# APPLIANCE OF CLIMATE PROJECTIONS FOR CLIMATE CHANGE STUDY IN SERBIAN VINEYARD REGIONS

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**ABSTRACT**

Climate projections considered here are for two periods in the future throughout two IPCC scenarios: 2001 – 2030 (A1B) and 2071 – 2100 (A2) obtained using Coupled Regional Climate Model EBU-POM. Results are used in calculation of Heliothermal, Drought and Cool Night Index for climate classification of vineyard regions in Serbia. Presented results show significant change of climate in the future, indicating that varieties of grapevine must be adaptable or vineyard regions should be shifted in other areas with appropriate climate.

**KEYWORD**

climate projections – grapevine – climate classification

**INTRODUCTION**

Grape growing and wine production with present knowledge and experience are largely weather and climate driven. Many studies have been done about climate – grape growing connection and analysis of climate change impact on vineyard regions (Jones et al., 2005; Metzger et al., 2008). This paper is an example of application of long term climate simulations in viticulture in Serbia. Presented results are obtained from the Coupled Regional Climate Model EBU-POM (Djurdjevic, Rajkovic, 2008) for the periods: 1961–1990 (experiment 20c3m), 2001–2030 (scenario A1B), 2071–2100 (scenario A2). The chosen period for climate simulations is thirty years because 30-years mean values should be able to capture 75% of the variance of the true signal according to Huntingford et al. (2003) as well as statistically significant changes in extreme precipitation. Scenario A1B is characterized as a *medium sensitivity* and A2 as a *high sensitivity* scenario (close to 850 ppm at the end of 21$^{st}$ century, equivalent to ~2.2 times higher value compared to today's value of ~385 ppm), in sense of carbon dioxide concentration. Details on concentrations of other Greenhouse Gases (GHGs) prescribed by these scenarios can be found in IPCC Special Report on Emission Scenarios (SRES; Nakicenovic et al., 2000). The SRES scenarios were also used for the IPCC Fourth Assessment Report (Christensen et al, 2007). Climate models have BIAS especially in the area of Pannonian valley where the northern half of the Serbia region is located. This problem is known as Summer Drying Problem in South-Eastern Europe (Hagemann et al., 2004). For calculation of climate indices it was necessary first to make corrections for model output data. Method used for this purpose is statistical BIAS correction method (Piani et al. 2009). Heliothermal Index (*HI*), Drought Index (*DI*) and Cool Night Index (*CI*) define a Multicriteria Climatic Classification System (Géoviticulture MCC System) for grape growing regions worldwide (Tonnieto, Carbonneau, 2004). Analysis of indices values up to the end of the century show how climate will change in present grape-growing regions, if some other areas will have appropriate climate for grapevine growing and if climate change could lead to necessary substitution of existing varieties or their adaptation to new climate conditions.

## MATERIALS AND METHODS

Dynamical downscaling of Atmosphere Ocean Global Circulation Model (AOGCM) SX-G (Gualdi et al., 2003) is done using Coupled Regional Climate Model (CRCM) EBU-POM (Djurdjevic, Rajkovic, 2008; Gualdi et al., 2008). Climate projections have been made for the periods: 1961–1990 (experiment 20c3m), 2001–2030 (A1B), 2071–2100 (A2). Model domain is Europe region. The model resolution is ~30*km*. In Fig.1 we can see that in the whole area temperature increases, for the first 30 years 2001-2030 about one degree (upper left) and in the last 30 years 2071-2100 more than three degrees (upper right panel). In the first thirty years (lower left) of the century change in precipitation amount is over 50*mm/year* near shore and in mountain areas. For the last thirty years (lower right) generally the whole model domain is much drier. Decrease in precipitation is more than 100*mm/year*. All results are shown as difference from model simulation for base period (mean values for 1961-1990). Results are consentient with those obtained for 21 climate global models (IPCC Fourth Assessment Report, Christensen et al, 2007, chapter 11).

