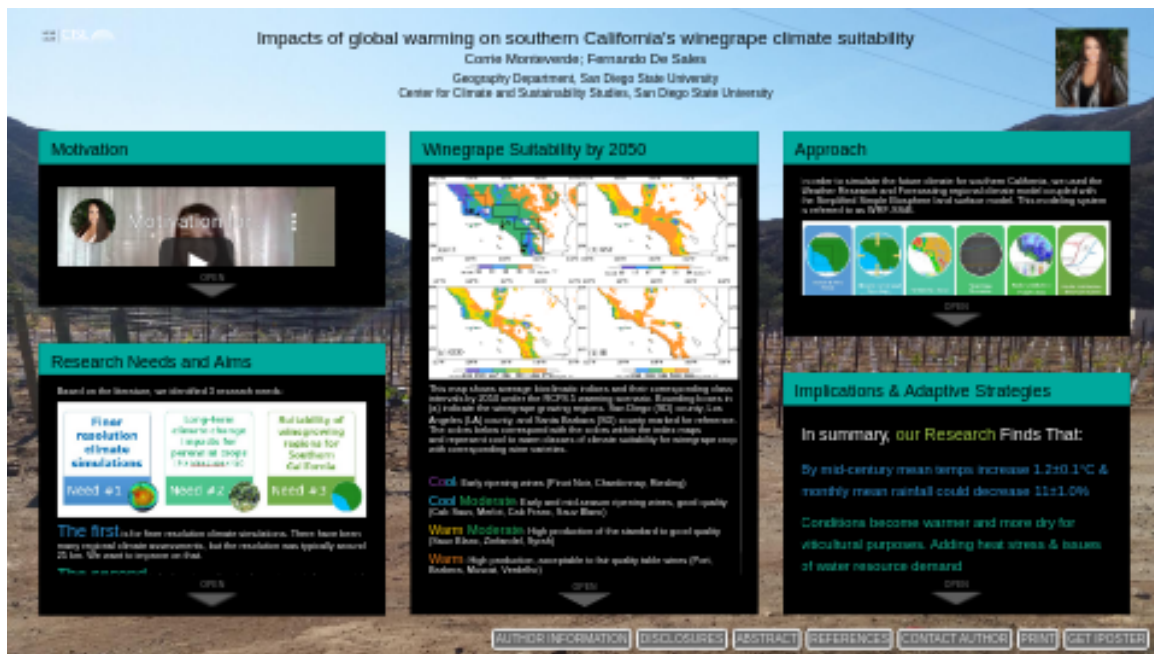


# Impacts of global warming on southern California's winegrape climate suitability

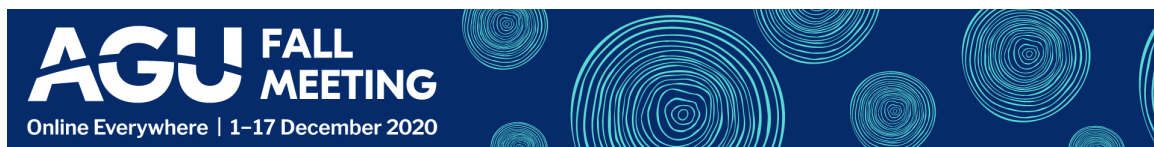


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PRESENTED AT:



## MOTIVATION

[VIDEO] <https://www.youtube.com/embed/H2ozfKpqvn4?rel=0&fs=1&modestbranding=1&rel=0&showinfo=0>

### Winegrape:

Type of grapes grown on grapevines

Used specifically for wine production

Economically important perennial crop



We know that this is an important crop because of the regional economic impact. Check out these two economic reports! One from San Diego for 2018 and one for Santa Barbara for 2013.

