

# GRAPHICS WORKSTATIONS AT THE IRISH METEOROLOGICAL SERVICE

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## 1. INTRODUCTION

This paper describes a number of graphics programs, in use by the Forecasting and Research Divisions, for displaying observations and NWP products using X/Motif. In particular, we discuss an X program called `xcharts` which replaces a command driven system called CHARTS [Hamilton 1984]. Backward compatibility has been maintained as much as possible.

## 2. HARDWARE

We have quite a mix of hardware but at present we are moving more and more towards unix platforms. The following is a summary of the systems relevant to this paper [for further details see Hamilton, 1993 and Hamilton, 1994] :

A VAX cluster [MicroVax 3100 and two VAX 4200] used for telecommunications

A MIPS RS-4000 Millenium used for decoding observations and NWP products and for the graphical display of such products.

A Silicon Graphics Challenge-L server [with two 150Mhz processors] which is used for running the HirLam NWP model.

Six Silicon Graphics Indy R4000 workstations used by the Research, Computer and Forecasting Division. Their primary use is to display output from numerical models.

## 3. SOFTWARE

There are a number of computer graphics packages in use in the service – some are commercial systems and some were developed in-house. Generally speaking, the various packages are not well integrated and it is hoped to rectify this in the future.

A package, supplied by Ericsson, is used to display the output of the Dublin airport radar on a VAX-station workstation. Also, we have a number of self-contained satellite display systems which use secondary data. We plan to purchase a unix radar display system and we are investigating the option of obtaining a PDUS system, to receive primary satellite data.

The in-house developed batch graphics systems is used to display observations and/or NWP products. It is used to produce hardcopy output on pre-printed sheets

using on-line Hewlett-Packard Draftmaster plotters. In addition, plots can be produced using Canon laser printers and/or Hewlett-Packard PostScript printers.

Plots, which will eventually be produced as hardcopy, are stored as random access binary files containing vectors. Each file may contain one or more plots [e.g. a file could contain a number of plots of geopotential at various standard levels]. Header records contain size information and alpha-numeric labels. Packages exist to display such plot-files on the available output devices which include X-windows workstations.

Since 1984 the forecasters have had access to an on-line command-driven interactive graphics system [called CHARTS] which allows the display of NWP products on a colour graphics terminal [Hamilton, 1984]. This program has recently been supplemented by an X-windows system called `xcharts`. It uses many X-windows features [such as pull-down menus, icons etc.] but is still backwards compatible with the old system via a command line interface.

#### 4. USE OF X-WINDOWS / MOTIF

A number of applications have been developed using X/Motif. The following are the main ones used by the Research and Forecasting sections :

**plotxw** : This package can display a plot-file [produced using the 'batch' plotting system] on an X-terminal. It is in daily operational use in the main forecasting office.

**xgrbplt** : This program is used for plotting NWP GRIB-code output from the HirLam model. It is mainly used by the Research Division.

**xcharts** : This package is an X-windows/Motif replacement for the command-driven CHARTS program. It is used, by the forecasters, to display NWP output and observations.

All three systems are written in a mixture of C and Fortran. They do not use any third party graphics libraries [apart from Motif and Xlib] and were written without the aid of a 4GL design tool. The main routine, which handles the Motif widgets and the various call-backs, is written in C; this then calls various Fortran packages [such as the contouring package]; and finally the Fortran packages call low level C routines [such as `XDrawLines` and `XFillPolygon`] to produce the actual output.

#### 5. PLOTXW : DISPLAY PLOT-FILES USING X-WINDOWS

Plots destined for the Hewlett-Packard plotters [or the various laser printers] are stored as random access binary files containing vectors. Each file may contain one or more

plots. `plotxw` can display such plot-files on an X-terminal or workstation. The user gives the command:

```
plotxw plot-file.plt
```

where 'plot-file.plt' is the name of such a file. If the file contains just one plot then the plot is displayed and the user is presented with a menu, along the top of the chart, with the following options:

```
File, Bgnd, Zoom, UnZm, Hard, Help
```

The 'File' button calls up a menu which includes the 'quit' option; The 'Bgnd' button allows the user to display the plot on a map corresponding to one of the pre-printed backgrounds used with the Hewlett-Packard plotters; the 'Zoom' button allows the user to select a rectangular zoom area by defining its two opposite corners using the mouse; the 'UnZm' button cancels the zoom and displays the whole chart; the 'Hard' button produces a hardcopy [of the area on the screen, which may be a zoom area]; and finally the 'Help' button produces some help text. The user can cascade zooms but the 'UnZm' option will always return to the entire plot [not the previous zoom level].

If the plot-file contains a number of plots then the menu contains additional entries and looks like this:

```
File, List, Bgnd, Next, Prev, Zoom, UnZm, Hard, Help
```

The 'List' button allows the user to list details of the plot-file entries [viz. alphanumeric labels within the plot-file] and then select one from the list; The 'Next' button moves to the next entry in the list; the 'Prev' button moves to the previous entry. If the user selects a zoom it remains in place as the user moves back and forth between plots within the plot-file. The program starts with a blank screen – the user must select the first plot for display.

