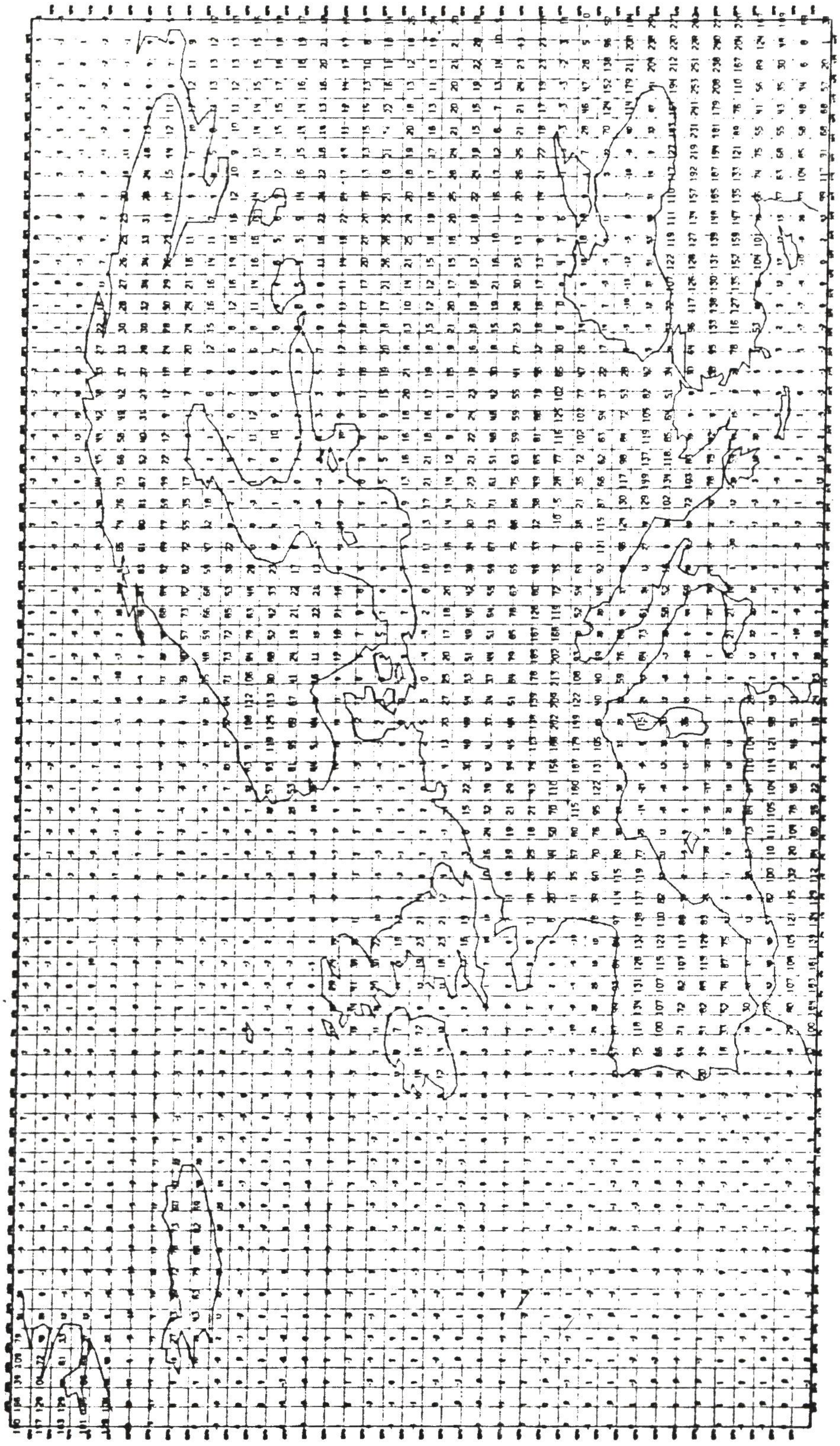
European Centre for Medium Range Weather Forecasts

ECMWF NEWSLETTER

Shinfield Park, Reading, Berkshire RG2 9AX, England. Tel: U.K. (0734) 876000, Int. (44 734) 876000, Telex: 847908

Number 29 - March 1985



This issue gives details of the new operational model to be introduced on 1 May 1985. This model has a higher resolution than the current version and an enhanced physical parameterisation scheme. Initial results of preliminary verification experiments are most encouraging: details of these are also given in this issue. More detailed verifications will be available for publication in Newsletters later this year. It is hoped that some of the meteorological services receiving ECMWF forecast products via the WMO Global Telecommunications System will find an article describing the way in which these grid code products may be manually decoded to be of interest.

Any service which is considering the acquisition of a multiprocessor will find a great deal of useful information contained in the article describing the implementation of a multitasking version of the ECMWF spectral model.

The 1985 ECMWF seminar will this year take as its topic "Physical parameterisation for numerical models of the atmosphere" and will be held in September. Further details are given on page 30.

* * * * * * * * * * * * *

CHANGES TO THE ECMWF OPERATIONAL FORECASTING SYSTEM

Recent changes

(i) A modified radiation scheme was introduced operationally on 4 December 1984, making use of a different approach to the treatment of gaseous effects in the solution of the longwave radiative transfer problem. The change only had a minor impact on the overall performance of the model. The largest effect of the modification was found in the middle and upper troposphere where the problem with the previously experienced strong infra-red cooling of layers containing minor cloud amounts was alleviated. Particularly in tropical and subtropical regions, the negative systematic temperature bias was found to be much reduced with the modified radiation scheme.

(ii) Spectrally filtered forecast fields at 1000 and 500 mb height, 850 mb temperature and 1000/500 mb thickness as well as the corresponding anomaly fields of temperature and thickness became available for dissemination to Member States as experimental products on 1 February 1985. The fields are truncated at total wavenumber 10 and valid at 12 GMT for the analysis and each day of the forecast out to day ten. Member States may request the products to be added to their dissemination list by specifying the appropriate ECMWF product catalogue number ($n_1n_1n_2n_2n_3n_3$) as given in Met. Bulletin M3.4/1(5).

Planned changes

(i) ECMWF plans to implement a high resolution forecast model (T106) on 1 May 1985. Preparations leading towards the implementation are according to schedule, but more work needs to be carried out and unforeseen problems may result in a change of the planned implementation date.

The high resolution model will have a positive overall impact on the forecasts in the free atmosphere. In the synoptic comparison of forecast experiments with the current operational T63 model the high resolution model consistently appears to improve on forecasting the smaller scale weather systems such as intense lows and frontal systems.

Some distinct improvements have also been found in near-surface fields, and these will be examined more objectively when extended data assimilation and forecast results are available from the quasi-operational "parallel runs" of the higher resolution model.

For further details of the change see the Newsletter article by Delsol and Simmons on page 3.

(ii) Together with the high resolution model it is planned to implement changes to the physical parameterisation scheme which include the addition of a treatment of shallow convention, modification of the Kuo convection scheme and the large scale condensation scheme and a new representation of clouds. Distinct improvements in forecast quality were found in both the extratropics and tropics with the new parameterisation package which is currently being tested at the T106 resolution. Further details on the impact of the new scheme will be given in a subsequent Newsletter.

Horst Böttger

* * * * * * * * * * * * *

THE NEW HIGH RESOLUTION FORECAST MODEL - TO BE IMPLEMENTED IN MAY 1985

ECMWF plans to introduce a high resolution forecast model at the beginning of May 1985. It should be noted that although the preparations leading towards this implementation are according to schedule, more work needs to be carried out and unforeseen problems may result in a change of the date for the switch-over to the new model.

The new forecasting system will be tested under operational conditions during a period of parallel runs with the operational suite in early April. The results from the parallel runs will be monitored carefully, the performance of the high resolution model will be assessed and compared to the operational output. Member States will subsequently be informed of the results of this comparison and the impact of the model change on the numerical products.

The following gives a description of the resolution and orography of the new T106 model and summarises the objective and synoptic evaluations of the forecast experiments carried out to date. Dissemination and archiving of the new model output are discussed at the end of the article.

It should be noted that ECMWF also plans to implement a significant change to the parameterisation scheme. Extensive tests of these changes (which include the addition of a treatment of shallow convection, modification of the Kuo convection scheme and large-scale condensation scheme, and a new representation of clouds) have been carried out at the current operational (T63) resolution. Some distinct improvements in forecast quality were found in both the extratropics and tropics, and it was therefore decided to test this new parameterisation package further at T106 resolution. Results to date indicate that the new schemes work well at higher resolution and, if additional testing is satisfactory, these changes will be introduced operationally at the same time as higher resolution. Further detail will be given in a subsequent Newsletter.

The resolution of the new model

The new spectral model will have 16 levels in the vertical (as in the present model) and the spectral representation in the horizontal will be truncated at total wavenumber 106. The physical (sub-grid scale) processes will be computed on the Gaussian grid of the model, which has a resolution of 1.125 degrees latitude/longitude. All the surface fields will be represented on this grid. In the free atmosphere, the truncation at T106 permits the resolution of horizontal motions with a half wavelength of approximately 190 km uniformly over the globe. Testing has led to the choice of a reduced envelope orography (mean plus one standard-deviation)*. Details of this new orography together with the land/sea mask are shown on the front cover illustration.

Objective verification of T106 experiments

Extensive experimentation has been carried out. The experimental forecasts were run systematically for the 15th of each month, starting with data from May 1983, and verified objectively. Attention has been concentrated on results for the extratropical Northern hemisphere. Predicted height and temperature fields were verified against operational T63 analyses.