## Economic Reports



**San Diego:**  
helped provide  
**697 jobs** and  
generated a  
regional impact  
of **\$58.6 million**  
for 2018



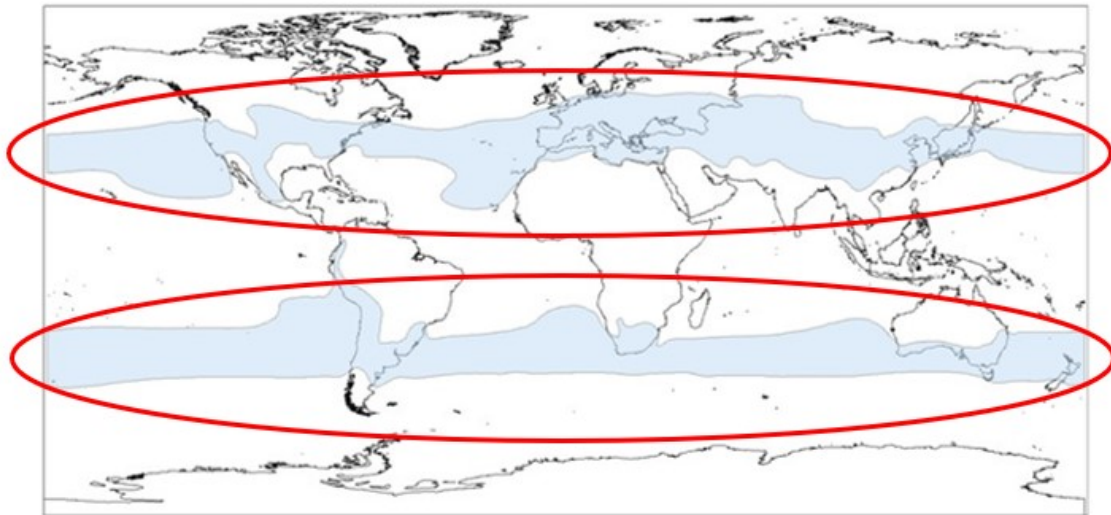
**Santa Barbara:**  
helped provide  
**9,158 jobs** and  
generated a  
regional impact of  
**\$1.7 billion** for  
2013

Clearly a very important crop for southern California.

**BUT!**



Winegrape crop is located in narrow climatic zones (see below).



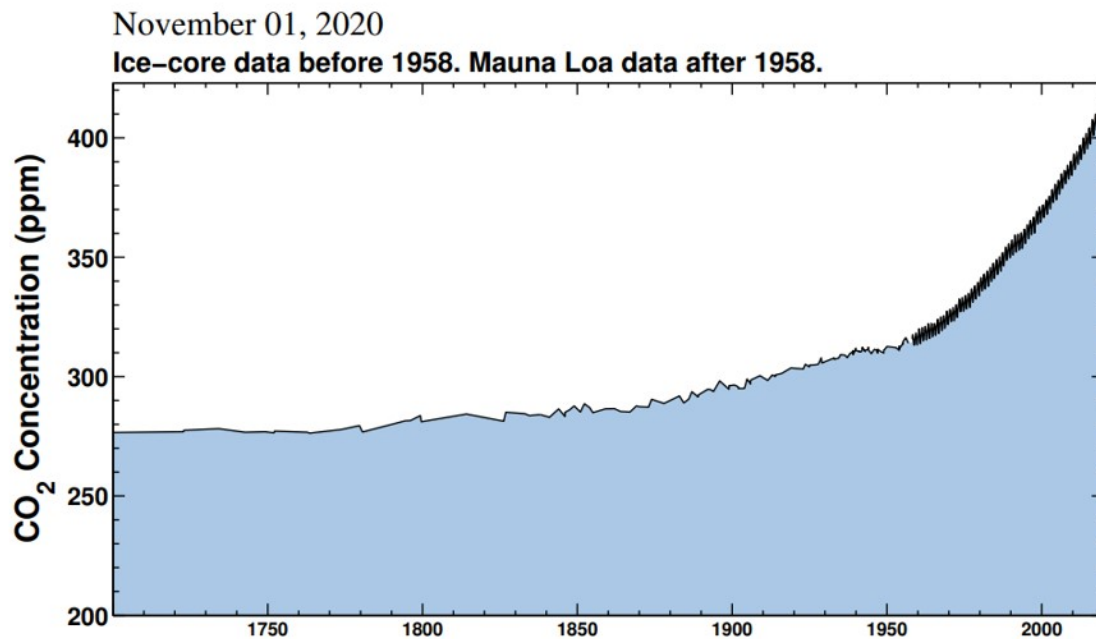
Geographic Extent\* of Winegrowing Regions (30-50° N/S)

\*based on 10-12° and 20-22° isotherms

Winegrape is sensitive to short-term variability & long-term change in climate, more than other crops (Jones & Webb, 2010)

Therefore, it is at risk due to future changes in climate

Recent trends in climate indicate global warming mainly due to the increase in greenhouse gases (GHGs) from anthropogenic activities, like fossil fuel burning. The graph below shows CO<sub>2</sub> concentration from 1700 to 2020, as CO<sub>2</sub> is the most common and worrisome GHG.



