# AEROCOM: Global Aerosol Models Tested Against Surface Observations

Adress the multi-parameter aerosol problem from the angle of multi-model evaluation with observations from the surface

# Surface observations

**Considered parameters :**

Surface concentrations : sulfate, black carbon, organic carbon, sea-salt

Optical depth

Angstrom coefficient

**Models / measurements comparisons :**

- collection of observational data (from web sites)

EMEP : SS and SO4 conc — Europe – until 2000 – 32 stations

IMPROVE : BC, OC, SS and SO4 concentration

North America – 1996 to 2002 – 26 stations

GAW : SS ans SO4 concentrations — 5 stations – 1996

AIRMON : SO4 concentration — 2 stations – 1996&1997

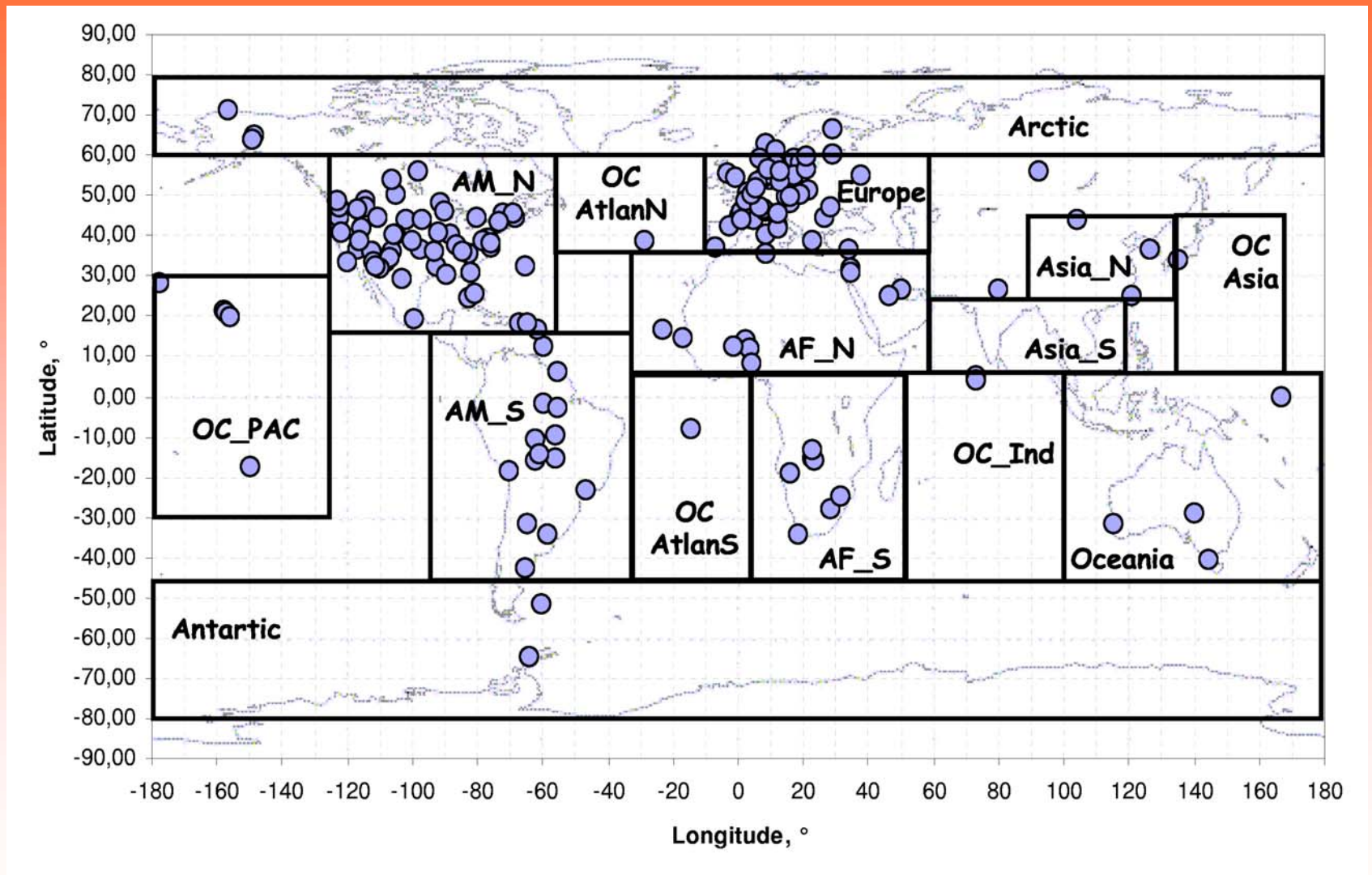
Paul Scherrer Institute : BC conc — 3 stations – 96 to 2001

AERONET : OD550 and Angstrom coefficient

98 stations – 1996 to 2001 (1998 to 2001 for Angstrom)

- model output to 166 station locations
- analysis of time series, global maps, scatter plots and synthesis graphs

# Stations location

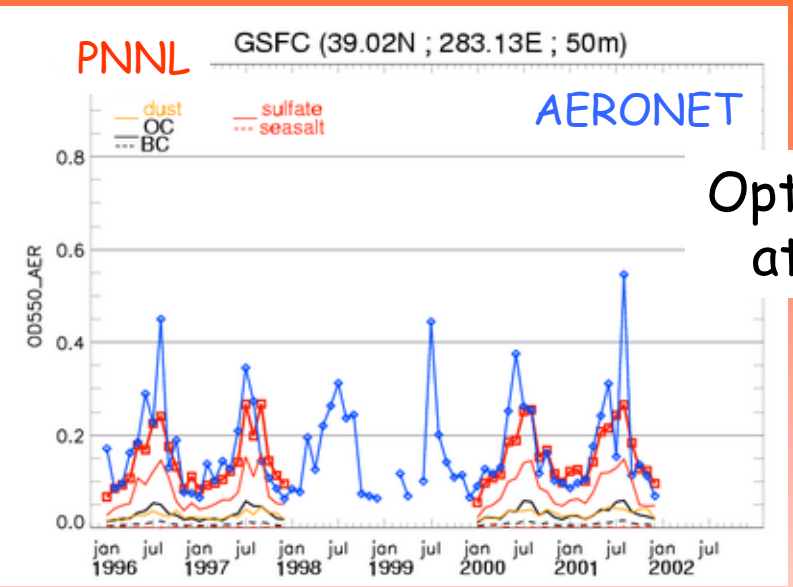



Selection of 15 regions on the world

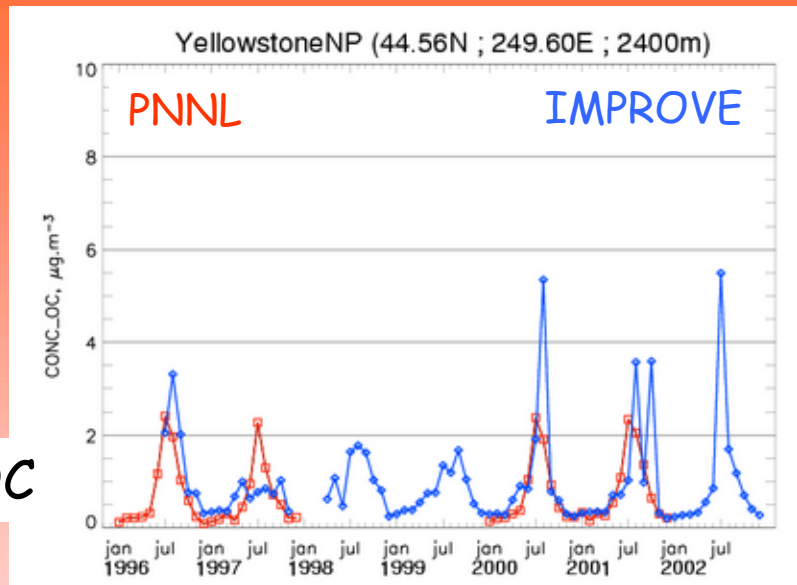
# Models

| | ARQM | KYU | LSCE | LOA | MATCH | PNNL | UIO CTM | UIO GCM | ULAQ | UMI |
|---|---|---|---|---|---|---|---|---|---|---|
| Optical depth | clim | 1997 | | | 1997 | 1997 | | clim | clim | 1997 |
| | | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | | | |
| Angstrom coefficient | clim | | | | 1997 | 1997 | | clim | clim | |
| | | | 2000 | 2000 | 2000 | 2000 | 2000 | | | |
| BC concentration | | 1997 | | | 1997 | 1997 | | clim | clim | |
| | | 2000 | 2000 | 2000 | 2000 | 2000 | | | | |
| OC concentration | | 1997 | | | 1997 | 1997 | | clim | clim | |
| | | 2000 | 2000 | 2000 | 2000 | 2000 | | | | |
| SO4 concentration | | 1997 | | | 1997 | 1997 | | clim | clim | |
| | | 2000 | 2000 | 2000 | 2000 | 2000 | | | | |
| SS concentration | | 1997 | | | | 1997 | | | clim | |
| | | 2000 | 2000 | 2000 | | 2000 | | | | |

