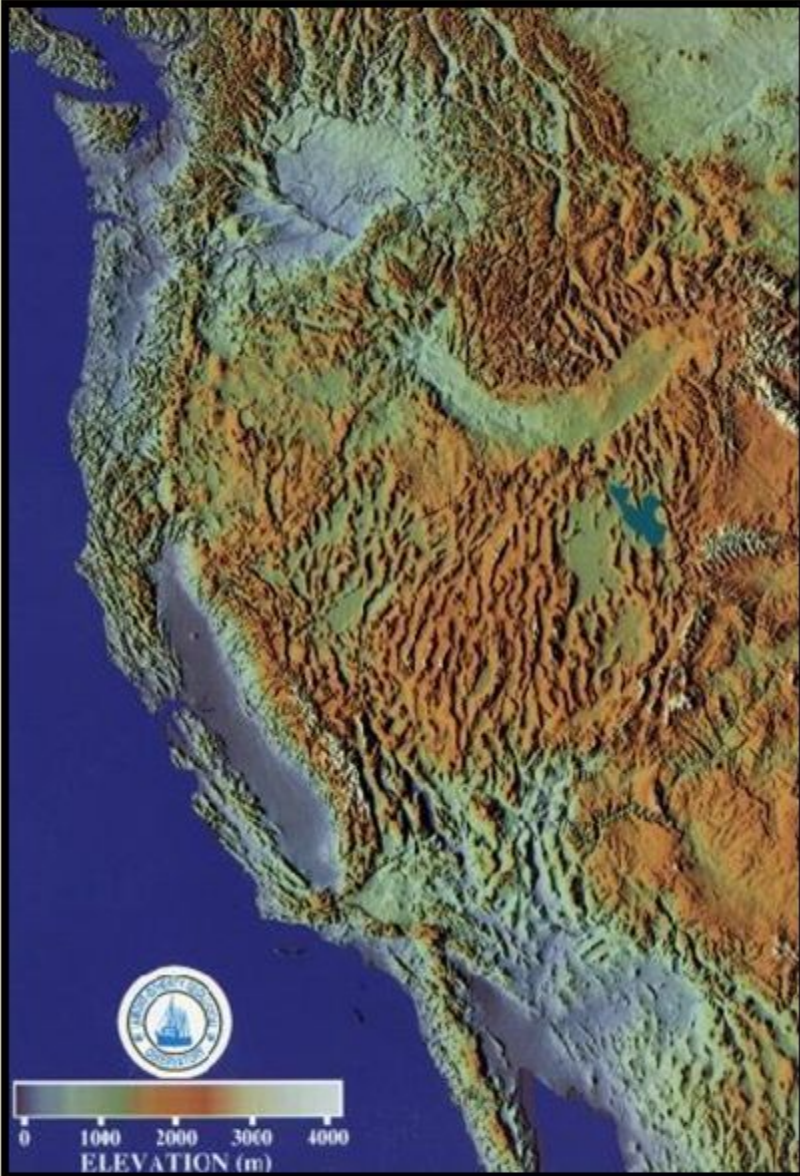




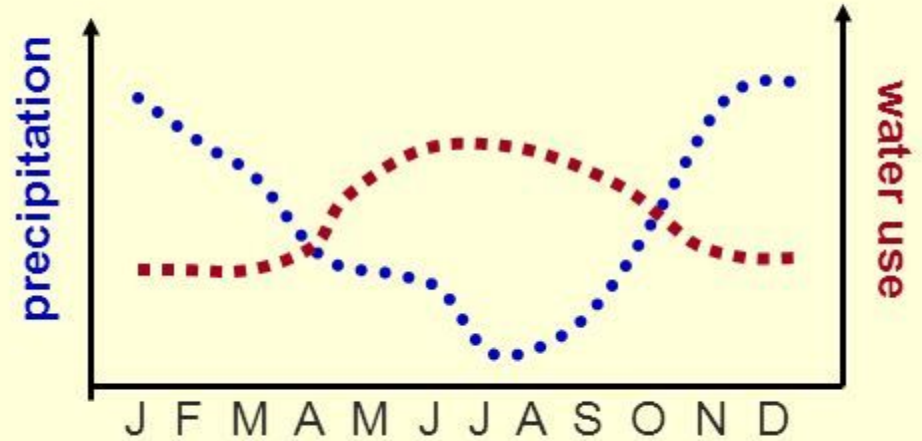
# Kings River Watershed Water Yield, Today and Tomorrow

Mohammad (Safeeq) Safeeq  
Assistant Research Scientist, Sierra Nevada Research Institute &  
Assistant Adjunct Professor, School of Engineering  
University of California-Merced



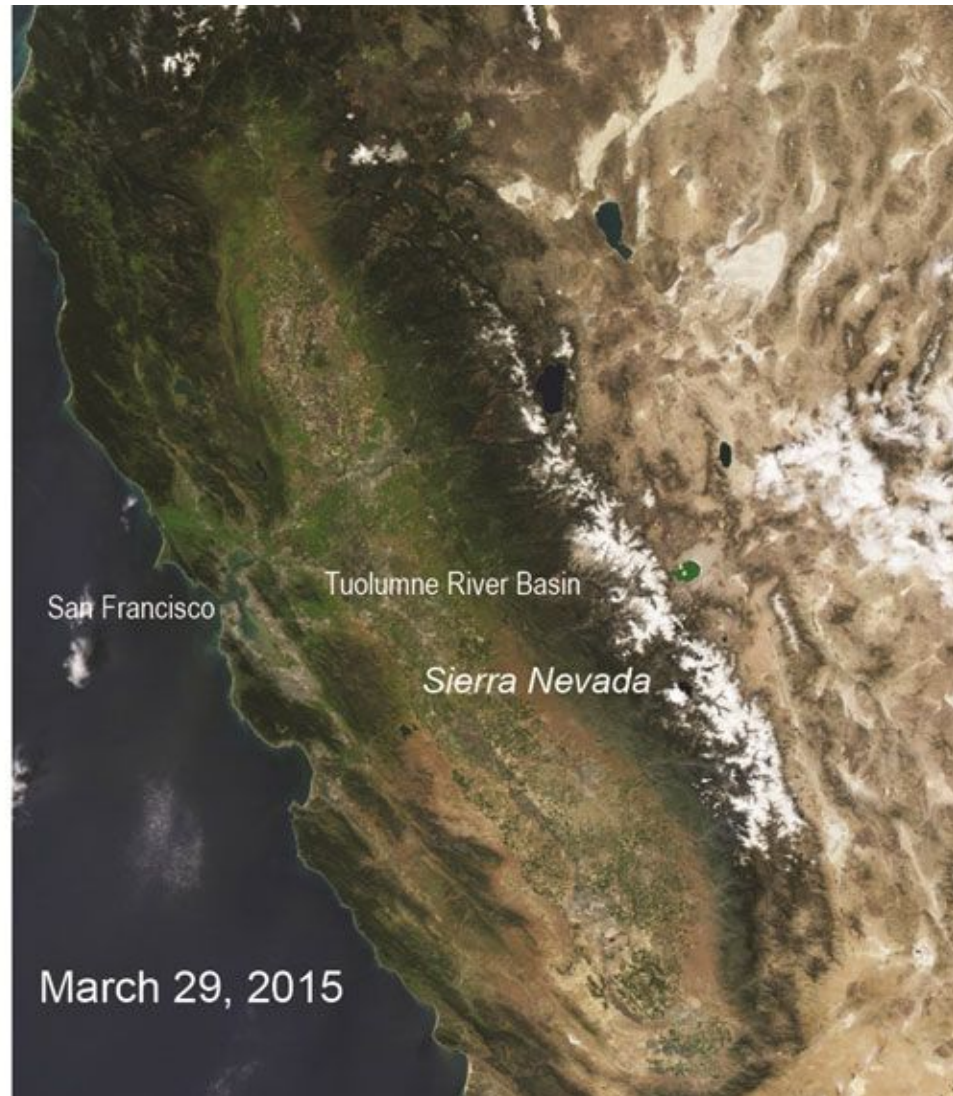
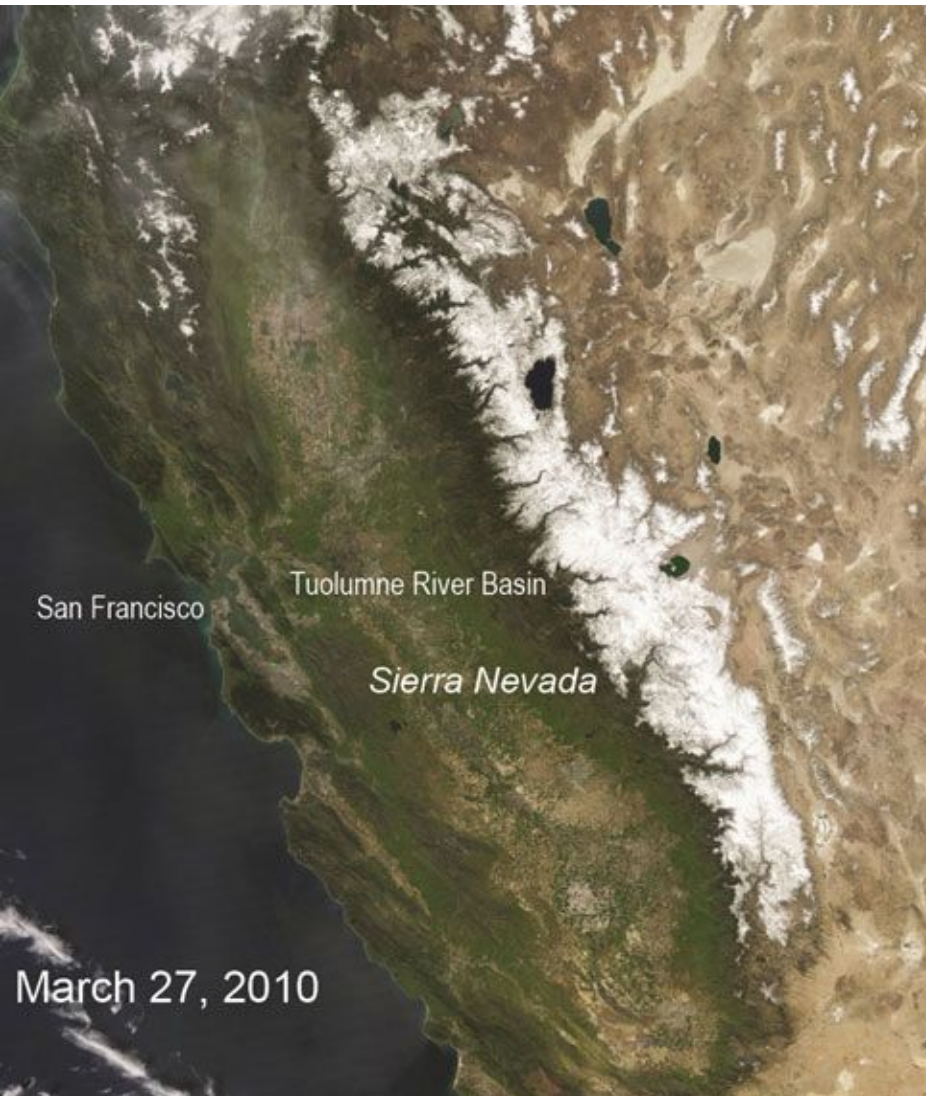


