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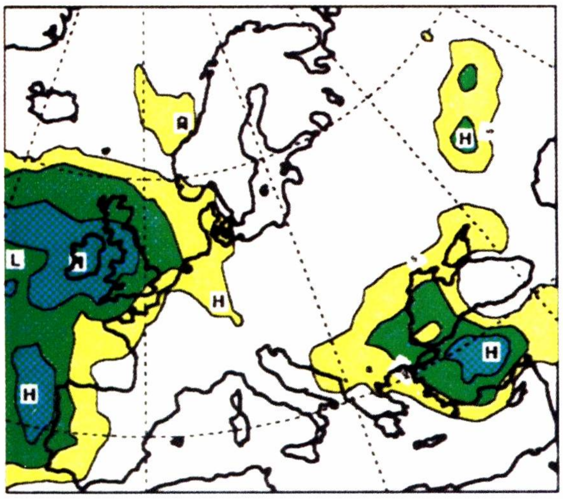
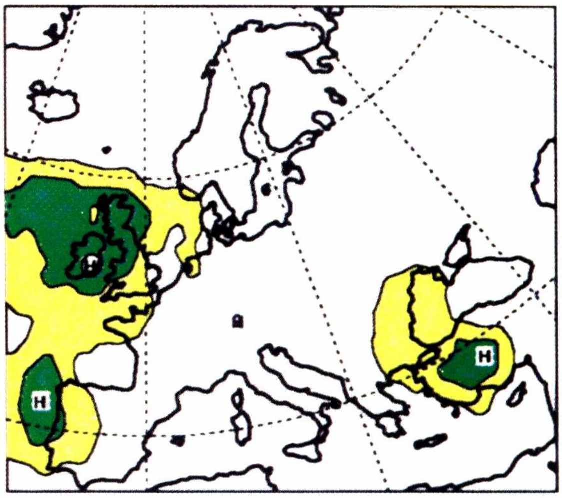


24hr Total Precipitation greater than 5 mm



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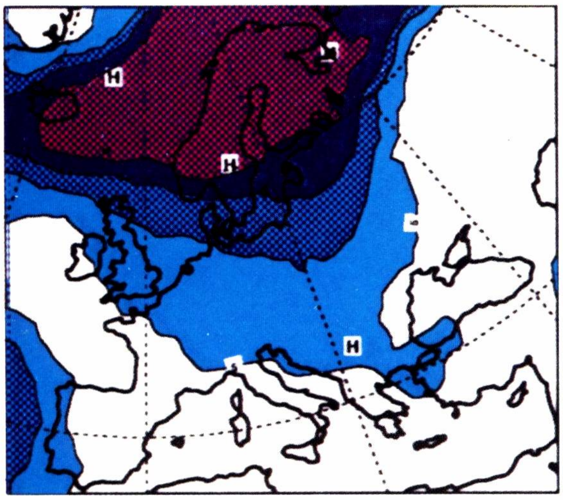
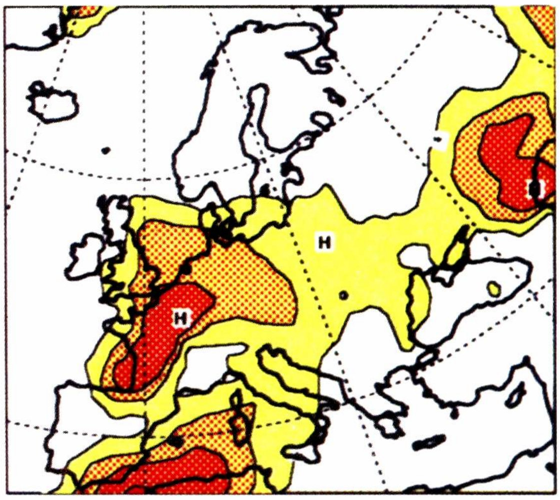


850hPa Temperature Anomaly less than -4 K



850hPa Temperature Anomaly greater than 4 K

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COVER: Section (rainfall and temperature) of probability maps of rainfall, wind speed and temperature (Fig. 4 from "The Ensemble Prediction System (EPS): Status and plans", page 3)

This Newsletter is edited and produced by User Support.

The next issue will appear in Summer 1994.

The illustration on the front cover of this edition of the Newsletter is a section from one of the new products of the ensemble prediction system. The status of, and plans for, this system are elaborated in this issue. The EPS will enter into routine production in May of this year.

Users of the forecast products will know that a major change, the introduction into operational forecasting of the Integrated Forecast System, took place at the beginning of March. They will also find a report on the Workshop on the representation of the stratosphere in Numerical Weather Prediction, which took place last November.

There is an account of the practical measures required to effect the upgrade of the IBM ES/9000 from a model 580 to a model 720. Two further articles by Jeanne Adams relating to use of Fortran 90 are reprinted.

Regular items include the list of Technical Advisory Committee Representatives, Computing Representatives, and Meteorological Contact Points.

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CHANGES TO THE OPERATIONAL FORECASTING SYSTEM

Recent changes

The Integrated Forecast System (IFS) was implemented on 2 March 1994. The IFS is a major rewrite of the forecast model which prepares the way for the planned later introduction of a variational analysis system. The model identification field in the GRIB headers of products was changed to 111.

Several meteorological modifications were implemented at the same time:

- introduction of the 2 metre dewpoint SYNOP observations in the humidity analysis;
- use of the sensible heat flux in addition to the latent heat flux to determine the cloud base mass flux in the shallow convection scheme;
- inclusion of the latent heat release due to freezing of condensate in convective updraughts.

These modifications addressed certain problems which were noted in the Tropics over the last few months, in particular with precipitation and 2 metre temperature. No significant meteorological impact was expected over Europe.

Planned changes

The 3-D variational analysis is planned for implementation in the second half of 1994.

- Bernard Strauss

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THE ENSEMBLE PREDICTION SYSTEM (EPS): STATUS AND PLANS

Brief Description of the EPS

Since the actual state of the atmosphere at any time is only known approximately, weather forecasting could be formulated in terms of the time evolution of an appropriate probability density function (PDF) for meteorological variables. Although this problem can be exactly formulated at a theoretical level through the so-called Liouville equation, its practical solution is impossible for non-linear models with more than a few degrees of freedom. Even restricting attention to the evolution of the first and second-order moments of the atmospheric PDF, one is still faced with a system of equations which have closure problems (unless a linear time-evolution operator is assumed) and which cannot be solved for the large numerical models currently used for NWP.

Using such complex models, ensemble forecasting represents the only feasible methodology to predict the evolution of the atmospheric PDF beyond the range in which error growth can be described by linearized dynamics. In ensemble forecasting, the PDF at the initial time is represented through a finite sample of possible initial conditions. A model integration is carried out from each of these states, and the properties of the PDF at any forecast time are assumed to be described by the sample statistics computed from the ensemble.

It is evident that these statistics will provide reliable information on the probability distribution of the real atmospheric state only if:

a) the sample of initial states provides a realistic estimate of the probability distribution of analysis errors;

b) the trajectories computed by the numerical model are good approximations of actual atmospheric trajectories.

The latter requirement is obviously valid also for traditional, 'deterministic' NWP; therefore, most of the recent research in ensemble forecasting has been focused on point (a), although it should be kept in mind that systematic or regime-dependent model errors can severely affect the quality of ensemble predictions.

Ignoring model deficiencies, to satisfy condition a) is still a problem of considerable theoretical and practical difficulty. Firstly, the PDF of analysis error is poorly known; and secondly, the number of independent directions in phase space spanned by this PDF exceeds by many orders of magnitude the maximum practicable ensemble size for a realistic NWP model. As demonstrated by early experiments in ensemble forecasting, sampling the phase space in a random way (even taking into account geostrophic and hydrostatic constraints) will not produce an adequate distribution of forecast states.

