Mausam, (1985), **36**, 3, 287-290

551.576(533)

Stratus clouds off Yemen coast

A. K. MUKHERJEE
Meteorological Office, Pune
and
G. GURUNADHAM
Regional Meteorological Centre, Bombay

(*Received 3 February 1984*)

सार — इस लेख में ग्रीष्म काल में यमन के तट के ऊपर तथा वहां से और संलग्न अरब तट से निम्न स्तरी मेघों के एक साथ उठने का अध्ययन किया गया है। यह नियमित रूप से होता है, जब दक्षिण-पश्चिम मानसून बढ़ता है तो ये मेघ उठते हैं और जब मानसून पश्चिमी राजस्थान से चला जाता है तो ये मेघ अदृश्य हो जाते हैं। इस सारी अवधि में ही मेघ विद्यमान रहते हैं, ये अरब सागर पर फैल जाते हैं। इन मेघों का सम्भावित कारण खोज लिया गया है। ऐसी धारणा है कि अरब सागर के ऊपर मेघों के आकार में भिन्नता का भारत में मानसून की सक्रियता के साथ कुछ सम्बन्ध है।

ABSTRACT. The concurrence of low stratus clouds over and off Yemen coast and adjoining Arabian coast during summer months is studied in this paper. It is found to be a regular occurrence, onset of these clouds agreeing with the advancement of southwest monsoon to, and disappearance agreeing with its withdrawal from west Rajasthan. The clouds are present throughout this period, they extend well over the Arabian Sea. The probable cause for these clouds has been investigated. It is suggested that the variation of the size of the cloud over Arabian Sea has some connection with the monsoon activity over India.

1. Introduction

One of the important seasonal phenomena on the Yemen coast over the Arabian Sea is the formation of low stratus clouds during major part of the summer (HMSO 1944). Occurrence of these clouds over and off Yemen coast during the summer months is a well known phenomenon to aviators. Though the aviation meteorological observations contained in the current weather registers of all the airports on the coast indicate their presence, no proper documentation has been made over the aerial extent of these clouds. It is only after regular satellite observations are available that the continuity in the existence and variation of aerial coverage could be studied.

In this note the result of this study is presented.

2. Data

Satellite pictures from the polar orbitting satellite of ESSA, TIROS-N and NOAA series have been studied from the year 1971 onwards. The APT pictures were taken at the Regional Meteorological Centre, Bombay, daily on an operational basis. These pictures were analysed to determine the existence and the aerial extent.

Most of the satellites had both visible and infra-red picture transmission facilities. From these it could be inferred that clouds seen daily over the Yemen coast during the Indian southwest monsoon season were actually low clouds. They were clearly seen in visible pictures and were not seen in the infra-red. From these the conclusion was drawn and extended to the cases when IR pictures were not available.

For finding out any relationship with onset of monsoon as well as with monsoon activity the working charts of Forecasting Office, Colaba, Bombay, were consulted.

That these clouds are stratus clouds and not fog have been inferred from the fact that over the Yemen coast the surface wind is strong. Thus the chance of formation of fog is rare. Even when fog forms it is lifted and converts itself into stratus cloud. The ships' meteorological reports in that area were also consulted. It must be mentioned here that due to some synoptic situation there may be other types of clouds present and satellite picture may not indicate the existence of stratus cloud at that time. However, excepting those few occasions when there may be cumulus and stratocumulus clouds as seen through the APT pictures, the stratus clouds were seen practically every day. It has, therefore, been presumed that even on those days when cumulus and stratocumulus clouds were present the stratus cloud existed.

