Analysing aerosol model diversity using AeroCom results

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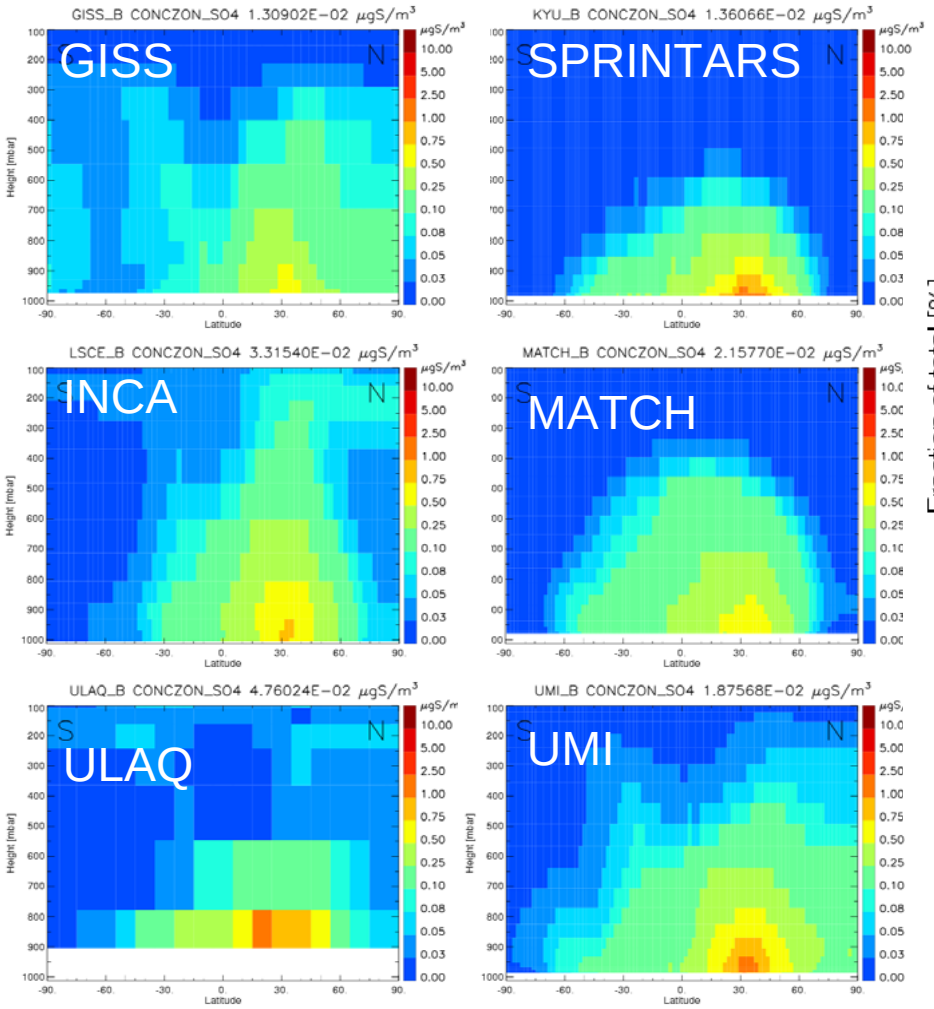
Acknowledgement especially to
Christiane Textor, Sarah Guibert, Stefan Kinne

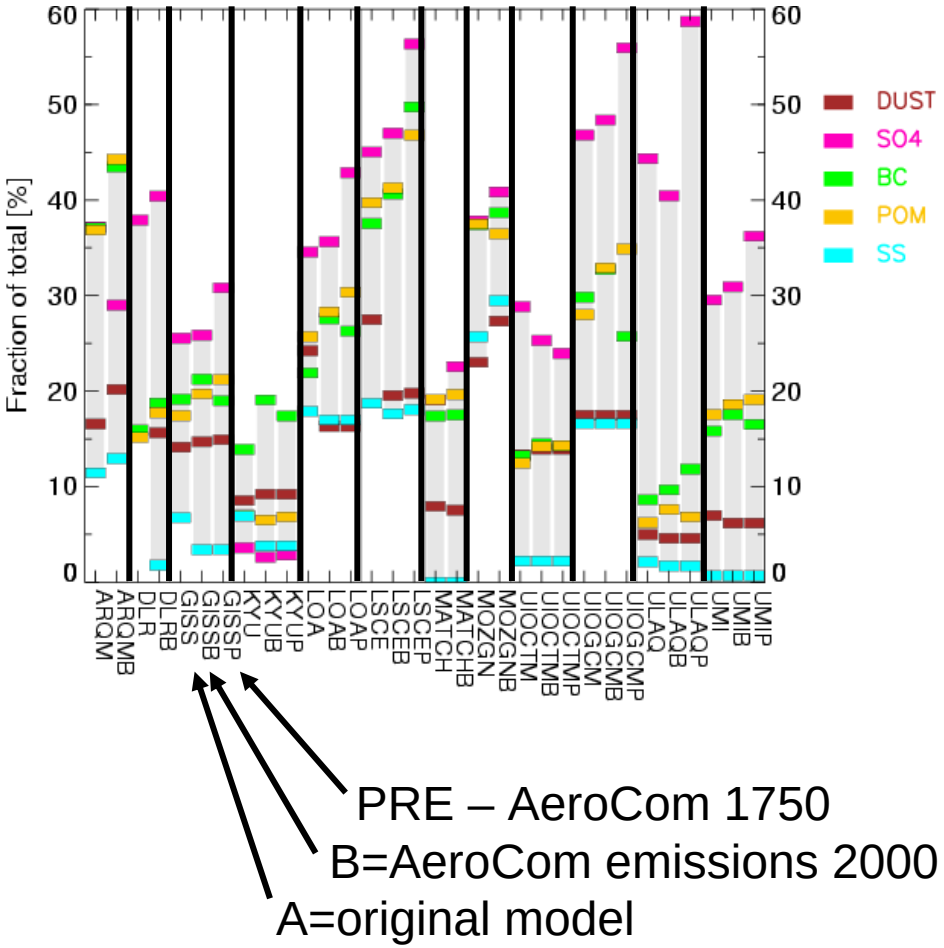
And to 20 modeling groups participating!!

