TECHNICAL MEMORANDUM

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A synoptic analysis of cyclones in ECMWF analyses and forecasts for winter seasons of 1980 81, 1981 82

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ABSTRACT

A study of systematic errors in the forecasts (up to ten days) of cyclones by the current ECMWF operational model (grid point model N48) has been completed for the 1980-81 and 1981-82 winter seasons.
The 1980-81 winter season is included for the geographical distributions of cyclones. The forecasts are verified over the north Atlantic and Europe. For the purposes of this study, a cyclone is defined to be a low pressure centre surrounded by one or more closed isobars analysed at 5 mb intervals on the ECMWF forecast and verification charts.
Cyclone statistics, including tracks, central pressures, deepening and filling rates, speed and life span, of cyclones are given and tabulated.
The regional distribution of cyclones in the forecasts and in the verifying analyses for the winter months 1980-82 is depicted.
The forecasts are shown to have a tendency to shift cyclone tracks towards the south, especially after day 4, except near the Newfoundland area where the northward shift is significant. A systematic phase error of the model in being too slow, usually at the developing stages of cyclones, is quite evident. The forecast deepening and filling rates are less than the observed deepening and filling rates. The magnitude of model cyclones is relatively smaller during the first two or three days, and relatively bigger during the later stages of the life cycle of the lows. Finally, the secondary track of cyclones from the Atlantic towards the continent of Europe is overestimated, and cyclonic activity over the Mediterranean is missed by the forecasts.

1. Introduction

The purpose of this paper is to identify systematic errors in the mean sea level pressure prognoses produced once daily from 1200 GMT analyses by the ECMWF Grid Point Model (N48). The results may help to improve the forecasters' understanding, interpretation and use of the ECMWF forecasts, as well as suggest avenues of future research for numerical modellers.

In the earlier study of cyclones in the ECMWF forecast and verifying analyses for the period September-October, 1980 (Akyildiz, 1980), it was shown that a systematic error of the forecasts was a southward shift of cyclones over the North Atlantic and northern Europe.

In a study investigating forecast differences between a spectral and a grid point model, written by C. Girard and M. Jarraud, it was shown that 1) young cyclones move more quickly than mature ones, 2) in the majority of cases, N48 model cyclones do not move as quickly northward, 3) for slow moving systems the models (N48 and spectral) are too fast, and finally, 4) for the fast moving systems both models are too slow.

The present study seeks to determine and quantify systematic errors in the short and medium range forecasts (up to 10 days) of mean sea level (MSL) pressure and position for surface cyclones in the ECMWF operational model (N48) for the 1980-81 and 1981-82 winter seasons over the north Atlantic and Europe. The life cycle of observed lows are separated into periods, and compared with the forecasts verifying at the same time. The ECMWF N48 model is run once daily from 1200 GMT data. This study covers two different periods, the first is the 1980-81 winter season which is included for the regional distribution of cyclones for the north Atlantic and European area, the second period is the 1981-82 winter season during which the main pilot study has been done, and also six cases of cyclones are included from November 1981. A cyclone is included in the sample if it has at least one closed isobar in the forecast and in the verification map. For the 1981-82 season, well-defined lows with a sufficient gradient around them in the analyses were selected. By plotting the central position of lows on a map during their whole life period up to D+10 (the life cycle of very few cyclones exceeds 10 days) at 24 hour time intervals, and drawing lines connecting those positions, the observed track was constructed. A similar procedure was applied to corresponding lows in the forecasts which verify the same period (see Fig. 1).

The following information is also extracted from the forecasts and from the verifying analyscs:

1. Speed of cyclones, expressed in Km/24hr, obtained by measuring the distance between two successive positions of a low in the cyclone tracks.

2. The cyclone central pressures estimated to within 2-3 mb.

3. The magnitude of cyclones, which is assessed relatively and subjectively.

4. The life span of cyclones in the forecasts and in the verifying analyses.

Three forecasts from three consecutive days, one from the day on which the observed cyclone was generated, the other two forecasts from one day earlier and two days earlier, have been verified for each observed low. Hereafter, in this paper, these three forecasts will be referred by the notations D, D-1 and D-2 respectively. During November 1981 to February 1982, 39 cases (39 well defined observed lows with complete life cycles) have been found. The statistics in this study were based on those lows, and on the corresponding forecast lows. For each observed low, three forecast lows from three different forecast days were counted in the calculation of statistics. Some of the forecast could not capture the observed cyclones, and in these cases, these forecasts were omitted from the calculation. A period of each calculation is a 24hr. time interval during the life cycle of an observed low, e.g. first day, second day... etc. of that low. The statistics of observed lows for a period, say, for the second day of the lows, was compared to the statistics of the forecast lows which verify the same period. Some of the forecasts did not capture the observed lows throughout their life cycles, therefore the sample size is not the same for each calculation. Since three different forecasts from subsequent days are verified for each case, the D+1 forecasts can only appear, at most, twice in a case, whereas, from Day 2 onwards three forecasts can verify the each observed low.

To assess geographical distribution, the cyclones in the forecasts and in the verifying analyses have been counted in 5 x 10 latitude - longitude quadrangles, and plotted on a map. A cyclone that verifies on a quadrangle boundary is recorded as belonging to the north and/or west adjacent box. This procedure is consistent with the one used by Leary (1971).

2. Cyclone Tracks

The cyclone tracks for both the analyses and forecasts have been established on a polar stereographic map which is in 1:25,000,000 scale for the Atlantic and European area.

Figure 1 shows the observed and predicted cyclone tracks. The date at the beginning of each track indicates the date on which the low was first observed. The letters

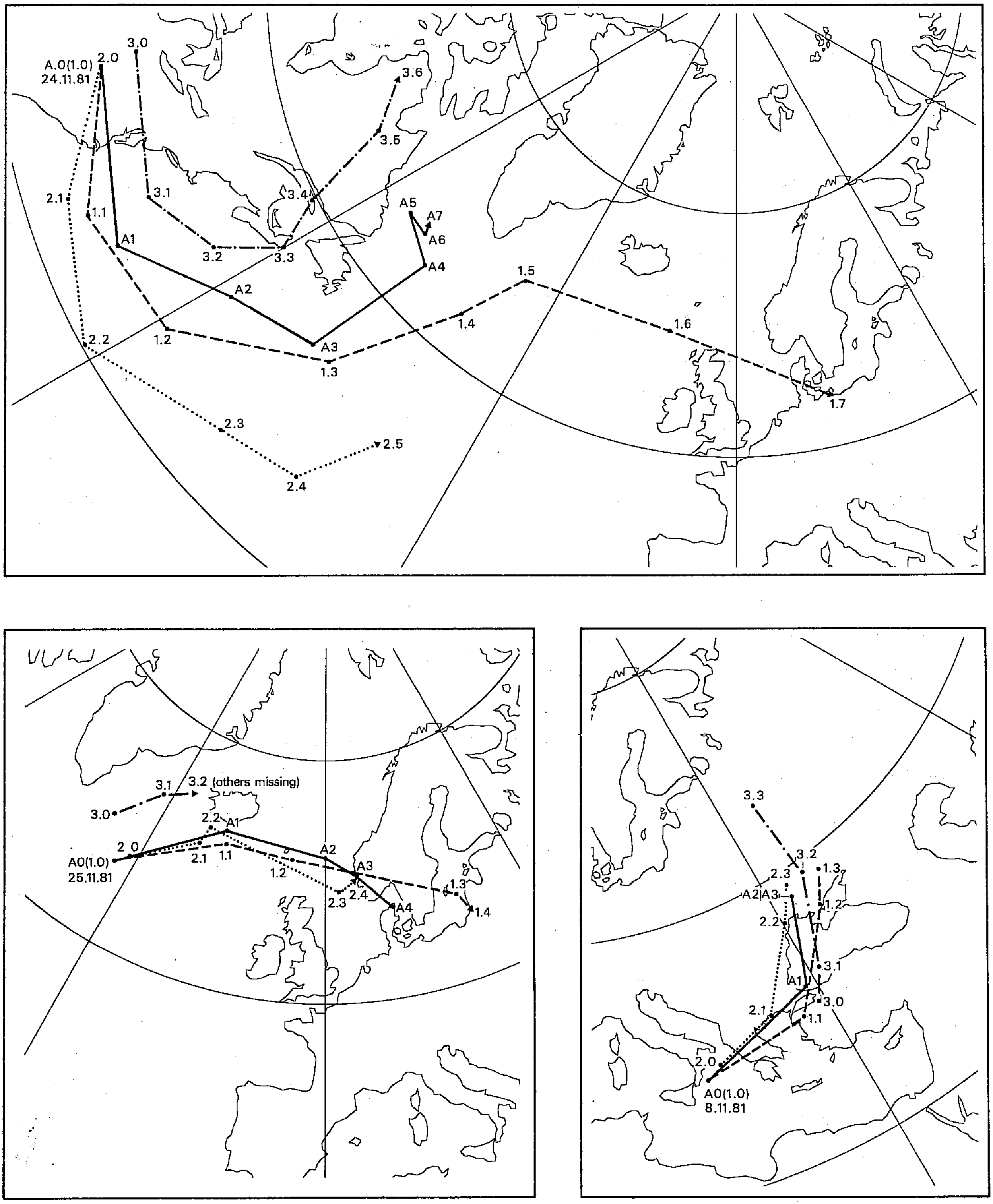
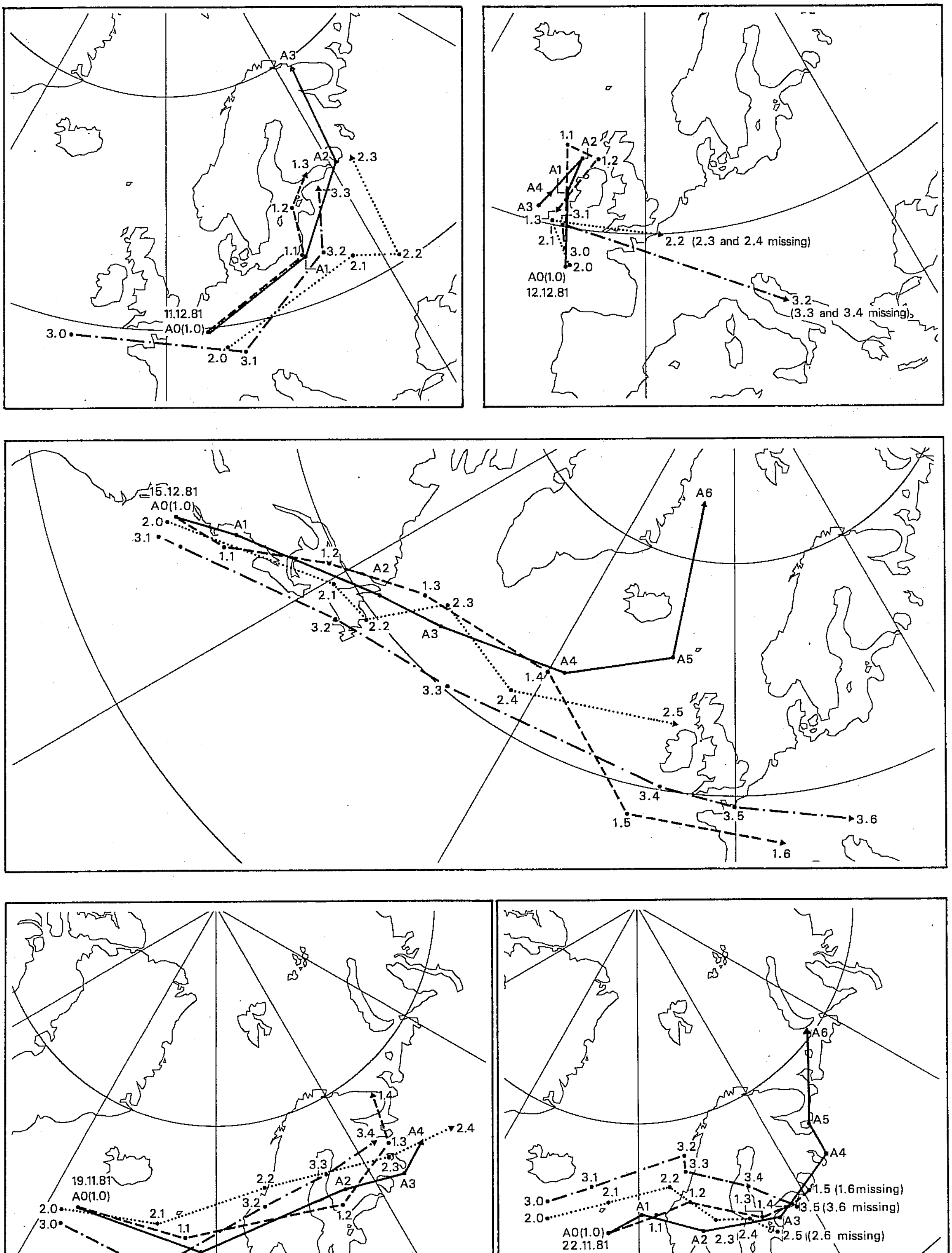


Fig. 1 Tracks of Cyclones (a) in the analyses (————), (b) in the forecasts from the day (D) on which the low was generated (– – – – –), (c) in the forecasts from the D-1 (·············) (d) in the forecasts from the D-2 (·—·—·—).



