Constructing a typical meteorological year -TMY for Voinesti fruit trees region and the effects of global warming on the orchard ecosystem

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Objectives

- Construction of the typical meteorological year –TMY for Voinesti apple production area;

- Calculation of principals agroclimatic indexes for Voinesti area;

- Study of the global warming effects on the evolution of the local agroclimatic indexes.

The research was conducted within POMOSAT project financed by Romanian Ministry of Education and Research

Materials and methods

The research used a meteorological statistical method introduced by J.M. Finkelstein, R.E. Schäfer (1971).

For discrete distribution, Finkelstein-Schäfer statistics gives better results in concordance tests than Kolmogorov-Smirnov statistics.

This type of statistics was used in Sandia Laboratories in USA to determine a typical meteorological year (TMY).

Depending on the activity domain, some climate characteristics are more important than others.

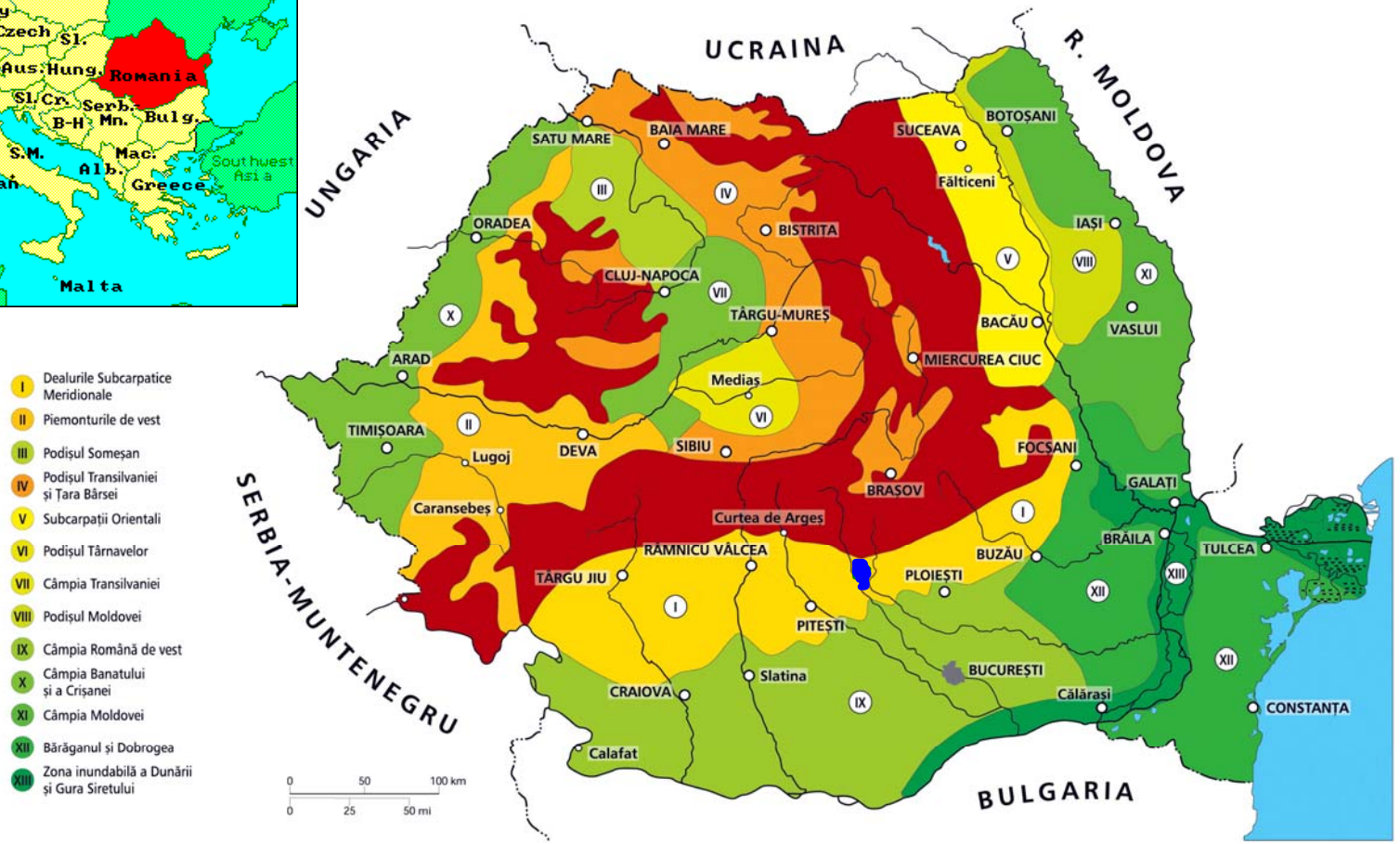
We have considered the following characteristics and corresponding weights:

Characteristics	Weights
Solar irradiation	0,4
Mean air temperature	0,2
Maximum air temperature	0,1
Minimum air temperature	0,1
Mean relative humidity	0,1
Precipitation	0,1

Materials and methods

The analyzed data were measured at Voinesti:

- **latitude 45º 08' N,**
- **longitude 25º 23' E,**
- **511 m altitude.**



The sample contains 17 years with complete observations between 1977 and 2002.

