A model system for the assessment of ambient air quality confirming EC directives

Alfred Trukenmüller, David Grawe, K. Heinke Schlünzen

• Outline of model system
• Results
• Conclusions
Requirements based on directives
- area coverage information -

- **Ecosystem and vegetation**
  Concentration representative for at least 1000 km² (e.g. 35x30 km²)

- **Human health (urban background sources)**
  Concentration representative for several square kilometres (e.g. 2x2 km²)

- **Human health (traffic)**
  Concentration representative for more than 200 m², e.g. 5×40 m²
Scales of M-SYS

Ecosystem and Vegetation resolution 16 km (G16km)

Ecosystem and Vegetation resolution 4 km (G4km)

Human Health (background) resolution 1 km (G1km)

Human Health (traffic) resolution several m

0.5 m/s

METRAS

MITRAS

M-SYS

MECTM

MICTM
Model communication and data flow

Date → Concentration data

Meteorological Observations → METRAS

Mesoscale Emission Inventory → M-SYS, METRAS, MITRAS

Micro-scale Emission Inventory → MECTM

Topographic Data, Building Mask

Maps of Exceedances and Concentration Patterns

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
Results
40 days in year 2000 selected for maps

measured concentration in Hanover-Linden

Data: NLO, Fig. MI-UniHH, Grawe et al. (2003)
Hit rates for 10 days
(area Lower Saxony, G16km)

Hit rates for 10 days
(area Lower Saxony, G16km)

average hit rate
METRAS other
Ps  44  42
Td  64  35
T   58  35
dd  44  38
ff  51  31

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
Evaluation of NO$_2$ concentrations (G16km)

Required model accuracy = 50% of limit value

Model - Observation (µg m$^{-3}$)

Hourly NO$_2$ concentration values in the year 2000

Hit rate 100%

Wurmberg
Cloppenburg
Solling
Hanover
Lingen
Norderney
Walsrode

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
Evaluation of O₃ concentrations (G16km)

Required model accuracy = 50 % of information threshold

→ Hit rate 95%

Hourly O₃ concentration values in the year 2000

Model - Observation (µg m⁻³)

Wurmberg
Cloppenburg
Solling
Hanover
Lingen
Norderney
Walsrode
Mean concentration of $\text{SO}_2$ ($\mu$g m$^{-3}$) calculated from G16km simulations of Hanover high NO$_2$ concentration days

Annual limit value for the protection of ecosystems: 20 $\mu$g m$^{-3}$

Contour lines: altitude above sea level

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
Mean concentration of nitrate plus sulphate aerosol (µg m⁻³) calculated from G16km simulations of Hanover high NO₂ concentration days.

Annual limit value for the protection of human health (PM10) 2005: 40 µg m⁻³, 2010: 20 µg m⁻³

Trukenmüller et al., 2004
19th highest hourly mean concentration of $\text{NO}_2$ ($\mu$g m$^{-3}$) based on G16km simulation
Hourly limit value for the protection of human health: 200 $\mu$g m$^{-3}$
Contour lines: altitude above sea level
Urban Scale
NO$_2$ 10 m above Ground, 9.5.2000 8 a.m.

1 km resolution

MI-UniHH Trükenmüller et al. (2003)
Comparison MICTM with wind tunnel data

C* (NOx)

DD = 220°

z = 9.8 m

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
Traffic emission data in MICTM
(emission data from IER Stuttgart)

full model area  |  central part of model area

Emission per grid cell for 11.4.2003, 07:00-08:00
NO concentrationen
for 11th April, 2003, 07:00-07:30

Horizontal cross section at z=1.5 m

Vertical cross section (bar in left figure)

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
O_3 concentration for 11th April, 2003, 07:00-07:30

Horizontal cross section at z=1.5 m

Vertical cross section (bar in left figure)

Grawe et al., 2004

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
NO$_2$ concentrationen for 11th April, 2003, 07:00-07:30

Horizontal cross section at $z=1.5$ m
Comparison of simulated concentrations and VALIDATA field measurements
(11.04.03, 07:00-7:30)

Heinke Schlünzen, Meteorologisches Institut, ZMAW, Universität Hamburg
Conclusions

• Results of nested meso- and micro-scale meteorology models (METRAS and MITRAS) agree well with meteorological routine (and wind tunnel) data.

• Results of nested meso- and micro-scale CTMs (MECTM and MICTM) agree well with routine, wind tunnel and field concentration data.

• M-SYS G16km NO₂ results fulfil the quality required by EU directives. For calculating the human health protection values resolutions 4km and 1km are essential.

• To fulfil current EU objectives for aerosols in 2010, reductions of the precursors (NOₓ, NH₃) are essential.
Next steps

• With M-SYS a research prototype was successfully developed. M-SYS needs now to be optimised with respect to computer and human resources.
• The selected days need to be simulated on G4km and G1km as well as on the microscale.
• Maps on all different scales have to be derived.
→ Application for further funding.
Acknowledgements

BMBF for funding research project 07ATF12,

German and British weather services for meteorology data,

The VALIUJM consortium for the past three years of great collaboration, the data (emission, concentration measurements and databank VALIDATA), intense discussions, critical questions, challenging tasks, ...

Thank you for your attention!