

Mitigating climate risks on the farm: tree nut perspective

David Doll

Tree Nut Pomology Advisor

UCCE Merced

Let's Talk About the Weather...

“It impacts everything we do.”

“Something we can't control, but....

“something in which we have to manage.”

Let's Talk About the Climate...

“They cant even get the weather right, how can they predict climate?”

Various forecasting models are adding to the confusion;

No ability to determine long range forecasts;

Lack of concern for the long term due to day-to-day operation management.

In many cases, not much can be done on a day-to-day basis to manage.

Concerns: Weather v/s Climate

Weather Concerns

- Rain during bloom/harvest
- Spring frost events
- Late season rains

Managed on a
day-to-day basis

Climate Concerns

- Flooding/drought
- Warmer winters and springs
- Hotter summers
- Shifting rainfall patterns

Managed on a farm
development level

Mitigating Risks: Almond Case Study

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Mitigating Weather: Almond Case Study

Rain during bloom:

- Placement of 2-2.5 strong, 8 frame hives/ acre;
- Utilization of fungicides;
- Varieties resistant to disease;
- Diversification of bloom timings.



Mitigating Weather: Almond Case Study

Spring Frost

- Almond flowers and nuts are sensitive to freezing temperatures
- Utilize strategies to increase orchard heat (e.g. mow cover crop, use of sprinkler systems)
- Plant later blooming varieties



Mitigating Weather: Almond Case Study

Late season rains

- All agricultural crops are susceptible to diseases, which thrive in warm, wet conditions;
- Use of properly timed pesticides;
- Resistant varieties.



Mitigating Weather: Almond Case Study




Rain During Harvest

- Almonds have to be brought to the processor at a specified moisture level
- Utilization of extra passes to reduce orchard debris, quicker drying time
- Select earlier harvesting varieties.



Mitigating Weather: On-farm Options

Methods of Management:

- Orchard layout and design (e.g. varieties, irrigation systems);  **Mid-term (10-20 years)**
- Increased investment;  **Short-term (1-5 years)**
- Increased operational costs;  **Long-term (20-50 years)**
- Increased environmental impact.

Mitigating Risks: Almond Case Study

Weather Concerns

- Rain during bloom/harvest
- Spring frost events
- Late season rains

Managed on a
day-to-day basis

Climate Concerns

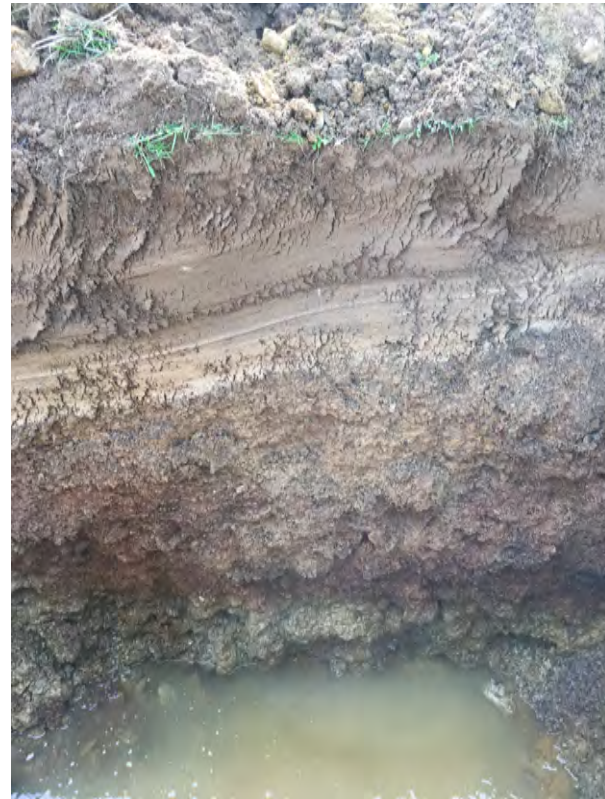
- Flooding/drought
- Warmer winters and springs
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Managed on a
development basis

Mitigating Climate: Almond Case Study

Managing Drought/Floods

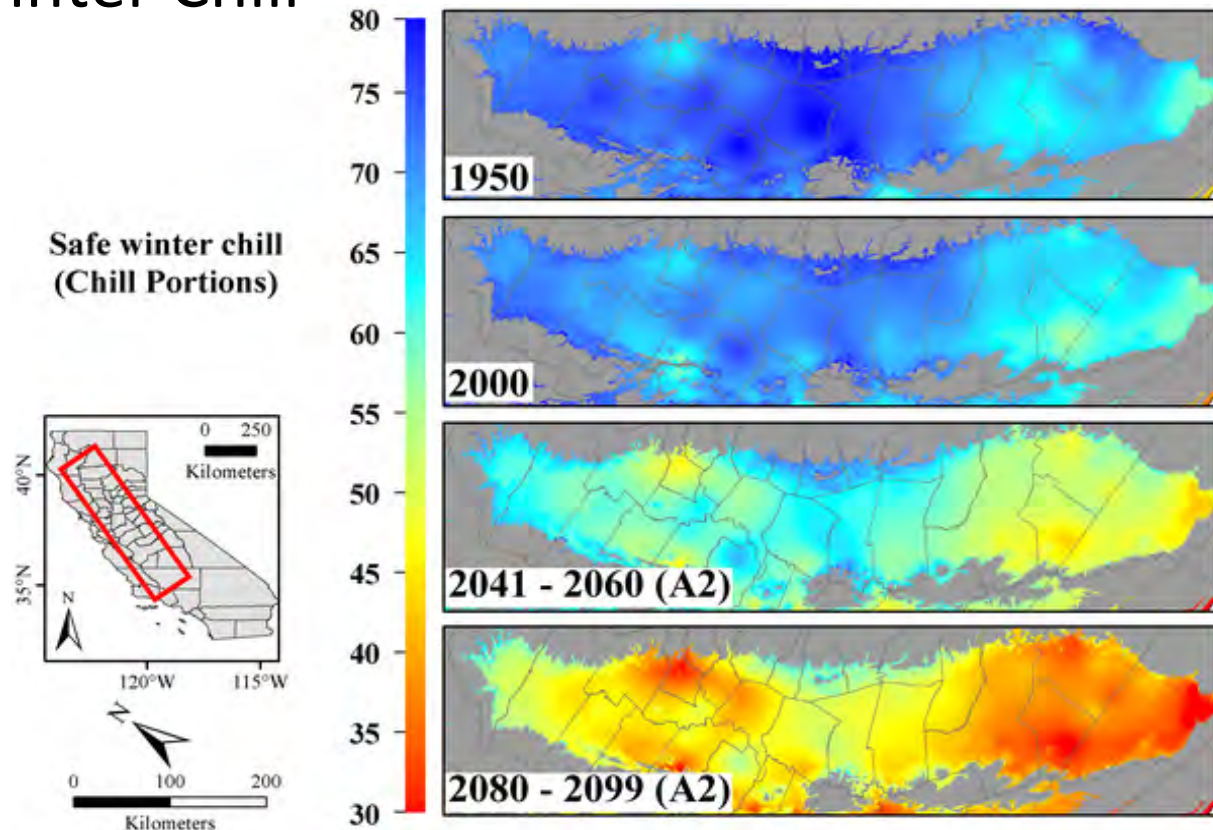
- Land selection and purchase;
- Diversification of parcel locations;
- Diversifying water resources on the ranch;
- Installing drainage systems



Mitigating Climate: Almond Case Study

Reduced Winter Chill

Figure 4. Safe winter chill in California's Central Valley in 1950, 2000, 2041–2060 and 2080–2099, calculated with the Dynamic Model.

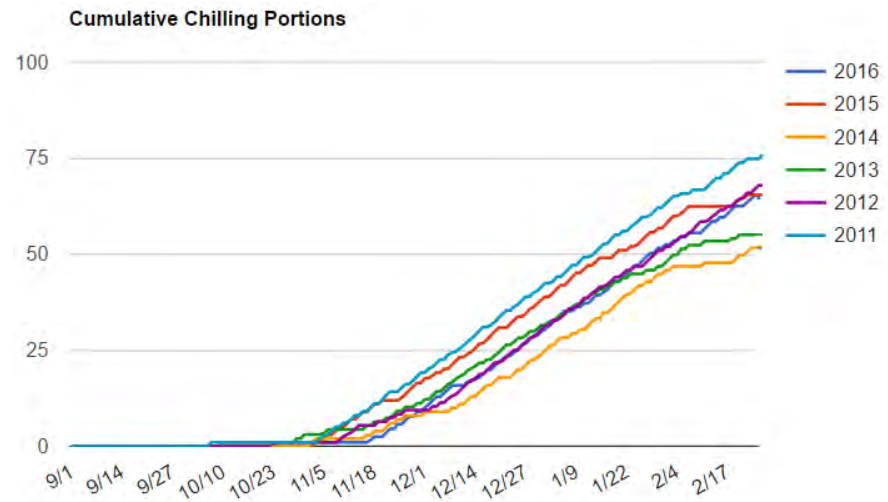


Luedeling E, Zhang M, Girvetz EH (2009) Climatic Changes Lead to Declining Winter Chill for Fruit and Nut Trees in California during 1950–2099. PLoS ONE 4(7): e6166. doi:10.1371/journal.pone.0006166
<http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006166>

Mitigating Climate: Almond Case Study

Warmer winters, springs

- Earlier bloom, increased frost risk;
- Development of low chill varieties/higher spring heat unit accumulation;
- Utilization of heat reflecting products to delay bloom;
- Different disease and insect pressures.



The Almond Doctor

University of California Cooperative Extension

PRESENTATIONS DISEASES GENERAL HORTICULTURAL AND WEATHER INSECTS IRRIGATION MANAGEMENT NUTRIENT MANAGEMENT
ELEMENT SOIL CONSIDERATIONS WEEDS

Comments?

1, please feel free to
ous posts or email us at
com

Sun Reflecting Products for Increased Winter Chill?

Posted on December 14, 2016 by David Doll

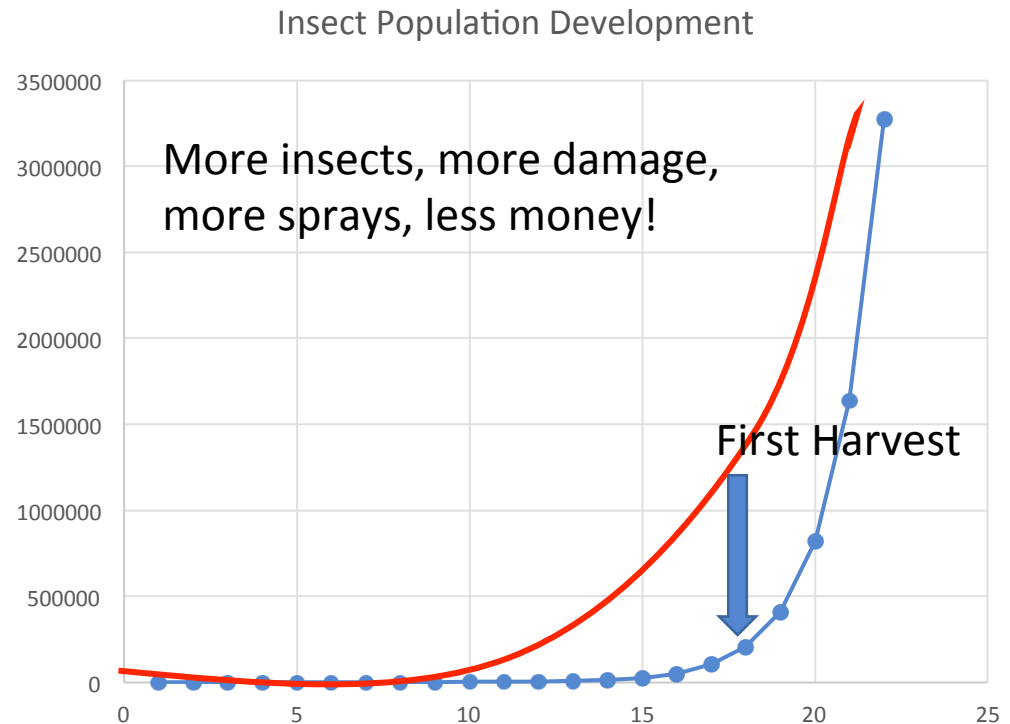
Who We Are:

The Almond Doctor contributors and
are University of California Cooper
Extension personnel with experience

Mitigating Climate: Almond Case Study

Hotter Summers

- Impacts on nut quality and rate of development;
- Increased insecticide applications;
- Increased water costs.



Mitigating Climate: Almond Case Study





Shifting Rainfall Patterns

- Increases in fungicide and herbicide usage;
- Impacts crop quality and productivity.

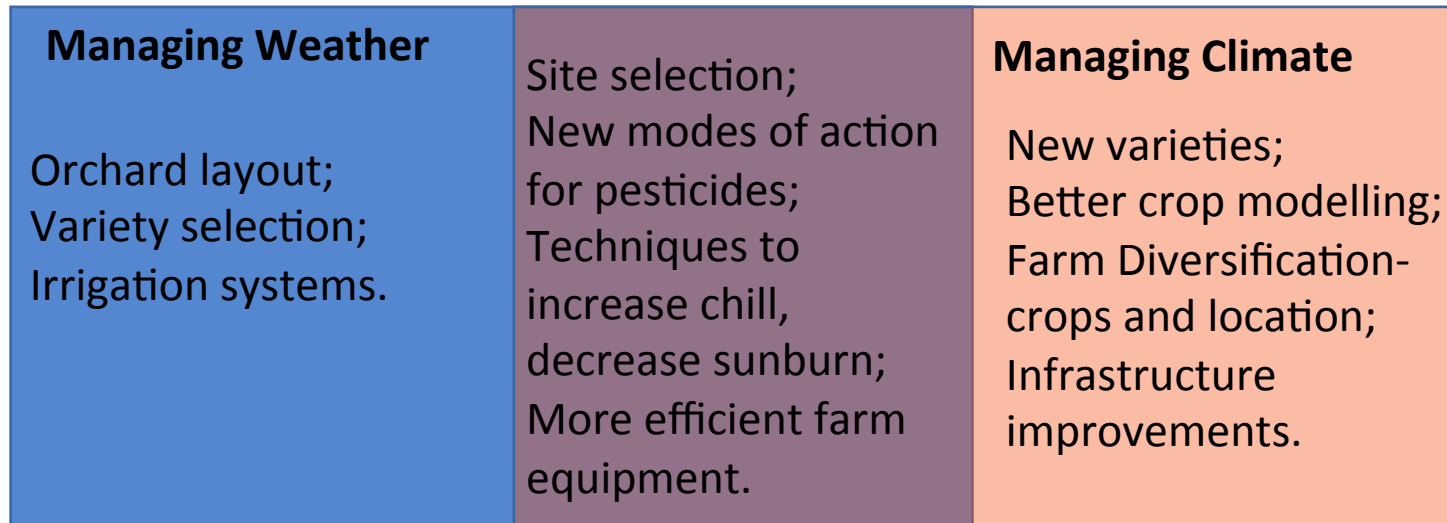


Mitigating Climate: On-farm Options

Methods of Management:

- Breeding of varieties;  **Long (20-50 years)**
- Increased capital outlay;  **Medium (10-20 years)**
- Increased farming costs (sprays, chilling options);  **Short/Medium (5-20 years)**
- Choice of crop.  **Medium/Long (10-50years)**

Mitigating Climate and Weather



Low/Short

Expenses/Research Timeline

High/Long

Economics will play a part in adoption of practices.

Farm size will influence the ability to adapt!

Mitigating Climate and Weather

What we know:

It is going to be expensive

- Crop loss;
- Increased operational expenses;
- Farmers will go out of business.

Changes in cropping patterns will occur.

It will require multiple strategies to manage.

What we need:

Better forecasting to help influence weather based decisions.

More tools to control unknown issues (emerging diseases, pests).

More investment in long term public research (breeding programs, more accurate crop modelling).

Policy that provides support to the industry;

Infrastructure or policy improvements that help manage climate influenced inputs.

Climate Impacts on California Agriculture and Tools for Managing Risks

Tapan Pathak, Ph.D.