We eliminated 29th of February from leap years, so that we had for 17 years, a number of 17 x 365=6205 days.

Construction of a typical meteorological year

The typical year is not built from data resulted by averaging the measurements on many years.

Each month of a typical year is a true (effective) month from one of the considered years.

In order to choose this typical month, for example January, for each meteorological characteristic, noted c), the empirical repartition function for all January months was built.

Typical month of January will be considered from indexed year i for which the distance Finkelstein-Schäfer between CDFc and CDFc,i is the smallest.

CDFc=cumulative distribution function (c is the distribution for long term)

CDFc,i=empirical distribution function for January for each year considered separately (where i is the year index).

Construction of a typical meteorological year

In order to take in account as many as meteorological characteristics a weighting of these distances was done.

Through previous steps a representative month from a certain year was obtained.

Those12 months were concatenated and smoothed for the transition between two succesive months using an average between neighbors data with the weights w=[0.3, 0.4, 0.3].

If n is the number of the data implied in smoothing operation (for us n=8, the last 4 days in month and first 4 days from the next month), the sequence of calculus is:

```
for i=2:n-1
date1(i)=w(1)*date(i-1)+w(2)*date(i)+w(3)*date(i+1);
end
```

where date is the vector of initial data and date1 is the vector of smoothed data.

Results and discussion

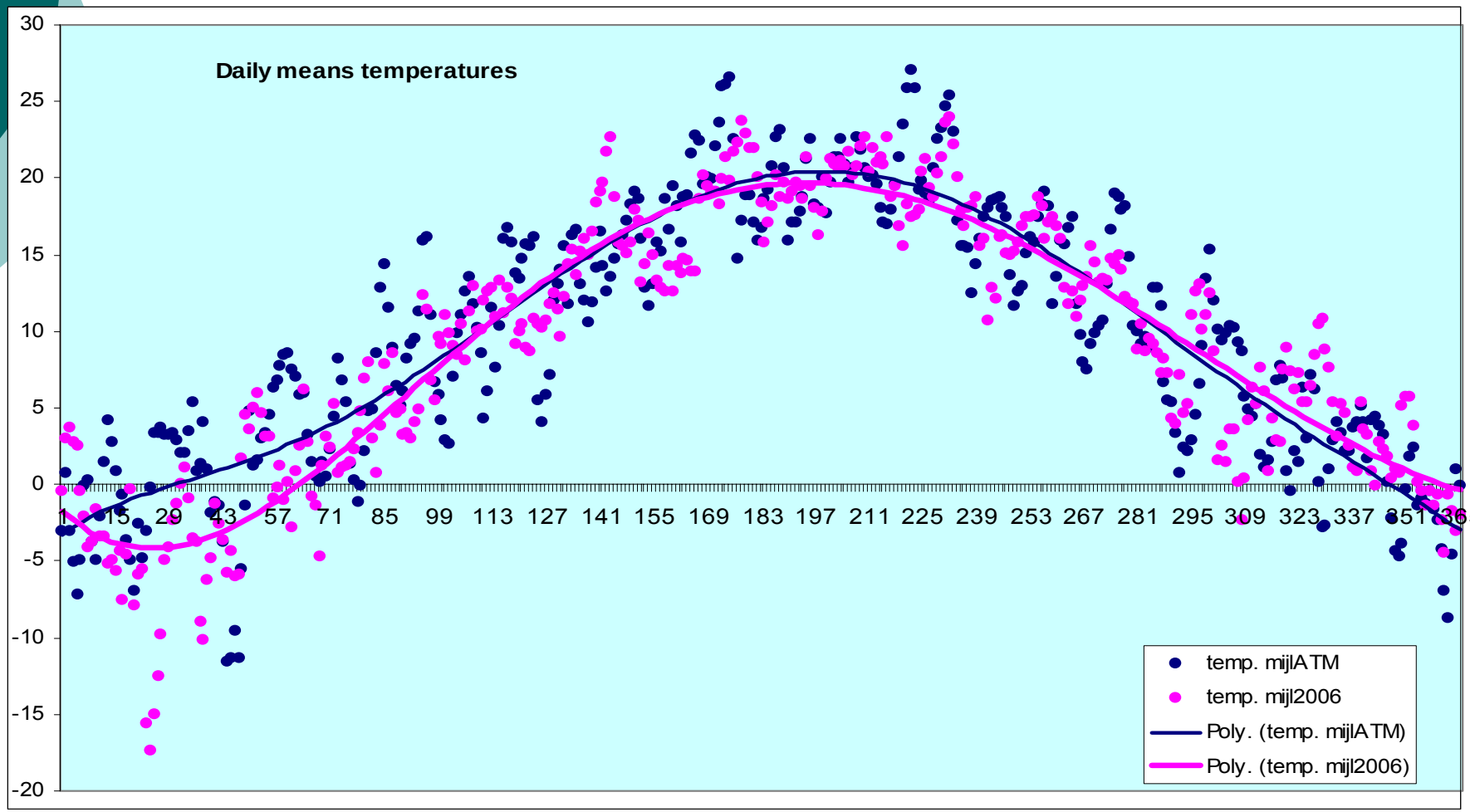
The program was coded in Scilab and follows the steps from TMY method described above.

