Observations and Modelling in AeroCom

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Norwegian Meteorological Institute

16th AeroCom workshop, Helsinki, 9 Oct 2017

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AeroCom ?

AeroCom is an open international initiative of scientists interested in the advancement of the understanding of global aerosol properties and aerosol impacts on climate, weather, and air quality. **A central goal is to more strongly tie and constrain modeling efforts to observational data from satellite, ground-based, and aircraft observations.** A major element for exchanges between data and modeling groups are annual meetings of AeroCom together with the satellite data oriented initiative AeroSAT. In addition to the comparisons among models and between models and data, **AeroCom initiates and coordinates model experiments to target particular research topics, leading to joint research papers of synthesizing character**. **A common database is maintained at the Norwegian Meteorological Institute to facilitate joint scientific exploration**.

The major objectives of the 16th AeroCom meeting are to (1) update the outcome of the Phase III AeroCom model experiments, (2) formulate a new phase activities of modeling and analysis, and (3) discuss the near-term goal and directions.

AeroCom workshop program outline

Special thanks

Stefan Kinne, Mian Chin

Gerrit de Leeuw, Hannele Korhonen, Edith Rodriguez

- **Monday** sessions: Indirect effect, poster introductions A , Observational constraints on forcing, Discussion on forcing uncertainty
- **Tusday**: Finnish Aerosol Research Perspective (Harri Kokkola); Aerosol components (soluble, dust, water), discussion of recommendations for modelling; AeroCom Experiments; *Dinner*
- **Wednesday**: Dust, Remote Sensing, Forcing – *Excursion*
- **Thursday**: AeroCom wrap up; Overlap AeroCom Aerosat, Aerosat challenges and Poster intro II, Aerosat starts

AERO-SAT

AeroCom

Goals of AeroCom workshop

This year's key **AeroCom** topics are:

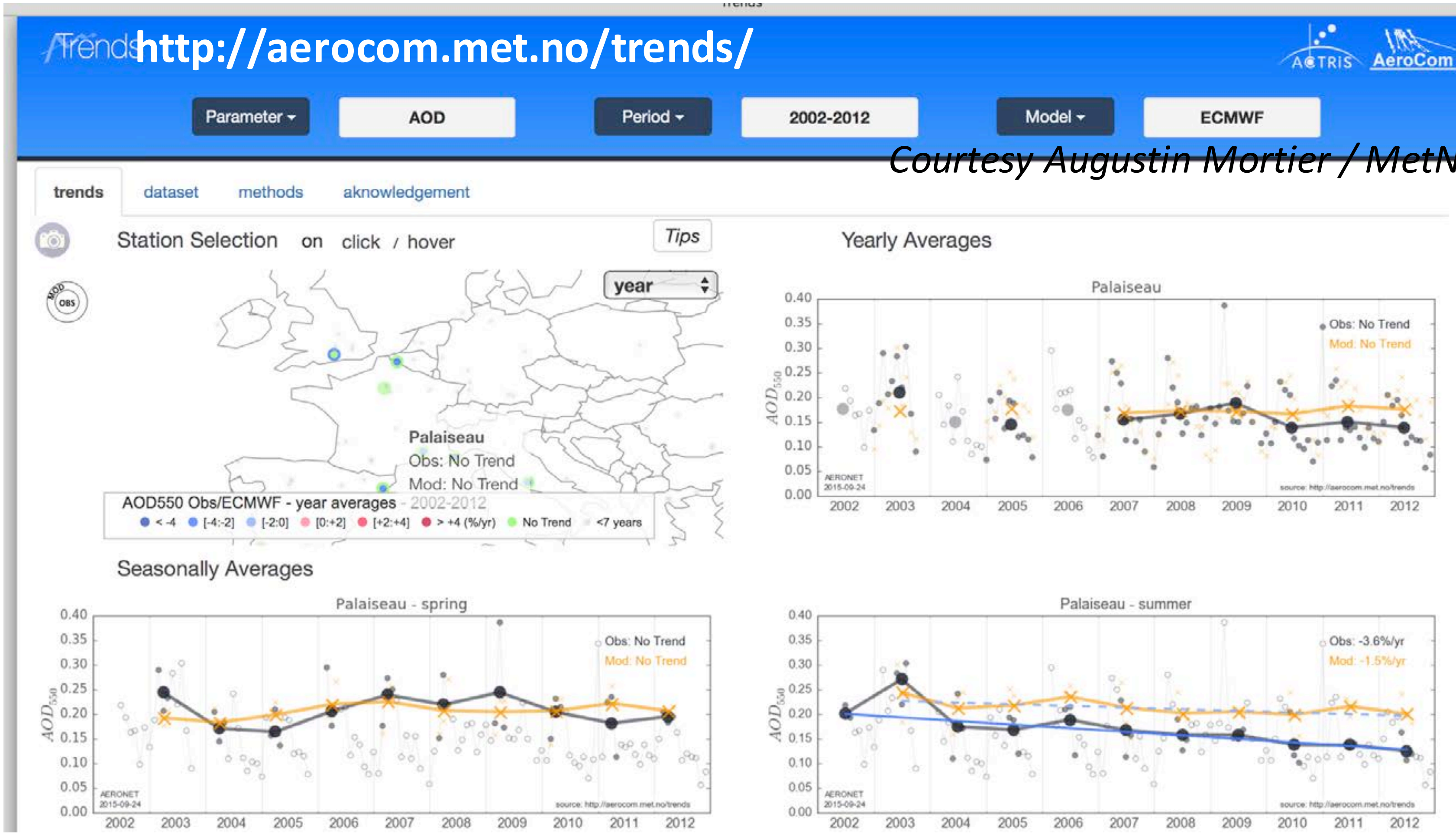
*- improved **evaluation strategies** for AeroCom models - recommendations for **best modeling practices** for different aerosol components - **emerging constraints** for global distributions and aerosol radiative effects - new **aerosol forcing** estimate (including aerosol cloud interactions) - **reference fields** from global modeling (e.g. model ensemble median maps) - examination and lesson learned from past/**ongoing model experiments** - **simulation** requirements (regular control) and new **plans** (hindcast, historical)*

