# Climate Change and Arizona: Challenge and Opportunity

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*IPCC, 2007*

# Global Warming is *unequivocal*

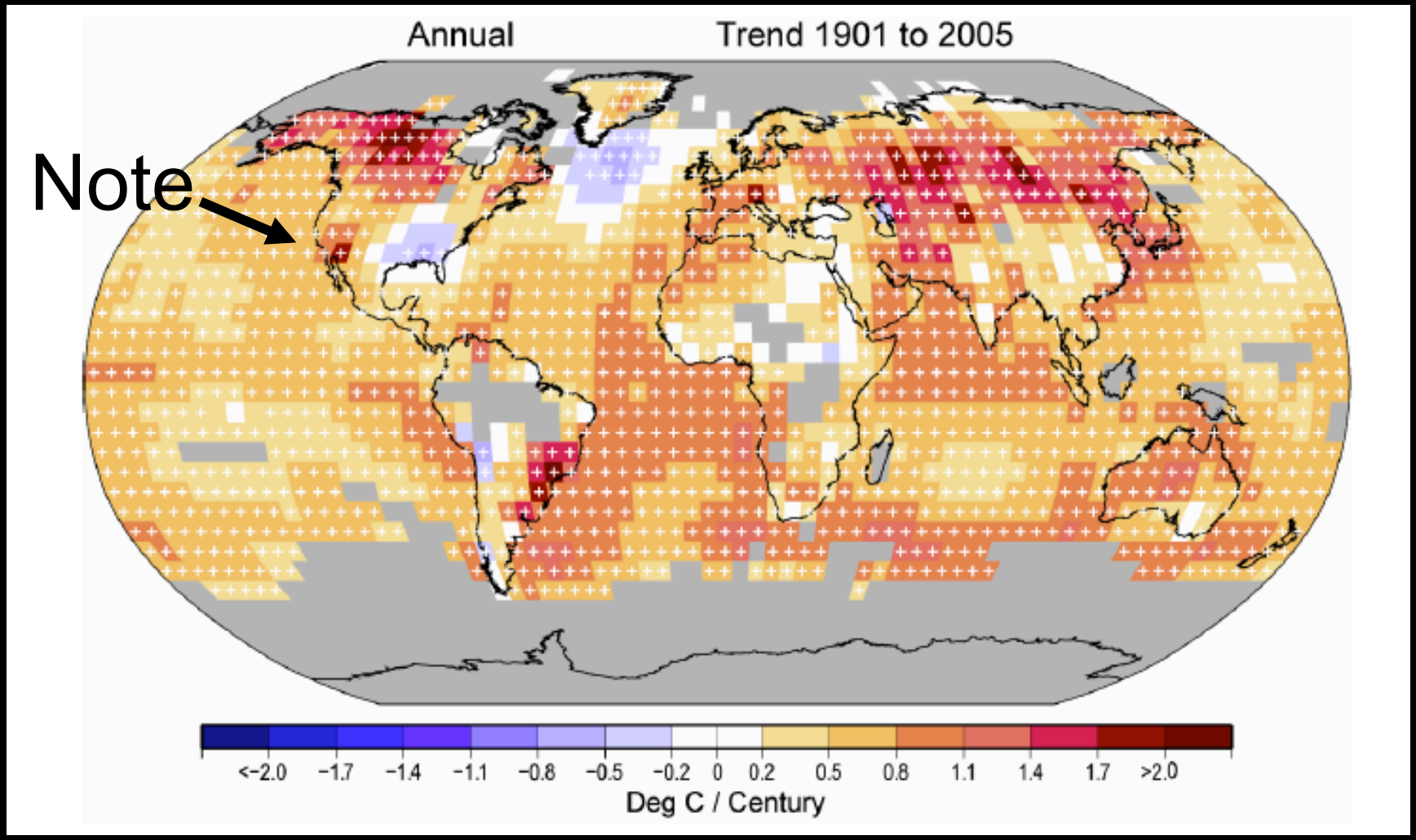
Since 1970, rise in:

- Global surface temperatures
- Extreme high temperatures
- Heat waves
- Lower atmosphere temperatures
- Global sea-surface temperatures
- Ocean heat content
- Water vapor
- Extratropical precipitation
- Rainfall intensity
- Drought
- Hurricane intensity
- Global sea level

Decrease in:

- NH Snow extent
- Arctic sea ice
- Glaciers
- Cold temperatures

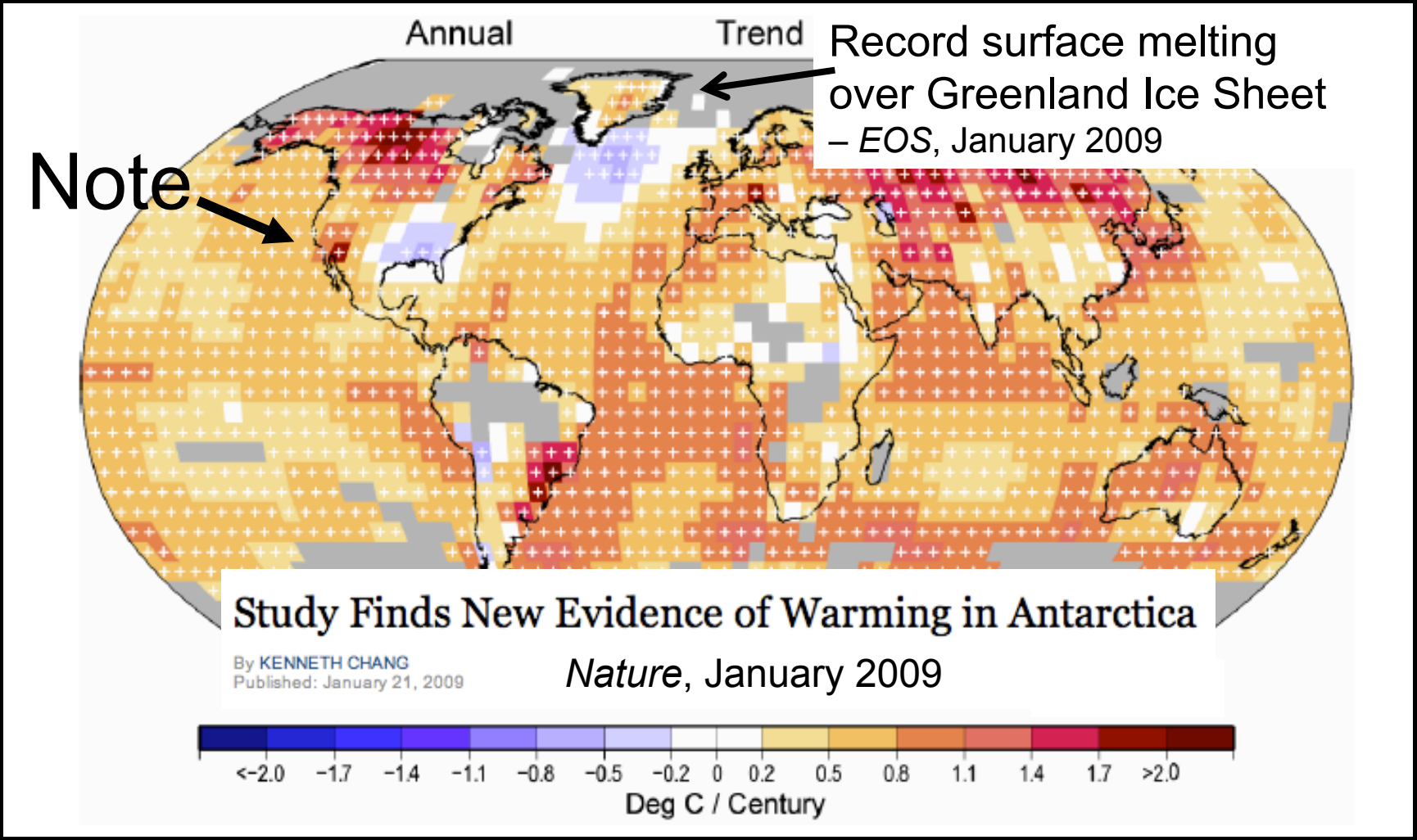
# *The Earth has warmed almost everywhere*




