THE GEOVOR INTERACTIVE GRAPHICS SYSTEM

by

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1. Introduction

The German Military Geophysical Office (GMGO) was established to satisfy the specific needs of the German Armed Forces in terms of analysing and forecasting geophysical influences on man and material as well as on planned and progressing operations of any kind in peace time and in case of defence.

The major task is analysing and forecasting weather and surface conditions. This is done by providing GMGO's Geophysical Support Sections via facsimile and telecommunication lines with the so-called "Zentrale Beratungsunterlagen" (ZEBU) which is time critical information such as evaluated weather data, text forecasts and analysis and forecast charts. The latter contain surface and upper air information such as fronts and information on clouds, precipitation, visibility, freezing levels, etc. They are hand-drawn by meteorologists based on incoming actual data and the output of numerical analysis and forecast models, and serve as guidance for forecasters at the Support Sections.

In 1979 a request for proposition was made for a complex computer system called "Geophysikalischer Vorhersagerechner" (GEOVOR), containing an Interactive Graphics System (IGS) which

- provides high level availability for 24 hours/7 days a week shift work
- accelerates the working process of creating the ZEBU's
- gives access to complete and detailed information in a wide range of geographical scales
- guarantees transparency in the presentation of weather observations
- allows a display quality close to colored paper prints
- reduces the number of paper documents meteorologists have to deal with
- liberates the meteorologists from sorting, identifying, searching and selecting teletype messages
- gains time by directly producing facsimile-proof copies
- saves personnel who were involved in time-consuming paper document preparation, evaluation, redrawing, etc.

The German company SIEMENS AG was contracted to deliver the main frame and the IGS, and particularly to develop the IGS-Graphics-Software according to GMGO's earlier very detailed hard- and software design. Nevertheless frequent consultative cooperation between SIEMENS and GMGO proved to be necessary in order to achieve an operational and reliable software behaviour in the meteorological application by both regarding the original requirements and profiting from the special technical features of the proposed graphics system.

2. Configuration and data paths

Fig. 1 shows the system configuration.
The regular data path is as follows:

Realtime data is entered from an automatic telecommunications unit and passed by the 11/34 (preprocessor running the WMO-telecom-procedure) to the main frame 7.880. The data relevant for graphical display is then passed to the graphics computer 11/70 of the IGS display (large dashed box). Here it is prepared and stored and may be accessed for display from each of the two work stations (smaller dashed box). Also the grid point field data base from the numerical model output in the 7.880 may be accessed by the IGS; additionally all SMA-data (see below) is transferred through the same channel.

When the backup path must be used due to maintenance or failure of the main frame,the 11/70 alone is able to receive realtime data, run the WMO-telecom-procedure, store the data, decode, and still drive the graphical work stations. Only the display of isoline fields from the 7.880 is not possible during backup situations.

3. Hardware of the IGS work stations

As shown in Fig. 1, 2 and 3 each of the two stations consists of:

- Ramtek 9400 color raster screen, 19" diagonal, resolution 1280 x 1024 pixels
- data tablet, 20" x 20"
- dialog screen, 13" diagonal, 24 lines with 80 characters

There are two additional monitors for alphanumeric realtime display of SPECIAL reports only (backpage feature included) and an electrostatic hardcopy device accessible by both work stations.

The refresh memory of the RAMTEK system is ten bit planes deep. Groups of one, two, or three bit planes are independently addressed via the Video Lookup Table and thus can carry independent information:

bit plane No.	contents	color
0 1 2	geographical map with four elevation ranges; areas colored	8 colors
3	underlay chart	violet
4	chart	black
5 6	non blinking) observations blinking)	black black/white
7	graphics	blue
8	T-Menu, subtitle	red
9	graphics	red

The display priority increases with the bit plane number.

4. IGS-Software

The IGS-Software features:

- realtime graphical display of both surface and upper air weather observations
- display of computed isoline charts of numerical model output
- manual chart construction
- computing of isoline charts from graphically entered spot values.

Each feature may be used in combination with the others.

User commands are entered over the data tablet whose menus are shown in Fig. 4. This tablet is divided into two areas. The upper one (20% of whole area) strictly serves as menu whereas the lower one (80%) is either menu or is used as a screen equivalent drawing area for handdrawn graphics. Switching between the two modes is implicitly done by the software as described later.

Commands are entered by hitting one or more command fields with the tablet pen (digitizer) and are submitted by touching the EXEC-field. Wrong commands may be erased before submitting by using the CLEAR ENTRY field. Generally the command sequence is optional. Once a command is given, it stays valid until it is changed.

The set of all commands may be divided into five subsets:

- common commands
- W.OBS.
- CHC
- SMA
- service commands

W.OBS., CHC, and SMA are the main commands of the respective subset and define the current area of application.

4.1 Common commands

This subset comprises all commands that may be used in any situation under any main command. It is possible

- to select a standard geographical map section:

  there are four standard sections:

  1 : 15 million North Atlantic and Europe

  1 : 5 million Central Europe

  1 : 2 million North) partly overlapping

  1 : 2 million South)

- to choose a zoom:

  any part of a standard section may be zoomed by a factor of 2 or 3. The user must define the center of the desired zoomed section. Zooming is done by pixel replication.

Therefore there is a scale range from 1 : 15 million through 1 : 667,000 (ratio 22.5 : 1). When zoomed all information on the screens is relocated according to its original geographical coordinates. As the zoom ratio increases, a successively smaller area fills the screen, and more data is plotted if available.

There also is the option of

- clearing (blanking out by setting a mask)
- recalling
- erasing

particular information like map background (MAP), all meteorological info (MI), station reports (ST), isolines (ISO), underlay chart (UC), handdrawn graphics (GRA), etc.

In about half a minute it is possible to get a black and white hardcopy from any display by giving a keyboard command. The user may decide whether he wants the hardcopy with or without grey shaded topography. The latter is suitable for facsimile broadcasting.

