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The aerosol distribution in Europe derived with CMAQ: comparison to near surface in situ and sunphotometer measurements

Outline

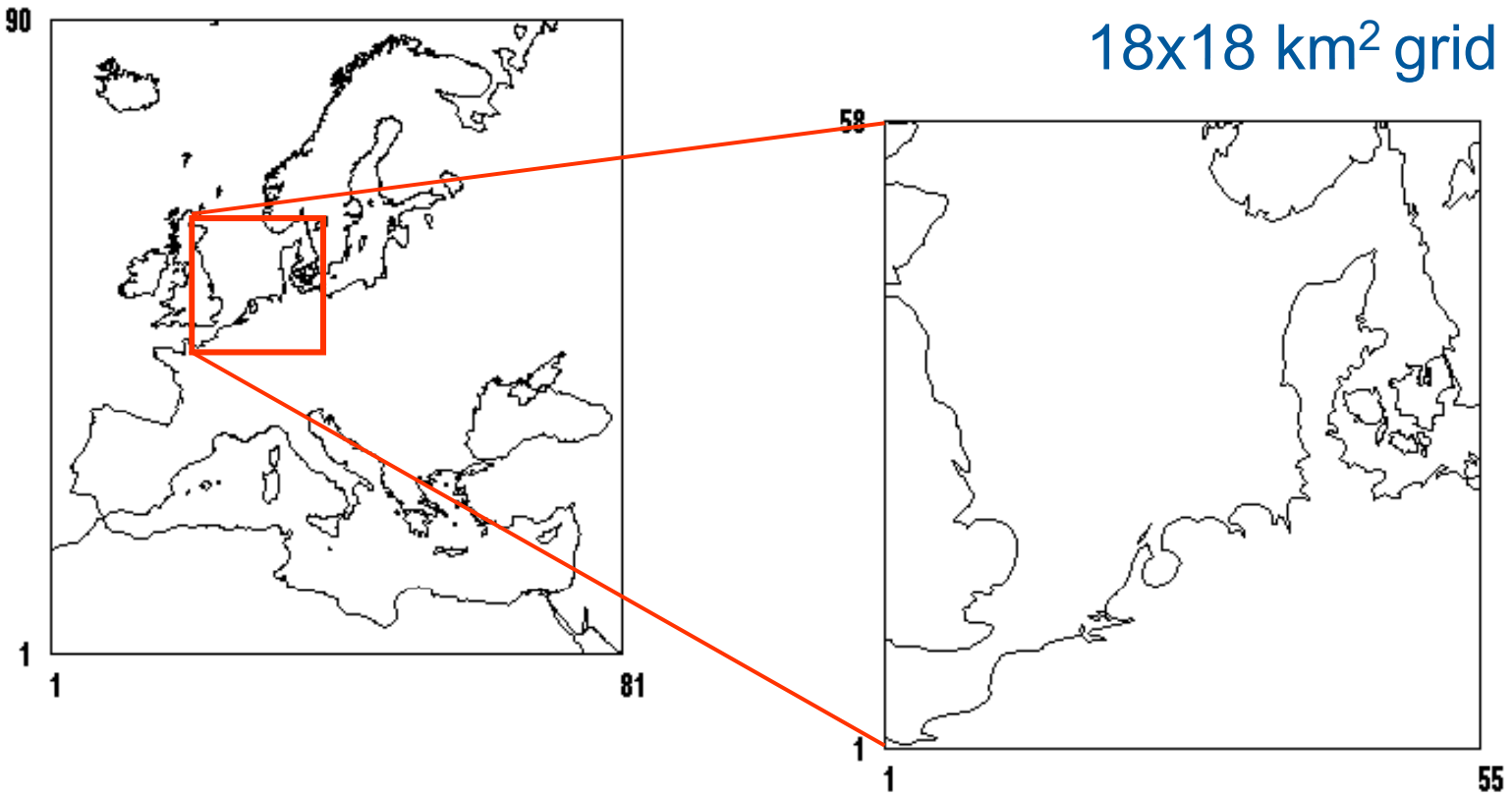
- Introduction
- Model system
- Check of meteorological input data
- Aerosol model results
  - Comparison to near surface in situ measurements
  - Frequency distributions
  - Comparison to sun photometer measurements
- CMAQ applications at GKSS
- Conclusions

New model domains

54x54 km^2 grid

30 vertical layers up to 100 hPa

18x18 km^2 grid

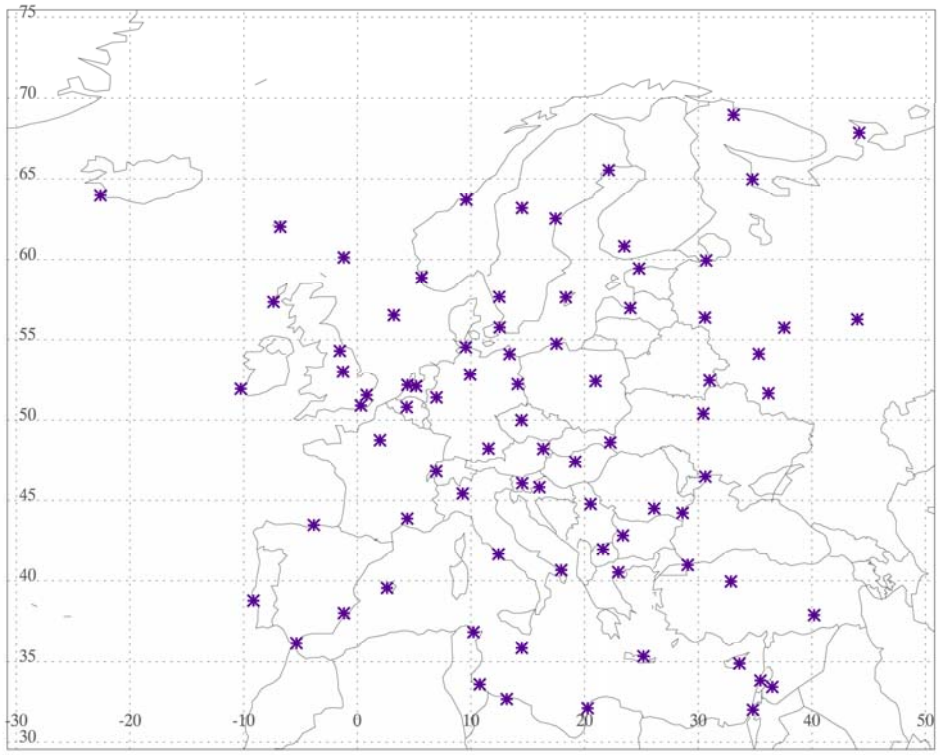


MM5 parameterizations

The use of MM5 at GKSS:

- Kain Fritsch 2 convective cloud scheme
- MRF (Hong and Pan) PBL scheme
- Reisner 2 microphysics scheme
- Noah LSM
- ERA40 6-hourly boundary conditions
- FDDA grid nudging with ERA40 fields

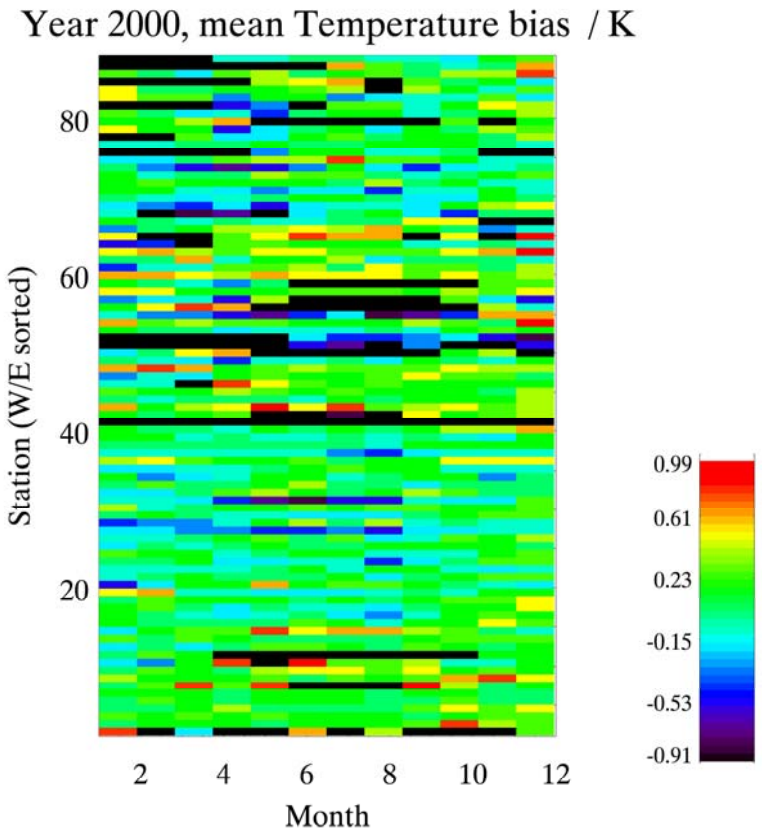
Checking meteorological fields

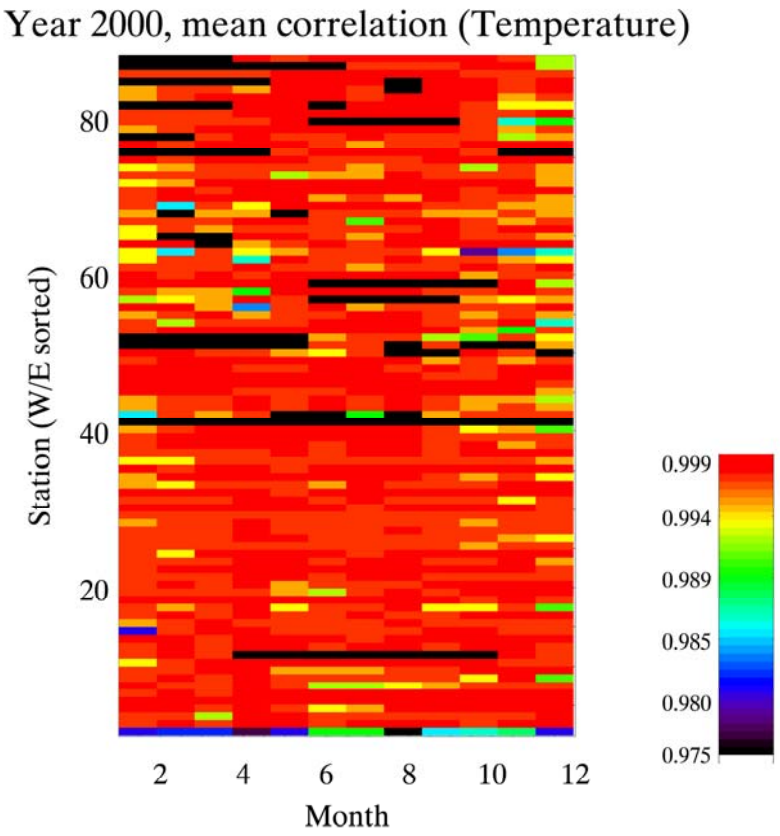


Comparison to ascents from 88 radiosonde station from the igra data base (Durre et al., 2006)

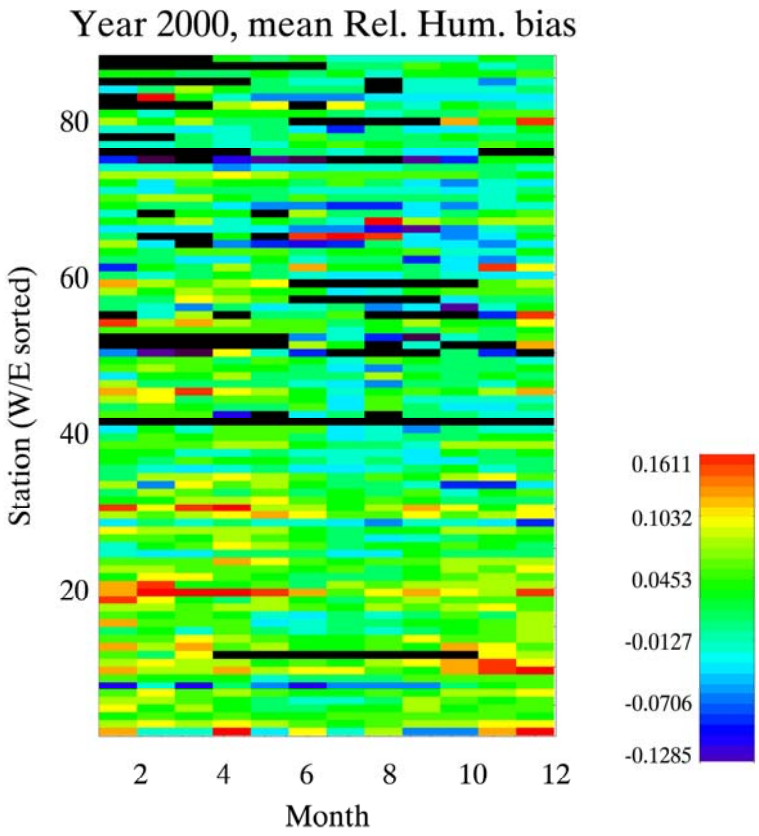
RS data is interpolated to model levels. Mean deviation and correlation are calculated for each profile.