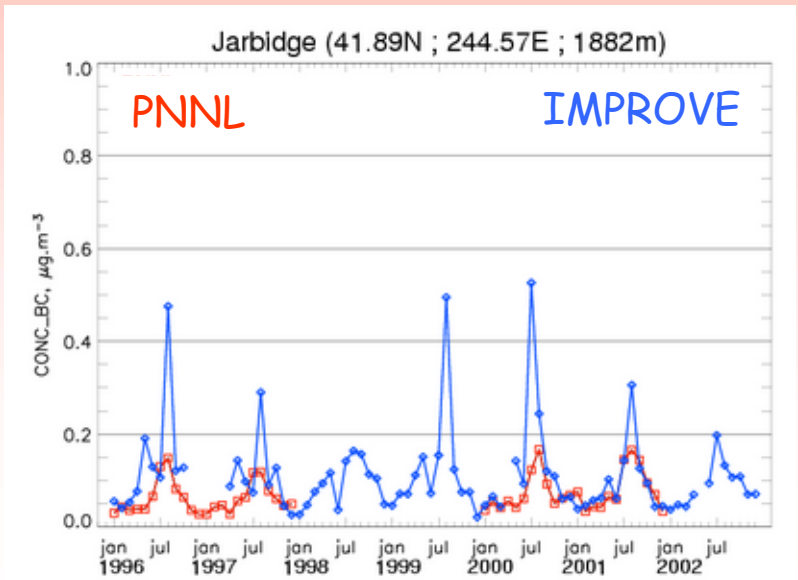
# Interannual variability



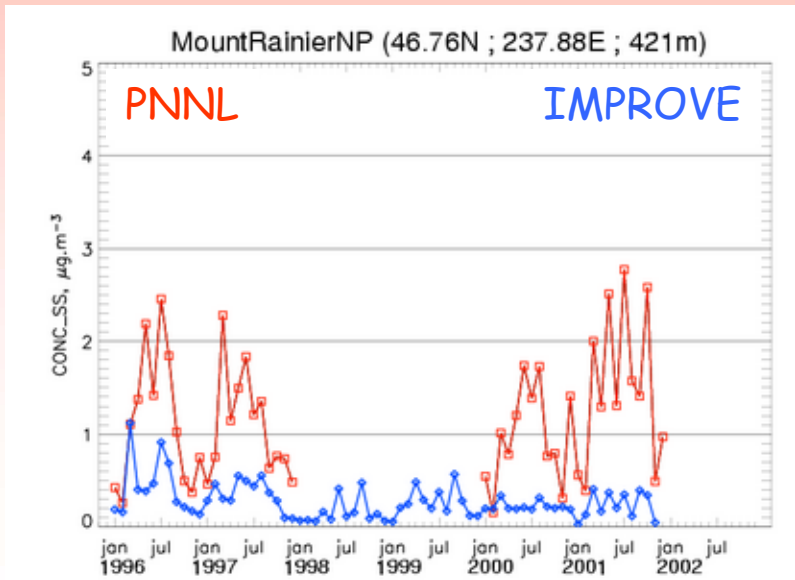

Optical depth at 550 nm




CONC OC



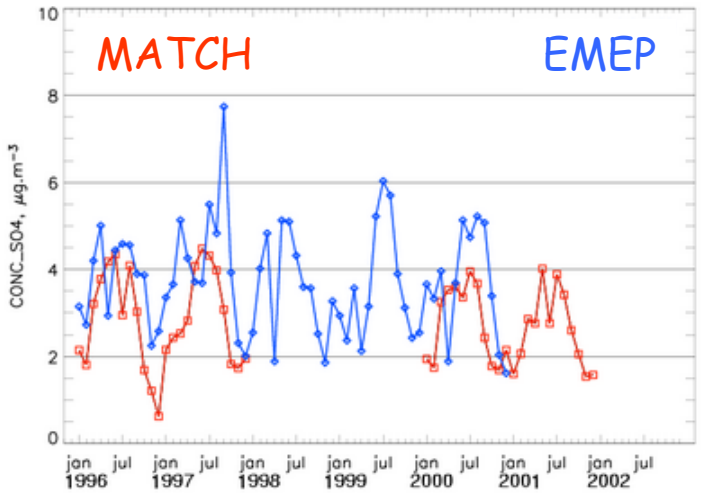

CONC BC



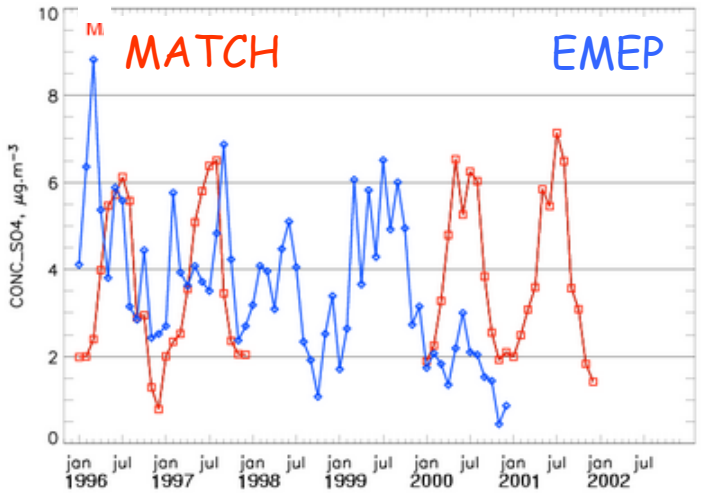

CONC SS

# Interannual variability

**Logrono, Spain : 1996-2002**

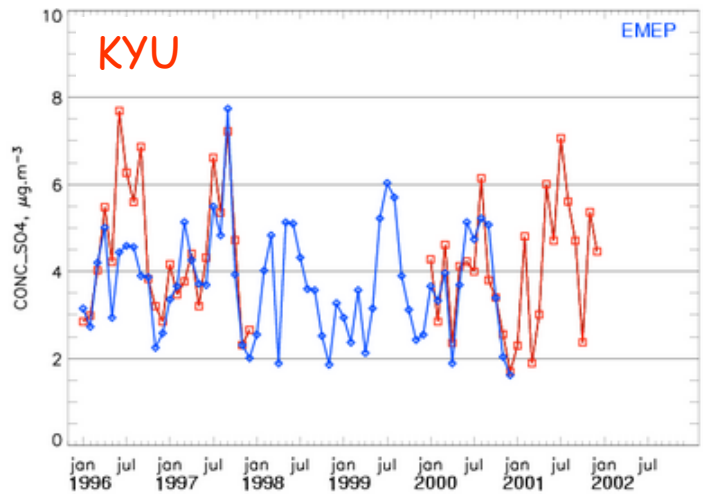



**Ispra, Italia : 1996-2002**

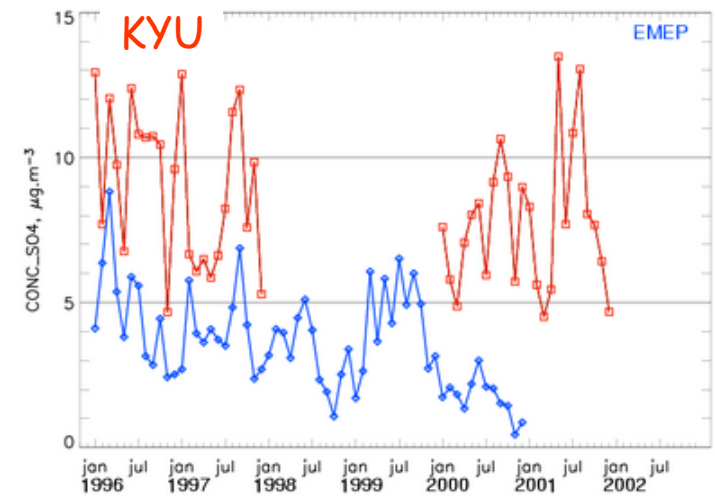



Use of same $SO_4$ emission data each year ⇒ problem with emission scenarios ?

**Logrono, Spain : 1996-2002**



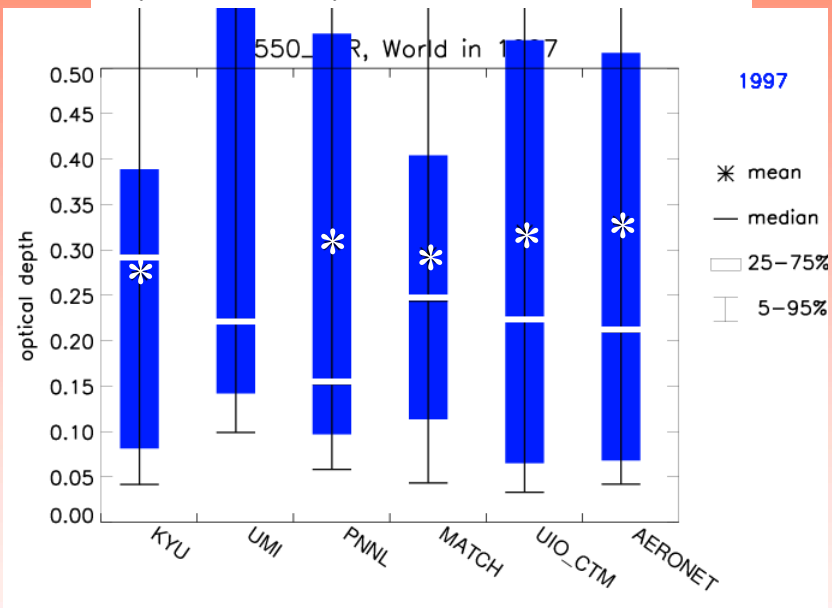

**Ispra, Italia : 1996-2002**



# Interannual variability

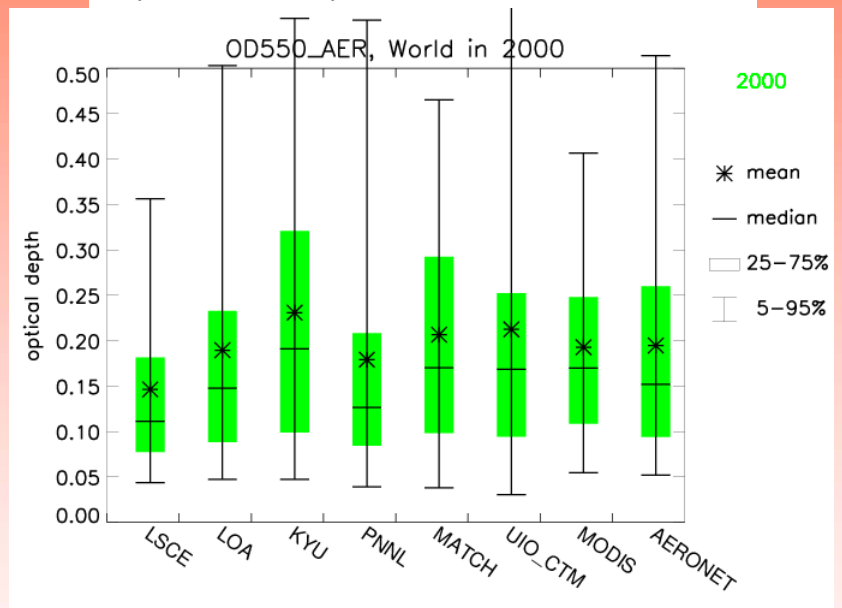
What is the influence of a different year use on the conclusion of comparison with surface observations ?

optical depth in 1997, world




81 points

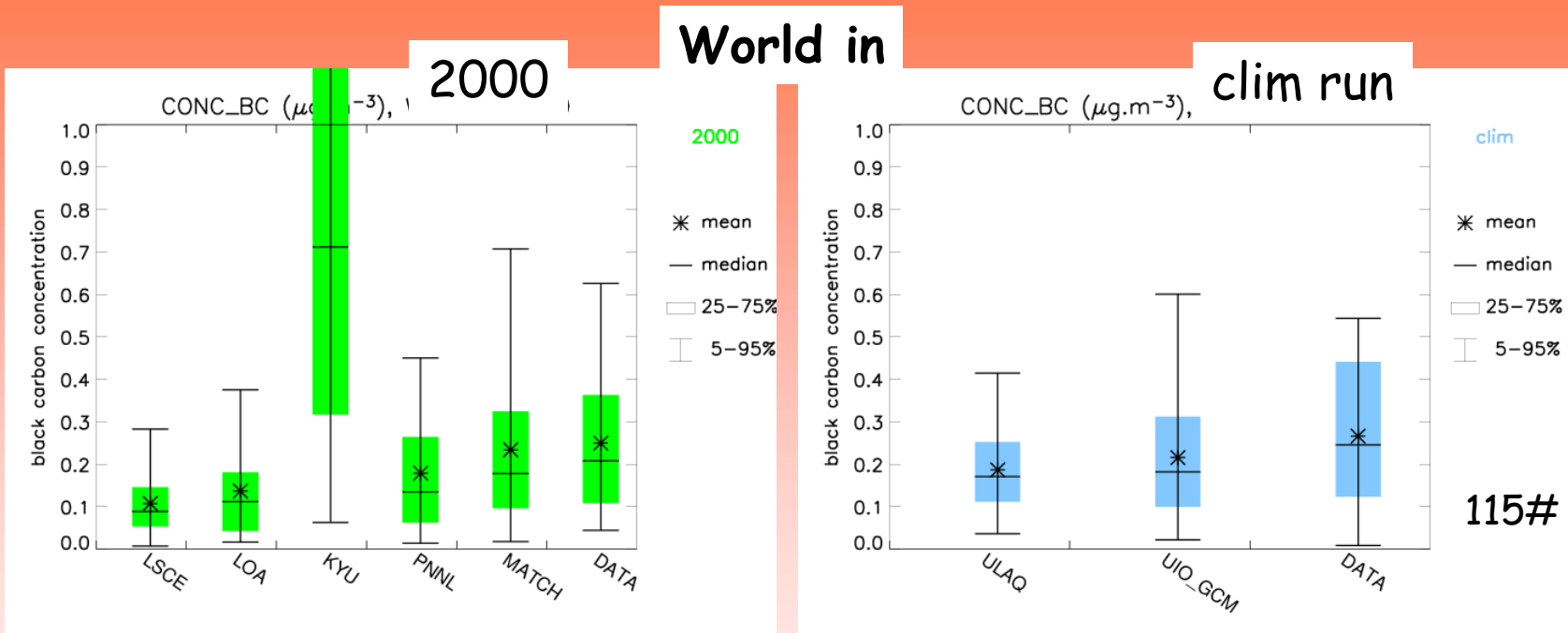
optical depth in 2000, world




506 points

The difference observed between 1997 and 2000 does not affect the conclusion for each model : comparison of mean and median does not change
The difference is due to the number of measurement points (stations, month) not to an interannual variability of the models

