TECHNICAL MEMORANDUM

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An experimental scheme to predict forecast skill

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1. INTRODUCTION

This memorandum describes an experimental scheme to estimate, a priori, the reliability of the ECMWF forecast. It is due to run in the operational suite from December 1 1987. Results will be accumulated on a computer file, accessible to all member states, and a small subset of these results will be displayed each day in the operations room at ECMWF. Below is given a brief description of background information used to define the particular scheme described in this memorandum, and describe how the scheme itself works. In section 4, practical details on how to access the output file are given. It should be emphasised that this scheme is experimental; it will only run during the 90 day period 1 December to 28 February. Evaluation of the scheme both during and after the experimental period (see section 5) will determine the extent and direction of further development and implementation.

2. PREDICTORS AND PREDICTANDS

The basis of the forecast skill prediction scheme is a set of statistical predictors whose properties were derived from data in the ECMWF forecast archives for winters 1981/82 to 1986/87 (training data). For simplicity, only 500mb height data was extracted from the archives. These predictors are defined and discussed in detail in Palmer and Tibaldi (1987). Each statistical predictor is conceptually at least, distinct from the others; in practice, however, they do overlap in the degree of variance of explained forecast skill. They are outlined in roughly order of importance below.

a. Consistency between forecasts

The first of the five predictors describes the consistency between forecasts initialised from consecutive 24 hour analyses. So, for example, in order to forecast the day 5 RMS error of 500mb height over Europe, the RMS difference in 500mb height over Europe, between the current day 5 forecast, and the preceding day 6 forecast would be taken.

b. Circulation pattern

The second class of predictor is an objectively defined measure of the hemispheric-scale forecast flow pattern. This type of approach had already been explored on a subjective basis, for a limited sample of data, by Gronaas (1982). The approach is made objective by first projecting the training data onto a set of empirical orthogonal functions (EOFs), and secondly performing a linear regression analysis between skill scores and EOF coefficients of the forecast flow. The regression weights define the 500mb height forecast anomaly most strongly correlated with forecast skill. The amplitude of the projection of a given independent forecast height field onto this circulation pattern gives the measure of skill provided by the second predictor class.

c. Skill of short range forecast

The third predictor is the skill of the short range forecast. In the present scheme the day 1 RMS error (in the region of interest) of the forecast preceding the current one is used.

d. Forecast persistence

The fourth predictor is a measure of how persistent the current forecast is, defined in terms of the RMS difference between the forecast 500mb height and the 500mb height of the initial conditions.

e. Magnitude of the forecast anomaly

Finally, the RMS difference between the forecast and climatological 500mb height is also calculated. It is well known that for the first few days of the forecast period, anomaly correlation coefficient is correlated with the magnitude of the forecast anomaly.

2.1 Predictands

Both RMS error and anomaly correlation coefficient are used as the predictand skill scores. These are calculated on a 3.75*3.75 degree latitude/longitude grid within each limited area. Note that there is a slight arbitrariness in the definition of the latter measure corresponding to the climate chosen to define anomalies. In the present study, a seven year wintertime average from ECMWF analyses is used. This contrasts with the NCAR climate used for operational verifications.

2.2 Today's and yesterday's forecast

During the investigation of the properties of these predictor sets, it was realised that it was often easier to predict the skill of the preceding ('yesterday's') forecast, than the skill of the current forecast ('today's'). For example, the RMS spread indicator correlates more strongly with the skill of the earlier forecast than with the skill of the later forecast. Similarly, the day 1 forecast error available today, gives a more reliable estimate of yesterday's day n forecast, because, of course, the two belong to the same forecast. It is a matter of user preference whether a reduction in the mean skill of the forecast can be tolerated if the a priori estimate of skill is more reliable. It was therefore decided to provide estimates of skill both of the current forecast, and also of the preceding forecast.

3. CATEGORIES

In the work of Palmer and Tibaldi (op. cit.), the skill of each of these predictors was individually assessed. In the proposed experimental scheme, the output from each predictor is combined using a probabilistic categorical approach. One advantage of this approach is that it gives a measure of confidence of the skill prediction. In addition, it was felt that the explicit treatment of skill prediction in terms of probabilities is intrinsically appropriate to studies of predictability.

