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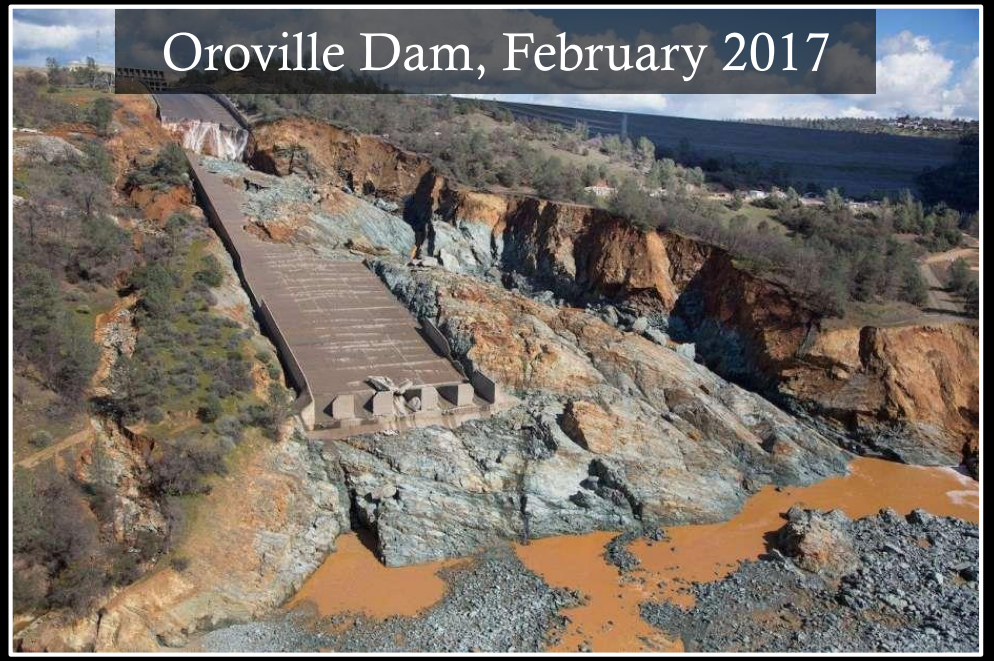
Drought, flood & wildfire amidst increasing climate whiplash: The challenging road ahead for water management in the West



Daniel L. Swain

Water Education Foundation Water Summit

September 20, 2018

UCLA IoES

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

The Nature Conservancy

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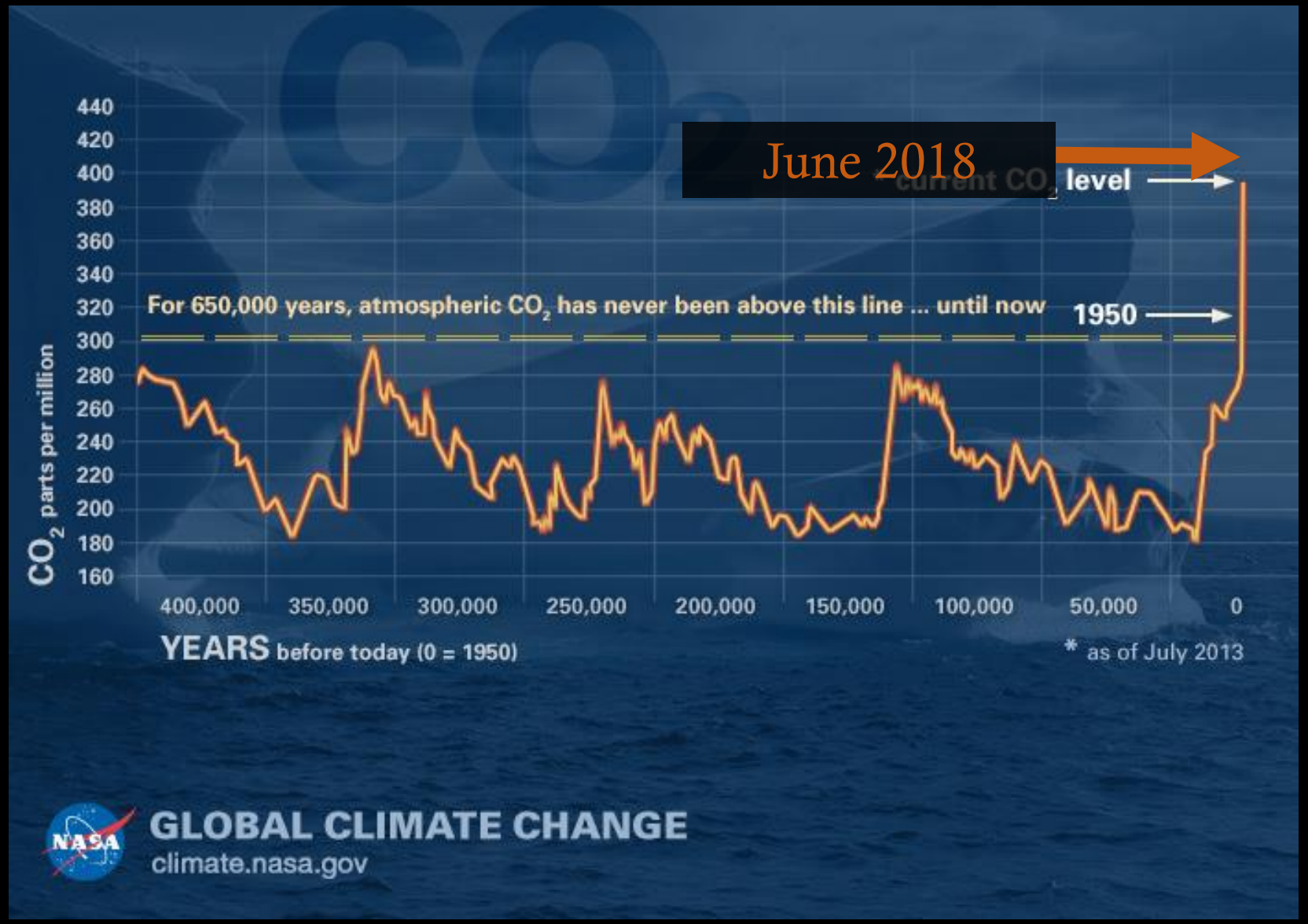
"Facing Reality"