Temperature trend from 1901 to 2005

*IPCC, 2007*

*2009 update… the story is not getting any better…*




Temperature trend from 1901 to 2005

*IPCC, 2007*

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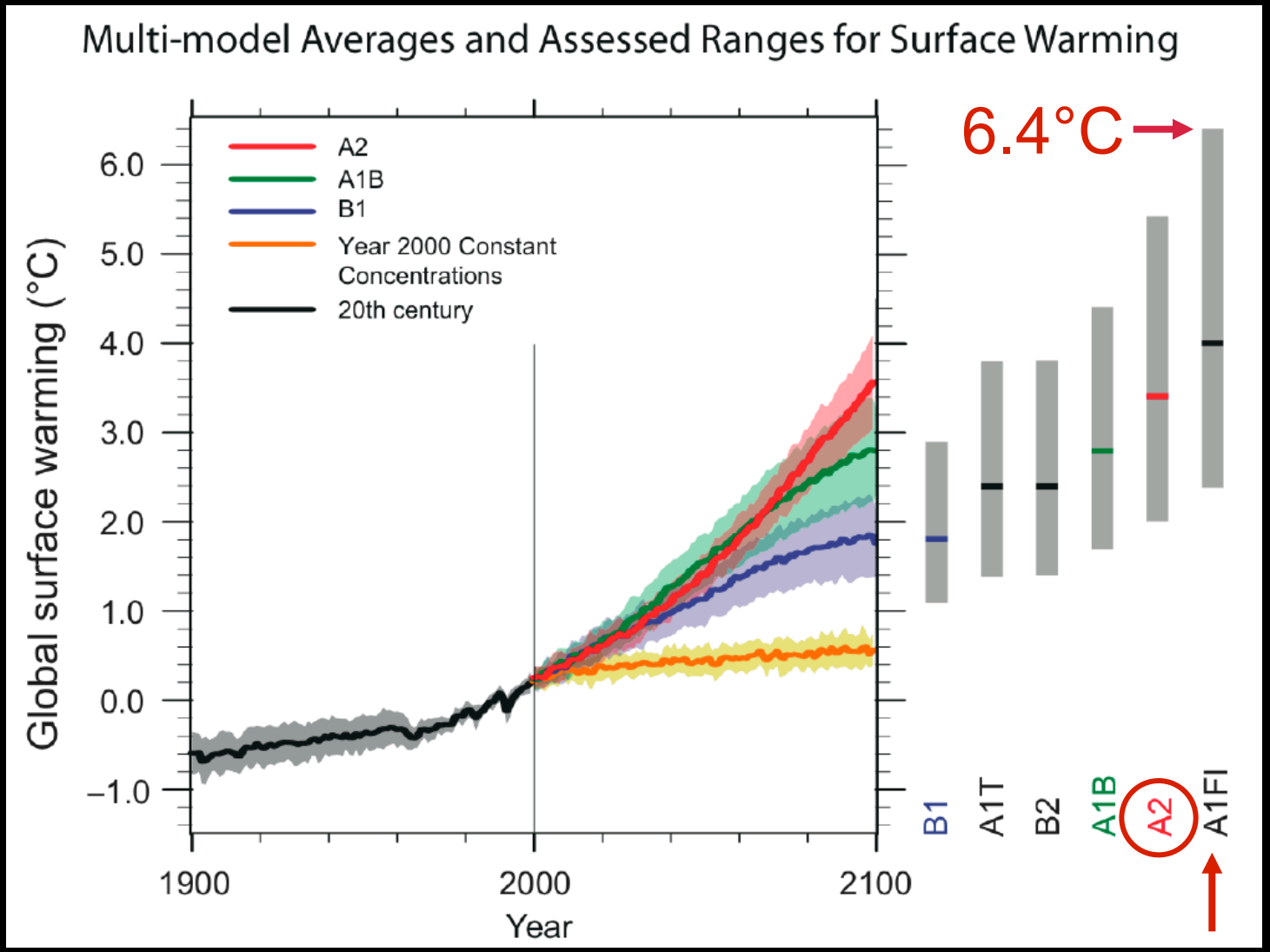
# Projected future global warming

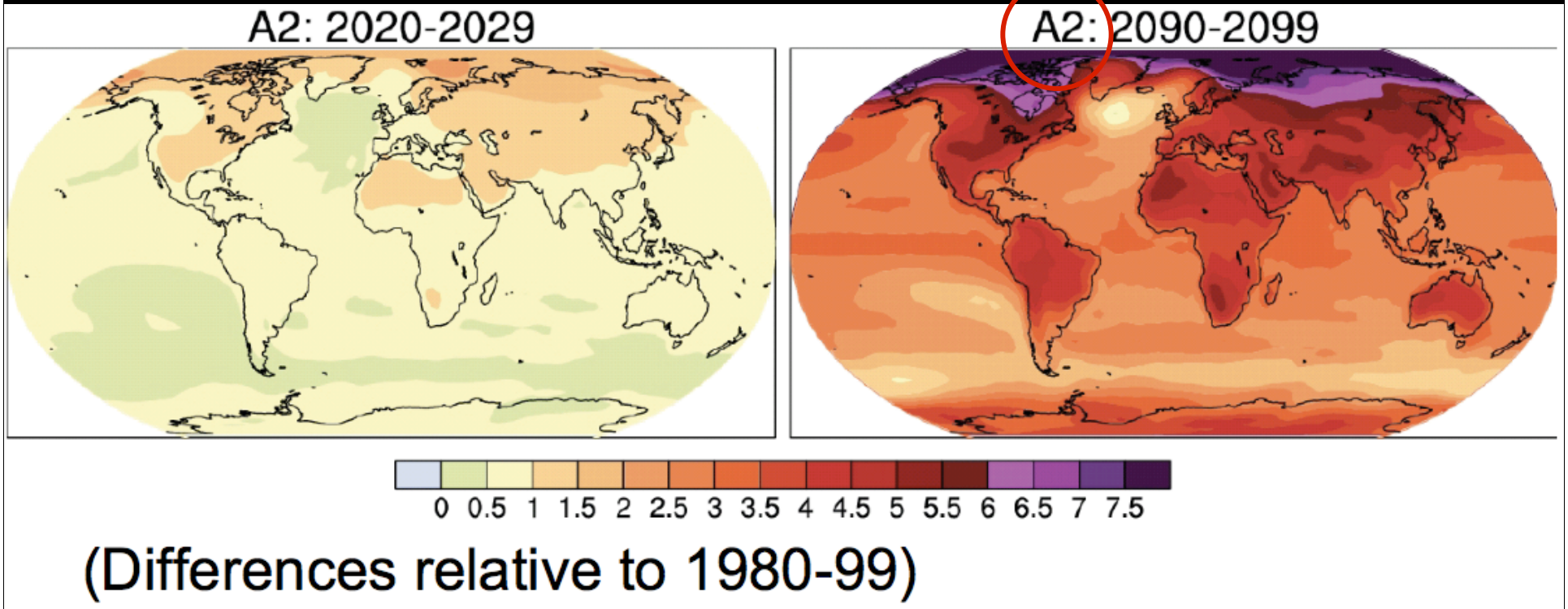



Likely warming depends on emissions scenario

Presently increasing than on the fast-track A2 scenario

*Bottom line… A2 scenario and average of all models yields 3.5°C global average warming*