The typical months for the analyzed period were found as following:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	1994	1992	1992	1999	2002	1992	1999	2000	1999	1999	1976

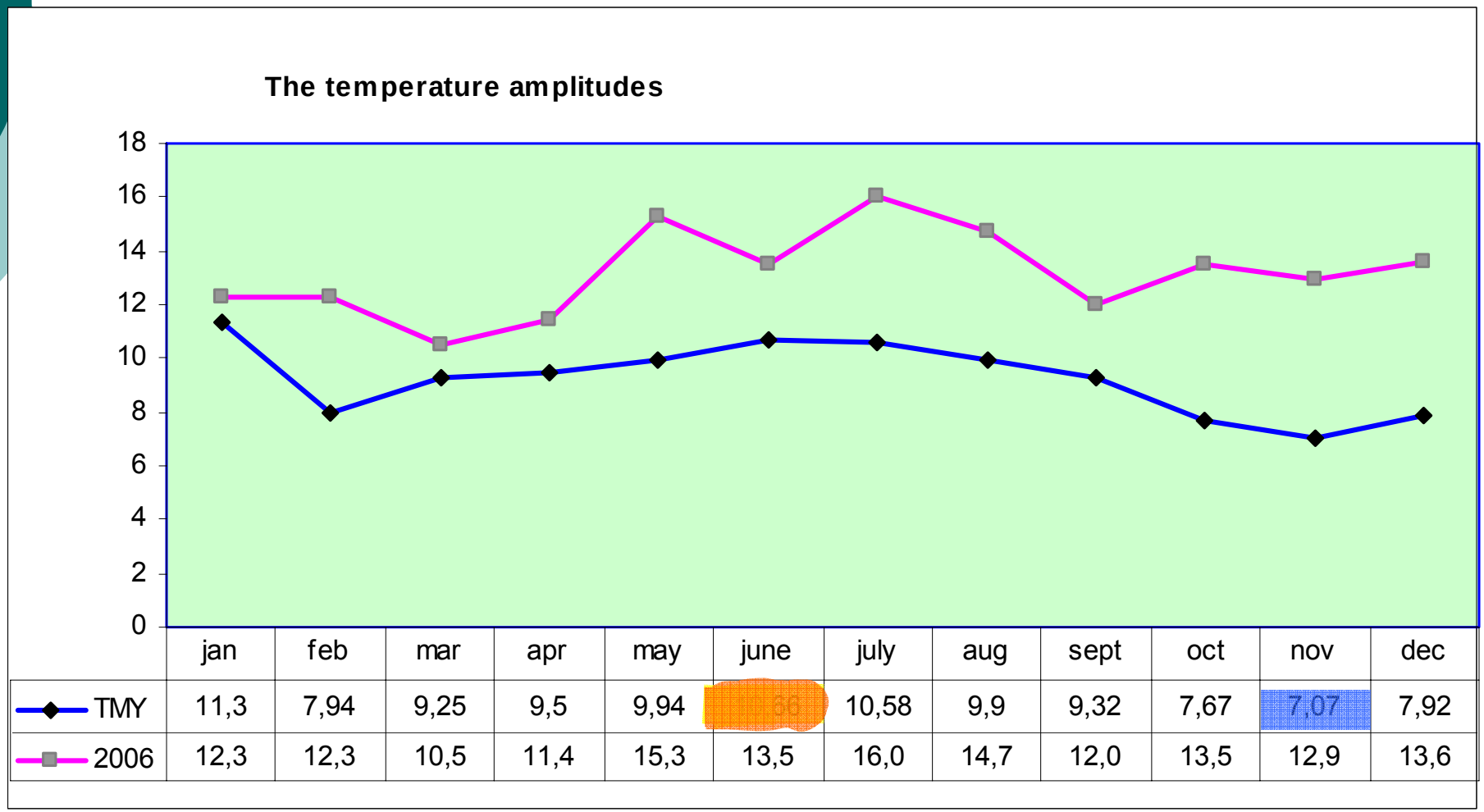
Principal agroclimatic indexes for Voinesti area

The general mean of temperature was 9.62 ± 8.44^{0}C for TMY, respectively, 9.00 ± 8.62^{0}C in 2006 (bigger variability)