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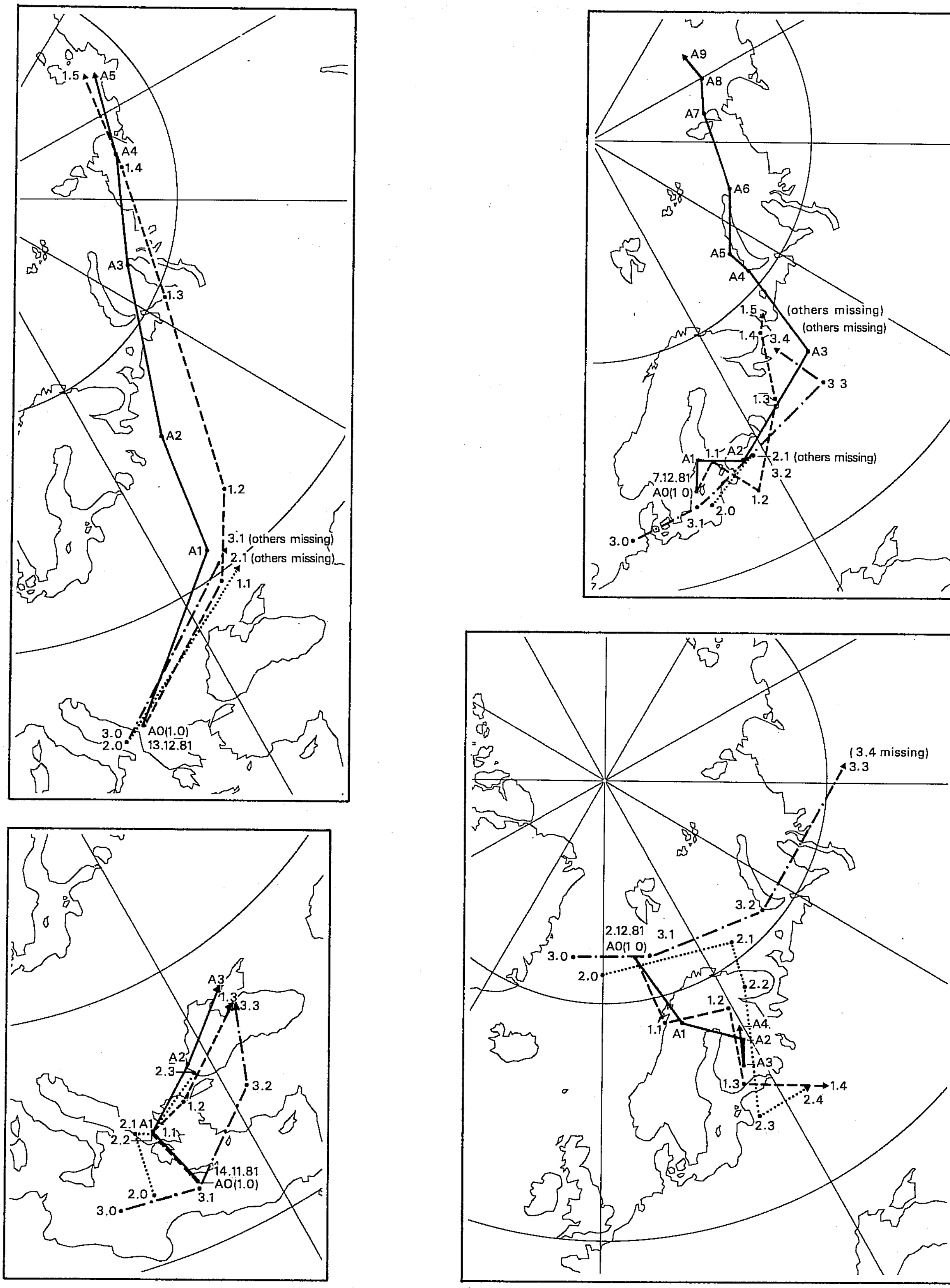

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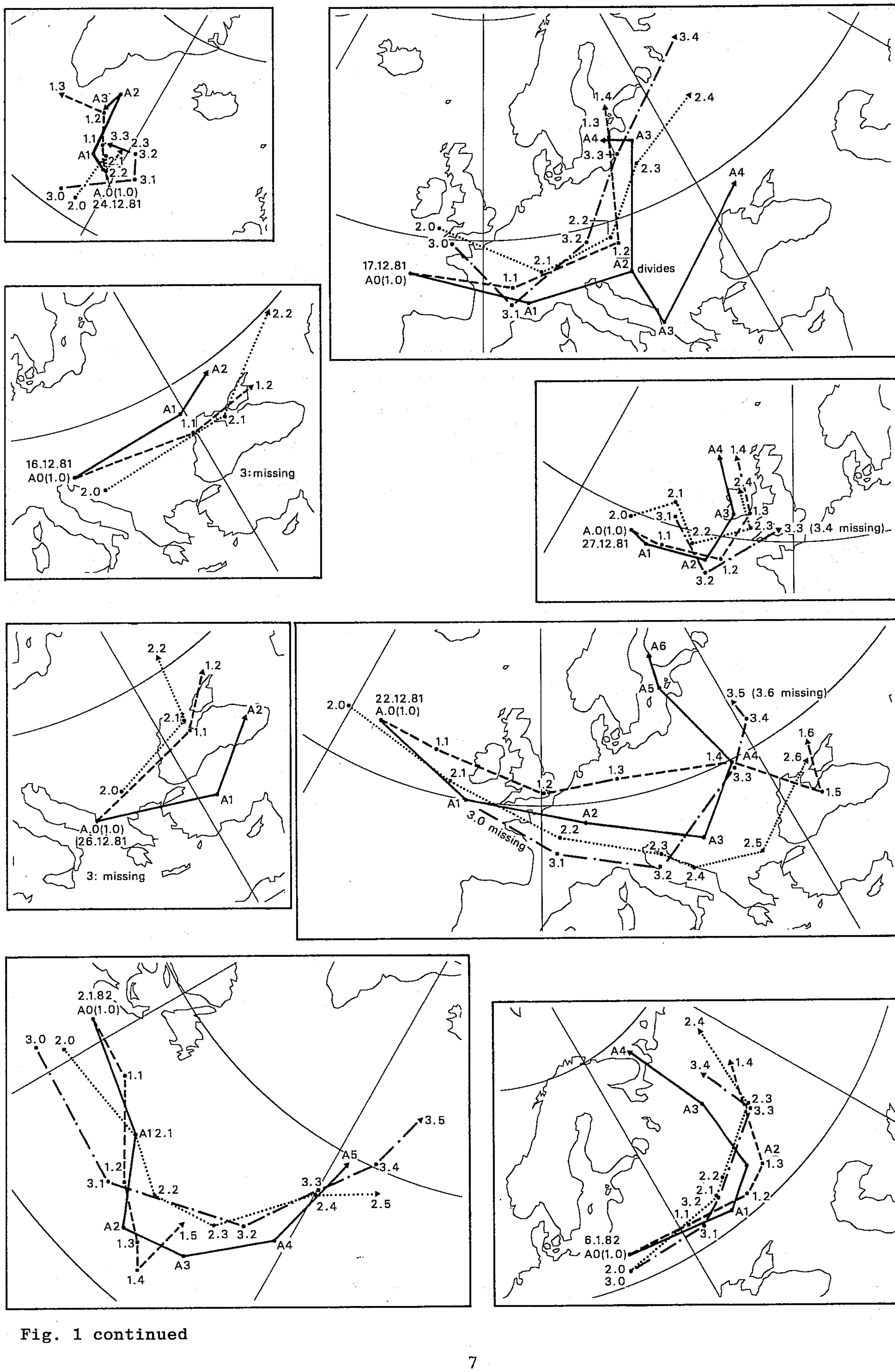

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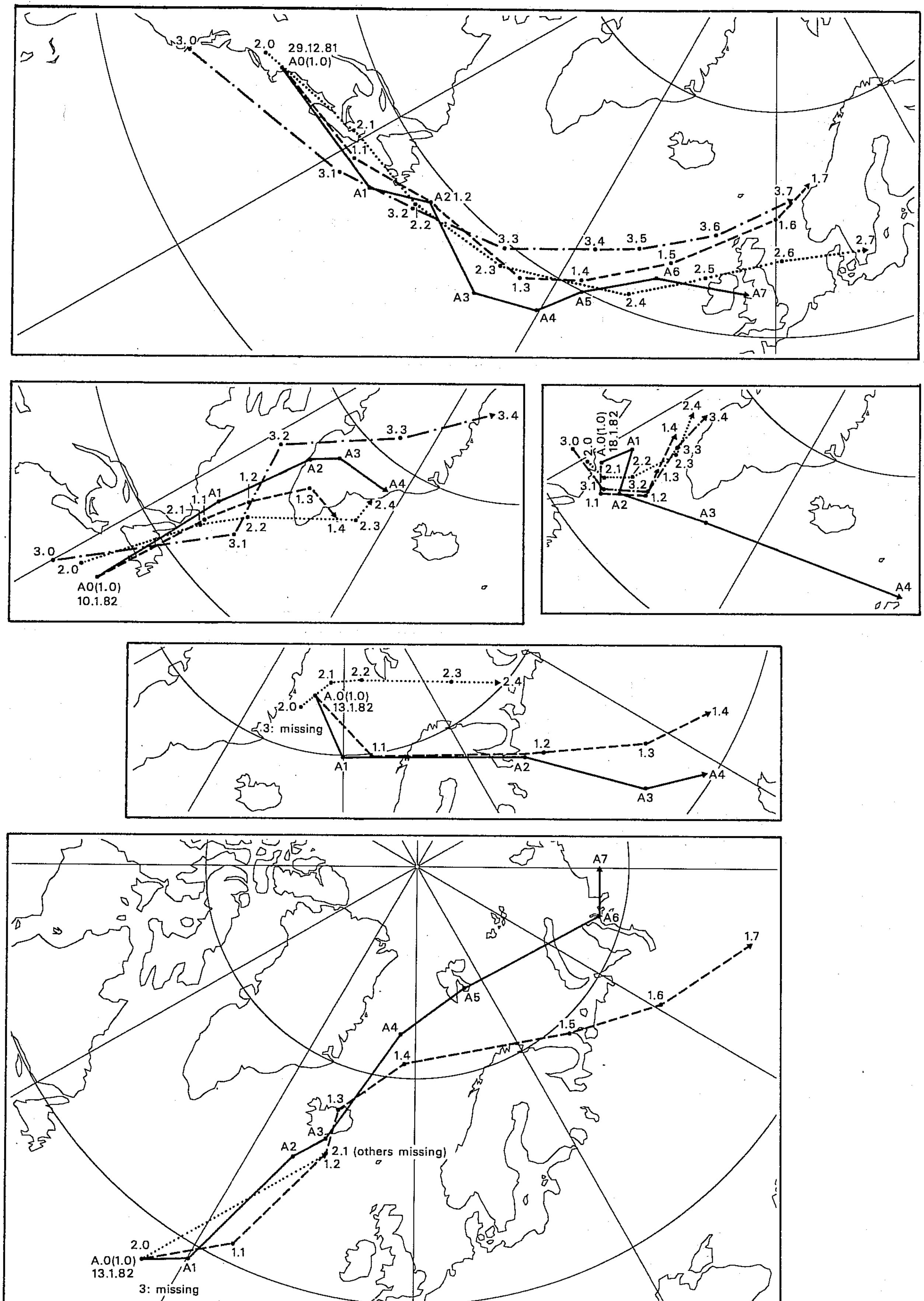

