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The Nor'wester and the lower level convergence

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ABSTRACT. A study of the field of convergence for a few days in nor'wester season reveals that though the afternoon nor'wester activity is invariably associated with the development of a field of convergence at lower levels, the velocity convergence, as could be assessed even quantitatively from the wind field of the morning pibal ascents (0200 GMT) does not seem to have significant prognostic value in the forecasting of subsequent nor'wester developments.

1. Introduction

It is well known that the atmosphere on most of the nor'wester days shows latent instability (*India met. Dep. Tech. Note*, 1944). It is believed that this latent energy, which is realised by the action of suitable triggers, gives rise to the active nor'wester cells. Amongst the triggers insolation is very important. But this alone, it is the usual experience, is not always sufficient and some other trigger is usually necessary for the realisation of this energy. Roy (1949) is of the opinion that lower level convergence shown by the curl in the moist airfield is one of the most important factors for providing this suitable trigger. In fact, most of the nor'wester developments are ascribed by the forecasters to this factor of lower level convergence. Apart from the consideration of the moisture content, it has, therefore, been the practice in the forecasting of nor'westers to distinguish the areas of convergence from considerations of the low pressure areas, isallobaric field and lower level streamline charts. These streamline charts, strictly speaking, show only "lines of flow" as they are not usually drawn either in regard to spacing or by the method advocated by Bjerknes *et al.* (1911).

In view of the importance attached to this lower level convergence, it was thought worthwhile to consider the magnitude of day-to-day convergence, its comparative values on the nor'wester and non-nor'wester days and also to consider its progressive variation from morning to evening. In the present note, a study has, therefore, been made for a few consecutive days, when conditions at lower levels seemed to be favourable for occurrence of nor'westers. Attempts have been made to find out whether the occurrence of nor'westers has any definite relation with the pattern or magnitude of convergence and the nature of such correlation, if there be any. It may, however, be mentioned that the convergence is only a partial measure of the lower level impulses. Other factors, *viz.*, insolation, height and depth of inversion at lower layers, moisture and stability conditions are also important in the genesis of nor'westers but these, being out of the scope of this paper have not been dealt with. Three consecutive dates from 1 to 3 May 1953 and six consecutive days from 9 to 14 May 1950 were selected for this study. The selection of dates were made primarily in view of the favourable lower level conditions on almost all these days. The period from 1 to 3 May 1953 afforded additional opportunity of presenting contrasting situations which, it was felt, would make any correlation between the nor'wester activity and the magnitude or the pattern of the field of convergence more marked and has, therefore, been discussed in more detail. The other cases have not been discussed but have only been shown in figures. As it may be argued that convergence must exist at least upto 5000 ft a.s.l. for the occurrence of nor'westers, the same was considered for the second set of days (9–14 May 1950).

2. Evaluation of the field of convergence

If x and y be the two cartesian co-ordinates in the usual east and north directions and if u and v be the velocity components along these directions respectively then the divergence (velocity) of the horizontal wind field may be expressed by the following equation—

$$\text{div } \mathbf{V} = \partial u/\partial x + \partial v/\partial y - v \tan\phi \, R$$

where R is the radius of curvature of the earth and ϕ the latitude. Neglecting this last term which is of a smaller order of magnitude, we have,

$$\text{div } \mathbf{V} = \partial u/\partial x + \partial v/\partial y.$$

The u and v data from pilot balloon observations were plotted and lines of equal speed were drawn for each of these components and the quantities $\partial u/\partial x$ and $\partial v/\partial y$ were found out. These values as obtained from these charts were added algebraically to find out the quantity $\partial u/\partial x + \partial v/\partial y$. These charts were prepared twice daily for the three days for 3000 ft and for six days for 5000 ft levels from the morning and afternoon pilot balloon ascents.

