Climate Change in Southern California

Is Our 20th Century Water Infrastructure Equipped for 21st Century Climate?

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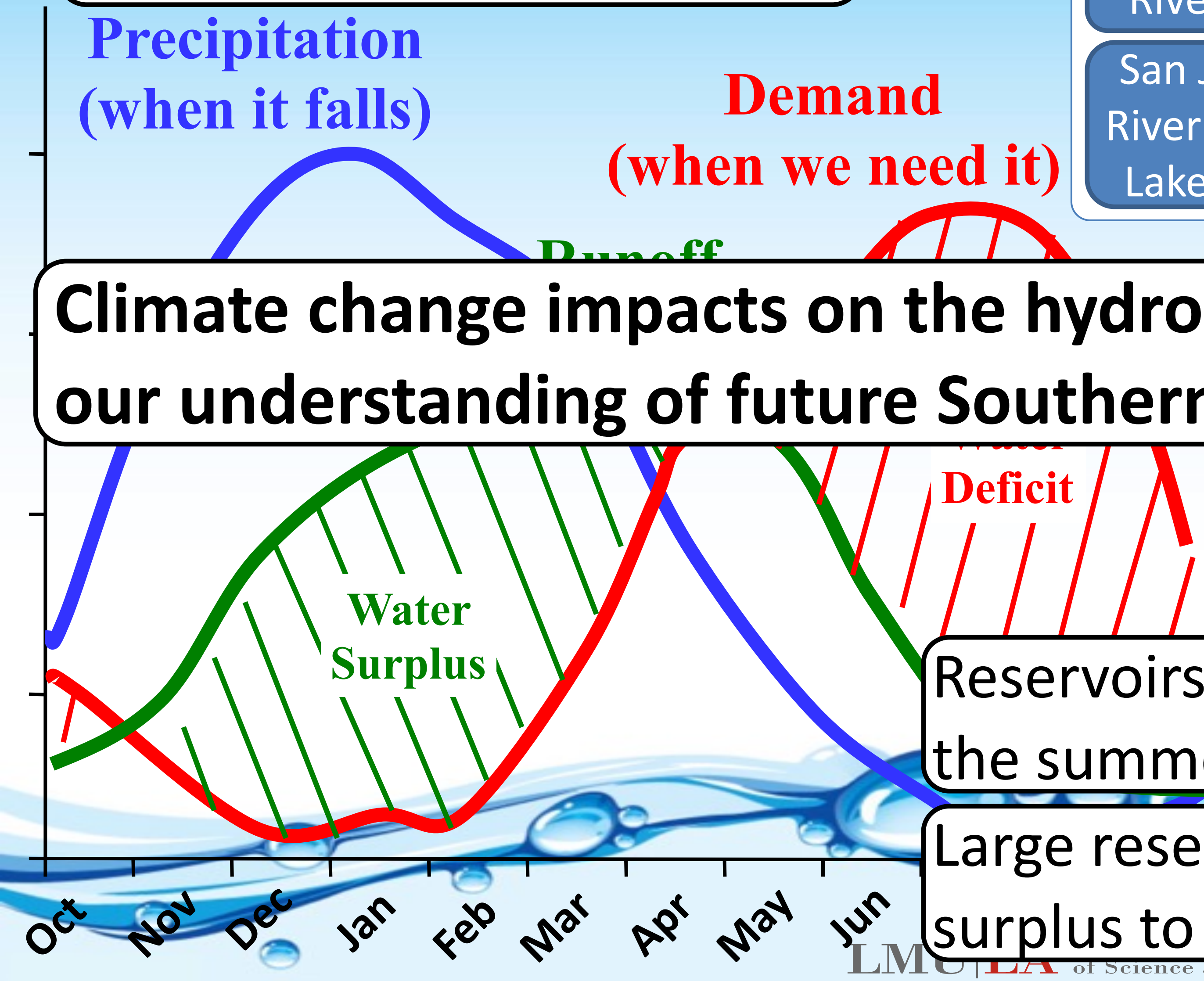
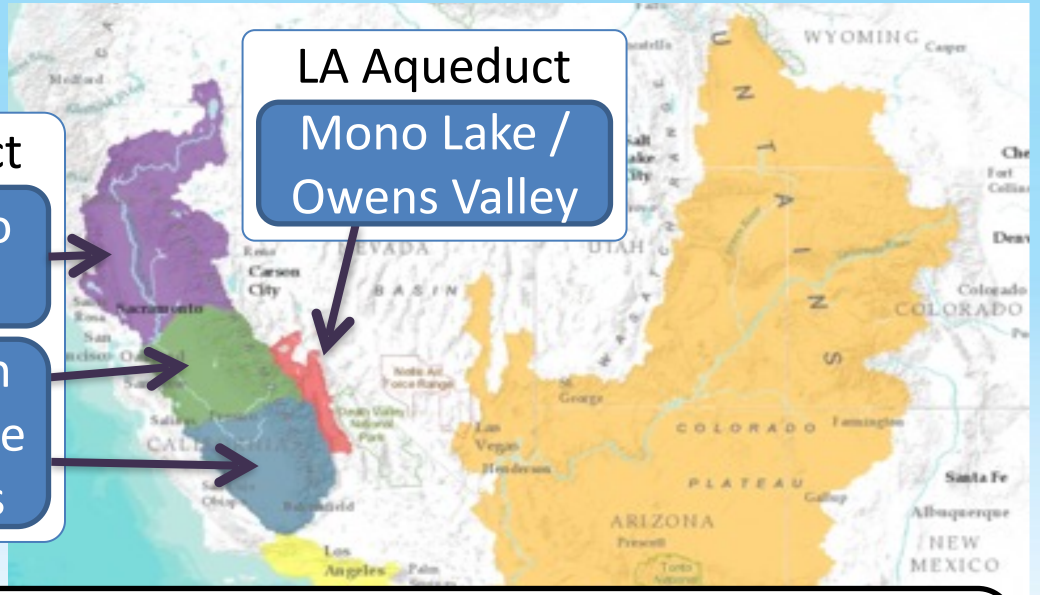
Where do we get our water?

75% of annual streamflow in California is snowmelt.



CA Aqueduct
- Sacramento River Basin
- San Joaquin River / Tulare Lake Basins

LA Aqueduct
- Mono Lake / Owens Valley



Climate change impacts on the hydrology of these basins is critical to our understanding of future Southern Californian water resources.

