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Editorial

The farewell speech to the 51st session of Council by Dr Carlo Finizio appears on page 2. Dr Finizio has been closely associated with the Centre since the early planning stages in the 1960s, and was elected Vice-President in December 1997.

In the article on page 3, Peter Janssen discusses how ship routing may benefit from ensemble prediction of wind and waves. He considers the impacts of weather on a broad range of costs incurred by shipping, including arrival delays, fuel and grease consumption and the possibility of engine damage. He concludes (using results from a large number of runs over the December - March 98/99 period) that worth-while benefits may be achievable by using the ensemblemean route, rather than routes deduced from climatology or from deterministic forecasts.

A comprehensive description of Metview, the ECMWF's meteorological data visualisation and processing system, is given by Rogério Bonifácio on page 6. He describes the applications and uses of Metview that are now available, following the recently completed major structural review of the system.

The research proposals for two successful bids for European Commission funded projects co-ordinated by the ECMWF are summarised on page 18 by Adrian Simmons, Sakari Uppala and Tim Palmer. The first project, ERA-40, is designed to provide a comprehensive reanalysis of observations from the global observing system over the period since 1957. The second project, DEMETER, aims to develop a coupled ocean-atmosphere multi-model ensemble fore-casting system for seasonal and inter-annual prediction.

Finally, Andrew Lea and Rob Hine request items of inter-est about ECMWF that might be suitable for inclusion in a brochure to be produced about the Centre and its work over the past 25 years (see page 27).

Changes to the Operational Forecasting System

No changes were made to the operational forecasting system before the new year period because of possible difficulties relating to the Y2K problem.

Address of farewell by Dr Carlo Finizio of Italy to the 51st session of the Council
1 December 1999

Dr Finizio was associated with the Centre from the earliest planning stages in the late 1960s. He participated in the Italian contribution to the cost-benefit study, which led to the agreement, to establish the Centre. He was active in several initiatives in Italy in developing tools for the advanced use of Centre products. He participated in ECMWF Seminars, and represented Italy at many sessions of the TAC and Council. He was elected Council Vice-President in December 1997. Below is the text of his farewell address to the Council.

D Burridge, Director ECMWF

Mr President,
Last October, in the course of restructuring of the Ministry of Defence, I was appointed to a new position as Head of the Department of Science, Technology, Economy and Industrial Policy of the Military Centre for Strategic Studies. Following the appointment to this new position I shall be leaving meteorology. Steps are being taken in Italy to change the representation of our country in the European and World meteorological agencies.

Therefore this is the last time that I shall represent Italy in ECMWF and more generally in the international organisations of meteorology. It is thus my duty to formally tender my resignation as Vice-President of Council. I would like to thank you for the trust you placed in me. I would also like to say a few words of farewell.

In meteorology I have had the possibility of working in a sector in which I felt very much at home and which gave me a great deal of personal and professional satisfaction thanks to the support of outstanding staff. I was also lucky enough to work in a climate of excellent relationships between European and more generally worldwide colleagues. So leaving meteorology is not just a turning point in my working life, it also means leaving many friends in Europe and throughout the world.

The fact that today I have the opportunity to say goodbye to you here, at the Centre, is something which is full of meaning to me. I think it has been clear to all of you how closely and positively I have always followed the work of the Centre as Italian delegate. Indeed it could not have been otherwise for a number of reasons: as a young man I made a modest contribution to the COST action and to the drafting of the Schneider report which led to the creation of ECMWF; I saw a great spirit of European cooperation grow and I too gained much in my professional career terms thanks to ECMWF. I am convinced that the Centre had a major role in the development of European meteorology and I may say without contradiction that this applies to the Italian Meteorological Service too. These are the reasons for which it pleases me to say goodbye to meteorology in this setting.

For my personal future, as Harry Fijnaut said in his very kind farewell letter, I hope that my new job will keep me on my toes by forcing me to reassess myself and by taking me back full-time, even though with different responsibilities and at different levels, to my early passion for research and studies that I cultivated until the mid 1980s. And who can say that my path will not occasionally bring me back into contact with meteorology, given the key operational role that meteorology has played during recent regional crises in the Gulf and the Balkans. This has demonstrated how worthwhile it is to study future crisis management in Europe, not only in the areas of interest to Europe, but also in the light of potential developments for the management of the environment in Europe and in the world.

As to Italy's position vis-à-vis ECMWF, I can confirm together with my team today, the very great attention with which Italy will continue to follow the work and developments of the Centre in the conviction that it is a centre of excellence which must keep its world leadership in this sector. We have the best possible conditions in Europe for adding value to the large investments made in the observational sector. This is also the position of the Ministry for Higher Education and Scientific Research and Technology, which will continue to be represented by Dr. La Peccerella, whom I would like to thank for an excellent institutional and personal co-operation here at the Centre, just as in Italy. As many of you have already seen in Amsterdam at the Spring meeting of ICWED, this is also the direction taken by the present Director of the General Meteorological Office, General Epifani, who will continue to operate in the steering and advisory bodies of the Centre, probably with the support of the same outstanding colleagues with whom I was fortunate to cooperate, Dr. Sorani, Dr. Capaldo, Dr. Tarantino and Dr. Pasquini, whom I would like to thank in particular for their excellent and outstanding support they have always given me.

To you, Mr Chairman, and to all of you delegates, I express my heartfelt thanks for the way we work together in Council and more generally in Europe, with the wish to extend my farewell greetings also to those Directors who could not be here today. It is my wish that this cooperation will generate more results and lead to common progress.

To you, Mr Director, and to all of the staff at ECMWF, heartfelt thanks for having been able to bring the Centre to the present level of excellence and for what you will be doing in the future to improve even more the support that you provide to the National Meteorological Services.

I would like to finish with my personal best wishes for you and your families.

Thank you.

Carlo Finizio

Potential benefits of ensemble prediction of waves

In June 1998 the ECMWF atmospheric model was coupled to the wave model, and the daily wave ensemble forecasts became an operational product (see Janssen, Newsletter Autumn 1998). In addition to the deterministic forecasts of wave fields on a 0.5° irregular grid, a control forecast and 50 ensemble forecasts are produced daily on a regular 1.5° grid; the 50 members are generated by perturbing the initial atmospheric conditions by means of the most unstable singular vectors, but the initial wave fields are not perturbed.

The skill and economic value of ensemble forecasts of atmospheric fields was recently discussed by Richardson (Newsletter Summer 1998). Two issues are the reliability of the predictions, and the possible benefits that the forecasts could have for the user. There is a wide range of verification methods for monitoring the reliability of forecasts. However, because, in general, "large" regions (such as Europe or the North Pacific) are considered, extreme local events tend to be averaged out. This type of verification is performed on a daily basis at operational weather centres, both for atmospheric and wave parameters; there are also intercomparisons between weather centres of the relevant scores. Many user requirements relate to locally confined regions (e.g. a farmer wants to know about precipitation in the coming week or an oil-rig manager needs to know about the likelihood of a storm approaching). In contrast to these applications, the optimisation of ship routes is a commercial requirement in which wave forecasts are considered over a large area, but local extrema must be taken into account rather than being averaged out. Therefore, the potential benefits of ensemble wave predictions are most likely to be evident when these products are applied to the problem of ship routing.

Cost function for ship routing

The principal objective in numerical ship routing is to find the global minimum of a cost integral within the relevant phase space, where a cost function is integrated in time from the time of departure to the arrival time. The cost function depends on various variables that depend implicitly or explicitly on time.

In our case, the essential weather parameters are wind, wind waves and swell. The resistance of the ship depends on its velocity, as well as on the wave height, direction and period of both swell and wind waves and on the wind speed and direction. The main contributions to the resistance of a large container vessel arise from water friction upon the ship's hull and the effects of wind waves and swell, while wind resistance is quite small. To overcome the total resistance, the ship's engine is required to output a certain power at a given revolution speed. This process is connected to consumption values of fuel and grease. Multiplying these figures with the current price for fuel and grease, and by the integration time step, yields the cost of the ship route segment under consideration. However, sometimes the resistance can reach such high values that it is not possible to run the engine with a power output and a rotational speed compliant with the engine's limits. In this case, a large amount would need to be added to the costs to account for the additional wear and tear and potential damage to the machinery. These costs are too complex to assess accurately, but calculations are made in the current routing program to indicate that engine damage might have occurred. This enables routes along which engine damage is likely to occur to be distinguished from routes without engine damage in the following statistical analysis.

In addition to the ship's physical limits, there are economic constraints to be taken into account. Since the investment in a container terminal is so enormous it cannot be allowed to stand idle, and ships have to be as punctual as possible. However, if one is to minimise engine damage during the voyage, late arrival or early departure cannot always be avoided. The calculations of harbour costs are quite complicated because every single ship company contractor has to be taken into account. As a compromise, we penalise the lack of timeliness by a cost that is similar to the running cost of a ship.

It may seem from the above discussion that the calculation of the cost function is already complicated enough, but a full calculation would be even more complex. The only impact of waves upon the ship included in the cost calculation is their resistance, but wave motion may result in rotational forces with respect to the ship's three major axes of rotation (rolling, pitching and yawing), and there is also the vertical movement of the ship called heaving. These movements can be a serious threat to the ship and its cargo and ought, therefore, to be included in the cost function. This is, however, a very difficult task. Ocean currents are also not included in the cost function, although they may not always be negligible. However, they can mostly be neglected because of their confined spatial extent. In extreme events, currents may be decisive, however, and ought therefore to be included in operational ship routing programs.

Having established the required form of the cost function, there is still the issue of how to obtain the global minimum of the costs. A popular method is the conjugate-gradient method, but this can sometimes produce only a relative minimum rather than the absolute minimum in the relevant phase space, implying that the solution may depend on the choice of the first guess. This clear disadvantage of the gradient method may be avoided by using the so-called Bellman method. This method performs a more global search of the minimum by taking into account not only the direction of the gradient but also its magnitude and whether the gradient changes sign after a certain distance. We therefore have chosen this method although it requires more computer power.

Ensemble ship routing.

In order to assess the benefits of ensemble wave prediction, the ship routing software was run for the period 1 December 1998 to 31 March 1999, a total of 121 days. The route between Brest and New York was taken as an example, and it was supposed that the ships leave the port of Brest at noon (UTC) and arrive in New York 6½, days later.

The shape and the size of a ship are important parameters for route optimisation (obviously different optimisation criteria apply for a rowing boat and for a container vessel!) The current ship routing program takes the features of the container ship *Bonn Express* owned by Hapag Lloyd (maximum ship speed 22.8 knots, maximum power 24800 kW, length 235 m, breadth 32m and draught 12 m). These parameters are used as input to the propulsion routine, which models the ship's engine. It outputs two crucial parameters: the power that the ship's engine has to deliver in order to overcome the total resistance and the related engine revolutions. These two parameters are translated into fuel consumption, grease consumption and engine damage.

Although the Bellman method is designed to be first guess independent, it is beneficial to choose a first guess that appears to be reasonable, as it may influence the number of iterations to reach the minimum of the cost function. A good choice is the great-circle route, as this is the shortest distance between two points on the sphere and is the route the master of the ship would follow by default. Another reason for the choice of the great-circle route is that it coincides with the ERA15 climatology of ship routes.

As this study deals with the subject of how ship routing can benefit from ensemble forecasts, routes obtained by means of ensembles have to be compared with other forecast ship routes, as well as being scored against the optimal ship route for the analysed weather.

The weather defined by the operational analysis is assumed to represent the truth. Plots of the optimised ship routes for the analysis fields allow one to make a qualitative assessment of the accuracy of the predictions to be made by looking at the spatial deviations from the forecast ship routes. The analysis can be used to verify a forecast route by running a simulation of the ship's passage along the forecast route using the analysed weather. On days of severe weather, a forecast route can deviate substantially from its reference analysis route, and may indicate engine damage during the voyage. In reality, the captain would slow down the ship or would try to alter the course. In this study, however, a clear indication of how reliable the forecast ship route would have been is preferred and, therefore, any changes in position or speed that, in reality, would have occurred are not considered within the forecast verification.

When considering the benefits of ensemble forecasts for ship routing, the target is to find routes based on the ensemble-forecast results that outscore the routes optimised by using the deterministic forecasts. Therefore, the route obtained from the T319 operational deterministic forecast of ECMWF will serve as a benchmark against which ensemble forecasts will be evaluated.

The ship route based on the control forecast is verified separately over analysed conditions, but the ensemble member routes are not. They are further processed in order to yield a single ship route that can be used as an unambiguous recommendation. It is not a straightforward task to extract from the 50 members of the ensemble the information on the best route to take. Several methods have been tested. One attractive method is to construct the probability-density distribution of the ship routes, and to select the spatial route that corresponds to the highest probability. Another method uses a simple mean of the three-dimensional points (two spatial dimensions and time) of the 50 ensemble ship routes. However, the second method can fail, as will be illustrated by the following examples.

