THE INTERACTIVE GRAPHICAL SYSTEM OF DWD

H.-J. KOPPERT
DEUTSCHER WETTERDIENST
OFFENBACH, GERMANY

1. INTRODUCTION AND HISTORY

The Deutsche Wetterdienst (DWD) is responsible for the preparation of surface forecast charts (SFC), news paper weather charts (NWS), significant weather charts (SWC) and a variety of other charts. Most of these products were constructed manually using paper charts of the relevant meteorological fields, e.g. surface pressure, geopotential 500 hPa, relative humidity 700 hPa, instability indeces. Due to strict deadlines there was no possibility to examine all the information that was available. In order to make use of all the data that could help to enhance the forecast, the idea was born to give an automated first guess to the forecaster. Starting early 1987 an automated mid level SWC and a semi automated high level SWC (Koppert, 1987; Koppert, 1989) were made available to the forecasters at the RAFC Offenbach. Both of them where still plotted on paper. These products were found very useful and served as an automated first guess. They were only revised if there was clear indication. With the rapid progress in workstation technology it was considered feasable to do the revision on workstation. Late 1987 a decision was made to develop a workstation capable to plot and interactivly revise an automated SWC. In October 1990 the new system went into operations. With the experience gathered during the development of the SWC it was considered useful to convert the SFC and the NPWC to an interactive workstation environment. This project started in 1989 and will be completed early 1992.

2. GENERAL CONCEPT

Numerical weather prediction models are producing large amounts of raw data. It is nearly impossible to review quantitivly all the information, that might be useful, even if it is animated or displayed in 3D. Therefore it is seen necessary to precompute weather maps. The input to these weather maps depends on the respective application. Figure 1 shows some possibilities of post processing just before the interactive revision on workstation.

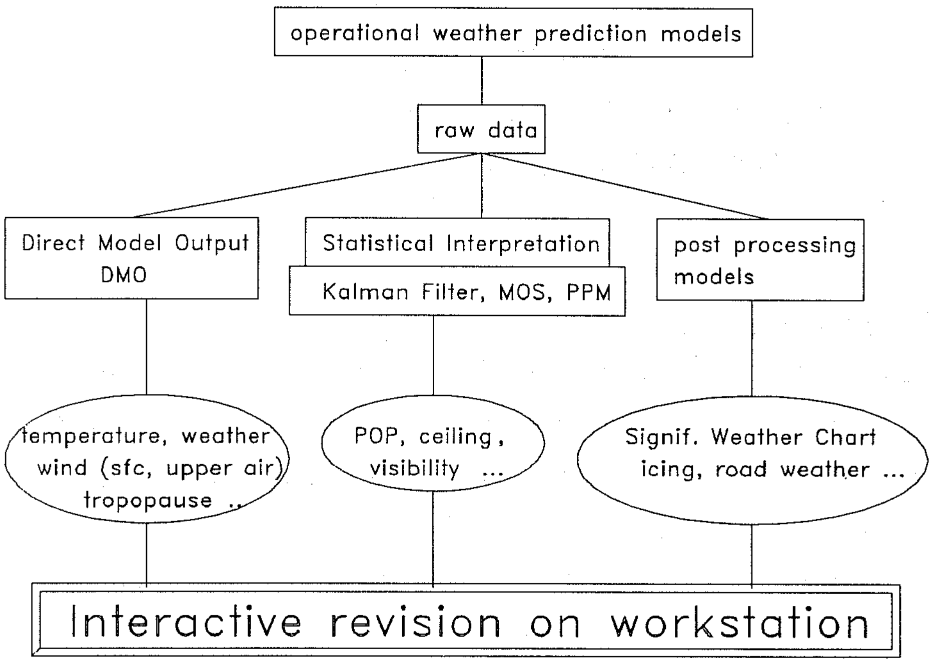

Fig. 1 flow of post processing

The NWP raw data can be used as direct model output (DMO). Furthermore some statistical interpretation can be applied. In the case of Kalman Filtering an enhancement in the quality of the DMO can be achieved, while PPM or MOS allow furthermore to predict variables that can't be derived simply by DMO. Post processing models allow to perform quite complex tasks. The DWD SWC models prepare high level and mid level SWC in a "display-ready" format. Bosart (1989) asked in the title of his article the question: "Automation: has its time really come?". My answer with respect to automated weather maps is yes. But there has to be a possibility to revise this automated first guess. It might be necessary to compensate for the deficiencies in the automated model or to check this forecast in the light of the latest observations or the latest satellite and radar pictures.