Diagnostic of transport : Vertical profiles of aerosol

Examples SO4 zonal concentration

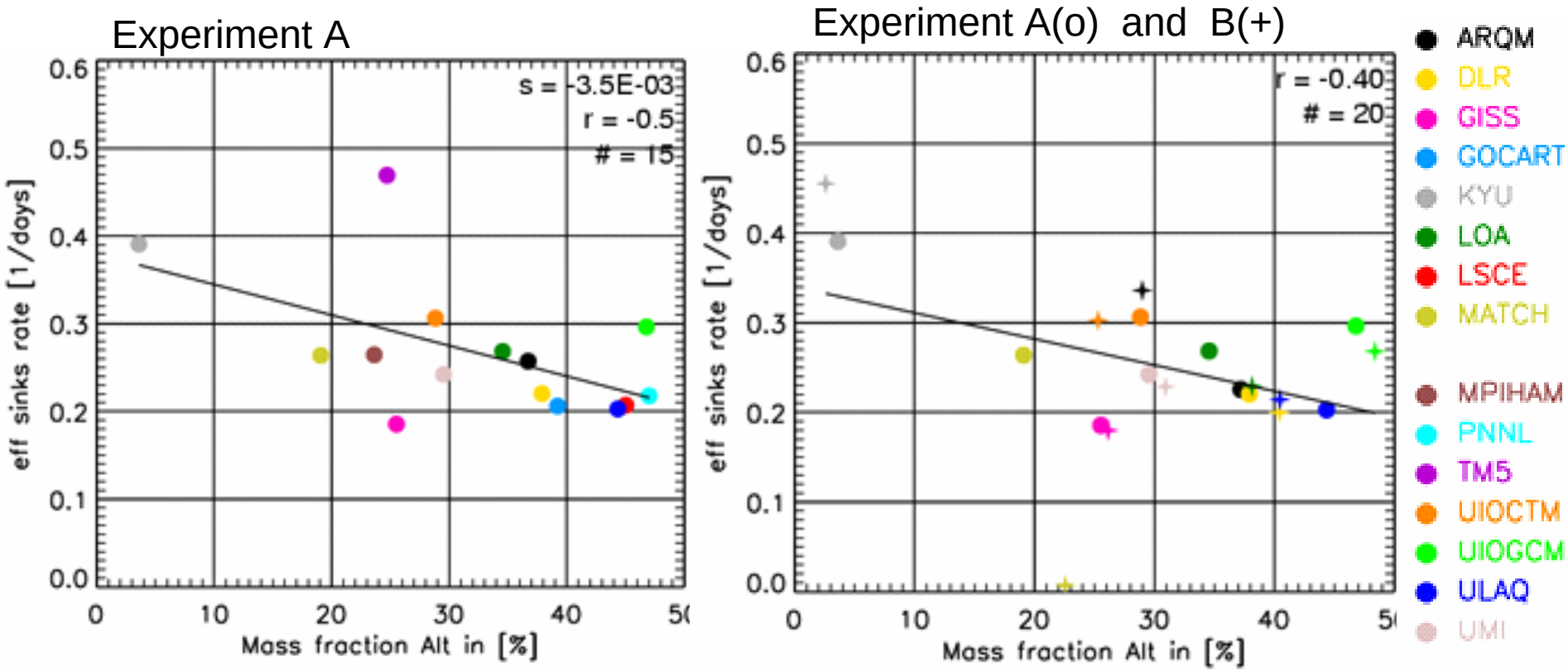


Mass fractions for components above 5 km height



Textor et al.
Atmos Chem Phys 2006

Is vertical distribution linked to residence times?



Sulfate removal rate (y)

versus Mass fraction above 5 km (x)

Decomposing reasons for forcing diversity

Precursor emissions (SO2, NOx, VOC)

chemical production, condensation

Primary aerosol emissions (BC, POM, dust, sea salt)