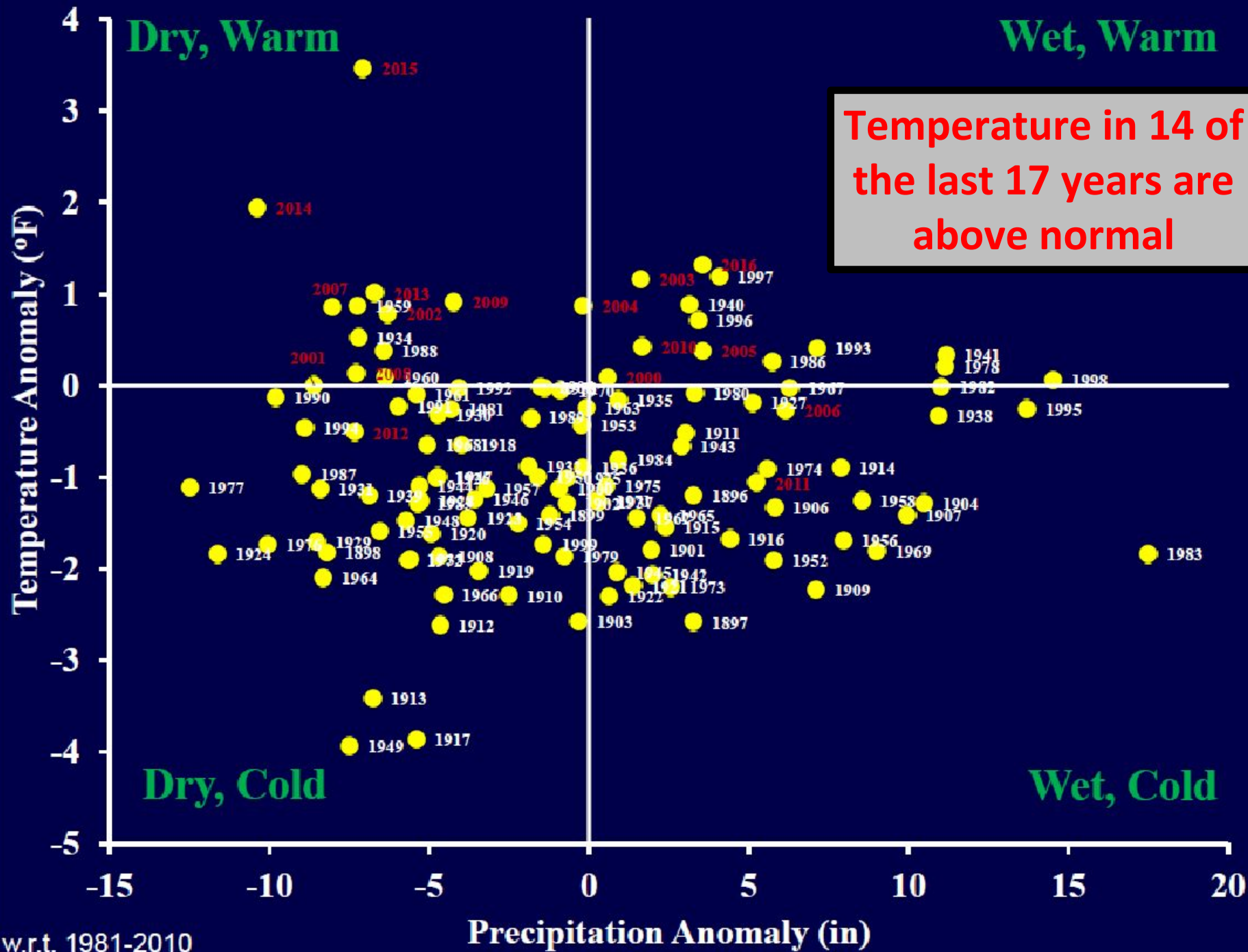
# The paradox of water in the West...

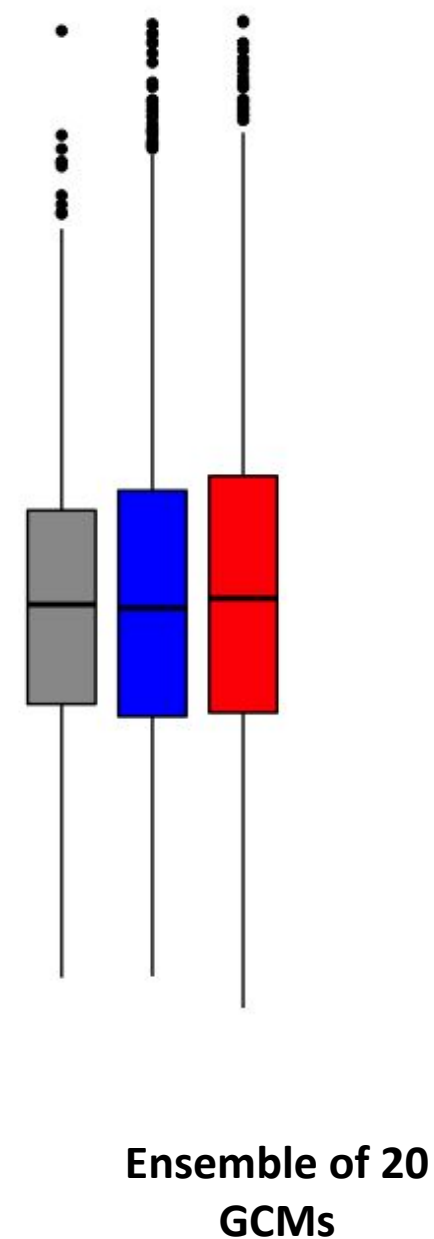
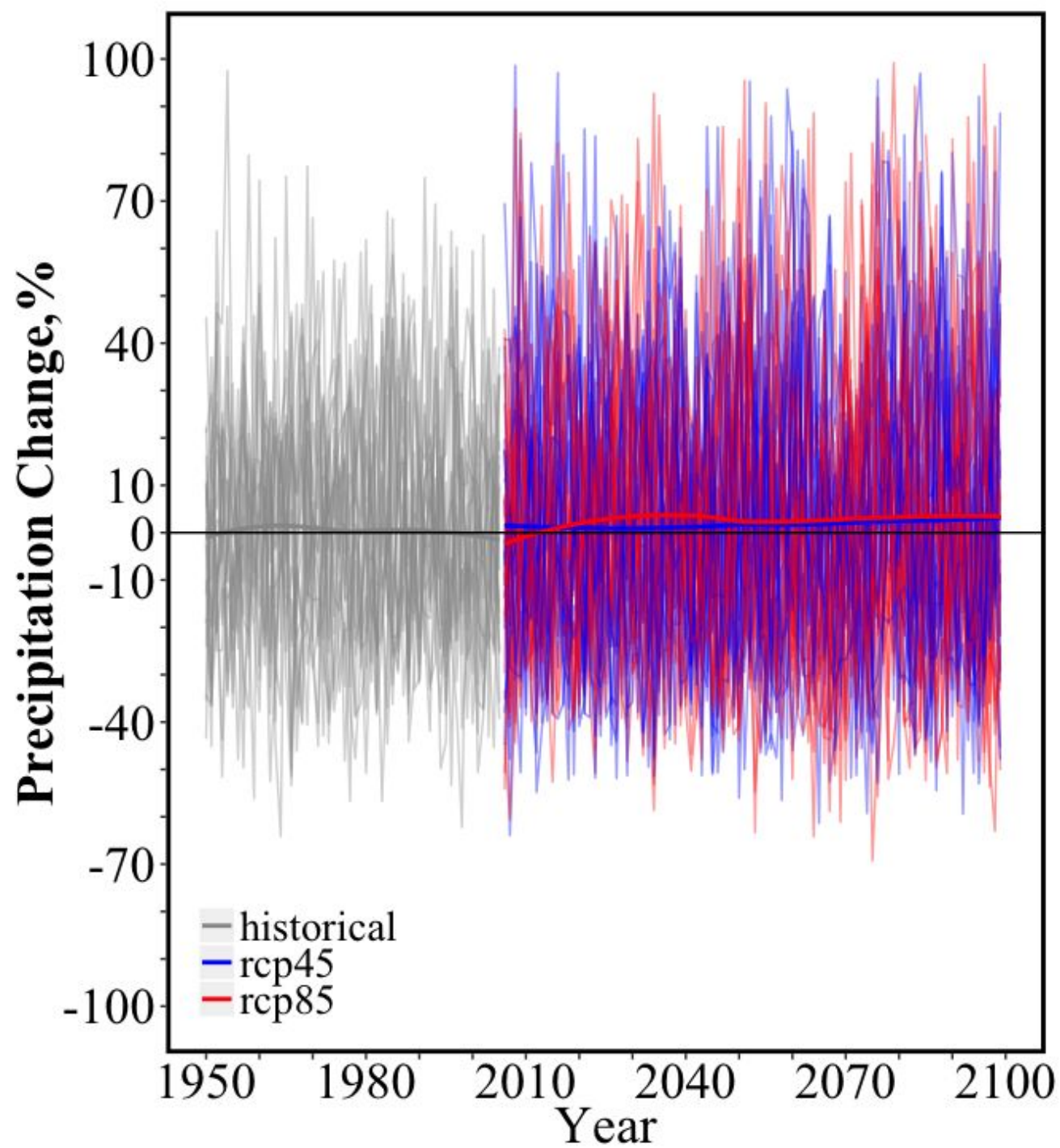