A comparison of objective scores of the T106 and T63 forecasts is presented in Fig. 1. Anomaly correlations of height computed over the extratropical Northern Hemisphere using data for the standard pressure levels from 1000 to 200 mb are presented in scatter diagrams for the forecast ranges D+3, D+4, D+5 and D+7. Here points lying above the diagonal represent cases in which T106 gave better results than T63. The diagrams show that T106 improves on T63 on each of the days presented, with an almost systematic advantage early in the forecast range. Similar results are found for standard deviations of the height fields. Although mean improvements do not appear to be substantial compared with the overall forecast error, they are nevertheless significantly larger than has been identified in the testing of many of the other changes to the ECMWF forecasting system that have been made since the start of operational prediction. Further benefit from the use of higher resolution is expected to accrue as the model becomes fully incorporated in the data assimilation system and as parameterisation schemes are refined.

Preliminary results for the European and North Atlantic areas confirm the above results for the first half of the forecast period, and show the resolution increase to have a particularly marked impact at the surface. Results are more variable later in the period, making it more difficult to draw conclusions from the limited number of cases sampled.

Synoptic evaluation

From the set of 18 experimental forecasts six cases were selected for a synoptic evaluation: 15 June 83, 15 Oct 83, 15 Dec 83, 15 Jan 84, 15 Aug 84, and

---

* This orography is derived by adding, for the points representing more than 50% of land, one standard deviation to a mean value computed on the Gaussian grid from a very high resolution orography. A spectral T106 fit is then applied, so that the true horizontal resolution of the orography is 190km and not the Gaussian grid resolution.

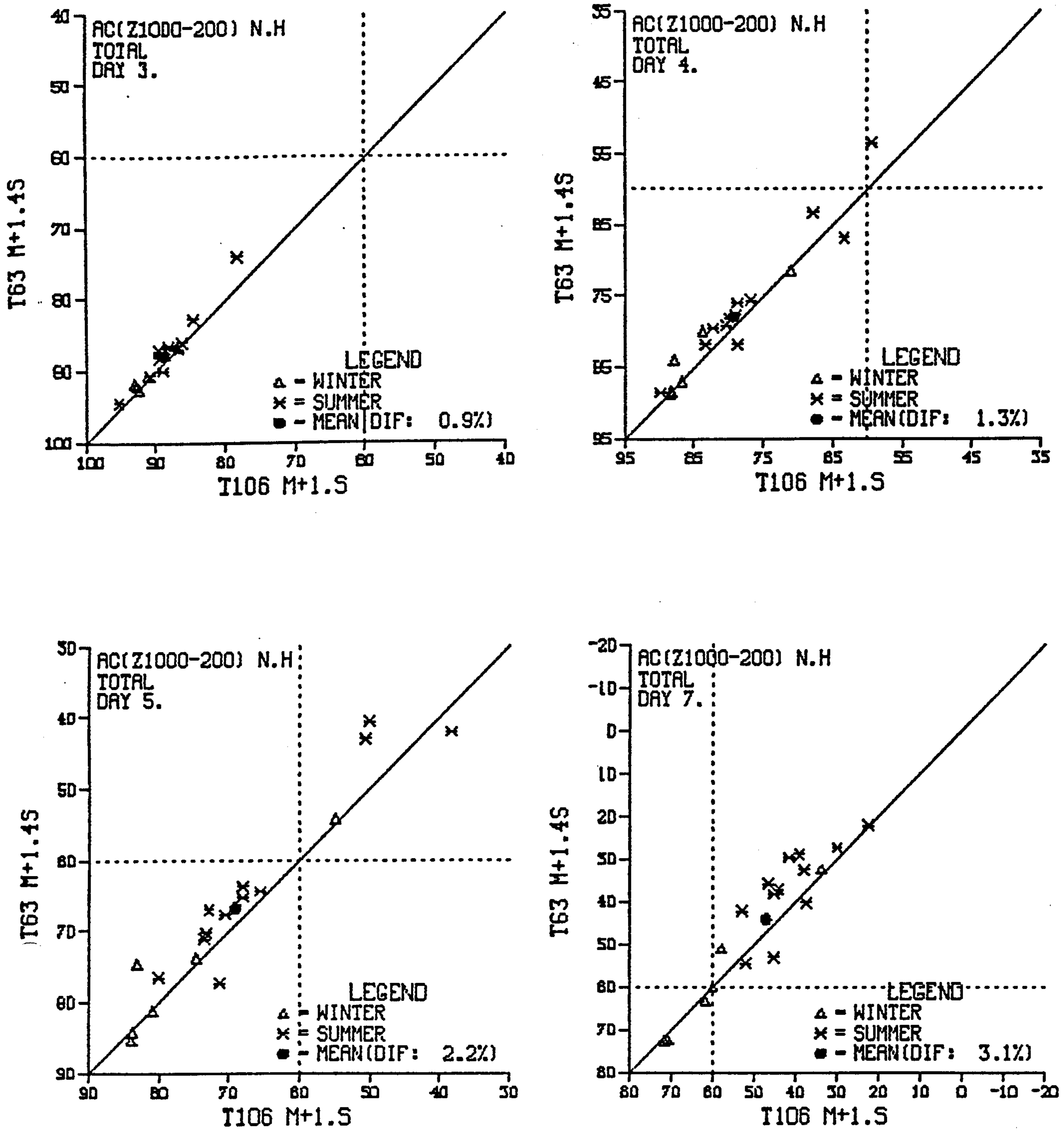


Figure 1: Scatter diagrams for height anomaly correlations from T106 and T63 forecasts, for D+3 (upper left), D+4 (upper right), D+5 (lower left) and D+7 (lower right).

15 Sept 84. These cases include synoptic events such as intense cyclogenesis in the Mediterranean (June 83), rapidly developing lows off the east coast of North America (Dec 83), cut-off lows forming over the North Sea and drifting over France to the Mediterranean (Sept 84), a subtropical low over the Atlantic being drawn into the westerlies (Jan 84), intense surface lows over the British Isles (Oct 83) and a case of slack summer gradients over Europe with unstable conditions (Aug 84). Many of these situations are usually considered difficult forecast problems, and the intention was to study the impact of the higher resolution on the model's skill to give useful information not only on the large-scale flow pattern, but also on parameters directly usable in forecasting, such as precipitation, cloudiness or near surface winds and temperatures. The structures of frontal systems were also studied.

In this synoptic comparison with the operational T63 model, the high resolution model consistently appears to improve on the forecasting of smaller scale weather systems such as intense lows and frontal systems, especially in the early stages of the forecast. In the few cases where the T106 forecasts resulted in lower objective scores than the T63 version, it was found that in the later stages of the medium range incorrectly positioned or spurious systems at the surface were more intense in the high resolution forecasts. At 500 mb the differences between the two models were marginal but nevertheless noticeable and in favour of the T106 model. An improvement in the handling of cut-off lows and to a lesser extent of blocking highs was found, together with a slight reduction in the phase errors of transient waves.

The near surface fields, such as 2m temperature, 10m wind, precipitation and cloudiness, are highly dependent on the model orography and the land/sea mask and will need to be assessed in detail by users in the Member States. In general, it can be stated that some distinct improvements have been found in the near-surface fields, reflecting in part the improved description of orographic details in the higher resolution model.

Further evaluation of the new model will be carried out when extended data assimilation and forecast results are available from the quasi-operational parallel runs of the higher resolution model.

Dissemination

Dissemination of data from the high resolution forecast will not require Member States to alter their dissemination arrangements, unless extra products are desired. Initially, it is not intended to offer additional products. Member States will be provided with products at the 1.5° resolution currently used for dissemination. This resolution is broadly consistent with the T106 resolution of the upper-air fields, but will entail some loss of resolution of surface fields. The current 1.5° resolution products are evaluated from the lower resolution fields of the operational T63 model. Enhancements to the dissemination service will be introduced using the facilities of the new telecommunications system, when this has been brought into service in 1986; the guidelines agreed at the seventh session of the ECMWF Technical Advisory Committee will be followed.

Archiving

The current archiving system will be modified to accommodate surface fields at the N80 Gaussian grid used by the high resolution forecast. Upper air data will continue to be archived at T63. In parallel with the current (i.e. GETDATA/ FINDATA) archive system, high resolution data (T106/N80) will begin to be archived under the new Meteorological Archival and Retrieval System (MARS), bringing the IBM 4341 Data Handling System and Local Area Network into full operational use. The two archive systems will continue to operate in parallel until such time as MARS can accommodate the backlog of data (probably late 1986). This will ensure Member States the facility to access the total ECMWF archive through a single system, and will enable initial development of the MARS service to continue without disturbance to users of the archives. A robust retrieval service for high resolution data will be available through MARS by the end of 1985, growing to a retrieval service for the complete set of ECMWF fields archive during 1986.

Frédéric Delsol
Adrian Simmons

* * * * * * * * * * * * *

MANUAL DECODING OF ECMWF GRID CODE PRODUCTS DISTRIBUTED VIA THE WMO GTS

In the September 1984 edition of the ECMWF Newsletter (No. 27, page 6) J. Chambers gave a comprehensive summary of the ECMWF grid code products which are currently distributed via the WMO Global Telecommunication System. For details concerning the dissemination grid and areas and the transmission times, the reader is referred back to that article. The purpose of this article is to provide some guidance on the decoding and manual use of the grid code bulletins.

The following ECMWF products are currently available on the GTS:

Northern (20°N-90°N) and southern (20°S-90°S) hemisphere

mean sea level pressure	)	
	)	analysis, day 1, ...day 5
500 hPa height	)	

Tropical belt (35°S-35°N)

850 hPa wind	)	
	)	analysis, day 1 and day 2
200 hPa wind	)	

All products are valid at 12 GMT. The horizontal resolution is 5 x 5 degrees latitude/longitude.

