Current climate change in the Oplenac wine-growing district (Serbia)

Darko Jaksic[1], Mirjam Vujadinovic Mandic[2], Ana Vukovic Vimic[2], Veljko Perovic [3], Jordana Ninkov [4], Pierfederico La Notte [5], Ivan Bradic[6]

[1] *Centre for Viticulture and Oenology Niš, office in Belgrade, 11111 Belgrade, bul. kralja Aleksandra 84, Serbia;* [2] *Department of Viticulture, Institute of Horticulture, Faculty of Agriculture, University of Belgrade, 11080 Belgrade, Nemanjina 6, Serbia;* [3] *Institute for Biological Research "Siniša Stanković", National Institute of the Republic of Serbia, University of Belgrade, 11060 Belgrade, bul. despota Stefana 142, Serbia;* [4] *Laboratory for Soil and Agroecology, Institute of Filed and Vegetable Crops, National Institute of the Republic of Serbia, 21000 Novi Sad, Maksima Gorkog 30, Serbia;* [5] *Consiglio Nazionale delle Ricerche, Istituto per la Protezione Sostenibile delle Piante (IPSP) 70126 Bari, Via Amendola 122/D, Italy;* [6] *Centre for Viticulture and Oenology Niš, office in Aleksandrovac, 37230 Aleksandrovac, 29. Novembra 21, Serbia*
Presenting author: Darko Jaksic (darkojaksic@yahoo.com.au)

Abstract

Serbian autochthonous vine varieties Smederevka (white wines) and Prokupac (rosé and red wines) are the primary representatives of typical characteristics of wines and *terroir* of numerous wine-growing areas in Serbia. In the past, these varieties were the leading vine varieties, however, as the result of globalization of winemaking and the trend of consumption of wines from widely prevalent vine varieties, they were replaced with introduced international varieties. Smederevka and Prokupac vine varieties are characterized by later time of grape ripening, and relative sensitivity to low temperatures. Climate conditions can be a restrictive factor for production of high-quality grapes and wine, and for the spatial spreading of these varieties in hilly continental wine-growing areas.
This paper focuses on the spatial analysis of changes of main climate parameters, in particular, analysis of viticultural bioclimatic indices that were determined for the purposes of viticulture zoning of wine-growing areas in the period 1961-2010, and those same parameters determined for the current, that is, referential climate period (1988-2017). Results of the research, that is, analysis of climate changes indicate that the majority of examined climate parameters in the Oplenac wine-growing district improved from the perspective of Smederevka and Prokupac vine varieties. These studies of climate conditions indicate that changes of analyzed climate parameters, that is, bioclimatic indices will be favorable for cultivation of varieties with later grape ripening times and those more sensitive to low temperatures, such as the autochthonous vine varieties Smederevka and Prokupac, therefore, it is recommended to producers to more actively plant vineyards with these varieties in the territory of the Oplenac wine-growing district.

Keywords: climate changes, Smederevka and Prokupac vine varieties, Oplenac wine-growing district.

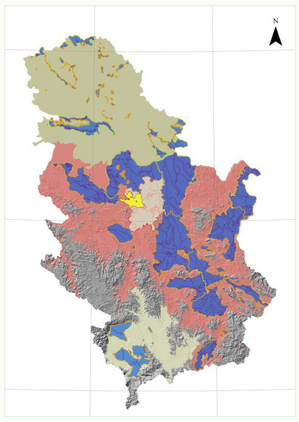
Introduction

Grape vine is one of the agricultural crops most affected by climate changes [1]. Growing temperatures recorded in previous decades in numerous wine-growing areas throughout the globe resulted in quickening, that is, it shortened the length of phenological phases of the grapevine [2, 3, 4, 5, 6]. Climate changes can extend the vegetative period, and quicken phenological phases of the grapevine plant [7, 8]. Because of the shorter duration of phenological phases, grape ripening happens in warmer temperatures, which can have a negative effect on the quality of grapes and wine [9, 10]. With the aim of avoiding such problems, traditional wine-growing areas are making efforts to optimize the combination of variety and rootstock, soil, climate, and vineyard management, with the aim of ensuring that relevant localities are suitable for grapevines in terms of heat and humidity, resulting in high-quality grapes [11]. If such a balance is accomplished, grapes will ripen after the end of the warmest period, in the time of moderate temperatures with higher daily temperature ranges that are favorable for preservation of acidity, flavor, and color [12]. Because local, i.e. autochthonous Serbian varieties Smederevka and Prokupac have later grape ripening times, and because in the past they were not recommended for cultivation in colder wine-growing areas, current climate changes can have positive effects on these varieties.

