EVALUATING CLIMATE CHANGE IMPACTS ON VITICULTURE USING THE MCC SYSTEM

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Abstract: Climate change may modify the viticultural and enological potentials of the productive regions around the world. Methodologies to evaluate the impact of climate change over grape-growing regions of the world are necessary. The objective of this work is to use the methodology of the Geoviticulture MCC System for estimating the viticultural climate change impact using the climatic indexes of the system: Heliothermal index (HI), Cool night index (CI) and Dryness index (DI). The MCC System was applied to the Serra Gaúcha region, Brazil. The evaluation compared the normal viticultural climate (1961-1990) with four potential regional scenarios for climate change, with increases in temperature and precipitation: +1.2°C by the year 2020; +2.2 °C by 2050; +3.5°C and +0.25 mm/day by 2080; +3.5°C and +0.1 mm/day by 2080. The results showed that, for all scenarios of climate change, the region would change its MCC System climatic group. In the worst scenario, the viticultural climate changes HI from Warm to Hot and CI from Warm nights to Hot nights, with no change in DI. The climate change will potentially alter the viticultural and enological profile of the region. The same methodology may be used in different regions of the world, allowing the MCC System to be used to compare future viticultural climate of a given region not only with its present condition, but also with the present viticultural climate of other regions worldwide. Therefore, the MCC System is a useful methodology to quantify the viticultural impacts of climate change.

Climate change may modify the viticultural and enological potentialities of the productive regions around the world (Jones et al., 2005b). In recent years, many viticultural regions had already presented a tendency of increase in temperature, with viticultural implications.

Methodologies to evaluate the impact of climate change on viticulture are necessary, in order to quantify changes and to compare present or future climate conditions of the grape-growing regions. The MCC System (Tonietto, 1999; Tonietto & Carbonneau 2004) has many uses (Tonietto, 2007), and may be applied to evaluate the impact of climate change on viticulture (Carbonneau and Tonietto, 1998; Lebon, 2004; Tondut et al., 2006).

The MCC System uses three climatic indexes: Heliothermal index (HI), Cool night index (CI) and Dryness index (DI). HI and CI may help to identify the climatic impact concerning thermal changes (minimum, maximum and mean air temperature) and DI integrates the climate change involving water and its interactions with the thermal environment (precipitation, PET, potential water balance).

The objective of this research was to use the methodology of the Geoviticulture MCC System for estimating the viticultural climate change impact using the climatic indexes of the system. The viticultural region used as an example was the Serra Gaúcha, in the South of Brazil.

MATERIALS AND METHODS

This research uses the methodology of the Geoviticulture MCC System (Tonietto, 1999; Tonietto & Carbonneau, 2004) for estimating the viticultural climate change impact using the climatic indexes of the system: Heliothermal index (HI), Cool night index (CI) and Dryness index (DI).

The MCC System was applied to the Serra Gaúcha region, the most important viticultural region of Brazil, in the southern part of the country. The evaluation compared the normal viticultural climate of Serra Gaúcha, characterized by the average of the period between 1961 and 1990, with potential regional scenarios of climate change, as proposed by Marengo (2007) (Table 1). Since the Serra Gaúcha is a humid region, complementary information was obtained by simulating DI with an Wo (initial useful soil water reserve) of 200mm, but without the usual upper limit on W (estimation of soil water reserve at the end of a given period) in the monthly computation (thus allowing DI to exceed 200mm).

To exemplify the use of MCC for this region, we chose four SRES scenarios using IPCC (2001a, b) models for South America, in particular for the Prata basin macro region, in which the Serra Gaúcha viticultural region is included. The first three scenarios represent the average of scenarios A2 and B2 and IPCC models CCCMA, CSIRO, HadCM3, CCSR/NIES and GFDL with increases in air temperature and precipitation (relative to 1961-1990): +1.2°C by the year 2020, +2.2 °C by the year 2050; +3.5°C and +0.25 mm/day by the year 2080 (Table 1, MCC case

Table 1. Anomalies of temperature and precipitation relative to the 1961-1990 period, for the Prata basin region, according to scenarios A2 and B2 and five IPCC models (Source: Marengo, 2007): in this viticultural study Cases "1" and "2" were characterized by the year 2020, 2050 and 2080.

SCENARIOS		IPCC MODELS					ANOMALYES						MCC Cases
							TEMPERATURES (°C)			PRECIPITATION (mm day)			
A2	B2	CCCMA	CSIRO	HadCM3	CCSR/ NIES	GFDL	2020	2050	2080	2020	2050	2080	
x	x	x	x	x	x	x	1,2*	2,2*	3,5*	0*	0*	0,25*	1
	x	x	x	x	x	x			2,7*				
x		x	x	x	x	x			4,0*				
	x		x					1,6	2,4				
x			x					2,1	3,6				
	x				x			2,3	3,0				
x					x			2,6	4,3				
	x			x				2,3	2,9	0	0	0,1	
x				x				2,5	3,5	0	0	0,1	2

* Average values for de IPCC model (s) and scenario (s) indicated.

1). Scenario A2 represents an extreme scenario of high emission ("pessimist") and B2 represents a scenario of low emission ("optimist").