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"Facing Reality"

- California making tremendous progress on climate mitigation
- Global leader in emissions reductions & path toward "carbon zero"

BUT…

- California's actual climate future at mercy of *global* climate policy
- *Pre-emptive climate adaption critical to resilient California*

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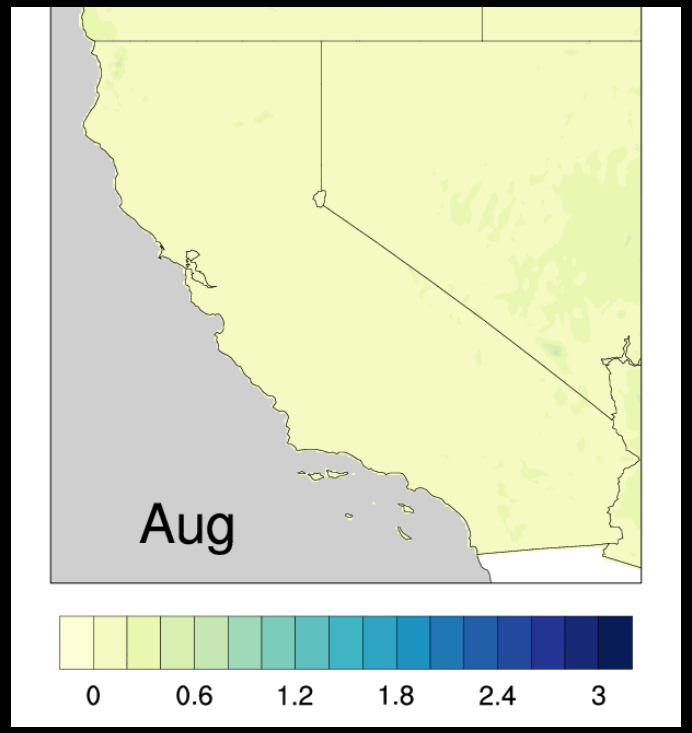
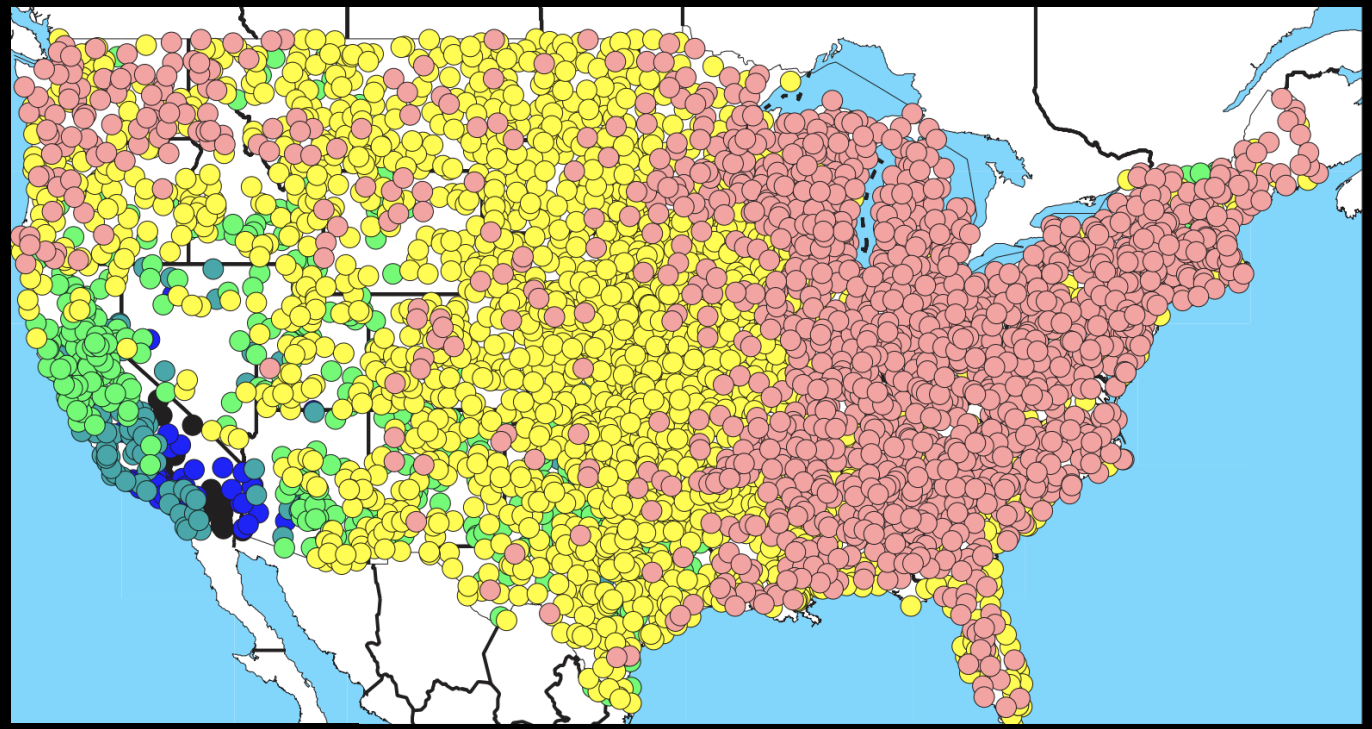
California's unusual climate context

Monthly precipitation



Swain 2016

Coefficient of variation in annual precipitation



Dettinger 2011

- California exists at margin of stable subtropics/active mid-latitudes
- Strong seasonal cycle of precipitation and latitudinal gradient
- Uniquely high year-to-year variation in precipitation; drought susceptibility

