Mitigating climate risks on the farm: tree nut perspective

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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.

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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;
- Increased operational costs; → **Short-term (1-5 years)**
- Increased environmental impact. → **Long-term (20-50 years)**

Mitigating Risks: Almond Case Study

Weather Concerns

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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

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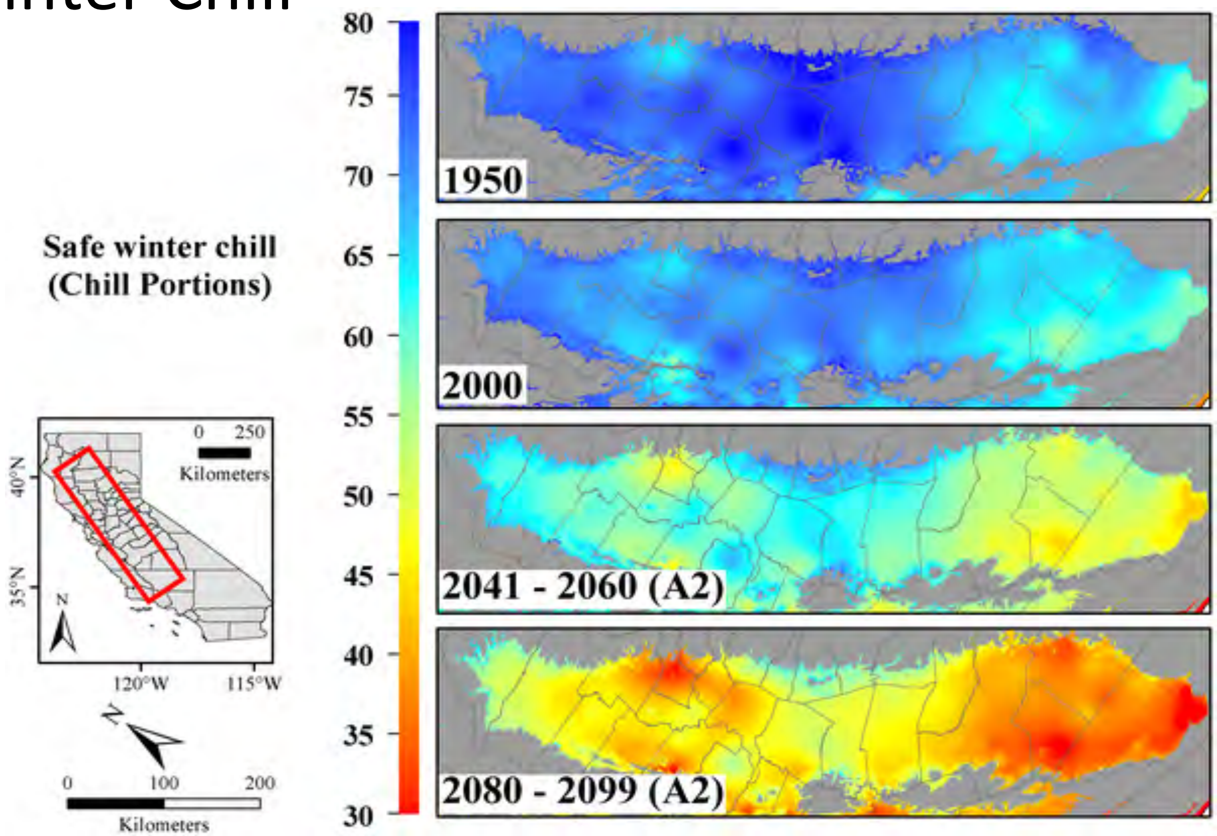
Mitigating Climate: Almond Case Study

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.

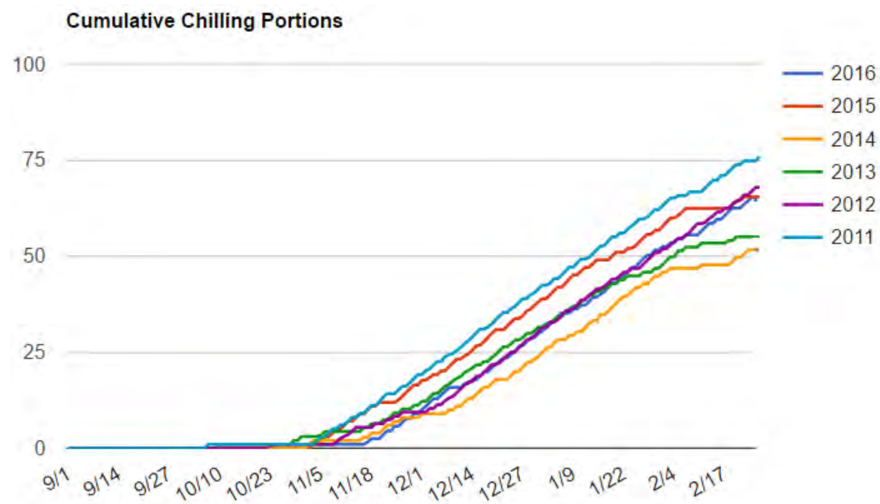


Luedeling E, Zhang M, Girvetz EH (2009) Climatic Changes Lead to Declining Winter Chill for Fruit and Nut Trees in California during 1950–2099. PLoS ONE 4(7): e6166. doi:10.1371/journal.pone.0006166
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006166

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.



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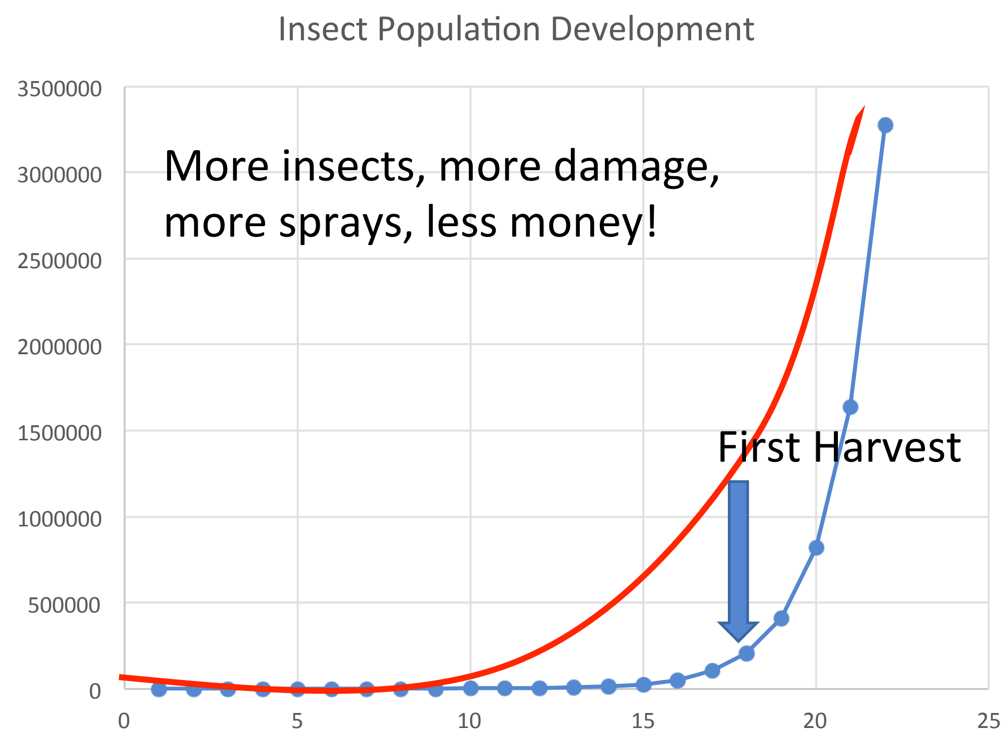
Mitigating Climate: Almond Case Study

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.

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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

Managing Weather		**Managing Climate**
Orchard layout; Variety selection; Irrigation systems.	Site selection; New modes of action for pesticides; Techniques to increase chill, decrease sunburn; More efficient farm equipment.	New varieties; Better crop modelling; Farm Diversification- crops and location; Infrastructure improvements.

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.

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Climate Impacts on California Agriculture and Tools for Managing Risks

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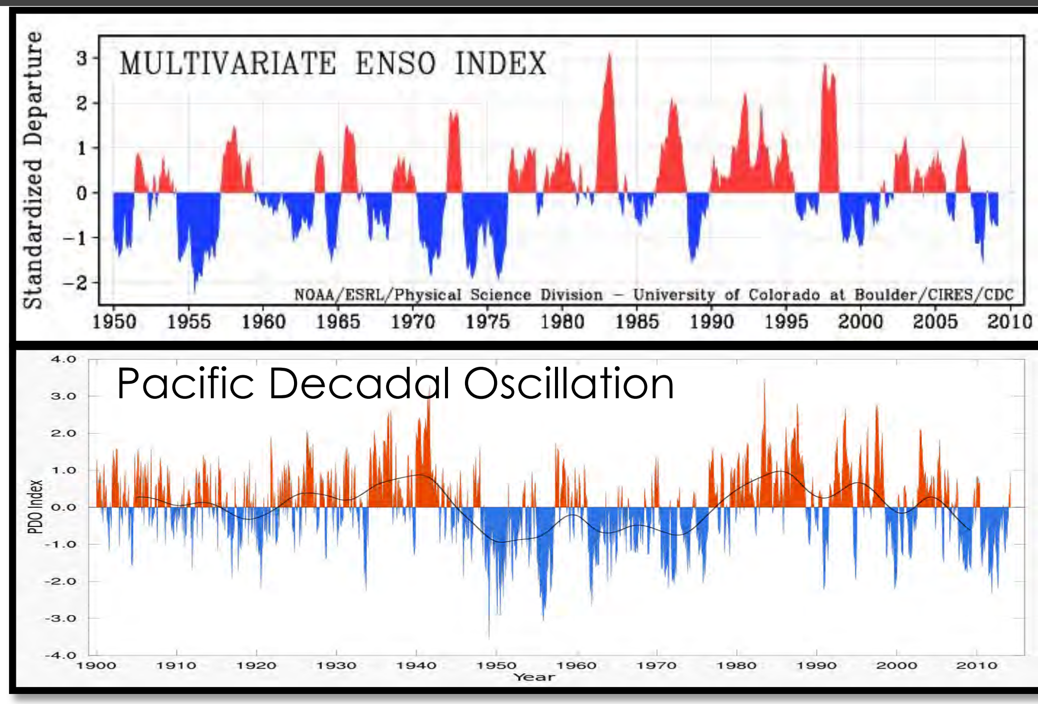
Facts about California Agriculture

- 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

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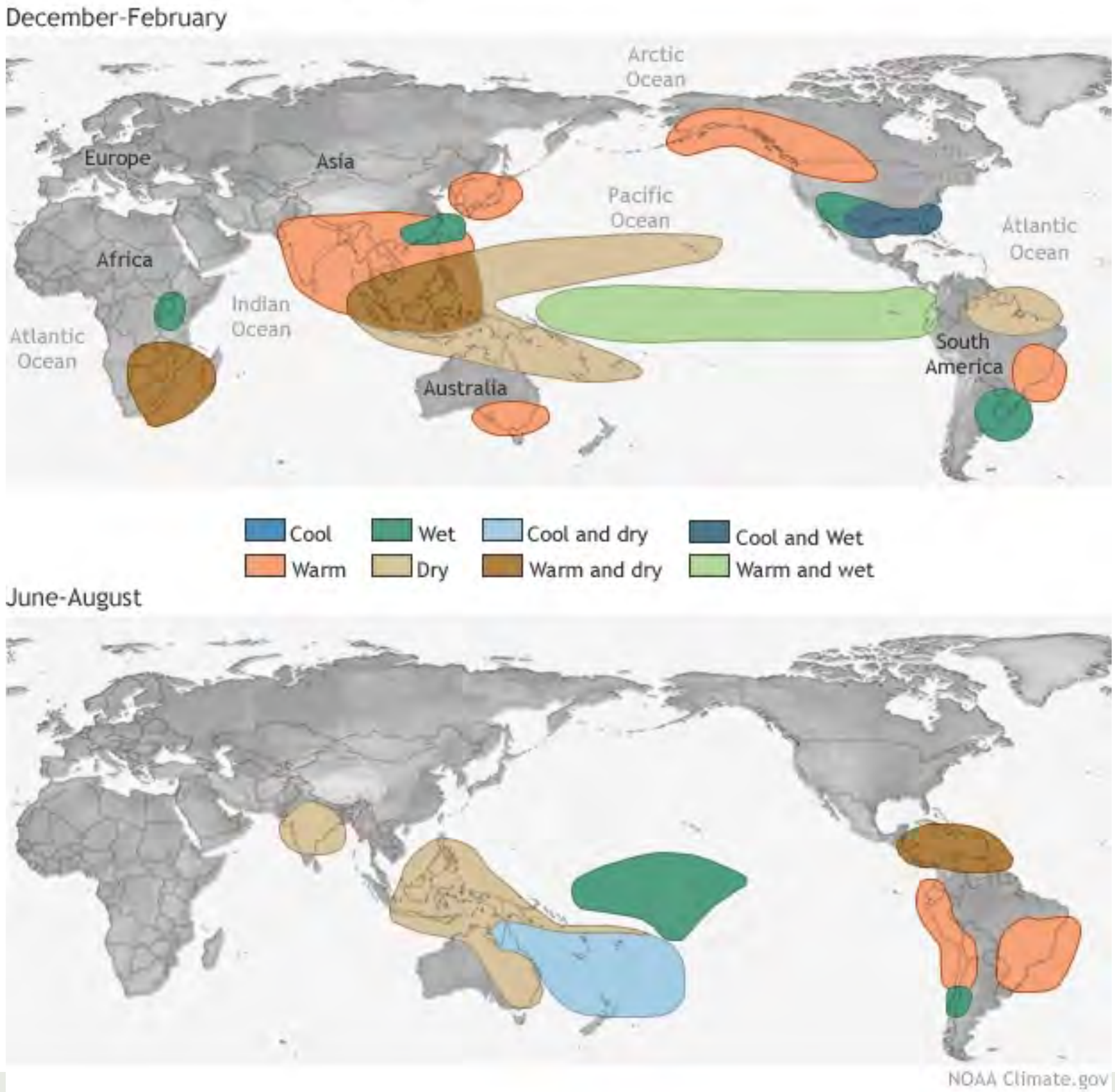
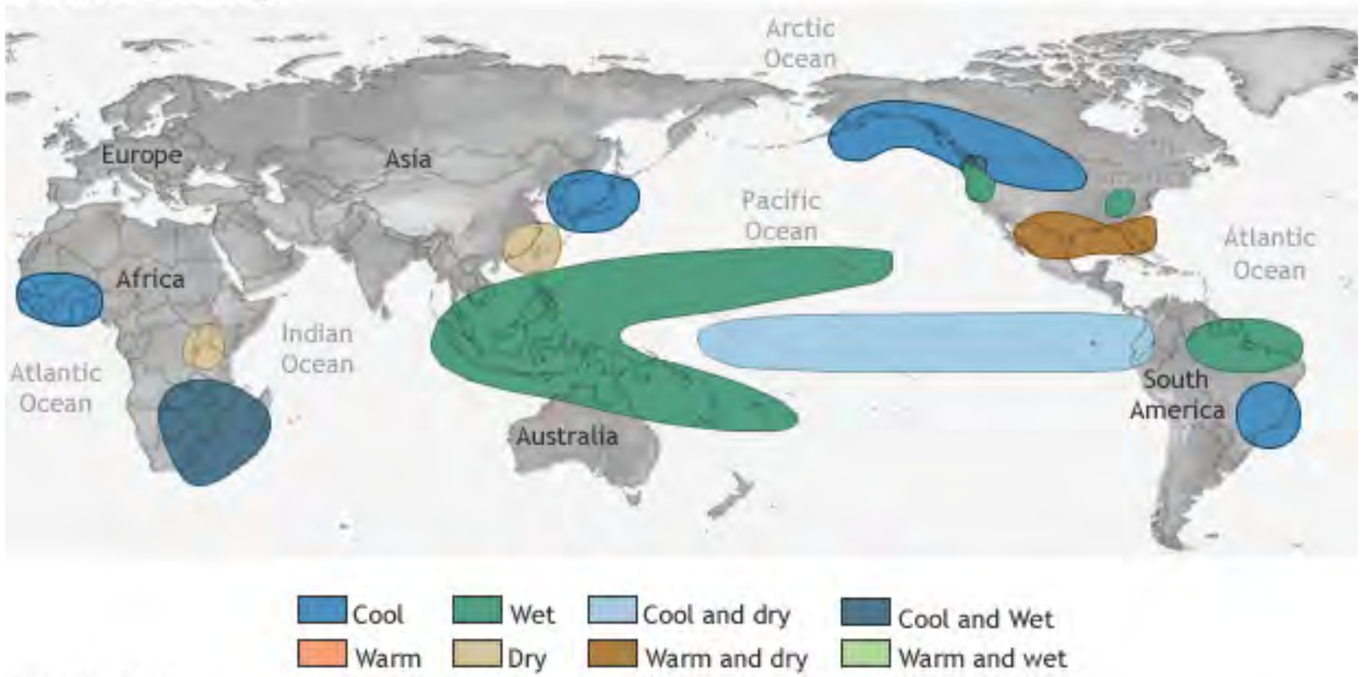
EL NIÑO CLIMATE IMPACTS

