LONG-TERM MODEL CALCULATIONS OF PARTICULATE MATTER AND PHOTO-OXIDANTS FROM REGIONAL TO LOCAL SCALE WITH FOCUS ON NORTH-RHINE WESTPHALIA

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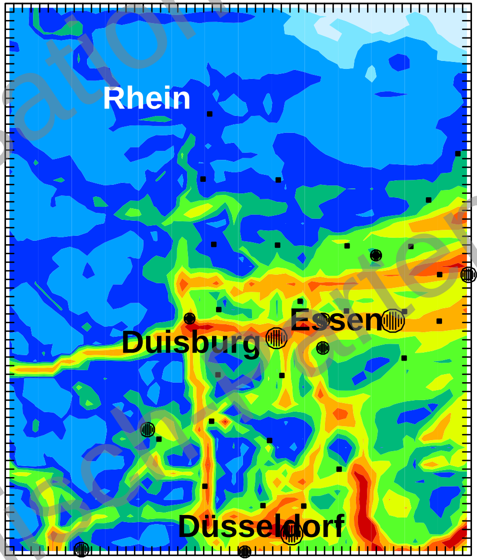


Landesumweltamt Nordrhein-Westfalen

AFO 2000

Bundesministerium für Bildung und Forschung

Rhenish Institute for Environmental Research, University of Cologne (RIU)

HARMO, Garmisch, 01.06.2004

OVERVIEW

1. Motivation
2. EURAD Model
3. Results
    - Annual runs 1997, (2002-2005-2010)
    - Comparison with measurements
    - Emission Scenarios
4. Conclusions and future plans

MODEL OUTPUT

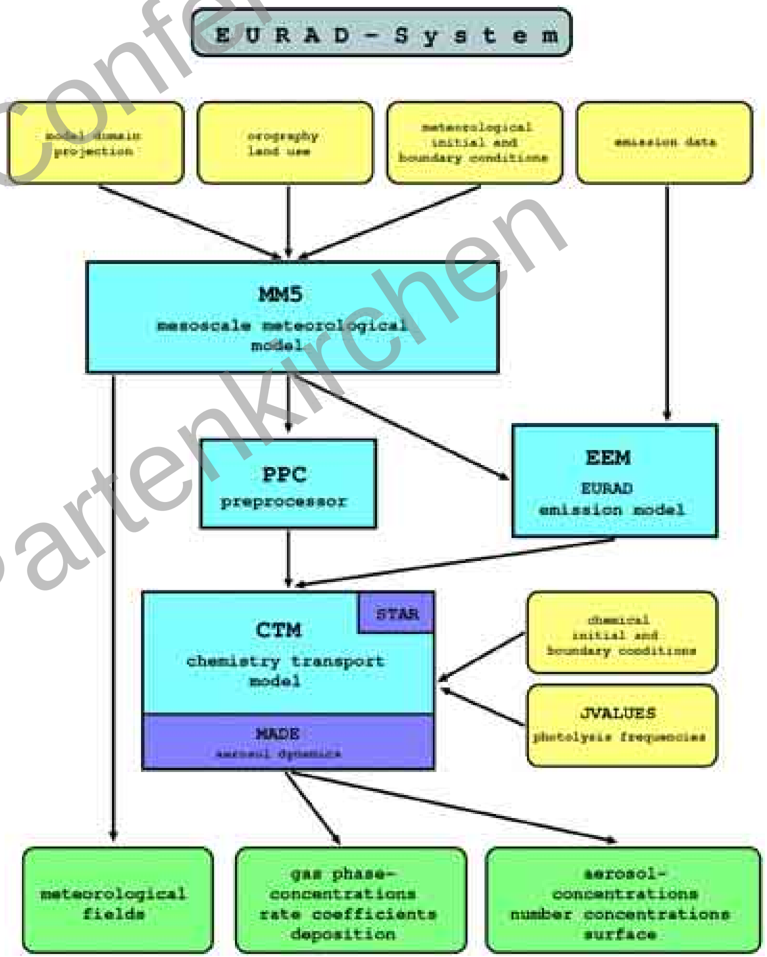
Focus on air pollutants relevant for EU-DD (health effects, effects on vegetation)

Near surface layer:
PM_{10}, SO_2, NO_2, CO, NO_x, O_3

More available from 3D-CTM:
VOCs, NH_3, particle size and composition
Deposition, vertical resolution

EURAD-SYSTEM

- Meteorology: MM5, input from ECMWF or NCEP
- Emissions: EEM, input from available emission data (e.g. TNO, EMEP, local, EDGAR)
- Chemistry: EURAD-CTM, MADE, Cloud chem. (aq.), RACM or RADM2, RACM-MIM
- Nesting option for local application



MODEL DESIGN

Horizontal grid resolution (km): 125 – 25 – 5 – 1

23 layers from the surface to the upper boundary

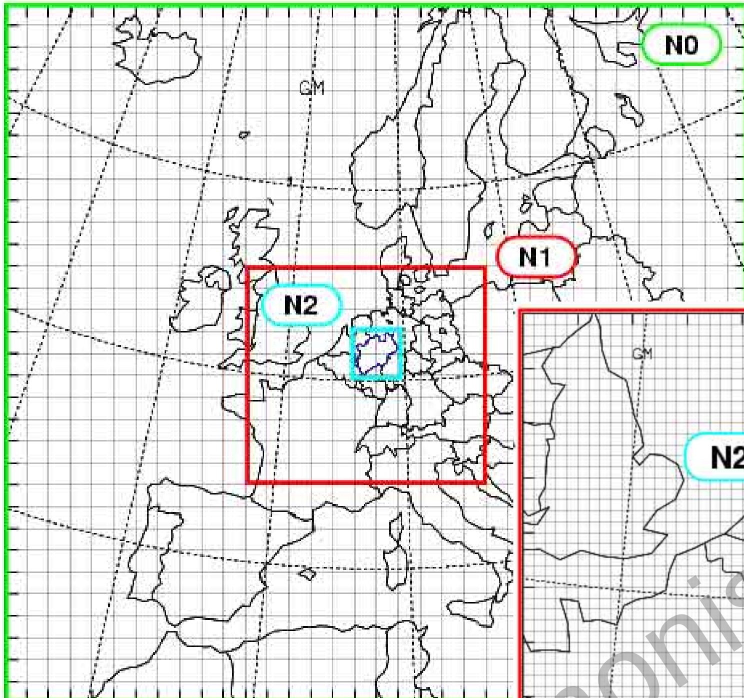
Near surface-layer about 40 m thick

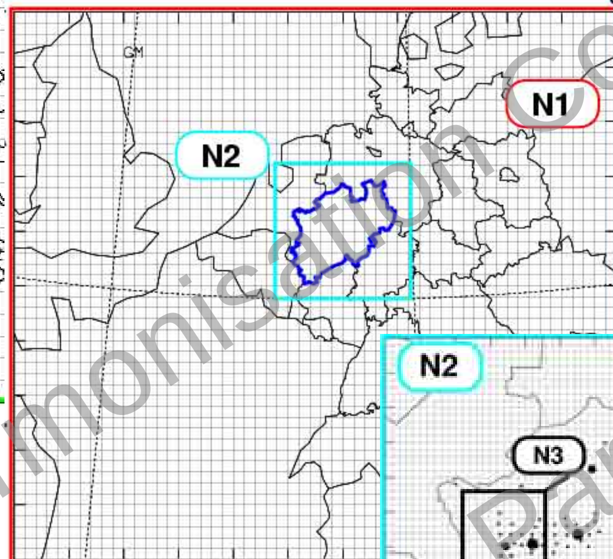
15 layers below 3000 m

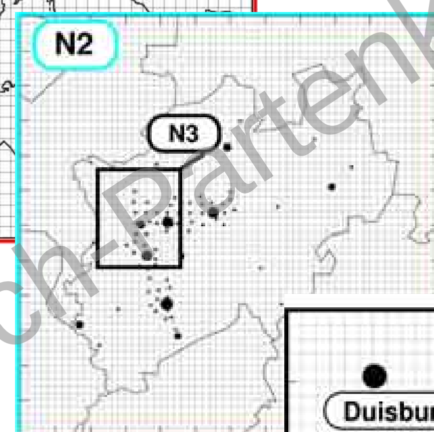
Upper boundary about 16 km (100 hPa)