This categorical approach to forecast skill prediction is outlined as follows. First of all, the range of each predictor (forecast spread, rotated EOF coefficient etc) and each predictand (RMS error, anomaly correlation coefficient) has been divided into five a priori equally likely categories (much above average, above average, average, below average, and much below average). In the present scheme, the boundaries between the categories will be determined from data for only the last two years. This of course is in recognition of the fact that a 'very good' forecast six years ago is,perhaps, 'not so good' by the standards of today's operational system. The last two winters cover the period when the T106 model was in operational use.

Secondly, contingency tables have been constructed for each predictor showing the probability that an occurrence in category i corresponded to forecast error in category j. Using these contingency tables, one can determine the weight that one predictor is given compared with another. The weight for each of the five predictors is given by the trace of the appropriate contingency matrix.

Hence, given an independent forecast, the category to which each of the five predictors belongs is first calculated. Using the appropriate contingency table, one estimates, for each predictor, the probability of occurrence for each category of the predictand. For each category, the probabilities computed from different predictors are then averaged according to the weights previously calculated.

4. INTERFACE TO THE SKILL FORECASTING FILE

a. Accessing the data

Results from the forecast skill prediction scheme will be written to a FORTRAN direct access file PROBFORSKIL8788 stored on CFS, and accessible by member states with the following JCL:

```
ACQUIRE, DN=OPFILE,ID=OZLIA,MF=CY,DF=TR.
OPFILE,ACQRCFS,DN=FT01,PDN=PROBFORSKIL8788,ID=NEF,ROOT=OPARCH,
     NODE=O/FCACC/MASTER,PASS=PPARCH,DF=TR.
```

This file will be updated every day, and results from all earlier forecasts will be kept on the file. Results for the current forecast should have appeared on the file by about 5am on the day following the initialisation date of the current forecast.

b. Record structure

Each record of the file contains 16 words. The first record will contain two integer words followed by 14 dummy words. The first word of the first record gives the initialisation date of the latest forecast for which a prediction of forecast skill has been completed. As the scheme will commence on December 1 1987, the value 871201 will be written to file in the early hours of December 2 1987. The second word of the first record gives the initialisation date of the latest prediction of forecast skill for which verification has been completed. The verification programs will be run 'off-line' about once a week, starting in mid-December. Clearly, this first record will be overwritten each time a prediction of forecast skill is made, and each time the verification program is run. The remaining records in the file all have the same structure comprising 6 integer words, followed by 10 real words. These are described individually as follows:

Word 1: The initialisation date of the forecast whose skill is predicted (eg 880112).

Word 2: The forecast time in days. This will only have values 3, 5, 7, and 9.

Word 3: This is an index for the verification region and lies between 1 and 7 inclusive. The regions correspond to operational limited areas, and are defined as follows:

Verification areas:	lat(n)	lat(s)	lon(w)	lon(e)
1. northern hemisphere	78.75,	18.75,	0.00,	356.25
2. north America	60.00,	22.50,	-120.00,	-71.25
3. Europe	71.25,	33.75,	-11.25,	41.25
4. Northern Europe	71.25,	52.20,	3.75,	37.50
5. south west Europe	45.00,	33.75,	-11.25,	15.00
6. south east Europe	45.00,	33.75,	15.00,	37.50
7. central Europe	56.25,	45.00,	-11.25,	15.00

Word 4: This is an index for the skill score measure. 1 corresponds to (500mb height) RMS error, 2 corresponds to (500mb height) anomaly correlation coefficient.

Word 5: This is another index which can take the value 0 or 1. A value of 0 means that the prediction of skill is for the current ('today's') forecast. A value of 1 means that the prediction is for the forecast immediately preceding the current one (yesterday's forecast). As discussed above, the scheme is expected to be more skilful in predicting the forecast error of yesterday's forecast, and that the penalty incurred by waiting a day need not be unacceptable. If it is helpful, one could think of the value of this index as giving the time lag (in days) between the current forecast and the forecast whose skill is to be predicted.