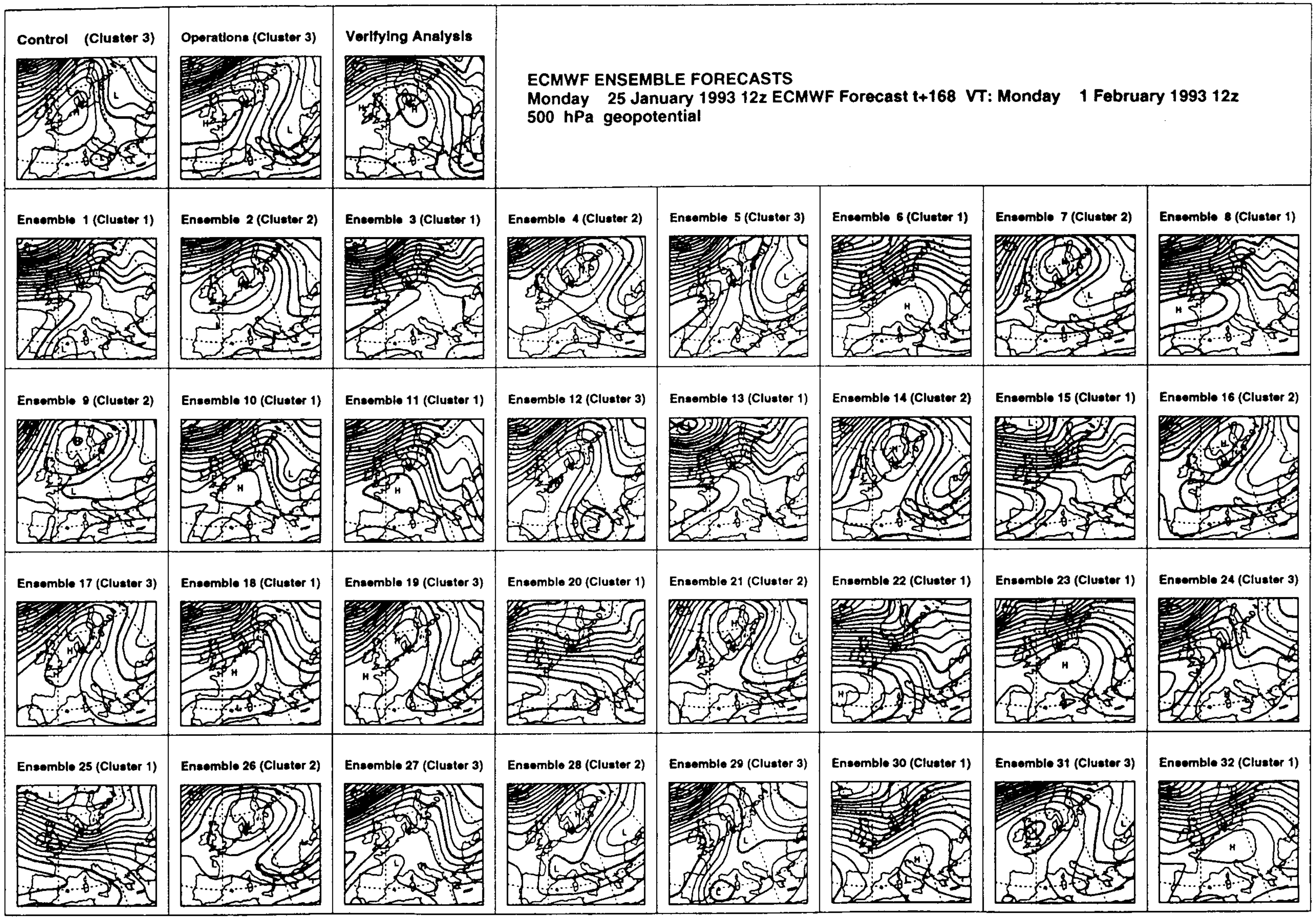


Fig. 1: Members of day 7 forecast of 500 hPa geopotential height for the ensemble originated from 25 January 1993.

Even assuming a white-noise spectrum for the initial error, which corresponds to an isotropic PDF in phase space at the initial time, the different amplification rates of perturbations along different axes would soon stretch the PDF along the directions of maximum instability. As first shown by E. Lorenz, for any finite time interval in which the dynamics of perturbations is assumed to be linear, the axes of maximum instability can be computed as the eigenvectors of a self-adjoint operator defined as the product of the linear propagator (i.e., the integral time-evolution operator over a given time interval) by its adjoint. This is equivalent to saying that the most unstable perturbations in a finite time interval correspond to the dominant singular vectors (SVs) of the linear propagator.

Ensemble forecasting experiments in which unstable SVs computed from a 3-level quasi-geostrophic (QG) model were used to construct initial perturbations for a multilevel primitive equation (PE) model were carried out at ECMWF in the past four years. This technique has proved to be more successful than those previously tested at ECMWF. However, the inconsistency between the vertical coordinates of the QG and PE model created difficulties in the vertical interpolation over high topography. Although this problem did not affect the strongly unstable SVs localized on the western side of the oceans, structures with large amplitude over the continents often had a smaller growth rate in the PE than in the QG model. Efforts were therefore directed towards the computation of SVs in a simplified PE environment, using an iterative Lanczos algorithm for the solution of the eigenvector problem.

On 19 December 1992, after almost nine years of experimentation in this field, ECMWF began to produce and disseminate real-time ensemble forecasts, started on 12 UTC of each Saturday, Sunday and Monday. Each ensemble comprises 33 10-day integrations of a reduced-resolution (T63) version of the operational forecast model. Post-processed products (including clusters of geopotential height fields and time-evolving PDFs for parameters at individual locations) are distributed to the Meteorological Services of ECMWF's Member States.

Brief Description of EPS Products available for Member States

"Stamp Maps"

With an ensemble size of 33 forecasts per day, it is just about feasible for the human eye to assimilate, qualitatively, information from each individual forecast. The set of forecast 500 hPa height maps over Europe can be plotted on a single sheet of paper. An example of such a "Stamp Map" collection is given in Fig. 1 where members of the day 7 forecast of 500 hPa geopotential height for the ensemble, originated from 25 January 1993, are illustrated. Although the size of an individual map is clearly minimal, it conveys the principal features of the synoptic-scale flow.

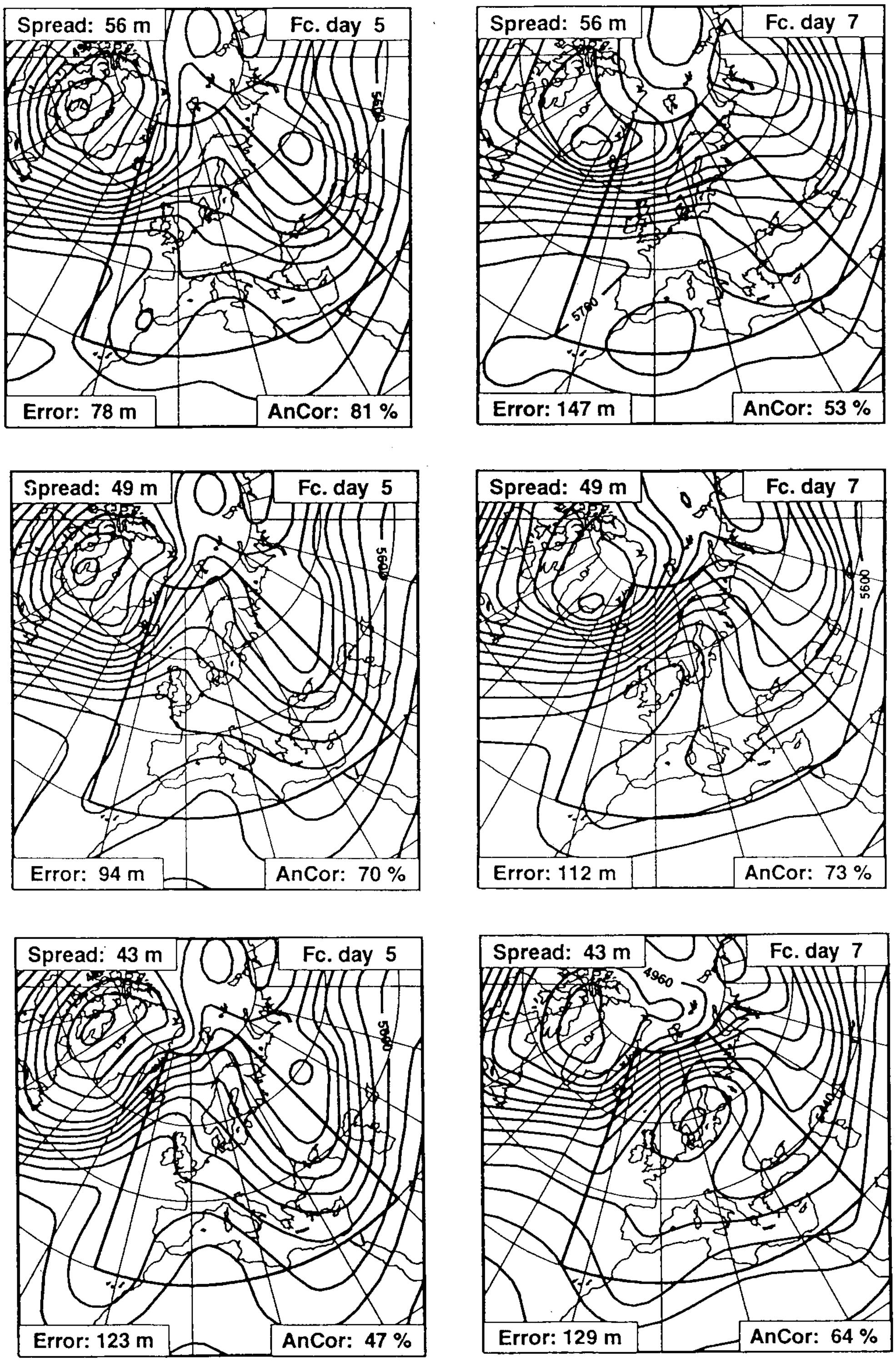


Fig. 2: Trajectory clusters obtained using Ward's hierarchical algorithm for time interval from day 5 to day 7, for the ensemble started on 25 January 1993.

