California's Water Future

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UCLA Center for Climate Science

In a series of studies over the past few years, we have been examining the implications of a changing climate for precipitation, snowpack, and streamflow in California.

We have relied on analyses of output from coarse resolution global climate models and high resolution regional climate models focused on California.

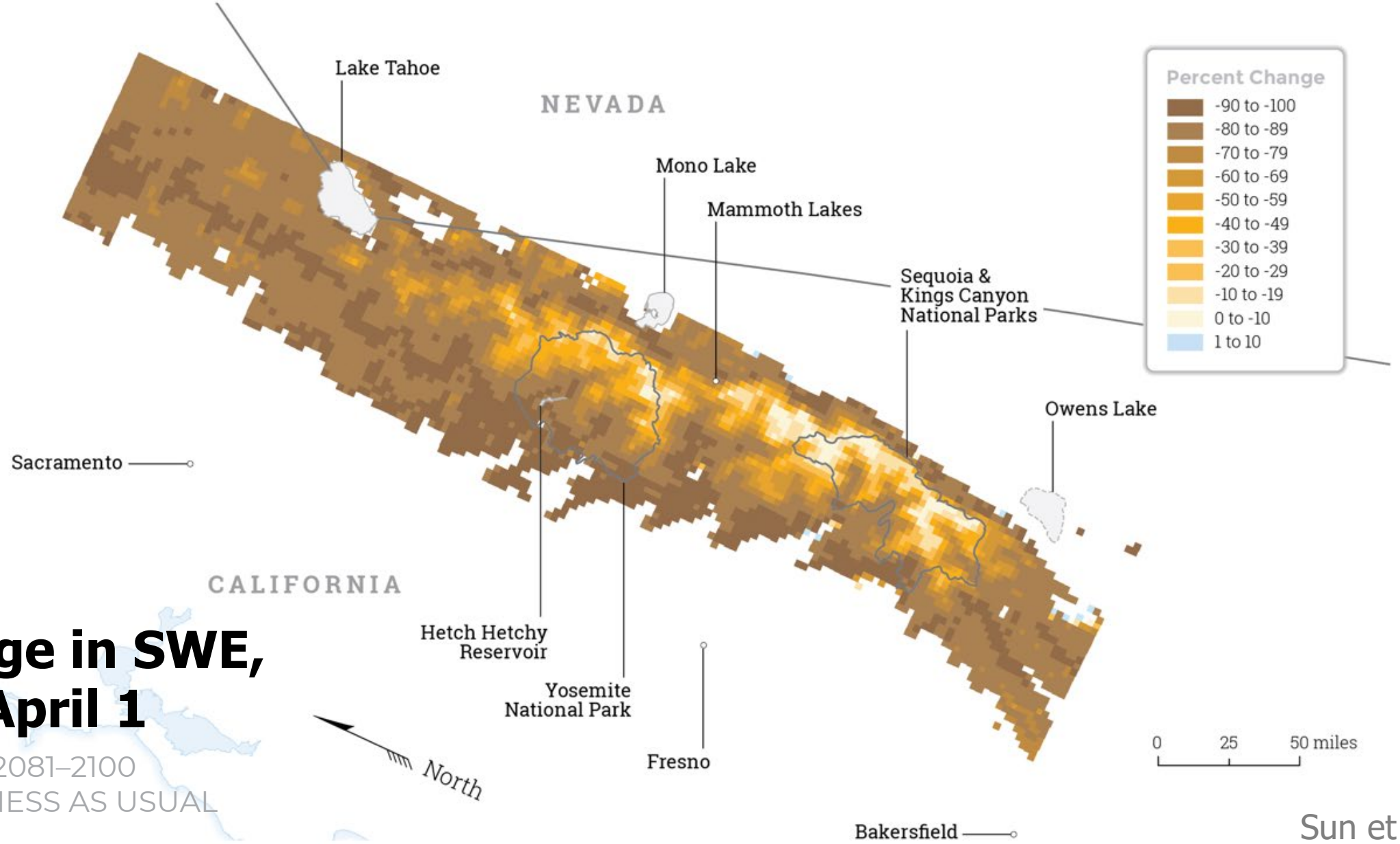
Today I'll show results from these studies. All of the results pertain to the end of the 21st century, and they assume a "business-as-usual" scenario of greenhouse gas emissions.

