The State of the Climate: Trends, Projections, and Relationships to Viticulture and Wine Production













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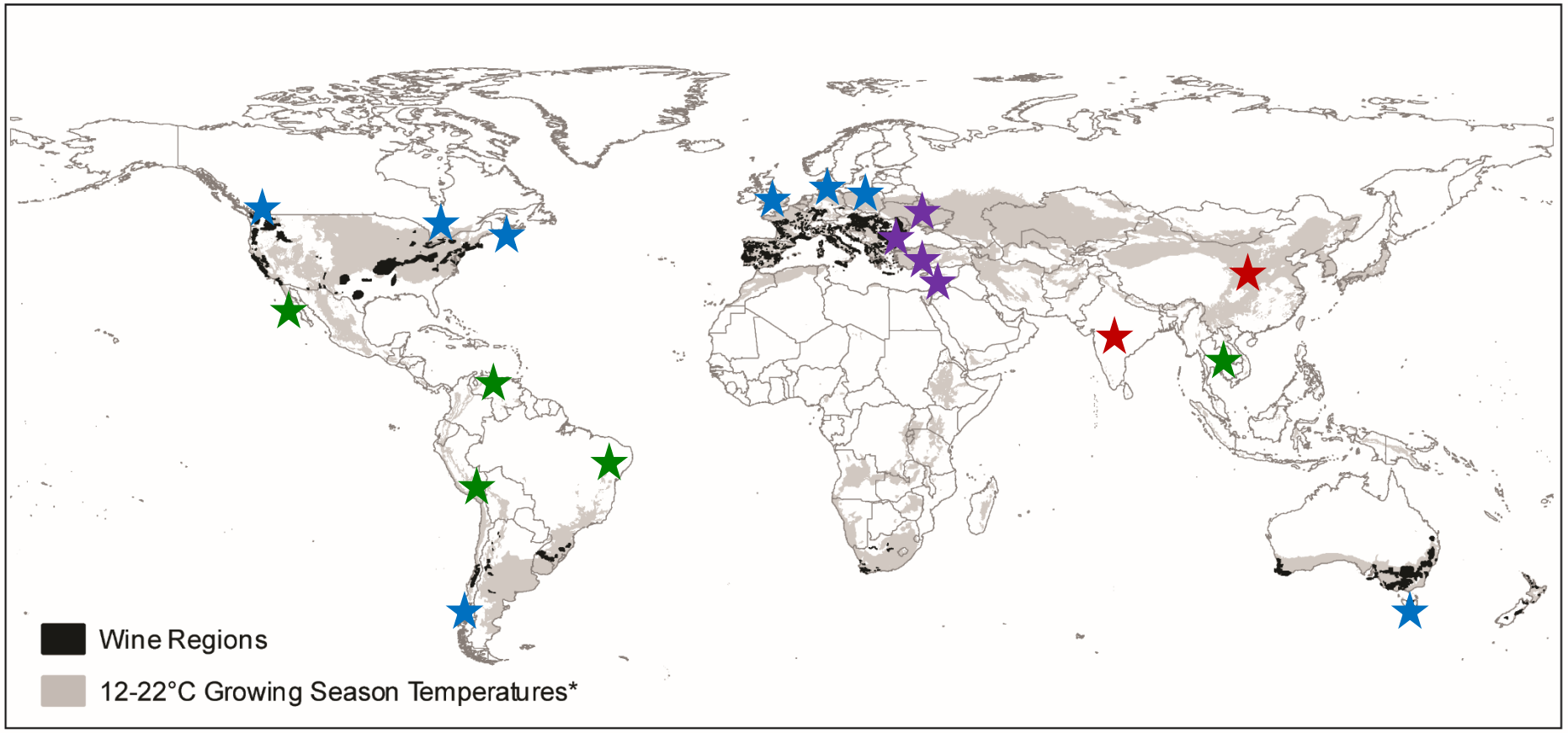
Talk Outline

- Changing Wine Map
- State of the Climate
- An Ideal Climate for Viticulture and Wine?
- Meta-Analysis of Climate Change Influences
- Recent Research and Future Changes
- Summary

A New World of Wine: How the Viticultural Map is Changing



Change Factors

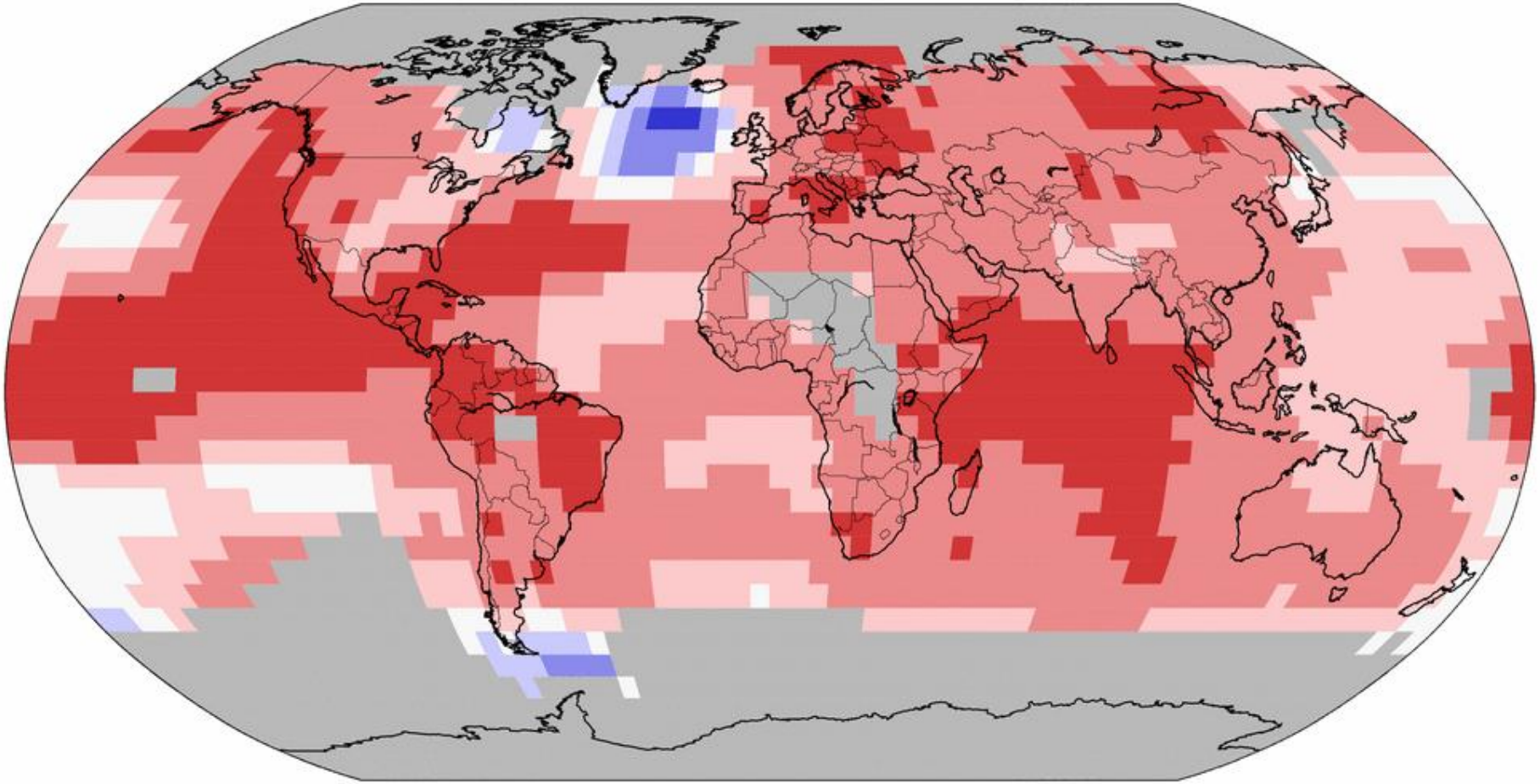
- National to international economics
- Growing demand, changing demographics
- New markets, new consumers, new styles
- New purchasing trends
- Changes in the tastes of wine writers/raters
- Production and movement of bulk wine
- Organic, biodynamic production and sales
- Pioneers looking for ‘fringe’ or new areas
- Climate