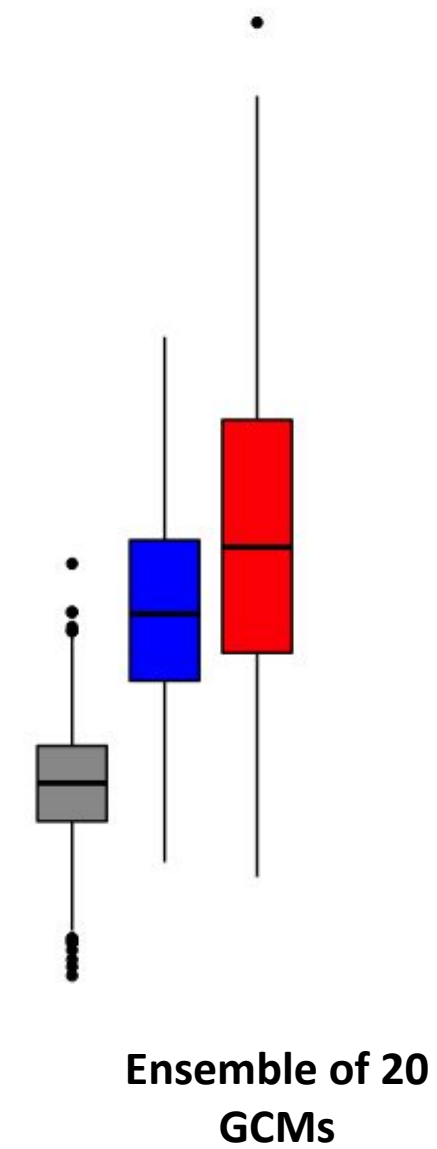
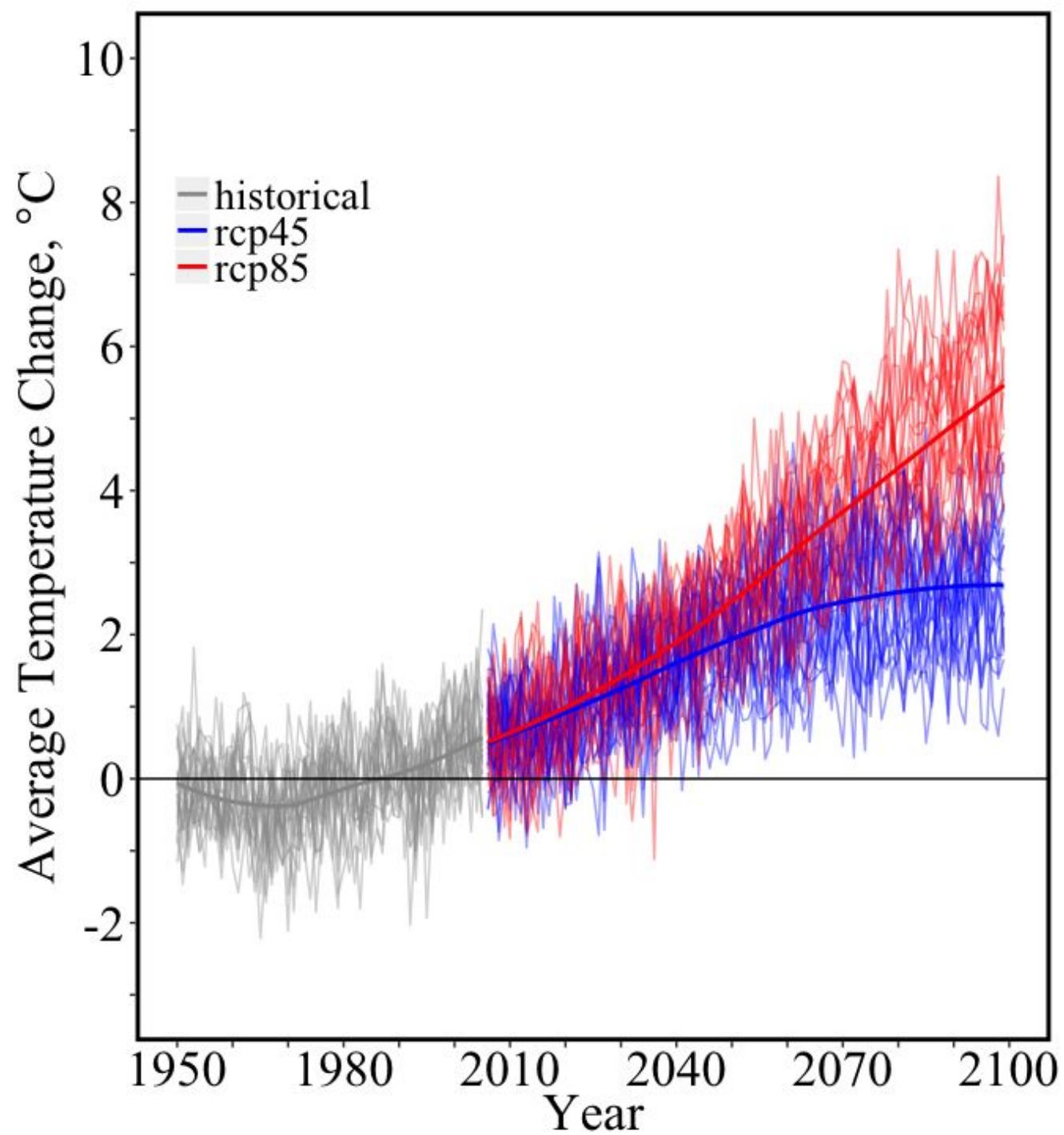
# Sierra Nevada Snowpack Shrinks to Lowest Level in 500 Years

(Belmecheri et al., 2015)





