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Climatic indicator analysis of blooming time for sour cherries

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Summary: County Szabolcs-Szatmár-Bereg produces more than the half of the total sour cherry grown in Hungary. Successful production, i.e. yield, depends largely on weather conditions. Most attention should be paid to the weather during the blooming period, being most decisive from the points of view of quality as well as quantity. In order to predict yields expected, the characterisation of the most important weather parameters is necessary. For that purpose, the database of the Institute of Research and Extension Service for Fruit Growing at Újfehértó Ltd. has been utilised. Records of weather conditions were collected throughout the period 1984-2005, i.e. daily minimum, maximum and mean temperatures (°C), precipitation (mm), and phonological diary of sour cherry varieties 'Újfehértói fürtös', 'Kántorjánosi' and 'Debreceni bőtermő'. Data of 7 indicators have been traced: number of frosty days, the absolute minimum temperatures, means of minimum temperatures, number of days when daily means were above 10°C, means of maximum temperatures, number of days without precipitation, and number of days when precipitation was more than 5 mm. On the one hand, we surveyed the changes; on the other hand, estimates have been attempted for the future changes expected during the following decades. The indicators being associated with certain risky events may serve for the prediction of the future recommendations to prevent damages.

Key words: climatic indicators, climate change, indicator analysis, RegCM 3.1.

Introduction

Hungary is traditionally suitable for production of fruit of high quality. The Carpathian basin is well protected with a balanced continental-type climate. At the same time, winter and spring frosts, drought and hail may cause heavy damages occasionally and locally. In the northern region of the Great Plain, especially in the county Szabolcs-Szatmár-Bereg, sour cherry production developed during the history, and contributed to the maintenance of the rural population in the communities. This region furnishes the 50–55% of sour cherry volume of the whole country.

Sour cherry is tolerant to winter frost; minimum temperatures of –25 ºC do not cause considerable damage. Phenophases of the plants are variably affected by weather anomalies, the susceptibility changes accordingly. As the period beginning 10 days before bloom and during bloom are decisive for the quality and quantity of yield, we examined it in this study. Several symptoms of climatic change have been observed in Hungary during the last 20 years, as fruit production of the Great Plain was also impaired. Changes affected the conditions of growing but they hit hard also on the outlooks of the future. The character and excesses of the climate of the region are determining the chances and risks of growing; therefore they ought to be registered, indispensably. We decided to characterise the climatic indicators of the fruit-growing region during the blooming period also with the purpose to get ideas referring to the changes of the anticipated future.

Material and methods

We utilised the database of the Institute of Research and Extension Service for Fruit Growing at Újfehértó Ltd. referring to the period 1984–2005. The following meteorological data have been registered: daily mean, minimum and maximum temperatures (°C) precipitation (mm). To examine the effect of climatic changes we took the RegCM3.1 (regional) climate model with 10 km resolution. The original model was developed by GIORGI et al. (1993) and was downscaled at Eötvös Loránd University, Department of Meteorology (*Bartholy* et al., *Torma* et al.). For the climatic characterisation of the sour cherry blooming, we introduced indicators as artificial parameters. Namely, some functions of weather parameters were created that are more tightly correlated with the responses of the plants than the original parameters. The main advantage of the use of climatic indicators is the fact that they are easier to be related to risks. By temporal and spatial analysing the values and their distribution in time and space, the indicators may signalise more exactly the risks of different type. An analysis of climatic indicators may serve also for the analysis of effects due to climatic changes. According to the literature, many authors use the method of creating specific indicators (*Bootsma* et al., 2005a,b). Indicators are applied to field crops, forest and fruit trees, or even for insects and vertebrate animals (*Erdélyi*, 2009, *Erdélyi* et al., 2008, *Koockheki* et al., 2006, *Salinger* et al., 2005). If we create a set of specific indicators using parameters, which are influenced by the climatic changes, many kinds of changes could be traced, moreover, the regional climate models of a given area we may gain information on the changes expected on the respective region. (*Carter* et al., 2007). Information of that type allows conclusions regarding the suitability of the respective site for fruit growing.

A successful analysis of indicators has to be based on relatively long periods of observations while the quality (reliability and relevancy) of the data is also crucial.

Subsequently, we will present the climatic indicators adopted for the period 1984–2005, and the changes expected for the 2021–2050 period.