Cooperative Extension Specialist-
Climate Adaptation in Agriculture
University of California Merced

Email: tpathak@ucanr.edu

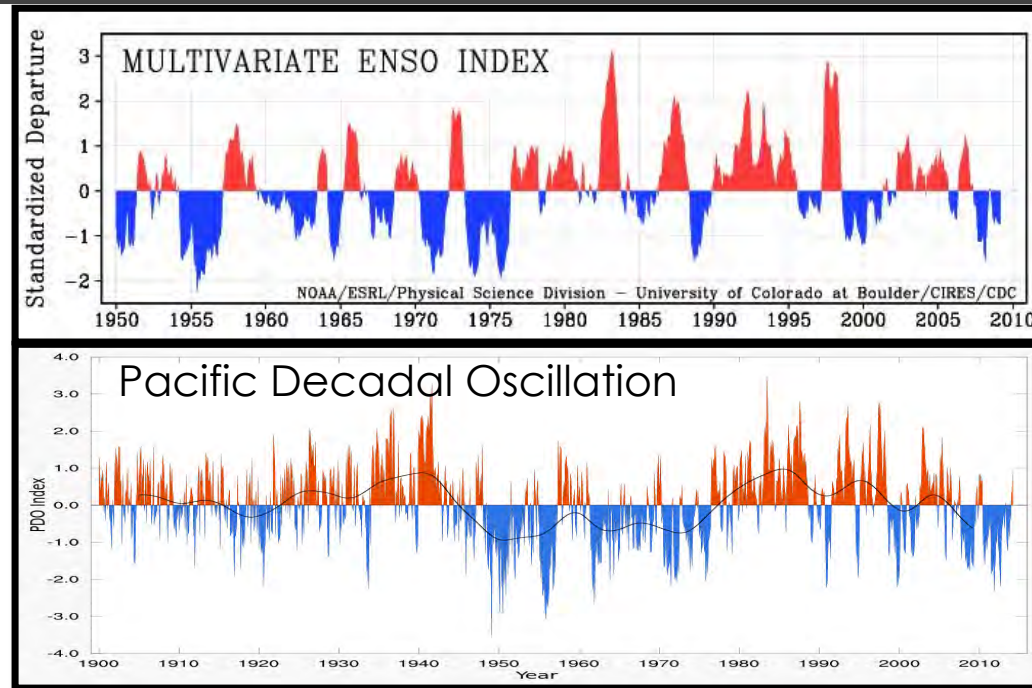
Facts about California Agriculture

- 76,400 farms producing more than 400 commodities with a farm-gate value of \$54 billion
- Leading producer of almonds and pistachios in the world
- Leading fresh market vegetable producing state
- Leading the nation in milk production, producing 41.2 billion pounds of milk

California's top—ten valued commodities

- Milk — \$9.4 billion
- Almonds — \$5.9 billion
- Grapes — \$5.2 billion
- Cattle, Calves — \$3.7 billion
- Strawberries — \$2.5 billion
- Lettuce — \$2 billion
- Walnuts — \$1.8 billion
- Tomatoes — \$1.6 billion
- Pistachios — \$1.6 billion
- Hay — \$1.3 billion

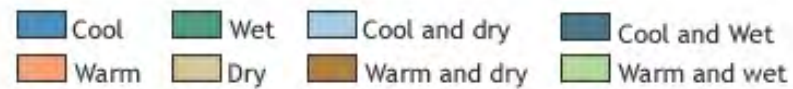
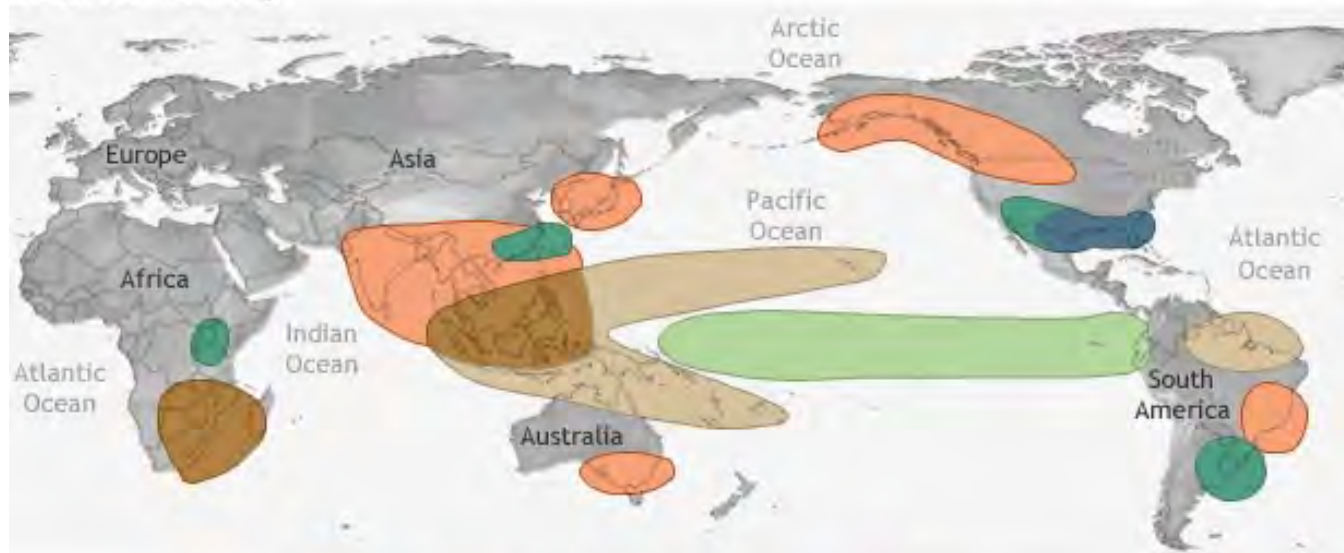
Climate Variability and Climate Change



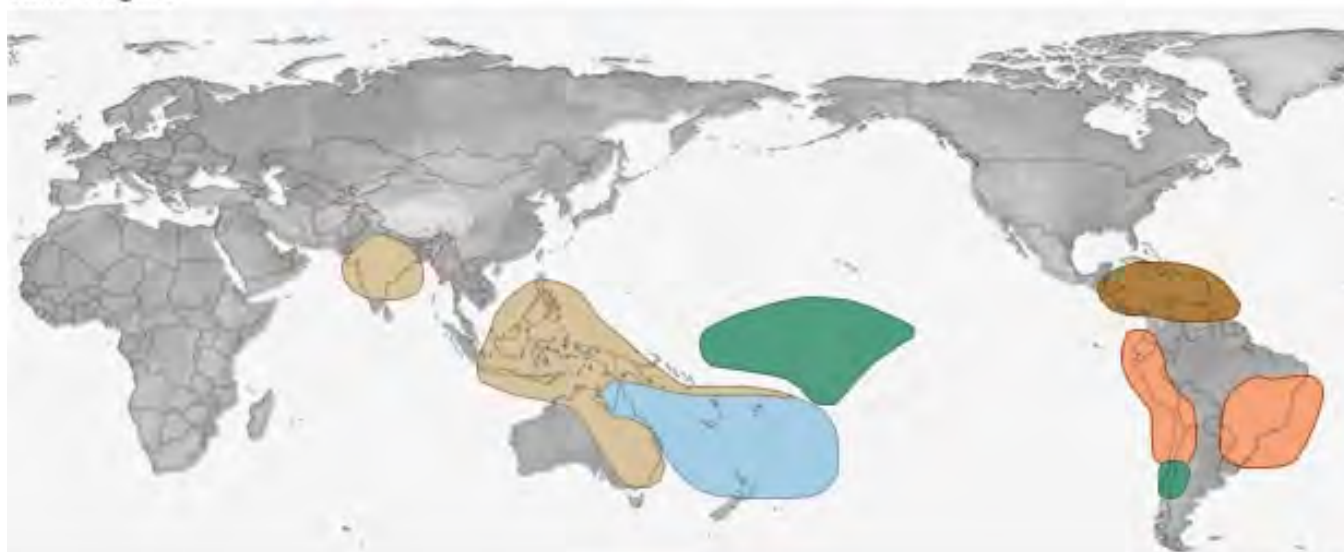
- **Climate Variability** is a measure of shorter term climate fluctuations above or below long term average
- **Climate Change** is a measure of longer term statistically significant continuous change
(increase or decrease) in the measures of climate, such as temperature.
rainfall, frequency of extreme events

EL NIÑO CLIMATE IMPACTS

December-February

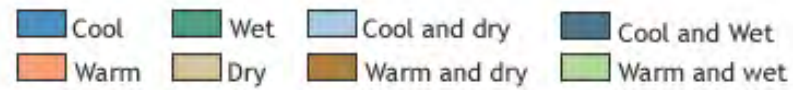
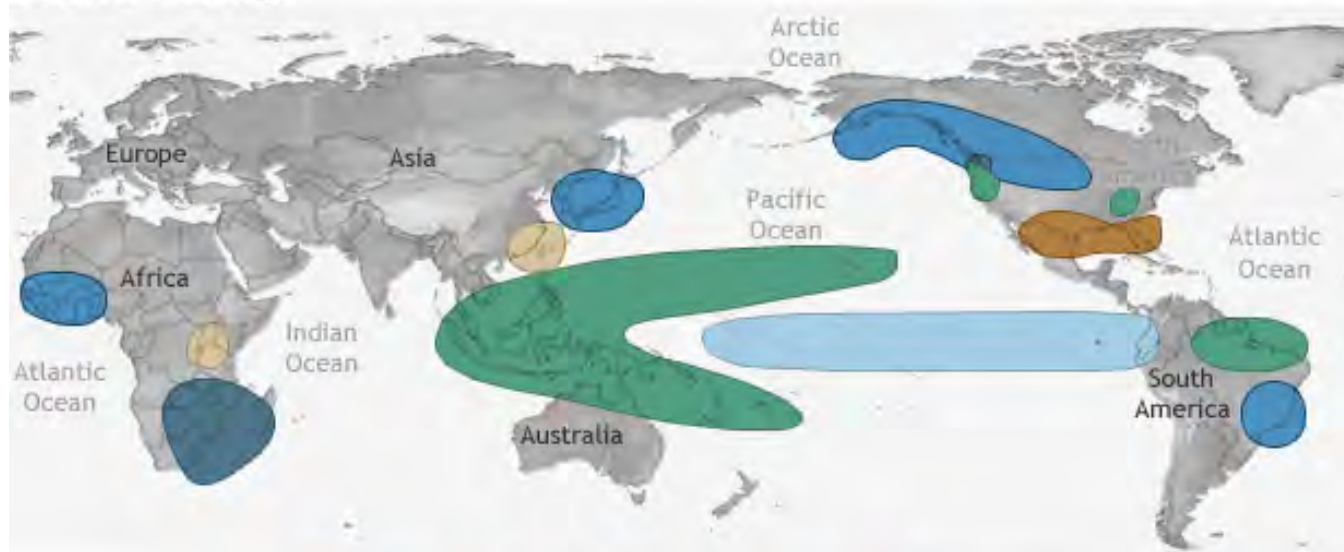


June-August

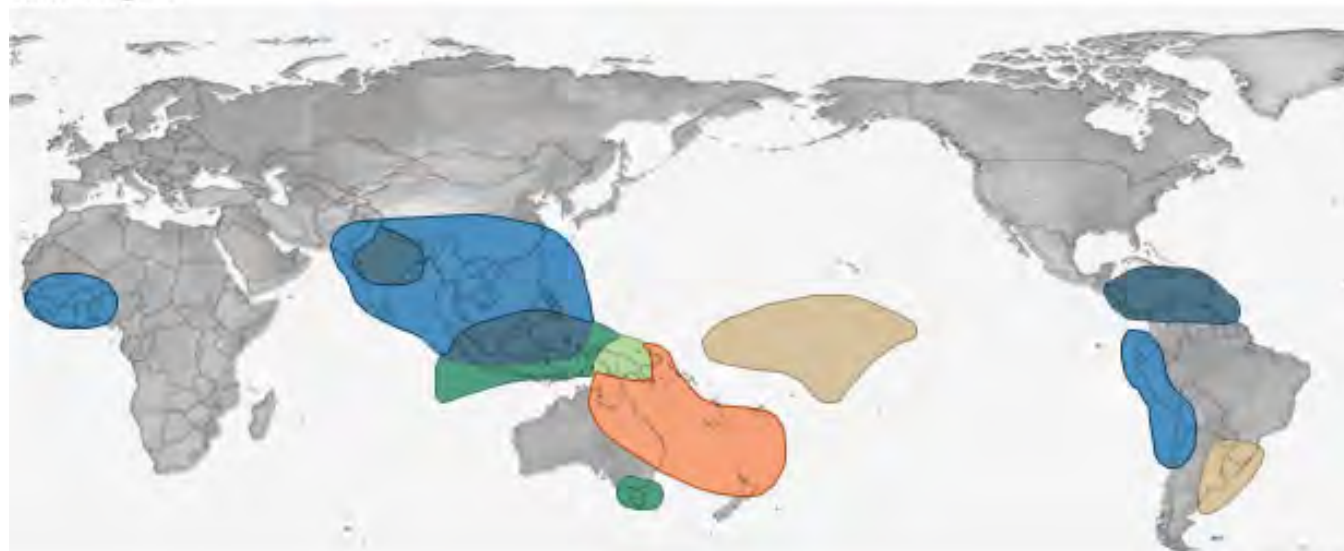


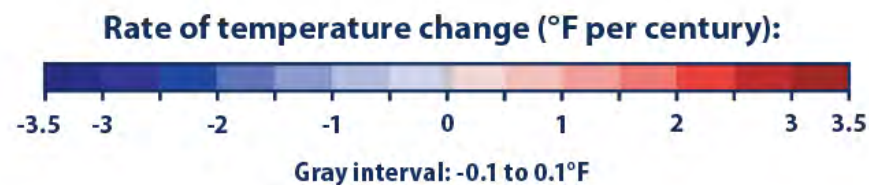
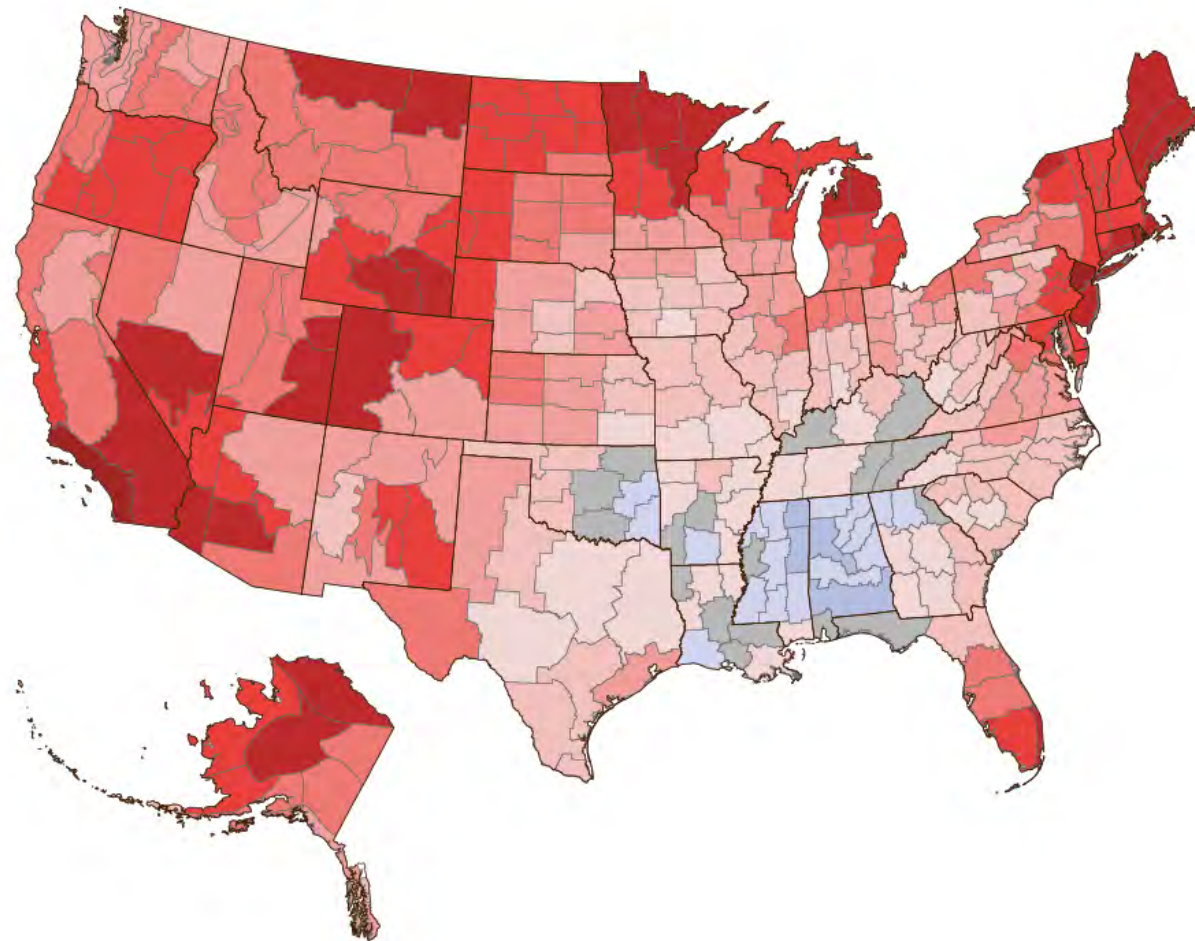
LA NIÑA CLIMATE IMPACTS

