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STUDY OF METEOROLOGICAL CONDITIONS IN THE NEAR EQUATORIAL REGION DURING THE PERIOD 17TH TO 21ST JUNE 1963 UTILISING UNITED STATES WEATHER BUREAU RESEARCH FLIGHT FACILITY AND OTHER IIOE DATA*

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ABSTRACT

Except for the observations from isolated island stations and occasional ships, the near-equatorial region of the Indian Ocean is a vast data-gap area. During the period 17 to 21 June 1963, the RFF instrumented aircraft of the IIOE flew at different levels, over the near-equatorial area between Gan and Singapore. In addition to observations at flight levels, drop-sondes and cloud photography were also made. These data suggest the westward movement of a feeble trough across the equatorial region with its associated cloud and weather developments and moisture distribution. The results of the detailed analysis using the RFF data and ship's observations, are presented in this paper.

INTRODUCTION

DURING the period of the International Indian Ocean Expedition (IIOE) the instrumented aircraft of the Research Flight Facility (RFF) of the U. S. Weather Bureau made a number of flights over the Arabian Sea, Bay of Bengal and the Indian Ocean to collect meteorological data. There were a few flights over the near equatorial regions of the Indian Ocean between 17 and 21 June 1963. These were the only flights in the IIOE period over the particular area during the southwest monsoon season. Since there is very little regular conventional data from this area, the RFF observations even for a limited number of days is valuable and it was considered desirable to examine them. The results of the study are presented in this paper.

In 1963, the monsoon set in by the normal date over the south Bay of Bengal during the last week of May and over the extreme South Indian Peninsula by 31 May. After advancing upto south Gujarat State by 11th June, the monsoon weakened along the west coast; however, it revived after about a week. It was during this period of the revival of monsoon activity along the west coast that the RFF flights over the near equatorial region discussed in this paper, took place.

The authors are thankful to the Deputy Director General of Observatories (Forecasting), Poona for providing the facility to carry out this study. The assistance given by the members of the Forecasting Manual Unit for this study is also gratefully acknowledged.

BASIC DATA

The RFF aircraft flew from Bombay to Gan on 17 June 1963 and from there to Singapore on 18th. They flew back to Gan on 20th and to Bombay on 21st.

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The Observations from Woods Hole Oceanographic Institution (WHOI) aircraft for 18th between Bombay and Gan were also utilised. The tracks of the research aircraft flights used in this study are indicated in Fig. 1. The wind, temperature, relative humidity and 'D' value data from RFF flights are available in the form of printouts. The cloud information obtained through time-lapse cameras have been summarised and pictorially represented by Bunker and Chaffee (1968). These form the basic data for this study. They have been supplemented by observations from ships and island stations. The study covers the oceanic area between Sumatra and the Maldives Islands.

MAIN SYNOPTIC FEATURE

Trough in zonal easterlies moving westwards across the south Bay of Bengal and south Arabian Sea is a known feature on the synoptic charts during the winter and pre-monsoon seasons. Westward moving troughs/low pressure areas are also noticed over this area during some monsoon 'breaks'. The present study shows the movement of a trough from east to west during the transition month of

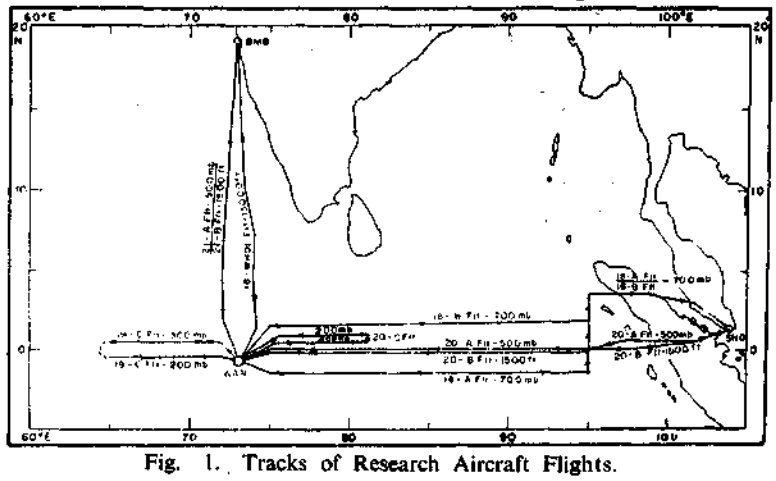

Fig. 1. Tracks of Research Aircraft Flights.

June when the monsoon advances over India. The analysis of the wind field revealed that during the period (18-22 June 1963) a trough moved westwards across the near equatorial area between 85° E and 70° E. It was seen mainly in the lower troposphere The RFF wind data showed the trough near 81°E on 18 June and later just east of Gan on 20–21 June. The trough moved westwards across Gan on 22nd early morning.

