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A study of evening convective clouds over Kochi and neighbourhood

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सार – दक्षिणी पूर्वी अरब सागर और कोची के समुद्र सतह तापमान के अध्ययन के साथ-साथ 1996 से 1999 तक की अवधि के दौरान कोची और उसके 200 कि.मी. तक के आस-पास के क्षेत्रों में 0900 और 1100 यू.टी.सी. पर रेडार की प्रतिध्वनियों के विषय में अध्ययन किए गए हैं। इन अध्ययनों से निम्नलिखित परिणाम प्राप्त हुए हैं :

(*i*) मानसून से पूर्व तथा मानसून के बाद के संवहनी मेघों की ऊँचाई की अपेक्षा मानसून के संवहनी मेघों की ऊँचाई कम थी।

(*ii*) औसतन, मानसून मेघों की ऊँचाई 1996 से 1998 तक शनैः शनैः बढ़ी और फिर इसके बाद कम होने लगी।

(*iii*) इस अध्ययन के दौरान अगस्त 1997 से जून 1998 की अवधि में अन्य अवधियों की अपेक्षा संवहनी मेघ बहुत अधिक सक्रिय रहे।

(*iv*) ऋतु के अनुसार समुद्र सतह तापमान में बढ़ोतरी के अनुसार ही संवहनी मेघों की ऊँचाई में बढ़ोतरी होगी।

(*v*) अंतःवार्षिक रूप से, समुद्र सतह तापमान की व्यापक सकारात्मक विसंगति, संवहनी मेघों की उच्च सक्रियता के अनुरूप होती है जिसका कारण उस समय एल निनों का प्रबल होना हो सकता है।

ABSTRACT. Radar echoes of 0900 and 1100 UTC over Kochi and 200 km around were studied from 1996 to 1999 along with SST of southeast Arabian Sea and Kochi. The following results are obtained :

(*i*) Monsoon convective cloud tops were lower than Pre-monsoon and Post-monsoon convective cloud tops.

(*ii*) In the mean, monsoon cloud tops gradually increased from 1996 to 1998 and then decreased.

(*iii*) Very large convective activity existed during August 1997 to June 1998 compared to other periods of this study.

(*iv*) Seasonally the higher the SST, the higher is convective cloud top.

(*v*) Interannually, large positive SST anomaly coincided with high convective activity and this may be related to then prevailing El Nino.

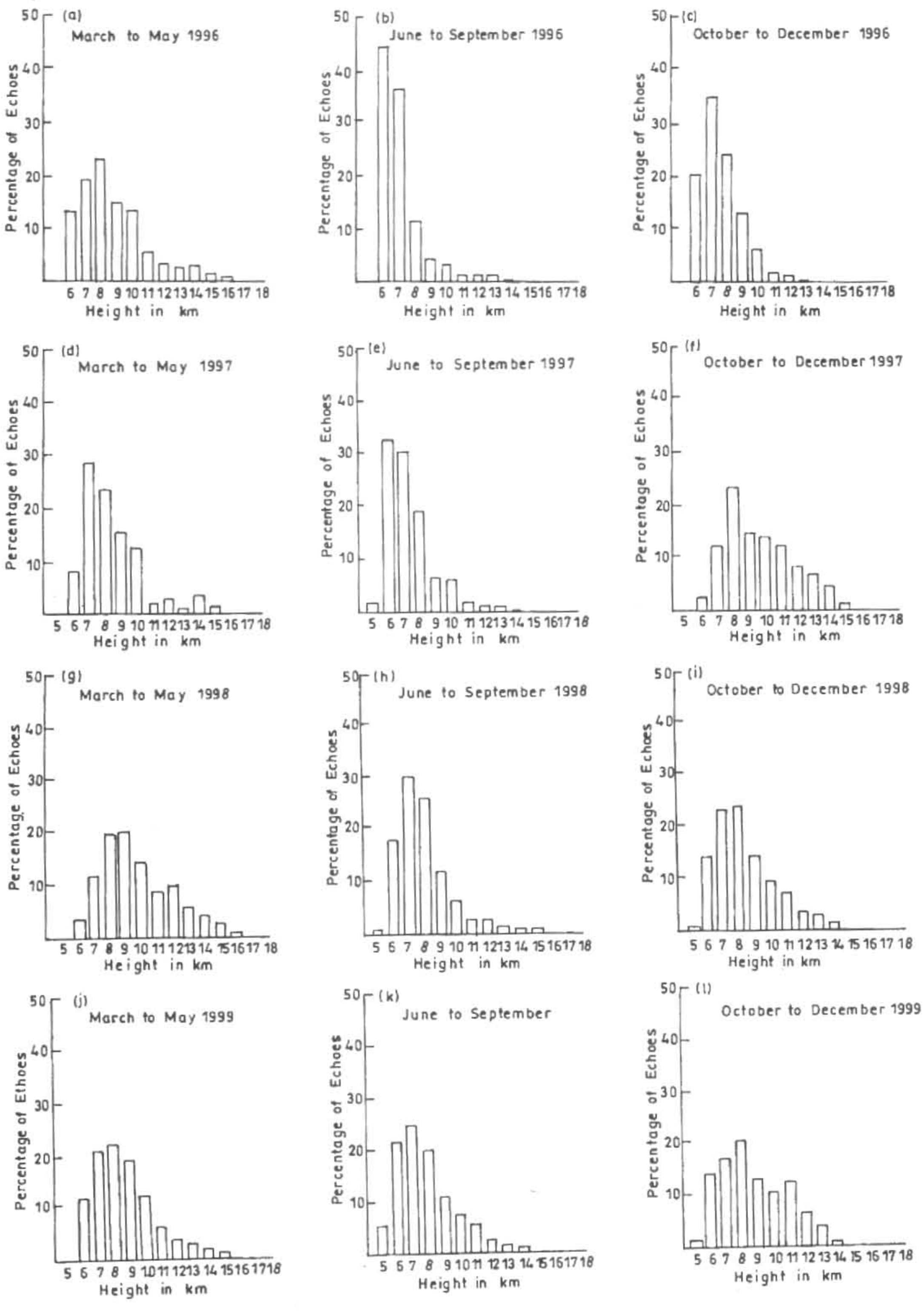
Key words – Convective cloud tops, Monsoon, Population of echoes, SST, El Nino.

