

Fourier Representation of Climatic Data of Kothara-Kutch

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Abstract

Fourier series representations of some climatic variables were developed using data from the site of an experimental greenhouse at Kothara (Kutch). Hourly data was averaged over a month to yield a profile of an average day of that month. That was put through harmonic analysis to determine Fourier coefficients. Analytical expressions would be useful to those working on modelling.

Introduction

Kothara is 85 km west of Bhuj (23° 24' N, 72° 38' E). An experimental greenhouse has been erected at Kothara to carry out studies on controlled environment agriculture. A multi-channel data logger is installed at the site. Ambient temperature, relative humidity, global solar radiation, wind speed and soil temperature are continuously recorded. Analytical expressions of these variables can be useful to those working on solar thermal applications, greenhouse modelling, crop growth modelling etc.

Hourly data of each variable was averaged over a month to get the profile of a typical or average day of that month. **Tables 1 to 7** show this data for each of the twelve months. Hourly data of the average day of each month was then put through harmonic analysis. Method to determine the coefficients of the series that could represent the data can be seen in [1].

Ambient Temperature

Equation-1 gives a general Fourier series expression in the interval $0 - 2\pi$,

$$T(t) = A_0 + \sum_{m=1}^n \left(A_m \cos \left(m \frac{\pi}{12} t \right) + B_m \sin \left(m \frac{\pi}{12} t \right) \right) \quad \dots(1)$$

where

T	ambient temperature (°C)
t	time in hours, midnight being the origin
A _m , B _m	Fourier coefficients which in this case will have dimension of temperature (°C)
n	number of harmonics

Table-8 shows the Fourier coefficients of first six harmonics for ambient temperature series. **Figure-1** shows the actual and computed values for the month of January as illustration. Visual examination suggests that use of just three harmonics would normally be sufficient. The maximum absolute deviation using three harmonics was 15% (table 8). Inclusion of more terms will of course improve it further. For this reason six terms are tabulated, in case needed.

Tables-9 & 10 show the coefficients for wind velocity, global solar radiation. **Tables-11 to 14** show the coefficients for relative humidity, soil temperatures at two levels, and air temperature inside greenhouse. Computed and actual values for each of the variables have been shown in **figures 1 - 7** for the month of January.

It may be mentioned that many a time interest lies only in daytime values of temperature. It would be equally convenient to develop sine or cosine series in half interval (π). Those dealing with green house modelling, crop growth etc. however, will be interested in night-time temperatures as well. Expressions given here may be more convenient for them.

Reference

1. Hildebrand F.B. (1956). Introduction to Numerical Analysis. Mcgraw Hill.

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	16.9	19.5	23.1	25.7	27.8	30.0	28.7	27.2	25.5	25.9	22.6	18.8
1	16.3	18.9	22.4	25.3	27.5	29.8	28.6	27.3	25.4	24.8	21.8	18.2
2	15.7	18.5	21.7	24.8	27.3	29.7	28.5	27.0	25.2	24.4	21.1	17.6
3	15.3	18.0	21.1	24.5	27.2	29.6	28.4	26.9	24.8	24.0	20.2	17.1
4	14.8	17.6	20.7	24.1	26.8	29.5	28.3	26.8	24.8	23.5	19.6	16.9
5	14.3	17.3	20.3	23.8	33.2	29.3	28.2	27.1	24.7	23.2	19.3	16.4
6	14.0	16.8	27.2	23.6	26.7	29.1	28.2	26.8	24.8	23.3	19.0	16.2
7	14.5	16.3	19.9	24.2	28.1	29.8	28.3	26.9	24.8	24.4	18.8	16.0
8	15.7	16.6	21.4	28.3	30.1	31.0	28.6	27.8	26.7	28.2	22.0	16.8
9	20.5	21.2	27.3	32.0	32.2	31.4	29.3	28.6	28.3	32.0	27.7	21.3
10	25.1	25.5	31.4	34.5	33.9	33.4	30.4	29.8	29.9	35.5	31.4	25.0
11	28.5	28.9	34.1	36.1	35.0	34.6	31.3	30.7	31.2	37.4	33.9	28.2
12	30.8	31.1	36.1	37.3	35.8	35.2	32.0	31.3	32.0	39.0	36.1	30.4
13	31.4	32.4	37.1	37.7	36.4	35.9	32.3	31.6	32.6	40.1	37.6	31.0
14	32.1	33.2	37.5	37.7	36.6	35.9	32.1	32.0	32.7	40.0	38.0	32.1
15	32.4	33.2	36.8	37.2	36.4	34.5	31.7	32.0	31.4	39.2	37.5	31.9
16	31.8	32.7	34.8	36.6	35.8	35.1	31.2	31.6	31.8	38.1	36.7	31.9
17	30.6	31.8	33.8	35.3	34.6	34.3	30.9	30.8	31.0	36.7	35.5	30.3
18	28.4	30.2	32.0	33.6	33.1	33.2	30.5	30.1	29.8	34.5	33.5	28.0
19	25.5	27.9	29.5	31.7	31.5	32.3	30.0	29.0	28.1	31.5	29.8	25.2
20	22.1	24.7	26.8	29.6	30.1	31.3	29.7	28.0	26.7	29.6	27.1	23.0
21	19.9	22.8	25.1	28.4	29.2	30.6	29.3	27.6	26.3	28.3	25.1	21.3
22	18.4	21.4	24.1	27.5	28.6	30.5	29.2	27.4	26.0	27.1	24.0	20.2
23	17.8	20.3	23.1	26.7	28.2	30.2	29.1	27.2	25.7	26.2	22.9	19.2

