THE ROLE OF INTERACTION WITH MIDDLE LATITUDE CIRCULATION IN THE BEHAVIOUR OF THE SOUTHWEST MONSOON OF 1972 AND 1979

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ABSTRACT

Failure of the southwest monsoon rains over India is identified to be linked with the occurrence of a blocking ridge over east Asia to the north of Tibet. Interactions between middle latitude troughs and the performance of the Indian monsoon have been elucidated.

INTRODUCTION

THE Monsoon Experiment (MONEX-79) was an important regional programme of the recent Global Weather Experiment sponsored by the World Meteorological Organisation in collaboration with national Governments. The southwest monsoon of 1979 turned out to be very highly deficient resulting in a severe and widespread drought over India—one of the five such drought years (1877, 1899, 1918, 1972 and 1979) in the last nearly hundred years. This aspect of the Monex year has naturally motivated an in-depth study of the most probable circulation anomalies.

So far, droughts arising from large deficiencies in southwest monsoon rainfall have been studied in relation to occurrence of prolonged breaks in monsoon in July and August. Malurkar[2] observed that southward extension of extratropical westerly troughs into northern India during summer led to "breaks". Ramaswamy[7] found that during monsoon breaks, pronounced low index circulation prevailed in the middle latitude westerlies north of the Himalayas. Large amplitude troughs protruded into the Indian sub-continent on such occasions and even remained quasistationary. Keshavamurti and Awade[1] found that during the pronounced drought of July 1972, the temperature between 1000 mb and 300 mb was considerably below normal, over the southern parts of USSR, Iran, Afghanistan and north India. Certain abnormalities were also noticed in the middle latitude circulation wave number regime.

Kanamitsu and Krishnamurti[3] have carried out a detailed analysis of dynamical parameters, contrasting the 200 mb wind flow regimes during a drought year (1972) with those during a normal rainfall year (1967) over the global tropics, for the northern summer months. They found that the deficient rainfall over central India during 1972 might be related to a sequence of events, commencing from warm sea surface temperatures over the equatorial Pacific leading to an excessive number of typhoon days in western Pacific, weaker easterly Jet, weaker meridional pressure gradient over India and ending with weaker westward steering of rain producing disturbances over India.

2. OBJECTIVE OF STUDY

Several circulation anomalies should have contributed to large deficiencies in monsoon rains of 1979. Monsoon came late by ten days and withdrew very early. Atmospheric circulation patterns of the southern hemisphere, the equatorial regions and the northern middle latitudes and sea temperature distributions are likely to have been different in 1979 from other normal monsoon years. Hence, during the present study, attention was focused on certain characteristics of large-scale circulation patterns which occurred during 1979 and which appeared to be common to such severe drought years. These patterns appear to fit in logically with the features of tropospheric wind shear oscillations in the southwest monsoon atmosphere recently observed, perhaps, as a determiner of monsoon activity (Raman *et al.*[4-6]).

In the Indian monsoon area, the tropospheric wind shear evaluated between 200 mb and 850 mb undergoes an oscillation within a range of 35 ms^{-1} with a period of about 5–10 days. The oscillation occurs in two parts, one around 20° N, another around 10° N with a zone of transition near about 16° N. The two parts are broadly in opposite phase. The waxing part of this oscillation follows the passage of a middle latitude westerly trough (north of 40° N) across about the 90° E meridian. Passage of a westerly trough across about 120° E is followed by the waning phase of the oscillation. This waning phase of tropospheric wind shear is the only favourable time for formation of monsoon depressions over the north Bay of Bengal. Formation of depressions in the Arabian sea is similarly linked with the phase of waning shear in those longitudes. Another interesting feature is that the decreases in shear seem to take place along narrow bands. On the whole, the present trend of evidence points to the waning phase of the tropospheric wind shear oscillation in its northern part as more conducive to pronounced monsoon

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activity. It has been pointed out earlier that regular traversal of the middle latitude troughs between the meridians of 70° E and 130° E is linked with the wind shear oscillations. *A logical synoptic projection would then be that a specific disposition and type of movement of westerly wave troughs of the middle latitudes might prevail in poor monsoon years and a totally different one in years of good monsoon precipitation.*

3. Data Used

The years 1972 and 1979 are two of the five worst monsoon years in the last one hundred and five years. In both these years, monsoon rainfall was deficient by more than 20% in half of India or more. On the other hand, in 1975 and 1977 monsoon rains were good over practically the whole of the country. Daily traversal of middle latitude troughs in July and August during these four years has been charted and contrasted. It is only in the last two decades that the upper air data, necessary for such analysis, have become available. The quality of the data has greatly improved in recent years.

Axes of westerly wave troughs at 200 mb were marked on a daily basis from Monex charts of 1977 and 1979. For, the years 1972 and 1975 charts for the northern hemisphere prepared and published by USSR were used.

