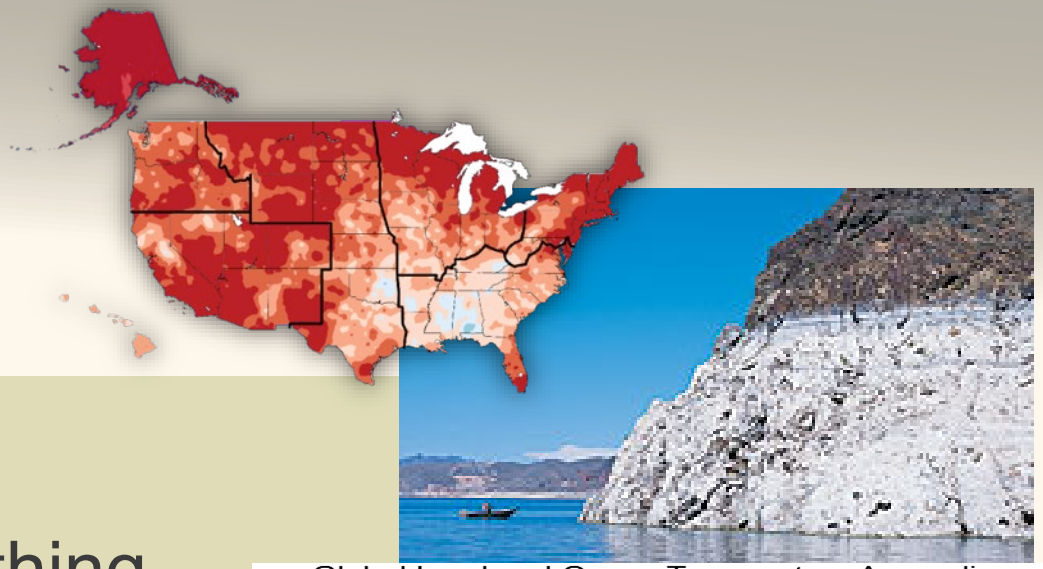
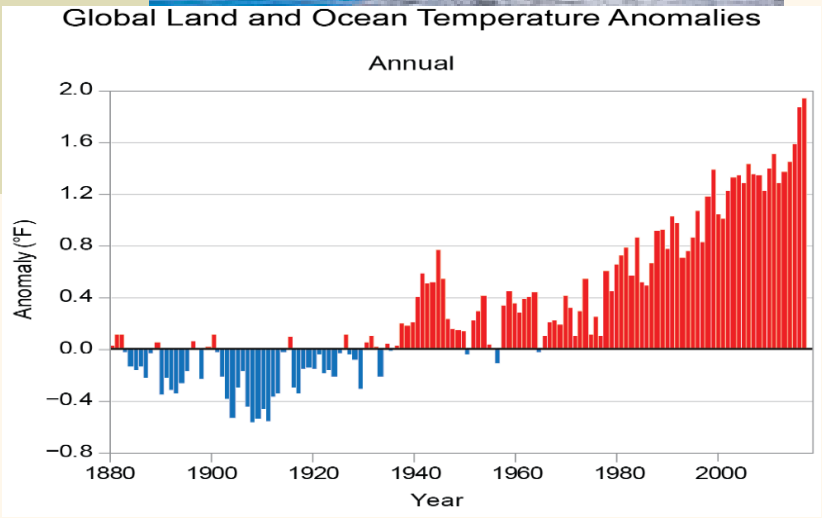
Lincoln Institute
March 29, 2019



How Warming is Changing Everything



Kathy Jacobs

University of Arizona
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Thanks to Don Wuebbles and NCA4 Authors and Staff

ARIZONA | Institute of the Environment

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

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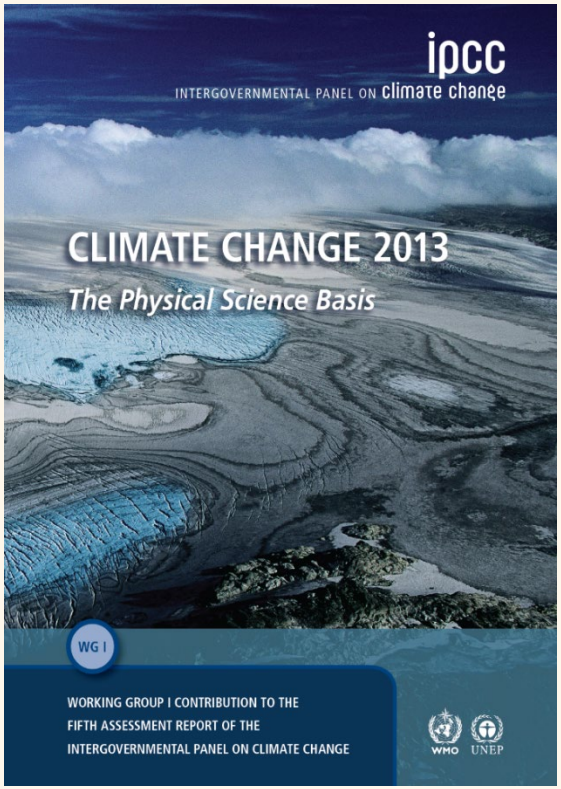
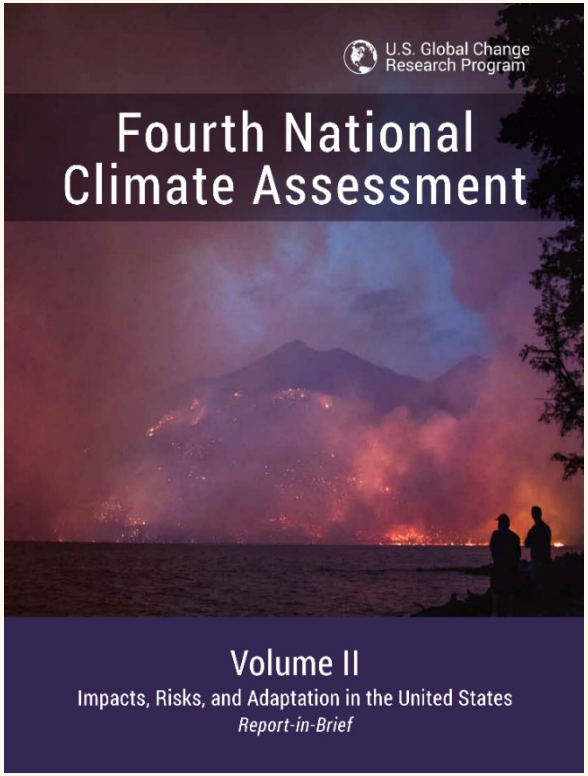
Assessing the Science of the Changing Climate and its Societal Impacts: 5 IPCC and 4 National Climate Assessments since 1990





