Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 7 (23): 3831-3835, 2007
ISSN 1812-5654

Calculation and Analysis of Frost Duration Times by Using Delphi Programming: A Case Study in Lorestan, Iran

Z. Hejazizadeh and M.H. Naserzadeh
Department of Geography, Teacher Training University of Tehran-15614, Tehran, Iran

Abstract: The purpose of the present study is to calculate the duration times of frosts by Delphi programming. To do this, the data related to the daily minimum temperature of four meteorology stations of Lorestan Province, i.e., Khoram-Abad, Boroujerd, Doroud and Aligoudarz that enjoy a ten-year statistics (from 1993 to 2003) were obtained from the information bank of the National Meteorology Organization. After taking out the frost days in desired threshold (zero and less than zero) during the statistical period, frost duration times of each station were calculated and extracted, using algorithm of the afore-mentioned program. Then, the duration times were selectively divided into eight (three-hour) classes. Their frequency percent charts were drawn and all stations were compared to one another in three classes of 0 to 3 h, 9 to 12 h and 21 to 24 h. It was concluded that Boroujerd Station enjoys the most frost hours and, hence damages to crops were the highest in this station compared with other stations. It was further concluded that the vegetation is the most effective factor in frost duration times of the region and that the height factor has no effect on frost duration times.

Key words: Delphi programming, Lorestan province, climatology, frost duration times

INTRODUCTION

Frost is one of the major climatological phenomena, which consists of temperature fluctuation. Technically it is defined as an event through which thin crystals of ice are formed on the surfaces whose temperature is below zero, while the temperature of air layer over these surfaces has reached dew point.

Frost or freeze may influence almost every activity directly or indirectly. However, the most outstanding effects are in three economical areas of energy, transportation and agriculture. Among the three above-mentioned issues, frost temperature fluctuations have the most effect on agriculture (Vega *et al*., 1994). For example, frost losses to agricultural products in Khouzestan in Esfand, 1375 (March, 1996) amount to 37500000 Dollar. Also in Kerman pistachio losses were beyond 250000000 Dollar in farvardin, 1376, i.e., April, 1997 (Karimi and Darzi, 2000).

Whenever the minimum temperature has been zero or less, that temperature has been utilized for the investigation of frost. Nevertheless, the significance and duration of zero-degree temperatures are the most important regarding their environmental effects. Frost may be referred to as weak, moderate, or severe (Michaels, 1991). When the temperature is between zero and minus two degrees, it is called a weak frost. The temperatures in this range destroy the sensitive vegetations, some various and certain sorts of fruit trees and a number of tropical species. If the temperature is between minus two and minus four degrees centigrade, we refer to it as a moderate frost. The temperatures included in this rang damage the sensitive and fragile plants, especially the semi-hardy plants. Therefore, most plants are affected by moderate frosts. Severe frosts (occasionally considered as hard frosts) occur when the temperature is less then minus four degrees centigrade, in which case they damage the majority of plants in the region. Destructive frost is the kind of frost that ruins a variety of plants in extensive scale. Growth season is known as a period between last spring frost and early fall frost, that is a period in which all kinds of vegetation will grow. Also according to agricultural meteorology the occurrence of frost, is an event taking place at lower temperatures, due to which vegetative tissues are damaged.

Frosts can also be classified in terms of intensity, duration and occurrence time. By intensity-based classification it is meant the power of energy distribution factors, which is usually measured on the basis of average temperature, minimum zero and below-zero average as well as the least minimum temperature.

Corresponding Author: M.H. Nasserzadeh, Department of Geography, Teacher Training University of Tehran-15614, Tehran, Iran Tel: +98 02166711032

Frost duration means the period of time during which a temperature of zero or below dominates a region. Frosts with a peak time more or less than index data are regarded early or late, based on their time of occurrence. The purpose of the present article is the calculation of frost duration times, using Delphi programming in Lorestan Province of Iran in order to reduce the severe losses to farmers and provide the required facilities for acceleration of transportation and reduction of energy-waste at the time of frost.