CO<sub>2</sub> concentration from 1700 - 2020

You can see very clearly that CO<sub>2</sub> is increasing, and this has many implications for rising global temperatures. Issues of global warming's impact are not just an issue to scientists.

The wine community recognizes the climate's impact on winegrape crop. There was a working group called the International Wineries for Climate Action established in 2019 specifically formed to address impacts on their business. They said that "membership will focus on wineries who recognize that climate change is the most significant threat facing the wine industry". -Torres and Jackson family Wineries



It is apparent that this crop is at risk due to future changes in climate, and this is coming from scientists and the wine community itself.

## RESEARCH NEEDS AND AIMS

Based on the literature, we identified 3 research needs:



**The first** is for finer resolution climate simulations. There have been many regional climate assessments, but the resolution was typically around 25 km. We want to improve on that.

**The second** is for long-term climate change impacts for perennial crops (meaning lasting longer than one year). These crops can act as a climate change indicator for other valuable crops in this region.

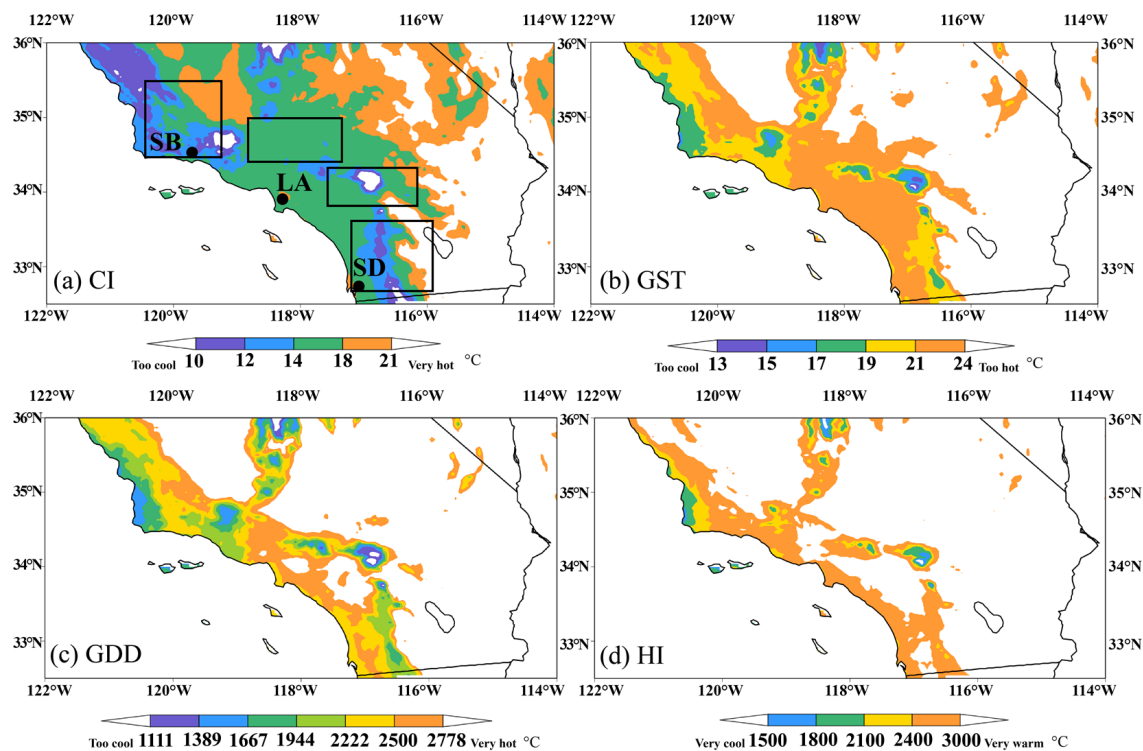
**The third** was for the suitability of winegrowing regions for southern California. With the increased interest in winegrape crop and its economic importance, this type of study is necessary.

