European Centre for Medium Range Weather Forecasts

ECMWF NEWSLETTER

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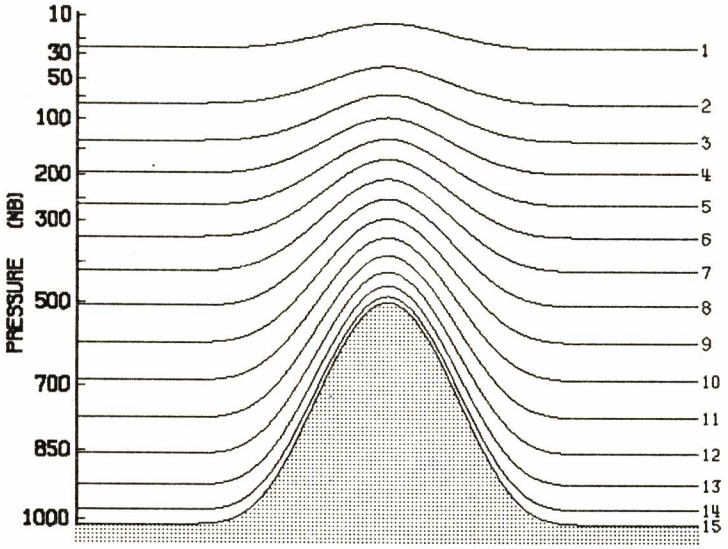
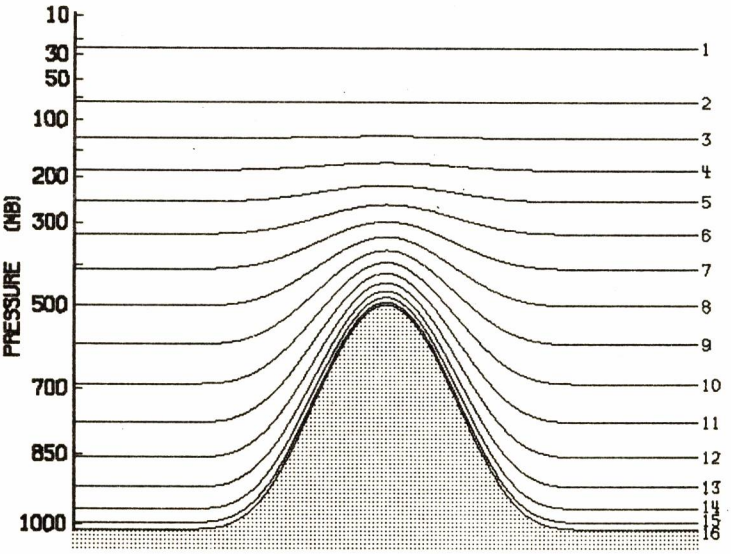
Number 20 - April 1983



SIGMA LEVELS OLD OPERATIONAL MODEL



HYBRID LEVELS NEW OPERATIONAL MODEL

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METEOROLOGICAL

COMPUTING

GENERAL

* NOTE: This article directly concerns the computer service; we recommend that computer users read it.

COVER: Distribution of levels for the old and new operational models (see article on p.1).

This Newsletter is edited and produced by User Support.

The next issue will appear in June 1983.

THE INTRODUCTION OF A NEW FORECAST MODEL AND REVISED OROGRAPHIC REPRESENTATION

1. INTRODUCTION

Final testing of two major changes to the ECMWF forecasting system is currently taking place, and operational implementation is expected shortly. The first change is the introduction of a new forecast model, together with related changes in the analysis/model interface, the initialisation and the post-processing. The principal differences from the Centre's first operational model are in the adiabatic formulation, which incorporates a spectral representation in the horizontal, a "hybrid" vertical coordinate, and a revised time-stepping scheme. The second important change is use of a higher, "envelope" orography in the lower boundary conditions of the forecast model. The purpose of this paper is to summarise the evidence on which the decision to make these changes was based, and to give some specific details of the changes.

2. THE NEW MODEL

The primary factor influencing the decision to change the operational model was the better performance of the spectral technique in an extended experiment comparing forecasts performed once per week during the first year of operational forecasting (Girard and Jarraud, 1982). In this experiment, the operational grid-point model forecasts were compared with spectral forecasts made using the model described by Baede et al.(1979) with triangular truncation at total wavenumber 63 (T63). The two models used identical parameterisation schemes, and required similar amounts of computing resources. Although the models often gave very similar forecasts, some clear differences in overall performance were found. An indication of this is given by Fig. 1 (overleaf). Following the completion of this experiment, further comparisons were made at regular intervals. Conclusions were unaltered, and one example of a markedly better local forecast from the spectral model is shown in Fig. 2 (overleaf).

The new model can use any vertical coordinate for which model layers are defined by interfacial pressures of the form

$$p = A + Bp_s$$

where p_s is the surface pressure and the values of A and B depend upon the model layer. When A=0, this reduces to sigma coordinates whereas B=0 gives pressure coordinates.

Simmons and Strüfing (1981) discuss a number of advantages of using a "hybrid" vertical coordinate which resembles the usual sigma coordinate close to the ground, but which reduces to a pressure coordinate at stratospheric levels. Provided final testing is satisfactory, such a coordinate will be used in the operational application of the new model. It is also proposed to use 16 layers in the vertical and, on the front cover of this issue, the levels at which the primary model variables will be predicted are compared with the 15 levels currently used.