The fourth scenario used IPCC scenario A2 and model HadCM3, which estimates an increase of 3.5 °C in air temperature and 0.1 mm/day in precipitation by the year 2080 (Table 1, MCC case 2). According to Marengo (2007), this is the best performing model for South America. The available data did not permit to include the seasonal distribution during the year. Since there were no estimates for minimum and maximum air temperature change, the same increase used on mean air temperature was adopted.

RESULTS AND DISCUSSION

The MCC System applied to the Serra Gaúcha region results in a present viticultural climate for the average of the period of 1961-1990 as follows: HI = 2362 (class Warm); CI = 16.1°C (class Warm nights); DI = 200mm (class Humid).

In the analyzed scenarios, the increase in temperature would change the HI accumulation end evolution curve during the vegetative cycle, reaching values of 2581, 2763 and 2999 by the years 2020, 2050 and 2080, respectively (Figure 1). One of the main implications of the increasing HI is the anticipation of the phenological stages, namely bud break, bloom, veraison and harvest, as demonstrated by Jones et al. (2005a). For mesoclimates and varieties that normally reach their harvest point in March, the climate change will bring harvest to February, the second hottest month of the year in the Serra Gaúcha region.

The CI will change, reaching values of 17.3, 18.3 and 19.6 °C, by the years 2020, 2050 and 2080, respectively (Figure 2), with potential implications on the color and flavor of grapes and wines.

With respect to DI, the region will continue to be classified in the MCC System Humid climate class. However, there will be less excess humidity in all scenarios of climate change, especially in 2050 / Case 1 and 2080 / Case 2 (Figure 3). When evaluating dryer viticultural regions, it is possible for climate classes to change to Sub-humid, Moderately dry or Very dry.

In all scenarios analyzed, the viticultural climate of Serra Gaúcha changes the climate group (Figure 4). Comparing with the actual viticultural climate (HI+1 CI-1 DI-2) climate change will result in the following climatic groups according the scenarios and projected years:

2020 / Case 1: HI class Hot, CI class Warm nights and DI class Humid (HI+2 CI-1 DI-2);

2050 / Case 1, 2080 / Case 1 and 2080 / Case 2: HI class Hot, CI class Hot nights and DI class Humid (HI+2 CI-2 DI-2).

In the MCC System, we considered that each climate group represents a different climatic potential for viticulture, with implications on the characteristics of grape quality and impact on wine typicity. The worst scenario considered was 2080 / Case 1 (increasing temperature by 3.5° C and precipitation by 0.25 mm/day), resulting in a viticultural climatic change from Warm to Hot (close to the Very hot class) and from Warm to Hot nights, with no change in the DI class condition (Humid) of the viticultural climate, despite the PET elevation by the thermal effect. In this scenario, the Serra Gaúcha region will have a very important change in its viticultural (agronomic adaptation and wine grape characteristics) and enological profile.

Another potential implication for the region will be the reduced agronomic adaptation for breaking dormancy and uni-

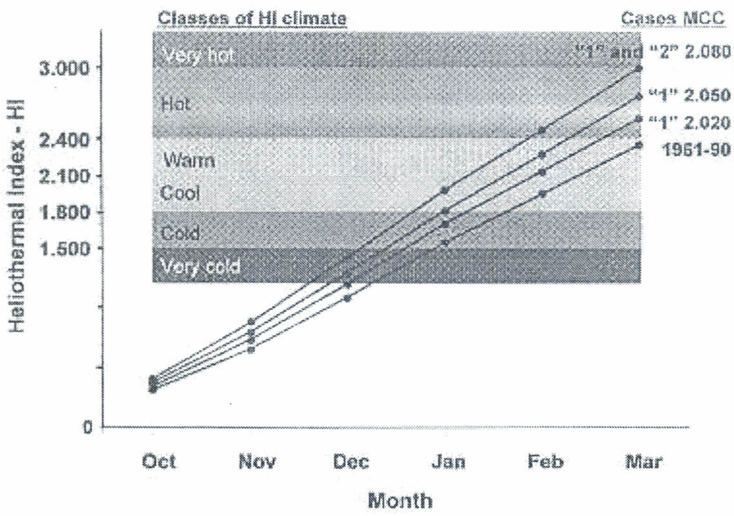

Figure 1. Evolution of the Heliothermal Index (HI), in the different scenarios and models of climate change for the Serra Gaúcha region: in all cases compared to the 1961-1990 series, the viticultural climate class changes from Warm to Hot.