Results

Temperature indicators

The number of frosty days during the 10-day long period before blooming and during the blooming time

The success of sour cherry growing depends largely on the climatic factors. If during the critical period - beginning with the 10 days before bloom and during the blooming period – the weather does not fit for the agro-meteorological claims of sour cherry, the yield of the season will be questionable (*Szabó*, 2007). One of the most decisive indicators is the occurrence of frosty days during the respective period (i.e. days when the minimum temperature drops below the freezing point: 0 °C). In *Figure 1* (Left), the number of frosty days diminished during 1984–2005 at Újfehértó. The mean of the 22-year long period was 1.4 days. In 1986, 1991 and 2002 the number of frosty days was 4, while in most years the blooming period was not frosty.

Taking the 1984–2005 period as a reference, we calculated the length of the "mean blooming period". Subsequently, we applied the results of the RegCM 3.1 model on the analogous period (average blooming time + 10 days before blooming) and calculated the number of frosty days expected to occur during the future 30-year-long (2010-2050) period. The result was simply: no frosty days are anticipated around the mid of the 21th century during the critical period of blooming (*Figure 1*, Right).

The absolute minimum temperature during the period: 10 days before bloom plus blooming time

The volume of yield depends not only the frequency of frosty days, but also on the temperature of the frost. Sour cherry – being an early blooming fruit species – may freeze in the spring. The most susceptible period of the developing flower is the full bloom and immediately before the fruit set. At that time, a temperature of –0.5 ºC already damages the seed primordium. The occurrence of the absolute minimum temperatures (the minimum of daily minima) is shown in Figure 2. The mean of 22 years is 0.09 ºC, however, salient values are also observed, as in 1993 and 1996 the values were relatively high (7 ºC and 5 ºC) as absolute minima, whereas in 1992 and 2002, it was –4 ºC or –5 ºC, respectively. According to the regional climate model the absolute minima in 2021–2050 is expected to be 6 ºC as a mean (*Figure 2* Right). The critical temperature will be much higher than

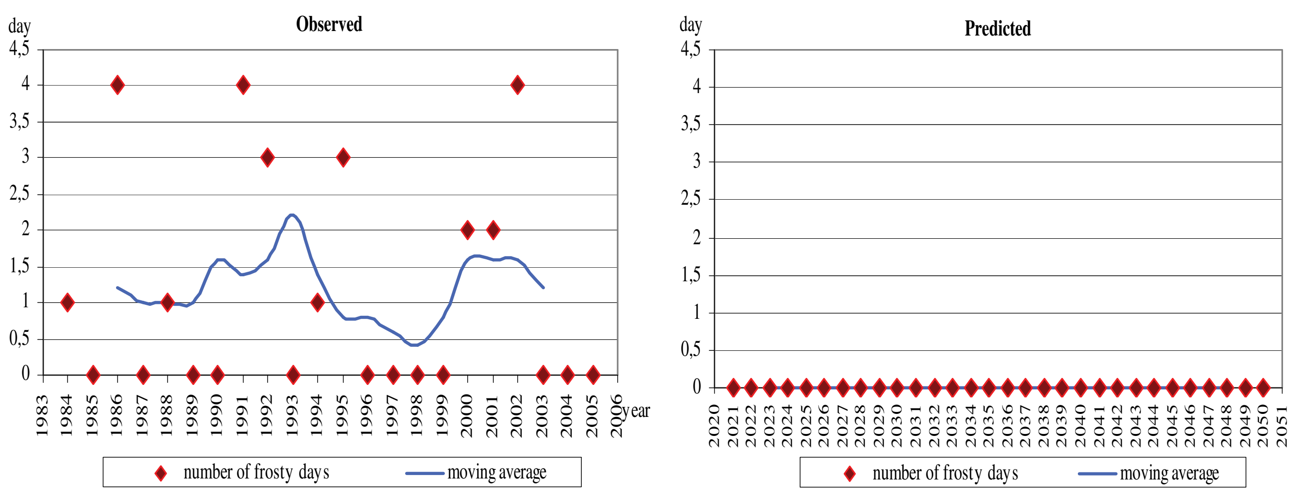

Figure 1: Number of frosty days at Újfehértó on the basis of historical data and of RegCM 3.1 data for the 10-day long period before bloom and during the blooming period

