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Clouding over the Arabian Sea and the synoptic situation over India during monsoon

A. K. MUKHERJEE, G. GURUNADHAM and K. P. PADMANABHAM

Regional Meteorological Centre, Bombay

ABSTRACT. Satellite cloud pictures for the period 1971-75 were analysed to examine the coverage and type of the clouding over the Arabian Sea in relation to two main synoptic features of the monsoon season, namely, (1) Break in monsoon, and (2) Movement of monsoon depressions. It is found that whenever breaks appear and the monsoon trough goes to the foot of the Himalayas, Arabian Sea north of Lat. 15°N is covered with stratocumulus cloud lines. With the revival of the monsoon, these cloud lines decrease. This situation continues when the monsoon depressions form and move westwards till they come to Long. 80°E. When the monsoon depressions move further either to the west of Long. 80°E or to the north of Lat. 25°N the stratocumulus cloud lines increase over the Arabian Sea.

1. Introduction

After the southwest monsoon fully establishes over the entire country during the months of July and August, satellite cloud pictures reveal stratocumulus (*Sc*) cloud lines in the central and north Arabian Sea between Long. 60° and 70°E in the direction of low level winds. It is noticed that there are variations in the area covered by these cloud lines and also in their density. These variations are studied to examine whether there is any relationship with the breaks in the monsoon, movement of the monsoon depression, passage of western disturbances across northwest India and northward movement of off-shore vorticies along the west coast of India. The observations made in this regard during the period 1971 to 1975 are presented.

2. Data

APT unit at Bombay has been receiving daily cloud pictures from the various weather satellites, which are mainly used in this study. Dropsonde and radiosonde data available over the Arabian Sea during the I.I.O.E. and Monex periods are also studied.

3. Discussion

3. 1. *Activity of the monsoon trough* — During July and August, the position of the monsoon trough oscillates in north-south direction about its normal position. When the trough moves upto the foot of the Himalayas, break monsoon conditions are likely to set in and continue as long as the monsoon trough remains in its extreme position causing heavy convective activity in that region. Slightly ahead of this time, the formation of *Sc* cloud lines are observed over the central and north Arabian Sea and their persistence is seen day by day as long as the monsoon trough remains at the foot of the Himalayas (Fig. 1). There was a long period of break monsoon conditions from second half of July 1972 and severe drought prevailed over the country. It was then observed that the extent of *Sc* cloud lines covered northwards even upto north Gujarat and adjoining Rajasthan (Fig. 2). However, it is noticed that those cloud lines decrease in extent and density, when the monsoon trough recedes from the foot of the Himalayas and consequently when there is good monsoon activity over the country.

3. 2. *Formation and movement of monsoon depression* — Depressions forming over the head Bay

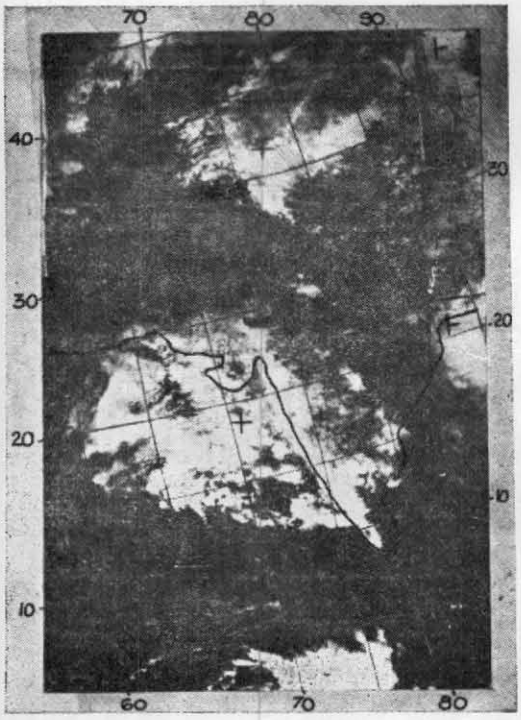

Fig. 1. Density extent of *Sc* clouds lines over the Arabian Sea when the monsoon trough is at the foot of the Himalayas (1 Aug 1972)