Table-2 : Wind Velocity (Kothara-Kutch)												
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	3.2	3.0	4.2	2.7	4.8	7.6	3.3	6.4	6.2	2.3	2.9	3.1
1	3.0	3.2	3.6	2.6	4.7	6.8	3.7	6.5	5.3	2.9	2.4	2.9
2	3.0	3.4	4.0	2.5	5.0	8.9	3.4	6.2	3.5	3.5	2.3	2.9
3	3.0	3.9	3.7	2.6	5.3	6.5	3.8	6.0	4.3	2.9	2.4	3.3
4	3.1	3.1	3.8	2.9	4.9	6.8	3.8	6.0	3.9	2.3	2.3	3.7
5	3.1	2.9	2.1	3.4	4.8	6.4	3.1	6.5	3.9	4.5	2.6	3.2
6	2.9	3.0	2.3	3.5	4.5	6.3	2.9	5.8	4.0	2.9	2.4	3.1
7	3.1	4.1	1.8	3.4	5.2	6.3	3.7	5.6	4.3	3.0	2.3	3.2
8	3.7	2.8	2.3	4.6	6.3	7.0	3.3	6.6	5.5	5.3	3.1	3.4
9	4.0	4.7	5.4	5.2	7.4	7.8	4.0	7.2	5.8	4.2	3.8	4.1
10	5.2	5.0	5.4	5.9	7.9	8.0	4.0	7.2	6.6	4.1	4.5	4.7
11	5.7	6.0	6.0	6.1	8.1	8.4	4.2	7.8	6.6	4.5	5.2	5.3
12	6.1	6.3	6.2	6.3	8.4	9.0	4.3	8.0	7.0	5.2	5.3	6.0
13	6.3	6.7	6.6	6.3	8.9	9.3	4.7	8.3	7.5	5.8	5.3	5.7
14	6.3	6.8	7.3	7.1	9.1	9.7	5.1	8.5	7.5	6.4	5.5	5.7
15	6.7	7.1	7.5	6.6	9.1	9.7	5.3	8.3	7.0	6.6	5.6	5.9
16	6.4	7.0	7.2	6.8	9.2	9.3	5.3	8.2	7.2	6.1	5.8	6.0
17	6.2	7.1	7.5	6.3	8.6	9.1	5.0	8.2	6.6	6.1	5.2	5.7
18	5.3	6.6	6.9	6.0	8.2	8.6	4.5	7.7	6.5	5.3	4.6	5.4
19	4.3	6.0	5.9	5.9	7.6	8.1	4.1	7.4	5.8	4.2	3.8	3.9
20	3.4	4.4	4.9	5.3	6.9	7.5	3.8	7.0	5.3	3.5	2.7	3.0
21	3.0	3.5	4.0	4.9	6.2	7.0	3.6	6.6	4.8	2.7	2.7	3.0
22	3.1	2.8	3.4	3.9	5.7	7.0	3.6	6.5	4.5	2.6	2.7	3.0
23	2.8	3.3	2.7	3.4	5.4	7.1	3.4	6.2	4.7	2.5	3.1	2.8

Table-4 : Relative Humidity (Kothara-Kutch)														
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
0	71.3	70.8	80.5	85.0	85.4	79.4	83.3	71.2	72.2	80.9	73.9	80.6		
1	72.0	71.5	81.3	86.2	86.6	80.3	84.2	72.4	73.7	82.7	75.0	80.8		
2	73.8	73.4	82.5	86.9	87.3	81.1	85.2	72.4	75.1	80.9	77.1	80.5		
3	74.6	74.2	83.7	88.0	88.3	81.9	86.1	73.1	76.6	84.2	77.9	80.6		
4	75.9	75.7	84.7	88.5	88.9	82.3	86.8	73.8	77.8	85.5	78.2	81.1		
5	76.9	76.7	85.4	88.7	89.4	82.5	87.4	74.5	78.0	86.6	79.1	80.7		
6	78.0	77.9	85.5	88.7	90.3	83.3	87.8	74.4	77.9	86.6	79.2	81.4		
7	78.8	78.8	85.5	90.3	90.5	83.6	87.9	74.4	76.9	86.8	79.5	82.1		
8	76.8	76.4	86.8	89.3	86.1	80.9	86.7	73.1	74.3	83.9	80.4	82.4		
9	70.6	69.4	85.3	78.8	74.4	72.9	82.5	66.4	64.1	73.7	74.1	81.1		
10	59.5	56.9	64.2	60.6	63.8	65.7	77.2	54.5	49.0	56.6	51.6	70.9		
11	39.7	37.4	47.3	49.5	56.7	58.5	71.1	46.4	37.7	41.6	39.8	54.8		
12	29.0	26.7	39.1	43.4	52.9	54.4	66.3	39.5	31.9	33.2	29.8	41.4		
13	28.2	26.6	36.2	41.0	50.6	51.5	62.8	35.8	30.2	27.5	24.6	34.1		
14	25.3	23.8	35.3	39.0	48.9	50.7	61.4	32.4	28.8	24.4	20.8	31.1		
15	24.9	23.3	35.7	41.3	49.0	51.4	62.5	31.7	27.9	24.7	23.9	30.1		
16	26.0	24.2	34.6	42.3	50.5	53.5	64.7	32.5	30.7	27.9	25.4	33.6		
17	28.0	26.6	36.6	44.1	53.9	56.4	66.1	36.3	37.2	32.9	25.3	37.2		
18	35.4	34.4	41.2	48.8	58.7	59.9	69.2	42.6	44.4	45.0	33.5	46.9		
19	48.7	48.1	48.3	58.2	66.0	63.5	69.5	51.1	53.6	58.8	47.7	60.3		
20	60.3	59.8	61.8	69.4	73.2	70.0	72.7	59.6	61.8	66.5	59.6	69.0		
21	67.7	67.3	70.8	76.8	78.5	74.4	77.0	64.3	66.5	71.8	65.8	74.1		
22	71.0	70.6	75.8	80.5	81.7	76.5	79.6	66.8	69.5	75.3	70.0	77.5		
23	73.3	72.9	78.3	83.3	83.6	78.0	81.1	69.1	71.9	76.4	73.2	79.8		