A large number of plot-files are generated automatically each day and they are used by the forecaster as needed. For example, the file `ecwave.plt` contains ecmwf wave forecasts. When the forecaster selects the 'List' button he/she sees a list like this :

```
Block 1 Analysis valid 12Z Wed 8 Nov 1995 : Combined Height/Period of Sea
```

```
Block 2 Analysis valid 12Z Wed 8 Nov 1995 : Height/Period of Swell
```

```
Block 3 Analysis valid 12Z Wed 8 Nov 1995 : Height/Period of Sea
```

## 6. XGRBPLT : DISPLAY GRIB-FILES

This package is used to display GRIB output files from the HirLam model. It is mainly used by the Research Division. A HirLam GRIB file typically contains all the output

data for a given time level i.e. it usually has a number of surface fields [such as msl-pressure, rainfall etc.] and a number of multi-level fields [e.g. temperature, geopotential, wind components etc.]. The user runs the package by giving the command:

```
xgrbplt fc9506150024pp
```

where 'fc9506150024pp' is the HirLam 24-hour forecast [from 15-June-1995] after post-processing onto pressure levels. [The system can also plot model level files].

The program starts by reading the GRIB file and determining the grid geometry. Then it draws a polar-stereographic map which just covers the grid. The user is then presented with a menu:

```
File, Optn, List, Prev, Next, Zoom, UnZm, Hard, Help
```

The 'File' menu button includes the 'quit' option; the 'Optn' button [discussed later] is used to select various options; the 'List' option allows the user to select a field for plotting; the 'Next' and 'Prev' buttons move to the next and previous plot in the list, respectively; the 'Zoom' button is used to specify a zoom using the mouse; the 'UnZm' button cancels the zoom; the 'Hard' button produces a hardcopy and the 'Help' button produces some help text.

The 'List' button produces a list of products by reading the file. The following is an example :

```
06 100 200 Geopotential on Isobaric surface
06 100 300 Geopotential on Isobaric surface
06 100 500 Geopotential on Isobaric surface
01 103 000 Pressure on Specified altitude
33 105 010 Wind on Specified height level
11 105 002 Temperature on Specified height level
61 105 000 Total precipitation on Specified height level
62 105 000 Large scale precipitation on Specified height level
63 105 000 Convective precipitation on Specified height level
```

The three numbers at the start of each line are the WMO parameter code, the WMO height code and the height value. Hence, the first entry specifies the 200mb geopotential, the fourth entry is the msl pressure etc. The package combines the u- and v- wind components [i.e. parameters 33 and 34] to produce a plot of WMO wind arrows.

The package allows the user to resize the window. When the window is resized the plot is redrawn i.e. re-contoured and a new background map generated. This is to allow for changes in resolution due to the resizing: the labels on the plot remain at constant size in terms of pixels.

The zoom option uses a cursor which follows the latitude/longitude lines i.e. the cursor appears as a circle intersected by a straight line on a polar-stereographic map. Basically, the user specifies two points on the chart, and the zoom area is defined by the range of latitude and longitude defined by the points. A plot area is then calculated which includes the area requested by the user; the plot is realigned with the central meridian of the plot vertical. A label is drawn at the top of the plot.

The user can plot difference charts with **xgrbplt**. The command is similar but two GRIB-files must be specified. They must be on the same area but need not contain the same number of fields or have the fields in the same order. The 'List' button will show just the fields common to both files.

The final way of using **xgrbplt** is to plot observations. An observation file [in a special format used as input to the Norwegian objective analysis system which we are using as part of HirLam] is specified on the command line. The result is that observations are displayed on the plots of geopotential and msl-pressure. The package uses a 'de-cluttering' algorithm to select the observations for display. The number of observations displayed varies with the size of the plot on the screen and the zoom level.

A typical plot can consist of a geographical background, a contour plot and a plot of observations. The 'Optr' button allows the user various choices via sub-menus. These include tabulation of data values, control over the contour spacing, various methods of plotting observations and a choice of coastline resolution.

## 7. XCHARTS : AN X-WINDOWS VERSION OF CHARTS

Until recently, CHARTS [Hamilton, 1984] was the main forecaster interface to NWP output. This is a command driven interactive system which allows the display of charts on a DEC VT-340 terminal. It uses a command language which has been designed to be as easy to use as possible. Commands can be abbreviated; there is an on-line HELP system, a hardcopy option, a script option [viz. the so-called 'obey' files], and ambiguous or incorrect commands produce meaningful error messages. The system remembers the parameters entered with previous commands and these become the defaults for subsequent commands – this reduces typing to a minimum.

Using CHARTS the forecaster can access output from the HirLam model as well as the models of ECMWF, DWD and UKMO. Available output includes plots of wave data. The forecaster can also request plots of upper-air ascents as tephigrams.

The forecasters are very familiar with the old system and so the new system was designed to be as compatible as possible with the old. The new system is called **xcharts**.

The user interface in **xcharts** combines a command line with menu buttons. This allows for continuity between the old and new systems; it also allows the use of the current set of script [i.e. 'obey' files]. Ideally, all features should be available with either the command interface or the menu interface but, in practice, some of the more obscure features are only available through the command line. However, in practice, the users almost always use the menu buttons.