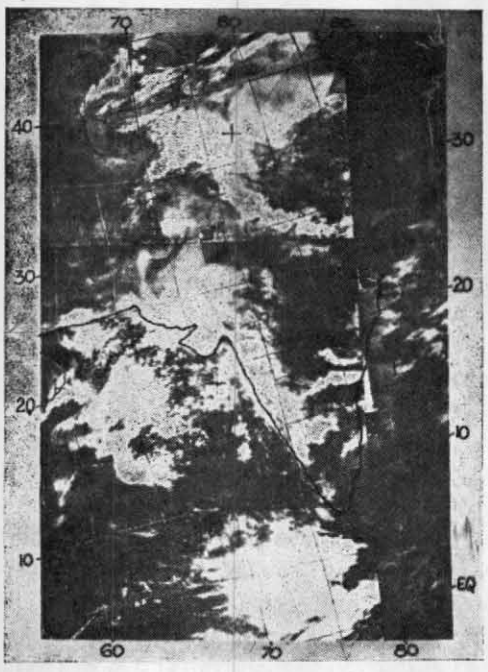

Fig. 2. Extent of *Sc* cloud lines into north Gujarat and Rajasthan when drought conditions prevailed over the country (23 Jul 1972)

during the monsoon season move westnorthwest along the monsoon trough. Some of them move further north of Lat. 25°N or west of Long. 80°E. During their formation and subsequent movement south of Lat. 25°N and east of Long. 80°E, the activity of the *Sc* cloud lines over the Arabian Sea is less (Figs. 3 a and 3 b). It is noticed that when these depressions move either northwards of Lat. 25°N or westwards of Long. 80°E, the activity of the cloud lines is more (Fig. 3 c).

3. 3. *Formation of the depressions over the Arabian Sea* — In the year 1972, advance of the monsoon was near normal. After the southwest monsoon fully established over the entire country there was unusual activity over the north Arabian Sea during the late June and early July, where a depression formed near Lat. 22°N, Long. 68°E and moved westwards. During this period there was no activity of *Sc* cloud lines which are normally seen over the Arabian Sea (Fig. 4).

3. 4. *Passage of western disturbances across northwest India* — Western disturbances move eastnortheast across Baluchistan, Pakistan and Western Himalayas during July and August. It is observed that the *Sc* cloud lines are on the increase whenever these disturbances pass across northwest India, even though monsoon trough is in its normal position and monsoon depressions move westnorthwest south of Lat. 25°N and east of Long. 80°E (Fig. 5).

3. 5. *Simultaneous presence of two depressions* — Some times a second depression may form over the head Bay before the earlier one is dissipated. Normally the activity of *Sc* cloud lines in the wake of formation of depression over the head Bay, is on the decrease. However, in the simultaneous presence of two depressions one of them being north of Lat. 25°N and the other over the head Bay it is seen that the activity of *Sc* cloud lines is on the increase (Fig. 6).

3. 6. *Movement of off-shore vortices along west coast* — During July-August, formation and subsequent northerly movement of low level off-shore vortices along the west coast is quite common. It is observed that the activity of the *Sc* cloud lines over the Arabian Sea increases in their wake, decreases in areas of their forward direction, irrespective of the activity of the monsoon over the rest of the country. As these vortices progressively move northwards along off coasts of Kerala, Karnataka, Goa and Maharashtra, the *Sc* cloud

