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CENTRAL TENDENCY OF ANNUAL EXTREMUM OF AMBIENT AIR TEMPERATURE AT SILCHAR

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ABSTRACT : An analytical method has been developed for determining the true value of the central tendency of each of annual maximum and annual minimum of ambient air temperature at a location. Also, the value of central tendency of each of annual maximum and annual minimum of ambient air temperature at Silchar has been determined by applying the method developed here from the data since the year 1969 onwards. Determination of these two values is based on the assumption that change in temperature over years during the period for which data are available occurs due to change cause only but not due to any assignable cause. The values of these two have been found to be 370.00(in 0.1Degree Celsius) and 86.00(in0.1 Degree Celsius) respectively.

KEY WORDS : Annual maximum, annual minimum, ambient air temperature, Silchar, analytical method of determination.

I. INTRODUCTION

There are many situations where observations are composed of some parameter and chance error[7]. Change in temperature at a location over temperature periodic year (abbreviated as TPY in this article) corresponds to such a situation.

Temperature at a location attains at a maximum and a minimum and during a TPY[2], 3, 4 & 5. The annual extremum (i.e. extremum occurred during a TPY) of temperature at a location is to remain the same provided there is no cause(s) influencing upon the change in temperature at the location other than the chance error which is universal [3,4 & 5]. For this reason, variation occurs among the observations on annual maximum as well as on annual minimum. Though variation exists, each of annual maximum and of annual minimum temperature has a central tendency. Thus if

$$X_1, X_2, \ldots\ldots\ldots\ldots\ldots\ldots, X_n$$

are observations on the annual maximum (or annual minimum) of the ambient air temperature at the location with μ as its central tendency and if the variation among the observations occurs due to chance cause only,

$$X_i = \mu + \varepsilon_i \quad , \quad (i = 1 , 2 , \ldots\ldots\ldots\ldots , n)$$

(1.1)

where ε_1 , ε_2 , ……….. , ε_n are values of the chance error associated to X_1 , X_2 , ………… , X_n respectively

The existing statistical methods of estimations namely least squares method, maximum likelihood method, minimum variance unbiased method, method of moment and method of minimum chi-square etc. provide

$$\bar{X} = n^{-1} \sum_{i=1}^{n} \mathrm{x_i}$$

as estimator of the central tendency μ (Kendall & Stuart [6] ; Walker, Helen , & Lev [7]).

This estimator, however, suffers from an error $e = e(\varepsilon_1 , \varepsilon_2 , \ldots\ldots\ldots\ldots , \varepsilon_n)$ given by

$$e = e(\varepsilon_1 , \varepsilon_2 , \ldots\ldots\ldots\ldots , \varepsilon_n) = \bar{\varepsilon_i} = n^{-1} \textstyle\sum_{i=1}^{n} \varepsilon_i \qquad (1.3)$$

Which may not be zero [4&5]

In other words, none of these methods can provide the true value of the parameter μ . A method has been developed by [3 & 8] for determining almost certain interval for the parameter μ . The method is based on the area property of normal probability distribution [9,10,11,12,13,14]. In another study [4 & 5], has developed an analytical method for determining the true value of the parameter μ in the situation where the observations are composed of the parameter itself and chance errors. This method is based on the idea of finding the sufficient shortest interval value for the parameter μ , using order statistics. In this method, it is required to exclude two extreme observations in cumulative manner for computing interval value at very stage in order to obtain the sufficient shortest interval. This method however fails in the situation where insufficient observations are remained after exclusion of the extreme observations at some stage before obtaining the sufficient shortest interval. A method for the same has been developed in order to overcome this inconvenience. This paper is based on the development of this method and on one numerical application of the method in determining the value of the central tendency of each of the annual maximum and the annual minimum of the ambient air temperature at

Silchar. The determination of these two values is based on the assumption that the variation among the observations used in determination occurs due to chance cause only.

The method developed is based on the theory of normal probability distribution discovered by a German mathematician[15] in the year 1809, the credit for which discovery is also given by some authors to a French mathematician[16 & 17] who published a paper in 1738 that showed the normal distribution as an approximation to the binomial distribution discovered by[20] in 1713[18 & 19]. The normal distribution [9,10,11,12,13 & 14] is described by the probability density function

$$f(x:\mu,\sigma) = \{\sigma(2\pi)^{\frac{1}{2}}\}^{-1}\, exp[-{}^{1}\!/_{2}\{(x-\mu)/\sigma\}^{2}], \quad -\infty < x < \infty, -\infty < \mu < \propto, 0 < \sigma < \infty. \qquad (1.4)$$

Where (i) X is the associated normal variable,

(ii) μ & σ are the two parameters of the distribution

and (iii) Mean of $X = \mu$ & Standard Deviation of $X = \sigma$.