December-February



June-August





- Average temperature across the US has increased at an average rate of 0.13°F per decade
- Southwest has experienced significant warming
- Seven of the top 10 warmest years on record have occurred since 1998

Changes in California Temperatures

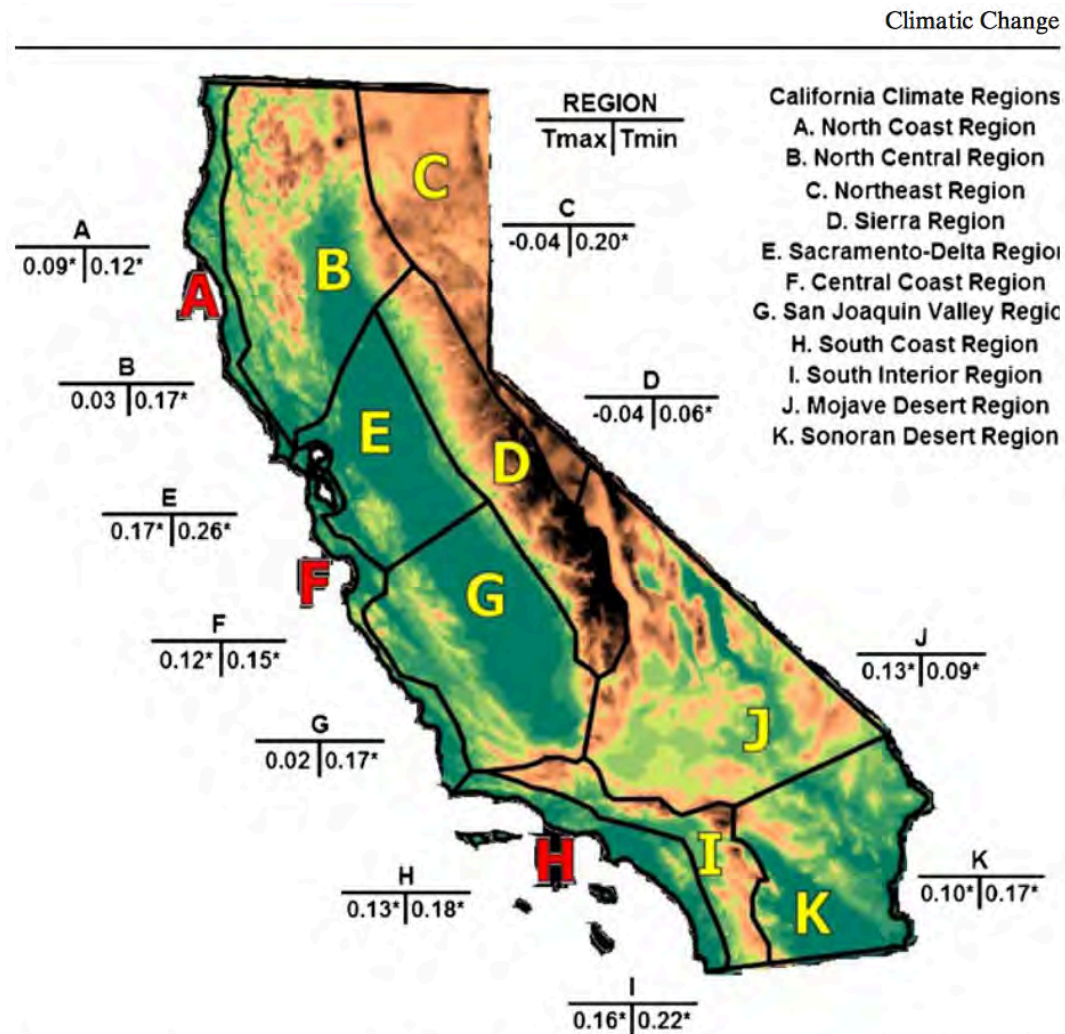
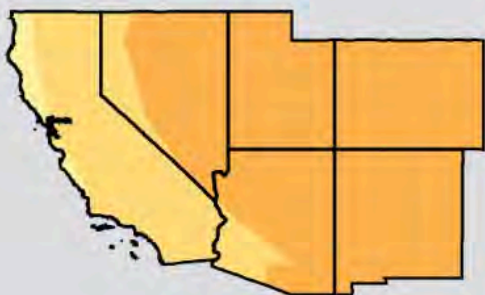


Fig. 4 Annual temperature trends ($^{\circ}\text{C dec}^{-1}$) for the 11 climate regions labeled A-K computed between 1918–2006 for Tmax (*left*) and Tmin (*right*), where the trends that are statistically significant at the 95% confidence level are indicated with an asterisk

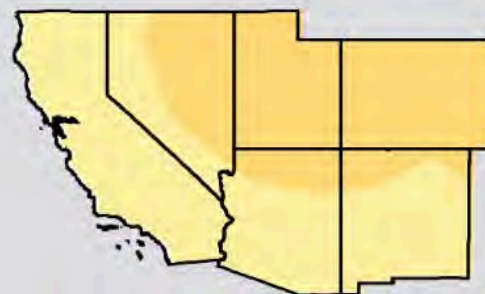
Changes in Average US temperatures

Higher Emissions (A2)

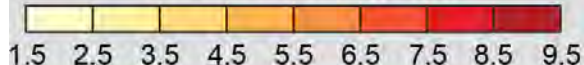


2041–2070

Lower Emissions (B1)



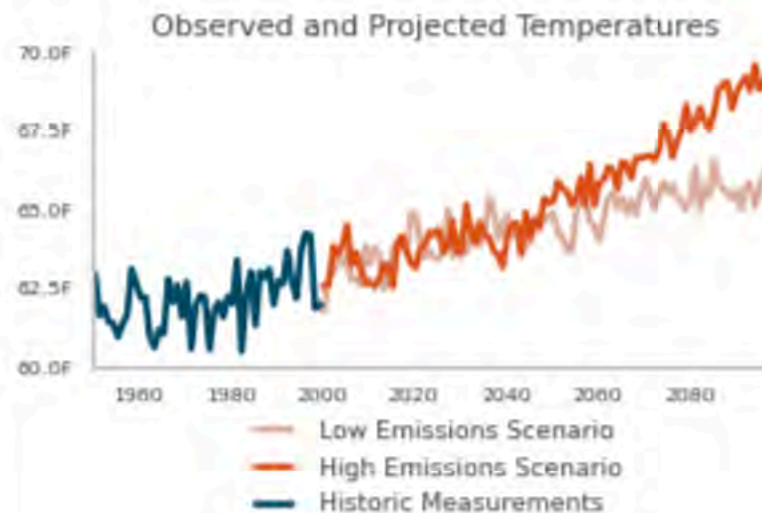
Temperature Change (°F)



MERCED COUNTY

The information in the chart below corresponds to the selected area on the map (outlined in orange).

Historical Average	62.0 °F	
Low-Emissions Scenario:	65.6 °F	+3.6 °F
High-Emissions Scenario:	68.2 °F	+6.2 °F



How can a change of one or two degrees in global average temperatures have an impact on our lives?

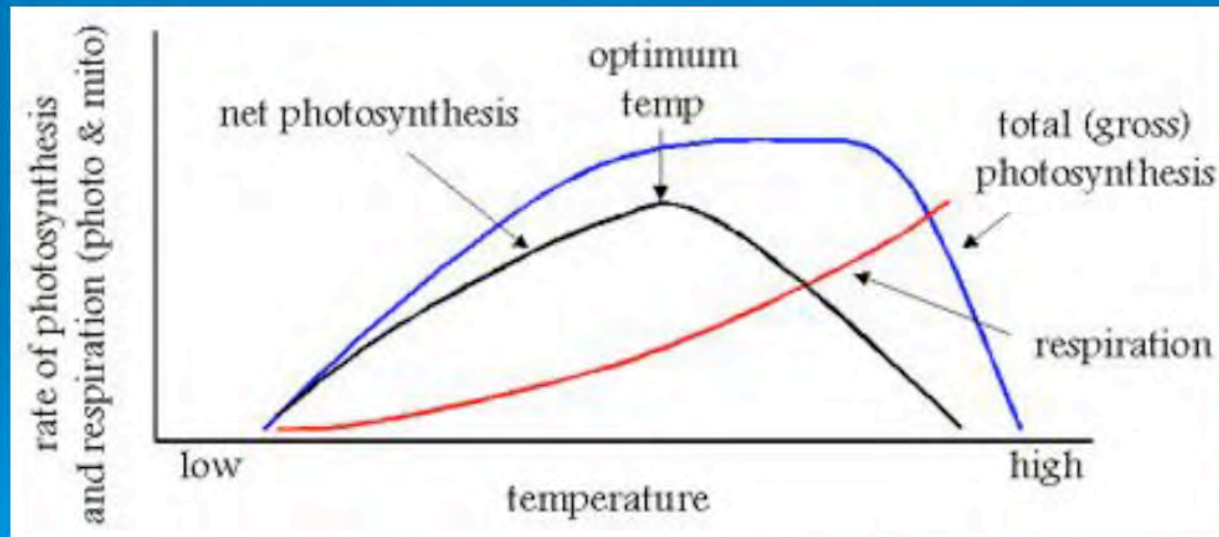
For about every 2°F of warming, we can expect to see:

- 5—15% reductions in the yields of crops as currently grown
- 3—10% increases in the amount of rain falling during the heaviest precipitation events, which can increase flooding risks
- 5—10% decreases in stream flow in some river basins
- 200%—400% increases in the area burned by wildfire in parts of the western United States

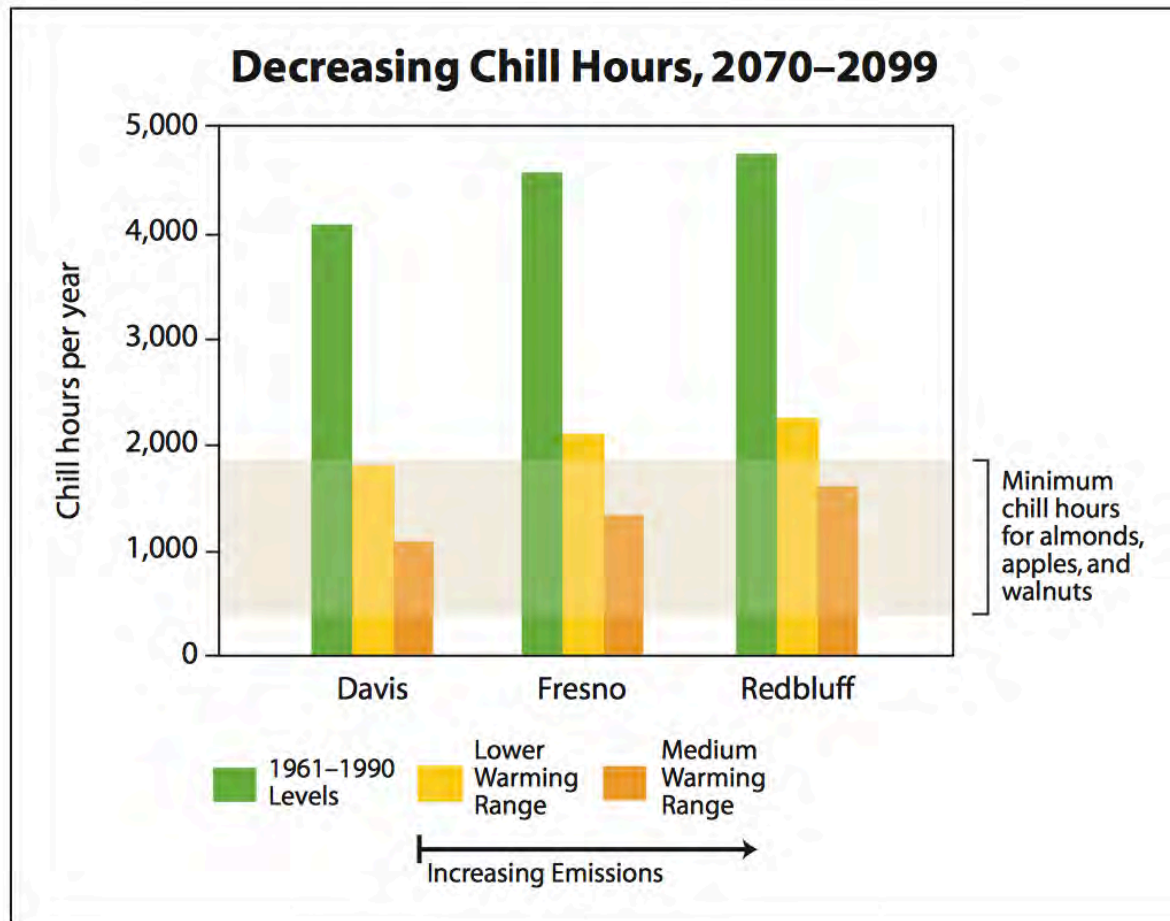
How does temperature increases affect plants?