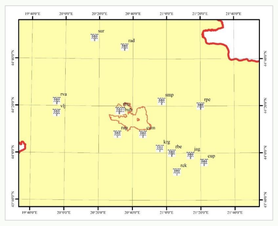
Material and methods

Area studied in this paper was the Oplenac wine-growing district, which occupies hilly terrain in the western part of the Šumadija wine-growing region, in particular, hills around the Venčac mountain, Oplenac peak, and east slopes of the Rudnik mountain [13]. With the area of 36,651 ha [14], it is the second wine-growing district in the region in terms of surface, and it occupies 14.84% of the Šumadija wine-growing region (map 1). However, in terms of quantity, the Oplenac wine-growing district is the most important district in the Šumadija region, as the agricultural census indicates that nearly half out of 1,119.79 ha of vineyards in the Šumadija region were registered in this wine-growing district [15]. Owing to its long-standing tradition of production of high-quality wines, the Oplenac wine-growing district is particularly important both for the Šumadija wine-growing region and for grape production and winemaking in Serbia as a whole. Wine production is organized mostly within family households, and consumers mostly associate this district with characteristics and high quality of white wines from the Sauvignon Blanc variety [13, 16].

Information on climate parameters, i.e. bioclimatic indices were obtained by collecting data from synoptic (main) and climate (regular) stations located in the Oplenac wine-growing district and in central Serbia (map 2). Median climate values (regular) were calculated by using daily data for each year individually and averaging for analyzed climate periods. With the aim of spatial representation of climate characteristics of the Oplenac wine-growing district, data from synoptic and climate stations were interpolated onto the regular lat/lon grid with the horizontal resolution of 1 km, through application of the successive correlation method [17]. Climate data were spatially stored as raster layers, i.e. as TIFF files, and were then processed in the QGIS 2.18 and ArcGIS software, and finally presented in thematic maps. Analyzed climate data was spatially presented as basic climate *terroir* elements broken down per favorability as defined in the Conceptual Multifactorial Spatial *Terroir* model (CMTS model)[14], in classes ranging from 1 (unfavorable) to 5 (most favorable). Bioclimatic indices for the referential period – present (period 1988-2017), being the basic climate *terroir* elements in CMTS models were compared with those same indices calculated from data obtained during the zoning of wine-growing areas for the period 1961-2010 (past).



Mapa 1. Wine-growing areas of Serbia and Oplenac wine-growing district (yellow colour)



Map 2. Spatial distribution of synoptic and climatological stations

Phot. 1. Smederevka v. variety

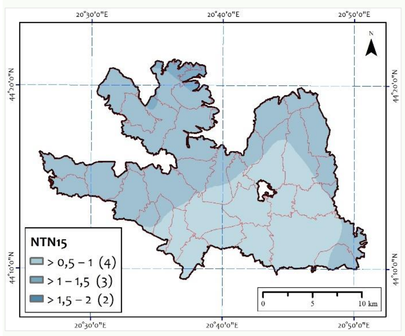
Phot. 2. Prokupac v. variety

Results

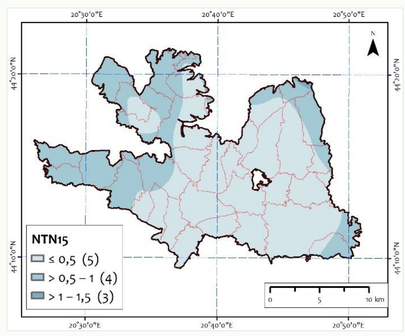
Risk indicators for vines based on extreme temperatures

NTN15 (Average number of days with daily minimum temperature bellow -15°C for the dormant period)

Results of the analysis revealed that, because of the climate changes, the NTN15 for the period 1988-2017 (present) improved significantly in comparison with the NTN15 for the period 1961-2010 (past, map 2 and map 3). With respect to this basic *terroir* element of the CMTS model, currently only 0.21% of the territory of the Oplenac wine-growing district has worse conditions, i.e. value 3 (CMTS model favorable class). A large portion, that is, 45.56% of the territory, has value 4 (very favorable). The majority of this wine-growing district, 54.23% of the territory, has value 5 (most favorable) with 0.5 or less freezing days during grapevine dormancy, which is favorable for grapevine varieties sensitive to low temperatures.