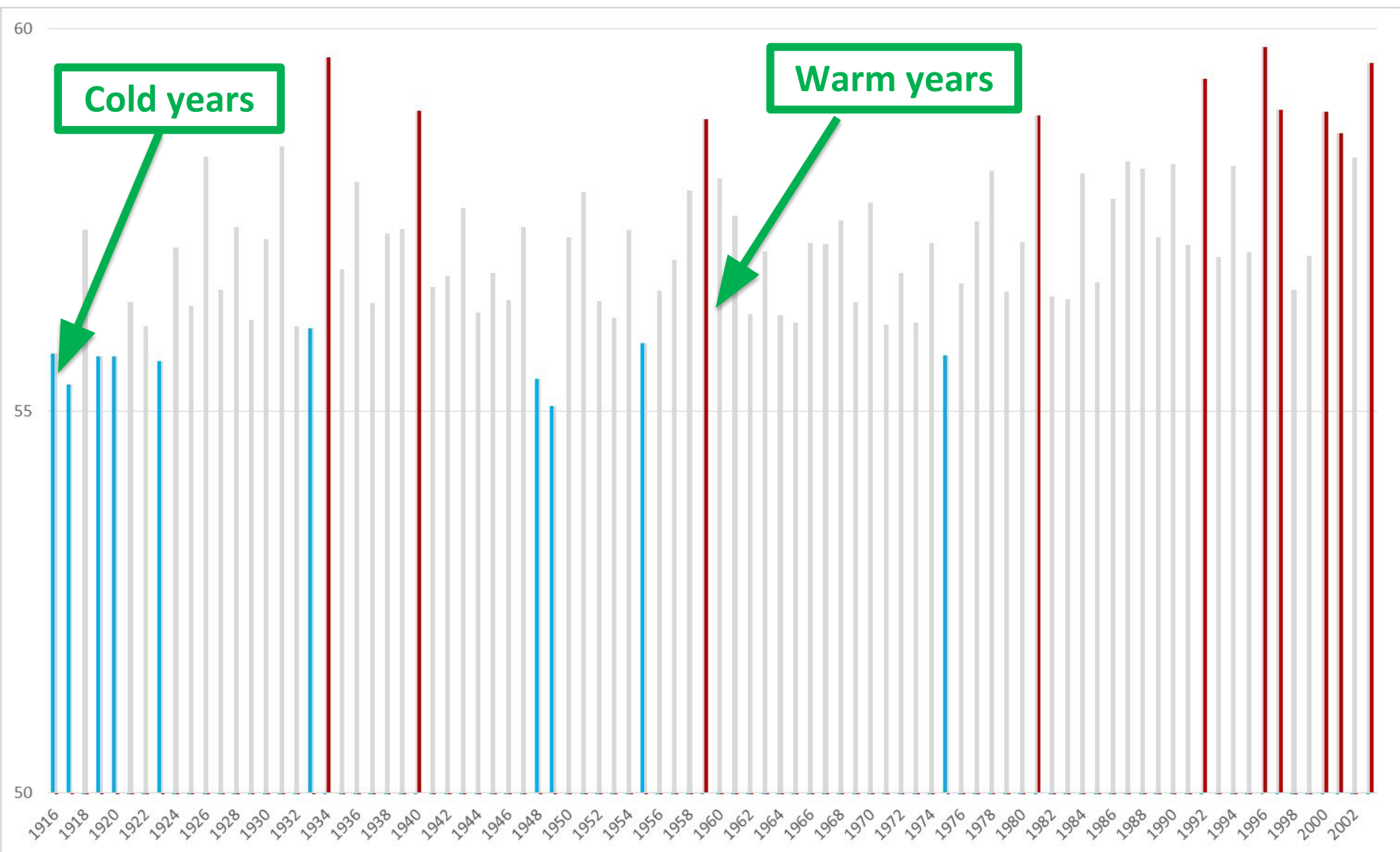




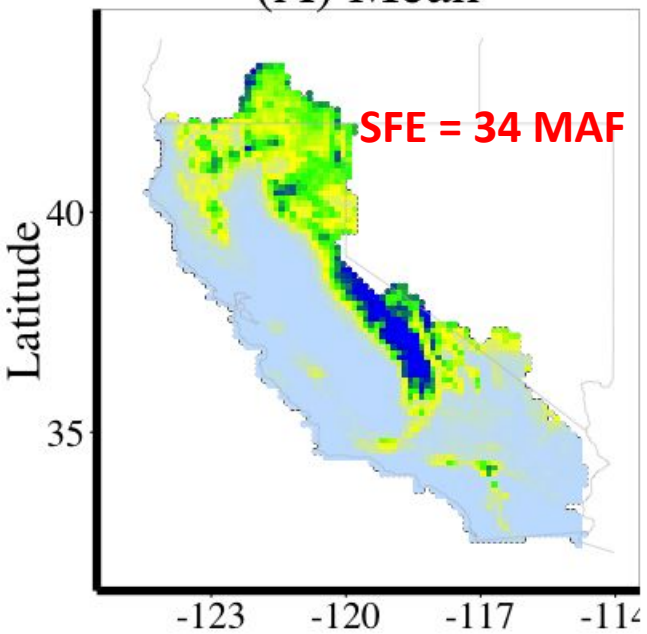
# Shifts in California's temperatures and why it matters

- Higher evapotranspiration
- Higher environmental flow
- Increase in the size of wildfires
- More heat waves, a longer frost-free season, and fewer cold snaps
- **A lack of snow accumulation during near-normal winter precipitation (a.k.a. warm snow drought)**
  - A shift in precipitation phase

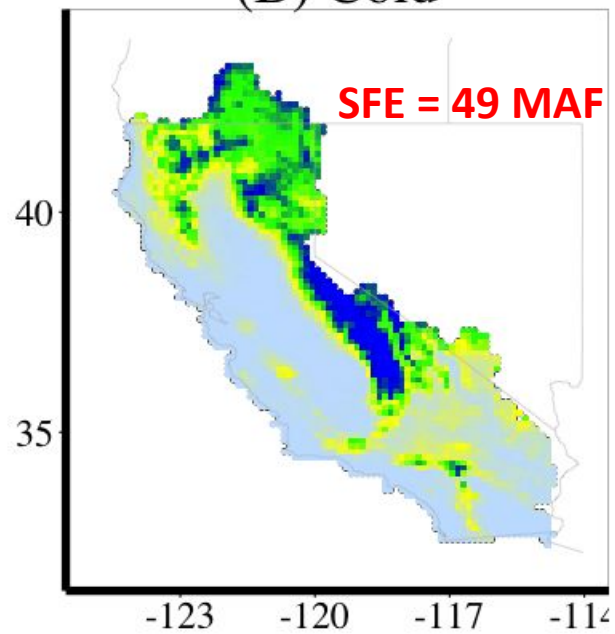
# Warm and cold periods of the past



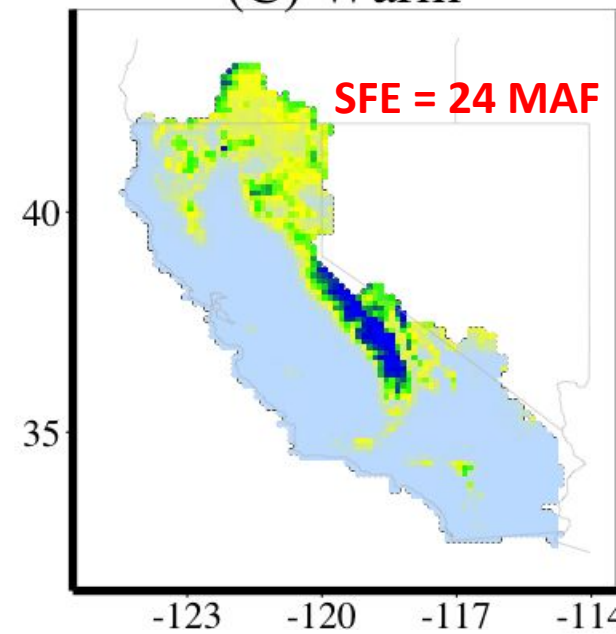
(A) Mean



(B) Cold



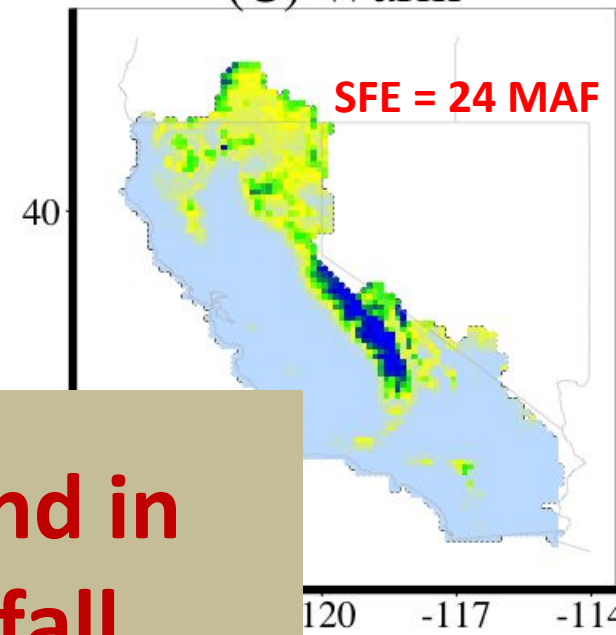
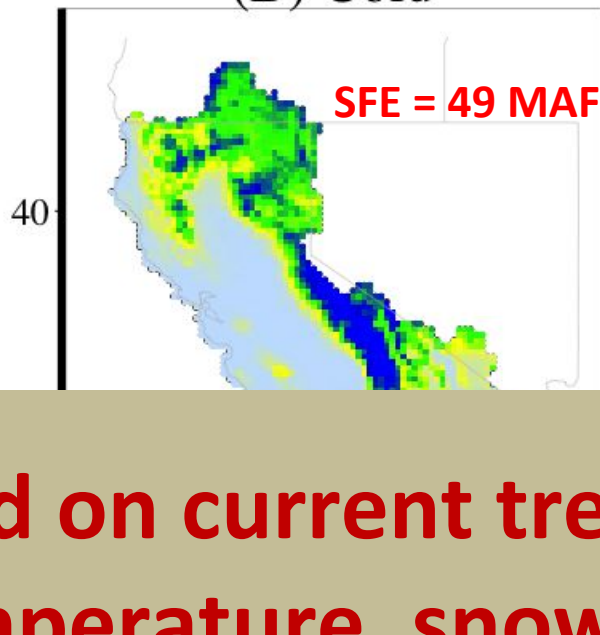
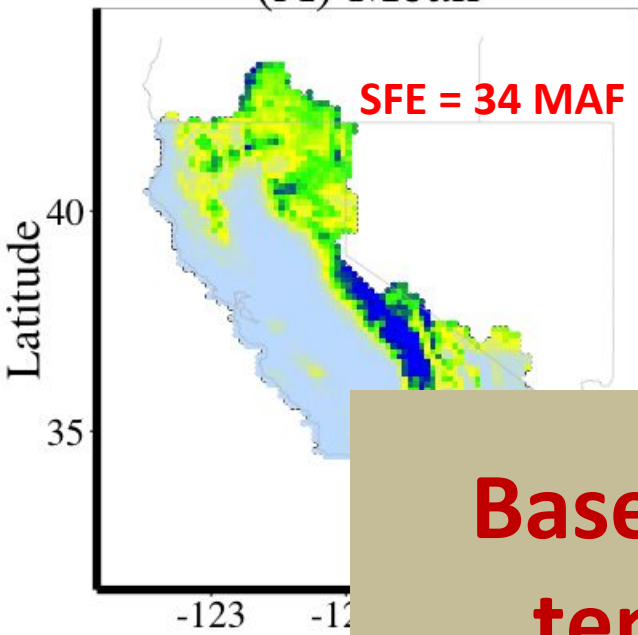
(C) Warm