State of AeroCom infrastructure 1/2

- 200 users have access to AeroCom users server
- AeroCom database new structure per phase and project
  - *0.7* - *2.5* - *1.5* TB AeroCom phases I – II – III
  - *0.04* - *0.03* – *1.1* TB AeroCom Indirect I - II – III
  - 0.11 – 8.2 TB HTAP phase I - II
  - 0.18 TB Satellite Data / 0.13 TB cci-Aerosol
  - 0.2 ACCMIP / 1.3 ECMWF / 0.8 ECLIPSE /
- **Backup, new postprocessing, provision for scalable data storage and new web server is now in place (took months..)**

AeroCom infrastructure 2/2

New visualization of station&model data
Expansion planned for sulfur trends, in-situ data,
comparison to multiple satellite/model data
Paper planned on S-trends, Optical trends and cci-aerosol trends…



Courtesy Augustin Mortier / MetNo

"AeroCom" publications 2016/2017

Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-1120, 2017
Manuscript under review for journal Atmos. Chem. Phys.
Discussion started: 10 February 2017

Atmospheric Chemistry and Physics Discussions

Aerosols at the Poles: An AeroCom Phase II multi-model evaluation

Maria Sand[1], Bjørn H. Samset[1], Yves Balkanski[2], Susanne Bauer[3], Nicolas Bellouin[4], Terje K. Berntsen[1,5], Huisheng Bian[6], Mian Chin[7], Thomas Diehl[8], Richard Easter[9], Steven J. Ghan[9], Trond Iversen[10], Alf Kirkevåg[10], Jean-François Lamarque[11], Guangxing Lin[9], Xiaohong Liu[12], Gan Luo[14], Gunnar Myhre[1], Twan van Noije[14], Joyce E. Penner[19], Michael Schulz[10], Øyvind Seland[10], Ragnhild B. Skeie[1], Philip Stier[15], Toshihiko Takemura[16], Kostas Tsigaridis[3], Fangqun Yu[13], Kai Zhang[17,9], Hua Zhang[18]

Atmos. Chem. Phys., 17, 2709–2720, 2017
www.atmos-chem-phys.net/17/2709/2017/
doi:10.5194/acp-17-2709-2017

Atmospheric Chemistry and Physics

Multi-model simulations of aerosol and ozone radiative forcing due to anthropogenic emission changes during the period 1990–2015

Gunnar Myhre[1], Wenche Aas[2], Ribu Cherian[3], William Collins[4], Greg Faluvegi[5], Mark Flanner[6], Piers Forster[7], Øivind Hodnebrog[1], Zbigniew Klimont[8], Marianne T. Lund[1], Johannes Mülmenstädt[3], Cathrine Lund Myhre[2], Dirk Olivié[9], Michael Prather[10], Johannes Quaas[3], Bjørn H. Samset[1], Jordan L. Schnell[10], Michael Schulz[9], Drew Shindell[11], Ragnhild B. Skeie[1], Toshihiko Takemura[12], and Svetlana Tsyro[9]

Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2017-359, 2017
Manuscript under review for journal Atmos. Chem. Phys.
Discussion started: 9 May 2017

Atmospheric Chemistry and Physics Discussions

Investigation of global nitrate from the AeroCom Phase III experiment

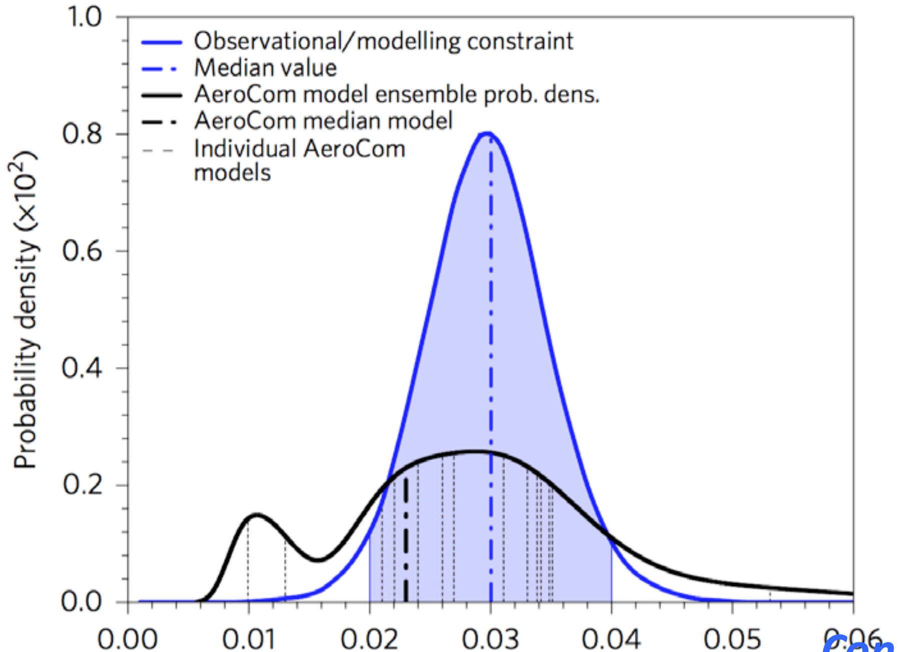
Huisheng Bian[1,2], Mian Chin[2], Didier A. Hauglustaine[3], Michael Schulz[4], Gunnar Myhre[5,6], Susanne E. Bauer[7,8], Marianne T. Lund[6], Vlassis A. Karydis[9], Tom L. Kucsera[10], Xiaohua Pan[11], Andrea Pozzer[9], Ragnhild B. Skeie[6], Stephen D. Steenrod[10], Kengo Sudo[12], Kostas Tsigaridis[7,8], Alexandra P. Tsimpidi[9], and Svetlana G. Tsyro[4]