Residence times

Transport, dispersion, wet and dry deposition

Aerosol Loads

Optical properties

Mass extinction/absorption coefficient

Aerosol Optical Depth

Forcing efficiency per unit optical depth

Single scattering albedo

Hemispheric Backscatter

Vertical Distribution of aerosol

Cloud and aerosol position

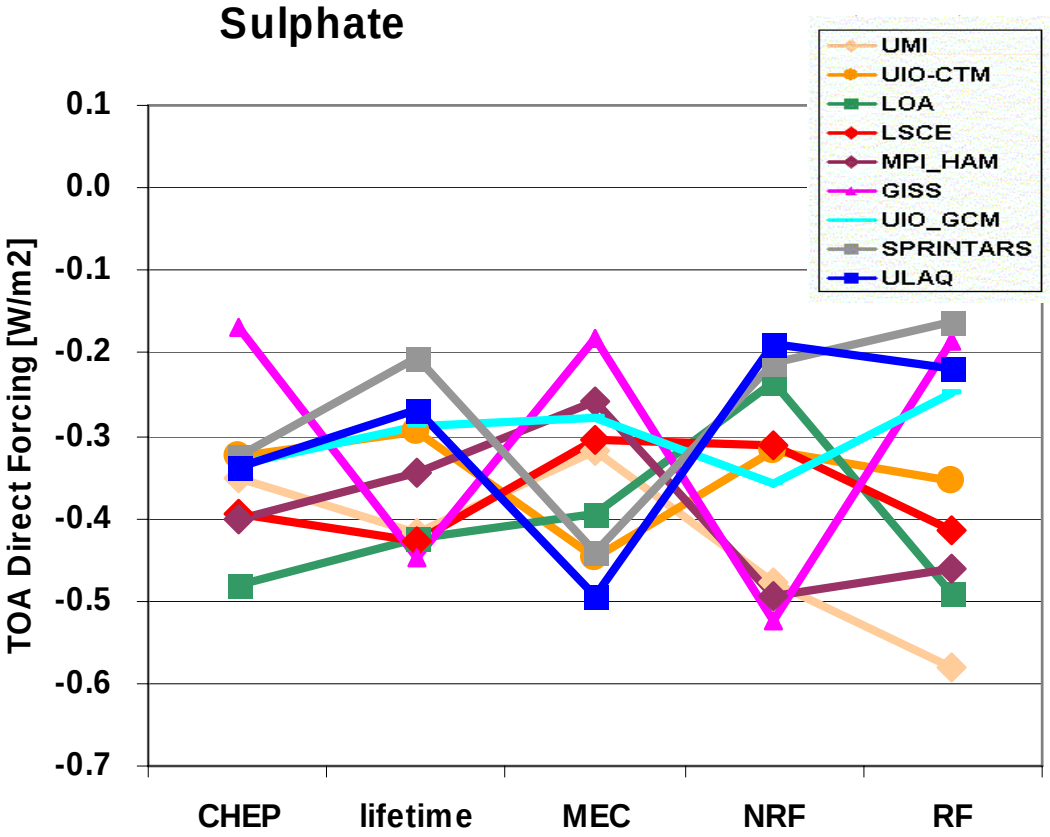
Direct radiative forcing

Interdependence of processes ??

Partial sensitivity analysis of impact of different properties on forcing estimate

How much would the simulated forcing vary
***IF** the variations of only one factor would determine forcing ?*

Forcing (RF) = chemical production (CHEP) x lifetime
x extinction_coefficient (MEC) x forcing efficiency (NRF)

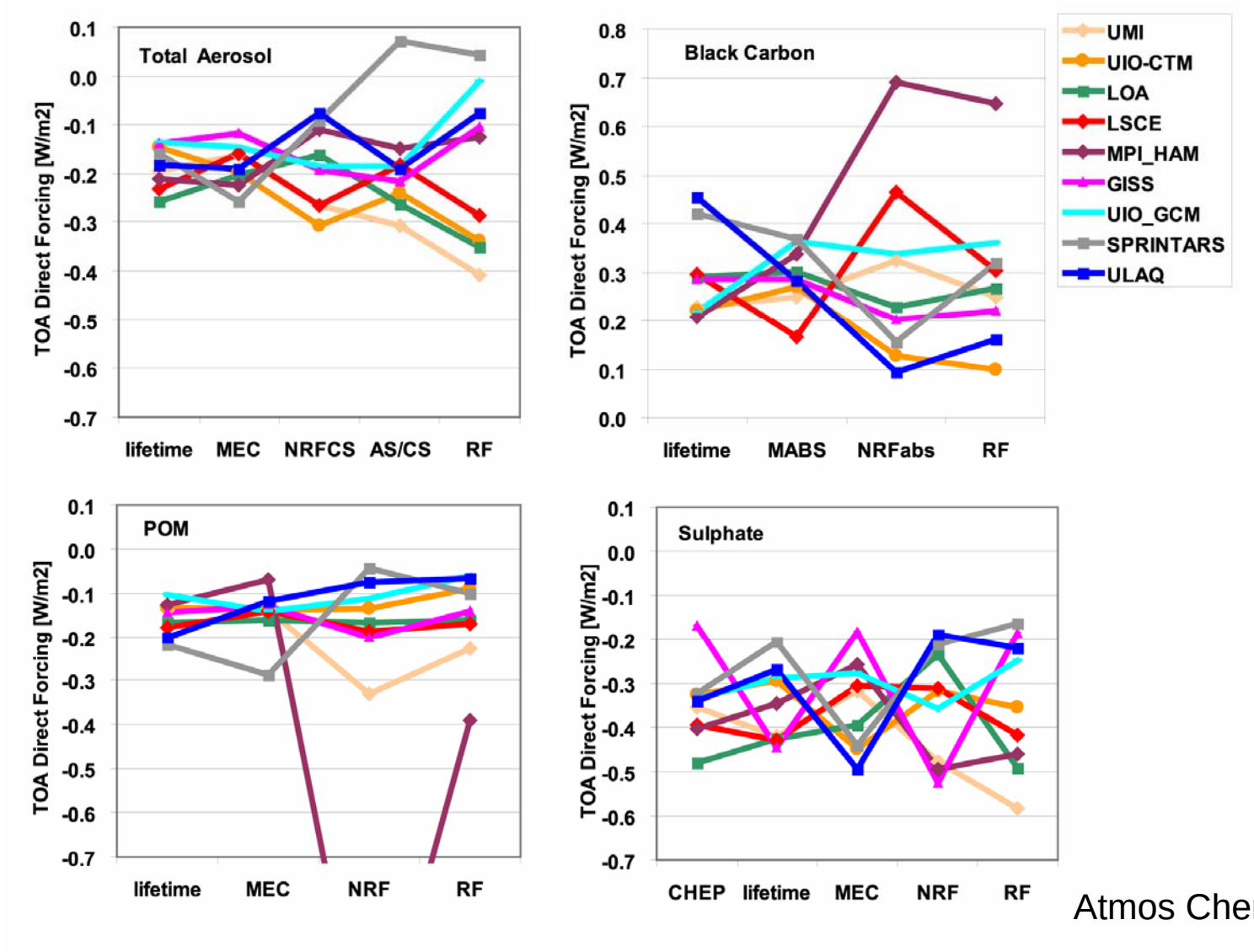


⇒ compensation of short life time and MEC because aerosol would reside in low levels in model with short lifetime?