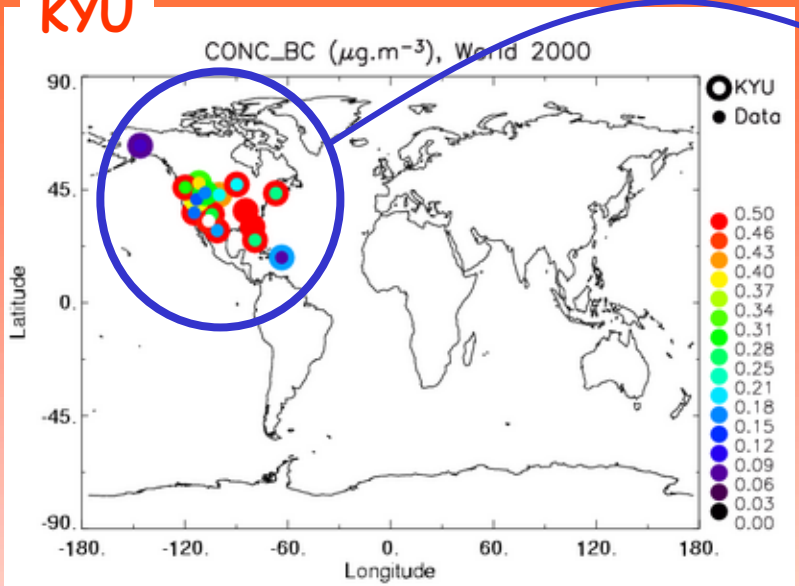
# BC concentration

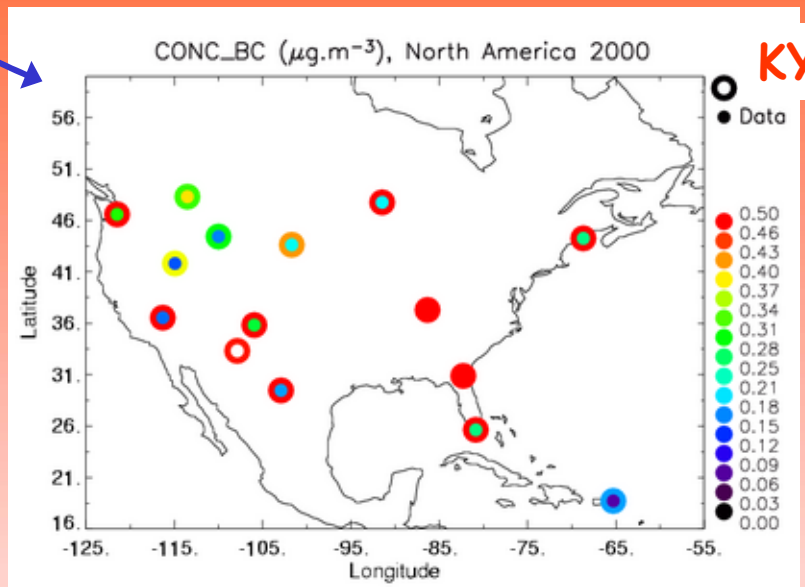



Underestimation by all models except KYU : large overestimation

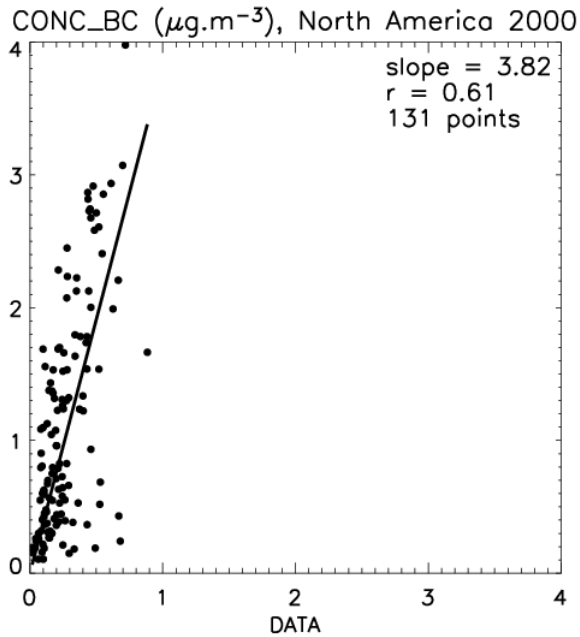
# BC concentration

KYU

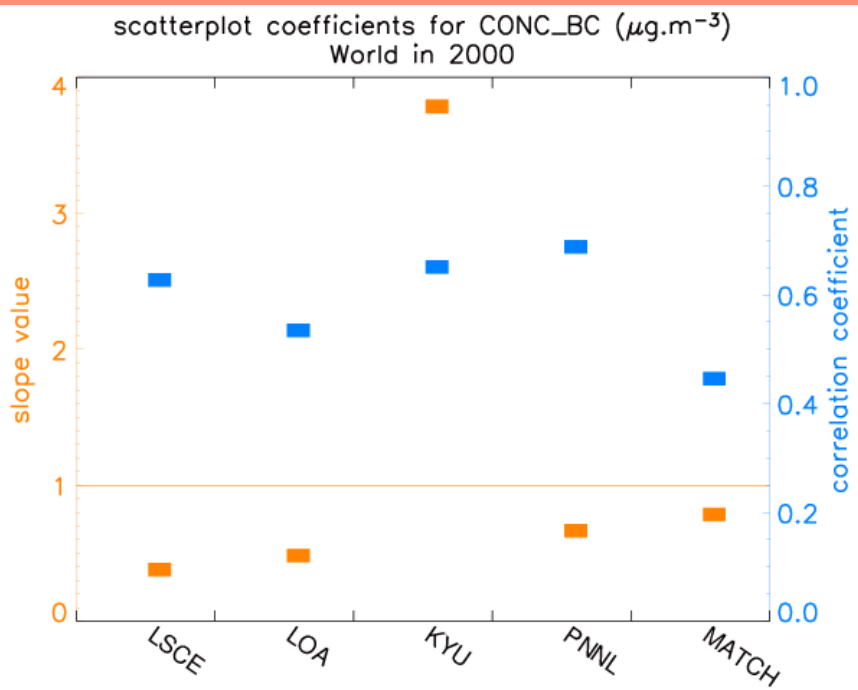


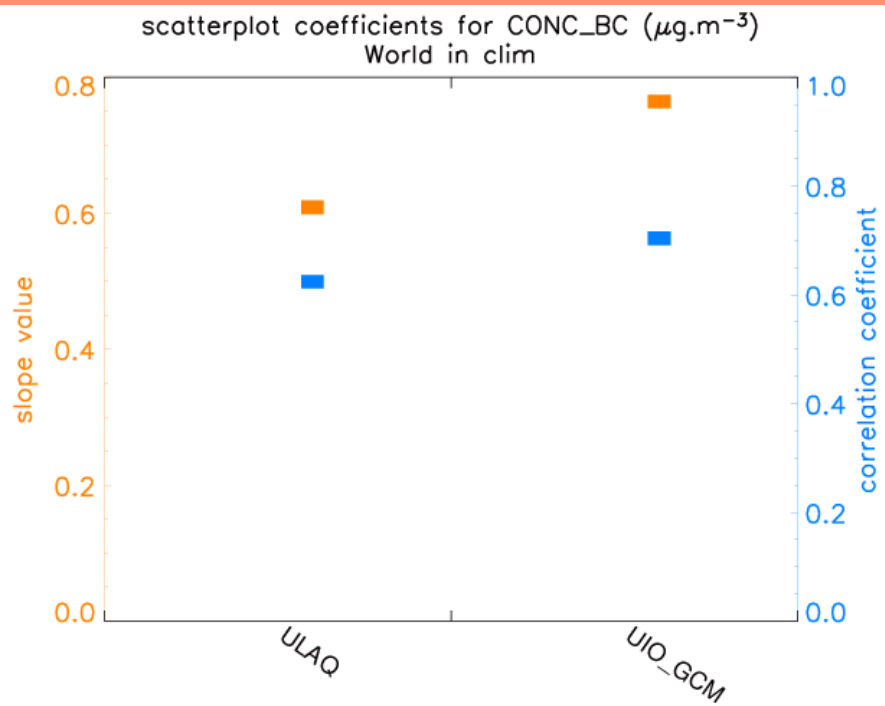




KYU



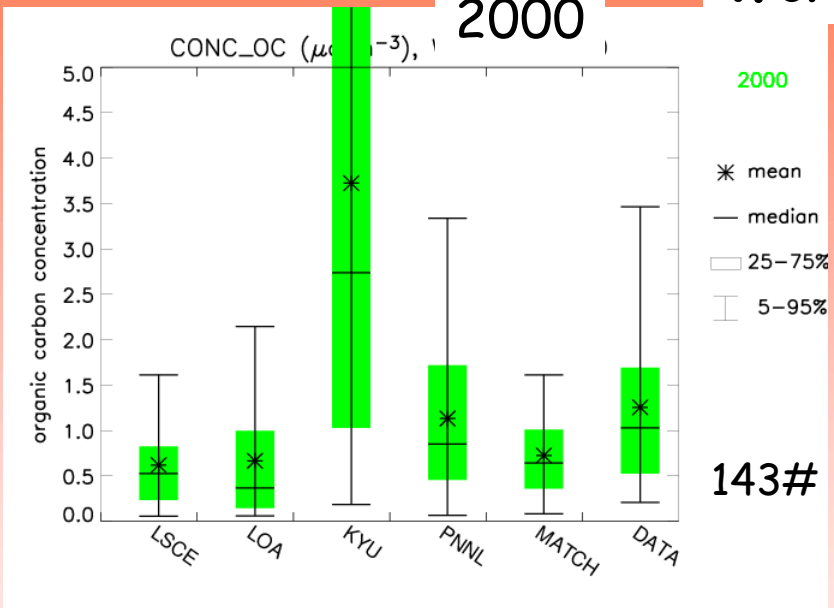
# BC concentration



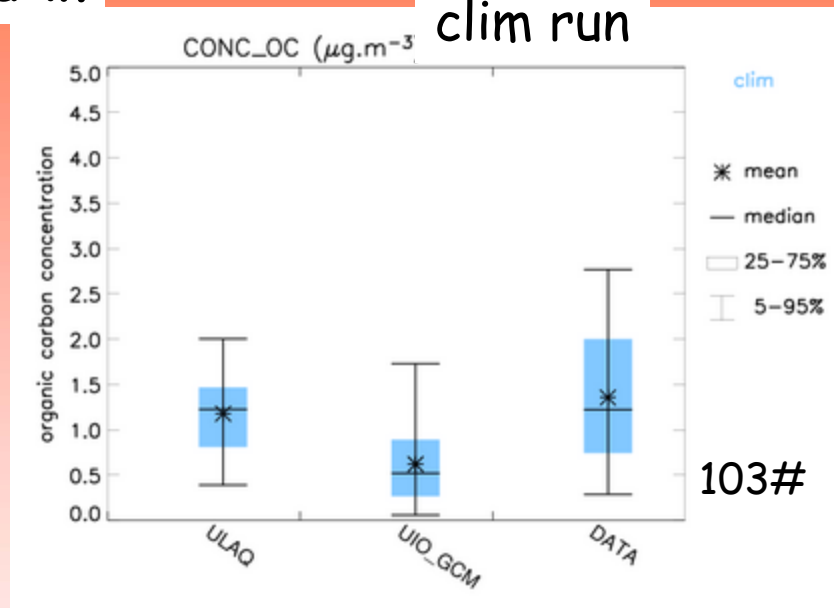



# OC concentration

World in 2000

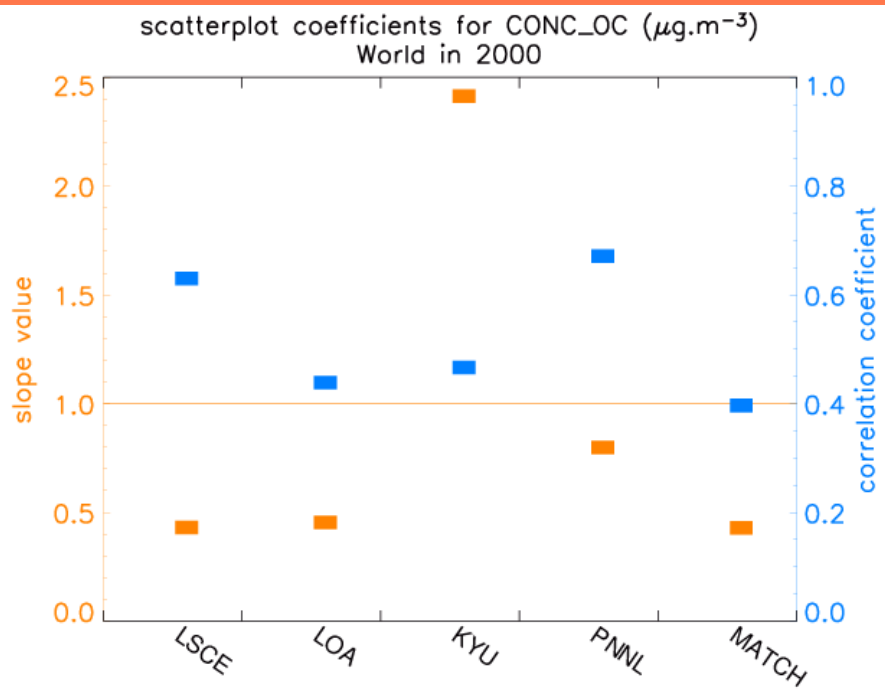


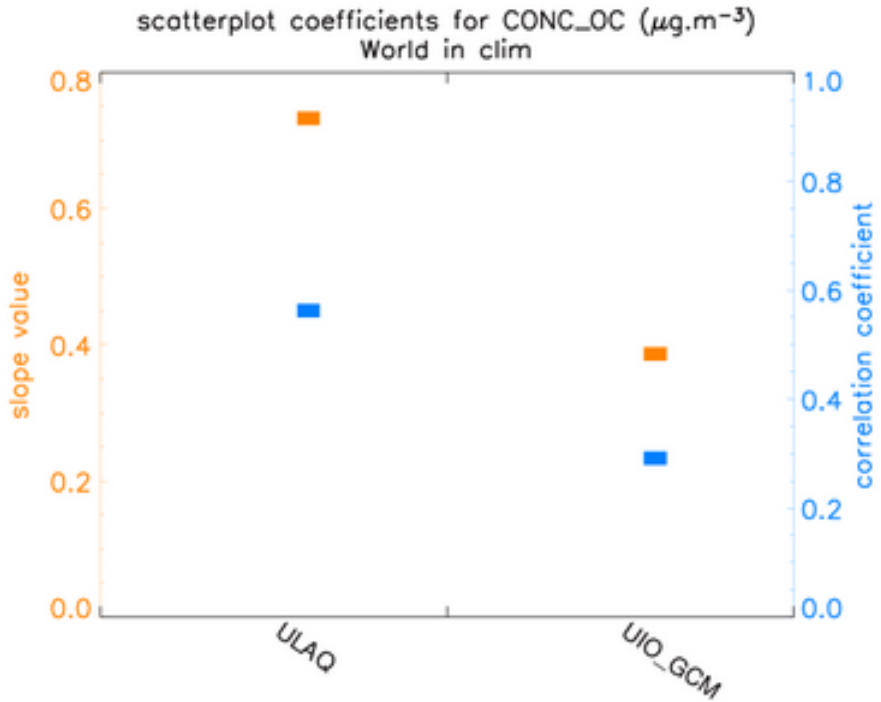

clim run




Same constatation than for BC concentration :
underestimation for all models except KYU : large overestimation

