Informace o pěstování révy vinné jako zdroj poznání vývoje klimatu České republiky v minulosti, současnosti a v budoucnosti

Grapevine information as a source of the climatological knowledge in the Czech Republic in the past, present and future

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Introduction

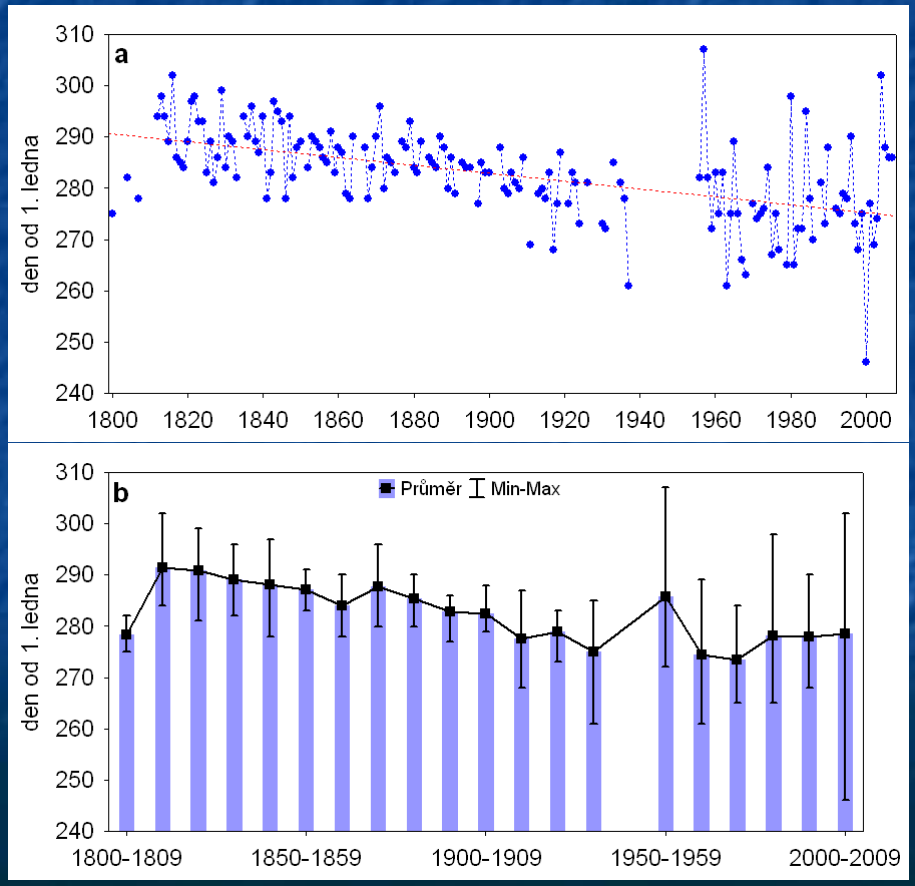
- Viticulture in the Czech Republic is strongly influenced by the fact that cultivation of the vine *Vinis vinifera*, which originally came from latitudes 25–40º N with only secondary extension to the south and north, is at northernmost extent of its range in Europe.
- Dependence on weather patterns increases enormously.
- Positive factors influencing yields and quality of the grapes: abundant sunshine and higher air temperatures, together with sufficient precipitation
- Negative factors: cold and rainy weather in the period of maturation, extreme winter frosts, late spring and early autumn frosts and hailstorms

Historical viticultare as source of climatological knowledge

- Start of the grape harvest (vintage)
- Quality of wine (subjective and sugar content)
- Quantity of wine
- Price of wine

Start of grape harvest

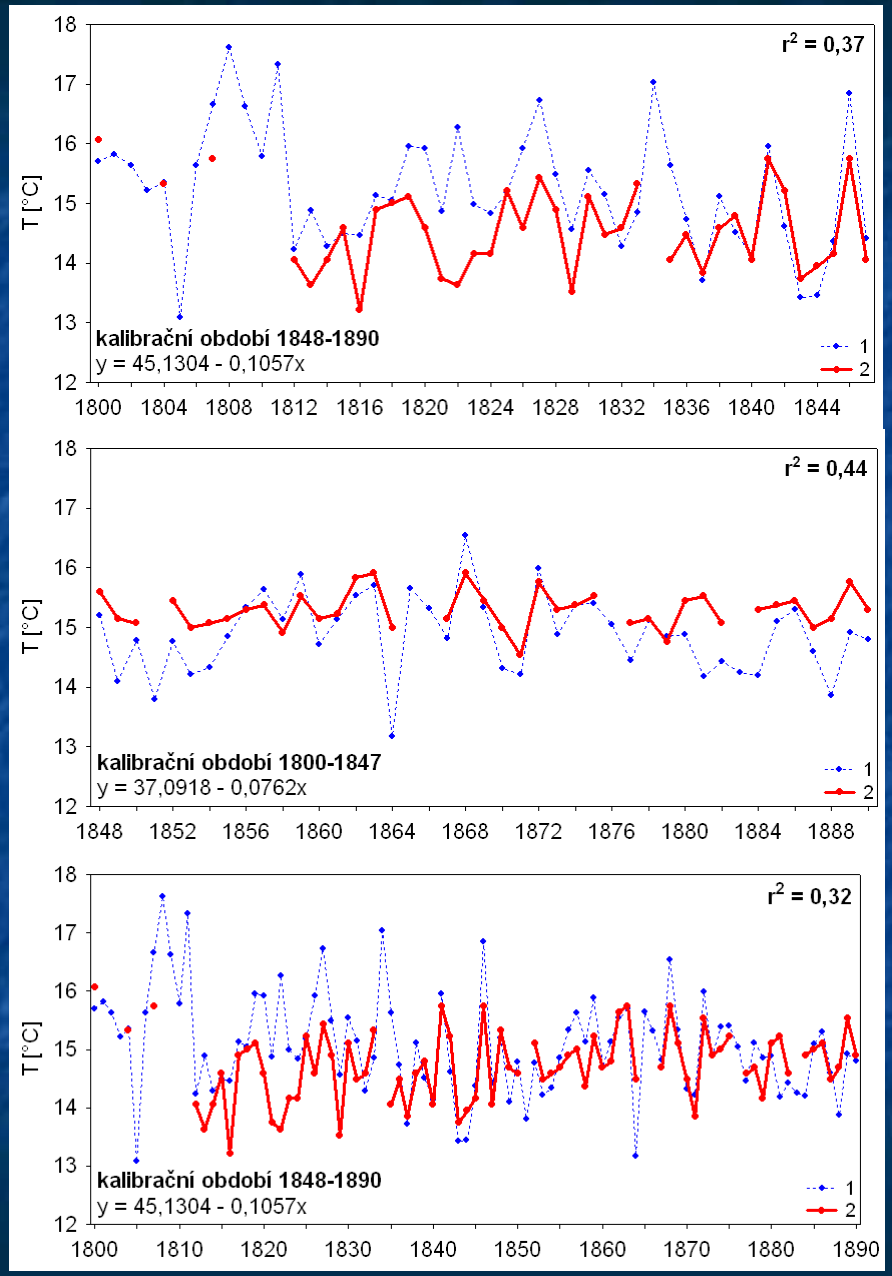
- Contain proxy information on temperature patterns in foregoing period, so systematic records may be used for quantitative temperature reconstruction.