Word 6: This contains a five digit integer. The first digit corresponds to the category predicted by the first predictor. The second digit corresponds to the category predicted by the second predictor, and so on. The categories are ranked in decreasing order of skill; both for rms error and anomaly correlation The predictors are ranked in the order they were described in section 2, ie

Predictor 1 spread
Predictor 2 circulation index
Predictor 3 day 1 forecast error
Predictor 4 forecast persistence
Predictor 5 magnitude of forecast anomaly

Words 7-10: These give the quintiles of the predictand, i.e. the real-number values (skill scores) at the boundary between two adjacent categories. Each category is, a priori, equally likely. So, for example, if the values were

0.799 0.715 0.547 0.271

(corresponding to anomaly correlation scores), the first (most skilful) category corresponds to scores between 1 and 0.799; the second category to scores between 0.799 and 0.715; and so on. The least skilful category would have scores between 0.271 and -1.00. (This example in fact corresponds to day 7 scores over region 3, Europe).

Words 11-15: These give the output from the categorical calculations of prediction of forecast skill. They are the probability of occurrence of forecast skill, expressed as real numbers, in each of the five categories. For example, if the values were

0.381 0.270 0.124 0.124 0.101

there would be a 38% chance that the forecast in question would have a skill score in the first category (ie. be exceptionally skilful), a 27% chance that the skill lies in the second quintile, and so on.

Word 16: This gives the actual skill score of the forecast, expressed as a real number. Until the verification program is run, this record will contain the number 9999..

This completes the description of the output records, computed and written by the program PROFOSK. Sample output from PROFOSK is appended to this memorandum. There are 7 regions, 4 verification times and 2 scores, both for the current forecast (lag 0) and for the preceding forecast (lag 1). Hence, each time PROFSOK is run, 112 new records are written, and the first record is updated.

c. Extracting and manipulating the data

Reading the file PROBFORSKIL8788 requires the use of appropriate FORTRAN statements for direct access files.

In order to select the appropriate record for a given forecast, verification region, skill score etc., the function

```
IRECDAF(I1,I2,I3,I4,I5)
```

can be used, where I1...I5 correspond to the values of the first give integer words of the record. A list of IRECDAF is also appended to this memorandum.

An example of a very simple program that reads and prints the data corresponding to an estimate of the skill a day-3 forecast over the western hemisphere (area 1) in terms of rms error, the forecast being started on the first of December 1987 and the estimate being issued on the same date, is the following:

```
DIMENSION INDICES(6), QUINTS(4), PROBS(5)
OPEN(UNIT=1,FILE='FT01',STATUS='OLD',ACCESS='DIRECT',RECL='8*16')
IREC=IRECDAF (871201, 3, 1, 1, 0)
READ(1,REC=IREC) INDICES, QUINTS, PROBS, SCORE
PRINT*, INDICES, QUINTS, PROBS, SCORE
STOP
END
```

Please note that the function IRECDAF will return a value of 2, and that the first 5 words of the array INDICES will be equal to the five input parameters of the function.

There is clearly a considerable amount of information in PROBFORSKIL8788, and not all of it can be displayed in real time. Any member state wishing to make use of the output of this experimental package should decide which, if any, of the output data they wish to monitor and display. In the operations room at ECMWF, histograms of day 3, 5, 7, and 9 RMS error for Europe and the hemisphere will be displayed both for the current forecast and the preceding forecast. Periodically, about once a week, a time series chart will be displayed showing a plot of actual skill scores, together with the quintile having highest probability. By the end of the winter the plot will show the time series of predicted and actual scores over the whole experimental period.

5. VERIFICATION AT ECMWF

In order to assess objectively the impact of this scheme, a program to calculate what is known as the 'ranked probability score' (Epstein, 1969) shall periodically be run. An outline of this score is given below.

The 'classical' objective test of a categorical scheme is the Brier score (see e.g. Murphy and Katz, 1985). Suppose for a given forecast, the probabilities of the five categories were

0.4 0.3 0.2 0.1 0.0

and the actual forecast skill occurred in category 2, ie the a posteriori probabilities were

0 1 0 0 0

The Brier score is the mean square of the difference between the a priori and a posteriori probabilities, ie

(0.4**2 +0.7**2 +0.2**2 +0.1**2)/5 = 0.14

The larger the Brier score the worse the skill of the scheme. The score can be compared with a 'chance' value of 0.16 (equal a priori probabilities of 0.2).

