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A satellite study of stratus clouds off Yemen coast

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सार — 1985 के दक्षिण-पश्चिम मानसून के दौरान यमन और सऊदी अरब से परे तटों पर मेघ बनने का अध्ययन तीन माह एवं 3 सप्ताह की अवधि तक 09 बजे ग्री. मा. समय पर इनसैट-1 बी के दृश्य प्रतिबिम्बों द्वारा किया गया। 27 जून से 20 सितम्बर 1985 तक के मेघों का परिमाणात्मक क्षेत्र मापन किया गया। यह ज्ञात हुआ कि इन तटों से परे स्तरी मेघों का बनना 8 जून से प्रारम्भ हुआ। प्रारम्भ में बहुत थोड़ा क्षेत्र ही इनसे आच्छादित था। 27 जून को इस क्षेत्र का अचानक विस्तार हुआ और यह विस्तार 18 सितम्बर 1985 तक जारी रहा। मेघों का अधिकतर क्षेत्र कुछ ऐसे दिनों दिखाई दिया जबकि मानसून भारत के पश्चिम तट पर सक्रिय अथवा प्रबल था। यह लगता है कि भारत के पश्चिम तट पर मानसून की सक्रियता तथा सऊदी अरब और यमन तटों से परे मेघाच्छादन में उतार-चढ़ाव का पारस्परिक सम्बन्ध है। बादलों के क्षेत्र में उतार-चढ़ाव की युक्तियुक्त प्रक्रिया को प्रतिपादित किया गया है।

ABSTRACT. Cloud formation off Yemen and Saudi Arabia coasts during southwest monsoon of 1985 was studied from INSAT-1B visible imagery of 0900 GMT for a period of three months and three weeks. The quantitative area-measurement of the clouds was done from 27 June to 20 September 1985. It was found that the formation of stratus clouds off these coasts began on 8 June. Initially only very small areas were found to be covered by them. There was a sudden increase of area on 27 June and this continued upto 18 September 1985. Large areas of clouds on some days were observed when monsoon was active or vigorous on west coast of India. It appears that the monsoon activity over the west coast of India and fluctuations in cloud cover off Saudi Arabia and Yemen coasts are related. A plausible mechanism for the fluctuation of the cloud area has been put forward.

1. Introduction

Mukherjee and Gurunadham (1985) reported that stratus clouds off Yemen coast are found to be a semi-permanent feature during southwest monsoon over India. In fact, the occurrence of low stratus clouds on these coasts during the major part of summer season was known earlier to the meteorologists working in this area (HMSO 1944). Mukherjee and Gurunadham's contribution was to show that these stratus clouds existed well over the Arabian Sea beyond the coast line. They also reported that there was a periodic variation of size in cloud cover and hinted on the possibility of the variation with southwest monsoon activity. In order to investigate this point in detail, the present study was undertaken.

2. Data and methodology

At Meteorological Data Utilisation Centre, New Delhi, INSAT-1B visible and infra-red pictures are taken round the clock at fixed hours. The resolution of the visible picture is 2.75 km and that of the infra-red picture is 11 km. INSAT-1B visible imagery of Sector II (Lat. 10°S-50°N; Long. 45°E-100°E) of 0900 GMT was chosen for the study of low clouds off Yemen and Saudi Arabia coasts as this hour was close to the local noon-time and the visible picture was expected to give best possible cloud imagery during the day. These clouds were not seen in IR pictures. They being low clouds were not significantly cooler than the surrounding surface and merged with it. The cloud top temperatures for the area covered by this cloud, as measured on Data Analysis and Interactive Display System, MDUC, were within 19.9°C to 20.8°C, whereas the sea surface temperature was between 22 and 24°C.

Mukherjee and Gurunadham established that these clouds are intimately connected with summer monsoon of India and they are caused by monsoon circulation over the Arabian Sea. They had to study these clouds from the satellite pictures of TIROS, ESSA and NOAA series satellites. Their observations could not be confined to a desired fixed time of the day. Moreover, quality and resolution of APT pictures from these satellites were not very good. At present, we have a geostationary satellite, INSAT-1B, which is continuously looking over this area. It has, therefore, been possible for us to have observations at a time of the day when visible picture would be the best. It is with the purpose of studying these clouds close to the local noon when the brightest imagery is expected, that the present work was undertaken.