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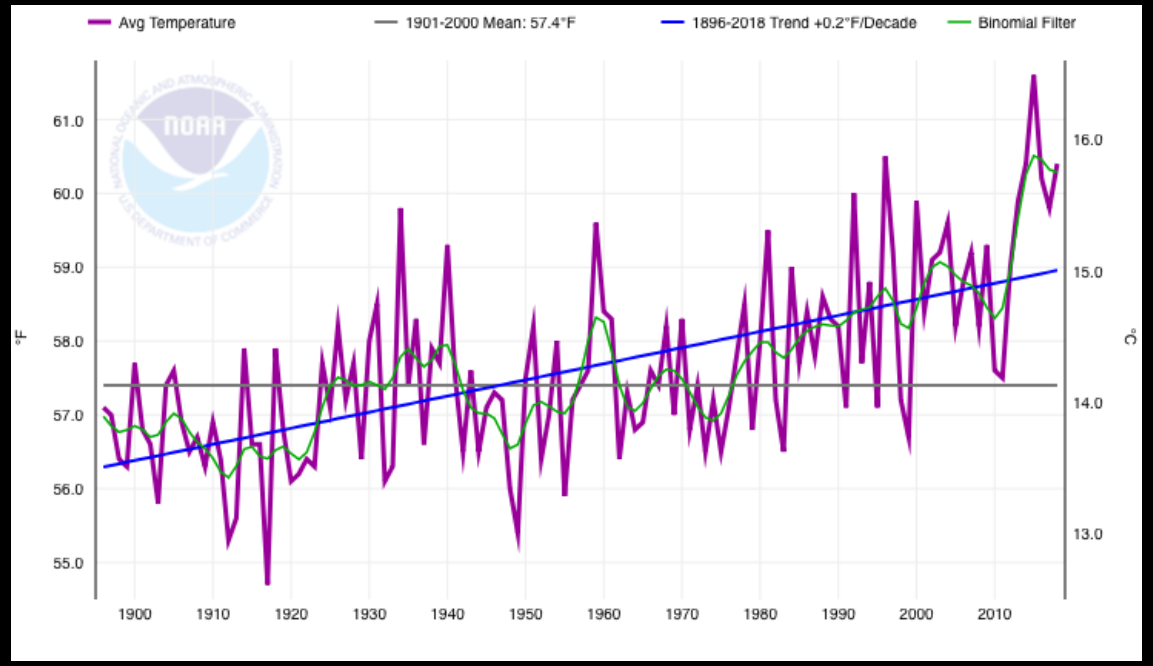
California changes so far: warmer, less snow, more flammable

California annual average temperature (NOAA)



- California now significantly warmer than during early 20th century
- Mountain snowpack now detectably decreasing; snow lines increasing
- Large increase in wildfire size/intensity*
  - *Not just a climate signal—other human factors at play!

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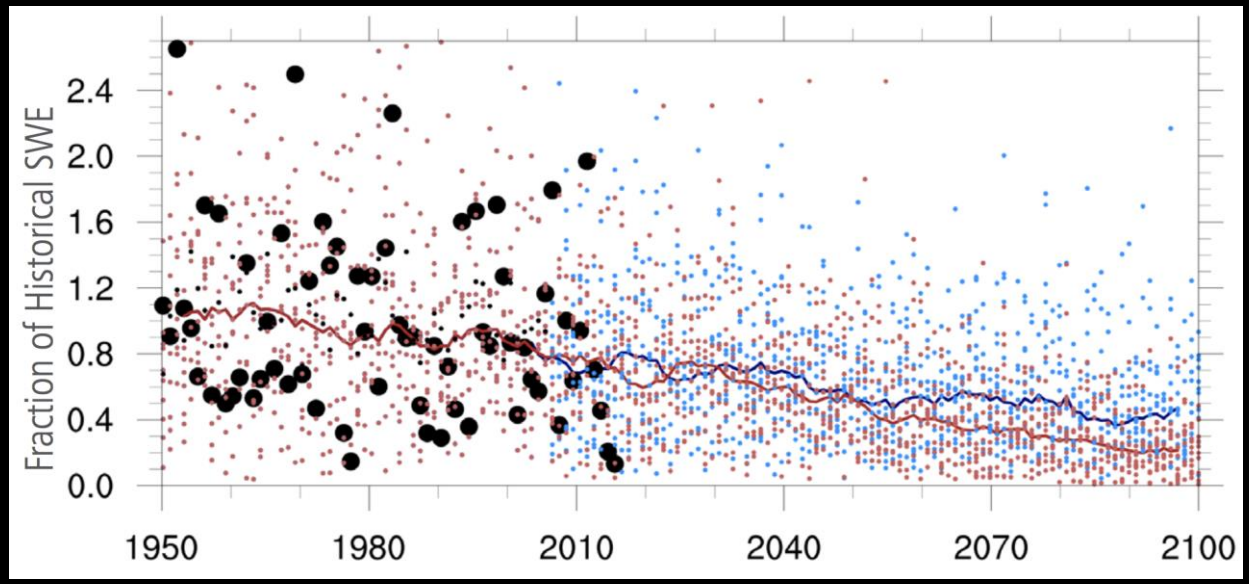
California changes to come: (dramatically) warmer, (much) less snow, more flammable (still), plus bigger floods

California snow water equivalent



Pierce et al. 2018
(California Climate Assessment)

- Future warming will be much greater than observed warming to date
- Very low/zero snow years (like 2014-2015) increasingly common
- Increasing runoff due to more rain vs. snow, plus wetter storms, will yield very large increases in peak flood volume