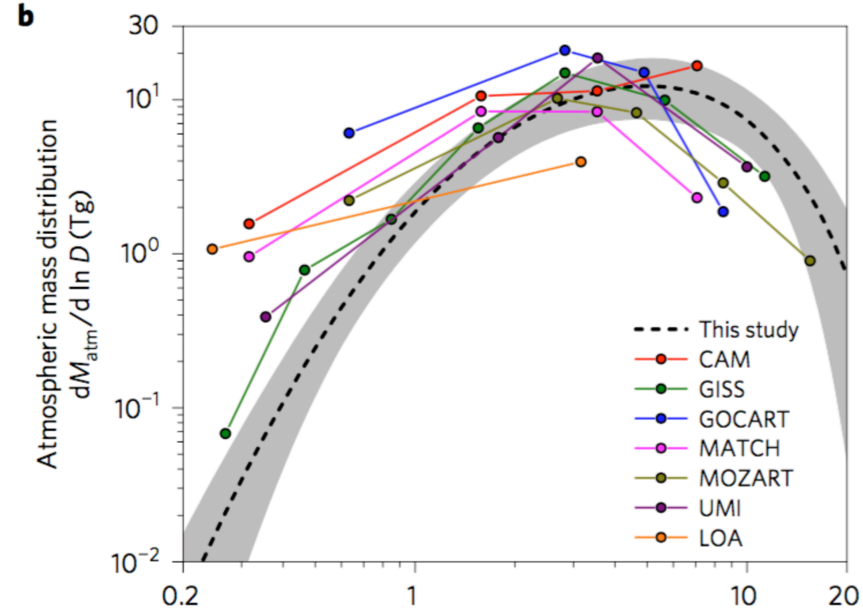
nature geoscience ARTICLES
PUBLISHED ONLINE: 13 MARCH 2017 | DOI: 10.1038/NGEO2912

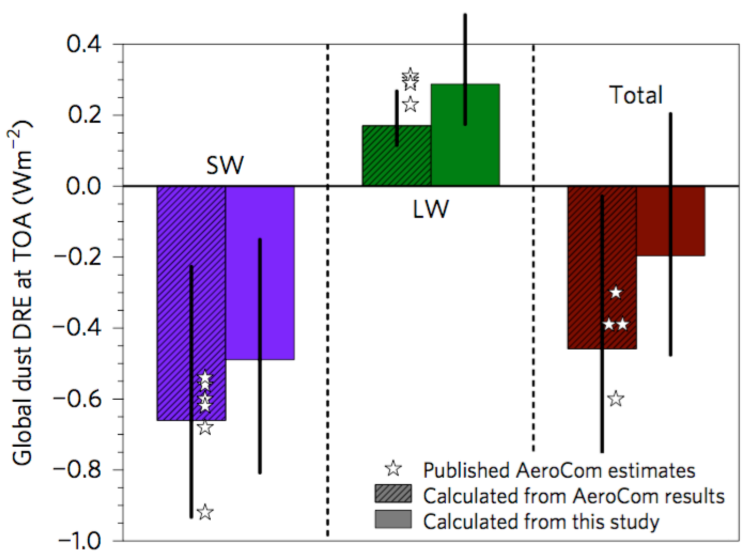
Smaller desert dust cooling effect estimated from analysis of dust size and abundance

Jasper F. Kok[1]*, David A. Ridley[2], Qing Zhou[3], Ron L. Miller[4], Chun Zhao[5], Colette L. Heald[2,6], Daniel S. Ward[7], Samuel Albani[8] and Karsten Haustein[9]

Can we get to recommendations for modelling???







Constraints suggest that AeroCom models

- ***emit too fine dust***
- ***underestimate extinction assuming sphericity***
- ***underestimate Dust AOD***

=> More dust absorption, more LW, less SW, less net radiative effect

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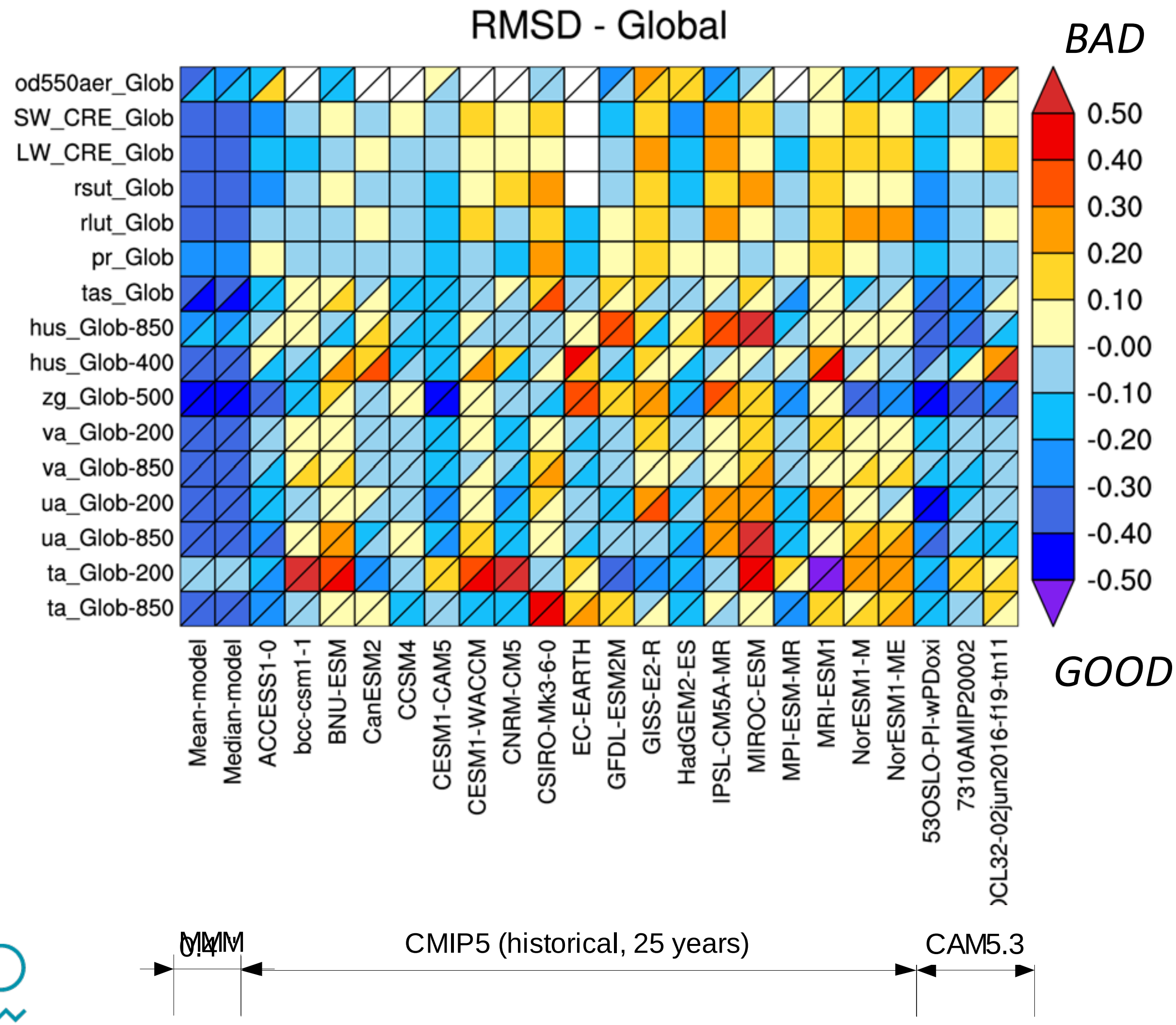
Portrait diagram showing performance