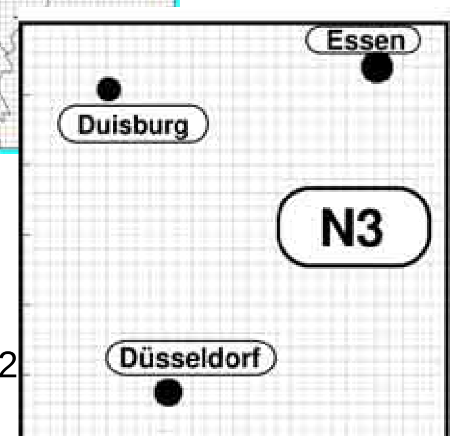
Annual run for 1997: 125 – 25 – 5 km

Sequential nesting









Europe
ds = 125 km

Central Europe
ds = 25 km

NRW
ds = 5 km

district
ds = 1 km

Chemica Weather forecast

www.eurad.uni-koeln.de

Vertical: 23 layers
Lowest layer: about 40 m
Upper boundary: about 15 km

NESTING

Sept. 30, 06 UTC, 1997

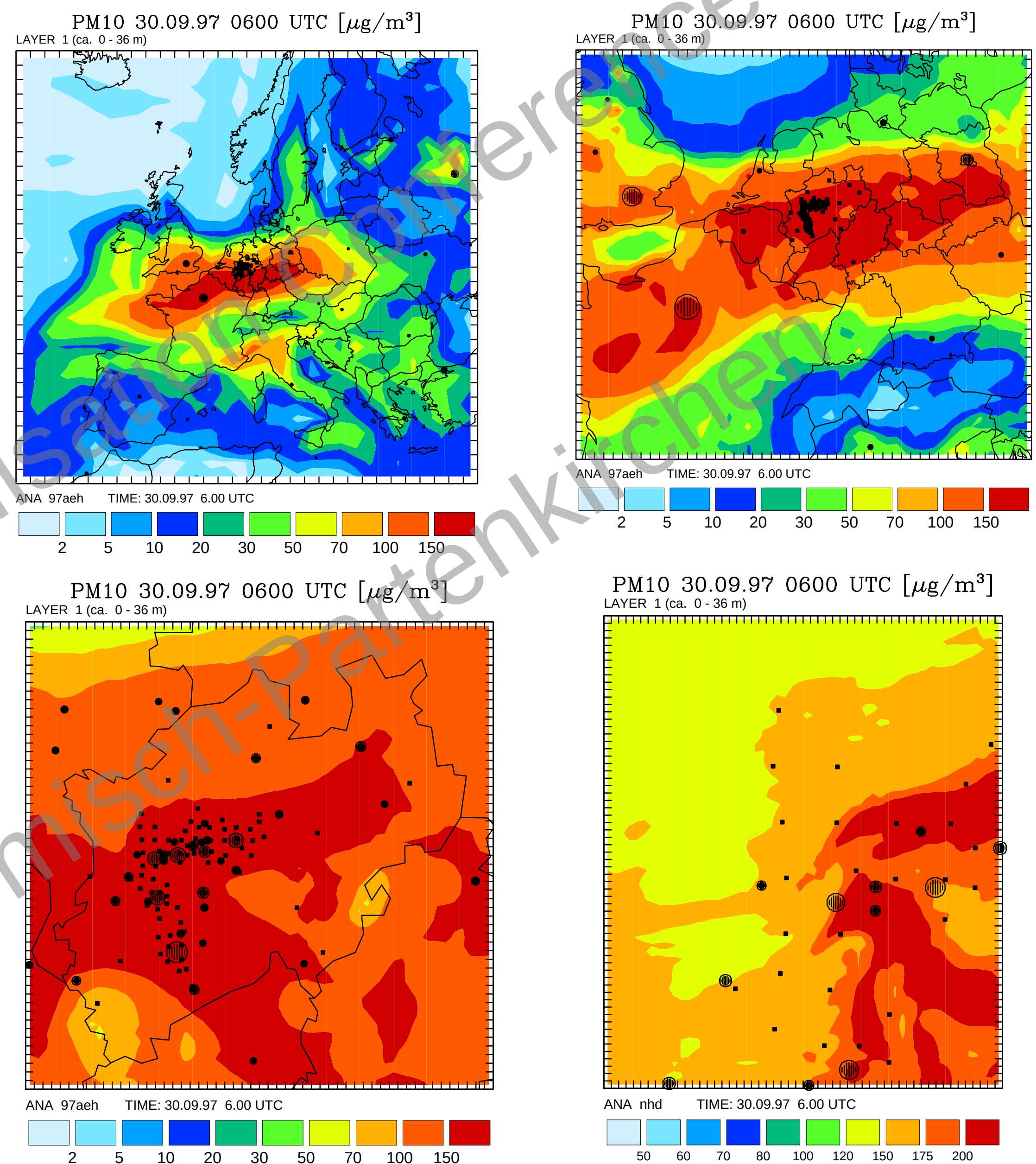
High pressure system

Over Central Europe

PM_{10} concentration more than 150 µg/m³

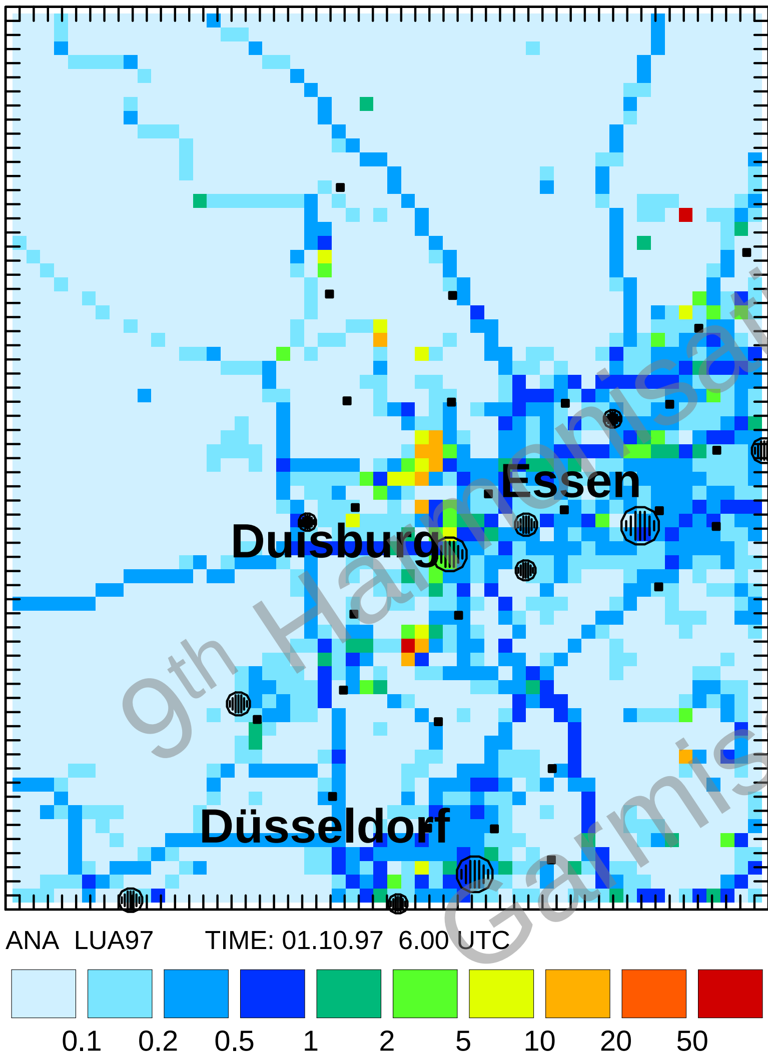
PM_{10}

ANABEL-Projekt LUA NRW



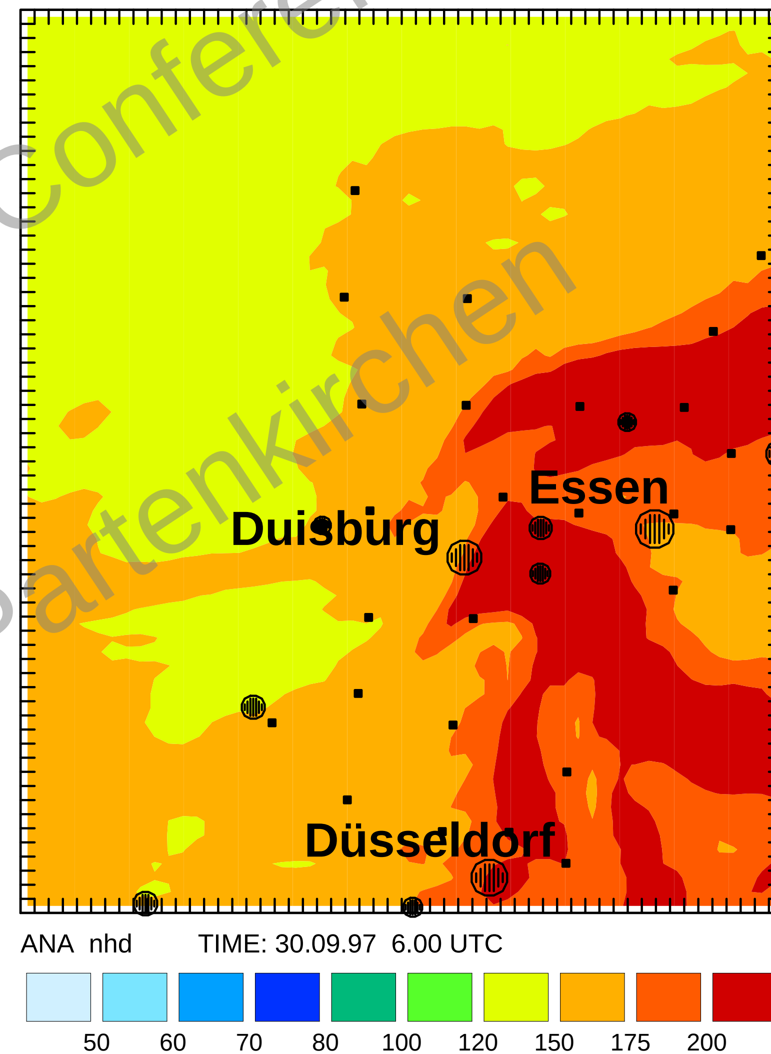
PM_{10} – N3 (1 km grid size)

TSP [g/(s*km**2)]

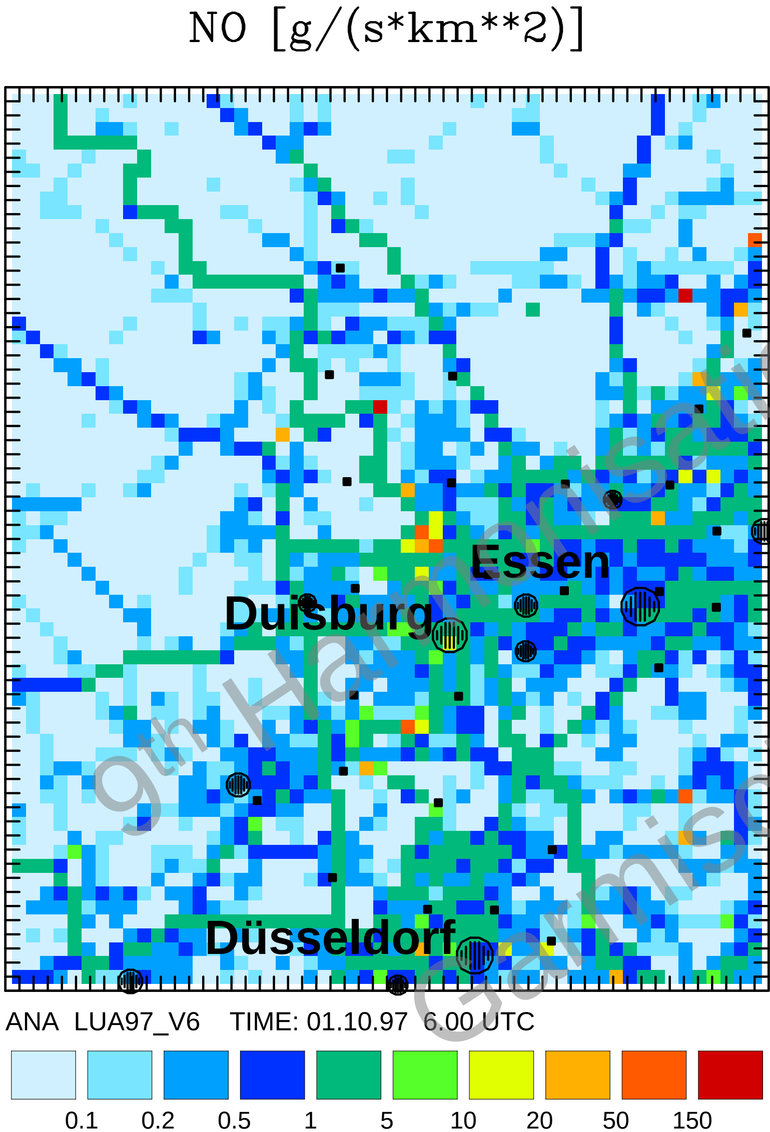


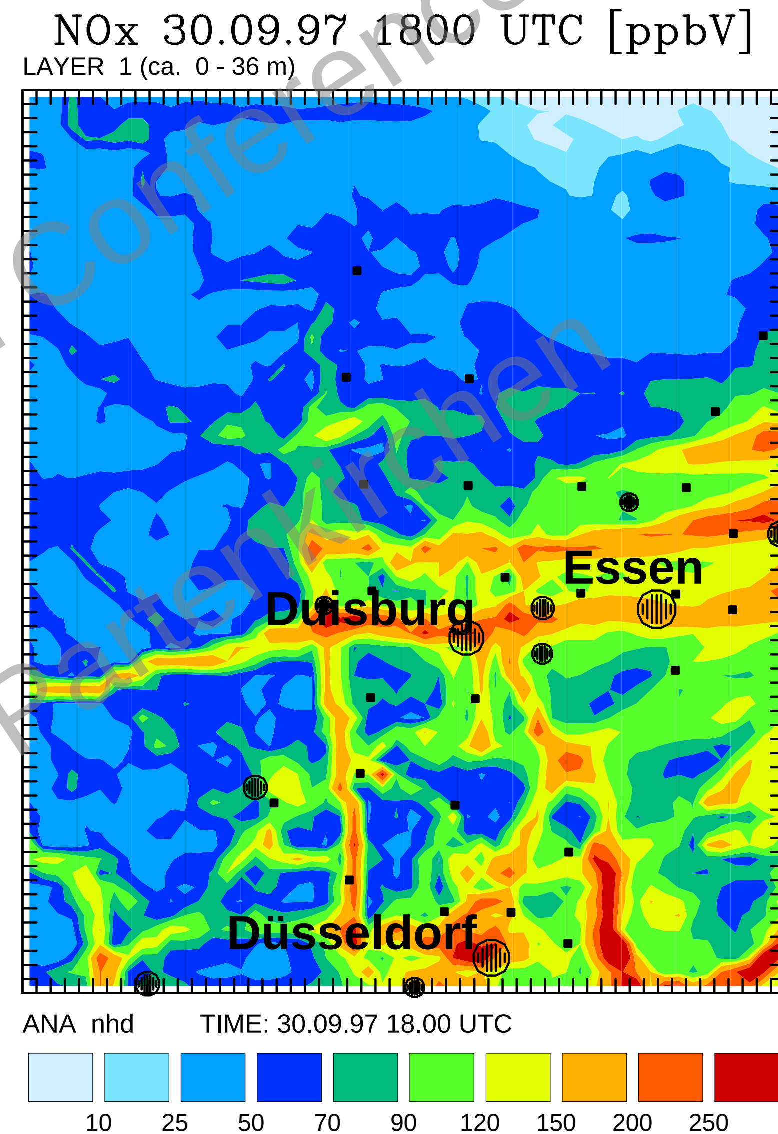
PM10 30.09.97 0600 UTC [$\mu g/m^3$]

LAYER 1 (ca. 0 - 36 m)



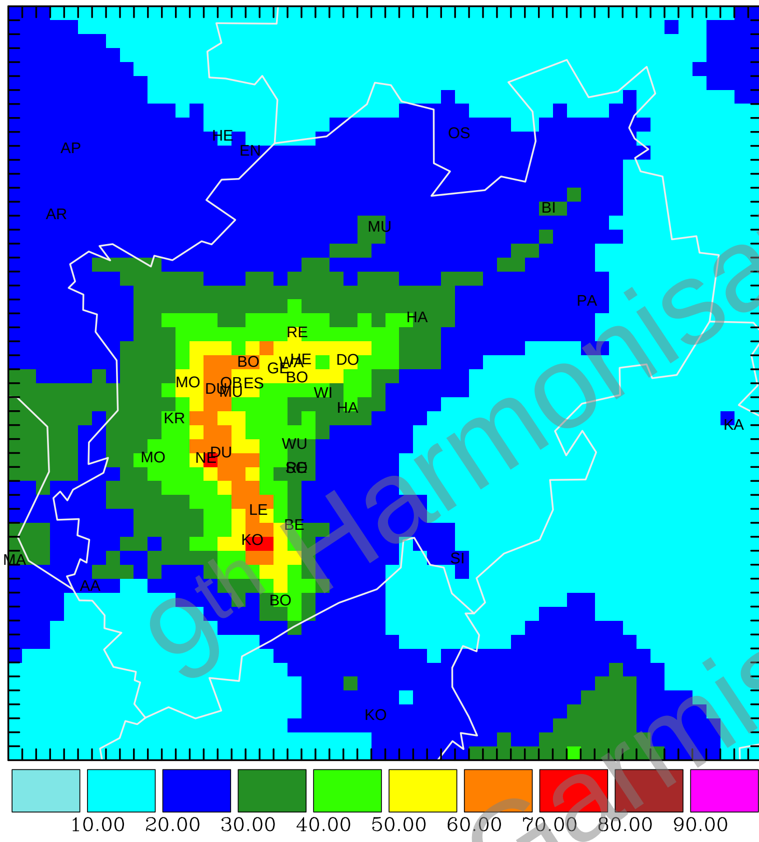
Nitrogen Oxides – N3 (1 km)





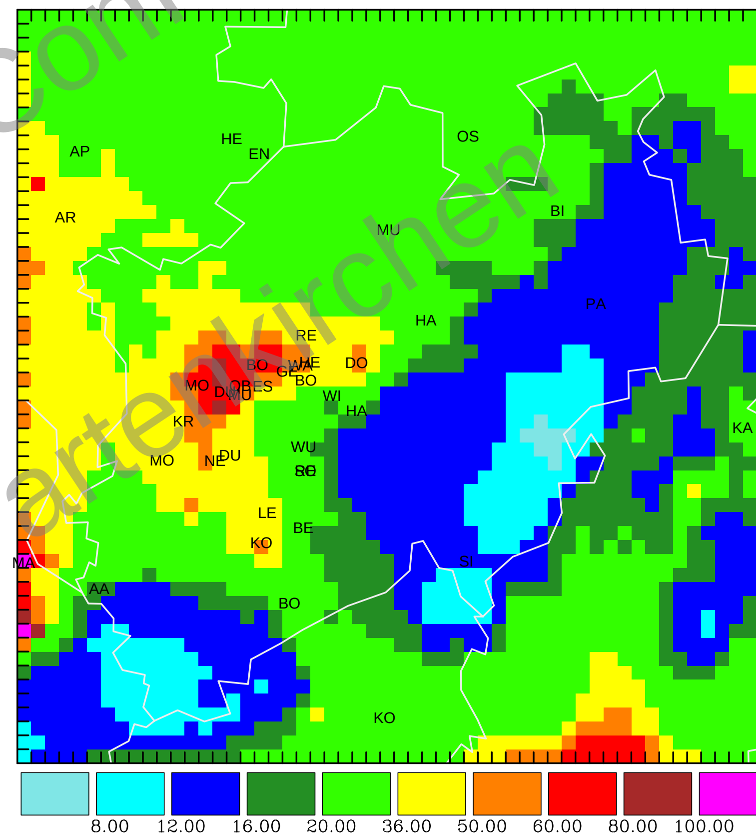
NO_x – PM_{10} – ANNUAL

NO_X: annual average 1997



NO_X limit value: 30 µg/m³

PM_{10}: number of days > 50 [µg/m3]



