Modelling of Particulate Matter on a European Scale

A contribution to subproject GLOREAM

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Summary

For the assessment of future EU-directive implementation for particulate matter (PM) it is necessary to understand the processes which determine the sources and sinks of PM and precursors on a European scale. Therefore, RIVM is developing a module to describe the dispersion of PM (PM_{10}, $PM_{2.5}$) over Europe. A first version of such a module has been completed describing hourly concentrations of primary emitted particles and the secondary formation of sulphate and nitrate particles in the chemical dispersion model called EUROS (a Eulerian air-quality model). We present EUROS model results for PM_{10} (yearly and daily averages) in comparison with measurements and results of other model approaches. Special attention is given to the application of grid refinement.

Introduction

For the assessment of future EU-directive implementation for particulate matter (PM) it is necessary to understand the processes which determine the sources and sinks of PM and precursors on a European scale.

Objectives

We aim to develop module for particulate matter which can assist to evaluate PM policy measures, especially directives for diurnal concentrations. We present EUROS model results for PM_{10} (yearly and daily averages) in comparison with measurements and results of other model approaches. Special attention is given to the application of grid refinement.

Activities

RIVM is developing a module to describe the dispersion of PM (PM_{10}, $PM_{2.5}$) over Europe. A first version of such a module has been completed describing hourly concentrations of primary emitted particles and the secondary formation of sulphate and nitrate particles in the chemical dispersion model called EUROS (a Eulerian air-quality model).

Results

Results of the EUROS model for the year 1995 - primary (anthropogenic) PM_{10} concentrations and sulphate and nitrate levels - are presented below in comparison with measurements and results of other model approaches.

Figure 1 shows the yearly averaged distribution over Europe of primary PM_{10} levels as calculated with the EUROS model applying local grid refinement around the Netherlands.

Figure 2 shows the effect of local grid refinement around the Netherlands. Yearly averaged primary emitted PM_{10} levels obtained using the highest level of grid refinement (a) and concentration levels obtained using the EUROS base grid (b).

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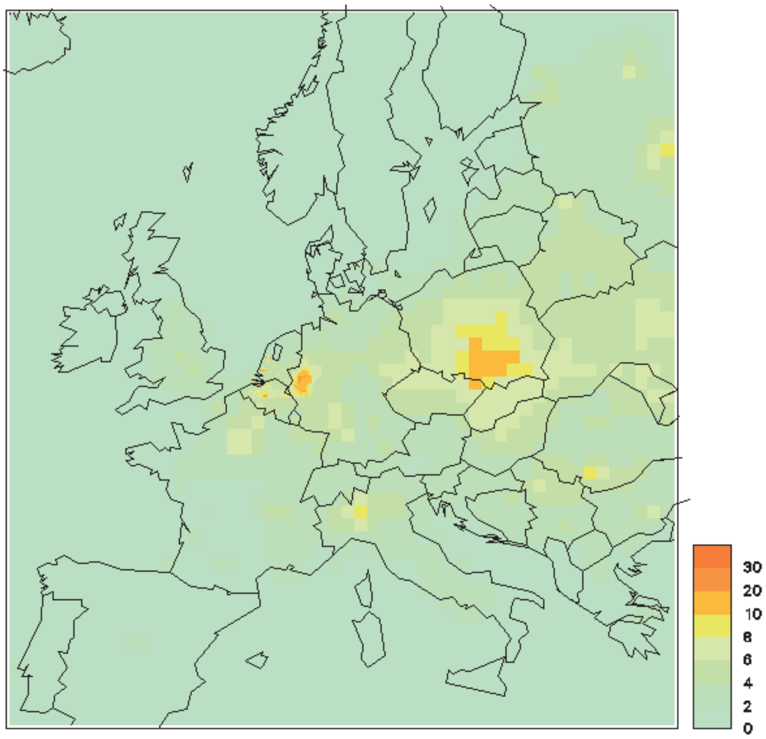


Figure 1. Primary emitted PM_{10}, yearly averaged concentration field ($\mu g/m^3$), calculated with the EUROS model for the year 1995. The area around the Netherlands has a refined resolution for transport and emissions (7.5x7.5 km) see **Figure 3**. The rest of the domain has a four times coarser resolution (about 55x55 km).

