International Journal of Natural and Engineering Sciences 4 (2): 5-9, 2010
ISSN: 1307-1149, E-ISSN: 2146-0108, www.nobel.gen.tr

A Study of the Effect of Change in Screen Height on the Various Thermal Indices in Different Environmental Conditions

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Received : February 07, 2010
Accepted : April 14, 2010

Abstract

In the present study, the role of change in screen height from 130 to 170 centimeters at Iranian Meteorological Stations on the thermal parameters was investigated. To this end, the necessity for carrying out a field study, a statistical survey and also a comparative study between a standard climatological station and a research station in forest conditions was felt.

The results of this study indicated that change in 40-centimeter screen height has created a significant difference (at 1% level) during all the observation hours (06:30, 12:30 and 18:30) of local time in thermal indices at both stations. Also, the amount of the difference created in bulb temperature, wet bulb temperature, relative humidity, and maximum temperature has been greater in the standard climatological station, and the minimum temperature in it has been less than the forest station.

The greatest effect of change in screen height on bulb temperature at climatological station was 1.61 degrees centigrade and at forest station 1.28 degrees centigrade. The greatest difference created in bulb temperature was observed at 06:30, and the least difference was observed at 12:30 (Local Time)

Keywords: Change in Screen Height; Temperature Indices; Meteorological Screen**;** Standard Climatological Station; Bulb Temperature

INTRODUCTION

The study and examination of meteorological actions and reactions and meteorological phenomena which determine the weather and climatic conditions are based upon observation. Meteorological observations are accomplished throughout the globe through a single and uniform method and with standardized instruments in order that the data registered can be compared with one another. The uniformity of the program for measurements is guaranteed within the framework of the standards of World Meteorological Organization (W.M.O) [1]. The greatest measurements of atmospheric elements are related to the atmosphere close to the earth surface which is carried out by surface meteorological stations. The establishments of these stations follow specific criteria. One of these standards is related to meteorological shelters. Meteorological shelter is a wooden rectangular box in which meteorological instruments are put. The distance between the floor of this box and the ground level shows the shelter height; the normal height varies between 100 and 200 centimeters [2]. In different countries, specific heights are considered as the screen heights within this range. In Iranian Meteorological Network, the minimum height from the ground is 170 centimeters [3].

The 130-centimeter height has been set for installing the screens from the beginning of the establishment of meteorological stations in Iran to 1980; after this date, Meteorological Organization decided to change the screen height of boxes from 130 to 170 centimeters; and gradually, the process of substitution continued and completed.

Today, in the majority of Iranian meteorological stations, screen boxes with 170 centimeters of height are utilized. Owing to the fact that during the years before the change, i.e., 1980 the statistics and data in shelters were based on different heights, and at the moment, the new generation of screen boxes is used, the need for a field study and statistical survey is felt for determining the impact of this change in height in various elements measured.

According to instructions No. 49 of World Meteorological Organization (W.M.O), the temperatures are measured by thermometer in the height range of 1.25 to 2 meters above the ground and ten minutes before observation time [4]. Hellmann [5], studied the temperature in two identical screens with the heights of 2.08 and 1.4 meters above the ground, and concluded that the maximum temperature of the screen with low height is more, and its minimum temperature is less than the screen with higher screen. Repeating Hellmann's work in Agra region in India, Ramanthan [6] compared the air temperature in two screens together (with the heights of 1.5 and 1.85 meters above the ground). The results indicated that the greatest difference in monthly average was maximum 0.17 degree centigrade and it was in June; and the greatest difference in monthly average was minimum 0.44 degree centigrade and it was in November. Nava [7] embarked on investigating the relationship between registered temperatures in the three screens. He concluded that the screen with 2.5 meters of height has a better relationship with adjustable screen in comparison with the screen with 1 meter of height. Nikzad [8] studied the temperatures registered in two different meteorological shelters having different heights; the results indicated that bulb temperature at some hours of observation is more in the screen with the height of 1.70 meters above the ground, and at some hours of observation is more in the screen with the height of 1.30 meters.