Table-5 : Soil Temperature at Surface (Kothara-Kutch)												
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	23.8	24.9	27.9	30.8	30.8	32.8	31.1	33.9	32.1	35.8	31.9	26.9
1	23.4	24.7	27.7	30.6	30.6	32.6	31.0	33.5	31.8	32.5	31.3	26.4
2	23.1	24.5	27.5	30.4	30.4	32.5	30.8	33.1	31.5	33.5	31.0	26.1
3	22.8	24.3	27.3	30.2	30.3	32.3	30.7	32.8	31.1	33.1	30.4	25.6
4	22.5	24.1	27.1	30.0	30.1	32.1	30.7	32.5	30.8	32.0	30.0	25.2
5	22.3	23.9	26.9	29.8	29.9	32.0	30.5	32.5	30.6	32.4	29.6	24.9
6	21.9	23.7	26.7	29.6	29.8	31.9	30.5	32.1	30.4	32.0	29.3	24.9
7	21.7	23.5	26.7	29.4	29.7	31.8	30.4	31.7	30.2	31.9	28.9	24.4
8	21.5	23.3	26.4	29.3	29.6	31.7	30.3	31.5	30.0	31.7	28.6	24.0
9	21.4	23.1	26.2	29.3	29.6	31.7	30.2	31.7	30.3	32.0	28.5	23.8
10	21.8	23.0	26.3	29.3	29.8	31.8	30.4	32.0	30.8	32.4	28.8	24.0
11	22.3	23.1	26.5	29.6	30.0	32.0	30.5	32.5	31.5	33.7	29.6	24.7
12	23.1	23.4	26.8	30.0	30.3	32.5	30.7	33.3	32.3	35.0	30.8	25.9
13	24.0	23.9	27.2	30.3	30.6	32.9	31.0	34.1	33.3	36.4	32.4	26.9
14	24.9	24.3	27.6	30.7	30.9	33.2	31.3	34.9	34.1	37.4	33.6	28.0
15	25.6	24.8	28.0	30.9	31.3	33.5	31.5	35.5	34.7	38.1	34.6	28.9
16	25.9	25.2	27.4	31.2	31.5	33.9	31.7	36.0	34.9	38.4	35.2	29.4
17	26.1	25.5	27.6	31.4	31.7	34.1	31.8	36.2	35.0	38.5	35.4	29.5
18	26.0	25.7	27.8	31.5	31.7	33.9	31.8	36.5	34.9	38.4	35.3	29.4
19	25.8	25.7	27.8	31.5	31.7	34.0	31.7	36.0	34.6	37.7	34.9	29.1
20	25.5	25.7	27.8	31.4	31.6	33.8	31.7	35.6	34.1	36.9	34.3	28.5
21	25.1	25.6	27.7	31.4	31.4	33.6	31.5	35.1	33.6	36.2	33.6	28.0
22	24.7	25.5	27.6	31.2	31.3	33.4	31.4	34.5	33.1	35.4	33.0	27.4
23	24.3	25.2	27.4	31.1	31.0	33.2	31.3	34.1	32.6	34.9	32.3	26.9

Table-6 : Soil Temperature at 30 cm depth (Kothara-Kutch)												
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	24.9	25.0	27.4	30.2	30.9	32.4	31.6	33.2	32.0	34.7	32.4	28.4
1	24.9	25.1	27.4	30.2	30.9	32.4	31.6	33.3	32.0	34.6	32.5	28.5
2	24.9	25.1	27.4	30.2	30.9	32.4	31.6	33.3	32.1	34.6	32.6	28.4
3	24.9	25.1	27.4	30.2	31.0	32.4	31.6	33.3	32.0	34.6	32.4	28.3
4	24.8	25.1	27.4	30.2	30.9	32.4	31.6	33.3	32.0	34.6	32.4	28.3
5	24.9	25.1	27.4	30.2	30.9	32.4	31.6	33.5	32.0	34.5	32.4	28.3
6	24.8	25.1	27.4	30.2	30.9	32.4	31.6	33.3	32.0	34.5	32.4	28.3
7	24.8	25.1	27.5	30.2	30.9	32.4	31.5	33.3	31.9	34.5	32.2	28.2
8	24.8	25.1	27.4	30.2	30.9	32.4	31.5	33.3	31.9	34.6	32.2	28.1
9	24.7	25.1	27.4	30.3	30.9	32.4	31.4	33.3	32.1	34.6	32.2	28.0
10	24.9	25.1	27.5	30.3	30.9	32.4	31.5	33.4	32.2	34.6	32.2	28.1
11	24.8	25.2	27.6	30.4	30.9	32.4	31.5	33.4	32.1	34.6	32.2	28.1
12	24.9	25.2	27.7	30.5	31.0	32.5	31.6	33.4	32.1	34.6	32.3	28.2
13	24.9	25.2	27.7	30.5	31.0	32.5	31.6	33.4	32.3	34.6	32.4	28.1
14	24.9	25.3	27.7	30.5	31.0	32.5	31.5	33.4	32.2	34.6	32.3	28.1
15	24.9	25.3	27.7	30.4	31.0	31.8	31.5	33.5	32.2	34.6	32.3	28.2
16	24.9	25.2	26.7	30.4	30.9	32.5	31.5	33.4	32.1	34.6	32.3	28.2
17	24.9	25.2	26.7	30.4	30.9	32.5	31.5	33.4	32.1	34.6	32.4	28.1
18	24.9	25.2	26.7	30.3	30.9	32.4	31.5	33.7	32.1	34.7	32.3	28.0
19	24.9	25.2	26.7	30.3	30.9	32.5	31.5	33.3	32.0	34.6	32.3	28.0
20	24.9	25.1	26.6	30.3	30.9	32.4	31.5	33.2	32.0	34.7	32.3	28.0
21	24.8	25.1	26.6	30.3	30.9	32.4	31.5	33.2	32.0	34.6	32.3	28.1
22	24.9	25.1	26.6	30.2	31.0	32.5	31.5	33.2	32.0	34.6	32.4	28.1
23	24.9	25.1	26.6	30.3	30.9	32.5	31.5	33.3	32.0	34.7	32.3	28.1