One should not underestimate the processing power of the visual cortex even in comparison with that of state-of-the-art supercomputers. In particular, the human eye is able to perform a subjective clustering which may be more relevant to the user than the objective methods discussed below. Moreover, the eye can readily spot whether the synoptic development of one or two individual ensemble members is unusual, and therefore worthy of further investigation. As ensemble sizes increase, this type of visual inspection will become less effective. Hopefully, objective probabilistic analyses will mature at a sufficient rate to compensate for this.

Clusters of 500 hPa height trajectories

A more synthetic description of the variety of flow patterns predicted by the ensemble members can be obtained by performing a cluster analysis on the 500 hPa height fields produced by the 33 individual forecasts. In order to do so, we have used a hierarchical algorithm to perform the clustering, which has been limited to the flow over the European area (defined as 30N-75N, 20W-45E). Although the clusters are defined from 500 hPa height only, clusters averages (i.e. centroids) of 1000 hPa geopotential height, 850 hPa temperature and 500 hPa temperature are also calculated.

The clustering procedure had originally been applied at individual forecast times. In operational implementation, however, it was felt that information for more than one forecast time should be taken into account, whilst at the same time avoiding potentially confusing situations in which the grouping of ensemble members was different at different forecast ranges. Therefore, it was decided to cluster portions of forecast trajectories rather than instantaneous fields. This was done by defining the 'distance' between two ensemble members as the rms difference between height fields in the forecast interval from day 5 to day 7.

After one year of operational experience, it can be said that this method performs well when there is a clear divergence of forecast trajectories in phase space, associated with possible transitions between large-scale regimes. An example of clusters obtained in one such case (the ensemble started on 25 January 1993) is given in Fig. 2.

In cases when the large-scale flow is more persistent, and the difference between ensemble members is mainly due to propagating baroclinic waves, trajectory clustering may lead to very smooth centroids in which the differences observed at individual forecast times are only weakly represented. Of course, each clustering option (such as the choice of the clustering area and the time window, or the criterion for the 'best' number of clusters) has advantages and disadvantages; the usefulness of objective clustering would be greatly increased if these choices were made at the 'consumer' (i.e. operational forecaster) level rather than at the 'producer' level.

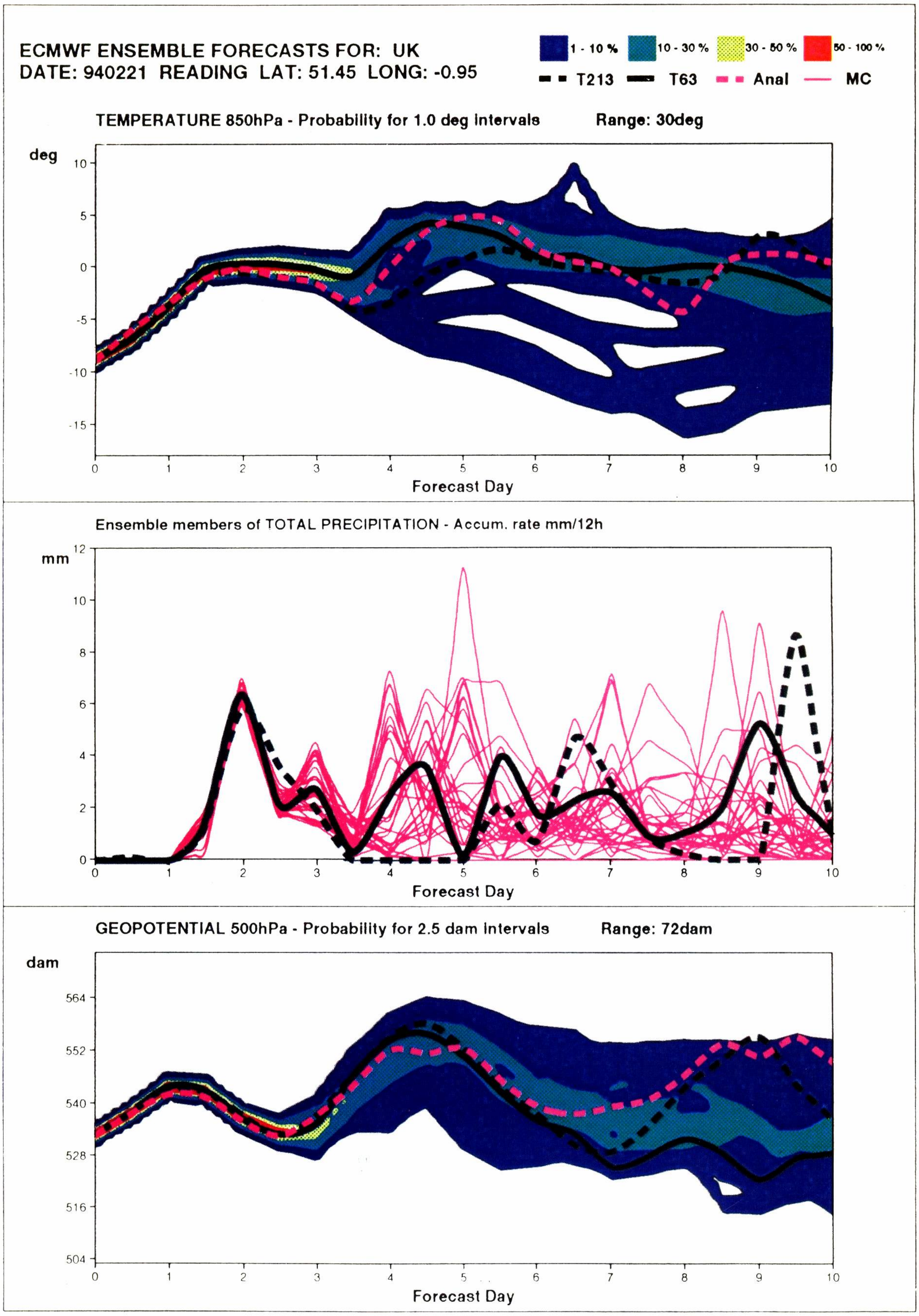


Fig. 3: Probability plumes for Reading UK, for the ensemble originated from February 21, 1994.

"Probability plumes"

In order to give an assessment of the ensemble dispersion occurring throughout the forecast range at a particular location, "plumes" showing the time-evolving probability that the 850 hPa temperature lies within intervals of 1°K width are produced for a number of locations within Member States. The probabilities are computed assuming that each ensemble member is equally likely, and are expressed as percentages. A Gaussian smoother is applied to the sample frequencies to produce smooth probability estimates.

Unfortunately, in regions of steep orography, the T63-L19 850 hPa temperature can be locally inconsistent with the operational forecast values (produced with a T213-L31 model), even when both models have essentially identical synoptic-scale forecasts. In order to be able to assess from the plumes whether inconsistencies in low-level temperature between operational and ensemble forecasts are due to differences in synoptic flow, plumes of 850 hPa temperature are supplemented with plumes of 500 hPa geopotential height. The width of the height categories is 2.5 dam. Since the aim of the EPS is to forecast the predictability of weather parameters, the ensemble members of total precipitation are also included. An example of these plumes is shown in Fig. 3; the different colours denote probabilities within the ranges 1-10%, 10-30%, 30-50% and 50-100%. The operational forecast and control forecast values are also shown on the plume.

Probability maps

Two dimensional fields representing probabilities of rainfall, 10m wind speed and 850 hPa temperature anomalies for specific forecast days are also post-processed. As with the plumes, the probabilities are calculated on the basis that each ensemble member is equally likely. The rainfall categories are: [> 1 mm/day], [> 5 mm/day], [> 10 mm/day] and [> 20 mm/day]. The wind speed categories are: [> 10 m/s] and [> 20 m/s]. Finally the temperature anomaly categories are : [< -8°K], [< -4° K], [> 4°K] and [> 8°K].

An example of probability fields for rainfall, temperature and wind speed categories is given in Fig.4, where the two dimensional probability of rainfall, 10m wind speed and 850 hPa temperature is shown for day 5 of the ensemble originated from 21 February 1994.