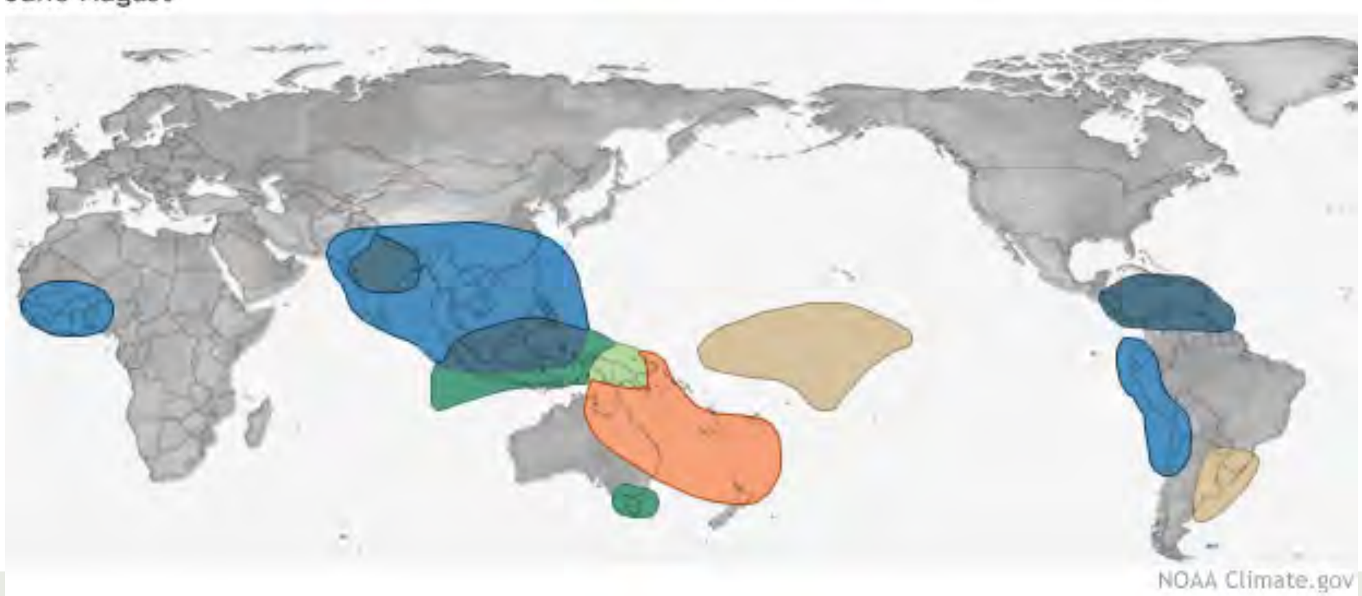


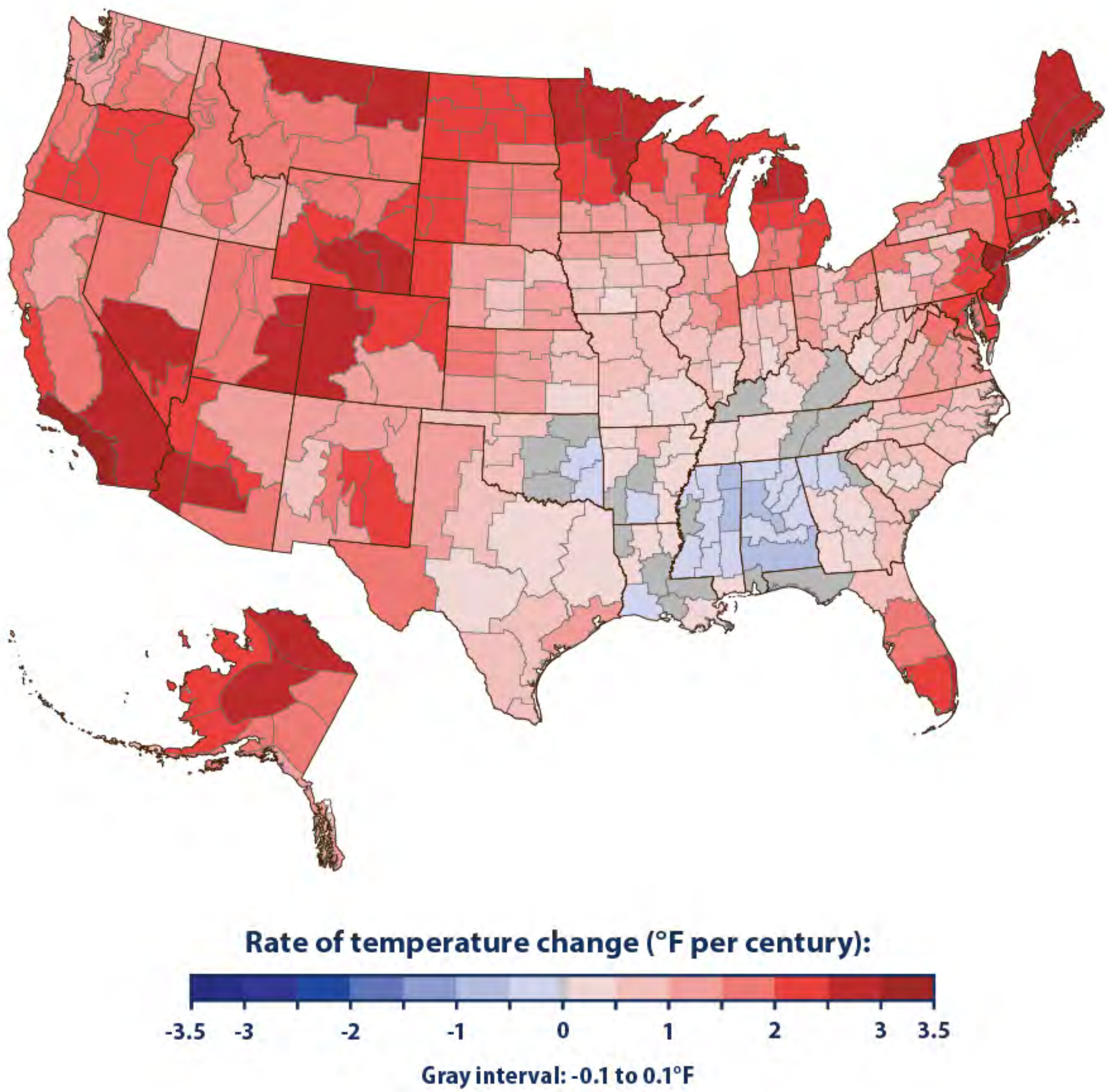
LA NIÑA CLIMATE IMPACTS

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

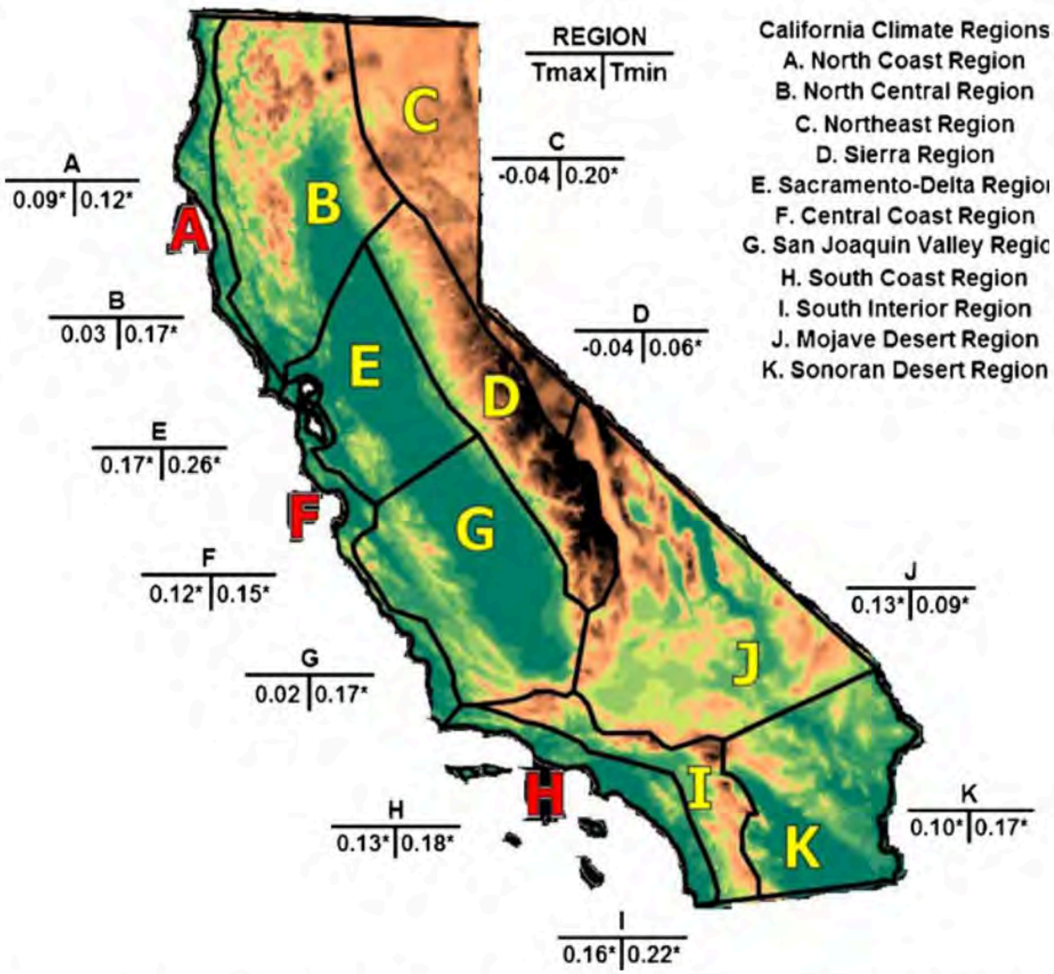
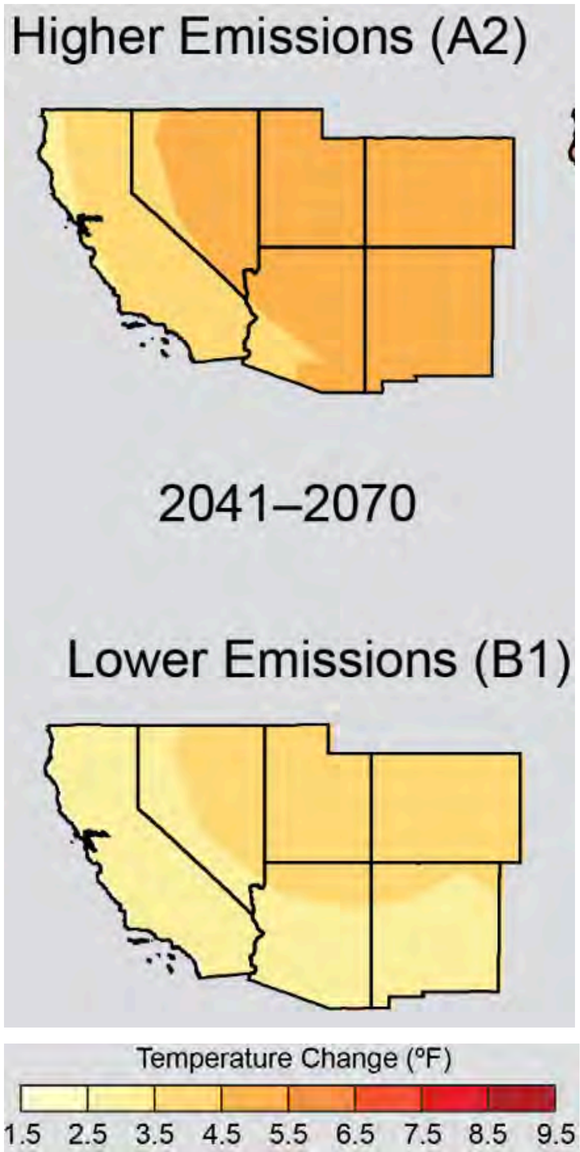


Fig. 4 Annual temperature trends (°C dec^{-1}) for the 11 climate regions labeled *A-K* computed between 1918–2006 for Tmax (*left*) and Tmin (*right*), where the trends that are statistically significant at the 95% confidence level are indicated with an *asterisk*