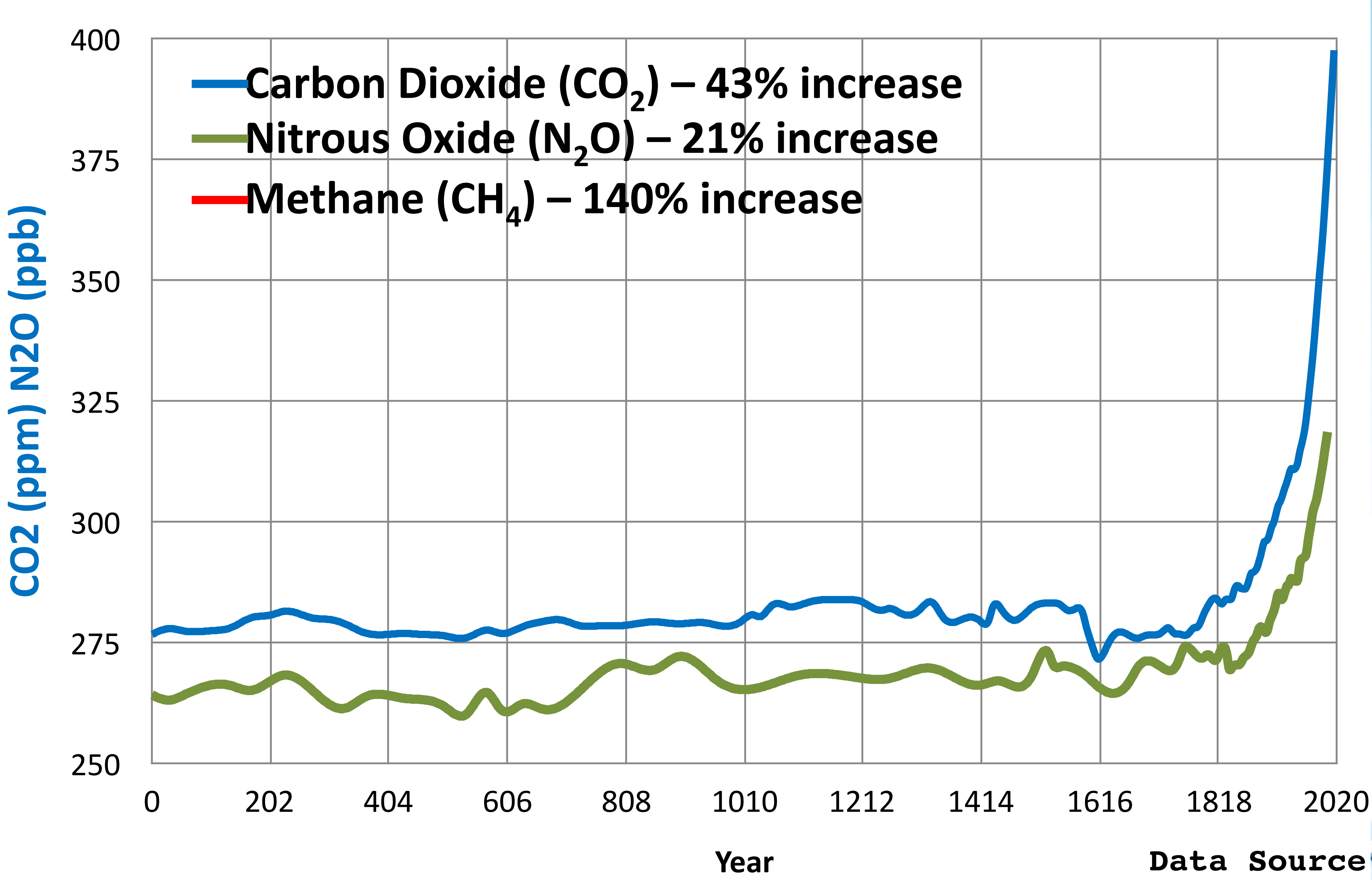
- Recycled Water
- Conservation

Colorado River Aqueduct
- Colorado River Basin

Reservoirs store surplus water in the spring for the summer when demands are highest.

Large reservoirs store water during periods of surplus to get us through multi-year droughts.

Greenhouse Gas Concentrations (0 - 2014)



IPC

Data Source: NOAA

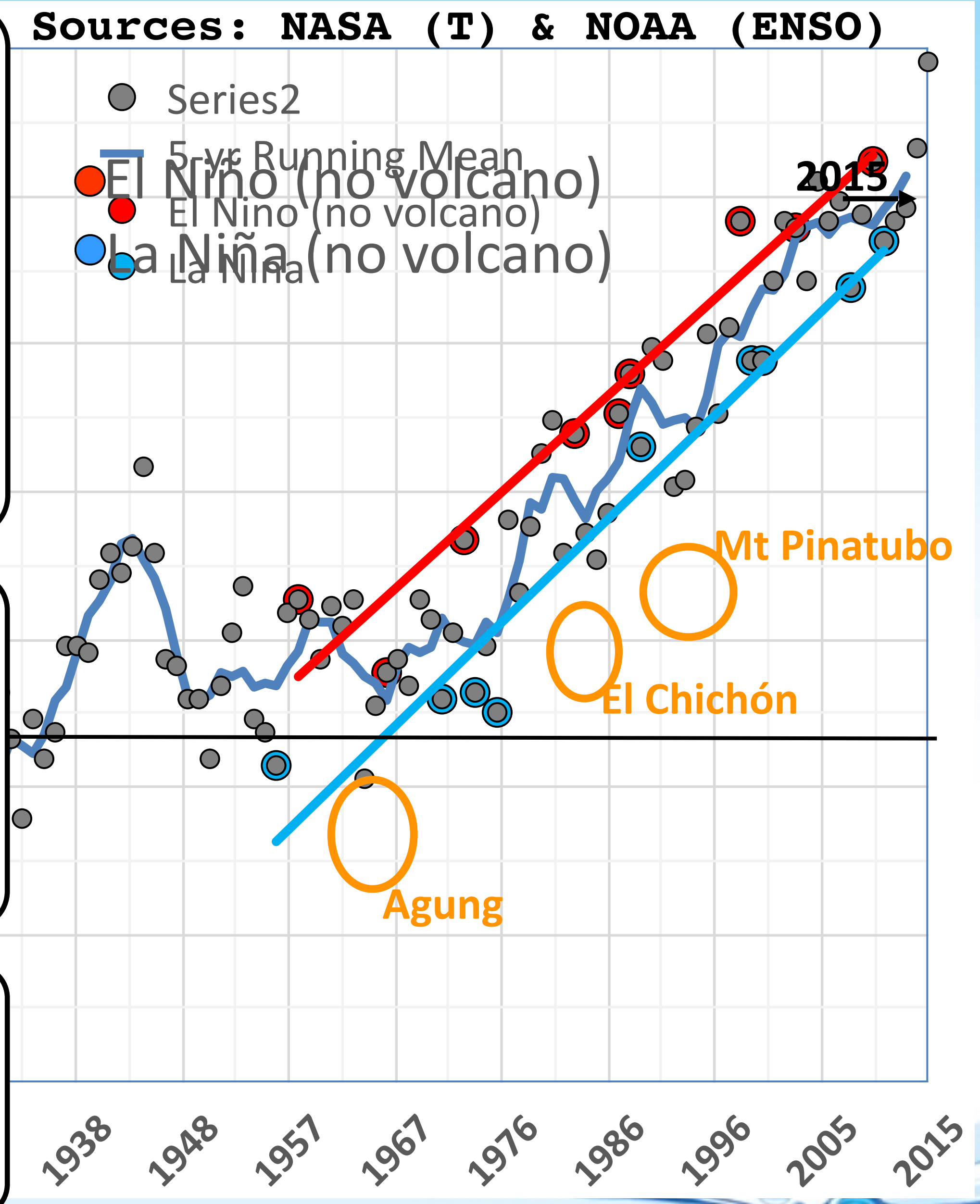
Global Surface Temperature Differences from 1951-1980

Most of the warming has occurred in the past 50 years or so (as have most of the anthropogenic greenhouse gas emissions).

- The 18 warmest years have occurred in the past 21 years.
- 1976 was the last cooler than normal year.

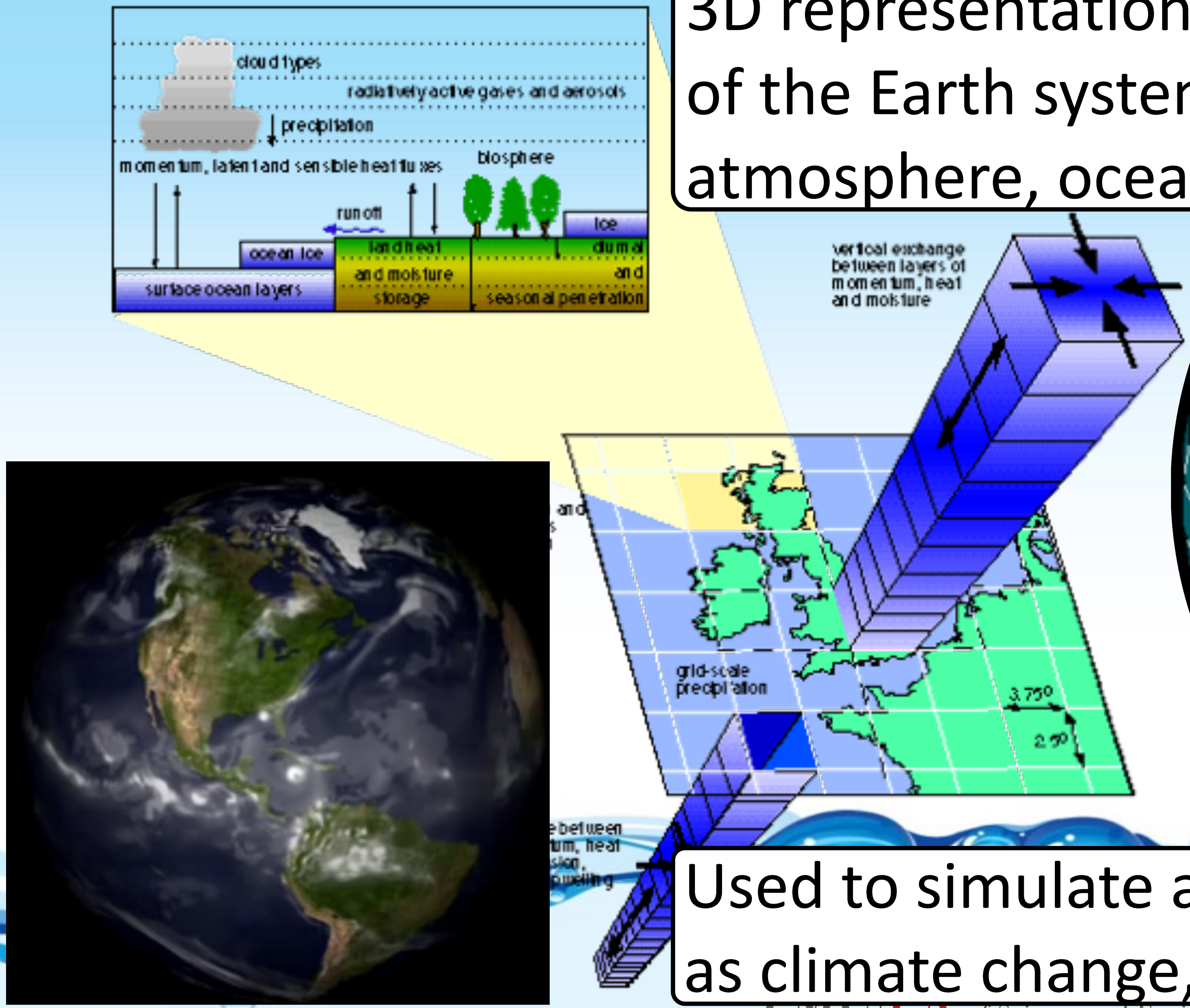
The observed warming signal is considerably greater than the fluctuations resulting from natural global climate drivers such as El Niño, La Niña, and volcanic eruptions.