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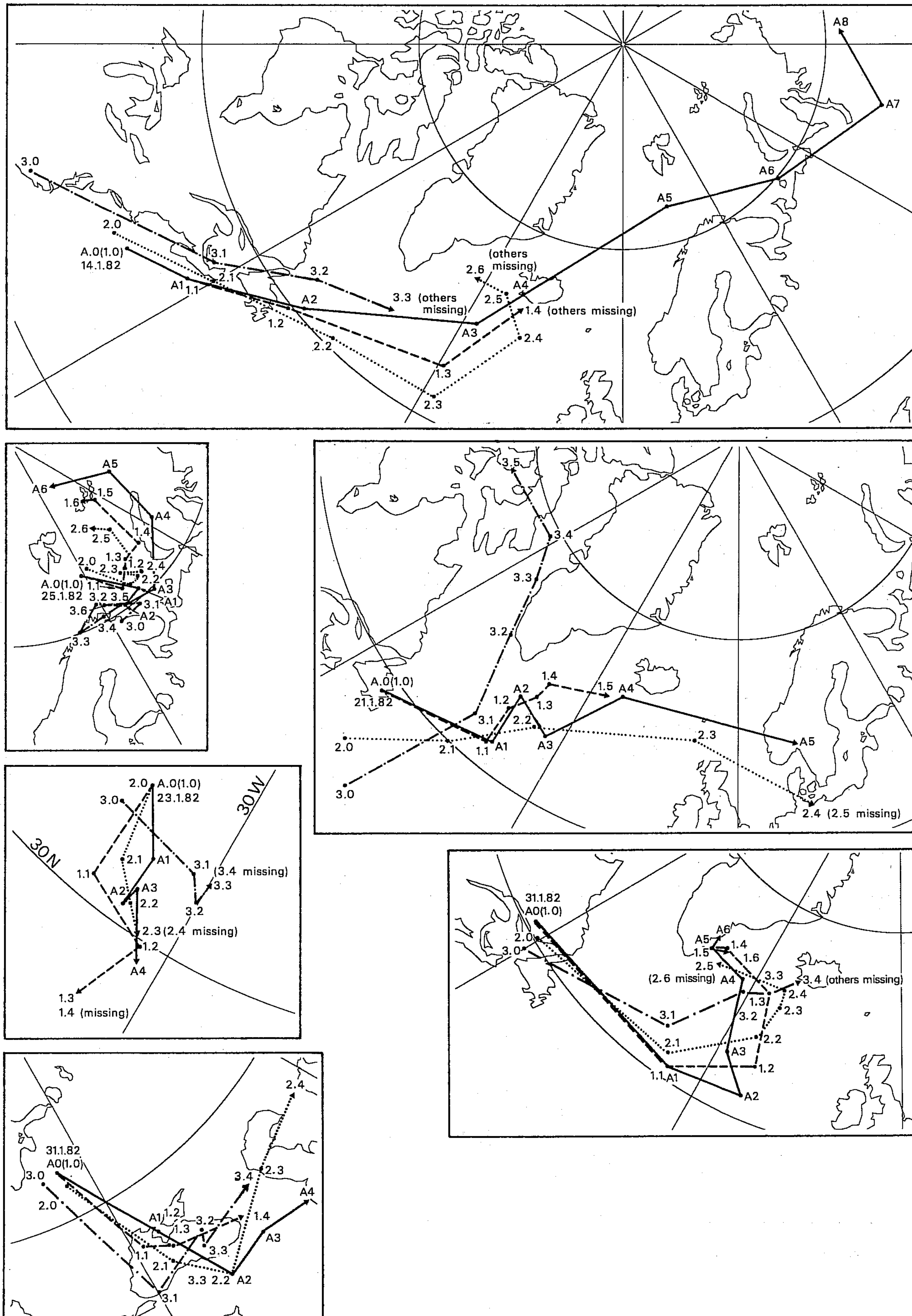

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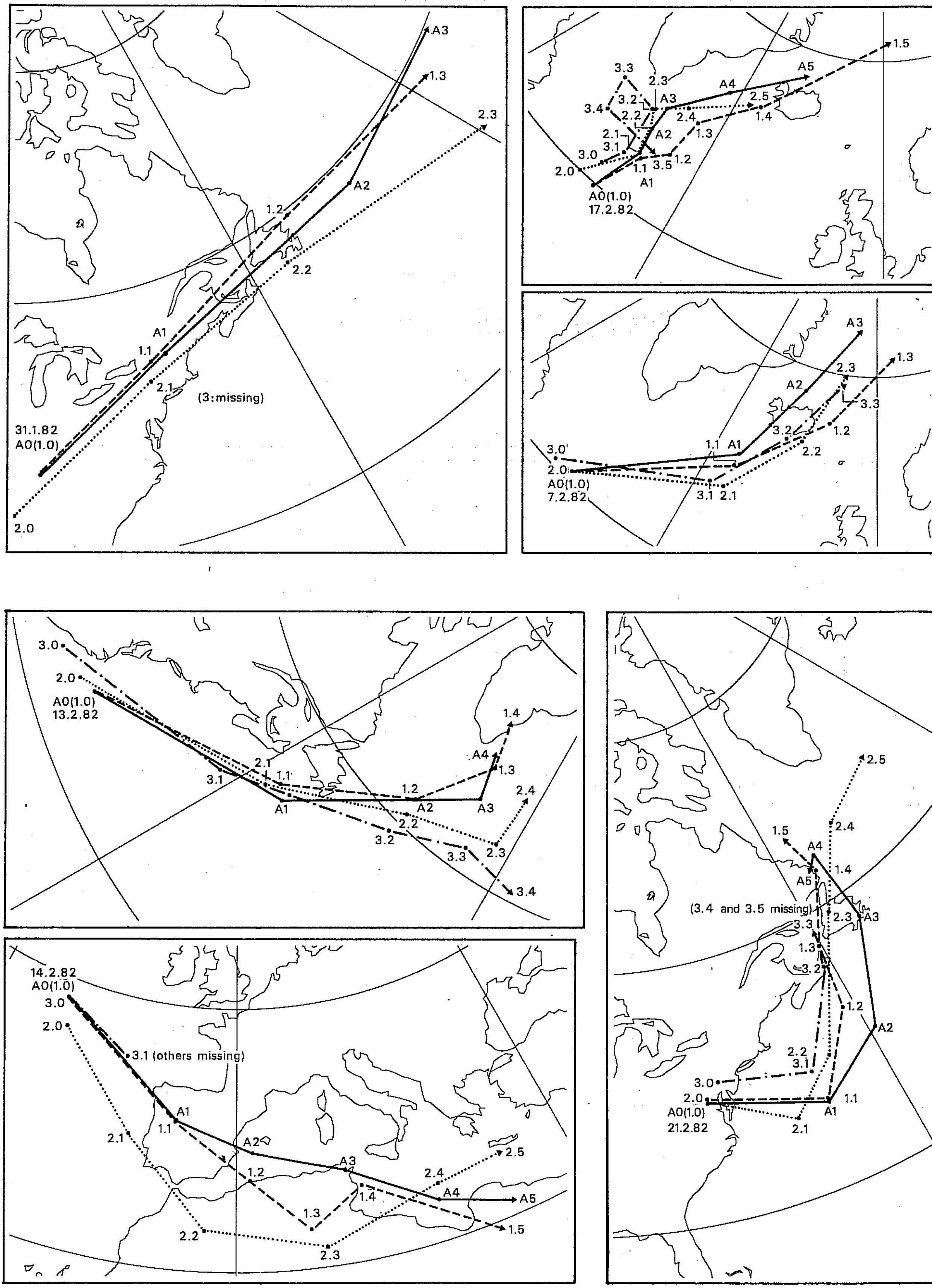

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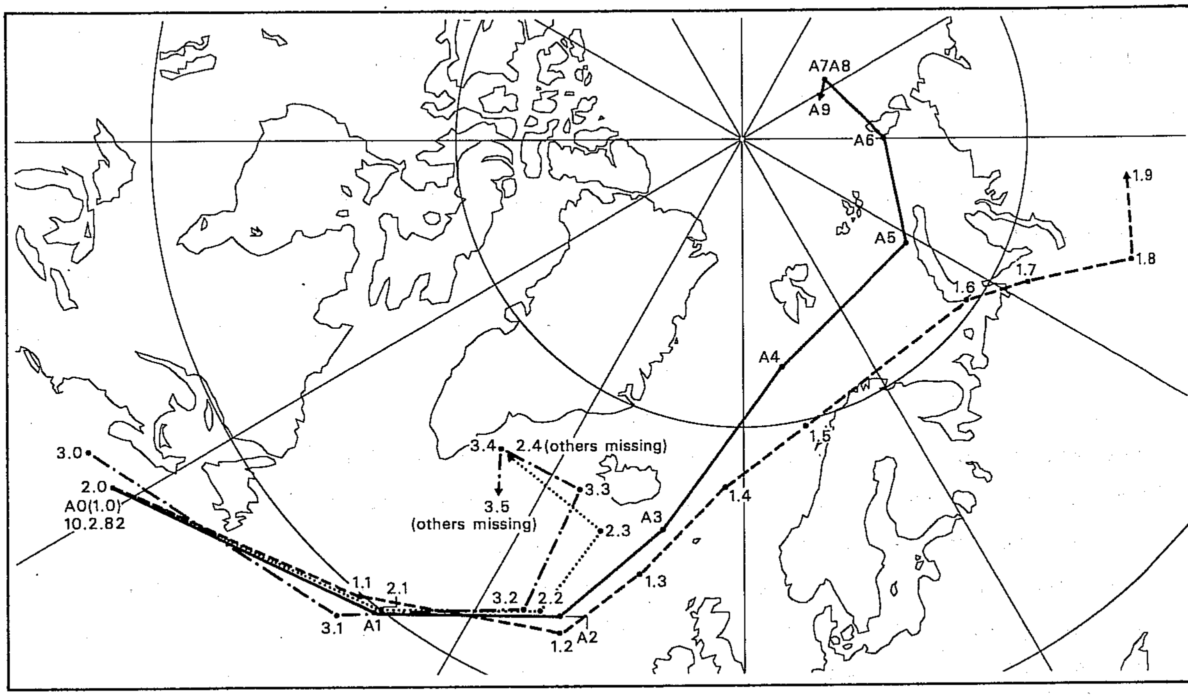

