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The climates of the world's wine regions

German Puga[1] and Kym Anderson[2]

[1] Wine Economics Research Centre, University of Adelaide, Adelaide, Australia, and Centre for Agricultural Economics and Development, University of Western Australia, Perth, Australia
[2] Wine Economics Research Centre, University of Adelaide, Adelaide, Australia, and Crawford School of Public Policy, Australian National University, Canberra, Australia

The aim of this article is to describe the climates of the world's wine regions and discuss implications of climate change for those regions. In doing so, we summarise a recent scientific journal article: Puga *et al.* (2022)[1]. We also incorporate insights from other work – part of which is first published here.

In Puga *et al.* (2022)[1], we analysed data on 16 climate variables for more than 800 of the world's wine regions. We used those data for doing a principal components analysis (PCA) for data reduction and then used the principal components from that in a cluster analysis. That led us to a three-group classification of the 800+ regions.

Figure 1 shows this three-group classification. Each bar denotes a region, and the height of each bar is proportional to its surface area of winegrapes: the larger regions have higher bars. The colour of each bar represents the group to which that region belongs.

The blue group is the coolest of the three and it includes regions that are both dry and wet. From the other two warmer groups, the orange one is drier than the green group. This orange group also has higher differences between day and night temperatures, higher vapor pressure deficit, and higher solar radiation than the other two groups. The blue group, which is the wettest, has the lowest levels of solar radiation.

Each of these three groups account for about one-third of the regions, and there are premium wine regions in every group — noting there is climate variation within each group. That suggests that high-quality wine can be produced in a wide variety of climates.

We also looked at the following question: Have the climates of these three groups already changed? For answering this question, we compared two three-decade periods, a recent one with an older one.
There have indeed been changes, most of them statistically significant. Annual precipitation has decreased a bit in all groups, while the precipitation in the growing season has decreased slightly in the driest (orange) group and increased in the wetter (green and blue) groups. In all groups, temperatures have increased, especially in the warmest months, while the differences between day and night temperatures have decreased. These changes in temperatures are usually detrimental for wine quality[2] and explain part of the changes in the vapour pressure deficits, which have increased across the three groups.

Figure 2 shows that much of the global winegrape area takes place in areas with temperatures that are hotter than 'ideal'. Each of the grey bars in this figure shows the 'ideal' growing season temperature range

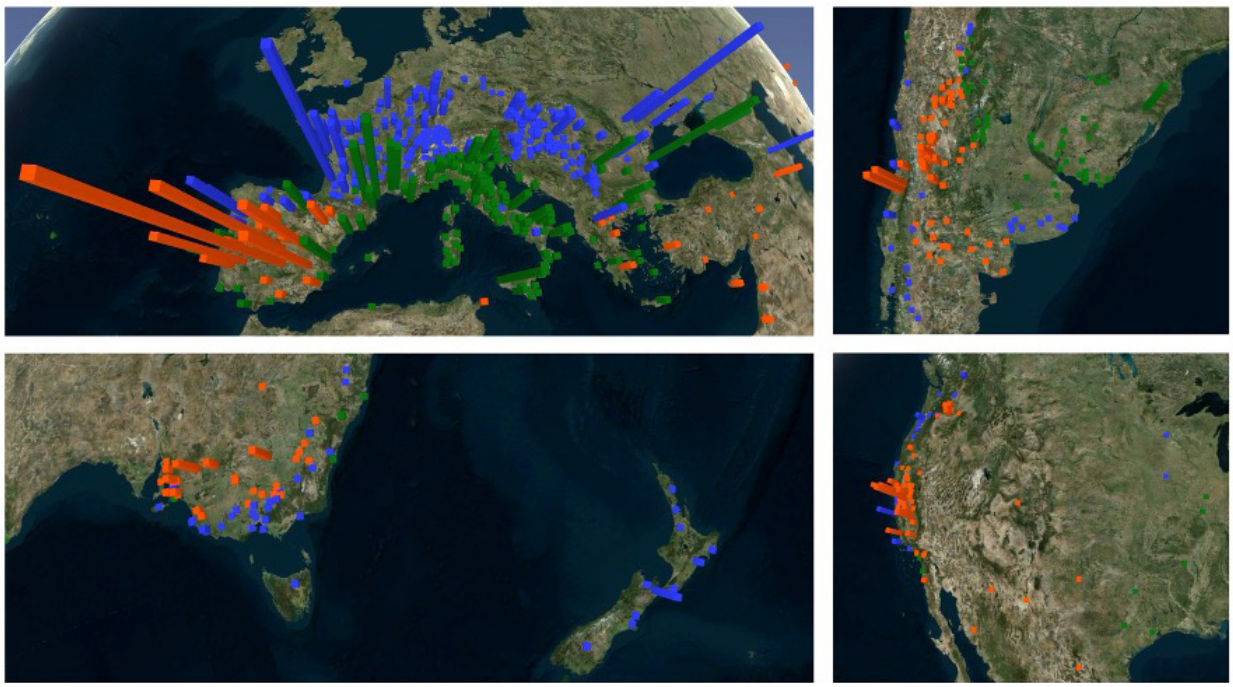


FIGURE 1. Three-groups climatic classification of the world's wine regions.
Notes: Authors' compilation based on the data and analysis of Puga *et al.* (2022)[1]. Each bar denotes a region, and the height of each bar is proportional to its winegrape area. The scales are different in the four maps. Orange group: WARM and DRY, high day-night temperature differences, high vapor pressure deficit, high solar radiation. Green group: WARM and WET, low day-night temperature differences. Blue group: COOL, mostly wet, low day-night temperature differences, low vapor pressure deficit, low solar radiation.