CMIP5 + NorESM versus divers observations



$$E'_{mfr} = \frac{E_{mfr} - \overline{E}_{fr}}{\overline{E}_{fr}}$$

E_{mfr} = RMS error of model m

$\overline{E}_{fr}$ = typical model error

(Gleckler et al. (2008))

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Can we do the same for Aerosol Properties ?

How could we use portrait diagrams for AeroCom?

- Model version evolution check
- Quick overview of model data availability, quality
- Investigate the good models for their solutions,
  develop best practice recommendations
- Select AeroCom median model
  Put less weight on worse models for AeroCom median?
- Understand which observations may constrain models
- Compare value of different observational datasets

Some initial findings….

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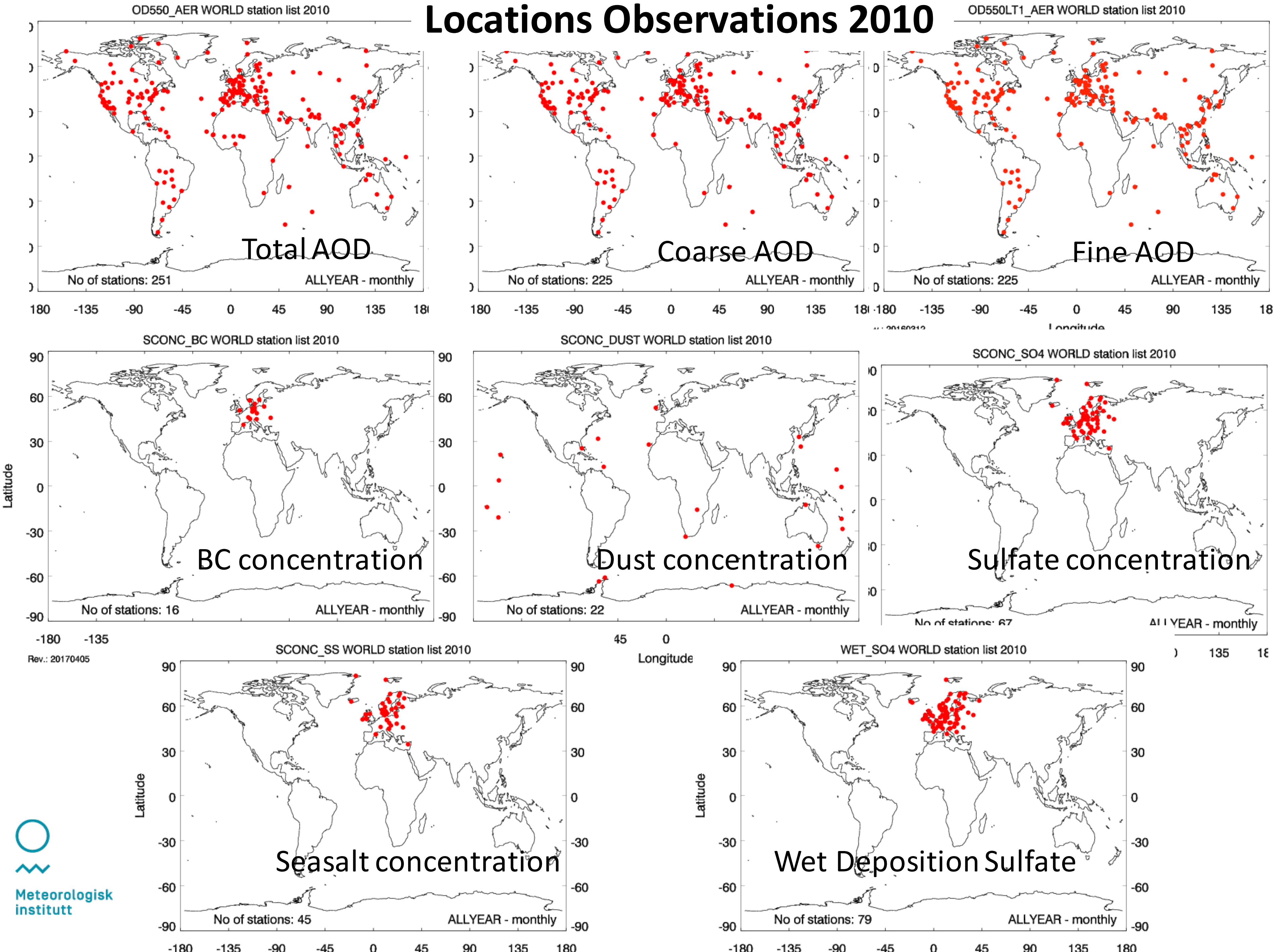
Locations Observations 2010



