Maximum and Minimum Temperature in Assam: Change over the Last Fifty Years

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ABSTRACT: A measure, termed as temperature index, of overall relative change in temperature over two different situations has been developed in a recent study by the application of the concept of Pythagorean geometric mean. This measure has already been applied in estimating temperature index at the five cities namely Dhubri , Dibrugarh , Guwahat , Silchar & Tezpur in Assam in order to obtain estimate of change in temperature over the last fifty years at these five cities. The same measure has here been applied in estimating temperature index of each of maximum and minimum of surface air temperature at these five cities in order to obtain estimate of change in temperature over the last fifty years at these five cities. It has been found that the maximum of surface air temperature at these five cities in Assam have increased by 6.4881% , 0.0908% , 2.6128% , 12.3208% & 3.9027% respectively over the last 50 years (from the year 1973 to the year 2023).

KEYWORDS*: Change index, surface air temperature, maximum, minimum, five stations in Assam

I. INTRODUCTION

It is observed that temperature at any place changes continuously over time due to either or both of assignable cause (or causes) and chance cause. The change is insignificant if it occurs due to chance cause only while the change is significant if it occurs due to some assignable cause(s) in addition to change cause [6 , 7 , 10 , 39]. There had been several studies on identifying the significance of change in temperature at a place as well as on its central tendency [6 , 7 , 11 , 12 , 21 , 54 , 57 , 59] and its confidence interval (also natural extrema) within a temperature periodic year [6 – 9 , 13 , 47 , 57 , 59 – 62]. However, it is also essential to know the degree or amount of change in temperature at a place over time. Due to this necessity, one concept namely "temperature index" has recently been defined with the help of the concept of average in order to measure the overall change in temperature at a location over time [42]. Attempt was made on defining this concept with the help of the concept of average [4 , 15 , 16 , 18 – 20 , 40 , 55] which is a single number taken as representative of a non-empty list of numbers (including a large set of numbers).

It is the great mathematician Pythagoras, the pioneer of defining average, who defined the three most common measures of average namely arithmetic mean, geometric mean and harmonic mean which were given the name "Pythagorean Means" as a mark of honour to him [5 , 14]. Later on, a number of definitions / formulations of average had been derived due to necessity of handling different situations. Some of them are quadratic mean or root mean square, square root mean , cubic mean, cube root mean, generalized *p m*ean & generalized p^{th} root mean etc. in addition to Arithmetic Mean , Geometric Mean & Harmonic Mean [5 , 15 , 16 , 18 – 20 , 23 , 36 , 40]. Recently, four formulations of average have been derived from the three Pythagorean means which are Arithmetic-Geometric Mean, Arithmetic-Harmonic Mean, Geometric-Harmonic Mean and Arithmetic-Geometric-Harmonic respectively [22 , 23].

In statistics, the three Pythagorean means are used in measuring the central tendency of data [1 – 3 , 34 , 37 , 48 – 50 , 52 – 54 , 64 , 65]. Recently, it has been established that in addition to the three Pythagorean means, the four formulations of average derived from them can also be used as mathematical measures of central tendency of data. [24 – 33 , 35 , 38] which implies that average is a basis of mathematical measures of central tendency of data. Moreover, Pythagorean means

can be hypothesized as a tool of constructing measures of various characteristics of data [17]. One common characteristic of data, in addition to central tendency, is dispersion [1 – 3 , 48 – 53 , 56 , 64]. Recently, it has been shown that average is also a basis of mathematical measures of dispersion of data [41 , 43 , 46]. In another study, an art had been shown on how to apply Pythagorean geometric mean in finding a suitable measure of average relative change in a group of variables [17] and consequently, this art was applied in deriving a measure, termed as temperature index, of overall relative change in temperature over two different situations [42]. This measure has already been applied in estimating temperature index at the five cities namely Dhubri , Dibrugarh , Guwahat , Silchar & Tezpur in Assam in order to obtain estimate of change in temperature over the last fifty years at these five cities [45]. The same measure has here been applied in estimating temperature index of each of maximum and minimum of surface air temperature at these five cities in order to obtain a picture of change in temperature over the last fifty years at these five cities.