STRUCTURE OF THE TROUGH SYSTEM

Winds :

The levels at which the RFF aircraft flew were not the same on all the days. Hence, composite wind charts (of 1–2 days) were prepared for different levels and these are shown in Figs. 2 to 6. Fig. 2 refers to 18 June. The aircraft observations from RFF flights between Gan and Singapore belong to 700 mb level; those from WHOI flight between Bombay and Gan belong to 13000 ft. Fig. 3 shows 20 June flight data from Singapore to Gan and 21st data from Gan to

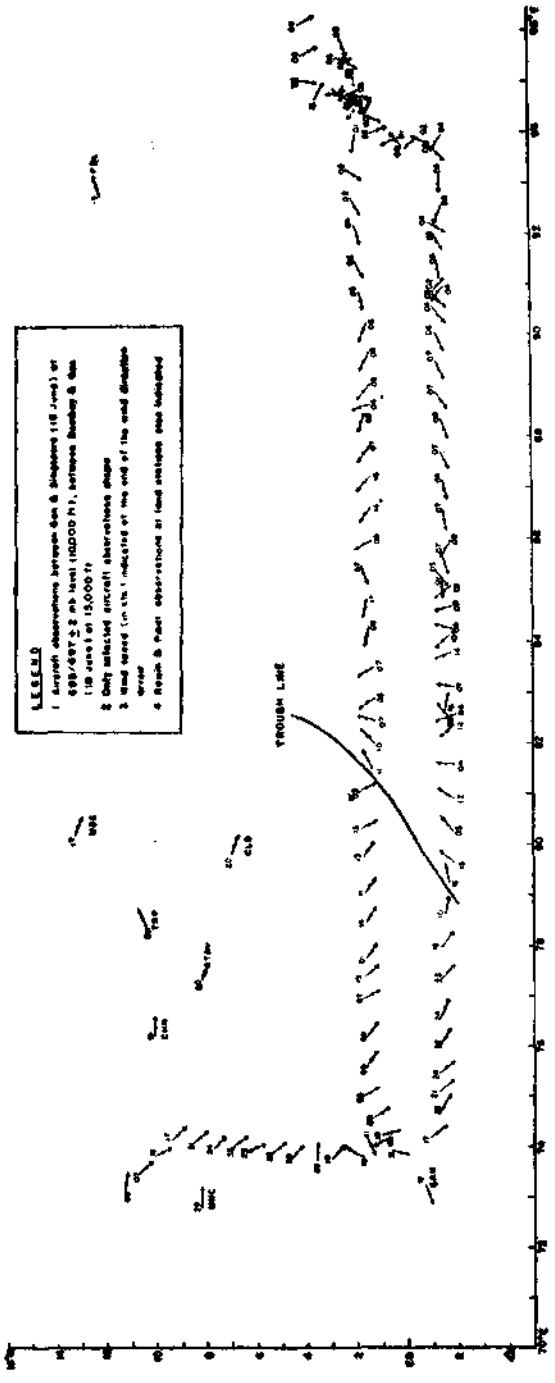

Fig. 2. Research Aircraft winds at 700 mb — 18 June 1963.

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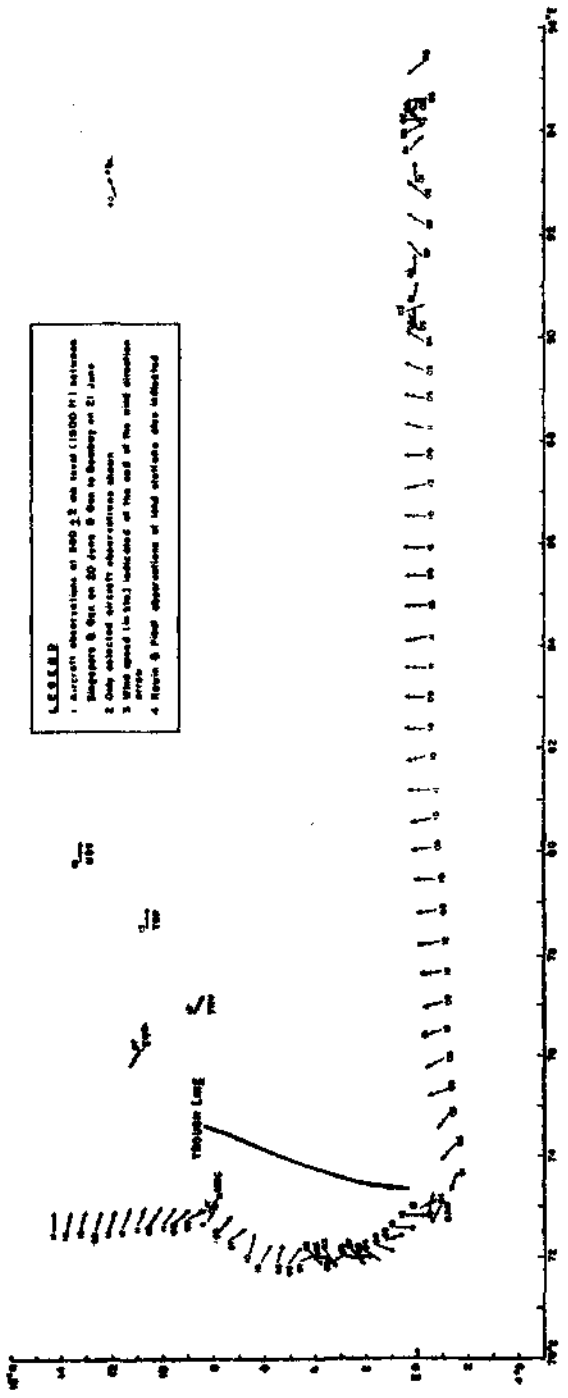

