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Tapping the Water–Energy Nexus

130th NARUC Annual Meeting and Education Conference

Committee on Energy Resources and the Environment

Climate Science and Regional Reactions

Climate update: IPCC 1.5 °C report & extreme weather

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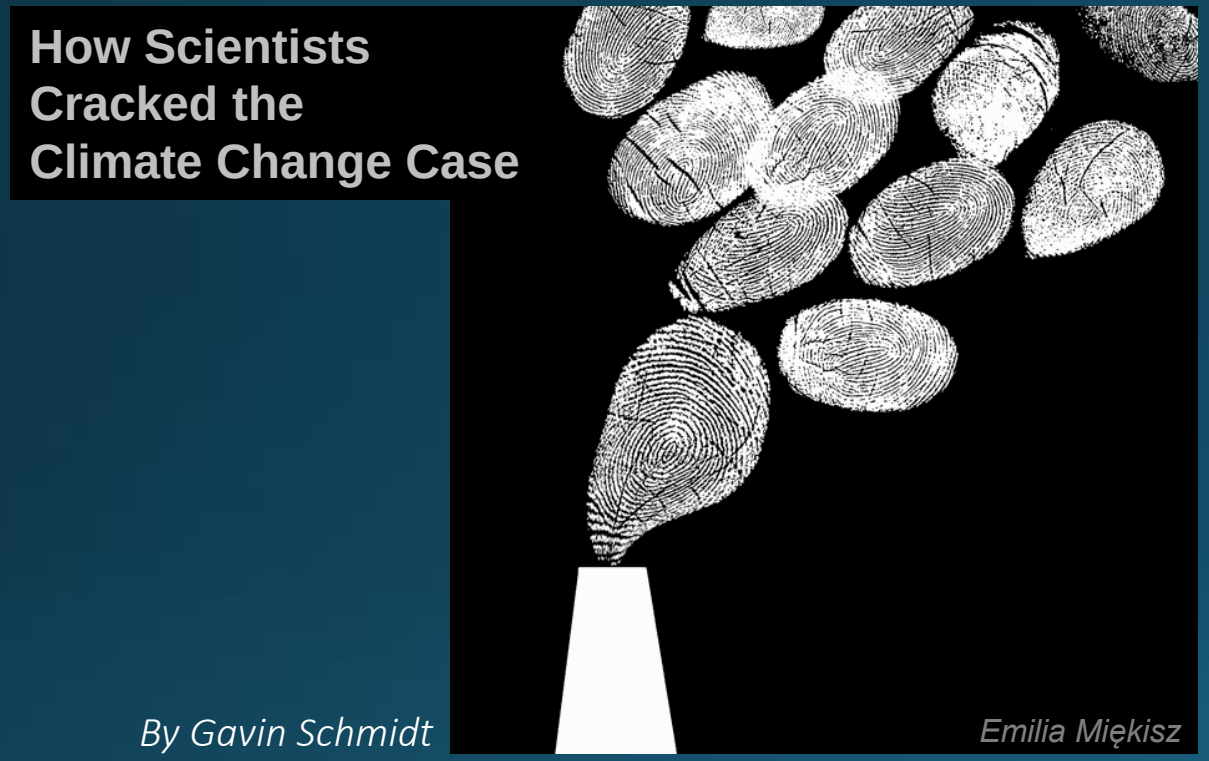
How much of global warming is due to humans?

(Hint: all of it)



By Gavin Schmidt
The New York Times

> Carbon dioxide is like the world's dumbest criminal — it leaves evidence all over the place that it's guilty.
>
> *--Andrew Dessler*
> *Houston Chronicle*

How much of global warming is due to humans?

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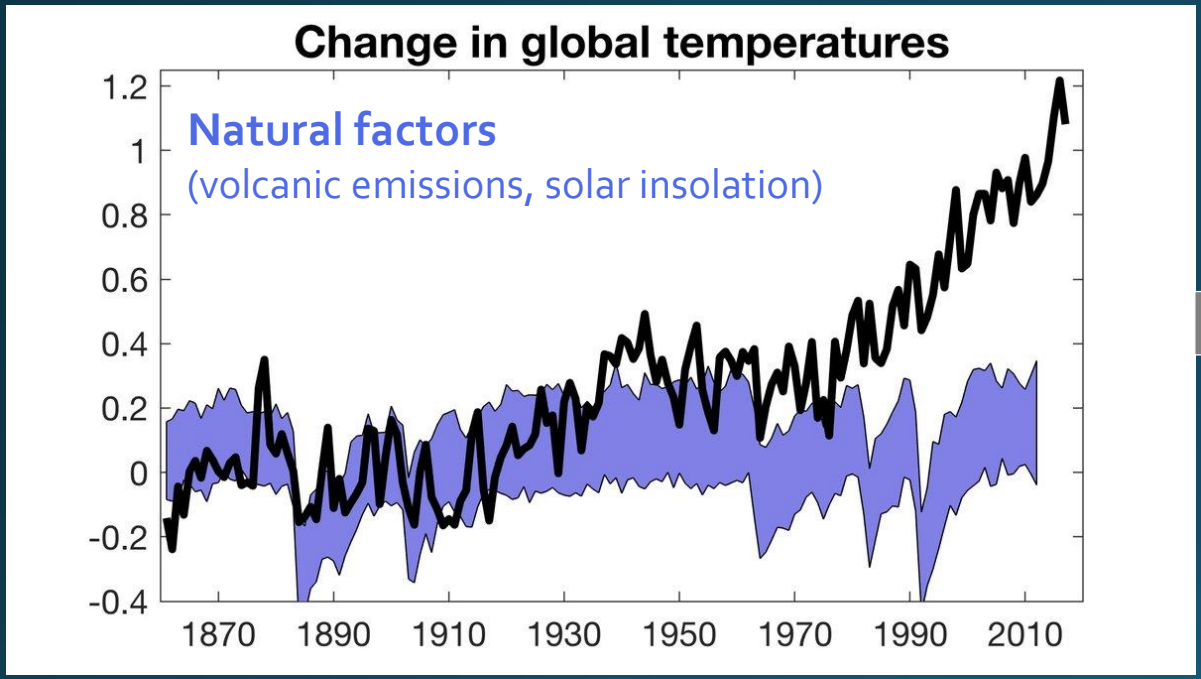
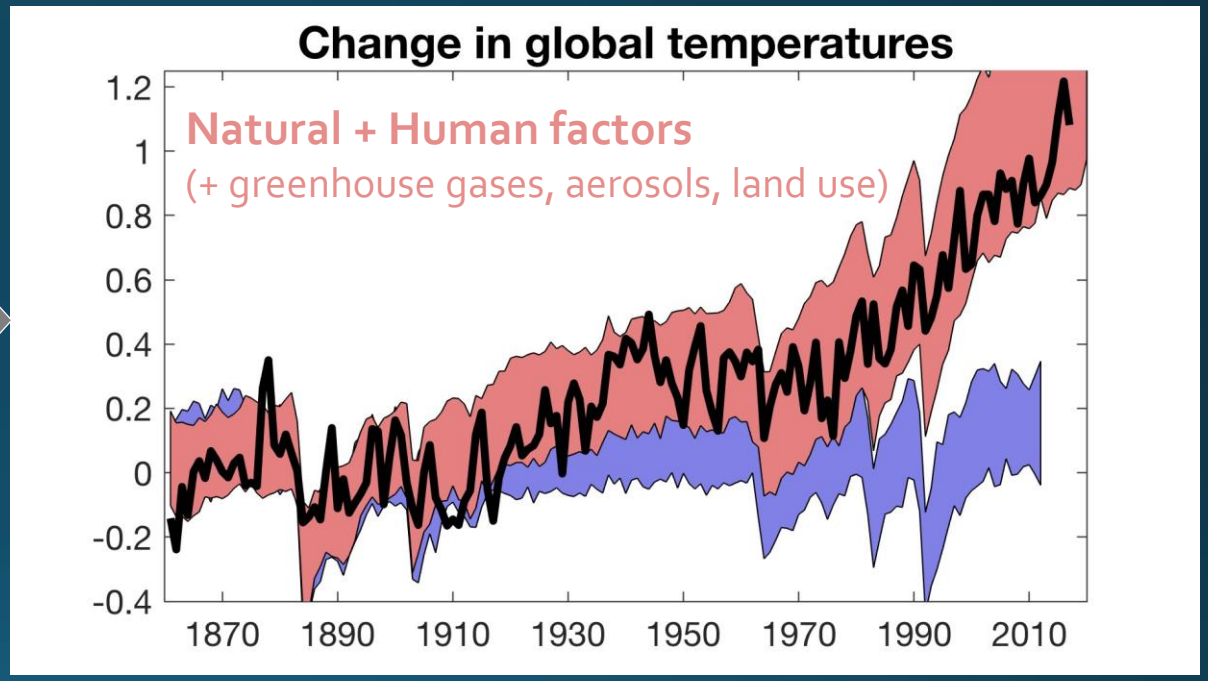


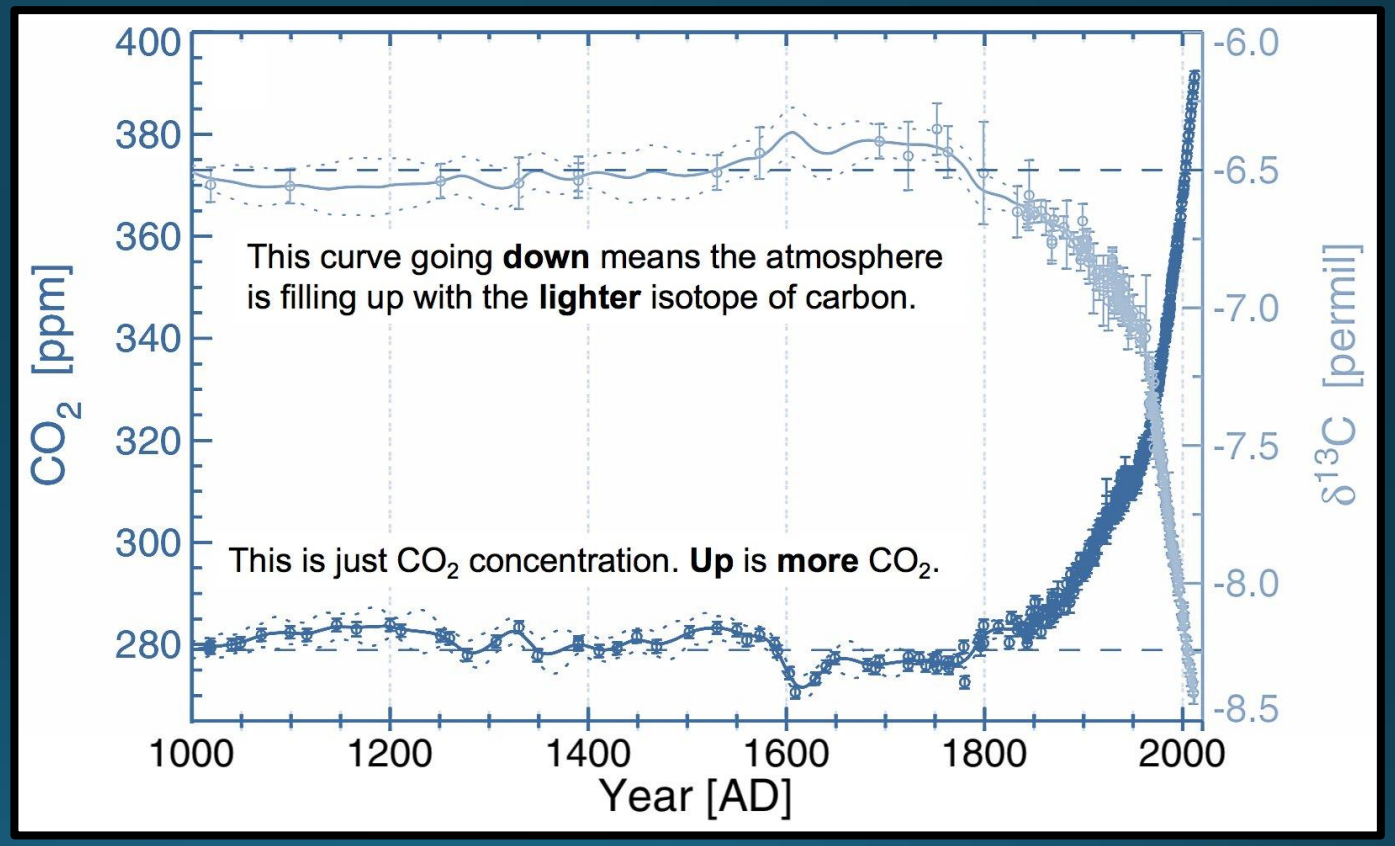


Data from NASA

How much of global warming is due to humans?