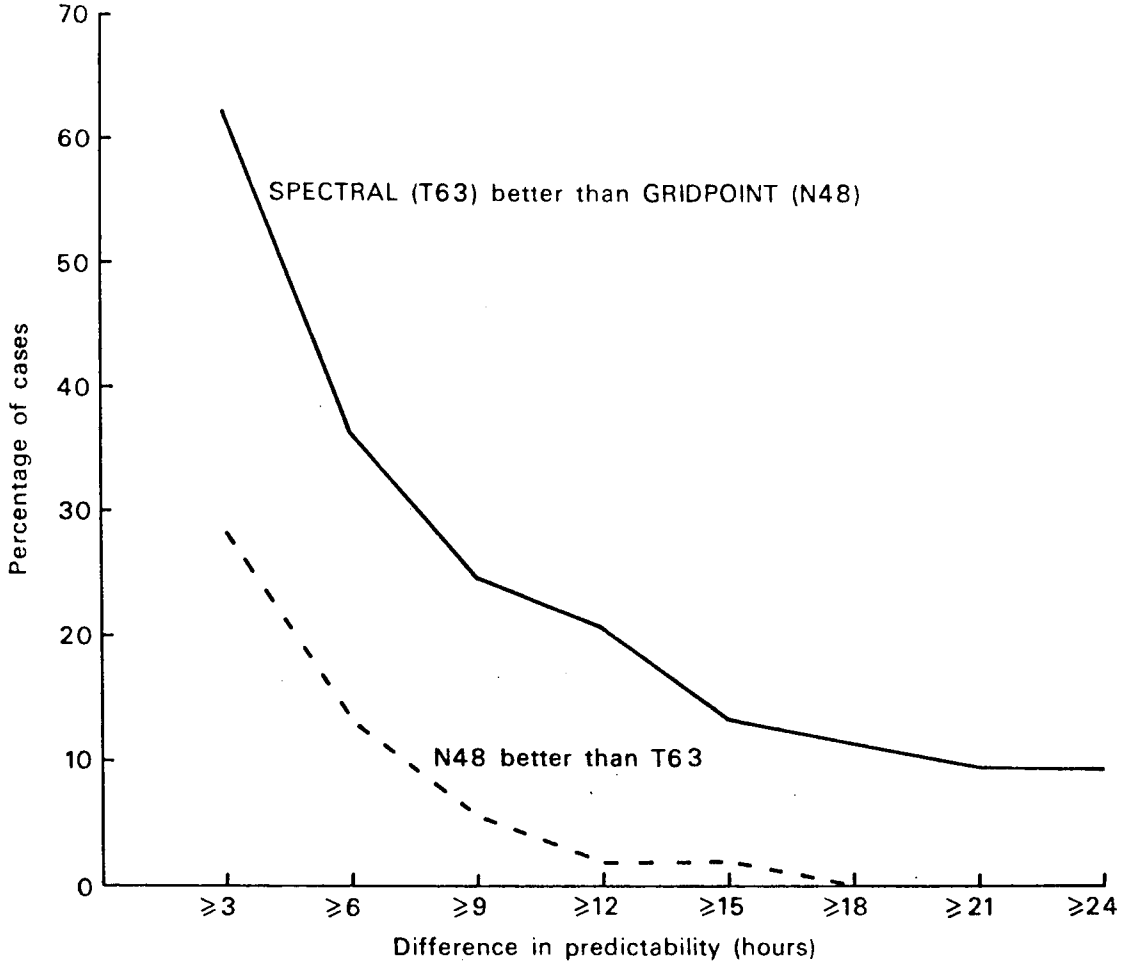

Fig. 1 **The difference in predictability (measured by the length of the forecast period for which the anomaly correlation of the 1000 mb height over the extratropical Northern Hemisphere remains above 60%) between spectral (T63) and grid-point (N48) models. Results are expressed in terms of the percentage of cases for which one or other model gave better results.**

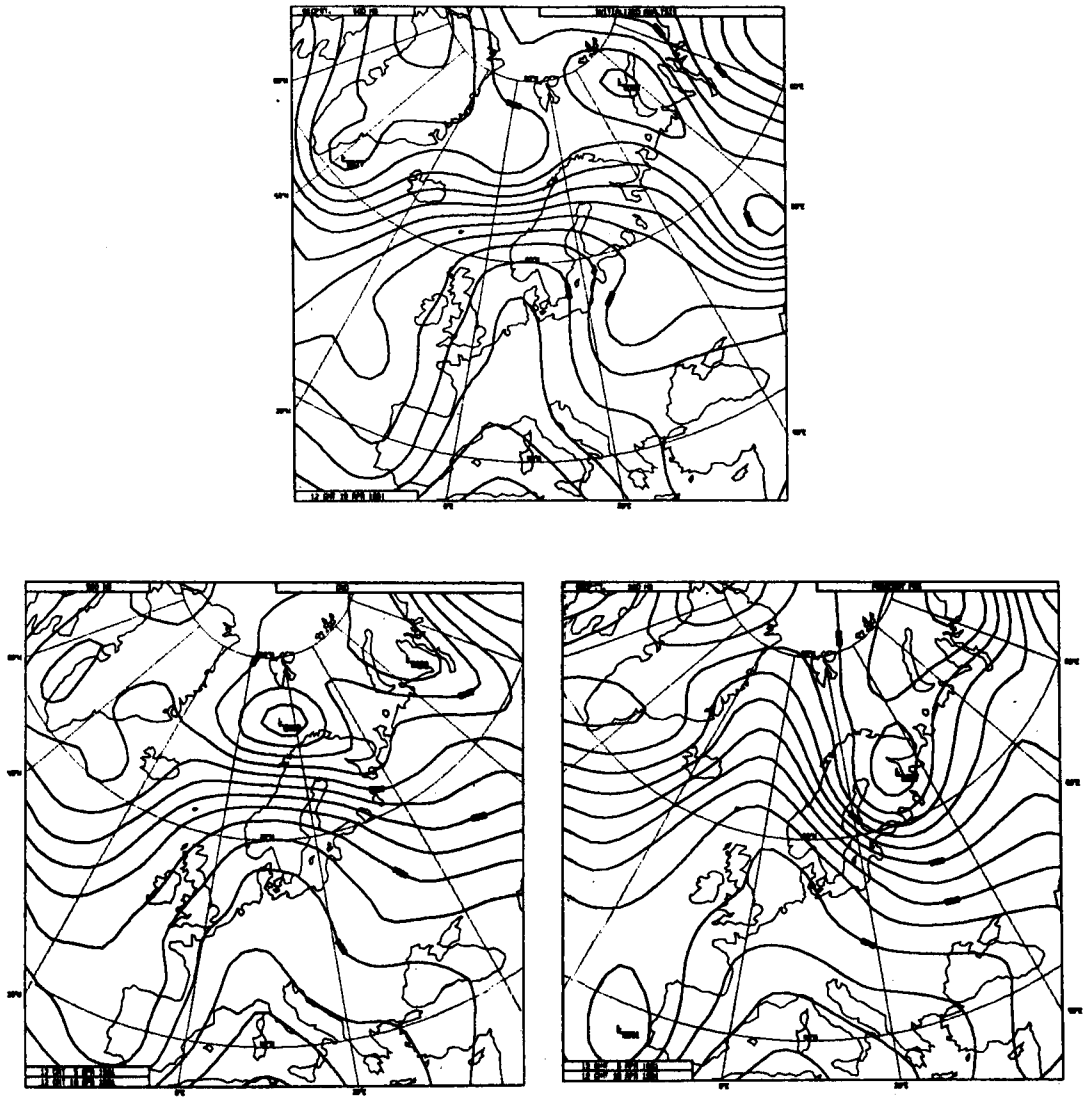

Fig. 2 **The analyzed 500 mb height for 10 April, 1981 (upper) and 5-day forecasts for this date by the T63 spectral model (lower left) and the N48 grid-point model (lower right).**

A third change to be introduced is in the time scheme of the model. A more efficient technique has been developed by using a semi-implicit method to represent not only the usual gravity-wave terms, but also the horizontal advection of vorticity and moisture. The new terms treated implicitly are those describing advection by the zonal mean flow, and this enables use of a timestep which has typically been found to be some 30% larger than that possible with the usual semi-implicit scheme. Taken in conjunction with use of the spectral technique and hybrid coordinate, a timestep more than twice as long as found necessary with the operational grid-point model has been successfully used in an extreme case of strong flow in the polar stratosphere of the Southern Hemisphere. A timestep of 20 minutes will be adopted for the initial operational use of the model.

Prior to the final testing of the new model, including its incorporation in near real-time data assimilation, forecasts have been carried out for one case per week from 5 December 1982 to 26 February 1983, using initial data produced operationally using the grid-point model in the data assimilation. All but one of the 13 cases were judged by objective verification to have given a better surface forecast than that produced by the operational model. For this rather limited sample, the mean improvement in predictability amounted to about 12 hours in the forecast range from 3 to 6 days ahead.

3. THE NEW OROGRAPHY

Diagnostic and barotropic model studies reported by Wallace et al.(1983) have suggested that the use of a grid-square mean orography significantly underestimates the orographic forcing of the synoptic and larger-scale flow in the operational ECMWF forecast model. Prediction experiments, some of which are described by Wallace et al., have been carried out using a series of "envelope" orographies formed by adding to the mean orography multiples of the standard deviation of the actual orography over the grid square, this being computed from a very high resolution data set. Some significant improvements in the accuracy of forecasts have been found, amounting in the mean to an increase in medium-range predictability of at least six hours. The growth of some systematic errors has also been substantially reduced, as illustrated by Figure 3.

Based on this experience gained with the grid-point model, several short series of experiments have been carried out using the new forecast model with different orographies. The prescription chosen for operational implementation is based on an envelope orography which is formed by adding $\sqrt{2}$ times the standard deviation of the sub-grid orographic height to the mean orography. This is then modified iteratively to reduce the variation of the spectrally-fitted orography over sea points. The latter reduces the unrealistic elevation of coastal points, and improves the analysis scheme's acceptance of data from coastal stations.

A nine-day data assimilation starting from 17 December 1982 has been performed using this new orography, and forecasts have been made from each of the last seven days of this period. Using the new model, results were substantially better than obtained from the operational grid-point orography, and objective verification revealed an average improvement in accuracy of 12 hours or more in the medium range. The limited duration of this particular experiment makes generalisation difficult, and a precise estimate of the general benefit of the new orography cannot be given on the basis of these encouraging results.