Amplitude of air temperature

- big variability of the air temperature in 2006



	jan	feb	mar	apr	may	june	july	aug	sept	oct	nov	dec
TMY	11,3	7,94	9,25	9,5	9,94	10,66	10,58	9,9	9,32	7,67	7,07	7,92
2006	12,3	12,3	10,5	11,4	15,3	13,5	16,0	14,7	12,0	13,5	12,9	13,6

Characteristic days

Four types of characteristic days were defined:

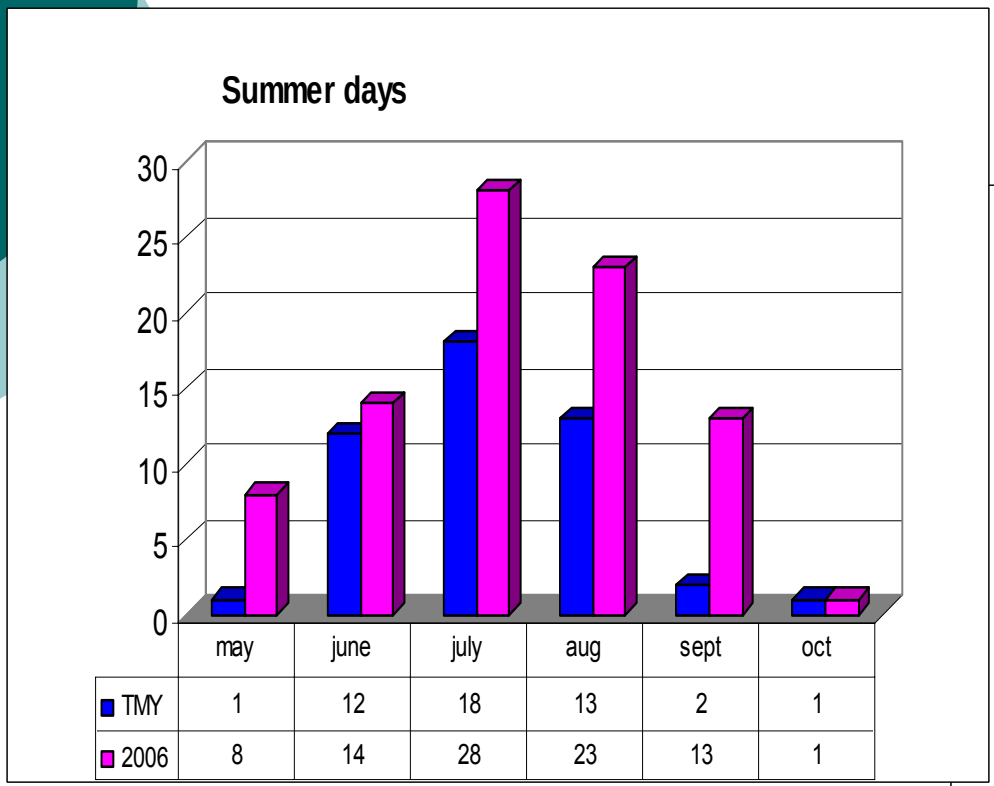
two of them are specific for the warm season:

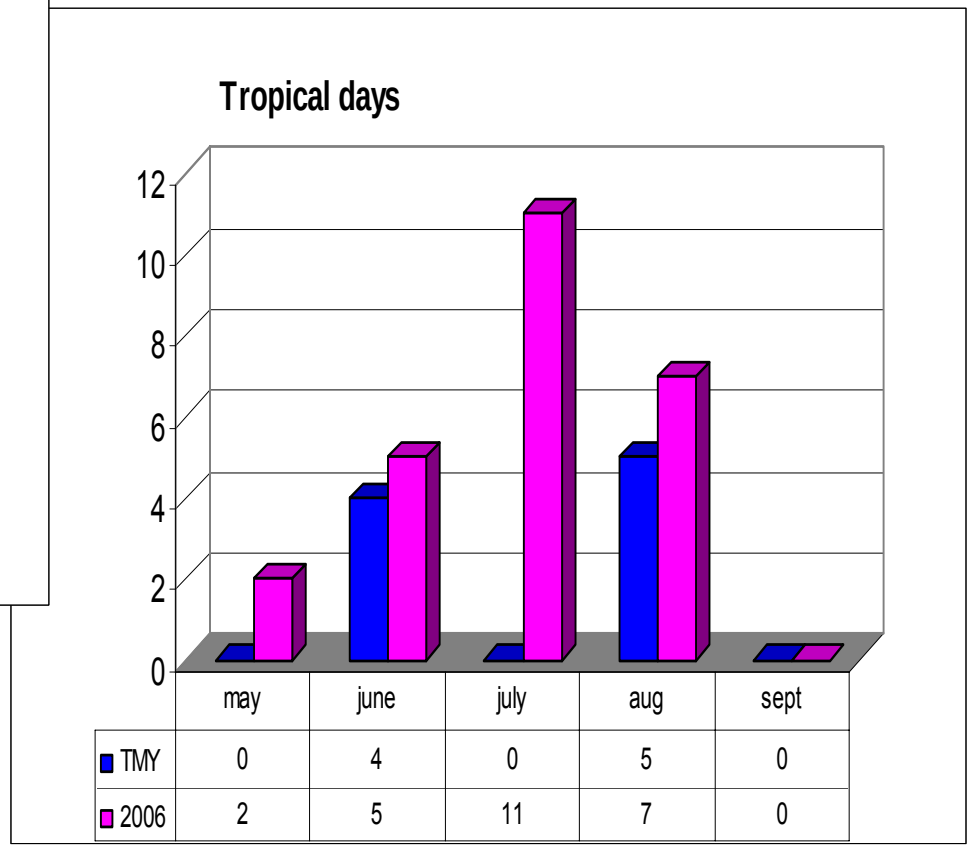
- **summer days** - maximum temperature is bigger than 25 ^{0}C,
- **tropical days** - maximum temperature is ≥ 30 ^{0}C,

