



Trends in frost days, late and early frost dates and the frost-free season over Iran during 1951-2005



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ABSTRACT

In the comprehensive and unique investigative study presented hereby the long term data of frost days, free frost period, dates of last spring and first fall frost in Iran during 1951-2003 span were studied in 45 meteorological stations. Based on the results of this study, the effects of global warming on forest events in Iran were also evaluated.

Frost days trend in the period of 1951-2003 show significant variation. The mean amount of this trend is -2.6 day per decade. The most decreased amount is 13 days per decade and the most increased amount is 7.4 days per decade which has occurred in Northeast and West respectively (Table II and Figure 2b). About 15% of area of the country has experienced increasing frost days, while 85% has experienced decreasing frost days. The trend of last spring frost variation averaged -0.6 days per decade, ranging +5 days per decade to -7 days per decade, which occurred respectively in West and Northeast of Iran. The dates of first fall frost has significant trend during period of 1951-2003. The most part of the country (about 95% of total area) have positive trend and about 5% has negative trends. The mean trend of free frost period is 1.8 days per decade and the most positive trend is 17 days per decade in Northeast and most negative trends is -10 days per decade in West of Iran. About 70% of the country area has negative trend and 30% of the country has positive trend.

The results of this comprehensive study on frost data of more than 50 years show significant positive and negative trends in minimum temperature, frost days. In west part of the country frost days has positive trends, first fall negative trends, last spring frost positive trend and free frost period negative trend. While in most parts of country minimum temperature has positive trend, first fall positive trend, last spring frost negative trend and free frost period positive trend. The absolute amount of extreme of trend of last spring frost date is more than in first fall frost. The results show the high affects of global warming on frost events in Iran, especially in Northeast and central parts.

Key words: Climate change, Global warming, minimum temperature, Frost, Iran

Extremes are a key aspect of climate change. Changes in the frequency of many extremes (increases or decreases) can be surprisingly large for seemingly modest mean changes in climate and are often the most sensitive aspects of climate change for ecosystem and societal responses. The first fall and last spring frosts frequently cause a lot of damages to plants. Trends in frequency of occurrence of freezing temperatures in Iran have not been examined so far. However, this type of study has been done in other places of the world. The purpose of this study is to examine changes in frost days, as defined by days when the minimum temperature is below or equal to 0°C, and changes in the dates of last spring and first fall frost and the length of the frost-free season for Iran for the latter half of the twentieth century.

METHODS

About 50 meteorological stations with long term data were selected at various elevations in different region of Iran. These stations had about 50 years of climatological data. The data of annual minimum temperatures and the first and last dates of frost events in each year as well as frost dates for all 50 stations has extracted from Iran Meteorological Organization data bank. Dates of last spring and first fall frosts were determined for each year of study. We started from the last month of summer and the first date with the daily minimum temperature 0°C was the date of first fall frost. For dates of last spring frosts we started checking daily minimum temperatures in the last months of winter and the last date it was 0°C was the date of last spring frost. (Bootsma, 1976). After providing frost dates, it was necessary to change them into a form that we could analyzed statistically. For this purpose Julian days were used. We gave number 1 to the 1st of January and 2 to the 2nd of January and for next days of January we devoted next numbers. For the month of February we used numbers 32 to 60 and for other months we followed the same method. The frost free period is the time between the date of the last spring frost and the first fall frost. Frost days (the number of days the temperature is 0°C during the year) of each station also were extracted. The number of frost days is always less than frost free periods. The trend of each frost series including minimum temperature, frost days, date of last spring and first fall frost and also the length of the frost-free season were calculated and then mapped.