One problem with the Brier score for the present purposes is that it takes no account of the ranking of the categories. In other words, if the a priori probabilities of the five categories were, instead of the above,

0.0 0.3 0.2 0.1 0.4

the Brier score would be identical. However the first example was only one category out in its prediction of maximum probability, whereas the second example was three categories out. A simple way to take this ranking into account is to calculate an analogous score, not on the probabilities of the categories, but on the cumulative probabilities that the predictand lies in a category equal to or less than a given category.

In the first example, the cumulative a priori probabilities are

0.4 0.7 0.9 1.0 1.0,

and the cumulative a posteriori probabilities are

0 1 1 1 1.

The ranked probability score is then equal to

(0.6**2 +0.3**2 +0.1**2)/4 = 0.115

(The average is computed over the first four classes only, since the cumulative probability of the last class is 1 in any case). For the second example, the cumulative a priori probabilities are

0.0 0.3 0.5 0.6 1

and the ranked probability score is equal to

(0.7**2 +0.5**2 +0.4**2)/4 = 0.225

It can be seen that the ranked probability score gives a better score for the first example, where the prediction with highest probability was one category out. For a complete description of this scheme, the reader should consult either of the two references given at the beginning of this section. This score will be used to verify the predictions for this experimental scheme. In order to make the score positively oriented (high skill corresponding to high score) with zero as the level of no skill, it will be normalised by a ranked probability score for a chance forecast,ie the score used will be defined as

RPSS=(RPSC-RPS)/RPSC

where RPS is the ranked probability score of the forecast, and RPSC is the ranked probability score of a chance or climate forecast.

6. CAVEAT EMPTOR

In Palmer and Tibaldi (1987), it was clearly recognised that the physical mechanisms giving rise to forecast skill variability were both complex and interactive. It was shown that the growth of analysis or short range forecast errors by instabilities of the flow was important. These instabilites were in part baroclinic, though, towards the end of the forecast period, they were also associated with barotropic instabilities of the zonally varying flow. From a theoretical point of view, these barotropic instabilities are poorly understood. In addition, it was found that a second important source of forecast skill variabilty is the systematic mistreatment of physical processes in the model. In some regions, instabilities of the flow appeared to be a dominant source of forecast error growth, in other regions the influence of systematic errors were dominant. However, over much of Europe, it was not possible to isolate either as a dominant mechanism. This suggestion of interactive mechanisms appeared to be confirmed when it was shown that from a practical point of view, the European region proved one of the most difficult in which to predict forecast skill. Nevertheless, it was shown that some degree of skill was obtainable for all regions, particularly in the slowly varying component of forecast skill. For example, for daily fields a typical correlation of 0.3 between predicted and actual skill scores can be expected. Lower frequency fluctuations in skill score (with timescales of a week) can be forecast with higher skill. However, the potential user should treat the output from the scheme with caution.

In future years, a move towards a more dynamical basis for predicting forecast skill is planned. In particular, the use of ensembles of Monte Carlo integrations of the operational model at perhaps T63 resolution would appear to be worthy of further investigation.

7. REFERENCES

Epstein, E.S., 1969: A scoring system for probability forecasts of ranked categories. J. Appl. Meteor., 8, 985-987.

Gronaas S., 1986: A pilot study on the prediction of medium range forecast quality. ECMWF Tech. Memo. 119, 23 pp.

Murphy A.H. and R.W. Katz, 1985: Probability, statistics and decision making in the atmospheric sciences. Westview Press pp 379-437.

Palmer T.N. and S. Tibaldi, 1987: Predictability studies in the medium and extended range. ECMWF Tech. Memo. 139, 29 pp, 20 figs.

Tennekes, H., A.P.M. Baede and J.D. Opsteegh, 1987: Forecasting forecast skill. ECMWF Workshop on Predictability in the Medium and Extended Range, 17-19 March, 1986, 277-302.

APPENDIX

A2 - A6: Sample output from program PROFOSK

A7: Listing of Fortran function IRECDAF used to access the correct records in the file PROBFORSKIL8788

E.C.M.W.F. EXPERIMENTAL FORECAST OF FORECAST SKILL FOR 500 MB HEIGHT

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LEGEND :

I1 = INITIAL DATE OF FORECAST

I2 = FORECAST TIME (DAYS)

I3 = AREA INDEX

I4 = 1 FOR R.M.S. ERRORS, = 2 FOR ANOMALY CORR.

