Climate, Grapes and Wine:
Climate Change Influences on Wine Production

Gregory V. Jones, PhD.
CEO, Abacela Vineyards and Winery
Abacela
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CLIMATE GRAPES AND WINE

PhD research in Bordeaux, additional research in many wine regions around the world.
Monthly reports, videos, publications can all be found at www.climateofwine.com

tapas
tempranillo advocates producers and amigos society

Oregon Tempranillo Alliance

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Talk Outline

- Weather, Climate, and Wine
- Climate Variability
- Past and Future Climate Change
- Summary

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Weather, Climate, and Wine

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Weather, Climate, and Wine

- Combined, weather and climate are the most basic and most profound environmental factors in terms of :
  - Driving overall suitability for viticulture and matching specific cultivars to individual sites
  - What wine styles can be produced in a given area
  - Driving substantial crop risk factors
  - Producing vintage variations in production and quality
- Geology, landscape, and soil are important factors that mediate the interaction between weather/climate and the vine, especially soil water supply and nutrition …
  - Producing subtle nuances and terroir expression

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Weather, Climate, and Wine

- Wine regions have developed worldwide where the weather and climate was most conducive
- But the weather/climates of wine regions vary greatly:
  - Some more at the climatic margin
  - Some with warmer days, some warmer nights
  - Some drier, some wetter
  - Some with reliable growing season rain, others none
  - Some more prone to risk from weather extremes
  - Others more equitable and consistent
- Is there a weather/climate structure that is best suited for a given variety for optimum wine quality and production?

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Influences, Risks, and Challenges

Weather and Climate present three distinct spatial and temporal scales of influences and risks to viticulture:

- Individual Weather Events (short-term/localized) **Crop Risk**
- Climate Variability (seasonal-decadal/regionalized) **Production & Quality Variability**
- Climate Structure/Change (long-term/regional-global) **Suitability**

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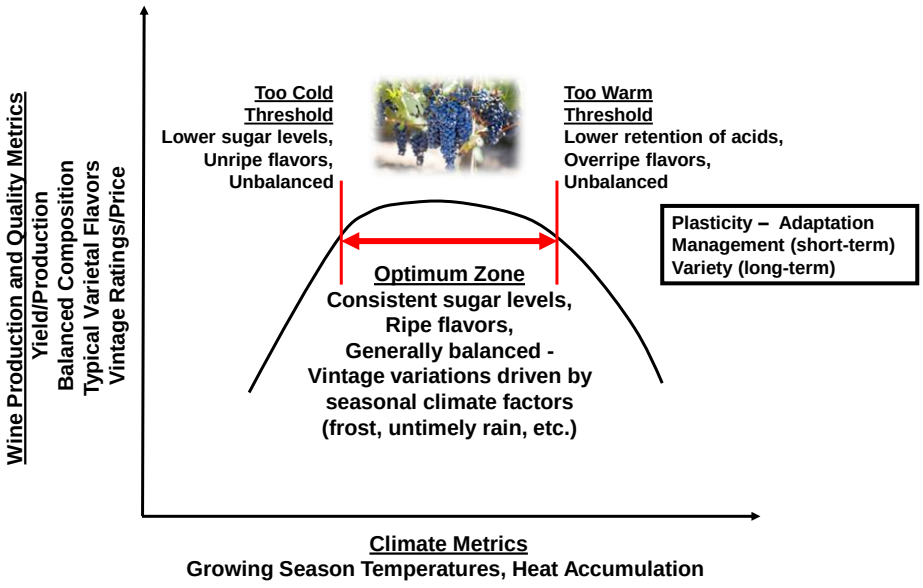
Variety-Climate Thresholds



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Climate Suitability

- All varieties have inherent climatic thresholds for optimum quality and production characteristics
- All varieties are grown across a range of temperatures, with wine style differences across the range
- Varieties can be found grown outside these bounds, but are often under or over ripe, also very limited in production, or focused on bulk markets

Jones, 2006

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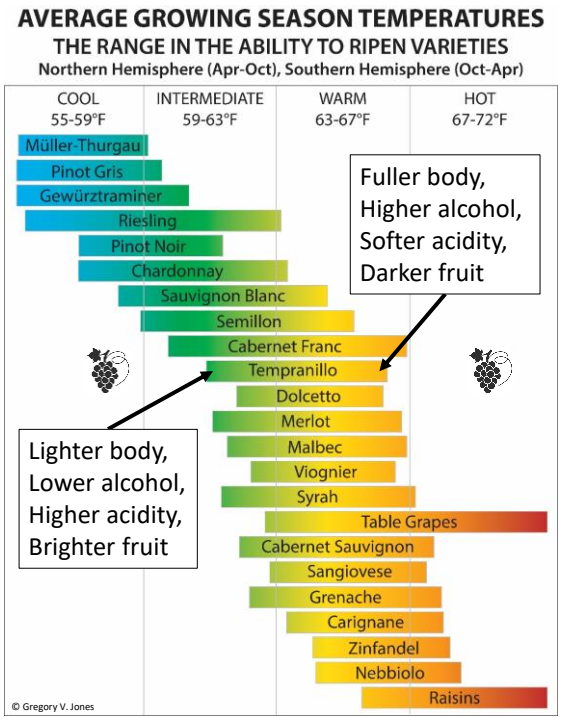

Climate Suitability

- Pinot Noir exhibits one of the narrowest climatic niches for premium quality production
- From what we know about today's Pinot Noir regions, growing season average temperatures range ~57-61°F, having ~ a 4°F climatic niche

Jones, 2006

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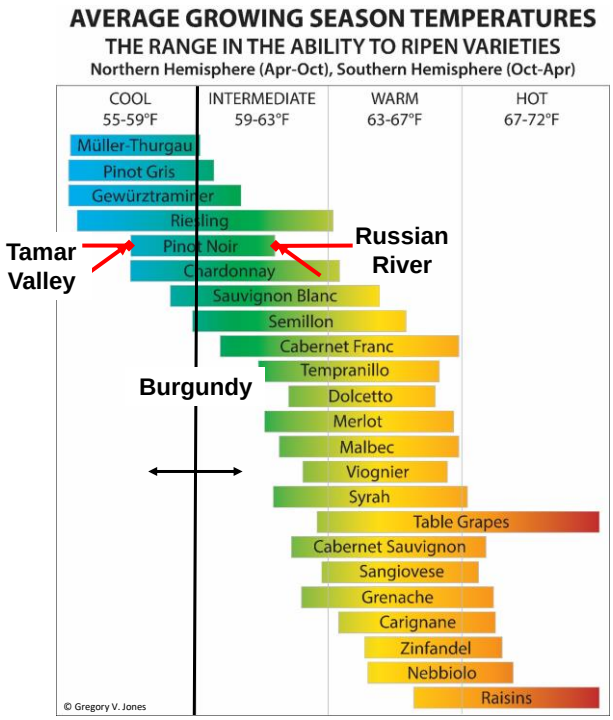
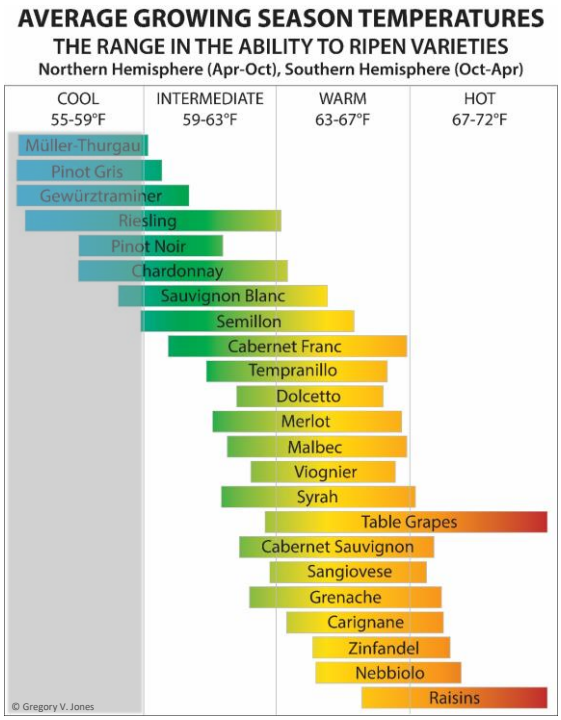


