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GLOBAL WARMING AS A BASIS FOR A NEW AGROCLIMATIC REGIONALISATION OF VINE IN SLOVAKIA

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Abstract. The study was devoted to evaluation of a new agroclimatic regionalisation of vine, as influenced by global warming under the conditions of Slovakia. Air temperature changes were evaluated for a reference period of the years 1951-1980, and generated according to regional outputs of the CCCM general circulation model for time horizons of the years 2010, 2030 and 2075. Active air temperature sum for vine growing was given by the mean air temperature t≥10.0°C ($\sum t_{vine}$ in °C). A comparison was made between $\sum t_{vine}$ in the Hurbanovo climatic station that represents habitats of low altitudes (lowlands) and at the climatic station at Liptovský Hrádok that represents a possible upper border of vine growing in Slovakia.

Keywords: global warming, grapevine, Slovakia

INTRODUCTION

Agroclimatic parameters can express environmental needs of plants in values that, in synthetic form, create a basis for agroclimatic regionalisation. Active air temperature sums (periods with daily mean air temperatures t≥10°C) are among the most effective parameters from the complex of energy factors that are related to plants during their ontogenesis.

The goal of this work was to evaluate space-time changes in the distribution of active air temperature sums during the vegetative period of grapevine as influenced by global warming (due to climate change) in the conditions of Slovakia. The results create a basis for a new agroclimatic regionalisation for vine growing on the territory of Slovakia.

The work was performed within a research project 'A study of productive potential of vineyards' in the Department of Biometeorology and Hydrology at the Faculty of Horticulture and Landscape Engineering of the Slovak Agricultural

University in Nitra. The project is connected with the National Climate Program of the Slovak Republic that has been supported by the government since 1994. Generally, this topic has been dealt with on the territory of the Slovak Republic before now [1,2,4] but the productive potential of vine as influenced by climate change impacts has not been studied properly till today.

METHODS

The Slovak Hydrometeorological Institute in Bratislava provided climatic data on air temperature during the reference period of 1951-1980. Space-time spread of air temperature was based on data from 27 climatic stations, taking into account the latitude, longitude and altitude profile of the present and the potential vine growing areas. Supposed changes of air temperatures were generated according to regional outputs of the CCCM general circulation model (Canadian Climate Center Model) for Slovakia, up to time horizons of the years 2010, 2030 and 2075 (tab. 1).

Table 1. Changes of mean air temperatures according to regional outputs of CCCM for Slovakia up to time horizons of the years 2010, 2030 and 2075

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
2010	0.76	0.75	0.97	0.71	0.32	0.66	1.05	1.06	1.01	1.12	1.15	0.96	0.88
2030	1.33	1.49	1.55	1.04	0,78	1.19	1.43	1.45	1.57	1.60	1.48	1.35	1.35
2075	2.59	2.90	2.80	2.22	2,16	2.82	3.40	3.68	3.59	3.27	2.88	2.54	2.90

The active air temperature sums during vegetative period of vine were selected for evaluation from among the complex of temperature parameters related to the productive process. This period is limited by daily mean air temperatures $t \geq 10$°C ($\sum t_{vine} \geq 10.0$°C). Active air temperature sums were statistically evaluated by means of linear regression. Vine varieties were separated into 3 categories according to temperature needs during their vegetative periods (according to harvest maturity):

Very early, early and medium early varieties Σt_{vine} = 2000-2500°C

Irsay Oliver, Perle von Szaba, Vitra, Dora, Olšava Dora, Opál, Julski biser, Panónia kincse, Malinger, Bouvier, Diamant, Aurélius

Medium and medium late varieties Σt_{vine} = 2501-2800°C

Devín, Chardonnay, Veltliner fruehrot, Mueller Thurgau, Pinot gris, Muscat Ottonel, Muškát moravský, Neronet, Weiss Riesling, Pálava, Portugieser blau, Pinot blanc, Pinot noir, Zweigeltrebe, Traminer rot, Sauvignon, Neuburger, Welschriesling

Late and very late varieties Σt_{vine} = 2801-3000°C

Veltliner gruen, Cabernet Sauvignon, Leanyka, Blaufrankisch, Muscat a petits grains blanc, Guzaľ Kara, Alibernet, Furmint, Harslevelue, André.

