ROYAL OBSERVATORY, HONG KONG

Technical Note No. 43

A METHOD FOR FORECASTING THE ARRIVAL OF COLD SURGES IN HONG KONG

BY

E.W.K. CHU

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SUMMARY

Surge days were defined as those days on which significant falls of temperature occurred. All such days were studied during the months October to March, 1959-1968. The positions of 500-mbar troughs and ridges two days before the surges were delineated and their mean position calculated. It was shown that a well-established trough east of Lake Baikal with an associated ridge west of Lake Baikal was an indication that a cold surge would arrive at Hong Kong two days later.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

The purpose of this investigation is to formulate an objective method of using 500-mbar hemispheric charts for forecasting cold surges in Hong Kong. 500-mbar synoptic and 48-hour prognostic charts are routinely available at the Royal Observatory. The latter can be used for making medium-range forecasts. The effect of cold surges on the weather in Hong Kong depend largely on the depth and path of the cold air and vary greatly from surge to surge.

2. SYNOPTIC CONSIDERATIONS

The 500-mbar hemispheric charts on days before the arrival of cold surges at Hong Kong were scrutinized. The main features on these charts were:-

(a) strong north or northwest winds near Lake Baikal,

(b) a trough just to the southeast of Lake Baikal,

(c) a ridge to the northwest of Lake Baikal near 90°E

Lake Baikal is situated near the same longitude as the eastern edge of the Tibetan Plateau. Thus strong northerly winds subsiding near Lake Baikal will not be blocked by the Himalayas but will drive cold air southwards across China towards Hong Kong.

The monthly mean 500-mbar contour charts for October through March (J.M.A. 1961) show that, extending from a low over the Artic, the westerly trough in middle latitudes has two preferred climatological positions. One of these lies along the east coast of Asia and the other stretches southwestwards to the Black Sea. These preferred climatological positions are where moving troughs most often intensify or slow down. This suggests that when a trough in Europe starts to move east it will sweep rapidly across Asia but slow down or stop over the east coast of Asia. Dao(1957) suggested that a breaking down of the blocking situation near the Ural mountains will effect a rapid migration of cold air from the northwest to the southeast.

3. DEFINITION OF COLD SURGES

The definition of a cold front has already been very well-documented in most text books. In Hong Kong the term "cold surge" is used for the arrival of colder air mass often accompanied by an increase in wind speed when there is no distinct line of discontinuity of wind direction or precipitation. A cold surge can arrive at Hong Kong either from the north or from the east (Chin, 1969). In order to find a simple criterion for cold surges the temperatures recorded at the Royal Observatory were analysed whenever cold fronts or cold surges were said to have arrived at Hong Kong in the Royal Observatory Monthly Weather Summaries during the months October to March, 1955 to 1969. Since the study aims at making use of a large scale phenomenon (500-mbar hemispheric flow) for making a 2 to 3 day forecast, daily mean values of temperature were used instead of hourly values. This tends to eliminate diurnal variations and other fluctuations due to precipitation or sky conditions. Also because there is often a short warm spell just before the arrival of a surge (on the day termed Day Zero), the changes in mean temperature are calculated by comparing the values of the day before the surge, called Day(-1), and the day after, called Day(+1). These changes are listed in Tables 1 to 6. Out of 154 cold surges that arrived at Hong Kong between 1955 and 1969, 117 caused a drop of more than 2 degrees in the mean temperature, 19 caused a drop of 2 degrees on either a day before or after the date of arrival of cold surges. 11 caused a drop of between 1 and 2 degrees and 7 less than 1 degree. A 2-degree drop in mean temperature appears, therefore, to be a good criterion for verifying the arrival of a cold surge in Hong Kong.

TABLE 1. TEMPERATURE DROP BETWEEN Day(-1) and Day(+1) FOR ALL SURGES SAID TO HAVE ARRIVED AT HONG KONG IN THE ROYAL OBSERVATORY MONTHLY WEATHER SUMMARIES DURING OCTOBER 1954 to 1967

SURGE DATE	TEMPERATURE DROP (°C)
9-10-1954	6.0
2-10-1955	1.0
8-10-1955	3.9
3-10-1956	0.2
11-10-1956	3.5
14-10-1956	0.5
17-10-1957	6.0
28-10-1957	4.2
1-10-1958	3.3
26-10-1958	2.1
2-10-1960	2.4
26-10-1960	4.0
24-10-1961	2.4
14-10-1962	6.5
2-10-1963	1.7
16-10-1963	3.6
17-10-1964	1.5
27-10-1966	5.5
1-10-1967	2.6
14-10-1967	2.6

TABLE 2. TEMPERATURE DROP BETWEEN Day(-1) and Day(+1) FOR ALL SURGES SAID TO HAVE ARRIVED AT HONG KONG IN THE ROYAL OBSERVATORY MONTHLY WEATHER SUMMARIES DURING NOVEMBER 1955 to 1968

SURGE DATE	TEMPERATURE DROP ($^{\circ}$C)
15-11-1955	4.7
5-11-1956	0.6
10-11-1956	1.2
22-11-1956	0.7
11-11-1957	2.5
16-11-1957	-1.8
29-11-1957	2.1
14-11-1958	2.4
9-11-1959	2.9
22-11-1959	-0.4
25-11-1959	4.8
3-11-1960	1.7
12-11-1960	0.7
25-11-1960	6.8
20-11-1961	2.6
3-11-1962	4.5
21-11-1962	4.1
24-11-1963	2.0
3-11-1965	0.6
9-11-1965	5.2
19-11-1965	2.4
24-11-1965	2.7
14-11-1966	5.0
19-11-1966	0.3
25-11-1966	4.1
30-11-1966	9.6
2-11-1967	0.9
10-11-1967	1.2
12-11-1967	3.9
4-11-1968	2.0
8-11-1968	0.0

TABLE 3. TEMPERATURE DROP BETWEEN Day(-1) and Day(+1) FOR ALL SURGES SAID TO HAVE ARRIVED AT HONG KONG IN THE ROYAL OBSERVATORY MONTHLY WEATHER SUMMARIES DURING DECEMBER 1954 to 1968

SURGE DATE	TEMPERATURE DROP (°C)
3-12-1954	2.4
8-12-1954	5.7
30-12-1954	2.9
4-12-1956	1.8
22-12-1956	4.7
14-12-1957	6.2
21-12-1957	0.8
29-12-1957	4.4
9-12-1958	0.4
1-12-1960	2.2
28-12-1960	3.7
27-12-1961	2.6
1-12-1963	0.6
8-12-1963	1.0
5-12-1965	4.6
16-12-1965	11.8
24-12-1965	8.8
25-12-1966	6.4
6-12-1967	4.3
15-12-1968	2.9

TABLE 4. TEMPERATURE DROP BETWEEN Day(-1) and Day(+1) FOR ALL SURGES SAID TO HAVE ARRIVED AT HONG KONG IN THE ROYAL OBSERVATORY MONTHLY WEATHER SUMMARIES DURING JANUARY 1955 to 1969

SURGE DATE	TEMPERATURE DROP (°C)
4-1-1955	3.2
9-1-1955	6.0
3-1-1958	4.8
14-1-1958	8.2
22-1-1958	4.9
26-1-1958	-0.6
30-1-1958	8.7
9-1-1959	6.4
16-1-1959	3.7
29-1-1959	3.3
23-1-1960	9.1
4-1-1961	2.9
10-1-1961	4.9
31-1-1961	5.4
9-1-1962	0.9
15-1-1962	3.3
29-1-1962	-0.4
4-1-1963	0.4
17-1-1964	5.0
6-1-1965	0.7
30-1-1965	2.7
27-1-1966	4.4
15-1-1967	6.4
15-1-1968	2.8
5-1-1969	-0.2

TABLE 5. TEMPERATURE DROP BETWEEN Day(-1) and Day(+1) FOR ALL SURGES SAID TO HAVE ARRIVED AT HONG KONG IN THE ROYAL OBSERVATORY MONTHLY WEATHER SUMMARIES DURING FEBRUARY 1955 to 1969

SURGE DATE	TEMPERATURE DROP (°C)
11-2-1955	3.1
19-2-1955	8.4
11-2-1956	4.9
18-2-1956	3.2
21-2-1956	1.4
10-2-1957	5.3
1-2-1958	-0.4
27-2-1958	5.0
7-2-1959	3.7
17-2-1959	5.2
21-2-1959	4.3
10-2-1960	2.4
12-2-1962	4.5
24-2-1962	1.0
10-2-1963	0.7
20-2-1964	5.8
11-2-1965	1.9
23-2-1965	4.4
4-2-1966	5.3
12-2-1966	8.4
17-2-1966	1.0
22-2-1966	12.5
11-2-1967	2.7
14-2-1967	2.9
23-2-1967	3.5
14-2-1968	2.5
19-2-1968	4.3
15-2-1969	0.2
17-2-1969	3.4
20-2-1969	8.4

TABLE 6. TEMPERATURE DROP BETWEEN Day(-1) and Day(+1) FOR ALL SURGES SAID TO HAVE ARRIVED AT HONG KONG IN THE ROYAL OBSERVATORY MONTHLY WEATHER SUMMARIES DURING MARCH 1955 to 1969

SURGE DATE	TEMPERATURE DROP ($^{\circ}C$)
19-3-1956	6.6
5-3-1957	5.8
12-3-1957	5.8
21-3-1957	3.1
24-3-1957	1.6
2-3-1958	3.3
7-3-1958	3.4
8-3-1959	5.1
26-3-1959	0.6
31-3-1959	3.6
12-3-1960	5.1
31-3-1960	9.9
21-3-1962	8.4
11-3-1963	4.1
24-3-1963	3.2
21-3-1964	3.5
3-3-1965	4.5
8-3-1966	9.8
18-3-1966	8.0
23-3-1966	5.6
5-3-1967	7.5
18-3-1967	2.2
23-3-1967	4.1
2-3-1968	2.2
8-3-1968	4.2
17-3-1968	2.8
21-3-1969	4.5
30-3-1969	5.5

4. POSITIONS OF RIDGES AND TROUGHS AT 500 MILLIBAR IN RELATION TO COLD SURGES IN HONG KONG

The monthly mean 500-mbar contour charts for the six coldest months in the 24-year period (1946 to 1969) were examined. In all six of these charts, a major westerly trough was found east of Lake Baikal with a corresponding ridge west of Lake Baikal (see Figure 1).