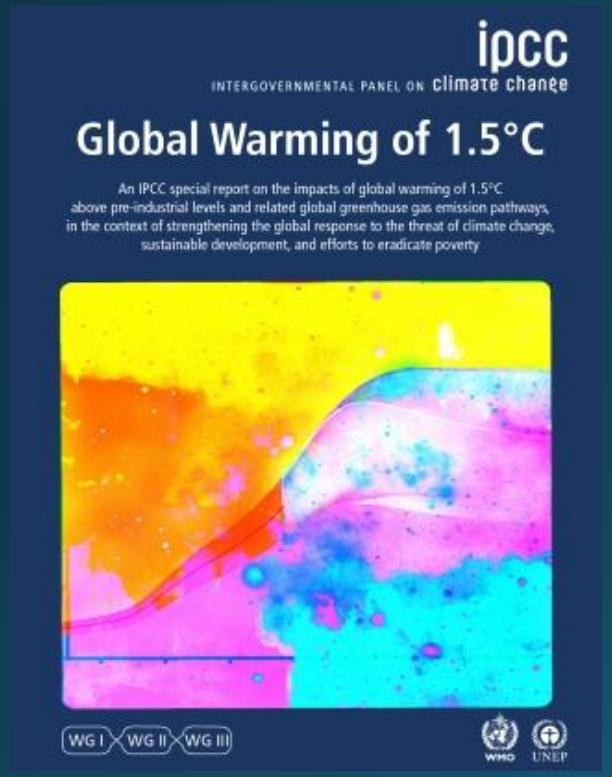
(Hint: all of it)

The isotopic fingerprint of fossil fuels in our atmosphere



Rubino et al. (2013) *Journal of Geophysical Research*

Background of the IPCC 1.5 °C report



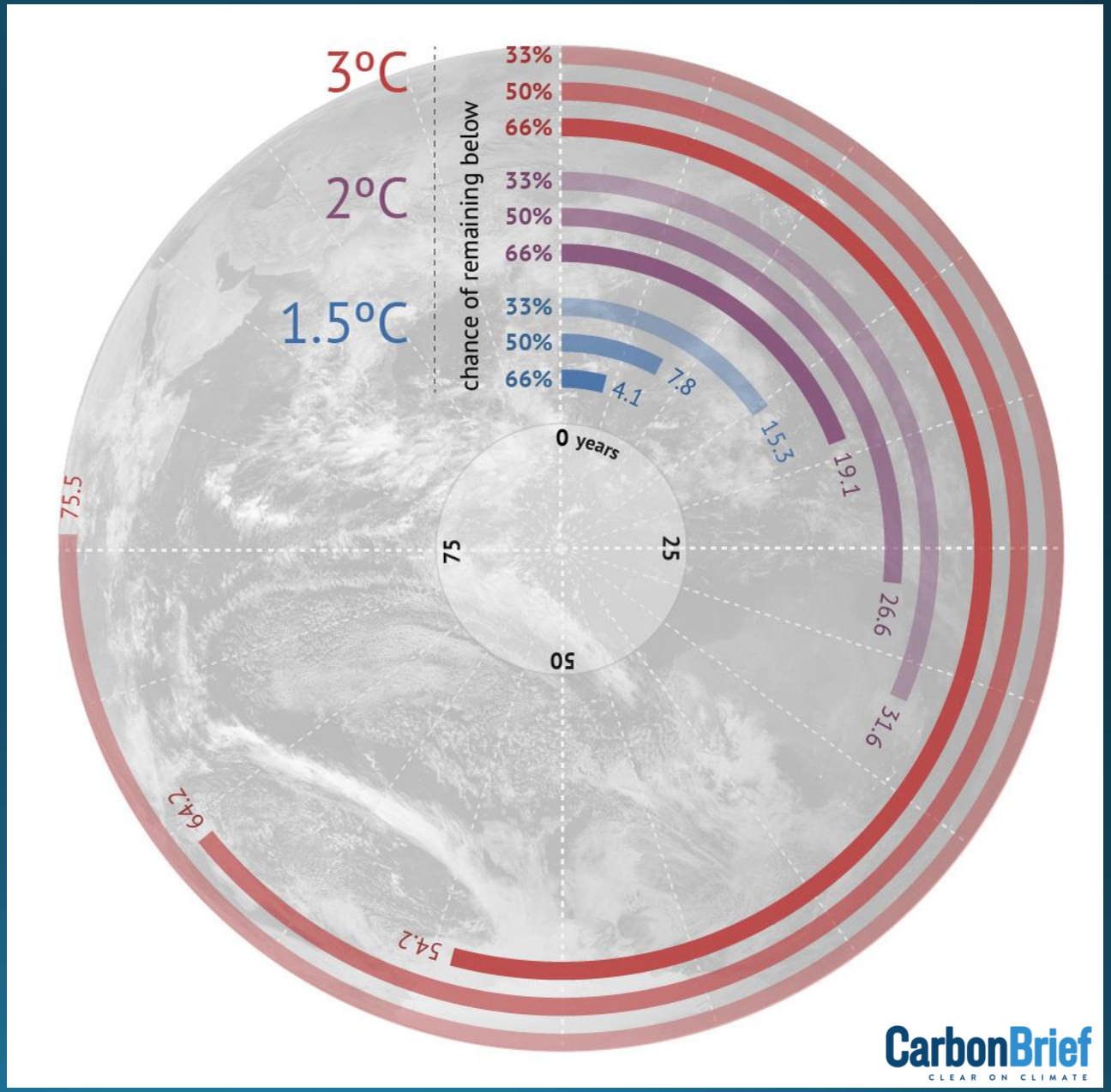
- World governments party to the Paris Agreement requested a comprehensive report on the impacts of 1.5°C of global warming, and how best to limit warming.
- The report assessed more than 6,000 scientific papers, with input from 91 authors and editors from 40 countries.
- Next year, the IPCC will release a report on land use as well as report on oceans and the cryosphere.

How long do we have?

Carbon Countdown

How many years of current emissions would use up the IPCC's carbon budgets for different levels of warming?

(as of the start of 2017)



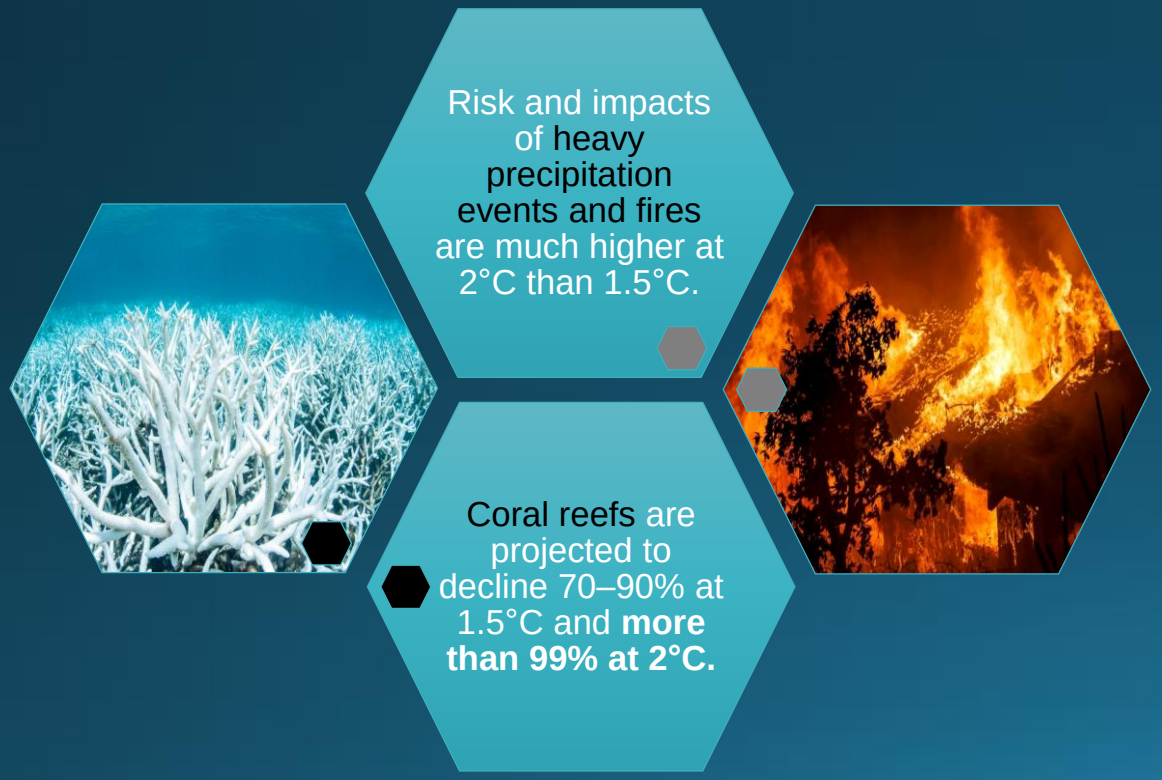
IPCC 1.5 °C report :
Why the doom & gloom? Is it justified or is it hype?

- 1.5°C of global warming is a decidedly tougher target for us to reach than 2°C.
- We are several years along since the last IPCC report. With the passing of each & every year, these targets are decidedly more difficult for us to reach.
- It turns out that 1.5°C doesn't sound like a big number but it has very big consequences for our planet and hence for our lives.

IPCC 1.5 ˚C report : What's new and what's not

NEW

Revises the misperception that 2°C is a safe goal to avoid the worst impacts of climate change.
It is not.



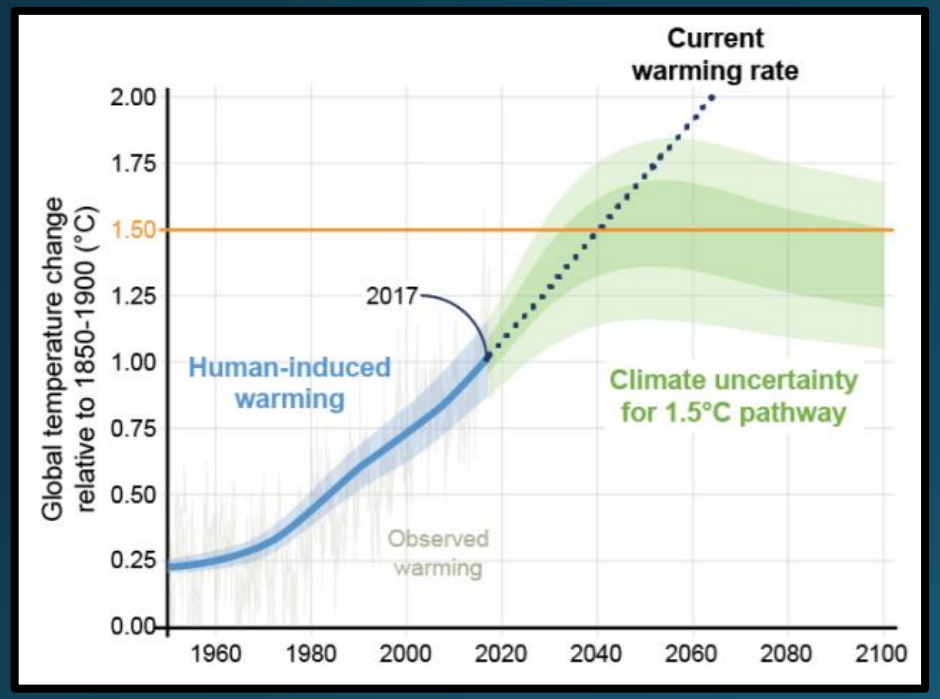
NOT

The fundamental science has not changed.

Continued emissions of greenhouse gases are warming the planet at unprecedented rates and causing dramatic changes to our weather and the environment on which we depend.

How damaging these effects are and how much our lives will be in peril is decidedly up to us.

Can we stabilize at or below 1.5 °C ?

