Tippling Points

Impacts on wine production from climate change induced disruption to major climate oscillation patterns

Introduction

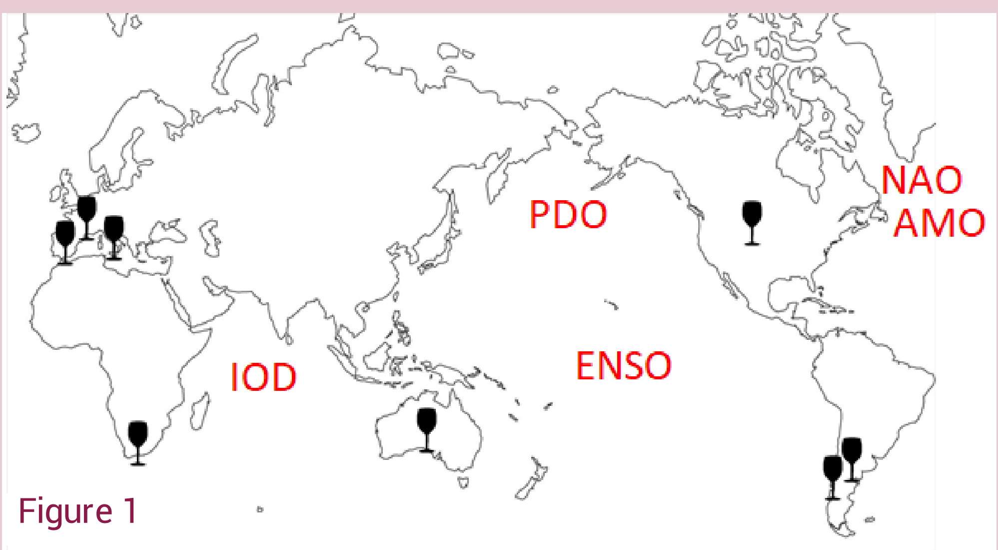

Figure 1

There are several large scale climate oscillations that dominate climate variability on inter-annual timescales. These oscillations (Figure 1) are associated with sea surface temperature (SST) anomalies and atmospheric pressure changes. Through atmospheric teleconnections, these oscillations have far-reaching impacts on weather patterns, vastly influencing precipitation and temperatures beyond the oceans in which they occur. With anthropogenic climate change, extreme events of these oscillations are predicted to become more frequent. For example the El Nino Southern Oscillation (ENSO), where extreme El Niño events are estimated to double from one event every 20 years in the control experiment to one event every 10 years in the climate change experiment (Cai et. al., 2014). The significant reorganisation of atmospheric convection in historic extreme El Nino events caused severe disruption to global weather patterns and lead to major natural disasters including catastrophic floods and droughts (Philander et al., 1983). With similarly severe impacts, the extreme frequency of positive Indian-Ocean dipole (pIOD) events are projected to increase by almost a factor of 3 (Cai et al., 2014) . Increased frequency of these events could have significant socio-economic repercussions, particularly in the agricultural industry. In order to gain a greater understanding of the potential impact, this study investigates the relationships between the index for each large climate oscillation and crop yield. For this particular explorative study we have selected grapes as they are a particularly climate sensitive and vulnerable crop (Ollat and Touzard 2014).

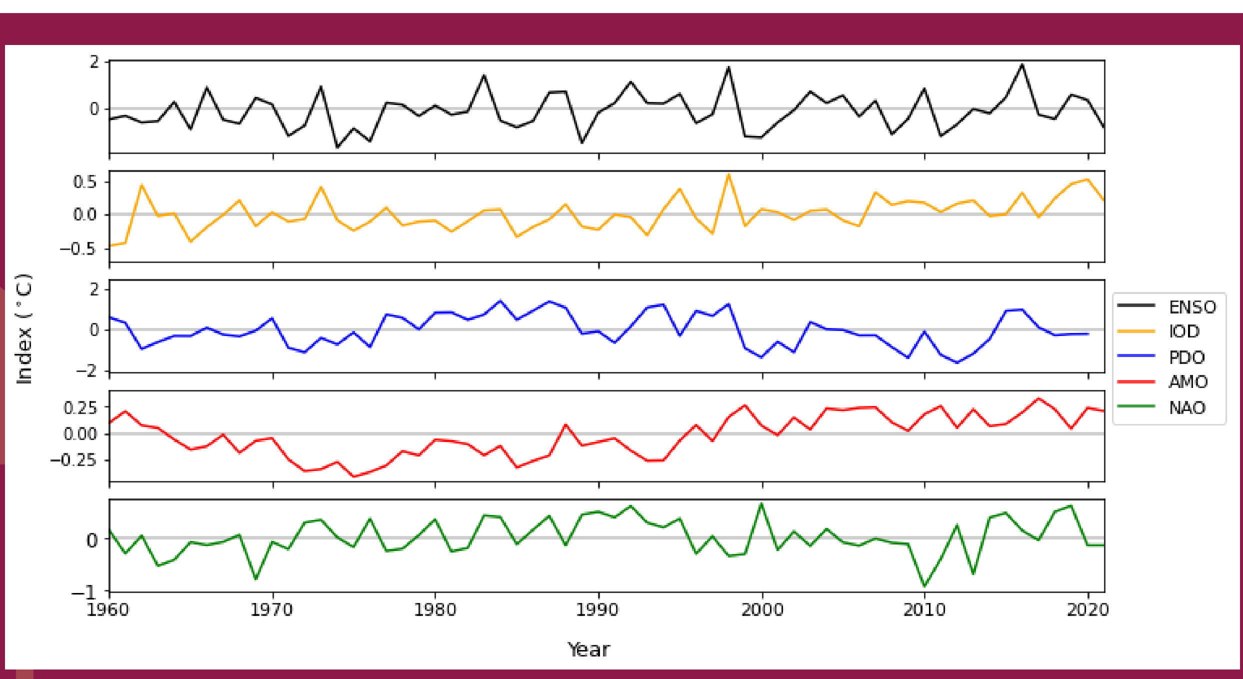

Figure 2 : Time series of annualised climate indices for the Southern Hemisphere vine cycle (June to June). Time series shown for the period of wine data available.