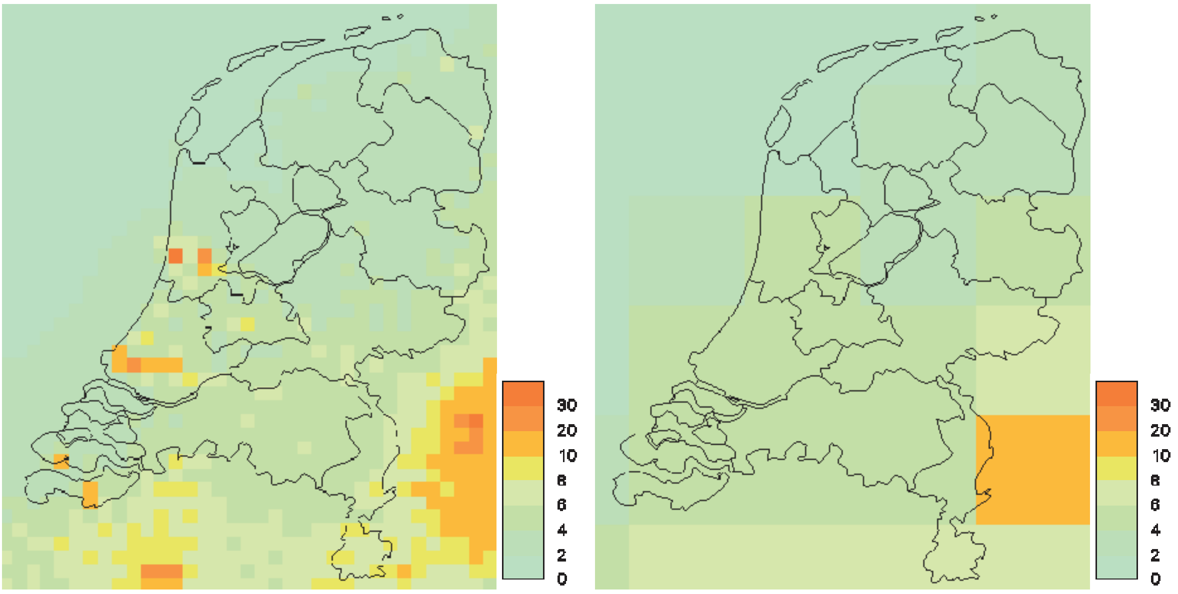
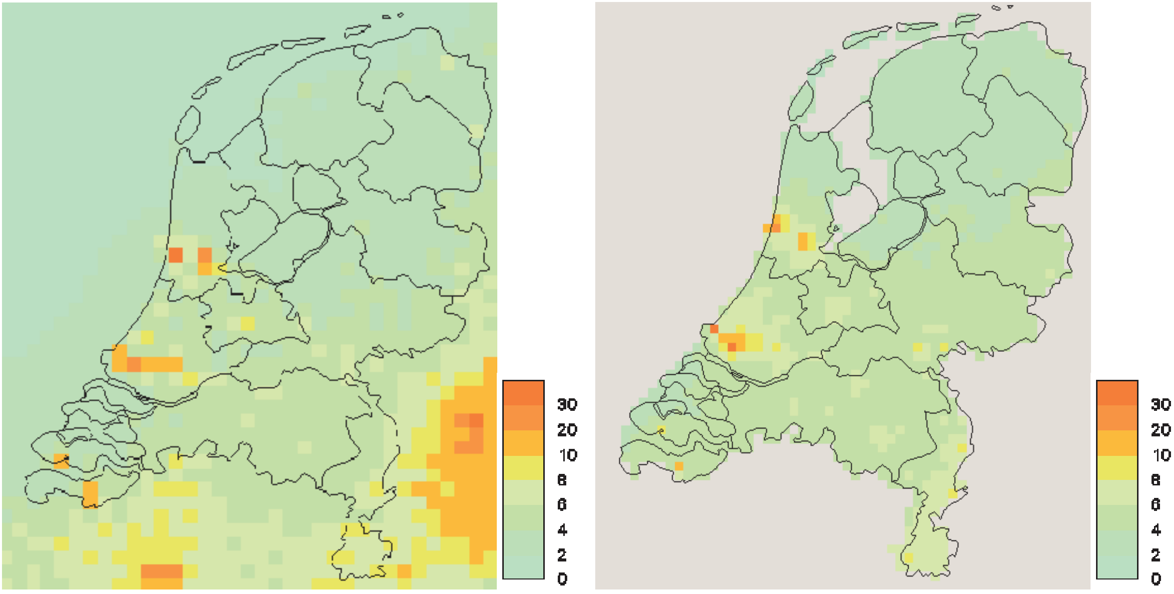