Temperature and Plants

- Crops respond to temperature
 - Photosynthetic rates respond to temperatures
 - Respiration increases with temperatures

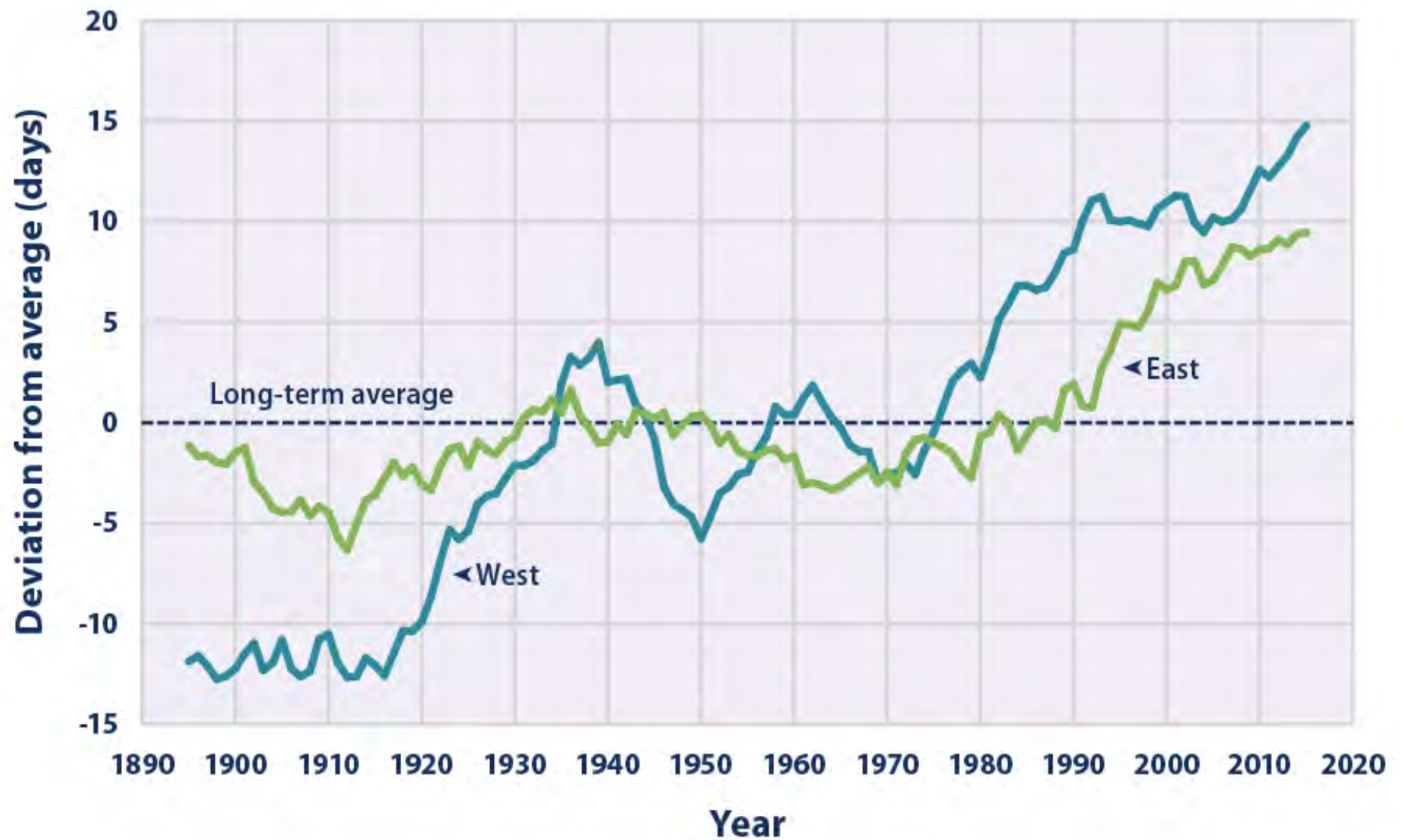


Trends in Chill Hours

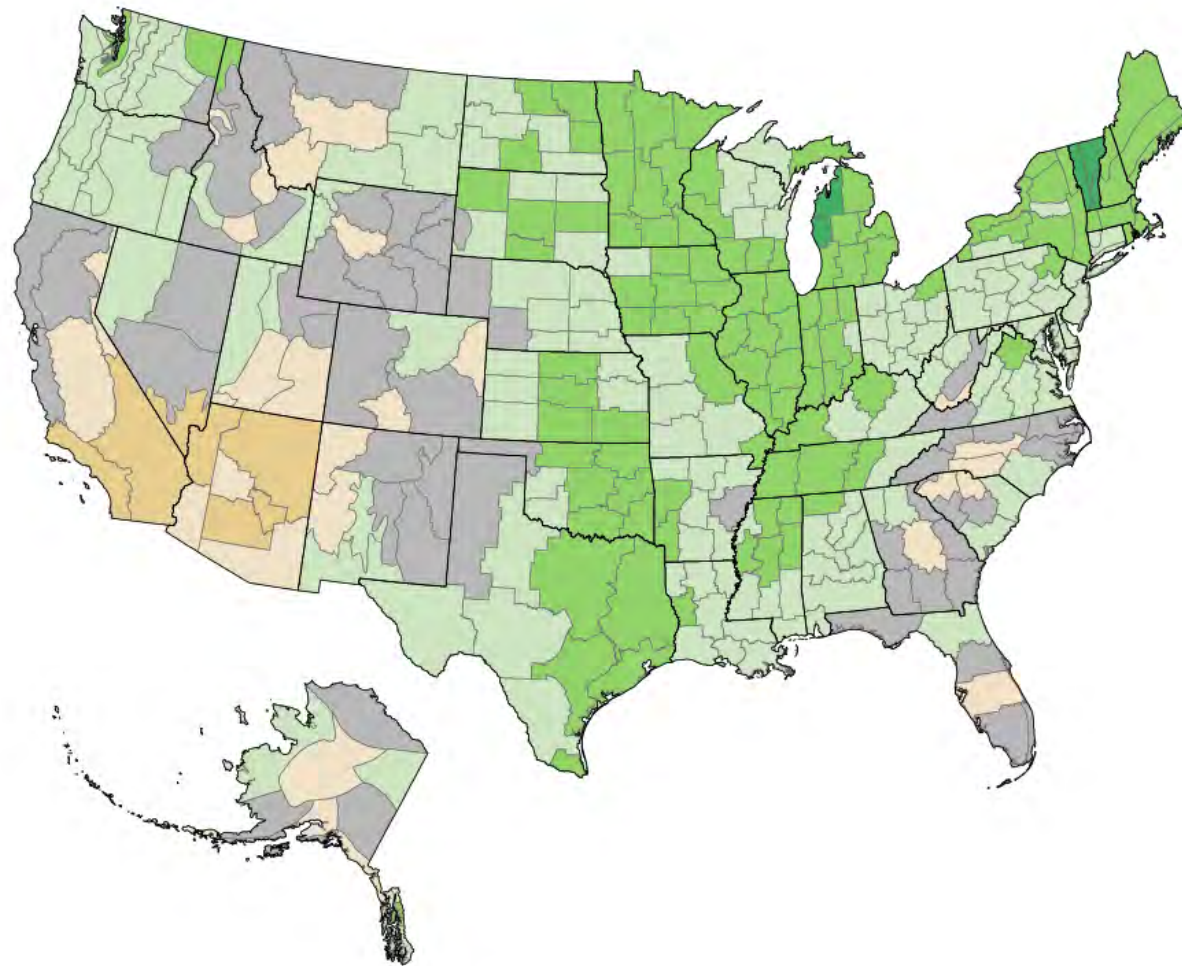


- Around the year 1950, growers in the Central Valley could rely on between 700 and 1200 Chilling Hours
- By 2000, this number had already declined by up to 30% in some regions
- Chill Hours are projected to decrease significantly under future climate change scenario

Length of Growing Season

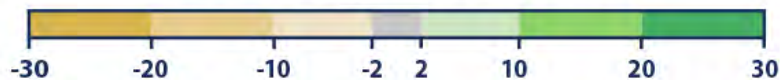


Precipitation Trends

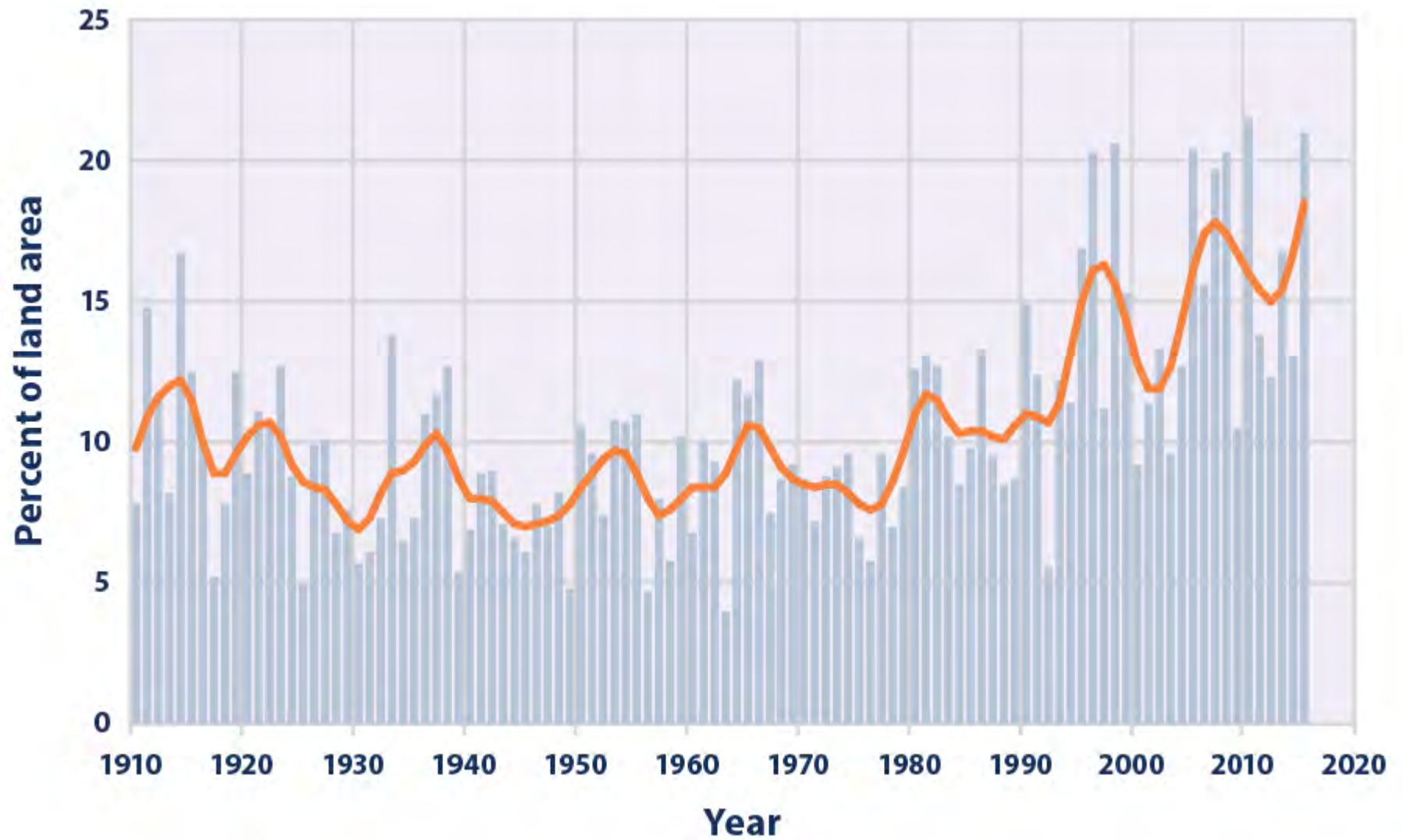


Since 1901, global precipitation has increased at an average rate of 0.2 percent per decade, while precipitation in the contiguous 48 states has increased at a rate of 0.5 percent per decade.

Percent change in precipitation:

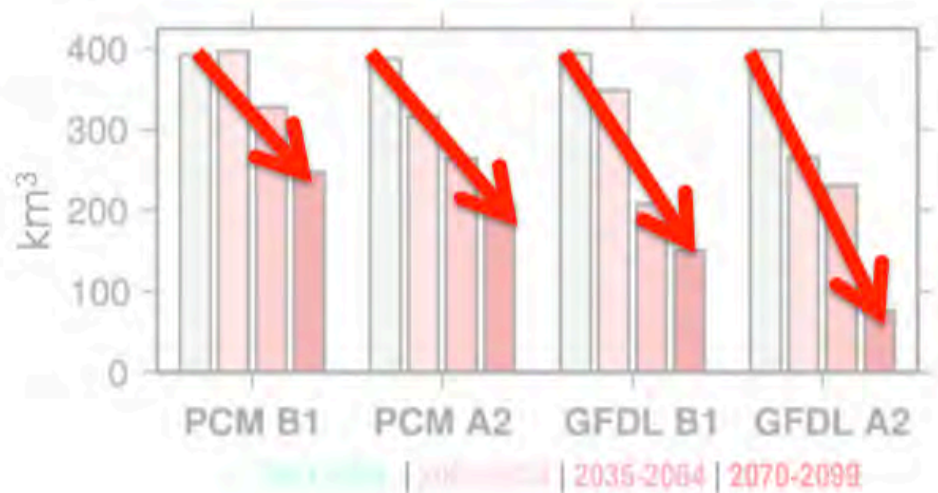


Extreme Precipitation Indicators



California state wide
snowpack is
projected to shrink
drastically

Cayan et al. Climatic Change (2007)



↓ 25%

of Sierra snowpack
will be lost by **2050**

Department of Water Resources, State of California

Climate Information for Managing Risks


- Climate has direct influence on agricultural production
- Integrating climate information into agricultural decisions can enhance agricultural resiliency to climate risks
- However, this information is not always available in a format that is desirable to agricultural producers/decision makers
- Translating climate information into actionable knowledge can greatly enhance growers' capacity to manage risks and increase productivity

Climate Information Needs

- *United States Government Accountability Office – “USDA faces the challenge of turning the large amount of often technical climate research into readily understandable information.”*
- Decision support processes need to take account of the values and goals of stakeholders, evolving scientific information, and perceptions of risk.
(National Climate Assessment)
- Climate Change Consortium for Specialty Crops report- **“CDFA should compile a list of grower needs for weather data and forecast products”**

Examples of Agro-Climate Decision Support Systems

Adaptation to Climate Variability- Southeast US




Current Climate Phase: Neutral
El Niño watch issued


HomeToolsForecastsState SummariesManagementClimateExtensionAbout

AgroClimate Tools


AllClimateDrought IndicesCrop YieldCrop DiseasesDegree Days and Chill HoursFootprint Calculators




Climate Risk
Air temperature and precipitation climatology and current observations




Freeze Risk Probabilities
Freeze probabilities based on El Niño Southern Oscillation (ENSO) phases




Climate Anomaly Maps
This tool provides maps showing the 3-month temperature and rainfall departures from average (1981-2010 climatology).




NWS Forecast
Site-specific, detailed 3-day forecast of hourly weather variables




ARID Monitoring and Forecast



LGMI Monitoring



County Yield Statistics



Regional Yield Maps

ENSO Adaptations – Example 1

Chill Hours Calculator



Find location

Select chill hours model

Select projected period

Start: 10/01/2013

End: 6/16/2014

Graph options

About chill accumulation

Map

Total Accumulated and Projected

Accumulated by Period

Temperature: < 45 °F - Highlands County (FL)

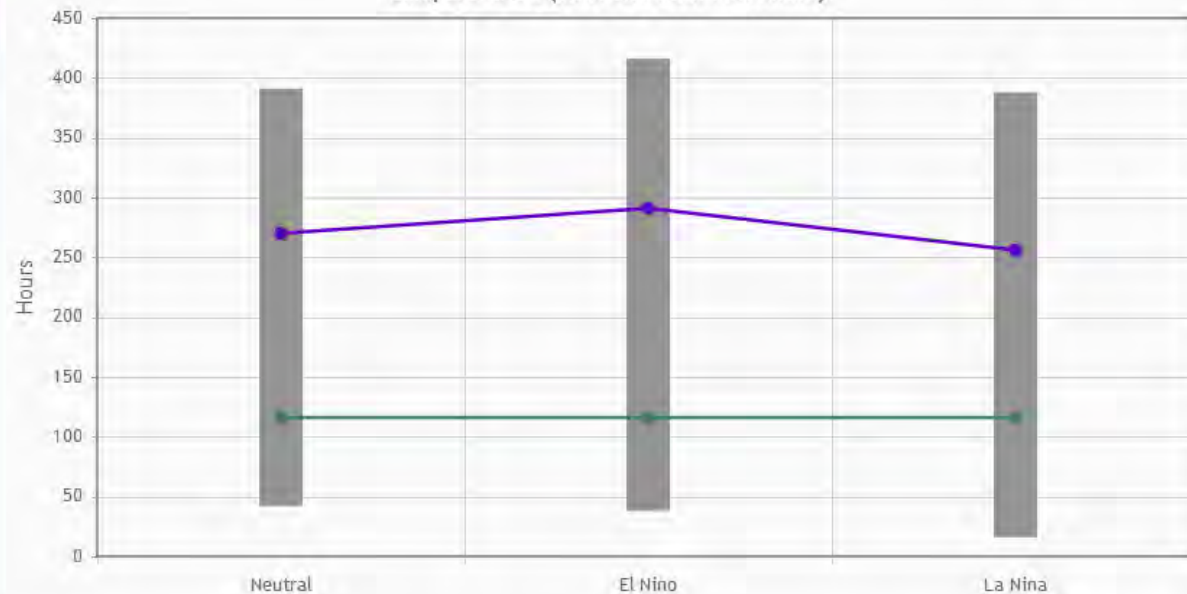
All season [Oct 1, 2013 - Mar 31, 2014]:	NEUTRAL	270 Hours	Last season	116 Hours
	El Niño	291 Hours	Historic average	271 Hours
	La Niña	256 Hours		