4.2 W.OBS.

Under this main command, surface weather observations (W.OBS.) can be displayed out of 48 continuously updated "half hour files" in which the surface data of the last 24 hours is stored. To get the display the user simply enters the desired TIME OF W.OBS. over the adjacent number fields and then calls the T-MENU (Fig.5) onto the screen from which the desired type of weather data is chosen.

The T-MENU permits the display of

- the conventional surface station model (COMPL. SURFACE OBS.) (Fig. 6)
- a choice of certain sets of its parameters (lower left square of T-menu)
- one of the special parameters (upper half of menu) which are displayed together with the observing station's identification number (Fig. 7 and 8).

If it is desired, values may be defined via the number fields for the upper limit of visibility, ceiling, or the combination of ceiling and visibility data to be displayed.

A blink function (B) may optionally be used for certain predefined weather parameters such as heavy thunderstorm, cb-clouds, strong winds, gusts, etc.

A statistical information on the dialog screen tells the user how many reports are available in the displayed geographical section, how many of these contain the desired parameter, and how many of these are actually shown on the screen (overlap problem!). The user therefore knows whether or not it would make sense to zoom.

4.3 CHC

This main command is used to open the chart construction mode (CHC) which makes it possible

- to display isoline fields and appropriate surface and upper air data
- to create graphics by hand (e.g. ZEBUs).

The isoline display feature works as follows:

In the 7.880 a data base containing all numerical model output as grid point fields is stored for 24 hours. The user calls for such a chart by hitting the appropriate command fields in the middle portion of the tablet (see Fig. 4). That is, from left to right:

- physical parameter (like pressure (PRES), geopotential (GEOP), etc; the field OBSERVATIONS is not used here)
- level (or layer i.t.o. relative topography (RETO))
- reference time (00.00, 06.00, 12.00 or 18.00Z)
- forecast period in hours (0 = analysis, 9 through 72 = forecast)

The requested isoline field may optionally replace an already existing field on the screen, may be combined to it by using the COMBINE command, or it may be defined as an underlay chart (DEF UC), which is displayed in a different color. The command field STA is used for an additional display of surface or upper air weather reports with respect to reference time and level (Fig. 9 and 10).

The "create graphics by hand" feature allows one to use the screen as a drawing area (Fig.11). An internal hierarchy rules the handling of graphical items: a set of such items consists of one or more "entities", each of which contains one or more "instructions". (An instruction is either a linked vector string or a filled area or a symbol; explanation follows below!)

The non-screen-equivalent upper part of the tablet (Fig. 4) contains all necessary commands for

- creating an entity
- adding an instruction
- selecting an entity
- displaying (identifying))
- deleting) an entity or an instruction
- adding a thicker vector string
- thickening an existing vector string
- selecting)
- deleting) a part of a vector string
- placing and adding predefined symbols

After touching the appropriate command field the screen equivalent part of the data tablet is considered to be a drawing area. The drawing of vector strings (ADD VECTOR) is done by moving the tablet pen on this area. Synchronously the vector string appears on the screen. Creating filled areas (ADD FILLED AREA) is done similarly by drawing the surrounding line of the desired area. The filling is done automatically. This feature is used for drawing the conventional front indicators.

Predefined symbols are created by striking the PLACE AND ADD SYMBOLS field, determining any desired starting point on the chart, and then choosing symbols out of the symbols menu which is the lower half of the screen equivalent tablet area. There are weather symbols, text fragments, alphanumeric characters, and single and combined symbols (e.g. L_{x}^{xx}). The latter have to be combined with the alphanumeric characters or the weather symbols, respectively, which are chosen for the x (e.g. L_{D}^{91}). The field NEW SYMBOL LINE allows one to create a new symbol line under the previous one without the necessity of a new placing.

There are predominantly two bit planes (No. 7 and 9) for creating graphics by hand. But it also is easily possible to do manipulations in the bit plane No.4 (chart), like modifying calculated isoline fields, because such fields are also internally stored in a graphically accessible display list.

4.4 SMA

The semimanual analysis (main command SMA) procedure is used for creating numerical analysis charts from spot values entered by the meteorologist. The values may be taken from a display of reports from up to 4 pressure levels by hitting the OBSERVATIONS field and choosing a series of pressure levels from 1000 through 100 mbars or SFC. This kind of display is shown in Fig. 12. The geographical point of observation is the thickened common corner of the report frames. A code number in the left upper corner of each frame gives the number of the observation level (1 for 1000, 2 for 850, ..., 9 for 150, 0 for 100 mbar). Only reports from radiosonde stations will produce frames.

To do an SMA the user has to define the desired analysis parameter and level (e.g. GEOP 700 mbar). Then he uses the EVAL command and enters any field value. After hitting the EPTS field he marks points on the chart where this value was observed (or where he thinks it might have been observed in data sparse areas). He can do this with as many values as possible or necessary. Touching the EXEC field terminates input and starts the internal computer procedure of analysing the given values, calculating, and displaying an appropriate isoline field on the screen (see Fig. 13).

All the "create graphics by hand" features of the CHC are available under SMA as well. Therefore it is also possible to first draw a temporary isoline field by hand and then enter spot values.

Principally this mixed man-computer procedure may be used for creating initial grid point fields for a simplified forecast model in case the available amount of data is too poor, too asynoptic, or too fragmentary for a good routine analysis result. The advantage is that the forecaster's experience, skill and imagination flow into the numerical analysis.

4.5 Service commands

There are some more commands at the user's service (Fig.4).

- Up to ten image contents may be saved (SAVE) on disk files and read in again (READ). After re-reading, they are subject to full graphical manipulation. They may also contain entire sets of observations. The CALL LIST command lists the disk file contents on the dialog screen. Different disk file fields may be combined to one image on the screen by using the COMBINE command.

- The 1 SCR and 2 SCR commands offer a choice between only one screen or both screens to be used by one operator. This makes the handling of foreground and background information more flexible in certain cases of application.

- The PLACE TEXT command allows a starting point on the screen for alphanumeric text to be defined, entered via keyboard (see Fig. 11, upper left corner).