The differences in the mean temperature between Day(-1) and Day(+1) were calculated for the months October to March in the years 1959 to 1968. Those days having a drop of more than 2 degrees after at least 2 days of rising temperature were taken as surge days (Day Zero). The positions of troughs and ridges 2 days before the date of arrival of surges, Called Day(-2), were plotted and are shown in Figures 2 to 13. From these figures it can be seen that most of the ridge and trough axes lie in a NE to SW direction. In general, the positions of the troughs lie between the east coast of Asia and Lake Baikal and most of them lie between 100°E and 120°E at 50°N. The positions of the ridge axes have a much bigger spread and most of them lie between 70°E and 110°E at 55°N. It can also be observed that there are no obvious differences between the positions of troughs in different months while the positions of the ridges in the winter months (December, January and February) appear to be further northwest than those in the transitional months (October, November and March).

A more detailed study was made for the months October to February in the years 1964 to 1968. There were altogether 54 surges in 20 months. Longitudes of ridges at 50°N and 60°N on Day(-2) were noted and their mean values calculated. Similarly, longitudes of troughs at 45°N and 55°N were noted and their mean values computed. They are shown in Table 7. Frequency distributions at 5°- longitude intervals for the mean positions of troughs and ridges on Day(-2) are shown in Figures 14 and 15. Figure 14 indicates that the most favourable positions of the troughs lies between 95°E and 125°E (a range of 30°), which accounts for 86% of the cases. The positions of ridges are more scattered, as indicated in Figure 15 and a range of 40° (65°E to 105°E) is necessary to cover 86% of the cases.

Using the mean value of the longitude of ridges, the preferred position of the ridge 2 days before the arrival of a surge is found to be from 79°E to 89°E between 50°N and 60°N and the preferred position of the trough from 102°E to 120°E between 45°N and 55°N. These preferred positions are plotted in Figure 10.

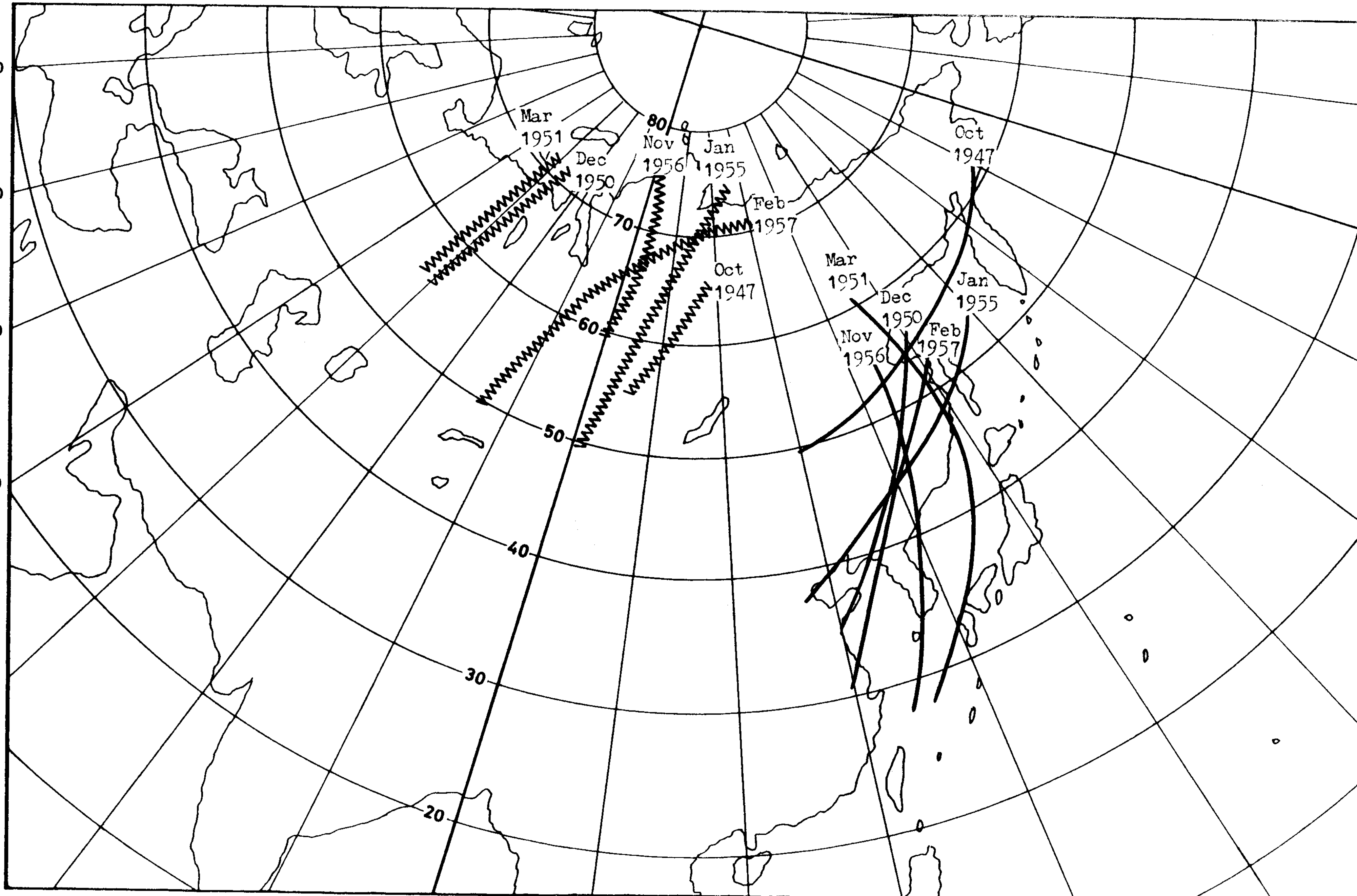

Figure 1. Monthly mean position of troughs and ridges at 500-mbar level for the coldest October, November, December, January, February and March in Hong Kong in the 24-year period (1946 to 1969)

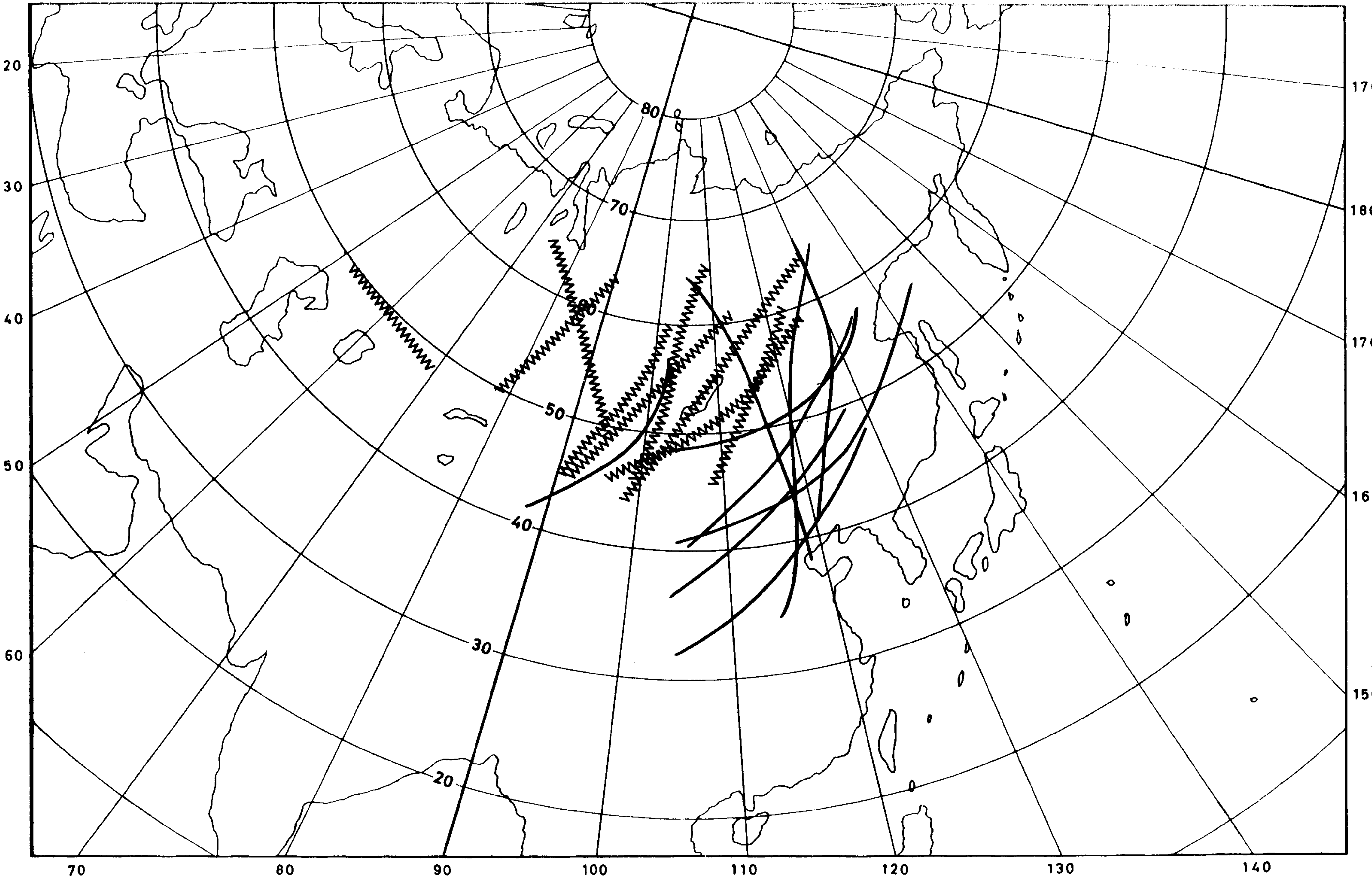

Figure 2. Positions of troughs and ridges 2 days before the arrival of surges in October 1959-1963