*Warming will be **more over land**, and at higher latitudes (e.g., in the Western U.S. and the poles)*




*NOTE: Some models project even warmer climates if carbon emissions are not curbed – even double above*

*IPCC, 2007*

## *Turning to the Southwest…*

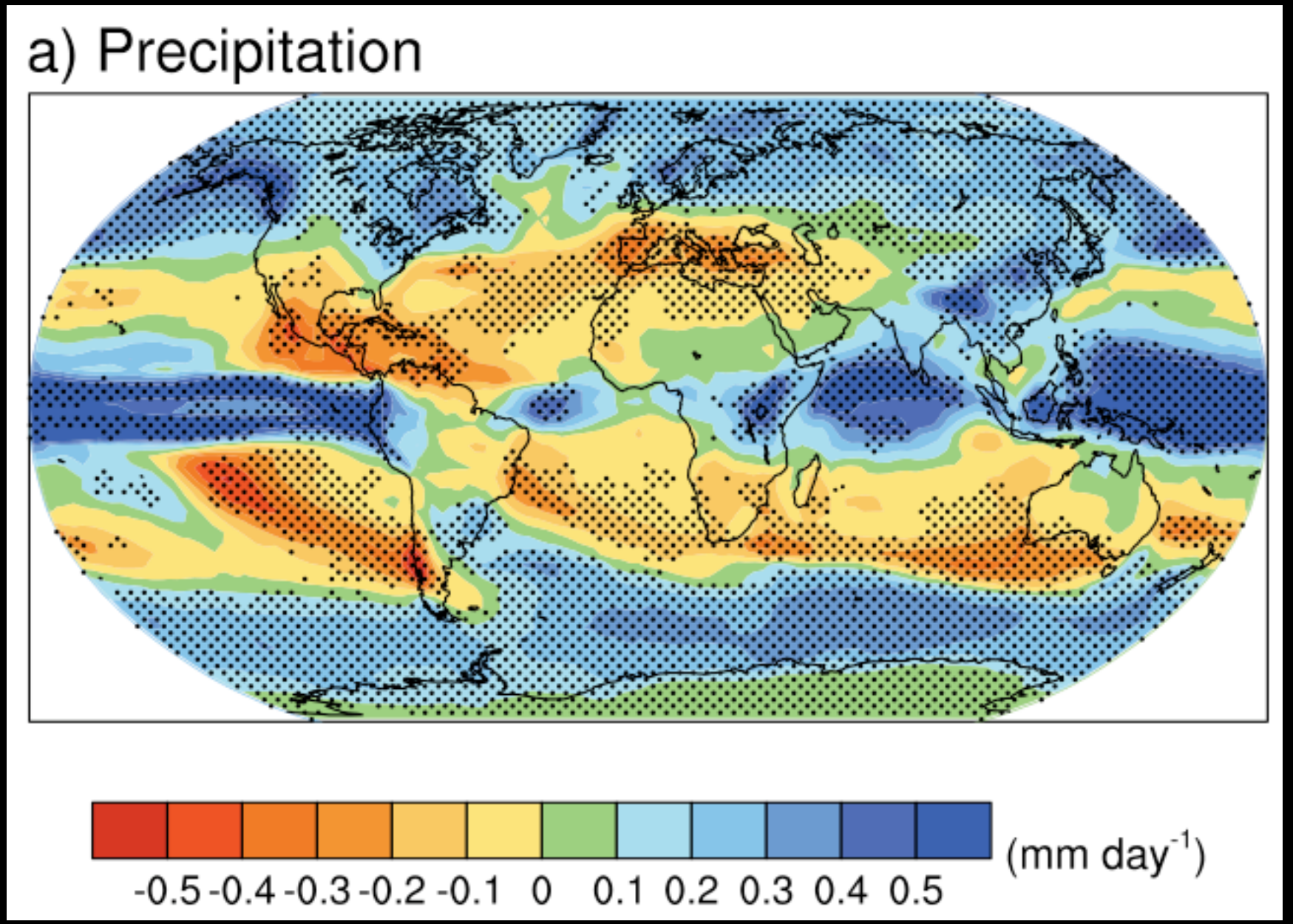
*With climate change, there may be winners and losers…*

**Climate change hotspots in the United States**

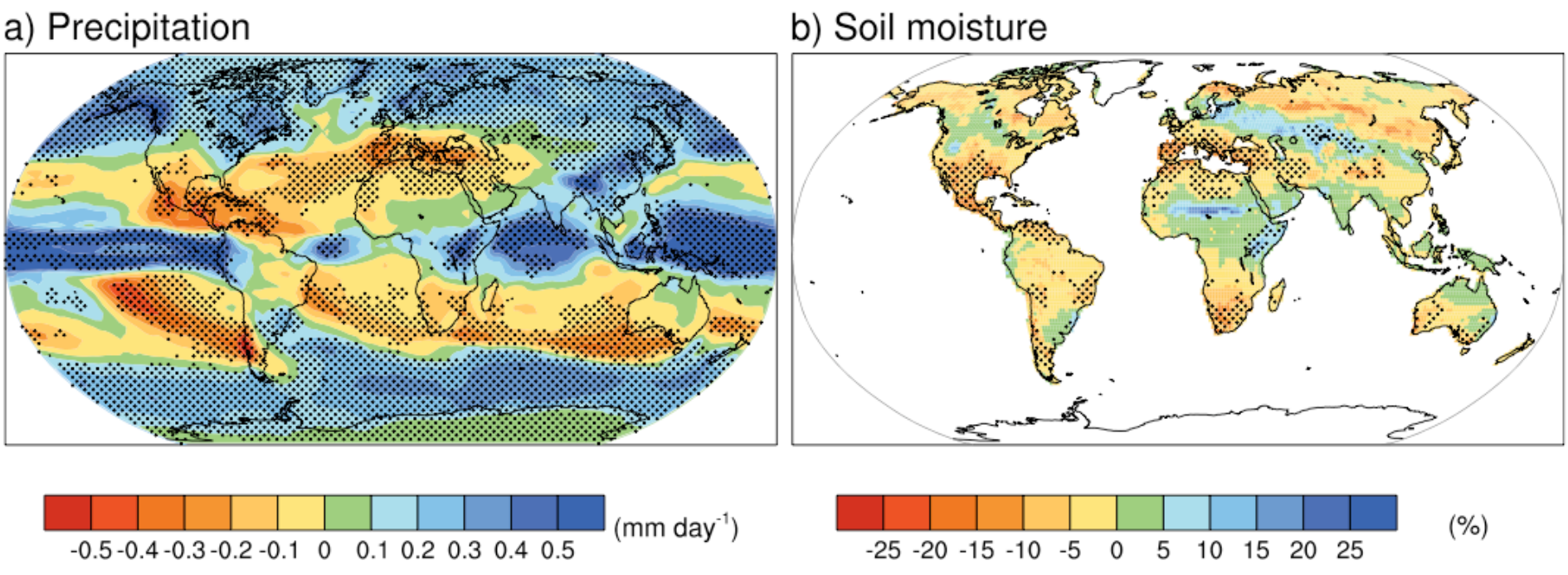
Noah S. Diffenbaugh,[1] Filippo Giorgi,[2] and Jeremy S. Pal[3]