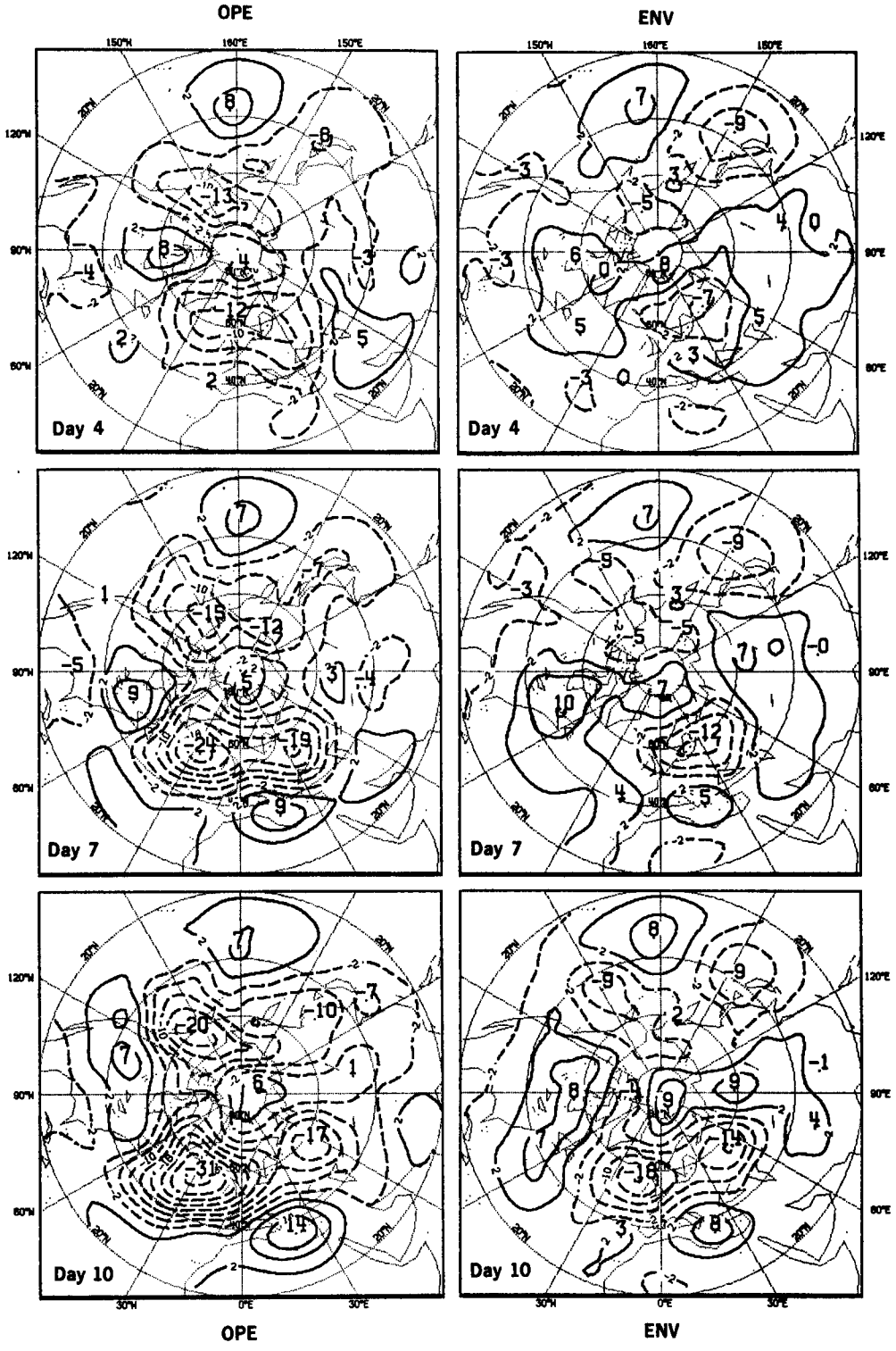

Fig. 3 Mean 500mb height errors of forecasts for days 4, 7 and 10 starting from initial dates within January 1981. Results from operational forecasts are shown in the left-hand column, while the right-hand column shows results from experimental forecasts including an "envelope" orography. The contour interval is 4 dam.

The introduction of an envelope orography will have a direct impact on a number of surface and near surface fields. Forecast values of surface and 2m temperatures will be those consistent with the enhanced height of the orography, and will thus be colder than for the grid-square mean orography. To minimise the effect on users, values will be corrected before dissemination so as to be appropriate to a mean orography, using a uniform lapse rate of 6.5 K/km. Uncorrected values will also be made available if requested. Associated with the colder surface temperatures, snowfall and snowcover will be more widespread than hitherto, and these fields cannot easily be corrected. Despite such detrimental features of the envelope orography, the improvements in forecasts of the large-scale atmospheric flow it brings about are considered sufficient to justify its operational implementation. Future research will be directed towards finding a more satisfactory way of representing the dynamical effects of sub grid-scale mountains.

References

Baede, A.P.M., Jarraud, M. and Cubasch, U., 1979: Adiabatic formulation and organisation of ECMWF's spectral model. ECMWF Technical Report No. 15, 40 pp.

Girard, C., and Jarraud, M., 1982: Short and medium range forecast differences between a spectral and grid point model. An extensive quasi-operational comparison. ECMWF Technical Report No. 32, 178 pp.

Simmons, A.J., 1983: Adiabatic formulations of the ECMWF forecasting system. Proceedings of the 1982 ECMWF Seminar on Interpretation of Numerical Weather Prediction Products.

Simmons, A.J. and Strüfing, R., 1981: An energy and angular-momentum conserving finite-difference scheme, hybrid coordinates and medium-range weather prediction. ECMWF Technical Report No. 28, 68 pp.

Wallace, J.M. Tibaldi, S. and Simmons, A.J., 1983: Reduction of systematic forecast errors in the ECMWF model through the introduction of an envelope orography. Proceedings of the ECMWF Workshop on Intercomparison of Large-scale Models used for Extended Range Forecasts.

- Adrian Simmons

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COMPARISON OF ECMWF AND NEW ZEALAND PROGNOSES

Prognoses for MSL and the 500 hPa level, valid at 1200 GMT, are compared using S1 skill scores. The prognoses come from three sources: the ECMWF NWP model (ECNWP), the NZ NWP model (NZNWP) and NZ manual methods (NZMAN). Skill scores cover the six-month period April-September 1982.

Values of skill scores can range from 0 to 200, with lower values for better forecasts. Typically, the best forecasts have scores of about 20, and the worst about 100.

There are three separate comparisons.

1. MSL prognoses valid at 1200 GMT - NZ area

S1 skill scores for the NZ prognoses are calculated using an 8-point NZ grid, skill scores for the ECMWF prognoses use a 4 x 5 grid over the same NZ region.

Table 1 gives the average scores of the ECMWF prognoses for four different forecast periods, and of the NZ prognoses for two forecast periods.

Source	Forecast period	(a)	(b)
ECNWP	T + 24	35.5	25.4
	T + 48	50.0	24.8
	T + 72	61.2	19.7
	T + 96	68.0	20.5
NZNWP	T + 24	48.0	14.8
	T + 48	60.7	11.8
NZMAN	T + 24	47.6	12.7
	T + 30	53.0	14.2

Table 1 Evaluation of MSL prognoses over the NZ region.
Prognoses valid at 1200 GMT.
(a) Average S1 skill score.
(b) Average improvement over persistence.
Period covered: April-September 1982.

This table shows that:

i. for each forecast period, ECMWF prognoses are noticeably more skilful than NZ prognoses;

ii. both the 24 hour prognoses prepared in NZ are only slightly more skilful than the 48 hour ECMWF prognoses;

iii. the ECMWF 48 hour prognoses are slightly more skilful than the NZ manual 30 hour prognoses;

iv. the ECMWF 72 hour prognoses and the NZ NWP 48 hour prognoses have similar scores;

v. items ii and iv support the conclusion reached in a quasi-subjective evaluation (Neale, 1982) of ECMWF and NZ prognoses in the NZ region, viz. that the former are superior to the latter by about one day.