Drozdov [9] investigated the registered statistics of air temperature in Russia in order to present a fixed coefficient concerning its fluctuations; his results indicated that depending on the topography and climate, the *a* coefficient varies; some researches were also carried out to find out the impact of type of screen on air temperature of observation; the results of all researches are indicative of the impressibility of air temperature [10, 11, 12, 13, 14]. Floid's [15] and Houg's researches [16] also proved that the place of installing the screen also affects the registered temperatures.

In a study, Tokizava [17] indicated that difference in the color of the screen can influence the registered air temperatures from 1 to 2 degrees centigrade. It has also been proved that inside a screen, there is a small vertical thermal gradient [18, 19]. Table I shows the findings of some researchers.

MATERIALS and METHODS

Materials

In order to achieve the objectives of this research, two stations with different environmental conditions were chosen; these stations were:

1- Climatological Station (Standard Climatology) with the east longitude of 50 degrees and 90 min and north latitude 35 degrees and 47 min. (Fig. 1)

Fig. 1- A View of Climatological Station (Normal Climatology)

2- The Research Station of Botany Park with the east longitude of 51 degrees and north latitude 35 degrees and 48 min. (Fig. 2)

Table 1. Findings of different researchers concerning the Impact of Change in Screen Height on Measured Air Temperature

Researcher	Locality of Experiment	Higher Shelter Height (meters)	Lower Shelter Height (meters)	Largest monthly mean difference		Largest individual difference	
				Month-Max (C)	Month-Min (C)	Max (C)	Min (C)
Hellmann	Potsdam	2.08	1.40	May- 0.40	May- 0.28	0.8	0.7
Ramanthan	Agra	1.85	1.25	June- 0.17	Nov.- 0.44	0.44 on 3.6 % of occasions	0.6 on 5.1 % of occasions
Nava	Obanazawa	2.5 Variable 1 above snow surface	Variable 1 above snow surface 1	-	-	0.6 in 3 % observations 0.6 on 20 % of occasions	0.5 1 on 9 % of occasions

Fig. 2- A View of the Research Station of Botany Park

The direct distance between the two stations is one kilometer (Arial photograph showing the distance between the two stations is seen in Fig. 3

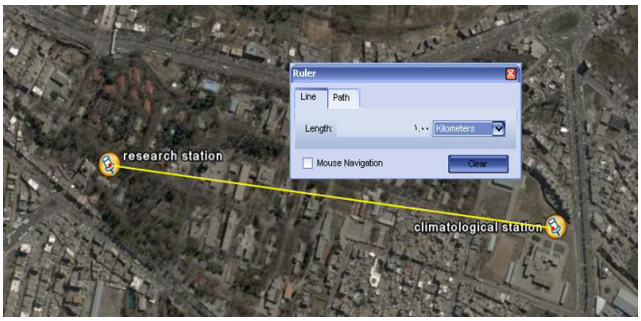

Fig. 3- Arial photograph showing the distance between The Research Station of Botany Park and Climatological Station

In this research, four normal thermometers, four wet bulb thermometers, four minimum thermometers, and four maximum thermometers with the accuracy of 0.1 degree of centigrade were used; in each station, two screen boxes (Stevenson Screen) were installed at the heights of 170 and 130 centimeters; in each screen, a bulb, a wet bulb, a minimum, and a maximum thermometer were set up.

Methods

The observation of different meteorological coefficients (bulb temperature, wet bulb temperature, minimum and maximum temperature) was carried out in the two stations under study for 62 days from 23-07-2007 through 22-09-2007 three times a day and at 03:00; 09:00 and 15:00 hours (Greenwich Mean Time) and 06:30, 12:30 and 18:30 (Local Mean Time). During this time, sprinkler irrigation was carried out for fifteen days in all at the Botany Park; in his research, in all 3840 data were collected and analyzed.

