551·515·21 (267) "1963·05 20-29"

ON SOME ASPECTS OF THE TROPICAL CYCLONE OF 20-29 MAY 1963 OVER THE ARABIAN SEA

Colon, Raman and Srinivasan (1970) have published a paper on the above subject in this journal. It may be stated that Mazumdar (1965) has discussed this cyclone. Using data presented by Mazumdar and other additional data, Desai (1967a) has published in this Journal a paper entitled 'On the formation, direction of movement and structure of the Arabian Sea Cyclone of 20-29 May 1963'. It would appear that Colon *et al.* have not seen either the paper of Mazumdar (1965) or of Desai (1967a) as no reference has been made by them to these two papers.

As the author has studied this particular cyclone as well as other cyclones in the Indian Seas (Mal and Desai 1931; Desai and Mal 1933; Desai and Basu 1933; Basu and Desai 1934; Desai and Rao 1954 a,b) he would like to make the following remarks on some of the points mentioned in the paper of Colon *et al.*

(1) It is the experience of the author that the streamlines method of analysis gives exaggerated pictures and leads to unwarranted inferences in some cases and omission of some vital points in others (Desai 1967 b, 1970 a, b). Usefulness of streamlines method of analysis has *not* yet been established in India on the basis of its use in day-to-day work in operational offices of the India Meteorological Department.

(2) According to Colon *et al.* the cyclone struck the Arabian coast near Lat. 17°N, Long. 55°E on 25 May and then recurved southwestwards. This conclusion is *not* correct as shown by Desai (1967 a). The cyclone passed to the east, south and southwest of Salalah as seen from its winds. The lowest pressure recorded at the station was only 991·7 mb at 12 GMT of the 26th against the lowest pressure at the centre of 947 mb on the 24th and 945 mb on the 27th. The station was affected only by the outer storm area.

(3) It is stated that no direct information on the intensity of the cyclone was obtained after 24 May. While this statement is correct with reference to RAF reports, it may be stated that an RAF reconnaissance aircraft flew on 27 May from Aden to the cyclone field and back and reported *lowest pressure of 945 mb near Lat. 16·0°N, Long. 52·7°E on that day.*

(4) *There were definite evidences of the continental and maritime air masses in the cyclone field.* The approximate positions of boundaries between the air masses at the surface at 12 GMT of the 26th are given in Fig. 2 of Desai's paper (1967 a). During May the continental air is warmer at the surface than the maritime air, but as a result of differences in lapse rates in the two air masses, it becomes colder than the latter above a certain level called the 'reversal level'. As a result, the structure is complex below the reversal level; a reference is invited to Fig. 3 of Desai (1967a) in which is given vertical cross-section showing distribution of rainfall at the surface in the continental and maritime air masses. Approximate vertical cross-section at about 1400 GMT of 27 May between Aden and Salalah when the cyclone was still of severe intensity utilising RAF aircraft flight data, upper winds at Aden and Riyan and surface data of Salalah, is given in Fig. 4 of Desai's paper (1967a).

(5) It is seen from the winds and pressure data given by Colon, *et al.* that *the cyclone had asymmetric structure.*

(6) They have stated that an interesting feature of the radar bands distribution on the 22nd is that they were located in the left and front quadrant of the circulation, with a radar void sector on the right and right-rear quadrants, while in tropical storm developing in the trade wind belt of the Atlantic Ocean, it is more common to see the main bands curving around the centre on the right side of the circulation. It is considered that the differences in the radar bands distribution in the two cases might be due to the fact that the continental air in the Atlantic Ocean trade wind belt region where storms develop might not be hottest at the surface as over the Arabian Sea in May. It is possible that in the post-monsoon cyclones where the continental air is *not* the hottest at the surface, radar bands distribution of the type in Atlantic storms might be found in the cyclones in the Bay of Bengal and the Arabian Sea.

(7) While discussing changes observed in the radar photographs of 22 May (Fig. 23) and 24 May (Fig. 28) Colon *et al.* have stated that it is not known with certainty whether the changes occur as an evolutionary continuous process from one form to the other, *i.e.*, from 22nd to 24th type, or by a revolutionary discontinuous process of disintegration and reformation. They have also stated that most probably it is the second one. From what has been stated by Basu and Desai (1934) regarding fronts and air sectors in the inner storm area, it is felt that the changes in the radar photograph of the eye of the cyclone from the 22nd to 24th might be a continuous and *not a discontinuous* process of dissipation and reformation.

(8) Regarding Colon *et al.*'s statement that intensification of the cyclone did not occur until the system had moved 10° away from the equator and that cyclogenesis at positions close to the equator is a rare occurrence, a reference might be made to papers of Desai and Mal (1933), Desai and Rao (1954 a, b) and Desai and Basu (1933) from which it would appear that *both during May and November cyclones did form with centres to the south of Lat. 8°N.* The main thing which decides the location of formation is the position of the trough which can be even south of 10°N and its coming under various influences which have been mentioned by Desai (1970 c).

(9) *Direction of movement of the cyclone* — Colon *et al.* have used 500 and 200-mb level charts as those levels are most commonly used in the Atlantic area to follow hurricane motion and intensification, the flow at 500 mb being found useful to forecast motion and at 200 mb to forecast intensification. In this connection it may be mentioned that *it is our experience that all the levels at 500 mb and above upto 200 mb can be used discriminatingly for both intensification and direction of movement* (Desai and Rao 1954 a). Baghare and Datta (1970) have stated that for the Bay cyclones upper tropospheric winds *upto* 200 mb in the vicinity of the centre are useful for prognostication of the movement; in some cases they found 300-mb level more useful than 200-mb level. Ramamurthi and Keshavamurthy (1964) also found 300-mb level more useful than 200-mb level.

