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Latitudinal distribution of water vapour over the Arabian Sea and Bay of Bengal using *Bhaskara-II SAMIR* data

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सार—इस कार्य का मुख्य उद्देश्य, समीर सिस्टम (तन्त्र) के इन–आर्बिट प्रचालन की सम्पूर्ण 18-माह की अवधि जनवरी 1982 से जून 1983 के लिए अरब सागर और बंगाल की खाड़ी के समीर से उत्पन्न जलवाष्प आंकड़ों की विश्वश्नीयता को स्थापित करना है । समीर आँकड़ों से व्युत्पन्न, विभिन्न महीनों के अरब सागर और बंगाल की खाड़ी पर जलवाष्प के औसत अक्षांशीय वितरण तटीय और द्वीपीय रेडियो सौन्दे स्टेशनों से जलवाष्प पर जलवायुमंडलीय आँकड़ों से व्यापक रूप से अनुकूल है ।

भारतीय सागरों में भूमध्य रेखा के निकट 4-5 ग्राम/सेमी^{2} के उच्चतम मान और 20° उत्तर के लगभग 2 ग्राम/सेमी^{2} के निम्नतम मान सहित उत्तरी शीत कालीन महीनों के दौरान जलवाष्प में महत्वपूर्ण अक्षांशीय समाश्रयण पाए गए हैं । ये समाश्रयण धीरे–धीरे परवर्ती महीनों में कम हो जाते हैं और दक्षिण–पश्चिम मानसून महीनों (जून से सितम्बर) के दौरान लगभग समाप्त हो जाते हैं, जब भारतीय सागरों पर 20° उत्तर से भमध्य रेखा से सम्पूर्ण अक्षांश परास में 4-5 ग्राम/सेमी^{2} के मान प्राय: एक समान होते हैं । अन्तत: यह पाया गया कि अरब सागर के सह अक्षांशीय स्थितियों की तुलना में बंगाल की खाड़ी पर जलवाष्प प्राय: अधिक होते हैं । इन परिणामों के आशय की चर्चा अन्य परिप्रेक्ष्य में की गई है ।

ABSTRACT. The main purpose of the present work is to establish the reliability of the SAMIR-derived water vapour (WV) data over the Arabian Sea and the Bay of Bengal for the entire 18-month from January 1982 to June 1983 period of the in-orbit operation of the SAMIR system. The average latitudinal distributions of WV over the Arabian Sea and Bay of Bengal for different months, derived from the SAMIR data were found to be *broadly consistent* with the climatological data on WV from the coastal and island radiosonde stations.

A significant latitudinal gradient in WV has been found during the northern winter months (Dec-Feb) with the highest value of 4-5 gm/cm^2 near the equator and the lowest value of about 2 gm/cm^2 at about 20°N over the Indian seas. This gradient gradually decreases during the subsequent months and almost vanishes during the southwest monsoon months (Jun-Sep) when the WV has nearly uniform value of 4-5 gm/cm^2 in the entire latitude range from the equator to 20°N over the Indian seas. Finally, it has been found that WV values over the Bay of Bengal are generally higher than those over the Arabian Sea at co-latitudinal positions. The implications of this result are discussed in the light of other considerations.

Key words — Bhaskara-II SAMIR, Total water vapour, Latitudinal distribution, Arabian Sea, and Bay of Bengal.

1. Introduction

Microwave remote sensing has long been recognised as a powerful tool for meteorological and oceanographic applications. A passive microwave sensor in space, with suitable frequency channels, has the unique capability to measure atmospheric water vapour and liquid water over ocean even in the presence of most types of clouds (*e.g.*, Staelin *et al.* 1976, Chang and Wilheit 1979, Prabhakara *et al.* 1982). The present work deals with a study of atmospheric water vapour (WV) over the Arabian Sea (AS) and Bay of Bengal (BB) as derived from the 'Satellite Microwave Radiometer (SAMIR) system onboard the Indian satellite *Bhaskara*-II.

A detailed technical description of the SAMIR system is given by Calla *et al.* (1982), while the method of determining WV over ocean from SAMIR data has been described by Pathak (1987). A brief summary of the essential features of the SAMIR system is given below.

The passive microwave radiometer system SAMIR onboard *Bhaskara*-II satellite measured the earth's brightness temperature (T_B) in three atmospheric channels at 19.35, 22.235 and 31.4 GHz frequencies in vertical polarization. The observations were taken close to nadir at angles of ±2.8° and ±5.6° along the satellite ground trace during each spin of the satellite. In addition, zenith sky temperature at 3°K was measured during each spin, which was used for calibration. The three radiometers had nearly coincident footprints of approximately 125 km diameter on the ground. However, due to the combined effect of the spin of the satellite and the large integration time of 300 m/sec for each radiometer, the footprint was smeared to a size of approximately 240 km for each observation. The advantage of coincident footprints is that it allowed simultaneous measurements of the three-frequency T_B data of the same area on the earth for the same atmospheric conditions. Thus, by comparing such simultaneous measurements at three frequencies, one can make important deductions about the atmospheric conditions over the ocean.