Table-7 : Greenhouse Temperature (Kothara-Kutch)												
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	16.9	18.2	22.7	25.9	28.2	30.7	29.7	29.4	26.9	26.6	22.6	19.2
1	16.1	17.9	22.2	25.3	27.9	30.7	29.5	29.3	26.6	25.9	21.9	18.7
2	15.2	17.5	21.6	24.8	27.7	30.4	29.4	29.0	26.3	25.5	21.4	18.2
3	14.7	17.1	21.2	24.5	27.4	30.3	29.2	28.8	25.8	25.1	20.4	17.6
4	14.2	16.8	20.8	24.2	27.2	30.2	29.1	28.6	26.0	24.6	20.8	17.3
5	13.7	16.4	20.6	24.0	27.0	30.0	28.9	28.9	26.0	24.2	19.4	16.9
6	13.3	16.2	20.3	23.8	27.3	30.0	28.9	28.5	26.2	24.6	19.0	16.7
7	13.8	15.7	20.1	25.1	28.8	30.5	29.1	28.9	26.5	25.9	19.0	16.6
8	15.9	15.7	21.0	28.1	31.3	32.2	29.7	31.2	29.8	30.8	21.6	17.4
9	20.2	17.5	26.2	31.7	33.7	34.0	30.9	34.7	35.5	37.9	29.7	22.8
10	26.5	23.2	31.4	34.5	35.5	35.9	32.8	38.8	40.6	42.9	36.6	30.3
11	30.5	28.0	34.7	36.6	36.9	37.3	34.4	42.5	44.9	47.8	40.4	34.8
12	31.3	30.6	37.3	38.1	37.8	38.7	35.9	45.2	47.3	51.6	44.0	35.9
13	32.4	32.7	38.9	38.9	38.4	39.8	36.8	46.8	48.8	54.2	47.7	36.8
14	33.2	33.8	39.5	39.1	38.6	40.2	37.0	48.7	49.3	54.9	48.8	38.0
15	33.4	33.9	39.0	38.9	38.3	40.0	36.3	49.3	48.6	54.1	48.4	38.2
16	32.8	33.6	37.4	38.5	37.7	39.7	35.8	48.6	47.4	52.6	47.0	37.7
17	31.7	32.4	36.0	37.4	36.5	38.4	34.9	46.1	44.5	48.2	43.5	34.5
18	29.5	30.7	33.9	35.7	35.2	37.2	34.1	43.2	40.5	43.0	39.2	31.6
19	25.6	25.8	31.9	33.4	33.6	36.3	33.8	39.0	36.0	36.7	33.3	27.7
20	21.3	22.2	28.7	30.7	31.7	34.6	32.9	34.6	31.5	32.4	28.1	23.7
21	18.9	20.6	25.3	28.5	30.2	32.7	31.5	31.7	29.1	30.1	25.6	21.5
22	17.6	19.5	23.8	27.4	29.3	31.9	30.8	30.5	28.1	28.4	24.3	20.3
23	17.2	18.8	22.8	26.7	19.4	31.4	30.4	30.0	27.3	27.4	23.2	19.4

Table 8 : Fourier Coefficients for Ambient Temperature Series - Kothara(Kutch)									
Month	n	0	1	2	3	4	5	6	Max Abs Dev(%)
January	A	22.16	-6.50	1.40	-0.44	0.30	0.13	-0.14	8.27
	B		-6.57	1.82	0.75	-0.57	0.11	-0.08	
February	A	24.01	-5.27	1.10	-0.71	0.36	0.18	-0.29	0.00
	B		-6.42	1.89	0.50	-0.49	0.15	-0.02	
March	A	27.81	-6.31	1.41	-0.58	0.76	0.41	-0.92	0.00
	B		-4.89	1.54	0.04	-0.43	0.66	0.12	
April	A	30.21	-5.67	1.51	-0.10	-0.25	0.17	0.00	0.00
	B		-4.21	0.47	0.75	-0.38	-0.21	0.17	
May	A	31.32	-4.02	0.43	-0.24	0.09	0.55	0.01	14.50
	B		-2.15	0.81	0.00	-0.62	0.04	0.55	
June	A	31.91	-2.54	0.71	-0.13	0.11	-0.08	0.02	0.00
	B		-1.79	0.56	0.17	-0.09	-0.11	0.03	
July	A	29.77	-1.38	0.55	-0.22	0.09	-0.03	-0.05	0.70
	B		-1.15	0.34	-0.04	-0.04	-0.02	-0.02	
August	A	28.81	-2.10	0.43	0.03	0.04	0.06	-0.03	1.49
	B		-1.48	0.67	0.12	-0.13	0.03	0.02	
September	A	27.91	-3.24	0.86	-0.04	0.09	-0.03	-0.08	2.53
	B		-2.16	0.67	0.30	-0.20	-0.14	0.19	
October	A	30.70	-6.75	1.83	-0.05	-0.15	0.14	-0.04	0.00
	B		-4.82	0.86	0.64	-0.35	-0.17	0.19	
November	A	27.54	-6.82	1.81	-0.20	0.04	0.29	-0.25	0.00
	B		-6.37	1.57	0.87	-0.52	-0.12	0.31	
December	A	23.03	-5.46	1.30	-0.37	0.20	0.07	-0.12	0.00
	B		-5.72	1.83	0.44	-0.58	0.20	0.07	

Table 9 : Fourier Coefficients for Wind Velocity Series - Kothara(Kutch)									
Month	n	0	1	2	3	4	5	6	Max Abs Dev(%)
January	A	4.30	-1.59	0.20	0.07	0.08	-0.01	0.01	9.10
	B		-0.99	0.58	0.17	-0.17	0.00	-0.01	
February	A	4.68	-1.58	-0.07	-0.06	0.15	-0.04	-0.08	0.00
	B		-1.37	0.63	0.39	0.01	-0.03	-0.17	
March	A	4.85	-1.45	0.30	-0.08	-0.17	0.25	-0.06	0.00
	B		-1.77	0.73	0.70	-0.13	-0.03	0.14	
April	A	4.73	-1.68	-0.09	-0.13	-0.14	0.11	-0.02	0.00
	B		-1.33	-0.11	0.03	-0.07	0.03	0.05	
May	A	6.74	-1.80	0.12	-0.03	-0.25	0.04	0.00	8.53
	B		-1.44	0.19	0.27	-0.07	-0.13	-0.02	
June	A	7.86	-0.89	0.39	0.11	-0.08	0.00	-0.11	0.00
	B		-0.92	0.55	0.26	0.10	-0.02	0.02	
July	A	3.99	-0.57	0.02	0.09	-0.17	-0.03	0.03	14.87
	B		-0.59	0.38	0.08	-0.04	-0.05	-0.04	
August	A	7.04	-0.86	0.19	-0.02	-0.01	0.10	0.01	8.64
	B		-0.79	0.26	0.11	-0.05	-0.02	0.16	
September	A	5.66	-1.22	0.48	0.27	0.18	0.27	0.21	32.67
	B		-0.96	0.15	0.18	0.06	-0.07	0.12	
October	A	4.14	-1.52	-0.23	0.26	-0.07	0.00	0.01	0.00
	B		-0.77	0.64	0.08	0.13	-0.12	0.23	
November	A	3.68	-1.41	0.31	0.15	0.10	0.05	0.01	0.00
	B		-0.92	0.38	0.14	-0.29	-0.03	-0.02	
December	A	4.14	-1.36	0.11	0.00	0.12	-0.07	0.03	0.00
	B		-0.74	0.57	0.19	-0.28	-0.09	0.03	