Climate Suitability

- This framework also allows for mapping current and future suitable zones
- For example … cool climate regions have growing seasons that tend be 5-7 months in length, averaging 55-59°F



Jones, 2006

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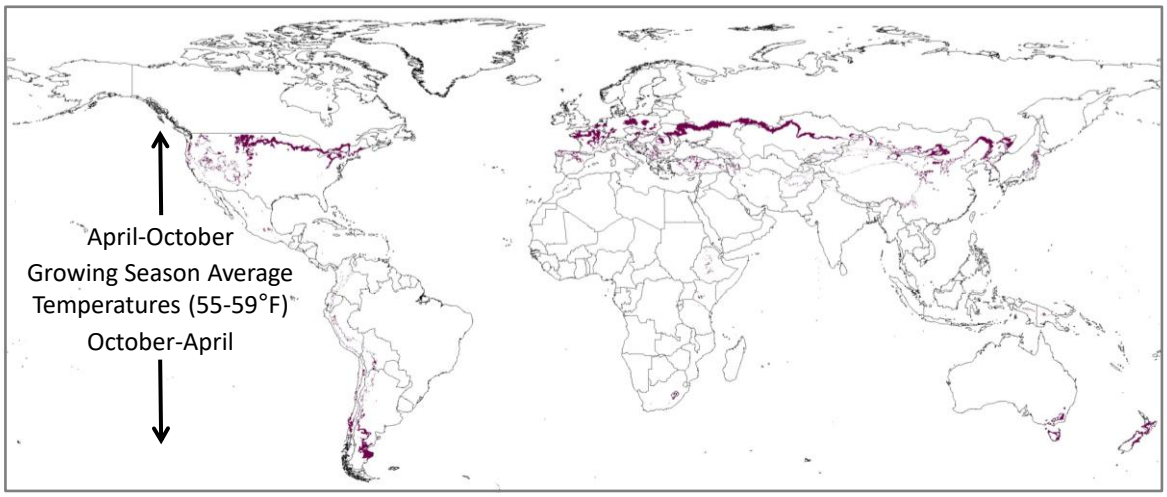
Cool Climate Zones Worldwide



Area Suitable 55-59°F

Represents 1950-2000 Average Growing Season Temperatures
(WorldClim database, 1 km resolution)

Jones and Schultz, 2016

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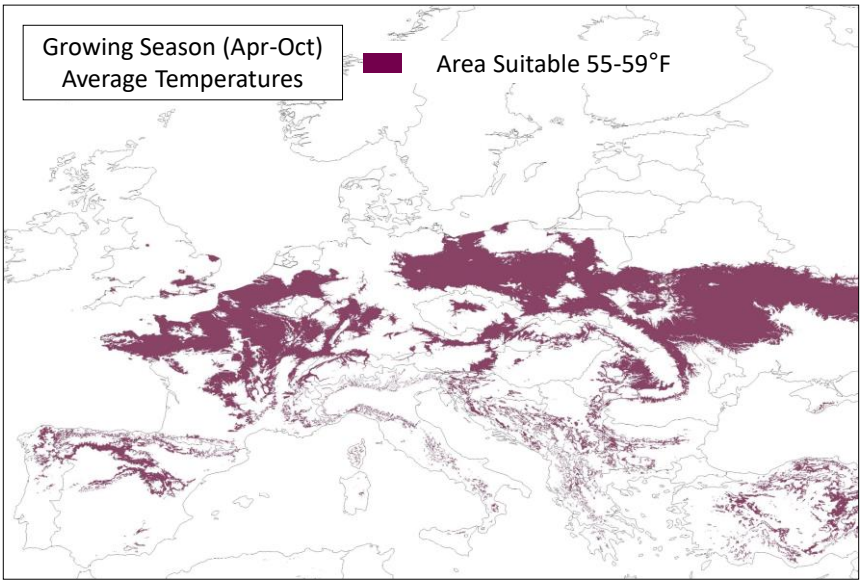
Cool Climate Zones - Europe



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(WorldClim database, 1 km resolution)

Jones and Schultz, 2016

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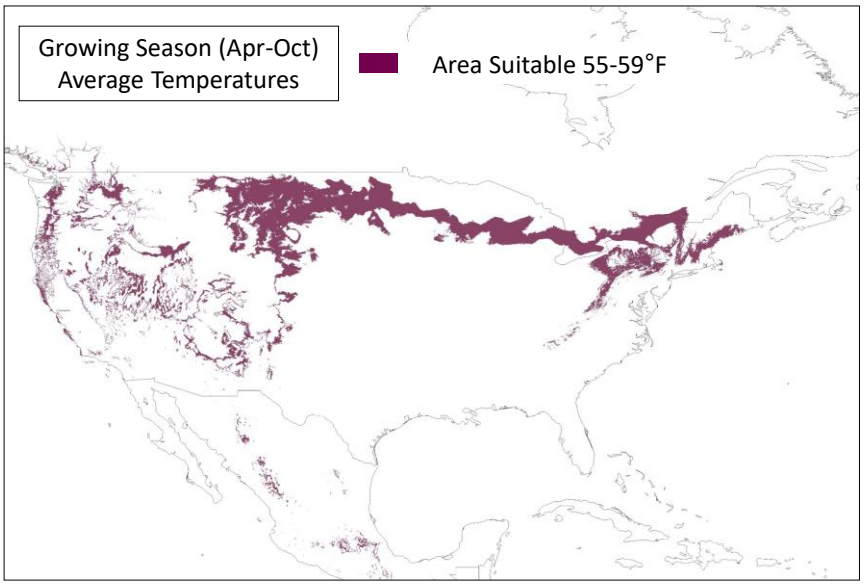
Cool Climate Zones - North America



Represents 1950-2000 Average Growing Season Temperatures
(WorldClim database, 1 km resolution)

Jones and Schultz, 2016

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Climate Variability

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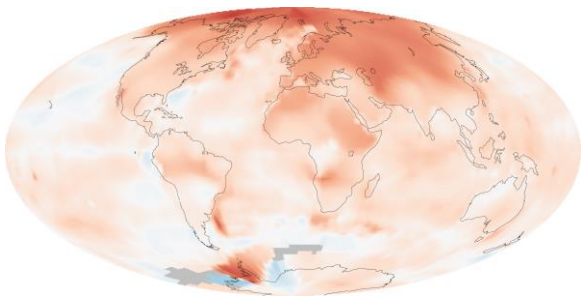
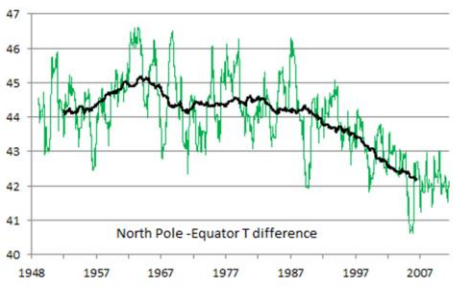
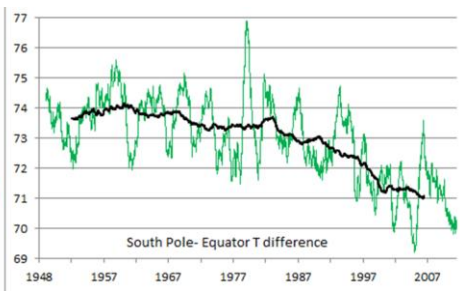
Tropics to Poles Temperature Gradient