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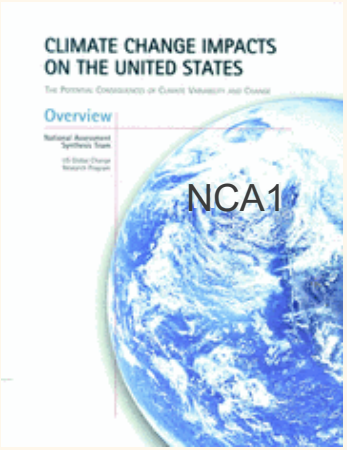
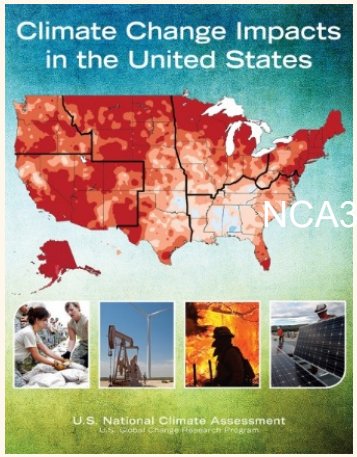
The US National Climate Assessment

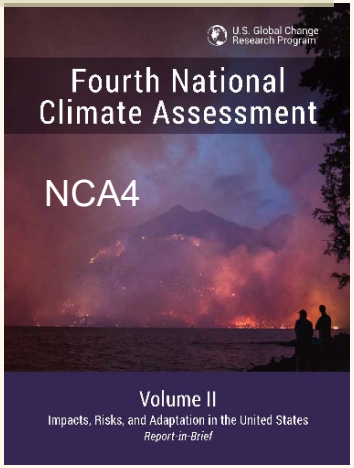
National Climate Assessment Mission (since NCA3)

To advance an **inclusive, broad-based, and sustained** process for assessing and communicating scientific knowledge of the impacts, risks, and vulnerabilities associated with a changing global climate in support of decision-making across the United States.

