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BelEUROS:

Implementation and extension of the EUROS model for policy support in Belgium

SUMMARY

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BelEUROS

Implementation and extension of the EUROS model for policy support in Belgium

The EUROS model is an atmospheric model that simulates tropospheric ozone over Europe on a long term basis. The model was originally developed at RIVM (The Netherlands). In the framework of the BelEUROS project, a new version of the EUROS model coupled with a state-of-the-art user interface has been installed at IRCEL/CELINE as a tool for policy support with respect to tropospheric ozone. This tool allows evaluating the impact of potential emission reduction strategies on ozone concentrations.

General context

During summertime, high ground-level ozone concentrations are often observed in Belgium and the surrounding countries. Ozone is chemically formed from nitrogen oxides ($NO_x = NO + NO_2$) and volatile organic compounds (VOCs). These precursors of ozone are mainly emitted by road traffic and industrial activities. Ozone formation is driven by photochemically initiated reactions and is correlated to air temperature, so that elevated ozone levels are typically found in meteorological situations with clear skies and high temperatures.

Ozone has significant effects on human health and vegetation. Through its oxidation capacity, ozone affects lung functions, particularly in children and asthmatics. Exposure to ozone also induces damage to agricultural crops, forests and ecosystems, as well as to materials such as rubber and paints. For the protection of human health, a warning threshold of 180 $\mu g/m^3$ has been defined. In Belgium, the threshold value is frequently exceeded. In 1995, a very hot summer, 32 days with exceedance in at least one of the Belgian monitoring stations have been reported (IRCEL/CELINE, http://www.irceline.be).

The concern about the damaging effect of ozone is shared at various policy levels. At the European level, long-term objectives for the reduction of ozone concentrations have been defined in the framework of the Directive 96/62/EC. According to the daughter directive in preparation, the target values should be attained by the member states by the year 2010. In order to reach these objectives, most of the member states will have to reduce drastically the emission of pollutants responsible for ozone formation, i.e. nitrogen oxides (NOx) and non-methane volatile organic compounds (VOC). The emission reductions are prescribed for each of the EU member states in the form of national emission ceilings under the Gothenburg Protocol (1999) en in de NEC (National Emission Ceilings) directive in preparation.

In this perspective, it is essential to provide the policy makers with adequate tools for evaluating the impact of possible emission reduction strategies on the ozone concentrations. Numerical atmospheric models are well suited for this task. These models represent the various atmospheric processes responsible for ozone formation and destruction: pollutant emission, atmospheric dispersion and transport, chemical transformations and deposition. Model simulations allow estimating the effect of specific emission reduction measures on ozone concentrations.

The BelEUROS project

The aim of the BelEUROS project was to provide the Belgian authorities with such a modelling tool for policy support with respect to tropospheric ozone. The EUROS model (EURopean Operational Smog model) was selected for this purpose. A schematic view of EUROS is given in Figure 1. It is a regional chemistry-transport model which has been developed at the RIVM (Rijksinstituut voor Volksgezondheid en Milieu, Bilthoven, The Netherlands). It simulates the hourly variations of ozone over Europe over long time scales (typically a few months) with a standard resolution of 60 km. A grid refinement procedure allows refining the spatial resolution in certain areas of the model domain, for example Belgium. A detailed emission module describes the emission of three pollutant categories (NO_x, VOC, SO_2) and for 6 different emission sectors (traffic, space heating, refinery, solvents use, combustion, industry). The implementation of EUROS in Belgium required the adaptation of some input data (emission and meteorology) and of some intrinsic features of the model as well. These developments on the EUROS were realised in close collaboration with the RIVM and mainly concern a better representation of the transport and dispersion of pollutants in the lower layers of the atmosphere.