Research on frost (Xiaomin *et al*., 2007), its prediction (Waylen, 1988), its effect in different area as agriculture (Héctor Viveros-Viverosa *et al*., 2007; Prášil *et al*., 2007) industry and frost economical costs have got a strong and long tradition. However, we could not find any research or paper in our research topic. Auer *et al*. (2005) investigate the linkage of frost frequency to monthly mean temperature and its sensitivity to temperature changes. They found that reduction in frost frequency has a direct impact on the firmness of permafrost and soil and hence, affects constructions including roads, cable cars or mountain huts. GCMs (Genera circulation models), which are forced by emission scenarios, project an enhanced probability of intense rain events in the decades to come (IPCC, 2001). Together with the melt of permafrost, this may cause mudflow and landslips. In addition, less frost means less storage of water in snow-covered areas, less quasi-permanent storage in glaciers and hence an enhanced run-off and possibly an enhanced chance of avalanches. Results derived within this study may also be of importance to agricultural production, as it shows a possible extension of the frost-free season. Certainly, the findings are significant to artificial snow production, which is only possible on frost days (Auer *et al*., 2005). In other study, Müller *et al*. (2005) have analyzed the atmospheric circulation patterns associated to extreme frost episodes which affect the extensive region known as the Wet Pampas in the center-south of America during the 1961-1990 period. They show that the analysis of different periods (seasonal, monthly, daily) confirmed the relationship between the intensification of the subtropical jet in South America and the higher frequency of generalized frosts. The intensification of the pressure gradient in the region due to the increase in Rossby wave activity (Müller *et al*., 2005).

MATERIALS AND METHODS

To calculate frost duration times, the data for minimum hourly temperatures of four meteorological stations, i.e., Khoram Abad, Boroujerd, Doroud and Aligoudarz were gained from the National Meteorological Organization (Fig. 1). For calculating frost duration times, it is necessary to measure the data related to the minimum hourly day by day temperature, whose processing and summarizing is time-consuming and can not be done manually. The review of Iranian papers regarding frost duration times indicates that due to the above-mentioned issue and owing to climatology and meteorology students' lack of mastery in and familiarity with programming for calculation frost duration times, no work has been done in this area. Therefore, in this study, frost duration times have been worked out for each station during the studied statistical years (1993-2003), with the study being done for the first time, using Delphi programming.

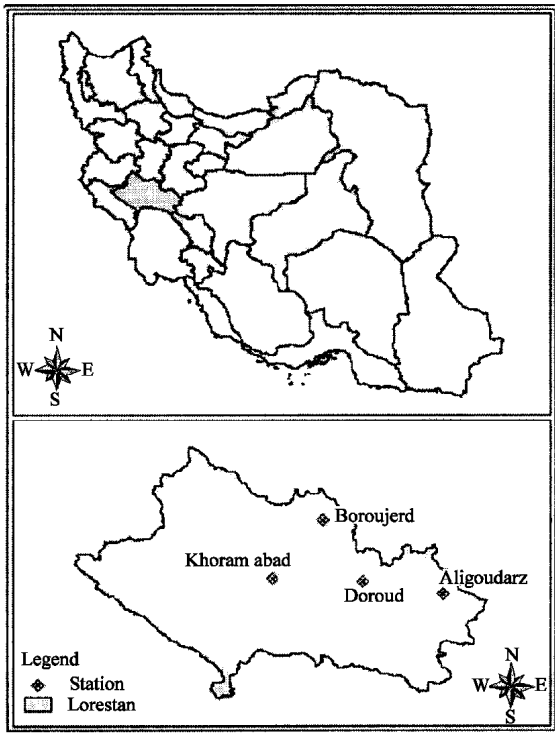

Fig. 1: Geographical position of the 4 climatic stations used for this study

The method used for the calculation of frost duration times is as follows (the algorithm for desired program):

$$x = \frac{\Delta d}{\Delta t} \quad (1)$$

Where:

x = Temperature changes within time unit
Δ = The temperature difference (d_2-d_1)
Δd = The time difference (t_2-t_1)

$$t = \frac{\Delta d'}{x} \quad (2)$$

Where:
t = The time of frost
$\Delta d'$ = Temperature difference ranging from minus to zero
x = The temperature changes within time unit