4. Wave Troughs of Middle Latitude

Circulation anomaly of 1972 as compared to 1975 and 1977—July

Figure 1 shows positions of troughs at 200 mb in July 1972. This strikingly brings out that the troughs had been confined to two definite longitudinal belts, the first between 60° E and 90° E and the second, with lesser frequency to the east of 115° E. Not even a single wave trough moved eastwards across 92° E through 112° E. In contrast, the July 1977 chart in Fig. 2 shows a more uniform progression of troughs from 60° E–140° E (Distribution of troughs to the west of 60° E though marked is not considered to be of direct relevance). Earlier analysis of tropospheric wind shear had shown that troughs had to move well eastward of 90° E, right across and beyond 115° E to trigger and maintain good monsoon activity over the Indian sub-continent. The absence of such a feature in 1972 seems to have kept the monsoon rains at a very low level in, that year.

In the good monsoon month of July 1975, the trough passage was similar to that of 1977 showing unimpeded eastward progression across all longitudes from 60° E–140° E.

A secondary feature appears to be the relatively greater southward extensions of troughs in July 1972 as compared to that in July 1977.

Similarity of 1979 with 1972

Monsoon of 1979 arrived late by about ten days in northern India and the first half of July 1979 went practically dry. Figure 3 shows the trough passages during this period. Troughs could not cross to the east of 97° E and reached even upto 25° N in the first week, the two features appearing to inhibit monsoon onset and activity.

On the other hand, monsoon rainfall had picked up in the second half of July 1979. In the second half of July 1979 (Fig. 4), the trough passage was evenly distributed across central Asia, as in the good July monsoons of 1975 and 1977.

Anomaly during August

Aberrations in monsoon rains are more common in August than in July. Rainfall was highly deficient in August 1972. Monsoon rains practically ceased in the second half of August 1979. Figures 5 and 6 present the traversal of westerly troughs in August 1972 and in the period 16–31 August 1979. The tight banding of the axes of the troughs, one to the west of 90° E and the other to the east of 115° E, with a free gap in between, seen in the bad July monsoons repeated itself in August 1972 and in the second half of August 1979 as well. In August of good monsoon years, the trough traversal was like the passage in good July years.

5. Blocking Ridge Over Central Asia

Concurrently, an examination was also made of the appearance and persistence of ridges in the meridional plane over central Asia. In the good monsoon years of 1975 and 1977, when the wave troughs progressed systematically eastwards across central Asia from 60° E to 140° E, north-south ridges were not prominent and their stagnation notably absent. On the other hand, in the bad monsoon years of 1972, 1979 warm ridges were found to be located almost every day in the longitudinal belt 90°–110° E to the north and east of Tibet, blocking the free eastward movement of westerly troughs. The westerly troughs were often found to retrograde against this barrier. This ridge was most prominent at 250 mb, its temperatures on occasions being even 2° to 4° C warmer than around. Simultaneously, a similar blocking ridge was also observed, almost on a daily basis in the longitudinal belt between 40 °E and 60 °E. Figure 7 illustrates the grouping of blocking ridges in preferred locations in July 1972. A similar congregation of ridges occurred in the second half of August 1979 (Fig. 8) when a pronounced and prolonged break in monsoon totally inhibited precipitation over India.

