Observed climatic trends in south african wine regions and potential implications for viticulture

Tendances climatiques observées dans les régions viticoles sud africaines et implications potentielles pour la viticulture

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Summary

Global warming is scientifically and widely accepted (IPCC). Climate change is a reality and its impacts are increasingly felt in South Africa. Using the longest data series from weather stations located in different South African wine regions and districts of South Africa, the Winkler index for viticulture can be calculated and a descriptive statistical analysis (moving averages, decade averages and linear trends) performed. This provides preliminary results with respect to climatic variation in South African vineyards over the past 40 years.
Analysis of the Winkler index showed that some regions reached the upper level of their group while others changed to warmer groups during the study period. Significant climatic trends, similar across the different wine regions of South Africa, were observed. The first signs of warming were visible in the maximum winter temperatures during the late 1960's and 1970's. The significant breakpoint occurs in the mid 1980's with an increasing acceleration since 2000. This is similar to trends found in literature. These trends hold implications for potential changes in cultivar distribution, adaptation of viticultural and oenological practices and may have already contributed to the development of new wine regions in South Africa.

Key-Words: Climatic trends, vineyards, South Africa
Mots-Clés: Tendances climatiques, vignes, Afrique du Sud

Introduction

Warming of the climate is unequivocal and clearly evident from observations of increases in global average air and ocean temperatures (IPCC, 2007). Although there is variability in the degree of change, warming has been observed in different wine producing regions worldwide. Research on climate change and viticulture has shown that cultivars have responded to the observed warming with earlier phenological stages or dates of harvest and shortening of periods between phenological stages (Jones, 2006; Barbeau, 2007; Ramos, 2007; Chabin, *et al.*, 2007; Monany & Gueydon, 2007; Moncomble *et al.*, 2007; Duchene & Schneider, 2007). Future climate projections indicate benefits for some regions and challenges for others (Jones, 2006).
South Africa is a young wine producing country with an increasing area under vines (102.000 ha in 2006), a production of 710 million litres of wine (3% of the world production) resulting in rank number 9 in the overall volume production (SAWIS, 2007). Locally, viticulture represents 8.2% of the gross product of the Western Cape Province and there are 257.000 persons working directly or indirectly for the wine industry. It forms one of the vital economic sectors of the province. Observed climatic trends and potential impacts for viticulture were studied in order to estimate the extent of the climatic challenge that viticulture in the Western Cape is and could be facing.

Data and method

Since 1940, the Institute for Soil, Climate and Water of the Agricultural Research Council (ARC-ISCW) has installed a countrywide network of weather stations aimed at monitoring the climate and meeting the climatic knowledge requirements of agriculture. Mechanical weather stations from the ARC-ISCW, located in the different wine regions, were chosen for this study due to their longer time series of daily data and a larger spatial representation of the wine regions as compared to the automatic weather station network, which has been more recently established in a reduced number of regions. Most of the weather stations used in this work have at least 13 years of records (Table 1). No change in location, instrument or observer was noticed unless specified.

Wine region / district / ward	Mechanical Weather Station	Period of record	Duration of record
Stellenbosch	Nietvoorbij + Automatic Weather Station	1967-2002 1995-2006	36 years 11 years
Stellenbosch	Lourensford	1942-1965	23 years
Paarl	Nederburg	1970-2006	36 years
Worcester	Veldreserwe	1967-2006	40 years
Olifant River	Klawer	1973-2006	33 years
Robertson	Robertson	1964-1994	30 years
Cape Point	Groot-Constantia	1967-1999	32 years
Overberg	Elgin	1964-1994	30 years
Ceres	Deelville	1978-2002	24 years
Walker Bay	Oude Hemel	1977-1990	13 years

Table 1 List of wine regions/districts or wards in the Western Cape of South Africa, weather station used; period and duration of records.

Results

Observed climatic trends

A significant increase in the annual temperature values was observed. Data from Nietvoorbij weather station in the Stellenbosch district showed inter-variability between years within a significant upward temperature trend over the 1967-2006 period (Figure 1).