RESULTS AND DISCUSSION

Vine (*Vitis vinifera* L.) has its origin in the East and Southeast Mediterranean. In Europe it is cultivated predominantly between 35° and 45° of northern latitude, but worldwide it can be found in a wider range, both in the Northern and Southern hemisphere. According to its energy and environment needs, vine can be considered as a warmth-requiring plant. Its active air temperature needs during the vegetative period range from 2000 to 3000°C, depending on the harvest maturity of different varieties [2].

CHANGES IN VINE PHENOLOGY

Environmental conditions underlie phenological conditions of vine growing as well as agroclimatic regionalisation. According to harvest maturity, the duration of vine vegetative periods is as presented below [5]:

Early, medium early varieties	121-140 days,
Medium and medium late varieties	141-170 days,
Late varieties	171-180 days,
Very late varieties	181 and more.

Temperature and water regimes influence vine phenology first of all. Acceleration of onset and delay of termination of vine vegetative period is caused by a rise of temperature up to the horizons of the years 2010, 2030 and 2075, as compared to the reference period of 1951-1980, in the sense of regional outputs of the presented CCCM global circulation model (tab. 1, 2).

According to calculations, a significant progressive extension of vine vegetative period may occur in the south (climatic station Hurbanovo), where the duration of the period will rise from 189 to 219 days (by about 18%), and in the north (climatic station Liptovský Hrádok) – from 138 to 172 days (by about 25%).

Phenological data can be utilized also for the estimation of the time horizon when the temperature condition allows successful vine growing on the territory of Slovakia. For instance, the late vine varieties need 170 days of active temperatures from budding to harvest maturity. At present, this condition can be observed in Hurbanovo (115 m above sea level), but consequently the altitude of favourable conditions will move, due to global warming, up to the climatic station Liptovský Hrádok in the horizon of the year 2075, while at higher altitudes successful vine growing is not expected even on this horizon.

Table 2. Onset (o), termination (t) and duration (d) of vine vegetative period ($t \geq 10°C$) in the reference period of 1951-80 and up to the time horizons of the years 2010, 2030 and 2075

Climatic station	1951-80			2010			2030			2075		
	o	t	d	o	t	d	o	t	d	o	t	d
Bardejov	28.4	3.10	158	25.4	10.10	168	22.4	12.10	173	14.4	22.10	191
Bratislava, airport	15.4	13.10	181	11.4	20.10	192	9.4	23.10	197	1.4	1.11	214
Čadca	7.5	28.9	144	4.5	5.10	154	2.5	9.10	160	24.4	20.10	179
Červený Kláštor	7.5	27.9	143	4.5	4.10	153	2.5	8.10	159	24.4	18.10	177
Hurbanovo	12.4	15.10	186	8.4	22.10	197	6.4	24.10	201	29.3	3.11	219
Kamenica n/ C.	22.4	7.10	168	17.4	13.10	179	15.4	16.10	184	8.4	27.10	202
Košice, letisko	21.4	8.10	170	16.4	14.10	181	14.4	17.10	186	8.4	26.10	201
Kuchyňa - Nový Dvor	21.4	12.10	174	16.4	19.10	186	14.4	21.10	190	6.4	31.10	208
Liptovský Hrádok	8.5	23.9	138	5.5	30.9	148	3.5	3.10	153	25.4	14.10	172
Moldava n/ B.	19.4	8.10	172	15.4	14.10	182	13.4	17.10	187	7.4	26.10	202
Myjava	26.4	7.10	164	22.4	14.10	175	20.4	17.10	180	12.4	26.10	197
Nitra	15.4	15.10	183	10.4	22.10	195	8.4	25.10	200	31.3	2.11	216
Oravská Lesná	22.5	12.9	113	19.5	20.9	124	16.5	24.9	131	8.5	6.10	151
Piešťany	18.4	12.10	177	14.4	19.10	188	12.4	22.10	193	4.4	31.10	210
Plaveč o. Stará Ľubovňa	4.5	29.9	148	1.5	6.10	158	28.4	9.10	164	20.4	19.10	182
Poprad	12.5	22.9	133	9.5	29.9	143	6.5	3.10	150	28.4	13.10	168
Prievidza	23.4	9.10	169	19.4	16.10	180	16.4	19.10	186	9.4	29.10	203
Rimavská Sobota	18.4	7.10	172	14.4	13.10	182	12.4	16.10	187	5.4	26.10	204
Rožnava	21.4	7.10	169	17.4	13.10	179	15.4	16.10	184	8.4	25.10	200
Sliač	25.4	4.10	162	21.4	11.10	173	19.4	14.10	178	11.4	24.10	196
Somotor	14.4	12.10	181	10.4	18.10	191	8.4	21.10	196	1.4	30.10	212
Štrbské Pleso	7.6	4.9	89	2.6	13.9	103	30.5	18.9	111	19.5	2.10	136
Švermovo	21.5	16.9	118	18.5	23.9	128	15.5	26.9	134	6.5	8.10	155
Trenč. Biskupice	21.4	10.10	172	16.4	17.10	184	14.4	20.10	189	7.4	30.10	206
Trstená - Ústie n/ P.	12.5	26.9	137	10.5	4.10	147	7.5	7.10	153	29.4	18.10	172
Vígľaš – Pstruša	26.4	3.10	160	22.4	10.10	171	20.4	13.10	176	12.4	23.10	194
Žiharec	15.4	14.10	182	11.4	20.10	192	9.4	23.10	197	1.4	1.11	214