Validation of ensemble products

One of the principal uses of an ensemble forecast is to provide an estimate of the confidence in a prediction; the larger the ensemble dispersion, the less reliable is the forecast of any one member (including the control). From this basic notion, it is often assumed that the ensemble spread can be taken as a predictor of the skill of the control forecast. However, even in a perfect environment, spread will not be perfectly correlated with skill. The reason is simple: when spread is relatively small, the control forecast trajectory (in a perfect system) is constrained to be close to the verifying analysis trajectory, however, when the spread is large, it could be either close to, or far from, the

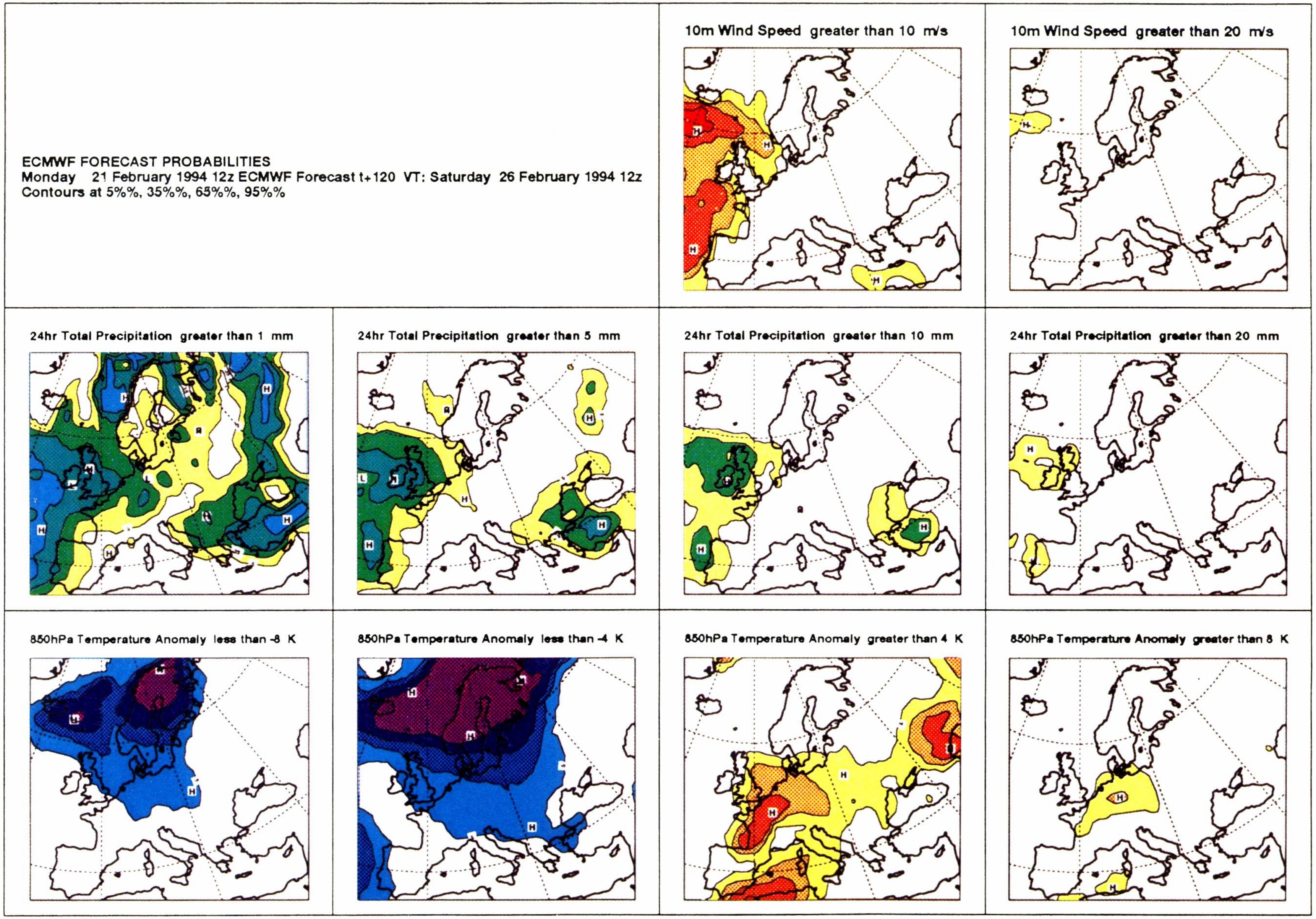


Fig. 4: Probability maps of rainfall, 10m wind speed and 850 hPa temperature for the ensemble originated from 21 February 1994.

verifying trajectory. Hence for large spread the control forecast could be either relatively skilful or relatively unskilful. As a result, when discussing relationships between ensemble spread and control forecast skill, we do so using scatter diagrams and contingency tables (rather than correlation values).

Such scatter diagrams have been made in two different ways; results from both methods are illustrated below. Fig. 5 shows scatter diagrams of skill and spread for the northern hemisphere as a whole, for winter and summer forecasts. Here the ensemble spread is taken as the 75 percentile value of the distribution of day 7 500 hPa height rms difference values between the perturbed ensemble members and the control. The day 7 rms error of the control is taken as the skill value. The number of elements in each of the categories: above/below average skill, above/below averaged spread, is also illustrated in Fig. 5. The diagonal entries are clearly dominant. This means that most of the time (i.e. 27 out of 39 times in winter, 29 out of 39 times in summer) if the ensemble dispersion is either above or below average, the forecast error will also be above or below average, respectively. The off-diagonal terms should not necessarily be viewed as a failure of the EPS system; it can be shown theoretically (from remarks at the beginning of this section), that even with a perfect ensemble system the off-diagonal elements will be non-zero.

Fig. 6 on the other hand, shows scatter diagrams for the European region (30N-75N, 20W-45E) based on forecast probability plumes for 500 hPa geopotential height at 513 grid points distributed uniformly throughout the region. Again results for winter and summer are shown. The spread is estimated from the forecast day on which a chosen probability contour first vanishes (for example, from the 500hpa geopotential plume shown in Fig. 4, the 30% contour first vanishes at about day 3.5). The mean day number averaged over all the grid points is then taken as the appropriate measure of spread (the smaller the spread the larger the day number). The chosen probability contour used to estimate ensemble dispersion varies with the season. For winter it is taken as the time at which the 20% contours disappears; for summer it is taken from the 30% contour. This variation in spread diagnostic is reasonable; after all, ensemble spread is generally weaker in summer so that the 30% contour more generally extends into the medium range, and is therefore a fair average indicator of medium range skill. By contrast in winter the 30% contour may vanish closer to the end of the short range, and therefore would not be a good a priori indicator of medium range skill. The skill measure of the control forecast is taken as the mean rms 500hPa height error of the forecast averaged over days 5, 6 and 7. The number of elements in each of the categories: above/below average skill; above/below averaged spread, is also shown in Fig. 6. As with Fig. 5, it can be seen that diagonal entries are dominant, i.e. in most occasions a prediction of either high or low forecast error will itself be skilful. One can also see (especially for summer) that low spread more often corresponds to high skill, than high spread corresponds to low skill (as anticipated by the theoretical remarks above).