⇒ diversity (=uncertainty?) only ca. +- 0.2 W/m2

Sensitivity analysis of impact of different properties on forcing estimate

Forcing = emission x lifetime x extinction_coefficient x forcing efficiency

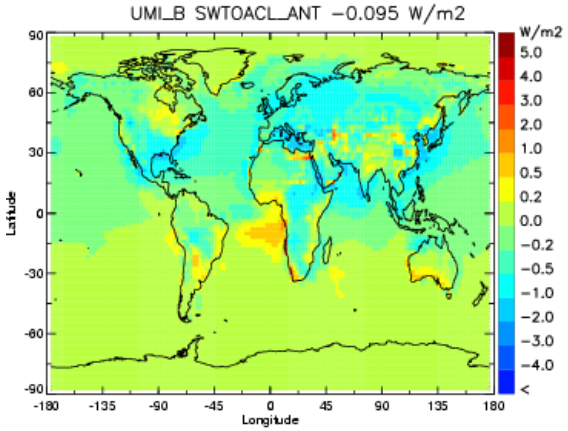


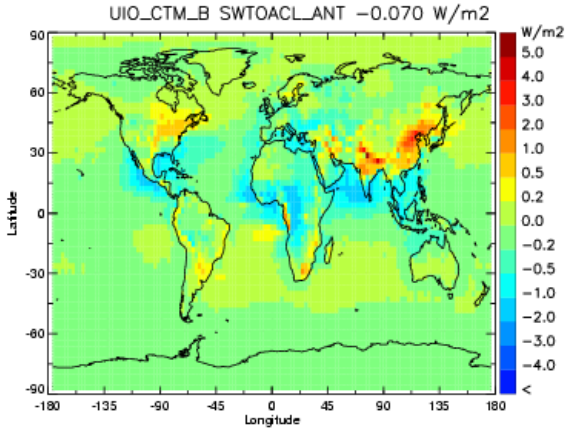
Schulz et al
Atmos Chem Phys 2006

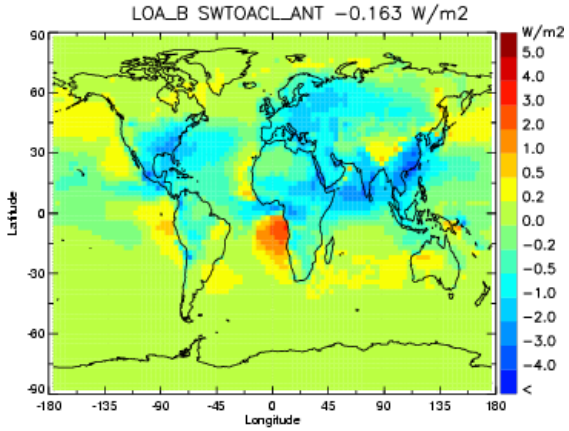
CLEAR SKY // Anthropogenic aerosol // Global but only 60°S to 60°N

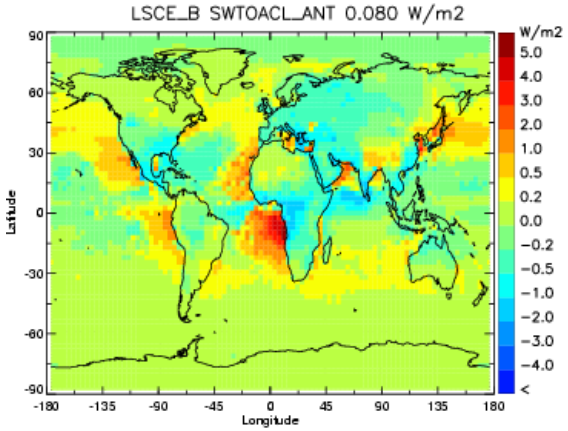
	ocean			**land**		
	AOD	RF	NRF	AOD	RF	NRF
Models		W m-2	W m-2 tau-1		W m-2	W m-2 tau-1
UMI	0.024	-0.68	-28	0.058	-1.33	-23
UIO_CTM	0.021	-0.69	-34	0.055	-1.64	-30
LOA	0.033	-0.67	-20	0.088	-1.47	-17
LSCE	0.026	-0.89	-34	0.063	-1.35	-21
MPI_HAM	0.038	-0.49	-13	0.073	-0.75	-10
GISS	0.013	-0.33	-26	0.026	-0.42	-16
SPRINTARS	0.030	-0.32	-11	0.078	-0.63	-8
AeroCom mean	0.026	-0.58	-24	0.063	-1.09	-18
Observational based estimate						
Yu et al. 2005	0.031	-1.10	-37	0.088	-1.80	-20