When we deduct model results for two periods BIAS is abrogated and it could be assumed that using this approach model error will have significantly less influence. For the purposes of this paper more complex method for model correction was necessary. Applied method is known as statistical BIAS correction method (Dettinger et al., 2004; Piani et al., 2009). Used data are daily observations (maximum, minimum and mean daily air temperature and daily precipitation amount) and model results at 00, 06, 12, 18*h* UTC for the present climate period. In Fig.2 is presented placement of 17 measurement stations that are near or within viticultural regions in Serbia. It is assumed that temperature data follow Normal (Gaussian) distribution and precipitation data follow Gamma distribution, with special consideration for dry days. In Fig.3 (left panels) we can see that corrected values are very close to the observations, which means that correction functions are well determined and can be used for correction of future climate projections.

Detailed description and classification of climate indices that define Géoviticulture MCC System can be found at Tonnieto and Carbonneau (2004). Here are presented only basic facts that are necessary for further understanding of obtained results. Heliothernal index (*HI*) is calculated according to Eq.(1)

$$HI = \sum_{1.04.}^{30.09.} \frac{(T - T_b) + (T_x - T_b)}{2} d \qquad (1)$$

where $T$ is daily average and $T_x$ daily maximum temperature, $T_b$ base temperature ($10^oC$) and $d$ is coefficient of the length of the day. Dryness index (*DI*) represents the value of soil moisture at the end of the growing season under assumption that the initial soil moisture ($W_0$) was 200mm. It was calculated using following equation

$$DI = W_o + \sum_{Apr.}^{Sep.} P - \left(E_t + E_s\right) \qquad (2)$$

where the second term in equation represents sum of monthly difference of precipitation ($P$) and water that is lost through transpiration ($E_t$) and evaporation from bare soil ($E_s$). In order to calculate $E_t$ and $E_s$, we need values of potential evapotranspiration that include radiation data. Because these data are not available we used Thornthwaite method (Willmott et al. 1985). Cool night index ($CI$) equals mean minimum air temperature ($T_{min}$) in the month of ripening and is calculated using equation