2000	2009	2014	2017	2018

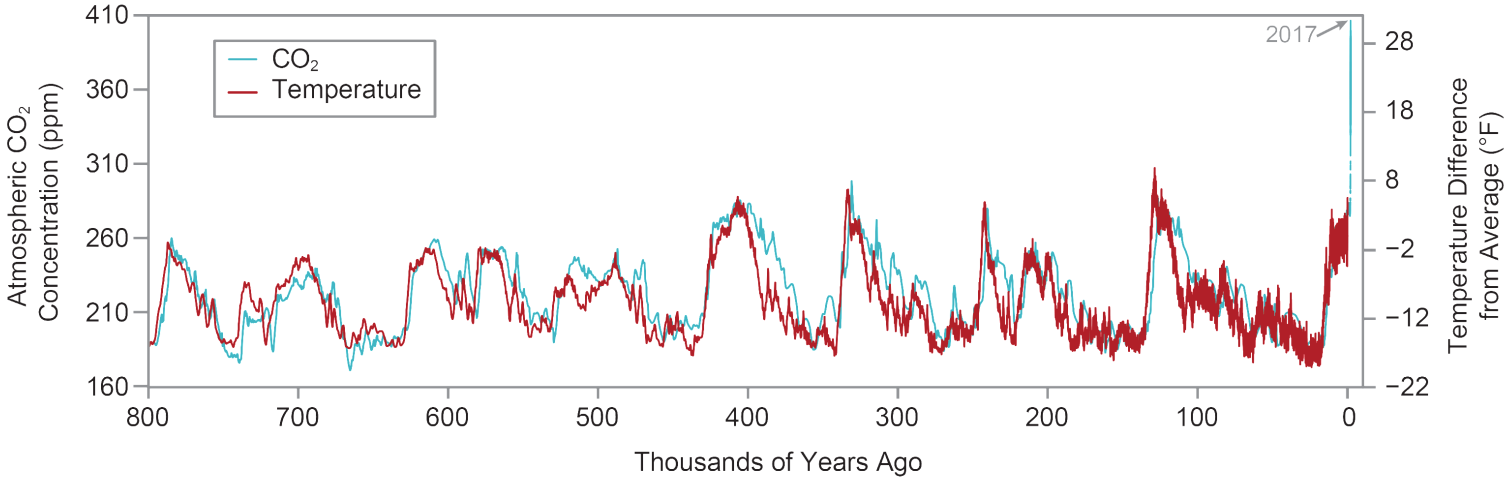






NCA4: The Bottom Line

- Our climate is changing,
  - It is happening now and extremely rapidly;
- Severe weather is becoming more intense;
- Sea levels are rising and oceans being affected;
- It is largely happening because of human activities;
- The climate will continue to change over the coming decades.



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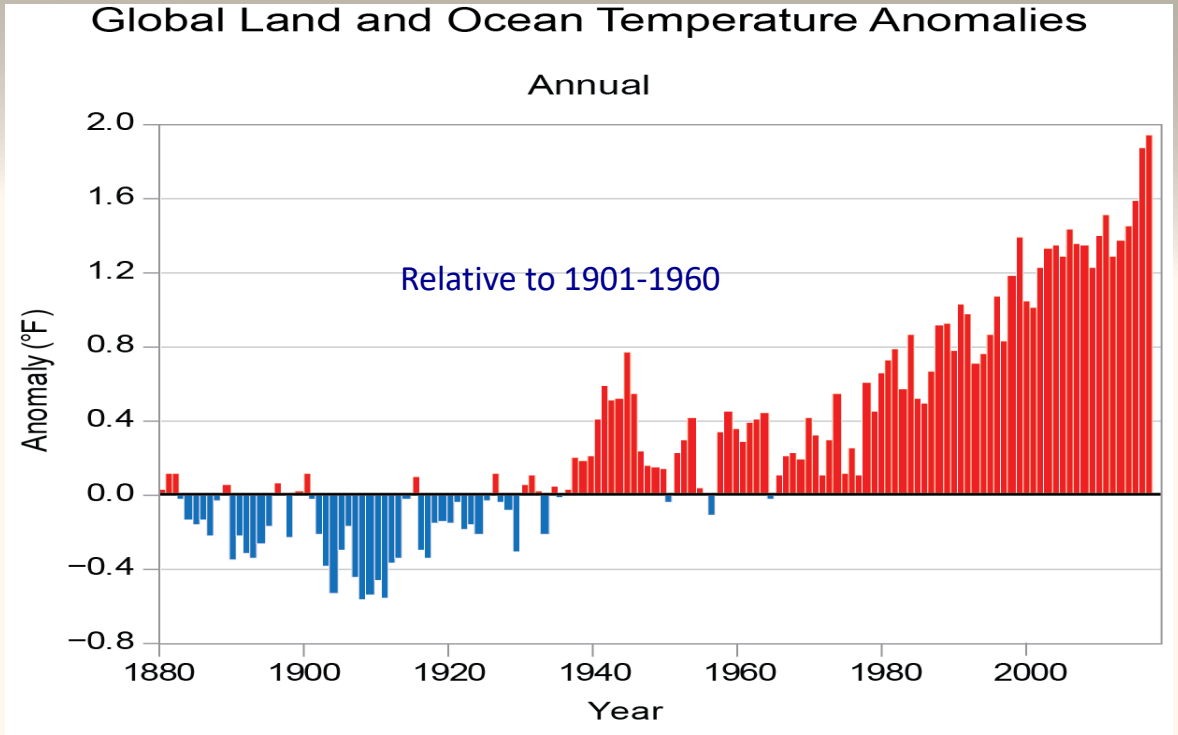
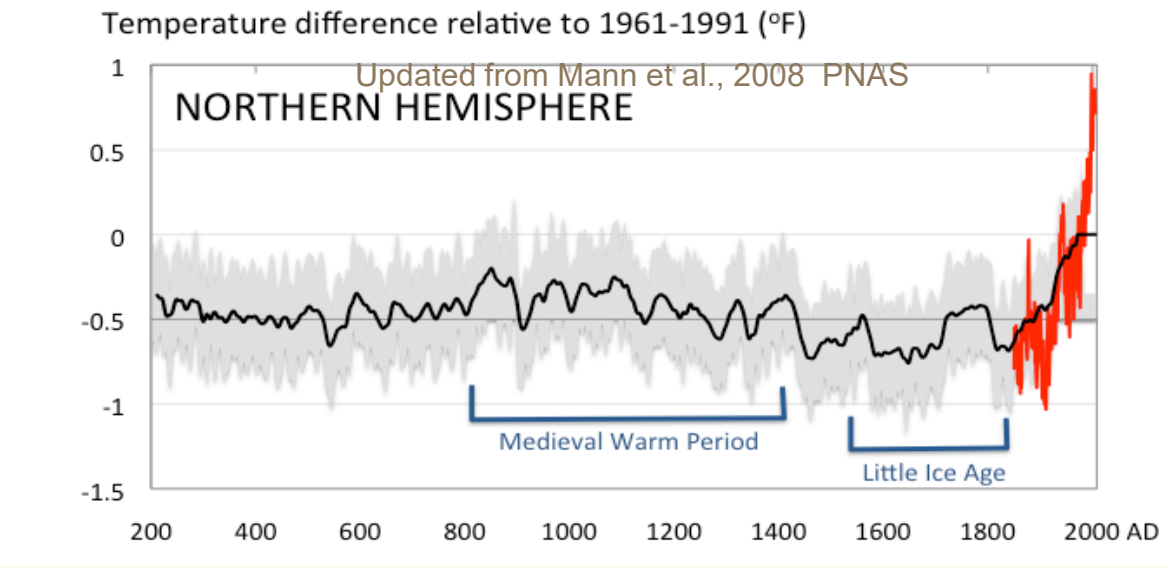
Sixteen of the last 17 years are the warmest on record for the globe