In the first case (Figure 1) no matter what forecast or method is used to obtain an optimal ship route, all perform equally well. It can be seen that the deviation from the climatological route for any of the routes is quite pronounced. In fact, while none of the routes would result in engine damage and the actual costs are relatively low, the climatology (which is the first guess) implies quite severe

Figure 1: Ship routes for the crossing leaving Brest at 12 UTC 22 February 1999 and arriving in New York at 00 UTC 1 March 1999. The caption explains the meaning of the different colours. This occasion provided good conditions for ship routing.
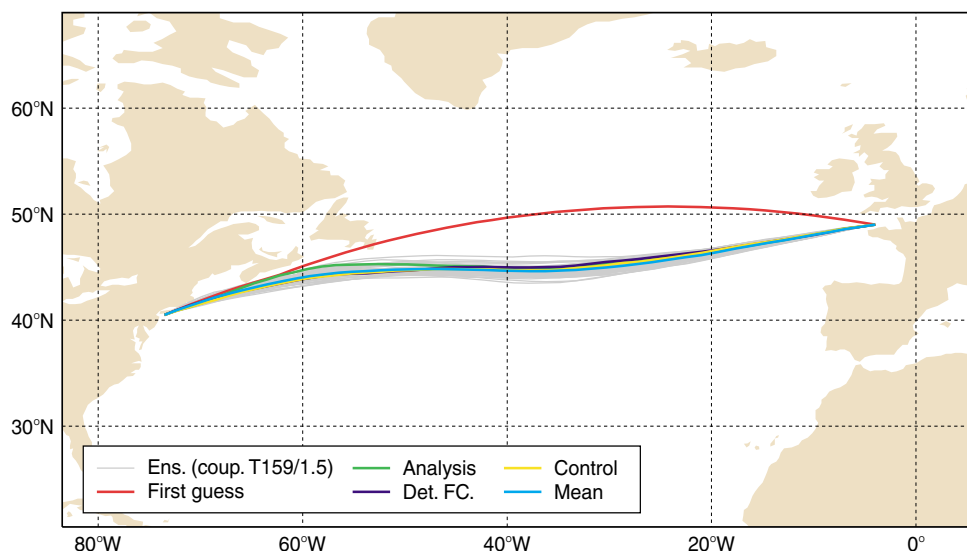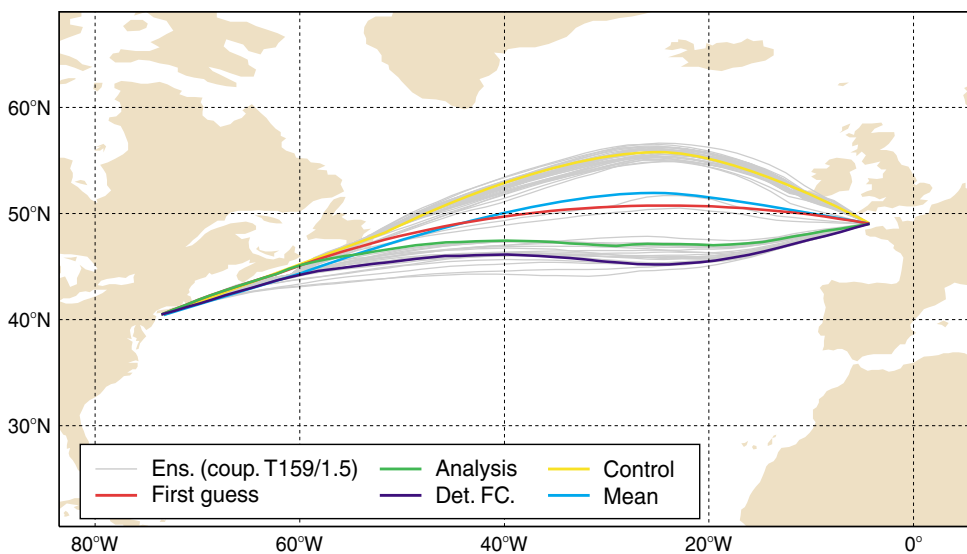
Figure 2: Ship routes for the crossing leaving Brest at 12 UTC 28 February 1999 and arriving in New York at 00 UTC 7 March 1999. Routing either to the north or to the south circumvents a storm centre. The ensemble-mean route method fails to provide an optimum track in these circumstances.

engine damage. In this case ship routing using the predictions would provide a valuable service and savings in costs up to 10% could be achieved.

The second case (Figure 2) is a very clear case of a bifurcation. Adverse weather in the middle of the relevant area causes most of the ensemble routes (including the control-forecast route) to deviate to the north, but some others opt to go south. It turns out that both the analysis and the deterministic forecast prefer the southern option, while the control forecast (which takes the northern branch) indicates some machine damage. The bifurcation around the axis of climatology, with approximately half of the ensemble member routes going to the north and half of them going to the south, causes the ensemble-mean route to be quite close to the climatology. When verified using the analysed weather it is evident that the ensemble-mean route (and the climatological route) runs right through the storm and, hence, provides the worst advice for the ship's track.

Although the method using the maximum of the probability-density function looks very attractive, when verified against the analysis for the whole winter season it did not perform particularly well compared with the deterministic forecast. The method using the ensemble mean of ship routes, however, provided a major improvement over the deterministic and control forecasts.

In order to assess the performance of the different forecast methods we considered several criteria, such as reduction in fuel and grease consumption, the frequency of occurrence of machine damage, safety, and to what extent the forecast method beats climatology. Here we concentrate on fuel and grease consumption because these are the most important parameters when assessing ship routing. Table 1 was computed for all ship routing forecast methods when none of them had any engine damage. It corresponds to quite favourable weather so that deviations from the climatological route were not very large. Note that in order to compare fuel or grease consumption of the different methods, it is necessary to filter out those cases where engine damage is indicated because the unrealistic power and revolutions of the ship's

engine that would be encountered would distort the calculations of fuel and grease consumption. Therefore, only 56 days out of 121 could be used. As a result, days where potentially the greatest benefits from the forecasts would be obtained (as in Figure 1) are not considered.

	Control Forecast	**First guess**	**Ensemble-mean**	**Operational forecast**
Fuel	0.74%	2.51%	0.54%	0.91%
Grease	0.65%	2.42%	0.48%	0.85%

Table 1: Average additional fuel and grease consumption as compared with the analysis.

Nevertheless, for the cases considered with favourable weather, the table already shows that there are some savings to be made. Whereas for the climatological (first guess) routes, over 2.5% more fuel has to be spent than from the analysis routes, only about half a percent has to be added when optimised by the method computed from ensemble-mean forecasts. Similar remarks apply to grease consumption.

However, the difference between the mean method and the other methods cannot be regarded as outstanding. A more convincing measure of the benefit of the ensemble method is based on counting how many days of the total period a certain method was the best (i.e. had the least total cost). It then turns out that the ensemble-mean route method performs best in 52% of the cases, which is significantly better than the control with 17% and the deterministic forecast with 20%. The climatology never performs best.

Summary

It has been shown that it is possible to get information for ship routing from the ensemble forecasts. Nevertheless, ensemble ship routing is only beginning. It is therefore expected, that in the near future other methods will be developed, which are able to extract more information from the ensemble forecasts. Presently, it seems that the ensemble

mean route method performs best. In cases where this method is most likely to fail (e.g. when there is a bifucation) one could simply choose another method.

The ship routing described in this paper is a research project. It was set up to show whether, and how, ship routing could benefit from ensemble prediction of wind and waves. There are some prominent differences to operational ship routing because the rotational motions of the ship and their effect on the ship and the cargo are not included in the cost function. Although this may not be so relevant for the statistical considerations in this article, it can be serious

for a real ship in specific conditions. Also, the forecast was not updated during the 6½-day crossing. Although this was useful in this ship routing project to enhance uncertainties of weather prediction, in today's operational ship routing business, with proper means of satellite communication, updates of the current optimal ship route are done regularly.

Peter Janssen

METVIEW
Meteorological data visualisation and processing software at ECMWF

Metview is the ECMWF's meteorological data visualisation and processing tool. By virtue of its design and extensive range of features, Metview can act as a complete working environment for the operational and research meteorologist by providing powerful data management visualisation and processing tools. It can be seen as a meteorological desktop plotting package, thanks to its WYSIWYG visualisation, but it is also a powerful meteorological data-processing software thanks to its macro language, and can be used for routine production of meteorological charts in an operational environment.

Metview is based on ECMWF software for data access (MARS) and graphics (MAGICS). These reliable "work-horse" applications were in routine use at the time of Metview development and provide its underlying data retrieval/handling and plotting capability.

Metview's user interface is based on MOTIF and the X Windows system. Metview was designed for the UNIX environment and it is highly portable within the UNIX world. At ECMWF, Metview is used on SGI systems, but elsewhere it has been installed and performs operational work also on SUN, HP and DEC workstations. It has recently been ported to LINUX/GNU, thus widening considerably its potential for deployment by being able to run on comparatively very low-cost hardware. Metview has a modular architecture and was conceived as a fully distributed system, its modules being able to run on different machines

Metview was developed as part of a co-operative project between ECMWF and INPE/CPTEC, Brazil with assistance from Météo-France. The development of Metview started in 1991 and the first release became available to internal ECMWF users in December 1993. Metview was released to ECMWF Member States in October 1995. It is now used in most Members States, plus Brazil and Australia.

Since this first release, Metview has gone through a number of operational versions, all of which were structurally similar. Metview has now undergone its first major structural revision embodied in the new version about to be released. This article presents Metview to a first time user readership.

Readers already familiar with Metview will note the modifications it has undergone.

Metview's new version presents a revised main User Interface with improved functionality where user customisation was a main priority. The greatest changes are in the visualisation tool, which was completely rewritten from scratch according to a different design principle. Internally extensive rewriting, streamlining and simplification of the code took place, which will make Metview easier to extend and maintain.

The Metview icon Concept

Metview can be described as a tool working on archived data (model fields, observations, user data) to produce either:
◆ a visualisation of the data or of a derived parameter (on screen, on file, on paper) - this can vary in complexity and format (from a contoured geographical field to an x-y plot; and/or
◆ a file on disk containing the retrieved data or some derived data - the file can be binary or ASCII and its content can vary in complexity.

The process from original data to final output constitutes a Metview task. This can range widely in complexity but the important concept is that:
◆ any Metview task can be decomposed into separate steps arranged in a logical sequence;
◆ each step is defined (specified) by the user - these definitions are represented in the GUI by Metview icons. The user operates on these icons to carry out each step.

Metview icons (definitions) are the components of Metview (from the user point of view). In fact, the design principle (paradigm) of Metview can be summarised by:
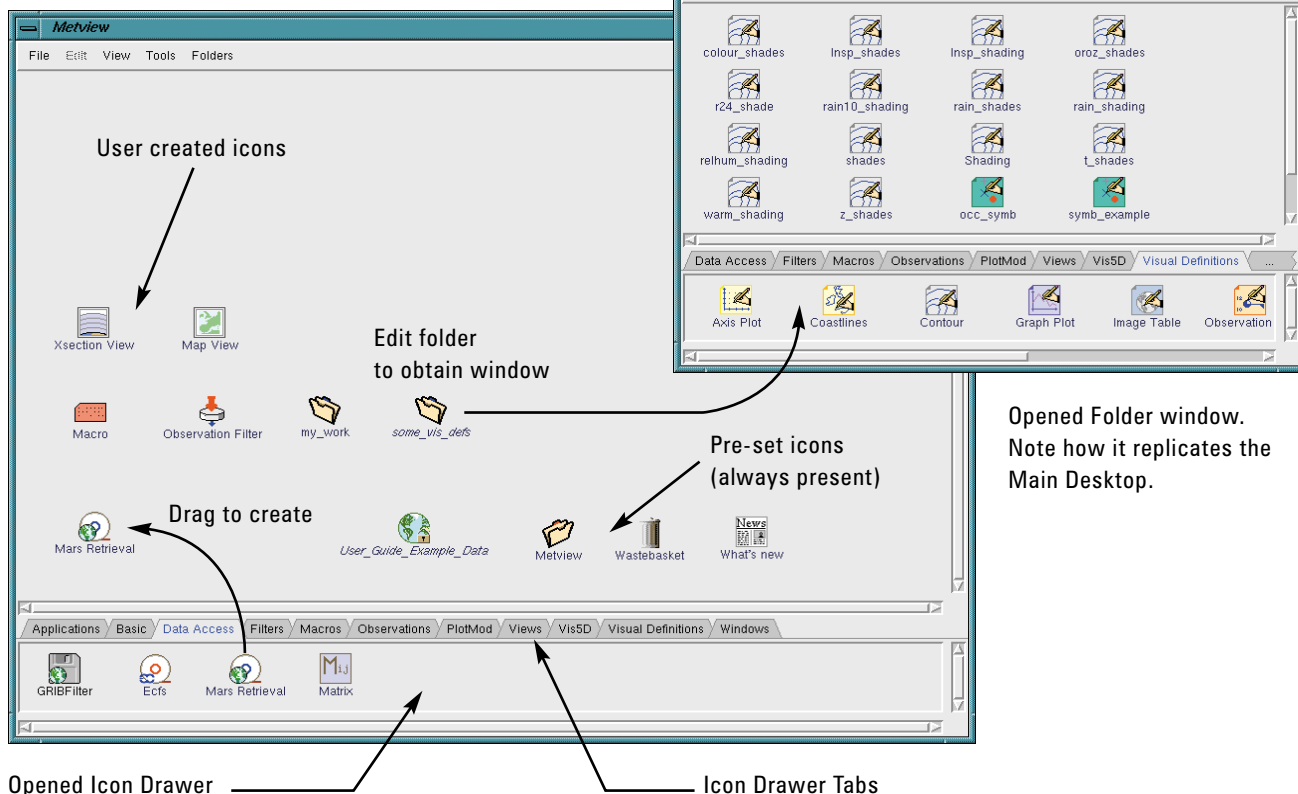
Everything in Metview is an icon,

while the operating principle of Metview is:

Every Metview task is a sequence of actions on icons.