# OC concentration

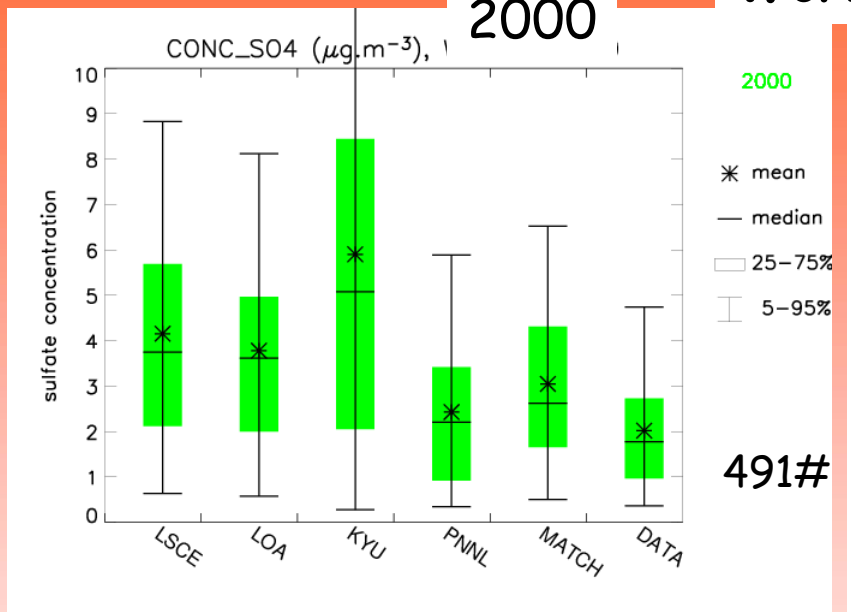


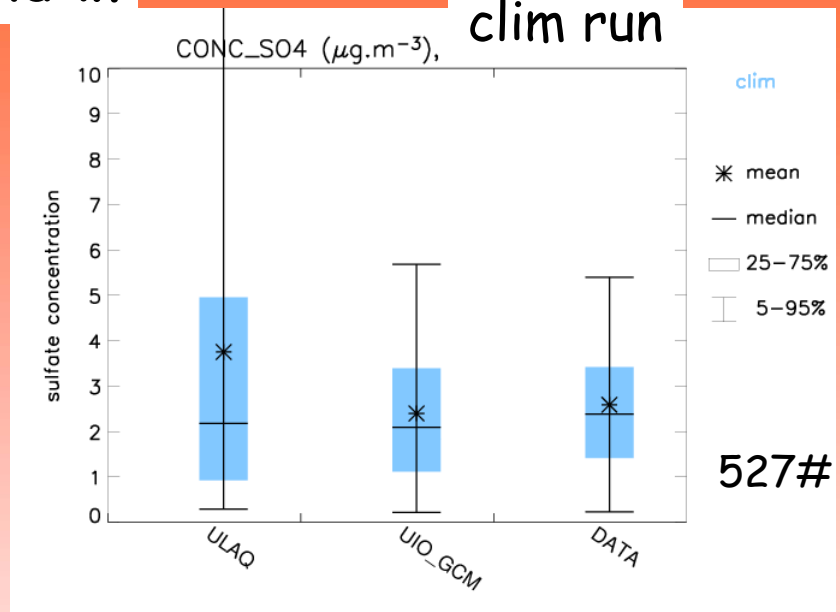

Not so different slope values than for BC except for MATCH and UIO_GCM (smaller values)
but correlation coefficient smaller for all models

