Journal of the Faculty of Environmental Science and Technology, Okayama University
Vol.3, No.1, pp.97-104, January 1998

Surface Air Temperature Distribution : A Study from Southwest Bangladesh

Muhammad Qumrul HASSAN* and Kenji OKUBO**

(Received October 31, 1997)

Surface air temperature distribution over the Ganges Delta Region of southwest Bangladesh and its tendency of warming are discussed through the analyses based upon the long-term temperature data from 1900-93. The data consist of two parts corresponding to the time-periods: 1973-93 and 1900-72. The study area is one of most affected places by the annual monsoon hydrological cycle and the present observation from these temperature data indicate that the surface air temperature gradient in the north-south direction is significant in the rainy season and that the temperature of the region is at an increasing tendency; the warming rate during the data periods (1900-93) on the long-term mean annual basis is estimated as 0.77°C at Satkhira of the Khulna division and 0.29°C as an areal average including the Barisal division, for the time difference of about half a century between the data periods before and after 1972.

1. INTRODUCTION

Temperature is an essential component in the local climatic as well as environmental conditions of the earth or in the universes. Temperature in high and low conditions prevailing in the hot and the cold regions which represents the different climatic zones on the earth's surface. It is observed that across the earth's surface air temperature recorded ranges from a minimum of -88.3°C in the Antarctic to a maximum of 57.8°C in the desert (Strangeways, 1985). Each life and non-life matters are developed with their specific temperature condition in respective environments. Photosynthesis demonstrates the influence of temperature and light intensity on crops. Growth of plant is equal to difference between photosynthesis and respiration (Growth = Photosynthesis - Respiration). Assimilation is particularly inhibited at 0°C. The optimum temperature for photosynthesis is 17.5°C under normal atmospheric (Manalo, 1977) and 32.5°C in an atmosphere rich in carbon dioxide. So that the variations of surface air temperature plays an important role on the different environmental aspects on the earth. For example, now-a-days global warming and the subsequent climatic change - ice melting in the northern regions and on the other hand sea level rising in the southern regions on the earth. This environmental situation in the present time is much popular in consideration to all levels of scientific research in national to international stages. Depth of knowledge on this issue could enable us to enter in the solution of the problems.

* Department of Geology, University of Dhaka, Bangladesh (visited the Faculty in May-June, 1997)
**Department of Environmental and Civil Engineering

Jagannathan and Parthasarathy (1972) reported increasing trend in the mean annual temperature at four Indian cities - Allahabad, Bahgalore, Bombay and Calcutta, among which Calcutta is a neighboring city of the western border of Bangladesh. Hingane et al. (1985) reported on a linear warming trend of about 0.5-0.9°C/100 years (at the 99% confidence level) in the mean annual temperature over northeast India which has a common border with Bangladesh. Srivastava et al.(1992) observed a slightly different increasing trend of surface air temperature of south 23°S and a decreasing trend north 23°N. Hassan (1994 and 1995) also reported about some changes in the local climatic variables (rainfall, surface air temperature and evaporation) of a small area of southwest Bangladesh. Recently, Okubo (1997) have reported thermal processes in the low-lying area of the northeast Bangladesh.

The main objective of this study on the surface air temperature at nine stations in the Ganges Delta Region (GDR) of southwest Bangladesh is to find out the present surface air temperature condition in relation to the global warming context on a preliminary basis. In this purpose, the present study has been undertaken for the whole southwestern part of Bangladesh which is shown in figure 1. Locations of the data points can also be seen in figure 1 and the nature of the data is on daily maximum-minimum basis. The administrative divisions in the southwest are the Khulna (western part) and Barisal (eastern part). These are included the four data points in the Khulna, and five in the Barisal division. The western data points are Chauadanga, Jessore, Satkhira and Khulna from north to south, and the eastern points are Patuakhali, Bhola, Barisal, Madaripur and Faridpur from south to north.