- The N and P fields determine a certain bit plane to be used during the process of creating graphics.

5. Operational performance

The behaviour and performance of an operationally used meteorological graphics work station is of major importance under different points of view:

The meteorologist who generally is not a data processing specialist must be provided with an easy-to-handle tool that does not require much system or software knowledge. Therefore is has to be self-explanatory as far as possible.

An input device such as a menu tablet in combination with an additional dialog screen seems to do the job quite well. Much effort has been put into designing the menu so that typical and often used command sequences will not require much concentration or hand movements. There is an acoustical feedback to ensure the user upon each touching of a menu field that his command has been accepted or to inform him that a system action has been terminated. Any wrong user command is commented on the dialog screen and a proposition is made of how to proceed. This screen also displays the contents of usable disk files and the system availability in a backup situation.

Conventionally meteorologists work with an enormous amount of paper documents, especially weather charts of all kinds. The IGS may liberate them from that, but only if the time consumed by the system for generating a particular display is short enough. Otherwise the operator will lose concentration and the system is much less valuable. Also the amount of action to be invested into creating, altering, or deleting any kind of graphics must be as small as possible. Pencil and eraser are powerful competitors!

The system described guarantees an average image completion time of 10 seconds. The reaction time between submitting a command and the first action on the screen is less than one second so that the meteorologist may already begin to analyse the data during the process of image generation. Most isoline charts which are retrieved from the grid point data base of the 7.880 are displayed in 8 seconds. Rereading an isoline chart from an 11/70 disk file takes about 5 seconds. Displaying weather reports consumes up to 10 seconds depending on how many reports are available and how many have to be brought on the screen considering the overlap criteria. (For example: the maximum number of reports of visibility possibly displayed on a 1 : 2.5 million map of Central Europe is more than 250 out of 750; this would take 10 seconds).

The average time of 10 seconds is only exceeded by the SMA procedure ($\approx$ 15 seconds), when charts with an unusually large number of isolines are displayed, or when a combination of an isoline chart and appropriate reports is displayed; in the latter case individual amounts of generation time add approximately together.

6. Conclusions and further outlook

The GEOVOR IGS has been in 24 hours/7 days a week operation since October 1, 1981. Latest experiences, as well as earlier simulative tests, have shown that it took our forecasters only a couple of days until they became accustomed to using the system and to profiting from its special advantages. Of course, the informative characteristics of the system were accepted immediately; whereas working creatively needed some days of training which consisted of individual introduction and considerable time for playful exercises. Already, the mere process of drawing a chart similar to the one in Fig. 11 does not require much more time than it did with conventional methods. The immediate availability of data displayed graphically, and in great detail, should lead to an enhancement of product quality.

Fast access to any model output that is needed in respect to the current weather situation is considered an extreme advantage compared to working with a standard chart set that consumes much plotting time and fills the walls with paper.

In the near future a couple of applications will be integrated into the system:

- display of satellite images together with actual weather data or computed charts.
- display of radio soundings in combination with their different computed properties
- display of user definable cross sections

and display of other data which is available in the computer's data base.

Introducing fast interactive graphical work stations into operational application in meteorology seems to be the right way to satisfy the forecaster's needs, because he gains much more opportunity and time to fully apply his scientific knowledge to a given forecasting situation and to integrate into his thinking a wider variety of meteorological considerations. When further developed, this new tool might acquire a status comparable to the computer itself after it was introduced into meteorological application years ago.