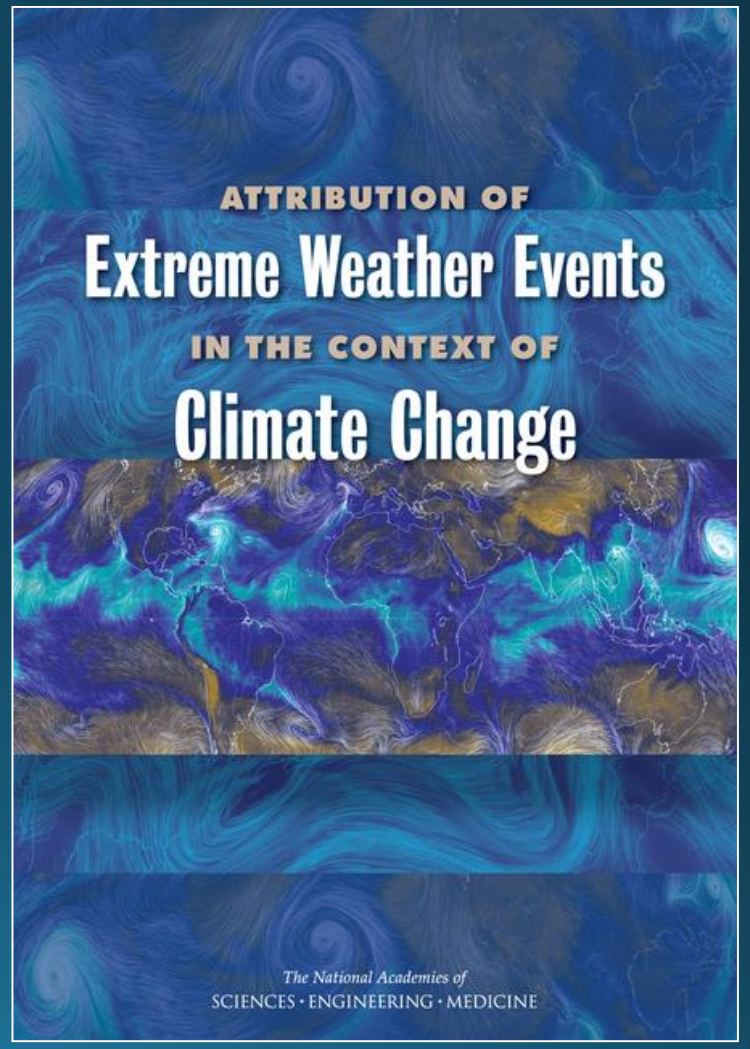


- Limiting global warming to 1.5°C would require "**rapid and far-reaching**" transitions in land, energy, industry, buildings, transport, and cities.
- These systems transitions are "unprecedented" in terms of scale, **but not necessarily in terms of speed**.
- Economic trends are already transforming the power sector, which is moving rapidly to wind and solar.
- The transitions in each sector must start now and be well underway in the next two decades.

How does global warming affect extreme weather?

- Observed frequency, intensity, and duration of some extreme weather events have been changing as the climate system has warmed

  Heat waves like the May-June 2015 India-Pakistan heat wave are expected to be more frequent

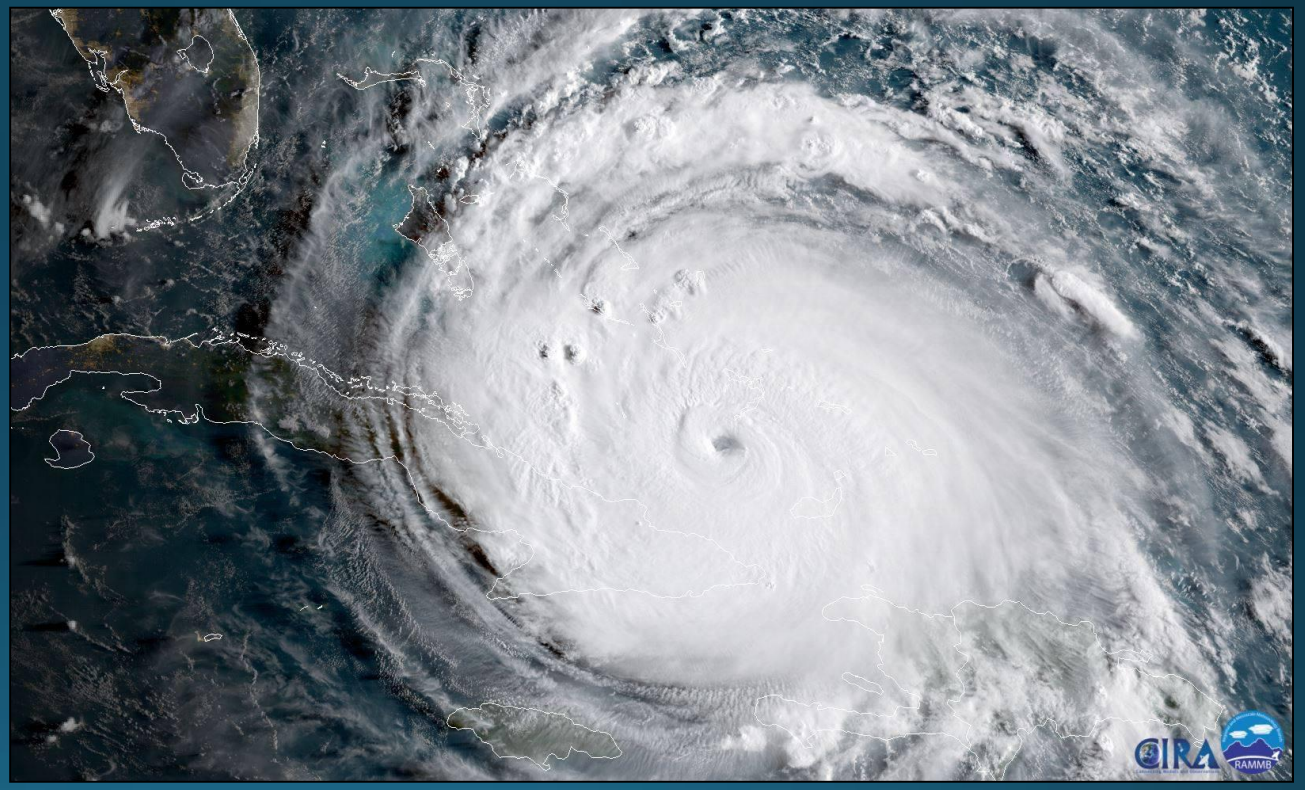


2016

What are the effects of global warming on extreme weather?

It is now possible to estimate the influence of climate change on some types of specific extreme events, in particular:

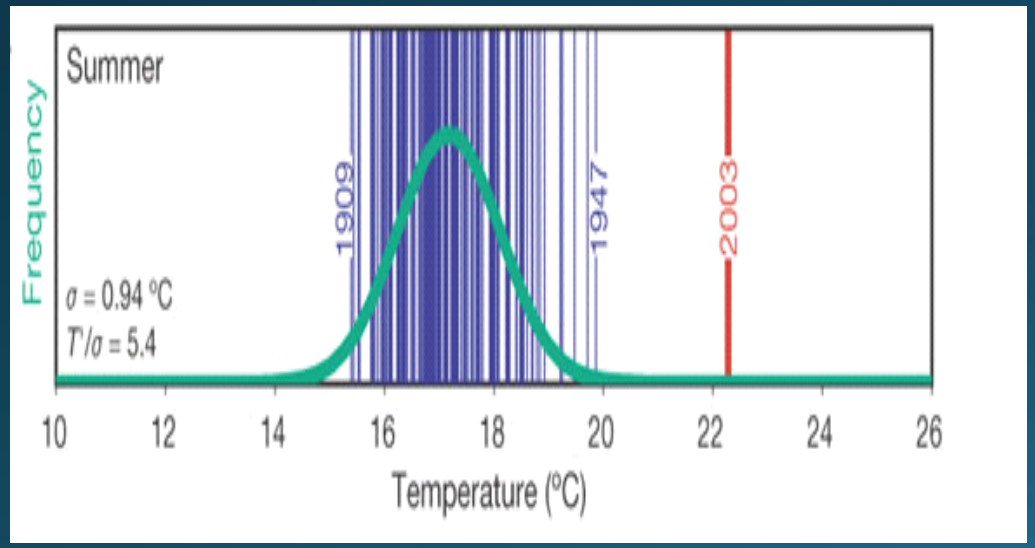
- Heat waves
- Cold events
- Droughts
- Heavy Precipitation



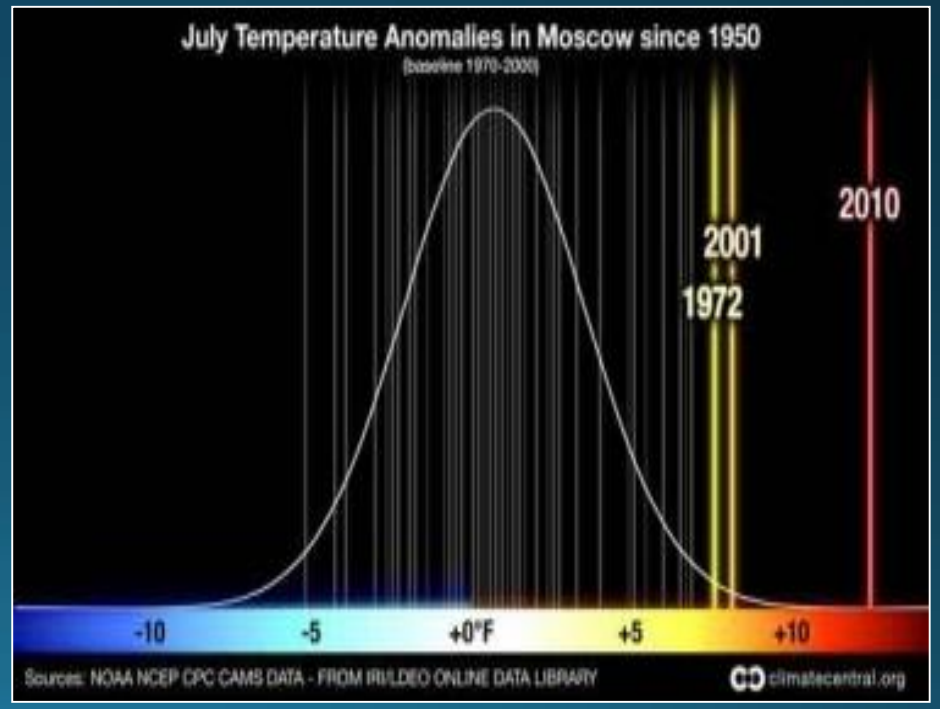
Hurricanes: intensity, rainfall amount, storm surge

What are the effects of global warming on extreme weather?

European heat wave of 2003



Russian Heat wave of 2010



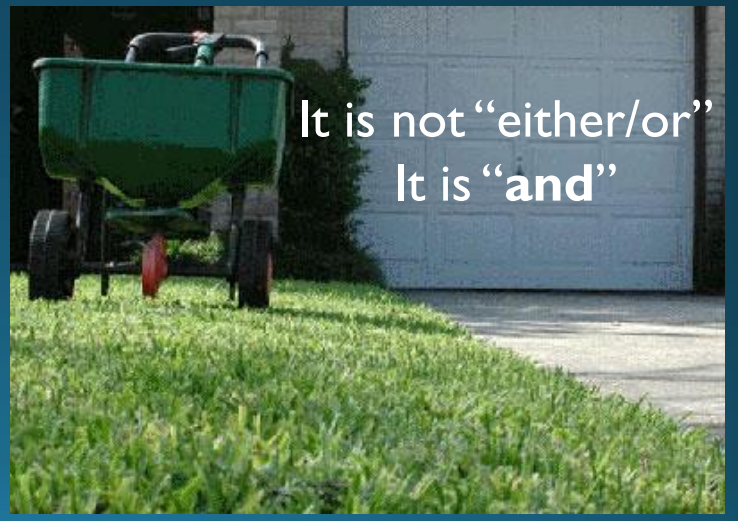
Can we attribute individual events to global warming?

Attribution

- process of evaluating the relative contributions of multiple causal factors to a change or event

Extreme event attribution

- studies that calculate how much human-induced climate change (or another factor) has affected an individual event's magnitude or probability of occurrence



Asking the right questions

- A definitive answer to the commonly asked question of whether climate change "caused" a particular event to occur cannot usually be provided
- Natural variability almost always plays a role

Not-so-great question:

- Was this event caused by climate change?

