WEATHER CLASSIFICATION OVER THE WESTERN CAPE (FEBRUARY, 1996 – 2000) AND VITICULTURAL IMPLICATIONS IN THE STELLENBOSCH WINE DISTRICT

C.B. du Preez[1], V.M.F. Bonnardot[1] and V.A. Carey[2]

1) ARC-Institute for Soil, Climate and Water, Private Bag X5026, Stellenbosch, 7599, South Africa. dpreezc@arc.agric.za
2) Department of Viticulture and Enology, University of Stellenbosch, Private Bag X1, Matieland, 7602, South Africa. vac@sun.ac.za

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Abstract
A preliminary study of the daily weather situations was performed for February in South Africa (ripening period of the grapes in the Western Cape), similar to the synoptic classification realized for the temperate latitudes in France (Jones & Davis, 2000), in order to focus the study of the relationships between climate and viticulture at lower latitudes. Daily weather bulletins of the South African Weather Service (SAWS) and surface data observed at Cape Town International Airport by the SAWS were used. The synoptic weather situations were classified in four main patterns, namely: the ridging of the Atlantic Ocean High over the western parts of South Africa, the passing of a cold front over the Western Cape, the dominance of the west coast trough, and the ridging of the Indian Ocean High over the eastern parts of South Africa. Of these four groups, two are predominantly occurring over the Western Cape, namely the ridging of the Atlantic Ocean High and the west coast trough. The Atlantic Ocean High occurs on 48% of the days in February over the five seasons (1996-2000) used for the classifications, whilst the trough occurs on 34% of the days. The occurrence of the Atlantic Ocean High varies between 61% (1997 and 1998) and 36% (1999). Comparing these occurrences with previous research on the influence of vintage and meso-climate on wine aroma, it was found, for instance, that warmer conditions (the result of sunny skies associated with the west coast trough situated over the Western Cape) in 1999 resulted in predominant tropical fruit aromas in the Sauvignon blanc wines, and tree fruit aromas in Chardonnay wines. It appears as if the weather associated with dominant synoptic conditions holds significant implications for wine style. Knowledge of these conditions and their variation over the entire season will then help in climatic modelling studies for application to viticulture.

Résumé
Une étude préliminaire des situations météorologiques journalières a été réalisée pour l'Afrique du Sud et pour les mois de février (période de maturation des raisins dans la Province occidentale du Cap), à l'image de la classification synoptique réalisée aux latitudes tempérées en France (Jones & Davis, 2000), afin d'étudier les relations entre le climat et la viticulture à des latitudes plus basses. Les bulletins météorologiques journaliers du South African Weather Service (SAWS) et les données de surface observées par le SAWS à l'aéroport international du Cap ont été utilisés. Les situations météorologiques synoptiques ont été classées en quatre groupes principaux: la crête de haute pression atlantique sur l'ouest de l'Afrique du Sud, le passage d'une dépression atlantique sur la Province Occidentale du Cap, la prédominance de la dépression ouest, et la crête de haute pression de l'Océan Indien sur l'est du pays. Parmi ces quatre groupes, deux prédominent sur la Province Occidentale du Cap: la crête de haute pression atlantique et de la dépression ouest. Pour les cinq saisons étudiées (1996-2000), la haute pression atlantique représente 48% des cas et la dépression ouest 34%. La fréquence de la haute pression atlantique varie entre 61% (1997 et 1998) et 36% (1999). Comparant ces fréquences avec des recherches antérieures sur l'influence du millésisme et du mésoclimat sur les arômes des vins (Carey *et al.*, 2003), il a été trouvé par example que des conditions plus chaudes en

1998 (résultant du temps ensoleillé associé à la dépression ouest centrée sur la Province du Cap) avaient abouti à la prédominance d'un arôme de fruits tropicaux dans les vins de Sauvignon blanc, et d'un arôme de fruits d'arbre dans les vins de Chardonnay. Il semble que le temps associé aux conditions synoptiques prédominantes aient des implications significatives sur le style de vin. La connaissance de ces conditions et de leur variation au cours de la période végétative aidera ainsi aux études de modélisation climatique avec application pour la viticulture.