If you are interested in the same information, but for the middle of the 21st century under "business-as-usual", or for the end of the century under a lower emissions scenario like the one envisaged in the Paris Climate Agreement, a simple rule of thumb is to cut the numbers I'm about to show in half.

FOUR LESSONS

1. We lose snow
2. Big atmospheric river events get bigger
3. Flooding increases dramatically
4. Dry years (probably) get drier

Warming leads to loss of snow

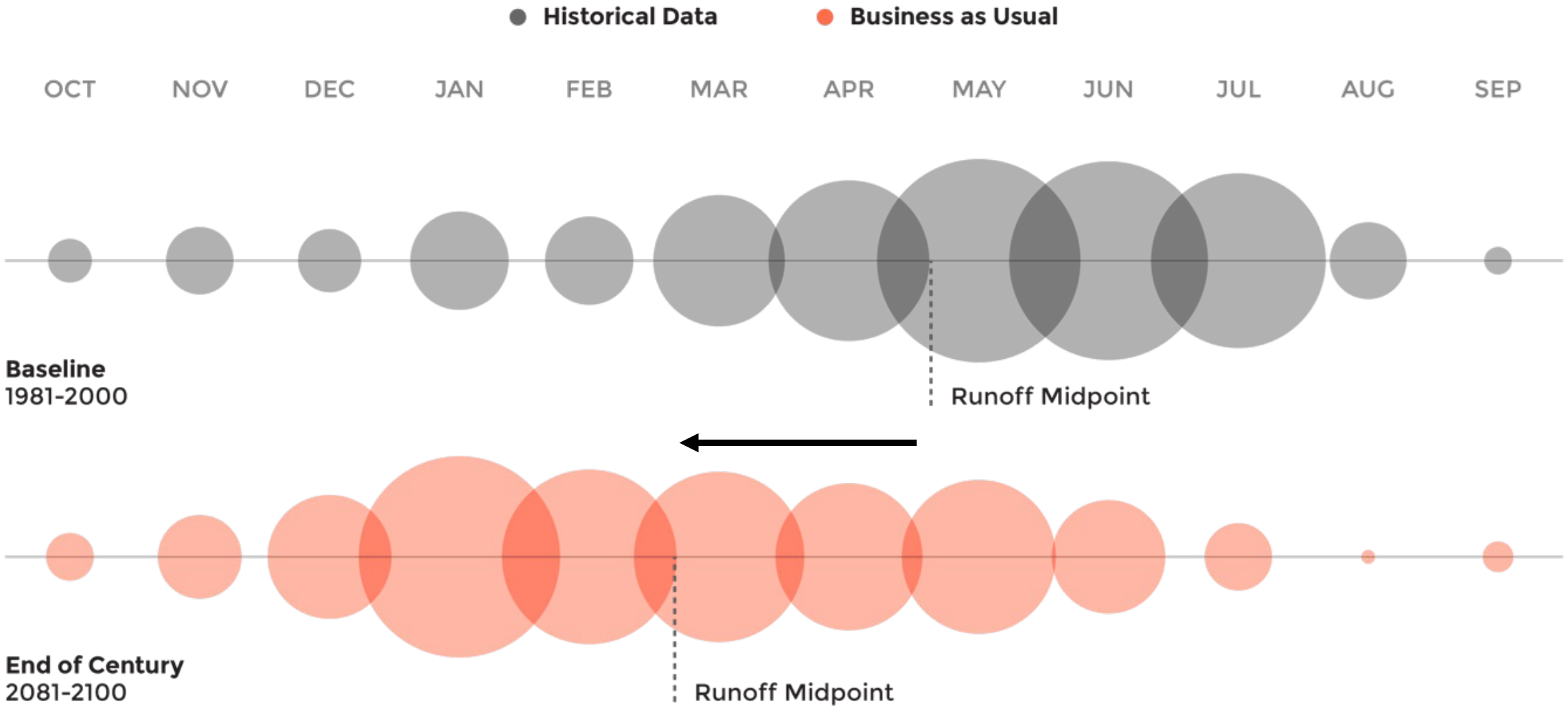


Change in SWE, April 1

2081–2100
BUSINESS AS USUAL

Sun et al. 2019

Change in the Timing of Sierra Runoff



Schwartz et al. 2017

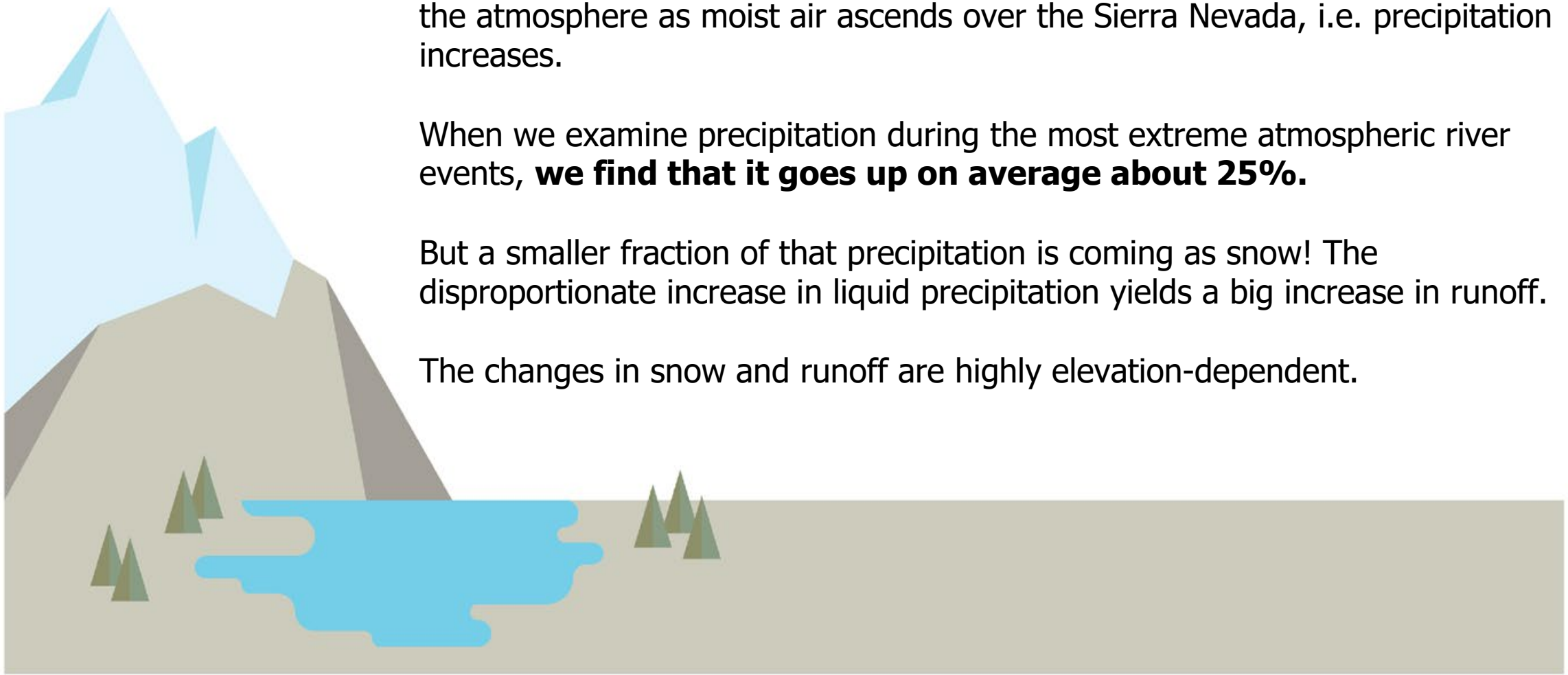
Warming has another implication: It increases the amount of water vapor in the atmosphere.