Fig. 3. Research Aircraft winds at 950 mb — 20 - 21 June 1963.

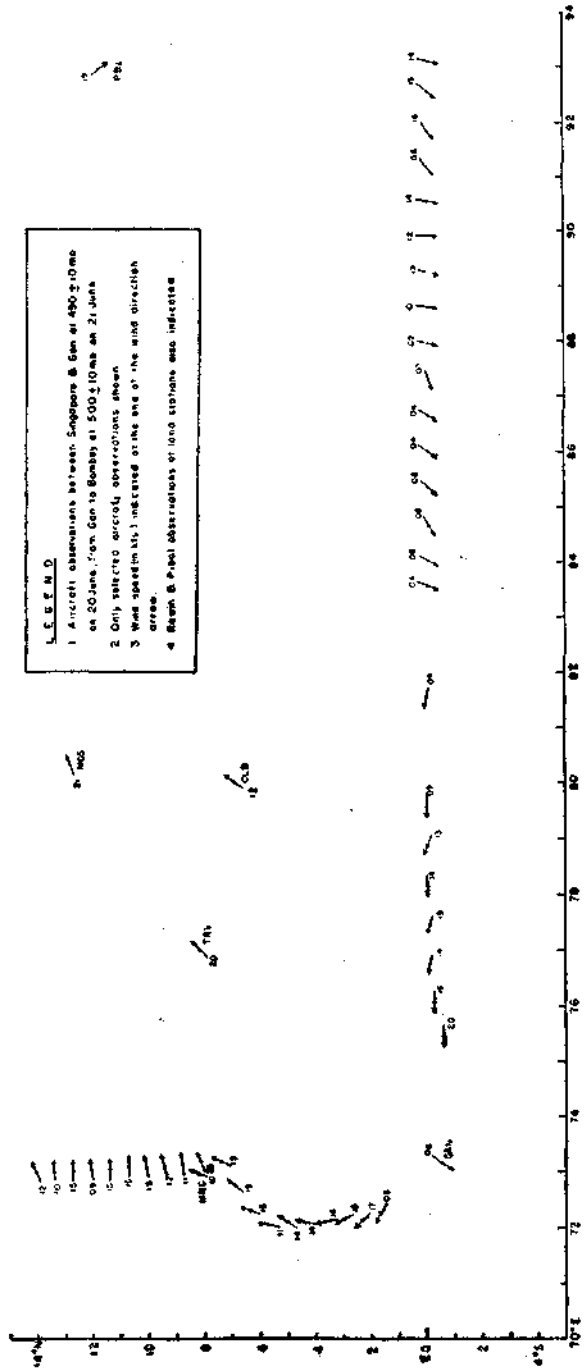

Fig. 4. Research Aircraft winds at 500 mb 20 — 21 June 1963.