$$CI = \frac{1}{N} \sum_{1.09.}^{30.09.} T_{\min} \qquad (3)$$

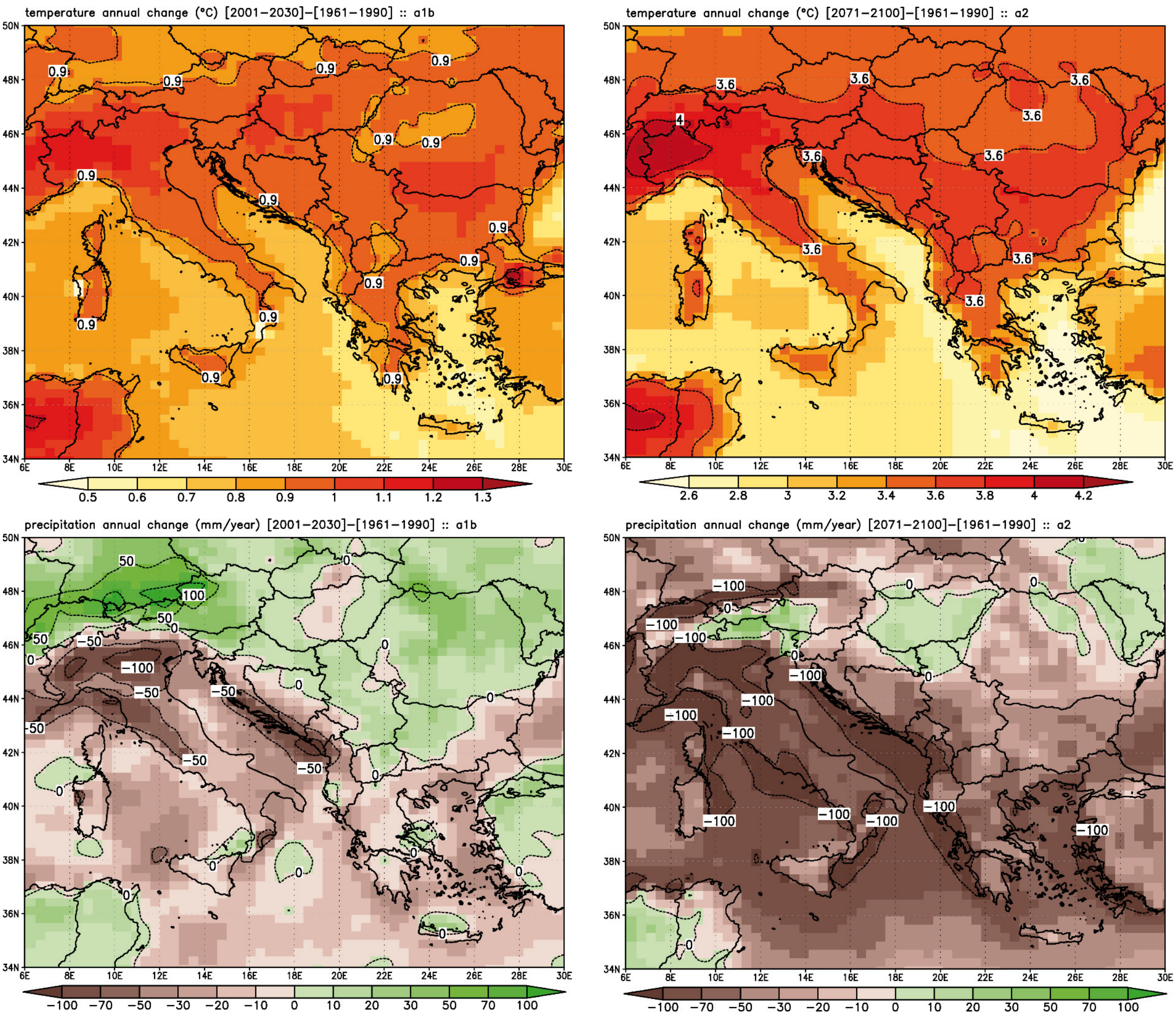


Fig1. Difference between mean annual air temperature for the period 2001-2030 (upper left), 2071-2100 (upper right) from value the period 1961-1990 in degrees and the same difference for precipitation (lower panels) in millimeters.