During atmospheric river events, this means that more water is wrung out of the atmosphere as moist air ascends over the Sierra Nevada, i.e. precipitation increases.

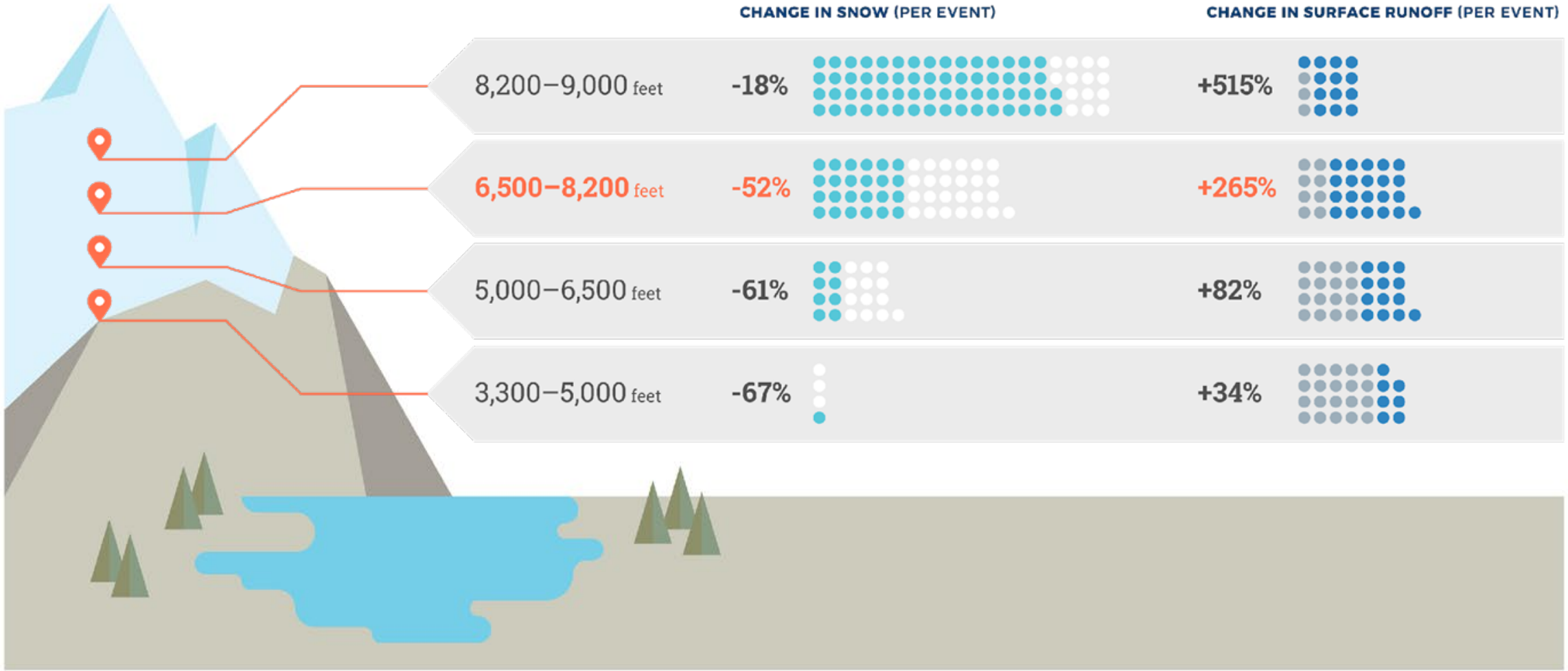
When we examine precipitation during the most extreme atmospheric river events, **we find that it goes up on average about 25%.**

But a smaller fraction of that precipitation is coming as snow! The disproportionate increase in liquid precipitation yields a big increase in runoff.

The changes in snow and runoff are highly elevation-dependent.

