# AeroCom

*an international collaboration*

*to improve aerosol modeling in climate models*

*Max Planck Institute for Meteorology*

Laboratoire des Sciences du Climat et de l'environnement

# Outline

- some background information on aerosol and climate
- initial results about the uncertainty in global aerosol modeling as part of an international scientific status report (IPCC 2001)
- the AeroCom project: goals, first results and future plans

# Background

# We change our atmosphere !

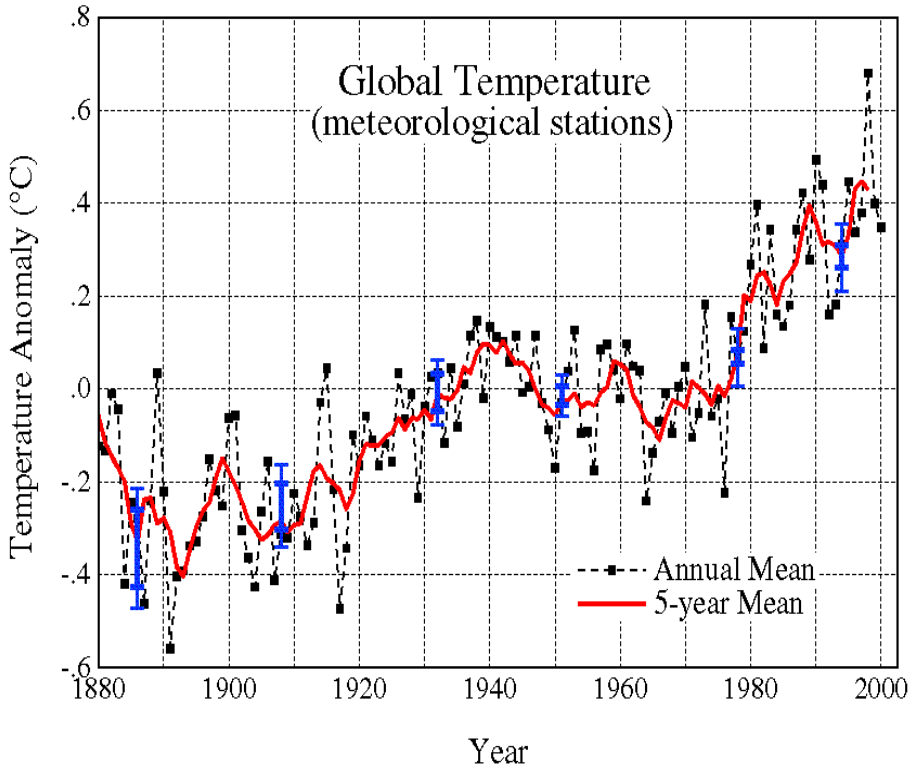
- human ‘footprints’ from
  - Industralization
  - Urbanization
  - Changes in Farming
- higher *(greenhouse)* gas concentration
  - CO2, CH4, O3, CFCs, …
- higher aerosol *(small particle)* concentrations
  - direct emission of aerosol particles
  - indirect emission via the gas-phase (gas ⇨ particles)

# Do we change our climate ?

*since 1880*

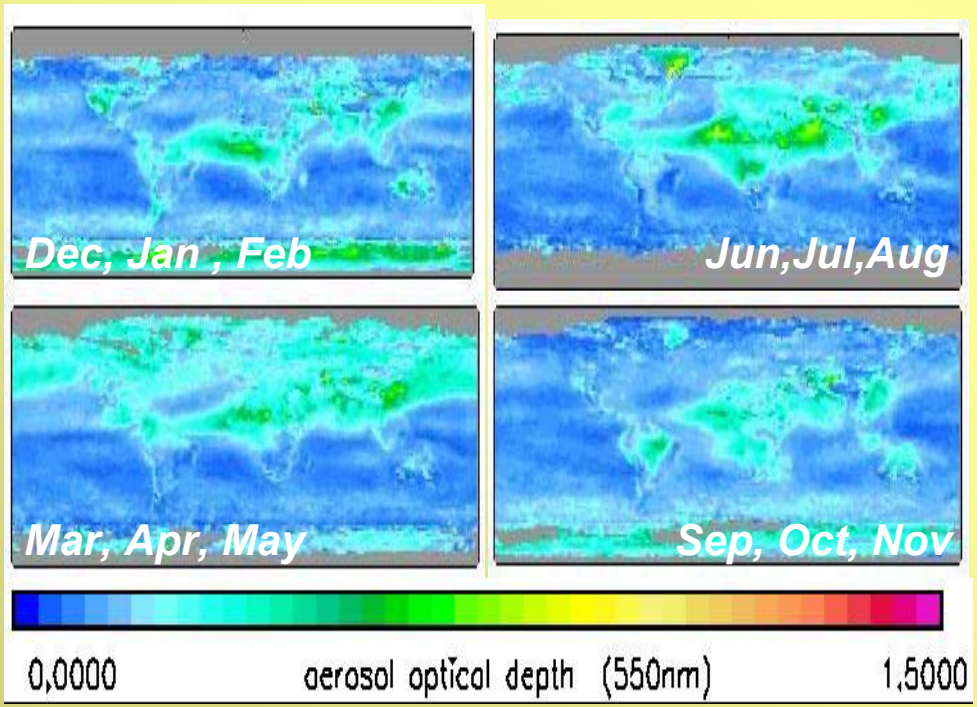
**temperature at the earth's surface has increased by 0.75K**

**this exceeds expectations for natural variability !**



# what do we expect?

- more greenhouse gases ⇨ *warming* T +
- more aerosol ⇨ *generally a* cooling T -




*generally* because aerosol is highly variable in properties and distribution

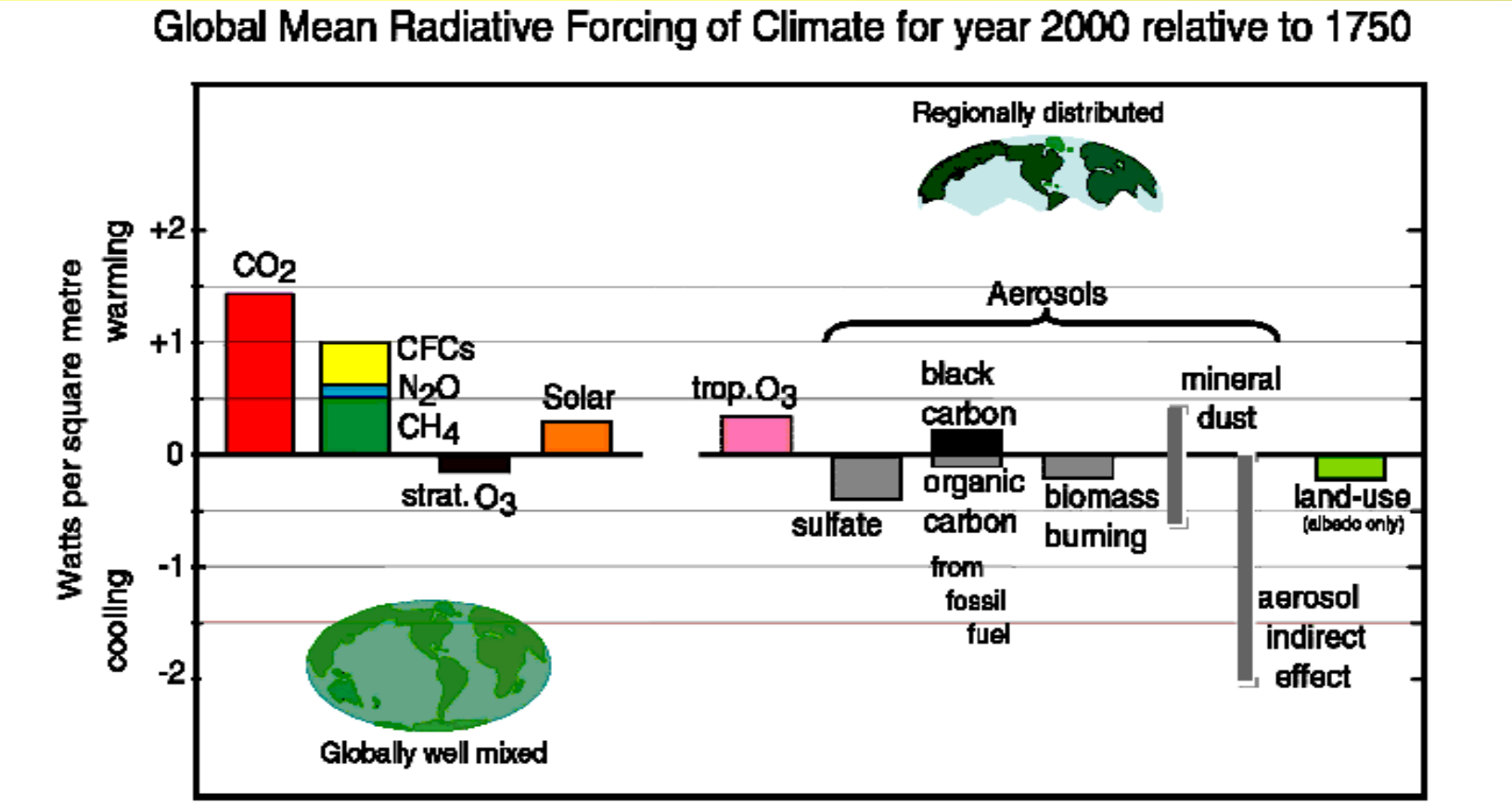
*e.g.* aerosol optical depth
(= attenuation of visible sunlight due to aerosol)