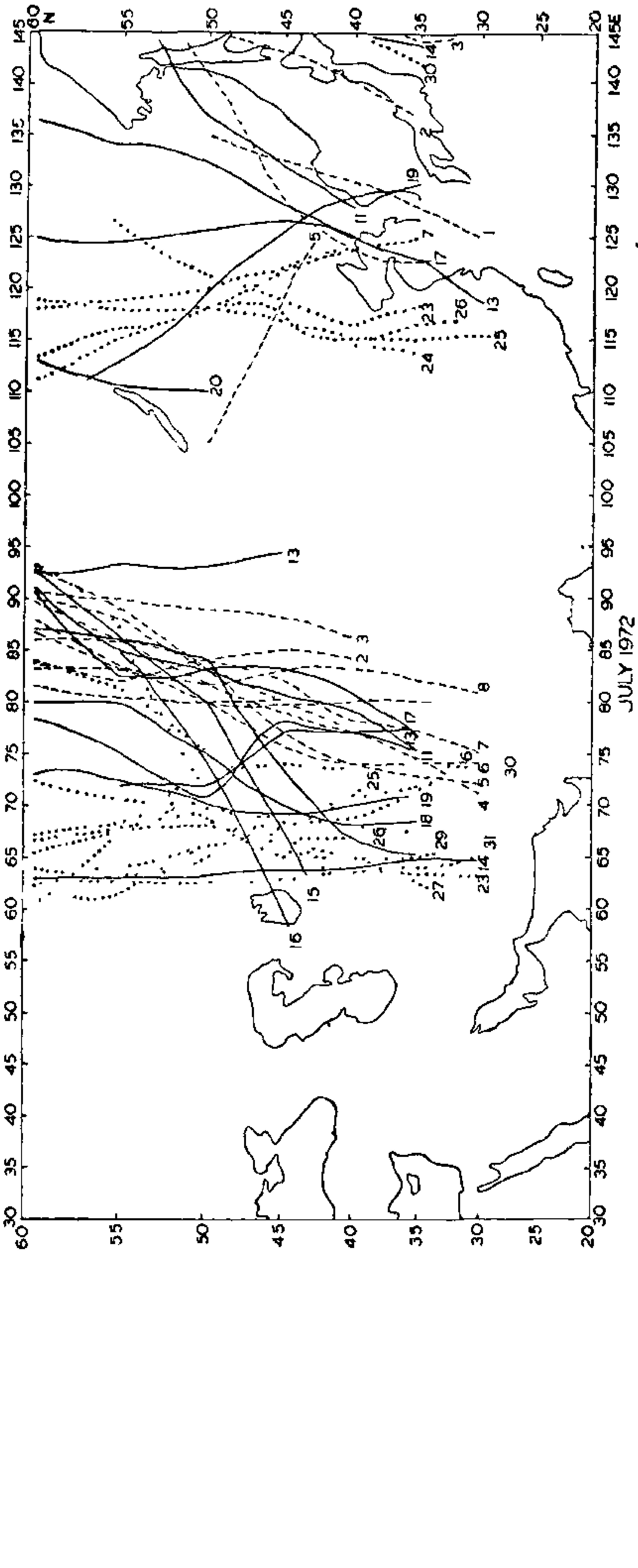

FIG. 1. Disposition of westerly wave troughs of middle latitude during July 1972. Daily positions of axes at 200 mb shown. Note congregation of trough axes between 60° E and 90° E.

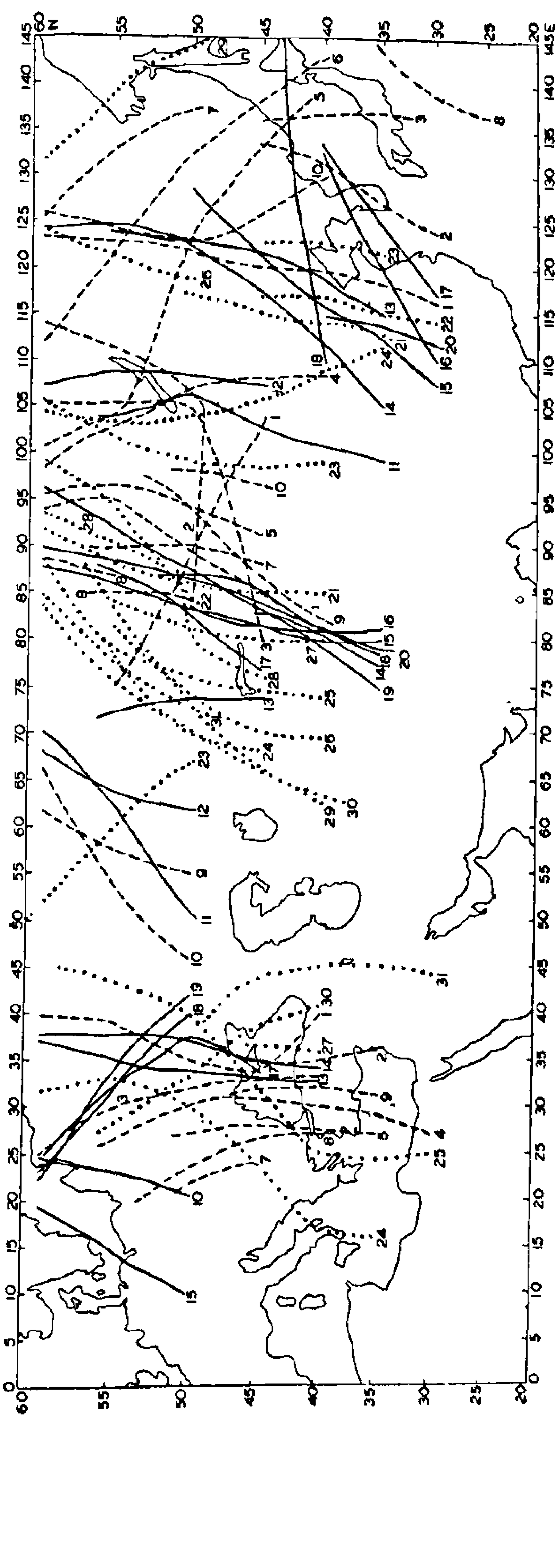

FIG. 2. Daily traversal of 200 mb trough axes during July 1977. Note unimpeded progression of troughs from 60° E to 140° E.