I5 = 0 FOR PROGNOSTIC SCHEME, = 1 FOR DIAG./PROG. SCHEME

I6 = PACKED VALUE OF THE CLASS INDICES OF THE PREDICTORS

Q1...Q4 = QUINTILES OF THE DISTRIBUTION OF THE PREDICTAND

P1 = PROBABILITY OF        RMS ER.  < Q1   IF I4 = 1
                           AN. COR. > Q1   IF I4 = 2

P2 = PROBABILITY OF   Q1 < RMS ER.  < Q2   IF I4 = 1
                      Q1 > AN. COR. > Q2   IF I4 = 2

P3 = PROBABILITY OF   Q2 < RMS ER.  < Q3   IF I4 = 1
                      Q2 > AN. COR. > Q3   IF I4 = 2

P4 = PROBABILITY OF   Q3 < RMS ER.  < Q4   IF I4 = 1
                      Q3 > AN. COR. > Q4   IF I4 = 2

P5 = PROBABILITY OF   Q4 < RMS ER.         IF I4 = 1
                      Q4 > AN. COR.        IF I4 = 2
```

VERIFICATION AREAS :	LAT(N)	LAT(S)	LON(W)	LON(E)
AREA 1 : NORTHERN HEMISPHERE	78.75	18.75	0.00	356.25
AREA 2 : NORTH AMERICA	60.00	22.50	-120.00	-71.25
AREA 3 : EUROPE	71.25	33.75	-11.25	41.25
AREA 4 : NORTHERN EUROPE	71.25	52.50	3.75	37.50
AREA 5 : SOUTH-WESTERN EUROPE	45.00	33.75	-11.25	15.00
AREA 6 : SOUTH-EASTERN EUROPE	45.00	33.75	15.00	37.50
AREA 7 : CENTRAL EUROPE	56.25	45.00	-11.25	15.00

I1	I2	I3	I4	I5	I6	Q1	Q2	Q3	Q4	P1	P2	P3	P4	P5
880120	3	1	1	0	45253	40.3	43.1	46.1	49.9	0.115	0.304	0.248	0.165	0.168
880119	3	1	1	1	55252	40.3	43.1	46.1	49.9	0.089	0.132	0.187	0.186	0.406
880120	3	1	2	0	45253	0.930	0.919	0.903	0.885	0.135	0.137	0.260	0.231	0.238
880119	3	1	2	1	55254	0.930	0.919	0.903	0.885	0.155	0.152	0.179	0.212	0.302
880120	5	1	1	0	55254	66.7	71.9	77.0	83.5	0.097	0.187	0.242	0.176	0.299
880119	5	1	1	1	55253	66.7	71.9	77.0	83.5	0.085	0.137	0.150	0.243	0.384
880120	5	1	2	0	55252	0.803	0.770	0.731	0.678	0.272	0.161	0.228	0.139	0.200
880119	5	1	2	1	55253	0.803	0.770	0.731	0.678	0.152	0.213	0.187	0.179	0.268
880120	7	1	1	0	55243	88.8	95.9	102.9	116.3	0.149	0.217	0.099	0.179	0.356
880119	7	1	1	1	55231	88.8	95.9	102.9	116.3	0.083	0.129	0.074	0.176	0.539
880120	7	1	2	0	55243	0.656	0.578	0.511	0.412	0.083	0.250	0.167	0.306	0.194
880119	7	1	2	1	55235	0.656	0.578	0.511	0.412	0.083	0.105	0.191	0.185	0.436
880120	9	1	1	0	45233	103.1	112.1	123.5	139.2	0.122	0.219	0.134	0.155	0.370
880119	9	1	1	1	55234	103.1	112.1	123.5	139.2	0.037	0.222	0.103	0.176	0.462
880120	9	1	2	0	45233	0.505	0.415	0.327	0.192	0.152	0.207	0.186	0.193	0.262
880119	9	1	2	1	55232	0.505	0.415	0.327	0.192	0.076	0.163	0.243	0.174	0.344
880120	3	2	1	0	55442	34.6	41.9	47.0	56.1	0.086	0.204	0.197	0.183	0.331
880119	3	2	1	1	55443	34.6	41.9	47.0	56.1	0.087	0.122	0.119	0.266	0.405
