REPORT FROM THE MEETING ON METEOROLOGICAL WORK STATIONS IN OSLO, NORWAY 5-7 JUNE 1990

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1. INTRODUCTION

There has been a very fast development during the latest few years of computers classified as work stations (WS), both in hardware and software. This development will continue and it is hard to predict its trends. At many meteorological services there exist meteorological WS (MWS), or projects to develop MWS, which are used or will be used by the forecasters in his daily forecasting work. Such stations will present all relevant information needed for weather monitoring (observations, output from numerical models available, satellite and radar imagery). The stations have fast response and user friendly interfaces. In this environment the meteorologist is able to make his decisions directly from interactive display sessions. The forecaster has the possibility to correct model output by means of interactive tools, for instance the preparation of traditional surface maps might take place on a WS. The development of MWS has just begun. It is believed that they will be introduced for all kinds of weather monitoring and forecasting and change the working methods in daily forecasting.

Every meterological centre has an interest in MWS and may have developed such systems (or will start some activity). Although the forecasting methods might change a little from country to country, the scope of the work is similar everywhere. The need for cooperation between centres is evident. In particular, the small countries with limited resources will benefit from exchange of ideas, knowledge and software.

This meeting was the first step in establishing a cooperation between European countries in the development of MWS for weather monitoring and forecasting. The initiative was taken after the ECMWF's workshop on operational forecasting, Dec. 1989. Informally, a small meeting between a few countries with ongoing projects in the field was then suggested.

Altogether, 12 participants from four countries and ECMWF were present at

our Oslo meeting (see Appendix 1). It started at 1300 tuesday 5. June and ended at lunch-time thursday 7th. Two main questions were addressed: What is the basis for future cooperation? or what is the actual position and actual plans for meteorological work stations at the different institutions? And then, what means of cooperation are possible and how can it be organized?

The meeting followed the agenda found in Appendix 1. Sigbjørn Grønås, Norway, was elected as chairman of the meeting. After the presentations, there were discussions and recommendations for further progress. Finally, further cooperation was discussed and recommendations given.

2. THE CONCEPT OF A METEOROLOGICAL WORK STATION

Before the presentations the concept of MWS was discussed and the scope of the discussion was limited towards a MWS for general weather monitoring and weather forecasting.

A meteorological centre will normally do data acquisition (e.g. GTS data), preprocessing, numerical weather prediction (NWP), postprocessing, presentation of results and dissemination of products to end users.

The data acquisition, preprocessing and NWP will make available the following kinds of data: reports (observations), fields from NWP, images (satellite, radar). In addition messages, mail and climatological databases should be available. A MWS will need access to all these data and data representation is an area of interest to designers of MWS.

The output from numerical models - preferably at model coordinates - and images will be postprocessed in different ways. Typical examples are vertical interpolation to pressure or potential temperature surfaces, interpolation to maps, derivation of additional parameters (e.g. vorticity, divergence, potential vorticity, stability indices, gust estimates), trajectories, image manipulation (e.g. rainfall estimation, fog detection, cloud classification), verification and dynamical/statistical interpretation.

A MWS should typically be able to perform such postprocessing and display

the results. When postprocessing is too time consuming, the processing necessary to make new numerical fields is made prior to the presentation (e.g. transformation to new vertical coordinate). However, very often the postprocessing will involve small computation amounts and the processing and the presentation might be done every time such a product is needed (e.g. vorticity, divergence from the wind fields).

More complicated forms of postprocessing might be mentioned, e.g. the running of oceanographic models, air pollution models etc. In our discussions we concentrated on general meteorological information and general weather prediction. Extensions to aviation forecasting or ocean monitoring, for example, are envisaged but this was decided to be outside the scope of our discussions. Dissemination to end users might also be included in a MWS, but this was not discussed during the meeting.

3. NATIONAL MWS STATUS AND DEVELOPMENT

Finland

A meteorological work station has already been developed and is operational at the central Finnish Meteorological Institute (FMI) and at six regional offices.

Why a work station:

During this decade computers have invaded meteorological offices: There are separate terminals for satellite and radar information, data communications (weather messages), word processing etc. Data is viewed on paper, and on different terminals having different scales and different user interfaces.

There are also meteorological reasons, that speak for the work station. There is a lot of observational material, and part of it gets discarded in the traditional handling. On the other hand, part of the material is superfluous in some situations. The work station offers a tool to use only the material that is needed, but maximizes the amount of material

available. Secondly, with traditional methods it is impossible to overlay pixel graphics with vector graphics, i.e. satellite and radar pictures with plottings and isoline charts. Combining different kinds of observations gives new extensions to the use of each type of observation material.