Based on needs...

### This study aims to:

- Improve the current understanding of the effects of global warming on the region's viticulture
- By generating accurate regional-scale information about the crop's climatic suitability
- That can assist local growers in the development of strategies to alleviate the negative impacts of a warmer climate

## WINEGRAPE SUITABILITY BY 2050



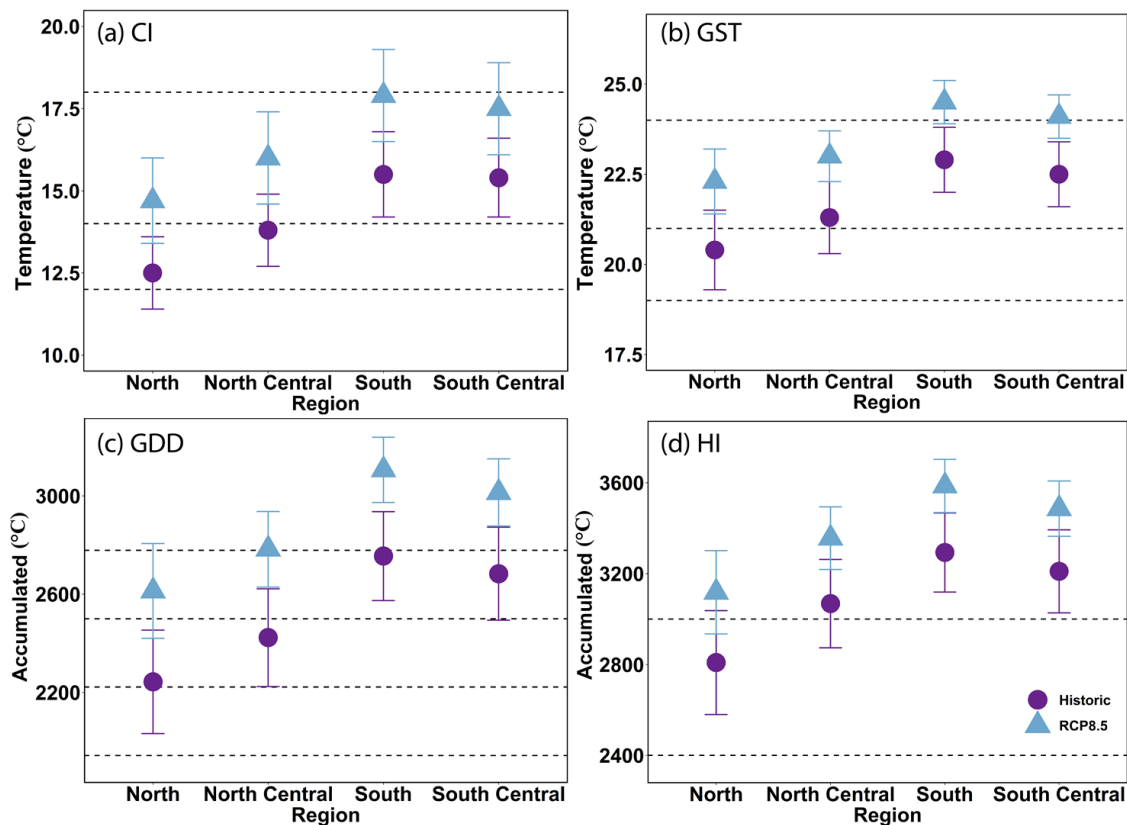
This map shows average bioclimatic indices and their corresponding class intervals by 2050 under the RCP8.5 warming scenario. Bounding boxes in (a) indicate the winegrape growing regions. San Diego (SD) county, Los Angeles (LA) county, and Santa Barbara (SD) county marked for reference. The colors below correspond with the colors within the index maps and represent cool to warm classes of climate suitability for winegrape crop with corresponding wine varieties.