Everyday, the visible INSAT-1B picture of Sector II for 0900 GMT was taken and the area covered by the clouds meant for this study measured with the help of a planimeter. The values of these cloud areas in sq km were noted. For the activity of southwest monsoon over India, working charts of NHAC of India Meteorological Department at its New Delhi headquarters were examined. Weather Bulletins issued by Central Weather Forecasting Office, Pune, were also consulted.

The climatological data mentioned here were taken from *Climatic Atlas of Indian Ocean* by Hastenrath and Lamb (1979). The main charts consulted were those for resultant winds, sea surface temperature and specific humidity for different months as given in the Atlas.

3. Results

An example of the cloud coverage is shown in Fig. 1 where clouding is also observed over the west coast of India. The results of measured cloud area in sq km are given in Table 1. From the analysis of this data, the following conclusions are arrived at :

(a) The stratus clouds off Yemen and Saudi Arabian coasts appear soon after the onset of the monsoon over India. The onset of monsoon on the southernmost part of India took place on 28 May 1985. The cloud was first observed on INSAT picture on 8 June 1985, when monsoon reached upto Bombay. Of course, the clouds were prominently seen from 27 June 1985, when monsoon advanced upto northeast Madhya Pradesh. These clouds could be seen on INSAT-1B picture upto 20 September 1985 when monsoon withdrew from Rajasthan. Mukherjee and Gurunadham (1985) stated that the appearance and disappearance of these clouds is connected with the onset of monsoon over west Rajasthan. The present study indicates that prominent cloud imagery from this area coincided with the onset and withdrawal of monsoon over north Madhya Pradesh and adjoining areas instead of west Rajasthan.

(b) The variations in the size of the cloud cover as shown in Fig. 2 are interesting in many respects. On the abscissa dates are given and on the ordinate the cloud cover area in sq km is given. The envelopes showing maximum and minimum cloud cover are also shown in this figure. It may be noted that some wave like character is discernible. The area of cloud cover increased upto 3rd week of the July and decreased upto 2nd week of August 1985. Afterwards, there was a slight increase and then the cloud gradually disappeared. It may be mentioned here that, in general, rainfall over India shows similar features. Mostly it is maximum in July and minimum sometime in August, followed by a small increase later.

(c) It is found that whenever the southwest monsoon is active over Konkan coast and a trough over sea level appears off Gujarat coast to Lakshadweep, the cloud cover under study shows an increase in the cloud area. Maximum cloud cover was on 18 July 1985, when the monsoon was vigorous over north Konkan and Gujarat region and active over the rest of west coast. In fact right from 14 July to 24 July 1985, the cloud cover was very high and the trough at sea level on all these days extended from north Maharashtra, south Gujarat to Lakshadweep. Coinciding with the increase of cloud cover from 13 August to 22 August 1985, a cyclonic circulation over Gujarat State could be seen. Here also the trough line on sea level chart off the west coast of India was present from Saurashtra to Lakshadweep.

TABLE 1

Cloud cover area in sq km

Jun 1985		Jul 1985		Aug 1985		Sep 1985	
Date	Cloud cover	Date	Cloud cover	Date	Cloud cover	Date	Cloud cover
27	7,500	1	5,250	1	12,500	1	7,250
28	10,250	2	2,500	2	3,500	2	C
29	9,700	3	5,000	3	N.A.	3	C
30	8,250	4	7,500	4	12,000	4	750
		5	1,250	5	4,500	5	C
		6	C	6	4,000	6	3,000
		7	3,000	7	4,500	7	5,000
		8	3,300	8	3,300	8	5,500
		9	10,000	9	2,000	9	6,250
		10	12,500	10	9,250	10	2,000
		11	14,500	11	4,000	11	3,000
		12	6,000	12	1,250	12	3,000
		13	6,500	13	4,750	13	C
		14	15,000	14	5,250	14	N.A.
		15	13,500	15	7,000	15	N.A.
		16	14,800	16	3,750	16	C
		17	15,750	17	4,000	17	2,500
		18	17,500	18	10,500	18	6,200
		19	15,000	19	4,750	19	C
		20	8,500	20	6,250	20	C
		21	16,250	21	6,250		
		22	17,500	22	3,750		
		23	15,900	23	3,000		
		24	17,500	24	1,000		
		25	10,000	25	1,250		
		26	9,700	26	5,750		
		27	15,750	27	4,750		
		28	8,750	28	1,500		
		29	6,250	29	1,000		
		30	8,750	30	8,250		
		31	8,750	31	4,750		

C—Clear N.A.– Not available.