The following formula is used for the calculation of frost-free times:

$$t' = \frac{\Delta d''}{x} \quad (3)$$

Where:
t′ = Frost-free time
d″ = Temperature difference from zero to positive
x = Temperature changes within time unit

The above-mentioned formulas are used in cases where temperature varies from minus to zero or more or vice versa. Since the resulted number is within a time unit and negative numbers have no meaning for a time unit, the number has been regarded as an absolute value.

If $d_1 \leq 0$, $d_2 \leq 0$, the total time is the frost time, that is; $t' = \Delta t = t_2 - t_1$. In cases in which $d_1 > 0$, $d_2 > 0$, the frost time is zero. When $d_2 = d_1$ the following conditions exist:

- If $d_1 > 0$, the frost time is zero, i.e., $t' = 0$.
- If $d_1 \leq 0$, the frost time equals Δt, i.e., $t' = \Delta t = t_2 - t_1$.

To evaluate and make sure of the correctness of results gained through programming, the calculation was done manually and by means of calculator at each station, for a number of days in different years and months. The results obtained through this calculation were satisfactory. After the calculation, frost duration times were divided into 83 h categories and the frequency and percentile were calculated for each station. Eventually, their charts were drawn. These charts are analyzed in the results section.

RESULTS

Duration and frequency are among the issues that are investigated in the studies related to frosts. Duration refers to the time period in which the temperature falls to zero or lower than zero. As mentioned above, for calculating frost duration times, after extracting the daily minimum temperatures data at the desired threshold temperature, they were calculated and extracted using Delphi programming. After frost duration times were taken out, they were categorized into eight three-hour classes. The frequency and frequency percent of each class were counted and then, a chart was drawn for each station. Finally, the frequency of three classes, i.e., 0 to 3, 9 to12 and 21 to 24 h, was compared to one another at all the stations (Table 5). In what follows, the results and explanations are provided for each station.

Khoram Abad: This station has a height of 1125 m over the sea level and is located in the center of Lorestan. Table 1 shows the frequency and frequency percent of frost duration times of this station. As is seen in the table, the total number of frost days is 587. According to the 3 h classification of these days, 0 to 3 h class has enjoyed the most frequency with the frequency of 215 and the frequency percent of 36.6. The 6 to 9 h class comes next with the frequency percent of 22.8. Then, comes the 21 to 24 h class with the frequency of 6 and the frequency percent of 1.02. The least frequency is related to the 18 to 21 h class with the frequency of 13 and frequency percent of 2.21. In sum, 90% of total frequency of frost duration times had less than 12 h of frost duration.

Borou jerd: This station is located at 1632 m over the sea level, northeast of Lorestan province. Table 2 shows the frequency and frequency percent of frost duration times. With regard to this table the frost days amount to 694. The highest frequency of this station is that of 9 to 12 h class with a frequency of 145 and frequency percent

Table 1: Frequency and frequency percent of different classes of frost duration times at Khoram Abad station in statistical period of 1993-2003

Classes	Class	Frequency	Frequency percent	Cumulative percent
1	0-3	215	36.60	36.6
2	3-6	76	12.90	49.6
3	6-9	134	22.80	72.4
4	9-12	104	17.70	90.1
5	12-15	20	03.40	93.5
6	15-18	19	03.24	96.8
7	18-21	13	02.21	99.0
8	21-24	6	01.01	100.0
Total	8	587	100.00	

Table 2: Frequency and frequency percent of different classes of frost duration times at Boroujerd station in statistical period of 1993-2003

Classes	Class	Frequency	Frequency percent	Cumulative percent
1	0-3	78	11.2	11.2
2	3-6	53	07.6	18.8
3	6-9	129	18.5	37.4
4	9-12	145	20.8	58.3
5	12-15	112	16.1	74.4
6	15-18	50	07.2	81.7
7	18-21	33	04.7	86.4
8	21-24	94	13.5	100.0
Total	8	694	100.0	