It should be noted that WV from the SAMIR data can be obtained only over ocean. This is due to the fact that warm microwave emission from atmospheric water vapour provides a good contrast against the cool microwave background of water which has low emissivity (~ 0.4), whereas it does not provide a good contrast over land which has high emissivity of ~ 0.9. In view of the large effective footprint of about 240 km, the SAMIR data within about 300 km of coastline have not been considered for deriving WV.

A large data set of SAMIR is available over a 18-month period from January 1982 to June 1983. In an earlier work, Pathak *et al.* (1985) using the SAMIR data for *only a few orbits* during two different periods derived the latitudinal distribution of WV. In the present study, we have made use of the *entire data set* to study the WV distribution over AS and BB. The main objective of the present work is to establish the reliability of the entire 18-month data set of SAMIR for determining WV over ocean. For this purpose, the average latitudinal distributions of WV over the AS and the BB have been derived for each month and compared with climatological data on WV.

2. SAMIR data

The geographical coverage of the *Bhaskara-II SAMIR* data over oceans is restricted to the region from the equator to 25°N and from 60° to 95°E by the radiovisibility zones of the two ground stations, SHAR and Ahmedabad, which received the SAMIR data in real time (*see* Fig. 1). There were a few passes that extended the data into the southern Indian Ocean by onboard recording but these data are not used here.

In relation to the radiovisibility zones shown in Fig. 1, it is necessary to understand the data availability over ocean for different typical orbits as shown in Fig. 1. For an orbit such as A, which is largely over land area, very little data over ocean would be available. Similarly, an orbit like B, which is at the edge of the radiovisibility circle, very little data over ocean would be available. In contrast, orbits C and D which are largely over ocean, data with complete coverage of the ocean along the ground trace can be obtained.

As regards the quality of the SAMIR data, it is important to note that the 31 GHz channel suffered from a serious noise problem during day-time. The other two channels, *viz.*, 19 GHz and 22 GHz, had no such noise problem. Therefore, only night-time data of 31 GHz have been used in the present study whereas the data for the other two channels are used both during day and night times. The quality of the SAMIR data has been evaluated by checking internal consistency of the T_B data corresponding to closely spaced beam-centre positions. The details of this method are given by Pathak [1987, 1989(a)]. In order to check the SAMIR data for the purpose of meaningful physical interpretation, the method of bi-spectral distribution was used. In this method, relative values of T_B data of the three channels are examined and inferences made about the effects of water vapour and liquid water over ocean. The details of this method are explained by Pathak (1987).

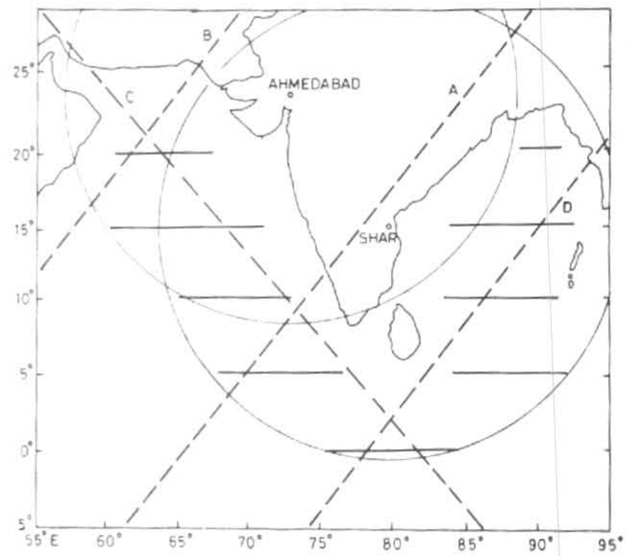

Fig. 1. The two circles represent the radiovisibility zones at 5° elevation of the ground stations Ahmedabad and SHAR. The latitudinal regions are shown by thick horizontal lines (*see* text). Some typical orbital passes are shown by dashed lines

3. Method of analysis

The quality-checked T_B data of SAMIR over ocean have been used to estimate WV by using the empirical equations which were established earlier between SAMIR T_B data and near-coincident NOAA WV data (Pathak 1987) for a six-month period (January-June 1982). For cloud-free conditions, any one of the following three empirical equations can be independently used for estimating WV over open ocean with an rms error of ± 0.5 gm/cm^2 :

$$WV(19) = 0.085\ T_B(19) - 9.049 \quad (1)$$

$$WV(22) = 0.053 T_B(22) - 6.731 \quad (2)$$

$$WV(31) = 0.119 T_B(31) - 16.766 \quad (3)$$

where, WV(19), WV(22) and WV(31) denote the total WV in gm/cm^2 derived from $T_B(19)$, $T_B(22)$ and $T_B(31)$ respectively.

For cloudy conditions, $T_B(19)$ and T_B (31) show very pronounced increase due to cloud liquid water emission, while T_B (22) tends to saturation due to pressure-broadening effect (Pathak 1987). Therefore, for cloudy conditions, the following non-linear equation connecting WV and $T_B(22)$ is used, which takes care of the saturation effect:

$$WV = 9.48 - 0.113 T_B(22) + 0.42 \times 10^{-3} \times T_B^2(22) \quad (4)$$

The SAMIR data for cloudy conditions are identified by using the threshold brightness temperature values for the three channels as obtained on the basis of a supervised classification of the SAMIR data using NOAA-7 cloud imageries [Pathak 1989 (b)].