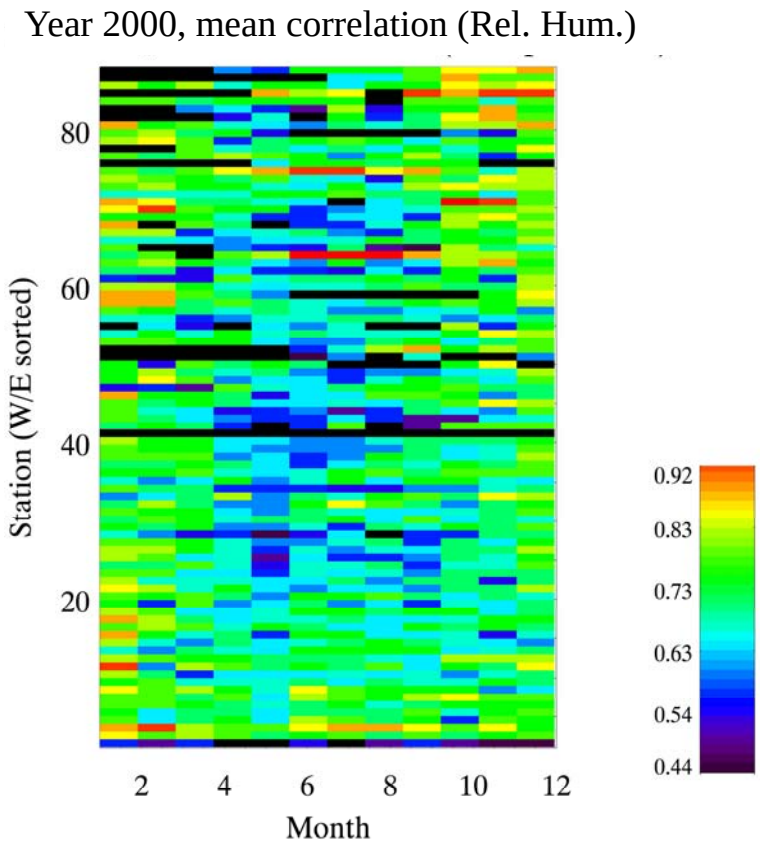
Monthly mean of correlation and bias sorted by station:Temperature





Monthly mean of correlation and bias sorted by station: Rel. Humidity





Aerosol representation in CMAQ

3 size classes, 10 species, e.g.

Sulfate

Nitrate

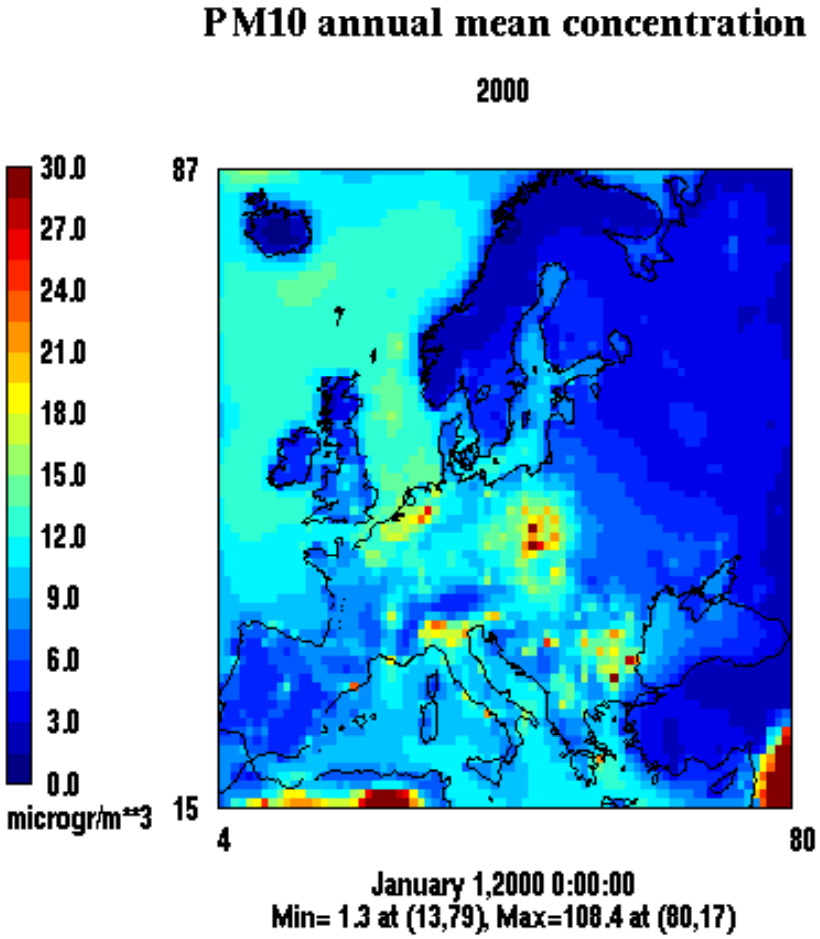
Ammonium

Sodium, Chloride

Elemental carbon

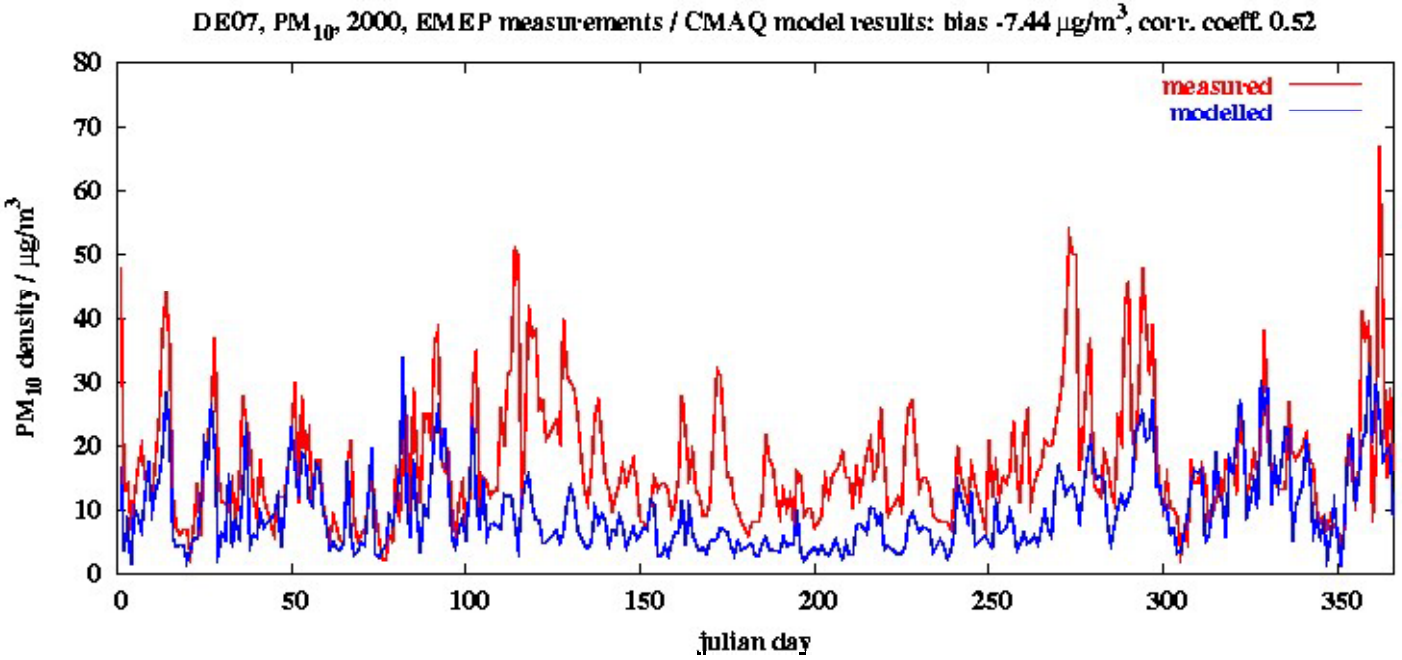
Organics:
(prim., sec., anthr., biog.)

Other (dust, …)



Annual PM10

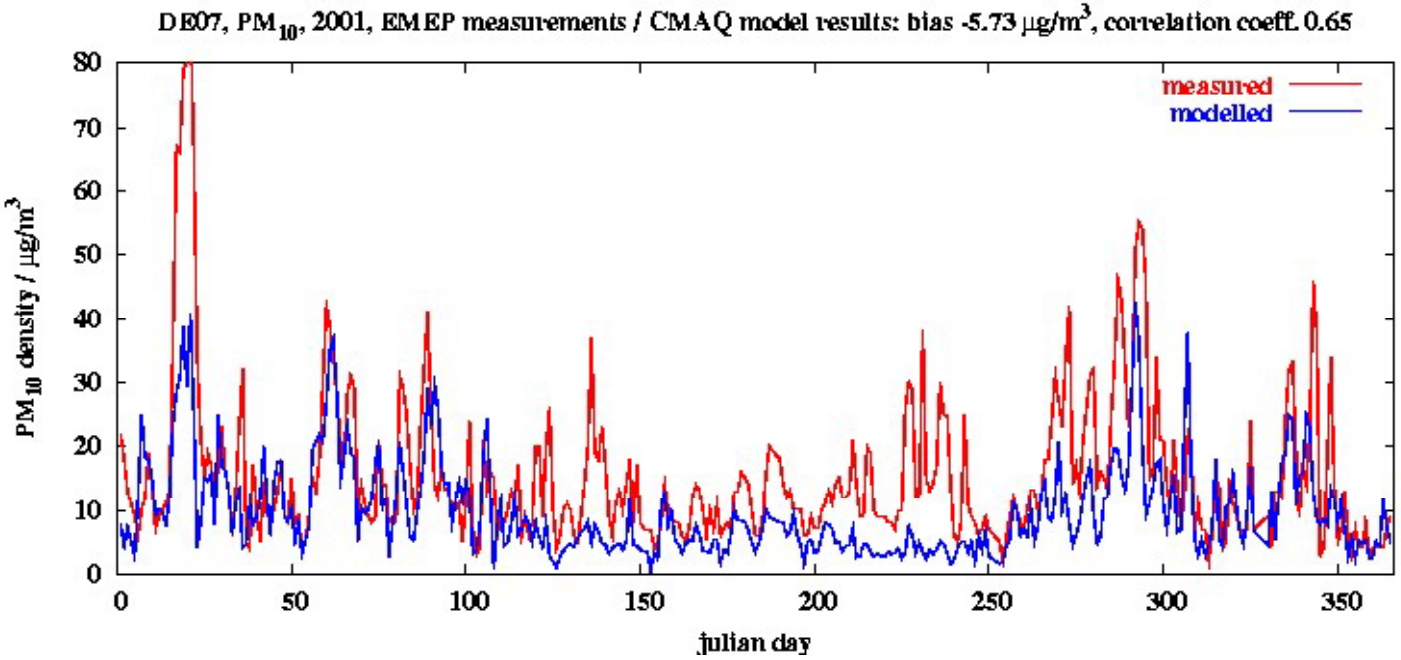
Time series of daily means at Neuglobsow/Germany, year 2000



mean bias -7.4 µg/m^3
(measured: 17.3 µg/m^3, modelled 9.9 µg/m$^{3)}$
corr coeff 0.52