(d) Fig. 1 shows the satellite picture of clouds at 0900 GMT of 18 July 1985. The cloud under study is indicated by an arrow. The clouds over northwest India and northern half of the west coast of India show that the monsoon was active over these areas. Fig. 3 gives 0300 GMT surface chart of the same date. The trough mentioned in the earlier paragraph can be seen in this figure. Rainfall figures given in this chart show that the monsoon was vigorous over north Konkan.

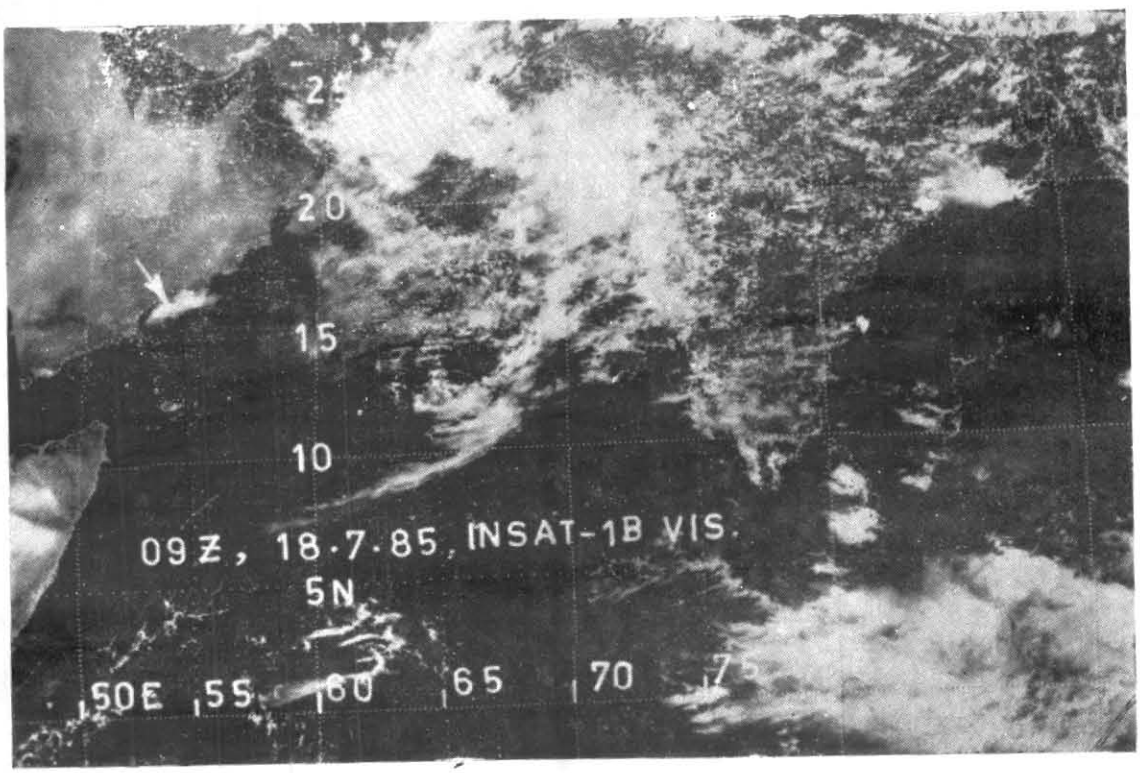


Fig. 1. Satellite picture of clouds at 0900 GMT of 18 July 1985. Arrow indicates the cloud under study. The clouds on northwest India and northern half of the west coast of India show that the monsoon was active in those areas

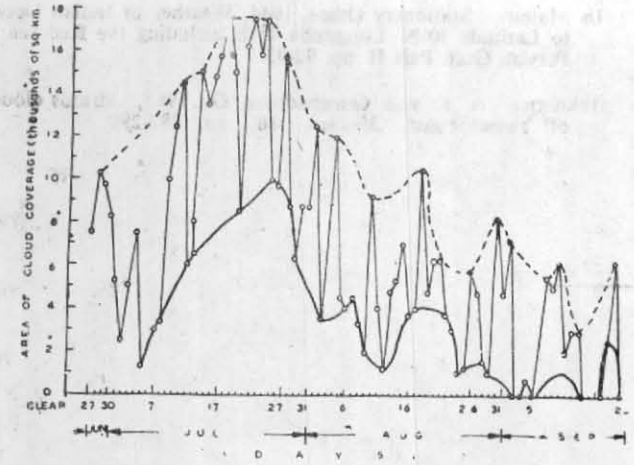
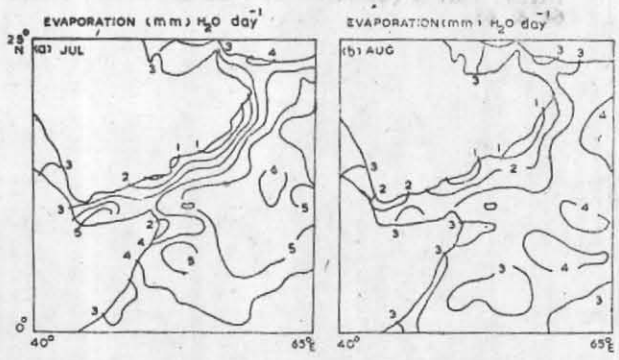


