III. WORKSHOP REPORT

1. Introduction

The Fourth Workshop on Meteorological Operational Systems was held at ECMWF, 22-26 November 1993. The programme and the list of participants are given in the front part of these proceedings.

The objective of the workshop was to review the state of the art of meteorological operational systems and address future trends in the use of medium-range forecast products, data management and meteorological workstations. The workshop was organised under the following main subjects:

1. Use and predictive skill of numerical forecasts in the medium-range

2. Operational data management

3. Meteorological workstations systems.

During the first session of the workshop, experience with the first year of experimental ensemble prediction forecast was reviewed in presentations from Member States. The related working group addressed the future operational requirements from the ensemble prediction system and the further development. The group also benefitted from the experience with the only other experimental ensemble prediction system currently operated at NMC Washington.

The other two sessions dealt with data bases in meteorological applications and with the development of meteorological workstations. Commercial products are considered by the developers to an increasing extent. Standards in user interfaces and the data representations were discussed as well as the suitability of Data Base Management Systems for handling on-line and off-line (archived) data. Meteorological workstations are under development in several Member States, in some cases the operational status of these systems is quite advanced. Much interest was expressed during the workshop in the potential use of 3D graphics on meteorological workstations. All participants appreciated the opportunity to exchange views on the whole spectrum of topics and to benefit from the expertise represented by organisations from all over the world.

2. Report of the Working Group on Ensemble Prediction Systems

Use of the Ensemble Forecast

The working group stressed that the proper use of an ensemble forecast should aim at something more sophisticated than simply smoothing the ensemble into a single, so-called deterministic forecast, or estimating an error bar for the high resolution forecast. The discussion was then organised around the three types of use foreseen for an ensemble prediction system.

(i) Forecast of forecast skill

According to the statistics produced at the Centre and in various Member States, good agreement between the various forecasts of the ensemble (small spread) tends to indicate high skill. Nothing can be said in cases of large spread. It seems that the skill estimate works best at shorter ranges, out to D+5. The occasions when the verification is not covered by any of the members have been relatively rare.

The experts from the Member States were encouraged to continue to try and assess the usefulness of the correlation between spread and skill in their operational environment. In particular, it was suggested that the forecast range when the 50% probability area stops in the "plume diagrams" might be a valuable indication of the longest useful forecast range.

(ii) Forecast of alternative scenarios

It was agreed that the present clustering does not provide satisfactory results, a probable reason being that the area on which it is based is too large. Also it is not clear whether the clustering should be based on individual days rather than a sequence of days as at present.

Ideally, each Member State should have the possibility to perform its own clustering, according to the local needs. Whether the clustering should be run on the computer system at ECMWF or locally, will be explored depending on the technical circumstances. ECMWF may consider the development of an export package for clustering.

The possibility of basing the clustering on synoptic patterns instead of RMS differences between fields was discussed. The application of a neuronal network to the synoptic analysis of a 500 hPa field has been tried at ECMWF and will be pursued further.

Another possibility is to base the clustering on the model output of weather parameters (T2m, precipitation and surface wind). In this case, the area should be very small. The forecasters would need to have a facility to view the synoptic situations leading to the various "weather clusters".

(iii) Probabilistic forecasting

This was seen as the real aim of the ensemble forecasting technique. However, it was stressed that the scientific requirement on the system is very stringent. To obtain statistically reliable estimates of probabilities requires for example that the spread of the ensemble, the frequency of extremes, etc. should be realistic. In addition, the number of elements should be sufficient, and the resolution of the forecast model high enough so as not to introduce undesirable systematic errors. All these topics are currently worked on at ECMWF.

A great interest was expressed for the probabilistic charts for weather events to be implemented during winter 1993-94. It is expected that the forecasters will be able to assess the usefulness of these products in a relatively short time, and to provide feedback to ECMWF.

It was recalled that post-processing is required when using the forecast weather parameters. PPM or adaptive filtering can be used, but not the MOS technique.

Many users will need additional training on the probabilistic forecasting technique when it is better established. The Centre should consider to organise training on the subject in 1995.