All the products are listed in the Catalogue of Meteorological Bulletins in the WMO Handbook Vol. C, where the user will also find the telecommunications headings and catalogue numbers used in transmission. Code form FM 47-V GRID is used to distribute the products. The format of the code is explained in WMO Publication No. 306 - Manual on Codes.

The following two examples of a height and a wind field may serve to explain the decoding of products.

Height field:

```
001 88135
GHDI50 ECMF 121200
GRID 98004 10101
111 10200 25099 68502 71212 81048 09999
333 11512 23020
0119 000000 587586585583581580579580581581582581580579578578579579
0219 000010 587586583579574571571573576578579580579576573571571572572
0319 000020 585582576569557550554562568572575576574570566566566561563
0419 000030 579575568556544540541551559565568570568565564564561563558
0519 000040 569565558547538532536542550556560562561562563564561559555
0619 000050 555554548542537531529534540547552555558561563561557551543
0719 000060 542542539536532529527526528534542548553557558556549542537
0819 000070 536533528523519516514516520525531538543547548545540536534
0919 000080 536530523516509505503503508516522526530533533532532533532
1019 000090 533528522515508503501500501505509513515517520525528529526
1119 000100 524522519515512509507505503503505509513518522524524521518
1219 000110 516517518517516514513513513514515516517518518517517516516
1319 000120 516517517517517517517517516516515514514513513513514515516
1419 000130 515515515515515515515515515515515515515515515516516517517
9901 000140 519
555 98004 10101
777  =
```

The first two lines correspond to the telecommunication headings.

001 is a sequence number.

88135 is the CLLLL number defining the product according to the Catalogue in Vol. C of the WMO Handbook. In this case, 88135 indicates the 48 hours prognosis of 500 mb.

GHDI50 is the TTAAII abbreviated heading. Full details are contained in para. 2.3.2 of Part II of Vol. I of WMO Publication No. 386 - Manual on the Global Telecommunication System.

ECMF denotes the originating centre which is then followed by the date and time group.

GRID = Processed data in the form of grid-point values
Group 98004
98 = ECMWF, 004 = the area (in this case 0-90E & 20-90N)
Group 10101 = Code used for transmission purposes

<u>III - SECTION I (Identification of the processed data)</u>

Group 10200
1 = Indicator, 02 = Geopotential Height, 00 is not used
Group 25099
2 = Indicator, 50 = 500 mb, 99 = only one level given
Group 68502
6 = Indicator, 85 = 1985 (year), 02 = February (month)
Group 71212
7 = Indicator, 12 = date, 12 = 1200 GMT (time), from which data is prepared.
Group 81048
8 = Indicator, 1 = Unit of time (1 hour) relating to next 3 figures,
048 = 48 hr forecast from 1200 GMT (see previous group 71212)
Group 09999 is unchanged for ECMWF.

<u>333 = SECTION 3 (Data format specification and data content)</u>

Group 11512
1 = Indicator, 15 = 15 lines of data, 1 = 1 grid point per group,
2 is not used
Group 23020
2 = Indicator, 3 = Number of digits used for each value (3), 0 is not used,
2 = No spaces between data groups, 0 is not used.
Groups 555 98004 777 are always included at the end of messages.

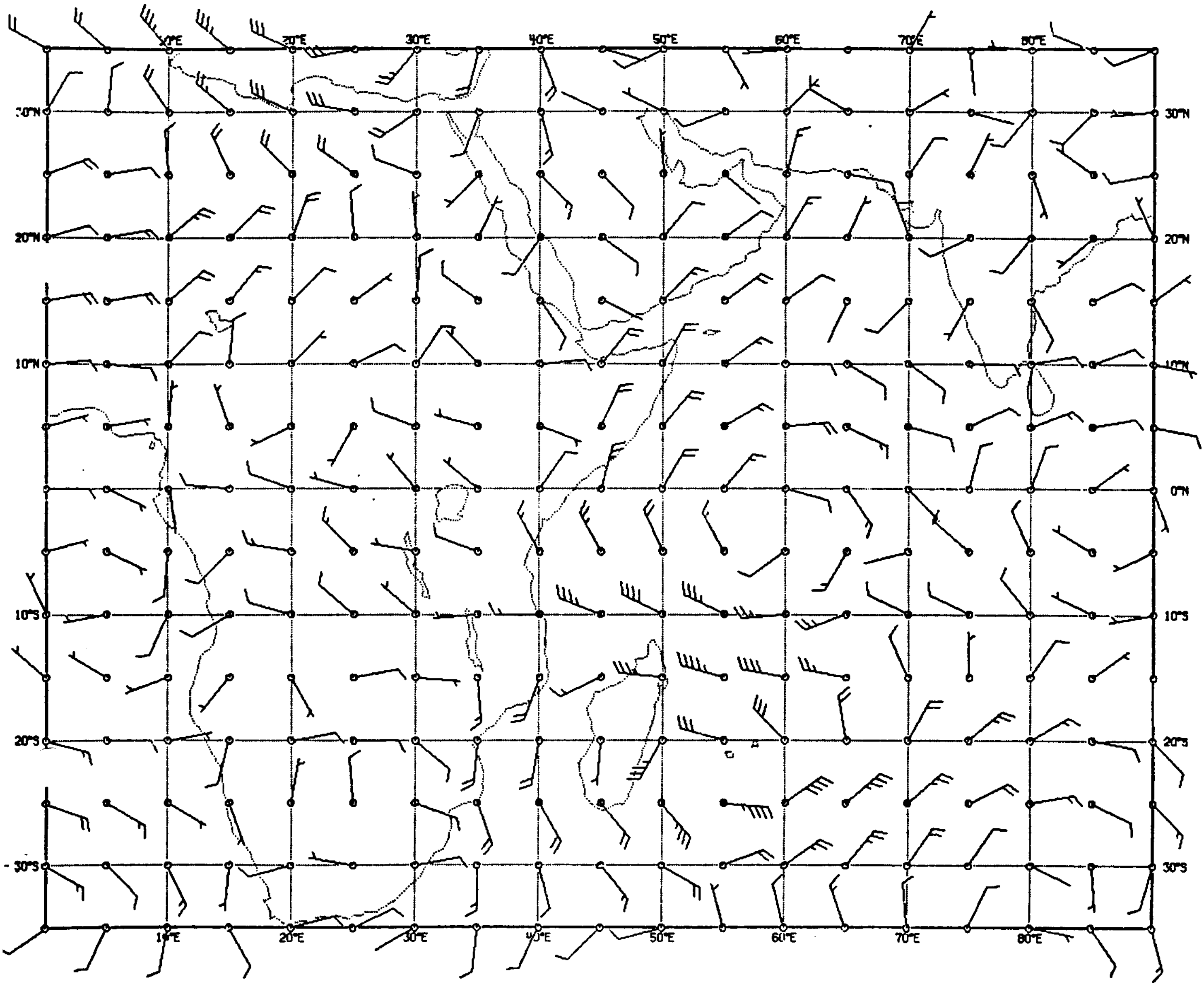
The section then provides the data, preceded by a line sequence number 01 to 14, 99, and the number of groups in each line (19). The second group in each line provides information on the orientation of the first grid point in each row with respect to the origin of the area. As ECMWF disseminates in regular lat/long grids this information may be ignored.

Grid point values are then given in 14 lines on a latitude row from left to right (west to east) within the area. In areas 01 to 04 (northern hemisphere) the latitude rows are given in order from south to north, i.e. in our example for area 4 the north pole is given in line 15 as a single value. Each line in the above bulletin contains 19 grid points for each latitude at 5 degree intervals. There are three digits for each point. The units are geopotential dekametres. The values can easily be plotted manually at the appropriate latitude/longitude intersections, if required, and may be contoured manually.

<u>**Wind field:**</u>

```
001 89811
GWHI85 ECMF 111200
GRID 98008 10101
111 12200 28599 68502 71112 81048 09999
333 11512 25020
0119 000000 3000931011320173101729516260142201219509160091050124504
150022650227001030021750127503290042 5004
0219 000010 0300600506325093101329516280142351120006165082950129503
2500404502300040600210501220042250626502
0319 000020 0700908006355063351131510305092900522502135081350535503
1300101507100040350602502160033050226006
0419 000030 0750608007050120451002009355043550302503215061250404004
0550503008025033400124506220052300333502
0519 000040 0801108010050110400704506055030050630505145061150104507
0551005506205012250421002150040650505503
0619 000050 0850509504045060050504503065040350431503085040400903010
0550809005120041250509004080050700410003
0719 000060 0750308002005023400224502210022900428502110020250904011
0600808509115071050506506070070800610005
0819 000070 0900511503170012750429005285033200231003035050151303010
0400710505145071350301505020050550216002
0919 000080 0750311502185042250628007315072800229004330073301233509
3300823505210072550131004335053000324503
1019 000090 3350226002205042400528504310043100226503270082901729521
2951726513250122950629506320062950326003
1119 000100 3100230003250022200315003080040950317507200112450827518
2852328021280123350636003035050550318001
1219 000110 1050709005080031950408006090061300618511190101850321018
2851431514350090301005012060081000613506
1319 000120 1100912007120031600201002355041100616011150101400914018
0952305521050180501306510080081150613508
1419 000130 1200713506155071850325505280020800418008165061400712010
0701105512040120350903504115011750319504
1519 000140 2350420505190051500507505065042400118504205062250525504
3450234506340073550602504100021450416507
555 98008 10101
777    =
```

Fig. 1: 850 mb wind forecast of 11 February 1985 valid at 13 February 1985 12 GMT for area 008 of the ECMWF GTS dissemination products.