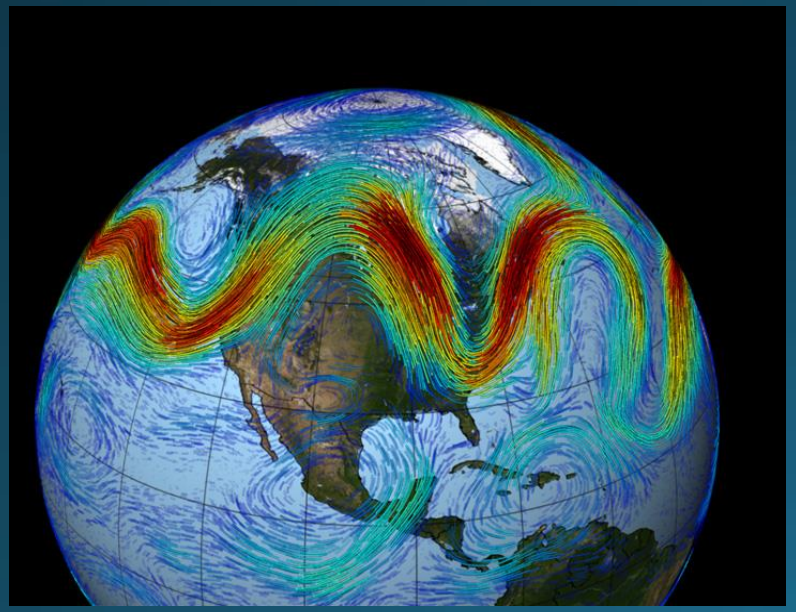
Better questions:

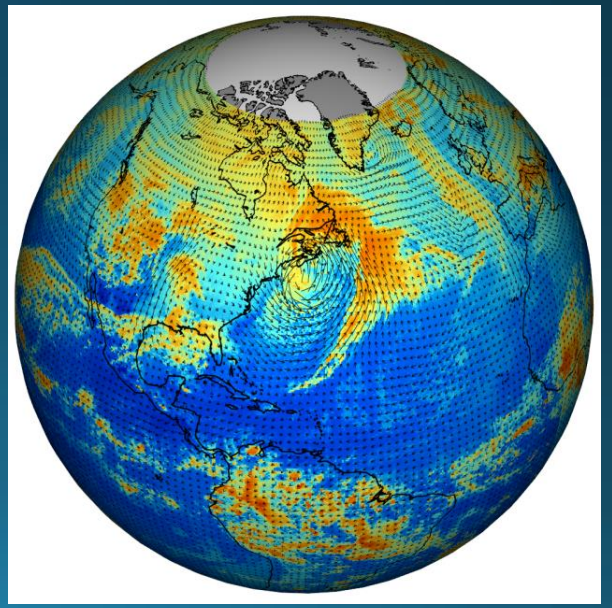
- Are events of this severity becoming more or less likely because of climate change?
- To what extent was the storm more or less intense because of climate change?

Some events are more attributable than others

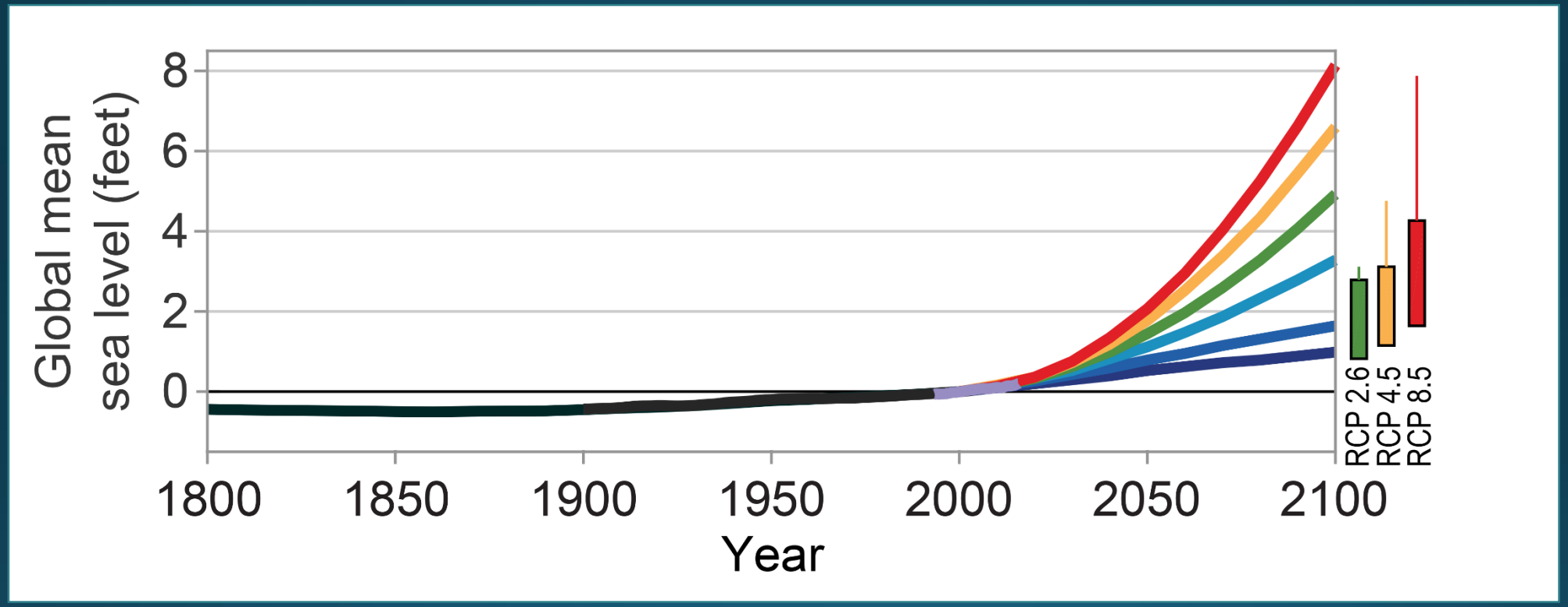
Event attribution is more reliable when based on:

- sound physical principles
- consistent evidence from observations
- numerical models that can replicate the event





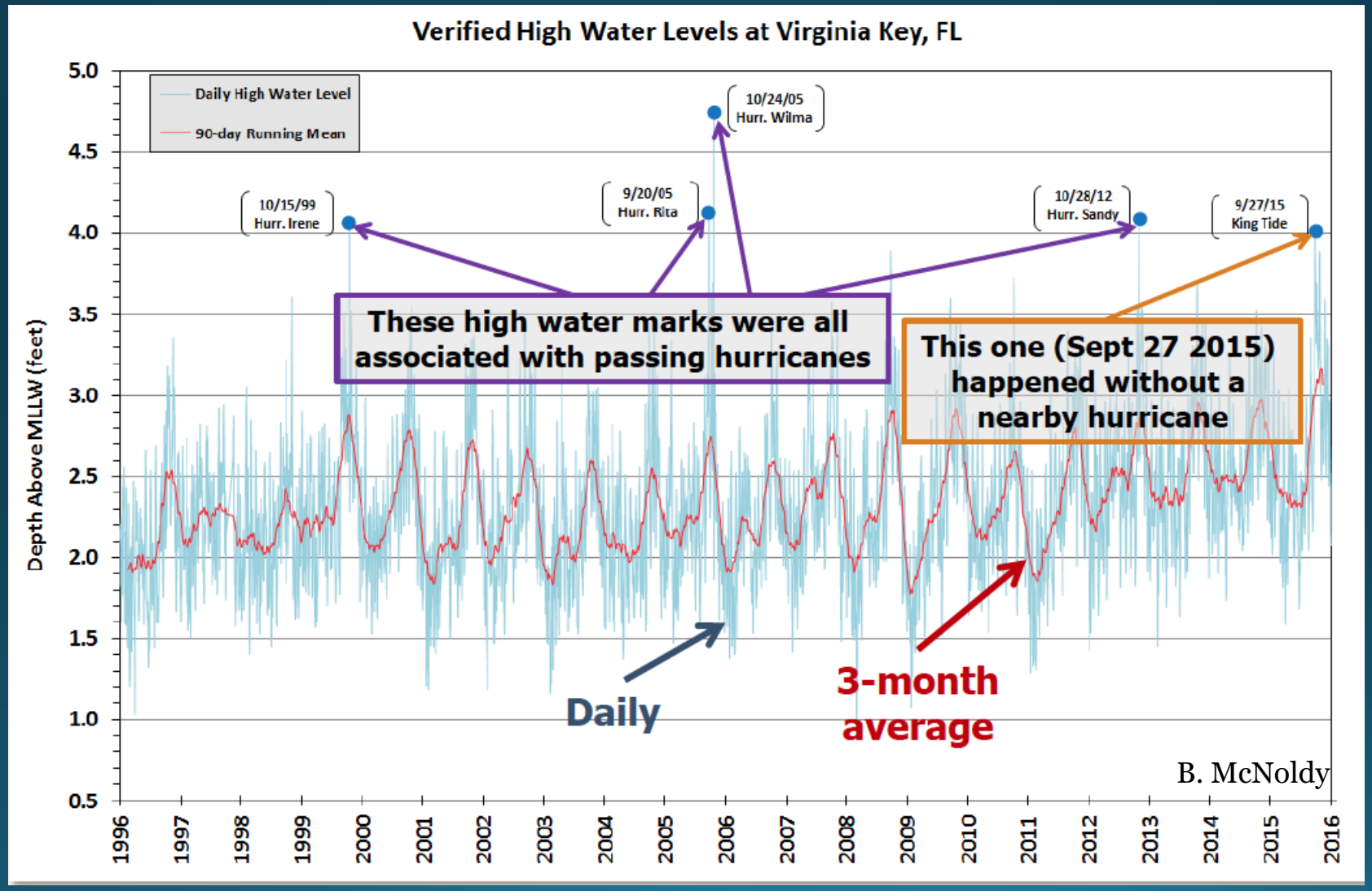
The future of sea level rise



National Climate Assessment (2017)

These are useful projections, but I can guarantee you that sea level rise will NOT look like any of these curves.

What will future sea-level rise look like?



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Committee on Energy Resources and the Environment

California's Fourth Climate Change Assessment

Overview of key findings for the energy sector

Guido Franco
Team Lead for Climate Change and Environmental Research
California Energy Commission

130th Annual Meeting and Educational Conference
National Association of Regulatory Utility Commissioners
November 12, 2018
Orlando, Florida

Outline

- Weather-related impacts to the US energy system: electricity
- Climate change research in California
- How climate is changing in California and how it may change in the future
- Overall climate impacts to the energy system in California
- How should the CA energy sector evolve in the next 30 years?
- Is the CA energy system adapting?

Weather-related impacts to the US energy system: electricity

- The impact of weather-related extreme events to the U.S. energy system is increasing. For example, the figure on the right shows an increasing trend of weather-related grid disruptions.
- States (e.g., New York) and IOUs (e.g., Con Edison) are examples of leadership on how to prepare for weather-related extreme events. In this case, superstorm Sandy provided the motivation for this exemplary work in New York State.
- The DOE has created the *Partnership for Energy Sector Climate Resilience*. About 19 energy utilities are participating.

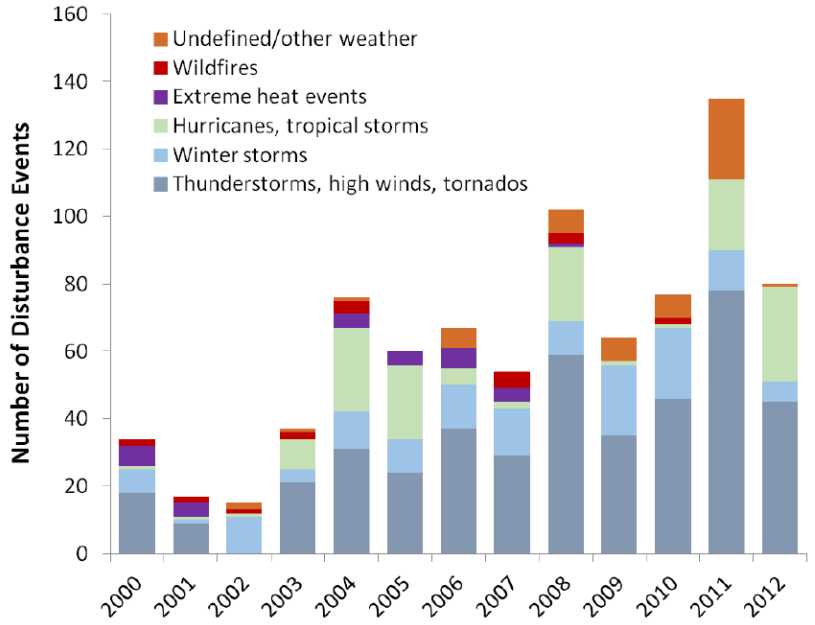


Figure 28. Weather-related grid disruptions, 2000–2012

Data source: DOE 2013b

DOE, 2013. U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather

Climate change research in California

California begins supporting regional climate change science again in 2001

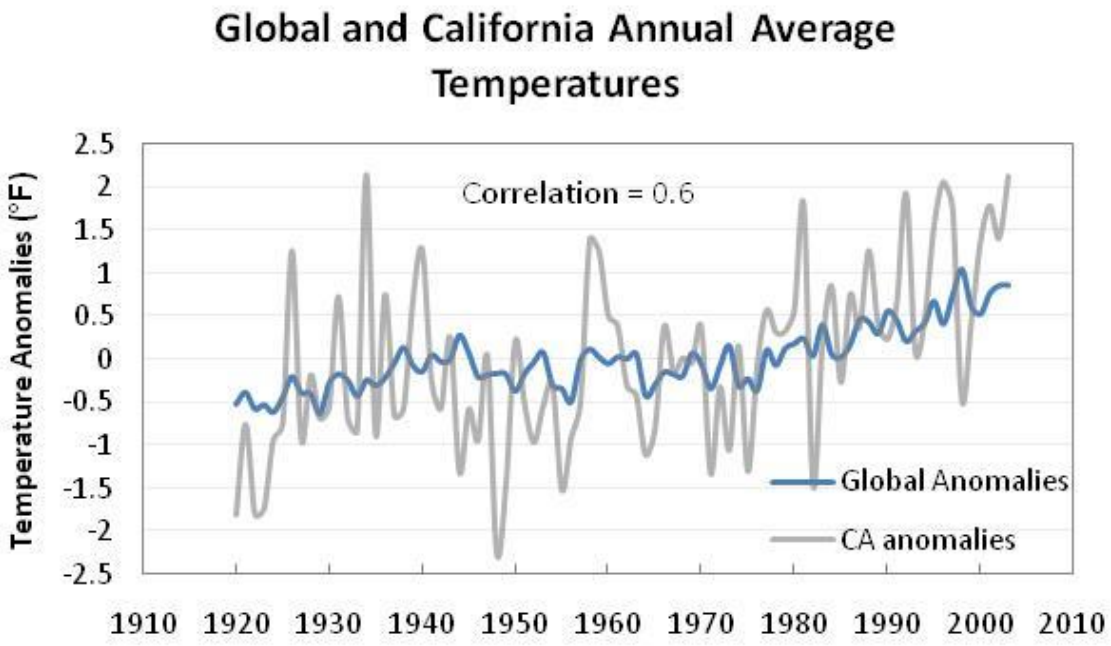
Research draws on and informs national research efforts

