Climate Change Trends and Impacts on Agriculture and Water in the West

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University of California Agriculture and Natural Resources

Outline

- Facts about agriculture in California
- Observed and Projected Trends
  - Temperature
  - Precipitation
  - Extreme events
  - Snowpack
- Agricultural Impacts
  - Yield declines
  - Chill accumulations
  - Growing season shifts
  - Pests and Disease pressure
- Summary and Key research directions

Facts about California Agriculture

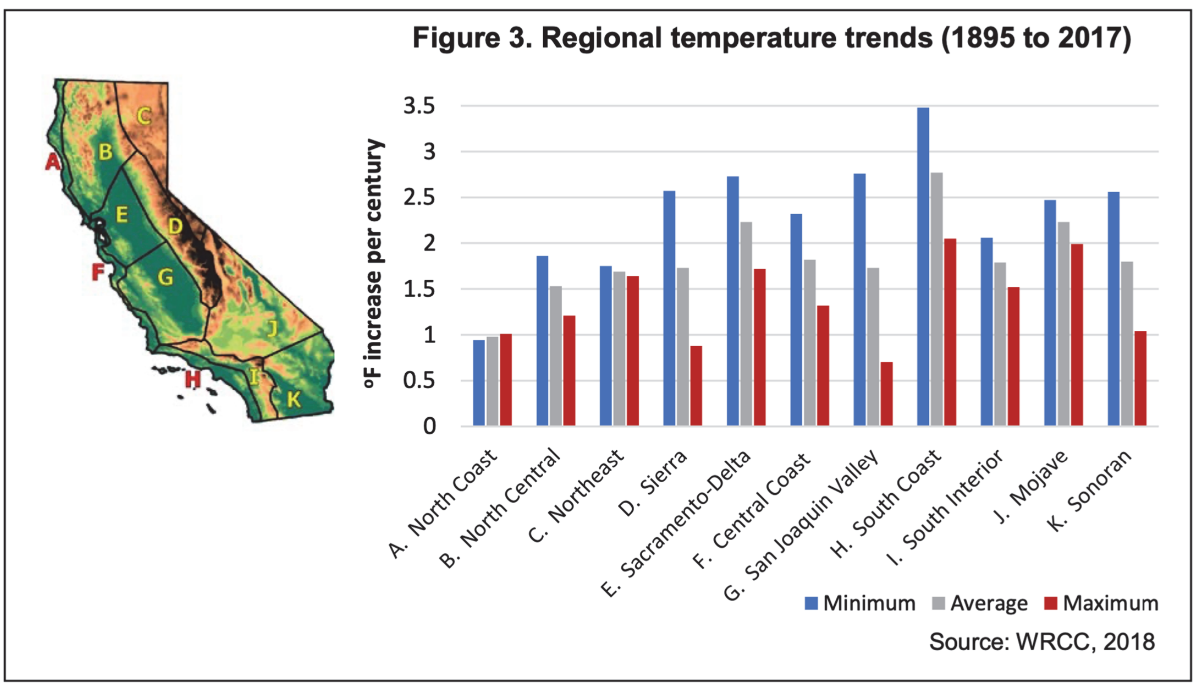
- 76,400 farms producing more than 400 commodities with a farm-gate value of $46 billion
- Of California's approximately 100 million acres of land, 43 million acres are used for agriculture
  - 16 million acres are grazing land, 27 million acres are cropland.
  - Only about 9 million acres of irrigated land
- Leading dairy production; 2/3 of US fruits and nuts production; 1/3 of US vegetable production

California's top—ten valued commodities

- Dairy, Milk — $6.37 billion
- Grapes — $6.25 billion
- Almonds — $5.47 billion
- Cattle — $3.19 billion
- Pistachios — $2.62 billion
- Strawberries — $2.34 billion
- Lettuce — $1.8 billion
- Floriculture — $1.2 billion
- Tomatoes — $1.2 billion
- Oranges — $1.12 billion

