# A GKS implementation for meteorological applications

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In this paper we describe a GKS implementation made
at ECMWF and we point out some problems encountered
related to the definition of GKS 6.2 and to the
necessity to adapt to the meteorological applications.
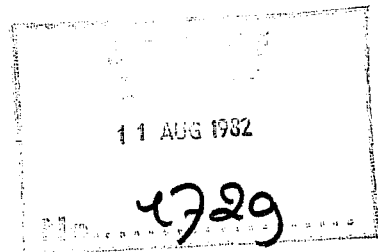
C O N T E N T S

# 1. INTRODUCTION

ECMWF was established in 1975 by seventeen European Member States in order to develop dynamic models of the atmosphere with a view to preparing medium range weather forecasts by means of numerical methods.

To meet its objectives, the Centre needs a computer facility with computing power from the largest scientific machines available. To provide this power, the Centre has installed a CRAY-1 system with a Control Data CYBER 175 acting as a front end. Further sub-systems provide specialist facilities. The graphical facilities include two on-line VERSATEC 8122 electrostatic plotters, four TEKTRONIX 4014 displays and a recently acquired AYDIN 5216 colour raster display. Furthermore, graphical output can be produced on a FR80 COM device on a bureau basis. At the time of writing most graphical output is produced in batch mode on the plotters. Typically the Centre produces on average 8000 pictures per week. This represents approximately eighteen hundred metres of plotter paper. Conversational graphics is also performed on the Tektronix displays and experiments have recently started on the Aydin system.

At ECMWF the primary graphical software is the so-called "Contour Package",(1) a Fortran subroutine package which includes such facilities as:

- coastline backgrounds and lat-long grids applying various projections e.g. polar stereographic, cylindrical, mercator.
- contouring of rectangular arrays.
- streamline diagrams
- tephigrams
- symbols, numbers and text plotting
- pseudo satellite pictures

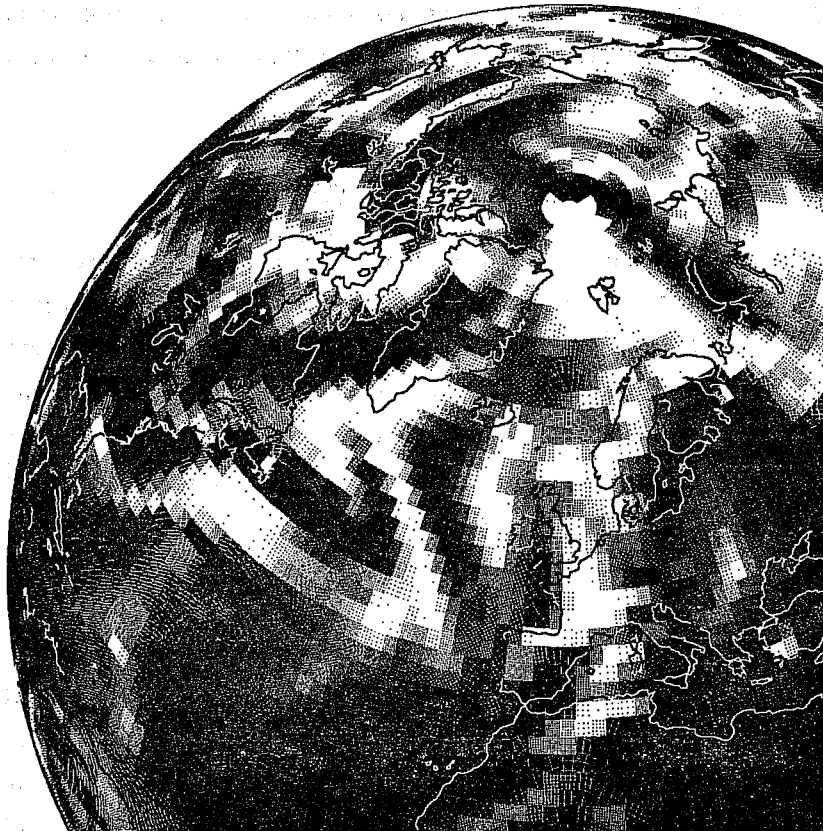Sample pictures are shown in Figs. 1 and 2.

Fig. 2    Pseudo satellite picture (forecasted cloud coverage)


This graphical software was first designed for the exclusive use of electrostatic plotters.  Since different devices are now available at ECMWF and in order to facilitate exporting the package to Member States with different hardware, it was necessary to:

    i)  introduce a device independent basic graphical package

    ii)  adapt the Contour Package to the new interface


GKS (3) was selected as a specification for our basic graphic package for the following reasons:

    i)  It just fulfills our requirements for meteorological applications.

    ii)  It is a good candidate for becoming an international standard.

    iii)  It has been designed and refined with the participation of many international experts.


