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Satellite pictures and low pressure areas or waves

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ABSTRACT. A study of low pressure areas or waves, which moved across south Bay of Bengal and south Arabian Sea has been made for the year 1968. Cloud features associated with the systems, as given once daily by ESSA-6 APT satellite, gave useful indications regarding intensification, weakening and track of these low pressures systems. Utility of this correspondence for simulation of synoptic analysis over data-gap areas has been pointed out.

1. Introduction

Low pressure areas or waves affecting Indian weather are well-known. Usually, these move from the east to west across the south Bay and Arabian Sea during non-monsoon months and across north Bay during the monsoon season. These disturbances appear in varied forms such as, (*i*) as closed sea level lows, (*ii*) as katallobaric centres, (*iii*) as cyclonic circulations in the lower troposphere and (*iv*) as low level easterly wave troughs during non-monsoon periods and as upper tropospheric easterly wave troughs during the monsoon months. They may occur individually or in combination of two or more of the above-mentioned forms. In all cases, the weather is significantly affected along the tracks followed by them. Owing to the proximity of land observations and comparatively small transit time, these disturbances are rarely missed by the forecaster as they move across north Bay during the monsoon. But over south Bay and south Arabian Sea, which have large data gap-areas between nearby land stations, tracking the progress of these disturbances is difficult. Although ships observations supplement land data, the former are few and far between over ocean areas. Cloud pictures from satellites can be of great help for keeping continuous track of these disturbances over such a large stretch of sea area. The present study is made with this purpose in view. These systems and their associated cloud features are traced until either they became unimportant, or intensified into a depression. The study is restricted to the year 1968 only.

2. Selection of APT cloud pictures

ESSA-6 satellite passes over Bay of Bengal between 0830-0930 IST and over the Arabian Sea between 1030-1130 IST. Instability clouds, if any, which are unconnected with synoptic systems are, therefore, likely to be photographed by the satellite over these areas. These clouds over the oceans, just as fog or stratus over the land, dissipate by noon. Only such cloud patches which have recognisable continuity from day to day, have been chosen for the purpose of this study, as these alone could be related to the synoptic features considered.

Since the purpose of the study, as far as possible, is to simulate synoptic features from the cloud patterns over data-gap ocean areas, attention has been paid to delineate the various cloud types associated with each synoptic system as originally reported by the APT unit. For economy of space, we have chosen to represent the cloud patches schematically rather than photographically.

3. Illustrative cases

(a) *Movement of a low pressure wave across Ceylon-Comorin area and south Arabian Sea during 12-21 March 1968*

Synoptic situation — On the 12th morning an isobraic trough developed over the Laccadive—Maldive area and a large pressure defect over the Comorin-Ceylon area was noticed; the lower level winds over south Ceylon strengthen to NE/25-35 kt and an anticyclonic cell at 500 mb lay over the Comorin area. By the 12th evening an easterly trough between 700 and 600-mb levels lay to the west of Ceylon roughly along longitude 77° E. This situation was unchanged till the 14th morning, when a larger pressure defect was noticed over east central Arabian Sea and adjoining land areas, with general fall of pressure over the Peninsula (south of latitude 19°N) and a rise of pressure over Ceylon. The low level trough lay along the meridian 75°E. With the convergent portion of this trough overlying Ceylon, together with the persistent upper level anticylonic cell, good precipitation occurred over Ceylon and south Peninsula

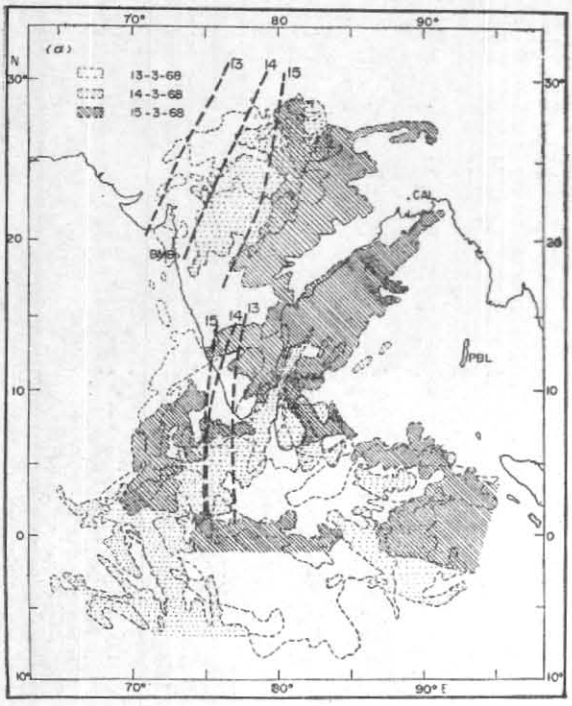


Fig. 1(a)