*(Geophysical Research Letters,* 2008)

*"Areas of the southwestern United States and northern Mexico are the most persistent hotspots"*



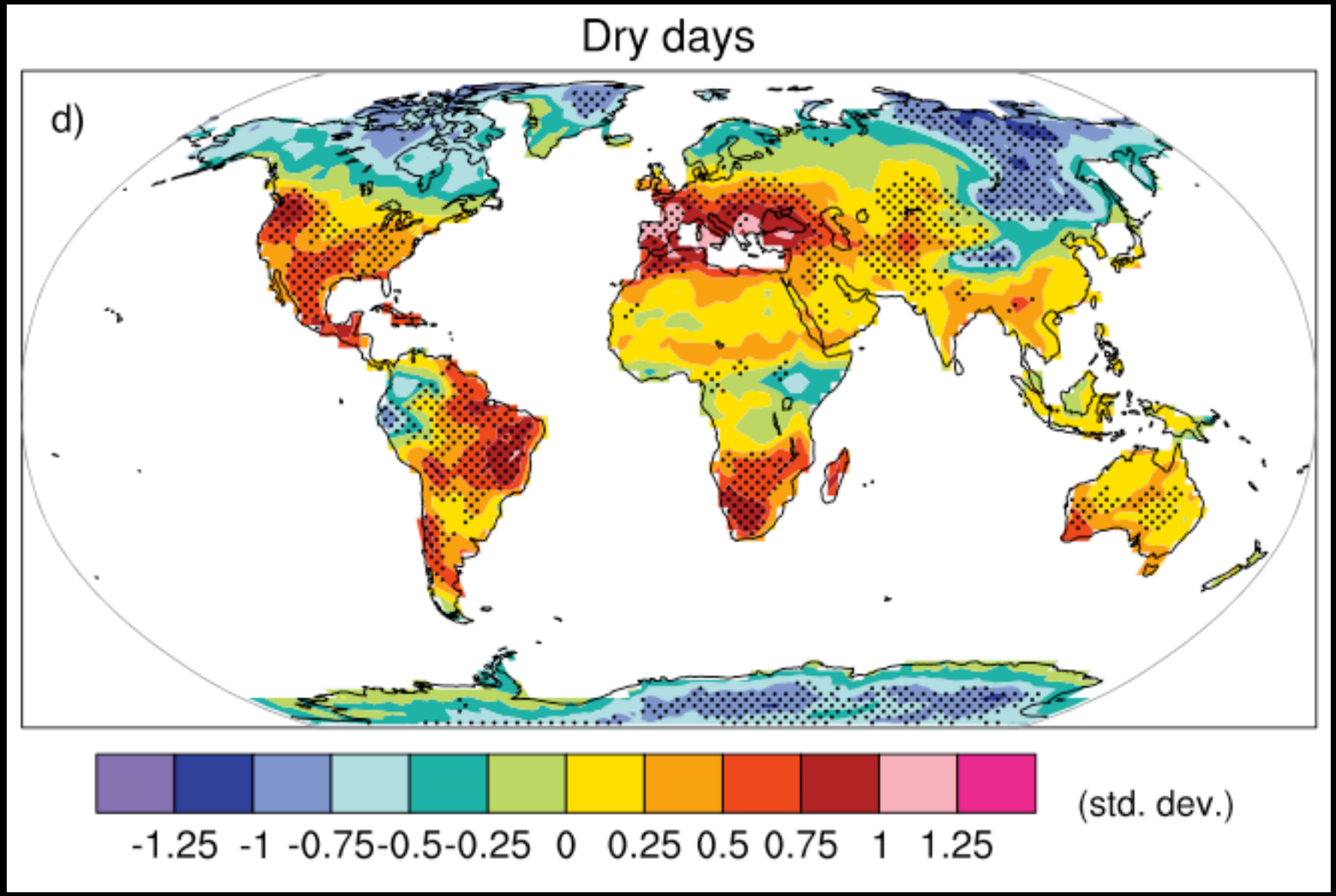

*IPCC, 2007*




It appears that the Earth's dry zones will get drier, and…

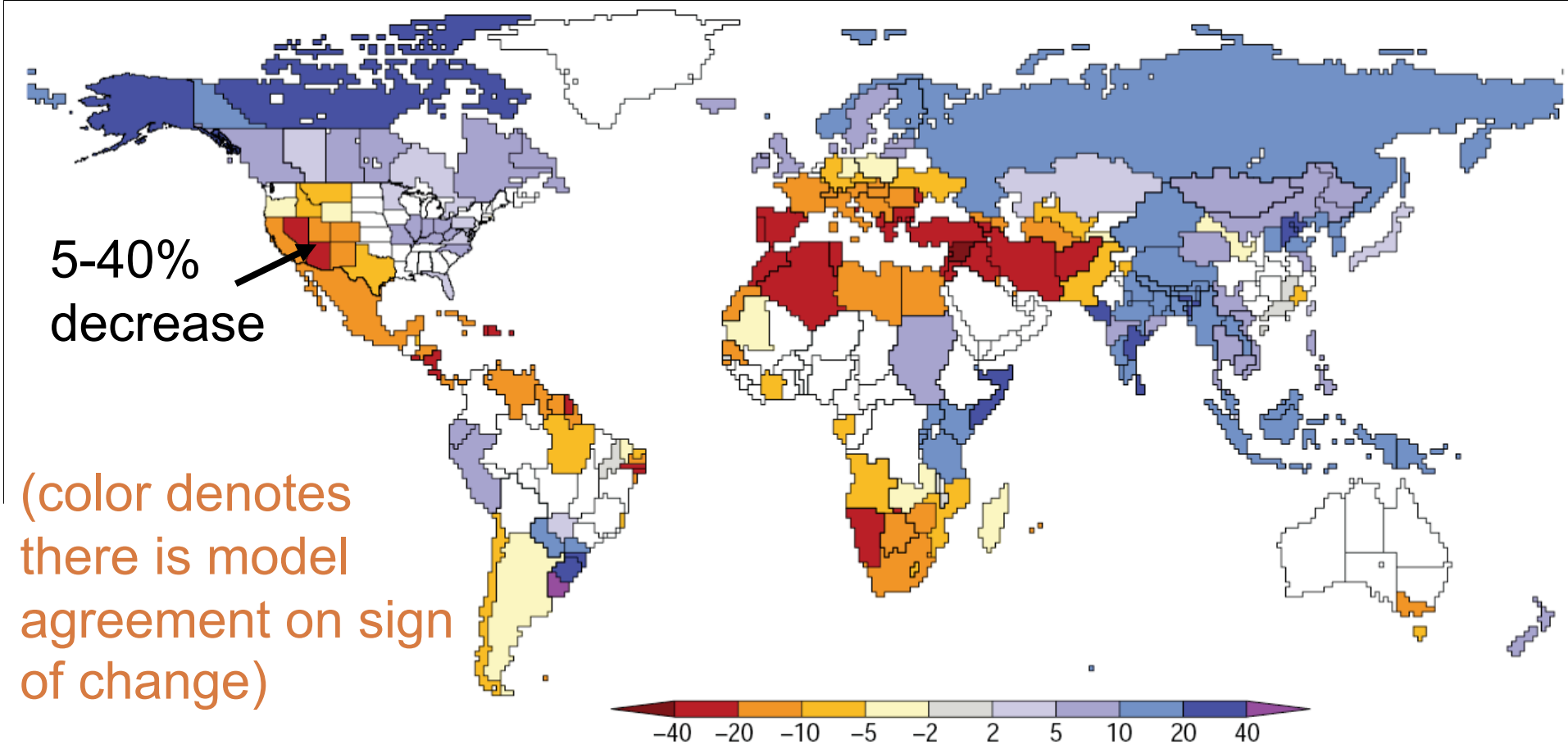
*IPCC, 2007*

# Dry zones will also see more drought too




*IPCC, 2007*

# Colorado River Flow Likely to Decrease
## even given the A1B reduced-emission scenario




Milly et al., 2008

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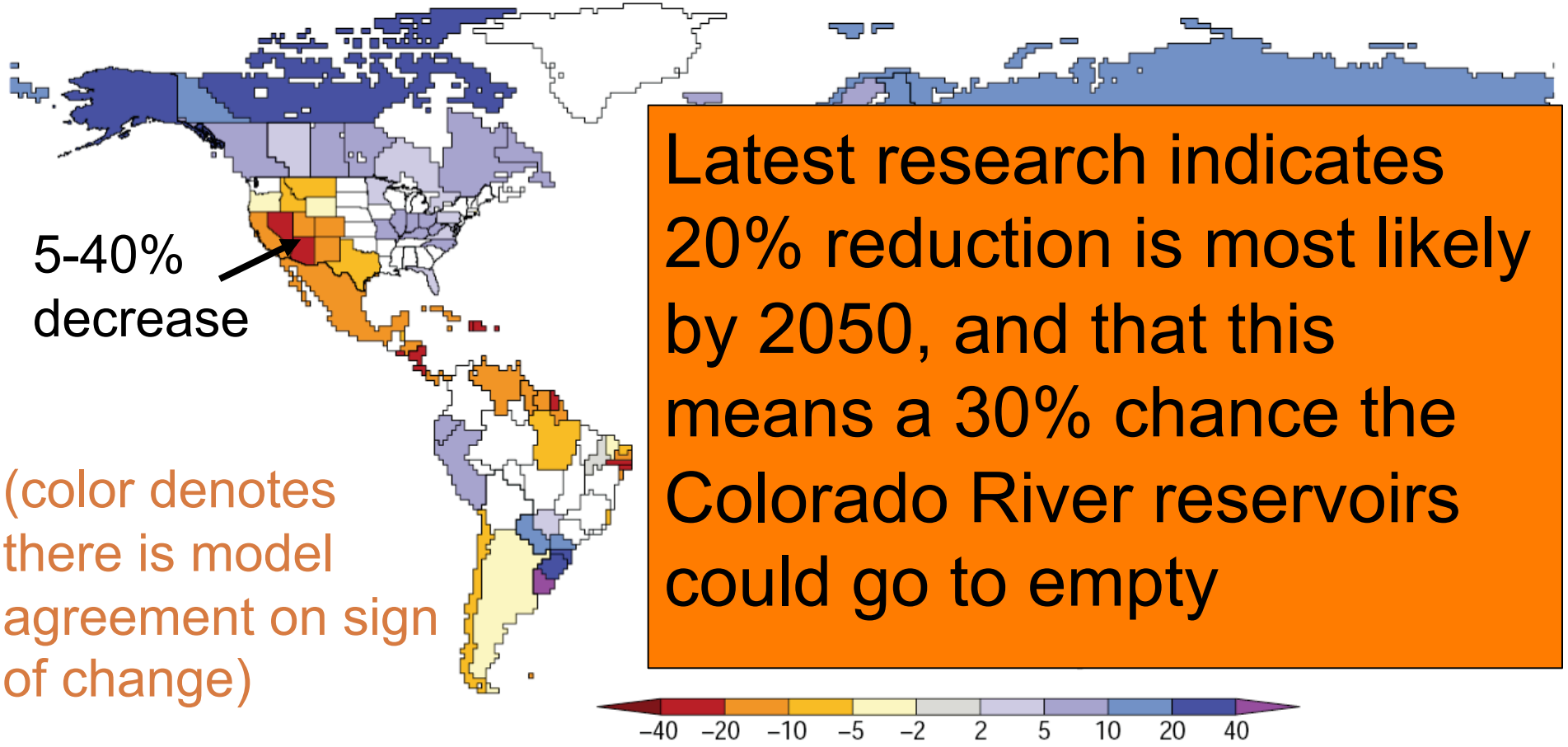