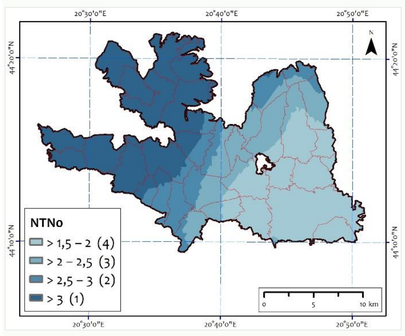
Map 2. Distribution of NTN15; 1988-2017 (past period)



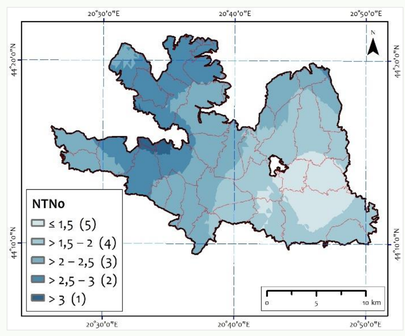
Map 3. Distribution of NTN15; 1988-2017 (present period)

NTNo (Average number of days with daily minimum temperature bellow 0°C for the standard growing season)

Climate changes resulted in improvement of the NTNo, which is favorable for local, i.e. autochthonous grapevine varieties Smederevka and Prokupac. In comparison with the analyzed period 1961-2010 (past), when the most significant western part of the Oplenac wine-growing district had unfavorable conditions (map 4), NTNo in this wine-growing district is now significantly improved (map 5). It was determined that 1.23% of the mountainous part of the territory of the Oplenac wine-growing district has the least favorable class (value 1 according to the CMTS model). A total of 21.38% of the territory has the less favorable class (value 2), while 33.85% of the territory has the favorable class (value 3). It was determined that 31.22% of the territory has the favorable class (value 4), while the most favorable class, which means 1.5 or less freezing days during the vegetative period, was determined for 12.32% of the south-eastern territory of the Oplenac wine-growing district.



Map 4. Distribution of NTNo; 1988-2017 (past period)

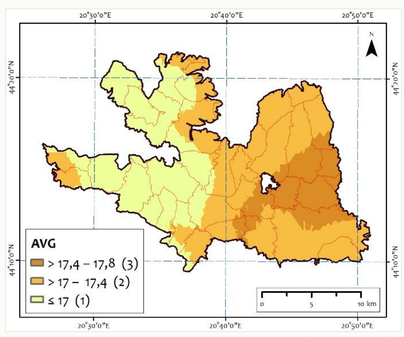


Map 5. Distribution of NTNo; 1988-2017 (present period)

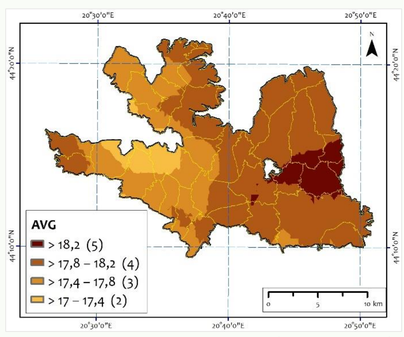
Bioclimatic indices based on vegetation temperature

AVG (Average Vegetation Growing Temperature)

AVG values in the Oplenac wine-growing district increased significantly from the period 1961-2010 (past, map 6) to the present (map 7), that is, they improved. Due to global warming and climate changes, the least favorable AVG class (unfavorable class, that is, value 1 according to the CMTS model) is no longer present in this wine-growing district. This class in the CMTS model corresponds to AVG intermediate class [2]. The less favorable class (value 2) was determined for territories around the mountains, which account for 5.37% of the wine-growing district. The eastern part, which accounts for 27.76% of the wine-growing district was classified as a favorable area (value 3), while 59.37% of the wine-growing district was classified as very favorable (value 4). The most favorable AVG class (value 5) was determined for 7.50% of the territory, which is located in the eastern part of the Oplenac wine-growing district. Favorability classes from 2 to 5 fall into the warm general climate AVG class [2].



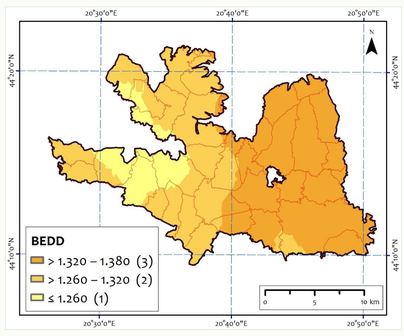
Map 6. Distribution of AVG; 1988-2017 (past period)



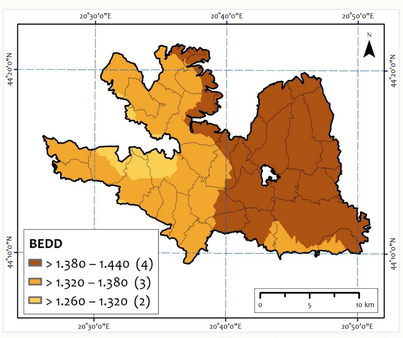
Map 7. Distribution of AVG; 1988-2017 (present period)

BEDD (Biologically Effective Degree Days)