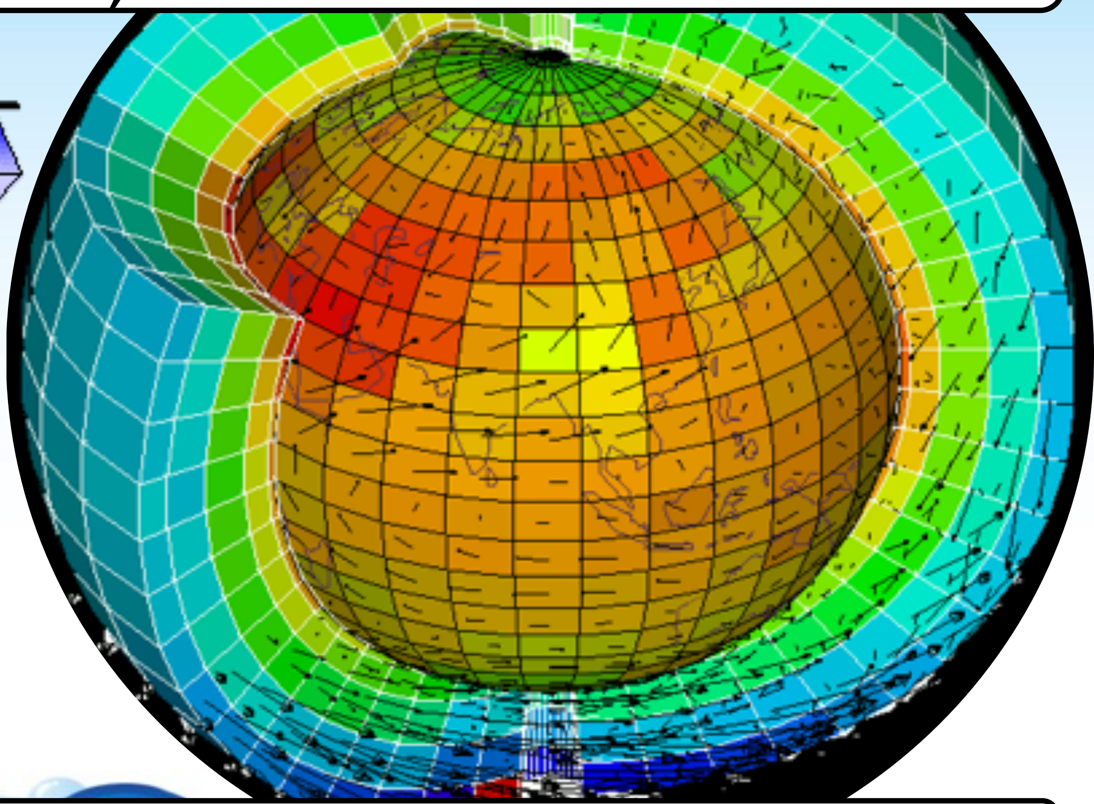
Temperatures in the Western US have increased by 2 to 4°F over the past century, which is well above the global average.



Climate Models or Earth System Models

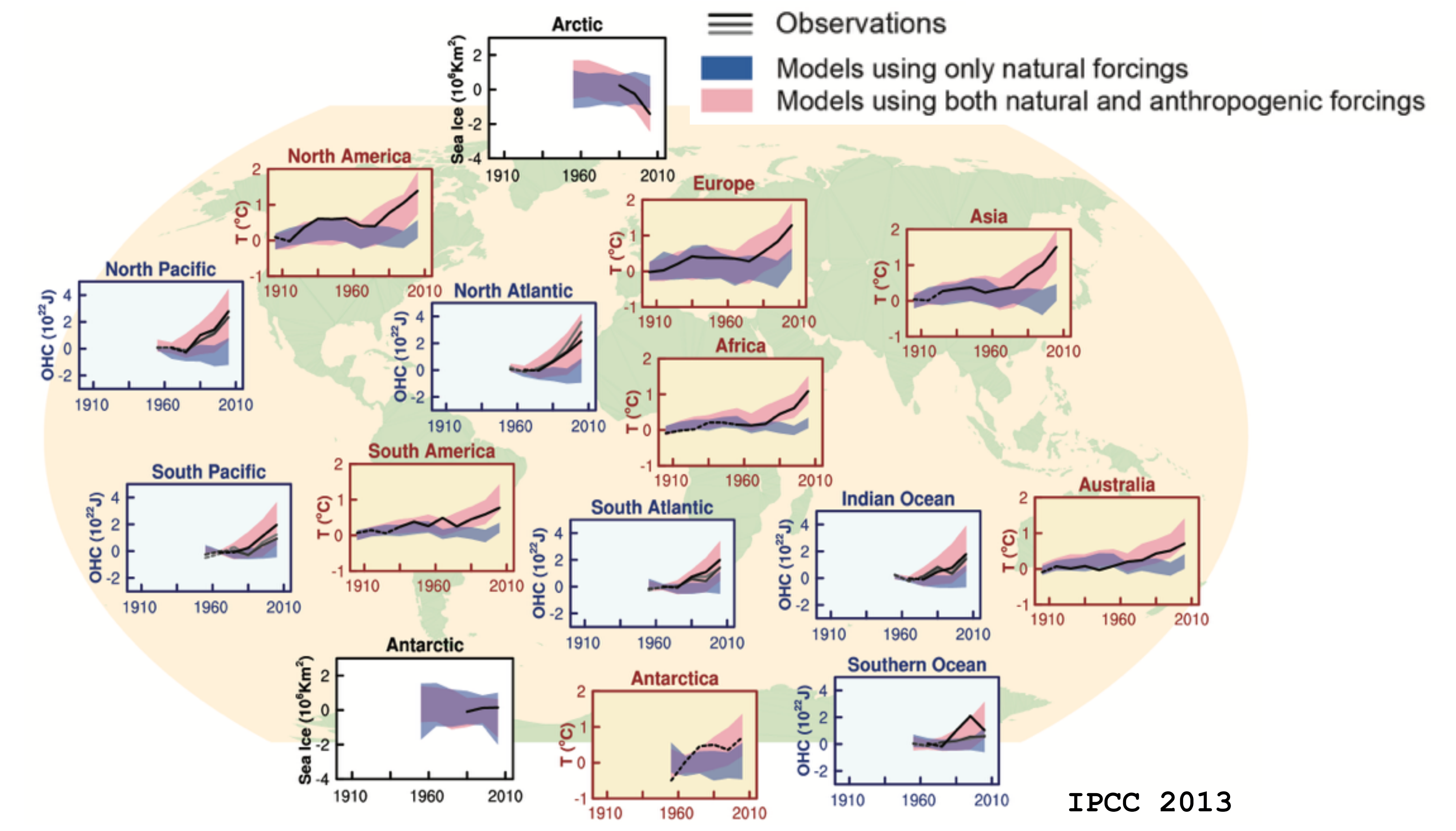
3D representations of the major components of the Earth system, including the land surface, atmosphere, oceans, and ice.





