Editorial

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Biographical notes: Krassimir Georgiev received his MSc Degree from the Sofia University and his PhD from the Bulgarian Academy of Science. He is an Associate Professor at the Institute for Information and Communication Technologies of the Bulgarian Academy of Science. He is a member of European Mathematical Society, Bulgarian Union of Mathematicians and SIAM. His main fields of interest include: numerical methods and algorithms for partial differential equations, mathematical and computer modelling and parallel computations. He has published more than 100 papers. He has organised many mini-symposia in the field of environmental modelling and high-performance computing (see more details in http://parallel.bas.bg/~georgiev/).

Zahari Zlatev received his MSc from the Sofia University and his PhD from the Sct. Petersburg University. He is a Senior Scientist (National Environmental Research Institute, Aarhus University) since 1980. He has developed, together with several co-workers, the Unified Danish Eulerian Model (UNI-DEM), which has been used by scientists of several European countries in many environmental studies and scientific projects (http://www.dmu.dk/Atmospheric Environment/DEM). He published six monographs five proceedings volumes, 11 special issues of international journals, 115 papers in international journals, 155 papers in proceedings of international conferences and more than 200 institutional reports (see more details in http://www.dmu.dk/Atmospheric Environment/zlatev.htm).

Adolf Ebel is Retired Professor of Geophysics at the University of Cologne, Germany. He is one of the originators of the Rhenish Institute for Environmental Research (RIU) at the University of Cologne and served as Head of the institute till 2008. His field of research is atmospheric science, in particular modelling of the regional atmospheric environment. He has been participating in numerous national and international projects of atmospheric research. For the European environmental project EUROTRAC he coordinated the sub-project for regional modelling (EUMAC). He is author and co-author of a large number of articles in scientific journals and books.

The control of the pollution levels in highly developed regions of Europe, Eastern Asia (first and foremost, China and Japan) and North America is a very challenging task for the modern society. This task is also very important or, at least, will soon become very important for many other highly industrialised regions of the world. Its relevance has been steadily increasing during the last two to three decades. The need of establishing reliable control strategies for the pollution levels in order to prevent damaging effects on plants, animals and human beings will become even more significant in the future. Large-scale environmental models for studying the harmful effects that are caused or may be caused by high pollution levels can successfully be used, when several conditions are satisfied, to design robust and reliable control strategies. In many cases, the application of advanced models is the only means by which many important physical and chemical processes can be investigated. The influence of future climatic changes on the high pollution levels is one example for a situation in which only models can be used. Many other examples can easily be given.

However, complex mathematical models can be used for obtaining the best and most reliable answers to many important questions related with our environment only if several demanding features regarding model quality and efficiency are met by them. Before starting to run operationally an environmental model, the developers must fulfil several extremely complex tasks in a satisfactory manner. The following points are most important:

- describe in an adequate way all important physical and chemical processes
- apply fast and sufficiently accurate numerical methods in the different parts of the model
- ensure that the model runs efficiently on modern high speed computers (and, first and foremost, on different types of parallel computers)
- use high quality meteorological data and emission inventories as model input
- verify the model results by comparing them with reliable measurements taken in different parts of the spatial domain of the model
- carry out sensitivity experiments to check the response of the model to changes of different key parameters
- visualise and animate the output results in order to make them easily understandable even to non-specialists.

It is absolutely necessary to fulfil efficiently all these tasks. However, the treatment of such large-scale air pollution models, in which all relevant physical and chemical processes are adequately described, leads to great computational difficulties related both to the CPU time needed to run the models and to the input and output data used during the runs and saved for future applications. Therefore, it is necessary to give a convincing answer to the question:

> *Why are large-scale comprehensive mathematical models needed (and also used) in many environmental studies?*