This article shows how these principles are realised in practice.

The Main Desktop

Figure 1. The Metview User Interface or Desktop. The four icons on the lower right part of the main window are predefined and always appear on start up. Folder icons open to reveal a new (replicated) desktop. Folders can be symbolic links, in which case their name appears in italics. Some examples of user created icons can be seen in the desktop. Every user task is carried out by means of operations (actions) on suitable icons. Icon templates are kept in icon drawers from where they can be dragged to create new instances on the user desktop.

The Metview Environment

Users launch Metview from a UNIX command line with the following command:

% metview

The first thing a user sees is the Metview Desktop as shown in Figure 1. Within this desktop you have icons and these can represent actual data, data requests, processing or plotting specifications, macro programs and applications.

Metview aims to create a complete interactive working environment. You can conceivably work exclusively on the Metview desktop. Metview icons can represent your working elements, from scraps of text to GRIB files, database requests, data filters, plotting specifications, etc. You can run UNIX shell scripts and Metview includes its own Mail tool with a facility for seamless sending of icons, so you can communicate with colleagues (e.g. exchange data and macros) and developers (e.g. questions, bug reporting).

What you see as the main desktop is in fact a UNIX directory, called **metview**, residing on your root directory. Every folder within the main user desktop is a sub-directory of this **metview** directory.

Given that symbolic links within the metview directory are also recognised as folders in the main user desktop, you can have your scratch space, or some data storage directory, present on the desktop. Its contents (for instance GRIB files) are transparently accessible to the user's visualisation and processing work. Should suitable permissions be in place, you can access other user's directories within the Metview desktop, thus facilitating exchange of work and ideas between users. Metview can handle several data/file types:

◆ GRIB for fields and satellite images
◆ BUFR for observations
◆ ASCII matrices of lat-long gridded data
◆ Geopoints (sets of irregularly spaced data points in ASCII)
◆ NetCDF for data other than model fields and point data (e.g. cross sections)

Users create most of the icons themselves. However, if a file is copied or brought in to the metview directory (or one of its subdirectories) it is automatically assigned an icon. There are a few file types which are recognised and automatically assigned a specific icon – those that Metview can handle (see above) plus shell scripts, PostScript files and plain text files; otherwise a generic binary file icon is used.
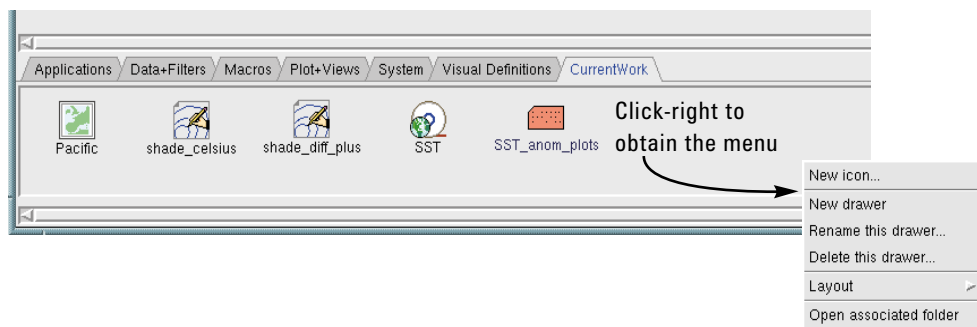
Figure 2: Example of a user-customised group of icon drawers. Note the renaming of most drawers, deletion of others the user will not use, and the creation of a drawer for a user project containing icons pre-specified with required parameters. The icon drawer menu shown on the right provides most of the functionality for these changes.

a) MARS Retrieval editor

b) Simple Formula editor

c) Macro editor
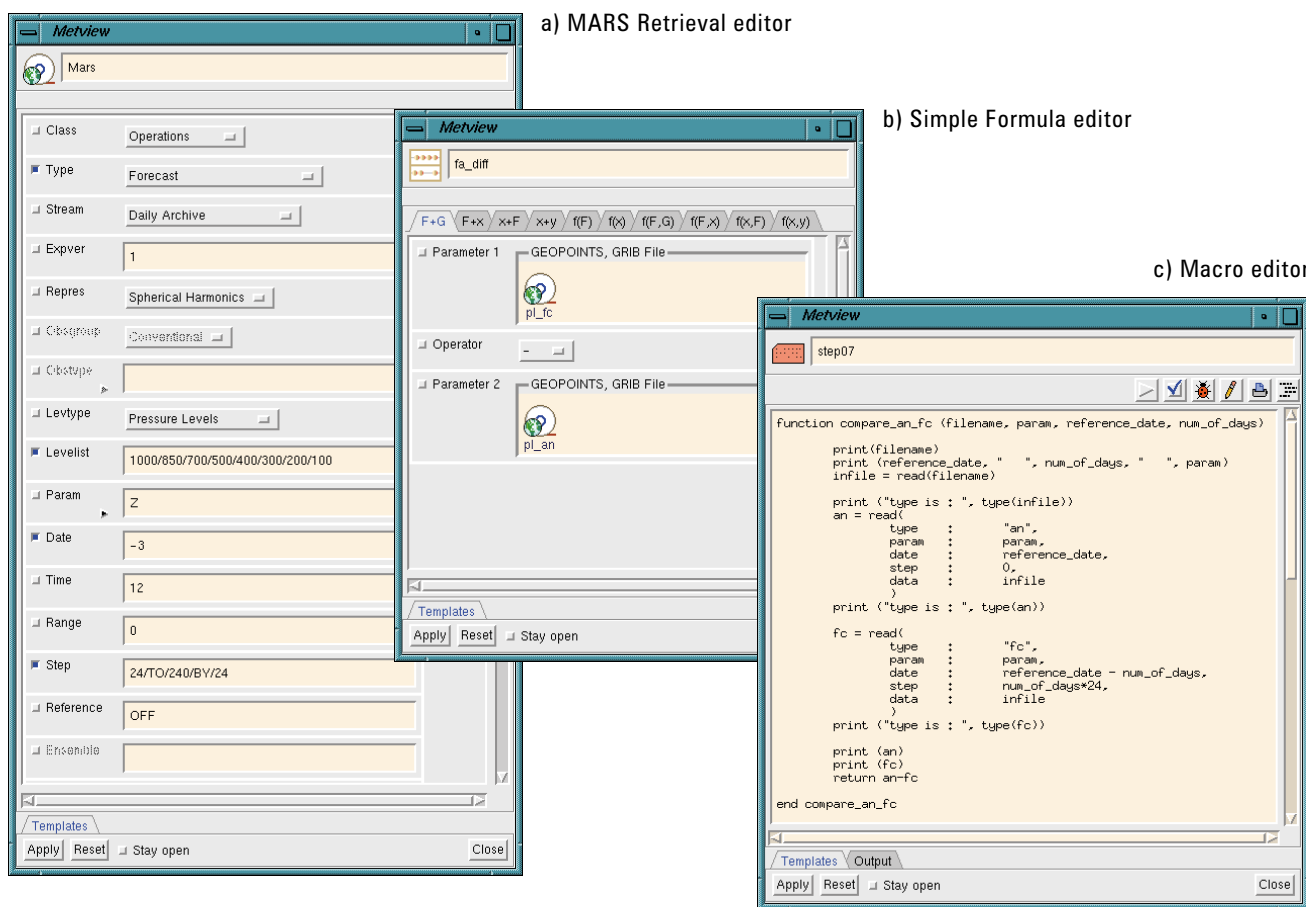
Figure 3: Examples of icon editors – (a) a standard editor (MARS Retrieval) with parameters set by means of text boxes and option menus, (b) a family editor (Simple Formula) with different interfaces in the same editor each selected by its own tab and (c) a macro editor, a plain text editor with extra functionality for code development (top row buttons).

Working with Metview Icons

The fundamental unit of Metview is the icon. Here we see how users can create icons and how one operates on icons to achieve a given outcome.

As you can see in Figure 1, icons are arranged in icon draw-ers. Each drawer reflects the icon types it contains, so you find drawers for visual definitions, for data icons, for macro-like operators, etc. You have full control over the arrangement of the drawers on your desktop and you can:

◆ name drawers;
◆ create new drawers;
◆ delete existing drawers.

The drawer contents are also subject to customisation. You can:

◆ remove or rename icons;
◆ transfer icons from drawer to drawer;
◆ transfer user created icons from the desktop to a drawer.

So you can group icons according to your own convenience and even create customised icons and group them in draw-ers to act as user icon libraries – e.g. you may have a drawer for specific types of data retrievals, or geographical areas, or plot window layouts (see Fig. 2)

Icons can be created by:
◆ dragging from an icon drawer to the main or folder desktop (as shown in Figure 1);
◆ clicking-right on a desktop or a drawer – this launches an icon list from where the required icon can be created by clicking on it;
◆ duplicating an existing (similar) icon of the same type and modifying it accordingly.

Once the created icon appears on the desktop, it must be edited to conform to your requirements. The icon editor window allows you to enter values for parameters by means of text entries, option menus, toggle buttons, icon drop fields and colour editors. Once you save and exit, the icon is then ready to be operated upon.

All Metview (interactive) work is carried out through actions (operations) on icons. To operate on an icon you click right on the icon and choose one from:

Execute Visualise Examine Save Drop Edit Duplicate Delete

The type of icon determines which actions apply to it. The last three actions in the list above apply to all icons and are self-explanatory. The first five are not applicable to all icons - e.g. you can't *Visualise* a visual definition icon since this type of icon only specifies how to contour data.
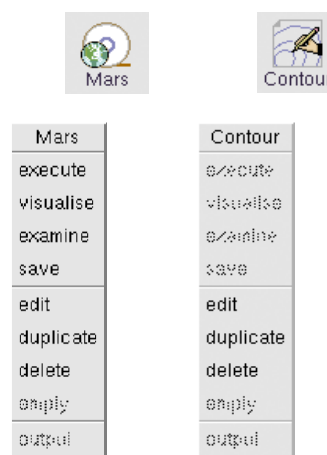
Visualisation in Metview

The visualisation concept in Metview has changed considerably from the current version to the new version. Previous functionality has been kept (e.g. point value query, re-projection and re-sizing,...) while new capabilities were added. The most striking new capability is the ability to display different types of plots in any arbitrary layout featuring effective WYSIWYG. Users may now display concurrently:
◆ 2-dimensional geographical plots - meteorological fields, observations, station locations, satellite images;
◆ cross-sections along defined spatial limits;
◆ tephigrams;
◆ vertical profiles of parameters for points or areas;
◆ time series of parameters for a given point;
◆ curves derived from users' data.

Figure 4: Examples of icon menus. The menu presents a choice of action to the user. Some actions may not be available as you can see from the menu on the contour icon.

Throughout, we refer to *visualisation* in a broad sense to include:
◆ on-screen display with interactive facilities;
◆ output to file, in PS (for printing) and PNG formats (Web publishing, presentation);
◆ hard-copy print-out (paper/transparency).

Central to the new visualisation module is the concept of a (plotting) view. Essentially, the view specifies how to plot a given data. For example, from a data unit composed of multi-level sets of fields for a number of forecast steps, a user can produce a set of 2D geographic fields, a time series of cross sections or vertical profiles or a set of time series plots for each level. Users have a view for each of the plots they may want to prepare from the data. Currently Metview provides:
◆ **Map View** (for 2D geographic plots) the user specifies area and projection;
◆ **Cross-Section View** (for cross-section plots) user specifies the geographic co-ordinates of the extremities of a line;
◆ **Vertical Profile View** (for vertical profiles) user specifies the geographic co-ordinates of a point or small area;
◆ **Curve View** (for plotting any x–y sequence of points, from trajectories to time series).

Icons for layout and plot control

Icons for retrieval and computations

Icons for plotting specification

Figure 5: Folder storing icons involved in a project, in this case a plain forecast-analysis difference. The icons present have just been dragged from their drawers. They will now be edited and modified according to requirements.
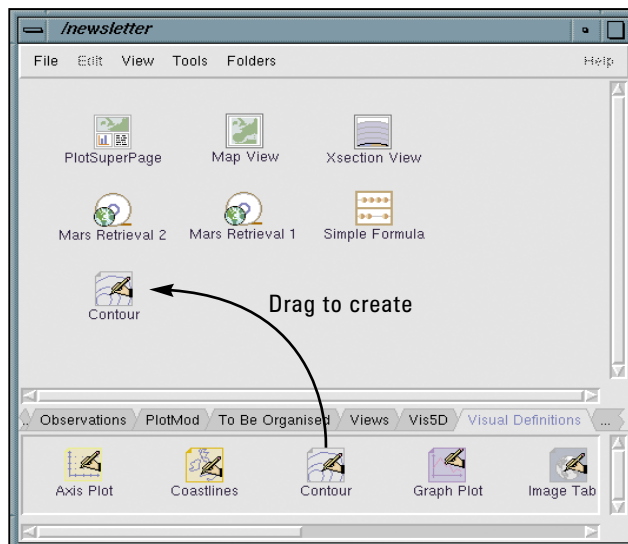
The principle behind the Metview visualisation tool is that the user specifies how he/she wants the data to be plotted by means of a view and is able to mix different views in the same display/paper sheet. The data unit passed to the display window will generate the appropriate plots, cascading through the different plotting perspectives. Users can still visualise data icons directly, without specifying anything relative to layout or view, in which case suitable defaults apply (e.g. single map plot on A4 landscape).

