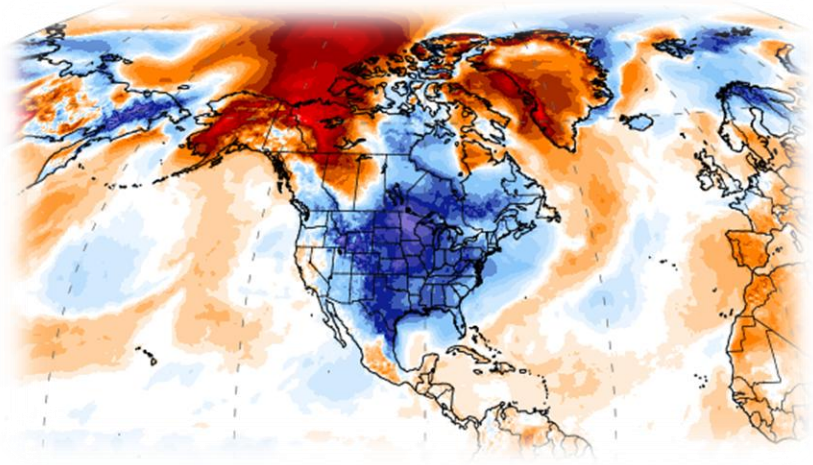
A Climate of Extremes



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University of Adelaide, Australia
Southern Oregon University, USA

Abacela
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Canadian Grapevine Certification Network
CGCN-RCCV
Réseau canadien de certification de la vigne

Webinar – January 22, 2025

1

Talk Outline

- Change Factors and Wine
- What do we know?
- What don't we know, but need to?
- Conclusions

2

Change Factors

- Climate change is one of many factors interacting to put pressure on the wine sector, these include;
  - National to international economics
  - Declining demand, changing demographics
  - Challenges from other beverages
  - New markets, new consumers, new styles
  - Changes in the tastes of wine writers/raters
  - Production and movement of bulk wine
  - Demand for greater sustainability

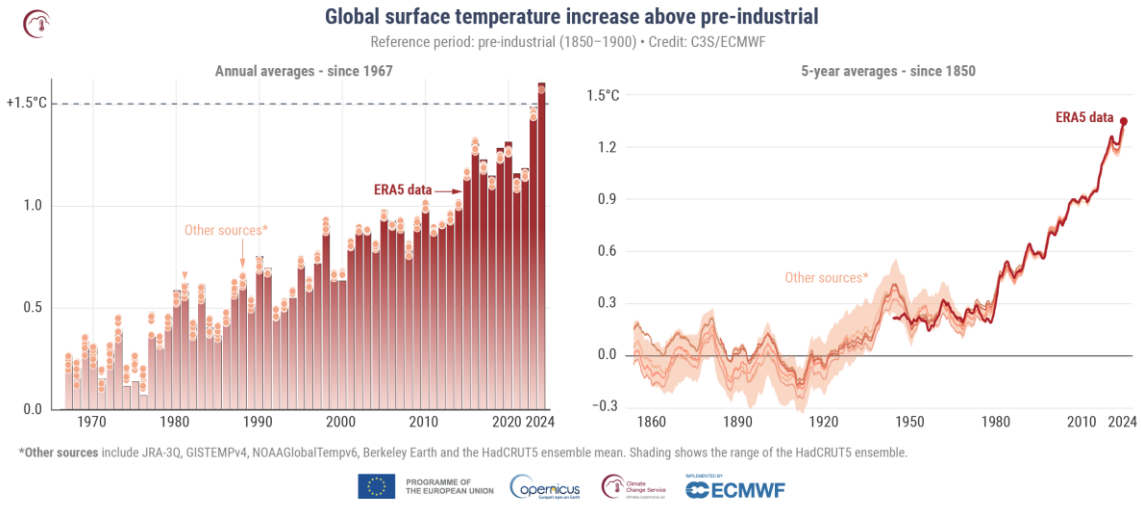
3

What do we know?

4

What do we know?

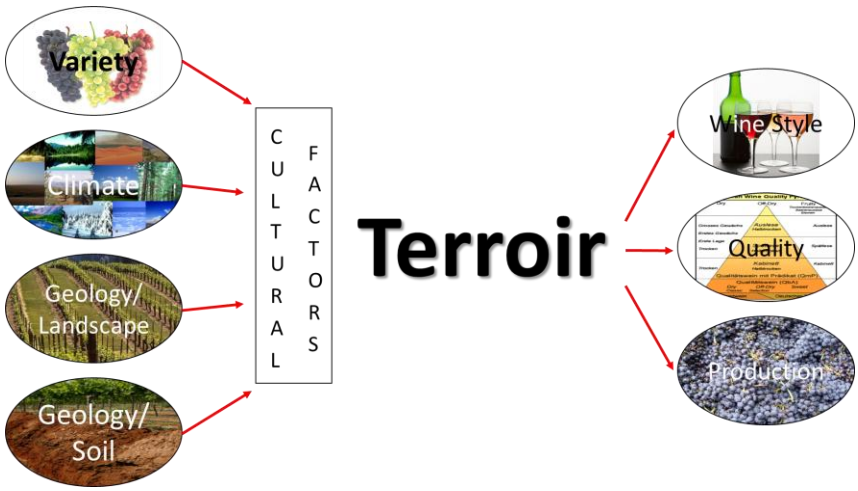
- The climate is unstable



5

What do we know?

- Terroir is important



6

What do we know?