7. Figures

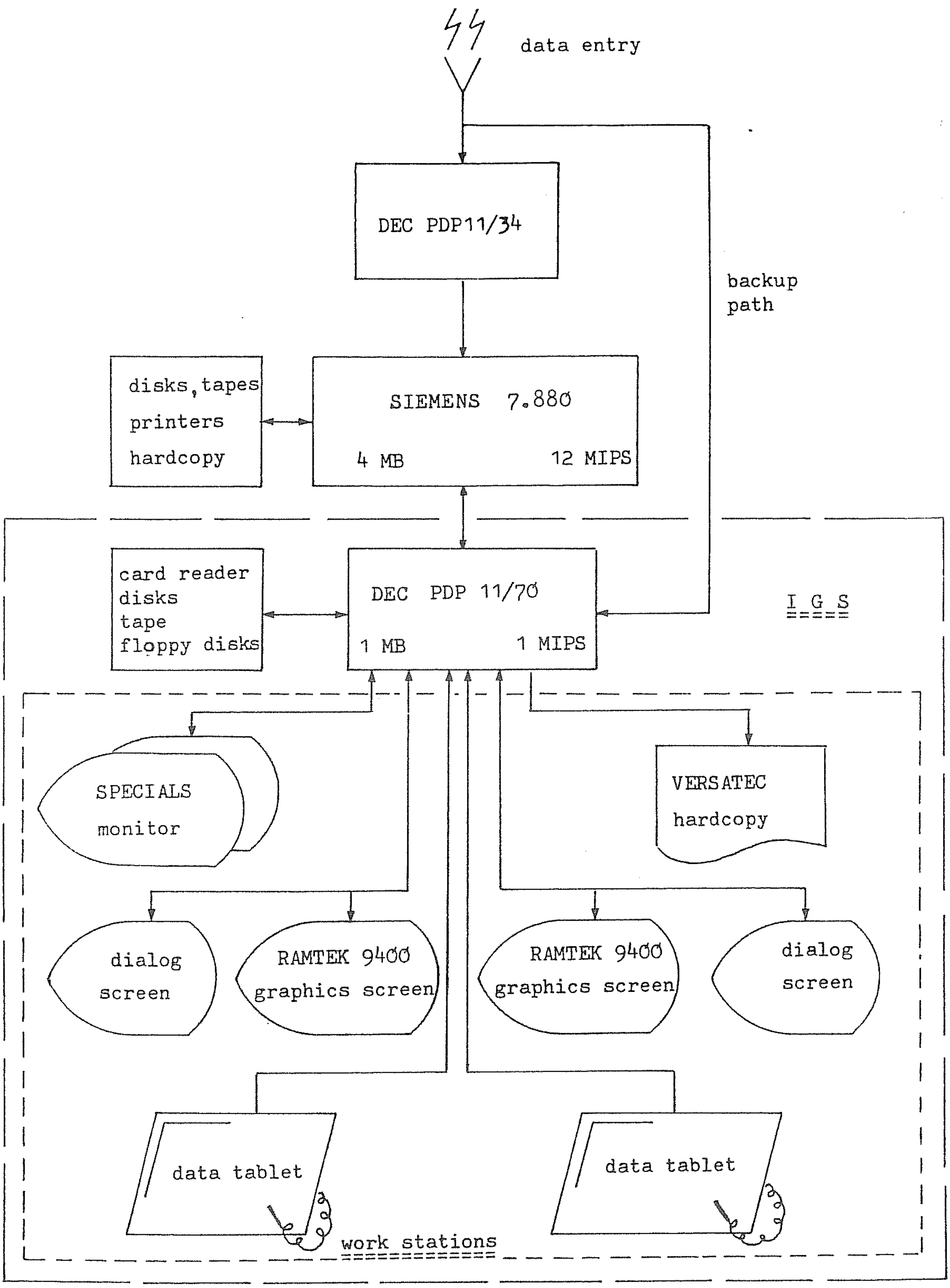

Fig. 1: System configuration

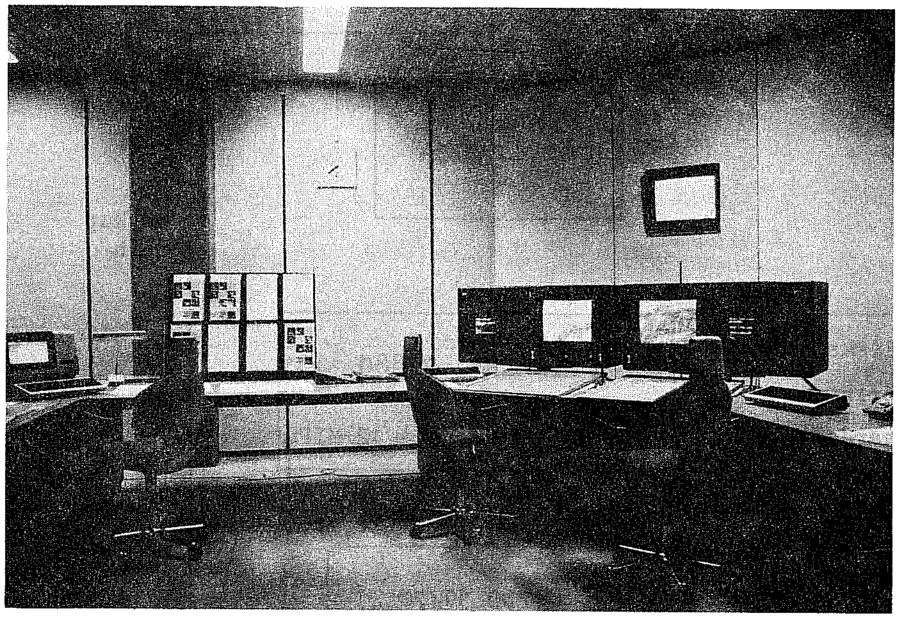

Fig. 2 IGS work stations. The SPECIAL reports are displayed alphanumerically on the monitors above and to the left of the two graphics screens. The hardcopy device is not shown. The clipbaord is used for clipping teletype messages like text forecasts, warnings, birdtams, etc. Meanwhile indirect room lighting and wall clips for other services' charts have been installed.

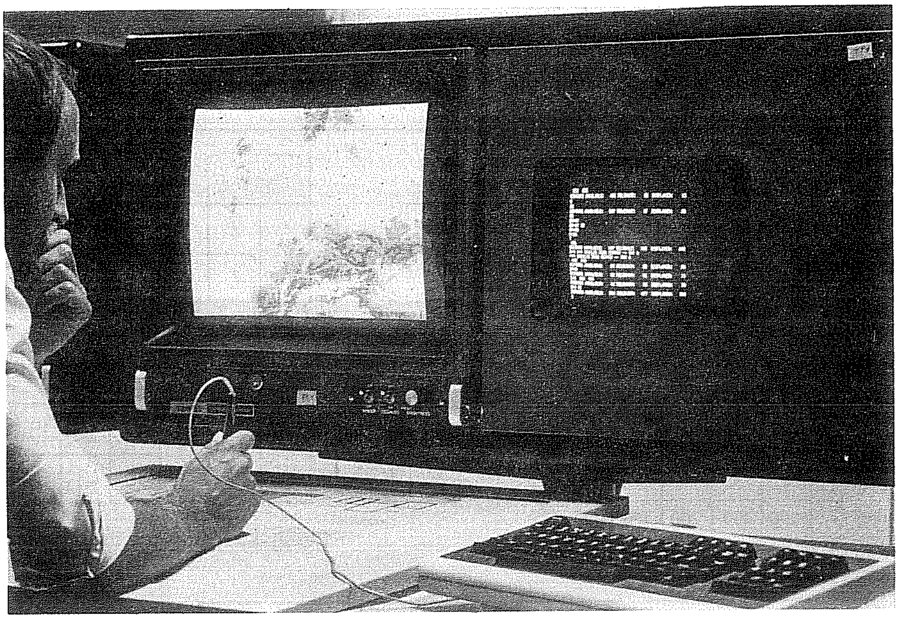

Fig. 3 Work station in detail

The box with the built-in graphics monitor and dialogue screen can be turned to both sides, so that the forecaster is able to see the display even if he is working at the adjacent table or at the neighbouring work station. The data tablet in front of the graphics screen can be tilted to a certain extent for comfortable use. The tablet pen (stylus) can be exchanged for a digitizer.

