Letters to the editor

On Sub-Tropical Jet Stream and its Role in the Development of Large Scale Convention

Dear Sir,

In a recent paper, RAMASWAMY (1956) has discussed the method of forecasting more than 12 hours ahead the broad regions in which thunder in general and thundersqualls or Nor'westers and convective dust-storms in particular would develop on the basis of his studies of vorticity patterns at 500 and 300 mb levels.

The writer of this letter would like to present the following points in connection with the claims made by Ramaswamy in the above-mentioned paper:

(i) It is known that Nor'westers and dust-storms in northern India and Pakistan *are most frequent generally late in the afternoons or evenings* in the plains and that only *a small number occurs at other times of the day or night;* this has also been stated by RAMASWAMY (loc. cit.). According to the instances quoted by Ramaswamy in his paper, the mass divergence associated with upper tropospheric vorticity patterns at 500 and 300 mb levels on the evening of any particular day is responsible for the Nor'westers and dust-storms in northern India and Pakistan during the 24 hours after the next morning. On referring to the synoptic charts, it is seen that a large number of the dust-storms and Nor'westers shown in Figs. 10 to 14 of his paper had occurred during the 6 hours or so in the afternoon or evening of the next day, i.e., after about 20 hours of the upper vorticity patterns in question. One should have expected the dust-storms or Nor'westers to occur over any particular area throughout the period of existence of such upper tropospheric vorticity patterns at all times of the day in stead of only after about 20 hours of their appearance and that too being most frequent in the afternoon or evening. Further, as seen from the synoptic charts, the upper vorticity patterns in question have on the illustrative occasions chosen by Ramaswamy, actually moved eastwards as seen from changes in wind directions by the time the phenomena developed over the areas in question. It would thus appear that some agencies in the lower troposphere particularly operative in the afternoon and evening over those areas play a vital role in the majority of dust-storms and Nor'westers although the existence of divergence in the upper troposphere would undoubtedly, under certain circumstances, help in the extension or intensification of the phenomena.

It is considered that it would be more appropriate to associate the upper tropospheric vorticity patterns on any evening with the weather produced during the 24 hours of that morning to the next morning, evening being about the mean time of the period, than with that produced during the 24 hours period after the next morning as done by Ramaswamy; but, by doing so, the utility of the evening patterns in forecasting 12 hours or more ahead as contemplated by him may not be directly recognised except through the persistence or slow movement of the patterns.

(ii) If the usual inversion at a height of about 5,000 ft. is destroyed by the large scale divergence in the upper troposphere which favours mass convergence in the lower troposphere as shown in Fig. 29 b of Ramaswamy's paper and not by insolation etc. (Fig. 29 a), one would also expect the Nor'westers to occur equally at all hours of the day and not particularly in the afternoons and evenings. Sounding balloon and radio-sonde ascents have shown that on many days of intensive activity of Nor'westers the inversion in question is noticed to persist practically till about the time of occurrence of the Nor'westers. The inversion would appear to be broken up mostly due to the effect of insolation (DESAI and MAL 1938; DESAI 1950) rather than due to large scale divergence in the upper levels giving rise to mass convergence in the lower levels.

It has also been stated that with large scale convergence in the upper troposphere and divergence in lower troposphere, there will be strong downward

motion of the dry air above the inversion and spreading of the moist air below it, which will probably intensify the already existing inversion. This has yet to be supported by actual observations when there is fair weather over northeast India. Further, it is considered that downward motion will be gentle and extensive rather than strong and localised as contemplated by Ramaswamy.

From what has been stated above, it will be seen that the claim made by Ramaswamy that one can forecast, more than 12 hours ahead, the broad regions of thundersqualls or Nor'westers and convective dust-storms on the basis of vorticity patterns in the upper troposphere at and above 500 mb level is not justified although the same will undoubtedly cause extension or intensification of these phenomena under certain circumstances.

Poona, June 5, 1956.

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REFERENCES.

DESAI, B. N., 1950: Mechanism of Nor'westers of Bengal, *Indian J. Met. & Geophys.*, **1**, pp. 74—76.

DESAI, B. N., and MAL, S., 1938, Thundersqualls of Bengal, *Gerl. Beitr. z. Geophysik*, **53**, p. 285.

RAMASWAMY, C., 1956: On the sub-tropical jet stream and its role in the development of large scale convection, *Tellus*, **8**, pp. 26 – 60.

Reply

Dear Sir,

Most of the points raised by B. N. Desai in the above note have already been discussed by the present writer in his paper ((RAMASWAMY, 1956). However, the following very brief remarks are offered for the purpose of clarification: —

(a) Desai's note would give the impression that the author does not attach any importance to the local factors such as insolation, nocturnal valley convergence, orographic influences etc. in the development of large-scale convection. This is not so: these factors do play a part in the development. The main thesis of the author, however, is that these local factors are either a constant feature (e.g. orographic effects) or are often present during fair weather as well as severe convective weather (e.g. insolation and nocturnal valley convergence) while, in contrast, upper level *divergence* is invariably present during occasions of large-scale convection and upper level *convergence* prevails during unusual spells of fair weather. In other words, upper level divergence seems to be an 'invariable factor' in the development of large-scale convection while insolation, valley convergence etc. appear to be "local perturbing factors" of the lower troposphere which determine, when coexistent with upper divergence, the times of occurrence of violent convection. These are the reasons which have led the author to conclude that large-scale convection is 'overwhelmingly determined' by the upper divergence field (see pages 26 and 54 of the original paper).

(b) Desai's note may give the impression that the upper air systems illustrated in figures 10—14 in the paper moved away eastwards during the subsequent 24 hour-period and that the convective developments shown in these figures actually took place when the vorticity systems referred to by the author were not present. Considerations of space do not permit the author to publish in this reply the charts for the 3 subsequent days referred to. All that the author would state here is that the eastward movement of the systems on these occasions was small and was, in any case, much slower than the movements of high-level systems usually observed in middle latitudes. It may be incidentally added that it is the slow movement of upper level patterns which seems to provide adequate time for the transmission of the associated upward motion to the lower parts of the troposphere.

(c) One of the important objectives in this investigation was to find out a significant scientific criterion for forecasting large-scale convection over Indo-Pakistan. As stated by Desai himself, there would have been no scope for achieving this objective if the synoptic hour for the high level flow patterns had been chosen as suggested by him. Regarding the other reasons which led the author to choose 09/15 GMT hours of the previous day for the high level patterns, the reader is referred to the original paper (pp. 30 & 31). It will also be quite relevant to mention in this connection that an extensive chart showing the sea level pressure changes in *24 hours* ending at 03 GMT is used on a routine basis by the Indian forecasters along with the 03 GMT sea level chart for prognosticating weather and pressure systems during a period of