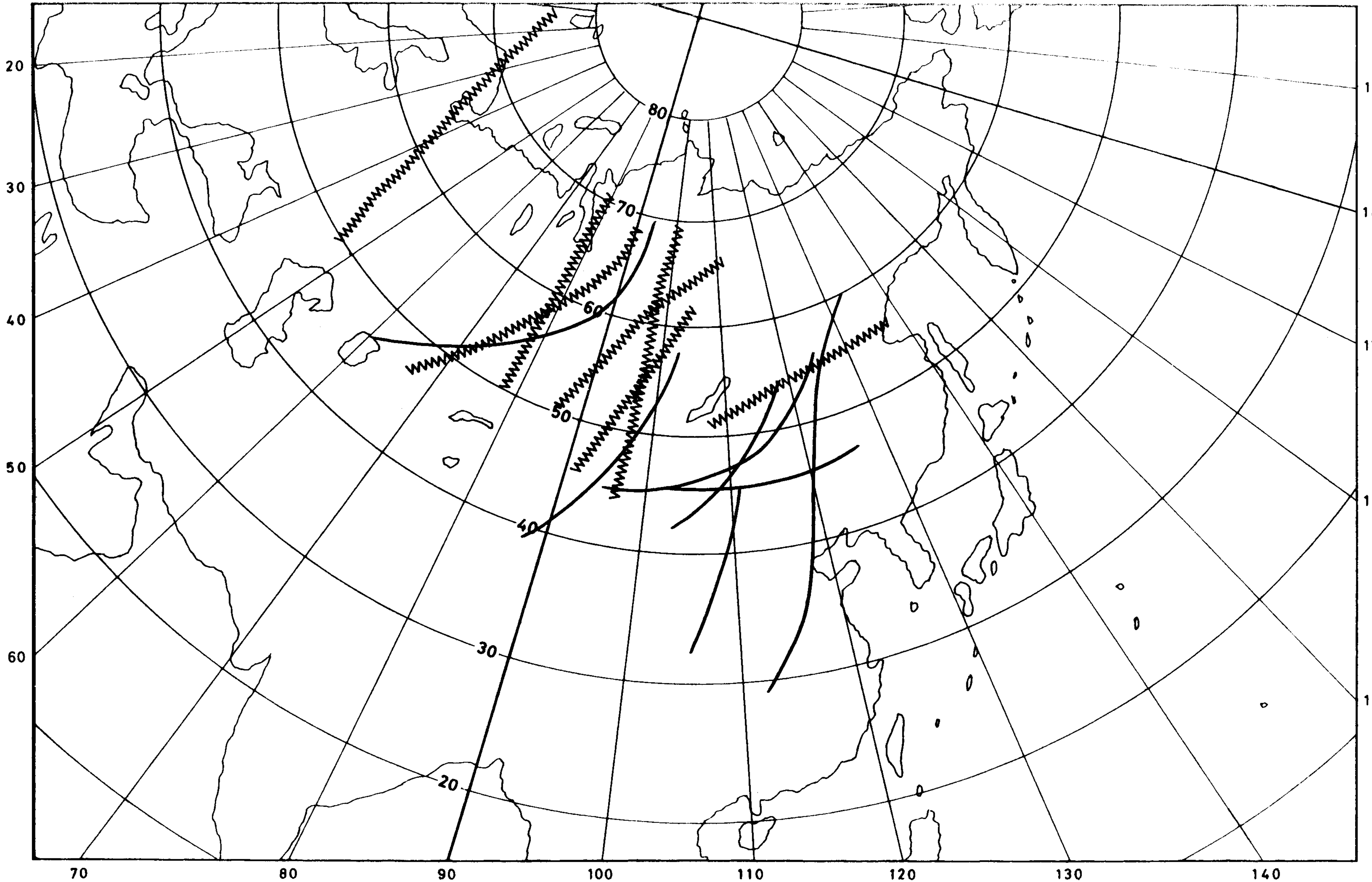

Figure 3. Positions of troughs and ridges 2 days before the arrival of surges in October 1964-1968

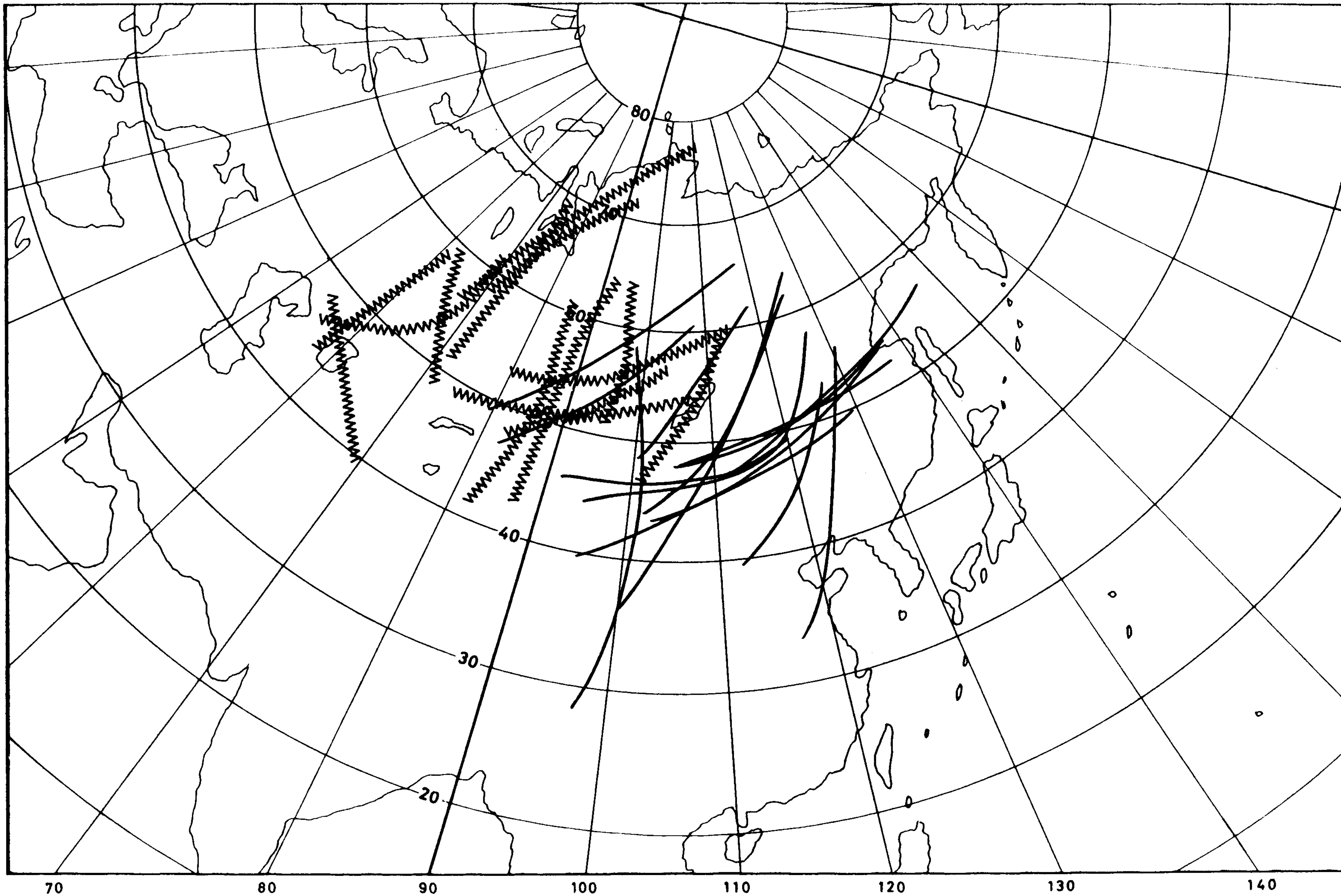

Figure 4. Positions of troughs and ridges 2 days before the arrival of surges in November 1959–1963

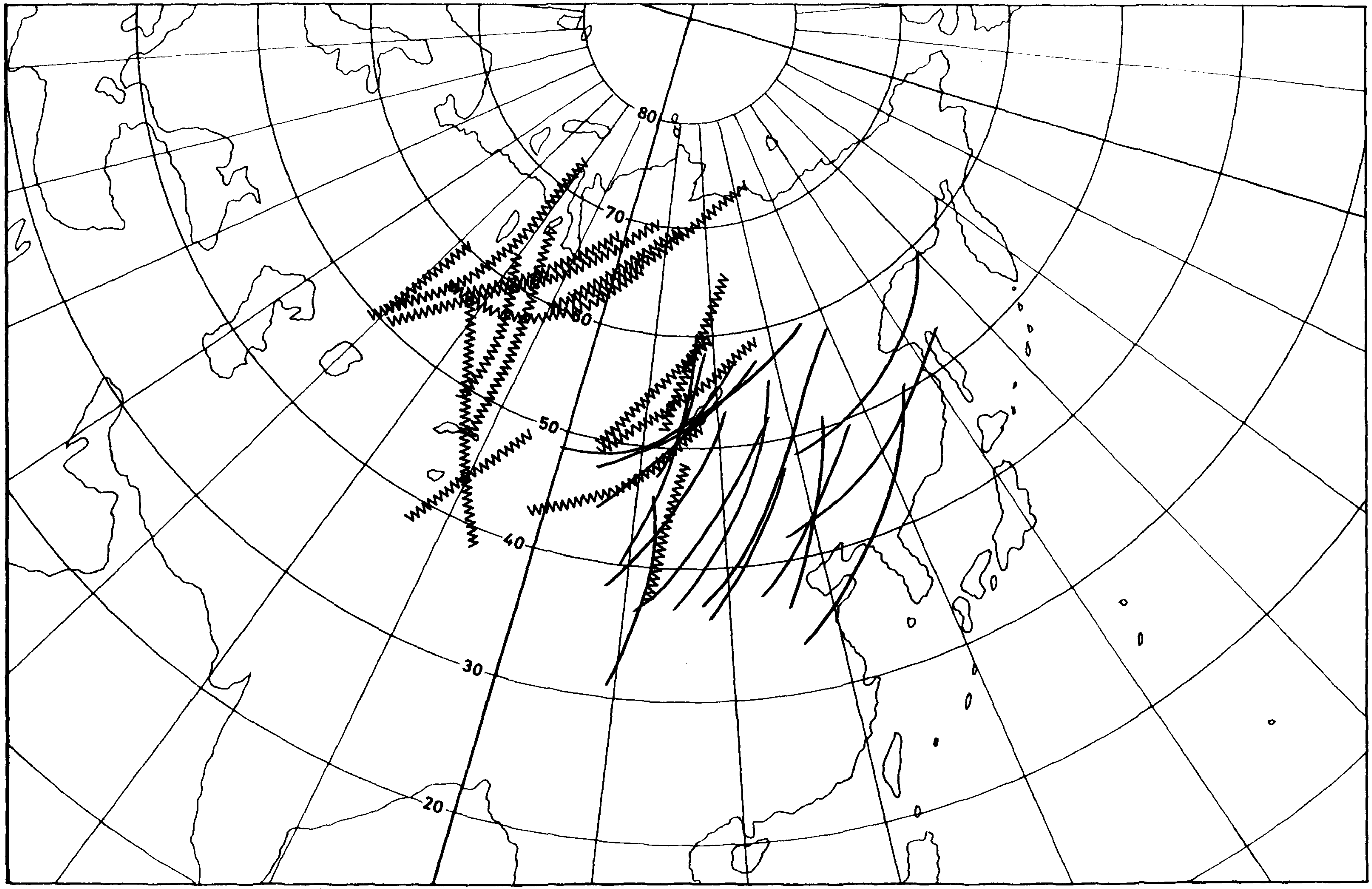

Figure 5. Positions of troughs and ridges 2 days before the arrival of surges in November 1964-1968