3. Discussions

1 May 1953—The magnitude of convergence at 0200 GMT of 1 May 1953 at 3000 ft level over Gangetic West Bengal and neighbourhood is shown in Fig. 1 (a) and the wind field for the same level is shown in Fig. 1(b). Fig. 1 (e) shows the thunderstorm activity on this day. The charts for the convergence pattern for the afternoon and the change chart showing the magnitude of change in convergence values from morning to evening (hereafter called change chart) are shown in Figs. 1(c) and 1(d) respectively. It will be seen from Fig. 1(a) that Chota Nagpur, the usual soft spot or rather the starting point for the chain of thunderstorms of the pre-monsoon season which culminates into nor'westers, is in a divergent zone whereas both Gangetic West Bengal and Orissa (except the southern parts of Orissa) are in a zone showing marked convergence. The chart (Fig. 1b) showing the winds at 3000 ft also shows a discontinuity passing very near Calcutta. The easterly field which is considered to be of importance in the genesis of nor'westers, can also be seen to have encroached as far as Calcutta at this level. Besides, a weak vortex seems also to exist at this level very near Calcutta. Local thunderstorms over Gangetic West Bengal was expected according to the forecast (*vide Indian Daily Weather Report*, 1 May 1953).

It will, however, be seen from Fig. 1 (e) that there was hardly any thunderstorm over Gangetic West Bengal, the thunderstorm activity being mainly over Orissa particularly over the coastal areas.

The morning convergence pattern shown in Fig. 1(a) shows convergent (positive) values over most of Gangetic West Bengal and north Orissa which is in keeping with our forecast based on inferences made from subjective considerations. Another interesting feature in this chart is the negative values (divergence) over Chota Nagpur, the usual soft spot for the thunderstorm activity of this season. By the evening (Fig. 1 c), however, the pattern changed considerably. Most of Gangetic West Bengal, Orissa and East Pakistan, excepting the coastal strips, became a zone of divergence. This tendency which is very well depicted in the change chart showed very clearly that Chota Nagpur area which was in a divergent field was becoming more unfavourable for the occurrence of thunderstorms. The Gangetic West Bengal which was in a convergent field in the morning also showed this tendency whereas in coastal Orissa the field of convergence was becoming more pronounced. It may, however, be mentioned that the coastal Orissa presents a convex structure which would consequently induce, in view of the structure of the coastal strip, a convergent wind field in the lowermost layers due to onset of sea breeze alone and thus make this area more favourable for thunderstorm activity in the afternoon.

2 May 1953—The morning convergence chart on this day (Fig. 2 a) also shows as in Fig. 1(a) a pronouncedly divergent area over Chota Nagpur and a convergent area over East Pakistan. By the evening, however, the pattern changed remarkably—Fig. 2 (c). Divergent areas over Chota Nagpur, Gangetic West Bengal and Orissa had become convergent ; in fact the whole of northeast India outside Bihar showed positive values (convergence) on this chart. This pronounced change is clearly shown in the change chart of this day (Fig. 2 d). The streamline chart of 0200 GMT of this day (Fig. 2 b) was, however, much less favourable than on 1 May 1953 in so far as there was neither any discontinuity nor the weak vortex near Calcutta. According to the *Indian Daily Weather Report*, the forecast on this day was "a few thunderstorms" for Gangetic West Bengal and Chota Nagpur and "local thunderstorms" for Orissa. The thunderstorm development on this day shown in Fig. 2(e) over Gangetic West Bengal was, however, fairly widespread in character and rather severe in intensity.

The evening chart of convergence pattern (Fig. 2 e) and the change chart (Fig. 2 d) show a good correspondence with the areas of positive values and areas of thunderstorm.

3 May 1953—Figs. 3 (a) and 3 (c) show that Gangetic West Bengal and neighbourhood was under the influence of a convergent field on this day from the very morning and continued to be so in the afternoon. The streamline chart of the morning (Fig. 3 b) also shows evidence of a vortex over Chota Nagpur. Moreover, the important empirical relation of Gaya wind showing northeasterly during noon, a favourable indicator for nor'wester occurrence, is seen even on this chart. In line with above, the forecast for the region had been "thundershowers will be widespread in Assam, occur locally in West Bengal, Chota Nagpur......... A few thunderstorms also likely to occur in Orissa". On this day there was hardly any thunderstorm activity over Chota Nagpur and Gangetic West Bengal as will be seen from Fig. 3 (e). It is significant to note the occurrence of the thunderstorm activity over the area of an already existent convergent field which was becoming more pronounced (*vide* change chart).