Introduction

Studying the daily frequencies of air masses and the various circulation regimes that control their movements is useful in understanding yearly variations in any plant system's phenology, as proven by various studies on pollution, plant phenology, human mortality, visibility and temperature variability (Kalkstein & Corrigan, 1986; Schwartz & Marotz, 1986; Kalkstein *et al.*, 1990; Davis, 1991; Kalkstein, 1991; Davis & Gay, 1993). Jones and Davis (2000) suggested in their study into using a synoptic climatological approach to understand climate-viticulture relationships, in Bordeaux France, that the usual mean-based climate change scenarios often mask the important day-to-day weather events that have significant impact on the yearly harvest. They proposed that weather should be grouped through the use of synoptic climatological techniques, to provide better representation of true meteorological situations at a moment in time (Jones & Davis, 2000).

The Western Cape Province of South Africa is in the path of various systems caused by air mass dominance changes between the Antarctic and subtropical source regions. The four major synoptic scale influences identified in the Western Cape are: the ridging Atlantic Ocean High (AOH), west coast troughs, cold fronts and the ridging Indian Ocean High (IOH) systems. It is important to link the different systems to the vintages in order to understand the relationships between them in this area.

Data and method

Two sets of data were used. The first, the Daily Weather Bulletins of February 1996-2000 published by the South African Weather Service, covers southern Africa and Madagascar between 15-50°S and 10-50°W. The surface weather patterns were classified according to the influence at noon UT or 14:00 Standard South African Time (SAST) directly over the Western Cape Province of South Africa. The second dataset used was the dry bulb temperature, dewpoint temperature, wind speed and direction measured at the Cape Town International Airport weather station of the South African Weather Service at 14:00 SAST. One day has no data.

Examples of the four major synoptic scale influences that were identified in the Western Cape are shown in Fig. 1. They are the ridging Atlantic Ocean high (AOH) (Fig.1a), the ridging Indian Ocean high (IOH) (Fig.1b), West Coast trough (Fig. 1c) and cold fronts (Fig. 1d)

Results and discussion

Mean monthly climatic data was used to describe the climate for each season (not shown). Briefly, the season ending in 1996, was cool and wet, with a slightly warmer than the five-year mean December and November. The 1996/1997 season was also cool and wet with the wettest winder of the five years. The 1997/1998 season was dry, with a warm summer. December and January were slightly cooler than the five-year mean but February was especially warm. The 1998/1999 season was the driest of the five years. Temperatures were moderate during winter with extremely high temperatures and a heat wave in late summer. The 1999/2000 season also recorded dry and hot conditions with some rainfall in July and August. December was exceptionally hot, while the summer rains were concentrated during the warm January. February was extremely dry and windy, with mean temperatures. (Carey *et al.* 2003)

Examples of the four major synoptic scale influences that were identified in the Western Cape are shown in Fig. 1. The AOH (Fig.1a) is classified when the Atlantic Ocean high-pressure system curves around the subcontinent of southern Africa. This usually happens shortly after a cold front has moved past or over the Western Cape. The cold front however may just move past the subcontinent without affecting the weather of the Western Cape and still precede the ridging AOH. The ridging IOH (Fig.

1b) is defined as when the IOH is situated south of the subcontinent and influences the weather of the Western Cape. This is, however, a relatively rare occurrence. These ridging high-pressure conditions (AOH and IOH) and the attendant subsidence bring clear, fine and hot weather, often accompanied by strong southeasterly winds (Preston-Whyte & Tyson, 1988). West coast troughs (Fig. 1c), referred to as troughs from here on, are defined as a surface trough of low pressure over the west coast of South Africa. West coast troughs are conducive to widespread rains over the western parts of South Africa. Surface convergence and upper-level divergence ahead of the trough combine to produce the conditions necessary for general upward vertical motion (Preston-Whyte & Tyson, 1988). A cold front (Fig. 1d) is a swath of cloud and precipitation associated with a significant horizontal temperature gradient, where cold air replaces warm air as the front passes. Cold fronts are associated with distinctive bands of clouds, which may extend far inland over South Africa. It is increasingly being accepted by meteorologists that summer cold fronts may be associated with severe weather conditions over the interior as they are associated with marked mesoscale wind shears and low-level convergence (Preston-Whyte & Tyson, 1988). Of these four classifications the AOH and the trough occur the most often during February over the Western Cape. Thus these days are examined closer, by counting the days when the dry bulb temperature was higher than 30°C or lower than 12°C, for each of the classifications. The deviation from the five-year mean was also calculated and compared to the seasonal wine aroma profiles for Sauvignon blanc wines (Carey *et al.*, 2003).