Globally, annually-averaged temperature has increased by 1.8 °F from 1901-2016

2016 warmest year on record, then 2017 and 2015, then 2014





NCA3 and NCA4: Impacts are already apparent in every region and sector, e.g., health, water, agriculture, ecosystems energy….

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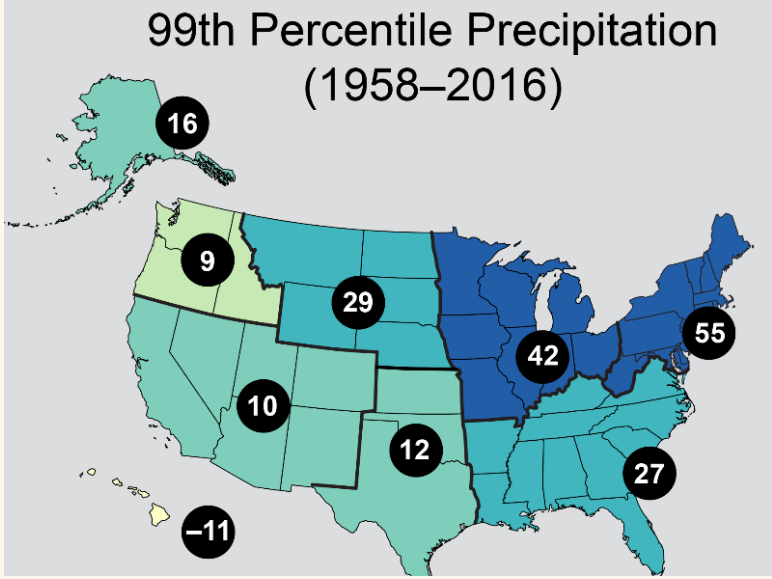
NCA4: Certain Types of Extreme Events Show Important Trends

- Heat waves are generally increasing in number and intensity.
- Cold waves are decreasing.
- More precipitation coming as larger events.
- Increasing risk of floods (NE, MW).
- Increasing intensity of droughts (SW, SE).
- Incidence of large wildfires has increased (esp. West, Alaska)
- Increasing intensity of hurricanes expected.