# $SO_4$ concentration

World in 2000

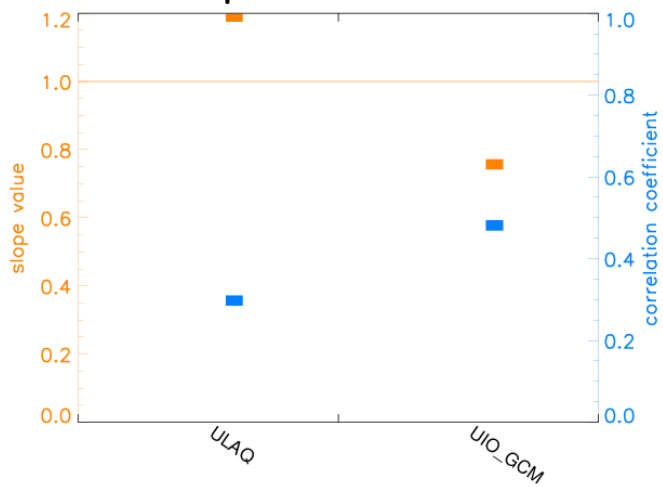



clim run



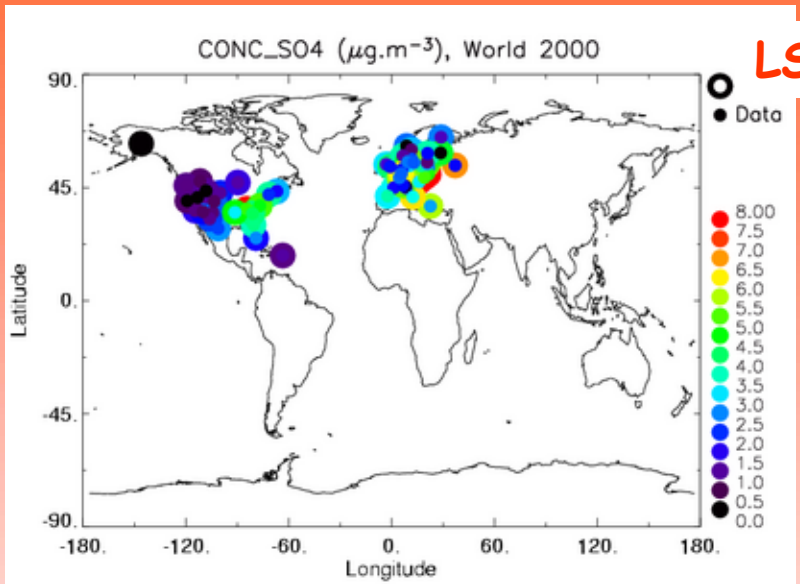

Overestimation by LSCE, LOA and KYU in 2000

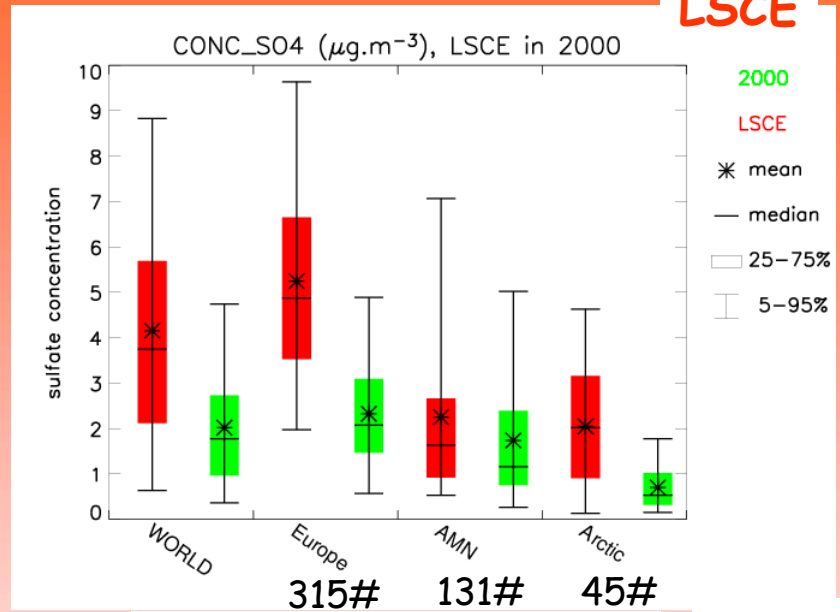
scatterplot coef in clim run

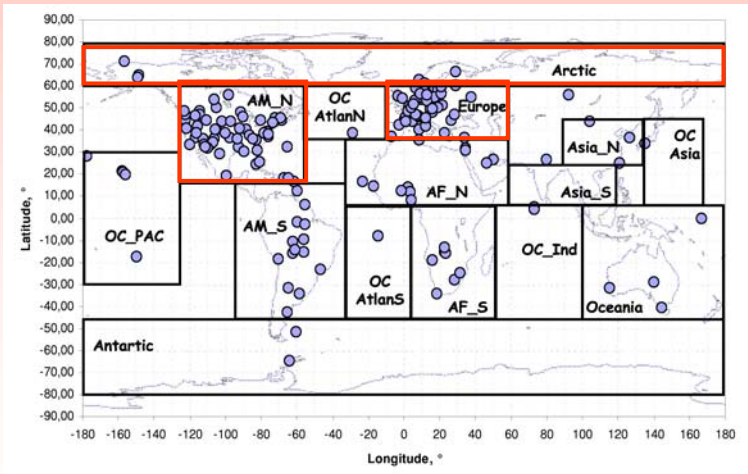


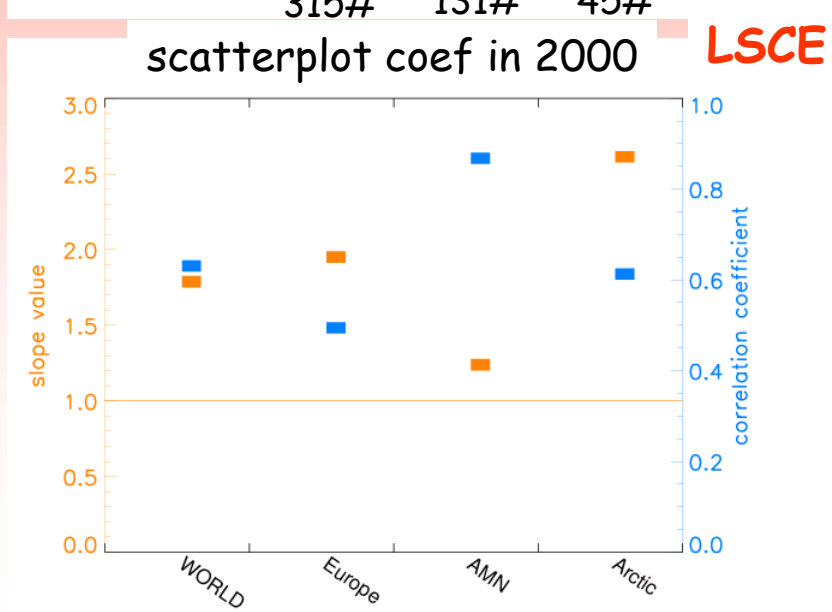

Small overestimation by ULAQ
Small underestimation by UIO_GCM

# $SO_4$ concentration



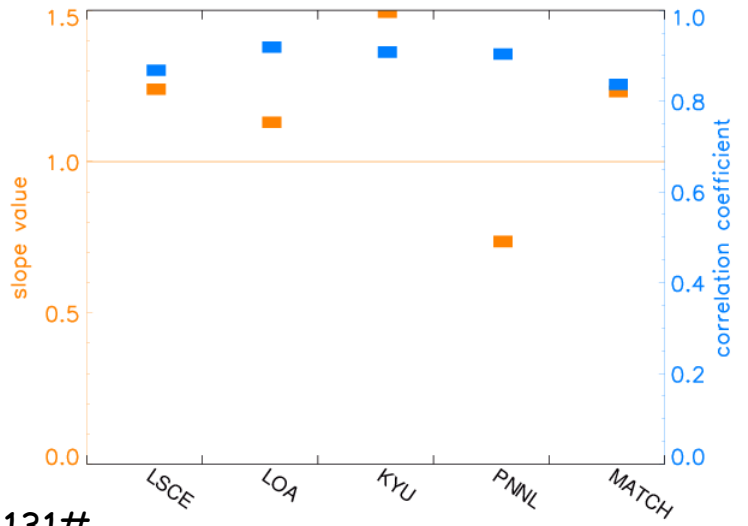



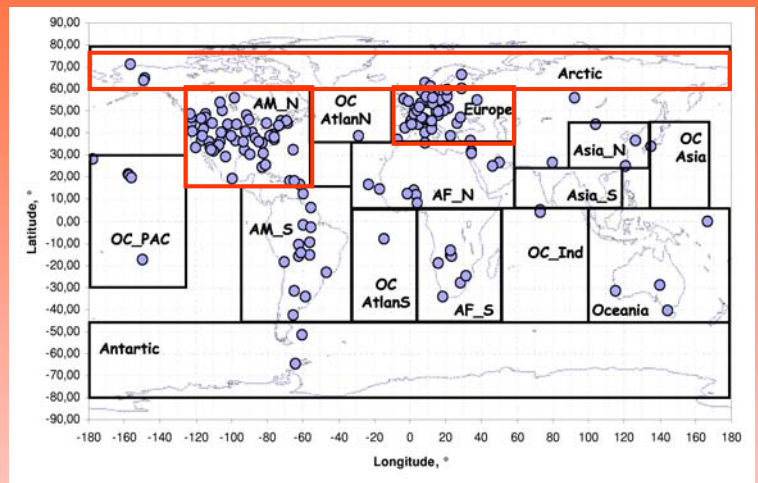

large disagreement in Arctic and Europe

# $SO_4$ concentration

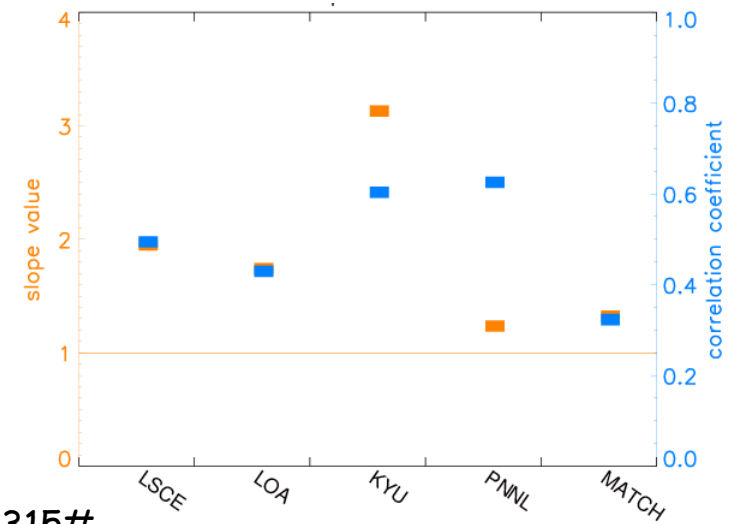
scatterplot coef, North america 2000




131#

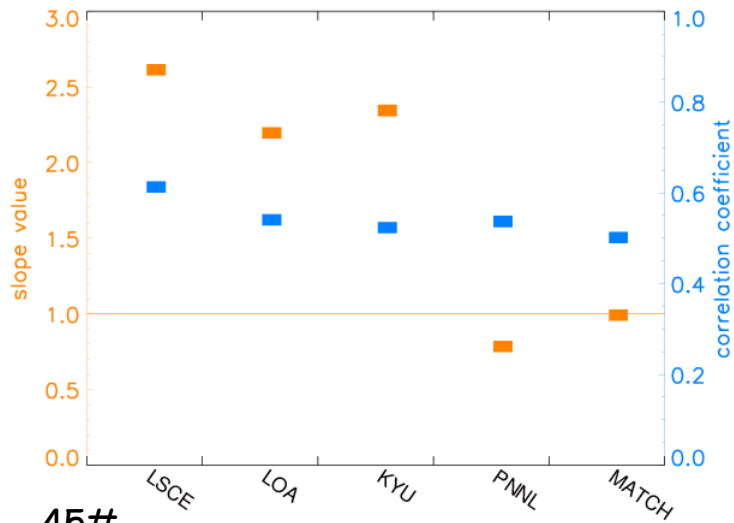



scatterplot coef, Europe 2000



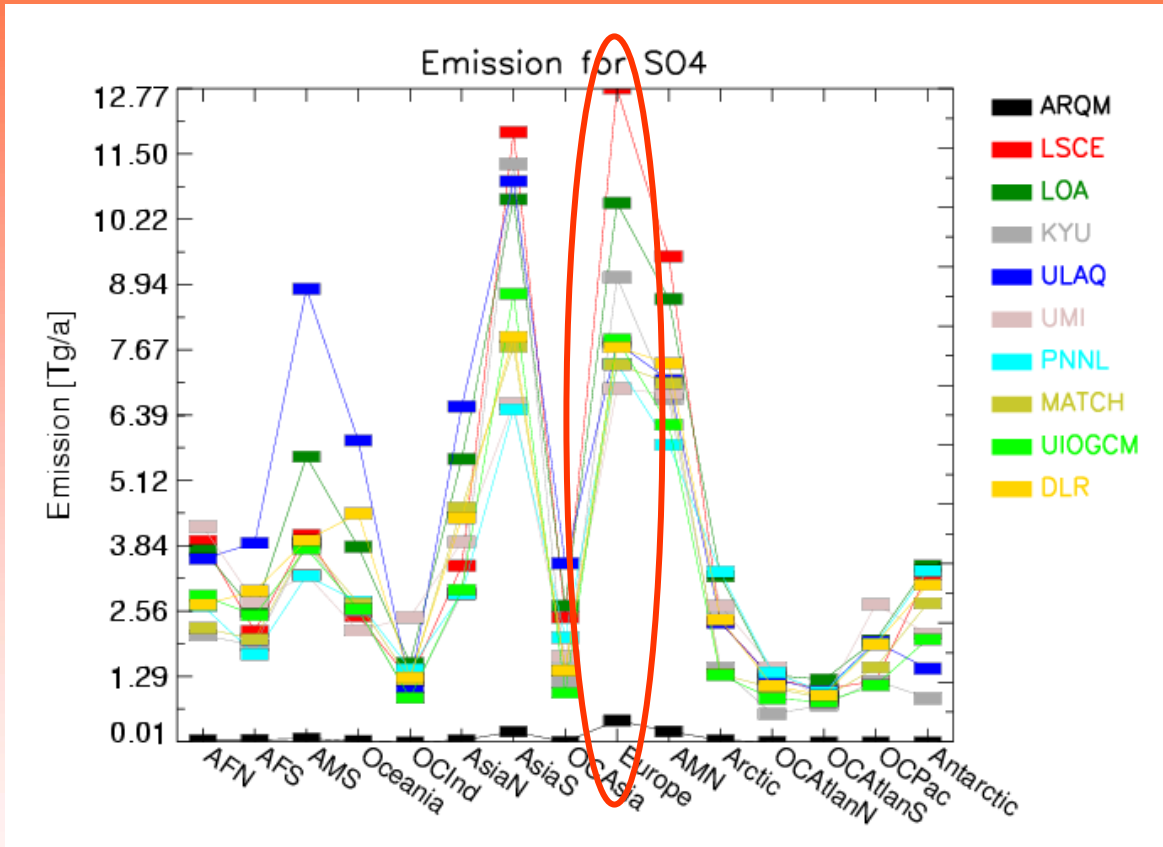

315#

scatterplot coef, Arctic 2000



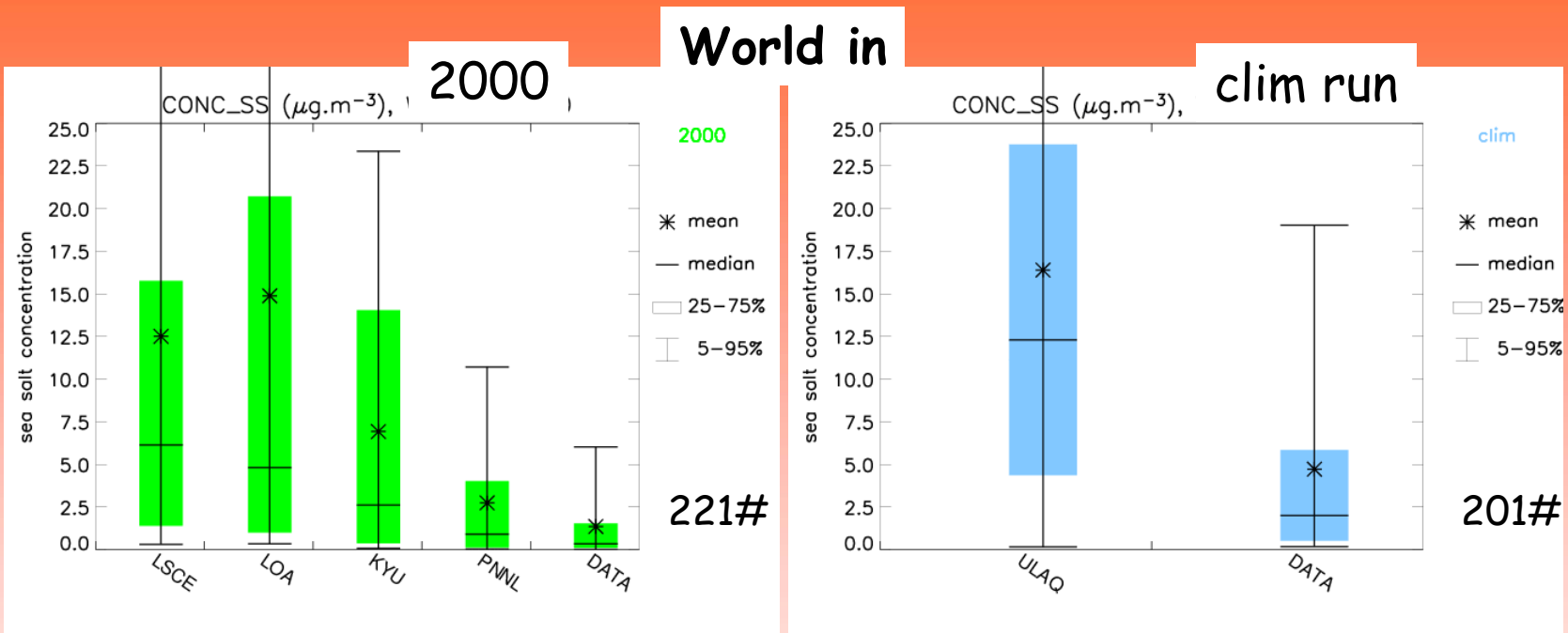

45#

# $SO_4$ concentration




2 groups of models regarding source strength
LSCE and LOA : larger emissions
MATCH, PNNL, UIO_GCM : smaller emissions

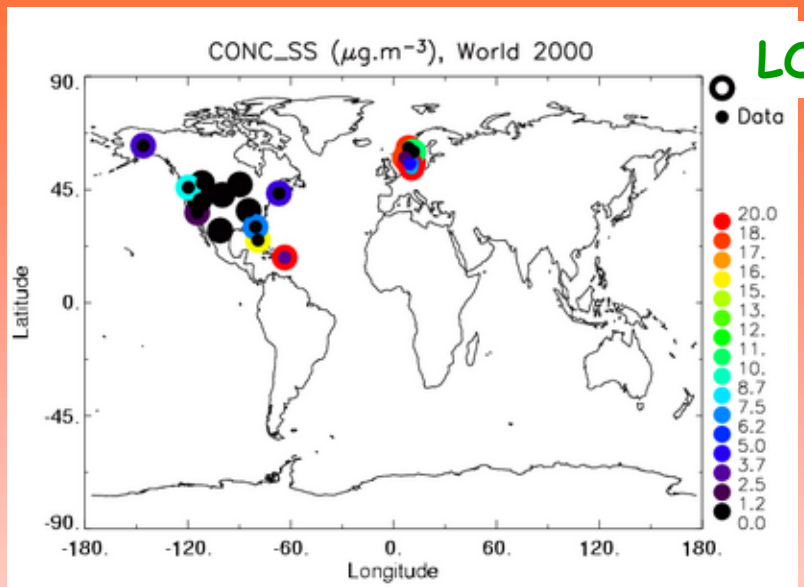
# SS concentration

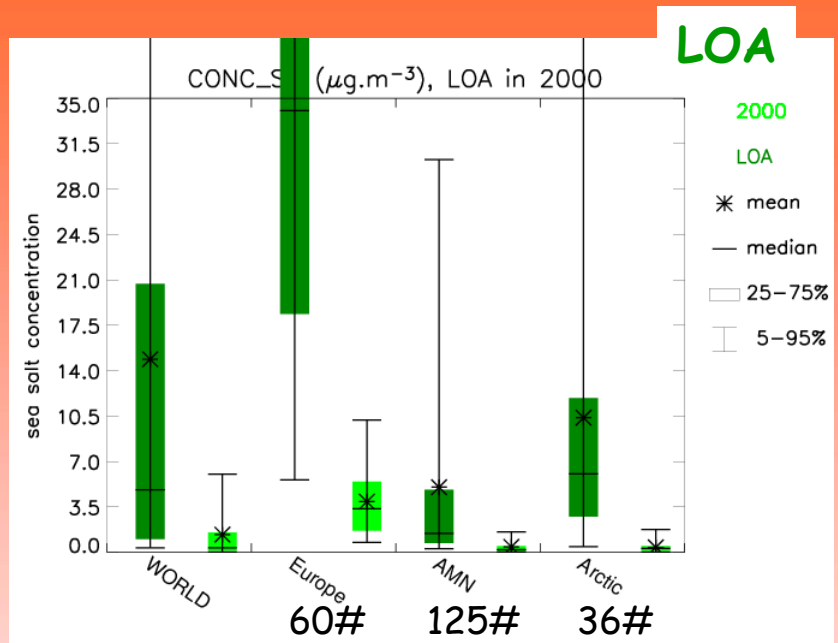


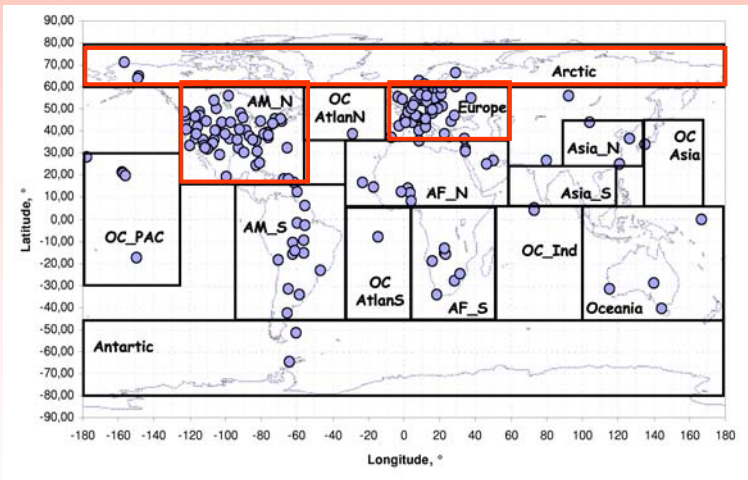

Overestimation by all models
→ partially due to cut off size in the measurements
models with larger particles

