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Satellite study of the cyclonic storm activity in the Indian Seas between 24 September and 5 October 1966

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ABSTRACT. The last week of September and the first week of October 1966 were characterised by the formation and movement of intense tropical disturbances over the Indian Ocean area in both the hemispheres. An uninterrupted sequence of satellite data for a storm season was for the first time available to Indian Meteorologists through the APT subsystem Satellite data combined with ships' observations showed the simultaneous existence of two cyclonic disturbances in the Bay of Bengal. Absence of well-defined cloud bands and striations in some of these storms and rapid extension of clouds towards northeast when storms recurve under influence of upper westerly trough as indicated in satellite pictures are discussed.

1. Introduction

A mention has been made in an earlier issue of this journal (Vol. 17 No. 3, July 1966, page 510) about the reception of cloud pictures from ESSA II and NIMBUS II satellites at the APT ground station, Bombay. The reception of pictures from ESSA II continues to be good. NIMBUS II pictures are even better and show greater resolution of the features. Bulletins giving salient features of each of the pictures are distributed as a routine to all the forecasting offices in India on an operational basis.

The last week of September and the first week of October 1966 were characterised by the formation and movement of intense tropical disturbances over the Indian Ocean area in both the hemispheres. During this period, the satellite information enabled the analysts to locate the cyclones and track them in the data-sparse south Indian Ocean and also showed the simultaneous existence of two disturbances in the Bay of Bengal on 28 and 29 September. In the brief note that follows, the history of the storms is illustrated with relevant satellite pictures and the usefulness of these pictures in the analysis of weather charts, in conjunction with conventional data, is pointed out. In all, there were five disturbances — two in the southern hemisphere, one in the Arabian Sea and two in the Bay of Bengal. In the final stages, however, the two storms in the Bay of Bengal merged into one. The tracks of all the storms except one in the southern hemisphere are shown in Fig. 1. This period of active cyclogenesis was preceded by a strengthening of equatorial westerlies in the lower troposphere. The seasonal trough became marked and at 850-mb level it extended from the south Andaman Sea to the east Arabian Sea with its axis roughly along Lat. 10°N to 12°N. The satellite pictures during this period showed east-west oriented heavy clouding over large oceanic areas in the near-equatorial region of both the hemispheres.

2. Disturbances in Bay of Bengal

On 24 September, a low pressure area was noticed east of Nicobar Islands. It moved gradually westnorthwestwards and was 250 km southwest of Car Nicobar on 26th morning. The winds in the periphery of the circulation were stronger than the winds near the centre as indicated by Car Nicobar and Port Blair 1·5 km winds at 12 GMT on 26th. (Car Nicobar — SE'ly 15 kts, Port Blair E'ly 30 kts). This is typical of the wind field in pre-storm stage. Nimbus APT pictures* (orbit No. 1783, time 0545 Z) for 26th (Fig. 2) shows the clouding associated with this disturbance. The long curved cloud band continuous over a length greater than a semi-circle, starting from 15°N, 95°E and curving cyclonically upto 7°N, 95°E, through 12°N, 88°E, is indicative of the commencement of the organisation of the circulation.

The pronounced shift of the lower tropospheric winds over Port Blair from strong easterlies to strong southwesterlies between 27th and 28th indicated that the disturbance moved to north of Port Blair latitude. It was centred near 12·5°N, 90·5°E on 28th morning when it intensified into a cyclonic storm. The marked strengthening of Akyab low-level winds to ESE'ly, 25–35 kts on 29th morning, as well as the location of a vortex near about 16°N, 91°E by the satellite led to the conclusion that the storm moved in a northnortheasterly direction between 28th and 29th. During this period another depression formed in the west Central Bay of Bengal with centre near about 13°N, 85°E on 28th morning. It also moved in

*Note — Latitude and longitude lines given on the APT pictures are those as gridded for operational use

