Status of phase III CTRL

Overview of Glïß et al., 2020 paper

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Phase III Control reference paper

AeroCom phase III multi-model evaluation of the aerosol lifecycle and optical properties using ground and space based remote sensing as well as surface in situ observations

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Under revision in ACP:

https://acp.copernicus.org/preprints/acp-2019-1214/

⇨ ***Revised manuscript available in AeroCom workshop material***

Overview

- 14 models participating in the AeroCom Phase III CTRL experiment have been worked up and evaluated in a new reference paper.
- Detailed information about the models has been collected, see here.
- ***Part 1:*** Aerosol lifecycle and inter-model diversity have been assessed and compared with Phase I (AP1) simulations.
- ***Part 2:*** Simulated optical properties have been evaluated against observations
  - Column optical properties (total, fine and coarse AOD, Angstrom Exponent) against ground and space based observations from AERONET, AATSR, MODIS and a merged satellite AOD dataset.
  - For the first time, models were evaluated against measurements of surface in situ dry scattering and absorption coefficients from GAW observation sites.
  - *Details & Discussion: see talk of B. Andrews in breakout session 1*

Some results (from the ensemble median)

- ***Absorption?*** BC burden and optical depth (OD) decreased by almost 50% compared to AP1.
- ***Natural aerosol?*** Relative AOD contribution of sea salt and dust shifted from approximately equal to ⅔ in AP3 compared to AP1
    - Documented emission parameterisation, resolution, lifetime changes.
    - Dust too fine but likely less fine than in AP1 → DU MEC overestimated?
    - Sea salt smaller and longer lived, possible implications for water uptake, scattering enhancement, cloud optical properties and lifetime.
- Ensemble underestimates all optical properties investigated
    - Coarse AOD and surf. scattering most underestimated → natural aerosol, sea salt water uptake
    - Fine AOD bias ca -15% → direct forcing underestimated?
    - Ambient Angstrom Exponent (AE) slightly underestimated → Difficult to interpret (see discussions below)
- Correlations with observations are fairly high

  → models capture spatio-temporal variability better than magnitude.

ToDo's - proposed activities

- Follow up studies should investigate the individual issues in more detail, e.g.,
- Incorporate pre-industrial state and link aerosol forcing to results
- Link to CMIP6 simulations (e.g., AOD biases)
- Closure: Incorporate more measurements, model diagnostics and dimensions, e.g.,
  - Surface mass concentrations of e.g., BC, SO_4, SS (sodium), SO_2, OC
    → are we missing mass or underestimating MECs?
  - Surface AE, SAE and AAE (additional diagnostics required)
  - Column AAOD from AERONET (link surface with column absorption)
  - Extinction / backscatter profiles from LIDAR or Ceilometer observations
  - Aircraft data (e.g., HIPPO campaigns)
- Some of this has been done already (preliminary), see here, e.g.,
  - Most models underestimate BC and SO_4 mass conc. (mostly European sites).
  - However, SO_2 tends to be overestimated → too inefficient conversion of SO_2 → SO_4 ?
  - Many models highly overestimate sea salt mass conc. over Europe.

Aerosol lifecycle diversity

- Documented speciated *Emissions, lifetimes, mass burdens, MECs & MACs and resulting optical depths (ODs)*
- Comparison with AeroCom phase I (AP1) simulations (Kinne et al., Textor et al., 2006)