Cordero et al. (201

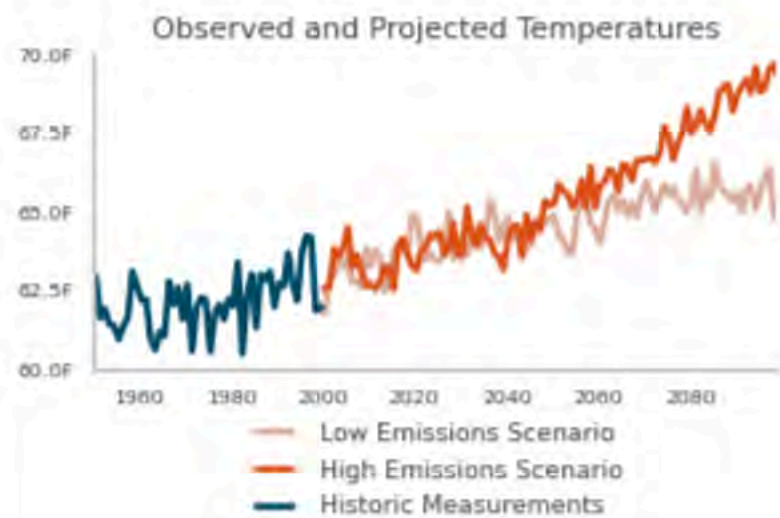
Changes in Average US temperatures



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:

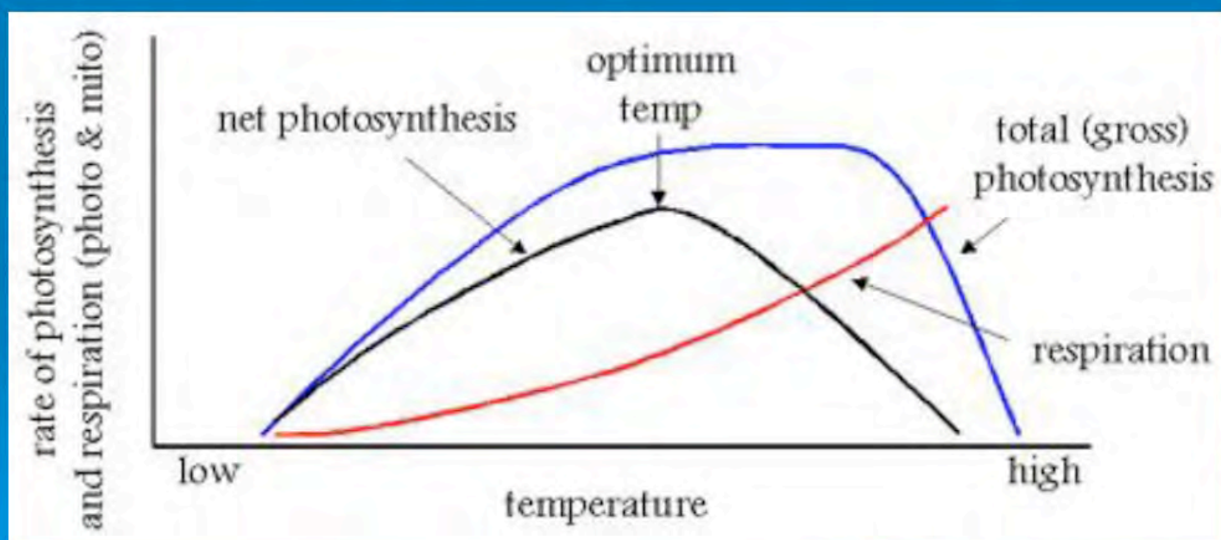
- 5—15% reductions in the yields of crops as currently grown
- 3—10% increases in the amount of rain falling during the heaviest precipitation events, which can increase flooding risks
- 5—10% decreases in stream flow in some river basins
- 200%—400% increases in the area burned by wildfire in parts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

Source: http://www.epa.gov/climatechange/facts.html

How does temperature increases affect plants?

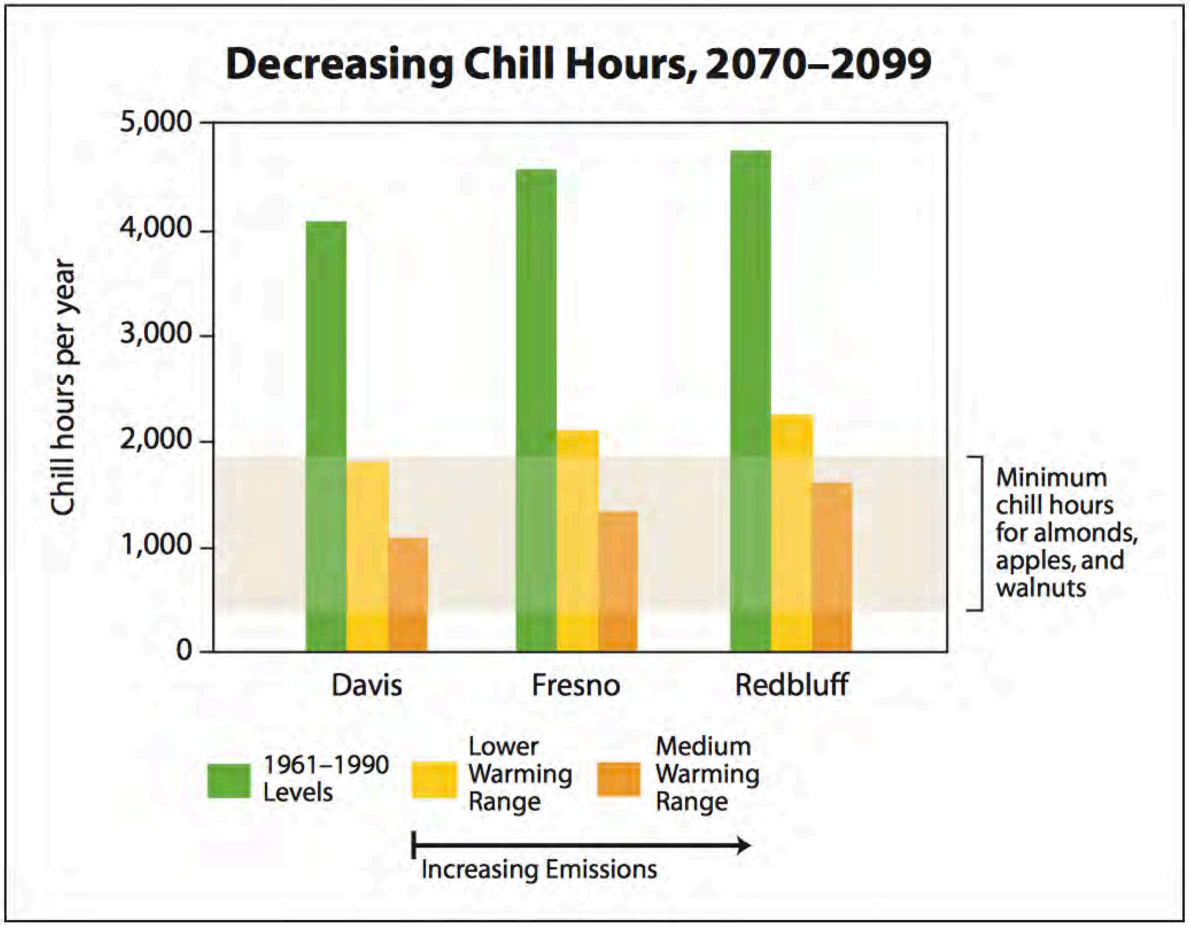
Temperature and Plants

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



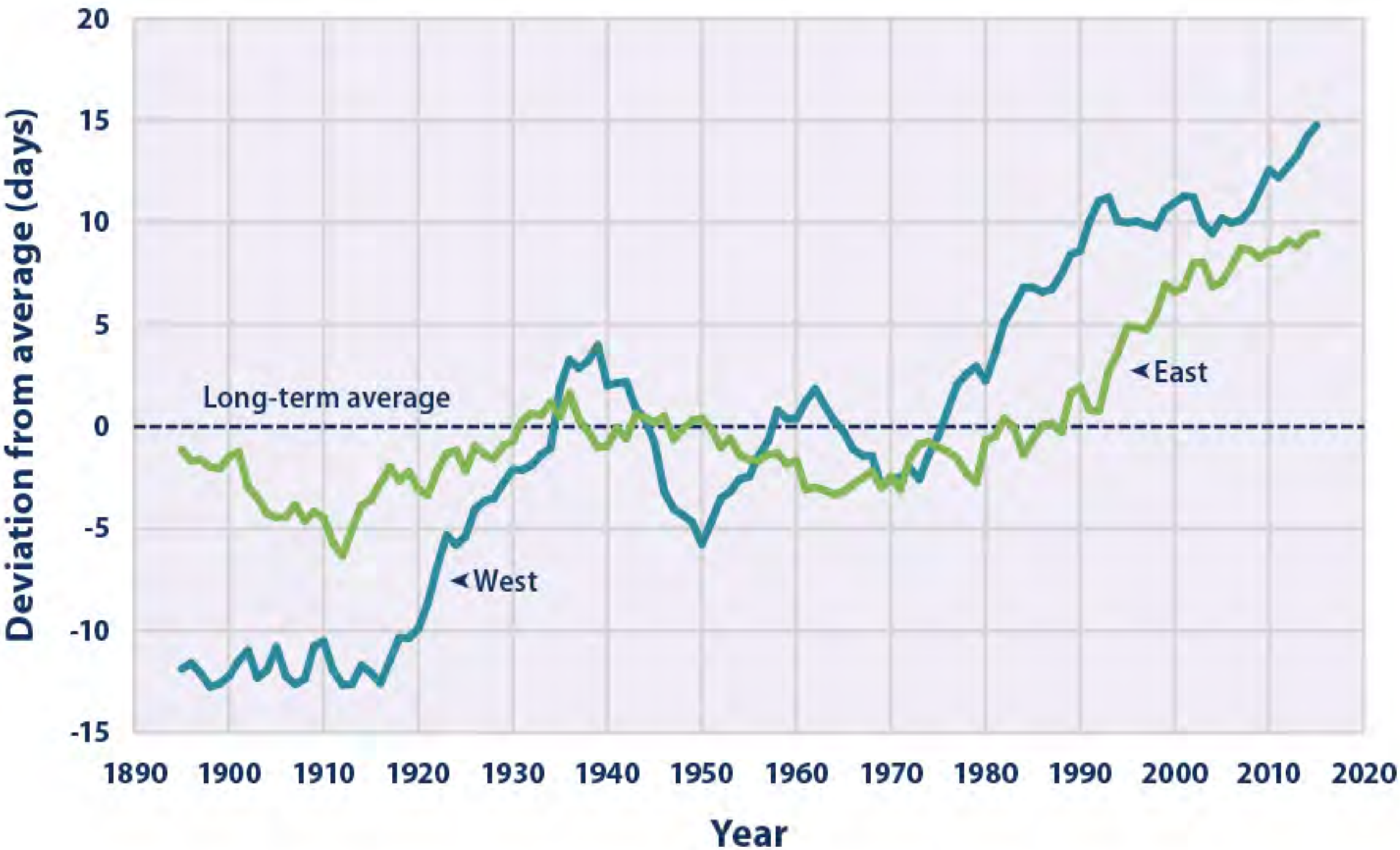
http://www.colorado.edu/eeb/courses/4140bowman/lectures/4140-06.html

Trends in Chill Hours

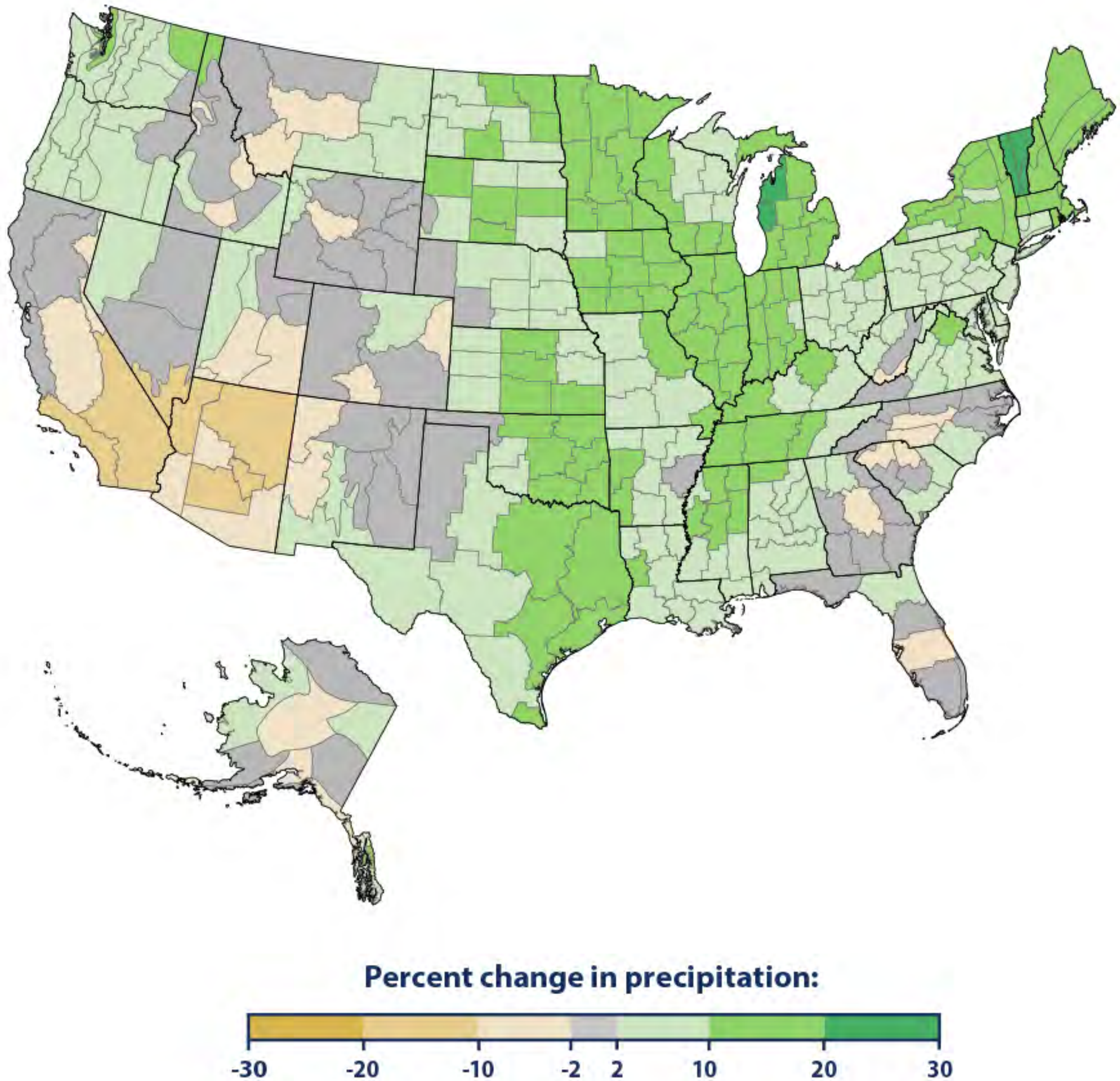


- Around the year 1950, growers in the Central Valley could rely on between 700 and 1200 Chilling Hours
- By 2000, this number had already declined by up to 30% in some regions
- Chill Hours are projected to decrease significantly under future climate change scenario