To clarify how Metview works, let us go through a schematic visualisation – visualising (forecast-analysis) differences both as a map over a given region and as a cross-section along a given transect. We'll create a folder for this task and create the icons inside it by dragging from their drawers (see Figure 5). Having assembled the icons, they have to be edited to conform to the user's requirements

To derive an forecast-analysis difference, a user has to retrieve forecast and analysis fields (at multiple levels) using the **MARS Retrieval** icons and compute their difference with the **Simple Formula** icon. Preparation of the forecast data icon is exemplified in Figure 6 as a sequence of edit-modify-save actions. Once the icon is prepared it can be used, in this case as input for a **Simple Formula** icon.

The **MARS Retrieval** icon is used for retrieval of any data present in the archives. Other institutions will have to adapt to their own archive/database retrieval procedures during Metview installation, but the principle will remain the same. Here we are using the **MARS Retrieval** icon as input to another icon, but you could have visualised its specified data directly or you could have used the **Save** action to obtain a GRIB file with that data.

The **Simple Formula** icon is a general icon for simple calculations with fieldsets, point values and scalars. You can specify an operation between fields, fields and point values, fields and scalar values, functions of scalars and functions of fieldsets. The icon can be used as input to yet another icon, visualised or saved to derive a GRIB or geopoints file with the result of the calculations. The **Simple Formula** icon illustrates an important Metview feature – many icons take data icons as input. These *embedded* icons are automatically activated upon operating on the external icon.

Similarly, the **View** icons have to edited and modified from the original defaults to the requirements. In this case we specify a cylindrical projection European window from (70°N, 20°W) to (20°N, 40°E) (top left, lower right) for the **Map View** and a line from (20°N, 20°W) to (70°N, 40°E) for the **Cross Section View**.

In order to define how the final plot will look, the visualisation window is specified with a **PlotSuperPage** icon. Edit this icon to reveal its graphical interface (see Figure 7). The editor allows users to define the size and orientation of the plot surface and divide the plot surface into any arrangement of arbitrarily sized fractions. In this example, we'll define an A4 landscape plot divided vertically in two equal sized plots. The result is saved under the name **map_xs**.

Contour icons specify how you want the plots to be contoured. The editor provides for a wide-ranging choice of types, using lines, shades and patterns. Since we are plotting differences we specify a contour such that very small differences are not plotted, positive differences (forecast warmer than analysis) are plotted in warm tones and negative differences (forecast colder than analysis) are plotted in cold tones.

Metview provides visual definitions other than contouring. Users have available definitions for meteorological observation plotting, symbol plotting, wind arrow/barb plotting, coastlines, plot axis, x-y curves and satellite images.

Once the **Plot Page** icon is prepared, you can carry out your visualisation. Following the example above, you would execute or visualise the plot page icon. Once the plot surface is up you can drop the **Simple Formula** icon inside each panel, followed, or in conjunction with, the contour icons.

The result is shown in Figure 8 and shows how you can visualise the same data concurrently in different perspectives. You can lay out your visualisation the way you want it and mix any views you require.

Each plot division can function independently of each other using its own data, views and contours. The plot window is equipped with features to ease your on-screen analysis. These are detailed in the next section and include:

◆ zoom and magnification;
◆ on screen manipulation of the visualisation via direct access to component icons;
◆ simultaneous animation of different plots;
◆ browsing through a stack of fields;
◆ re-projection and windowing of visualised data;
◆ querying of point values;
◆ printing of visualisation (WISIWYG).

Visualisation features

Once you have a visualisation up and running, you can use the features offered by the visualisation tool to help in your analysis. These are exemplified below, using different visualisations:

Zoom and magnification

These tools are available from action buttons on the plot window button. They lead to different results, in that a magnification is a purely graphic process while a zoom leads to re-calculation of the plotting (see Figure 9).

Querying point values

To check the value of fields at any location, or the values of plotted observations, the plot window provides a point tool. Click on its button, then anywhere on a field or on an observation location to produce, respectively, the interpolated field value at that location or the values of the observation parameters printed to a floating window, as shown in Figure 10.
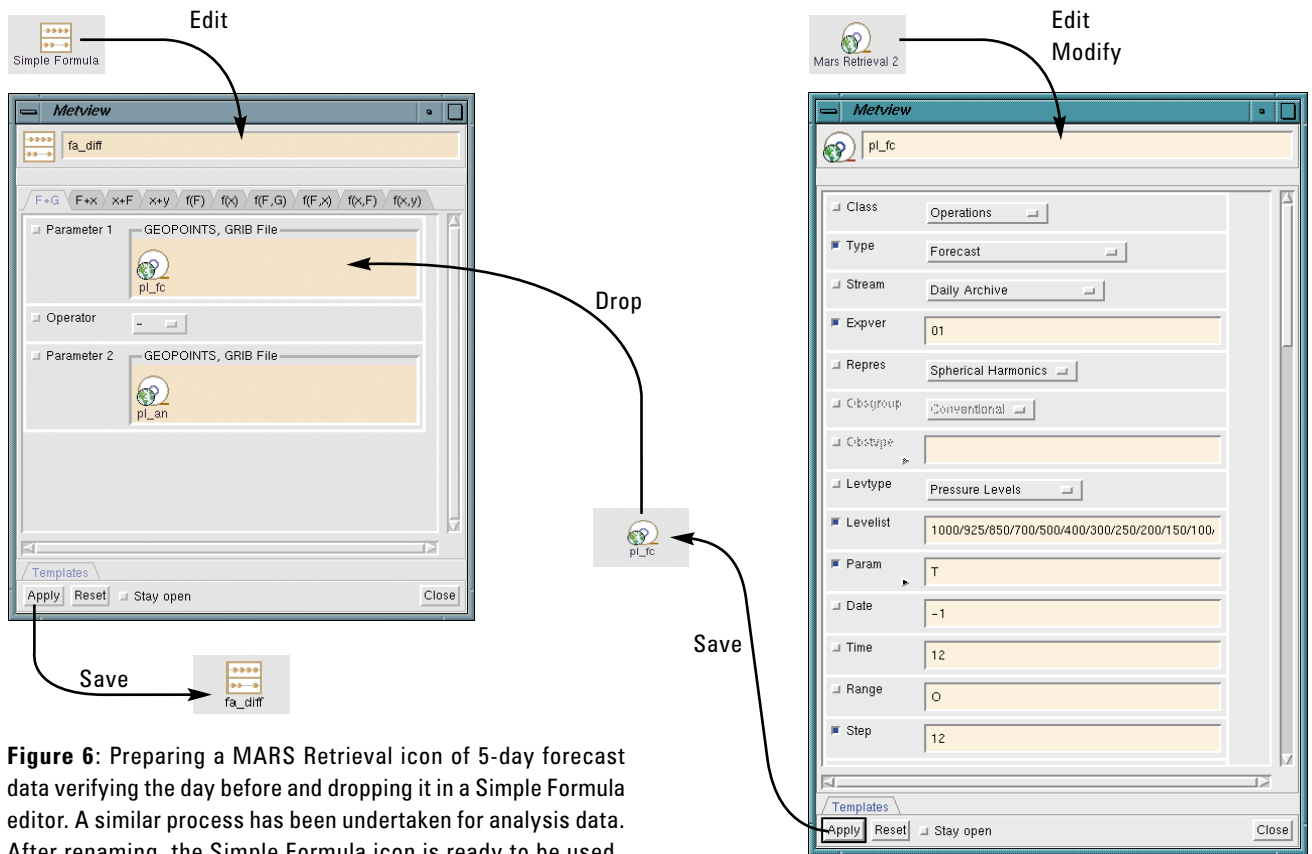
Figure 6: Preparing a MARS Retrieval icon of 5-day forecast data verifying the day before and dropping it in a Simple Formula editor. A similar process has been undertaken for analysis data. After renaming, the Simple Formula icon is ready to be used.
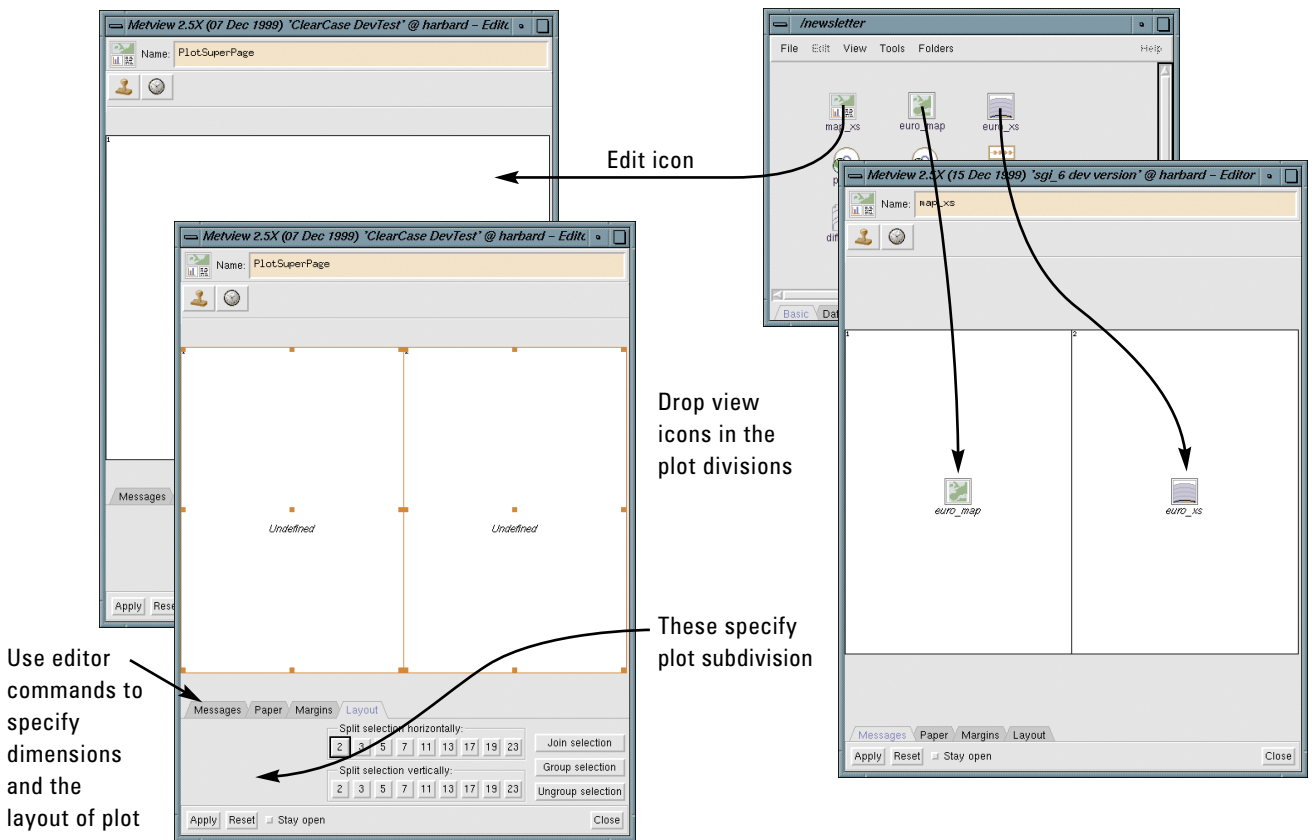
Figure 7: Interactive preparation of a visualisation layout. The initial blank plot surface is sized to A4 landscape and then subdivided in two vertically. Subdivision is achieved by selecting one or several rectangular regions and clicking on numbered buttons. Once this is ready, users can drop view icons in the subdivisions according to their needs.

Visiualise the plot page icon

Plot window commands

Drop the formula and the contour icons

Contents and Control drawers
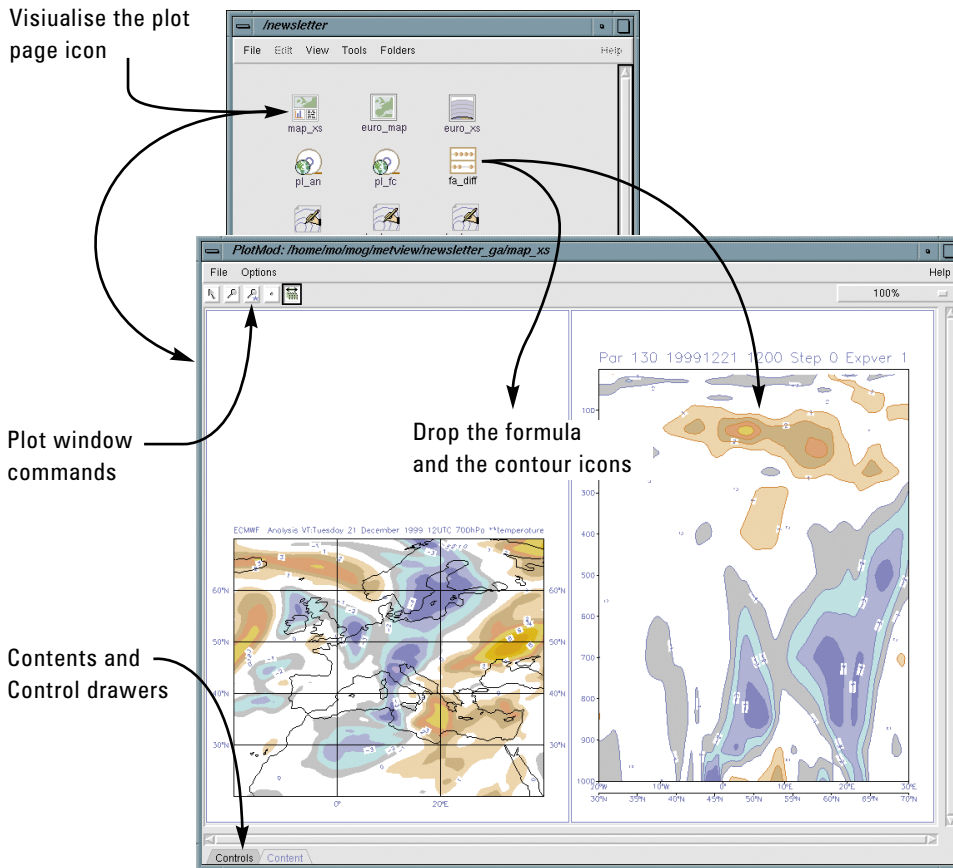
Figure 8: Result of a simple visual-isation: forecast minus analysis differences as geographical fields (left) and cross-section (right). Visualise the plot page icon and then drop the data and contour icons to derive the visualisation. The two plots can have indepen-dent contours and title styles.

