Strawberry yield forecasting and climate impacts on fruits and vegetables in California

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Strawberry Yield Forecast

- Large amount of variability in crop yield can be explained by variability in weather
- Crop yield forecast with certain lead-time can help growers make important decisions such as marketing decisions, labor management etc.
- Can we use past records of daily yield and weather data to develop yield prediction tools for strawberry?
- Can we provide predictive skills in time of peak productions?

Pathak et al., 2016. http://dx.doi.org/10.1155/2016/9525204

Benefits of Yield Forecasting

- Before season use of yield forecast
  - Land allocation
  - Insurance decisions
  - Marketing decisions
- Use of in-season yield forecast
  - More precision = Better Marketing decisions
  - On-farm management/labor management

Weather – Yield Correlations

TABLE 2. Months and weather variables* used for yield forecasts

	Year prior to harvest					Year of harvest								
Crop†	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Grapes, wine		ppt							tmn		ppt			
Lettuce			tmx				tmx		tmx					
Almonds						ppt	tmn							
Strawberries				all										
Grapes, table			ppt			ppt			tmn			tmn		
Hay							ppt				ppt			
Oranges					tmn					ppt				
Cotton										tmx	tmn			
Tomatoes, processing									tmx		tmx			tmn
Walnuts				tmx			ppt							
Avocados	tmx		ppt							tmn				

* tmn = average minimum temperature; tmx = average maximum temperature; ppt = total rainfall; all = all three variables.
† No weather variables are shown for pistachios, which were modeled using only previous years' yields.