- *V. Vinifera* has a 7-month, average growing season temperature niche of ~12-22°C
- Within these bounds, individual varieties have average growing season temperature niches of 1.5-3.5°C for viable economic productivity and quality
- *V. Vinifera* also does not tolerate extremes very well
- Do varieties have genetic adaptative capabilities?
- How much will external measures adapt varieties to current and future climates?

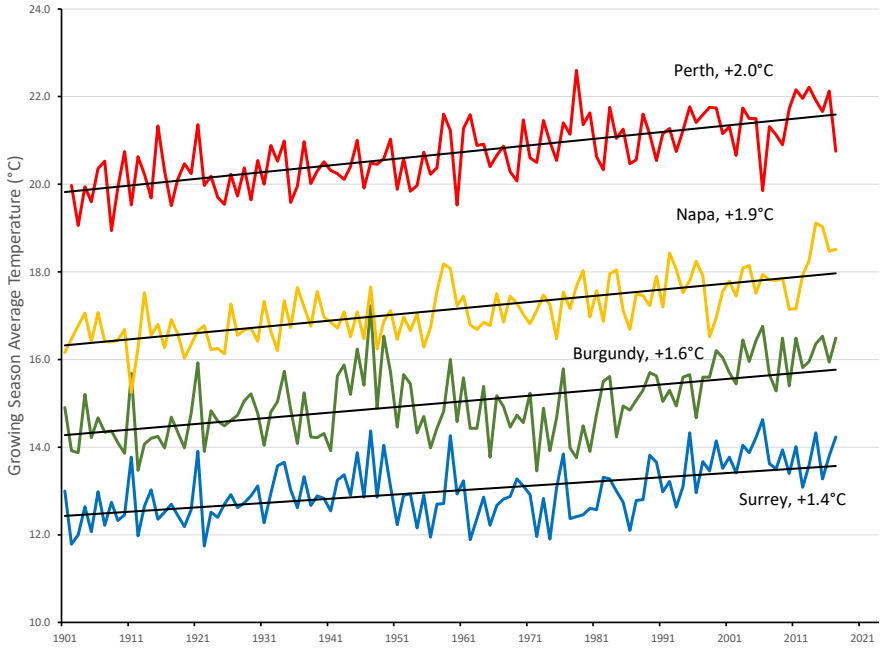
7

What do we know?

- Climates have changed in wine regions worldwide
- Temperature more than precipitation
- Changes in extremes occurring in many aspects of the climate system

8

Average Growing Season Temperature Trends 1901-2018



25 prominent wine regions around the world have warmed an average of 1.4°C

Emerging cool climate zones in both hemispheres warming, but significantly more in the NH

Jones-GiESCO, 2019; CRU TS v. 4.03

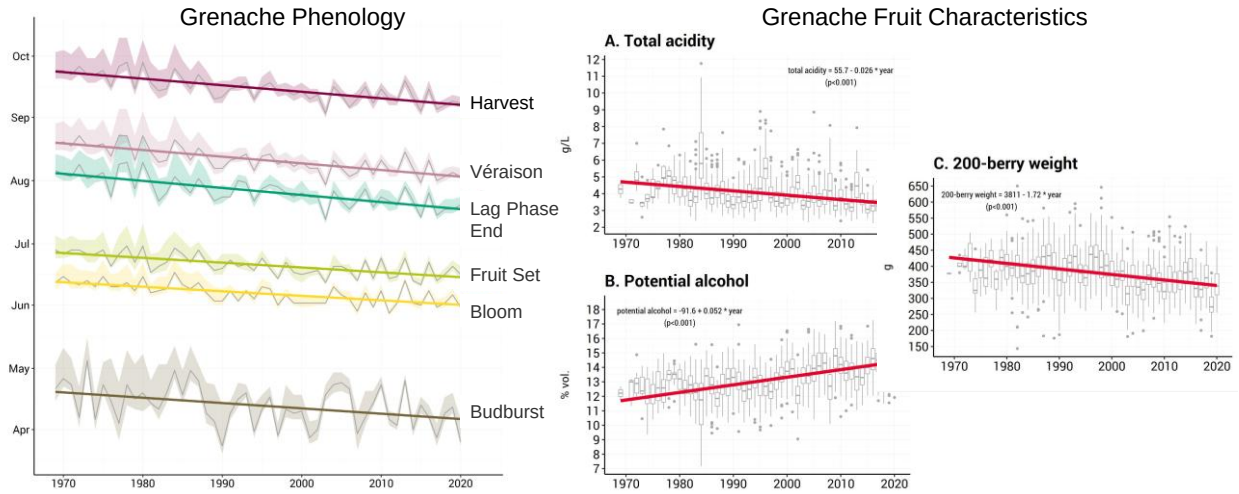
9

What do we know?

- Grapevine phenology has shifted 4-8 days per 1°C
- Growth intervals have contracted
- Earlier harvests, in a warmer part of the year
- Harvest compression has occurred across varieties
- Ripeness clocks are often out of sync
- Changes in wine styles are evident

10

Rhône Valley Phenology and Fruit Composition



Bécart et al. 2022 Oeno One

11

What do we know?