Table 10 : Fourier Coefficients for Solar Radiation Series - Kothara(Kutch)									
Month	n	0	1	2	3	4	5	6	Max Abs Dev(%)
January	A	222.91	-356.01	164.00	-14.50	-28.19	9.38	5.83	140.45
	B		44.05	-41.63	5.96	16.11	-8.91	-3.88	
February	A	250.30	-354.05	102.93	1.01	9.19	-3.11	-12.73	0.00
	B		-174.31	134.93	-0.51	-35.99	2.40	7.12	
March	A	295.22	-421.17	126.95	3.50	1.11	1.69	-10.77	0.00
	B		-178.54	130.64	10.82	-41.21	0.86	6.32	
April	A	323.19	-468.61	144.73	20.47	-19.42	-0.12	-0.65	0.00
	B		-129.46	84.86	24.28	-35.87	-7.85	11.80	
May	A	337.37	-472.20	123.51	22.69	-3.49	-4.88	-3.80	16.37
	B		-166.32	109.71	19.40	-27.35	-12.36	2.38	
June	A	313.28	-464.40	156.08	14.72	-11.21	-15.33	-0.57	0.00
	B		-135.35	111.07	-0.81	-35.31	-3.24	15.42	
July	A	193.11	-284.29	103.83	-15.19	5.47	3.14	-8.48	24.51
	B		-112.52	90.68	-10.08	-11.35	-4.71	3.23	
August	A	269.39	-384.71	117.92	-0.75	7.23	-9.68	1.72	1226.82
	B		-167.95	128.59	-1.52	-30.67	0.75	6.63	
September	A	316.51	-463.48	153.59	8.05	-13.97	0.93	-3.35	170.64
	B		-145.44	105.85	12.37	-37.39	-2.42	12.99	
October	A	272.92	-420.50	165.61	7.22	-32.27	-0.58	10.48	0.00
	B		-54.46	42.33	5.77	-20.99	0.84	9.61	
November	A	230.05	-351.68	137.73	-2.39	-15.07	-0.05	-1.90	0.00
	B		-105.69	93.33	-8.46	-29.94	4.71	14.56	
December	A	202.77	-314.81	134.23	-15.57	-6.81	-0.73	-1.53	0.00
	B		-102.09	95.29	-15.01	-31.81	17.50	6.50	

Table 11 : Fourier Coefficients for Relative Humidity Series - Kothara(Kutch)									
Month	n	0	1	2	3	4	5	6	Max Abs Dev(%)
January	A	56.83	18.64	-2.87	1.44	-2.96	1.00	-0.29	16.72
	B		19.56	-9.52	-1.43	0.98	-0.27	0.29	
February	A	55.89	19.46	-3.29	1.49	-2.97	0.97	-0.29	0.00
	B		19.88	-9.57	-1.72	1.25	-0.41	0.29	
March	A	64.53	17.10	-1.91	3.18	-3.55	0.85	0.25	0.00
	B		21.50	-7.61	-1.28	0.78	-0.93	1.39	
April	A	68.75	18.72	-3.23	2.56	-2.22	-0.25	1.12	0.00
	B		18.55	-6.20	-1.96	1.65	-0.57	0.41	
May	A	72.36	15.68	-3.20	1.07	-0.37	-0.60	0.54	3.49
	B		14.29	-4.10	-1.85	1.50	-0.28	-0.06	
June	A	69.75	11.71	-2.59	1.18	-0.56	-0.50	0.27	0.00
	B		11.27	-3.54	-0.77	0.57	-0.05	0.10	
July	A	76.71	7.30	-1.77	1.36	-0.30	-0.30	0.01	1.92
	B		10.21	-2.60	0.28	-0.27	-0.11	0.14	
August	A	57.92	14.99	-1.97	0.63	-0.86	0.19	0.55	3.77
	B		15.58	-6.17	-0.59	1.25	-0.27	0.32	
September	A	57.84	19.27	-4.76	0.99	-1.05	0.05	0.33	8.24
	B		16.25	-6.09	-1.14	1.63	-1.02	0.43	
October	A	62.46	22.26	-5.23	1.02	-1.03	0.84	0.76	0.00
	B		21.08	-9.05	-0.32	2.07	-0.59	0.22	
November	A	56.92	20.32	-3.14	1.95	-2.89	0.51	1.27	0.00
	B		21.63	-9.02	-1.02	1.60	-0.37	0.17	
December	A	64.70	17.52	-1.54	0.80	-1.99	1.37	-0.01	0.00
	B		18.17	-10.85	1.51	0.35	0.04	0.02	