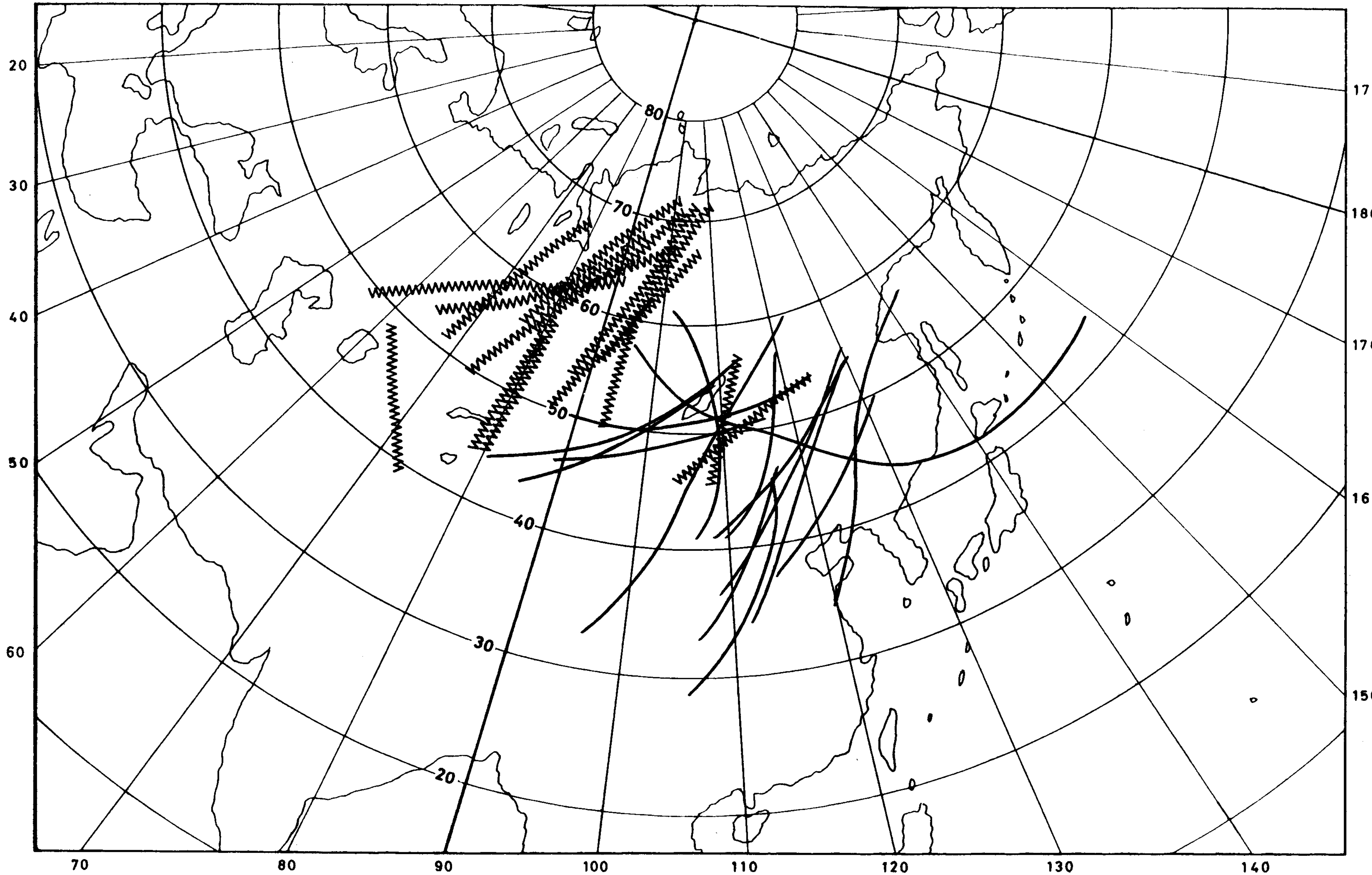

Figure 6. Positions of troughs and ridges 2 days before the arrival of surges in December 1959-1963

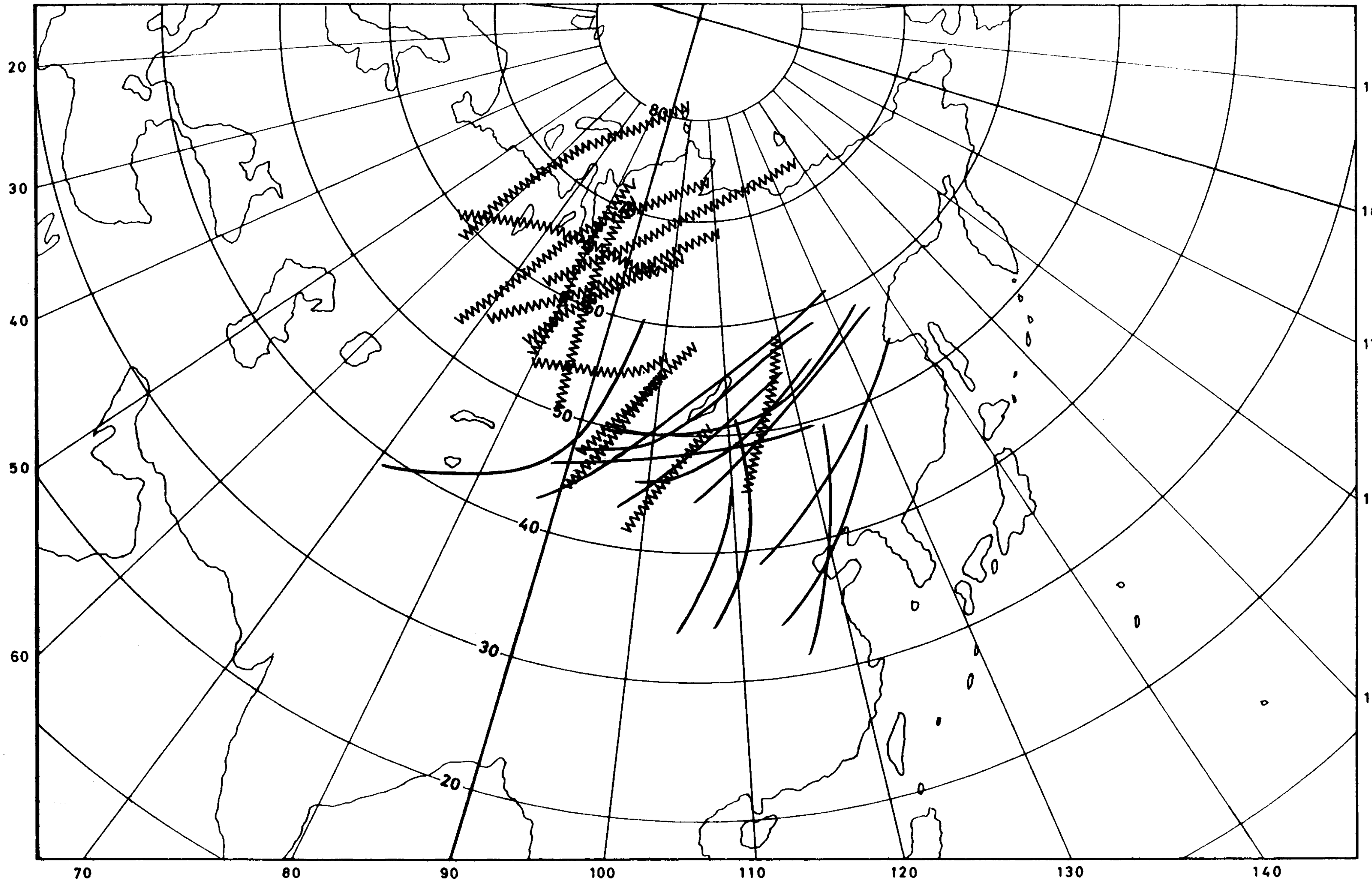

Figure 7. Positions of troughs and ridges 2 days before the arrival of surges in December 1964-1968

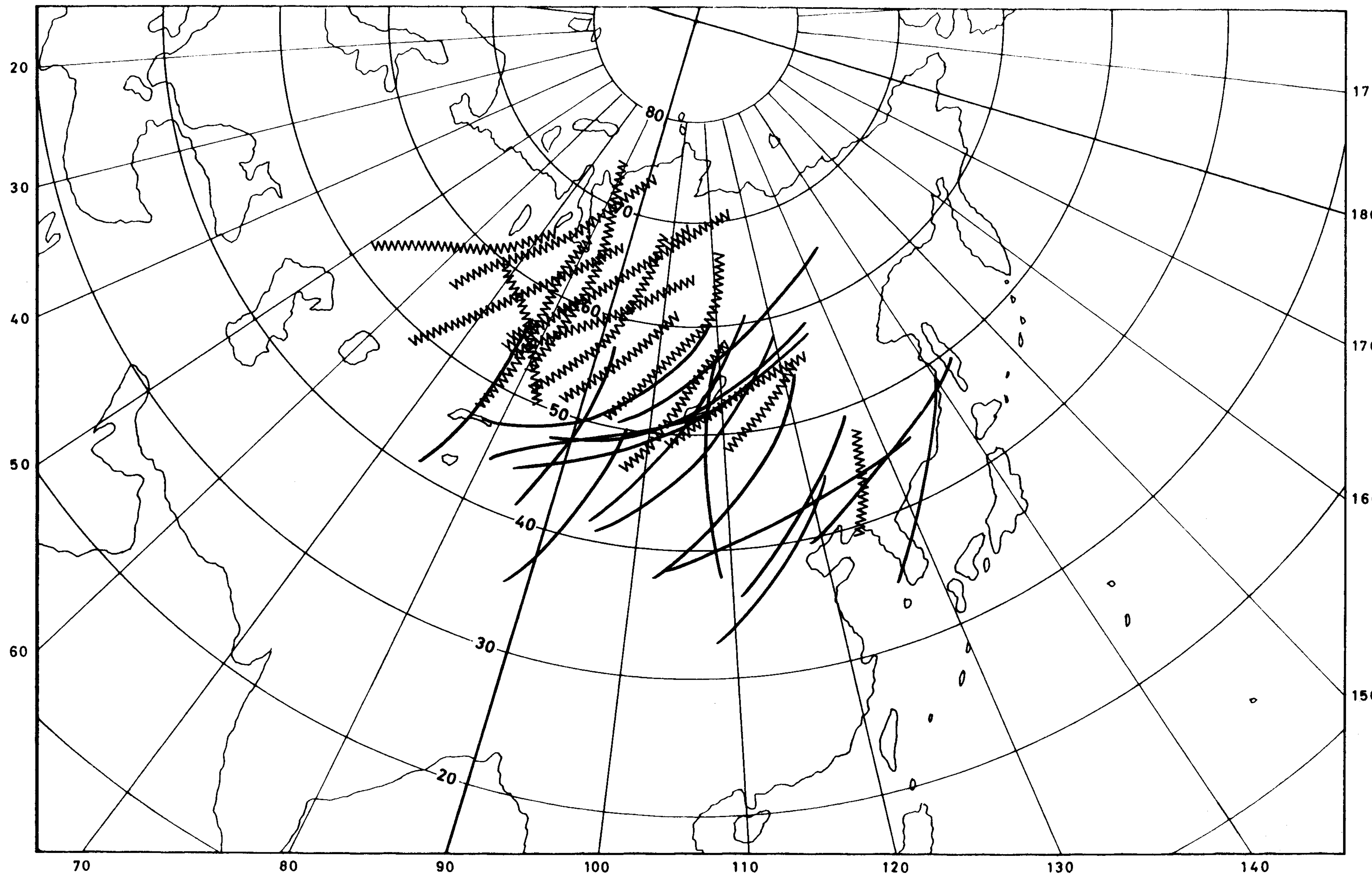

Figure 8. Positions of troughs and ridges 2 days before the arrival of surges in January 1959-1963