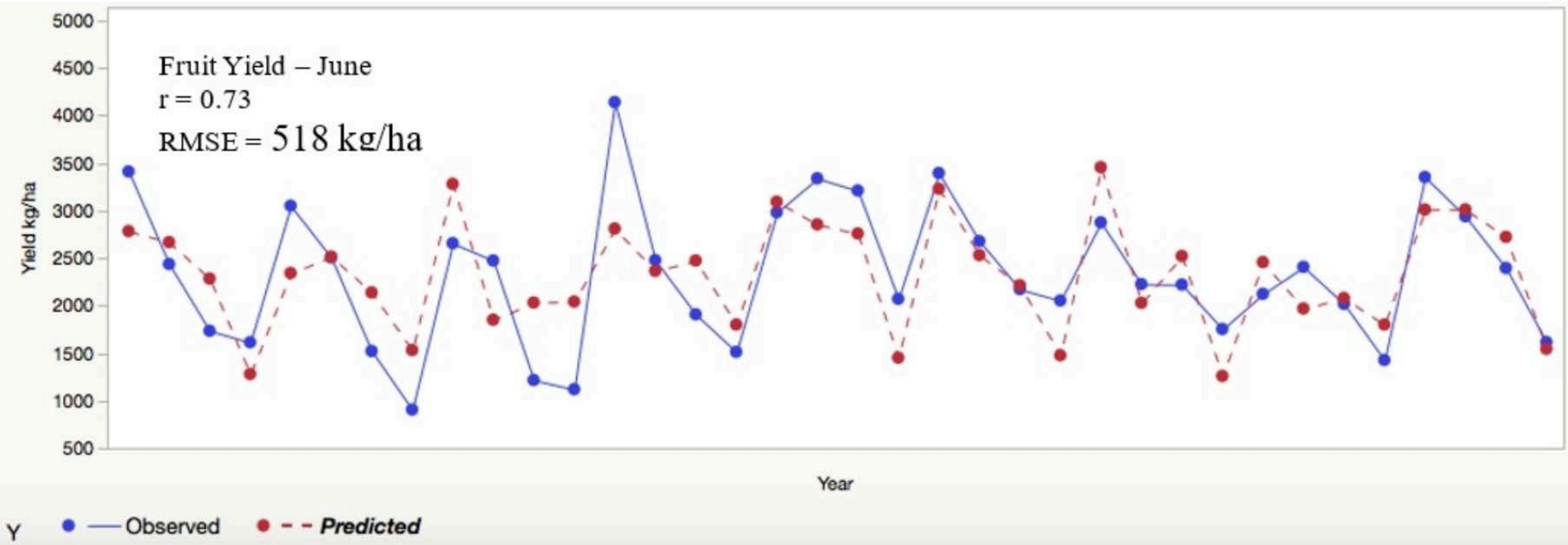
Lobell et al., 2006

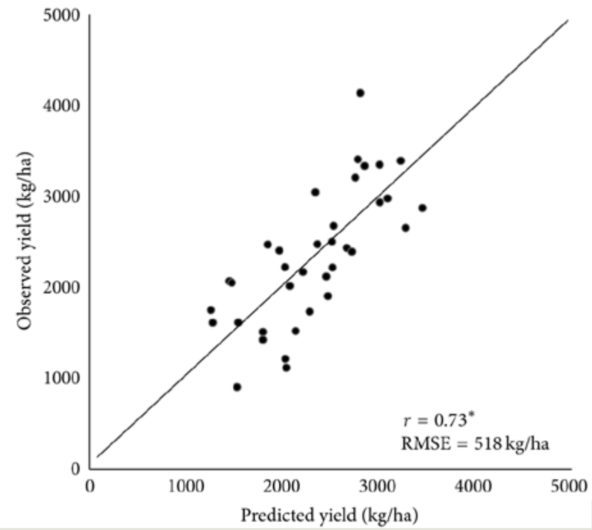
Weather – Strawberry Yield Correlations

	Weather parameters	April	May	June	July
Oct	ET_o	*(−)		*(+)	
Oct	Net radiation	*(−)		*(+)	
Oct	Max vapor pressure		*(+)	*(+)	*(+)
Oct	Min vapor pressure			*(+)	*(+)
Oct	Max relative humidity			*(+)	*(+)
Oct	Min relative humidity				*(+)
Oct	Dew point			*(+)	*(+)
Oct	Maximum soil temperature		*(+)	*(+)	*(+)
Oct	Minimum soil temperature		*(+)	*(+)	*(+)
Nov	ET_o	*(−)	*(+)	*(+)	*(+)
Nov	Net radiation	*(−)	*(+)	*(+)	*(+)
Nov	Max vapor pressure			*(+)	
Nov	Min vapor pressure			*(+)	
Nov	Maximum air temperature	*(−)			
Nov	Min air temp			*(+)	
Nov	Dew point			*(+)	
Nov	Maximum soil temperature			*(+)	
Nov	Minimum soil temperature			*(+)	
Dec	Net radiation	*(−)			
Dec	Max vapor pressure			*(+)	
Dec	Min vapor pressure			*(+)	
Dec	Dew point			*(+)	
Dec	Average wind speed		*(−)		*(−)
Dec	Maximum soil temperature			*(+)	
Dec	Minimum soil temperature			*(+)	*(+)
Jan	ET_o	*(+)			
Jan	Net radiation	*(+)			
Jan	Max vapor pressure		*(−)		
Jan	Min vapor pressure		*(−)		
Jan	Min air temp		*(−)		
Jan	Max relative humidity	*(−)			
Jan	Min relative humidity	*(−)	*(−)		
Jan	Dew point		*(−)		
Jan	Average wind speed			*(−)	
Jan	Maximum soil temperature		*(−)		
Jan	Minimum soil temperature		*(−)		
Feb	Net radiation	*(+)		*(−)	
Feb	Average wind speed		*(−)		
Feb	Maximum soil temperature				*(−)

Pathak et al., 2016

Weather based strawberry yield prediction model





Pathak et al., 2016

Future work to improve yield forecast skill

- To develop field specific models merging weather and easy to obtain agronomic parameters such as:
  - flower count
  - green fruit count
  - Nitrogen levels in plant tissues
  - Pest presence/absence
  - Leaf wetness
  - Plant stress
  - Soil Properties
- Model validations at various fields within the area