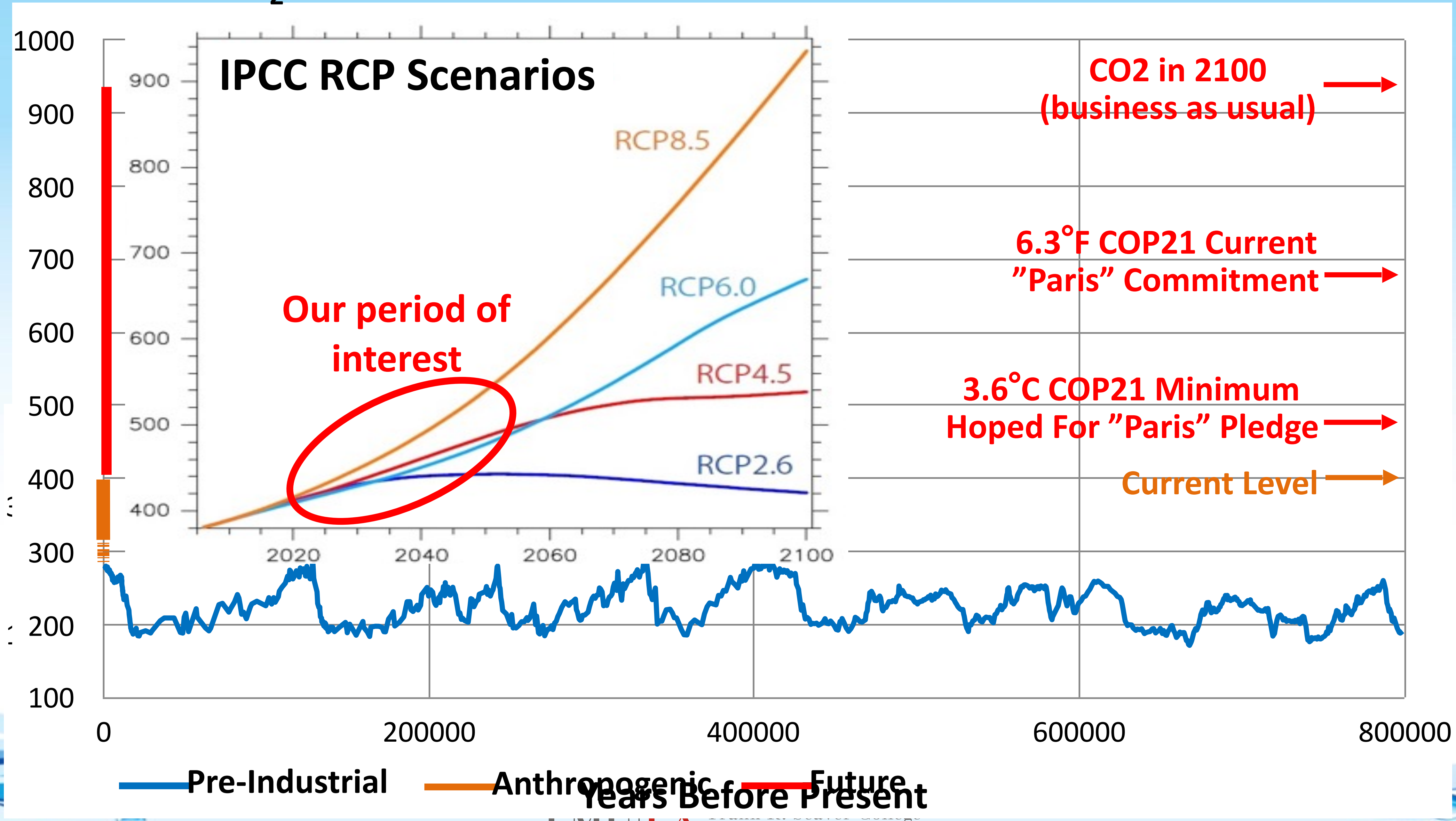
Used to simulate a variety of processes, such as climate change, land cover change.

Climate Model Simulations of the Past (1900-2005)



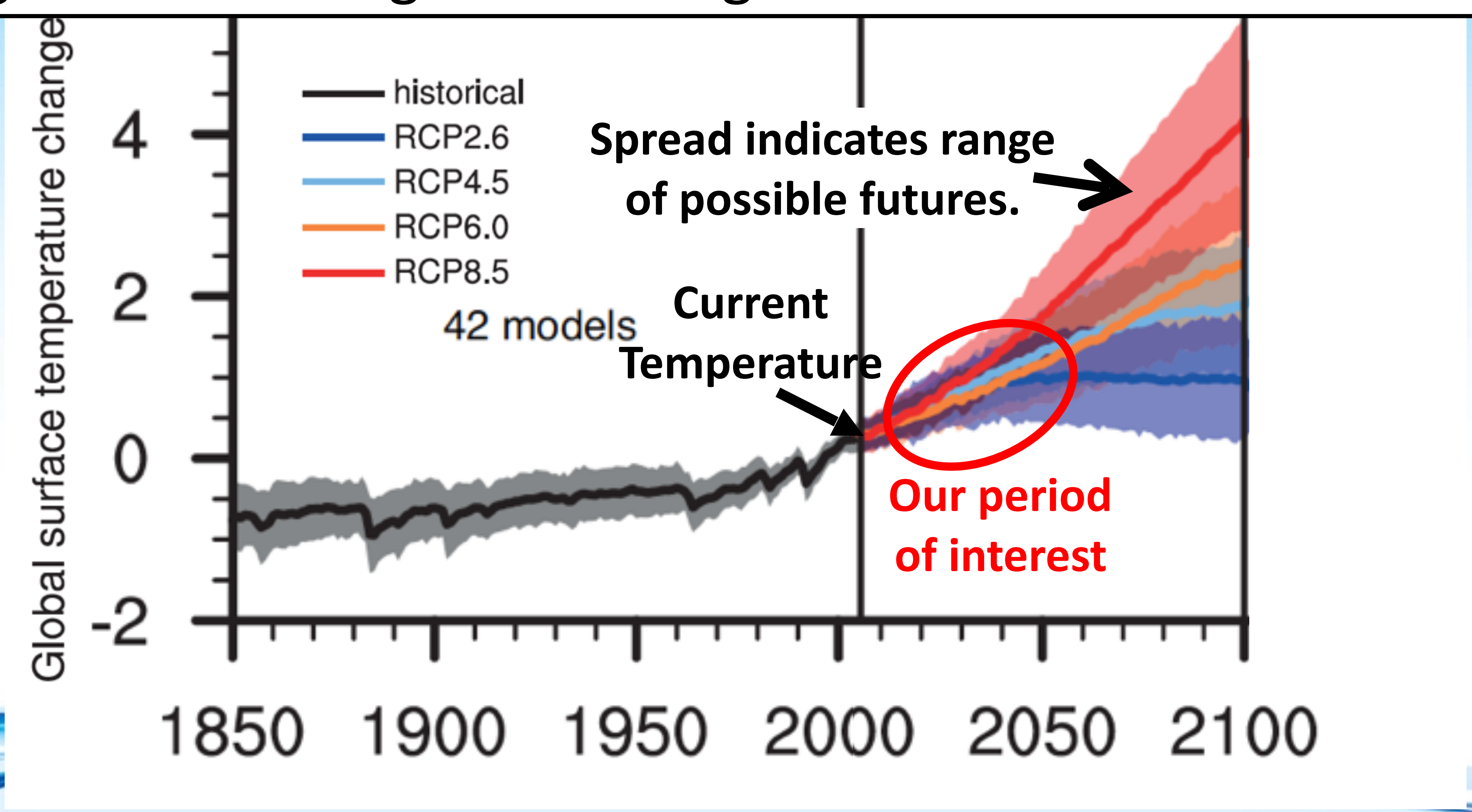
IPCC 2013

CO_2 Concentrations from the Past 800,000 years (ice cores)



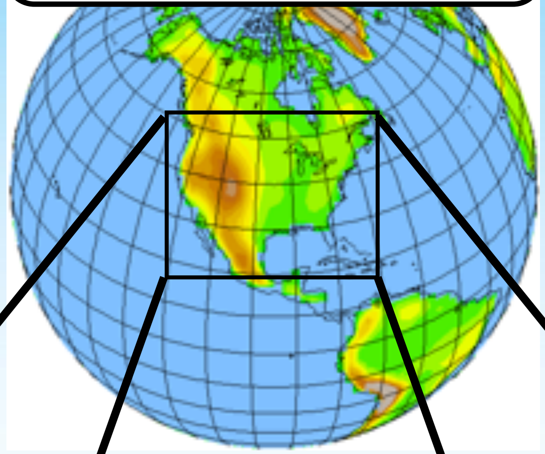
Projected Global Surface Temperature Change

Global temperature projections range from 1 to 3°F by 2050 regardless of the greenhouse gas concentration scenario.