The Interactive Graphical System (IGS) of DWD is designed to plot and revise automated weather maps (forecasts from 12 to 96 hours). It is not intended to support nowcasting or the issueing of warnings like the DARE II workstation. The DARE workstation (Bullock et al., 1991) is designed to diagnose and nowcast meso-scale phenomena. It is very important to make all the incoming data as quickly as possible available to the forecaster. Weather map generation is based mainly on model forecasts. Therefore less performance with respect to real time data access is needed. Another example of a workstation which is designed to make interactive modifications is the Forecast Production Assistant FPA (McLeod, 1990). It is used to create automated worded weather forecasts. The forecaster interactivly draws timeseries of forecast elements. The system does the interpolation in time and issues the forecast. While the interactive revision of an automated forecast in DWD's IGS is the last step of the weather map production, the FPA needs manual interaction to help the system automatically interpolate in time and to construct weather areas.

3. THE DISTRIBUTED DESIGN

The preparation of station related data (DMO for predefined locations), the calculation of synoptic diagnostic parameters, the execution of postprocessing models and the generation of graphical metafiles and satellite imagery is done on the DWD mainframe computers. Three types of data are transfered to the workstations. Raw data (2D gridded fields, e.g. msl pressure, tropopause heights) are intended to be interpreted (calculations, contouring) and revised on workstation. Graphical data (GKS-metafiles) are intended to be overlayed during the interactive revision. Images can be underlayed to check for the latest developments.
The workstation performs the automated plot of the weather maps and supplies the tools to interactivly modify the first guess. Output is downloaded to a variety of plotters, to digital FAX or to GKS- or CGM-metafiles.

4. HARDWARE CONFIGURATION

Postprocessing is run on DWD's CYBER 995/860 and CRAY YMP4. Satellite and radar imagery is processed on two micro VAX's. These machines are linked via CDCNET to the workstation network. CYBER 910-487 are used for editing weather maps, while CYBER 910-470 are used for display and backup.
A pilot project was started in summer 1991 in Hamburg. Satellite imagery and graphical data are transfered on a scheduled bases via PSDN from Offenbach to the regional weather office in Hamburg, where the display part of the IGS is installed on a CYBER 910-460.

5. SOFTWARE STANDARDS AND INTERFACES

CYBER 910's run SGI's UNIX (IRIX). The programming languages used are FORTRAN and C. In order to keep the system portable and to interface with a variety of graphical systems the GKS standard was choosen. Only some minor

extension using SGI's Graphics Library (GL) were added. The IGS features a mouse driven user interface and a window based environment (SGI's 4Sight).
It was a stringent requirement for the realization of the IGS to have a consistent concept for different applications. Different programs should look and feel the same. The structure of the source code allows to build new interactive applications by combining already existing modules with newly written ones.
The user interface is simple and easy to use. It should be obvious to the inexperienced user what to do. This is very important, when one has to deal with heterogenous forecasting staff. There is always a guidance by message (e.g.: please enter control point), if possible. There are simple menus for text and label modifications. Drawing and editing of lines and areas is based on control points. The number of menu layers is restricted as much as possible. To speed up execution cursor position is initialized, when its next location is known. Double click can be used instead of an explicit confirmation or to plot with default values.
The request of products is done with the most suitable interface. Priority is given to the picking of graphical objects instead of choosing elements from a list. Examples are the horizontal track line of a vertical cross sections, the locations of meteograms or the starting points of trajectories. Fields are requested by specifying type of model, model run, verification time, element and level. Parts of the specification can be saved for subsequent requests.