- All west coast mid-latitude environments have the same challenges that come with winter/cold/wet, summer/hot/dry cycles
- These regions all have strong climate variability mechanisms
- These regions are all prone to long-term droughts on top of seasonal drying
- These regions are all prone to extreme winter temperatures and precipitation events

12

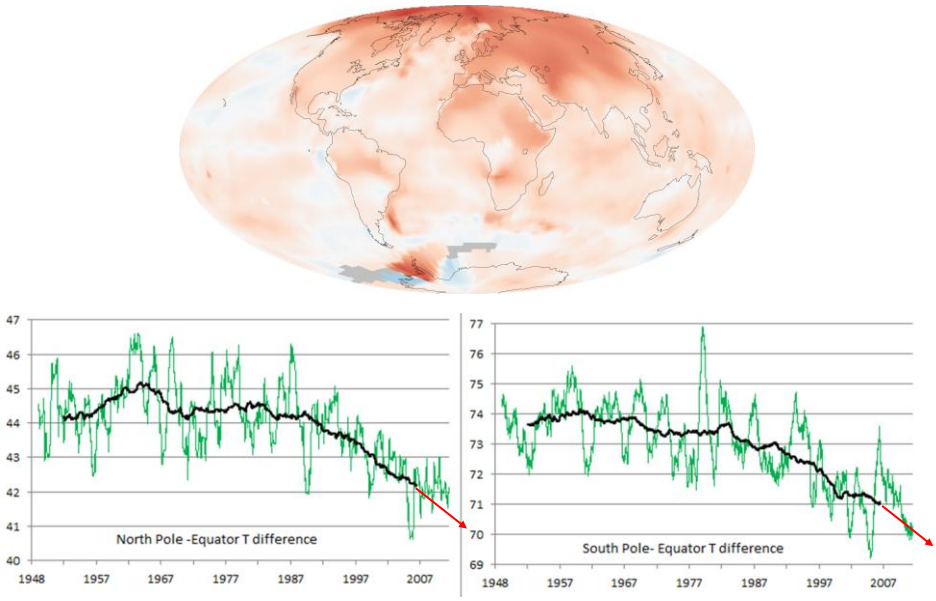
Pacific – North American Climate Variability Mechanisms

13

British Columbia Climate Variability Factors

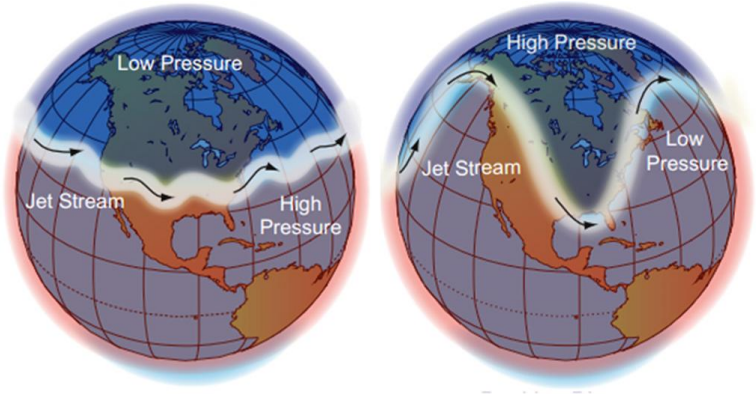
14

Tropics to Poles Temperature Gradient



15

Increased Weather/Climate Variability

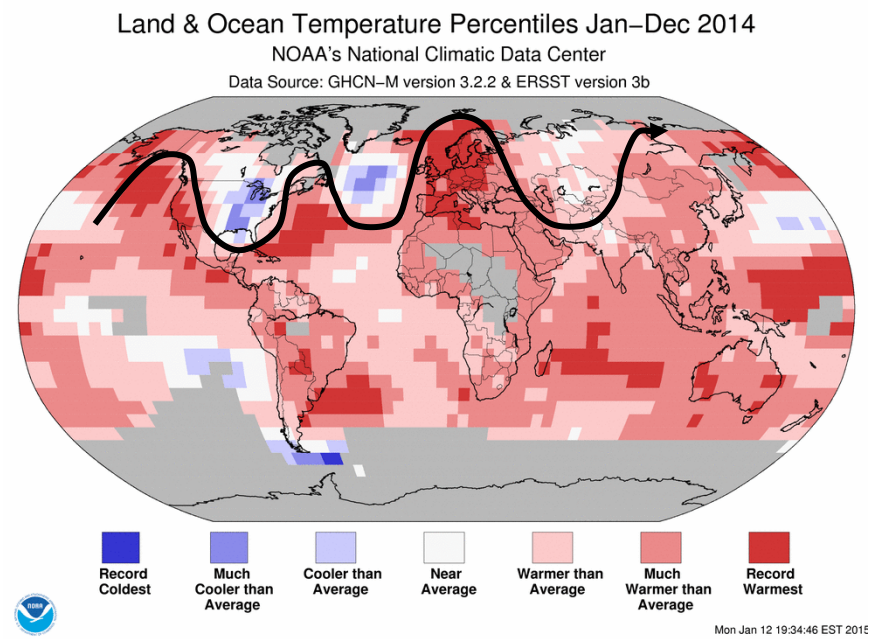


Arctic amplification (4x the rate of warming of the rest of the planet) has produced a slower jet stream, with more amplified north-south waves, more extreme weather and greater swings in climate conditions from year to year, season to season, and month to month. Some indication of similar changes in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

NOAA, Insiders Inc.

