Investigation of the Persistence of Frost Days in Iran using Chain Markov Model

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Extended Abstract

Introduction

Extreme temperature events can impose serious impacts on environments and societies. Frost is one of the most severe weather conditions that affect human activities in many parts of Iran. The first fall and the last spring frosts usually cause damages to plants. Occurrence of the first fall frost, at the beginning of freezing period, damages crops that are still in the field. The last spring frost at the end of freezing period, which occurs at the beginning of growing season, causes damages to seedlings and young plants and to those that are already in the flowering stage. In addition to these characteristics, one of the other most important characteristics of frost is its persistence in a region.

Materials and Methods

In the present study, persistence of frost days of Iran studied with use of two state (frost days and non-frost days) one, two and three orders Markov chain models. Talley matrix and transition probabilities matrix of the occurrence of frost and non-frost days were computed during 15 years (1991-2005) for 58 Synoptic stations from October to May.

We consider a stochastic process $(X_n, n = 0,1,2,...)$ that takes on a finite or countable number of possible values, if $X_n = i$, then the process is said to be in state i at time n. We suppose that whenever the process is in state i there is a fixed probability p_{ij} that it will next be in state j. That is, we suppose that

$$probability(X_{n+1} = j | X_n = i, X_{n-1} = i_{n-1}, ..., X_0 = i_0) = p_{ij}$$

For all state $i_0, i_1, ..., i_{n-1}, i, j$ and all $n \geq 0$. The conditional distribution of any future state X_{n+1}, given the past state $X_0, X_1, ..., X_{n-1}$ and the present state X_n, is independent of the

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past states and dependent on the present state only. Such a stochastic process is called a Markov chain. The value p_{ij} represents the probability that the process will, when in state i, next make a transition into state j. Let P denote the matrix of one-step transition probabilities p_{ij}, so that

$$P = \begin{bmatrix} p_{00} & p_{01} & \cdots \\ p_{10} & p_{11} & \cdots \\ \cdots & \cdots & \cdots \\ p_{i1} & p_{i1} & \cdots \\ \vdots & \vdots & \end{bmatrix}$$

In this paper the tally matrix n_{ij} of the frequencies of transitions between two successive states and the transition probabilities matrix p_{ij} of the daily frosts occurrence is represented as follows:

$$N = \begin{matrix} & W & D \\ W & \begin{bmatrix} n_{00} & n_{01} \\ D & n_{10} & n_{11} \end{bmatrix} \end{matrix} \qquad P = \begin{matrix} & W & D \\ W & \begin{bmatrix} p_{00} & p_{01} \\ D & p_{10} & p_{11} \end{bmatrix} \end{matrix}$$

Where n_{ij} and p_{ij} represent the number of transitions and probabilities from the state i to the subsequent j, respectively. This Markov property has been developed for second and third orders as well. Then dependent of frost days to each other, stationary and spatial homogeneity of frost days, from the Markov chain properties were investigated.

Results and Discussion

Some frost persistence characteristics in Iran show that the occurrence of frost days in this country, with the exception of south and north that usually have not got frost, possess the Markov chain property. In other words, the transition of occurrence of frost days is not random but depends on that of the previous days. Frost occurrence for two months of October and May that are famous to early-fall and late spring frosts possess two state first orders Markov chain, that is frost occurrence depends on only climatic condition of previous day.

Spatial distribution of persistence of two-days in October is limited to part of west, north-west and north-east of Iran. While this persistence in May is only observed to part of north-west of Iran. November, December, January, February, March and April are the months that two, three and four persistence of frost days experience. Statistical tests show that Markov chain properties of frost days' occurrence are stationary in time.

Conclusion

In the present study, persistence of frost days of Iran studied with use of two states (frost day and non-frost day) one, two and three orders Markov chain models. Result shows that two months of October and May have characteristics of two states one order Markov chain. And other months in cold period have both two states two and three orders Markov chain. Therefore Markov Chain model is a suitable model for studying frost persistence in Iran. This study can become more complete with synoptic studies in feature. *www.SID.ir*