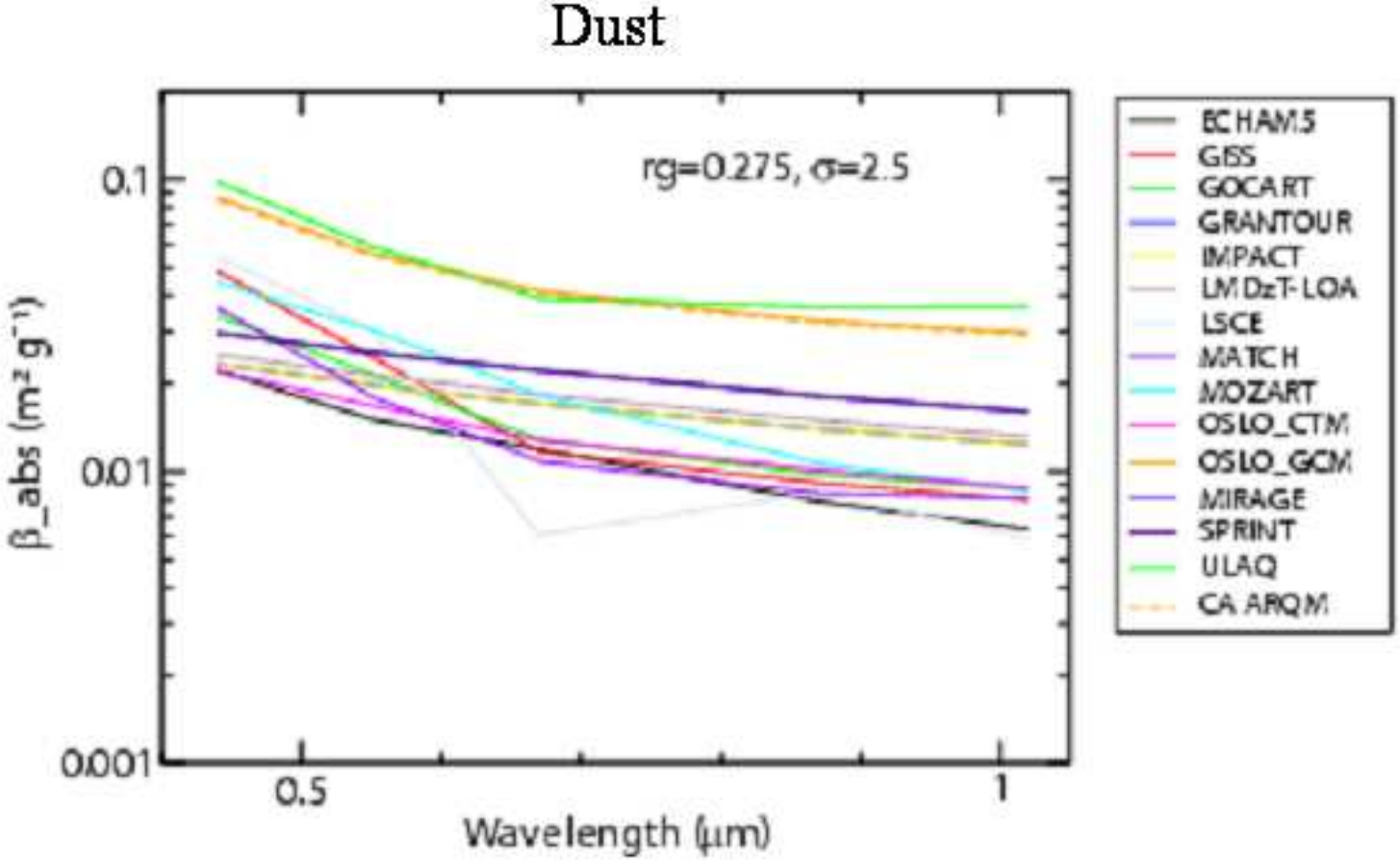
Mass Absorption Efficiency (m^2 /g)