16

Influences both short- and long-term omega blocking along with tilted rex blocking that influences cold events, heat events, and Santa Ana winds



NOAA, climate.gov

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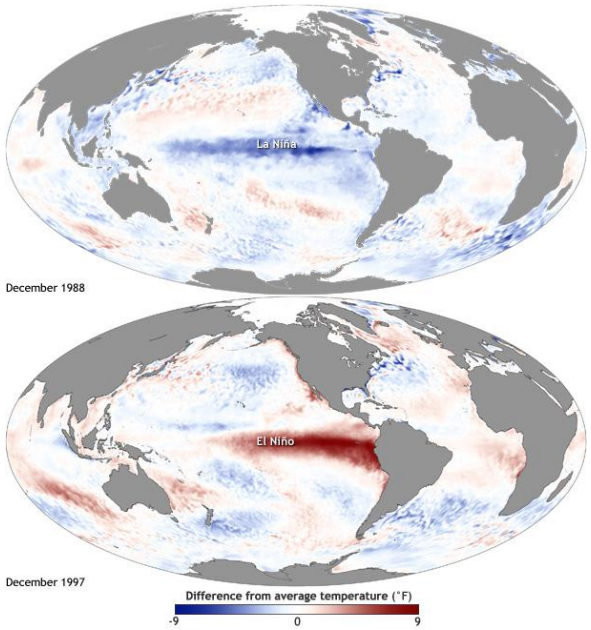
ENSO & Climate Variability

The swings from El Niño to La Niña and back again are the largest source of predictable interannual variability in the global temperature record



Typical La Niña Pattern

Typical El Niño Pattern

NOAA, climate.gov

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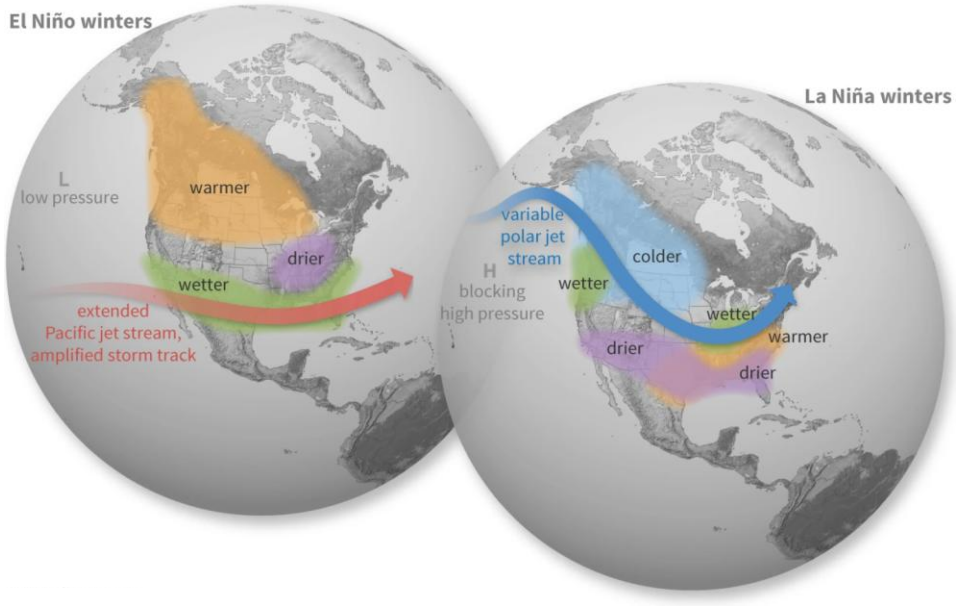
ENSO North American Influence



NOAA, climate.gov

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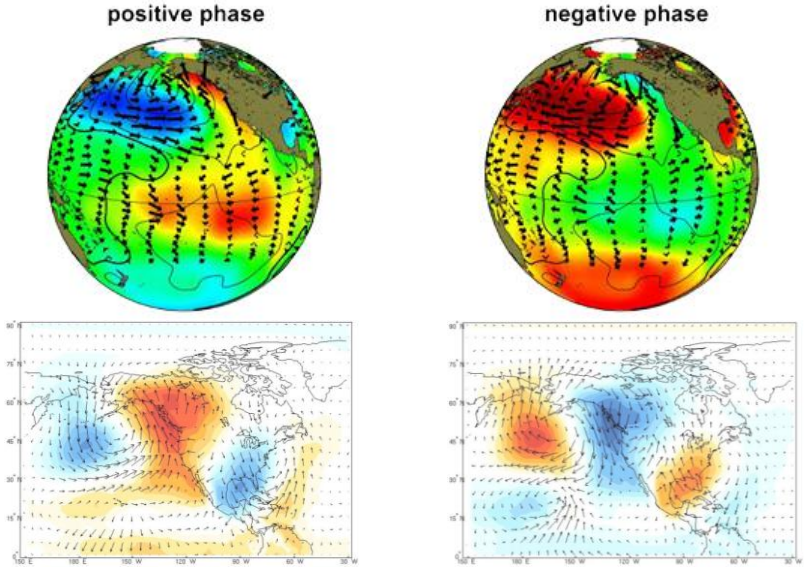
Pacific Decadal Oscillation & Climate Variability



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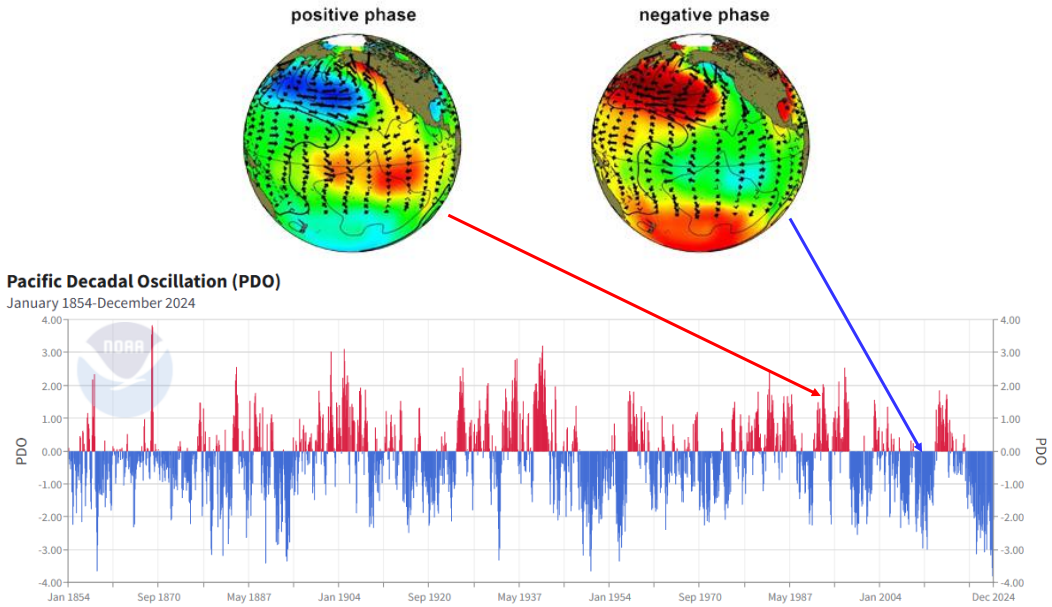
Pacific Decadal Oscillation & Climate Variability