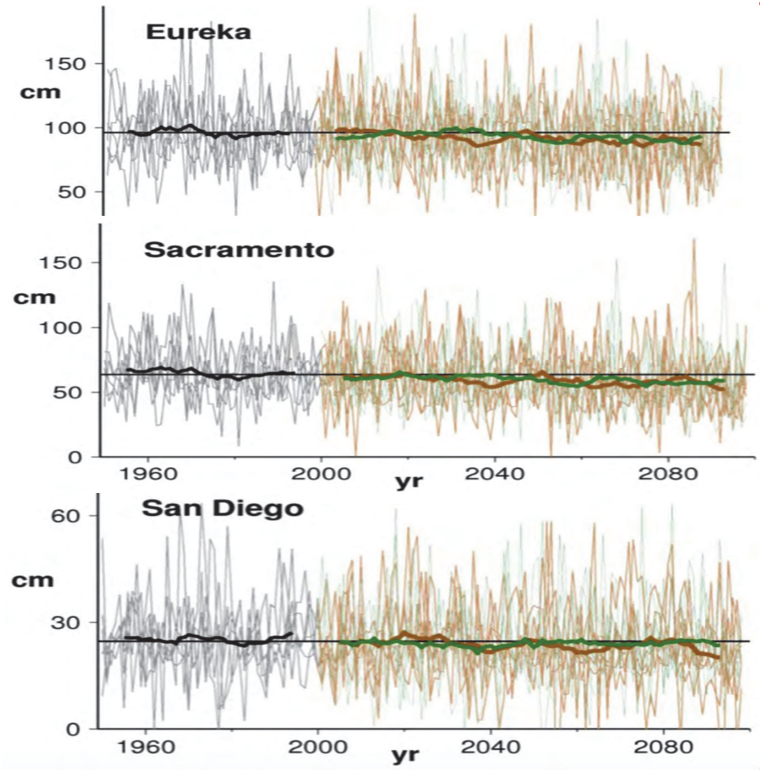
Information Source: CDFA, 2018

Changes in California Temperatures



Cordero et al. (2011)

Precipitation Trends



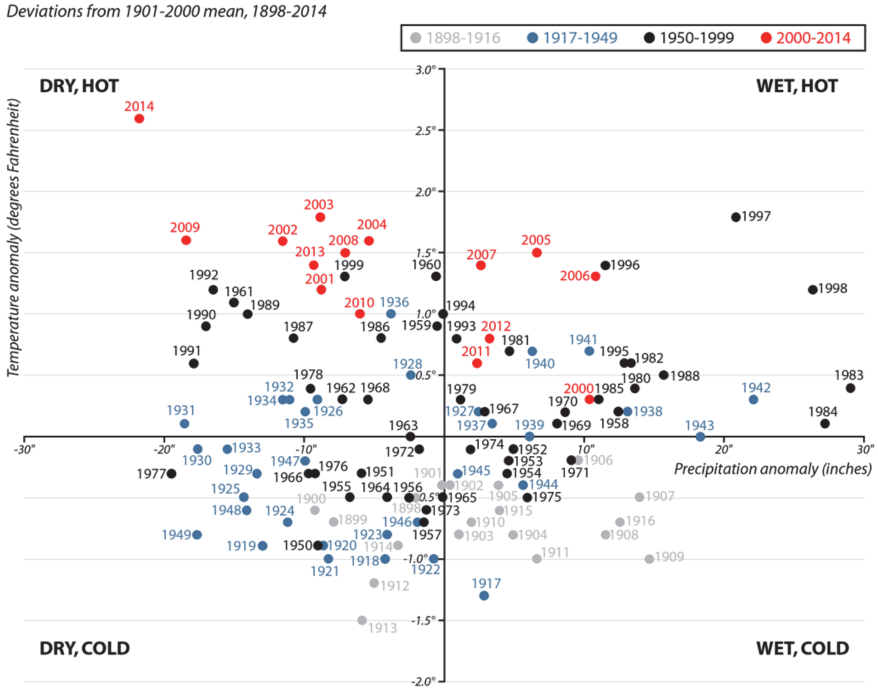
- No clear trend in precipitation
- Large amount of variability, not only from month to month but from year to year and decade to decade suggesting California will remain vulnerable to drought and flooding

Hot, Dry Years Becoming More Common in California

California recently emerged from a five-year drought, but data show the state has been slowly shifting over the past century toward hotter, drier years.