based on MODIS and MISR sensor data on NASA's Terra platform for the four seasons of the year 2001

# IPCC 2001

# human influences on climate

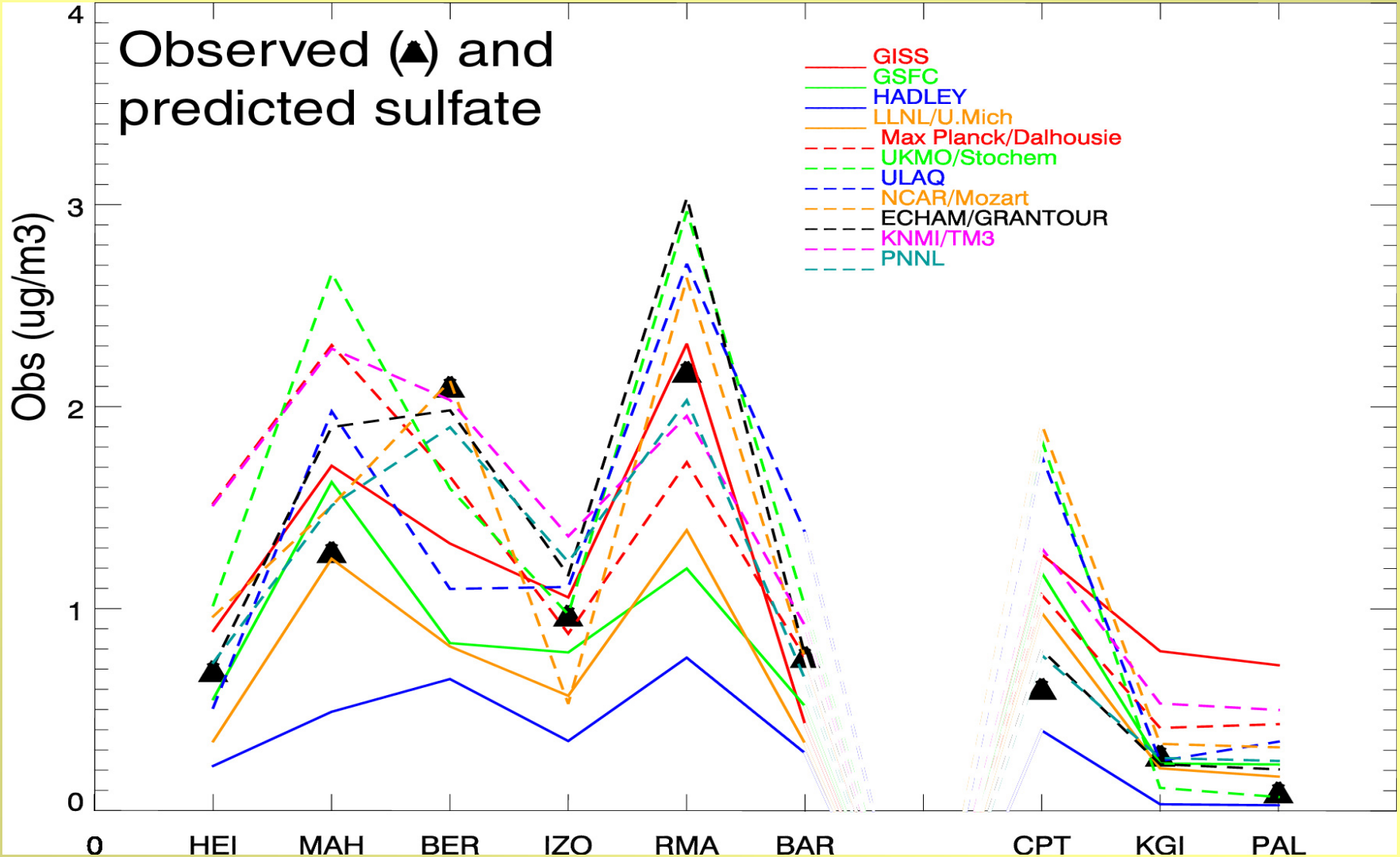
## our understanding is based on MODELING