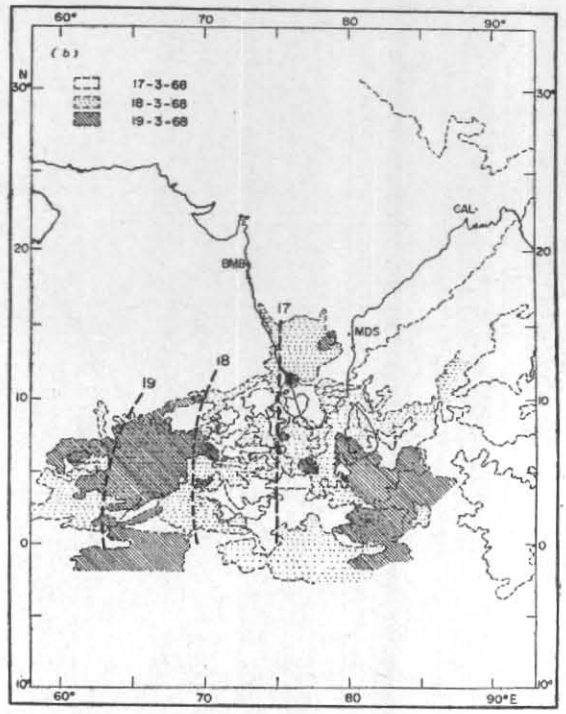


Fig. 1(b)

Three-day cloud patterns and positions of easterly troughs (dashed lines)

by the morning of 15th. On this day, the easterly trough noticeable upto 500-mb level probably got into juxta-position with a well-marked westerly trough, extending upto 200 mb which was running from west Uttar Pradesh to Marathwada. On the 16th morning, precipitation as also the pressure defect continued over Ceylon and south Peninsula, but the large pressure rise spread from Ceylon to south Peninsula and SE Arabian Sea and the low level trough persisted along Amini Divi-Minicoy longitude. This situation was largely unchanged till the 18th morning, when a feeble surface low could be located near Amini Divi and precipitation continued over Ceylon/Kerala. Pressure changes, continued to be positive. By the 19th morning, the rainfall area shifted westward, when Minicoy recorded 6 cm and Kozhikode and Trivnandrum 2 cm each. From 20th morning, land stations lost grip of the synoptic system as evidenced by larger pressure defect over south Bay than over SE Arabian Sea and nothing could be traced over south Arabian Sea except by the persisting cloud features, which are described below. The observed larger pressure defects over south Bay compared to SE Arabian Sea was presumably due to the approach of a fresh disturbance from the east.

Cloud features — Commencing from the 11th, a north-south belt of clouding covering Tamil Nadu coast and the east coast of Ceylon progressively increased in brightness and areal extent upto the 13th, when the easterly trough was approximately along Long. 77°E. (Fig. 1 a—c) Conspicuous cloudiness could be seen over the equatorial belt between 5°S to 5°N and 73-87°E on the 13th. This patch split into two slices on the next day. The easterly trough and associated cloudiness to its rear persisted along and east of 75°E on the 14th . On this day, a patch of cloud ahead of a westerly trough had its western edge running from west U.P. to Marathwada. On the 15th, while the trough in the easterlies persisted along 75°E, the westerly trough and the cloudiness to its east moved further eastwards and both the troughs probably got inter-locked. The extension of clouds into west central Bay off the Tamil Nadu—Andhra coast on this day was very significant. As a result of this juxta-position of two troughs, the westward progress of the easterly trough slowed down and it persisted along 75°E on 16th and 17th. From the 18th, the cloud patches to the rear (east) of this trough started moving westwards, as the westerly trough got completely 'fractured'. The easterly trough could be located along 70°E as judged from the cloudiness on the 18th morning. The significant rainfall over the Arabian Sea islands on the morning of 19th was consistent with the above orientation of the easterly trough, which moved to 65°E on the 19th and 60°E on the 20th, slanting eastwards with higher latitudes. By 21st, the

trough got very much weaker as evidenced by broken narrow patches of clouds near the equator and 55°E extending to 7°N, 60°E. On 22nd, even these patches disappeared.