For a normal distribution mean, median and mode are equal. Moreover, the midrange of the distribution coincides with each of them.

DEVELOPMENT OF THE METHOD:

Let

$$X_1 , X_2 , \ldots\ldots\ldots\ldots , X_n$$

be distinct observations on the annual extremum (maximum or minimum) of the ambient air temperature at a location in the years

$$1 , 2 , 3 , \ldots\ldots\ldots\ldots , n$$

respectively.

(If the available observations are not distinct, one can extract the distinct observations from them.)

If μ is the central tendency of the annual extremum of the ambient air temperature at the location and if the variation among the observations occurs due to chance cause only,,

$$X_i = \mu + \varepsilon_i \quad , \quad (i = 1 , 2 , \ldots\ldots\ldots\ldots , n) \qquad (2.1)$$

where $\varepsilon_1 , \varepsilon_2 , \ldots\ldots\ldots\ldots , \varepsilon_n$ are values of the chance error variable ε associated to $X_1 , X_2 , \ldots\ldots\ldots\ldots , X_n$ respectively.

It is to be noted that

(1) $X_1, X_2, \dots\dots\dots\dots, X_n$ are known,

(2) $\mu, \varepsilon_1, \varepsilon_2, \dots\dots\dots\dots, \varepsilon_n$ are unknown

& (3) the number of linear equations in (2.1) is n with $n + 1$ unknowns implying that the equations are not solvable mathematically.

Reasonable facts /Assumptions regarding ε_i:

(1) $\varepsilon_1, \varepsilon_2, \dots\dots\dots, \varepsilon_n$ are unknown values of the variables ε.

(2) The values $\varepsilon_1, \varepsilon_2, \dots\dots\dots\dots, \varepsilon_n$ are very small relative to the respective values

$X_1, X_2, \dots\dots\dots\dots, X_n$.

(3) The variable ε assumes both positive and negative values.

(4) $P(-a - da < \varepsilon < -a) = P(a < \varepsilon < a + da)$ for every real a.

(5) $P(a < \varepsilon < a + da) > P(b < \varepsilon < b + db)$

& $P(-a - da < \varepsilon < -a) < P(-b - db < \varepsilon < -b)$

for every real positive $a < b$.

(6) The facts (3), (4) & (5) together imply that ε obeys the normal probability law.

(7) Sum of all possible values of each ε is 0 (zero) which together with the fact (6)

implies that $E(\varepsilon) = 0$.

(8) Standard deviation of ε is unknown and small, say σ_ε.

(9) The facts (6), (7) & (8) together imply that ε obeys the normal probability law with

mean (expectation) 0 & standard deviation σ_ε. Thus

$$\varepsilon \sim N(0, \sigma_\varepsilon)$$

(2.2)

Note (2.1): Since

$$\varepsilon_1, \varepsilon_2, \dots\dots\dots, \varepsilon_n$$

are independently and identically distributed $N(0, \sigma_\varepsilon)$ variates, their mean defined by

$$\overline{\varepsilon_i} = n^{-1} \sum_{i=1}^{n} \varepsilon_i$$

is a $N(0, \sigma_\varepsilon/\sqrt{n})$ variate.

The Method

Let the observations be arranged in ascending order of magnitude as

$$X_{(1)} < X_{(2)} <, \ldots\ldots\ldots < X_{(n)} \quad (2.3)$$

From the model (2.1) satisfied by the observations,

$$X_{(i)} = \mu + \varepsilon_{(i)} \quad , \quad (i = 1, 2, \ldots\ldots\ldots, n) \quad (2.4)$$

where $\varepsilon_{(1)} < \varepsilon_{(2)} < \ldots\ldots\ldots, \varepsilon_{(n)}$

Which implies that $X_{(1)}$ contains the maximum negative error and $X_{(n)}$ contains the maximum positive error among the errors associated to the observations.