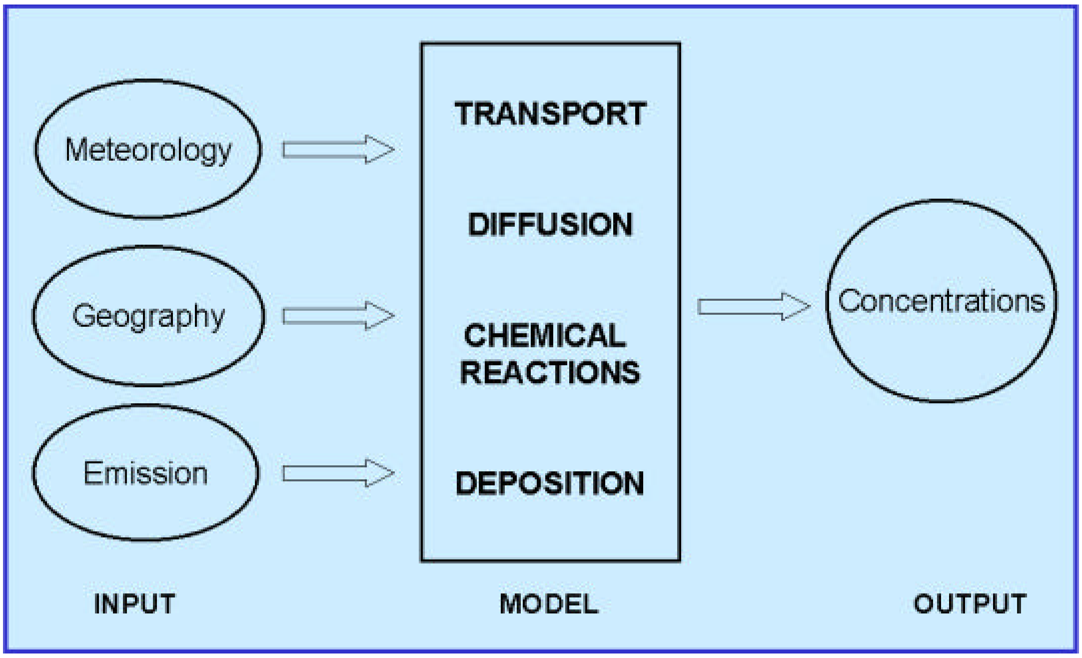

Figure 1: A schematic view of the EUROS model

The new version of the model has been installed at the Interregional Cell for the Environment (IRCEL/CELINE) in Brussels and made available to user groups in the three Belgian Regions (http://www.beleuros.be). A complex model as EUROS can not be used efficiently by policy makers if it is not provided with a user friendly interface allowing the user to define the general characteristics of his simulation, to specify the emission scenarios and to visualise and analyse the output results. Therefore, an important task of this project was the development of an effective Windows user interface. This interface must also control the Internet exchanges between the local computer of the user and the central computer at IRCEL where the model runs. This allows the user to start a simulation from a remote location through Internet connection.

The distribution of the tasks between the various partners was organised as follows. VITO (Mol) was in charge for the development of a new emission inventory. The new developments on the EUROS model itself were realised by VITO in collaboration with UCL (Louvain-la-Neuve) for the meteorological aspects. FPMs (Mons) was in charge for the development of the user interface and for the installation at IRCEL in collaboration with the VITO and IRCEL. The task of RMI (Brussels) was to provide the meteorological data. VITO was also in charge of a study concerning the impact modelling of ozone on human health and vegetation. As user and associate partner, IRCEL has played an important role as adviser throughout the whole project. The co-ordination of these tasks was ensured by the VITO.

Main results

Generation of new input data for EUROS

A dynamic emission inventory has been compiled for the European countries that are covered by the EUROS domain. The inventory provides the spatial and temporal variations in anthropogenic emissions for six economical sectors and the distribution of biogenic emissions varying with temperature. This inventory was implemented in a Geographical Information System (Arcview) which proved to be very helpful in this context.

As far as the meteorology is concerned, a new three-dimensional input data set for EUROS has been generated from the ECMWF meteorological data (European Centre for Medium-Range Weather Forecasts, Reading, UK). Moreover, an important atmospheric parameter in EUROS is the mixing height, i.e. the height of the atmospheric layer adjacent to the ground, where the pollutants are well mixed through the action of turbulence and convection processes. Several methods have been explored to estimate the mixing height from the meteorological data set. The results have been compared with observational data and with the results of detailed model simulations. Based on these results, a new method has been proposed for the determination of the mixing height in air quality models.

Development of a new version of EUROS

The EUROS model has been further developed in close collaboration with the RIVM (Rijksinstituut voor Volksgezondheid en Milieu, Bilthoven , The Netherlands). A new version has been set up. It includes a spatially variable mixing height and a multi-layer representation of the horizontal transport. This allows a much more realistic representation of the atmospheric processes responsible for the transport and dispersion of pollutants. The model is now provided with a three-dimensional grid structure, which constitutes a first step towards a fully three-dimensional representation of the transport and dispersion processes. The new version has been tested by comparing the simulated ozone concentrations with observational data.