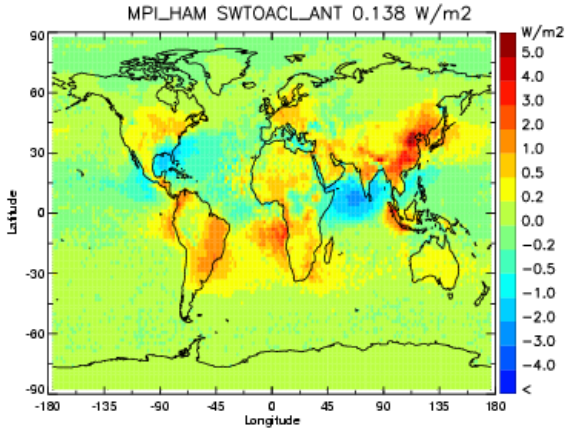
Aerosol focing in cloudy-skies

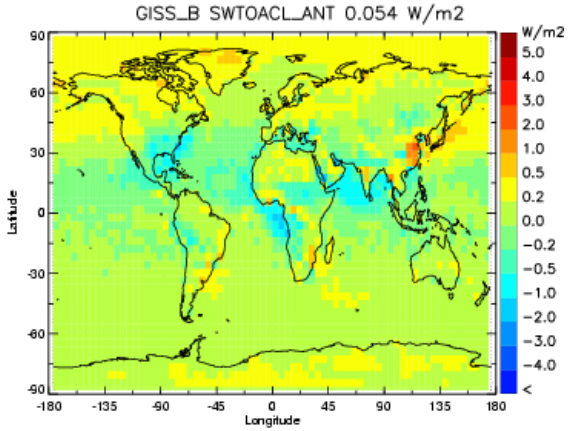


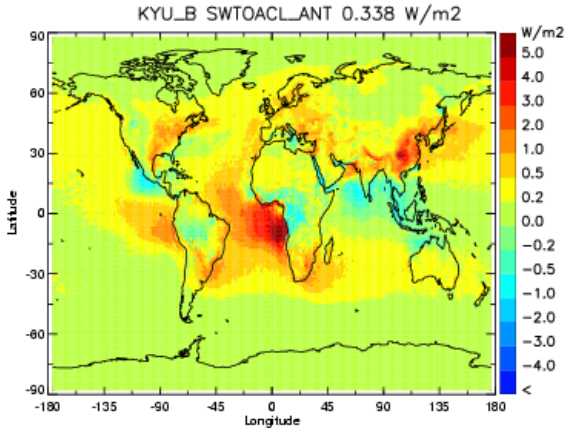




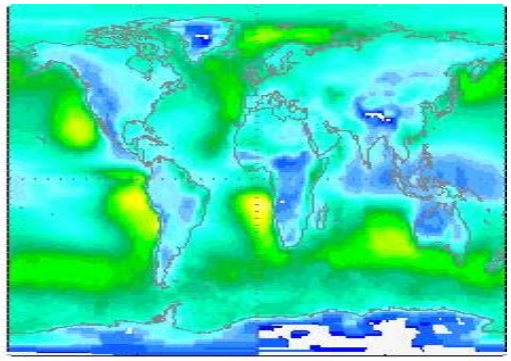




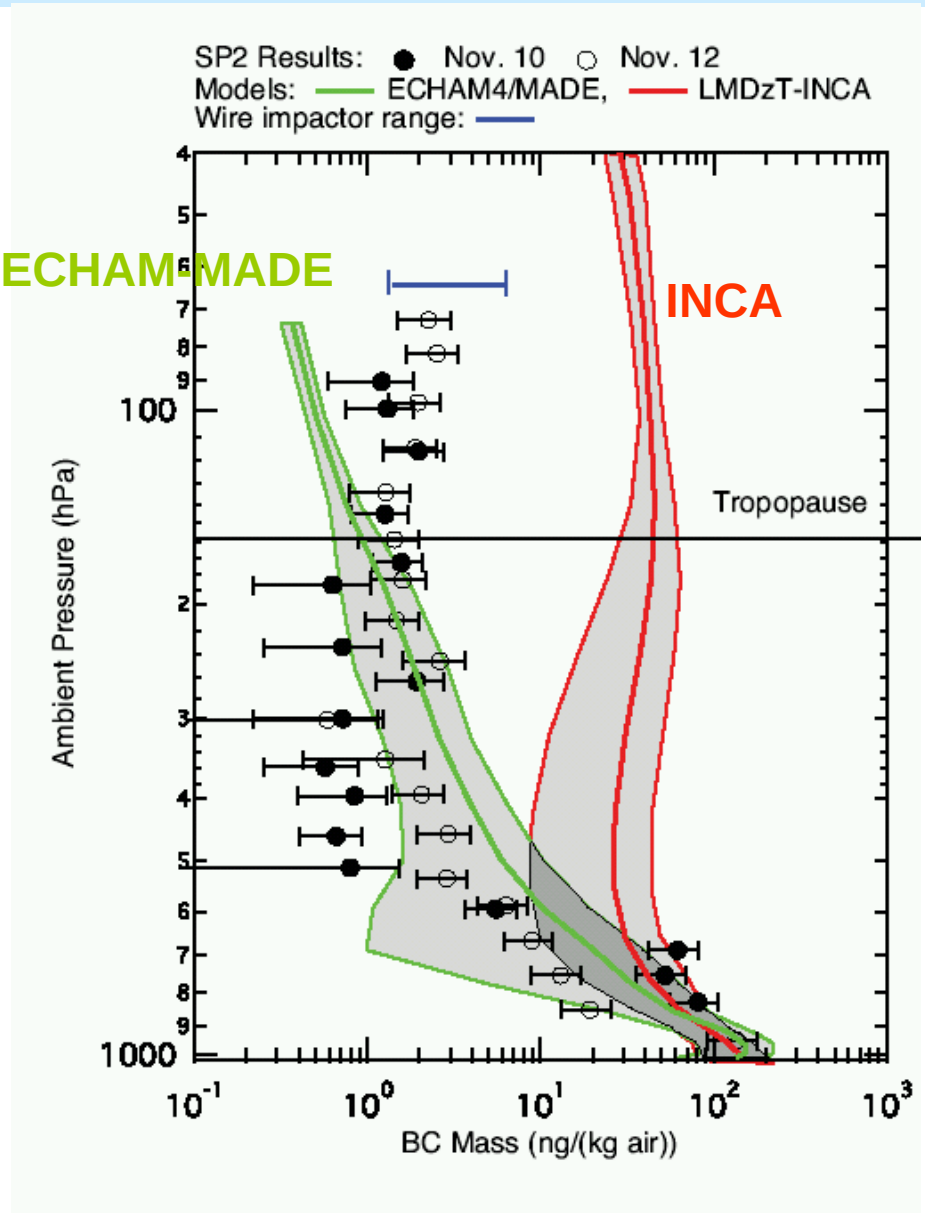




ISCCP low level cloud cover

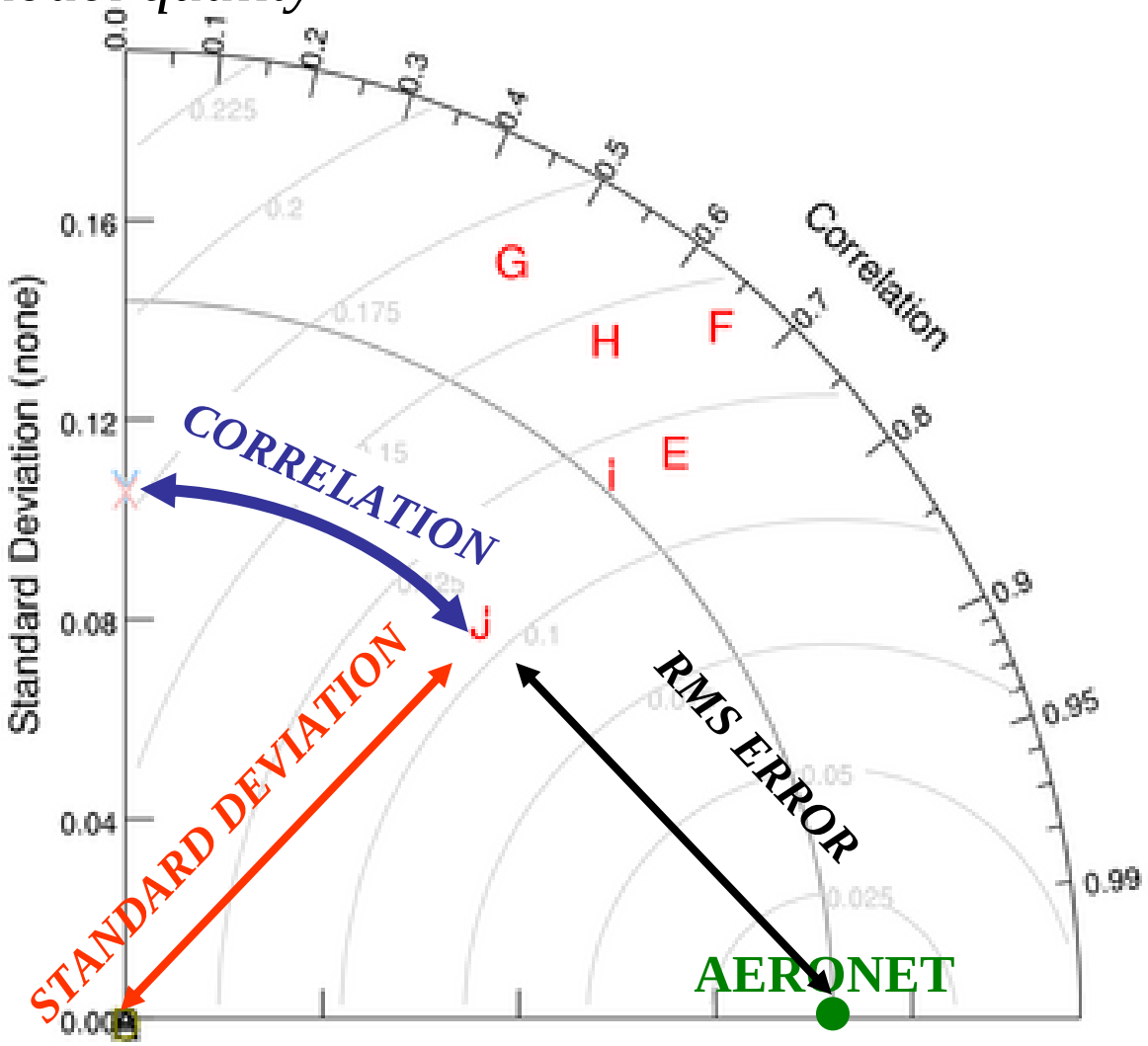