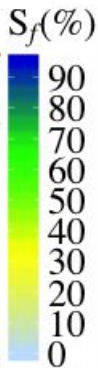
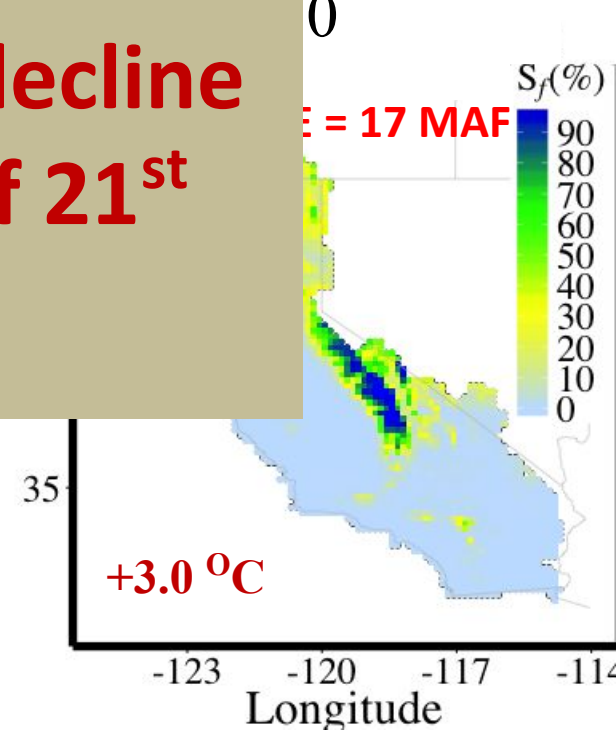
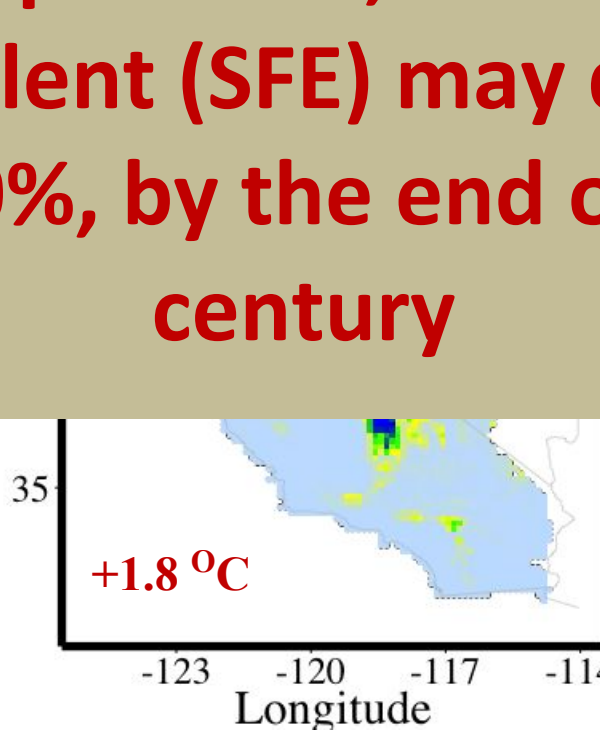
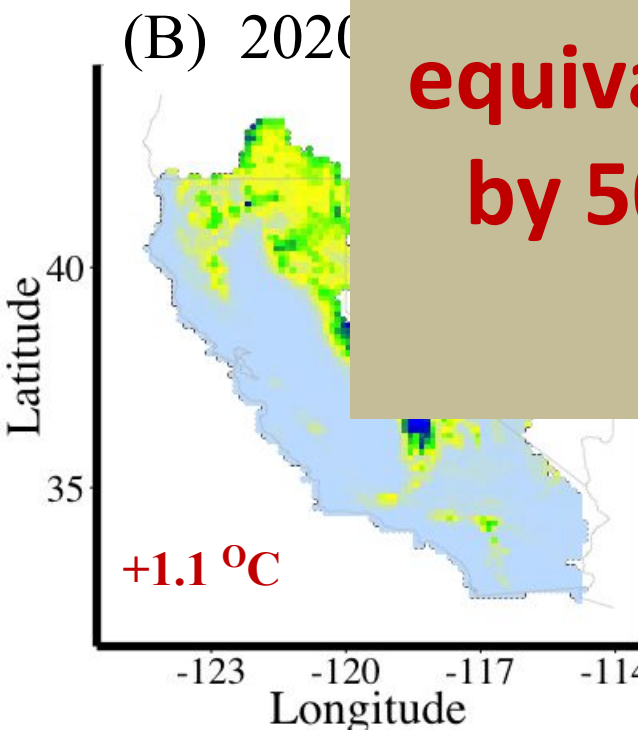
(A) Mean