**Level of scientific understanding: “ Very low ”**

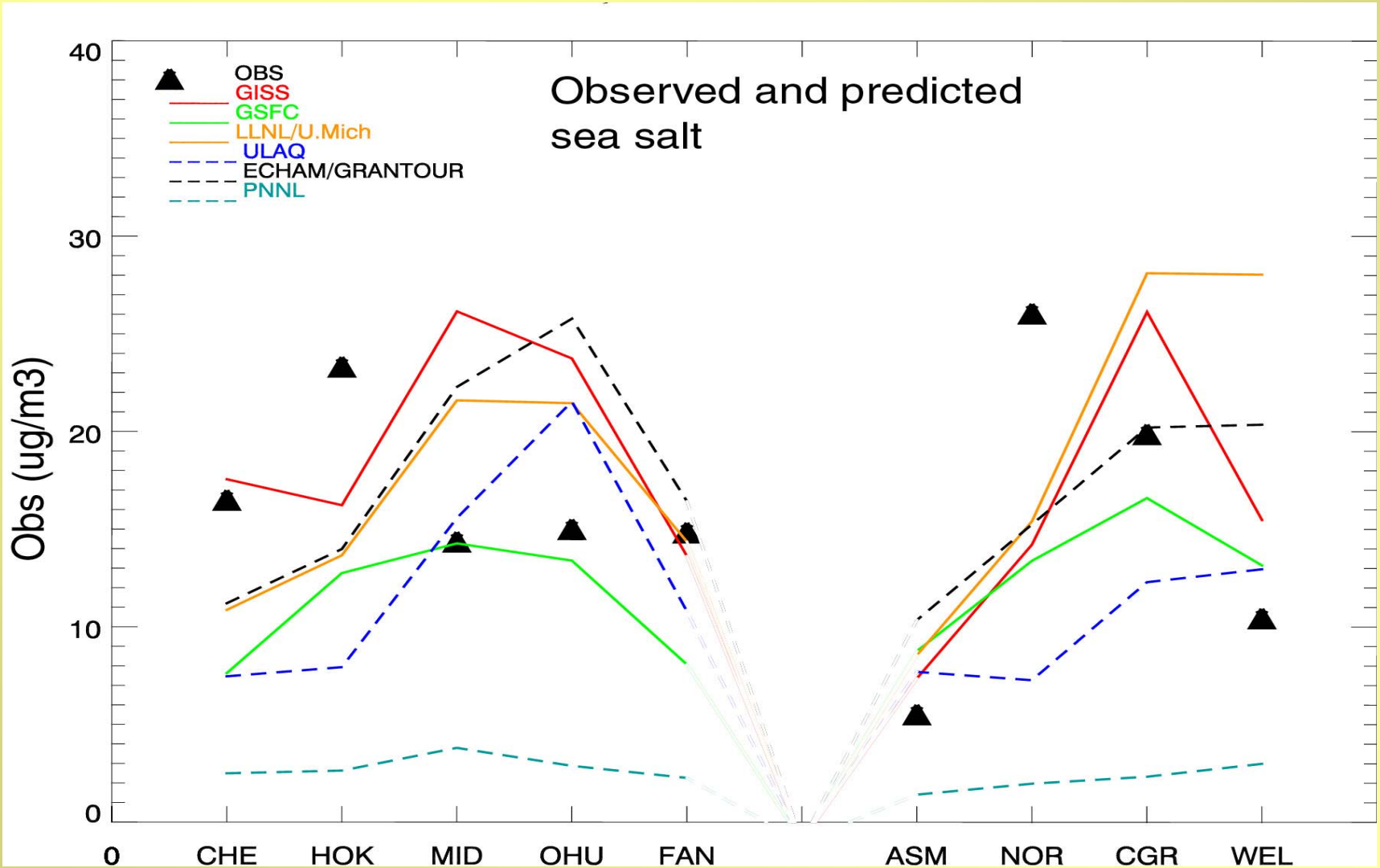
# Sulfate Modeling

## comparisons to ground data at 9 sites



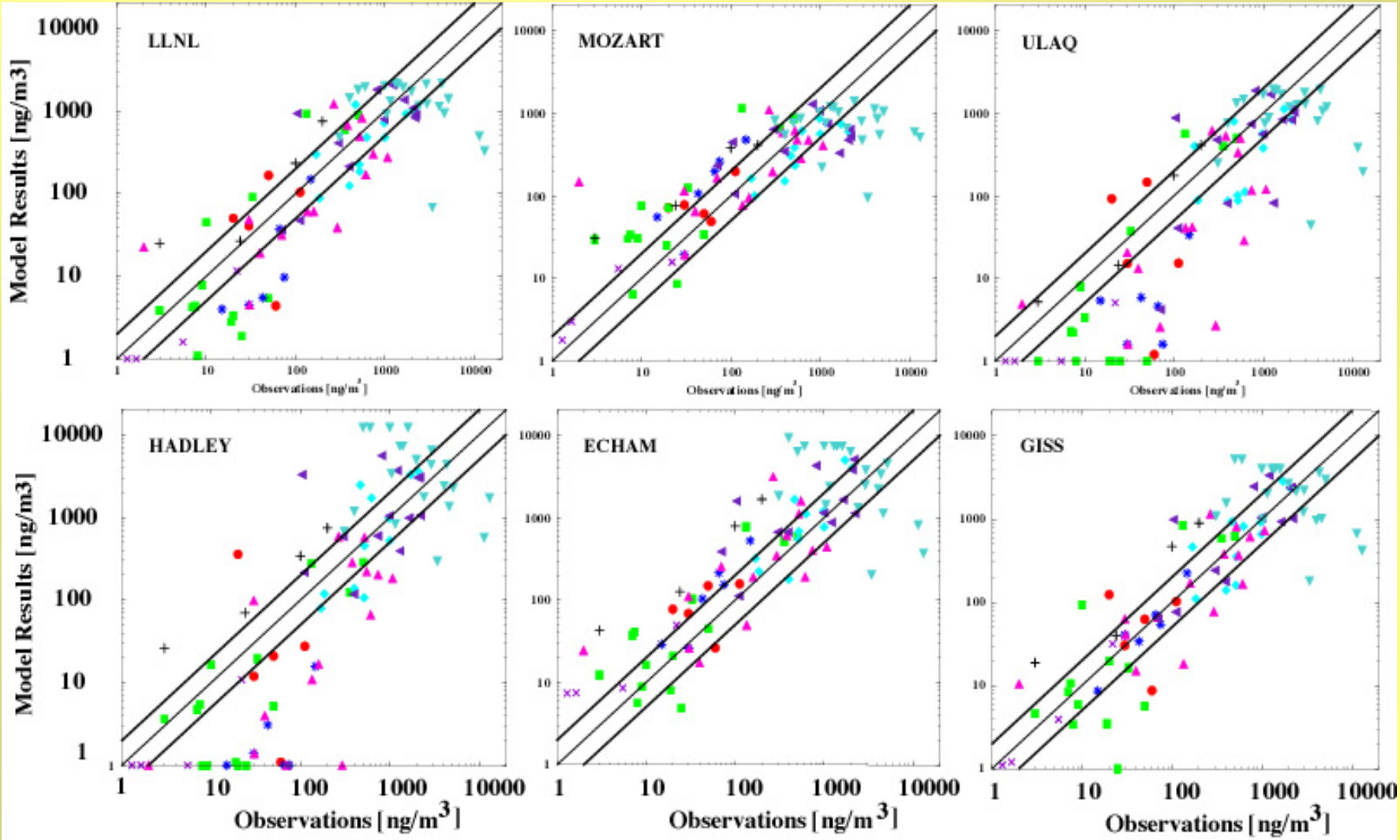
# Sea-Salt Modeling

## comparisons to ground data at 9 sites



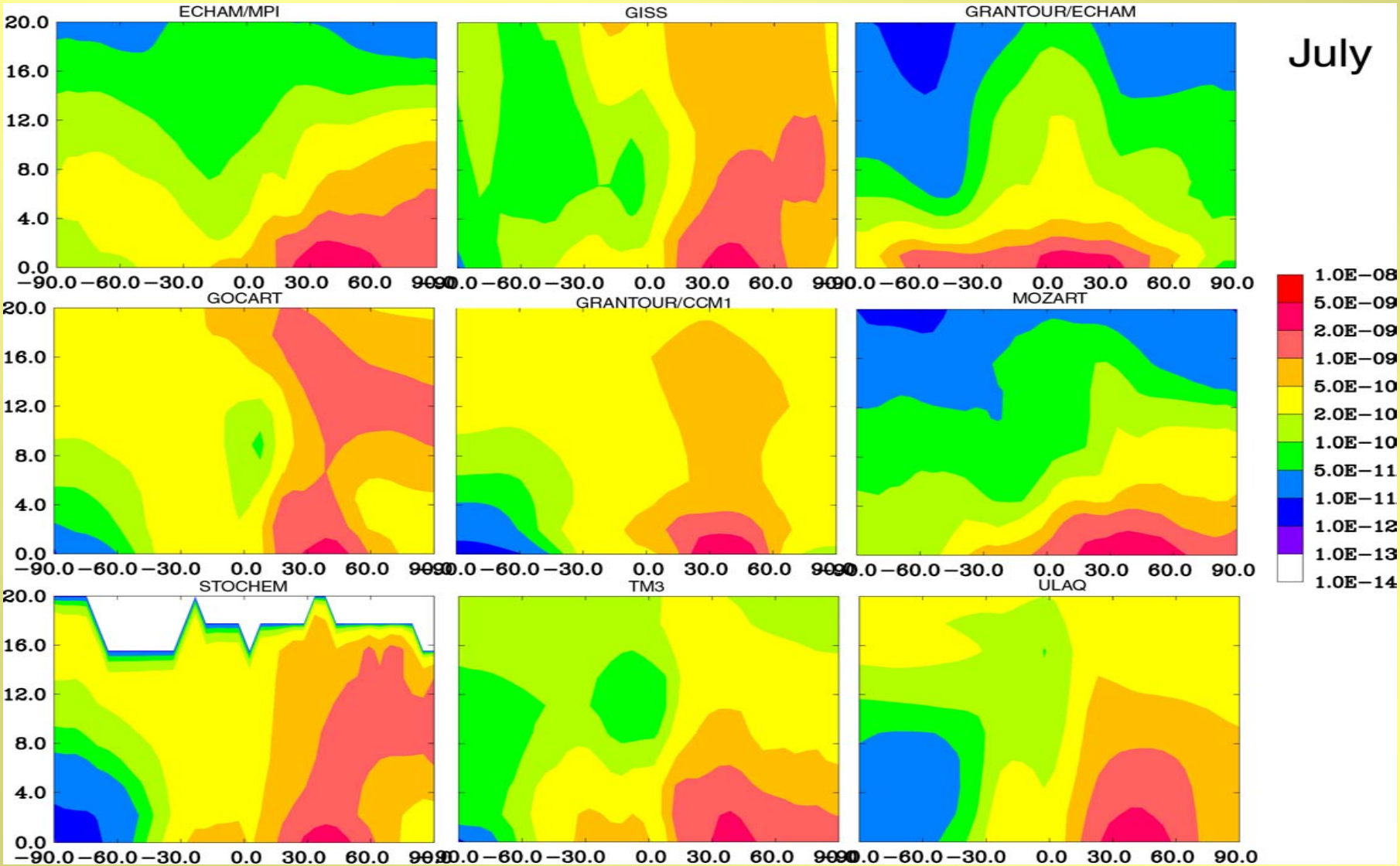
# Black Carbon Modeling

## comparisons to ground data

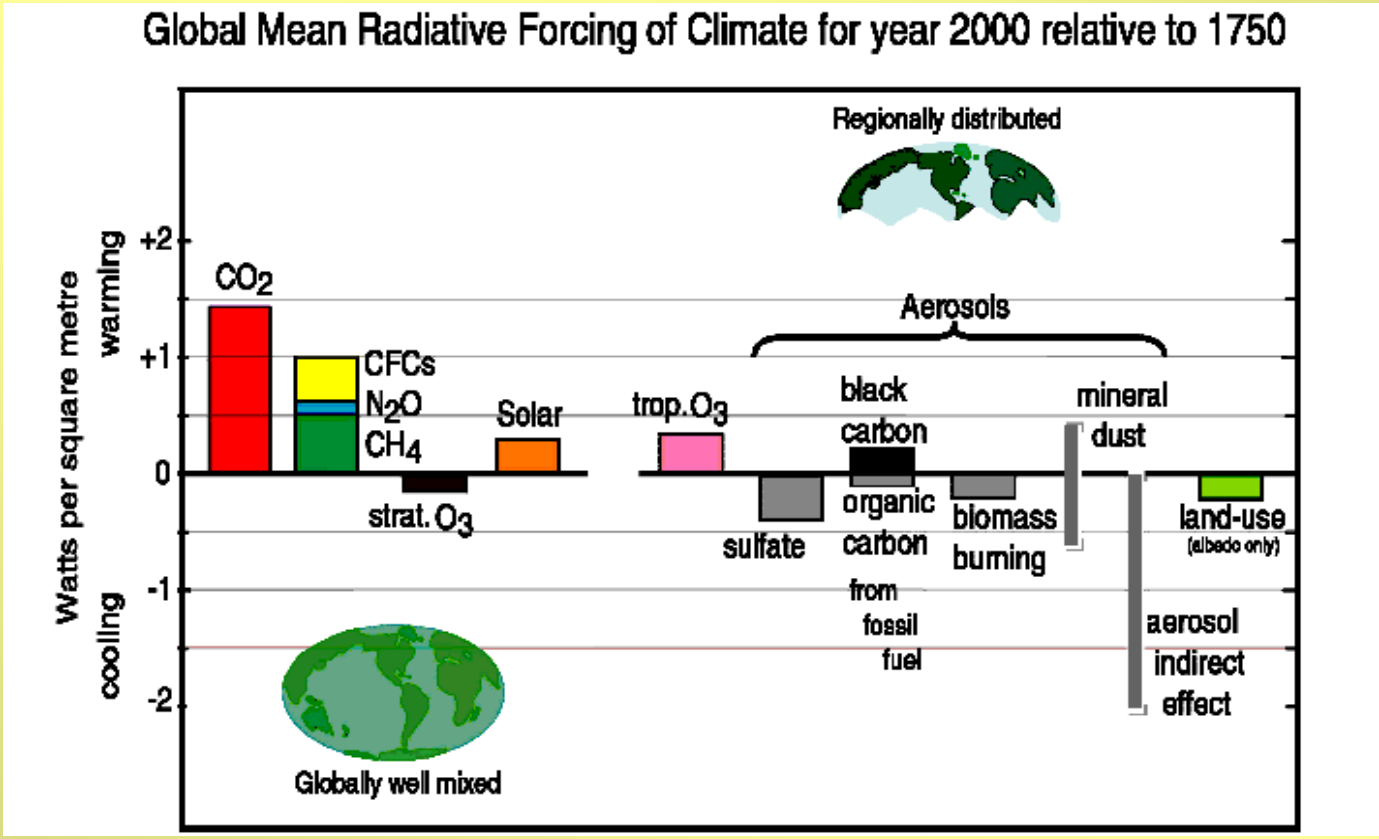


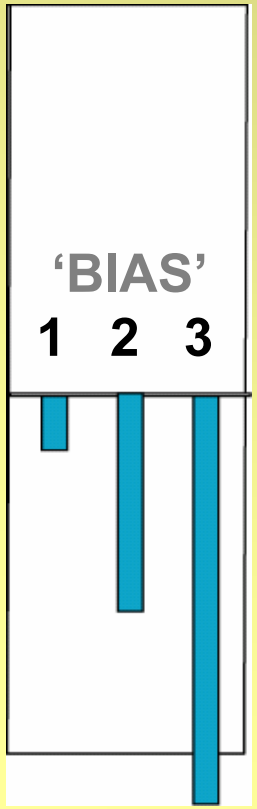
# Modeling vertical distribution

## sulfate mix.ratios: latitude(x) vs height(y)



# Modeling vs Satellite




**AVHRR satellite analysis by:**

1. **Stowe**
2. **Nakajima**
3. **Mishchenko**

***Differently retrieved impacts based on identical satellite data-sets illustrate the quantification problem with data from space*** *(non unique solutions)*

# AEROCOM: Why now?

- Now we have better satellite data; more network observations
- Models are improved by being more physically realistic
- How good are they now for determining radiative forcing?
- Goal:  Use comparisons to data to improve the models

# AeroCom

# AeroCom - Goals

- **diagnose aerosol modules** ***of global models***
- **assemble useful data-sets** ***for evaluations***

⇨ **identify (and eliminate) weak components**
***in aerosol modules of global modeling***