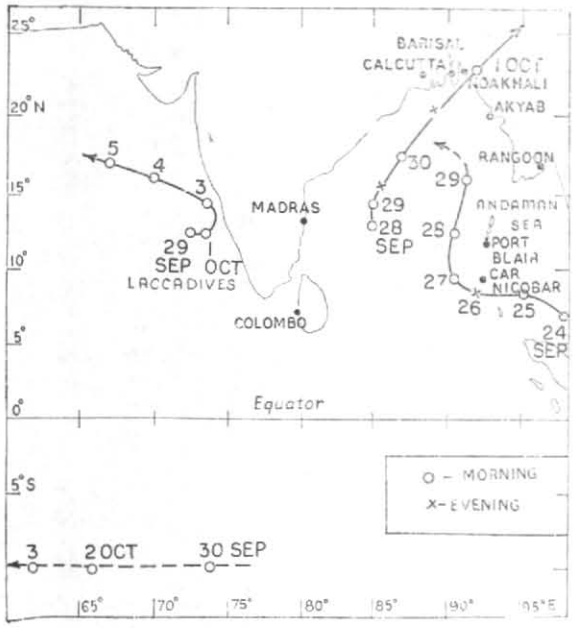

Fig. 1. Tracks of storms during the period 24 Sep to 5 Oct 1966

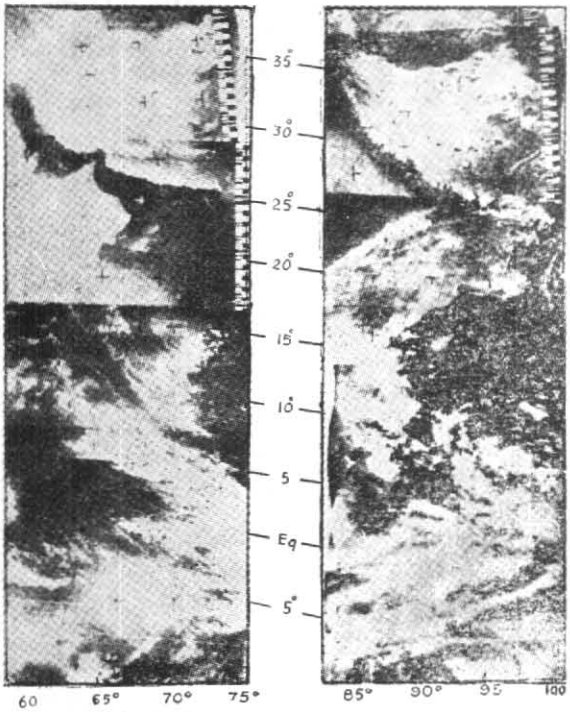

Fig. 2. 26 September 1966 NIMBUS II (Orbit 1783, Time 1115 IST and Orbit 1784, Time 1300 IST)

The picture shows the clouding associated with the initial stages of the disturbance in the south Andaman Sea. A fairly broad band of clouding starting from 15°N, 95°E and curving cyclonically to 7°N, 95°E through 12°N, 88°E and a patch of bright cloud mass (heavy *Cb*) along Lat. 10°N in the central area of the disturbance are noteworthy. The heavy clouding in the region of near-equatorial strong westerlies south of 5°N and extending eastwards from 62°E may also be seen

northnortheasterly direction and intensified into a cyclonic storm within the next 24 hours.

APT pictures for 28th and 29th are shown in Figs. 3 and 4 and the surface isobaric analysis for 00 GMT of these two days in Figs. 5 and 6. Figs. 7 and 8 depict the outlines of the major cloud fields over the Bay of Bengal on 28th and 29th as seen on the APT pictures with the centres of the disturbances (from Figs. 5 and 6) indicated on them. The isobaric analysis for 28th (Fig. 5) shows one centre near 13°N, 85°E and the other near 12·5°N, 90·5°E. The breaks in the clouds in between the two systems in Fig. 7 is noteworthy. Thus the ship and island observations, supported by satellite pictures point out to the existence of two disturbances on 28th, one a depression and another a storm.