It has been mentioned above that many difficult and important problems can be studied only by using models. However, it is also well-known, by the broad public in Europe, North America and all other parts of the world, that the air pollution levels in a given region depend not only on the emission sources located in it, but also on emission sources located outside the region under consideration, and even on sources that are far away from the studied region. The relationship between emission sources and pollution levels is important and can most successfully be studied by applying advanced mathematical models. It is important to find out how the pollution can be reduced to safe levels and, moreover, to develop reliable control strategies by which the pollution can be kept under certain prescribed critical levels. In European Union the critical levels are clearly formulated in a series of directives issued by the European Commission and the European Parliament (see, for example, European Parliament, 2002). The reduction of the pollution levels is a very expensive process. This is why one must try to optimise this process by solving at least two important problems:

- the air pollution levels must be reduced in a reliable and robust way to prescribed critical levels
- since air pollution levels in different parts of a big region (as, for example, Europe or North America) are varying in a quite wide range, the optimal solution (a solution which is as cheap as possible) will require reducing the emissions by different amounts in different parts of a big region.

Complex environmental problems are usually studied by coupling *several* models each of which is normally described mathematically by a large system of partial differential equations. Weather forecast models, air quality models, climatic models, models for emission generation (including here generation of biogenic emissions) and models for studying formation, transport and transformation of aerosols (including here organic aerosols) are among the most used at present models in environmental research. Often some and even all of these models are combined in complex modelling systems, the treatment of which is very difficult both because different physical and chemical processes are to be handled simultaneously and because enormous sets of data, involving meteorological, chemical and emission data, are to be made available and used continuously during the whole computational process. Such modelling systems become even more complicated when some sufficiently accurate data (collected at measurement stations or supplied by satellites) have to be assimilated in the models. This procedure leads to problems related to control theory. The implementation of data assimilation requires the solution of huge optimisation tasks and the treatment of inverse problems. The numerical and computational challenges are enormous in this case (see, for example, Zlatev and Dimov, 2006) and the development of some special algorithms for meeting them is absolutely necessary.

On the other hand, the development and the subsequent treatment of complicated modelling systems allow the specialists to resolve successfully many important environmental problems for the modern society.

Both the development of modern modelling systems and, even to a greater degree, advanced applications of such systems in different environmental studies are employed in many countries by researchers from different scientific areas. Studies and simulations related to

- implementation and use of data assimilation
- use of advanced computer architectures to handle modelling systems numerically
- impact of climatic changes on pollution levels
- damaging effects caused by aerosols
- dust simulation
- sensitivity analysis
- forest fires, etc.

are major topics of investigations in the area of environmental modelling.

Some of the above topics are studied in the papers included in this special issue. The impact of climatic changes on pollution levels is studied in the papers of Pieczka et al. (for the area around the Carpathian Mountains) and Syrakov et al. (for Bulgaria). The difficult problem related to the application of data assimilation in a complex modelling system is treated in the paper of Strunk et al. The preparation in a robust way of some meteorological parameters is discussed in the paper of Batchvarova et al. Short periods of very high pollution levels, which are potentially dangerous for human beings, are called episodes. The application of the US EPA Model 3 System in the investigation of episodes of some high levels of PM 10 concentrations is discussed in the paper of Todorova et al. The sensitivity of the model results to changes in the rates of some chemical reactions is studied in the paper of Ostromsky et al. on a large space domain containing the whole of Europe. Inter-annual variations of ozone and some quantities that are related to the ozone concentrations and can be harmful for plants and human beings when critical levels prescribed by the European Union are exceeded, are studied in the paper of Georgiev and Zlatev.

The papers in this issue were presented at the International Conference on Large Scale Scientific Computations held in June 4–8, 2009 (Sozopol, Bulgaria). The conferences on Large Scale Scientific Computations are regularly held in every second year. The last conference was the seventh one. The next conference will presumably be held in June 2011. Sozopol is a very nice and quiet small town on the coast of the Black Sea and normally more than 100 participants from many countries from all parts of the world are attending these conferences. We advise the readers of this special issue to consider the possibility of attending the next conference in Sozopol.

References

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