880120	3	2	2	0	55444	0.943	0.913	0.882	0.828	0.155	0.171	0.230	0.270	0.175
880119	3	2	2	1	55443	0.943	0.913	0.882	0.828	0.099	0.171	0.237	0.275	0.219
880120	5	2	1	0	53443	55.0	63.5	71.4	87.4	0.202	0.179	0.142	0.216	0.261
880119	5	2	1	1	55453	55.0	63.5	71.4	87.4	0.111	0.135	0.115	0.191	0.448
880120	5	2	2	0	53443	0.873	0.782	0.707	0.565	0.251	0.254	0.156	0.204	0.135
880119	5	2	2	1	55453	0.873	0.782	0.707	0.565	0.225	0.191	0.175	0.240	0.168

880120	7	2	1	0	53444	66.9	78.7	96.4	121.1	0.120	0.213	0.246	0.215	0.206
880119	7	2	1	1	54442	66.9	78.7	96.4	121.1	0.154	0.146	0.101	0.308	0.291
880120	7	2	2	0	53442	0.767	0.646	0.481	0.218	0.222	0.139	0.222	0.250	0.167
880119	7	2	2	1	54444	0.767	0.646	0.481	0.218	0.111	0.111	0.278	0.278	0.222
880120	9	2	1	0	32422	78.3	94.3	110.8	133.0	0.172	0.202	0.235	0.223	0.169
880119	9	2	1	1	55453	78.3	94.3	110.8	133.0	0.083	0.130	0.225	0.184	0.378
880120	9	2	2	0	32424	0.656	0.463	0.261	0.020	0.156	0.258	0.202	0.233	0.151
880119	9	2	2	1	55453	0.656	0.463	0.261	0.020	0.166	0.104	0.127	0.242	0.362
880120	3	3	1	0	55443	34.7	40.3	47.2	57.0	0.172	0.196	0.164	0.186	0.282
880119	3	3	1	1	45442	34.7	40.3	47.2	57.0	0.099	0.068	0.139	0.388	0.306
880120	3	3	2	0	55443	0.969	0.953	0.932	0.905	0.139	0.187	0.206	0.210	0.258
880119	3	3	2	1	45444	0.969	0.953	0.932	0.905	0.076	0.175	0.234	0.265	0.250
880120	5	3	1	0	45442	61.0	70.4	83.8	102.5	0.173	0.211	0.184	0.244	0.188
880119	5	3	1	1	54441	61.0	70.4	83.8	102.5	0.083	0.063	0.074	0.267	0.512
880120	5	3	2	0	45444	0.908	0.845	0.786	0.648	0.066	0.201	0.246	0.287	0.199
880119	5	3	2	1	54445	0.908	0.845	0.786	0.648	0.068	0.091	0.146	0.311	0.383
880120	7	3	1	0	42422	81.8	98.2	120.5	157.2	0.224	0.146	0.196	0.272	0.162
880119	7	3	1	1	52421	81.8	98.2	120.5	157.2	0.098	0.059	0.174	0.247	0.420
880120	7	3	2	0	42424	0.799	0.715	0.547	0.271	0.222	0.222	0.139	0.167	0.250
880119	7	3	2	1	52425	0.799	0.715	0.547	0.271	0.092	0.135	0.128	0.254	0.392
880120	9	3	1	0	33422	105.6	129.4	151.0	193.5	0.182	0.179	0.268	0.204	0.167
880119	9	3	1	1	33435	105.6	129.4	151.0	193.5	0.180	0.163	0.264	0.237	0.157
880120	9	3	2	0	33424	0.651	0.454	0.241	-0.093	0.201	0.187	0.208	0.243	0.160
880119	9	3	2	1	33431	0.651	0.454	0.241	-0.093	0.210	0.179	0.206	0.218	0.187
880120	3	4	1	0	54353	32.0	42.2	52.8	67.8	0.201	0.118	0.176	0.272	0.233
880119	3	4	1	1	34333	32.0	42.2	52.8	67.8	0.225	0.241	0.167	0.227	0.140
880120	3	4	2	0	54353	0.982	0.963	0.932	0.865	0.141	0.221	0.171	0.235	0.232