Magnification: (on separate window)
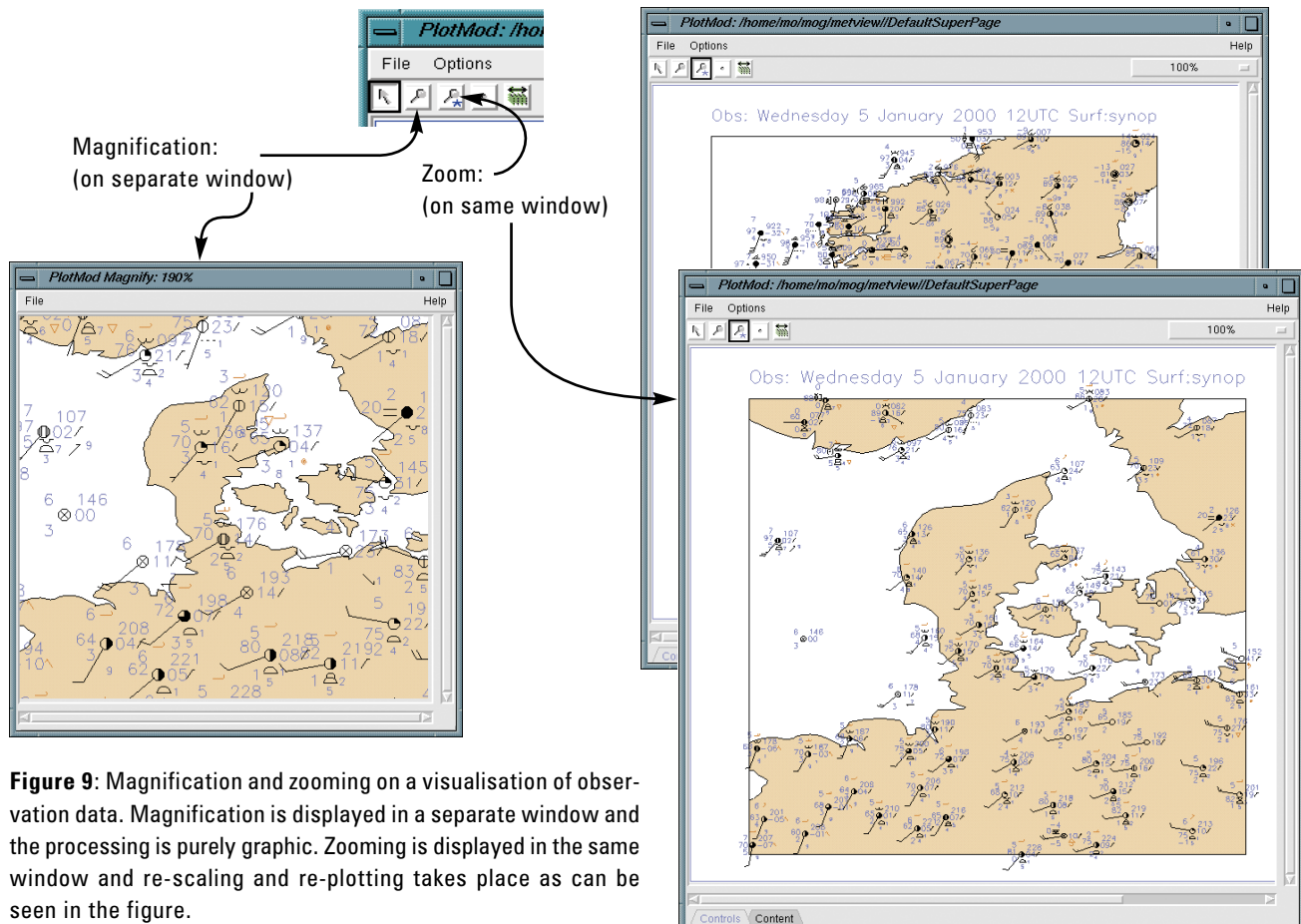
Zoom: (on same window)

Figure 9: Magnification and zooming on a visualisation of obser-vation data. Magnification is displayed in a separate window and the processing is purely graphic. Zooming is displayed in the same window and re-scaling and re-plotting takes place as can be seen in the figure.

Point tool button
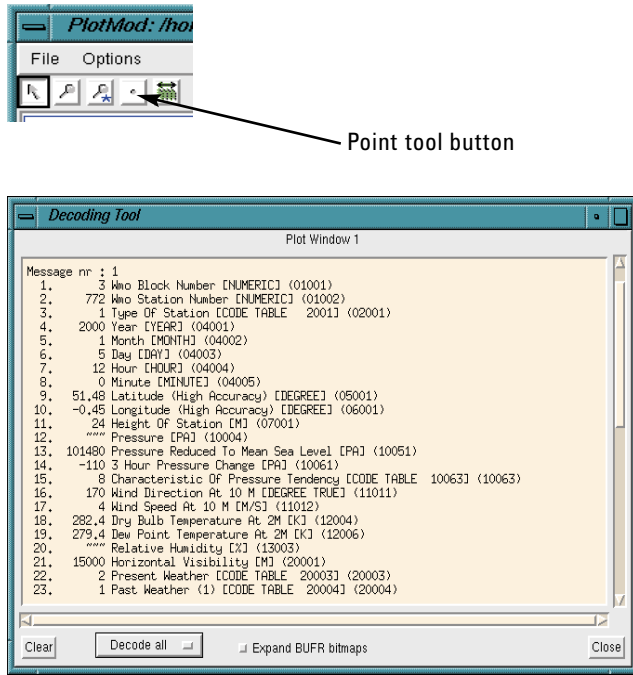
Figure 10: Example of point tool output from a visualisation of observations.

Click to open and close

Icons of the global plot

Icons of the component plots
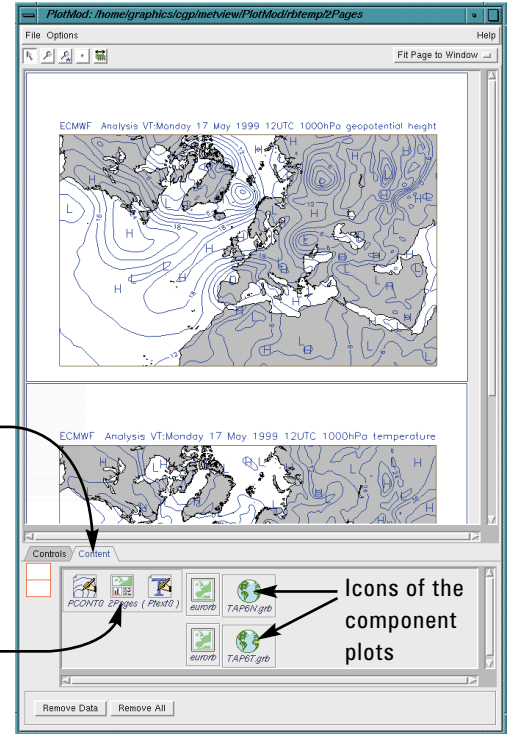
Figure 11: A sample visualisation with the contents window open. The left-most rectangle contains the icons valid over the global plot. The two areas on the right contain the icons that apply to each component plot.

Once data is loaded you can control the animation of the data

Click to open/close

Meter shows progress of data loading

Once data is loaded, pick any field from the drop list. The drop list provides information on the data available.

Figure 12: A sample visualisation with the controls window open to allow users to browse through a long data sequence or animate it. You can animate each plot division independently.

Visualising contents

As you have seen there are a number of icons involved in a visualisation. You require a way to manipulate each one of them individually. This is the case when you are modifying a view, tweaking a contour definition, a coastline or an axis. You may also want to add a new icon or remove an existing one. Access to visualisation components is provided through the *contents window*. As the name implies it shows you the contents of the visualisation, i.e. the icons and how they are organised in order to produce what you see on the screen. The contents window organises the component icons in rectangular areas, one for the global plot and one for each of the component plots (see Figure 11). The plot window icon is shown for reference, since it can't be modified or removed. The data icons can't be modified but can be removed. All other icons can be modified and removed. You can drop new icons in the plot rectangles – depending on which one you drop the icon in, different modifications aris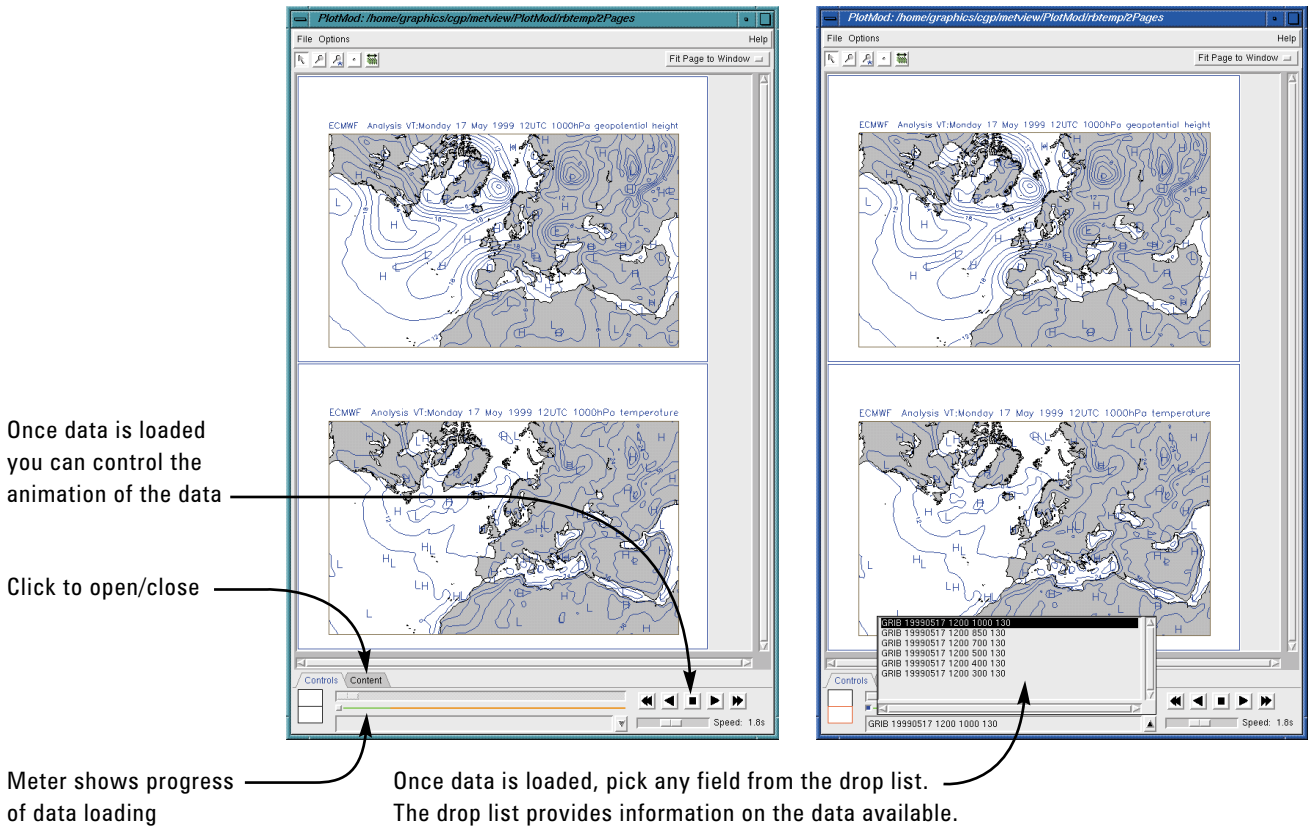e on the plot - e.g. drop a data icon on the global plot contents area and the data is plotted on all component plots (cascading through the views). You can associate contour icons with a given plot or make them apply to all plots.

Animation and browsing

When you load a long sequence of fields on a visualisation, you may want to animate the sequence (e.g. a temporal sequence). You may also want to browse through the sequence, i.e. being able to pick any field in the sequence. The plot window has a *Controls* drawer which provides controls for both browsing of the data set and controls for animation (start, stop, advance, rewind). Figure 12 provides details.