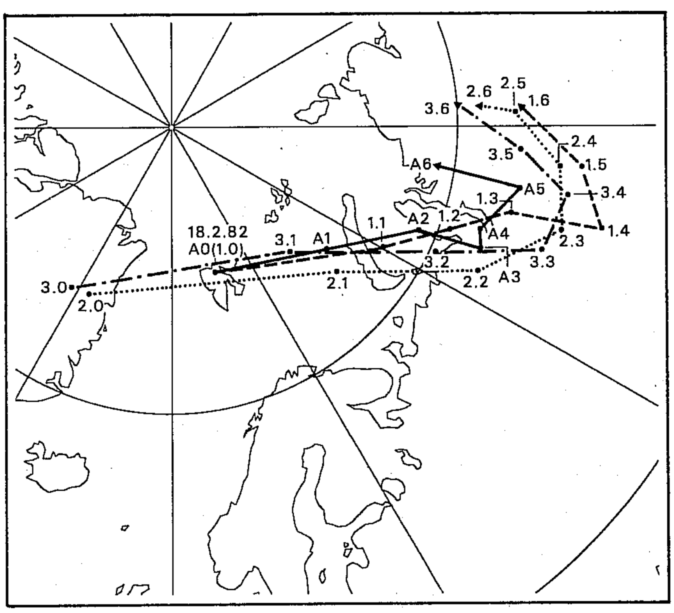

Fig. 1 continued

with subscript number, such as A0, A1, A2, A3, etc., indicate the central position of the observed lows for each timestep (24 hr interval) from the beginning stage to the ending (decaying) stage.

The first number on the forecast track indicates the day on which the forecast is initiated -

1 : the forecast from the day (D) on which the observed low was generaged,
2 : the D-1,
3 : the D-2,

the second number, also true for the observed track, indicates the verifying time. For example, the numbers, such as, A3, 1.3, 2.3 and 3.3 have the following meanings: 3 indicates the verifying time, say, 13th January, 82, in this case; A.3 shows the observed low which was generated on 10th Jan. 82, 1.3 shows the D+3 forecast from the analysis day D(10.1.82), 2.3 shows the D+4 forecast from one day earlier, D-1(9.1.82), 3.3 shows the D+5 forecast from two days earlier D-2(8.1.82).

Some of the forecasts missed some time steps, mostly during the later stages of the forecasts.

Tracks, which were oriented in the east-west direction, were sorted into these cases when the forecast track was to the left (north) of, to the right (south) of, or along the observed track (see Table 1). In this table the cases were also sorted by the days from which the forecasts were made, as well as by the periods of the life cycle of observed cyclones. Table 1 shows that for each stage of the forecast period the percentage with southward positions of the forecast track is greater than the percentage of northward positions of the track. This difference increases with forecast period. For first two days of the period, 50% of the forecast tracks were more or less along the observed track. The overall summary of Table 1 is shown in the last row of the table, which indicates the weighted mean of cases (as percentages). According to the left side of this table, of the 121 forecast cyclones, 39% moved to the right (south) of the observed track, 22% moved to the left (north) of the observed track, and 39% moved more or less along the observed track. Examining the forecasts from the D-1 (on the right side of the table) we can see that, of 114 tracks, 45% moved to the right (south) of the observed track, 25% moved to the left (north) of the observed track, and 30% moved along the observed track. Thus, the model shows a systematic error of not curving the forecast track sufficiently towards the north as is found in reality. The sample size from Day 5 onward is small but it confirms the trend seen in the earlier forecast days.

From Figure 1 and Table 1 it can be seen that the shift of the forecast track from the observed becomes significant from Day 4 onwards. Moreover, some forecast tracks in the forecast from D-2, even in the early stages, follow quite different paths from the observed tracks. In several cases the observed lows showed later deepening, which was not captured by the forecasts, and also in some other cases the identification of the lows was doubtful in the longer ranges of the forecasts. In these the forecast track diverged from the observed track significantly. The track north west of Russia, which starts on 7.12.81, and the track near Greenland, which starts on 18.1.82, are examples. In one case the observed track over central Europe, which starts on 17.12.81, was split into two minor tracks which moved in different directions. The forecast did not predict this split.

TABLE 1

Cases sorted by position of forecast track : to the south (S), to the north (N), or along (M) the observed track. Only the cases in which the cyclones in the forecasts and in the verifying analyses show a tendency to move in an east-west direction have been included in the table.

Forecast Days	Forecast from analysis day D				Forecast Days	Forecasts from one day earlier D-1			
	S	N	M	Sample Size		S	N	M	Sample Size
	%	%	%			%	%	%	
D+1 and D+2	25	19	56	52	D+2 and D+3	35	28	37	51
D+3 and D+4	41	32	27	44	D+4 and D+5	50	26	24	46
D+5 and D+6	64	12	24	25	D+6 and D+7	65	12	23	17
Weighted Mean (%)	39	22	39	121	Weighted Mean (%)	45	25	30	114

3. Speed of Cyclones

Systematic phase errors are examined by comparing the speed of observed lows to the speed of the forecast lows. The mean speed of the lows in the forecasts and in the verifying analyses has been calculated for every 24 hr time interval, and tabulated in Tables 2 and 3. The standard deviation of cyclone speed is also included in the Tables. The calculation is only up to sixth day of the life cycle of observed low, for the forecasts it is up to Day 6 or Day 7, depending on whether the forecasts are from day D, or from day D-1. A graphical presentation of the cyclone speed is depicted in Fig. 2. Also a frequency distribution of the cyclone speed has been prepared, and shown in Tables 4 and 5. Since the life cycles of some cyclones are short, on the order of three or four days, also since the later stages of several cyclones were missed by the forecasts, the sample size of the cases decrease rapidly by Day 5 or 6.

TABLE 2

Mean Speed of Cyclones (Km/24 Hrs)
(The Forecast from the D)

D A Y S	ANALYSES		FORECASTS		N
	$\bar{V}$	SD	$\bar{V}$	SD	
First Day of the Cyclones F/C : DAY 1	1002	473	964	434	39
Second Day of the Cyclones F/C : DAY 2	860	426	790	403	39
Third Day of the Cyclones F/C : DAY 3	719	429	759	437	36
Fourth Day of the Cyclones F/C : DAY 4	737	327	666	332	28
Fifth Day of the Cyclones F/C : DAY 5	738	430	773	449	17
Sixth Day of the Cyclones F/C : DAY 6	741	525	871	546	9

TABLE 3

Mean Speed of Cyclones (Km/24 Hrs)

(The Forecasts from the D-1)

DAYS	ANALYSES		FORECASTS		N
	$\overline{V}$	SD	$\overline{V}$	SD	
First Day of the Cyclones F/C : DAY 2	1020	455	1021	452	36
Second Day of the Cyclones F/C : DAY 3	849	426	698	392	36
Third Day of the Cyclones F/C : DAY 4	692	401	860	439	32
Fourth Day of the Cyclones F/C : DAY 5	690	310	647	346	25
Fifth Day of the Cyclones F/C : DAY 6	620	287	686	296	12

Where, $\overline{V}$: Arithmetic Mean

SD : Standard Deviation

N : Sample Size

TABLE 4

Frequency distribution of cyclones speed (Km/24hrs)

(The forecast from day D)

SPEED (Km/24hrs)	STAGES OF CYCLONES AND THE F/C PERIODS: First two Days of the low		Third and Fourth Days of the low		Fifth and Sixth Days of the low	
	ANAL.	F/C (D+1,D+2)	ANAL.	F/C (D+3,D+4)	ANAL.	F/C (D+5,D+6)
0-300	5	4	8	9	4	5
300-600	17	19	22	15	6	5
601-900	17	18	16	24	9	6
901-1200	21	22	9	8	3	4
1201-1500	11	8	5	4	1	4
1501-1800	2	5	4	3	2	2
1801<	5	2	0	1	1	0

TABLE 5

Frequency distribution of cyclones speed (Km/24hrs)

(The forecast from day D-1)

SPEED (Km/24hrs)	STAGES OF CYCLONES AND THE F/C PERIODS: First two Days of the low		Third and fourth Days of the low		Fifth and Sixth Days of the low	
	ANAL.	F/C(D+2,D+3)	ANAL.	F/C (D+4,D+5)	ANAL.	F/C (D+6,D+7)
0-300	4	8	7	9	1	2
301-600	15	17	21	11	6	5
601-900	17	12	16	15	6	9
901-1200	20	21	7	15	3	0
1201-1500	10	7	3	5	0	0
1501-1800	1	4	3	1	1	1
1801<	5	3	0	1	0	0

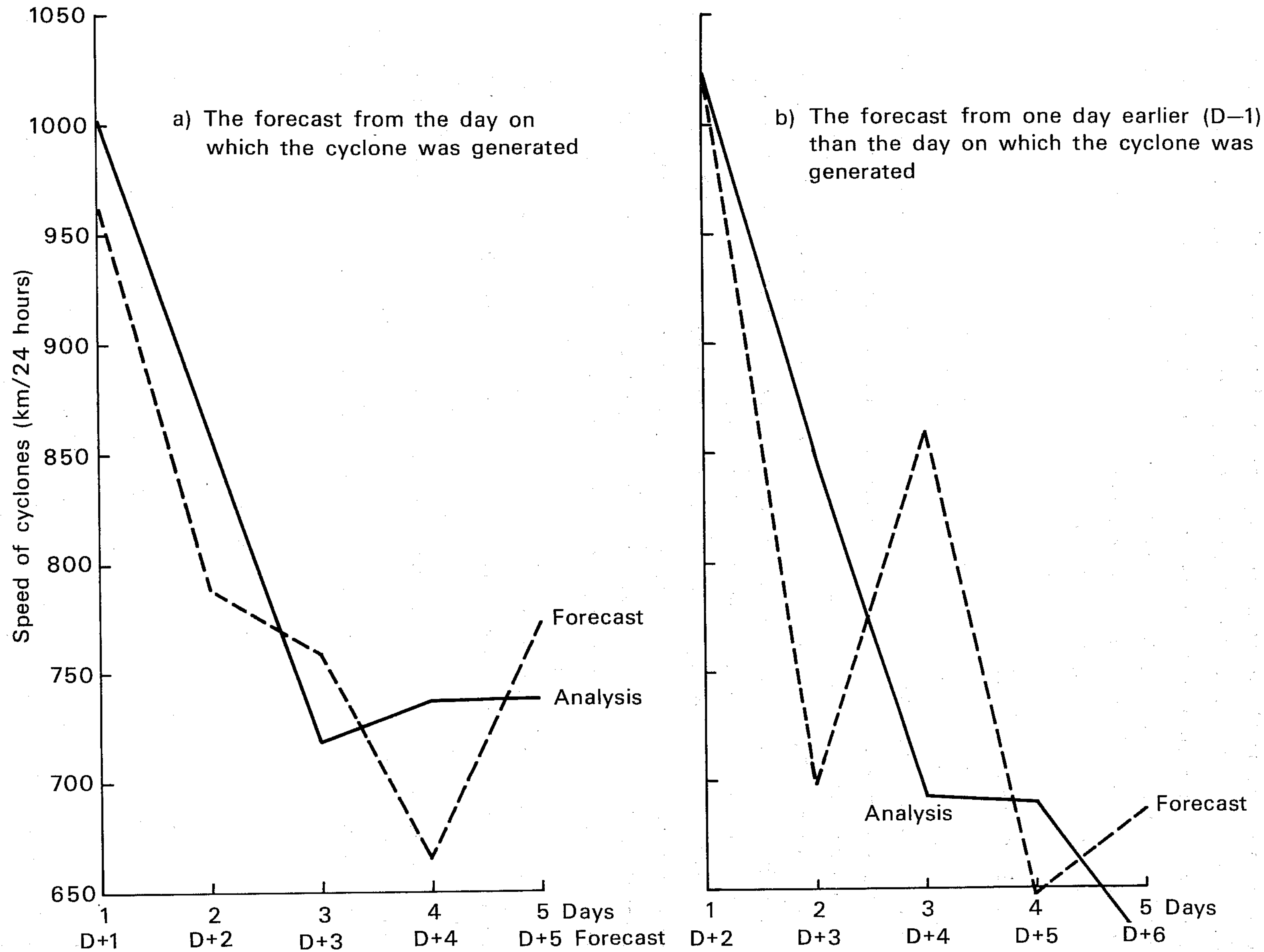

Fig. 2 Mean speed of cyclones in the forecasts (dashed lines), and in the verifying analyses (solid lines), km/24 hours.