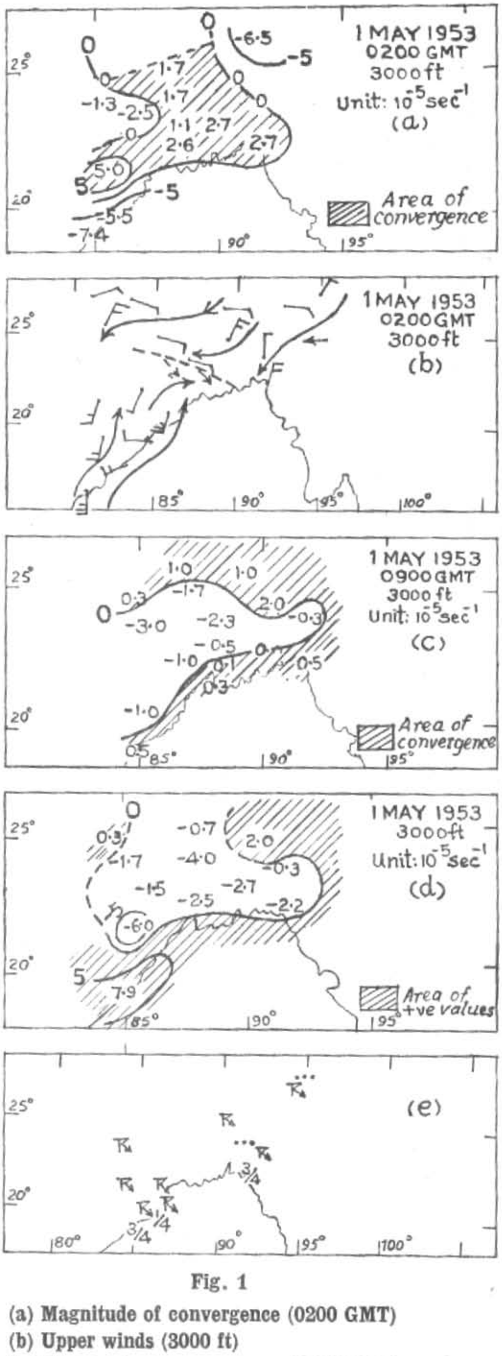

Fig. 1

(a) Magnitude of convergence (0200 GMT)
(b) Upper winds (3000 ft)
(c) Magnitude of convergence (0900 GMT)
(d) Change in convergence (from 0200 to 0900 GMT)
(e) Weather during 24 hrs ending at 0300 GMT of 2 May 1953

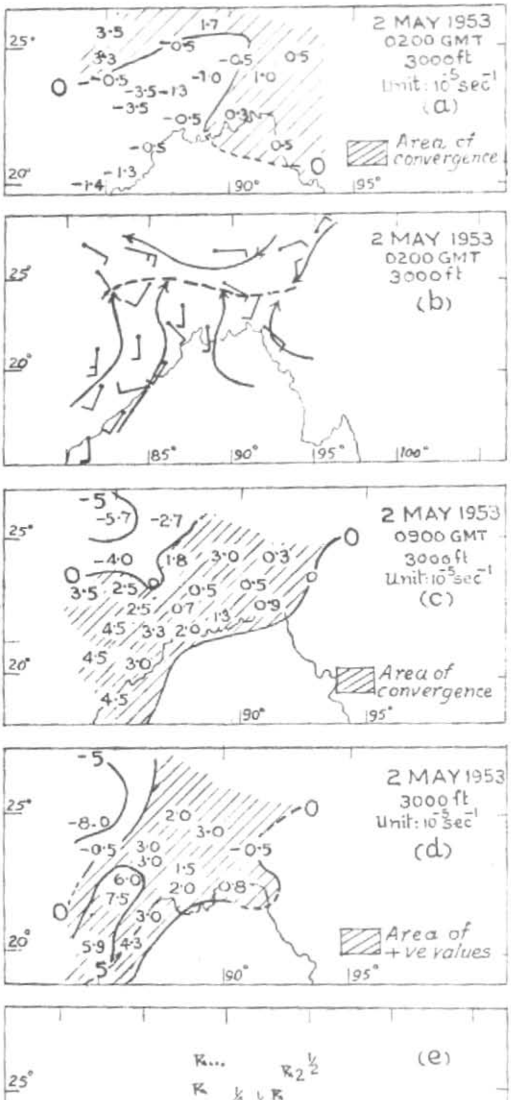

Fig. 2

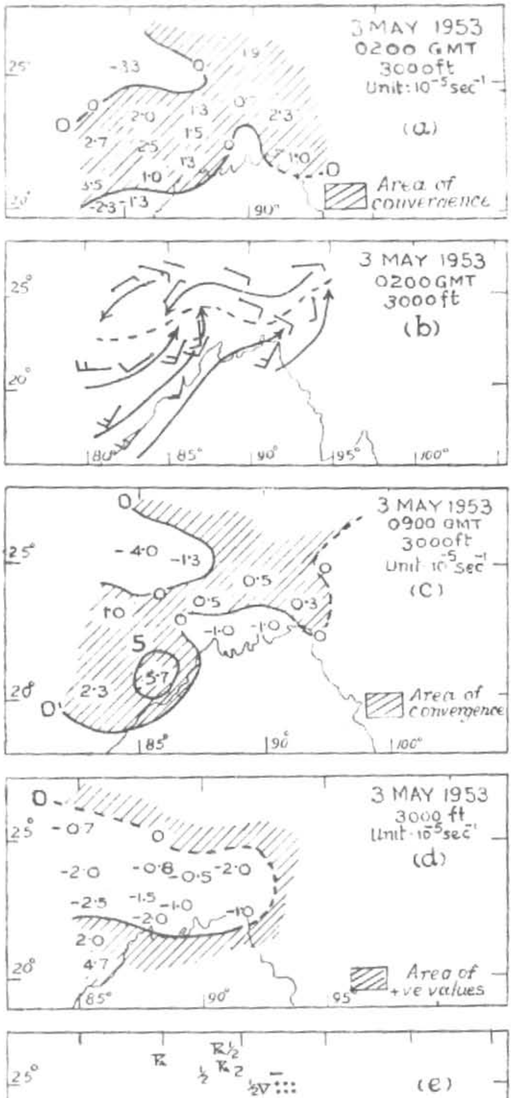

Fig. 3

(a) Magnitude of convergence (0200 GMT), (b) Upper winds (3000 ft), (c) Magnitude of convergence (0900 GMT), (d) Change in convergence (from 0200 to 0900 GMT), (e) Weather during 24 hrs ending at 0300 GMT of 3 May 1953 (Fig. 2 e) and of 4 May 1953 (Fig. 3 e)