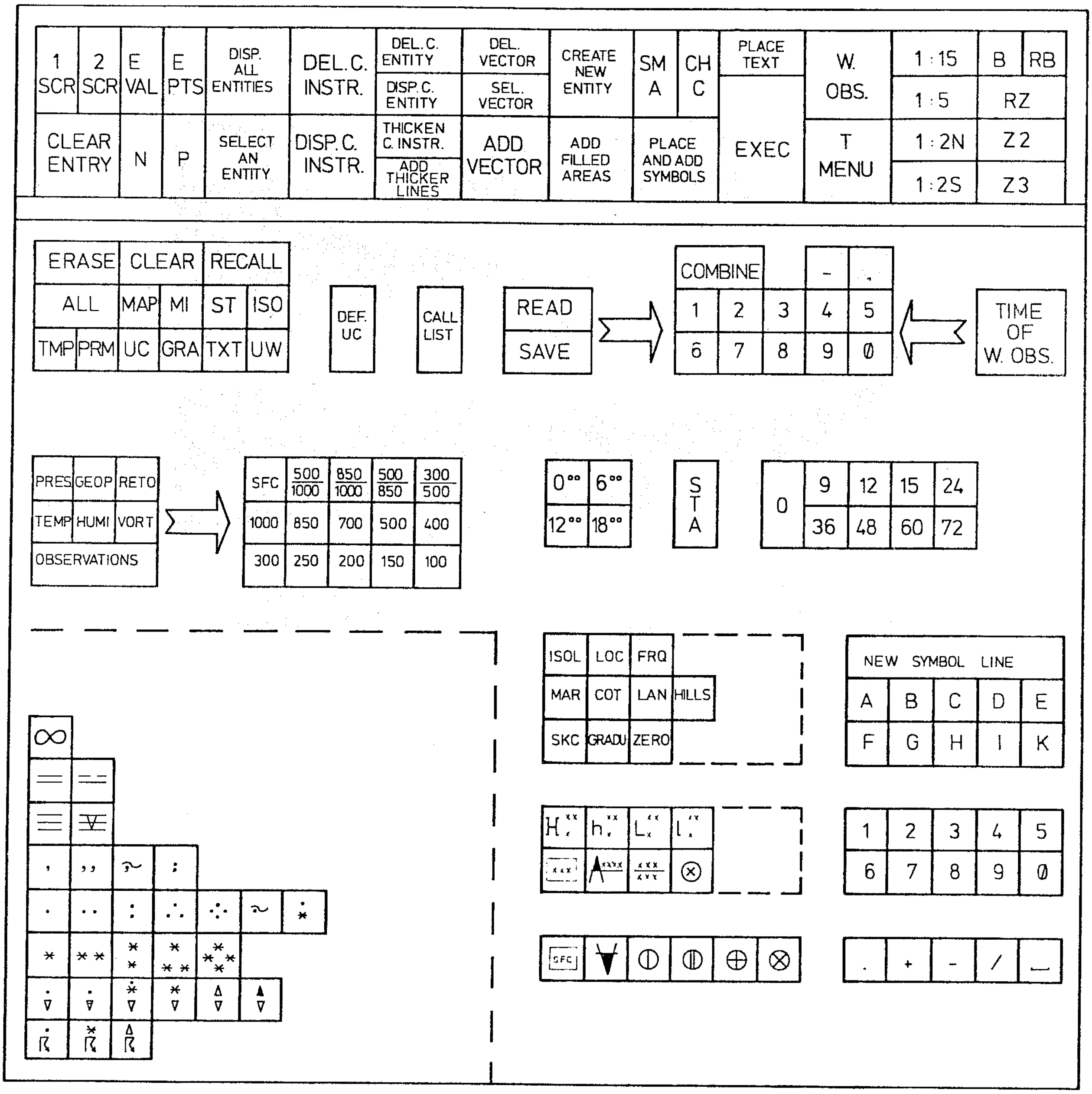

Fig. 4: Data tablet menu

CLOUDS	PR. WEATHER	WIND	PRESS. TEND.	
CH	RAIN/SNOW	T,TD	FOG	VSBY
CM	PRECIPITATION		VSBY</=....,.KM	
HCLNH	SHOWER/THUNDERST.		CLG</=...HFT	
N	CLG</=...HFT/VSBY</=....,.KM			

TT	CH			PPP	E X E C			DELETE		
VV	CM			PP						
WW	N	DD/FF		A	COMPL. SURFACE OBS.					
TD	H	CL	NH	W	.	1	2	3	4	5
TW			DS	VS	/	6	7	8	9	0

Fig. 5: T-menu

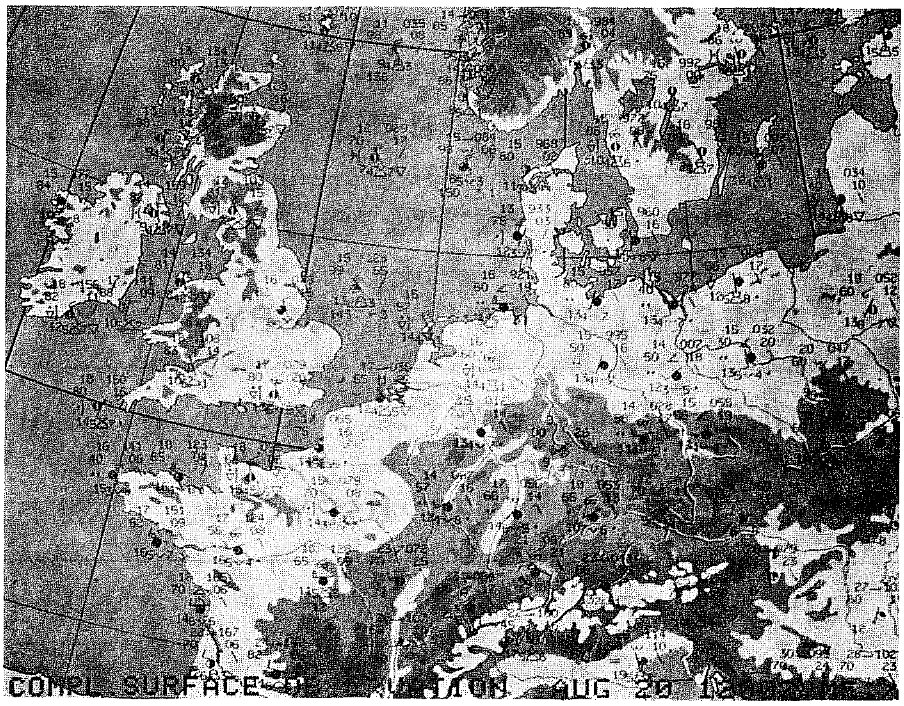

Fig. 6 The subtitle informs the user on the contents of the display:

Type of display:	complete surface observation (WMO-standard station display)
Date:	20 August
Time of observation:	1200Z
Standard section:	1 : 5 million
Zoomed by factor:	1 (i.e. no zoom)

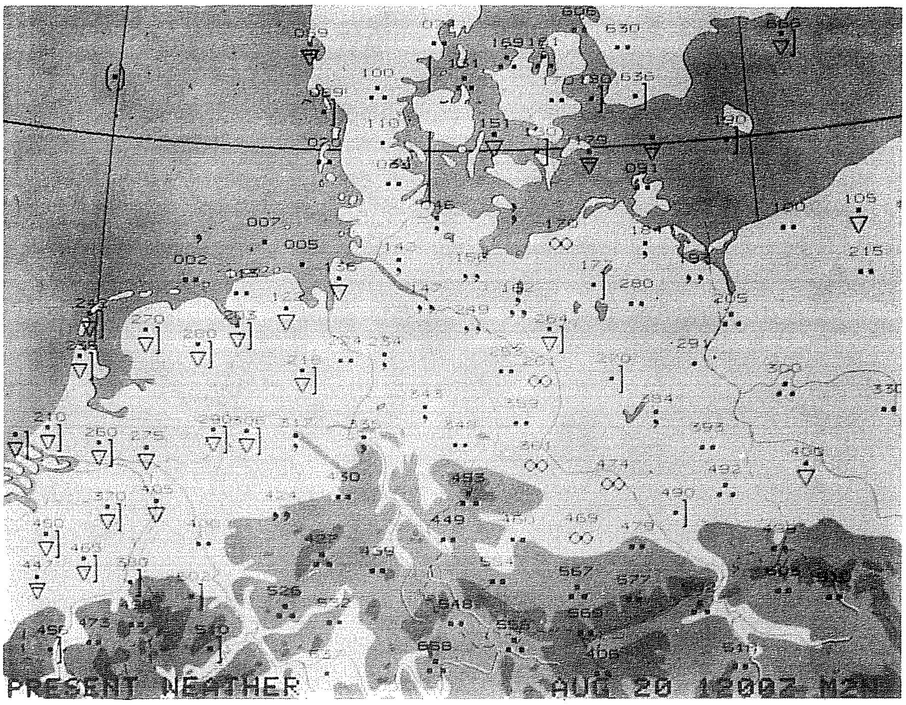

Fig. 7 Type of display: present weather (ww)

Standard section: 1 : 2 million North

Zoomed by factor: 1

The numbers above the ww-symbols are the last digits of the WMO station indicators. The density of displayed reports is very much increased compared to a complete station display in the same scale. An even higher density may be acquired when zooming by a factor of two or three inside this map section. The ratio between the numbers of displayed and available reports usually reaches 100%.

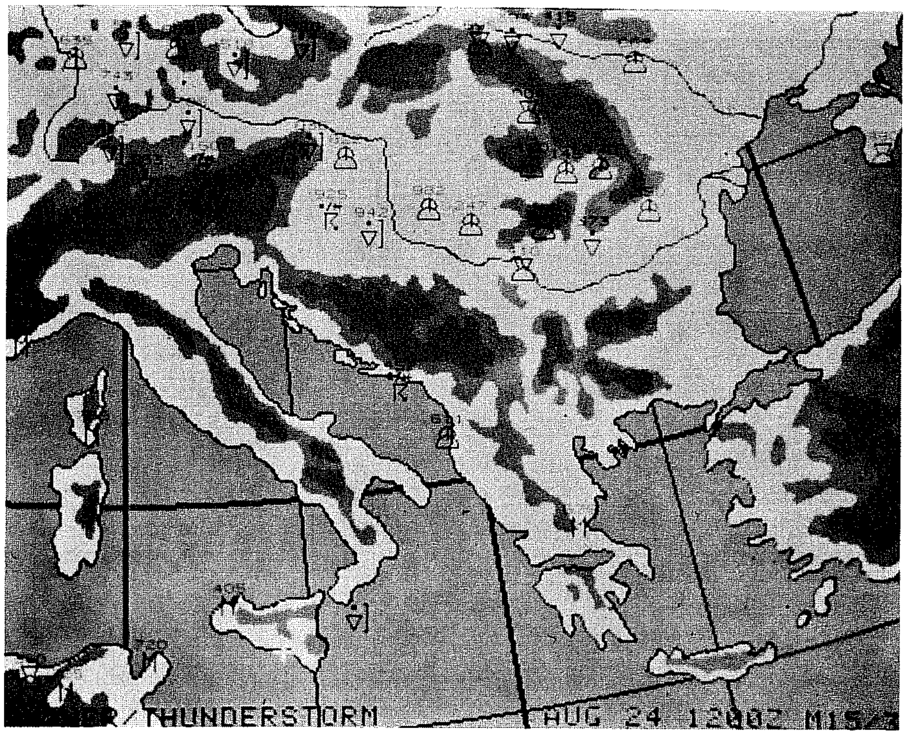

Fig. 8 Type of display: shower/thunderstorm

Standard section: 1 : 15 million

Zoomed by factor: 3

Black and white blinking of reports of heavy thunderstorm may optionally be activated by the forecaster.