State of the Climate

Land & Ocean Temperature Percentiles Jan–Dec 2015

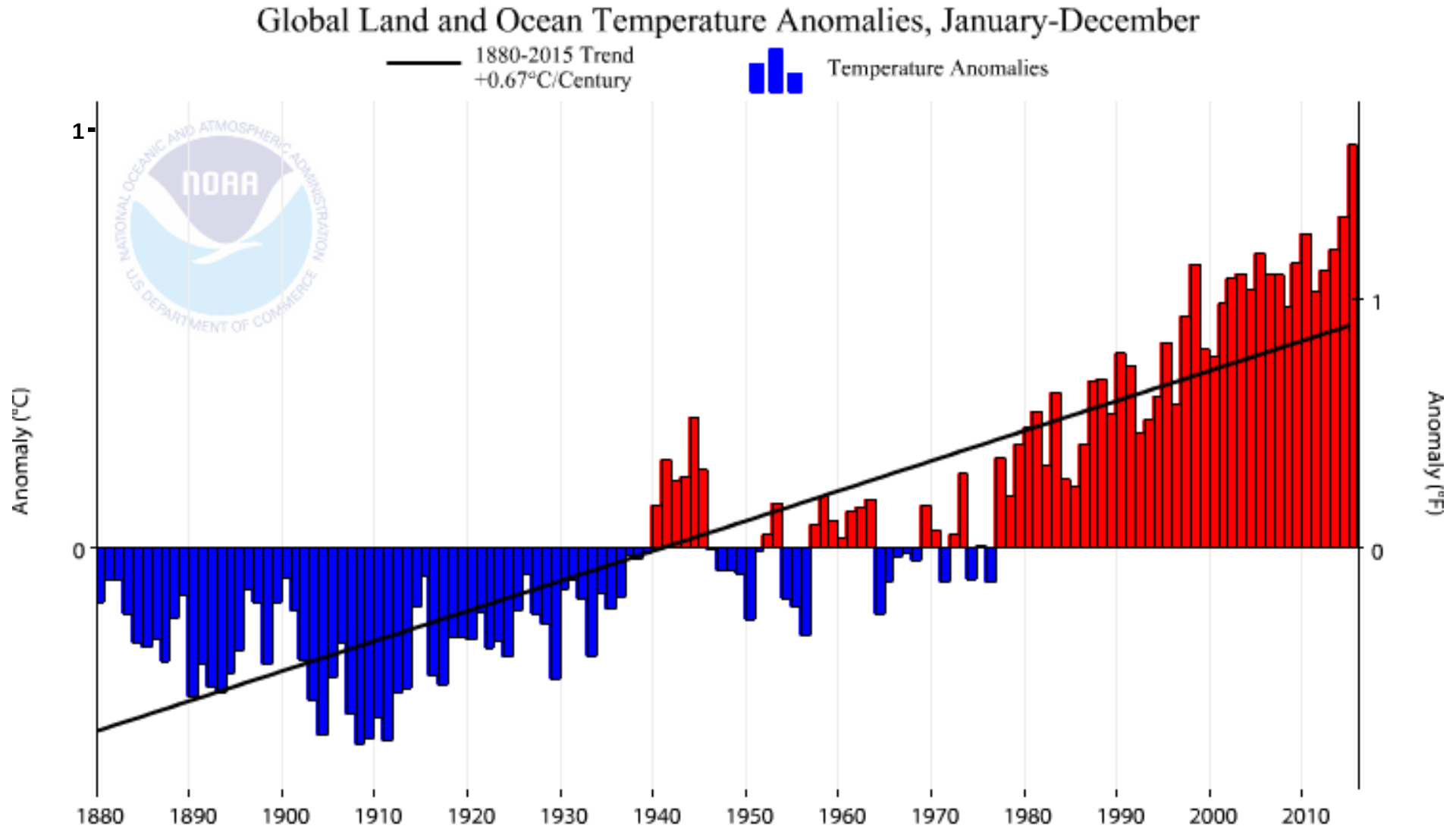
NOAA's National Centers for Environmental Information

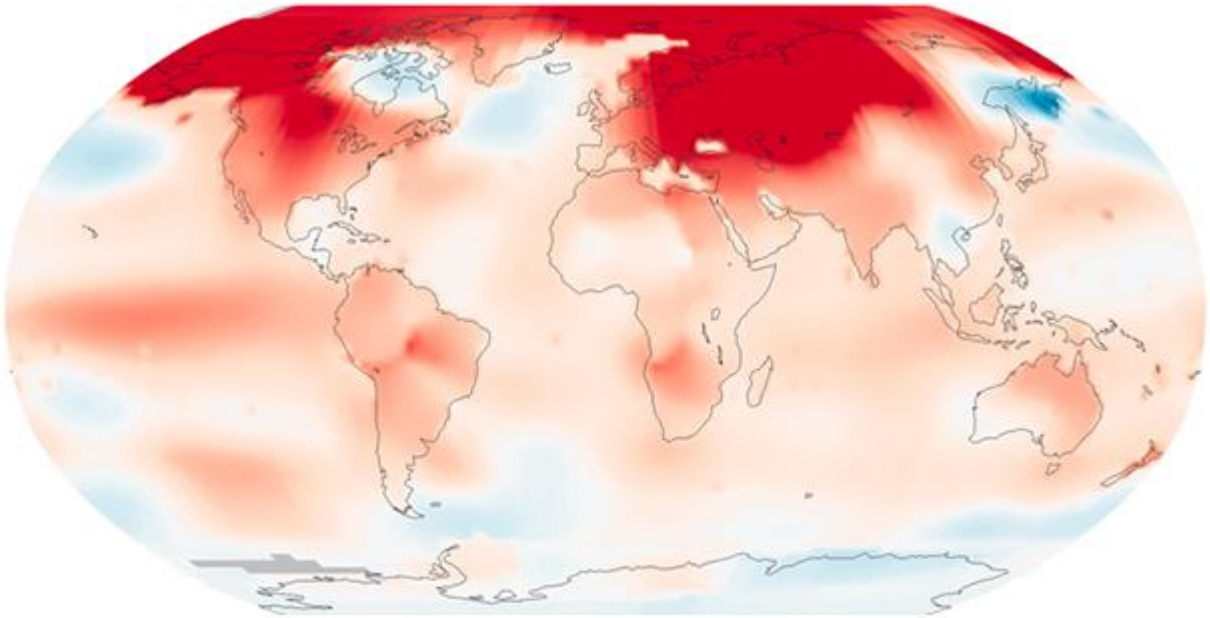
Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0

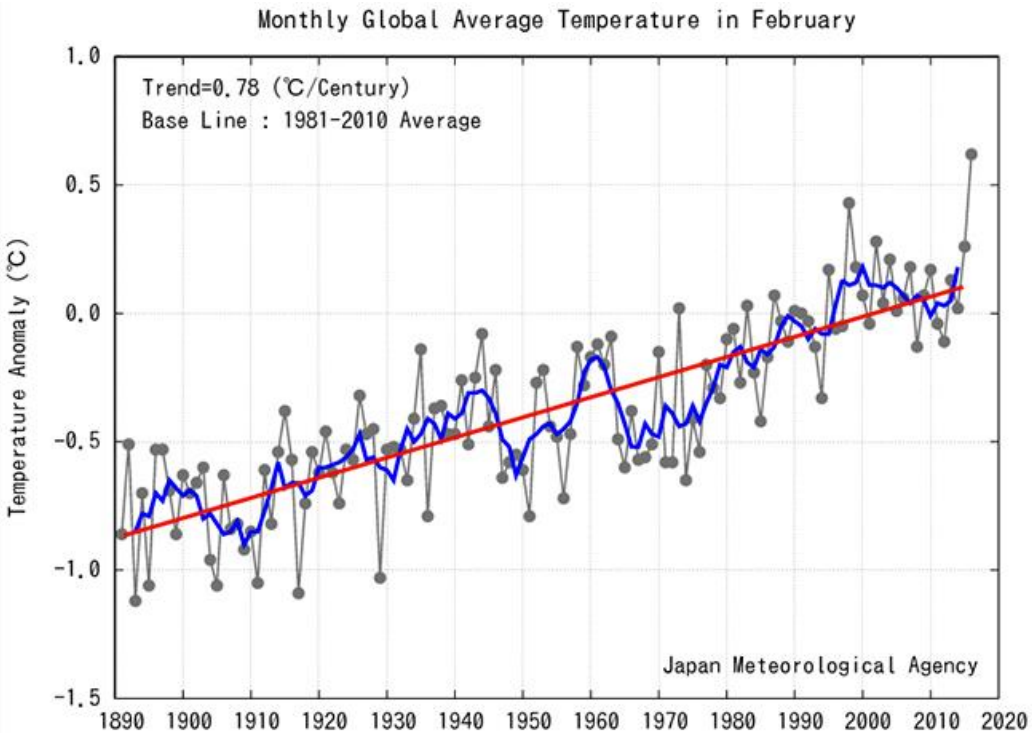


Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

Wed Jan 13 12:15:02 EST 2016


Global Land and Ocean Temperature Anomalies, January-December
1880-2015 Trend
+0.67°C/Century
Temperature Anomalies
Anomaly (°C)
Anomaly (°F)
1
0
1
0
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