Bombay. Both flights were at the same level (960 ± 2 mb). Fig. 4 shows the Singapore-Gan flight data on 20th and Gan-Bombay flight data on 21st, both at 500 mb level. Figs. 5 and 6 give respectively 300 mb and 200 mb winds on 19th-20th along the equator for about eight dregees distance to the east and west of Gan. These upper winds charts show

i. The trough is seen only in the lower troposphere (950 and 700 mb levels). It is not noticed at 500 mb level. In contrast to the westward moving trough in zonal easterlies, this particular trough was not embedded in any deep zonal flow. At any rate, there was no zonal easterly flow in the lower troposphere.

ii. The trough is oriented in a southwest-northeasterly direction and was near about 81° E on 18th and near 74° E on 20th and 21st.

iii. At 950 mb there is a pronounced southerly flow across the equator, over a large area, to the east of the trough line. Such strong cross-equatorial flow is, however, not present at 700 mb.

iv. There are small anticyclonic eddies (evident from wind observations plotted) in the general wind field at both 950 mb and 700 mb levels.

v. At 500 mb there is a pronounced anticyclone over the area.

vi. Figs. 5 and 6 show that the prevailing winds are mainly easterlies in the upper troposphere and they are increasing with height.

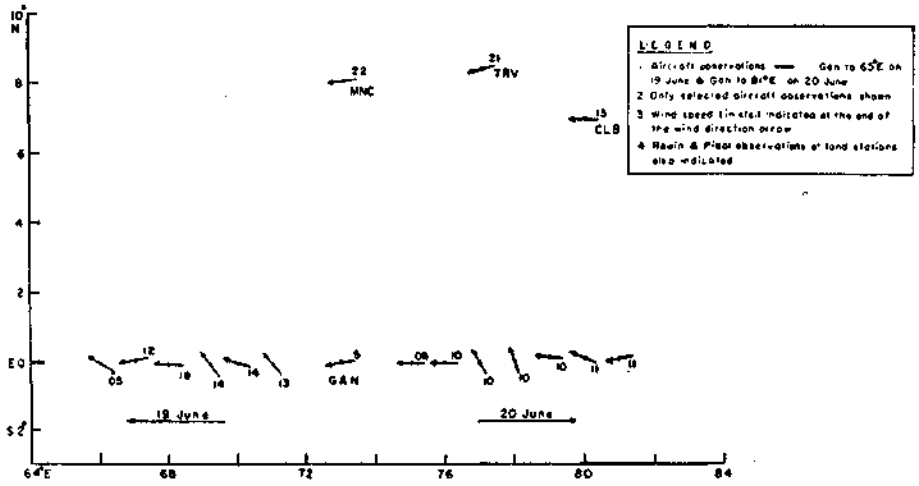

Fig. 5. Research Aircraft winds at 300 mb — 19 - 20 June 1963.

Temperature:

The temperature distribution at 700 mb level on 18th across the trough is shown in Fig. 7. The maximum data was available only on this day and for this level. The figure shows that the air is coldest near the trough line and there is also considerable north-south gradient of temperature in the trough region. The gradient of about 7°C(10° C-3°C) in about 1000 km distance seen in this figure is appreciable

for the near equatorial region. Such a large difference in temperature is not to be seen in the lower level (950 mb) flight, though even at this level, the trough region is slightly colder than the surrounding area.

Humidity:

The humidity profiles at 700 mb level across the trough is given in Fig. 8. The counter values of humidity as available in the printouts have been used. These profiles show that to the east of the trough line, the air is quite moist and to the west of it is considerably dry. The actual humidity values reported by 'B' flight at half hourly intervals are also given in the inset diagram for purpose of comparison with the counter values. This diagram shows that the relative humidity changes by 40% to 50% across the trough line.

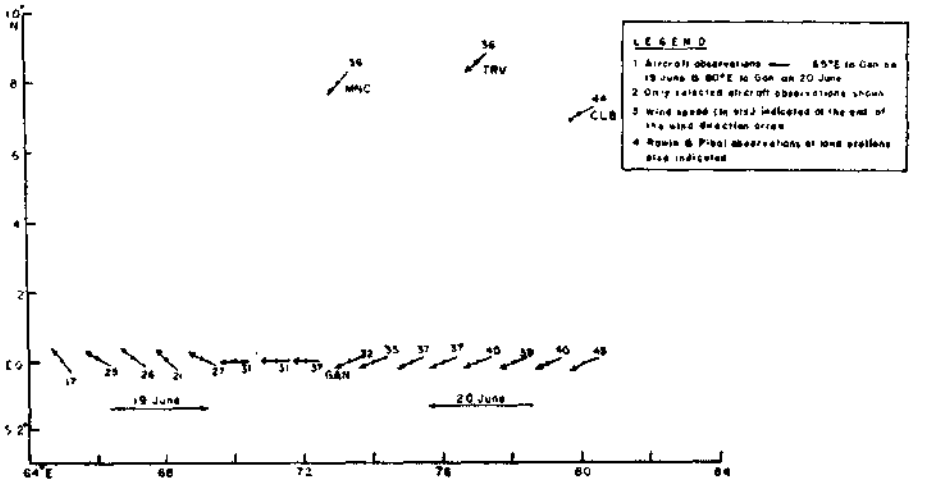

Fig. 6. Research Aircraft winds at 200 mb — 19 - 20 June 1963.