Tables 2 and 3, and Fig. 2 show that while during the first two or three days of the forecast period the model cyclones are too slow, in later stages their speed tends to increase. According to Tables 4 and 5 most of the cyclones in the forecasts and in the verifying analyses have a speed between 600 and 1200 km/24hr. Thus, the model shows a phase error with a tendency for observed lows to occur east of the forecast position on days 1, 2 or 3. This conclusion generally agrees with the results of Girard and Jarraud (1982) concerning the N48 model.

4. Central Pressure of Cyclones

The central pressure of cyclones were estimated to within 2-3 mb. Only those cases in which the cyclones reached the minimum central pressure at the same time (normally 1 or 2 days after generation) in the forecasts and in the verifying analyses have been taken for computation. Central pressures of analysed and corresponding forecast lows were averaged. Figures 3 and 4 depict the mean central pressure of the observed and the forecast lows. It can be seen from these Figures that the mean central pressure of the cyclones in the D+1 forecast (which is from the day on which the low was generated), and in the D+1 and D+2 forecasts (which are from one day earlier) is higher than that for the verifying analyses. Thus, the model is delayed in deepening the central pressure of the forecast cyclones during the first 24 and 48 hours. On the other hand, it retained the low pressure after day 2, rather than filling it.

Figures 5 to 8 show the central pressure of the cyclones in the forecasts and in the verifying analyses for four cases, one each from a month, for November 81 to February 82. These Figures show the same conclusion which was derived from Fig. 3 and 4. However, a few time steps in these cases seem to be unusual. For instance, in Fig. 7 the forecast from 1st January 1982 overestimated the central pressure of the low off Newfoundland. In Fig. 8 the forecast from 29th and 30th missed the lows after day 6.

4.1. Deepening and filling rates of cyclones

The forecast deepening (or filling) rate when compared with the observed deepening (or filling) rate, can reveal systematic errors in central pressure of forecast lows.

The forecast deepening rate is defined as the difference between the central pressure of the low centre at the initial time and the 24-hour forecast central pressure. The observed deepening rate is defined similarly. Only the cases with zero and positive sign (initial central pressure - verified central pressure) have been taken into account. Table 6 shows a contingency table of 32 cases where the deepening rates are divided into categories depending on the combination of forecast deepening rate

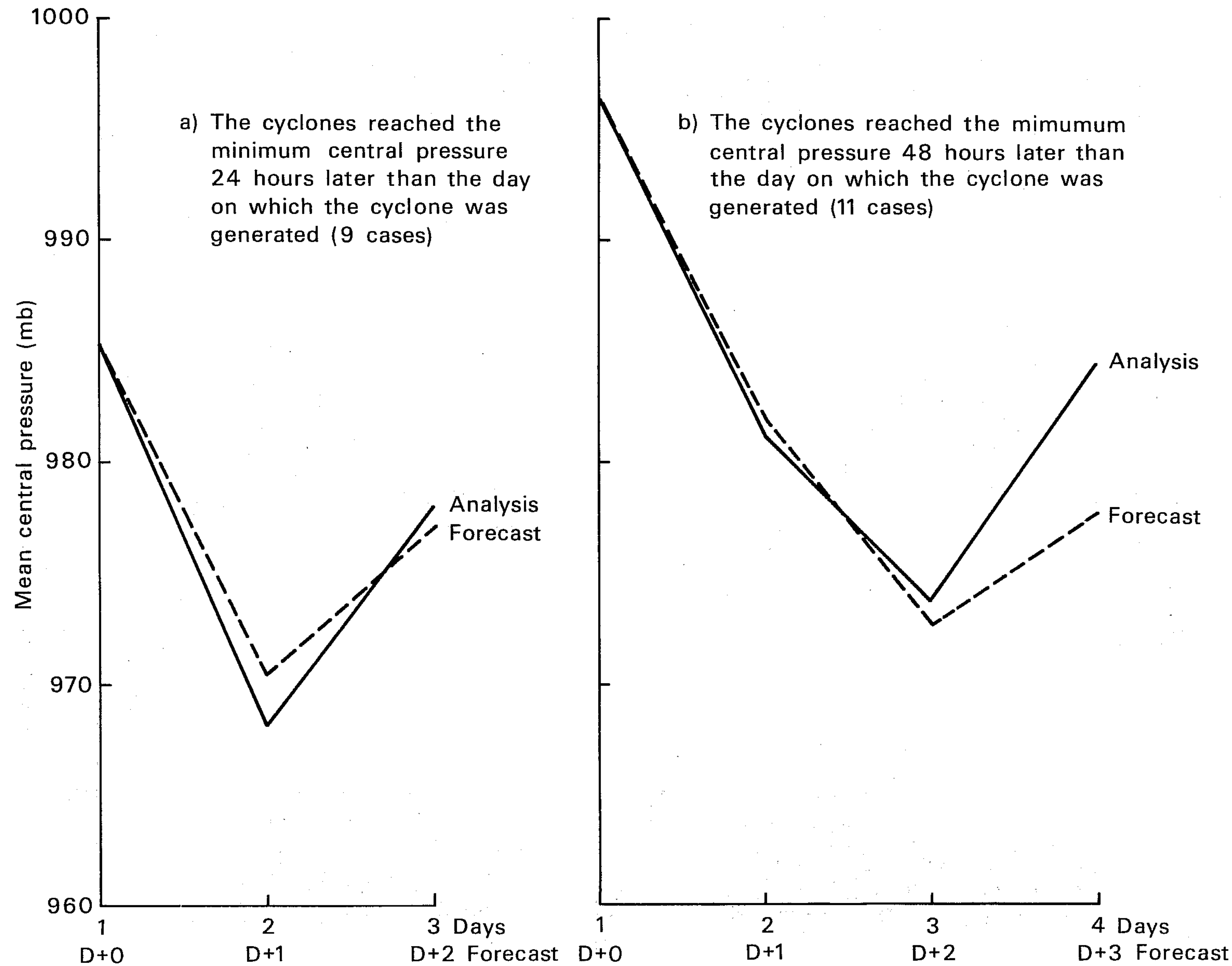

Fig. 3 Mean central pressure of cyclones in the forecasts (dashed lines), and in the verifying analyses (solid lines). The forecasts were initiated from the day on which the cyclone was generated.

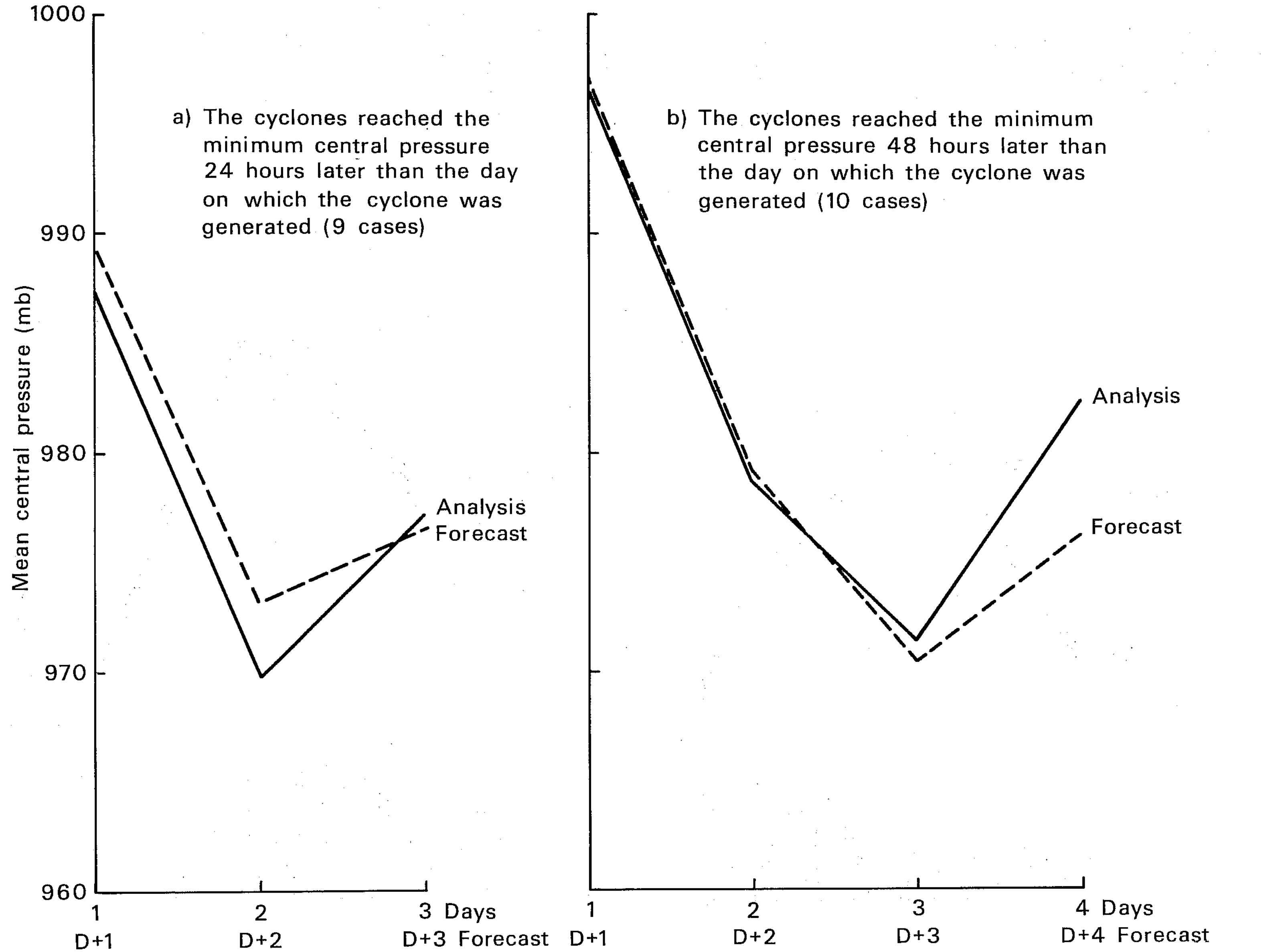

Fig. 4 Mean central pressure of cyclones in the forecasts (dashed lines), and in the verifying analyses (solid lines). The forecasts were initiated from one day earlier than the day on which the cyclone was generated.

