Report of the

EGOWS '96 Meeting

held at

The Met. Office College, Shinfield Park, Reading, UK

3–6 June 1996

The Met. Office

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Foreword

The seventh meeting of the European Working Group on Operational Meteorological Workstations (EGOWS) in June 1996 was attended by 27 representatives from 16 European organizations. As well as all the scheduled presentations, discussions and demonstrations of software, the gathering again provided invaluable opportunities for the informal exchange of views and experiences, and for the making of contacts.

An important result of the meeting is the updated list of recommendations for operational meteorological workstations and associated development strategies and standards. This is contained in 'Recommendations' at the end of this report. The list was produced at the plenary session on the final morning and has expanded significantly compared to previous years. This reflects the growing maturity of development in the group and our increasing confidence and understanding of what is feasible in an operational environment.

Following on from the discussions, Dick Blaauboer from KNMI has now set up an electronic mailing list (egows-1@knmi.nl) of participants so that information can speedily be sought, discussed or disseminated throughout the group. Please notify him of any names to be added or deleted.

It was also decided that future meetings should focus on more-detailed strategic or technical issues, and it was felt that most presentations on what has been or will be achieved in each organization should be limited to no more than 10 minutes. It was suggested that sessions could be devoted to specific topics with a mix of upfront presentation, informal tuition if appropriate and discussion from the floor. Some topics could be decided nearer the time via the e-mail list, dependent upon which are ongoing interests and which are new.

These are exciting times in that there is still much development progress to be made. Ideas are abundant, but commercial hardware and software continue to advance ahead of our ability and budgets so that many of us are unable to take full advantage of them. Workstations provide a suitable platform for much innovation in meteorological visualization and production, so that it is an increasing challenge to meet the aspirations of both the customers and the developers.

Thank you all for your valuable contribution to the meeting and for making it such a useful and enjoyable occasion. Thank you to Lynda Jones too for all her hard work organizing the meeting, I am sure you will agree that she did an excellent job. Even the weather was perfect!

Météo-France have kindly volunteered to host the next meeting in Toulouse between the 9th and 12th of June 1997, but a volunteer is now required for 1998...

See you in Toulouse?

Angela Smith

1996 EGOWS Meeting at
The Met. Office College, Shinfield Park, Reading, UK
3–6 June 1996

Meeting programme

Monday, 3 June 1996

0900–0930	Registration
0930–0940	Introduction — Angela Smith
0940–1030	Guest speaker — Terry Hewitt, University of Manchester
1030–1100	Group photograph then tea/coffee
1100–1215	Guest speaker
1215–1330	Lunch
1330–1500	Session 1 — Virtual workstations and 3D presentation
1500–1530	Tea/coffee
1530–1700	Session 2 — Recent developments

Tuesday, 4 June 1996

0900–1030	Session 2 — Recent developments (cont.)
1030–1045	Tea/coffee
1045–1215	Session 2 — Recent developments (cont.)
1215–1330	Lunch
1330–1700	Visit UKMO Headquarters Bracknell
1700	Social evening — Visit to Windsor, followed by skittles

Wednesday, 5 June 1996

0900–1030	Demonstration session
1030–1045	Tea/coffee
1045–1215	Session 3 — Meteorological applications
1214–1330	Lunch
1330–1445	Demonstration session
1430–1500	Tea/coffee
1500–1700	Visit ECMWF
1700	Conference Dinner — Hosted by Dave Shaw Hd(FS)

Thursday, 6 June 1996

0900–1030	Plenary session — Requirements
1030–1045	Tea/coffee
1045–1215	Plenary session — Recommendations
1215	Close

Introduction

Guest speaker

Monday, 3 June 1996

Data visualization

Terry Hewitt

University of Manchester, UK

Visualising Multidimensional Data

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Introduction

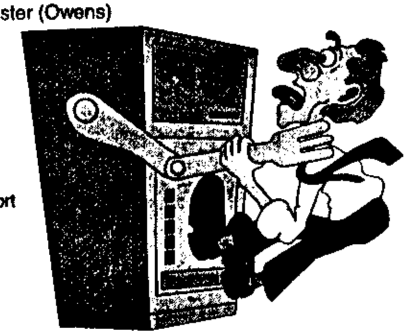
- Who am I?
- Reference Model
- Perception Issues
- Visualising multiDimensional Data
- Visualising Flow
- Systems & Conclusions

University of Manchester

- 44 Academic Departments
  - Department of Computer Science
- Manchester Computing

Manchester Computing

- Provides services to:
  - University of Manchester (Owens)
  - UMIST
  - UK Academia
    - Supercomputing
    - Large Datasets
    - Video Facility
    - MM support
    - Visualization Support

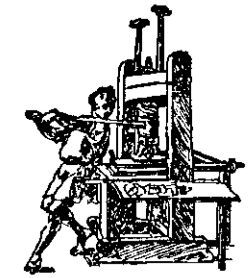


Projects as at 1 August 1996

- JTAP Visual
- JTAP Impact
- JTAP WWW & Chris Birchenhall
- WANDA
- VIPAR
- RCNET
- E=MC2
- MP/EXPRESS
- SMART: PVV
- International AVS Centre
- MIMES/ICAM
- PhD Students (2)
- MSC Students (4)
- ISSC Video Service (perhaps)
- INDEX (perhaps)

The CGU Service

- Established 1974 (outside of MC at that time)
- To provide high performance graphics services to the University
- + other support services:
  - Software installation, maintenance, support
  - Printing services
  - Video services
  - Consultancy service

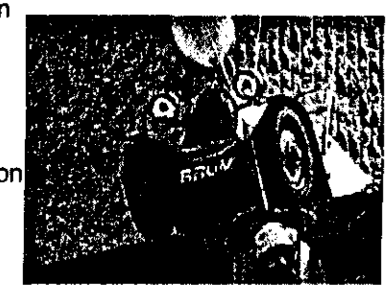


The CGU Service (2)

- National Multimedia Support
- National Visualization Support
- SuperJANET Demonstrator Site
- WEB Servers: AGOCG, JTAP
- International AVS Centre
- Manchester & North Training & Education Centre

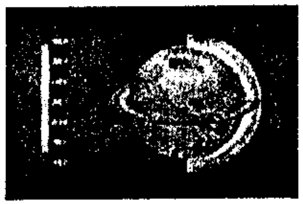
National Video Facility

- Funded by: JISC NTI, JTAP, AGOCG, University of Manchester
- Create video clips from digital images
- Real-time digitising of video tapes
- Video format conversion



International AVS Centre

- WORLD-WIDE COMMUNITY SUPPORT
- Mainly via WWW, FTP, EMAIL
- 2 FTE
- Starting soon



ADVANCED VISUAL SYSTEMS INC.

Visualization vs Presentation

- Visualization: understanding the data
- Presentation: communicating the results

Perception

- How do we perceive images?
- Perception: reading non-sensed characteristics of objects from available sensory data. It is difficult to hold that our perceptual beliefs - our basic knowledge - is free from contamination. We not only believe what we see: to some extent we see what we believe.

- Basic question is: What (kind of) 3D object does this 2D surface show?
- Problem is acute - any 2D image could represent an infinity of possible 3D shapes.
- Extra information is essential.

Clues

- Context
- Perspective
- Depth Cueing
- Haziness & Blueness
- Motion
- Stereo (or Virtual Reality)
- Shadows
- Light sources from above

Reference Model

Multidimensional Data

Flow Visualization

Systems

- AVS/Express
- IBM Data Explorer
- IRIS Explorer (SGI & NAG)
- In-house Systems

Thanks

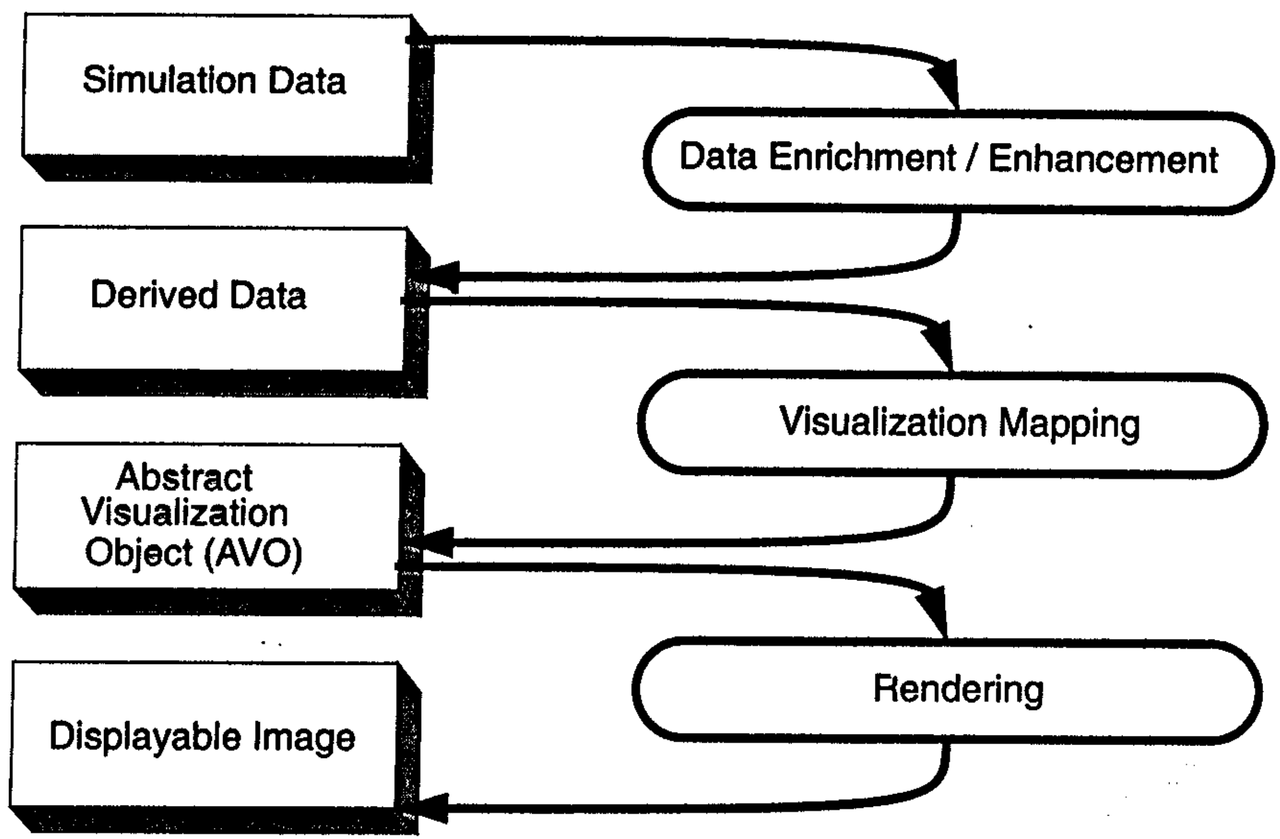
- CGU Staff, in particular, for the lecture preparation:
  - Andrew Grant
  - Steve Larkin

Resources

- URLS:
  - http://info.mcc.ac.uk/CGU
  - http://www.agocg.ac.uk:8080/agocg/
  - http://www.jtap.ac.uk/
  - http://www.iavsc.org/
- Email: cgu-info@mcc.ac.uk
- Telephone: +44 161 275 6095
- Fax: +44 161 275 6040

manchester computing

Visualization Process



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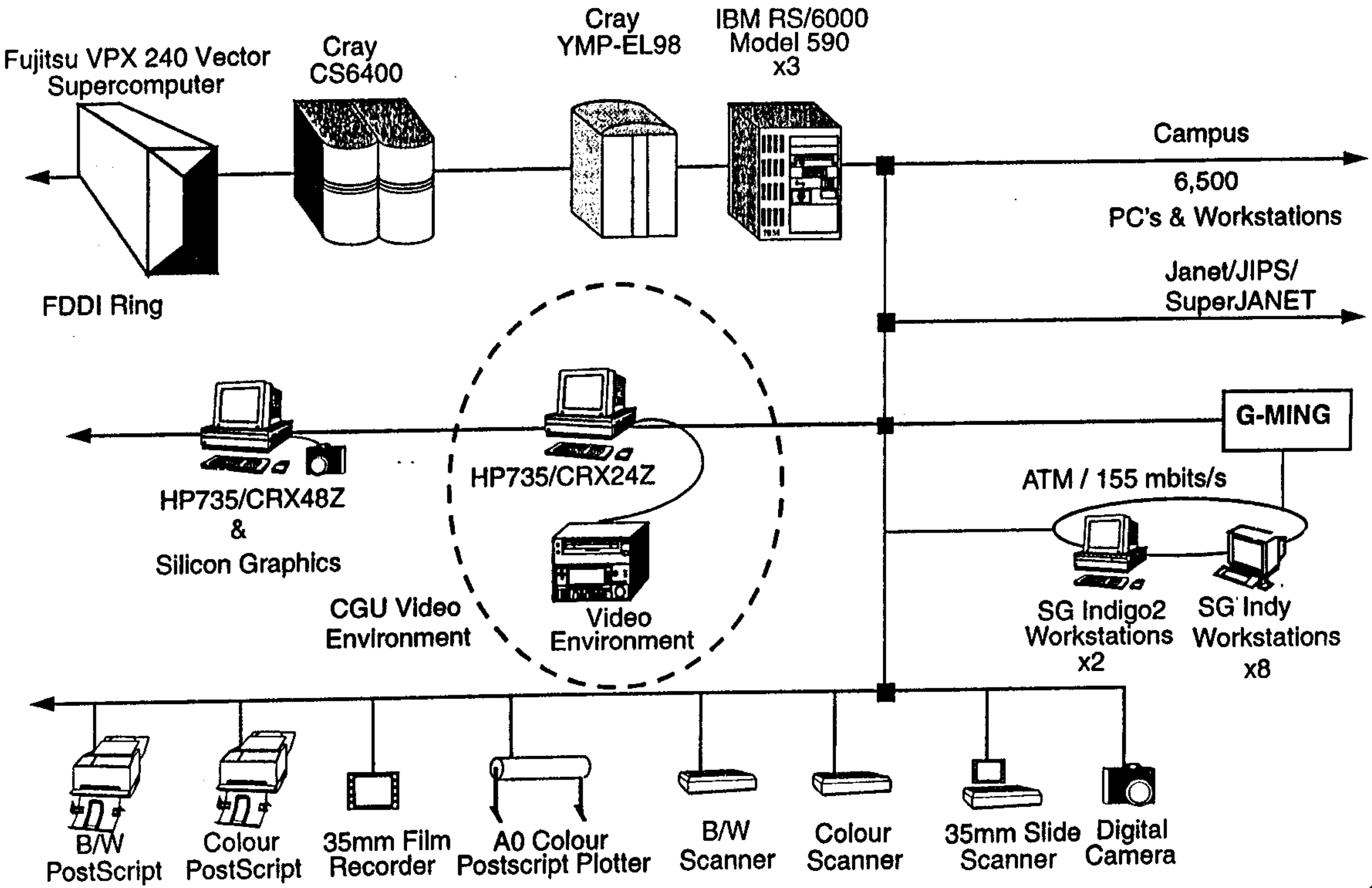

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CGU Video Environment

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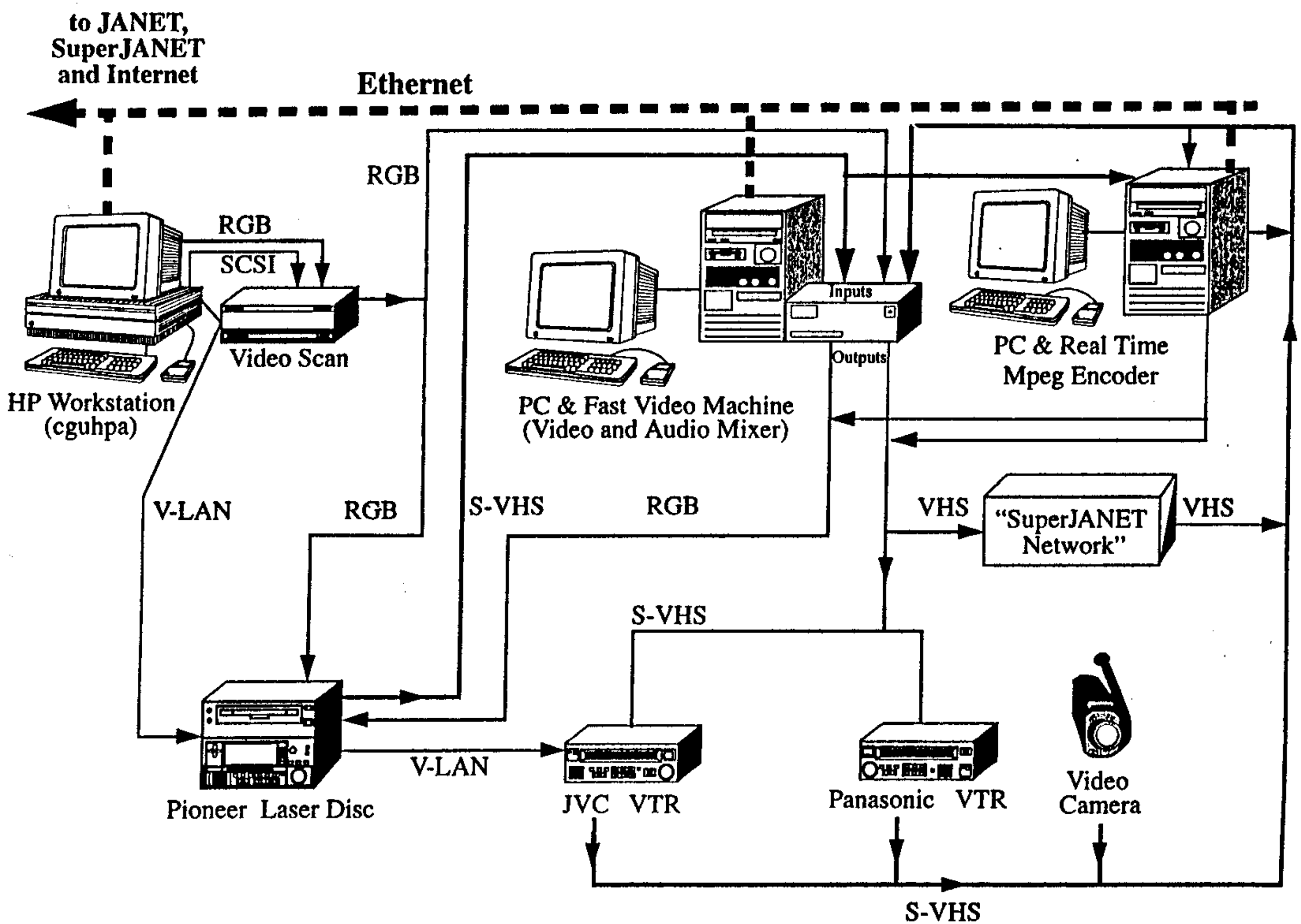
MANCHESTER COMPUTING



MAN T&EC
The Manchester and North HPC Training and Education Centre

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Techniques for Visualizing Multidimensional Data

Overview

- ❑ What is multidimensional data (mDv)?
- ❑ A look at the problems and some examples
- ❑ Techniques and use
- ❑ Some visualization systems which cater for multidimensional data
- ❑ Conclusions and summary

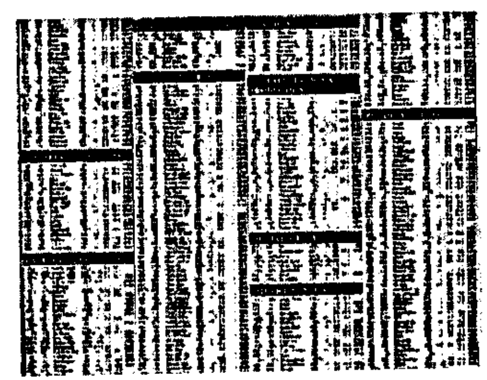
What is mDv?

- ❑ M dimensional data, V data components but also referred to as:
  - Multidimensional multivariate data
  - range data or extremes
- ❑ Some examples are:
  - Traditional areas such as Census data
  - We will also treat 2nd order tensors as a class of mDv
  - National Power: 300 companies, 13 cost components, each bidding to sell electricity to them in units of 30 minutes. How do you provide timely analysis?
  - Sociology data: a researcher has collected data over the last 20 years from people who held office in Medieval times. It contains person, year and position.

    He needs to analyse job movement, promotion/demotion, and kinship/nepotism.

Stock Exchange Data

- Vast amounts of data which changes every day and has complex relationships.



Traditional Techniques

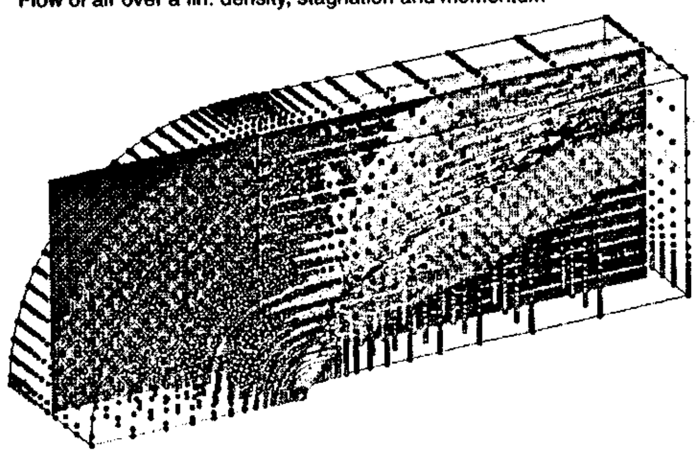
- ❑ Why not use these techniques for multidimensional data?
- ❑ These techniques are very useful for 2D, 3D scalar and vector datasets
- ❑ Problems still occur from perceptual issues:
  - ■ arrows in 3D
  - ■ colour
  - ■ locating/probing values in 3D space
- ❑ But in the majority valid assumptions can be made from the figures produced for this class of data

Applying traditional techniques

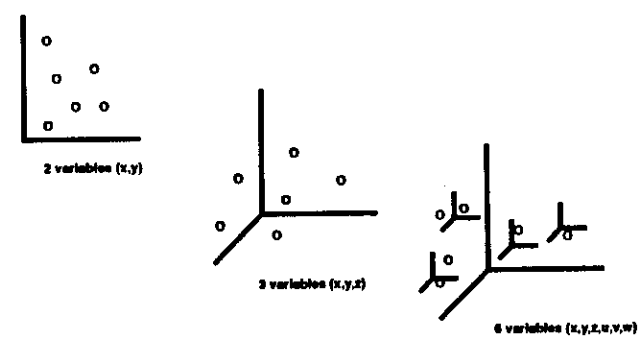
- ❑ The multidimensional data components can be viewed separately using these techniques
- ❑ Correlations can be made by stacking or overlaying results
- ❑ Careful use is need as they can produce cluttered and incomprehensible results
- ❑ We will see more examples in the techniques section

Using Traditional Techniques

- ■ Flow of air over a fin: density, stagnation and momentum



Coping with greater than 3D



- ❑ It becomes hard to navigate, relate and compare values
- ❑ We will introduce some other techniques

Some techniques

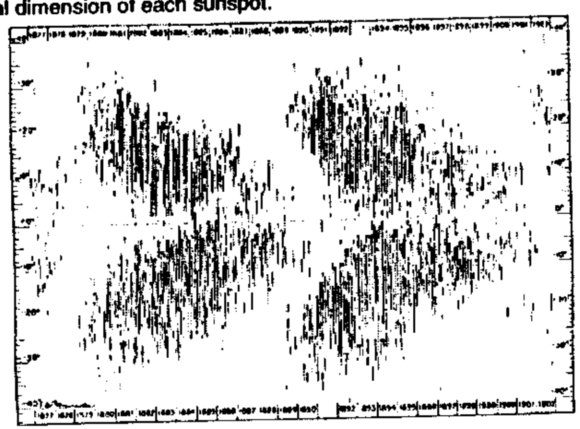
- ❑ Glyphs [1], [2], [4], [5], [6], [16],
- ❑ Textures [3], [9], [13], [17]
- ❑ Tables and Stacked Plots [2], [12]
- ❑ Scatterplots [2], [7]
- ❑ Andrews curves [10]
- ❑ Permutation Matrix [8]
- ❑ Parallel coordinates [11]
- ❑ Data Sonification [18], [20]
- ❑ Virtual Reality [22]

What are you looking for?

- ❑ The techniques sometimes produce results which appear to be very cluttered
- ❑ The viewer is specifically looking for:
  - ■ unexpected results or anomalies (spotting a stranger)
  - ■ grouping or clusters
  - ■ identifying patterns or trends and correlations
- ❑ These techniques require the viewer to be trained in their use and application
- ❑ Their effectiveness is very dependent upon the viewer

Sunspots

- ■ The sunspots travel towards the equator of the sun over time. The figure only shows the vertical dimension of each sunspot.



Glyphs

- ❑ Graphical icons (glyphs) are not new
- ❑ 1957: Edgar Anderson - circular icons with rays

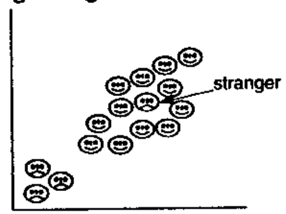
- ❑ 1966: Pickett White - triangle with sides and orientation related to different variables
- ❑ 1973: Chernoff - used a traditional 2D scatterplot with facial characteristics to represent 3,4,5,...,22 variables
- ❑ Referred to as "Chernoff Faces"

Chernoff Faces

- ❑ The variations are normally grouped into distinct classes:

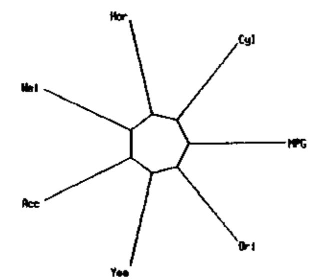
Encoding error as variation of the mouth

- ❑ Allows the viewer to try and spot trends or strangers as it relies on the fact we are good at recognising faces



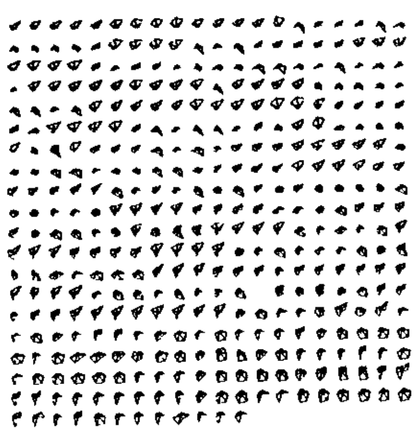
Star Glyphs

- ❑ Each dimension in the dataset is represented as a "prong" in the star, [19]
- ❑ For each datapoint a star is drawn with the size of the "prongs" representing the value in each dimension for that particular point



Star Glyphs

Produced from XmdvTool, University of Illinois



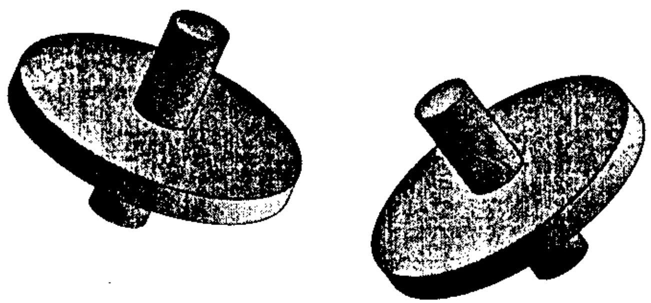
Haber Glyphs

- ❑ Used to visualize the stress-strain in a tensor
- ❑ Split the tensor into symmetric and anti-symmetric parts

$$J^{(s)} + J^{(a)}$$

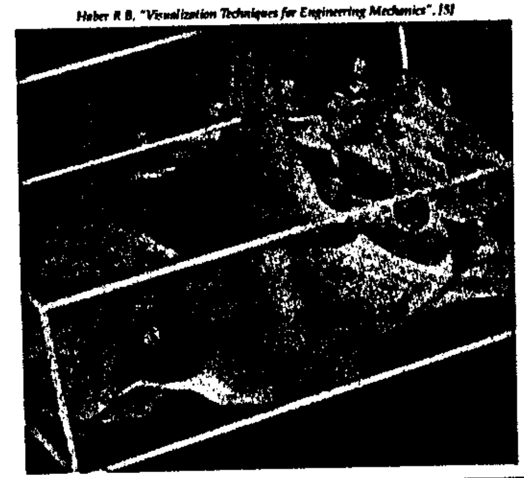
- ❑ $J^{(s)}$ is the stress-strain tensor
- ❑ Glyph is a cylinder and an ellipse
- ❑ Cylinder axis direction shows major principal direction, ellipse axes show the other two
- ❑ Cylinder and axis lengths show stretching in each axis.

Haber Glyph



Example of Haber Glyphs

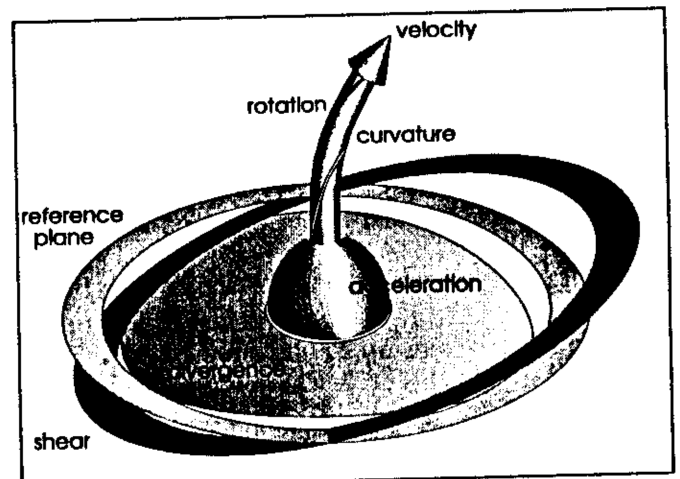
Haber R B, "Visualization Techniques for Engineering Mechanics", [5]



de Leeuw and van Wijk glyphs

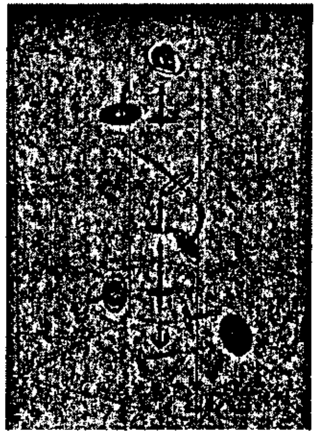
- Visualise the tensor field in the context of the associated velocity field
- Steady state flows only
- Best used as a probe or small multiple
- Constructs local coordinate axis as with Haber glyphs
- Decompose tensor into *parallel* and *perpendicular* components
- Extract further components from these
  - acceleration, shear, curvature (parallel)
  - torsion, divergence (perpendicular)

de Leeuw and van Wijk glyphs



de Leeuw and van Wijk glyphs

- Flow in a vortex



Textures

- ❑ In addition to surface height, colour and vectors we can use texture (bump mapping)
- ❑ Bump map is a collection of bumps (texture) used to add additional information to a graphical primitive
- ❑ Interactive adjustment of parameters is desirable to obtain best results
- ❑ Careful use is needed as additions to an already rough surface can be distracting

Climate Model Example

- ❑ Climate model produces a number of components:
  - wind velocity
  - heat (outgoing long wave radiation from earths surface)
  - surface height
- ❑ We want to correlate these components:
  - Reference map (surface plot): surface heights
  - Colour of Reference map: heat (blue - red)
  - Bump mapping: wind velocity (smooth - rough)

Climate Model using Texture

Crawfis R A, Allison M J, LLNL [13]

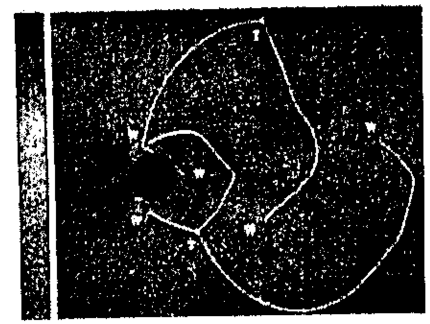
More use of textures

- Texture maps can be used to represent more information about vectors and tensors than just magnitude, [9], [17]
- The process is called "Line Integral Convolution"
- You take:
  - a vector field defined on a cartesian grid
  - a texture map of the same dimensions
- "The output image is a one-one correspondence of a 1D convolution of a filter kernal and texture pixels along a local streamline in the vector field"
- More simply the texture is "smeared" in the direction of the vector field

Texture for tensor fields

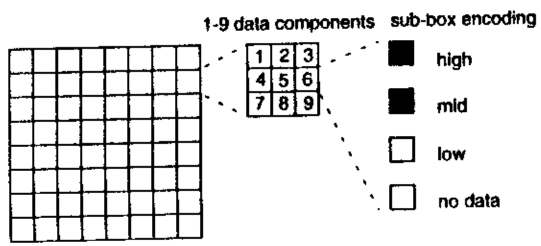
- texture is the eigen vector of the stress tensor
- colour is the magnitude of the compressive force

Demarcelle T. Hesselink L. Stanford University, [9]



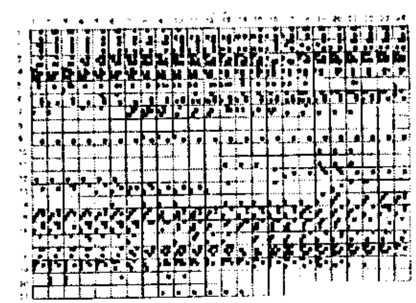
Tables

- Each point in the dataset is represented as a rectangle
- The rectangle contains encodings for the value of the point in each particular dimension in the dataset [1]



Magnetosphere and solar wind

- The readings were taken every hour over a number of days from NASA Goddard Space Flight Center.
- 13 parameters of magnetosphere and solar wind data

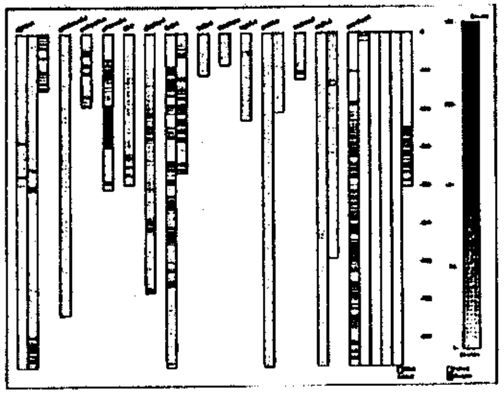


Beddow J. Microsimulations Research, [1]

Table - Profiling Code

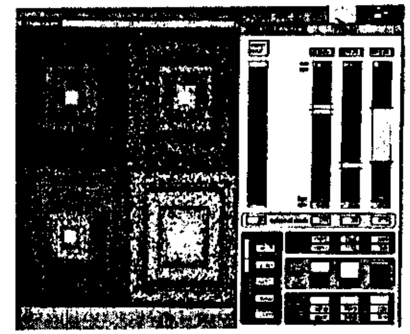
- Displays "hot-spots" in programming code

Eick S G, Steffen J L, AT&T Bell Labs [12]



Querying Databases

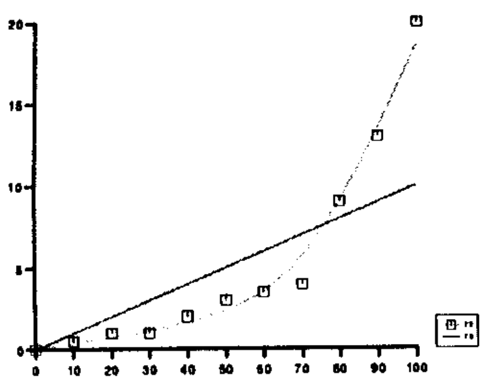
- Each data item in the database is represented as a pixel where the colour indicates the relevance for the query



Kiem D A, Kirgel H P, Seidl T, University of Munich [29]

Simple dataset

- We will use a simple dataset of temperature, pressure and velocity:



Complex dataset

- The dataset is taken from a selection of 406 different cars: (`http://www.hensa.ac.uk`)
  - This data set is a version of the CRCARS data set of Donoho, David and Ramos, Ernesto (1982), ``PRIMDATA: Data Sets for Use With PRIM-H"
- 8 Variables
  - MPG, # cylinders, engine displacement, horsepower, vehicle weight, time to accelerate from O to 60 mph, model year
  - origin of car (1. American, 2. European, 3. Japanese)

Scatterplot Matrix

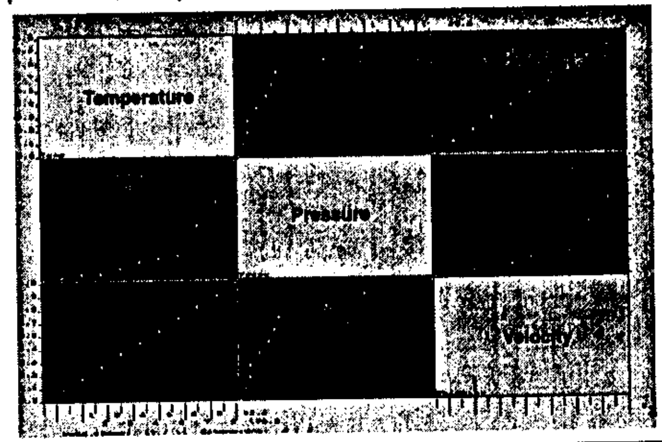
- A scatter plot shows the relationship of 2 variables
- Addition of colour can represent a 3rd variable
- A scatterplot matrix of n variables are projected onto n*(n-1) scatter plots
- For example: pressure, temperature, velocity (6 plots)

pressure	PvT	PvV
TvP	temp	TvV
VvP	VvT	velocity

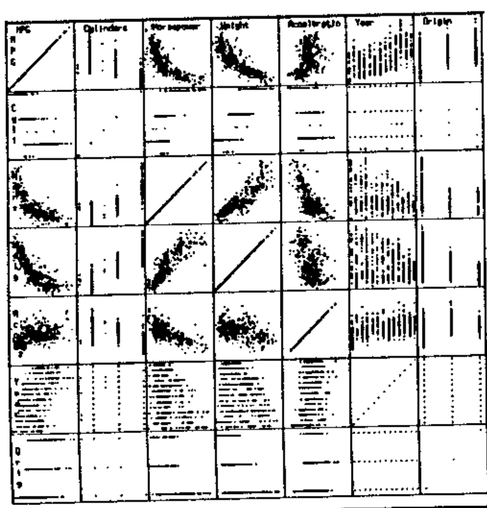
☐ scatterplot

Scatterplot Matrix - Simple

- Shows pressure, temperature, velocity



Scatterplot Matrix - Complex



Andrews Curves

- Introduced by D Andrews in 1972
- Each multidimensional point x $(x_1, x_2, \ldots, x_m)$ is mapped to a periodic function G(t):

$$G(t) = \frac{F1}{\sqrt{2}} + F2\sin(t) + F3\cos(t) + F4\sin(2t) + F5\cos(2t) + \ldots$$

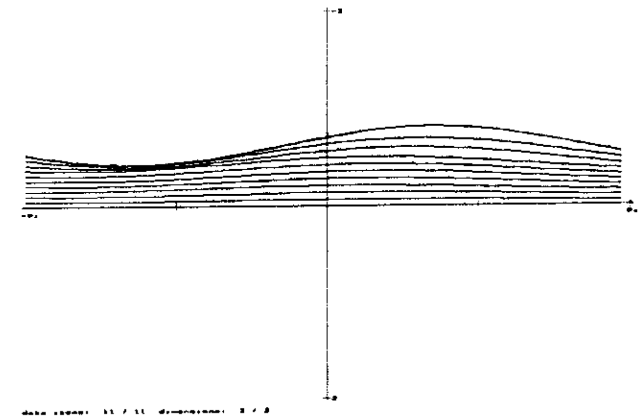
- The curves are plotted over the range $-\pi \ldots \pi$

What do the curves show?

- Produces an iconic representation of each point through multidimensional space
- Clusters of points map to similar shaped curves
- It is not possible to pinpoint single data components i.e., all the data components are combined into one function

Andrews curves - Simple

- Points through pressure, temperature, velocity

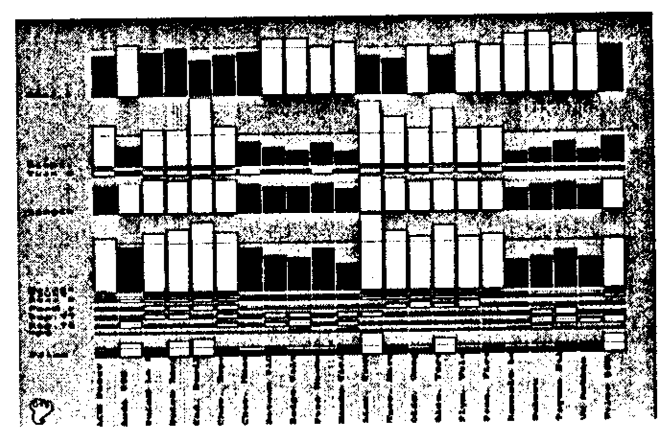


Permutation Matrix

- The dataset is transformed into a matrix of graphical elements where the rows and columns correspond to:
  - dimensions in the dataset
  - points in the dataset
- The chart has three main parts:
  - a line indicates mean value
  - black bars are values below mean
  - white bars are values above mean
- This matrix reveals structure of the whole dataset
- Individual points and dimensions can be identified

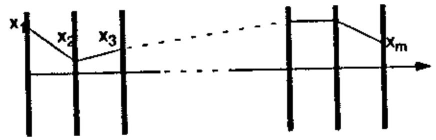
Permutation Matrix

- Shows individual cars and their characteristics



Parallel Coordinates

- Introduced by Alfred Inselberg
- Organise each axis vertically and for each multidimensional point x $(x_1, x_2, \ldots, x_m)$ mark the appropriate axis
- Join the marks with line segments

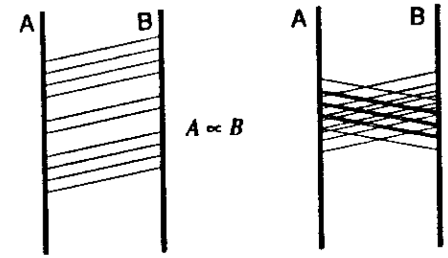


x $(x_1, x_2, \ldots, x_m)$

- Therefore a m dimensional point is represented as a line through m parallel coordinates

What are you looking for?

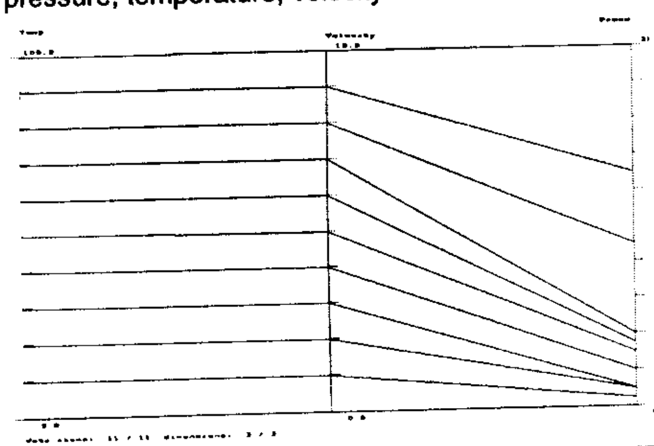
- The results seem extremely cluttered
- Systems which provide this technique allow interactive marking and highlighting of groups of lines
- There are some patterns/shapes to look for:



$A \propto B$ $A \propto \frac{1}{B}$

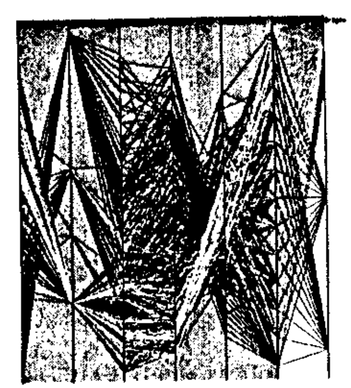
Parallel coordinates - Simple

- Shows pressure, temperature, velocity



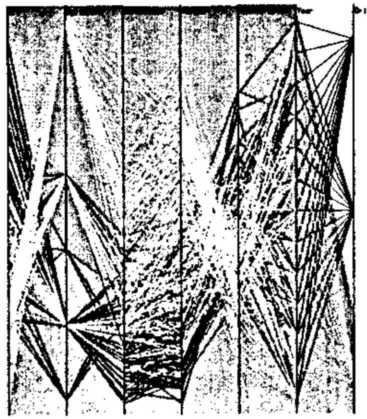
Parallel coordinates - Complex

- We have highlighted all Japanese cars



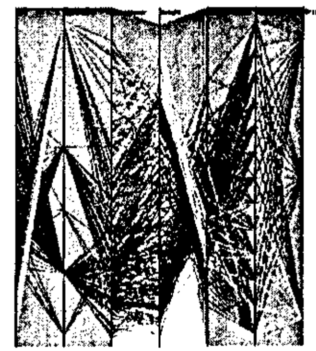
Parallel coordinates

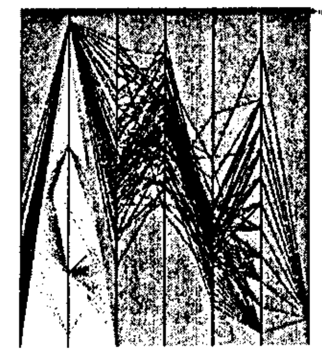
- We have highlighted all US cars



Parallel coordinates

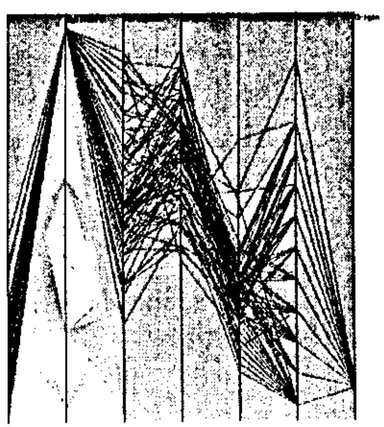
- We now look at top weight and top cylinder





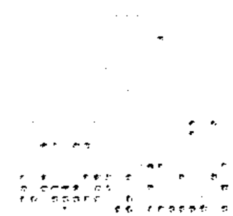
Parallel Coordinates

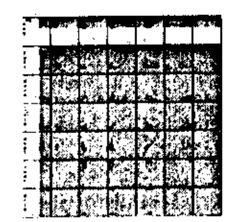
- ...and now we take a look at low MPG



Brushing

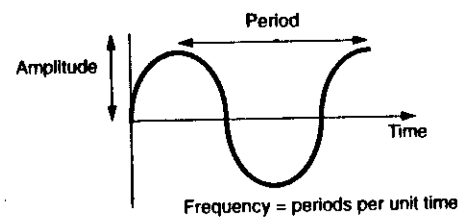
- In all the techniques which we have seen we make extensive use of facilities to highlight data which falls between certain ranges
- The XmdvTool [21] implements N dimensional brushing
- Links can be made between views of same data





Data Sonification

- The use of sound to complement a graphical representation
- But what is sound?
- It is the sensation of pressure variations in air caused by a vibrating source:



- The assimilation to data is simple, or is it?

Sound Attributes

- Pitch
  - logarithmic changes in frequency = linear changes in pitch
  - intuitive for relating to magnitude of a scalar component
  - similar problems as with colourmaps; adjacent values are difficult to distinguish
- Loudness
  - variations in amplitude
  - it is not linear as it is also affected by frequency and timbre changes
- Timbre
  - waveform: different instruments playing the same pitch/loudness
  - used to differentiate between data components

Sound Attributes

- Location
  - physical location of the sound source which is affected by acoustics of the surrounding environment
  - can provide locational cues to results
- Rhythm
  - music is organised around a periodic event rate or pulse
  - can be used to represent temporal separation between time stamped events or behav-ioural cycles
- Duration
  - hard to distinguish unless exaggerated
  - not a quantitative measure but useful to identify outliers or activity lifetimes

Sound Attributes

- Melody
  - "the first thing remembered, the last thing forgotten"
  - What constitutes a melody is the subject of considerable research
  - Certain patterns of notes are more "melodic" than others
  - Therefore the choice of scale or starting pitch is significant
- Conclusions
  - Sound is as complex a medium as other more traditional ones for visualization e.g., col-our
  - There are many pitfalls
  - You have to be aware of the "tone deaf" equivalent of a "colour blind" user

Some real examples

- Analysis of climate data - a probe samples data components and assimilates them to sound:
  - wind: varying the pitch of a siren
  - rain: varying the amplitude (loudness) of the sound of "rain"
- Audio Cues to signal an event or condition has been reached:
  - data component outside a specified range
- Application to Stanford ParalleL Applications for SHared memory benchmark suite (SPLASH)
  - type of process (system, network, application) = pitch
  - process's time quantum = duration
  - processor = instrument

Systems

- The application builders (Modular Visualization Environments) have little support for these techniques:
  - AVS has some public domain modules for sonification
  - IBM Data Explorer: Some of Inselberg's group are working in this area
- Systems being developed primarily for this analysis e.g.,
  - VisuLab: Hans Hinterberger, Institute for Scientific Computing, ETH, Zurich
  - XmdvTool: Computer Science Department, Worcester Polytechnic Institute, MA, US (`ftp://ftp.wpi.edu:/contrib/Xstuff/XmdvTool2.tar.gz`)
  - Porsonify: A Sonification toolkit, Madhyastha & Reed, Dept. of CS, University of Illinois
  - XmdvTool and Visulab were used to produce some of these figures and we wish to acknowledge the developers of these software packages.

The Future - Virtual Reality?

- This can integrate traditional techniques for visualization with other less familiar media
  - sound
  - tactile (touch)
  - Olfactory (smell)
  - taste?
- Some more current and real examples are:
  - NASA Ames Virtual Wind Tunnel
  - CAVE: The Virtual Reality Theatre
  - Advanced Interfaces Lab: Dept. of CS, University of Manchester

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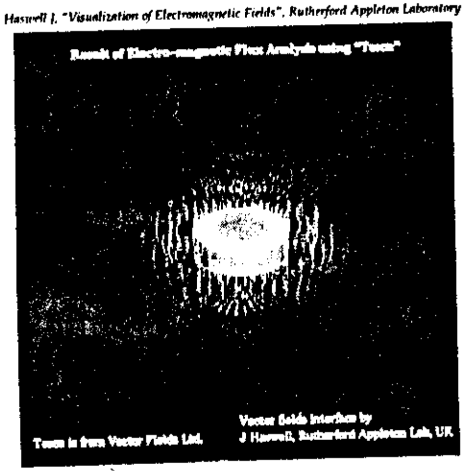
Flow Visualization

Overview

- Classes of data: scalar, vector, tensor
- Introduction to experimental flow visualization
- A look at some techniques and use [3], [5], [11], [13], [19], [21], [22]
- Double Glazing case study
- Conclusions and summary

Areas of application

Haswell J, "Visualization of Electromagnetic Fields", Rutherford Appleton Laboratory



Other Application Areas

- Design of cars, aircraft, ships, submarines & spacecraft [1], [2]
- Design of the components: turbines, combustion engines
- Flow inside blood vessels
- River and ocean flow [7], [24]
- Wind effects between buildings

Classes of Data

- Fluid flow deals with vector and tensor fields
  - Magnitude, 2D or 3D direction, stress-strain components
- Scalar fields have one value at each point
  - simple to visualise as colour, height, etc
- Vector fields have multiple values at the same place
  - need to encode the vector for display or use techniques which reveal information
- Tensor fields are more complex and we will review some of these techniques in the section Multidimensional data

Scalar	Vector	Tensor
[S]	$[V_1\ V_2\ V_3]$	$\begin{bmatrix} T_{11} & T_{12} & T_{13} \\ T_{21} & T_{22} & T_{23} \\ T_{31} & T_{32} & T_{33} \end{bmatrix}$

Experimental Visualization

(without computers)

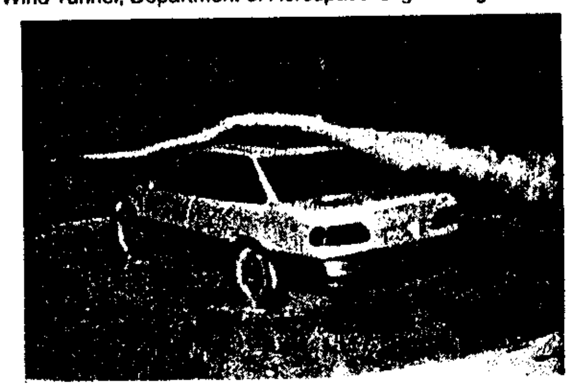
- There are three main classes of technique
  - addition of foreign material
  - optical techniques
  - addition of heat and energy

Addition of foreign material

- time lines: lines transformed by the motion of fluid flow
  - *e.g.*, a line of hydrogen bubbles
- streak lines: shows the motion by injecting a dye from a fixed position for a defined time
  - *e.g.*, dye in fluid, smoke in air
- path line: path of a particle introduced into the flow
  - *e.g.*, exposure of photographic plate to light emitting particle
- For flow over surfaces
  - *e.g.*, direction of tufts fixed to the surface or traces left by viscous fluid on surface

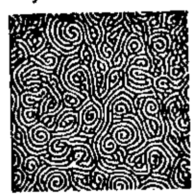
Addition of Foreign Material

- GLM Wind Tunnel, Department of Aerospace Engineering University of Maryland



Optical techniques

- change in density causes a change in refractive index
- shine light through a flow to visualise changes
- shadowgraphs:
  - passing parallel beams of light through a fluid and then focusing light onto a photographic plate resulting in light and dark patches
  - Spiral Defect Chaos: Morris S B - University of Toronto, Bodenschatz E - Cornell, Ahlers G, Cannell D S - University of Santa Barbara



Flow analysis

- There are two main methods of analyzing the flow:
- Eulerian
  - physical quantities are calculated at fixed grid positions in 2D/3D space

- Lagrangian
  - physical quantities are calculated for small particles moving with the flow

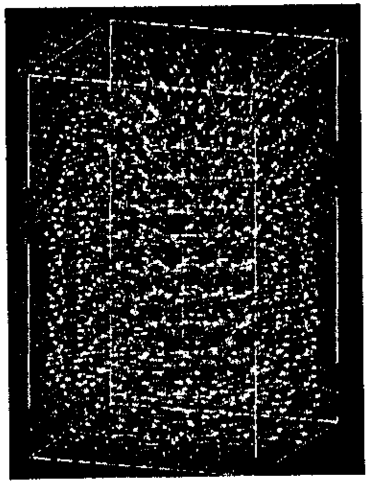
Arrow Plots (Hedgehogs)

- Arrow icon at each grid point (Eulerian analysis)
  - Magnitude maps to arrow length
  - Direction maps to shaft direction
- Useful in 2D provided grid points not closely spaced
- Bad problem of occlusion in 3D
- Succeptible to artefacts because of the spurious high-frequency detail
- Gives behaviour at point samples, not behaviour of the field as a whole

Arrow Plot

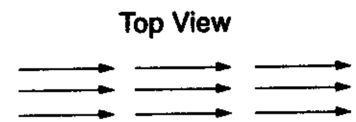
Data Courtesy of UK MET Office, Visualization by the Computer Graphics Unit

Cluttered View of a Vortex



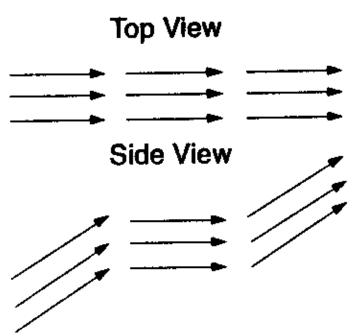
Perception Issues - question

- ❑ What is happening in this simple flow field?



Perception Issues - answer

- ❑ Not what you may have expected



- ❑ We will look at some ways to improve the situation for arrows

Unit Arrow (hedgehog) fields

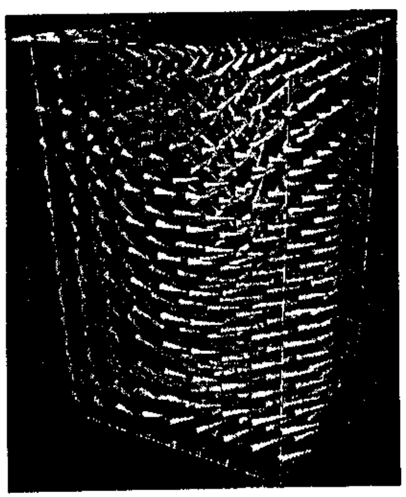
- ❑ Arrow shafts all same length
  - reduces orientation ambiguity
  - less occlusion
- ❑ Gives information about direction of vectors
- ❑ No information on magnitude, but this can be added:
  - Shaft or arrowhead colour

Unit Arrows

Shadowed hedgehog fields

- ❑ Use with either plain or unit hedgehogs
- ❑ Best with 2D domain
- ❑ Shadows cast onto plane help show orientation
- ❑ Depth cueing of arrows can also reduce orientation ambiguity
- ❑ Instead of arrows you could use other geometric objects which themselves offer more visual cues e.g., cones

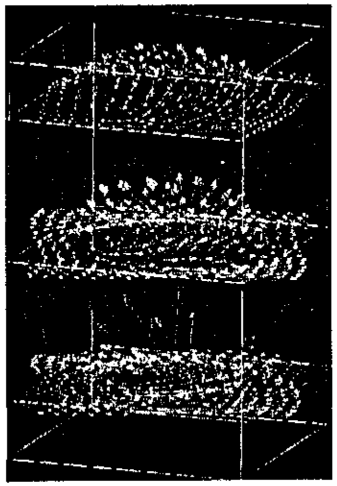
Cones with depth cue and perspective



Subsetting the domain

- ❑ Probe shows point behaviour, [20]
- ❑ Rake of probes shows behaviour at intervals
  - ■ limits number of arrows seen at once
- ❑ Slicing plane views a 2D slice of a 3D domain
  - ■ extra dimension freed to represent another parameter
  - ■ Interactive positioning and adjustment allows exploration of interesting regions

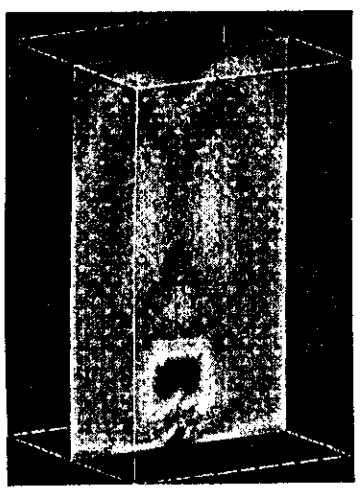
Three Planes of Arrows



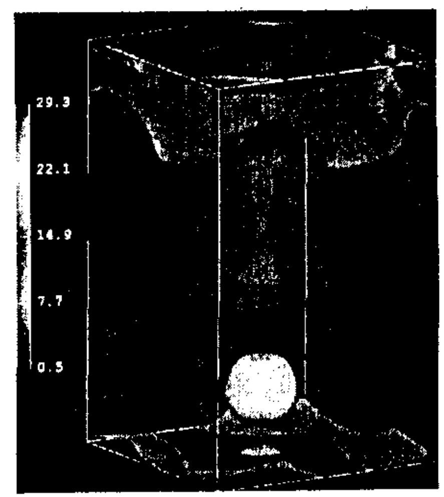
Convert vectors to scalars

- Simplest possible method
- Extract a scalar:
  - Single component (x, y, z) of a vector is rarely useful
  - *Vector magnitude* – good overview of a field
  - *Divergence* can be interesting
- Visualise using standard scalar techniques:
  - colour on a vector technique
  - slicing
  - isosurface
  - volume rendering

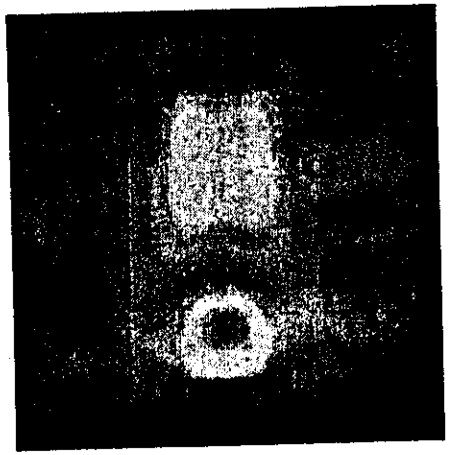
Slice through Vortex data



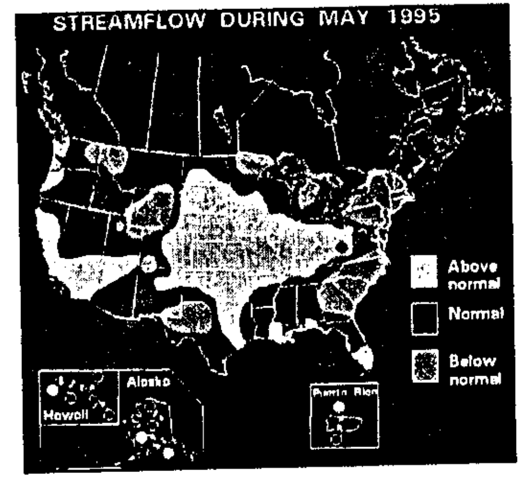
Isosurface in Vortex



Volume Rendering of Magnitude

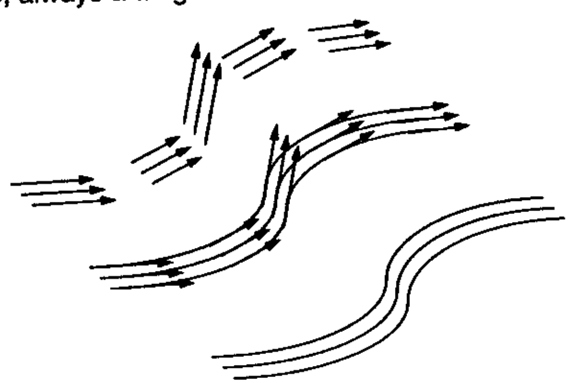


Flow in Streams in the US



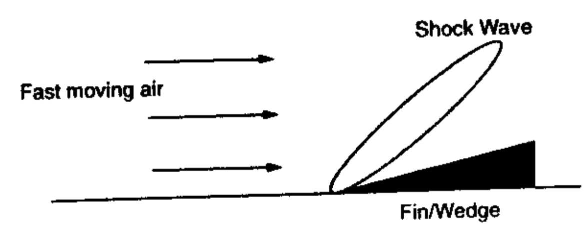
Streamlines

- A curve, always a tangent to the direction of flow

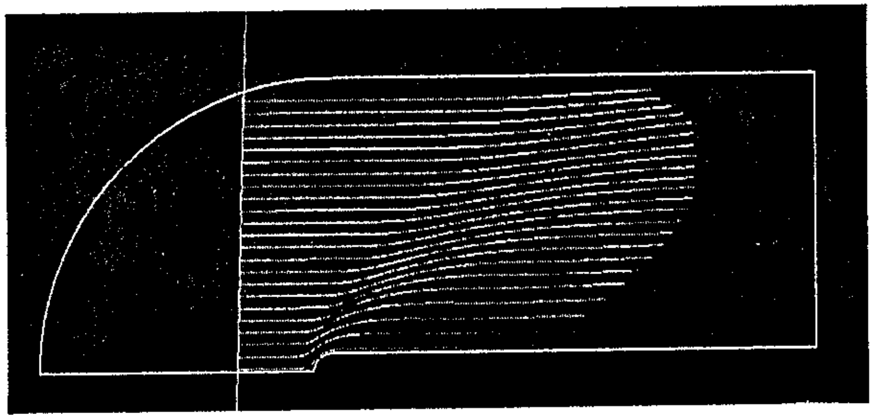


Colour Streamlines

- Magnitude of velocity not shown
  - use colour mapping, unless colour already used
  - deduce from spacing of adjacent streamlines
  - The next example shows how streamlines reveal the shock wave being formed



Coloured Streamlines

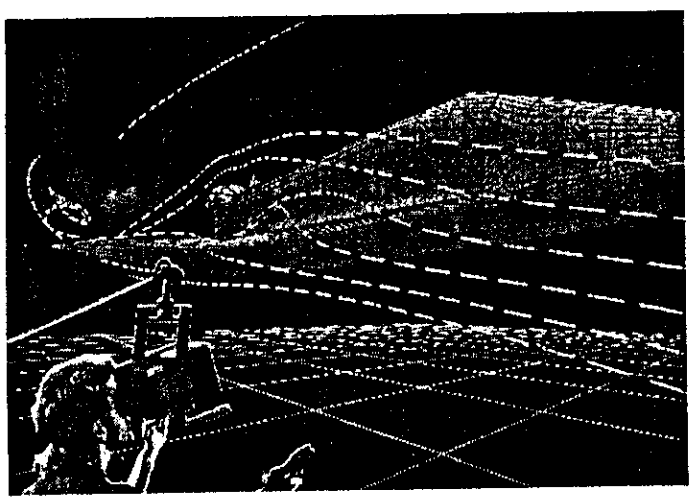


Perceptual Issues

- Problem of occlusion, if lots of them
  - adjust viewpoint or use clipping planes
- Perception problem with 3D location
  - use depth cueing by hue or saturation
  - add colouring by height or depth
  - use stereoscopic or immersive VR to aid location
  - A list of sites can be found under

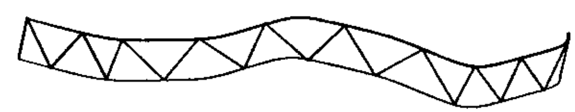
    `http://ccf.arc.nasa.gov/ra/page3.html`

NASA Ames Virtual Wind Tunnel [6]



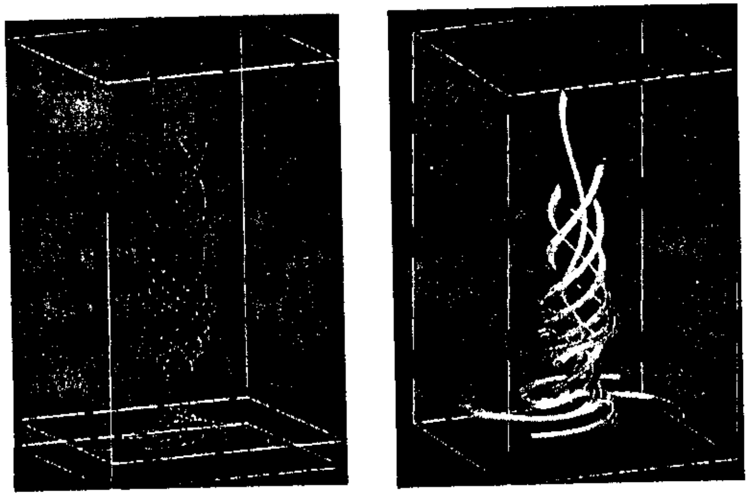
Stream ribbons

- Form ribbons from two adjacent streamlines



- Thin ribbons indicate fast flow, turbulent twisting effects are clearer

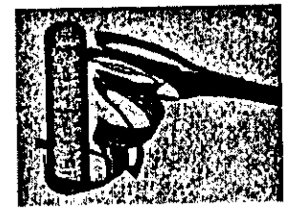
Stream Ribbons



Other techniques

- A stream surface is formed by joining 3...n streamlines [18]
- These surfaces can split and merge showing areas of high divergence.

Hultquist J P M. [18]



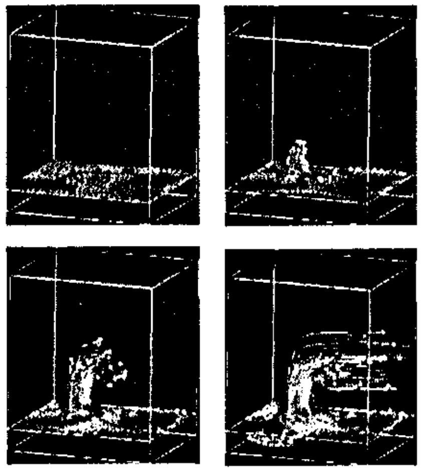
- Other techniques include Streamballs [4]
- These can both be coloured to add extra information

Particle advection

Streak and path lines

- These are directly related to the experimental counterpart
- Another common name for path lines are particle traces [15], [17]
- They are usually shown as animated sequences:
  - a single instance in an unsteady flow
  - over a defined time interval in a steady flow

Particles in a Thunderstorm



Computing particle path lines

- The motion of a particle is given by

$$\frac{dX}{dt} = v(x)$$

- where x = position vector and v(x) is the velocity field at x
- If you integrate the above equation you can find the next position at Δt

Calculating the next position

- Decide upon starting position (x0,y0,z0)
- Starting at t=0 find the velocity vector for this position
  - using nearest neighbour, tri-linear or tricubic interpolation
- Integrate the motion of a particle equation to find the next position at Δt
  - Euler
  - Runge-Kutta
- Repeat until particle leaves space or some other termination criteria is true

Integrating the equation

Euler method

- Approximates the integral to be $v(x(t))\Delta t$
- The next position is then calculated as
  - $x(t+\Delta t) = x(t) + v(x(t))\Delta t$

Integrating the equation

Runge-Kutta method

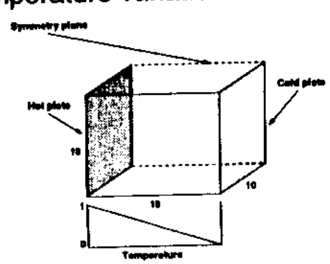
- Estimate the next position for a more accurate result
- Predictor step
  - Estimate new position using Euler to give $x^*(t+\Delta t)$
- Corrector step
  - Use this to estimate velocity at $(t+\Delta t)$ to compute
  - $x(t+\Delta t) = x(t) + 1/2[v(x(t)) + v(x^*(t+\Delta t))]$

Deciding upon Δt

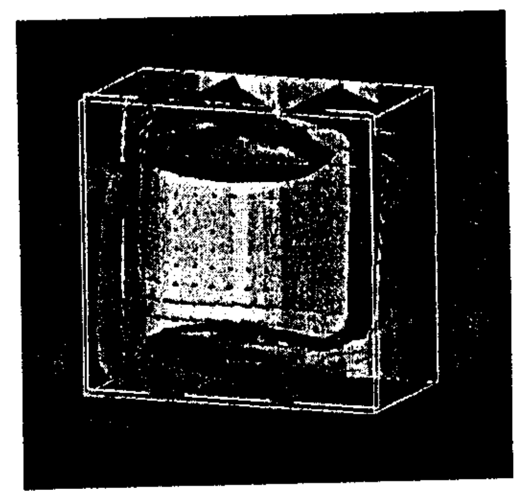
- Critical to choose a good value
- Trade off between accuracy and computational cost
- Best to use a variable Δt depending on gradient of velocity field
- *Animated* particle paths clearly require a fixed Δt for smooth and comprehensible animation

Double Glazing Case Study

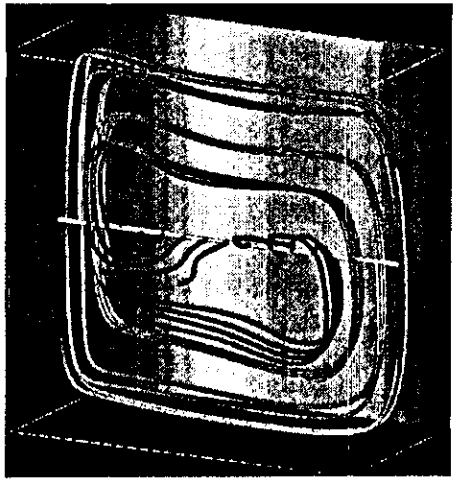
- The dataset and observations came from Dr Tim David, Mechanical Engineering Department, University of Leeds [8]
- It is a study of the behaviour of air flow between two plates, where one plate is cold and the other is warm e.g., double glazing
- There is a linear temperature variation between the two plates



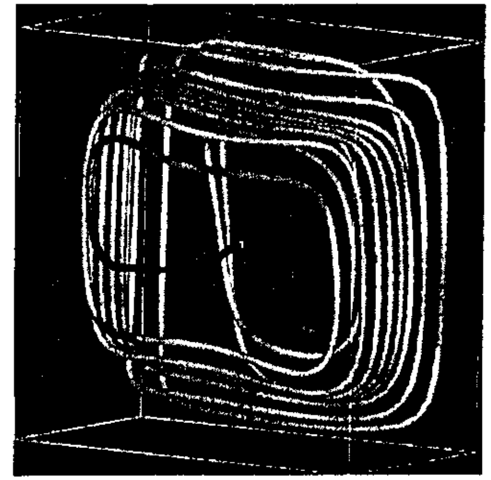
Double Glazing - Arrows



Double Glazing - Streamlines



Double Glazing - Particles



Systems

- Most of the current Visualization Environments support the major flow visualization techniques:
  - Application Visualization System (AVS)
  - IBM Data Explorer
  - Iris Explorer
- More limited techniques are available in Khoros, PV-Wave, IDL

More Systems

- Other turnkey/public domain systems with extra features for flow visualization:
  - Data Visualiser
  - FAST: NASA Ames (`http://www.nas.nasa.gov/FAST/fast.html`) [23], [14]
  - ISVAS: research prototype developed by Fraunhofer Institute for Computer Graphics Darmstadt, Germany (`ftp://ftp.igd.fhg.de:pub/isvas`)
  - Visual3: (`http://raphael.mit.edu/visual3/visual3.html`)
- A good list of available software can be found on
  - `http://www.ccs.ornl.gov/news/code/codes.html`

Conclusions

- The techniques are very useful for 2D flow.
- We can represent single 3D vectors but we ideally want to visualize the 3D flow field [9], [10], [16]
- Lot of current research in methods to represent fields of vectors and some of these include
  - Direct volume rendering
  - Stream surfaces with additional cues
  - Area glyphs to summarise characteristics
- We will see some of these in the section on Multidimensional data

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Session 1

Virtual workstations and 3D presentation

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Monday, 3 June 1996

3D presentation for the forecaster and the public

Hans Koppert

Germany

3D-Presentation for the Forecaster and the Public

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1. Introduction

The amount of data produced by numerical weather prediction models is growing dramatically in the near future. The Deutsche Wetterdienst DWD is developing Workstation systems, that should be able to handle these amounts of data.

We have to differentiate between two groups of users. The forecaster is interested in scientific visualization. He wants to see the most accurate visualization. Looking at the results of the new NWP models it is no more sufficient to display only isolines of the 500 hPa geopotential height. It is essential to make the whole four dimensional dataset (including time) available to the forecaster. He or she should be able to interact efficiently with these datasets assisted by some AI-Tools.

On the other hand we have to supply the public with weather forecasts. The conventional depictions using icons are not suitable to show the evolution of weather systems. Therefore the DWD together with the Fraunhofer Institut for Computer Graphics in Darmstadt has developed TriVis. TriVis allows to create intuitively understandable animated videos in 2D and 3D.

2. DWD's - Workstation for 3D-Visualization

3D-Visualization in meteorology is the display of meteorological variables in a 3D box and the possibilty to interact with these datasets. Interaction means zooming, panning and rotating the scene as well as changing the attributes of visualization (isoline spacing, color tables ...) or adding or deleting meteorological parameters.

There are new primtives like isosurfaces, volumes, 3D particles and streamlines.

It is possible to do these visualizations with commercial software like AVS or Explorer. These "Application builders" are usually to slow, but are very useful for prototyping. Bill Hibbard's (Hibbard, 1991) VIS5D is the most elaborated visualization package for meteorological data. It implements most of the visualization techniques and performs extremely well, but uses rectangular grids.

2.1 Coordinate Systems

Meteorological grids are not rectangular. They are irregular, not equally spaced in the horizontal. In the vertical we have for example a hybrid coordinate system, that follows the terrain and depends on time, because of the surface pressure change. We have decided to use the original model grid. This means, we are using the original grid nodes for the visualization of horizontal slices. This involves no interpolation. In the case of vertical cross-sections we are transforming the geometry of the slice from the coordinate system of the depiction (e.g. a polar stereographic plane) to the original model grid. There the data is sampled and transformed back to the display coordinate system.

2.2 Current Status of the Visualization System

We have concentrated on the correct treatment of coordinate systems. The system is therefore able to ingest grids according to the GRIB standard (rotated lat/lon grids) and to display them on a polar stereographic plane. We could have choosen any coordinate system for display because of the explicit treatment of the model grid.

Model level/layer, pressure- and z-coordinate systems are available for display. Scalars and vectors can be handled. The following visualization techniques are available:

- contouring
- color shading
- arrow plotting

Horizontal cross sections at model level or at arbitrary levels can be displayed for GRIB leveltype 109 and 110. Vertical cross sections can be done along model axis or along an arbitrary straight line. 3D Interaction uses a virtual trackball. Animations are triggered using a VCR style GUI. The user can select a parallel or a perspective view and can easily toggle on orthogonal views of vertical and horizontal slices.

2.3 Further Developments

The system will be implemented at CFO Offenbach in autumn 1996. It will be running on SGI Solid Impacts with R4400 Processors and 128 MB RAM. It is implemented in C, OpenGL and OSF/Motif.

Late in 1996 new functionality will be added:

- isosurfaces
- trajectories, streamlines
- data cropping
- data probing

3. 3D Visualization for the Public

Visualizations created with scientific visualization systems can not be interpreted by lay audiences. Conventional iconic weather depictions are not able to show the horizontal structure and the dynamic behavior of weather. With our system TriVis we wanted to achieve:

- intuitively understandable and thus perceptually effective weather depictions
- full usageof NWP -model forecasts to visualize the development of weather systems
- flexible user interface to allow interactive control over the weather presentation ona daily basis
- fully automated production environment

3.1 Data Sources

NWP data (grids and station related data) is used according to the scale of the application:

- global scale (3 hourly intervals, 170 km mesh, e.g. DWD's T106)
- european scale (1-2 hourly intervals, 50 km mesh, e.g. DWD's Europamodell)
- regional scale (0.5-1hourly intervals, 10-15km mesh, DWD's Deutschlandmodell)

Satellite and radar imagery is displayed in 2D and 3D.

Surface observations are created offline using the MAP-database.

3.2 The Depiction of Clouds

Clouds are visualized like they can be seen from the ground. Cloud depths is mapped on the grey value. Cloud cover is mapped on transparency and contrast. Deep clouds appear dark and threatening while fair weather clouds appear white and fluffy. In order to achieve a naturalistic cloud appearance fractal methods (Rescale and Add method; Sakas, 1993) are used. The error introduced by this random variation of the original forecast is small compared to the error of the forecast itself because the mean value of forecast is kept during processing.

3.3 The Depiction of Scalars

Scalars can be mapped on the 3D terrain as shaded polygons. Isolines of any scalar data set can be overlayed. Precipitation fields can be depicted as polygons, as animated pixmaps (overlayed on 2D clouds) or as 3D-precipitation objects falling out of 3D clouds.

3.3 3D-Visualization

All meteorological parameters including satellite imagery can be displayed an animated in 3D. The following combinations of animations are available:

- virtual camera moves, constant weather
- virtual camera is fixed, weather is animated
- virtual camera is animated synchronously together with the weather situation
- moving or static 3D objects can be combined

3.4 Daily Video Production

TriVis allows to completely automate the production of video-sequences. If necessary a pick&edit style user interface allows to modify the forecast or to interactively create graphics. Every individual clip is configured according to the needs of the customer and could be created on the spot.

4. Combined Usage of Systems

2D and 3D animations created with TriVis are displayed as MPEG videos in map. This an easy an cost effective way to present demanding standard animations because they are produced only once.

Within TriVis we have developed new visualization techniques like fractal clouds and animated weather pixmaps. These techniques are extremely useful for condensing information. As mentioned above we have to face a growing data output of our NWP models. Therefore it is very important to show clouds and weather instead of humidity, temperature, geopotential, and so on.

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Automatic production and distributed systems in the RiPP project

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Automatic production and distributed systems in the RiPP project.

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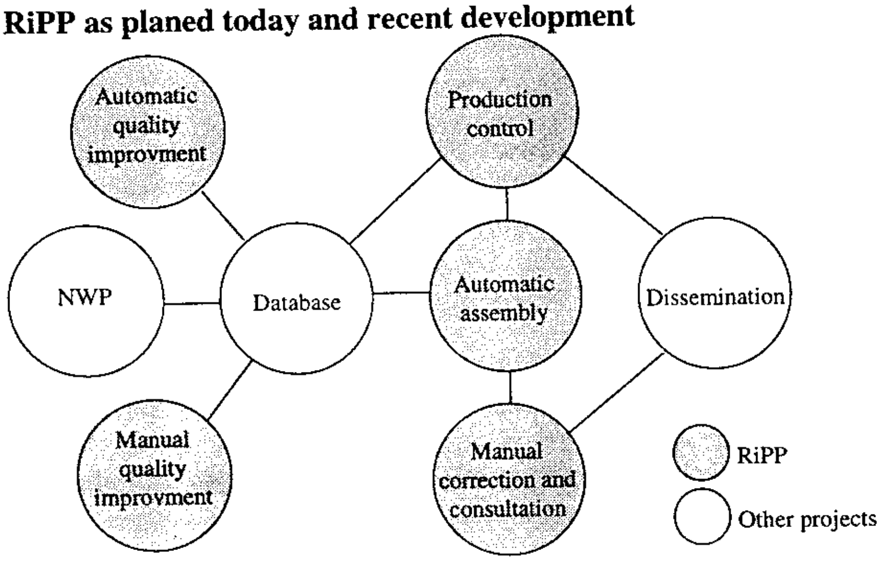
At the sixth EGOWS meeting I reported about the plans for the RiPP project and about the technical principles that was going to be used. During the past year the plans has developed and are now more precise then they were a year ago. The technical principles has been tested in practice and the project members has learned to use the new technology.

RiPP as planed today and recent development



Schematical illustration of the RiPP system

Automatic quality improvment
This subsystem consists of automatic systems for improvment of model output such as mesoscale analysis and statistical interpretations.

Manual quality improvment
At this position the forcasters are monitoring the model output and can choose which model to select as the official SMHI model at this time. The forcasters can also manually edit the fields in the database.

We are now evaluating posible solutions for editing field data. Since the last EGOWS we have evaluated the FPA system (Forecast Production Assistant) from AES in Kanada We will continue to evaluate the AFPS system (AWIPS Forecast Preparation System) from NOAA.

Database
A year ago the database was a part of the RiPP project. It has since then been assigned to an own project. The reason for this is that the database is not a concern for RiPP only but for the whole of SMHI. The database will contain all data necesary in the production process. This means fields from different models and analysis, observations, radar and satelite information etc.

The database will be built on a comersial relational DBMS that will be purchased this autumn. The DBMS of interest is Sybase, Informix, Oracle and Ingres. One important aspect at the purchase is future posibilities to handle objects in the database.

Automatic Assembly
Automatic assembly of products is the heart of the whole system. This subsystem produces graphical products (text and graphics). The information needed for the products comes from the database and the quality of the products depends on the quality of the database.
Texts are generated in a special component using recent developments of linguistic methods. Texts can be generated in any language.
The primary consideration governing the development of the automatic assembly is flexebility. Products are described by textual descriptions and by changing the descriptions you change the product.
The first part of the subsystem will be finished this summer. This first iteration is meant to test the principles and will have a limited functionality.

Production control
This subsystem is responsible for the control of the automatic assembly. The subsystem also contains components that supervise the database and trigger alarms at certain events or if previous forecasts differ to much from reality.

Manual correction and consultation
This subsystem is used by forcasters to view and, if needed, correct automaticly generated products. It will also be used by forcasters working in direct contact with customers needing special attention.
This subsystem will as much as possible be built on standard PC components as text editors, grapical editing tools, web browsers (for internal use).

Dissemination
The dissemination system has, precisly as the database, been assigned to an own project. The reason for this is the same as for the database. The system is not a concern for RiPP only.

Other RiPP components
The RiPP project consists of two parts. One is to build the system described above. The other is to build a number of small components that solves problems in the production today.
During the last year we have built a number of such komponents. All but one uses PCs as clients and our VAX/VMS cluster as servers.

- TAF monitioring.
- TAF editing and distribution.
- Automatic TAF coding and visualization of TAF parameters as a function of time.
- Visualization and printing system for radar, satelite, fields, observations, lightning location etc.
- Manual production and distribution of graphical forecasts as SWC and precipitation charts.
- Workstation for special forecasts and trace at nuclear accidents.

Design issues
At the sixth EGOWS meeting I described our main design goals and some of the solutions we have choosen to reach these goals. Design goals mentioned were for instance portability, interoperatibility and scalability. Some of the means to reach our goals deserves a closer look.

Client/Server and PCs
The idea with client/server solutions is that every forecaster who needs to reach an application can do so using relativly cheap hardware. The PC will then only contain the user interface software and all complex logics will be placed in the servers. PCs are very well suited for graphical presentations.

Object technology
Object technology logically follows on the client/server technology. Client/server applications replaced the monolithic applications. Objects break-up the client and server sides into smart components that can play together. During the last year we have introduced OO programing within the project and within our system development unit. This includes a method followed in the development process (Booch), programing language (C++) and other parts of the system development environment such as class libraries etc.

Corba
Corba is a standard for communication within distributed object oriented systems.
We have chosen the corba implementation from Digital called ObjectBroker.
This technic gives us language, OS and hardware independency at least for our server components. It also gives us possibilities to scale up the systems when needed by just adding more hardware to share the load. ObjectBroker is today used to connect processes on OpenVMS, Solaris, Dec Unix and Windows NT.

Web browsers
The internet technology has made it possible to reach information and interact with systems over large distaces. But it has also opened new possibilities to interact with systems within the local network. This autumn we intend to test this technology to build plattform independent client components using Web browsers and probably the Java language. These clients can then use information stored in the Web server database but also start and control server components anyware within our network.

SMHI standard hardware
SMHI has chosen to use two Unix plattforms, SUN and Digital. These plattforms are also the plattforms that is used for server components within the RiPP project. User interface components will use Windows NT.

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A technique for interactive four-dimensionally consistent editing of NWP fields

Eddie Carroll

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A technique for interactive, four-dimensionally consistent alteration of NWP fields

E B Carroll UK Met. Office

A workstation-based scheme has been developed for the three-dimensionally consistent modification of numerical weather prediction (NWP) fields, based on either distortion of geopotential height (gph) and pressure at mean sea level (PMSL) or quasi-geostrophic potential vorticity (QGPV). The gph/PMSL approach offers most direct control, allowing forecasters to specify explicitly new central pressures and positions of features, but can easily lead to the generation of very strong gradients of temperature and geopotential and totally insupportable horizontal wind shears, especially at jet level. The quasi-geostrophic potential vorticity method is more rigorous, giving stronger vertical coupling than the simple hydrostatic balance used in the PMSL/gph method. A method of editing the precipitation fields based on pasting in or cutting out is described. A means of time-interpolating alterations to achieve consistency in the fourth dimension is also proposed, and ways of deriving wind discussed.

1. Introduction

1.1 The perceived need for a grid point based NWP modification scheme

Forecast automation and semi-automation play a key part in plans for rationalization of the forecast process. The operational NWP models provide data in a suitable form for input into various automatic procedures for the generation of forecast products for the customer. However, the NWP output is not regarded as sufficiently reliable that human expertise and experience can be dispensed with. In order to be able to use numerical data in grid point form, but, at the same time, allow human intervention to add value to the final products, it is suggested that a means of modifying, or quality controlling, NWP forecast grid point data is desirable.

In addition to the goal of automatic product generation, the issue of how guidance is communicated to the outfield is relevant. If a senior forecaster were able to intercept the NWP forecast output at source and modify it where it was thought necessary, that modified data could be used as guidance. This would obviate the need for lengthy verbal advice, as is given out in the synoptic reviews, would also avoid the possibility of outfield forecasters reverting to the raw NWP data against the advice from the centre and would force the forecaster determining the 'story' to be explicit. Consistency in line taken would be assured in the products issued by all offices, and the modified output in graphical form (e.g. 3 or 6 hourly frames of PMSL and precipitation) would be easier to assimilate than verbal guidance, which could be restricted to shorter comments, say on confidence or possible alternative scenarios.

The fact that modified grid point data would be produced by such a system would also allow objective verification to be carried out which quantified how much value was being added (or subtracted) from the raw model data.

1.2 Some comments on the Canadian Forecast Production Assistant (FPA) system

The Canadian FPA system allows the modification of forecast via distortion of the PMSL fields. These modified fields, together with fronts, isobars and weather areas defined by the forecaster using the NWP fields as guidance, go to make up a 'depiction'. A series of depictions for different times can be linked together and interpolated to represent a time sequence showing the movement and development of systems and their associated weather. Automated products can then be derived using the information contained in the depictions. Any alterations made to the PMSL field can be matched by changes in forecast surface winds by using various combinations of geostrophic / gradient /isallobaric winds and specified corrections for friction.
One drawback of this approach is that in altering the fields, no regard is given to how the fields should be changed in the vertical. For

instance, in taking upper winds and temperatures from the model for an aviation forecast, the 2000 FT winds might bear no relationship to the forecast surface winds if the PMSL pattern has been altered. In addition, the forecaster has to delineate and describe areas of weather, such as rain, separately from adjusting the PMSL fields. Within these areas, the detail contained in the grid point data in terms of temporal and spatial variations, is lost. In the development of modification schemes, it was considered important to address these shortcomings, aiming for vertical consistency, and also consistency between parameters so that only one transformation would have to be specified by the forecaster and fields of geopotential, humidity, temperature and precipitation would be realistically altered, retaining the level of detail.

2. Methods of horizontal distortion

In imposing a change on model fields, discontinuities at the edges of modified regions can be avoided if the translation/ alteration in intensity approaches zero as the defined edges of the modified area are approached. This can be achieved in various ways. Fig. 1 shows an imposed translation from point **O** to **O'** given by the vector **D**, magnitude *D*. All points at a distance *d* from **O** and within a radius of influence, *R*, are subject to a translation vector **s** given by

$$\mathbf{s} = \mathbf{D}\frac{R-d}{R}$$

There are a number of alternative weightings for **s**, such as

$$\mathbf{s} = \mathbf{D}\frac{R^2-d^2}{R^2+d^2}$$

It will be noticed that gradients are significantly altered by the transformation, the extent depending on the size given to the radius of influence. In the basic scheme, this is set as proportional to the size of the displacement, $R = ND$, where $N > 1$. In the choice of *N* there is a compromise to be struck between limiting the horizontal extent of a change and avoiding too large a change in gradient.

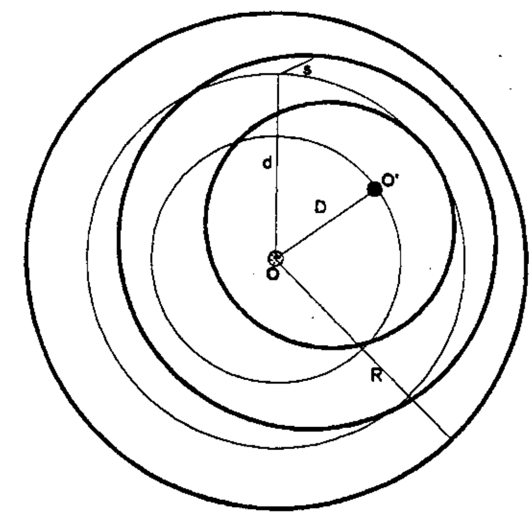

Fig. 1 *Light lines: original, circularly concentric distribution of some parameter. Dark lines: modified distribution using* **D** *(R – d)/R weighting for* **s**.

The method just described will be referred to as Method 1. A variation on this method, Method 2, is to make the new defined position, **O'**, the centre of the distorted area rather than the original position, **O**, and to define the vectors **D** and **s** as leading from transformed to untransformed points rather than the other way round (i.e. **O** = **O'**+**D** rather than **O'** = **O**+**D**). This reduces the amount of gradient tightening in the direction of translation, but increases the amount of gradient slackening in the opposite direction. The table shows the increase in average gradient in the direction of the translation and the decrease against it.

	new gradient ahead (x original gradient)	new gradient behind (x original gradient)
method 1	$\frac{N}{N-1}$	$\frac{N}{N+1}$
method 2	$\frac{N+1}{N}$	$\frac{N-1}{N}$

So, for instance, if *N* is set equal to 2, as in Fig. 1, method 1 results in a doubling of the gradient ahead of the translated point and a reduction by one third behind it, whilst method 2 gives an increase by half the original value ahead of the point but a reduction by half behind. As the value of N increases, the difference between the methods decreases.

It is also possible to define a line which is to be moved, whose end points can be moved in different directions and by different amounts. d then refers to the distance between the point value to be moved and the nearest point on the line. A facility whereby an area of influence may be explicitly defined has also been developed. Here the distance R, the local radius of influence, is set to the shortest distance between the central transformed point and the edge of the area through the transformed point. This allows alterations to have greater influence in some directions than others, and also allows the exclusion of nearby synoptic features or influential orography.

An intensification or weakening factor can also be defined, weighted similarly according to the relative values of d and R. To change the intensity of features without altering their position, a radius of influence can be set independent of that used for translation.

3. The PMSL/gph method

The most direct approach to changing, say, the PMSL field is to apply the distortions by one of the methods described in section 2 directly to values of PMSL. In addition, to achieve a three dimensional structure, the temperature fields can be transformed in a similar way and partial thicknesses can be integrated to give a hydrostatically consistent set of geopotential fields at higher levels. However, this results in a significant change of wind strength, even if is merely a translation that is implied with no intensification. This is especially noticeable at upper levels, where thermal gradients can be increased sufficiently for, say, a 100 kn jet to be increased to 150 kn, using Method 2 with $N = 2$. This in itself is bad enough, but even more unjustifiable from a dynamical point of view are the very strong horizontal wind shears which accompany such increases, with anticyclonic shear much exceeding theoretical limiting values on occasions.

The approach, however, does seem to work quite well for minor translational adjustments such as repositioning of isobars or sharpening of troughs. If the repositioning vector lies across the gradient (i.e. along an isopleth) of temperature, or the gradient is not strong, it can also be a reasonable approach for larger changes. In addition, it works well for the *in situ* redefinition of the central pressures of systems, and has been found to be a useful way of post-processing an alteration which has been performed using QGPV in order to alter the central pressure of a feature, which is not always predictably affected by changes in QGPV. Fig. 2 shows a simple adjustment made to the central pressure of a depression, deepening it by 8 hPa. Fig. 3 shows such an adjustment made by pulling the 1016 hPa isobar southwards over East Anglia indicated, to smooth out the trough. The frontal gradient over northern France has been slightly tightened, but not unrealistically so, whilst the precipitation over the North Sea has been dragged southwards; in a separate adjustment, precipitation has been reduced consistent with the implied reduction in dynamic forcing. Fig. 4 shows a situation where the PMSL approach is not advisable. In repositioning a depression in a direction towards and across the thermal gradient, the jet strength has been much increased, and very strong horizontal shears generated. This effect can be mitigated by specifying a weighting distribution which is flat for some distance around the transformed point and then falls away to zero beyond. This will prevent the alteration of gradients in your area of interest but will generate them even more markedly elsewhere.

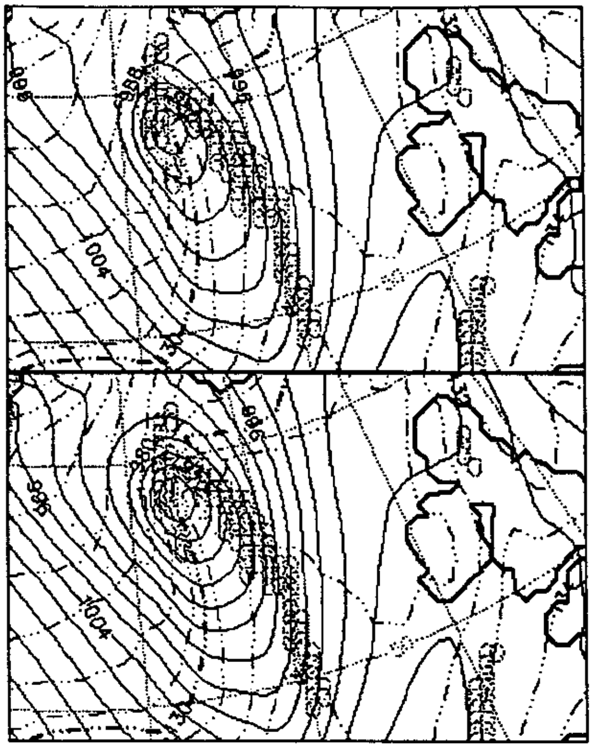

Fig. 2 *Top: original fields showing PMSL, 1000-850 hPa thickness and dynamic precipitation. Bottom: same fields but with central pressure of depression reduced by 8 hPa.*

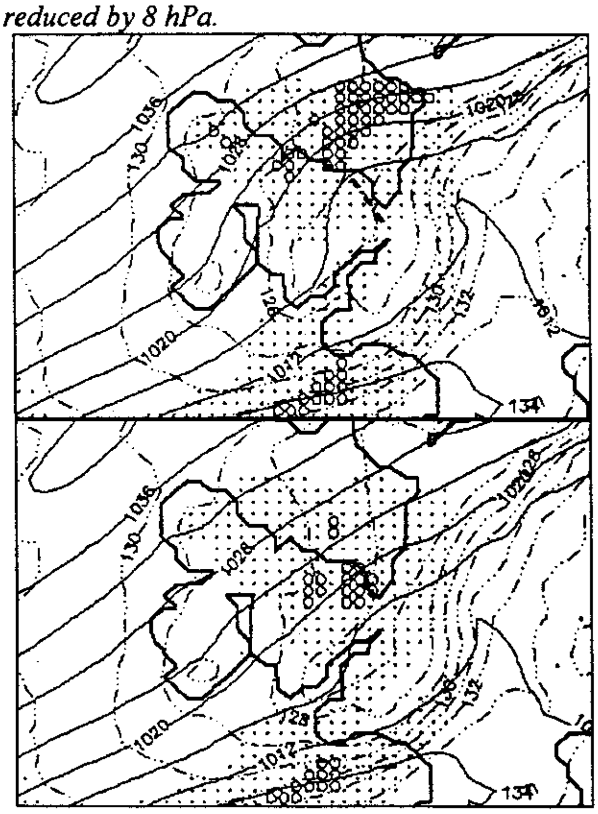

Fig. 3 *Top: original fields, parameters as in Fig. 2. Dotted line over East Anglia shows defined translation. Bottom: same fields but with 1016 hPa isobar moved and preciptiation distribution altered.*

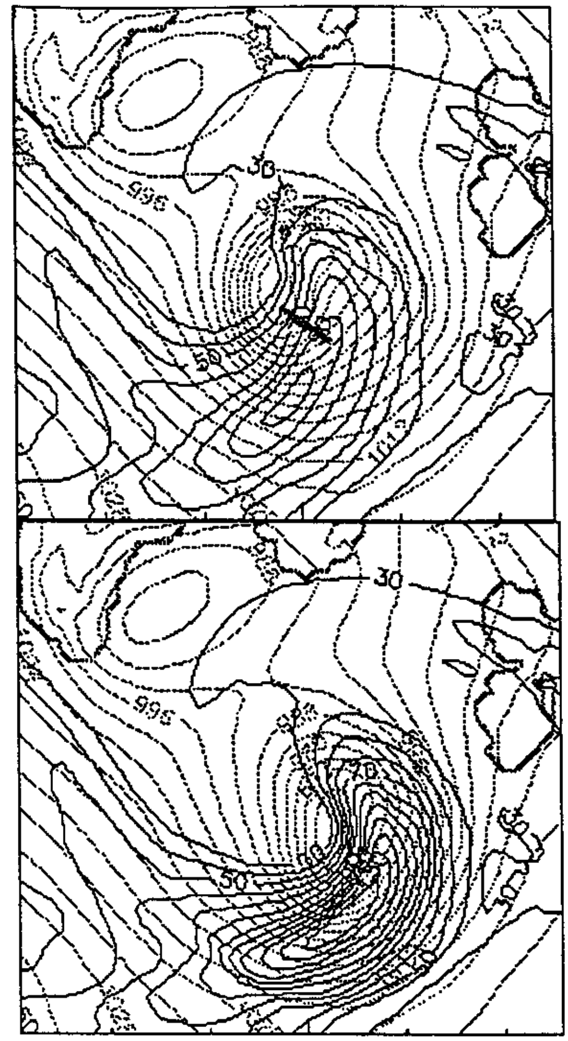

Fig. 4 *Top: PMSL (light) and 300 hPa geostrophic isotachs (dark). Line shows defined translation.*
Bottom: Adjusted fields resulting from vertically constant distortion to gph.

4. The quasi-geostrophic potential vorticity (QGPV) approach

4.1 PV thinking

QGPV can be given by

$$q = \frac{1}{f_0}\nabla^2\phi + f + f_0\frac{\partial}{\partial p}\left(\frac{1}{\sigma}\frac{\partial\phi}{\partial p}\right)^{1} \qquad (2)$$

So q is the sum of geostrophic absolute vorticity calculated using reference (f_0) rather

[1] $\sigma = -\frac{1}{\rho\theta}\frac{\partial\theta}{\partial p}$, i.e. a measure of static stability, so q is not just dependent on static stability but also on its vertical variation.

than actual Coriolis parameter (f), plus a term which depends on the static stability. In simplified quasi-geostrophic dynamics it is equivalent to full, or Ertel's, potential vorticity, given by

$$P = (\zeta_\theta + f)(-g\frac{\partial\theta}{\partial p}) \quad ^2 \qquad (3)$$

Both quantities appeal as fundamental parameters since they are conserved following the motion in adiabatic, frictionless flow, P in full three dimensional motion along isentropic surfaces, q in quasi-horizontal motion along pressure surfaces. The abbreviation PV for potential vorticity will be used in the following general discussion where what is stated is applicable to Ertel's PV or QGPV.

In addition to being conserved, PV is invertible, in the sense that knowledge of its distribution plus lateral and vertical boundary conditions, allows the fields of gph, temperature and geostrophic wind to be gained under some balance assumption, such as geostrophic balance. Just as vorticity has an at-a-distance effect on the fields of gph/PMSL horizontally, PV has a similar remote effect, but this time in three dimensions. The mathematics of the problem bear a striking resemblance to those associated with electrostatics (see e.g. Bishop and Thorpe, 1994) — just as electrical charges induce effects remote from their location on the three dimensional field, so do PV centres in the atmosphere; in the first sense it is the electrical field, whilst in the second it is the field of geopotential. This point is worth emphasizing, since, as will be seen, the use of QGPV introduces quite strong coupling between different levels of the atmosphere; if, for instance, one alters the PV distribution aloft but leaves it exactly the same at the surface, the PMSL field will still be affected. The degree to which the atmosphere 'conducts' or 'insulates from' the PV influence is determined by the average static stability; high static stability inhibits vertical coupling, whilst unstable air encourages it.

It turns out that temperature anomalies on the vertical boundaries, i.e. the ground and the upper level of the domain, are equivalent to PV sources, a warm (cold) anomaly acting like a cyclonic (an anticyclonic) PV anomaly. It is important, therefore, in any translation, that the boundary temperature is transformed in a consistent way. In fact, transforming the Laplacian of boundary temperature turns out to be an especially appropriate expedient. A drawback of the PV approach is that the distortions mean that PV is not conserved. In particular, the increase in size of a PV anomaly as it is stretched due to a translation away from it can give that anomaly an unduly large influence on the fields around, above and below it.

4.2 Inversion of QGPV

The inversion of QGPV to gain geopotential is achieved by a variation of an iterative technique known as *successive overrelaxation* (Frankel, 1950). A three-dimensional, second order partial differential equation lies at the heart of the problem (i.e. equation 2), the solution of which requires boundary conditions not only laterally but also along the top and bottom of the volume. These conditions are somewhat complicated by the fact that, whereas values of geopotential can be provided *a priori* for the lateral boundaries, they can't for the upper and lower surfaces, since they are part of the solution being sought. If, however, the temperature field is transformed first, this information, being information on the vertical variation of geopotential with height under the hydrostatic assumption, can be used. The vertical derivative of geopotential on the upper and lower boundaries suffices, together with geopotential itself round the sides, to enable the interior geopotential to be obtained. To speed up the relaxation procedure with little loss of accuracy, a varying domain size relaxation technique was developed.

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[2] ζ_θ is relative vorticity on an isentropic surface. So P is simply proportional to vorticity multiplied by static stability.

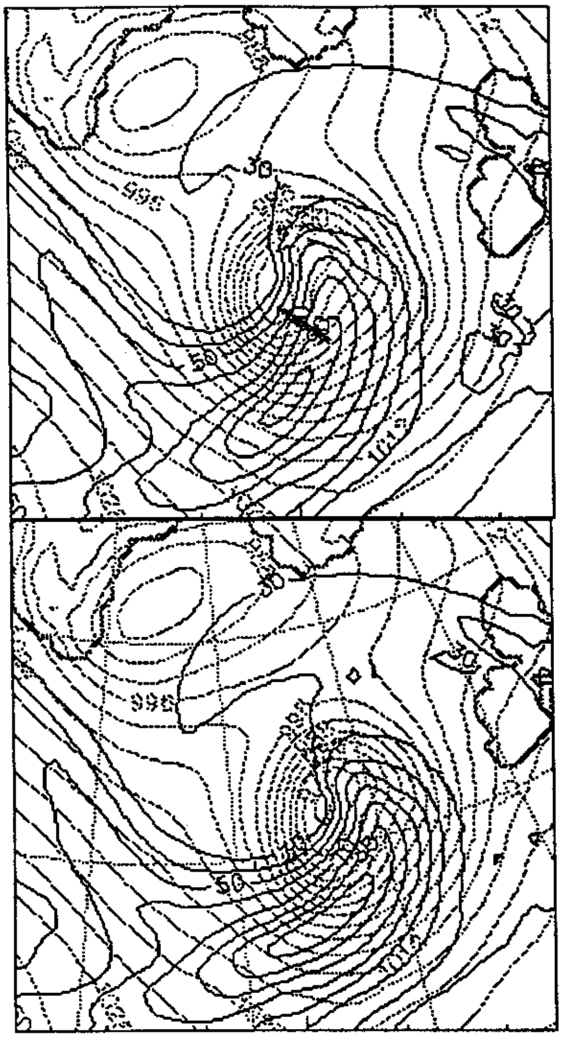

Fig. 5 *Transformation as in Fig. 4 but via QGPV. Note that whilst jet is moved, its structure is essentially preserved.*

5. Vertically varying transformations

For many purposes, it might be desirable that, whilst the low-level structure of the atmosphere is altered, the upper level should be left alone, or, at least, not changed as much. Some might argue that the jet level winds for aviation, for instance, are best left untouched by human hand (apart from any routine enhancements in strength which are carried out automatically). To allow a vertically limited change to be made, a facility was introduced whereby the user specifies the level at which the gph/QGPV alteration is to be made, plus an e-squared lengthscale of decay vertically above and below, i.e. a Gaussian profile is given to the translation and strength change in the vertical, with the height specified by the user being that at which the changes fall to e^{-2} (about 1/7) of their values at the level on which the transformation is defined.

If a translational change is made, this option can lead to serious problems using the gph/PMSL approach. Simply to move a surface feature while keeping the upper level flow fixed can generate huge vertical wind shears, which in turn require very strong horizontal temperature gradients. The use of PV allows these problems to be avoided, and, furthermore, injects a degree of dynamic intelligence into the modification. If, for instance, it were considered likely that a surface depression would be more likely to have developed in a different position relative to an upper feature, the PV inversion will calculate the implied effect on the intensity of the depression.

Fig. 6 shows the effect of moving a surface depression closer in to an upper trough, limiting the translation in the vertical to about 500 hPa. Notice the significant deepening (1003 to 990 hPa) due to the proximity to the region of high PV aloft (cross-section, Fig. 7[3]). The influence of this upper feature was largely neutralized in the original fields by a cold dome of potential temperature; moving the surface feature with its attendant warm air closer to the upper PV anomaly also shifted this cold dome out of the way. The zero isotach (indicating no wind into or out of the plane) marks the axis of the trough. Note how the altered cross section shows this trough/depression axis becomes more vertical. Figs. 8 and 9 show different views of the same transformation.

[3] The PV isopleths in the cross sections are in units of 'Ertel's geostrophic PV', i.e. PV as given in equation 3 but using geostrophic vorticity on a pressure surface instead of vorticity on an isentropic surface. This is more easily interpreted than QGPV, which varies strongly with height due to the dependence on vertical variation in static stability; it can be significantly greater than true Ertel's PV in flow with strong cyclonic curvature.

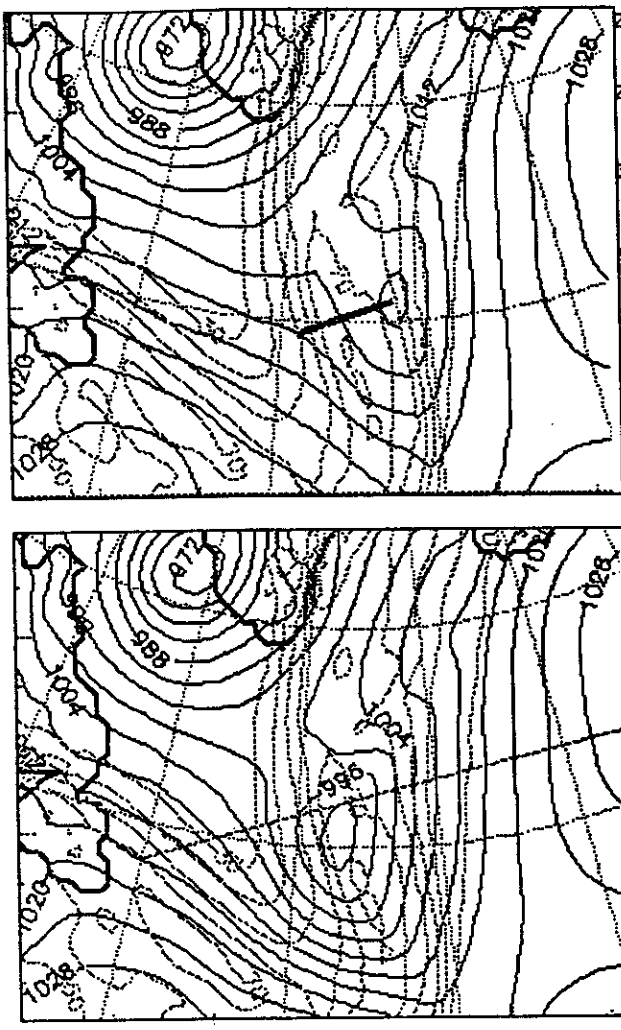

Fig. 6 *Before (top) and after (bottom) PV translation at surface, decreasing with height. Dark lines PMSL, light lines 300 hPa geostrophic isotachs. Also shown line of cross-section shown in Fig. 7.*

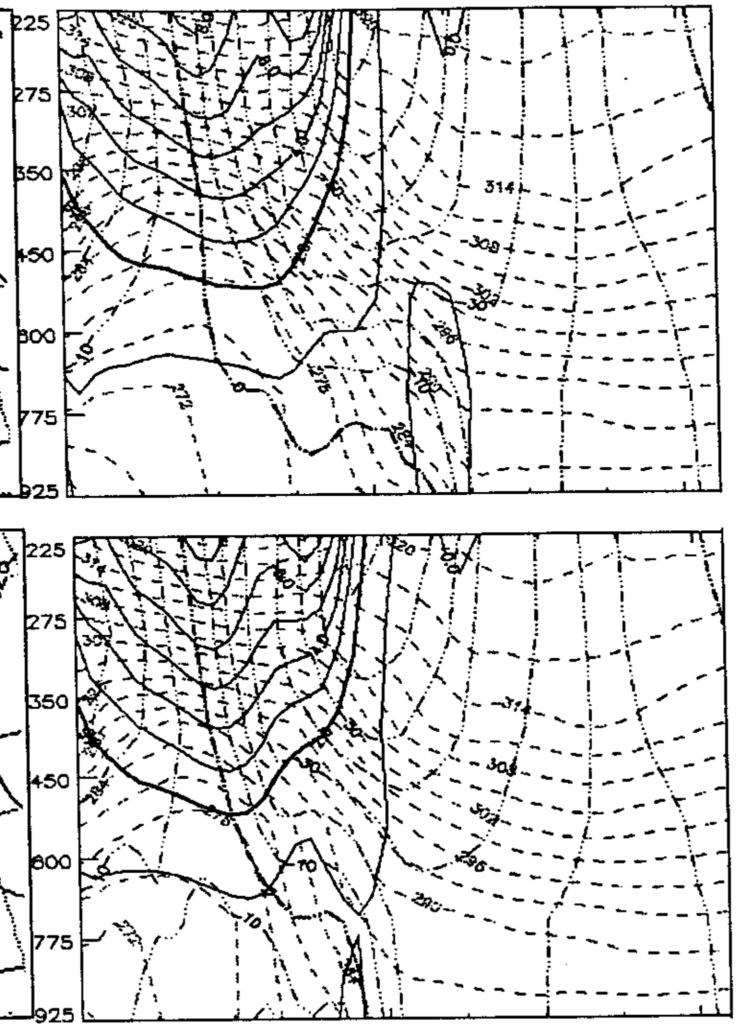

Fig. 7 *Cross sections for transformation shown in Fig. 6. Top: Original, showing PV (solid, see footnote 3), potential temperature (dashed) and wind component into plane (dash-dot with zero in bold).Bottom: altered cross-section as above.*

It should be noted that, even if the imposed translation is vertically constant, stronger or weaker coupling between surface and upper level features can result. For instance, moving a feature towards an upper trough will result in a squashing up of the PV in the direction of motion and a consequent reduction of the distance separating the surface and upper structures, strengthening the cyclonic influence on the surface feature.

If no translation is specified, simply a change in strength, this can usually be applied without any difficulties directly to PMSL/gph. If this change is limited in vertical extent, it will be accommodated hydrostatically by a change in temperature. For instance, the deepening of a surface depression with a limited vertical knock-on will result in the warming of the lower layers. Fig. 10 shows the effect of directly increasing the central pressure of a anticyclone, in this case by 4 hPa with the

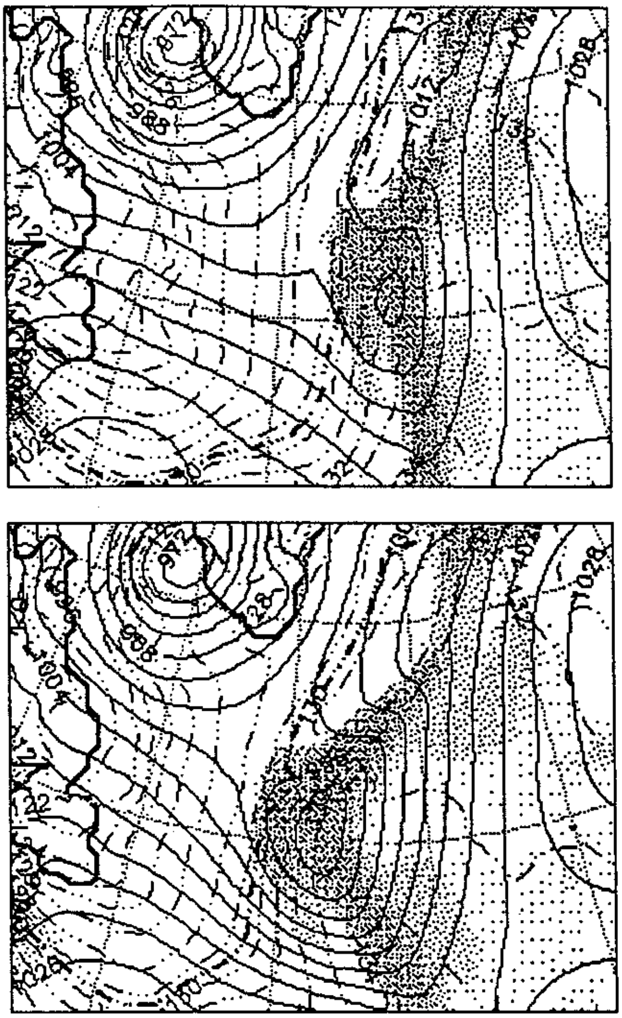

Fig. 8 *As Fig. 6, but showing 1000-850 hPa thickness (dot-dash) and dynamic precipitation (stippling).*

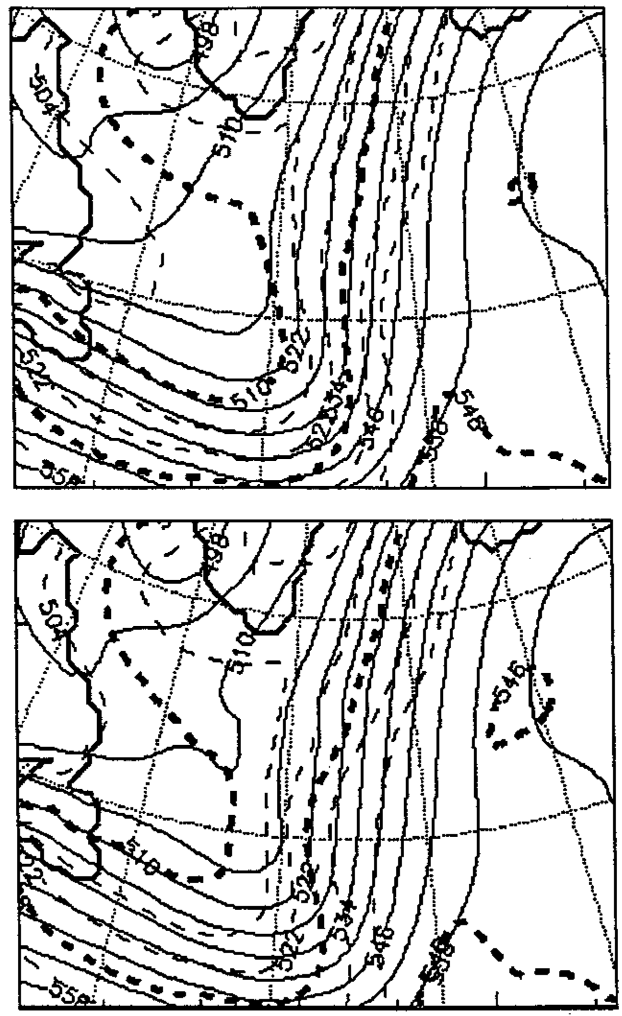

Fig. 9 *As Fig. 6 but showing 500 hPa gph (solid) and 1000-500 hPa thickness (dashed).*

knock-on limited to below about 700 hPa. The necessary cooling to maintain hydrostatic consistency is indicated by the change in position of the dark 1000-850 hPa thickness contour (corresponding with the 20% snow probability). This expedient of altering the gph/PMSL directly can be a useful final step taken after a translation has been effected by QGPV, since it allows direct control over the final pressure of a system if the user want to override the dynamical intelligence.

5.1 The superadiabatic lapse rate problem

In addition to the constraints of hydrostatic balance and the influence of some PV-induced coherence, a separate, thermodynamic condition we would want to satisfy is that the vertical lapse in temperature should not unrealistically exceed the dry adiabatic lapse rate. It is especially true with vertically non-uniform transformations that we run the risk of violating this condition; with the QGPV method, it is even occasionally possible to do so with a vertically uniform translation. In

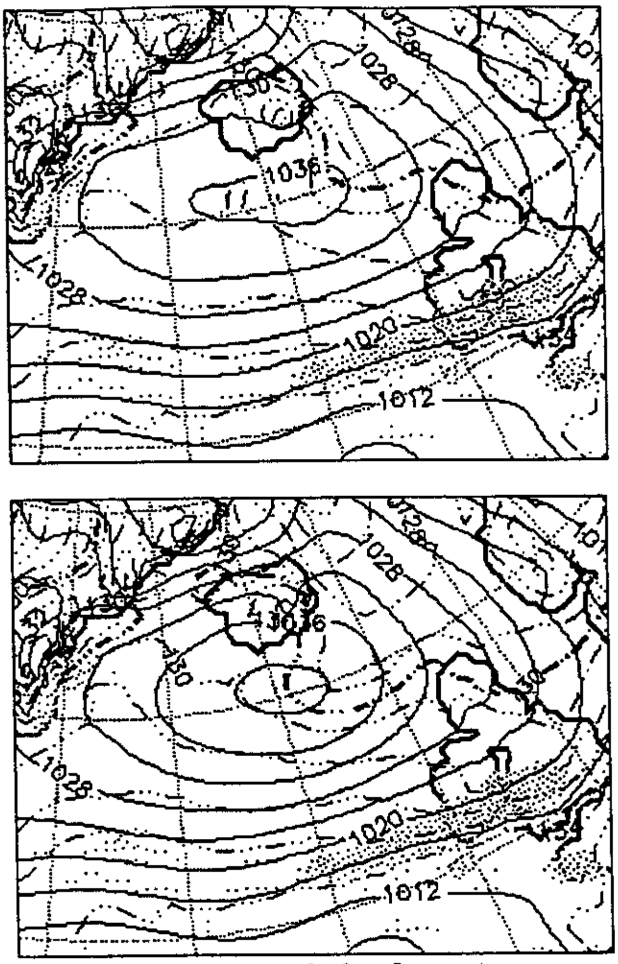

Fig. 10 *Before (top) and after (bottom) increase to surface pressure of anticyclone by 4 hPa, vertical influence limited to 700 hPa. PMSL (solid), 1000-850 hPa thickness (dash-dot) and precipitation (stippled).*

order to eliminate such a possibility, firstly the initial data are checked for superadiabats, and those which exist are recorded. Then, after the specified transformation has taken place, the data are rechecked for super-adiabatics, from the top level downwards at each grid point. If any exist, and, furthermore, if they exceed the maximum pre-existing values between those levels in the original data, the lower layers are cooled sufficiently to eradicate them. The gph of the lower pressure level is recalculated accordingly so that hydrostatic balance is maintained. Thus, such lapse rates are avoided by the cooling of the atmospheric column and the increasing of surface pressure. On its own, this is liable to lead to noisiness in the PMSL/gph fields, so a subsequent filtering routine is called to smooth the data out.

6. Precipitation editing

The option is provided in the scheme to link the intensity of dynamic precipitation to that of low-level relative vorticity. The reasoning is that, since both vorticity and precipitation are generated by low level convergence, a change in the strength of development should imply a corresponding change to the precipitation rate. (This sort of change is quite separate to the translational alteration where precipitation is linked to the transformed dynamic variable.) If the intensity linking option is taken, the program performs a least squares regression of 1000 hPa relative vorticity onto precipitation for those grid points where there is precipitation. After the transformation, the new 1000 hPa vorticity is calculated, and compared with its previous value before transformation took place. Precipitation is then altered according to the regression equation and the change in vorticity. It is almost certainly the case that this sort of adjustment could be made more rigorously by using the change in quasi-geostrophically determined vertical velocity in the place of vorticity.

A final manual editing step is also allowed, whereby areas of precipitation can be painted in or cut out (see Fig. 3). This level of control is important, since it may be that a translation has simply moved an area of orographic precipitation away from the forcing orography, which should be deleted (it would also be possible to pull the isobars straight to smooth out any orographic ridging/ troughing that was moved away from the orography).

Furthermore, it may be considered necessary to override the precipitation distribution and/or intensity for other reasons, say in the light of the forecaster's experience. It is also worth noting that, due to the nature of the distortion method, regions of precipitation in the direction of translation will shrink, whilst those behind will grow, and these artificial alterations in size may need to be rectified.

7. Time interpolations

It is envisaged that the alterations to the forecast fields will be made to a, say, T+24 forecast. In order to achieve a preceding evolution consistent with that altered snapshot, it is necessary also to alter the intermediate time frames. The methodology to achieve this will now be described.

When a feature is altered, in addition to clicking on its original and desired final positions on the T+24, the forecaster will also identify the current position of that feature on the T+0, position **O**, giving **M**, a vector representing its movement over the 24 hours. To get intermediate fields at T+ ΔT the transformations, weighted by the factor $\Delta T/24$, will be applied to the raw model data for T+ ΔT at a position **O** + **M**ΔT /24. In this way changes are applied linearly in a system-relative manner. Of course, it may be desirable to use a function other than the linear one given, and it might be that the theory of error growth favours something more exponential.

In this way, all the detail inherent in the raw data is retained, and the time interpolation process results in little smoothing. Of course, it might be that some precipitation, for instance, which has been added to the forecast is simply expected to develop in situ over the preceding few hours. In this case a separate vector and *T*+0 could be defined so that position **O** is in the same place as the final central point, and the precipitation develops, say, over a three hour period.

8. Diagnosing wind

Whichever basic alteration method is used, the field of motion in the model is not directly acted upon. In order to obtain the wind field it is necessary to assume balanced flow, most simply geostrophic balance. However, there are many important instances where this can be a poor approximation, notably in the boundary layer, where frictional drag affects speed and direction significantly. In tightly curved flow, too, the geostrophic wind can be misleading even above the boundary layer, with the gradient and geostrophic winds easily being as much as factor of two or more different where the flow is cyclonic and up to a factor of two different where it is anticyclonic. Even if the gradient wind were calculated there are other ageostrophic affects, for instance a significant isallobaric component to the wind where a pressure feature is moving quickly — this can cause winds around a depression which is moving rapidly eastwards to be stronger then one might otherwise expect in the southern and western quadrants (see e.g. Holton, 1992, page 73).

To allow for these effects and others without attempting to quantify them explicitly, a pragmatic approach has been adopted whereby, in the case of 10 m winds, a simple boundary layer model is used which assumes the wind at the top of the boundary layer (taken as 600 m) to be geostrophic and the wind profile to be logarithmic, falling to zero at a height of the roughness length. These assumptions become more questionable the more the free-flow wind departs from geostrophic and the more the stability of the boundary layer departs from neutral. However, this doesn't matter too much, since, at each grid point, the 10 m wind is calculated under these assumptions in the unaltered fields and compared with the actual 10 m wind. The ratio between the two is stored and translated according to the specified transformation. Then the same simple model is applied to the transformed fields and adjusted using the transformed ratio to regain the new estimated 10 m wind. A limiter is also applied to ensure that the 10 m wind does not exceed the geostrophic value.

A similar technique could be employed to calculate upper winds, though frictional effects need not be considered. A refinement to the technique could be introduced by using the gradient rather than geostrophic wind as the initial free-flow wind estimate.

9. Potential applications in bogussing

It has been recognized for some time that there exists a relationship between water vapour imagery and the potential vorticity fields, dark regions coinciding with high PV (or low PV=2 height) and light regions with low PV (or high PV=2 height) (Mansfield, 1996, Young et al., 1987). This relationship certainly often works well over and poleward of the frontal cloud mass. The author contends that an even better relationship exists between the water vapour imagery and absolute vorticity fields (Carroll, 1995). Using model fields of vorticity or PV overlaid with water vapour imagery, the relationship is sometimes sufficiently good for model errors to be confidently spotted. Using the field editing scheme, it is possible to reposition and change in strength the, say, 300 hPa PV to try to rectify any apparent mismatch, perhaps limiting the knock-on effect to the upper and mid troposphere. The PV inversion process will then produce a consistent set of dynamic fields (gph/PMSL, temperature) which could be presented to the model as bogus data. Thus useful dynamical information contained in the water vapour imagery and interpretable by a human analyst as vorticity or PV data, can ultimately be fed through into the model's assimilation scheme as bogus data.

Fig. 11 shows a situation where there is clear evidence of a difference between the model 300 hPa distribution and that suggested by the water vapour imagery (the light coloured hook cloud should be associated with low vorticity and the dark-coloured dry intrusion with high vorticity). In fact, in this case nothing could have been done since the model fields are from a 36 hour forecast, but the example illustrates the principle that with a water-vapour image and a model background field, it is possible to spot errors in that background field.
Fig. 12, taken from a different situation, shows how a similar feature could be repositioned (and/or intensified/weakened), in this case using the PV technique with a vertically varying influence. The primary translation was made on the 300 hPa level, with the vertical knock-on limited to 700 hPa in the vertical. Note that, despite the fact that vorticity is the parameter used for the image comparison, PV is the transformed parameter, since this allows us safely to apply a vertically varying change.

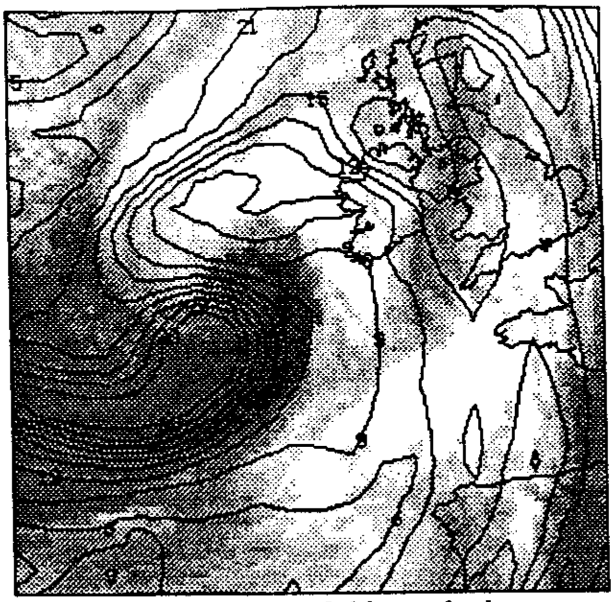

Fig. 11 *Model vorticity fields overlaid on Meteosat water vapour image for the same time indicating 200 km positional error in upper level vorticity maximum.*

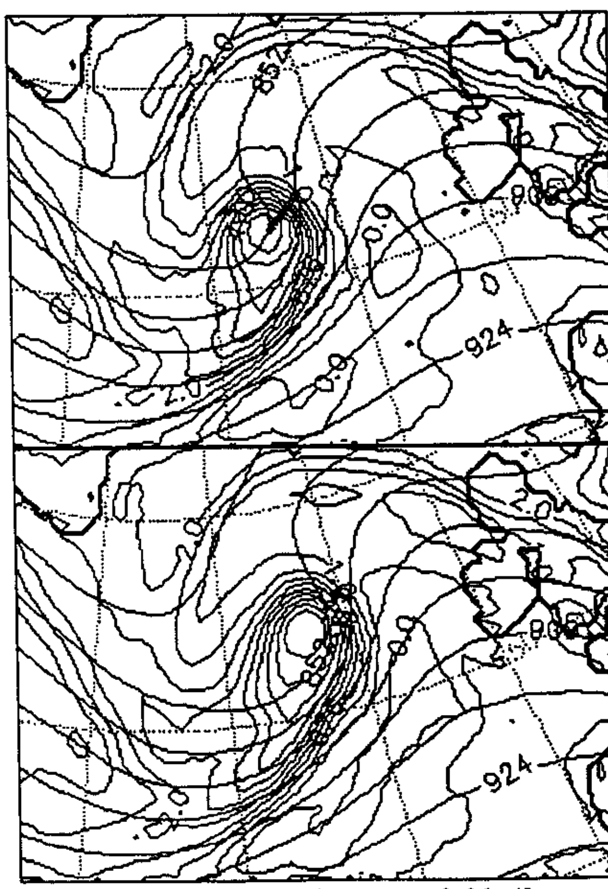

Fig. 12 *300 hPa gph and vorticity fields (for different case from that shown in Fig. 11 but with similar feature) showing effect of PV translation applied at 300 hPa with vertical influence extending to about 700 hPa. Top, before and bottom, after.*

10. Conclusions

1. The feasibility has been demonstrated of altering model output in a four-dimensionally, dynamically consistent way. The preferred primary method for dynamical alterations is via QGPV, with the direct PMSL/gph scheme useful for final adjustments to achieve the required central pressure, or perhaps as the only step if all that is required is a change in pressure without a translation.

2. Translations which are applied equally to the QGPV structure through the depth of the atmosphere are most likely to retain the original character of the feature, though vertically varying transformations can actually give the forecaster information on what the likely changes in structure and intensity of a surface feature would be through the dynamic intelligence inherent in the technique. Of course, if the forecaster wants the upper air to remain unaltered, it may be that what he or she is trying to achieve in terms of low-level changes is not possible, but such constraint is useful in assuring dynamic realism.

3. Together with the precipitation editing facility, it is possible to exert considerable control over the final product, whilst time interpolation will allow a time sequence of consistent frames to be disseminated. It would, of course, be possible to go in and edit individual intermediate frames separately if so desired.

4. Winds can be retrieved from the gph field without relying on simple empirical relationships. In addition, it would be possible to set up a facility whereby forecasters could define regions within which winds were to be altered by a given increment or factor.

5. Other applications, quite separate from the goal of control of the disseminated forecast, could benefit from the basic technique. It would be feasible to use the scheme to alter the field of PV to be consistent with the water vapour imagery. The PV inversion could then supply grid point values of temperature, gph and geostrophic wind consistent with adjustments to the PV. This would be a quick and simple way of deriving many bogus 'observations' and of allowing the dynamical information inherent in water vapour imagery into the model assimilation.

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Session 2

Recent developments

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Monday, 3 June 1996

The development at the Finnish Met. Institute

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Finland

Lars Winberg/FMI/25.7.1996

The development at the Finnish Meteorological Institute

The VMS workstation

The meteorological workstation (MWS) developed for Digital's VMS platforms is now running on 38 machines, of which 25 serve the forecasters, 7 are in other in-house use (follow-up, demo) and 6 are placed outside the institute (other authorities, University, scientific centres).

The first version of the MWS was in operation in 1987 and most of the functions were developed during the first few years. Very little efforts have been put on the MWS anymore during the three last years. Minor modifications have, however, been carried out to include new products available, e.g. the ECMWF EPS products. The functionality of the MWS includes 3D-trajectories, manual plotting capabilities (also contur editing) and overlays of different data types (Synops, Temps, NWP products on satellite imageries, lightnings on radar imageries).

The new concept

The VMS workstation was developed upon Digitals UIS software, which isn't supported on their newer models. Partly because of this FMI had to reconsider the whole meteorological product generation cycle, starting from the database and ending with products on the meteorologist's and other customer's presentation devices. A project, called WETO (WEather TOols), was started to plan end develop a new system for the institute.

Figure 1 illustrates the design issues of the new system. The database is the centre for the entire system. The different processes will use data from a common storage rather than having dedicated databases. This will make the management easier and will enable creation of versatile applications without data conflicts. New interactive tools for data editing will be developed. The generation of products for the end users is an essential part of the system. The automation of these processes will be paid much attention to. The system will be modular separating the data production, the database itself and the visualisation from each others by standardised and well defined interfaces. Furthermore, it has to adhere to the open system model and the interface seen by the application developer has to be uniform.

The visualisation features from the current MWS will be integrated in the new overall system. The implementation will not necessarily anymore be a dedicated MWS platform, but flexible separate services, which can be run on client/server basis. The call of the services will not be restricted to only one kind of platforms. Object oriented methods will be used for the various processes (visualisation, communication, editing etc.).

Implementation

The WETO staff has, in implementing the new system, made use of the following products and standards:

- TCP/IP
- ORACLE 7
- NEONS (Naval Environment and Oceanographic Nowcasting System)
- C++

The NEONS was found to need some further development (e.g. point data for observations and forecasts, data loading), so FMI contacted Meteo-France and was luckily to get a copy of their version. A lot of functionality and automation has been added in the NEONS-MeteoFrance version. Some modifications were necessary at FMI due to the different environment. The observation data is stored in GRIB format and the numerical products in GRIB format.

The object oriented C++ was chosen as programming language for new development. From the very beginning a multi platform approach, aiming at Windows, Macintosh and Unix, was taken. This has been accomplished by an intermediate level in the code structure, which interfaces to the varying windowing and displaying routines. This level has to be written for each different platform and consequently shall be kept as small as possible. Code generation has taken place similarly on all three different platforms. Primarily, however, PC-machines are used. The work was started with Borland's C++ developer, but during 1995 this was replaced by Microsoft's Visual C++. The main reason for this was that Borland's version 4 didn't have 32 bit support for the SQL interface. On Macintosh the Symantec compiler is used and on UNIX CaseVision has been used.

Current status

The progress of the development has been slower than anticipated. Reasons for this are that staff has been busy with other projects but also that the change from old style programming techniques to object oriented ones has been more tough than assumed. Most of the resources have so far been spent on developing the database and the basic classes, not much on visualisation features.

Figure 2 shows the status of FMI's system in spring 1996. A layer (FmiDataBase) has been written upon NEONS-MeteoFrance, consisting of C and Fortran functions and Unix commands, which can be used as such in data retrieve. The intention is, however, to primarily use an object layer (ObjectDataBase) for all data retrieving. For this purpose an object class (MetBox) has been developed to control the wanted piece of data. The MetBox can fill itself with data from the database's lower layers using its own knowledge, and this data can be used in a number of ways through the object's functions (methods). The user doesn't have to worry about details in the database structure (filenames, formats etc) as do users of traditional applications calling lower level functions. The MetBox is primarily a 3D data table with dimensions of times, parameters and stations.

The MetBox object is capable of writing/reading itself on/from a file. This feature is used for transmission of data in a compact format. An interactive meteogram application (Figure 3) has been created, which uses the MetBox data interface. Different versions of meteograms will be developed using the inheritance mechanism of C++. The meteogram application has also been used with the Web-browsers, having links to MetBox data files and having the visualisation program as the helper application for the MetBox file type. In this way you can run an interactive application with little communication load on the Web.

The sea forecast production system at FMI has been adapted to the new database system according to Fig. 4. The forecaster edits postprocessed wind and weather values in a table originating from the NWP model. Normally this is done four times per day, but can be carried out whenever a change is foreseen. The table is reloaded into the database, from where the different product generating processes make use of the values. Automatic products are prepared for conventional phone (code to tele operator), portable GSM (texts), public PC program (gif images) and the TV (special code).

The Weather Window

A visualisation application for the general public ("the so-called Weather Window") has been developed for PC/Windows platforms. The program is capable of viewing images in gif, jpeg and bmp formats. Sequences of images can be animated and limited image processing is possible (zooming, back/forgrounds). Text messages (forecasts) can be attached to individual images.

The client application is freely distributed through the Web including also the communication protocol. A normal user with a modem operates via the public tele operator, which is connected to FMI's server and takes care of the invoicing. The other category of users are those who make contract on a certain set of products and get an account to the server. These communicate directly over the internet or via modems.

The images available on the Weather Window service were in June 1996

- radar image over Southern Finland
- composite radar over Scandinavia
- Meteosat IR images
- sea forecasts up to 48 hours (Figure 5)
- sea observations (three regions)
- text forecasts

The frequency of the observational products are 15-60 minutes. Some of the product are transmitted as entire gif images, while other products contain only the data part the background (optionally foreground) being added locally. The transmitted product are stored locally and the communication protocol will prevent unnecessary multiple loading.

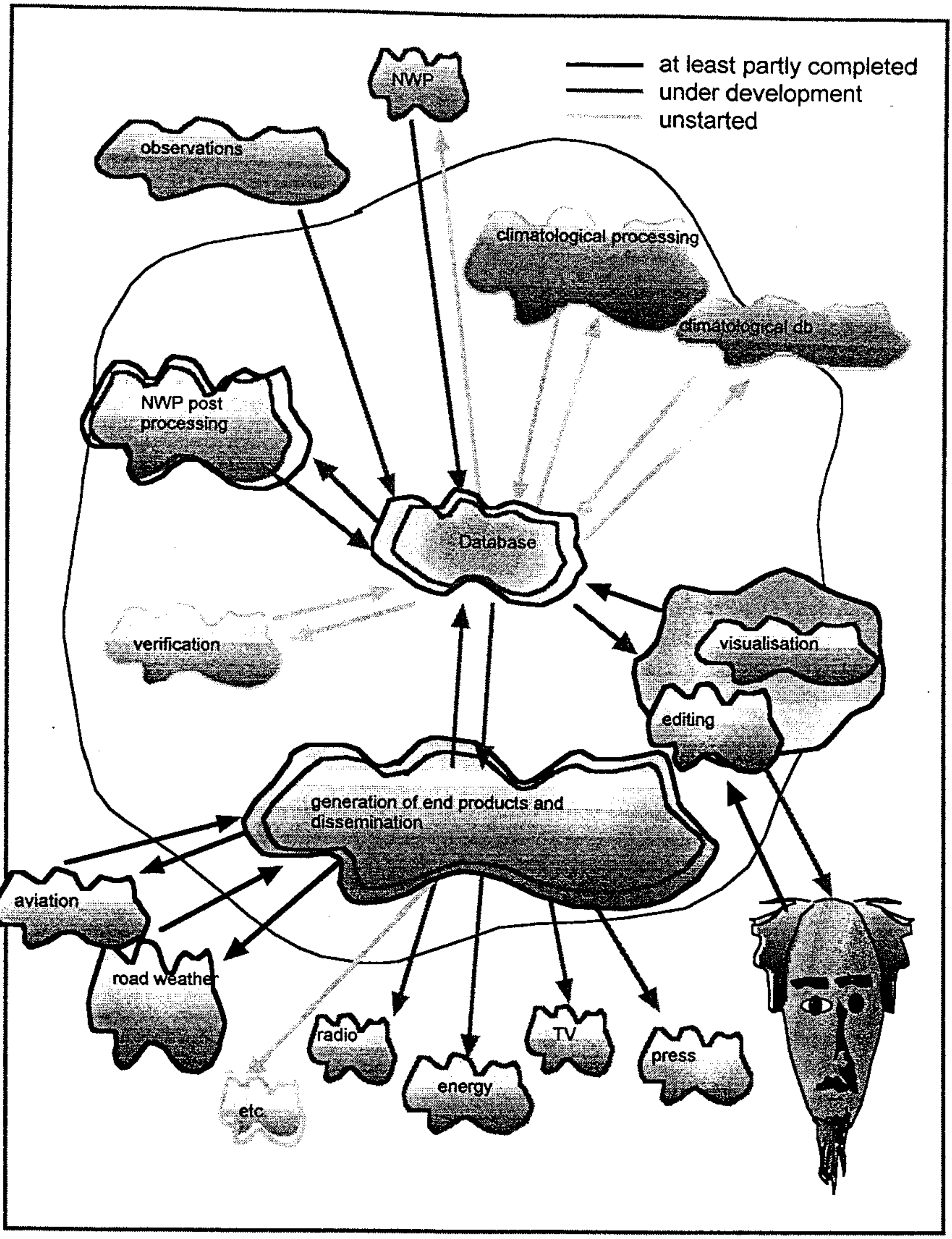

Figure 1. The new production system at FMI

31.5.1996/LW

at least partly completed

under development

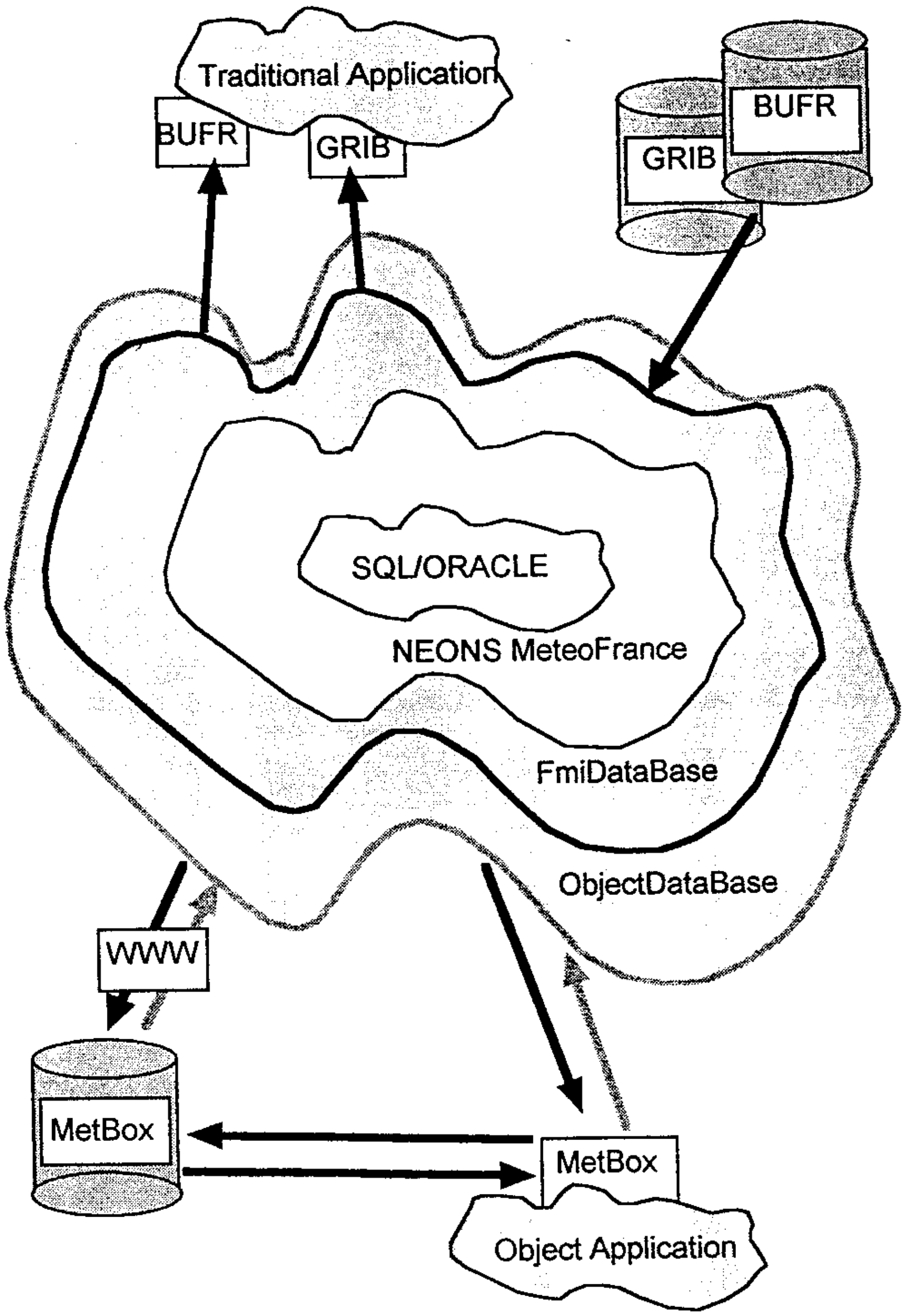

Figure 2. FMI's new database system

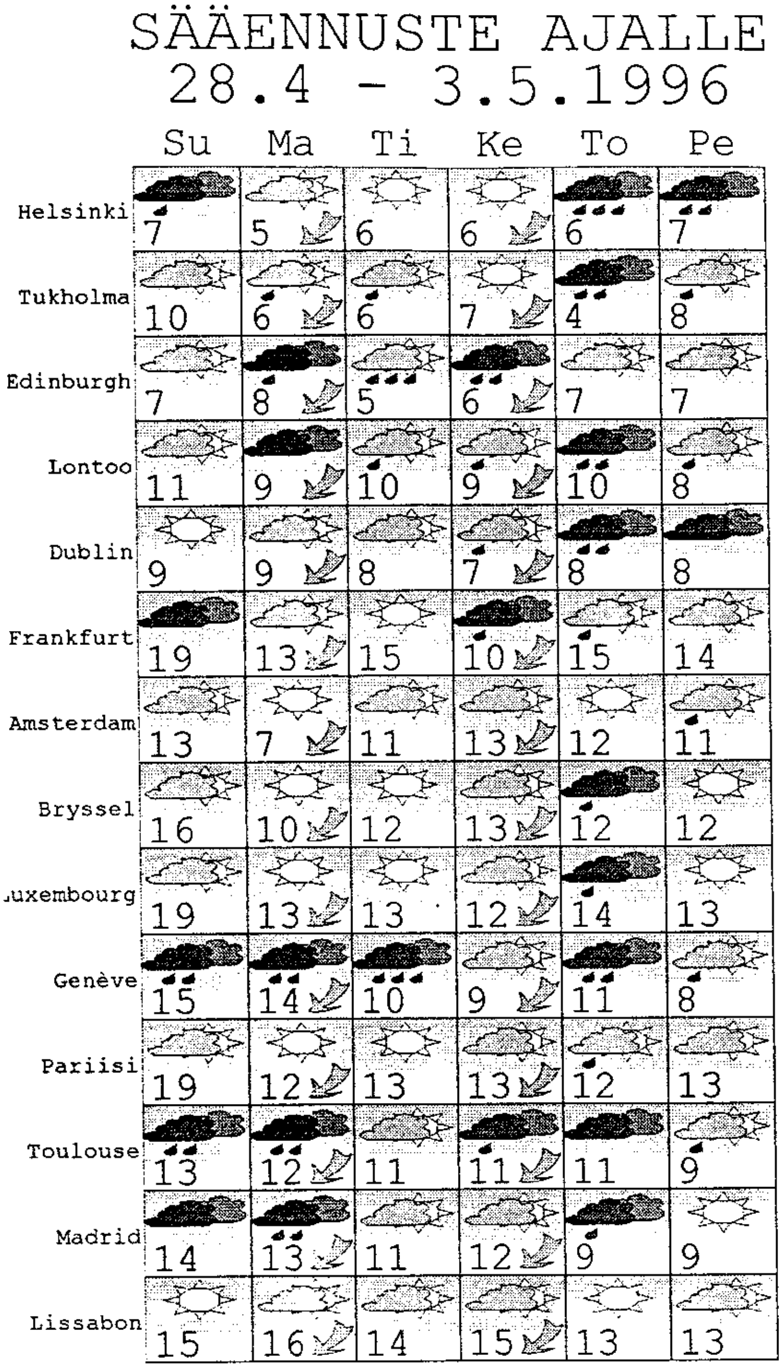

Figure 3. An Example of a Meteogram print-out.

OPERATIONAL WORKSTATIONS AT THE HELLENIC NATIONAL METEOROLOGICAL SERVICE

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1. INTRODUCTION

The DEDALOUS system is a Hellenic National Meteorological (HNMS) project for the weather monitoring and forecasting, aimed to be used at all levels of operational weather forecasting for the support of both, national economy and military meteorological needs. This project started at 1993 and since the begging o 1996, DEDALOUS ver. 1.0 has been installed and is operational in three Weather Centres, five principal and two local Weather Offices.

DEDALOUS enables operational forecasters to interactively access, manipulate and visualise meteorological data on UNIX workstations. The same architecture has been used to develop on PC platforms a smaller display system for local Weather Offices.

2. FEATURES OF DEDALOUS

DEDALOUS features are :

a. To select, process and visualise (2D) meteorological data so forecasters can access all kinds of information in useful formats, for their daily work through a friendly graphical user interface.

b. Classical functionality's such as superimposition, animation and zooming of data.

c. Tools for the production of various products for the forecaster or customers (Greek Electricity, shipping, TV etc.)

d. The transparent distribution of the raw data to other workstations that are in operational use.

3. DEDALOUS INPUT DATA.

The DEDALOUS system ingests the following data types :

a. Global Telecommunication System (GTS) Data. (Classical alphanumeric surface and upper air data, GRID format NWP data)

b. Satellite Data. (METEOSAT, NOAA, TOVS).

c. Binary, T4 and BUFR data.

It is notable that DEDALOUS can also handle Radar Data but this feature is not operational since the Greek radar network has not been up to now installed.

4. SOFTWARE

The systems main design has been developed by HNMS personel and its features are based on open architecture and HNMS standards :

a. UNIX platforms
b. S-GKS
c. Programming languages C, C++ and some FORTRAN when necessary.
d. Communications with TCP/IP, NFS.
e. X-WINDOWS, OSF/Motif, X-Designer interface generator.
f. TCL, TK
g. MAGICS
h. McIDAS

The development of the application software has been separated from the GUI (fig. 1) and the amending or improvements of the applications do not always effect the performance of the user. The code is modular and thus new features of the software can easily be ingested into the system. DEDALOUS works both on SGI and SUN workstations.

Finally a low end display system has been developed under WINDOWS NT operating system and VISUAL C for aeronautical support and general information providing (fig. 2).

5. HARDWARE

The main system hardware consists of SGI Indy R4400 or R4600 and SUN ULTRA Spark 140 with 2 GB disk and 64 MB RAM . The low end system uses i486 or PENTIUM PC with 1 GB disk and 16 MB RAM. The present and future installations are shown in fig, 3.

6. COMMUNICATIONS

The distribution of the raw data to the local outstations is done via the Message Switching System (MSS) for the GTS Data and the system itself for the binary and image data.

The local workstations are connected with the main HNMS DEDALOUS system via synchronous communications using 64 Kbits or 28800 bps lines depending on the user category and the Greek Telecom capabities. The protocols that are used are IP, PPP.

7. GUI TOOLS

The main features (fig. 2) that are available on screen (2 D x,y - cross sections) or hard copy layouts (Laser A4 - A3, PLOTTER A0) to the forecaster are :

- The display of surface plotted or analysed charts in various projections.
- The METAR display as in the complete bulletin or according to the desired variable (weather, wind, etc.).
- Tephigram display and analysis (CAPE, instability indexes, LCL etc.).
- NWP data display from various centres.
- Dynamic variable chart display (PV, Q-Vectors, $\grave{e}_w$, CSI, other instability charts, omega equation terms, vorticity, divergence, thermal and vorticity advection, thermal wind, geostrophic/ageostrophic wind, thickness,).
- HNMS wave model output display.
- ECMWF ensemble forecast products.
- ECMWF fields.
- Satellite display
- Significant weather chart editor.
- Meteograms
- Verification of daily forecasts.

8. FUTURE PLANS

DEDALOUS ver. 2.0 is now on the way and the system will include Nowcasting techniques (cloud classification, thunderstorm traking, liquid water content, synoptic weather toolls), and a new upgraded production level. Also the new version of the software will use NEONS software above the RDBMS. Furthermore, there will be an upgrade of the hardware in terms of disk capacity up to 5 GB and RAM up to 96 MB.

Finally we expect by the end of 1996 to have installed DEDALOUS in five more Weather Offices and one overseas country.

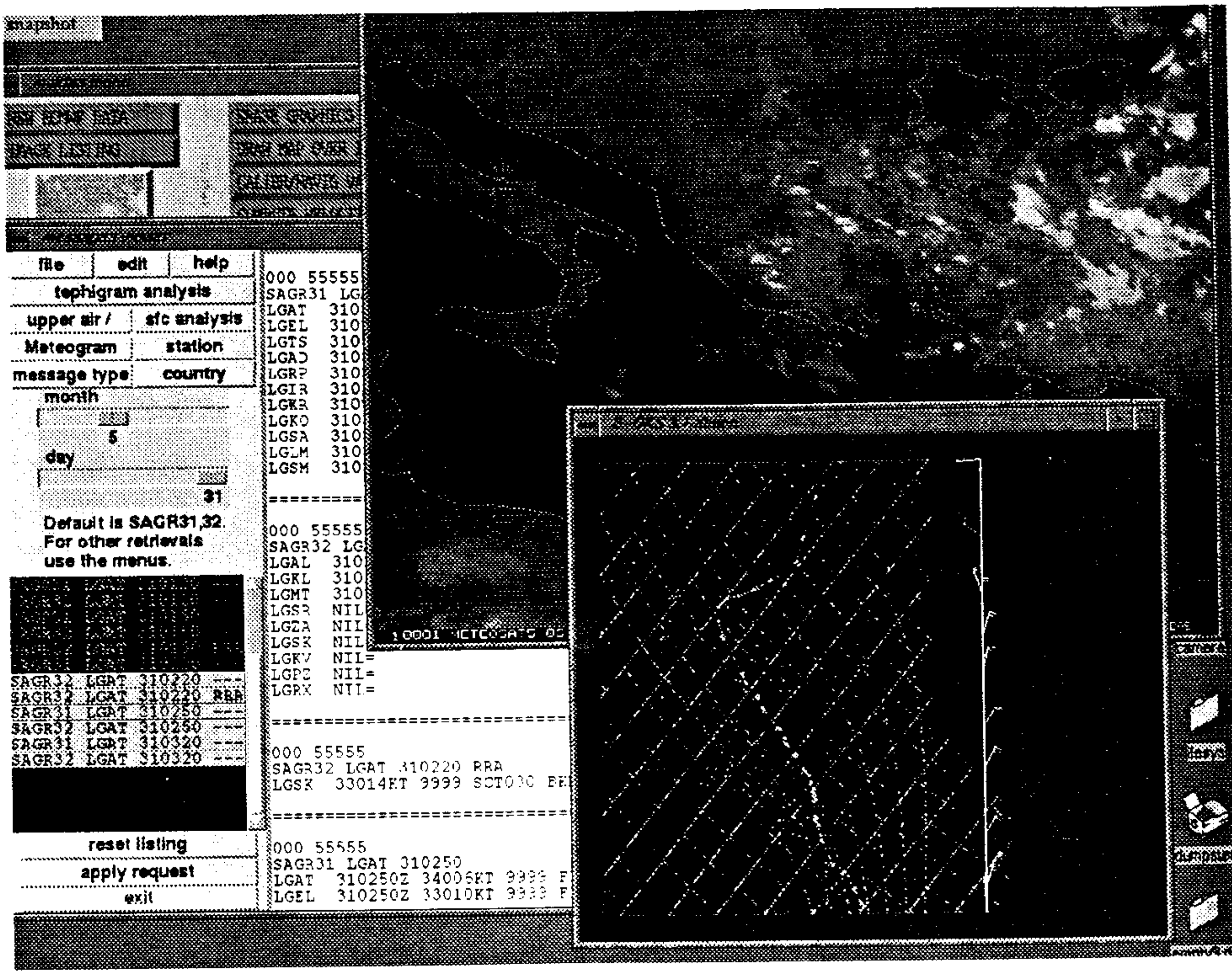
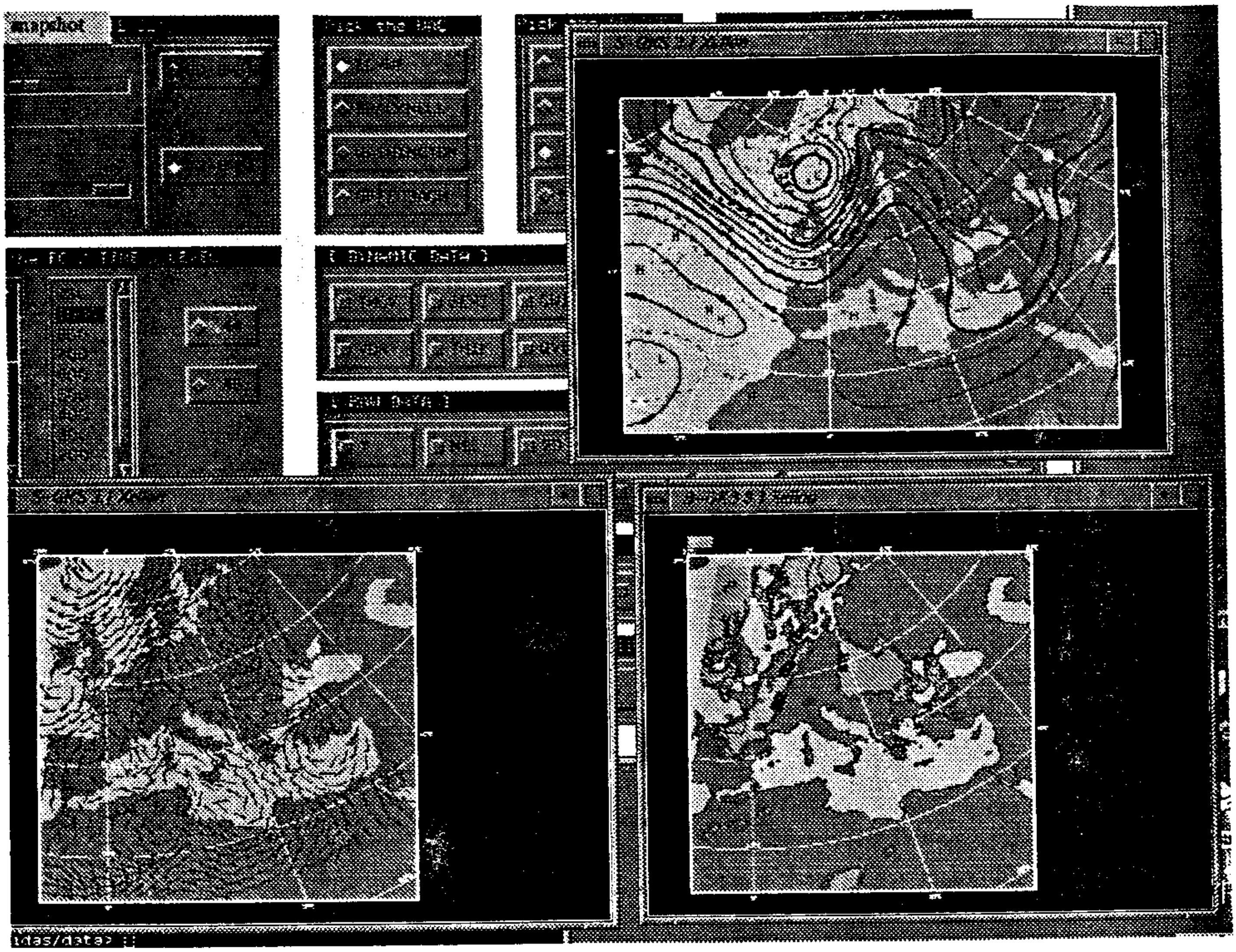
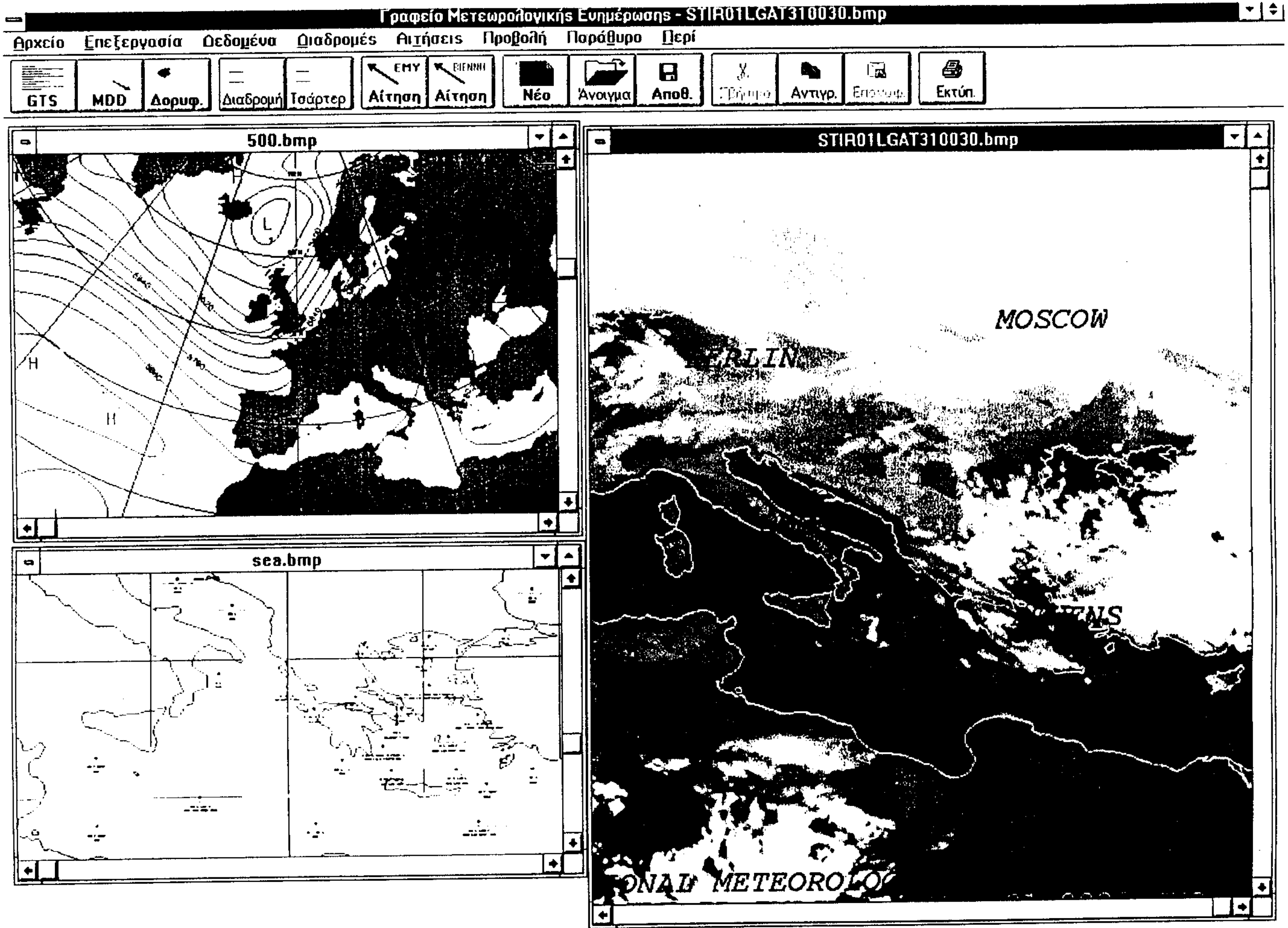
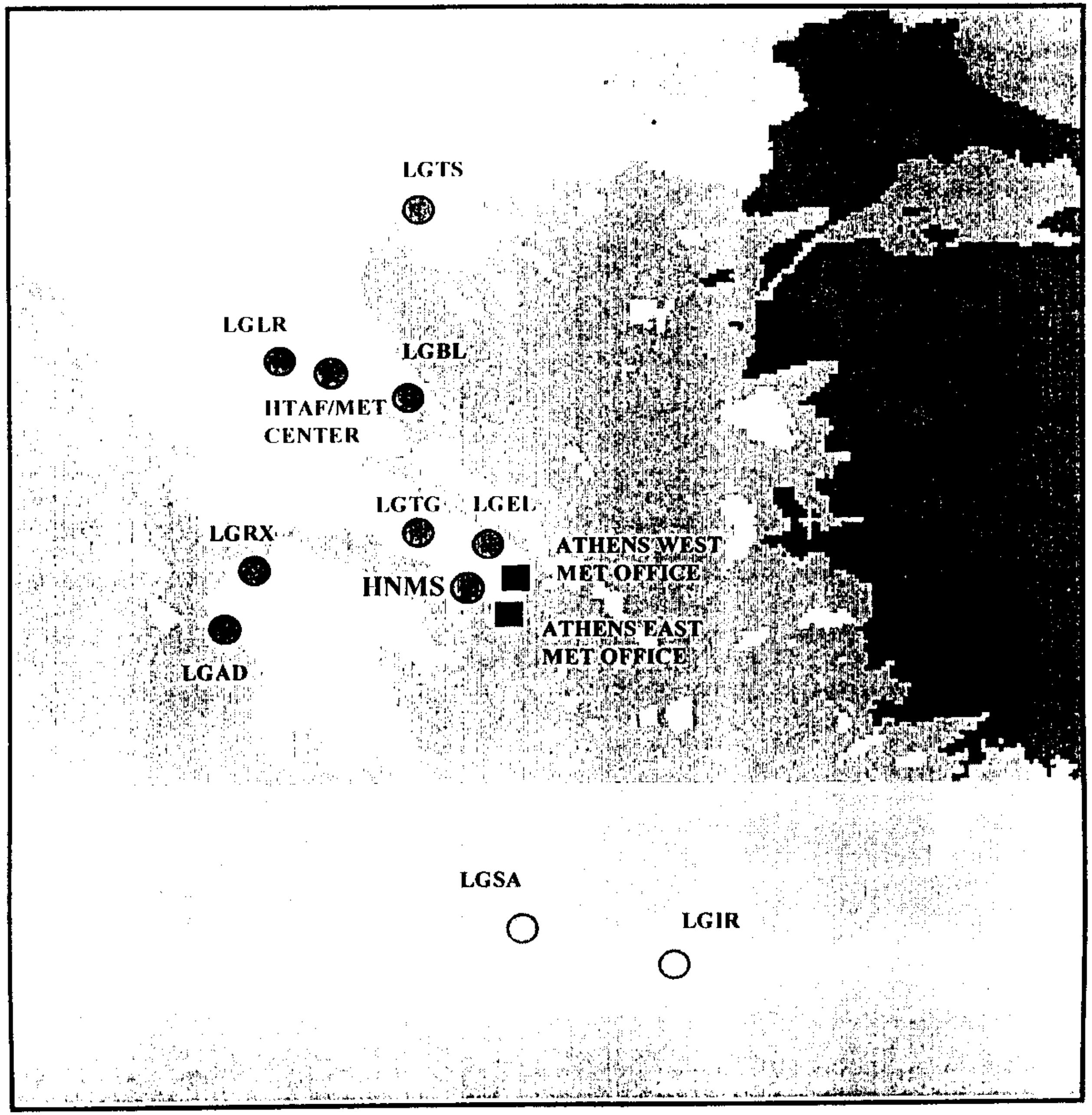


Fig1a GUI interface of the workstation platform


snapshot


Γραφείο Μετεωρολογικής Ενημέρωσης - STIR01LGAT310030.bmp
Αρχείο
Επεξεργασία
Δεδομένα
Διαδρομές
Αιτήσεις
Προβολή
Παράθυρο
Περί
GTS
MDD
Δορυφ.
Διαδρομή
Τσάρτερ
ΕΜΥ
Αίτηση
ΒΙΕΝΝΗ
Αίτηση
Νέο
Άνοιγμα
Αποθ.
Αντιγρ.
Εκτύπ.
500.bmp
L
H
H
sea.bmp
STIR01LGAT310030.bmp
MOSCOW
ERLIN
ENS
ONAL METEOROLO

DEDALOUS INSTALATIONS BY THE END OF 1996



○ DEDALOUS WORKSTATION INSTALATIONS

■ DEDALOUS PC INSTALATIONS

fig.3

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3–6 June 1996

Session 3

Meteorological applications

1996 EGOWS Meeting at
The Met. Office College, Shinfield Park, Reading, UK
3–6 June 1996

Session 3

Meteorological applications

Wednesday, 5 June 1996

Graphical presentation of meteorological data at DNMI

Øystein Godøy

Norway

1. 2 dimensional NWP fields, conventional observations and satellite imagery
2. vertical cross sections of NWP fields
3. vertical profiles of observations and NWP fields
4. meteograms
5. weather radar alone (still and loop)
6. satellite imagery alone (still and loop)

Apart from the last 2 presentation categories, all programs are coded in Fortran 77 and use Phigs for rendering. In the remaining part of this section a brief presentation of the last 2 presentation categories will first be given, then the first 4 categories are presented.

2.2 Satellite and weather radar imagery:

Concerning the last 2 presentation categories, the software used in these are partly self produced and partly the data input are preprocessed before presentation.

Weather radar data may be presented as still imagery or in loop. The software for presentation of weather radar data is programmed in C, it uses IRIS GL for rendering and Motif for user interface. The file format of distributed weather radar imagery is TIFF. In the processing a colour table categorizing the echo intensities and a map is added to the image data. Thus, these data may be presented without special software.

For presentation of satellite imagery alone standard SGI image presentation tools based on ImageVision Library (imgworks) has been used. Like the weather radar images, satellite images used in this tool are distributed in TIFF file format with land contours, date and satellite information and grid "burned" into the image as the presentation tool provides no option for overlay of a map.

However, though these data sources are discussed by themselves so far, work has been undertaken to include them in the main presentation tool for NWP data, and so far satellite imagery is included.

2.3 NWP data:

The software used for graphical presentation of NWP data is developed at DNMI. It is programmed in Fortran 77 and use Phigs for rendering. None of the first 4 software modules listed under Section 2.1 on page 2 have a user interface based on X or Motif. They are all single window applications which present the menu in the same window as the actual data. That is, the user first specify the wanted data, then the menu is removed and the data are presented until the user indicates that the menu is wanted by clicking the mouse.

The most widely used module (see Section 2.1 on page 2) among the forecasters is the 2 dimensional presentation tool, with the opportunity of presenting satellite imagery and conventional observations along with NWP fields.

Satellite imagery processed for presentation in the 2 dimensional software are stored in TIFF format as is the "stand alone" satellite imagery mentioned in Section 2.2 on page 2, but the ASCII commentary tag is formatted with the information necessary for collocation with other data (e.g. NWP fields or observations) and calibration information. Thus, the image data is not damaged by grid or land contours burned into the image.

Loop performance is available both for NOAA and METEOSAT imagery and soon weather radar data will be available.

Concerning image manipulation, like histogram equalisation and RGB modification, only some primitive image enhancement functions (histogram scale and additionally 1% cut off of data in each end of the scaled histogram) are available at present, and it is not possible to present imagery in RGB mode yet.

While vector data is rendered using Phigs, raster data is rendered using IRIS GL in the present version of the presentation tool. This way, the fastest possible rendering of both vector and raster data is achieved. A disadvantage of this division of rendering software is the construction of hardcopies. In Phigs drivers for both postscript and CGM are available, none of these are available in IRIS GL. Thus, at present it is only possible to make hardcopies of the NWP fields and conventional observations and not the satellite imagery - unless screendump is used.

Hardcopies are not a problem in vertical cross section or profile presentation tools. These programs are coded in Fortran 77 and use Phigs for rendering as the software for 2 dimensional fields but the outer menus have to be changed before they can be controlled from a single menu.

All applications have full zooming performance.

The main advantages of the presentation tolls for NWP data are quick response and easy configuration of menus, the main disadvantage is that the menus are not in X or Motif as most users are familiar with. A new user thus may need some practise before full performance of the application is achieved. Furthermore, the software is originally developed for NWP products and this limits the flexibility of the software when presentation of NWP fields are not the main purpose.

There is yet no decisions on whether this system will be ported to a new software and the menus changed.

3.0 Satellite imagery presentation tool:

In the Section for Remote Sensing in the Research and Development Department a prototype of presentation software for meteorological satellite imagery is developed. At present this is programmed in C and C++ with rendering in ImageVision Library and IRIS GL. ImageVision is used for the imagery, while all vector data - like land contours and annotation is rendered in IRIS GL. Pop up menus (IRIS GL) are used for user interface at present. In the future a Motif style interface will be provided instead.

The main properties of the software being developed for satellite applications are:

- Full control over window size
- Roaming
- Zooming
- Optional overlay of land contours
- Histogram scale
- Histogram equalisation
- Sharpen
- RGB modification tool
- Information about image date, satellite calibration etc.
- Cloud top temperatures for regions chosen by mouse
- Optional hardware acceleration mode
- Optional double buffering mode

At present it is not possible to make hardcopies.

In order to simplify the collection of training data for development of a cloud classification, computation of statistics for regions outlined with mouse is implemented. Computation and graphical presentation of statistics are made with the statistical software package Splus.

This software package is by no means complete and will be further developed in 1996.

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3–6 June 1996

Session 3

Meteorological applications

Wednesday, 5 June 1996

Use of graphics workstations at Met. Éireann

Jim Hamilton

Ireland

USE OF GRAPHICS WORKSTATIONS AT MET EIREANN

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Ireland

1. INTRODUCTION

This paper summarises the graphics hardware and software systems in use at Met Eireann - the Irish Meteorological Service. It describes a number of programs used by the Forecasting and Research Divisions to display observations and NWP products using X/Motif. In particular, we discuss three X programs viz. **plotxw**, used to display plotfiles [i.e. pre-calculated metafiles]; **xgrbplt**, used with GRIB output from the Hirlam NWP model; and **xcharts** used by the forecasters to look at NWP output from various centres. The latter replaces a command driven system called CHARTS [Hamilton 1984]. Much of the discussion will concentrate on developments since the last EGOWS meeting [Hamilton 1995a] and plans for the future.

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, 1995a and Hamilton, 1995b] :

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. [An older, and less powerful, MIPS RS-3000 Magnum is used as a backup.]

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 General Forecasting Divisions. Their primary use is to display output from numerical models. In is planned to install an additional SGI-Indy at the Aviation Forecasting office, in Shannon Airport, within the next two months.

A number of Pentium PC's [running MS-Windows and LanWorkplace for Windows] used in the General Forecasting Division as X-terminals to provide additional screens.

Figure 1 summarises the hardware configuration. Note that it includes hardware used by the Climatology Division [a Sun Ultra server running Ingres which replaces

Met Éireann

Computer and Lan Configuration at Glasnevin H.Q.

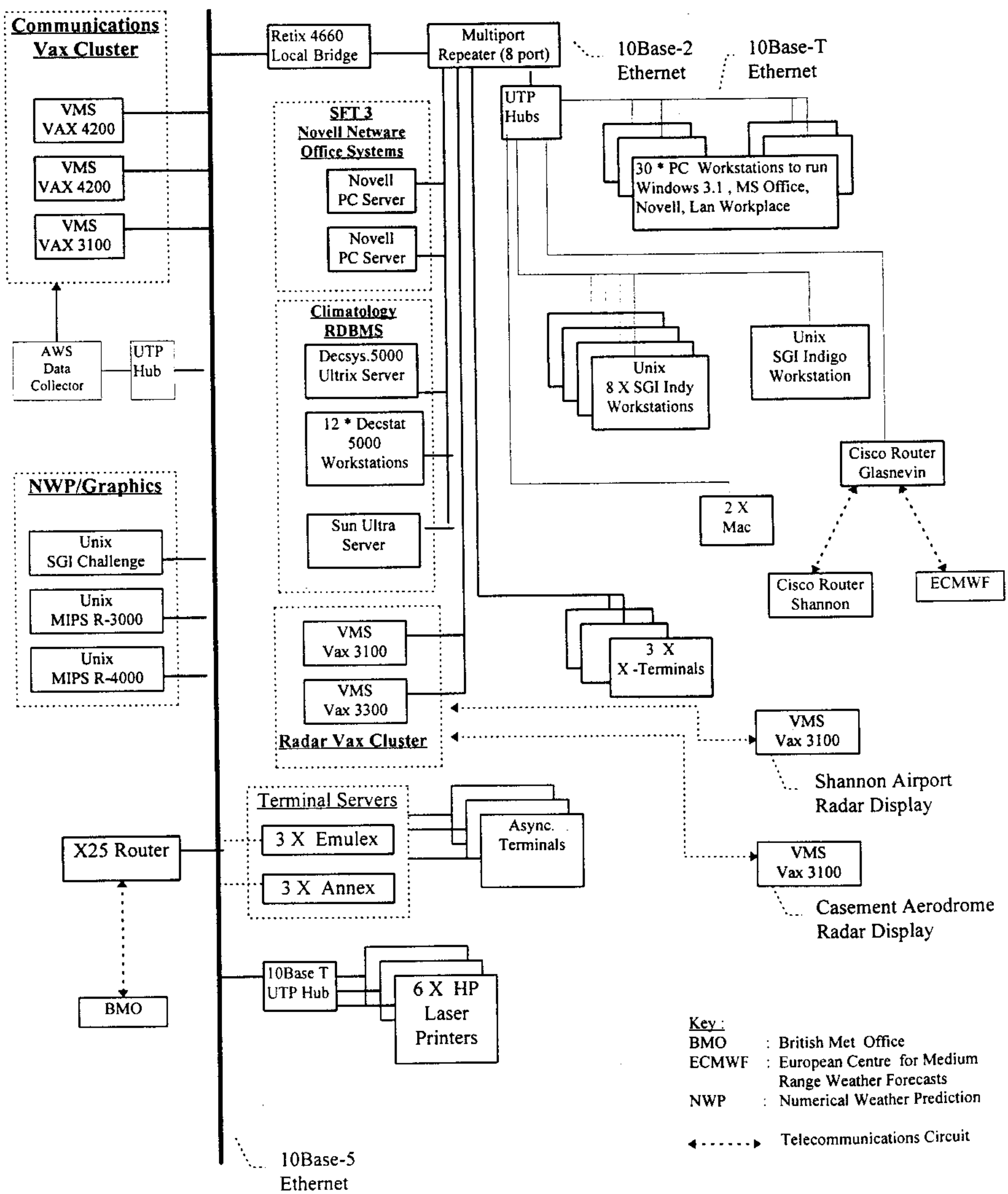

Figure 1 : The hardware configuration at Met Eireann - the Irish Meteorological Service.

a DEC Unltrix system], two Macintosh's [used for desktop publishing] a VAX cluster [used for the Dublin Airport radar] and various networked PC's.

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. We have just installed a new radar at Shannon Airport [from Gematronik] which uses DEC alpha workstations and we hope to integrate the two radars on one display.

We have a number of self-contained satellite display systems which use secondary data. We plan to acquire a PDUS system, to receive primary satellite data, later this year.

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. The system has been developed further in the past year and new features include animation, cross-sections and solid shading [Nishimura, 1995].

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. Recent enhancements allow the forecaster to draw in fronts using the mouse.
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:

31.5.1996/lw

Automated Sea Forecast Production at FMI

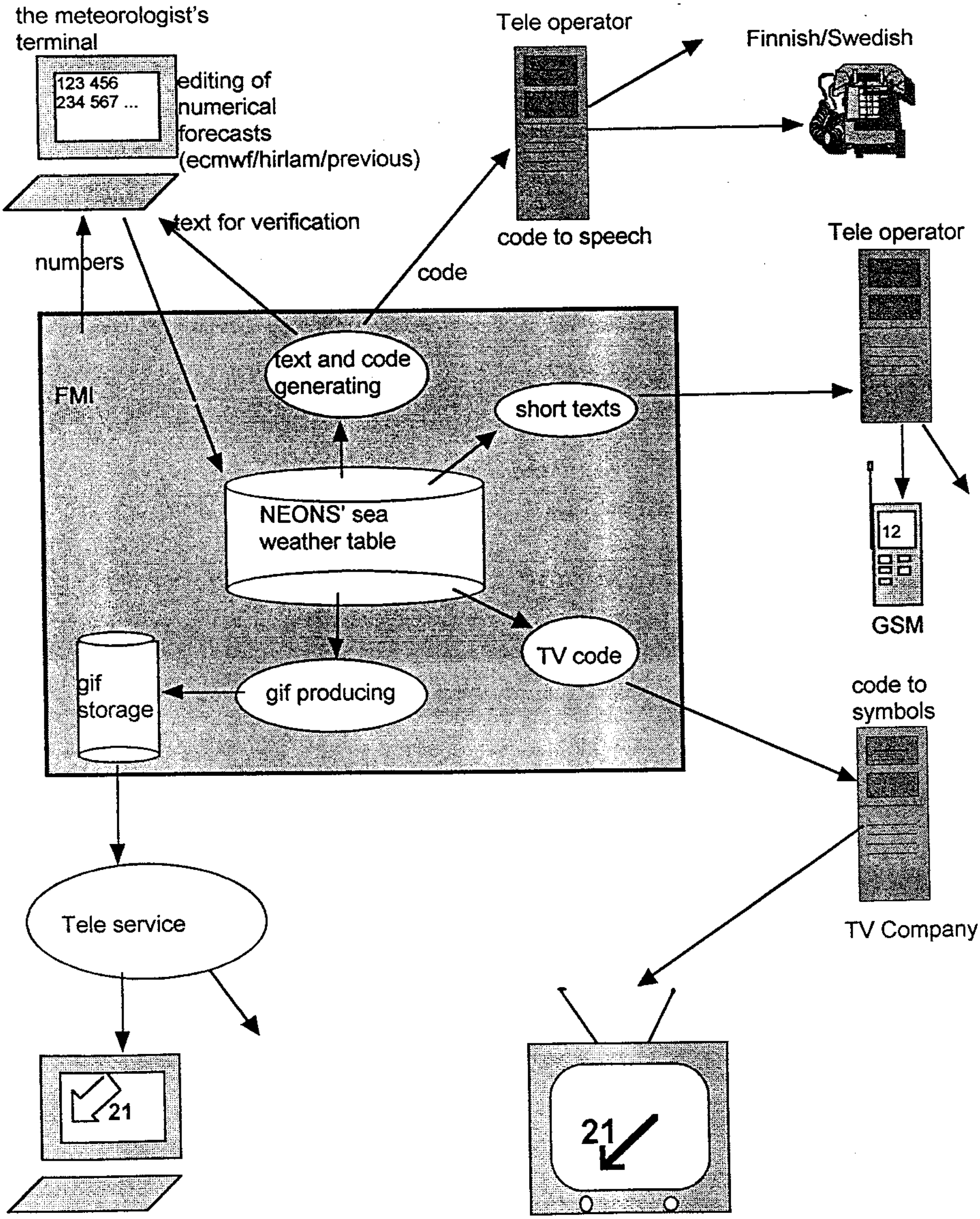

Figure 4.

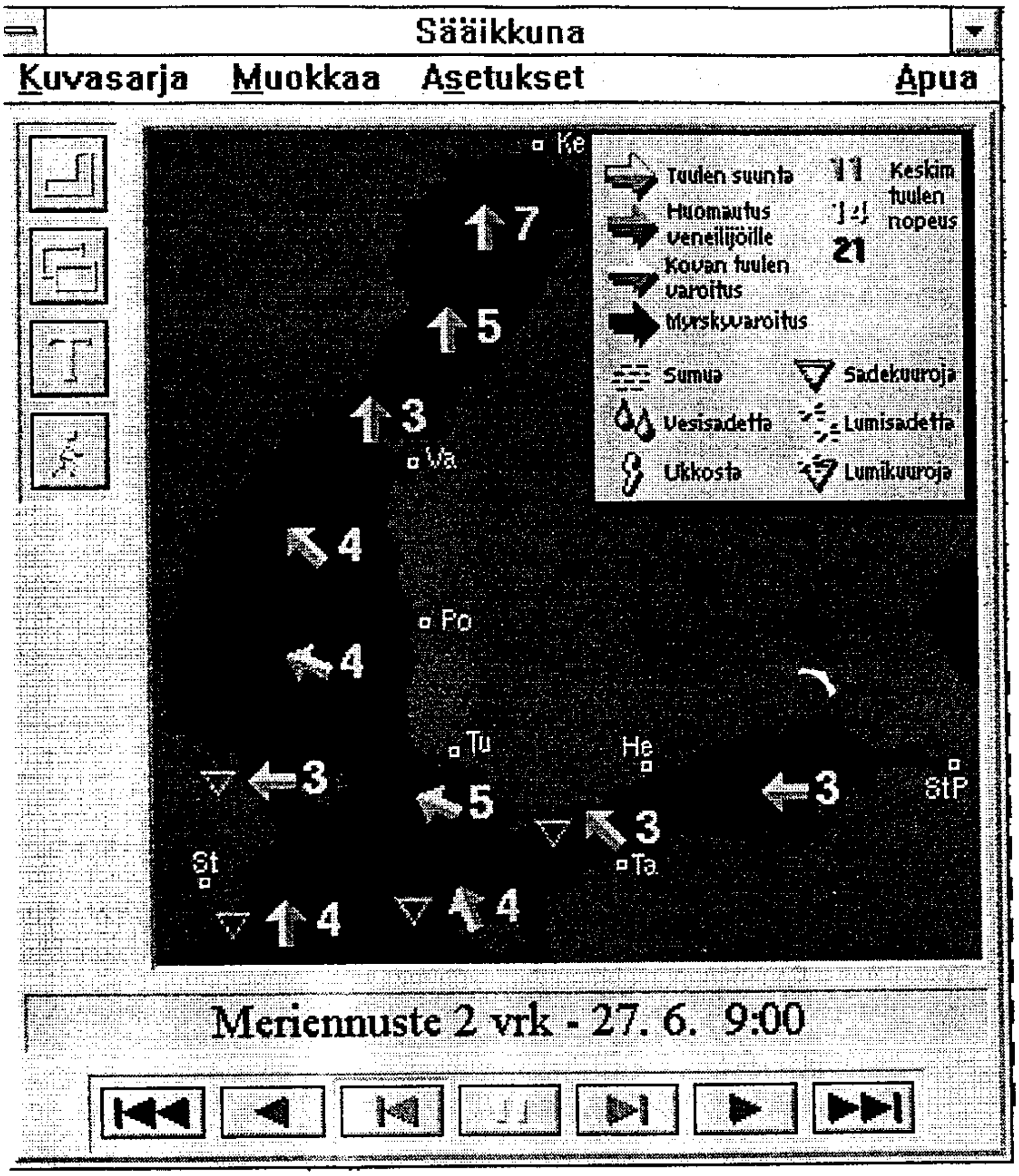

Figure 5. An Example of a Weather Window view.

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3–6 June 1996

Session 2

Recent developments

Monday, 3 June 1996

What we work with at the Danish Met. Institute

Jacob Brock

Denmark

What We Work With

A presentation at EGOWS VII

Jacob Brock
Danish Meteorological Institute

The development group

Throughout the last year, there has been no changes to the development group. The group consists of 12 developers and a project coordinator. 2-3 are developing for PCs and the rest for workstations. Our area of work is specification and implementation of new programs, maintenance of existing ones, and testing new standard programs, like new operating system releases. And although we do not have the responsibility for the daily operations, every now and then we get involved in solving problems in operations too.

As goes for work methods, most new projects go through proper specification before implementation. After implementation, a set of guidelines for testing (particularly for memory leaks) has been set up, but they are only being performed by the developer. Revision control and maintenance of documentation and manuals threatens to get out of hand at the moment, but it looks as if management is finding the funding for it now.

From Diatel to WWW

Last year, we put a number of our products onto a national computer service network called Diatel. Part of the information could be accessed for free, the rest had to be paid for. The Diatel company took care of servers, to which the users could connect, and also took care of accounting for pay-services.

In the meantime, danish Telecom has taken over the Diatel company, and all the services are being moved to WorldWideWeb. The WWW version was introduced at the beginning of May and the old Diatel will be closed down by the end of June.

This change has kept two of the PC developers and a couple of others busy for several months. All the text based products had to be moved to HTML, and changes had to be made to the programs, which users can download onto their PCs in order to view time series of radar and satellite images.

There were two particular problems, which were hard to get around. One was to keep up with the new inventions of the latest versions of Netscape - and at the same time try to keep compatibility with older versions and other brands of browsers. And the other was to get the accounting for pay-services working. The actual accounting system was not done by us, but we were given hardly any time to test it.

But the service is up and running by now, and can be visited at www.dmi.dk. Most of it is in danish, but some parts are in english as well.

World Weather

Out duty meteorologists often get questions from the public about the weather conditions at various destinations all over the world, these places being destinations of holiday, business trips or whatever. To aid them in answering these questions, forecasts for the next week are automatically produced every night based on the ECMWF model. It is a completely automatically generated product with no human intervention.

The destination can be selected through a graphical user interface, and the forecasts can be presented as either text in one of several languages or as graphics as a sort of meteogram. The initial presentation is on the workstation screen, but the products can be printed or it can be faxed to the customer by entering the fax number.

At the moment, the program is only used inhouse, but at a later stage, it may be put on the WWW-server.

As an example, the meteogram like presentation for London for the start of the EGOWS meeting has been included.

Radar extrapolation

For the benefit of nowcasting, an application for extrapolating the latest radar image into the future has been developed, and is being tested. Test data have been sparse this past winter as the only precipitation for months was snow, which our radars are not too good at detecting. But spring has given some good test cases.

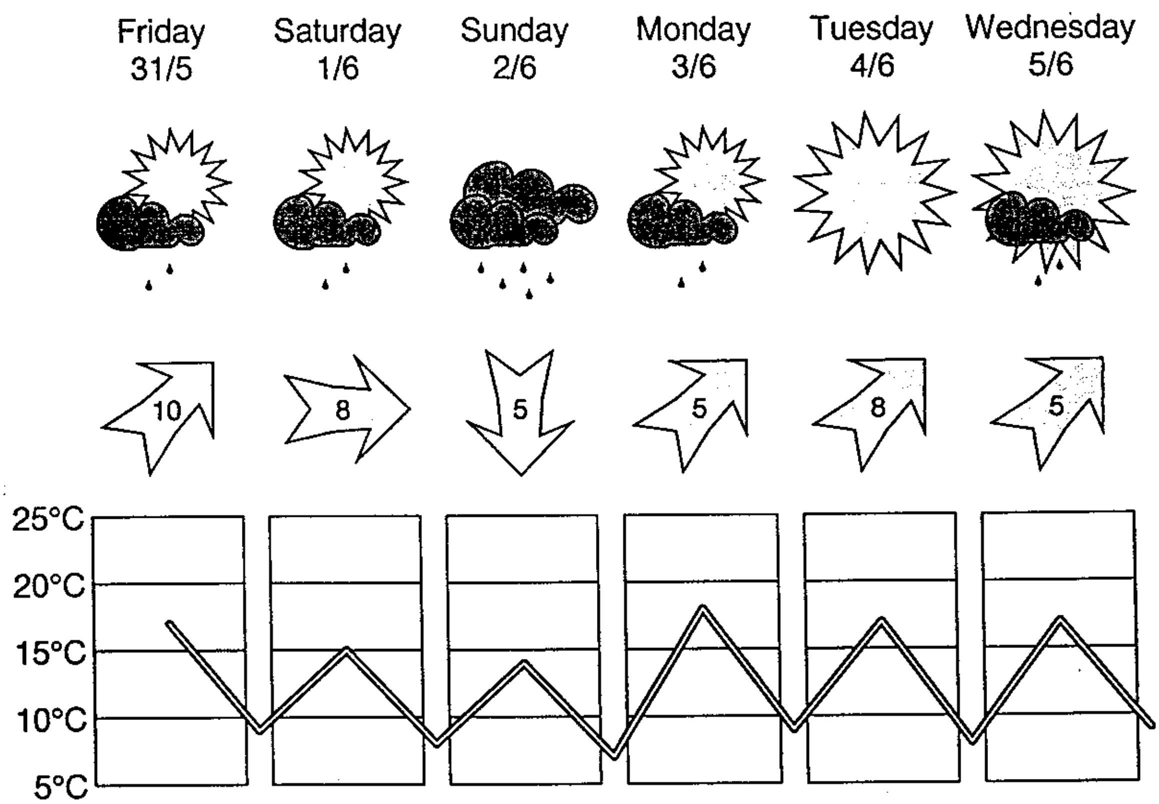
WORLD WEATHER

Date: 31/5 1996

Danish Meteorological Institute, Lyngbyvej 100, DK-2100 Copenhagen Ø
Telephone +45 39 15 75 00

DMI

London, England



The forecast has been produced automatically, and has not been checked by a meteorologist.

The extrapolation is using 700 hPa wind from HIRLAM for advection, and in cases where precipitation is entering the coverage area of the radars, the future precipitation on the border is taken from HIRLAM as well.

The program is still being tested and improved. From a draft of a report on how the extrapolation is doing, a figure has been included, showing 1 hour extrapolations compared to the real situations.

Metview for plotting

When Metview was released by ECMWF for general use by the member states, we implemented it on a dual SGI Challenge setup. This was not without problems. An error in the C++ compiler for instance meant that everything would compile nicely, but when the main user interface was started, it would core dump during initialization. This problem and a few others have been cleared away, and by now we are in the middle of porting our production to Metview.

The main use of the plots is for interactive use on the MWS. As we do not have license to use SGKS (on which Metview is based) on all the end-user workstations, we produce PostScript files, which we process further to be partial PostScript files. These parts, each containing the plot of just one field, are distributed to the MWS's. Here, a presentation program will join the pieces with maps and texts and put the whole lot onto the screen or a printer.

So far Metview has been working very stable as a batch producer of plots. The macro language is powerful and reasonably user friendly, and we have been able to achieve nearly everything, we wanted.

The interactive part of Metview is only used for setting up the batch plots at the moment. Later on, when our HIRLAM model is changed to generate standard GRIB, we expect it to be used by the Research & Development department for studying HIRLAM.

Miscellaneous projects

The development of PC programs is getting still more important as it is creating revenue for us. At the moment we are working on two major systems, water level monitoring at coastal areas and road conditions.

Within the water level monitoring scheme, data are collected automatically at 10 minute intervals. The information is monitored by local and regional authorities, and is also copied into our system. Along with numerical predictions it will be entered into a water level model, and the result is to be presented for the duty sea area forecaster. He will be able to change the source data and put it through another model run. And if the result indicates expected water levels of critical heights, he can put up warnings and inform local authorities.

This project has become important, as we during the last 2-3 years have experienced several cases of unexpected high water levels in the domestic sea areas, some of them resulting in flooding. The monitoring part of the project is done with PCs, whereas the model and related presentation will be running on workstations.

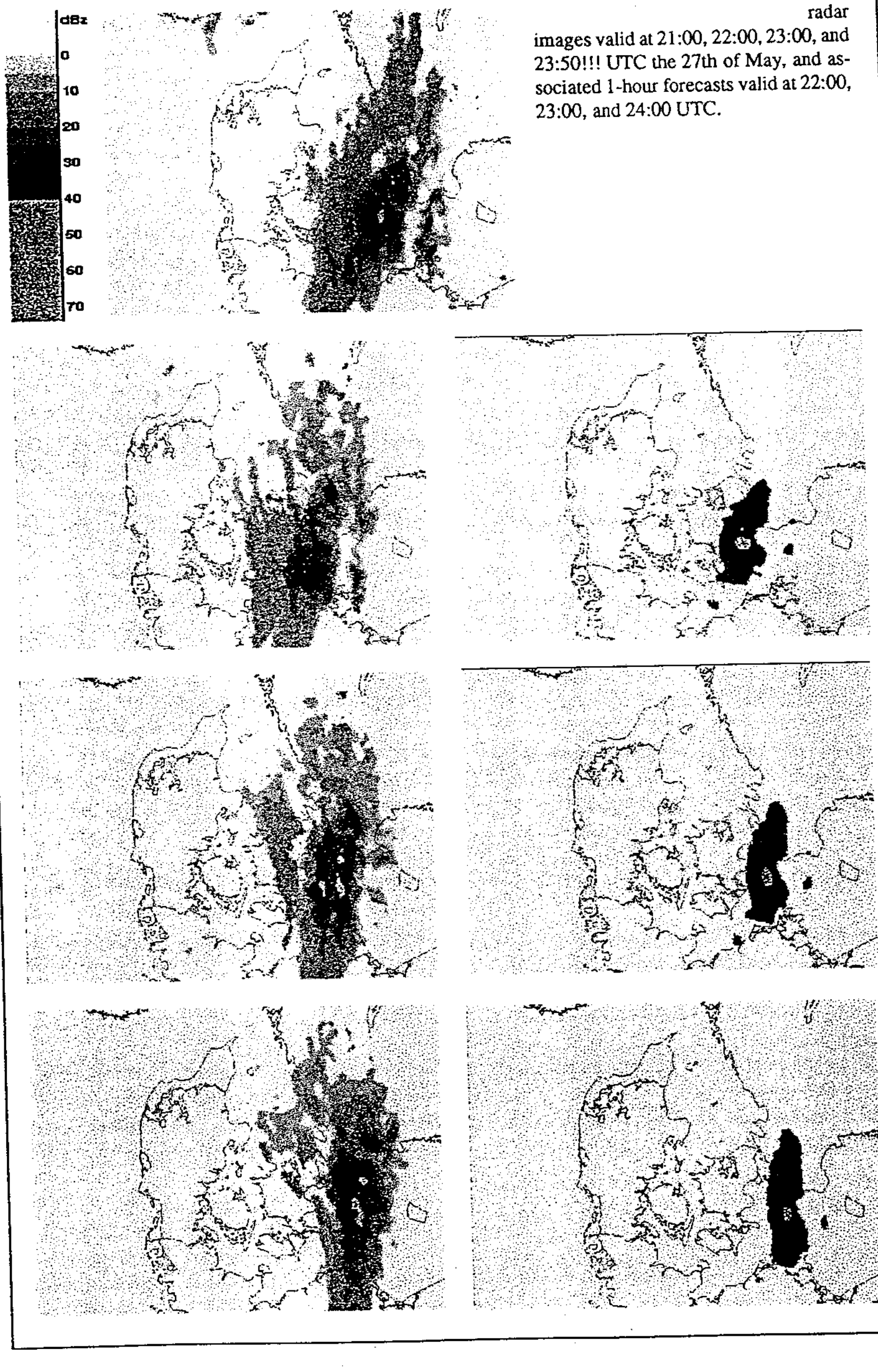
The other major PC system is a reimplementation of the road condition system. The special model, based on standard observations, our numerical model and data, collected from special road sensors around the country, is still running on the supercomputer and can be adjusted on the workstations. But in competition with another member of the project, we won the contract on implementing a PC based presentation system, which is going to be used for the presentation of the results of our model at the offices of the regional road authorities.

TAF monitoring is continuing with only minor changes, the changes mainly due to changing opinions on the interpretation of the official code manual. As goes for TAF verification, a scheme agreed on by the nordic countries is being implemented.

Automatic or semiautomatic TAF generation is still at the specification phase.

On ship routing, a program, which will come up with a first guess on the best route to follow for a ship, is nearly complete. The automated routing is based on wind, wave and swell information from the latest ECMWF model output available. The route is presented to the forecaster, and he decides whether to use it as is, or to change it.

The routing program generates a tree structure around the most direct route. Each new branch is calculated based on the weather condition at the starting point of the branch. As the tree grows, branches are pruned if they go to far astray, either in distance or in time compared to other branches. The first branch to reach the destination port is backtracked to the current position of the ship, and presented as the best route.



radar images valid at 21:00, 22:00, 23:00, and 23:50!!! UTC the 27th of May, and associated 1-hour forecasts valid at 22:00, 23:00, and 24:00 UTC.

The program is still being tuned on how wide to spread new branches, how far apart to put them and so on.

An example run from the program is included. It shows the tree structure generated with all the branches as thon lines. Each twelve hours down the track, a black dot is placed on the branches (forming the thick lines across the route). The branches forming the best route is shown as a line of medium thickness.

Our lightning monitoring program is now used by a large number of (electric) power distribution companies. Lightning detection informations are copied to their central office, from where it is distributed to the individual company offices.

Windmills for power generation are quite popular at the moment. The power is sent into the general distribution network, and in order to be able to plan the production at the conventional power plants, the power producers want to know how much power can be expected from the windmills. Hence we are running a project, which will predict the production based on our HIRLAM model. There is another research institute, which is doing nearly the same thing. Which of us who are going to be the best, is to be seen later this year.

A growing number of newspapers, radio- and television stations require forecast. They want forecast, produced to their specific needs, and they have to be cheap. To accommodate this, we have implemented a generalized media forecast application. With this application, the forecaster will produce a general forecast for the whole country, but with enough detail that information for a local area can be extracted and sent to customers in that area.

On-line documentation

As mentioned earlier, the task of keeping user manuals for the meteorologists and technical manuals for the computer operators up to date is getting very big. Particularly the time spent on copying new pages and replacing the old ones in the written manuals takes a lot of time at best - and is not done at worst. And even if it is done, there is inevitably a delay when papers are being sent from one department to another.

Hence we have decided to put all our documentation on-line, formatting it with HTML and making it available to the users through a web-browser, most likely Netscape. In this way it should be possible to have a set of manuals, which is always up to date, and which can always be found, even if you have to log in from your PC at home.

To get there, there is a hurdle to pass: converting all our documents to HTML. Our documentation is written using FrameMaker, and FrameMaker now supports HTML. We "just" have to find the money for an upgrade, and the time for converting nearly 200 documents.

At the first stage, the user manuals will be "passive". That is, if you want to find out about an application, you will have to look it up in the on-line manual by hand. But we are planning methods for applications to be able to jump straight into the manual when the Help button is pushed.

Heading for CDE on operational workstations

A the moment, all our Meteorological Workstations have a common user setup. Everyone is using the same login name, and the applications are the same all over the place. It is only the number of available applications, which differ. And although most of our applications by now are Motif based, we are still using the Open-Look window manager.

This fall, we are scheduling to move the presentation machines to the Common Desktop Environment, CDE. Some of the development machines have already been changed to gain experience.

In the new setup, there will be different logins for different duties. The CDE comes with virtual screens, giving the user the ability to change from one (set of) application(s) to another by the press of a single mousebutton or even just pressing a function key. It is also possible to save your session (the layout of applications on the screens) at logout time.

From a system administration point of view, the CDE has tools for disabling multiple running versions of a program. We have had problems in this area, as the users tend to forget, which applications are up and running. It may just be hidden behind another window, but it is faster to start a new version than to go looking. Or if they hit the configured limit of a memory expensive application, they just start another version.

Voyage :

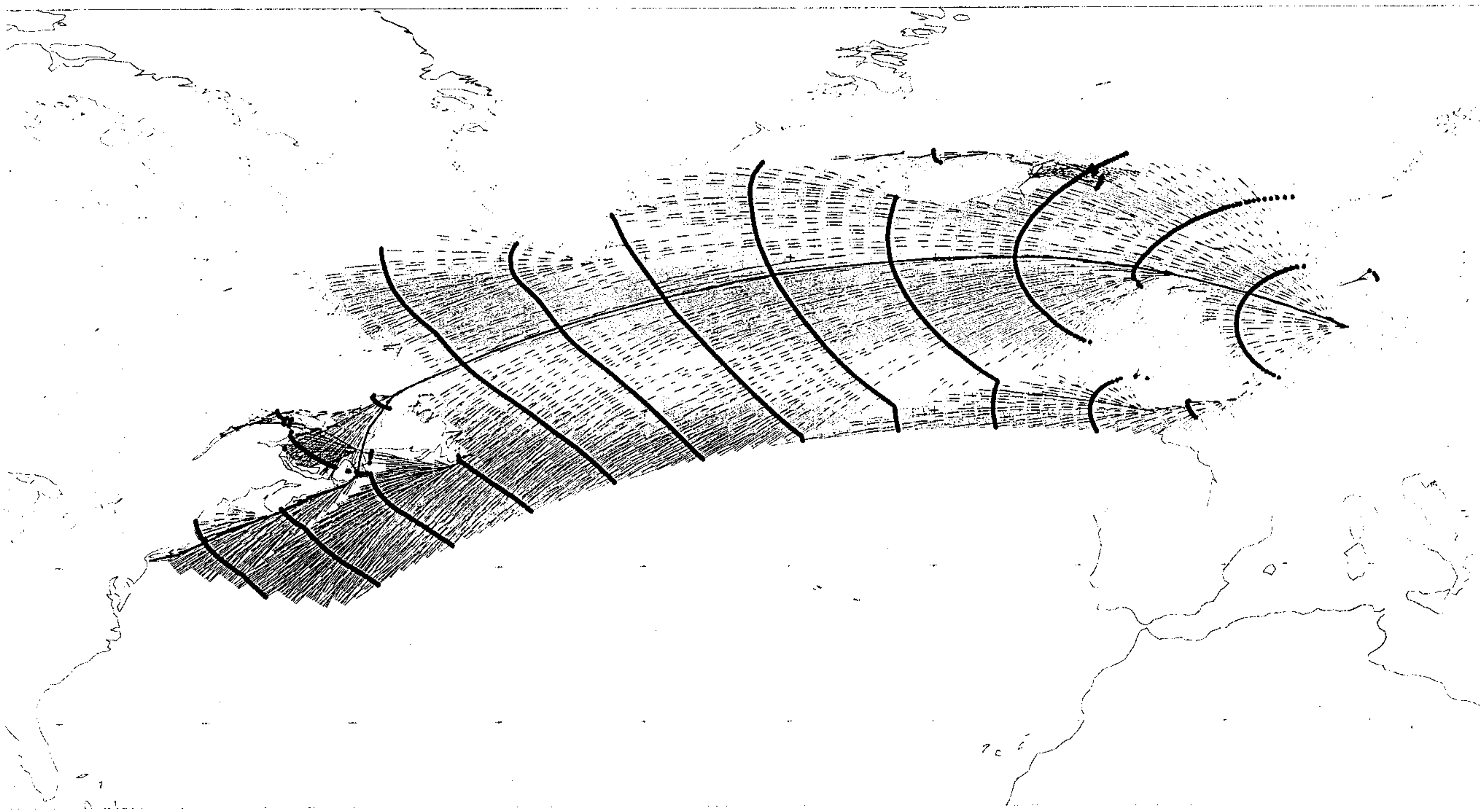
Start :	(55.35 , 8.48)	960730 12:00 Z
End :	(40.47 , -73.83)	960805 20:16 Z

Dist :	3335.2 nm
Time :	152.3 hrs
Average speed:	21.9 kts

Legs :

		nm	hrs	kts
(40.47 -73.83) Op L I 78 0	960805 20:16 Z	3335.2	152.3	21.9

DMI



Hardware

Our hardware situation has not changed very much as goes for workstations for presentation. We are only using SUNs for this purpose, having a total of approximately 70 for development, production and presentation. Production of NWP plots have been moved to two SGI Challenge machines. The Challenge is an Onyx with no graphics board, and the two are backup for each other.

At the high end, our supercomputer running the HIRLAM model is being changed from Convex 3880 to a NEC SX-4. It will start off with 8 CPUs, and within a year it will be upgraded to 16. The expected increase in computing power in HIRLAM operations is a factor 20. Whether this will be utilized for lower grid-spacing or smaller time steps is to be seen.

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Session 2

Recent developments

Monday, 3 June 1996

The HAWK project

Akos Horvath

Hungary

*H*ungari*an* Meteorological *Work*station (*HAWK*) Project

Akos Horvath
Hungarian Meteorological Service

The Hungarian Meteorological Service, collaborating with Forecast System Laboratory of NOAA, runs a project to develop a UNIX based meteorological workstation. The result of the project would be a highly interactive system designed for Mid-European environment. This system would allow meteorologists of Hungarian Meteorological Service to use much more and higher quality of meteorological information. Primary usage is planned in short range forecasting, but the system should be able to operate on wide scale of meteorological fields, like pollution transportation, aerology, climatology, etc. The full operative usage are planned in 1997, but some parts of the system are already used in operative practice.

Main requirements

Main requirements from meteorologist users are follows:

1. Fast display capability of chosen information:

meteorological maps
diagrams
images
tables
characters etc.

2. Space and time synchronizing of different data.
The system has to find the optimal map projection and place different products to this common map. The user may modify it.
The system also offers an optimal time resolution of different products which can be modified.

3. Run as many applications as possible "on the fly" way.
This concept helps increase the flexibility of the system, and there are some tasks, like cross sections, time sections, where this is the only way of solution. The price for it is the slower speed of displaying.

4. Full data handling.
All data preprocessing and encoding, decoding procedure run in background.

5. High level interactive connection between the user and the system.

6. Open system for special (and new) applications

Used Software Devices

HP-UNIX operation system is used.
All graphic tasks are written in **X, Xt and Motif**.
For data storage **netCDF** format is applied.
Programming languages are :
Fortran-77 for meteorological tasks,
ANSI C for data handling.
C++ is the backbone language of the HAWK system, all other languages are called from C++.
The system is based on object oriented programming technique.

Object oriented "plug in" programming technique

Object oriented programming technique is used. Two kinds of objects are defined: data objects and application objects. Data objects are for data storing and manipulating. These are:

Parcel which contains the basic parameters like temperature, height, humidity, pressure, wind speed and wind direction (Fig. 1).

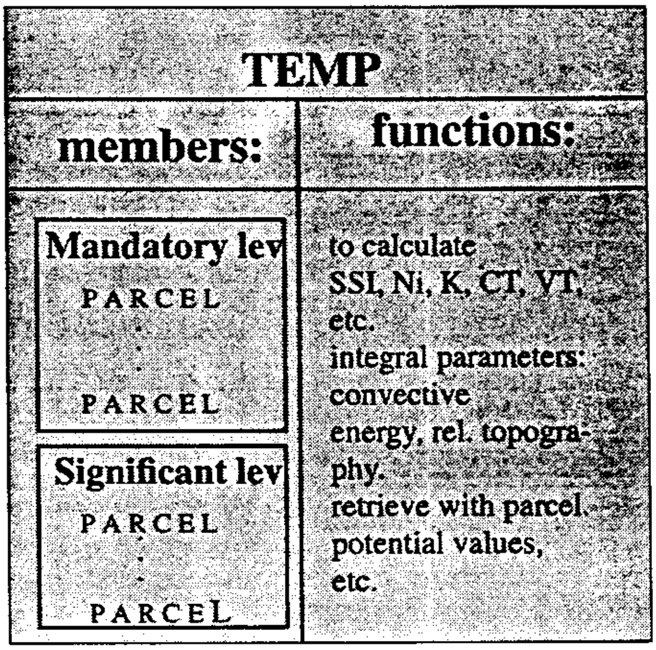
PARCEL	
members:	**functions:**
Temperature **Pressure** **Height,** **Humidity** **Wind speed,** **Wind dir**	to calculate rel.hum. abs.hum. impulse, pot. temp. wet. pot.temp, etc.

Example to get potential temperature and temperature of a parcel

```
{
Parcel pc;
.:
:
float poT = pc.getPot();
float temperature = pc.getT();
}
```

Figure 1.

Temp, which contains vertical columns of Parcels of mandatory and significant levels, and some other special parameters (Fig 2).

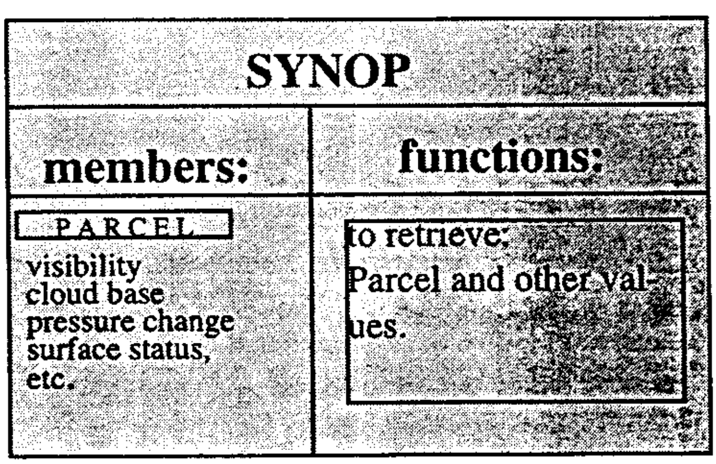


Examples to get Showalter index (ssi), temperature of 850 hPa level, and temperature at 1550 m.

```
float ssi, T850;
Parcel pc850;
Temp tp;
:
:
ssi = tp.getSSI();
T850 = tp.getPressLev(850.0).getT();
T= tp.getHeight(1550.0).getT();
;
```

Figure 2.

Synop, which contains synop information (Fig. 3),



Figures 3.

Grid, which contains Parcels at grid points.

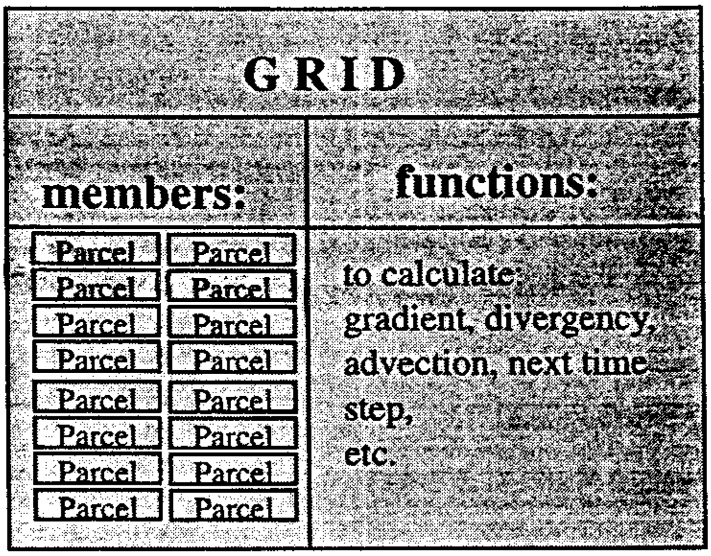


Figure 4.

And several other objects like above mentioned can be defined(Fig.4).

Application objects are objects which are able to display data objects. For example: plugging a Temp class variable into an Emagram class we can get a sounding diagram, or plugging a Grid class variable into a Map we can display contours of a meteorological field (Fig.5).
This "plug in" technique are preferred in HAWK processes.

Using application classes and data classes at "plug in" technique"

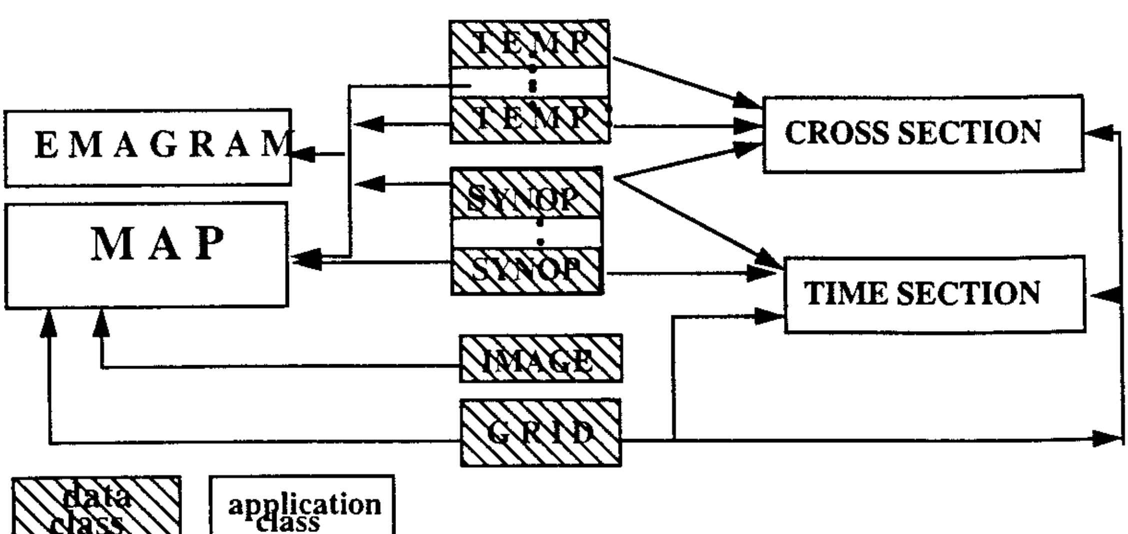


Figure 5.

Server oriented process organizing

Different processes running on the workstation are organized under three servers (Figure 6).

The **Data Server** responsible to collect information, and keep the connection with the outside world. This server runs decoding and encoding processes, data inventory processes and informs other servers about the existing or new information. When a new information arrives, data server take care with placing it to the appropriate place, and sends a message to **Local Product Generator (LPG)** server asking it to do the necessary manipulations or preprocessing with given data. When LPG has done the preprocessing the Data Server stores the processed information and informs the Display Server about the existence of given data.

The **LPG** server responsible for running preprocessing programs, like map transformations, or calculations of derived meteorological fields. It receives raw data from Data Server and sends back processed data for Data Server. Most of meteorological programs run under this server.

Display servers display preprocessed or raw data required by the user and keep connection with users via Graphical User Interfaces. Display Servers turn for information to Data Server, but some applications use services of LPG servers, too. (Especially "on the fly" applications like vertical cross sections, where users set up the direction of a cross section and the system has to calculate field at once.)

Processes inside a server use unix-pipes for inter process communication. Between servers RPC are used for communication.

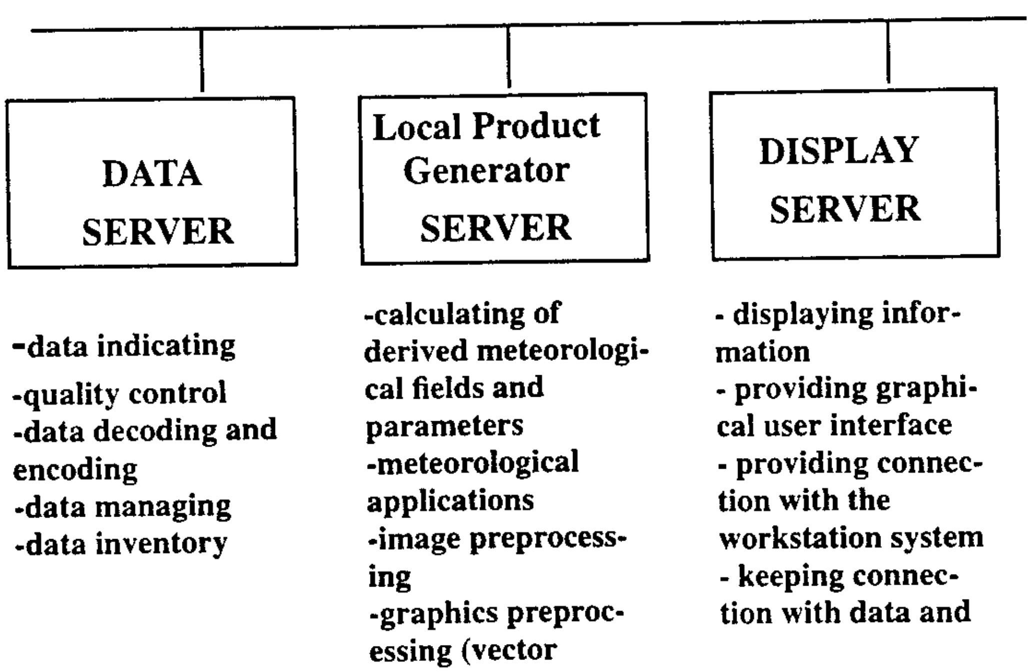


Figure 6

Hardware configuration of HAWK

From hardware point of view, HAWK workstation consists of three HP workstations. An HP 755 responsible for data server and LPG server functions, and there are two HP-715 where display programs are running. GTS informations for HAWK comes from a NETSYS telecommunication computer, from ECMWF via ftp. Radar and satellite centre supports digital radar and satellite information (Fig.7).

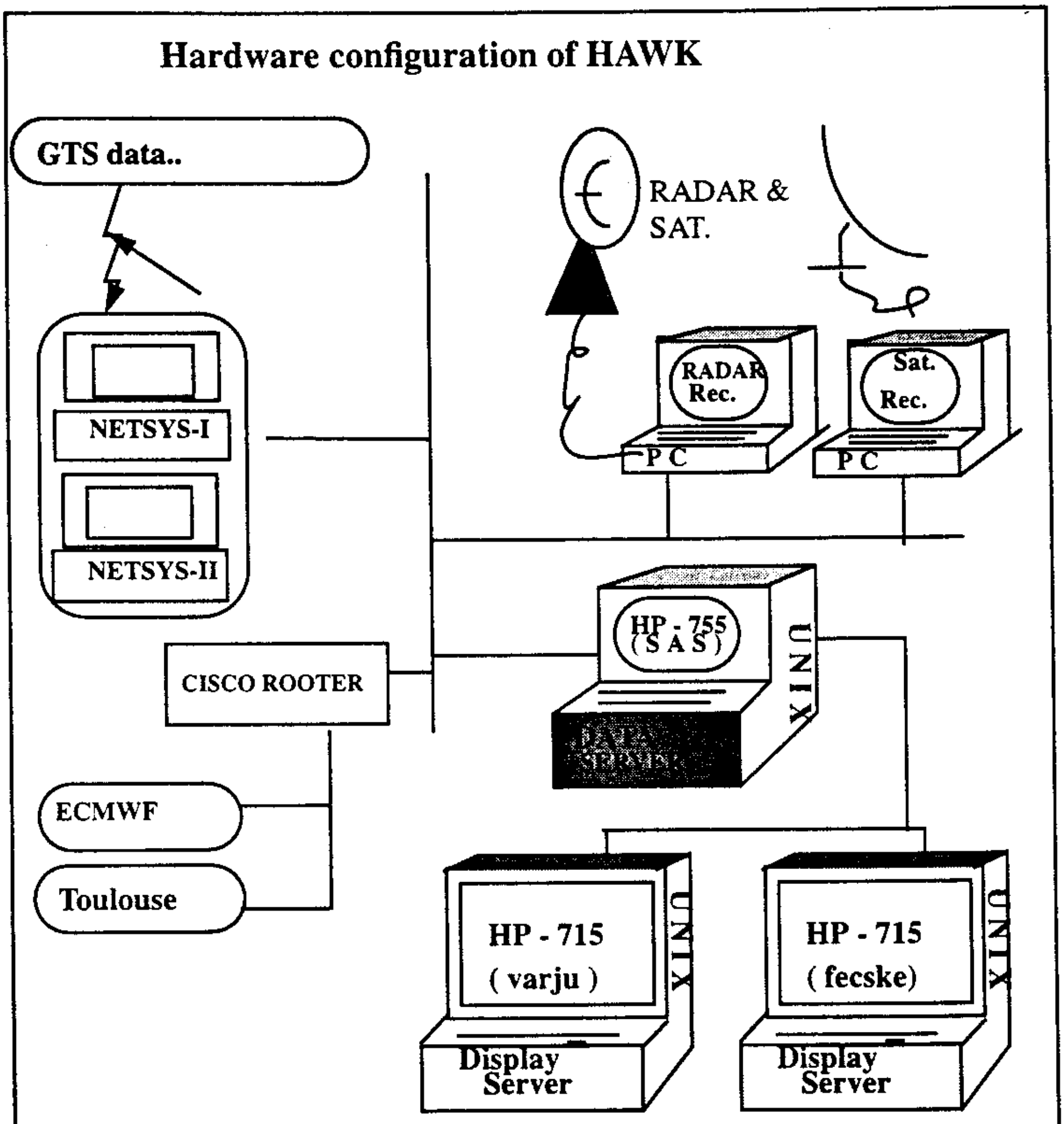


Figure 7.

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Tuesday, 4 June 1996

Horace: a review and progress report

Peter Trevelyan

UK

HORACE
A REVIEW and PROGRESS REPORT

Summary :- The purpose of this report is to look at how successfully the HORACE project has fulfilled its initial aims and detail the lessons that have been learned on the way.

1) Background to the project

The HORACE project was initiated in 1991 as a response to the need to modernise and rationalise the main forecast offices of the UK Met Office (principally the central forecast office (CFO) and Strike Command (STC) at High Wycombe). The older systems suffered from overloading, were becoming unreliable and because they had evolved over a period of fifteen years were not integrated and suffered from having involved interfaces. Since the start of the HORACE project there has been some broadening of this objective, but it remains substantially the same, which is to exploit the power and versatility of modern workstations and create an environment where the forecaster is able to do an increasingly significant amount of work on the workstation and so be less reliant on paper output.

2) Progress report

a) The progress of the project can be mapped into distinct phases, with each phase adding significant functionality. In 1993 the initial release of software installed at the High Wycombe site replaced the ageing OASYS (a PDP 11/40 computer plus pen plotter) system. This was very important as it meant that the now obsolete computer at High Wycombe could be disposed of and the (not insignificant) maintenance payments saved ! This first phase completely replaced all the hard copy charts; the customisation of these charts proved to be quite demanding as they had been developed over many years and the forecasters had grown used to a particular style of output. In addition to the hardcopy, NWP data was displayed as a simple grid point plot and a limited number of pre-processed NWP products made available. The only text application was the display of raw observational data and that had a full MOTIF menu.

b) The main addition for phase two was the text editor which was the first production facility on HORACE and gave the forecaster the capacity to create and transmit the text forecast all on the same platform. Routine products such as NWP upper winds were also produced and fed directly into the text production and after scrutiny, and if necessary amendment, transmitted. This would be particularly important for the CFO as this meant that the old and overloaded PCs could be retired when HORACE was installed in the CFO.

c) Phase three was a big jump forward as satellite imagery and sflocs (spherics) could be displayed for the first time. Many of the raw data displays were enhanced. Up to this point all the applications had been written in two halves, a MOTIF GUI and an application written in Fortran and GKS. For the imagery and the enhanced raw data displays the applications were now written as one entity, in C and X. This was a shift in IT strategy and marked the point where future major applications would be written mainly in C, X and GKS. Phase three also saw the introduction of HORACE into the CFO. This was not without its problems and it took a time before some of the hard copy charts were accepted by the senior forecasters !

d) The next phase saw the introduction of a more sophisticated imagery display which now included radar data. From the outset of the project it was decided that

especially if the work practices have not substantially changed. Over the period of the project there has been a lot of interaction between the users and developers and a formal discussion meeting takes place every two months. Part of this meeting is given over to the users looking at applications currently under development and making suggestions as to how they may be improved. This has proved very useful so minimising the risk of the customer not being satisfied with the product.

b) The IT strategy:- Initially HORACE development was split, so that one team wrote the GUIs in Motif and C and the applications were written in Fortran and GKS with a message queue gluing the two together. One of the main reasons for this strategy was the rather traditional skill set available at the outset of the project. Initially the majority of the expertise was in Fortran and GKS and therefore the project would have been delayed if all the programmers had been re-trained. A formal analysis and design method was also used using the Yourdon methodology and a CASE tool to help with its implementation. Over the last four years things have moved on. Firstly the use of Fortran has diminished and most code is now written in C and only in certain circumstances will Fortran be used. The use of message queues has ceased, the interactive applications are now written as one program with the GUI using a set of call back routines written by the applications team. This still allows the two teams to work together, but has the advantage of the application being more integrated so simplifying the handling of errors. A major problem has always been the integration of Xlib and GKS. GKS is designed to take control of the display and this conflicts with the way MOTIF works. A lot of code already exists in GKS and it would be very expensive to rewrite it all in 'X'. This incompatibility had become a real headache and has only recently been solved. GTSGRAL has been for many years the chosen supplier for GKS, but last year a decision was made to change to XELION after a lot of work had been carried out benchmarking the two versions. XELION was not only faster, but has on major advantage over GTSGRAL, namely the ability to write to a Pixmap. After some prototyping a the mechanism was worked out whereby the GUI passed the pixmap id to the graphical application, which then copied the graphical output directly to the pixmap. This means that the GUI controls the whole display including the mouse. An example of this arrangement is the GV where the map is zoomed and rotated by using mouse buttons two and three and when the required map is displayed and the buttons released, the application automatically redraws the NWP overlay. The contouring is still done by a GKS program , but all the output is handled by X. The GKS colour information is passed within the Pixmap so the colours are faithfully reproduced. One noticeable feature is the very quick response time and this is almost certainly due to not using segments within the GKS program.

c) Hardware: - The initial procurement was a mixture of HP720s and HP735s each with 24 bit HRCX graphics cards. As the applications have become more resource hungry there has been a gradual upgrading to HPC110s with twin monitors. The C110s have twin graphics boards each with 8 bit graphics rather than one 24 bit. The reason for not going for 24 bit was not just one of cost, but it became apparent that we were not exploiting the 24 bit graphics, but what was required was the ability to have more than one private colour map. This has been tested and found to work well such that there is no flashing of the displays when the private colour maps are used. XELION works equally well with private or default colour maps and the way looks open to create more sophisticated applications and for there to be sufficient colours available. The use of twin screen displays will soon be a standard feature and enable the forecaster to view data and create products solely on the HORACE system.

4) The Future

A lot of lessons have been learned over the lifetime of the project so far and it is certain that more will be learned in the future. New techniques will emerge, and will need to be exploited. There will almost certainly be more use made of the World Wide Web and it is quite likely that a browser will be available from the HORACE main menu. Already a lot of the documentation is written in HTML. There is no question that the real pay off with a system like HORACE will be in the production of routine products. More and more effort will therefore be spent in this area as the pressure increases to provide an increasingly cost effective way of product production.

Session 2

Recent developments

Tuesday, 4 June 1996

Recent developments with the KNMI METLAB system

Dick Blaauboer

Netherlands

RECENT DEVELOPMENTS WITH THE KNMI METLAB SYSTEM

D. Blaauboer
Royal Netherlands Meteorological Institute
De Bilt, the Netherlands

Summary: During the last three years KNMI introduced an important new system in the operational forecast production process: the Meteorological Workstation. In this system much data from various sources have been integrated: observations, radar, satellite, model output. The functionality of the system has been growing through this period and is still growing. At the same time new interactive applications, some of them using AI techniques, have been developed for use by the forecaster at his workstation.

In this contribution an overview is given of the current Meteorological Workstation with special attention to the role of the forecaster in the operational production process. It is an updated version of the contribution given at the ECMWF Fifth Workshop on Meteorological Operational Systems, November 1995.

1. HISTORY

One of the starting points in the KNMI meteorological workstation (MWS) project was the use of proven technology. Therefore a commercially available MWS has been purchased from an American vendor: RMS Technology Inc., current name Spatial Software Solutions Inc. The system has been customized for KNMI on the basis of KNMI requirements. The system is flexible in the sense that it is relatively easy to make changes or extensions to the system. Flexibility was also one of the requirements. Other basic requirements include use of UNIX operating system and X-windows (OSF/Motif) graphics.

The project started in 1991 while the contract was signed in June 1992. In December of the same year the first MWS was available. In September 1994 MWS's had been introduced at all 16 operational sites. In July 1995 the system has been accepted operationally. In December a project started for the development of an extension to the operational system. First part of the new release will be operational in July 1996, early 1997 the complete new release will be available.

2. CONFIGURATION

Starting with DEC-Ultrix systems the MWS is now running on the DEC-Alpha 3000 series. The system has been built as a client server system: on the ingest server the databases reside and all data-ingest processes are running; on the client the display applications are running. The display machine uses three screens (fig. 1). Ingest as well as display units include at this time 96 Mb of internal memory and 1.4 Gb disks. Display systems are available at all operational sites, i.e. 17 display systems at 7 sites. At each main site two ingest servers are available, whereas at the local services ingest and display applications are running on the same machine. By using the same machines for data ingest and display a high degree of availability is reached. At each site all systems are connected to the local area network (ethernet). Using the network data are retrieved from external databases and the GTS.

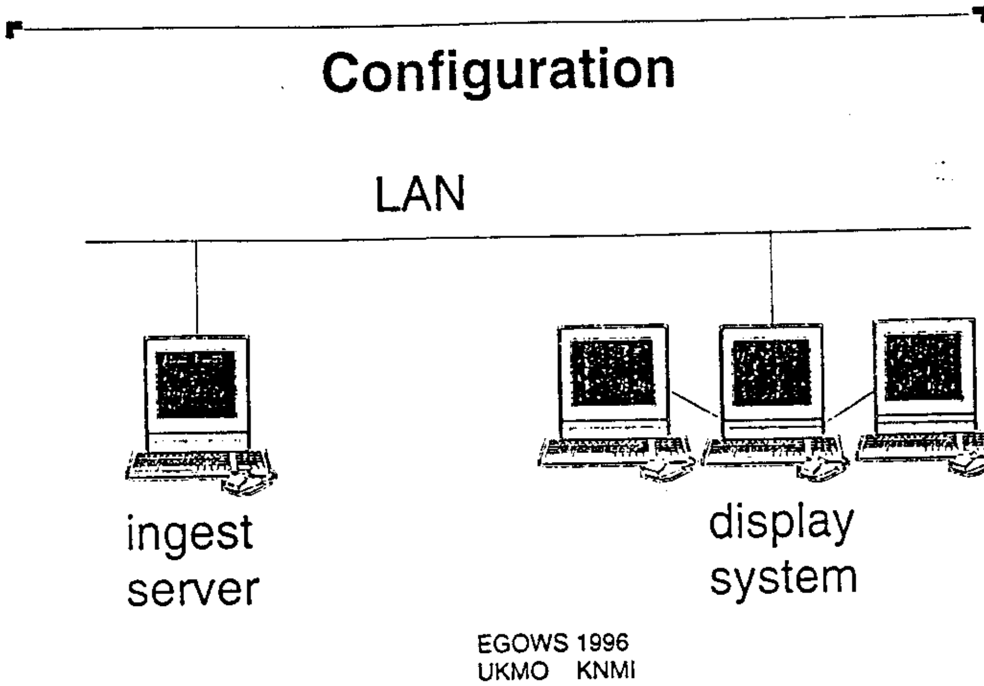

Fig. 1 Client-server configuration

The different sites are connected by a wide area network. The main sites are coupled via double 64 kbit lines. The local services have single 64 kbit connections (fig. 2).

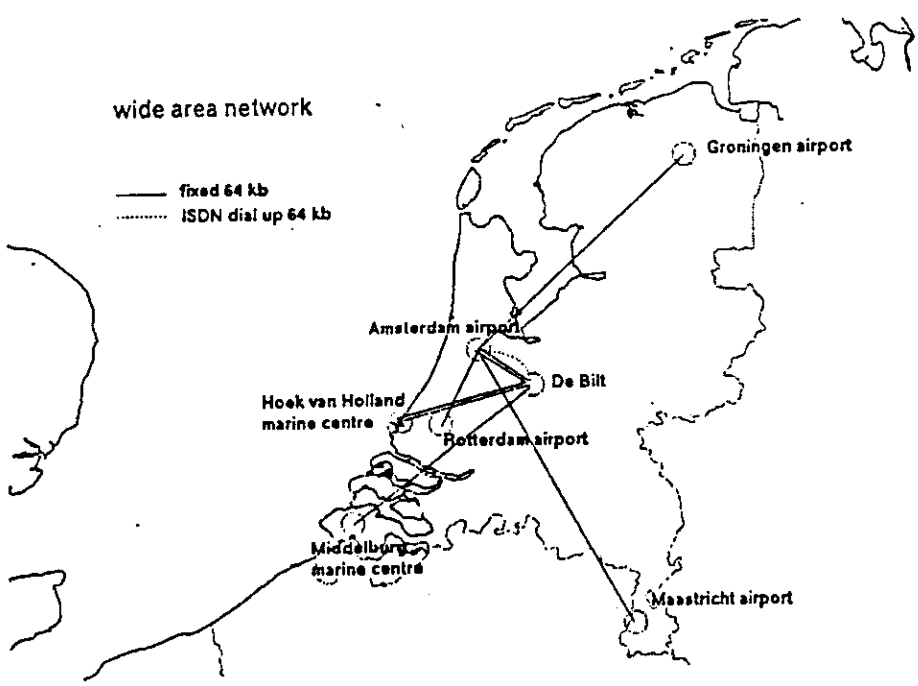

Fig. 2 Wide area network

The ingest process is split into two phases. In the primary process observations and imagery from satellites and radars is received by active transmission from the datasource. The modeldata are retrieved by a "grabber" process running on the primary ingest machines. At predefined times the grabber is looking for new model data. Then, during the secondary process, data-copiers disseminate the data to the other ingest servers after which the data is stored in the MWS databases (fig. 3).

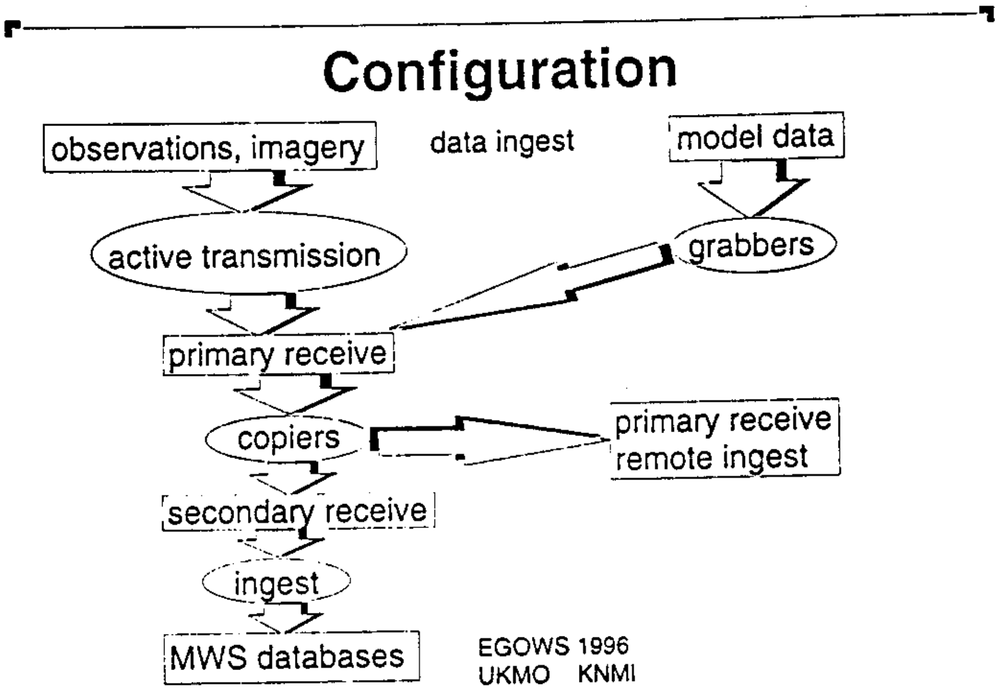

Fig. 3 Two phases data ingest process

3. FUNCTIONALITY

3.1 **Datasources**

The following datasources are available in the MWS:

* satellite: Meteosat, Goes and NOAA, all channels;
* radar: 2 Dutch sites as well as mosaics with data from surrounding countries, sofar 1 from Belgium and 1 from Germany;
* difax: digital facsimile data, mostly originating from the Bracknell database;
* profiles: observed TEMP-data as well as profiles retrieved from model GRIB-data; the latter can be selected from a map with all model gridpoints;
* station plots: plotted SYNOPS, METARS, upper air data from TEMPS, SATOBS, SATEMS, spheric locations from SFLOCS; observed parameters as well as derived parameters from observations (like all kinds of stability indices);
* alphanumeric: all ascii data can also be presented in alphanumerical form; this is mostly used as control;

* modelfields: contoured GRIB-data from various models: ECMWF, UKMO, HIRLAM, VIMOLA (vertically integrated short range model), NEDWAM (Netherlands version of WAM-model), WAQUA (model to predict sea level); standard model parameters as well as derived parameters;
* time series: observed as well as derived from models or combined timeseries;
* vertical cross-sections: from observed TEMP-data as well as from model profiles; arbitrary cross-sections can be selected from a map with all available station-data or model gridpoints respectively;
* trajectories: backward and forward trajectories are computed from modeldata (ECMWF, and HIRLAM).

3.2 Functions

Apart from presentation data can be manipulated using a set of functions.

* overlays can be produced from all kinds of geographical data (satellite, radar, stations, modelfields, trajectories);
* folders can be produced consisting of a set of information relevant for production of special forecasts or for briefing purposes;
* many projections can be used from the entire globe until a small region; stereographic as well as Mercator projection are available;
* together with the projections map-backgrounds are available or can be defined to display details about infrastructure like cities, rivers, motorways, railways etc.
* a contouring package is available to contour observational data;
* a drawing package is available to add all kinds of graphical information to a product like fronts, weather symbols, lines, shadings, texts etc.
* many datasources can be animated: radar and satellite but also observations, modeldata and even profiles;
* data can be printed, plotted and sent to other sites; during 1996 the system will be extended with a possibility to create products in standard formats to send to customers;
* standard actions of panning, zooming, distance measuring are also available.

3.3 Features

Some special features should be mentioned here.

* In the background products can be created automatically. In this way products that are needed at standard times can be created without interaction.
* A macro facility is available to pre-programme a series of actions. At an arbitrary time this macro can be used to perform this series of actions. This is a very effective way to speed up the interactive process.
* Within the MWS other applications can be started using a separate window.

* A big deal of all system parameters and defaults can be configured externally using configuration files. In this way also product lists can be extpanded by the system manager: for intstance insertion of a new model.

4. OPERATIONAL INTRODUCTION

The operational introduction of MWS's at KNMI took place in the period summer 1994 until summer 1995. So the introduction was gradual. After a short training on how to use the system the forecasters needed time to build up experience. Some pioneer users were charged to develop macros and new techniques which were helpful for the other users. The time spent on this developments was needed to root the system in the organization.

5. PRODUCTION PROCESS

The Meteorological Workstation System occupies an important place in the current operational production process. Currently observational data is directly fed into the MWS, while satellite and radar data as well as model output is retrieved from databases. The model databases contain GRIB data from all models in use (see section 3.1) and are filled fully automatically. Human interaction takes place mainly at the MWS where the forecaster does his diagnostic work and makes fundamental forecasts. Final products are produced by a set of applications called "product generators" (fig. 4). Currently these product generators are not fully automatic, forecasters spend an important part of their time on these applications.

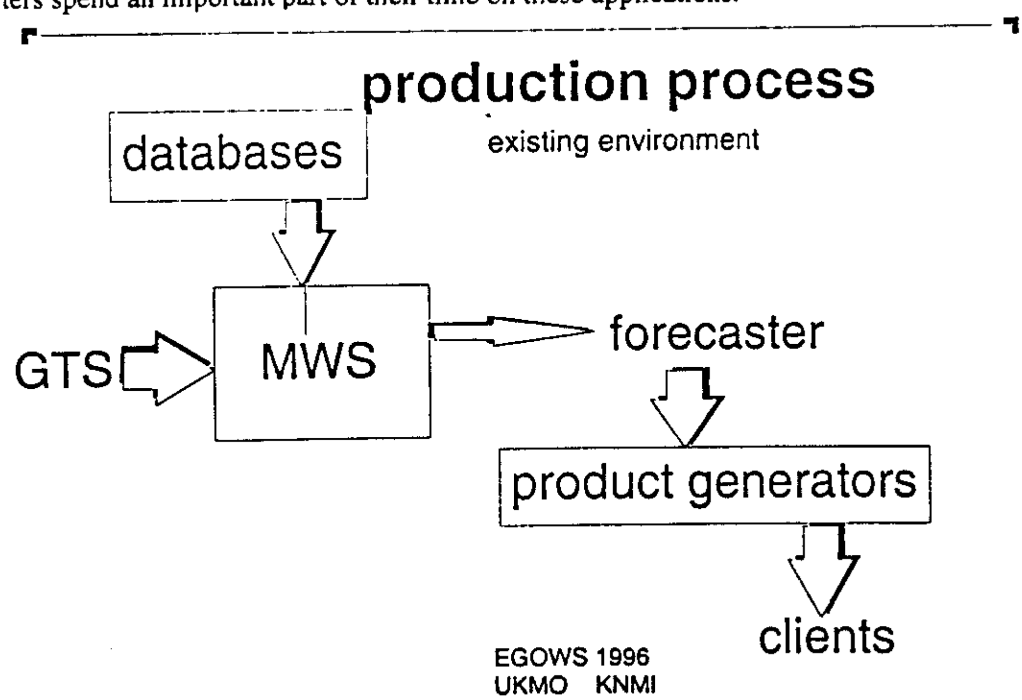

Fig. 4 Production process, current environment

The next few years KNMI will transform its production process in a way to make it still more efficient.

Though not all details are already clear the main concept will look like fig. 5. At the data input side the current databases will be integrated using the NEONS database structure from the Naval Research Laboratory in Monterey, Calif. The MWS will be extended to incorporate interactive tools for the forecaster to make basic forecasts. These basic forecasts will be stored in a special database that will be the input for the product generators. Another feature will be the Automatic Text Generator (ATG) that transforms basic forecast numbers into basic forecast texts. The product generators will be automized as much as possible, while their output will be stored in a product database from where distribution to customers can take place.

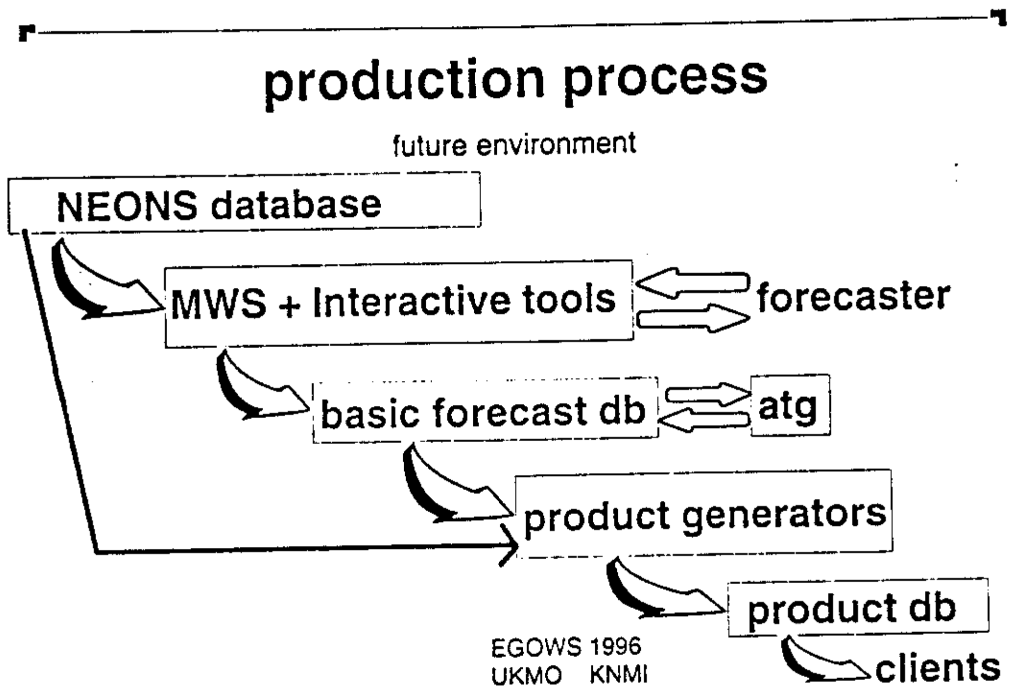

Fig. 5 Production process, future environment

6. NEW DEVELOPMENTS

The developments that will take place with respect to the Meteorological Workstation during the next few years are listed in this section.

* phasing-out of non cost-effective systems
* integration of current systems
* making available of new datasources and datatypes, including graphics metafile, lightning data (Safir system), windprofiler data, aircraft data (AMDAR)
* output to standard output formats: GIF, HPGL, FAX etc.
* enhancement of current functionality
* connection to NEONS database
* enhancement of production tools

7. CONCLUDING REMARKS

The KNMI Meteorological Workstation System is a user tailored commercial system. It has been gradually introduced and is now fully operational. It is the focal point of the interactive production process. The technical development of the system still goes on and is expected to go on also the next few years. These new developments are driven by two main causes. Firstly the need to rationalize the operational production process in order to make service to customers as efficient as possible and secondly the importance to make use of new developments in operational meteorology, like new datatypes and new methods. It is believed that the current MWS is capable to manage both kinds of future developments.

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Tuesday, 4 June 1996

Recent progress of the metAP project

Paolo Ambrosetti

Switzerland

Recent Progress of the metAP Project

Paper for the

EGOWS 7 Meeting

UKMO College
Reading, 3-6 June 1996

SWISS METEOROLOGICAL WORKSTATION PROJECT

P. Ambrosetti
Swiss Meteorological Institute
Locarno-Monti, Switzerland

Philosophy of the Project

Paper for the

Fifth ECMWF Workshop
on Meteorological Operational System

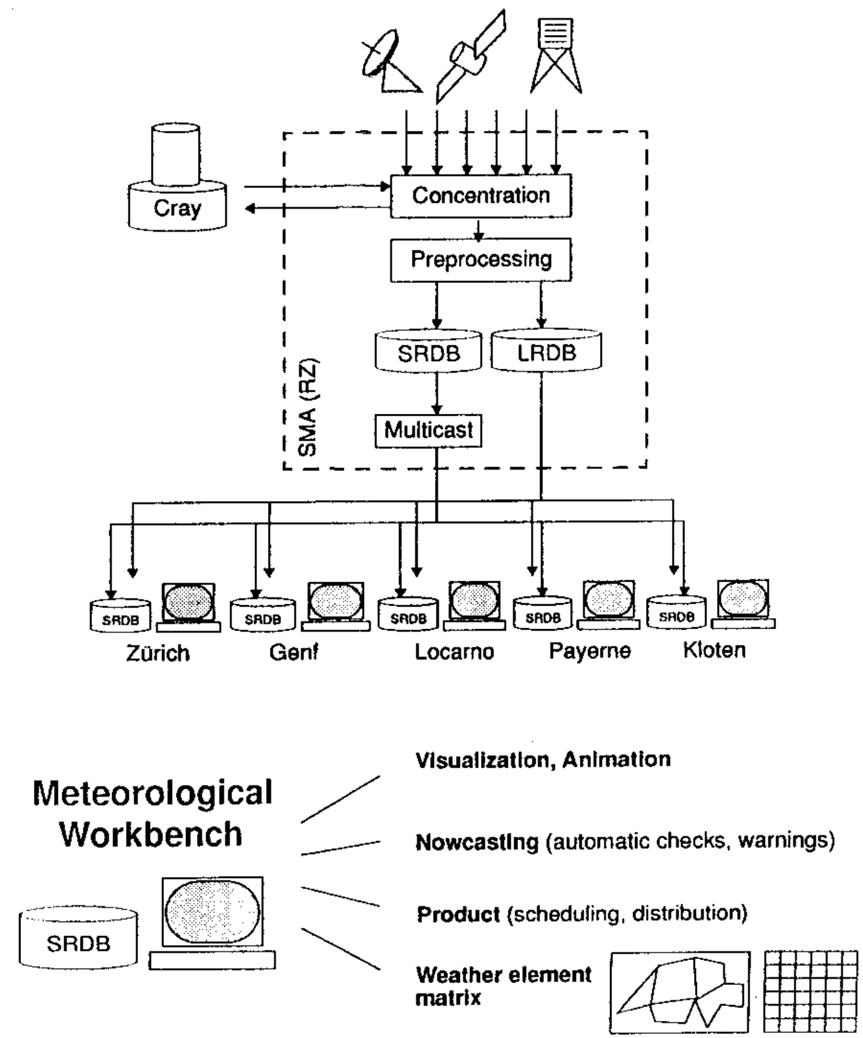
Reading, 13-17 November 1995

SWISS METEOROLOGICAL WORKSTATION PROJECT

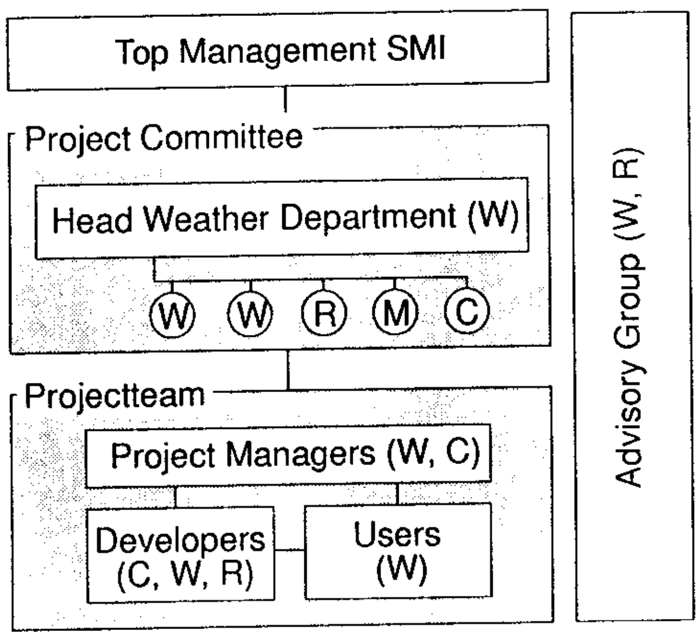
C. Pauli, D. Matter
Swiss Meteorological Institute
Zürich, Switzerland

P. Ambrosetti
Swiss Meteorological Institute
Locarno-Monti, Switzerland

Flow of weather data at SMI



Project organisation



W = Weather, C = Computer Science, R = Research

Swiss Meteorological Institute

Project organization

Subprojects:

o 1 Framework application

o 2 Visualization

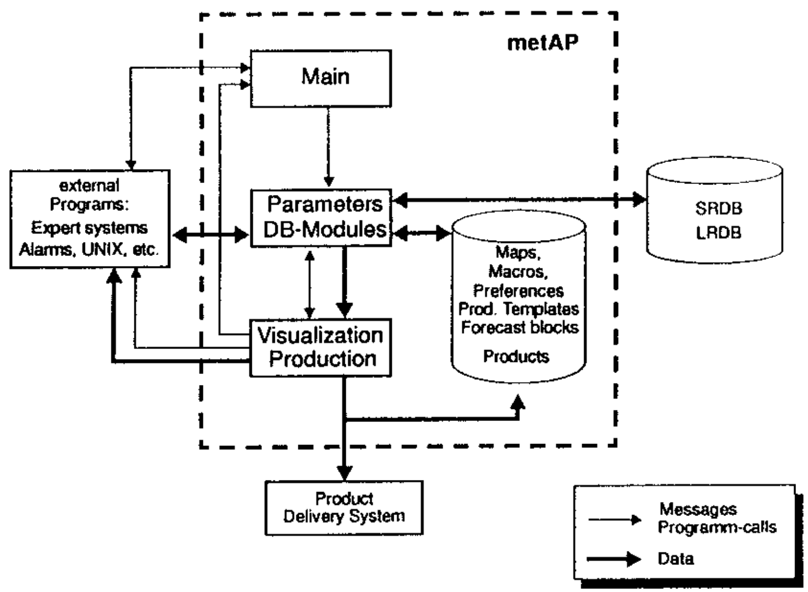
o 3 Forecast editor

o 4 Forecast product editor

o 5 Gateway facilities

o 6 Forecast- and Nowcasting tools

Software design



Subproject 2: Visualization

- o Observations (Point data)
- o Modell output (charts)
- o Soundings
- o Meteogramms
- o Alphanumeric Text and Tables
- o Radar and Satellite Images

Subproject 3: Forecast Editor

Forecast Matrix:

- ca. 35 regions (at least one meterological station)
- ca. 25 time interval (variable lenght)
- ca. 8 parameters

Input:

- Direct Model Output, Model Output Statistics
- Previous forecast

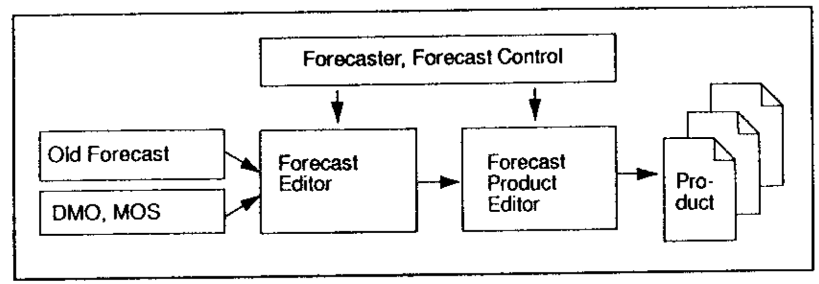
Graphical Forecast Editor Interface
(time interval and region clustering)

Output:

- full Forecast Matrix (for most products)

Swiss Meteorological Istitute

Subproject 3: Forecast Editor



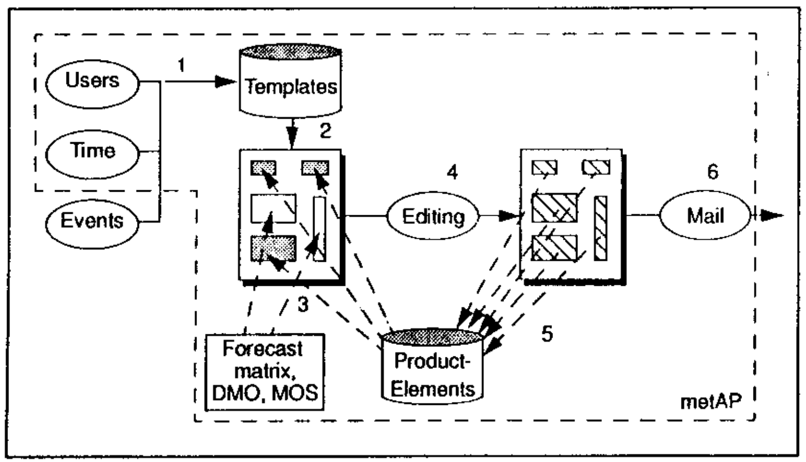
The Forecast Process will be separated between

- filling the Weather Matrix with the Forecast Editor

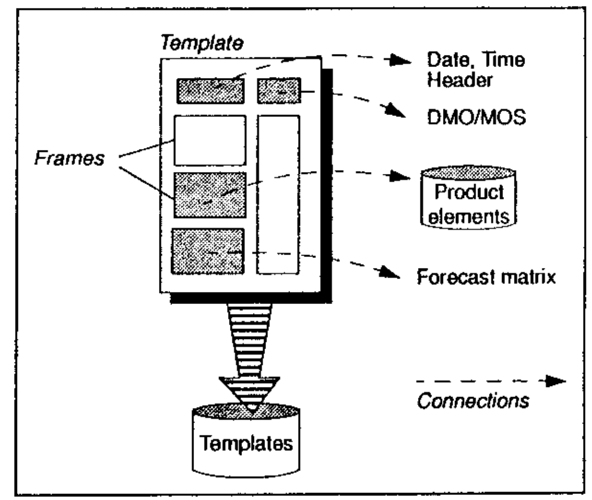
and

- preparation of the Products with the Forecast Product Editor

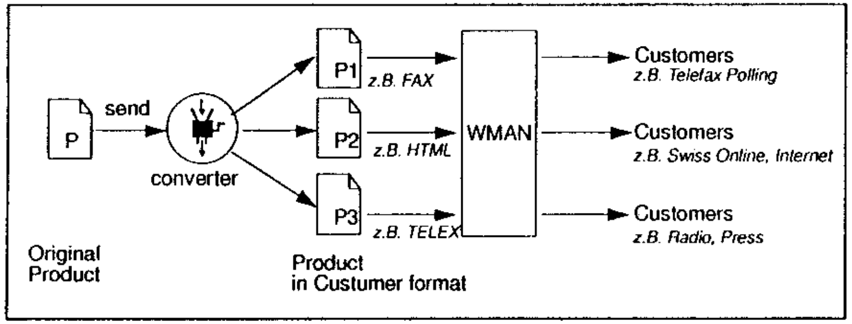
Subproject 4: Forecast Product Editor



Subproject 4: Templates



Subproject 4: Distribution



Present State of the Project

o Short Range DB almost completed

o Long Range DB under costruction

o Multicast of the SRDB under construction

o General requirements from the users completed

o Evaluation of several commercial solutions
-> decision to develop an inhouse system

o Highest Priority for Forecast Product Editor an Visualization of alphanumeric data

o Object Oriented Programming will be used (mainly with Java)

o Use Cases for different Subproject

o First prototype for mid '97

o Project completed by End '99

1996 EGOWS Meeting at
The Met. Office College, Shinfield Park, Reading, UK
3–6 June 1996

Session 2

Recent developments

Tuesday, 4 June 1996

Experience with Metview installation

Vesa Karhila

ECMWF

EXPERIENCE WITH METVIEW INSTALLATION

V. E. Karhila[1]

ECMWF

INTRODUCTION

Metview is a flexible tool to access, manipulate and visualise meteorological data on a Unix workstation [*Daabeck & al., 1995*]. Metview has been developed at ECMWF in co-operation with Brazil and France.