California creates the CA Climate Change Center – a virtual organization tasked with implementing 2003 research plan

Research informs policy and long-term climate planning

How climate is changing in California and how it may change in the future

Historical statewide and global annual average temperatures

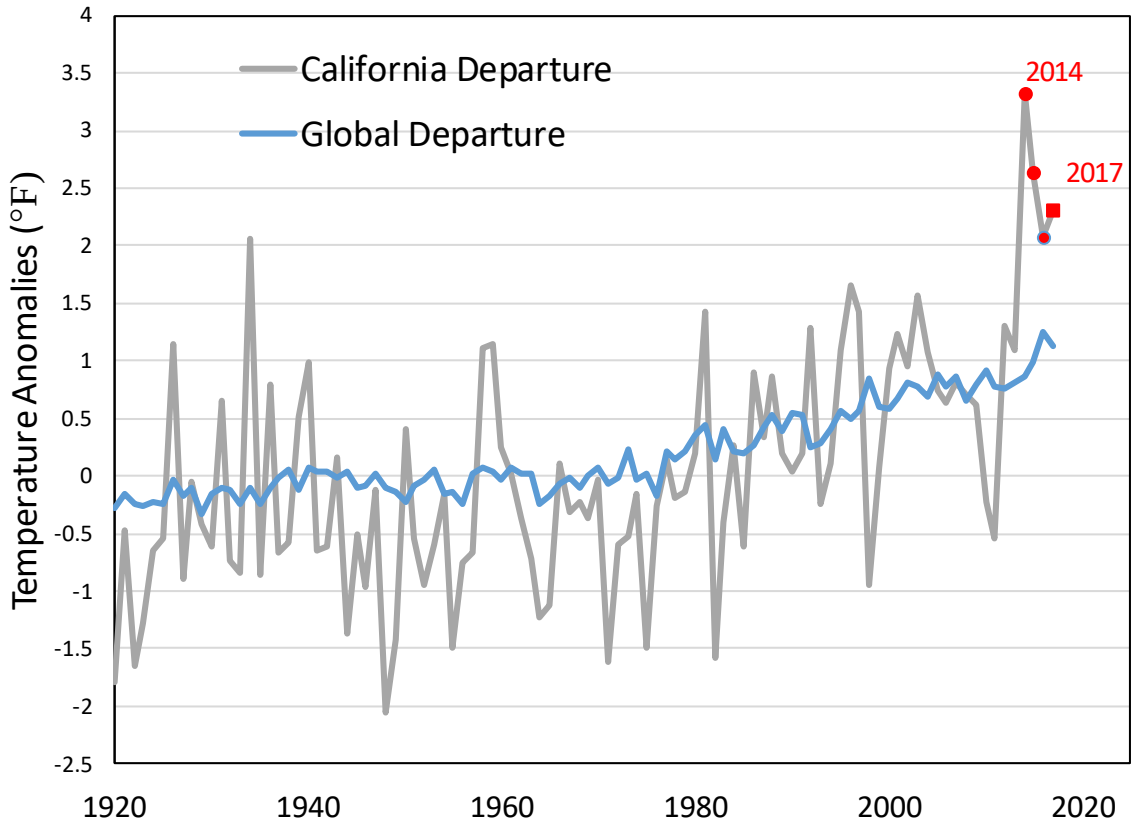


Graph prepared in ~ 2008

Data Sources: NASA, Western Regional Climate Center

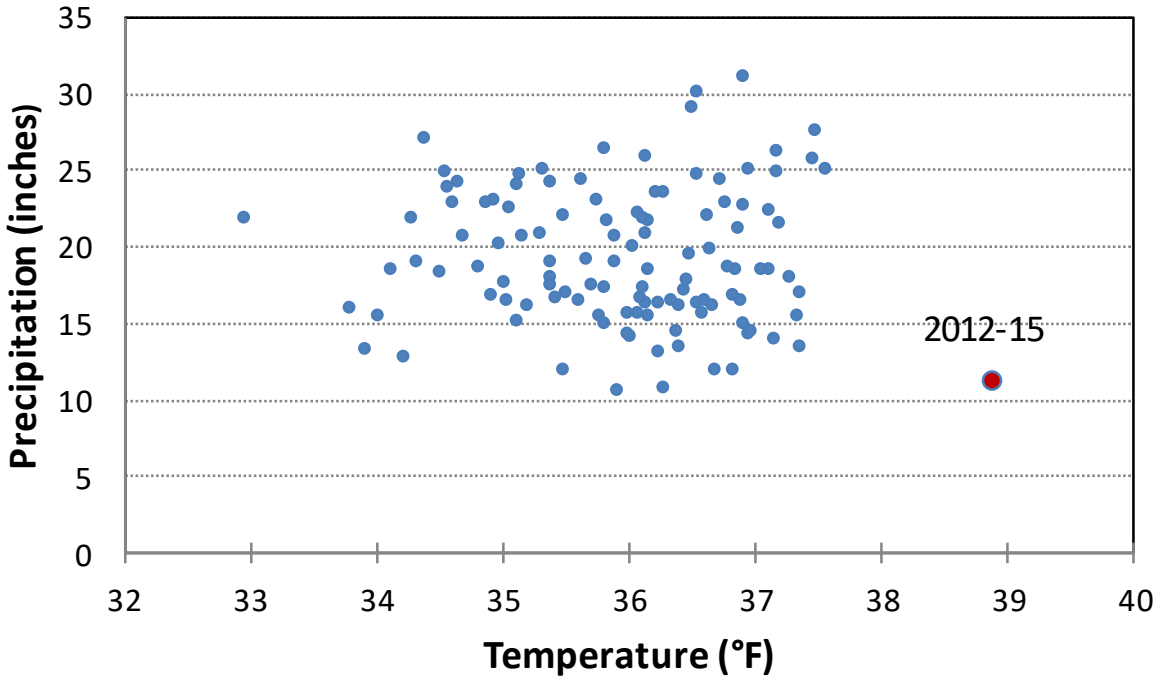
Climate variability can be relatively strong at the state scale, such as California

Annual average temperatures moving beyond historical ranges



Data Sources: NASA, Western Regional Climate Center

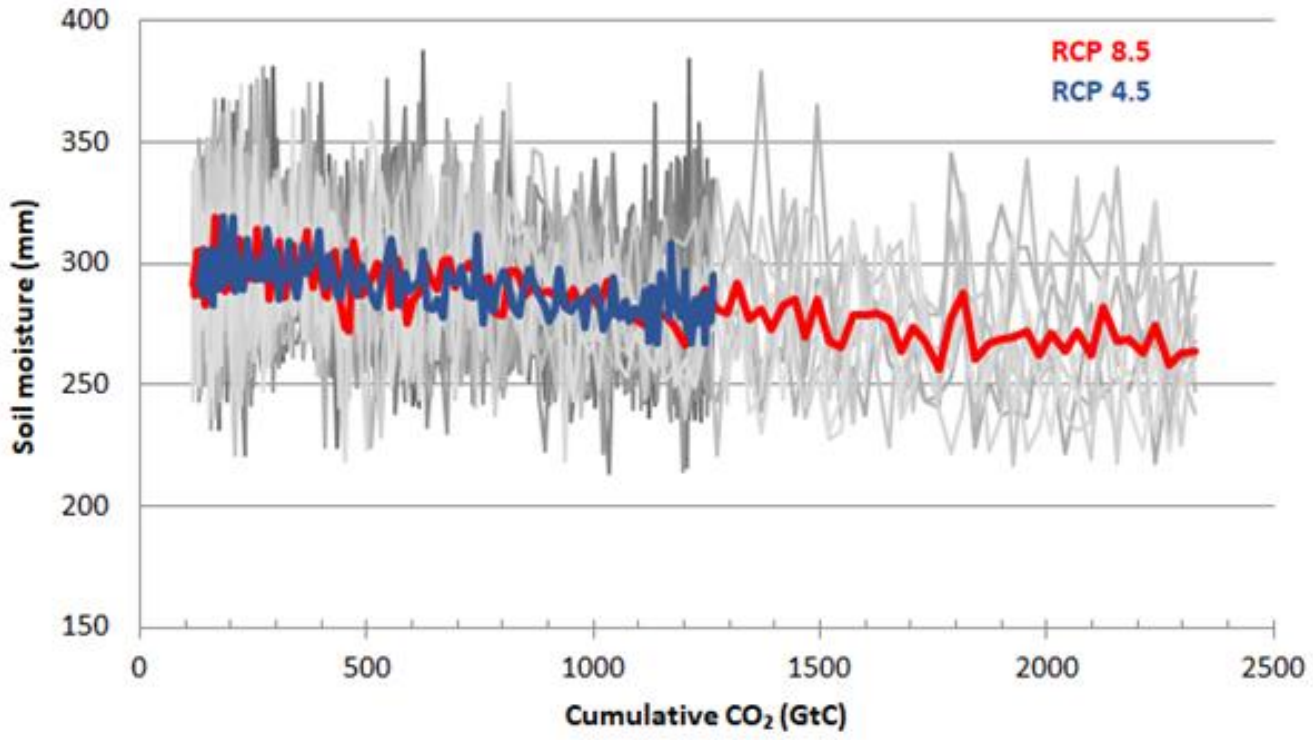
Droughts



Data Source: Western Regional Climate Center

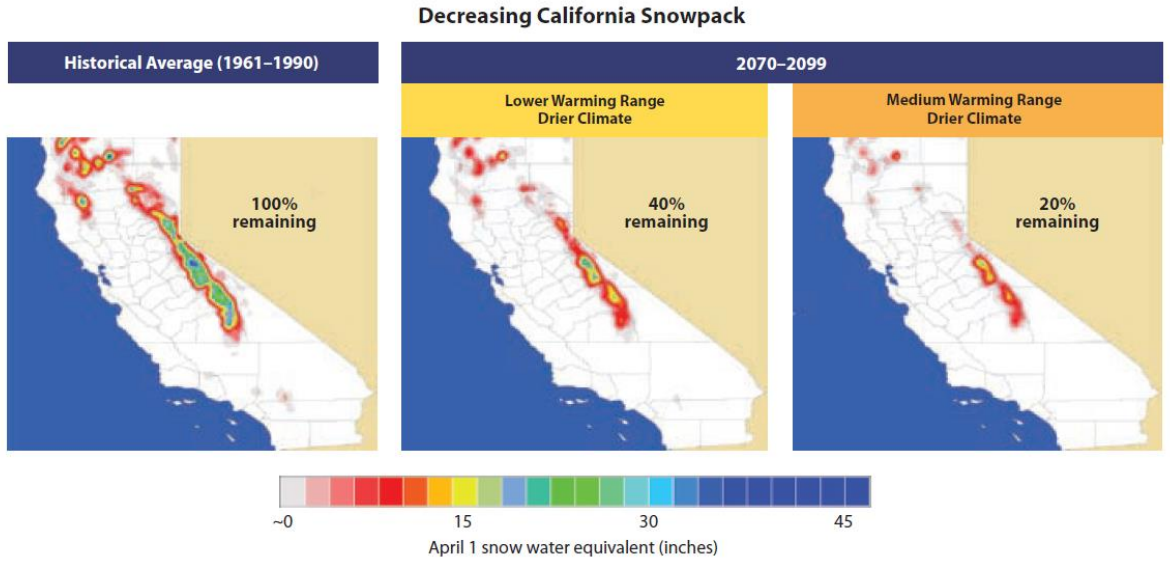
Four-year averaged wintertime precipitation and temperature in the Sierra Nevada. The worst drought in the last 1,000 years in California that occurred in 2012-2015 was associated with very warm winter-time temperatures.