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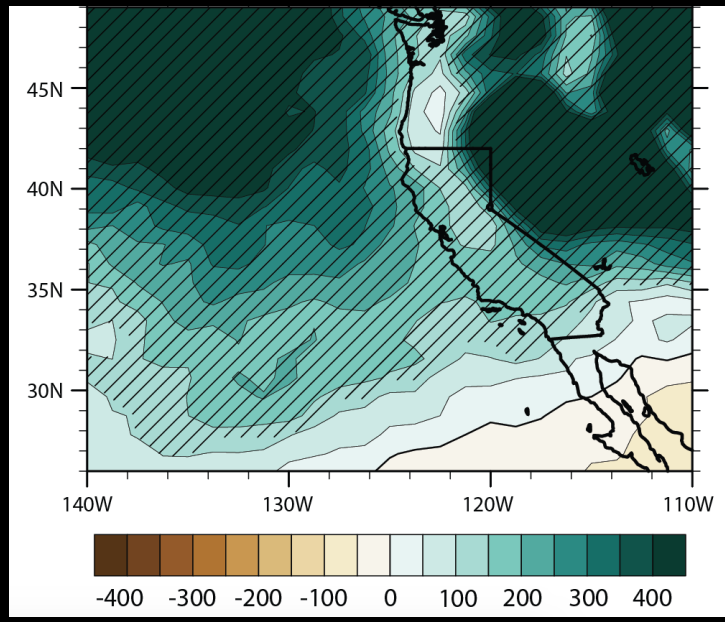
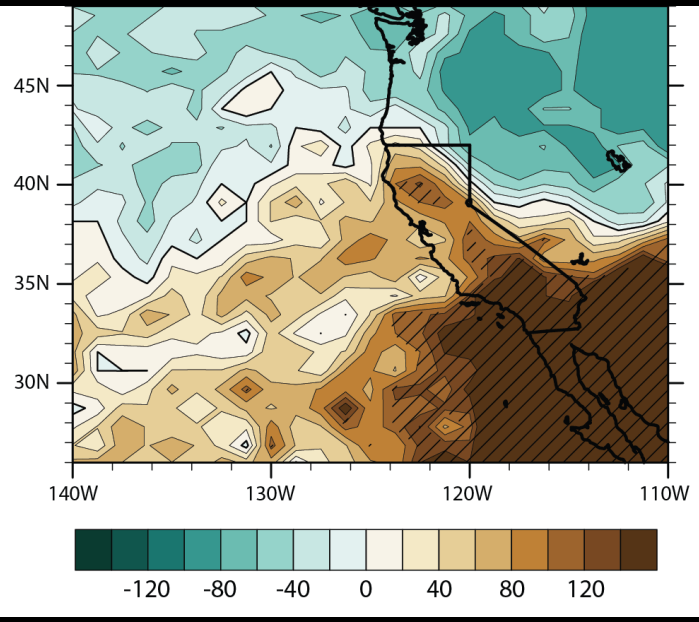
Increasing California "precipitation whiplash"

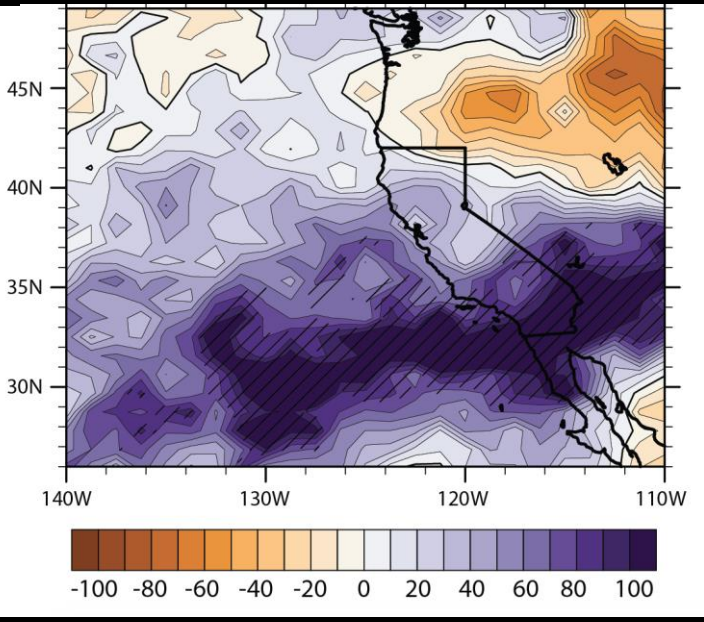
Increase in very wet years



Increase in very dry years



Increase in "whiplash"



Swain et al. 2018

Large increase in both wet & dry extremes

despite little mean precip change!

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Why care about precipitation whiplash?

Thomas Fire,
Ventura County
Dec 2017

Debris flows,
S. Barbara County
Jan 2018

- On average, it was mild & mostly sunny with modest breezes in Dec-Jan

- *If we only consider changes in average climate, then we're largely missing the point*

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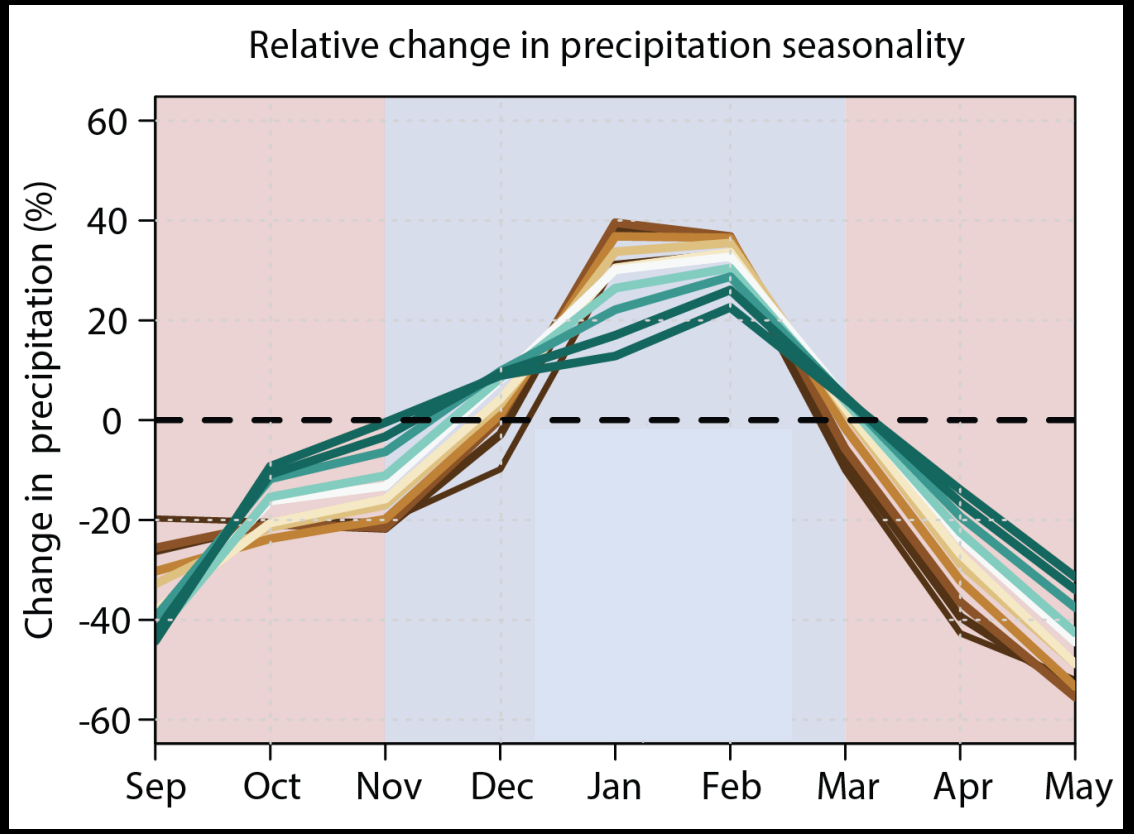
An (even) shorter, (even) sharper rainy season