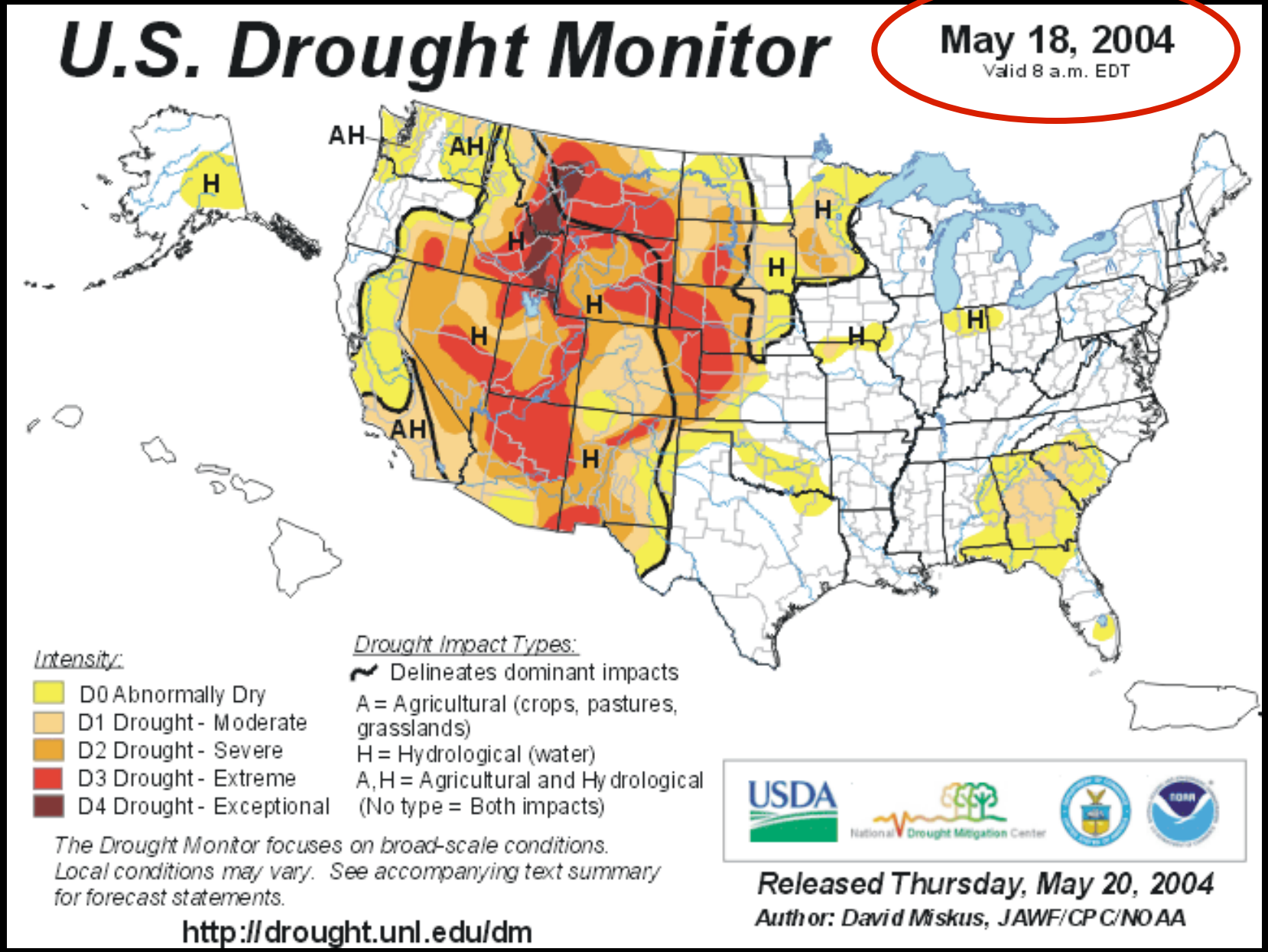

Milly et al., 2008

*That's what is projected by theory and climate models….*

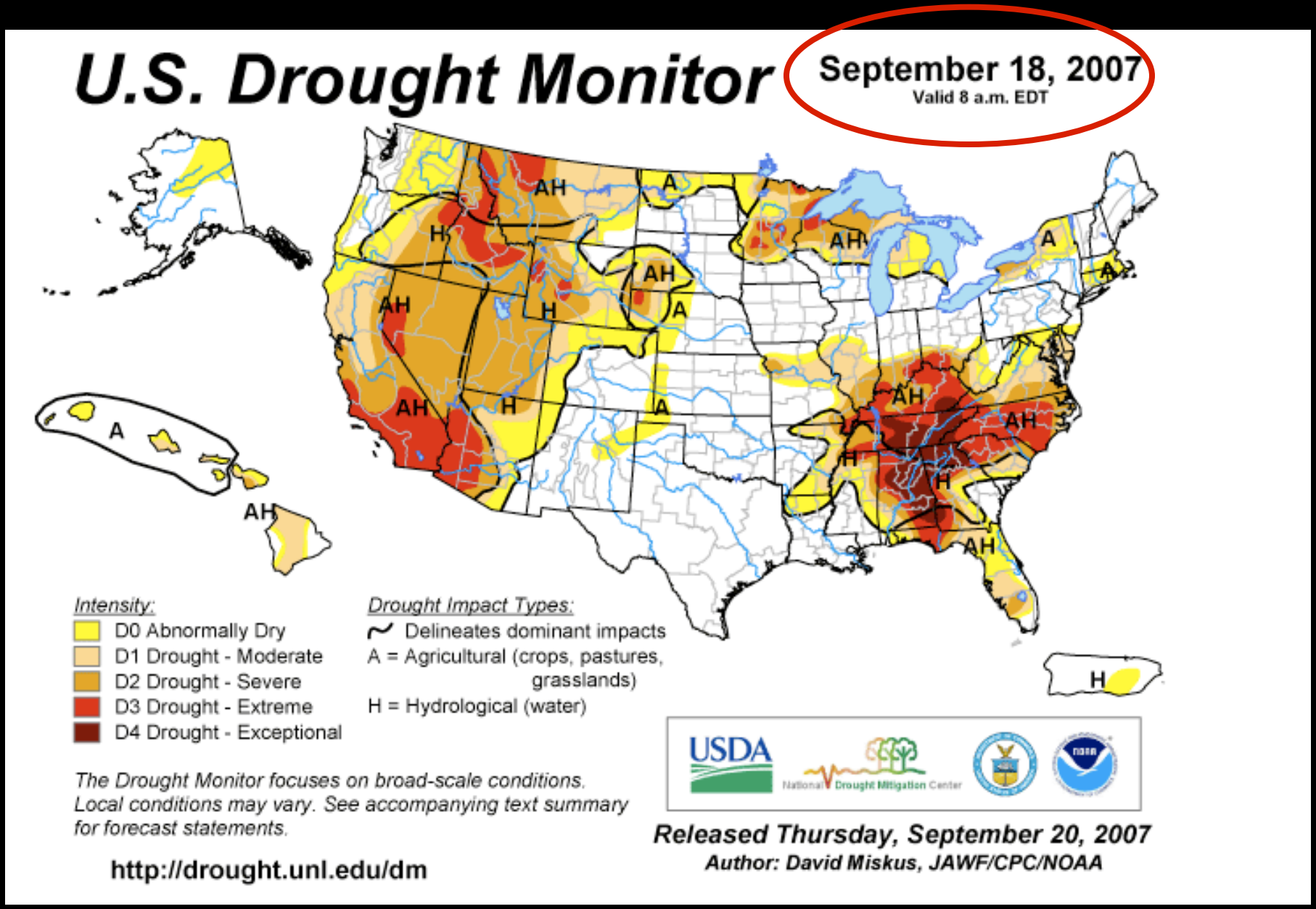
*What's actually happening?*


http://www.npr.org

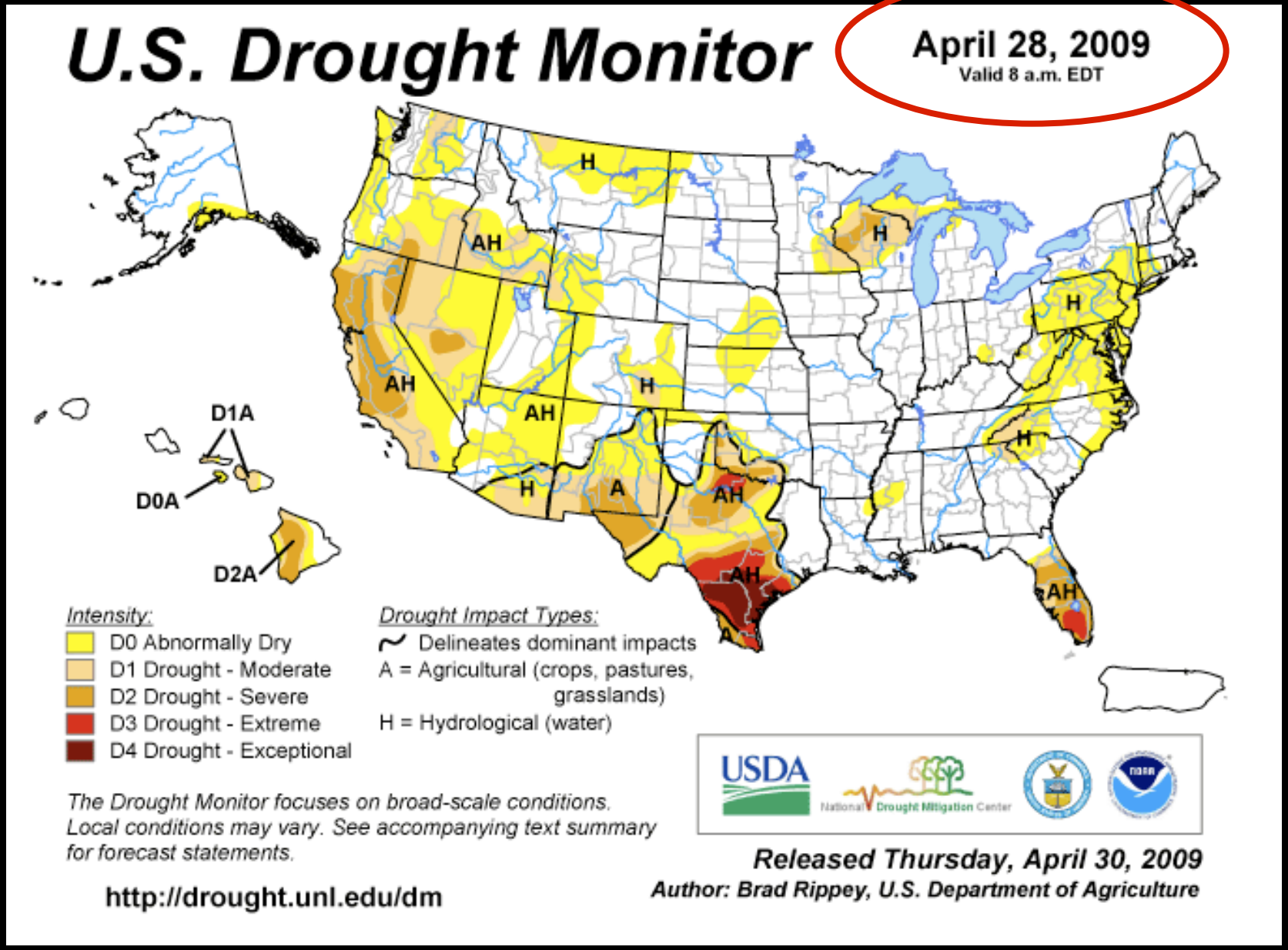
# *The current western drought began in the late 1990's…*