75th-25th percentile ENSO phases

Average for ENSO phases

Last season

Compare ENSO (75th and 25th Percentile)



ENSO Adaptations – Example 2

Planting Date Planner



Select crop

- ☐ Corn
- ☐ Cotton
- ☐ Peanut
- ☐ Potato
- ☐ Tomato Fall
- ☒ Tomato Spring
- ☐ Tomato Winter

Select variety

Select location

Select soil

Irrigation management

Select nitrogen

Select ENSO phase

About crop yield risk

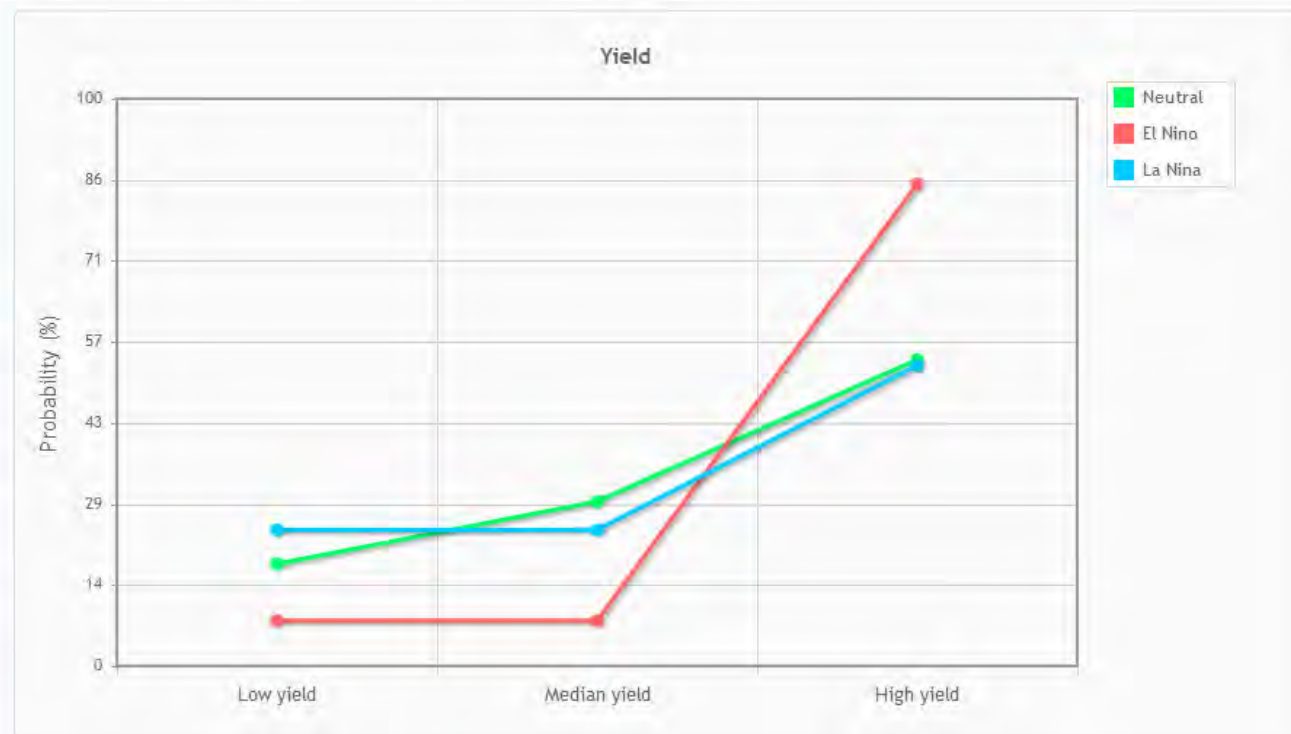
Yield Probability

Phenology Table / Freeze probability

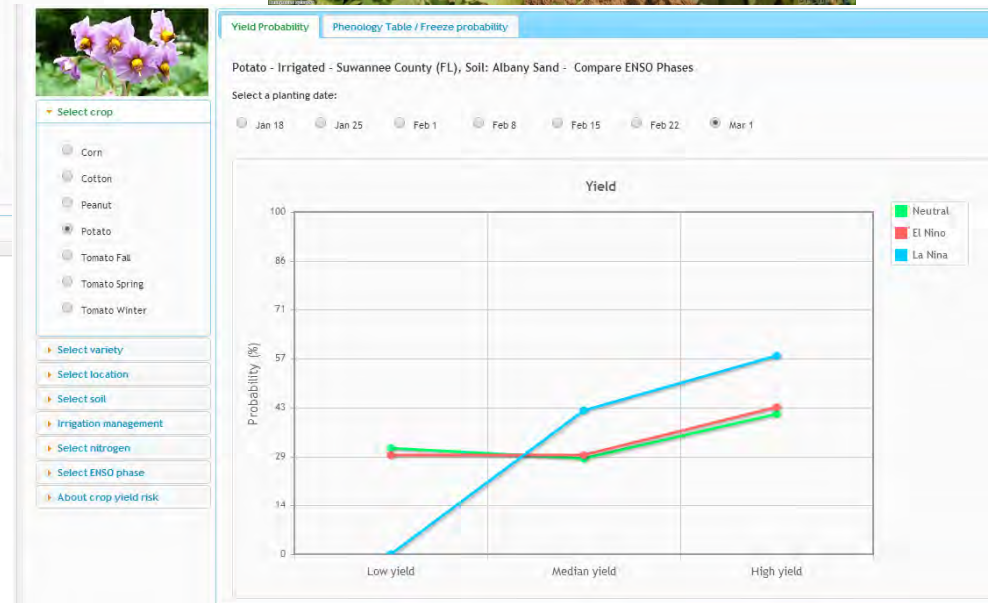
Tomato Spring - Irrigated - Collier County (FL), Soil: Boca Fine Sand - Compare ENSO Phases

Select a planting date:

☒ Dec 22 ☐ Dec 29 ☐ Jan 6 ☐ Jan 13 ☐ Jan 21 ☐ Jan 28



ENSO Adaptations – Example 3



Example from the Midwest

[DECISION DASHBOARD](#)[MEDIA CENTER](#)[NEWSLETTER](#)[ABOUT US](#)

Decision Dashboard

[U2U_{DST} Suite](#) | [Other Decision Resources](#) | [Agro-Climate Reports](#) | [Weather/Climate Maps](#) | [Drought Info](#) | [Climate Outlooks](#) | [Helpful Links](#)

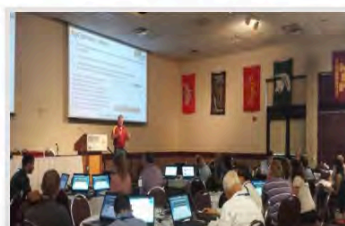
U2U_{DST} SUITE

Featured Tools and Resources



Irrigation Investment_{DST}

The U2U Irrigation Investment DST lets you explore the potential profitability of installing irrigation equipment at user-selected locations across the Corn Belt. Discover how many years from 1980-



U2U Educational Resources

The U2U Educational Resources page includes everything you need to quickly learn about and disseminate U2U decision support tools.

GDD Start: April 1

GDD Comparison Year: 2012

Corn Maturity Days: 95

Freeze Temperature (°F): 28

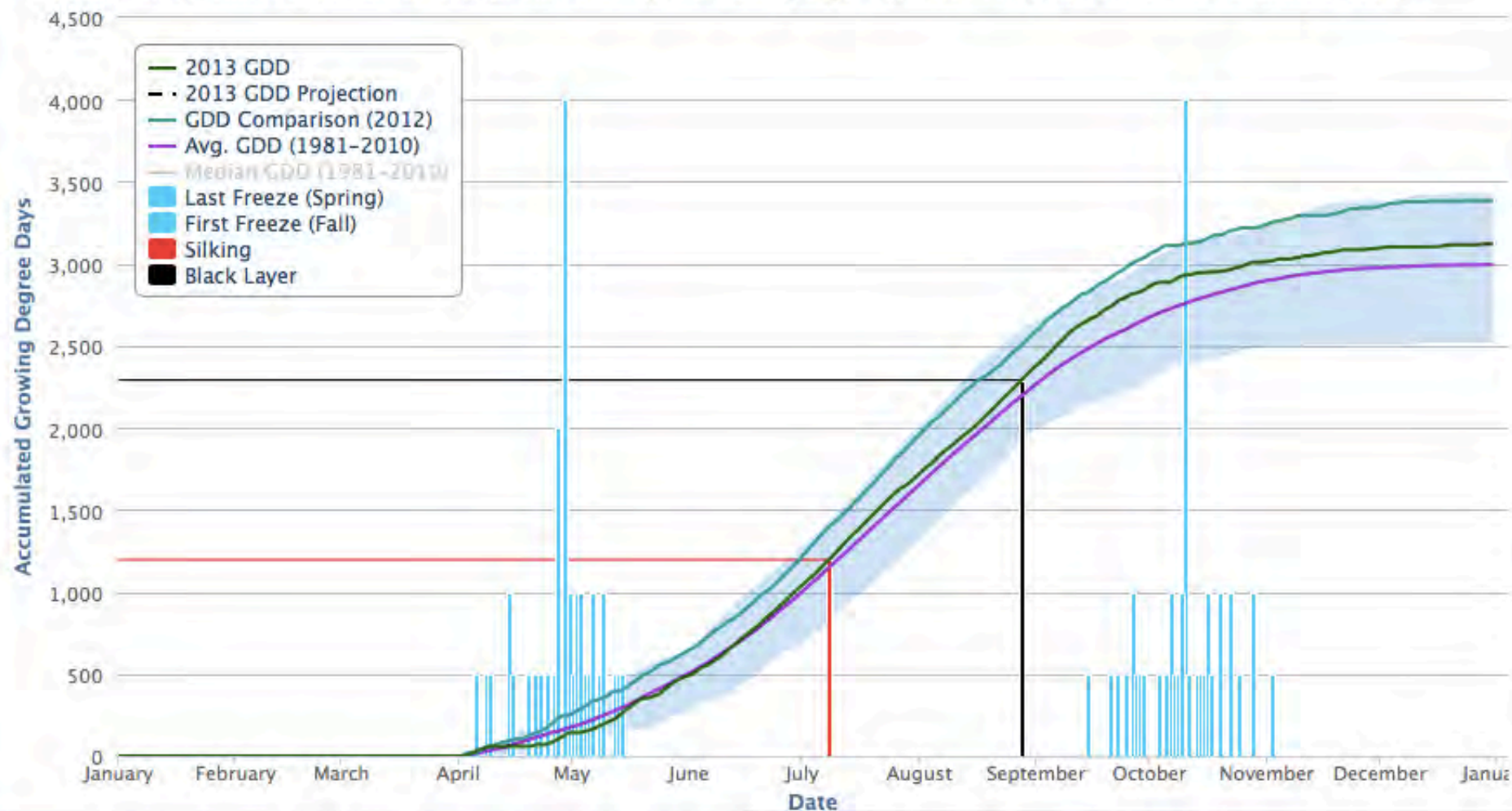
Percentile Variation: 0-100%

Current Day: Today

Growing Degree Day Tool

Chart Options

Location: 41.73, -103.57 in Scotts Bluff Co., NE, Start Date: April 1, Maturity Days: 95, Freeze Temp: 28°F, Percentile Variation: 0-100%



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Using climate information for long-term adaptation planning:

Information needs, modeling capabilities & tools

Kripa Jagannathan - PhD candidate, UC Berkeley



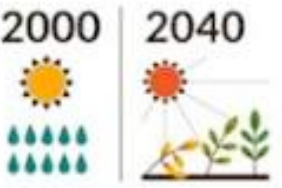
**“On-Farm Climate Adaptation Decisions: Where Theory
Meets Practice”: CalCAN 2017 Summit - 28 Feb 2017**



BACKGROUND

Why to use climate information in long-term planning?

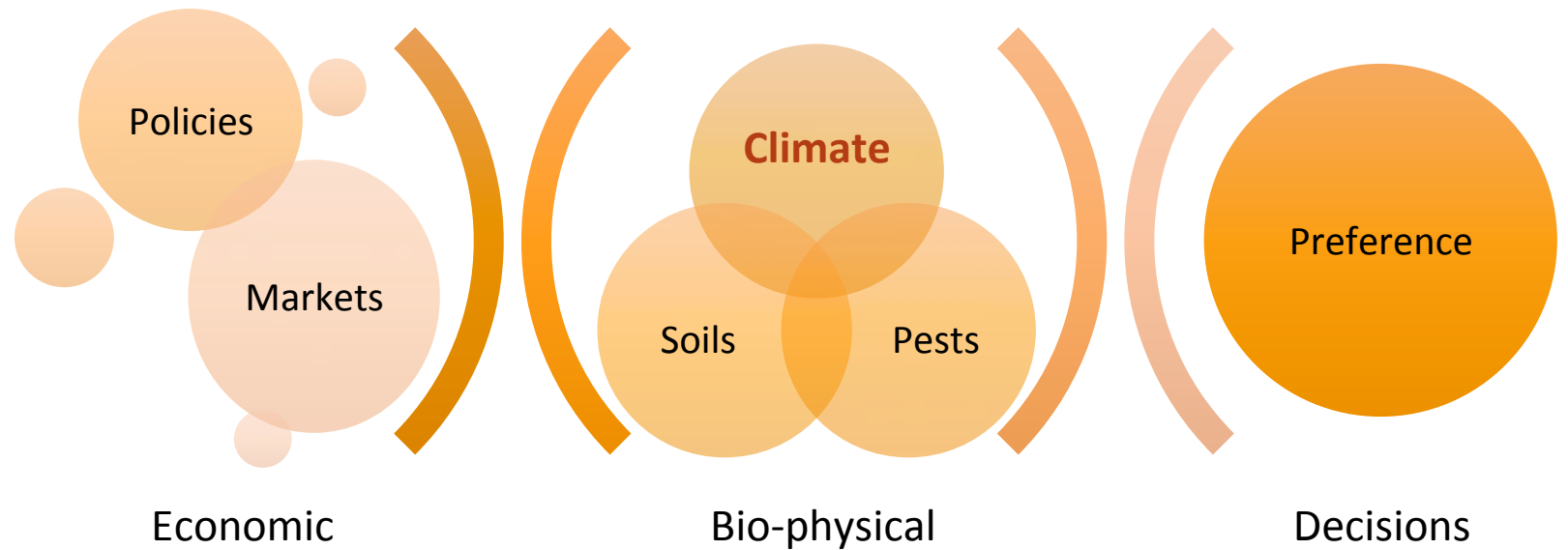
CLIMATE & WEATHER INFO ARE IMPORTANT

	Type of information	Farm decisions affected
Weather (days to weeks) 	<ul style="list-style-type: none"> Daily forecasts up to a week ahead of time 	<ul style="list-style-type: none"> Timing of planting or harvest, fertilizer or pesticide application Irrigation scheduling
Weather/Climate (months to years) 	<ul style="list-style-type: none"> Probabilities of seasonal rainfall & temperature Seasonal forecasts of dry spells 	<ul style="list-style-type: none"> Crop varieties to plant Intensity of fertilizer or pesticide or water Intensify or diversify crops
Climate (10 yrs or longer) 	<ul style="list-style-type: none"> Projections of future temperature or rainfall or heat waves Future droughts/floods 	<ul style="list-style-type: none"> Major capital investment land purchase, irrigation system etc. Deciding whether or not to farm Changing farming systems



UTILITY OF LONG-TERM PROJECTIONS OVERLOOKED...

- Information not immediately actionable but go into 5-10 year or longer plans i.e. 'farm development plans'
- Climate one among many factors influencing decisions
- Uncertainty



Some factors affecting long-term decisions

....BUT UN-PREPAREDNESS CAN BE VERY COSTLY!



Cost of inaction & unpreparedness can be very high!

Effective adaptation requires use of robust climate knowledge (Dilling & Lemos 2010, Tang & Dessai 2012).

Informed decisions about uncertain future may be better than uninformed decisions.

Despite uncertainty, long-term projections can provide information on broad trends that help in better planning or preparation.