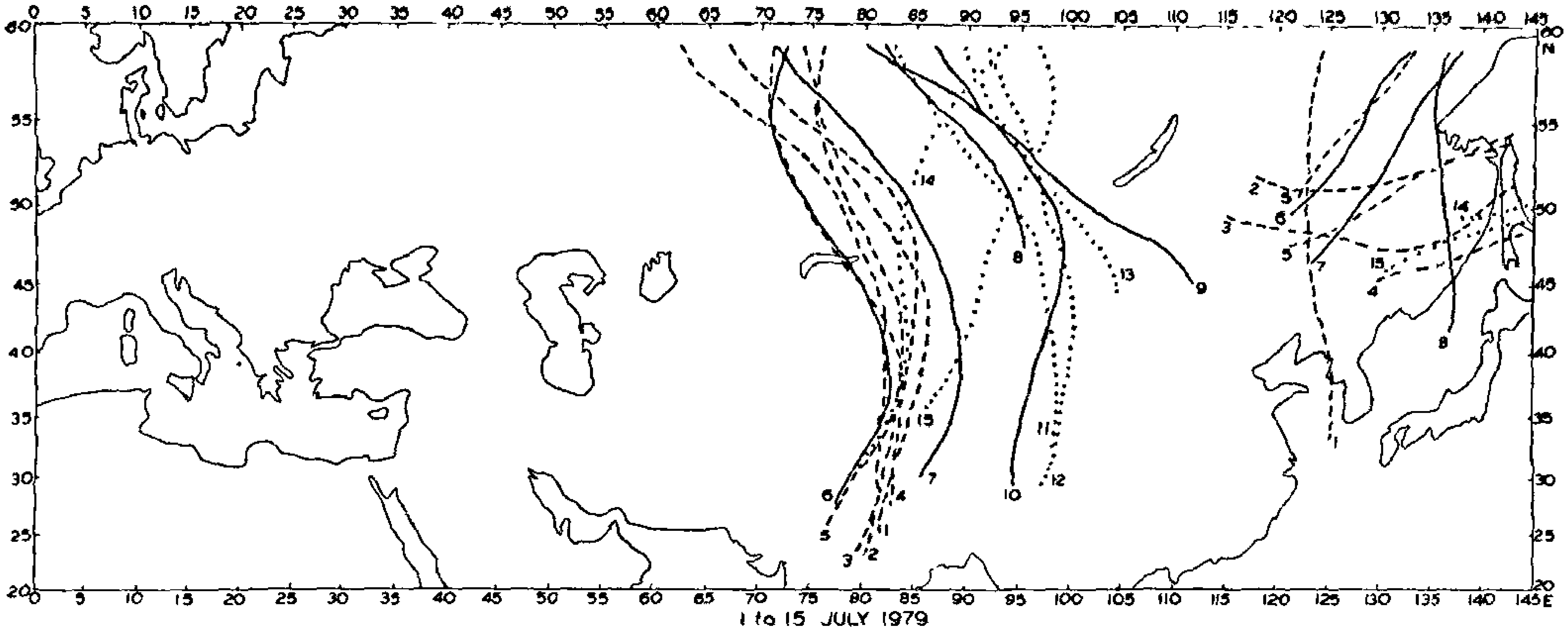

FIG. 3. Disposition of 200 mb wave troughs during first half of July 1979. Note congregation between 60° E and 80° E and southward extension to 25° N.