(10) The Tiros observations in this case of the Arabian Sea cyclone *were found very useful* (Table 2 of Desai 1967 a) in forecasting the direction of movement northwestwards at first and southwestwards later.

(11)* *Dropsondes data of 24 May (Fig. 31 of Colon et al's paper)*—The data show very high humidity and unstable lapse upto about 825 mb, mainly isothermal layer above upto 675 mb with high humidity upto about 775 mb and relatively lower humidity above upto about 600 mb, nearly dry adiabatic lapse between 675 and 600 mb and saturation adiabatic lapse from 600 to 500 mb. Although sounding was recorded during the pass across the eye at 500 mb, it is probable that it drifted from the eye during its journey to the sea level as a result of violent winds all around and might have entered even the outer storm area. This would mean that the data may *not* represent conditions at the centre; further down, the data would represent conditions only around the eye at various distances from the centre, being farthest away from the centre at the sea surface. *In view of this it can be stated that there was maritime air upto about 825 mb. continental air above upto about 600 mb and maritime air again between 600 and 500 mb.* This would support the view that in the outer storm area there might be a 'nose' of continental air mass between lower and upper moist air mass (Fig. 3 of Desai 1967a). The near isothermal layer was probably produced due to cooling of the continental air by the rain falling through it.

(12) It is stated that perhaps one other factor which had a significant bearing on the behaviour of the cyclone was the topography over the Arabian coast. In this connection it may be mentioned that as pointed out by Desai (1970 c) the Western Ghats affect the path of the cyclones in the east Arabian Sea and the Eastern Ghats and the Arakan mountains of the cyclones in the Bay. Topography also prolonged duration of rainfall over Salalah on the Arabian coast (Table 3 of Desai 1967 a).

(13) Subsidence occurs in the Indian cyclones (Desai and Rao 1954 a). It occurred in the forward portions of cyclone at Veraval to the northeast of the centre at a distance of about 200 km from the centre, the subsiding air coming from the inner storm area as could be inferred in the November 1948 Bombay Cyclone. In the 1952 May Cyclone in the Bay of Bengal there was subsidence at Vizagapatam on two days to the northeast of the severe cyclone at a distance of 350-450 km from the centre, the cyclone moving northwestwards on the first day and northwards on the second day.

In May 1963 Arabian Sea cyclone available data would *not* show subsidence in the inner or outer storm area of air originally risen in the central area.

Note added later :

It may be mentioned that the nature of temperature and dewpoint curves of the sounding on 24 May 1963 in the eye at 15°N, 63°E in Fig. 31 of Colon *et al.*, is about the same as of the curves of the soundings on 2 July 1963 at 14°N, 57°E and 19°N, 63°E given in Fig. 1 of Desai (1970 a), *i.e.*, maritime air in the lower level and continental air above with an inversion of isothermal layer between the two and moist air again between about 550 and 500 mb, the latter two soundings being far away from the cyclone centre near 19°N, 71°E. The dewpoints in the continental air were higher on 24 May 1963 than on 2 July 1963 due to the same being humidified by evaporation of rain falling through it, there being heavy rain at about the time of the soundings on 24 May 1963 as mentioned by Desai (1967 a). Thus the three soundings represent characteristic air mass conditions of that part of the Arabian Sea, the soundings on 24 May 1963 also representing conditions in the continental air in the outer storm area of the cyclone as modified by rain falling through it. The conditions over the Arabian Sea during April to September are such that there can be continental and maritime air masses, the former being hottest at the surface but becoming colder than the latter above a certain level-reversal-level due to a difference in the lapse rates in the two air masses; the continental air mass over the pacific and Atlantic Oceans may not be the warmest at the surface and the ideas about the structure of cyclones over those areas cannot beapplied without modification to the Arabian Sea cyclones as mentioned by Desai (1970 b).

(14) Desai (1970 c) has given a comprehensive review of the various factors associated with the formation, intensification and direction of movement of depressions and cyclones both in the Arabian Sea and the Bay of Bengal during the months, April and May and November to January as well as in the transitional month October. A reference to that paper will give an idea about the work done in India on the cyclones in the Indian Seas and their characteristics. An important point to remember is that there are definite evidences of air masses in the field of the disturbance although in severe cyclones due to rapid dissipation and regeneration of fronts and air sectors in the inner storm area due to violent winds characteristic weather and rainfall associated with the fronts noticed in the outer storm area, may not be noticed (Desai and Basu 1933; Basu and Desai 1934). Further, as during the months April and May the continental air is the hottest at the surface over the Indian Seas in contrast to November to January when it is coldest at the surface as in the middle latitudes, the characteristics of weather are not the same at the different fronts at the surface during the two periods. During April and May the continental air becomes colder than the maritime air only above 'reversal level' above which an upglide surface of the warm front type is noticed due to spreading of warm moist air over it; below the reversal level the warmer continental air spreads over the cool maritime air giving rise to 'dry warm front'.

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REPLY

Dr. Desai's remarks concerning the paper on the 1963 Arabian Sea cyclone of which I was a co-author, contain opinions that may well be valid, and pertinent, even though contrary to views that I have held for some time. In other points raised, we have no basic disagreement.

First, it is quite correct that the previous discussions on this same cyclone by Dr. Desai (1967 a) and by Mazumdar (1965) were unknown to me. I regret the fact, which I hope to remedy soon. There was no attempt on my part to ignore their contributions.

The following specific comments are made in regard to similar numbered remarks of Dr. Desai.