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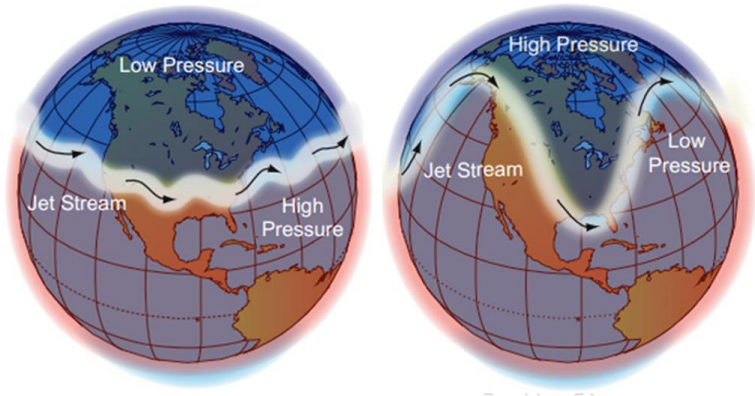
Increased Weather/Climate Variability



Arctic amplification (4x the rate of warming of the rest of the planet) has produced a slower jet stream, with more amplified north-south waves, more extreme weather and greater swings in climate conditions from year to year, season to season, and month to month. Some indication of similar changes in the Southern Hemisphere

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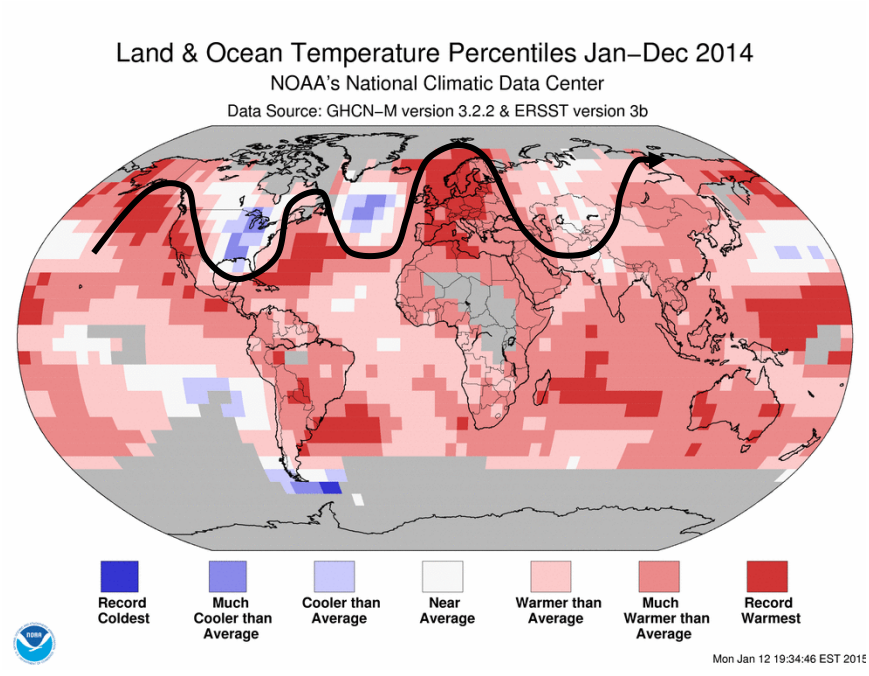

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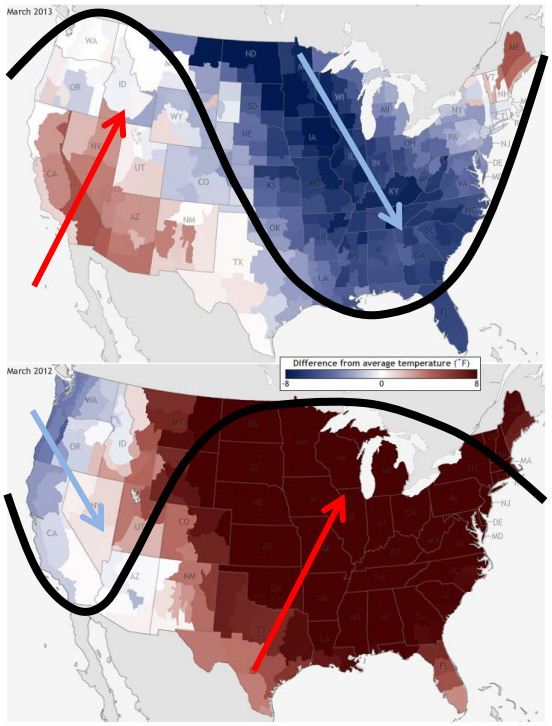

For example, in the US, March 2012 was exceptionally warm over most of the US, while March 2013 was much cooler than average

Over the last 20 years in the US, more extreme records in temperatures (both cold and warm) and precipitation (both heavy events and drought severity) have been broken than in the previous 40 years combined

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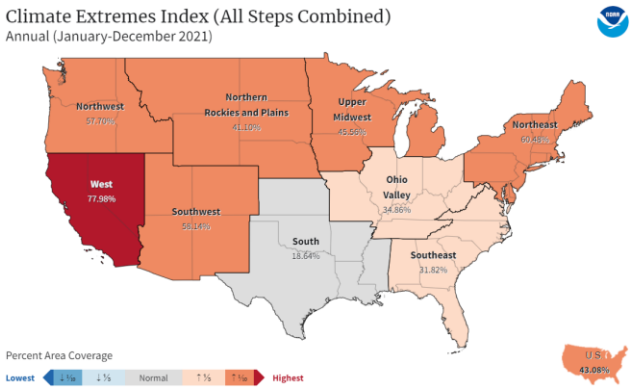
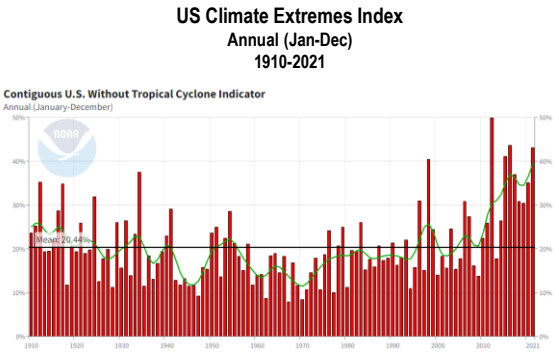
US Climate Extremes Index





- US Tmax, Tmin and 1 day precipitation totals, and tropical storms much above average
- Record warm extremes are occurring 15-25 times the rate of record cold extremes
- A stable climate would be close to 50/50

NOAA National Centers for Environmental Information

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Eastern North America Climate Variability Factors

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Climate Change: The Past & Present