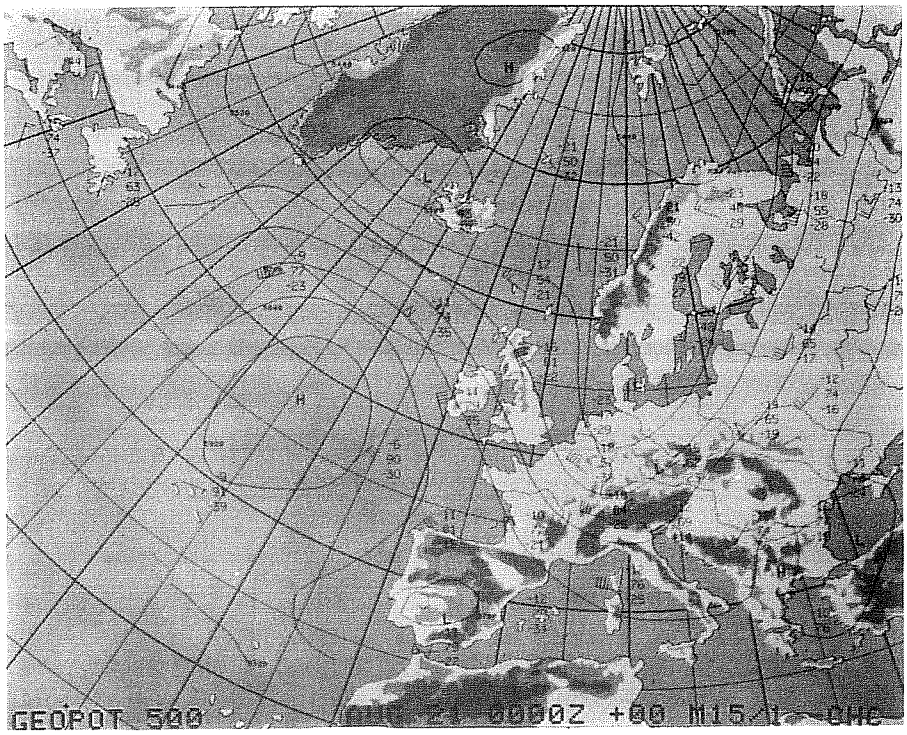

Fig. 9 Absolute topography analysis of 500 mb geopotential height

Date:	21 August
Time:	0000Z
Forecast period:	+00 hours (analysis!)
Standard section:	1 : 15 million
Zoomed by factor:	1

The analysis is combined with 500 mb upper air reports

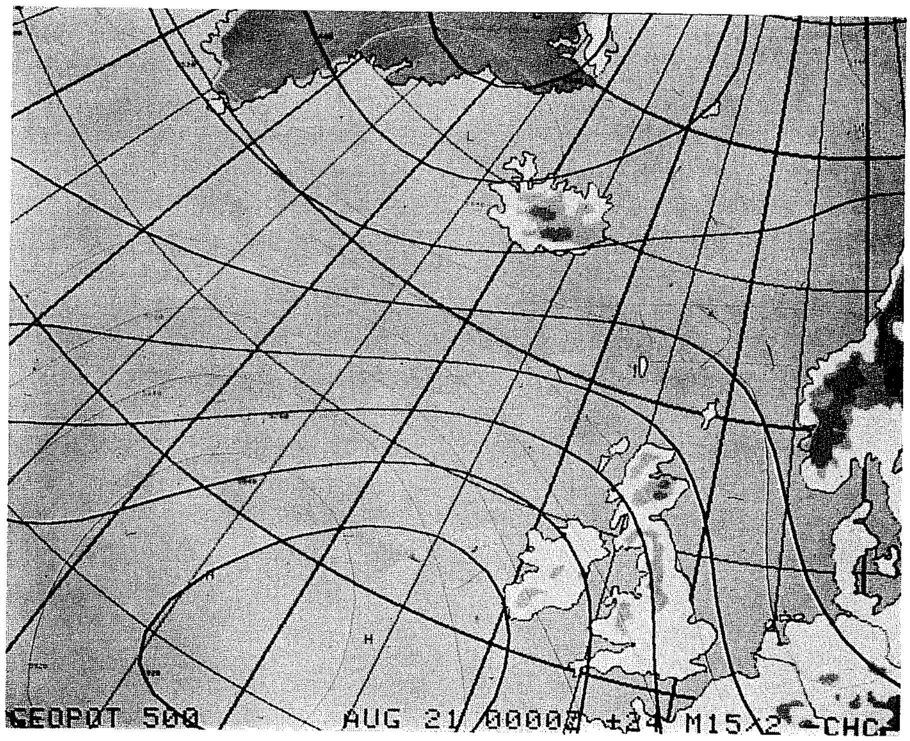

Fig. 10 The analysis of Fig. 9 is displayed as an underlay chart. The thickened isolines represent the 24-hour forecast (+24)

Standard section: 1 : 15 million

Zoomed by factor: 2

Upper air reports are blanked out.