It would thus be seen that over the ocean area west of the Arabian Sea islands, the low pressure system could be followed upto Long. 55°E on the basis of the APT cloud pictures. In doing so, one has to assume that the identity of the synoptic feature, *viz.*, a low level easterly wave trough which could unambiguously be attributed to the cloud features, when these as well as the synoptic pattern were traceable with available observations near land regions, persisted till the trough was completely damped out by 22nd over southwest Arabian Sea.

(b) *Movement of low tropospheric wind circulation across south Andaman Sea and south Bay of Bengal between 4-8 October 1968* .

Synoptic situation — Pressure started to fall and became below normal over Tenasserim & Malaysia coasts on 4th morning. Cyclonic turning of winds was discernible over this area between 700—500 mb. Fairly widespread and scattered heavy rain occurred over the Bay islands by 5th morning, and the cyclonic circulation lowered upto 850 mb. No change was seen in the isallobaric field on this day. On the 6th, rainfall over the Bay islands decreased and pressures were above normal and rising over the Andaman Sea. On the other hand, these were negative over south Bay. The upper air cyclonic circulation, now between 900—700 mb had its apparent centre over sutheast Bay. No winds were available over Port Blair above 3·6 km and, presumably, a trough existed over south Bay between 700—500 mb. A feeble cyclonic circulation at 850 mb noticed over north Interior Mysore on the 5th became more marked and extended from sea level to 600 mb on 6th morning. At 850-700 mb, a westerly trough also could be seen along Long. 70°E, north of Lat. 20°N. On 7th morning, a large number of ships' observations over SW and W central Bay reported rain as present weather and the sea level isobar bulged into this area. A similar bulge noticed over east central Arabian Sea from the 3rd became more marked on this day. Below normal pressures and negative pressure changes were confined to the peninsular region west of 80°E approximately. Rainfall significantly decreased over the Bay islands and increased over south Peninsula. In the upper air, cyclonic circulation over east central Arabian Sea became more marked on 7th and an associated trough extended from west central to southeast Bay upto 600 mb. On the 8th, the low over east central Arabian Sea intensified into a depression

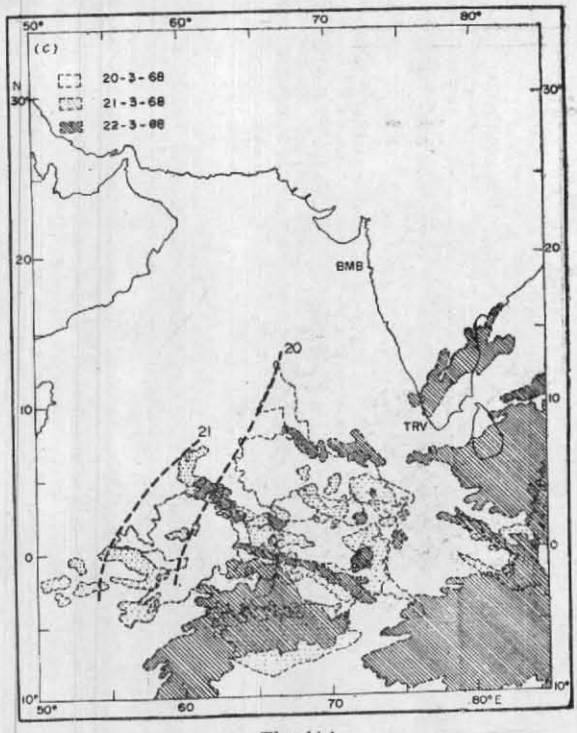


Fig. 1(c)

Three-day cloud patterns and positions of easterly troughs (dashed lines)

and the pressure fields became positive over the entire Peninsula and Bay, except for small pressure falls over Andaman Sea and Tenasserim coast. Rainfall increased over the Peninsula between 14-18° N in association with the trough passing across this area from the depression into west central Bay. The trough in the westerlies at 850-700 mb seen on the 6th progressively became a circulation associated with an approaching western disturbance over north Rajasthan and adjoining West Pakistan. On 9th morning, the depression over east central Arabian Sea weakened into a low; the rainfall patch shifted from south Kerala to the Laccadive Islands. By 11th morning, rainfall decreased over the Arabian Sea islands.