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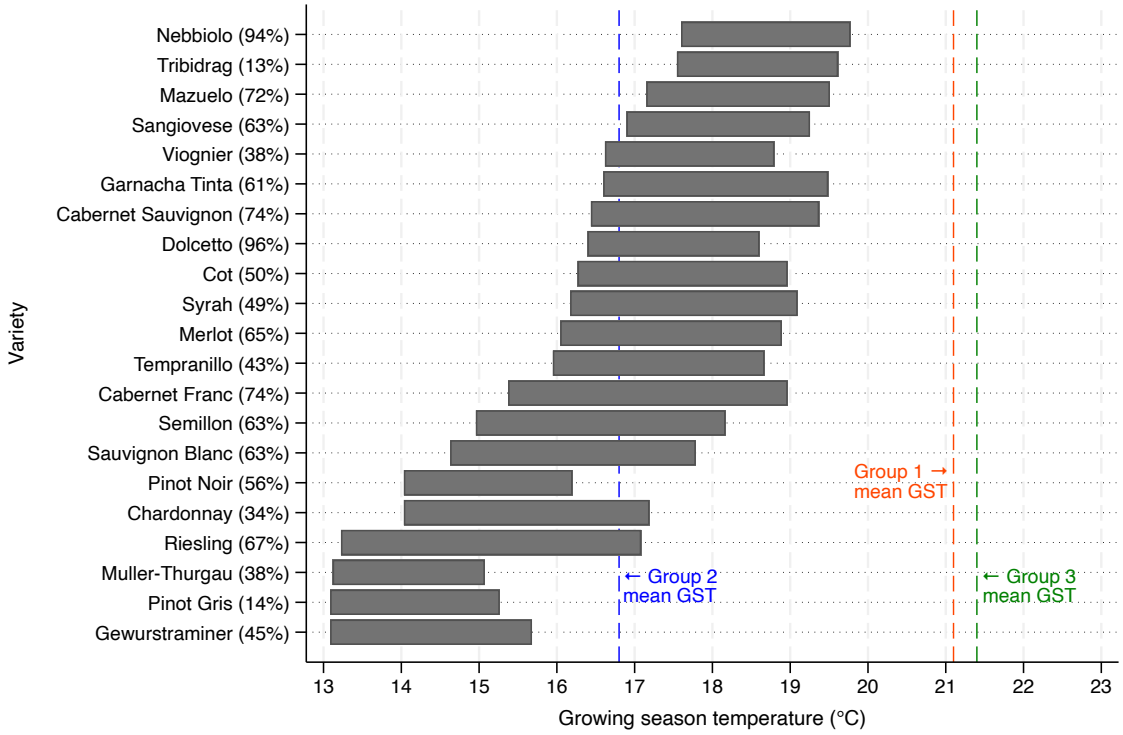


FIGURE 2. 'Ideal' growing season temperature (GST) ranges for producing high-quality wine, average GST for each group, and area share planted to each variety under its 'ideal' GST range.
Notes: Authors' computation based on the data and analysis of Puga *et al.* (2022)[1] and Anderson and Nelgen (2020b)[6]. 'Ideal' GST ranges according to Jones (2006)[3]. The area shares planted to each variety under its ideal GST range are in parentheses.

for producing high-quality wine of each of these varieties, according to Jones (2006)[3]. The vertical lines in this figure show the mean growing season temperature for each group. The orange and green groups have mean growing season temperatures that are higher than what may be 'ideal' for producing high-quality wine from the varieties. The numbers in parentheses in this figure show the area of each variety that is planted within these 'ideal' temperature ranges in the world. Some varieties, like Cabernet Sauvignon, have a large share under their 'ideal' temperature ranges. Others, like Zinfandel, have a very low share.

The 21 varieties in Figure 2 account for close to half of the global winegrape area. For these varieties, 44 % of their area is cultivated outside these 'ideal' temperature ranges for high-quality wine production – mainly in places that are too hot rather than too cold.

These 'ideal' temperature ranges are of course contentious, as there is research showing that high-quality wine of these varieties can be made outside these temperature ranges[4]. Indeed, our research shows the same. But it is still a good figure for illustrating the point that many of these mainstream varieties are planted in regions that are probably hotter than ideal. That may become even more of an issue, for two reasons: one is climate change, and the other is that the global demand for wine is favouring higher-quality products.

van Leeuwen *et al.* (2024)[5] provide a more detailed assessment of the changes in suitability levels across major wine regions. They also review and recommend climate adaptation strategies for the wine industry.

More of the data used in Puga *et al.* (2022)[1] are available in the Supplementary Data of that paper. That includes the area-weighted average growing season temperature for more than 1,700 varieties. As well, more data can be freely downloaded as Excel files from the website of the Wine Economics Research Centre of the University of Adelaide (https://economics.adelaide.edu.au/wine-economics). ■

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