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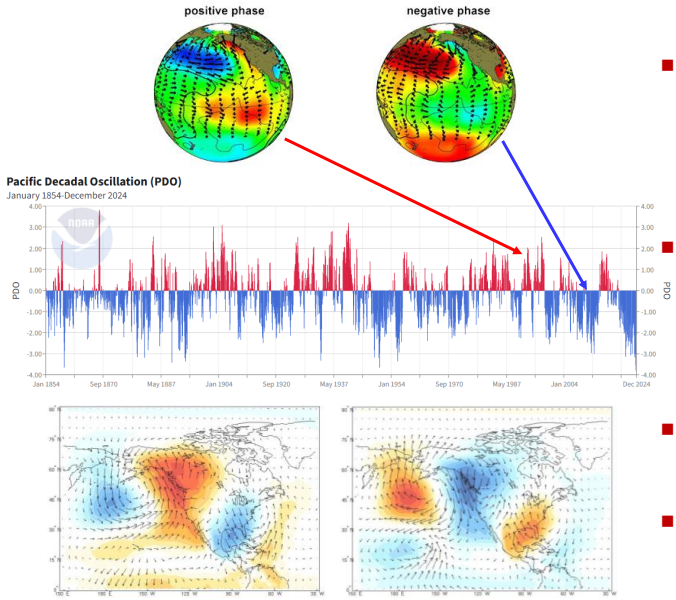
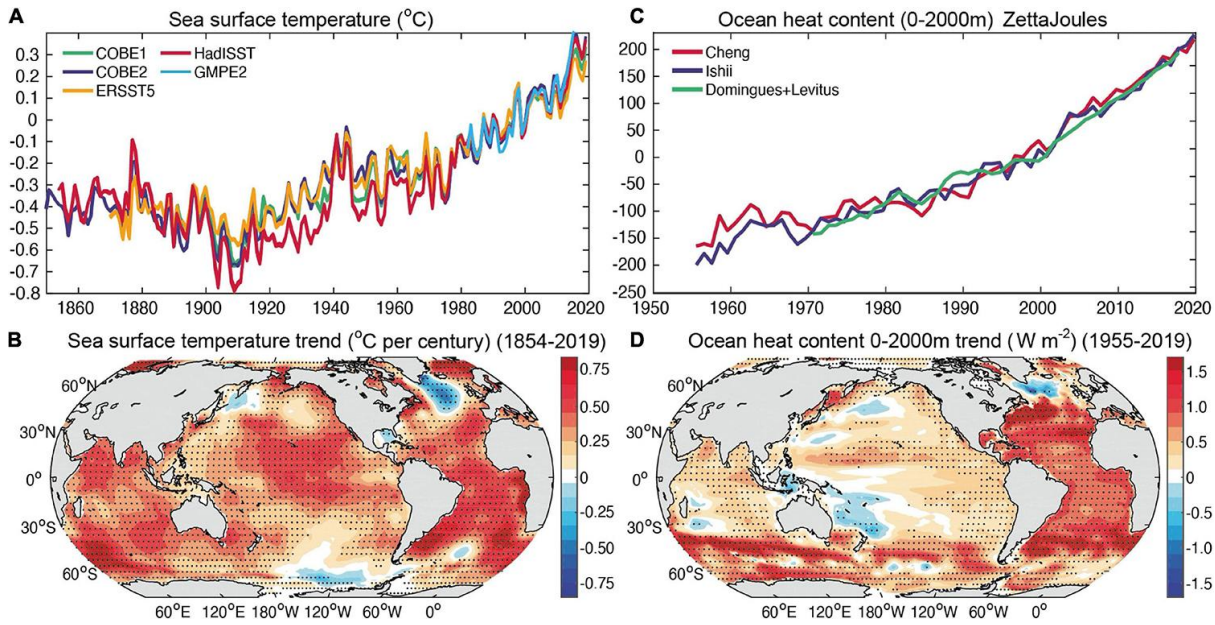
Pacific Decadal Oscillation & Climate Variability



- PDO is highly correlated to North American temperatures and moisture variability, especially in the winter and spring
- Positive/warm PDO linked to warmer than average temperatures and fewer winter freeze events and lower spring frost frequency
- Negative/cold PDO linked to colder and wetter winters and springs
- ENSO phase very important