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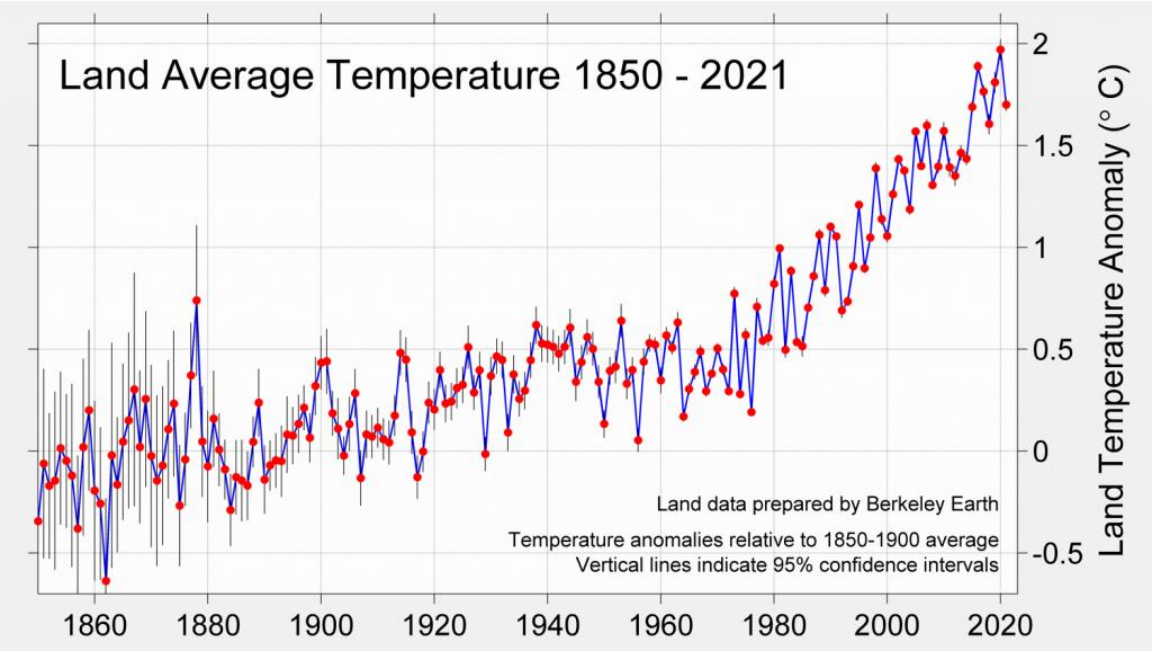

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Observed Trends in Wine Regions Worldwide

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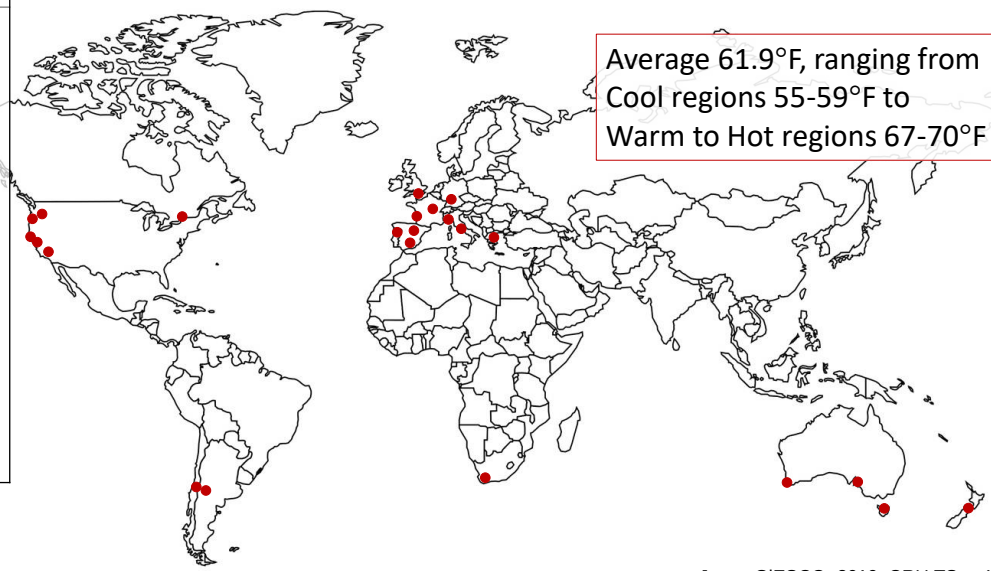
Wine Region Average Growing Season Temperature Trends 1901-2018

REGION
ADELAIDE, AUSTRALIA
BORDEAUX, FRANCE
BURGUNDY, FRANCE
CURICO, CHILE
DOURO, PORTUGAL
GEISENHEIM, GERMANY
LA MANCHA, SPAIN
MADERA, CALIFORNIA
MARLBOROUGH, NZ
MENDOZA, ARGENTINA
NAPA VALLEY, USA
NAUOSA, GREECE
NIAGARA, CANADA
PERTH, AUSTRALIA
PIEDMONT, ITALY
RIOJA, SPAIN
SONOMA, USA
STELLENBOSCH, SA
SURREY, ENGLAND
TASMANIA, AUSTRALIA
TUSCANY, ITALY
WILLAMETTE VALLEY, USA
WALLA WALLA, USA



Average 61.9°F, ranging from Cool regions 55-59°F to Warm to Hot regions 67-70°F

Jones-GiESCO, 2019; CRU TS v. 4.03

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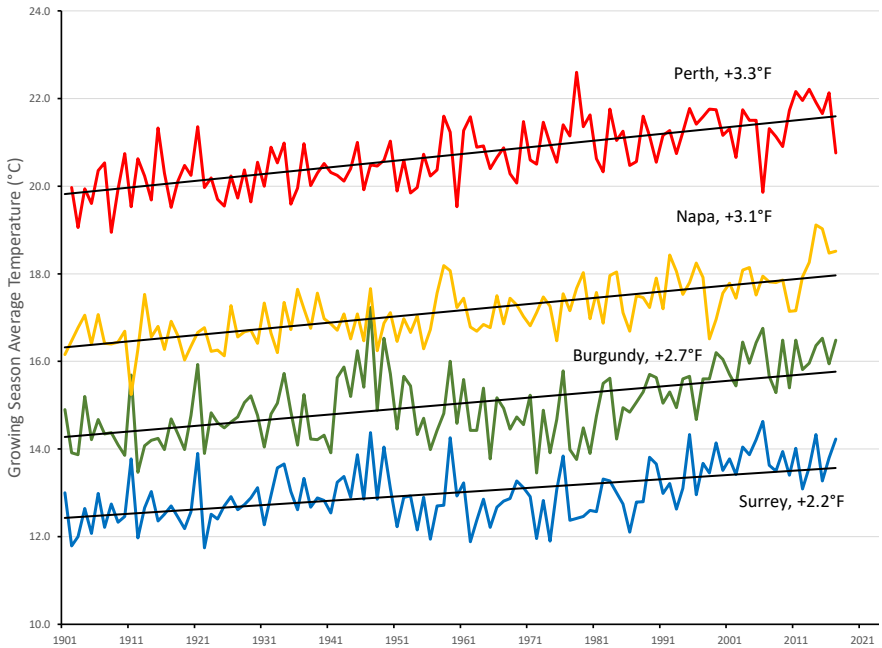
Average Growing Season Temperature Trends 1901-2017



All locations warmed significantly ($0.11<R^2<0.54$)

