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A climatological study of storms and depressions in the Bay of Bengal*

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A study has been made of the climatological statistics relating to frequency, formation, movement and dissipation of storms and depressions in the Bay of Bengal for the period 1890-1950.

During the 61-year period under study, the total number of disturbances in the Bay of Bengal was 793, out of which the number of cyclonic storms† was 288, the rest being depressions. The disturbances are nearly absent in January, February and March and occur most frequently during the monsoon and post-monsoon seasons, the frequency being highest in August and September. If cyclonic storms alone are considered, October and November are the most favourable months for their formation. A study of the seasonal distribution of the disturbances shows that there was not a single year in which the monsoon or the post-monsoon season was altogether free from the incidence of such disturbances. There were, however, 8 monsoon seasons and 7 post-monsoon seasons when no cyclonic storm developed. Five disturbances developed in September 1891 and this is the highest number of disturbances that ever developed in a particular month. The highest number of cyclonic storms that occurred in a particular month in a year is 3 but the frequency of such occurrences is very small and is limited chiefly to the end of the monsoon season or the post-monsoon season. The probability of occurrence of a certain number of disturbances or more in a particular month has been calculated. The probability of formation of at least one disturbance during each of the months of July, August, September and October is about ·9 or 1·0 while that of at least three disturbances during the same period is about ·3 or ·4. The probability of development of at least one cyclonic storm in October or November is about .6 and that of at least three such storms is only about ·03.

The average annual frequency of disturbances of all intensities is 13 while the actual number during the various years varied from a minimum of 8 in 1910 to a maximum of 18 in 1908. The highest number of cyclonic storms that developed in a year was 8.

To get an idea of the extent to which a particular portion of the sea area is liable to be affected by storms and depressions, the number of such disturbances crossing the different one degree latitude longitude squares were determined and plotted in those squares and then iso-lines of the number of disturbances were drawn for the various months. The chart for August is reproduced in Fig 1. In winter the activity of the disturbances is confined mainly to a small area in the south Bay of Bengal. During the pre-monsoon months the activity spreads out over a much wider area, the north Andaman Sea and the eastern parts of the Bay of

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†A disturbance was treated as a cyclonic storm when at least one ship's observation was received from the disturbed area, reporting wind speed of 8 B.F. or more. Otherwise, a disturbance was considered as a depression

Bengal being generally more affected by such disturbances. The affected areas again begin to shrink with the advent of the monsoon season and is most restricted in July. In this season, the northwest and the adjoining west central Bay of Bengal are the main affected areas, the worst zone being the region off the north Orissa coast. The area again spreads out in the post-monsoon season. In October, the frequency is relatively high in the sea area off the eastern coast of India while the southwest Bay is found to be the worst affected area in the other two months of this season.

Risk determinations have been made for all the important ports in the eastern coast for the various months. The probability of disturbances endangering Calcutta is minimum, *i.e.*, zero during the period January to April and is maximum, *i.e.*, ·5 in July. Similar statistics in respect of the other ports along the eastern coast have been prepared for the different months.

A detailed climatological study has been made of the speed and direction of movement of all storms and depressions in the different one degree squares in the Bay of Bengal during the different seasons. The diagrams, in the form of roses, summarising information in regard to movements of storms and depressions while they lie over different small areas out at sea, enable one to make an estimate readily of the probability of movement of the storm in one particular direction. It is seen that the movement of the post-monsoon storms and depressions is by far the most uncertain and may take any of the directions between W and NE. For instance, in October the disturbance originating in the southeast Bay of Bengal and the south Andaman Sea usually move in a direction between west and north. Some of them, however, undergo recurvature in the southwest Bay and then follow a northerly or northeasterly course. On the other hand, the storms and depressions which form in the north Andaman Sea usually move northwestwards initially and later north or northeastwards across east central and northeast Bay. If a December storm moving initially north or northwestwards, crosses Lat. 13° or 14°N, it is found that its subsequent course is northeasterly. In winter the disturbances which develop in the south Bay, south of 8°N, mostly move westwards affecting Ceylon and the tip of the peninsula and those which lie north of 8°N usually move northwest. With the advent of the pre-monsoon season, there is a well marked decrease in the tendency of movement in a westerly direction. In this season, even those which form in the extreme south Bay are found to follow some northerly course instead of westerly course. The disturbances which develop in the southeast Bay and the Andaman Sea initially move northwestwards and later recurve towards northeast and mainly affect Burma. On the other hand, those which form in the southwest Bay move N/NW-wards and affect Ceylon and south peninsula. In the monsoon season although the predominant direction of movement is northwesterly, some of the disturbances which lie in the northeast Bay in June move in a northeasterly direction.