Length of Growing Season

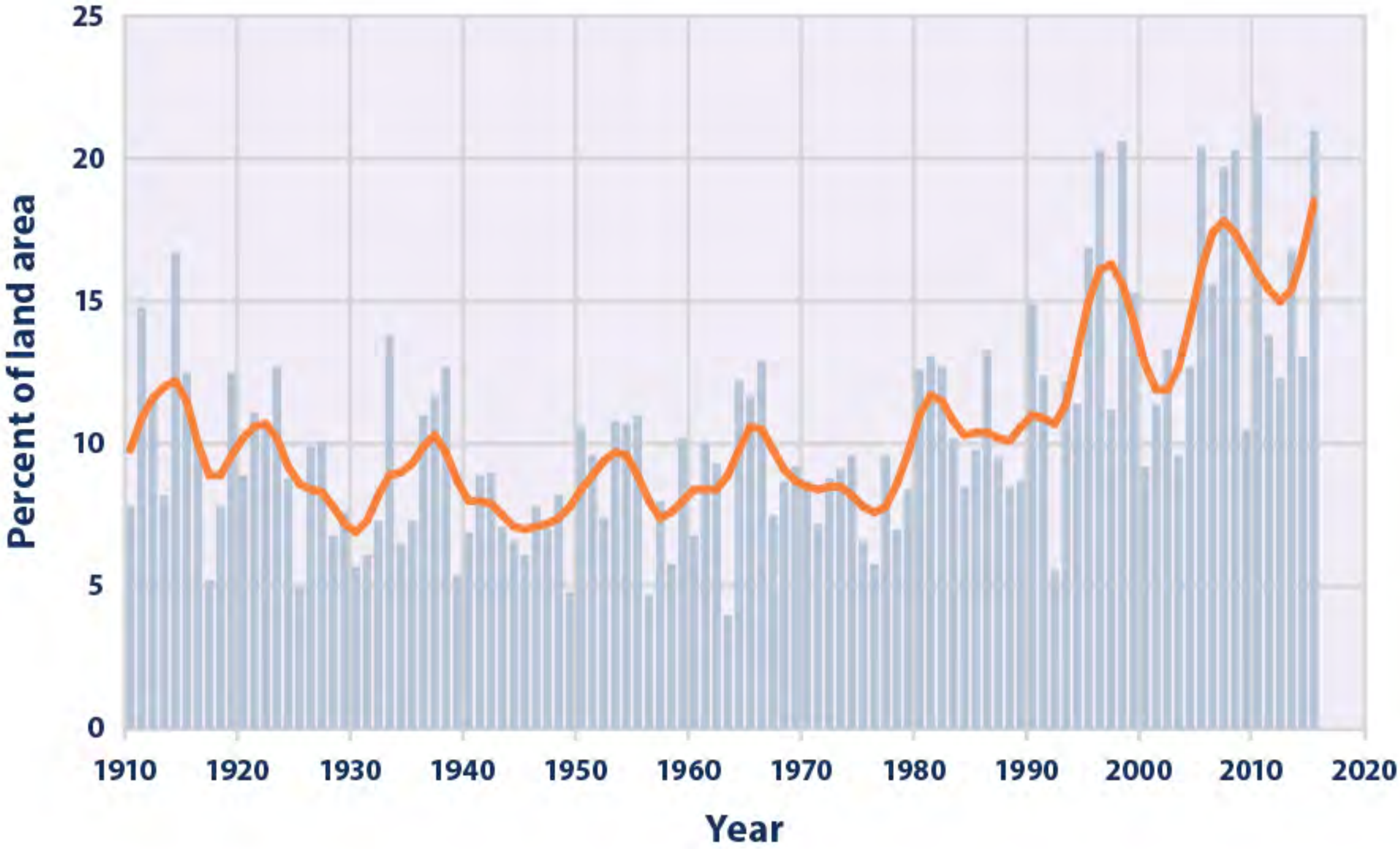


Precipitation Trends



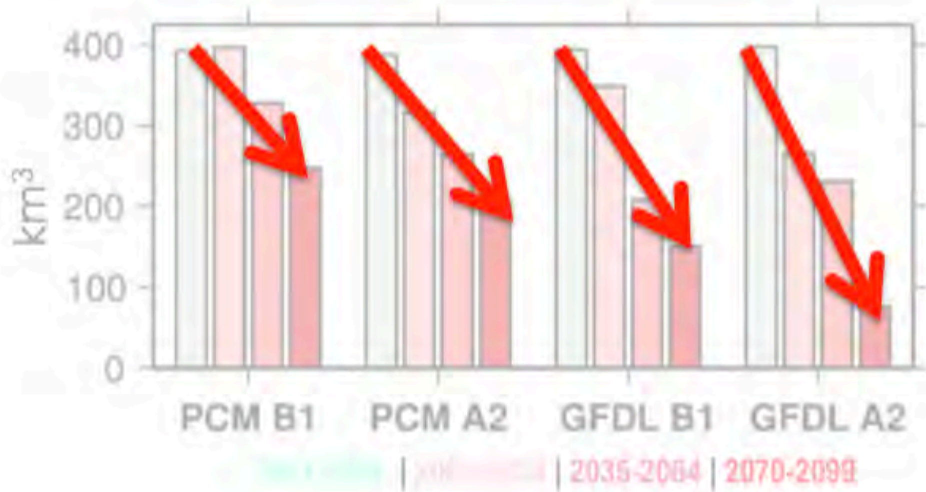
Since 1901, global precipitation has increased at an average rate of 0.2 percent per decade, while precipitation in the contiguous 48 states has increased at a rate of 0.5 percent per decade.

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

Slide Courtesy: Teamrat Ghezze

Climate Information for Managing Risks

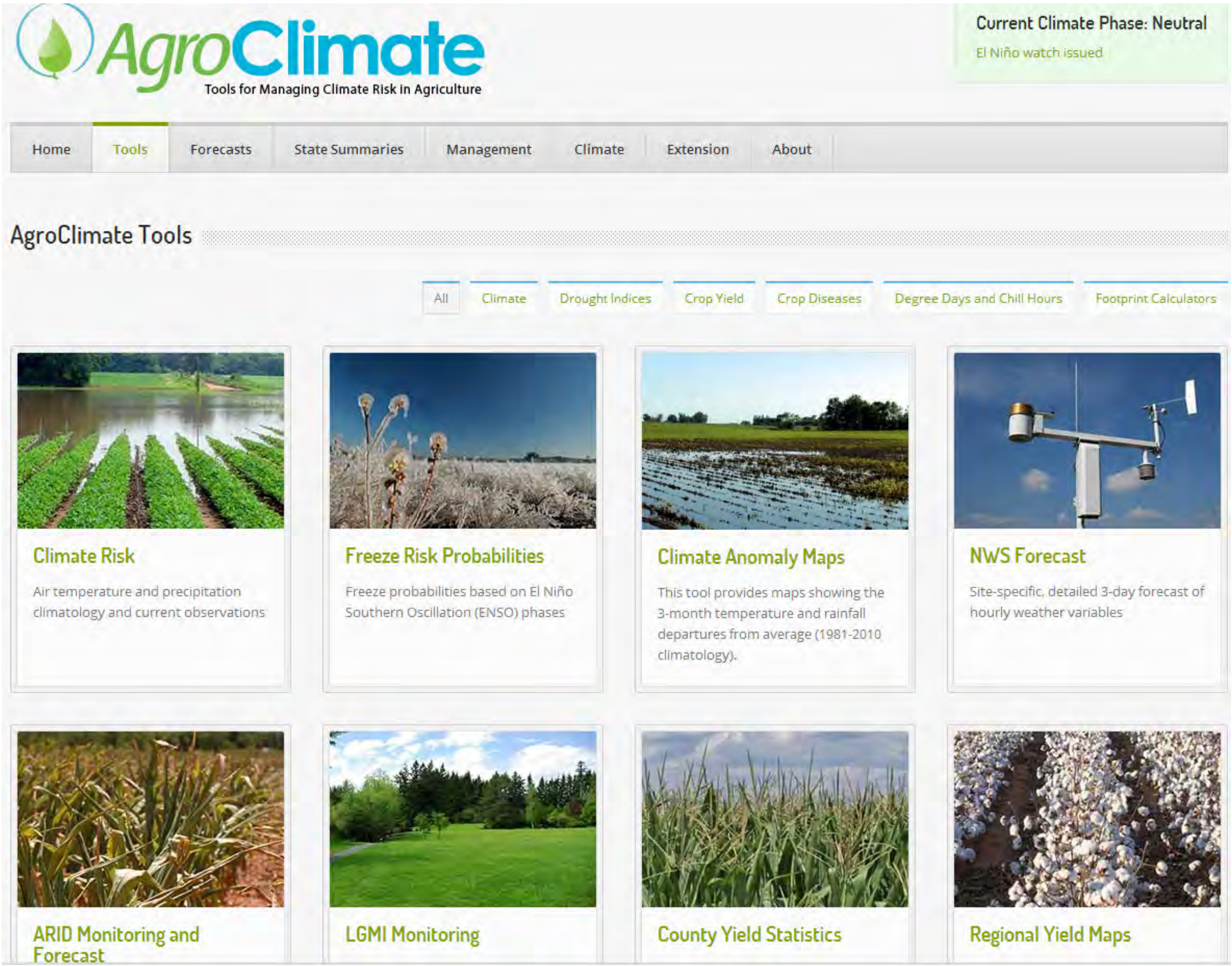
- Climate has direct influence on agricultural production
- Integrating climate information into agricultural decisions can enhance agricultural resiliency to climate risks
- However, this information is not always available in a format that is desirable to agricultural producers/decision makers
- Translating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

Climate Information Needs

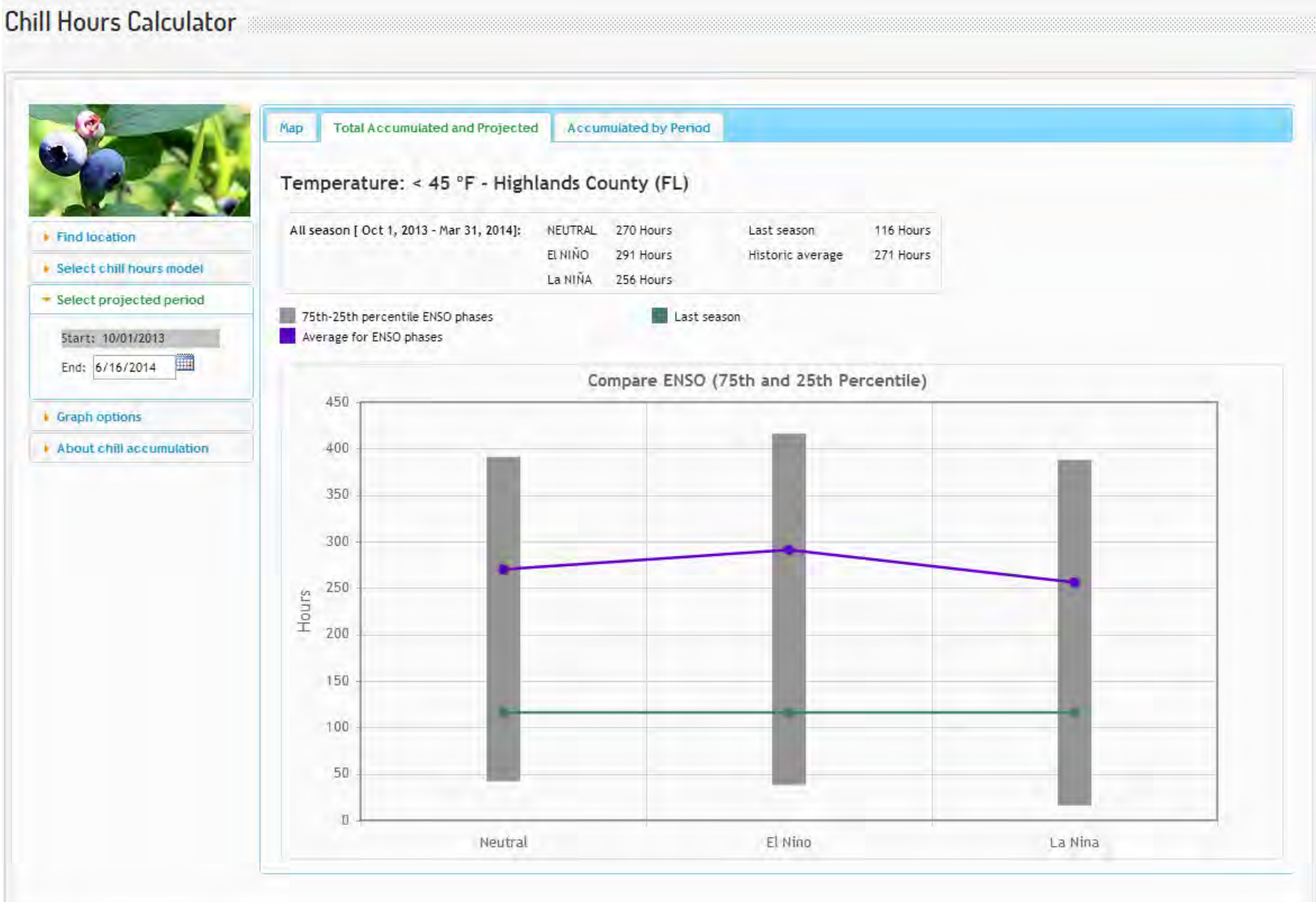
- *United States Government Accountability Office – "**USDA faces the challenge of turning the large amount of often technical climate research into readily understandable information.**"*
- Decision support processes need to take account of the values and goals of stakeholders, evolving scientific information, 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