Fig. 2. Daily coverage of stratus clouds as seen in INSAT-1B visible pictures



Figs. 4 (a&b). Climatological evaporation charts (after Hasten rath and Lamb 1979)

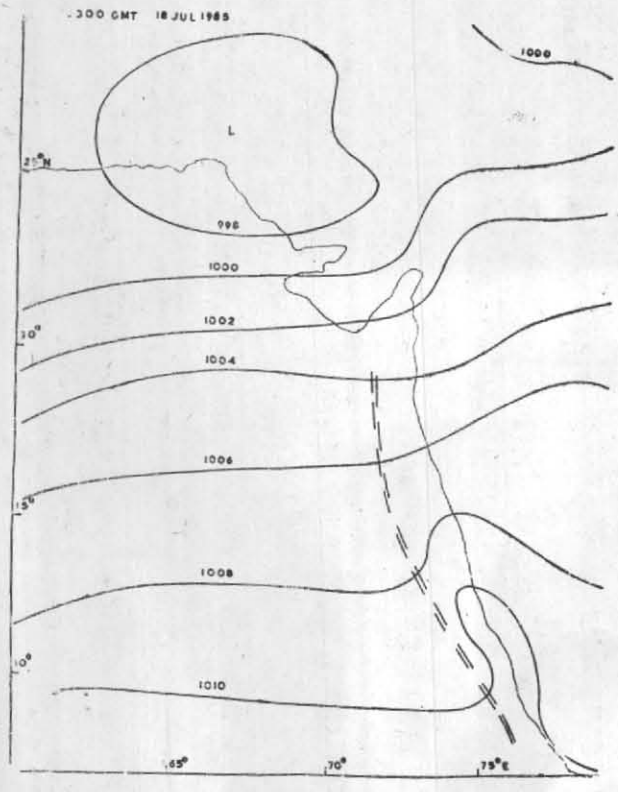


Fig. 3. Surface chart of 0300 GMT, 18 July 1985

4. Discussions

The occurrence of stratus clouds off Yemen and Saudi *Arabia coasts is a* semi-permanent feature during the southwest monsoon in India. It has a close connection with the monsoon activity over India. It seems to be connected directly with the monsoon activity over west coast of India and Rajashthan, M. P. In general, cloud cover increases in July and decreases slowly afterwards. This is in conformity with the wind speed over west Arabian Sea as seen on the climatological charts. An explanation for the variation in cloud cover is attempted here. An examination of climatological wind speed over west Arabian Sea as reproduced by Mukherjee and Gurunadham (1985) shows an increase gradually from June to July and decrease in August and further in September. They explained the occurrence of these clouds by interaction of warm moist air from Gulf of Aden with the cold sea surface. Examination of climatological sea surface temperature in July and August did not, however, show much difference indicating that in both the months the temperature structure of the underlying water surface is the same. From an examination of evaporation from surface for July and August as shown in Figs. 4 (a&b) (Hastenrath & Lamb 1979), it will be seen that more moisture is transported from Gulf of Aden to this region by the prevailing winds, where cloud forms during July and August. This seems to be the reason for the areal fluctuation in the monthly cloud cover over the region. The finer details in fluctuation cannot be explained from the available data.

5. Conclusion

The semi-permanent feature of cloud cover off Yemen and Saudi Arabia coasts during Asian summer monsoon period has been investigated with INSAT-1B Satellite pictures. The behaviour of cloud coverage has been explained broadly. It is not possible to draw more detailed conclusions from one year's data, but some indications exist to show that fluctuation in cloud cover and activity of Indian summer monsoon are related. More detailed study and probably some special observations would be required to estimate any forecasting potential from the occurrence of this cloud.

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