Climate impacts on fruits and vegetables in California

Changes in California Temperatures

Climatic Change

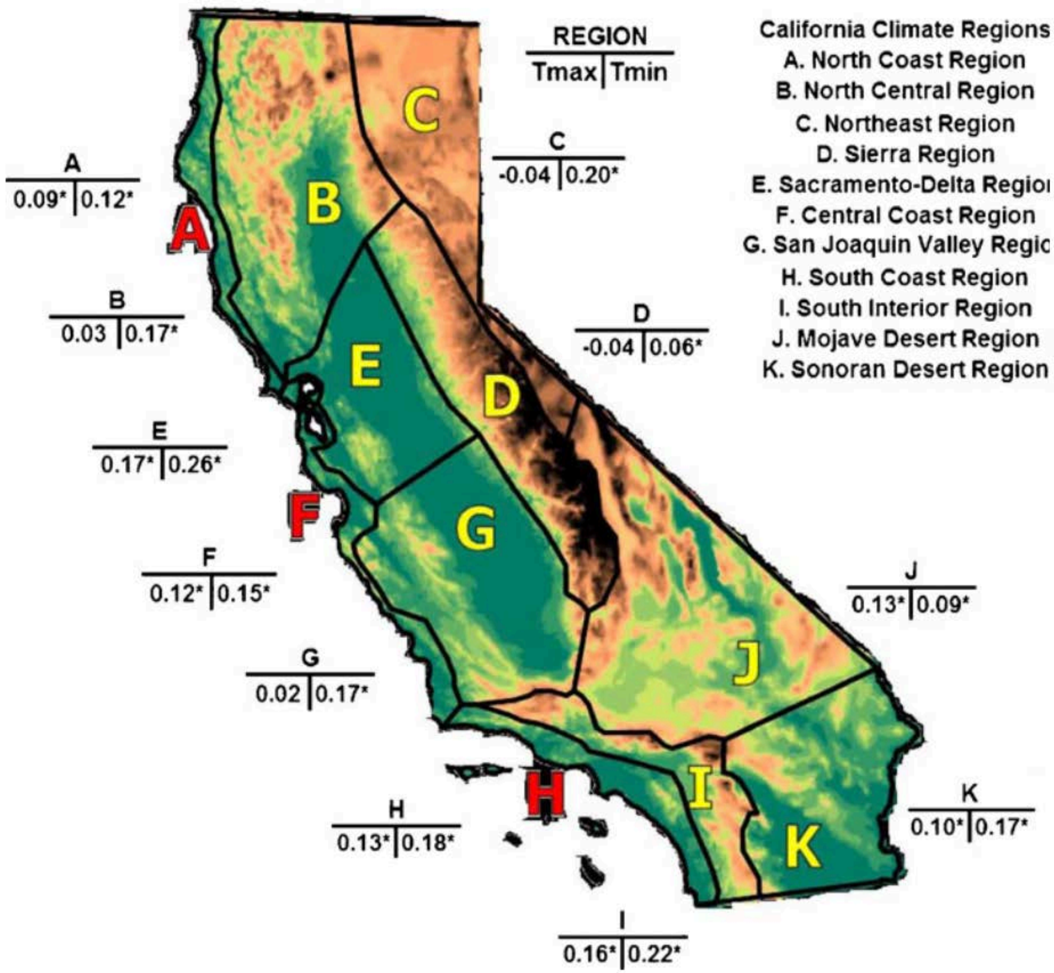
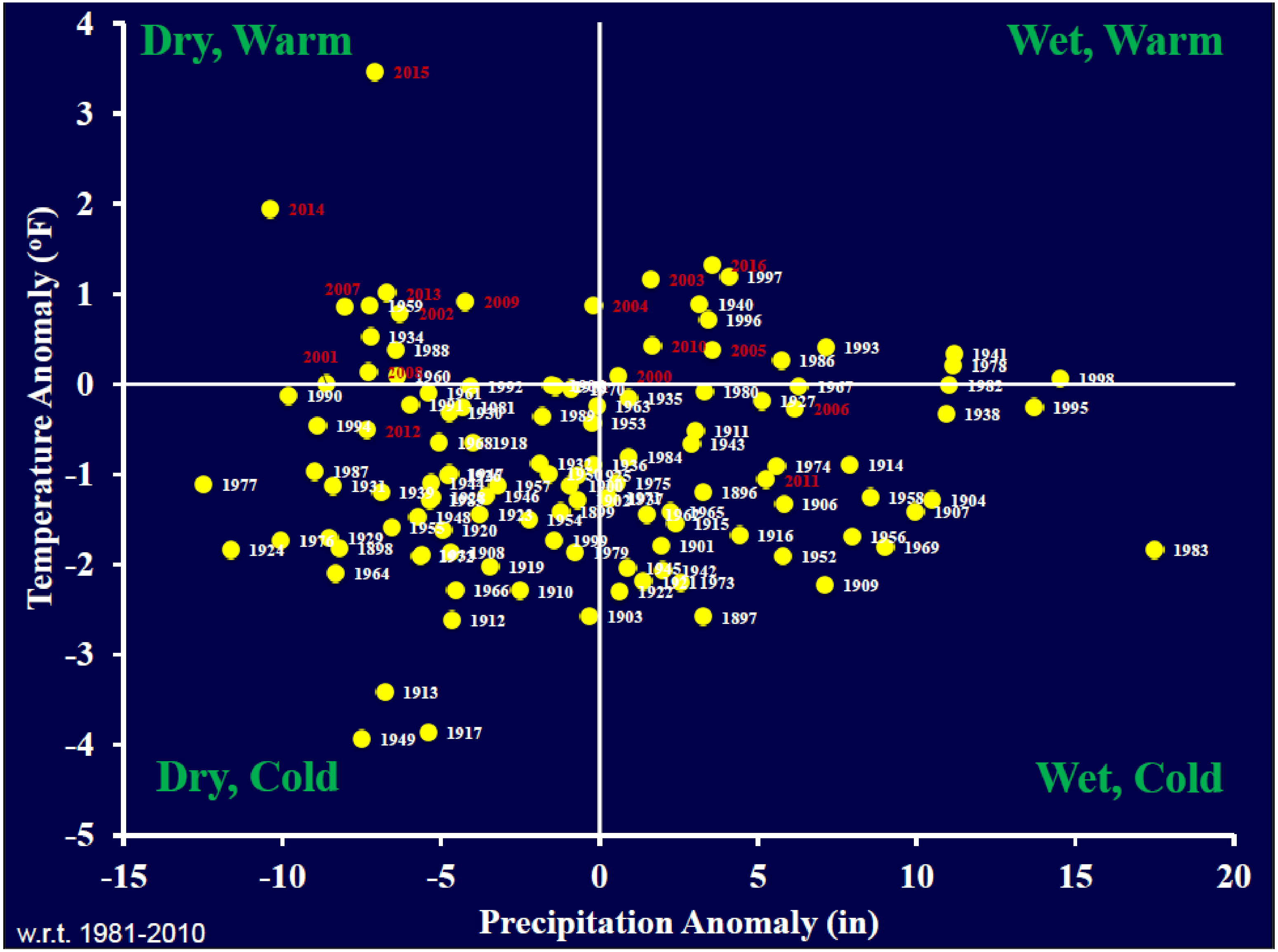