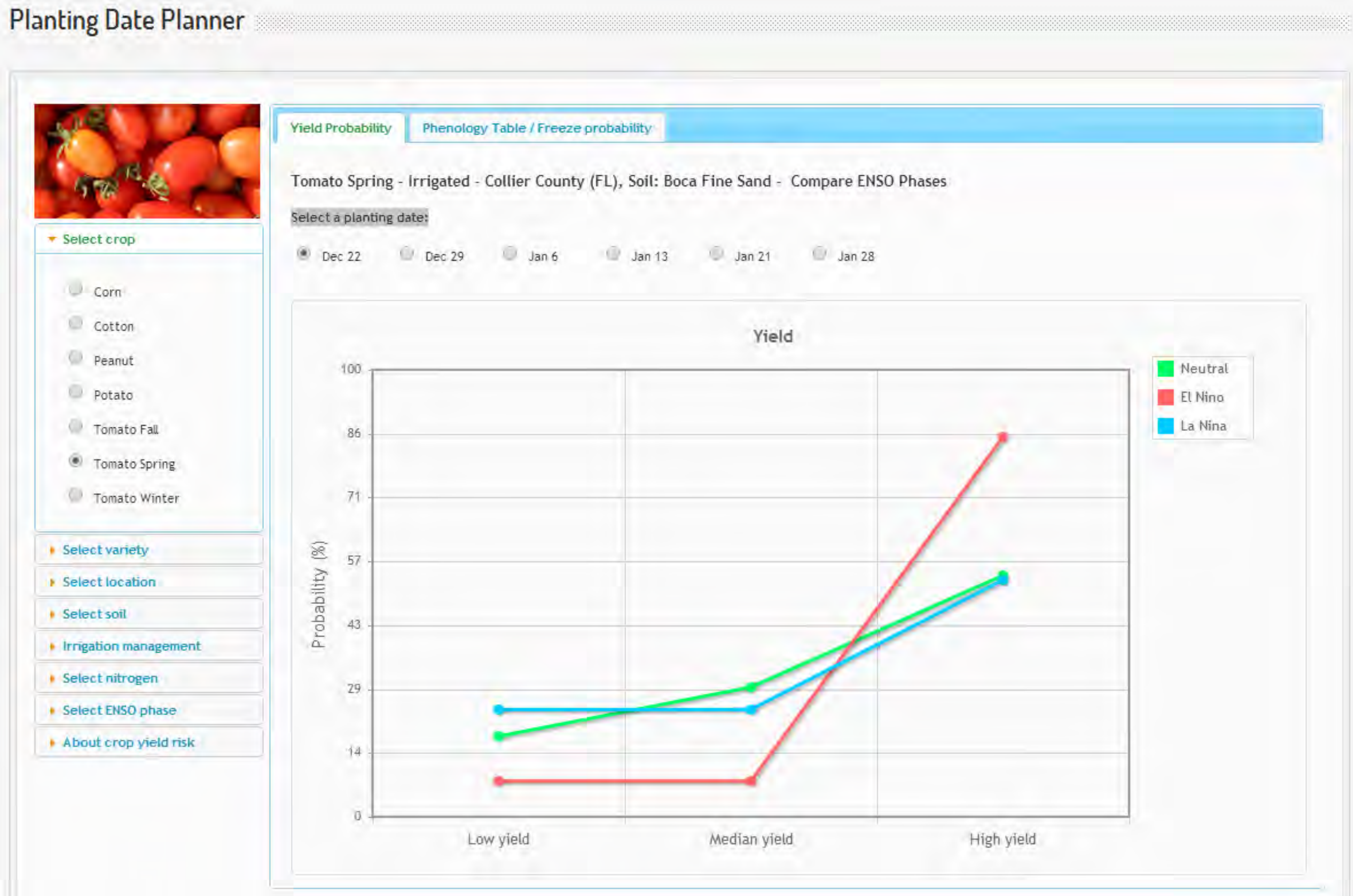
Adaptation to Climate Variability-Southeast US



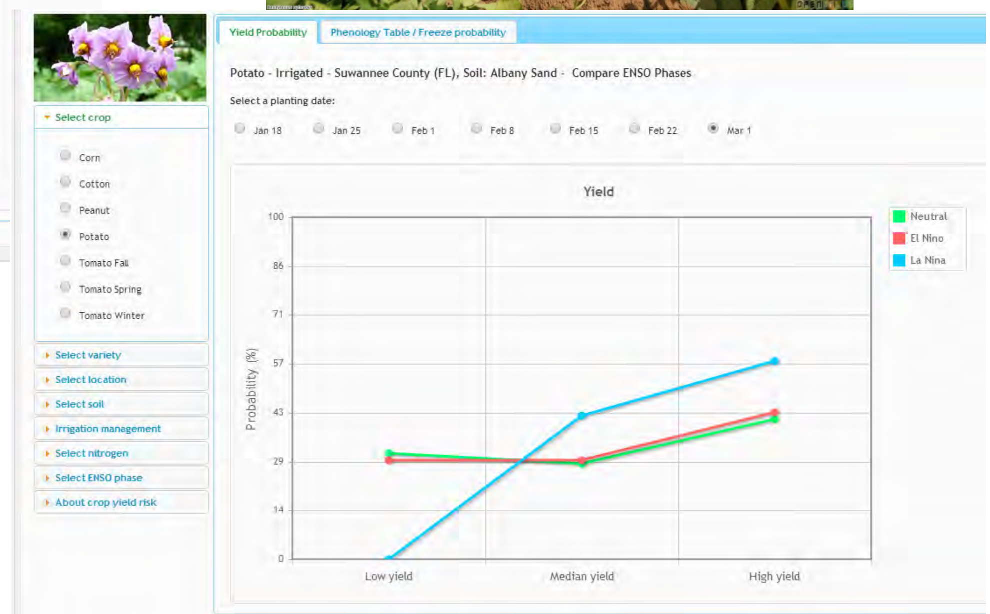
ENSO Adaptations – Example 1



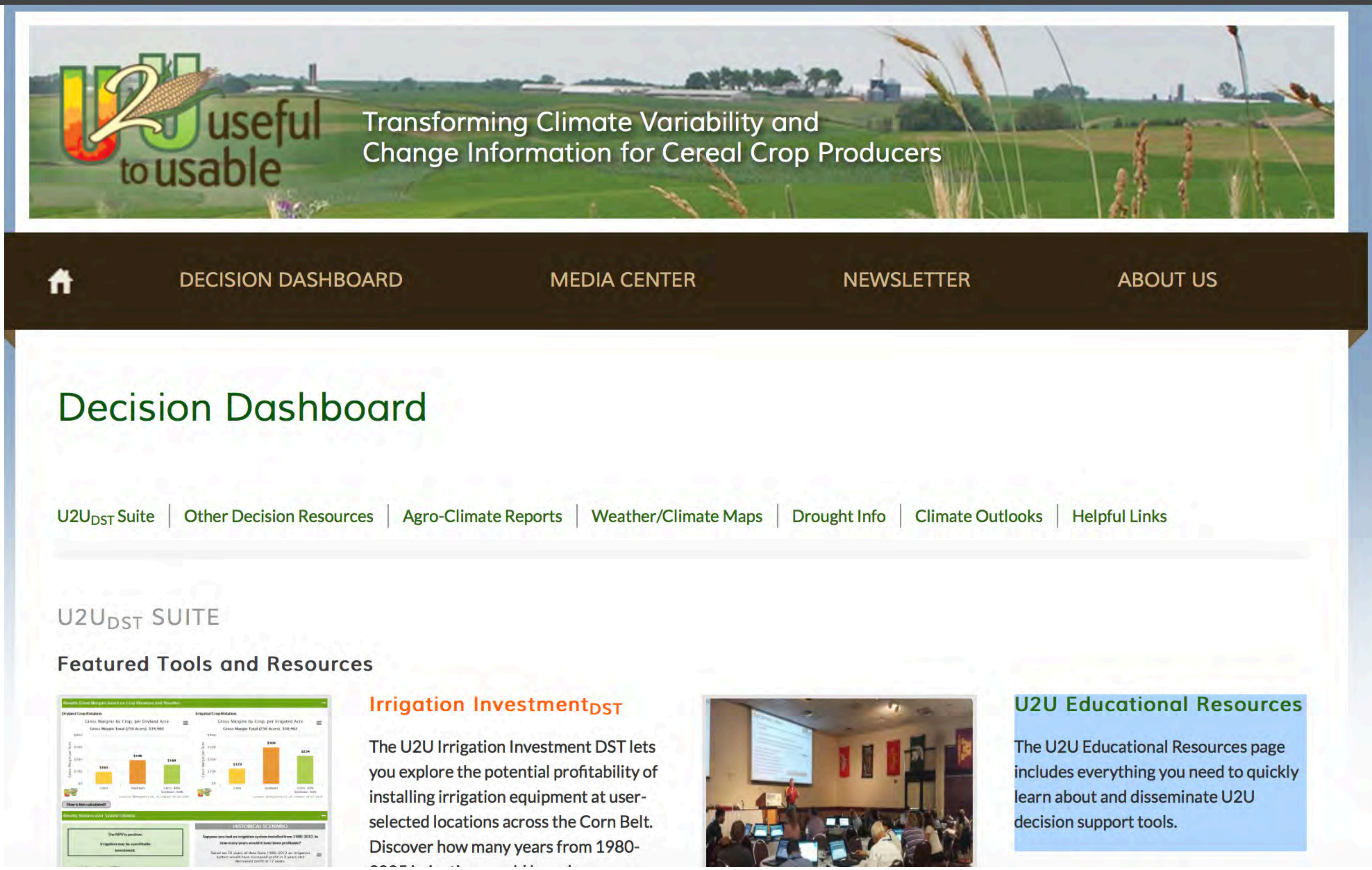
ENSO Adaptations – Example 2

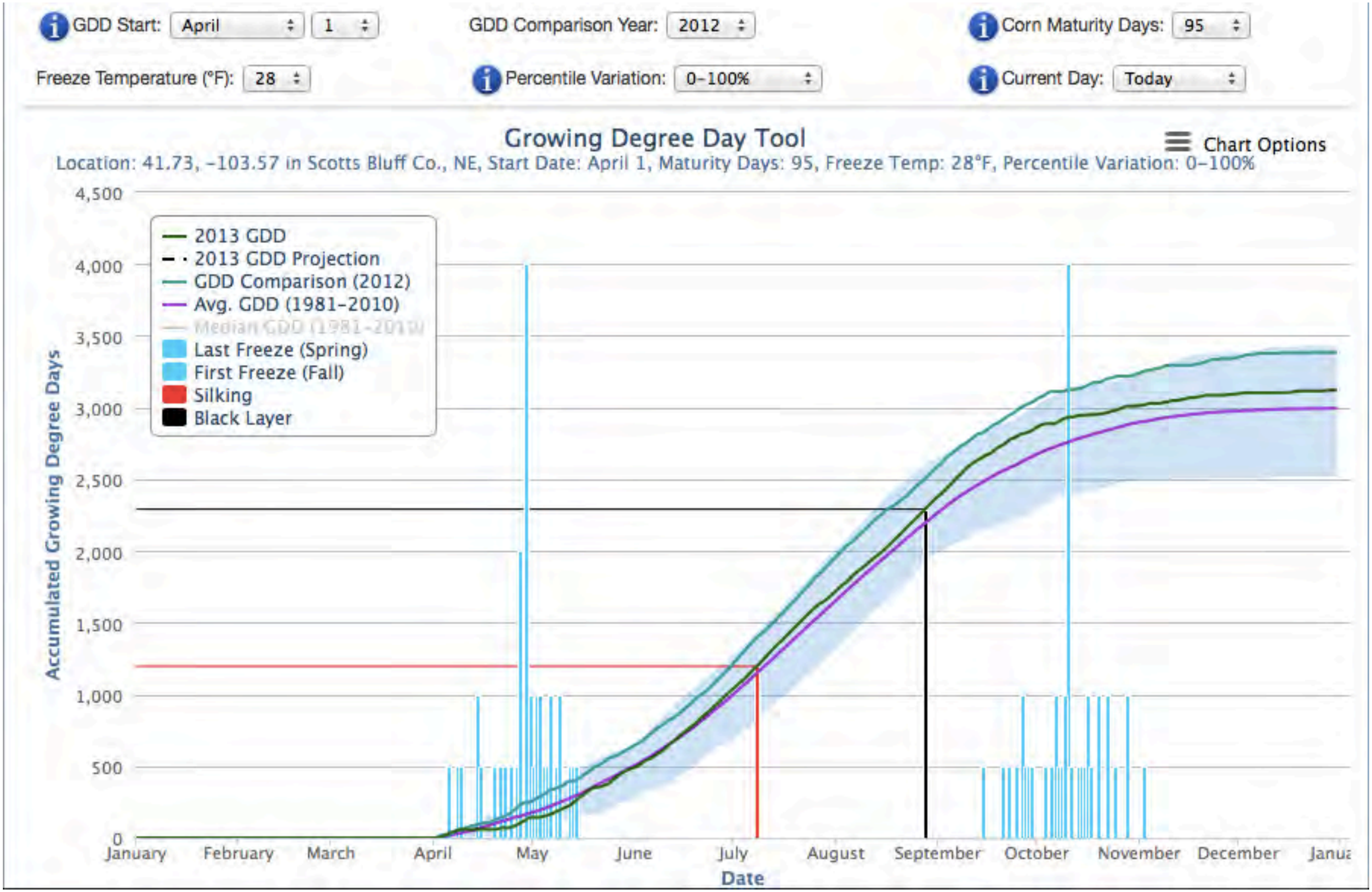


ENSO Adaptations – Example 3



Example from the Midwest




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%
2013 GDD
2013 GDD Projection
GDD Comparison (2012)
Avg. GDD (1981-2010)
Median GDD (1981-2010)
Last Freeze (Spring)
First Freeze (Fall)
Silking
Black Layer
Accumulated Growing Degree Days
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
January
February
March
April
May
June
July
August
September
October
November
December
Date

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Using climate information for long-term adaptation planning:

Information needs, modeling capabilities & tools

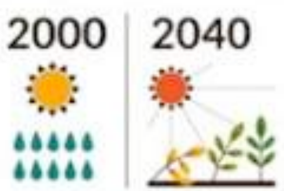
Kripa Jagannathan - PhD candidate, UC Berkeley

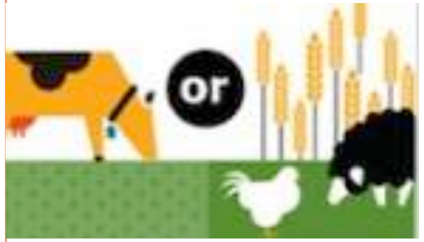
"On-Farm Climate Adaptation Decisions: Where Theory Meets Practice": CalCAN 2017 Summit - 28 Feb 2017

Background

Why to use climate information in long-term planning?

Climate & Weather info are important

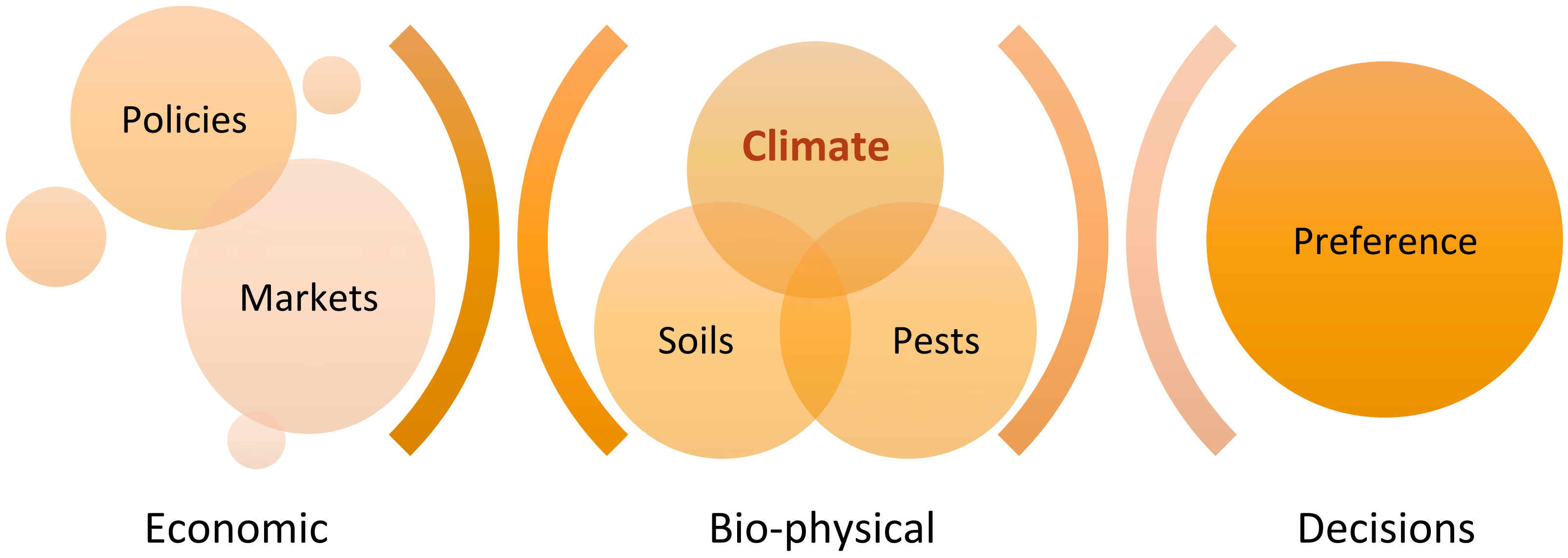
	Type of information	Farm decisions affected
Weather (days to weeks) 	• Daily forecasts up to a week ahead of time	• Timing of planting or harvest, fertilizer or pesticide application • Irrigation scheduling
Weather/Climate (months to years) 	• Probabilities of seasonal rainfall & temperature • Seasonal forecasts of dry spells	• Crop varieties to plant • Intensity of fertilizer or pesticide or water • Intensify or diversify crops
Climate (10 yrs or longer) 	• Projections of future temperature or rainfall or heat waves • Future droughts/floods	• Major capital investment land purchase, irrigation system etc. • Deciding whether or not to farm • Changing farming systems



Source: CGIAR CCAFS

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!