Climate Change Projection Simulations

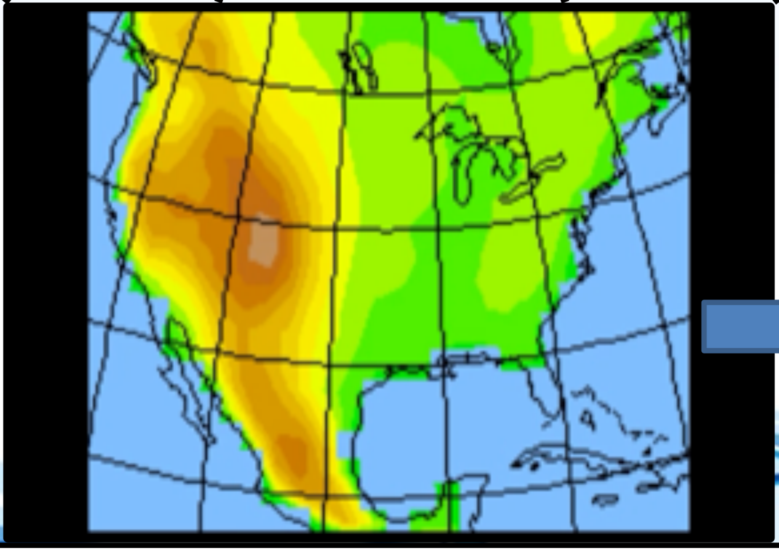
Ten Global Climate Models (~150-km)



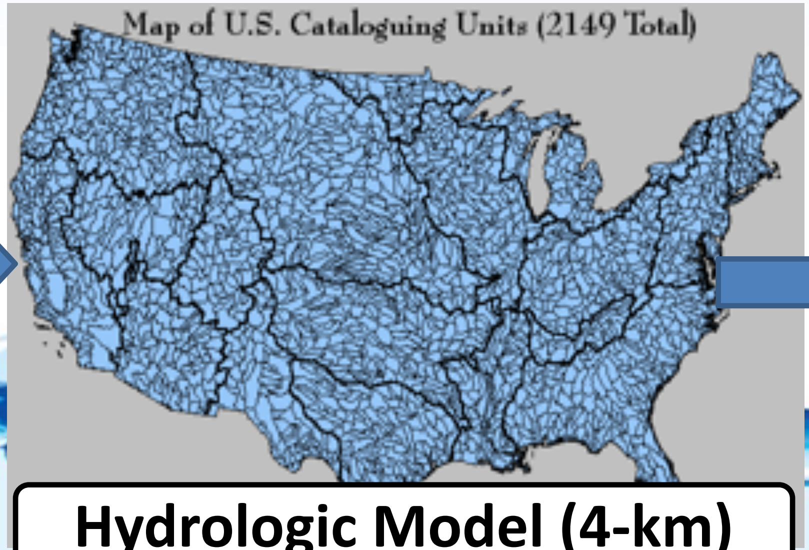
<u>Greenhouse Gas Concentrations:</u>
Historical (1976-2005)
RCP 8.5 Future Scenario (2021-2050)

Simulations performed on ORNL's Titan – The fastest supercomputer in the US.

To date, the most comprehensive and highest resolution assessment.



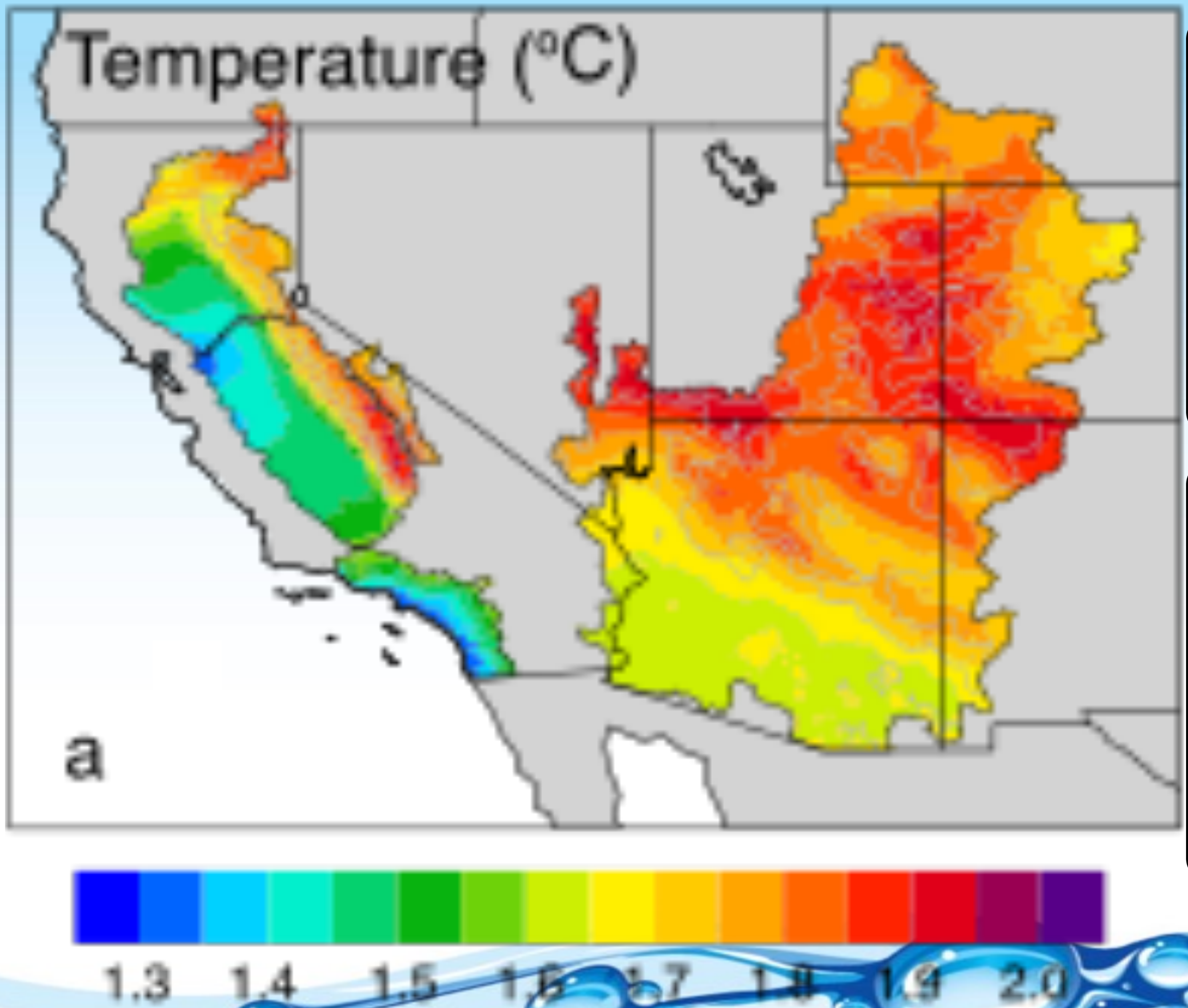
Regional Climate Model (18-km)



Hydrologic Model (4-km)

Climate Change Impacts on Water Resources:

Projected Temperature Changes
2021-2050 minus 1976-2005

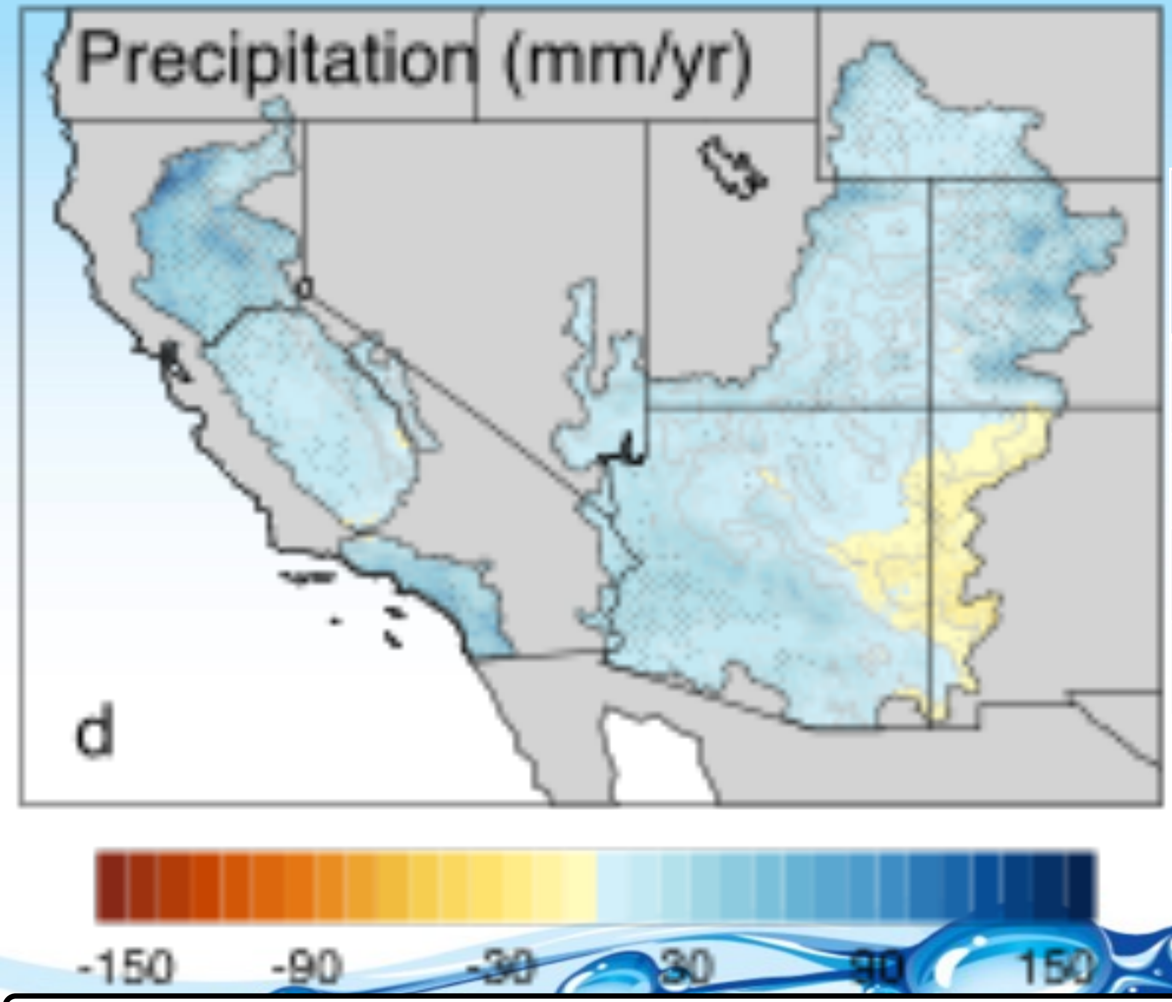


Temperatures are projected to increase an additional 2 to 4°F by 2050, which is higher than the global average.