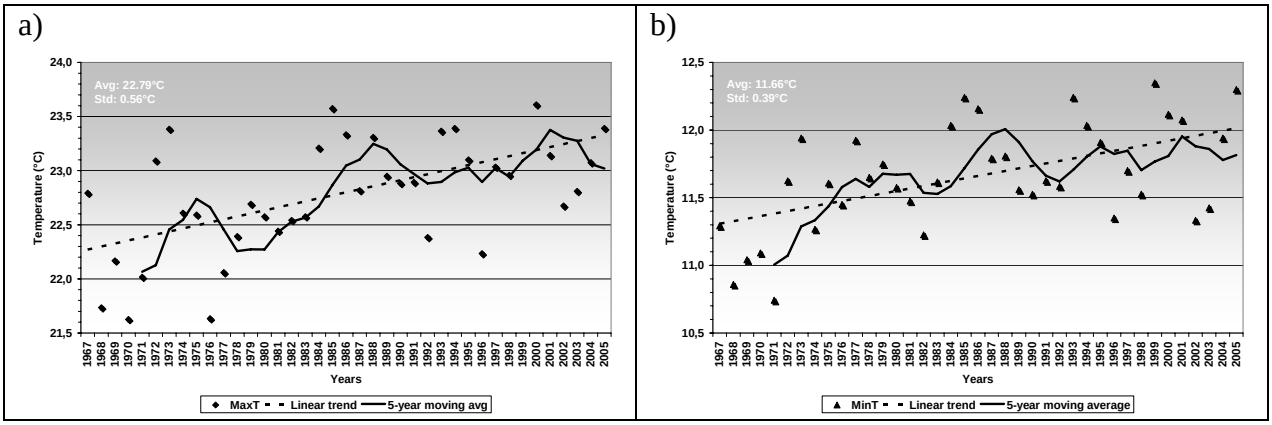


Figure 1 Annual a) maximum and b) minimum temperature at Nietvoorbij in the Stellenbosch wine district between 1967 and 2006.

A 1°C and 0.7°C increase for annual maximum and minimum temperature respectively was calculated over the past three decades (Table 2). Taking an earlier annual temperatures time series at Lourensford in the Stellenbosch district into consideration, there was no significant trend during the 24 years prior

to this period, with the exception of winter maximum temperatures. The increase of 1.5°C that was identified for August maximum temperature over the 24-year period, from 1942 to 1965, could have been the first marker of a warming in this region (results not shown). Using the 1967-2006 time series of Nietvoorbij, the winter temperature increase was clearly observed from the beginning of the 1970's, with more than 2°C and up to a 1°C increase for July maximum and minimum temperature, respectively, over the past four decades (Table 2). The most significant trend was found during the growing period, especially during February, the ripening period of most of the cultivars in the Western Cape. February was warmer in terms of minimum as well as maximum temperatures. Maximum and minimum temperatures increased by more than 2°C and up to 1.3°C, respectively, over the past three decades, i.e.since the beginning of the 1980's (Table 2).

Average temperature	Periods				
	1967-1970	1971-1980	1981-1990	1991-2000	2001-2006
Annual MaxT (°C°)	22.1	22.5	23.0	23.1	23.1
Annual MinT (°C°)	11.1	11.6	11.7	11.8	11.9
February MaxT (°C°)	27.4	27.4	28.4	28.7	29.1
February MinT (°C°)	14.8	14.7	15.9	15.7	16.1
July MaxT (°C°)	16.1	17.2	17.2	17.4	18.0
July MinT (°C°)	7.0	7.6	7.8	8.0	8.2

Table 2 Average temperature measured over different periods at Nietvoorbij, Stellenbosch district.

Of the 12 warmest years over the 1967-2006 study period at Nietvoorbij, eleven were recorded in the period from the 1980's onwards (Table 3).