6. PRINCIPLES OF INTERACTIVE REVISION OF WEATHER MAPS

Every graphical object can be edited, created or deleted. Every text object can be edited through a menu, moved, deleted or created.
A set of high level graphical routines ensures that graphical objects are readily available. Drawing of a jet streams for example consists of four steps. At first "draw jet stream" must be choosen. Then one has to lay down the control points defining the axis. After that, one is immediately forced to fill in the label menu. The label is plotted automatically tangential to the axis after the center of the label was defined.
It is very important to make the system as secure as possible. It should never happen that large parts of the forecasters work gets lost. Therefore an undo function is implemented. Three states of the production cycle are kept in memory: the initial state (the first guess), the state before the last interaction (recoverable by undo) and the actual state. There is a permanent backup of the interactive

work. After every executed action the state of the weather map is saved in external backup files. These files are exchangeabel. Work could be continued on the same weather map at another workstation.
There is an exchangeability of certain products between different application programs independent of the map projection. The SFC for example produces fronts. The SWC allows to import these fronts with the appropriate attributes defined inside the SWC.

7. APPLICATION SOFTWARE

The graphical routines briefly described in chapter 6 are used through all the applications and are therefore not described. Application dependend routines are shortly explained.

7.1 Significant Weather Chart (SWC)

The automated part is executed on a workstation that performs the interactive part or on a compute server that produces a hardcopy and transfers the backup files to all interactive workstations. Tropopause highs and lows, areas of significant weather, labels of significant weather areas, tropopause heights at discrete locations, isolines of height of freezing level, jetstreams and areas of CAT are plotted automatically. Fronts are added, either newly constructed or imported. The modification of significant weather areas is based on grid points. Gridpoints can be added or subtracted. There is a possibility to fuse weather or CAT areas. Figure 2 gives an example of the revised SWC.

7.2 Surface Forecast Chart (SFC)

The automated part consists of the contouring of isobars and the plotting of homogenized mid level clouds (encirceled by scalloped lines). The interactive part allows to enter bogus values to apply more global modifications to the pressure field.

7.3 News Paper Weather Chart (NPWC)

The automated part contours the surface pressure, plots DMO derived temperatures and weather at predefined locations. Fronts are imported or created. Weather pictograms can be created, deleted, modified or moved. There is a way to insert free text. Arrows indicating temperature advection are created or deleted.