Aridity trend in California

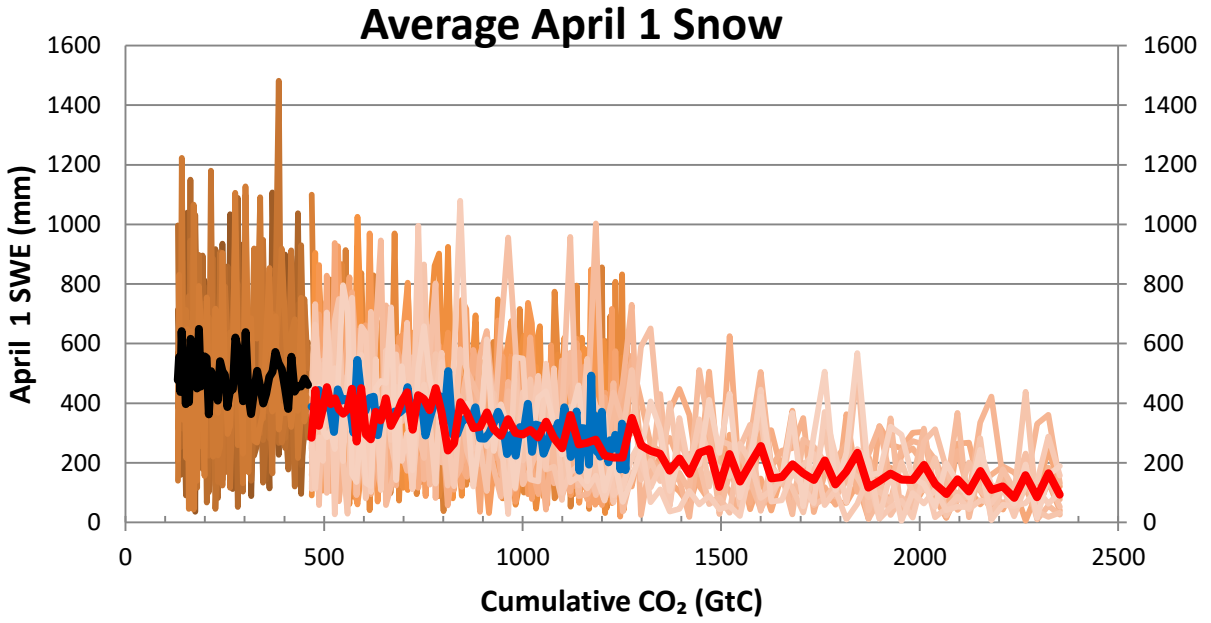


Franco, Cayan, et al., 2018

Snowpack will continue to decrease with a warming climate



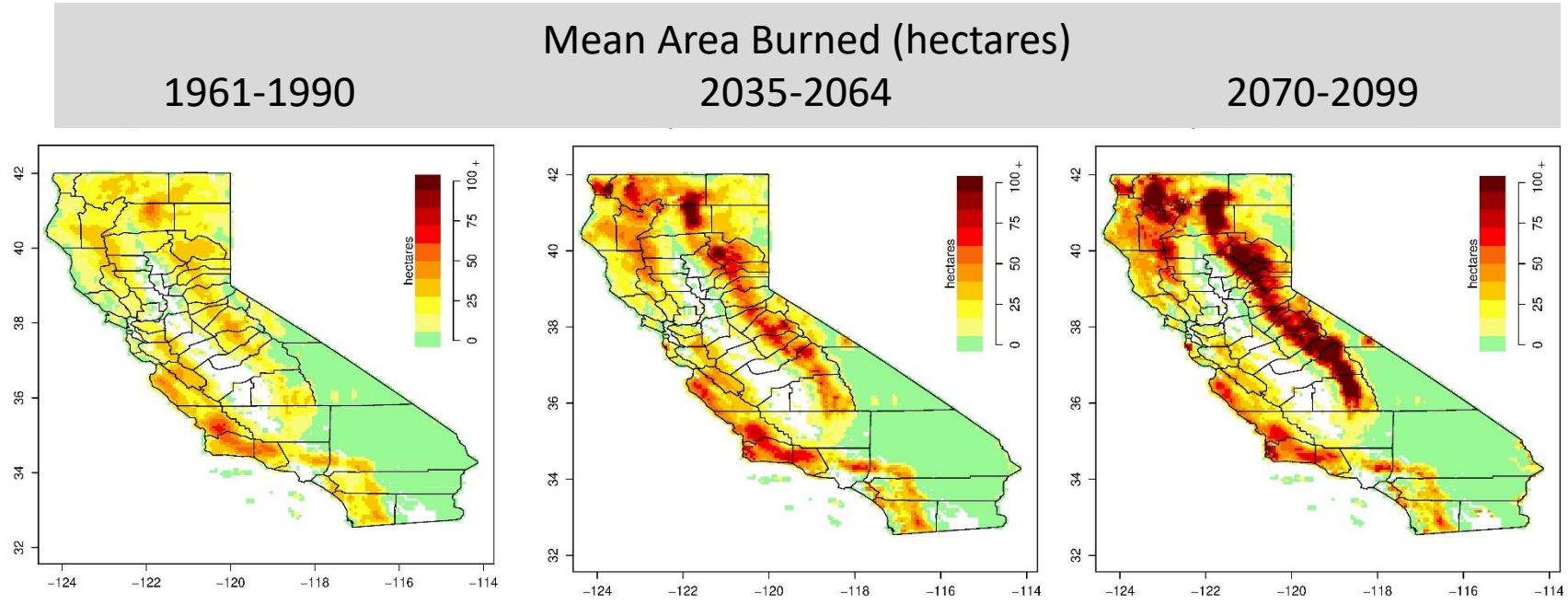
Source: Luers, Cayan, Franco, Hanemann, Croes. Our Changing Climate. 2006



Franco, Cayan, et al., 2018

Wildfire projections

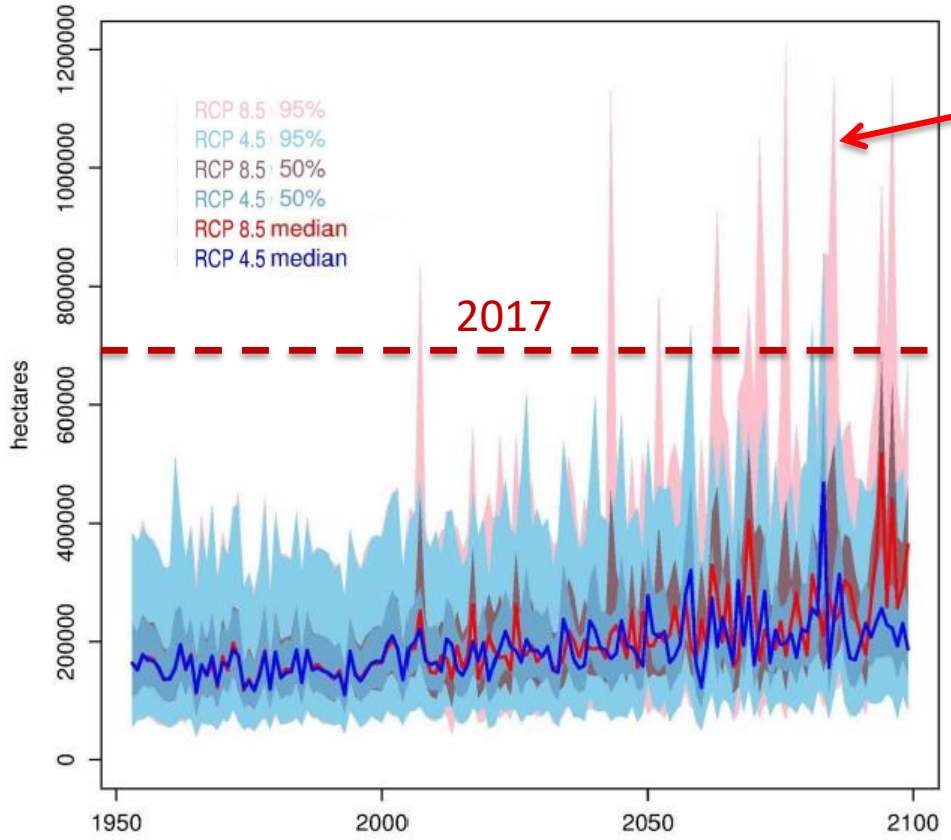
- There is a trend of increasing area burned by wildfires in California
- Simulations for the rest of the century project substantial increases in area burned



Source: Westerling, 2018

Extreme wildfires

- The complete set of wildfire simulations from Westerling, 2018 included extreme wildfire years and found that these extremes (e.g., pink area below) could rise to unprecedented levels.



97.5th upper percentile range

RCP4.5 vs 8.5 California Area Burned Quantities. Even though the model was developed using wildfire data prior to 2017, it captures high extreme wildfire events.

Source: Westerling, 2018

Overall climate impacts to the energy system in California

Electricity and natural gas demand

- Prof. Auffhammer used billions of monthly bills to empirically estimate, at the zip code level, the impact of ambient temperatures to electricity and natural gas consumption.
- Increased residential annual electricity consumption approximately offset by decreased demand for natural gas (end-use basis).
- Peak electricity demand will increase at a faster rate and the electricity generating system must be designed for these higher peaks.

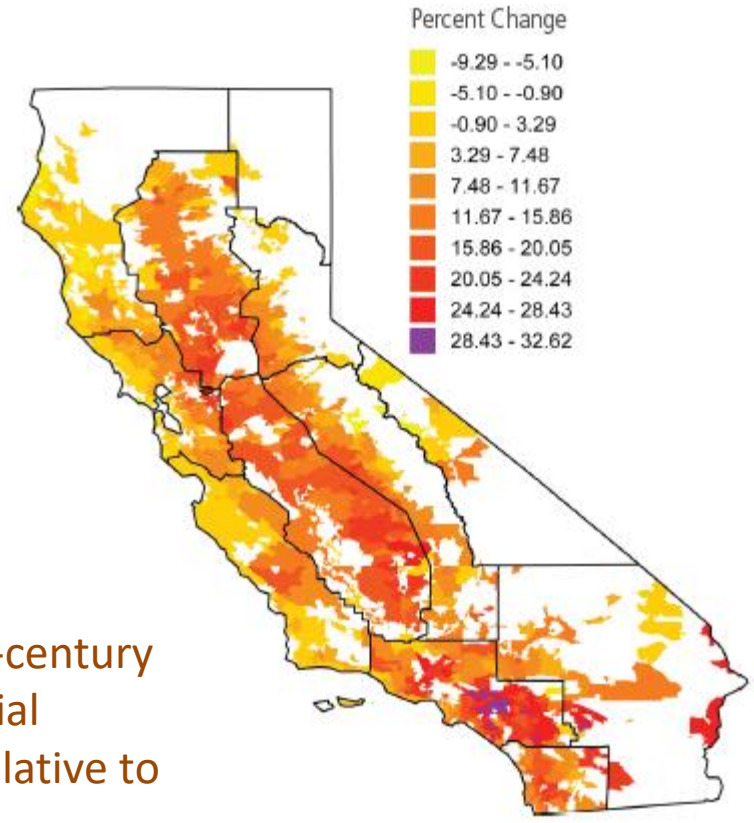


Figure*: Projected end-of-century change in annual residential electricity consumption relative to 2000-2015 baseline.

* *Data source:* Auffhammer, Maximilian (2018). *Climate Adaptive Response Estimation: Short and Long Run Impacts of Climate Change on Residential Electricity and Natural Gas Consumption Using Big Data*. Publication Number: CCA4-EXT-2018-005.
Figure source: Bedsworth, L., D. Cayan, G. Franco, L. Fisher, S. Ziaja (2018). *Statewide Summary Report*. Publication Number: SUM-CCCA4-2018-013.