Years	MaxT (°C)	MinT (°C)	MeanT (°C)	Anomaly (°C)			Warmest year (rank)
				MaxT	MinT	MeanT	
1973	23,4	11,9	17,7	+ 0,6	+ 0,2	+ 0,5	8th
1984	23,2	12,0	17,6	+ 0,4	+ 0,3	+ 0,4	11th
1985	23,6	12,2	17,9	+ 0,8	+ 0,5	+ 0,7	4th
1986	23,3	12,2	17,7	+ 0,5	+ 0,5	+ 0,5	9th
1988	23,3	11,8	17,6	+ 0,5	+ 0,1	+ 0,4	10th
1993	23,4	12,2	17,8	+ 0,6	+ 0,5	+ 0,6	6th
1994	23,4	12,0	17,7	+ 0,6	+ 0,3	+ 0,5	7th
1999	24,1	12,4	18,2	+ 1,3	+ 0,7	+ 1,0	1st
2000	23,6	12,1	17,9	+ 0,8	+ 0,4	+ 0,7	3rd
2001	23,1	12,1	17,6	+ 0,3	+ 0,4	+ 0,4	12th
2005	23,4	12,3	17,8	+ 0,6	+ 0,6	+ 0,6	5th
2006	23,6	12,1	18,2	+ 0,8	+ 0,4	+ 1,0	2nd

Table 3 Annual temperatures and anomalies (yearly temperature *vs* the 1967-2006 period mean temperature) for the top 12 warmest years over the 1967-2006 period for Nietvoorbij - Stellenbosch wine district.

This warming has also been observed in other wine-producing regions of the Western Cape. The annual temperature increase ranges from 0.5°C to 1.7°C, depending on the region and the record period (Table 4).

The Winkler index was calculated for the different wine-producing regions (Figure 2). The frequency of warm years has and is clearly increasing for the various wine-producing regions of the Western Cape. Nietvoorbij in the Stellenbosch wine district showed a mean index, which fell into the lower level of Region IV for the 1967-2005 period (Fig. 2a). The years with a low index (Region III) were

found at the beginning of the time series; these became scarcer after 1985; and from the mid 1980's the index was regularly higher. The mean Winkler index for Groot-Constantia in the Cape Point wine district for the 1967-2000 period was situated in the lower level of Region III. Up to the 1980's, the index varied between the upper level of Region II and the lower level of Region III. In the 1990's, the index reached the upper level of Region III (Fig. 2e). In the other districts (Paarl, Robertson, Worcester) as well as in the Olifants River region (Klawer), the Overberg (Elgin) and the Ceres ward (Deelville), the same tendencies (a higher index after the mid 1980's) were observed (Fig.2). The increase in growing-degree days ranged from 100 to 240 degree-days depending on region and period (Table 4).

Wine region / district / ward	Temperature increase : Max / Min	GDD increase	Period of record	Duration of record
Stellenbosch	+1.7°C / +0.7°C	+150	1967-2006	40 years
Paarl	+1.1°C / +0.5°C	+200	1970-2006	36 years
Worcester	+1.0°C / +1.1°C	+150	1967-2006	40 years
Olifant River	+1.1°C / +0.8°C	+240	1973-2006	34 years
Robertson	+0.5°C / +1.1°C	+150	1964-1994	30 years
Constantia	+1.0°C / +1.0°C	+180	1967-1999	32 years
Overberg	+1.6°C / +1.1°C	+180	1964-1994	30 years
Walker Bay	+0.8°C / +0.5°C	+100	1977-1990	13 years

Table 4 Annual maximum and minimum temperatures and growing degree days (GDD) increases for 8 wine regions in the Western Cape Province during different period between 1967 and 2006.

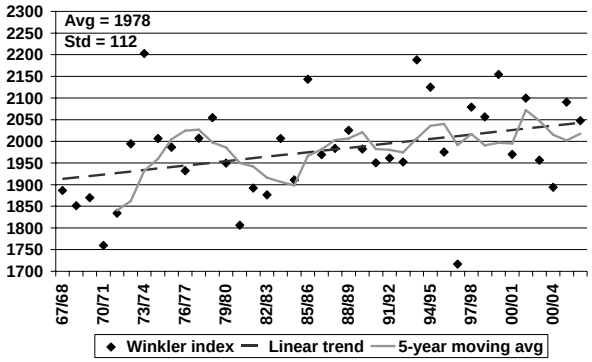
Implications for viticulture

The increase in annual temperature implies increased evaporation and reduced water availability, which in turn could interfere with general grape physiology (reduced duration for optimum physiology) (Schultz, 2007) and may cause some regions to become unsuitable for certain cultivars. The temperature increase during the ripening period (February) may hasten sugar accumulation in the grapes, or, in extreme cases, prevent proper ripening (Sepulveda & Kliewer, 1986). A change of aroma profiles must be expected for certain cultivars.