- 3. September 2000: vintage was earliest
- 3. November 1957: vintage was latest

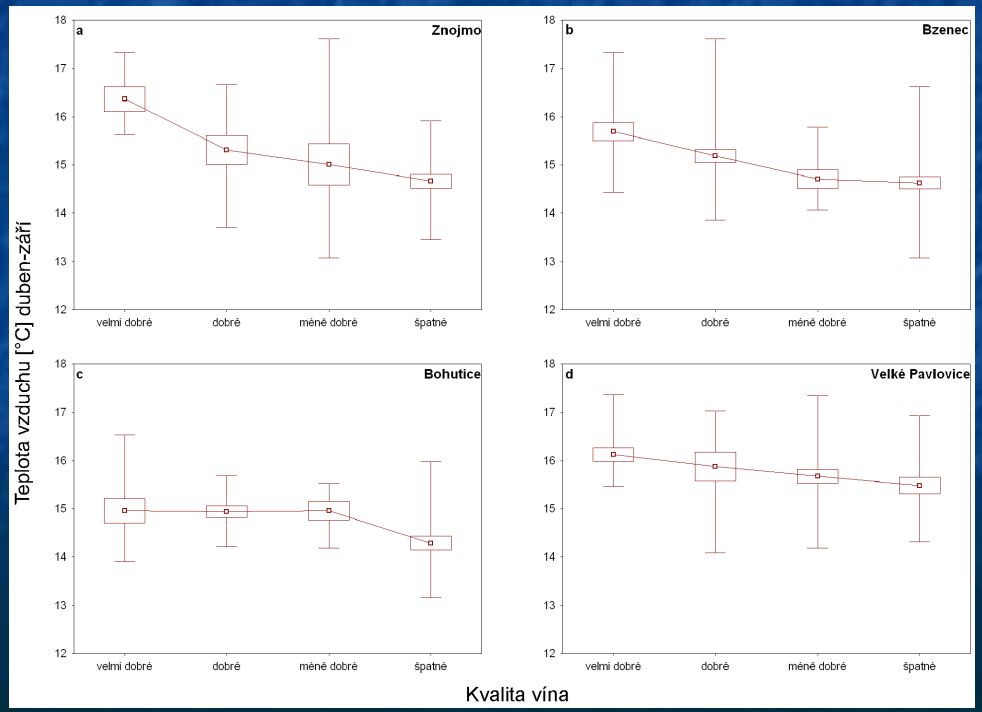
Time series of beginning of vintage (a) and their decadal averages (b) for South Moravia in the period 1800-2007

- For application of the linear regression model,calibration/verification between Znojmo vintage data (predictor) and Brno temperatures (predictand) was performed, separating whole period into two parts with 38-years always avalaible 1800-1847, 1848-1890
- Linear model was calculated for first part and verified with second part and vice versa
- For whole series was used calibration perion 1848-1890
- The suitability of the regression model was evaluated by correlation coeficient (normal, squared), RMSE and other statistical characteristic
- r = 0,57-0,66, RMSE = 0,633-0,844
- Results are similar as temperature reconstruction of the vegetation period from tree rings in the North Bohemia



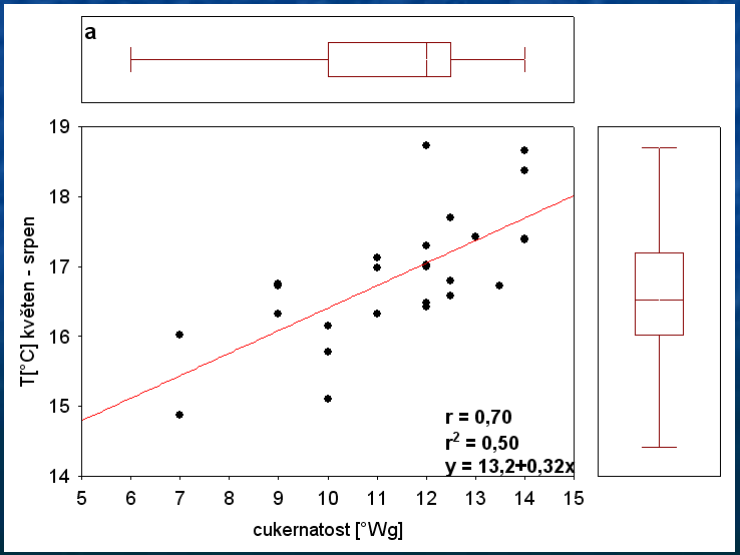
Quality of wine – subjective

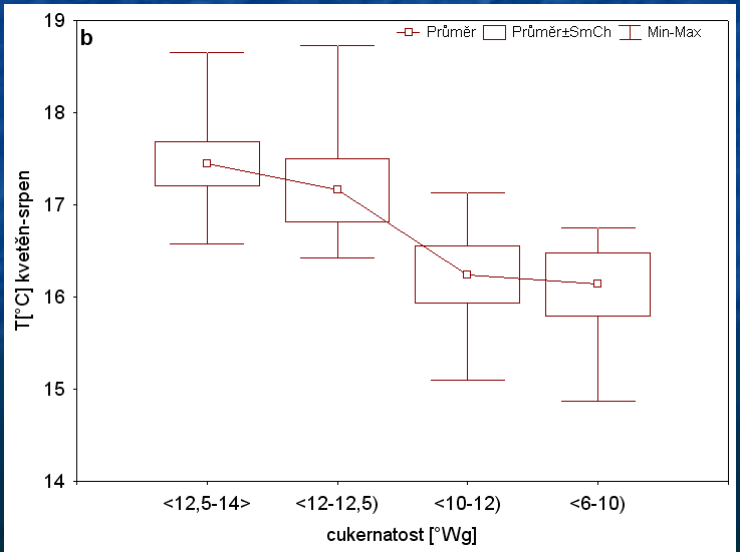
- Is often a reflection of the temperature and humidity patterns that precede the harvest – sweet wine (warmer and drier weather), low sugar content (cold and rainy weather)
- For Bzenec (1800–1899), Znojmo (1802–1845), Bohutice (1861–1912) a Velké Pavlovice (1926–1998) is analysed with respect to temperatures corresponding to excellent, good, averages and bad wine.
- In the case of Bzenec, Znojmo and Velké Pavlovice was found statistical significant difference between mean temperatures corresponded with individual category quality of wine, for Bohutice only difference between firt three category and bad wine