Some findings

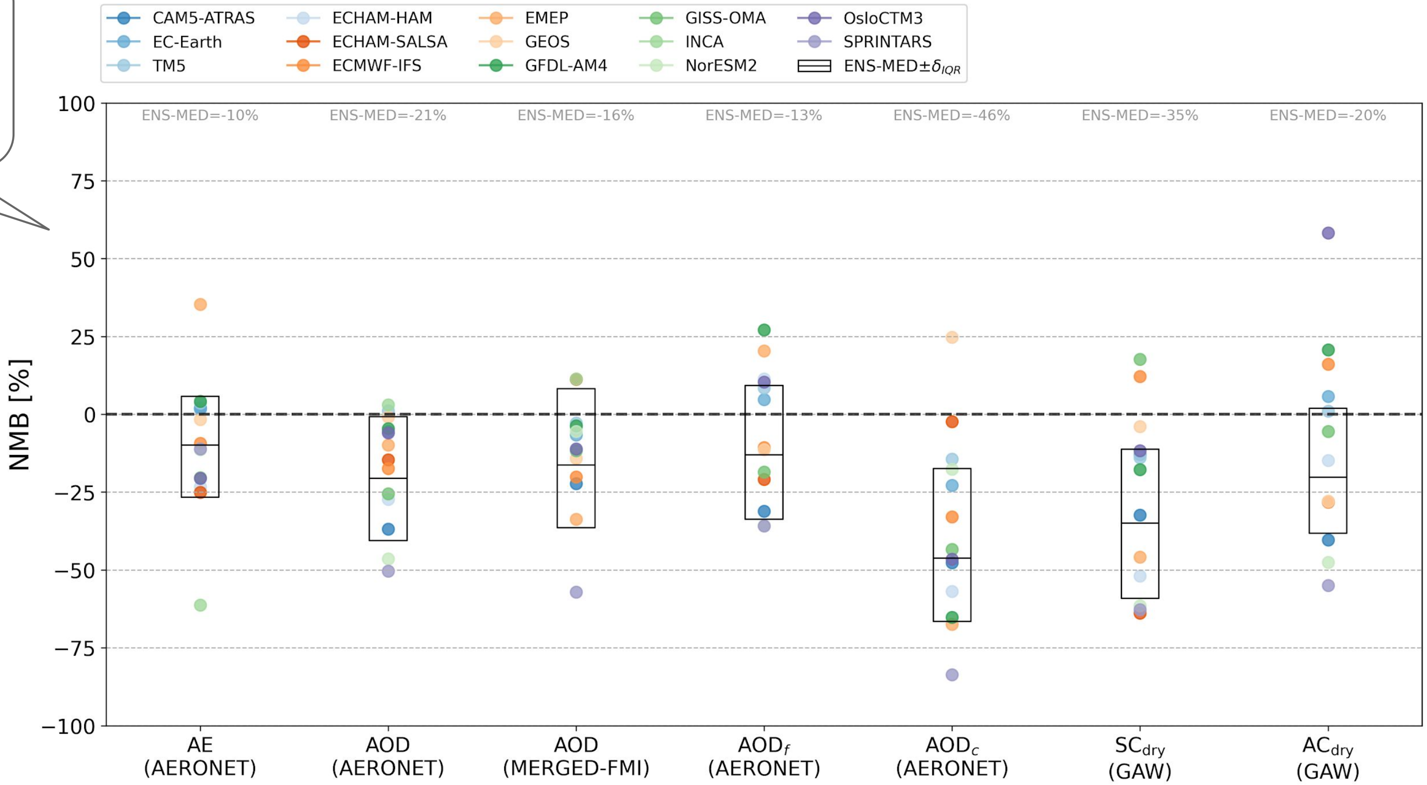
- Considerable diversity in all parameters (lot's of blues and reds)
- BC lifetime decreased from 6.5 to 5.5 days (still too large, Samset et al., 2014).
- BC burden decreased by almost 50% → underestimate of surf. abs. (see *B1_AndrewsB*).
- Natural OD: relatively more SS than DU in AP3.
- Species ODs more diverse than total AOD (like in AP1).
  → indeed, total AOD shows overall lowest diversity.
- Very large diversity in new NO3 tracer.