A total of 141 days were examined and classified into the four synoptic conditions. Of these, 68 days (47.89%) were classified as AOH, 16 (11.26%) as cold front, 48 (33.8%) as trough and 9 (6.34%) as IOH during the February (ripening period of grapes) 1996-2000. Table 1 gives the percentages of occurrence of the different synoptic conditions per season. AOH occurred most during 1997 and 1998 although 1997 was a significantly cooler year than 1998 (Table 2), this can be explained by the amount of cold fronts that moved over the Western Cape more often than in 1998, when the cold fronts all moved past the subcontinent far to the south. Fig. 2a and b show the movement of a cold front past the subcontinent to the south pulling the AOH around the subcontinent. In Fig.2c the cold front has moved over the western cape the previous day causing cooler temperatures during the AOH classification. Cold fronts occurred more often during 1997 than 1998, but they occurred most during 1999 and 2000, which were both warm years according to the mean temperatures in Table 2. Of the trough classifications the highest occurrence was during 1999. IOH occurred most in 1996 and 2000 but never in 1997.

The daily temperatures at 14:00 SAST for the days classified as AOH or trough influenced were compared with the five-year mean for February of 25.9°C. The deviation of daily temperature from the mean for the AOH days is plotted in Fig. 3. With the exception of 1998 the temperatures were mostly below the mean for the days classified as AOH. There were 46 days where the temperature was below the mean, of which 25 days measured temperatures more than 1.5°C below the mean. Of the 21 days where the temperature was above the mean, 11 days were more than 1.5°C above the mean. Only one day had a temperature equal to the five-year mean.

For the days classified as trough days, the deviation of the temperatures at 14:00 SAST were plotted (not shown). These days showed mostly above-average temperatures with 32 of the 48 days warmer than the mean, of which 27 days had temperatures more than 1.5°C above mean. Of the 15 days below mean, 7 were more than 1.5 °C below the five-year mean. Temperature was equal to the five-year mean on only one day. The years 1998 and 1999 showed the biggest deviation from the mean, with trough days in 1997 showing the least deviation from the mean.

According to Carey *et al.* (2003) wines from cooler seasons (1996, 1997) had high acidity on taste and displayed intense fresh vegetative, and cooked vegetative characters. The years where the maturation period was hot (2000) the wines displayed higher tropical fruit aromas, though the fresh vegetative and cooked vegetative characters still dominated in 1998 and 1999. (Fig. 4)

Conclusions

Days classified under AOH influence show temperatures below the long term mean mainly because of the cold fronts influencing the atmosphere before the occurrence of AOH over the Western Cape, if the cold fronts however doesn't move over the Western Cape but pass to the south of the subcontinent the temperatures do not follow this cooler tendency. Classification of the AOH may have to be expanded to include whether the cold front influenced the atmosphere over the Western Cape or not. The frequency of trough classifications showing higher than mean temperatures, can give rise to tropical fruit aromas in Sauvignon blanc wines, while cooler years, possibly with high frequency of AOH with cold front, classifications cause vegetative aroma characteristics. The classification of synoptic conditions also needs to be expanded to the whole growing season, to facilitate the possible climatic modeling studies for the application to viticulture.