Figure 2. Primary emitted PM_{10}, yearly averaged concentration field ($\mu g/m^3$) calculated with the EUROS model in an area around the Netherlands; grid refined (~7.5x7.5 km) (a) on a base grid level (~55x55 km) (b).

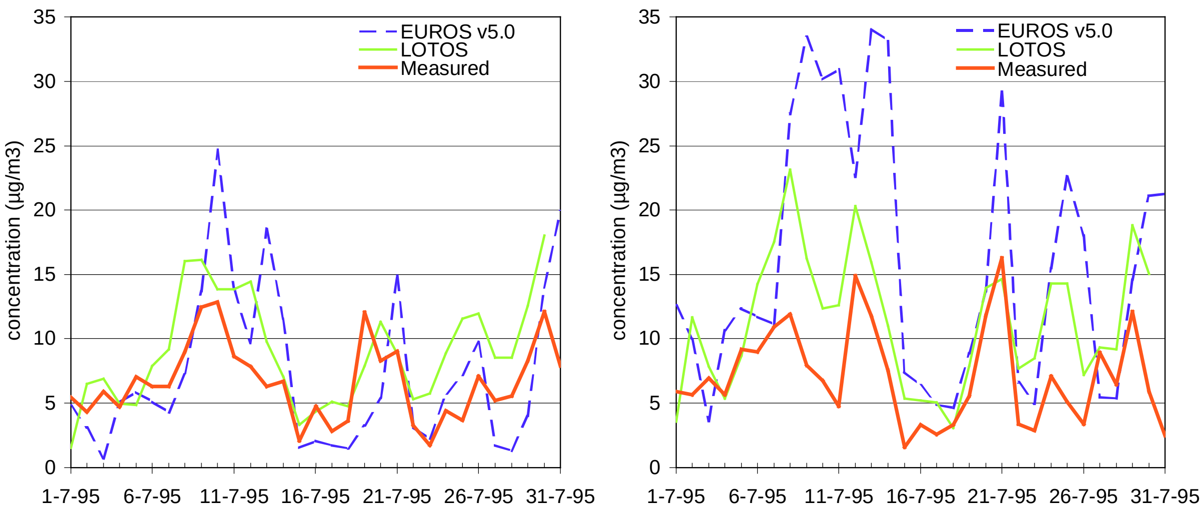
Figure 3 gives a comparison of the grid refined EUROS results with OPS results. The OPS model can be characterised as a Lagrangian model in which the transport equations are solved analytically [Van Jaarsveld, 1991]. Contributions from the various sources are calculated independently using backward trajectories. based on yearly Dutch meteo statistics for 1995. Local dispersion is introduced via a Gaussian plume formulation. Dry deposition, wet deposition and chemical transformation are incorporated as first-order processes and are independent of concentrations of other species. OPS model results for PM_{10} have been evaluated in terms of measurements [Visser et al., 2001]. Because primary PM_{10} levels can not be distinguished in total PM_{10} measurements, a comparison as in Figure 3 is essential for the evaluation of these levels.



(a) **(b)**

Figure 3. Primary emitted PM_{10}, yearly averaged concentration field ($\mu g/m^3$) in the grid refined area around the Netherlands (7.5x7.5 km) calculated with the EUROS model (a) and with the OPS model [Van Jaarsveld, 1991; Visser *et al.*, 2001] (b).