SPACE-TIME CHANGES OF $\sum t_{VINE}$

The indirect dependence between an increase of altitude and $\sum t_{vine}$ is generally valid, but also a rise of $\sum t_{vine}$ up to the time horizons of the years 2010, 2030 and 2075, as compared with the reference period of 1951-1980, can be observed (tab. 3). A shift of the upper borders of possible vine grow areas, as influenced by altitude, can be proposed on the basis of correlation analyses (fig. 1) for different varieties given in table 4.

Vine growing areas on the territory of Slovakia according to $\sum t_{vine}$ computed for the reference period of 1951-1980 and for 3 categories of varieties according to their harvest maturity [2] are given in figure 2. The most productive vineyards for late and very late varieties ($\sum t_{vine} \geq 2800$°C) can be found in a range of altitudes of 110-200 m. Today this area covers Záhorská nížina, the Danubian lowland and the East-Slovak lowland. Favourable conditions for medium and medium late varieties can be found in the folds of the rivers Ipeľ, Rimava, Slaná and Hornád, and for early or moderate varieties – in the folds of the upper Nitra river, Hron, and in some parts of south Slovakia.

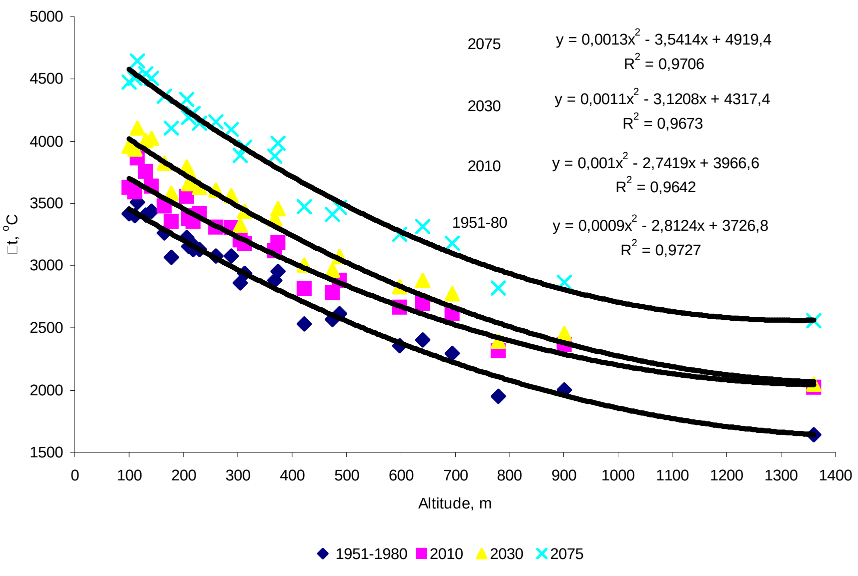

Fig. 1. Dependence of potential Σt_{vine} as influenced by altitude in Slovakia up to the time horizons of the years 1851-1980, 2010, 2030 and 2075