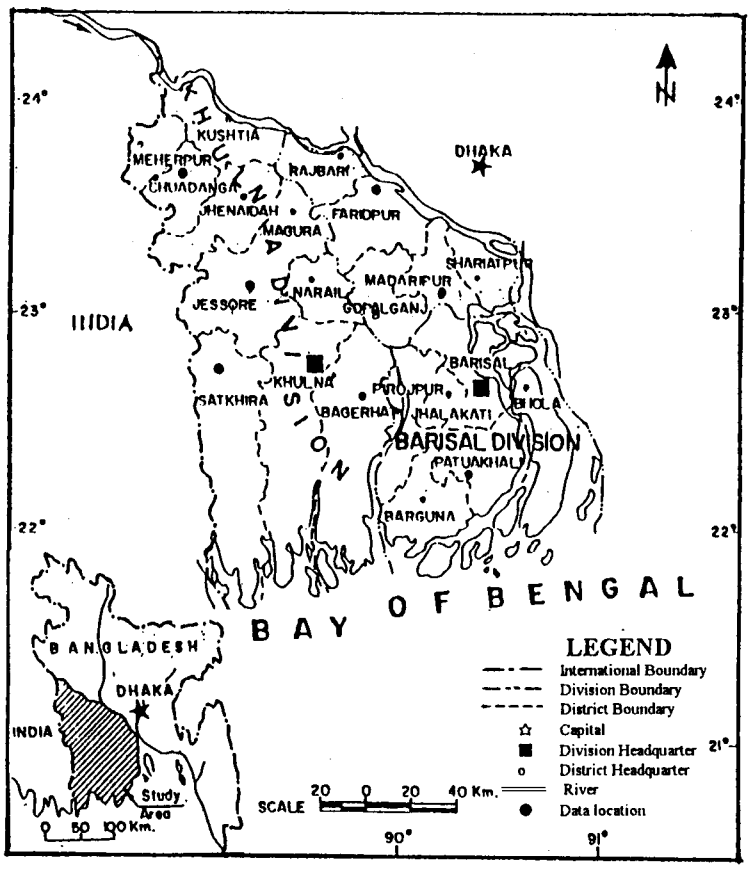

Fig. 1 Location map of the study area in the Ganges Delta Region (GDR) of Southwest Bangladesh. Data points are also shown in this map.

2. METHOD AND MATERIAL

For the present research work, nine locations were considered for surface air temperature data collection program which ranged from 1973 to 1993. The data were collected from Bangladesh Meteorological Department (BMD) and the collected data were formulated in a systematic manner: first manually, and then were used in the spread-sheet handling program for the statistical results. Afterwards the surface air temperature distribution figures in two-dimension of the study area were constructed. The results of the previous investigation of surface air temperature of the area were collected from the published report (Manalo, 1977), which ranged from 1900 to 1972 for comparing with the present study results.

3. RESULTS AND DISCUSSION

Table 1 shows the long-term averaged(1973-93) monthly maximum and minimum surface air temperature (T°C) of the nine different locations of the GDR of Bangladesh (Fig. 1). The month of April shows the maximum recorded surface air temperature which ranged from 37.2°C(Chauadanga) to 32.7°C(Patuakhali). The month of January shows the minimum recorded surface air temperature which ranged from 10.5°C(Chauadanga) to 13.8 °C(Patuakhali). The regional differences between the long-term mean monthly maximum and minimum surface air temperatures are 4.5°C in the wet period and 3.3°C in the dry period of the Ganges Delta Region, respectively. The sign of surface gradient of air temperature between Chauadanga (north) and Patuakhali (south) is thus seasonally reversed in the lower latitude area.

This table further shows that the long-term mean annual maximum recorded surface air temperature ranged from 31.9°C (Chauadanga) to 30.3°C (Patuakhali) and the minimum surface air temperature ranged from 20.9°C (Chauadanga) to 21.0°C (Madaripur), respectively. The regional difference between long-term mean annual maximum and minimum surface air temperatures are 1.6°C and 0.1°C, respectively. The regional difference on the minimum surface air temperature did not show any significant (0.1 °C) variation especially in the dry period.

Figure 2 shows graphical presentation of the annual monthly change in the surface air temperature at the nine locations in the GDR of southwest Bangladesh, where the monthly maximum, minimum, their deviation and mean temperatures are separately shown. In these figures (a)-(d), isothermal contour lines are shown in every degrees, and the contour labels denote temperatures in °C. The maximum surface air temperature in (a) is spatially uniform and rapidly changing from October to March while the minimum temperature in (b) is uniform from September to April. The distribution of the minimum air temperature in the wet period is rather weak. Monthly maximum difference in surface air temperature in (c) is normally large in the dry period and the profile of averaged temperature in (d) is similar to that of the maximum temperature, showing the difference between the western and eastern locations. In the wet period the surface air temperature is higher in the Khulna division (west) than in the Barisal division (east). Values of monthly averaged temperatures are shown in Table 2.