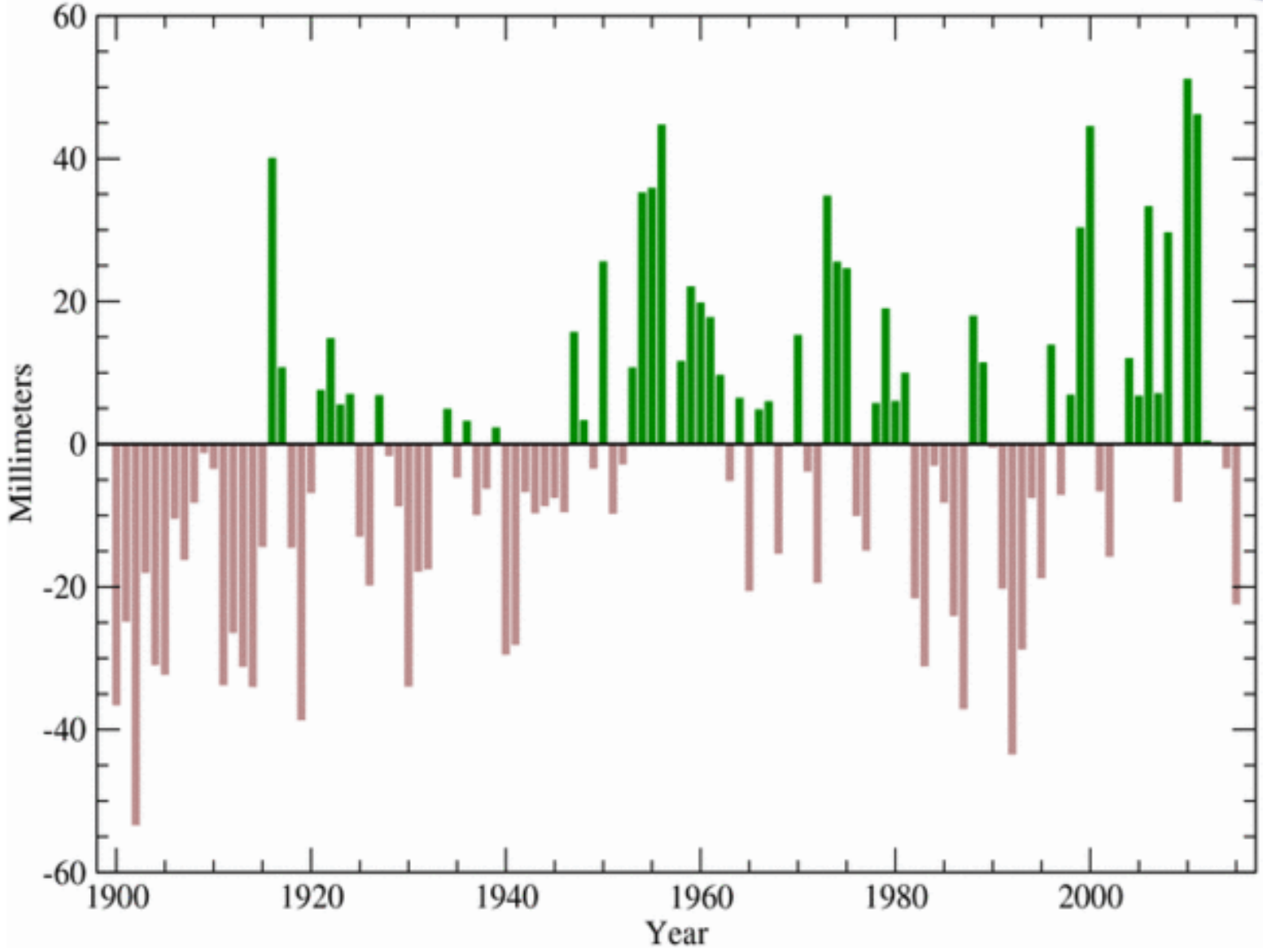




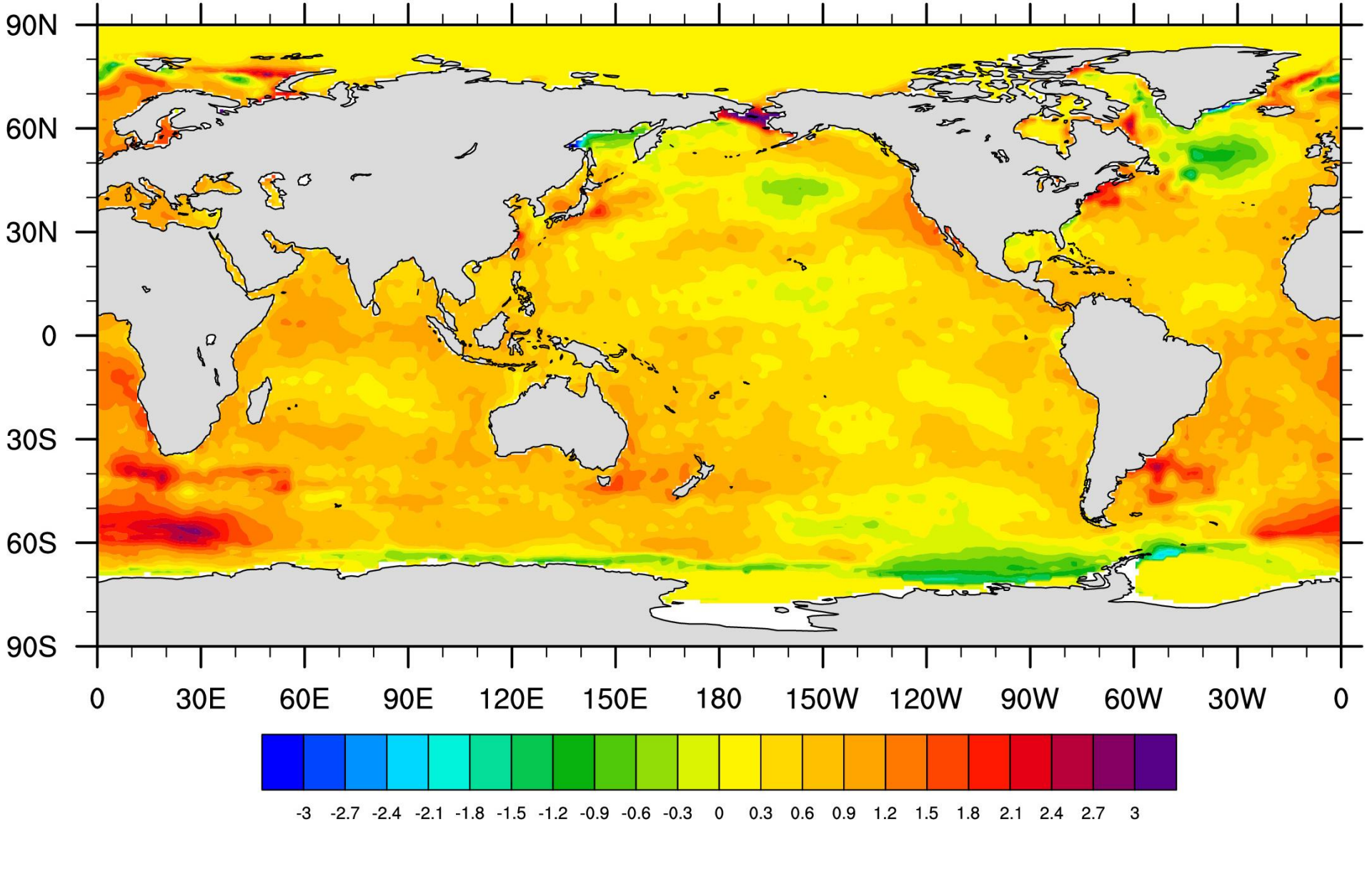
- February 2016 was the warmest month ever recorded
- The five largest monthly global warm anomalies have all occurred within the past five months, topped by February 2016

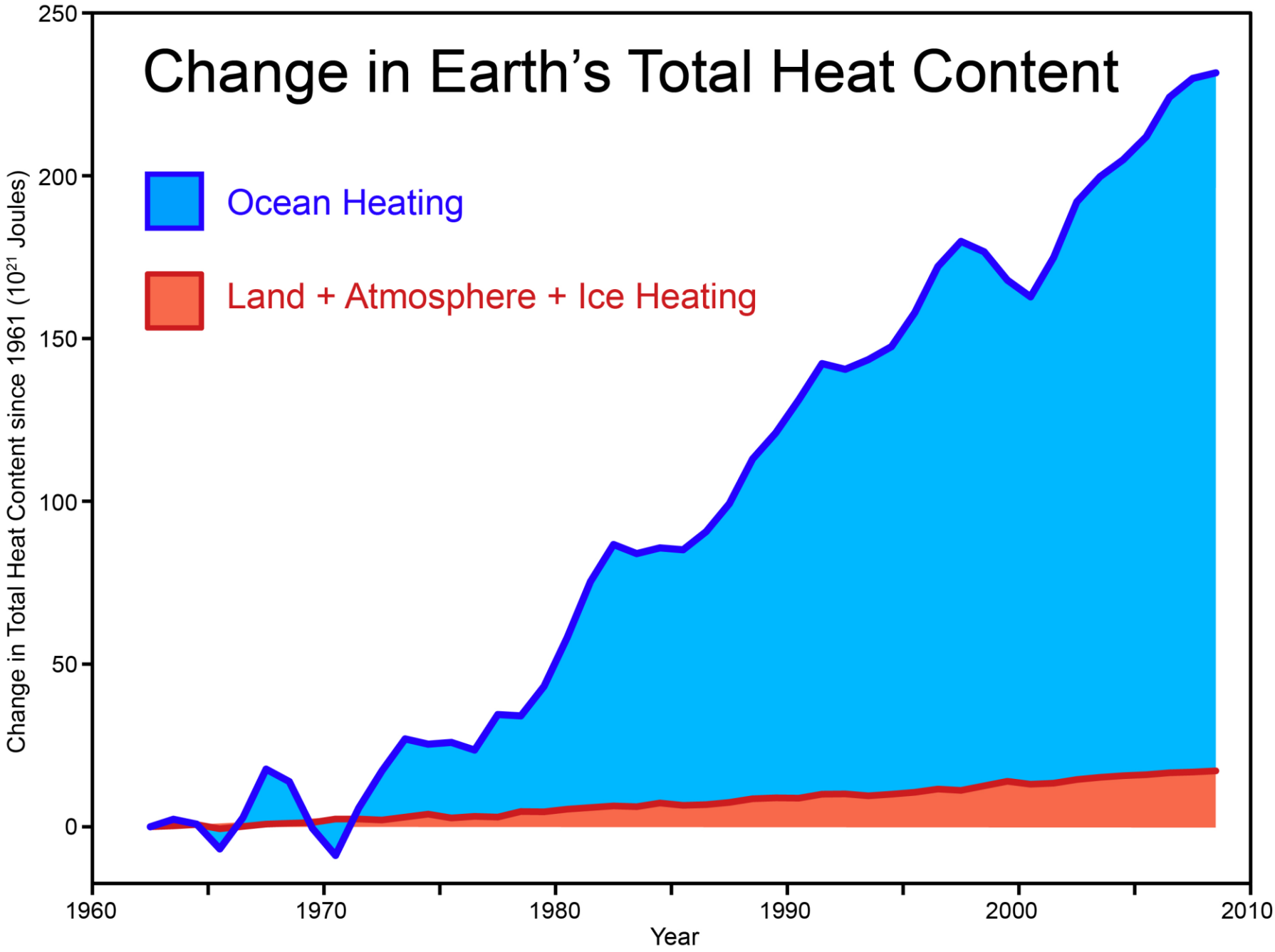
January-December Precipitation Anomalies