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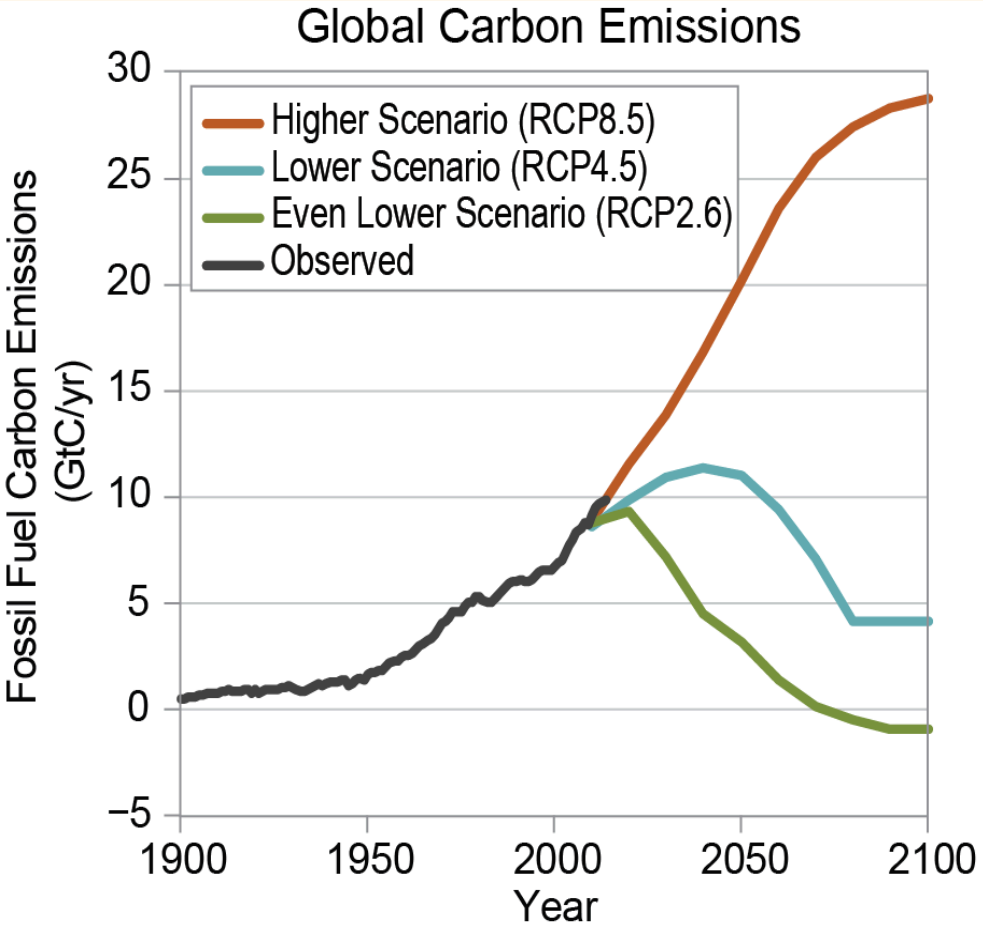
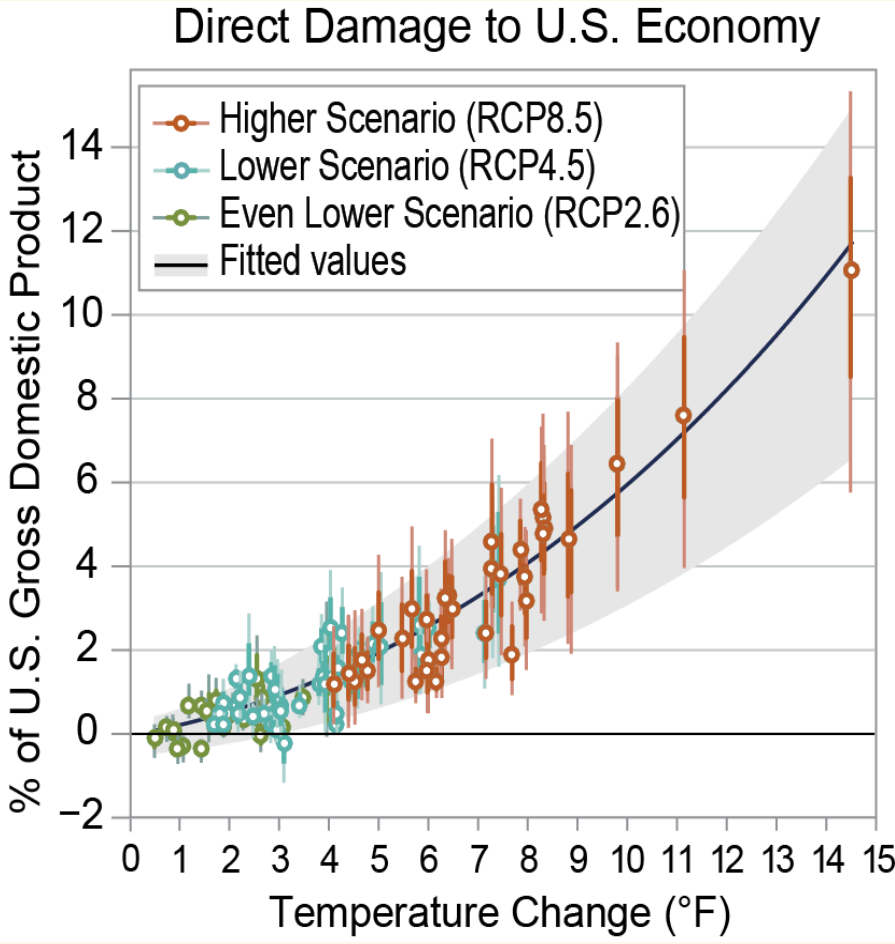
Projected Significant Economic Impacts on the U.S. (and Globally)





Based on Hsiang et al. (2017) in Science

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Advances in Detection and Attribution for Severe Weather Events

For example:
Climate change likely affected Hurricane Harvey:

- Occurrence 3 to 3.5 times more likely
- Rainfall 15 to 38% greater because of climate change

Major journal papers: Emanuel 2017; Risser & Wehner 2017; van Oldenberg et al. 2017

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Simplifying climate impacts for the **Southwest**

- It is going to get hotter
- Streamflow is likely to be reduced (impacting supply)
- ET will increase (impacting demand)
- Drier on average but with intense rainstorms
- Likelihood of cascading effects increasing (eg heat waves, brown outs, forest fires, air quality problems, sedimentation of reservoirs, etc)
- Lake Mead is currently at lowest level since reservoirs were built… our CAP allocations are at risk
- Serious implications for ecosystems, human health and historically disadvantaged populations