		CAM5-ATRAS	EC-Earth	TM5	ECHAM-HAM	ECHAM-SALSA	ECMWF-IFS	EMEP	GEOS	GFDL-AM4	GISS-OMA	INCA	NorESM2	OsloCTM3	SPRINTARS	MED (AP3 (this study))	δ_{IQR} (AP3 (this study))	δ_{std} (AP3 (this study))	MED (AP1)	δ_{std} (AP1)
"Emissions" [Tg/yr]	BC (↑)	9.5	9.7	9.7	9.8	9.8	9.6	8.4	9.7	9.7	9.7	9.7	9.7	9.1	9.7	9.7	0.4%	3.8%	11.3	23%
	DU (↑)	1930	848	1120	1170	1380	5650	1640	1480	1360	1400	1560	1090	2150	1880	1440	42%	64%	1640	49%
	NO_3 (↓)	20.2	6.2	5.4			101.0	109.0	128.0		11.1	44.8				32.5	286%	90%		
	OA (↓)	117.0	108.0	108.0	69.2	76.6	160.0	246.0	158.0	170.0	75.6	48.0	177.0	114.0	134.0	116.0	64%	40%	96.0	26%
	POA (↑)								62.0	71.2			81.5	77.9		74.6				
	SO_4 (↓)	156.0	142.0	146.0	218.0	216.0	122.0	94.3	95.3	110.0	122.0	144.0	124.0	188.0	240.0	143.0	41%	30%	186.0	22%
	SS (↑)	5090	6640	6620	5920	4160	5e+04	2030	5300	7100	2760	4030	3450	4880	3650	4980	54%	150%	6280	199%
Lifetime [d]	BC	4.5	8.7	8.4	6.4	9.6	3.9	2.9	4.1	5.9	4.2	5.5	6.4	4.4		5.5	41%	35%	6.5	33%
	DU	3.0	3.9	4.0	6.0	7.0	1.4	3.2	5.4	3.5	5.3	4.5	1.9	3.4	2.2	3.7	56%	39%	4.0	43%
	NO_3	3.0	9.9	10.4			2.5	3.1	2.7		4.7	5.4				3.9	94%	58%		
	OA	6.1	9.3	8.8	6.0	8.2	4.3	4.3	4.6	4.5	6.3	6.0	6.2	5.3	3.4	6.0	29%	29%	6.2	27%
	SO_4	3.3	6.7	7.0	4.3	5.0	3.1	2.6	4.9	6.3	4.2	4.9	4.9	5.3	1.8	4.9	36%	32%	4.1	18%
	SS	0.61	0.36	0.41	0.63	1.51	0.19	0.50	0.67	0.45	1.09	3.13	1.02	0.46	0.24	0.56	92%	91%	0.41	58%
Burden [Tg]	BC	0.119	0.231	0.224	0.174	0.260	0.104	0.068	0.105	0.157	0.111	0.143	0.171	0.117	0.119	0.131	46%	36%	0.210	42%
	DU	16.1	9.1	12.3	19.5	17.1	22.3	14.3	21.9	12.9	20.5	19.4	5.7	20.1	11.7	16.6	45%	31%	20.5	40%
	NO_3	0.164	0.167	0.154			0.690	0.926	0.929		0.142	0.662		0.084		0.167	321%	78%		
	OA	1.95	2.73	2.61	1.14	1.71	1.87	2.87	1.98	2.07	1.30	0.79	2.99	1.65	1.24	1.91	57%	34%	1.76	27%
	SO_4	1.41	2.62	2.78	2.58	2.95	1.02	0.66	1.29	1.92	1.39	1.92	1.67	2.76	1.18	1.80	72%	39%	1.98	25%
	SS	8.6	6.5	7.5	10.3	10.2	26.4	2.8	9.8	8.8	8.3	10.9	9.7	6.2	2.5	8.7	38%	59%	6.4	54%
OD	BC	0.002	(0.003)	(0.002)	(0.002)	(0.003)	0.002	(0.001)	0.002	0.004	0.003	(0.001)	0.002	0.002	0.001	0.002	20%	33%	0.004	45%
	DU	0.013	0.022	0.029	0.031	0.025	0.020	0.011	0.026	0.019	0.021	0.031	0.019	0.024	0.017	0.021	32%	27%	0.032	42%
	NO_3	0.002	0.003	0.002			0.005	0.010	0.007		0.005	0.005		0.002		0.005	60%	57%		
	OA	0.016	0.041	0.036	0.013	0.018	0.017	0.035	0.027	0.031	0.014	0.009	0.029	0.011	0.034	0.022	82%	43%	0.018	34%
	SO_4	0.010	0.035	0.036	0.045	0.045	0.017	0.018	0.027	0.046	0.024	0.047	0.015	0.044	0.040	0.035	70%	39%	0.034	32%
	SS	0.060	0.029	0.033	0.058	0.065	0.048	0.015	0.036	0.040	0.059	0.061	0.078	0.038	0.013	0.044	60%	41%	0.030	41%
	H_2O	0.063	0.055	0.058	0.096	0.087							0.089	0.048	0.070	0.067	45%	24%		
	AOD (AS)				0.148		0.110	0.097	0.125	0.140			0.144	0.130	0.104	0.128	26%	14%	0.127	18%
	AOD (CS)	0.106	0.132	0.138	0.135	0.155					0.127	0.156	0.130		0.060	0.132	9%	22%		
MEC [m^2/g]	BC	10.2	(5.8)	(5.3)	(6.0)	(5.7)	9.4	(8.2)	10.5	11.9	13.7	(4.8)	7.1	13.4	3.7	10.3	34%	31%	9.1	35%
	DU	0.39	1.24	1.21	0.80	0.73	0.46	0.40	0.60	0.74	0.52	0.82	1.68	0.62	0.74	0.74	37%	45%	0.92	44%
	NO_3	5.2	8.1	8.1			3.8	5.5	3.9		18.2	4.2		9.7		5.5	71%	58%		
	OA	4.3	7.6	7.0	5.6	5.2	4.6	6.2	7.0	7.8	5.5	6.0	5.0	6.3	13.3	6.1	28%	33%	5.4	28%
	SO_4	3.8	6.9	6.6	8.8	7.7	8.2	13.8	9.2	12.3	8.9	12.5	4.7	8.2	17.2	8.5	52%	38%	9.0	54%
	SS	3.58	2.28	2.23	2.86	3.25	0.93	2.82	1.85	2.33	3.68	2.86	4.11	3.11	2.62	2.84	33%	28%	2.94	53%
MAC [m^2/g]	BC	9.1			(10.2)	(15.0)		(10.4)	7.8		10.0	(7.5)	3.2	13.0	3.1	8.5				
	DU	0.027			0.015	0.033			0.046		0.053	0.048	0.050	0.042	0.031	0.042	40%	31%		
	OA	0.163			0.080	0.112					0.274	0.142	0.265	0.110	0.122	0.132	58%	43%		