CALIFORNIA TEMPERATURE AND PRECIPITATION ANOMALIES

Deviations from 1901-2000 mean, 1898-2014



SOURCE: M. Mann and P. Gleick, PNAS, 2017

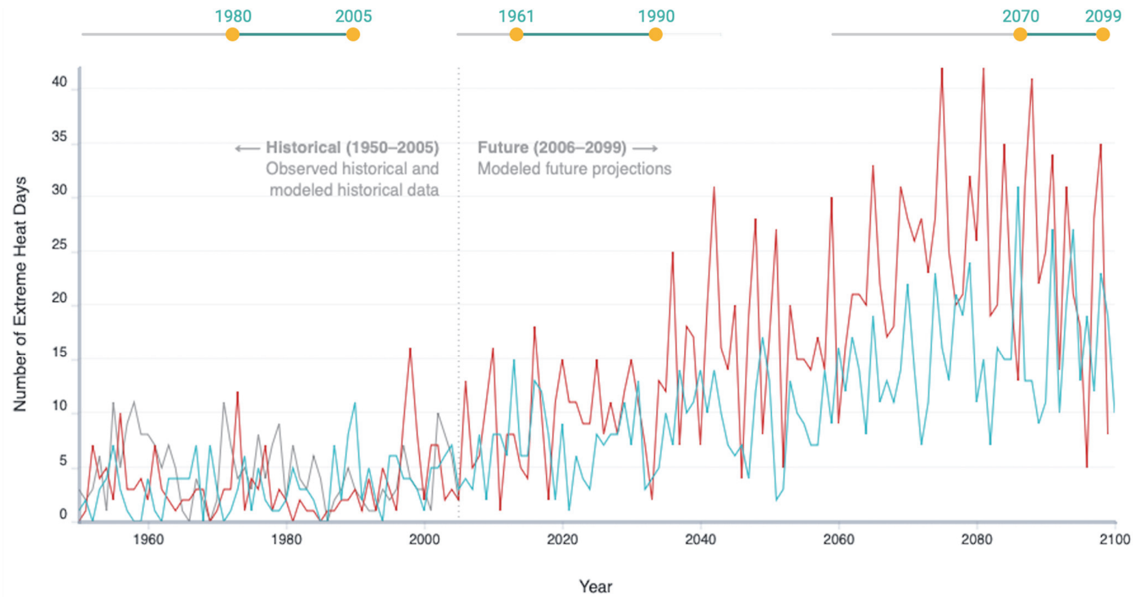
PAUL HORN / InsideClimate News

Extreme Heat Days – San Diego

OBSERVED HISTORICAL
1980–2005
4

MODEL HISTORICAL
1961–1990
3

MODEL PROJECTIONS
2070–2099
21

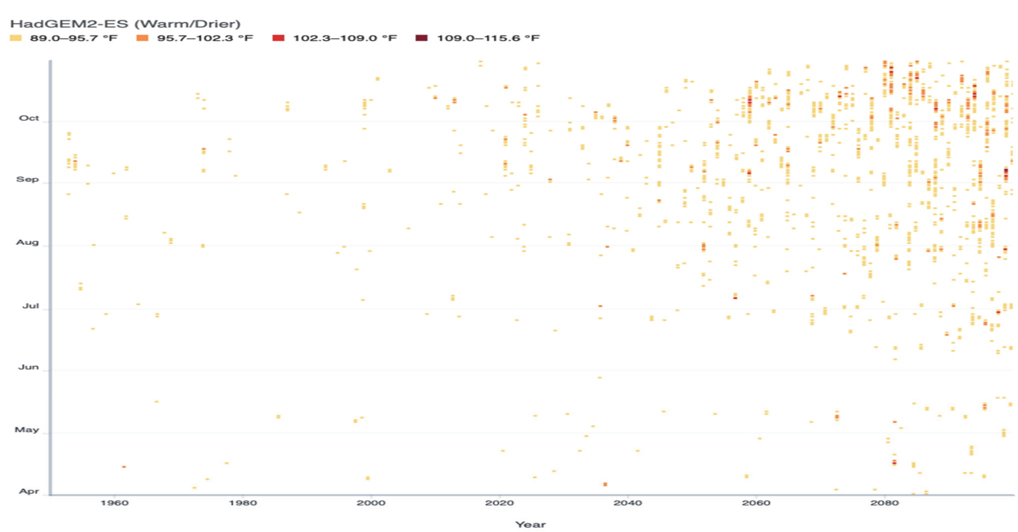


Reference: cal-adapt.org

Timing of Extreme Heat Days

Timing of Extreme Heat Days by Year

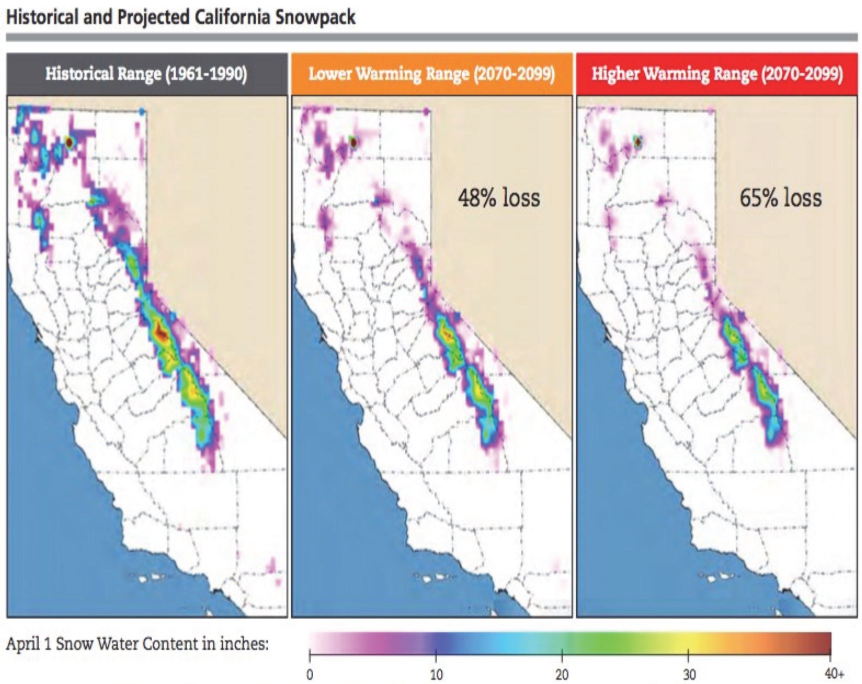
This chart displays a point for each day between April and October in a year when the daily maximum temperature is above the extreme heat threshold of 89 °F. Data is shown for Grid Cell (32.71875, -117.15625) under the RCP 8.5 scenario in which emissions continue to rise strongly through 2050 and plateau around 2100.



- Source: Cal-Adapt. Data: LOCA Downscaled CMIP5 Projections (Scripps Institution of Oceanography), Gridded Observed Meteorological Data (University of Colorado, Boulder).
- Four models have been selected by California's Climate Action Team Research Working Group as priority models for research contributing to California's Fourth Climate Change Assessment. Projected future climate from these four models can be described as producing:
  - A *warm/dry* simulation (HadGEM2-ES)
  - A *cooler/wetter* simulation (CNRM-CM5)
  - An *average* simulation (CanESM2)
  - The model simulation that is most unlike the first three for the best coverage of different possibilities (MIROC5)

Reference: cal-adapt.org

Snowpack



Source: CA DWR

- A loss of 48% and 65% of the snowpack is projected under low and high emission scenarios, respectively
- By 2081–2100, average temperatures in the Sierra Nevada are projected to increase by about 7–10 degrees F (UCLA study)