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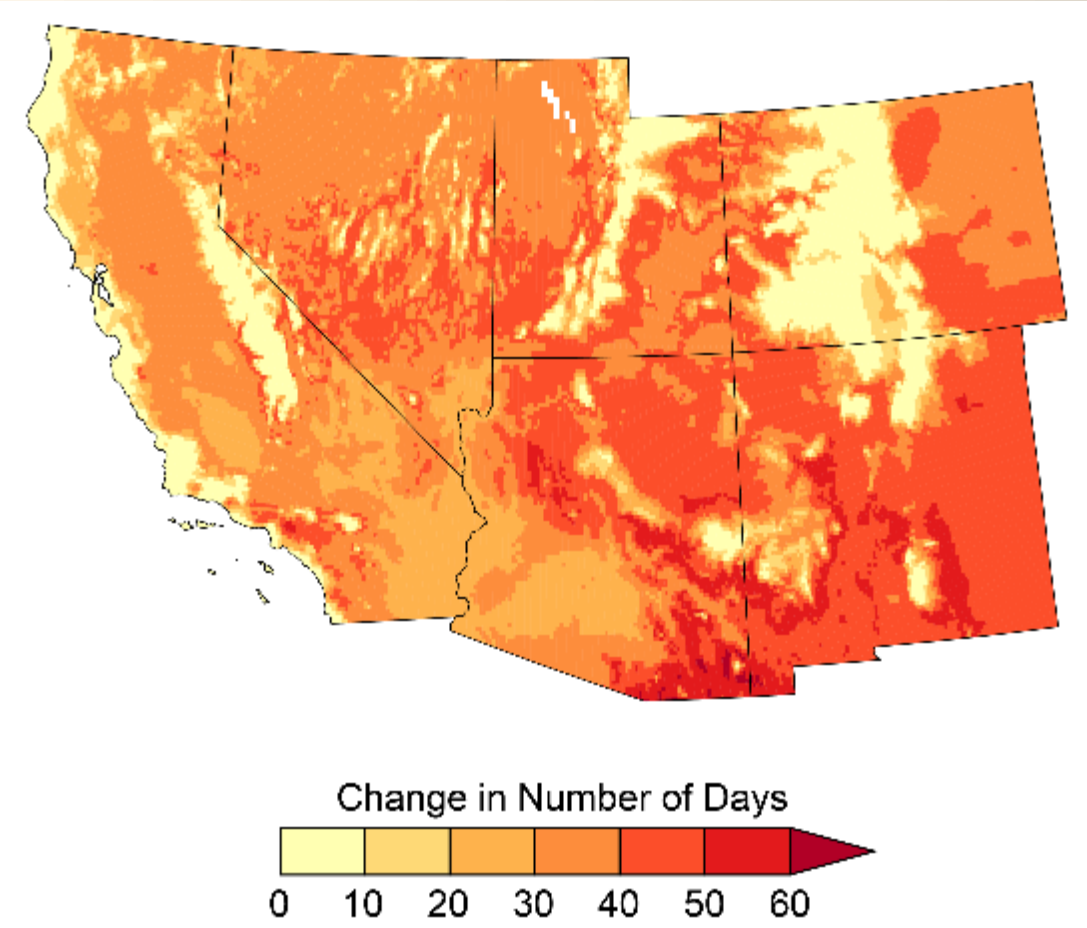
NCA4 SW Chapter: Projected Increases in Extreme Heat

Under the higher scenario (RCP8.5), extreme heat would increase across the Southwest, shown here as the **increase in the average number of days per year where the temperature exceeds 90°F** (32°C) by the period 2036–2065, compared to the period 1976–2005.[23] Heat waves increase the exposure of people to heat stroke and other illnesses that could cause death.[30] *Source: adapted from Vose et al. 2017.*[23]