22

Observed SST Changes 1854-2020



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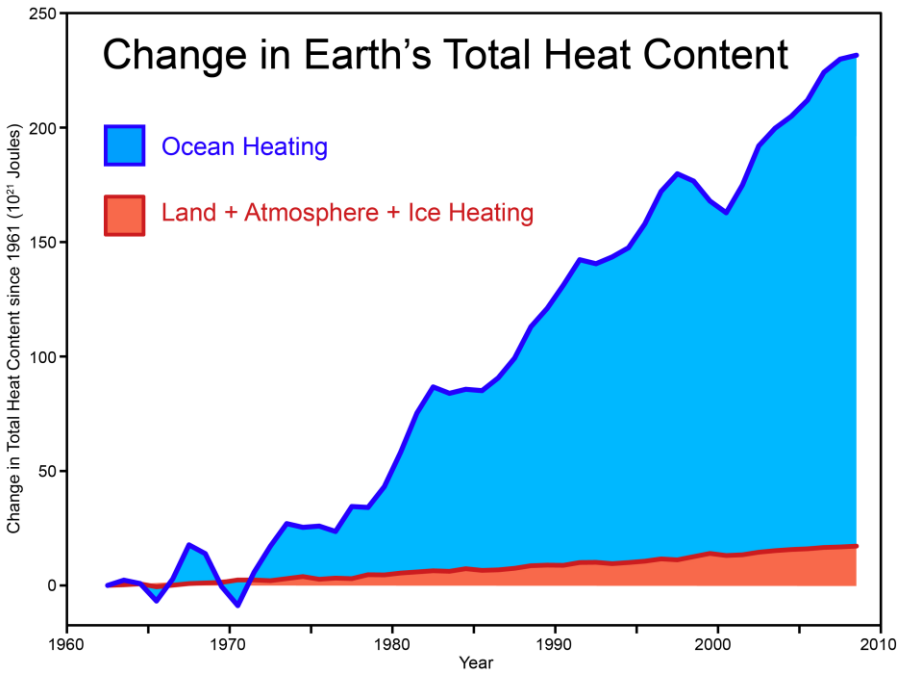

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What do we need to know?

25

What do we need to know?

- How will climate extremes change over time?
- How will drought characteristics and frequency change?
- How will cold extremes change?

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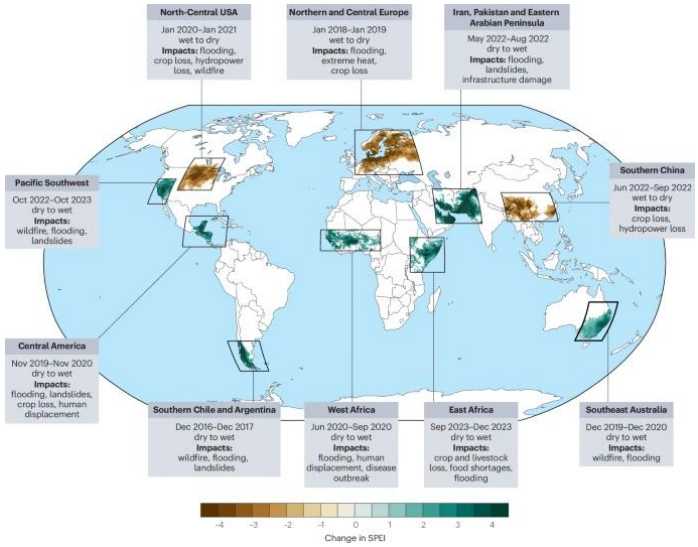
Hydro-Climate Volatility

- Sudden, large and/or frequent transitions between very dry and very wet conditions
- Connected to a warming atmosphere where rising water-vapor-holding capacity and potential evaporative demand of the atmosphere has increased
- Sub-seasonal and interannual whiplashes have increased by 31–66% and 8–31%, respectively, since the mid-twentieth century



Swain et al. (2025) Nature Reviews: Earth and Environment

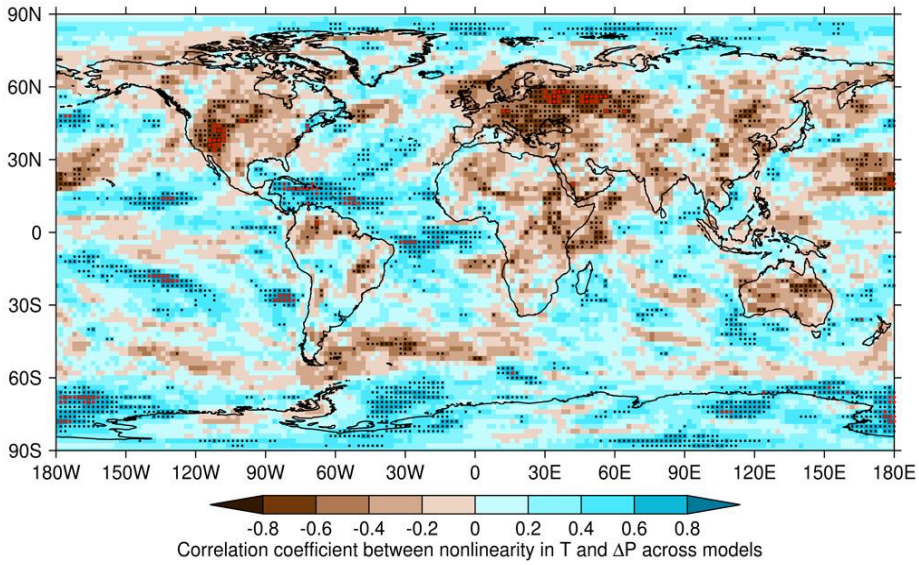
27

Drought and Mega-Drought Sensitivity

Ault et al. (2016)

28

Dry regions that get drier, will also likely see accelerated local warming:

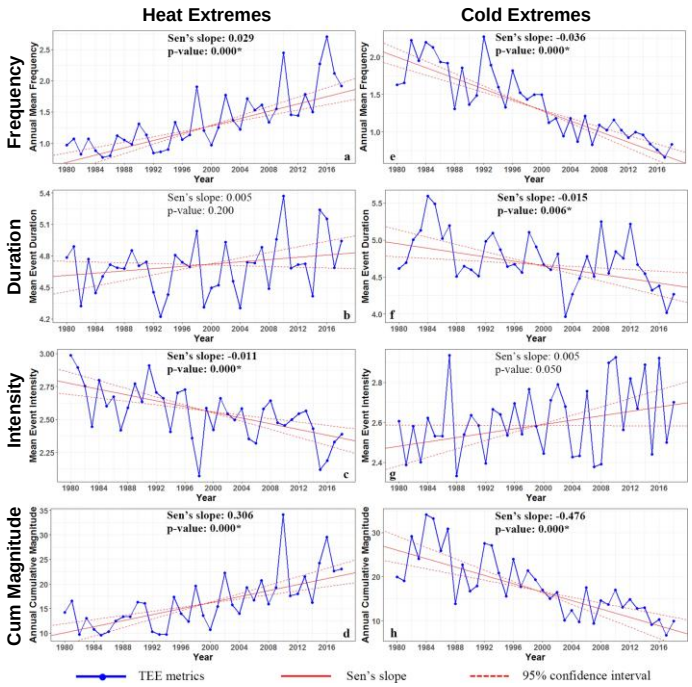


King (2019) Environmental Research Letters

29

Temperature Extremes

- Globally heat extremes have increased while cold extremes have decreased at a faster rate
- Record warm extremes are occurring 15-25 times the rate of record cold extremes
- A stable climate would be closer to 50/50
- Additionally, the magnitude of multiple successive temperature extreme events has shifted more in warmer events

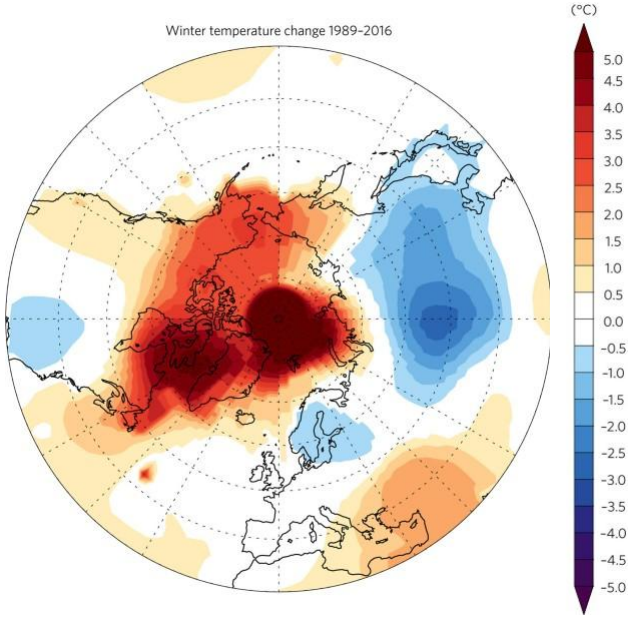


Zhang et al. (2022) Communications Earth & Environment

30

Temperature Extremes

- How climate change is impacting winter cold extremes is uncertain
- Significant warming during the winter over the Arctic is clear
- Decreasing winter temperature variability over NA which suggests a reduction in frequency and intensity of cold extremes relative to mean changes
- But cold air outbreaks are becoming more likely because of Arctic-induced changes in atmospheric circulation

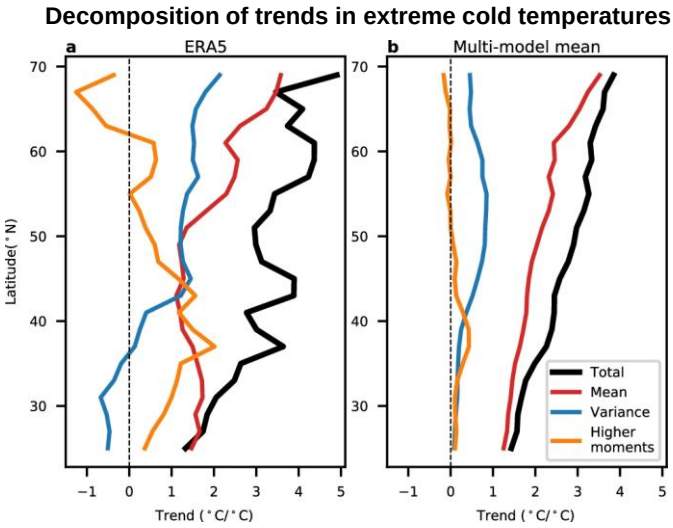


Screen (2017) Nature Geoscience

31

Temperature Extremes

- Cold extremes over NA have warmed 2.2 times more than winter mean temperatures and 3.2 times more than the global annual mean trend since 1980
- Warmest days over NA have fluctuated with some regions warming and others near average
- This amplified warming is linked to both decreasing variance and changes in higher moments of the temperature distributions



Blackport & Fyfe (2024) Nature Communications

32

Cold Extremes in the Future

- Winter temperatures over North America in the current climate have the highest variance and are some of the most strongly negatively skewed on Earth
- This means that extreme deviations below the mean are expected to continue to occur in the future, even with rising global temperatures
- Increasing mean temperatures, combined with the changes in temperature variability, cold extremes over North America will likely occur less frequently, and when they do occur, they will likely be less intense … however

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What do we need to know?

- How will varieties perform in a climate that is more variable in some ways and less so in others?
- Performance of varieties at warmer temperatures over the long term?
- Anthocyanin losses at higher temperatures?
- Cold limits and heat stress limits across varieties?
- Drought tolerance limits across varieties?
- Disease pressure with higher humidity?
- Will terroir influences remain the same?