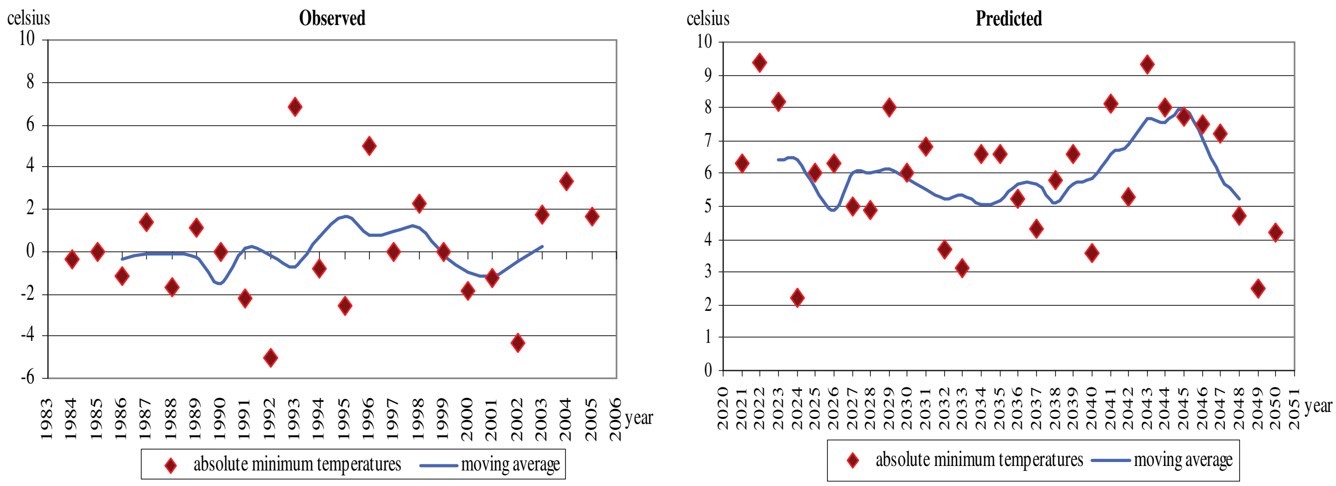

Figure 2: The observed (Left) and estimated (Right) absolute minimum temperatures at Újfehértó, estimation have been made by means of the RegCM 3.1 model for the period 10 days before bloom plus blooming time

earlier during this period, and it is highly probable that there will not be year with temperatures below 0 ºC. We can conclude that the risk of spring frosts will be very low in the future.

The means of the daily minimum temperatures during the period: 10 days before bloom plus blooming time

Analysing the data of time period 1984–2005, we stated that the trend of the means of minimum temperatures increased from 5.5 ºC to 7 ºC. The mean of the 22 years was 6.3 ºC. The highest value (9.44 °C) was measured in 1993, the lowest (4.14 °C) in 1988, and the estimates according to RegCM 3.1 for 2021–2050 will approach temperatures of 14.35 ºC, while in other years 7.26 ºC, only. The RegCM 3.1 model predict the mean of minimum temperatures of 10.88 °C in 2021–2050 (*Figure 3* Right). It is stated that the differences are significant between the measured 22 years and the estimated 30 years, regarding the means of minimum temperatures. The probability of the occurrence of minimum temperatures below 7°C will be low, which means also the low risk of spring frost.

The number of days with warmer than 10 ºC as mean temperatures during the period 10 days before bloom plus during blooming

Results show that during the observed 22-year-long period (1984-2005) the number of days with means above 10 ºC did not increase, significantly. The mean of the 22 years was 16 days. In 1991 there was 27 days with mean temperature higher than 10 ºC in the observed period, on the contrary, in 1993, 10 days only. In *Figure 4* Right, the prognosis according to RegCM 3.1 the estimates refer to the period of 30 years (2021–2050). It is expected that the number of days with means above 10 °C will increase slightly, but with strong fluctuation. The increasing tendency of the amplitude together with former information may