The statistics for sprinkler irrigation at the Botany Park Station was eliminated and as many as 47 days of non-irrigation were analyzed; however, at Climatological Station, all the 62 days were analyzed; the elements observed in each hour (06:30, 12:30 and 18:30 Local Mean Time) and at the two heights of 170 and 130 centimeters formed our statistical sample; this was a subdivision of a large population the average and variance of which were not known (62 elements were in Climatological Station, and 47 elements were in Botany Park Station). The Average Test of the two universes with unknown variance was used for our analysis in order to know the degree of difference of these two universes (meteorological elements in two counterpart times and at the two heights of 170 and 130 centimeters), and whether this degree of difference makes a significant difference in the observation of those elements at the two heights or not.

In order to investigate the significance of the difference in the data in the two heights, the Test of Relation of 1 and 2 was utilized [20].

Relation 1:

$$T = \frac{\overline{X_1} - \overline{X_2} - \delta}{S_P \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

In this case, test parameter has a T-student distribution with degree of freedom: $d.f = n_1 + n_2 - 2$.

While the variance of the two universes is unknown and unequal, the test parameter is calculated on the basis of Relation 2:

Relation 2:

$$T = \frac{\overline{X_1} - \overline{X_2} - \delta}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where the test parameter has a T-student distribution with the following degree of freedom:

$$d.f. = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(s_1^2\right)^2}{n_1 - 1} + \frac{\left(s_2^2\right)^2}{n_2 - 1}}$$

($\overline{X_1}$ is the mean of the first sample; S_1^2 is the variance of the first sample; n_1 is the first sample size;

$\overline{X_2}$ in the mean of the second sample; S_2^2 is the variance of the second sample; n_2 is the second sample size. then, this amount of T was compared with the amount of Table T-student.

This test was carried out for the five meteorological elements in various environmental conditions (Climatological Station and Botany Park Station); since the accuracy of the thermometers used in this research is 0.1 centigrade, consequently, for making decision on the probable difference in observed meteorological elements, this type of Test was used; in other words, if the difference is less than 0.1 centigrade, the difference is insignificant; however, if the difference is 0.1 centigrade or more, the difference will be insignificant.

RESULTS and DISCUSSIONS

The results of the analysis utilizing the Average Test of two universes with unknown variance indicated that change in the 40-centimeters of screen height has created a significant difference in all the thermal elements at 1% confidence level at all the hours of observation; the only exception is wet bulb temperature at 18:30 at Botany Park Station where this change in screen height has not been able to create a significant difference in it (Tables 2 & 3). The greatest difference created in bulb temperature was observed in the two stations at 06:30, and the smallest difference was observed at 12:30 (Table 4). Also, the results of the comparative study of the two environments indicated that the rate of the difference created as a result of change in height is different in various environmental conditions, too, so that at all the hours of observation, the rate of the difference created in the bulb temperature, wet bulb temperature, relative humidity and maximum temperature at Climatological Station is more, and this rate at maximum temperature is less than the Botany park Station (Table 5).

Table 3. General Effect of Change in Screen Height on Meteorological Elements registered at 130 and 170 centimeters at Botany Park Station and Climatological Station

Station	Botany Park Station			Climatological Station		
Time / Element	06:30	12:30	18:30	06:30	12:30	18:30
Bulb Temperature	**	**	**	**	**	**
Wet Bulb Temperature		**	n.s	**	**	**
Minimum Temperature	**	-	-	**	-	-
Maximum Temperature	-	-	**	-	-	**

**: Significant at 1% confidence level n.s: not significant

Owing to the fact that the maximum and minimum temperatures are observed only once in the 24 hours, we cannot give any comment on these two factors in table 5.