Vertical variation of Temperature and Humidity:

On some of the flights, dropsonde observations were taken. The dropsonde data for 20th and 21st, on either side of the trough line, are discussed in this paragraph. These observations together with Gan radiosonde data for 20th are shown in the form of a space cross-section in Fig. 9. Isopleths of temperature and relative humidity are shown in the figure. Height values (isopleths not drawn) also indicate the trough close to Gan. The cross-section shows that the air is coldest near the trough line and the difference in temperatures at the trough line and at the periphery is about 2° - 3°C. Also the air is very moist near the trough line and the moist layer extends to much higher levels than on either side. The observations to the east of the trough line (at 80°E and 85°E) show that the higher moisture values are confined to below 700–800 mb levels. A stable lapse rate between these levels is evident from the temperature readings at 80°E. It is also seen from the cross-section that changes in temperature and humidity associated with the trough are predominently confined to the lower troposphere. At 500 mb level the changes are quite small.

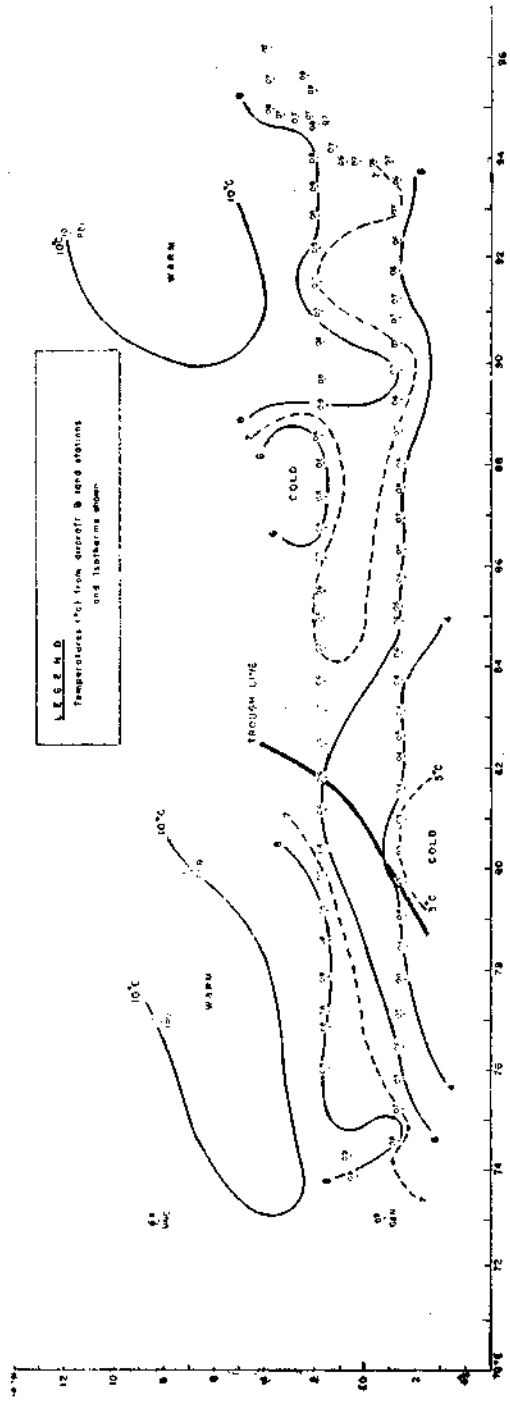

Fig. 7. Temperature distribution at 700 mb — 18 June 1963.