Annual PM10

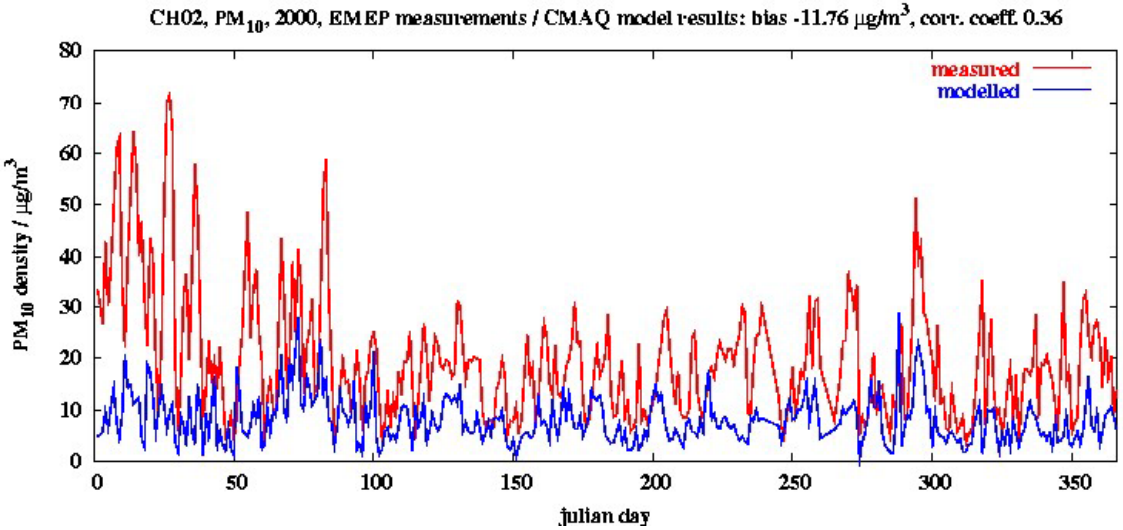
Time series of daily means at Neuglobsow/Germany, year 2001



mean bias -5.7 µg/m³
(measured: 15.6 µg/m³, modelled 9.9 µg/m³)
corr coeff 0.65

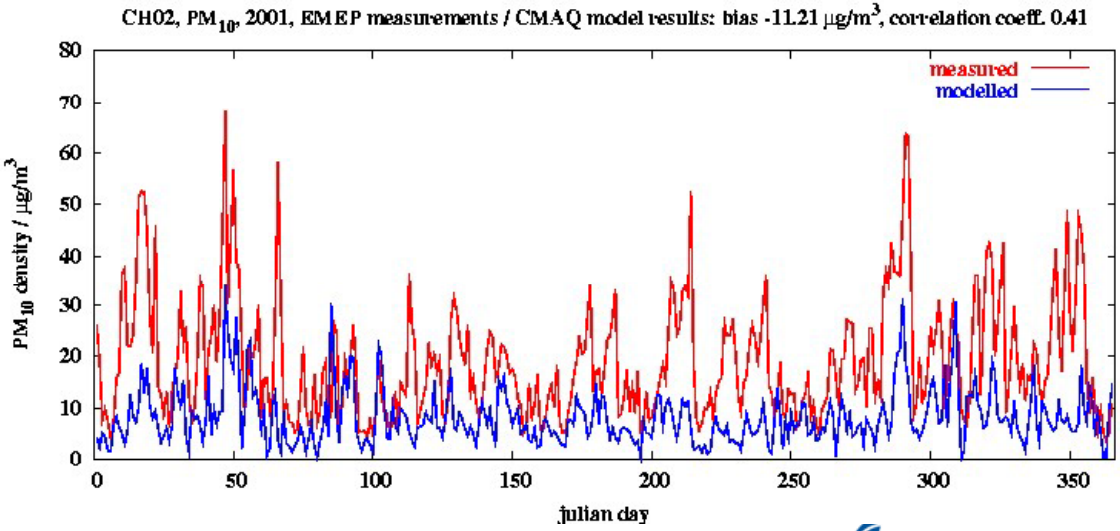
Annual PM10

Time series of daily means at Payerne/Switzerland, 2000 and 2001

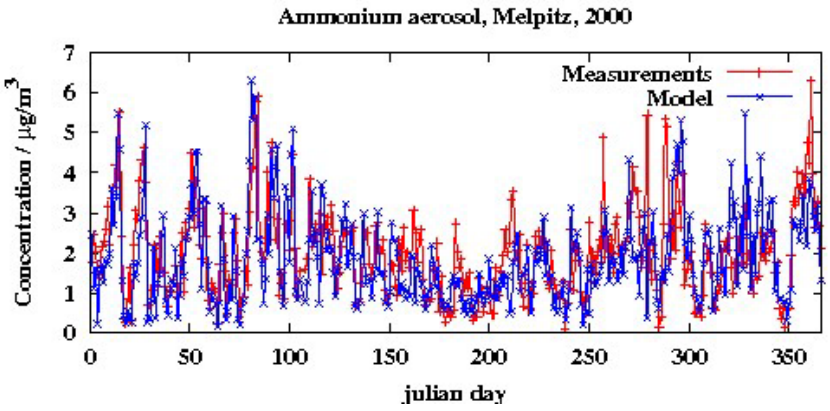


2000:
mean bias -11.8 µg/m^3
corr coeff 0.36

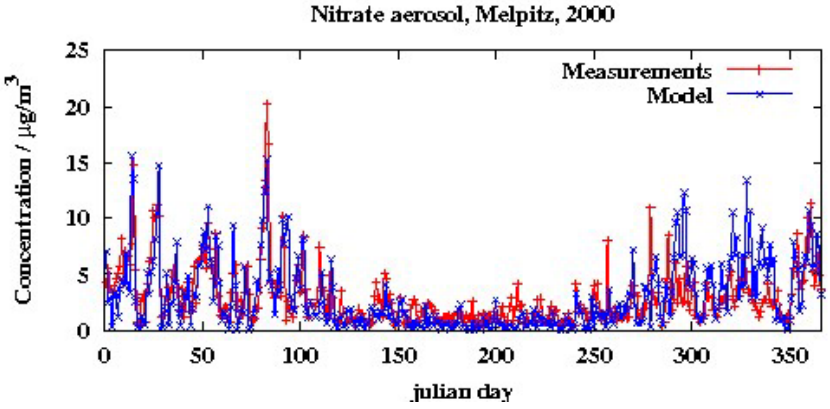
2001:
mean bias -11.2 µg/m^3
corr coeff 0.41