Photo credits: ww2.kqed.org, Josh Edelson/ AFP/Getty Images

Photo credits: House Committee on Natural Resources.



FARMERS' INFORMATION NEEDS

Interviews with almond growers in the Central Valley



INTERVIEWS

- Semi-structured interviews (Central Valley)
 - Farmers, Farm advisors, industry board members
- Non-random, purposeful, and snowball sampling

INTERVIEW THEMES

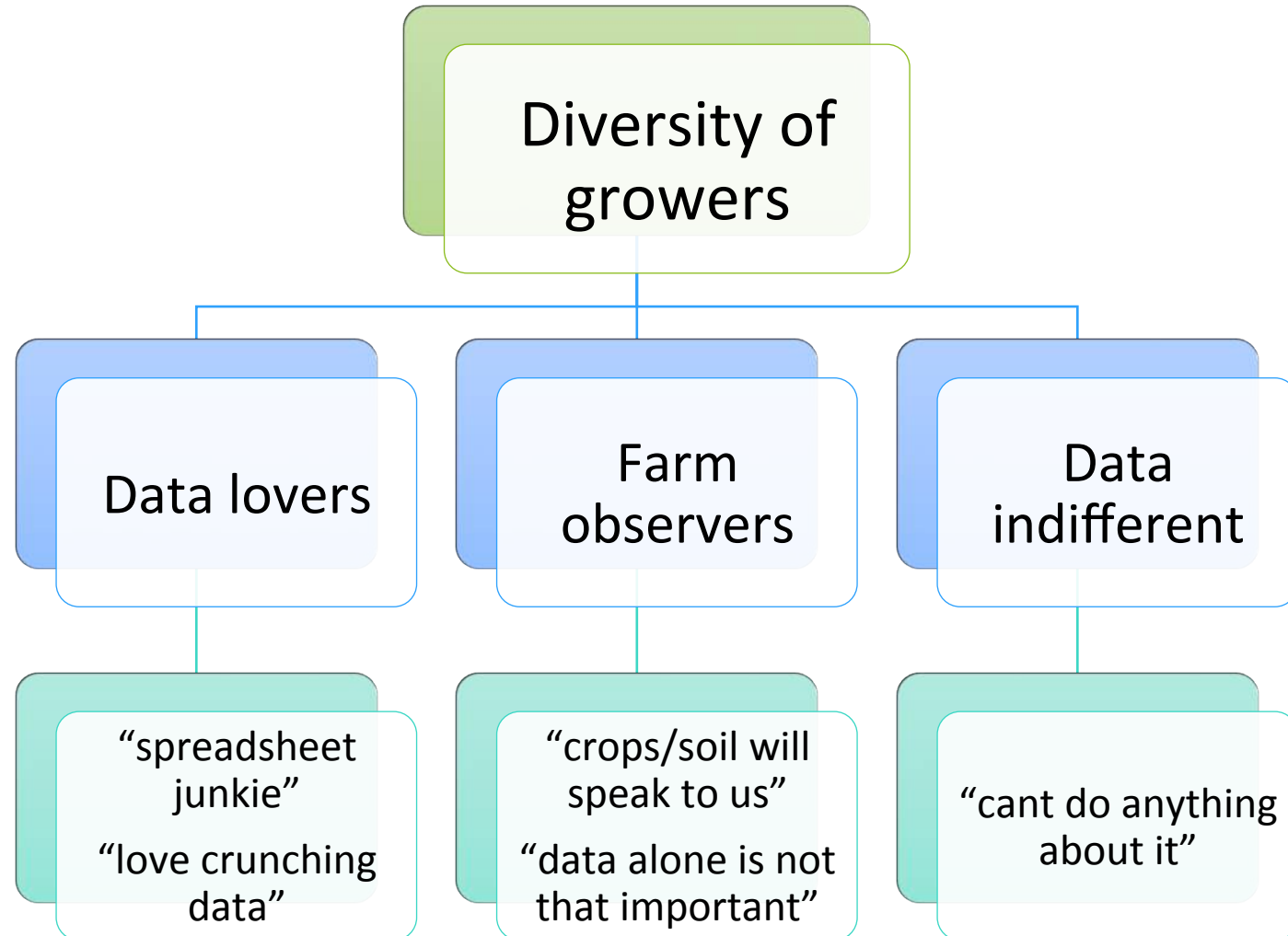
Role of climate info in decision-making

Relevant climatic variables/metrics

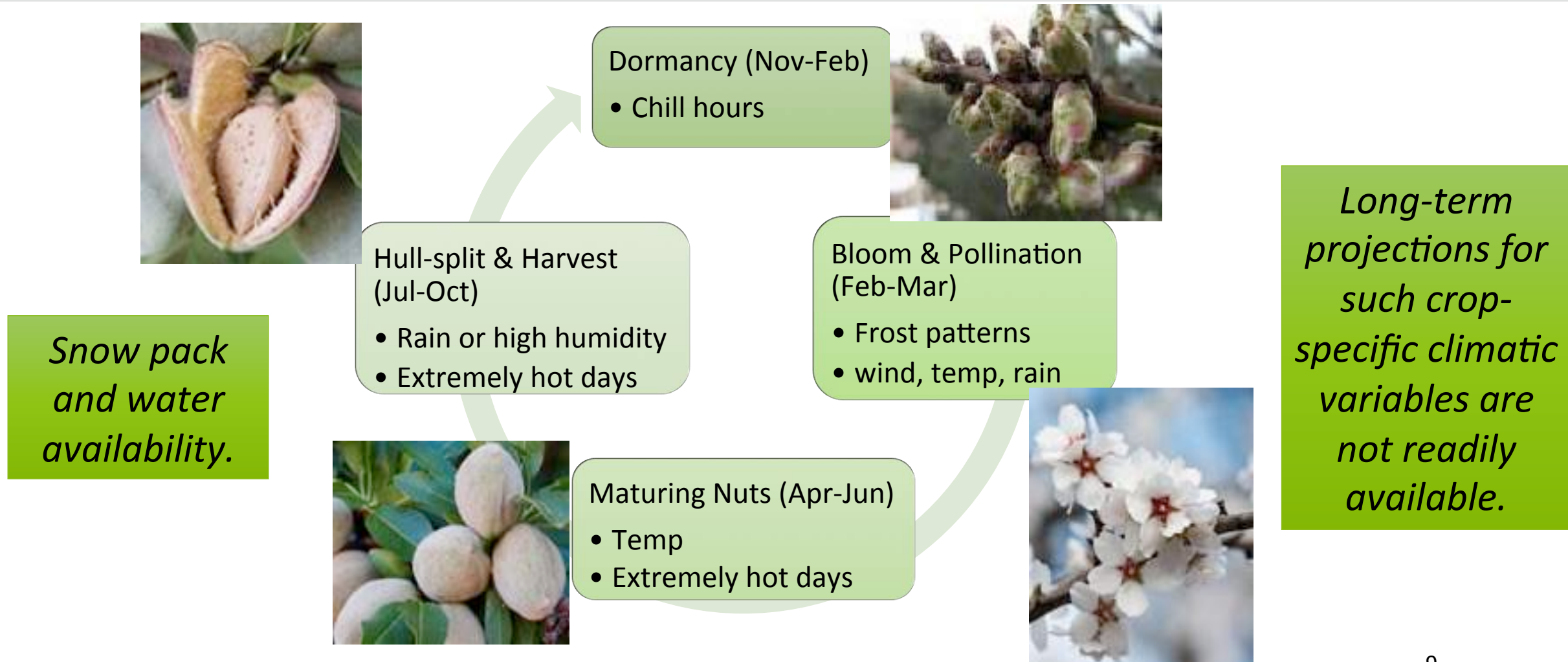
How to make info on future climate 'usable'



CURRENT USE OF WEATHER/CLIMATE DATA



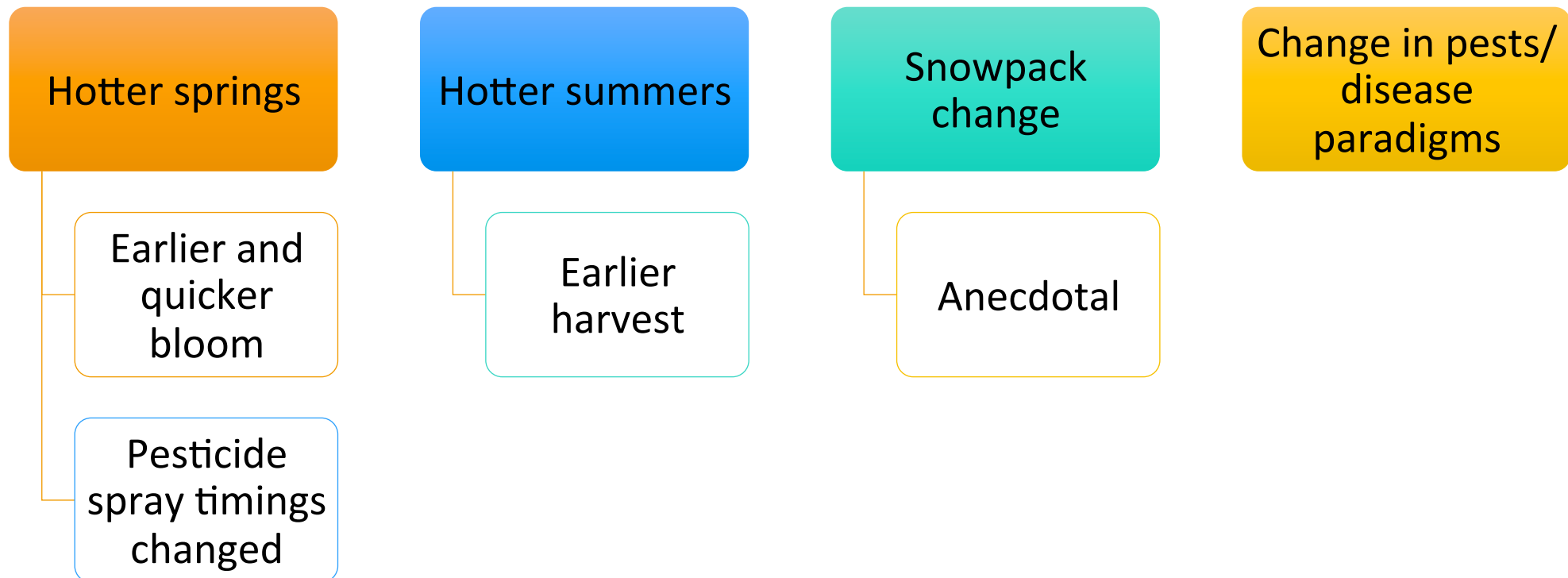
KEY CLIMATIC VARIABLES FOR THE ALMOND CROP





GROWERS ARE EXPERIENCING CHANGES IN CLIMATE

- Most said they experienced warmer winters and lesser fog.
- Other key impacts mentioned were:





USEFULNESS OF INFORMATION DEPENDS ON ITS SPECIFICITY TO CONTEXT



Not useful

- Broad average temp projections:
- *“Statewide avg temp will increase by 3-5 deg F by 2050”*
- *“Winter min temp will increase by 2-4 deg F by 2050”*
- Climate info provided without decision-making context

Useful

- Contextualized projections:
“Chill hours will reduce by 10 hrs/yr in the next 10-20 yrs”
- Clarify that info is for longer term decision-making scales not day-to-day decisions



Tailored



Purpose



WHAT ABOUT UNCERTAINTY?

Accuracy

Need accurate weather not climate.

Tolerant of uncertainties at climatic time scales

Risk expression

Confidence, likelihood, or scenarios.

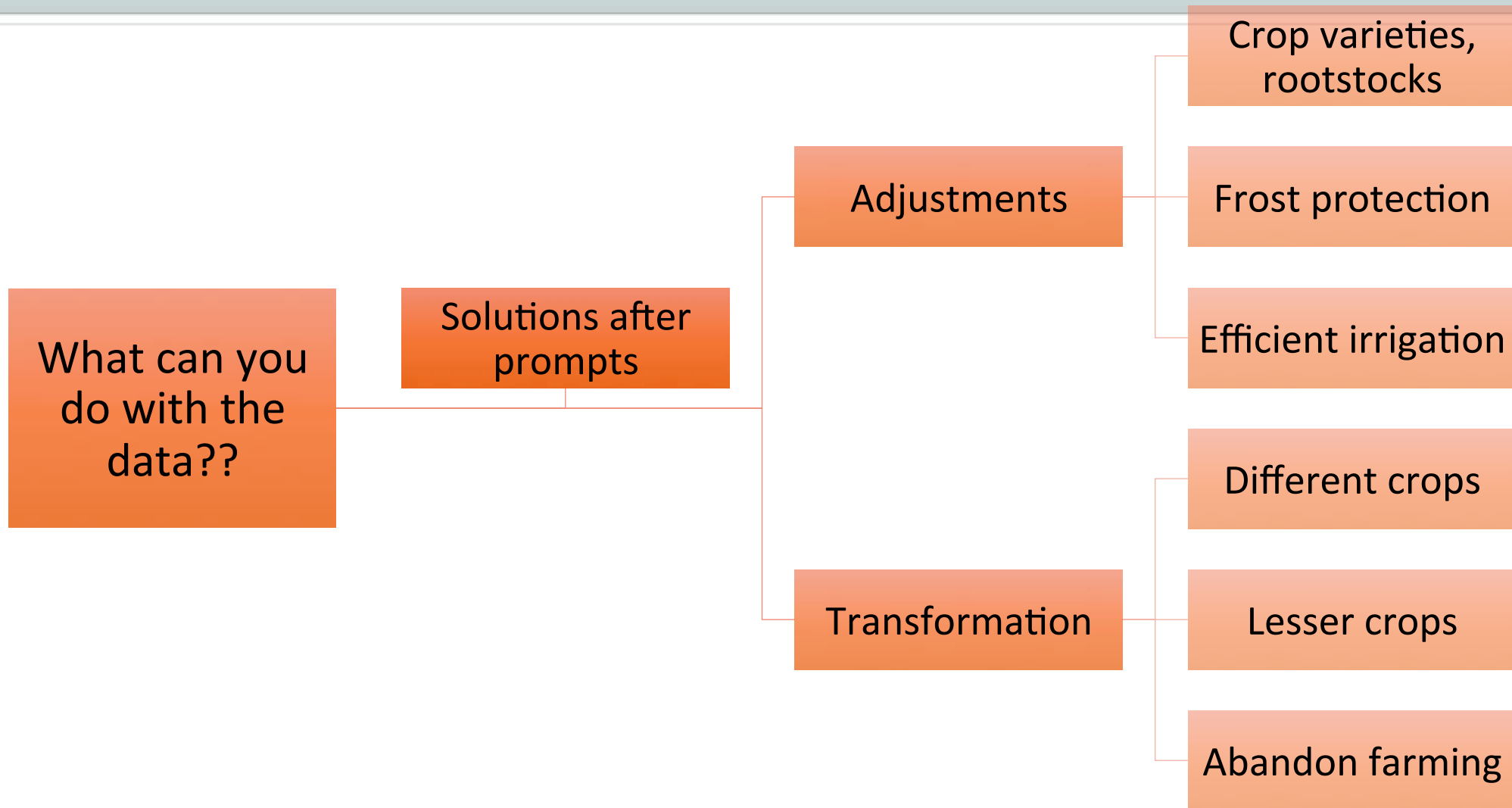
> 60% likelihood ok,
70-80% very good

“Every predication comes with uncertainty and we work with that all the time”

“Yes – I know you do not have a crystal ball”



CAN THIS INFORMATION LEAD TO ADAPTIVE DECISIONS?





SUMMARY OF INTERVIEW FINDINGS

There is interest in long-term information if it is context & crop-specific

Projections must transparently include uncertainties/likelihoods/confidence

Farmers may be open to thinking about adaptive actions based on projections

Great value in having open discussions and dialogues with growers!!