Quality of wine – sugar content

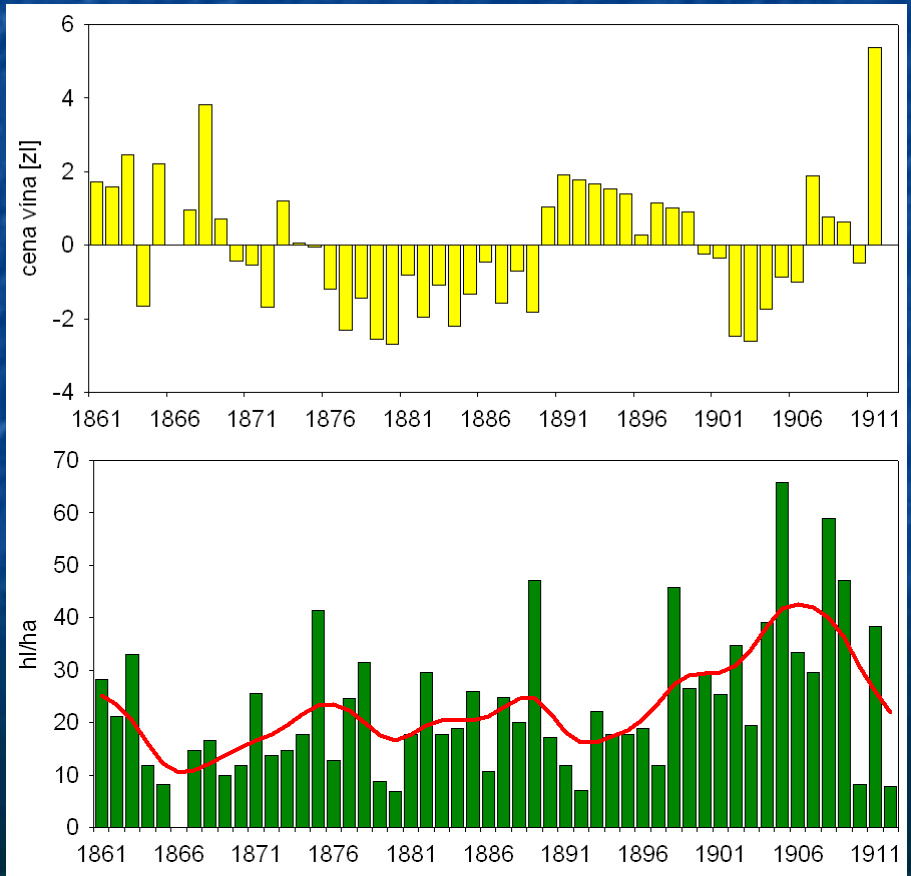
- Exact indicator of quality of wine, sugar content in the berry in the time of vintage
- Znojmo 1846-1872, in the old unit °Wg
- Highest correlation coeficient with mean temperature in Brno was performed in the period May-April (0.70) and from individual month – July (0.58), May (0.52)
- Values of sugar content was divided to the category of calculated quartils and compared with temperatures in Brno





Quantity and price of wine

- Influence by many factors, but one of them are meteorological extremes
- For example Bohutice 1861-1912
- Year 1866 – spring frost destroyed whole harvest
- Year 1912 – hailstorm

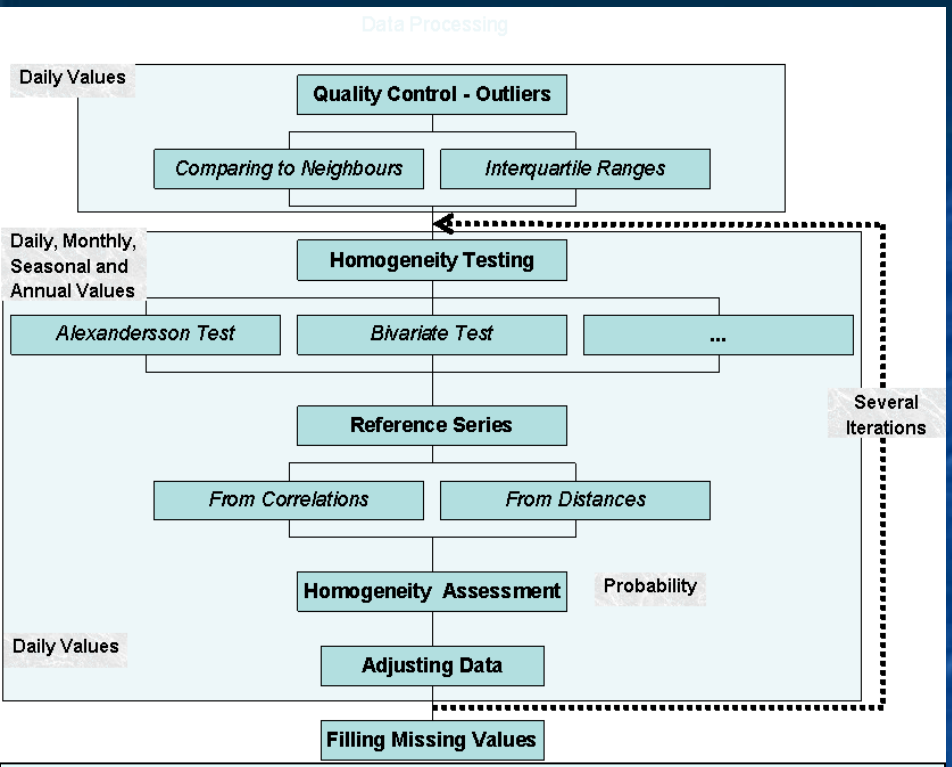


Recent phenology data as indicator of climatic change

- Long tradition of the phenological observations (began in the 1780s, Antonín Strnad)
- Phenological yearbooks: from 1923, without wine observations
- The guideline for observers Vitis vinifera (vine) was set up in 1956, but replaced by the new CHMI methodology instruction number 3 in 1984. This case study researched available period 1984-2007.
- For this study was select Velké Pavlovice, where is situate the phenological and climatological station belong to the CHMI network