and other two specific, for the cold season:

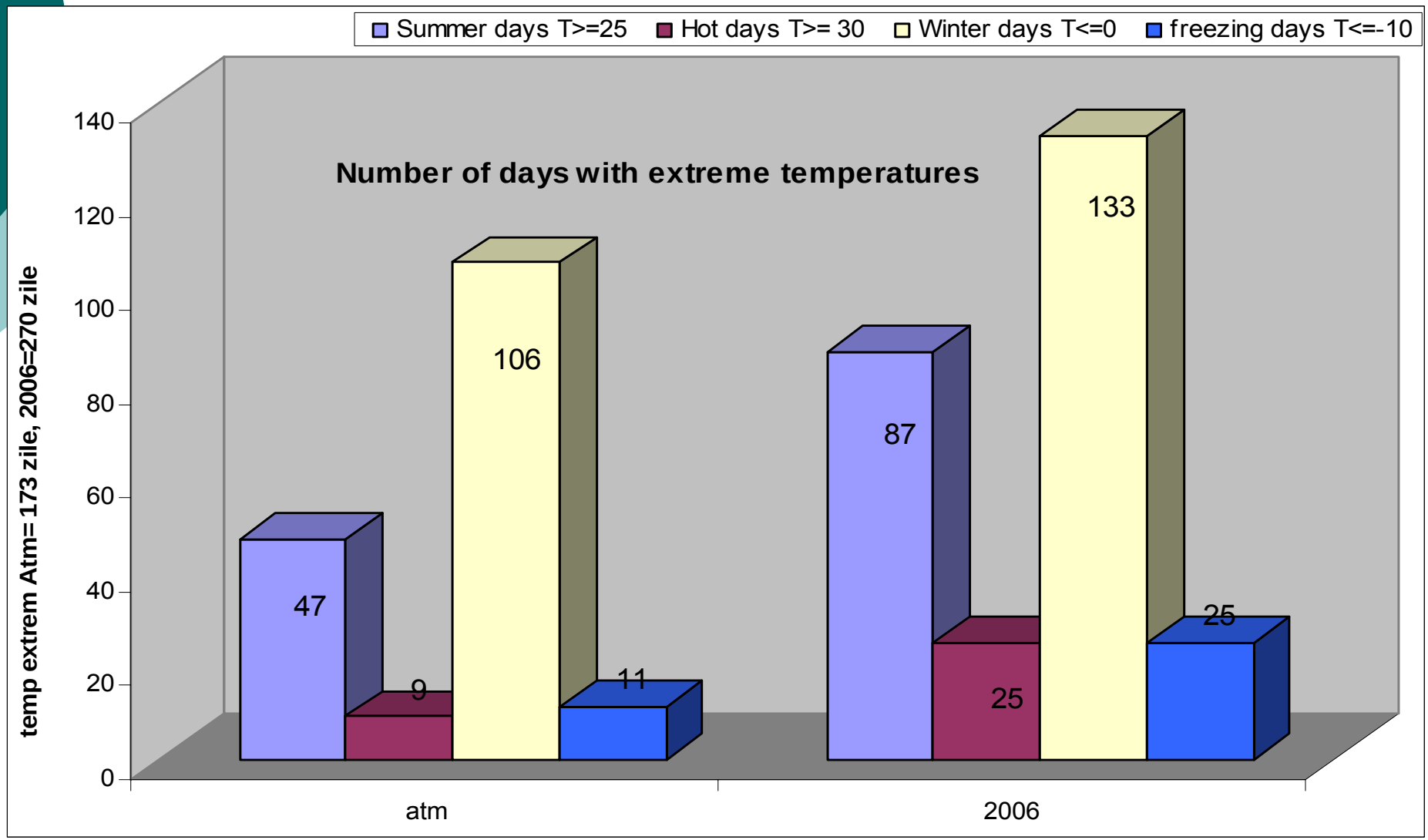
- **winter days** - minimum temperature is ≤ 0 ^{0}C,
- **freezing days** - temperature is ≤ -10 ^{0}C.