**Cool:** Early ripening wines (Pinot Noir, Chardonnay, Riesling)

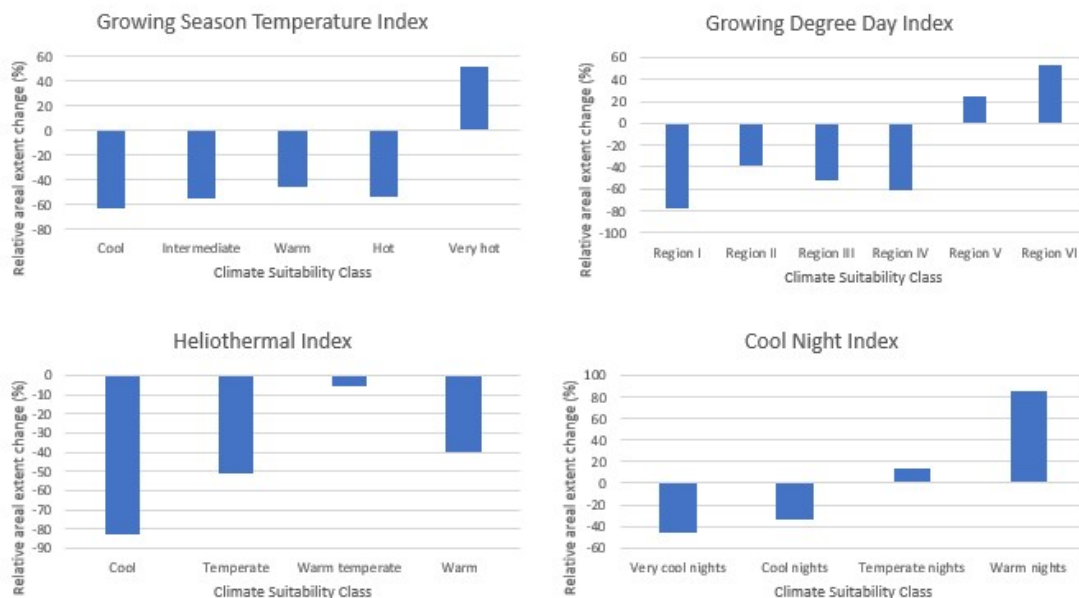
**Cool Moderate:** Early and mid-season ripening wines, good quality (Cab Sauv, Merlot, Cab Franc, Sauv Blanc)

**Warm Moderate:** High production of the standard to good quality (Sauv Blanc, Zinfandel, Syrah)

**Warm:** High production, acceptable to fair quality table wines (Port, Barbera, Muscat, Verdelho)



Regions transition into some of the warmest climate suitability classes based on index calculations (see figure above). This shows the change in average indices from historical to future period based on the RCP8.5 warming scenario for 2041-2050 with index class breaks represented by dashed lines. Grapevines and winegrowers need consistency, so shifts in climate structures can produce unreliable yields and ultimately change the quality of the grape.



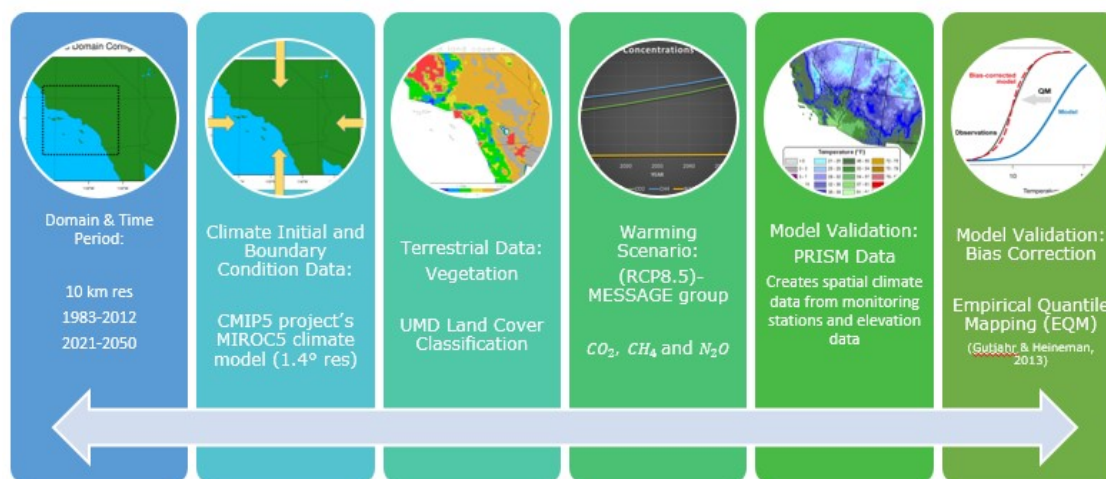
These graphs show changes in areal extent between the historical and future time period for each index categorized by classes. The main conclusions from these graphs are:

- By 2050, areal extent of regions across all indices reduce an average 42% for cool to warm categories
- Increase 59% for the warmest category of GST, GDD, CI
- Reduction of 8600 and 8700 km<sup>2</sup> for GDD and HI, respectively



## APPROACH

In order to simulate the future climate for southern California, we used the Weather Research and Forecasting regional climate model coupled with the Simplified Simple Biosphere land surface model. This modeling system is referred to as WRF-SSiB.



## Important Model Information:

Resolution of WRF-SSiB modeling system: 10 km

Time period: 1983-2012 (historical or baseline simulation); 2021-2050 (future climate simulation)

Climate Initial and Boundary Condition data: MIROC5

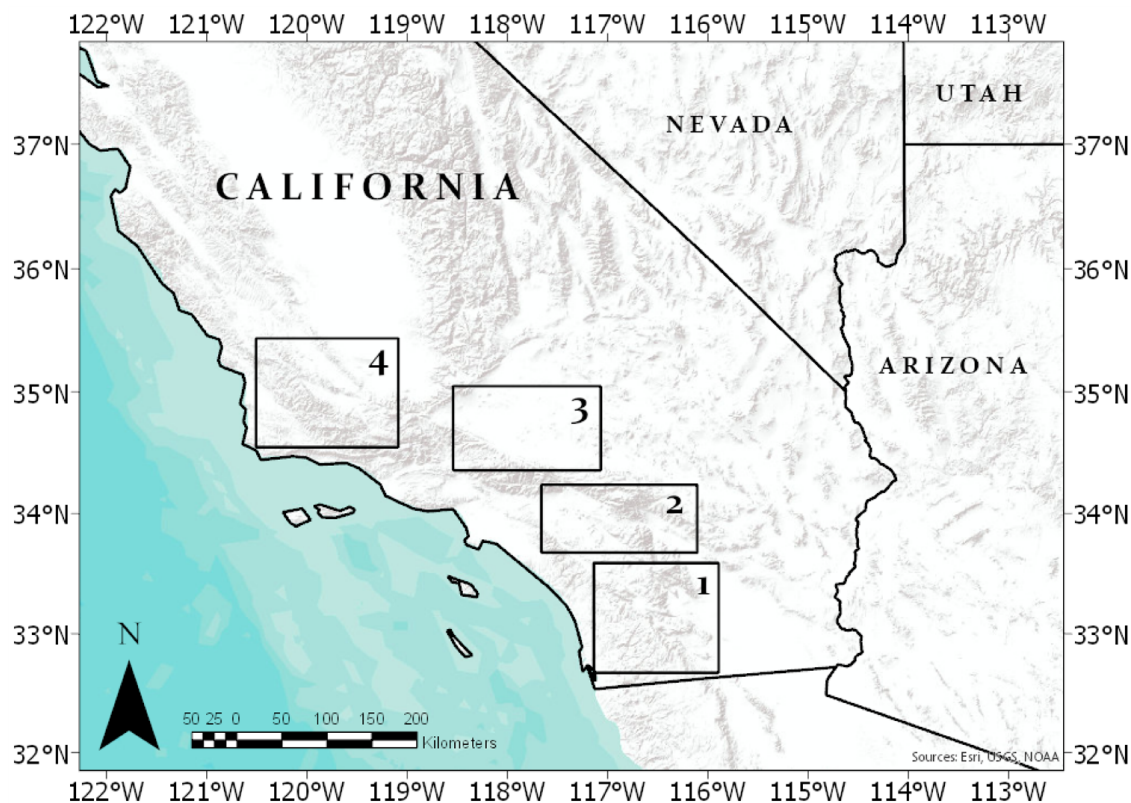
Terrestrial data: UMD Land Cover Classification

Warming Scenario: RCP8.5 created by MESSAGE group (including  $CO_2$ ,  $CH_4$ , and  $N_2O$ )

Model validation data: PRISM data

Model validation bias correction: Empirical Quantile Method

## Study Area:



This study focused on four regions in southern California based on 14 American Viticultural Areas (AVAs) in the counties of Los Angeles (Region 3), Santa Barbara (Region 4), San Luis Obispo (Region 4), San Bernardino (Region 2), San Diego (Region 1), and Riverside (Region 1).