Decadal rates average 0.22°F (0.16 to 0.31°F)

Period of Record averages 2.5°F (1.6 to 3.7°F)

Jones-GiESCO, 2019; CRU TS v. 4.03

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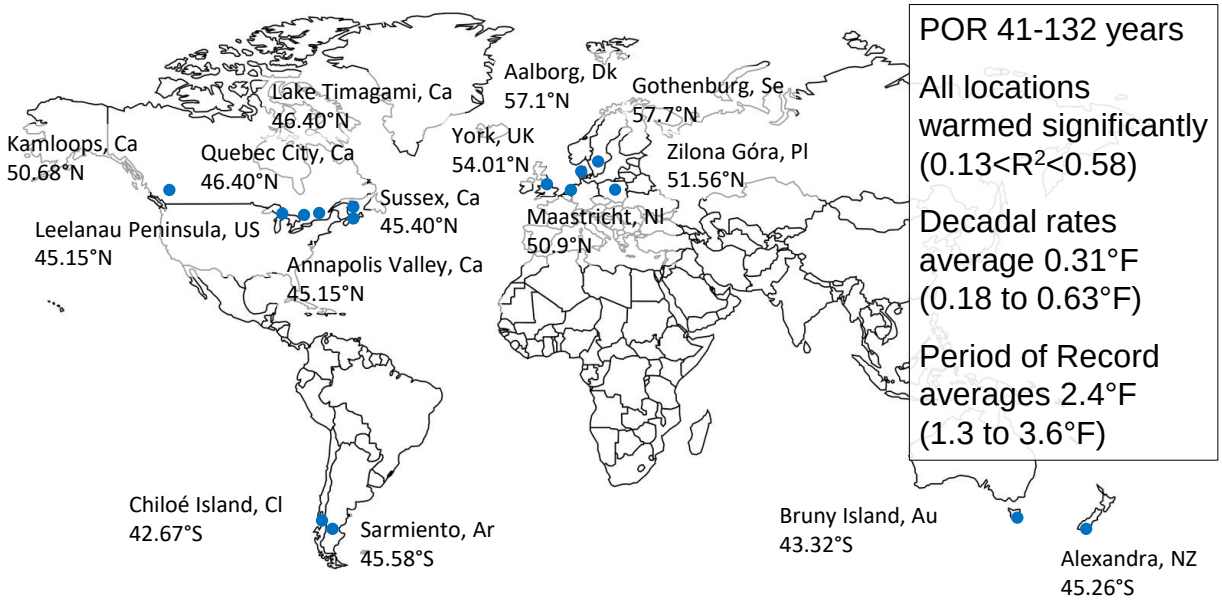
Extreme Cool Climate Locations and Trends



Jones and Schultz, 2016

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Cool Climate Region Trends

Location	Time Period	Trend (°F/decade)	Trend (°F, POR)	Current GSTavg (°F)
Malleco, Chile	1932-2016	0.22	1.8	55.8
Rio Negro, Argentina	1952-2015	0.18	1.3	55.6
Puget Sound, USA	1892-2016	0.20	2.7	56.1
Leelanau Peninsula, USA	1895-2015	0.20	2.3	57.9
Okanagan Valley, Canada	1900-2015	0.18	2.2	59.0
Niagara, Canada	1883-2015	0.27	3.6	60.4
Nova Scotia, Canada	1913-2015	0.23	2.3	57.4
Tasmania, Australia	1893-2015	0.20	2.5	60.4
Otago, New Zealand	1930-2016	0.34	2.9	58.1
Eastbourne, UK	1959-2015	0.49	2.7	58.8
Oxford, UK	1900-2015	0.23	2.7	58.1
Geisenheim, Germany	1900-2015	0.25	2.9	60.4
Zielona Góra, Poland	1973-2015	0.63	2.7	58.6
Maastricht, Netherlands	1955-2015	0.23	1.4	58.3
Gothenborg, Sweden	1961-2015	0.41	2.2	57.0
Aalborg, Denmark	1974-2015	0.58	2.3	55.8

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Observed Trends in Eastern North America

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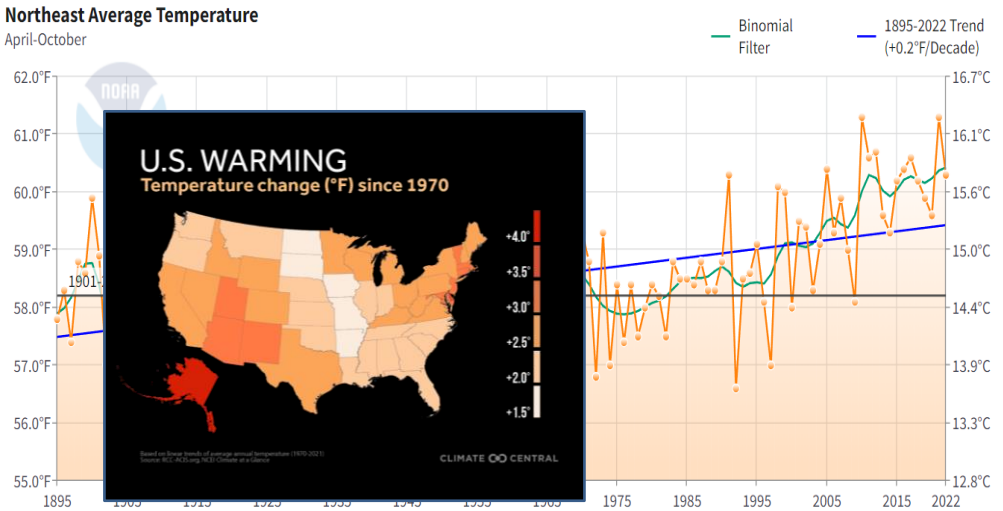
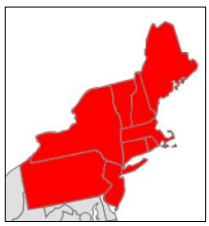
Northeast - Growing Season Average Temperature Trends for 1895-2022





All Northeast Climate Divisions have warmed, ranging from +2.5-3.0°F since 1895, but since 1970 +3.5-4.5°F

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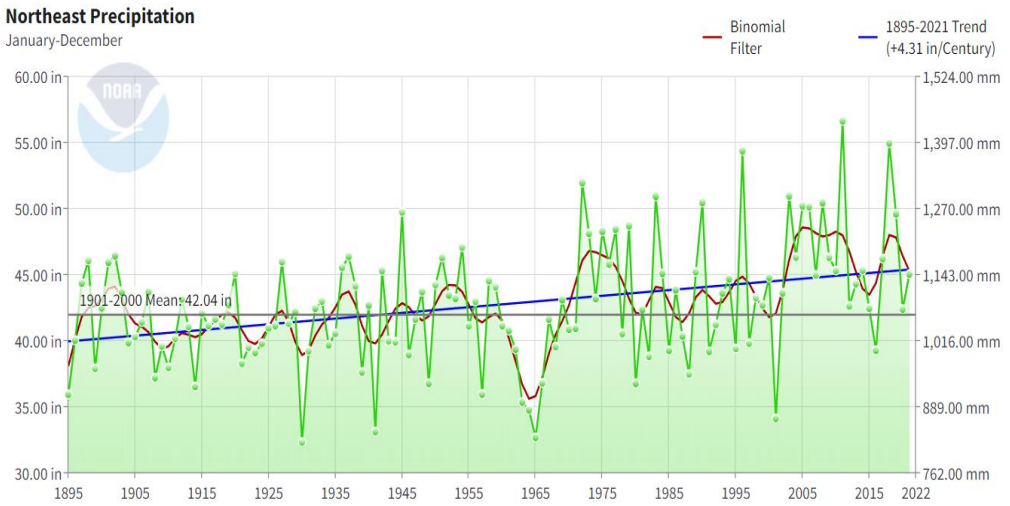
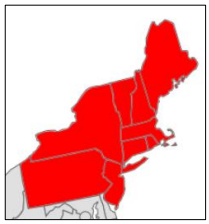
Northeast – Annual Precipitation Trends for 1895-2021