880119	3	4	2	1	34333	0.982	0.963	0.932	0.865	0.163	0.205	0.240	0.207	0.185
880120	5	4	1	0	55354	60.3	78.3	99.8	128.0	0.217	0.106	0.155	0.156	0.366
880119	5	4	1	1	52321	60.3	78.3	99.8	128.0	0.075	0.147	0.130	0.280	0.368

880120	5	4	2	0	55352	0.939	0.860	0.753	0.571	0.204	0.172	0.194	0.206	0.224
880119	5	4	2	1	52325	0.939	0.860	0.753	0.571	0.000	0.091	0.238	0.266	0.405
880120	7	4	1	0	14342	79.7	103.7	136.8	181.5	0.281	0.212	0.143	0.225	0.139
880119	7	4	1	1	32322	79.7	103.7	136.8	181.5	0.154	0.207	0.288	0.207	0.144
880120	7	4	2	0	14344	0.880	0.725	0.523	0.140	0.201	0.176	0.178	0.203	0.242
880119	7	4	2	1	32324	0.880	0.725	0.523	0.140	0.243	0.236	0.229	0.181	0.111
880120	9	4	1	0	23321	110.6	135.2	163.7	234.5	0.245	0.190	0.206	0.173	0.185
880119	9	4	1	1	12333	110.6	135.2	163.7	234.5	0.254	0.264	0.177	0.179	0.126
880120	9	4	2	0	23325	0.767	0.534	0.115	-0.268	0.206	0.186	0.215	0.228	0.165
880119	9	4	2	1	12333	0.767	0.534	0.115	-0.268	0.266	0.187	0.213	0.197	0.137
880120	3	5	1	0	34142	25.0	32.1	40.5	49.0	0.186	0.176	0.301	0.103	0.234
880119	3	5	1	1	44153	25.0	32.1	40.5	49.0	0.105	0.213	0.206	0.213	0.263
880120	3	5	2	0	34244	0.986	0.971	0.937	0.881	0.103	0.170	0.152	0.308	0.266
880119	3	5	2	1	44153	0.986	0.971	0.937	0.881	0.193	0.184	0.289	0.202	0.132
880120	5	5	1	0	43121	38.2	54.8	69.5	90.8	0.176	0.227	0.251	0.131	0.215
880119	5	5	1	1	33142	38.2	54.8	69.5	90.8	0.170	0.286	0.191	0.229	0.124
880120	5	5	2	0	43225	0.953	0.903	0.786	0.571	0.007	0.089	0.172	0.326	0.406
880119	5	5	2	1	33144	0.953	0.903	0.786	0.571	0.123	0.203	0.245	0.217	0.211
880120	7	5	1	0	52124	54.2	70.6	100.7	135.4	0.243	0.162	0.185	0.225	0.185
880119	7	5	1	1	53142	54.2	70.6	100.7	135.4	0.129	0.122	0.151	0.266	0.332
880120	7	5	2	0	52222	0.889	0.756	0.572	-0.020	0.167	0.250	0.176	0.194	0.213
880119	7	5	2	1	53144	0.889	0.756	0.572	-0.020	0.130	0.146	0.178	0.254	0.291
880120	9	5	1	0	54145	77.7	106.6	128.9	165.0	0.214	0.151	0.194	0.188	0.252
880119	9	5	1	1	34145	77.7	106.6	128.9	165.0	0.228	0.196	0.206	0.227	0.143
880120	9	5	2	0	54241	0.790	0.453	0.129	-0.359	0.204	0.157	0.231	0.231	0.176
880119	9	5	2	1	34141	0.790	0.453	0.129	-0.359	0.228	0.159	0.174	0.292	0.146
880120	3	6	1	0	55243	23.3	30.4	36.9	46.9	0.166	0.240	0.119	0.225	0.250
880119	3	6	1	1	45253	23.3	30.4	36.9	46.9	0.095	0.234	0.205	0.222	0.245
880120	3	6	2	0	55243	0.981	0.963	0.936	0.880	0.215	0.176	0.254	0.262	0.093
880119	3	6	2	1	45253	0.981	0.963	0.936	0.880	0.191	0.180	0.222	0.252	0.155