Table 3: Frequency and frequency percent of different classes of frost duration times at Doroud station in statistical period of 1993-2003

Classes	Class	Frequency	Frequency percent	Cumulative percent
1	0-3	160	25.50	25.5
2	3-6	23	03.60	29.1
3	6-9	96	15.30	44.4
4	9-12	208	33.10	77.6
5	12-15	52	08.20	85.9
6	15-18	24	03.80	89.7
7	18-21	13	02.07	91.8
8	21-24	51	08.10	100.0
Total	8	627	100.00	

Table 4: Frequency and frequency percent of different classes of frost duration times at Aligoudarz station in statistical period of 1993-2003

Classes	Class	Frequency	Frequency percent	Cumulative percent
1	0-3	349	33.90	33.9
2	3-6	193	18.70	52.6
3	6-9	173	16.80	69.4
4	9-12	75	07.27	76.6
5	12-15	137	13.30	89.9
6	15-18	42	04.07	94.0
7	18-21	20	01.94	95.9
8	21-24	42	04.07	100.0
Total	8	1031	100.00	

of 20.8. After this class, the highest frequency belongs to 6 to 9 h class. The lowest frost frequency is that of 18 to 21 h class with a frequency of 33 and a frequency percent of 4.7. Next to this class, the 15 to 18 h class has the least frequency number with a frequency percent of 7.2. Three classes, i.e., 6 to 9, 9 to 12 and 12 to15 h classes, had the highest frequency percent among all the other classes.

Doroud station: This station is located at 1182 m over the sea level, northeast of the province. Table 3 shows the frequency and frequency percent for frost duration times. Based on this table the total frost time amounts to 627 days, with the highest frequency of this station belonging to 9 to12 h classes. Frequency and frequency percent of this class are 208 and 33.1, respectively. Next to this class, 0 to 3 h class has the highest frequency. The lowest frost duration frequency belongs to 18 to 21 h class with a frequency of 13 and a percentile of 2.07. The lowest number of frequency after this class, having a frequency percent of 3.6 belongs to 3 to 6 h class. As a whole, four classes, i.e., 0 to 3, 3 to 6, 6 to 9 and 9 to 12 h classes enjoy the highest frequency of frost duration hours, amounting to 77.5% of the total frequency altogether.

Aligoudarz station: Aligoudarz station is situated at 2034 m over the sea level, south-east of the province. Table 4 shows the frequency and frequency percent for the frost times at this station. On the basis of the table the sum of frost days is 1031. A 3 h classification of these days reveals that the highest frequency belongs to

Table 5: Frequency comparison of station with regard to frost duration times in the three selected classes

Station classes	Khoram abad	Boroujerd	Doroud	Aligoudarz
0-3	215	78	160	349
3-6	104	145	208	75
6-9	6	94	51	42

0 to 3 h class with a frequency of 349 and a frequency percent of 33.9. Next to this class the highest frequency goes to 3 to 6 h class whose frequency and frequency percent are 193 and 18.7, respectively. The lowest frequency also goes to 18 to 21 h class, having a frequency of 20 and a frequency percent of 1.94. The next lowest frequency belongs to 15 to 18 h and 21 to 24 h classes with a frequency of 42 and a frequency percent of 4.07. Totally 69.4% of frost duration times had below 9 h of frost, whose frequency being 715.

FREQUENCY COMPARISON OF FROST DURATION TIMES AT DIFFERENT STATIONS

To compare the frequencies of frost duration times of all station three classes of 0 to 3, 9 to 12 and 21 to 24 h were considered. According to Table 5 the highest frequency of 0 to 3 h class among all 4 stations belongs to Aligoudarz with a frequency of 349 and the lowest to boroujred with a frequency of 78. Also, the highest and lowest frequencies of 9 to 12 class are those of Doroud station with a frequency of 208 and Aligoudarz station with a frequency of 75, respectively. For 21 to 24 h class, frequency of frost duration times is low for every station, with a maximum of 94 for Boroujerd station and a minimum of 6 for Khoram Abad station. Based on what was said, it can be concluded that although the number of frost days in Aligoudarz is twice that of resulted losses, the cold weather is more renowned in Boroujerd as compared to Aligoudarz.