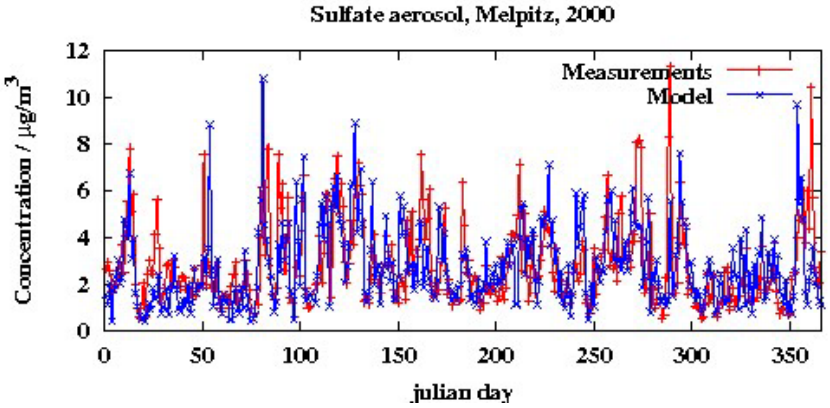
NH_4



NO_3



SO_4



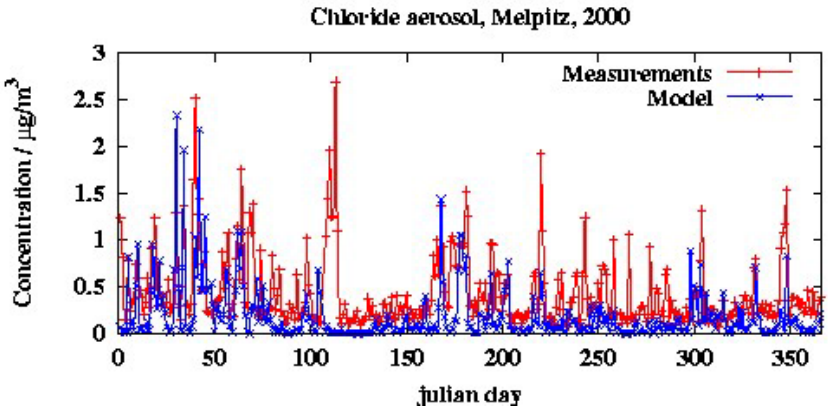
sec. inorganic aerosol

Melpitz/Germany, 2000

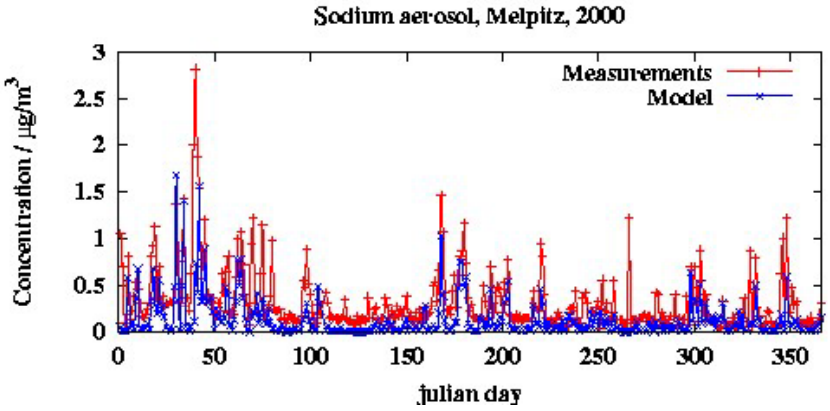
Daily means

	Bias/µg/m³	Corr
NH_4	-0.14	0.63
NO_3	0.04	0.67
SO_4	-0.08	0.55

Cl



Na



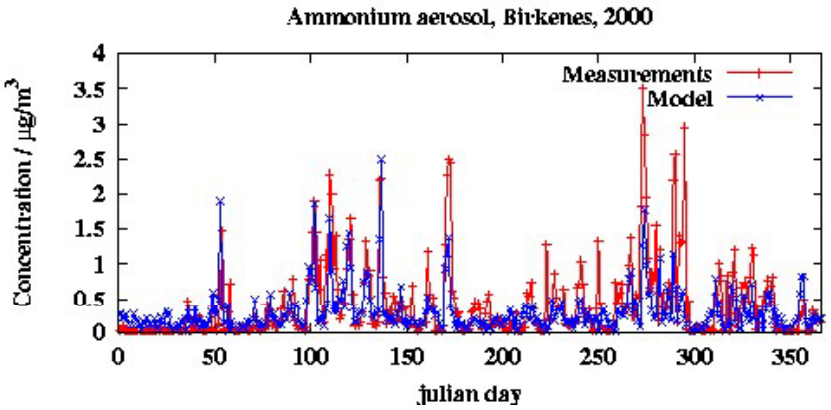
sodium/chloride

Melpitz/Germany, 2000

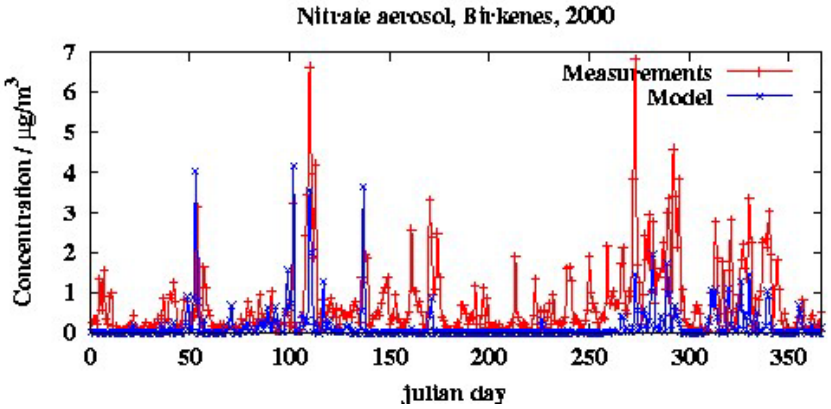
Daily means

	Bias/µg/m³	Corr
Cl	-0.25	0.48
Na	-0.19	0.69

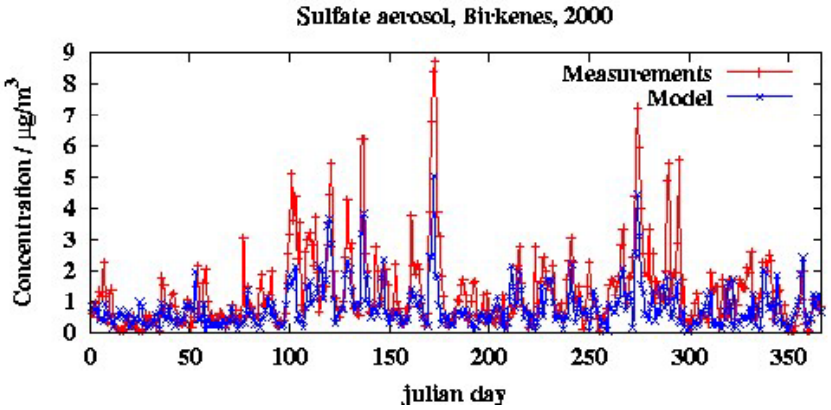
NH_4



NO_3



SO_4



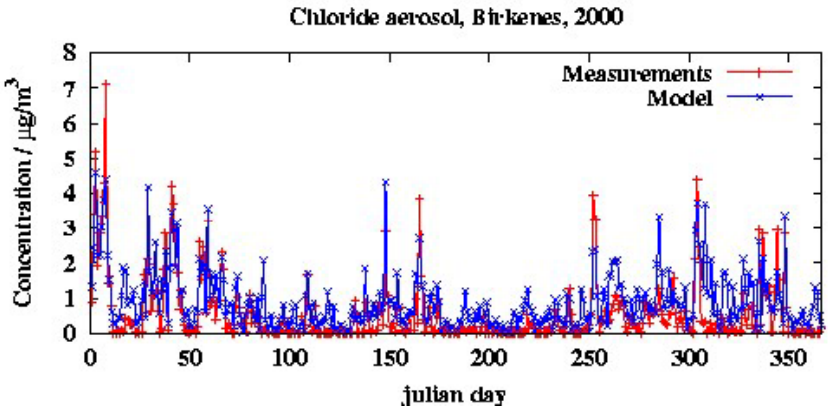
Sec. inorganic Aerosol

Birkenes/Norway, 2000

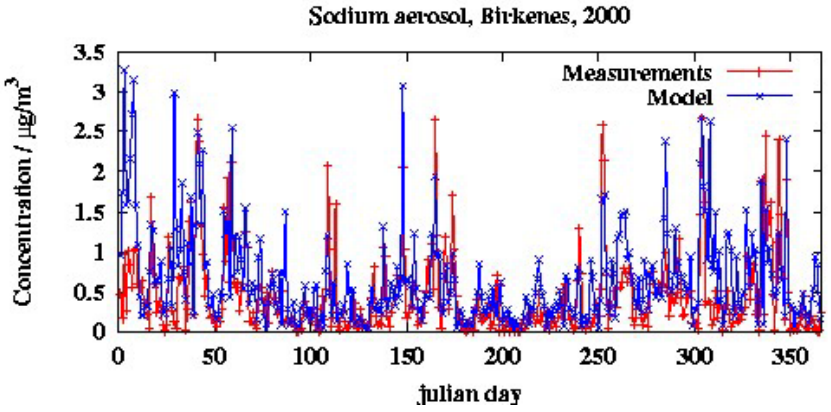
Daily means

	Bias/µg/m³	Corr
NH_4	0.04	0.67
NO_3	-0.56	0.49
SO_4	-0.52	0.69

Cl



Na



sodium/chloride

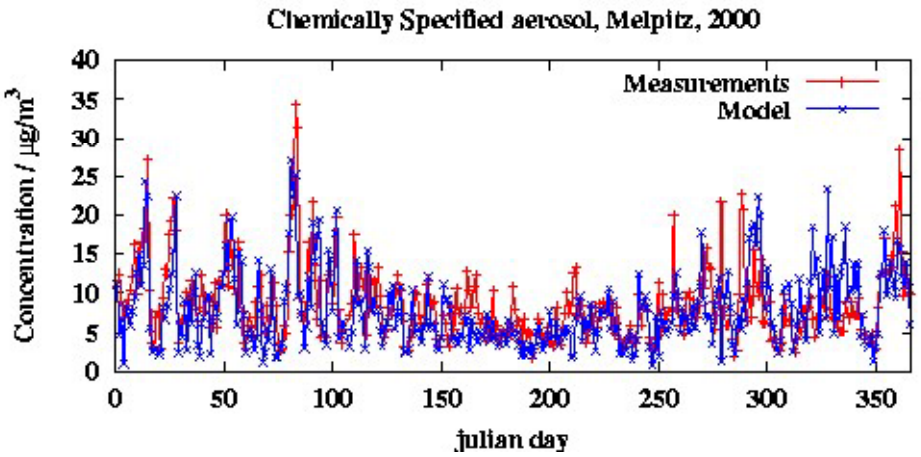
Birkenes/Norway, 2000

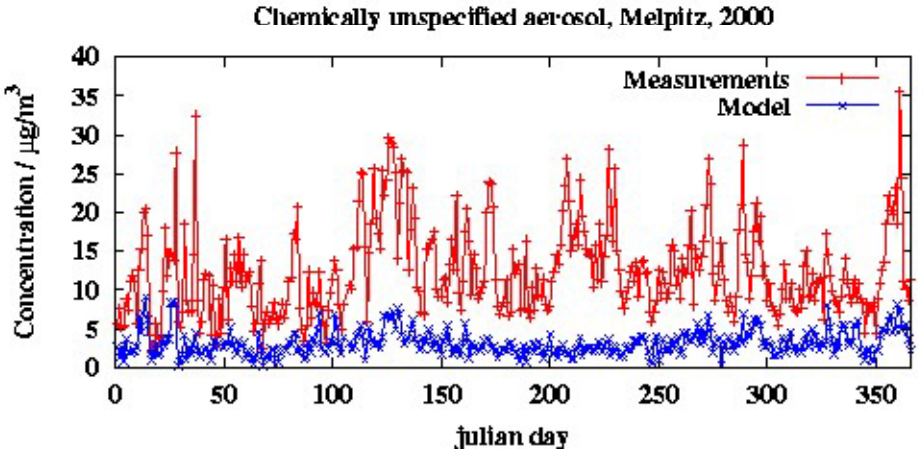
Daily means

	Bias/µg/m³	Corr
Cl	0.36	0.81
Na	0.19	0.65

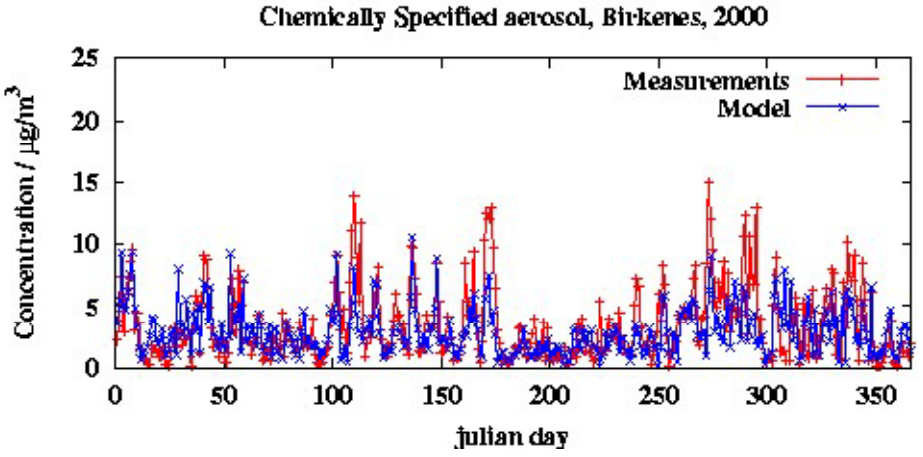
Chemically specified / unspecified aerosol