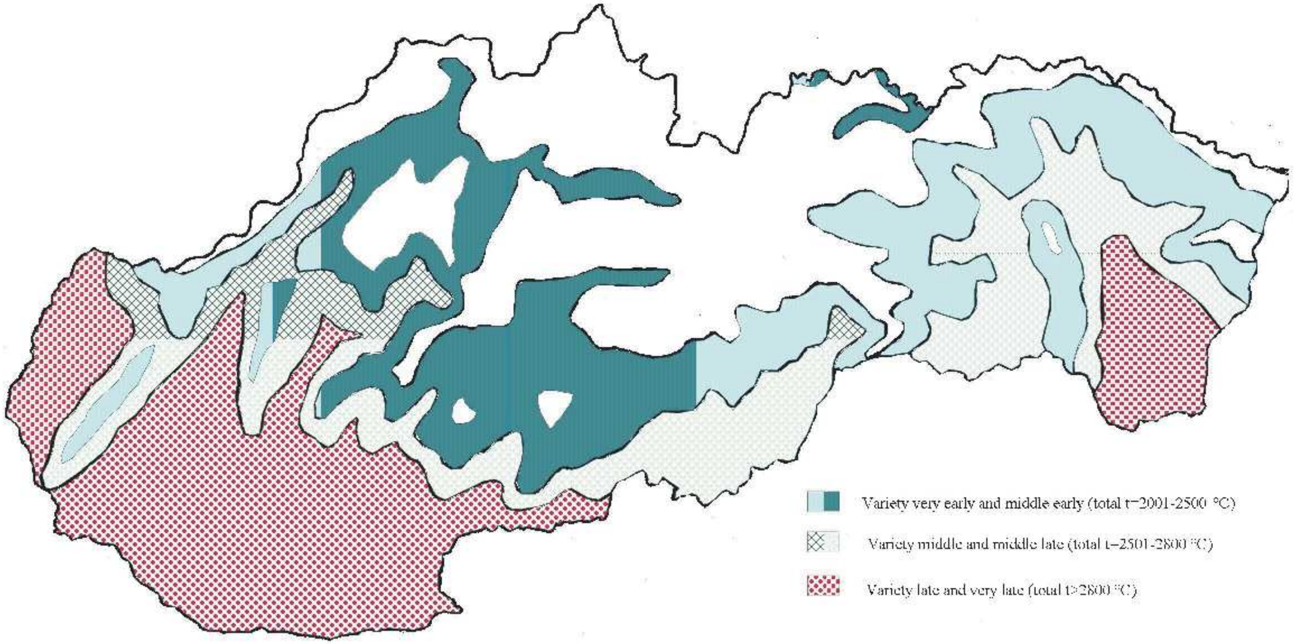

Fig. 2. Growing areas on the territory of Slovakia a according to $\sum t_{vine}$ computed for reference period of years 1951-1980

Table 3. Active air temperature totals during vine vegetative period ($\sum t_{vine}$) v °C in the reference period of 1951-80 and up to the time horizons of the years 2010, 2030 and 2075

Climatic station	1951-80	2010	2030	2075
Bardejov	2385.2	2621.5	2750.0	3256.0
Bratislava, airport	2958.0	3224.5	3362.6	3891.0
Čadca	2031.3	2257.9	2390.6	2889.7
Červený Kláštor	2009.5	2235.2	2367.3	2854.5
Hurbanovo	3072.4	3343.0	3473.0	4017.3
Kamenica n/ C.	2603.2	2857.8	2990.5	3511.0
Košice, letisko	2691.8	2947.8	3081.0	3572.1
Kuchyňa - Nový Dvor	2764.3	3035.4	3160.9	3690.7
Liptovský Hrádok	1922.9	2143.8	2263.4	2751.9
Moldava n/ B.	2732.0	2979.0	3112.6	3604.8
Myjava	2486.3	2738.4	2869.7	3375.0
Nitra	2991.5	3270.9	3410.1	3931.7
Oravská Lesná	1450.1	1665.1	1793.5	2259.1
Piešťany	2805.9	3069.5	3206.1	3729.6
Plaveč o. Stará Ľubovňa	2126.5	2355.5	2489.8	2983.6
Poprad	1818.3	2036.9	2174.5	2647.1
Prievidza	2609.8	2866.7	3010.3	3523.9
Rimavská Sobota	2745.7	2993.1	3126.8	3640.0
Rožnava	2637.4	2882.2	3014.9	3514.5
Sliač	2469.6	2719.0	2849.1	3361.1
Somotor	3009.2	3265.1	2402.8	3918.2
Štrbské Pleso	1045.6	1275.9	1404.1	1892.6
Švermovo	1517.1	1725.4	1845.9	2327.6
Trenč. Biskupice	2664.7	2933.5	3068.2	3585.4
Trstená - Ústie n/ P.	1866.9	2089.4	2219.0	2709.1
Vígľaš – Pstruša	2400.4	2648.4	2777.9	3288.0
Žiharec	2972.4	3229.3	3367.5	3895.4