Swain et al. 2018

- Drying trends in autumn & (especially) spring, strongest south
- Further "narrowing" of rainy season (w/modestly wetter winters)
- Key implications: wildfire risk, snowpack, ecosystem stresses, agriculture

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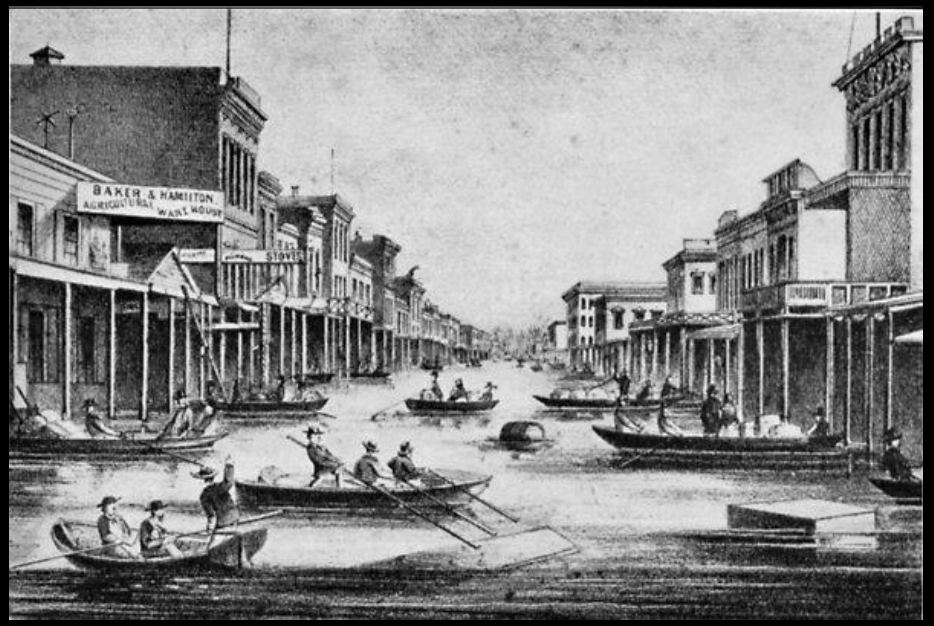
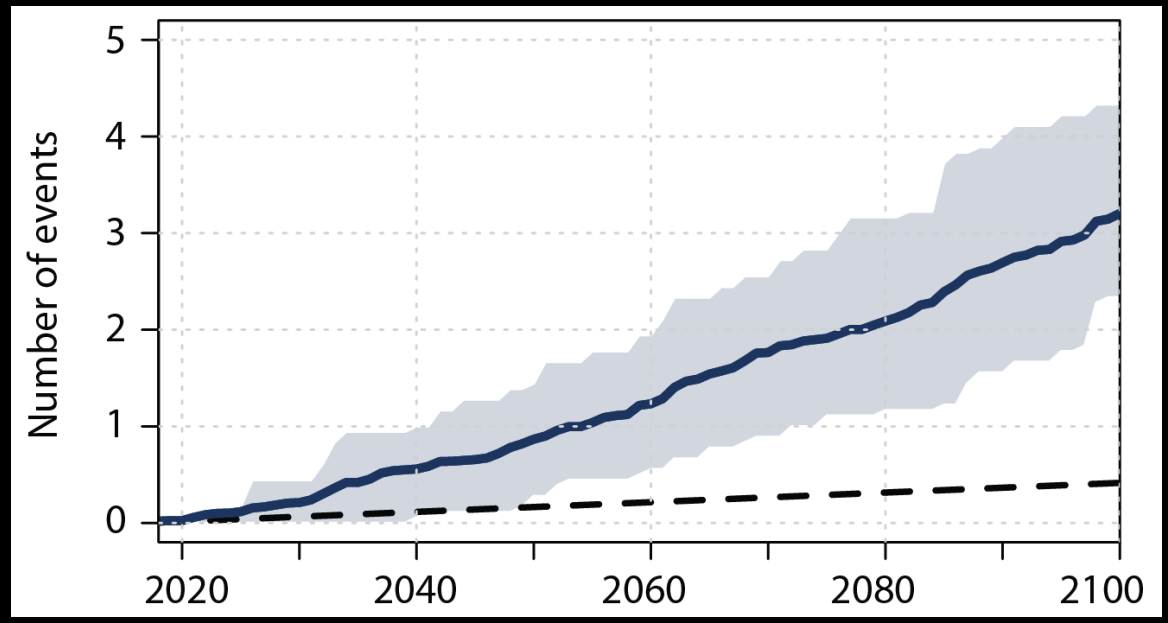
California's "Other Big One": Month-long atmospheric river deluge

Downtown Sacramento, Jan 1862



San Francisco Chronicle

Cumulative likelihood of "1862-like" event



Swain et al. 2018

- California "great floods" have occurred every ~200 years
- Modern day repeat would be disastrous for California
- Greater than 50% risk of an 1862-level in next ~40 years