⇨ **reduce uncertainty in simulated forcing**

***'home' website***
**http://nansen.ipsl.jussieu.fr/Aerocom**

***(contacts: schulz@lsce.cea.fr or kinne@dkrz.de)***

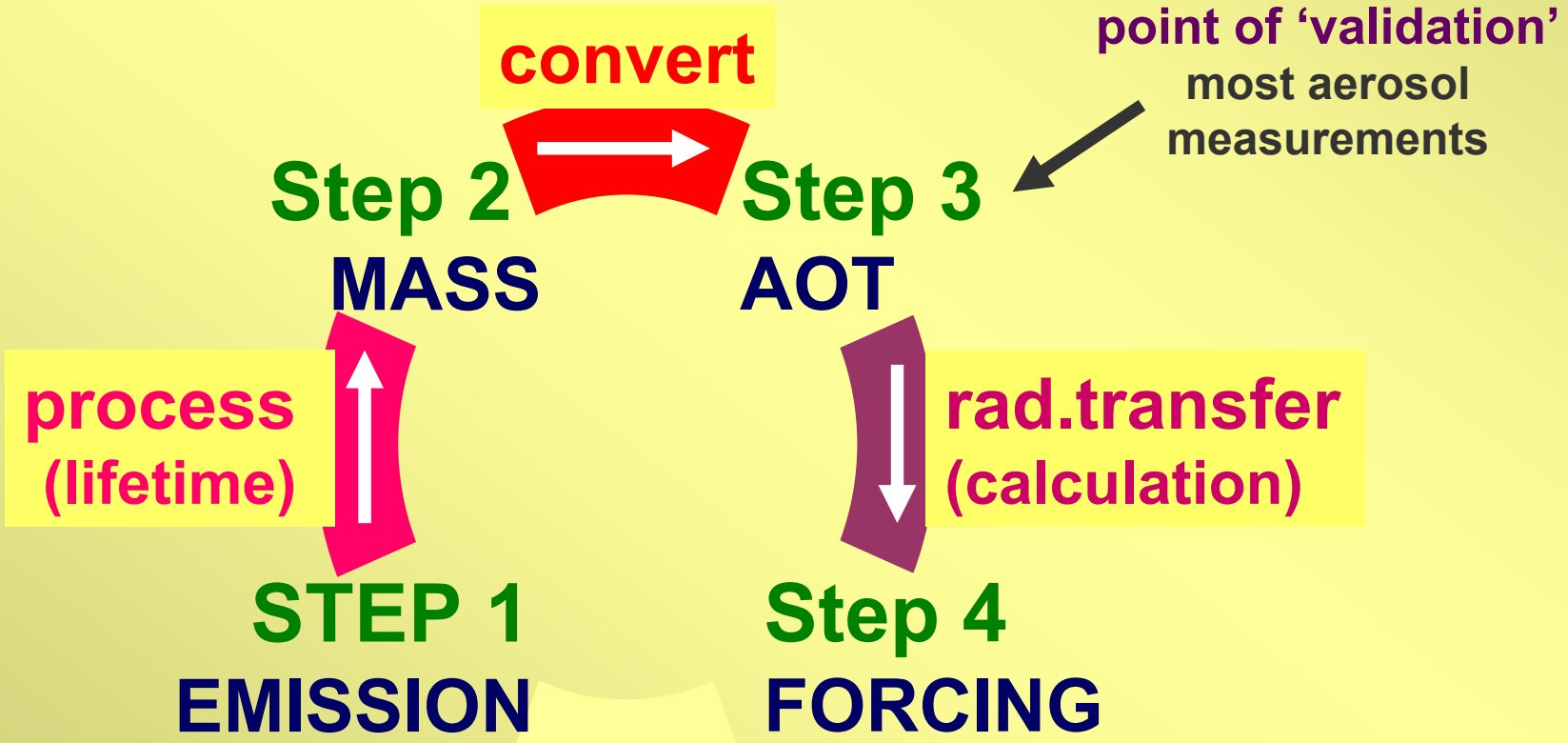
# AeroCom - Participation

- **Modeling**
  - **15 groups indicated their participation**
    - **… and more groups are expected to join**
  - **8 groups contributed to PHASE 1**
    ***('best effort' - if possible for the year 2000)***
    - **from US, Germany, France, Italy, Norway and Japan**

# AeroCom - Participation

- **Measurements**
  - **numerous data-groups provided data**
    - **remaining problems**
      - **accuracy**
      - **lack to long-term commitment**
      - **scale issues (differences in space and time)**
    - **MODEL- and MEASUREMENT community interactions must be improved**
      - **MODELING communities: to express NEEDS**
      - **MEASUREMENT communities : to indicate, what is AVAILABLE – at what QUALITY?, to convey current CAPABILITIES**

# Modeling - a 4 STEP process



# Modeling: OLD vs. NEW

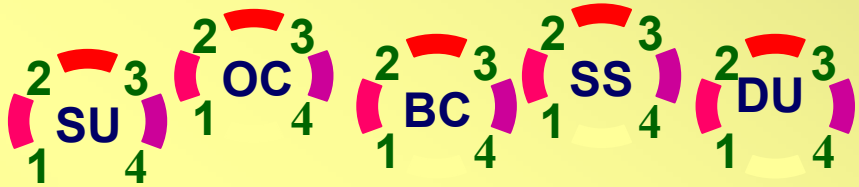
## OLD

- aerosol = sulfate


  - low absorption
  - focus on industry
  - globally incomplete

## NEW

- aerosol = many types




  - better characterization
  - more processes

⇨ more errors ?!

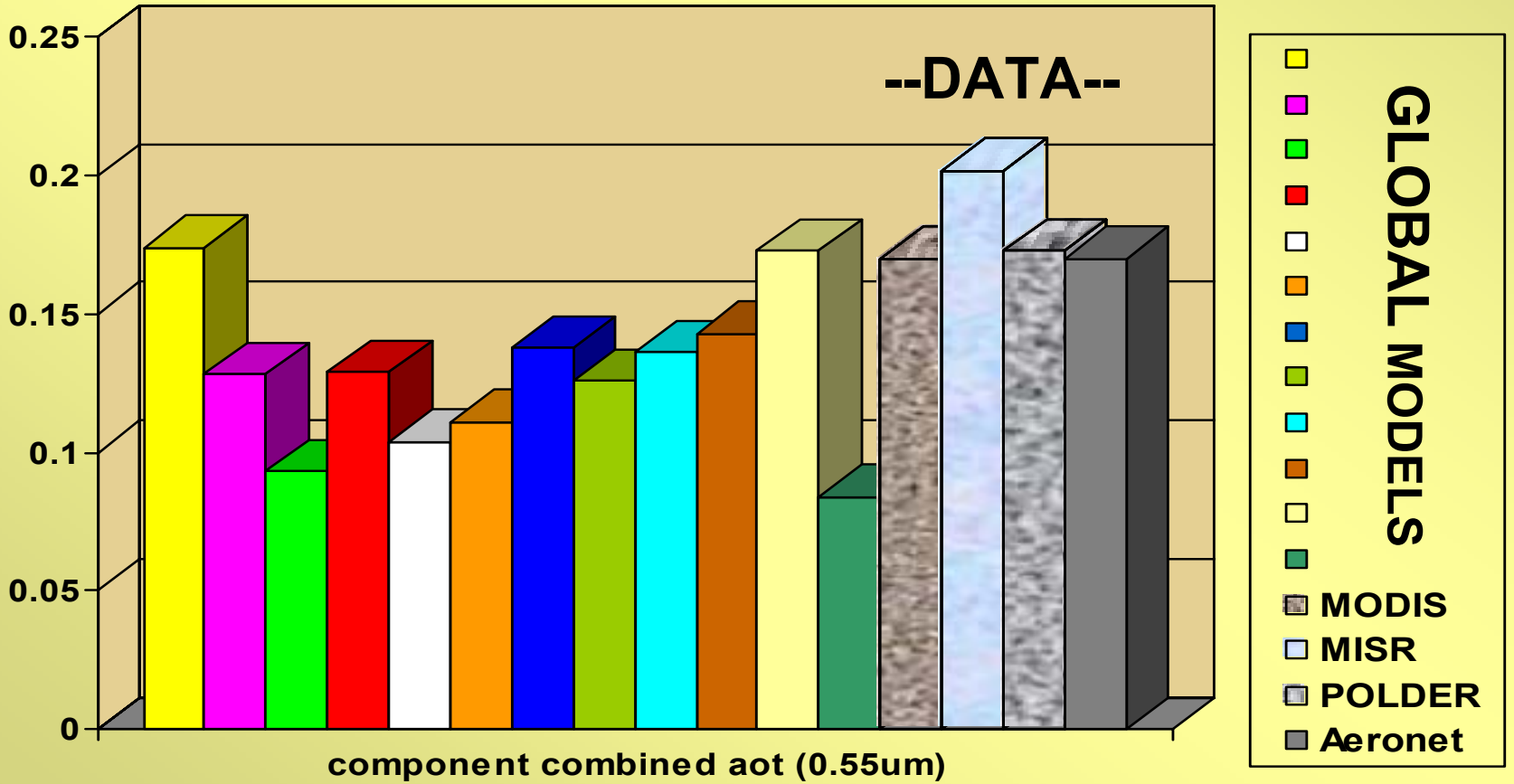
despite better representation in new aerosol modules

… the associated climate uncertainties remain large !