1900-2015



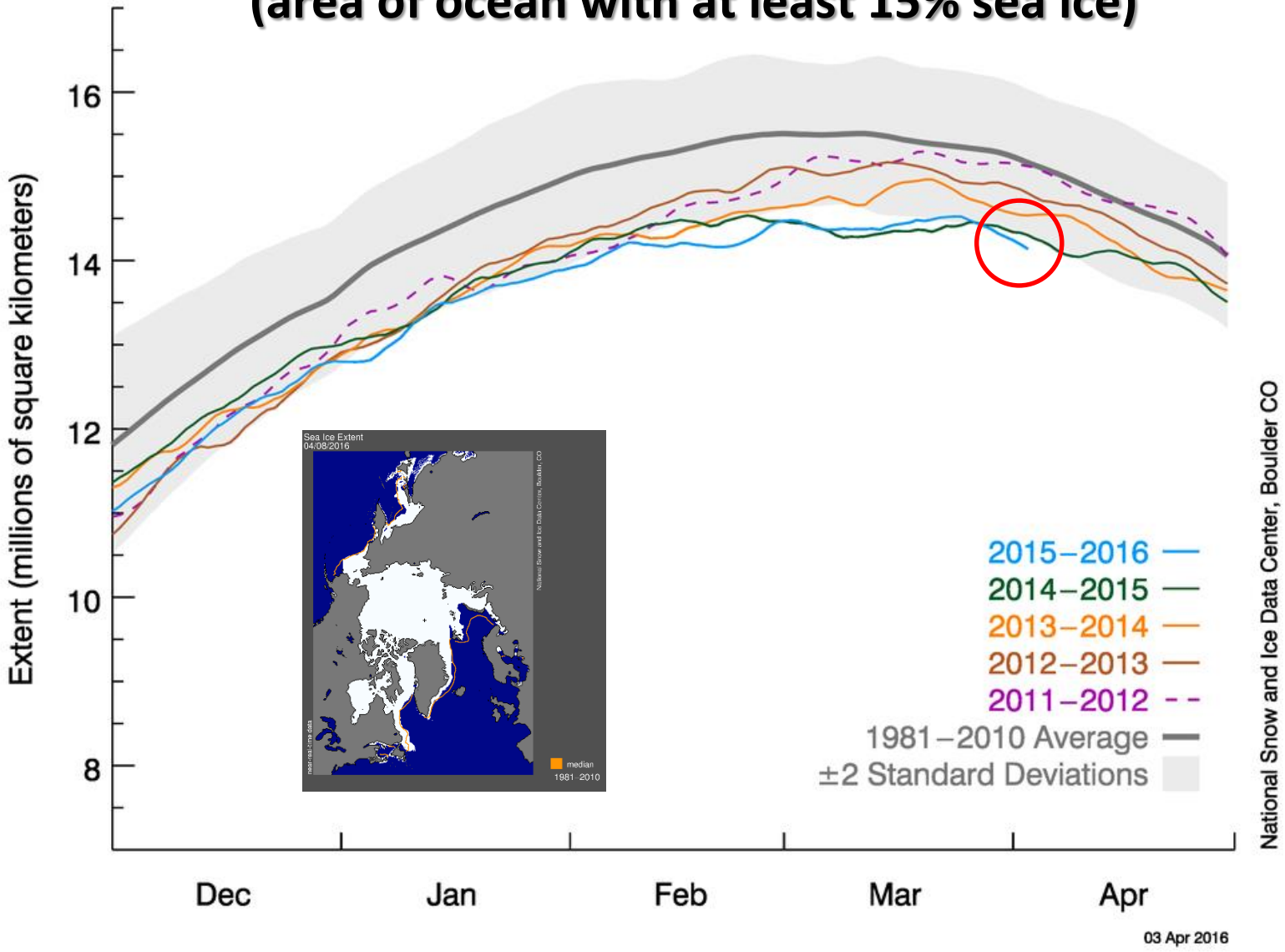
Observed SST Changes 1870-2015



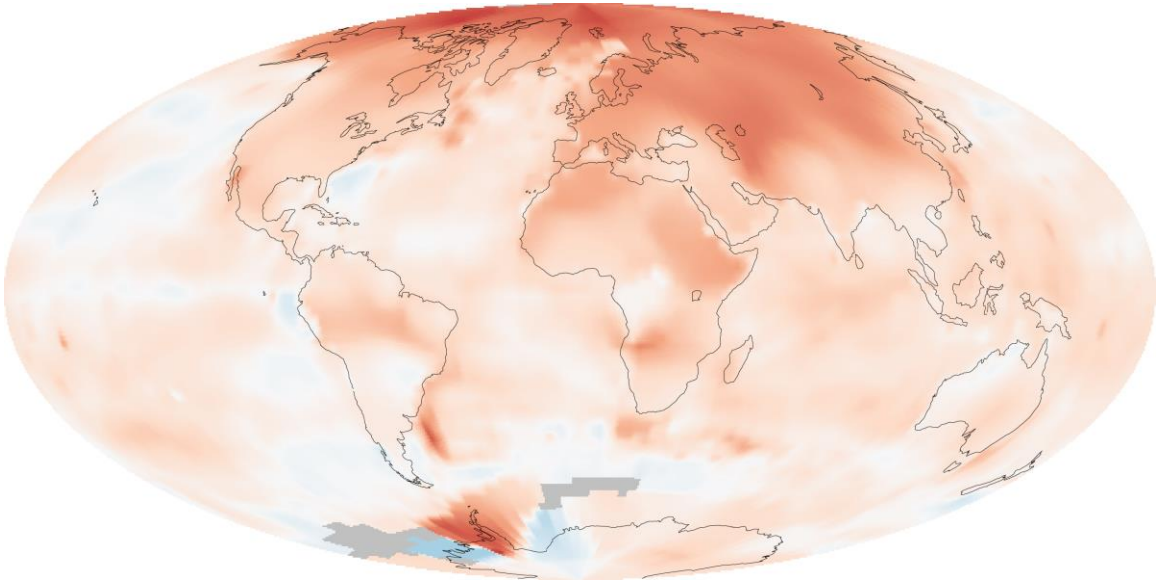

Change in Earth's Total Heat Content
Ocean Heating
Land + Atmosphere + Ice Heating
Change in Total Heat Content since 1961 (10^{21} Joules)
250
200
150
100
50
0
1960
1970
1980
1990
2000
2010
Year

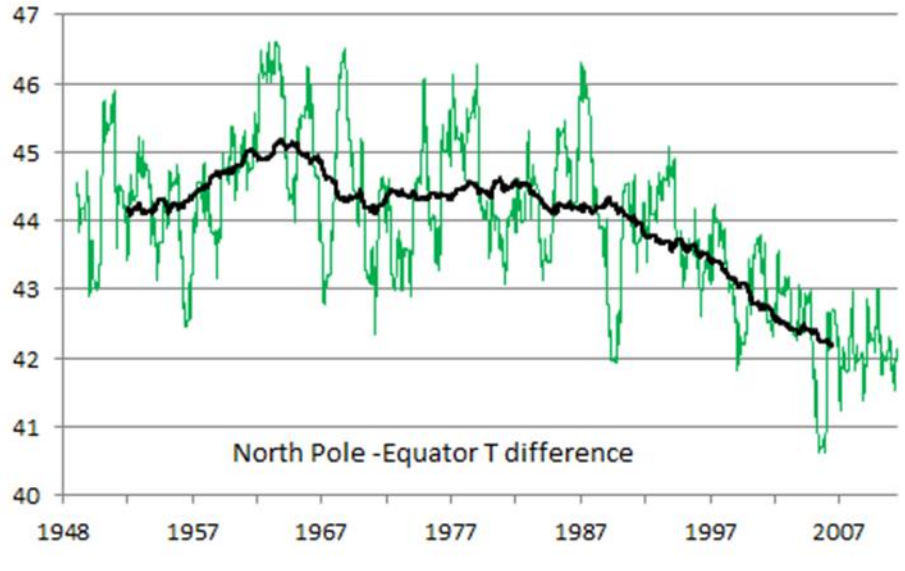
Arctic Sea Ice Extent

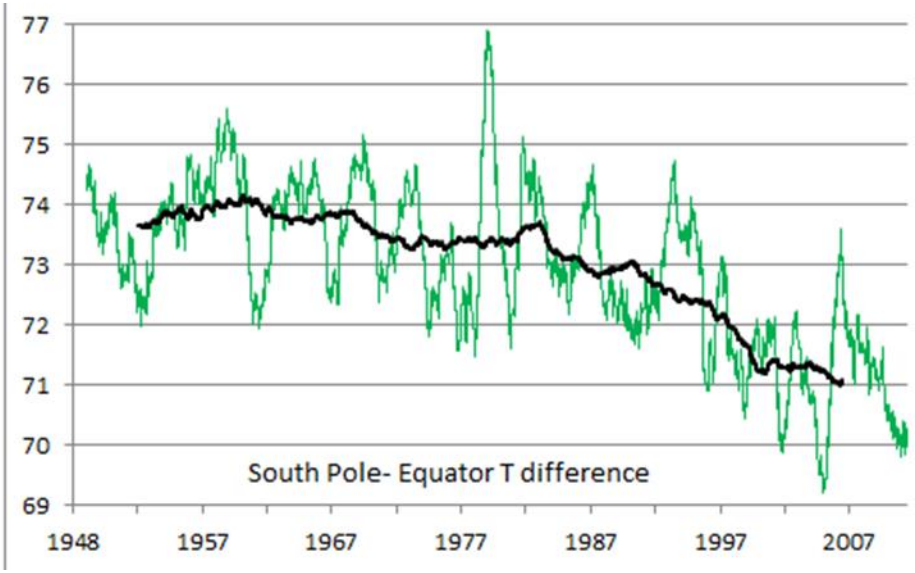
(area of ocean with at least 15% sea ice)