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Portrait Diagram Display of Relative Error Metrics

AeroCom Phase III Models vs Multiple Observational datasets

		AeroCom-Median2000	CAM5-CTRL2016	CAM53-Oslo-AP3-CTRL2016-PD	Chaser	CNRM_CM6.2_CTRL2015	ECHAM-Salsa-CTRL2015	ECHAM6-HAM2	EMEP_BASE	GEOSChem-v11-CTRL2016	GFDL-AM3p10-GLOFIR1	GISS-MATRIX-NGLOBASE	GOCARTv5Base	IFS-AP3-CTRL2016-PD	IMPACT	INCA-BCinCTRL2016PD	INCA-GLOFIR1	OsloCTM3-CTRL2015	OsloCTM3-CTRL2016	SprintarsT213_CTRL2016	TM5-CTRL2016	Variation
Aerosol Optical Depth																						
Total AOD	**Aeronet Sun mode**	-0.45	-0.02	0.14	2.38	0.10	-0.04	-0.06	0.08	-0.22	0.02	0.23	-0.27	-0.23	0.03	0.19	0.11	-0.12	-0.30	0.05	-0.21	57%
Coarse mode AOD	**Aeronet SDA**			1.22		-0.04	0.00	0.11		-0.01				-0.18	-0.33	0.29		-0.15		0.00	0.07	41%
Fine Mode AOD	**Sky inversion**	-0.42	-0.52	0.28	0.08						-0.02	0.10			0.08	0.30	-0.05	0.00	0.00		-0.26	25%
Surface Concentration																						
Black Carbon	**EMEP**			0.05		0.04	-0.02	-0.02		0.00		0.11		0.05						-0.01	-0.02	4%
Dust	**Aeroce Climatology**	0.13		-0.07		0.02	-0.04	0.10	0.00	-0.12		0.30		0.00		0.08		-0.05		-0.07	0.52	18%
Sulfate	**EMEP**	0.31		0.30		2.19	0.19	0.52	-0.15	-0.07		0.06	-0.30	0.04			-0.26	-0.04		-0.18	-0.10	63%
Seasalt	**EMEP**			-0.57		23.88	0.14	0.00	-0.66	-0.60		0.60	1.74	-0.49		1.91		0.64		-0.43	-0.12	663%
Wet Deposition																						
Sulfate	**EMEP**			0.02		0.00			-0.44	0.00		0.00									0.00	18%
		2000	2010	2010	2010	2010	2010	2010	2010	2010	2008	2010	2010	2010	2008	2006	2008	2010	2010	2010	2010	

$$E'_{mfr} = \frac{E_{mfr} - \overline{E_{fr}}}{\overline{E_{fr}}}$$

E_{mfr} = RMS error of model m

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GOOD -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 BAD

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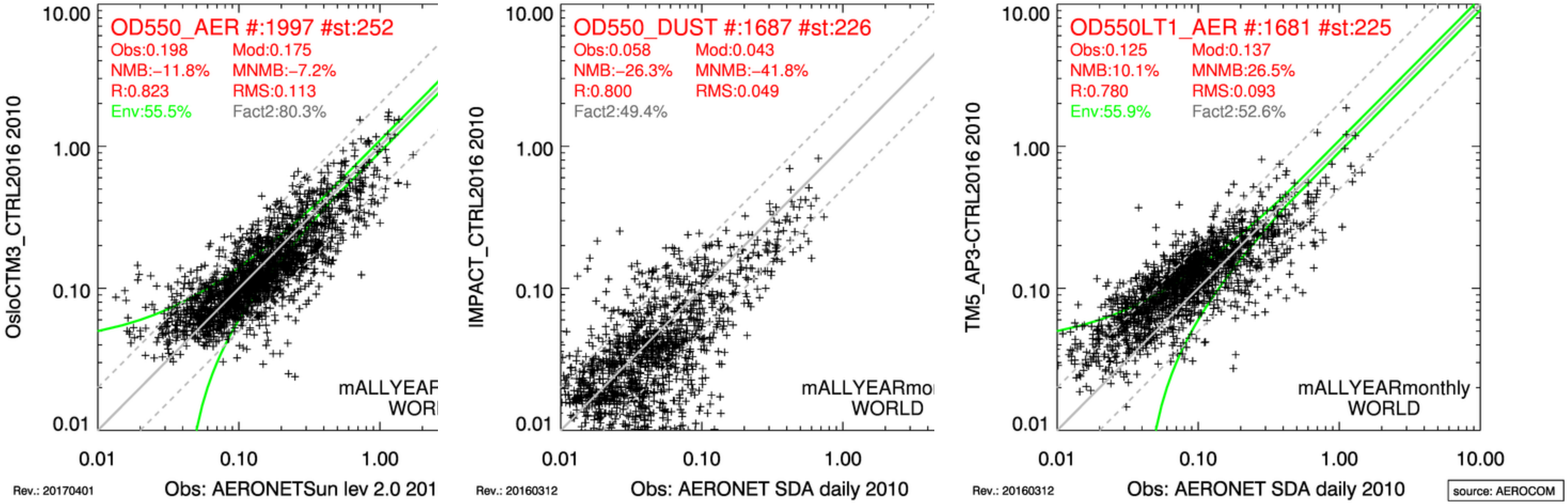
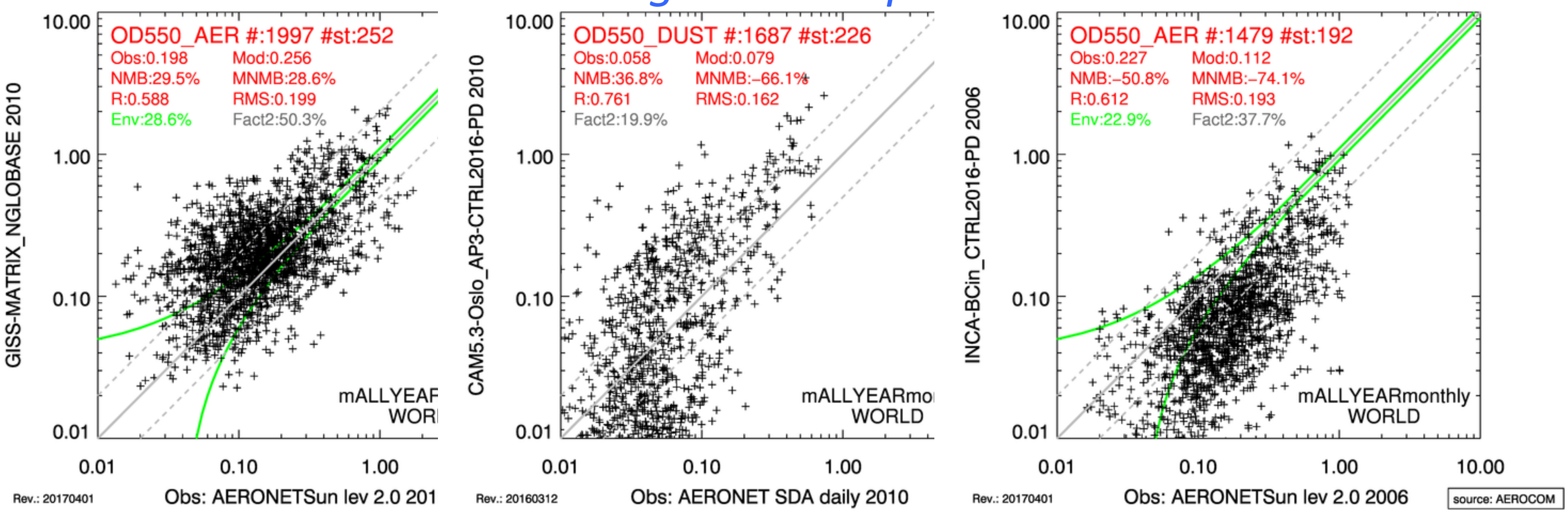
Total AOD | *Coarse AOD* | *Fine AOD*