Other Metview Features

Metview offers an extensive range of features that allow a meteorologist to use it as a complete working environment. These include not only an extensive range of pre-defined application (icons) but also built-in utilities.

Metview provides its users with the facilities to communicate and exchange work samples with other users and development teams. This achieved by means of two built-in applications, Metview Mail to send and Metview News to receive information.

◆ **Metview Mail** is a simple mail tool developed to send (not receive!) messages from Metview users to other people, other Metview users, and user support and development teams. Its distinguishing feature is the ability to send icons as attachments (automatically unencoded), which can then be extracted at the destination address. It enables one user to demonstrate work results to other users. It may be used in co-operative tasks, sending bits of work back and forth between participants. Any number of icons can be mailed, and icons used as input to the mailed icon are also mailed. Mailing a folder icon will also mail all icons contained in the folder (which is a convenient and effective way to send groups of icons). A simple example is shown in Figure 13.

◆ **Metview News** is the application used to read Metview mail messages, provided the incoming mail has an icon in attachment. For messages without attached icons, use your UNIX mail server. Metview News is also used to install predefined examples, short tutorials and information on new features. The tool is launched from the **What's New** icon on the main desktop (one of the preset icons always present – see Figure 1).

SENDER: address and write the mail; drop the icon in the icon field
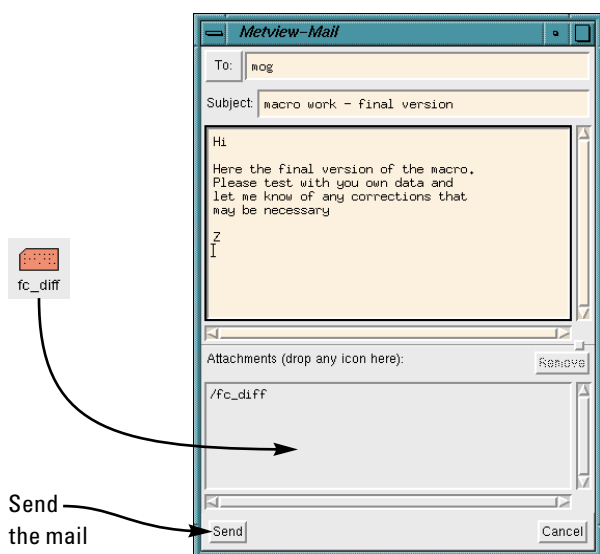
RECIPIENT: select received mail to read its contents
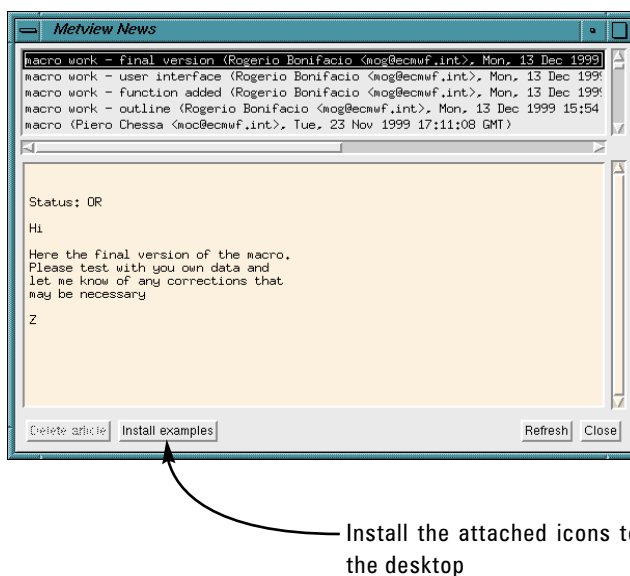
Figure 13: Working with Metview Mail and Metview News to send/receive messages and interchange icons. Your Metview administrator may also place in News some examples and short tutorials for self practice and study.

Metview provides two levels of user help:

◆ **A context sensitive *online help* system**: To activate, position the mouse pointer over a target (which may be an icon, a button, the toolbar, a menu choice, the desktop) and press **F1**. A window with hyperlinked information about the chosen target will appear.

◆ For more in-depth help, the Metview installation provides a set of *HTML manuals* that can be viewed with your system's web browser. The HTML manuals have an equivalent normal text version, provided as a set of PS files which institutions can print out to their users. The manuals are divided in three volumes, the first on general Metview usage, the second on the Metview macro language and the third an icon reference.

More direct help can be had by a built-in *Bugs Report* utility. This is simply a pre–addressed mail message, where you describe your problem and drop the troublesome icons.

Metview includes a number of meteorological applications as icons, covering a wide range of tasks. Applications are understood to be icons which can produce a new dataset from some input data. These data can be saved to a (NetCDF format) file on disk, or can be simply visualised – note that there is no difference between visualising a set of model level GRIB files in a cross-section view and visualising the result of a cross-section application on the same data. However, only the cross-section application allows you to save the cross-section data.

The Metview applications include:

◆ **Formula/Simple Formula** – for simple mathematical computations of GRIB fields (more complex manipulation should be done in Metview Macro);

Figure 14: Metview HTML manuals – equivalent printed version exists as well.

◆ **Cross Section** – derives a cross section from pressure- or model–level fields;

◆ **Average** – derives a zonal average from pressure or model-level fields;

◆ **Vertical Profile** – derives a vertical profile from pressure- or model-level fields for a point or a rectangular area;

◆ **Tephigram** – generates tephigram plots from either model fields or observations;

◆ **Potential Temperature** – derives potential temperature, equivalent potential temperature and saturated equivalent potential temperature from model-level or pressure-level fields of surface pressure, temperature and humidity;

◆ **Vector Family** – derives vector fields from scalar fields of *u* and *v* components (Cartesian co-ordinates) or intensity and direction (polar co-ordinates). Option to colour vector arrows according to a third field (e.g. colouring wind arrows according to temperature);

◆ **Budget Family** – calculates and plots various budget quantities (atmospheric energy, surface energy, hydrological and top radiation);

◆ **Spectra** – generates plots of spectra as a function of Legendre polynomial order;

◆ **Velocity Potential/Streamfunction** – derives fields of velocity potential or streamfunction from input fields of divergence or vorticity;

◆ **Rotational/Divergent Wind** – derives fields of divergent or rotational wind vectors from input fields of divergence or vorticity;

◆ **Data Coverage** – generates plots and files of observations according to their quality and arrival time.

An element lacking in previous versions of Metview was the ability to produce 3D visualisations. Rather than developing such facilities from scratch, it was thought that a far more fruitful and inexpensive approach would be to integrate Metview with some other software with 3D capability. Given its features, free availability and wide user community, the strongest choice was Vis5D from the Space Science and Engineering Centre of the University of Wisconsin – Madison's Graduate School **(http://www.ssec.wisc.edu/~billh/vis5d.html)**. A co-operative venture was established between ECMWF and SSEC in order to integrate both pieces of software.

Metview was equipped with features that enable it to talk to Vis5D and Vis5D was enhanced with the ability to accept Metview icons. Vis5D is controlled via TCL/Tk scripts, so a drop of a Metview icon translates the icon's content into TCL/Tk. Metview provides the interested user with a set of Metview icons specially designed to work with Vis5D. The approach from the point of view of a Metview user is to use Vis5D as if it were a Metview application. This is to say that a Metview user can do all the data retrieval and processing within Metview and then launch Vis5D via a Metview icon.

The simple example in Figure 15 shows that you are able to control Vis5D by means of Metview icons, i.e. you can drop Metview icons that specify how Vis5D will display
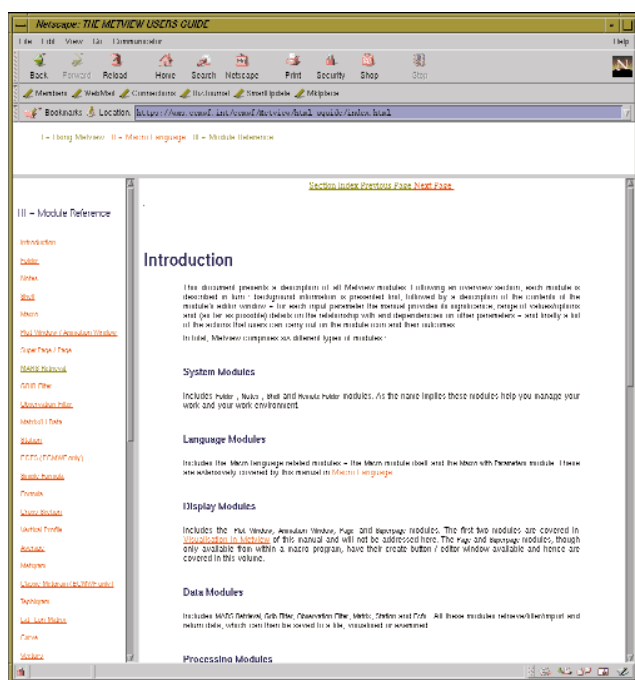
your data. Further data icons can be dropped in the Vis5D window. This allows you to use Vis5D without in–depth knowledge of this software thus satisfying those who only have episodic need of Vis5D abilities. On the other hand, Metview users expert with Vis5D can use Metview for retrieval and computations of data and then, once Vis5D is launched, use it as a stand–alone element. Also, since you can control Vis5D with Metview icons you can also make Vis5D run from Metview macro programs.
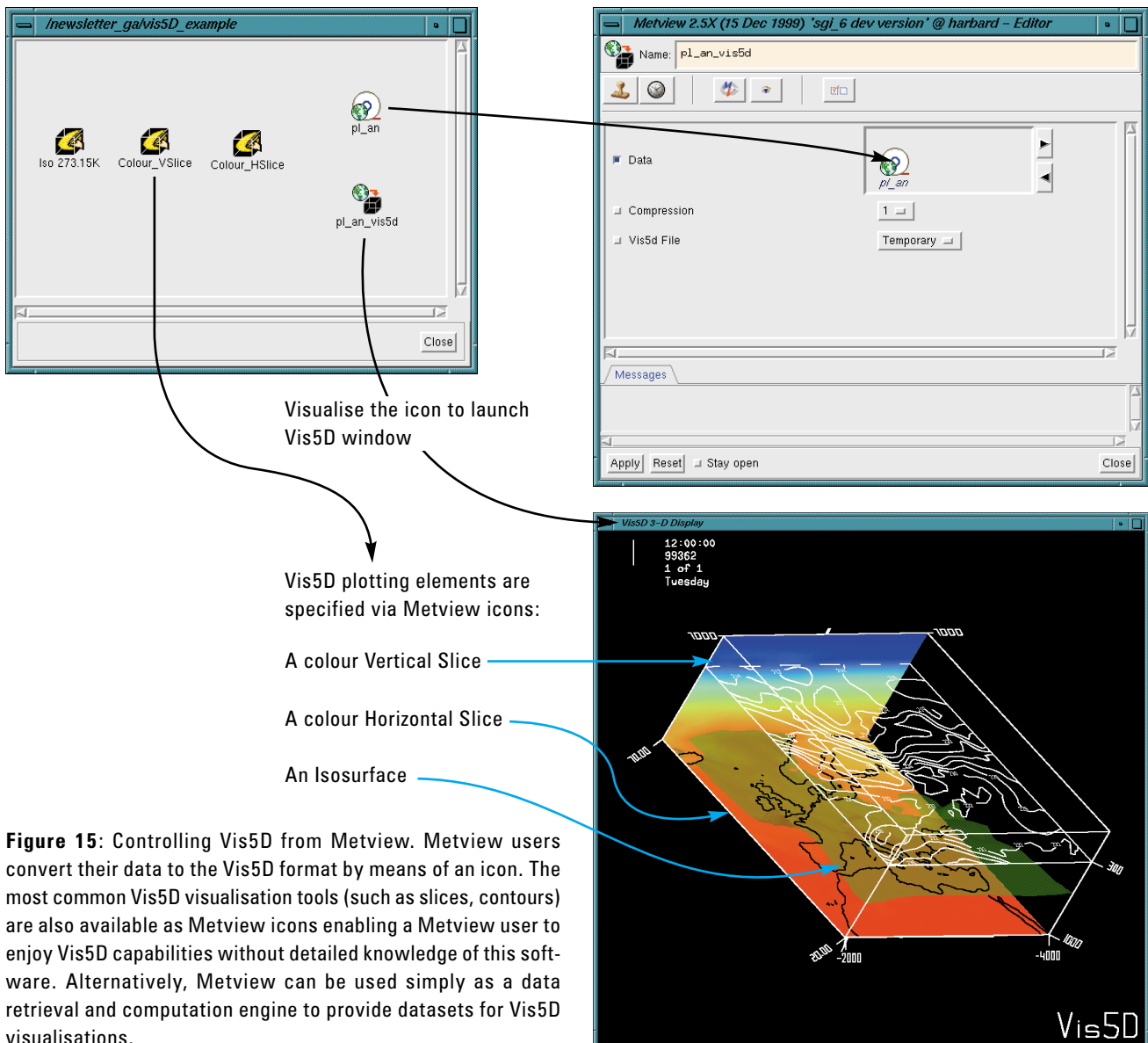
The Metview Macro Language

The Metview Macro language was designed to provide an easy, powerful and comprehensive way for a researcher/operator to manipulate and display meteorological data. A language is the best *user interface* to describe very complex sequences of actions, particularly if the flow of action is conditional. It extends the use of Metview into an operational environment as it enables a user to write complex scripts that may be run with any desired frequency.