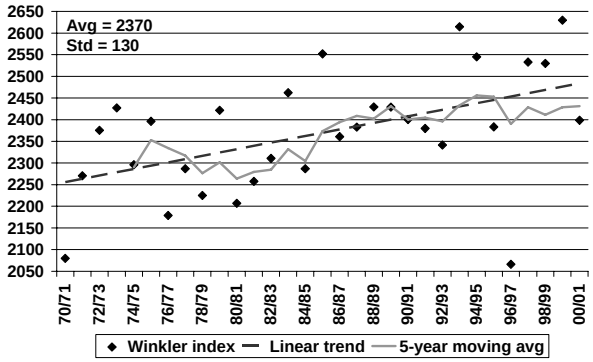
With a significant temperature increase from April to July, the winter season has shortened. A warmer autumn delays the leaf fall. The lack of sufficient cold during late autumn and beginning of winter may interfere with the release of bud dormancy (Lavee & May, 1997), which may in turn lead to irregular budburst, resulting in uneven growth, berry set, fruit ripening and crop loss or reduced crop quality. The use of chemical agents to get an even budburst may have to increase.

The examination of the Winkler index for viticulture calculated for the different wine regions showed a shift upwards: either to the upper level of categories or a change towards warmer categories. This suggests that there will be a definite requirement for a change or adaptation of cultivars. More heat tolerant varieties would have to be planted. Changes in the regions of suitability for certain cultivars could have an impact on regional economies. Viticulture could, however develop into non traditional regions. Adaptation, change in production practices and development of new wine regions are the keys to surviving climate change. The search for cooler locations towards the coast, where the moderating effect of the ocean is expected to temper increasing summer temperatures or at altitude, as well as the development of vineyards towards the eastern part of the Western Cape Province with a more evenly distributed rainfall are example of current responses to climate change that are already being noted in South Africa.