(B) Cold

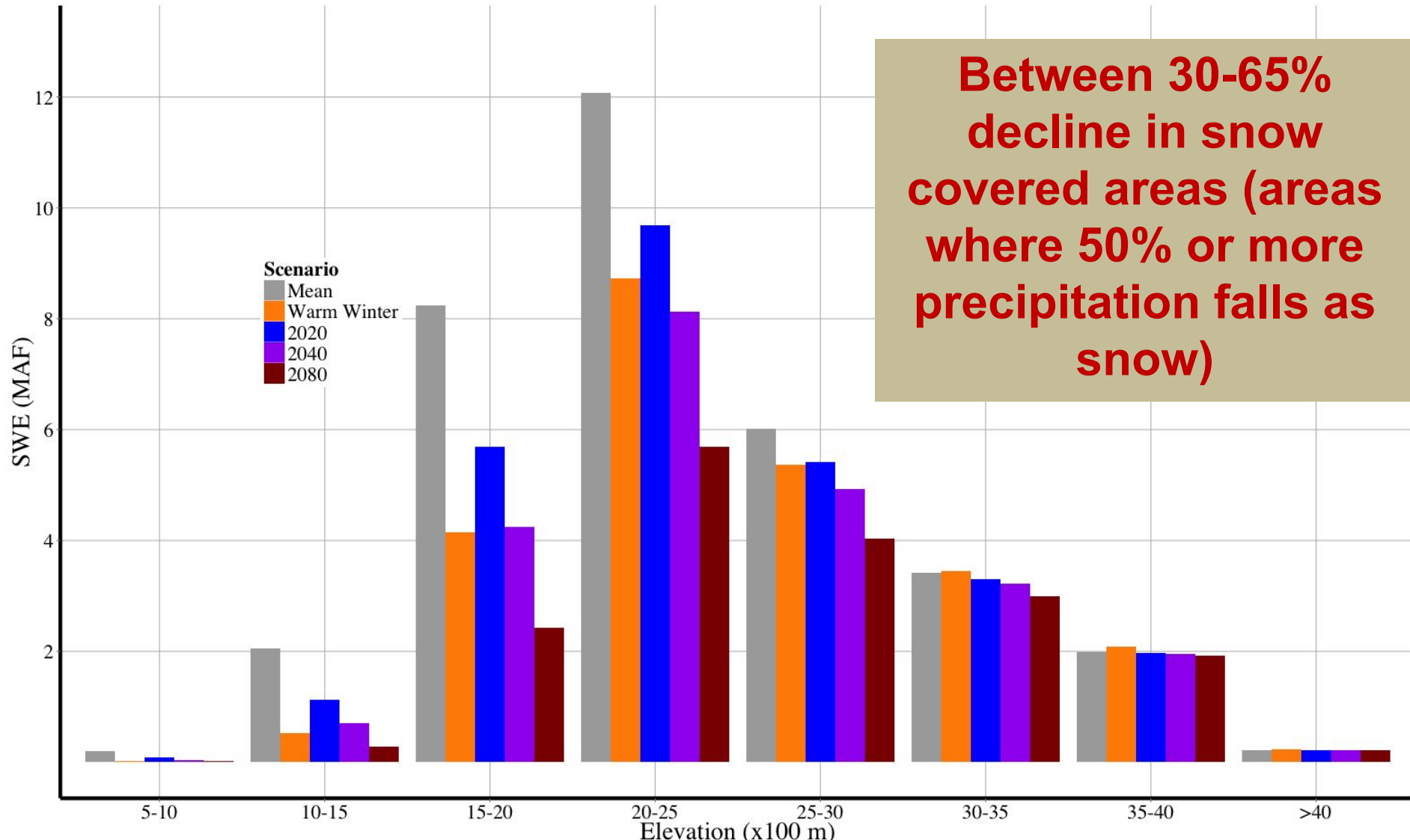
(C) Warm



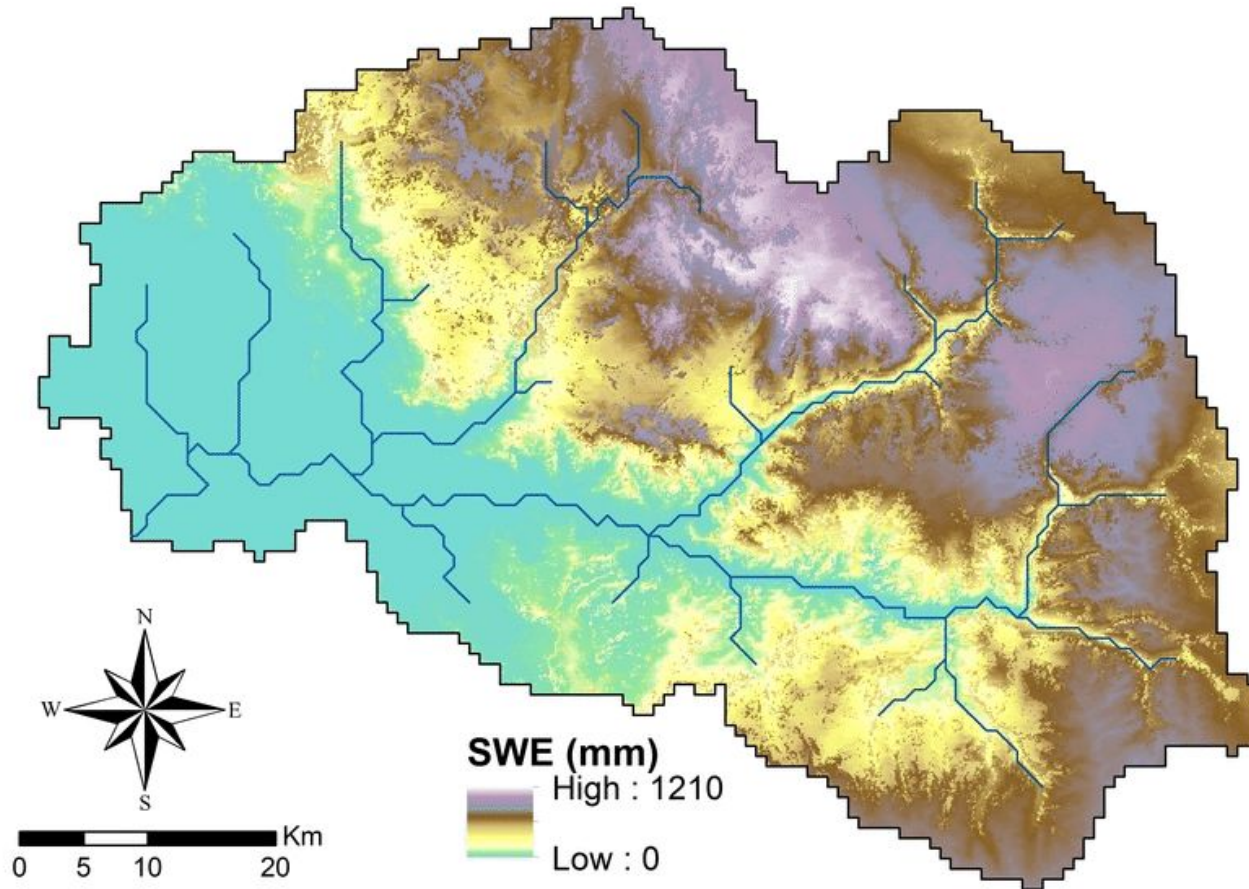
**Based on current trend in temperature, snowfall equivalent (SFE) may decline by 50%, by the end of 21<sup>st</sup> century**



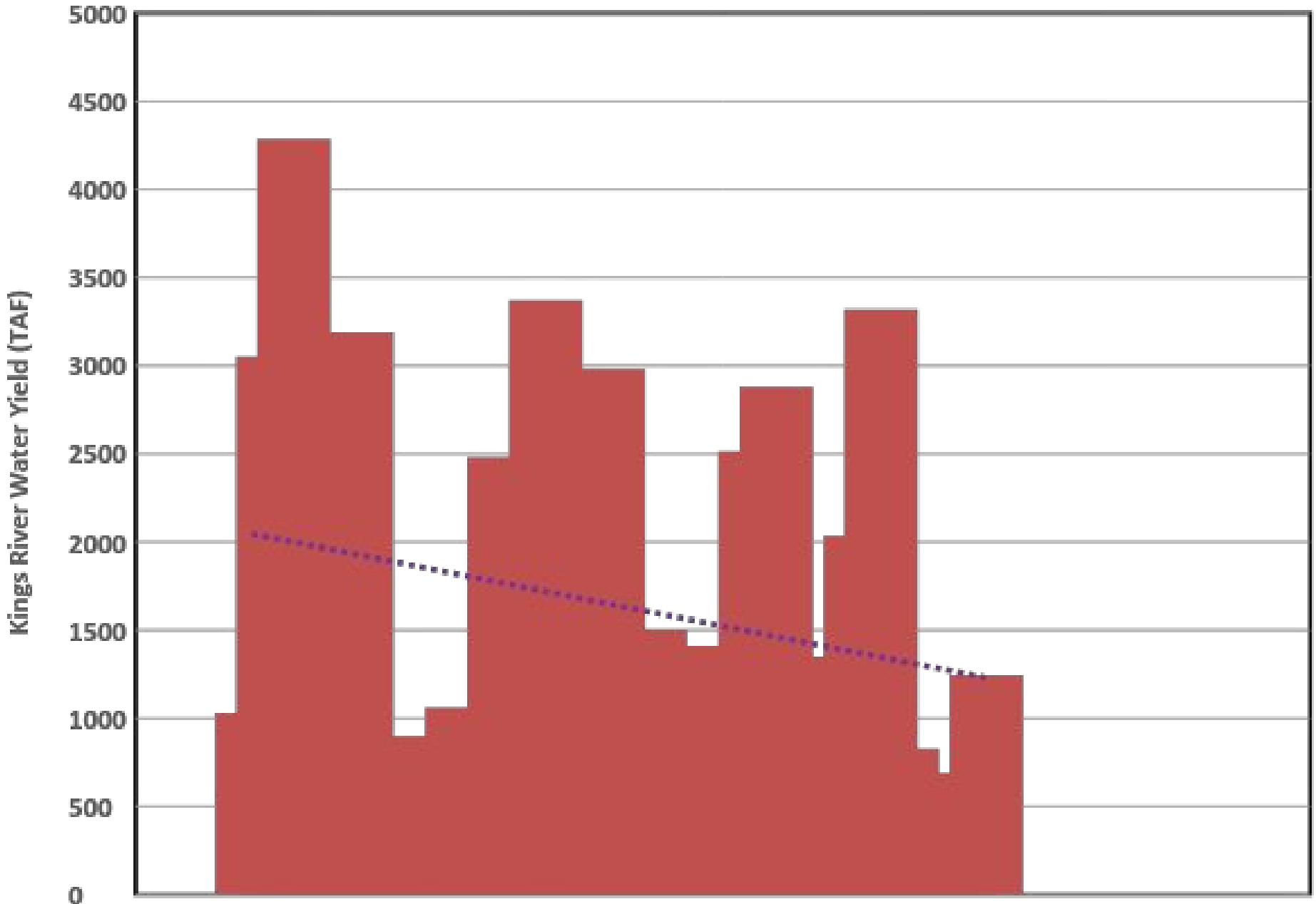
# 2/3<sup>rd</sup> of the snow is below <2500 m elevation



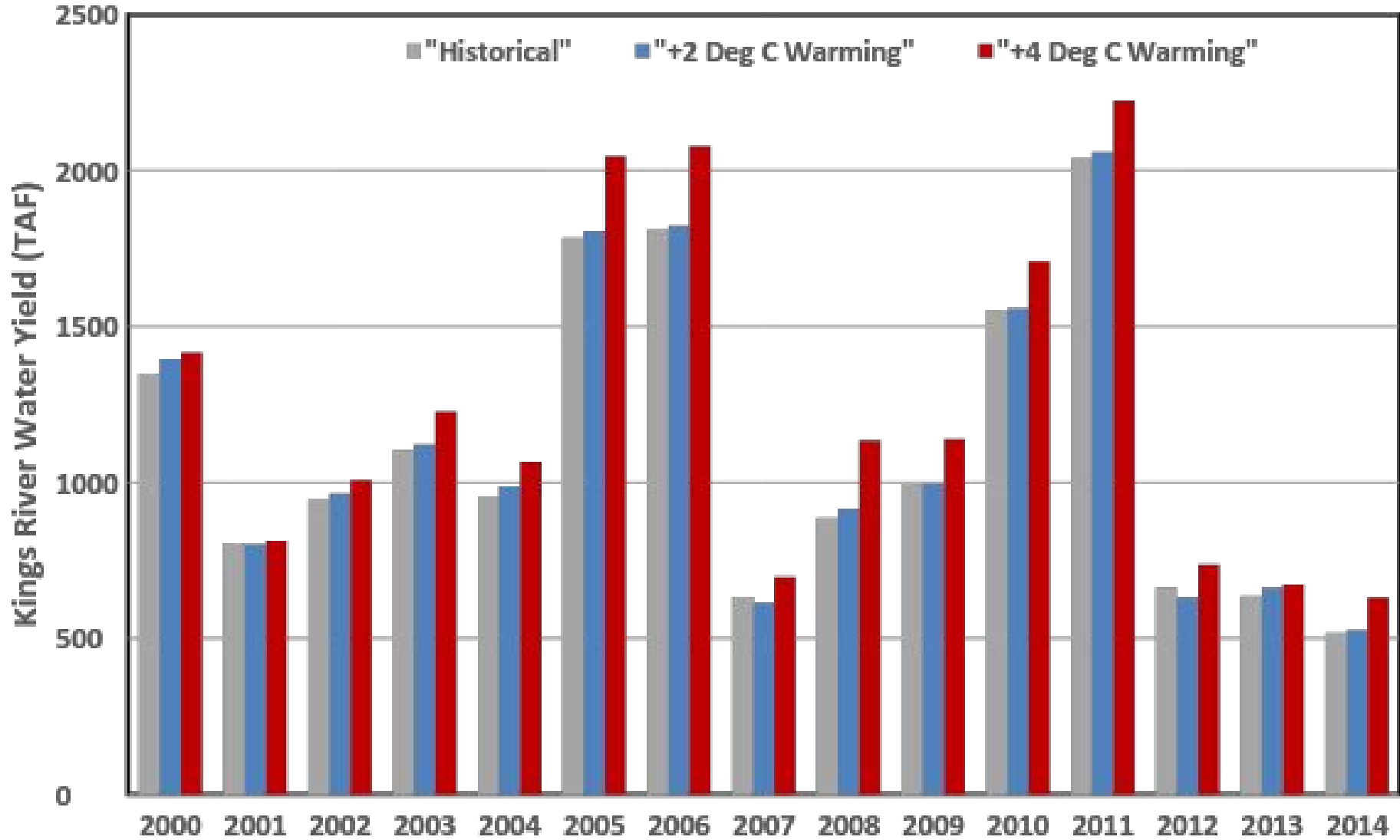
# Impact of warming on simulated April 1<sup>st</sup> snowpack storage