The frequency of characteristic days





Number of days with extreme temperatures



Comments

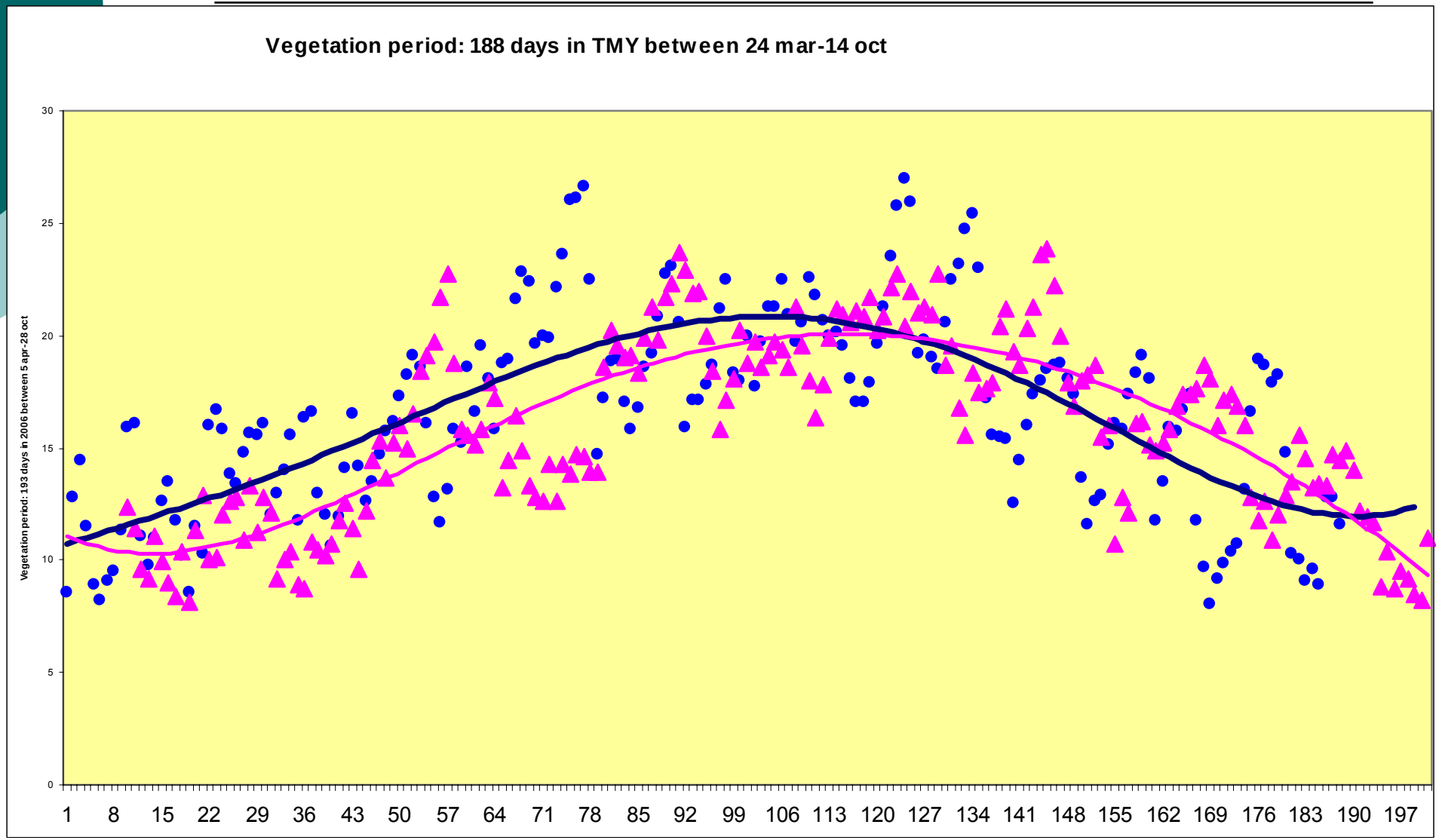
- Totally, there were 153 situations of extreme values in TMY and 220 in 2006 (***the bigger variability we were discussing about, is a typical aspect of the global warming on the orchard ecosystem***).

- The number of hot days and freezing days during the year 2006 is 50 days comparative with 20 days in TMY.

- Using a statistical test of Z type to analyze the difference between the frequencies appearing in those cases in both compared years, it was accepted the hypothesis that the difference is significant.