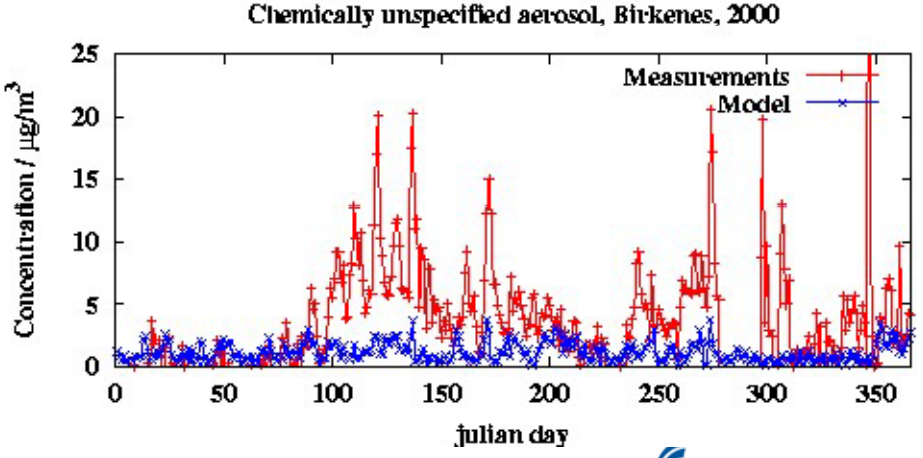
Melpitz





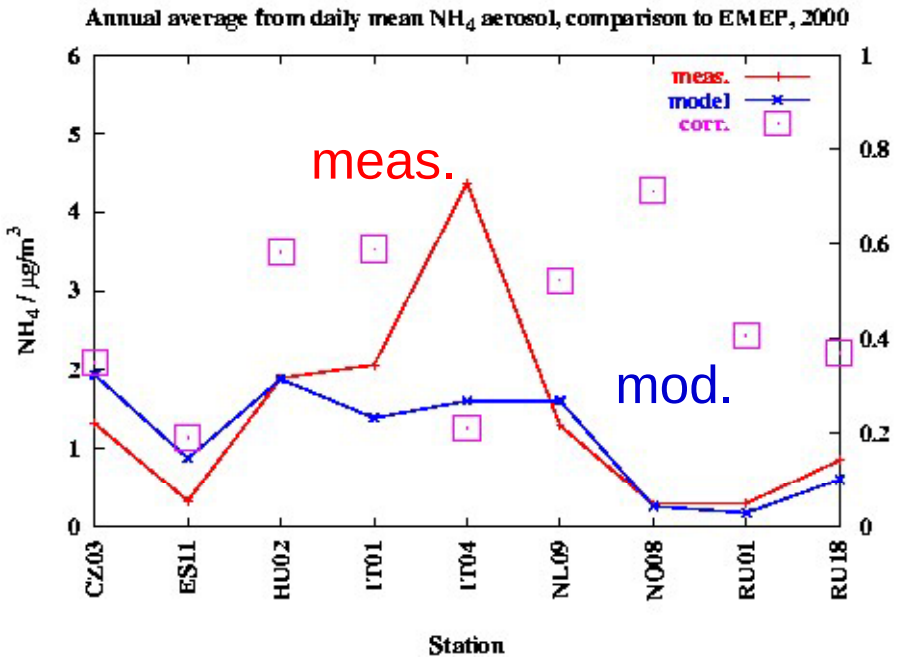
Birkenes



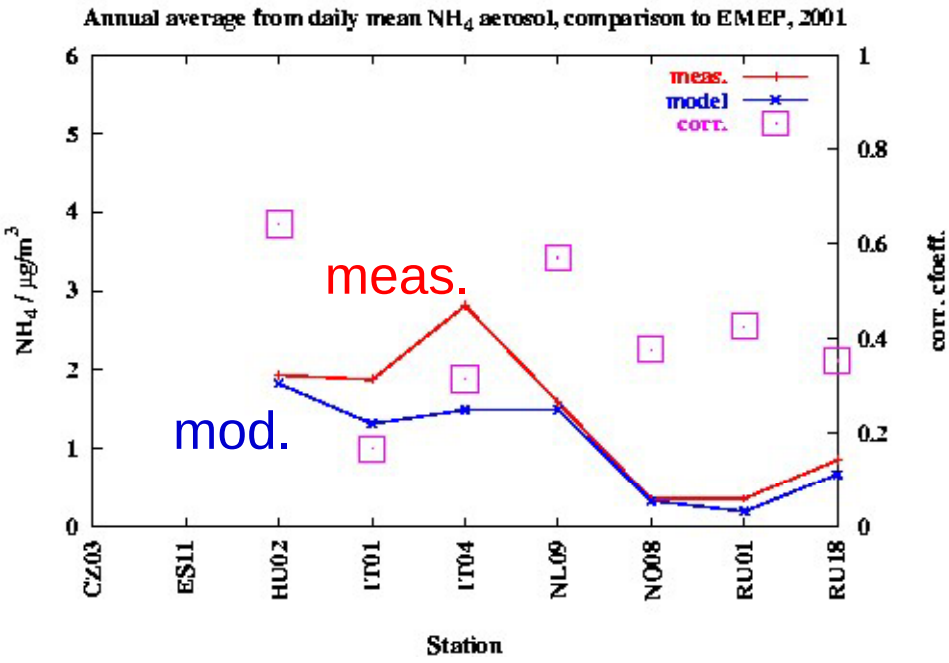


Ammonium aerosol at EMEP stations

Annual average and correlation coefficient



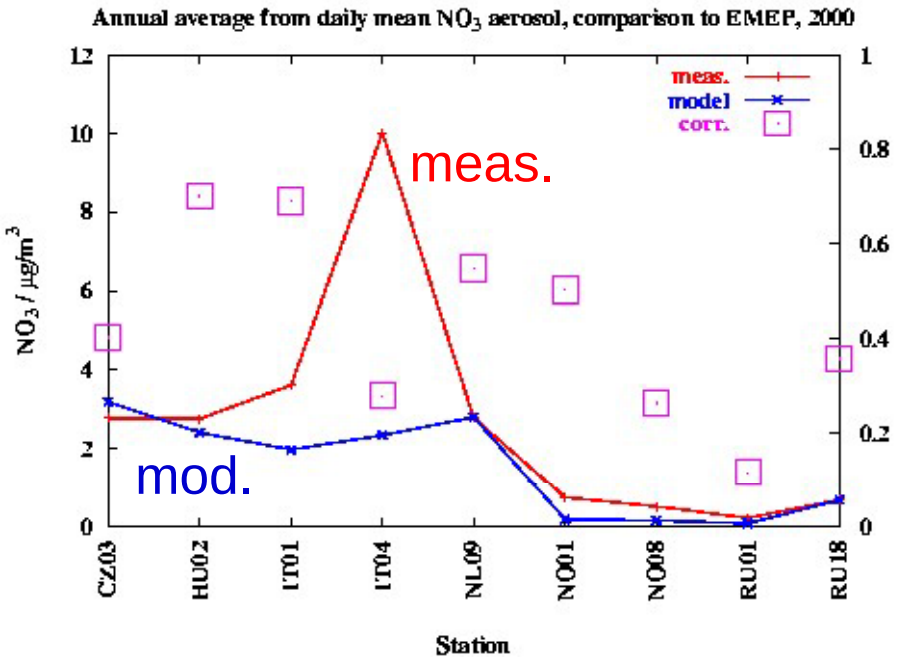
2000



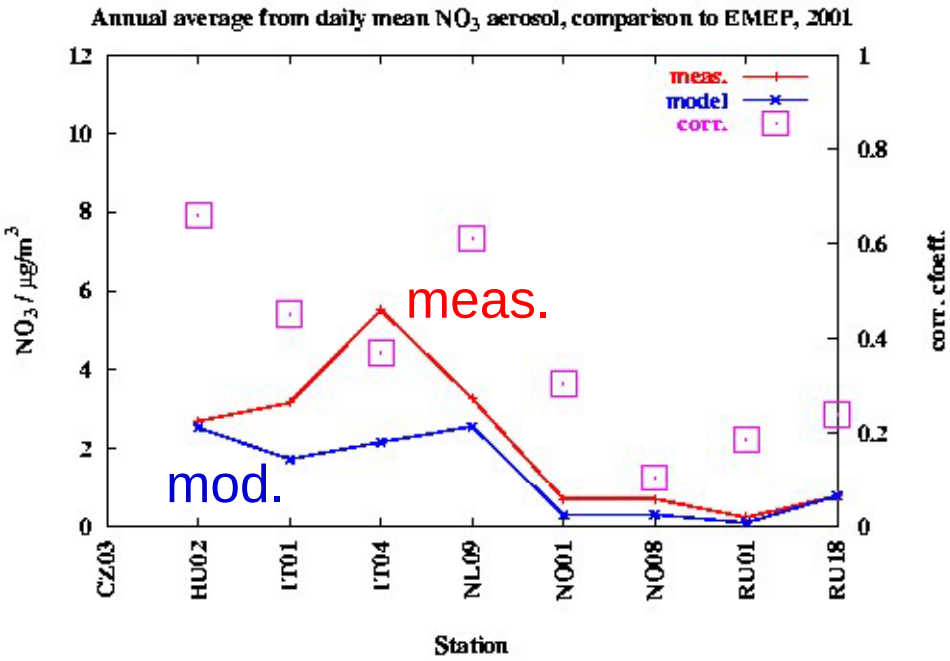
2001

Nitrate aerosol at EMEP stations

Annual average and correlation coefficient



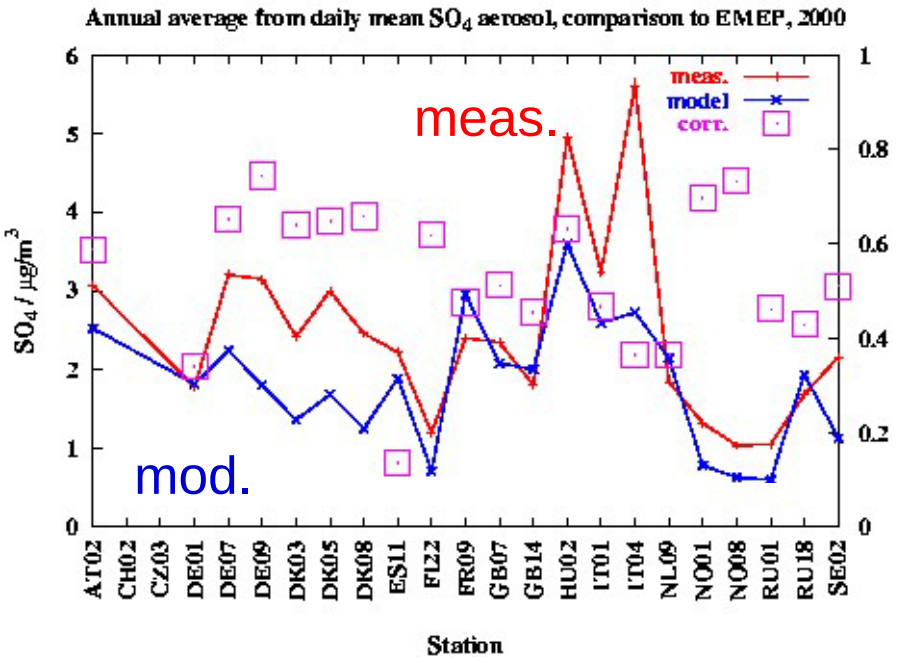
2000



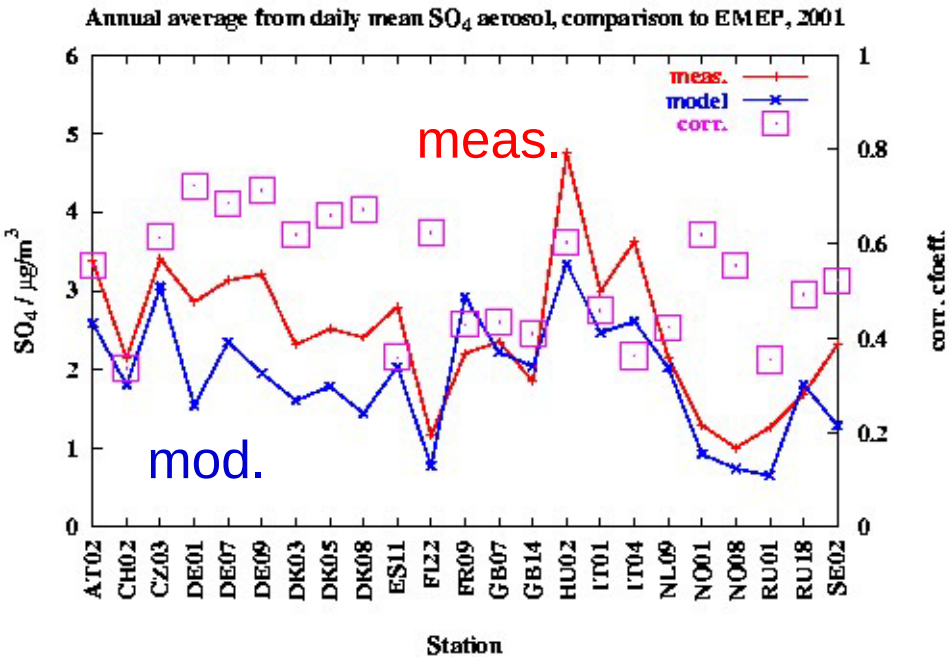
2001

Sulfate aerosol at EMEP stations

Annual average and correlation coefficient



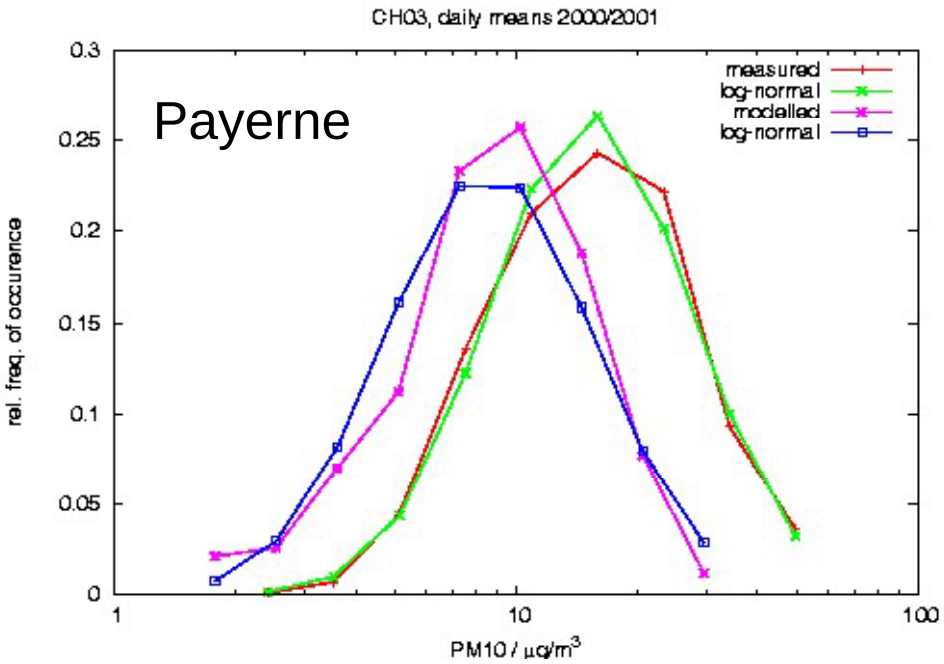
2000

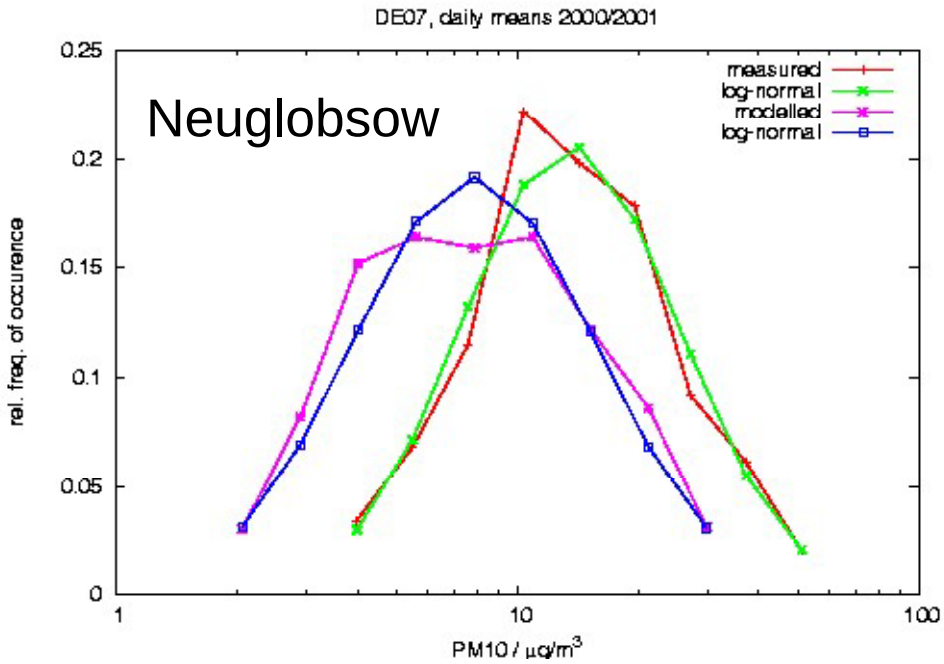