Comparison to aircraft measurements



BC mass mixing ratio comparison to high altitude aircraft data (Schwarz et al JGR 2006)

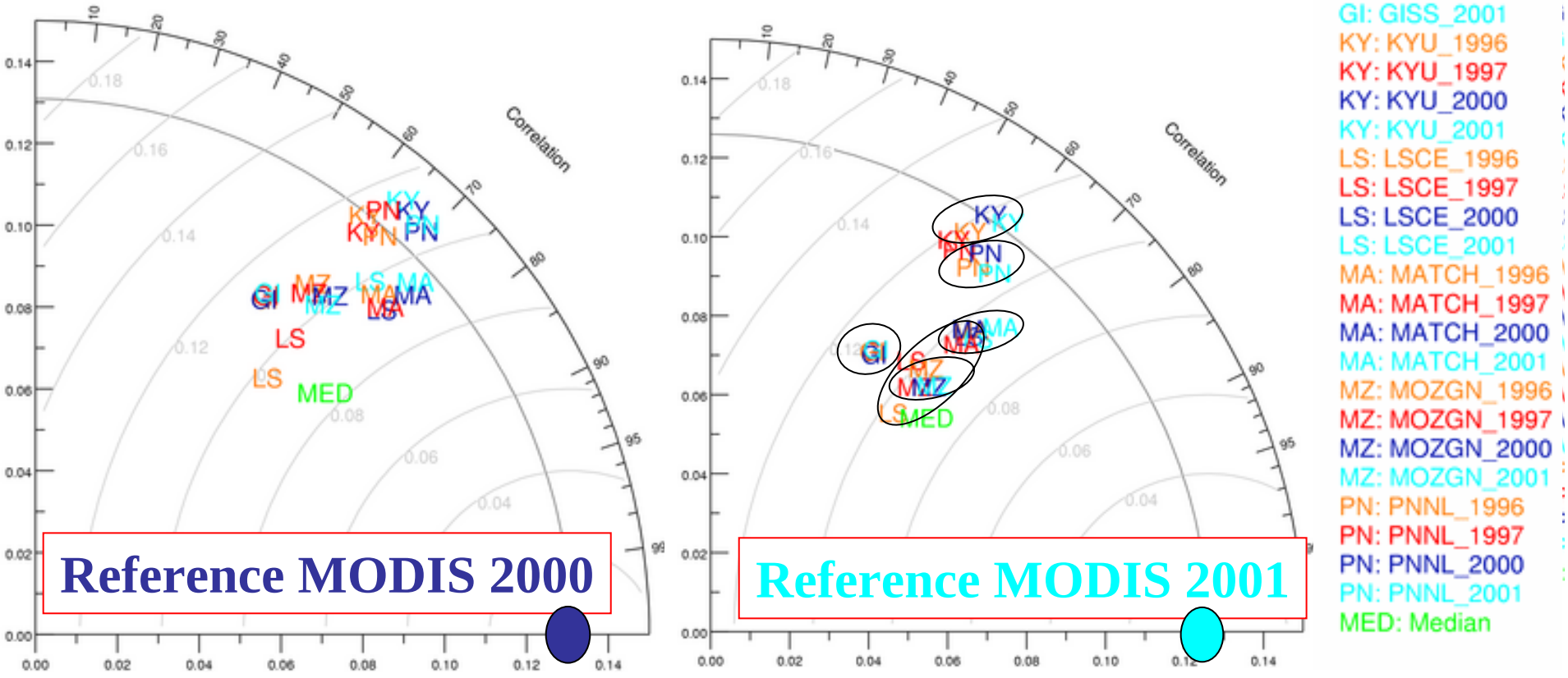
Taylor Diagrammes - condense info of spatio-temporal varying fields
Use geometric relation between RMS – STDDEV - CORRELATION to judge model quality