Table 1 Long-term mean (1973-93) monthly maximum, minimum and annual mean surface air temperature in °C of Southwest Bangladesh

Place / Month	Chauadanga		Faridpur		Madaripur		Jessore		Khulna		Satkhira		Barisal		Bhola		Patuakhali	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	24.8	10.5	24.7	12.2	25.6	12.0	25.8	11.7	25.7	12.7	26.2	12.6	25.7	12.0	25.9	12.9	25.7	13.8
February	28.7	14.4	27.9	14.7	28.6	14.7	28.8	14.6	28.5	15.5	29.2	16.1	28.4	15.1	28.7	16.2	28.4	16.7
March	33.2	18.8	32.6	19.3	32.7	19.7	33.2	19.7	33.1	20.5	33.2	20.9	32.0	20.4	32.0	20.9	32.1	21.1
April	37.2	23.5	34.3	23.0	34.3	23.1	35.3	23.8	34.7	24.2	35.4	24.7	33.4	23.9	32.9	24.1	32.7	24.2
May	35.7	25.2	33.3	23.8	33.6	24.0	34.7	24.7	33.9	25.1	35.0	25.5	32.9	24.7	32.6	24.6	32.9	25.3
June	34.2	26.2	32.1	25.5	32.5	25.6	33.0	25.9	32.8	26.2	33.4	26.4	31.7	25.8	31.4	25.8	31.4	25.9
July	32.7	26.3	31.3	25.7	31.8	25.6	32.0	25.9	31.7	26.1	32.0	26.2	30.8	25.6	30.6	25.7	30.6	25.7
August	33.3	26.4	31.6	26.1	32.0	25.9	32.2	26.0	31.7	26.4	32.1	26.2	31.0	25.7	30.9	25.9	30.8	25.8
September	33.1	25.6	31.6	25.7	32.3	25.6	32.5	25.6	31.9	25.9	32.2	25.8	31.3	25.4	31.3	25.6	31.0	25.6
October	32.4	23.3	31.4	23.9	32.2	23.5	32.1	23.4	31.9	24.3	32.4	23.8	31.4	23.8	31.7	23.8	31.4	24.3
November	30.3	17.6	29.0	19.2	30.1	18.8	29.8	18.3	29.8	19.7	30.4	18.8	29.5	18.9	29.8	19.3	29.4	20.8
December	26.6	12.3	25.5	13.9	26.8	13.7	26.4	12.6	26.3	14.2	26.9	13.6	26.3	13.4	26.8	14.1	26.5	15.7
Annual	31.9	20.9	30.5	21.2	31.1	21.0	31.4	21.1	31.1	21.7	31.7	21.8	30.4	21.3	30.4	21.6	30.3	22.1