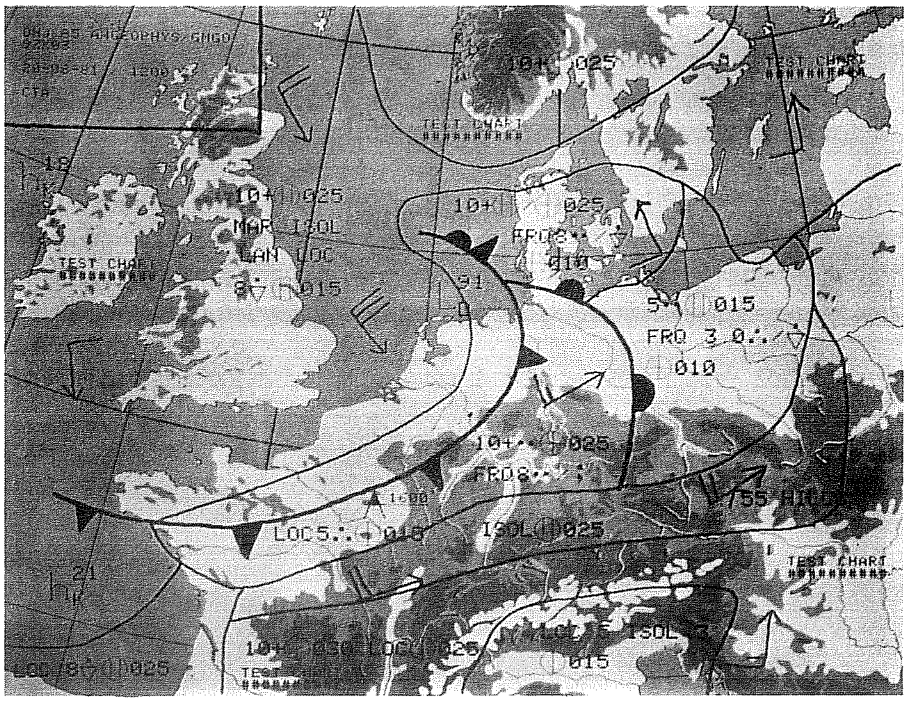

Fig. 11 Manually drawn analysis chart showing graphical features described in the text

Standard section: 1 : 5 million

Zoomed by factor: 1

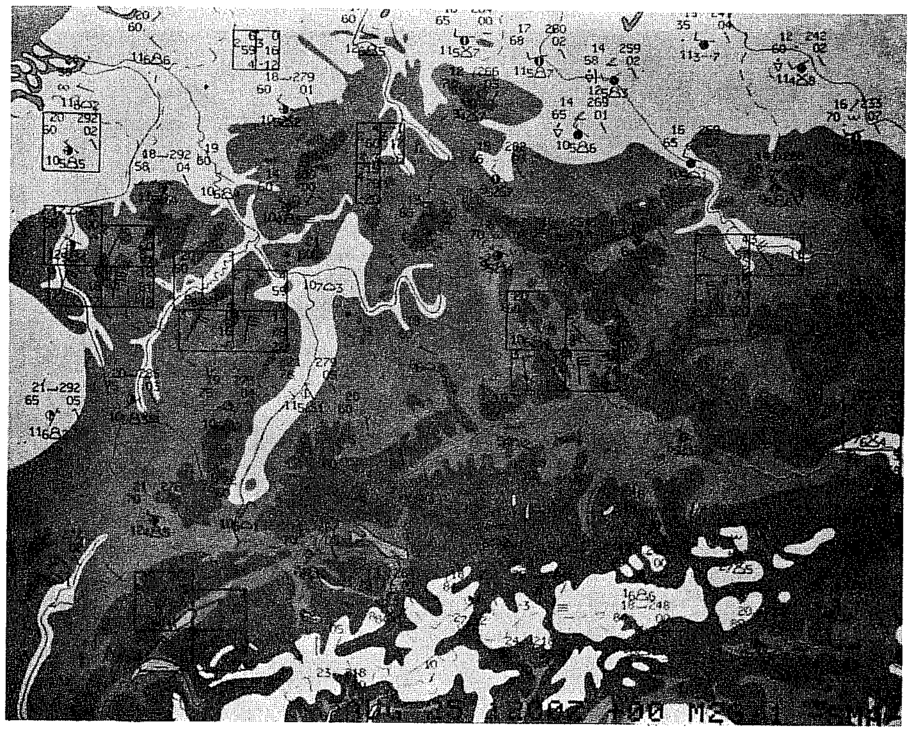

Fig. 12 Simultaneous display of surface and upper air 850, 700 and 500 mb reports. Each frame cluster belongs to one radiosonde station report

Standard section: 1 : 2 million South

Zoomed by factor: 1

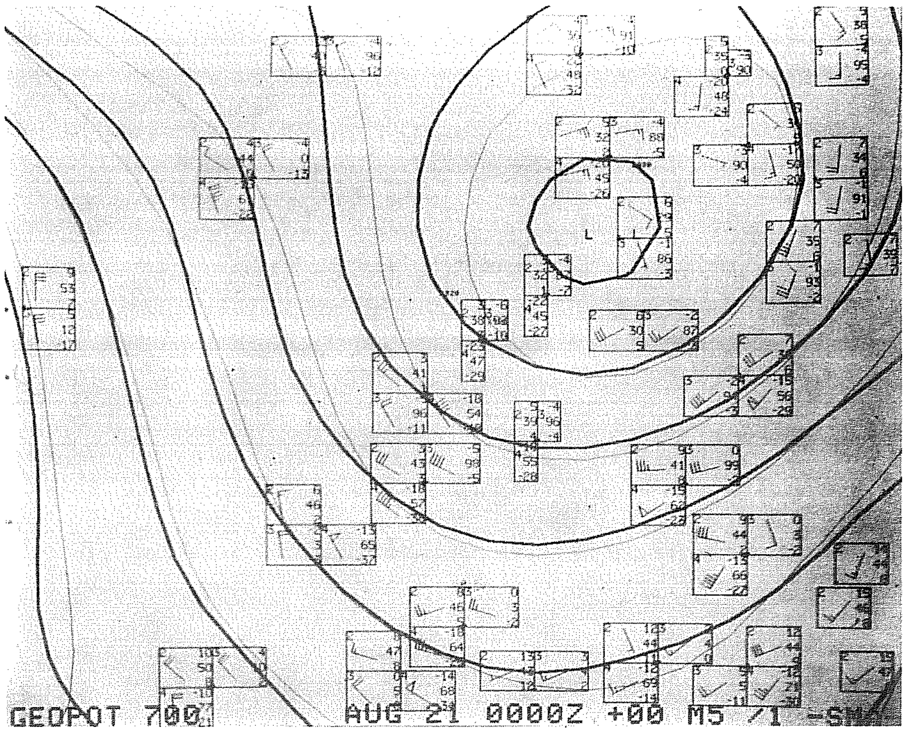

Fig. 13 The thickened isolines represent the semimanual 700 mb geopotential height analysis created in the standard section 1 : 5 million. Map background is removed. The field was computed from manually entered spot values according to the displayed reports. For comparison, the numerical model analysis, calculated hemispherically, is displayed as an underlay chart.