# Aerosol Optical Depth (STEP 3)

## global yearly average

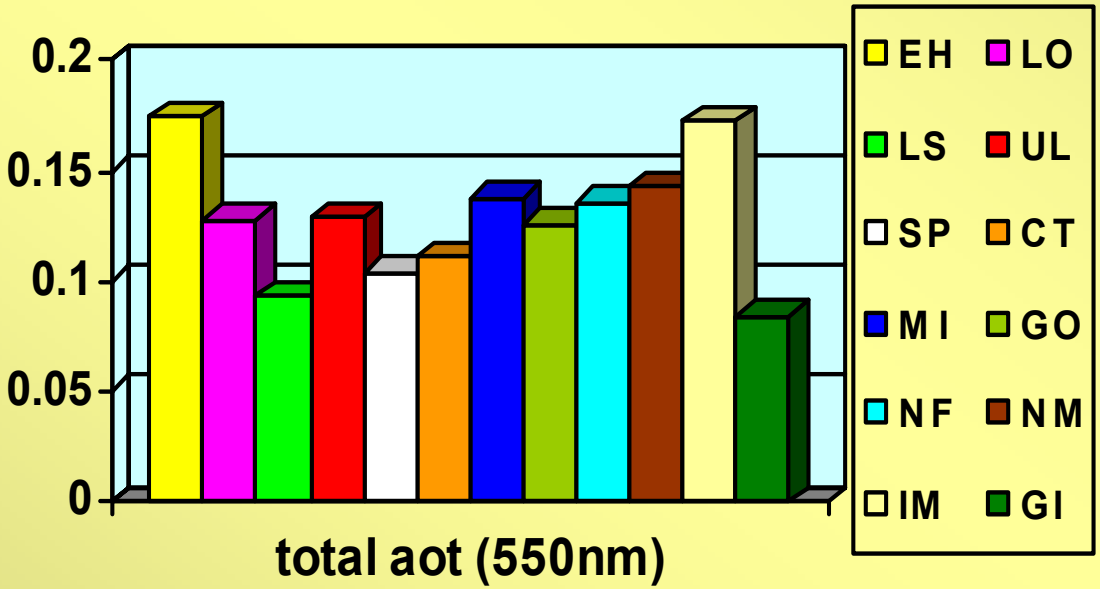
- model simulations vs data



# aerosol optical depth (STEP 3)

- let us look just at models
- let us explore the details behind differences in simulated aerosol optical depths

**12 models:**
**simulated global yearly averages for visible aerosol optical depth**

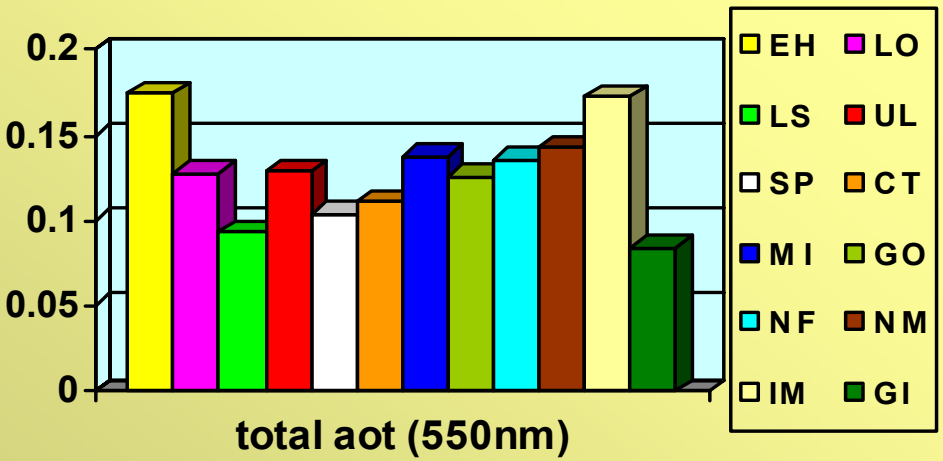


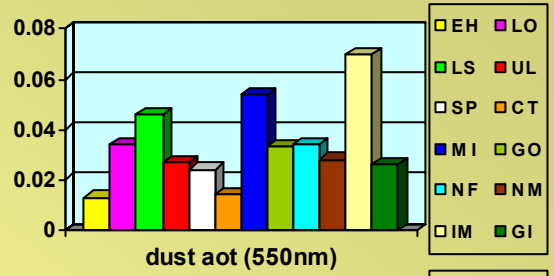
# opt. depth (STEP 3)

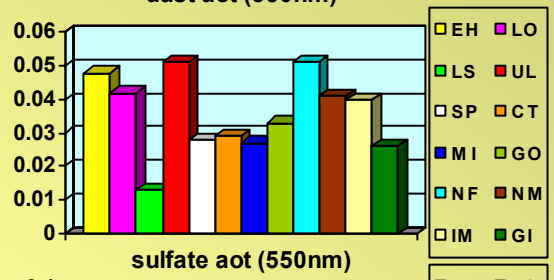
**by type ⇨**

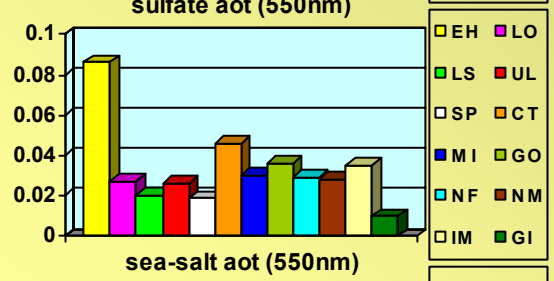
- **notice the different 'make-up'**
  - **different aerosol properties mean**
    - differences in size (e.g. water uptake)
    - differences in absorption

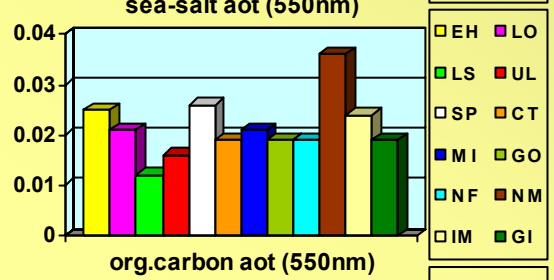
    ⇨ **differences in aerosol forcing !**