Originally Metview was installed in co-operative centres too. These installations were done by Metview experts. In October 1995 it was announced to the ECMWF Member States that Metview was available on an as-is basis. This decision brought new requirements into the installation of Metview. From then on it should be possible for non-Metview experts to install Metview locally and hopefully easily.

PRE-RELEASE

After the above announcement a release of Metview was created and the installation was tested at FMI (Finnish Meteorological Institute). Although this installation was done on the same hardware platform, the site environment was different and operating system and the compilers were of later releases.

New compilers revealed portability problems in Metview source code but also Metview source code revealed bugs in the compiler. Some of the Metview modules crashed the C++ compiler.

We also ran into problems with libraries and we had to manually edit some configuration files to accommodate Metview to a new site.

In the end the test installation was successful but only because all kinds of expertise was available and heavily used.

ABOUT METVIEW ARCHITECTURE

Metview is a fairly large software package designed to run only on Unix platforms. One might think that it is not too difficult to produce and maintain portable software within a single operating system. However, Unix implementations differ.

Main parts of Metview are written in C++ but Metview utilises a lot of existing older software, such as ECMWF standard libraries Magics and Emoslib to generate meteorological graphics and to access GRIB and BUFR files. These libraries are written mainly in Fortran.

There is also quite a lot of C code within Metview.

Following is a crude list of problems we have tackled while building Metview.

PROBLEMS WITH COMPILERS

C++ is still an evolving language. There is an ANSI draft for a standard language syntax, but it is still a draft and also contains several new features that are not yet available on most compilers. Some of the old language features will become obsolete in standard compilers.

Probably it will become easier to produce portable code with future ANSI compatible compilers. But ANSI compatibility will not guarantee 100% portability as there will be differences between compiler implementations. We found some Fortran code where one compiler nicely accepted variable declarations in unconventional order without any warnings and another compiler produced syntax errors.

Although most common compiler flags (debugging and optimising) are the same for all platforms you will very soon find several flags that either differ on different platforms or that you have to use different values on different platforms. It gets worse if you have to tell your compiler whether you want 32 or 64 bit code to be produced or you want to compile it on one platform for another processor type.

PROBLEMS WITH HEADER FILES

With pre-ANSI compilers there are small differences between header files of different systems: some functions are declared in several header files, but not necessarily all in the same files across platforms.

Sometimes you have to work a little to locate

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Experience with Metview Installation

Vesa Karhila
ECMWF

Metview Introduction

- ***flexible meteorological tool***
  - ***data access (MARS)***
  - ***manipulation (powerful macro language)***
  - ***visualisation (MAGICS)***
- ***interactive and batch modes, timers, etc.***
- ***developed at ECMWF***
  - ***started 1991***
  - ***in co-operation with Brazil and France***
- ***remember the visit to ECMWF on Wednesday***

Metview History

- ***December 1993***
  - ***version 1.0 released for in-house use***
- ***Brazil and France***
  - ***installed by Metview experts***
- ***October 1995 TAC meeting***
  - ***version 1.3 released on <u>as-is basis</u>***
  - ***available to all Member States***
  - ***=> to be installed by non-Metview experts***

Pre-release 1.3A

- ***installed at four sites:***
  - ***Finland, SGI, Metview expert***
  - ***Norway/Bergen Univ., SGI, non-Metview expert***
  - ***Ireland, SGI, Metview expert***
  - ***UKMO, HP, non-Metview expert***
- ***lots of problems encountered***
- ***lesson: must be much easier!***

Some Installation Pitfalls

- ***compiler problems***
  - ***crashing compilers***
  - ***crashing executable (due to compiler bugs!)***
  - ***C++: old cfront contra new C++ standards***
- ***calling Fortran routines from C/C++***
  - ***append underscore to function name, capitalise function name, use function name as is...***
- ***hardware differencies***
  - ***byte order***
  - ***length of variables***

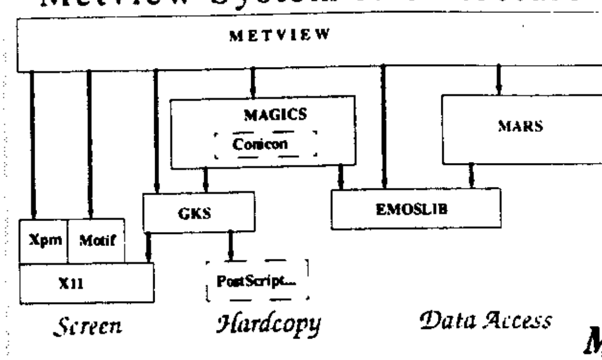
ECMWF Development Environment

- ***Silicon Graphics Indy/Indigo***
  - ***8 bit graphics***
- ***main language C++***
  - ***also: C, Fortran, Lex, Yacc, sh,...***
- ***X-Designer (GUI)***
- ***Clear Case (version control)***
- ***CASEVision WorkShop (debugger etc)***
- ***Purify (memory management etc)***

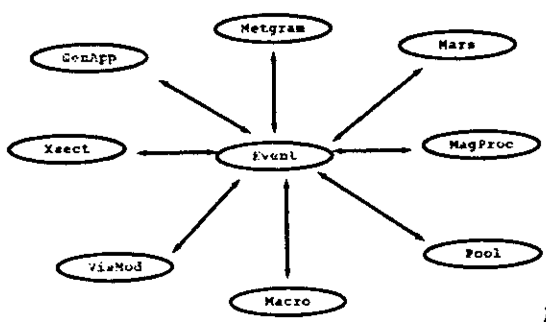
Metview System Architecture

- ***use of existing 'standard' software***
  - ***MARS for database access (at ECMWF)***
  - ***MAGICS for meteorological graphics***
- ***several modules, communicating***
- ***request passing***
- ***icon based user interface***
  - ***build with different icons (Lego analogy)***
  - ***drag&drop***

Metview System Architecture



Metview Modules



Platform Differencies

- ***compilers***
  - ***length of variables (pointers, int,...)***
  - ***multilanguage programs***
- ***unix dialects***
  - ***library functions (names, parameters,...)***
  - ***command names, flags***
- ***byte order***
  - ***bit structures (require int or long...)***
- ***what/where libraries***

Site Differencies

- ***where to install Metview***
- ***where to find***
  - ***Magics, coastlines, etc***
  - ***Emoslib, BUFR-tables, etc***
  - ***GKS***
- ***site identification***
- ***compiler flags (debug/optimised)***
- ***=> interactive utility to enter the info***

Imake

- ***developed for X11 (X-Window) distribution***
  - ***book: "Software Portability with Imake"***
- ***Makefiles contain always dependencies***
- ***simple Imakefile + set of configuration files***
  - ***Imakefiles contain no dependencies***
  - ***minimum editing of config files***
- ***real Makefiles created automatically***
- ***do NOT edit Makefiles!!! CREATE them!!!***
  - ***xmkmf (~ "X11 make makefile")***

Basics of the Installation

- *Unix runs on different hardwares*
  - *no binary compatibility (unlike Intel 80x86)*
- *Metview runs on different platforms*
  - *platforms are different*
  - *site environments are different*
- *Adapt Metview to your environment*
  - *your configuration must be defined!*
- *Metview distributed as source code*
  - *must be compiled after configuration!*

Installation Mainlines (a positive approach)

- *create Metview root directory*
- *unpack tar files into Metview root directory*
- *build Metview*
  - *customise configuration*
  - *create Makefiles from Imakefiles*
  - *compile Metview (first Magics & Emoslib)*
  - *test!*
- *install into production environment*

Installation Pitfalls (a negative approach)

- *errors in configuration or Makefiles*
  - *Unix differencies or typing errors?*
- *compilation errors*
  - *correct compiler flags? correct definitions?*
  - *source code changes required? Feedback!!!*
- *user id constraints*
  - *quotas for disk space, swap, no of processes,...?*
- *shared library problems*
  - *share also GKS library!*

I'd like to finish
with a semi advertisement:

Are You interested in getting Metview to your site?

What is required to run Metview?

- *available to Member States!*
- *data in GRIB or BUFR format*
- *Unix Workstation with X-Window & Motif*
  - *currently runs on SGI, HP, Sun, DEC Alpha*
- *S-GKS graphics package (commercial)*
- *Conicon contouring package (Bath Univ.)*
  - *Member States get it with Magics*

What is required to install Metview?

- *Metview distribution files from ECMWF*
  - *Metview + MAGICS + EMOS library*
- *75++ MB free disk space min.*
- *standard Unix and X11 tools*
  - *plus C++ compiler*
  - *plus Fortran compiler*
  - *plus Xpm library (Public Domain)*

1996 EGOWS Meeting at
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Session 2

Recent developments

Tuesday, 4 June 1996

Software Configuration Management

Malcolm Field

UK

Software Configuration Management by Malcolm Field, UKMO

1. Overview of Configuration Management (CM)

1.1 Introduction

Most software projects are at risk from one or more of the following problems,

* The reappearance of an old bug that was thought to have been fixed.
* A bug that has been fixed fails to be implemented for an end user
* An old file containing useful source code is needed but has been lost.
* The behaviour of the software is not consistent with current versions of the source code.

CM products have arisen in response to a need, namely of reducing the risk of problems such as these occurring.

CM is the process of controlling the evolution of a software system by managing the versions of its components and their relationships. It is a means of gaining control of the software development process and of managing complexity.

1.2 Key aspects of CM

The key aspects are,

(a) Version Control
This is at the heart of CM. It involves the checking of files in and out from the product, normally via a Graphical User Interface. Parallel working by more than one developer is sometimes supported.

(b) Configuration Control
The grouping together of related objects so they can be managed together, e.g. a 'makefile' with its associated source and object code files.

(c) Change Control
The tracking of changes through the software lifecycle, e.g. from the arrival of a Problem Report from a user to the final testing and implementation.

(d) Build and Release Support
Some tools supply enhanced features such as,
* a distributed 'make' utility that utilises processing units across a network to speed up a software build
* the automated checking of the dependencies between source and include files.

1.3 CM Tool revenues and vendors

CM Tool revenues have been growing steadily over the past few years, rising from about $100M globally in 1993 to a projected $900M in 1997.

The key CM Tool vendors that were considered for the supply of a product for the Horace project are as follows,

Tool	Vendor	Operating Sys
Adele	Verilog	Unix
Aide-de-Camp	SM&DS	Unix, VMS, DOS
CaseWare/CM	CaseWare	Unix, DOS
CCC	Softool	MVS, VM, VMS, Unix, OS/2, MS Windows
ChangeMan	Serena	MVS, OS/2
ClearCase	Atria	Unix
CMVision	Expertware	Unix, VMS
CMVC	IBM	Unix
Continuus/CM	Continuus	Unix, VMS, MS Windows
Endevor	Legent	MVS, DOS, OS/2, MS Windows
PCMS	SQL	Unix, VMS
PVCS	Intersolv	Unix, DOS, OS/2, MS Windows
TeamNet	TeamOne Systems	Unix

1.4 Criteria for selecting a CM Tool

The main criteria are as follows,

(a) Cost
This is likely to be a major deciding factor.

The procurement for the Horace project was limited to £50K for licences, consultancy and training.

(b) Ease of Set up
This is a hidden cost. The overhead of procuring and installing the tool, training staff and building it into a project should not be overlooked. This applies particularly if the project is well established.

(c) Version Control
It is essential for this aspect to be strongly supported by the tool. It must be easy for developers to use, with an intuitive interface and quick response.

(d) Configuration Management
It is important to understand what the tool vendor means by this term. There is no general agreement (see under 1.2(b)).

(e) Change Control
Having good control over the process of managing change is key to CM. A specific Problem Tracking facility, if available, is a useful addition.

(f) Build and Release Support
Again it is important to understand what the tool vendor means by these terms. With some tools access to the command line may not be supported. It may not be possible to use the various Unix utilities with the files that are under the tool's control. This was a key factor in the decision on the Horace project.

(g) Usability
An essential factor in the selection of a CM Tool that is likely to be in use for much of the time by developers.

(h) Customisability
It is useful to be able to modify the menu selection options. This will, for example, enable the terms used by the tool to tie in more closely with those in use in the existing software lifecycle.

(i) Workgroup Support
Some tools are usable across a Wide Area LAN, i.e. will support use between sites. Others will support a mix of platforms, e.g. Unix workstations and PCs.

2. CM and the Horace Project

2.1 Development of CM on Horace

From the outset of the project neither RCS nor SCCS, the two standard Unix version control utilities, were used. A paper based system of managing the development of software was implemented.

At the end of 1994 an independent research and consultancy company, Ovum, was commissioned by the Met Office to investigate the feasibility of introducing a CM tool into the project. Ovum recommended that a CM tool be introduced and shortlisted 3 products. These were subsequently evaluated and the preferred product, Continuus/CM, was procured in Jan 1996.

Before Continuus/CM could be brought into use it was necessary to reorganise the structure of the software so that it could more easily be incorporated into the product. This has now been partially completed and the tool is expected to be brought into regular use next month (July 96).

In total over 3000 C source files and nearly 1500 FORTRAN files have been ingested into the tool's database. In total this amounts to about 1/2 million lines of code.

2.2 Experience of CM so far

There have been a number of difficulties with the installation, especially in providing access to the tool from a remote LAN. There have been further difficulties in integrating with HP's 'Softbench', a third party software product.

The learning curve has been steep. Although the basic skills needed by users in the role of Developer are modest, other roles such as Build Manager are more demanding.

The existing software lifecycle has had to be modified to conform to the tool's methodology. There is further work to be done here.

Finally the tool itself was upgraded in May, which has meant further reorganisation during a period of upheaval.

2.3 Problems and Benefits

(a) Problems

These mostly amount to the upheaval caused to the established working practices. This has caused a delay in the deliverables to users.

Not all of the technical difficulties have yet been solved.

(b) Benefits

There will be greater control over the development of software using the tool. It is hoped that software quality will thereby improve with a reduced risk of errors being made during the software lifecycle.

When the tool is in regular use it possible that software will be deliverable sooner.

2.4 Conclusion

It is not possible at the present time to say how beneficial the CM Tool will be to the project. It will probably be in about a years time that this judgement can be made.

In addition to the benefits the tool brings, its cost effectiveness also needs to be assessed. In other words the benefits to both developers and users need to be offset against the cost of obtaining them.

1996 EGOWS Meeting at
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Session 2

Recent developments

Tuesday, 4 June 1996

MAP update 96.6

Michael Pogoda

Germany

MAP

The Meteorological Application and Presentation system

Update 96.6

Michael Pogoda
Deutscher Wetterdienst
pogoda@w3-map.wa-potsdam.dwd.d400.de

Outline

- MAP 96.3

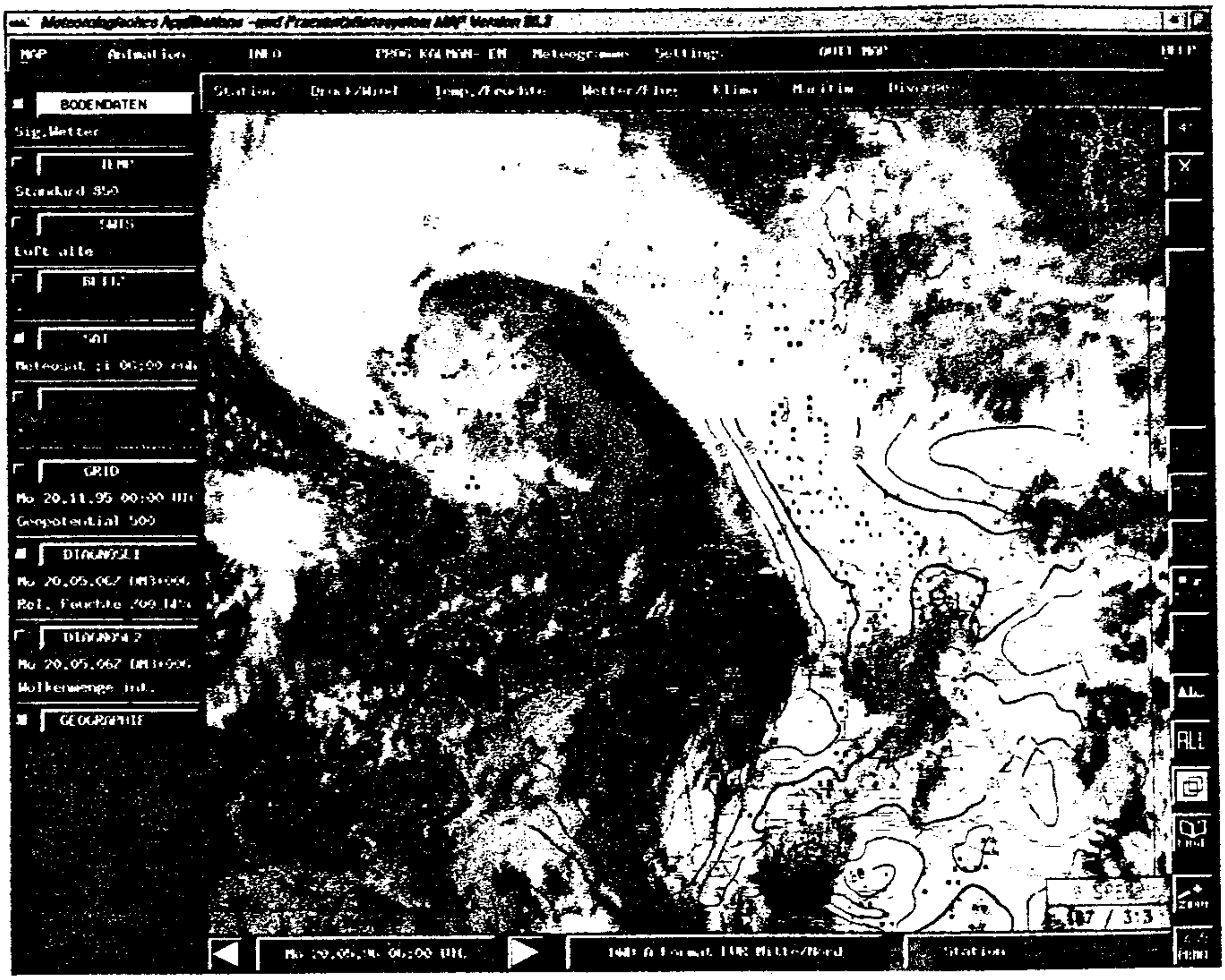
- Installation

- next version:
  no longer GKS

- General Graphics Interface
  "Allgemeine Graphikschnittstelle" (AGS)

- further plans

MAP 96.3

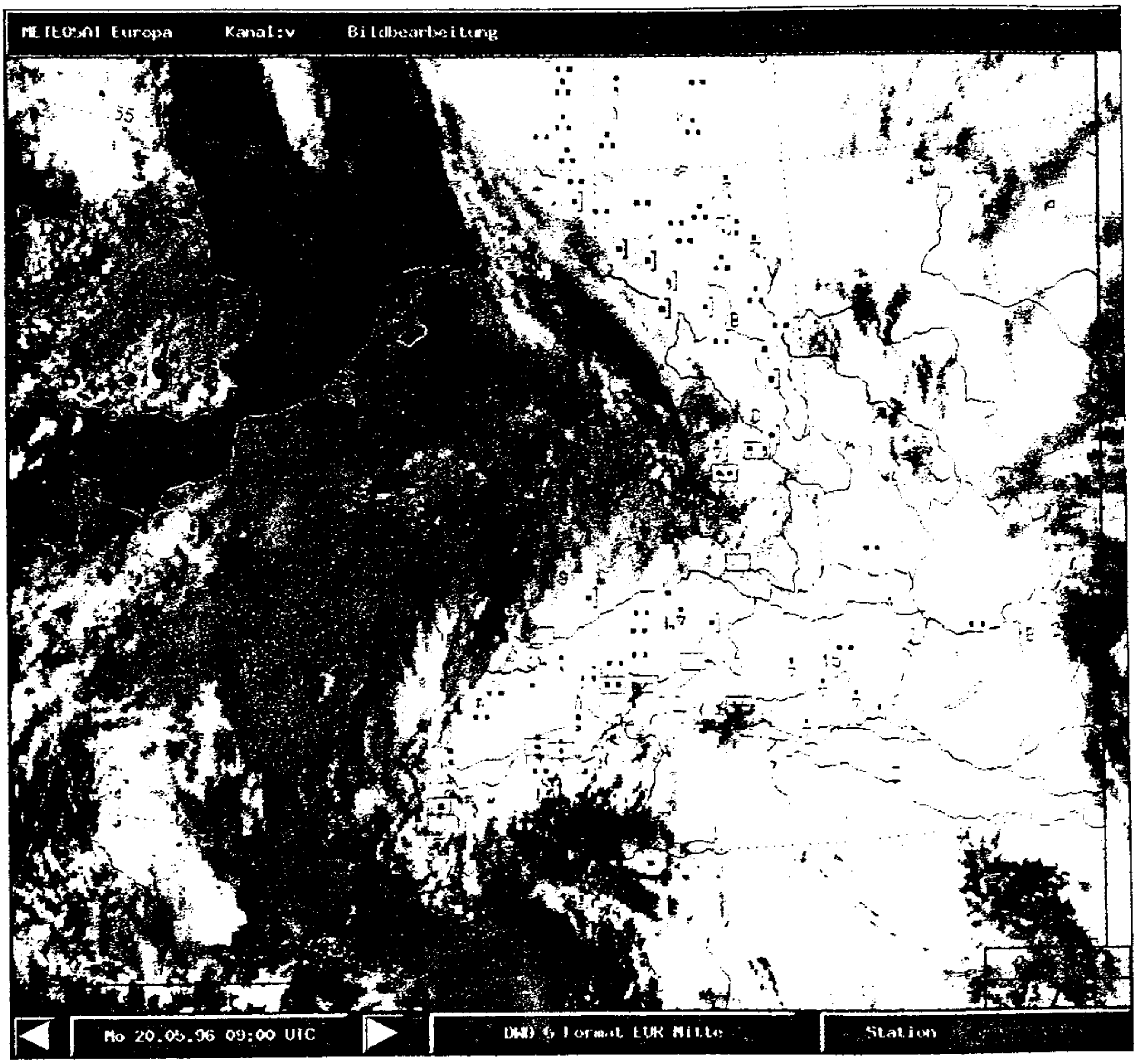


MAP
Animation
INFO
Meteogramme
Settings
QUIT MAP
HELP
BODENDATEN
Sig.Wetter
TEMP
Standard 850
SAT
GRID
Geopotential 500
GEOGRAPHIE

Data Types (41)

- Observations
  SYNOP, METAR, SHIP, EKDA, TEMP,
  PILOT, MREP, SPECI,
  Ligthning data,
  Road and Wind data,
  Warnings (processed by Warning monitor)
- NWP output
  DMO for SYNOP and TEMP,
  GRID,
  Statisticaly processed midrange forecasts,
  Metafiles (Isolines, Meteograms,
  cross sections)
- Forecasts
  TAF, local forecasts
- Satellite Images (Meteosat, NOAA, GOES)
  TRIVIS videos (MPEG)
- Station and area data
  WMO, ICAO, SWIS,
  Midrange Forecast Areas

Overlay of data



Flight Routing (1)

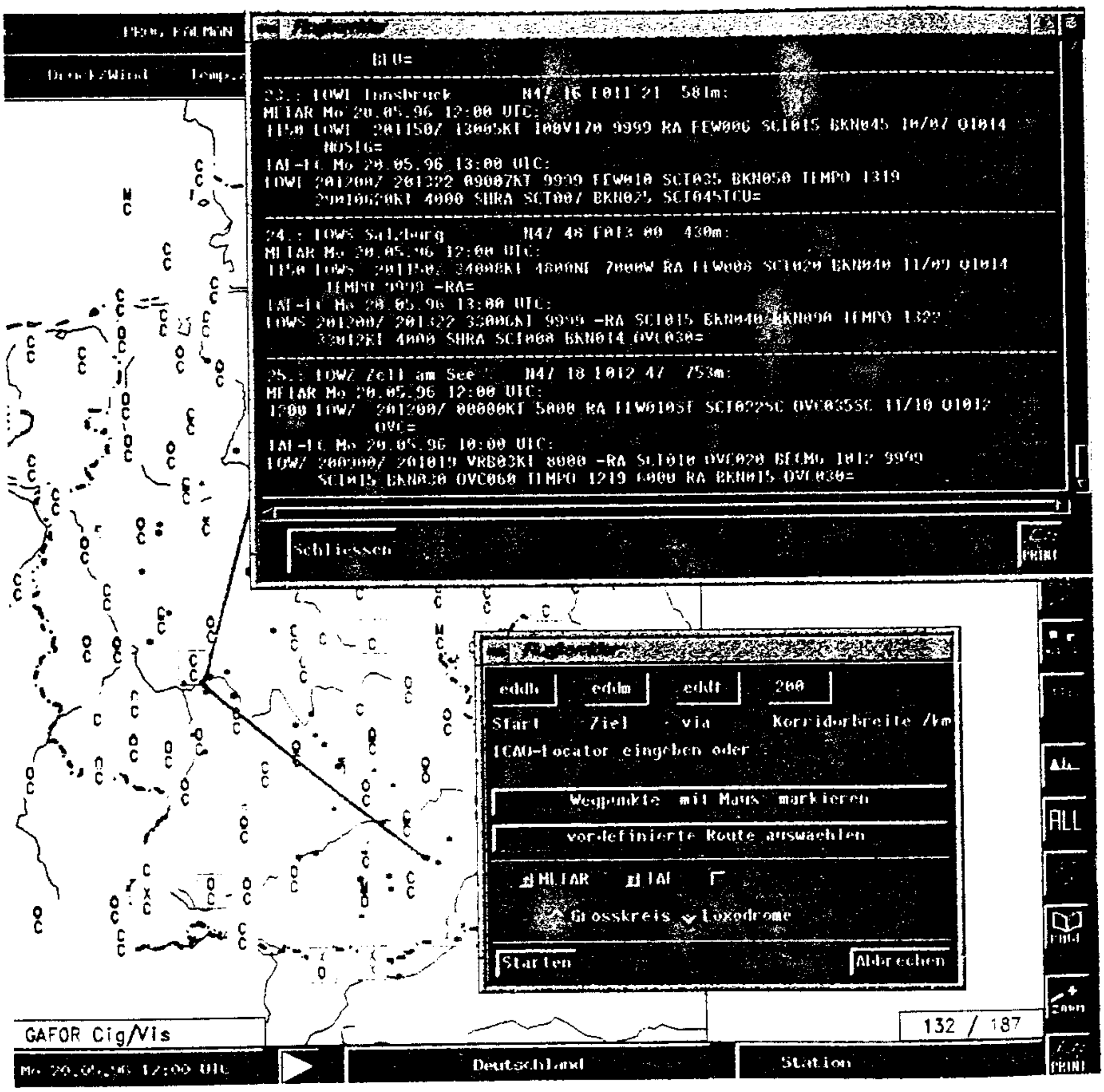
- tool for aviation services

- 3 types of selection:
  interactive by clicking
  begin and end of route by location indicator
  predefined route

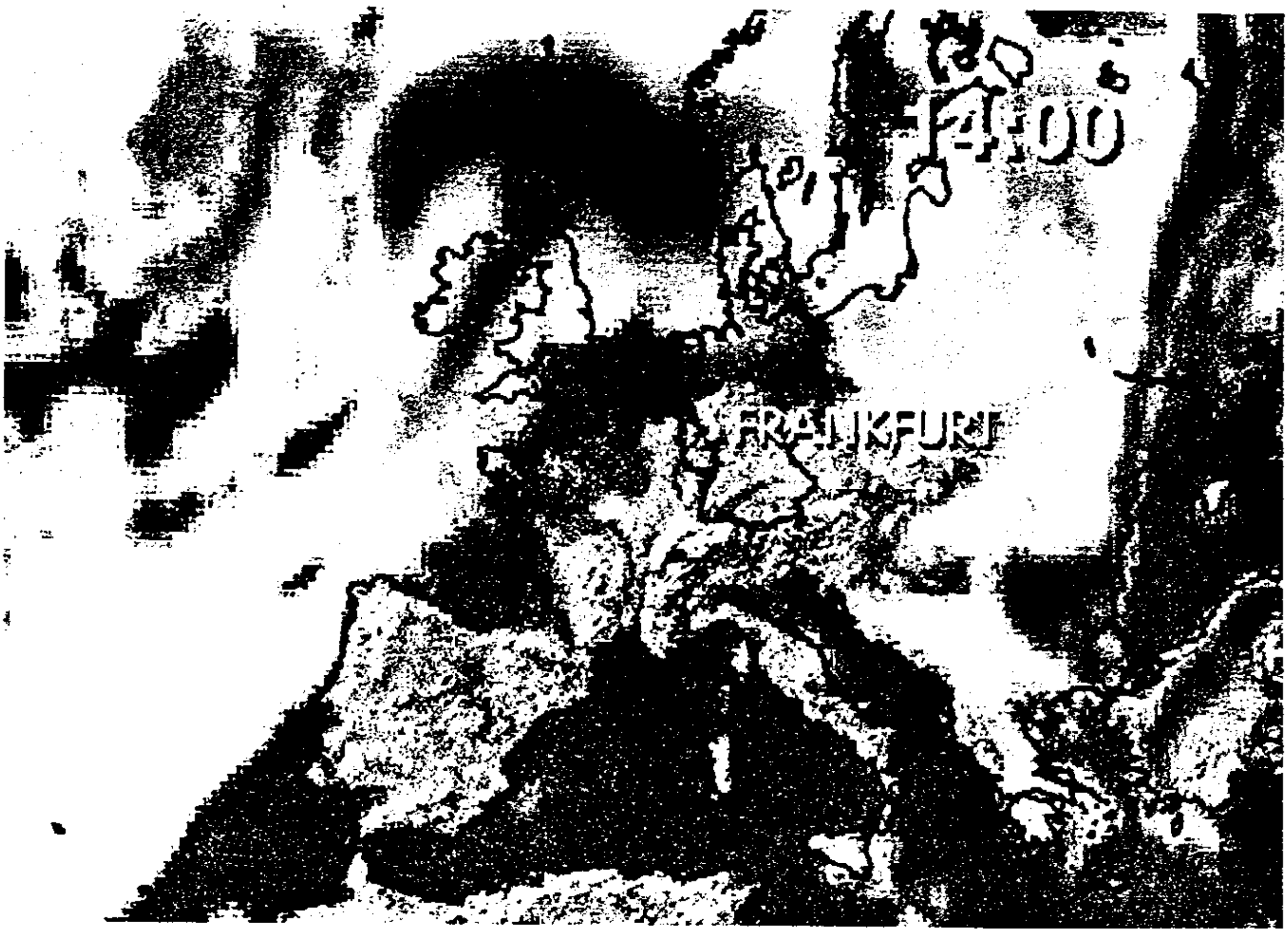
- all available METARs and TAFs for the flight route are selected and may be printed

- predefined routes may be locator lists or may be defined by some points

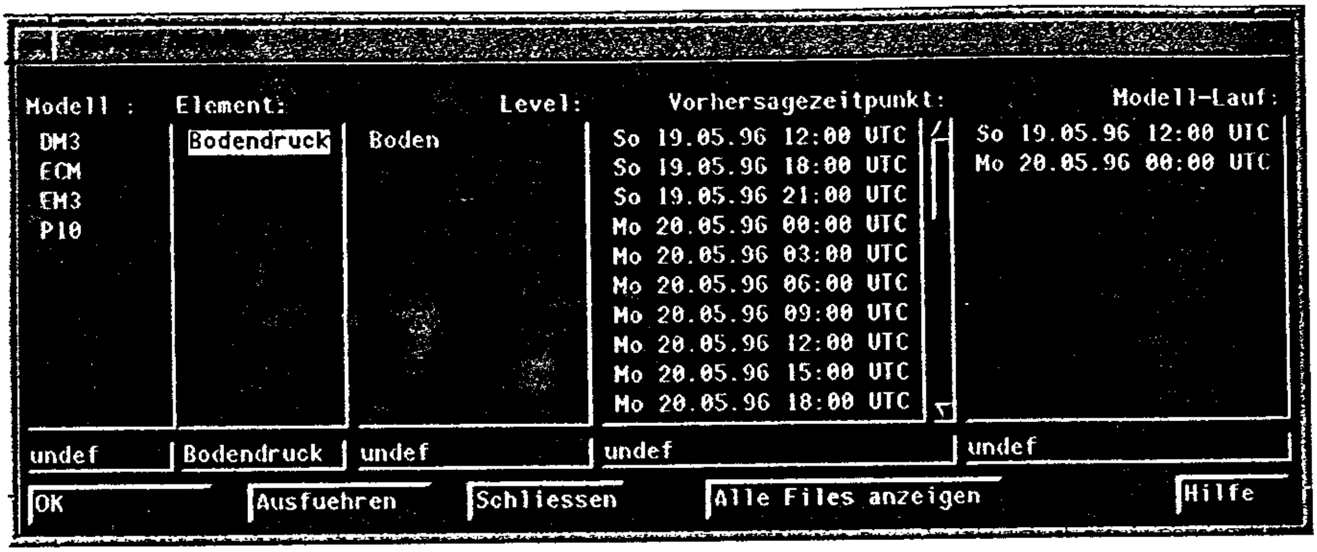
Flight Routing (2)

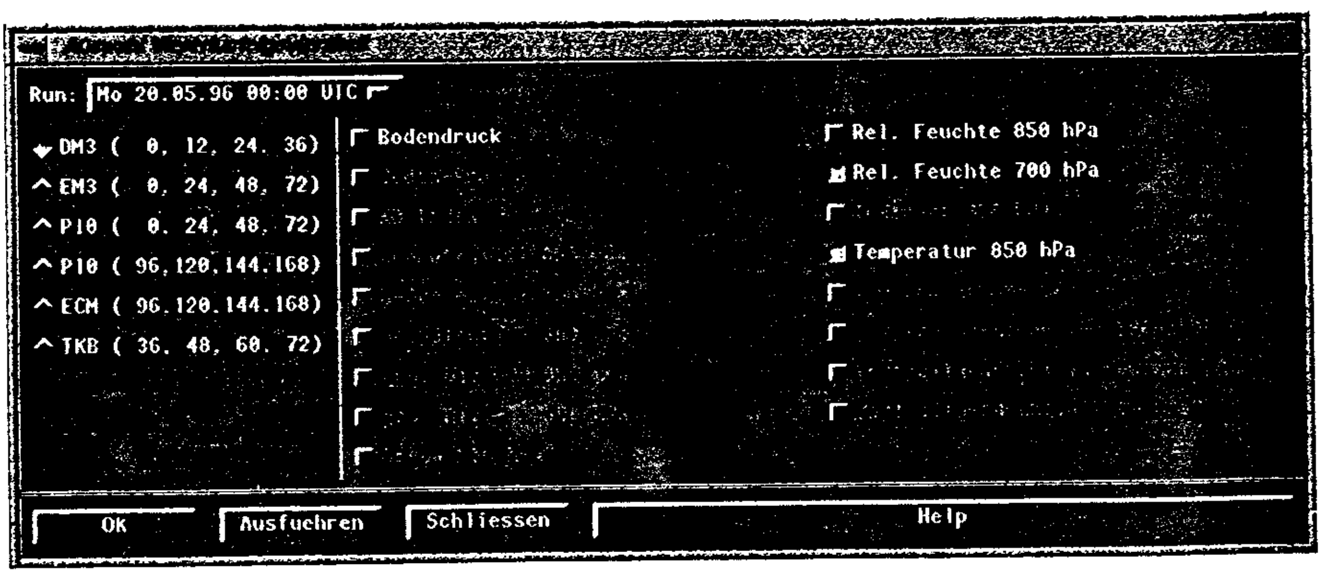


TRIVIS MPEG videos

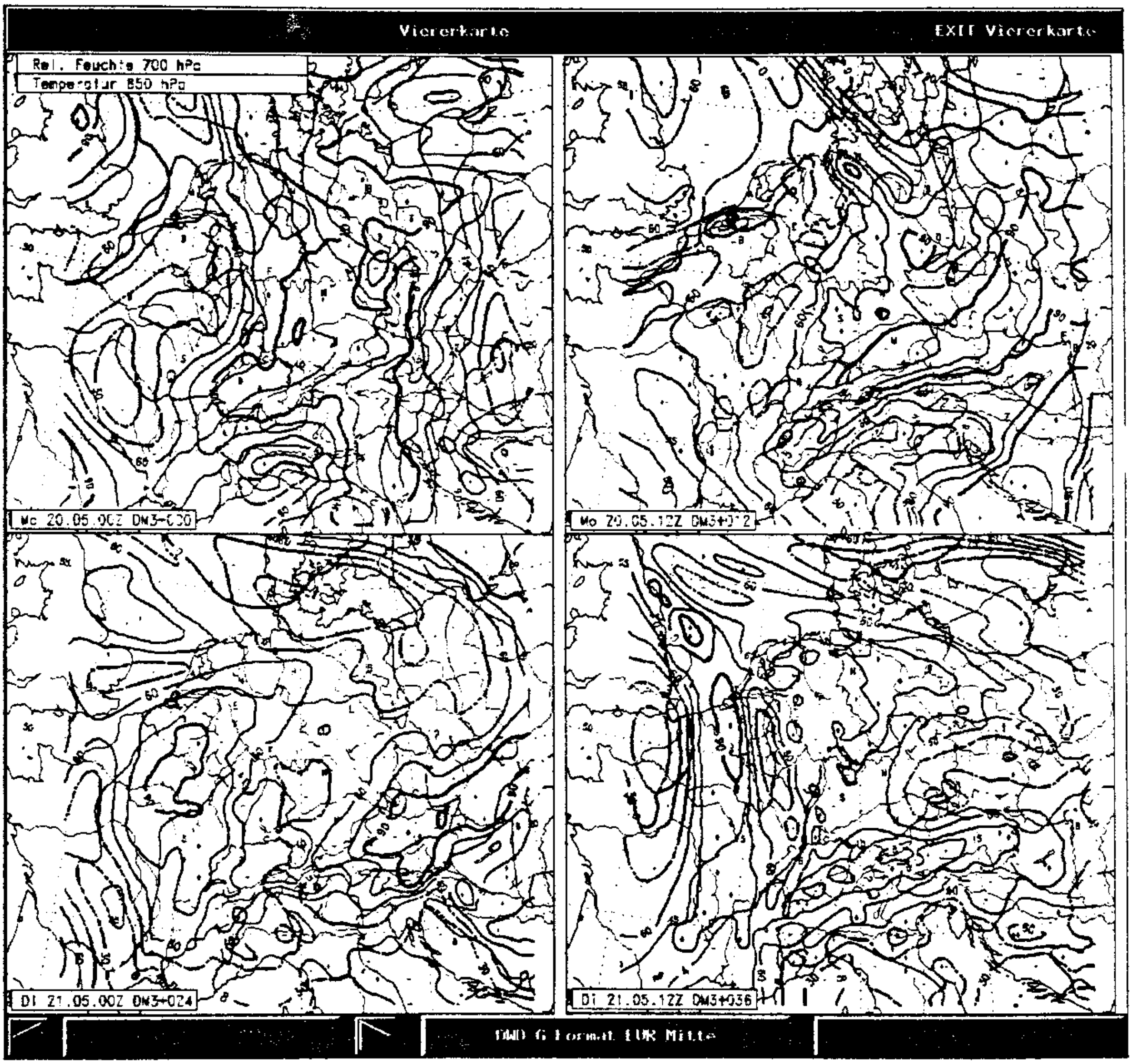


Optimized User Interface





Example: 4 forecast times



WWW: MAP

- information service within DWD

- actual information for users

- tool for all users to exchange information

- easy way to contact developer

- technical documentation

- *some state-of-the-art service*

Deutscher Wetterdienst

MAP-Projekt

Mit diesen Seiten wollen wir allen Nutzern und Interessenten eine einfache und hoffentlich ansprechende Informationsquelle eröffnen.

Das MAP-FORUM (24.05.1996)	SAT-Bilder aus MAP (Alle 30 Minuten neu!)	Neuigkeiten! (23.05.1996)
MAP-Nutzerkonferenzen	Release Notes der aktuellen Version!	MAP-Dokumentationen
Beiträge der Verifikations-Gruppe	Die MAP-Gruppe	Eine kurze Geschichte des MAP-Projekts
Technische und organisatorische Informationen	Technischer Support	Support Graphikgrundsoftware

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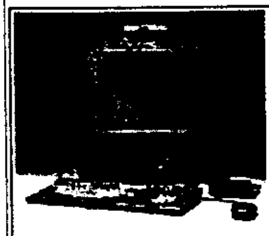
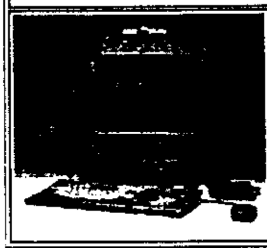
Im Rahmen des MAP-Projekts wird allen DWD-Nutzern eine Bibliothek angeboten, die die Nutzung der MAP-Datenbasis erlaubt.
Näheres erfahren Sie hier.

Wir würden uns freuen, wenn Sie wieder bei uns hereinschauen.