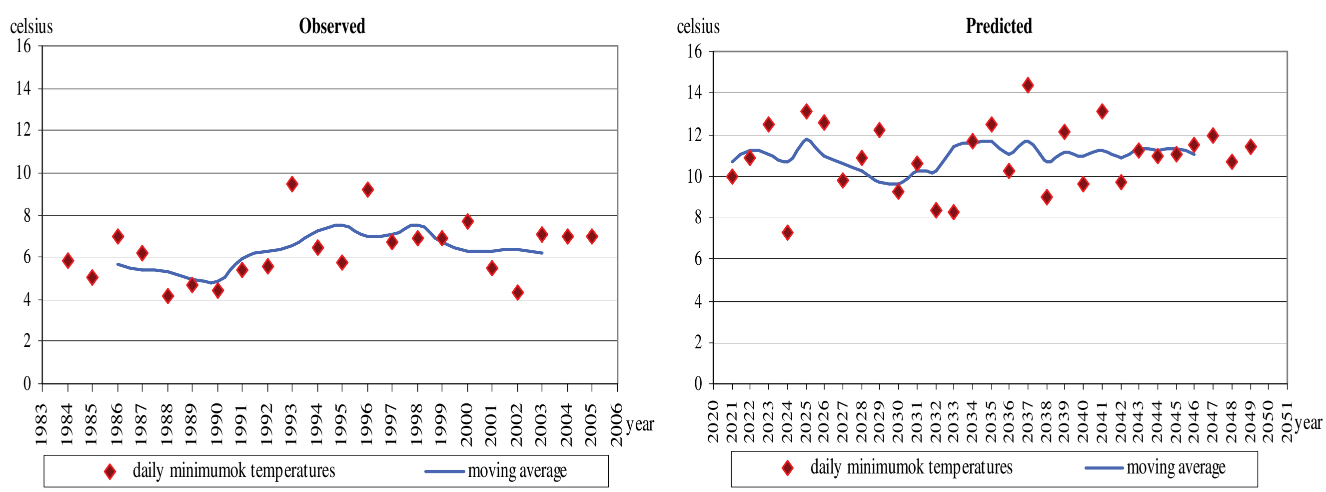

Figure 3: The observed (Left) and estimated (Right) daily minimum temperatures at Újfehértó, estimation have been made by means of the RegCM 3.1 model for the period 10 days before bloom plus blooming time

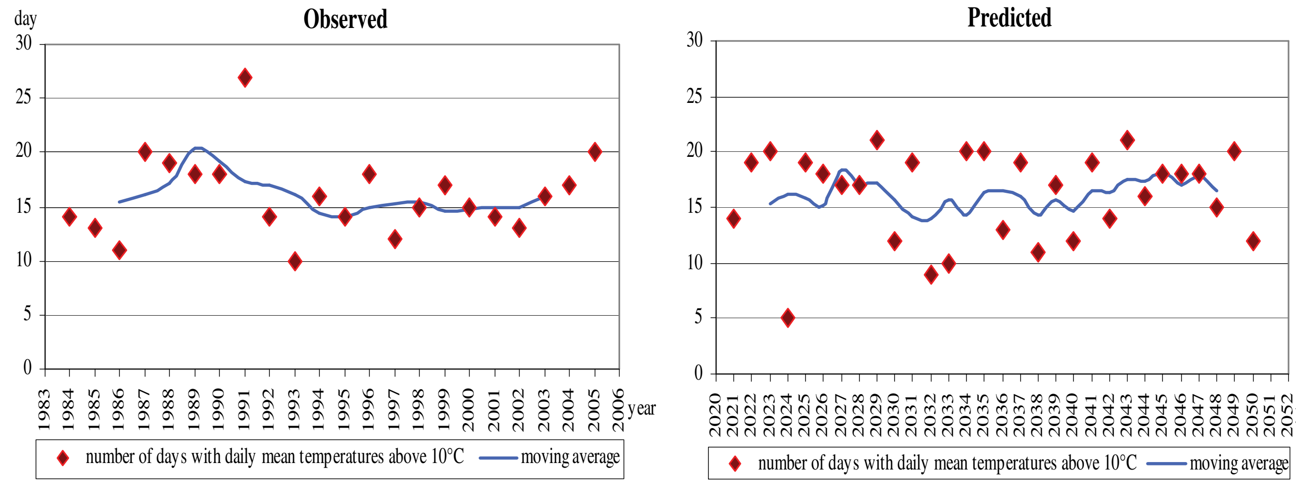

Figure 4: The observed (Left) and estimated (Right) number of days with daily mean temperatures above 10°C at Újfehértó. Estimation have been made by means of the RegCM 3.1 model for the period 10 days before bloom plus blooming time

predict very variable pre-blooming and blooming periods with high probability of no frost.