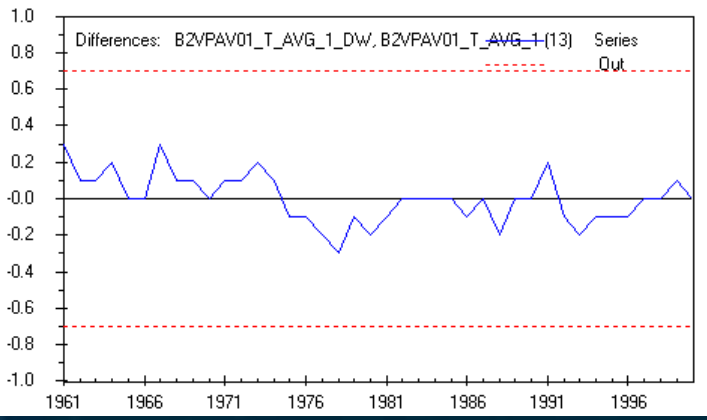
Beginning of the phenophases were correlated with these meteorological characteristics:

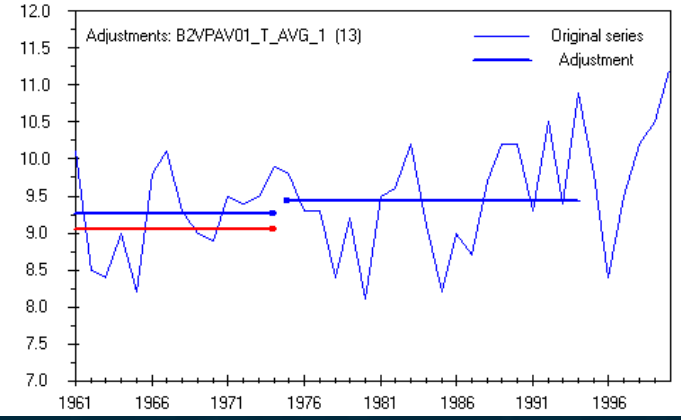
meteorological characteristic	short cut	unit	B2VPAV01
average temperature	T	°C	9.4
active sum of the temperature higher than 5°C	ΣT >5°C	°C	3464.1
active sum of the temperature higher than 10°C	ΣT >10°C	°C	3018.5
maximum temperature	TMA	°C	14.2
absulute maximum temperature	TMA MAX	°C	30.9
active sum of the maximumum temperature > 5°C	ΣTMA >5°C	°C	5126.3
active sum of the maximum temperature > 10°C	ΣTMA >10°C	°C	4732.1
minimum temperature	TMI	°C	5.0
sunshine duration	SSV	hour	1785
water vapour	E	hPa	9.3
precipitation	SRA	mm	494
number of the days with precipitation > 0.1 mm	SRA > 0.1 mm	day	124
number of the days with precipitation > 1 mm	SRA > 1 mm	day	80
number of the days with precipitation > 5 mm	SRA > 5 mm	day	29
evapotranspiration	PEVA	mm	613.6

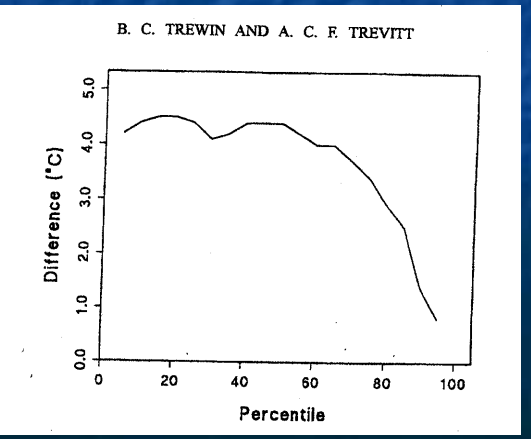


Štěpánek, P., Zahradníček, P., Skalák, P., Data quality control and homogenization of the air temperature and precipitation series in the Czech Republic in the period 1961-2007, *Adv.Sci.Res.*, 3, p. 23-26, 2009.

1. Quality control: comparing of the values to values of the neighbours stations. Errors were replaced with new calculated value
2. Homogeneity testing: SNHT, Bivariate
3. Adjusting daily data: method of the variable correction
4. „Technical series": without outliers, break points and fill all gaps for the period 1961-2007 (268 climatological stations and 789 precipitation stations) by method IDW and local linear regresion