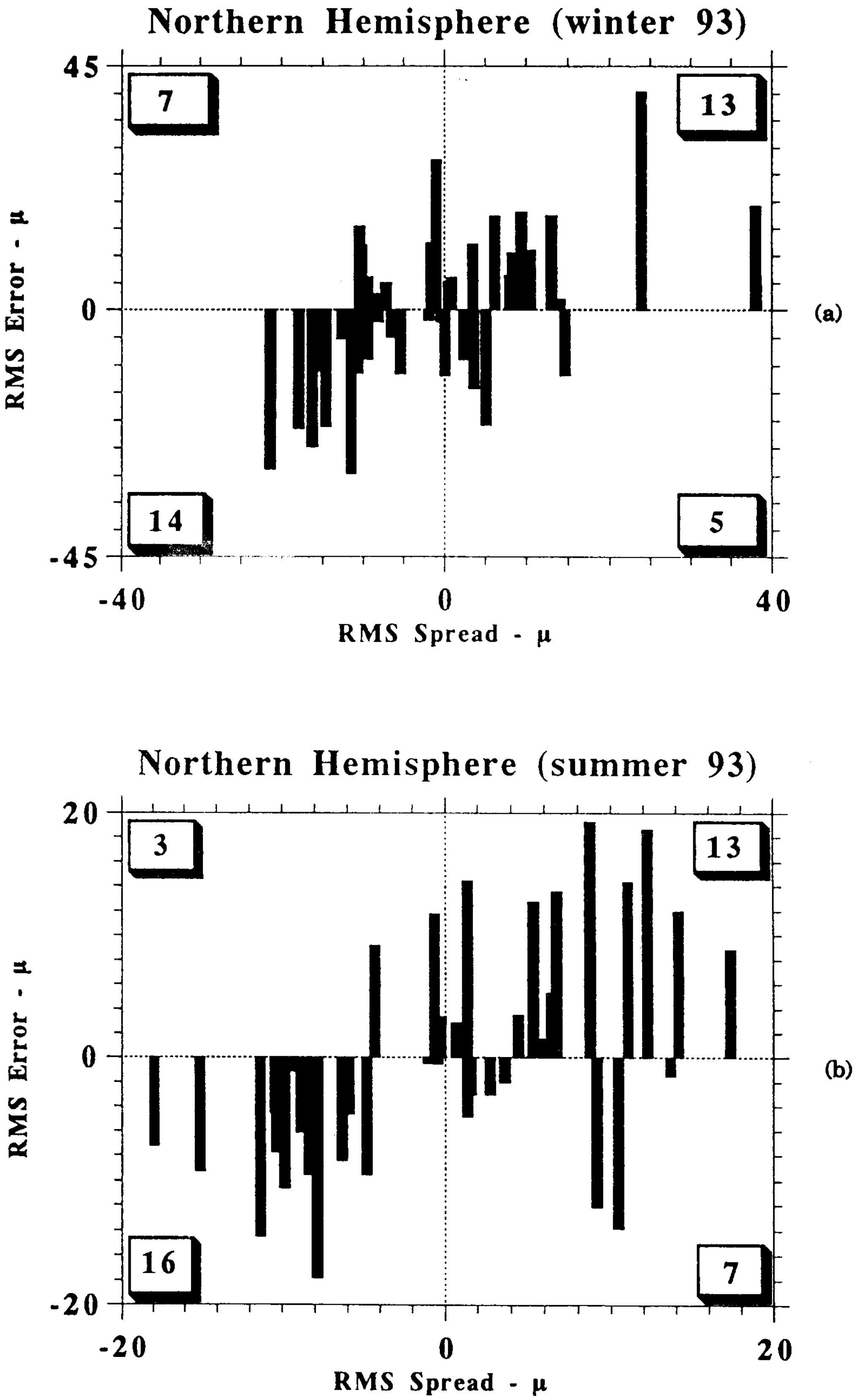
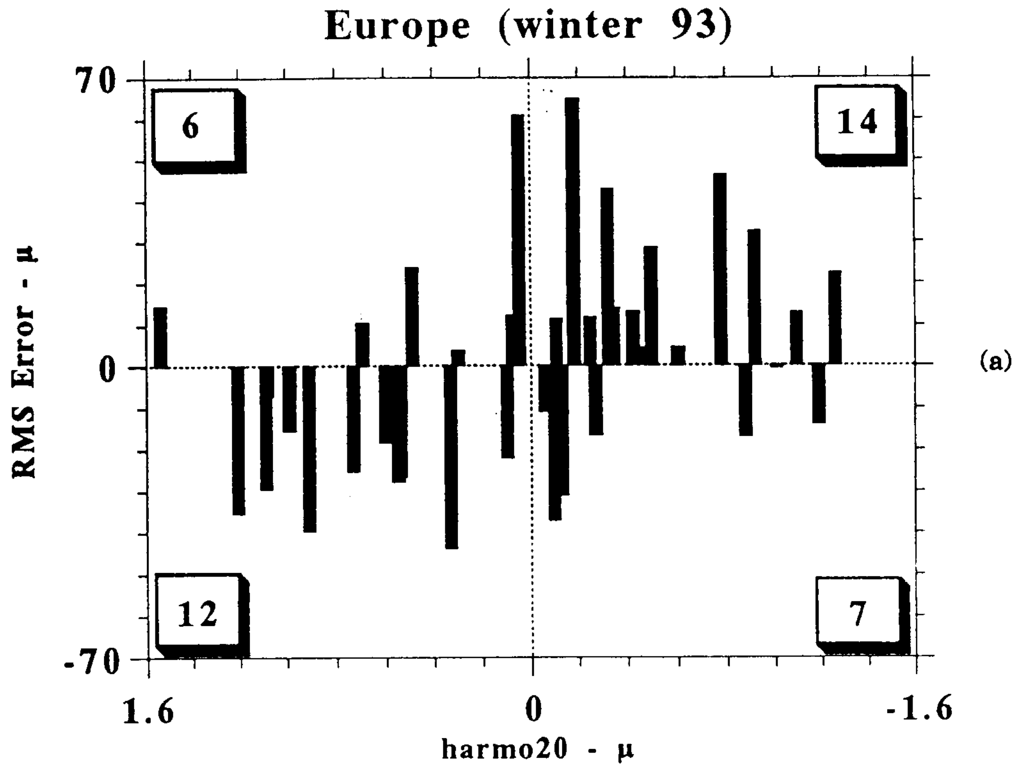


Fig. 5: Scatter diagrams (deviations from mean seasonal values) of skill and spread for the northern hemisphere as a whole for (a) winter and (b) summer 1993, using day 7 rms error and rms spread. The number of elements in each of the categories above/below average skill, above/below averaged spread is also shown. Ensemble spread increases from left to right. Ensemble error increases from bottom to top.



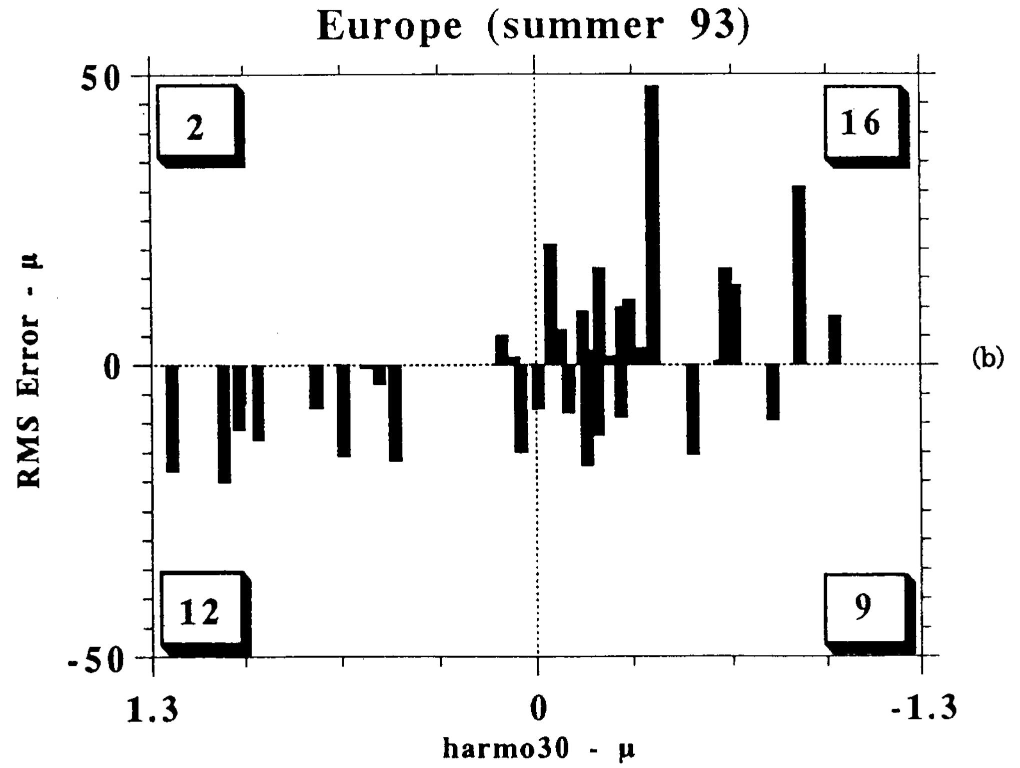
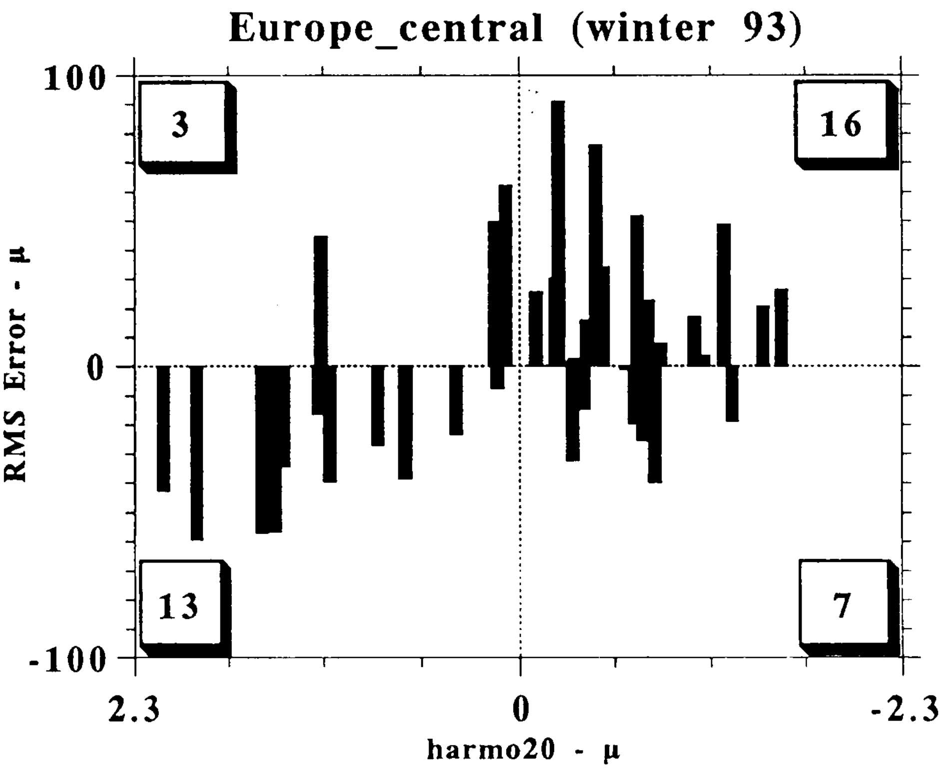


Fig. 6: Scatter diagrams (deviations from mean seasonal values) for the European region based on forecast probability plumes for 500hPa geopotential height at 513 grid points distributed uniformly throughout the region for (a) winter and (b) summer. The number of elements in each of the categories above/below average skill, above/below averaged spread is also shown. Ensemble spread increases from left to right. Ensemble error increases from bottom to top.