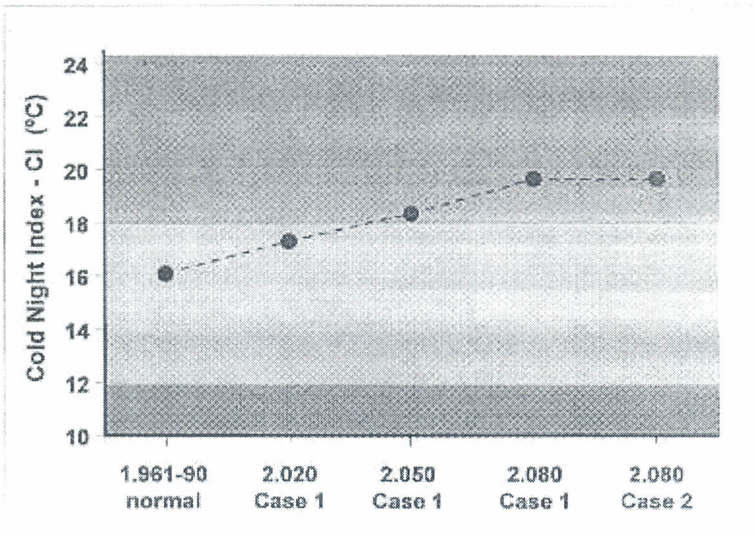

Figure 2. Cold Night Index (CI) in the different scenarios and models of climate change for Serra Gaúcha region: by the year 2050 and 2080 viticultural climate change the class from Warm to Hot nights.

form budbreak, caused by milder winters.

The use of the MCC System to evaluate climate change impacts on viticulture

The methodology of the MCC System may be used in different regions of the world to simulate the impact of climate change on viticulture. The future viticultural climate of a region may be compared with its present condition and with current conditions of other viticultural regions of the world. The international site of the CCM System (SISTEMA CCM Geovitícola, 2008; Fialho and Tonietto, 2008) offers a database of viticultural climates around the world, which may be used as a reference for comparison. This may be helpful to indicate, for example, the possibility of adaptation of different varieties to the news scenarios caused by climate change and to identify potential characteristics of typicity of future wines.

On the other hand, new regions in higher latitudes may be prospected with respect to their potentialities, as a result of climate change, and one may use the system to compare their future conditions with the climate of the present viticultural regions.

The MCC System is a useful methodology to quantify the viticultural impacts of climate change, especially when combined with other tools in this field.

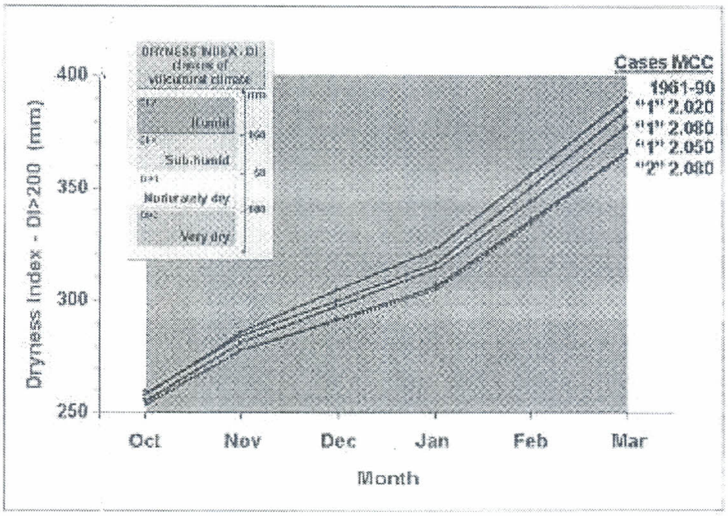

Figure 3. Evolution of the Dryness Index (DI), in the different scenarios and models of climate change for the Serra Gaúcha region: in all cases the region maintains the Humid climate class.

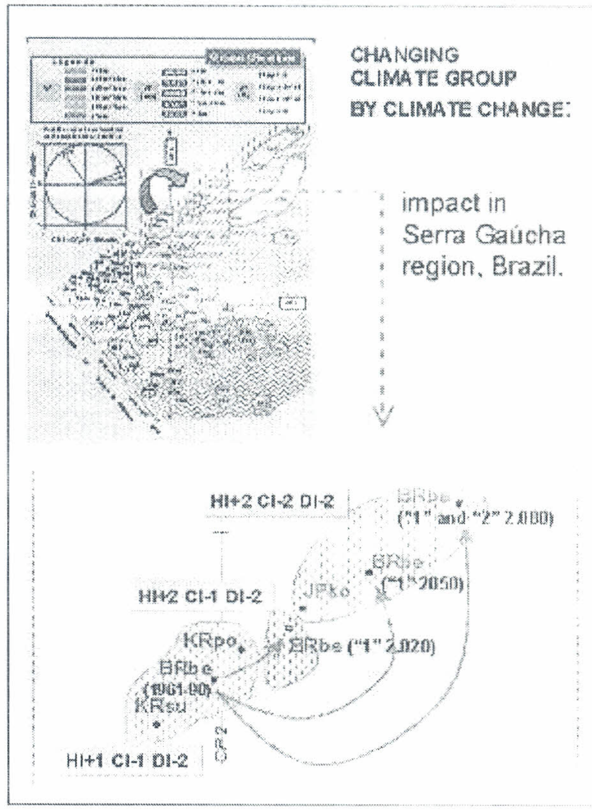

Figure 4. Impact of climate change on the viticultural climate of the Serra Gaúcha region, Brazil, according to the MCC System in a world context: in all scenarios and models, Serra Gaúcha changes the viticultural climatic group.

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