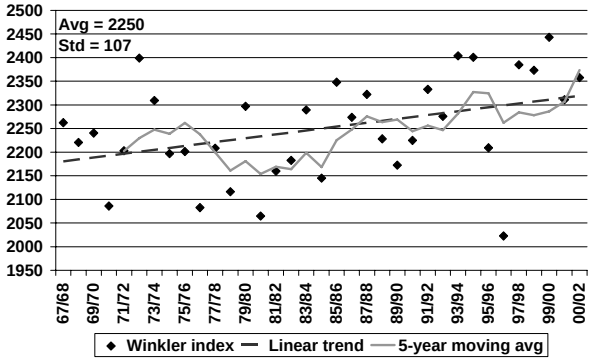
a) Nietvoorbij



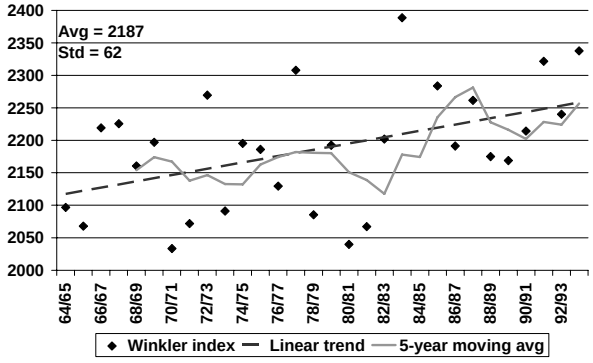
b) Nederburg



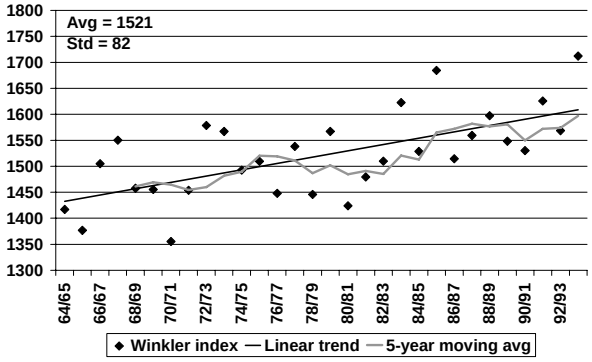
c) Veldreserwe



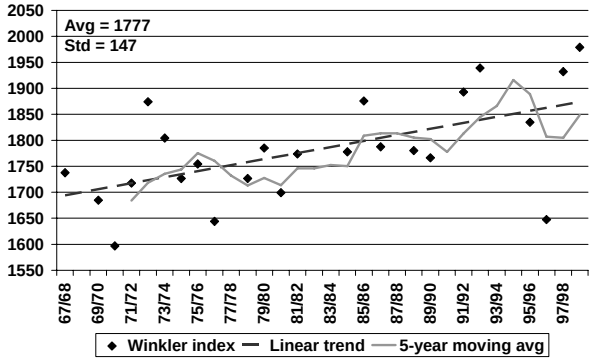
d) Robertson



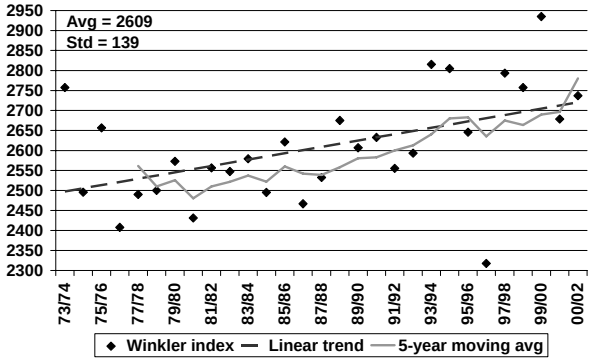
e) Elgin



f) Groot-Constantia



g) Klawer



h) Deelville

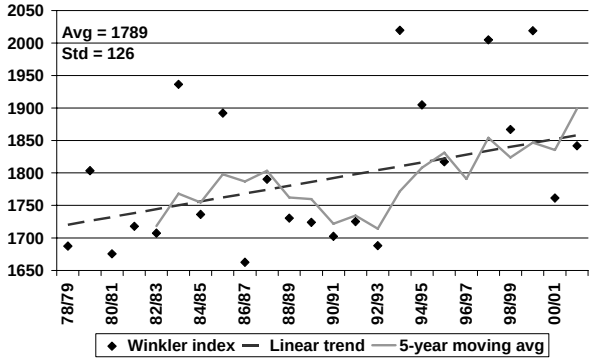


Figure 2 Winkler index, Mean Winkler index and linear trend for a) Nietvoorbij – Stellenbosch district (1967-2006), b) Nederburg – Paarl district (1970-2006); c) Velderserwe – Worcester district (1967-2002); d) Robertson – Robertson district (1964-1994); e) Elgin – Overberg (1964-1994); and f) Groot-Constancia – Constantia ward (1967-1999) ; g) Klawer – Olifant River (1973-2002); h) Deelville – Ceres ward (1978-2002). Avg and Std are the Winkler index average and Standard deviation respectively over the study period.

Conclusion

Significant temperature trends, similar in the different wine regions of the Western Cape were observed. The first signs of warming were visible on winter maximum temperatures during the late 1960's and 1970's. The significant break seemed to occur in the mid 1980's. The temperature increase has accelerated rapidly since 2000.
Further investigations, using data from the more recently established automatic weather station network, has been undertaken. Other statistical tests are in progress to confirm the date of break in the time series. Relationships between other climatic parameters (relative humidity, evaporation and wind) and vine phenology are also being investigated in specific districts to obtain a better indication of the potential impact of climate change on viticulture in South Africa.

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