PM_{10} limit value: 35 days

SCATTER DIAGRAMM PM10

Daily average

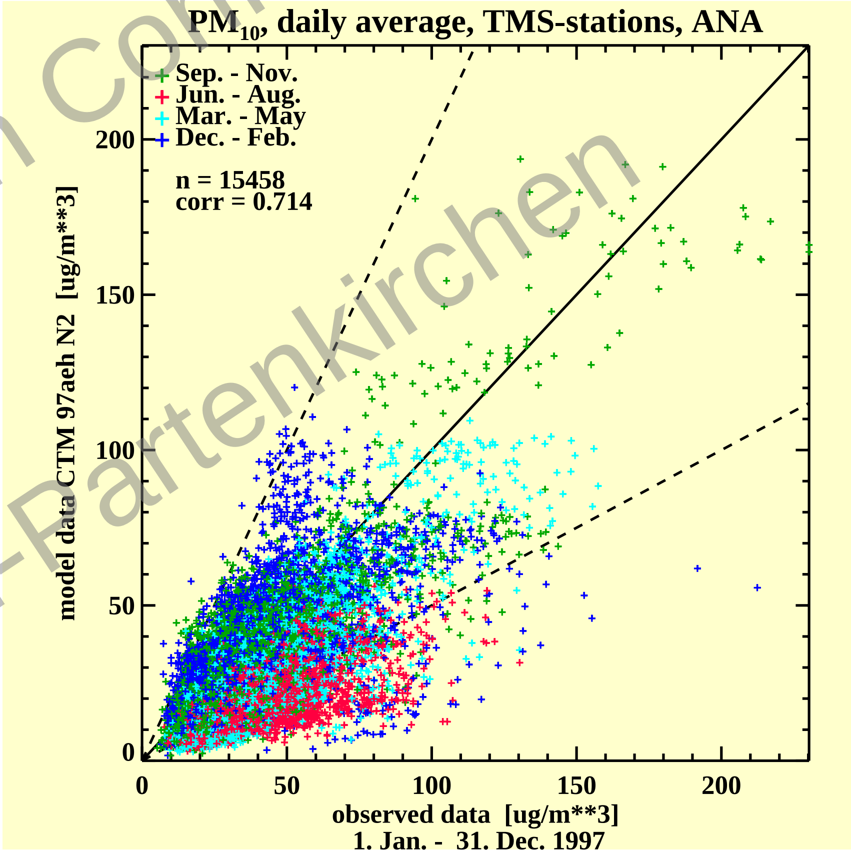
Based on hourly values

PM10 from NRW stations only

PM10 = 0.83*TSP

Underestimation in summer

(Nest 2 results, 5 km grid res.)



Emission Scenario

No anthropogenic Emissions in NRW (noNRW)