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Fig. 4. Mean aroma profiles for Sauvignon blanc wines for the Stellenbosch-Kleindrakenstein wine producing area. (Carey *et al.* 2003)

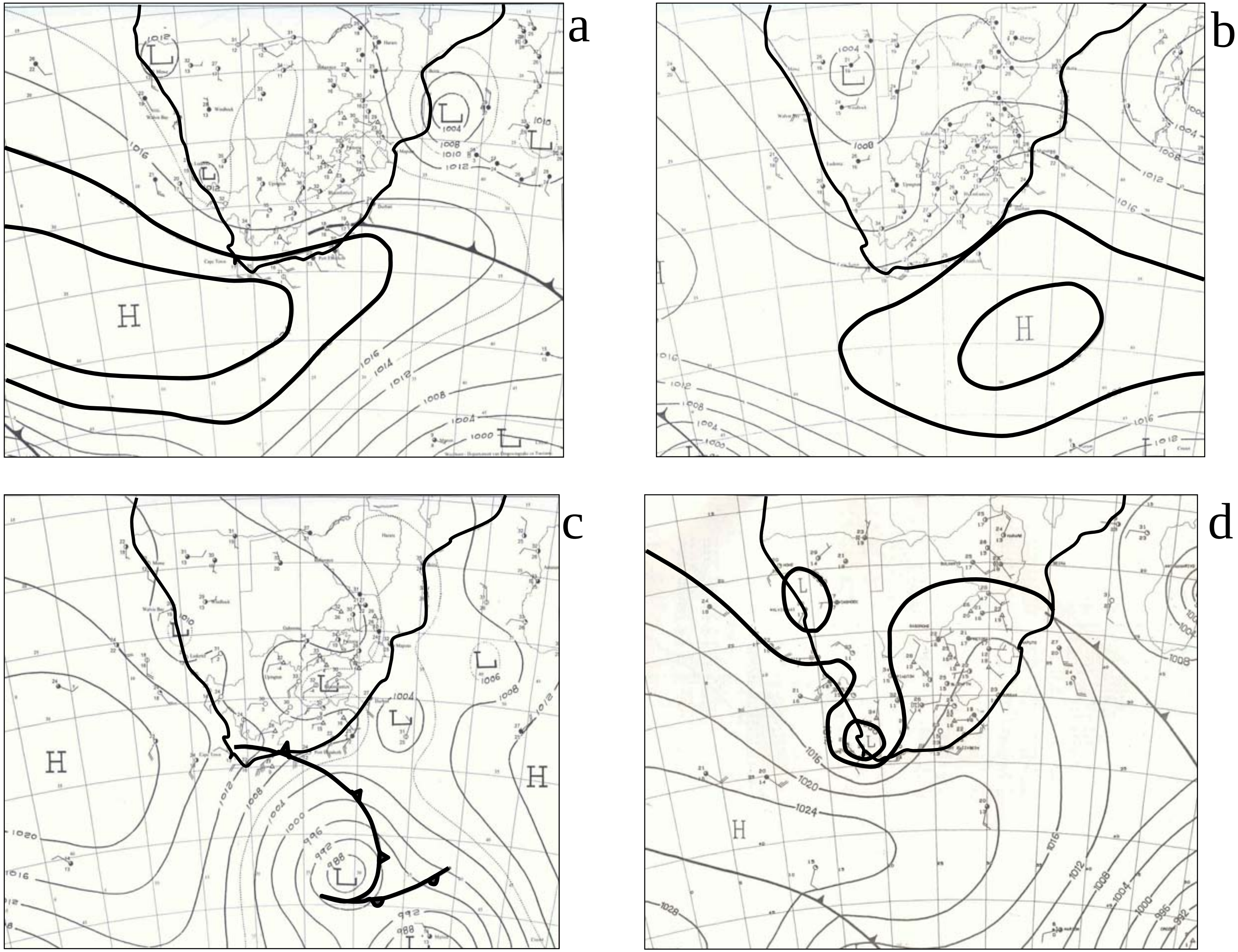

Fig. 1. An example of daily bulletins classified as a) ridging Atlantic Ocean High (AOH), b) ridging Indian Ocean High (IOH), c) the West Coast trough, and d) cold front..