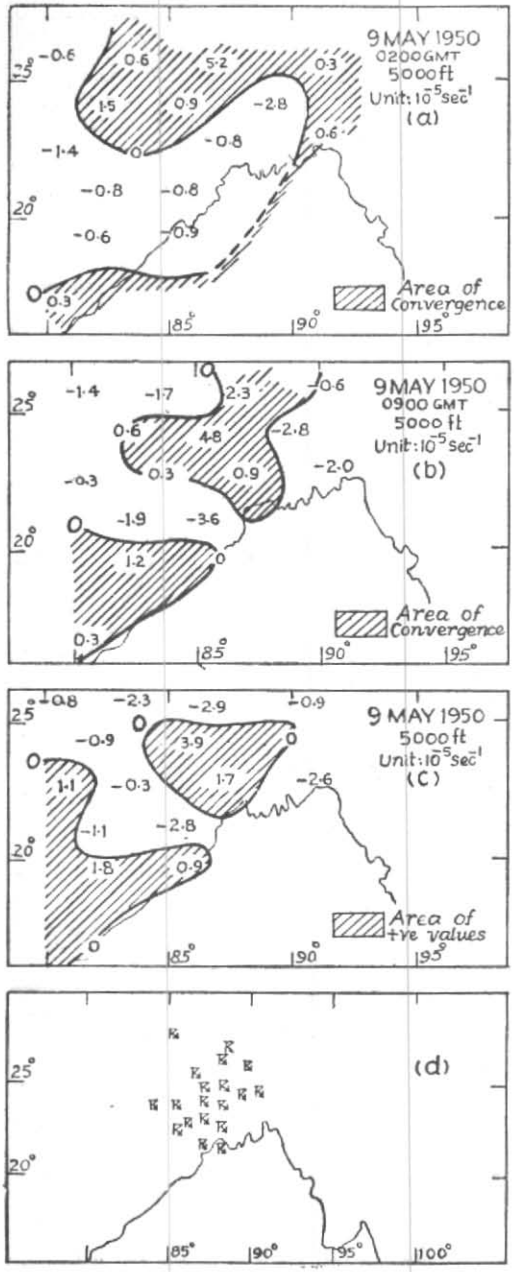

Fig. 4

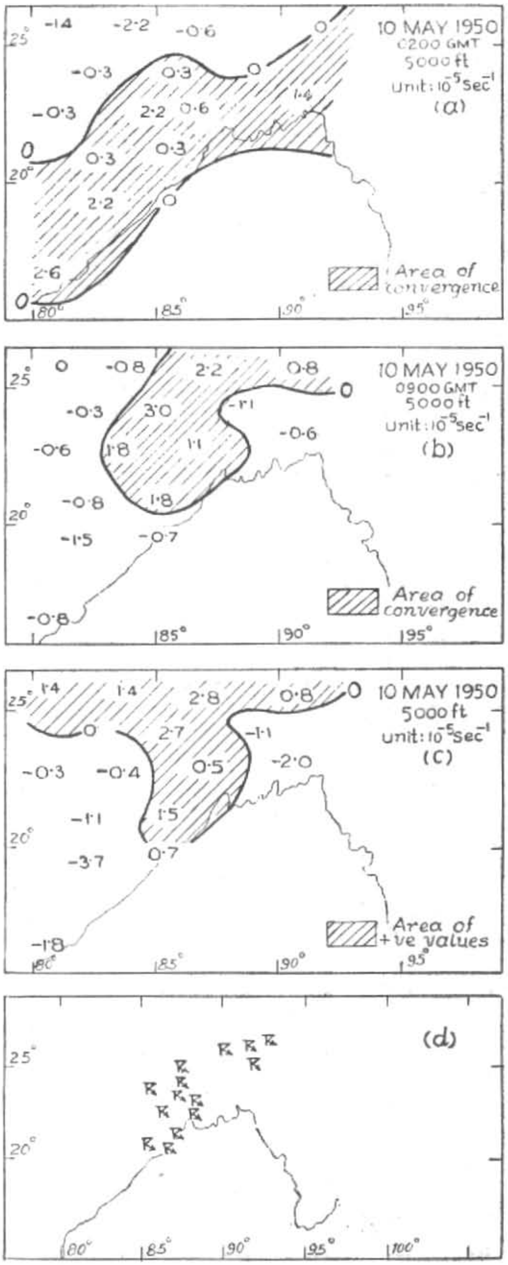

Fig. 5

(a) Magnitude of convergence (0200 GMT), (b) Magnitude of convergence (0900 GMT), (c) Change in convergence (from 0200 to 0900 GMT), (d) Weather during 24 hrs ending at 0300 GMT of 10 May 1950 (Fig. 4 d) and of 11 May 1950 (Fig. 5d)