2001

Frequency distrbutions of daily mean PM10

Measured and modelled values follow lognormal distributions



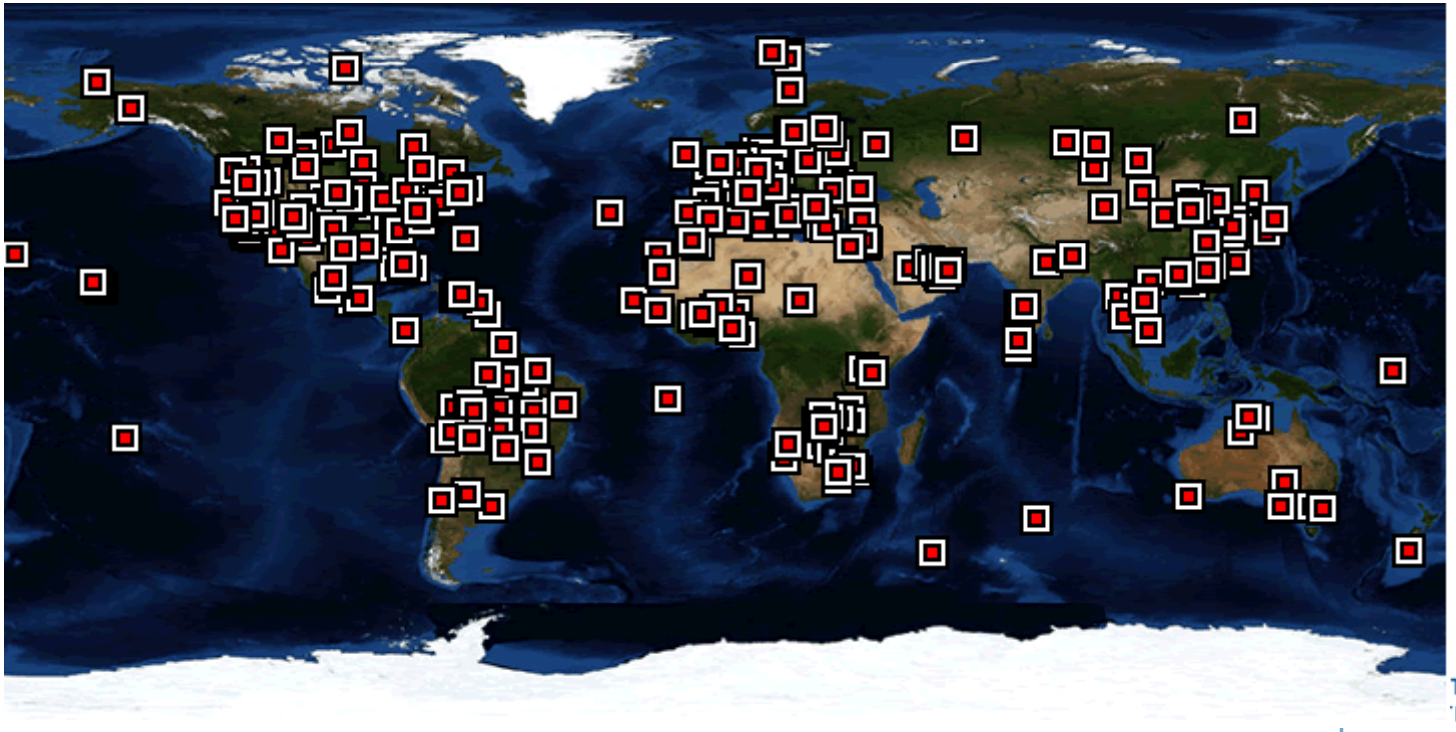


χ^2 –test **not** passed for modelled values

KS-test passed

χ^2 –test and KS-test passed for modelled and meas. values

Aeronet: a global network of sun photometers



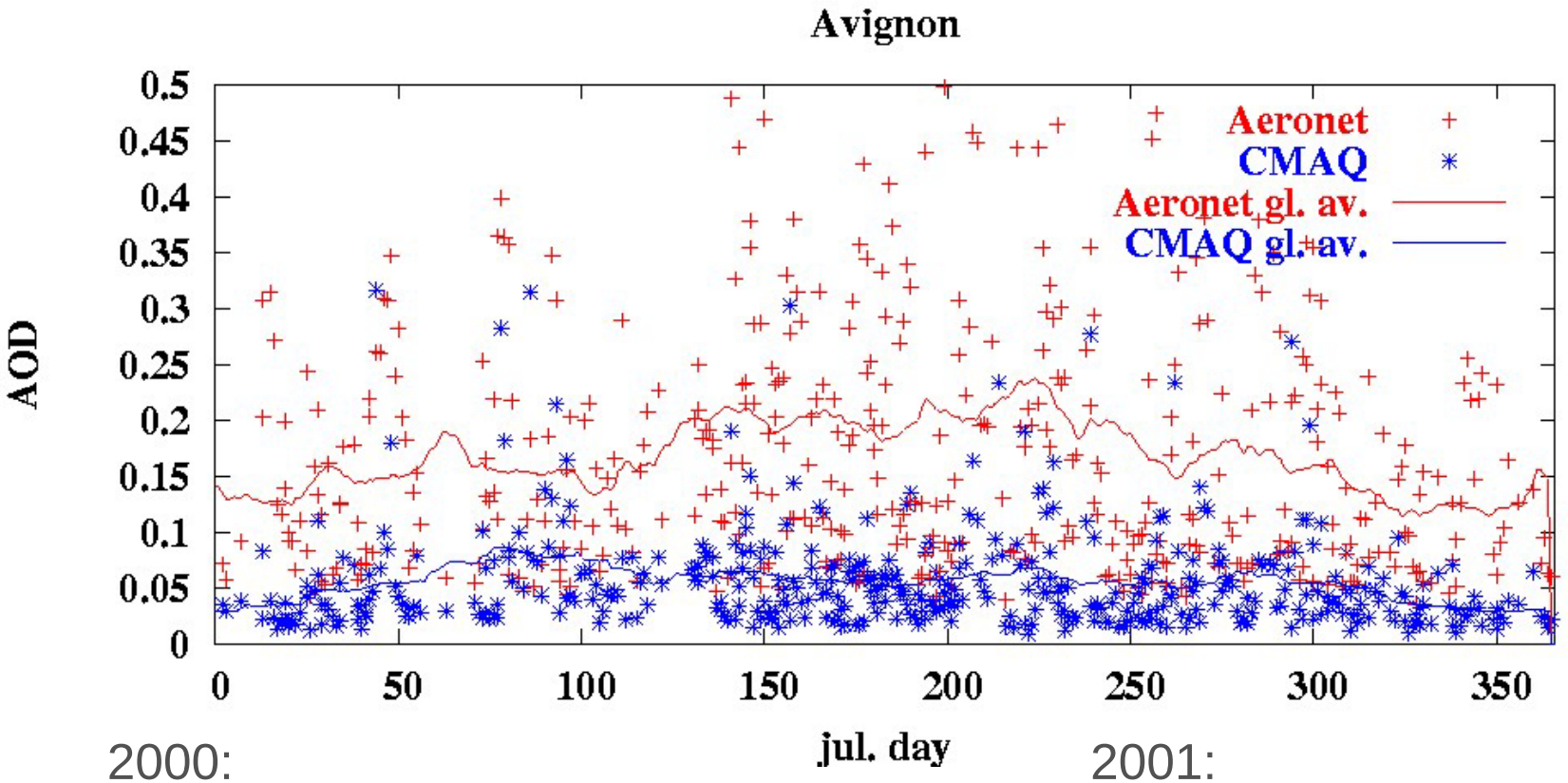
Aerosol Optical Depth

Relation between aerosol mass and extinction coefficient (Malm et al., JGR (1994)):

$$\begin{aligned}\alpha_{ext} = {} & 0.003 f(RH)(m_{NH_4} + m_{NO_3} + m_{SO_4}) + \\ & 0.004 m_{OM} + 0.01 m_{EC} + \\ & 0.001 m_{PM2.5_{oth}} + 0.0006 m_{PM_{coarse}} \quad ,\end{aligned}$$