Sept. 29, 1997

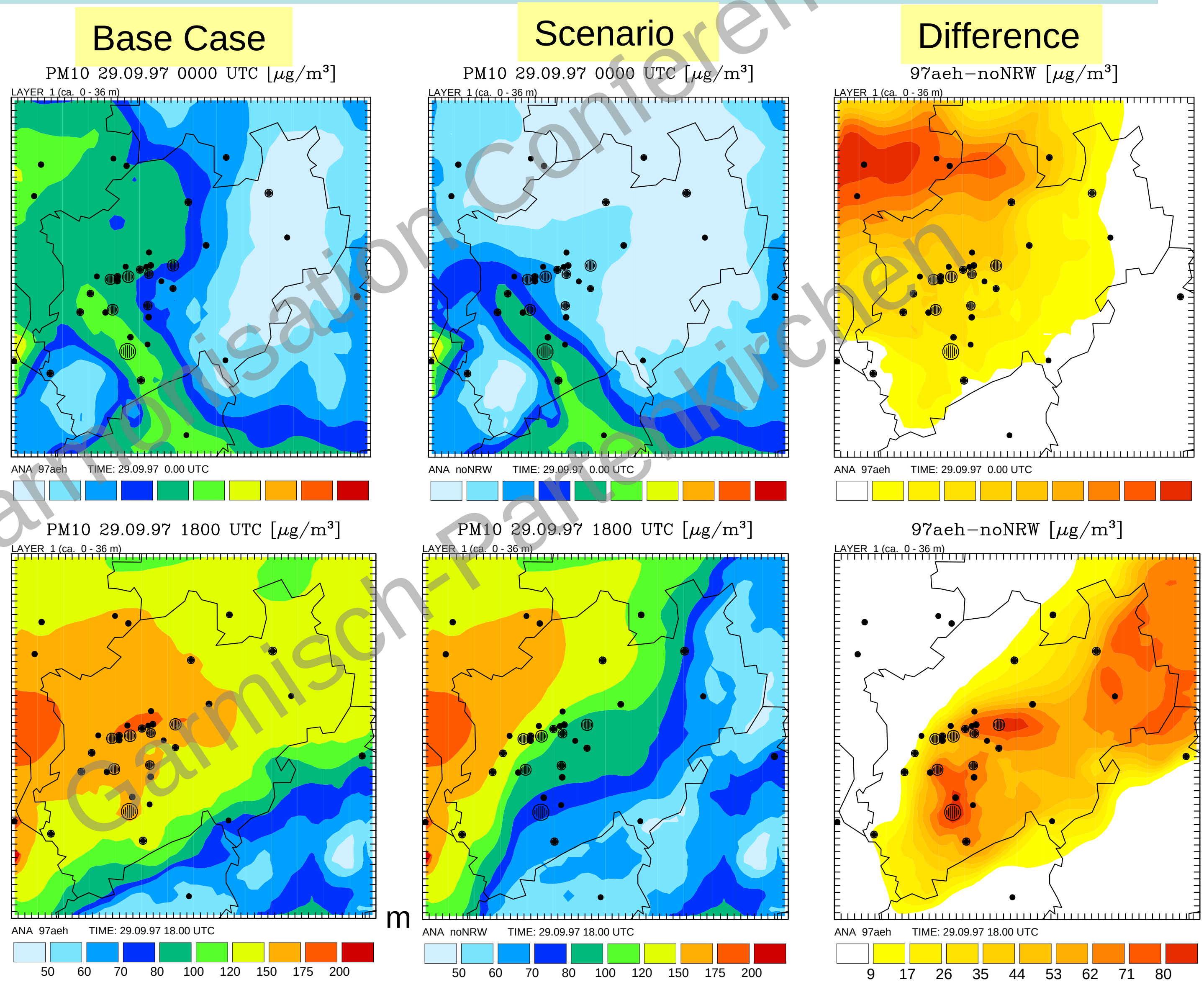
Left: Base Case

Middle: noNRW

Right: Difference

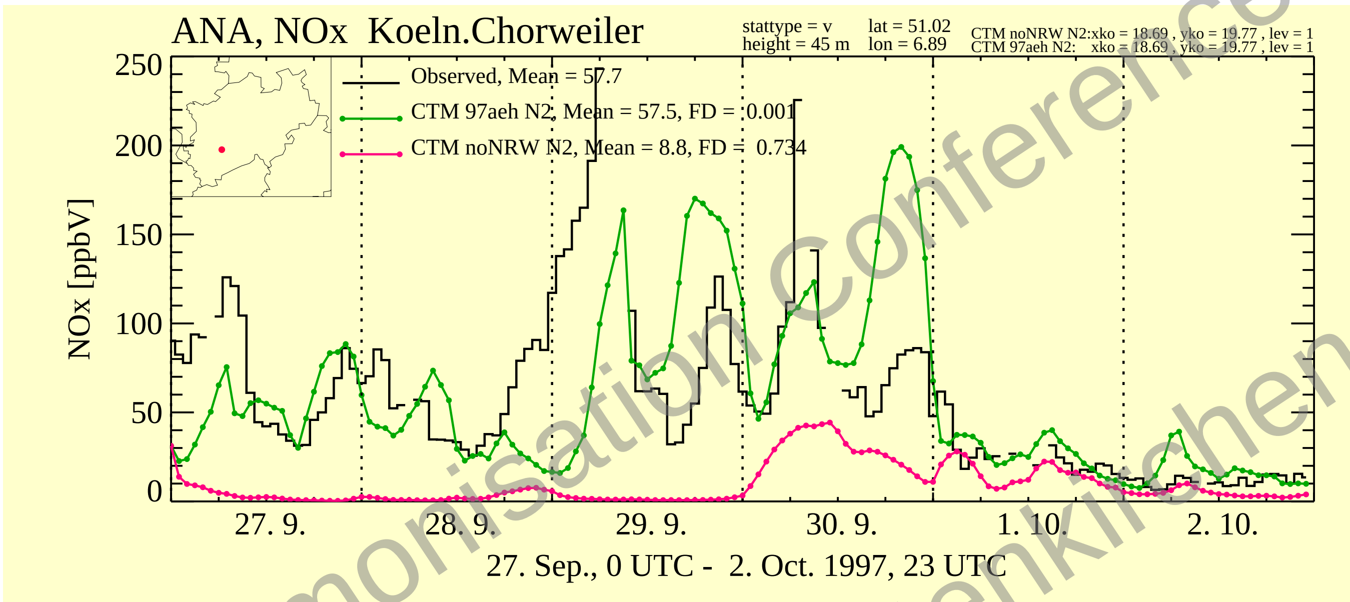
Wind turns from Southeast to Southwest

PM_{10}

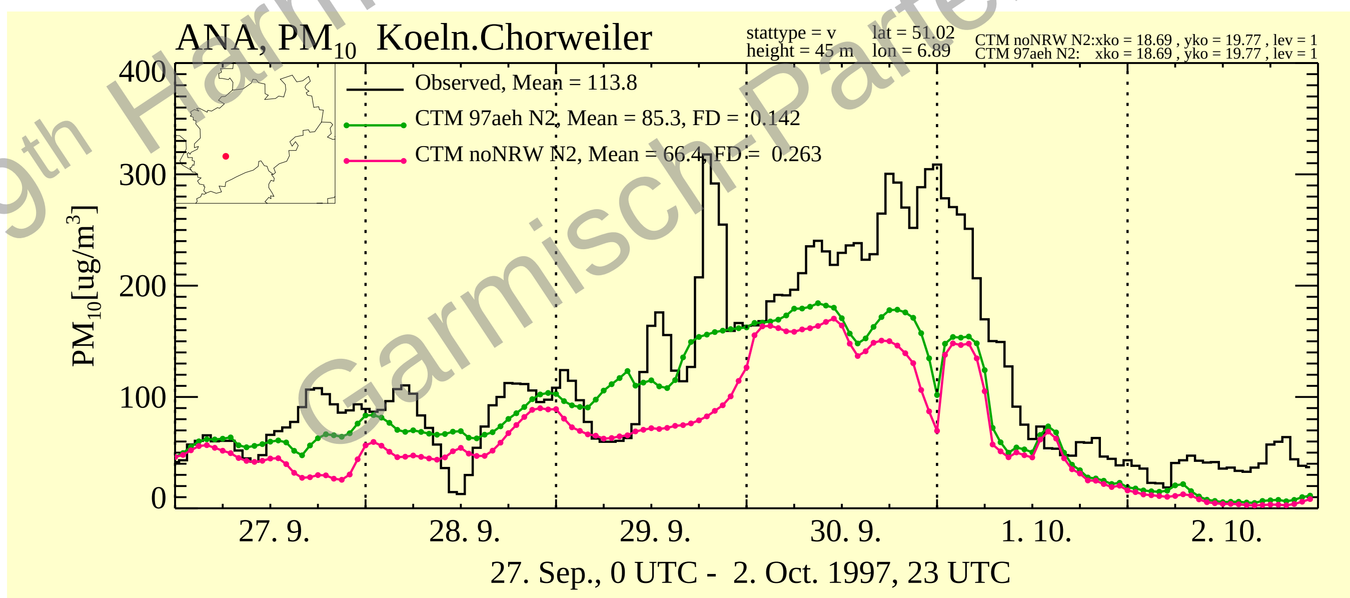


Emission-Scenario noNRW

NO_x

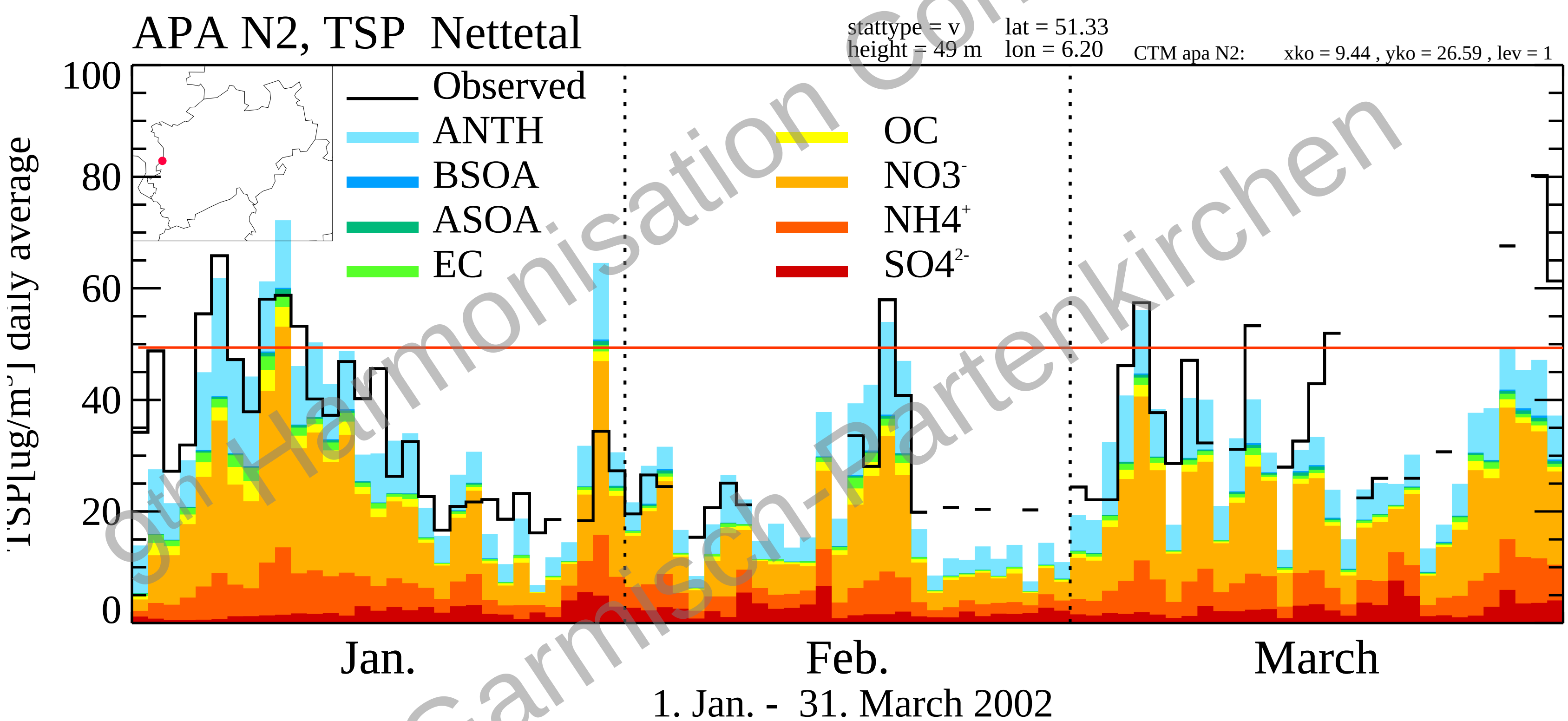


PM_{10}



COMPOSITION

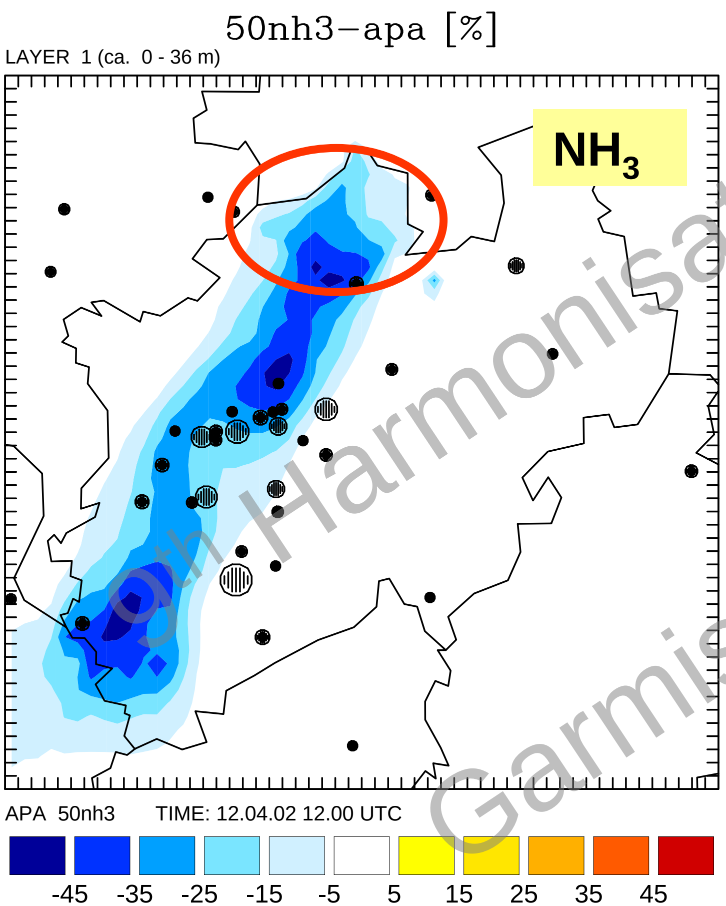
DAILY AVERAGE

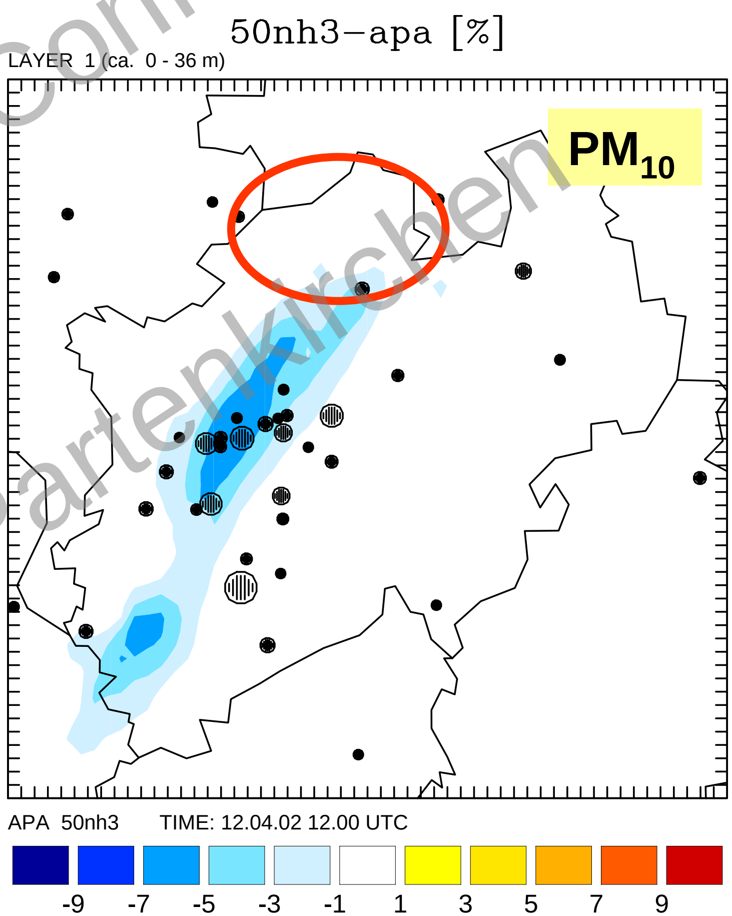


Emission-Reduction NH_3 (local)