In the following,we first point out the main characteristics of graphical applications at ECMWF.  Then we examine how and to what extent GKS satisfies the
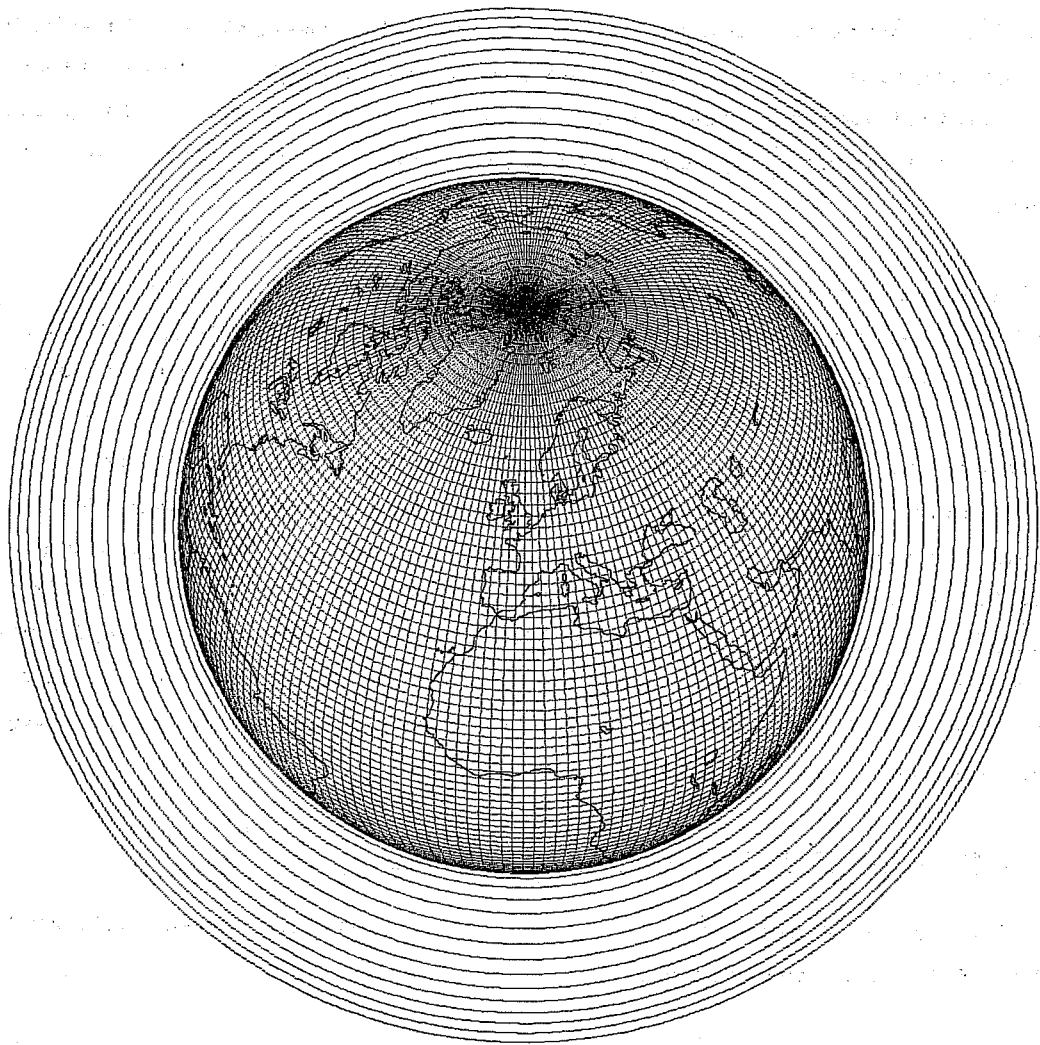
Fig. 3  The 15 layers of ECMWF's model

As far as graphical primitives are concerned polylines are the most commonly used
e.g. contour lines, coast lines.  They are characterised by their large numbers of
points, typically thousands.  In some cases, contour lines need to be interpolated
to obtain smoother curves.  Circles  and circular arcs are also used for some grid
generation.  Text and symbols are also often used.  Most texts are displayed
horizontally (titles and additional information) but some are randomly oriented.
Text height is specified in centimetres or inches.  The symbols used are mostly
meteorological symbols which are of a fixed size (with respect to the page size)
and need not be transformed.  Recently grey scaled areas have been successfully
used for representing pseudo satellite pictures.  The number of vertices of the
defining polygon is also very large.  It should be noted that when overlaying such
a picture on a geographical background, one may require that the background is
always visible, e.g. black on white or white on black.

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white.  This approach is highly specific of raster devices but has been selected for two reasons: the absence of a shielding facility in GKS and the actual use of this facility in the Contour Package.  The problem of handling a large number of definition points for polyline and fill area with respect to efficiency and memory saving has been solved through implementation techniques which are described in the next section.

Also related to efficiency is the problem of using one or several identical backgrounds, e.g. coastlines and grids in a series of "pages".  The concept of "page" or "frame" is not relevant with most interactive displays where the screen can be updated continuously.  It becomes more explicit with storage tubes where some modifications of the image require the redrawing of all permanent information on the screen.  It is an essential one for plotters and COM devices (advance paper or film).  In this latter case the notion of permanent information to be redrawn is still relevant, e.g. predefined backgrounds.  The GKS "update" function allows one to implement the "page" concept.  The "segment" concept in GKS appears to be the useful capability to implement this feature, but the INSERT and TRANSFORM functions which are not required imply an important overhead as it will be shown in the next section.  This problem is always under discussion in the ISO working group(4).Another alternative which has been envisaged was the use of a metafile but has been abandoned for this purpose because of its inefficiency.