Impacts on Agriculture

Impacts on Yield

Lee et al. 2011

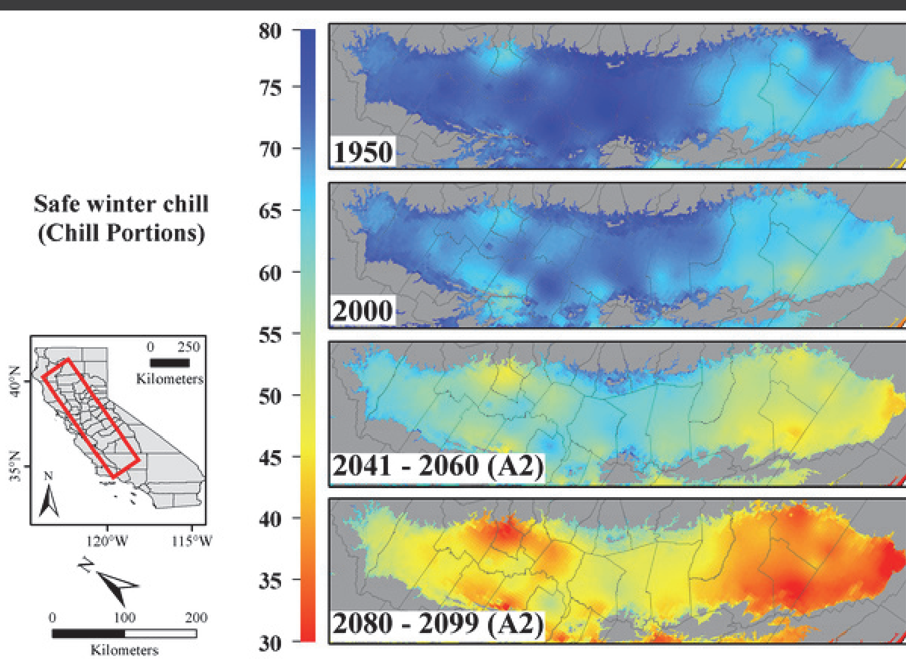
Expected yield reductions by 2097: cotton (≈ 29%) > sunflower (≈ 26%) > wheat (≈ 15%) > maize (12%) > rice (≈ 10%) > tomato (≈ 9%)

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

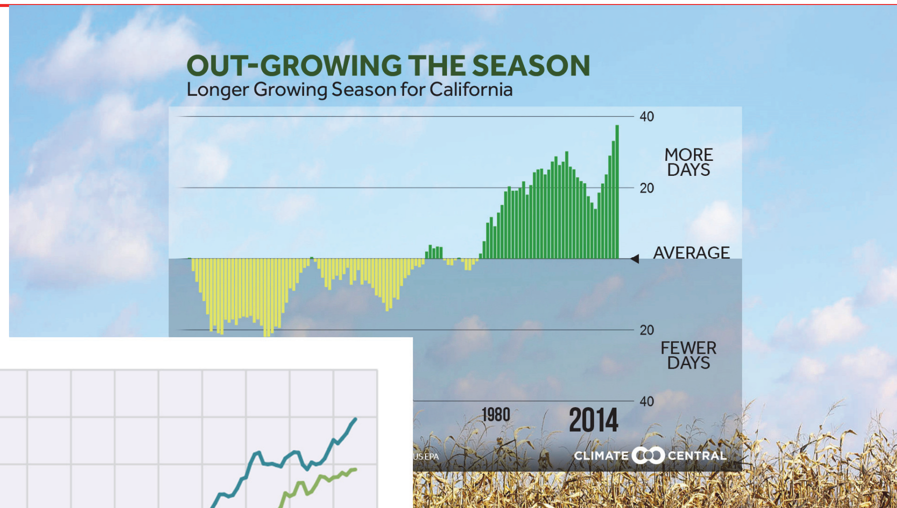
Adaptation measures such as management practices and improved cultivars may alleviate some of the impacts

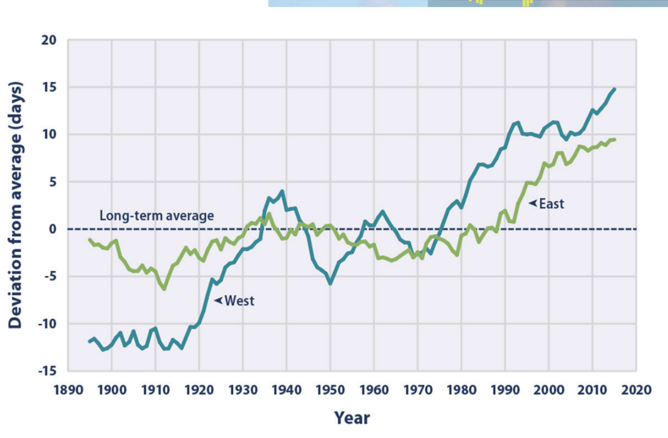
Trends in Chill Accumulations



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://journals.plos.org/plosone/article?id=info:doi/10.1371/journal.pone.0006166