Northeast Climate Divisions show highly variable annual rainfall, trends in some seasons and across some divisions

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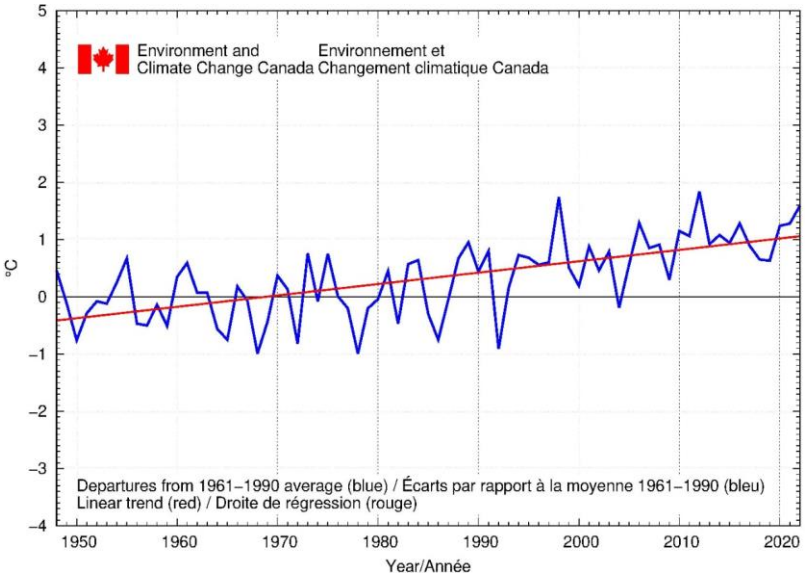
Canada – Average Summer (Jun-Aug) Temperature Trends for 1948-2022

- Average summer temperatures across Canada have warmed by 2.9°F (1.6°C) over the past 75 years



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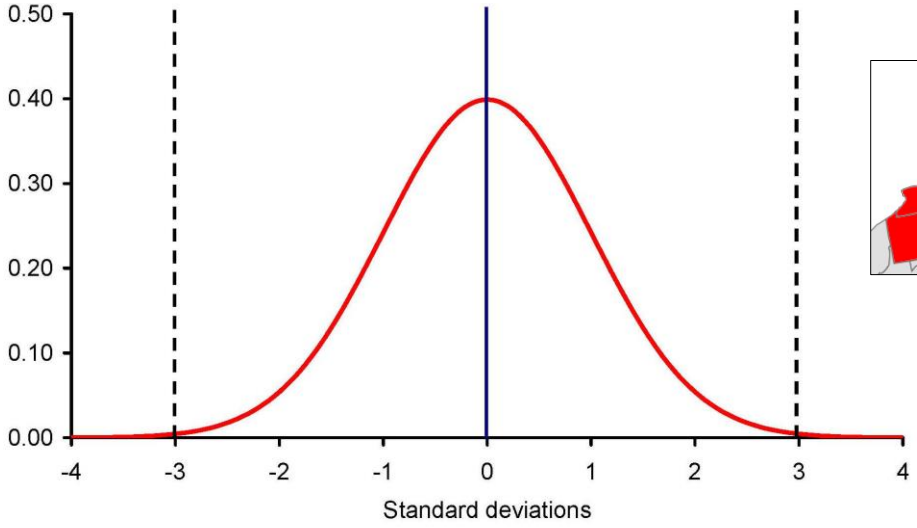
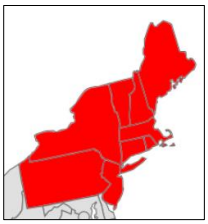
Northeast - Growing Season Average Temperature Distribution for 1895-2022





Each Standard Deviation is equivalent to +/- 1.2°F

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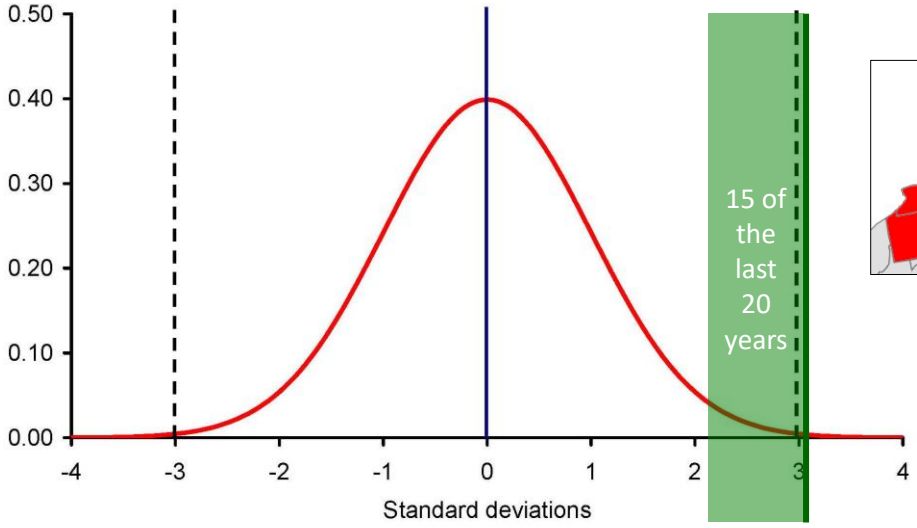
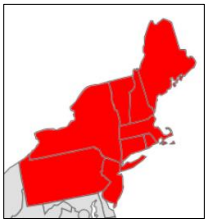
Northeast - Growing Season Average Temperature Distribution for 1895-2022