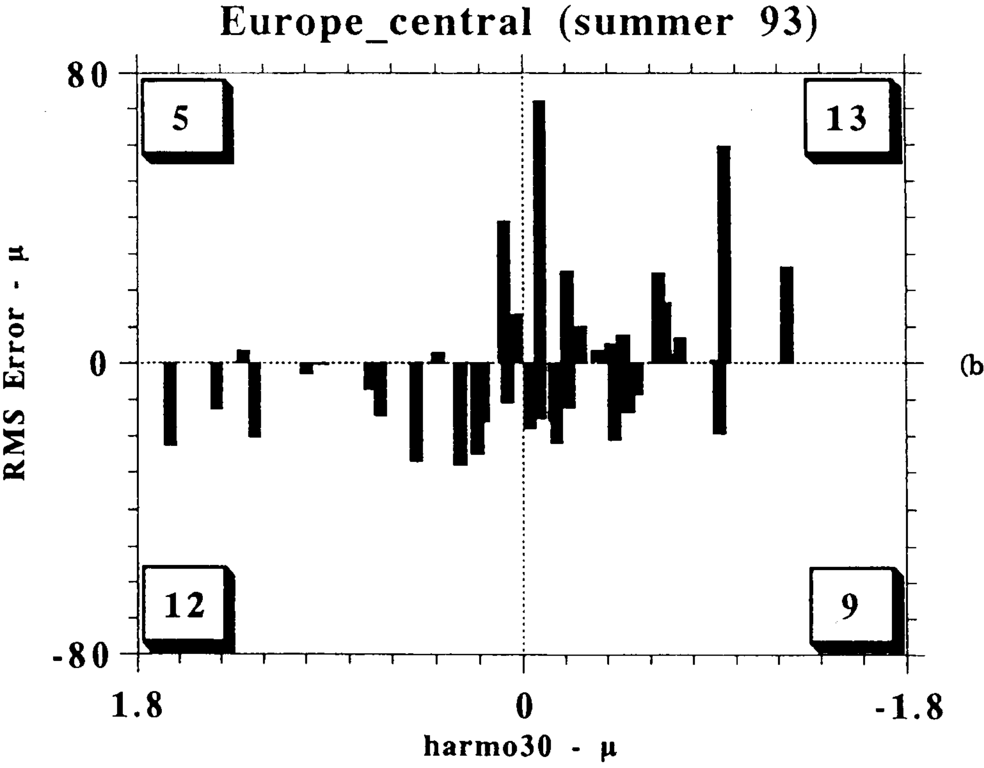


Fig. 7: As in Fig. 6, but for central Europe (140 grid points).

In order to study the regional forecast skill over different subregions of Europe we followed the same approach (using probability values from plumes taken over a total number of 140 gridpoints) for areas equal to 1/4 of Europe. For one of these areas bounded by 41.25-63.75N, 3.75W-28.75E, which actually represents central Europe, results for winter and summer 1993 are shown in Fig.7. Similar conclusions hold for this smaller region as for the larger regions in Figs. 5 & 6.

Future Plans

Routine daily operation of the EPS will commence in early May 1994. Later in the year, experimentation will include a comparative study of the relative merits of an increase in basic resolution to an increase in ensemble size. However, in addition, research will continue on the construction of initial perturbations, and on EPS products. For example we are testing the use of a climatological short-range forecast error covariance matrix to condition the SV calculation, as well as increasing the resolution of the SV calculation. Furthermore a so-called simplex method will be tested for estimating the distribution of perturbations about the central analysis. Research will also be done using a local projection operator applied in spectral space, to study the relative efficacy of largescale barotropic singular vectors in exciting regime transitions, compared with the faster growing unconstrained singular vectors.

Acknowledgements

The work above summarises many years of research by the predictability group at ECMWF, specifically R. Buizza, F. Molteni, R. Mureau, T. Petroliagis and J. Tribbia. The work and comments of P. Chapelet, N. Reed, A. Persson and B. Norris are also acknowledged.

- Tim Palmer

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ECMWF WORKSHOP ON THE STRATOSPHERE AND NUMERICAL WEATHER PREDICTION

15-17 November 1993

The representation of the stratosphere in numerical weather prediction systems is a subject of increasing interest. There are growing demands for analyses and forecasts of the stratospheric circulation and distribution of the ozone field. Systematic model errors can be quite substantial in the lower stratosphere, and the impact of limited stratospheric resolution and a reflective upper boundary condition on the treatment of upward propagating wave motion has long been a matter for concern. The quality of the stratospheric first-guess influences the assimilation of observations, and variational assimilation methods offer the promise of using observations of trace species, ozone in particular, to improve stratospheric analyses of conventional meteorological fields. The workshop thus addressed issues of stratospheric modelling, stratospheric aspects of data assimilation, and the diagnosis and use of ECMWF's stratospheric forecasts.

The first part of the workshop comprised invited lectures, written versions of which will shortly be published in the Proceedings of the workshop. This was followed by a series of short presentations by a number of other external participants in the meeting. Three working groups then met to discuss modelling, assimilation and diagnosis.

A number of issues pertinent to the stratosphere and NWP were considered by the working groups. Among the questions addressed were the following:

- Where should the top level of the model be located?
- How should the model levels be distributed?
- Are better numerical schemes needed?
- What are the specific issues concerning the parametrizations of radiative transfer and gravity-wave drag?
- What do we need to consider with regards to water vapour, ozone and other trace constituents?
- What are the particular problems of data availability and quality control?

- Do we need to revise the structure functions used for stratospheric analysis?
- Can we exploit new observations?
- What can we learn from systematic errors and to what extent are these in common with other centres?
- What is the requirement for forecasts for the stratosphere itself?

Implicit in the above questions is the overall question as to how much is to be gained from a further investment in better stratospheric analysis and modelling, particularly in respect of tropospheric predictability. It was not expected that the workshop would provide a definitive answer to this question, but some indications of sensitivity of the troposphere to the treatment of the stratosphere were discussed. More generally, the workshop provided an informative review of progress in a number of relevant areas and recommendations for future studies aimed at improving the representation of the stratosphere in NWP systems.

The discussions of the working groups will be summarized in the forthcoming Proceedings.

- Adrian Simmons

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THE IBM ES/9000 UPGRADE

Late in 1993 an upgrade of the IBM ES/9000 Data Handling System from a model 580 to a model 720 with refurbished equipment was decided.

The upgrade involved the addition of eight large boxes, which doubled the footprint of the computer. Unfortunately, its location in the Computer Hall meant that these boxes could not easily be added to the mainframe; we had the choice of either moving the existing model 580 mainframe to a clearer space in the Computer Hall or moving all the IBM disks.

Both possibilities were investigated, and the cost and downtime associated with each evaluated. It became clear that moving the mainframe was a better solution than moving the disks because, although more site preparation work would be necessary, the downtime and the cost would be less.

It was tentatively planned to move the ES/9000-580 on 18 December 1993, which would allow IBM to install the upgrade by the end of 1993, provided they could deliver the additional equipment in time. Since the upgrade consisted of refurbished equipment, firm delivery times could not be guaranteed. During December we were informed that IBM would not be able to deliver the upgrade by the end of the year, and we seriously considered delaying the move of the 580. However, we went ahead with it, which was fortunate since on 22 December IBM announced that the upgrade would be delivered on 30 December.

Site preparation work involved refurbishing the false floor to bring it up to the latest standards for strength and rigidity; installing new chilled water pipework to provide water cooling for the system; installing two 200 amp electrical feeds, and re-laying 60 channel data cables. This last task took longest and involved the most expense because new cables had to be purchased for many channels where they had to be lengthened.

It was planned that the move of the IBM would begin after the 10-day forecast and the wave forecasts had been completed early on 18 December. The cutoff time for the suite had been brought forward by about an hour and the IBM was taken down at around 0100 hrs. The Cray continued to run normal user work, and the 00 UTC forecast later in the night. The work on the IBM finished early, at about 1000 hrs, but the system could not be brought back into service for a further hour as preventive maintenance work was also being done on the Comparex disks. The system came up smoothly and the backlog was soon dealt with.

