

## ABNORMALLY DRY AND WET WESTERN DISTURBANCES OVER NORTH INDIA

BY S. L. MALURKAR

(Poona 5)

WESTERN disturbances which produce rain in winter months in N.W. India are of great importance in agriculture, particularly for wheat in the Punjab. Some of the western disturbances give well-disturbed and abundant rain over the area, while others pass away without giving appreciable rain or even go dry. The obvious mode of explanation of the difference, by the insufficiency of moisture supply, begs the question to a certain extent. Upper air circulations due to the two western disturbances may *at first sight* appear to be similar (particularly when the extent of the weather charts is limited); but the resulting effects are widely different. A criterion was arrived at and used by the author for help in furnishing medium-range forecasts to agriculturists and aviators who need short-range forecasts.<sup>1</sup>

Western disturbances over India are due to the passage of complex low pressure areas or waves over North India under the influence of extra-tropical depressions. These areas, if dealt as such, are not easily understandable either as regards their effects or their motion. A simple method would be to treat the complex

low pressure area as composed of a number of simple low pressure areas or successive secondaries with distinct identity and circulation.<sup>2</sup> All these secondary low pressure areas travel in an almost east-northeasterly direction, and in the course of the travel one or more of them may fill up or sometimes intensify. The upper air circulation and rain are due to the combined or resulting effect of the various secondaries at a place. When a primary extra-tropical cyclone passes at a higher latitude, the secondaries form at certain places, which are favoured by orography and the distribution of land and sea.<sup>3</sup> Some of these favoured places (with reference to India) are: the coastal region west of the Nile river; upper of south Egypt; Sudan and Red Sea; Gulf of Aden and the Oman Peninsula; North Arabian Sea off Mekran; East Arabian Sea off Kathiawar and Konkan; and occasionally the head of the Bay of Bengal. The lesser component of earth's rotation in the tropics compared with the higher latitudes probably needs that the secondaries form only when favoured by orography. The secondaries that develop in lower latitudes

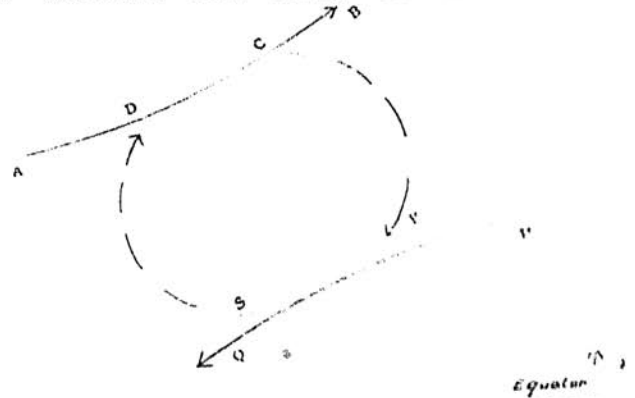
(Sudan, Red Sea, off Mekran or off Konkan) affect India, and lack of rain in N.W. India would mean that the particular secondaries were not fully developed.

In the first three or four days of April 1944, a very active western disturbance passed over N.W. India and the rain it produced resembled a day when the S.W. monsoon extends to N.W. India. But it dried up in the course of the next couple of days and hardly showed the activity in N.E. India which one expected. From the clouding and other features, the disturbance could be located in Deltaic China on the 8th. In South Indian Ocean east of Madagascar, a deep depression was found on 7th, and it had moved from the east. Similarly in January 1945, the rainfall which was fairly good in N.W. India during the first ten days of the month fell off rapidly, and simultaneously a depression could be located in S. Indian Ocean. Due to depressions in S. Indian Ocean which formed in quick succession and moved westwards, there was a dry spell over N.W. India during the greater part of the next four or five weeks. It was, therefore, deduced that western disturbances were not quite active or even passed dry when there was a deep depression south of the equator (but not too far south and not widely separated in longitude)<sup>1</sup> or when the seasonal low pressure area south of the equator was more marked than usual. A tentative explanation of the mechanism involved in drying up the northern disturbance based on divergence and subsidence was given.<sup>4</sup> The dynamics of the process can now be given in relation to other known phenomena.

Just north of the equator, in the lower levels of the atmosphere, there is an easterly or east-northeasterly flow of air (N.E. Trades). At higher latitudes, there is a westerly or west-southwesterly stream. (The higher levels are not immediately under consideration.) The easterly winds become stronger when fresh 'pulses' or low pressure areas travel from the east and cross the equator to feed a southern cyclonic storm or a depression. The westerly winds at higher latitudes feed into the western disturbances or their secondaries as tropical air (T) and may strengthen (see Fig. PQ easterly, AB west-southwesterly). When there is such a juxtaposition in the northern hemisphere—an easterly at a lower latitude and a westerly at a higher latitude—the high pressure area in between divides itself into cells of high pressure, or a series of anticyclones. When there is no disturbance to the north or south of it, the anticyclone may be described as stationary in intensity and in approximate position (CRSD). The subsidence would be small and the air in it generally stable.