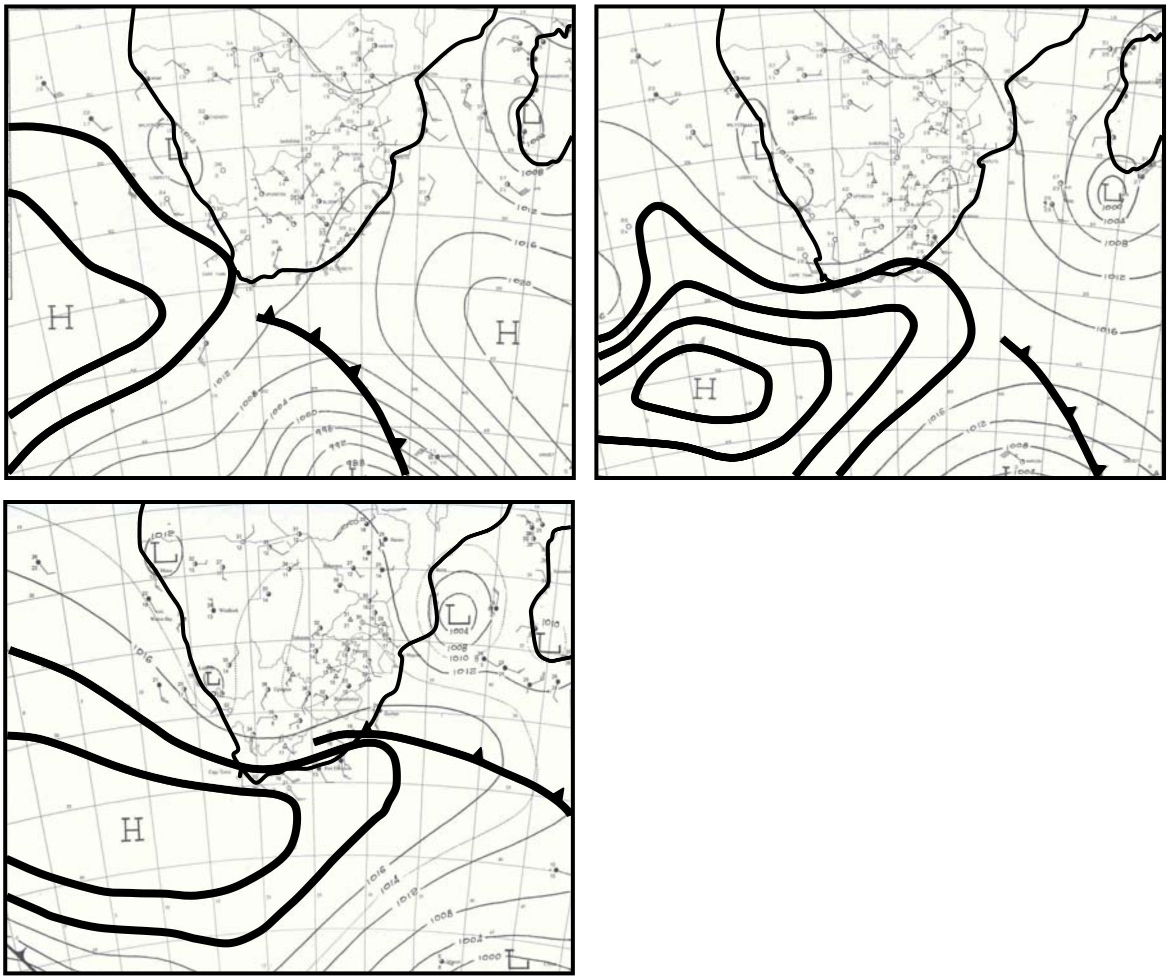

Fig. 2. Example of ridging Atlantic Ocean High classifications without cold front influence over the Western Cape (a and b) and with cold front influence over the Western Cape (c).