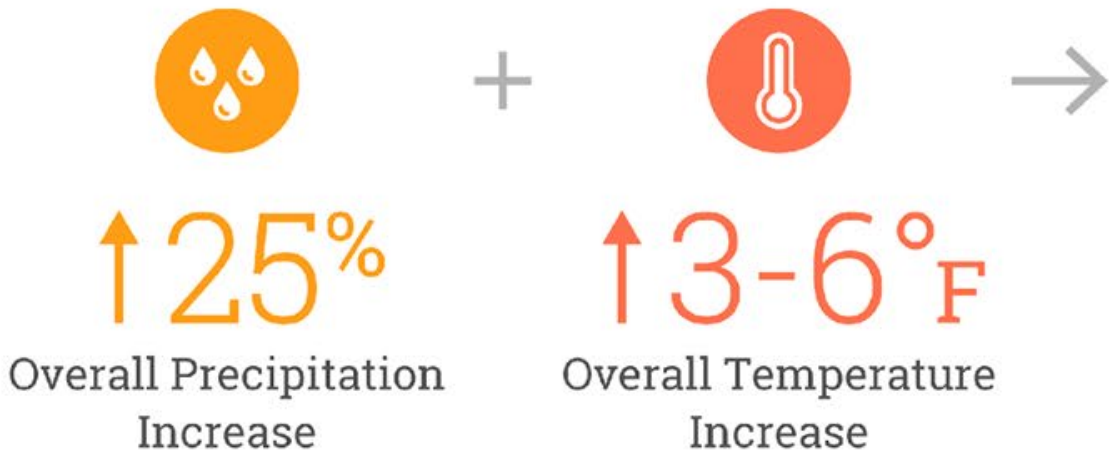


Huang et al. 2020



Huang et al. 2020

Precipitation and runoff changes during extreme atmospheric river events



Huang et al. 2020

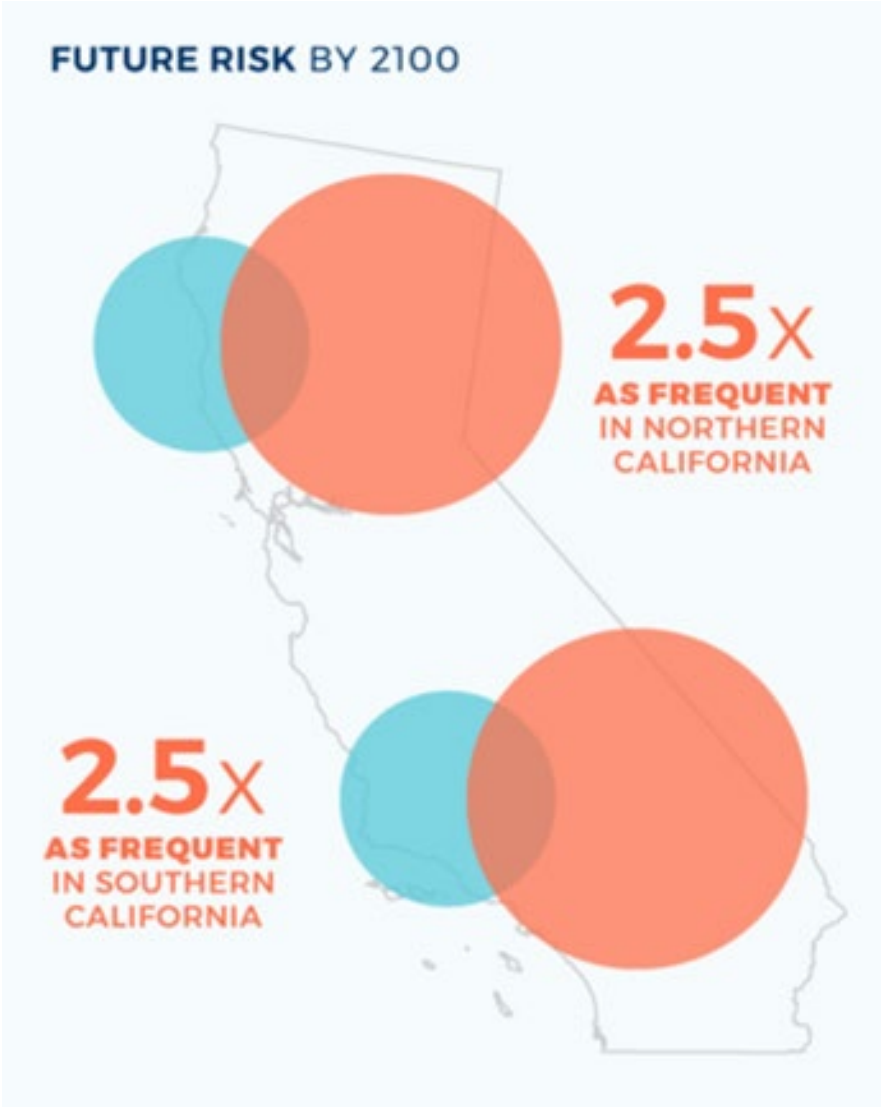
Precipitation and runoff changes during extreme atmospheric river events