Tabulations of 'improvement over persistence' - the difference between the S1 skill score of the prognosis, and the S1 score obtained by assuming the initial analysis to persist as the prognosis - show a marked difference between ECMWF and NZ products. In the former, improvements drop only slightly even out to 96 hour forecasts (remaining in the range 20 to 24), remaining always greater than improvements achieved by NZ prognoses.

2. MSL prognoses valid at 1200 GMT - SW Pacific area

S1 skill scores for the NZ prognoses are calculated over the area bounded by 20S, 50S, 130E and 160W. For the ECMWF prognoses, calculation is over the area bounded by 25S, 55S, 130E and 160W. Both these areas are shown in Fig. 1.

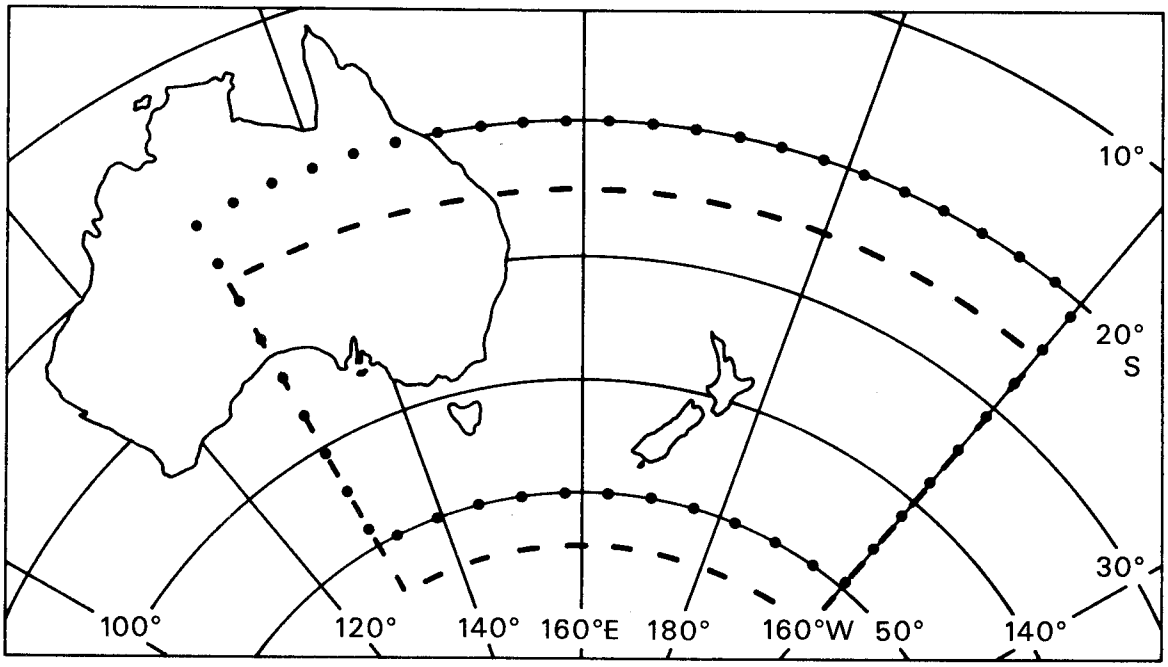

Fig. 1 Areas over which S1 skill scores are calculated. New Zealand prognoses are evaluated over the area bounded by dots; ECMWF prognoses by dashes.

Table 2 gives the average skill score, improvement over persistence and the correlation coefficient of forecast change vs actual change.

Source	Forecast period	(a)	(b)	(c)
ECNWP	T + 24	32.0	24.0	0.86
	T + 48	45.4	22.0	0.81
	T + 72	54.3	18.8	0.76
	T + 96	60.5	18.5	0.72
NZNWP	T + 24	49.2	12.5	0.72
	T + 48	65.5	6.6	0.61

Table 2 Evaluation of MSL prognoses over the south west Pacific region. Prognoses valid at 1200 GMT.
(a) Average S1 skill score.
(b) Average improvement over persistence.
(c) Average correlation coefficient (forecast change vs actual change). Period covered: April-September 1982.

This table shows that:

i. ECMWF forecasts tend to be more skilful over the larger area than they are over the limited NZ area.

ii. NZ NWP forecasts tend to be less skilful than over the limited NZ area. A contributing factor here could be the fact that the area boundary is nearer the upwind limit of the regional NWP model.

iii. As a consequence of i and ii, ECMWF forecasts are superior to those prepared in NZ by more than one day.

iv. Improvements over persistence values are similar to those for the limited NZ area, except for the 48 hour NZ NWP prognoses, where the improvement has become quite small.

v. ECMWF forecasts reproduce changes more accurately than the NZ forecasts. The highest correlation coefficient for the latter (0.72), for the 24 hour prognoses, is similar to the lowest for ECMWF forecasts (the 96 hour prognoses).

3. 500 hPa prognoses valid at 1200 GMT - SW Pacific area

Areas over which skill scores are calculated are the same as in section 2, and Table 3 lists similar data to those in Table 2.

Source	Forecast period	(a)	(b)	(c)
ECNWP	T + 24	22.0	26.2	0.91
	T + 48	33.1	24.8	0.87
	T + 72	41.8	20.3	0.80
	T + 96	48.1	17.8	0.75
NZNWP	T + 24	36.8	14.7	0.78
	T + 48	48.7	11.0	0.66

Table 3 Evaluation of 500 hPa prognoses over the south west Pacific region. Prognoses valid at 1200 GMT.
(a) Average S1 skill score.
(b) Average improvement over persistence.
(c) Average correlation coefficient (forecast change vs actual change). Period covered: April-September 1982.

Table 3 shows that:

i. Both models (ECMWF and NZ NWP) produce more skilful forecasts for the 500 hPa level than for MSL.

ii. The ECMWF 48 hour forecast is slightly more skilful than the NZ NWP 24 hour forecast.

iii. The ECMWF 96 hour forecast is as skilful as the NZ NWP 48 hour forecast.

iv. Improvement over persistence, and correlation coefficients confirm that forecasts of the 500 hPa level are better than those for MSL.

References

Neale, A.A., 1982: Subjective evaluation of MSL prognoses (unpublished).