The above mentioned situation was chiefly characterised by a rather fast-moving low tropospheric cyclonic circulation and associated negative pressure changes from the Tenasserim coast and adjoining south Andaman Sea on the 4th upto south coastal Andhra Pradesh and neighbouring west central Bay on the 7th. They became less marked by 8th, when a fresh katallobaric centre probably advanced westwards from the Tenasserim coast.

Cloud features — The above situation was borne out by the changes in the APT cloud patterns between 4th and 10th (Fig. 2 a-c). On the 4th, a very extensive cloud system covered the area

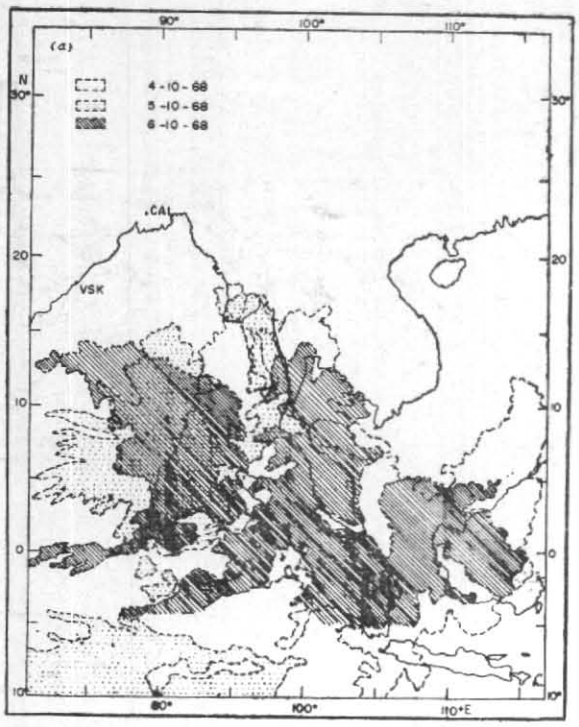


Fig. 2(a)

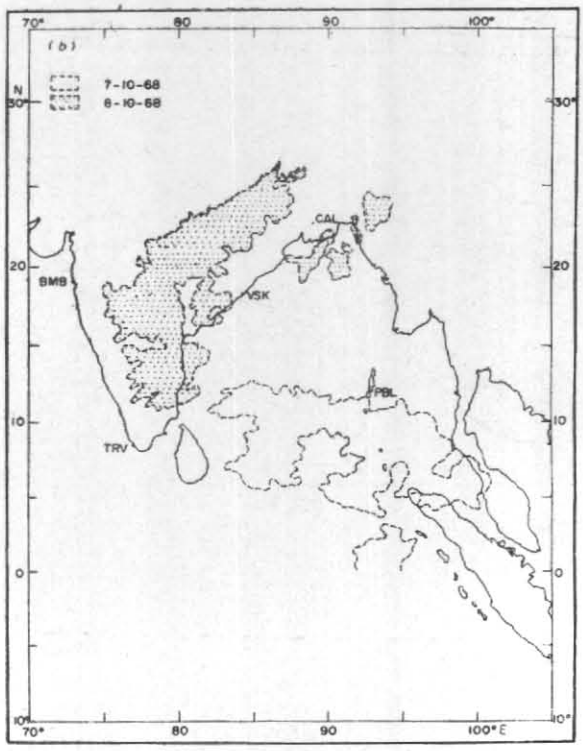


Fig. 2(b)