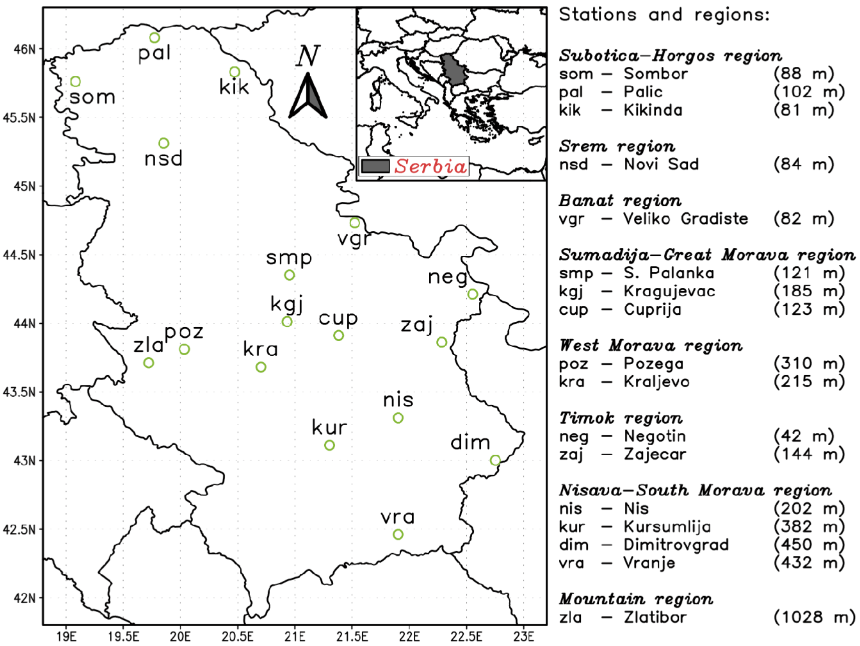


Fig.2 Position of stations and list of vineyard areas in Serbia

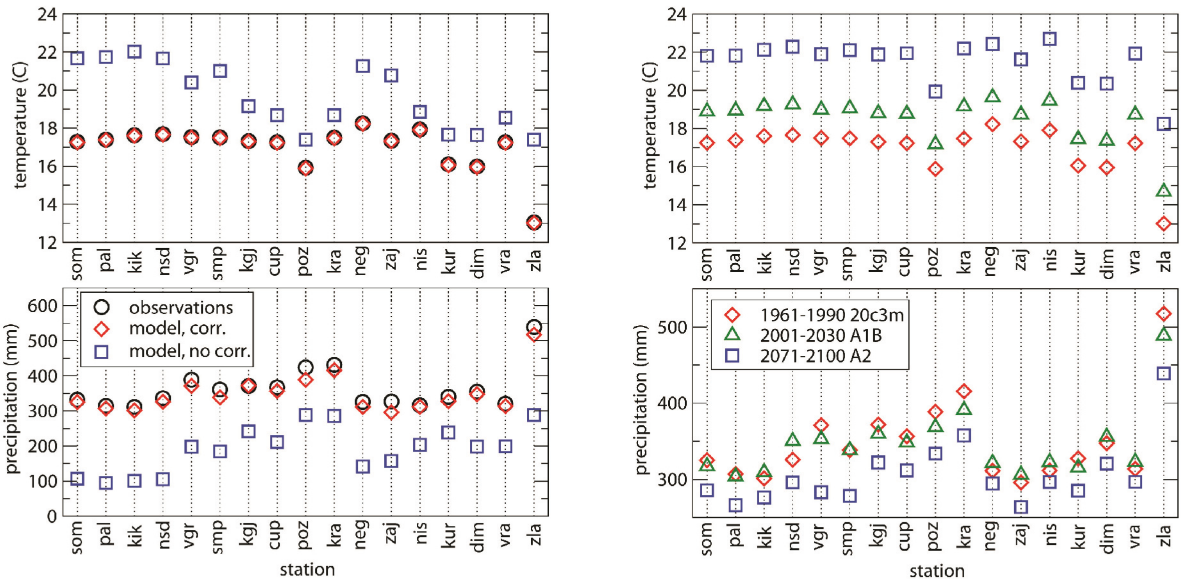


Fig.3 Mean original, corrected model and observed values for growing season period for mean daily temperature (upper left), for cumulative precipitation (lower left) for present climate period (1961-1990) and the same parameters obtained with corrected model values (right) for periods 1961-1990 (20c3m), 2001-2030 (A1B) and 2071-2100 (A2).

## RESULTS AND DISCUSSION

Indices are calculated using corrected model values for three periods: present climate period (1961-1990, experiment 20c3m), period 2001-2030 (A1B scenario) and period 2071-2100 (A2 scenario). In Fig.4 are presented results obtained for *HI* (left panel). In the first thirty years of the century index values switch one category up, to *temperate warm*. Zlatibor, mountain area station where grape is not cultivated nowadays stays in *very cool* category. In the last thirty years of the century results are in *warm* or *very warm* category. Zlatibor area enters in *temperate* climate. Precipitation has more complex dependence on surrounding geo morphology. This contributes to larger variation in categories of *DI* (Fig.4, right panel). In the first thirty years of the century *DI* has small decrease. In the last thirty years all vineyard regions enter the *moderately dry* category, except West Morava region, and west and east border parts of Nisava-South Morava region. Zlatibor stays in *humid* category. In Fig.5 are presented values for *CI*. In present climate all vineyard regions are in *very cool nights* category. In the first thirty years mean annual temperatures are about 1 degree higher, but most regions stay in the same category. In the last thirty years climate change impact is considerately large. Banat region, Timok region and north part of Nisava-South Morava region enter *temperate nights* category. Largest change is at mountain station Zlatibor. It is known that areas with higher altitudes will be more affected with climate changes.