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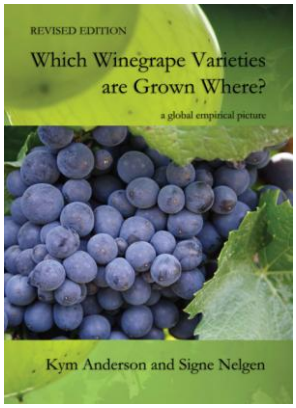
Genetic Diversity and Declining Use

- 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, 7 varieties make up 50% of the plantings



1990-2020

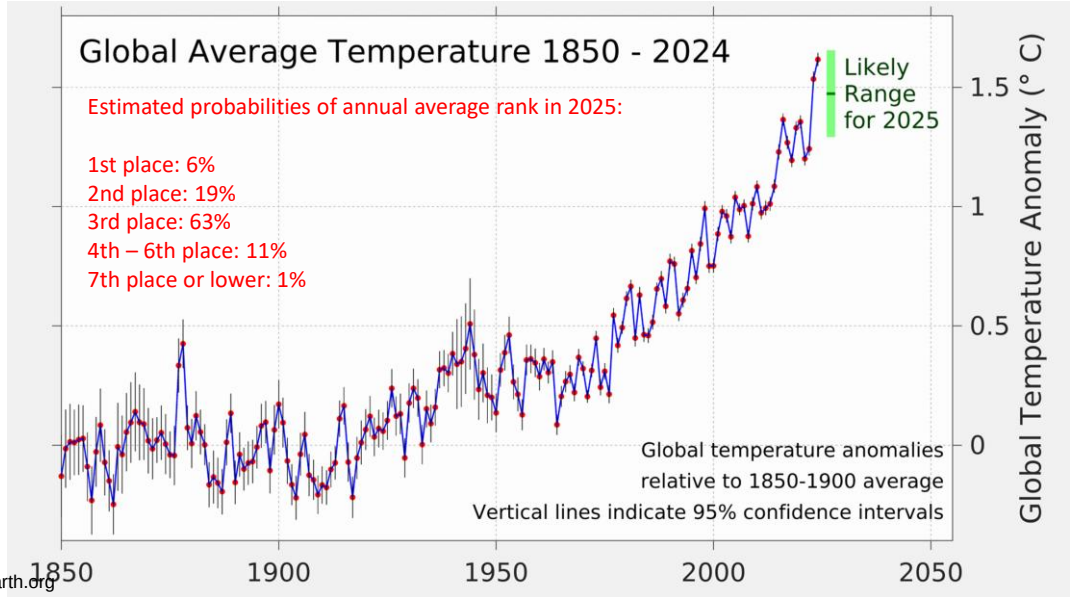
35

Conclusions

- The planet is warmer than at any time in our recorded past, and continued warming is highly likely

36

Over the short-term, persistence in the global climate system points to continued warming:



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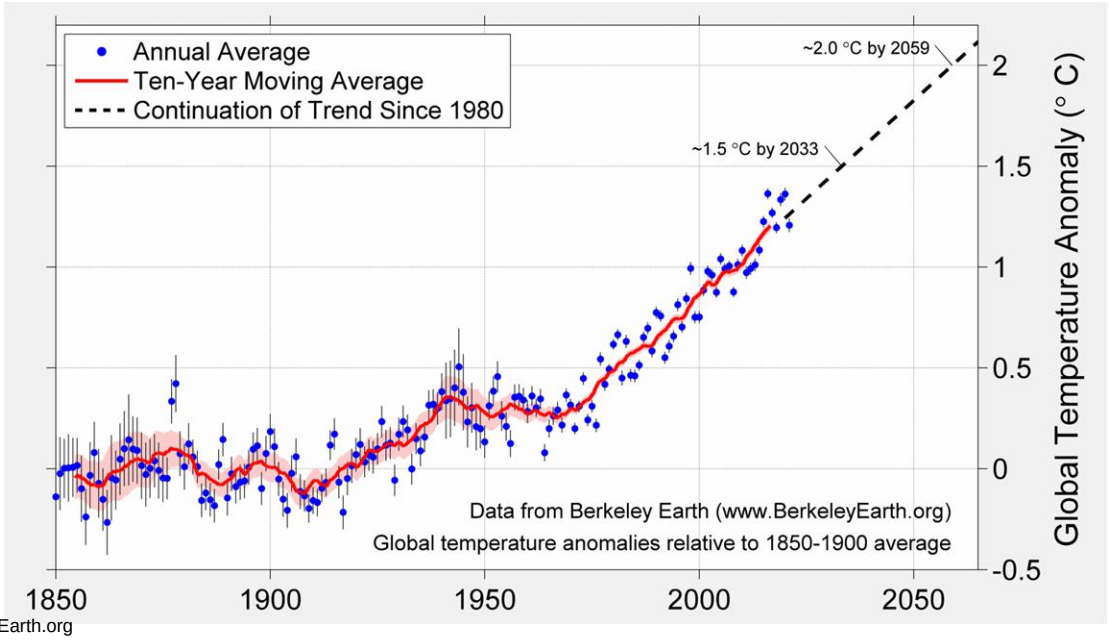
Over the longer-term, continued warming is likely as well:



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Conclusions

- The planet is warmer than at any time in our recorded past, and continued warming is highly likely
- Agriculture is both part of the problem, and part of the solution
- Mitigation is necessary, adaptive potential is large
- Utilizing the wealth of crop diversity is essential
- Building resiliency in our agricultural systems is a must
- No silver bullet … portfolio of responses is required

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Thank You!

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