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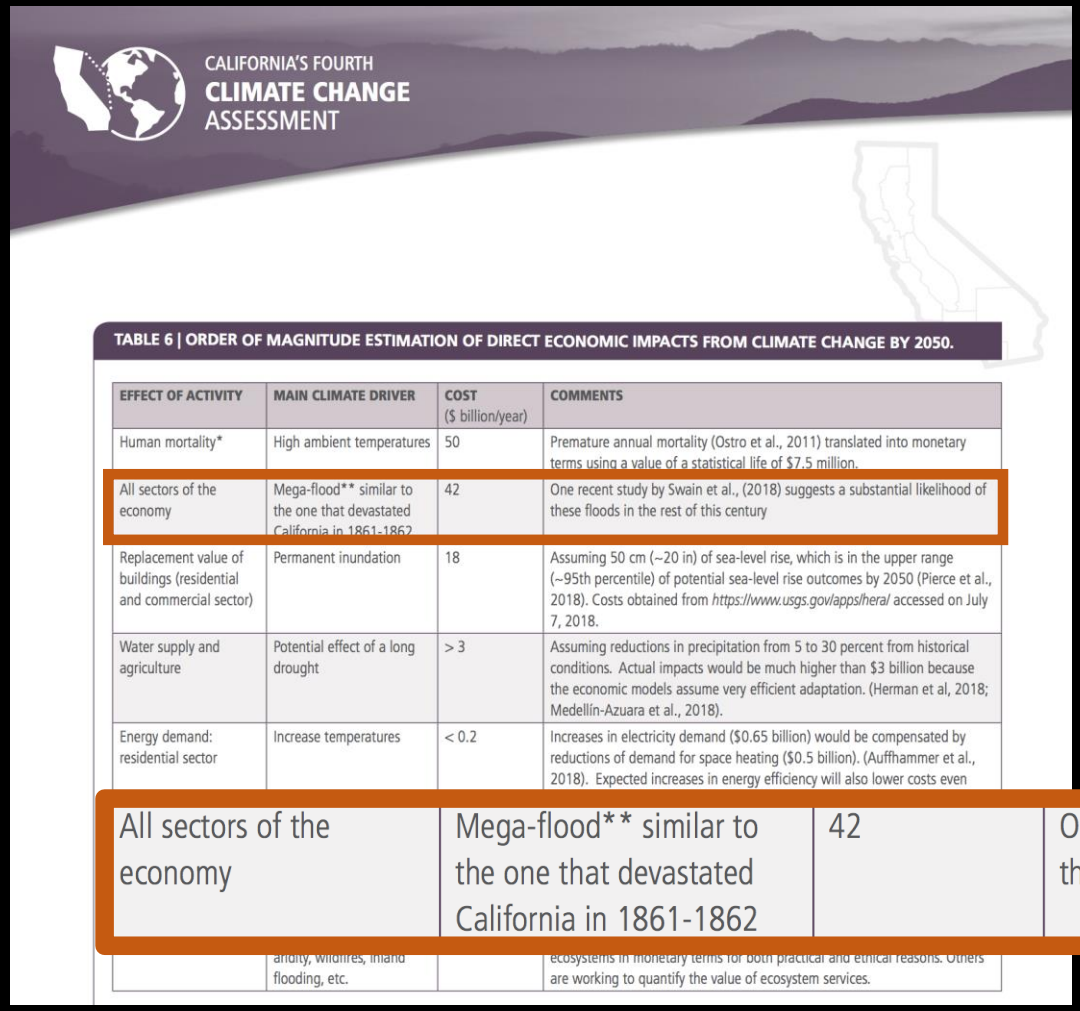
When it comes to future floods, we need to think big. Really big.



CALIFORNIA'S FOURTH
CLIMATE CHANGE
ASSESSMENT

TABLE 6 | ORDER OF MAGNITUDE ESTIMATION OF DIRECT ECONOMIC IMPACTS FROM CLIMATE CHANGE BY 2050.

EFFECT OF ACTIVITY	MAIN CLIMATE DRIVER	COST ($ billion/year)	COMMENTS
Human mortality*	High ambient temperatures	50	Premature annual mortality (Ostro et al., 2011) translated into monetary terms using a value of a statistical life of $7.5 million.
All sectors of the economy	Mega-flood** similar to the one that devastated California in 1861-1862	42	One recent study by Swain et al., (2018) suggests a substantial likelihood of these floods in the rest of this century
Replacement value of buildings (residential and commercial sector)	Permanent inundation	18	Assuming 50 cm (~20 in) of sea-level rise, which is in the upper range (~95th percentile) of potential sea-level rise outcomes by 2050 (Pierce et al., 2018). Costs obtained from *https://www.usgs.gov/apps/hera/* accessed on July 7, 2018.
Water supply and agriculture	Potential effect of a long drought	> 3	Assuming reductions in precipitation from 5 to 30 percent from historical conditions. Actual impacts would be much higher than $3 billion because the economic models assume very efficient adaptation. (Herman et al, 2018; Medellín-Azuara et al., 2018).
Energy demand: residential sector	Increase temperatures	< 0.2	Increases in electricity demand ($0.65 billion) would be compensated by reductions of demand for space heating ($0.5 billion). (Auffhammer et al., 2018). Expected increases in energy efficiency will also lower costs even
	aridity, wildfires, inland flooding, etc.		ecosystems in monetary terms for both practical and ethical reasons. Others are working to quantify the value of ecosystem services.

- How bad can things get?
- Consider:
  - New Orleans (Katrina)
  - Houston (Harvey)
  - North Carolina (Florence)?
- Except instead of single region, 1862 scenario affects *entire state*
- More studies underway

All sectors of the economy	Mega-flood** similar to the one that devastated California in 1861-1862	42	One recent study by Swain et al., (2018) suggests a substantial likelihood of these floods in the rest of this century