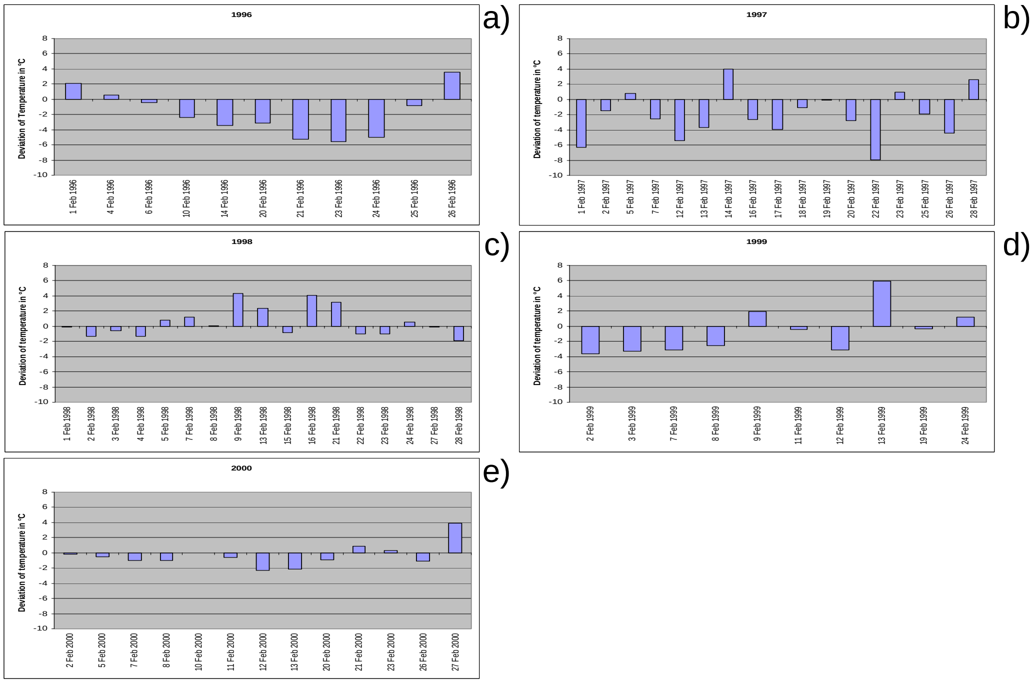

Fig. 3 The deviation of daily temperatures at 14:00 SAST from five-year mean for days classified as ridging Atlantic Ocean High for the month of February a) 1996, b) 1997 c)1998 d) 1999 and e)2000

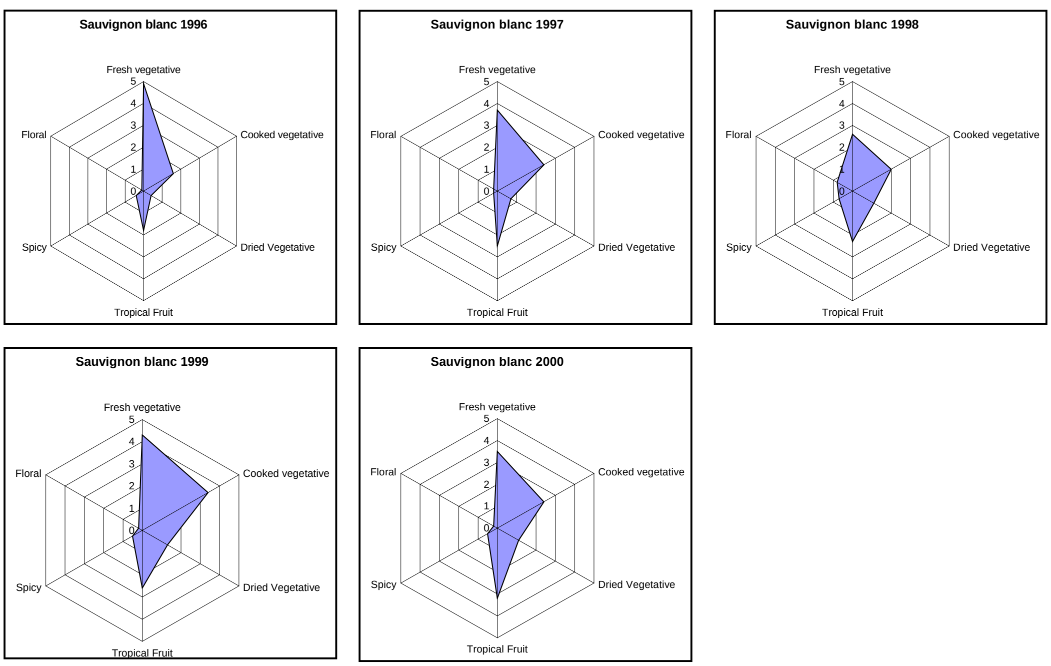

Fig. 4. Mean aroma profiles for Sauvignon blanc wines for the Stellenbosch-Kleindrakenstein wine producing area. (Carey *et al.* 2003)

Table 1. The number of days classified into the four different synoptic conditions and the percentage of occurrence for the month of February for the different seasons.