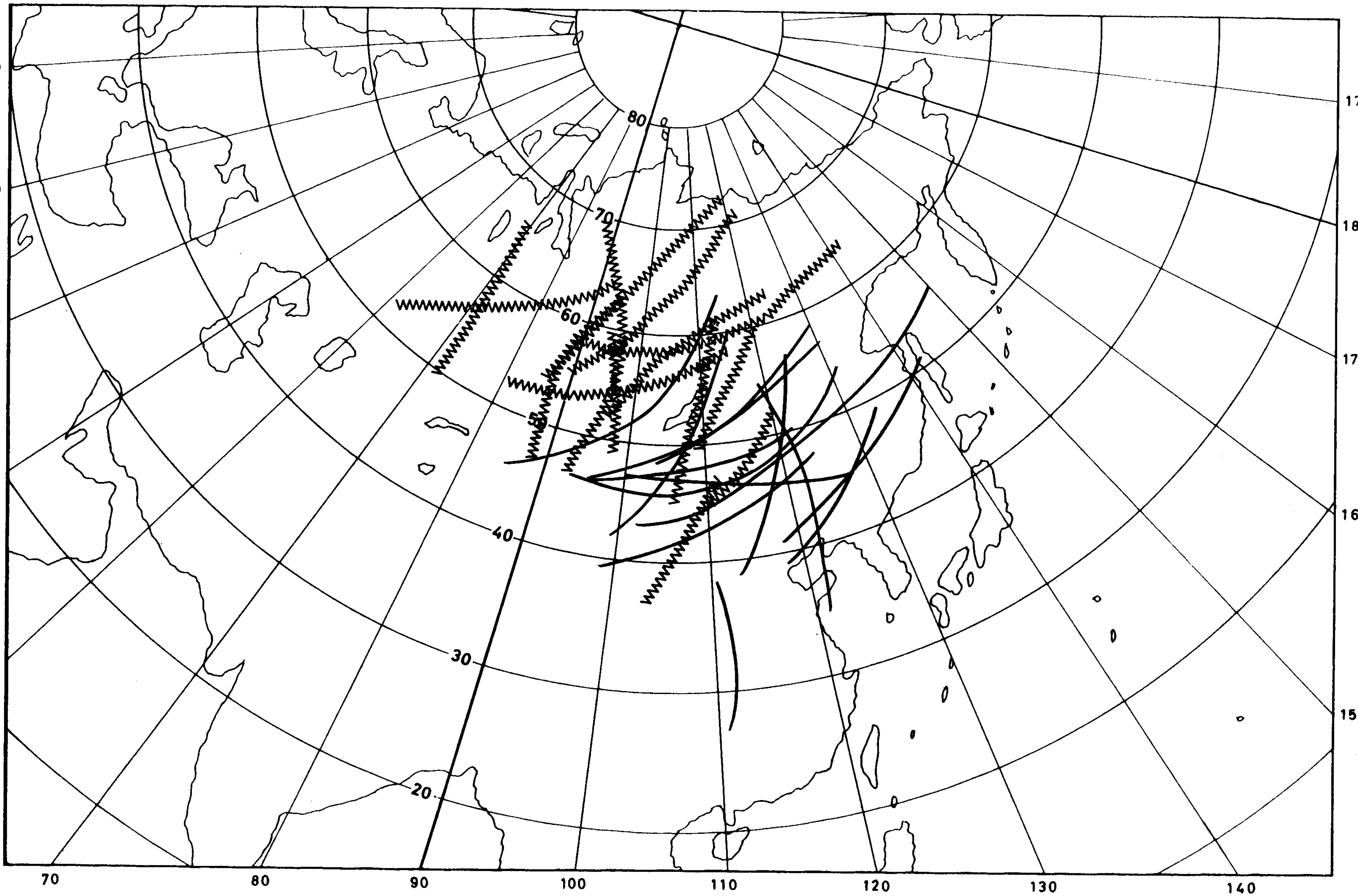

Figure 9. Positions of troughs and ridges 2 days before the arrival of surges in January 1964-1968

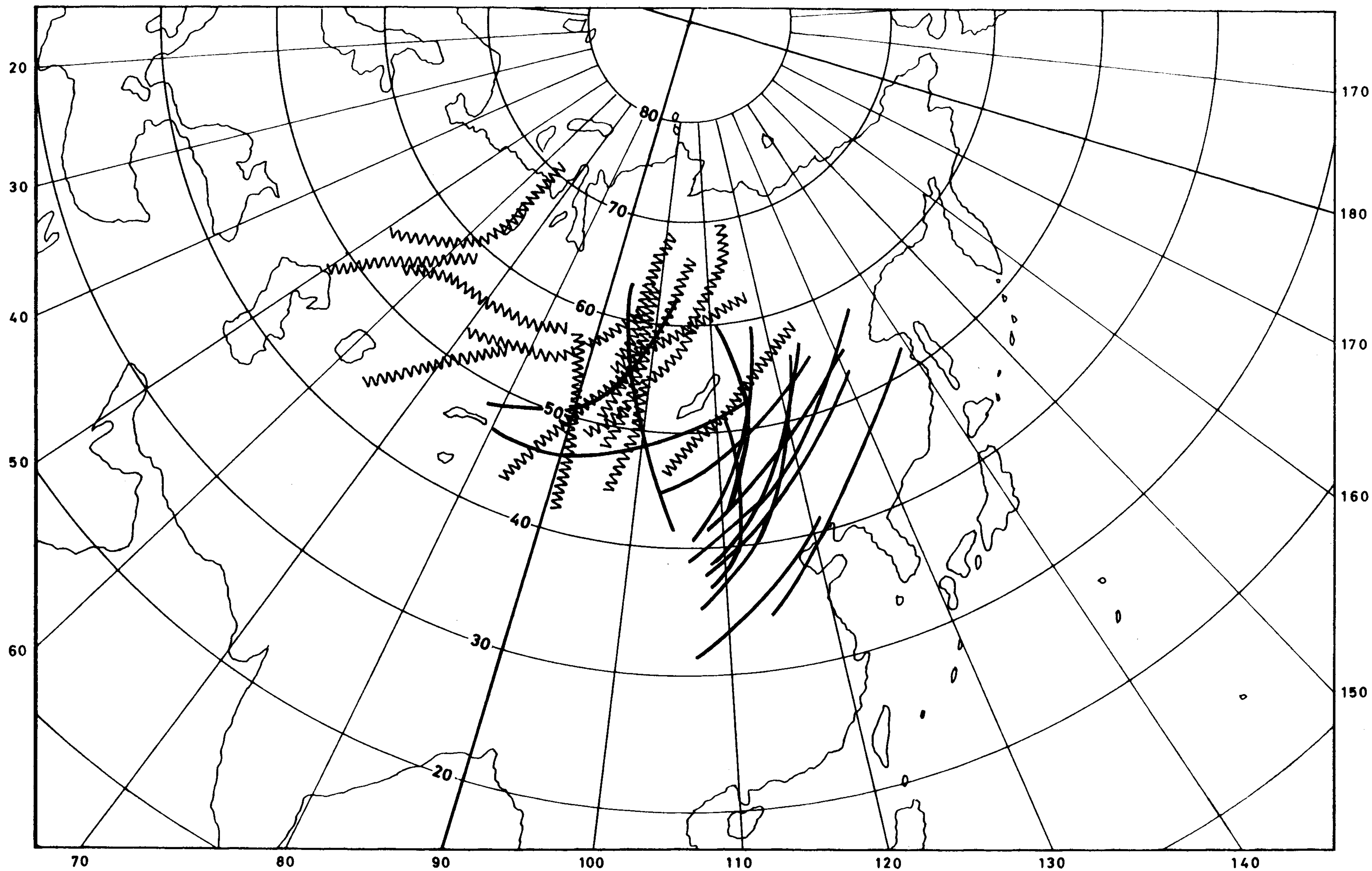

Figure 10. Positions of troughs and ridges 2 days before the arrival of surges in February 1959-1963