Let us construct the n averages defined by

$$\bar{X}_{(i)}(1) = (n-1)^{-1} \sum_{j=1, j \neq i}^{n} X_{(j)} \quad (2.5)$$

$$(i = 1, 2, \ldots\ldots\ldots, n)$$

Here

$$\bar{X}_{(1)}(1) > \bar{X}_{(2)}(1) > \ldots\ldots\ldots\ldots > \bar{X}_{(n-1)}(1) > \bar{X}_{(n)}(1) \quad (2.6)$$

From the model (2.1),

$$\bar{X}_{(i)}(1) = \bar{\mu} + \varepsilon_{(i)}(1) \quad (2.7)$$

Where

$$\bar{\varepsilon}_{(i)}(1) = (n-1)^{-1} \sum_{j=1, j \neq i}^{n} \varepsilon_{(i)} \quad (2.8)$$

$$(i = 1, 2, \ldots\ldots\ldots, n)$$

By Note (2.1), some of the averages

$$\bar{\varepsilon}_{(1)}(1), \; \bar{\varepsilon}_{(2)}(1), \; \ldots\ldots\ldots\ldots > \bar{\varepsilon}_{(n-1)}(1), \; \varepsilon_{(n)}(1)$$

will lie above 0 and the others below 0.

Consequently, some of the averages

$$\bar{X}_{(1)}(1), \; \bar{X}_{(2)}(1), \; \ldots\ldots\ldots\ldots > \bar{X}_{(n-1)}(1), \; X_{(n)}(1)$$

Will lie above μ *and the others below* μ.

$$\bar{X}_{(1)}(1), \; \bar{X}_{(2)}(1), \; \ldots\ldots\ldots\ldots, \; \bar{X}_{(k)}(1)$$

Fall above μ *and*

$$\bar{X}_{(k+1)}(1), \; \bar{X}_{(k+2)}(1), \; \ldots\ldots\ldots\ldots, \; \bar{X}_{(n)}(1)$$

Fall below μ.
Then μ *will lie within*

$$\bar{X}_{(k+1)}(1) \; \& \; \bar{X}_{(k)}(1) \text{ with}$$

$$\bar{X}_{(k+1)}(1) < \mu < \bar{X}_{(k)}(1)$$

(2.9)

Of course, it is trivial that

$$\bar{X}_{(n)}(1) < \mu < \bar{X}_{(n)}(1)$$

(2.10)

The interval (2.9) can help to determine the true value of μ.

Note that positive error associated to $X_{(i)}(1)$ decreases as i moves from 1 towards some point *p* and that negative error associated to $X_{(i)}(1)$ decreases as *i* moves from *n* towards the point *p*.

Thus, $X_{(p)}(1)$ is the true value of μ. However, it is still unknown.

It can be thought that it can be possible to detect / determine the true value of μ from an interval value of μ which is of sufficiently small length.

It is to be noted that if one among the large number (n) of observations is excluded and the same method is applied on the remaining observations, one can obtain valid interval for the true value of μ of the type given by (2.9).

Thus, one can obtain a number of such valid intervals for the true value of μ of the type given by (2.9) based on all the observations excluding each one of the available observations.

From the set of these intervals one can obtain the shortest possible interval for the true value of μ. This shortest interval can provide the true value of μ.

AMBIENT AIR TEMPERATURE AT SILCHAR

Observations on annual maximum and annual minimum of the ambient air temperature at Silchar, which have been collected from the metrological department of India, are available from the year 1969 to the year 2013. These have been presented in Table -1 and Table - 4 respectively.

Computation of the Central Tendency of Annual Maximum :

Table – 2 has been constructed for distinct observed values on annual maximum obtained from Table-1

In Table - 2 has been constructed for distinct observed values on annual maximum arranged in ascending order of magnitude.

In order to determine the value of the central tendency of annual maximum, interval values have been computed by the formula (2.9) from the distinct observations excluding each one of them one after another starting from approximately the middle position and then alternately one from above and from below along with the corresponding shortest interval. These values have been presented in Table - 3.

The shortest interval, obtained, for the central tendency of annual maximum is

(370.3810 , 370.6667).

Computation of the Central Tendency of Annual Minimum :

Table - 5 has been constructed for distinct observed values on annual minimum obtained from Table -4

Interval values are to be computed from order statistics.

Therefore, Table - 6 has been constructed for distinct observed values on annual minimum arranged in ascending order of magnitude.

In order to determine the value of the central tendency of annual minimum, interval values have been computed by the formula (2.9) from the distinct observations excluding each one of them one after another starting from approximately the middle position and then alternately one from above and from below along with the corresponding shortest interval. These values have been presented in Table - 6.

Hence, the value of central tendency of annual minimum of surface air temperature at Silchar, obtained by the shortest interval method, can be taken as 86.00 (in 0.1 Degree Celsius).
The shortest interval, obtained, for the central tendency of annual minimum is

(85.6875 , 86.0625).

Now, the real number which is strictly greater than 8.7409 and strictly less than 8.75 is 8.8 (corrected up to one place of decimal).

Hence, the true value of the central tendency of annual minimum of the ambient air temperature at Silchar is 8.8 Degree Celsius.