	AOH		**Cold Front**		**Trough**		**IOH**	
	Nr. Of Days	**%**	**Nr. Of Days**	**%**	**Nr. Of Days**	**%**	**Nr. Of Days**	**%**
1996	11	37.93	4	13.79	10	34.48	4	13.79
1997	17	60.71	2	7.14	9	32.14	0	0
1998	17	60.71	1	3.57	9	32.14	1	3.57
1999	10	35.71	5	17.85	12	42.85	1	3.57
2000	13	44.82	4	17.24	8	27.59	3	10.34
Total	**68**		**16**		**48**		**9**	
%	**47.89**		**11.27**		**33.8**		**6.34**	

Table 2: Yearly averages of temperature, dewpoint temperature, wind direction and wind speed grouped per classification.

<table>
<tr><th>Year</th><th>Classification</th><th>Temp</th><th>Ave</th><th>Dew-point</th><th>Ave.</th><th>Wind speed</th><th>Ave</th></tr>
<tr><td rowspan="4">1996</td><td>AOH</td><td>22.72</td><td rowspan="4">24.63</td><td>11.91</td><td rowspan="4">13.35</td><td>20</td><td rowspan="4">16.33</td></tr>
<tr><td>Trough</td><td>27.3</td><td>15</td><td>14</td></tr>
<tr><td>IOH</td><td>27.3</td><td>13.25</td><td>15</td></tr>
<tr><td>Cold front</td><td>21</td><td>13.25</td><td>17.5</td></tr>
<tr><td rowspan="4">1997</td><td>AOH</td><td>22.94</td><td rowspan="4">23.83</td><td>11.47</td><td rowspan="4">12.65</td><td>19.17</td><td rowspan="4">17.13</td></tr>
<tr><td>Trough</td><td>25.56</td><td>14</td><td>17.22</td></tr>
<tr><td>IOH</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>Cold front</td><td>23</td><td>12.5</td><td>15</td></tr>
<tr><td rowspan="4">1998</td><td>AOH</td><td>26</td><td rowspan="4">28.08</td><td>15.12</td><td rowspan="4">14.03</td><td>19.12</td><td rowspan="4">16.03</td></tr>
<tr><td>Trough</td><td>28.3</td><td>15</td><td>15</td></tr>
<tr><td>IOH</td><td>33</td><td>8</td><td>15</td></tr>
<tr><td>Cold front</td><td>25</td><td>18</td><td>15</td></tr>
<tr><td rowspan="4">1999</td><td>AOH</td><td>25.3</td><td rowspan="4">26.34</td><td>11.9</td><td rowspan="4">13.35</td><td>19</td><td rowspan="4">14.02</td></tr>
<tr><td>Trough</td><td>28.25</td><td>14.08</td><td>12.08</td></tr>
<tr><td>IOH</td><td>29</td><td>14</td><td>10</td></tr>
<tr><td>Cold front</td><td>22.8</td><td>13.4</td><td>15</td></tr>
<tr><td rowspan="4">2000</td><td>AOH</td><td>25.62</td><td rowspan="4">25.95</td><td>14.25</td><td rowspan="4">13.56</td><td>19.62</td><td rowspan="4">15.79</td></tr>
<tr><td>Trough</td><td>26.38</td><td>14.25</td><td>15.63</td></tr>
<tr><td>IOH</td><td>27.3</td><td>13</td><td>16.67</td></tr>
<tr><td>Cold front</td><td>24.5</td><td>12.75</td><td>11.25</td></tr>
</table>