II. TEMPERATURE INDEX

Let us consider some characteristic (like mean, median, extremum, etc.) of surface air temperature at a place/location/station.
Suppose,

$$T_1 , T_2 , \ldots\ldots , T_n$$

are n variables representing the characteristic in a group of n period and

$$T_{1b} , T_{2b} , \ldots\ldots , T_{nb}$$

are the values of the respective variables in the situation 'b'
as well as

$$T_{1c} , T_{2c} , \ldots\ldots , T_{nc}$$

are the values of the respective variables in the situation 'c'.
Then the change index (describing the overall relative change) of these variables, which can be termed/interpreted as Temperature Index [42 , 45], in the situation 'c' with respect to the situation 'b' can be given by

$$\text{Temperature Index} = \left\{ \frac{(T_{1c} \, T_{2c} \, \cdots\cdots \, T_{nc})}{(T_{1b} \, T_{2b} \, \cdots\cdots \, T_{nb})} \right\}^{1/n} \times 100 = I_{bc} , \text{ say} \qquad (1)$$

which implies, the overall change in the group of temperature variables

$$T_1 , T_2 , \ldots\ldots , T_n$$

can be interpreted as increasing or decreasing according to the values of Change Index is greater than 100 or less than 100.

III. CHANGE IN TEMPERATURE IN ASSAM

Change in temperature at a place can be described by the change of maximum and minimum of surface air temperature at the place. Accordingly, it has been planned to estimate index of maximum and minimum of surface air temperature. The formulation of temperature index, described above, has been applied in estimating temperature index of these two at the five cities Dhubri , Dibrugarh , Guwahat , Silchar & Tezpur in Assam in order to obtain a picture of change in temperature over the last 50 years at these five cities. Data on maximum and minimum of surface air temperature have been collected from Indian Meteorological Department for the year 1973 and from the websites
Weather Underground
https://www.wunderground.com › guwahati › date ,
Weather Underground
https://www.wunderground.com › dibrugarh › date ,
Weather Underground
https://www.wunderground.com › guwahati › date ,
and
Weather Underground

https://www.wunderground.com › silchar › date
Weather Underground
https://www.wunderground.com › tezpur › date **.**

for the year 2023.

Then monthly average maximum and monthly average minimum of surface air temperature have been calculated from the original data. Values of monthly average maximum and monthly average minimum obtained have been shown in **Table – 3.1** & **Table – 3.2** respectively.

Then temperature index of monthly average maximum and monthly average minimum have been calculated by the application of the formula (1) from the values in **Table – 3.1** & **Table – 3.2** respectively. Values of temperature index along with the respective percentages of change, obtained, have been shown in **Table – 3.3**.

Table – 3.1
(Average Maximum of Surface Air Temperature at 5 stations in Assam)

Month	Value of Average Maximum (in Degree Celsius)									
	Dhubri		Dibrugarh		Guwahati		Silchar		Tezpur	
	1973	2023	1973	2023	1973	2023	1973	2023	1973	2023
January	22.8	26.16	22.3	24.08	24.0	25.09	22.1	26.16	23.9	26.48
February	27.5	28.25	24.1	24.51	27.4	27.04	25.4	28.25	27.7	28.25
March	30.3	30.48	28.7	26.31	30.3	29.59	28.1	30.48	31.3	30.48
April	33.8	32.87	29.4	28.29	33.2	31.89	30.4	32.53	33.2	32.87
May	30.9	33.52	29.9	28.87	31.2	32.4	28.4	31.77	31.1	32.55
June	30.5	33.43	30.1	30.94	31.0	32.32	28.2	33.43	31.9	33.43
July	32.5	34.65	32.8	31.08	33.4	33.35	30.4	34.65	34.0	34.65
August	32.6	34.26	31.9	31.04	32.4	32.74	30.0	31.68	32.9	33.9
September	31.3	35.17	31.2	33.59	31.4	34.24	30.0	29.97	32.3	35.17
October	29.8	32.19	30.6	30.45	30.5	31.08	29.5	32.19	31.7	32.19
November	26.3	29.4	26.8	28.87	26.9	29.29	25.2	30.43	28.8	30.43
December	23.3	23.77	23.6	25.71	24.0	25.57	21.5	27.0	25.0	27.0

Table – 3.2
(Average Minimum of Surface Air Temperature at 5 stations in Assam)