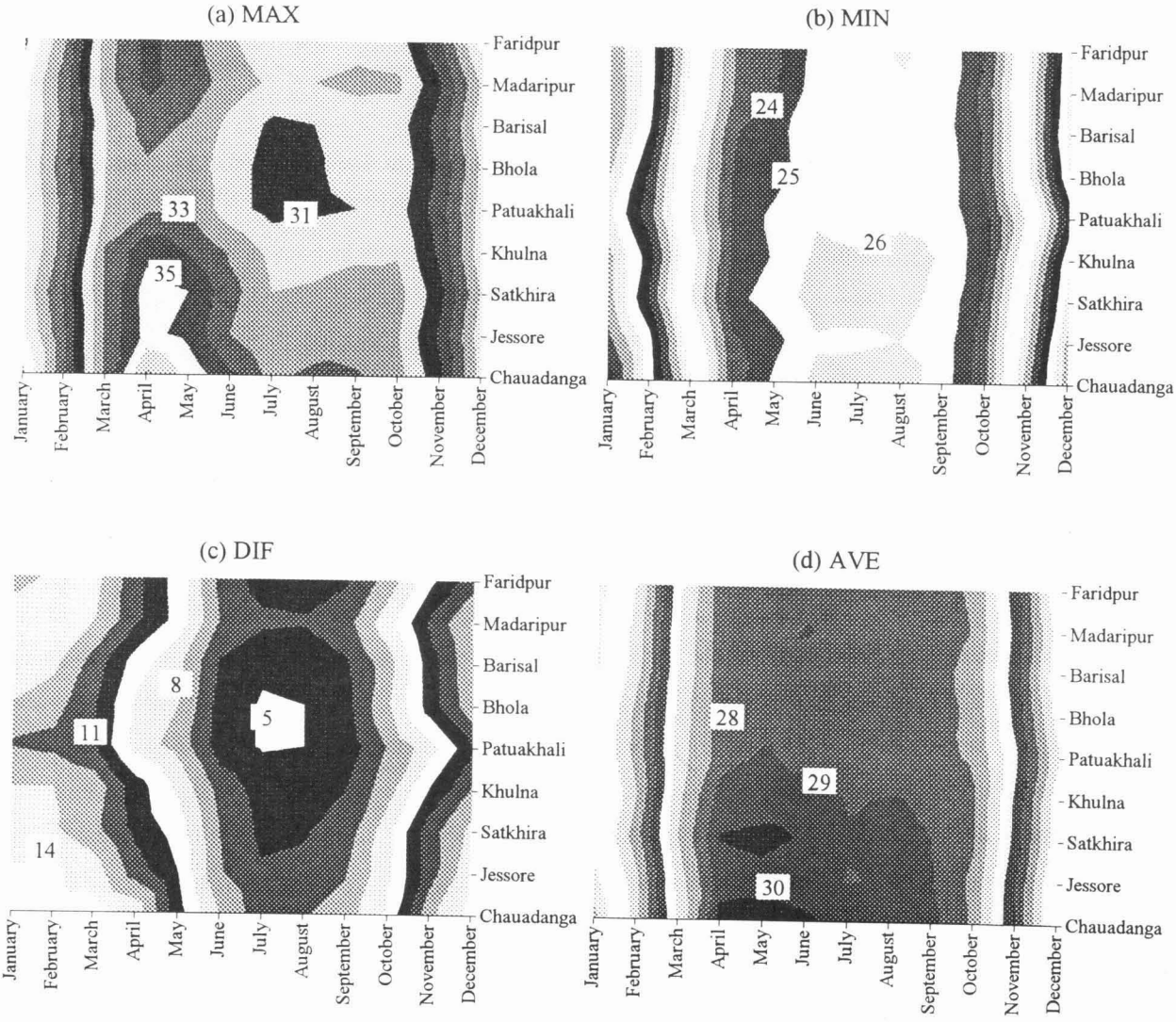

Fig. 2 Long-term (1973-93) monthly maximum, minimum and annual surface air distribution of different locations in the Ganges Delta Region (GDR) of Southwest Bangladesh: (a) maximum; (b) minimum; (c) difference; (d) average surface air temperature

Table 2 shows the long-term mean monthly and annual, maximum, minimum and their fluctuation of surface air temperature at the nine locations in the GDR of southwest Bangladesh. The long-term mean annual maximum surface air temperature can be seen in this table which ranged from 30.45°C(Chauadanga) to 28.60°C (Bhola). The regional difference in maximum surface air temperature between Chauadanga and Bhola is about 1.85°C. The long-term mean monthly minimum surface air temperature can be found from 12.80°C (Chauadanga) to 9.20°C (Bhola). The regional difference in the surface temperature between Chauadanga and Bhola is about 3.60°C. Figure 3 shows the long-term mean monthly temperature curves over the year of the GDR of southwest Bangladesh. From the line-curves it can be easily seen that from April to September, the surface air temperature is prevailed between 28 °C and 31°C, showing a rise from the south-east toward the north-west.

Table 2 Long-term mean (1973-93) monthly and annual maximum, minimum and their fluctuation of surface air temperature in °C of Southwest Bangladesh