The isobaric chart for 29th (Fig. 6) definitely indicates that the depression in west Central Bay of Bengal had moved northnortheastwards and intensified into a cyclonic storm. As on 28th, the cloud masses associated with the two systems (Fig. 8) are separated from each other by a distinct break. This break can be seen better in NIMBUS II picture (Fig. 4) than in ESSA II picture for the day. The cloud mass in the east half of the picture (Fig. 4) in the shape of a large roughly circular patch (in the area between 15°N and 20°N and 90°E and 95°E) with an extensive trail southwestwards is suggestive of a tropical disturbance in the region of the nearly circular cloud patch. It is interesting to note that the shape of this cloud mass is somewhat similar to the "comma" cloudiness described by Fett (1964) as a pre-storm stage when easterly waves develop into tropical storms. It may be added that based on night-time infra-red data NIMBUS II reported a vortex at 281753 Z near 17°N, 92·5°E.

In his study of the simultaneous existence of tropical storms and depressions over Indian area Raghavan (1965) found no occasion when two storms/depressions existed simultaneously in the Arabian Sea or in the Bay of Bengal and the shortest distance between co-existing disturbances was 1000 km. The simultaneous existence of storms in the Arabian Sea or in the Bay of Bengal being a rare feature might have gone unnoticed before the advent of meteorological satellites due to paucity of observations. In this particular case the satellite data together with the conventional reports have shown that tropical storms/depressions do co-exist in the Bay of Bengal. The distance between the centres of the disturbances is also less than 1000 km.

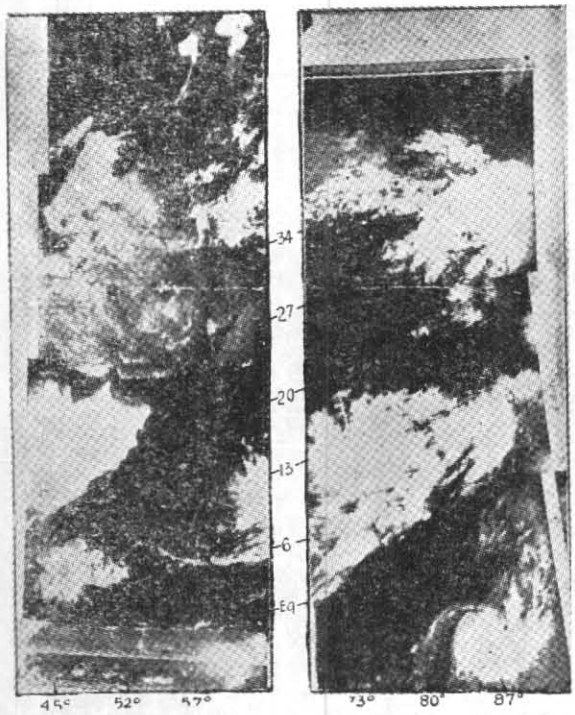

Fig. 3. 28 Sep 1966 ESSA II (Orbit 2683, Time 0805 IST)

A large compact cloud mass of diameter over seven degrees with central region near about 12·5°N, 83·5°E is the one associated with the depression in the west Central Bay of Bengal. The cloudiness associated with the cyclonic storm west of the Bay Islands, is seen in the picture as a separate entity with its western border along 88°E. The tropical storm in the southern hemisphere is also seen in the right bottom corner of the mosaic. The storm is fairly intense with nearly circular heavy central overcast from which cirrus is radiating outwards. Bands on the northern and eastern sides may also be seen.

