Visualization of meteorological data

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Visualization

During the 1960-70's computer graphics was used for displaying scientific results. High cost equipment and limited available funding in the non-commercial area meant that progress was slow.

In the mid seventies, commercial use of computer graphics became common practice, e.g. CADCAM for industrial usage, advertising, film and TV. The developments in the computer graphics area were often commercially funded.

The **visualization** concept was introduced in USA in 1987, the goal being to provide better computer graphics tools for visualization of scientific results. Initially, the aim was to make use of techniques developed by industry. However, many of the available techniques required further development to make them useful for scientists.

The expectations for visualization are great but the availability of sufficient funds for non-commercial developments is a problem.

The problem of visualizing meteorological data

Meteorological data is given in 3-dimensional space with many parameters in time. The purpose of visualization is to display the evolution of the parameters and their interactions in time. The aim of visualization is to provide better insight into the nature of the data, better understanding of model behaviour and better support for the analysis of problems. The development cycle, where more powerful graphics systems are becoming available and the amount of model data to analyse continues to grow, is likely to continue. There will also be an increasing complexity in the relationship between parameters.

Visualization techniques for meteorological data

Current techniques enable the display of a small amount of available information from the model within a reasonable time. Traditionally, 2-dimensional maps are used. The aim is to find better software and hardware techniques to visualize more information within a given time. But, it is not only a question of throughput; new visualization techniques will probably be more important if (eventually) accepted by the users.

Non-interactive 2-dimensional representation

Monochrome maps, often produced as hardcopies, are still standard in many meteorological services. They can be filed, copied and sent via telefax.

The use of colour allows more information to be presented [1]. Problem areas are: hardcopy cost, turnaround and reliability. Often graphics terminals are used to display colour maps. Hardcopies on transparencies are popular for presentations.

Animation sequences in time, on video tape or slides, are the most efficient solution [2].

An example of a non-interactive 2-dimensional package is MAGICS [3, 4], developed by ECMWF. It is used for most of the general graphics meteorological applications at ECMWF and conforms to standards (WMO GRIB and BUFR, ISO GKS and Fortran 77). The use of standards aids portability. MAGICS includes a flexible and user friendly interface, modern contouring methods. A UNIX version is planned. MAGICS has been made available to the Member States.

Interactive 2-dimensional representation

An example is MicroMAGICS [5, 6], which was developed in a joint project with CPTEC in Brazil. It is suitable for IBM PC/AT's and their compatibles. The essential functionality of MAGICS is maintained with an interactive layer added. The input format is in GRIB with BUFR to be added later. A workstation/UNIX version is planned. MicroMAGICS has been made available to the Member States.

Three-dimensional representation

To find better techniques to visualize more information within a reasonable time, the use of 3-dimensional graphics is attractive. This will not only allow more information to be displayed on the same chart but will also help analyzing true 3-dimensional problems, e.g. evaluation of model errors.

Non-interactive 3-dimensional representation

At the Cray Experimental Graphics Workshops in Meteorology [7] several tests have been done. Non-interactive 2 1/2-dimensional animation is acceptable but the amount of information per frame is limited. An example of 2 1/2-dimensional animation is four tilted planes where each contains one or two meteorological variables over the same limited area.

Non-interactive 3-dimensional animation has been found of limited value. It is difficult to understand and the position of data is not always obvious. Wind fields can be shown as vector fields or trajectories whereas other fields are often displayed as volumes. Volumetric transparency adds to the understanding of the images. Currently, high quality 3-dimensional animation often implies slow turnaround and is heavy on computer resources.

Interactive 3-dimensional representation

Recently, graphics supercomputer workstations have become available. These allow realtime 3-dimensional animation.
The user can interactively control the type of display technique to be used for each meteorological parameter and the viewpoint

for the area can be interactively modified. This solves most of the problems encountered with non-interactive 3-dimensional techniques.

Available supercomputer workstations allow only the visualization of a subset of the model output, due to limitations e.g. in memory. The cost of these workstations is high and it is not easy to predict the lifetime of such systems.

Promising experiments in this area have been done by William Hibbard at the University of Wisconsin, Madison [8].

Conclusions

Graphics is very important for ECMWF and meteorological centres. Gradually, with better techniques, more and more information can be presented to the user in a given time. Two-dimensional representations are very useful (e.g. MAGICS, MicroMAGICS) whereas interactive 3-dimensional representations are promising but not yet mature.

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