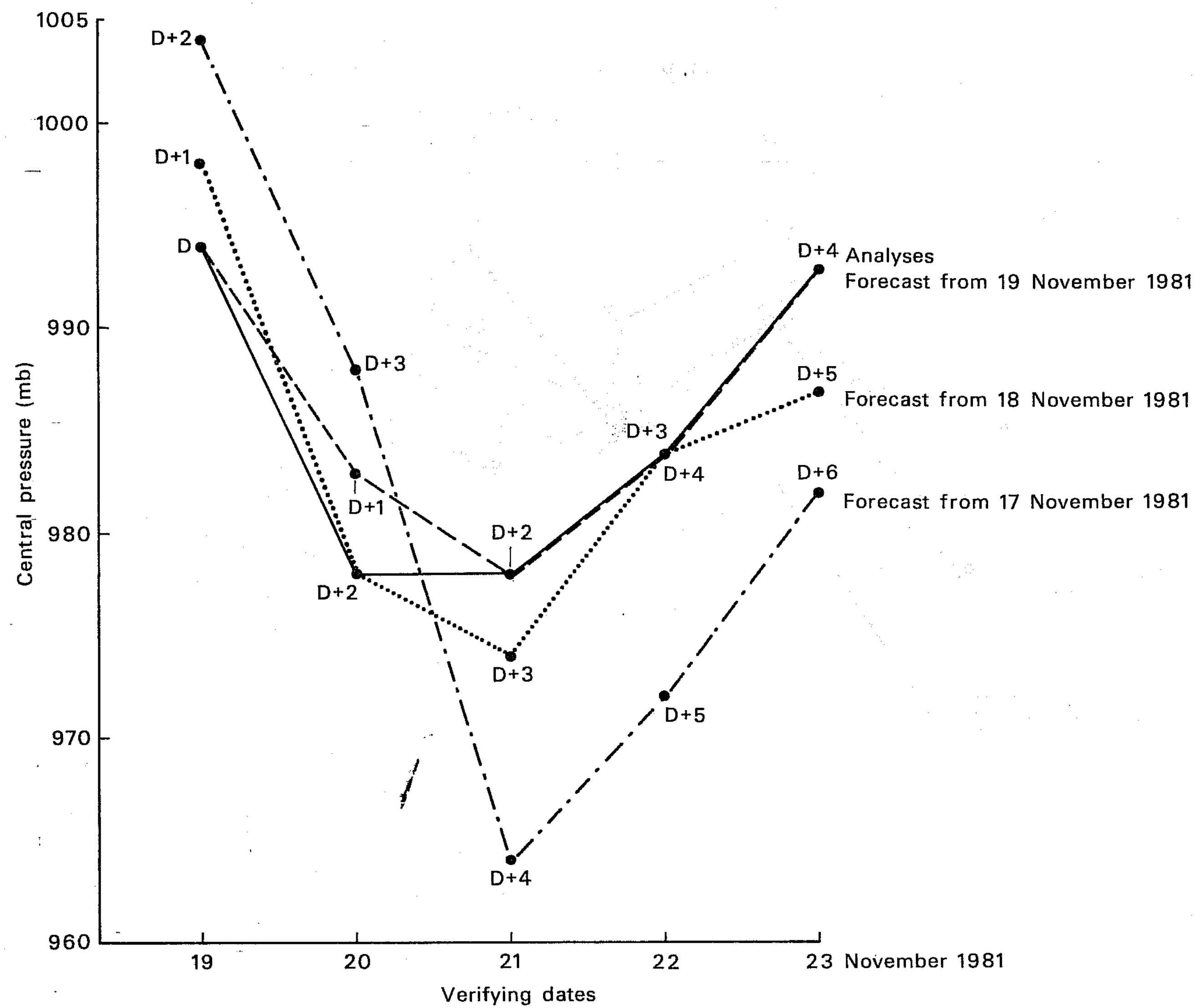

Fig. 5 Central pressure of cyclones in the analyses (solid line) and in the forecasts (dashed lines) for a case in November, 1981.

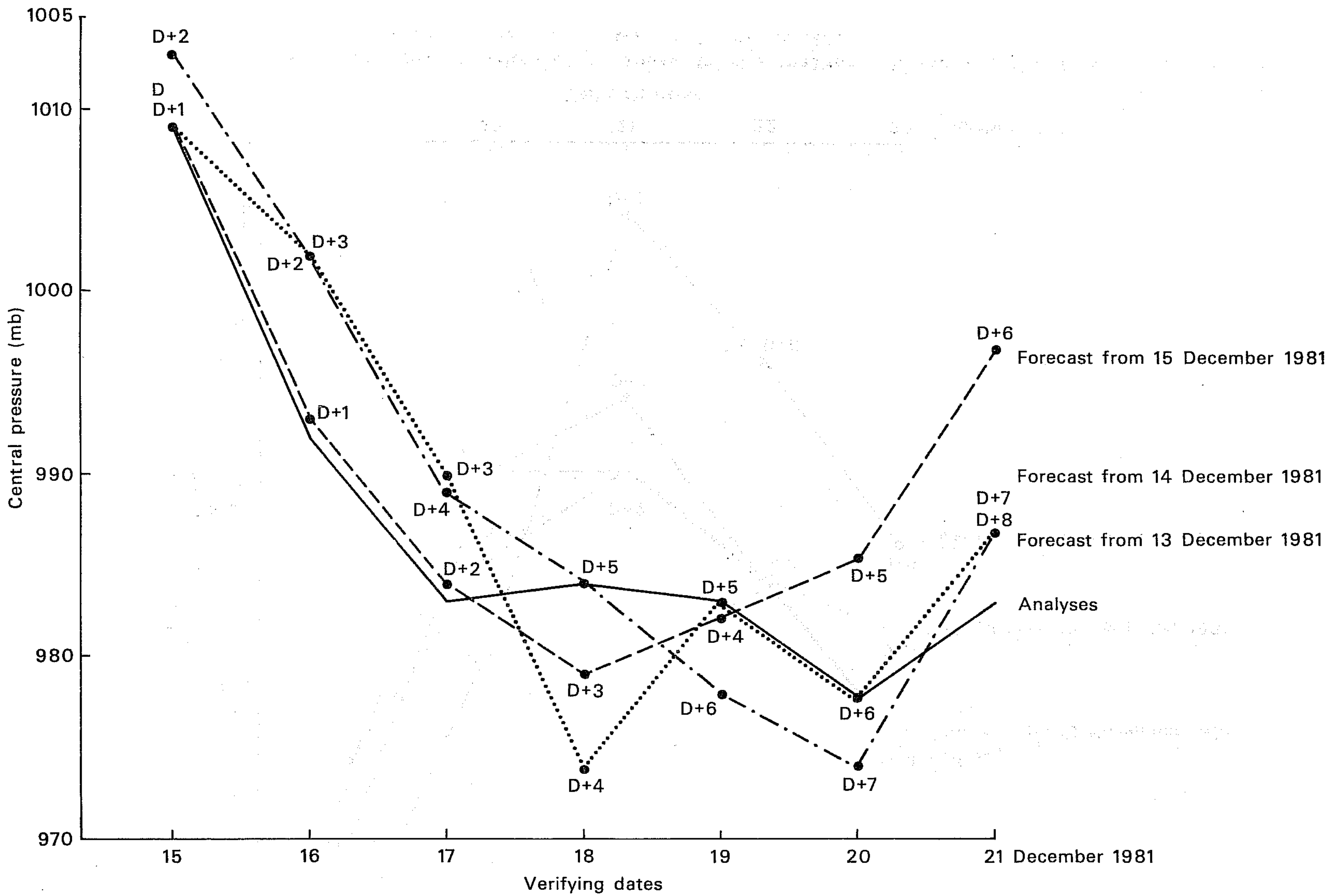

Fig. 6 Central pressure of cyclones in the analyses (solid line) and in the forecasts (dashed lines) for a case in December 1981.

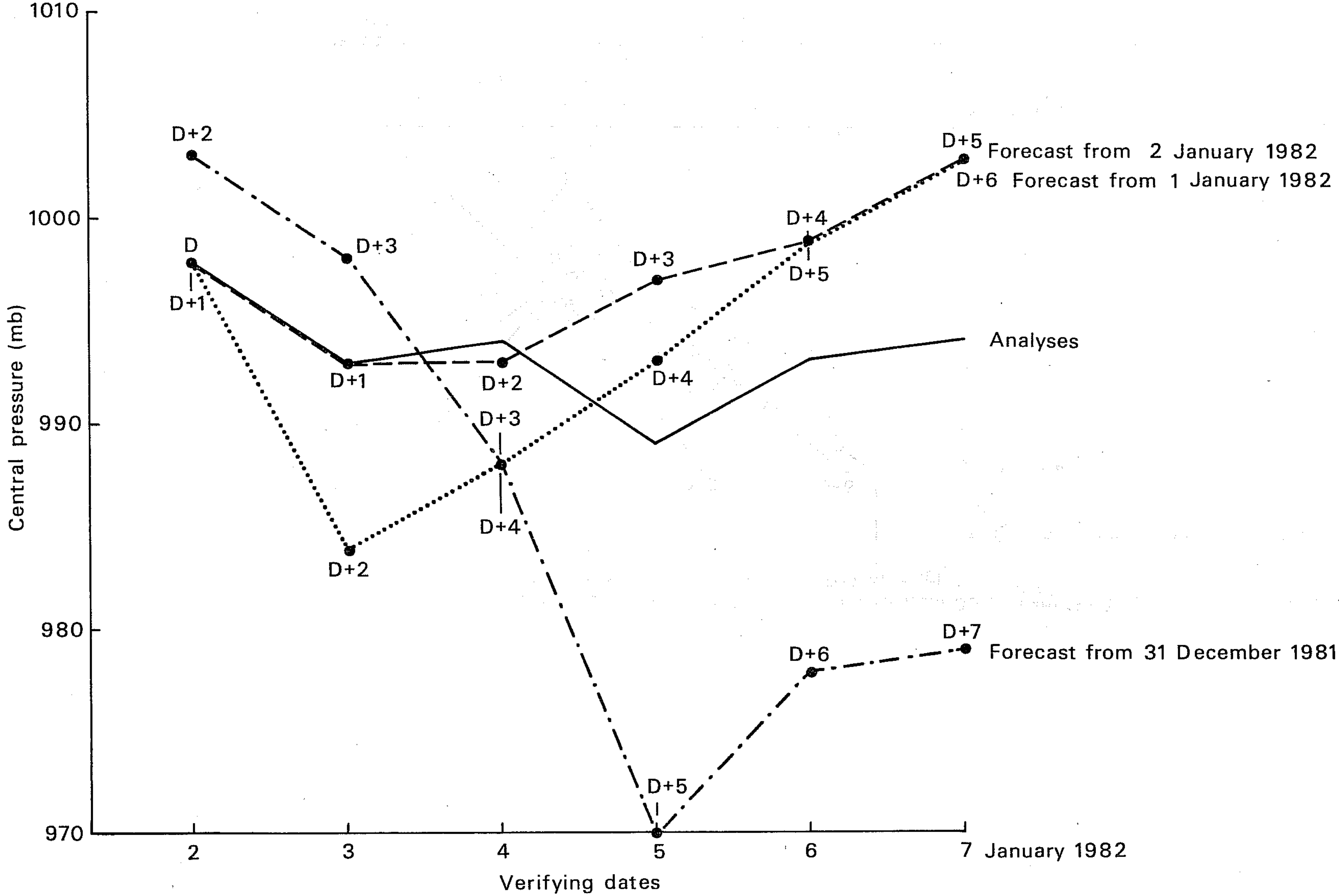

Fig. 7 Central pressure of cyclones in the analyses (solid line) and in the forecasts (dashed lines) for a case in January 1982.