3. Results and discussions

3·1. *Results*

After examining the satellite pictures the dates of first appearance and the dates of disappearance of

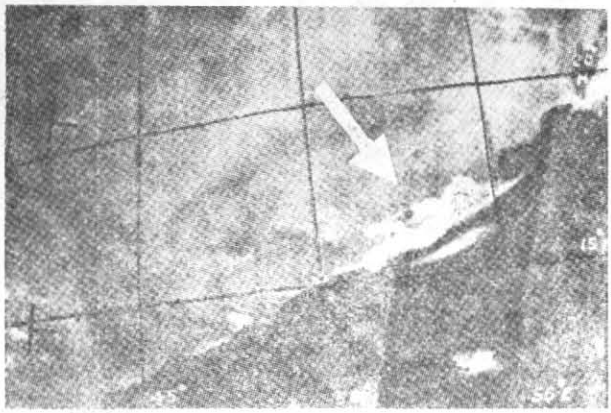

Fig. 1. Location of stratus cloud off Yemen coast

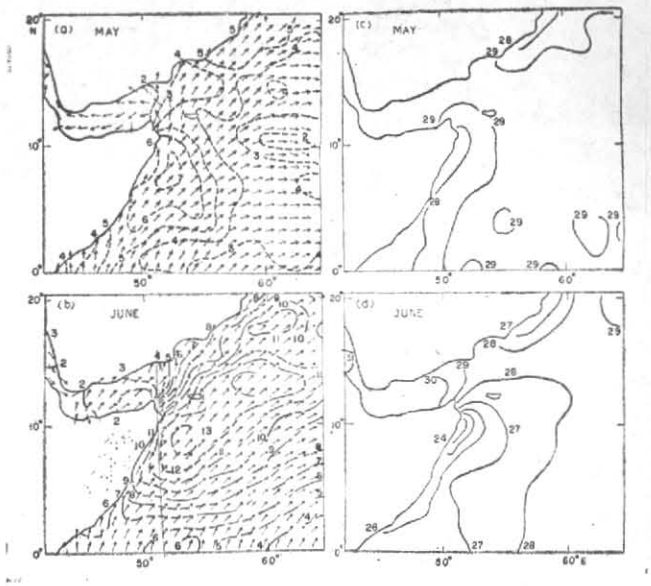

Fig. 2. Resultant winds (mps) for (a) May & (b) June. Sea surface temperatures (°C) for (c) May & (d) June

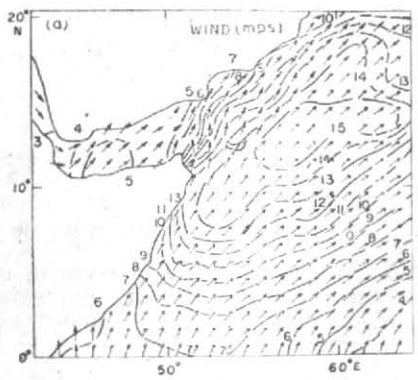

Fig. 3 (a). Resultant wind (mps) — July

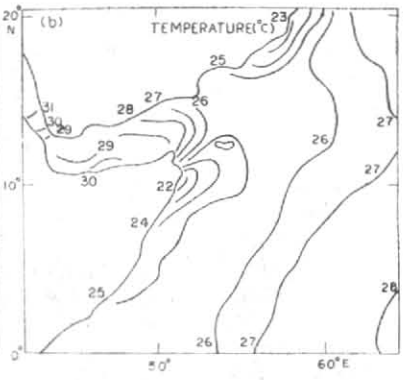

Fig. 3 (b). Sea surface temperature (°C) — July

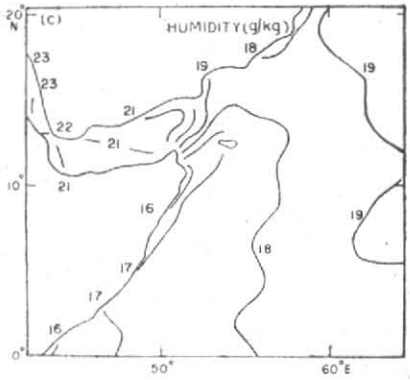

Fig. 3 (c). Specific humidity (g/kg) — July

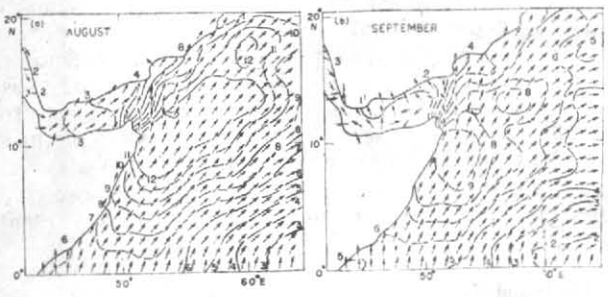

Fig. 4. Resultant winds (mps) — (a) August, (b) September

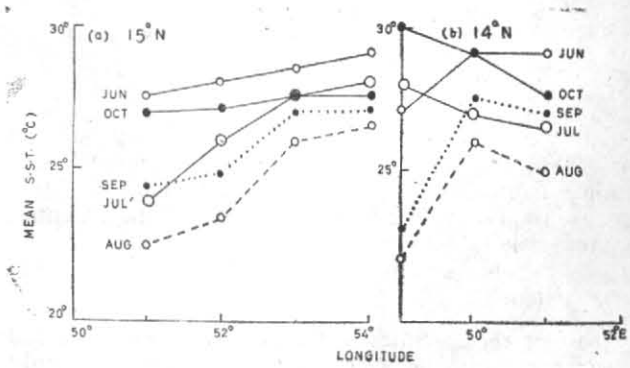

Fig. 5. Variation of sea surface temperature along latitudes 14° N & 15 °N (Note the amount of cooling of sea surface due to monsoon winds)

TABLE 1

Year	Date of first appearance of cloud	Date of advance of S.W. monsoon over west Rajasthan	Date of disappearance of cloud	Date of withdrawal of S.W. monsoon from west Rajasthan
1971	16 Jun	24 Jun	22 Sep	15 Sep
1972	18 „	30 „	22 „	6 „
1973	7 Jul	6 Jul	29 „	27 „
1974	5 „	12 „	13 „	4 „
1975	27 „	23 „	20 „	23 „
1976	10 „	8 „	18 „	19 „
1977	10 „	15 „	27 „	25 „
1978	15 „	3 „	16 „	11 „
1979	1 „	15 „	16 „	21 „
1980	22 Jun	26 Jun	23 „	15 „
1981	4 Jul	3 Jul	3 „	3 „
1982	23 „	22 „	3 „	3 „
1983	4 „	6 „	13 „	13 „

the stratus clouds were noted every year. These are shown in Table 1. It was observed that these clouds were present every day during the (Indian) southwest monsoon period with maximum extention from latitude 13° N to 17° N, and longitude 49° E to 55° E. To confirm occurrence of the stratus clouds from the available surface observations, the synoptic data of Salalah and ships' observations in that area were examined. An example of such cloud as seen in APT picture is shown in Fig. 1.

It will be seen from the Table 1 that the cloud appears in the end of June or in July every year and persists till middle of September. The cloud appears to be present throughout the day for the whole period mentioned above. In Table 1 the dates of advance of southwest monsoon into west Rajasthan as well as the dates of withdrawal of southwest monsoon from the same place are shown. It would be seen from this that there is some sort of association of the date of appearance of stratus clouds with the date of advancement of southwest monsoon to northwest India (west Rajasthan) and of date of disappearance of these clouds with the date of withdrawal of southwest monsoon from the same region.

3.2. *Explanation*

Since it is a routine feature, an attempt has been made to explain the occurrence of these clouds. Figs. 2-4 are reproduced from the Hastenrath and Lamb (1979) Atlas.

In Fig. 2(a) it can be seen that in May surface wind over west Arabian Sea and the Gulf of Aden is generally light. Only off Somalia 7 mps wind speed is observed. Wind is southwesterly to the west of longitude 60° E and turns to easterly in Gulf of Aden. In Fig. 2(c) we see that the sea surface temperature is between 28° C and 29° C throughout the area under consideration.

In Fig. 2(b) it can be seen that, in June, the wind speed has increased considerably throughout the area. The wind direction at Gulf of Aden has changed radically from easterly to southwesterly. Fig. 2(d) shows that the sea surface temperature has shown considerable change. Off Somalia coast there is a fall of temperature by 4° C. Off Yemen and Arabian coast the temperature fall is marginal. But in the Gulf of Aden the sea surface temperature has actually shown a rise. Referring to Fig. 2(b) again we can, therefore, see that off Yemen coast there is a mixing of air from two sources. One is from Somalia coast which is cold and moist, the other from Gulf of Aden which is warm and moist.

Fig. 3(a) shows that in July, there is a further rise in the wind speed throughout the area and better mixing of cold and warm moist air off Yemen and Arabian coast. Fig. 3(b) shows that there is further fall of temperature off Somalia coast, but there is a considerable fall in temperature off Arabian coast. This may be due to the surface current produced in June carrying cold water upto the coast of Arabia. To some extent this may be due to upwelling near the coast also. That cold water had moved with surface current is apparent since there is some fall in sea surface temperature on the mouth of Gulf of Aden, whereas in the interior of the Gulf the sea surface temperature remains as high as 30°C. The mixing of these two air masses would cause a formation of stratus clouds off Yemen and Arabian coast. In Fig. 3(c) the specific humidity, in gm of water vapour per kg of dry air, is shown for the whole area. It may be seen that off Somalia coast the air is saturated with respect to temperature 22 °C. Similarly, the value of 21 gm/kg of specific humidity is at the mouth of Gulf of Aden and that is saturation specific humidity at 26° C. When air from Gulf of Aden and from Somalia meet the temperature of air from Gulf would fall and the excess humidity will be converted into clouds. The difference is about 3 gm/kg which is fairly high. This means that stratus cloud with considerable thickness would form off Yemen coast. Sometime if the wind is light there may be occurrence of fog. Otherwise this will continue to be stratus cloud.

Fig. 4 shows that the condition for August is very similar to that in July. The sea surface temperatures are also found to be similar and therefore the figure has not been reproduced. In September (Fig. 4b) suddenly there is a change. The winds have become light and over Gulf of Aden the winds are variable. In October (figure not shown) the wind and temperature conditions completely change. Thus the stratus clouds are formed due to mixing of cold and warm moist air current which prevails during the Indian southwest monsoon season. Naturally, it takes sometime to make the temperature low over the sea surface and similarly for the clouds to form after southwest monsoon has set-in over the area. Again, as soon as the southwest monsoon current (air) weakens, the upwelling off Somalia coast and consequent cooling of sea surface decreases and stratus clouds disappear.

How much should it extend would, therefore, depends on the sea surface temperature. It can be seen from

Fg. 5 that at latitude 15° N there is cooling of the sea surface upto 53°E. At 14°N there is a cooling of sea surface upto 51°E. The fall in temperature occurs from June to August and then the temperature rises. The stratus cloud, therefore, should have an extension in a similar way. In the northern latitude they normally extend to 53°E and in southern latitude it normally extends upto 51°E. However, the day-to-day variation of wind depends on the synoptic situation. It has been found by Shyamala (1982) that when a depression forms over north Bay of Bengal the surface wind strengthens upto Somalia coast. As a result there is further cooling of sea surface off the coast, and consequent increase in both north-south and east-west extension of clouds. From the day-to-day variation of aerial extension it was found that the clouds can go upto 55 °E when monsoon is strong and vigorous over Arabian Sea. However, it may be mentioned that on some occasions increase in aerial extent of the cloud could be seen in APT pictures though no prominent synoptic situation or change in monsoon activity could be observed.

4. Conclusion

From this study it is clear that the stratus clouds off Yemen coast which is a prominent feature during major part of summer monsoon is caused by the south-west monsoon. The variation of size of the cloud cover has some connection with the monsoon activity. It is felt that more study is required in this line to establish this observation.

References

Her Majesty's Stationery Office, 1944, *Weather in Indian Ocean to Lat.* 30, *Long.* 95 *E including the Red Sea and Persian Gulf*, **II**, Pt. 2, pp. 92-93.

Hastenrath, S. and Lamb, P.J., 1979, *Climatic Atlas of the Indian Ocean*, Pt. 1, Univ. of Wisconsin Press.

Shyamala, B., 1982, "Distant effects of monsoon depressions", Ph. D. thesis, Bombay University.