Month\ Place	Chauadanga	Faridpur	Madaripur	Jessore	Khulna	Satkhira	Barisal	Bhola	Patuakhali
January	17.65	18.45	18.80	18.75	19.20	19.40	18.85	19.40	19.75
February	21.55	21.30	21.65	21.70	22.00	22.65	21.75	22.45	22.55
March	26.00	25.95	26.20	26.45	26.80	27.05	26.20	26.46	26.60
April	30.35	28.65	28.75	29.55	29.45	30.05	28.65	28.50	28.45
May	30.45	28.55	28.80	29.70	29.50	30.25	28.80	28.60	29.10
June	30.20	29.00	29.05	29.45	29.50	29.90	28.75	28.60	28.65
July	29.50	28.50	28.70	28.95	28.90	29.10	28.20	28.18	28.15
August	29.85	28.85	28.95	29.10	29.05	29.15	28.35	28.40	28.30
September	29.35	28.65	28.95	29.05	28.90	29.00	28.35	28.45	28.30
October	27.85	27.65	27.85	27.75	28.10	28.10	27.60	27.75	27.85
November	23.95	24.10	24.45	24.05	24.75	24.60	24.20	24.55	25.10
December	19.45	19.70	20.25	19.50	20.75	20.25	19.85	20.45	21.10
Mean annual	26.35	25.78	26.03	26.17	26.41	26.63	25.80	25.98	26.16
Maximum	30.45	29.00	29.05	29.70	29.50	30.25	28.80	28.60	29.10
Minimum	17.65	18.45	18.80	18.75	19.20	19.40	18.85	19.40	19.75
Fluctuation	12.80	10.55	10.25	10.95	10.30	10.85	9.95	9.20	9.35

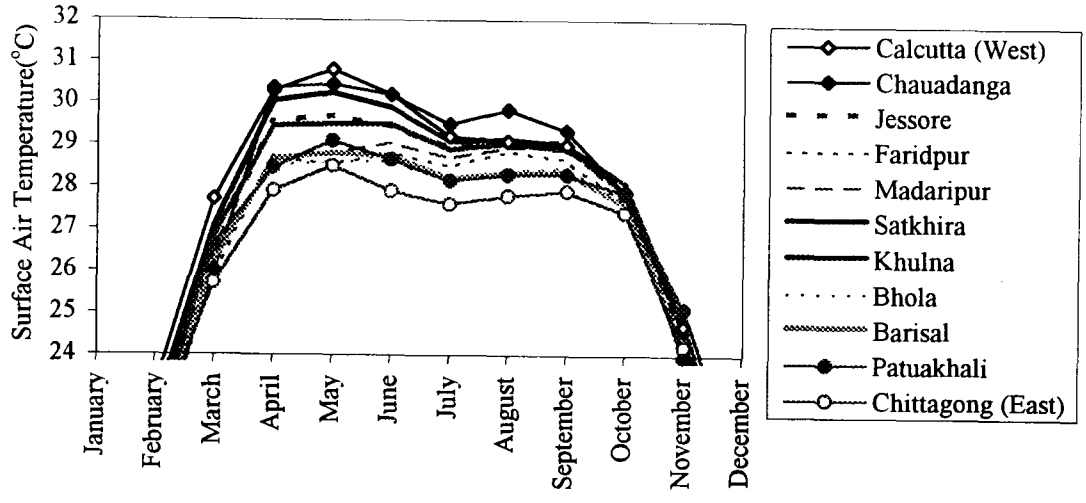

Fig. 3 Long-term mean (1973-93) monthly surface air temperature distribution over the year of different places in the Ganges Delta Region (GDR) of Bangladesh and India.

Temperature observed in cities in- and outside the country (Calcutta) are also compared in Figure 4. Those extra data are cited here which have been collected from the NAO(1994). In the GDR, local minimum temperature in the wet period is consistently observed in July at all the locations examined. It is more clearly seen at Calcutta (1961-90 duration) in the west Bengal. The locally minimum temperature in July is also found in Chittagong (1961-81 duration) of southeast Bangladesh to the east of the GDR.

Table 3 shows the long-term mean monthly and annual, maximum, minimum, and their fluctuation between 1973-93 and 1900-72 time periods of 5 locations of the GDR of southwest Bangladesh. In this table it has been remarkable that in Jessore, the fluctuation of surface air temperature of these two studies 1973-93 and 1900-72, are 10.95 °C and 12.05 °C, respectively. Table 3 also shows the results of the gradual temporal change between 1973-93 and 1900-72 time periods of the GDR of southwest Bangladesh, where the central time difference is about 47 years. In this table it can be seen that in Faridpur district the surface air temperature is increasing in every month except May (-0.25 °C). The increased surface air temperatures are ranged from 0.55 °C to 1.10 °C. It is remarkable that in the month of November, the increased surface air temperature can be found in whole over the GDR of southwest Bangladesh. The increased surface air temperature especially in the month of November of the different locations of southwest Bangladesh are as follows: 1.10 °C (Faridpur), 1.35 °C (Jessore), 0.65 °C (Khulna), 2.45 °C (Satkhira) and 0.25°C (Barisal). The highest increased surface air temperature in November occurred in Satkhira which was 2.45°C and the peak is also found in Figure 4. In Satkhira, the increased surface air temperature has crossed over 1°C in the other following months of the year, which are February (1.50°C), July (1.10°C), October (1.85°C) and December (1.30°C). In contrast, the highest peak among all the months and points is found in figure 4, at Khulna in June (2.49 °C).