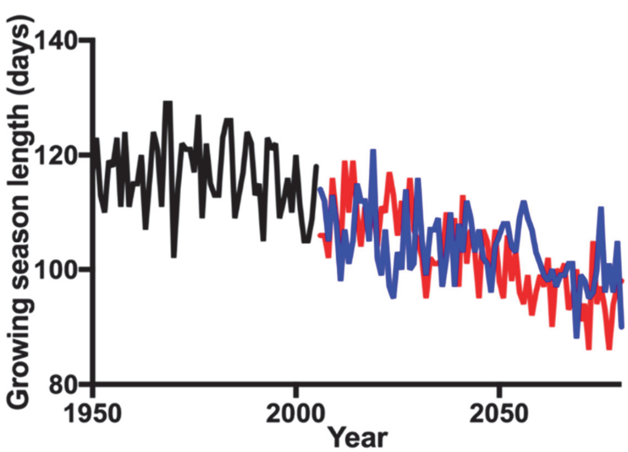
Length of Growing Season

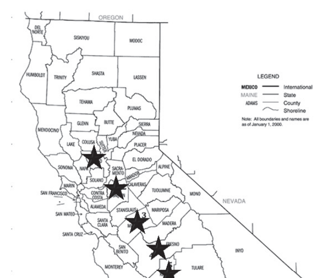




Source: EPA

Impacts on Crop Growing Season





Pathak and Stoddard, 2018

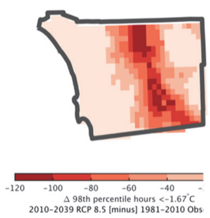
Photo credit: California Tomato Growers Association

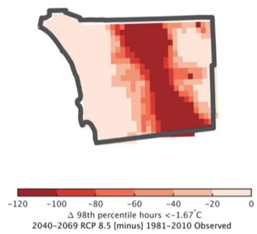
https://link.springer.com/article/10.1007/s40808-018-0460-y

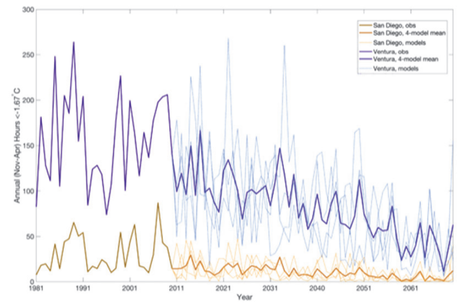
Reduced frost risk under future climate

Lauren Parker, UC Davis;
Tapan Pathak, UC Merced; Steven Ostoja, USDA-ARS

https://doi.org/10.1016/j.scitotenv.2020.143971



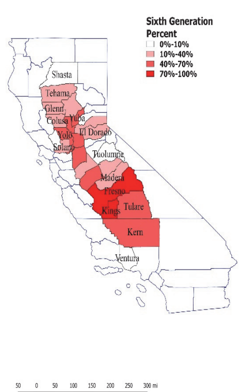




Potential impacts – Weeds Pests and Diseases

Till 2005

2100



Pathak et al. 2020

- Declines in crop and livestock production due to weeds, diseases, insect pests, and other climate change induced stresses (NCA, 2014)
- Frost sensitive pests may survive due to reduced frost risks
- Increased rate of development and potentially northward migration of pests
- Increased weed biomass due to elevated temperature and CO_2, competing with crops for water and nutrients

Cal-AgroClimate
Web-Based Decision Support System
(in development)

Project Lead: Tapan Pathak and Steven Ostoja

- Collaborative work between UC and USDA California Climate Hub
- Web interface that integrates historical weather and short-term forecast to provide crop specific guidance with respect to
  - Heat Advisory
  - Frost Advisory
  - Growing degree day tracking
  - Pest and diseases advisory
  - Trends and forecasts of agroclimatic indices
  - Relevant resources for growers to use these tools to manage risks
- Tools and resources will be developed and modified based on on the feedback received from the stakeholders

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Potential Research Needs

- Enhanced understanding and quantification of agricultural impacts due to extreme events and viable adaptation strategies
- Need better parameterization and validation of models to be utilized for optimizing crop performance under limited water supply and future climate scenarios
- Need for crop specific, region specific framework to translate weather and climate information into meaningful agroclimatic decision support system
- Simply providing the scientific facts is inefficient. Solutions need to integrate stakeholder challenges and help them translate the science into actionable strategies

Thank You!

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