TABLE 1

Total number of orbits available at different latitudes over the Arabian Sea (AS) and Bay of Bengal (BB) for each month

Month	0° Lat.	5° Lat.		10° Lat.		15° Lat.		20° Lat.	
		AS	BB	AS	BB	AS	BB	AS	BB
Jan	8	12	9	15	8	17	13	14	6
Feb	7	4	22	14	15	19	13	14	7
Mar	19	19	15	22	25	20	16	18	5
Apr	6	13	5	14	17	17	13	12	2
May	19	11	13	12	18	17	16	13	1
Jun	11	9	9	14	12	18	13	12	6
Jul	14	11	7	10	9	13	10	6	2
Aug	13	13	10	13	11	9	8	8	4
Sep	8	3	12	6	11	8	10	8	4
Oct	6	5	7	7	8	6	6	4	3
Nov	5	6	13	6	16	6	17	3	6
Dec	5	3	8	9	6	6	6	5	6

For each orbit over ocean, the SAMIR data can be used to determine WV at different latitudes *along* the satellite ground trace*. Combining such data over a number of orbital passes in a given oceanic region, one can obtain WV data at different latitudes/longitudes from which the distribution of WV can be obtained.

Table 1 gives the statistics of the total number of orbits available over the AS and the BB for different months. Note that the data for 1982 and 1983 have been combined for each month for the period January to June. The following points may be noted :

(*i*) At 20°N over the BB, the number of orbits is very small. This is mainly due to the fact that the region over open ocean at that latitude is very small.

(*ii*) At other latitudes, the number of orbits shows wide variations — the highest being 25 at 10° over the BB for March and the lowest being 3 which occurs twice. March has the highest number of orbits for all latitudes except for 20° over the BB. It can be thus seen that the WV data, derived from SAMIR observations, available for this study is some-what meagre, being more so for the months September to December.

Further, it should be noted that due to front (+2.8° and +5.6°) and aft (—2.8° and —5.6°) sampling along the satellite ground trace, the footprints for the successive spins get considerably overlapped. Secondly, as mentioned earlier, each footprint also gets smeared to an effective size of ~240 km. Thus, due to the overlapping and smearing of the footprints, the SAMIR data are always found to be extremely smooth [Pathak 1989 (a)]. Consequently, all spatial variations in WV with scale size smaller than about 250 km or ~2.5° latitude get averaged out. In the present work, therefore, we have determined WV at an interval of 5° latitude both over the AS and the BB (using data for few orbital passes, it has been verified that due to the smoothness of the data, smaller interval of 2.5° does not essentially change the nature of the latitudinal variation of WV). When WV data for all orbital passes are considered in a given month, we can get WV data distributed at different longitudes along each 5° latitude over the AS and the BB. These regions are shown in Fig. 1. Note that the data along each latitude are terminated at about 300 km away from coast-line to avoid the contamination due to land emission.

The WV data can be meaningfully presented and studied by deriving contours for each month. However, in view of the rather meagre statistics of the data, as mentioned earlier, this could not be done. It was, therefore, decided to derive average WV data along each 5° latitude. Wherever the data were not available at the pre-selected latitudes, the nearby data within ±0.5° were used for interpolation.

While latitudinal averaging may be justified for each month from November to May, when the WV distribution is essentially zonal, for the remaining months June to October, the zonal nature is modified due to monsoon circulation and considerable longitudinal variation in WV is expected at different latitudes both over the AS and BB (Colon 1964, Rangrajan and Srivastava 1965, Mokashi 1971). In order to check this point, the SAMIR WV data at different latitudes/longitudes over the AS and the BB for each month from June to October are listed in Table 2. As regards the statistics of these data, it may be noted that the values of WV in italics are the averages of two or more observations while all remaining data denote single observations. Blanks with dashes indicate data not available. The frequencies for two or

*In the *alternate* mode of SAMIR, where the data could be collected *across* the satellite ground trace at a number of angular positions, it would have been possible to map WV over large oceanic area for each orbital pass. Unfortunately, due to some problem, the data for this mode could not be used.

TABLE 2

WV data at different Lat./Long. for different months (June to October)