Development of a user interface

A user-friendly interface has been developed. It consists of a Windows platform written in VISUAL-C++. The interface allows the user to define his emission scenario, to start the simulation from his computer and to visualise the output results. The user has the possibility to modify the emission rates of a given pollutant (NOx or VOC) for a given emission sector (traffic, space heating, refinery, solvents use, combustion, industry) and for a given geographical area. Monthly, daily and hourly emission factors can also be modified for each sector. These factors account for the influence of the month in the year, the day in the week, and the hour of the day. As far as the output results are concerned, the user interface allows an easy visualisation of the geographical distribution of the pollutants over Europe with the possibility to zoom on Belgium (Figure 2). The visualisation of long term indicators like AOTs (Accumulated Exposure over a Threshold) is also possible. In addition, the time evolution of pollutant concentrations on a specific location can be displayed.

Installation at IRCEL/CELINE

The new version of the EUROS coupled with the user interface is now installed at IRCEL/CELINE and can be used by policy makers en researchers for evaluating the impact of possible emission reduction strategies on ozone concentrations. The output results of EUROS allow an evaluation of the indicators currently used for estimating the impact of ozone on vegetation and human health. Some of these indicators are also used in the current European legislation related to ozone in ambient air.

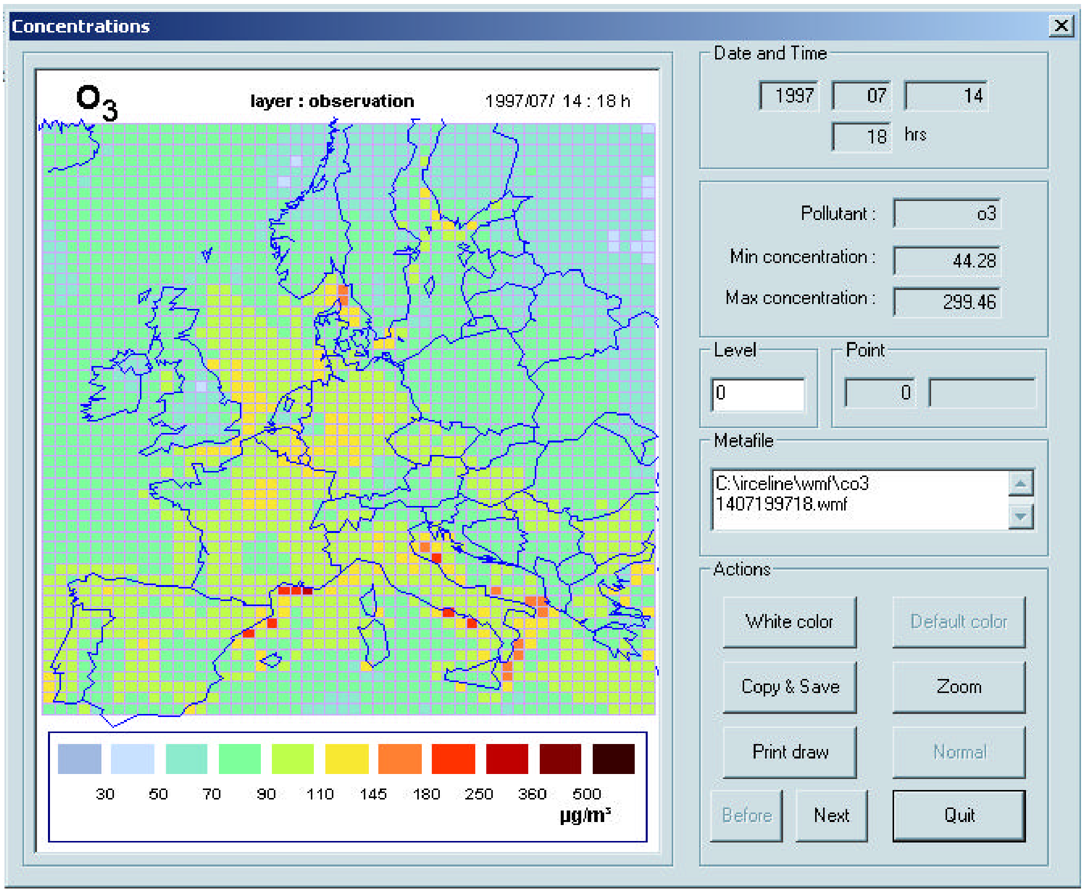

Figure 2: Visualisation of ozone concentrations over Europe