Good examples

Less good examples



Quite some gaps in the database….

		AeroCom-Median2000	CAM5-CTRL2016	CAM53-Oslo-AP3-CTRL2016-PD	Chaser	CNRM_CM6.2_CTRL2015	ECHAM-Salsa-CTRL2015	ECHAM6-HAM2	EMEP_BASE	GEOSChem-v11-CTRL2016	GFDL-AM3p10-GLOFIR1	GISS-MATRIX-NGLOBASE	GOCARTv5Base	IFS-AP3-CTRL2016-PD	IMPACT	INCA-BCinCTRL2016PD	INCA-GLOFIR1	OsloCTM3-CTRL2015	OsloCTM3-CTRL2016	SprintarsT213_CTRL2016	TM5-CTRL2016	Variation
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Coarse mode AOD	**Aeronet SDA**			[illegible]		[illegible]	0.00	[illegible]		[illegible]				[illegible]	-0.33	[illegible]		[illegible]		[illegible]	0.07	41%
Fine Mode AOD	**Sky inversion**	-0.42	-0.52	0.28	[illegible]						[illegible]	[illegible]			[illegible]	0.30	-0.05	0.00	[illegible]		[illegible]	25%
Surface Concentration																						
Black Carbon	**EMEP**			0.05		0.04	-0.02	-0.02		0.00		0.11		0.05						-0.01	-0.02	4%
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Wet Deposition																						
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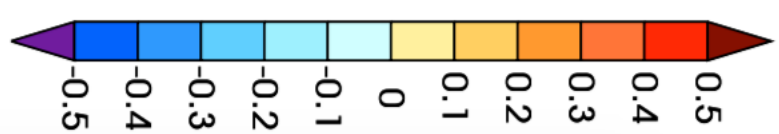
GOOD



BAD

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Coarse Mode AOD and surface dust concentration error is correlated

		AeroCom-Median2000	CAM5-CTRL2016	CAM53-Oslo-AP3-CTRL2016-PD	Chaser	CNRM_CM6.2_CTRL2015	ECHAM-Salsa-CTRL2015	ECHAM6-HAM2	EMEP_BASE	GEOSChem-v11-CTRL2016	GFDL-AM3p10-GLOFIR1
Aerosol Optical Depth											
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Coarse mode AOD	**Aeronet SDA**			1.22		-0.04	[illegible]	0.11		-0.01	
Fine Mode AOD	**Sky inversion**	-0.42	-0.52	0.28	0.08						-0.02
Surface Concentration											
Black Carbon	**EMEP**			0.05		0.04	-0.02	-0.02		0.00	
Dust	**Aeroce Climatology**	0.13		-0.07		0.02	[illegible]	0.10	[illegible]	-0.12	
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		2000	2010	2010	2010	2010	2010	2010	2010	2010	2008

		GISS-MATRIX-NGLOBASE	GOCARTv5Base	IFS-AP3-CTRL2016-PD	IMPACT	INCA-BCinCTRL2016PD	INCA-GLOFIR1	OsloCTM3-CTRL2015	OsloCTM3-CTRL2016	SprintarsT213_CTRL2016	TM5-CTRL2016	Variation
Aerosol Optical Depth												
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Coarse mode AOD	**Aeronet SDA**			-0.18	[illegible]	0.29		-0.15		[illegible]	0.07	41%
Fine Mode AOD	**Sky inversion**	0.10			0.08	0.30	-0.05	0.00	0.00		-0.26	25%
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Dust	**Aeroce Climatology**	0.30		0.00		0.08		-0.05		[illegible]	0.52	18%
Sulfate	**EMEP**	0.06	-0.30	0.04			-0.26	-0.04		-0.18	[illegible]	63%
Seasalt	**EMEP**	0.60	1.74	-0.49		1.91		0.64		-0.43	-0.12	663%
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Improvements from version to version….