It aims to be as simple as a script language (e.g. UNIX shell) to get started, and to be as powerful as a modern computer language. "To be as simple as a script language" implies that no variable declarations or program units should be required. "To be as powerful as a computer language" implies support for variables, flow control, functions and procedures, I/O and error control.

Macro programs are created with the Metview Macro editor, a text editor with added functionality such as run, debug, beautify, shown in Figure 3(c). The language is easy to learn with a relatively shallow learning curve and there are self–learning tutorials prepared for Metview Macro complementing an extensive user guide.

Metview Macro can handle (read, process and write) a variety of file types: GRIB, BUFR, Geopoints and plain ASCII data files. Input and output are done via **read()** and **write()** functions but, in keeping with the Metview Macro approach, the user does not need to specify or know details about the file type, dimensions and format.

Visualise the icon to launch Vis5D window

Vis5D plotting elements are specified via Metview icons:

A colour Vertical Slice

A colour Horizontal Slice

An Isosurface

Figure 15: Controlling Vis5D from Metview. Metview users convert their data to the Vis5D format by means of an icon. The most common Vis5D visualisation tools (such as slices, contours) are also available as Metview icons enabling a Metview user to enjoy Vis5D capabilities without detailed knowledge of this software. Alternatively, Metview can be used simply as a data retrieval and computation engine to provide datasets for Vis5D visualisations.

The following data types are seamlessly handled by Metview Macro:

◆ strings;
◆ numbers;
◆ dates;
◆ lists (a vector whose elements can be of different types);
◆ definitions (like a list, but the elements are named);
◆ fieldsets (for arrays of model fields);
◆ satellite images;
◆ observations;
◆ geopoints (for irregularly spaced point data);
◆ vectors and matrices.

Variables of the types above are defined when set and there is no need for variable declarations. Users can specify operations between variables of these data types and between variables of different types (when applicable) without any effort spent in variable declarations and worrying about compatibility.

For the data types above Metview Macro provides an extensive range of built-in functions which give the user a very powerful set of processing tools; many of these functions are of a specific meteorological nature. Data entities which are cumbersome to handle in a seamless way can be easily converted (and filtered) into other more convenient types (e.g. BUFR into geopoints).

Use of functions in Metview Macro can augment significantly the power of the language. At the simplest, user-written functions can be left embedded in a program. However, Metview Macro makes it very easy for a user to build a library of functions – it is enough to save the function code files in a particular folder within the Metview system for them to be accessible as if they were system functions.

Another powerful feature of Metview Macro is the ability to use FORTRAN executables within a Macro program as if they were built-in macro functions, i.e. nothing in the macro code would identify a particular function as a FORTRAN external function. This extends immensely the scope of the macro language and enables you to make efficient use of existing resources.

A very attractive feature of Metview Macro is that it allows the user to design his/her own user interface. User interfaces are useful to provide small applications to operators who may not be conversant with the Metview Macro language. More importantly user interfaces provide generality to macro programs enabling them to accept a variety of input parameters. The basic task remains the same but it can be applied to different types of data and/or with different visual definitions.

Figure 16 shows an example of a simple user interface in action. You simply have to execute the macro program icon for the user interface to pop up. Enter the appropriate input, click the **Apply** button and the macro runs.

User interface components such as text fields, sliders, option menus, icon boxes, colour tools, etc, are defined by a set of functions known as *dialogue functions*. To implement a user interface you only need to specify the required functions and the retrieval of the input from the user interface.

Metview can run macro programs in a non-interactive or batch mode, i.e. from the command line without recourse to the user interface. To run Metview Macro in batch mode it is enough to call it from the UNIX command line, such as:

% metview –b a_macro Z 500 20000127

Execute the icon to launch user interface

Enter the input elements in the user interface

OK to start the macro
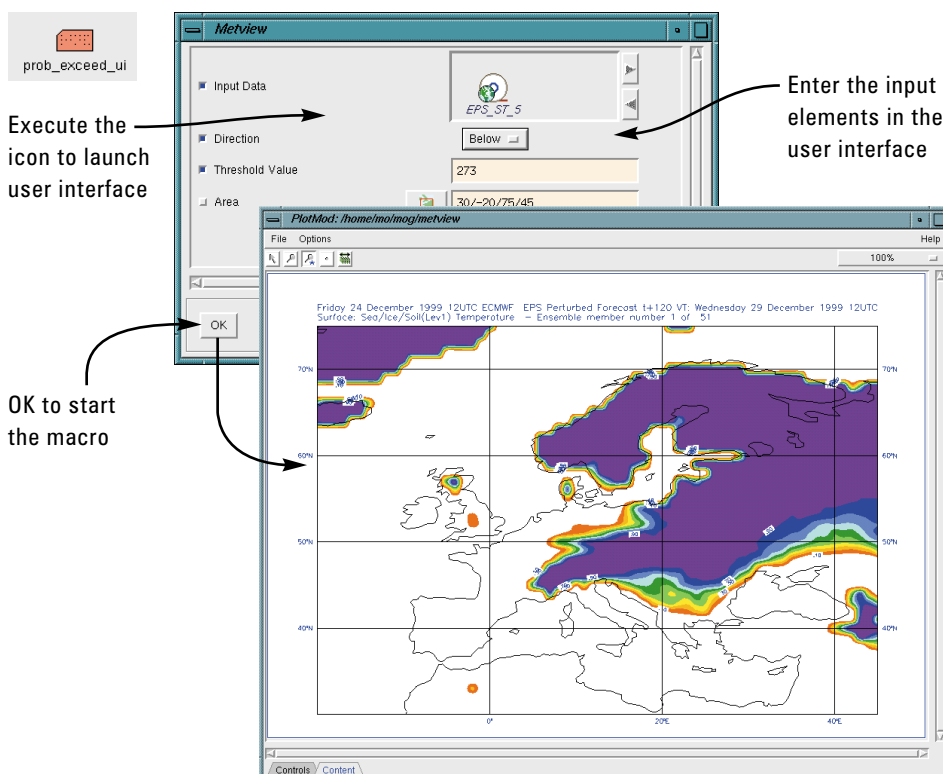
Figure 16: A macro with a simple user interface. This macro is taking an EPS set of forecast fields of surface temperature verifying at a given date, and calculating the proportion of EPS members for which temperature falls below 273 K. The macro is general in that it accepts any set of fields. EPS probabilities are the most obvious application. You may extend the macro by having it save the derived field (as well as visualising it).

Note the use of the option -b; the macro name must follow and after the macro name you specify the list of arguments the macro may need (optional).

Running macros in batch presents no special requirements, except that you are restricted to the following actions:

◆ saving output to a file (GRIB, BUFR, ASCII); and/or
◆ produce a visualisation to a file (PS or PNG) or straight to a printer.

An example of batch-mode application is in the running of operational macros (such as production of routine datasets and hard-copy plots), as the running of these jobs can be set up in shell scripts and managed with scheduling software (i.e. run during periods of minimum activity and/or network traffic).

A macro program resides in the Metview system as a **Macro** icon. As with any icon you can run it by specifying an action **(Execute Visualise Examine Drop)**. A useful feature of Metview Macro is that inside the Macro program you can retrieve its run mode, i.e. which action was specified by the user (including running in batch). This gives the user the opportunity to specify different outcomes according to the run mode the user has chosen.

A typical example is for a macro that produces a visualisation to direct the result to the screen if visualised or executed, and to a printer or PS file if run in batch mode. The user may want/need to restrict the operationality of the macro, e.g. by only allowing to run if it is dropped somewhere or by preventing it from running in batch when its only outcome is an on- screen visualisation.

Further control over a macro program run may be achieved by the user being able to read and set environment variables and to run UNIX shell scripts from within the macro program.

Rogério Bonifácio

European Union Fifth Framework Programme

Two bids to the European Commission have been successful in attracting funding for research projects co-ordinated by the ECMWF as part of the European Union's Fifth Framework Programme for Research, Technical Development and Demonstration activities in the area of Energy, Environment and Sustainable Development. The projects, ERA-40 and DEMETER, will be funded for three years, and will commence shortly.

ERA-40

The objective of the ERA-40 project is to produce, validate and undertake studies of a reanalysis covering the period since mid 1957, when major improvements were made to the atmospheric observing system in preparation for the International Geophysical Year (IGY) that took place in 1958. The project will build on the experience gained by ECMWF in carrying out ERA- 15 (an earlier reanalysis of the period 1979-1993) and on the experience of the National Centers for Environmental Prediction (NCEP) and the National Aeronautics and Space Administration (NASA) in carrying out reanalysis projects in the USA.

The reanalysis will use a three-dimensional variational (3D-Var) version of ECMWF's data assimilation system to make a new synthesis of the in-situ and remotely-sensed measurements collected during the more than 40-year period. Analyses will be produced six-hourly, with supplementary forecasts providing fields at three-hourly intervals. The basic spectral horizontal resolution will be T159, and the model grid-spacing will be close to 125 km in the horizontal, with 60 levels in the vertical located between the surface and a height of about 65 km (as is currently used for operational forecasting at ECMWF). The basic analysed variables will include not only the conventional meteorological wind, temperature and humidity fields, but also stratospheric ozone and ocean-wave and soil conditions.

Additional information will be produced concerning the quality of both the observations used and the analyses generated. ECMWF's archival/retrieval system MARS will be used to store the observations, the analyses, the forecast products and the generated data. The database will be made widely available. Users without MARS access will be able to obtain a comprehensive range of data through ECMWF's Data Services, and data may also be available from some national data centres. Particular attention will be given to generating data subsets on compact media, which can then be made available to users at an affordable cost. The information produced by the project will be unique in its combination of time-range, vertical extent, variety and accuracy. An extensive documentation will also be produced to facilitate the use of the data.

The analysed products will be enhanced by short periods of higher-resolution global assimilation using 4D-Var, which will promote further exploitation of the data from major international observing experiments, such as GATE (1974), FGGE(1979), ALPEX (1982) and TOGA-COARE (1992-93). It is planned to carry out medium-range forecasts at regular intervals from the ERA-40 analyses to enable study of variations in predictability during the period.

ERA-40 will be innovative in its direct variational assimilation of raw-radiance data from satellites from 1972 onwards, and will use some new types of observation and improved specifications of sea-surface temperatures and sea-ice distributions. Analyses will be produced for overlap periods with and without each significant addition made to the observing system since the IGY. This will enable assessment and quantification of the impact of these additions and, in particular, the documentation of the benefit of the development of the satellite observing system (VTPR, TOVS, Meteosat/GOES/GMS, SSM/I, ERS and ATOVS) over the past three decades.

Validation of the assimilated fields will be carried out either by direct verification of the analysed or simplyderived values, or by verifying the output of different types of model that have been forced by the analysed values, for example an ocean-circulation model or a snow model. A selection of diagnostic, process and climatological studies based on the analyses will focus on trends in the observing system, the hydrological cycle, clear-sky radiation, Alpine snow simulation, upper-tropospheric and stratospheric ozone and water vapour, ocean waves, global mass, heat, energy and moisture budgets, and diagnosis of atmospheric circulation systems.

The six other organisations participating in the project are: the Koninkijk Nederlands Meteorologisch Instituut, Météo-France, the UK Meteorological Office (UKMO), the Max-Planck-Institut für Meteorologie, the University of Reading, and the National Center for Atmospheric Research (NCAR). ECMWF will produce the analyses, as well as acting as the co-ordinator for the project. The other partners will carry out the bulk of the validation, diagnostic and exploitation studies. NCAR has supplied ECMWF with observational data not previously held in the ECMWF archives. Additional data have been obtained from NCEP, and the database of satellite radiance observations has been expanded using data provided by the Laboratoire de Météorologie Dynamique, France and NASA. The new sea-surface temperature and sea-ice fields have been prepared by UKMO and NCEP, in collaboration with participants in the Arctic Climate System Study (ACSYS) project of the World Climate Research Programme.

Several other institutions are also supporting the project:
◆ Institutions in China (IAP), Japan (JMA) and the USA (PCMDI) have funded the secondment of staff to work on the project;
◆ Fujitsu Ltd is providing substantial computing support for the project;
◆ EUMETSAT has committed to re-deriving winds from Meteosat-2 images for the period 1981 – 1988;
◆ The World Climate Research Programme and the Global Climate Observing System are providing funds in support of an External Advisory Group for the project.

The principal milestones and direct results of the project are:
◆ Production rate rising to two analysed years per month by spring 2001.
◆ Analyses for 1987-1998 and 1957-1968 completed, monitored and archived by summer 2001.
◆ Interim validation and exploitation reports in autumn 2001.
◆ Mid-project workshop to present project and interim results to users in autumn 2001.
◆ Complete archive of analyses for 1957-2001 by autumn 2002.
◆ Affordable data dissemination service by spring 2003.
◆ Full delivery of climate and statistical data by spring 2003.
◆ Final validation, exploitation and project reports in spring 2003.

DEMETER

DEMETER is the acronym of the project entitled 'Development of a European Multi-model Ensemble system for seasonal to inTERannual prediction'. (According to Greek mythology the daughter of Demeter, the Greek goddess of fertility, was condemned to spend three months every year in the underworld, and in retaliation Demeter cast a great chill on the Earth so that nothing would grow for three months - hence the seasons, and winter in particular).