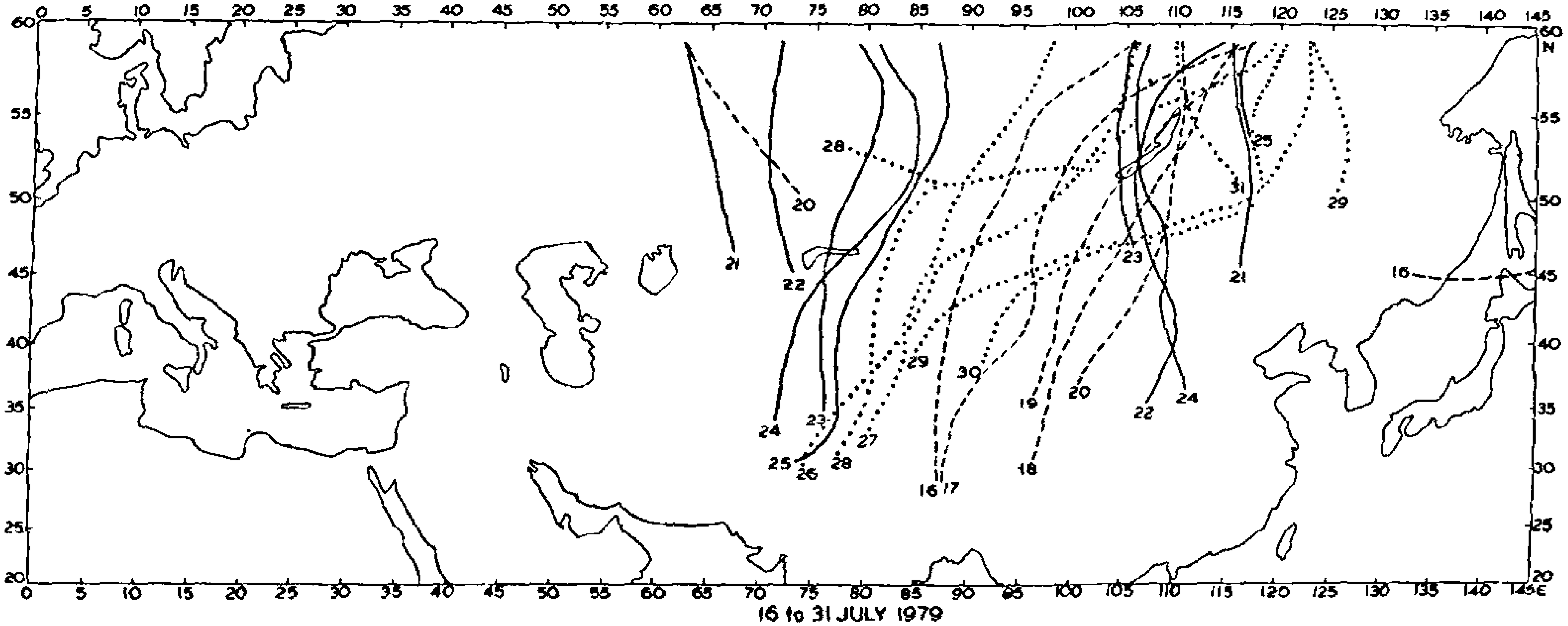

FIG. 4. Progression of 200 mb wave troughs in second half of July 1979. Note free movement in the longitudinal belt 80° E to 115° E.