The maximum temperatures during the period: 10 days before bloom plus blooming time

Excessively high temperatures may become deleterious by causing heat stress in the plant, impair the water supply or troubles in the metabolism (*Lakatos* et al., 2005). *Figure 5* shows the daily maximum temperatures of the blooming period (10 days before and during the blooming period). The observed mean of the 22 years was 18.6 ºC. The yearly oscillation was conspicuous. In 1985 and 2002, it was 16 ºC only, whereas in 1993, it reached 25 ºC, which is 6 °C more than the mean of the 22 years. The expected mean of maximum temperatures is 13.2 °C in 2021–2050 for the 10 day pre-blooming plus blooming period. According to the RegCM 3.1, in some years it may be 17.4 ºC and 9.9 ºC in others. The means of maximum temperatures differ significantly between observed and estimated means. As within the interval 1984–2005, the 90% of means remained between 16 ºC and 22 ºC, the estimated predictions for 2021–2050 vary within 10 and 16 °C. During the pre-blooming and blooming period, the predicted warming up is not associated with the increasing of maximum temperatures, on the contrary, decline of maximum temperatures is expected.

Precipitation indicators

The data of yearly precipitation and its distribution are of prime interest. Water requirement of sour cherry is mediocre regarding the fruit species, yearly 500–600 mm is claimed to be sufficient for successful production (*Pór*, 1982). Rainy weather during bloom is very disadvantageous for the grower. Pollination is impaired and several diseases caused by bacteria and fungi are promoted.

The number of days without precipitation during the period of 10 days before bloom and blooming time

The number of days without precipitation has been compared within the time of 10 days plus blooming time

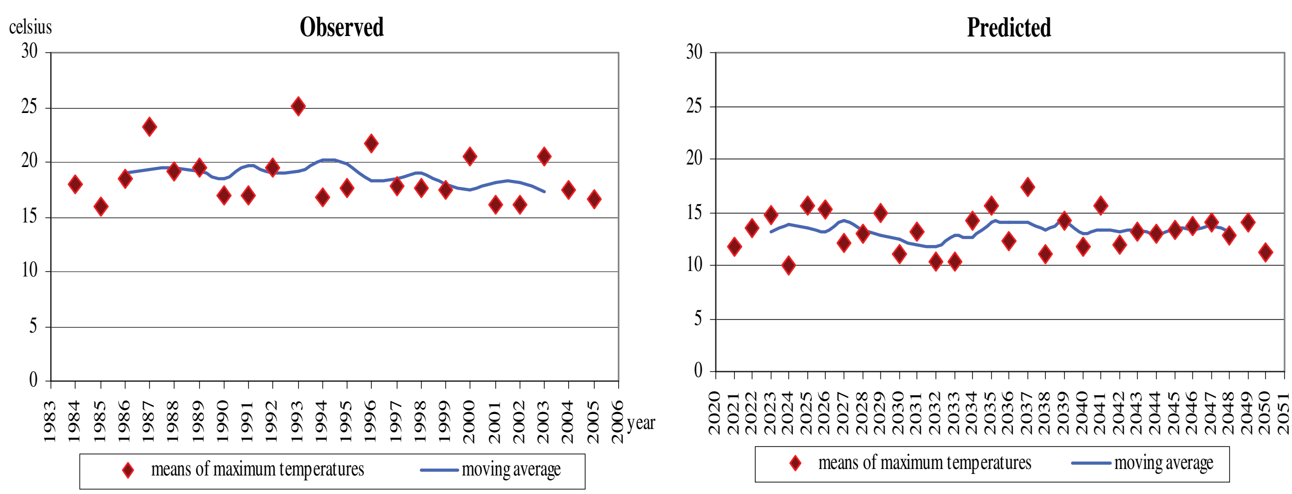

Figure 5: The observed (Left) and estimated (Right) means of maximum temperatures at Újfehértó. Estimations have been made by means of the RegCM 3.1 model for the period 10 days before bloom plus blooming time