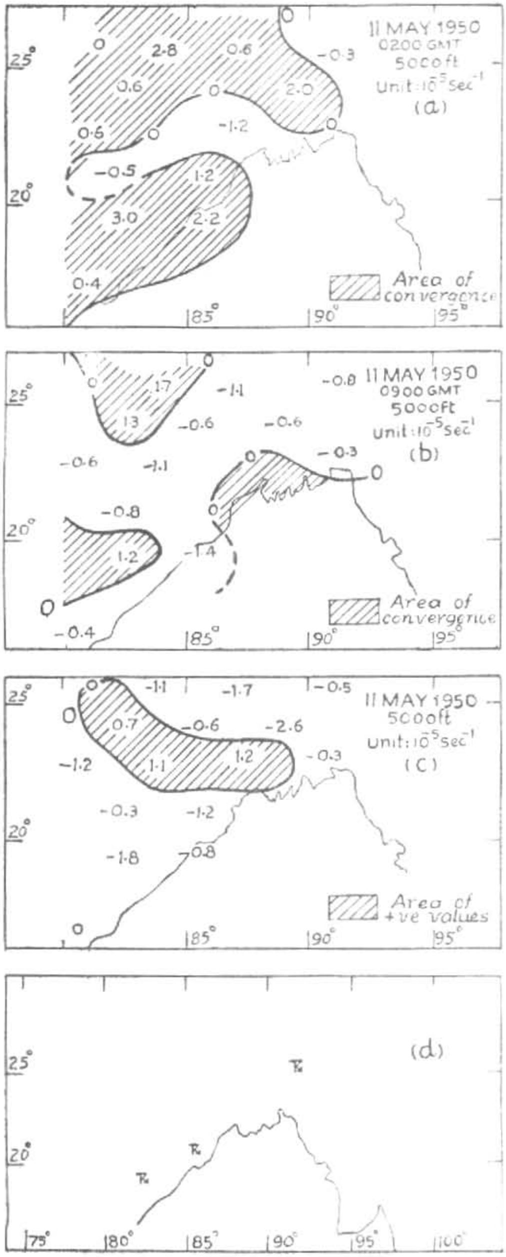

Fig. 6

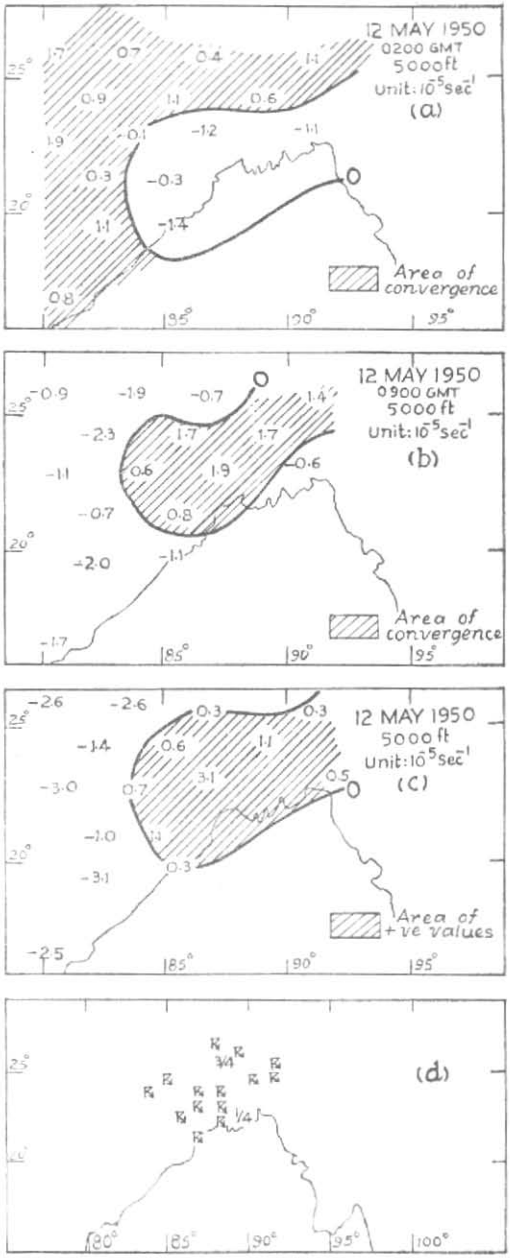

Fig. 7

(a) Magnitude of convergence (0200 GMT), (b) Magnitude of convergence (0900 GMT), (c) Change in convergence (from 0200 to 0900 GMT), (d) Weather during 24 hrs ending at 0300 GMT of 12 May 1950 (Fig. 6 d) and of 13 May 1950 (Fig. 7 d)