The total precipitation during a particular water year is generally determined by a small number of large atmospheric river events (e.g. Dettinger, 2013)

The increase in precipitation during extreme atmospheric river events means that **wet years will generally occur more frequently**.

Extreme Wet Years

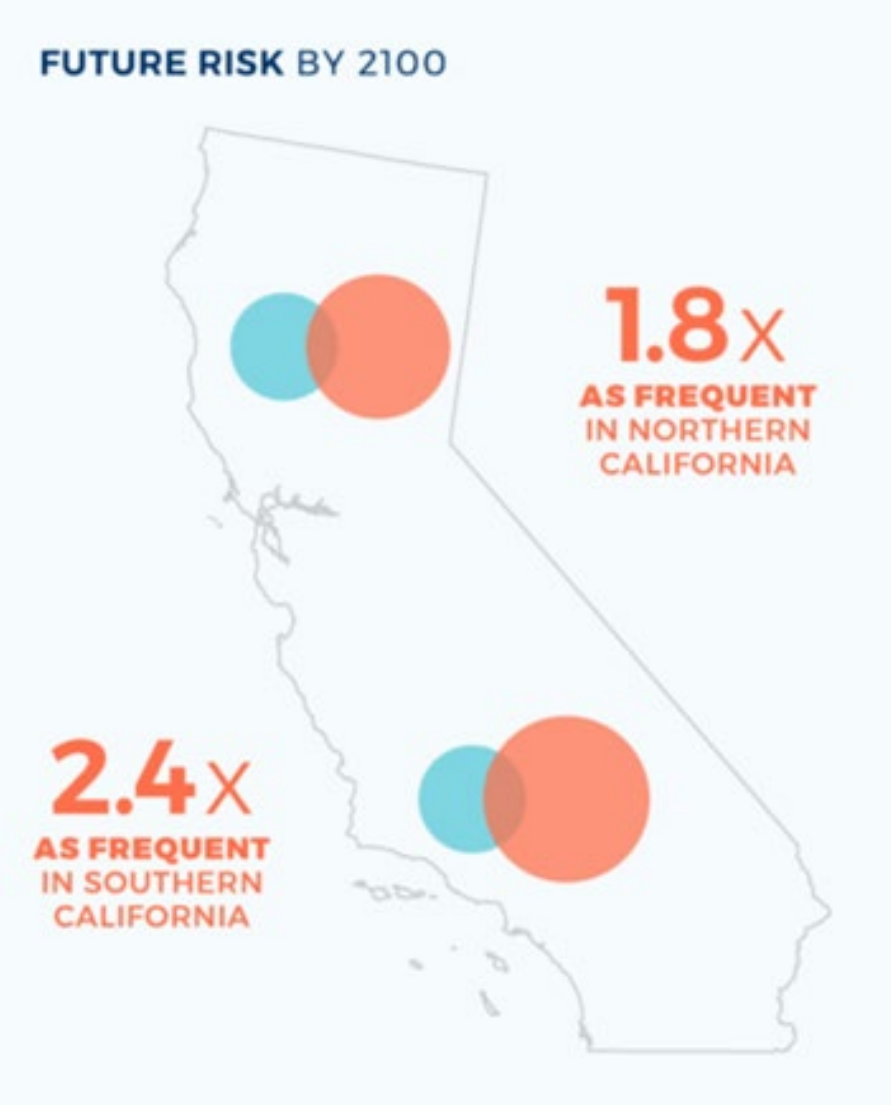
- Analog: 2016–2017
- Wet November–March period
- Key impact: infrastructure stress
- 1895–2017 frequency: ~4/100 years