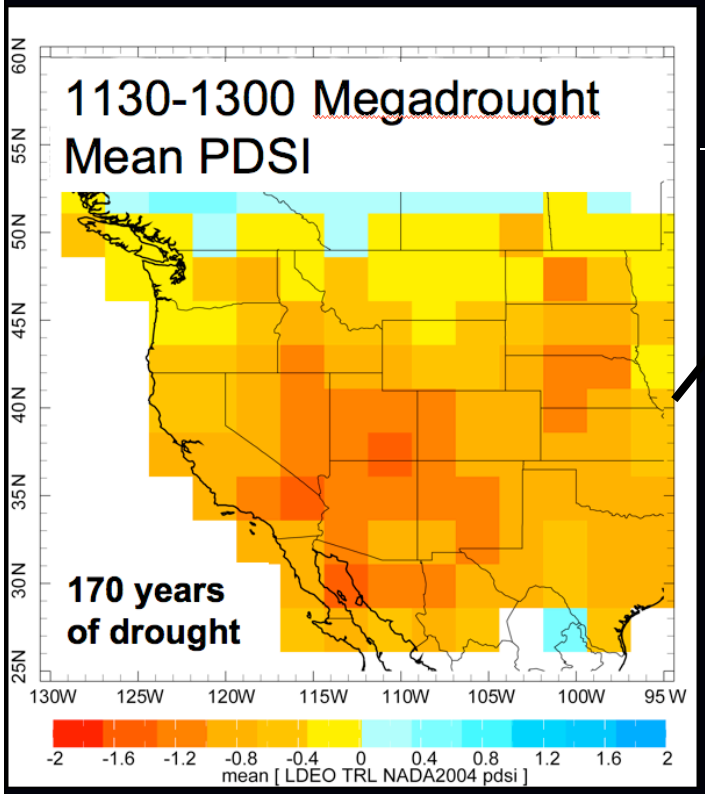
# *As we exited summer 2007, the drought persisted…*