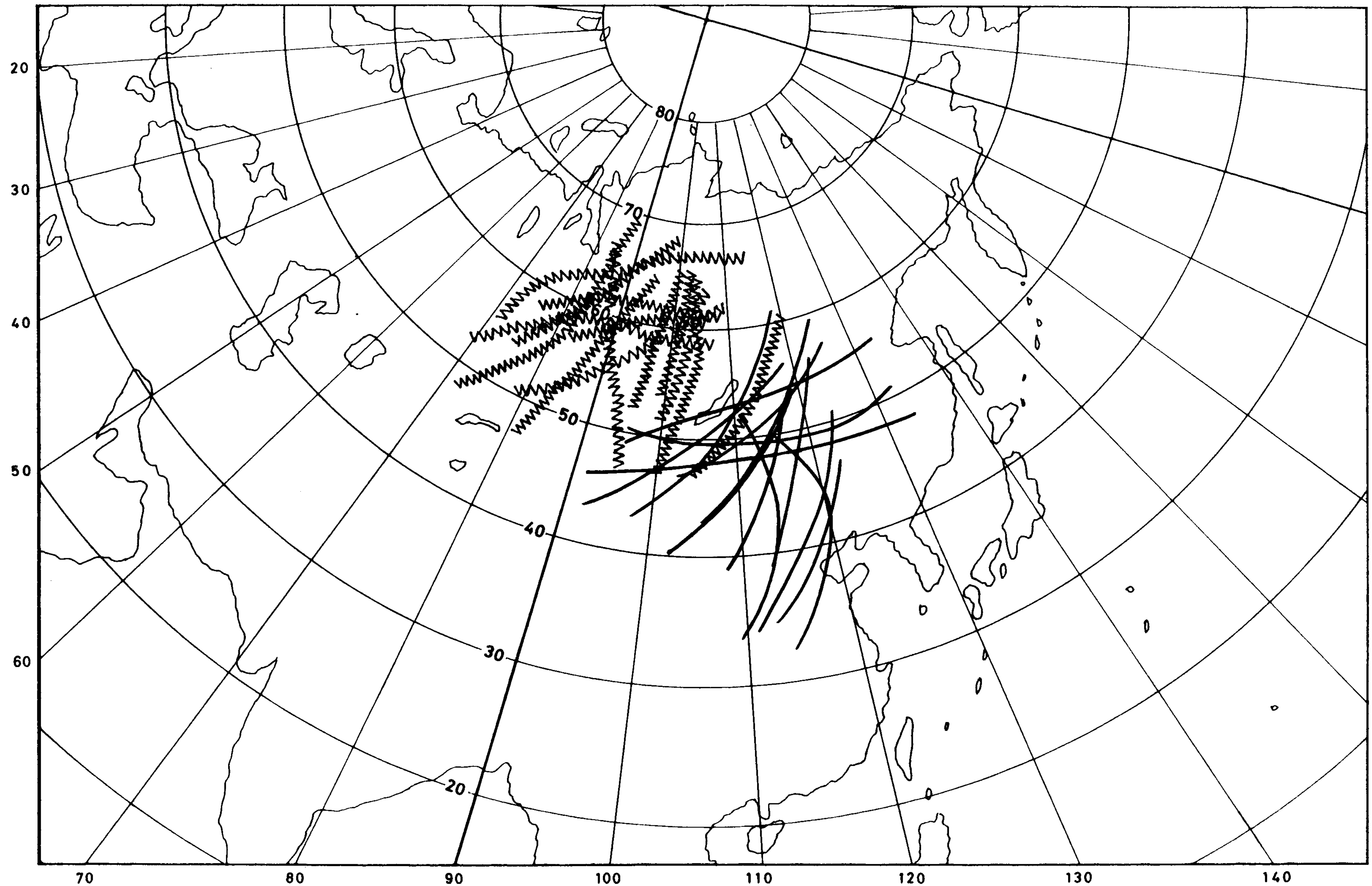

Figure 11. Positions of troughs and ridges 2 days before the arrival of surges in February 1964-1968

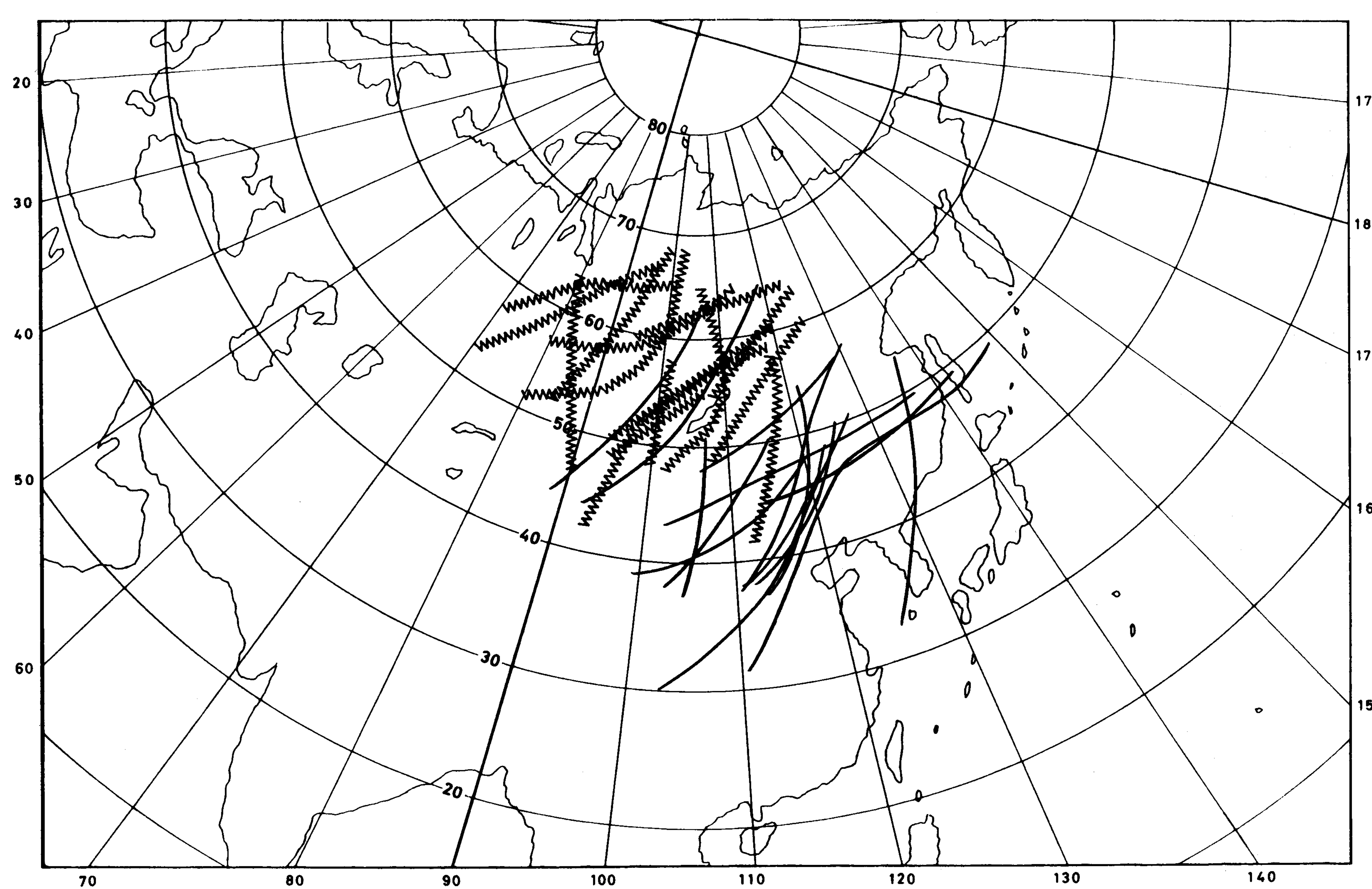

Figure 12. Positions of troughs and ridges 2 days before the arrival of surges in March 1959–1963

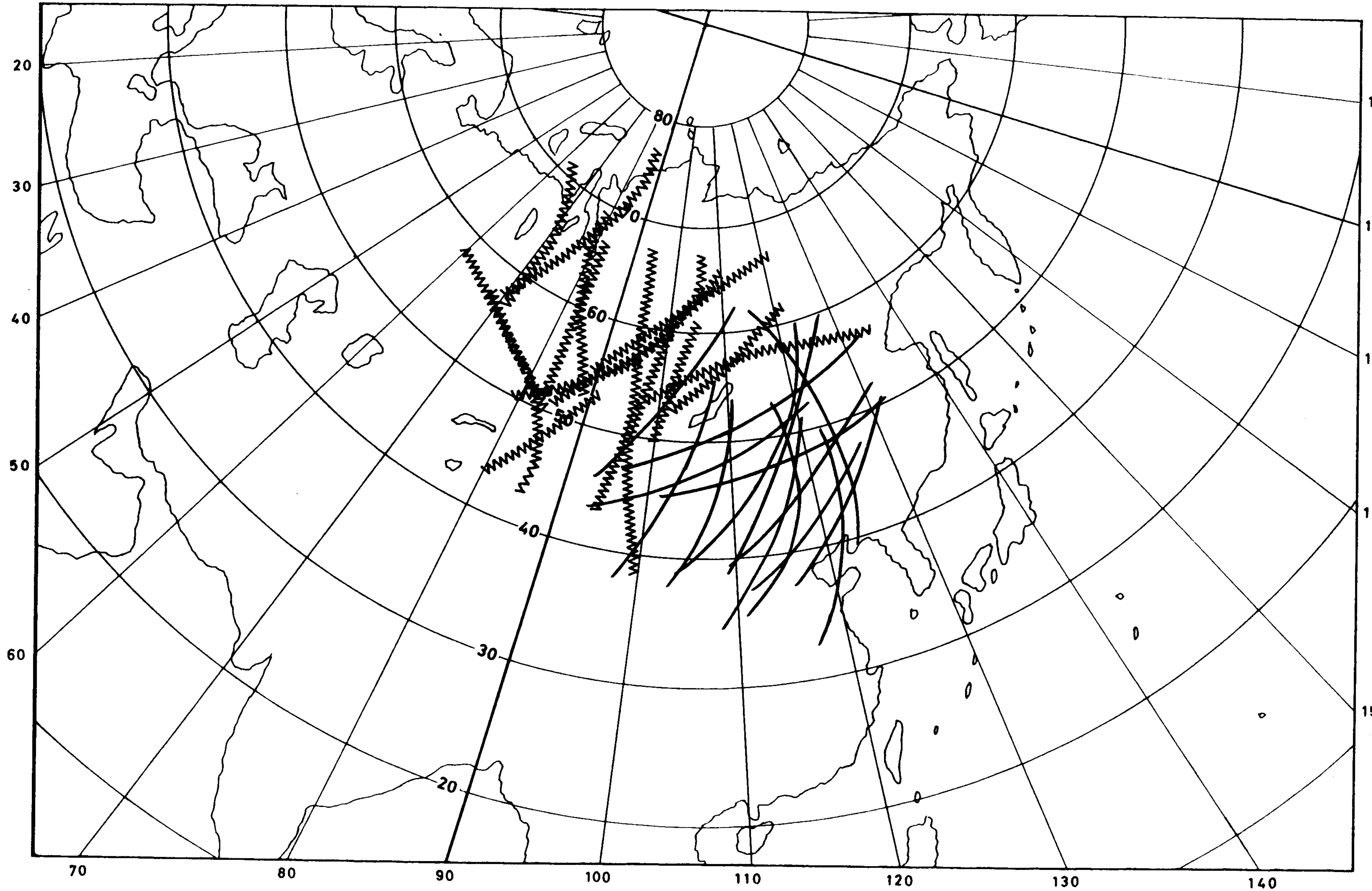

Figure 13. Positions of troughs and ridges 2 days before the arrival of surges in March 1964-1968