The following explanation only describes the differences from the bulletin of the 500 mb height explained above.

89811 is the CLLLL number for 850 hPA wind forecast for 48 hours.

GWHI85 is the TTAAII indication of 850 mb wind fields.

Group 98008
008 = the area (in this case 0-90E & 35N-35S)

III (SECTION I)
Group 12200
22 = wind direction & speed
Group 28599
85 = 850 mb
Group 7(11)12
11 = date (11th)

333 SECTION 3
25020
5 = Number of digits used for each value (5)

The first line of data along 35N starting from 0E going to 90E in 5 degree intervals may then be interpreted as: 300 deg 09 m/s; 310 deg 11 m/s; 320 deg 17 m/s and so on. The data can be plotted manually or by computer at the appropriate grid points. The above bulletin is decoded and plotted by means of conventional windflags as shown in fig. 1.

A fuller description of the ECMWF GTS products is given in ECMWF Meteorological Bulletin M1.8/1 (copies available on request).

- Horst Böttger
John Humphreys

* * * * * * * * * * * *

ECMWF WORKSHOP, 26-28 NOVEMBER 1984

CLOUD COVER PARAMETERISATION IN NUMERICAL MODELS - DESIGN VALIDATION AND DYNAMICAL IMPACT

Cloudiness is an important quantity to be predicted by a medium range forecast model for several reasons. Firstly, it is a forecast product required by the user, especially the general public, for whom forecasts of cloudiness and sunshine are of considerable interest. Secondly, although the impact of cloudiness in modifying the circulation is not well understood, recent experience at the Centre suggest that it may be significant by the end of a 10 day forecast.

Unfortunately, the problem of predicting the cloudiness in a numerical model is not well defined and has no clear solution. A pragmatic approach is thus necessary: various methods for predicting and treating clouds need to be explored to find the optimum scheme for a particular application.

Present cloud schemes may conveniently be divided into two classes:

(a) diagnostic or statistical schemes in which cloudiness is derived from other variables within the model, such as relative humidity, atmospheric stability and vertical velocity (the scheme described in the article on page 14 falls into this category);

(b) prognostic schemes which include extra model variables (e.g. cloud liquid water) to represent clouds and to model their formation, dissipation and, in some cases, advection through the model.

These schemes have various advantages and disadvantages, and at present it is not clear which type gives the best results. Therefore it was recommended by the workshop that several approaches to the problem of cloud representation should be pursued, with particular attention being paid to making the cloud scheme compatible with the other aspects of the model.

Clearly accurate initialisation of moisture and divergence fields is necessary for successful cloud forecasting. In a four-dimensional data assimilation system, there is a strong interdependency between the moisture and divergence fields through the model's parameterisation of convection. If the moisture convergence is initially wrong, so will be the parameterised precipitation; this in turn deteriorates the moisture field which then becomes the first guess for the subsequent analyses. Consequently, it was concluded that successful cloud forecasting requires a good moisture analysis, as well as a good analysis of the divergence field and the use of a physically sound convection scheme.

The effect of clouds on the radiation fields manifests itself in two distinct ways. The first is by modifying the surface radiative flux, and the second is by a redistribution of the atmospheric radiative cooling both horizontally and vertically.

Sensitivity studies have shown that these effects can have an impact on the forecasts within 10 days. For example, the imposition of a simplified cloud distribution, particularly in the horizontal, leads to a weakening of the extratropical synoptic scale circulations. Also, a simple representation of enhanced mixing due to shallow convection has produced a marked improvement in the simulation of trade winds and the monsoon circulation. These considerations led to the recommendation that attempts should be made to unify the treatment of all cloud-related processes, and that their effects on the atmosphere should continue to be studied.

Validation of cloud parameterisation schemes is obviously very important. The ability to do this has been greatly enhanced by the availability of satellite based cloud property datasets with sufficient coverage, resolution and detail. There was agreement that validation studies should lead to the identification of both the data and model diagnostics best suited to testing the performance of the cloud schemes. However, it is essential that several strategies are followed - tests should be made on both regional and global scales, and comparisons should be made with individual forecasts and the statistical cloud distributions.

It was apparent from the workshop that the parameterisation of cloud processes in numerical models is very important, both for the accuracy and interpretation of forecasts. However, much work remains to be done on understanding the role of clouds and finding the best way to parameterise them. The implementation of the recommendations of the workshop, both at the Centre and elsewhere, will go some way towards achieving these aims.

\- Bob Riddaway

* * * * * * * * * * * * * *

A NEW CLOUD COVER SCHEME

ECMWF has had an interactive cloud scheme in operation for several years. It performs acceptably in both short and long integrations and there are no indications of undesirable feedback between the clouds and the radiative fluxes. However, a recent study of this cloud scheme (ECMWF Technical Report No. 46) has revealed four major shortcomings: too many deep clouds, too little tropical cirrus, too little subtropical cloudiness, and poor representation of the diurnal variation in cloudiness (particularly in the tropics).

In order to overcome these deficiencies, it was decided to develop a new cloud scheme.

The new scheme is based on the premise that condensation on the smaller scales is part of a larger scale condensation regime related to the synoptic scale situation. In other words, it is feasible to parameterise cloudiness in terms of large-scale model variables - the following parameters were chosen for diagnosing cloudiness: relative humidity, convective activity, atmospheric stability and vertical velocity.

There are four types of cloud allowed in the new scheme - convective cloud and three layer clouds (high, middle and low). The convective cloud can fill any number of model layers, its depth being determined from the convection scheme, whilst the layer clouds are constrained so that they cannot exceed one model layer in thickness. The levels at which the layer clouds occur are determined by dividing the atmosphere into three parts, and the maximum cloud amount in each part ascribed to the layer of maximum cloudiness.

Fig. 1 gives a schematic representation of the vertical cloud distribution and the division into high, medium and low cloud. The cloud prediction equations for each type of cloud are given below:

Convective cloud (C_c) is determined by a scaled, time averaged precipitation rate (P) given by the model's convection scheme:

$$C_c = a + b \log_e \overline{P}$$

An upper limit of 80% is placed on C_c. The relationship between C_c and precipitation is illustrated in Table 1.

Fig. 1: Vertical cloud representation

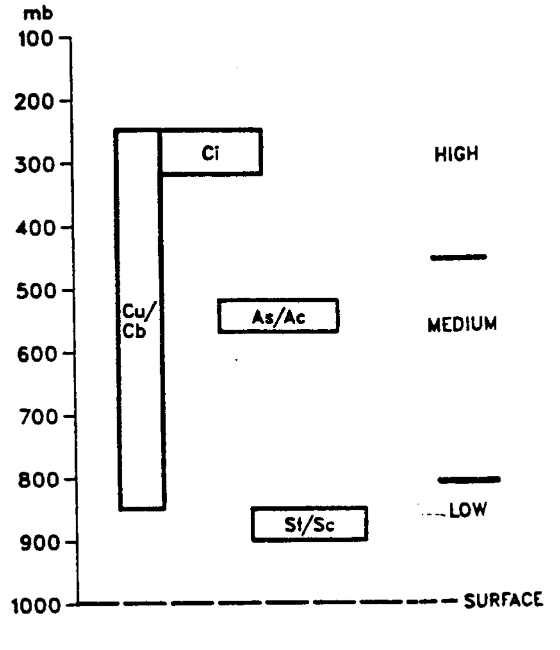


Table 1: Relationship between convective cloud cover and precipitation rate (P)

C_c	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
P(mm/day)	0.14	0.31	0.70	1.6	3.4	7.7	17	38	85

High cloud (C_H) is assumed to be associated with either outflow from deep convection or frontal disturbances. For convective cirrus,

$$C_H = 2.0(C_c - 0.3)$$

provided that convection extends above 400mb and the cloudiness exceeds 40%. Amounts of extratropical and frontal cirrus are determined from

$$C_H = \left\{\text{Max}\left(\frac{RH-0.8}{0.2}, 0.0\right)\right\}^2$$

where RH is the relative humidity.

Middle cloud (C_m) is difficult to parameterise because little is known about it. However, in the new scheme allowance is made for the effects of dry subgridscale down draughts due to convection by linking the relative humidity for cloud to the amount of convective cloud:

$$C_m = \left\{\text{Max}\left(\frac{RH_e - 0.8}{0.2}, 0.0\right)\right\}^2 \quad \text{with } RH_e = RH - C_c$$

Low Cloud (C_L) is the most difficult to predict because it is dependent on the structure of the model's boundary layer and the interaction with the radiation field. These clouds seem to fall predominantly into two classes: those which are associated with extratropical fronts and frontal disturbances, and those which occur in relatively quiescent conditions and are directly associated with the boundary layer. The first class are characterised by generally moist air and large scale ascent - therefore they are parameterised in terms of relative humidity and the vertical velocity, ω in pressure coordinates.

$$C_L' = \left\{\text{Max}\left(\frac{RH_e - 0.8}{0.2}, 0.0\right)\right\}^2$$

Then $C_L = C_L'$ if $\omega < -0.1$ Pa.s^{-1} } ascent

$C_L = C_L'\left(\frac{\omega}{-0.1}\right)$ if $-0.1 < \omega < 0.0$ Pa.s^{-1} } ascent

Otherwise $C_L = 0.0$ if $\omega > 0.0$ - subsidence

Again the relative humidity is adjusted to take account of convection, as for middle clouds. The second type of low level clouds is strongly linked to the boundary layer, and so is determined by the lapse rate $(\Delta\theta/\Delta p)_{min}$ in the most stable layer below 750 mb:

$$C_L = -6.67\left(\frac{\Delta\theta}{\Delta p}\right)_{min} - 0.667.$$

For the purposes of comparison between the new scheme and the present operational scheme, Fig. 2 shows the combined low level stratus and cumulus clouds for a one day forecast. There is a marked increase in subtropical cloudiness with the new scheme and the transition from the dense frontal cloud of the extratropics to the broken convective regimes of the tropics is striking. In particular, the scheme has been successful in capturing the areas of cloudiness off the western seaboards of the major continents. The shortcomings of the operational scheme, mentioned earlier, have been largely rectified. The diurnal variation in cloudiness is now well represented with a late afternoon maximum in cloudiness over the tropical continents associated with the convective activity. The impact of the new cloud scheme on the model leads to a slight improvement in skill and a reduction in the model's systematic error. Implementation of the scheme in the operational model is planned within the next few months.