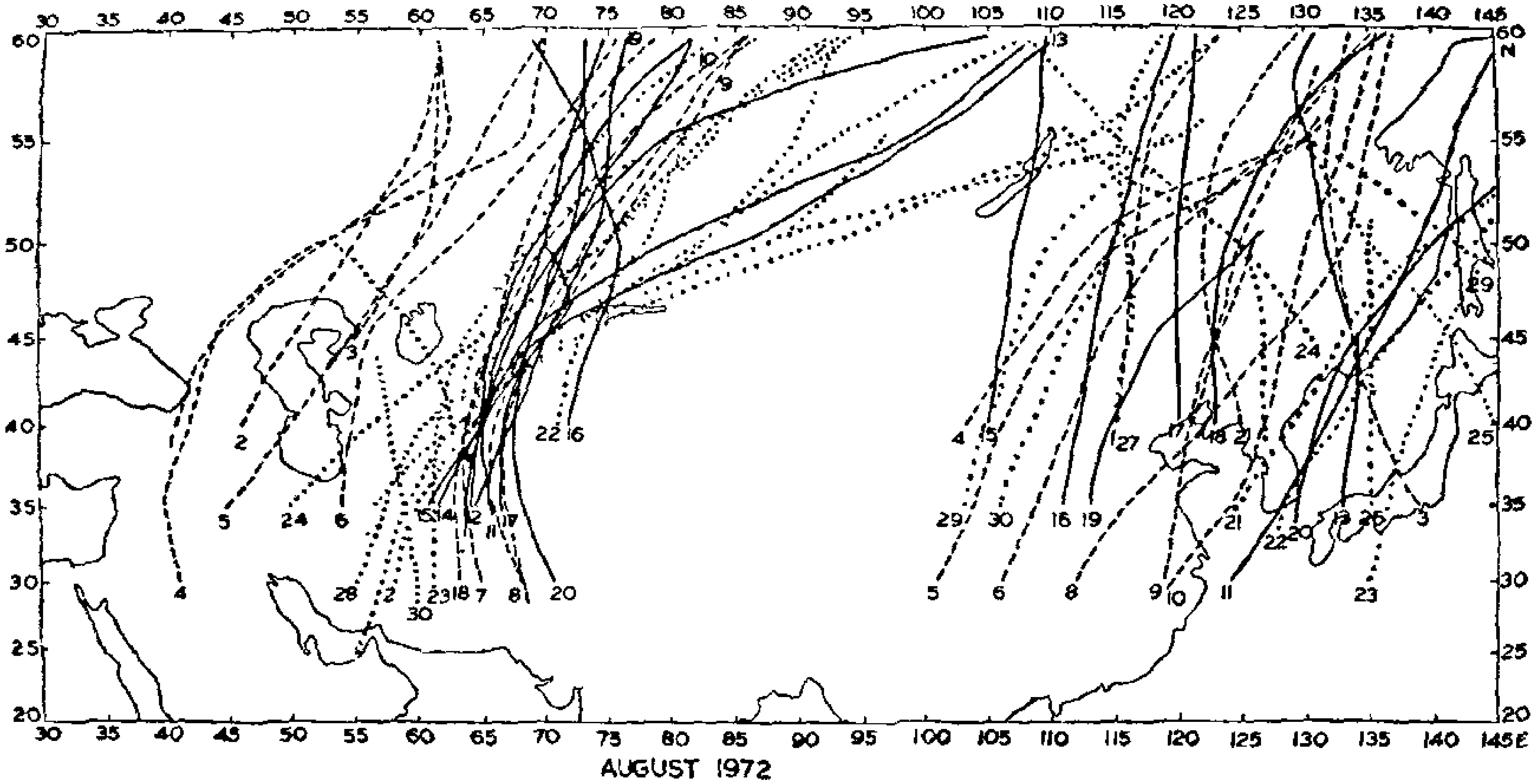

FIG. 5. Disposition of axes of 200 mb wave troughs during August 1972. Note tight banding of wave troughs, one to the west of 90° E and another to the east of 105° E.

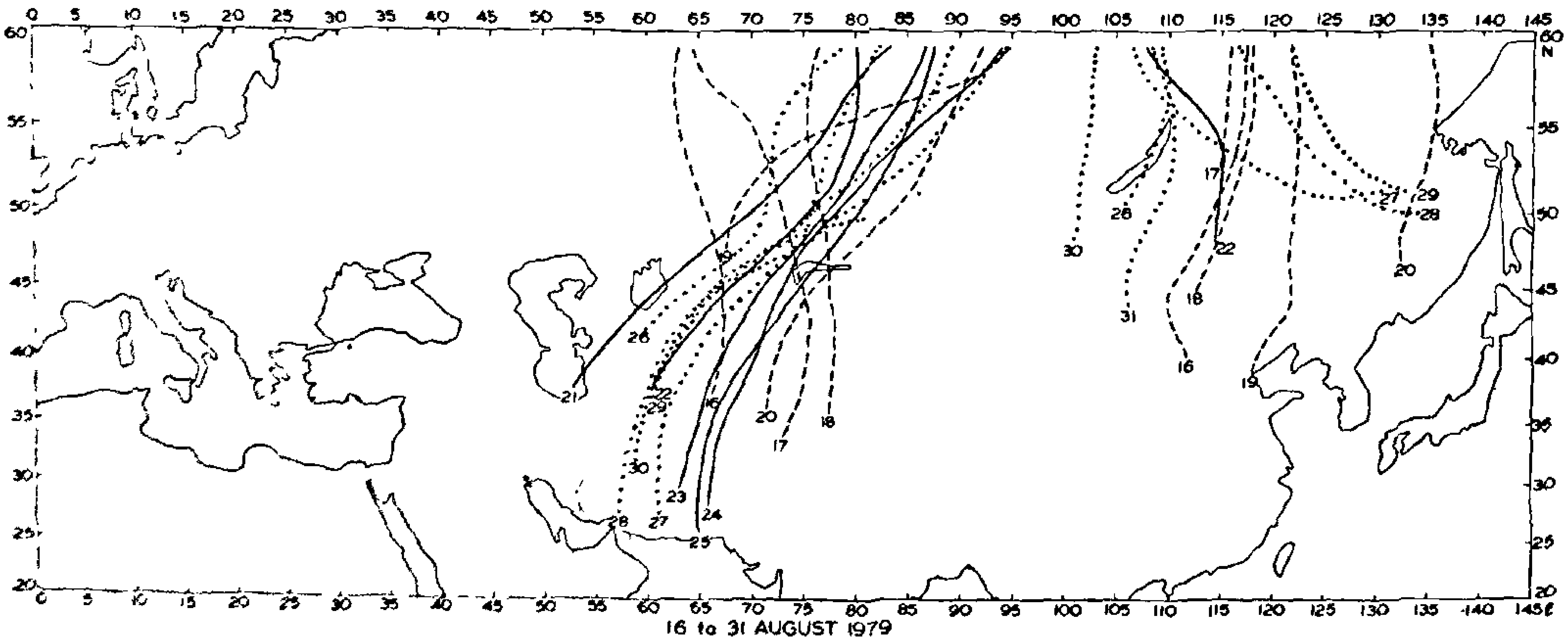

FIG. 6. As in Fig. 5 for second half of August 1979. Note anchoring of 200 mb trough axes between 60° E and 90° E and extensions to 25° N, strikingly similar to August 1972.