1. Introduction

The limited number of available studies, Narayanan (1967, 1970) and Rao (1976), suggest that compared to other seasons monsoon cloud tops are of relatively low heights along west coast of India. The authors decided to look into the data available at the Cyclone Detection Radar Station at Kochi. A study was made with available radar data of years 1996 to 1999 along with sea surface temperature data for Kochi available with Cochin Port Hydrographic Survey Office and for southeast Arabian Sea available from Climate Diagnostic Bulletin of India.

2. Data and presentation

The radar being meant for cyclone detection only, a routine observation is being taken daily at 0900 UTC and an occasional observation is taken at 1100 UTC. Radar data is available for 1996 to 1999 except for periods from 8 June to 11 June 1996 and from 11 March to 23 April 1997 and for dates 16 June 1996, 29 September 1996, 2 October 1996 and 19 July 1997. There were 2030 observations during 1996 to 1999 at 0900 UTC and 1100 UTC together and obtained 7953 echoes of convective clouds of height above 5 km within a circle of radius



Figs. 1(a-l). Percentage distribution of echoes at various heights

TABLE 1

Number of observations taken and echoes obtained

Year	0900 UTC		1100 UTC	
	Number of observations	Number of echoes above 05 kms	Number of observations	Number of echoes above 05 kms
1996	358	741	162	448
1997	320	1594	177	1031
1998	365	1533	136	754
1999	365	1290	147	542

TABLE 2

Monthly mean heights and average number of echoes above 05 kms

Month	Mean height in kms								Average number of echoes per day at 0900 UTC			
	0900 UTC				1100 UTC							
	1996	1997	1998	1999	1996	1997	1998	1999	1996	1997	1998	1999
Jan	7.3	6.8	6.7	6.9	6.3	7.4	6.8	9.0	0.35	0.35	0.52	0.35
Feb	7.5	6.0	6.8	9.0	7.6	6.0	6.5	8.8	0.66	0.04	0.32	0.86
Mar	7.7	-	7.4	7.9	8.9	-	8.4	8.6	0.74	-	0.50	0.61
Apr	8.5	7.6	9.1	8.7	9.4	8.8	10.9	8.3	2.13	1.29	3.47	2.93
May	8.1	7.7	9.4	8.7	8.8	9.2	10.4	8.4	1.94	3.06	8.13	5.71
Jun	7.4	7.1	8.3	7.9	9.8	7.6	9.0	8.1	2.04	5.00	8.87	4.43
Jul	6.5	6.5	7.3	7.3	7.2	6.3	7.6	8.2	4.29	5.47	6.60	5.94
Aug	6.4	7.5	7.3	6.9	6.2	7.5	8.7	8.3	2.13	9.55	5.16	6.65
Sep	7.3	7.8	7.5	8.2	7.4	7.9	7.9	9.0	4.28	6.33	6.07	5.60
Oct	7.5	10.1	8.3	9.1	8.0	10.8	9.1	9.3	2.24	7.71	5.35	6.87
Nov	7.0	9.4	8.1	7.2	8.0	9.8	8.1	8.3	2.40	9.57	3.40	1.90
Dec	7.6	8.7	8.3	6.8	7.6	9.8	8.9	6.0	1.71	4.90	2.68	0.32