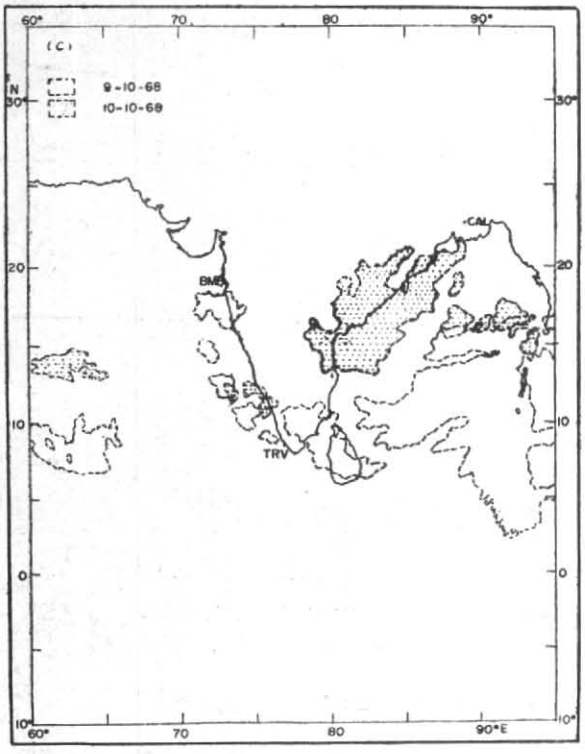


Fig. 2(c)

Fig. 2. APT cloud patterns between 4-10 October 1969

between 5°S/5°N and 92°/115°E, with two northward protrusions into (*i*) south Andaman Sea and (*ii*) South China Sea off North Borneo. The former expanded into SE Bay and got detached from the cloudiness over the south hemisphere on the 5th in keeping with the lower tropospheric circulation which was moving westwards from the Tenasserim coast. This patch further advanced westward and covered southwest Bay east of 85°E on the next day and was slanting more to the west than north on this day. On the 7th, it became oriented east-west in accordance with the trough between 700-500 mb, which could thus be located east-west over south Bay. As this trough became less marked on the 8th, cloudiness completely vanished over the Bay area. Cloudiness was confined to north Tamil Nadu and coastal Andhra Pradesh in the vicinity of the trough over south coastal Andhra Pradesh and adjoining west central Bay. With the simultaneous weakening of the trough and the depression over east central Arabian Sea, this patch of cloud disappeared on the 9th. Significant patches of clouds observed over SE Bay on the 9th and over coastal Andhra Pradesh on the 10th were probably associated with the pressure falls noticed over and near the Tenasserim coast on the 8th and their progress westnorthwestwards thereafter.

4. Adjustment of chart analysis to fit APT cloud pictures

On the basis of the observed cloud features, analysis of the sea level chart and the stremlines

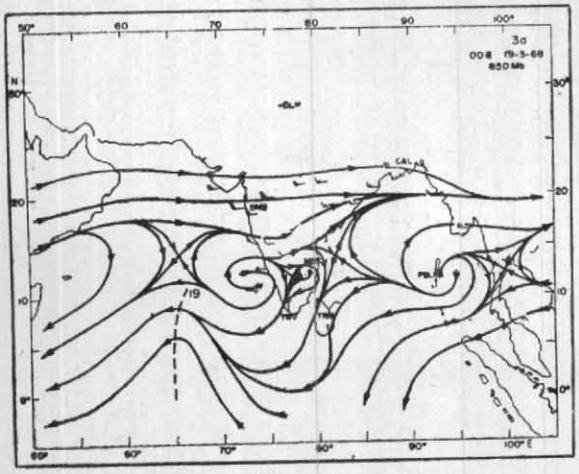


Fig. 3(a)

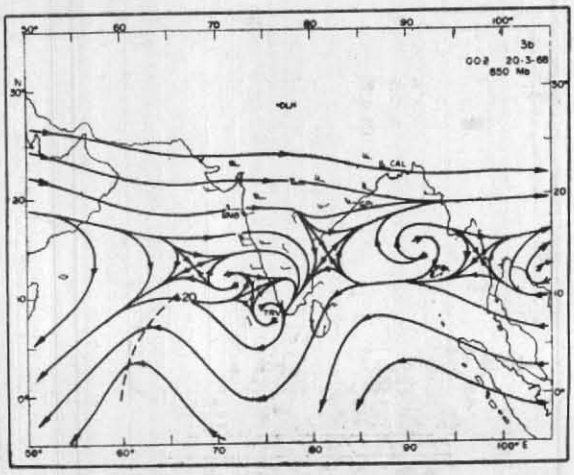


Fig. 3(b)