HOME

Michael Pogoda, webmaster@mapindy.dwd.de

MAP-Rechner der Fww Köln-Bonn

	Host	Hardware	OS	Peripherie	Anwendungen	Bemerkungen
	**fwkbwv01** 141.38.102.11	Indy R4400SC 150MHz Indy 24-bit 64MB 2*1GB	IRIX 5.2	P1: LaserJet	MAP 96.3 (MFS) FSS ALLGET Diagnose SAT	.
	**fwkbwv02** 141.38.102.12	Indy R4600PC 100MHz Indy 8-bit 64MB 1GB	IRIX 5.2	.	MAP 96.3 (DSP) LCS	AFW an serieller Schnittstelle 2 (ttyd2)

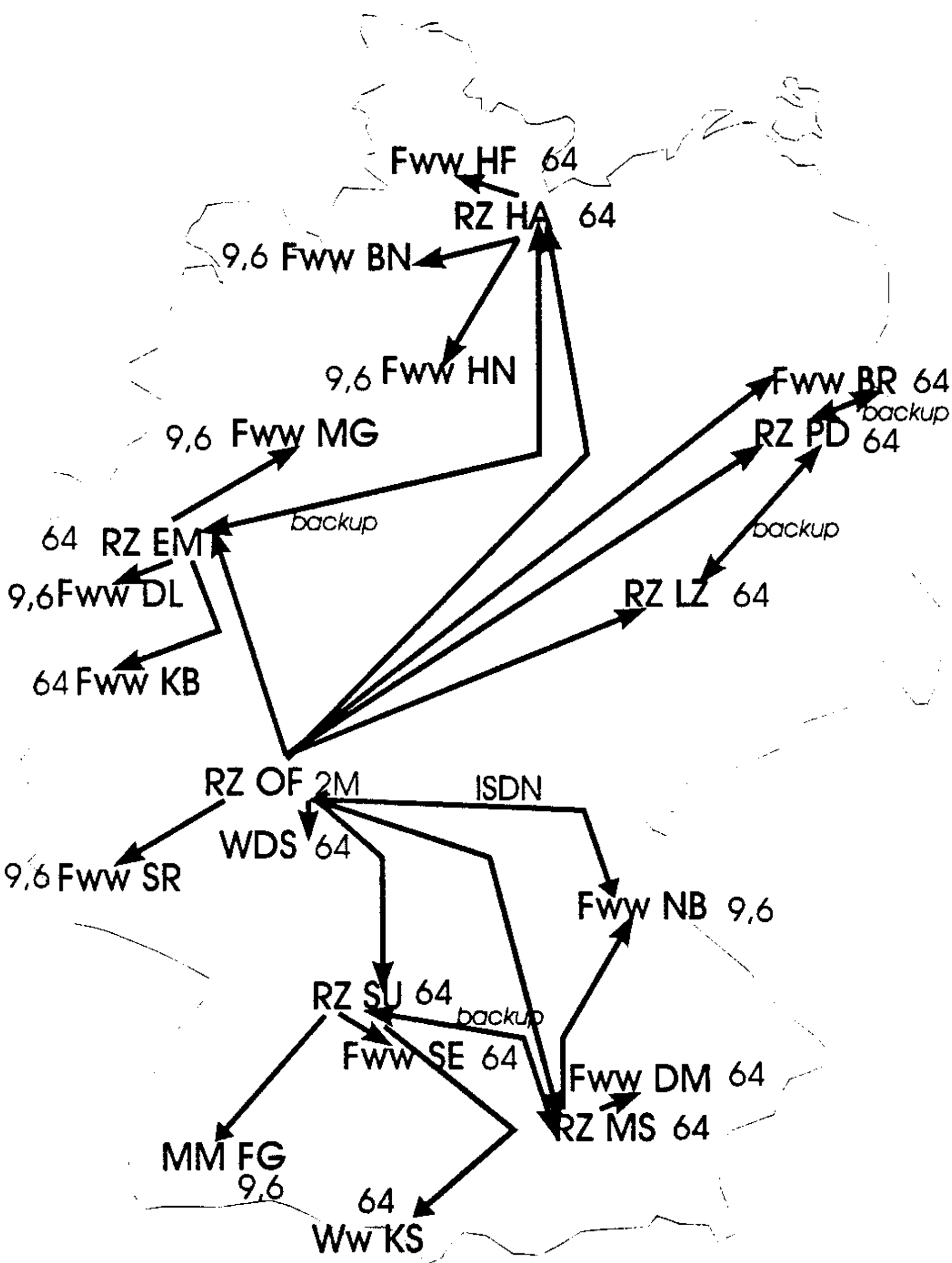
Ansprechpartner:

- Herr Braun 02203-40-2558 oder 2428

Letztes Update dieser Seite: Thu May 23 12:27:39 UTC 1996

Michael Pogoda, webmaster@mapindy.dwd.de

Installations and data flow



22.05.1996

Installations and Hardware

- 7 Regional Offices
  11 Aviation Service Offices
  Media Service Centre, Central Forecast
  Met. College, 1 Weather Station
- 2 Meteorological Observatories
  1 Office for Medicine Meteorology
  4 other Departments

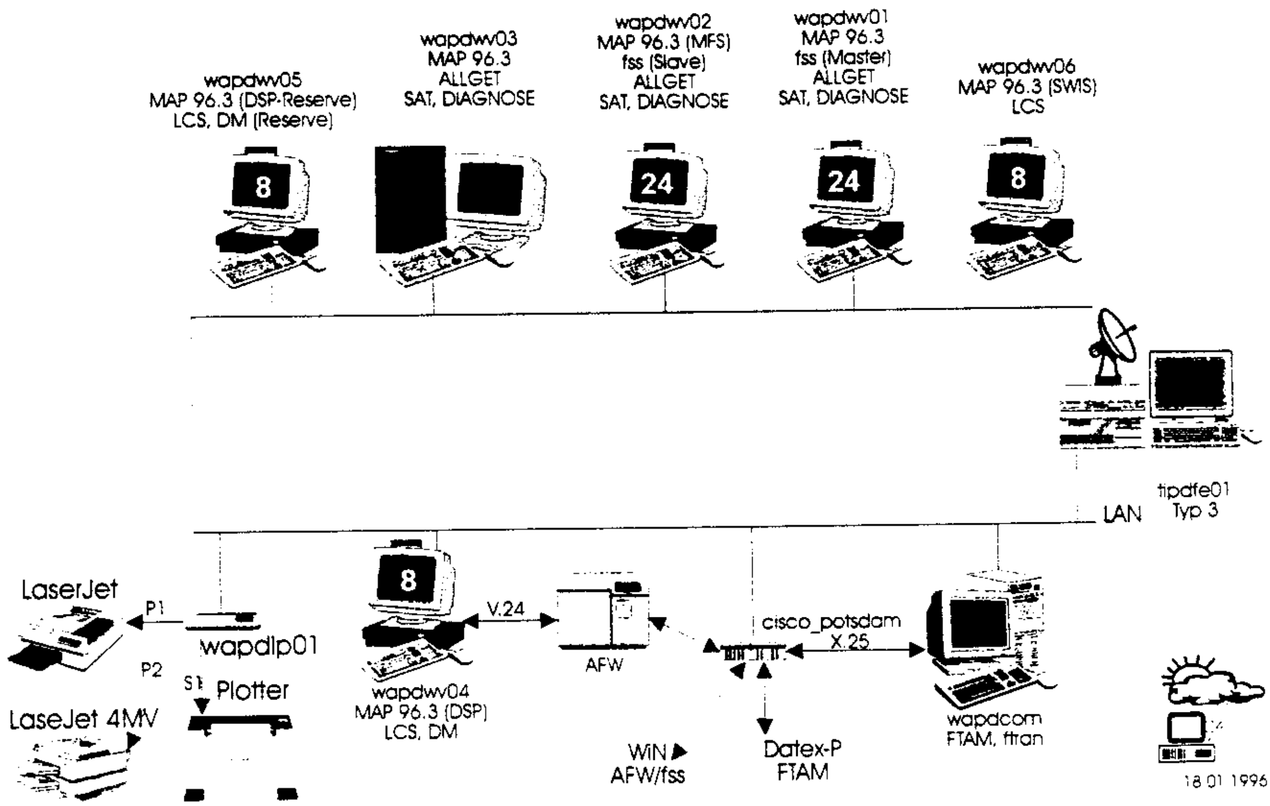
- 34 Indy R4400SC, 7 Indigo R4000
  (24-bit Graphics, 64MB, 2GB Harddisc)
- 40 Indy R4000PC and R4600PC
  (8-bit Graphics, 64MB, 1GB Harddisc)
- Printer:
  HP LaserJet III and 4 (A4, PCL)
  HP LaserJet 4MV (A3, PCL, Postscript)
  WDV (A3, A4, Postscript, PCL)

MAP-Installationen

RZ Hamburg	• RZ Hamburg (5-3) (96.3) • Fww Fuhlsbüttel (1-1) (96.3) • Fww Bremen (0-1) (96.3) • Fww Hannover (0-1) (96.3)
RZ Essen	• RZ Essen (2-3) (96.3) • Fww Münster-Osnabrück (0-1) (96.3) • Fww Köln-Bonn (1-1) (96.3) • Fww Düsseldorf (1-1) (96.3)
RZ Potsdam	• RZ Potsdam (3-3) (96.3) • Fww Berlin (1-1) (96.3)
RZ Leipzig	• RZ Leipzig (4-5) (96.3)
RZ Offenbach	• RZ Offenbach (3-4) (96.3) • Fww Saarbrücken (0-1) (2.3)
RZ Stuttgart	• RZ Stuttgart (3-2) (96.3) • Fww Stuttgart (1-1) (96.3) • GF MM Freiburg (0-1) (2.3) • Ww Konstanz (1-1) (96.3)
RZ München	• RZ München (3-3) (96.3) • Fww München (1-1) (96.3) • Fww Nürnberg (0-1) (96.3)
ZA Offenbach	• Medien-Service-Zentrum (2-1) (96.3) • Zentrale Vorhersage (2-1) (96.3) • WDS Langen (2-2) (96.3)
Observatorien, Forschungsstellen und andere Installationen	• MO Potsdam (1-0) (2.3) • MO Hohenpeißenberg (1-0) (2.3) • ZAMF Braunschweig (1-0) (96.3) • GB TI 14 (1-0) (96.3) • GB FE (1-0) (96.3) • IA Hamburg (1-0) (96.3)

Zur Zeit ist MAP auf **42 Workstations** mit 24-bit-Graphik und auf **40 Workstations** mit 8-bit-Graphik installiert.

Example: Regional Office Potsdam



General Graphics Interface (AGS) (1)

- problem: GKS can not solve our problems

- we need a strong tool with features from different libraries:
  fast and good display
  object storage
  portable software
  use of different hardcopy devices
  proper event handling
  ready for 3D

- AGS solves our problems

- isolation layer to serve portability with object storage facilities

General Graphics Interface (AGS) (2)

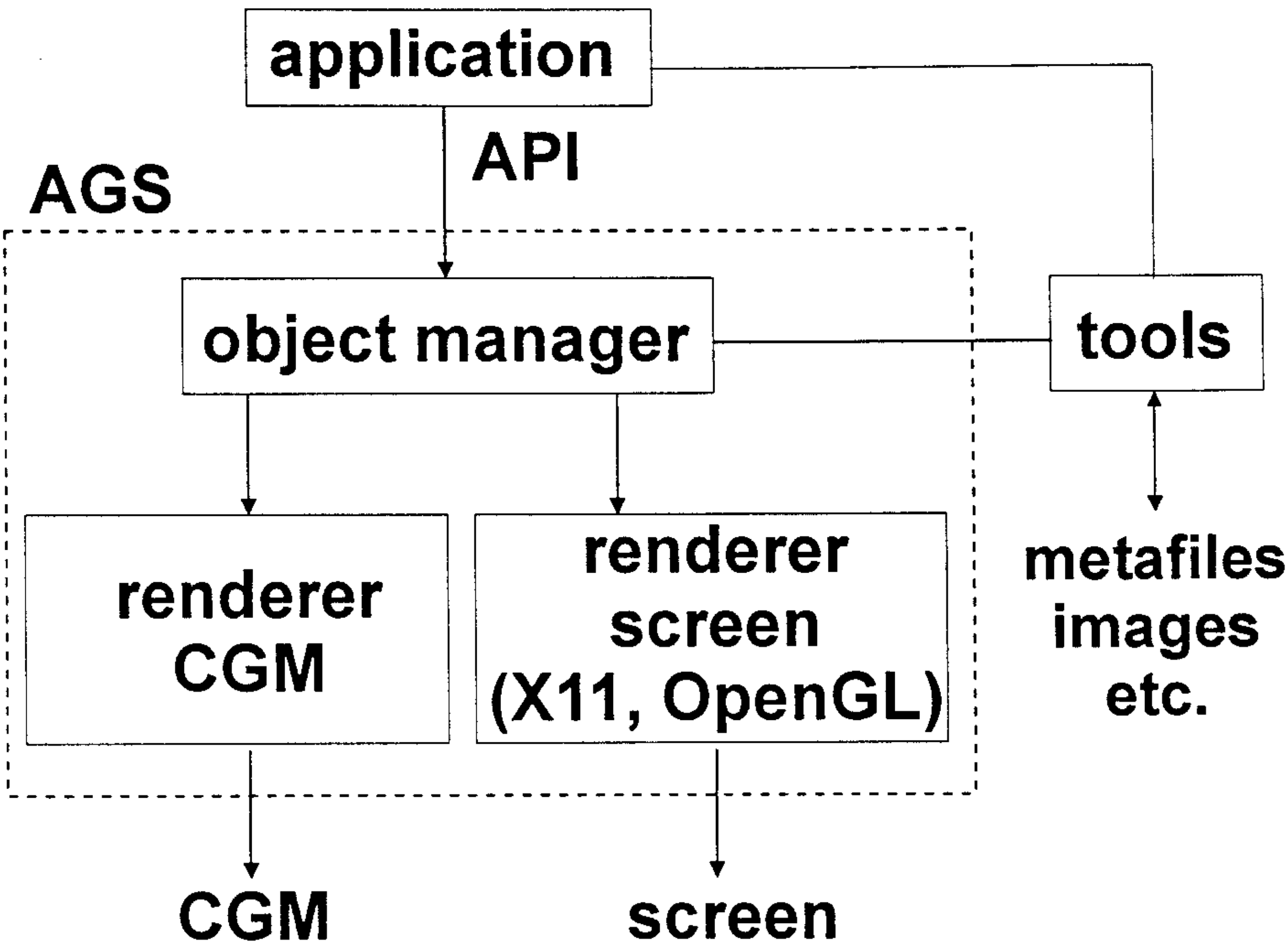
- optimized for OpenGL

- also available for X11

- printing with CGM

- integration of services by tools:
  GKS metafile interpreter

General Graphics Interface (AGS) (3)



Further plans: MAP 96.10

- porting MAP 96.3 (GKS) to 96.10 (AGS) (LINUX version)
- include RADAR images and AUTOTAF to MAP 96.10
- integration of some plug-in procedures
  some special aviation routines
  other programs

- new HTML Help and on line manual (using Netscape facilities: IPC by X Properties)

Further plans: still open

- local calculation of isolines based on GRIB, replacing metafiles
- nowcasting procedures
- storage of interesting weather situations
- use of Digital Chart of the World better geographical background
- automatic production tool
- more and more data

Session 2

Recent developments

Tuesday, 4 June 1996

Operational workstations
at the Hellenic National Meteorological Service

J Bassiakos, J Alexiou, A Emmanouil

Greece

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

A new version of **plotxw** was developed in the past year which allows the forecaster to draw in fronts [warm, cold, stationary or an occulsion] on the chart using the mouse. This involves extra buttons on the main menu line and figure 2 is a screen dump which illustrates this. The plot shown is used for a premium rate fax service. At present, such charts are input manually [by making a hardcopy and inserting it into a fax machine] but it is planned to produce HPGL files [including the fronts entered by the forecaster] and then include these products in the fax system automatically. In the longer term, it is hoped to produce a system that will allow the forecaster to alter the contours and the depths and positions of lows and highs.

6. XGRBPLT : DISPLAY GRIB-FILES

This package is used to display GRIB output files form 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 fc9605150024pp

where 'fc9605150024pp' is the Hirlam 24-hour forecast [from 15-May-1996] 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 [see figure 3 for an example]:

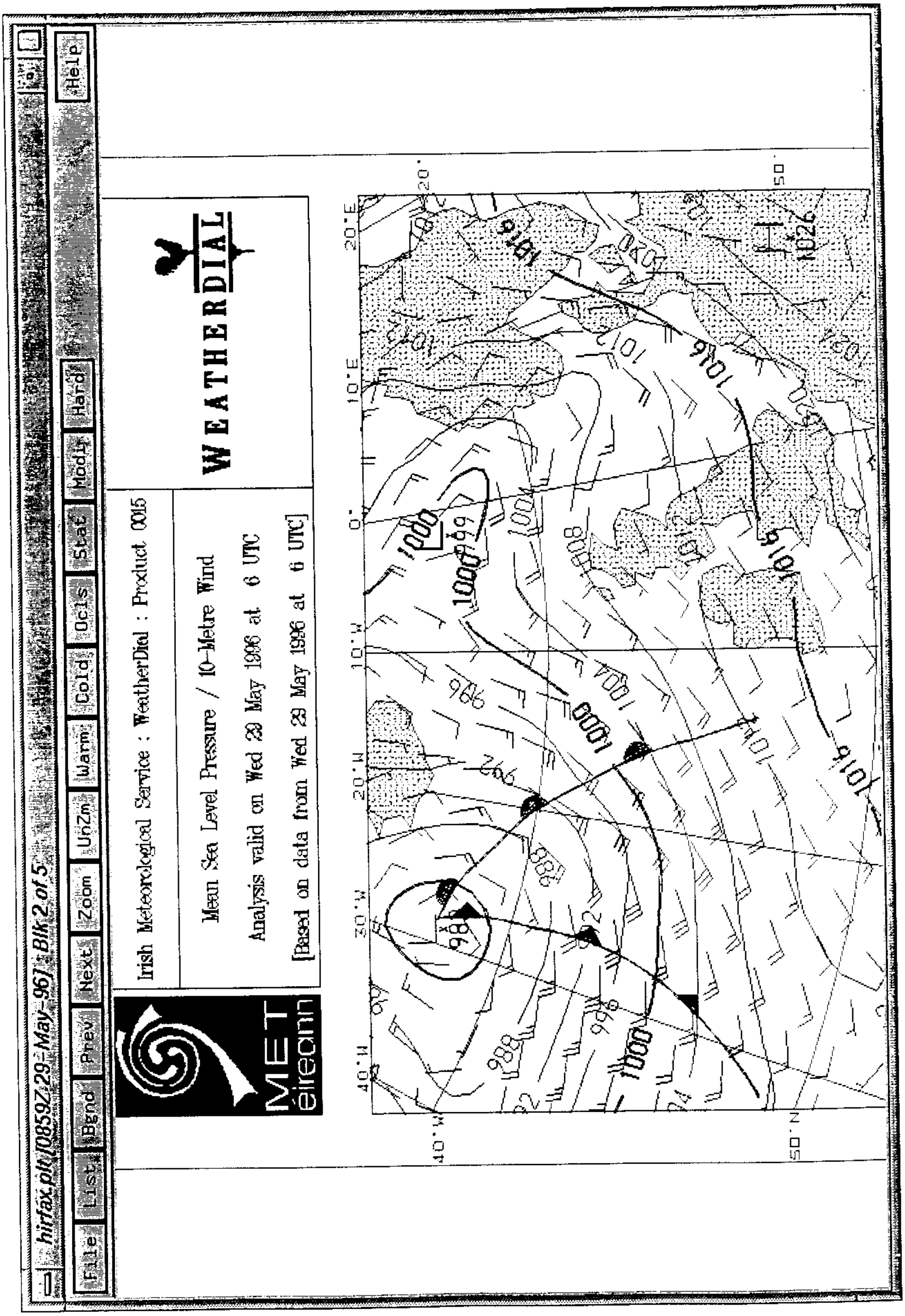


Figure 2 : Use of **plotxw** to display a chart used as input into the premium rate fax system. The fronts were added manually using the mouse.

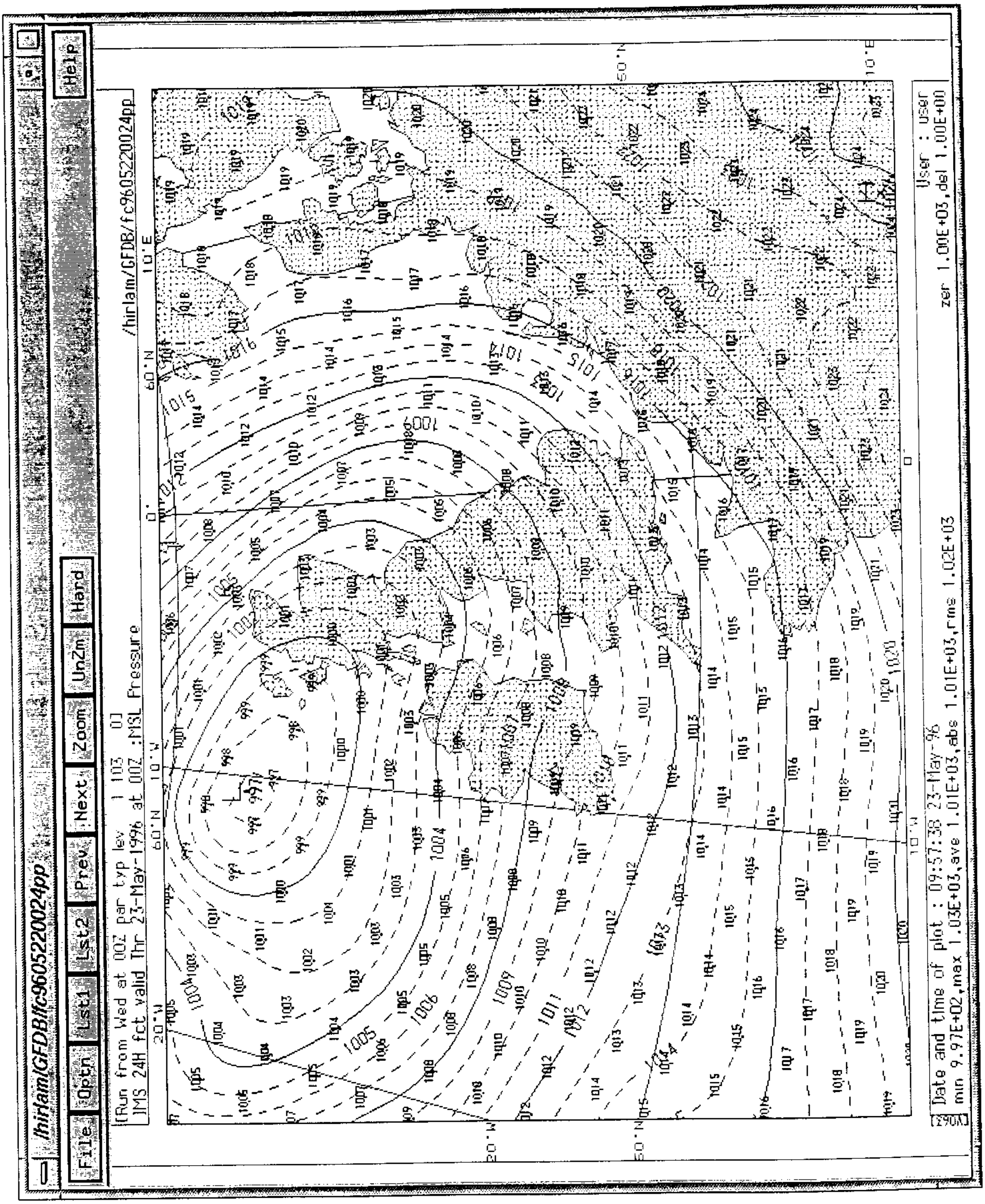


Figure 3 : Typical output of **xgrbplt**. The plot shows output from the Hirlam model.

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 realligned 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.

Finally, **xgrbplt** can be used to plot observations if the appropiate file is specified on the command line. The package uses a 'de-clutterring' algorithm to select the observations for display and the number 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 'Optn' 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 ambigious 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 [see figure 4]:

File, Optn, Modl, Parm, Levl, Time, Misc, Prev, Help

and, in addition, icons for zooming, un-zooming, hardcopy, animation, cross-sections, page-layout and the selection of the next and the previous plot. Also, the 'Plot' button is available as a pop-up menu when the user presses the right-hand mouse button in the drawing area. [See Nishimura [1995] for a discussion of the icons]. We will look at these options 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 [obtained by pressing the right-hand mouse 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
...	...	...	...
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'. In addition there are arrow icons corresponding to 'Next+6' and 'Prev-6', respectively.

The 'Zoom' icon 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.

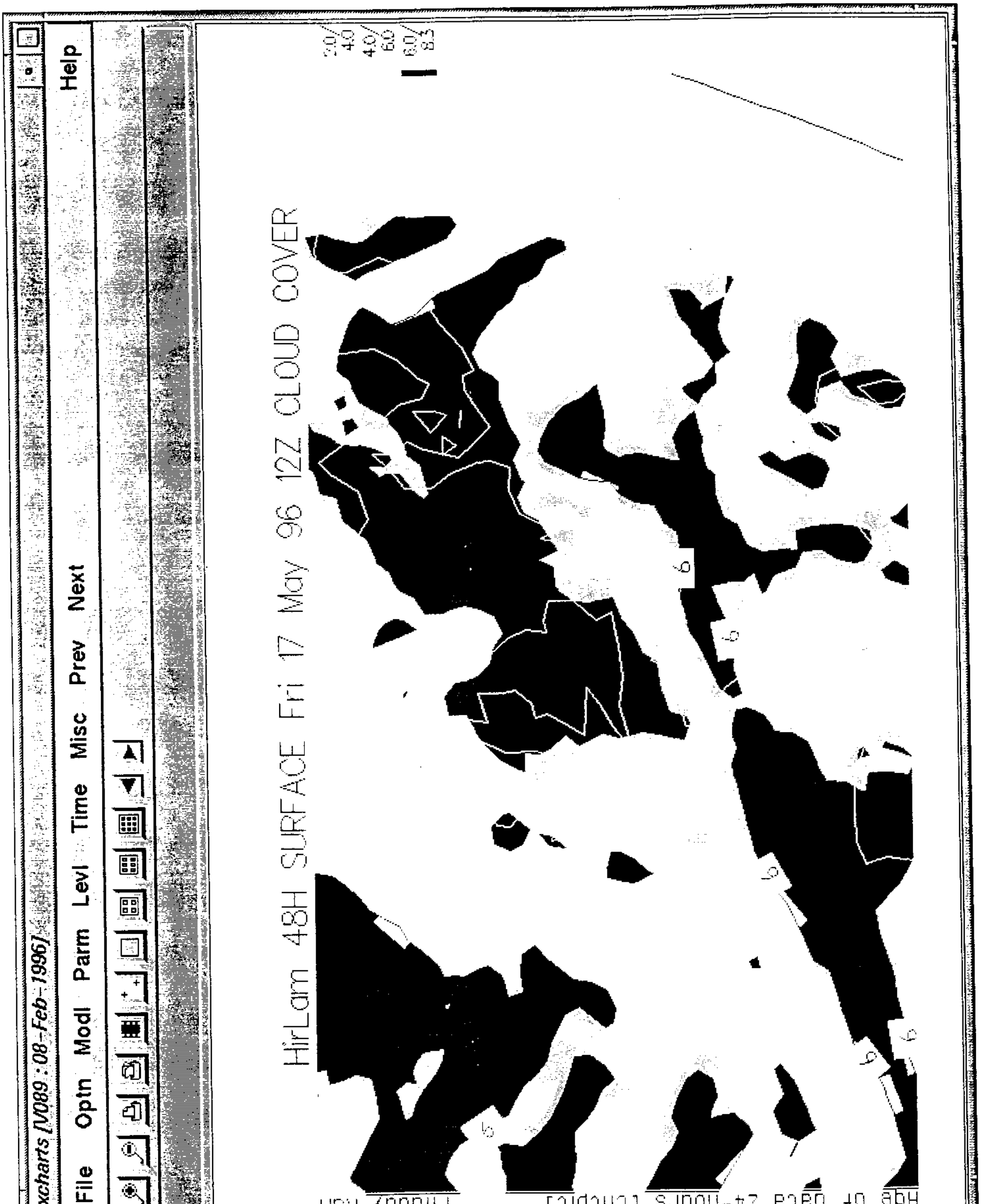


Figure 4 : Typical output of **xcharts** showing the main list of menu buttons and icons. Note the use of solid shading to display the cloud amounts.

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

The 'Animate' icon allows the user to animate the display. This option was developed by E. Nishimura [1995]. The 'Cross-section' button is used to select two points to define a track and the cross section along the track is then displayed in another window. Figure 5 shows an example.

The user can divide the screen into sections and plot four, six or nine charts. Figure 6 shows an example.

Finally, the user can display tephigrams by first selecting a plot of the data available and then pointing at the required station. Figure 7 shows an example.

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. Thus the first four 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.

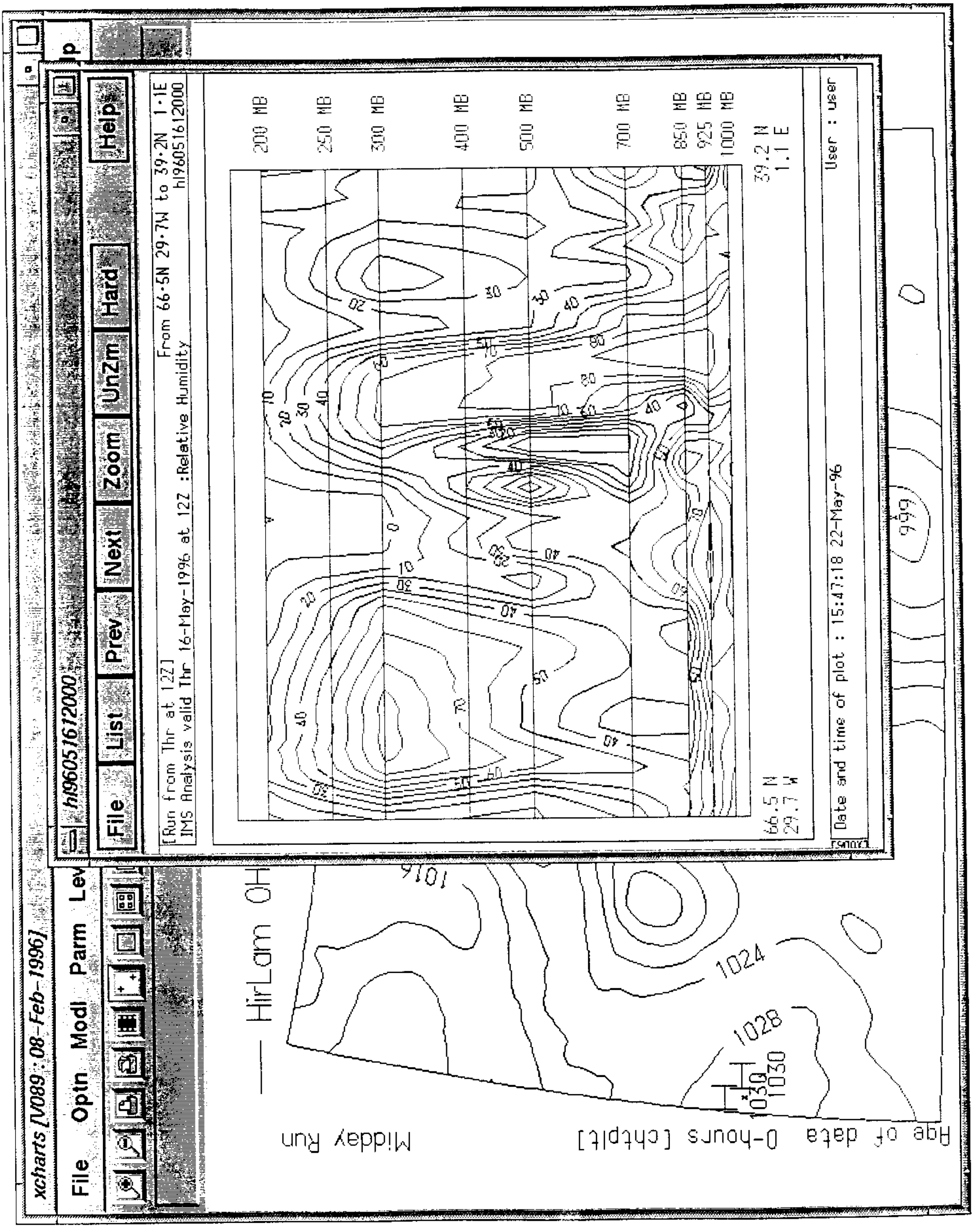


Figure 5 : Output of **xcharts** showing a cross-section plot. The track for the cross section is defined by two points on the main **xcharts** window; a second process is started to display the cross-section.

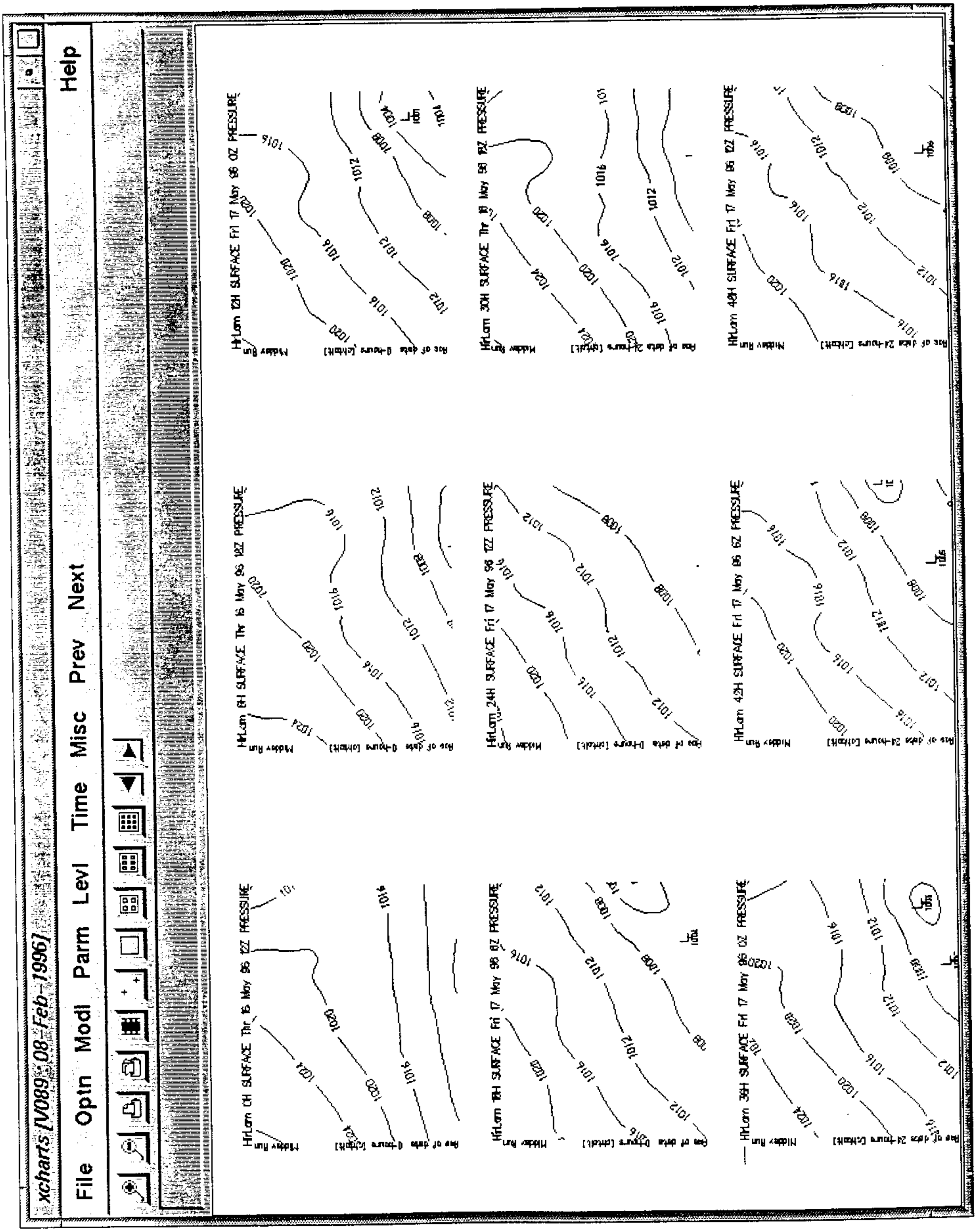


Figure 6 : Output of **xcharts** showing the screen divided into 9 sections. If required, more than one plot can be displayed in each of the sub-windows.

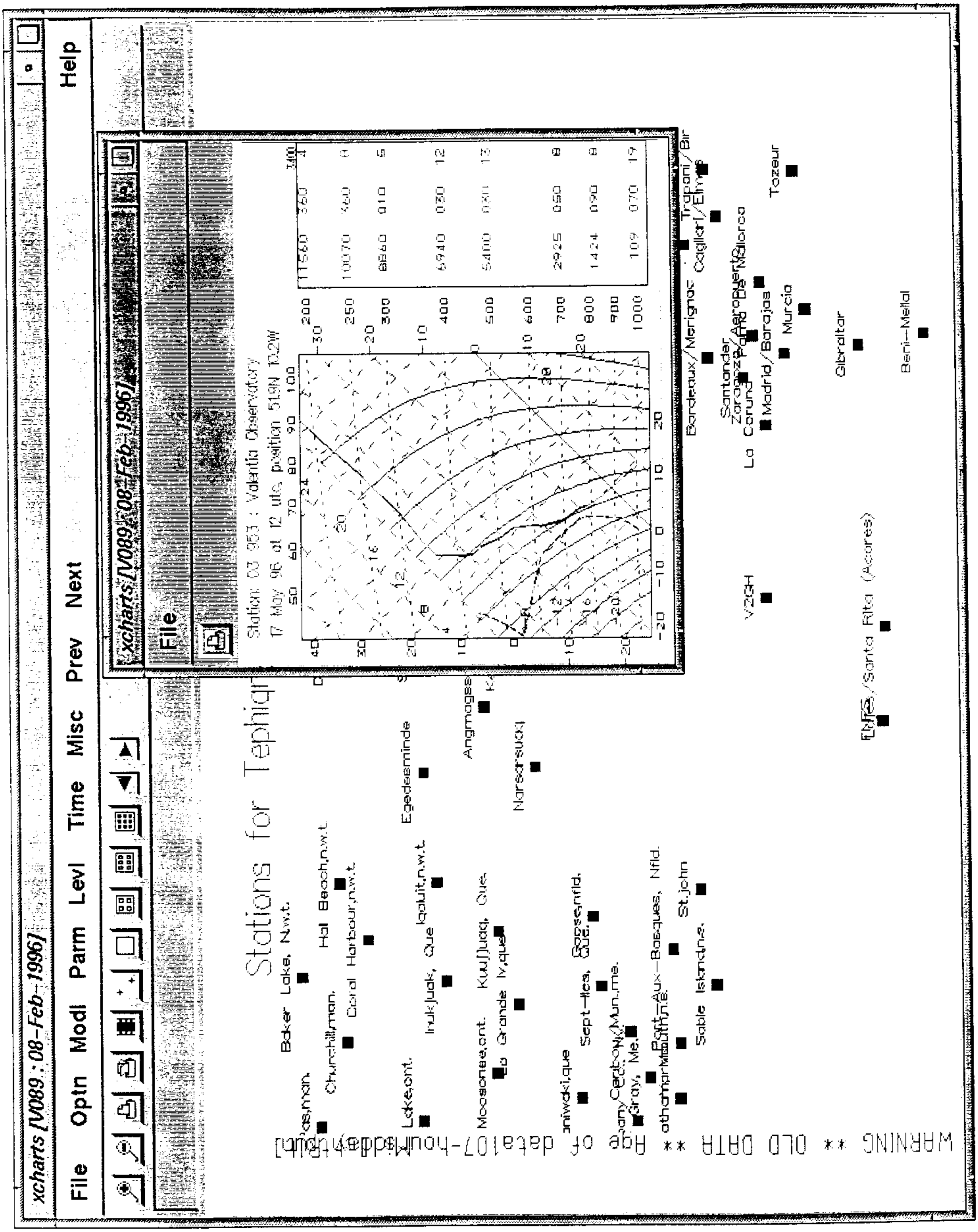


Figure 7 : Output of **xcharts** showing the main screen used for selecting tephigrams and a plot of the tephigram [in a separate window] for Valentia [03953].

At present **xcharts** is running in the main forecast office [viz. CAFO] in Dublin. It is planned to install it in the main aviation office [i.e. the CAO at Shannon Airport] within the next two months.

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.

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.

The forecaster can add fronts to charts using a drawing option in **plotxw**; in the future we would like to extend this option to allow him/her to modify contours and/or alter the the depths and positions of lows and highs.

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Recommendations on Meteorological Workstation Development

1. Requirements for a Meteorological Workstation System (MWS)

- Access to all types of meteorological data, messages, plotted observations, satellite and radar images, fields from NWP, elaborated maps and products, climatological databases and geographical data.
- Automatic updating of the observations and other meteorological information.
- Manipulation of data: including interpolation from NWP fields, derivation of additional parameters, trajectories, image manipulation, dynamical or statistical interpretation, verification procedures.
- Interactive manipulation of NWP data to create and display products such as cross-sections and meteograms.
- On-screen graphical editing, addition of new information and interactive modification of automatically generated information. Facilities to edit maps.
- On-demand computation of as many products as possible in preference to using pre-computed products.
- Access to all products including those created from automatically generated information.
- Visualization of the above.
- A 2D graphical display. This is still the main purpose of an operational MWS, though 3D graphics should be investigated to identify how they can best be used in operational forecasting.
- Display manipulation including superimposition, animation, roaming, zooming, retransformation and coloration.
- As short a response time as possible.
- An intuitive user interface for the forecaster, based on icon representation and mouse (or equivalent) interactions. Accelerator keys, function keys and macro functions can be used.
- Personal configuration of default interface variables, maps, etc.

- Modularity of applications, where clear separation between data handling, graphics and the user interface is essential.

- Monitoring of observational and NWP data on arrival, plus issue of an alarm to the user when pre-set criteria are matched. Ability to reject spurious data.

- The ability to save and disseminate output products.

- The ability to archive data and/or products.

2. Recommendations on standards

A: Meteorological

- The GRIB and BUFR WMO codes should be used for data representation.

- The exchange format for data should be uniform, following WMO guidelines, but each country should be able to keep its own internal storage format. For internal handling of observations in particular an alternative format to BUFR may be considered for performance reasons.

- Standard GRIB format is currently being updated and should be able to handle 3D information in future.

- Extended GRIB format, currently in use by ECMWF, France and Brazil, should be considered for the exchange for satellite image data. There may still be a problem storing tracking information for polar-orbiting satellites.

- It is recommended that BUFR is used for the exchange of radar images. Specifications are expected from OPERA/EUMETNET by 1998.

- Extended BUFR code should be used for the exchange of additional information such as jet streams and other significant weather objects. A proposal for the extension has been accepted by the code sub-group of WMO. *(Details from Lynda Jones, UKMO.)*

B: Computational

- No recommendation is given on the hardware platform to be used. Care should be taken to specify sufficient memory if X-terminals are used. The maximum possible screen size should be used.

- The overheads of operational monitoring, supervision and support should not be overlooked.

- A multitasking capability using a UNIX operating system, Windows NT or equivalent is desirable.
- PC/Mac desk-top publishing (DTP) software should be part of the MWS, ideally via integrated command libraries.
- C and C++ are the recommended programming languages. JAVA and FORTRAN 90 can be considered too.
- Object-oriented methods should be considered when designing the next generation of meteorological systems.
- The X-Windows system is ideal for visualization using the MOTIF tool-kit to develop the user-interfaces. Windows NT and OS2 can be considered too.
- The 'look and feel' of meteorological applications should follow the 'look and feel' of less-specialized IT applications. A uniform style guide should be developed which will reduce user training costs.
- The Common Desktop Environment (CDE) is useful for style management and work area personalization although some network dependencies can prove troublesome.
- The X-Windows system (Xlib), GKS and Open GL are the accepted graphics standards. The ISO Computer Graphics Metafile (CGM) output format should be considered for the exchange of graphics information because its rich format maps onto many drivers.
- Compression techniques suited to the data type can be used to improve data transfer rates and storage capacity at the expense of accuracy and fine detail. MPEG is suitable for animations without too many colour variations. GRIB is good for NWP data. Fractal techniques can be considered for imagery.
- For printing purposes Postscript, Encapsulated Postscript, T4, PCL and PDF (which is 90% postscript) might be considered. It was noted that Hewlett Packard are not expected to support postscript on their next family of printers.
- An extended form of SQL is already in use and is worth considering for accessing organized databases. Several sites successfully use NEONS, but a replacement is under development and is awaited from the US Navy.
- Intranet systems are useful for the internal exchange of data across a network. HTML is recommended for on-line documentation.
- The commercial product 'Purify' has proved useful in testing memory leaks.

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