RESULTS

Frost Days

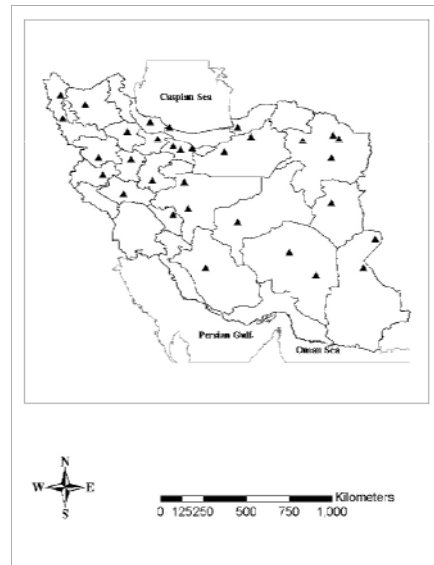
Frost days trend in the period of 1951-2003 show significant variation. The mean amount of this trend is -2.6 day per decade. The most decreased amount is 13 days per decade and the most increased amount is 7.4 days per decade which has occurred in Northeast and West respectively (Table II and Figure 2b). About 15% of area of the country has experienced increasing frost days, while 85% has experienced decreasing frost days (Figure 3b and Table III)

Date of last spring frost

The trend of last spring frost variation averaged -0.6 days per decade, ranging +5 days per decade to -7 days per decade, which occurred respectively in West and Northeast of Iran (Table II and Figure 2d). About 55 percent of country area experienced negative trends and 45% experienced negative trends.

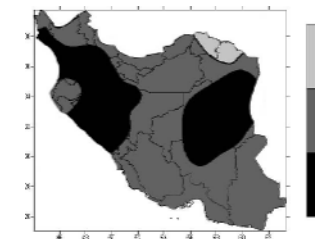
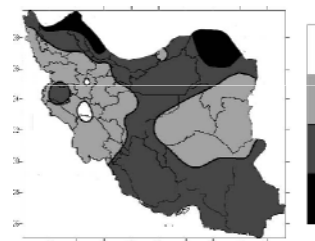
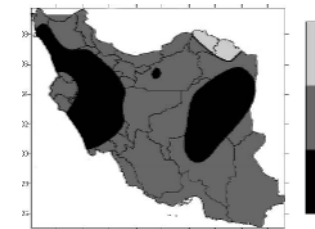
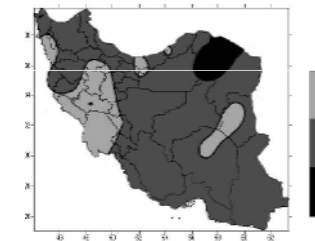
Date of first fall frost

The dates of first fall frost has significant trend during period of 1951-2003. The average of trend is 1.4 days per decade which in North East this trend is 10 days per decade and in West of country this trend is -6.1 days per decade (Table II and Figure 2c). The most part of the country (95% of total area) have positive trend and 5% has negative trends (Fog 3c and Table III).



RESULTS

Decadal trends in : a) frost days, b) date of last spring frost, c) date of first fall frost and d) length of frost-free season during 1951-2003 period in Iran.



Statistical characteristics of decadal trend series of the study area

Trend series	Average	Median	SD	Lowest	highest	range
Frost Days (days)	-2.6	-2.7	4.4	-13.0	7.4	20.4
Free frost Period (days)	1.8	2.6	6.0	-10.1	17.0	27.1
Date of first fall frost (days)	1.4	1.7	3.3	-6.1	10.0	16.1
Date of Last spring frost (days)	-0.6	-0.9	3.0	-7.0	5.0	12.0

Percentage of decadal trends in the study area

Minimum	Frost days	Free frost season	Early frost	Late Frosts
Range	Range Percent	Range Percent	Range Percent	Range Percent
>0.5	>0 15	>10 5	>6 25	>0 45
0 to 0.5	0 to -7 80	0 to 10 65	0 to 6 70	-4 to 0 45
-0.5 to 0	<-7 5	-10 to 0 30	-6 to 0 5	<-4 10
Positive	Positive 15	Positive 70	Positive 95	Positive 45
Negative	Negative 85	Negative 30	Negative 5	Negative 55
Total	Total 100	Total 100	Total 100	Total 100

CONCLUSIONS

In west part of the country frost days has positive trends, first fall negative trends, last spring frost positive trend and free frost period negative trend. While in most parts of country minimum temperature has positive trend, first fall positive trend, last spring frost negative trend and free frost period positive trend. The absolute amount of extreme of trend of last spring frost date is more than in first fall frost. The results show the high affects of global warming on frost events in Iran, especially in Northeast and central parts