The largest increases at projected at higher elevations due to snow related changes in surface albedo (reflectivity).

Projected Precipitation Changes

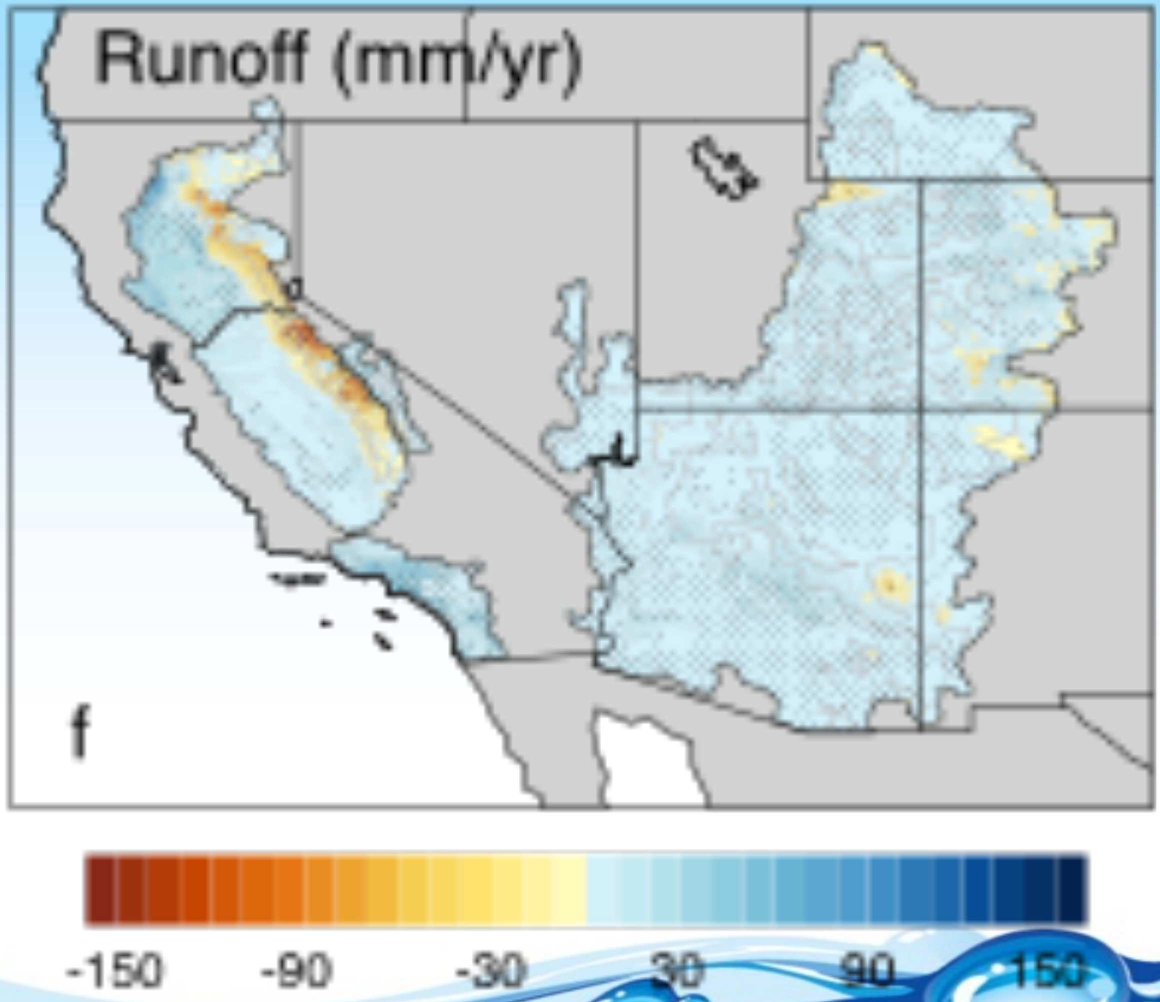
2021-2050 minus 1976-2005



Basin	Ensemble Average	Ensemble Range
Colorado River	+3%	-4 to 21%
Owens Valley – Mono Lake	+3%	-10 to 16%
Sacramento River	+4%	-13 to 12%
San Joaquin – Tulare Lake	+2%	-11 to 15%

2 to 4% increase in precipitation, but with a large range of uncertainty.