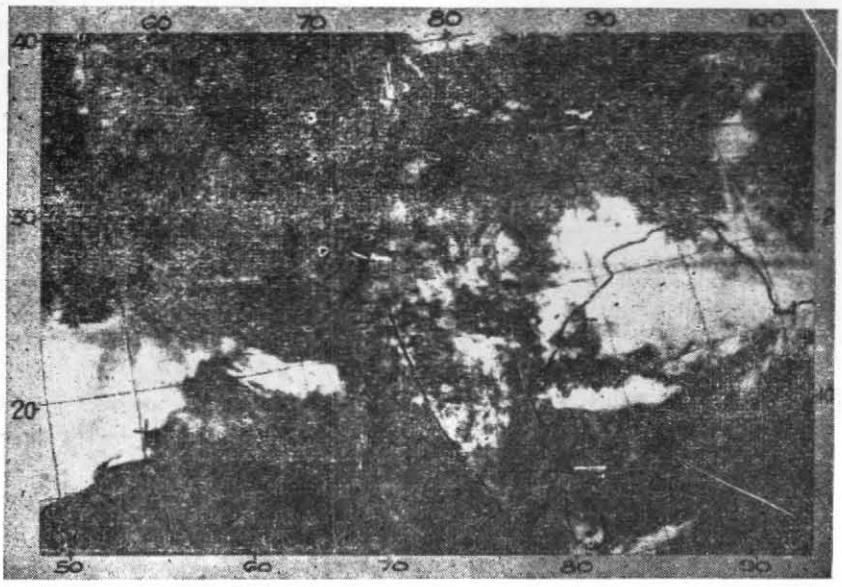

Fig. 3 (a). Decrease in *Sc* activity over the Arabian Sea in the wake of formation of depressions over the head Bay (13 Jul 1972)

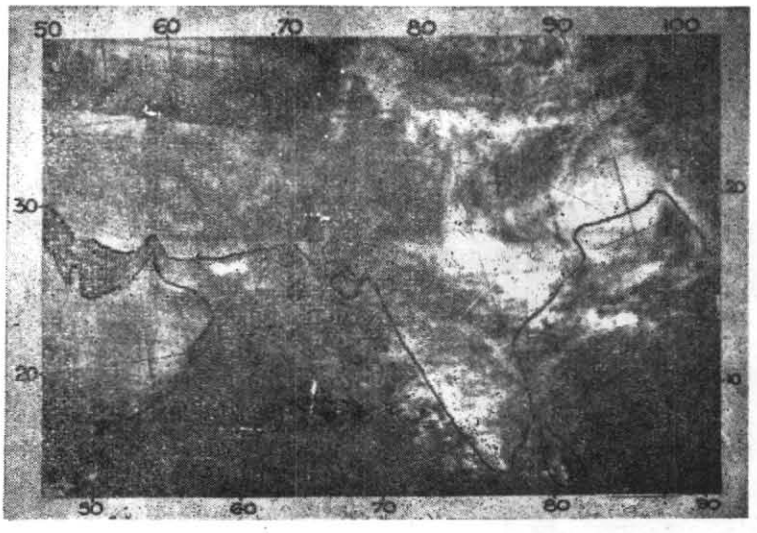

Fig. 3 (b). Decrease in the intensity and extent of *Sc* cloud lines over the Arabian Sea when monsoon depression move WNW south of Lat. 25°N and east of Long. 80°E (15 Aug 1974)

lines are pushed from east central and northeast Arabian Sea to west Arabian Sea (Figs. 7, 8 and 9).

4. Conclusions

4.1. An examination of the dropsonde and radiosonde data during the I.I.O.E. and Monex periods shows that near dry adiabatic conditions exist in the very low layers of the atmosphere following by isothermal or inversion layers varying between 950 and 800 mb levels during July and August over the central and north Arabian Sea. This may be the cause of the formation of *Sc* clouds in that area. Thiruvengadathan and

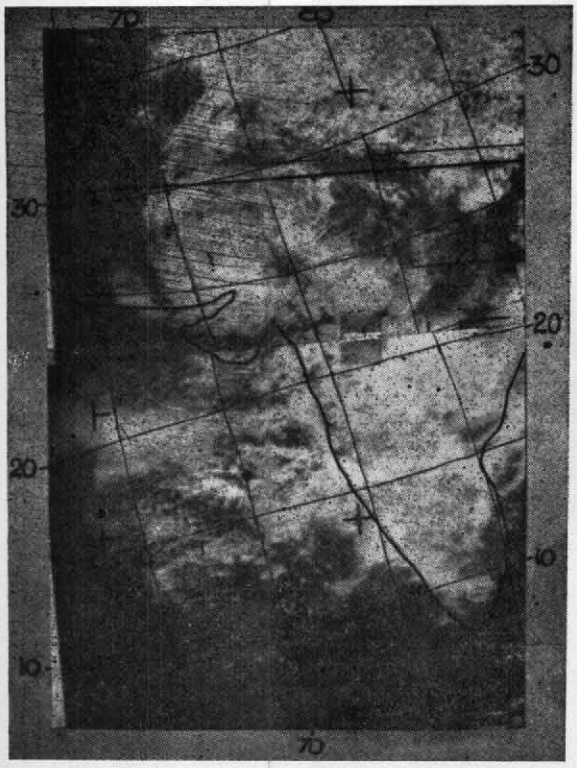

Fig. 3 (c). Increase in *Sc* activity over the Arabian Sea when the depression is west of Long. 80°E (17 Aug 1973)