TABLE 7. POSITIONS OF RIDGES AND TROUGHS TWO DAYS BEFORE COLD SURGES AT HONG KONG

Day(-2)	Longitude of ridge			Longitude of trough			Temperature drop Day(+1) - Day(-1)
	50°N	60°N	mean	45°N	55°N	mean	
5-10-64	85	95	90	105	120	113	2.7
10-10-64	47	43	50	70	76	73	2.6
6-11-64	100	108	104	130	138	134	2.2
29-11-64	96	106	101	123	141	132	3.3
9-12-64	70	104	87	83	127	105	2.7
28- 1-65	116	136	126	127	147	137	2.7
3- 2-65	73	103	88	108	122	115	2.6
8- 2-65	94	88	91	116	122	119	2.0
19- 2-65	97	103	100	113	117	115	2.2
13-10-65	83	93	88	120	124	122	2.3
7-11-65	75	75	75	90	102	96	5.2
17-11-65	70	74	72	108	108	108	2.4
22-11-65	84	92	88	104	112	108	2.7
28-11-65	78	76	77	106	124	115	2.2
3-12-65	58	66	62	106	108	107	4.6
13-12-65	64	70	67	98	118	108	4.8
21-12-65	65	79	72	64	122	93	6.3
27-12-65	80	76	78	100	124	112	2.0
11- 1-66	58	80	69	84	104	94	3.4
16- 1-66	86	90	88	122	118	120	2.3
25- 1-66	73	99	86	85	132	109	4.4
2- 2-66	108	118	113	122	130	126	5.3
9- 2-66	73	83	78	90	122	106	5.4
16- 2-66	95	102	99	107	121	114	3.0
20- 2-66	66	80	73	95	115	105	12.5
12-10-66	93	101	97	110	116	113	3.2
25-10-66	80	92	86	92	100	96	5.5
9-11-66	95	120	108	112	118	115	2.0
18-11-66	66	74	70	115	117	116	4.5
23-11-66	60	72	66	95	115	105	4.1
27-11-66	59	65	62	102	106	104	3.4
11-12-66	94	110	102	122	116	119	2.4
18-12-66	*	*	*	*	*	*	2.0
29-12-66	60	56	58	97	135	116	2.5
6- 1-67	64	118	91	70	150	110	4.4
13- 1-67	85	95	90	93	135	114	6.4
21- 1-67	87	83	85	117	123	120	3.7
27- 1-67	97	98	99	86	120	103	6.6
7- 2-67	73	83	78	*	*	*	3.6
21- 2-67	75	91	83	99	115	107	4.5
12-10-67	78	80	79	90	124	107	2.6
3-11-67	**	**	**	102	120	111	2.0
9-11-67	60	82	71	82	118	100	3.3
19-11-67	67	81	74	74	142	108	3.0
27-11-67	70	78	74	95	115	105	6.8
4-12-67	80	86	83	78	122	100	4.3
25-12-67	87	83	85	113	115	114	6.4
5- 1-68	67	65	66	102	112	107	2.1
13- 1-68	94	94	94	120	130	125	2.8
18- 1-68	73	75	74	*	*	*	2.0
28- 1-68	85	91	88	107	123	115	3.5
12- 2-68	100	106	103	120	124	122	2.5
17- 2-68	83	89	86	114	110	112	4.3
28- 2-68	94	96	95	120	112	116	3.5
Mean	79.23	88.52	84.02	102.02	120.14	111.10	

* ridge or trough axes parallel to the latitudes

** no ridge axes could be depicted

Period: 20 months (October to February 1964–1968)

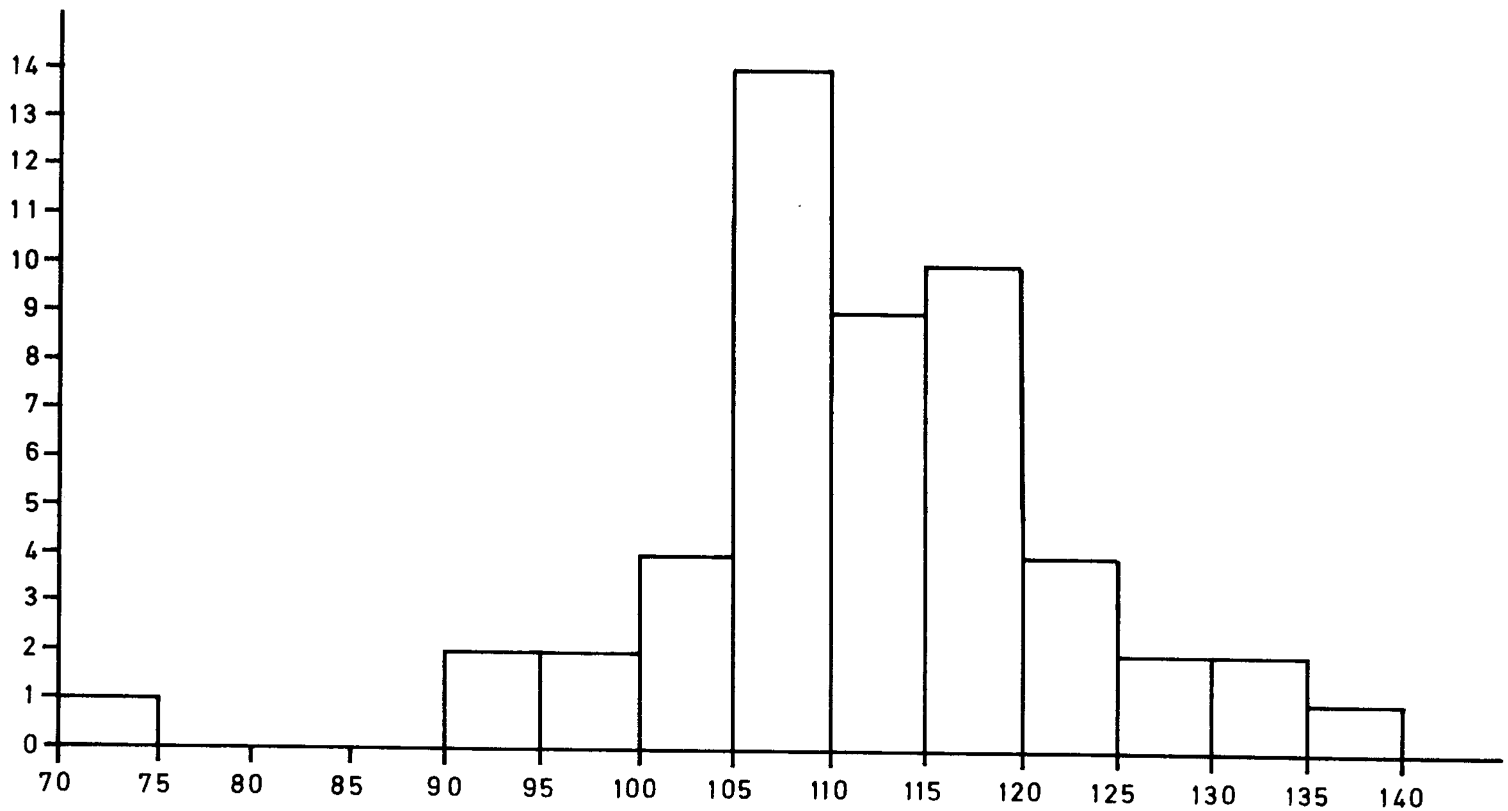

Figure 14 Frequency distribution at 5° longitude intervals for positions of troughs between 45°N and 55°N 2 days before the arrival of cold surges

Period: 20 months (October to February 1964-1968)

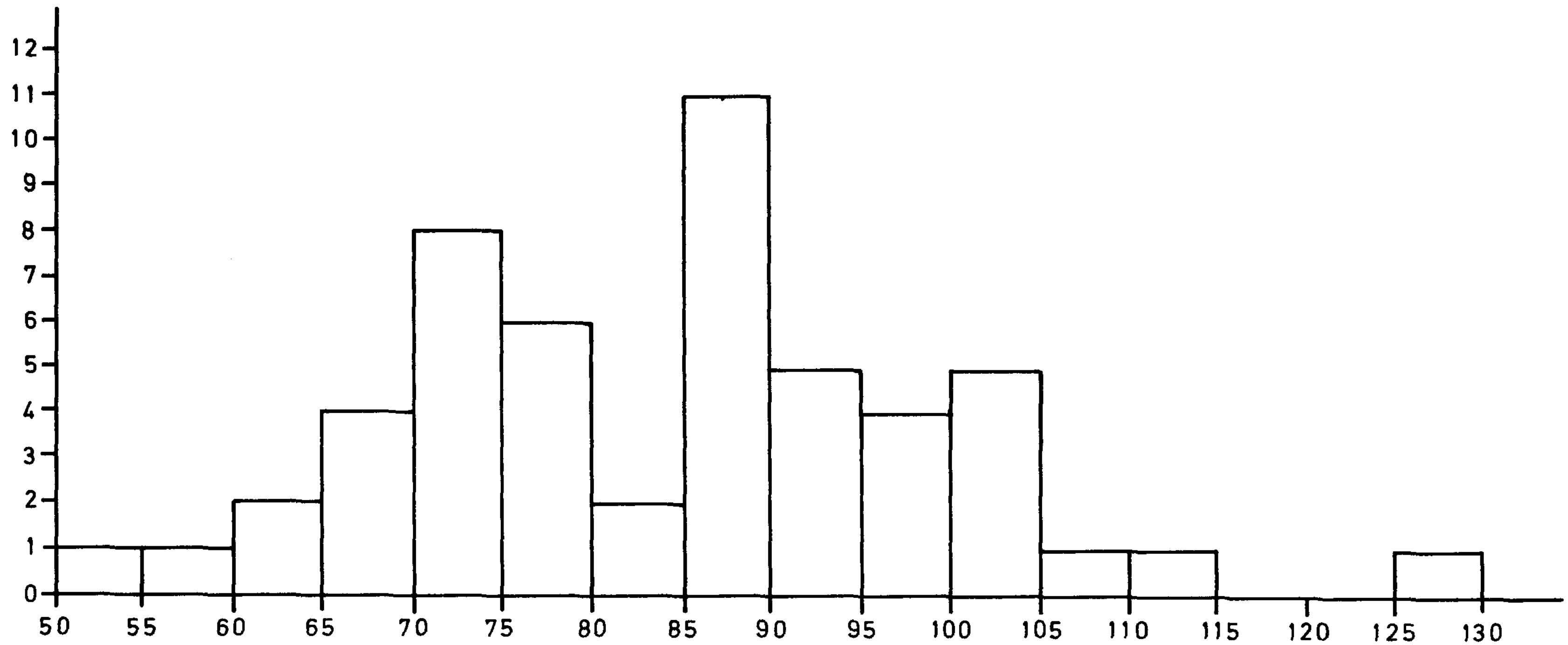

Figure 15. Frequency distribution at 5° longitude intervals for positions of ridges between 50°N and 60°N 2 days before the arrival of cold surges