Coastal flooding

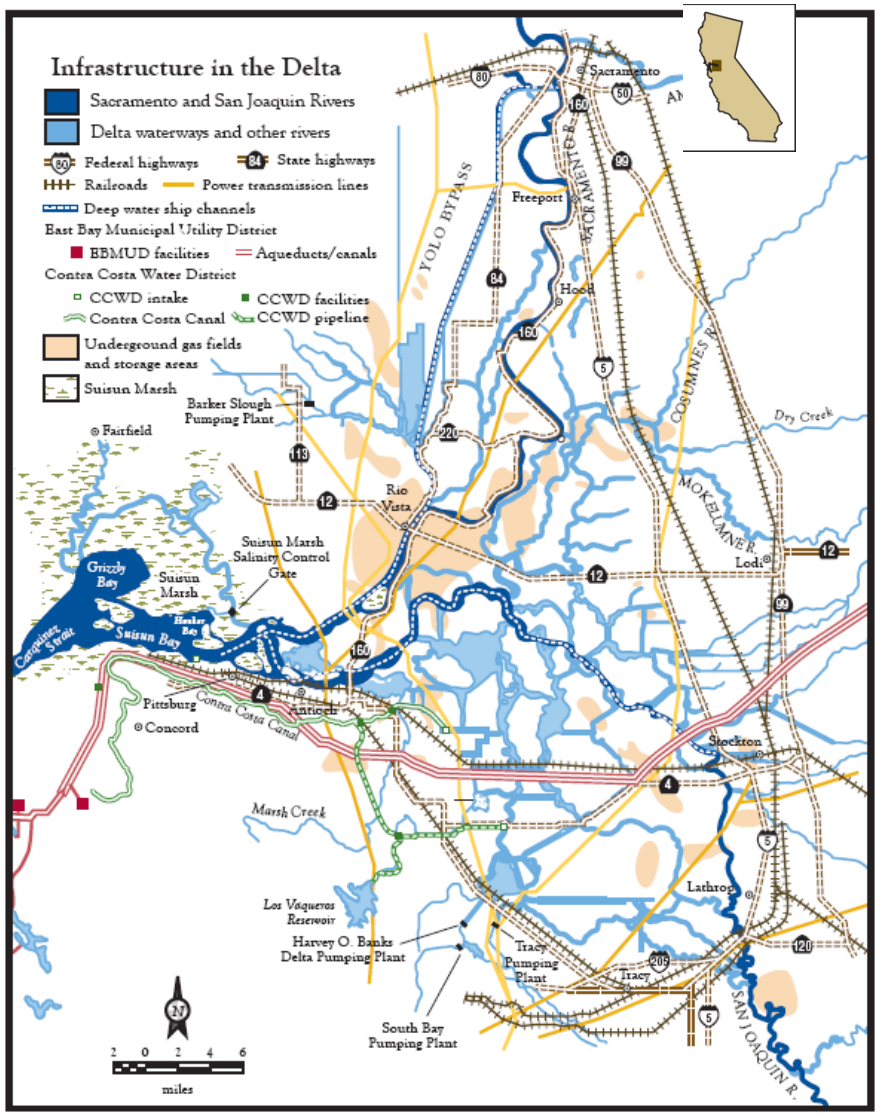
- Researchers have identified energy infrastructures (e.g., power plants, substations) that would be flooded under different sea level rise scenarios
- Transportation system, including airports and seaports, must contend with flood-related risks as sea level rises

Figure*: Near-term (left) and end-century (right) flooding projections for Andeavor Long Beach Terminal 1, where 80% of Southern California's crude oil is offloaded from marine tankers.

Source: Radke, J.D, G.S. Biging, K. Roberts, M. Schmidt-Poolman, et al (2018). *Assessing Extreme Weather-Related Vulnerability and Identifying Resilience Options for California's Interdependent Transportation Fuel Sector*. Publication Number: CCCA4-CEC-2018-012.

Subsidence of the Sacramento-San Joaquin Delta levees compounds flood risks

- The Sacramento-San Joaquin Delta is the hub of water transfers from the northern part of California to the arid regions in the central and southern parts of the state. Important energy facilities (e.g., natural gas pipelines and underground storage) are located in the Delta.
- High subsidence rates for some Delta levees: ~0.4 to 0.8 inches per year.
- Risk of overtopping during storm events compounded by subsidence, sea level rise.
- Some levees may fail to meet federal safety standards for levee height by 2050-2080 at current subsidence rates.



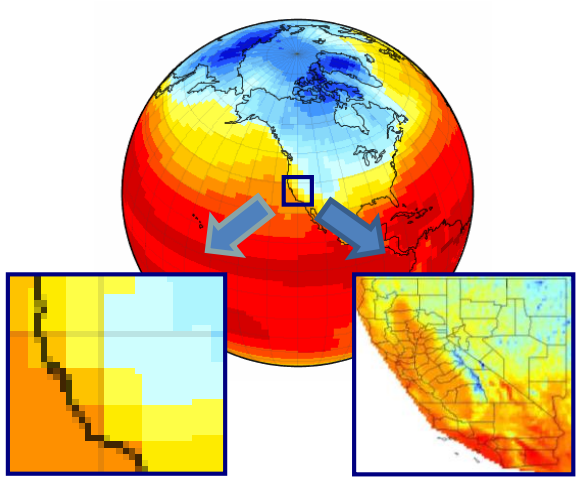
Source: PPIC 2007

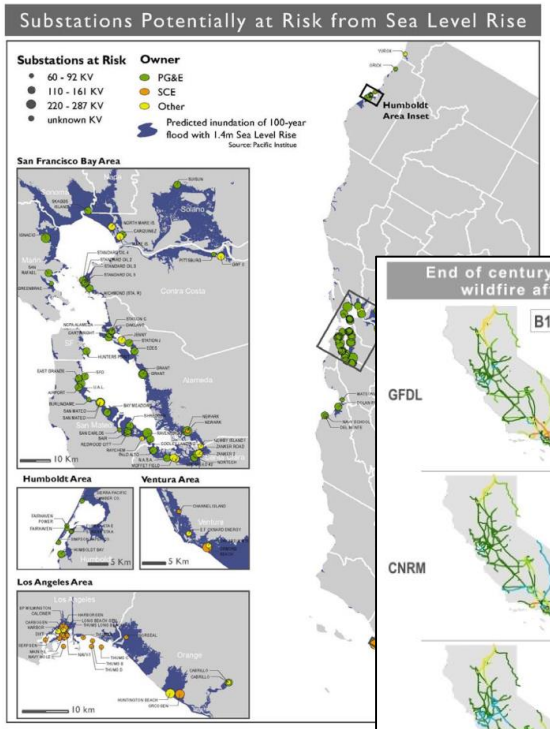
Source: Brooks, B. A. et al (2018). *High Resolution Measurement of Levee Subsidence Related to Energy Infrastructure in the Sacramento San-Joaquin Delta*. Publication Number: CCCA4-CEC-2018-003.

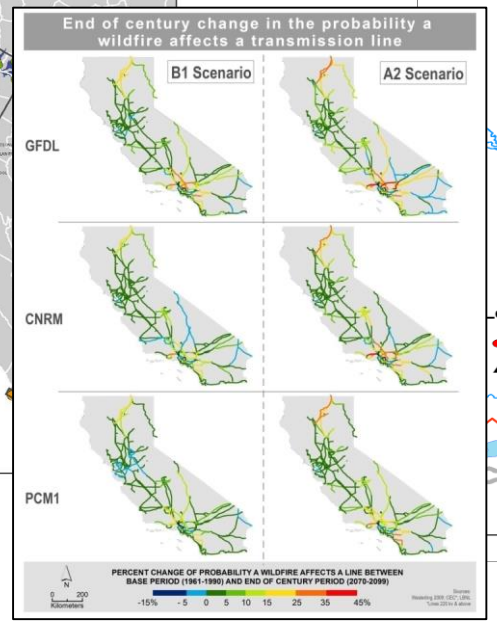
Summary of potential major impacts

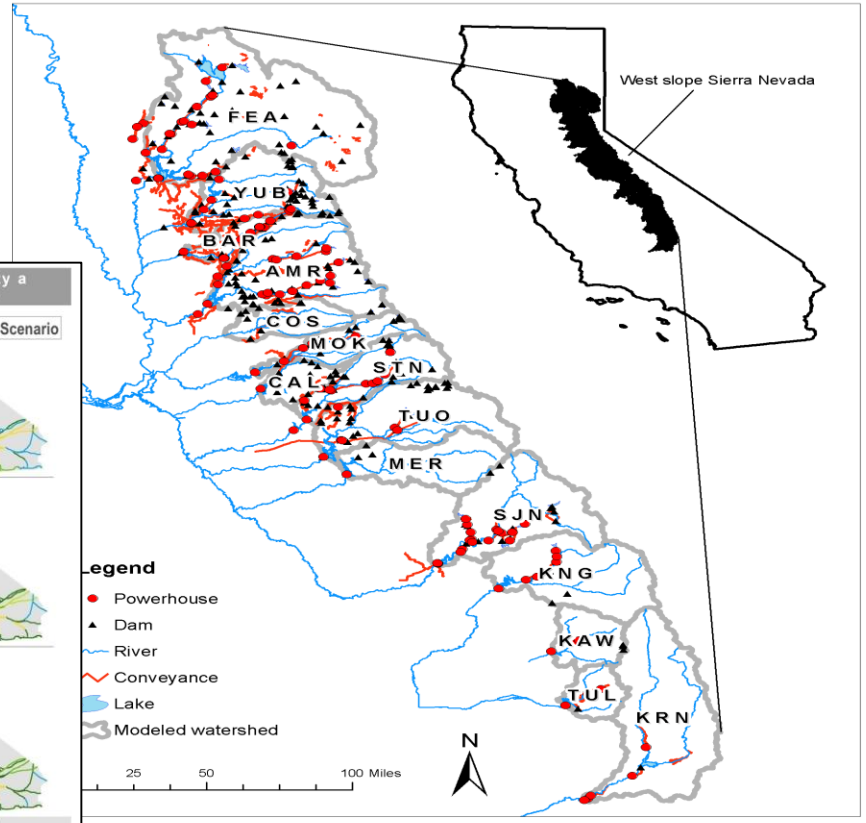
- Reduction of hydropower during hottest months of the year.
- Continued record breaking high temperatures resulting in increases in peak electricity demand.
- Lower performance of thermal power plants (e.g., natural gas combined cycle units) with high temperatures.
- Increased risk of exceeding design temperature limits for transmission and distribution lines, transformers, etc.
- Increased risks of wildfires to the electricity system.
- The natural gas system seems to be less vulnerable.

There is now a wealth of data/information about potential impacts of climate change on the energy system in California



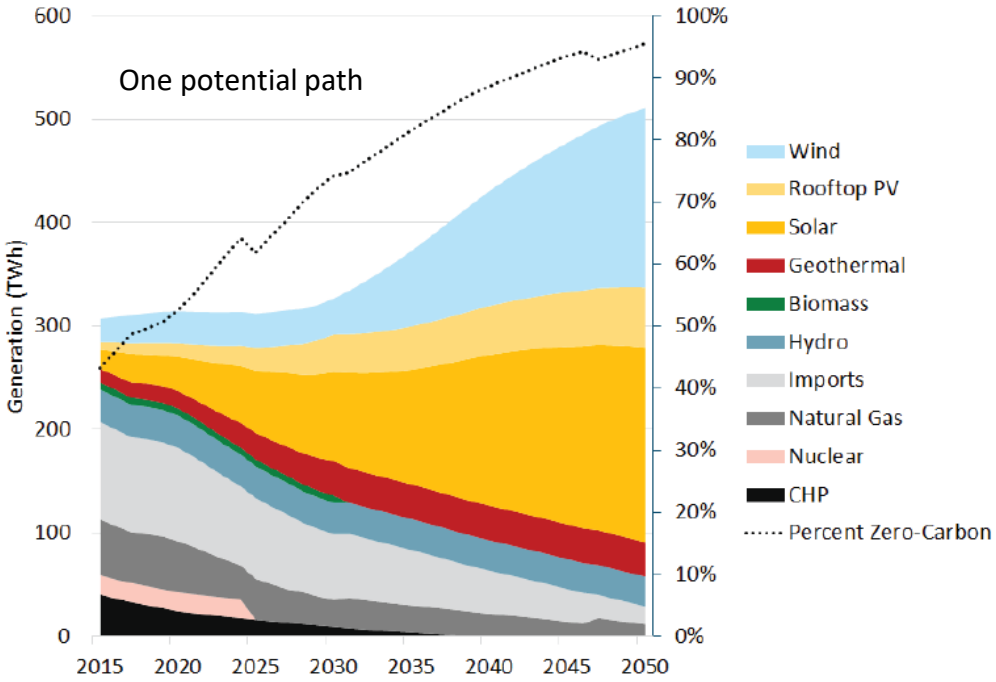






How should the energy sector evolve in the next 30 years?

- The energy system in California contributes more than 80% of total GHG emissions.
- SB 100 mandates 100 net zero GHG emissions from the electricity generating sector by 2045.
- By state law, California must reduce GHG emissions by 40% by 2030. A new Executive Order (B-55-18) also adds the goal of GHG neutrality by 2045. This requires a **drastic and rapid transformation of the energy sector**.
- The **electricity sector must decarbonize** as required by legislation and all the energy services (e.g., space heating, transport) that can be electrified must do so.
- **Natural gas should also be decarbonized**.



One potential electricity generation scenario by source type from 2015 to 2050, and percent contribution from renewable generation to total generation (dotted line and right y-axis). Generation is measured in terawatt hours (Twh). Source: Mahone et al. 2018.