Table 12 : Fourier Coefficients for Surface Soil Temperature Series - Kothara(Kutch)									
Month	n	0	1	2	3	4	5	6	Max Abs Dev(%)
January	A	23.71	0.33	-0.25	0.03	0.00	0.00	-0.01	0.24
	B		-2.14	0.45	-0.11	0.00	0.01	-0.01	
February	A	24.42	0.74	-0.24	0.03	-0.01	-0.01	0.00	0.00
	B		-1.03	0.10	-0.05	0.01	-0.01	0.01	
March	A	27.27	0.41	0.01	0.01	0.01	0.07	0.00	0.00
	B		-0.54	0.28	-0.07	0.14	0.04	-0.02	
April	A	30.43	0.44	-0.07	-0.02	0.01	-0.01	0.00	0.00
	B		-0.97	0.12	-0.04	0.01	-0.02	0.01	
May	A	30.64	0.27	-0.10	-0.01	0.00	-0.01	0.00	0.12
	B		-0.98	0.12	-0.01	-0.01	0.01	0.00	
June	A	32.78	0.22	-0.16	0.01	0.02	-0.04	0.01	0.00
	B		-1.10	0.15	-0.05	-0.01	-0.01	0.01	
July	A	31.02	0.18	-0.10	0.01	0.00	-0.01	0.00	0.20
	B		-0.71	0.12	-0.04	-0.01	0.00	-0.01	
August	A	33.80	0.26	-0.32	-0.02	0.08	0.05	-0.03	0.65
	B		-2.15	0.42	0.00	0.00	0.01	0.03	
September	A	32.40	-0.09	-0.18	-0.02	0.01	0.01	-0.04	0.35
	B		-2.34	0.47	-0.08	0.03	0.00	0.00	
October	A	34.88	-0.31	-0.21	0.07	0.17	0.05	0.07	0.00
	B		-3.27	0.66	-0.18	0.03	-0.10	-0.11	
November	A	31.78	0.41	-0.47	0.09	0.01	-0.01	-0.03	0.00
	B		-3.15	0.74	-0.15	0.08	0.00	0.00	
December	A	26.62	0.40	-0.41	0.10	0.06	-0.01	0.01	0.00
	B		-2.46	0.67	-0.11	0.09	0.07	-0.02	

Table 13 : Fourier Coefficients for Soil Temperature (Below 30 cm) Series - Kothara(Kutch)									
Month	n	0	1	2	3	4	5	6	Max Abs Dev(%)
January	A	24.87	0.00	0.01	0.00	0.02	0.00	0.00	0.23
	B		-0.03	0.04	-0.01	0.00	0.01	-0.01	
February	A	25.13	-0.07	-0.01	-0.01	0.01	0.00	-0.01	0.00
	B		-0.07	0.04	-0.01	0.00	-0.01	0.00	
March	A	27.26	-0.30	0.20	-0.01	0.02	0.09	-0.01	0.00
	B		0.36	0.21	-0.03	0.13	0.04	-0.03	
April	A	30.30	-0.09	0.04	-0.02	0.01	0.00	0.00	0.00
	B		-0.06	0.03	-0.01	0.00	-0.01	0.00	
May	A	30.94	0.00	0.02	0.00	-0.01	-0.01	0.00	0.15
	B		0.00	0.01	0.00	-0.01	-0.01	-0.01	
June	A	32.41	0.03	0.01	-0.03	0.06	-0.06	0.00	0.00
	B		0.01	-0.04	0.01	-0.01	-0.06	0.05	
July	A	31.55	0.02	0.02	0.00	0.01	0.00	0.00	0.21
	B		0.01	0.03	0.00	0.00	0.01	0.00	
August	A	33.34	-0.07	-0.02	0.00	0.06	0.03	-0.05	0.90
	B		-0.04	0.04	0.04	-0.03	-0.03	0.00	
September	A	32.05	-0.08	0.05	-0.02	-0.01	0.02	-0.04	0.35
	B		-0.03	0.03	0.00	-0.01	0.00	0.03	
October	A	34.60	0.02	0.03	0.01	0.01	0.02	0.01	0.00
	B		-0.04	0.00	0.02	-0.01	-0.01	0.02	
November	A	32.34	0.07	0.02	0.00	0.03	-0.03	-0.02	0.00
	B		0.00	0.07	0.01	0.01	0.00	0.03	
December	A	28.19	0.08	0.04	0.03	0.03	0.00	0.02	0.00
	B		0.09	0.11	0.01	0.03	0.04	0.00	

Table 14 : Fourier Coefficients for Green House Temperature Series - Kothara(Kutch)									
Month	n	0	1	2	3	4	5	6	Max Abs Dev(%)
January	A	22.31	-7.39	1.62	-0.29	0.49	0.22	-0.25	7.56
	B		-6.95	2.05	1.13	-0.76	0.15	-0.18	
February	A	23.10	-5.79	0.92	-0.44	0.79	-0.19	-0.31	0.00
	B		-6.82	3.06	0.19	-0.54	0.11	-0.17	
March	A	28.22	-6.91	1.56	-0.83	0.34	0.44	-0.22	0.00
	B		-6.60	2.10	0.60	-0.26	0.21	-0.05	
April	A	30.87	-6.08	1.10	-0.10	0.00	0.16	0.00	0.00
	B		-4.99	0.84	0.79	-0.28	-0.16	0.04	
May	A	32.27	-5.65	0.19	-0.49	-0.53	-0.12	0.03	35.39
	B		-3.08	0.86	1.08	0.61	0.64	0.78	
June	A	34.26	-3.86	0.54	-0.16	-0.07	0.14	0.04	0.00
	B		-3.41	0.87	0.27	-0.01	-0.06	-0.02	
July	A	32.13	-2.67	0.63	-0.42	0.08	0.08	0.01	1.07
	B		-2.76	0.72	-0.04	0.08	0.02	-0.07	
August	A	36.33	-7.99	0.83	0.10	0.20	0.18	-0.09	3.03
	B		-6.72	2.86	0.56	-0.46	0.01	-0.08	
September	A	34.96	-10.20	2.09	-0.15	0.22	0.18	-0.16	3.69
	B		-6.59	2.67	0.74	-0.72	0.03	0.12	
October	A	36.44	-12.73	2.83	0.20	-0.18	0.04	-0.05	0.00
	B		-8.51	3.21	0.63	-0.72	-0.16	0.30	
November	A	64.05	-13.91	-0.75	-3.43	-3.18	-2.79	-3.65	0.00
	B		-33.55	-8.38	-7.02	-6.52	-4.26	-2.98	
December	A	25.48	-8.24	2.02	-0.52	0.38	0.22	-0.32	0.00
	B		-7.10	2.72	0.82	-1.01	0.59	-0.28	