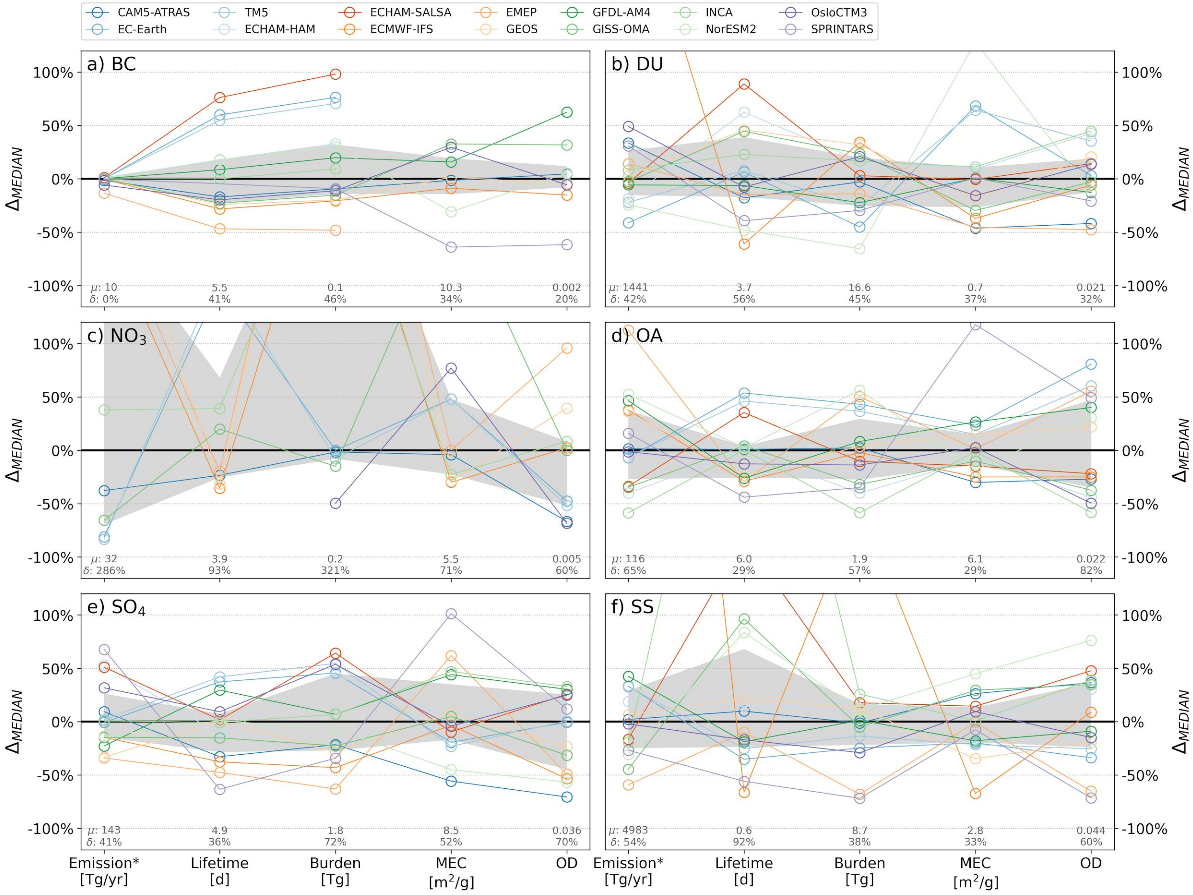
Δ_{MEDIAN}: 100%, 75%, 50%, 25%, 10%, -10%, -25%, -50%, -75%, -100%