TABLES OF DATA, COMPUTATIONS AND RESULTS
Tables of Annual Maximum of ambient air temperature at Silchar :

TABLE – 1

Observed Value of Highest Maximum Temperature (in 0.1 Degree Celsius) occurred during Temperature Periodic Year at Silchar

Year no	Observed value	Calendar year, Month & Date of occurrence	Year no	Observed value	Calendar year, Month & Date of occurrence
1	351	1969, May 30	17	379	1996, September 14
2	360	1970, June 15	18	373	2000, May 14
3	349	1971, July 7	19	375	2001, July 8
4	345	1972, June 11 & July	20	375	2002, May 17
5	355	1973, July 6	21	373	2003, July 26
6	344	1974, May 29	22	369	2004, May 17
7	380	1986, August 11	23	379	2005, September 15
8	384	1987, May 14	24	391	2006, May 25
9	377	1988, September 20	25	379	2007, May 5
10	364	1989, June 11	26	391	2008, September 24
11	371	1990, June 14	27	385	2009, July 19
12	379	1991, August 21	28	372	2010, August 6

13	382	1992, August 15	29	376	2011, August 2
14	365	1993, September 20	30	381	2012, September 8
15	369	1994, July 16	31	386	2013, June 12
16	369	1995, June 11			

TABLE – 2

Distinct Value (observed) of Annual Maximum of Surface Air Temperature at Silchar in ascending order

TY No	Value (observed)	TY No	Value (observed)	TY No	Value (observed)
1	344.00	9	369.00	17	380.00
2	345.00	10	371.00	18	381.00
3	349.00	11	372.00	19	382.00
4	351.00	12	373.00	20	384.00
5	355.00	13	375.00	21	385.00
6	360.00	14	376.00	22	386.00
7	364.00	15	377.00	23	391.00
8	365.00	16	379.00		

In the above table

(i) The Value (observed) are in 0.1 Degree Celsius

(ii) **TY** means Temperature Year (Year starting with March and ending with February).

TABLE – 3

Interval values of Annual Maximum of Surface Air Temperature at Silchar

TY No	Value (observed)	Interval Obtained	Shortest Interval Obtained
1	Nil	(369.2272 , 371.3636)	(369.2272 , 371.363)
2	373.0	(369.0476 , 371.2857)	(369.2272 , 371.285)

3	375.0	(368.9524 , 371.1905)	(369.2272 , 371.190)
4	372.0	(369.0952 , 371.3333)	(369.2272 , 371.190)
5	376.0	(368.9048 , 371.1429)	(369.2272 , 371.142)
6	371.0	(369.1429 , 371.3809)	(369.2272 , 311.420)
7	377.0	(368.8571 , 371.0952)	(369.2272 , 371.095)
8	369.0	(369.2381 , 371.4762)	(369.2381 , 371.095)
9	379.0	(368.7619 , 371.0000)	(379.2381 , 371.000)
10	365.0	(369.4286 , 371.6667)	(369.4286 , 371.000)
11	380.0	(368.7143 , 370.9524)	(369.4286 , 370.952)
12	364.0	(369.4762 , 371.7143)	(369.4762 , 370.952)
13	381.0	(368.6667 , 370.9048)	(379.4762 , 370.904)
14	360.0	(369.6667 , 370.9523)	(369.6667 , 370.904)
15	382.0	(368.6190 , 370.8571)	(369.6667 , 370.857)
16	355.0	(369.9048 , 372.1429)	(369.9048 , 370.857)
17	384.0	(368.5238 , 370.7619)	(369.9048 , 370.761)
18	351.0	(370.0952 , 372.3333)	(370.0952 , 370.761)
19	385.0	(368.4762 , 370.7143)	(370.0952 , 370.764)
20	349.0	(370.1905 , 372.4286)	(370.1905 , 370.714)
21	386.0	(368.4286 , 370.6667)	(370.1905 , 370.6667)
22	345.0	(370.3810 , 372.6190)	(370.3810 , 370.6667)

The shortest interval, obtained, for the annual maximum is

(370.3810 , 370.6667).

The common value of the lower limit and the upper limit of this interval is 370.00

Hence, the value of central tendency of annual maximum of Surface air temperature at Silchar, obtained by the shortest interval method, can be taken as 370.0 (in 0.1 Degree Celsius).