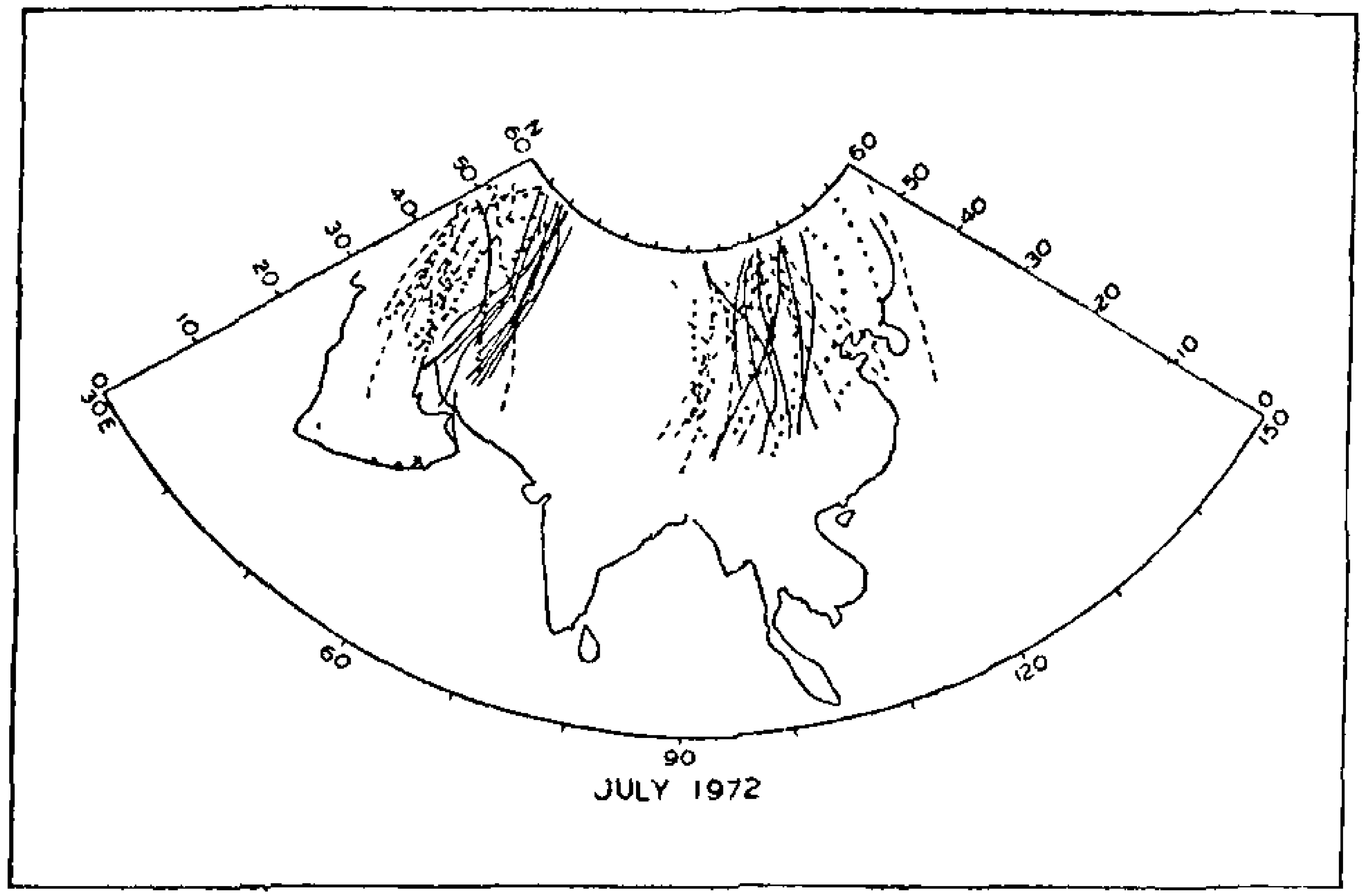

FIG. 7. Stagnant blocking ridge at 200 mb over east Asia to the north of Tibet during July 1972. Also note congregation of ridge axes over west Asia between 40° E and 60° E.