Fig. 4 Annual temperature trends (°C dec^{-1}) for the 11 climate regions labeled *A-K* computed between 1918–2006 for Tmax (*left*) and Tmin (*right*), where the trends that are statistically significant at the 95% confidence level are indicated with an *asterisk*

Cordero et al. (2011)

Temperature in 14 of the last 17 years are above normal



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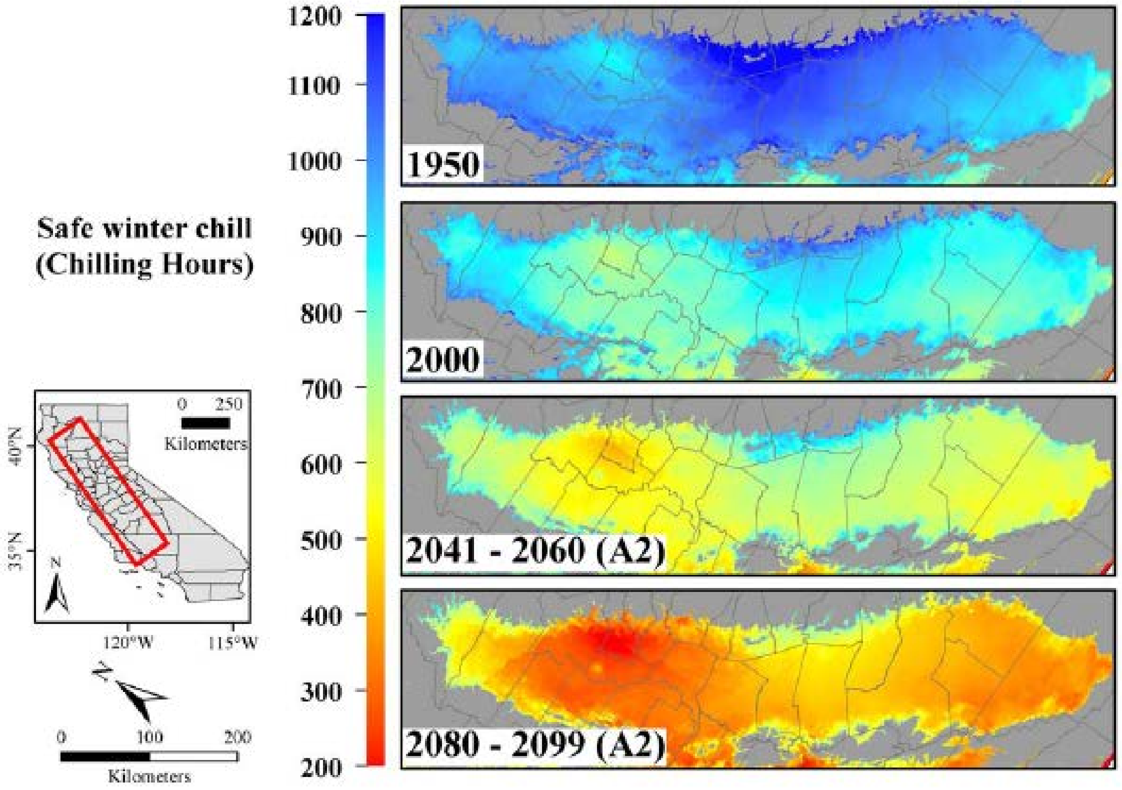
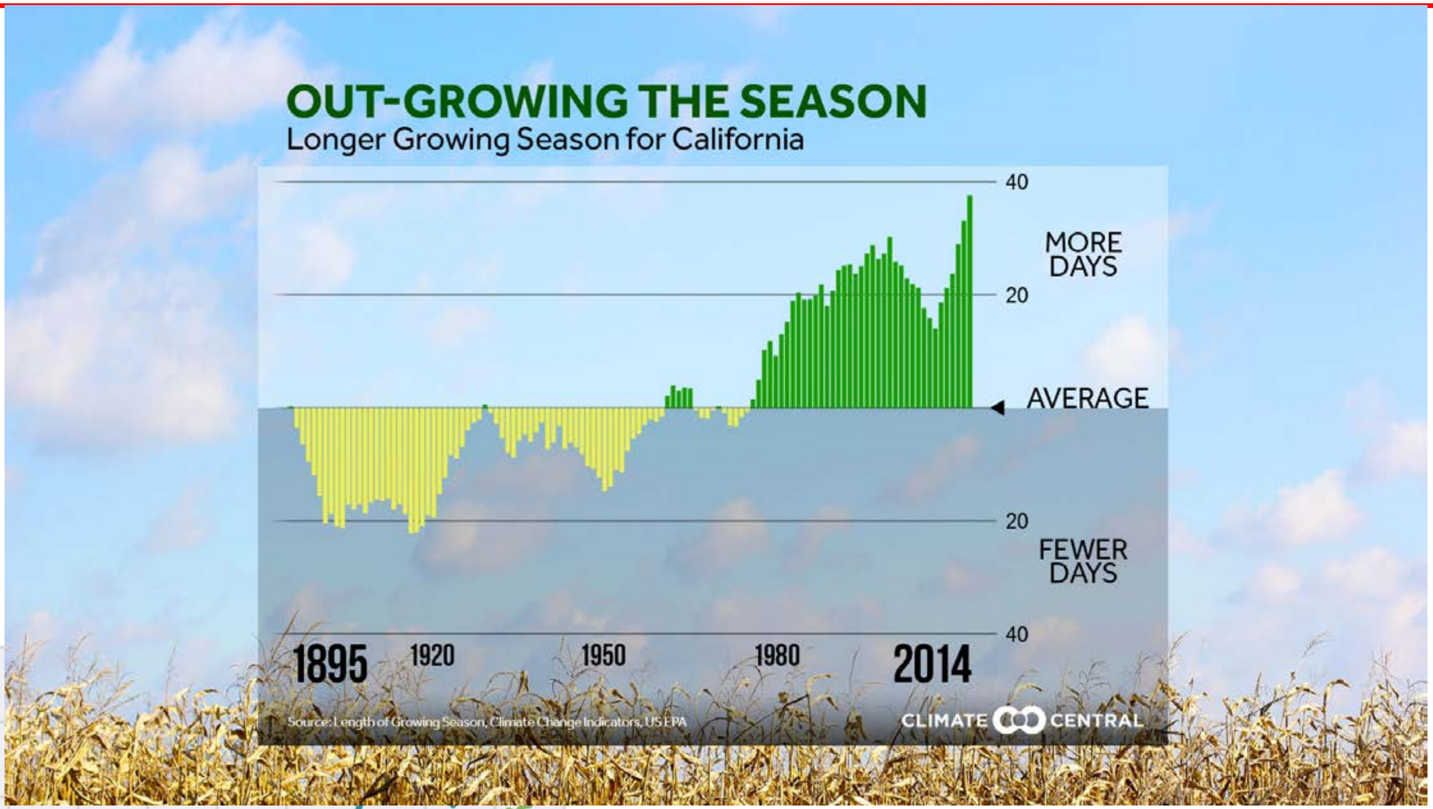
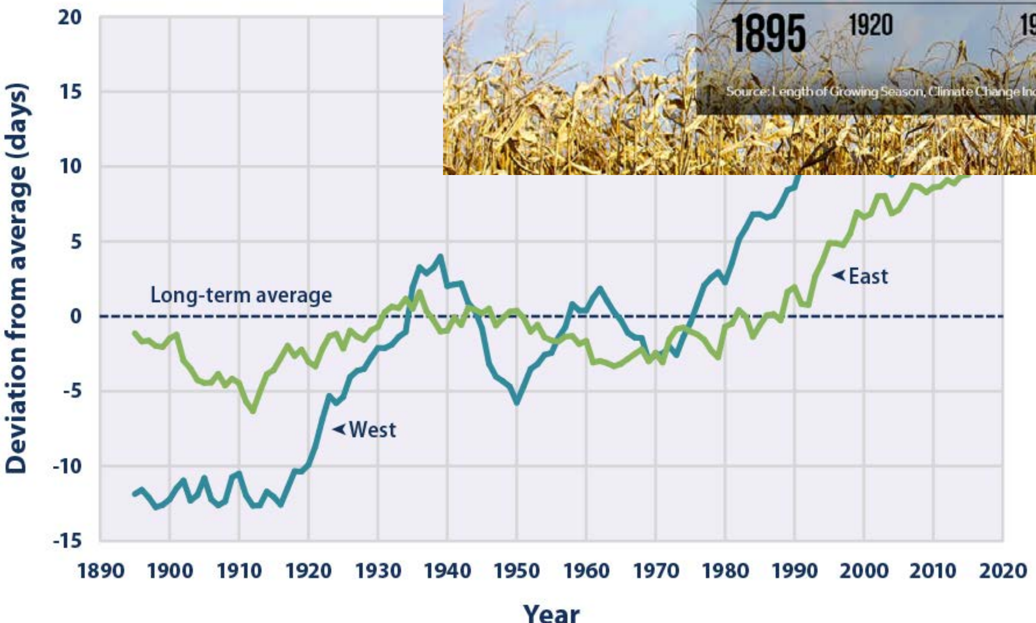
Trends in Chill Hours