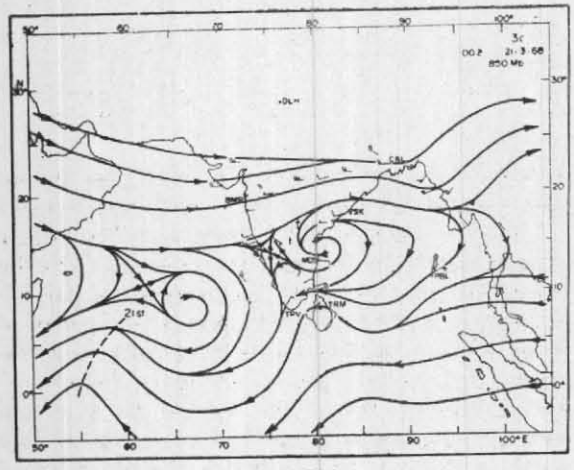
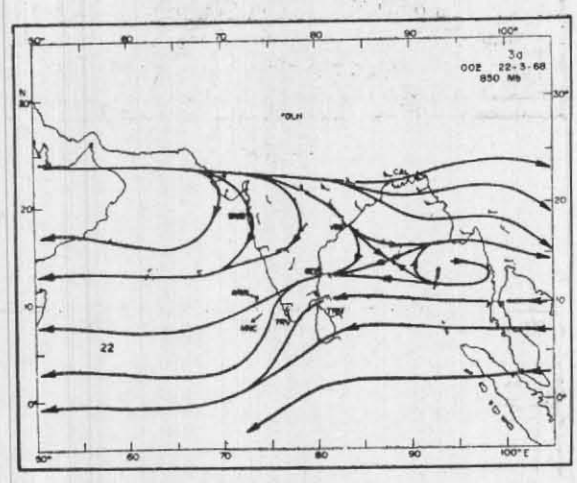


Fig. 3(c)



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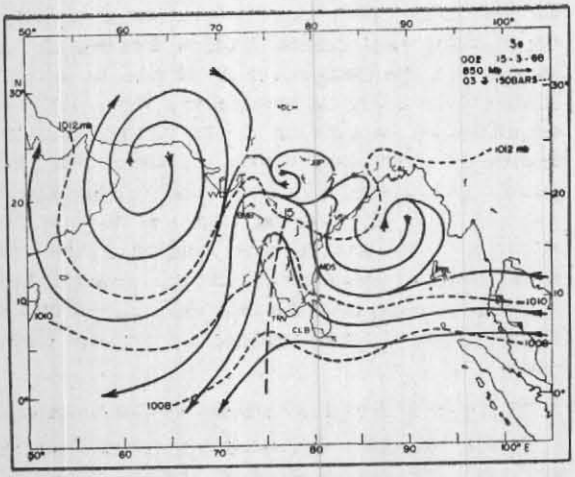

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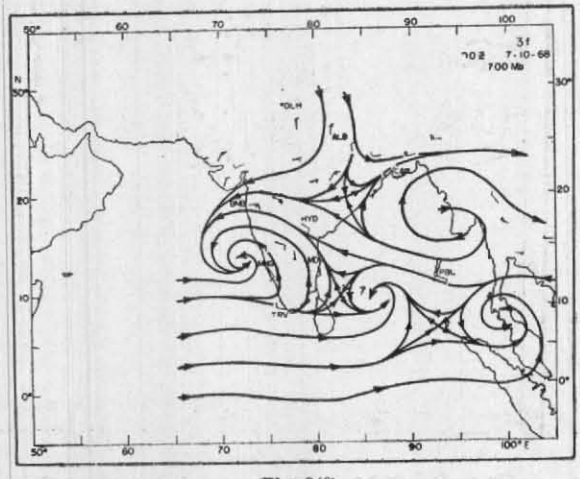

Fig. 3(f)