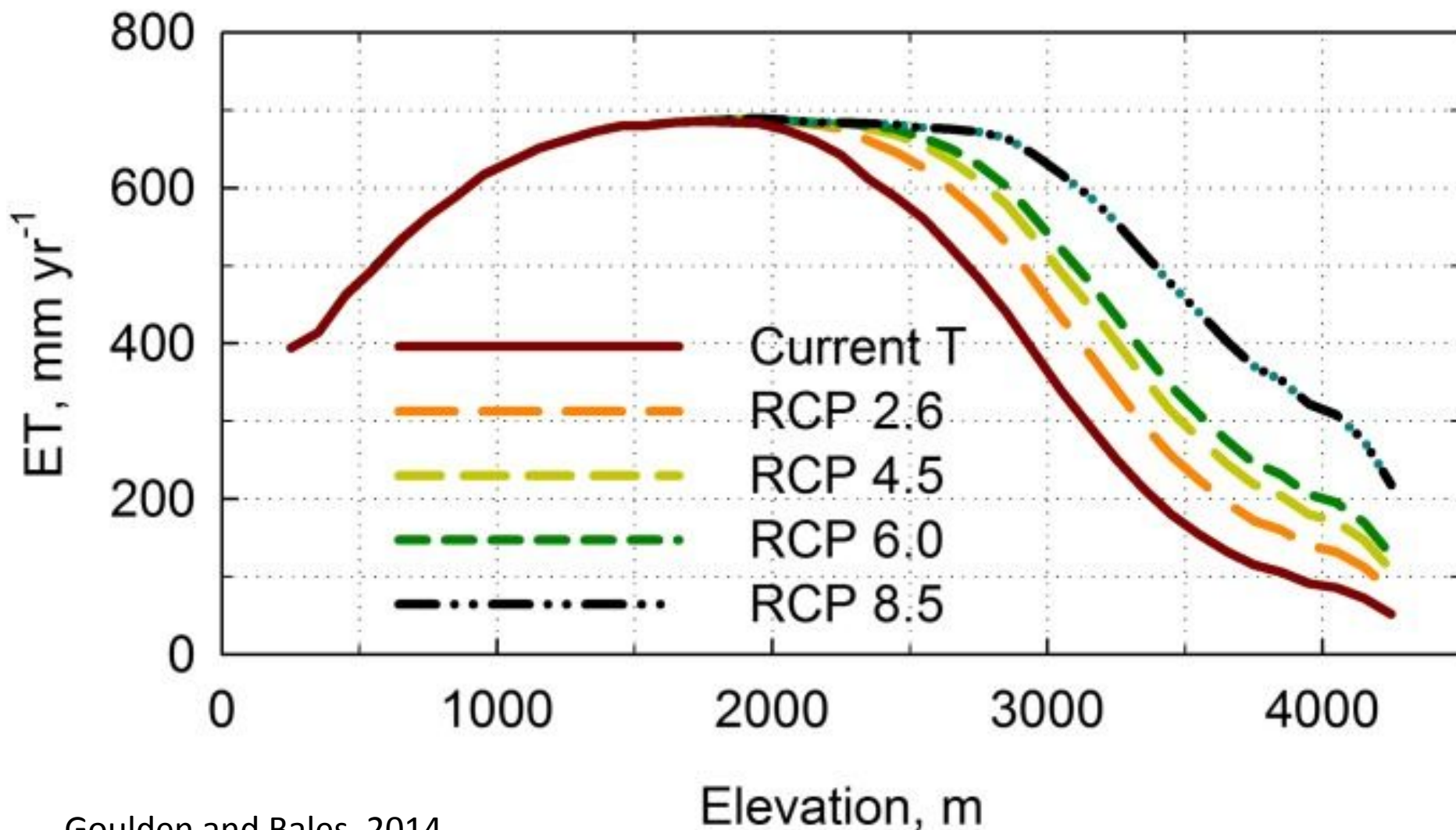
**Historic Simulation**  
**1.5 MAF water stored in snowpack**