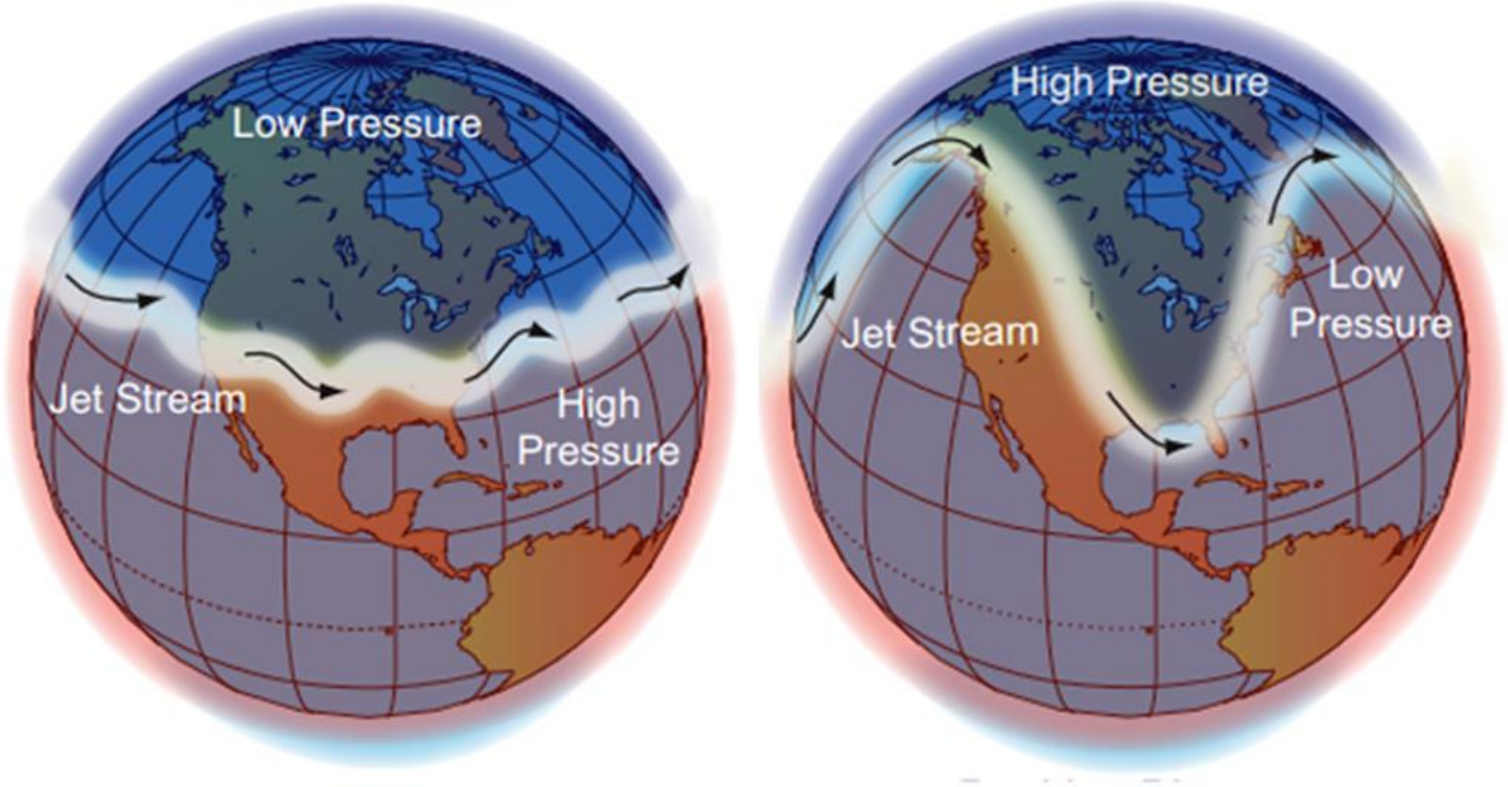
Tropics to Poles Temperature Gradient





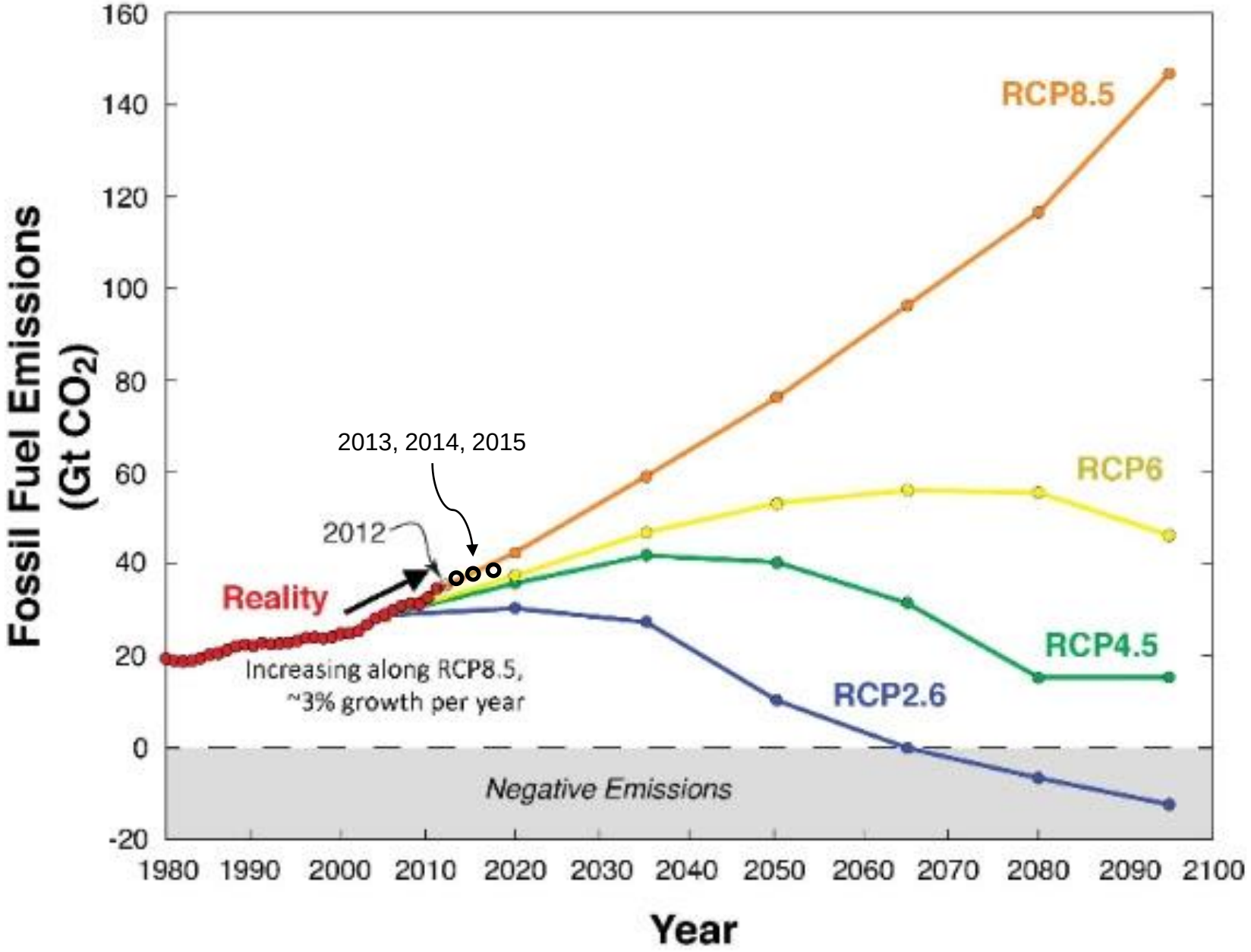


Increased Weather/Climate Variability

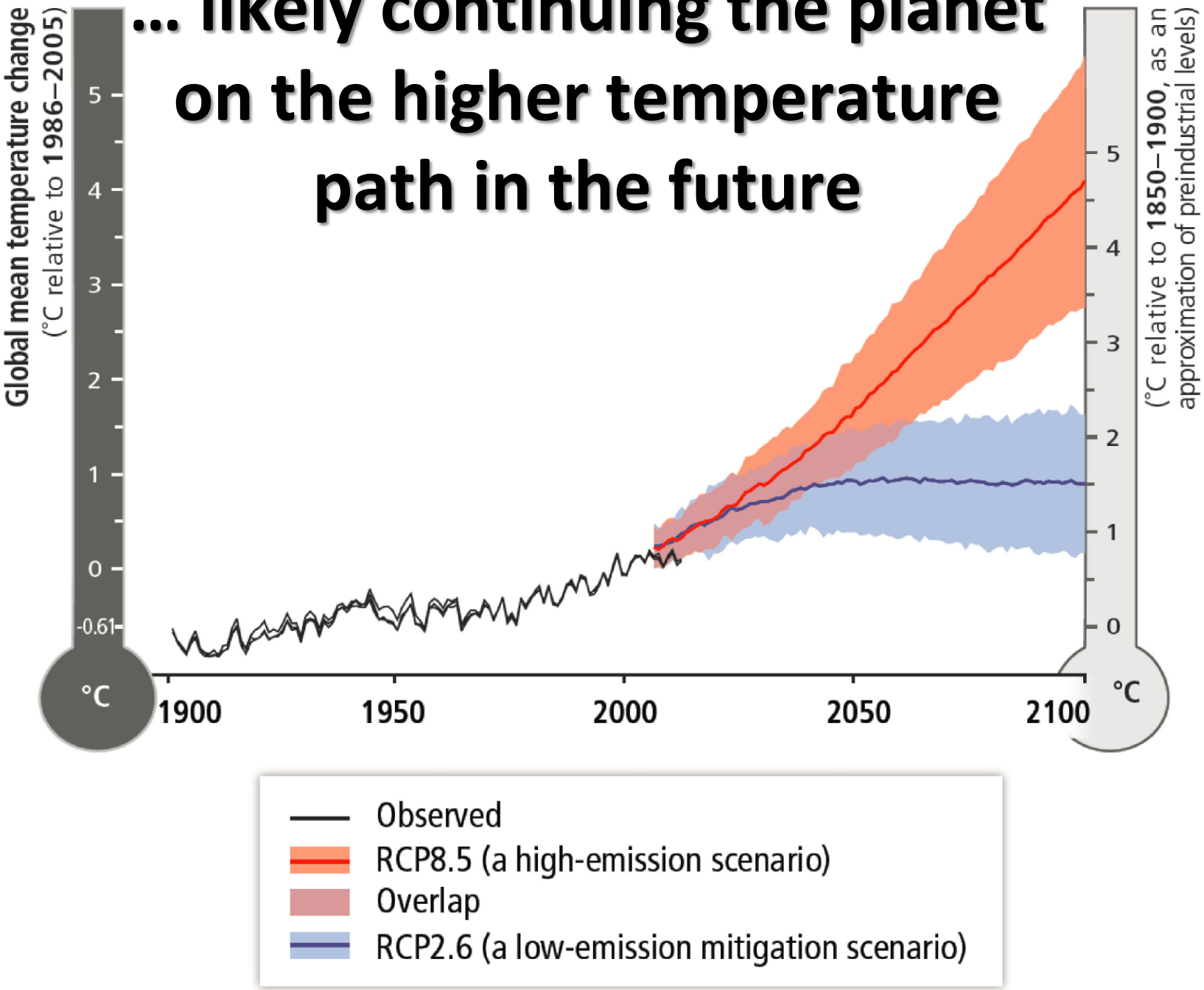


Arctic amplification has produced a slower jet stream, with more amplified north-south waves, more extreme weather and greater swings in climate conditions from year to year, season to season, and month to month. Some indication of similar changes in the Southern Hemisphere

Emissions have slowed, but not enough ...



… likely continuing the planet on the higher temperature path in the future



An Ideal Climate for Viticulture and Wine Production?

Climate Influences on Vine Growth, Productivity, and Quality

Harvest	Bud Break	Flowering	Véraison	Harvest
				
Slow hardening of vines, sufficient chilling units, low impact from winter extreme temperatures	Recharged soil moisture, gradual warming coinciding with day length changes, and low frost risk	Optimum daytime maximum temperatures, high solar potential, low cloud cover and rainfall	Optimum heat accumulation, low temperature variability, low heat stress	High diurnal temperature range, truncation of season due to day length changes, low rainfall

Meta-Analysis of Observed Climate Change Influences

Climate Influences on Vine Growth, Productivity, and Quality

Harvest | Bud Break | Flowering | Véraison | Harvest





Warmer dormant periods reducing chilling and cold hardiness, but winter freezes still occur