Lat./Long.	June					July					August					September					October				
	0°	5°	10°	15°	20°	0°	5°	10°	15°	20°	0°	5°	10°	15°	20°	0°	5°	10°	15°	20°	0°	5°	10°	15°	20°
60				4.5																3.3					
61				—											*5.0*					4.1				3.2	
62				4.6											—					3.0				—	
63				4.7	3.7								4.7	4.7	—					*3.5*			3.7	3.7	
64				*4.9*	4.5								—	—	4.6			4.1		3.1			—	—	2.9
65				4.9	*4.3*			4.0	4.7				—	4.7	—			—	*3.6*	4.1			3.9	—	2.9
66				4.9	*4.3*			—	*5.0*	*4.6*			4.7	*5.1*	—			—	—	3.8			3.7	—	—
67				*5.2*	3.5			—	4.7	4.2			4.8	—	5.7			—	4.2				3.6	3.7	3.2
68			4.6	4.7	—			5.1	*4.7*	4.1			—	5.3	*5.4*			—	4.3			4.6	—	3.1	3.2
69		*4.3*	*4.8*	*4.8*	5.5			4.0	4.7	5.0			*4.9*	5.1	5.2	—	—	4.3	4.0			—	—	3.7	
70		—	*4.5*	5.6	*4.5*			*4.7*	*4.1*	—			4.7	4.9	5.9			*4.1*	4.7			—	3.9	—	
71		4.6	*4.9*	3.6	5.1		5.0	4.4	*4.8*	4.5		4.4	—	—				—	—			4.5	*4.0*	—	
72		*4.5*	5.1	3.4	5.7		—	*4.7*	4.8			—	*4.8*	5.0				*4.5*	4.6			—		3.8	
73		4.5	*4.9*	4.2			—	4.1				*4.4*	5.0	5.0			4.8					—			
74		4.9	5.8	4.5			4.8					*4.6*	4.9				—					4.5			
75	4.2	4.4	*4.9*			4.0	*4.3*					5.1	4.3				—					4.5			
76	*4.5*	4.7	4.7			3.9	—					4.5				4.5	—					—			
77	4.5	4.5	—			4.4	*4.9*				4.7	*4.7*				—	*5.0*					—			
78	*4.0*	—				4.1	—				*4.4*	5.1				5.2	—				4.6	—			
79	4.0	5.2				—	*4.5*				—					—	—				—	5.0			
80	4.9	—				*4.4*	4.3				—					—	—				*4.8*	—			
81	—	*4.8*	5.8			5.3	—				*4.9*		6.1			—	4.8				—	4.6			
82	—	—	—			4.5	—				—	*4.9*	—			—	5.1				4.8	—	4.2		
83	4.5	5.1	*5.7*			*5.0*	—	4.9			*4.9*	*4.8*	—			4.7	5.7				4.5	—	4.4		
84	—	5.0	6.7	5.8		4.9	5.2	—			—	4.8	—			5.2	5.3	5.1			4.4	*5.0*	—		
85	—	4.7	*5.2*	5.0			—	*5.0*	—		—	*4.7*	*5.0*	*5.4*		5.2	—	4.0				5.1	4.5	3.8	
86	—	—	4.8	*5.4*			*4.7*	4.8	—		4.6	5.0	—	5.5		—	*4.3*	*4.8*	*4.9*			*5.2*	—	—	
87	4.6	5.1	5.3	4.9			4.4	5.1	5.2	5.4	4.8	*5.0*	4.7	5.3		5.2	—	—	4.9	5.2		—	*5.1*	4.3	
88		*5.5*	5.6	*6.0*	6.0		*4.6*	—	*5.2*	—			*5.4*	*5.9*	5.9	—	*4.9*	—	4.8	4.3		5.3	—	—	4.0
89		—	—	*5.9*	4.5		—	5.2	5.2	5.6			4.5	5.2	6.2	4.9	*4.8*	5.0	5.2	*5.2*			4.5	4.4	3.7
90		5.2	—	—	5.0		—	*4.6*	5.5				5.2	—	6.0	4.5		4.6	*4.8*				5.0	4.4	4.5
91			5.4	5.9	*5.8*		4.7	—	—				5.1	5.7				*4.9*	4.8				—	4.6	
92			—	5.8	—			5.0	5.3				5.5					4.6					4.7	3.9	
93			*5.5*	5.4	6.7																				

All italic values are averages of two or more observations. Remaining values denote single observations.

TABLE 3

Geographical locations of coastal and island radiosonde stations of India and neighbouring countries

Station	Latitude (°N)	Longitude (°E)	Period of averaging of WV
Bombay	19.07	72.51	1955-65
Calcutta	22.39	88.27	1955-65
Madras	13.00	80.11	1955-65
Minicoy	8.18	73.00	1963-65
Port Blair	11.40	92.43	1957-65
Trivandrum	8.28	76.57	1956-65
Veraval	20.54	70.22	1956-61
Visakhapatnam	17.43	83.14	1956-65
Akyab	20.19	92.54	1945
Chittagong	22.20	91.50	1944-46
Colombo	6.56	79.51	1958-62
Karachi	24.52	67.03	1951-60
Rangoon	16.47	96.10	1960-63

more observations for the entire data set of Table 2 are : Two-66, Three-9, Four-5, and Five-1.

A careful examination of the data in Table 2 will show that the longitudinal variation in WV at different latitudes is generally small. However, during June at 15° and 20° over the AS, low values of WV (~3.5 gm/cm²) occur at some longitudes. It should be noted that these low values are all based on single observations. From these data no consistent pattern of WV can be clearly discerned. It seems, therefore, that due to the poor statistics, the true pattern of longitudinal variation of WV cannot be studied using the present data. In view of this consideration also, the WV data for each month have been averaged along each 5° latitude both over the AS and the BB and the standard deviation at each latitude is considered to represent the longitudinal variation of WV at that latitude.

In order to support our results, we require some ground truth in the form of near-coincident (both in space and time) measurements of WV over the AS and the BB. Since such ground truth is not readily available, we have used the climatological data on WV from the coastal and island radiosonde stations of India and neighbouring countries situated at different latitudes ranging from about 7°N to 25°N (*see* Table 3). These data have been taken from the work of Mokashi (1971). It should be noted here that the climatological data have been used only to provide *rough support* to our results through a comparison in terms of the nature of latitudinal variation and the relative values of WV in the two datasets. The climatological data are not used for a detailed validation of the SAMIR-derived WV data.