Much of the upgrade installation work was done while normal operations carried on, and the final merge of the system, creating a model 720, was performed on Saturday, 29 January. At the time of writing, the additional HiPPI interface has not yet been delivered and installed but this is expected imminently.

The upgrade increased the memory size by 50% and the processor power by 100%, enabling the Data Handling System to provide an improved service for the Centre's growing workstation population.

- Peter Gray

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The following two articles are reprinted here by courtesy of SCD Computing News. The first appeared in the September/October 1992 issue, and the second in the November 1992 issue of that publication. Jeanne Adams chaired the International Programming Languages Committee of the ISO (International Standards Organisation) and chaired the ANSI Committee which developed Fortran 90. She also co-authored the book "The Fortran 90 Handbook: Complete ANSI/ISO Reference".

THE *WHERE* CONSTRUCT IN FORTRAN 90 AND CF77 6.0

In addition to the transformational functions (see "Fortran 90, CF77 5.0 make use of vector intrinsic functions" in the previous issue), the 6.0 version of CF77 has the WHERE construct as well. The WHERE statement and the WHERE construct are referred to as masked-array assignment. In other words, these instructions perform an array assignment selectively using a mask - that is, only certain elements of one array are assigned to another array based on whether the mask is true or false. The mask is a logical array expression. The arrays in an assignment statement must be comformable. Every assignment in a WHERE construct is executed, whether in the WHERE block or in the ELSEWHERE block (if there is one). Assignments are made based on the evaluation of the mask expression. (Note that WHERE constructs may not be nested.) For example, a WHERE statement might be:

```
WHERE  (M.EQ.0)  Y = 0.0
```

and a simple WHERE construct might be:

```
WHERE  (M.LE.N)
 Y = Z
ELSE WHERE
 Y = 2 * Z
END WHERE
```

where M, N, Y, and Z are all arrays dimensioned with the same number of elements (i.e., are conformable). The expressions (M.EQ.0) and (M.LE.N) generate a logical mask used to selectively assign values to Y.

Example 1. A simple program using the WHERE construct

Program

```
PROGRAM SELECT
 IMPLICIT NONE
 REAL TRADE(10), ELEMENTS(10), GROWING(10)
 DATA GROWING/1., 2., 3., 4., 5., 0, 0, 0, 6., 0/
 TRADE = 3.33
 WHERE (GROWING .NE. 0.)
   ELEMENTS = 2. + GROWING
 ELSEWHERE
   ELEMENTS = TRADE
 END WHERE
PRINT "(A,10F6.2/)", "TRADE", TRADE, "GROWING", GROWING
PRINT "(A,10F6.2/)", "ELEMENTS", ELEMENTS
END
```

Output

```
TRADE      3.33  3.33  3.33  3.33  3.33  3.33  3.33  3.33  3.33  3.33

GROWING    1.00  2.00  3.00  4.00  5.00  0.00  0.00  0.00  6.00  0.00

ELEMENTS   3.00  4.00  5.00  6.00  7.00  3.33  3.33  3.33  8.00  3.33
```

Syntax

The Fortran 90 formal syntax for the WHERE statement and the WHERE construct is:

```
where-stmt          is        WHERE (mask-expr) assignment-stmt

where-construct     is        WHERE (mask-expr)
                                 [assignment-stmt]...
                               [ELSEWHERE
                                 [ASSIGNMENT-STMT]...]
                              END WHERE
```

In CF77 5.0, you may preprocess the WHERE construct or the WHERE statement in a Fortran preprocessor using the **-zv** or **zp** options on the **cf77** control line. The simple program in Example 1 uses a preprocessor for code generation before compilation. In this program, a comparison is made between GROWING and 0 in a logical (or mask) expression. For elements of GROWING that are not 0, the corresponding elements of ELEMENTS are set to (2.+ that element of GROWING). For all other elements (that is, those that are 0), the value in ELEMENTS is set to the corresponding element of TRADE, 3.33.

The Fortran generated for the WHERE construct in the preprocessor uses the IF-THEN-ELSE construct of Fortran 77 and a DO loop, which will generate element-by-element sequential assignment. The preprocessed code (which is then processed by the CF77 compiling system) is:

```
DO J1X = 1,10
 TRADE(J1X) = 3.33
 IF (GROWING(J1X) .NE. 0.) THEN
  ELEMENTS(J1X) = 2.+GROWING(J1X)
 ELSE
  ELEMENTS(J1X) = TRADE(J1X)
 ENDIF
END DO
```

In Fortran 90, no order is implied for these elemental operations in a WHERE statement or construct. Assignments may be done in any order or simultaneously. The ordering of elements within the array itself is retained, of course. The elements of the array do form a sequence; subscripts along the first dimension vary most rapidly.

\- Jeanne Adams

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FORTRAN 90 AND CRAY CF77 5.0 INCORPORATE NEW FACILITIES FOR DATA TRANSFER

Only modest changes and extensions to FORTRAN 77 have been made in the area of Fortran 90 data transfer. A NAMELIST feature has been added in Fortran 90, and a slightly different implementation is available in the Cray CF77 5.0 compiling system. The complete Fortran 90 list of specifiers for the OPEN, CLOSE, and INQUIRE statements is implemented in CF77. Only a few of these specifiers are new.

A "stream" or nonadvancing character-oriented feature is now in Fortran 90, but not implemented in CF77. (In nonadvancing input/output operations, the file may be at a character position within the current record. This is in contrast to advancing input/output operations, in which the file is positioned at the end of the record after the I/O operation.)

NAMELIST

It is possible to shorten the list in data transfer statement by using NAMELIST. A list of variable names is given a collective or group name using a NAMELIST declaration. In subsequent input/output statements, the group name is used instead of the list of variable names.

The form of the declaration is:

```
NAMELIST /group-name/ list of variables
```

For example,

```
NAMELIST /COLORS/ RED, WHITE, BLUE
```

The NAMELIST group name for RED, WHITE, and BLUE is COLORS.

To transfer this data, use the group name as the second parameter in a READ or WRITE statement, as in:

```
READ  (5, COLORS, ERR = 99)
```

The variables RED, WHITE, and BLUE are transferred using the group name COLORS.

In the sample program shown in Example 1, two NAMELIST group names are used: EXTERIOR for the arrays APPLES and BANANAS, and INTERIOR, for I, J, K. and L. A data statement assigns values for the list of variables in INTERIOR, and two array-assignment statements assign values for the arrays.

The following is an input file that could be used with Example 1:

```
&INTERIOR K = -1, I = 12 &END
```

Example 1. Sample program using NAMELIST

```
      PROGRAM INPUT_OUTPUT
      REAL APPLES(10), BANANAS(10)
C
      DATA I, J, K, L/ 2*15, 3, 1/
C
C     Define some namelists (INTERIOR and EXTERIOR)
C
      NAMELIST /EXTERIOR/ APPLES, BANANAS
      NAMELIST /INTERIOR/ I, J, K, L
C
      APPLES = 1.0
      BANANAS = 2.0
C
C     Read in the INTERIOR namelist (see sample input file).
C       Note that the input need not be in the declared order and only
C       needs to include variables whose values need to be changed
C       from the default values given in the DATA statement.
C
      READ (5, INTERIOR)
C
      WRITE (6, INTERIOR, ERR = 99)
      WRITE (6, EXTERIOR, ERR = 98)
      PRINT "(A)", "SUCCESSFUL NAMELIST WRITE"
      GOTO 100
 98   PRINT "(A)", "Error in NAMELIST EXTERIOR"
      STOP
 99   PRINT "(A)", "Error in NAMELIST INTERIOR"
 100  END
```

Example 2. Output for Example 1

```
     &INTERIOR  I = 12  J = 15,  K = -1,  L = 1,           &END
     &EXTERIOR  APPLES = 10*1.0,  BANANAS = 10*2.0,      &END
 SUCCESSFUL NAMELIST WRITE
```

If this file is used as standard input to Example 1, the output for the program run would be as shown in Example 2.

OPEN and INQUIRE specifiers

Four Fortran 90 specifiers have been added to the list for the OPEN statement. These are POSITION, ACTION, DELIM, and PAD. Five Fortran 90 specifiers have been added to the list for the INQUIRE statement that respond to inquiries about the new specifiers that can be used in the OPEN statement. These are READ, WRITE, READWRITE, DELIM, and PAD.

There are no new CLOSE specifiers in Fortran 90.