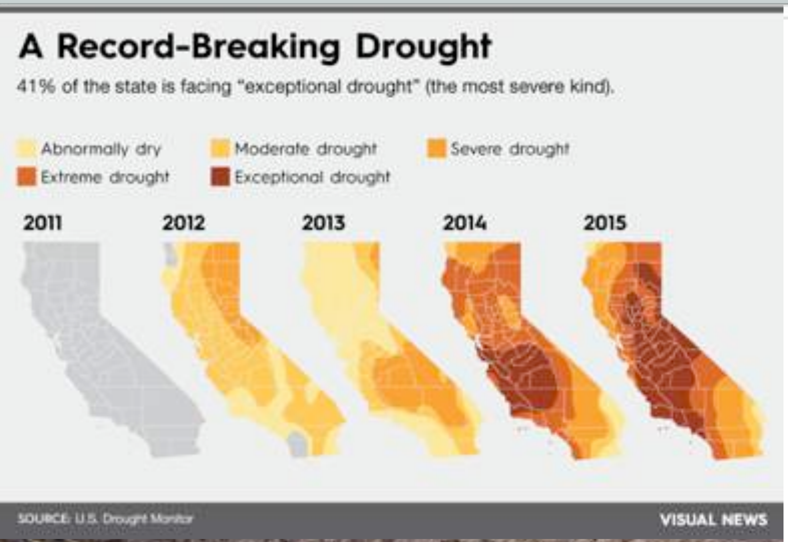


Photo credits: House Committee on Natural Resources.

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

Farmers' information needs

Interviews with almond growers in the Central Valley

INTERVIEWS

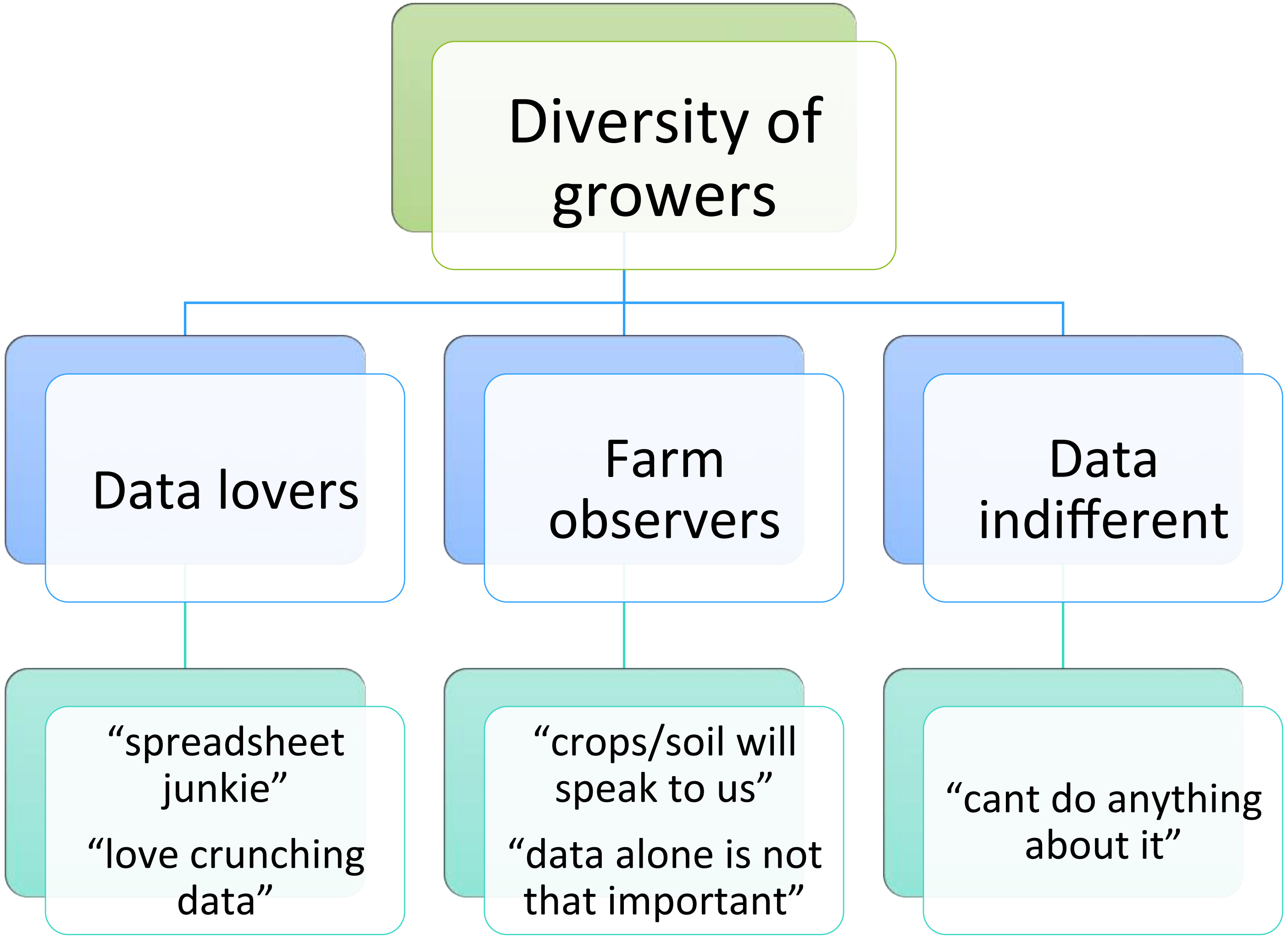
- Semi-structured interviews (Central Valley)
  - Farmers, Farm advisors, industry board members
- Non-random, purposeful, and snowball sampling

INTERVIEW THEMES

- Role of climate info in decision-making
- Relevant climatic variables/metrics
- How to make info on future climate 'usable'

Preliminary findings (not to be cited or distributed)

CURRENT USE OF WEATHER/CLIMATE DATA



Key climatic variables for the almond crop

Dormancy (Nov-Feb)

- Chill hours

Bloom & Pollination (Feb-Mar)

- Frost patterns
- wind, temp, rain

Maturing Nuts (Apr-Jun)

- Temp
- Extremely hot days

Hull-split & Harvest (Jul-Oct)

- Rain or high humidity
- Extremely hot days

Snow pack and water availability.

Long-term projections for such crop-specific climatic variables are not readily available.

Photo credits: http://www.amira.ca/en/info_almond.htm and http://www.belehrisestates.com.au/almond_growing_cycle.php

Growers are experiencing changes in climate

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

- **Hotter springs**
  - Earlier and quicker bloom
  - Pesticide spray timings changed
- **Hotter summers**
  - Earlier harvest
- **Snowpack change**
  - Anecdotal
- **Change in pests/ disease paradigms**

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?

- What can you do with the data??
  - Solutions after prompts
    - Adjustments
      - Crop varieties, rootstocks
      - Frost protection
      - Efficient irrigation
    - Transformation
      - Different crops
      - Lesser crops
      - Abandon farming

Summary of interview findings

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

Projections must transparently include uncertainties/ likelihoods/confidence

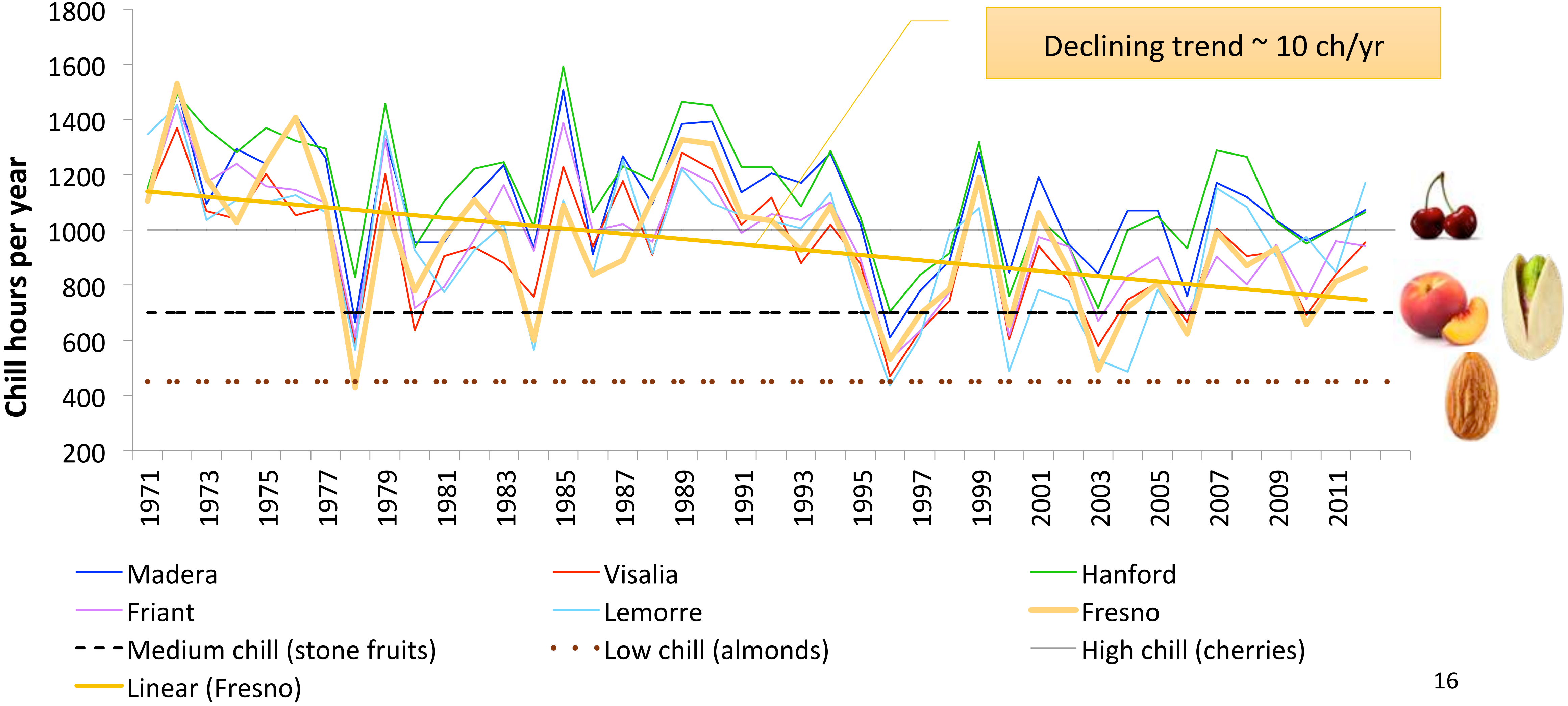
Farmers may be open to thinking about adaptive actions based on projections