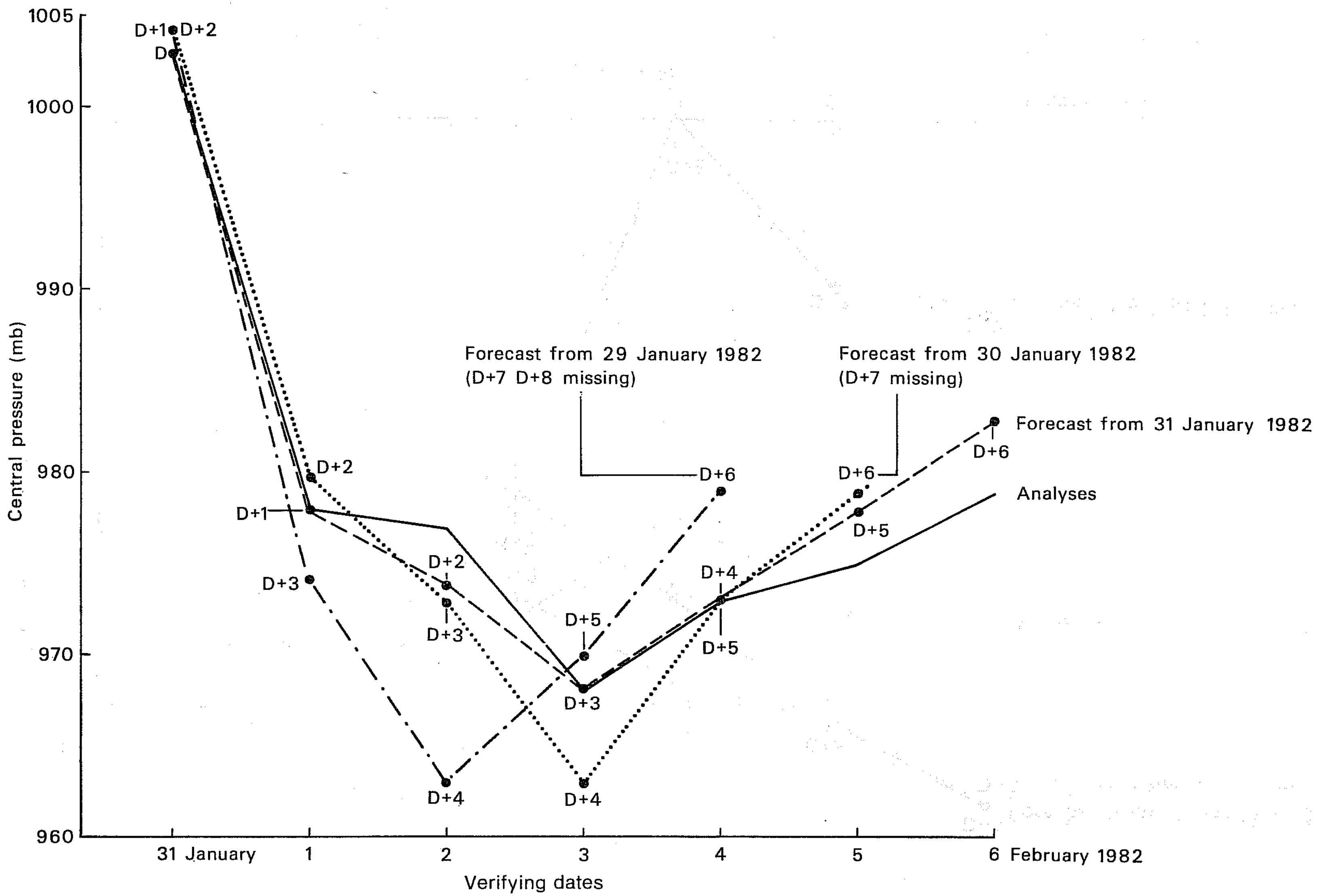

Fig. 8 Central pressure of cyclones in the analyses (solid line) and in the forecasts (dashed lines) for a case in February 1981.

and observed deepening rate. This table shows that, on the average, the forecast deepening rate is less than the observed deepening rate. Thus, lows deepen faster in reality than the model predicts.

Similarly, the forecast filling rate (for forecasts from day D, day D-1 and day D-2) and the observed filling rate have been calculated, and compared to each other in Tables 7 to 9. The filling rate is defined as the difference between the minimum central pressure of the low centre and the central pressure of the low centre at a time 24hr later than the time at which the low centre reached minimum central pressure. Cases chosen here are those for which the lows in the forecasts and in the verifying analyses reached the minimum central pressure simultaneously. For the calculation of the forecast filling rate and the observed filling rate 26, 24 and 15 cases have been used respectively. All three tables, show that, on average, the forecast filling rate is less than the observed filling rate, that is, the observed lows fill faster than the model predicts. Thus we can see that the model neither deepens nor fills lows as quickly as the atmosphere.

TABLE 6

Cyclones sorted by forecast deepening rate (initial central pressure - verified central pressure) and observed deepening rate of cyclones (both in mb/24hr). N=32.

Observed Deepening rate	Forecast deepening rate					
	0≤7	+8≤15	+16≤23	+24≤31	+32≤39	+40≤
0≤7	6	1				
+8≤15		7	1			
+16≤23		6	5			
+24≤31			2	1		
+32≤39					1	
+40≤				2		

TABLE 7

Cyclones sorted by observed filling rate (-(minimum Central Pressure - Central Pressure 24hr later)) and forecast filling rate in verifying F/Cs to the Analyses, (Both in mb/24). The F/Cs are from the day on which the cyclone was generated. N=26.

Observed Filling Rate	Forecast filling rate				
	0⩽	+5⩽	+10⩽	+15⩽	+20⩽
0⩽	2	1	1		
+5⩽	2	5			1
+10⩽	4	2	2	1	
+15⩽	1	1	1		
+20⩽			2		

TABLE 8

Cases sorted by observed filling rate (-(minimum Central Pressure - Central Pressure 24hr later)) and forecast filling rate in verifying F/Cs to the Analyses (Both in mb/24). The forecasts are from one day earlier than the day on which the cyclone was generated. N=24.

Observed Filling Rate	Forecast filling rate				
	0⩽	+5⩽	+10⩽	+15⩽	+20⩽
0⩽	4	1			
+5⩽	2	2	2		
+10⩽	4	4	1	1	
+15⩽	2			1	
+20⩽					

TABLE 9

Cases sorted by observed filling rate (-(minimum Central Pressure - Central Pressure 24h later)) and forecast filling rate in verifying F/Cs to the Analyses (Both in mb/24). The forecasts are from two days earlier than the day on which the cyclone was generated. N=15.

Observed Filling Rate	Forecast filling rate				
	0<	+5<	+10<	+15<	+20<
0<		3			
+5<	2	1			
+10<	2	2	2		
+15<	1	1	1		
+20<					

5. Magnitude of Cyclones

The Magnitude of cyclones, i.e., the geographical area enclosed by the largest closed contour, in the forecasts were subjectively compared to the magnitude of cyclones in the verifying analyses for searching the systematic error in magnitude. Cases were sorted by this comparison, e.g. the forecast low is larger than the observed low, or vice versa, and also by the forecast period; the results are shown in Table 10 below.

TABLE 10

Cases sorted by comparison of cyclone magnitudes in the forecasts and in the verifying analyses.

FORECAST FROM	FORECAST PERIOD								
	D+1 and D+2			D+3 and D+4			D+5,D+6 and D+7		
	A<F	F<A	F=A	A<F	F>A	F=A	A<F	F<A	F=A
Day D	12	17	49	20	17	29	9	4	18
Day D-1	4	22	50	22	18	26	16	8	18
*Day D-2	2	7	22	8	19	36	26	9	21

*There is no Day D+1 forecast from the D-2

Where,

D	:	The day on which the cyclone was generated.
$A<F$	:	Magnitude of forecast lows larger
$F<A$	:	Magnitude of observed lows larger
$F=A$	:	Magnitude of lows are more or less the same size in both, in the forecasts and in the verifying analyses.

Table 10 shows that, in general, the observed cyclones are larger than the model predicts during the first two or three days of the forecast period, whereas during the later stages of the forecasts, the model cyclones show a tendency of being bigger than the observed lows. This is in keeping with the result of para. 4 above i.e. that the model is slow in both deepening and filling depression.

6. The Life Span of Cyclones

The time period between the cyclogenesis stage and the cyclolysis (occlusion) stage of a cyclone is defined as the life span of that cyclone. The span of the cyclones in the forecasts (from day D and from day D-1) and in the verifying analyses were compared (see Table 11).

TABLE 11

Life spans of the observed cyclones and the forecast cyclones.

FORECAST FROM	PERCENTAGE OF CASES (%)			SAMPLE SIZE
	$L_A<L_F$	$L_F<L_A$	$L_F=L_A$	
day D	48	10	42	38
day D-1	42	29	29	38

Where

D	:	The Day on which the cyclone was generated
$L_A<L_F$	:	Life span of forecast cyclones are longer than the analyses
$L_F<L_A$	:	Life span of observed cyclones are longer than the forecasts
$L_F<L_A$	:	Life span of cyclones are equal in the forecasts and in the verifying analyses.

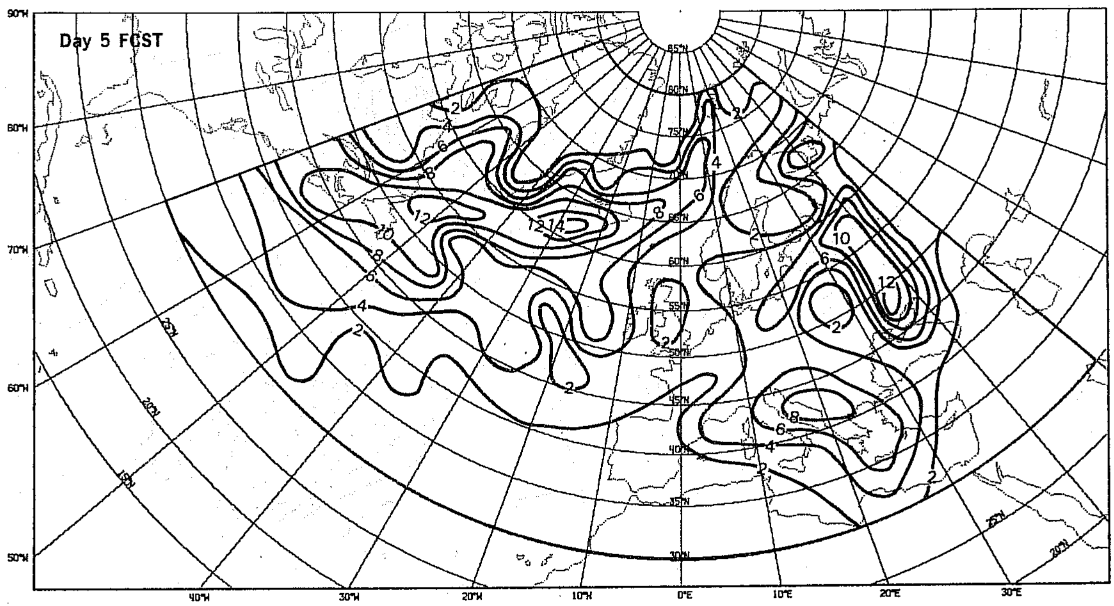

Fig. 9 Number of cyclones in 5° latitude by 10° longitude areas for five-day forecasts for the winter months, 1980-81 and 1981-82.