12.04.2002, 12 UTC

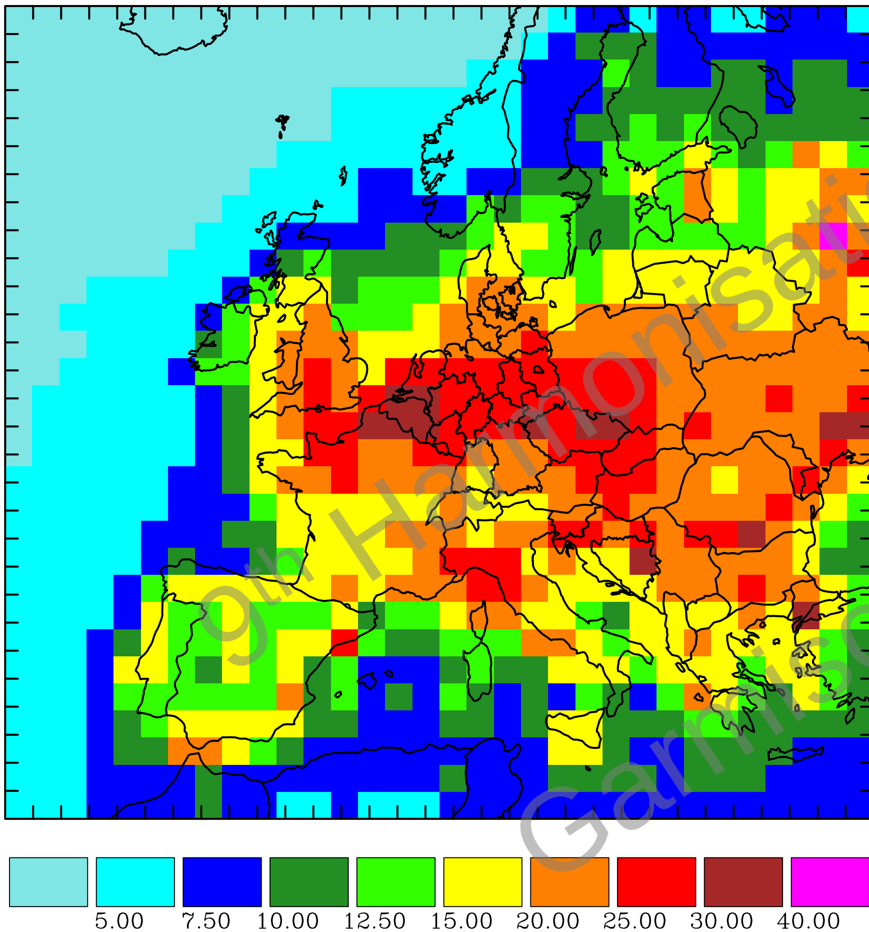
Sensitivity, Change in %



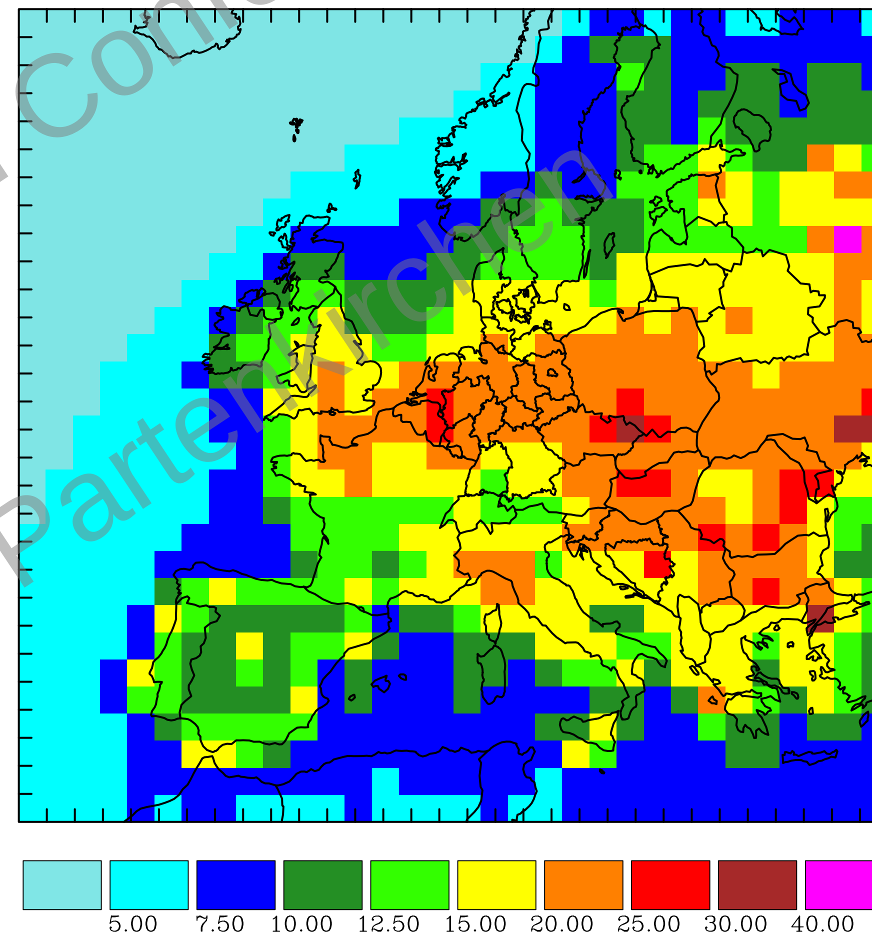


PM_{10}: 2002 – (2005) - 2010

ANNUAL AVERAGE PM10 - 2002

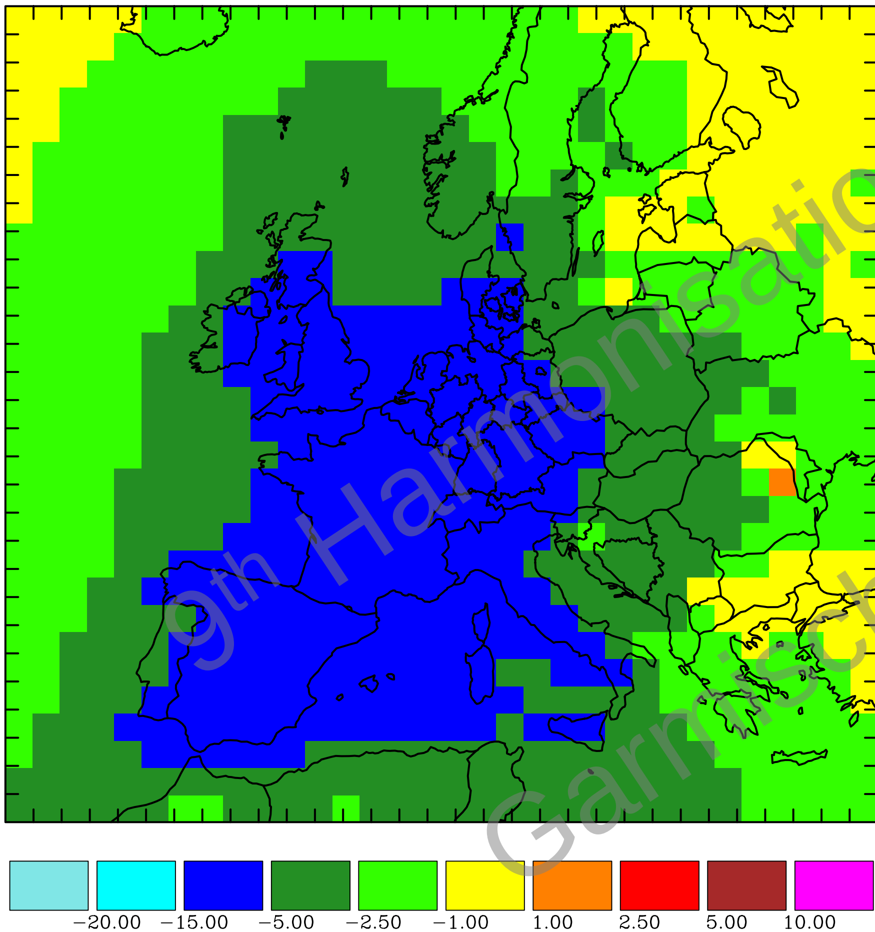


ANNUAL AVERAGE PM10 - 2010

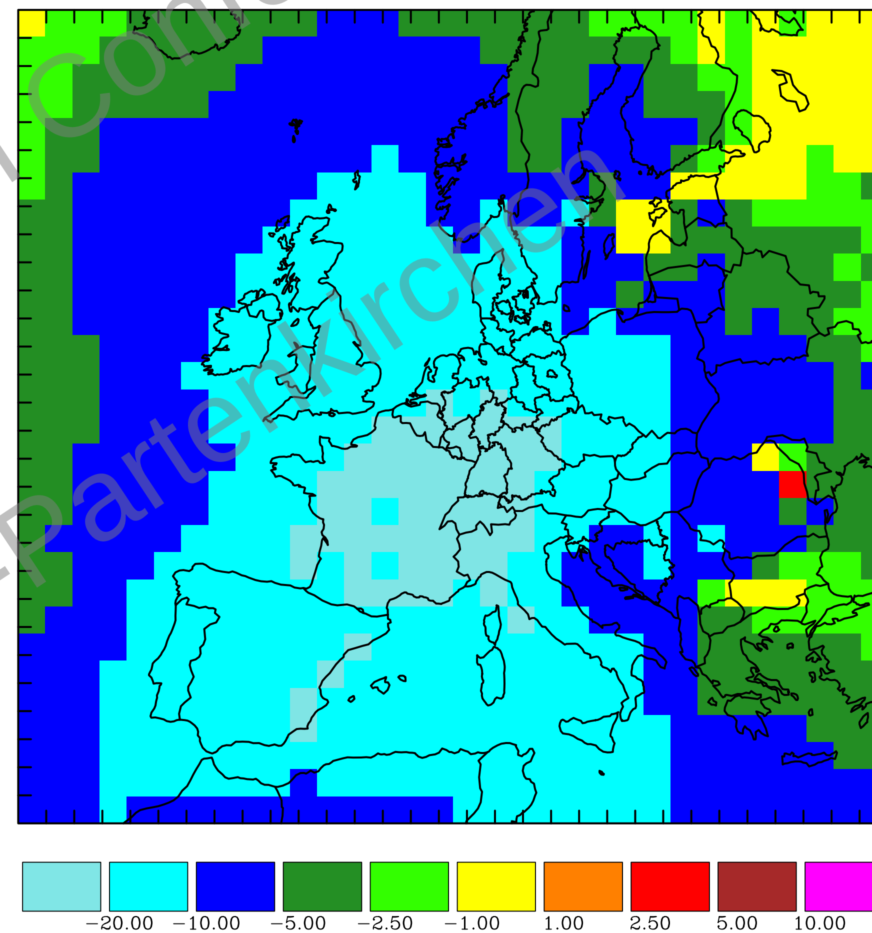


PM_{10}: Changes (%) 2002 – 2005 - 2010

ANNUAL AVERAGE PM10: 2005 - 2002

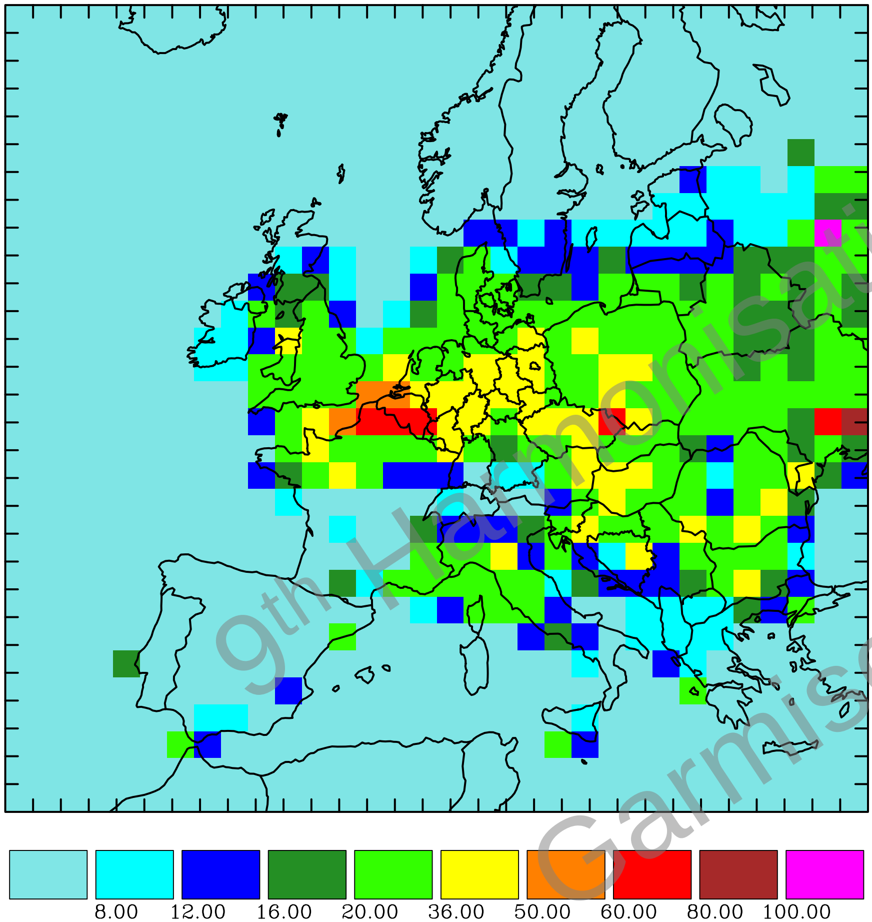


ANNUAL AVERAGE PM10: 2010 - 2002

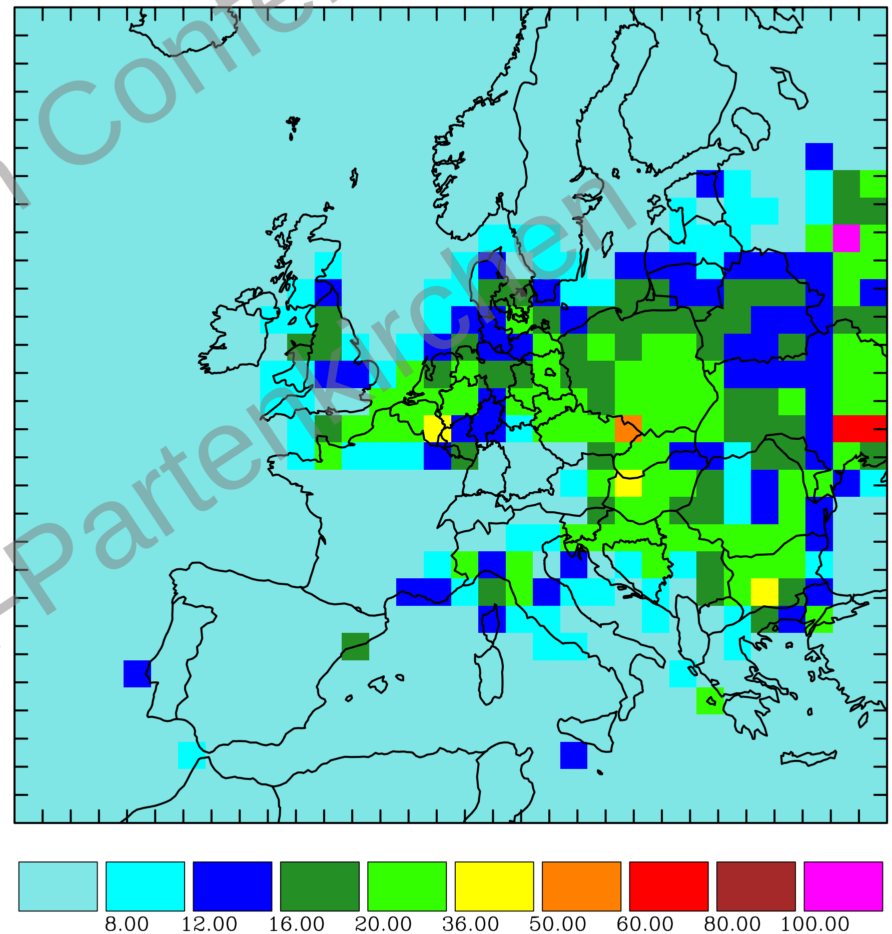


PM$_{10}$: 2002 - 2005 - 2010

2002



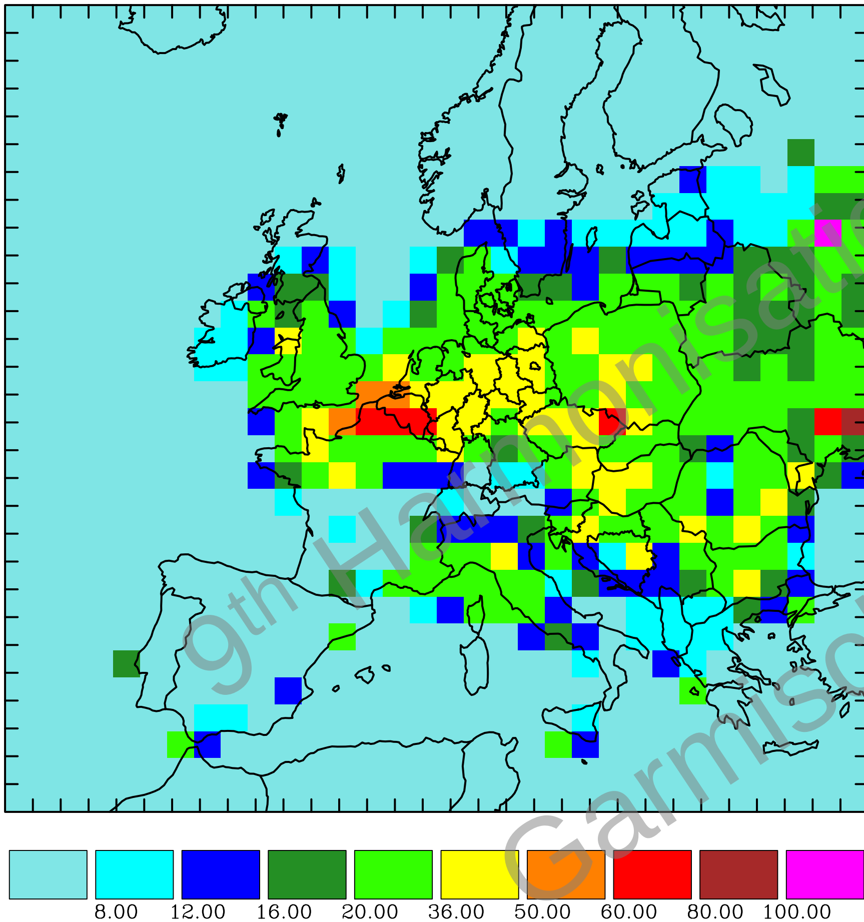
2010



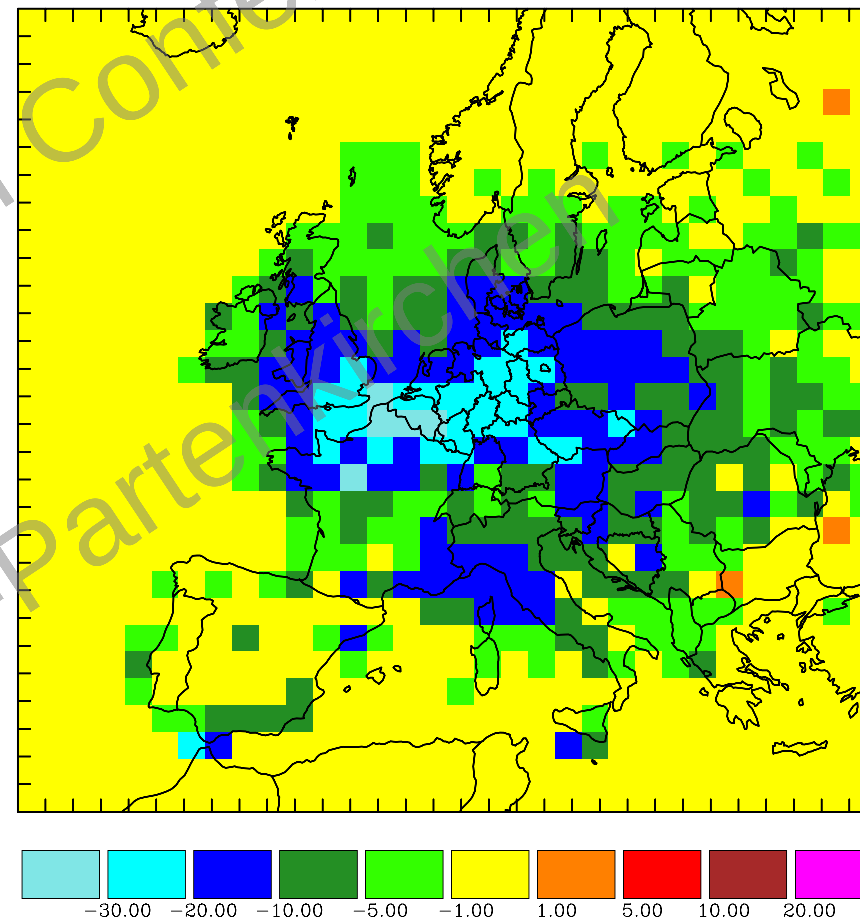
NUMBER OF DAYS WITH DAILY AVERAGE > 50 µg/m^3