The menu interface contains the following buttons:

File, Plot, Optn, Modl, Parm, Levl, Time, Misc Prev, Next, Zoom, UnZm, Hard, Help which we will now explain in turn.

The 'File' button produces a menu with the options 'Reset' [which resets parameters to their default values], 'Exit' [which exits the system] and 'Obey' [which allows the user to select and run an 'obey' file i.e. a scripts file with a chart definition].

The 'Plot' button produces the main menu of which the following is a [greatly-simplified] version :

HirLam	Pressure	Surface	Analysis
ECMWF	Geopotential	1000mb	12hour
UKMO	Temperature	925mb	24hour
DWD	Windarrows	850mb	36hour
Physics	Rainfall	700mb	48hour
Plot		OverPlot	

The procedure is for the user to specify a model, parameter, level in the atmosphere and length of forecast. Then, clicking on the 'plot' button will produce a new plot; clicking on the 'overplot' button will superimpose the chart on the previous plot. The systems remembers previous values [which are highlighted] and it is unnecessary to specify any value which has not changed. Difference charts and thickness charts are specified by means of sub-menus [not shown].

The 'Optn' menu allows the user to specify various options, such as the colour of the plot, which are of secondary importance.

The 'Modl', 'Parm', 'Levl', 'Time' and 'Misc' buttons are 'short-cut' buttons which are designed to reduce the amount of typing required. Thus, the 'Modl' button is used to change the model [e.g. from HirLam to ECMWF] and plot immediately. So, for example, if a 24-hour HirLam forecast of surface pressure is displayed and the user clicks on the 'ECMWF' option in the 'Modl' menu then an ECMWF chart will be displayed, without the need to click on anything else.

The 'Prev' and 'Next' buttons are used to retard or advance the time of the plot. Thus, if the plot consists of a number of superimposed charts, these buttons will retard/advance all the charts. The 'Prev' button has the options '-6hours', '-12hours', '-18hours' and '-24hours' with similar options for 'Next'.

The 'Zoom' button implements a zoom where the zoom cursor is defined as a latitude/longitude intersection i.e. as a circle of latitude and a straight line of longitude. The new area is defined by the lower-left and upper-right corners in latitude/longitude. All charts are recontoured after the zoom; if observations are being displayed a 'de-clutter' algorithm is applied.

The 'UnZm' button cancels a zoom [i.e. it displays the entire chart]; the 'Hard' button produces a hardcopy and the 'Help' button displays a help menu with some simplified help on various options.

## 8. DESIGN CONSIDERATIONS IN XCHARTS

The program is based on the earlier command driven CHARTS program. Consequently, it still allows users to use a command line. In fact, clicking buttons actually generates command strings which are sent to the original CHARTS command interpreter.

The 'obey' file option has been retained and users can write scripts to display charts. The following file will display a set of HirLam forecasts [with the screen divided into quarters] :

```
Underplot Quarter=1 HirLam surface press 6Hour
Underplot Quarter=2 12Hour
Underplot Quarter=3 18Hour
Underplot Quarter=4 24Hour
Display
```

The 'Underplot' command stores a chart for later plotting. The four underplot commands define the 6-hour, 12-hour, 18-hour and 24-hour HirLam forecasts of surface pressure in the four quarters of the screen. The 'Display' command then displays the plot.

The user can use the main 'Plot' menu [or the command line] to select non-existent products [e.g. HirLam 3-day forecasts are not available]. In such a case the system prints a warning message.

At present **xcharts** is running in the main forecast office [viz. CAFO] in Dublin but it has not yet been installed in the main aviation office [i.e. the CAO at Shannon Airport]. This is because we are waiting to upgrade the communications lines to

Shannon.

The raw field data, used by **xcharts** in CAFO, is stored as a set of GRIB fields on a server machine. The data disks are nfs mounted on the workstation. Tests with routers and/or bridges and with 64-kilobit/128-kilobit lines have shown that this approach is too slow for Shannon. In this case we intend to broadcast the GRIB products as soon as they are available [either from a run of HirLam or from one of the sets of model output we receive over the GTS]. The GRIB fields will be stored locally on the workstation in Shannon and this will make the response time much faster. It will also make the system more resilient to line outages, server breakdowns etc.

## 9. FUTURE PLANS

We hope to continue the development of **xcharts** and include many more derived products such as vorticity, potential temperature, height of CB-tops etc. Also, we hope to investigate the possibility of letting the forecaster draw fronts on the chart using the mouse. A cross-section program is under development and will eventually be integrated into **xcharts**.

The command-line version of CHARTS is likely to persist for quite some time since it can be run from an ordinary graphics terminal over a relatively slow line; the X version needs a workstation or X-terminal with at least a 64-kilobit line.

## 10. CONCLUSIONS

A number of X/Motif packages have been developed, including the **xcharts** program, to display NWP output in the main forecasting office.

The **xcharts** system remains backwards compatible with the old command driven CHARTS program and the latter is still in use at Shannon Airport and at two other sites.

## REFERENCES

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