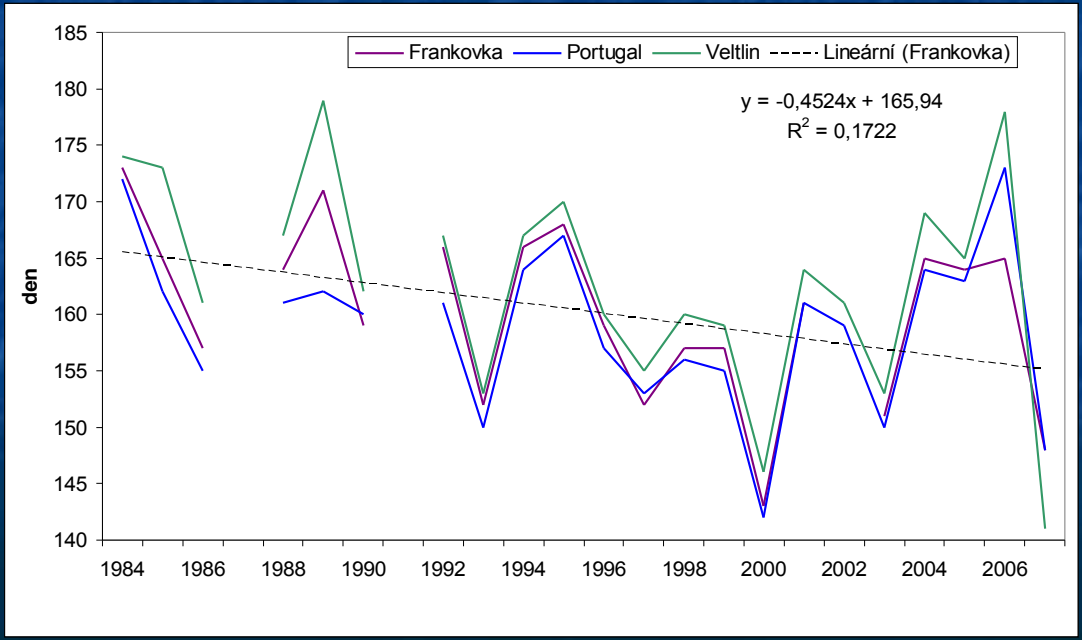


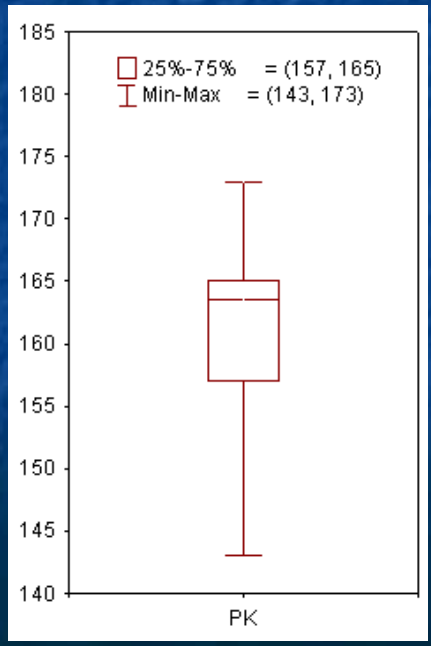


Begining of flowering - present

AVG	10th.perc	25th.perc	50th.perc	75th.perc	90th.perc	STD
10.6	31.5	7.6	14.6	15.6	18.6	7.3

- earliest phenophase (Frankovka): 23rd. May 2000
- latest phenophase (Frankovka): 22nd. June 1984
- variability: about 30 days





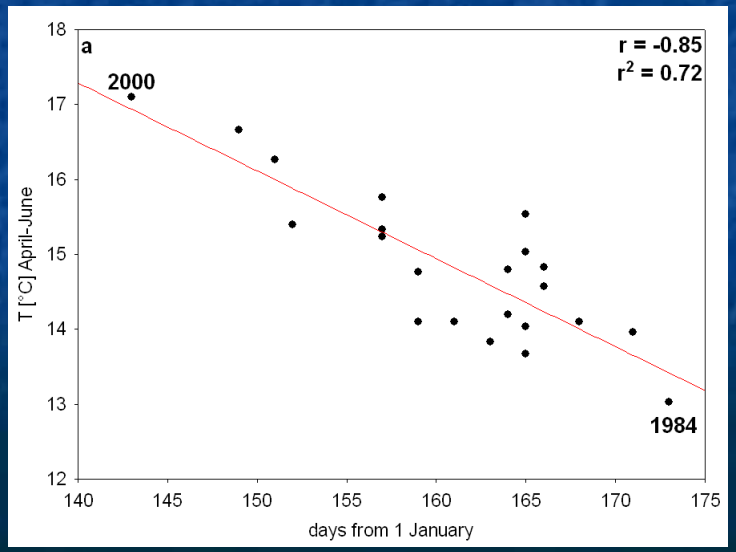
Begining of flowering - present

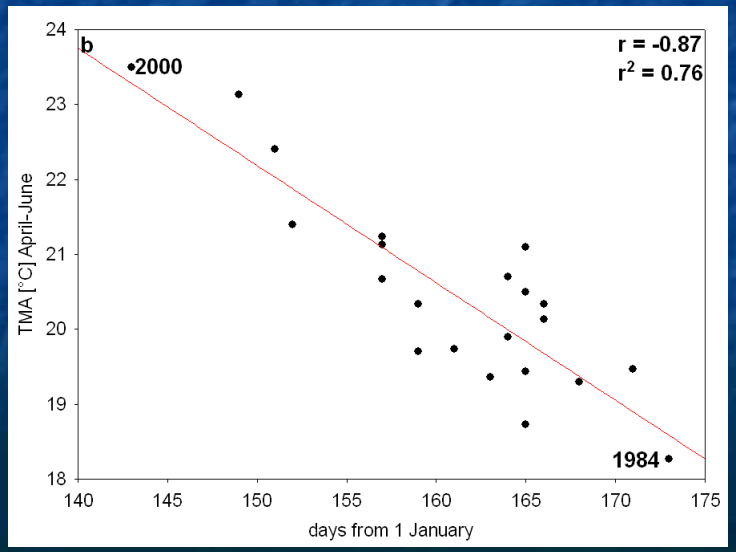
Table. Correlation between the beginning of flowering of the variety Frankovka and meteorological characteristics for the period 1984-2007 at the station Velké Pavlovice (in italics statistically unimportant, p = 0.05)

	IV	V	VI	IV-V	V-VI	IV-VI
T	-0,53	-0,73	-0,63	-0,80	-0,79	-0,85
ΣT >5°C	-0,53	-0,72	-0,63	-0,79	-0,79	-0,84
ΣT >10°C	-0,49	-0,73	-0,62	-0,78	-0,79	-0,80
TMA	-0,59	-0,79	-0,67	-0,84	-0,83	-0,87
TMA MAX	*-0,40*	-0,47	-0,60	-0,61	-0,67	-0,74
ΣTMA >5°C	-0,58	-0,79	-0,67	-0,84	-0,83	-0,87
ΣTMA >10°C	-0,60	-0,78	-0,67	-0,83	-0,83	-0,83
TMI	*-0,24*	-0,49	-0,5	-0,53	-0,63	-0,67
SSV	-0,64	-0,51	-0,58	-0,77	-0,68	-0,78
E	*-0,18*	*-0,30*	*-0,19*	*-0,39*	*-0,31*	*-0,38*
SRA	*0,40*	0,42	*0,04*	0,53	*0,27*	0,48
SRA > 0,1 mm	0,66	*0,02*	*0,31*	0,54	*0,24*	0,57
SRA > 1 mm	0,49	*0,34*	*0,33*	0,57	*0,40*	0,62
SRA > 5 mm	0,42	*0,26*	*0,16*	0,46	*0,29*	0,51
PEVA	-0,71	-0,70	-0,59	-0,80	-0,71	-0,78

Begining of flowering - present

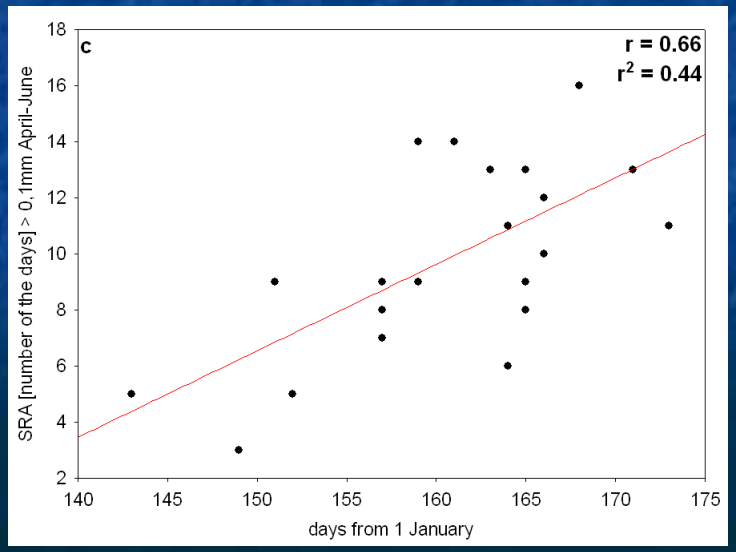
- Beginning of flowering is most influence by temperature conditions of the previous period April-June.
- From the single month is close relationship with the May.
- The strongest correlation was show with the maximum temperature.
- Correlation between beginning of flowering and average, maximum temperature, active sum of the temperature higher then 5 a 10°C is very high and it is mean the temperature is very significant factor for evolution of the grapevine.