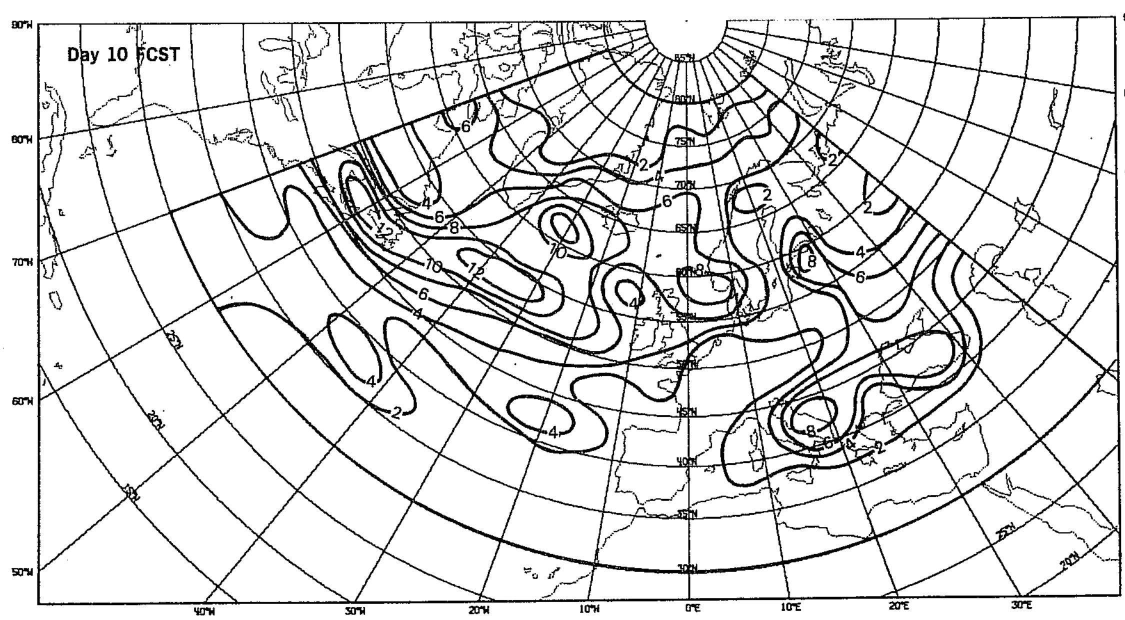

Fig. 10 As Fig. 9, but for 10 day forecasts.

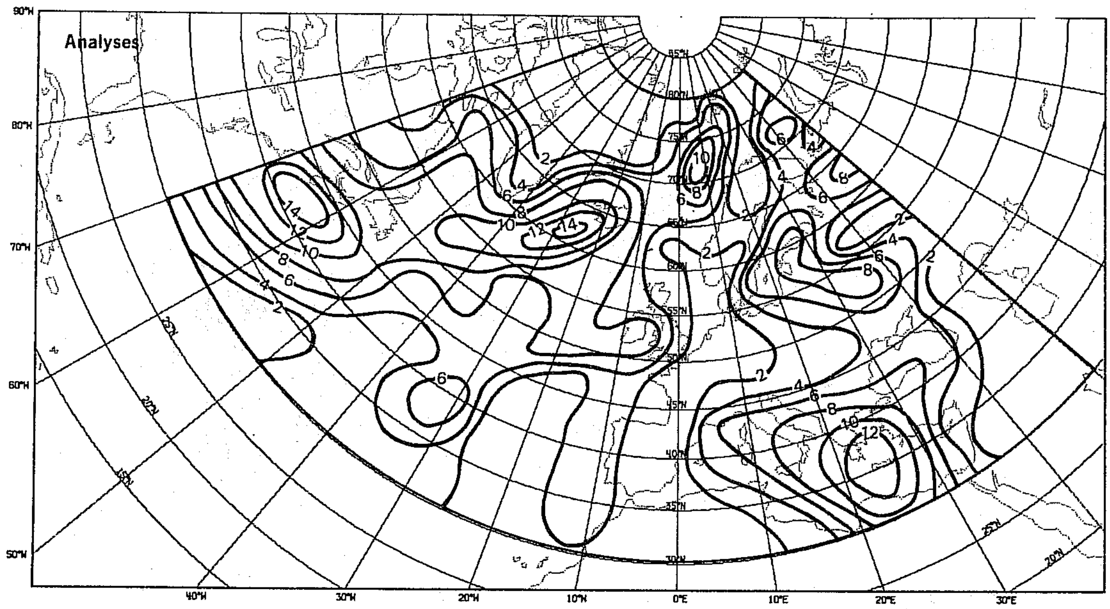

Fig. 11 As Fig. 9, but in verifying analyses.

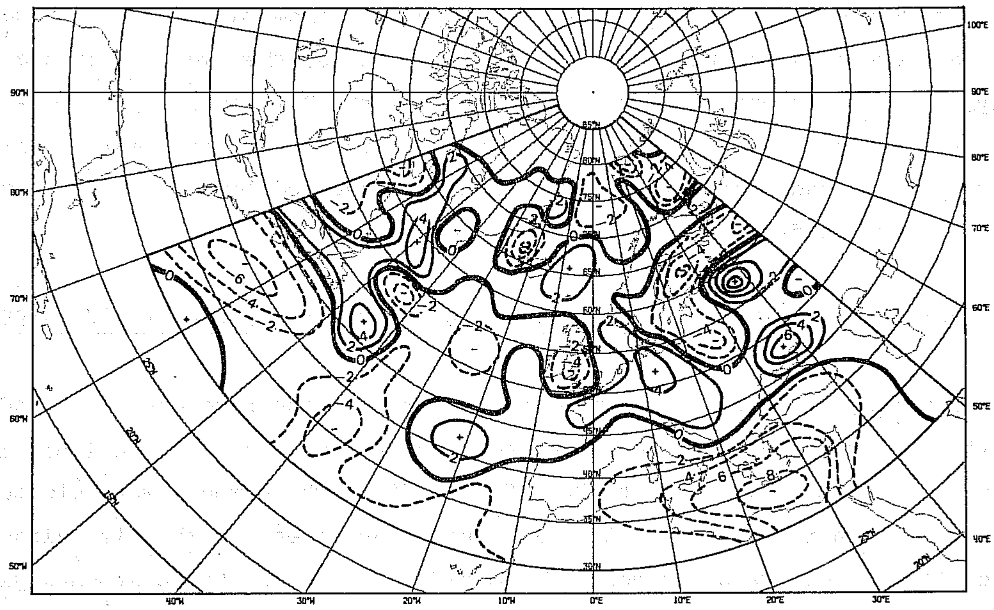

Fig. 12 Differences in number of cyclones in the five-day forecasts and in the verifying analyses. (D+5 forecasts - analyses) for the winter months, 1980-81 and 1981-82.

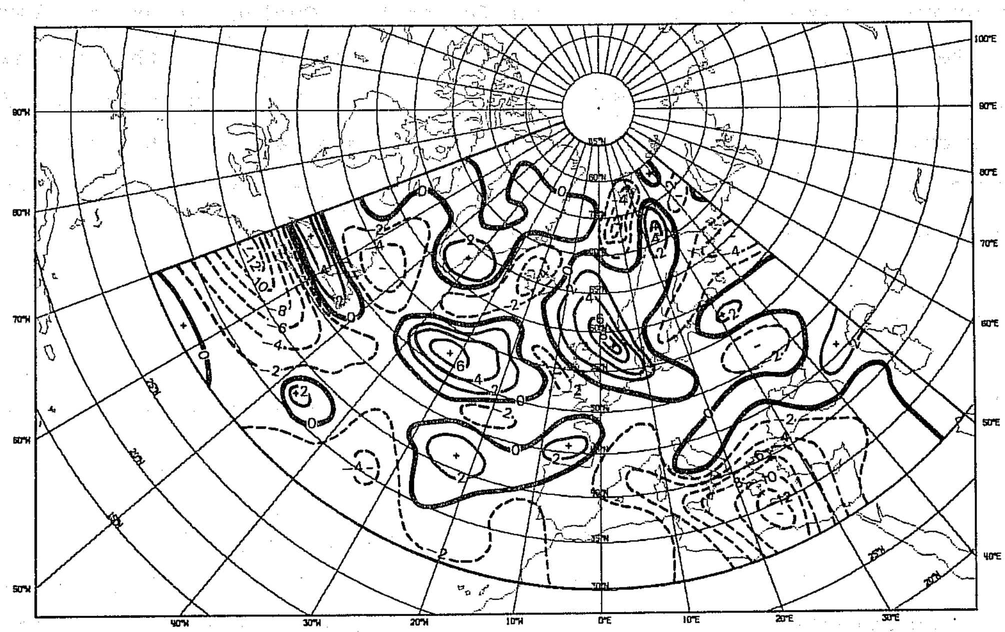

Fig. 13 As Fig. 12, but for 10-day forecasts.

According to Table 11, and considering the forecasts from Day D, 42% of observed and forecast cyclones has the same life cycle, that is, they were decayed on the same day, whereas, according to the forecast from the D-1, only 29% of forecast and observed cyclones has the same life span. On the other hand, almost half of the forecast cyclones had longer life spans than the observed lows. Thus, the model is usually too late in decaying the forecast cyclones.

7. Regional Distribution of the Cyclones for Winter Months, 1980/81-1981/82

For winter months, 1980/82, the number of cyclones in the forecasts (D+5 and D+10) and in the verifying analyses have been counted in 5 x 10 degrees latitude-longitude grid boxes in the area 30N to 70W, 80N to 50E. The numbers were plotted on maps and are shown in Figs. 9 to 11. In these figures each number is valid at the Centre of the respective quadrangle. Also difference maps (Forecasts-Analyses) are made to reveal the areas where there is an excess or a deficit of forecast cyclones (see Figs. 12 and 13). The positive numbers are indicative of over forecasting, and negative numbers are indicative of under forecasting of cyclones. Figures 12 and 13 show that both forecasts (D+5 and D+10) underforecast the occurance of Mediterranean cyclones, especially cyclones over the eastern Mediterranean, and also underforecast the cyclones near Novaya Zemlya, whereas the number of cyclones over western and eastern Europe was overestimated by the forecasts. Cyclones south of Newfoundland were shifted too far North in both forecasts. The main track of the cyclones from the Newfoundland towards the North of Norway was well captured by the D+5 forecasts, however significant southward shift of this track is notable in the D+10 forecasts. Both forecasts missed the cyclonic activity near Madeira, southwest of Iberian peninsula, and on southern parts of the mid-Atlantic.

8. Conclusions

The ECMWF surface forecasts by fifteen layer Grid Point Model show several systematic errors with respect to tracks, central pressure, and positions of cyclones. The northward curving of cyclone track is underestimated by the forecasts. Especially after day 4, a southward displacement of the forecast track from observed is significant. The model shows a phase error of being too slow, at least at the beginning stages of the forecasts (D+1 to D+3). Forecasts, on the average, underestimate both the deepening rate and the filling rate of lows. There exists a tendency that forecasts generally make the lows small in magnitude at the beginning and large towards the end of life cycles of lows. A similar result to the filling rate error of the model has been found by comparing the life span of cyclones in the forecasts and in the verifying analyses. According to this comparison, almost 50% of forecast lows have longer life span than the observed cyclones; that is, the model delays in decaying the forecast lows.

The D+5 and D+10 forecasts missed most of the cyclone activity over the Mediterranean, especially over the eastern part, whereas the forecasts overestimate the secondary track from the east Atlantic towards the Continent of Europe, as well as the cyclonic activity over the eastern Europe.

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