The regions which are specially susceptible to formation of storms and depressions and also the areas where they usually weaken and die out have been marked out from month to month. The starting points of the tracks of storms and depressions as published in Part C, 11, India Weather Review, have been taken as the places of their origin. As these points may easily be out by one degree, the Bay area has been divided into somewhat bigger squares, *viz.*, 2 degree squares (instead of one degree squares as earlier) for purposes of examination of the various active regions of depression or storm development. The total number of storms and depressions forming in a particular two degree square during the period under study have been plotted on a monthly basis and isolines drawn to locate the areas having different susceptibility to depression or storm formation. The chart relating to August is reproduced in Fig. 2. In the monsoon months there is a well marked concentration of the areas of formation in the northwest

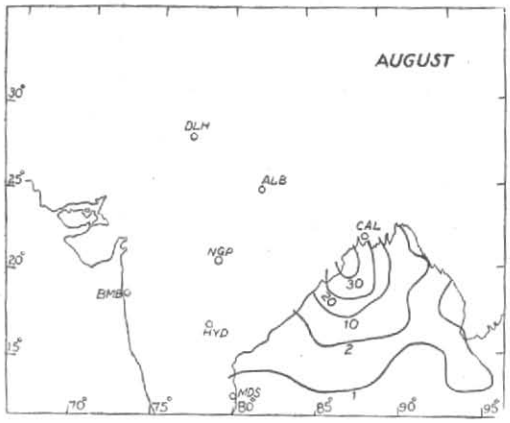

Fig. 1. Frequency of disturbances crossing each one degree lat.-long. square during the period 1890-1950

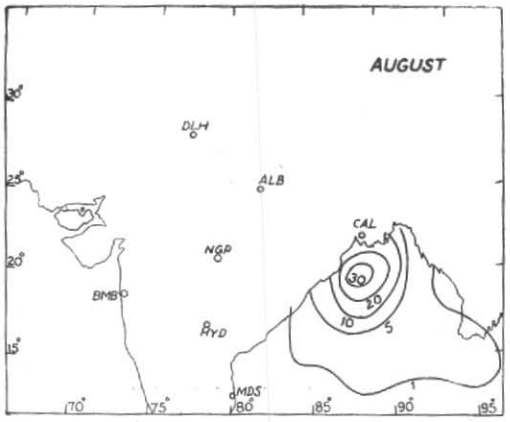

Fig. 2. Frequency of disturbances originating in various two degree lat.-long. squares during the period 1890-1950

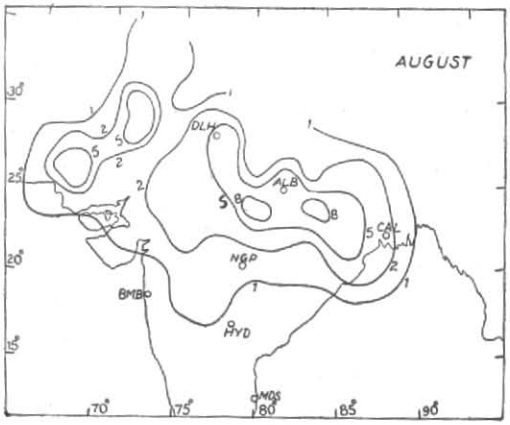

Fig. 3. Frequency of disturbances dissipating in various two degree lat.-long. squares during the period 1890-1950

Bay. In May and October, disturbances may develop at any place in the Bay. In these two months the I.T.F. moves northwards and southwards respectively across the Bay and this apparently accounts for the scattered nature of their place of formation. In the winter season (January-March) the disturbances are found to develop only in the extreme south Bay.

Similarly, the areas of dissipation of the disturbances originating from the Bay of Bengal have been studied by considering the ends of the published tracks as the points where the disturbances filled up. The chart in respect of August is shown in Fig. 3. It is seen that during the winter season most of the disturbances dissipated over the sea or in the south peninsula. In the pre-monsoon season, the maximum number of storms broke over the Arakan hills or hills of Central Burma. The majority of the monsoon disturbances filled up over Chota Nagpur, north Madhya Pradesh, Vindhya Pradesh and west Uttar Pradesh. In October, the maximum number die out in Eastern Pakistan while in November, the majority dissipate over the Arakan hills and north

Tamilnad. It is seen that, unlike the monsoon disturbances, the majority during the pre-monsoon and post-monsoon seasons die out before they have moved far into the land.

The average life period of storms and depressions (from the day of formation to the day of filling up) has been determined for the various months and is found to vary between 3 and 5 days.

A study of storm tracks has shown some close relation between the place of origin of a disturbance and the track followed by it, particularly during the pre-monsoon and post-monsoon months when such disturbances develop in various regions in the Bay of Bengal and move in various directions. The probability of a particular disturbance striking the coast at a particular spot after originating in a given region has been computed and shown in tabular form as this information may be of use in connection with issue of heavy rainfall and gale warnings for the coastal districts well in advance. It is seen that 5% of the May storms develop in square lat. 11, 13°N long. 93, 95°E in north Andaman Sea and that 45% of the storms originating in this square hit Bengal-Chittagong coast and 36% move across Arakan coast, while only 18% affect Circars coast. Again, if a storm develops in square lat. 11, 13°N long. 81, 83°E in southwest Bay during the same month, there is 100% chance of its moving inland across north Coromandal or south Circars coast. A study of the data for November shows that the square lat. 9, 11°N long. 85, 87°E in south Bay is a very favourable spot for the formation of storms in that month, the frequency being 8%. It is seen that 73% of the storms forming in this square move across Coromandal coast while the rest fill up out at sea. Again, if a storm develops in square lat. 9, 11°N long. 89, 91°E about 200-300 miles further to the east, it is likely to follow a more northerly course and strike north Circars or south Orissa coast.

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