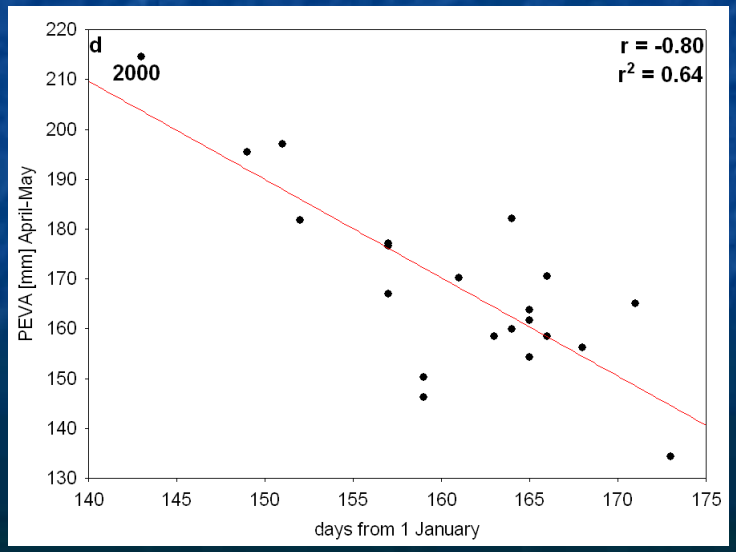




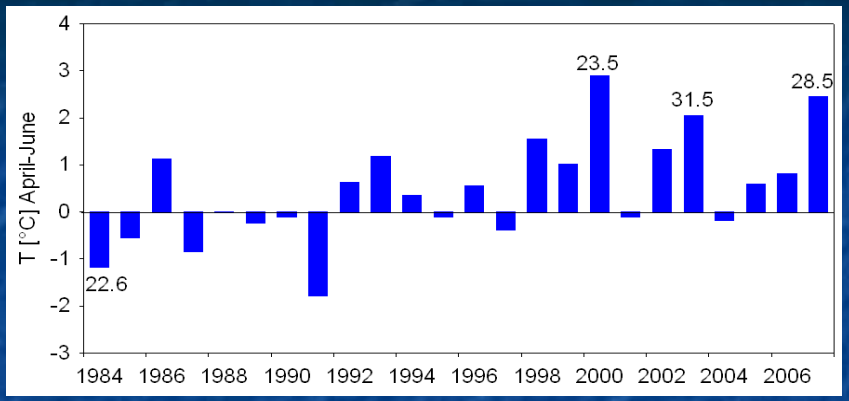
Begining of flowering - present

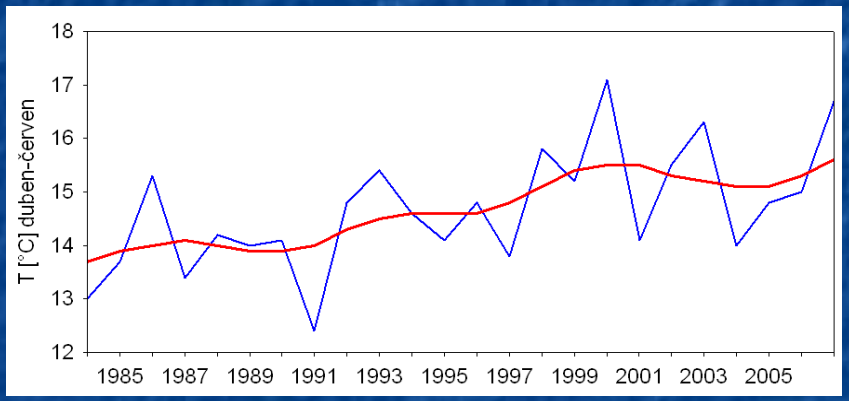
- From the other meteorological elements is begging of flowering influence by sunshine duration, mainly in the month April and in the period April-June.
- Precipitation and number of the precipitation´s days have positive correlation relationship with this phenophase. Less precipitation mean earlier start of flowering. This result could be affect by temperature, because generally speaking, rainy weather is colder and vice versa.
- Strong correlation is with potencial evapotranspiration too.
- Unsignificant correlation with water vapour