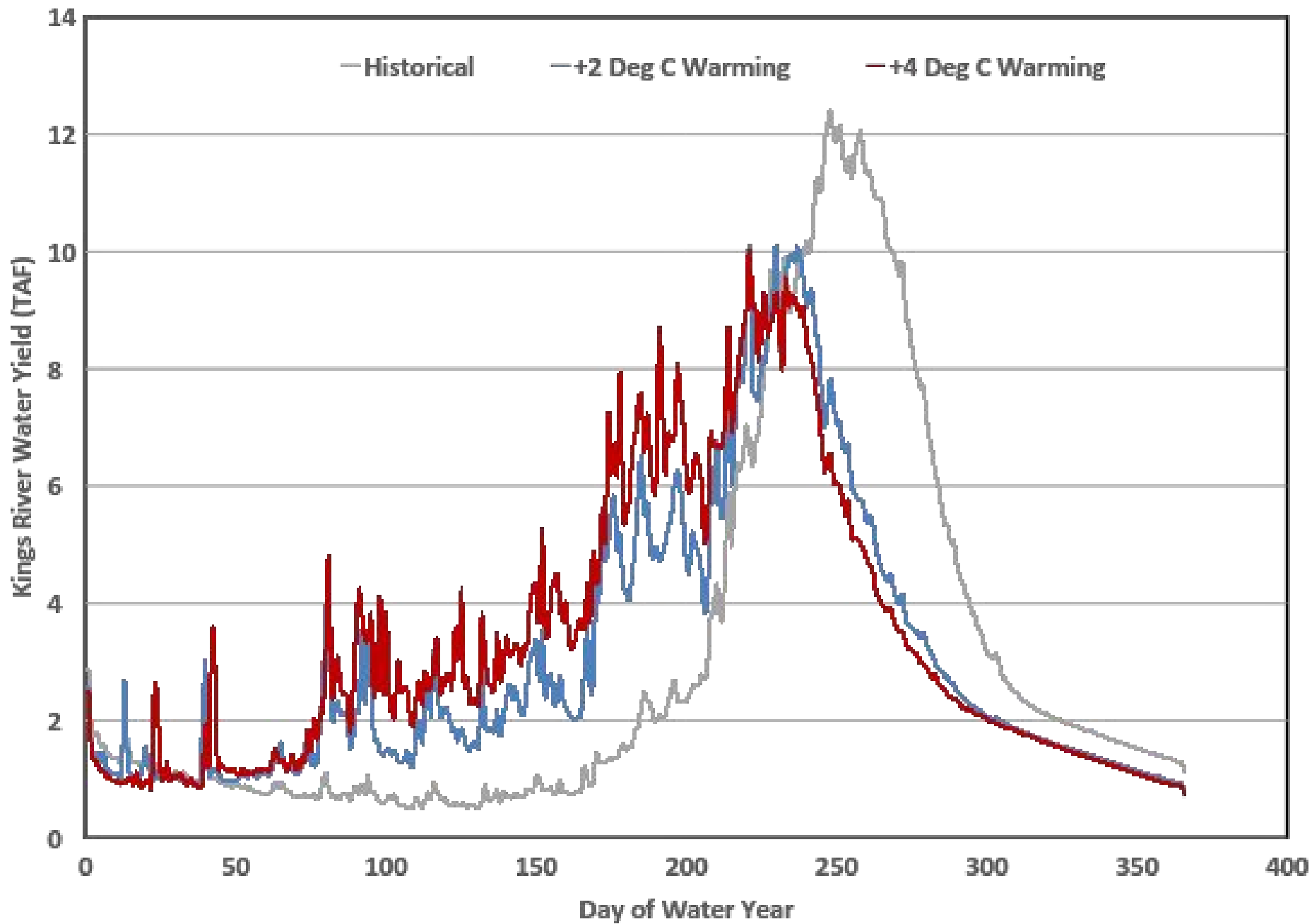


# Warmer temperature = more water yield

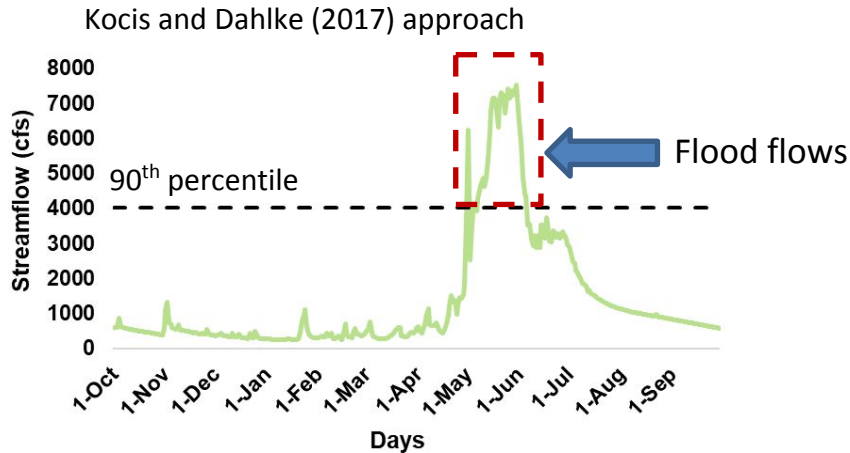


# Warmer temperature = more evapotranspiration (ET)

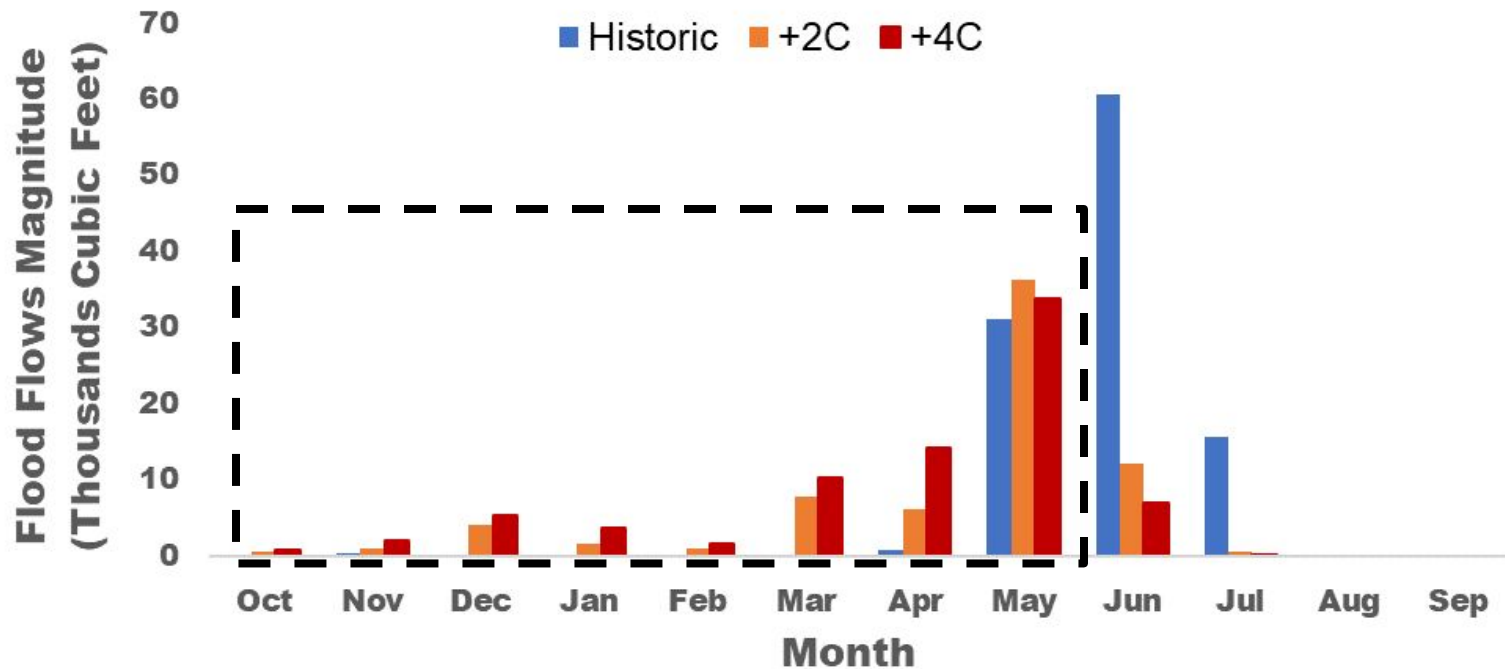




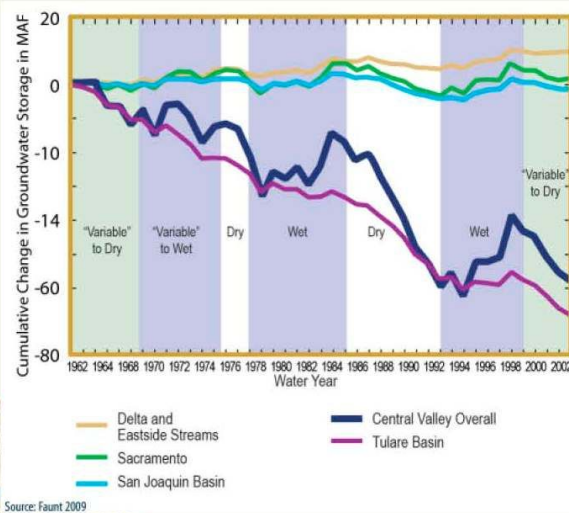
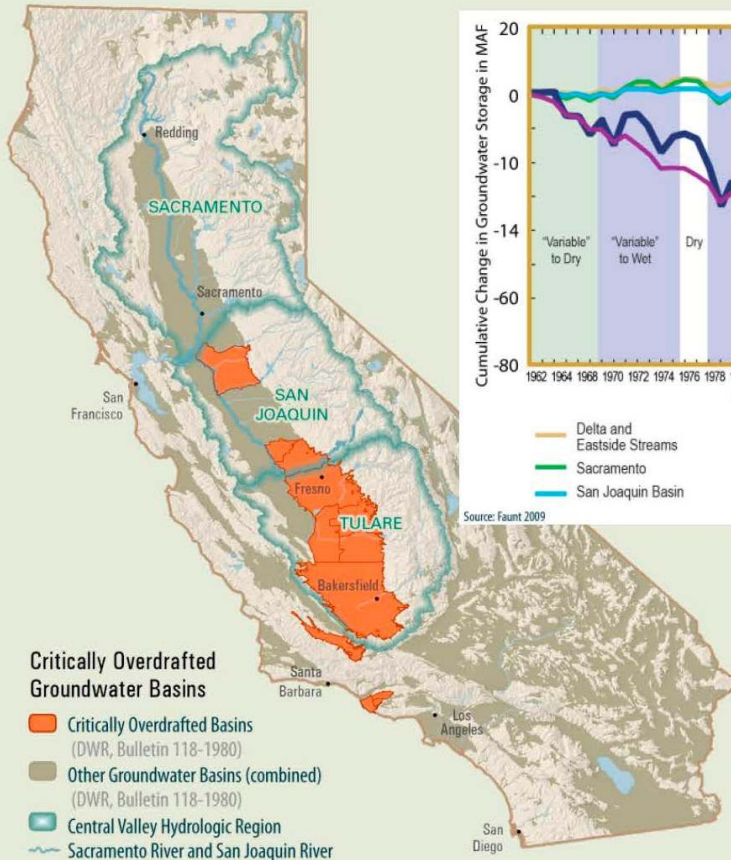
# Analyzing the effect of temperature changes on groundwater banking potential



**1-day peaks  
increased by more  
than 3 folds.**



## GROUNDWATER OVERDRAFT CHALLENGES



### Critical Overdraft by Region

#### Sacramento Hydrologic Region

None

#### San Joaquin Hydrologic Region

Eastern San Joaquin County Basin  
Chowchilla Basin  
Madera Basin

#### Tulare Hydrologic Region

Kings Basin  
Kaweah Basin  
Tulare Lake Basin  
Tule Basin  
Kern County Basin

#### Other Hydrologic Regions

Cuyama Valley Basin  
Oxnard Basin  
Las Posas Basin  
Valley Basin

Groundwater is California's single largest source of water. More than 40 percent of Californians rely on groundwater for some portion of their supply, and many small- and moderate-sized communities are entirely dependent on groundwater for drinking water.

Groundwater overdraft is a critical problem facing specific regions of California. Overdraft is a condition in which the amount of water withdrawn from a basin by pumping exceeds the amount of water that recharges a basin over the long term, resulting in permanent loss of storage capacity, water quality degradation, and environmental impacts. It is estimated that the San Joaquin Valley (Tulare Lake Basin) has lost about 60 MAF of groundwater storage in the past 50 years, and land subsidence affects more than half this region.

Sources: DWR 2003a; DWR 2009 [https://mavensnotebook.com/dpg/Chapter\\_3.html](https://mavensnotebook.com/dpg/Chapter_3.html)

## Reservoir reoperation



## Managed Recharge



## Opportunistic Recharge



# Conclusions

- Historical variability in snowfall closely resembles the projected 2040-warming scenario (+1.8 °C)
- By 2080s (+3.0 °C), mountain snowfall will be reduced to 17 MAF, 30% lower than the average snowfall in 10 warmest years.
- Snowpack storage in the Kings River Basin may decline by 50% under +4 °C warming
- Water yield in the Kings River Basin may likely increase under warmer climate
- Flow will likely shift early in the year, i.e. more winter runoff.