- Julia Slingo

* * * * * * * * * * * * *

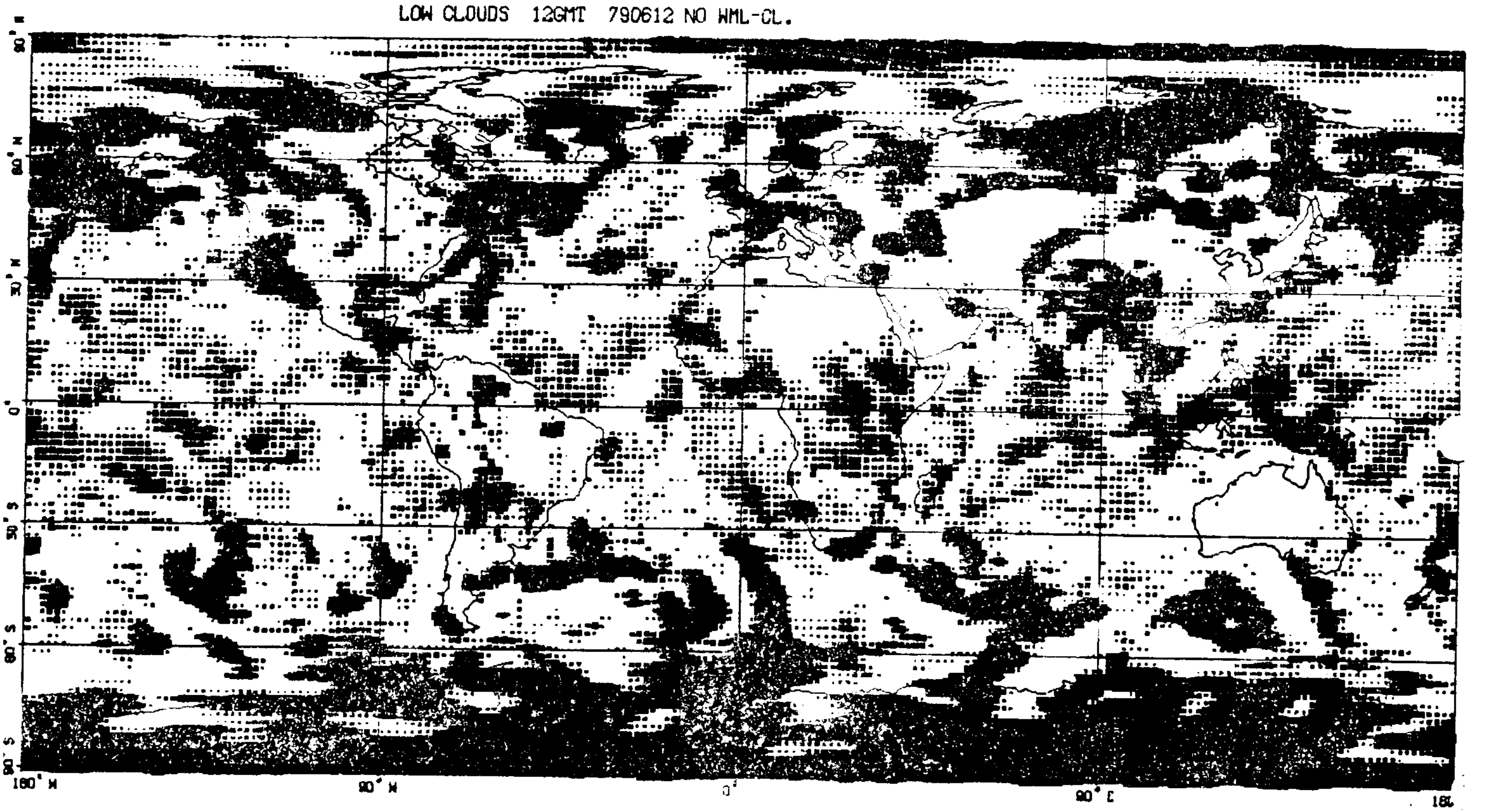
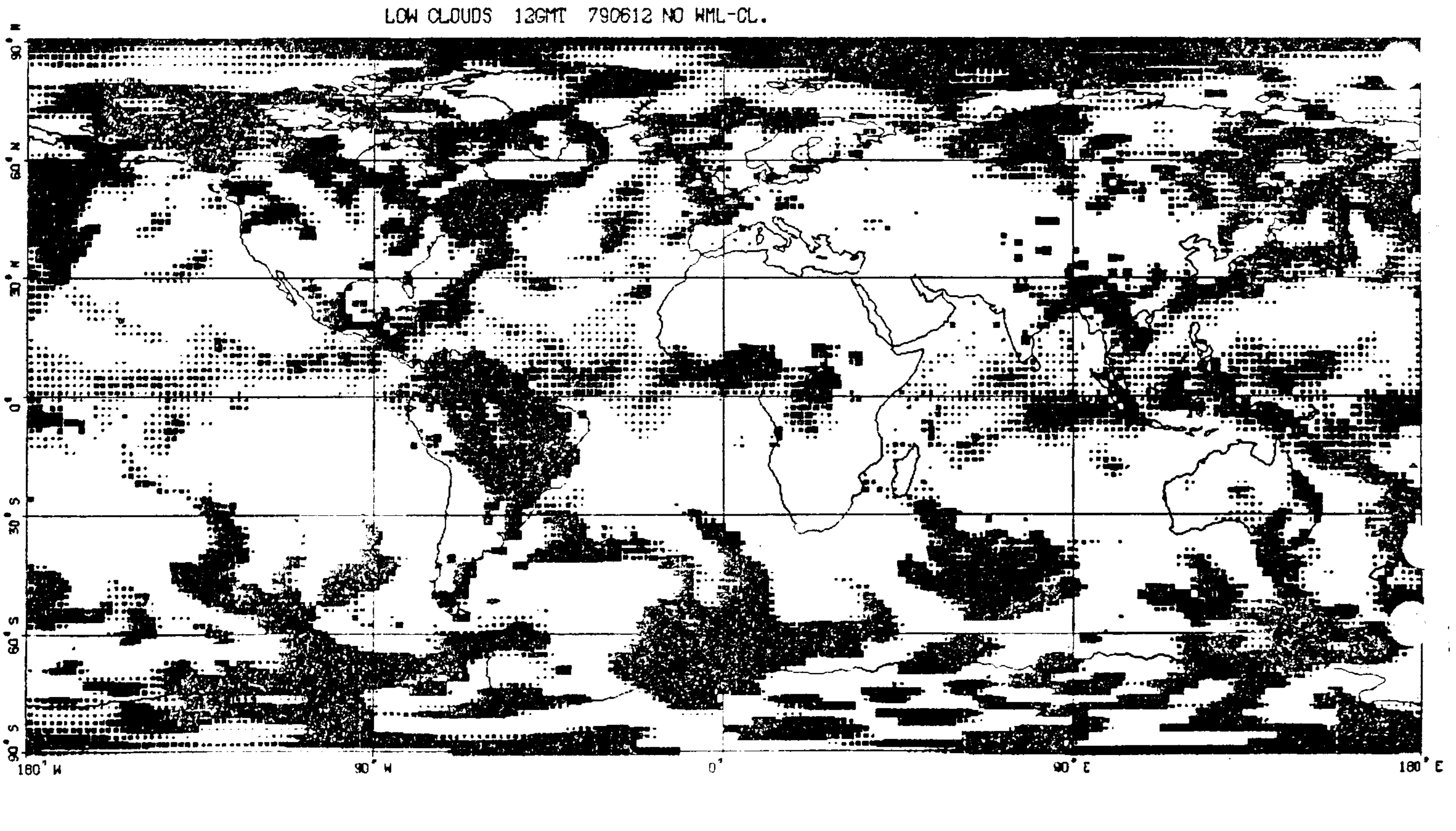


Fig. 2a) New Scheme



ECMWF FORECASTS PREDICT SNOWFALLS IN ITALY

The following report on the practical use of ECMWF products during extreme cold spells this January was recently received from the Italian Meteorological Service.

"In the first 20 days of January 1985, Italy was affected by unusually intensive weather phenomena which caused severe damage to people and the national economy. Among other events, some historic temperature minima were observed, such as -23° C in Florence and -11° C in Rome. An initial cold outbreak culminated with snowfalls in Rome on 6 January. During this period the 72 and 96 hours forecasts by ECMWF proved to be excellent and also the 120 hours forecast was useful. This outbreak was followed by a further cold spell which reached the highest intensity between 9 and 10 January. On this occasion the ECMWF weather maps again gave very good results for the three above mentioned forecast days. Subsequently, from 14 to 17 January, a radical change in the weather pattern occurred, with the displacement of the cold flow towards the Iberian Peninsula and, as a consequence, the development of lows over the central-western Mediterranean was observed, which gave rise to heavy precipitation all over Italy, and in particular to snowfalls over the northern regions.