Finally, the metafile concept suits very well our need for storing and transporting pictures.  The concept of "virtual device metafile" as actually considered by ANSI X3H3 (5) is closer to our conception of how to implement metafiles in GKS than the actual GKS - Metafiles proposal.

4.    IMPLEMENTATION POLICY

When designing our implementation policy, we have decided not to restrict ourselves to our specific requirements but to consider it from a more general point of view. This approach, similar to applying good general programming rules when writing a program of some size, is a guarantee of easier extensions and transportability.

The basic principle which has been followed for this implementation was to make each workstation perform most of the work.  We believe that this approach is consistent with the GKS emphasis on the workstation concept.  Anyhow, it corresponds to the current trend of graphical devices to bear more and more computing and storage capabilities, due to the development of micro-processors and fast hardware operators.  A similar approach is suggested in (2) especially for raster oriented systems.

and the workstation transformation. It is further combined by the workstation
with the device coordinate (in metres)-screen coordinates (in raster units)
transformation. The primitive coordinates are provided to the workstation in
world coordinates. This technique has two important advantages. First the
coordinates are transformed only once, which saves computation time. Secondly,
it prevents the intermediate storage of partly transformed coordinates, which
saves memory. These savings are particularly important for meteorological
applications as mentioned earlier.

WC

NDC

DC

WINDOW
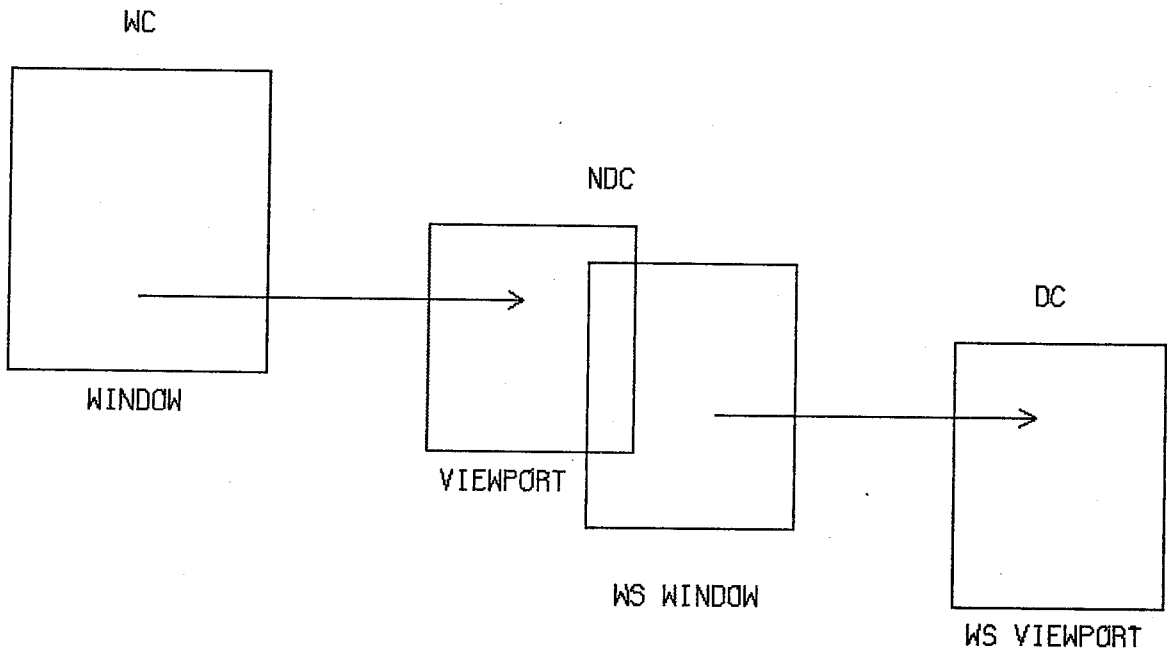
VIEWPORT

WS WINDOW

WS VIEWPORT

Fig. 4 Compound transformation

A further advantage of this approach is that it provides a uniform definition of
the clipping process, i.e. keep everything inside the rectangle and eliminate
everything outside. This is not possible when an intermediate clipping must take
place at the NDC level. For instance, text and marker have to be clipped in NDC
as if they were of stroke precision even if they are displayed with char or string
precision; the clipping of generalized drawing primitives is optional.... When the
workstation is a metafile, the viewport is stored and the clipping will be performed
only when we read the metafile. This solution is not compatible with the actual
proposal but presents many advantages.

Another point of disagreement with GKS is about text attributes. Text attributes
such as character height are specified and stored in world coordinates. This
implies that each time the window-viewport is changed, these attributes are
changed. Our users require fixed size character heights. In order to solve this
problem, these parameters are stored in normalized device coordinates.

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