GLOREAM
Subproject Overview for 2001
"Global and Regional Atmospheric Modelling"

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Content

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1. Summary

The GLOREAM modelling community is alive and kicking, and clear progress has been made over the last year.

Special emphasis has been given to the further development in aerosol modelling. Progress has been made in model-intercomparison and model validation, and the GLOREAM-models are widely used within other subprojects.

2. Aims of the subproject GLOREAM

GLOREAM-GLObal and REgional Atmospheric Modelling-, is the successor of the EUROTRAC-1 subprojects EUMAC-EUropean Modelling of Atmospheric Constituents and -to a large extent- of GLOMAC-GLObal Modelling of Atmospheric Chemistry.

GLOREAM, as the previous projects, has as main aim to investigate –by means of advanced and integrated modelling- the processes and phenomena which determine the chemical composition of the troposphere over Europe, and on a global scale. An essential element is the development of state-of the-art models, the interaction within GLOREAM between the different model-groups and modellers in Europe to discuss occurring problems and exchange information, and the determination of the model capabilities and performance.

GLOREAM has been structured in five closely related working groups:

- Model investigation and improvement
- Global modelling
- Computational aspects
- Model evaluation and validation
- Model application and assessment

In the process of Synthesis and Integration which takes place in this final stage of EUROTRAC-2, a distinction has been made in Science, Tools and Application. Generally speaking, model investigation and improvement and global modelling is the science part of GLOREAM. Tools is covered by computational aspects and model evaluation and validation, whereas model application and assessment is clearly the application, policy part.

Analysing the research performed in GLOREAM over the last 1-1.5 years a distinct pattern can be recognised.

There is an increase in activities in the area of global modelling, which is also related to the subproject TROPOSAT and to the start of the new subproject EXPORT-E2, European export of particulates and ozone by long-range transport: a study in EUROTRAC-2.

There is an increase in aerosol model development, which is also related to activities in the subproject AEROSOL.

There is an increase in model evaluation studies and model intercomparison studies, which are related to the sub-projects TOR, LOOP and also partly TROPOSAT.

These is an increase in the assessment of model-input, related to the sub-project GENEMIS.

All these developments show that the cooperation between GLOREAM and other sub-projects is growing, and that GLOREAM models and model activities are spreading within EUROTRAC, the borders between subprojects are more and more dissolving and 'GLOREAM'-models are widely used in other subprojects.

This overview is largely based on the poster-presentations at the Garmisch workshop under GLOREAM, combined with related posters of other sub-projects, guest- and AFO-posters.

3. GLOREAM-activities and principal results

The results can be grouped in the following manner:

3.1 Model and input-improvements (Science-part)

Several modelling groups have improved their capabilities in aerosol modelling on a European scale. In GLOREAM the following models are involved in this: EURAD, LOTOS,REM-3, EUROS, DEM (see for a description of the models the GLOREAM annual report 2000, available on the webpage: www.dmu.dk/AtmosphericEnvironment/gloream) Next to the modelling of the inorganic aerosols sulfate, nitrate and ammonium also organic aerosols and primary PM 2.5 and PM 10 emissions are often incorporated. The models focus on long-term simulations of a year or more, on an hour-by-hour basis. A special activity is the aerosol-model intercomparison for the year 1995 in which the models mentioned participate. Model evaluation is mainly based on (EMEP) observations of inorganic aerosols, but also available observations of PM 10, and sometimes PM 2.5 are used.

The MADE -Modal Aerosol Dynamic model for Europe- which is used by several groups- is under further development including an improved representation of the nucleation and the freshly nucleated particles.

A scheme for an improved calculation of photolysis rates in the troposphere has been developed, which shows that the vertical distribution of ozone is of comparable importance as the ozone column as such.

Several modelling groups have performed studies which do not focus primarily on further improvements of the models as such, but they use the developed models to investigate the sensitivity to, or the uncertainty of model input data.

The influence of the biogenic emissions on peak ozone levels have been tested. The study shows that the evaluation of the abatement strategies becomes more difficult because of the large uncertainty in biogenic emissions and because of the increasing importance of biogenic VOC-emissions relative to anthropogenic VOC-emissions, in view of the steady decrease in anthropogenic emissions over the last decade.

Work has also been carried out to improve the accuracy of the biogenic emission input by provision of plant species-specific land use, foliar biomass data and emission rates.

Modelling of the emission-plume of Augsburg by the KAMM/DRAIS model system indicated by comparing observed with modelled concentrations a possible underestimation of the CO-emissions input data by a factor of 2. The same model system has been used to analyze ozone formation in the city plume of Berlin (BERLIOZ-experiment) Inverse modelling using Lagrangian models (FLEXPART) is under development to derive information on emissions from measurements over the regional scale.

Although most models developed and used at the moment in GLOREAM are capable of performing hour-by-hour calculations over Europe over extended periods of a year or more, it is clear that the computer resources required to perform such long period calculations are considerable. Consequently, several groups are studying the possibility to reduce the amount of calculations.

The DWD is performing cluster analysis on model results for the tropospheric composition over Europe, JRC is working on the CART-method (Classification and Regression Tree).

3.2 Global modelling (Science part)

The 3D global model TOMCAT has been used to calculate columns of tropospheric NO_2 and HCHO. The objective was to compare the model results with observations from the GOME-instrument. The agreement between modelled and observed NO_2-columns was generally good, provided a correct separation was made between tropospheric and stratospheric contributions to the NO_2 column.

A similar study to compare GOME NO_2 columns with modelled data has been performed using ECHAM4.

Both studies can be considered as at the same time a model and an observation evaluation and validation.

Also in the framework of AFO-2000 studies have been started to integrate satellite observations with especially the 3D global model MOZART focusing on processes in the upper troposphere.

A combination of a Lagrangian chemistry transport model and TOMCAT has been used to investigate transport and transformation of ozone precursors from the European boundary layer, showing the importance of sub-grid scale mixing processes.

Climate change will have an impact on the chemical composition in the troposphere over Europe, and the exceedances of limit values.

Using as input a climate change scenario for the last 30 years of the 21 th century, the DEM-Danish Eulerian Model- has been used to calculate the impact on peak ozone levels. The calculations, as shown in the figures below, show a clear increase of up to 60 % in the number of days in which the 60 ppb level is exceeded, and an increase of up to 15 % in the ozone daily maxima.

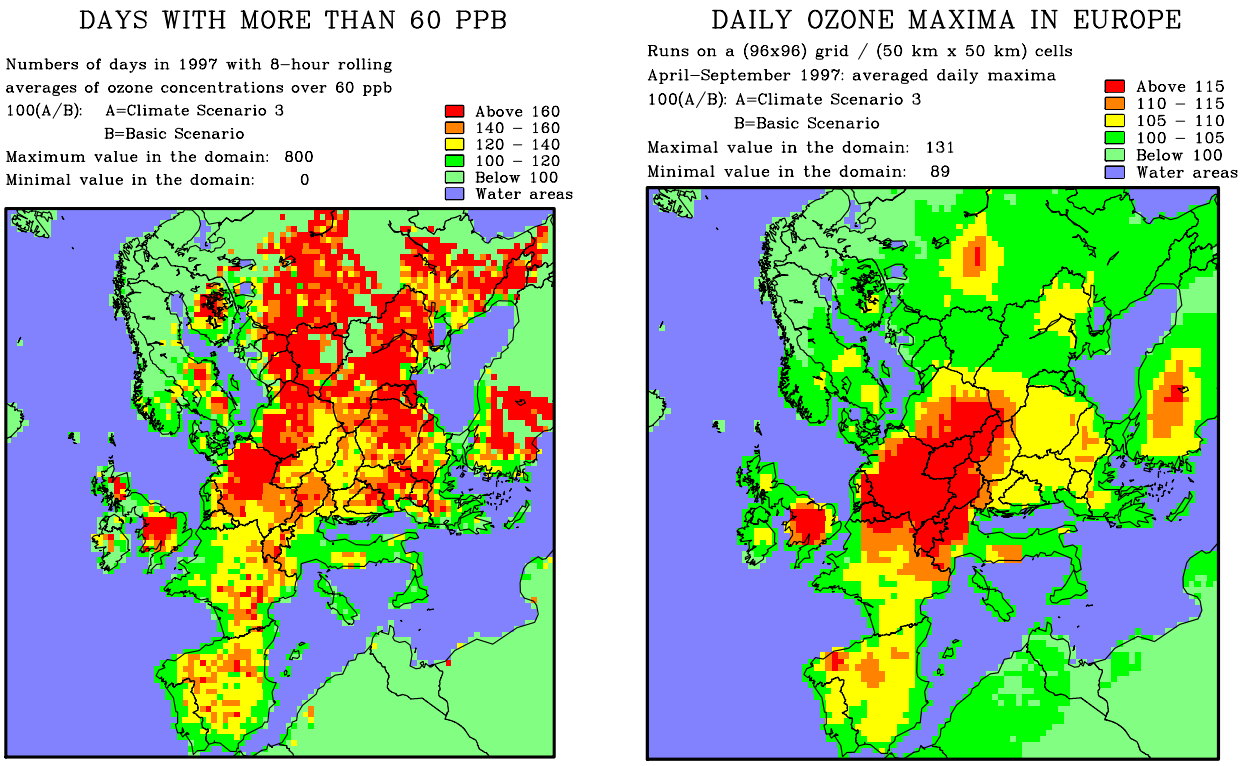

Figure 1. *Impact of climate change on peak ozone levels*

3.3 Model evaluation and validation (Tools part)

Model evaluation is of critical importance. It should be known, before models are used, to which extent the models are reliable and reflect reality.

In cooperation with the subproject LOOP in which field campaigns over limited areas are performed and analysed to investigate ozone production, indicator values as observed and as calculated by models have been compared. The same comparison is performed between calculated and observed photo-oxidant formation rates. These results indicate that model results are not clearly in contradiction with observations, but that a definite conclusion could not be made yet.

Using a combination of statistical indices and data-assimilation (Kalman filtering) the performance of the LOTOS model for ozone and aerosols has been investigated. Also in the AFO-2000 cluster of projects ASADA, special attention is given to the further development and application of data-assimilation. Data-assimilation is also of importance in the sub-project TROPOSAT. It can been seen that data-assimilation has an increasing impact in model evaluation and input data evaluation, especially concerning emissions.

The CARIBIC observational database is put into a retrieval and archive system which makes a direct comparison between observations and (global) model results much more feasible than in the past.

The model intercomparison study of regional scale aerosol models, and the TOR-2 model intercomparison study focusing on trends in ozone will deliver very useful information about the performance of atmospheric chemistry transport models.

3.4 Model systems (Tools part)

More and more complete model systems are under development consisting of a cascade of models. The items addressed by these model systems are nesting, scale interaction which means that in an optimal and smooth way modelling can in principle be performed from the global/ hemispherical scale via the continental/regional scale down to the urban scale and further to the street level. Which means from grid resolutions of the order of 2.5 x 2.5 degrees (about 100-300 km) down to the meter-resolution.

Approaches in this direction are the THOR Integrated Model system under development by NERI, the BelEuros system by VITO, the MM5-CMAQ operational air quality modelling system by the Technical Univ. of Madrid and the EURAD-modelling system of the Univ. Koln.

All these model systems address nesting and scale interaction in a one-way or two-way mode and cover part of the scales mentioned above.

Critical elements are the availability of the required input data and the required computer resources.

4. Policy relevant results (Application part)

First, it should be mentioned that every suited, validated model can, and often will, be used in application studies. Recent examples can be found in GLOREAM and related projects as SATURN.

The EURAD model system has been used in a real-time forecast mode, related to the EU ozone directive. MAR IV has been used for the analysis of ozone deposition in a Portuguese coastal zone in view of the Gothenburg protocol.

More urban scale modelling in support of city authorities has been performed in the Napels area, for Mexico city and for the Vienna/Bratislava region.

5. Main conclusions

The current situation in GLOREAM is that the models are approaching maturity, and they are used often outside GLOREAM in other subprojects both in scientific studies as well as in policy applications.

Recent progress can be seen in aerosol-modelling, in model-intercomparison and -evaluation and in scale interaction/nesting, of which also new findings are expected in the remaining time of EUROTRAC-2.