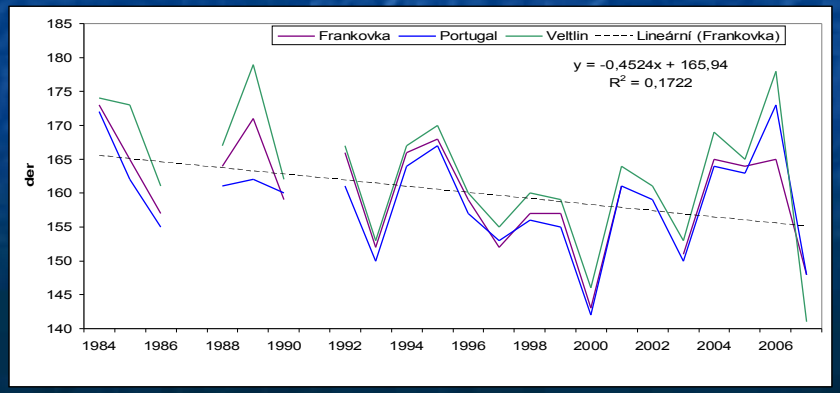




April-June temperature





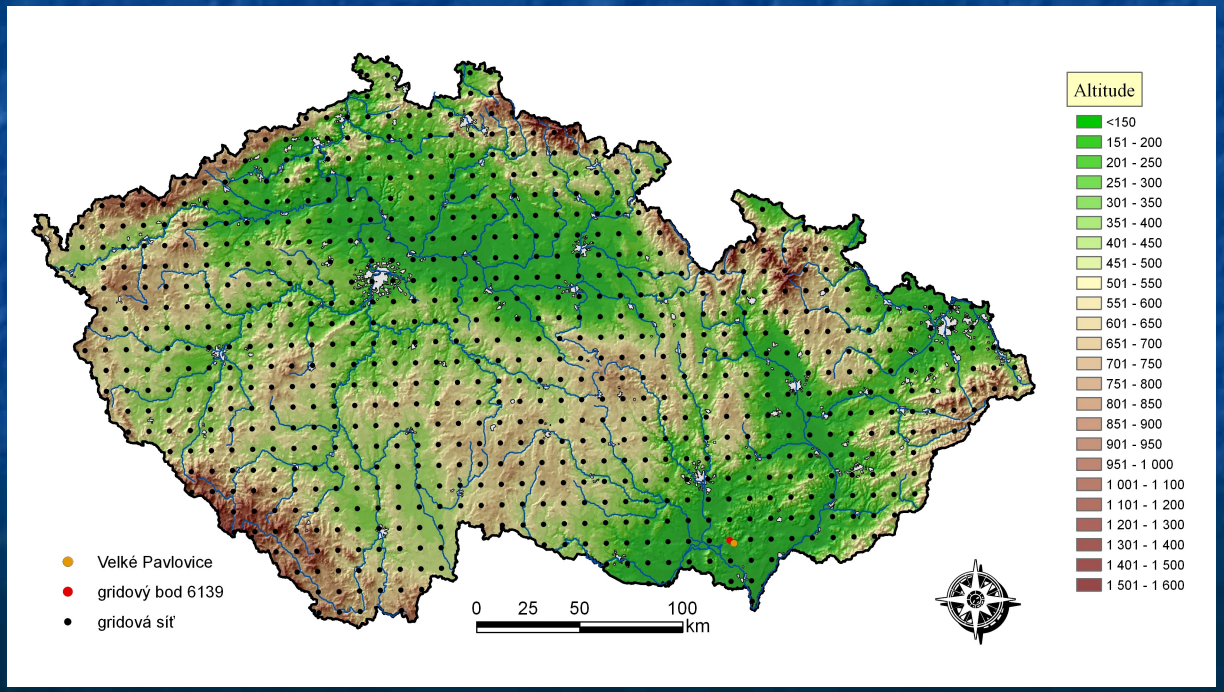


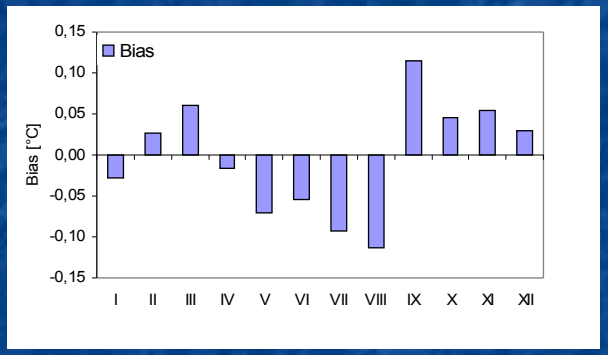
- the biggest diference from the long-term average 1961-2000 at the station Velké Pavlovice was measured in the years 2000 and 2007 = phenophase started very quickly, almost 20 days earlier
- In the year 1984 the temperature of the April-June was 1.2 lower than long-term average = beginning of flowering started 14 days later
- Year 1991 was very cold (-1.9°C) and vine was damaged by late spring frost
- In the period 1984-2007 temperature increase about 0.5°C per 10 year in the Velké Pavlovice and beginning of flowering is still earlier. In the 80th years was about 8 days late. The linear trend is 4.5 days per 10 years.

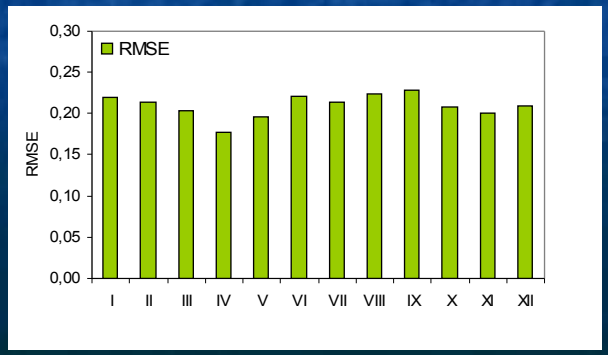
Prediction of beginning of phenophases in the 21. century

- This study work with hypothesis that increase of the temperature will be continued.
- For the future were calculated change of the beginning of phenophases in the depend on the temperature
- Values of the future temparature were prepared by team of the Petr Štěpánek (CHMI Brno), Petr Skalák and Aleš Farda (both CHMI Praha)
- Within the CECILIA project, the regional climate model ALADIN Climate/CZ is driven by GCM ARPEGE with the IPCC A1B emission scenario
- Two time slices: 2021-2050 and 2071-2100
- For the territory of the Czech Republic was create the new gridded dataset with spatial resolution 10*10 km based on records stored in the CHMI climatological database.

- For prediction grapevine phenophases in the future was necessery take temperature from the gridded dataset.
- The nearest grid point from the Velké Pavlovice is 6139 (2,5 km distanc and similar altitude).
- The correlation between these two point is 0.999 (p = 0.05); annual Bias = 0.00; annual RMSE = 0.21; annual MAE = 0.15



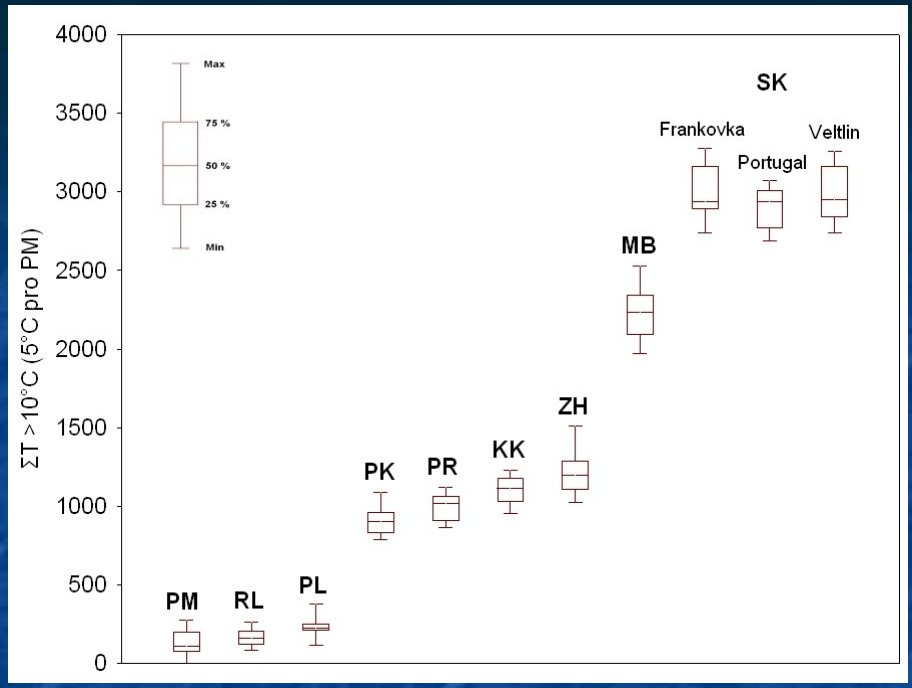




- **2 methods**
  - Linear regresion model between average temperature and phenophase