New OPEN connection specifiers

POSITION=c	C is a scalar character expression indicating the file position status on connection
ASIS	File position unchanged
REWIND	File position at initial point (rewound)
APPEND	File position at terminal point before EOF
ACTION=c	C is a scalar character expression indicating permissible actions for the file
READ	WRITE and ENDFILE actions are prohibited
WRITE	READ actions are prohibited
READWRITE	Any input/output action is permitted
DELIM=c	C is a scalar default character expression indicating the delimiter to be used for character constants in list-directed or namelist formatting
APOSTROPHE	Use apostrophe as the delimiter
QUOTE	Use quote as the delimiter
NONE	No delimiter is used

PAD=c	C is a scalar default character expression indicating whether to pad with blanks or not on formatted input
YES	Pad with blanks if needed
NO	Do not pad, the blanks are already there

The following example shows use of the OPEN specifier.

```
OPEN (8, FILE = "TENG", POSITION = "REWIND", ERR = 99)
```

New INQUIRE inquiry specifiers

READ=c	C is a scalar character variable returned with values:
YES	Reading is allowed
NO	Reading is not allowed
UNKNOWN	Condition not known

WRITE=c	C is a scalar character variable returned with values:
YES	Writing is allowed
NO	Writing is not allowed
UNKNOWN	Condition not known

Formal syntax for NAMELIST

namelist-stmt	is	NAMELIST / *namelist-group-name / &* *variable-name[,variable-name]...*
namelist-read-stmt	is	READ([UNIT=]*io-unit &* ,[NML=]*namelist-group-name &* [,IOSTAT=*scalar-default-integer-variable] &* [,END=*label]) &* [,ERR=*label]*
namelist-write-stmt	is	WRITE ([UNIT=]*io-unit &* ,[NML=]*namelist-group-name &* [,IOSTAT=*scalar-default-integer-variable &* [,END=*label] &* [,ERR=*label*])

The optional characters NML = are part of the Fortran 90 standard and are not implemented in CF77 5.0. If these characters are omitted, the standard says that the namelist group name must be second in any data transfer statement. The Cray implementation is standard Fortran 90 with the optional characters omitted; however, the keyword form is not used on the CRAY Y-MP8/864 (shavano).

Formal syntax for the OPEN statement

open-stmt	is	OPEN (*connect-spec-list)*
connect-spec	is	[UNIT=]*external-file-unit*
	or	IOSTAT=*scalar-default-int-variable*
	or	ERR=*label*
	or	FILE=*file-name-expr*
	or	STATUS=*scalar-default-char-expr*
	or	ACCESS=*scalar-default-char-expr*
	or	FORM=*scalar-default-char-expr*
	or	RECL=*scalar-int-expr*
	or	BLANK=*scalar-default-char-expr*
	or	POSITION=*scalar-default-char-expr*
	or	ACTION=*scalar-default-char-expr*
	or	DELIM=*scalar-default-char-expr*
	or	PAD=*scalar-default-char-expr*

Formal syntax for the INQUIRE statement

inquire-stmt	is	INQUIRE(*inquire-spec-list*)
inquire-spec	is	[UNIT=]*external-file-unit*
	or	FILE=*file-name-expr*
	or	IOSTAT=*scalar-default-int-variable*
	or	ERR=*label*
	or	EXIST=*scalar-default-logical-variable*
	or	OPENED=*scalar-default-logical-variable*
	or	NUMBER=*scalar-default-int-variable*
	or	NAMED=*scalar-default-logical-variable*
	or	NAME=*scalar-default-char-variable*
	or	ACCESS=*scalar-default-char-variable*
	or	SEQUENTIAL=*scalar-default-char-variable*
	or	DIRECT=*scalar-default-char-variable*
	or	FORM=*scalar-default-char-variable*
	or	FORMATTED=*scalar-default-char-variable*
	or	UNFORMATTED=*scalar-default-char-variable*
	or	RECL=*scalar-default-int-variable*
	or	NEXTREC=*scalar-default-int-variable*
	or	BLANK=*scalar-default-char-variable*
	or	POSITION=*scalar-default-char-variable*
	or	ACTION=*scalar-default-char-variable*
	or	READ=*scalar-default-char-variable*
	or	WRITE=*scalar-default-char-variable*
	or	READWRITE=*scalar-default-char-variable*
	or	DELIM=*scalar-default-char-variable*
	or	PAD=*scalar-default-char-variable*

READWRITE=c	C is a scalar character variable returned with values:
YES	Reading and writing are allowed
NO	Reading and writing are not allowed
UNKNOWN	Condition not known

DELIM=c	C is a scalar character variable (used in character constants in list-directed or namelist) that may be returned with:
APOSTROPHE	Is used as a delimiter
QUOTE	Is used as a delimiter
NONE	No delimiter is used
UNDEFINED	File is not connected or not formatted
PAD=c	C is a scalar character variable that may be returned with:
YES	Padding is used when input is too short
NO	No padding is used.

The following example shows use of the INQUIRE specifier:

```
INQUIRE (9, EXIST = EX, WRITE = CHAR)
IF  (CHAR.EQ."NO") STOP
```

- Jeanne Adams

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STILL VALID NEWS SHEETS

Below is a list of News Sheets that still contain some valid information which has not been incorporated into the Bulletin set (up to News Sheet 305). All other News Sheets are redundant and can be thrown away.

PLEASE NOTE: This is the last time this list will be puslished in the ECMWF Newsletter. All users now have access to the ECMWF online help system, *echelp* - see page 44 of the December 1993 Newsletter. The News Sheets are stored in this system, and deleted when they are no longer valid. Hence there is little need to publish this list every quarter here.

No.	**Still Valid Article**
204	VAX disk space control
224	Job information cards
235	VAX public directory - how to create
253	Copying complete UNICOS directories to ECFILE
260	Changes to PUBLIC directories for VAX users
261	Meteogram system on UNICOS
265	Lost UNICOS outputs submitted via RJE or VAX Microfiche changes
266	Reminders on how to import/export magnetic tapes
268	Changes to WMO FM 92 GRIB
271	New ECFILE features on UNICOS
280	UNICOS on-line documentation: docview
281	File transfer via FTP (possible problems)

No.	**Still Valid Article**
283	New features for Member State batch users (RQS 1.1)
284	UNICOS 7 features & differences
286	Improving the performance of "model" jobs on the Cray Y/MP8 at ECMWF (pre-allocating disk space)
294	Changes to the Meteogram system
296	Introduction of the new (TCP/IP) ECFILE on the Y/MP16-C90
297	Automount on the C90
298	New Member State job queues
300	Techniques to reduce memory requirements and improve I/O performance on the C90
301	Use of *sendtm* (hints on how to use)
303	Change to the default retention period for files in ECFILE
305	TCP/IP network connections to external hosts
306	An improvement to SDS scheduling Cray account unit - change to definition

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United Kingd.	Dr R Wiley	Dr A Dickinson	Mr C R Flood

* At its 37th Session (December 1992) the Council decided that the telecommunications link between ECMWF and Belgrade would be terminated with immediate effect, and that henceforth no ECMWF documents would be sent to the Federal Republic of Yugoslavia (Serbia and Montenegro).

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ECMWF CALENDAR 1994

12 - 13 April	Technical Advisory Committee Subgroub meeting
21 - 22 April	Scientific Advisory Committee, 22nd session
25 - 26 (am) April	Technical Advisory Committee, 19th session
26 (pm) - 27 April	Policy Advisory Committee, 2nd session
29 April	Finance Committee, 52nd session
2 May	*ECMWF HOLIDAY*
9 - 10 May	Security Representatives meeting
30 May	*ECMWF HOLIDAY*
18 April - 17 June	Meteorological training course:
18 April - 6 May	**Met 1:** Numerical methods, adiabatic formulation of models, data assimilation and use of satellite data
9 - 20 May	**Met 2:** Parametrization of diabatic processes
23 - 26 May	**Met 3:** General circulation, systematic model errors and predictability
6 - 17 June	**Met 4:** Use and interpretation of ECMWF products
1 - 2 June	Council, 40th session
20 - 22 June	Workshop - Semi-Lagrangian methods
29 August	*ECMWF HOLIDAY*
5 - 9 September	Seminar - Parametrization of the physical processes in models

26 - 28 September	Scientific Advisory Committee, 23rd session
28 - 30 September	Technical Advisory Committee, 20th session
4 - 5 October	Finance Committee, 53rd session
6 - 7 October	Policy Advisory Committee, 3rd session
14 - 16 November	Workshop - Modelling and assimilation of clouds
21 - 25 November	Workshop - Parallel processing in meteorology
1 - 2 December	Council, 41st session
23 - 27 December	*ECMWF HOLIDAY*

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ECMWF PUBLICATIONS

TECHNICAL MEMORANDA:

No. 198 Accuracy of the ERS-1 altimeter-derived Fast Delivery Products for wave data assimilation

Workshop Proceedings on parametrization of the cloud topped boundary layer, 8-11 June 1993

Forecast and Verification Charts to 28 February 1994

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INDEX OF STILL VALID NEWSLETTER ARTICLES

This is an index of the major articles published in the ECMWF Newsletter series. As one goes back in time, some points in these articles may have been superseded. When in doubt, contact the author or User Support.

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