4. Results

Figs. 2(a & b) show the latitudinal variation of the SAMIR-derived monthly mean WV values over the AS and BB for different months. Each error bar denotes one standard deviation and, as mentioned earlier, also indicates longitudinal variation of WV at that latitude. The climatological data on WV from the relevant radiosonde stations (Table 3) are also shown in the same figure by different symbols at their appropriate latitudes.

It can be seen from Fig 2(a) that in the AS from October to March there is a sharp latitudinal gradient with WV values decreasing from ~4-5 gm/cm² at the equator to ~2-3 gm/cm² at 20°N, while from April onwards the gradient slowly decreases and becomes almost zero during the southwest monsoon months (June-September), when the WV has an almost uniformly high value of ~4-5 gm/cm². The SAMIR-derived WV data are broadly consistent with the climatological WV data both in terms of latitudinal variation and in their relative values.

For the BB region [Fig. 2(b)], it can be seen that from December to March the WV decreases from the equator to 20°N, while from April onwards, the gradient slowly disappears and even slightly reverses during July and August. In contrast with AS the effect of the northeast monsoon appears to lead to an almost constant value of WV of ~4 gm/cm² from the equator to 20°N during October and November. The gradient again starts appearing from December onwards. The SAMIR-derived WV data are consistent with the climatological data.

Fig. 3 depicts the seasonal variation of SAMIR WV data at each 5° latitude over the AS and the BB. It can be seen that the WV data at the equator and 5° latitude over the AS and the BB do not show much seasonal variation and their annual average values are high (4-5 gm/cm²). This is also consistent with the observation that over the year the SAMIR data in this region (equator to 5°N) have shown cloudy conditions with WV ≥5 gm/cm² for about 60% of the time. At higher latitudes (10°-20°) the WV values during winter months are low but there is a prominent increase during the southwest monsoon months (June-September) both over the AS and the BB. The observed seasonal variation of SAMIR-derived WV data is consistent with that shown by the climatological data (Ananthakrishnan *et al.* 1965 and Mokashi 1971).

It has been generally found that for a given period, the SAMIR-derived WV values over the BB are higher than those over the AS at the same latitude. This can be also seen from Table 2 and Fig. 3. In order to show this feature clearly, Fig. 4 gives a scatter plot between the monthly mean co-latitudinal WV values over the AS and the BB at different latitudes. It can be seen from this figure that while there is a good correlation between the two datasets, there is clearly a bias showing higher WV over the BB compared to the AS. The difference is significant particularly at 10°-15°N for the southwest and northeast monsoon periods. In order to corroborate this finding, we have analysed the available 'finished product' WV data from NOAA satellites during the southwest monsoon period for the years 1979-1981. A similar scatter plot (Fig. 5) using data over 2°×2° grids also shows the same feature with WV over the BB being significantly more than that over the AS.