PM$_{10}$: 2002 – (2005) - 2010

2002



 # OF DAYS (2010) - # OF DAYS (2002)



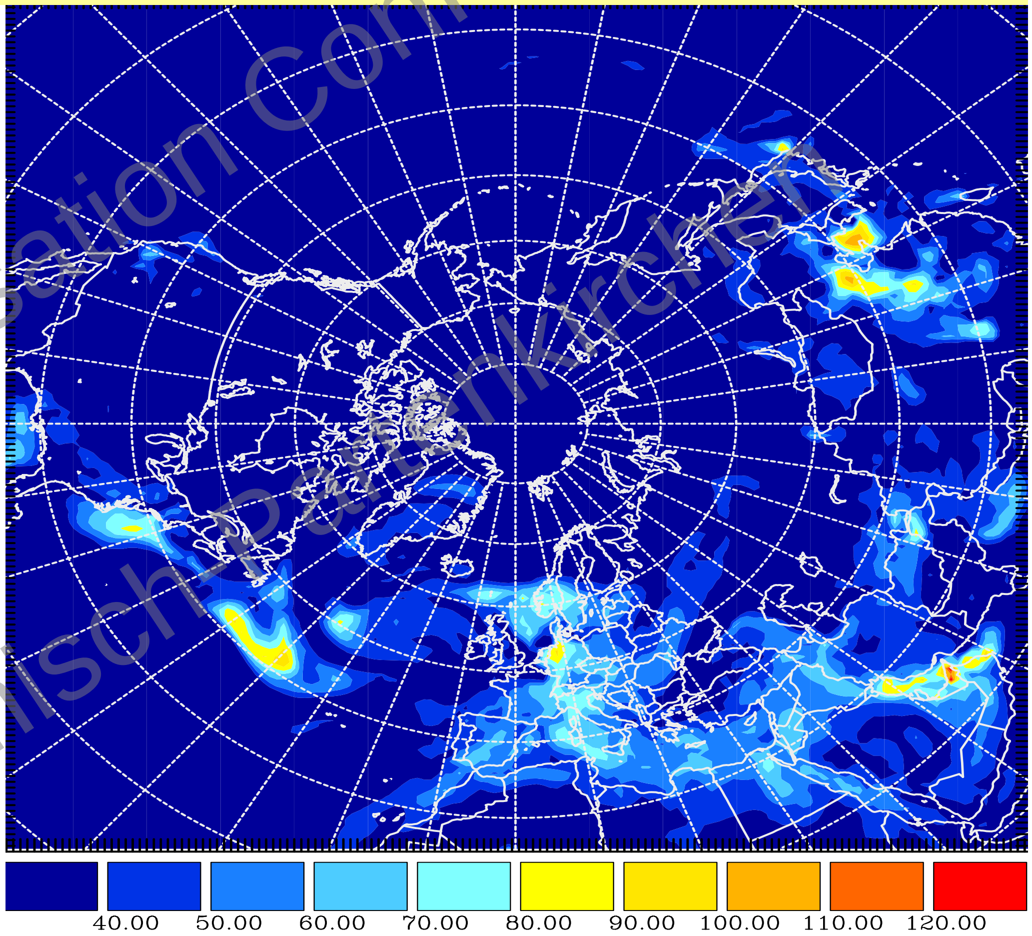
NUMBER OF DAYS WITH DAILY AVERAGE > 50 µg/m³

RIU EURAD

HEMISPHERIC SIMULATION

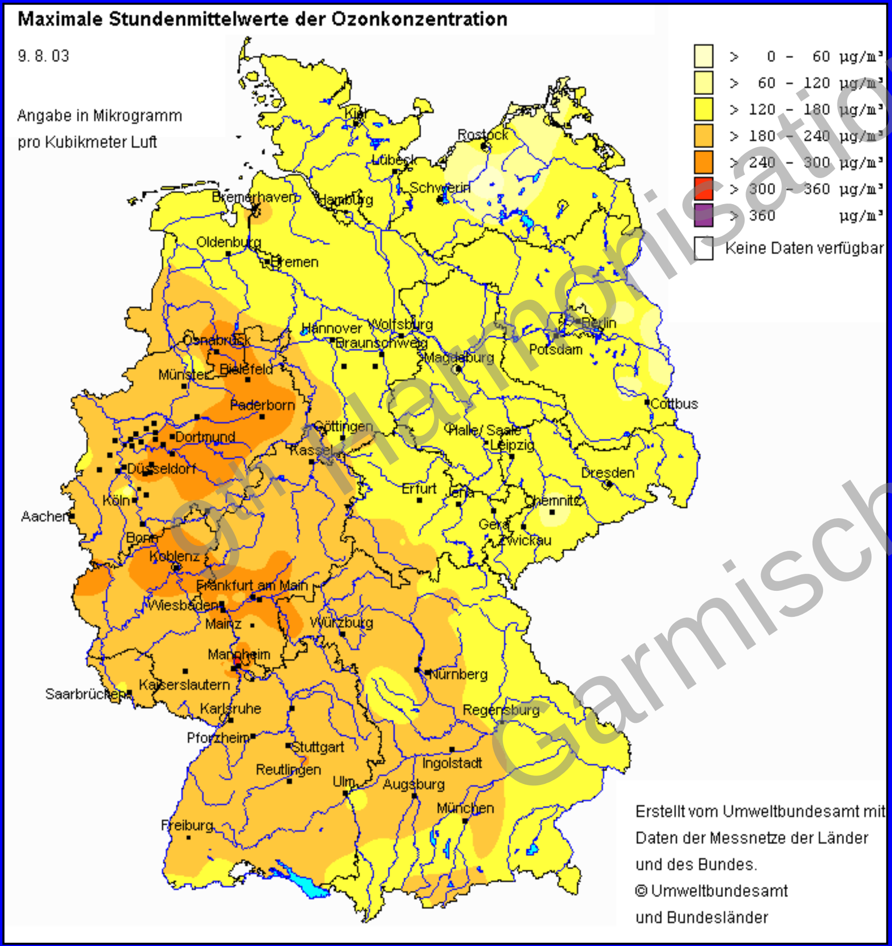
- **29 layers**
- **Upper boundary: 10 hPa**
- **Hor. grid size: 100 km**
- **EDGARV3.2 emission data**
- **Meteorology: MM5**

Ozone, lowest layer, August 13, 1997, 12 UTC

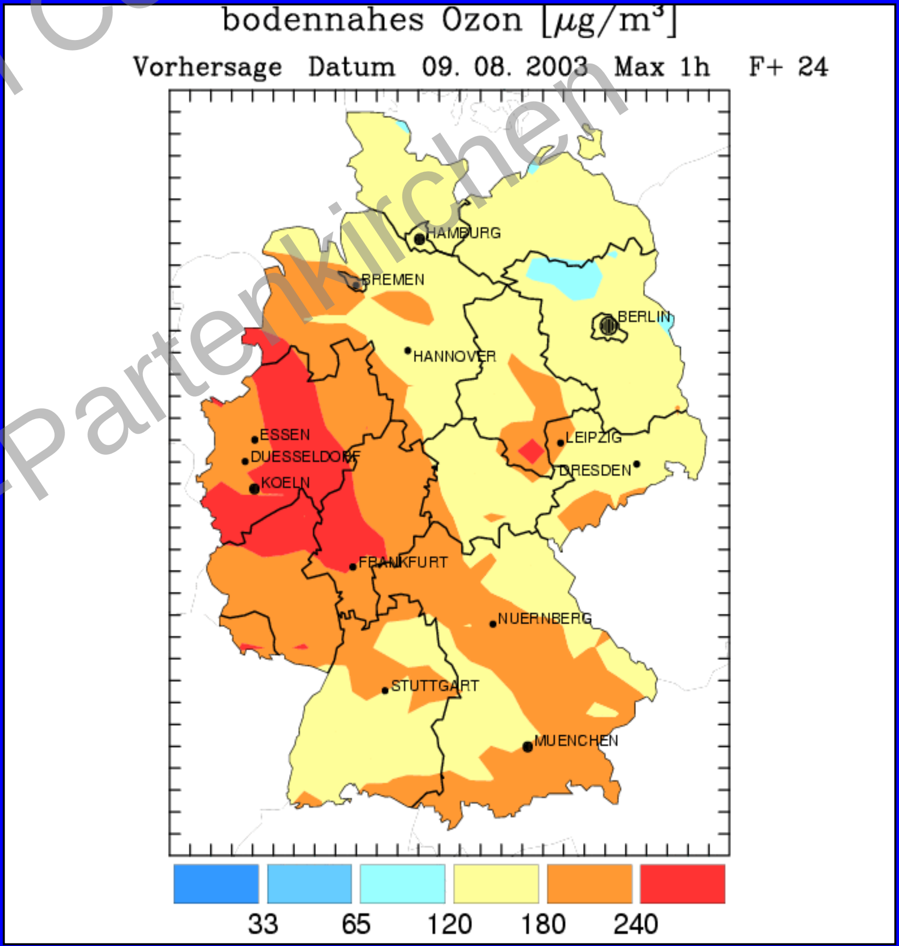


Verification: Germany: 09 August 2003
Ozone (µg/m³), daily Maximum

Observation (UBA)



Forecast (EURAD)



SUMMARY

- In general good agreement between observation and model for „PM_{10}“ (but: underestimation in summer)
- Problems with incomplete and/or not harmonized emission data
- Long range transport is important for background concentrations
- Composition of particles has not been investigated in detail yet, but: secondary aerosols are important
- Lack of information in the vertical (LIDAR, satellite)

RIU EURAD

FUTURE PLANS

- Long-term calculations for 2002, 2005, 2010
- Hemispheric version (long-term, forecast)
- Data assimilation to improve air pollution forecast
- General improvement of model numerics, physics and chemistry

Acknowledgements

Landesumweltamt Nordrhein-Westfalen (LUA)
Umweltbundesamt (UBA)
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EUROTRAC-2 (GLOREAM)
EMEP
TNO
Ford Research Center Aachen (FFA)
Regionales Rechenzentrum der Universität zu Köln (RRZK/ZAIK))
Research Center Jülich (ICG-II, ZAM/NIC)
National Center for Atmospheric Research (NCAR)
NCEP
German Weather Service (DWD)

CITY-DELTA INITIATIVE

Aerosol Chemistry in MADE

Modal **A**erosol **D**ynamics Model for **E**URAD/**E**urope

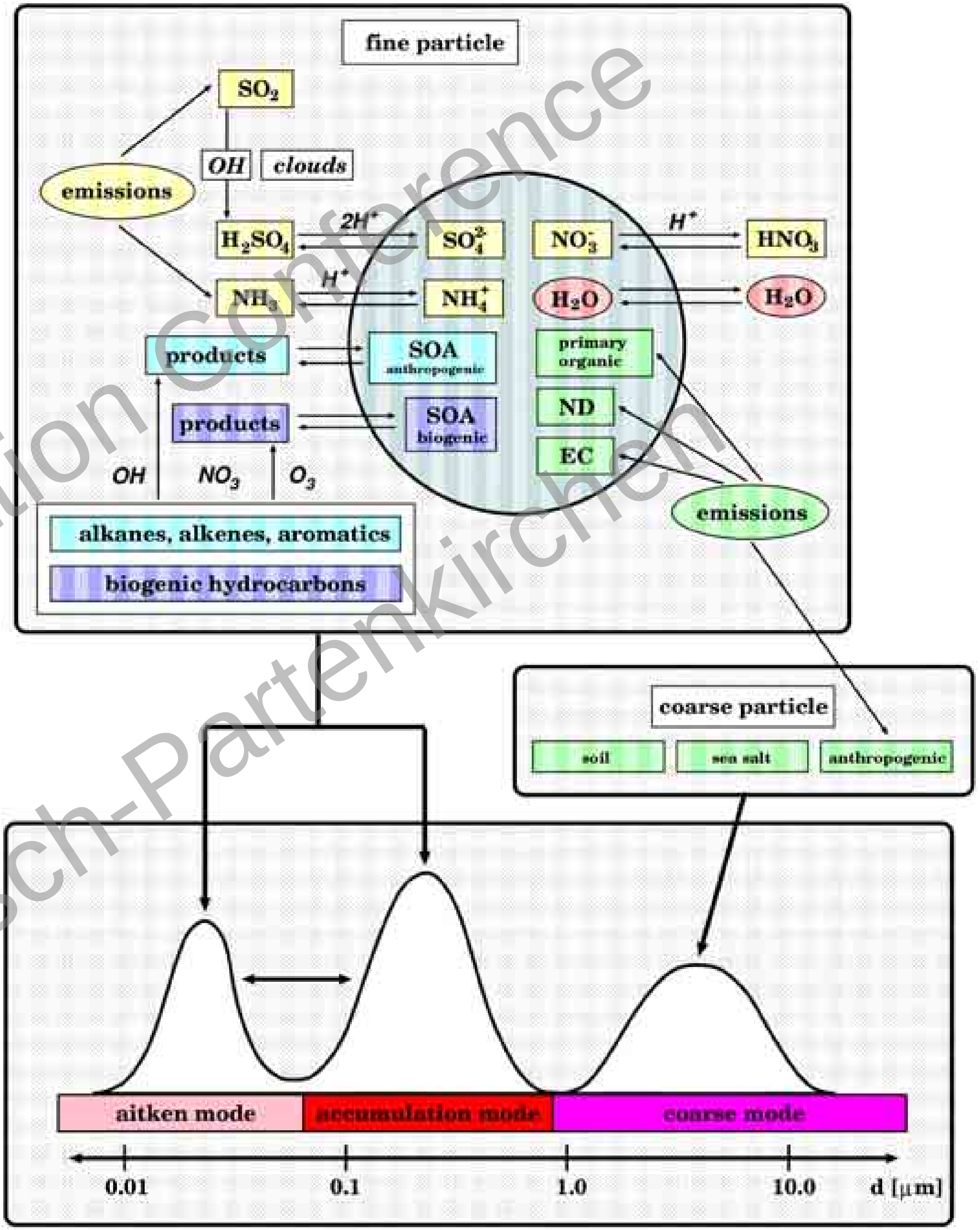
(Binkowski et al., 1995, Ackerman et al., 1998, Schell et al, 2001)