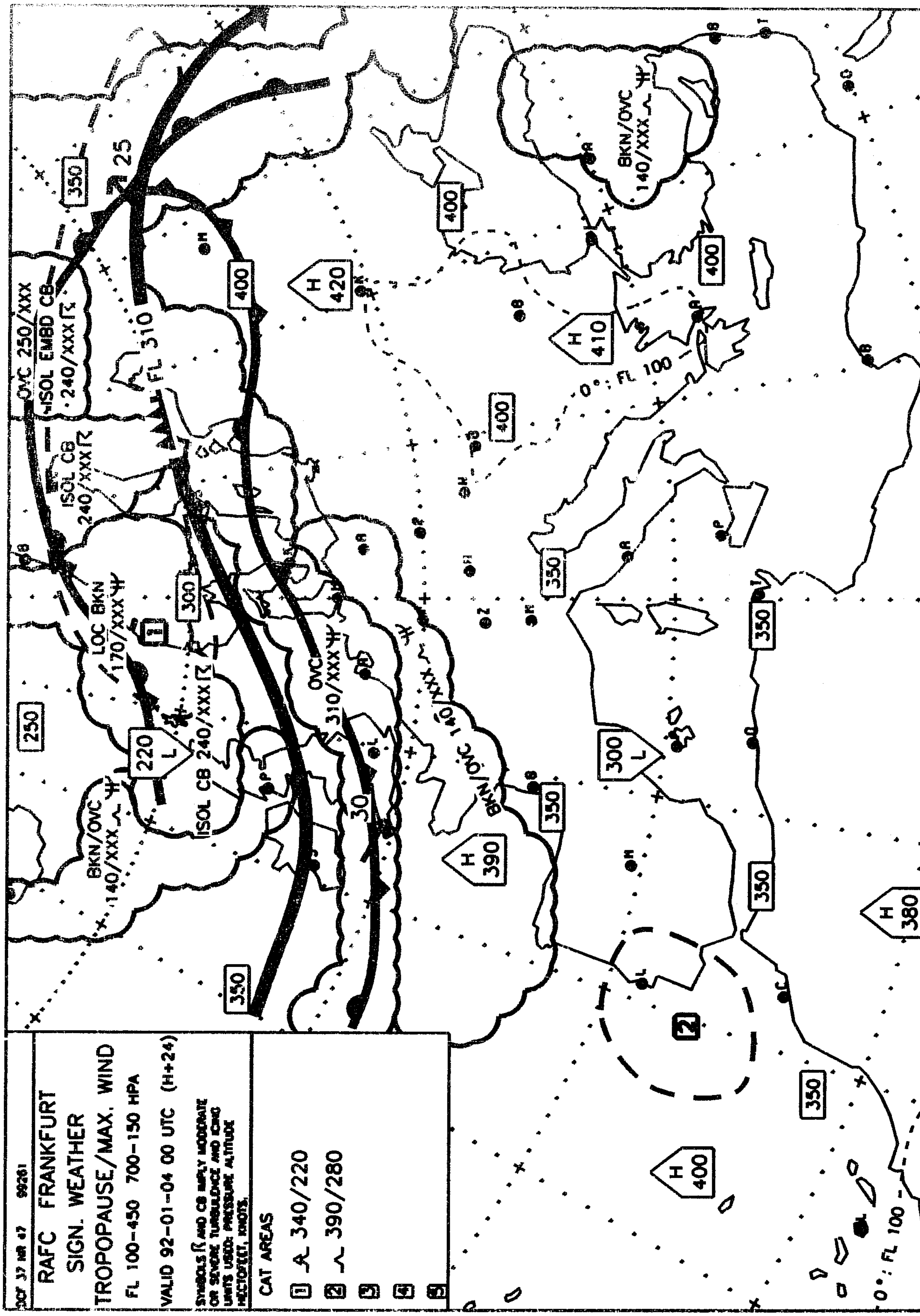

Fig. 2 interactivly revised Significant Weather Chart (valid 92-01-04)

7.4 Interactive Application System (IAS)

The SFC and the NPWC are special cases of the IAS. The IAS is a more general program system to produce charts with graphically enhanced weather information. It is a flexible tool to set up quickly new interactive applications. A new application is defined by filling in a definition file. This is done by the "product designer". The definition file contains all the information about the desired elements, their attributes and interactions. Gridded data for continous fields or yes/no information at gridpoints and data at discrete locations has to be supplied by the "product designer". This preprocessing is centralized. The system is intended to run at regional weather offices. The first request for a special application is expected to come from the regional office.

The IAS features possibilities to display continous fields contoured with isolines or with filled areas, weather regions encirceled with lines or scalloped lines, filled with different hatch styles or with markers (weather symbols). Values can be plotted at gridpoints; values, pictograms and text at discrete locations.

7.5 Display System

The display system allows to display images, interactive thermodynamic diagrams, weather element meteograms, vertical cross sections based on model forecasts, trajectories, analyses, forecast fields, weather maps, surface- and upper air observations. Products are built on a scheduled basis on the CYBER mainframes (GKS-metafiles) or on micro VAX's (satellite imagery of predefined formats). The forecaster can interactivly request the build of products that are not pregenerated. Images, observations, trajectories, analyses- and forecast fields can be over or underlayed respectivly. Graphics or images can be animated. Static four window screens of predefined content give quick access to graphical data and are used heavily.

8. CONCLUSION

The automated production and revision of SWC's is operational since 1990. The SFC and the NPWC will be operational early 1992. The IAS, which is still under development, will be brought to regional weather offices late 1992.

The acceptance of automated weather maps strongly depends on the performance of the whole system. This concerns the automatically supplied first guess, the

graphics software and hardware. Acceptance can only be reached, if less than 10-15% of the map has to be revised. Otherwise it would be better to draw it from scratch. Revision of automated weather maps is a highly interactive procedure. Objects are moved, labels are edited, contour lines are modified and so on. The workstation, software and hardware, has to redraw the picture in a short timeframe. Response times of less than 2 or 3 seconds are indispensable. It is absolutly necessary to supply high level graphical tools to make editing as simple, quick and straight forward as possible. Forecaster training is essential, otherwise he or she wouldn't be able to use a system with great functionality effectivly.
The DWD is developing a new system, called MAP (Meteorological Application and Presentation System for regional weather offices). MAP will support nowcasting and weather map production. The IGS will be integrated in MAP. This will overcome existing deficiencies like the missing observational data base.

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