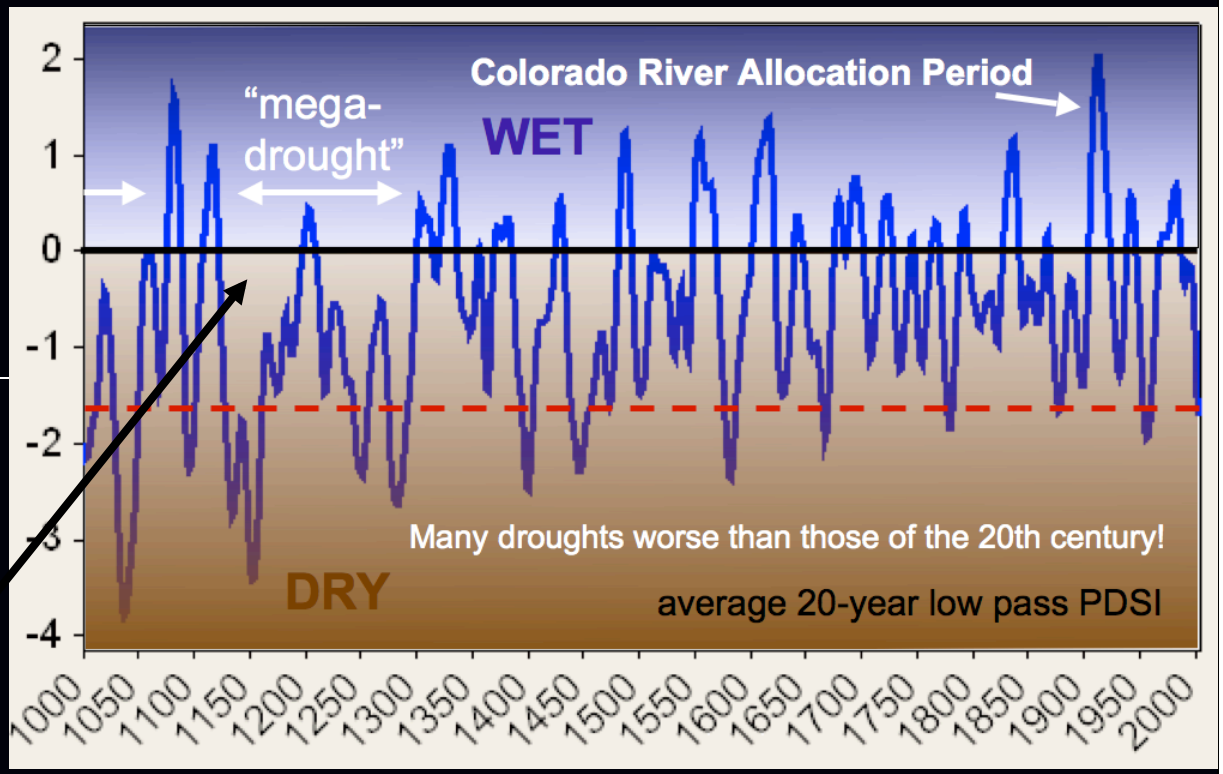


***And even with our "wet" 2007/8 winter and summer in 2008, the drought still persists…***



# Climate change adaptation is also a "no-regrets" option that could reduce our vulnerability to natural drought as well

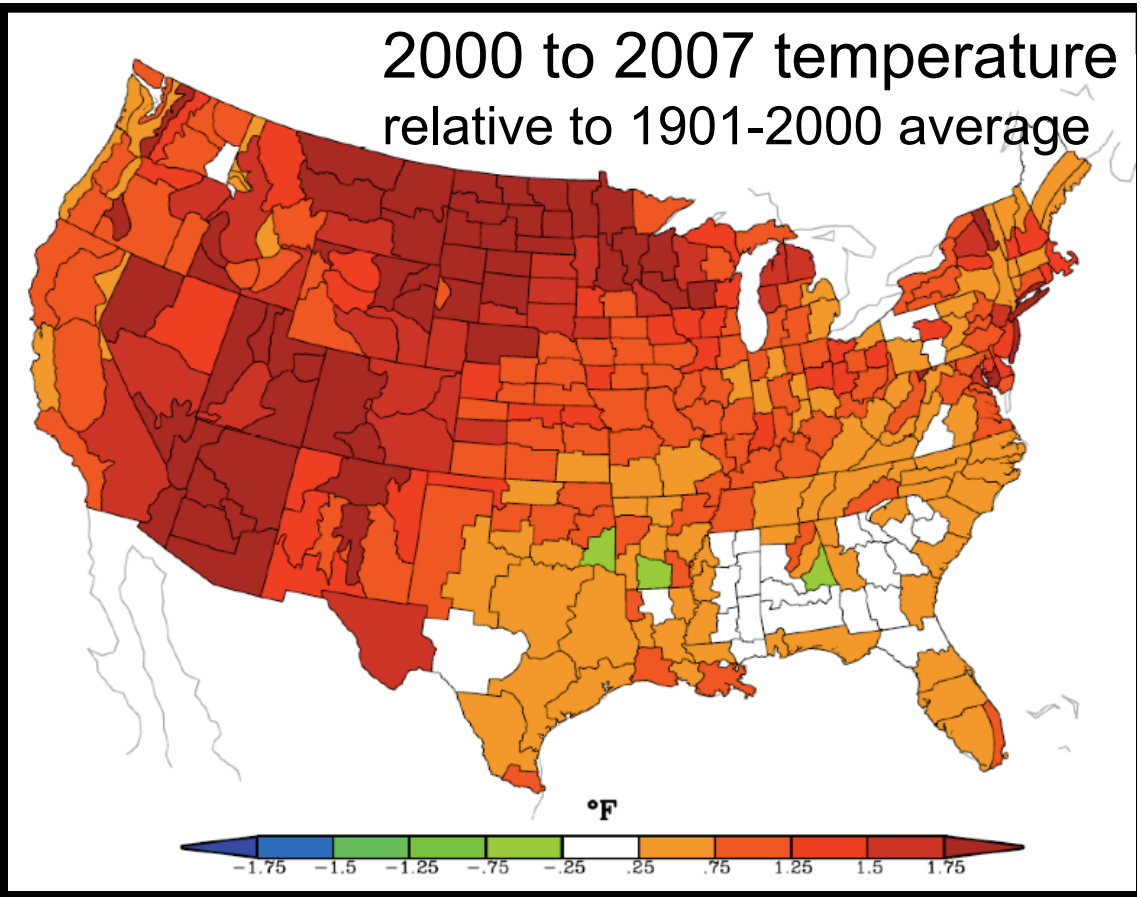



After Cook et al., *Science,* 2004

*But it is very likely that future droughts will be unlike those of the past…*

*Future droughts will be significantly hotter*




*Parts of the West have **already** warmed more than 2°F relative to average 20th century temperatures*

(map from M. Hoerling, NOAA)

# *Conclusions*

- Global warming (etc.) is very real - and impacting the Southwest (and the West more generally)
- Humans are causing the problem - little doubt
- More climate change (e.g., warming and drought) is a sure bet – ***and natural variability could make it worse with a megadrought***