ECMWF captured the essential and most significant features 4-5 days before the occurrence of these changes in the weather pattern. The excellent basic products coming from ECMWF allowed the Italian Meteorological Service to provide an efficient support to the nation."

* * * * * * * * * * * * *

TRANSLATED EXTRACT FROM A PRESS RELEASE FROM SMHI, NORRKOEPPING, 31 JANUARY 1985

SMHI'S 5-DAY FORECASTS ARE IMPROVING

The Swedish Meteorological and Hydrological Institute recently issued a press release regarding the improved quality of their forecasts and gave one of the reasons for this as being that "SMHI uses some of the best forecast material in the world". The release continues thus:

"From the sixties to 1980, the quality of weather forecasts remained approximately the same. Since then, there has been a steady improvement in 5-day forecasts. This is true in particular for temperature forecasts, which achieved a general success rate of 75 per cent until the end of the seventies. Since 1980, this success rate has gone up to reach above 80 per cent in 1984. Similar improvements were also achieved for wind and precipitation forecasts.

This increase in the forecast quality can, to a large extent, be explained by the use of forecasts from ECMWF. This is a meteorological institute, a European computer centre, near Reading, England, which is based on the co-operation of 17 west European countries including Sweden. The Centre has the task of producing with its computer, numerical ten day forecasts of the highest possible reliability. The Centre also carries out advanced research and development work in this area. Objective verification results show that the ECMWF forecasts are the best in the world for the day 3 to 7 forecast range.

Researchers at the Centre are optimistic about improving numerical products in the future. This will then lead to even better weather forecasts from SMHI, which interprets the comprehensive forecast material."

Fig. 1 shows the combined verification results of temperature, precipitation and wind forecasts. The improvement in the forecasts since 1980 are obvious. The average results of 1982, 1983 and 1984 are the highest observed since 1966, when general 5 day forecasting commenced. Persistence refers to a forecast based on known weather at the time of the start of the forecast which is supposed to remain unchanged until the verifying time.

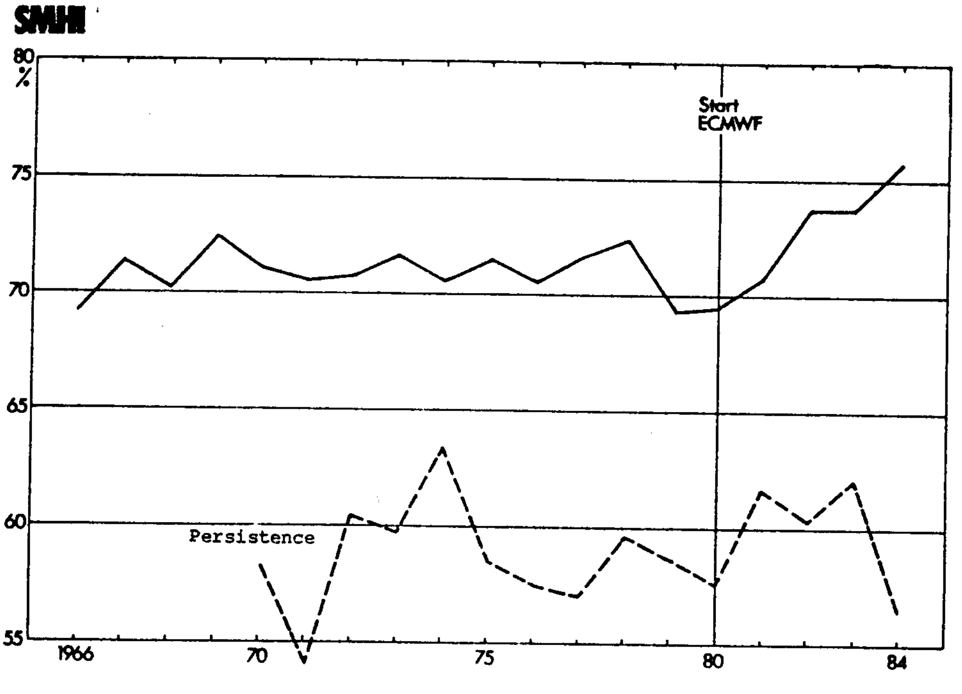


Fig. 1: 5 day weather forecasts 66-84

* * * * * * * * * * * * *

THE MULTITASKING SPECTRAL MODEL AT ECMWF

Introduction

ECMWF has 3 major applications which could benefit from multitasking because they are both time critical and require a large proportion of main memory. To date, only the forecast has been modified to make use of more than one processor, although work is proceeding on the other applications.

Background

The original ECMWF production forecast was made using a grid point model. Over a period of 2 years, a spectral model was developed to replace it. This went into daily production in April 1983 executing on a CRAY-1A, with spectral resolution T63.*

The code is independent of resolution and can be run without recompilation, using any desired data. It consists of:

96000 source lines
26000 Fortran statements

Since the resolution T63 was chosen as appropriate for a CRAY-1, a computationally more demanding resolution is possible on a CRAY-XMP. Given the available configuration, a resolution of T106 was chosen for a comprehensive set of meteorological experiments with the target of making this model available for production use by April 1985.
To achieve an acceptable wall clock execution time, it is obviously essential to make efficient use of both central processors of the CRAY-XMP from within the application code. Hence, a multitasking version of the spectral model was developed over a period of about 1 year. The first working version went into regular experimental use in July 1984. Since then, efforts have been made to reduce the execution time by identifying and removing inefficiencies.

Computer resources used by the spectral model

At resolution T106, the single-tasking model requires:

1.5 Mwords of central memory
15.3 Mwords of SSD (Solid State Storage Device)

The model uses 3 major work files:

Legendre coefficients - 0.9 MW - read twice each time step

grid point data - 8.7 MW - read and written each time step

fourier coefficients - 5.7 MW - read and written each time step

that is, a total of 30 MW I/O per time step

---

* A model with spectral horizontal representation and triangular truncation at total wavenumber 63.

Putting these files on the SSD, with its high transfer rate (80MWps) to/from central memory, allows I/O to be carried out synchronously without much overhead. This reduces the central memory requirements for buffer space and costs less than 4% of the elapsed time for a 10 day forecast.

Multi-tasking software interface

The following FORTRAN based facilities available in the Cray multi-tasking library are used in the model:

```
CALL TSKSTART(ctltab,routine)
CALL TSKWAIT (ctltab)
CALL LOCKON  (lock)
CALL LOCKOFF (lock)
```

```
where- 'ctltab' is a task* control block
       'lock'   is a unique lock identifier
       'routine' is the name of a subroutine to be executed
```

These tools enable tasks to be started (TSKSTART) and synchronised (TSKWAIT), and critical areas of code to be protected against simultaneous execution (LOCKON/OFF). Event setting (synchronisation) is also supported in the library but the current version of the model does not use this technique. It is possible to pass parameters to 'routine' but this facility is also not used.

General Structure

The model is organised into 2 passes, or scans, over the data as shown in figure 1. Within each scan, there is a loop over all latitude rows (160 for the T106 resolution). Between scans is a smaller area of computation associated with diffusion and semi-implicit calculations('D' in fig. 1). The loop over time steps is repeated 1200 times (subsequently reduced to 960) for a 10 day forecast. However, every 3 forecast hours, significant additional computation is performed for radiation calculations.

Fig. 1: General structure

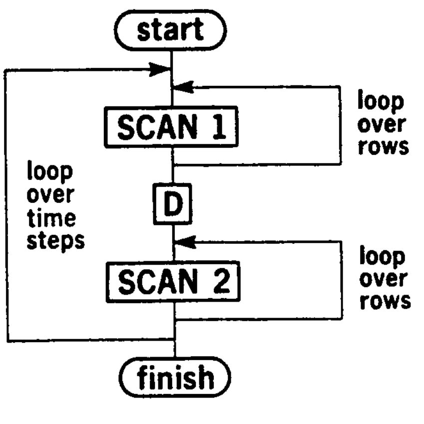
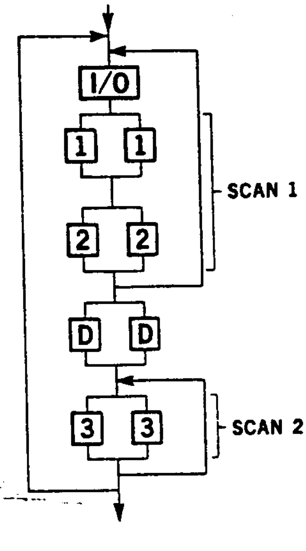


Fig. 2: Multi-tasking structure



---

* A task is any block of executable code which can run independently of other blocks. On the CRAY X-MP, a task may be as small as one subroutine.

A multi-tasking version of an application requires more main memory than its single-tasking equivalent. Given (a) the desire to maximise the resolution and (b) the shortage of main memory, it is important to select a multitasking strategy which has low additional memory requirements.

It turns out to be convenient and efficient in memory to split Scan 1 and perform it in 2 pairs of tasks with a synchronising point in between (see fig. 2). This is because each Northern row generates the symmetric part of a Fourier component while the equivalent antisymmetric part is generated by the appropriate Southern row. Both components are combined in different ways to provide contributions to the legendre transform. By computing one Northern row and one Southern row simultaneously, not only is the memory requirement minimised, but also the legendre computation is performed efficiently.