200 km around Kochi. The echo whose height is reported is scanned from base to top by raising the elevation angle of the radar in each case, as it is the usual and routine practice in determining the altitude of convective cloud in radar meteorology in India.

The Radar echoes considered in this study have been identified as coming from the convective clouds by their discreteness and vertically oriented reflectivity pattern reaching beyond freezing level (05 km). Table 1 gives the number of echoes whose altitudes are known and number of observations used under this study.

Monthly mean heights of echoes above 05 km at 0900 UTC and 1100 UTC and average number of echoes per day at 0900 UTC expressed in numbers correct to second decimal are tabulated in Table 2.

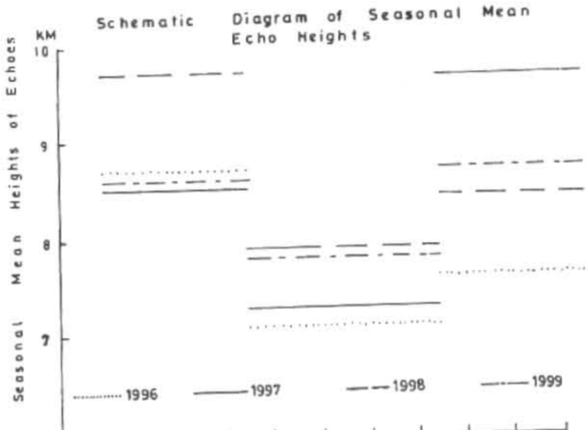
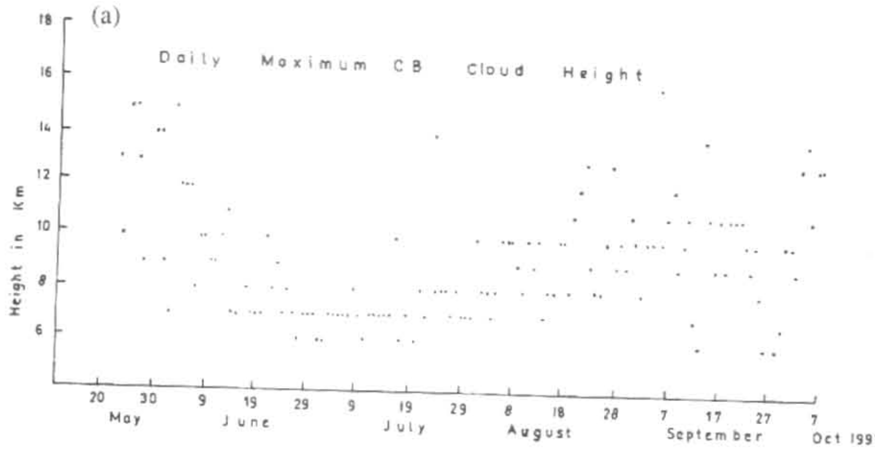
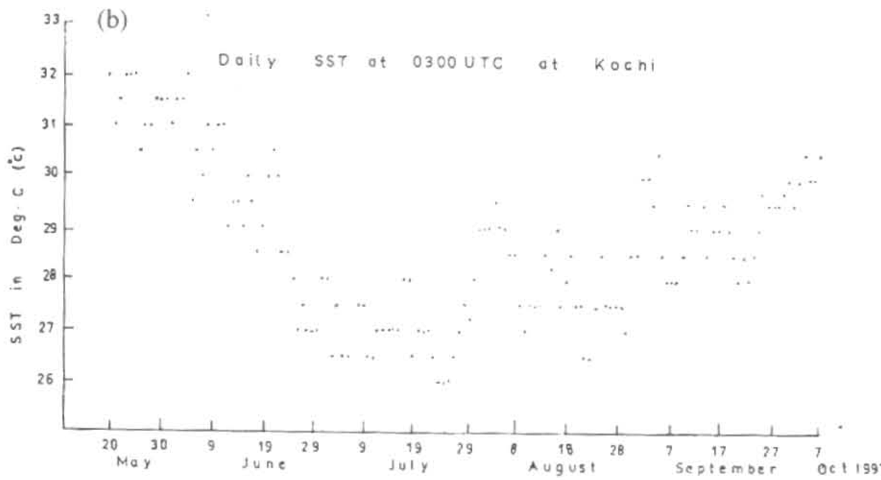