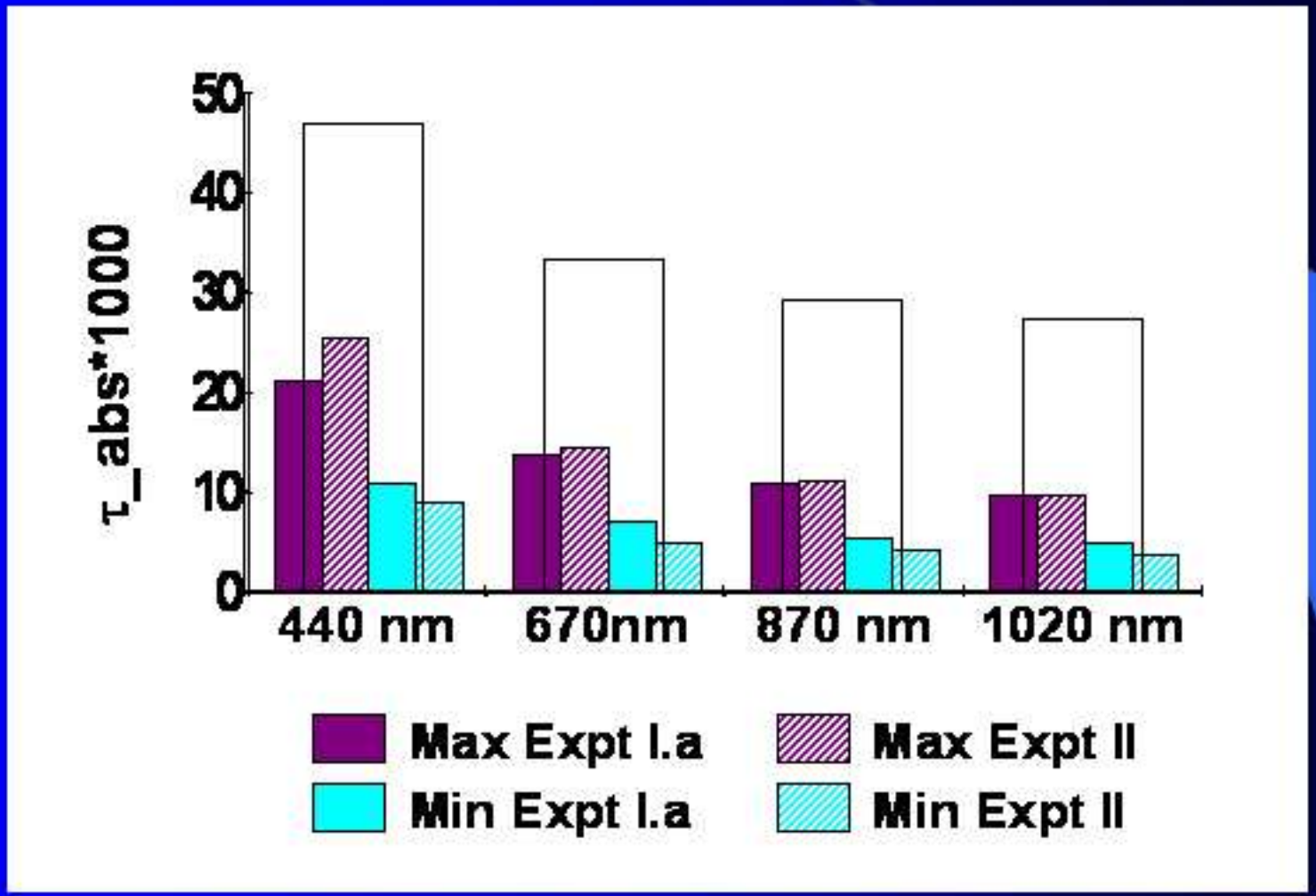
Mass Absorption Efficiency (m^2 /g)



Mass Absorption Efficiency (m^2 /g)



Annual Average τ_abs*1000.



Conclusion

- The annual global average absorption AOD differs by a factor of 2.3-2.5 at all wavelengths among models if a set of fixed aerosol optical properties are used.
- In Expt I.a and Expt II, models underpredict absorption AOD by a factor of 1.8 to 4.4 at 440 nm. The underprediction is larger at 1020 nm.
- The two largest underpredictions occur in North America and Australia.

Conclusion

- Internal mixed BC and OM results in a higher absorption AOD (20% - 35%), but still can not explain the discrepancy between model results and observations.
- Modeled Ångström parameter is 1.0, compared to 0.7 in observations. Increasing BC effective radius to 0.14 μm gives the best match between observations and models.