CONCLUSIONS

Year-to-year and day-to-day variation of weather complicates scheduling of agriculture practices. However, the use of continuous weather observation, weather and frost forecasts and climate data may assist in scheduling crop management practices for optimum benefit.

Frost, one of the important climate phenomenons, affects both human activities such agriculture, transportation, energy, bioenvironmental matters and biological activities of plant and animals. The effect depends on its intensity, duration and extension. Frosts have different elements such as beginning, end, frost season, duration, etc. In this study we extracted frost duration time in selected weather station, then we classified them, so our study is a progress in this field,

more exact and practical. Applying this result and data in agriculture management and scheduling, in selection of suitable plant and crop can improve benefit. Because every type of plant has got a particular temperature threshold, the degrees below or above this threshold my lead to plant extinction. Therefore, the study of the duration of frosts is necessary. In addition, the results of such studies can also be used in dam construction, the kind of asphalt to be used in road building construction materials, preventing heat waste in transportation. Than, to improve the safety standards and to prevent loss of asset, it is essential to study the frosts duration these studies can help loss of source and asset in a short time and enjoy sustainable development. Also, the coming generations are accounted for while fulfilling the present generations needs.

ACKNOWLEDGMENTS

The author would like to express his sincere appreciation to all those who had a share in fulfilling the present study, especially Mr. Ebrahim Sahafizadeh, holding an engineering of computer programming, Parviz Alavinia, Ph.D. student of TEFL, Majid Soleimani-damaneh, Ph.D. in Mathematics, Mohammad Reza Yaghoubi, MA in TEFL and National Meteorology Organization, that provided the researcher with the needed data.

REFERENCES

Auer, I., Ch. Matulla, R. Böhm, M. Ungersböck, M. Mauger, T. Nanni and R. Pastorelli, 2005. Sensitivity of frost occurrence to temperature variability in the European Alps. Int. J. Climatol., 25: 1749-1766.

Hector, Viveros-Viverosa, Cuauhtémoc Sáenz-Romero, JavierLópez-Uptona and J. Jesús VargasHernándeza, 2007. Growth and frost damage variation among *P. pseudostrobus*, *P. montezumae* and *P. hartwegi* I tested in Michoacán, México. For. Ecol. Manage., pp: 10534.

IPCC, 2001. Climate Change: The Scientific Basis. Contribution of Working Group Ito 3rd Assessment Report of the Intergovernment Planel on Climate Change, Houghton, J.T., Y. Ding, D. Griggd, M. Noguer, P. Van der Linden, X. Dai, K. Maskell and C. Jones (Eds.). Cambgridge University Press, Cambridge and New York, pp: 881.

Karimi, M. and M.T. Darzi, 2000. Chilling and frost and methods of pant protection. Jihad and Agricultural Ministry.

Michaels, P.J., 1991. Frost and Freezes: Southeastern Climate Review. Spring, 2 (4): 3-14.

Müller, G.V., T. Ambrizzi and M.N. Nuñez, 2005. Mean atmospheric circulation to generalized frosts in central Southern South America. Theor. Applied Climatol., 82: 95-112.

Prášil, I.T., P. Prášilova and P. Maøik, 2007. Comparative study of direct and indirect evaluations of frost tolerance in barley. Field Crops Research, pp: 1021-1028.

Vega, A.J., K.D. Robbins and J.M. Grymes, 1994. Frost/Freeze Analysis in the Southern Climate Region. Southern Regional Climate Center.

Waylen, P.R., 1988. Statistical analysis of freezing temperatures in central and Southern Florida, 8 (6): 607-628.

Xiaomin, W., D. Wantian, X. Wangfa and T. Liming, 2007. Mesoscale investigation of frost formation on a cold surface. Exp. Thermal Fluid Sci., 31: 1043-1048.