2010 & 2021

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Climate Change: The Future

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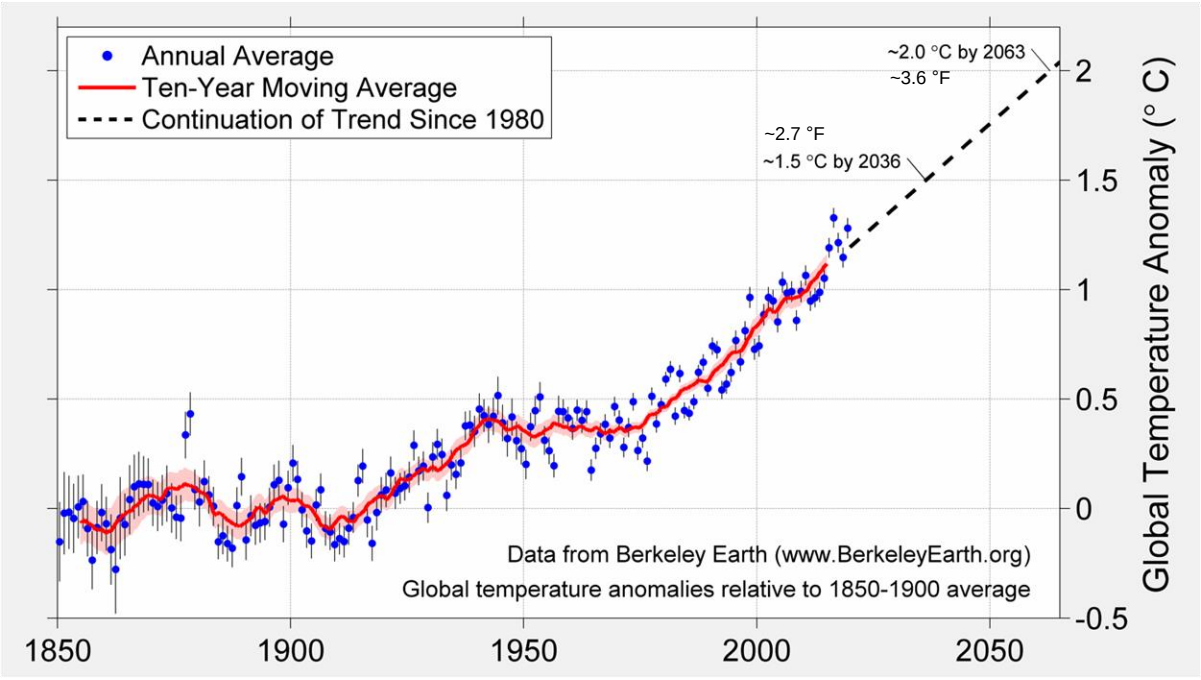

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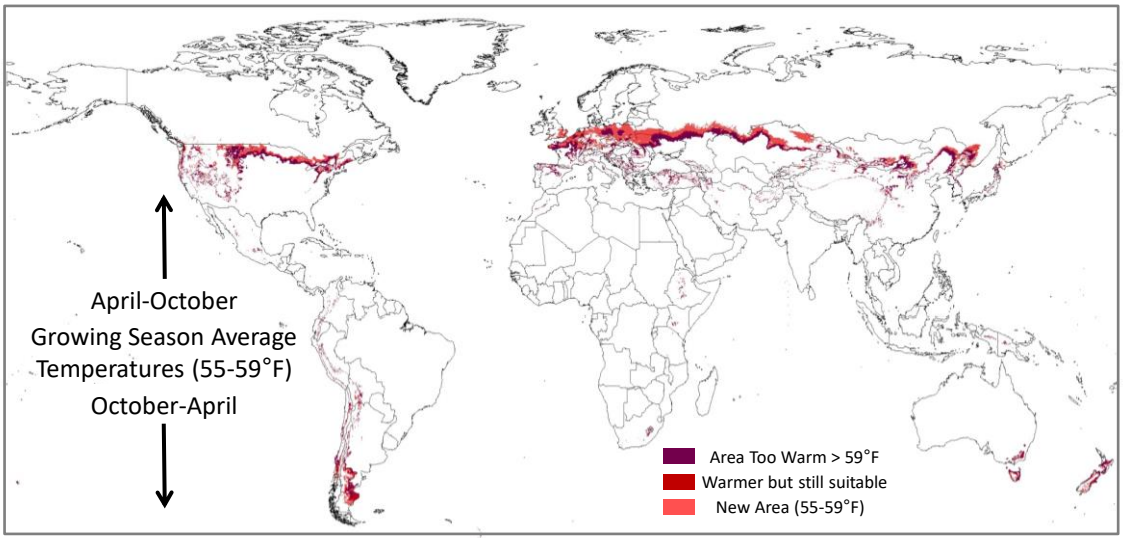
Cool Climate Zones Worldwide +2°F



Represents ~2°F warming from the 1950-2000 time period for Average Growing Season Temperatures, based on an A1B emission scenario for 2050

Jones and Schultz, 2016

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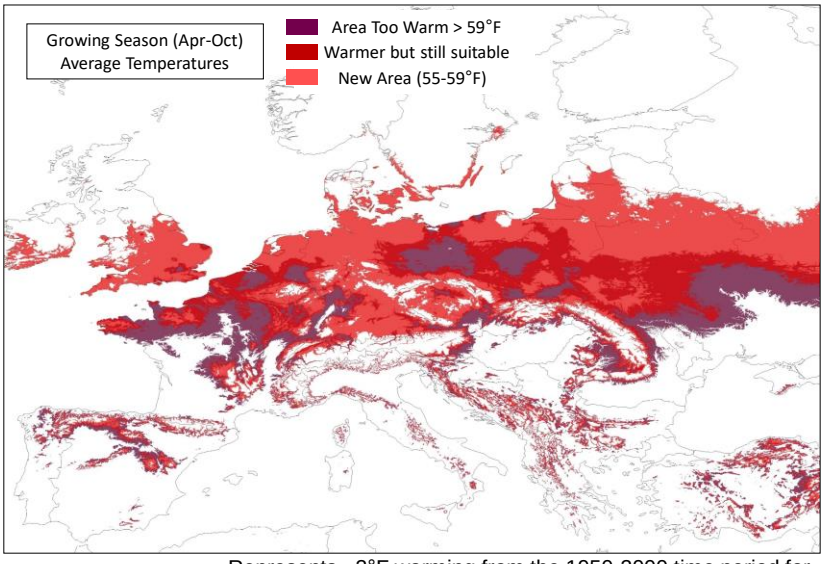
Cool Climate Zones in Europe +2°F



Represents ~2°F warming from the 1950-2000 time period for Average Growing Season Temperatures, based on an A1B emission scenario for 2050

Jones and Schultz, 2016

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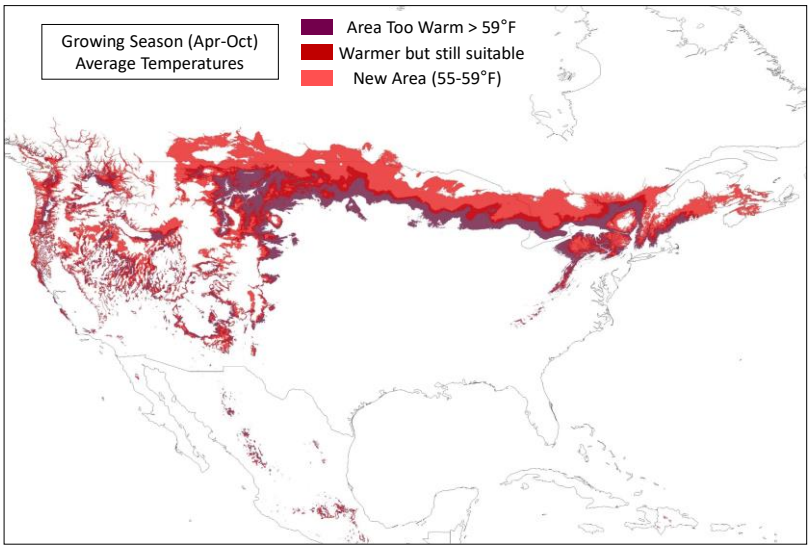
Cool Climates Zones in North America +2°F