Fig. 4. Absence of *Sc* cloud lines when a depression formed over the north Arabian Sea (1 Jul 1972)

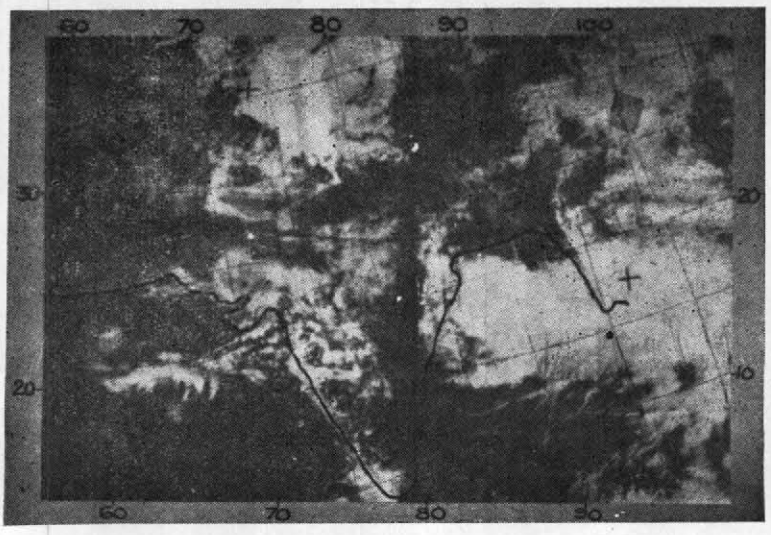

Fig. 5. Extent and density of *Sc* cloud lines when a western disturbance is passing across north India and monsoon activity over the head Bay (12 Jul 1972)

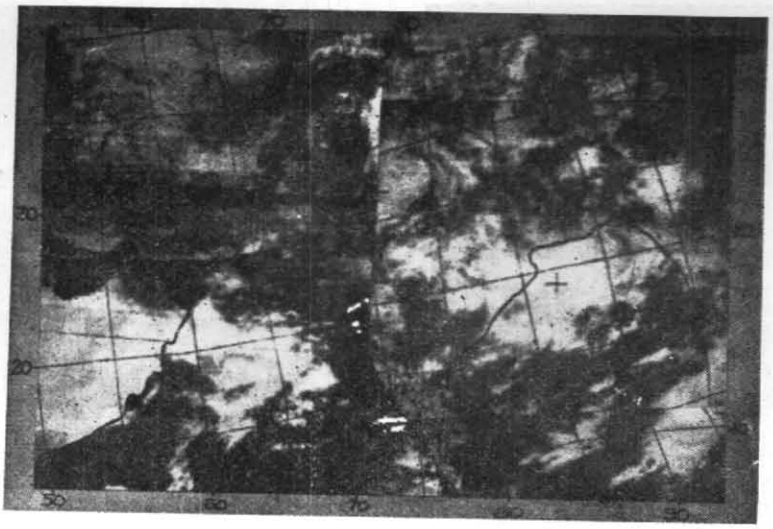

Fig. 6. *Sc* cloud lines is on the increase in the presence of two monsoon depressions one over the head Bay and the other north of Lat. 25°N (11 Aug 1972)