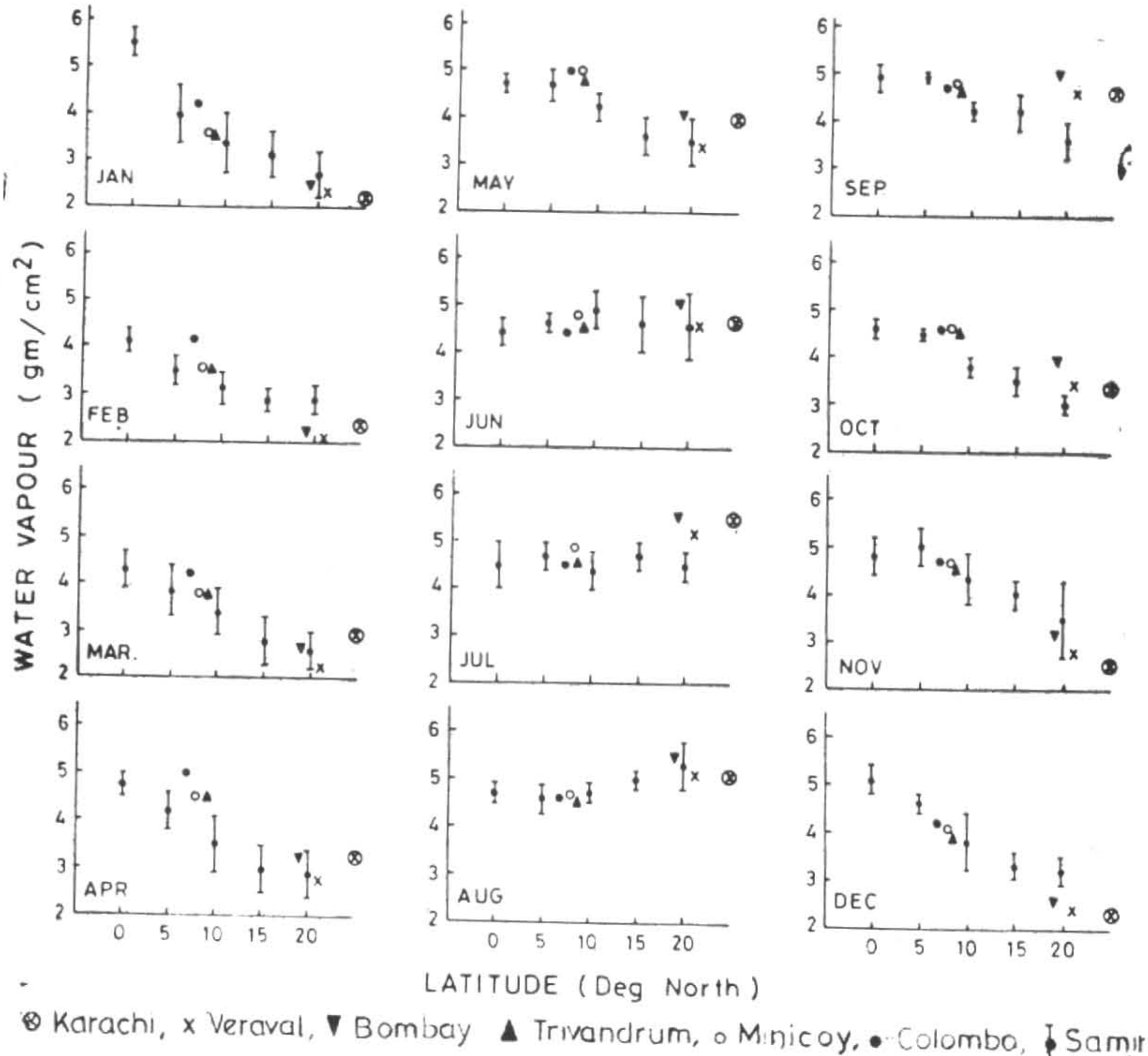

Fig. 2 (a). Latitudinal distributions of SAMIR-derived WV data and climatological WV data for different months over the Arabian Sea

5. Summary and discussion

In the present work, we have studied total WV content over the AS and the BB as derived from the SAMIR data. In view of the limitation of the data statistics and the poor effective spatial resolution of SAMIR data, only monthly mean *latitudinally averaged* WV data have been derived and compared with climatological WV data. The main conclusions of the present study are summarized below:

(a) It has been found that the SAMIR-derived WV data show a significant latitudinal gradient with WV decreasing from the equator to 20°N during the period December-March both over the AS and the BB. This gradient gradually decreases during the subsequent months and almost vanishes during the southwest monsoon period both over the AS and the BB when the WV value is uniformly high (4-5 gm/cm^2) from the equator to 20°N. The latitudinal distribution of SAMIR-derived WV data is found to be broadly consistent with the climatological data both in terms of latitudinal variations and the relative values of WV.

(b) The seasonal variation of SAMIR-derived WV at the equator and at 5°N both over the AS and the BB is very small, and the yearly average value is high $\sim$4.5 gm/cm^2. However, at 10°-20°N, there is a pronounced build-up of WV during the southwest monsoon months (June-September) both over the AS and the BB. These