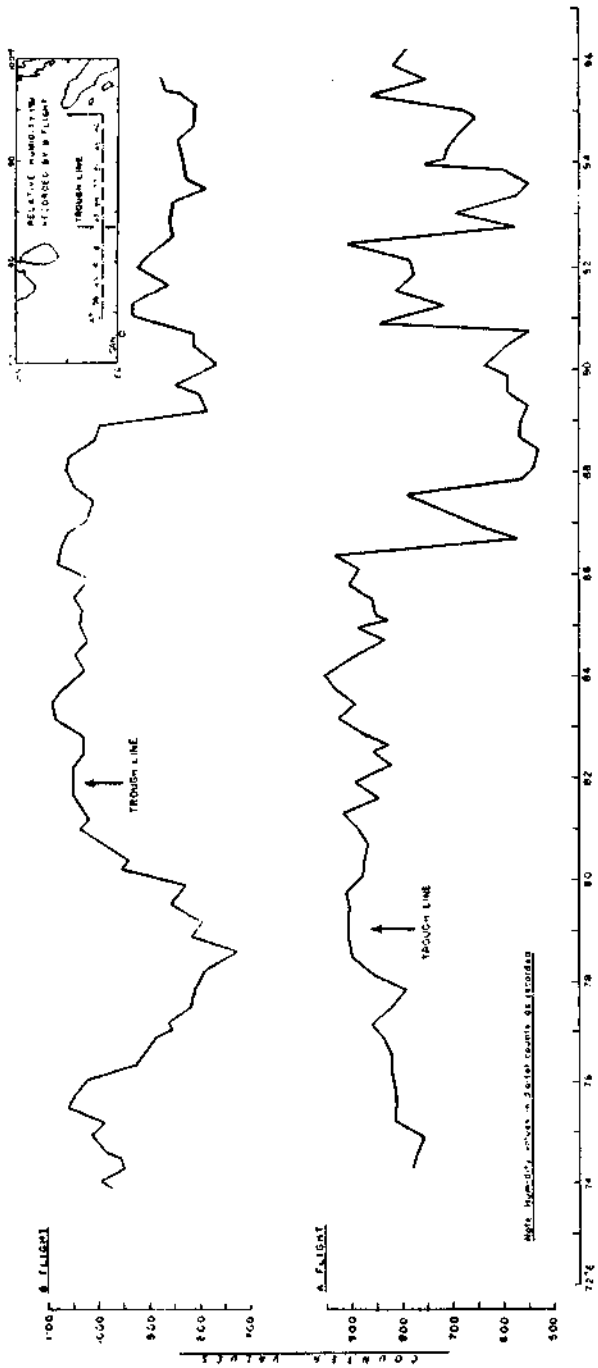

Fig. 8. Humidity profiles at 700 mb - 18 June 1963.

Clouds and Weather:

The clouds and weather associated with the trough were studied with aircraft observations as reduced by Bunker and Chaffee and observations from ships and island stations. These are depicted for 18th, 20th and 21st June in Figs. 10–12. These diagrams bring out that close to and to the east of the trough line, large cloud developments and weather occur, while to the west there is relatively less weather. This is consistent with the humidity observations discussed earlier. Cu and Cb developments reached at many places 5 to 6 km and individual towers as high as 10 km (see 20th cloud cross-section in Fig. 11) were reported from the areas. In addition to convective type of clouds, thick As (amounts 7-8/8) was also present near 4-6 km level.

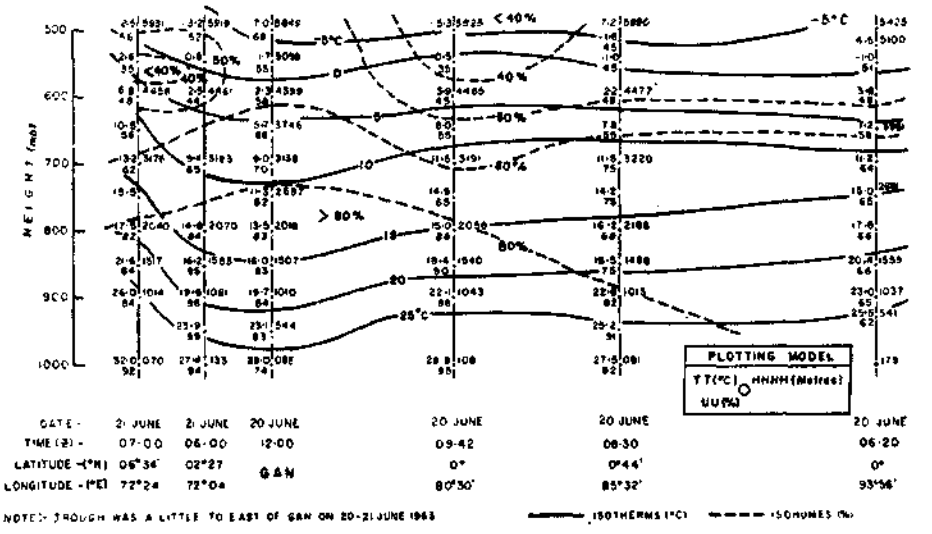

Fig. 9. Space cross-section — 20-21 June 1963 (Drosponde & Radiosonde data).