Table 3 further shows the increased long-term mean annual surface air temperature of southwest Bangladesh which ranged from 0.11 °C (Khulna) to 0.77 °C (Satkhira) but in Barisal it can be seen a little declining (-0.30 °C). This surface air temperature decrease shows a tendency of increasing variance of the surface air temperature.

Table 3 Long-term mean monthly (between 1973-93 and 1900-72) surface air temperature in °C of five locations of Southwest Bangladesh and the temperature increment(ΔT) between the terms.

Place / Month	Faridpur			Jessore			Khulna			Satkhira			Barisal		
	1973-93	1900-72	ΔT	1973-93	1900-72	ΔT	1973-93	1900-72	ΔT	1973-93	1900-72	ΔT	1973-93	1900-72	ΔT
January	18.45	17.90	0.55	18.75	18.00	0.75	19.20	19.95	-0.75	19.40	19.20	0.20	18.85	19.60	-0.75
February	21.30	20.55	0.75	21.70	20.85	0.85	22.00	22.65	-0.65	22.65	21.15	1.50	21.75	22.25	-0.50
March	25.95	25.50	0.45	26.45	26.15	0.30	26.80	27.20	-0.40	27.05	27.10	-0.05	26.20	26.65	-0.45
April	28.65	28.60	0.05	29.55	29.55	0.00	29.45	29.40	0.05	30.05	30.15	-0.10	28.65	29.00	-0.35
May	28.55	28.80	-0.25	29.90	30.05	-0.15	29.50	29.95	-0.45	30.25	30.20	0.05	28.80	29.50	-0.70
June	29.00	28.45	0.55	29.45	29.25	0.20	29.50	27.01	2.49	29.90	29.60	0.30	28.75	28.75	0.00
July	28.50	28.25	0.25	28.95	28.55	0.40	28.90	28.70	0.20	29.10	28.00	1.10	28.20	28.20	0.00
August	28.85	28.40	0.45	29.10	28.65	0.45	29.05	28.75	0.30	29.15	28.20	0.95	28.35	28.30	0.05
September	28.65	28.55	0.10	29.05	28.65	0.40	28.90	28.85	0.05	29.00	28.85	0.15	28.35	28.65	-0.30
October	27.65	27.20	0.45	27.75	27.15	0.60	28.10	27.80	0.30	28.10	26.25	1.85	27.60	27.75	-0.15
November	24.10	23.00	1.10	24.05	22.70	1.35	24.75	24.10	0.65	24.60	22.15	2.45	24.20	23.95	0.25
December	19.70	19.10	0.60	19.50	18.95	0.55	20.25	20.70	-0.45	20.25	19.45	0.80	19.85	20.50	-0.65
Mean	25.77	25.35	0.42	26.16	25.70	0.46	26.36	26.25	0.11	26.62	25.85	0.77	25.79	26.09	-0.30
Maximum	29.00	28.80	0.20	29.70	30.05	-0.35	29.50	29.95	-0.45	30.25	30.20	0.05	28.80	29.50	-0.70
Minimum	18.45	17.90	0.55	18.75	18.00	0.75	19.20	19.95	-0.75	19.40	19.20	0.20	18.85	19.60	-0.75
Fluctuation	10.55	10.90	-0.35	10.95	12.05	-1.10	10.30	10.00	0.30	10.85	11.00	-0.15	9.95	9.90	0.05