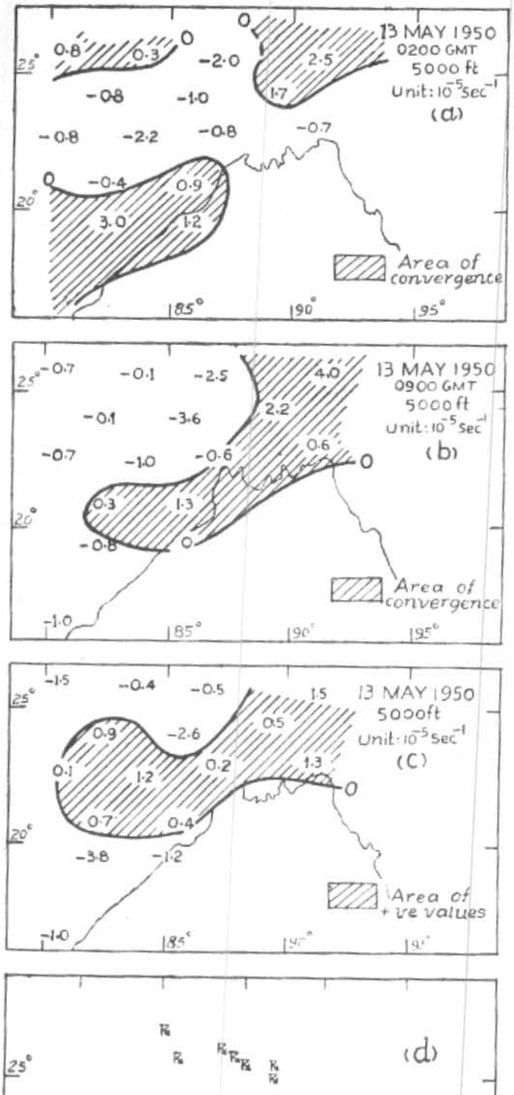

Fig. 8

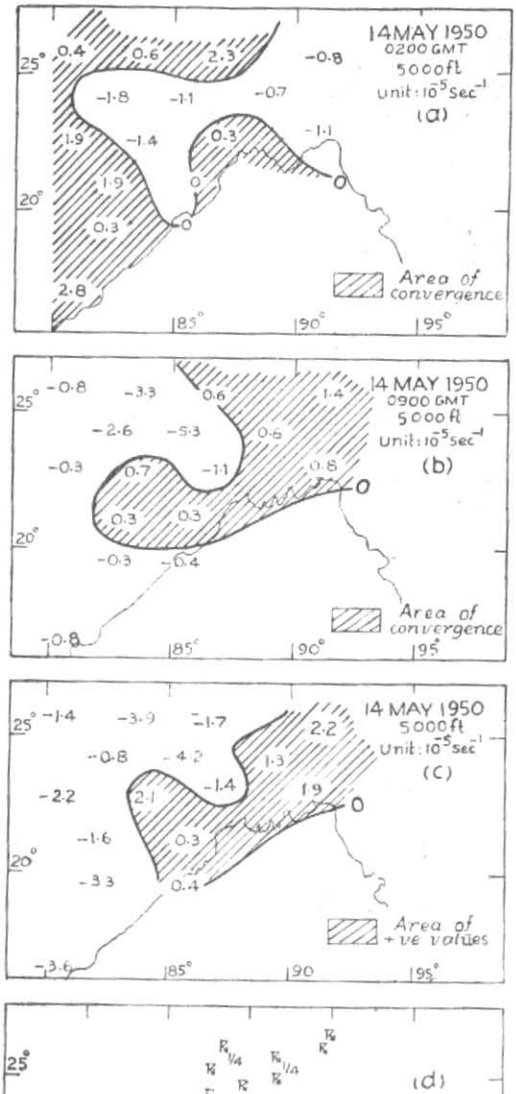

Fig. 9

(a) Magnitude of convergence (0200 GMT), (b) Magnitude of convergence (0900 GMT), (c) Change in convergence (from 0200 to 0900 GMT), (d) Weather during 24 hrs ending at 0300 GMT of 14 May 1950 (Fig. 8 d) and of 15 May 1950 (Fig. 9 d)

9 to 14 May 1950—Figs. 4 (a) to 9(d) show the relevant convergence patterns for morning and afternoon, the changes in convergence values and the thunderstorm activities for the period 9 to 14 May 1950. These figures except those on 13 May show similar characteristics as revealed by the three cases (1 to 3 May 1953) which have been discussed in more detail. On the 13th, most of the convective activity was over by 1500 IST but there was, however, a good correspondence between the thunderstorm activity and the morning convergence pattern.

4. Conclusions

The following conclusions may be drawn from the above study—

(*a*) There is apparently no significant relation between the convergence pattern in the morning and the subsequent nor'wester activity and as such, even a quantitative evaluation of convergence values from the morning pibal ascents would not be of much use in the prognosis of afternoon nor'westers.

(*b*) The lower level convergence is a necessity for the genesis of nor'westers. This is clearly brought out from the good correspondence observed between the thunderstorm activity and afternoon convergence. This is in conformity with the findings of Mull, Gangopadhyaya and George (1955).

(*c*) The fact that even with good convergence no thunderstorms have occurred in the morning shows that factors, other than lower level convergence are also, if not equally or more decisive, important in the genesis of nor'westers.

5. Acknowledgement

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