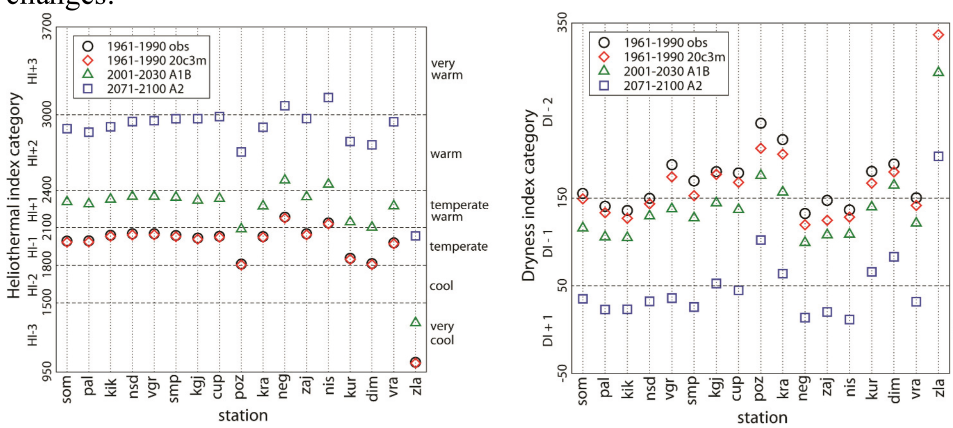


Fig. 5 Mean Heliothermal Index (left) and Dryness Index (right) values for present climate (1961-1990) obtained from observations and corrected model values (20c3m), for 2001-2030 obtained from corrected model values (A1B) and for 2071-2100 obtained from corrected model values (A2).

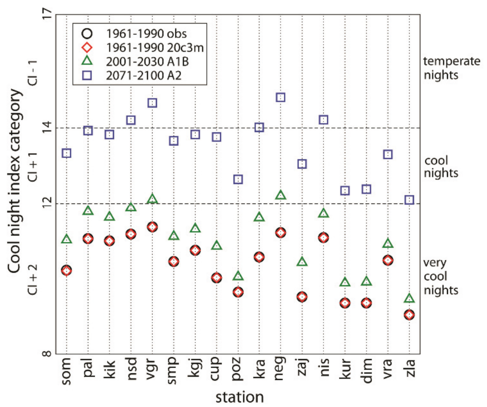


Fig.6 The same as Fig.5 but for Cool Night Index

Full grape ripening, for varieties in Serbian vineyard regions that have late time of ripening, is assured when the night temperature conditions belong in *very cool nights* category. These results show that at the end of the century in the most part of the vineyard regions temperatures in ripening period will be to warm for present varieties that have negative impact on color and aroma.

## CONCLUSIONS

Serbian vineyard regions show tendency to become warmer and dryer. In the period 2001-2030 changes in air temperature and precipitation do not have large influence on heat and water requirements of grapevine. In the period 2071-2100, according to A2 SRES scenario, grape could be under influence of higher temperatures and less precipitation during its development. This could lead to early ripening stage, after which high temperatures could disable plants to prepare for the dormant season. Late varieties will be affected with warmer temperatures in ripening period, which will have negative effect on skin color and aroma of grape and wine. Areas on higher altitudes will have more appropriate climate for present varieties and this could lead to relocating vineyards to higher areas.

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