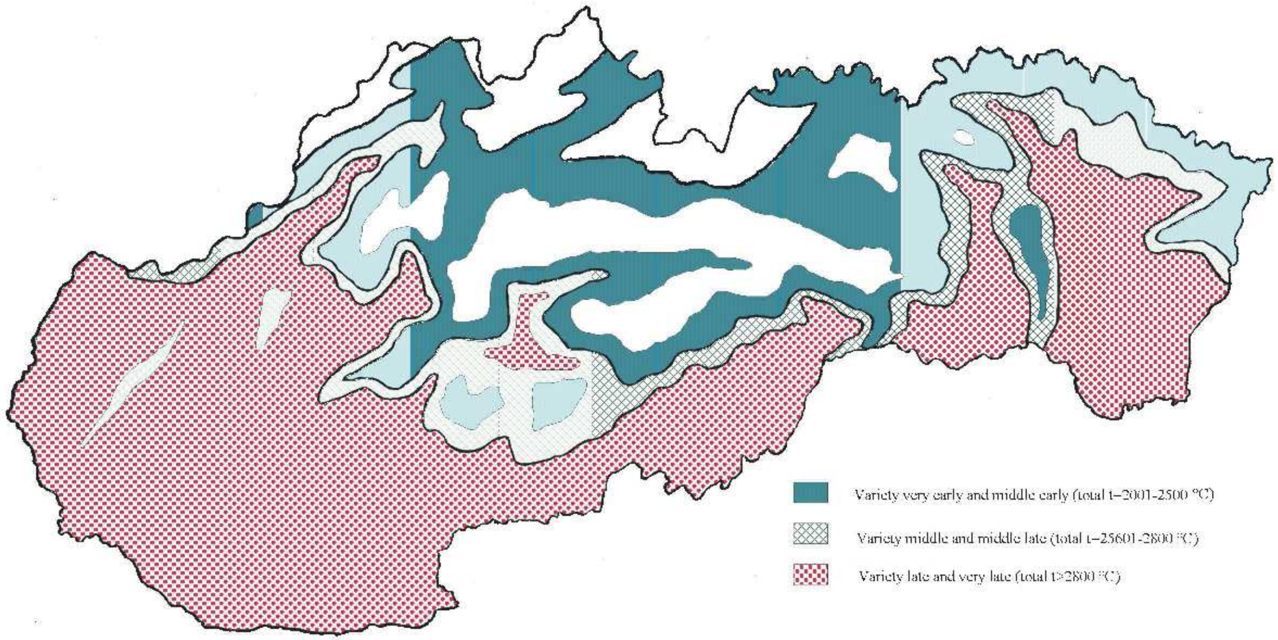

Fig. 3. Vine growing zone for 3 categories of varieties in horizon of year 2030

Table 4. Vine growing area distribution in Slovakia according to altitudes, up to the time horizons of the years 1851-1980, 2010, 2030 and 2075

Years	$\sum t_{vine}$: ≥ 2800°C	$\sum t_{vine}$: ≥ 2500°C	$\sum t_{vine}$: ≥ 2000°C
	Altitude in m		
1951-1980	170	300	550
2010	290	420	710
2030	360	700	850
2075	570	>700	850

Vine growing zones for 3 categories of varieties in the horizon of the year 2030 are given in figure 3. A significant shift of the growing areas of each category towards a higher altitude can be observed. The limiting altitude, from the climatic point of view, for growing early vine varieties is supposed to be about 850 m above sea level in the time horizon of the year 2075.

CONCLUSIONS

1. The temperature and water regimes generated according to the CCCM global circulation model outputs under the conditions of Slovakia will significantly influence the duration of the vegetative period of vine.

2. Global warming will cause a prolongation of the vegetative period of vine by about 18% (from 189 to 219 days) in the southern part of Slovakia, and by about 25% (from 138 to 172 days) in the northern part.

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GLOBALNE OCIEPLENIE JAKO PODSTAWA NOWEJ AGROKLIMATYCZNEJ REJONIZACJI WINOROŚLI NA SLOWACJI

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Streszczenie. Przedstawiono nową agroklimatyczną rejonizację uprawy winorośli na terenie Słowacji w kontekście zmian temperatury powietrza w procesie globalnego ocieplenia. Przeprowadzone symulacje wykazują, że zasięg uprawy winorośli zwiększy się odpowiednio do wysokości 290, 360 i 570 m. npm w kolejnych horyzontach czasowych lat 2010, 2030 i 2075.

Słowa kluczowe: globalne ocieplenie, winorośl, Słowacja