Projected Runoff Changes
2021-2050 minus 1976-2005

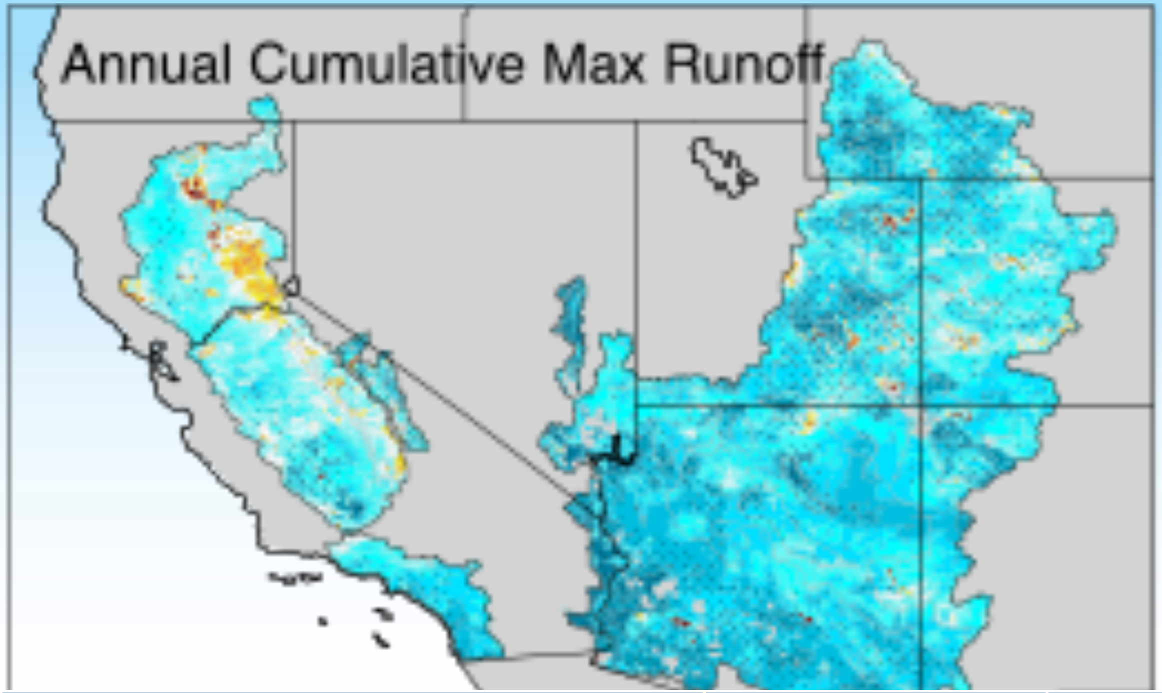


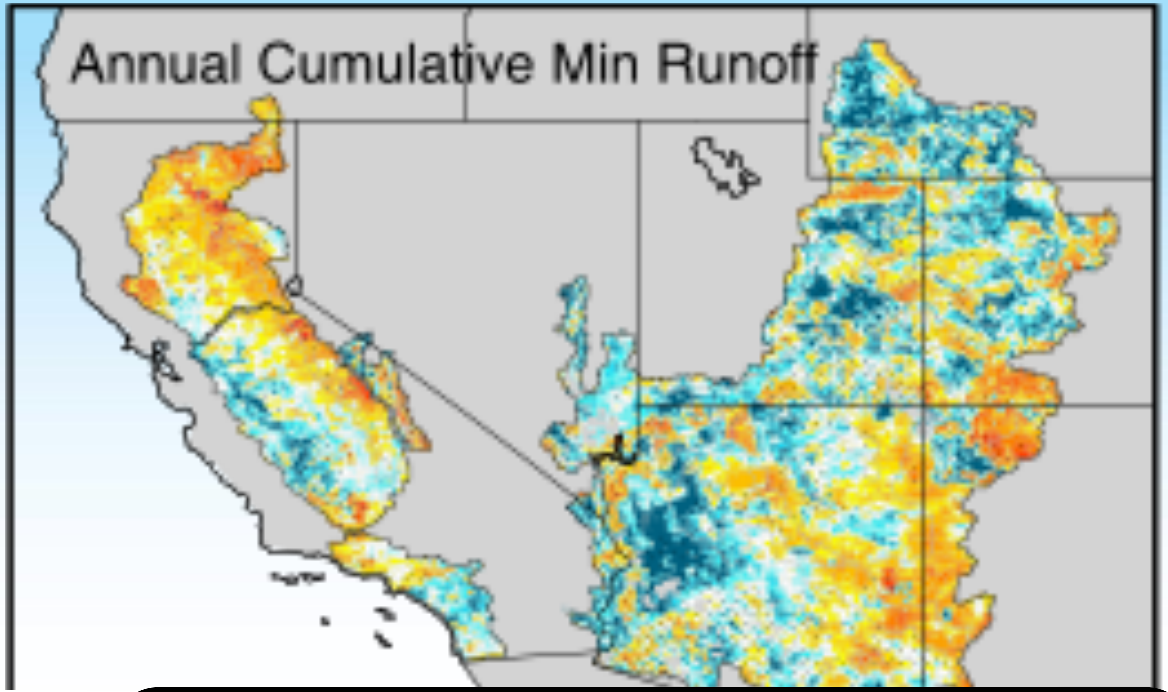
Basin	Ensemble Average	Ensemble Range
Colorado River	+9%	-3 to 50%
Owens Valley – Mono Lake	+9%	-13 to 35%
Sacramento River	+2%	-30 to 22%
San Joaquin – Tulare Lake	-1%	-27 to 30%

-1 to 9% change in runoff at basin level, but with a large range of uncertainty.

Projected 50-year Cumulative Annual Runoff Changes

2021-2050 minus 1976-2005





Basin	Wet Periods	Dry Periods
Colorado River	+20% (14 yr)	+3% (38 yr)
Owens Valley – Mono Lake	+10% (26 yr)	-4% (69 yr)
Sacramento River	+3% (42 yr)	+13% (29 yr)
San Joaquin – Tulare Lake	+6% (38 yr)	+10% (36 yr)

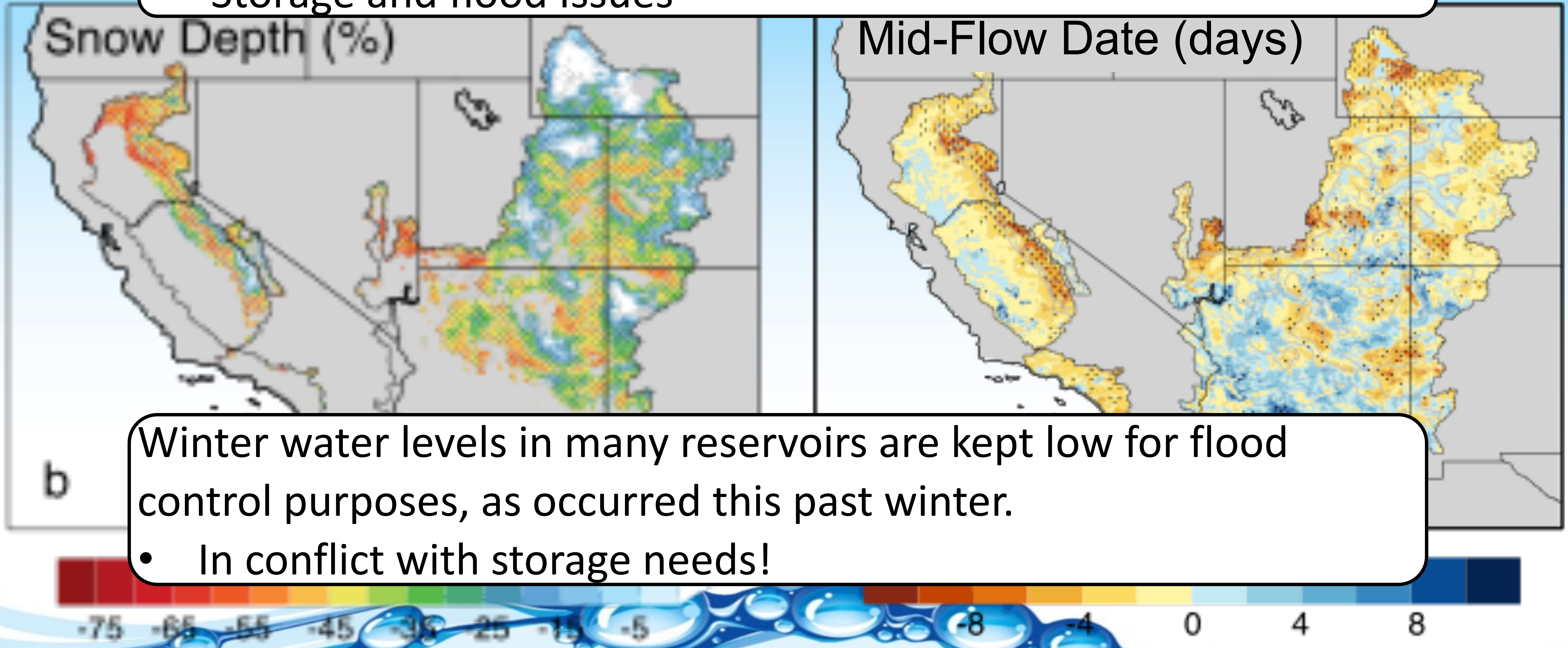
Increased periods of surplus and deficit (Except OV-ML)

- Less normal years
- Multi-year storage solutions
- Less reliability

Snowpack and Runoff Timing Changes:

More precipitation falls as Rainfall and snow melts earlier.

- Storage and flood Issues



Winter water levels in many reservoirs are kept low for flood control purposes, as occurred this past winter.

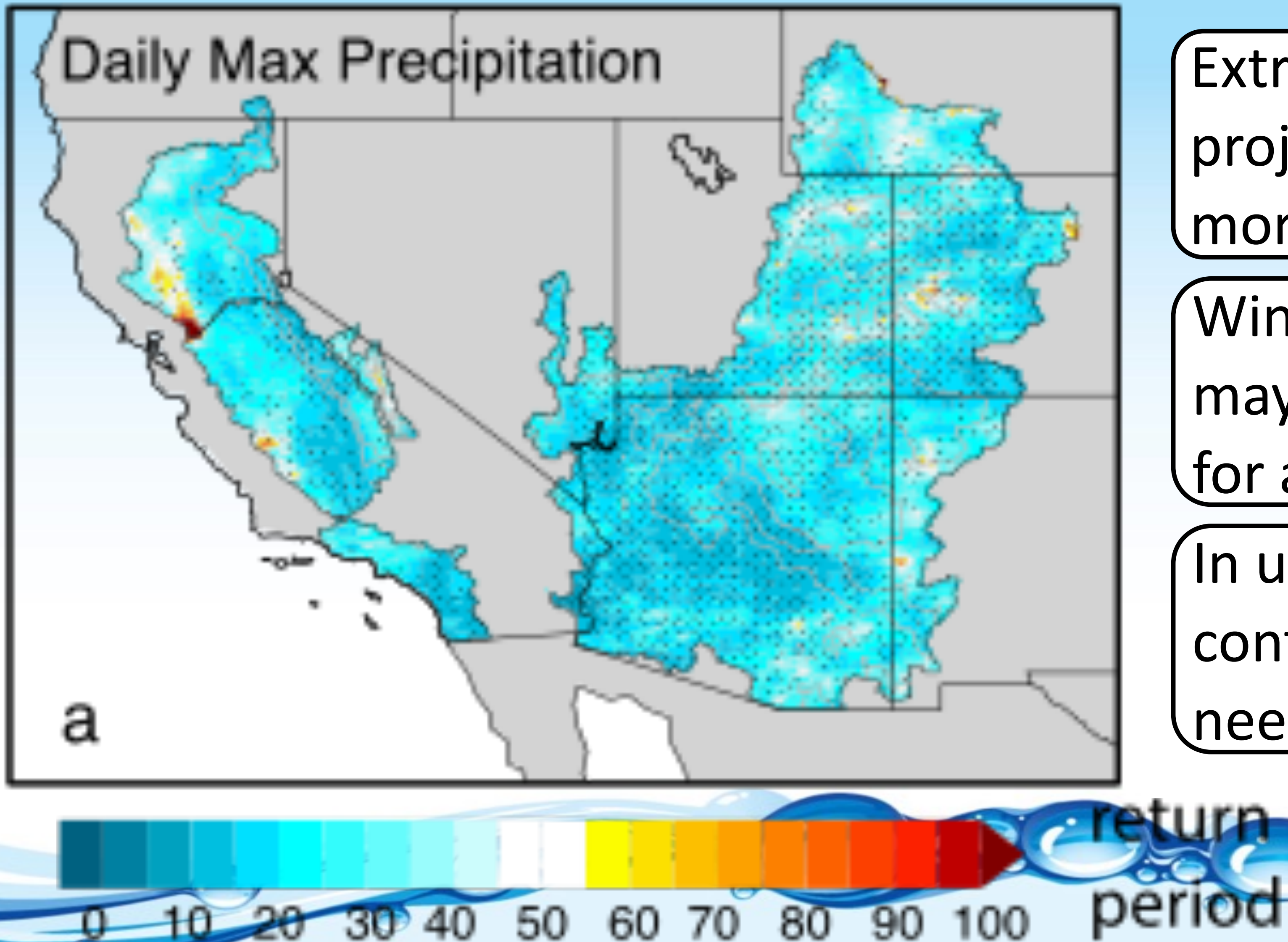
- In conflict with storage needs!