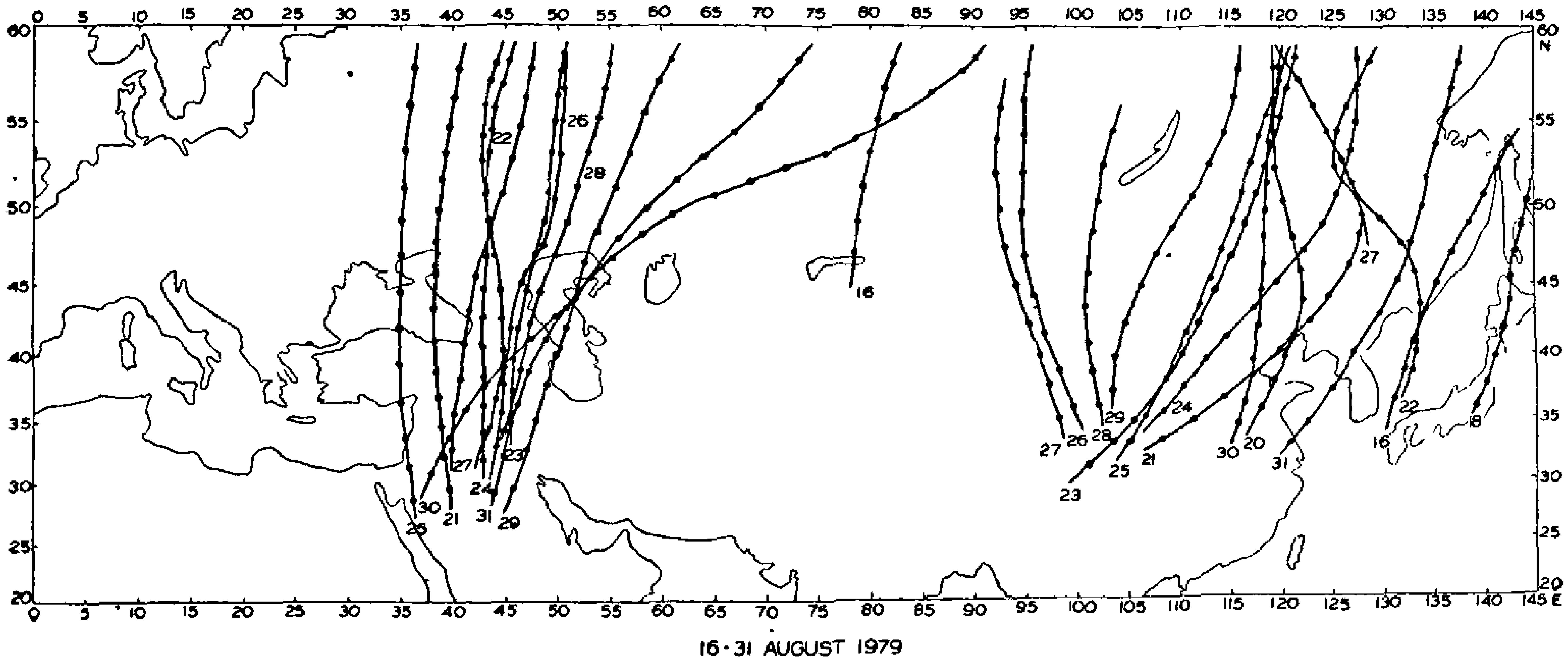

FIG. 8. Congregation of blocking ridges at 200 mb over east Asia during second half of August 1979 as also over west Asia. Wave troughs lay anchored in between—See Fig. 6.

6. Discussion and Summary

Earlier workers considered the influence of middle latitude westerly troughs on the Indian monsoon, ranging from westerly troughs inducing monsoon depression to initiating a break. No clear thought had, however, emerged as to how the westerly troughs influenced monsoon activity so divergently. The present study has clearly indicated that the obstruction by a blocking high between 90° E and 115° E to the free eastward passage of westerly troughs, leads to an inhibition of monsoon activity and rains. It is well known that in situations of blocking high, a cold low also develops to its southwest. Though we have not examined the actual occurrence of the cold low in these cases, it is very likely that a cold low was also present between 60° E and 90° E around 30° N. This may account for the southward extension of troughs noticed in 1972 and 1979 and the low temperatures observed by Keshavamurti and Awade[1] over Iran, Afghanistan and northwest India during 1972. The superposition of this cold low apparently explains the displacement of the monsoon trough into the Himalayas, which is observed in all break situations. This requires to be analysed further and confirmed.

The interaction between middle latitude westerly roughs and monsoon activity over north and central India can be summed up as follows :

(i) Free and unimpeded passage of westerly wave troughs across the longitudinal belt 90° E through 120° E (between 40°–50° N) is essential for the maintenance of good monsoon activity.

(ii) Movement of such troughs from the west across 120° E sets the stage for monsoon depression formation in the north Bay of Bengal.

(iii) Development of a blocking ridge between 90° E and 115° E leads to the anchoring of troughs to its west and inhibition of monsoon activity over central and northern India.

(iv) The persistence of this blocking ridge and the consequent stagnation of westerly troughs lead to monsoon droughts.

Further detailed synoptic and dynamical study on the interaction of the middle latitude troughs with monsoon activity is essential for the development of more reliable early warning and timely action programmes in the area of drought management.

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