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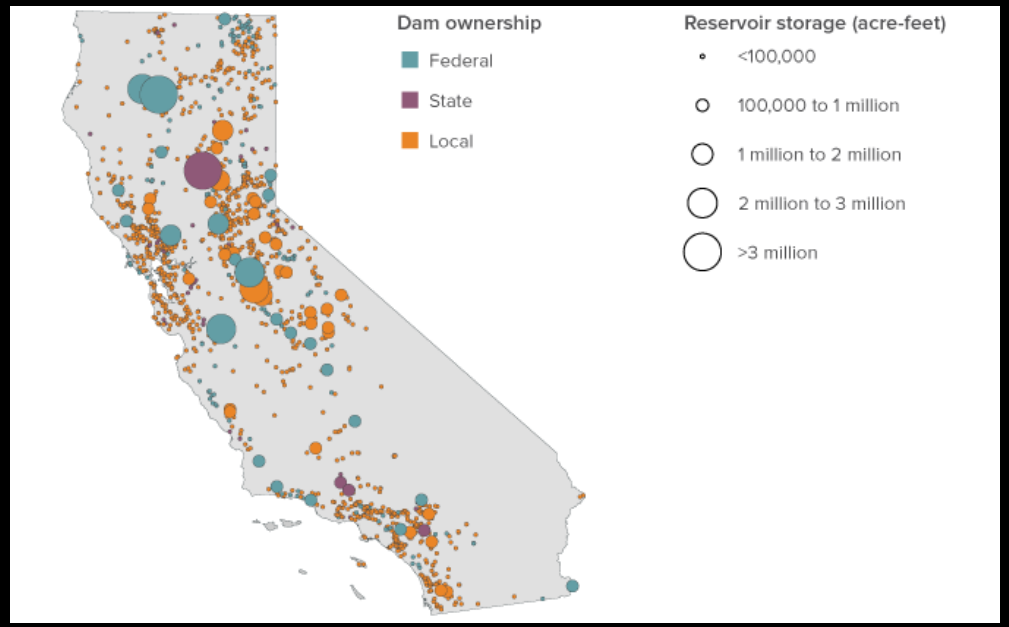
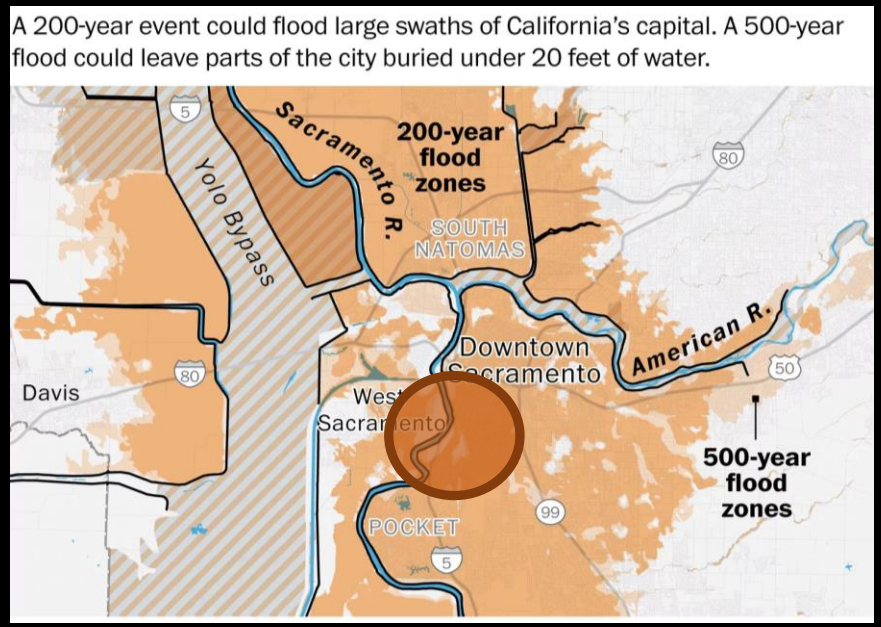
A challenge for policymakers, decision-makers, and engineers

Significant dams in California



Public Policy Institute of California

"200 year" flood map for Sacramento, CA



Washington Post

- Existing infrastructure is "under-engineered" for future climate
- "200 year" flood protection could become "25-50 year" protection
- Tension between competing flood control & drought mitigation mandates will become even more pronounced

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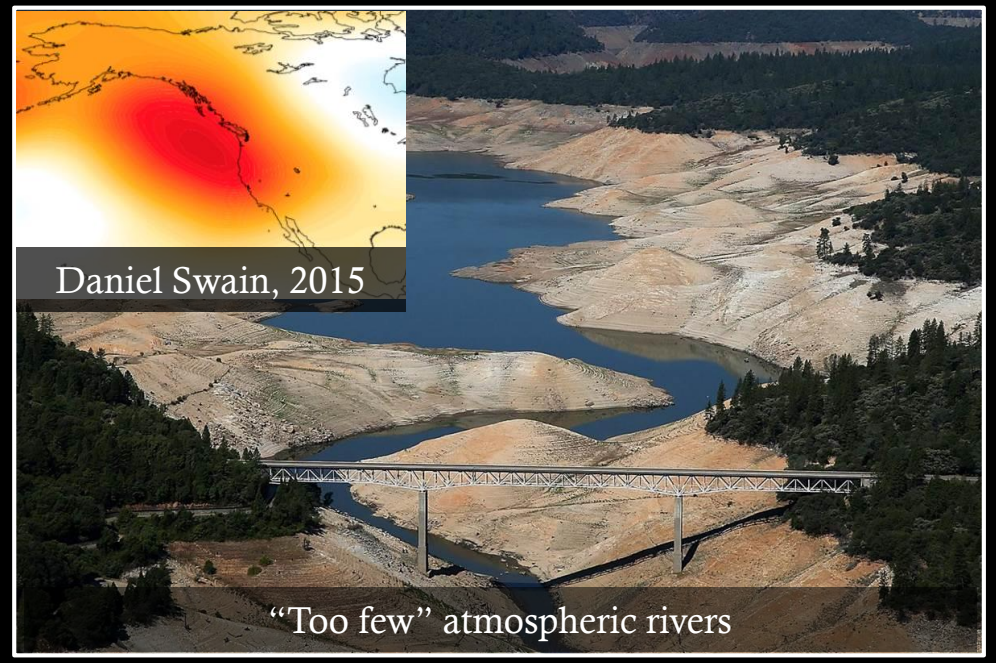
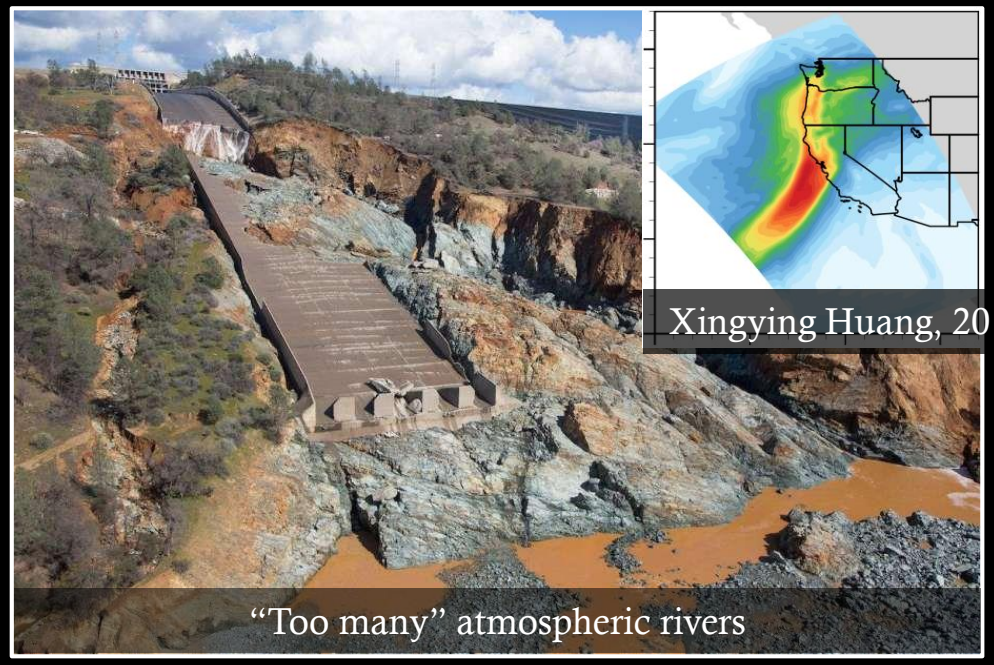
Case study: Oroville Dam Crisis of 2017