- A.A. Neale
Chief Forecaster,
New Zealand
Meteorological
Service

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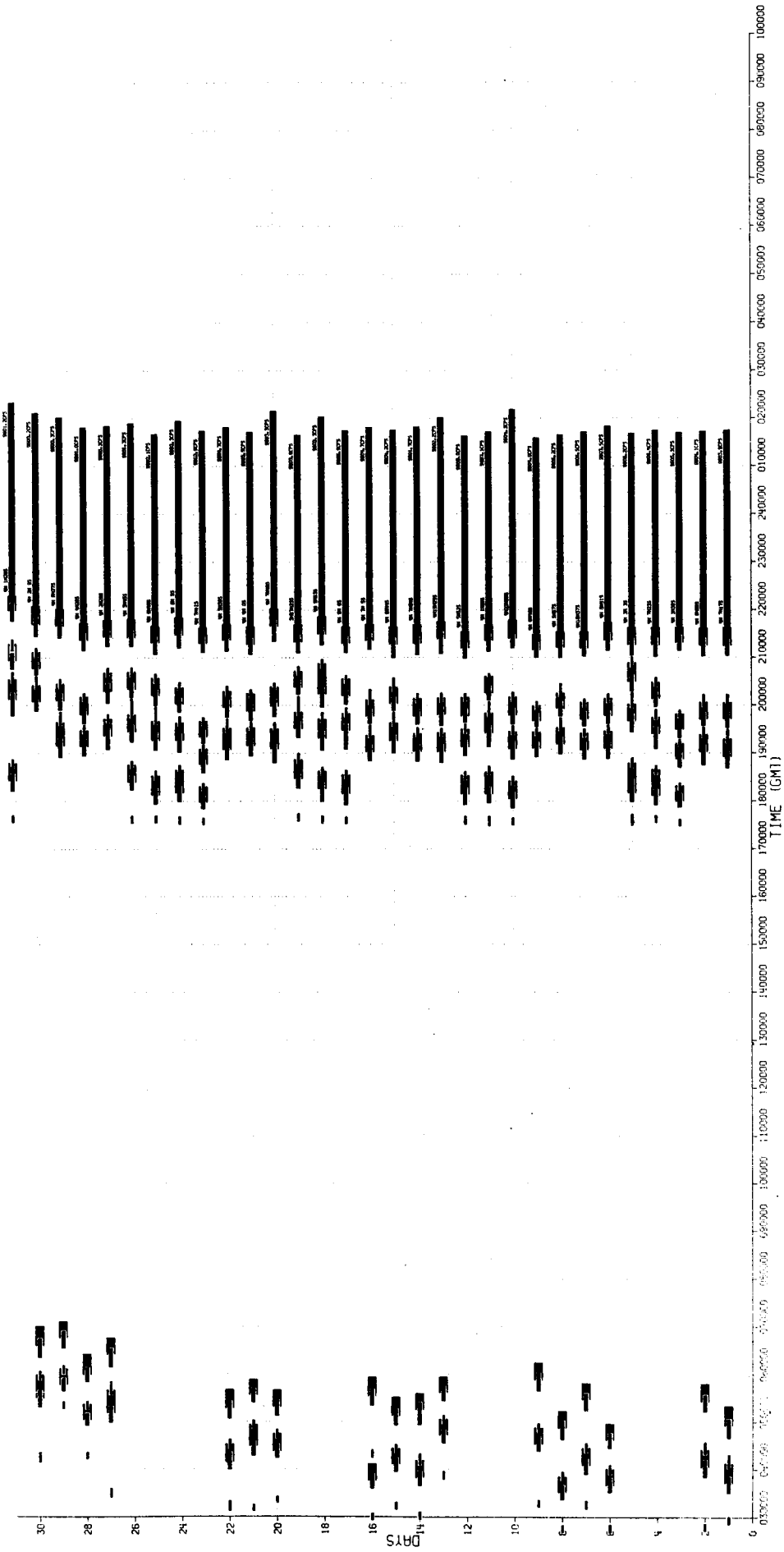
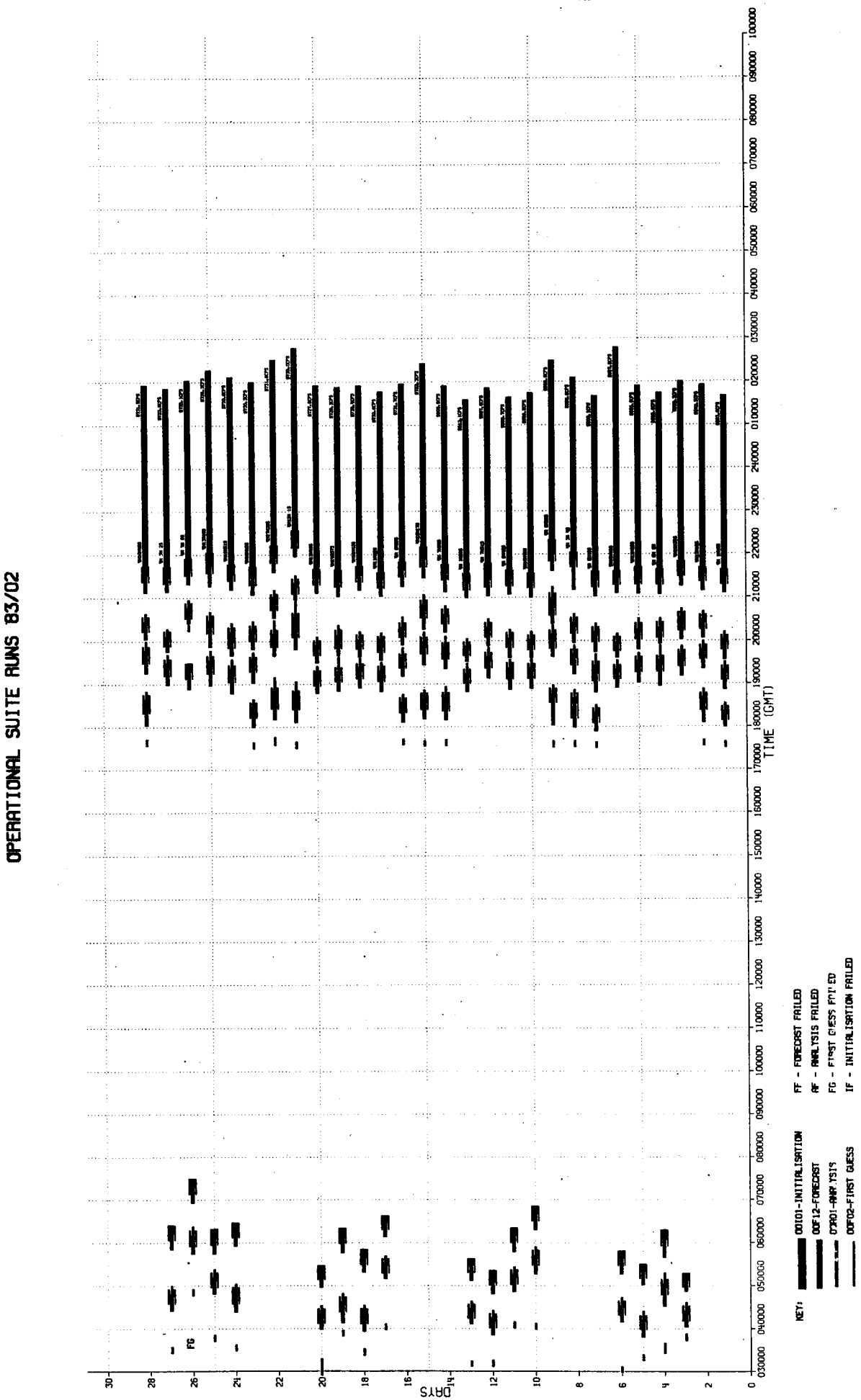
OPERATIONAL SUITE RUNS 83/01