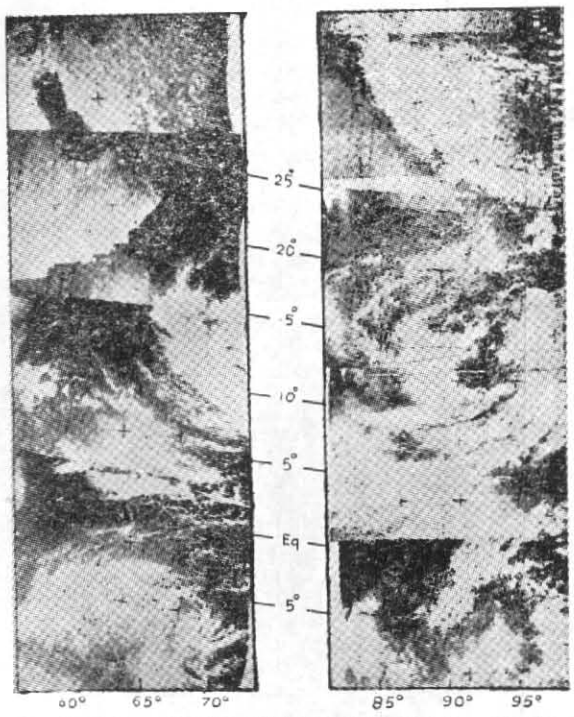

Fig. 4. 29 Sep 1966 NIMBUS II (Orbit 1823, Time 1120 IST)

This picture shows the two disturbances. The one off Burma coast has an extended cloud mass trailing south-westwards towards Ceylon. The cloud mass associated with the other disturbance in the west Central Bay of Bengal is seen separated from the first by a clear area which is at least three degrees wide.

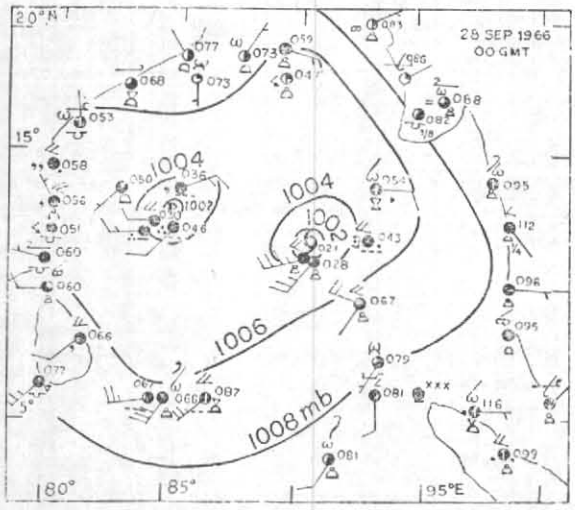

Fig. 5. Surface chart for 0000 GMT of 28 September 1966

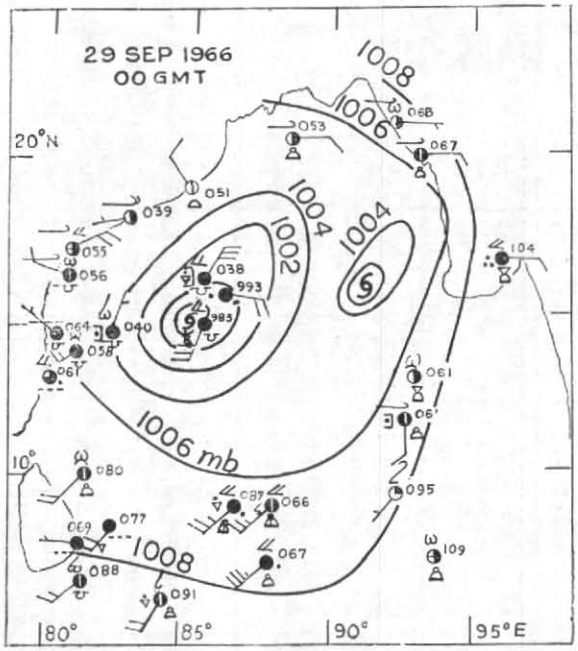

Fig. 6. Surface chart for 0000 GMT of 29 September 1966

Available observations for 0000, 0300 and 0600 GMT used. Pressures of off-time reports corrected for diurnal variation