Verification of the EPS

No criteria have been generally accepted to measure the skill of an ensemble forecast. The advantages or disadvantages of the Brier scores and other similar scores were discussed. They are difficult to interpret in terms of practical usefulness and reliability of the forecast. Probabilistic charts can be more easily verified, because they focus on the realisation of a single well defined weather event.

Future work on the system

The work on the generation of the perturbations and on the forecast model to be used is continuing, as mentioned above. Meanwhile, it is planned that the EPS will be run daily in the 1st half of 1994, thereby providing the forecasters in the Member States with the possibility to assess the use of the system in quasi-operational conditions.

A study to improve the clustering will be undertaken along the lines described above.

There is a variety of possible products based on the ensemble, which has yet to be explored. Many ideas were mentioned. Member States users should be involved as much as possible in this work, however, the access to the basic data from the Member States is sometimes difficult. In order to facilitate that aspect, a data set of direct model output interpolated to particular locations in Europe for all the members of the ensemble could be created at end of the runs of the EPS and kept on-line for a limited period of time.

Interfaces

From the discussion, it was obvious that there is a need for different types and levels of interface. Batch applications generally use C interface routines for the sake of efficiency, but are not as portable as a result. Embedded SQL is also used, with a small performance loss, but if standard SQL is used there is a gain in portability. For interactive use X, workstations and GUI's are appropriate.

Retrieval of data from databases generated the liveliest debate, as it was felt that most input to the databases would be through batch applications. The problem is not in storing the data, but in retrieving it in the appropriate form. From the meteorologists' point of view, SQL was seen as far too complicated and was strongly resisted by users. It was seen as a computer programming development language not suitable for meteorologists but for computer programmers. SQL is too low a level and is for specialists who have particular needs beyond the application level. The meeting was also warned about the power of SQL, where mistakes can very easily be made which could result in overloading the computer and blocking database access.

Users do not want to know about database layout and tables, just query their data. A pseudo-SQL, allowing users to query the database without this type of knowledge is very desirable. Most sites provide higher level interfaces, and it was suggested that commercial database companies could provide commonly used interfaces, e.g. selection of observations on a map. Another suggestion was to make use of the WMO software registry for the exchange of commonly needed software. If standard tools were not available, each site would continue to develop its own user interfaces in its own way. If meteorological data was described in a conceptual model, it could be queried as such, perhaps paving the way for a 4-GL for meteorologists.

Meteorologists want to use simple queries, by means of an interface where they can describe data in meteorological terms. Ideally, they would like a standard way of making queries with a fast track access if a request is repeated.

Databases and archives

All Unix based mass-storage archive systems are file based, where files would have to have many observations or fields in a file. These bigger entities are needed for archiving, whereas individual observations or fields are more appropriate units for on-line databases. There seems to be a reluctance to address this important problem. One solution that was put forward was to archive large files on

tape and, when retrieval of data was necessary, restore them to disk in the on-line database form and then extract the required data. The argument was that disks will always be expensive, but CPU speeds are still increasing rapidly, making the conversion easy and cheap.

There was a general reluctance to use the archive facilities provided by the commercial database companies. The preferred solution seemed to be for sites to dump files to tape and manage the archive themselves.

When such data is off-line, RDBMS could be used for managing the metadata necessary for retrieval. The view that users should not tie themselves to archive systems provided by database vendors was expressed, because by keeping an archive in an independent form, moving from one database system to another would be easier. However, the view that an archive could be truly independent with standard data representation forms, BUFR and GRIB, was challenged and the point made that BUFR and GRIB do not cover all types of data needing to be stored and are themselves liable to change. The fear of archive conversion was not felt by all, as magnetic tapes have, in any event, to be copied regularly and adding format conversion at this stage would not be a big overhead. In addition, new data volumes are increasing so rapidly that the amount of data to be converted to a new format will always be small. One database user had a system which was transparent to users, exporting less frequently used tables to archive, with these being returned to the online DBMS when required, and planned to keep everything online on optical disks in the future.

The idea was expressed that what the users really wanted was their data, and did not want to know whether data came from an archive or from an on-line database. The system should take care of these matters. However, it had been found very useful to provide users with the means to find out which data was off-line and what effort was involved in retrieving it.