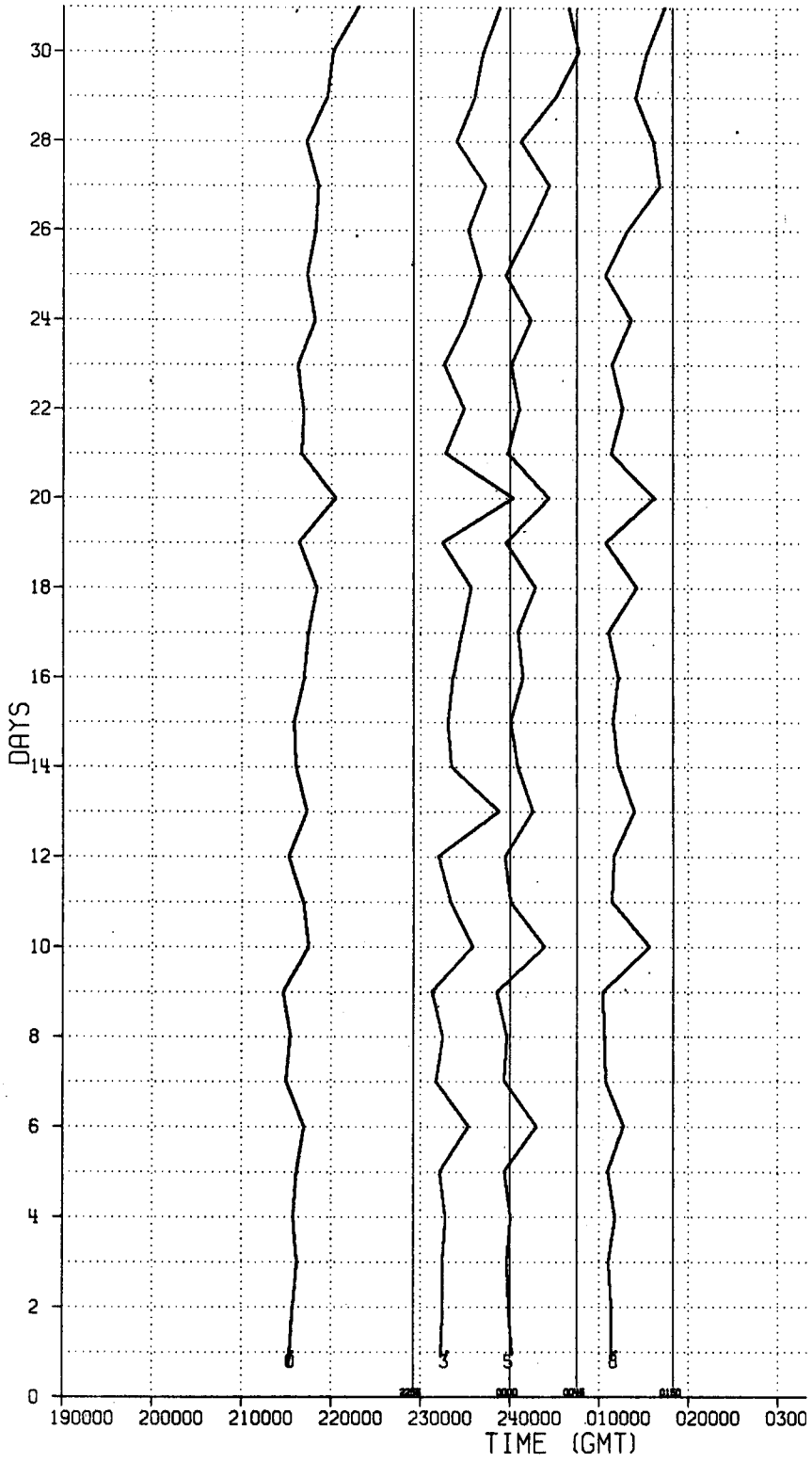
The plots (above and overleaf) show run times for the major Cray components of the daily forecast run for January and February respectively. The plotted lines show the elapsed time of each program in different thicknesses, for each day of the month.

There were no significant delays to the running of the operational suite in either month.


OPERATIONAL SUITE RUNS 83/02
DAYS
TIME (GMT)
KEY:
OD101-INITIALISATION
OOF12-FORECAST
OTR01-ANALYSIS
OOF02-FIRST GUESS
FF - FORECAST FAILED
AF - ANALYSIS FAILED
FG - FIRST GUESS FAILED
IF - INITIALISATION FAILED

DISSEMINATION RUNS
January 1983

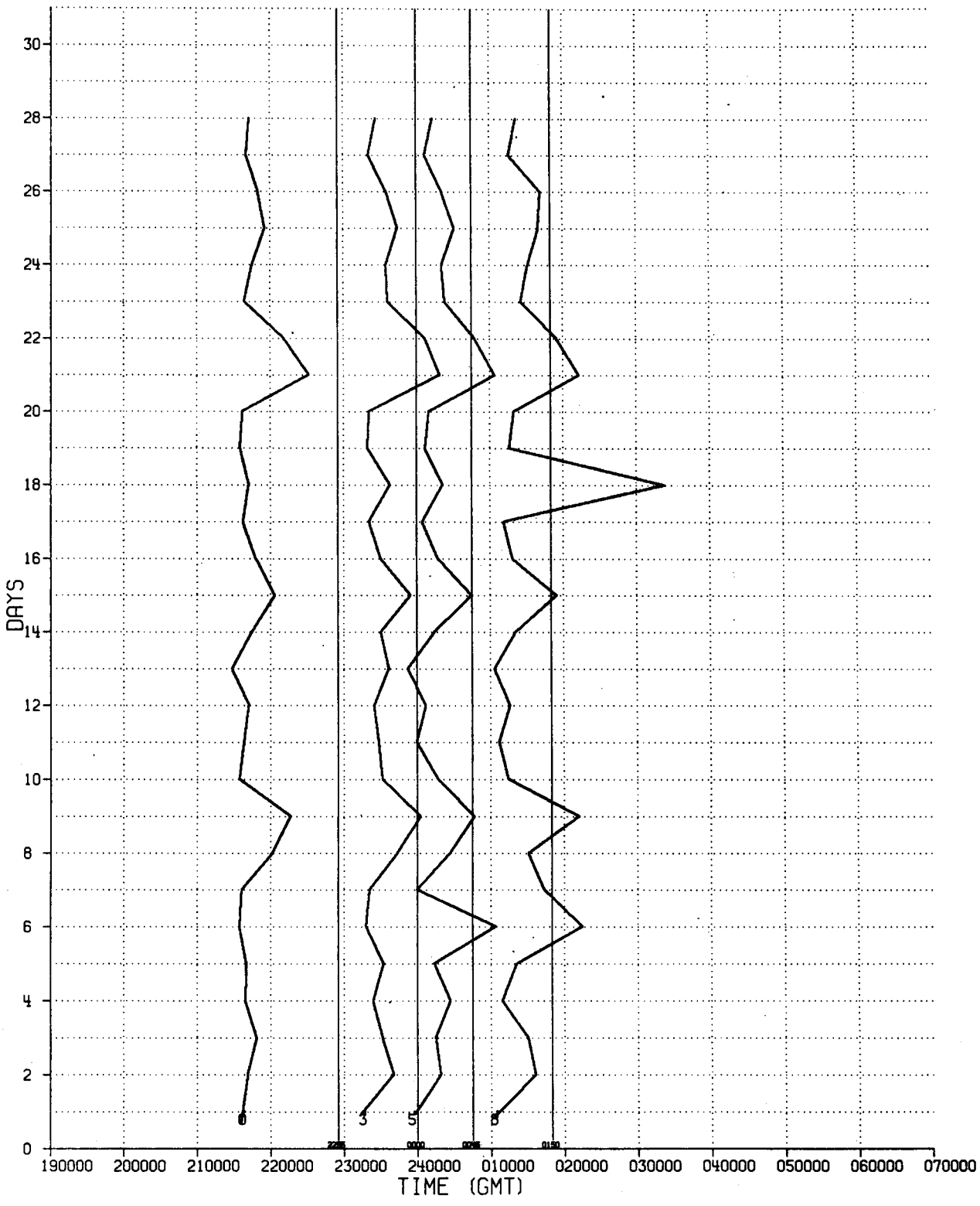
This edition of the Newsletter includes diagrams for January and February 1983 (overleaf) showing times at which dissemination products were produced during the operational forecasts.



The zig-zag lines show times by which analysis products (day 0) and forecast products (days 3, 5 and 8) were completed on the CYBER and routed to the NFEP telecommunications computer, but not the times at which products were routed onward to individual Member States. Also shown, as solid vertical reference lines, are corresponding clock times (GMT) by which products are expected to be available on ninety percent of occasions. The 'ninety percent' time for day 0 is 2255, for day 3 is 0000, and so on.

- John Chambers

DISSEMINATION RUNS
February 1983



CRAY SOFTWARE PLANS FOR 1983

The major software development emphasis in 1983 will be multi-tasking support for the Cray X-MP and continued stability. The plans fall into two main categories:

COS - Operating system

CFT and Libraries

COS plans include:

X-MP support

This will enable COS to support multi-tasking for the CRAY X-MP. This means that one program running on the X-MP will be capable of using both CPUs simultaneously.

Device Allocation Enhancements

These will include the ability to specify that a dataset is to be allocated a contiguous area on disk. This minimises the amount of time taken to read and write to the dataset, since it reduces the number of times that the disk heads have to be moved (which is relatively time-consuming).

Error Recovery Enhancements

Jobs will no longer be aborted if the system runs out of disk space. Neither will the system "crash" if a disk error occurs when trying to roll-in a job from disk to memory. These modifications will make the system more stable than it already is.

