The SATURN model inventory

Contribution to subproject SATURN

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Summary

Within the EUROTRAC2 subproject SATURN (Studying-Atmospheric Pollution in Urban Areas) several models have been developed and applied to investigate flow, transport and pollution phenomena in the urban area. An overview on nineteen models has been made available on the internet and was regularly updated during EUROTRAC2. The final update will be made beginning of 2002. Besides details on each model, summarising tables are provided that include information on the equations solved, the parameterisations used, the treatment of sources and chemical transformations, the nesting method applied and the validation and evaluation of the model. The models are classified into six main application ranges based on the equations solved and the parameterisations used.

Introduction

Already at the beginning of SATURN (Studying-Atmospheric Pollution in Urban Areas) a model overview was provided to easy communication and module exchange within SATURN and - more general - to inform on the current status of urban scale and smaller scale atmospheric models in Europe. The overview has been made available on the internet and was regularly updated since its first version (Schlünzen, 2001).

Objectives

Within SATURN model development and validation were two of the main objectives. To give all SATURN participants information on the models used in SATURN and to easy model exchange and discussion on model results, an overview on all the models and detailed information on single models were made available.

Activities

The SATURN model overview was updated several times and discussed within the SATURN group. It was presented at all SATURN meetings.

Results

Nineteen Models (ADMS, CALGRID, CAR-FMI, CHENSI, EPISODE, FVM, GRAMM, MARS, MEMO, MESO-NH, METRAS, MIMO, MITRAS, MUSE, OFIS, SUBMESO, UDM-FMI, VADIS) of eleven different countries (Austria, Denmark, Finland, France, Germany, Greece, Portugal, Norway, Switzerland, UK, USA) are summarised in the model inventory. They are classified with respect to the equations solved in CFD models (calculate wind, temperature, humidity and concentrations from 3-d prognostic equations) and non CFD models (prescribe the flow field or use diagnostic equations with empirical factors for treating obstacle influences, or the flow field is derived from shallow water equations. Temperature, humidity, etc. are not calculated from prognostic equations but stratification may be considered. Concentrations may be solved from prognostic or diagnostic equations.).

Non CFD models may be applied to study flow and transport regimes in order to receive values on a statistical basis. The models can resolve some spatial differences, but have no temporal resolution. They are not developed to study pollution transport in single cases. In contrast, CFD models may be applied to study flow and transport regimes for specific situations. The model results are resolved in time and space, but the models need more computer resources than non CFD models. Therefore, they are rarely used for calculating statistical values, however, there is no principal restriction for deriving statistical values from the results of several single case studies. Based on the complex CFD models coupled model systems are currently developed to provide concentration maps as required by the European Framework Directive (e.g. Trukenmüller et al., 2002).

About each second model used in SATURN derives wind and temperature fields three-dimensionally from prognostic equations (CHENSI, FVM, GRAMM, MEMO, MESO-NH, METRAS, MIMO, MITRAS, SUBMESO). All mentioned models except CHENSI also calculate humidity from a prognostic equation. They additionally calculate pollutant concentrations from prognostic equations, which is also done by models ADMS, CALGRID, CAR-FMI, EPISODE, MARS, MUSE, UDM-FMI, VADIS. However, these models need to prescribe the three-dimensional flow fields and temperature effects. Model OPSM calculates flow and temperature fields at a 10 m level and uses a diagnostic equation for calculating concentrations.

The models differ not only in the basic equations but also in the parameterisations applied and in the treatment of chemistry. For example, only a minority of the models considers cloud micro-physical processes and the coupling of water phase and chemistry is even less refined. Concerning pollution transport Gaussian models, Lagrangian models and statistical analysis are applied within SATURN. Most models, however, use an Eulerain approach to calculate pollution transport. The chemistry modules applied reach from no chemistry, via simple gas phase chemistry considering NO, NO_2 and O_3 to complex gas phase reaction schemes. Aerosols are mostly treated as passive, but some steps are taken to consider chemically active aerosol or aqueous phase chemistry (MESO-NH, METRAS, MITRAS, MUSE). Most models use a resistance model for calculating dry deposition, and some consider wet deposition for different pollutants (EPISODE, MESO-NH, METRAS). The differences in the cloud treatment and multi-phase chemistry lead to quite different complexity when simulating wet deposition. This reflects the uncertainty in our current knowledge on cloud processes and multi-phase chemistry.

Most models can be nested one-way into results of larger scale models, and model MESO-NH also provides a two-way nesting. Compared to non-nested model simulations, already the one-way nesting should deliver better lateral boundary values for smaller scale models and thus increase the reliability of the results, especially when using small domains. However, studies performed with the METRAS model have shown that nesting is per-se no insurance for model performance. The data used at the lateral boundaries need to be of high quality too, otherwise the model performance might decrease – despite the nesting performed (Lenz et al., 2000). This leads to a point very relevant for all models, which was also one of the focal points of SATURN subproject: the model testing and validation is essential. One SATURN specific task were the MESOCOM test cases where several of the SATURN models participated. A further test case uses comparison data from the ESCOMPTE field experiment. Several models participated in this model inter-comparison. All these test cases focus on the urban scale. Street canyon model results were compared with wind tunnel data (e.g. Grawe and Schlünzen, 2002). Several models participated in the street canyon model test cases of the TRAPOS project. The results of the models differed considerably from each other and also from the comparison data. The reasons are still not fully understood.

Conclusions

The status of the models applied within SATURN has been summarised in the SATURN model inventory. The models differ in their complexity, since they have been developed for different purposes. Not all models need all qualities. It is by far more relevant to evaluate the models with respect to their specific application range and to ensure their performance for the tasks they are intended to do, than including all qualities into all models. Model evaluation is a continuous task of model development and it is essential, when model results are used for cost-effective planing, political decisions or environmental impact studies.

References

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Aims for next year (i.e. 2002) and list of publications in 2001

Final update of the SATURN model inventory.

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