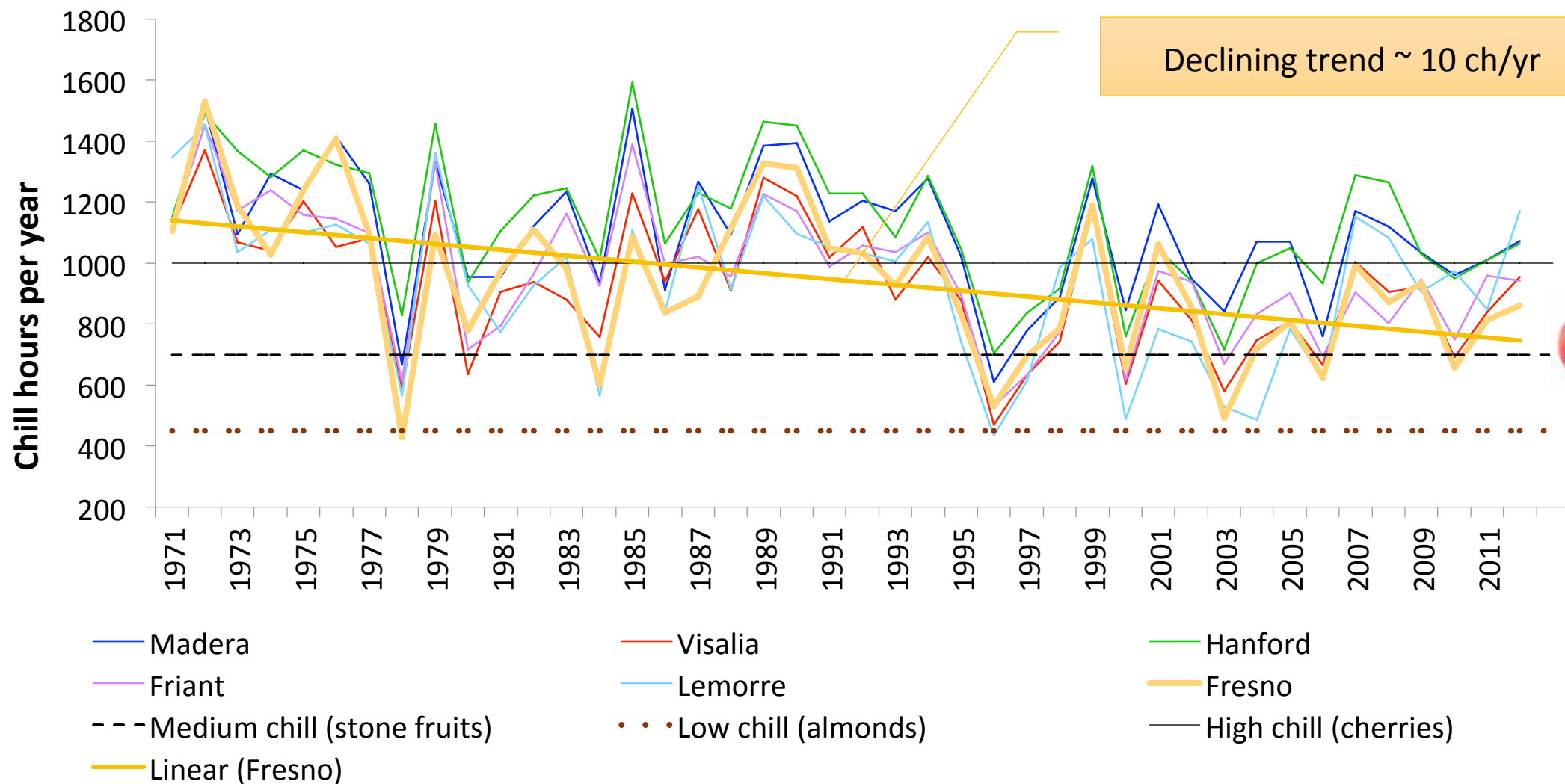


CLIMATE MODELING CAPABILITIES

**Can models provide “usable” info?: A deeper delve
into analysis of chill hour projections**

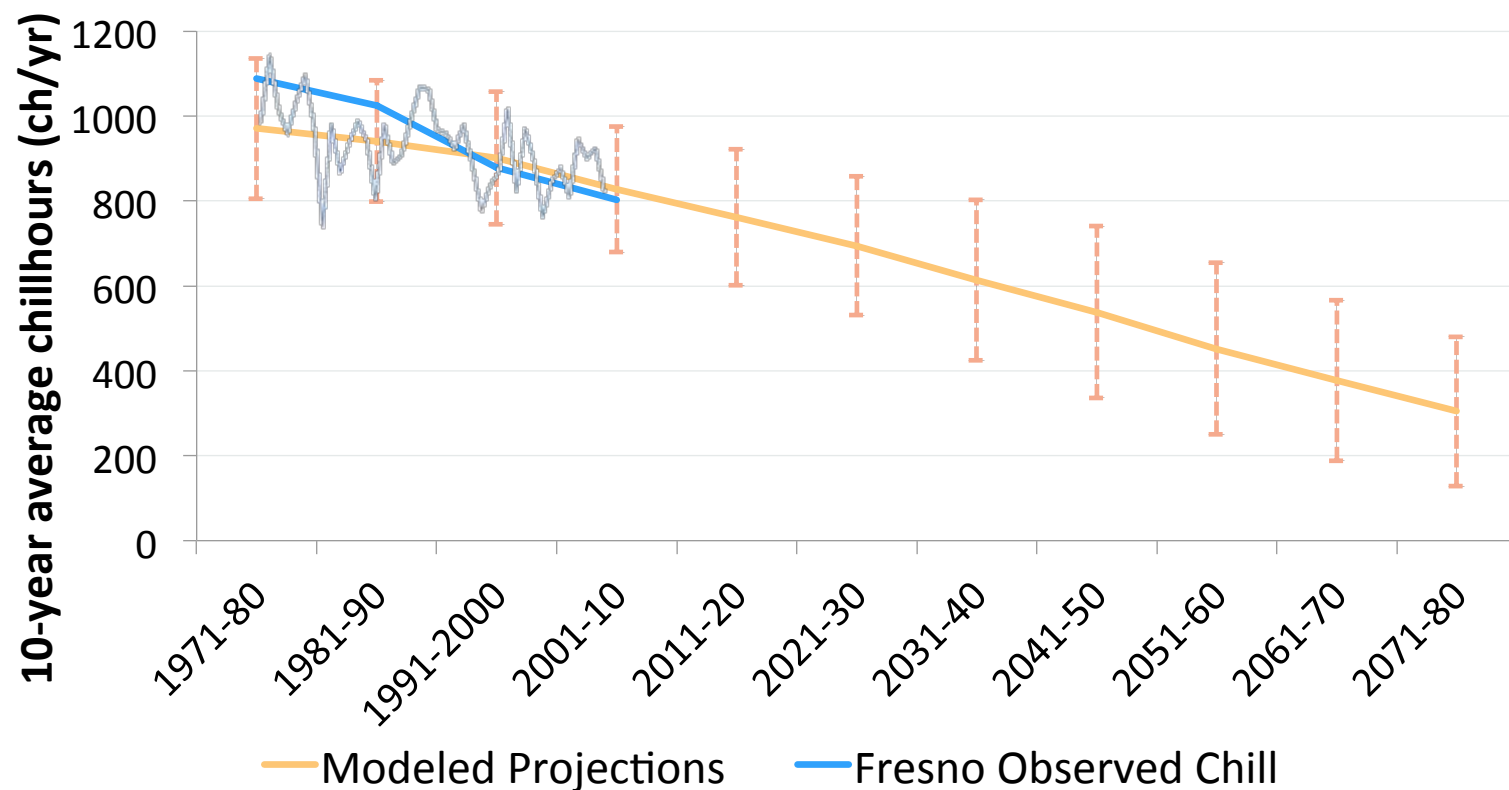


OBSERVED CHILL HOURS IN AND AROUND FRESNO





FUTURE PROJECTIONS FOR CHILL HOURS IN FRESNO



Climate projections will remain somewhat uncertain. However, there are broader trends or patterns that models can predict reasonably well. But is this enough?

What the models can say:

- Broader trends: By 2040 ~ 600 ch/yr, By 2060 ~ 500 ch/yr

What the models cannot say:

- Year to year variability

2030	31	32	33	----	2040	Avg 2030-40
800	400	900	300	----	-----	600
650	550	550	650	----	-----	600

- Chill in a particular year, 5-year or very near-term trends
- Specific micro-climatic projections



CAL-ADAPT TOOL

**Platform for climate data and other resources for CA
adaptation**



CAL-ADAPT

Cal-Adapt

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Climate Tools

The tools featured here are built using LOCA downscaled CMIP5 climate change projections. If you are looking for our other Climate Tools (local snapshots, snowpack, wildfire, extreme heat) built with CMIP3 downscaled climate change projections visit cal-adapt.org.

ANNUAL AVERAGES



Explore charts of projected annual averages of maximum temperature, minimum temperature and precipitation for your location.

Sources: Pierce et al., 2014; Livneh et al., 2015

EXTREME HEAT



Explore charts of projected frequency and duration of extreme heat events for your location.

Sources: Pierce et al., 2014; Livneh et al., 2015

SEA LEVEL RISE - CalFloD-3D



Explore maps of inundation location and depths for San Francisco Bay Area, Sacramento - San Joaquin Delta and the California coast during near 100 year storm events coupled with projected Sea Level Rise scenarios.

Source: Radke et al., 2016

SNOWPACK



View a map displaying the projected snow water equivalent for each year from 2006-2099 for each month of the year using a variety of climate models and scenarios.

Source: Pierce et al., 2014

[Fresno extreme heat projections](#) , [Temperature degrees of change](#)



CAL-ADAPT EXTREME HEAT TOOL DEMONSTRATION

- **Questions for audience:**

- Is the tool useful for you to understand extreme heat projections?
 - What information did you find useful, what is not useful?
- What other metrics would you like information on?
- Does such data help you in planning for the future i.e. consider adaptive decisions?
 - {e.g. switching to heat tolerant crops/varieties, temperature management strategies, pest control, irrigation planning, changing cropping patterns, Alter planting and harvesting schedules, etc.}
- Any other comments on useful tools/information that can assist in taking adaptation action?



THANK YOU!

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PILEUS PROJECT OF MICHIGAN STATE UNIV

- Future climate tool, for GDD for tart cherries in Great Lakes Region.

http://pileus.msu.edu/tools/t_future.htm

Future Scenarios Tool

[Learn about this tool](#) [User Cases](#)

1 Choose a station from the list below. [?](#)



2 Choose a sector.

Agriculture

3 Choose a climate parameter. [?](#)

Temperature

4 Choose a variable type or time period. [?](#)

Growing Degree Days

5 Choose a base. [?](#)

Base 39°F Tart Cherry

6 Choose a variable. [?](#)

Median Number of Growing Degree Days (GDDs) per Year

[View Conversion Calculator](#)

Note: If you need to convert degree or growing degree day units from Fahrenheit (°F) to Celsius (°C), you can use the Converter button above to

[View Result](#)

☒ Bad Axe ☐ Harrow ☐ Maple City
☐ Eau Claire ☐ Hart ☐ Marquette
☐ East Jordan ☐ Ironwood ☐ Pontiac
☐ Fredonia ☐ Lake City ☐ Sturgeon Bay
☐ Greenville ☐ Lockport ☐ Sault Ste. Marie

OTHERS

- Climate-smart farming tools (Cornell University)
 - <http://climatesmartfarming.org/tools/>
- Useful to Usable Project (U2U)
 - <https://mygeohub.org/groups/u2u/tools#U2Utools>
- UC Davis Fruit & Nut Research and Information Center
 - http://fruitsandnuts.ucdavis.edu/Weather_Services/chilling_accumulation_models/Chill_Calculators/

Note: Some of these tools only have historical records, or near-time forecasts {not long-term climate projections}

The screenshot displays the UC Davis Fruit & Nut Research and Information Center website. The header includes the CSF (Climate Smart Farming) logo and navigation links for news, about us, and contact. The main banner reads "Climate Smart Farming Tools" and "University of California". Below this, the UC Davis logo and "FRUIT & NUT RESEARCH & INFORMATION" are visible. A navigation bar lists: Home, About, Our Endowment, UCCE Farm Advisors, Weather-Related Models, and Websites of Interest. The left sidebar menu includes: HOME, EXTENSION CLASSES, WEATHER-RELATED MODELS, Chilling Accumulation Models (with sub-items: About Chilling Units & Hours, Fruit & Nut Crop Chill Portions Requirements, Chilling Calculators, and Subscribe to Email List), Prune Chilling Prediction, Nitrogen Prediction Models for Almond and Pistachio, Irrigation Scheduling, Harvest Prediction for Peaches, Plums & Nectarines, Almond Hull-Split Prediction, and Pistachio Bloom Cast. The main content area is titled "Chill Calculators" and features four sections: "Cumulative Chilling Hours: Cumulative Chill Hours and Modified Chill Hours" (Hours below 45° F, November 1 through February 28/29), "Chilling Hour & Unit Accumulations: Historic Accumulation of Chill Hours, Modified Chill Hours, & Chill Units (Utah Model)" (Hours below 45° F, September 1 through August 31), "Cumulative Chilling Portions: Dynamic Model" (September 1 through August 31), and "Harvest Prediction Model: for Peaches, Plums and Nectarines". A link "View Station Map" is provided. Below these is a section "Chilling Hour & Unit Accumulations - Select Station from List" with a table:

County	Station
Alameda	191 Pleasanton
	171 Union City
Amador	227 Plymouth
Butte	012 Durham
Colusa	032 Colusa
Contra Costa	047 Brentwood

At the bottom, there are two small graphs: "the U.S. Corn Belt. View graphs of monthly temperature and precipitation, plot corn and soybean yield trends, and compare climate and yields over the past 30 years." and "Most risk, and guide decisions related to planting, harvest, and seed selection. This innovative tool integrates corn development stages with weather and climate data for location-specific decision support tailored specifically to agricultural production."



EXTRA SLIDES

Cal-Adapt



CAL-ADAPT EXTREME HEAT FRESNO PROJECTIONS

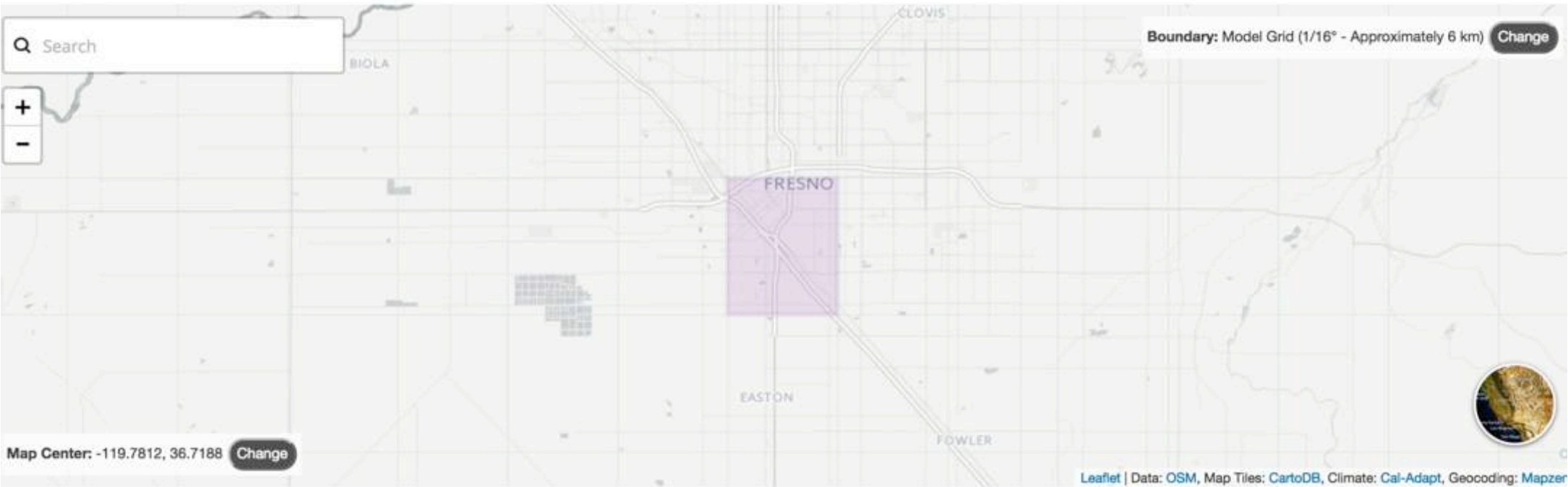
Extreme Heat

For most areas around the state, the climate models project a significant rise in the number of days exceeding what is now considered extremely hot for the given area. Explore how the frequency and timing of extreme heat days and warm nights is expected to change under different emission scenarios for your location.