Fig. 2. Schematic diagram of seasonal mean echo heights





Figs. 3(a&b). (a) Daily maximum CB cloud height and (b) Daily SST at 0300 UTC at Kochi

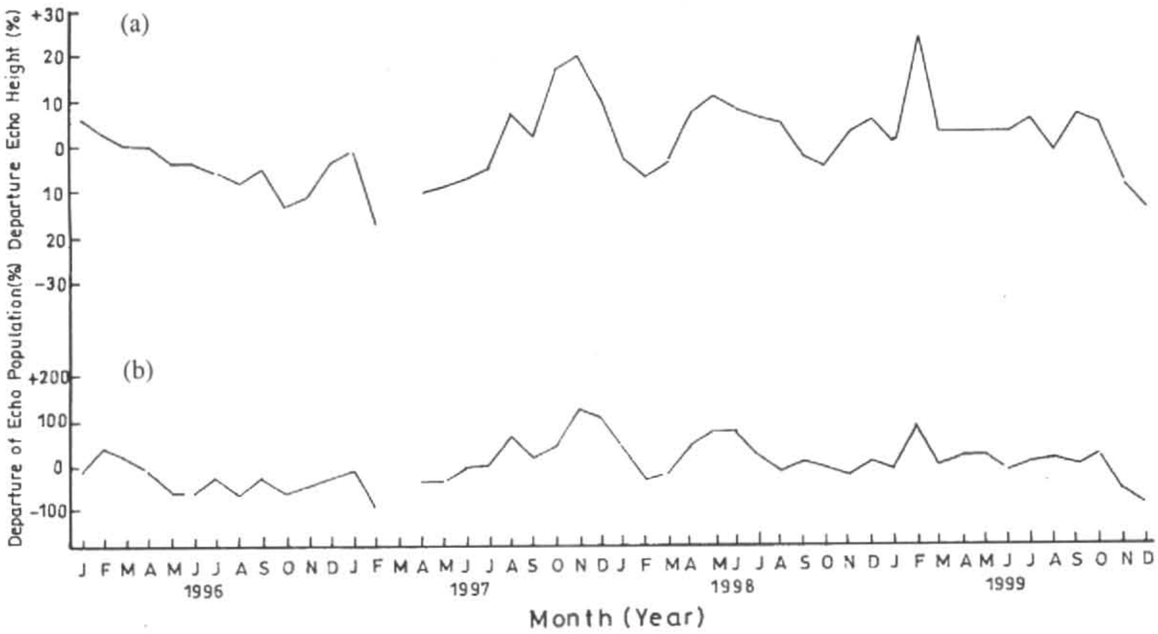
Concentrating on pre-monsoon, monsoon and post-monsoon periods, echoes of March to May, June to September and October to December for the years 1996 to 1999 are classified height-wise for heights above 05 km. The percentage distribution of echoes of various heights are graphically represented in Figs. 1(a-l). Mean heights are taken for pre-monsoon, monsoon and post-monsoon of 1996 to 1999 and are schematically presented in Fig. 2.

Daily maximum echo heights of convective cloud tops observed over a circular area of 200 km radius around Kochi and the daily SST values at 0300 UTC at Kochi Port are presented for the period 20 May to 7 October 1997 in Figs. 3(a&b) respectively.

The percentage departure from the average value of mean echo heights and echo population for every month for the years 1996 to 1999 are given in Figs. 4(a&b). Also the SST anomaly of monthly mean SST of southeast Arabian Sea is presented monthwise for the years 1996 to 1999 in Fig. 5 where only positive anomaly points above one degree Celsius are joined by lines.