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Coarse mode AOD	**Aeronet SDA**			1.22		-0.04	0.00	0.11		-0.01				-0.18	-0.33	0.29		-0.1[illegible]		0.00	0.07	41%
Fine Mode AOD	**Sky inversion**	-0.42	-0.52	0.28	0.08						-0.02	0.10			0.0[illegible]	0.30	-0.05	0.00	0.00		-0.26	25%
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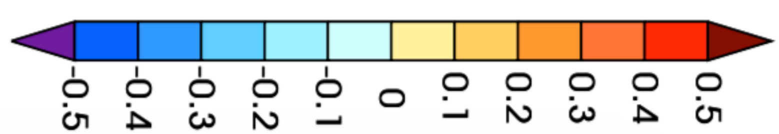

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E_{mfr} = RMS error of model m

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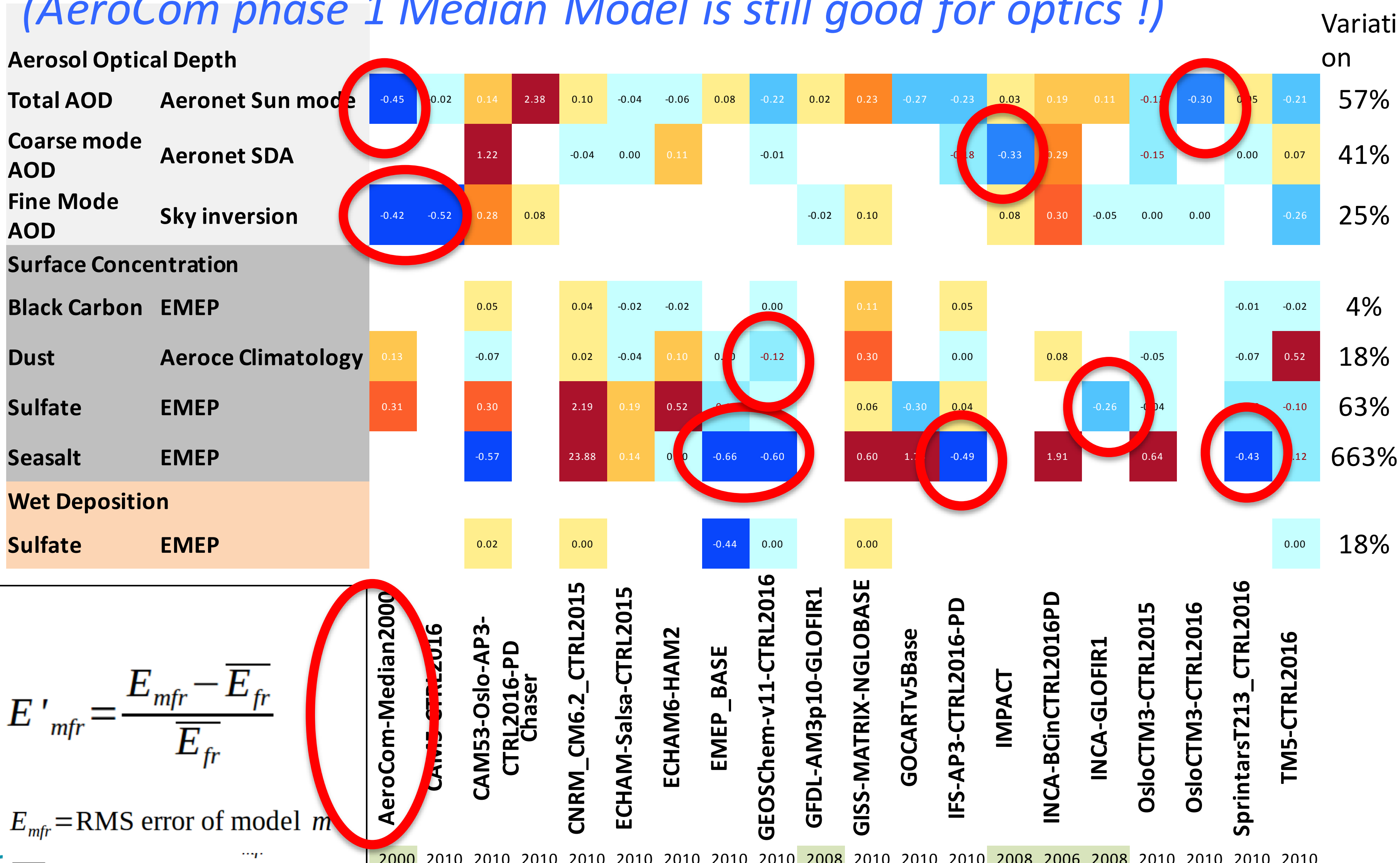
We should be able to learn from the good ones…
(AeroCom phase 1 Median Model is still good for optics !)