[EXPLORE DATA](#)

[ABOUT](#)

[DATA SOURCES](#)



PAST TREND AND PROJECTIONS FOR 2030-40

Number of Extreme Heat Days

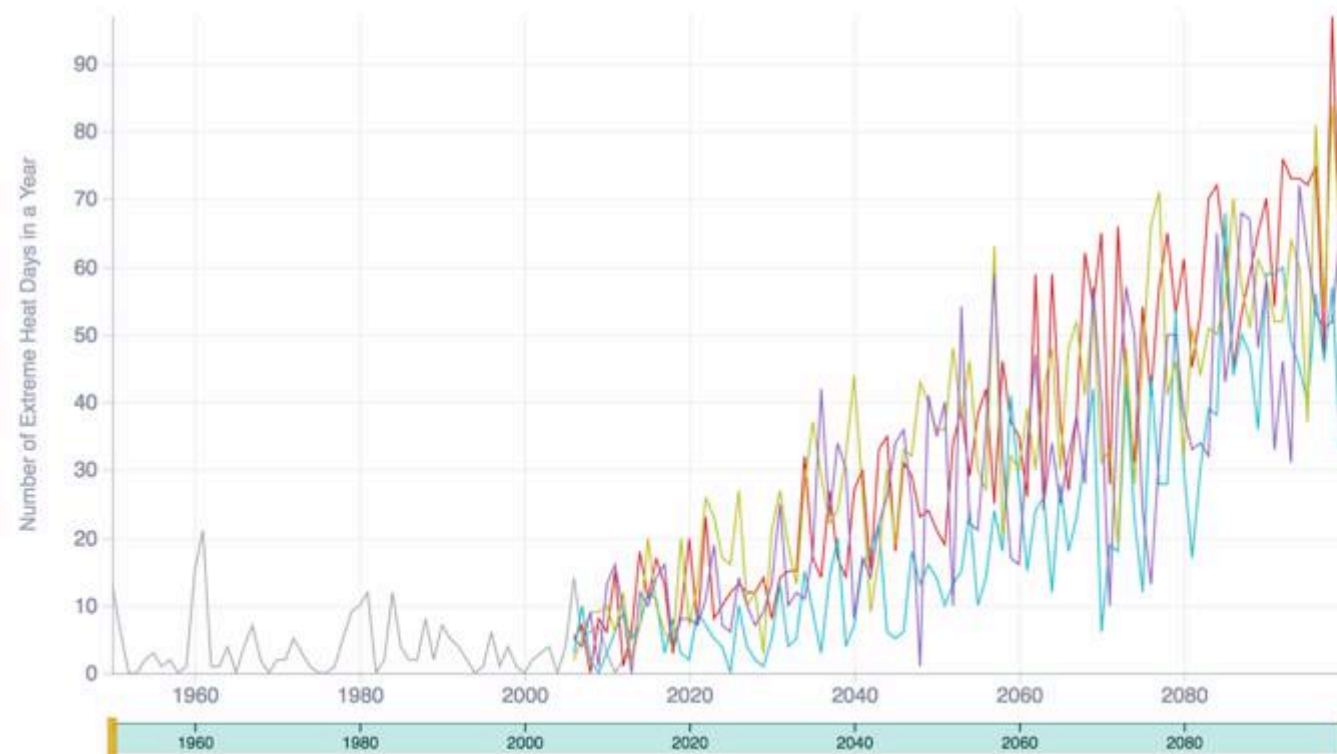
AREA NEAR CALWA, CA, USA

Emissions continue to rise strongly through 2050 and plateau around 2100 (RCP 8.5)

[Download Data](#)

[Save Chart](#)

— Observed Data (1950–2013), Model Projections (2006–2100)



Extreme Heat Threshold

106.6°F

Average number of days with high above 106.6°F in 1961–1990

4.3

Average number of days with high above 106.6°F in 2030–2040

19

RCP 4.5

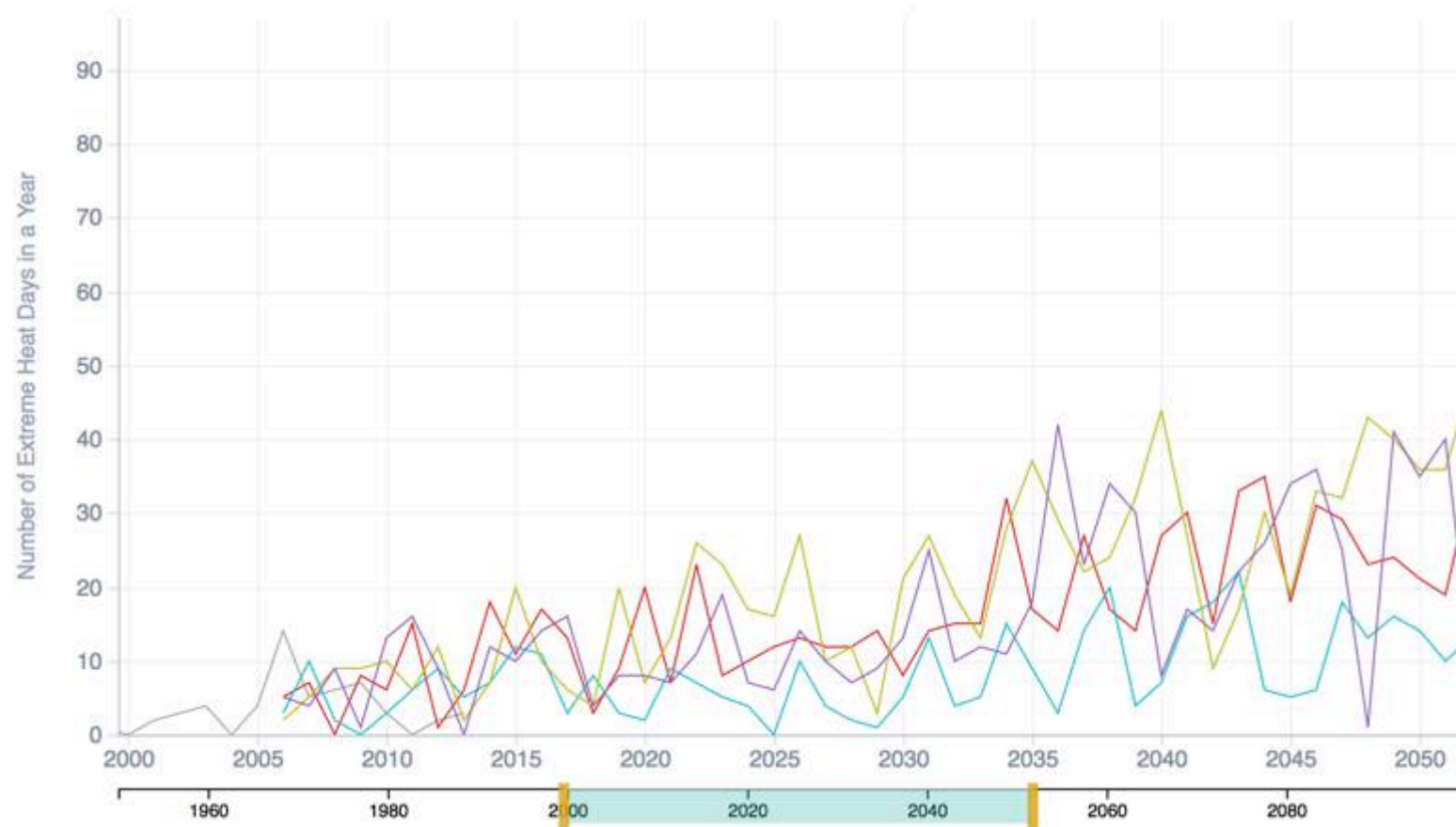
Emissions peak around 2040, then decline

RCP 8.5

Emissions continue to rise strongly through 2050 and plateau around 2100

SHORTER TIME SERIES GRAPH

— Observed Data (1950–2013), Model Projections (2006–2100)



Extreme Heat Threshold

106.6°F

Average number of days with high above 106.6°F in 1961–1990

4.3



Average number of days with high above 106.6°F in 2040–2050

23



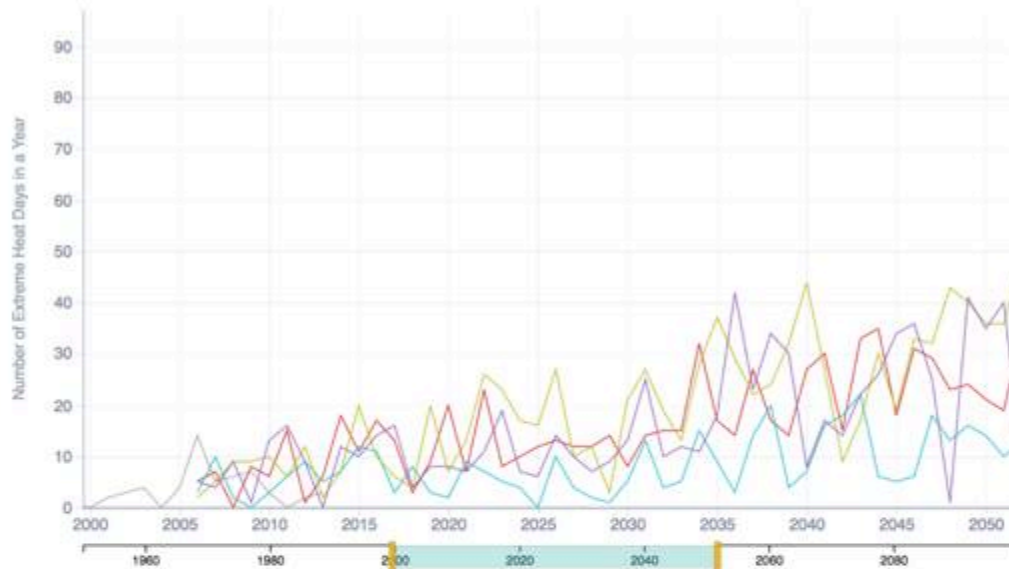
RCP 4.5

Emissions peak around 2040, then decline

RCP 8.5

Emissions continue to rise strongly through 2050 and plateau around 2100

PROJECTIONS FROM DIFFERENT MODELS TO ASSESS UNCERTAINTY



106.6°F

Average number of days with high above 106.6°F in
1961–1990

4.3

Average number of days with high above 106.6°F in
2040–2050

23

RCP 4.5

Emissions peak
around 2040,
then decline

RCP 8.5

Emissions
continue to rise
strongly through
2050 and plateau
around 2100

Climate Models

☒ HadGEM2-ES* ☒ Show/Hide Warm/Dry

☒ CanESM2* ☒ Show/Hide Average

☐ ACCESS1-0 ☐ Show/Hide

☐ CESM1-BGC ☐ Show/Hide

☐ GFDL-CM3 ☐ Show/Hide

☒ CNRM-CM5* ☒ Show/Hide Cool/Wet

☒ MIROC5* ☒ Show/Hide Complement/Covers range of outputs

☐ CCSM4 ☐ Show/Hide

☐ CMCC-CMS ☐ Show/Hide

☐ HadGEM2-CC ☐ Show/Hide



MONTHLY TIME-SERIES GRAPH FROM ONE MODEL

Days above 106.6°F derived from HadGEM2-ES model



This chart displays a point for each day that exceeds the extreme heat threshold. Time of year between April through October is plotted along the y axis and each year 1950-2100 along the x axis. For most areas around the state, the models project not only an increase in the number of days expected to exceed the extreme heat threshold, but also their occurrence both earlier and later in the season.

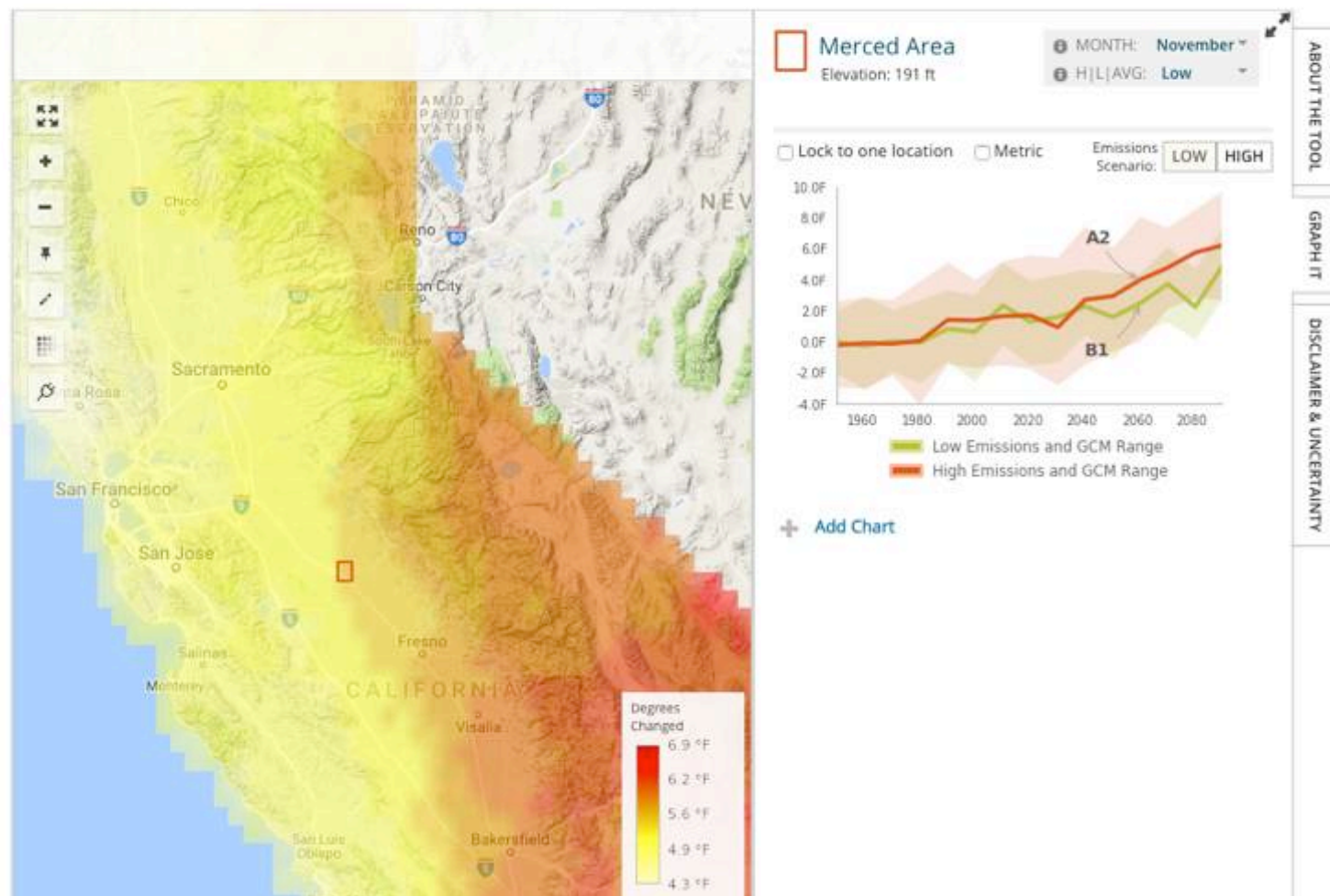


SUMMARY OF PROJECTIONS FOR FRESNO

- The tool shows extreme heat days (EHD) in Fresno. In the past EHD were ~ 4 days/yr, but it is projected to increase to:
 - ~18-23 days in 2040-50
 - ~ 20-30 days in 2050-60, and so on

TEMPERATURE DEGREES OF CHANGE MAP

TEMPERATURE: DEGREES OF CHANGE MAP





THANK YOU!

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