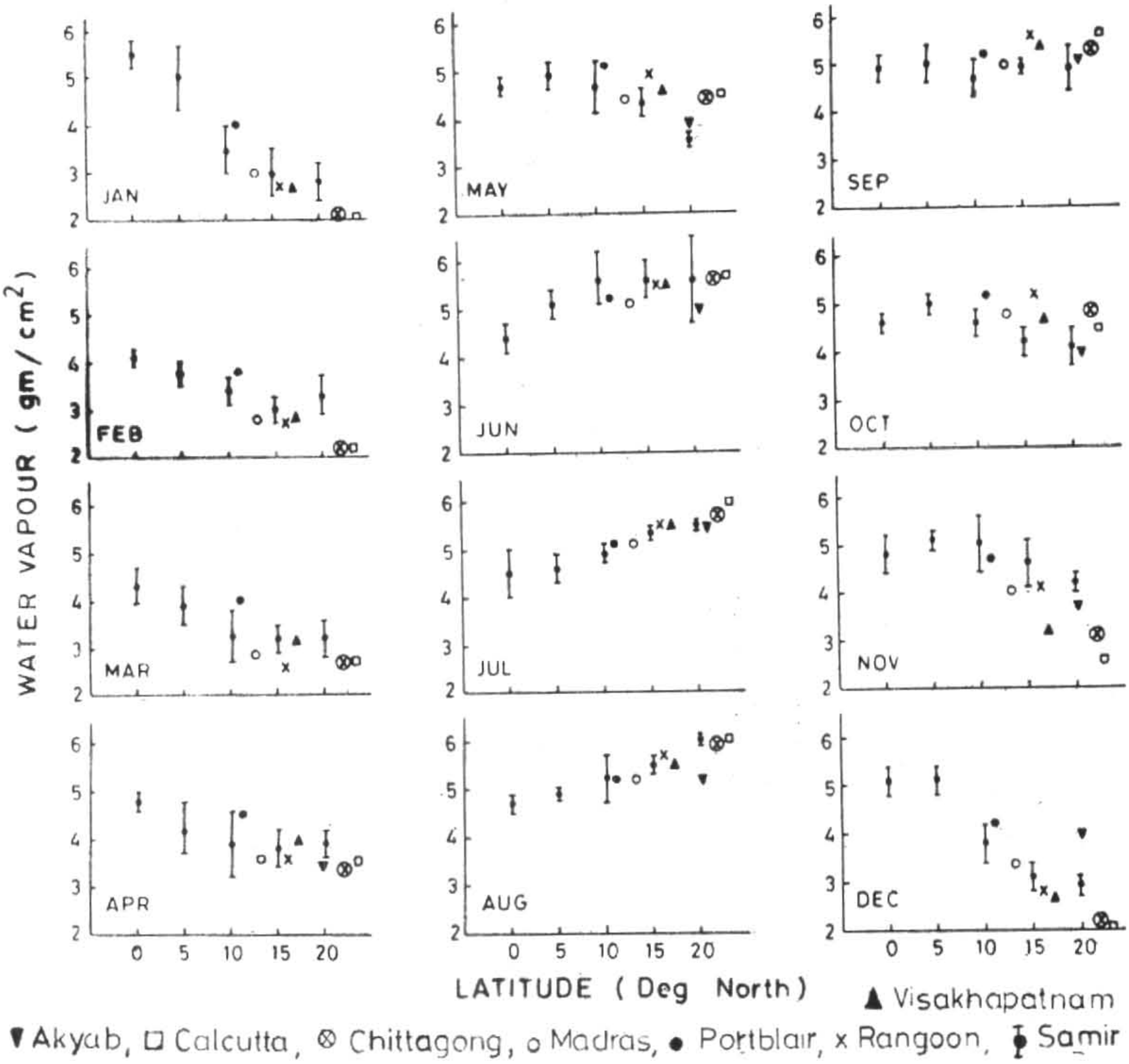

Fig. 2(b). Latitudinal distributions of SAMIR-derived WV data and climatological WV data for different months over the Bay of Bengal

features are also in agreement with the climatological data from different coastal stations.

(c) It has been found from the present data that, for a given period, the WV values over the BB are generally higher than those over the AS for the same latitudinal region. This difference is found to be more significant particularly during the southwest monsoon period (June-September) and the northeast monsoon period (October-November) at latitudes 10° and 15°N.

The empirical equations used to derive WV from the SAMIR data are based on a six-month data set (January-June 1982) of SAMIR and NOAA WV (Pathak 1987). It is important to note that these empirical equations, when used for the later period beyond June 1982 give WV values that are found to be quite reasonable and consistent with the climatological data. This indirectly shows that the SAMIR radiometers have performed well without showing any substantial degradation over the period of one and a half year of in-orbit operation.

Apart from the coarse effective spatial resolution and somewhat meagre statistics of the data, the main factor which limits the usefulness of the SAMIR data is the fact that the WV data over ocean can be obtained only along the satellite ground trace for each orbit. Therefore, data for a number of days and over many orbits are required to completely map the WV over a given oceanic