For each country studied, the relationship between grape yield and mean climate index (annualised by the grape growing season for the corresponding region) was analysed using linear regression. A positive correlation (+0.432) was found between the mean annual IOD index and grape yield in Chile as in Figure 3a. This suggests that as positive IOD events are projected to increase, grape yield will also likely increase in Chile.
Additionally, there is a trend in grape yield increasing with time (shown by the colour of the data points), however this could be due to other relevant factors such as improved growing practices and an increase in demand. Figure 3b shows the relationship between mean annualised Nino 3.4 index and log grape yield in the US, where no statistically significant correlation was found, matching findings in previous studies (Jarvis et al., 2017). However, this relationship proved to be more complex when modelled using a distributed lag model (DLM), which took into account the monthly variation in Nino 3.4 values (Figure 3c). Such discrepancies suggest that linear regression using annual mean values of climatic indices may overlook more nuanced trends and should be studied further to include other factors.

A DLM (Gasparrini, 2011) was run for all pairs of countries and climatic indices. An excellent example of the extra information that such a model can elicit is presented in Figure 3d, which shows the yield anomaly for Australian grapes in relation to a PDO index (negative index leads to lower yields, and vice versa). Generally, the relationship between PDO and yield is a positive one, but the strength of this positive correlation increases with time after a specific PDO index value. In other words, a positive PDO index will have a much stronger positive influence on yield 12 months after occurrence compared to 1 month after occurrence.

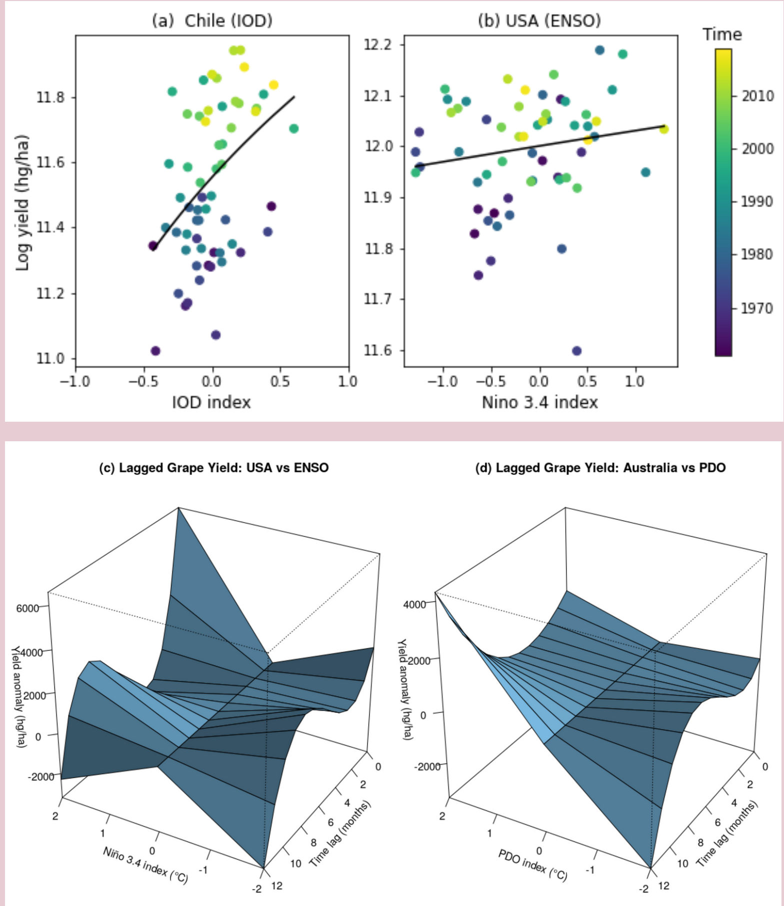

Figure 3

In 2019 the global wine market was estimated at $364.25 billion with North America contributing almost $60 billion. In 2019-20 Australia exported 729 million litres of wine valued at $2.8 billion. However, ENSO and IOD can significantly impact wine grape flavour, form and therefore quality. When both in the positive phase Australia experiences drier and hotter than average conditions and the two combined can impact the growing season by rapidly maturing the grapes (Ceranic, 2019). When grapes mature too quickly the sugar levels increase providing a high alcohol content however the quality and body of the wine is significantly reduced. These changes can diminish the value of the wine produced and can negatively impact wine revenue. With an increase in extreme climate events this could have a serious impact on the Australian wine economy. However, better understanding of these relationships and short term seasonal predictions can help to mitigate losses and allow for better economic planning.

This preliminary study has found links between several large-scale climate oscillations and grape yield. However, it is not sufficient to only consider yield in respect to wine production and economies. As with many crops, the quality is important, with changing climates the taste and quality will alter. Therefore, further investigation into links of quality of wine and large-scale climate oscillations will be required to provide insight into the potential tipping points of wine production and thus the associated migration and adaption of wine economies. These methods can be applied to any food crop and any country/region with data.

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