CONCLUSIONS

Though we have some information on the structure of major systems like tropical storms and monsoon disturbances over the Indian sea areas based on RFF flights during the IIOE period (Ramage, 1963; Miller and Keshavamurthi, 1967; Colon, Raman and Srinivasan, 1970), we have as yet no details on minor disturbances like the trough system in the near equatorial region discussed in this paper. The present study shows that even such weak weather systems have well-defined three dimensional structure. The main features brought out are:–

i. The trough system is most clearly delineated in the lower tropospheric wind field. The RFF observations, winds reported by ships and upper winds from stations like Gan have all shown the movement of the trough.

ii. The temperature close to the trough line is much lower than the temperature at the periphery. Considering that over the large oceanic equatorial areas, the airmass is nearly uniform, the temperature gradient in the trough region

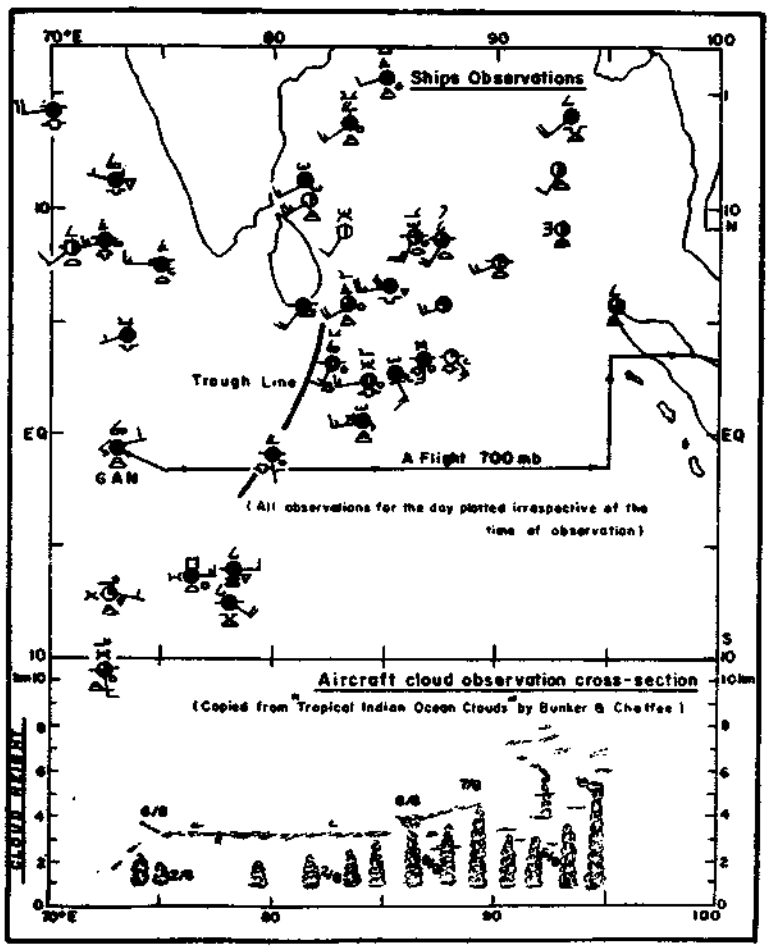

Fig. 10. Clouds and weather — 18 June 1963.

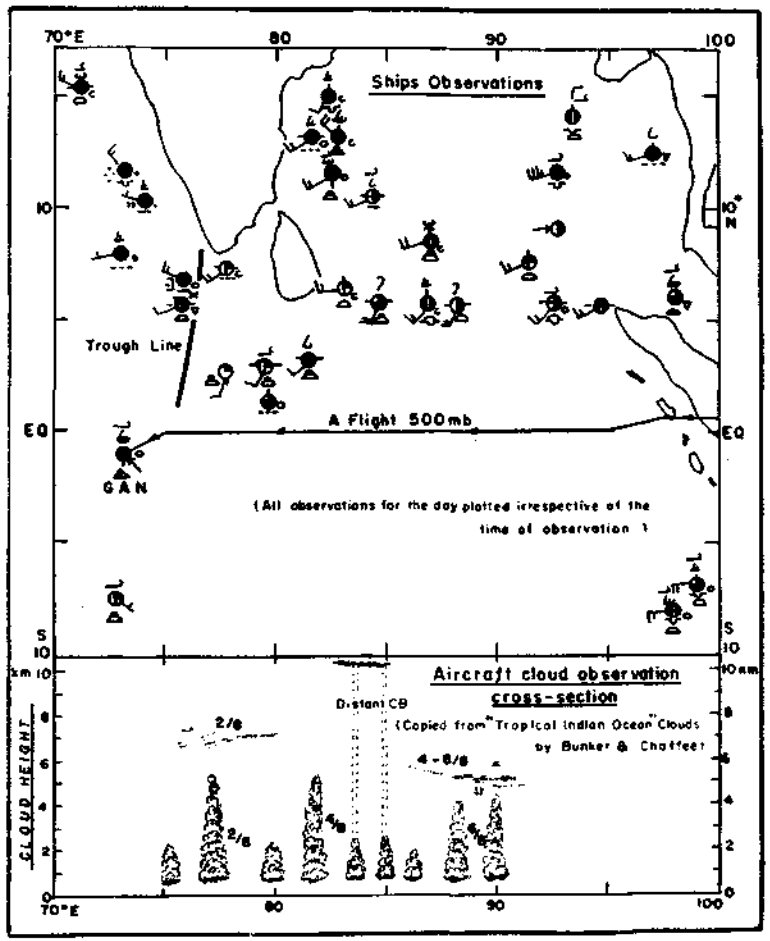

Fig. 11. Clouds and weather — 20 June 1963.