Resource Scheduling

This will enable jobs to inform the system what resources they require and in what quantities. This applies to disk, Buffer Memory and Solid-state Storage Devices. In this way, it is possible to prevent system deadlocks and to make efficient use of system resources.

CFT and Libraries - plans include:

CFT 1.11 and 1.12

New calling sequence

This will unfortunately involve re-compiling all Fortran code and re-assembling all CAL code, as it involves changing the way in which parameters are passed to subroutines/functions. This feature is required for re-entrant code, which in turn is needed for multi-tasking on the X-MP.

(Greater detail will be given in a later Newsletter, nearer the time of release.)

"IF" replacement by CVMGT CDIR$

CFT will recognise logical "IF" statements and attempt to replace them, if possible, by CVMG functions (vector merge instructions). This will improve performance by allowing loops containing these statements to vectorise.

GATHER/SCATTER vectorisation

This will allow the compiler to vectorise loops such as:

```
Y(JVAL(I)) = X(KVAL(I))....
```

where JVAL and KVAL are arrays used to index Y and X. Such constructs inhibit vectorisation at present.

Improved Instruction Scheduler

This should improve both vector and scalar performance.

Re-entrant Code

This will make use of stack-based or heap-based dynamic memory management routines to allocate memory at runtime for user temporary arrays and subroutine local variables.

1-Line "DO" Loops

These recognise some loops which perform specialised functions (sums, dot products, etc.) and replace them with calls to optimised routines in $SCILIB.

Various other optimisations.

Libraries 1.11 and 1.12

Multi-tasking support

Routines will be provided to enable multi-tasking to be used.

Stack and Heap Manager

These will be widely used by software (libraries, user codes, operating system) to allow dynamic runtime memory management.

Segment Loader

This allows very large programs to run in a limited memory space and is similar in design to CDC's segment loader.

PASCAL

This compiler should be available by the end of 1983.

Another area into which a large amount of effort is being concentrated is NFT, the new Fortran compiler. This will be written in PASCAL and will be an optimising and vectorising compiler with the inclusion of array-processing syntax. It is needed to improve the reliability, maintainability and extensibility of Cray Fortran. NFT will not be available for some time yet, but work on its design has been underway since last year.

- Neil Storer

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* FURTHER PROCEDURE LIBRARY CHANGES

1. The following enhancements to the procedure library have been completed recently:

a. SUB,lfn,ST= [MCY / CRA] ,TEXT=$.....$,...

TEXT allows any character string to be added to the job statement generated by SUB., additional job statement parameters, such as 'GE1' may therefore be added.

b. PRINT,lfn,PE.

PE forces a Page Eject after the header page. Useful when 'lfn' contains print control characters but does not commence with a new page.

c. FICHE.
FICHE,SELECT=lfn.
FICHE,SELECT=ALL.

This procedure is now consistent with PRINT. If no filename is given and the SELECT keyword is omitted, FICHE operates on the last file processed by TYP. (Please note that this changes the action of FICHE compared to the previous implementation.) To operate on files in the remote output queue, use

SELECT=lfn.
or SELECT=ALL. to put on microfiche all files in your remote output queue.

2. The fileset procedures

GETFILE, ADDFILE, REPFILE, DELFILE, SURFILE, MAKFILE, LOOK

have been simplified for efficiency reasons and no longer support the 'old type' compressed files based on UPDATE and selected by the 'TYPE=' keyword.

3. Since it is now possible to execute PROCIN automatically during the INTERCOM LOGIN process, a new procedure

DEFPROC.

is available to create a startup procedure with pfn=PROLOGI. This procedure contains the statement:

BEGIN,,PROCIN,AC=ac,ID=uid.

A description of Intercom login procedures will be included in the Procedure Library Computer Bulletin B6.5/1, currently being revised.

- David Dent

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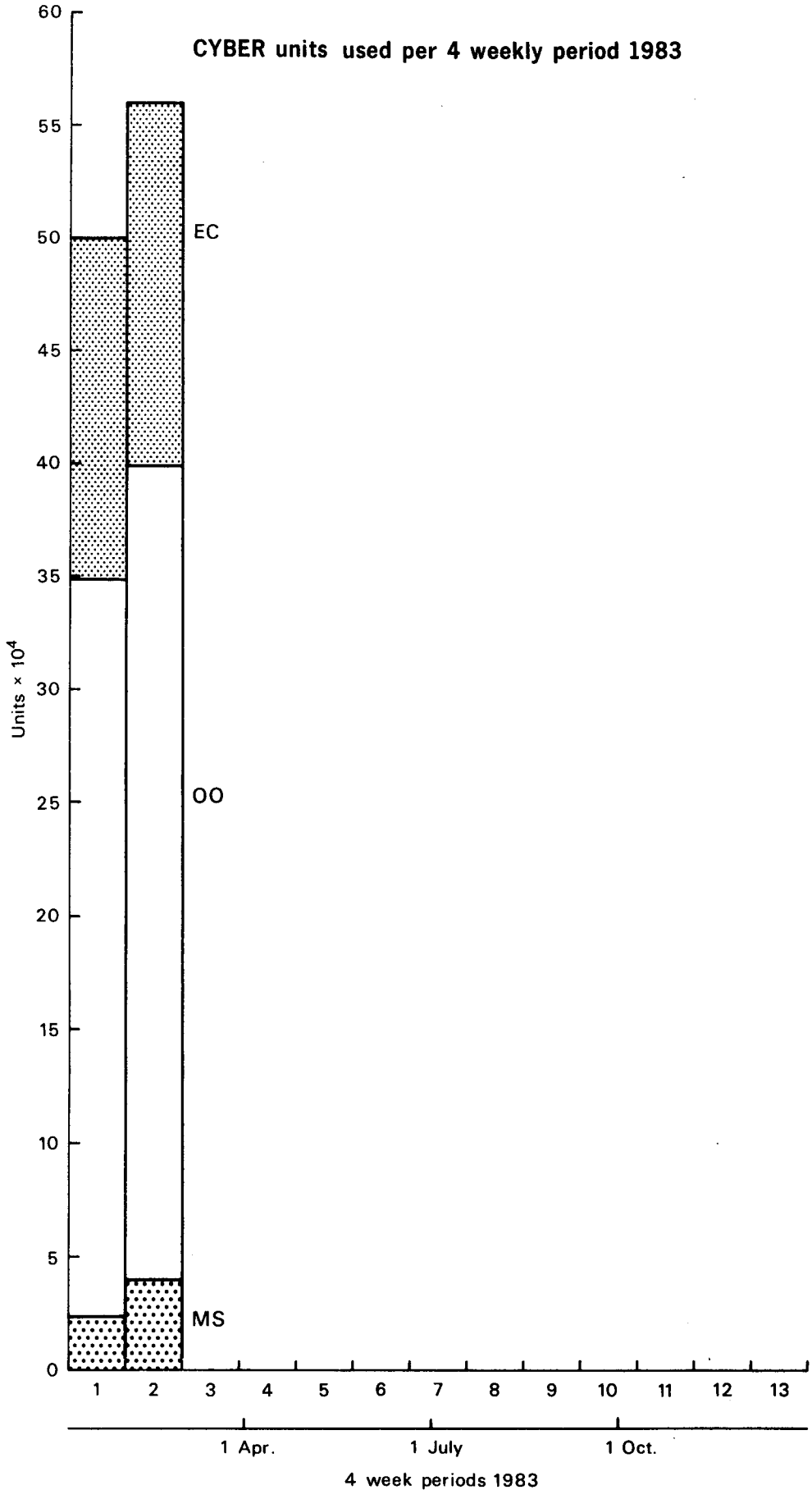
COMPUTER USAGE STATISTICS