Swain et al. 2018

Extreme Dry Years

- Analog: 2013–2014
- Low November–March precipitation
- Key impact: water scarcity
- 1895–2017 frequency: ~1/100 years



Swain et al. 2018

FOUR LESSONS

1.We lose snow

2.Big atmospheric river events get bigger

3.Flooding increases dramatically

4.Dry years get drier

We are **very confident** about some changes, less confident about others.

We are very confident about certain changes because they are seen in almost all climate models, and the reasons for them are well documented and well understood.

Other changes might be documented on in one or a few models, and the mechanisms underpinning them may be only partially understood.

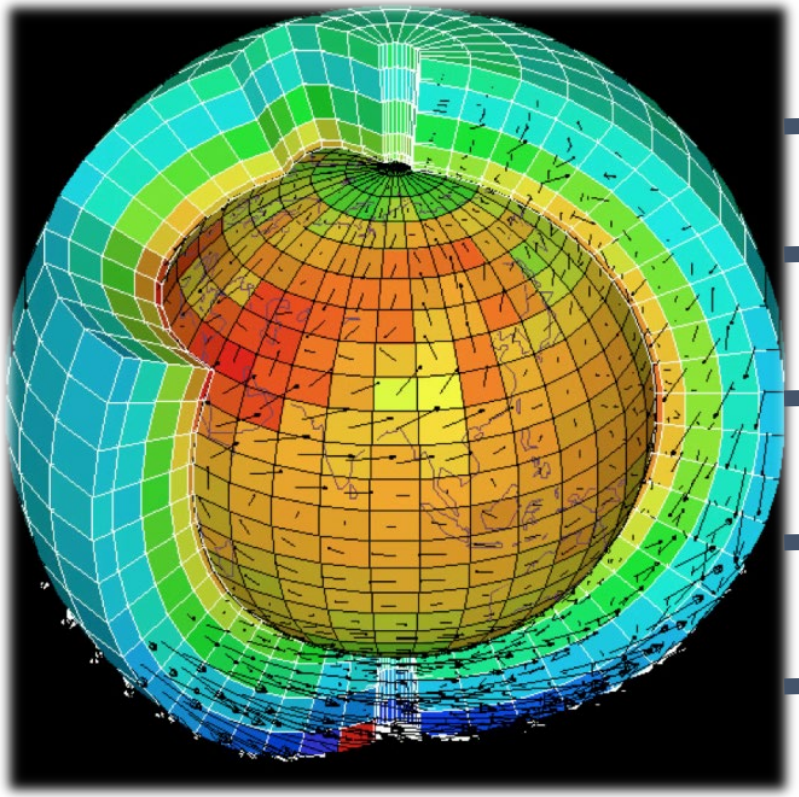
IMPLICATIONS

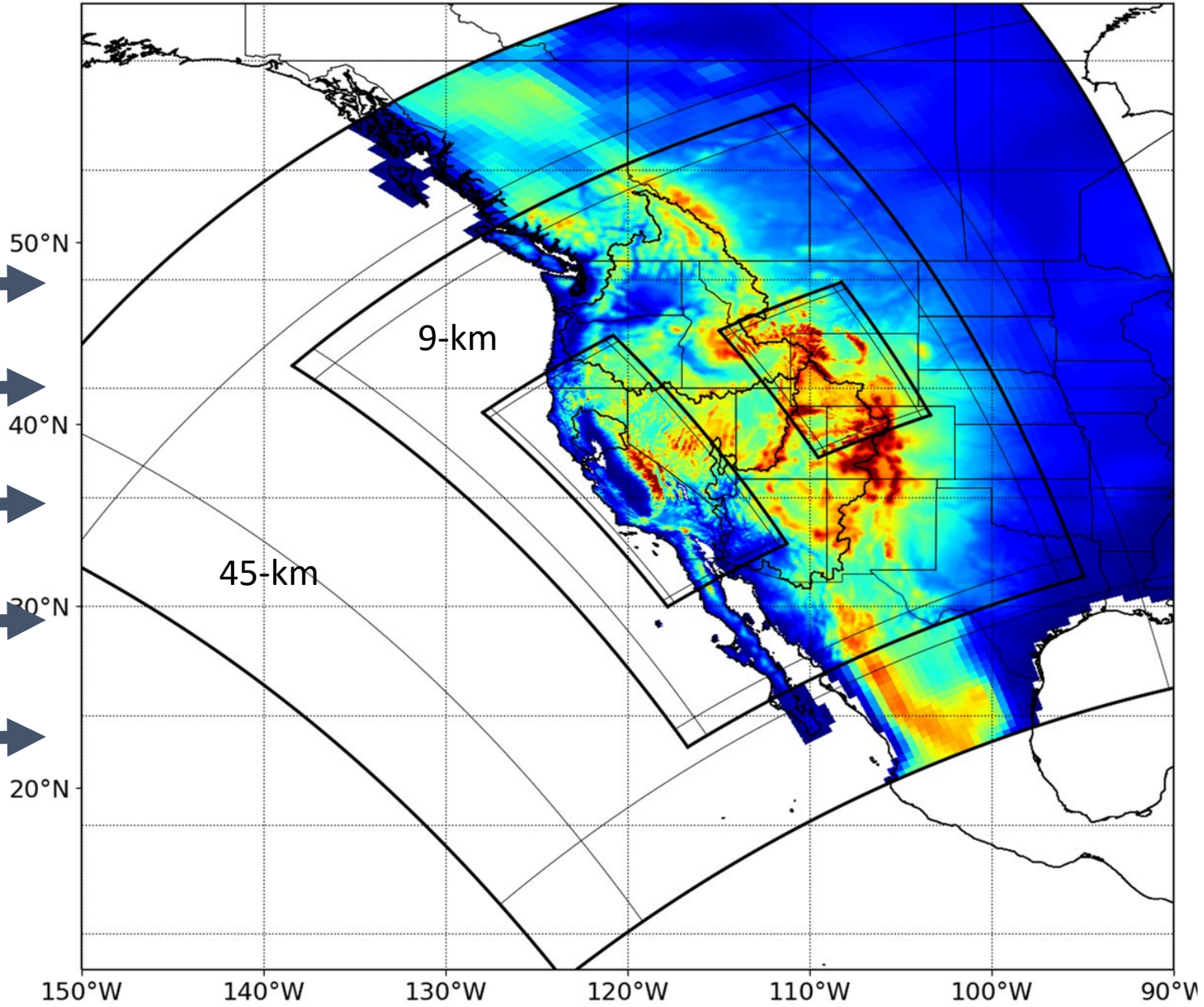
Water storage – To maintain the same water resource, the loss of the snowpack must be compensated for by an increase in other forms of storage. The increase in swings between wet and dry years implies that more water must be stored during wet years to get through the deeper dry spells.

Flood control – The large increase in runoff during extreme precipitation implies a major flood control challenge and a rethinking of the rules and regulations associated with existing water resource infrastructure. Storage increases also help here, but capture may be a challenge.

Fire – The increase in precipitation during wet years, and the decrease in precipitation during dry years has the potential to significantly increase fire risk. During wet years, vegetation will grow more, and during dry years, it will dry out more, periodically creating the perfect conditions for large blazes when the vegetation is ignited. Warmer temperatures also favor larger, more intense fires.

Producing data for the next (5th) California climate assessment





The experiments are designed to answer new questions…

How much more frequent will multi-year drought become and how would it play out across the State?

What is the likelihood of a drought so deep that urban areas run out of water?

How will flooding risk change on a watershed-by-watershed basis?

What is the likelihood of a flood like the 1861-1862 event? What would flooding during such an event be like in a much warmer world with reduced snow?

How will warmer temperatures affect evapotranspiration and ultimately, streamflow?

Fire risk…

Thank you

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