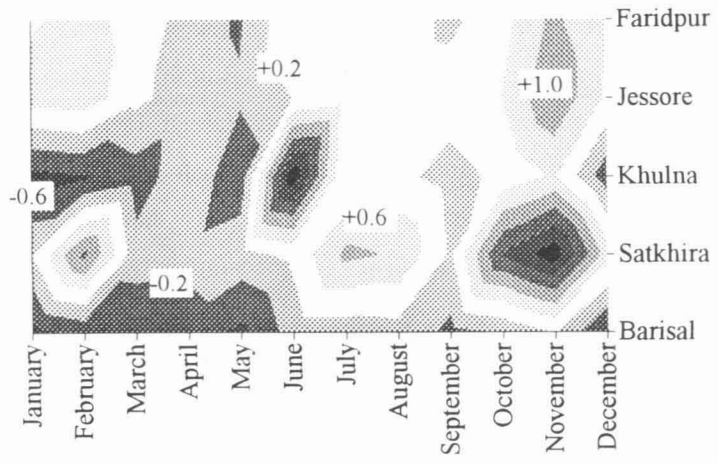

Fig. 4 Distribution of surface air temperature after obtaining from the two investigation results (1973-93 and 1900-72), positive values indicate increasing and negative values indicate decreasing tendency of surface air temperature of the Ganges Delta Region of Southwest Bangladesh.

Actually no warming of the air is found in Barisal (-0.30 °C) and in Khulna (0.11 °C) and typical warming is observed in Satkhira (0.77 °C). Warming in Faridpur (0.42 °C) and Jessore (0.46 °C) seems to be moderate and it is close to the average (0.29 °C) in the Ganges Delta Region of southwest Bangladesh.

4. CONCLUSIONS

The study area of the Ganges Delta Region of southwest Bangladesh is a transient zone from the tropical to the subtropical and landing area of the monsoon from the ocean, where strong gradient and variance in the surface air temperature is observed here. This study gives us an indication of temperature increasing tendency during the time-period from 1900 to 1993 in the GDR of southwest Bangladesh like other places on the earth's surface. From this point of view on the surface air temperature, it is now essential for undertaking an investigation immediately for concerned authority in Bangladesh. The new investigation data locations would be on a systematic grid-network basis over the country which is highly recommended.

ACKNOWLEDGEMENT

The first author likes to thank Prof. Dr. Abdus Samad, Ex-Director of the Delta Study Center (DSC) in the Department of Geology, University of Dhaka for encouraging the research work and also provides the initial financial support from the DSC is duly acknowledged. The data for this research were collected from the

Bangladesh Meteorology Department (BMD) is acknowledged. Thanks are also to Mr. M. M. Rhaman, Mr. M. Shams and Mr. M. S. Islam for helping during the data collection program. Thanks are extended to Prof. Dr. A. Pekdeger, Director, Institute for Geology and Environmental Geology of the Free University of Berlin, Germany for critical discussion. The authors expressed much appreciation to Prof. Dr. H. Nago for his initiative arrangement for the stay of the first author in the Department of Environmental and Civil Engineering, Faculty of the Environmental Science and Technology, Okayama University. They also thank to Mr. S. Nagai and Mr. M. F. Mia in the Hydraulic laboratory for the helps during the manuscript preparation.

REFERENCES

Hassan, M. Q. (1994): Long-Term Rainfall Distribution : A Correlation between 1968-88 and 1900-72 periods of Jessore-Khulna Regions, Southwest Bangladesh. Dhaka University Journal of Science, 42(1), 21-31.

Hassan, M. Q. (1995): Changes in Some Climatic Variables : A Preliminary Study From Southwest Bangladesh. Dhaka University Journal of Science, 43(1), 35-43.

Hingane, L. S., Kumar, K. R. and Ramanamurty, B. H. V. (1985): Long-Term Trends of Surface Air Temperature in India. Journal Climatol., 5, 521-528.

Jagannathan, P. and Partassarathy, B. (1972): Fluctuations in the seasonal oscillations of temperature in India. Indian Journal Met. Geophys., 23, 15p.

Manalo, E. M. (1977): Agro-Climatic Survey of Bangladesh. Bangladesh Rice Research Institute and International Rice Research Institute Publ., 361p.

NAO (National Astronomical Observatory) ed. (1994): Chronological Scientific Tables (Rika Nenpyo), Maruzen Co., Ltd., 306-307 (in Japanese).

Okubo, K. (1997): Annual Flooding Process Forming Haors, the Seasonal Lakes in the Northeast Bangladesh and Their Thermal Responses. Final Seminar on Japan-Bangladesh Joint Study Project on Flood. II-7, 1-10.

Srivastava H. N. Dewan, B. N., Dikshit, S. K. Rao, G. S, Singh, S. S. and Rao, R. (1992): Decadal trends in Climatic over India. Mausam 43(1), 7-20.

Strangeways, I. C. (1985): Automatic Weather Station. Facets of Hydrology, 2, edited by J. C. Rodda, John Wiley & Sons Ltd., 25-68.