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Jones and Schultz, 2016

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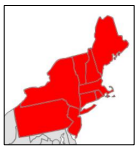
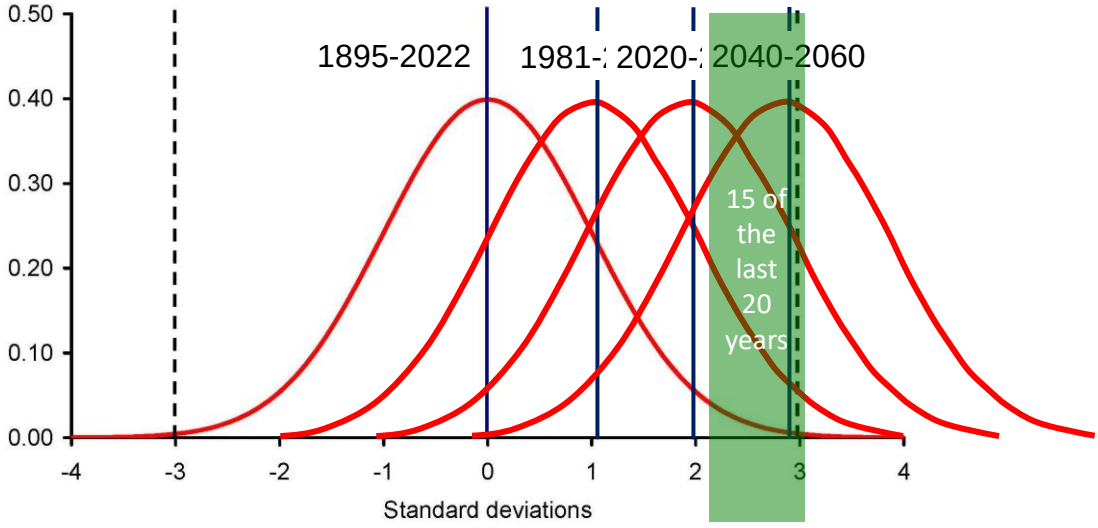
Northeast - Growing Season Average Temperature Distribution Changes





Each Standard Deviation is equivalent to +/- 1.2°F

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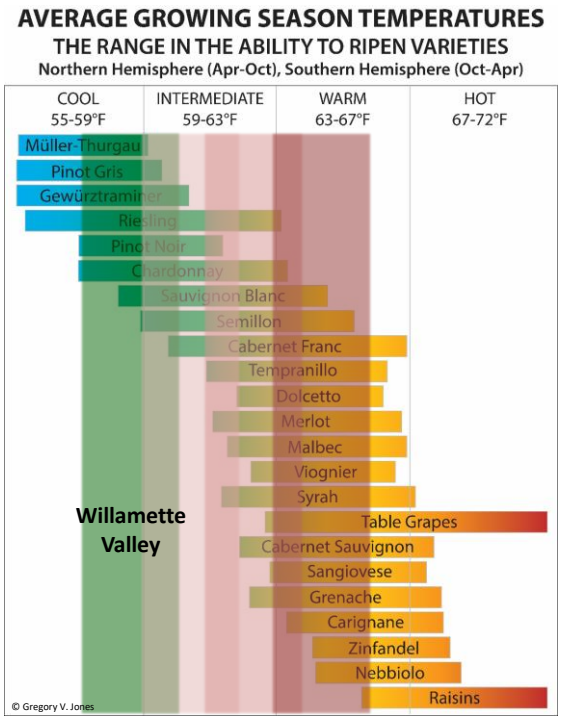
Climate Suitability

- What does a changing climate mean for a given wine region?
- Average warming from current conditions would push the regions climate envelope …

  +2°F +4°F +6°F

- Warming of 2-6°F is projected to occur in the region by 2040-2060



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Summary

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Summary

Numerous impacts on the wine sector have been observed in regions worldwide, including:

- Advanced phenology (~4-8 days per 1°F of warming): early bud break increases frost risk, ripening now occurs in a warmer period of the year
- Changes in soil moisture, drought frequency, and salinity
- Supply and timing of irrigation water
- Nature of changes, Tmax changes mean something different than Tmin changes

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Summary

Numerous impacts on the wine sector have been observed in regions worldwide, including:

- Changes in cool season chilling, lack of dormancy
- Increasing impacts of heat stress on quality
- Higher humidity increasing disease pressure
- A warmer atmosphere increases thunderstorm frequency and severity
- Sugar, acid, phenolics, and flavors out of balance

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Summary

- Meta-Analysis: ~3-5°F warming in wine regions globally by 2050, with plants likely showing an additional 7-21 day shift
- Increasing climate variability highly likely
- Ocean warming is concerning
- Wine industry challenges include:
  - Changes in ripening characteristics and wine styles
  - Water resource issues
  - Long term variety suitability
  - Increasing adaptive capacity and reducing vulnerability

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Cool Climate Regions

- Many new potential regions are emerging due to climate, but other factors need to be considered
- Research for cool climate regions worldwide have shown average trends of 0.31°F/decade or POR warming of 1.3-3.6°F since the late 1800s
- Daylength and the adaptive capacity of photosynthesis are important assets for these regions

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Cool Climate Regions

- Despite increasing summer suitability to ripen fruit, low winter temperatures will remain a risk due to increased mid to high latitude climate variability
- Despite more consistent precipitation in cool climate regions, annual/season variability is expected to increase
- Adaptive capacity in cool climate regions is large, but issues with varieties, soils, and vineyard management are critical

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Climatic Change and Grapevine Diversity

- Climate change has already altered the basic framework of growing grapes for wine production and will likely continue to do so for years to come
- Is cultivar diversity the key?
- Do varieties have genetic adaptative capabilities?
- How much will external measures adapt varieties to current and future climates?

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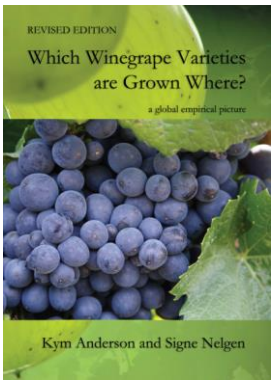
Genetic Diversity and Declining Use

- Roughly 5000 unique varieties are grown worldwide
- *Wine Grape* (Robinson et al.) identifies 1368 commercially grown 'prime' varieties
- Concentration of varieties has increased, 50% of the world's plantings are now done with 16 varieties
- New world wine regions, seven varieties = 50%



1990-2020

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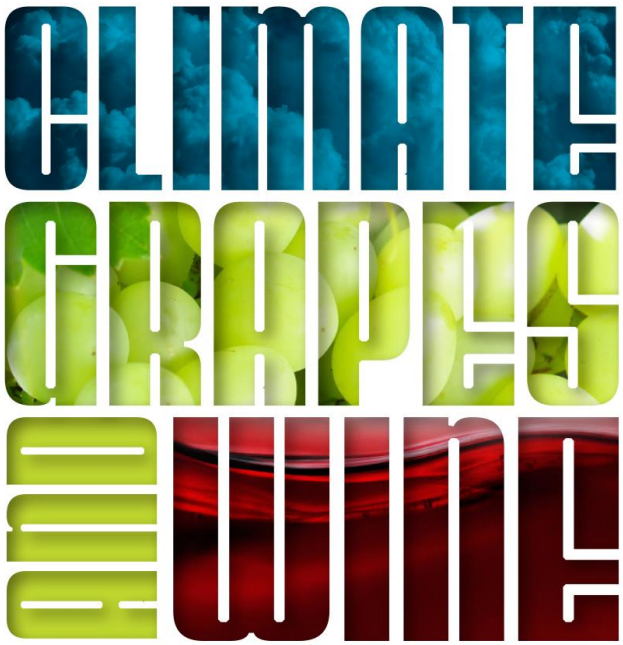

Monthly reports, videos, publications can all be found at https://www.climateofwine.com/reports

Thank You!

Gregory V. Jones, PhD.
CEO, Abacela Vineyards and Winery

Abacela
AN ICON OF INNOVATION EST. 1995

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