The effect of harmonized emissions on aerosol properties in global models - an AeroCom experiment

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&

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Outline

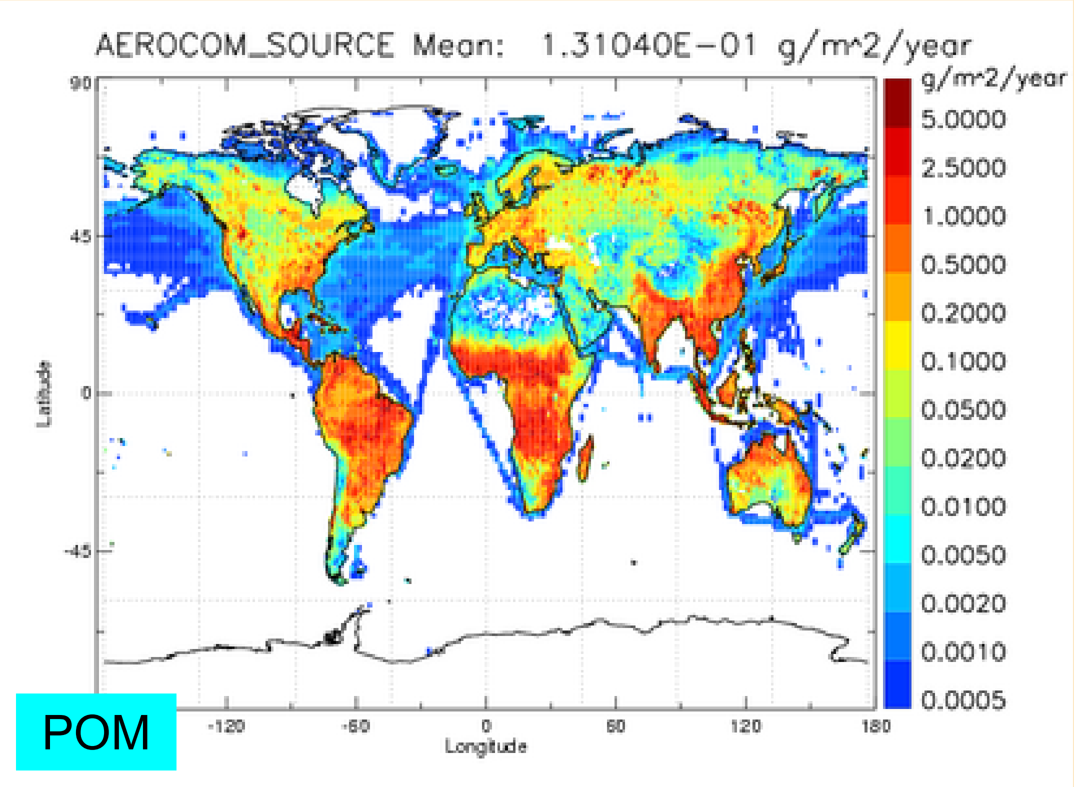
- emissions
- load
- particle sizes
- residence times, removal processes
- composition
- optical properties
- conclusions, outlook

emissions

AeroCom Experiment B

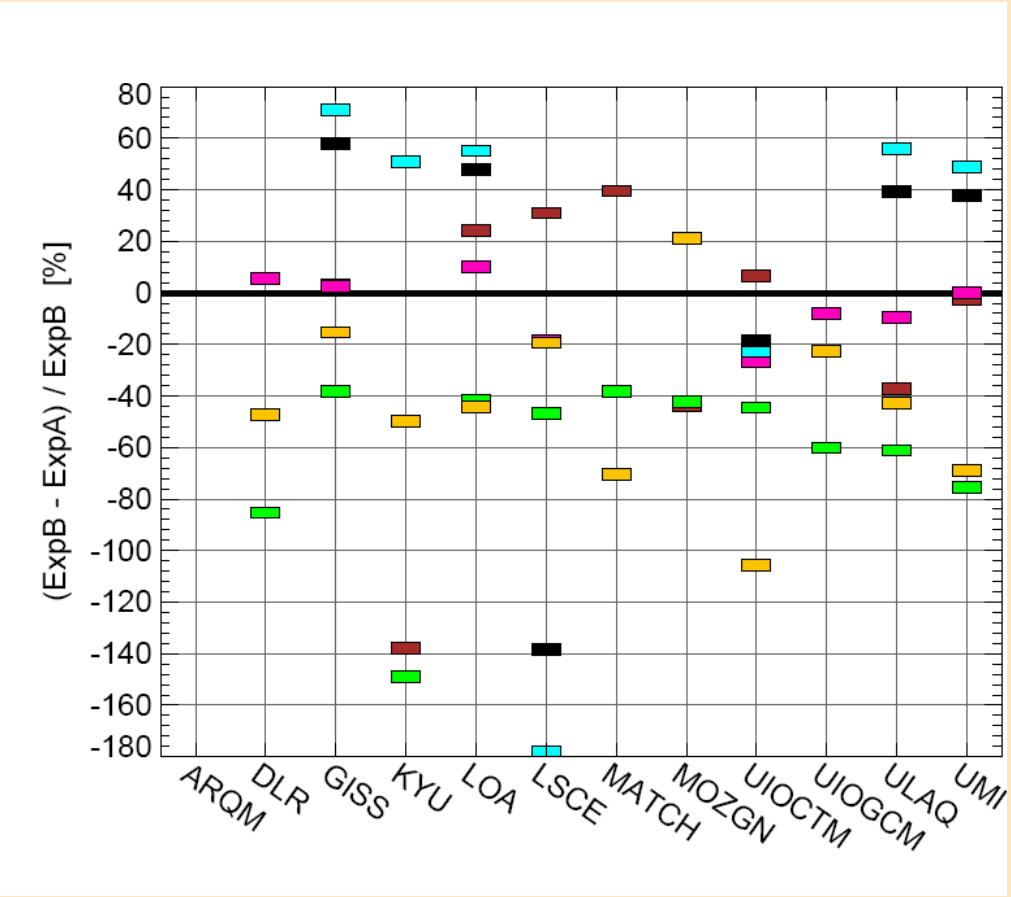
Prescribed emissions:

- 2d/3d fields for dust, sea salt, SO_2, SO_4, DMS, BC, POM
- Particle sizes



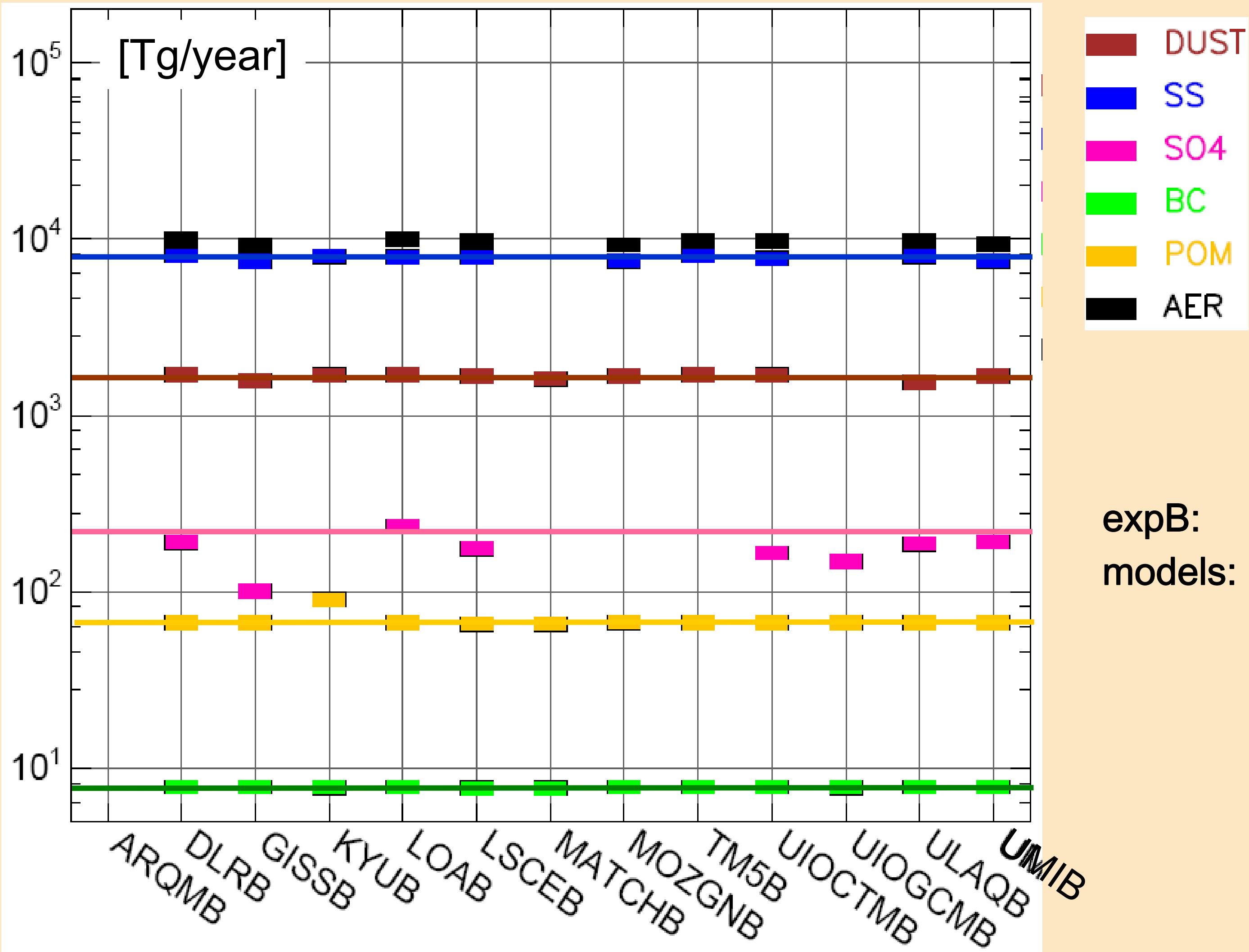
Dentener et al. ACP 2006

Relative changes in emitted masses
Exp B in relation to Exp A



- More SS and DU
- Less BC and POM
- Unchanged SO4

Exp B: „unified“ gobal aerosol emissions



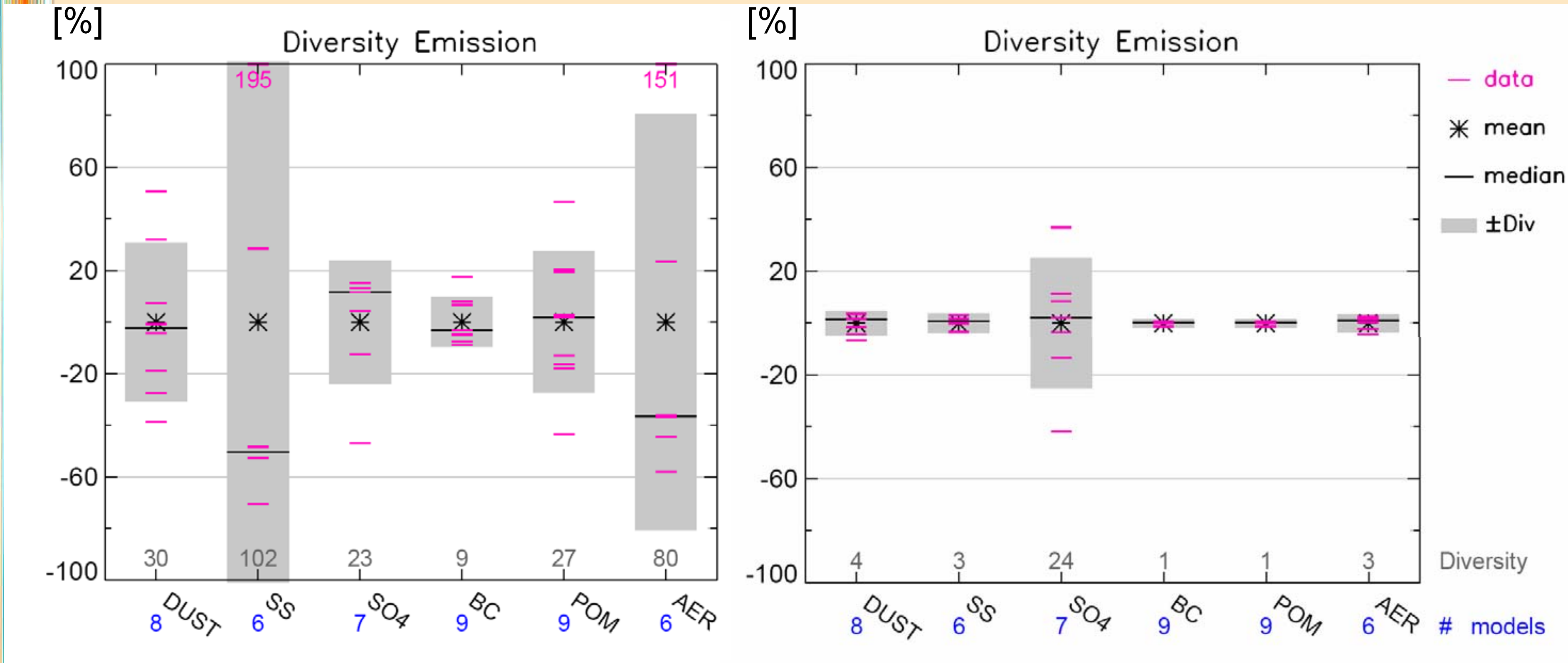
AEROCOM B models

expB: SO2 + SO4 + DMS
models: emi+chep SO4

global annual averages
year 2000 if available

SO4 [TgSO4/a]

Model diversity of emissions in Exp A and Exp B



$$data = \frac{\text{model-all models average}}{\text{all models average}} * 100$$

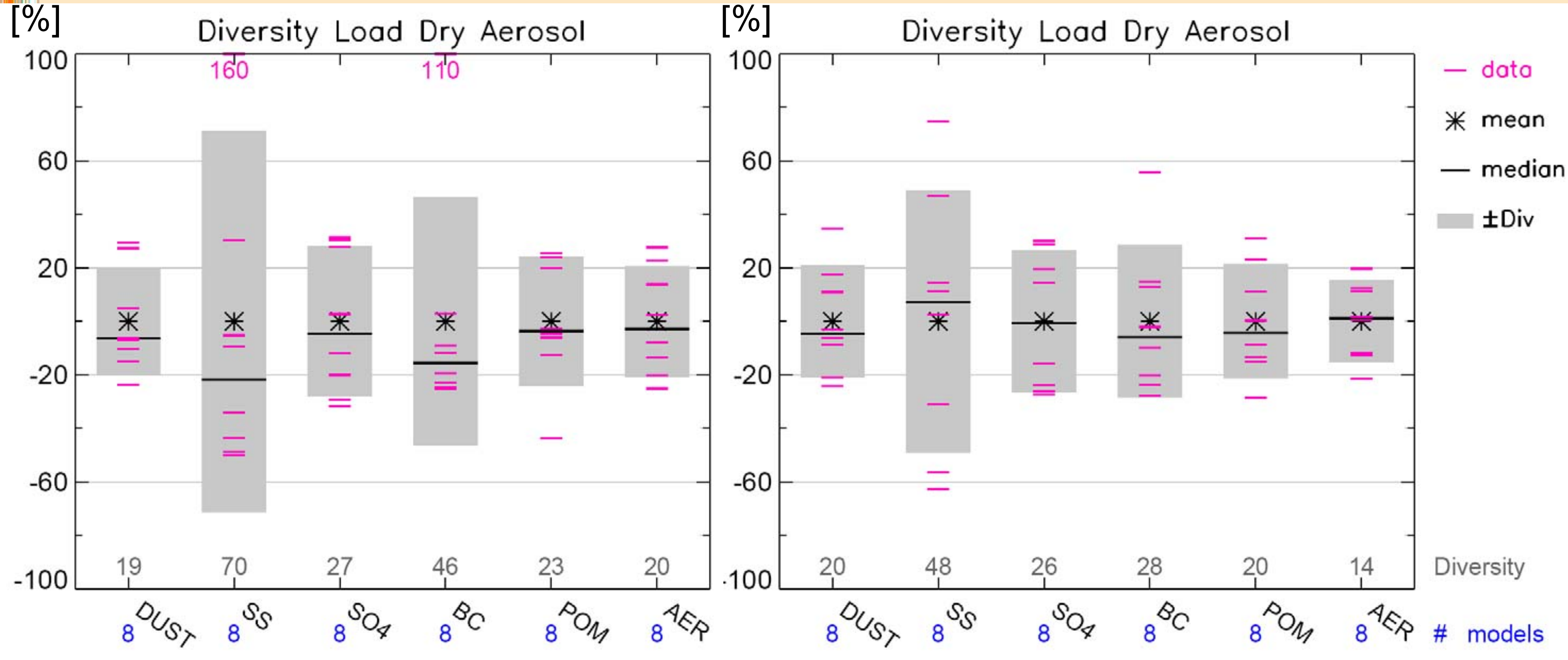
diversity = Standarddeviation of data

global annual averages
year 2000 if available

Differences in model versions in Exp A and B

• KYU	indirect effect included, carbonaceous aerosols: internal/external mixtures in ExpA/B
• DLR	coarse mode included, updated water uptake (EQSAM)
• LOA	no dry deposition for fine aerosols
• MATCH	prescribed SS
• UIO_GCM	prescribed SS and DU
• ARQM	flawed implementation of ExpB emission

Model diversity of total aerosol mass in Exp A and Exp B



Harmonized emissions do not harmonize aerosol mass !

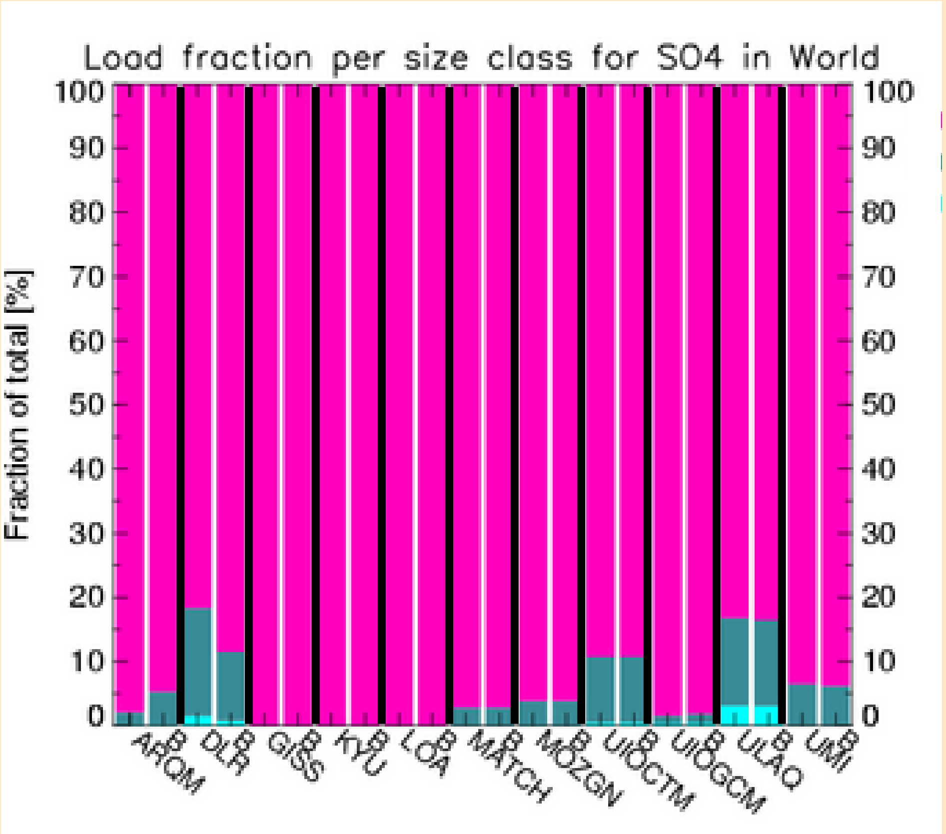
global annual averages
year 2000 if available

Aerocom B emissions: potential problems

- How are the fields interpolated to the model grid?
- How are the emissions filled into the vertical grid?
- How are the sizes represented?
- Bugs…

particle sizes

Mass fraction per size class in Exp A and B



SO4

Size classes	
Radius intervals [mum]	
Acc	<0.5
Coo	0.5 – 1.25
Sup	>1.25

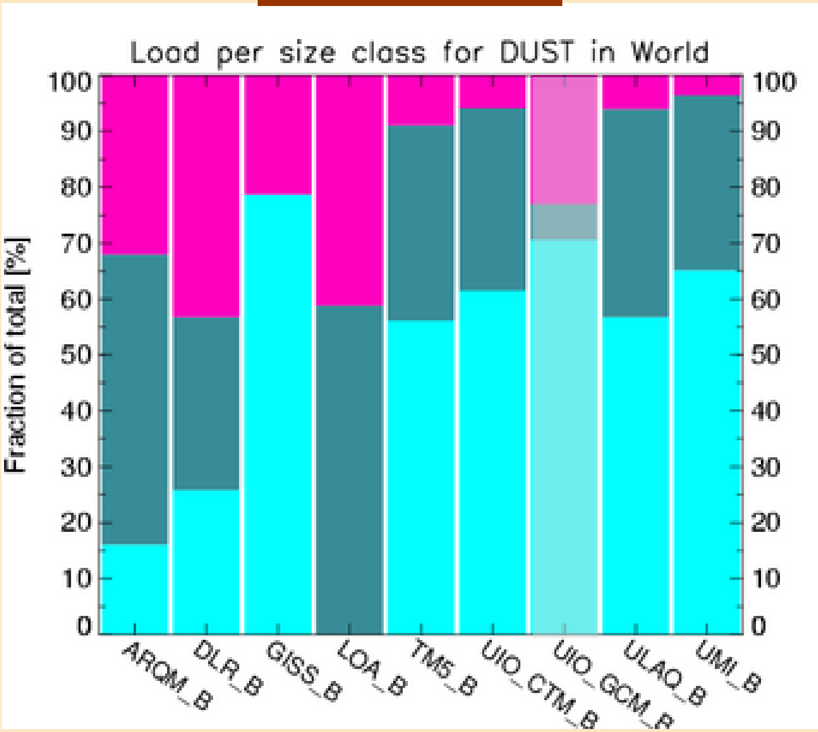
Similar sizes for fine fraction in Exp A and B

global annual averages

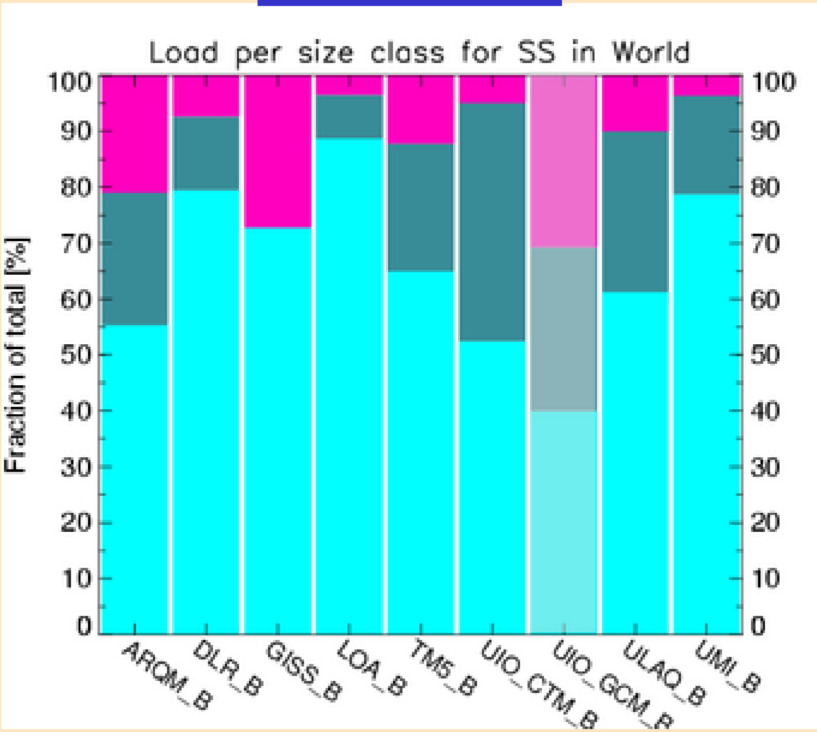
year 2000 if available

Mass fraction / size class in Exp B: DU and SS

DUST



SeaSalt



Unified size (?) of emitted particles is not transmitted to load.

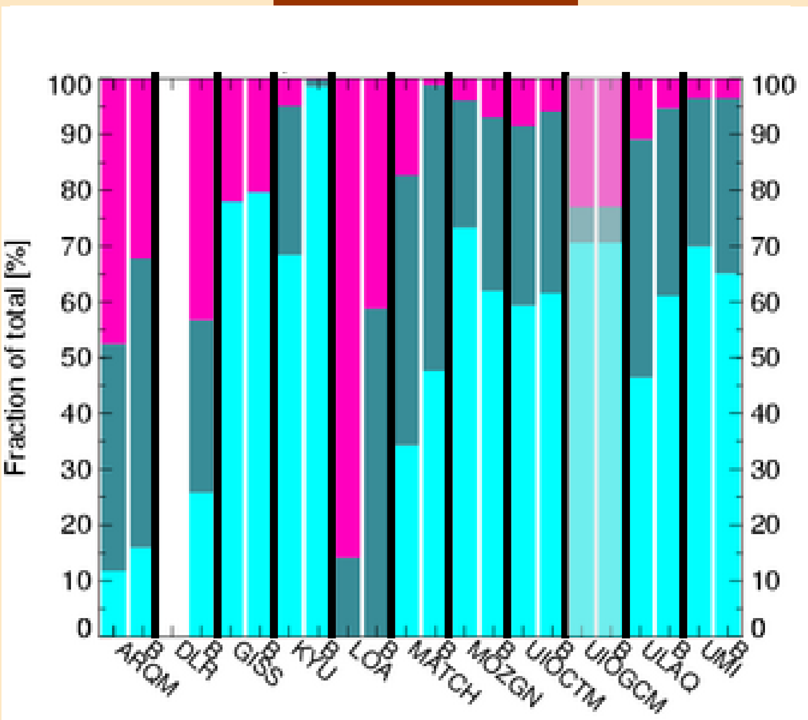
Size classes

Radius intervals [mum]

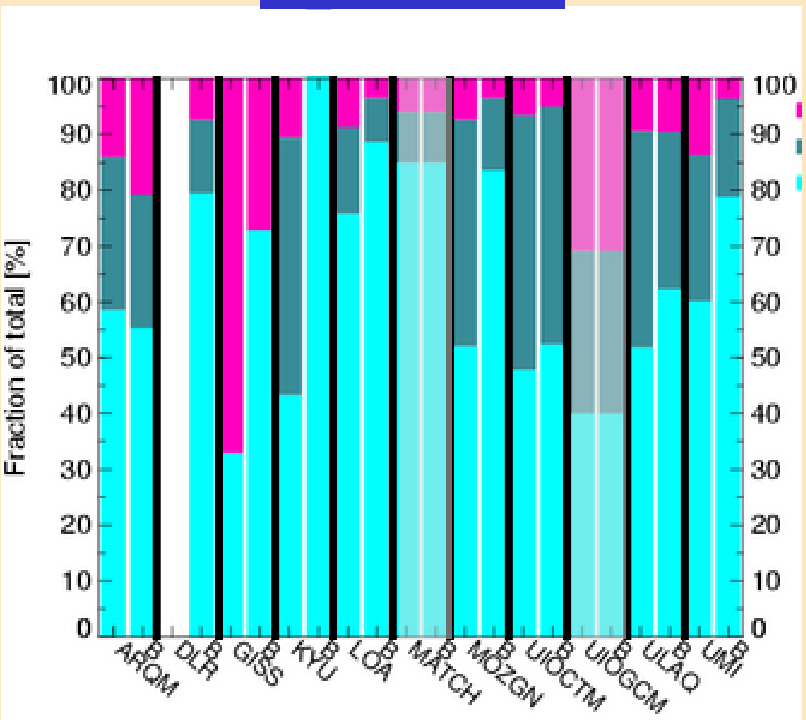
Acc	<0.5
Coo	0.5 – 1.25
Sup	>1.25

Mass fraction per size class in Exp A and B

DUST



SeaSalt



- Particle size is similar for a given model for both experiments.
- Different representation of sizes in schemes?
- Deficiency of AeroCom diagnostics?

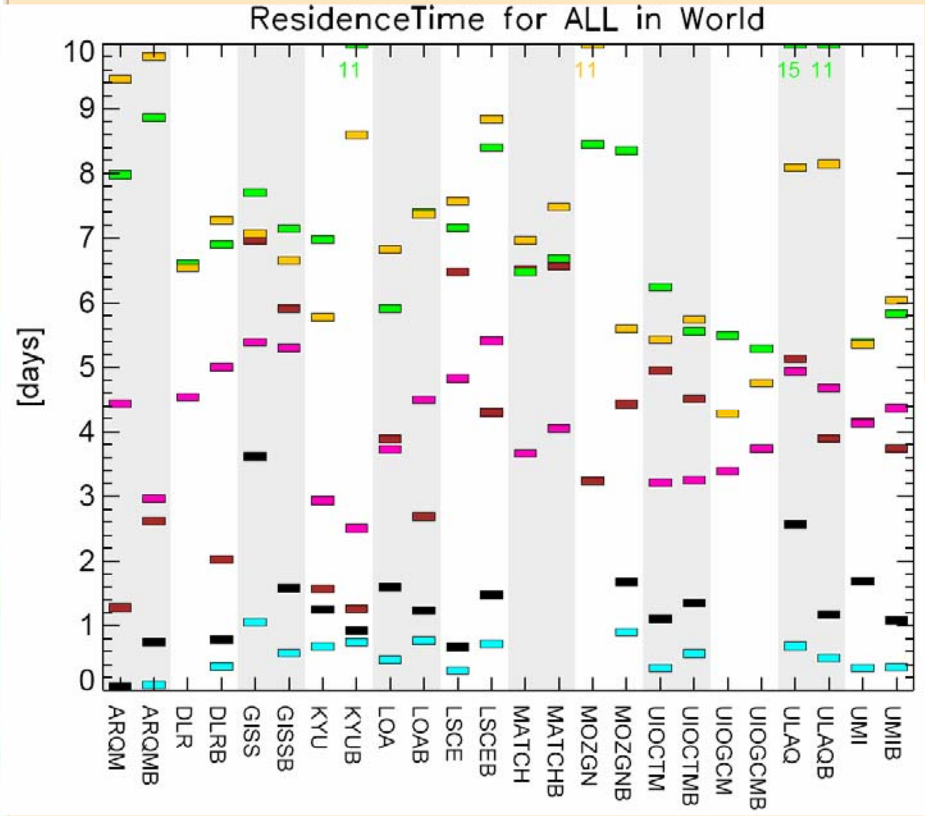
Size classes

Radius intervals [mum]

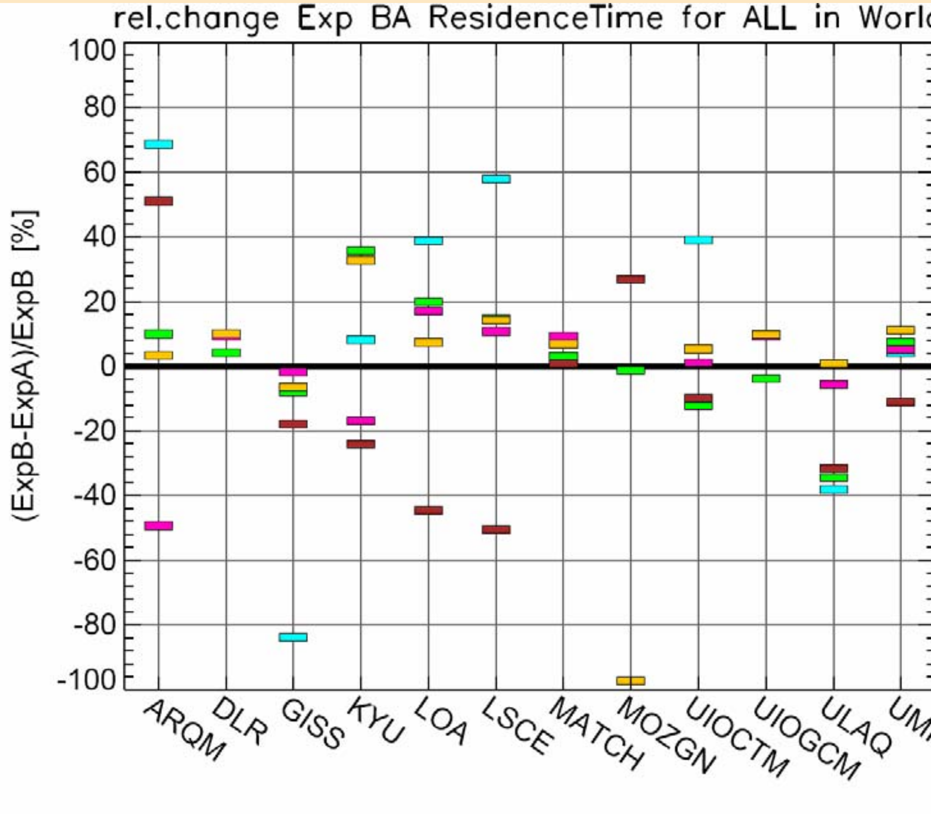
Acc	<0.5
Coo	0.5 – 1.25
Sup	>1.25

Residence times

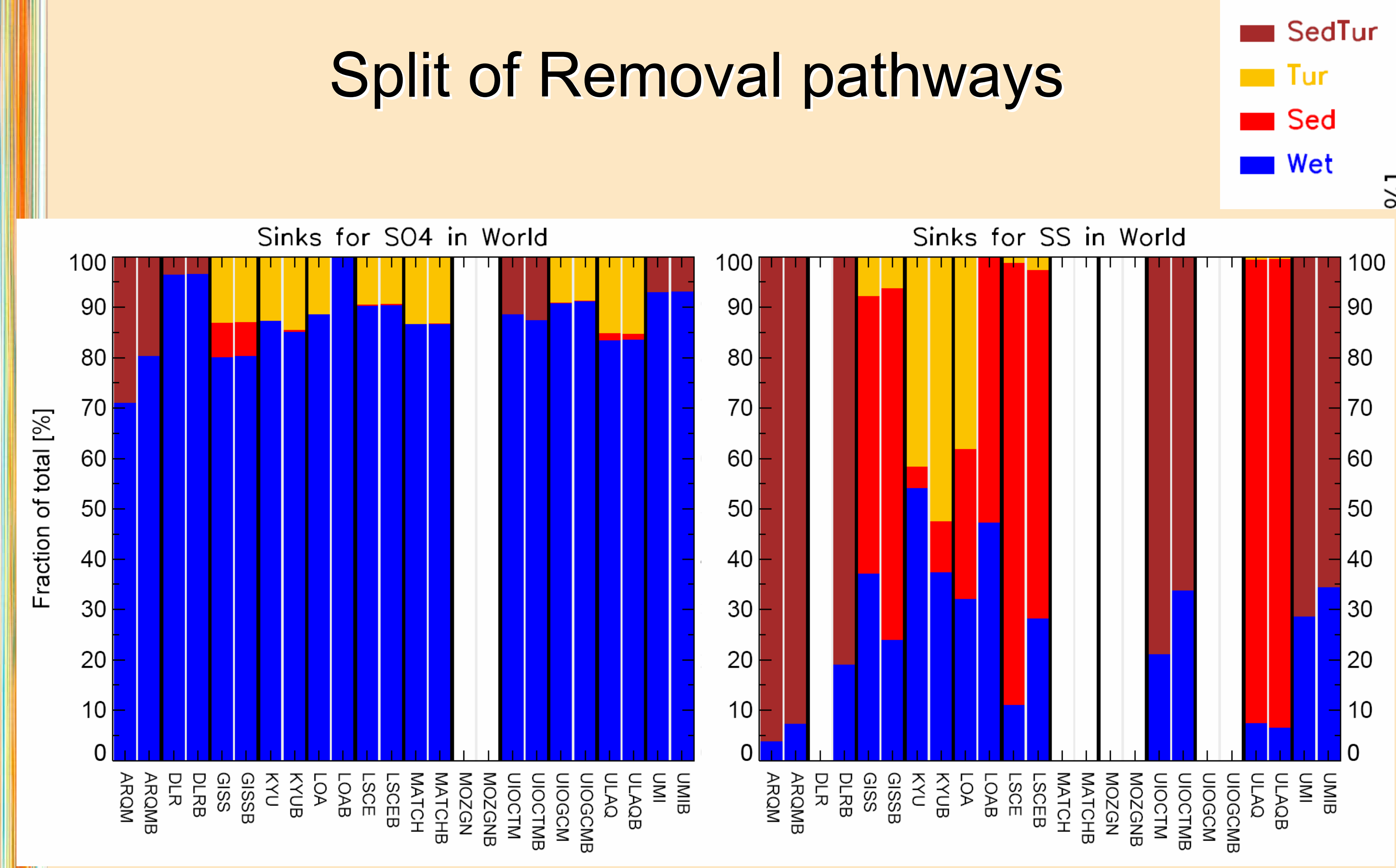
Residence times in Exp A and B



Effects of modified spatial distributions and particle sizes.

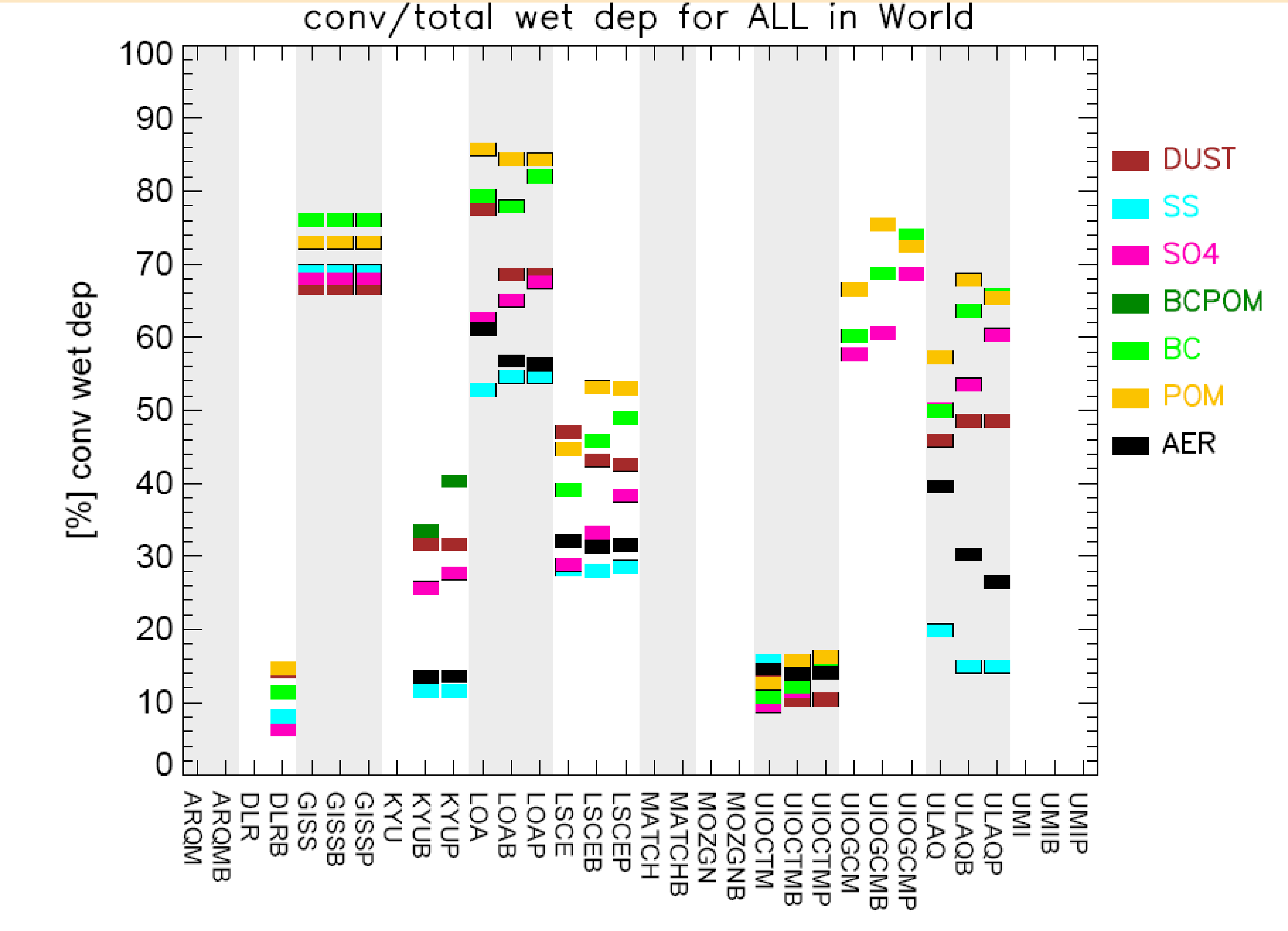


Split of Removal pathways



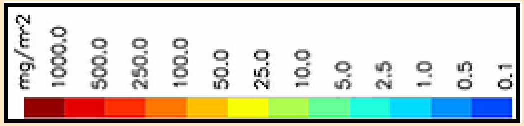
Results of the two exp‘s are more similar for a given model than for a given experiment.

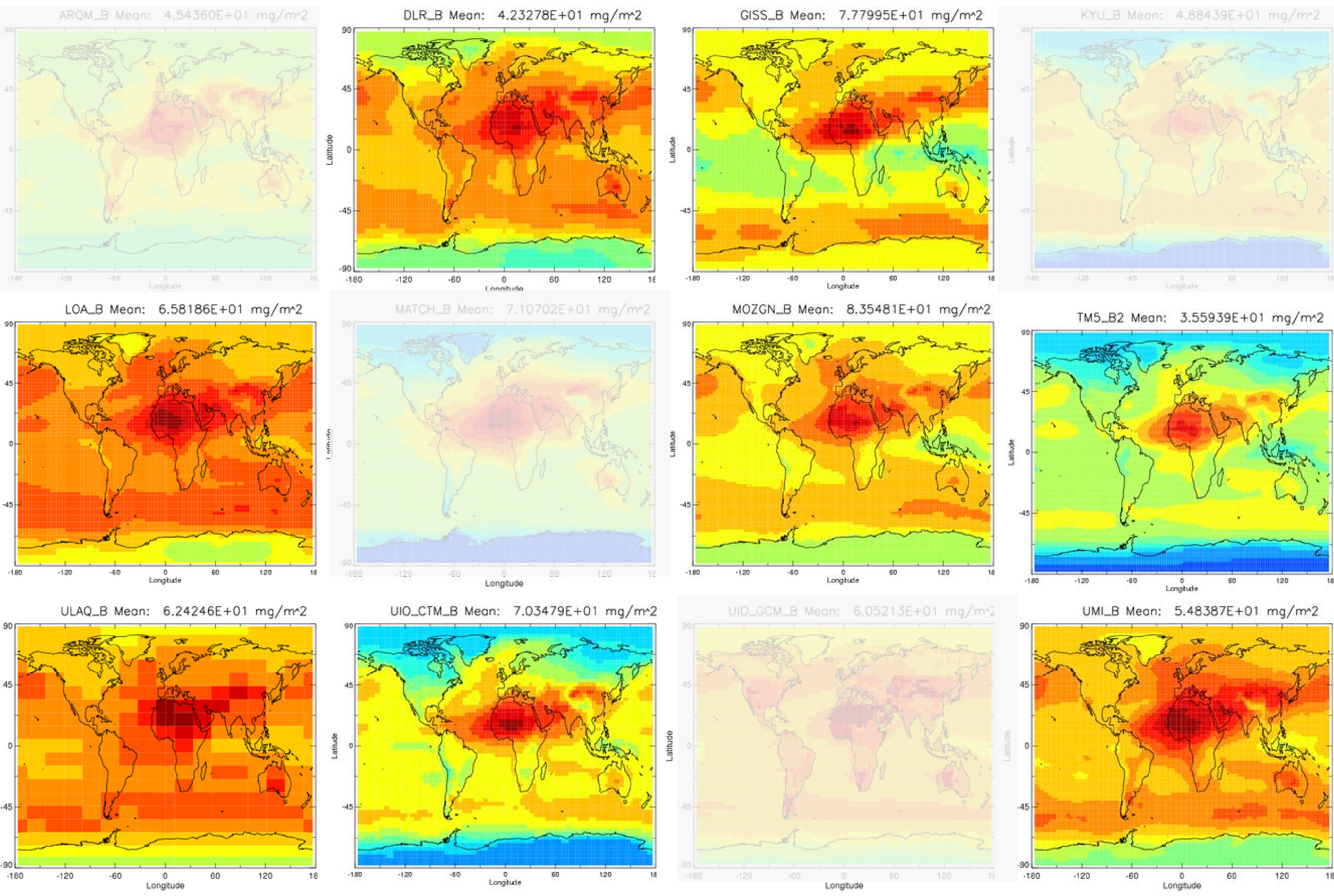
Split between stratiform and convective wet depostion



simulated spatial aerosol distributions

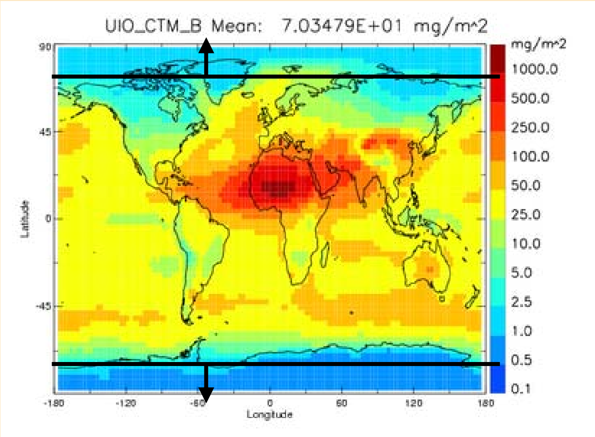
Aerosol load in Exp B [mg/m²]

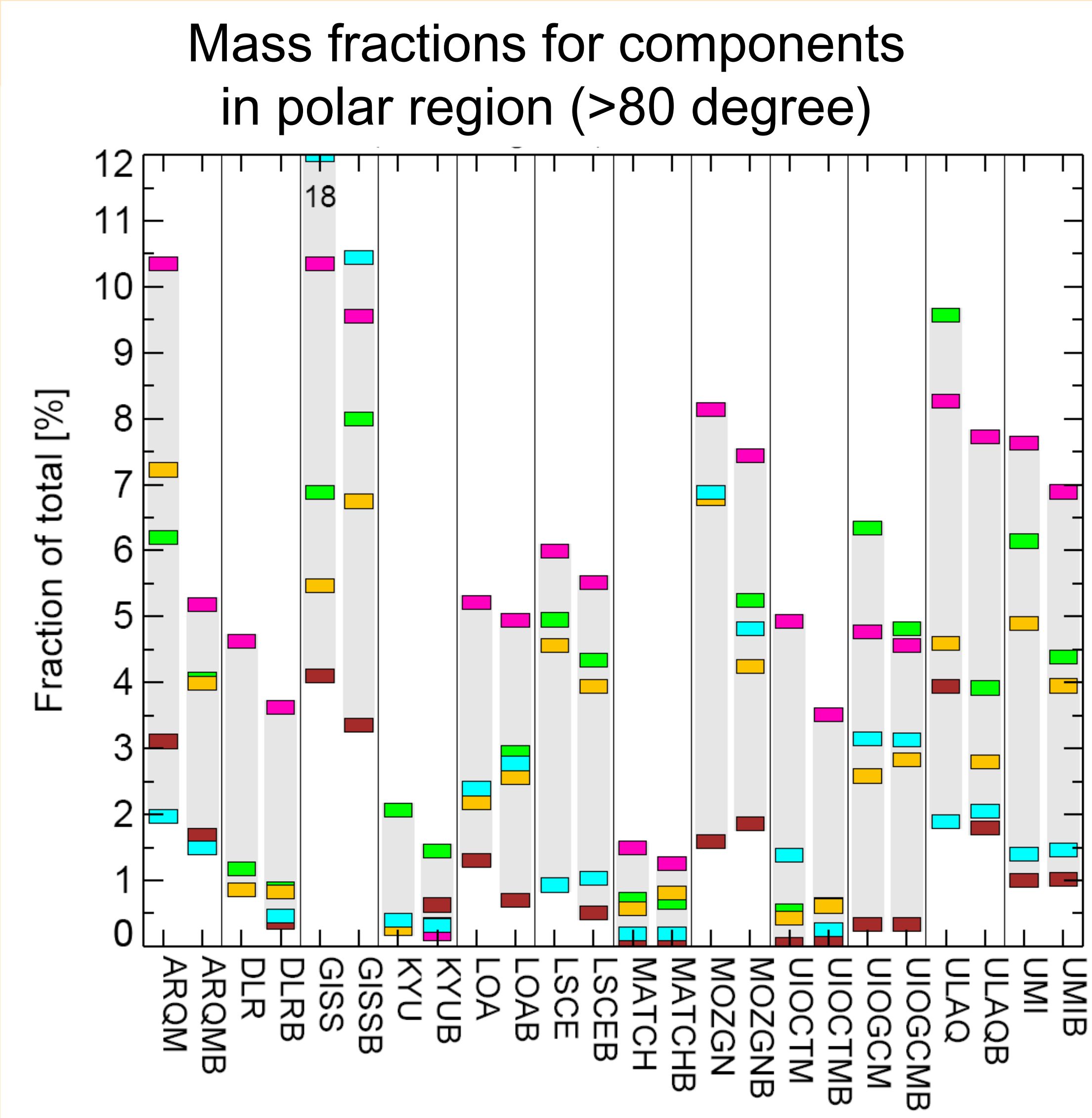




Meridional distribution of Aerosols

load

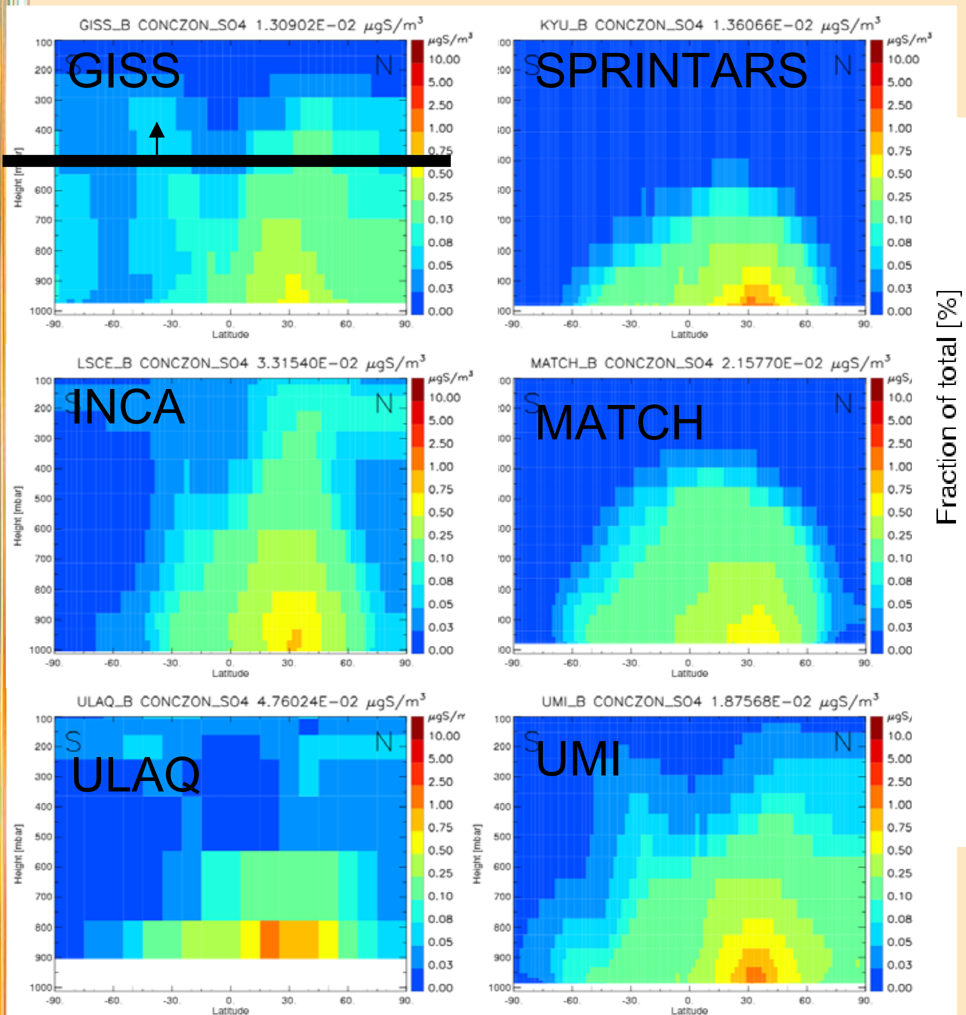




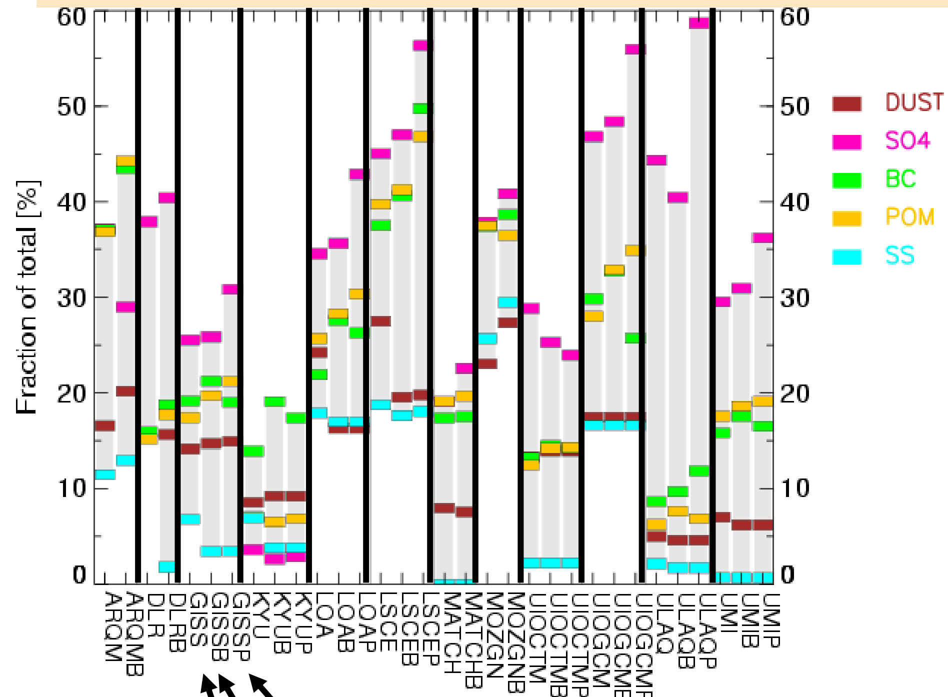
… is model specific

Vertical distribution of Aerosols

SO4 zonal concentration



Mass fractions for components above 5 km height



PRE=AeroCom 1750

B=AeroCom emissions 2000

A=original model

… is model specific

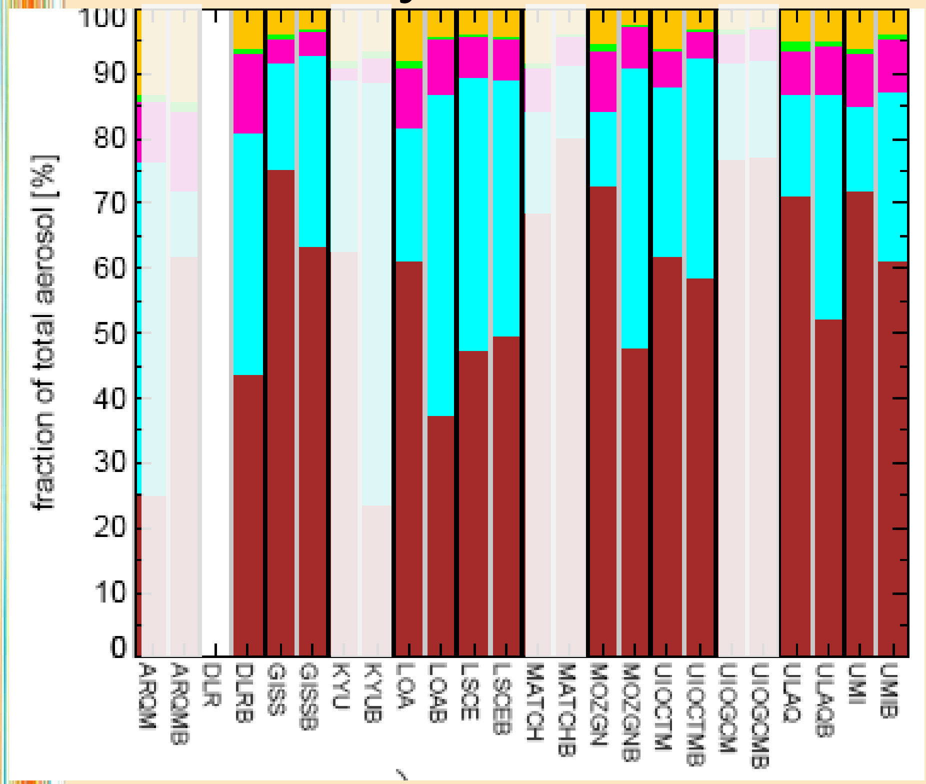
Textor et al. 2006

composition

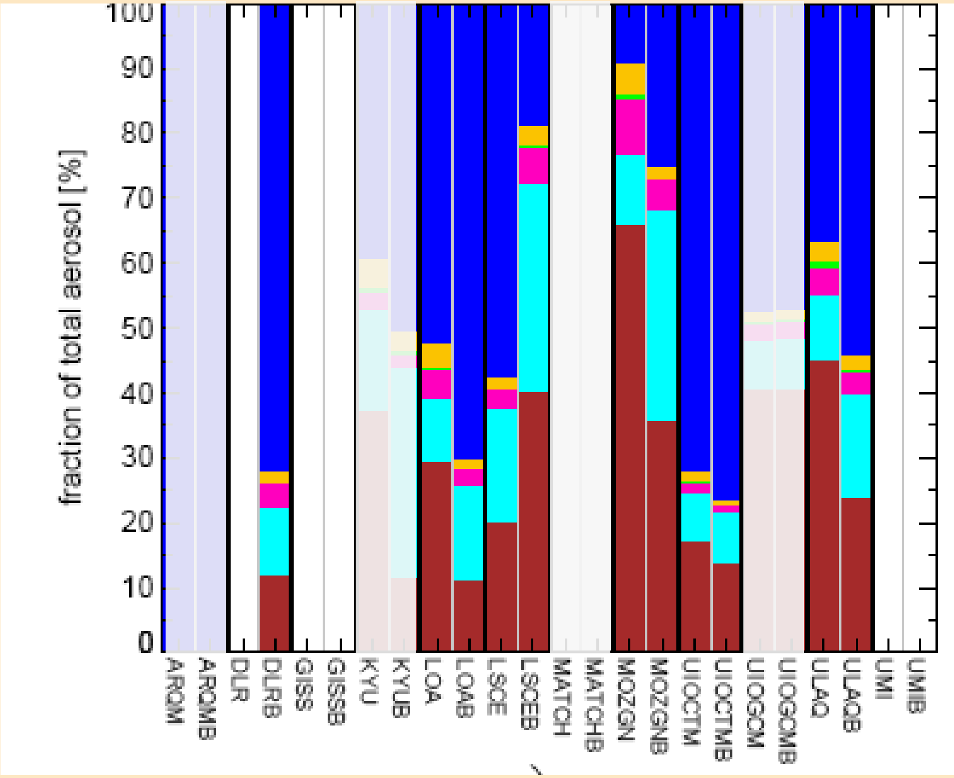
Composition

contribution to total mass per component

Dry aerosol

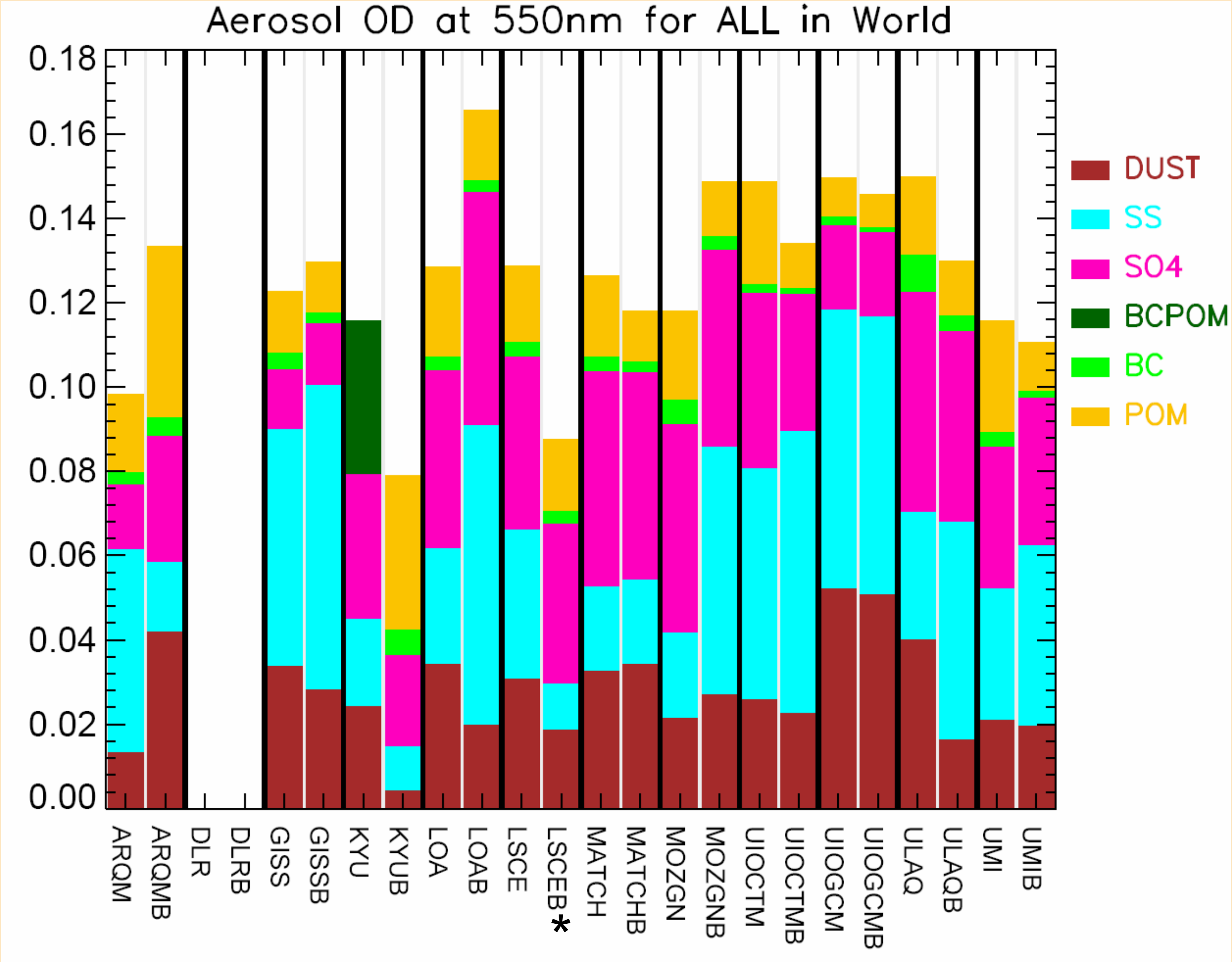


Ambient aerosol

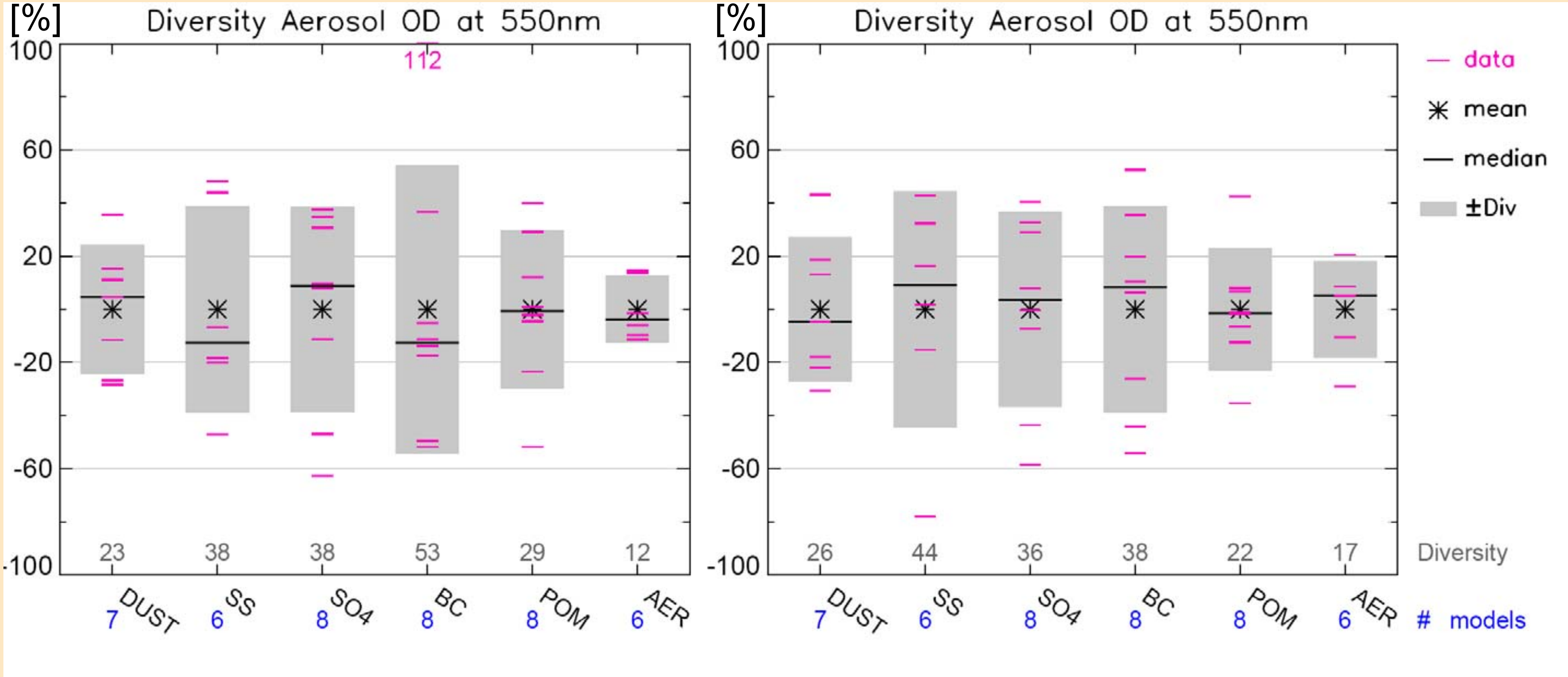


Optical properties

Aerosol Optical Depth per component



Aerosol Optical Depth

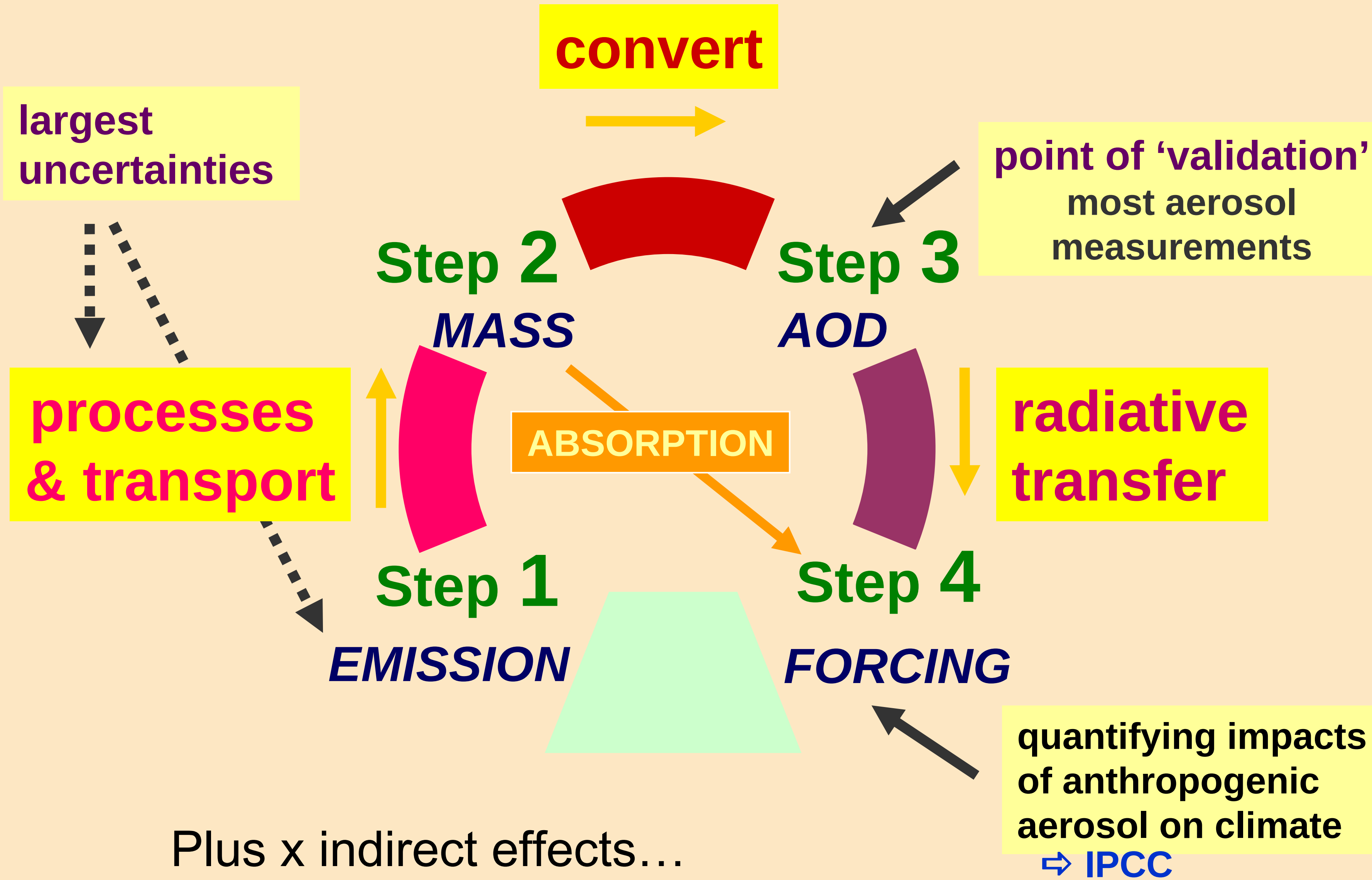


Harmonized emissions do not harmonize aerosol optical depth !

Conclusions

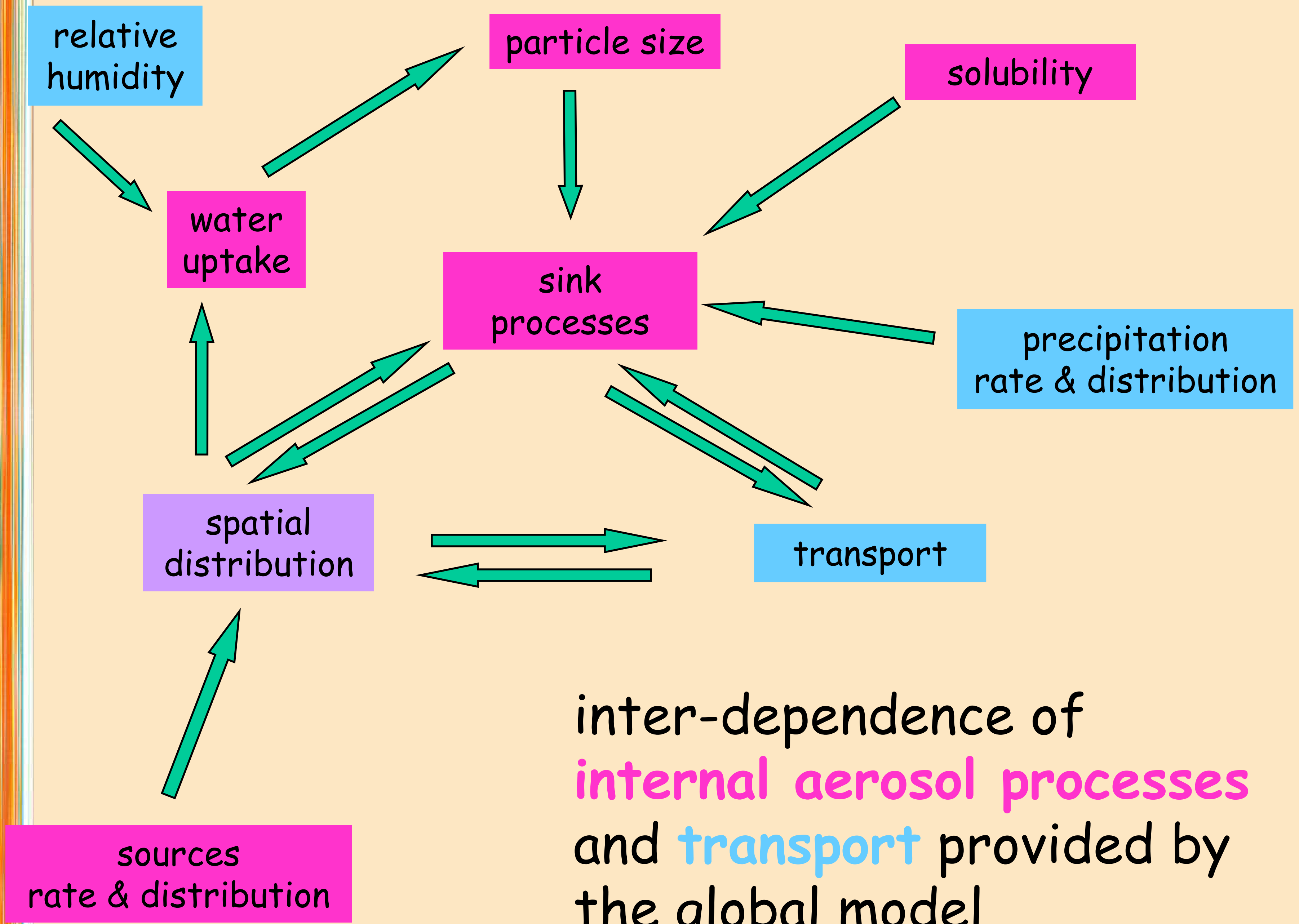
- Implementation of prescribed aerosol (precursor) sources is not straightforward.
- The diversity among model results is about the same in both experiments.
- Harmonizing emissions has only a small impact, models are ‘pre-wired’.
- <u>Aerosol microphysics is not the only problem.</u>
- Important implications for pollution abatement strategies inferred from such model results.

Outlook: Modeling of aerosols - a “ 4 Step process “



THANK YOU !

The aerosol life cycle



inter-dependence of **internal aerosol processes** and **transport** provided by the global model

Sink processes analysis

The rates differ between the species:

- **wet removal rates**
  increase with the solubility
  from DU, BC, POM to SO4 and SS.
- **dry removal rates**
  increase with the particle sizes.
- **main removal processes**
  BC, POM to SO4: > 80% wet dep.
  DU andSS: ~66% dry dep.

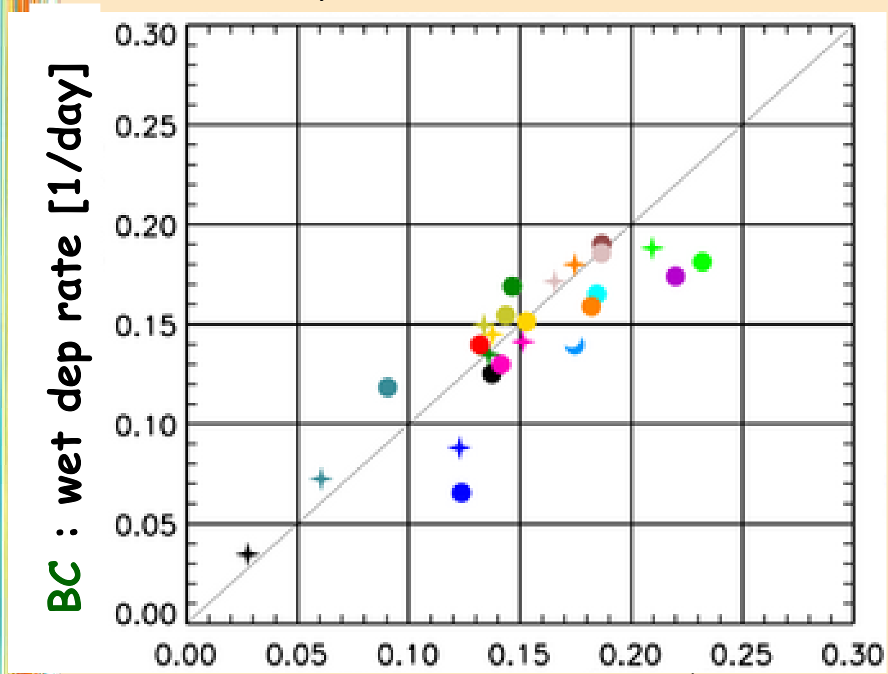
Why do the removal rates for a given species differ between the models ?

Removal rate vs vertical dispersal

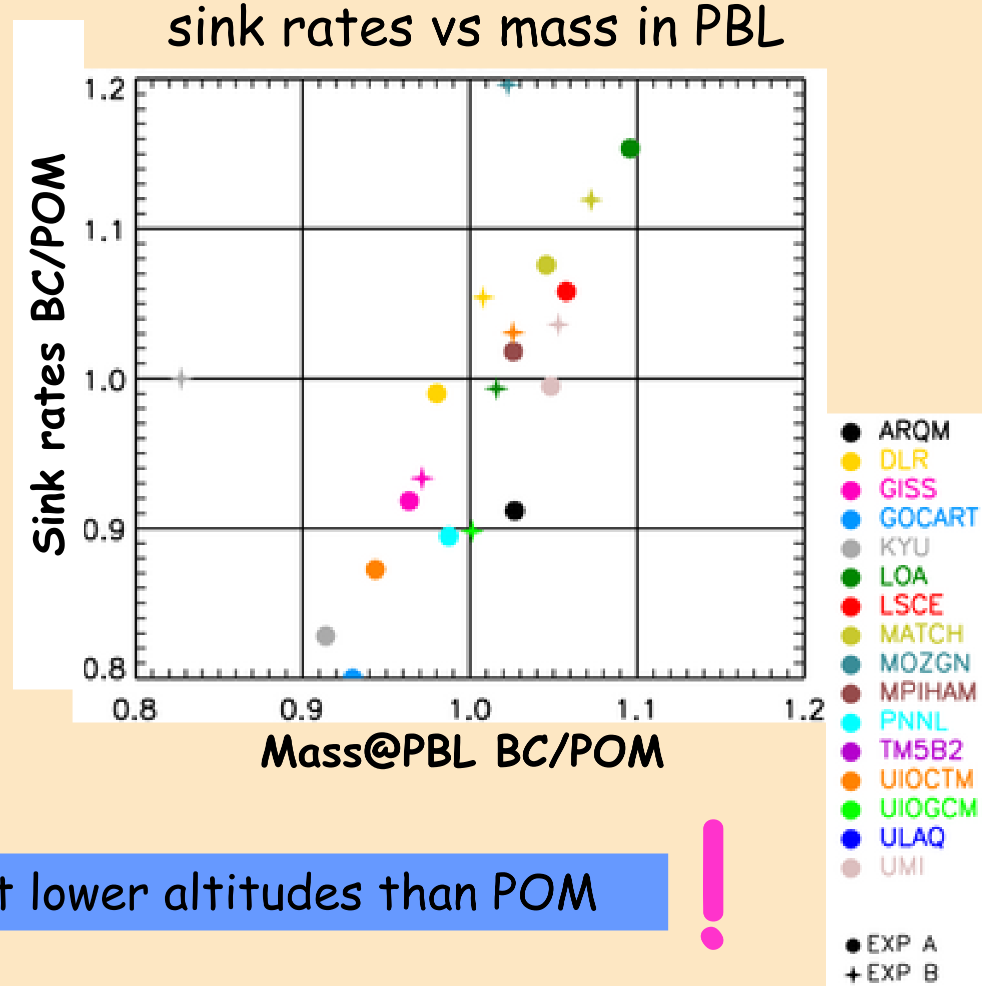
Faster sink rate for BC than for POM

?

Wet dep rate BC vs POM



Ratios BC/POM:
sink rates vs mass in PBL



If BC at lower altitudes than POM

!

Composition

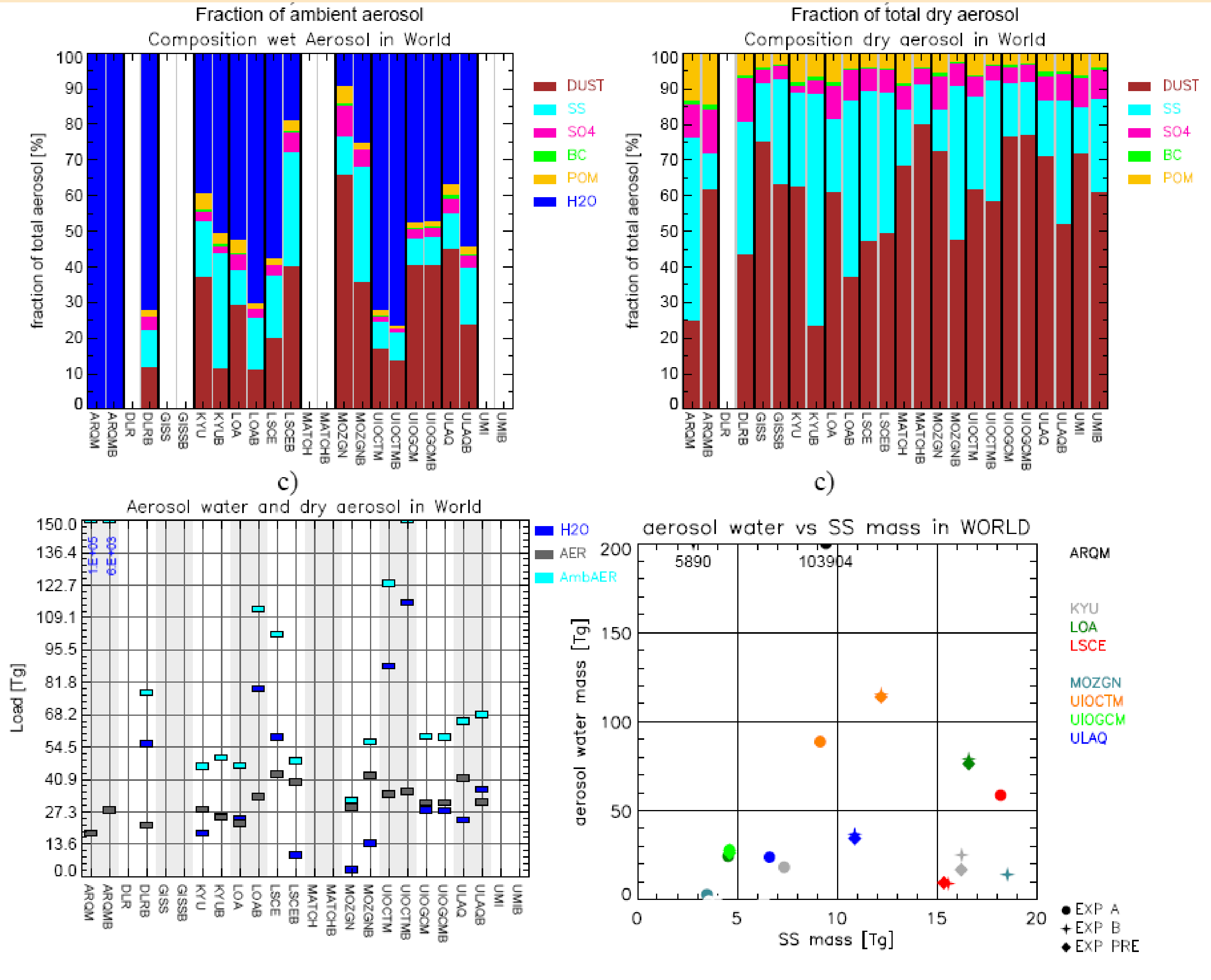
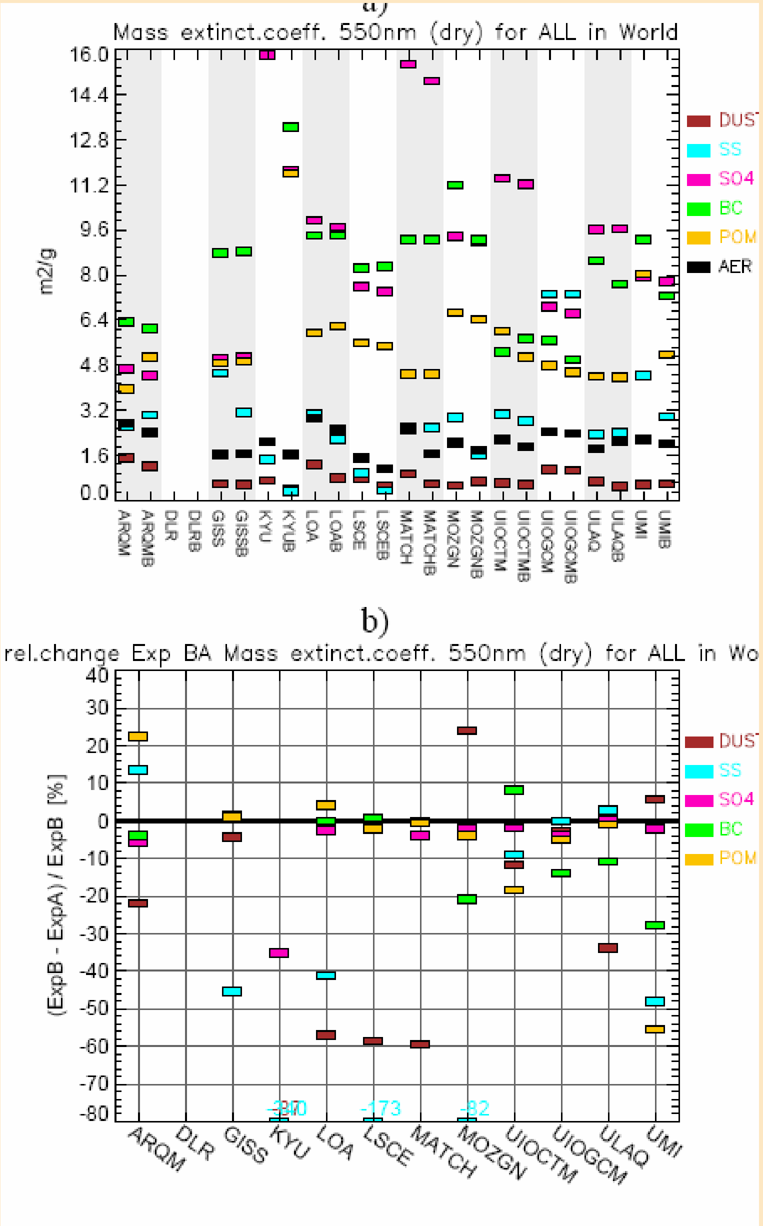


Fig. 11. a) Global annual average masses of dry aerosol (DryAER) and of aerosol water (H2O) and ambient aeros...

Mass Extinction coefficient



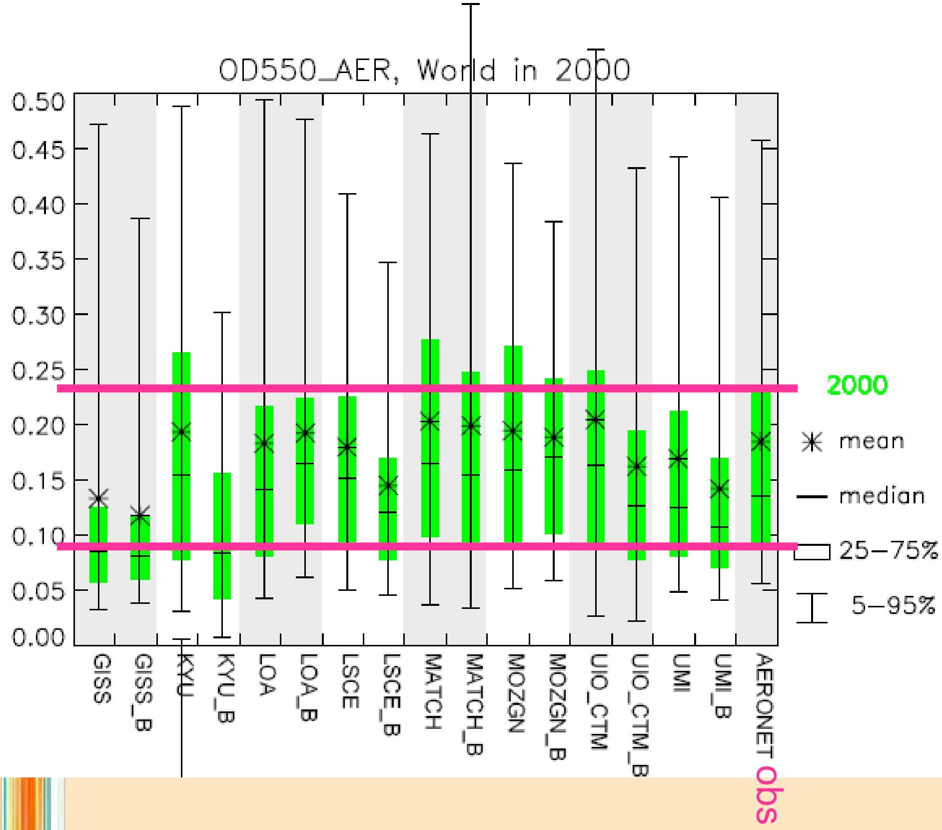
MEC

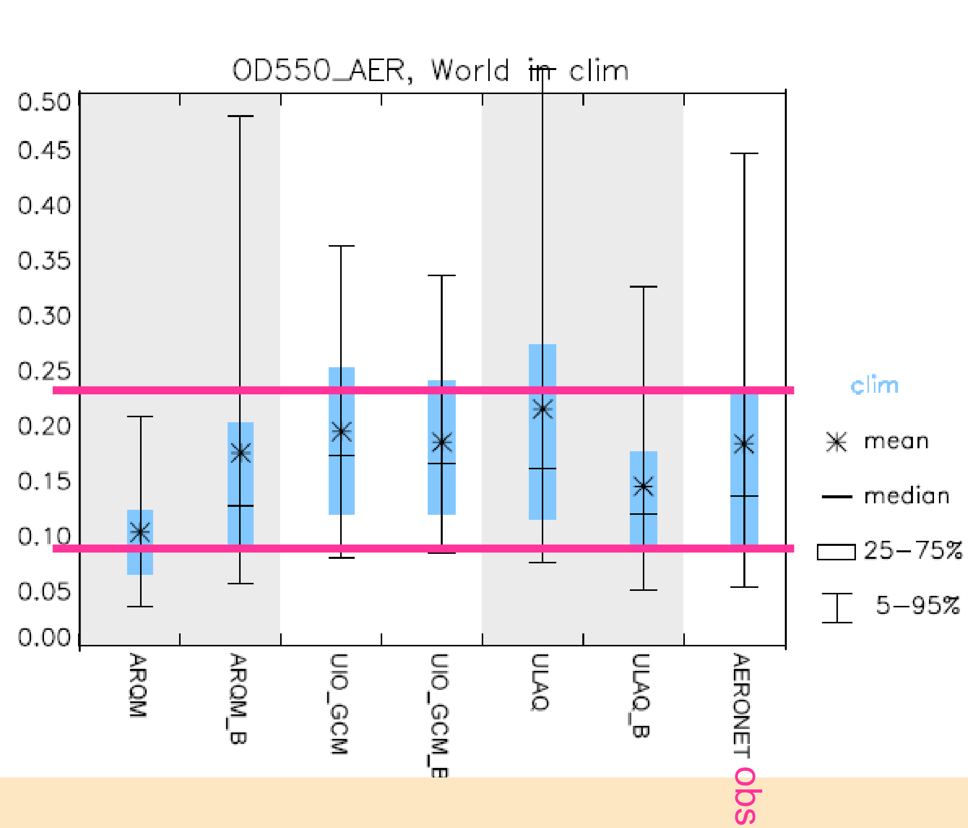
= AOD550 /dryload

= 3*opt_prop/(4*rho*r_eff) *(water+dryload)/dryload)

Chin et al., JAS 59, 461-483,2002

Comparison to Observations





Exp B

- Smaller AOD due to smaller anthropogenic emissions
- Better match to obs