Lake Oroville, September 2015



Oroville Dam, February 2017



- Weather/climate did not "cause" crisis. *However*…
- Extreme atmospheric river storm turned an engineering issue (failure of primary spillway) into crisis (headward erosion on emergency spillway)
- Historical warming increased Oroville inflows by ~30%.
  What about the future? (Huang et al. 2018 (runoff), Swain et al. 2018 (precip))

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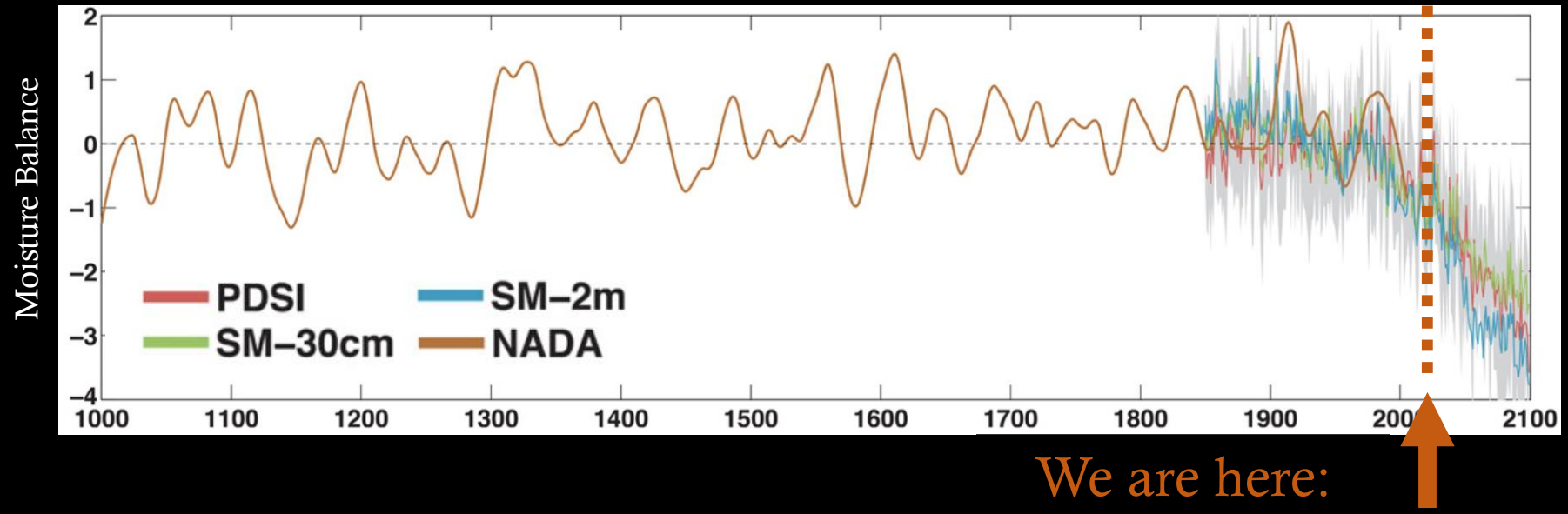
Not just California: Dramatic changes underway throughout West

Rising risk of "megadrought" in American Southwest



- Permanently warmer temperatures (rather than precip) main driver of future West-wide drought risk. Megadrought?? (Cook et al. 2015)
- Over 50% of observed decline of Colorado River flow due to historical warming! (Xiao et al. 2018)
- 90% of West now experiencing snowpack decline (Mote et al. 2018)

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Closing thoughts

- In order to face reality, we have to adapt to ongoing and future climate changes (which are inevitable)
- Increasing extremes (especially flood & wildfire) will likely push existing systems to their limits; perhaps beyond
- Major opportunities may arise amidst increasing whiplash:
  - Sustainable floodplain management (beyond“flood control”)
  - Sustainable groundwater management (co-manage drought & flood risk)
  - New policies & practices surrounding wildfire & emergency response
  - Ecosystem management that has urban/carbon co-benefits

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Announcing a novel partnership between:

- University of California, Los Angeles
  (Institute of the Environment and Sustainability)
- National Center for Atmospheric Research
  (Capacity Center for Climate and Weather Extremes)
- The Nature Conservancy

Thoughts on California weather & climate on the Weather West blog:
www.weatherwest.com

For even more frequent real-time updates, follow me on Twitter: @Weather_West

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