880120	5	6	1	0	45221	37.7	49.1	59.9	73.8	0.157	0.222	0.167	0.241	0.213
880119	5	6	1	1	55254	37.7	49.1	59.9	73.8	0.092	0.127	0.111	0.278	0.392
880120	5	6	2	0	45225	0.956	0.894	0.808	0.640	0.085	0.114	0.129	0.307	0.364
880119	5	6	2	1	55252	0.956	0.894	0.808	0.640	0.161	0.268	0.222	0.198	0.151
880120	7	6	1	0	52235	49.4	64.2	80.9	107.0	0.198	0.198	0.184	0.163	0.257
880119	7	6	1	1	54231	49.4	64.2	80.9	107.0	0.147	0.148	0.192	0.245	0.267
880120	7	6	2	0	52231	0.884	0.788	0.585	0.218	0.250	0.167	0.167	0.111	0.306
880119	7	6	2	1	54235	0.884	0.788	0.585	0.218	0.171	0.194	0.222	0.194	0.218
880120	9	6	1	0	33233	63.5	86.9	102.4	130.9	0.177	0.260	0.184	0.165	0.213
880119	9	6	1	1	52221	63.5	86.9	102.4	130.9	0.157	0.120	0.191	0.258	0.273
880120	9	6	2	0	33233	0.778	0.547	0.249	-0.203	0.190	0.196	0.210	0.196	0.206
880119	9	6	2	1	52225	0.778	0.547	0.249	-0.203	0.157	0.173	0.192	0.194	0.284
880120	3	7	1	0	54554	31.8	40.4	50.6	63.7	0.169	0.159	0.162	0.240	0.269
880119	3	7	1	1	55552	31.8	40.4	50.6	63.7	0.067	0.128	0.142	0.220	0.444
880120	3	7	2	0	54552	0.984	0.969	0.932	0.871	0.305	0.260	0.191	0.121	0.123
880119	3	7	2	1	55554	0.984	0.969	0.932	0.871	0.068	0.121	0.202	0.273	0.336
880120	5	7	1	0	34533	50.4	66.3	87.7	118.1	0.139	0.222	0.178	0.181	0.280
880119	5	7	1	1	54541	50.4	66.3	87.7	118.1	0.071	0.146	0.120	0.217	0.446
880120	5	7	2	0	34533	0.936	0.886	0.796	0.614	0.150	0.312	0.183	0.171	0.183
880119	5	7	2	1	54545	0.936	0.886	0.796	0.614	0.064	0.117	0.208	0.254	0.356
880120	7	7	1	0	51525	72.4	97.9	129.0	170.8	0.194	0.194	0.222	0.222	0.167
880119	7	7	1	1	54541	72.4	97.9	129.0	170.8	0.084	0.261	0.135	0.168	0.352
880120	7	7	2	0	51521	0.880	0.774	0.453	0.066	0.144	0.214	0.222	0.219	0.200
880119	7	7	2	1	54545	0.880	0.774	0.453	0.066	0.119	0.182	0.189	0.199	0.311
880120	9	7	1	0	53525	90.9	130.9	171.6	227.7	0.172	0.186	0.242	0.206	0.194
880119	9	7	1	1	44545	90.9	130.9	171.6	227.7	0.199	0.147	0.209	0.240	0.205
880120	9	7	2	0	53521	0.786	0.487	0.013	-0.435	0.147	0.246	0.171	0.214	0.222
880119	9	7	2	1	44541	0.786	0.487	0.013	-0.435	0.123	0.242	0.286	0.254	0.095

```
FUNCTION IRECDAF (I1,I2,I3,I4,I5)

IDAY=MOD(I1,100)
IMON=MOD(I1/100,100)

IF (IMON.EQ.11) THEN
  IDAY=IDAY-30
ELSE IF (IMON.LE.2) THEN
  IDAY=IDAY+31*IMON
ENDIF

IFOR=MAX(1,MIN(4,I2/2))
IAREA=MAX(1,MIN(7,I3))
IERR=MAX(1,MIN(2,I4))
ILAG=MAX(0,MIN(1,I5))
IDAY=MAX(1,MIN(91,IDAY+ILAG))

IRECDAF=(IDAY-1)*112+(IAREA-1)*16+(IFOR-1)*4+(IERR-1)*2+ILAG+2

RETURN
END
```