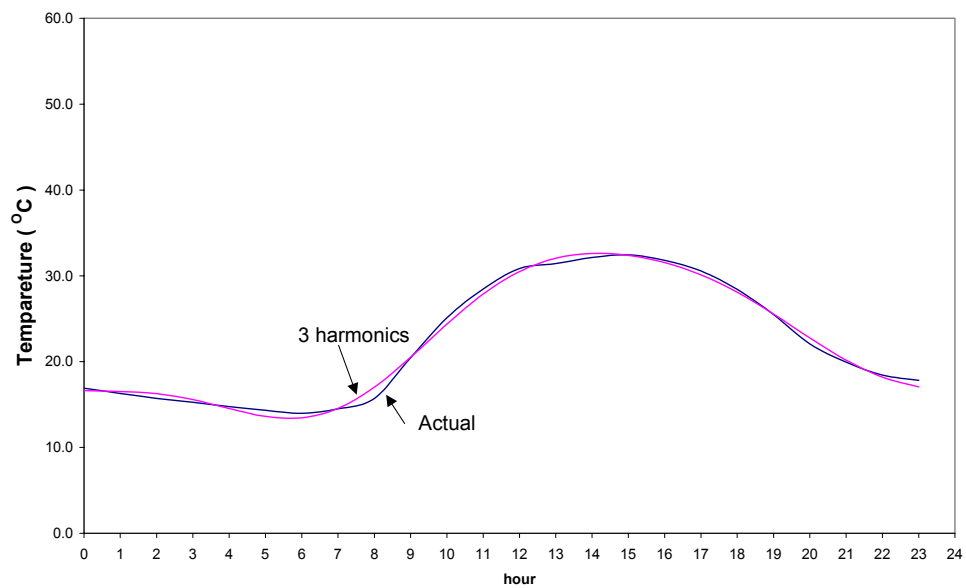
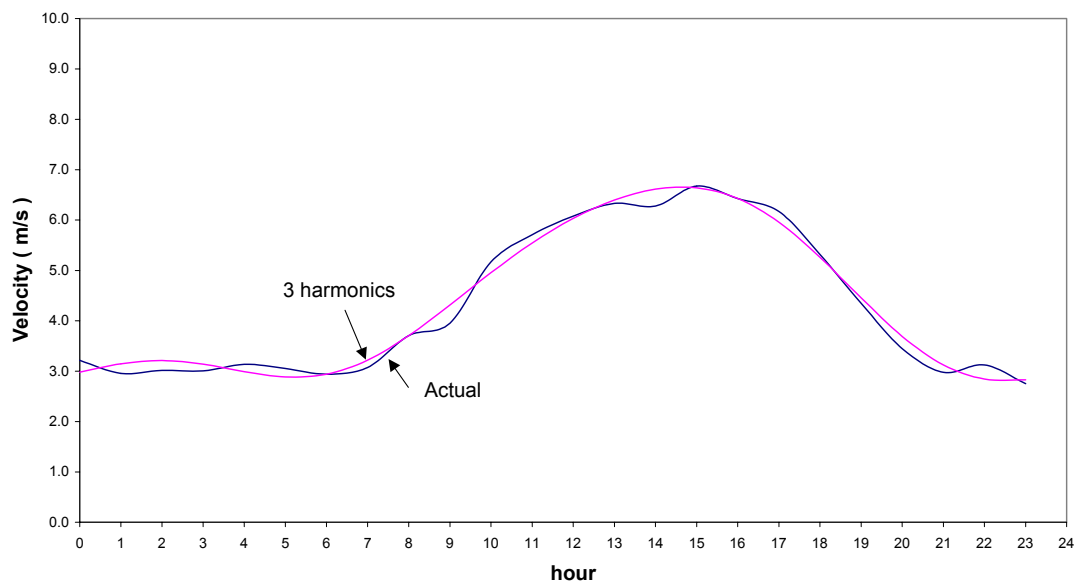
Fig. 1 Ambient Temperature on a typical day in January (Kothara-Kutch)**Fig. 2 Wind Velocity on a typical day in January (Kothara-Kutch)**

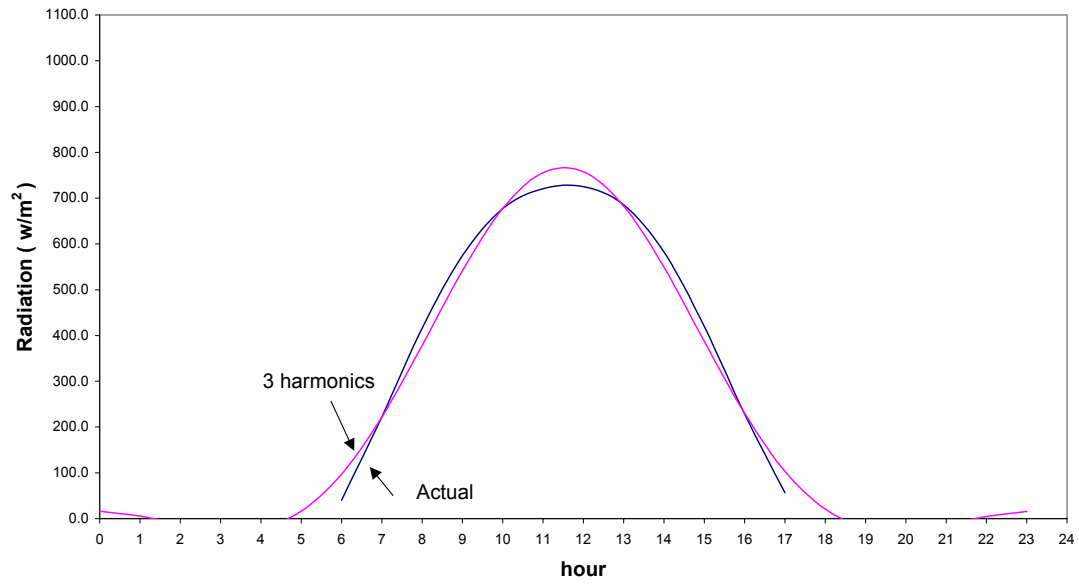
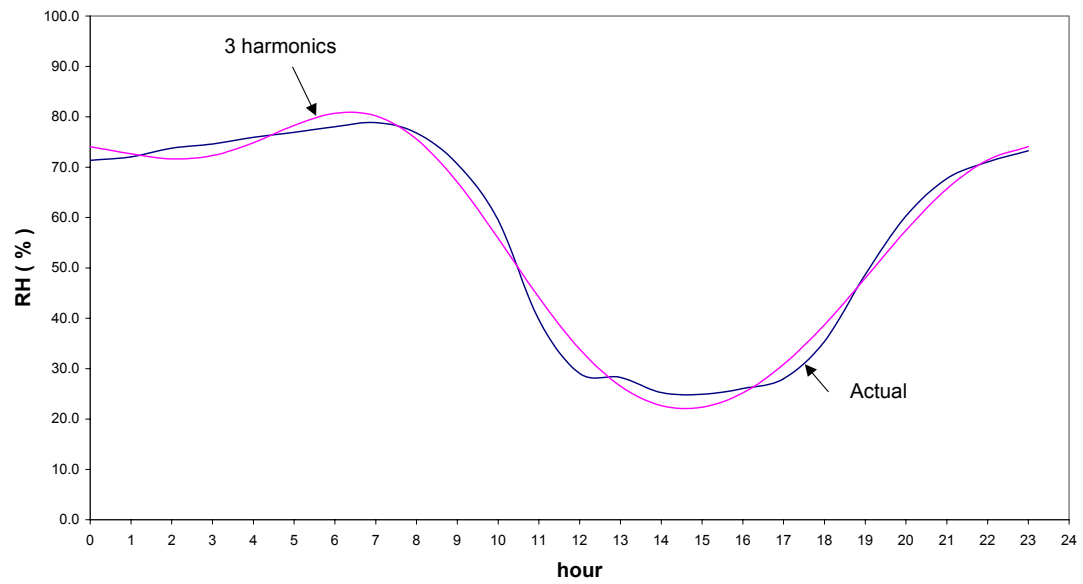
Fig. 3 Global Solar Radiation on a typical day in January (Kothara-Kutch)**Fig. 4 Relative Humidity on a typical day in January (Kothara-Kutch)**