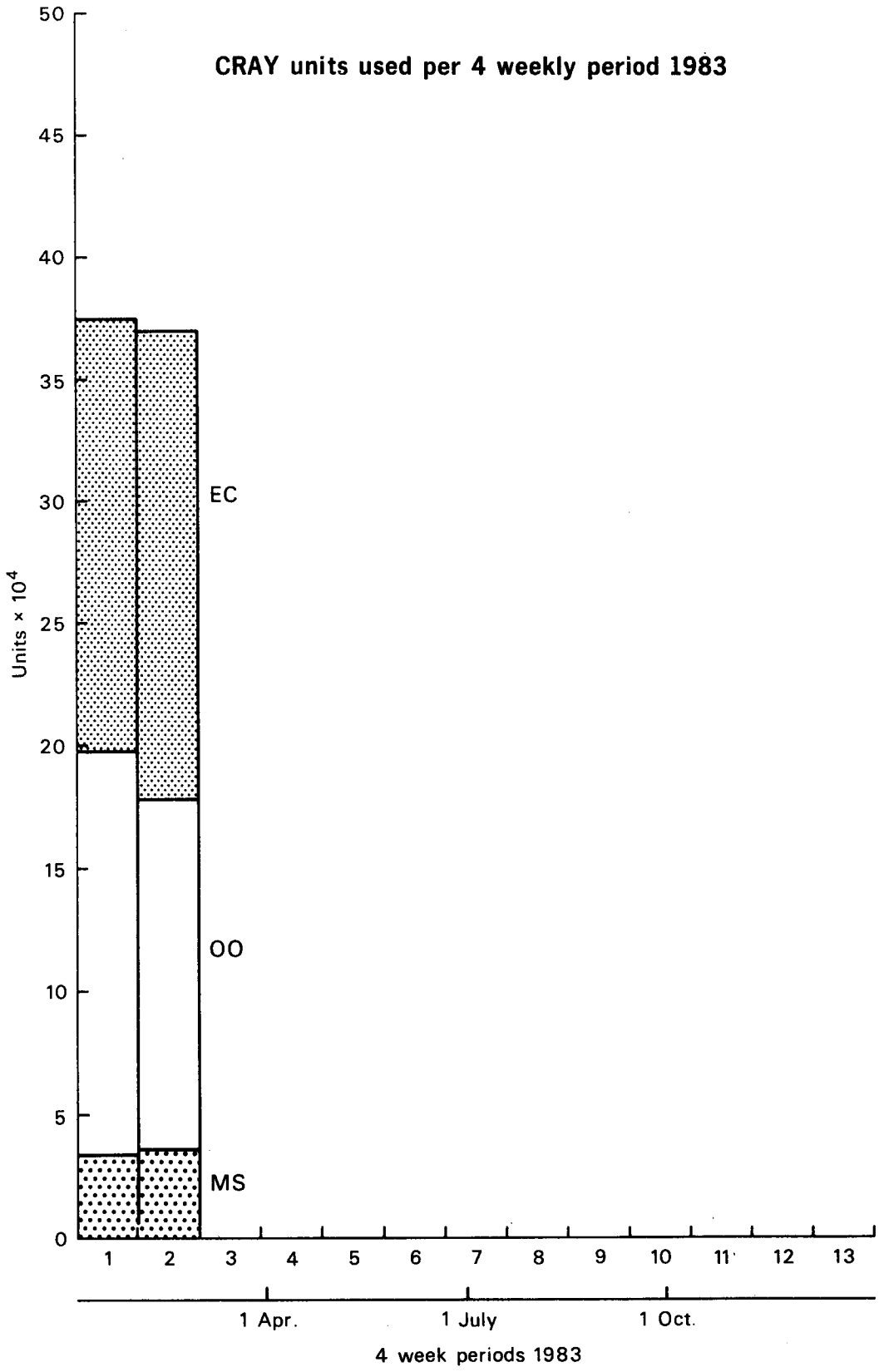


EC = Centre users

OO = operational suite running

MS = Member State users, including Special Projects

EC + OO + MS = total usage, less those jobs classed as systems overheads



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 143). All other News Sheets are redundant and can be thrown away.

No.	Still Valid Article
16	Checkpointing and program termination
19	CRAY UPDATE (temporary datasets used)
47	Libraries on the Cray-1
53	Writing 6250 bpi tapes (EEC parameter)
54	Things not to do to the Station
56	DISP
67	Attention Cyber BUFFER IN users
73	Minimum Cyber field length
89	Minimum field length for Cray jobs
93	Stranger tapes
118	Terminal timeout
120	Non-permanent ACQUIRE to the Cray
121	Cyber job class structure
122	Mixing FTN4 and FTN5 compiled routines
127	(25.1.82) IMSL Library
130	Cyber software: PACKS, SPACE
	Contouring package: addition of highs and lows
131	File storage on TEMP
132	(21.6.82) NOS/BE level 552, including SORT/MERGE5.
135	Local print file size limitations
136	Use of TEMP disk space
	Care of terminals in offices
140	PURGE policy change
141	AUTOLOGOUT - time limit increases
142	INTERCOM login default procedures
143	APOLLO - a new version of GEMINI

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ECMWF PUBLICATIONS

Technical Report No. 35	Energy budget calculations at ECMWF - Part 1 : Analysis 1980-81
Operational Data Assimilation System	Daily global analysis, Jan-Mar 1982, April-June 1982
Forecast Report No. 20	October/December 1982
ECMWF forecast and verification charts	to 13 January 1983 to 23 February 1983

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CALENDAR OF EVENTS AT ECMWF

20-21 April 1983	17th session of Council
3 May - 17 June 1983	Meteorological Training Course

The course is divided into four modules:

3-13 May	Introduction to numerical modelling
16-26 May	Parameterisation of physical processes and the dynamics of large scale processes
31 May-3 June	The ECMWF forecast system
6-17 June	Use and interpretation of ECMWF products

17 - 20 May 1983	Member States Computing Representatives' Meeting and MSCR "technical update" meeting (subject to confirmation)
5 - 9 September 1983	ECMWF 1983 Seminar on Numerical Methods for Weather Prediction
12 - 14 September 1983	11th session of Scientific Advisory Committee
14 - 16 September 1983	6th session of Technical Advisory Committee
28 - 30 September 1983	30th session of Finance Committee
23 - 24 November 1983	18th session of Council

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INDEX OF STILL VALID NEWSLETTER ARTICLES

This is an index of the major articles published in the ECMWF Newsletter plus those in the original ECMWF Technical 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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Alpex data management and the international Alpex data centre	11	Sept.81	1
ECMWF Analysis and Data Assimilation System	T3	June 79	2
ECMWF Limited Area Model	16	Aug. 82	6
ECMWF Operational Forecasting Model	5	Oct. 80	2
" " " "	6	Dec. 80	7
ECMWF Operational Schedule, Data and Dissemination	12	Dec. 81	1
ECMWF Production Schedule	6	Dec. 80	5
Facilities to verify and diagnose forecasts provided by the Data & Diagnostics Section	8	Apr. 81	3
Forecast products of various centres decoded and plotted at ECMWF	9	June 81	3
Forecasting: development of the new system	15	June 82	1
Meteorology Division.	T1	Feb. 79	4
Operational Archive Access facilities	16	Aug. 82	14
Operational Forecast Suite (EMOS)			
- general description	T1	Feb. 79	6
- data acquisition and decoding	T6	Dec. 79	1
- initialisation	T6	Dec. 79	4
- quality control	1	Feb. 80	3
- bulletin corrections (CORBUL)	2	Apr. 80	1
- archiving	3	June 80	4
- post processing	4	Aug. 80	3
- significant change made	12	Dec. 81	3
Pseudo "satellite picture" presentation of model results	1	Feb. 80	2
Research Department activities	13	Feb. 82	3
Retrieval of data from the Centre's data bases	5	Oct. 80	3
Spectral model	7	Feb. 81	4
- as new operational model	20	Apr. 83	1

*T indicates the original Technical Newsletter series

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Reception Counter)			
Tape Requests)	- Jane Robinson	CB Hall	332
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Deputy Ops. Section Head	- Graham Holt	CB 024	306
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