Part of the diffusion calculation is also multi-tasked and in addition Scan 2 can be computed 2 rows at a time.

There remain some relatively small parts of the code which are computed in single-tasking mode.

The memory requirements for this multi-tasking strategy are 1.8 Mwords. Note that alternative strategies are, of course, possible. However, task structures, which may be preferred for optimising reasons, require either more central memory or additional SSD.

Overall timings

All the timings reported here are elapsed times corresponding either to a single time step or to a complete 10 day forecast.

For a normal timestep:

single tasking : 25.36 secs/step
multi tasking : 14.28 secs/step
speedup ratio : 1.78

For a radiation timestep:

single tasking : 75.0 secs/step
multi tasking : 39.4 secs/step
speedup ratio : 1.9

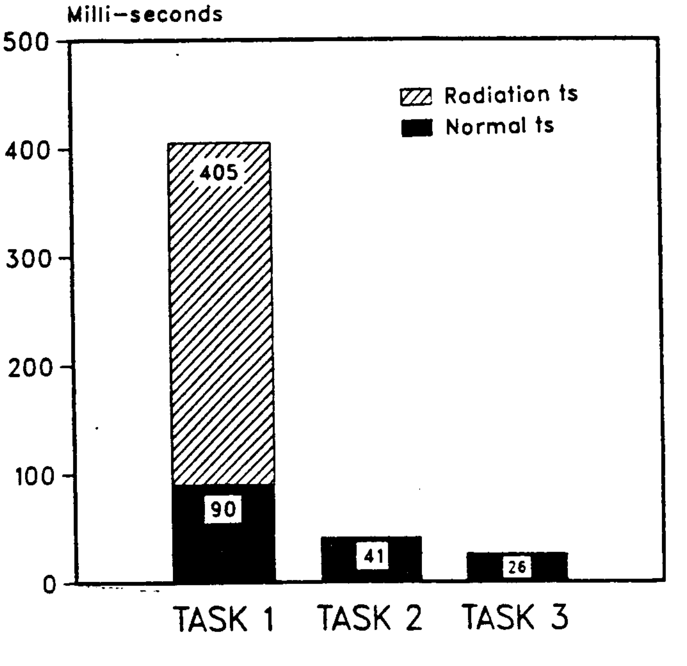


Fig. 3: Task times

These times correspond to a total time of 6 hours for a 10 day forecast, including the creation and post-processing of history data.

<u>More detailed timings</u>

Since the above timings are very simple and made at the very highest level they tell nothing about the behaviour of individual tasks within the model. Currently, there is no support within the Cray multi-tasking library for obtaining detailed timings. Consequently, all the following timings were obtained by inserting code into the model at strategic places in order to record times as reported by the real time clock. The measurements were done in such a way as to disturb the model as little as possible. The model was run in a dedicated environment with no disturbances other than any caused by the operating system (COS X.13). Analysis of the measurements was done subsequently in a normal batch environment.

The average times taken by each of the tasks as identified in the previous section are shown in Fig. 3.

By measuring the time taken by the Cray multi-tasking library routines, it is possible to obtain estimates of the cost of starting tasks etc.

For TSKSTART , three distinctly different times are observed as follows:

40 milliseconds for one case only

0.4 milliseconds for 96% of all TSKSTARTs

0.04 milliseconds for 4% of all TSKSTARTs

The expensive start corresponds to the very first TSKSTART in the complete application, when additional memory has to be requested from the operating system for table space.
The intermediate time corresponds to the case when a 'logical CPU' has to be established (table creation etc).

The shortest time corresponds to the case when a logical CPU already exists. In this execution, the Cray multi-tasking scheduler has released the logical CPU in nearly all cases before the next task is created. The small percentage of fast TSKSTART times were all observed for TASK 2 where there is a very small time gap after completion of TASK 1. In the future it will be possible to tune the scheduler to retain the logical CPU in all cases.

The measured minimum times for other multi-tasking calls are:

TSKWAIT	0.007 milliseconds
LOCKON/LOCKOFF	0.001 milliseconds

hence it is clear that the TSKSTART times dominate the task overheads.

The approximate total overhead cost in a 10 day forecast is about 2 minutes or 0.7% of the total time; with scheduler tuning, this is likely to be reduced to 0.1%.

An obvious conclusion is that task overheads are small compared to the size of tasks which exist in the spectral model.

Inefficiencies

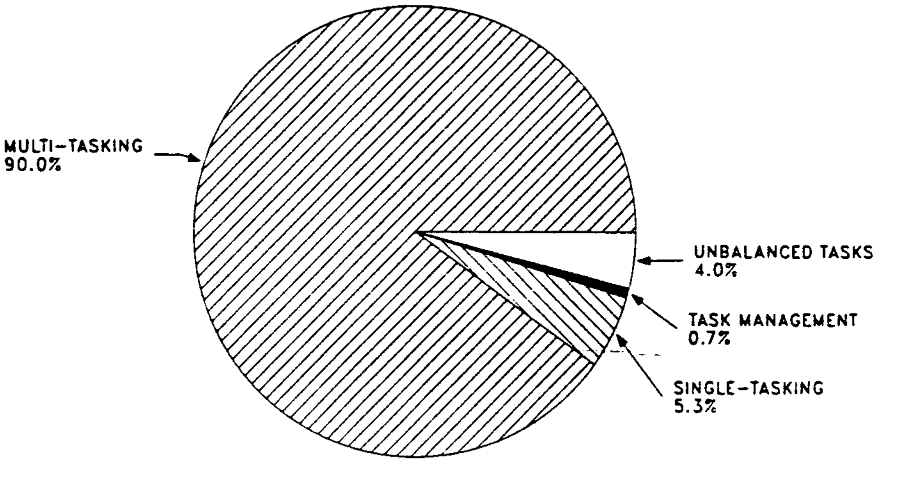
By measuring the amount of time spent outside the tasks, it can be seen how much of the code has been multi-tasked and therefore what additional improvements might be made in the future (see Fig. 4).

The TSKWAIT time reported in the previous section was the minimum observed i.e. for the case where the master task completed after the started task and was therefore not held up in the synchronising process. By examining average TSKWAIT times, it is possible to obtain estimates of how imbalanced the pairs of tasks are. Figure 4 shows that these imbalances account for about 4% of the overall model time. Most of the imbalance was observed in TASK1. TASK 2 and TASK 3 imbalances were smaller by a factor of 9.

There are at least 2 reasons for this imbalance. One concerns LOCKS and will be discussed below. The other concerns the nature of the computation in grid-point space (part of TASK 1). Although the amount of work done for each latitude line is exactly equal for the dynamics part of the code, this is not always true in parts of the physical parameterisation. Convection and condensation calculations are affected by synoptic conditions and will therefore vary in space and time. The magnitude of these variations in terms of computing expense has not yet been measured.

LOCKS are used to protect critical regions of code in some 20 places, mostly for statistics gathering purposes. These locks all occur in TASK 1 and are mostly insignificant in time. However some random I/O is carried out to a single dataset which is common to both tasks. In the current Cray operating system software, a lock is applied whenever I/O is initiated to any dataset, so the strategy of splitting this single dataset into 2 will not be useful until Cray move this high level lock to the level of the individual dataset. Indications are that this causes most of the imbalance observed in TASK 1.

Fig. 4: Multi-tasking inefficiencies



Further improvements

All timings presented thus far were made during November 1984. Since then, substantial additional savings have been made in several areas:

(a) reduction of processing requirements for Legendre transforms;

(b) development of a more selective treatment of short waves by horizontal diffusion, allowing an increase of timesteps from 12 to 15 minutes;

(c) introduction of a shallow convection scheme leading to a reduction in the time needed for convective adjustment.

The overall time for a 10 day forecast is now less than 5 hours.

Future improvements

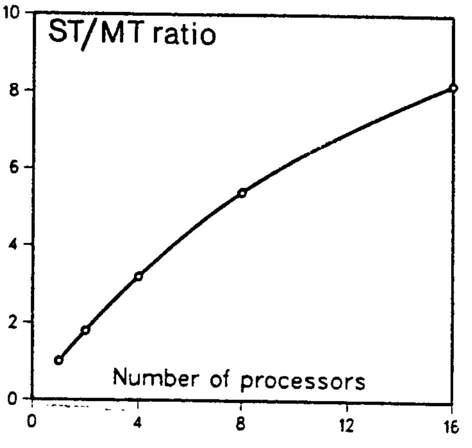
There are many ideas which may be tried in order to achieve additional savings. By reducing the single-tasking time and by attacking the out of balance inefficiency, it should be possible to improve the multi-tasking performance. It may be possible to bypass the I/O lock and hence substantially reduce the imbalance due to locking. There is also some scope for optimising at the loop level (loop unrolling etc).

Alternative multi-tasking strategies can be tried in order to reduce the number of synchronising points and hence the imbalance time. Unfortunately there is little scope for this effort given the constraints of central memory and SSD space. EVENT synchronising is known to be more efficient than TSKSTART-TSKWAIT and this could be implimented easily in at least part of the application. However, since the task overhead is relatively small, this is unlikely to be useful.

It is interesting to speculate on the model's performance when executed on future hardware with additional processors. Code already exists in the model for N processors but it is largely untested to date. It is based on the current multi-tasking strategy and therefore performance may be made estimated based on the measurements reported earlier in this paper. Fig. 5 indicates that a multi-tasking efficiency of about 3.2 could be achieved with 4 processors, but with 16 processors a speedup of only 8.2 would be achieved over the single-tasked model.