Climate Influences on Vine Growth, Productivity, and Quality

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Warmer soil temperatures and spring air temperatures driving earlier growth, but frosts still occur

Climate Influences on Vine Growth, Productivity, and Quality

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Evidence of rainfall and cloud cover shifts in some regions that affect flowering and set

Climate Influences on Vine Growth, Productivity, and Quality

Harvest | Bud Break | Flowering | Véraison | Harvest





Overall longer growing seasons and higher heat accumulation, higher temperature variability and heat stress in many regions

Climate Influences on Vine Growth, Productivity, and Quality

Harvest | Bud Break | Flowering | Véraison | Harvest





Lower diurnal temperature ranges in many regions, fruit ripens too early, sugar ripe, but not flavor/aroma … ripeness clocks out of sync

Climate Influences on Vine Growth, Productivity, and Quality

Harvest | Bud Break | Flowering | Véraison | Harvest





Phenology has shown shifts to:

- Earlier occurrences (5-10 days/1°C), and
- Compressed phases (5-20 days on average)

Climate Influences on Vine Growth, Productivity, and Quality

Harvest | Bud Break | Flowering | Véraison | Harvest





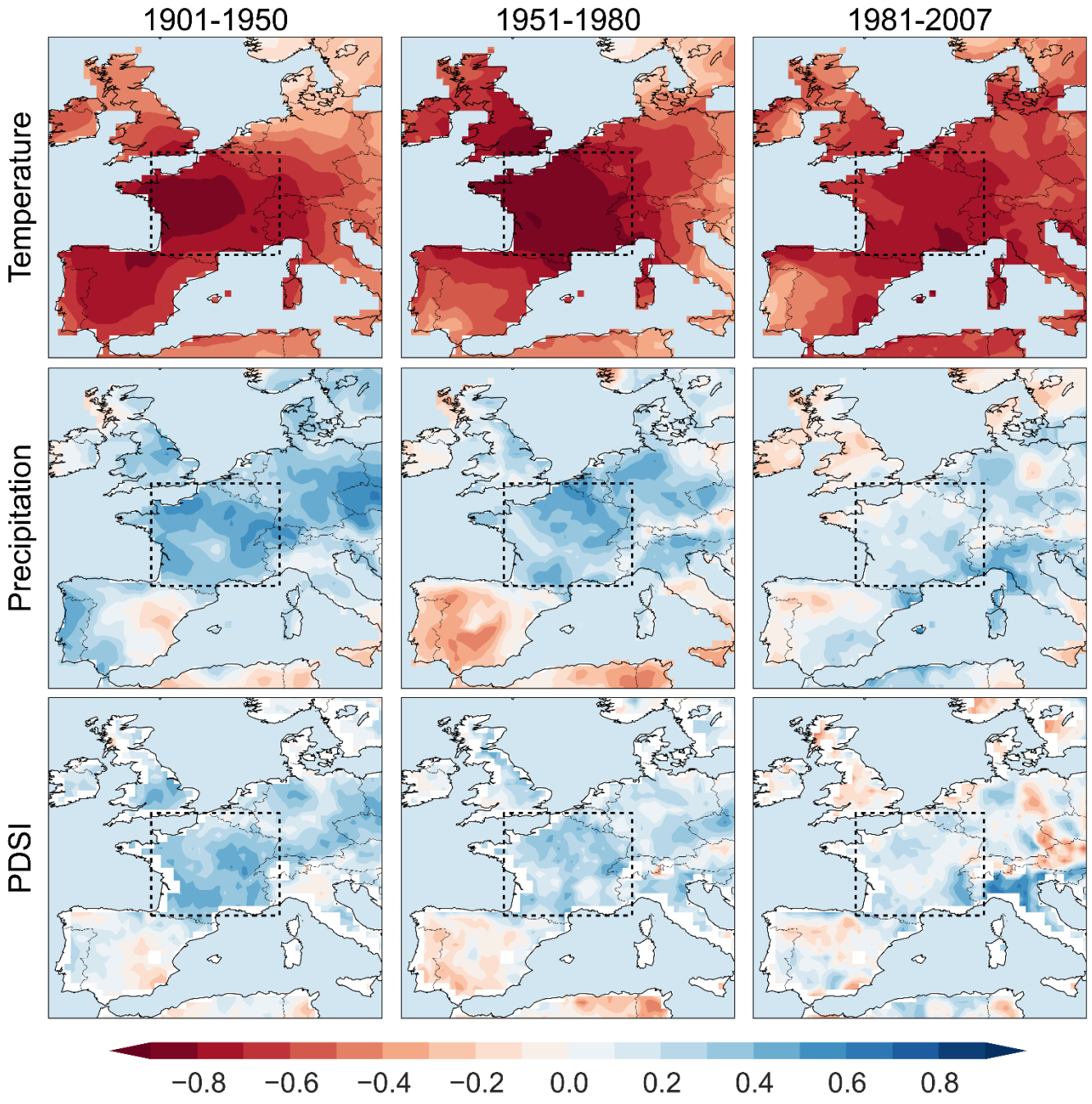
- Altered/new disease/pest timing and severity
- Increased drought frequency and severity
- Changes in soil fertility and erosion
- Water availability and timing of irrigation