<u>Aerosol dynamics (included)</u>

Coagulation,
nucleation,
condensation-evaporation
Cloud-aerosol interaction
Diffusion, advection
Dry deposition,
sedimentation

$$\frac{dM_i^k}{dt}=nuk_i^k+coag_{ii}^k+coag_{ij}^k+cond_i^k+sink_i^k+emi_i^k$$

M_i^k:= k^{th} Moment of i^{th} Mode



HARMO,

OBS – MODEL: COMPOSITION

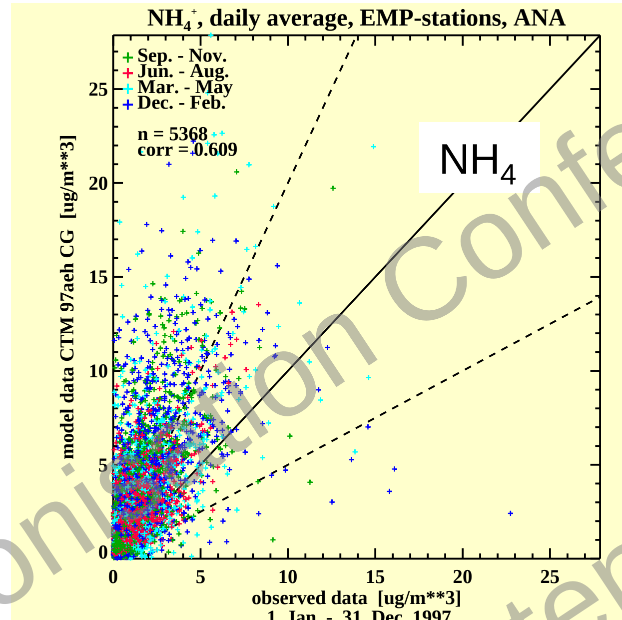
Observation from EMEP

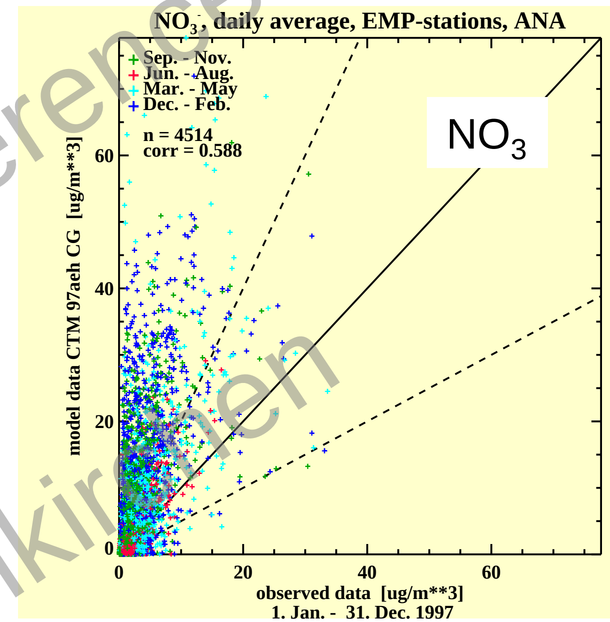
Ammonium

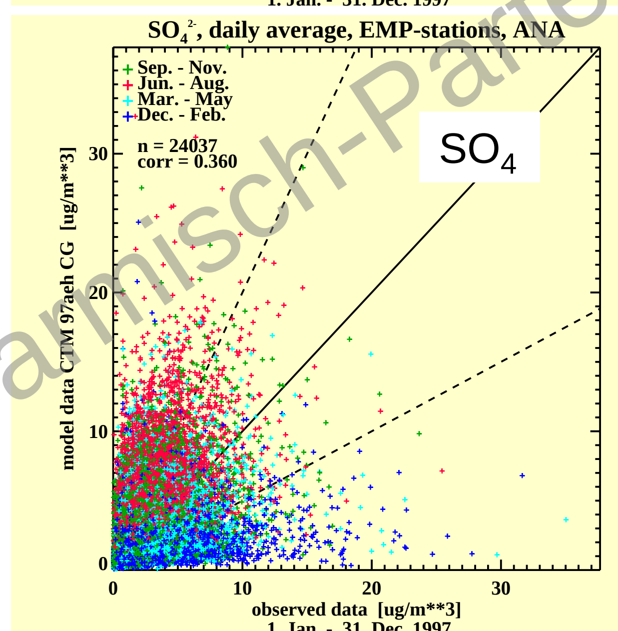
Nitrate

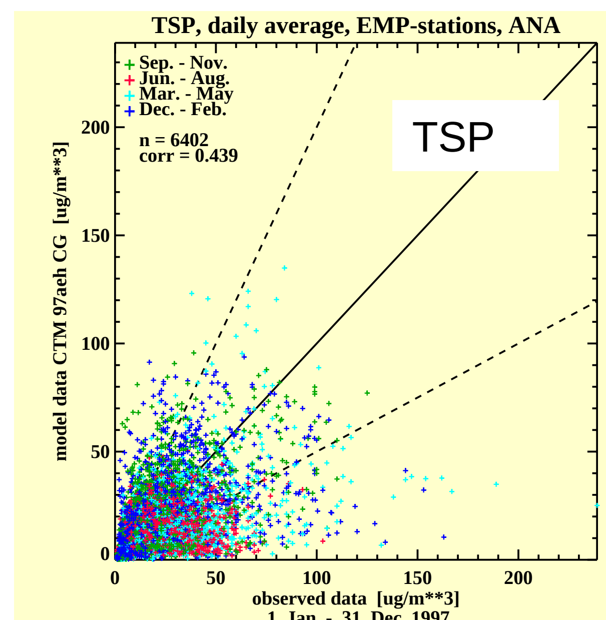
Sulfate

TSP

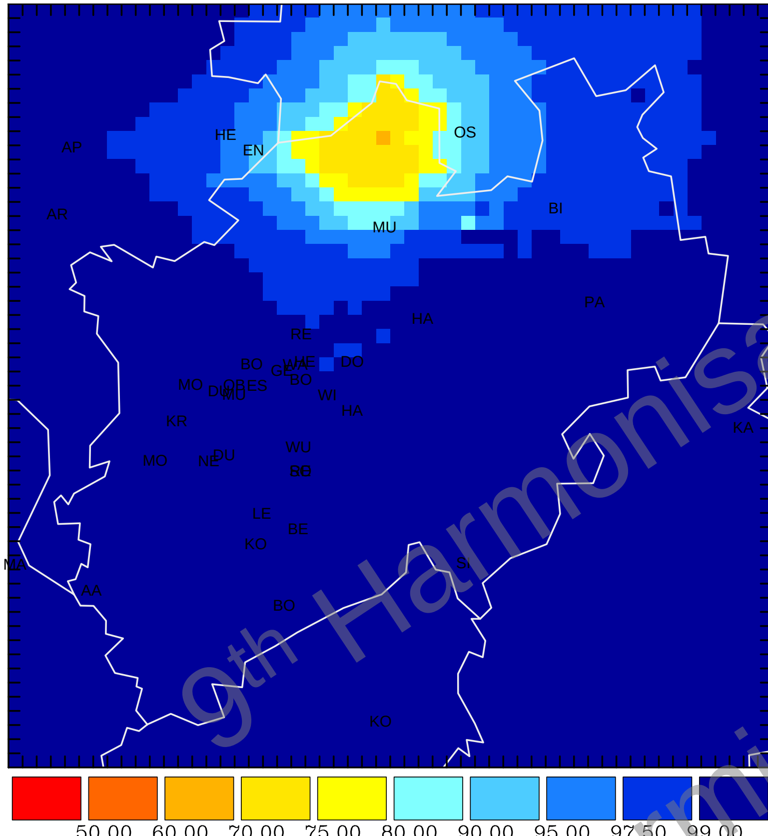


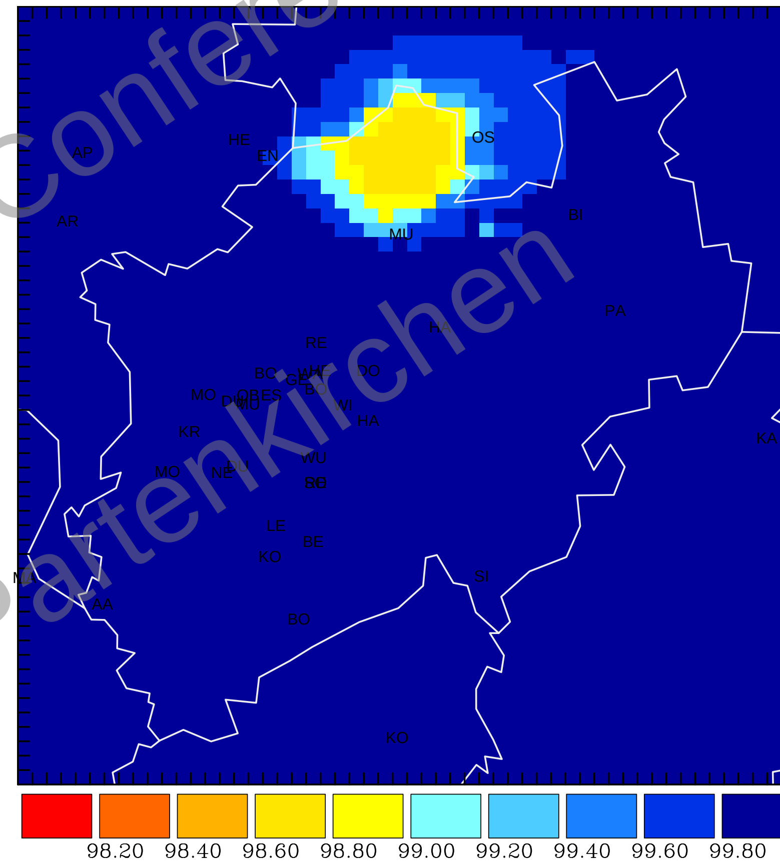






Emission-Reduction NH_3



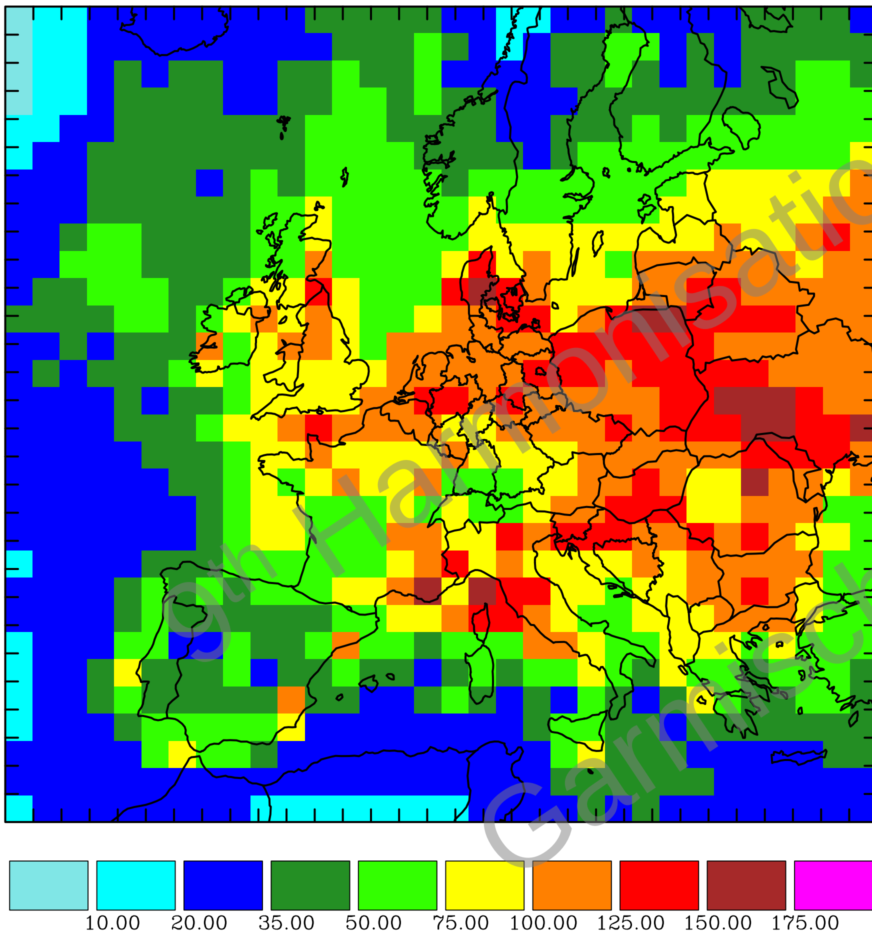


NH_3 (red)/NH_3(Basis) [%]