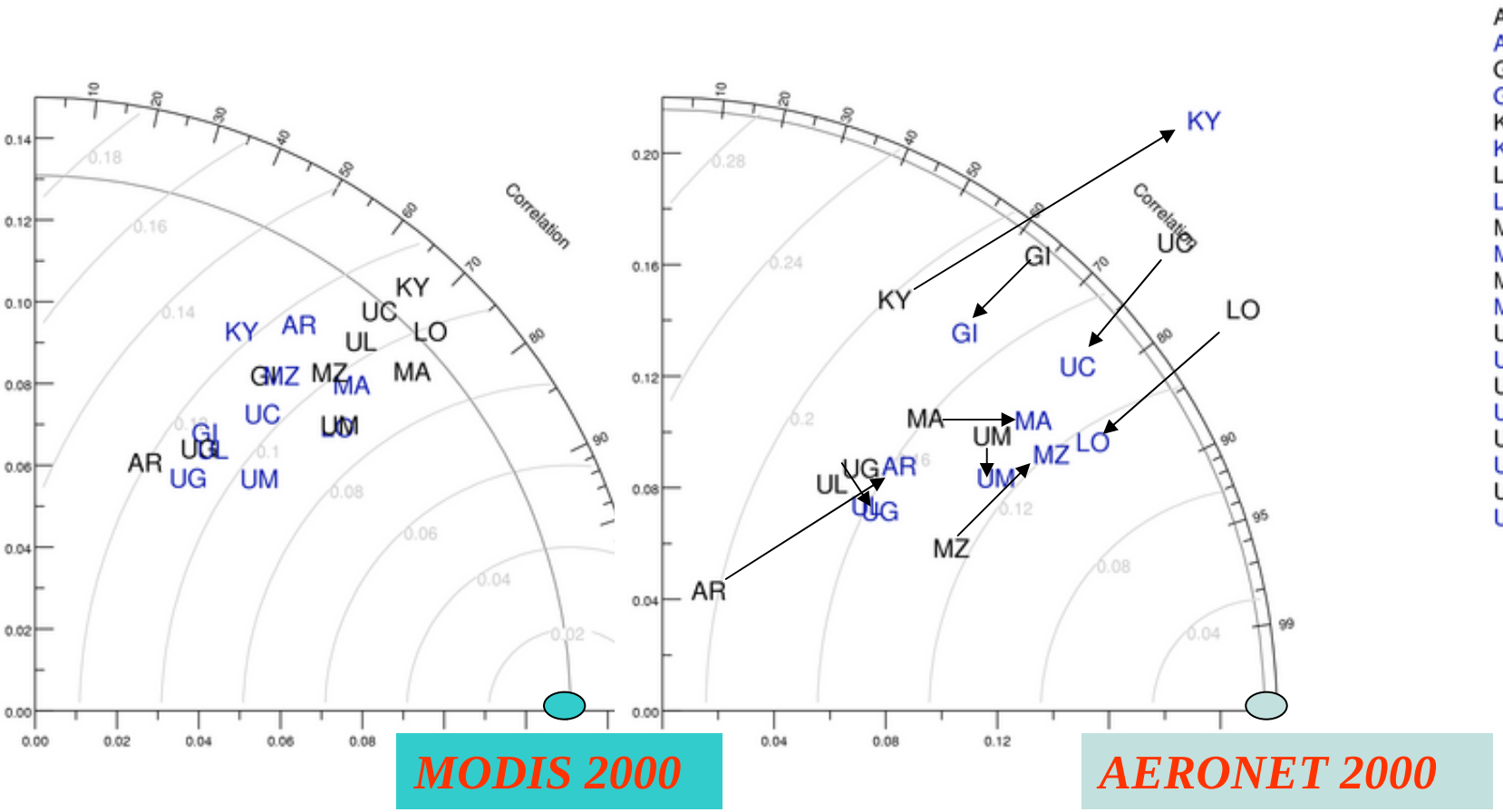
STANDARD DEVIATION OF REFERENCE DATA SET

Interannual variability
versus model differences
versus change in reference data set

Model simulations of 1996 1997 2000 2001



What is the effect of exchanging emissions?