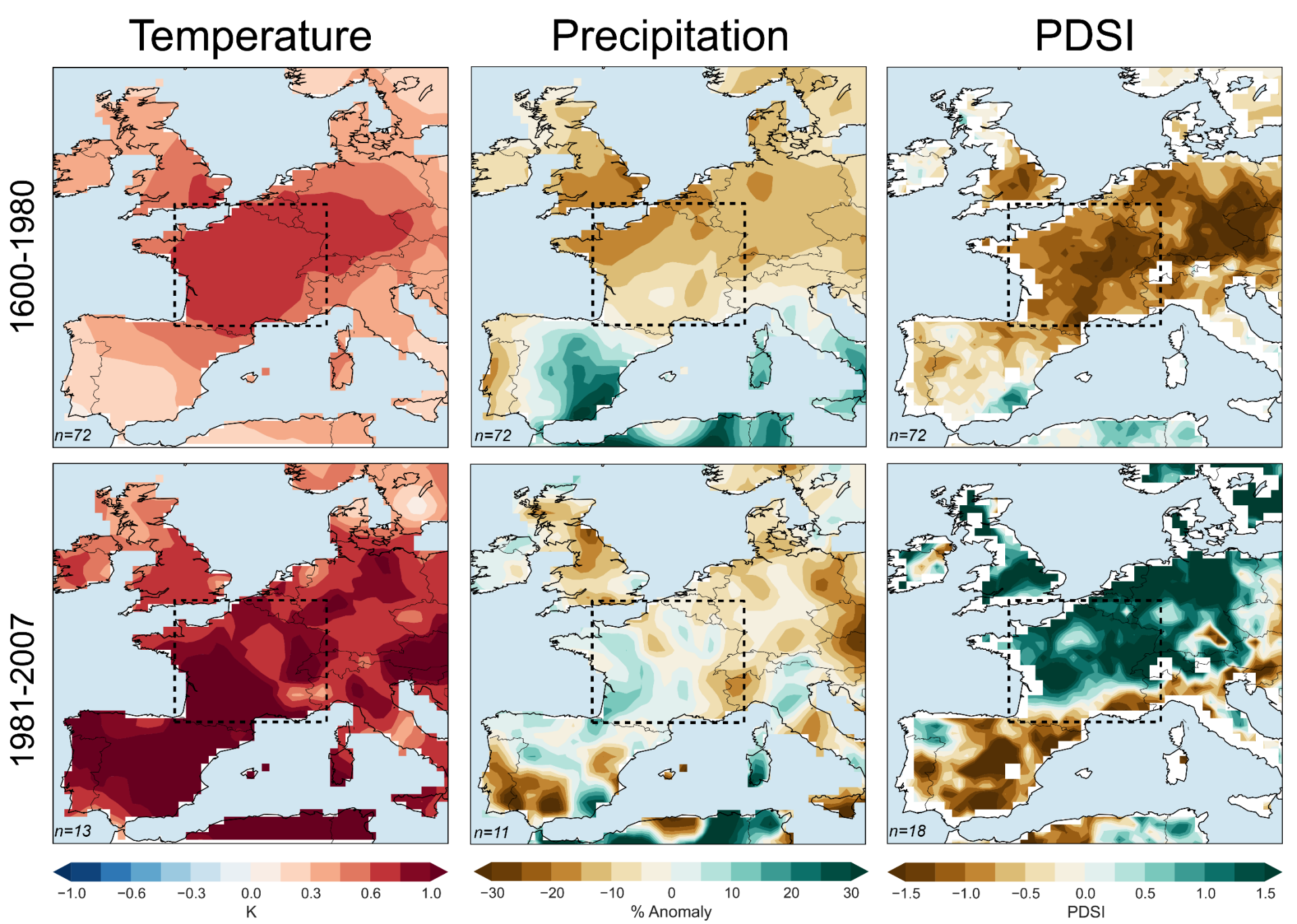
Recent Research in Europe

Temperature, Drought and Winegrape Harvests

May-June-July correlations with GHD

Cook and Wolkovich (2016) Nature Climate Change

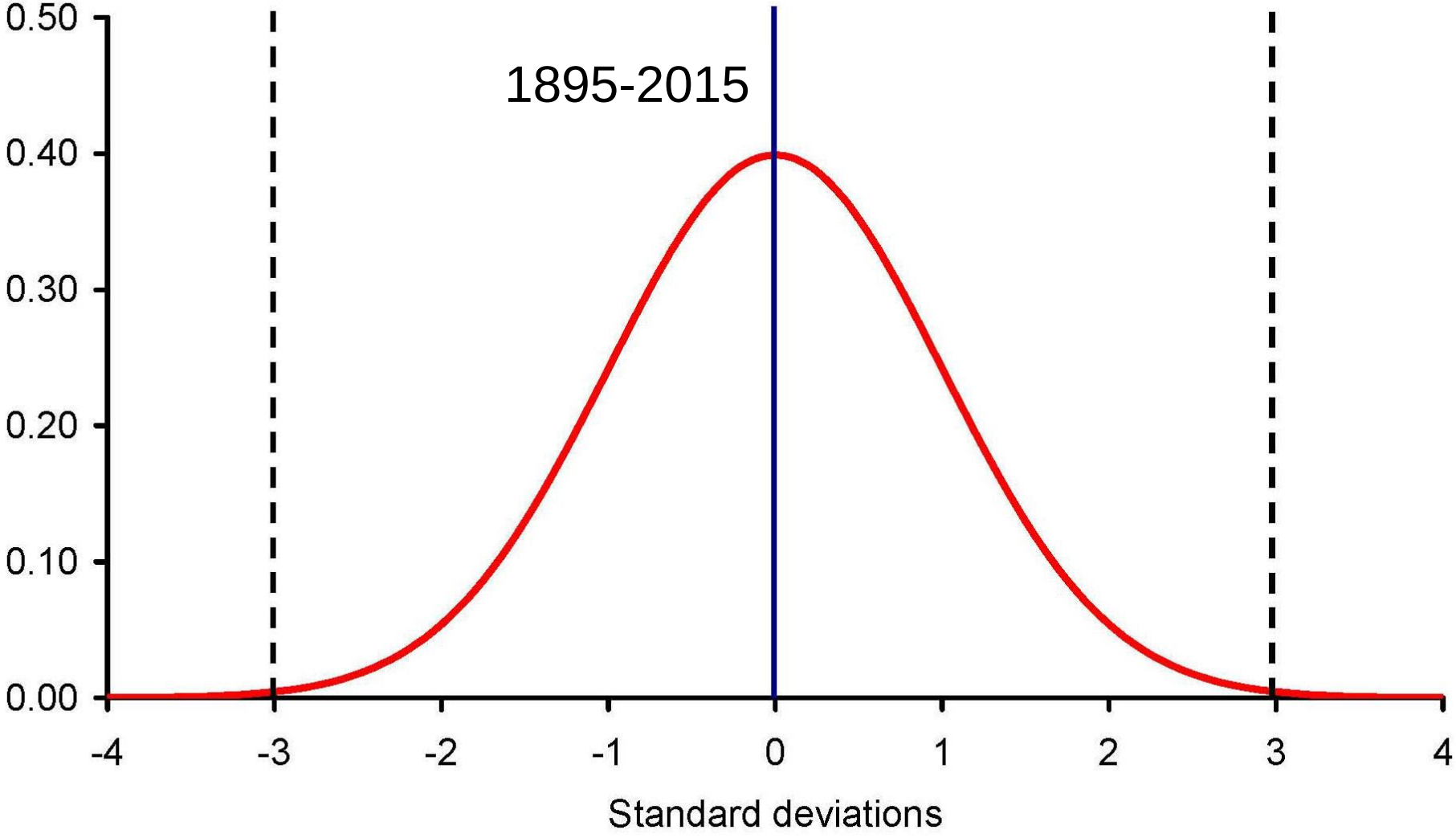




Cook and Wolkovich (2016) Nature Climate Change

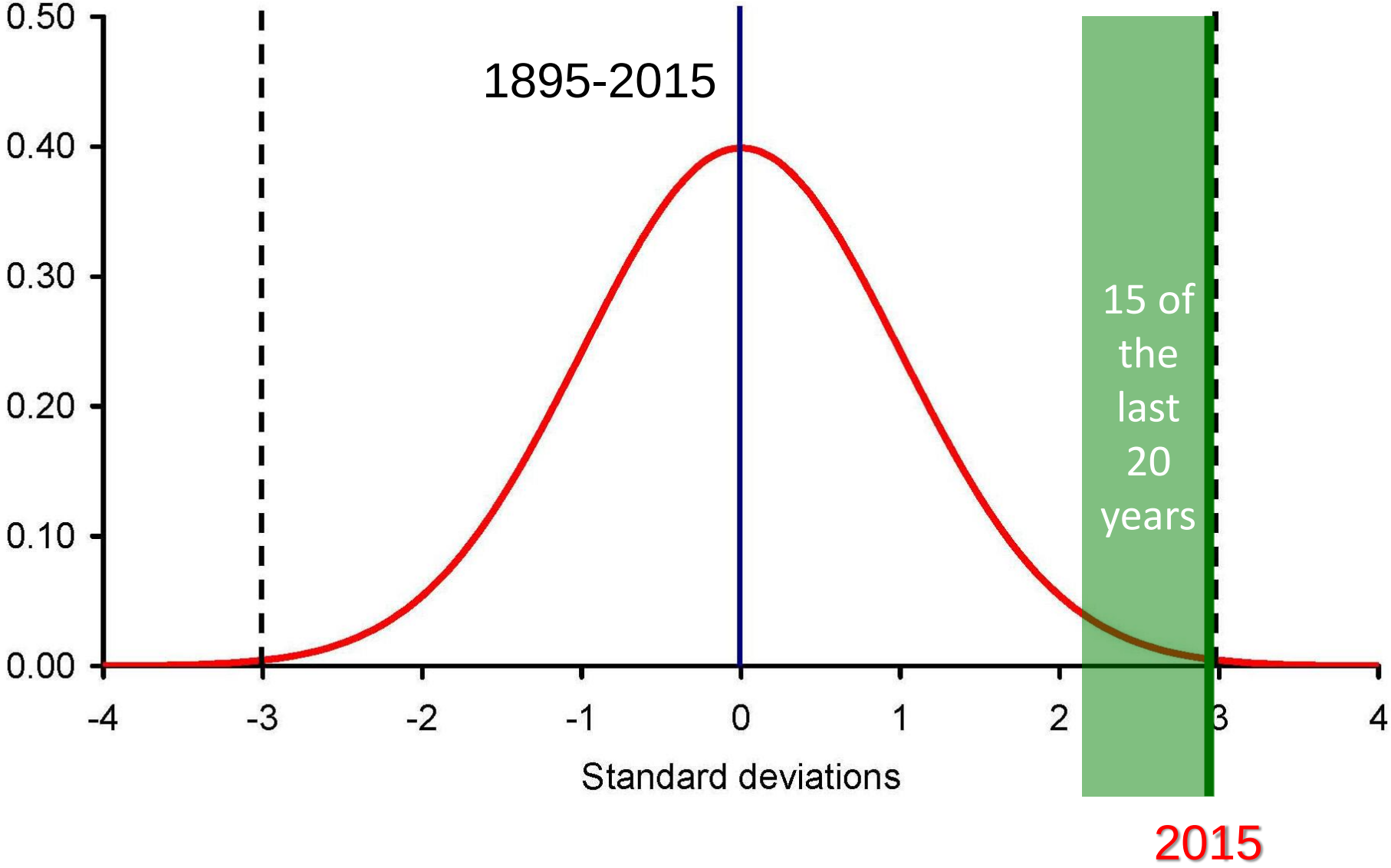
Historic vs Future Temperature Distributions in the Western US