Thank you

Details in talk of B. Andrews (breakout 1)



Aerosol lifecycle diversity



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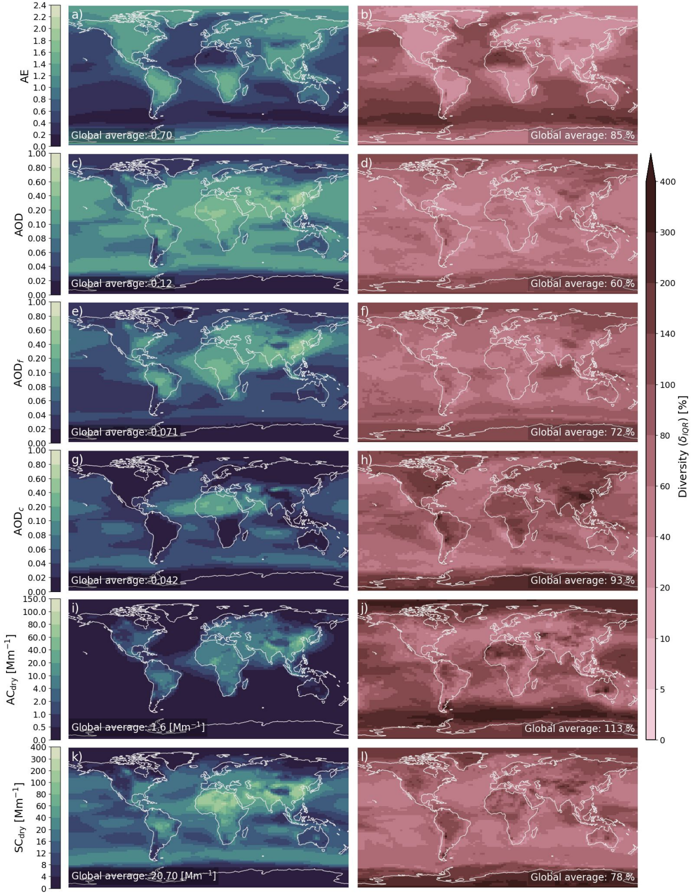
Aerosol lifecycle - regional diversity



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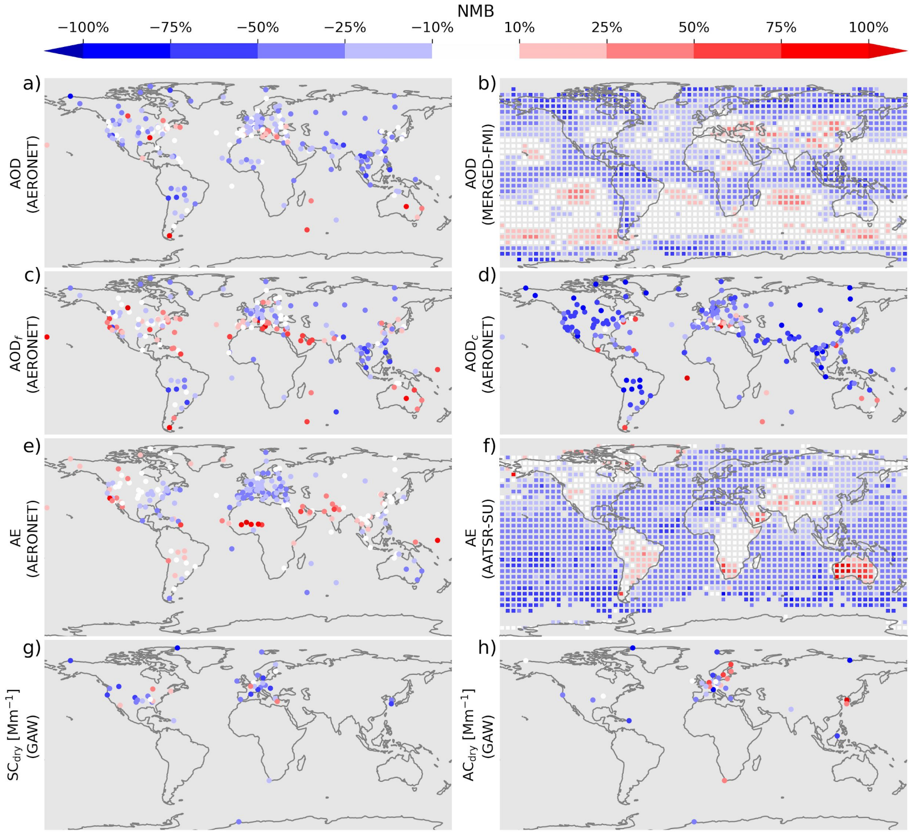
Ensemble median biases vs observations



Ensemble median 2010 biases vs different observations

Model biases and correlation compared to observations

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NMB [%]

	CAM5-ATRAS	EC-Earth	TM5	ECHAM-HAM	ECHAM-SALSA	ECMWF-IFS	EMEP	GEOS	GFDL-AM4	GISS-OMA	INCA	NorESM2	OsloCTM3	SPRINTARS	**ENS-MED**	**Q1**	**Q3**
AE (AERONET)	2	2	4	-23	-25	-9	35	-2	4	-20	-61	-11	-21	-11	-10	-27	6
AE (AATSR-SU)	-37	-2	1	-25	-30	-35	40	-22	-2	-43	-68	-34	-23	-9	-22	-44	-1
AOD (AERONET)	-37	-6	1	-27	-15	-17	-10	-1	-5	-26	3	-46	-6	-50	-21	-41	-1
AOD (MERGED-FMI)	-22	-7	-3	-4	11	-20	-34	-14	-4	-12	11	-6	-11	-57	-16	-36	8
AOD (MERGED-FMI-LAND)	-26	1	3	-31	-13	-15	-16	-1	2	-25	9	-26	0	-38	-17	-37	7
AOD (MERGED-FMI-OCN)	-19	-10	-5	11	25	-22	-43	-21	-7	-5	13	6	-17	-67	-15	-35	10
AOD (AATSR-SU)	-18	-5	-2	-6	12	-18	-34	-15	-8	-18	10	-9	-12	-55	-17	-37	7
AOD (MODIS-A)	-37	-22	-19	-21	-9	-35	-45	-28	-19	-26	-8	-22	-25	-64	-31	-48	-10
AOD (MODIS-T)	-42	-29	-26	-28	-17	-40	-49	-34	-26	-33	-16	-29	-32	-68	-37	-52	-18
AOD_c (AERONET)	-48	-23	-14	-57	-2	-33	-67	25	-65	-43		-18	-46	-84	-46	-67	-17
AOD_c (AATSR-SU)	-2	-20	-10	-28	24	15	-70	5	-54	-8		44	-39	-82	-27	-55	7
AOD_f (AERONET)	-31	5	8	11	-21	-11	20	-11	27	-19		-36	10	-36	-13	-34	9
AOD_f (AATSR-SU)	-28	4	3	20	3	-40	-11	-28	22	-24		-29	5	-38	-17	-39	8
SC_{dry} (GAW)	-32	-13	-14	-52	-64	12	-46	-4	-18	18		-62	-12	-63	-35	-59	-11
AC_{dry} (GAW)	-40	6	1	-15	-28	16	-28	-28	21	-5		-48	58	-55	-20	-38	2

R (Pearson)

	CAM5-ATRAS	EC-Earth	TM5	ECHAM-HAM	ECHAM-SALSA	ECMWF-IFS	EMEP	GEOS	GFDL-AM4	GISS-OMA	INCA	NorESM2	OsloCTM3	SPRINTARS	**ENS-MED**	**Q1**	**Q3**
AE (AERONET)	0.66	0.69	0.69	0.49	0.50	0.77	0.71	0.76	0.52	0.68	0.65	0.58	0.68	0.53	0.73	0.73	0.72
AE (AATSR-SU)	0.72	0.72	0.73	0.73	0.71	0.68	0.65	0.67	0.72	0.74	0.74	0.73	0.70	0.66	0.78	0.79	0.77
AOD (AERONET)	0.77	0.83	0.79	0.65	0.63	0.85	0.77	0.84	0.80	0.81	0.74	0.76	0.80	0.80	0.88	0.88	0.87
AOD (MERGED-FMI)	0.65	0.83	0.82	0.58	0.60	0.80	0.72	0.86	0.80	0.69	0.72	0.55	0.82	0.77	0.87	0.86	0.86
AOD (MERGED-FMI-LAND)	0.70	0.80	0.79	0.67	0.67	0.83	0.70	0.84	0.77	0.85	0.72	0.67	0.84	0.75	0.88	0.87	0.88
AOD (MERGED-FMI-OCN)	0.53	0.82	0.82	0.52	0.52	0.69	0.70	0.86	0.78	0.44	0.68	0.42	0.75	0.77	0.82	0.80	0.79
AOD (AATSR-SU)	0.66	0.75	0.75	0.49	0.57	0.82	0.73	0.85	0.79	0.74	0.70	0.57	0.83	0.77	0.85	0.84	0.83
AOD (MODIS-A)	0.57	0.79	0.79	0.53	0.53	0.71	0.68	0.81	0.77	0.64	0.66	0.49	0.76	0.71	0.80	0.78	0.80
AOD (MODIS-T)	0.55	0.78	0.76	0.52	0.51	0.69	0.66	0.78	0.76	0.63	0.63	0.49	0.74	0.70	0.78	0.76	0.78
AOD_c (AERONET)	0.73	0.61	0.62	0.39	0.48	0.79	0.69	0.73	0.71	0.78		0.48	0.78	0.67	0.80	0.78	0.80
AOD_c (AATSR-SU)	0.63	0.56	0.64	0.26	0.59	0.78	0.64	0.81	0.62	0.70		0.12	0.82	0.75	0.74	0.68	0.76
AOD_f (AERONET)	0.74	0.82	0.79	0.56	0.78	0.79	0.76	0.79	0.75	0.76		0.78	0.75	0.79	0.83	0.84	0.82
AOD_f (AATSR-SU)	0.68	0.85	0.81	0.53	0.62	0.81	0.74	0.83	0.83	0.76		0.79	0.77	0.79	0.85	0.86	0.85
SC_{dry} (GAW)	0.44	0.71	0.70	0.27	0.51	0.59	0.74	0.73	0.56	0.66		0.51	0.69	0.61	0.72	0.66	0.73
AC_{dry} (GAW)	0.60	0.68	0.72	0.80	0.79	0.81	0.79	0.75	0.63	0.69		0.80	0.74	0.62	0.75	0.72	0.71