Some other topics were brought up at this point. The security of systems in guarding against unauthorised access, loss of data and recovery were considered adequate. Performance did not seem to be as big a problem as portability, even though there were different performance expectations for different applications eg real-time operational applications or climatological queries. Metadata for meteorological data is getting more complicated and is in many cases a bigger problem than the data itself.

Databases on supercomputers were discussed. One user described his experience with such a system. The general feeling, however, was that a DBS should reside elsewhere rather than on the supercomputer and that networking to a database server was preferable, especially in view of DBMS licence costs. New NWP models will produce terabytes of data and you will need a good tool to get this data into a database.

As for MPP's, do not worry about databases, worry about getting the models to run.

Data formats

BUFR and GRIB, the WMO standard formats for the representation of meteorological data, were discussed at some length. BUFR provides good compression of data when many observations are packed in one BUFR record. These compressed subsets are very useful and efficient for extraction of data for an analysis and model run, but make queries difficult for a single entity. However, the point was made that with the power and facilities of relational databases this could be resolved, and that it could simply be a question of cost. Many sites did not use BUFR internally, but relied on their own internal data formats, converting to the standard BUFR only for exchange of data, making translation to/from the binary formats needed. A view was expressed that BUFR was not a suitable data format for use on workstations. BUFR is machine readable only, and conversion is necessary for users to read. The WMO character format for BUFR data, CREX, is on the way and should be used to provide a standard human readable form for observations coded in BUFR. The data themselves are important, but forecasters still like to know the type of observation (e.g. SYNOP or METAR) from which the information came, and this facility must be retained.

4. Report of the Working Group on Meteorological Workstations

1. OBJECTIVES AND REQUIREMENTS

1.1 Data types and access

Many data types are required, e.g. model output fields, observations, satellite and radar images, lightning reports, etc. Also, many different formats for data storage were required (GRIB, BUFR, TIF, T4, CGM, PostScript...). The WMO working groups still need to decide on a suitable data representation of satellite images. RADAR images are currently being stored in BUFR but it has not been proven if this will enable a fast enough response time. JPEG for storing satellite data is fast and compression with no degradation is possible. JPEG is also used for animation. X Window dumps are useful. Public domain software is available for converting from one format to another. There is also the possibility that hardware will become available for performing data conversions from one format to another.

The working group felt that it was important to be able to choose the most suitable format for an application and to be able to convert files into suitable standard formats.

Data access done by manufacturers has improved and relational databases have worked better than expected. This could shape the future of Meteorological Workstations.

1.2 Data manipulation

With distributed systems, it should be possible to have the possibility to decide where to carry out data manipulation.

1.3 Visualisation

Screen dumps are useful for internal purposes but have low resolution. When high resolution is required, appropriate drivers should be used. Screen output does not appear to have decreased the use of paper hard copies. Faster printers would result in more hard copy plots.

1.4 Performance vs. standards

Managers, users and programmers all have different objectives with respect to standards. While generally users are unconcerned about standards, the managers and programmers would both prefer to have them. It is desirable to build systems using as many standards as possible. However, this can result in both benefits and problems. It improves portability but introduces the risk of degrading performance. Standards are always slightly out of date and, therefore, they should be continually reviewed and standards sought.

While it is recognised that it is not always possible, a short response time is regarded by everybody as being important. The widespread use of distributed systems and networks makes it difficult to predict response times. If a long response time is expected, the user could be given some sort of estimate, with the option to stop the process. The user could also be given a progress report from time to time, bearing in mind that degradation may occur with too many system inquiries.

1.5 Portability

The working group felt that UNIX, NFS, X and Motif are still useful for some time to come. Portability between UNIX systems is still a problem. The appearance of Windows NT could be a challenge to UNIX but a 'wait and see' approach is most sensible for the time being. Windows NT has put pressure on UNIX suppliers to make their system more compliant. Some companies are trying to integrate UNIX and Windows NT.

1.6 Batch

The general consensus of opinion was that there is, and will continue to be, a demand for the automatic production of plotted output on paper via batch. For most organisations, the cost of providing workstations for everybody is too prohibitive and, therefore, the use of batch will continue for some time. It was recommended that batch facilities be provided with the Meteorological Workstations so that users can keep their options open.