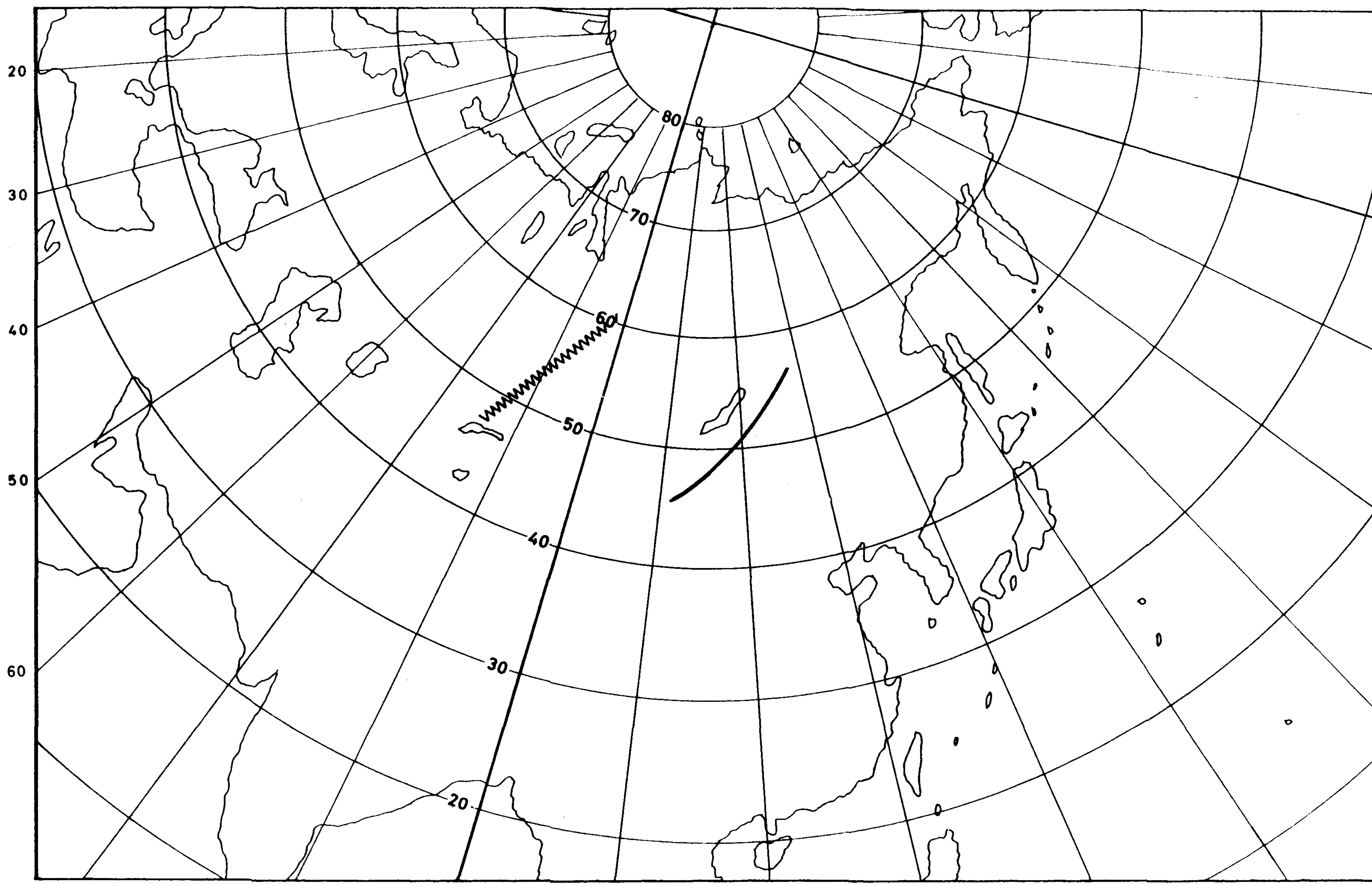

Figure 16. Preferred position of trough and ridge 2 days before the arrival of cold surges

5. FORECASTING PROCEDURE AND VERIFICATION

The observations in the previous paragraphs show that when a 500-mbar trough at 50°N passes eastwards through 111°E with a ridge behind it, a cold surge should be forecast to arrive in Hong Kong about 2 days later. On those occasions when there was no significant ridge immediately to the northwest of the trough it appears that the gradient at the 500-mbar level was not strong enough to drive cold air all the way to Hong Kong.

In order to verify the technique, the date for two winters (1974-1975 and 1975-1976) were examined. The results are tabulated in Table 8. Surges would have been forecast on 39 occasions and 32 surges eventually arrived at Hong Kong. Also 32 out of the 39 surges that actually arrived would have been forecast by this technique. Altogether there were 38 successes out of a total of 51 cases. It is also noted that the majority (7 out of 13) of the failures occurred in the month of January.

TABLE 8. VERIFICATION

Case	Date when trough reached $111^{o}E$ at $50^{o}N$	Position of ridge (^{o}E) at $55^{o}N$	Date of surge	No. of days after trough reached $111^{o}E$	Surges forecast	Cases successful	Remarks
1	7-10-74	55	9-10-74	2	Yes	Yes	
2	13-10-74	-	-	-	No	Yes	
3	16-10-74	60	17-10-74	1	Yes	Yes	
4	26-10-74	93	28-10-74	2	Yes	Yes	
5	10-11-74	90	-	-	Yes	No	There were drops of mean temperature of 1.5 and 5.0 deg. on 8-11-74 and 9-11-74 respectively
6	15-11-74	86	17-11-74	2	Yes	Yes	
7	19-11-74	88	-	-	Yes	No	There was a drop of mean temperature of 0.4 deg. on 21-11-74
8	24-11-74	111	-	-	Yes	No	There was a drop of mean temperature of 1.1 deg. on 25-11-74
9	2-12-74	79	3-12-74	1	Yes	Yes	
10	7-12-74	64	10-12-74	3	Yes	Yes	
11	11-12-74	66	13-12-74	2	Yes	Yes	The drop of mean temperature was 1.9 deg. on 13-12-74
12	16-12-74	79	18-12-74	2	Yes	Yes	
13	23-12-74	74	25-12-74	2	Yes	Yes	
14	29-12-74	72	1- 1-75	3	Yes	Yes	
15	3- 1-75	95	-	-	Yes	No	This was a replenishment of cold air for the surge on 1-1-75. There were drops of mean temperatures of 5.4 and 2.9 deg. on 2-1-75 and 3-1-75 respectively
16	6- 1-75	83	-	-	Yes	No	There was a drop of mean temperature of 1.1 deg. on 9-1-75
17	-	98	16- 1-75	-	No	No	There was a quasi-stationary low north of Korea
18	20- 1-75	100	-	-	Yes	No	The trough dissipated after reaching $116^{o}E$ on 20-1-75
19	25- 1-75	75	26- 1-75	1	Yes	Yes	
20	30- 1-75	-	-	-	No	Yes	
21	5- 2-75	94	7- 2-75	2	Yes	Yes	
22	18- 2-75	85	21- 2-75	3	Yes	Yes	The drop of mean temperature was 1.7 deg. on 21-2-75
23	4- 3-75	95	6- 3-75	2	Yes	Yes	
24	7- 3-75	98	10- 3-75	3	Yes	Yes	The drop of mean temperature was 1.8 deg. on 10-3-75
25	12- 3-75	86	14- 3-75	2	Yes	Yes	
26	18- 3-75	70	21- 3-75	3	Yes	Yes	

Case	Date when trough reached 111°E at 50°N	Position of ridge (°E) at 55°N	Date of surge	No. of days after trough reached 111°E	Surges forecast	Cases successful	Remarks
27	–	–	24– 3–75	–	No	No	This was a replenishment of cold air for the surge on 21–3–75. The trough position on 22–3–75 was at 128°E
28	1–10–75	99	3–10–75	2	Yes	Yes	
29	5–10–75	85	8–10–75	3	Yes	Yes	The drop of mean temperature was 1.7 deg. on 8–10–75
30	11–10–75	90	13–10–75	2	Yes	Yes	
31	21–10–75	–	–	–	No	Yes	
32	27–10–75	86	29–10–75	2	Yes	Yes	
33	–	–	6–11–75	–	No	No	There was a weak trough at 104°E on 5–11–75
34	10–11–75	100	13–11–75	3	Yes	Yes	
35	17–11–75	82	19–11–75	2	Yes	Yes	
36	20–11–75	77	22–11–75	2	Yes	Yes	
37	26–11–75	–	–	–	No	Yes	
38	30–11–75	–	–	–	No	Yes	
39	8–12–77	79	8–12–75	0	Yes	No	The trough was E–W oriented. It reached 111°E on 7–12–75 at 55°N
40	25–12–75	103	27–12–75	2	Yes	Yes	
41	3– 1–76	86	5– 1–76	2	Yes	Yes	
42	–	94	10– 1–76	–	No	No	There was a quasi-stationary low north of Korea
43	–	90	22– 1–76	–	No	No	The trough was E–W oriented. It reached 100°E on 19–1–76 at 45°N
44	27– 1–76	91	30– 1–76	3	Yes	Yes	
45	–	95	5– 2–76	–	No	No	The trough was E–W oriented. It reached 120°E on 3–2–76 at 45°N
46	13– 2–76	–	–	–	No	Yes	
47	16– 2–76	83	18– 2–76	2	Yes	Yes	
48	26– 2–76	91	28– 2–76	2	Yes	Yes	
49	10– 3–76	94	12– 3–76	2	Yes	Yes	
50	16– 3–76	74	18– 3–76	2	Yes	Yes	
51	28– 3–76	69	30– 3–76	2	Yes	Yes	

6. CONCLUSION

There is a definite relationship between the disturbance in the westerlies at mid-latitudes at 500-mbar and the southward movement of cold air. A well-established trough at 500-mbar level east of Lake Baikal is an indication that a cold surge will arrive at Hong Kong. On average, the trough should have passed Lake Baikal and a ridge should be positioned between 80° to 90°E two days before a cold surge arrives in Hong Kong.

This is an initial study on the use of 500-mbar hemispheric charts as a tool for making medium-range forecasts of cold surges, or to be more specific, forecasts of a sudden drop in mean daily temperatures in Hong Kong. The study is confined to the onset of surges and no attention was given to the length of the cold spell which might be estimated, for instance, from the speed of movement of the 500-mbar wave. One of the difficulties of such a study would be to provide a precise, yet complete definition of a cold spell. Also, it would seem possible that the amplitude of the 500-mbar waves may provide some indication of the intensity of the cold surges.

REFERENCES

1. Chin, P.C. 1969 "Cold Surges over South China", Royal Observatory Technical Note No. 28

2. Dao, S.Y. 1957 A Synoptic and Aerological Study of Cold Wave in the Far East showing the Period of the Break down of the Blocking Situation over Eurasia and Atlantic, Acta Met. Sinica Vol. 28, No. 1, 1957, p. 63-73

3. J.M.A. 1968 "Monthly mean 500-mbar charts for the northern hemisphere", J.M.A.

4. Lam, C.Y. 1976 "500-millibar troughs passing over Lake Baikal and the arrival of surges at Hong Kong", Royal Observatory Forecasters' Note No. 1.