AR: ARQM_9999
AR: ARQM_B_9999
GI: GISS_2000
GI: GISS_B_2000
KY: KYU_2000
KY: KYU_B_2000
LO: LOA_2000
LO: LOA_B_2000
MA: MATCH_2000
MA: MATCH_B_200
MZ: MOZGN_2000
MZ: MOZGN_B_200
UC: UIO_CTM_200
UC: UIO_CTM_B_2
UG: UIO_GCM_999
UG: UIO_GCM_B_9
UL: ULAQ_9999
UL: ULAQ_B_9999
UM: UMI_2000
UM: UMI_B_2000

MODIS 2000

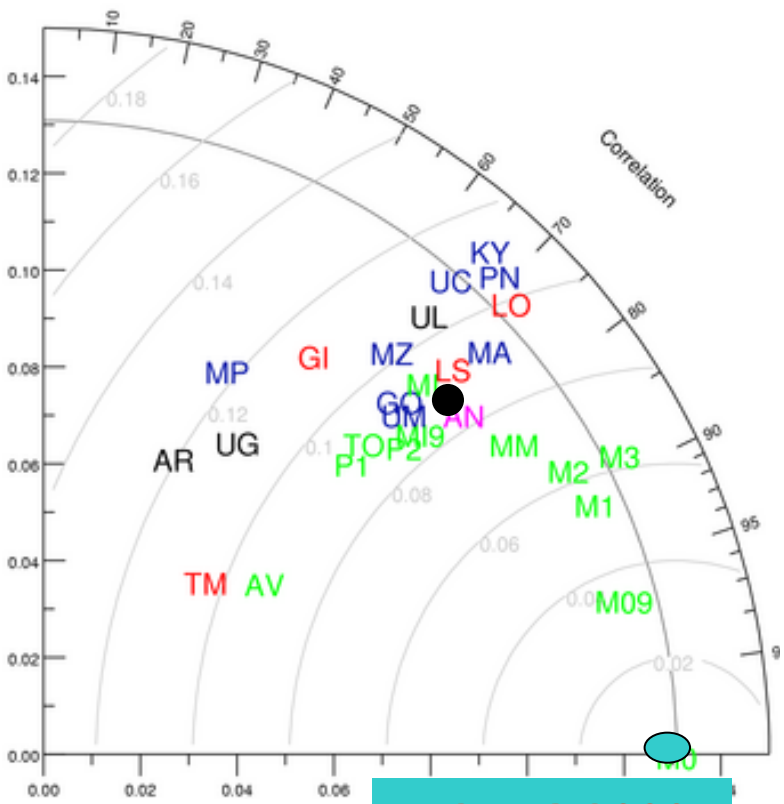
AERONET 2000

AEROCOM A

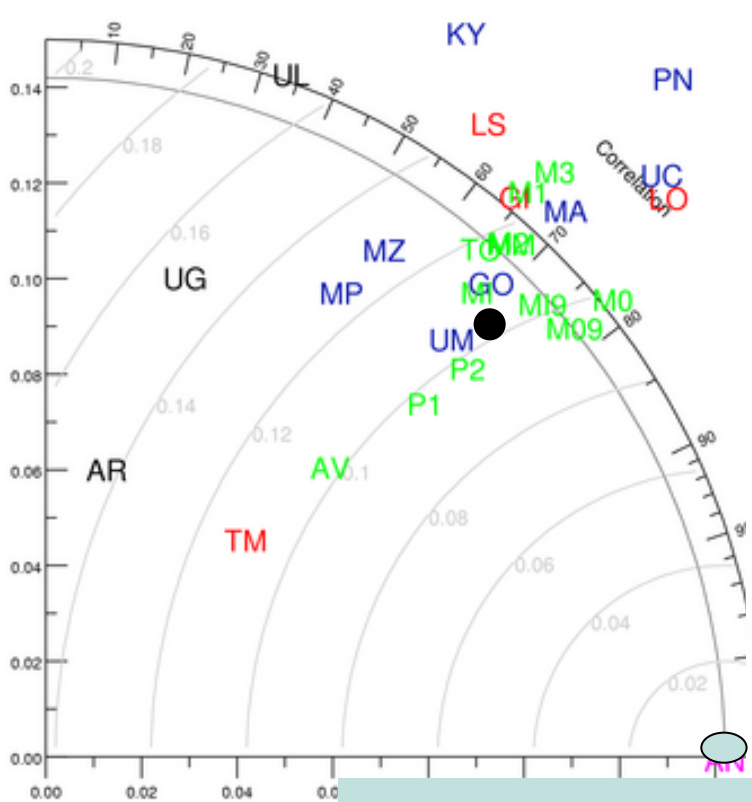
AEROCOM B (models with identical emissions)

Models and Satellites against MODIS 2000 and Aeronet

- Median AeroCom model



MODIS 2000



AERONET 2000

AN: ANET_2000
AR: ARQM_9999
AV: AVHRR_9999
GI: GISS_2000
GO: GOCART_2000
KY: KYU_2000
LO: LOA_2000
LS: LSCE_2000
MA: MATCH_2000
MI: MISR_2000
MI9: MISR_9999
M0: MODIS_2000
M1: MODIS_2001
M2: MODIS_2002
M3: MODIS_2003
M09: MODIS_9999
MM: MODMIS_2000
MZ: MOZGN_2000
MP: MPI_HAM_200
PN: PNNL_2000
P1: POLDER_1997
P2: POLDER_2003
TM: TM5_B_2000
TO: TOMS_9999
UC: UIO_CTM_200
UG: UIO_GCM_999
UL: ULAQ_9999
UM: UMI_2000

GREEN : satellite retrievals

Blue/Red/Black : models

AeroCom Scientific findings

Aerosol dynamics formulation in models is not the only problem

Transport & aerosol model & forcing efficiency diversity
dominate over emission assumption diversity

Considerable differences in modelled vertical aerosol profile,
can explain part of life time differences

Model evaluation against multiple observational data sets
allows no simple ranking of models

Median model quality, compensating effects and constraints on optical depth
suggest that the average aerosol forcing is a BEST estimate

Other environmental factors such as humidity fields and
relative position of clouds and aerosol plumes
have significant impact on forcing estimate

Major differences in direct aerosol forcing can be traced back
to treatment of carbonaceous aerosol in models

BASIC bricks of the future of AeroCom

Phase II requires reorientation

Analysis of aerosol impact on climate and aerosol-climate feedbacks
(in preparation of next IPCC)

Cooperation with HTAP initiative on interhemispheric transport

Organisation as subgroup to
IGAC/WCRP initiative « Atmospheric Chemistry & Climate » AC&C
With steering committee

Installation of working groups on specific problems

Development of process oriented benchmark tests

Automatization of model documentation
Maintenance of AeroCom database
Formatting standards