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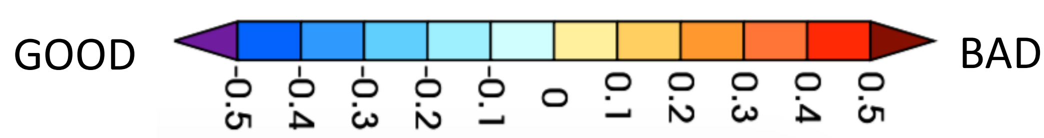

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Observations are more or less a good constraint

Black carbon measurements are reproduced bad by all

Seasalt surface concentrations performance largely different

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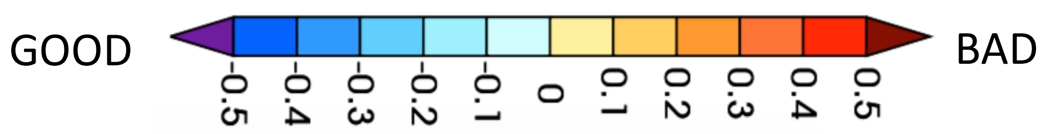
		GISS-MATRIX-NGLOBASE	GOCARTv5Base	IFS-AP3-CTRL2016-PD	IMPACT	INCA-BCinCTRL2016PD	INCA-GLOFIR1	OsloCTM3-CTRL2015	OsloCTM3-CTRL2016	SprintarsT213_CTRL2016	TM5-CTRL2016	Variation
Aerosol Optical Depth												
Total AOD	**Aeronet Sun mode**	0.23	-0.27	-0.23	0.03	0.19	0.11	-0.12	-0.30	0.05	-0.21	57%
Coarse mode AOD	**Aeronet SDA**			-0.18	-0.33	0.29		-0.15		0.00	0.07	41%
Fine Mode AOD	**Sky inversion**	0.10			0.08	0.30	-0.05	0.00	0.00		-0.26	25%
Surface Concentration												
Black Carbon	**EMEP**	0.11		0.05						-0.01	-0.02	4%
Dust	**Aeroce Climatology**	0.30		0.00		0.08		-0.05		-0.07	0.52	18%
Sulfate	**EMEP**	0.06	-0.30	0.04			-0.26	-0.04		-0.18	-0.10	63%
Seasalt	**EMEP**	0.60	1.74	-0.49		1.91		0.64		-0.43	-0.12	663%
Wet Deposition												
Sulfate	**EMEP**	0.00									0.00	18%
		2010	2010	2010	2008	2006	2008	2010	2010	2010	2010	

$$E'_{mfr} = \frac{E_{mfr} - \overline{E_{fr}}}{\overline{E_{fr}}}$$

E_{mfr} = RMS error of model m

$\overline{E_{fr}}$ = typical model error



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*"Classical" Atmospheric Chemistry models **seem** to outperform GCMs wrt aerosol composition and wet deposition*

EMEP, GEOSCHEM, TM5, Sprintars.

	Observation	AeroCom-Median2000	CAM5-CTRL2016	CAM53-Oslo-AP3-CTRL2016-PD	Chaser	CNRM_CM6.2_CTRL2015	ECHAM-Salsa-CTRL2015	ECHAM6-HAM2	EMEP_BASE	GEOSChem-v11-CTRL2016	GFDL-AM3p10-GLOFIR1	GISS-MATRIX-NGLOBASE	GOCARTv5Base	IFS-AP3-CTRL2016-PD	IMPACT	INCA-BCinCTRL2016PD	INCA-GLOFIR1	OsloCTM3-CTRL2015	OsloCTM3-CTRL2016	SprintarsT213_CTRL2016	TM5-CTRL2016	Variation
Aerosol Optical Depth																						
Total AOD	**Aeronet Sun mode**	-0.45	-0.02	0.14	2.38	0.10	-0.04	-0.06	0.08	-0.22	0.02	0.23	-0.27	-0.23	0.03	0.19	0.11	-0.12	-0.30	0.05	-0.21	57%
Coarse mode AOD	**Aeronet SDA**			1.22		-0.04	0.00	0.11		-0.01				-0.18	-0.33	0.29		-0.15		0.00	0.07	41%
Fine Mode AOD	**Sky inversion**	-0.42	-0.52	0.28	0.08						-0.02	0.10			0.08	0.30	-0.05	0.00	0.00		-0.26	25%
Surface Concentration																						
Black Carbon	**EMEP**			0.05		0.04	-0.02	-0.02		0.00		0.11		0.05						-0.01	0.02	4%
Dust	**Aeroce Climatology**	0.13		-0.07		0.02	-0.04	0.1	0.00	-0.12		0.30		0.00		0.08		-0.05		-0.07	0.52	18%
Sulfate	**EMEP**	0.31		0.30		2.19	0.19	0.5	-0.15	-0.07		0.06	-0.30	0.04			-0.26	-0.04		-0.18	0.10	63%
Seasalt	**EMEP**			-0.57		23.88	0.14	0.0	-0.66	-0.60		0.60	1.74	-0.49		1.91		0.64		-0.43	0.12	563%
Wet Deposition																						
Sulfate	**EMEP**			0.02		0.00			-0.44	0.00		0.00									0.00	18%
Year		2000	2010	2010	2010	2010	2010	2010	2010	2010	2008	2010	2010	2010	2008	2006	2008	2010	2010	2010	2010	

GOOD -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 BAD

$$E'_{mfr} = \frac{E_{mfr} - \overline{E_{fr}}}{\overline{E_{fr}}}$$

E_{mfr} = RMS error of model m

$\overline{E_{fr}}$ = typical model error

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AeroCom Median 2017 => the BAMS paper…

- Which Model versions to take?
- ?? HTAP BASE, CONTROL 2016/2015 , GLOFIRE1, NGLOBASE, etc could be used….
- **Please contact during Helsinki workshop**
  Jan Griesfeller and/or Michael Schulz
  to signal which model version we should use and which model version you could complete with missing data
- See "AeroCom Median 2017" category for updated list on AeroCom web interface
- http://aerocom.met.no/cgi-bin/aerocom/surfobs_annualrs.pl

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Goals of AeroCom workshop

This year's key **AeroCom** topics are:

*- improved **evaluation strategies** for AeroCom models - recommendations for **best modeling practices** for different aerosol components - **emerging constraints** for global distributions and aerosol radiative effects - new **aerosol forcing** estimate (including aerosol cloud interactions) - **reference fields** from global modeling (e.g. model ensemble median maps) - examination and lesson learned from past/**ongoing model experiments** - **simulation** requirements (regular control) and new **plans** (hindcast, historical)*

Thanks for the attention
Wishing everyone a fruitful inspiring workshop