f(RH) is given in tables

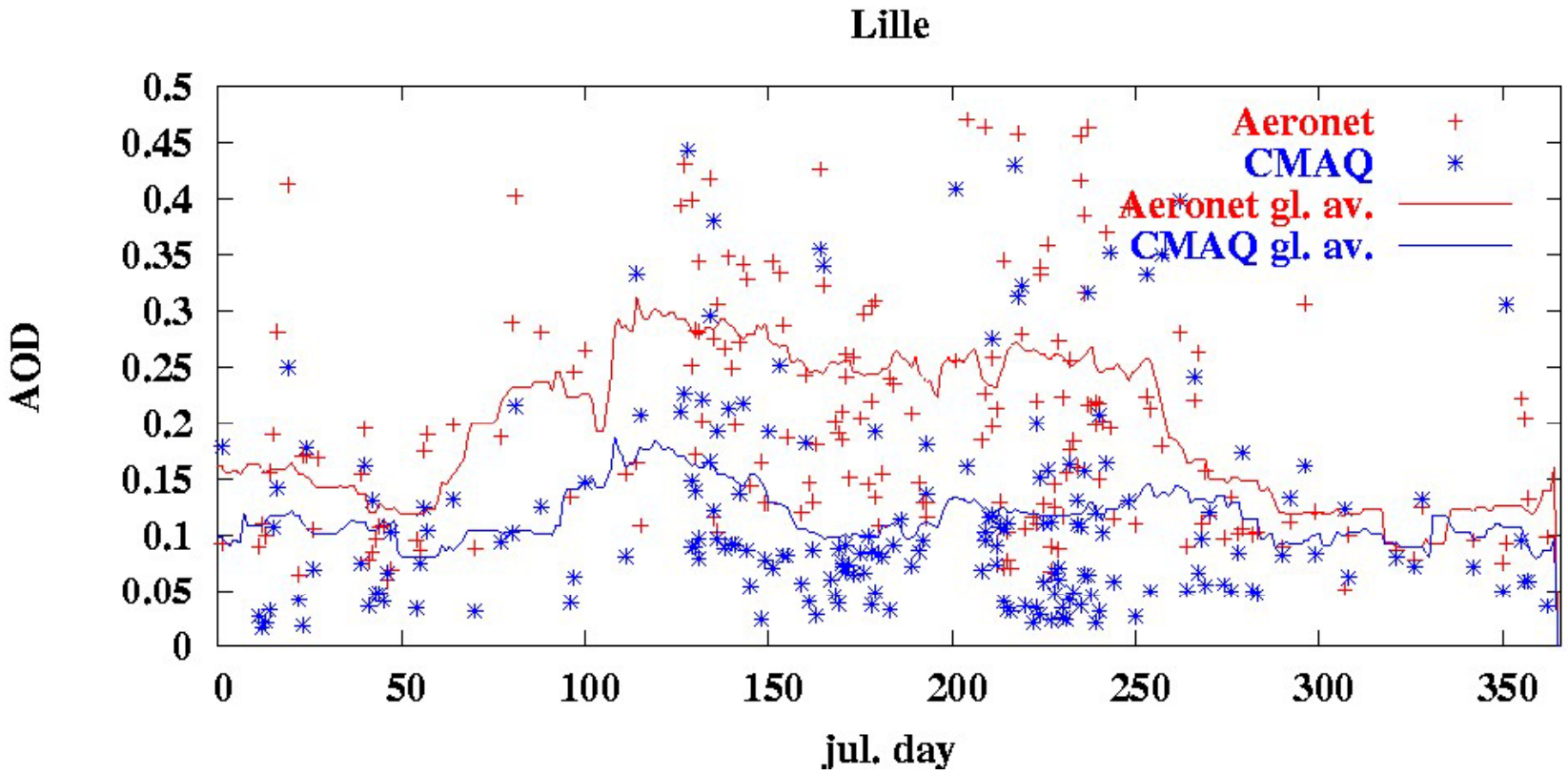
AOD Avignon 2000 and 2001



2000:
Measured: 0.17
Modelled 0.05
Correlation coeff. 0.54

2001:
Measured: 0.18
Modelled 0.06
Correlation coeff. 0.50

AOD Lille 2000 and 2001

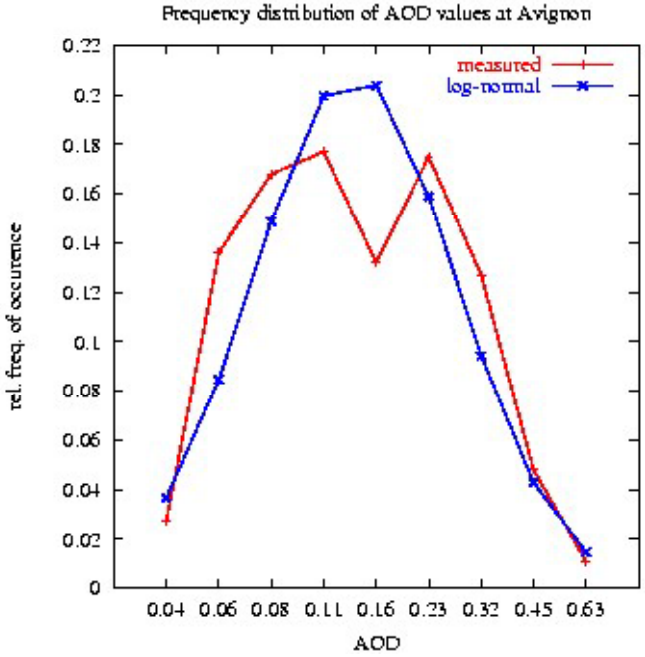


2000:
Measured: 0.21
Modelled 0.13
Correlation coeff. 0.39

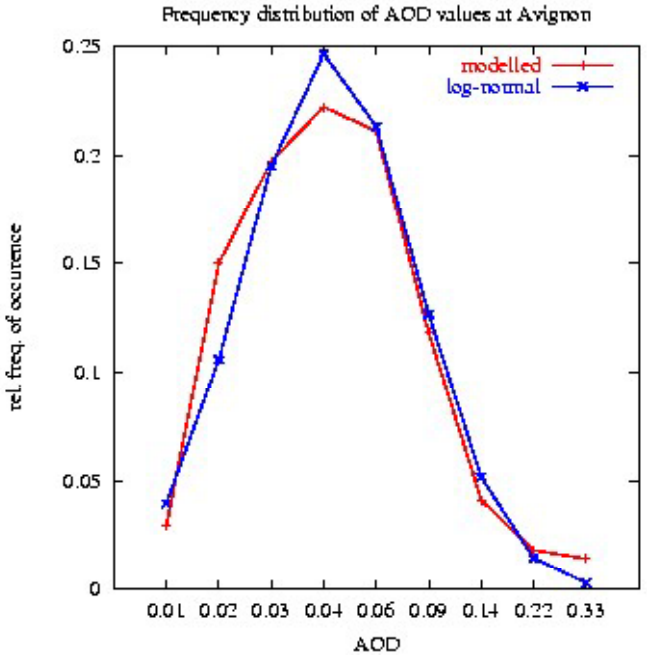
2001:
Measured: 0.25
Modelled 0.11
Correlation coeff. 0.38

AOD frequency distribution at Lille

Usually AOD follows a log-normal distribution
χ^2 test is not passed for the meas. in Lille



Measurements

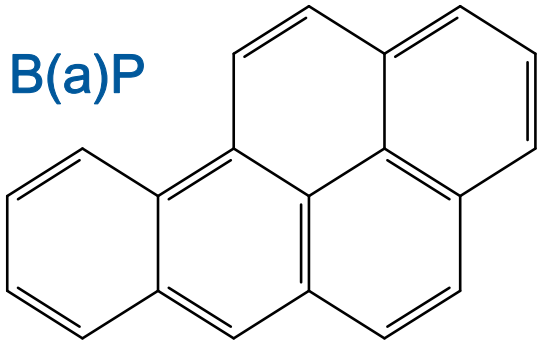


Model

Application: PAHs

PAHs imperil humans and ecosystems

- highly bioaccumulative (food chain)
- persistent in various environmental compartments
- significant adverse effects already at low doses
  - carcinogenic
  - impair immune system
  - impair reproduction



Object of international reduction conventions

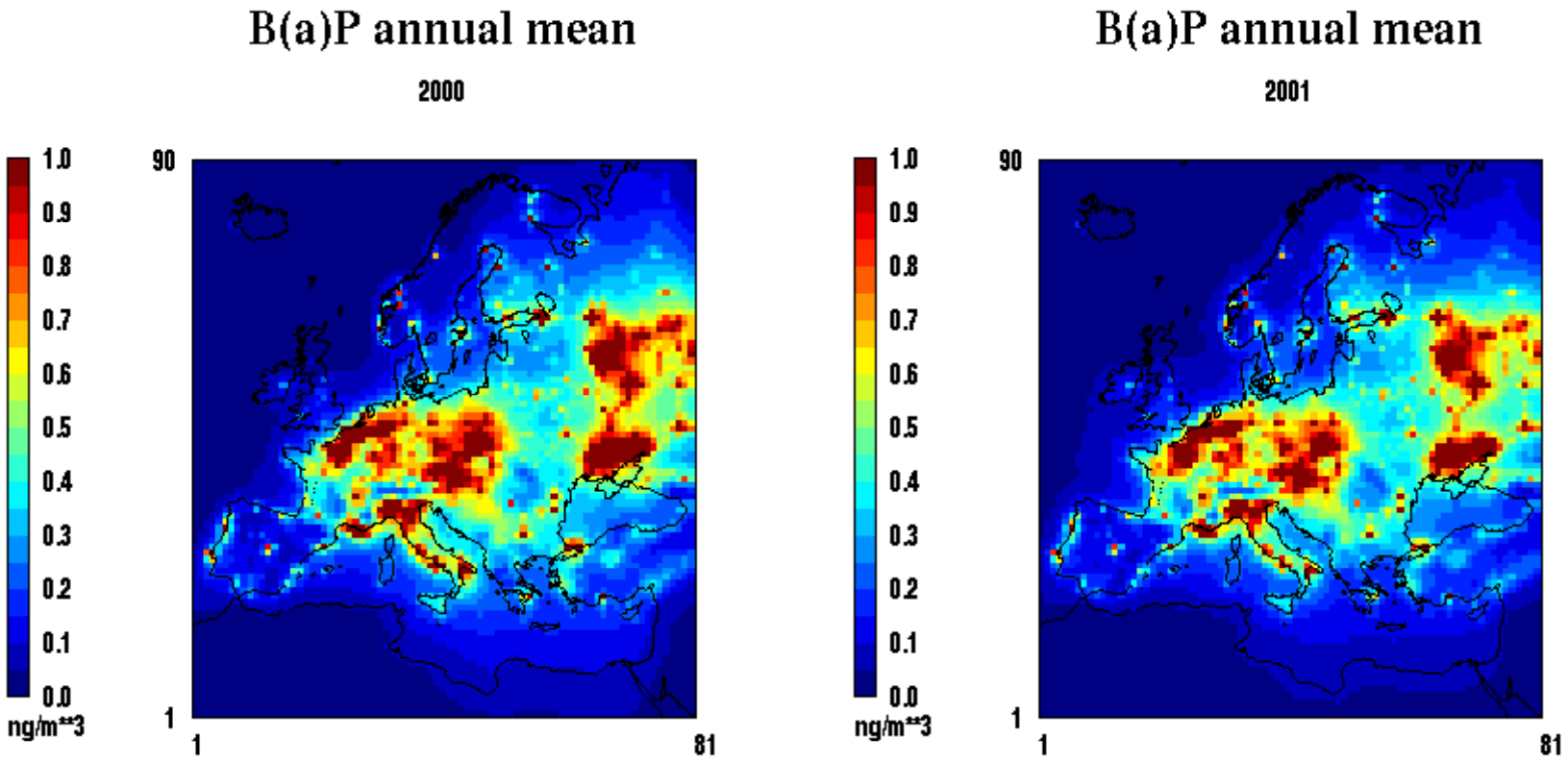
(Target values for air concentrations -

EU: 1 ng/m3 (annual average), UK: 0.25 ng/m3)

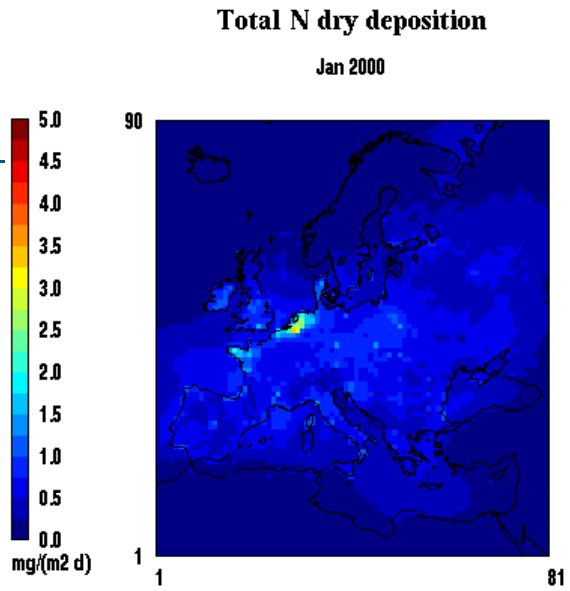
Emissions are likely to increase → wood burning, ship traffic