Growing Season Temperature Distribution Changes in the Western US - Historic



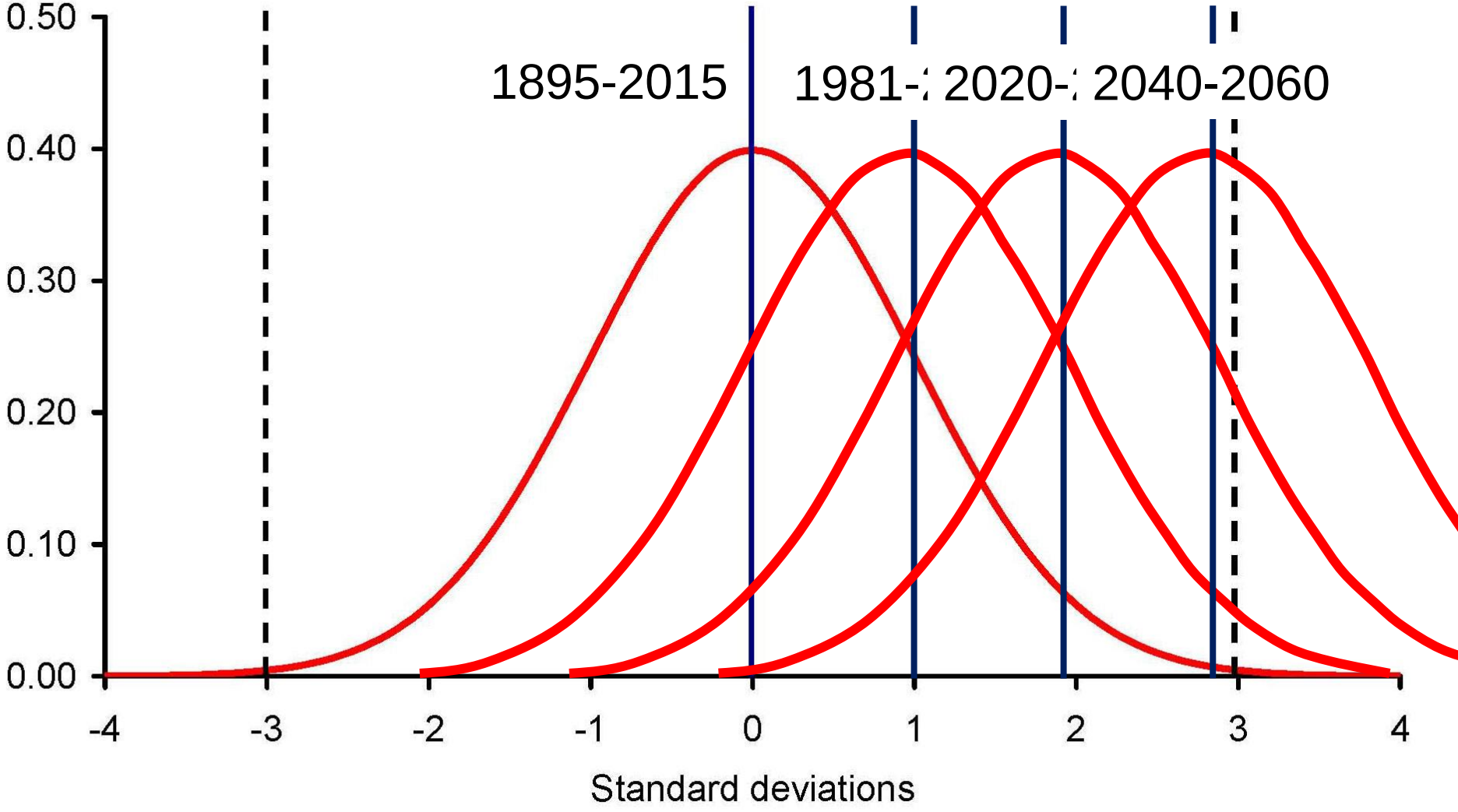
Each Standard Deviation is equivalent to +/- 1.1°C

Growing Season Temperature Distribution Changes in the Western US - Recent



USHCN 2016; NCEI 2016 update

Growing Season Temperature Distribution Changes: Historic and Projected



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Summary

Global Climate Summary

- The planet is warmer than at any time in our recorded past
- The past 15 years has produced conditions expected to be on average by 2050, or sooner
- Oceans are absorbing much of the heat, disrupting biogeochemistry cycling and climate feedbacks as we know them
- Extremes in temperature and precipitation, along with drought events, have increased in severity and frequency

Global Viticulture/Wine Summary

- Altered phenological timing (globally 5-10 days per 1°C) and intervals (5-20 days overall)
- Altered ripening profiles (challenges in managing timing of sugar, acid, flavor and phenolic development)
- New and/or altered disease and/or pest timing and severity
- Altered irrigation needs, especially with drying summers and higher Tmax
- Increasing need for management and production adaptations

Risk and Adaptive Capacity/Strategies

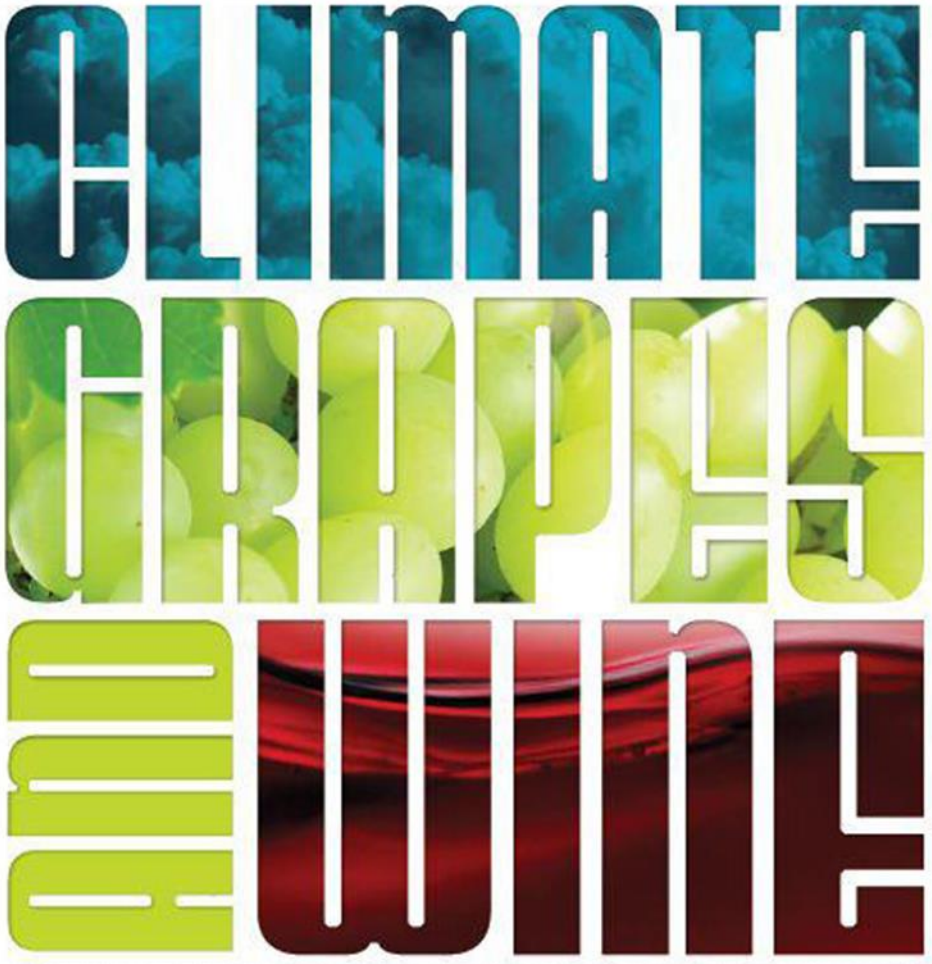
Much research and innovation is needed in both physical and social frameworks to enhance the wine producer community's understanding of:

- Impacts & Uncertainties
- Potential Opportunities
- Need & Options for Adaptation Strategies

Ultimately Growers/Producers need to:

- Understand/Maximize their Adaptive Capacity
- Reduce Exposure/Risk
- Build Resilience in their Operations

Critically … governments need to close the Policy/Decision Relevance Gap as soon as possible to make our jobs easier!



Thank You!

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