Data

The real time data available are 24h backwards and three and a half days of forecasted data (up to 10 days). There is also a possibility to show historical data. The data base includes:*

- *surface SYNOP observations*
- *upper air soundings*
- *satellite images:*
    - *METEOSAT IR*
    - *NOAA IR and VIS***
    - *combined Meteosat and NOAA images***
- *weather radar images:*
    - *three Finnish radars*
    - *Scandinavian and other european radars**
- *numerical forecasts from HIRLAM, ECMWF (and others*)*
    - *classical direct model fields*
    - *interpreted fields (cloudiness, weather, etc.)*
    - *computed images (pseudo satellite images, etc.)*
    - *manual analysis from other regional centres (see Functions)*
    - *lightning detection***
    - *special data from automatic stations***

User Interface

The design goal for the User Interface was that "it should be easy to learn and use, and that no user manuals are needed" or, in other words, "it should be as easy and fast as a pencil and paper":

- *icon driven user interface*
- *all selections (parameters,area,time) are independent from each other*
- *fast response times*

- *context sensitive help, in three languages*

Functions:

- *scanning through the data (through time or through any parameter combinations)*
- *all observations available (e.g. there are some 1500 synoptic stations in Europe:*
  - *instant analysis by colour coding when only one or two parameters chosen, all observations are shown*
  - *traditional plotting when more than two parameters chosen, observation density depends on the size of the area shown*
- *subjective analysis on the screen by mouse:*
  - *drawing option customized for meteorological analysis*
  - *possibility to use numerical analyses or forecasts as a first guess*
  - *distribution to other meteorological work stations in other offices (and to newspapers and TV*)*
- *three dimensional trajectories*
- *real time data or historical data**
- *colour copies using an ink jet printer (size A4) or traditional plottings together with objective or subjective analyses using an eight colour pen plotter (size A3)*

Technics:

- *programmed in VAX-Fortran, 500-700 subroutines, 30000-70000 lines of code (nobody has ever counted)*
- *graphics system based on UIS-library (DEC software), in 1987 it was the only choice available*

The system includes several separate programs, all of which are controlled by one master program, which is:
- *user interface to several display programs*
- *user interface to context sensitive help and selection of the language*

All display programs have in common:
- *all functions selected by mouse: no command language*

- active state (has windows on the screen) or background state (running with all windows closed, but still collecting data etc)

- most of the data are kept in the central memory:

- fast response times, in most actions about one second

- independent selection of time, area and any combination of parameters

- file structure becomes obsolete

- real time data input

Demo

This work station was demonstrated at the meeting, on a VAXstation 3100 with 8 MB memory (made available by Norwegian DEC).

Footnotes:

* *option already included, but the data not yet available*

** *option already designed, but not yet coded*

France

At the French weather service there exist two different systems for the visualization of meteorological data:

the Meteotel system on dedicated raster hardware, which includes radar and satellite imagery, lightning data and model output from the PERIDOT model, and
Meteopac application, which is PC based and visualizes reports and plotted charts in vector form.

None of these systems could be characterized as a MWS. An ambitious project called SYNERGIE has been established in order to develop a station for weather monitoring and forecasting. The project was created in spring 1989 and a Tektronix station XD8830 was received at the end of 1989. Experiments have started and according to the project plan a MWS will be installed operationally in 1994. Two persons are working full time and several part time in the project. Hopefully, the manpower

will increase.

The objective is to provide forecasters with all available information, to help forecasters to select, display and combine the various sources of information, to assist forecasters in producing final products (charts, messages) and to facilitate the man-machine communication through a friendly user interface.

General graphics treatments such as visualization in windows, animations, superimpositions will be included and in addition, special treatment to draw surface maps and interactive correction of both model output and several interpretations of model output. The data sources will be fed in real time and a DBMS could be used. The station will include prospecting tools, which means editors for different media including video I/O.

In addition to these main functions for interactive weather monitoring and forecasting, the SYNERGIE work station will include data delivery, archiving, data base management and access to external data bases.

An important challenge of the project is to develop software based on industrial standards like UNIX and X-WINDOWS and to integrate these with meteorological standards like GRIB, BUFR, and MAGICS. Much efforts will go into user interface modelling.