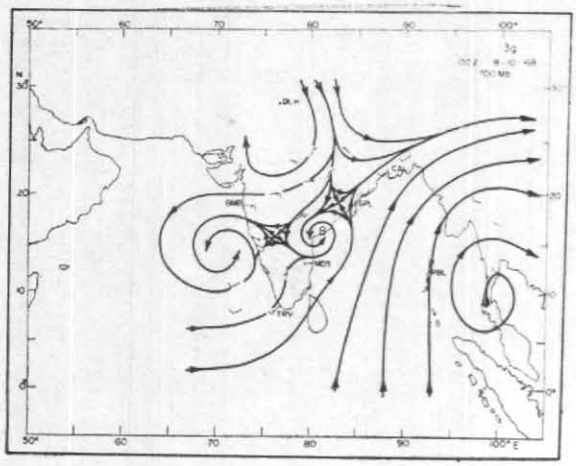

Fig. 3(g)

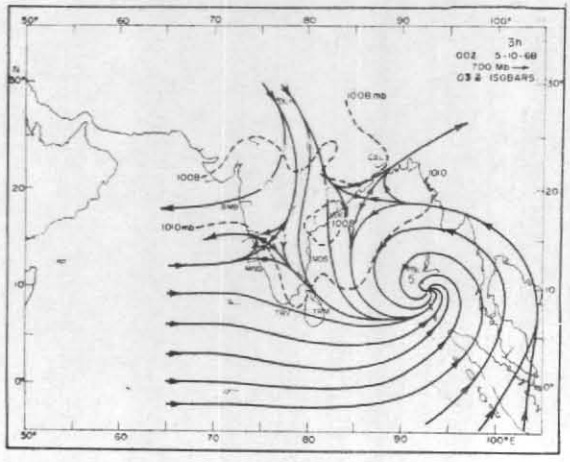

Fig. 3(h)

at 850-mb level over south Arabian Sea for the period 19-22 March 1968 are given in Fig. 3 (a-d). Compare these with Fig. 3 (e) depicting the synoptic analysis over the Ceylon-Comorin area on 15th March on the basis of actual observations. Similarly, Fig. 3 (f-g) give the streamlines at 700 mb over south Bay on 7 and 8 October 1968 on the basis of the cloud patterns. These may be compared with Fig. 3(h) showing the streamlines at the same level over Andaman Sea and neighbourhood on 5 October when observations are available over the area. As already stated in Section 3 (a), identity of the synoptic features as depicted in Figs. 3 (e) and 3 (h), as could be inferred from observations over land areas, has been kept in view in making simulated analyses given in Figs. 3(a-d) and 3 (f-g) over data gap areas, on the basis of the APT cloud patterns.

5. Concluding remarks

Mapping out regions of upward velocities leading to cloudiness in relation to known lower tropospheric synoptic features is an extremely difficult endeavour, even with computer facilities and over regions under the exisingt network of observations —it is much more so over data-gap areas. Satellite cloud pictures represent this important end product of synoptic analysis. Once the synoptic model and associated cloudiness could be reliably determined, one can, at least qualitatively, derive the former over data-gap regions from the variations in the orientation, areal extent and brightness of the cloud patterns which result therefrom. It is clear that the synoptic model simulated on the basis of APT cloud patterns over data-gap areas may be only approximate, though useful. In this context, the study highlights the need for evolving synoptic models with associated cloudiness, both in type and aerial extent, for effective utilisation of satellite cloud information for synoptic analysis and prognosis over data-gap areas of our region.

Acknowledgement

The authors are grateful to Shri Y. P. Rao, Deputy Director General (Forecasting) for his kind interest in this study.

DISCUSSION

(Presented by C. A. George)

SHRI M. G. GUPTA : In this case the cloud was first seen over land area and it was possible to fix the level of the easterly wave. But if, the clouding is first over sea area how to make sure whether the wave is in the low or high troposphere ?

SHRI C. A. GEORGE : The synoptic model, if developed, will take care of it.

DR. G. C. ASNANI remarked that this interesting study emphasises where synoptic meteorology should go hand in hand with objective methods of filling data gaps in tropical Indian Ocean for getting initial flow field for NWP work.

SHRI R. K. DATTA remarked that the same system may have different cloud organisation over land and sea.

SHRI J. SUKLA remarked that he and his colleagues had made some similar bogussing of data for an easterly wave for the purpose of making input for a NWP model. However, it was seen that the phase speed was forecast only with large errors.