The vegetation period

Temperatures over the threshold of 8^0C



Comments

The vegetation period is between 24th of April and 14th of October during 188 days for TMY with a sum of 3112^0C.

In 2006 the vegetation period is of 193 days, between 5th of April and 28th of October, with a sum of 3058^0C.

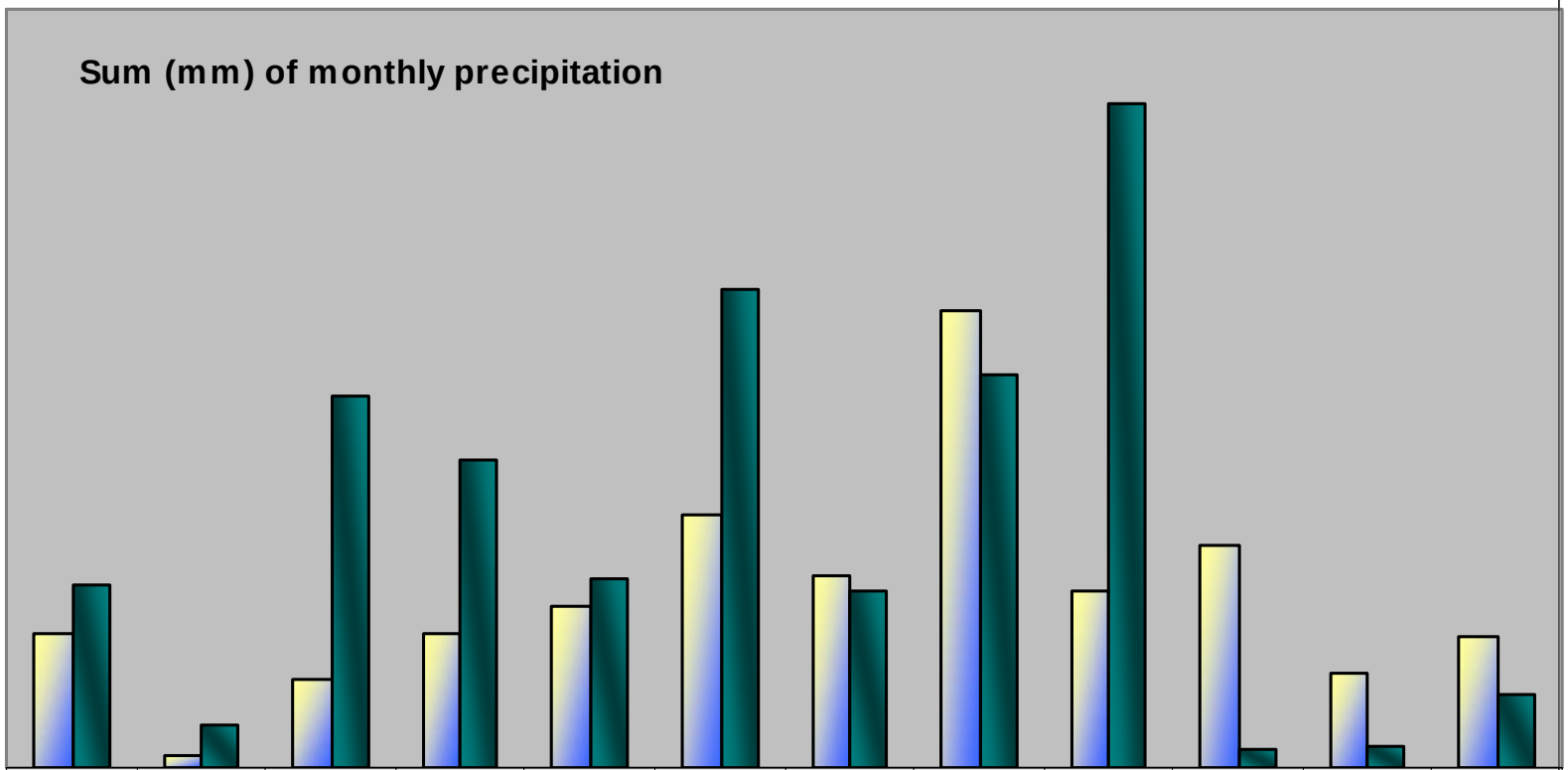
An effect of the global warming is clearly indicated here; the vegetation period of 2006 starts 9 days latter, but the warm autumn determines the end of vegetation period after 28th of October.

The difference between TMY and 2006 is not significant statistically, concerning the length of the interval and the cumulated temperatures value as well.