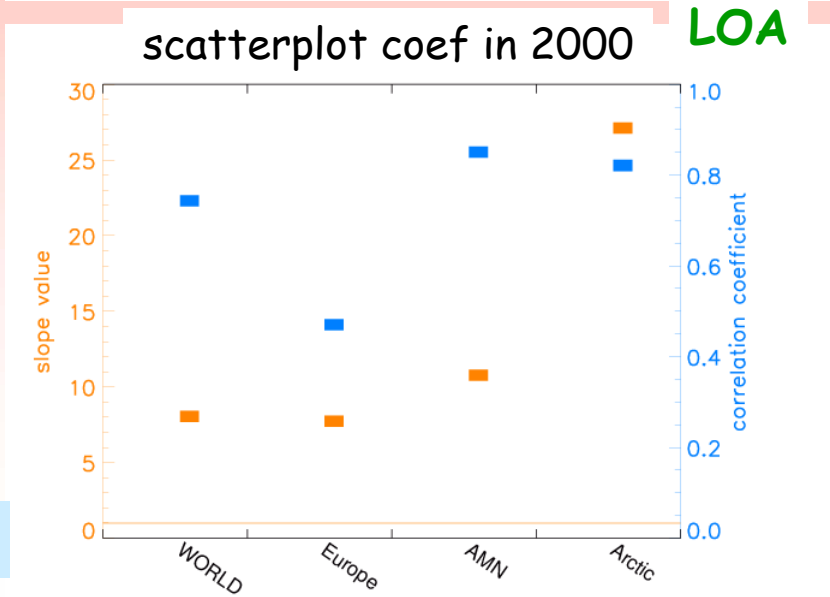
especially KYU, LSCE, LOA in 2000 and ULAQ in clim

# SS concentration



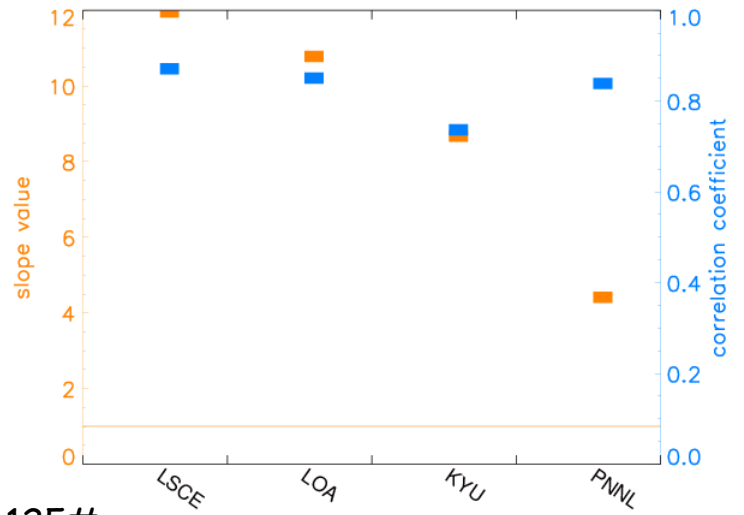



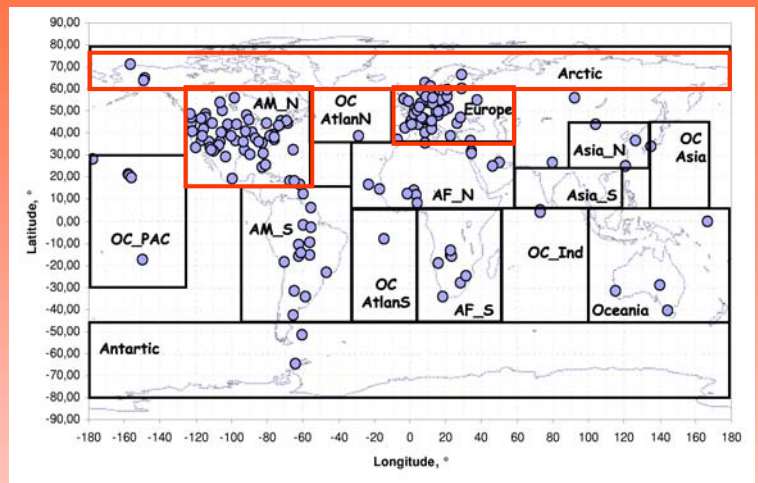

largest disagreement in Arctic

# SS concentration

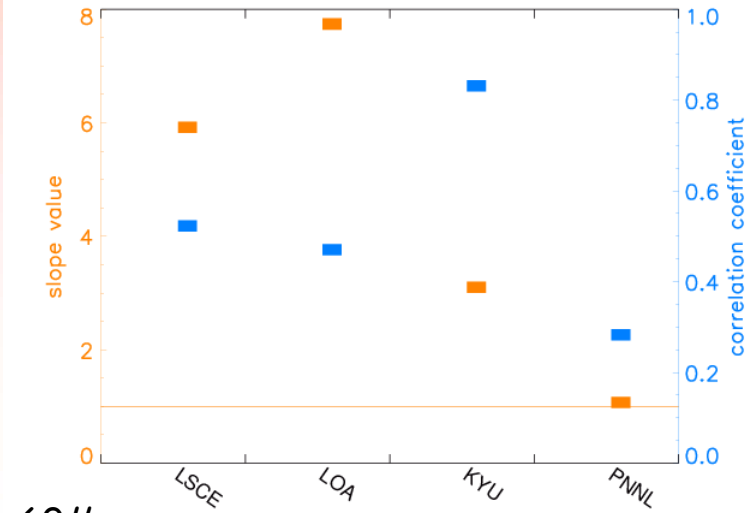
scatterplot coef, North america 2000




125#

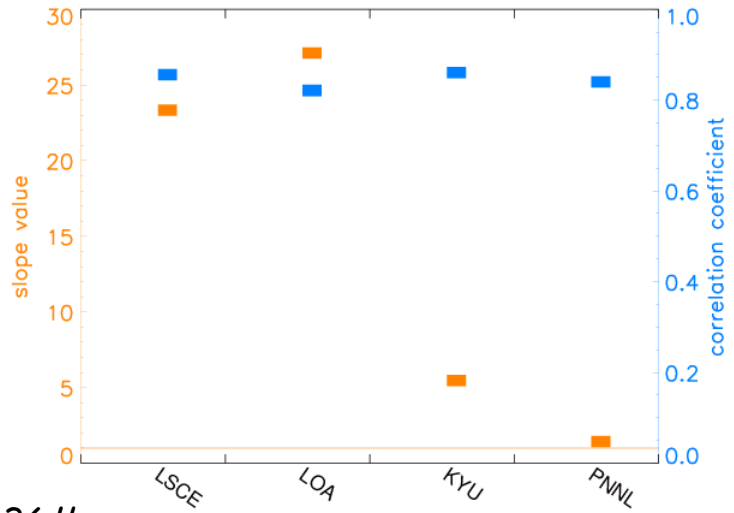



scatterplot coef, Europe 2000



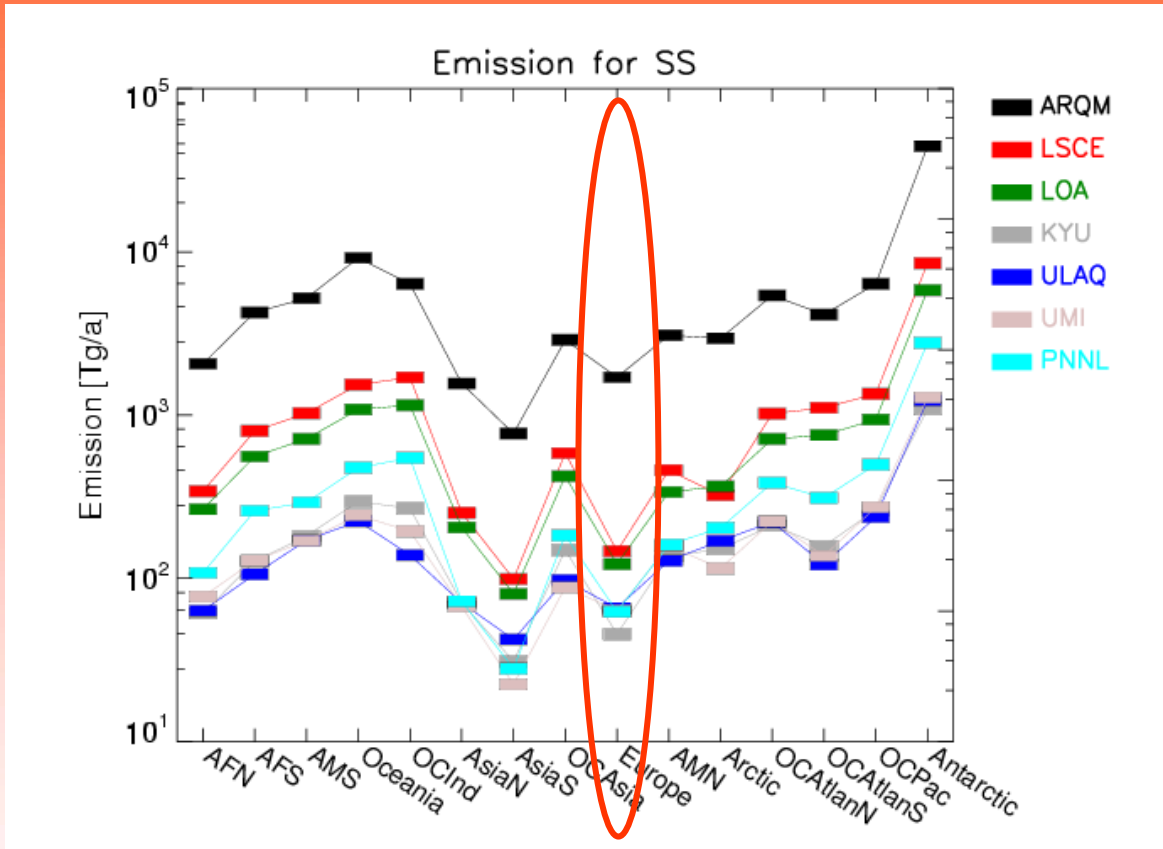

60#

scatterplot coef, Arctic 2000




36#

# SS concentration




LSCE, LOA : larger emissions
PNNL, ULAQ : smaller emissions
but ULAQ overestimates obs → importance of aerosol processes leading to higher load

# Summary for surface observations

| | KYU | LSCE | LOA | MATCH | PNNL | UIO GCM | ULAQ |
|---|---|---|---|---|---|---|---|
| BC concentration | > | < | < | ≤ | ≤ | ≤ | < |
| OC concentration | > | < | < | < | ≤ | < | ≤ |
| $SO_4$ concentration | > | > | > | ≥ | ≥ | ≤ | ≥ |
| SS concentration | > | > > | > > | | ≥ | | > > |

KYU : overestimation of all surface concentrations
↳ most of the load in the lowest layers (below 800hPa)
(see Christiane's presentation)
Is that the explanation ?

2000
clim

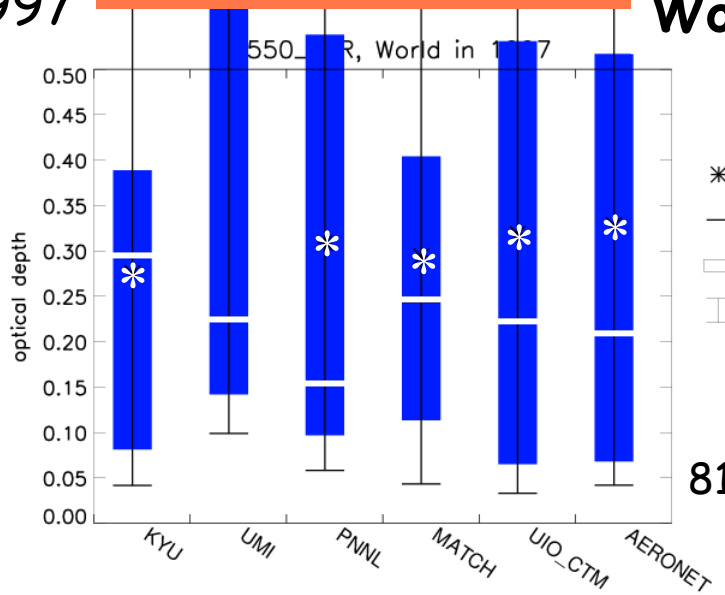
LSCE and LOA : same features because of same GCM

Clim models : similar bias with regard to the observations but lower correlation for $SO_4$ and SS
⇒ no influence of exact meteorology a priori

Do we observe the same features for optical properties ?
What are the consequences of these findings on the prediction of optical depth ?