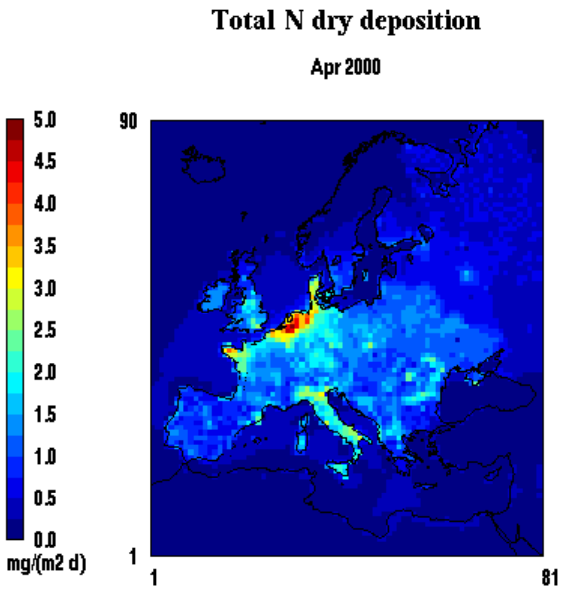
B(a)P concentrations in Europe

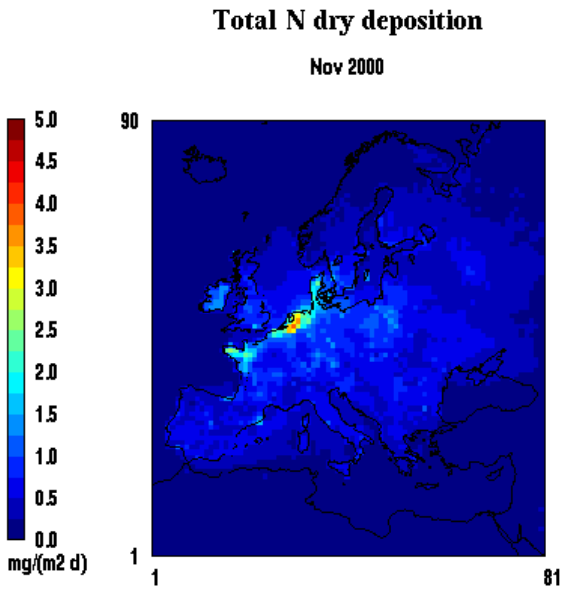
for lowest layer



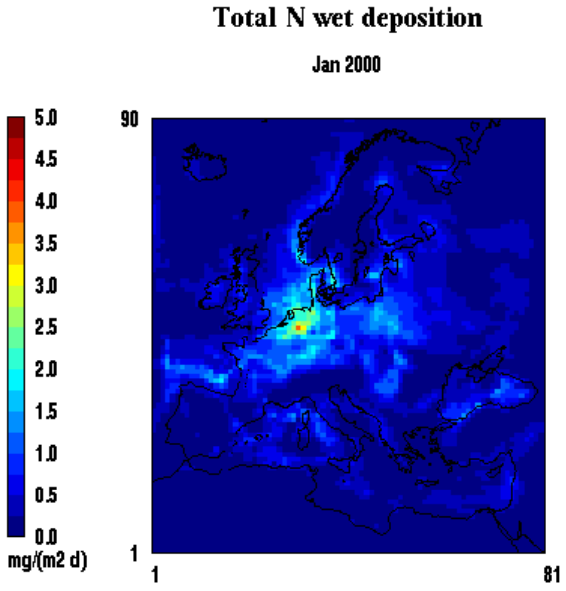
total annual amount of emitted B(a)P was the same for both model runs (based on 2000 data)

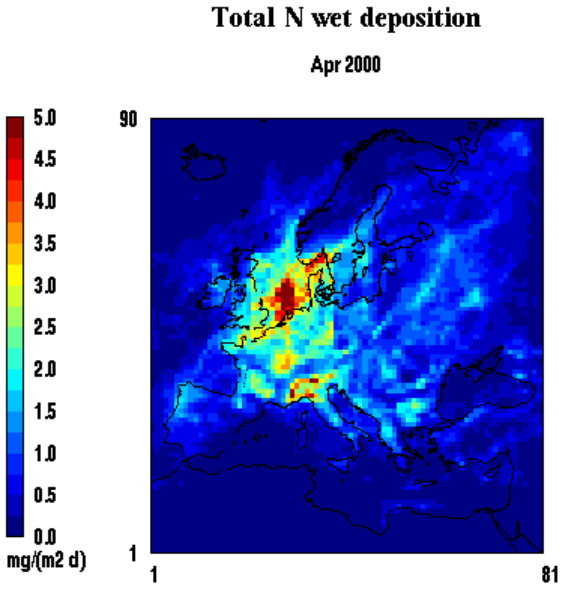


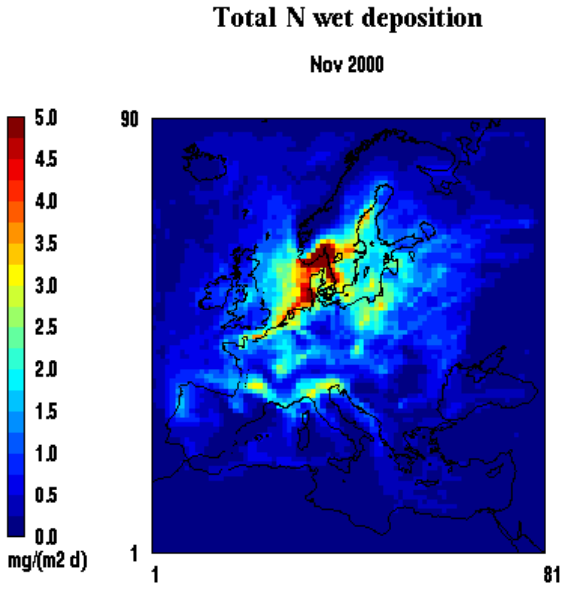




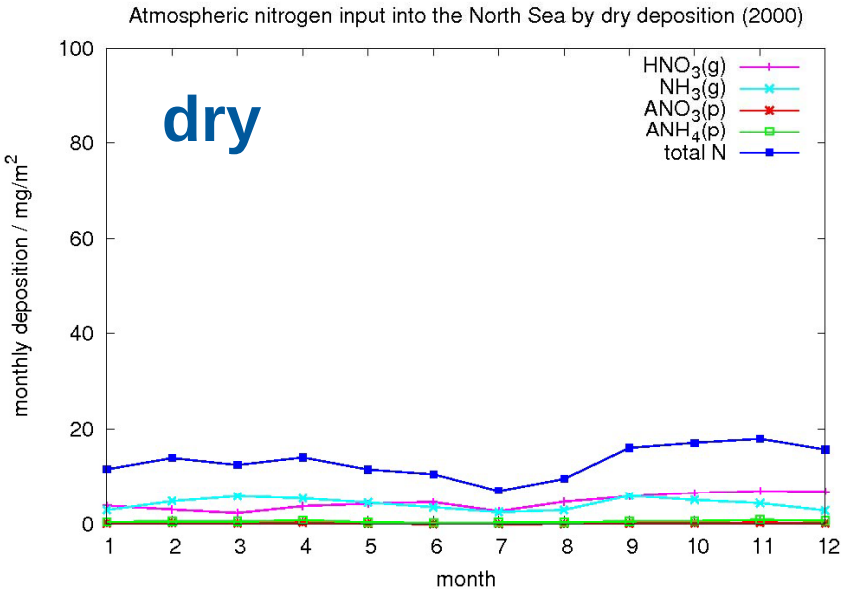
Application: nitrogen wet and dry deposition

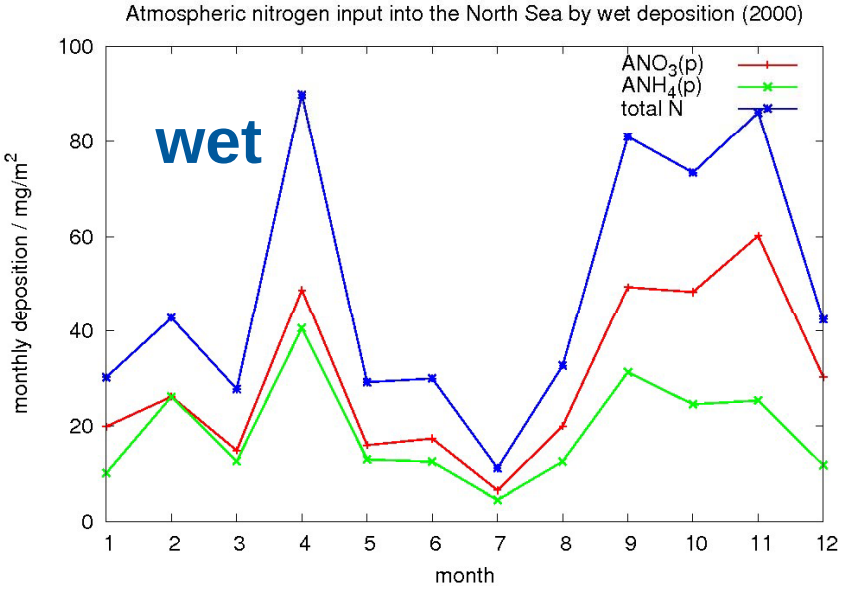


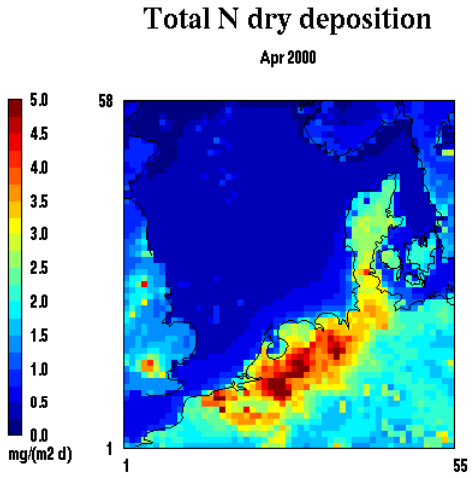




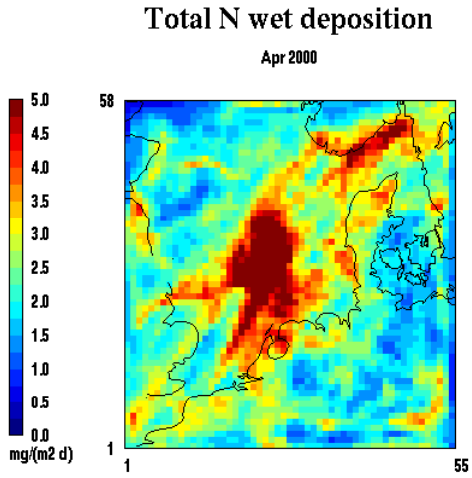
Nitrogen input into the North Sea







- 30 % of total N comes via the atmosphere
- atmospheric input is dominated by wet deposition of particle bound nitrogen



Summary and Outlook

Simulation of the aerosol distribution in Europe in 2000 and 2001 → multidecadal runs

Validation of model results by comparison to EMEP measurements → missing organic aerosols / natural aerosols (dust) / resuspension ??

Lognormal distributions are (mostly) followed by model results and measurements

AOD underestimated → missing aerosol mass, vertical distribution?

CMAQ applications at GKSS: PAHs, nitrogen eutrophication

Most of this work is described in
V. Matthias: The aerosol distribution in Europe derived with the Community Multiscale Air Quality (CMAQ) model: Comparison to near surface in situ and sun photometer measurements, ***Atmospheric Chemistry and Physics****, submitted 2007*