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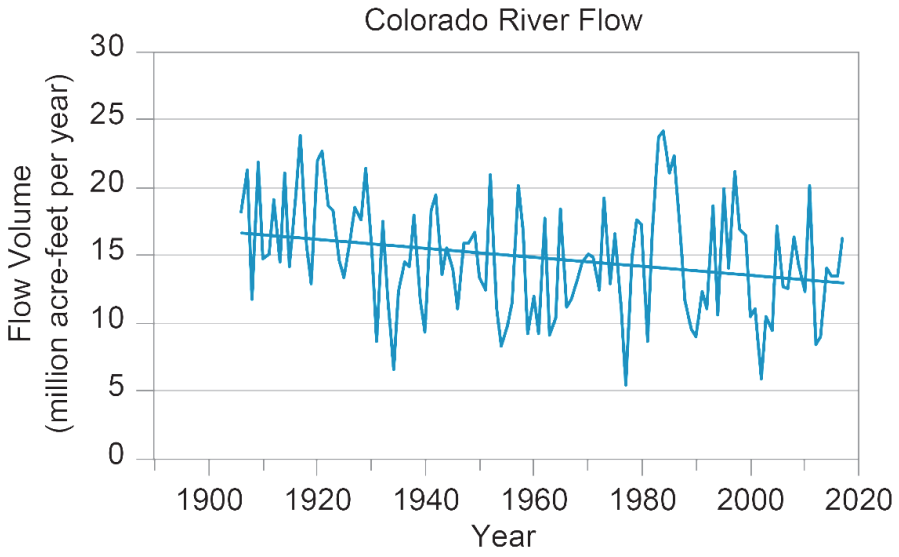
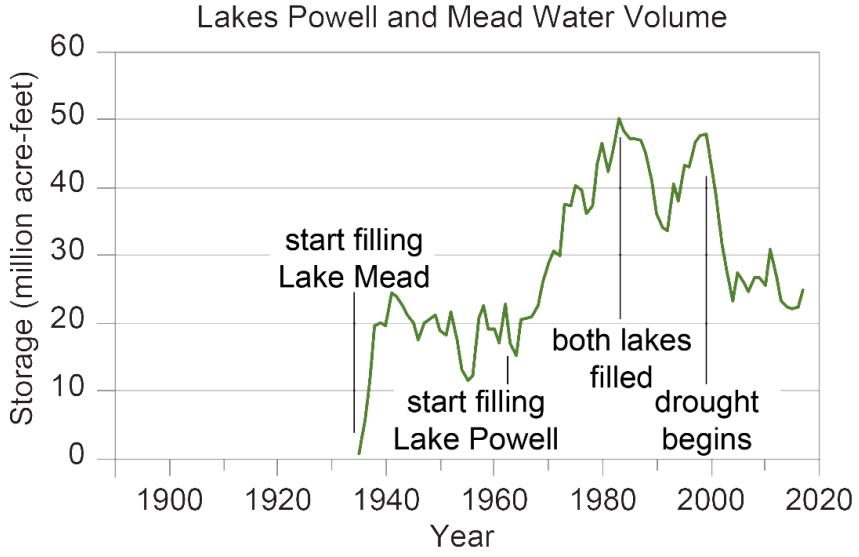
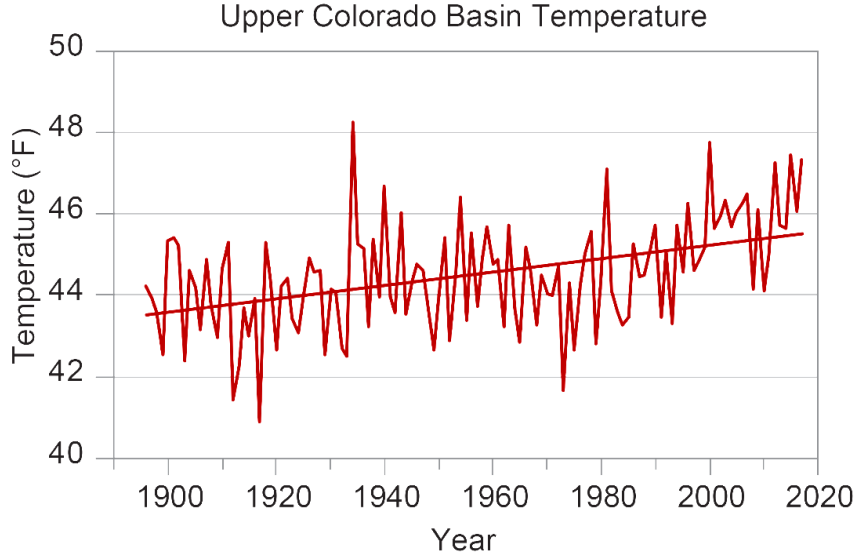
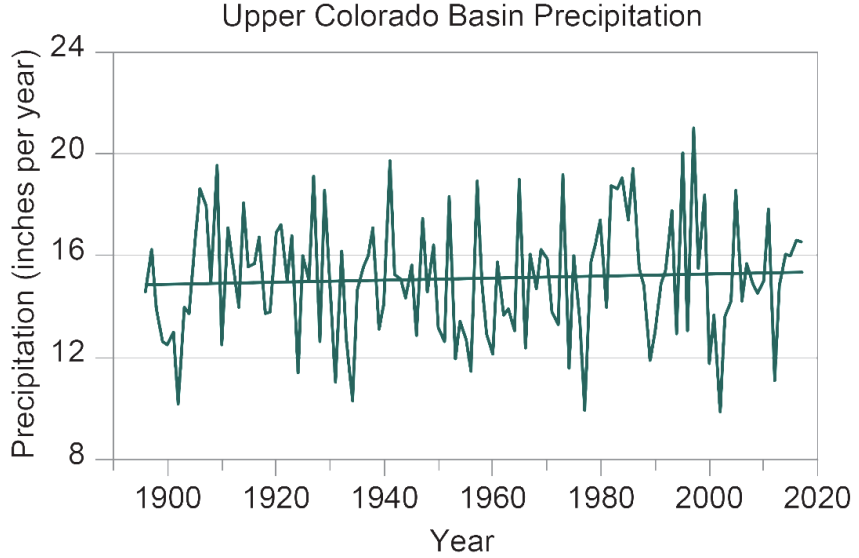
NCA4: Colorado River and Climate Change