<u>Norway</u>

No MWS has yet been developed, however, a project has started to develop a work station for the purpose of monitoring the ocean (wind, ocean waves, current, temperature, ice, etc.). Two Silicon Graphics work stations have been bought for this purpose. The present presentation system, called AFOSS, will be included, but new user interfaces will be built.

The AFOSS system is developed in order to cover the needs of the research department doing NWP research, ocean modelling and air

pollution research. At the same time it is used operationally and at the universities for NWP research.

The AFOSS system presents meteorological observations and model output from all available numerical models including experimental models. Radar and satellite imagery are not included, but will be provided by a separate system. The presentation is always made fully interactively from the data files. The system consists of the following elements: 2D horizontal fields (pressure and model vertical coordinate) and observations (including full SYNOP plotting), 2D fields using isentropic coordinates, 2D oceanographic fields, cross-sections (meteorological and oceanographical), vertical soundings (observations and prognoses), meteograms and trajectories. Normally the system is used on colour terminals to a IBM9377 computer, which is used for postprocessing and as front-end computer to a CRAY X-MP. A PC version exists for some elements.

Each of the elements in AFOSS is a Fortran program. The data files are direct access files with the structure used at The Norwegian Meteorological Institute. The files contain tables of the content with record numbers to the individual fields or observations. The IBM graphics standard GDDM is used. The programs have clean interfaces between data handling, data manipulation and graphics. The user interfaces are given by alphanumeric strings by the user. There is maximum flexibility concerning zooming, combination of fields from different numerical models, arithmetic manipulations, contouring, styles, smoothing, etc.

All the elements of AFOSS will be merged and implemented at the Silicon Graphics station, windowing will be introduced and new user interfaces will be made. So far only one person has been involved in the development of AFOSS. Hopefully, more resources will be added.

Satellite information will be provided through a special system called MISAT which will be ready this summer. This system will receive

satellite information, position the images, transform information to maps and do different types of image processing. The computer system is based on I²S 600 image processing software and hardware, a micro VAX II host computer, a Bulk Image Transformation Engine (BITE) and an Interactive Viewing and Analyzing Station (IVAS).

Sweden

During the last ten years The Swedish Meteorological and Hydrological Institute has through the project PROMIS developed a prototype work station for weather monitoring (nowcasting) and short range forecasting. This system includes monitoring of special local area observations, interactive use of simple dynamical models, presentation of satellite and radar images and lightning location data. Interactive drawing and text editing are included. The system platform is DEC VAX-VMS and a TERAGON work station with fast discs. The PROMIS work station is operational and the project is now being validated.

Some effort has been spent during the last year to develop yet another set of programmes for graphical presentation of meteorological fields and observations. Although external software packages can serve many purposes, it was found advantageous to use locally developed programmes in order to easily tailor the presentations for optimum acceptance by the users. For the generation of isoline charts ease-of-use is essential. In operational routines, a standard set of maps is usually sufficient, but for R&D and special investigations very high flexibility is needed. It is advantageous if exactly the same package can be used on different computers, e.g. a "mainframe" and office PCs. Also, it is essential that input fields and observations are in standard GRIB/BUFR formats and that it is easy to select experiments, dates, parameters etc. from the database.

In our new chart package, called MetgraF, these features have been central in the design work. Derived fields not in the database, such as e.g. wetbulb temperatures, Q-vectors or differences, are calculated from the available archived fields. A special feature is the contouring

algorithm, which does not require any coordinate transformation of the fields. There is only one preliminary transformation of the coordinates of the input grid-points. Hence it is very easy to plot maps for different projections and arbitrary subareas.

The package also contains facilities to plot cross-sections, Thermodynamic diagrams with observed and predicted profiles, observations (BUFR is not yet implemented, the operational SMHI format is used) as well as pixel information (satellite imagery).

MetgraF is so far running on PCs (MS/DOS), VAX(VMS) AND Convex C-2(Unix+GKS).

ECMWF

The introduction of a new generation of super-computers and work stations that are based on several common platforms (UNIX, X-windows, NFS, ISO/OSI) paves the way for meteorological visualization software systems that benefit from these environments.

Some planned developments in this area are :

MAGICS

MAGICS 3.0 has now become available to the Member States. At ECMWF, MAGICS 3.0 will be implemented on Cray COS/UNICOS, Cyber NOS/VE and VAX VMS.

A UNIX implementation for the SUN 4/110 work station using SUN Fortran and GKS will be announced in July. MAGICS 3.0 will also be implemented on the DEC station 5000 model 200 PX.

A pre-release version of MAGICS with support for observations in BUFR has been developed and is currently undergoing testing on VAX VMS. It is planned to release MAGICS with support for BUFR by the end of the year.

MicroMAGICS

MicroMAGICS 1.1 for MS-DOS has been developed by CPTEC, Brazil, and will become available to the Member States in June. MicroMAGICS 2.0, which is planned to become available in the first quarter 1991, will add support for display of satellite images and observation plotting using BUFR.

MicroMAGICS/UNIX for Sun work station is also being developed by CPTEC and is planned to become available by end of the year. This version, which is based on the full MAGICS 3.0, requires SUN GKS and Fortran.

It is considered, for later version of MicroMAGIC/UNIX, only to use GKS for generating graphics output and use X-windows for all mouse/menu handling etc. CPTEC is developing a GKS-like library called GKX which is call-compatible with the GKS output primitives. The GKX library is internally fully based on X-windows.

Metview

There are plans to develop a general and unique system for the visualization of meteorological data at ECMWF which should serve the scientist and the operational analyst alike. The Metview concept will provide a standard framework within which applications relating to the retrieval, processing and visualization of meteorological data can be implemented, and will enable both Operations and research Departments to use the same facilities. Over the next years Metview is expected to progress in a modular way. Batch procedures for running applications on the Cray should be enhanced by a fully interactive system running under Cray UNICOS and, possibly, VAX VMS systems. The user interface will be based on X-windows, enabling it to tun on both UNIX and VMS work stations. This development will take place in Operations Department in collaboration with the Research Department.

4. RECOMMENDATIONS ON MWS DEVELOPMENT

The technical and meteorological aspects necessary for further progress in the continuous work on MWS were discussed and the following recommendations made.

4.1 Allocation of resources

The meteorological services in the different countries should allocate the necessary resources for the development of meteorological work stations for weather monitoring and forecasting. Groups of minimum three/four persons should be working more than half time (in projects) in each country.

The arguments for increasing the efforts might be listed as follows:

- *A MWS represents a comprehensive way of presenting large amounts of meteorological information.*

- *A MWS with all observations, images and model output available makes it possible to develop new methods of weather monitoring.*

- *The environment of a MWS makes it possible for the forecaster to add information by human intervention.*

- *A higher productivity might be obtained since the monitoring is more easily performed and the duty meteorologist will do the visualization himself without assistance.*

- *A rapid development takes place towards more comprehensive and advanced systems. Evaluation of the trends need people with sufficient knowledge.*

4.2 Requirements for a MWS

- *The response time to get a new product should be small and less than a few (two/three) seconds.*

- *A MWS should include postprocessing and presentation. The presentation should be interactive, which means computation of the*

graphics from the data files every time a new product is displayed.

- Flexible interactive presentation of observation plots (e.g. the WMO synop model and vertical soundings), model output (e.g. accumulated precipitation, clouds) and images should be available. Normal meteorological maps for visualization, such as cross-sections, meteograms and trajectories, should be included.

- Verification of forecasts should be included.

- A "mouse" or equivalent equipment should be used to select products.

- The user interfaces for operational use should be based on icons. Language dependent systems should be avoided.

- The computation system should be flexible and open-ended.

- Animation or "flipping" of products should be available.

- The design of a MWS should be modular with clean separation between the data handling, graphics and user interface.

- Two-dimensional systems should be implemented. Extensions toward three-dimensional graphics are welcomed. Also such graphics should be interactive.

- No recommendation on the hardware platform is given.

4.3 Recommendations on standards

Meteorological

- The WMO meteorological standards GRIB and BUFR should be adopted, and the suitability of these standards for image data should be investigated. To fit the different data formats available in different countries the processing programs should be kept independent of the formats. Then only one interface between data and processing is needed.

- *In addition to the mentioned standards, there is a need of a data base system, or arrangements of the data files, which makes it easy to select data from a file. SQL systems for catalogues should be investigated.*

Computational

- *A WS platform will normally use UNIX operating system and UNIX is recommended.*

- *The programming languages should be C or Fortran. Use of object oriented languages should be investigated (e.g. C++).*

- *The user interfaces should be designed using window concepts such as X-window.*

- *There is a need for high level tool kits when developing user interfaces. In this connection standards like MOTIF/OPEN LOOK are desired.*

4.4 Cooperation

Designers of MWS are encouraged to cooperate with the ongoing efforts of WMO in promoting the exchange of software, as well as other meteorological application software.

5. ORGANIZATION OF FUTURE COOPERATION

Ways of further cooperation were discussed and the following decisions were made.

5.1 Formation of a working group

The meeting agreed on forming a working group to promote development of meteorological work stations for weather monitoring and forecasting. The name of the group will be:

European working group on operational meteorological work stations (EGOWS)

The objectives are:

> *To promote cooperation between the meteorological organizations in Member States of ECMWF in the field of work stations for operational weather monitoring and forecasting. The group will establish cooperation to promote development and progress in this field and serve as a medium for exchange of information between the participating organizations.*

The meeting decided to focus on the following activities to fulfil the objectives:

- *Exchange of information, including meetings and computer codes*
- *Exchange of people working in the field*
- *Establishment of projects between two or more countries*

In order to concentrate the cooperative efforts, contact persons, acting as representatives for the organizations, were nominated at the meeting. They are:

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This report will be submitted to all national meteorological services in the Member States of ECMWF. Other national services in Member States of ECMWF that are interested in participating in the working group are kindly requested to write to Anstein Foss, Norway. The name of a contact person should be included.

The meeting discussed the formality of the working group. It was decided to let the group be informal in the same way as the European working group on limited area modelling. If the national services so wish, a formal relation to the TAC of ECMWF is possible.

5.2 Exchange of information

5.2.1 Computer programs and electronic mail

The meeting agreed on the following recommendations concerning exchange of information in daily work:

- Common simple rules for programming should be established. Separation between different kinds of processing, such as decoding, graphics, data handling and computations, should be included.

- Program comments should be in English and should contain a heading with information on: function, language (including information of nonstandard programming), libraries needed, author and creation date, information of input/output.

- A list of available programs and subroutines should be made.

- Designers in the different services should be able to exchange codes and ask technical questions through electronic mail. A bulletin board should be established for a closed group of users. The possibility to establish a mailing system through ECMWF should be investigated.

5.2.3 Meetings and newsletters

It was agreed that an international annual meeting is required. Such a meeting will concentrate on presentations of developments and plans in the different organizations. Special lectures on relevant topics from the participants or invited speakers are welcomed. The organizer is encouraged to make suitable equipments available for demonstration sessions at work stations.

Cooperational and organizational matters will also be dealt with. An important point will be to review and discuss cooperation between the organizations.

The meeting should normally start after lunch the first day and last for three days.

France has tentatively offered to host the next meeting in Paris May/June 1991.

After the annual meeting a Newsletter should be circulated to members. This

publication will be devoted to achievements and technical problems concerning MWS. It is important that both successes and failures as well as plans are reported. The publication will be held at an informal level and will primarily contain short contributions. The newsletter will be in A4-format and the manuscripts submitted must be ready to print with figures fitted into the text.

The organization organizing the last annual meeting will be responsible for the next newsletter and the issue should be distributed within six weeks after the annual meeting. This report could be considered as the first newsletter. The manuscripts should be ready at the annual meetings.

The newsletter will automatically be distributed with a certain number of copies to the contact persons.

Some of the participants had good experience with small brain-storming meetings in order to bring forward new ideas, for instance in the design of user interfaces. In some cases vendors have arranged such meetings, some times at the national services. In most cases such meetings will depend on the availability of sufficient equipment. Organization of such meetings should be promoted.

5.3 Exchange of persons

An important aspect of cooperation is the possibility for persons actively involved in the development of MWS to go to some of the other organizations on an exchange basis. The meeting agreed on this being of great importance in the promotion of a European cooperation. Possible ways of exchange were discussed, such as:

- *temporary positions at the organizations*
- *exchange grants*
- *providing accommodation for visitors*

It is up to each organization to find out the best possible ways to promote such exchange programs.

5.4 Formation of projects

The aim of the work with meteorological work stations is, as mentioned, similar in the different organizations. Common projects between two or more organizations should therefore be beneficial. Possibilities exist for grants from European science foundations for the purpose of projects between organizations. These possibilities should be exploited.

Oslo, August 1990

Appendix 1

PARTICIPANTS AT OSLO MEETING ON METEOROLOGICAL WORK STATIONS

5. - 7. JUNE 1990

Vesa Karhila, Finland
Pertti Kukkonen, Finland
Åke Larsson, Sweden
Bo Lindgren, Sweden
Jean Coiffier, France
Isabelle Schmidely, France
Marie Francoise Voidrot, France
Jens Daabeck, ECMWF
Anstein Foss, Norway
Sigbjørn Grønås, Norway
Magnar Reistad, Norway
Jens Sunde, Norway