3. Results and discussion

Over the area comprising 200 km radius around Kochi with almost half over Arabian Sea and the remaining over land, there were convective echoes of altitude 5 km or more on more than 244 days each in 1996 and 1997, on 263 days or more in 1998 and 262 days or more in 1999. There was high chance of a convective cell being detected at 0900 UTC during the period April to December all these years except for December 1999. Generally height of convective cloud tops increased at



Figs. 4(a&b). Percentage departures from average values of (a) Echo height and (b) Echo population

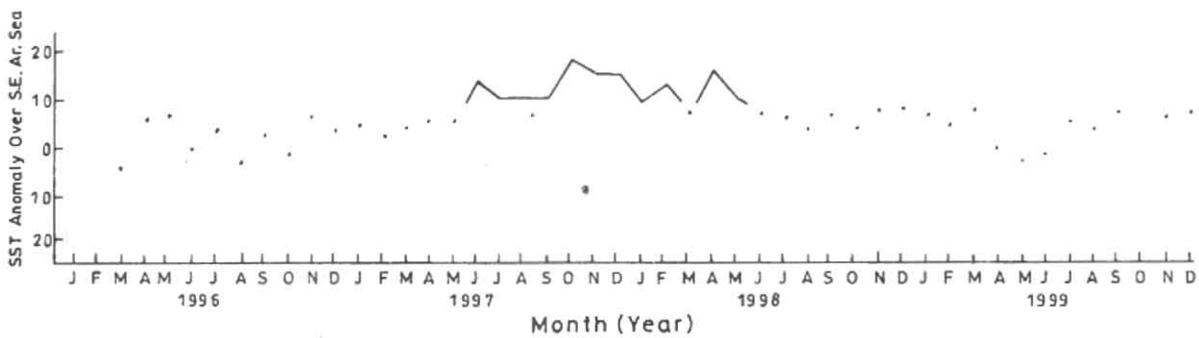


Fig. 5. Variation of SST anomaly over southeast Arabian sea

1100 UTC compared to that at 0900 UTC. Maximum convective development was observed in respect of height and number of echoes during evenings of post monsoon of 1997 and summer of 1998 (Table 2).

Figs. 1(a-l) show that during monsoon (June to September) majority of convective echoes were within 6 to 8 km in height while in other seasons (March to May and October to December) majority of echoes are of height 7 to 9 km or more. Fig. 2 gives the mean heights of echoes showing monsoon months on low side compared to pre-monsoon and post-monsoon months. Fig. 3(a) also shows that monsoon period has low maximum cloud tops. It is, therefore, confirming that monsoon period has low cloud tops over the southern parts of west coast of India.

It is also seen from Figs. 1(b,e,h &k) and Fig. 2 that monsoon cloud height gradually increased from 1996 to 1998 and then decreased in 1999.

In Table 2, we see echo numbers were comparatively less during 1996 and 1999. The large echo numbers seen during 1997 and 1998 show that echoes increased from May to August and September to November in 1997 and echoes decreased from June to August and September to December in 1998. It is seen that when echoes were less in May 1997, the succeeding August and post-monsoon period witnessed quite large number of echoes. The situation reversed in 1998. In May 1998 echoes were quite large in number compared to May 1997 and the succeeding August and post-monsoon period experienced less number of echoes. However monsoon echo totals were more or less same in 1997 and 1998.

As evidenced by the Table 2 and Fig. 2, post-monsoon of 1997 and pre-monsoon of 1998 had large echo population and very high echo heights showing convective activity of very high intensity compared to other years.

Figs. 3(a & b) taken together is an example of the seasonal variations of daily maximum convective cloud heights and 0300 UTC SST values having almost same characteristic mean rise and fall. The higher the SST, the higher is convective cloud top. This shows that cloud height and sea surface temperature suffer seasonal variations.

Figs. 4(a & b) show that the cloud height and echo population have interannual variation in their percentage departures from average values. Maximum intense activity from August 1997 to June 1998 in height and amount of cloud echoes as seen in Figs. 4(a & b) correspond to high SST anomaly of 1° Celsius or more in Fig 5. SST anomaly of SE Arabian Sea has been high corresponding to then prevailing El Nino. This higher SST anomaly was coinciding with very high activity of convective clouds. Thus El Nino is seen to cause increased convection and instability. Recent studies have shown that when east Pacific is warm due to El Nino a large area of equatorial Indian Ocean also gets a warm anomaly. (Tourre and White, 1997). This warm anomaly in Indian Ocean was particularly strong during the 1997-98 El Nino especially in southeast Arabian Sea. (Monthly Climate Diagnostic Bulletins issued by NOAA, Washington, USA).

4. Conclusion

Compared to pre-monsoon and post-monsoon, monsoon convective cloud tops are lower in height. Monsoon cloud tops increased from 1996 to 1998 and then decreased. Very large convective activity existed during August 1997 to June 1998. The higher the SST, the higher is convective cloud top and sea surface heating is a deciding factor in convective development as far as seasonal variation is concerned. Interannual variation of convective activity is linked with large positive SST anomaly. High instability of atmosphere and increased convective activity during 1997 and 1998 seemed related to high value of SST anomaly and then prevailing El Nino.

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