# Optical depth

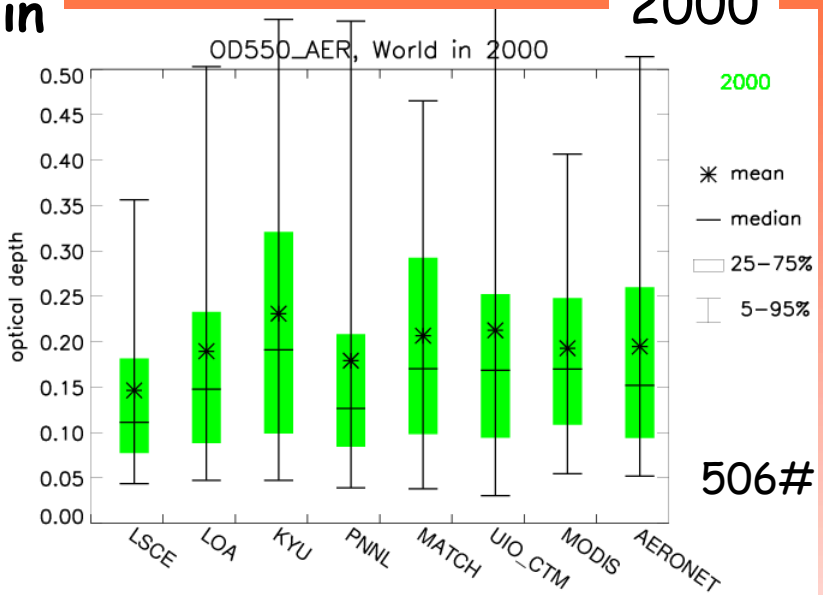
1997




81#

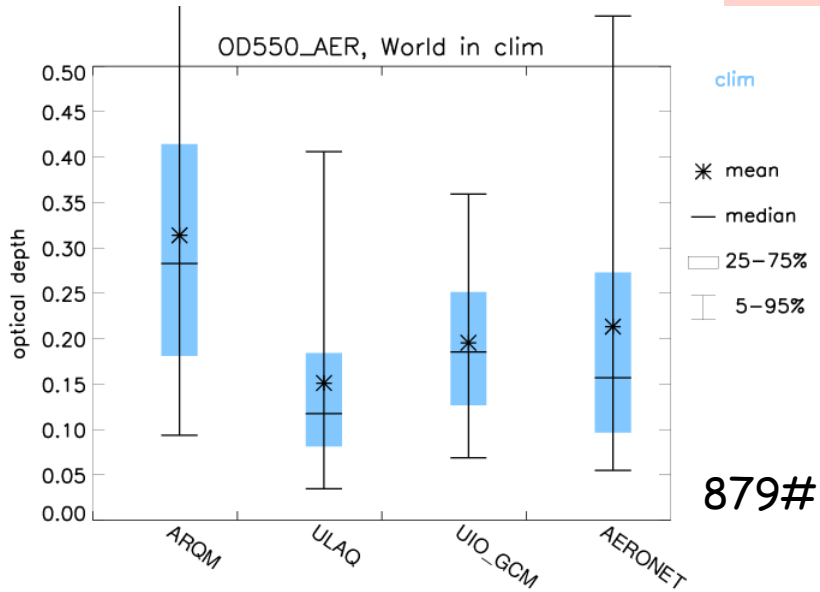
World in

2000




506#

clim run



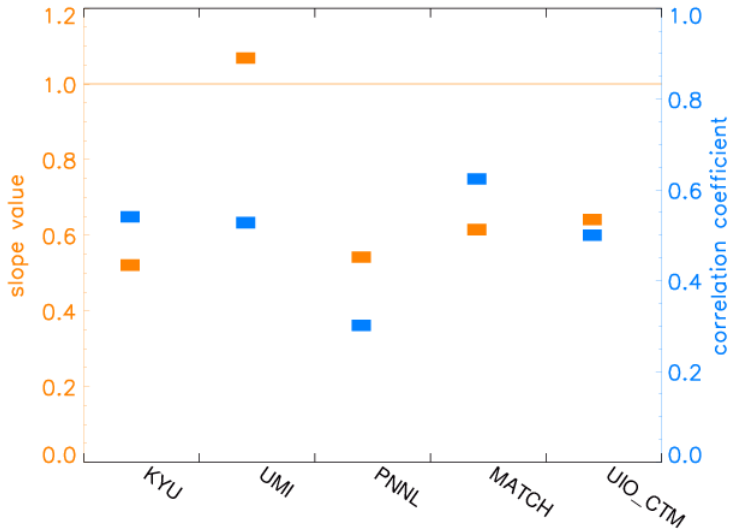

879#

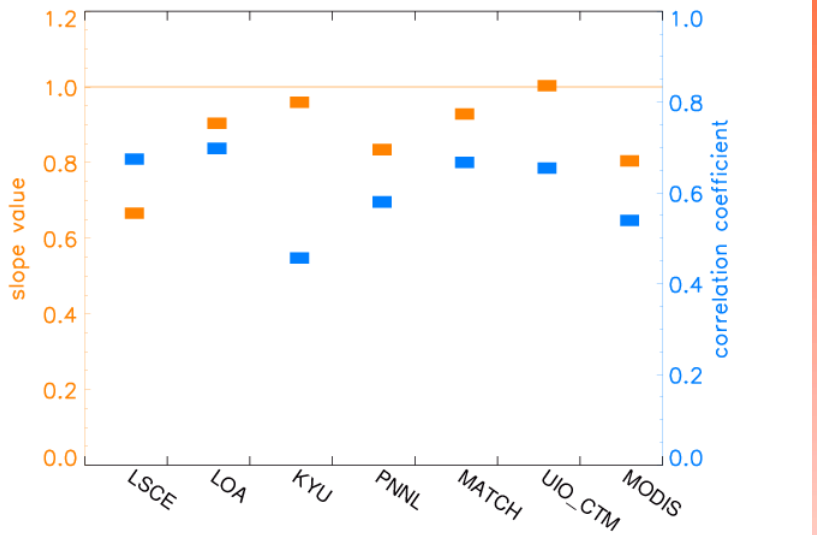
Overestimation by UMI in 1997 regarding the mean : due to outlier ?

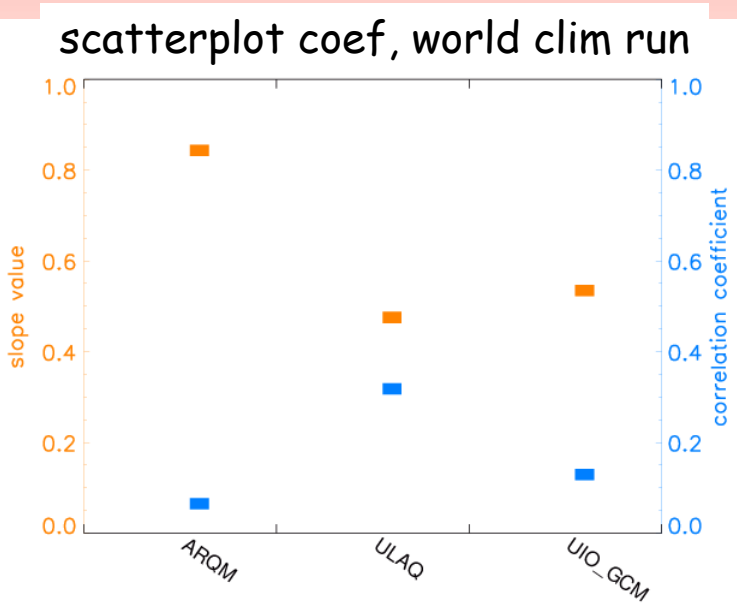
Underestimation by LSCE in 2000 + by PNNL too

Overestimation by ARQM in clim
Underestimation by ULAQ

# Optical depth




UMI : agreement regarding the slope

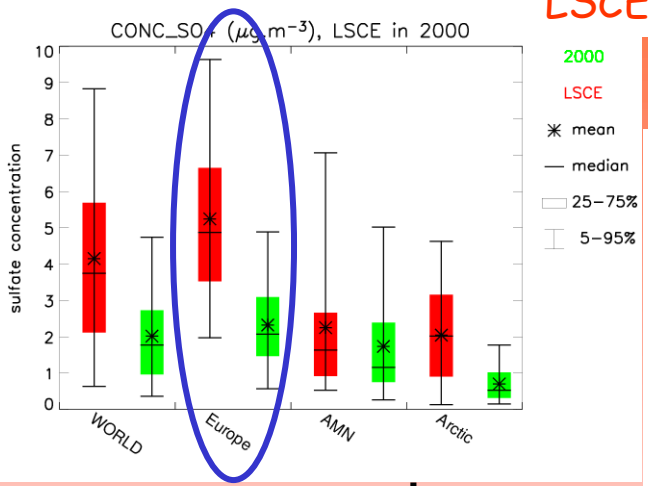
All models in the same range of slope and correl except
LSCE for slope : underestimation
KYU for correl : low correl

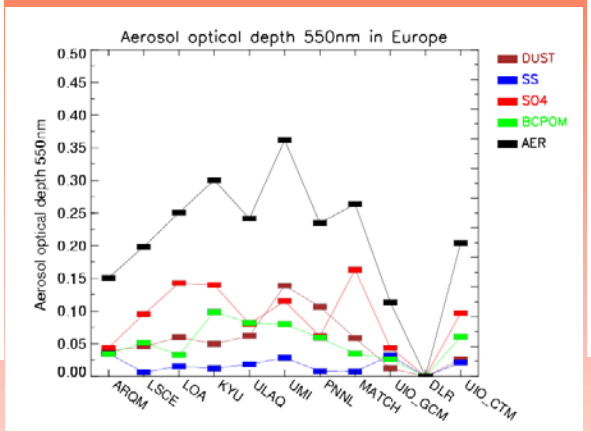
Clim models : lower agreement

# Optical depth

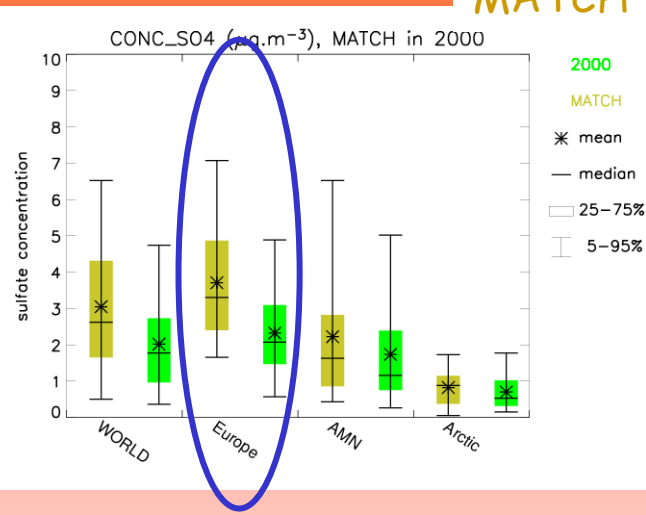
## CONC_SO4

LSCE



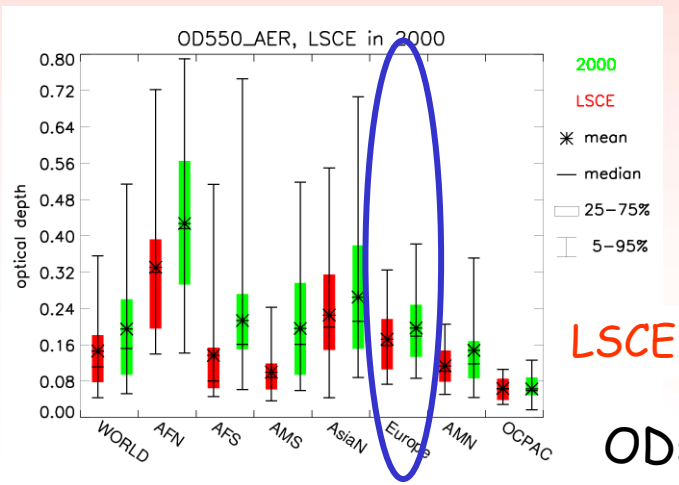




MATCH




Different mass extinction coefficient between model and observations

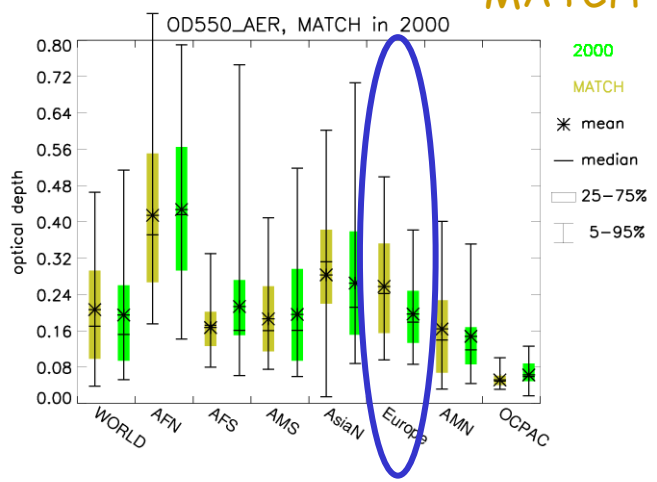
Different mass extinction coefficient between the different models