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

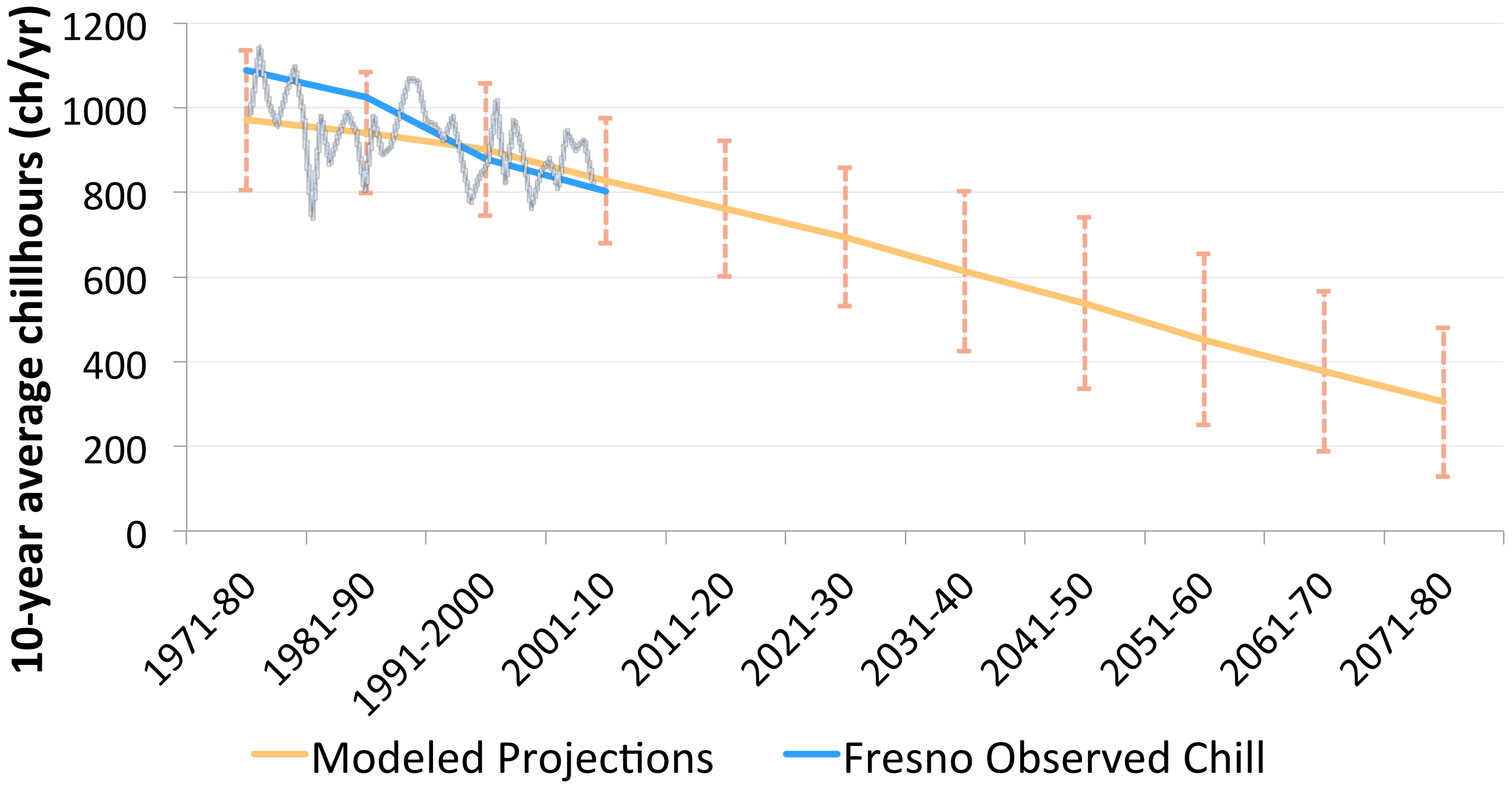
CLIMATE MODELING CAPABILITIES

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

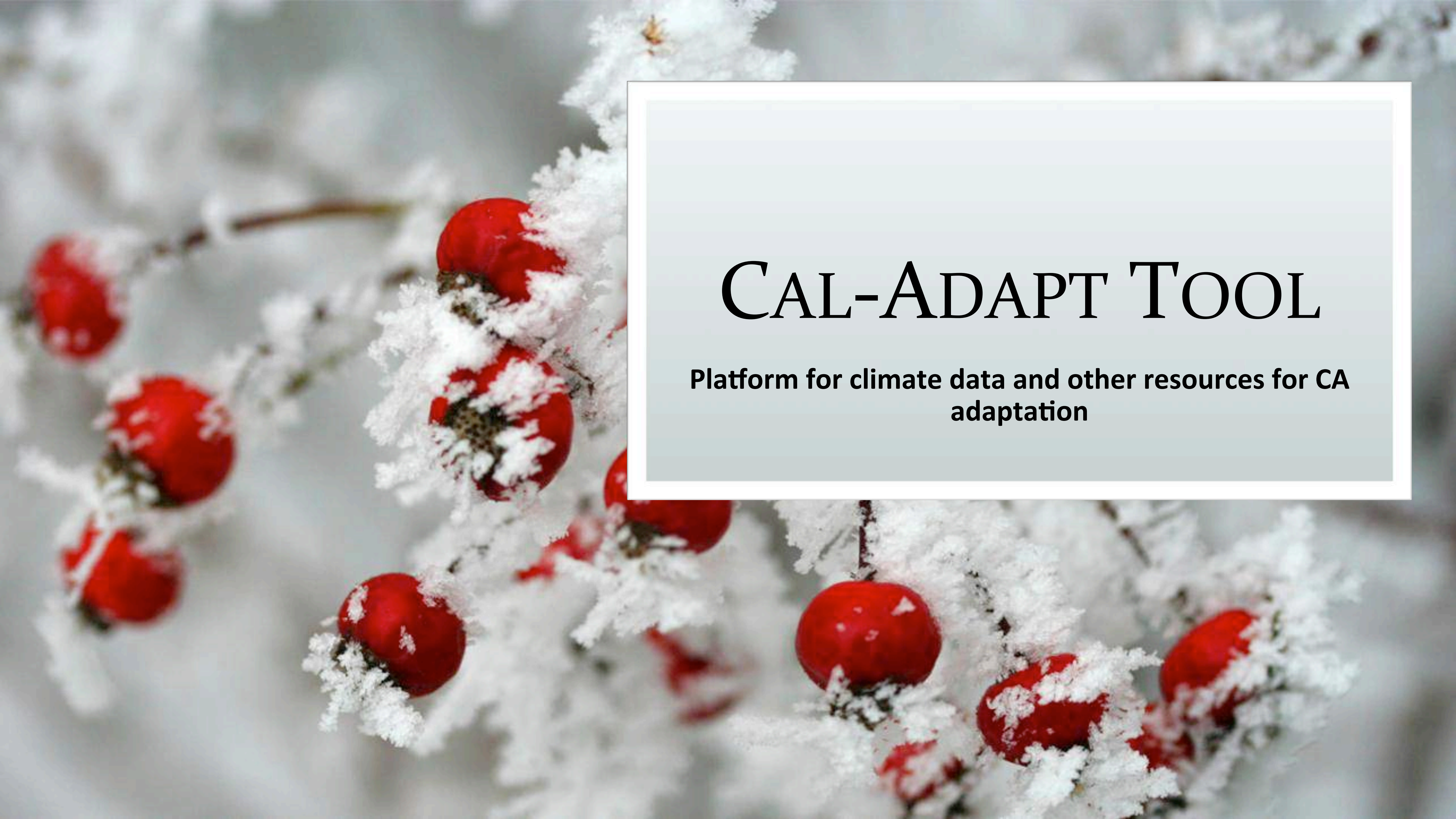


Climate projections will remain somewhat uncertain. However, there are broader trends or patterns that models can predict reasonably well. But is this enough?

- ***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

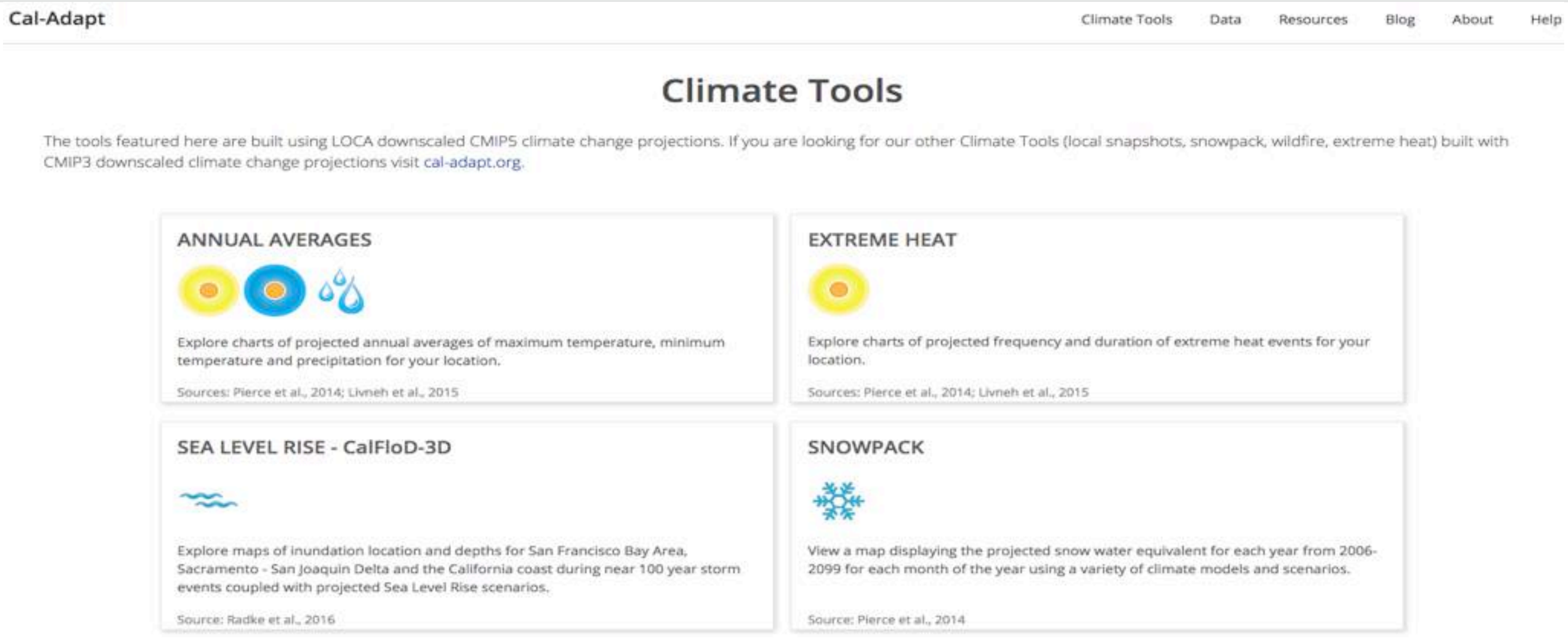
  - Chill in a particular year, 5-year or very near-term trends
  - Specific micro-climatic projections



Cal-Adapt Tool

Platform for climate data and other resources for CA adaptation

CAL-ADAPT



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

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}

EXTRA SLIDES

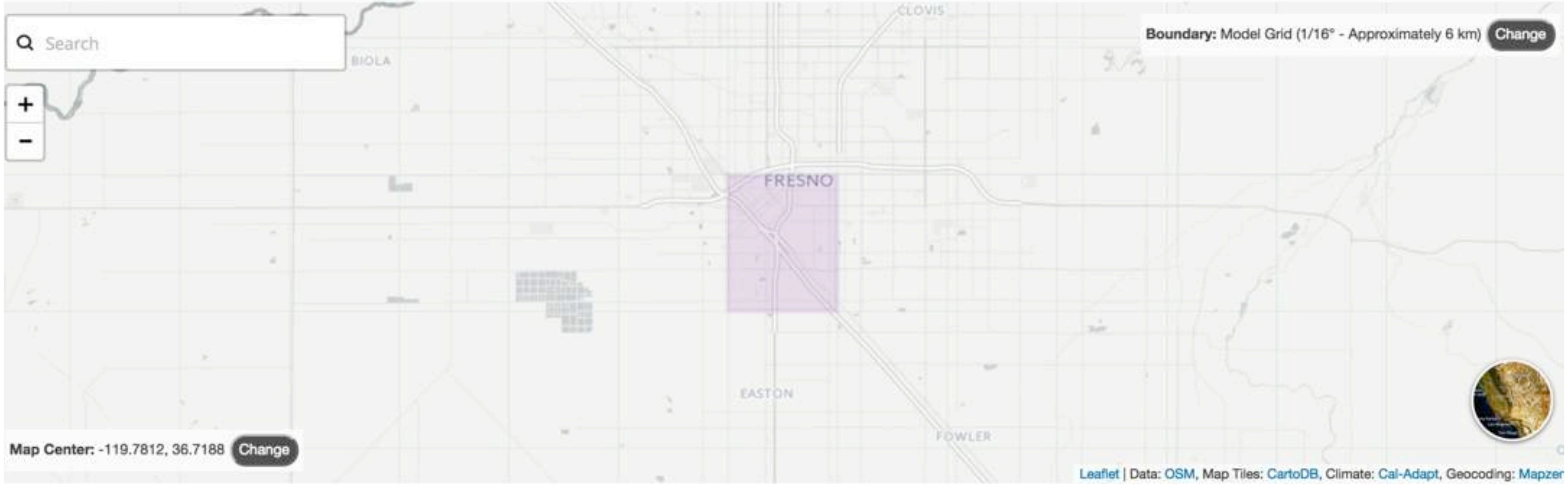
Cal-Adapt

Cal-Adapt extreme heat Fresno Projections

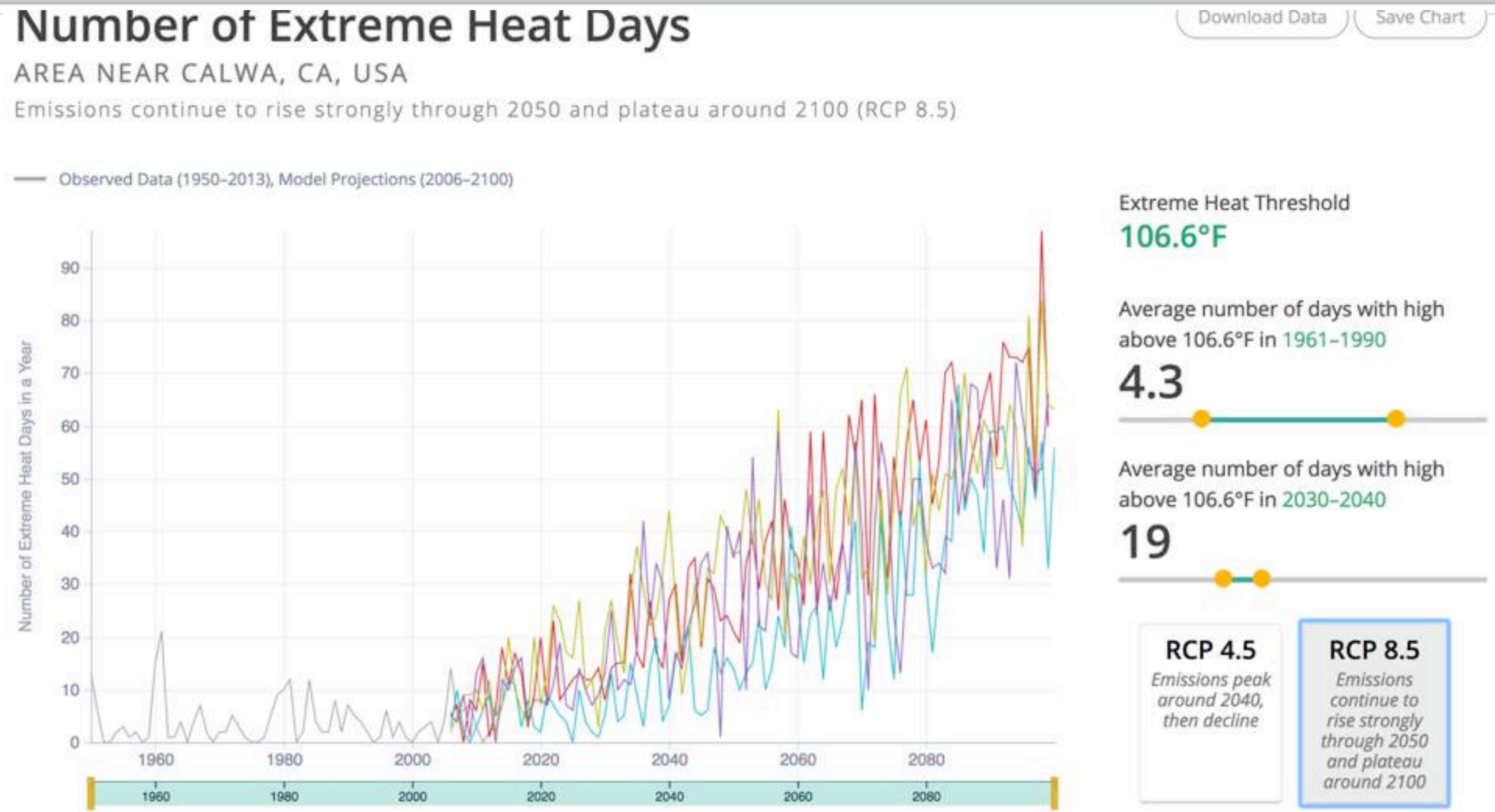
Extreme Heat

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.