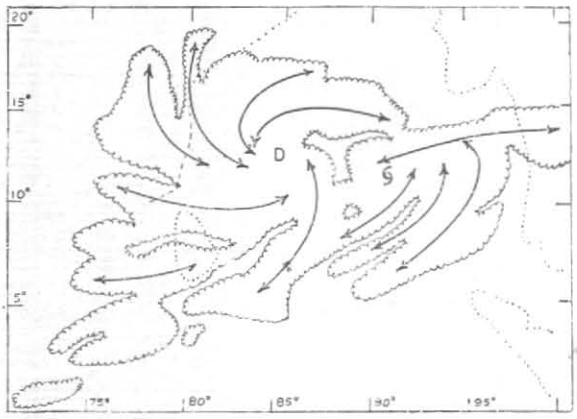

Fig. 7. Outline of major cloud field seen in ESSA II picture on 28 September 1966. Schematic orientation of cloud bands and centres of disturbances also shown

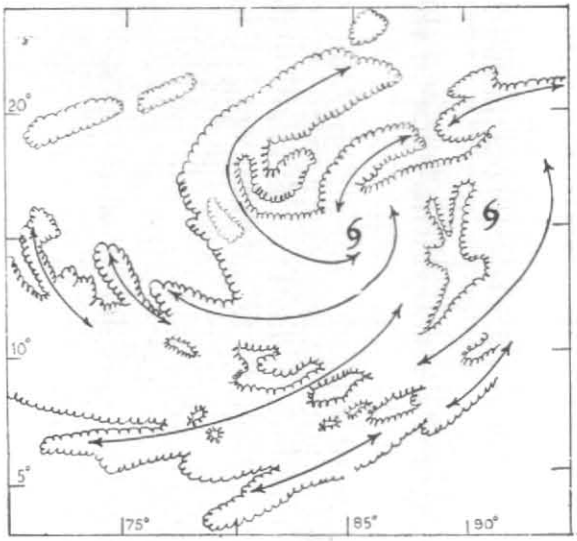

Fig. 8. Outline of major cloud field seen in ESSA II picture on 29 September 1966. Schematic orientation of cloud bands and centres of disturbances also shown

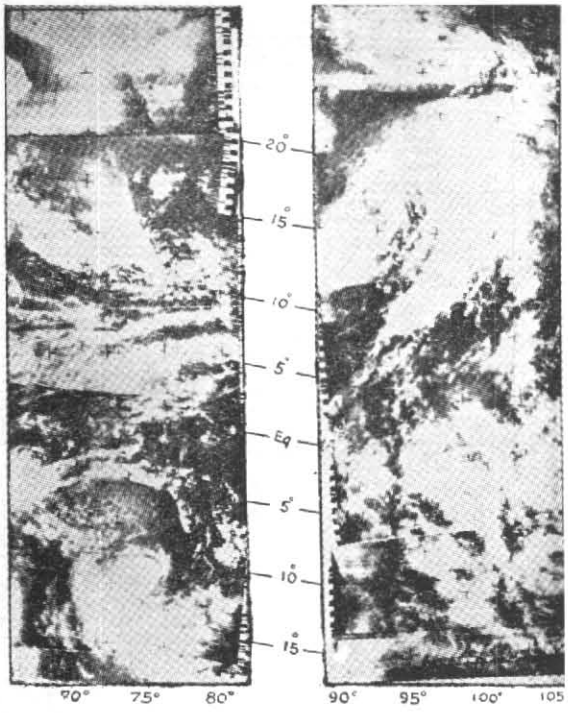

Fig. 9. 30 Sep 1966 NIMBUS II (Orbit 1836, Time 1040 IST and Orbit 1837, Time 1230 IST)