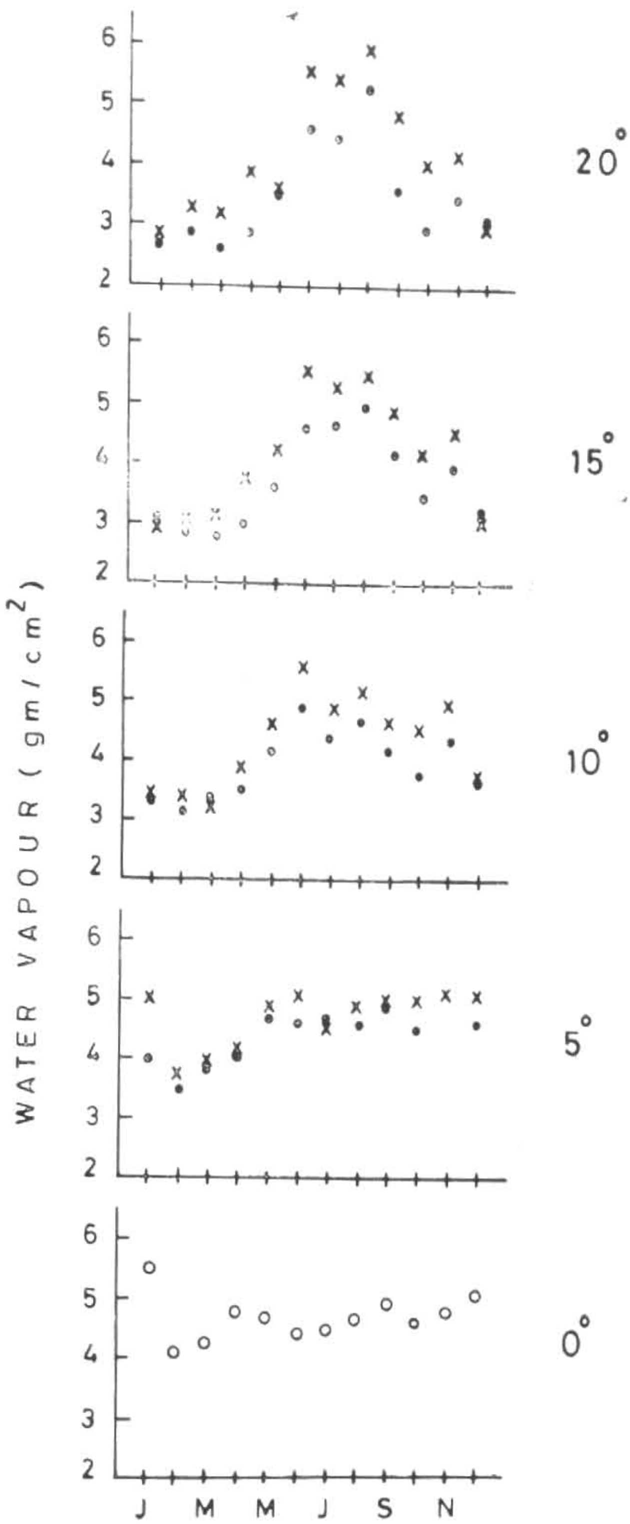

Fig. 3. Seasonal variation of SAMIR-derived WV data at the equator (o) and at other latitudes over the Arabian Sea (●) and the Bay of Bengal (×)

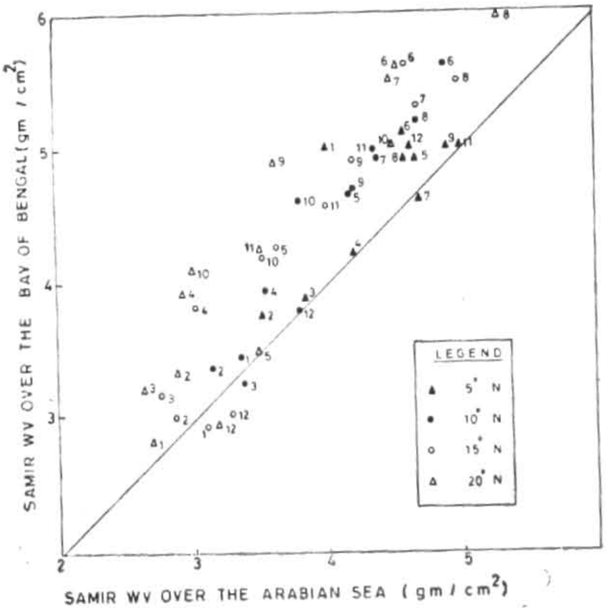

Fig. 4. Scatter plot between the SAMIR-derived monthly mean WV values over the Arabian Sea and the Bay of Bengal for each 5° latitude from 5°N to 20°N. Numbers 1 to 12 refer to months from January to December

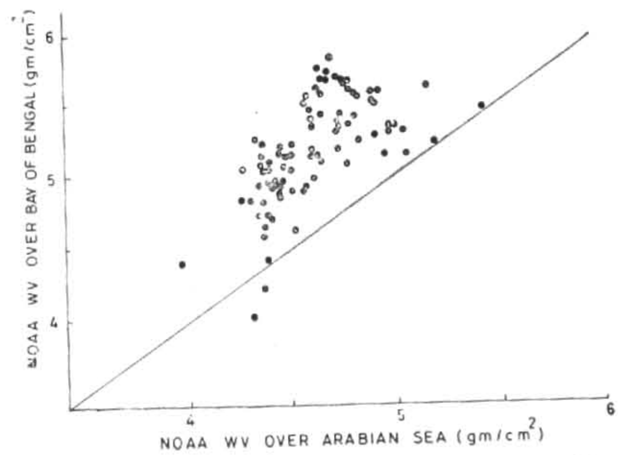

Fig. 5. Scatter plot between NOAA WV data for the Arabian Sea and Bay of Bengal

area. As has already been pointed out earlier, the *alternate* mode of SAMIR, where the data could be gathered *across* the satellite ground trace, a single orbit would be sufficient to obtain WV data over large oceanic area. Such data can be meaningfully applied to study WV distribution in relation to some specific events like onset/break periods of southwest monsoon and depression/cyclonic storms. In this connection, the unique advantage of microwave remote sensing even during cloudy conditions can be of added importance. It would be, therefore, desirable to include a scanning multichannel microwave radiometer system with wide swath on one of the future Indian remote sensing satellites.

Our results regarding the latitudinal distribution and seasonal variation of WV at different latitudes are in general agreement with the intra-annual variation of large scale moisture fields derived by Piexoto *et al.* (1981) using 5-year global upper-air sounding data.

It is important to consider the implications of the observed excess of WV over the BB compared to the AS. The total moisture content of the atmosphere at any place over ocean is the sum of that generated locally due to evaporation and transported from other areas. Our results are thus consistent with the findings of Piexoto *et al.* (1981) who have shown that both the total WV content and zonal transport of WV is highest over the BB during summer months. In this connection, it is important to note that Stephens (1990) has recently shown that monthly mean WV data over oceans obtained from the Scanning Multichannel Microwave Radiometer (SMMR) onboard the Nimbus-7 satellite are correlated well with the monthly mean sea surface temperature (SST) data. However, he has noticed significant deviations in this relationship which are shown to be due to the effects of regionally-dependent large-scale motion of atmospheric water vapour. For the present dataset of SAMIR-derived WV, it would be interesting to study similar correlation with SST and thereby determine the relative importance of evaporation and transport mechanism.

6. Conclusion

From the present analysis it can be concluded that the WV data over ocean derived from the entire 18-month dataset of SAMIR are reliable and broadly consistent with the climatological data.

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