Precipitations

did not exceed 671 mm in the analyzed TMY,

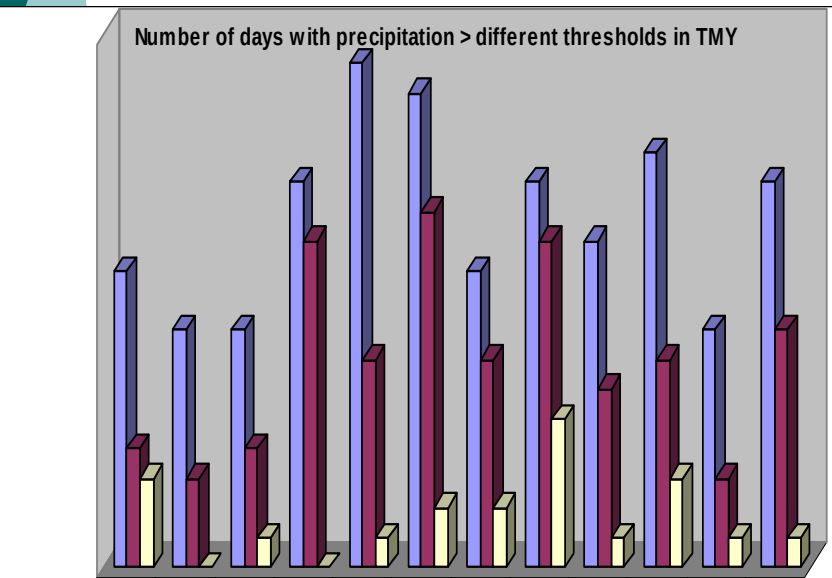
but much more in 2006, respectively 960 mm



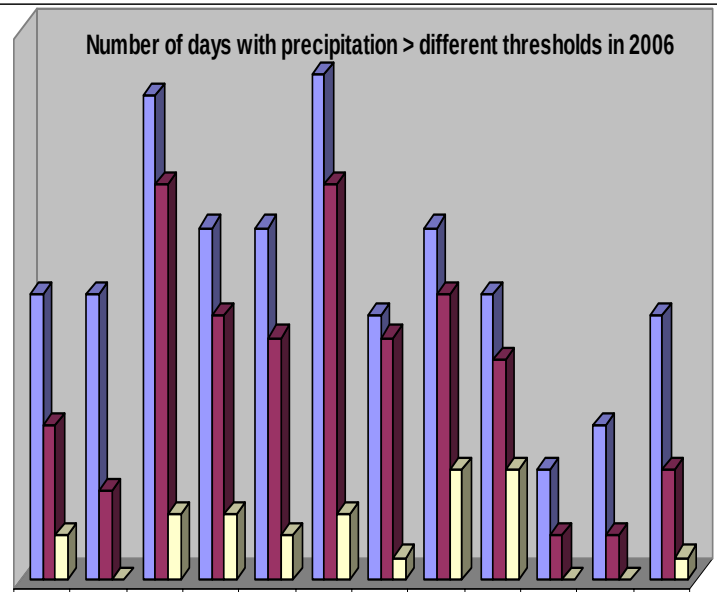
Sum in TMY=677.11 mm Sum 2006=960 mm

	ian	feb	mar	apr	mai	iun	iul	aug	sept	oct	nov	dec
Sum TMY	44.3	4.3	29.05	43.97	53.54	82.87	63.28	150.66	58.08	72.8	31.1	43.16
Sum 2006	60	14	122.2	101	62	157.2	58	130	219	6	6.6	24

Number of days with precipitation over different thresholds



	ian	feb	mar	apr	mai	iun	iul	aug	sept	oct	nov	dec
pp>0.1	10	8	8	13	17	16	10	13	11	14	8	13
pp>1	4	3	4	11	7	12	7	11	6	7	3	8
pp>10	3	0	1	0	1	2	2	5	1	3	1	1



	ian	feb	mar	apr	mai	iun	iul	aug	sept	oct	nov	dec
pp>0.1	13	13	22	16	16	23	12	16	13	5	7	12
pp>1	7	4	18	12	11	18	11	13	10	2	2	5
pp>10	2	0	3	3	2	3	1	5	5	0	0	1

Comments

The maximum of precipitation was registered in August for TMY and in September for 2006. A minimum of precipitation caused by dynamics, especially by anticyclone areas, was remarked in October-November.

The sample years used to build TMY had inside a long drought period. By comparing, the year 2006 was characterized by the fact that the months with precipitation are consecutive and cumulated 168 days with precipitation, than TMY where we have 141 similar cases.

Conclusions

The temperature means for the TMY are similar with the 2006 means, but a warmer autumn and a colder winter brings a bigger variability.

- **The amplitude of the annual air temperature mean in TMY, of about 9.25 degrees Celsius, is specific for Voinesti center characterized by a continental climate.**
- **The number of hot days and freezing days in the meteorological year 2006 was 50 days, comparative with 20 days in TMY, the difference being very significant.**
- **The difference between TMY and 2006 is not statistically significant concerning the length of the vegetation period, as well as the value of the cumulated temperatures.**
- **In 2006 there was a number of 168 cumulated days with precipitation comparing with TMY where there were only 141 days with precipitation. The difference is statistically significant.**

Thank you!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