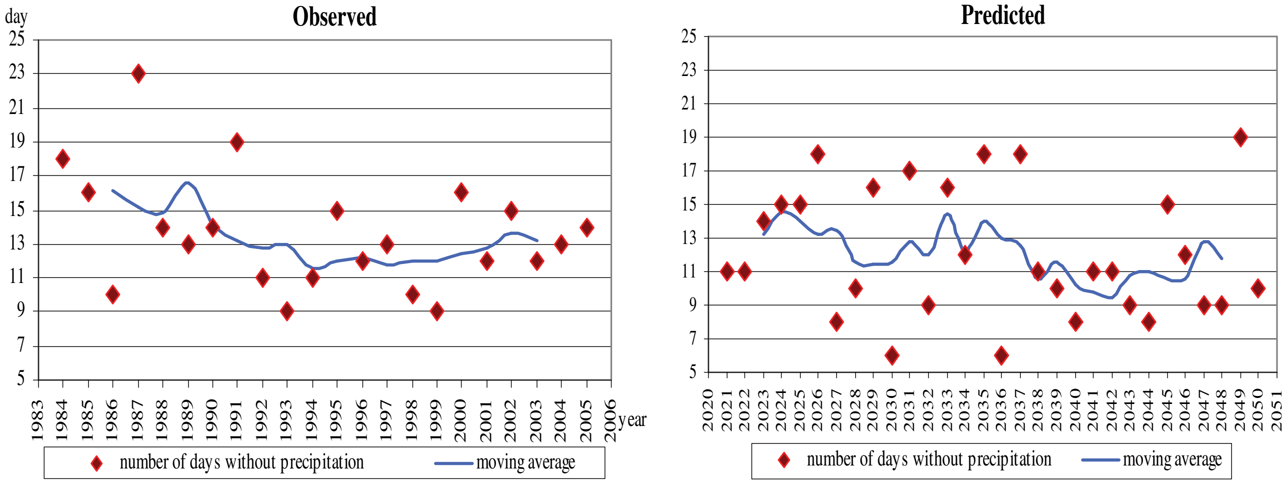

Figure 6: Number of days without precipitation at Újfehértó as observed (Left) and estimated (Right) by the RegCM 3.1, for the 10 days + blooming period

during the years 1984–2005 *(Figure 6)*. During the pre-blooming and blooming period the average number of days without precipitation was 13.6, but a drastic decline was observed. During the 80-es the value of the trend was 15.5 days, and today it is 12 days only. In 1987, 23 were the number of dry days, in 1993 and 1999, 9 days only. Predictions for the period 2021–2050 signed a slight decline, i.e. a mean of 12 days. The coefficient of variation of observed data was high, i.e. 25.04%, the coefficient of variation according to the predictions of the RegCM 3.1 is even higher than 31.45%. On this basis, blooming weather will be rainier in the future, which will increase the risk of production.

The number of rainy days with more than 5 mm precipitation during the 10 days plus blooming period

The quantity of precipitation above 5 mm is already considerable from the point of view of agronomy. It is more than the quantity lost by daily transpiration. Water reserves of the plant are maintaining the normal life. It is claimed that after fertilisation, cell division is stimulated by precipitation, whereas bee pollination is impaired. Growers' information related to the frequency of rains in pre-bloom and bloom should be coupled with the amount of precipitation to trace its effect on the quantity of yield *(Figure 7)*. During the 10 days plus the blooming period, between 1984 and 2005, mean number of days with precipitation above 5 mm was 2.3, in 1983, 3 days, in 2005, 2 days only. 1985 was outstanding with 6 days, but in 6 years (1984, 1992, 1992, 2000, 2003 and 2004) no rain above 5 mm/day occurred during this period.

The mean number of rainy days (with more than 5 mm precipitation) during the pre-blooming and blooming period is expected to be around 3 in the future according to RegCM 3.1 estimate for 2021–2050, which does not differ significantly from the present trend.