The cyclonic storm in the Bay of Bengal centred near 18°N, 87°E has an extensive clouding towards the northeast. The trailing cloud mass (noticed on the previous day) southeast of the centre could be seen in this picture also. However, the trailing terminates near 10°N. The tropical storm ANGELA in the southern hemisphere, as well as the formative stages of the disturbance in the Laccadives area are seen in the picture on the left (Orbit 1837)

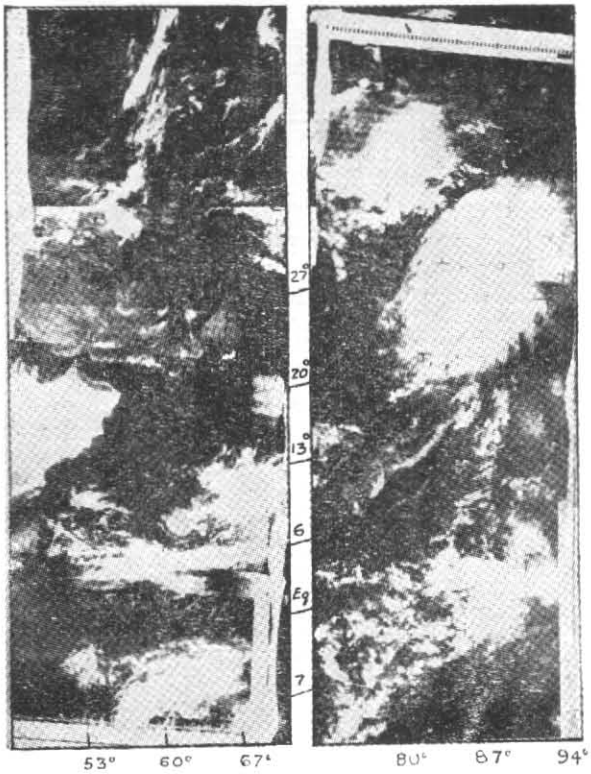

Fig. 10. 1 Oct 1966 ESSA II (Orbit 2721, Time 0800 IST)

This picture shows the tropical storm over East Pakistan with extensive cloudiness towards northeast. The western edge of the cloud mass is close to the trough line at 300-mb level. The central overcast associated with the storm can be distinguished by a thin break in clouding seen in the original picture and marked by dotted lines in this figure

The close proximity of the two disturbances as well as the fact that the monsoon trough itself, even without a storm, has a large amount of cloudiness associated with it, makes the picture of these two storms somewhat different from the well-known pictures of satellite views of tropical storms and hence to that extent a little difficult to recognise also. The limited grey scale range of the APT subsystem also could have contributed to this lack of definition. This is a new point to be reckoned with.

Between 29th and 30th, the two cyclonic storms apparently merged into a single severe cyclonic storm located near 17·5 °N, 87°E on 30th morning. No intermediate satellite observations were available to indicate how this occurred. Thereafter, the severe cyclonic storm moved in a northeasterly direction and crossed East Pakistan coast near about Barisal between the night of 30 September and morning of 1 October. It was centred near 23°N, 92°E over East Pakistan on 1 October morning. The APT pictures of 30 September and 1 October (Figs. 9 and 10) show the extension of clouding towards northeast upto Assam and eastern Tibet in association with an upper westerly trough which moved over northeast India. The axis of the trough was along 85°E over northeast India at 300-mb level on 30 September.

According to press reports, the storm caused extensive damage to both life and property as it passed through Barisal, Noakhali, Sandwip Island and other coastal areas of East Pakistan.

3. Disturbances in the Arabian Sea

During the period under study, a well-marked low pressure area also formed over Laccadives on 27 September. It gradually concentrated into a depression by 29th and persisted over the same area without any appreciable movement till 1 October. By 1 October morning, it rapidly intensified into a cyclonic storm of small extent and was centred near 12·5°N, 73·5°E. Winds of speed 30–40 kts were reported by ships in the area. The APT picture for 1 October (Fig. 11) shows the well-organised bandings of cloud in the storm-field. The heavy overcast area was displaced to the west of the centre. Moving in a northerly direction it weakened into a depression and was centred near 14·5°N, 73·5°E on 3rd morning. Subsequently, it recurved towards the left and moved in a northwesterly direction. It was near 17°N, 67°E on 5 October when it weakened into well-marked low pressure area.