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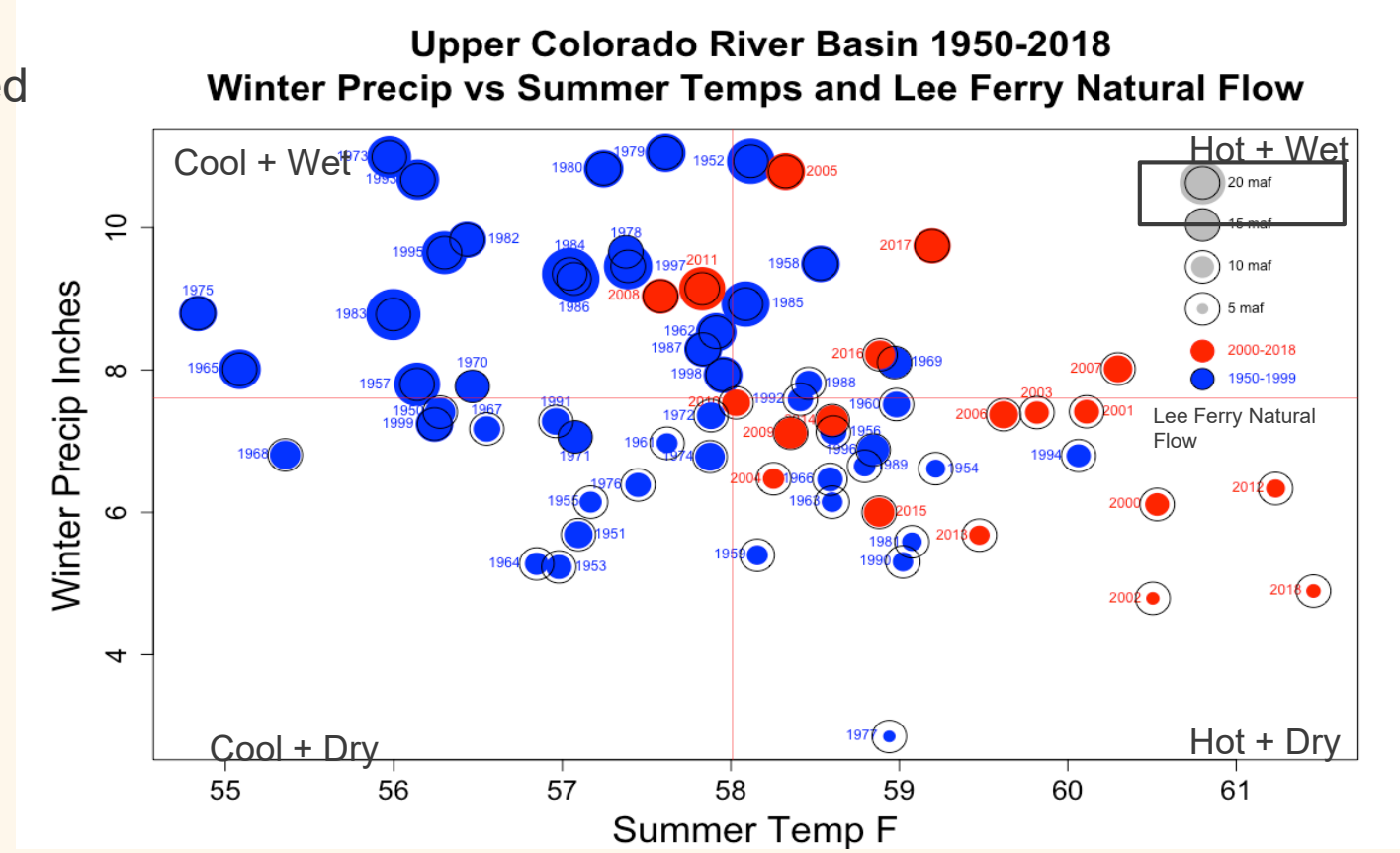
Colorado River Non-Stationarity Evident

- Warming Everywhere
- Record Setting Flow Reductions
- Temperature Induced Losses
- Snow Loss
- Earlier Runoff



Lukas et al, 2014

Woodhouse et al, 2016

Udall and Overpeck, 2017

Xiao et al, 2018

McCabe, et al, 2018

Mote et al, 2018

NCA4, 2018

Thanks to Brad Udall

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Basin Studies: Topics for the future:

(1) the full range of plausible future flow reductions;

(2) groundwater impacts;

(3) extreme flood/sediment management;

(4) accuracy/relevance of water demand forecasts;

(5) ecological/biodiversity impacts;

(6) water quality; and

(7) climate change vulnerability across coupled human-environmental systems.

(8) impact of climate change on integrated physical systems

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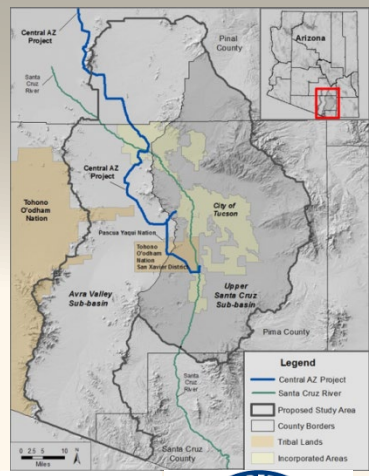
Connecting Science and Decisions: Lower Santa Cruz River Basin Study



Important contributions:

- Consideration of alternative scenarios and management options through local area modelling
- Considers impacts of climate change on both supply and demand
- Considers both local and imported (CAP) supplies
- Uses dynamical downscaling as a primary source of future projections; risk based strategy
- Explicitly considers environmental impacts and options *first government study in Tucson area*

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Challenges of Climate Change for Decision Makers

- Knowing “what to adapt to” especially if outside the envelope of prior experience
- Non-stationarity is a new paradigm: Access to timely, useful scientific information at the right scales is exceedingly rare
- Understanding trends vs. variability
- Anticipating cascading effects

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Defining success: Assessing adaptation outcomes

- Costs and benefits of action vs inaction (who are the winners and losers?)
- Potential for adverse consequences of decisions, including unanticipated consequences at the interface of adaptation and mitigation
- Monitoring for effectiveness – what are the metrics?
- Deciding when to move from low regrets options to more significant/higher investment options
- Environmental justice and equity issues

Choices

- Our future depends on how we act to limit climate change.
- Adaptation is not a choice – our choice is whether to adapt proactively or respond to the consequences.
- Adaptation requires focusing on managing risks and taking advantage of opportunities.

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