- Electrification will result in changes in seasonal and daily loads. For example, the electrification of space heating may create new winter peak demand.
- Exploratory studies about the potential evolution of the energy system in California taking climate change into account (e.g., reduction of hydropower generation in the summer, increased peak electricity demand in the summer) suggest that the negative impacts of climate change would not impede compliance with GHG reduction targets.
- The reduction of fossil fuel combustion will substantially improve air quality with estimated **public health benefits exceeding estimated costs of** reducing GHG emissions.*

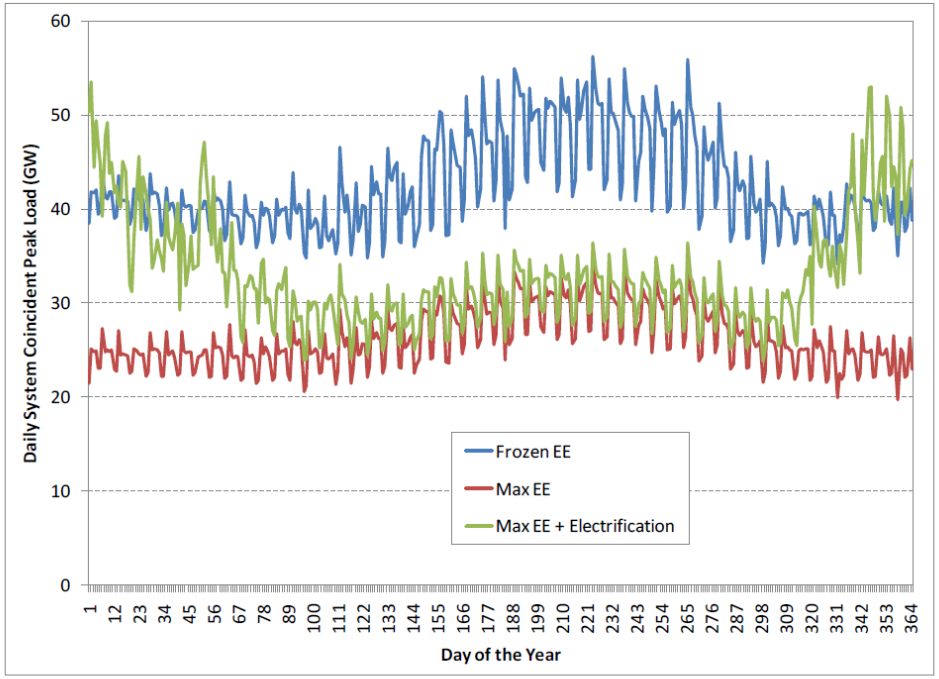


Figure 4-13. *Daily system coincident peak load from buildings in 2050 in California.*

Source: Wei et al., 2012

The rapid transformation of the energy system in California also represents an opportunity to develop a more resilient system to climate impacts

*Bedsworth, Louise, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCCA4-2018-013.

Is the California energy system adapting?

- YES !
- The Energy Commission has been supporting climate research for the last decade to inform the evolution of a clean and more resilient energy system.
- The CPUC and CEC have formed an adaptation working group headed by CPUC Commissioner Randolph and CEC Chairman Weisenmiller to coordinate climate adaptation policies.
- The CPUC recently released an Order Instituting Rulemaking (quasi-legislative) to open stakeholder discussions regarding how energy utilities and the Commission could identify and implement adaptation options.

Thank you!

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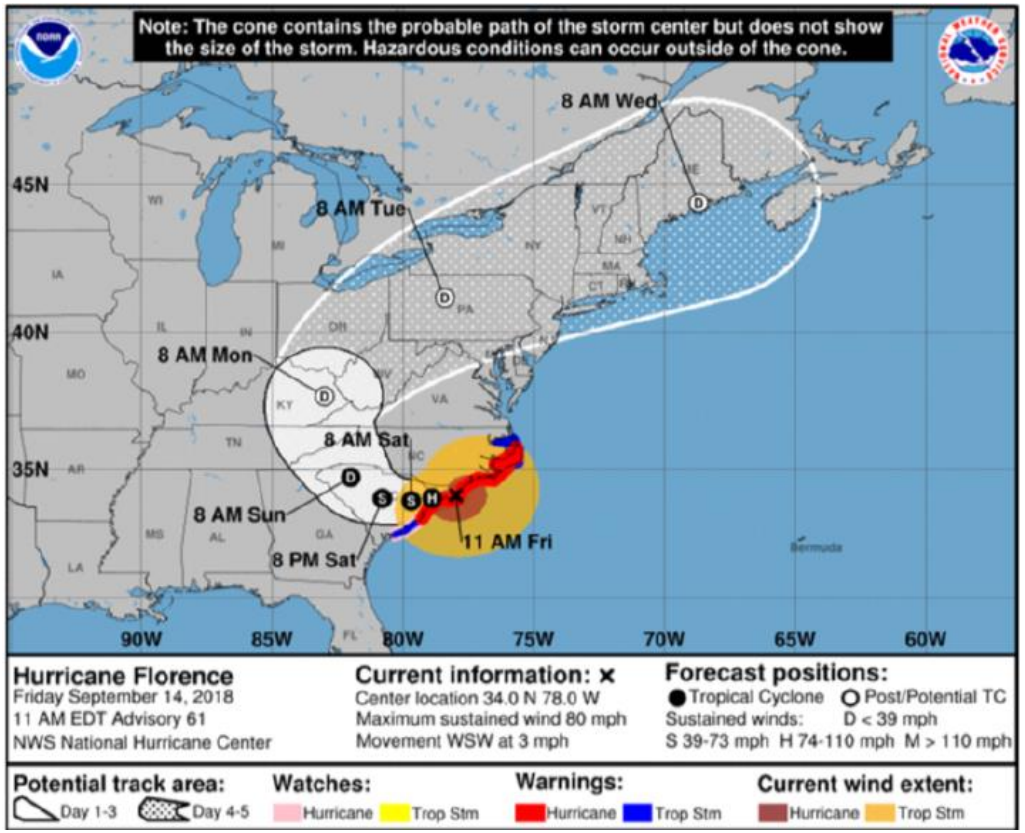
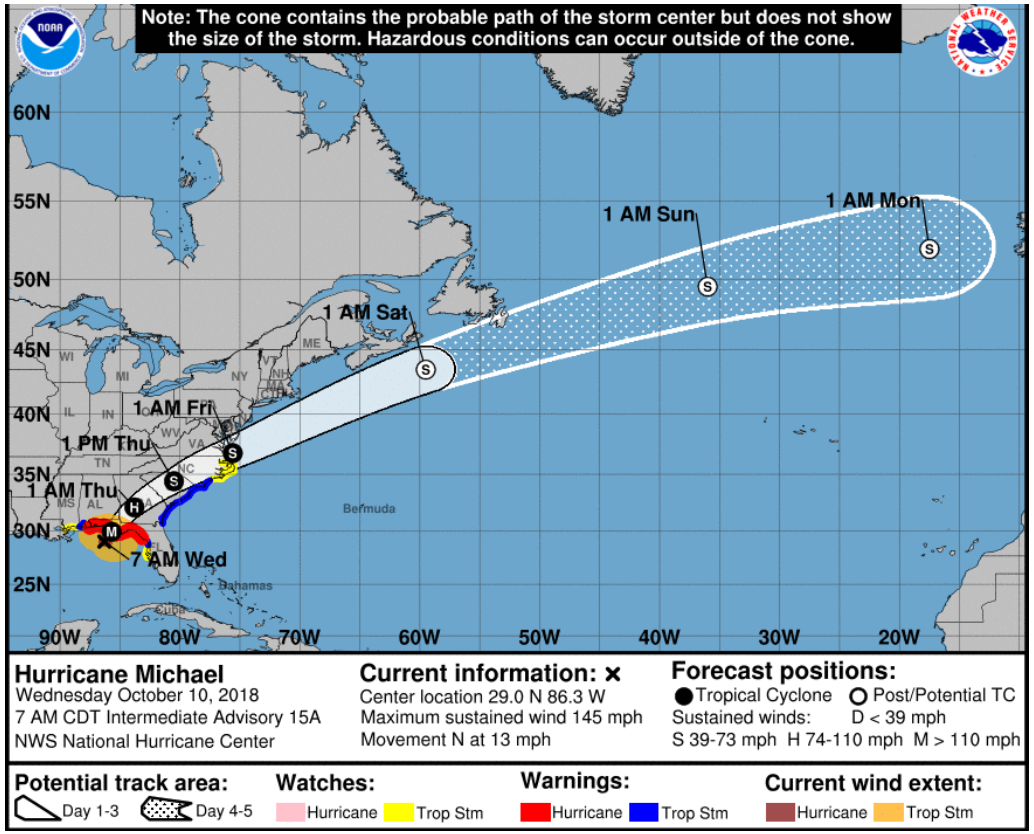
2018 Hurricane Response

Hurricane Tracks

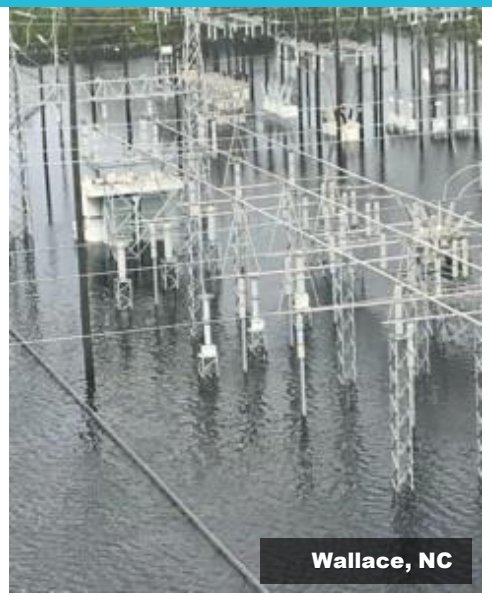
Hurricane Florence



Hurricane Michael



Damage – Hurricane Florence

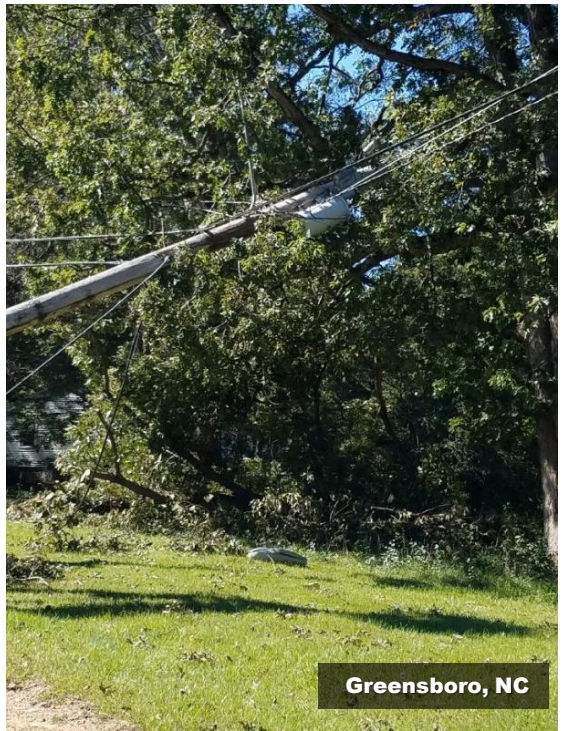


Damage – Hurricane Michael


Mexico City Beach, FL


Alligator Point, FL


Charlotte, NC


Greensboro, NC


Davie County, NC

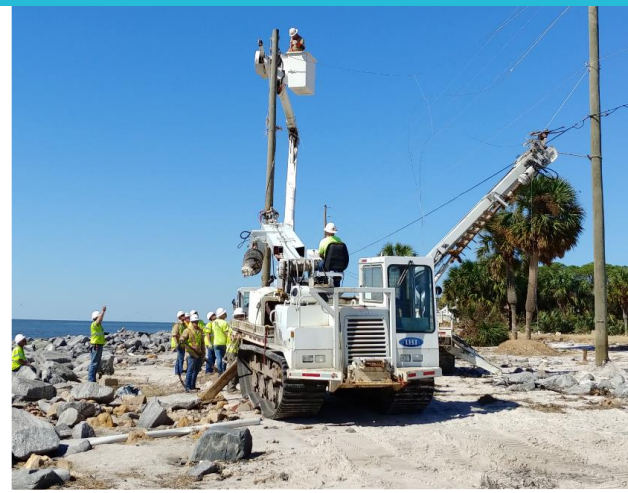
Storm Response – By The Numbers

	Peak Outages #	Customers Restored	Resources	Customer Calls
Florence – Carolinas	605,000	> 1.81 million	> 20,000	1.1 million
Michael – Carolinas	554,000	> 1.12 million	>10,000	1.6 million
Michael - Florida	33,600	>75,000*	>4,500	170,000
Totals	**>1.1 million**	**>3.01 million**	**>34,000**	**>2.8 million**

*To those that can receive power

More than 90% of customers were restored within three days for both storms.

Reactive and Proactive Customer Response

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