4. Disturbances in the Southern Hemisphere

The southern hemisphere near-equatorial trough was also active during this period. With the available data at least two tropical disturbances

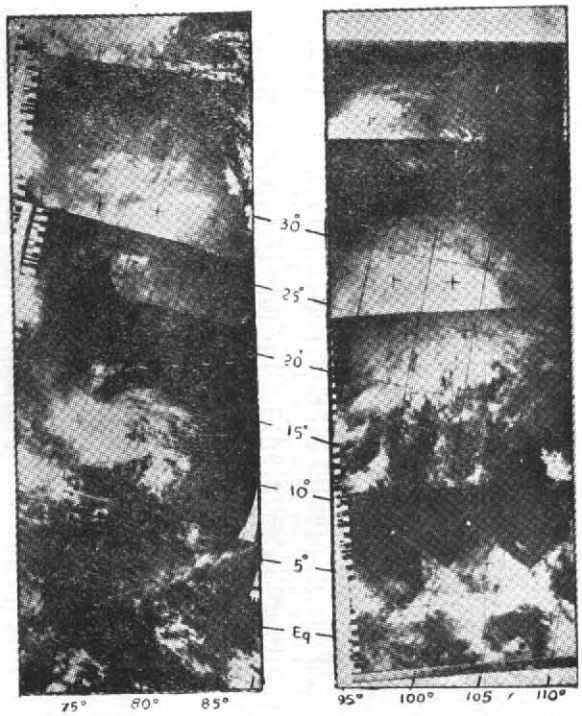

Fig. 11. 1 Oct 1966 NIMBUS II (Orbit 1850, Time 1155 IST)
This shows the Arabian Sea disturbance organising itself into a cyclonic storm. The cloud bands can be seen very clearly spiralling towards the centre

could be identified. One of them was seen in ESSA II pictures on 28 September (Fig. 3) with the centre approximately in the longitudes 85° to 87°E. The storm was in a fairly mature state of development. The second also could be tracked with satellite information from 10°S, 74°E on 30 September (Fig. 9) moving in an almost westerly direction to about 10°S , 62°E on 3 October. It probably continued to move in a westerly direction for the next one or two days also.

5. Conclusions

The last quarter of 1966 was the first storm season when an uninterrupted series of satellite pictures was available from the APT subsystem to Indian Meteorologists for daily study. The case on 28-29 September is a good example where satellite and ship data could be usefully combined to infer the existence of two disturbances in the Bay of Bengal on these days. Even the few pictures discussed in this paper have brought out a number of features. They are—

(*i*) Tropical storms/depressions co-exist in the Bay of Bengal within 1000 km. Available earlier records did not show this feature. Lack of enough ship observations at the time of issue of the storm bulletins, and perhaps to some extent the climatological conclusion derived from earlier

inadequate data, apparently precluded the mention of the simultaneous existence of the two storms in the Bay of Bengal in the operational bulletins.

(*ii*) Tropical storms in or close to the seasonal monsoonal trough where massive clouds already exist, apparently do not exhibit all the well defined characteristics of cloud bandings and striations in the satellite pictures. Restricted APT grey scale is another limitation.

(*iii*) The rapid extension of clouds over large area towards northeast of the storm location when storms recurve under the influence of east moving upper westerly troughs, has been well brought out by these satellite pictures.

(*iv*) Malurkar (1951) and Pisharoty and Kulkarni (1956) have shown some mutual influence of tropical storms on either side of the equator, and not too far separated longitudinally. During this period tropical storms existed simultaneously on either side of the equator in nearly same longitudinal belts; but no obvious influence of the tropical storm in one hemisphere on the storm in the other hemisphere could be detected.

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