Fenofaze	měsíc	regresní rovnice	r	r^2
PM	II-III	y=90,6151-2,2094t	-0,45	0,20
RL	II-IV	y=129,8758-3,8382t	-0,70	0,49
PL	III-IV	y=150,1331-4,4178t	-0,71	0,51
PK	IV-VI	y=251,5127-6,1081t	-0,85	0,72
PR	IV-VI	y=263,7894-6,6322t	-0,87	0,75
KK	IV-VI	y=287,8267-7,8344t	-0,92	0,84
ZH	IV-VI	y=326,8984-10,0658t	-0,86	0,73
MB	IV-VI	y=331,0754-6,9654t	-0,75	0,56
SK-FR	IV-IX	y=385,5607-6,4746t	-0,45	0,20
SK-MP	IV-IX	y=417,2284-9,0135t	-0,71	0,51
SK-VZ	IV-IX	y=375,4985-5,9059t	-0,50	0,25

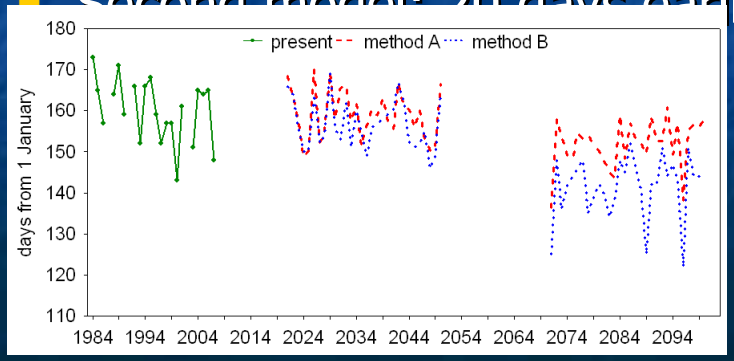
Active sum of the temperature: for each phenophase was calculated median active sum of the temperature > 10°C, which was achieved in the day of beginning of phenophase and for this value was calculate the start of the phenophase in the future for each year in the time scale 2021-2050 and 2071-2100

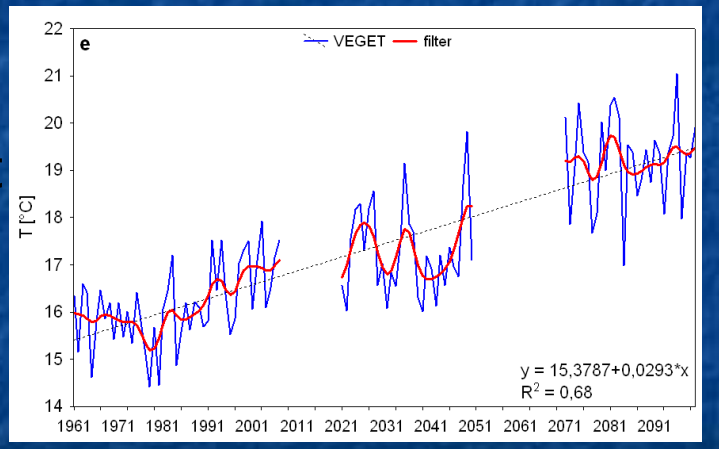


Charakteristiky	PM	RL	PL	PK	PR	KK	ZH	MB	SK-FR	SK-PM	SK-VZ
počet roků	21	20	24	21	21	20	22	21	21	21	21
průměr	133,7	163,9	227,2	901,2	991,4	1103,6	1215,4	2223,0	3004,6	2888,1	2995,5
minimum	0,0	82,9	112,6	789,4	863,2	954,4	1022,2	1970,2	2736,3	2686,8	2736,3
10. percentil	36,1	110,1	145,6	809,0	885,7	979,5	1041,7	2067,5	2786,1	2720,6	2778,9
25. percentil	79,1	125,1	213,4	830,5	907,5	1033,6	1106,6	2093,2	2893,9	2773,3	2842,5
medián	**108,9**	**158,1**	**224,0**	**902,0**	**1019,6**	**1116,9**	**1200,5**	**2234,6**	**2938,1**	**2938,1**	**2951,8**
75. percentil	199,1	202,5	251,9	960,1	1060,5	1180,1	1284,3	2340,1	3162,1	3008,5	3162,1
90. percentil	268,3	238,7	278,7	988,8	1089,5	1203,5	1414,4	2423,4	3256,6	3015,0	3204,8
maximum	277,8	265,8	379,4	1085,2	1119,9	1231,4	1511,0	2528,8	3280,0	3070,3	3256,6
sm. odchylka	83,1	50,1	54,3	78,0	88,1	86,6	136,8	156,7	180,4	129,2	171,7

	method	AVG	10th.perc	25th.perc	50th.perc	75th.perc	90th.perc	STD
1984-2007		10-VI.	31-V.	7-VI.	14-VI.	15-VI.	18-VI.	7.3
2021-2050	**A**	8-VI.	1-VI.	4-VI.	7-VI.	12-VI.	17-VI.	6.2
	B	6-VI.	30-V.	1-VI.	5-VI.	11-VI.	14-VI.	6.1
2071-2100	**A**	1-VI.	24-V.	29-V.	2-VI.	6-VI.	7-VI.	5.8
	B	22-V.	10-V.	19-V.	24-V.	26-V.	30-V.	7.5

- 2021-2050:
  - First model: about 2 days earlier than average in the present, but 7 day earlier than median.
  - Second model: similar, 2 day earlier than linear regression model
  - STD for both model is lower
- 2071-2100
  - Results of the two models are different
  - First model: 10-12 days earlier
  - Second model: 20 days earlier





Temperature of the vegetation season for grid point 6139

Thank you for your attention