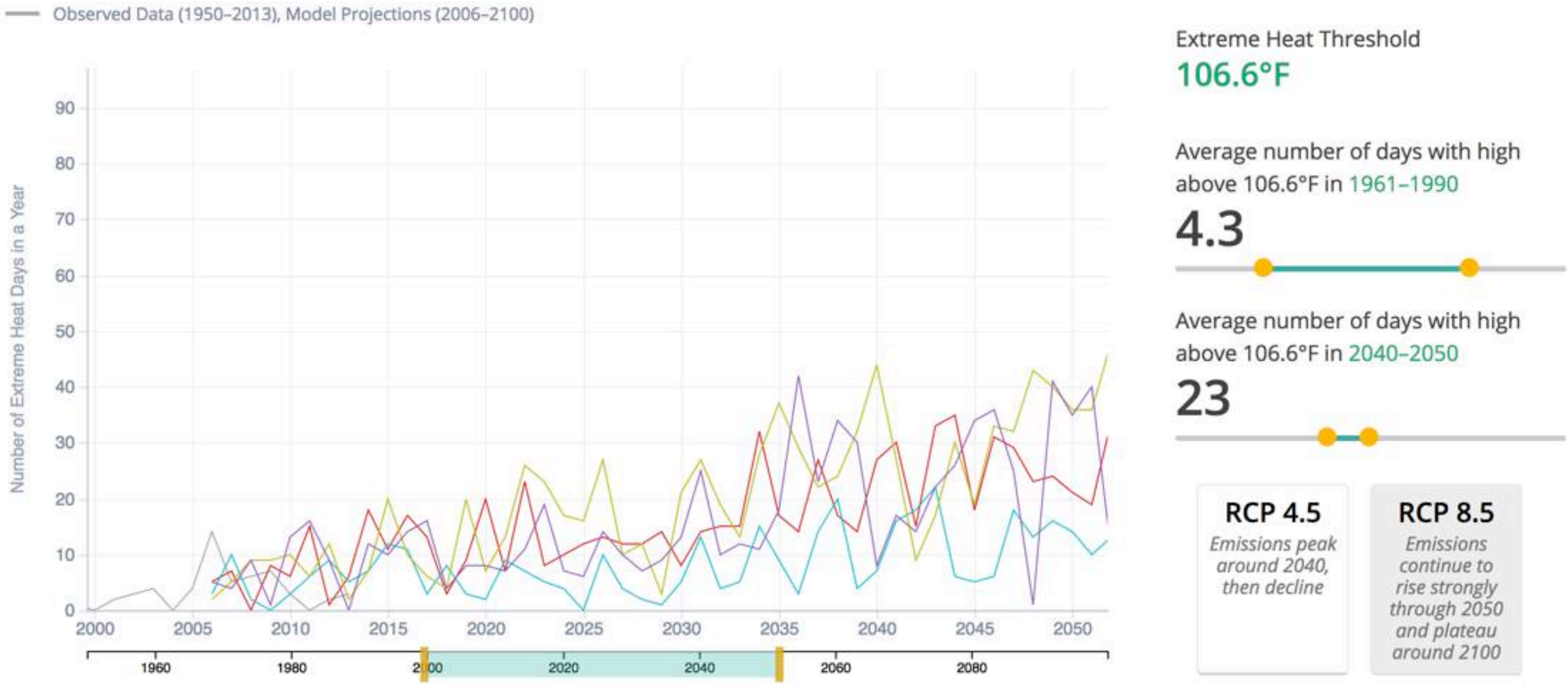
EXPLORE DATA ABOUT DATA SOURCES



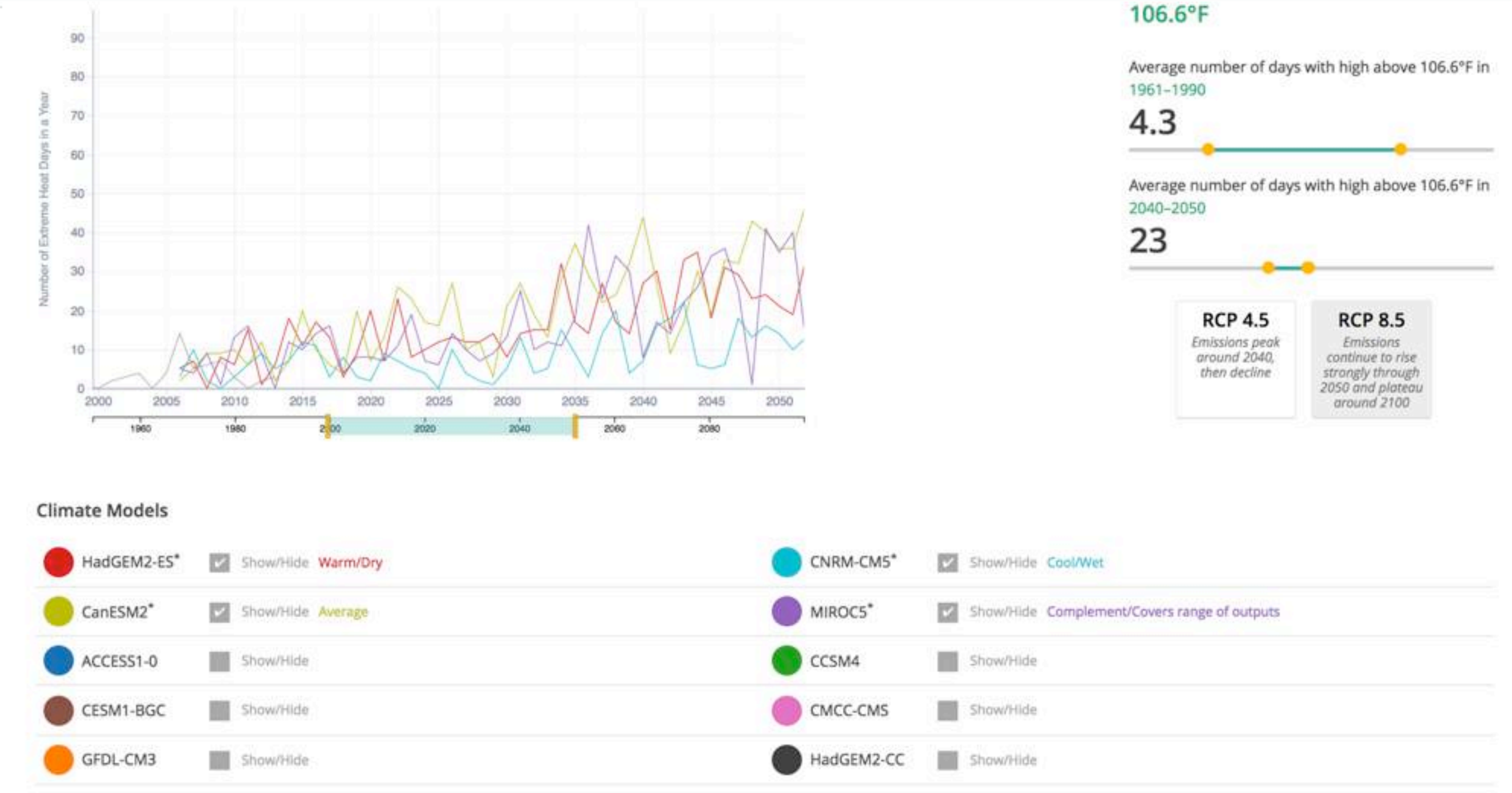
Past trend and projections for 2030-40



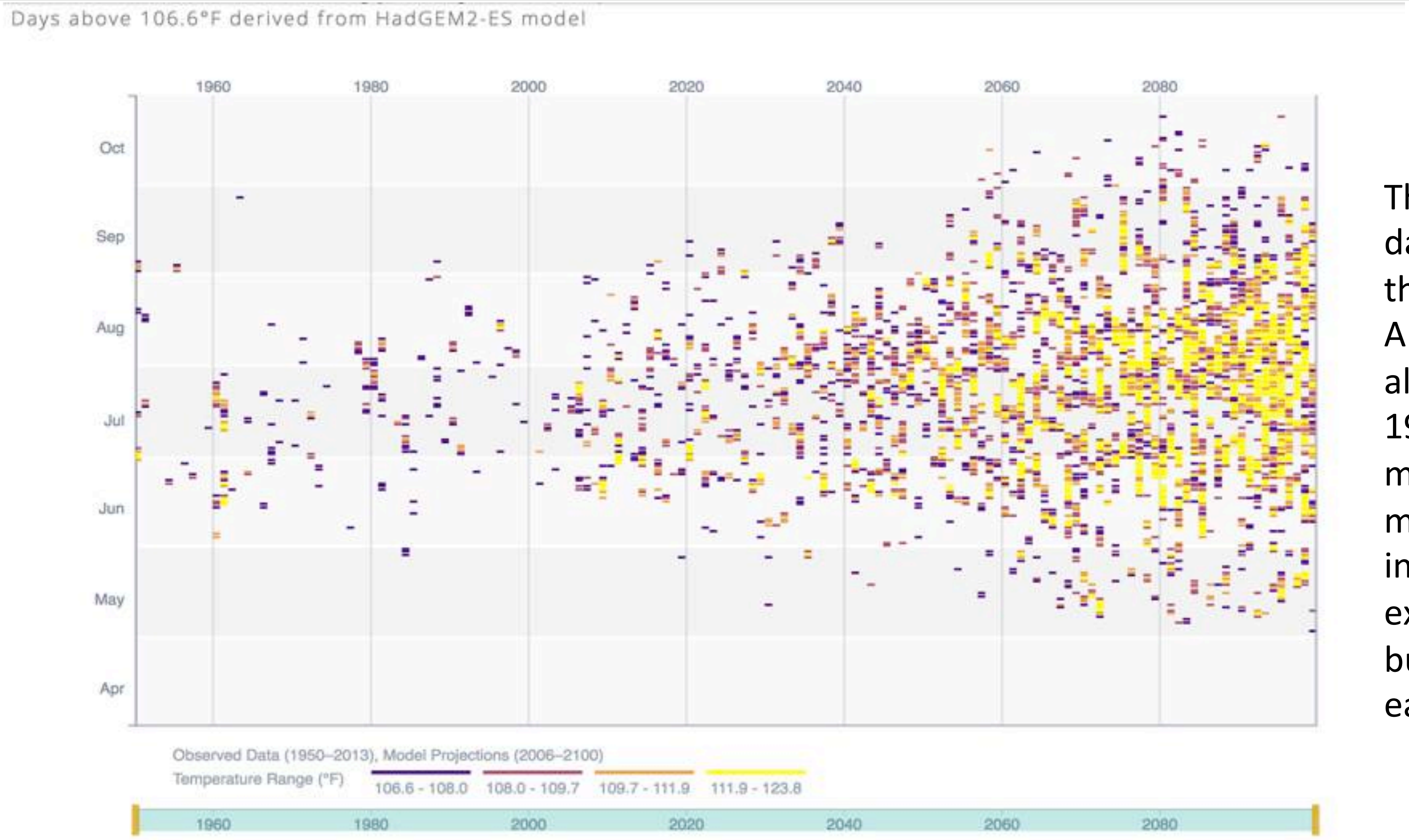
SHORTER TIME SERIES GRAPH



PROJECTIONS FROM DIFFERENT MODELS TO ASSESS UNCERTAINTY



MONTHLY TIME-SERIES GRAPH FROM ONE MODEL

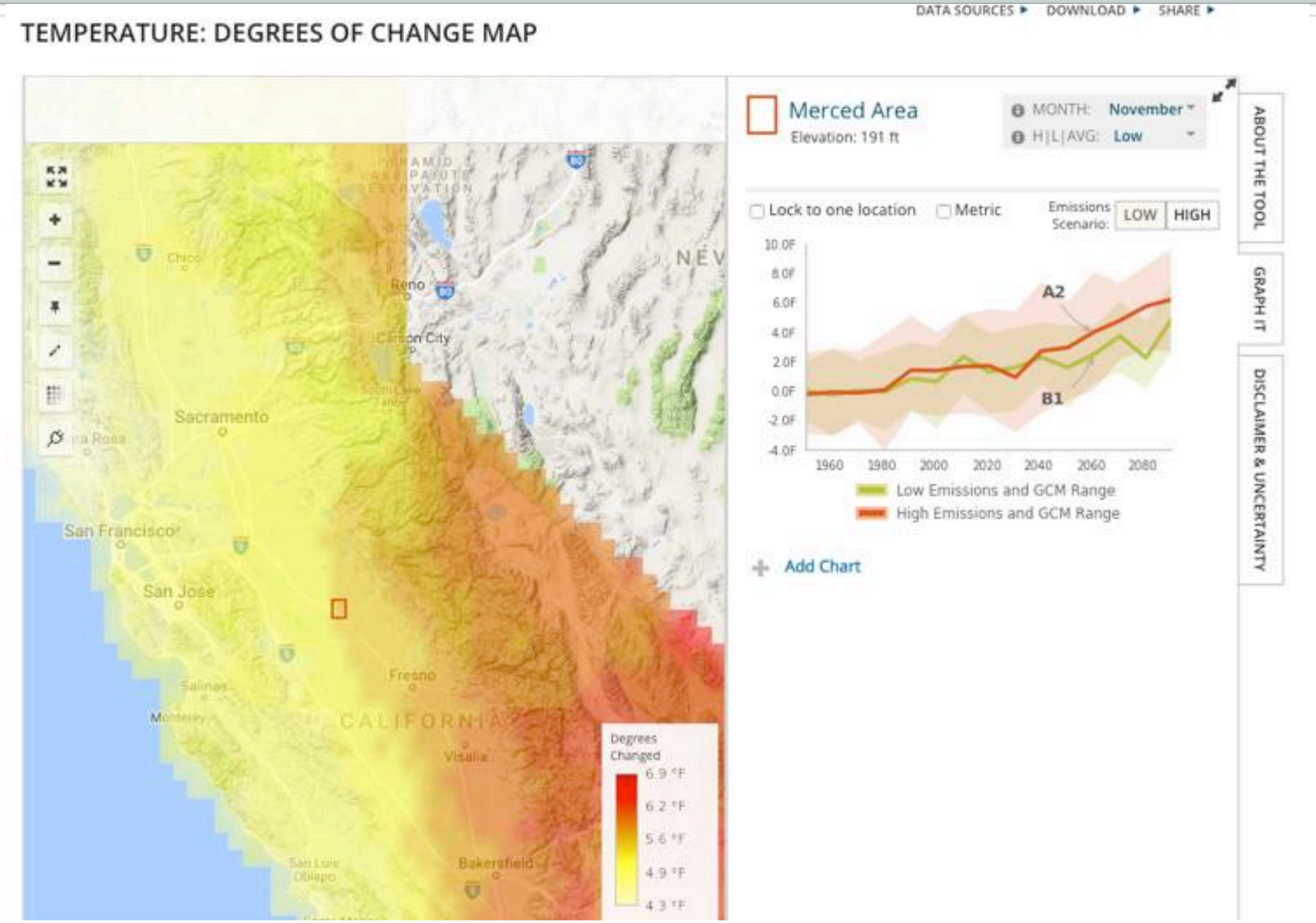


This chart displays a point for each day that exceeds the extreme heat threshold. Time of year between April through October is plotted along the y axis and each year 1950-2100 along the x axis. For most areas around the state, the models project not only an increase in the number of days expected to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



Thank You!

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