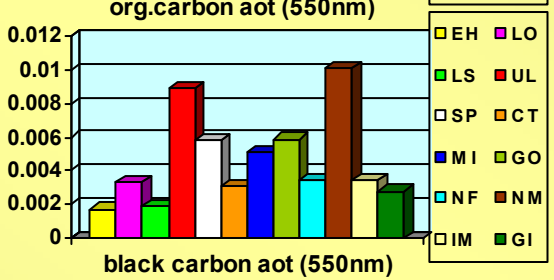


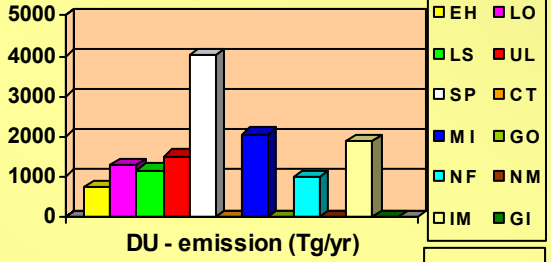



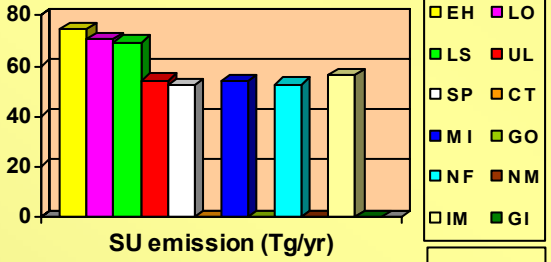



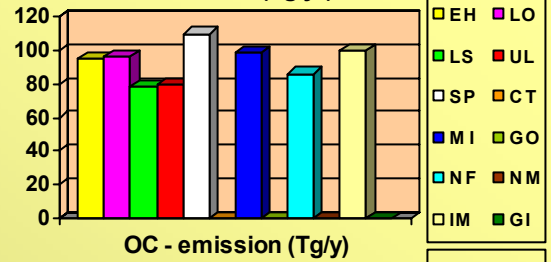



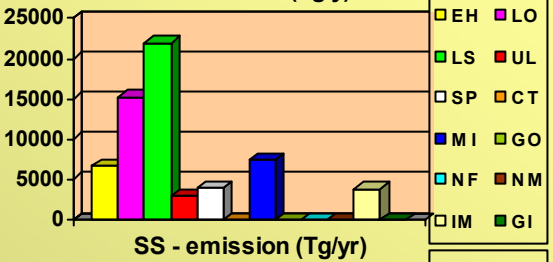
# simulated aerosol - by type

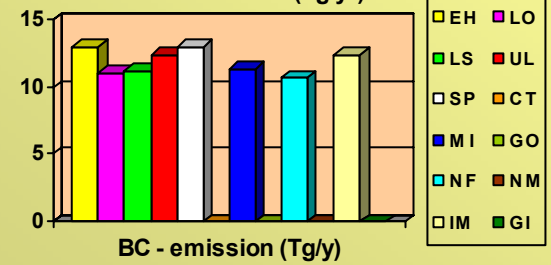
## emission



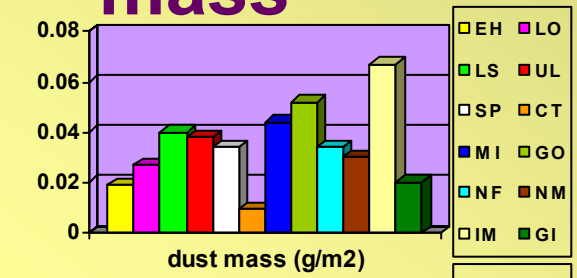



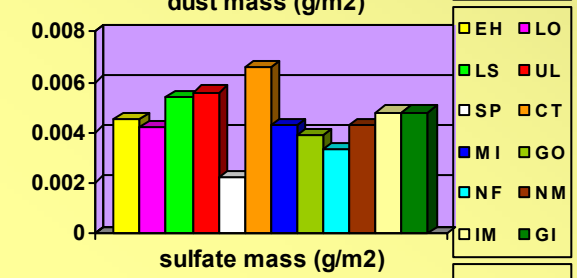



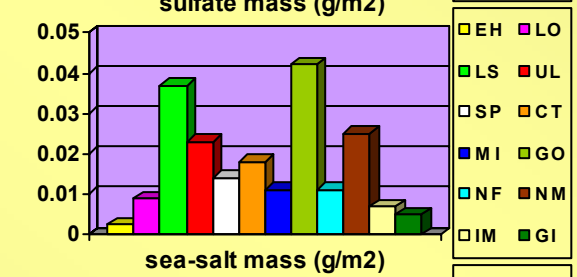



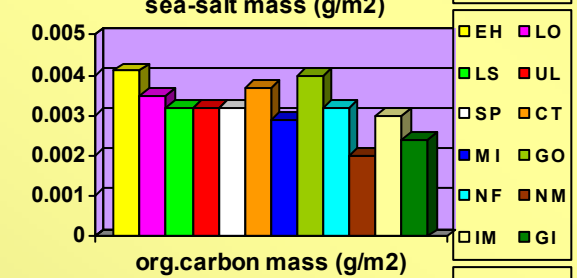



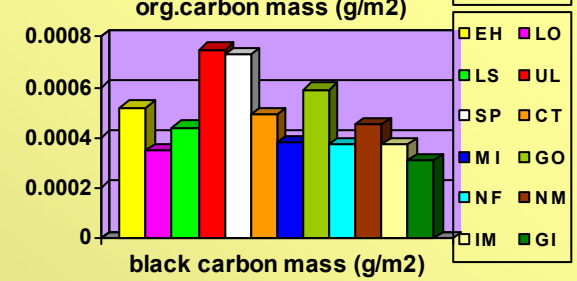

## mass



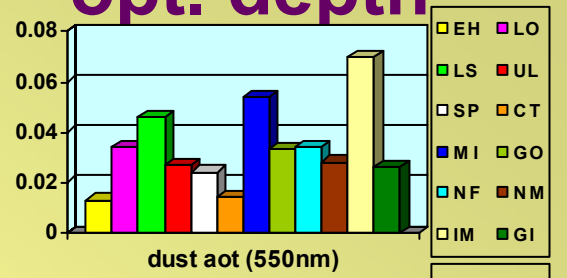



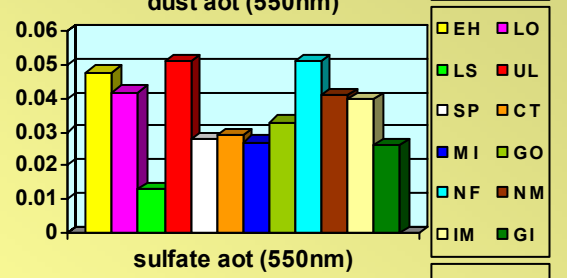



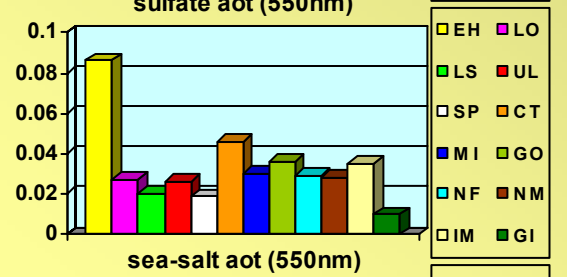



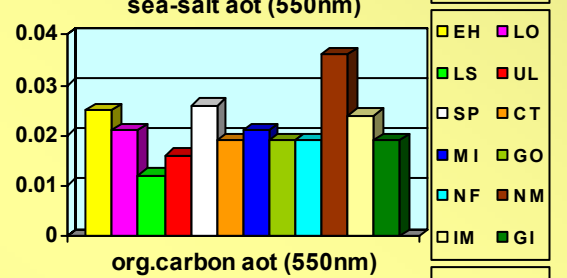



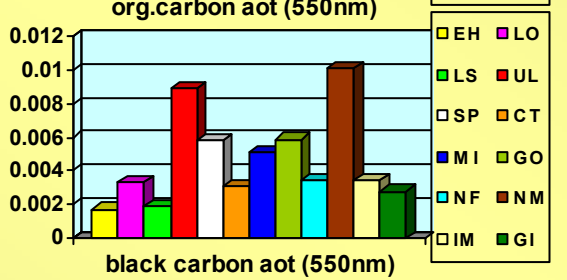

## opt. depth




**differences in ‘aot’ do not correspond to differences in ‘mass’ or ‘emission !**

# Aerosol

## by type

**Trans-formations:**

**lifetime**

**STEP 1 ⇨ STEP 2**
**emission ⇨ mass**

**mass ext. eff.**

**STEP 2 ⇨ STEP 3**
**mass ⇨ opt.depth**

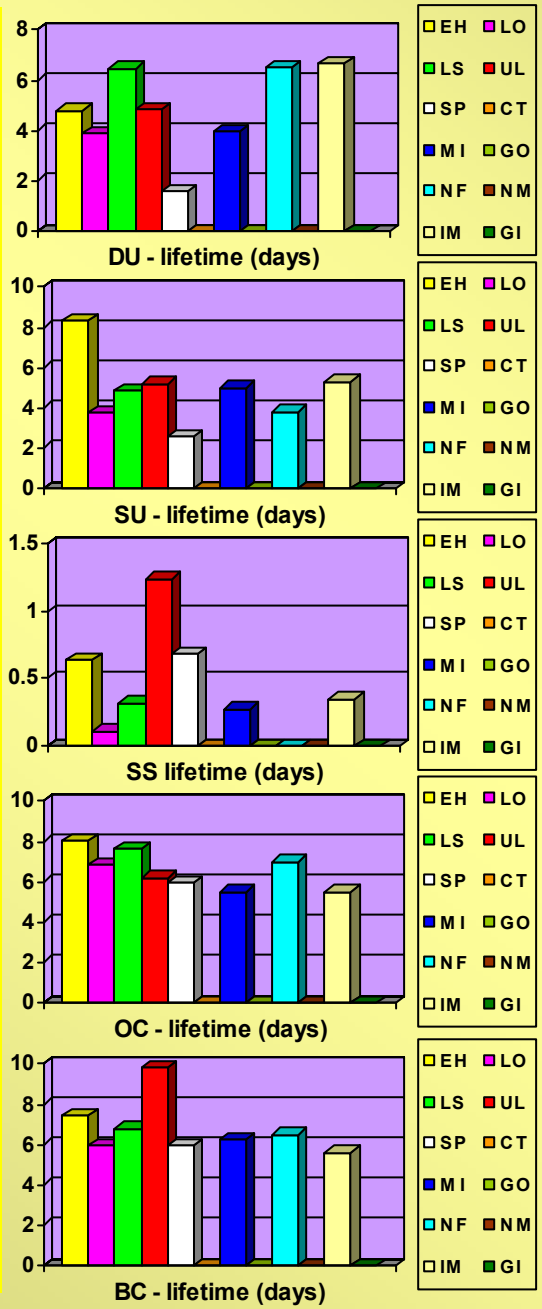
**… control experiments to understand differences …**