2. PRODUCT PRESENTATION

2.1 2D, 3D, 4D

2D with or without animation is very acceptable. It has recently been shown that 3D with animation can be a powerful tool for research purposes but there were no demands from forecasters at this stage. The VIS5D system has been used to demonstrate the 3D graphics, particularly for features which are difficult to visualise in 2D, e.g. jet streams and vertical velocity. This gave a better understanding of the atmosphere. There are some data problems with 3D as model data has to be transformed before use and some difficulty was encountered in getting all the required variables into the system. Forecasters may need considerable training before 3D could be used operationally. Other considerations are that 2D requires less system resources than 3D and that some details in 2D are lost in 3D, e.g. geographic position.

2.2 Interactive editing/visualisation

Editing visual data is important. It was considered useful to be able to modify fields for a fast re-display.

2.3 Graphics systems

Recent public presentations have suggested the use of

GKS and Xlib for 2D
PEX, OpenGL, AVS, Explorer, VIS5D for 3D with animation.

OpenGL, originally implemented by SGI, will be available on most platforms and should be assessed for its 3D capability and performance.

Some good results with PVWAVE based on GKS were experienced. Others disagreed and it was pointed out that it was not portable.

3. USER INTERFACE

3.1 Metaphors

A user interface metaphor is a conceptual view of the interface or a perception of how a user works. The desktop metaphor, i.e. many windows overlapping, is similar to the way one works at a desk. The Working Group reached no firm decisions on the selection of metaphors or the number of windows that should be used; some preferred to allow only one or two windows while others recommended that the user be allowed to select the number of windows. There was a suggestion that a help button be made available to re-order windows if they get 'out of control'. There was agreement that it should be possible to expand a window to its fullest possible size. Some organisations use more than one monitor in their configuration which allows them to have more/bigger windows.

3.2 Tailoring of the user interface

The various windows of a Meteorological Workstation should conform to the recommendations of the window system (e.g. Motif) used. Motif provided style guides but many users care more about the tasks to be performed than being consistent with the Motif Style Guide. There was general agreement that the user should be allowed to tailor the user interface except in a shift work situation where it might cause problems.

3.3 Local language

Users seemed to prefer their own national language rather than English, but English was an option in some Member States. Some expressed a preference for pictures or icons rather than text. Apparently, there are no standards for icons and they can often be confusing for new or occasional users and they can also be used inconsistently. There is a danger in using national language, as Motif imposes strict behaviour for certain keywords which could be lost in an inconsistent translation. Some users, after a while, seem not to read the actual text on a button but rather tend to use a button because it is in a given context or position.

The problem with language is more political than technical and there are many more important issues, e.g. standardising scientific terms and units. It was recommended that the number of languages used should be balanced against the labour used to produce them. A book has been published giving standard translations of keywords between all European languages.

3.4 Development tools

An exchange of experience with various development tools took place. Tools like XDesigner, Codecentre, QA-FORTRAN, Workshop were mentioned. XDesigner was especially praised as an excellent tool for building Motif window interfaces. The programming languages used are C, C++ and less frequently FORTRAN. C++ provided modularity but there are some problems with portability as the compilers can vary quite a lot on the different platforms. Mixing languages can be a problem, especially between FORTRAN and C++. C++ allows organisations the ability to group programmers according to their skills; some are best at designing basic concepts and others at inherent classes. The C language allows the programmer a good deal of freedom and, therefore, the danger of inconsistent usage. Style guides should be provided for users to avoid obvious traps.

3.5 Structural analysis and design

Structural analysis and design methods were discussed. Different opinions were offered as to whether a project should start with a solid analysis or go straight into programming. Some think it is desirable to start with programming as it often gave valuable insight into the problem which could not have been obtained otherwise. Others felt it was important to have a clear idea of basic concepts before programming began. Structural analysis was considered difficult to use with graphics as proper tools were not yet available. There was a demand for better case tools even though it is thought that case tools can cause time loss.

Big projects with dependencies need a good case tool, which could be a central repository for data. This would enable users to know who is using what.