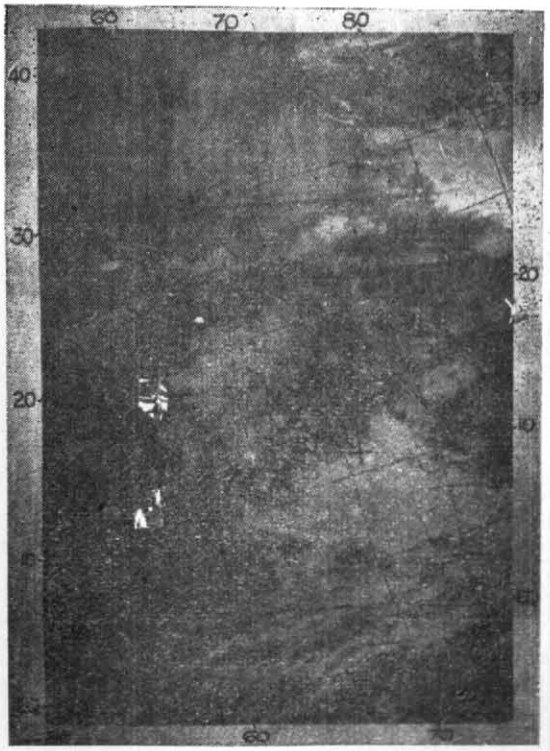

Fig. 7. *Sc* cloud lines over the north and central Arabian Sea when off-shore vortices are present along Kerala-Karnataka coasts (19 Aug 1971)

Fig. 8. *Sc* cloud lines over the west central Arabian Sea when off-shore vortices are present along Karnataka-Goa coasts (21 Aug 1971)

Fig. 9. *Sc* cloud lines over the west Arabian Sea when off-shore vortices along Goa-Maharashtra coasts (24 Aug 1971)

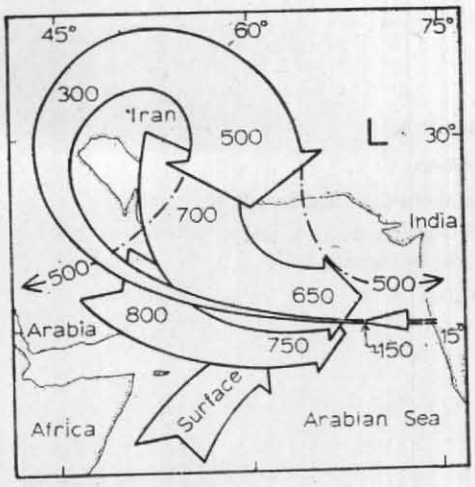

Fig. 10. Schematic representation of major air flows over southwest Asia and the Arabian Sea during Summer
(Fig. 7 of Walker : *Tellus*, 27, 1975)

Jambunathan (1971) discussing the average forenoon cloud cover over the Arabian Sea during the southwest monsoon season, also opined the inversion in the lower layers over the Arabian Sea inhibits the development of clouds. Walker (1972), and Ramage (1966) are of the opinion that the air subsiding widely over Sahara and Southwest Asia in summer, ascends originally in monsoon rain systems over Ethiopia and India respectively. Walker (1975) has further schematically illustrated the formation of trade wind cumulus in the areas of subsidence, north Arabian Sea (Fig. 10). In a paper on distribution of dry clouds in India, Satakopan and Sen (1955) have shown that even in July, north Gujarat and Rajasthan gets 10-15 days and Pakistan 20 days of prevalence of dry clouds, a majority of those are low clouds, presumably *Sc*. Das (1972) has shown that northwest India, *i.e.*, north Gujarat, Rajasthan and Pakistan constitute a well marked zone of subsidence during the monsoon season. From all the above considerations, it appears that this area of subsidence over the western parts of the subcontinent extends into the Arabian Sea. It appears that when a depression is north of Lat. 25°N or whenever a western disturbance is passing across northwest India, the Arabian Sea is coming under the areas of subsidence.

4. 2. The above observations show that there appears to be a definite relationship between the formation, persistence, extension and density of the *Sc* cloud lines over the Arabian Sea and (1) the position of the monsoon trough and its north-south oscillations, (2) formation and their subsequent westnorthwest movement of monsoon depressions, (3) eastnortheast movement of western disturbances across Pakistan and the western Himalayas, and (4) movement of off-shore vorticies northwards along the west coast.

4. 3. Authors agree in this respect with the statement of Walker (1975) that, until there is adequate coverage of tracts west of India, explanation of atmospheric behaviour are bound to remain conjectional. Whether the activity of the *Sc* cloud lines over the Arabian Sea has any bearing on the forecasting aspects of the activity of the monsoon trough is to be further examined. Observations during the ensuing Monex period (1977-79) may be able to provide adequate coverage of surface and upper air observational data to examine these aspects.

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