The results of the present research indicated that change in the height of installing screen can be effective in meteorological screens in various observed thermal elements and create significant differences at 1% level; owing to the fact that various thermal indices are among the most important data required in meteorological and hydrological studies like evaporation and transpiration models, if there is any significant difference in the quantity of these elements as a result of change in the height of installing screen, other elements which will be calculated on the basis of them will change, too, particularly the fact that in many of these equations, a standard height has been given for measuring the temperature.

It is suggested that the research be carried out for a one-year cycle and in various climates of the country in order that the process of changes in various regions and in cold seasons be investigated as well. And if the results of the present study are confirmed in other regions, a correction coefficient be defined for the observed data in the years after 1980 and be notified to State Meteorological Organization. In addition, it is possible to use Data Logger measuring instruments at different heights so that the observation interval be narrowed down to one hour and eleven less in order to be investigated with more accuracy.

Table 2. The Difference Created as Result of Change in Screen Height in the Averages of Meteorological Elements at 130 and 170 centimeters in Different Environmental

Station	Botany Park Station			Climatological Station		
Time / Element	06:30	12:30	18:30	06:30	12:30	18:30
Bulb Temperature	1.28 C Screen 170 more than 130	0.27 C Screen 170 more than 130	1.20 C Screen 170 more than 130	1.61 C Screen 170 more than 130	0.54 C Screen 170 more than 130	1.43 C Screen 170 more than 130
Wet Bulb Temperature	0.37 C Screen 170 more than 130	0.12 C Screen 170 less than 130	0.05 C Screen 170 more than 130	1.50 C Screen 170 more than 130	0.80 C Screen 170 more than 130	3.09 C Screen 170 more than 130
Relative Humidity	2.78 % Screen 170 more than 130	3.81 % Screen 170 more than 130	0.66 % Screen 170 less than 130	2.99 % Screen 170 less than 130	4.29 % Screen 170 more than 130	7.40 % Screen 170 more than 130
Minimum Temperature	1.11 C Screen 170 more than 130	-	-	1.02 C Screen 170 more than 130	-	-
Maximum Temperature	-	-	0.56 C Screen 170 more than 130	-	-	0.94 C Screen 170 more than 130

Table 4. Maximum and Minimum Amount of Difference Created in Meteorological Elements as Result of Change in Screen Height

Quantity	Maximum Difference Created as Result of Change in Screen Height		Minimum Difference Created as Result of Change in Screen Height	
Station / Element	Botany Park Station	Climatlogical Station	Botany Park Station	Climatlogical Station
Bulb Temperature	1.28 C at 06:30	1.61 C at 06:30	0.27 C at 12:30	0.54 C at 12:30
Wet Bulb Temperature	0.37 C at 06:30	3.09 C at 18:30	0.05 C at 18:30	0.80 C at 12:30
Relative Humidity	3.81 % at 12:30	7.40 % at 18:30	0.66 % at 18:30	2.99 % at 06:30

Owing to the fact that the maximum and minimum temperatures are observed only once in the 24 hours, we cannot give any comment on these two factors in table 5.

Table 5. A Comparative Study on the Rate of Difference Created as Result of Change in Screen Height in Different Environmental Conditions

Time / Element	06:30	12:30	18:30
Bulb Temperature	Climatlogical Station 0.33 c more	Climatlogical Station 0.27 c more	Climatlogical Station 0.23 c more
Wet Bulb Temperature	Climatlogical Station 1.13 c more	Climatlogical Station 0.68 c more	Climatlogical Station 3.04 c more
Relative Humidity	Climatlogical Station 0.21 % more	Climatlogical Station 0.48 % more	Climatlogical Station 6.74 % more
Minimum Temperature	Botany Park Station 0.09 c more	-	-
Maximum Temperature	-	-	Climatlogical Station 0.38 c more

APPRECIATION

I express my deep appreciations and gratitude for the sincere cooperation of Agricultural and Natural Resources Campus of Tehran University in taking the basic preliminary actions for establishing Research Station of Botany Park and the scientific guidelines of the supervisors and advisers and also the State Meteorological Organization for providing me with the instruments needed for this research.

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