If the wind stream PQ becomes stronger due to a cyclonic storm south of the equator and the passage of 'pulses' from north to the southern hemisphere, the anticyclone becomes a developing or an increasing one. There would be a tendency for an increased flow of air along CR. The flow along SD may also be slightly increased, but as the passage of 'pulses' is almost explosive across the equator (shown by the squalls and thunderstorms) this point

may be considered later. For the stream AB, the increased flow along CR would mean



divergence, one an actual due to separation from the original stream and the other one due to descent in latitude. Due to these two effects, the air gets very stable. As the rate of subsidence is greater in a developing anticyclone than in a stationary one as shown by Napier Shaw, the air in the anticyclone would be greatly stabilised. If there be a secondary of a western disturbance to which the stream AB is feeding, both the currents CB and CR speed up and may result in greater divergence. When N.E. Trades get stronger due to the fact that 'pulses' are feeding into a southern tropical cyclonic storm or depression or due to an intensification of the southern monsoon low, the air mass (along AB) that would normally have gone to feed the secondary of a western disturbance is attaining great stability and produces little weather in the shape of precipitation. If the southern depression is too far south of the equator (when no 'pulses' feed it from the north), or when it is widely separated longitudinally, the effect on the particular anticyclonic cell would be less, and it can be assumed that the western disturbance is not being affected from the southern hemisphere.

Regarding subsidence on a large scale in Peninsular India, the surface observations at the higher hill stations (Dodda-betta, Coonoor, Kodaikanal) show it by the very low humidities observed on some winter days there.<sup>5</sup> Hahn<sup>6</sup> has given instances of very low humidity at hill stations in Dutch East Indies (Sumatra, Java, etc.). With the help of Radiosonde observations in these days, it is possible to actually notice subsidence at higher levels of the atmosphere over a wider area. There would not be any definite time sequence in the subsidence observation. The dot diagram<sup>5</sup> connecting the extreme dryness at Kodaikanal and the inversion layer at Poona (found by sounding balloons) is almost contemporaneous.

The sudden clearing up of the sky in Central parts of India when there is a depression south of the equator is so striking that a forecaster with a big chart can hardly escape noticing it.

Regarding the increased flow along SD due to the developing anticyclonic cell, though there is divergence in the easterly stream, there is also a latitudinal convergence as it is gaining in latitude. It is likely that some weather can be expected to the west of the

anticyclonic cell. This may perhaps account for some of the rain in the extreme south Peninsula when a southern depression is passing fairly near the equator.<sup>7</sup>

The 'pulses' or low pressure areas that travel from the east to feed the southern depression are not entirely unaffected by the secondary of the western disturbances over India. The western disturbance might 'pull' the low pressure area towards it and delay and occasionally prevent its crossing into the southern hemisphere. Whether the 'pulse' or low pressure area would be pulled towards the low of the western disturbance or to the southern depression depends very much on the relative intensities and positions of the tropical and extra-tropical depressions. The non-crossing of the 'pulse' to the southern hemisphere would create a 'break' in the monsoon there, weaken the depression and might sometimes kill or allow the depression to recurve.<sup>8</sup>

In the event of the western disturbance 'pulling' the low pressure area from the east to west even temporarily, the anticyclonic cell would once again be developing. The stream QSD which leaves the easterlies PQ is gaining in latitude and sometimes would cause weather; to the west of the anticyclonic cell there could be weather due to latitudinal convergence. But if it happens that the low pressure area or 'pulse' is not allowed to cross the equator at all, then there would be a general flow of the stream PQ along SD. In such an event, the resulting convergence would be more pronounced and the rainfall due to the secondary of the particular western disturbance which gets this feed would be greater than usual.<sup>9</sup> Such a contingency (the 'pulse' or the low pressure area not crossing to the southern hemisphere) can arise if the southern depression was filling up or recurved to an easterly direction.

On the other side of the developing anticyclonic cell CR, there would again be stability in the air along the region and the easterly side would be dry. (Rao Bahadur M. G. Subramanyam used to mention a belief held in Rajputana that there would be no rain in North Rajputana in winter so long as there was rain in S.E. Madras, and it is likely that the above is an explanation.)

Hence it follows:

(1) When there is a cyclonic storm in the

South Indian Ocean moving from east to west and it is expected to continue strong or intensify and expected to retain a westward motion, it is safe to tone down the amount of rain due to a western disturbance in Upper India (the longitudinal separation must not be too much between the cyclonic storm and the western disturbance).

(2) When the southern cyclonic storm in the S. Indian Ocean is expected to fill up or recurve towards an easterly direction and the 'pulses' or low pressure areas from the east continue strong north of the equator, the western disturbance gives more rain than usual.

A similar criteria can be used at other places. When the N.E. Trades (in the northern hemisphere) which have had a sea travel continue to be strong, the extra-tropical depression just above that latitude would be more active or less active according as the N.E. Trades feed into or away from the depression. The extreme case of the situation is a recurved tropical cyclonic storm, which can give abundant rain or weather. The cyclonic storm recurves when the equatorial maritime air is cut off and the storm is guided by an extra-tropical depression in a higher latitude. In other words, the recurved depression can be considered as a secondary of the extra-tropical depression, which has had a good N.E. Trades feed. Such a criterion would be particularly useful in the Pacific Ocean.

1. S. L. Malurkar, "Forecasting Weather in and Near India," May 1945, p. 108 2. *ibid.*, pp. 101-04; also Tech. Notes, *Ind. Met. Dept.*, No. 1, p. 3. 3. Forecasting Weather, *loc. cit.*, p. 20. Tech. Notes, *ibid.*, No. 20. 4. Forecasting Weather, *loc. cit.*, pp. 106-07. 5. "Sci. Notes," *Ind. Met. Dept.*, 4, p. 137 *et seq.* 6. Hahn, "Handbook of Climatology," Macmillan & Co., 1908, p. 200. 7. Forecasting Weather, *loc. cit.*, p. 99. 8. *ibid.*, p. 95; and also *Curr. Sci.*, 1946, 15, 11, 9. "Forecasting Weather," *loc. cit.*, p. 111.

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