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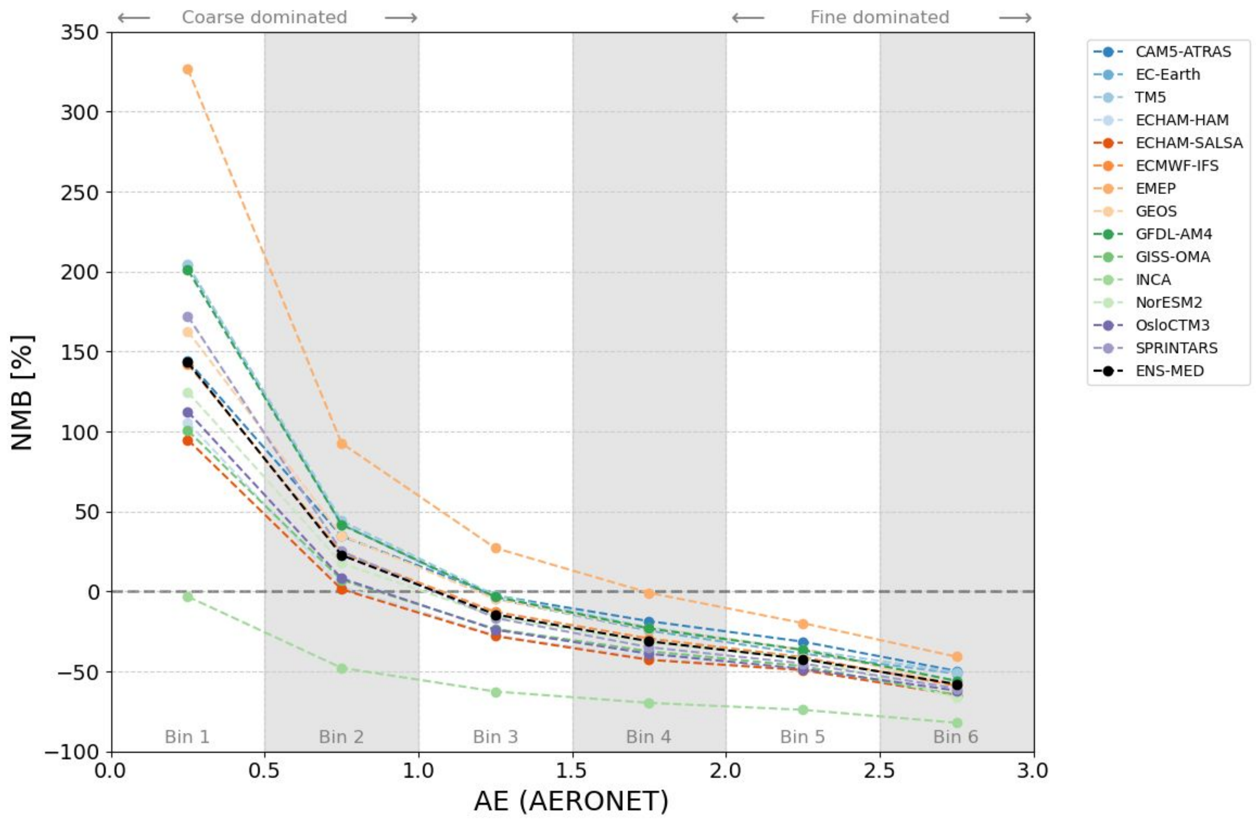
Model AE biases in different size regimes



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