As was determined for other viticultural bioclimatic indices, i.e. basic climate *terroir* elements of the CMTS model, global warming resulted in changes of the BEDD from the period 1961-2010 (map 8) to the present (map 9), which changes significantly increased the possibility of cultivating varieties with later ripening times such as Smederevka and Prokupac varieties. Currently, only 5.44% of the territory in the western part of the wine-growing district that has a higher elevation is classified in the less favorable BEDD class (value 2 in the CMTS model/grape ripening group 5 [18]). A good portion of the wine-growing district (42.99%) located in the western part was classified as favorable (value 3/grape ripening class 6 [18]), while the majority of the territory of the Oplenac wine-growing district (51.57%) was classified as very favorable BEDD class with the value of 4, which is favorable for 7. grape ripening group of grapevine varieties [18].



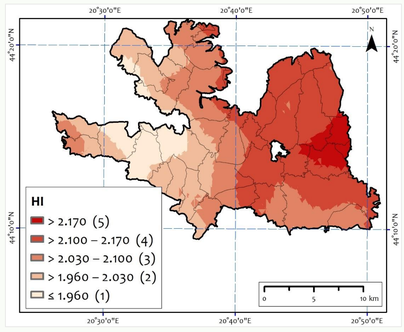
Map 8. Distribution of BEDD; 1988-2017 (past period)



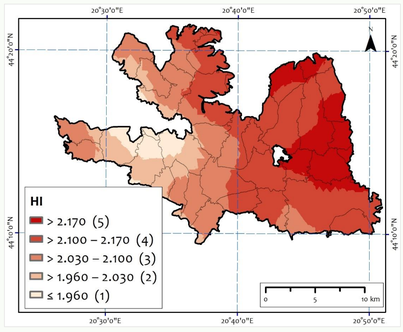
Map 9. Distribution of BEDD; 1988-2017 (present period)

HI (Huglin Heliothermal Index)

Analyzing the two relevant periods, past 1961-2010 (map 10) and present – referential period (map 11), it was concluded that the territory with favorable HI values increased. A total of 4.59% of the mountainous western part of the Oplenac wine-growing district was classified as unfavorable territory (value 1) in accordance with the CMTS model, while 12.08% of the territory of this part of the wine-growing district was classified as less favorable (value 2). A significant portion of the western part of the wine-growing district, i.e. 26.53% was classified as favorable (value 3). These less favorable CMTS model classes fall into the general climate class HI-1 (temperate climate class) [20]. The eastern part of the wine-growing district has a better HI, and 41.98% of the territory is classified as very favorable area (value 4), while 15% of the territory is classified as the most favorable (value 5). These two favorable CMTS model classes fall into the HI+1 (warm temperate climate) [19] general HI index climate class.



Map 10. Distribution of HI; 1988-2017 (past period)



Map 11. Distribution of HI; 1988-2017 (present period)

Bioclimatic index based on night temperatures

CI/CNI (Cool Night Index)

Because of climate changes and global warming, the Oplenac wine-growing district experienced a worsening of the CI index (average minimum temperature (°C) in September) from the period 1961–2010 (map 12) to the period 1988–2017 (map 13). Currently, the unfavorable CI class (value 1 in the CMTS model) is determined for 0.17% of the territory, while the less favorable CI class (value 2) is determined for 11.39% of the Oplenac wine-growing district territory. The majority of the district's territory (71.26-%) is classified into the favorable class (value 3), while very favorable class (value 4) is determined for 16.69% of the territory. These classes in accordance with the CMTS model fall into the CI+1 (cold nights) general climate CI class [20, 21]. The most favorable CI class in accordance with the CMTS model (value 5), which falls into the CI+2 (very cold nights) general climate CI class [20, 21], currently exists in only 0.49% of the Oplenac wine-growing district territory. This deterioration of CI is unfavorable from the perspective of production of high-quality wines, as it contributes to aggregation of metabolic constituents in grapes, such as aromatic mater and color, which recommends cultivation of varieties with later grape ripening times.

Map 10. Distribution of CI; 1988-2017 (past period)

Map 11. Distribution of CI; 1988-2017 (present period)

Conclusion

Analyses and spatial representation of examined bioclimatic indices, that is, basic climate *terroir* elements in the CMTS model for the Oplenac wine-growing district (Serbia) indicate that significant changes have occurred when the period 1961-2010 (past) is compared with the referential climate period 1998-2017 (present). Results obtained confirm that basic climate *terroir* elements have improved in terms of possibilities for cultivation of grapevine varieties that are relatively sensitive to low temperatures and have later grape ripening times, such as the local, i.e. autochthonous Smederevka and Prokupac varieties. In addition, due to the worsening CI index, planting vineyards with these grapevine varieties can be recommended, because grapes will ripen in the later, cooler period.

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