Mathematical background of a large-scale environmental model

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The Unified Danish Eulerian Model (UNI-DEM) is a mathematical model for studying pollution levels in different European countries. It is described by a non-linear system of partial differential equations (PDEs). The number of equations in this system is equal to the number q of chemical species involved in the model. The space domain contains the whole of Europe together with parts of Asia, Africa and the Atlantic Ocean. The discretization of this domain on a (480×480×10) grid transforms the system of PDEs into a huge system of (480×480×10×q) ordinary differential equations (ODEs). If the number of chemical species is q=56, then the system of ODEs contains 129 024 000 equations. More than 200 000 time-steps are needed if a run over a time-interval of one year is to be performed. Finally, long-term runs (over many years) and runs with many different scenarios are often required (for example, in important studies related to the influence of the climatic changes on pollution levels, [1], [2]).

The above discussion shows clearly that the computational work is enormous and can successfully be carried out only when four crucial requirements are satisfied. It is necessary (a) to select fast and sufficiently accurate numerical methods, (b) to apply reliable and efficient splitting procedures, (c) to exploit the cashe memories of the available computers and (d) to parallelize the code.

Some of the applications of UNI-DEM in large scientific studies will be discussed in this talk. Results related to pollution levels in Hungary and its surroundings will be shown in order to illustrate the ability of the model to resolve efficiently some essential practical tasks.

[1] Z. Zlatev, Impact of future climate changes on high ozone levels in European suburban areas, *Climatic Change* **2010**, *101,* 447-483.

[2] Z. Zlatev, Á. Havasi and I. Faragó, Influence of climatic changes on pollution levels in Hungary and its surrounding countries, *Atmosphere* **2011**, *2,* 201-221.