Fig. 5:

Efficiency with more processors
ST: single tasked
MT: multi tasked



- David Dent

* * * * * * * * * * * * *

USER CHANGES UNDER NOS/BE LEVEL 604

NOS/BE level 604 has been in production since 14 January. There are several minor differences between this level and the previous level (577) and they are defined below. Some are due to a "tightening up" of code, so that "illegal" practices previously allowed are no longer allowed; this is, the software now conforms to specifications in the relevant manufacturer's manuals. If you find any other changes, please inform the Advisory Office.

1. Buffer In/Out can no longer be intermixed with Read/Write on the same file.

2. REWIND/RETURN control statements now check their arguments, and abort if the local file name is more than 7 characters.

3. Some tightening up has occurred with OPEN/CLOSE, in particular, files must be closed before changing certain options (such as the mode).

4. The FTN 5 compiler may use slightly more memory under some circumstances. Jobs currently using less than 6000 central memory words will have to increase the CM value on the job card.

5. Many programs require more execution time memory. This is due to an increase in space required by certain capsules, and will also affect users with absolute programs.

6. Since the latest version of Post Mortem Dump (PMD) does not provide as much information as level 577 PMD, we have temporarily reverted to level 577)as from 13 February).

7. It used to be possible to write long locks to L-tapes by just using BUFFER OUT; a FILE card is now necessary. The problem is likely to occur when reading tapes from or writing tapes for non CDC-machines.

- John Greenaway

* * * * * * * * * * * *

CFT 1.14

As announced in Computer News Sheet No. 172, the Centre now has a pre-release version of the new compiler CFT 1.14. It has been tested with a limited number of multi-tasking jobs and found to give some errors.

At the time of writing, we are still awaiting the arrival of fixes to CFT 1.14, to prevent the compiler errors which were found. Once we are satisfied with the latest version, it will be made available for general testing via the NEXT(PROD=CFT) control statement.

Given below are some details of the new features available in CFT 1.14.

1. Support for new Cray X-MP models with more than 4 million words of memory.

2. Utilisation of hardware GATHER/SCATTER and compressed index instructions on machines where these are available.

3. Improved code for exponentiation and DO-loops (including two version loops - the compiler will generate both vector and scalar code for certain loops and then test the loop trip count at run time to determine which version to use).

4. An option to flag non-ANSI Fortran 77 standard code.

5. The maximum length of character variables is increased from 504 to 16,383 characters.

6. Recursion is permitted - subroutines and functions may call themselves both directly and indirectly (ALLOC=STACK must be used to compile recursive code).

7. A new kind of common - TASK COMMON - is provided for use with multi-tasking programs. Each task will have its own copy of such common blocks.

- Richard Fisker

* * * * * * * * * * * *

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 173). All other News Sheets are redundant and can be thrown away. The following News Sheets can be discarded since this list was last published: 147, 169.

No.	Still Valid Article
16	Checkpointing and program termination
19	CRAY UPDATE (temporary datasets used)
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	Contouring package: addition of highs and lows
135	Local print file size limitations
136	Care of terminals in offices
140	PURGE policy change
141	AUTOLOGOUT - time limit increases
144	DISSPLA FTN5 version
152	Job information card
158	Change of behaviour of EDIT features SAVE, SAVEX.
	Reduction in maximum print size for AB and AC
164	CFT New Calling Sequence on the Cray X-MP
165	Maximum memory size for Cray jobs
166	Corrections to the Contouring Package
167	CFT 1.13 improvements
170	NOS/BE level 604
171	" " "
172	" " "
	Change to CFT Compiler default parameter (ON=A)
173	T106 Model Operational Trials

* * * * * * * * * * * * *

1985 ECMWF SEMINAR

PHYSICAL PARAMETERISATION FOR NUMERICAL MODELS OF THE ATMOSPHERE

9-13 SEPTEMBER 1985

All the processes represented in forecasting models may be considered as possible sources of forecast error. Certainly the sensitivity of the medium-range forecasts to the specification of orographic forcing and thermal forcing arising from convection has been demonstrated clearly as a result of research carried out at ECMWF and other centres. In addition, the prescription of surface processes and specification of turbulent vertical diffusion has been shown to be important for both short and medium-range forecasts.

Until now the forecast skill of large-scale models has been measured mostly by their capability to forecast upper air fields. However, if it is required that there is skill in forecasting weather elements such as cloudiness and precipitation, the quality of the parameterisation schemes becomes a crucial element.

The 1985 Seminar will review the developments in parameterisation theory and practice over the last ten years. This will benefit both the Centre and young scientists and numerical modellers in the Member States.

The format of the Seminar will be the same as in previous years: formal lectures by invited speakers and staff from the Centre, followed by publication of the proceedings of the Seminar.

Registration forms, along with details of the topics and lecturers, will be sent to Member States. Alternatively, further information about the Seminar can be obtained direct from the Centre. The closing date for registration will be 28 June 1985.

- Bob Riddaway

* * * * * * * * * * * * *

ECMWF PUBLICATIONS

TECHNICAL REPORT NO. 42:	On Long Stationary and Transient Atmospheric Waves
TECHNICAL REPORT NO. 43:	A New Convective Adjustment Scheme
TECHNICAL REPORT NO. 44:	Numerical Experiments on the Simulation of the 1979 Asian Summer Monsoon
TECHNICAL REPORT No. 45:	The Effect of Mechanical Forcing on the Formation of a Mesoscale Vortex
TECHNICAL REPORT No. 46:	Cloud Prediction in the ECMWF Model
TECHNICAL MEMORANDUM NO. 88:	Differences between the initialised and uninitialised analyses of the upper air fields and the impact on the verification results.
TECHNICAL MEMORANDUM NO. 91:	A Production Multi-tasking Numerical Weather Prediction Model
TECHNICAL MEMORANDUM NO. 92:	The 1984 Revision of the ECMWF Analysis System
TECHNICAL MEMORANDUM NO. 93:	Collecting Surface Ship Observations Data via Maritime Telex Service - A Pilot Study
TECHNICAL MEMORANDUM NO. 94:	Evaluation of Analysis Increments at Model Levels
TECHNICAL MEMORANDUM NO. 95:	The Application of Filtered Forecasts to Synoptic Weather Prediction. Presentation of the products and recommendations on their use

Report on the application and use of ECMWF Products in Member States, including verification results - 1984

SEMINAR 1983:	Numerical Methods for Weather Prediction, Vols. 1 and 2
ECMWF FORECAST REPORTS:	Nos. 25-27: Jan.-March, April-June and July-September 1984
DAILY GLOBAL ANALYSIS:	October - December 1983 January - March 1984
FORECAST AND VERIFICATION CHARTS:	to 31 August 1984

CALENDAR OF EVENTS AT ECMWF

18-29 March 1985	Computer user training courses
29 April 1985	9th session of Technical Advisory Committee
30 April 1985	34th session of Finance Committee
29 April - 21 June 1985	Meteorological training courses
8-9 May 1985	21st session of Council
9-13 September 1985	Annual ECMWF seminar: "Physical Parameterisation for numerical models of the atmosphere"
16-18 September 1985	14th session of Technical Advisory Committee
18-20 September 1985	10th session of Technical Advisory Committee
20-21 November 1985	22nd session of Council

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.

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.

USEFUL NAMES AND 'PHONE NUMBERS WITHIN ECMWF

			Room*	Ext.**
Director	-	Lennart Bengtsson	OB 202	200
Head of Operations Department	-	Daniel Söderman	OB 010A	373
ADVISORY OFFICE - Open 9-12, 14-17 daily			CB Hall	309
Other methods of quick contact:				
- telex (No. 847908)				
- COMFILE (See Bulletin B1.5/1)				
Computer Division Head	-	Geerd Hoffmann	OB 009A	340/342
Communications & Graphics Section Head	-	Peter Gray	OB 101	369
COMPUTER OPERATIONS				
Console	-	Shift Leaders	CB Hall	334
Reception Counter) Tape Requests)	-	Jane Robinson	CB Hall	332
Terminal Queries	-	Norman Wiggins	CB 035	209
Operations Section Head	-	Eric Walton	CB 023	351
Deputy Ops. Section Head	-	Graham Holt	CB 024	306
DOCUMENTATION	-	Pam Prior	OB 016	355
Distribution	-	Els Kooij-Connally	Library	430
Libraries (ECMWF, NAG, CERN, etc.)	-	John Greenaway	OB 017	354
METEOROLOGICAL DIVISION				
Division Head	-	Frédéric Delsol	OB 008	343
Applications Section Head	-	Rex Gibson	OB 227	448
Operations Section Head (Acting)	-	Horst Böttger	OB 004	347
Meteorological Analysts	-	Veli Akyildiz	OB 005	346
	-	Herbert Pümpel	OB 006	345
	-	Liam Campbell	OB 003	348
Meteorological Operations Room	-		CB Hall	328/443
REGISTRATION				
Project Identifiers	-	Pam Prior	OB 016	355
Intercom & Section Identifiers	-	Jane Robinson	CB Hall	332
Operating Systems Section Head	-	Claus Hilberg	CB 133	323
Telecommunications Fault Reporting	-	Stuart Andell	CB 035	209
User Support Section Head	-	Andrew Lea	OB 018	353
RESEARCH DEPARTMENT				
Head of Research Department	-	David Burridge	OB 119A	399
Computer Coordinator	-	David Dent	OB 123	387
Meteorological Education and Training	-	Bob Riddaway	OB 319	478

---

* CB - Computer Block
OB - Office Block

** The ECMWF telephone number is READING (0734) 876000
international +44 734 876000