Month	Value of Average Minimum (in Degree Celsius)									
	Dhubri		Dibrugarh		Guwahati		Silchar		Tezpur	
	1973	2023	1973	2023	1973	2023	1973	2023	1973	2023
January	12.0	11.1	10.4	11.74	11.5	12.12	12.2	11.1	12.0	11.1
February	14.1	15.0	12.8	15.26	11.4	14.72	15.1	15.0	14.5	13.89
March	17.0	20.52	15.6	17.54	16.1	18.32	18.0	17.45	16.7	17.52
April	21.4	20.0	19.7	20.11	19.4	19.57	22.1	20.0	21.3	20.0
May	23.4	22.13	22.2	22.21	22.4	21.56	23.6	22.13	22.7	22.13
June	24.4	24.77	23.8	25.54	24.4	25.54	24.9	24.87	24.4	24.87
July	26.4	26.16	25.3	26.29	25.5	27.17	25.9	26.16	25.7	26.12
August	25.9	25.97	25.0	25.09	24.7	26.97	25.6	25.97	25.0	25.97
September	25.0	25.47	23.7	26.79	24.1	26.48	25.2	25.47	24.5	23.13
October	23.1	22.67	20.9	22.91	21.3	23.44	24.1	22.68	21.6	26.45
November	18.5	17.53	14.3	17.22	16.1	18.74	19.0	17.53	16.8	17.53
December	14.1	14.1	9.7	14.23	11.1	15.33	13.5	14.1	12.6	14.1

Table – 3.2
(Index of Maximum & Minimum of Surface Air Temperature in the year 2023 with 1973 as Base Year)

Station	Surface Air Temperature			
	Maximum		Minimum	
	Index	Overall % of Change	Index	Overall % of Change
Dhubri	106.4881	6.4881	100.027	0.027
Dibrugarh	100.9077	0.0908	111.7321	11.7321
Guwahati	102.6128	2.6128	111.1583	11.1583
Silchar	112.3208	12.3208	97.0421	2.9579
Tezpur	103.9027	3.9027	101.7822	1.7822

IV. DISCUSSION AND CONCLUSION

Temperature Index, defined by equation (1), is as follows:
The overall (average) change of temperature in the situation 'c' is

$$\frac{I_{bc}}{100}$$

times with respect to the temperature in the situation 'b' and the amount of that change is

$$(I_{bc} - 100)\%$$

The change is increasing or decreasing according to $(I_{bc} - 100) > 100$ or $(I_{bc} - 100) < 100$.

The index of maximum temperature at Dhubri over the last 50 years has been found to be 106.4881 which implies, the overall increase in maximum temperature at this place over this period is 6.4881%. Since average is a measure of central tendency of data, the finding implies that the tendency of maximum temperature at Dhubri has increased by 6.4881% over the last 50 years (from the year from 1973 to the year 2023). Similarly, the tendency of minimum temperature at Dhubri has increased by 0.027% over this period of 50 years. Similarly, the tendency of minimum temperature at Dhubri has increased by 0.027% over this period of 50 years.

Similarly over this 50 years, the tendencies of maximum of surface air temperature at Dibrugarh , Guwahat , Silchar & Tezpur have been found to be increased by 0.0908% , 2.6128% , 12.3208% & 3.9027% respectively while the tendencies of minimum of that at Dibrugarh , Guwahat & Tezpur have been found to be increased by 0.0908% , 11.7321% , 11.1583% & 1.7822% respectively. It is to be noted that the tendency of minimum of surface air temperature at Silchar has been found to be decreased by 2.9579% over this 50 years.

The findings have shown that the highest increase in the tendency of maximum temperature has occurred at Silchar among the five stations considered in the study while the lowest increase of this has occurred at Dibrugarh. Similarly, the highest increase in the tendency of minimum temperature has occurred at Dibrugarh while the lowest increase (in fact decrease) of this has occurred at Silchar. The ranks of the stations as per the increase in change have been shown in the following table (Table – 4.1):

Table – 4.1
(Rank of Index of Surface Air Temperature)

Rank in change of minimum temperature →	1	2	3	4	5
Rank in change of maximum temperature ↓					
1					Silchar
2				Dhubri	
3			Tezpur		
4		Guwahati			
5	Dibrugarh				

Finally on the basis of the findings obtained, it can be concluded that there is necessity of initiating action on reducing the temperature at these five stations by

6.4881% at Dhubri , 0.0908% at Dibrugarh , 2.6128% at Guwahati , 12.3208% at Silchar & 3.9027% at Tezpur

for the interest of restoring the warming level at what was 50 years ago.