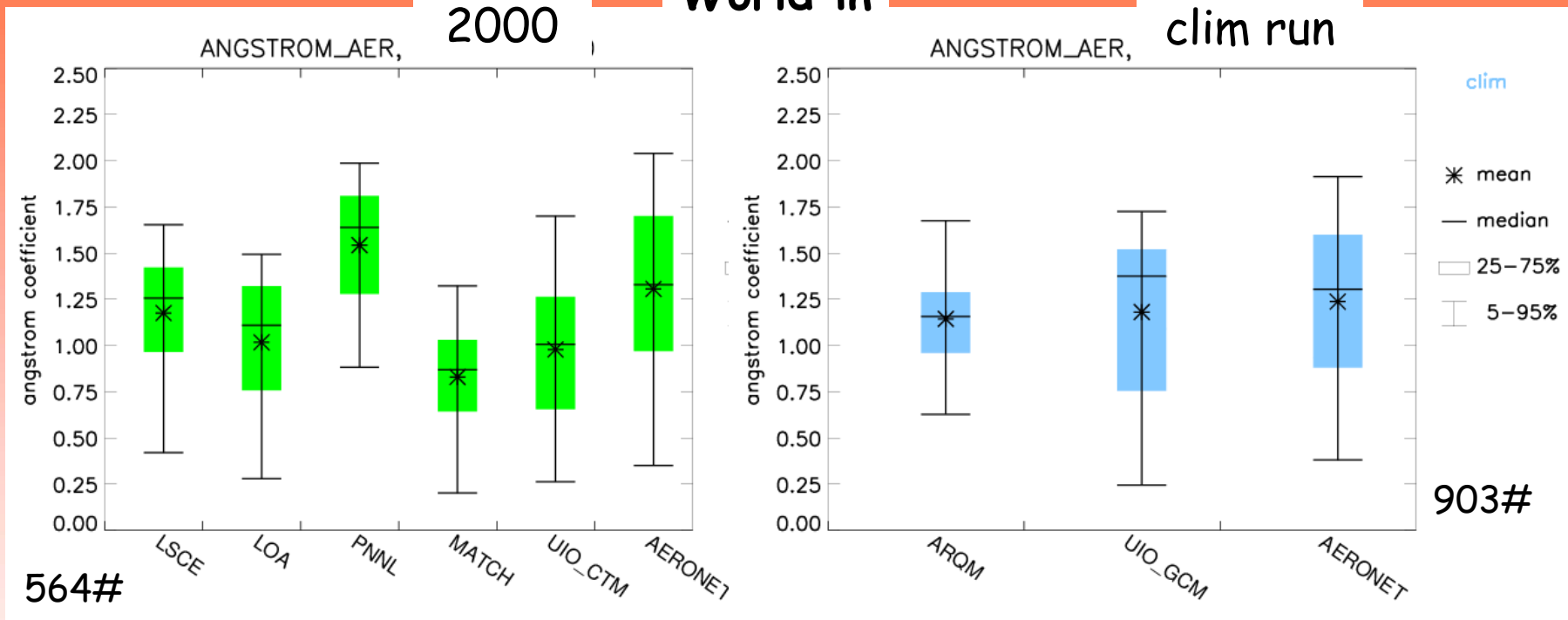

LSCE

OD550_AER

MATCH

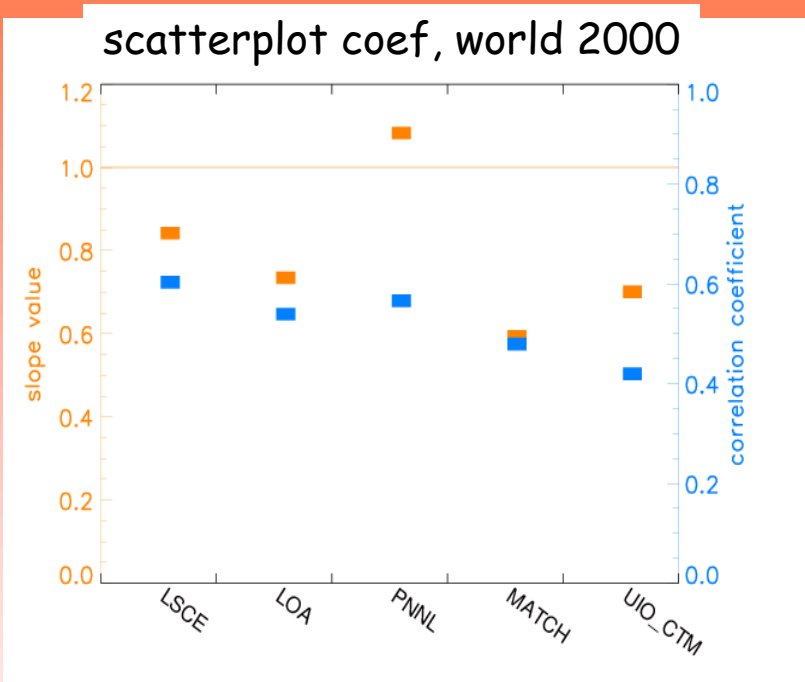


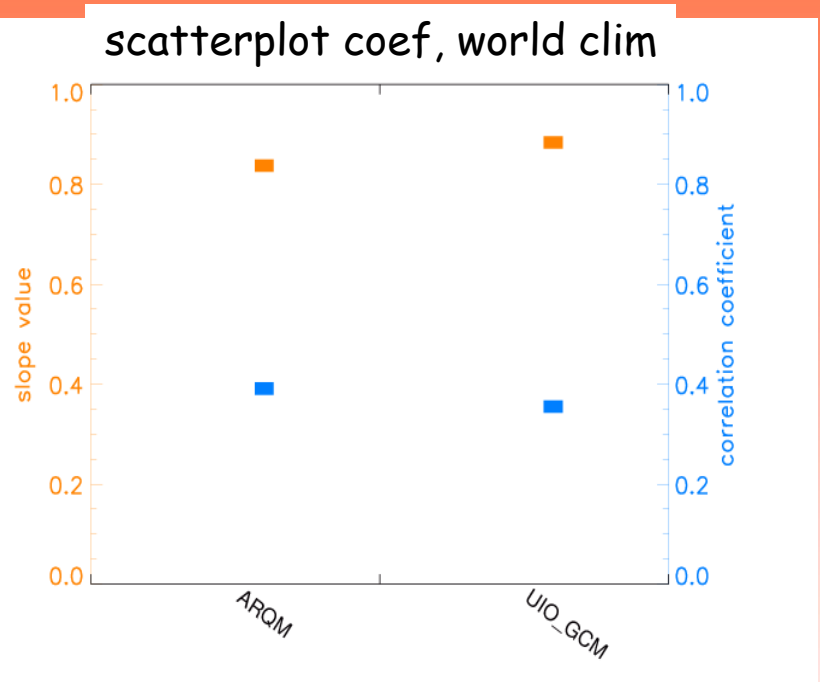
# Angstrom coefficient




Underestimation by all models except PNNL

# Angstrom coefficient




All slopes between 0.6 and 1.1
All correlation coefficient in the same range :
lower values for clim models

# Summary of optical properties

| | ARQM | KYU | LSCE | LOA | MATCH | PNNL | UIO CTM | UIO GCM | ULAQ | UMI |
|---|---|---|---|---|---|---|---|---|---|---|
| Optical depth | > No correl | ≤ Low correl | < | ≤ | ≤ | ≤ | ≈ | < Low correl | < Low correl | ≥ |
| Angstrom coefficient | ≤ Low correl | | ≤ | < | < | ≥ | < | ≤ Low correl | | |

1997
2000
clim

Optical depth :
Smaller agreement between data and clim models

Angstrom coefficient :
No large difference between the models
Independant of optical depth

# Outlook

- Collecting more data to make the comparisons (SS, BC, OC)
  $\Rightarrow$ some regions without any data
- Dust data ?
- Size distribution validation : effective radius
- Investigation of optical properties with regard to RH
- Filtering the daily model output according to available measurements (instead of monthly averages)

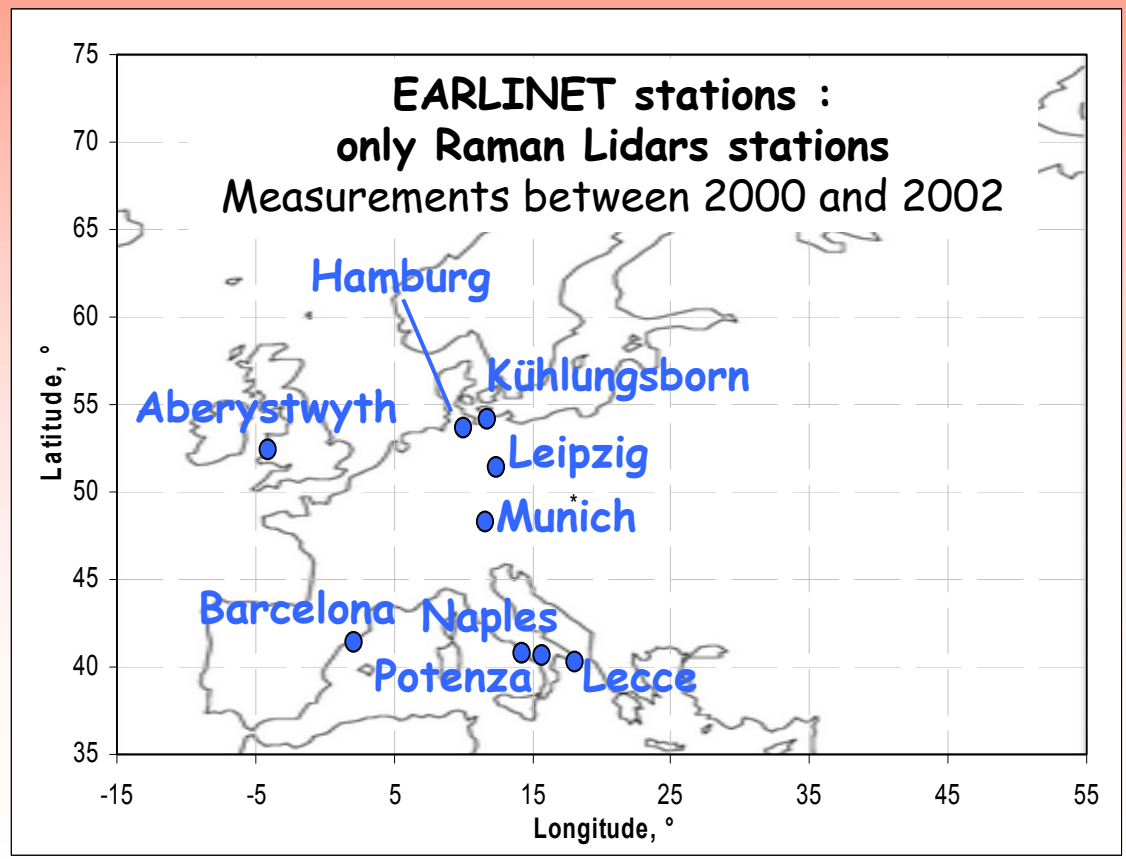
- Comparison of aerosol vertical distribution : lidar measurements

# Another way of comparison : Lidar measurements

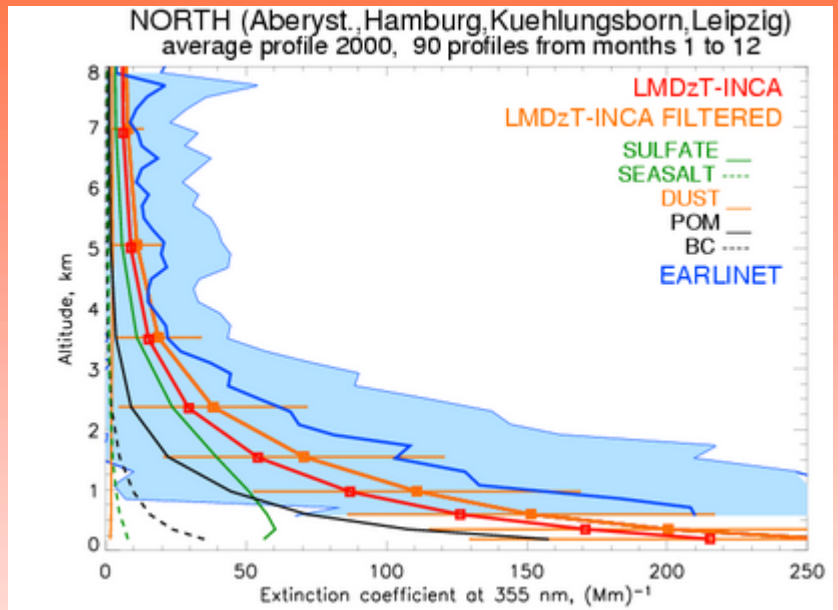
## Example of comparison between EARLINET and LMDzT-INCA

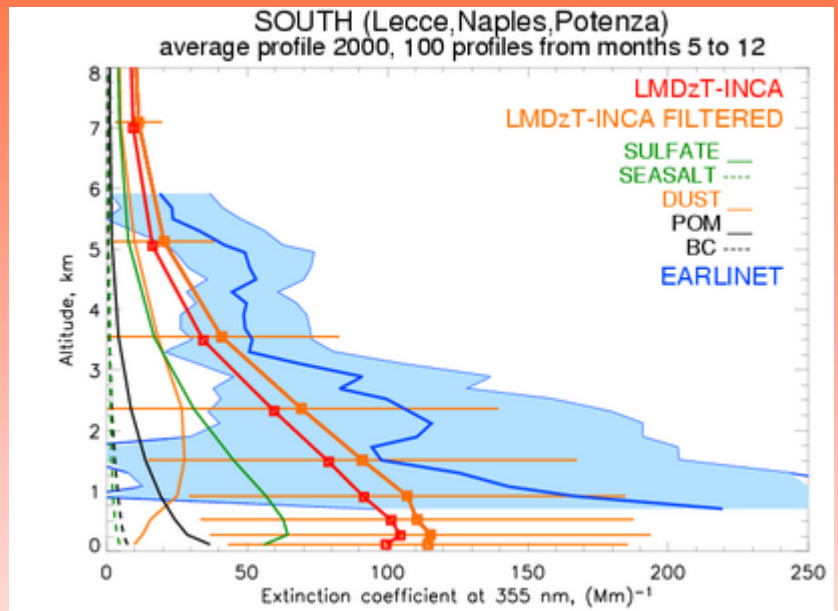
*In collaboration with Volker Matthias and Jens Boesenberg (MPI-M, Hamburg)*

Looking at differences between models and measurements regarding the vertical distribution of aerosol



# Comparison of average profiles




Agreement between modeled and measured yearly mean profiles

Difference of shape between profiles at northern and southern European stations : both modeled and observed

→ Presence of dust in elevated layers at Mediterranean stations well represented by the model

# Another way of comparison : Lidar measurements

Possible comparison with EARLINET measurements :
2000 then 2001

Comparison with DOE data : South Great Plains (Rich Ferrare)

Only yearly mean profile
Only KYU, MATCH, PNNL, UIO_CTM