is significant. These temperature gradiens have, therefore, only to be attributed to the dynamics of the motion associated with the trough.

iii. The main cloud development and weather were noticed close to and to the east of the trough line. Humidity observations also showed high values as well as relatively deeper moist layer in these locations.

iv. The movement of this trough across the Maldives caused an intensification of the pre-existing feeble trough along the west coast of the Indian peninsula. A spurt of monsoon activity was reported from Kerala and Arabian Sea Islands on 20th when the near equatorial trough was moving across the Maldives. The passage of this trough was also noticeable in the time-section of Gan. There are also some indications of the passage of the trough in the time-sections of Colombo, Trivandrum and Minicoy.

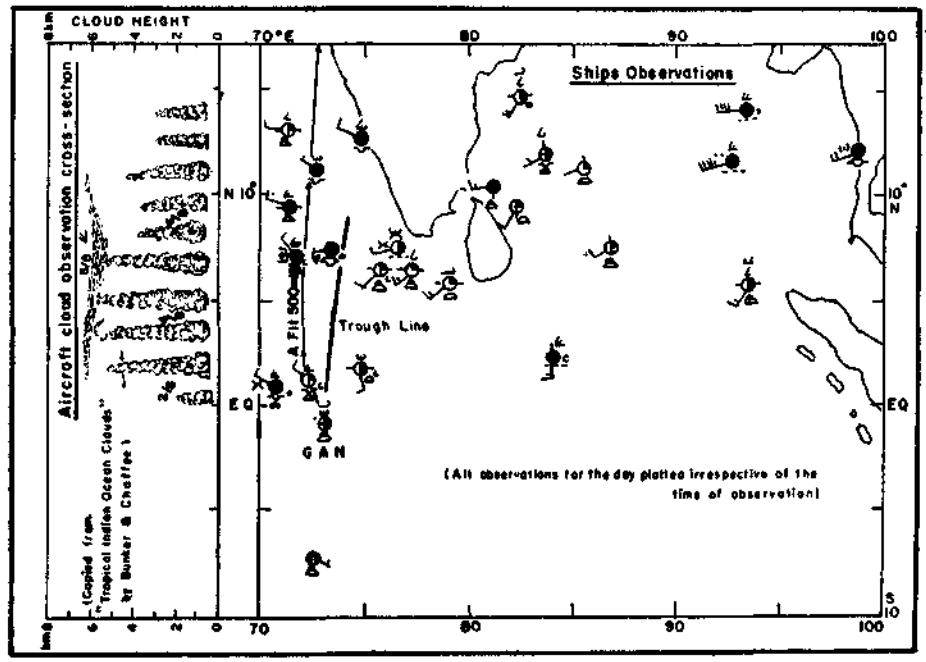

Fig. 12. Clouds and weather — 21 June 1963.

v. Pressure and height fields did not give any consistent or conclusive evidence of the presence or movement of the trough. Wind, Temperature and humidity fields were better organised.

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DISCUSSION

R. JAYAMAHA: I would like to know whether the trough shown in the 3 slides was one and the same trough or two different troughs, one following the other. I find this type of trough moves from west to east and is sometimes followed by one or two others.

V. SRINIVASAN: All slides showed one and the same trough which moved from east to west.

K. R. SAHA: Did you check your finding of a trough in the wind field with any pressure data?

V. SRINIVASAN: The disturbance was primarily traced in the wind field. For want of a better terminology, the term 'trough' has been used in this paper. The disturbance was essentially in the northern hemisphere and the southern portion of the trough extended a little into the southern hemisphere. On the sea level chart the available ships observations indicated the trough in a rather feeble manner in the pressure field.

P. K. DAS: Could you tell us what was the estimated speed and displacement of the disturbance you have described? If I may make a suggestion, you may like to examine how far the speed agrees with the speed of mixed gravity-Rossby waves in low latitudes.

V. SRINIVASAN: The trough moved from 81° E to 73° E in about 3 days time which works out to a mean speed of about 6 kt.