Snowpack decreases up to 75%.

Streamflow arrives up to 10 days earlier.

50-year Precipitation Return Period Changes

2021-2050 minus 1976-2005



Extreme precipitation events are projected to occur 2 to 8 times more frequently by 2050.

Winter reservoir water levels may need to be further lowered for additional flood control.

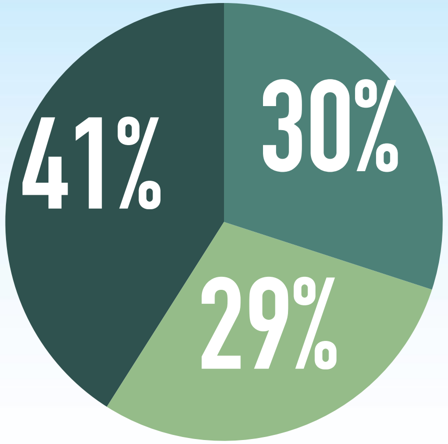
In urban environments, flood control channel capacities may need to be increased.

What are our water agencies doing about climate change?

Climate Change in UWMPs

Climate change in 2010 California Urban Water Management Plans (sample of 59 of 422 submitted)

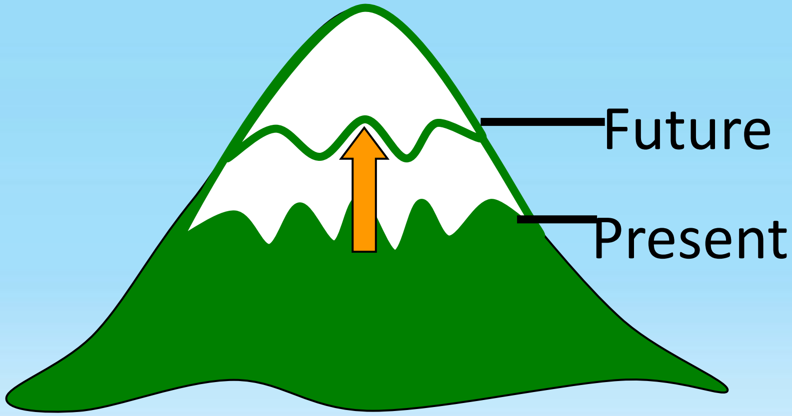
Only 41% of sampled UWMPs from California water agencies directly addressed how climate change would impact the agency’s service area.



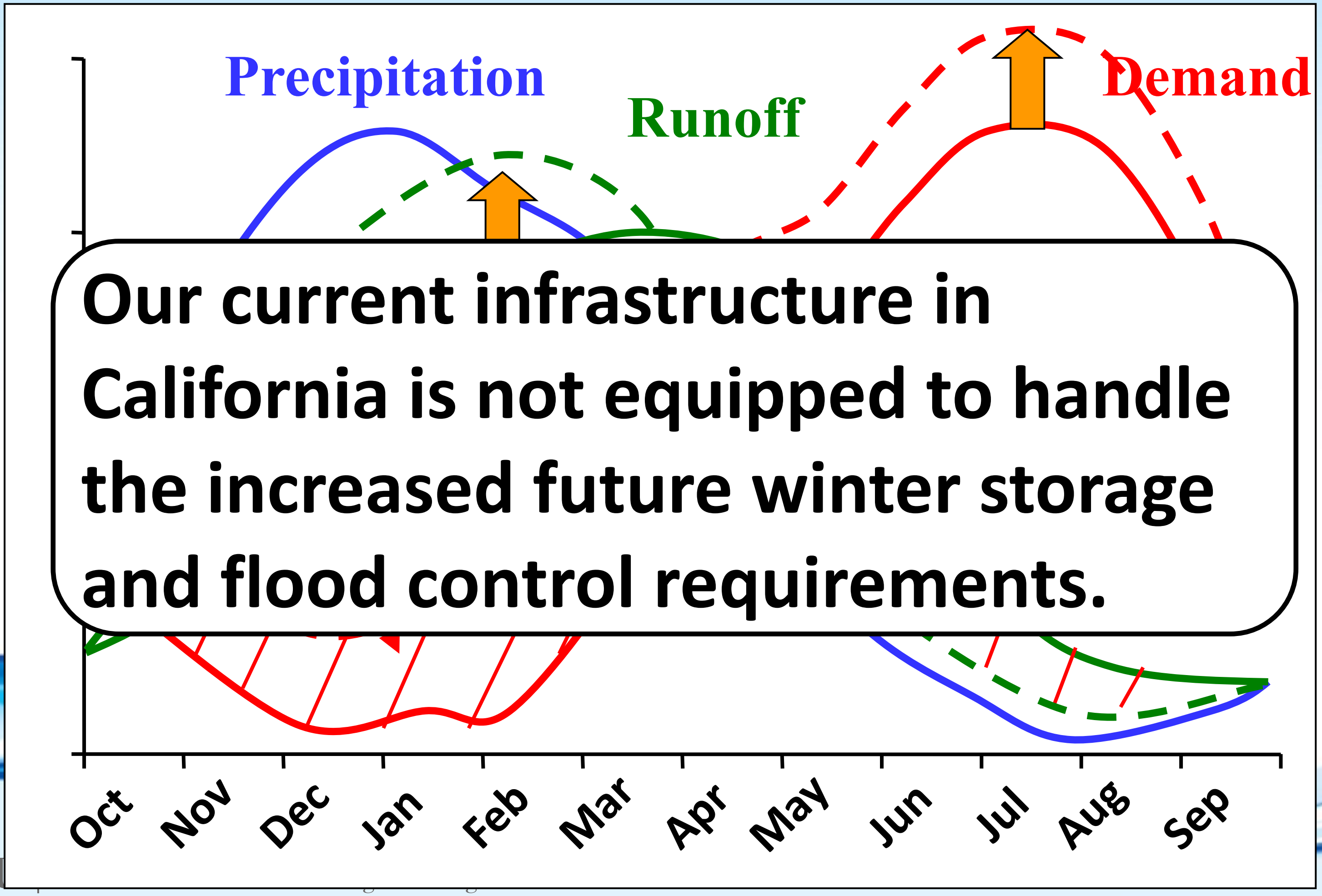
- No Mention
- General Mention
- Identified Specific Impacts

Adapted from Conrad, 2013

Our Future Water Cycle



- Substantial reductions in snowfall (and snowpack).
- Earlier snowmelt
- Increase in “rain flood” risk
- Substantial increase in extreme storm frequency and intensity
- Higher irrigation demands
- Higher evaporative losses from reservoirs
- Increased summer water deficit and decreased spring surplus



Our current infrastructure in California is not equipped to handle the increased future winter storage and flood control requirements.

Potential Adaptation Solutions

Conservation:

- Expected population increases are likely to negate conservation measures.
- Implement efficient irrigation practices and change to lower water use agriculture.

Management:

- Implement Forecast Informed Reservoir Operations (FIRO).
- Agriculture to urban water transfers.

Recycled Water Direct Reuse: Reduce negative public perception.

Groundwater: Increase groundwater banking and reduce groundwater mining.

Existing Infrastructure:

- Raise in-stream storage structures.
- Reduce conveyance channel and pipe leakage and cover aqueducts.

New Infrastructure:

- Stormwater Capture
- Delta 2 Tunnels – Perhaps as a last resort