Fig. 5 Soil Surface Temperature inside Greenhouse on a typical day in January (Kothara-Kutch)

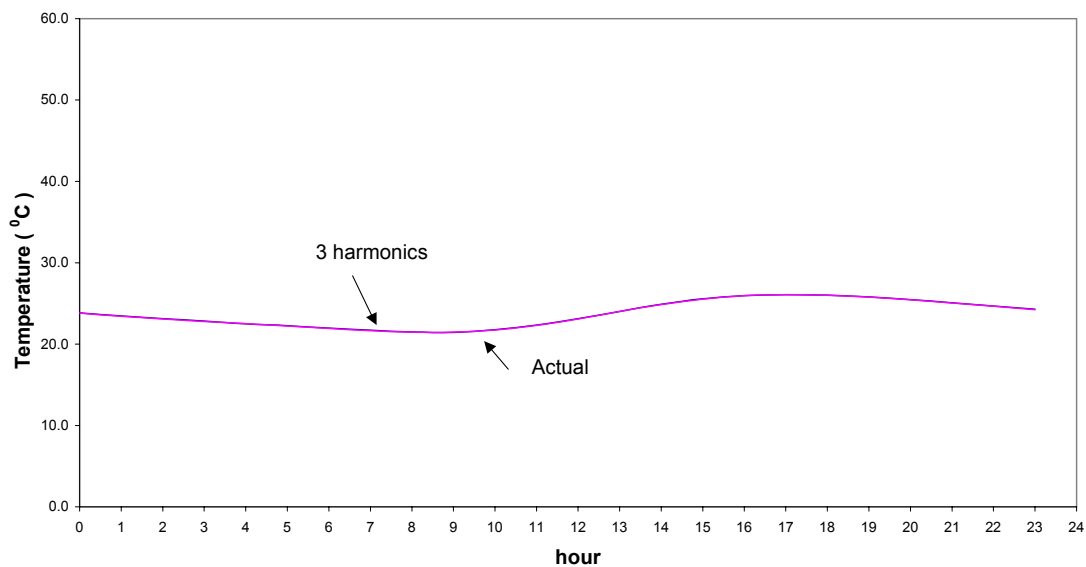


Fig. 6 Soil Temperature at 30 cm depth inside Greenhouse on a typical day in January (Kothara-Kutch)

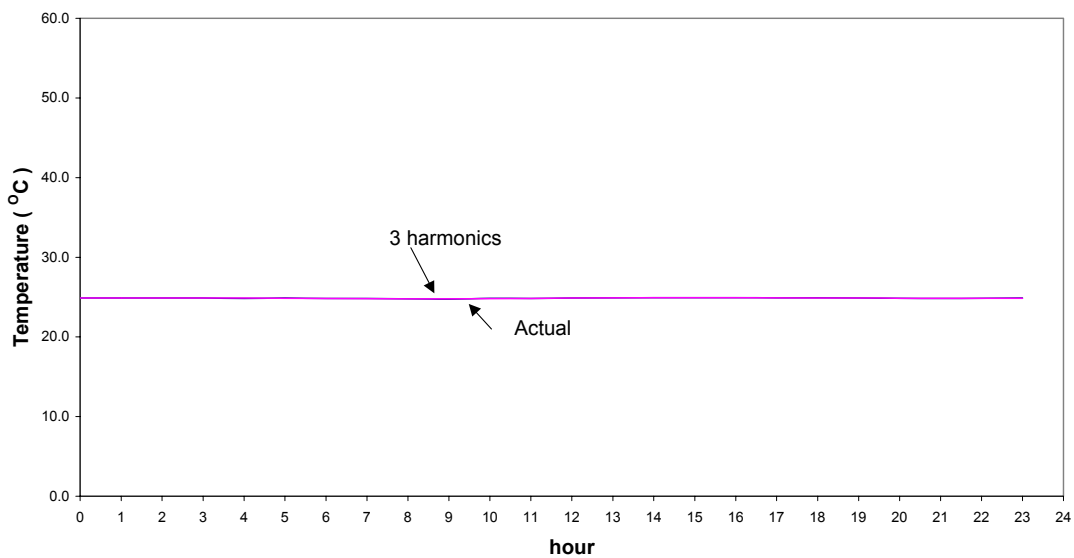


Fig. 7 Greenhouse Temperature on a typical day in January (Kothara-Kutch)