STEP 1 EMISSION

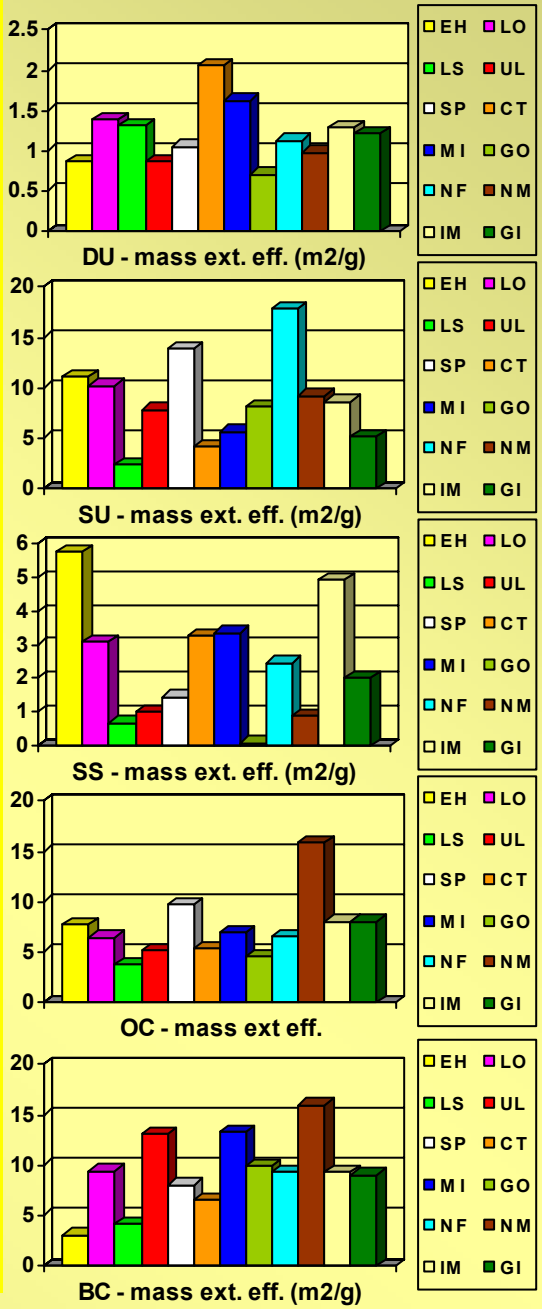
STEP 2 MASS

STEP 3 AOT

## lifetime




## mass ext. eff.



# AeroCom – First Results

- comparisons of aerosol optical depth are NOT ’validations‘ of models
  - one bad parameterization can kill an overall good effort
  - offsetting errors (and/or tuning) can elevate poor efforts

⇨ only a look at detail can provide answers !

⇨ identical input will help understanding model assumptions and deficiencies

# AeroCom - Plans

- unify model input
  - common emission data *(just established)*
    - amount, horiz. distribution, size, injection height
  - common met-data (use year 2000 data)
- examine detailed model-output
  - identify problem areas, give recommendations
- acquire relevant data to test models
  - reach out to the measurements community
- establish an aerosol climatology data-base

# AeroCom - Activities

- organize workshops
  - present model evalutions / highlight problems
  - discuss future strategies
  - forum to connect model and data communities

  – next meeting at ISRPA, Italy, Mar 10-12, 2004

- provide community support via the web

# Extra Slides

# AeroCom facilities *(websites)*

- **http://nansen.ipsl.jussieu.fr/Aerocom**
  - **data request** ***(volume and format)***
  - **performance feedback**
    **(help) evaluate your model to other model and to data !**
  - **results** ***(workshop summaries /publications)***

- **ftp.ei.jrc.it … cd pub/Aerocom**
  - **prescribed emission sources (+sizes +heights) for nudged simulations of year 2000**

  **(overview in an 'aerocom...ppt' [powerpoint] file)**

# Aerosol is complex

*global differences in aerosol concentration*
*global differences in aerosol absorption*
*global differences in aerosol size*

⇨ **aerosol impact varies by region and season !**

***the aerosol impact on climate has many faces:***

- ***aerosol only effect "direct effect"***
- ***aerosol associated feedbacks "indirect effect"***
  - ***modifications to clouds (particles, lifetime, water content)***
  - ***modifications to dynamics (cloud convection)***
  - ***Modifications to precipitation***

# anthropogenic radiative forcing

## magnitude and uncertainties

- aerosol introduces one of the largest uncertainties
- results are based on MODEL –simulations
- 'low understanding' reflects deficiencies in modeling: aerosol modules in global models

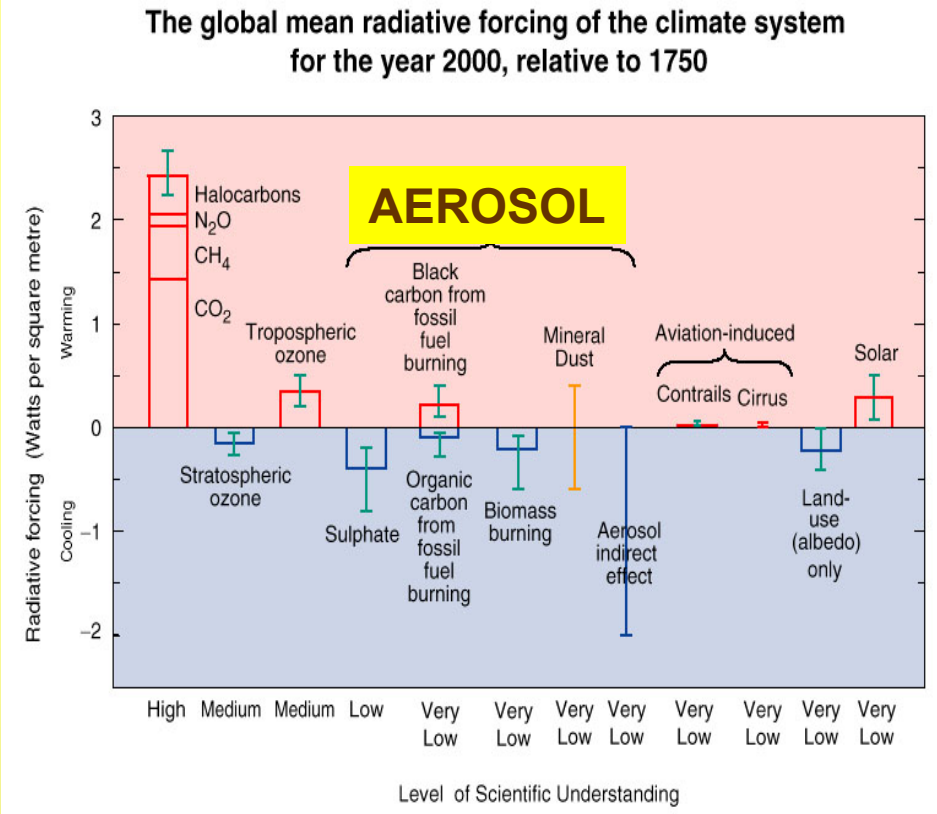



illustration of changes to the radiative energy budget at the top of the atmosphere

# Aerosol Optical Depth (STEP 3)

## global yearly average

**SUMMARY**

- simulations tend to underestimate aot
  - newer models underestimate less than older models
- global yearly totals smear deviation detail
  - regional deviations
  - seasonal (and inter-annual) deviations
  - deviations by aerosol type
- limited relevance to aerosol processing
  - one bad parameterization can kill an overall good effort
  - offsetting errors (and/or tuning) can elevate poor efforts

⇨ only a look at detail can provide answers !