TABLE – 4

Observed Value of Lowest Minimum Temperature (in 0.1 Degree Celsius) occurred during Temperature Periodic Year at Silcha

Year no	Observed value	Calendar year, Month & Date of occurrence	Year no	Observed value	Calendar year ,Month & Date of occurrence
1	89	1970, January 30	15	97	2000, January 05
2	92	1971, February 02	16	85	2001, January 12
3	93	1972, February 10	17	99	2002, February 01
4	95	1973, January 18	18	91	2003, January 24
5	90	1974, February 08	19	90	2004, january 29
6	70	1988, January 28	20	89	2004, December 28
7	64	1989, January 15	21	94	2006, January 22
8	68	1990, January 03	22	76	2007, January 16
9	90	1991, January 26	23	85	2008, February 15
10	94	1991, December 31	24	96	2009, January 03
11	85	1993, January 22	25	74	2010, February 04
12	90	1994, January 22	26	76	2011, January 21
13	79	1995, January 26	27	86	2012, January 28
14	91	1996, January 22	28	76	2013, January 12

TABLE – 5

Distinct Value (observed) of Annual Minimum of Surface air temperature at Silchar in ascending order

TY No	Value (observed)	TY No	Observed value	TY No	Value (observed)
1	64.00	7	85.00	13	93.00
2	68.00	8	86.00	14	94.00
3	70.00	9	89.00	15	95.00
4	74.00	10	90.00	16	96.
5	76.00	11	91.00	17	97.00
6	79.00	12	92.00	18	99.00

TABLE – 6

Interval values on Annual Maximum temperature (in 0.1 Degree Celsius)

TPR No	Value (observed) Neglected	Interval Obtained	Shortest Interval Obtained
1	Nil	(84.6471 , 86.7059)	(84.6471 , 86.7059)
2	90	(84.3750 , 86.5000)	(84.6471 , 86.5000)
3	89	(84.3750 , 80.6556)	(84.6471 , 86.5000)
4	91	(84.2500 , 86.4375)	(84.6471 , 86.4375)
5	86	(84.5625 , 86.7500)	(84.6471 , 86.4375)
6	92	(84.1875 , 86.3750)	(84.6471 , 86.3750)
7	85	(84.6250 , 86.8125)	(84.6471 , 86.3750)
8	93	(84.1250 , 86.3125)	(84.6471 , 86.3125)
9	79	(85.0000 , 87.1875)	(85.0000 , 86.3125)
10	94	(84.0625 , 86.2500)	(85.0000 , 86.2500)
11	76	(85.1875 , 87.3750)	(85.1875 , 86.2500)
12	95	(84.0000 , 86.1875)	(85.1875 , 86.1875)
13	74	(85.3125 , 87.5000)	(85.3125 , 86.1875)
14	96	(83.9375 , 86.1250)	(85.3125 , 86.1250)
15	70	(85.5625 , 87.7500)	(85.5625 , 86.1250)
16	97	(83.8750 , 86.0625)	(85.5625 , 8.6.0625)
17	68	(85.6875 , 87.8750)	(85.6875 , 8.6.0625)

From the interval values, in **Table-3.1.2**, the shortest interval value (i.e. the interval value with the minimum length of interval) is found to be

(85.6875 , 86.0625).

Hence, the value of central tendency of annual minimum of surface air temperature at Silchar, obtained by the shortest interval method, can be taken as 86.00 (in 0.1 Degree Celsius).

IV. CONCLUSION

Each of the existing statistical methods of estimation provides an estimate of the central tendency of annual extremum of the ambient air temperature which suffers from an error though may be small. Moreover, the amount of error involved in this estimate is unknown. The method developed here provides an estimate which is free from error.
The determination of central tendency of the extremum of ambient air temperature at Silchar is based on the assumption that change in temperature at this location over years during the period for which data are available occurs due to chance cause only but not due to any assignable cause.
Thus if the assumption is true, the values of the central tendency of annual maximum and annual minimum of the ambient air temperature at Silchar namely 370.0 Degree Celsius and 86.00 Degree Celsius respectively, as obtained in this study, are acceptable. Moreover, one can conclude that

i) The central tendency of Annual Maximum of the Ambient Air temperature at Silchar is 370.00 (in 0.1 Degree Celsius).However, it is yet to examine whether the assumption upon which the current study is based is true.
ii) The central tendency of annual minimum of the Ambient Air temperature at Silchar is 86.00 (in 0.1 Degree Celsius).However, it is yet to examine whether the assumption upon which the current study is based is true.

For a normal distribution mean, median and mode are equal. Each of them is a measure of central tendency. It seems that there exists some method of determination of central tendency in the same situation. Thus, it is a problem for the researchers at this stage to search for whether there exists method for the same based on mean, median and mode as well as to discover the hidden method if exists.

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