Summary

Our climate changed during the last 40 years according to a trend of warming up. The sour cherry plantations in Hungary are concentrated on the Northern Great Plain,

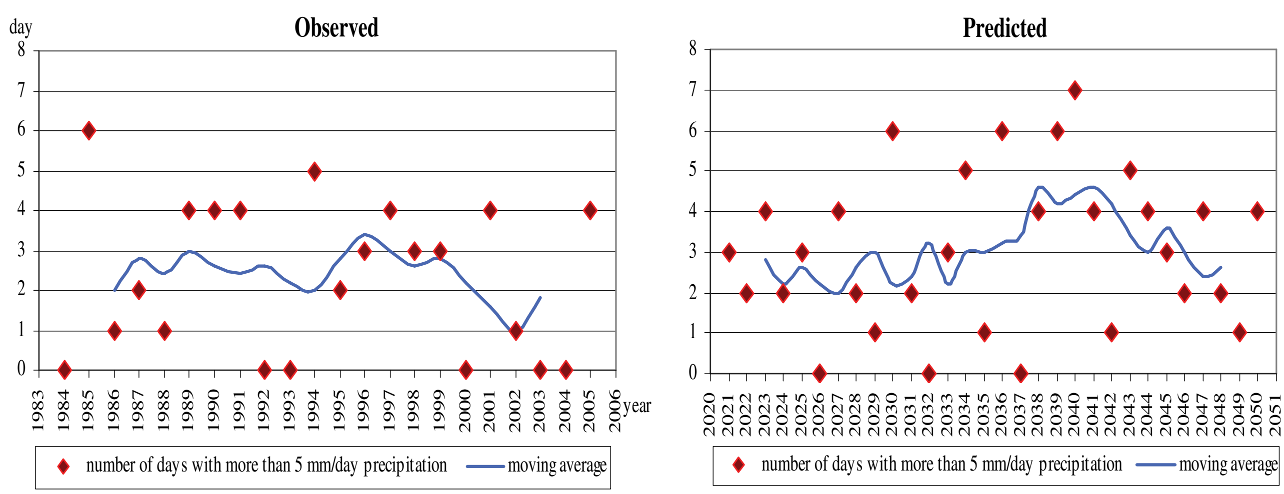

Figure 7: Number of days with more than 5 mm/day precipitation at Újfehértó as observed (Left) and estimated (Right) by the RegCM 3.1, for the 10 days + blooming period

especially in the county Szabolcs-Szatmár-Bereg. The Institute of Research and Extension Service for Fruit Growing at Újfehértó Ltd. recorded systematically, during the 22-year-long period between 1984 and 2005, the meteorological data: daily minimum, maximum and mean temperatures, as well as precipitation during the blooming period of sour cherries (i.e. 10 days before plus the blooming of flowers). The records of the database have been collated with the Regional Climate Model (RegCM 3.1.) downscaled to the respective area, and the following statements have been attempted:

- Considering the number of frosty days, the mean of 22 years was 1.4 days. The prognosis according to the RegCM 3.1 for the period 2021–2050 stated that no frosty days are expected because the probability of frosty days will decline drastically.
- The absolute minimum temperature of the period was 0.09 ºC as a mean. The prediction of the RegCM 3.1 is much higher: 6 ºC, i.e. no risk of spring frost is expected.
- The mean minimum temperature was 6.3 ºC as recorded, whereas the RegCM 3.1 model predicts 10.88 ºC as a mean. There was a significant increment.
- The number of days with mean temperatures higher than 10 ºC was 16. According to the Reg CM 3.1 model, the increment is moderate but the yearly variation will be large.
- The mean of daily maximum temperatures was 18.6 ºC during the 22 years. In some years, it attained even 25 ºC, and was 16 ºC only in others. The RegCM 3.1. estimated 17.4 ºC and 9.9 °C as extremes for 2021–2050, which means a drastic decline in relation to the data recorded earlier.
- The number of days without precipitation recorded as 13.6 days, mean of 22 years. The RegCM 3.1 model predicted a slight regression, i.e. 12 days, however, the yearly variation will increase.
- The mean of the number of rainy days with more than 5 mm precipitation/day was 2.3 days during the recorded period (1984–2005). The prognosis shows an increment to 3 days, which is a small change only.

Growers are compelled to increase the yields in order to compensate for the increasing costs of production as well as for the irrationally low producer's prices. These efforts are jeopardised by the warming up the climate, because the decline of precipitation, increased frequency and intensity of weather anomalies. Conscientious of these predictions, strategies of adaptation should be developed.

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