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Dr. Dhritikesh Chakrabarty passed B.Sc. (with Honours in Statistics) Examination from Darrang College, Gauhati University, in 1981 securing 1st class &1st position. He passed M.Sc. Examination (in Statistics) from the same university in the year 1983 securing 1st class & 1st position and successively passed M.Sc. Examination (in Mathematics) from the same university in 1987 securing 1st class (5th position). He obtained the degree of Ph.D. (in Statistics) in the year 1993 from Gauhati University. Later on, he obtained the degree of Sangeet Visharad (inVocal Music) in the year 2000 from Bhatkhande Sangeet vidyapith securing 1st class, the degree of Sangeet Visharad (in Tabla) from Pracheen Kala Kendra in 2010 securing 2nd class, the degree of Sangeet Pravakar (in Tabla) from Prayag

(Dr. Dhritikesh Chakrabarty, 2nd from the left, with teaching faculties of Statistics Department of Handique Girls' College on his last official working day (December 31, 2021) at the institution)

Sangeet Samiti in 2012 securing 1st class, the degree of Sangeet Bhaskar (in Tabla) from Pracheen Kala Kendra in 2014 securing 1st class and Sangeet Pravakar (in Guitar) from Prayag Sangeet Samiti in 2021 securing 1st class. He obtained Jawaharlal Nehru Award for securing 1st position in Degree Examination in the year 1981. He also obtained Academic Gold Medal of Gauhati University and Prof. V. D. Thawani Academic Award for securing 1st position in Post Graduate Examination in the year 1983.

Dr. Dhritikesh Chakrabarty, currently an independent researcher, served Handique Girls' College, Gauhati University, during the period of 34 years from December 09, 1987 to December 31, 2021, as Professor (first Assistant and then Associate) in the Department of Statistics along with Head of the Department for 9 years and also as Vice Principal of the college. He also served the National Institute of Pharmaceutical Education & Research (NIPER) Guwahati, as guest faculty (teacher cum research guide), during the period from May, 2010 to December, 2016. Moreover, he is a Research Guide (Ph.D. Guide) in the Department of Statistics of Gauhati University and also a Research Guide (Ph.D. Guide) in the Department of Statistics of Assam Down Town University. He has been guiding a number of Ph.D. students in the two universities. He acted as Guest Faculty in the Department of Statistics and also in the Department of Physics of Gauhati University. He also acted as Guest Faculty cum Resource Person in the Ph.D. Course work Programme in the Department of Computer Science and also in the Department of Biotechnology of the same University for the last six years.

Dr. Chakrabarty has been working as an independent researcher for the last more than thirty years. He has already been an author of 260 published research items namely research papers, chapter in books / conference proceedings, books etc. He visited U.S.A. in 2007, Canada in 2011, U.K. in 2014 and Taiwan in 2017. He has already completed one post doctoral research project (2002 − 05) and one minor research project (2010 − 11). He is an active life member of the academic cum research organizations namely (1) Assam Science Society (ASS), (2) Assam Statistical Review (ASR), (3) Indian Statistical Association (ISA), (4) Indian Society for Probability & Statistics (ISPS), (5) Forum for Interdisciplinary Mathematics (FIM), (6) Electronics Scientists & Engineers Society (ESES) and (7) International Association of Engineers (IAENG). Moreover, he is a Reviewer/Referee of (1) Journal of Assam Science Society (JASS) & (2) Biometrics & Biostatistics International Journal (BBIJ); a member of the executive committee of Electronic Scientists and Engineers Society (ESES); and a Member of the Editorial Board of (1) Journal of Environmental Science, Computer Science and Engineering & Technology (JECET), (2) Journal of Mathematics and System Science (JMSS) & (3) Partners Universal International Research Journal (PUIRJ). Dr. Chakrabarty acted as members (at various capacities) of the organizing committees of a number of conferences/seminars already held.

Dr. Chakrabarty was awarded with the prestigious SAS Eminent Fellow Membership (SEFM) with membership ID No. SAS/SEFM/132/2022 by Scholars Academic and Scientific Society (SAS Society) on March 27, 2022.