- Around the year 1950, growers in the Central Valley could rely on between 700 and 1200 Chilling Hours
- By 2000, this number had already declined by up to 30% in some regions
- Chill Hours are projected to decrease significantly under future climate change scenario

Length of Growing Season

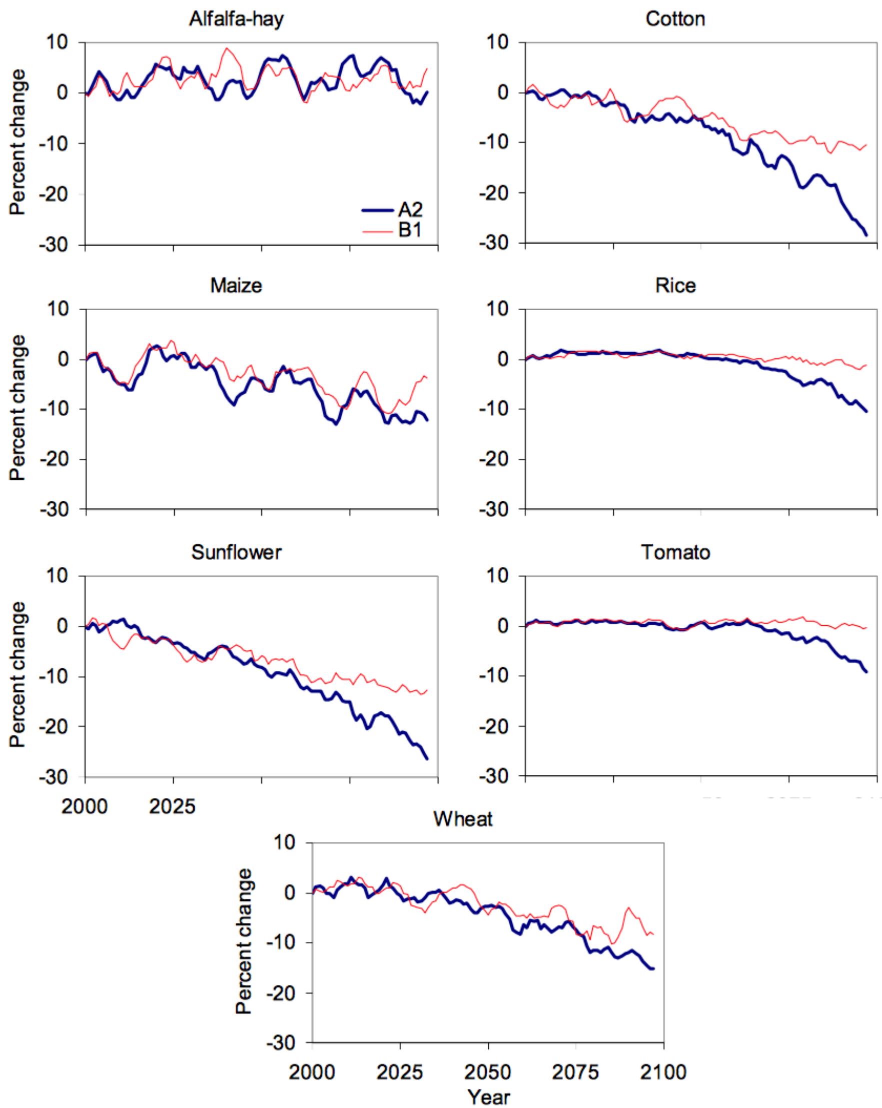




Crop Sensitivity

- **Vegetables**: exposure to temperatures in the range of 1.8°F to 7.2°F above optimal moderately reduces yield. exposure to temperatures more than 9°F to 12.6°F above optimal often leads to severe if not total production losses
- **Perennial specialty crops**: Yields decline if the chilling requirement is not completely satisfied, because flower emergence and viability is low
- **Soybean and Alfalfa**: Elevated CO2 has been associated with reduced nitrogen and protein content
- **Corn**: high nighttime temperatures, high temperatures during pollination negatively impacts yield
- **Rice**: Temperature extreme during pollination
- **Cotton**: Higher temperature during boll filling stage

Projected Impacts



- Expected yield reductions by 2097: cotton (≈ 29%) > sunflower (≈ 26%) > wheat (≈ 15%) > maize (12%) > rice (≈ 10%) > tomato (≈ 9%)
- These yield decreases were mainly because high temperatures under climate change shorten the duration of phenological phases
- Limitations related to water supply to irrigated croplands
- Adaptation measures such as management practices and improved cultivars may alleviate some of the impacts

Summary

- Climate change is already impacting state's highly productive agricultural industry
- Improving agricultural resilience to climate change requires protection of water and soil and development of new adaptation research
- Translating weather and climate information into decision support information can help growers reduce agricultural risks
- Need more localized research efforts and decision tools that integrate agronomic, social, and economic aspects for effective adoption of new innovations

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