## Bioclimatic Indices:

$$HI = \sum_{April\ 1}^{Sept\ 30} \left( \frac{(T - T_b) + (T_x - T_b)}{2} \right) * d$$

$$GDD = \sum_{April\ 1}^{Oct\ 31} ([T_{max} + T_{min}]/2) - 10^{\circ}C$$

$$CI = \left(\frac{1}{N}\right) \sum_{Sept\ 1}^{Sept\ 30} T_n$$

$$GST = 1/n \sum_{April\ 1}^{Oct\ 31} (T_{max} + T_{min})/2$$

To help classify winegrowing regions and corresponding climate suitability, we use bioclimatic indices (see above).

**Heliothermal Index (HI):** Describes the level of heliothermal potential and provides a better idea of the sugar potential according to varieties than the classic temperature sums

**Growing Degree Days (GDD):** This is very similar to HI and calculates the heliothermal potential during the growing season but does not take into account maximum temperature, like HI

**Cool Night Index (CI):** This is the night coolness variable when ripening usually occurs beyond the ripening period. It helps give a better idea of the secondary metabolites (aromas, polyphenols) in grapes. It describes grape and wine color and aromas

**Growing Season Average Temperature (GST):** This calculates the average growing season temperature and correlates broadly to the maturity potential for winegrape varieties

(Explanation of variables: T= average temperature; Tmax= maximum temperature; Tmin= minimum temperature; Tn= minimum temperature for individual day; N= number of days in month; d= length of day coefficient)

## Class Intervals:

Index	Class Interval		Index	Class Interval	
<b>HI</b>	Very Cool	<1500	<b>GDD</b>	Too cool	<1111
	Cool	1500-1800		Region I	1111-1389
	Temperate	1800-2100		Region II	1389-1667
	Warm Temperate	2100-2400		Region III	1667-1944
	Warm	2400-3000		Region IV	1944-2222
	Very Warm	>3000		Region V	2222-2500
<b>CI</b>	Very cool nights	<12°C		Region VI	2500-2778
	Cool nights	12°C-14°C	<b>GST</b>	Too hot	>2778
	Temperate nights	14°C-18°C		Too cool	<13°C
	Warm nights	>18°C		Cool	13-15°C
				Intermediate	15-17°C
				Warm	17-19°C
				Hot	19-21°C
				Very hot	21-24°C
				Too hot	>24°C

These are the indices and their corresponding class intervals. They range from cool to hot classes.

## IMPLICATIONS & ADAPTIVE STRATEGIES

### **In summary, our Research Finds That:**

By mid-century mean temps increase  $1.2 \pm 0.1^\circ\text{C}$  & monthly mean rainfall could decrease  $11 \pm 1.0\%$

Conditions become warmer and more dry for viticultural purposes. Adding heat stress & issues of water resource demand

Regions transition into some of the warmest climate structures which might change the overall wine style framework that can be produced

### **Impact on Winegrape Crop:**

1. Increased temperatures and decreased precipitation indicate growing regions could become more prone to experience moisture deficit stress, resulting in changes to quality, appearance, flavor, taste and aroma
2. Changes in CI are associated with grape color and wine aroma and could be impacted greatly
3. Higher temperatures and increased GST can negatively impact yield in the future
4. As heat accumulation changes, associated with increases in GDD, the ability to ripen certain varieties may change
5. Very warm temperatures can destroy entire crops, which these regions might experience more frequently in the future

**Although regions are in very warm climate classes, this is not the final say for viticulture. There are adaptation strategies!**

### **Strategies include:**

- Planting hotter climate varieties
- Using subsurface drip and night irrigation
- Installing cooling equipment
- Purchasing land in cooler climates
- Using different plant material rootstock
- Implementing dry farming

### **What is dry farming?**





Dry farming works to conserve soil moisture during long dry periods primarily through a system of tillage, surface protection, and the use of drought-resistant varieties. Find out more about dry farming here ([http://agwaterstewards.org/practices/dry\\_farming/](http://agwaterstewards.org/practices/dry_farming/)).

## Future Research Should Focus On:

