METEOROLOGICAL APPLICATION- AND PRESENTATION SYSTEMS (MAP, TRITON) OF DEUTSCHER WETTERDIENST (DWD)

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1. INTRODUCTION

Some of the main tasks of Regional Weather Forecast Offices are Weather Watch, Nowcasting (0-2 hours), Very Short Range Forecasts (2-12 hours) and the issue of severe weather warnings. All this is based on different observational data which are mainly presented in a conventional way on FAX-charts and processed by hand. Only the Short Range Forecast (12-36 hours) and the extended Short Range Forecast (36 - 72 hours) is based on numerical model output.

2. DEFICIENCIES

2.1 Present Regional Weather Forecasting

Since the start of our new model chain and the use of modern measure and observation-systems, the efficiency of our weather service has increased remarkably, but this progress has not yet improved the local weather forecast in the same way. The charts are still disseminated by an old fashioned Faksimile system with a transmission time of nearly twenty minutes per chart. The present FAX-System does not meet the demands of Regional Offices to receive data as early as possible. As a consequence, a lot of information does not reach the offices in time. Furthermore, we need Workstation power to run local numerical models or numerical Forecasting methods for Warnings (e.g. thunderstorms) and to support aviation forecasts like TAF or General Aviation Forecast (GAFOR). The enormous amount of data produced by our forecast models cannot be processed in the conventional way. Another application that makes a powerful Workstation-System necessary at regional offices is the animation of Satellite and Radar Pictures.

This way of Forecast Service does not meet the user's demands from Business, Economics and Public Media for a more accurate forecast and warning service in good time.

2.2 User requests

If the user wants more accurate forecasts, we have to offer more forecasts with higher resolution in time and space expressed in discrete values for temperature, dewpoint, precipitation and wind instead of forecasts in general phrases.

Moreover, the user expects expressive graphical presentation and special services for all parts of the public and economic parts of our life, for example traffic, leisure and sports. Print media like newspapers and Radio- and TV-Stations are also unsatisfied with the present form of presentation of weather forecasts.

2.3 The Increase of Model Data

The amount of data available to the forecaster has increased enormously since the beginning of numerical weather prediction in the year 1966. This increase of data demands new ways of data processing.

Model	BTP/BKL	BKF/BKN	GM/EM/DM	GM_E/LM
Period	1966-1977	1978-1990	1991/93	1998
Data / MByte	.46	4.4	300	70.000
Resolution / km	381	254/127	200/54/14	50/1
Increase of Data	-> * 10	-> * 70	-> * 230	

Table 1: Data volume of different NWP-Models for 24 hour in MByte

3. THE DWD-SYSTEM FOR REGIONAL WEATHER FORECASTING: MAP

These points show the necessity of a modernization program for the Regional Forecast Offices to keep and improve the quality and reliability of their products and services. MAP will enable the Regional and Aviation Offices to receive, to store, to process and to present the data in a fast mode on powerful workstations. In order to solve some of the problems in short time we decided in 1990 to integrate four existing software systems AUTOTEMP, DATA PRESENTATION SYSTEM, INTERACTIVE GRAPHICAL SYSTEM and SATELLITE PICTURE PRESENTATION and ANIMATION SYSTEM to a single Application and Presentation system for the regional weather offices step by step.

3.1 Autotemp, DPSU

AUTOTEMP performs the automatic and interactive evaluation of radiosoundings and forecast soundings of the Numerical Weather Prediction model. The development of AUTOTEMP started in 1985 after a severe thunderstorm event in Southern Germany in July 1984 causing large damage and economic losses.

The Development of the Data Presentation System was started in 1988 by the Meteorological Service of the former East Germany. It provides the forecaster with graphical and alphanumerical presentation of synoptic data, Direct Model Output for different stations, plots of actual and forecast synoptic data and information in map presentation. AUTOTEMP and DPSU have been developed for operational use at Regional Weather Offices. The original Operating System was MS-DOS. Now all systems have been integrated to MAP and are now running on UNIX machines.

3.1.1 The Graphical User Interface of DPSU

As a first step of integration of AUTOTEMP and DPSU, both programs are used under a common graphical user interface. Almost all actions are mouse driven. The Main Menu helps to select items like type of data, time-intervall and type of chart. The user's interface is simple and easy to use even for inexperienced users. This is very important due to the heterogenous structure of the forecasters' staff. A Help message is shown if necessary.

3.1.2 Administrator Software

DPSU software can be configured for individual demands of the local Met Office.
Some special service programs are restricted for use by the administrator. This means, that he only can configure new map projections, special observation models and other configurations of meteogramms. The administrator tool is very important to achieve a configuration of the system just requested by the single offices.

3.2 Interactive Graphical System

The next software system we integrated into MAP is the Interactive Graphical System (IGS)
The development of the IGS started in 1987 for the Central Office with the goal to replace manually plotted forecast charts by computer generated charts on workstations with an interactive edit mode. It was not intended to support Nowcasting, short range forecast or the issue of warnings. IGS was developed as it was no longer possible to exploit manually the large amounts of raw model data and observations in an acceptable time and way. It was found necessary to find new ways of processing and visualizing this information in order to get a better understanding of the forecast. The first product which was developed under IGS was the Significant Weather Chart. Tropopause Highs and Lows, areas of significant weather, Height of Tropopause at certain locations, jetstreams and CAT areas are drawn automatically by the system. Only fronts must be constructed by hand in an interactive way or can be imported from another workstation. The system is able to produce different forms of Significant Weather Charts for any region. The workstation has access to the latest

observations and satellite images. The forecaster can accept or correct the machine's draft at any time if necessary. The interactive Significant Weather Chart has been operational since 1990. The Significant Weather Chart does not meet the demands of regional offices, but the design principles can be used to produce other informative weather forecast charts, for instance surface pressure forecast chart or newspaper weather chart.

Furthermore we have developed a system for the diagnostic presentation of model output. Standard fields such as geopotential, temperature or humidity and fields of special parameters like Vorticity Advection, Q-Vector, Isentropic Potential Vorticity can be displayed. Furthermore meteograms, cross-sections and trajectories are available.

3.3 Interactive Application System

The Interactive Application System is a general program system to produce charts with graphically enhanced weather information. It is a flexible tool to set up new applications using a definition file. The default settings of IGS can be changed by a special administrator software. The definition file contains all information about the desired elements, their attributes and interactions.

3.4 Satellite Data Processing System

The fourth system , the Satellite Data Processing System, can be used to display METEOSAT and NOAA Pictures and to generate animated loops. All received data are transformed to a stereographic projection. Animated loops are used to determine speed and direction of synoptic cloud systems, which is very important for the regional offices as it supports the forecaster in the nowcasting business. In it is also possible to show and to superimpose Radar composite pictures.

4. MAP SYSTEM DESIGN

The basic equipment of Regional Forecast Offices consists of workstations in a local network (LAN), file server and output devices such as printer or plotter. The number of workstations depends on specific tasks of the Forecast Office. We now do have a system with different types of workstations. On the less powerful Indy's runs a restricted version MAP based on alphanumerical data input. On the more powerful workstations Personal Iris and INDIGO, which habe been introduced to service this summer, runs the full MAP System with Satellite Module using metafile input. The Regional Offices receive their alphanumeric data from our message switching system. Satellite images, graphical and other data are disseminated via Packet Switching Data Network with a transmission rate of 64 KBit/sec. All data have to pass a filter-system which checks the data and sorts them for direct storage

and decoding for a proper MAP - Format. A Client-Server-Model, which controls the data access from any client within the local area network, is implemented in the MAP-System. The first MAP database was C-Isam orientated. As the response time exceeded the requested time of 10 seconds considerably, it was substituted by an own system with a data format reducing the typical response time to 5 seconds less.

MAP systems with different equipment are in operational use at 11 Regional Forecast Offices since 1992. Installation of MAP systems for all 22 Regional Forecast Offices and Aeronautical Met Offices will be completed in 1995.

5. IT - STANDARDS

The European Group On Meteorological Workstations (EGOWS, founded in 1990) has formulated recommendations for Workstation Systems. The goal of this group is to exchange information and ideas and to achieve a common standard for the interchange of software modules and information. On the last meeting in June 1993 the following recommendations were given:

- Requirements for Meteorological Workstations
  - access to all data with possibility of data manipulation
  - Response time should be 2 or 3 seconds or less

There is no recommendation for databases. Many commercial databases are in use like Oracle V.6, Ingres, Sybase, Empress.

Computational (platform standards) agree with the DWD-standards:

- GKS level 2b(GTS GRAL GKS) with fast pixel output
- UNIX (Operating System IRIX)
- Programming Languages FORTRAN, C
- Communication with TCP/IP, NFS
- X-WINDOWS, OSF/Motif

6. OUTLOOK FOR MAP

Although the tools for data dissemination, presentation and processing have been improved using MAP, we still have to reduce the data flood using automatic numerical methods. But I think this is not enough. The amount of data still increases so that we also have to develop new methods for the Forecaster to handle all these data. For the time being, we do not have the methods for processing all the numerical data, as we do it for the Significant Weather Chart. This new methods will support the forecaster in his everyday work of weather watch, Nowcasting and very short range forecast.

The goal is to take the MAP-System as basis for all tasks of the forecaster. This means, that the forecaster has to control the products and if necessary to correct them. With a system working in the described sense, it should be possible to have more time to fulfill the individual requests of users.

It is planned to realize the following programme :

Next Future (until spring 1994):

- Development of a Standard MAP Graphical User Interface (GUI) based on OSF/Motif
- Full integration of all software modules with access to one database
- Installation of an automatic warning-system with optical and acoustic information all alphanumerical observations
- Presentation of METARs, SPECIs, TAFs
- Integration of new modules:
- The structure of MAP allows to add or to integrate new modules. The first module we added was the Road State Information and Forecast System (SWIS) which uses a energy-balance-model as a local model to forecast the road surface temperature.
  -- GALE WARNING: presentation of gusty winds received from a special network, if necessary every ten minutes
  -- REPORT: semiautomatic production of text combined with values
- Correction of DMO by Kalman Filter

Extended Future:

1993 - 1995 Aviation forecasts based on statistical guidance (TAF and GAFOR based on MOS forecast, TREND (METAR) based on MARKOV)

1994 - 1995 Local forecast model for vertical profiles of temperature, dewpoint, wind and visibility up to 3 kilometer heigth

1994 - 1997 Development of numerical evaluation system for satellite and radar data to support Nowcasting

1994 - 1996 Start of a programe to develop a visualizing system for regional weather forecasts as part of the model run. We want to start with thunderstorm and fog situations.

The full integrated version of MAP will reduce the workload significantly by providing automatic guidances. It enables the forecaster to concentrate on forecasting local events (warnings more accurate and in-time). It will bring more productivity and improve the service for the users. All this will only become true if we accompay the introduction of the new system and later new modules by an excessive education and training. This is necessary to get a great acceptance by the forecaster.

7. VISUALIZATION SYSTEM FOR THE PUBLIC: TRITON II

7.1 Introduction

The weather forecast is an important part of the daily TV-news. In Germany it usually includes satellite image loops and weather maps showing isobars, pictograms and fronts. The static presentation of the forecast does not reveal the dynamic behavior of the atmosphere. Some German TV-Stations were not satisfied with this traditional way of presentation. They were requesting a naturalistic and animated presentation of the forecast. Satellite image loops were found useful to give a review of the weather situation. Therefore, intuitively understandable NWP forecasts should look like satellite images or even more realistic. This means, that we don't want to generate a true satellite image. The TV spectator is not able to interpret the grey-scale of an infrared image or to distinguish between cirrus und low stratus clouds. Therefore it was decided to show clouds as they can be seen from the ground. High level clouds appear transparent, cumulus clouds are fluffy and deep clouds dark. Furthermore we were asked to complete the system with animated forecasts of scalar variables, pictograms and text at discrete locations in order to be able to produce a complete integrated animated weather show.

7.2 TRITON II

We have developed, in cooperation with the Fraunhofer Society, a system called TRITON that meets all these demands. TRITON runs on CDC-SGI Workstations with X Windows and OSF/Motif using a Graphics-Library drawing widget. To support machines with less bitplanes or limited RAM-Space dithering and data compression techniques are available. Triton is of strict modular structure with programming languages being C and Fortran.

TRITON uses a topographical database with a horizontal resolution of 1 by 1 km. It can process the model output of all of our three NWP-models. These data are currently transformed to polar stereographic projection but can be tranformed to any other projection if the customer wishes so.

Three values are considered to define the forecast clouds: averaged amount of cloud cover, cloud thickness and thunderstorm occurance. In order to obtain these data, raw model data, e.g. temperature, humidity, liquid water, winds and pressure are scanned at each gridpoint and at each level. The calculations distinguish between stratiform (layer) and cumuliform (thunderstorm) clouds. The vertical data column is checked for thunderstorm development by applying a 1-dimensional cloud model with cloud microphysics, giving a yes/no information about thunderstorm occurence in the data column and - if yes - the vertical extent of the thunderstorm cloud. The thickness of stratiform

clouds is evaluated by calculating cloud top and cloud base. Then the attached grey value is assigned. The averaged amount of cloud cover completes the information, that is necessary to give a detailed and realistic image of the forecast clouds. This animation system makes it possible to visualize the results of quite complex numerical simulations in a more familiar way which can easily be understood even by non-experts.

Fractal models are best suited for generating clouds. The main advantages of this method are: each fractal point may be generated individually, all parameters can vary locally and it is well suited for parallel processing. The resolution of TRITON is higher than the numerical model. In order to avoid sharp edges and to obtain a naturalistic image of the clouds, the data have to be interpolated. Methods with different accuracy are available in the system. During the next step fractal cloud data and background data are merged. The color of the mixed pixel is determined by the grey value (that means cloud-thickness), the mixed coverage and the background image. The mixing process leads to dark "threatening clouds" in regions with severe weather activity and to white and "friendly" clouds in regions with fair weather. Thunderstorm areas are presented in flashing color. Two images are created for every timestep: one with the grey value derived from the thunderstorm, the other with the thunderstorm cloud area in white. Sharp contrasts in these regions are interpolated from dark to white. Mean values of the forecast are kept constant during visual processing. Errors due to this method can be ignored when compared to errors of the simulation itself.

We have developed a graphical interface to make it easy building a weather show by defining the sequence and the attributes of the appropriate modules (satellite review, cloud forecast, temperature forecast, ozon forecast). It allows to adapt the broadcasted videosequences to the daily weather situation and to define new modules showing for example different geographical regions with different scales or new parameters or only different graphical attributes.

7.3 Outlook for TRITON II

The system offers a high degree of flexibility to meet the demand of different TV Stations. Triton offers many editing features such as changing terrain colours and illumination, enhancing areas of interest, blanking of water or land areas and adding or deleting clouds. It is also possible to use customer supplied digital backgrounds. Forecast Video Clip Production using Triton has been in operational use for almost one year. A 2 1/2 D version of this system is currently under development. Conceptual work on a full 3D version started this year and will become operational next year.

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