The objective of the project is to develop a well-validated European coupled multi-model ensemble forecast system for reliable seasonal to interannual prediction, and to establish the practical utility of such a system, particularly to the agriculture and health sectors. Six comprehensive global coupled atmosphere-ocean models that exist in Europe will be installed at ECMWF. The use of a multi-model ensemble system will allow for uncertainties in model formulation to be fully included in the estimation of seasonal forecast probabilities. Based on evidence from the earlier Fourth Framework project PROVOST, it is believed that such a multi-model system will produce the most reliable seasonal climate forecasts possible. The DEMETER system will be fully tested on past cases using the ERA-40 database for initial and validation data.

An extensive set of 6-monthly hindcast ensemble integrations will be generated using the DEMETER system; these will be run four times a year over a period of 30 years. Each model will produce nine members of the multi-model ensemble. A number of key meteorological and oceanographic variables (temperature, precipitation humidity, etc.) will be archived on a daily basis from the ensemble integrations. Output from the individual members of the multi-model ensemble will be linked with tropical disease prediction models and European crop-yield models. The utility of the DEMETER predictions will be directly assessed by an analysis of the output from these user-application models. Sensitivity and downscaling studies will also be undertaken.

In order to combine ensemble members from models with different systematic- error characteristics, it is desirable to apply a model correction technique to each individual-model ensemble. Datasets containing corrected multi-model ensembles (using correction methods based on singular-value decomposition) will be produced. The sensitivity of the coupled-model hindcasts to the inclusion of satellite altimeter data, to changes in the model parametrizations, and to the use of persisted sea surface temperature anomalies (rather than the full coupling of ocean and atmosphere models) will be investigated.

Estimates of the skill of the seasonal predictions of weather elements, such as rainfall and near-surface temperature, will focus on Europe and tropical Africa, as well as on the predictions of the EI Niño/Southern Oscillation and the North Atlantic Oscillation. Probability distributions for crop yield in Europe and the incidence of disease in trop-

ical Africa will be obtained by running application models on each of the ensemble members individually; this will enable the value of the DEMETER system to be assessed directly by the user community. The feasibility of applying the DEMETER output to scales smaller than can be resolved by the global models will also be assessed.

The models will be installed and run on the ECMWF computer system (the cost of the computer time required for running the DEMETER system will not be charged to the European Commission project grant) and will act as the project co-ordinator. It is planned that selected results from the project will be written onto CD-ROMs and made available to the world scientific community through the WMO CLIPS (Climate Information and Prediction Services) programme. There are 11 other participants in the project, involved in modelling, user applications and downscaling. The following institutes comprise the modelling consortium: UK Meteorological Office; Météo-France; Max-Planck Institut für Meteorologie; Consiglio Nazionale delle Ricerche (Instituto di Scienze dell'Atmosfera e dell'Oceano); Laboratoire d'Oceanographie Dynamique et de Climatologie; European Centre for Research and Advanced Training in Scientific Computation; Danish Meteorological Institute. The

following institutes make up the user consortium: University of Liverpool School of Tropical Medicine; Joint Research Centre of the European Communities Agriculture and Regional Information System; Regional Meteorological Service of Emilia-Romagna. The following institutes comprise the downscaling consortium: Danish Meteorological Institute; Spanish National Institute of Meteorology.

The main project milestones are as follows:

◆ Ocean analysis for 1987–1998: spring 2001
◆ Hindcasts for 1987–1998 summer: 2001
◆ Ocean analysis for 1969–1986: spring 2002
◆ Hindcasts for 1969-1986: autumn 2002
◆ Dataset of bias-corrected model output: autumn 2002
◆ Production of CD-ROMs: winter 2002
◆ Final reports and evaluation of economic benefit of DEMETER: spring 2003

ERA-40 contribution – Adrian Simmons and Sakari Uppala, DEMETER contribution – Tim Palmer

The ECMWF Educational Programme

ECMWF has an extensive education and training programme to assist Member States and Co-operating States in the training of scientists in numerical weather forecasting and in making use of ECMWF computer facilities. The programme for 2000 is as follows:

Computer Course

A three-week course in February–March on the use of ECMWF computer facilities. This course consists of six modules.

COM1 (28 Feb – 1 Mar)	Introduction for new users
COM2 (2 – 3 Mar)	MARS
COM3 (6 – 8 Mar)	Advanced use of ECMWF supercomputing resources
COM4 (9 – 10 Mar)	SMS/XCdp
COM5 (13 – 14 Mar)	MAGICS
COM6 (15 – 17 Mar)	Metview

Meteorological Course

A course on numerical weather prediction and the use of ECMWF products. This course consists of five modules. Four of the five modules emphasise scientific training and one module is aimed more at forecasters or people with forecasting experience.

METOP (20 – 29 Mar)	Use and interpretation of ECMWF products
METPR (3 – 7 Apr)	General circulation, systematic model errors and predictability
METDA (10 – 19 Apr)	Data assimilation and use of satellite data
METPA (2 – 12 May)	Parametrization of diabatic processes
METNM (15 – 24 May)	Numerical methods, adiabatic formulation of models

Seminar

A one-week series of lectures dedicated to one specific topic, given in the beginning of September. The subject is different every year. This year it is on "The exploitation of the new generation of satellite instruments for medium-range and seasonal forecasts" 4 – 8 September.

In the first half of the new decade a range of innovative operational (MSG, METOP) and research (ENVISAT, JASON-I, ADEOS-II, EOS-AM, EOS-PM, Earth Explorer) satellite missions will provide data from a wide range of new instruments for use in medium-range and seasonal forecasting. Exploitation of the new instruments will require the forecast models to provide good simulations of the observations; this requirement will probably lead to new model developments and refinements. Following the necessary model development, work will be needed to address the problems of assimilating the new data streams. The complexity of the modelling and assimilation problems will depend on the complexity and non-linearity of the relations between the measured variables and the model variables. The Seminar will provide a pedagogic overview of the new satellite

instruments, of methodologies for model improvement, and of the problems to be addressed in assimilating the new streams of data.

For further details about the ECMWF Training Programme, please refer to the ECMWF Web page on http://www.ecmwf.int/services/training/index.html

Member State computer resource allocations 2000

Member State	Fujitsu (kunits)			Data (Gbytes)
	Basic allocation	Boundary condition project	Net allocation	
Belgium	333	55	278	1118
Denmark	277	46	231	930
Germany	1586	0	1586	5321
Spain	522	86	436	1750
France	1096	0	1096	3675
Greece	245	40	205	822
Ireland	208	34	174	699
Italy	875	144	731	2936
Yugoslavia*	208	34	174	697
Netherlands	416	68	348	1396
Norway	262	43	219	880
Austria	307	51	256	1029
Portugal	234	38	196	785
Switzerland	354	58	296	1189
Finland	244	40	204	817
Sweden	314	52	262	1052
Turkey	282	46	236	946
United Kingdom	918	0	918	3081
Special Projects	549	0	549	2877
Total	**9230**	**835**	**8395**	**32000**

* In accordance with UN Security Council Resolution 757 (1992) of 30 May 1992, the Council instructed the Director to suspend the telecommunications connection to Belgrade with immediate effect. This took place on 5 June 1992. As a consequence no operational products are disseminated to Belgrade and access to the Centre's computer system is not available to Belgrade.

Special Project allocations 2000

Member State		Institution	Project title	Fujitsu (units)	Data storage (Gbytes)
Continuation Projects					
Austria	1	Univ für Bodenkultur, Vienna (Kromp-Kolb)	Vertical ozone transport in the Alps	500	5
	2	Univ Innsbruck (Mayr)	Heavy convective precipitation over and along mountains – numerical simulations	1700	3
	3	Univ Vienna (Dorninger)	Estimating the energy budget climatology over the Alps from different data sources	500	10
Belgium	4	Univ Louvain (van Ypersele)	Modelling the climate and its evolution at the global and regional scales	22000	600
France	5	LAMP (Cautenet)	Chemistry, cloud and radiation interactions in a meteorological model	93	2
	6	CERFACS (Thual)	Universal software for data assimilation: variational method for a global ocean	10000	50
	7	CNES (Blanchet)	MERCATOR	88500	500

Member State		Institution	Project title	Fujitsu (units)	Data storage (Gbytes)
France	8	CERFACS (Terray)	Decadal variability over the North Atlantic–European region	10000	150
	9	CERFACS (Rogel)	Seasonal to interannual predictability of a coupled ocean-atmosphere model	10000	150
Germany	10	Univ Koln (Speth)	Interpretation and calculation of energy budgets	93	6
	11	MPI, Hamburg (Bengtsson)	Numerical experimentation with a coupled ocean/atmosphere model	35000	150
	12	MPI, Hamburg (Bengtsson)	Simulation and validation of the hydrological cycle	33000	120
	13	Univ Munich (Wirth/Egger)	The behaviour of cut-off cyclonesin ECMWF analyses: impact of diabatic processes on their development and decay	50	1
	14	Freie Univ, Berlin (Fisher)	Comparison of the ECMWF cloud scheme with multi-spectral satellite data in the Baltic area	70	0.5
	15	GKSS, Geesthacht (Rockel)	Energy and water cycle components in regional forecasts, remote sensing and field experiments	10	0.2
	16	Univ Munich (Stohl)	Validation of trajectory analysis	300	10
	17	DLR, Wessling (Hoinka/Egger)	Climatology of the global tropopause	2050	30
	18	MPI, Hamburg (Manzini)	Middle atmosphere modelling	28000	240
Ireland	19	Met. Eireann (Lynch)	The Hirlam 4 project	5000	10
Italy	20	ISDGM –CNR (Cavaleri)	Testing and applications of a third-generation wave model in the Mediterranean Sea	3000	3
	21	Univ Bologna (Rizzi)	TOVS 1B radiances and model simulations 300	10	
	22	ICTP, Trieste (Molteni)	Non-linear aspects of the systematic error of the ECMWF coupled model	20000	30
Netherlands	23	KNMI (Siegmund)	Transport relevant for atmospheric chemistry		
	24	KNMI (van Velthoven)	Chemistry and transport studies with a 3D off-line tracer model	3500	25
	25	KNMI(Drijfhout)	Agulhas	20000	0
	26	KNMI (Komen)	Validation of reanalysed A/S fluxes	20000	5
	27	KNMI (Siebesma)	Large Eddy Simulation (LES) of boundary layer clouds	15000	15
	28	KNM1 (Opsteegh/Hersbach)	Short term regional probabilistic forecasting	10000	12
	29	KNMI (Kelder)	Data assimilation of chemical species as observed by GOME and SCIAMACHY	1700	10
	30	KNMI (Burgers)	OGCM mixed-layer modules and assimilation	15000	100
Norway	31	Univ Bergen (Gronas/Kvamsto)	Cloud parameterisation in general circulation models (GCMs)	30000	10
	32	Univ Oslo (Isaksen)	Ozone as a climate gas	1300	5
Switzerland	33	Univ Berne (Schupbach)	The climatology of global transport (long-range transport) to background stations	5000	85
UK	34	Univ Reading (Hoskins)	Routine back trajectories	3000	4
	35	Univ Reading (Hoskins)	EPS and regime changes	12000	15
	36	CGAM, Univ Reading (Slingo/Becker)	Predictability of the Indian Summer Monsoon (PRISM)	0	7
	37	Br Antarctic Survey, Cambridge (Turner/Cachlin achlin– Cope)	Assessment of ECMWF forecasts over the high–latitude areas of the southern hemisphere	0	1
New Projects					
Austria	38	Univ Vienna (Ehrendorfer)	Singular vector-based multivariate normal sampling in ensemble prediction	3400	6
Denmark/ Finland/ Sweden	39	FMI (Fortelius)	BEEOS in BRIDGE (Better Exploration of Existing Observations in BRIDGE)	5000	20
France	40	LSCE, CEA-CNRS (Claquin/Balkanski/Schultz)	Are the ECMWF weather predictions improved by accounting for mineral dust?	7000	40

Member State		Institution	Project title	Fujitsu (units)	Data storage (Gbytes)
Italy	41	Italian Met. Service & ARPA-SMR, Emilia Romagna (Ferri/Paccagnella)	Limited area model targeted ensemble prediction system (LAM-TEPS)	10000	12
Norway	42	DNMI (Nordeng)	Targeted ensembles providing boundary values for limited area models	10000	12
Switzerland	43	Univ Berne (Schupbach)	Classification of atmospheric circulation during extreme events in the Alps	5000	50
Turkey	44	Turkis Met. Service (Yildirim/Demirtas)	Numerical investigation of meso-scale systems over Mediterranean Sea and Black Sea regions	2500	2
UK	45	Univ Cambridge (Lary)	Chemical data assimilation	1000	20
France	46	Univ Nice, CNRM, UNAM (Vernin, Bougeault, Masciadri)	Forecasting optical turbulence for astronomy applications with the MesoNH mesoscale model coupled with ECMWF products	3000	30
Germany	47	DLR, Wessling (Dörnbrack)	Influence of non-hydrostatic gravity waves on the stratospheric flow field above Scandinavia	7500	80
Netherlands	48	Netherland Energy Research Foundation (Slanina)	RECAB	0	1
			Total allocated	466066	2657.7
			Reserve (to be allocated by ECMWF)	92300	320
			TOTAL	558366	2977.7