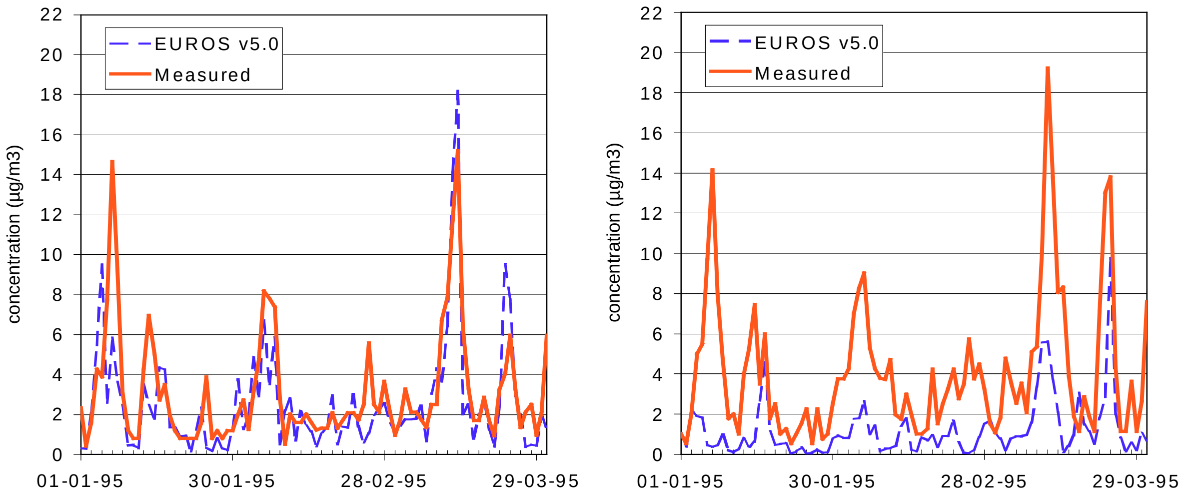
Figure 4 shows daily averaged levels of sulphate (a) and nitrate (b) in the summer month July. EUROS model results are compared with LVS (low-volume-sampler) measurements and the results of the LOTOS model. The LOTOS model [Roemer *et al.*, 1997] is in most aspects similar to EUROS, however for the inorganic secondary particulates LOTOS applies the more elaborated parameterisation MADE [Ackermann *et al.*, 1995].



(a) SO_4 summer **(b) NO_3 summer**

Figure 4. Secondary PM_{10}, daily averaged sulphate (a) and nitrate (b) concentrations ($\mu g/m^3$) for the Dutch measurement station Vredepeel calculated with the EUROS model (dashed blue line), the LOTOS model (green solid line) and measured at the site with a Low-Volume-Sampler (thick solid red line) for July 1995.

Figure 5 is similar to Figure 4 (without LOTOS results) but for the winter months January, February and March.



(a) SO_4 winter **(b) NO_3 winter**

Figure 5. Secondary PM_{10}, daily averaged sulphate (a) and nitrate (b) concentrations (µg/m^3) for the Dutch measurement station Vredepeel calculated with the EUROS model (dashed blue line) and measured at the site with a Low-Volume-Sampler (thick solid red line) for January, February and March 1995.

Conclusions

To represent the major PM_{10} source areas in the Netherlands a relatively high grid resolution of the order of 10x10 km is necessary. The application of grid refinement in and around the Netherlands leads to a relatively good agreement between yearly averaged concentrations of primary emitted PM_{10} concentrations calculated with the EUROS and OPS model. EUROS results of summertime sulphate and nitrate levels overestimate the measurements, although temporal behaviour is reasonable. In wintertime sulphate levels are well predicted by the EUROS model whereas wintertime nitrate levels are largely underestimated. Using the LOTOS approach (CB-IV/MADE) for the inorganic secondary particles leads to a better comparison with measurement during summer.

Acknowledgements

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