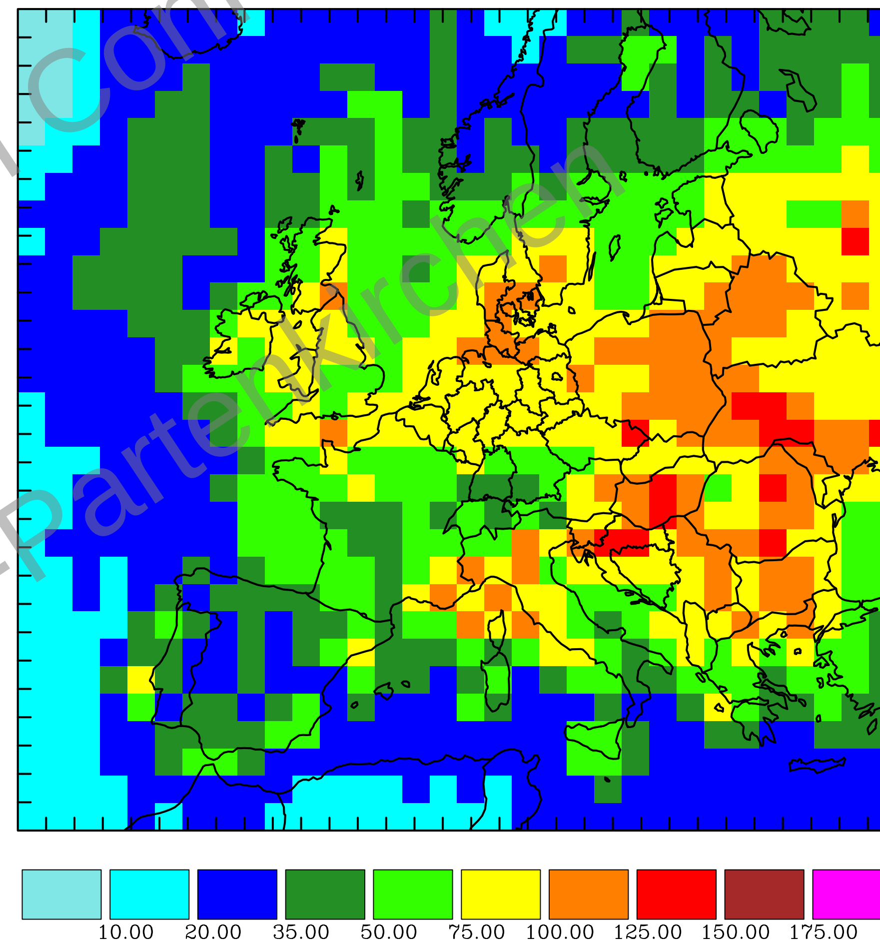
PM_{10} (red)/ PM_{10} (Basis) [%]

PM_{10}: 2002 – (2005) - 2010

MAX. DAILY AVERAGE: PM_{10} - 2002

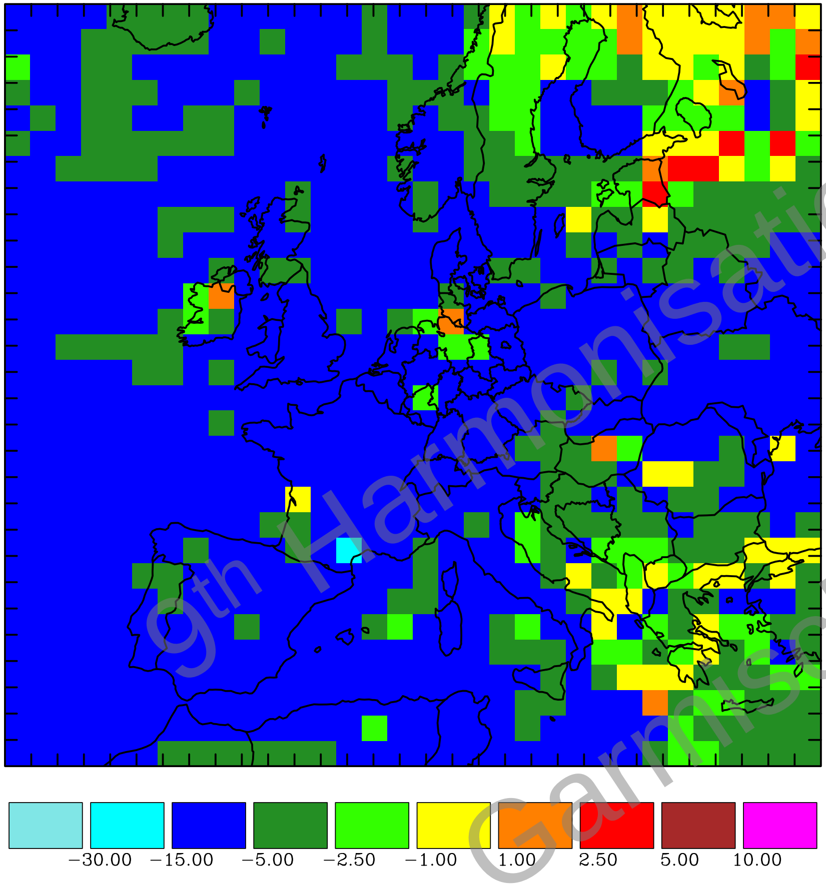


MAX. DAILY AVERAGE PM_{10} - 2010

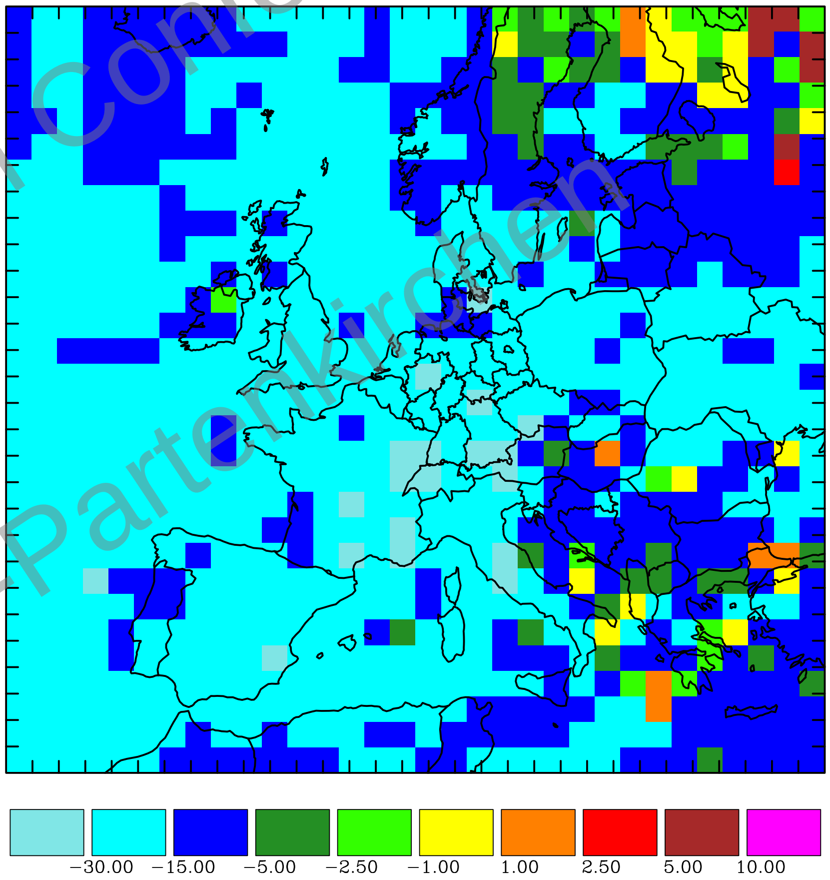


PM_{10}: Changes (%) 2002 – 2005 - 2010

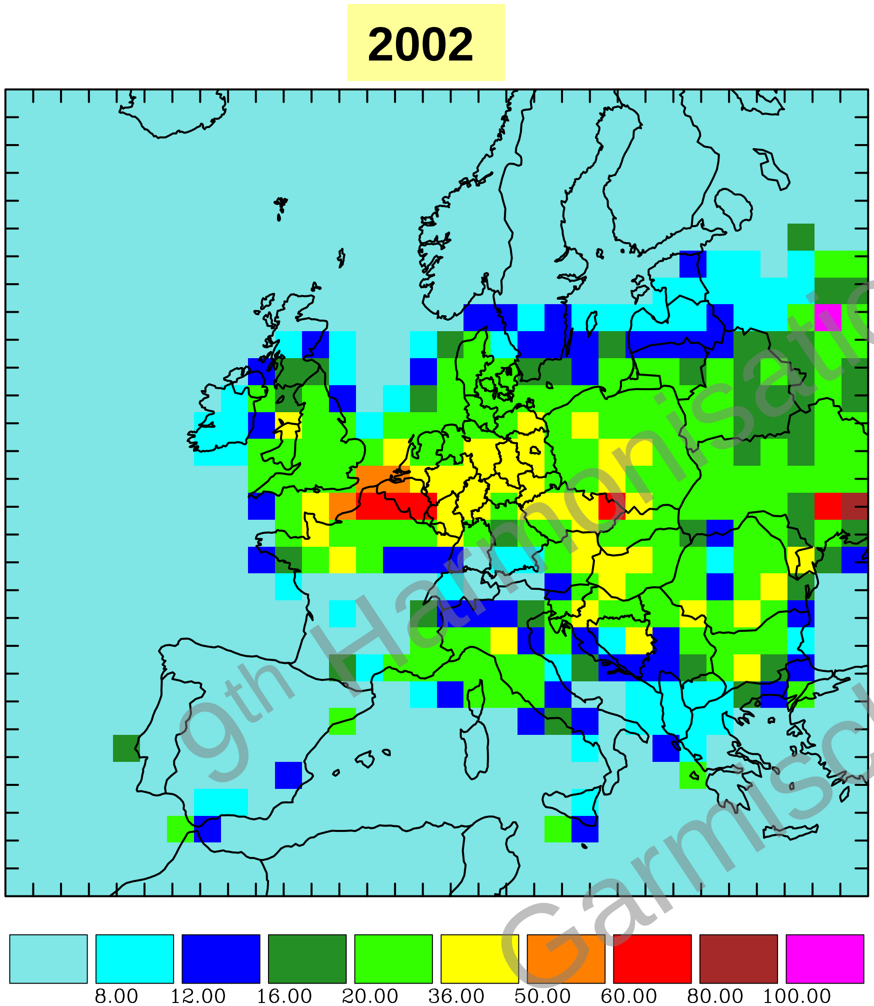
MAX. DAILY AVERAGE PM10: 2005 - 2002

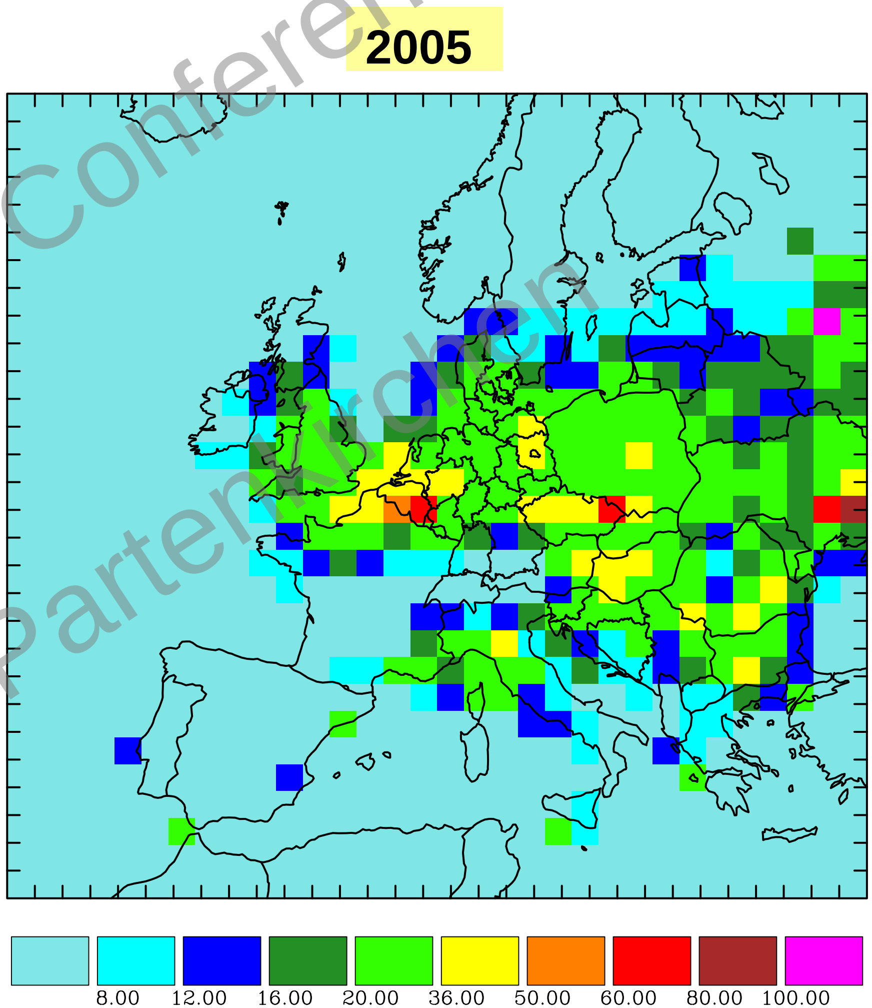


MAX. DAILY AVERAGE PM10: 2010 - 2002



PM_{10}: 2002 - 2005 - 2010





NUMBER OF DAYS WITH DAILY AVERAGE > 50 µg/m³

FUTURE PLANS

- Extension of the modelling system to hemispheric scale to treat the intercontinental transport of pollutants
- Coupling of models with satellite data (4DVar-data assimilation including aerosols)
- Gaps in observation (vertical, composition)
- Improvement and harmonization of emission data
- Process-oriented model evaluation, composition, size
- Multiphase chemistry
- Modal → sectional
- Coupling of clouds and aerosols