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Arizona needs to plan how to *adapt* to climate change

# *Conclusions*

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Colorado population projected to increase 55% (2.6M) by 2030

Arizona population (5M) projected to double by 2030

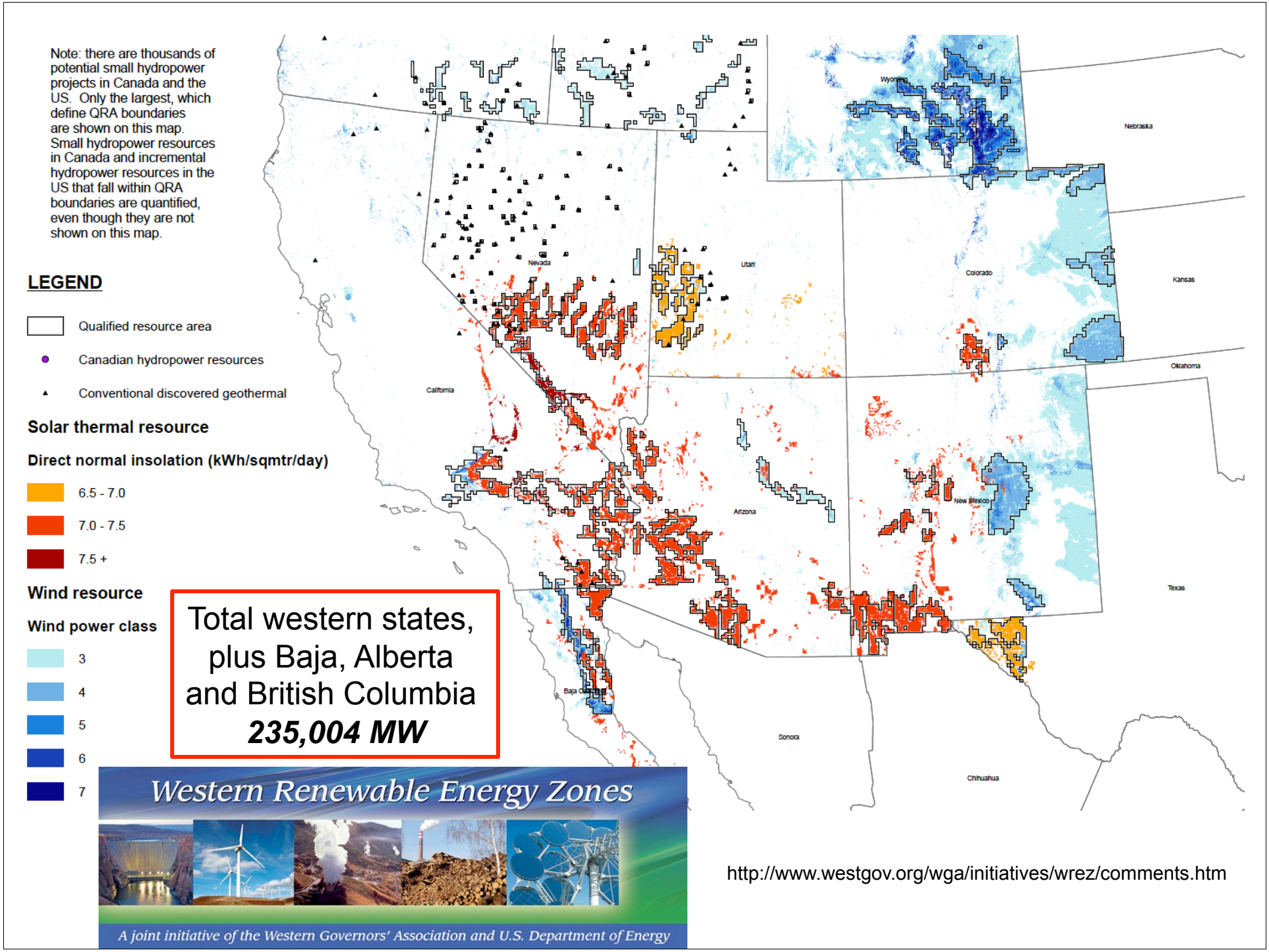
Possible ???

California population to go up 37% (up 12M) by 2030

*But we must also be a leader in reducing the causes of climate change…*

- Conservation and increased efficiency
- **Carbon-free electricity -** coal with carbon capture, wind, solar, hydropower, geothermal
- **Carbon-free fuels -** advanced biofuels, hydrogen generated with carbon-free electricity
- **Natural carbon sinks -** forestry and agricultural soils
- **Nuclear? -** problems with waste problems with NIMBY, and… problems with proliferation

Photo: J. Overpeck


Note: there are thousands of potential small hydropower projects in Canada and the US. Only the largest, which define QRA boundaries are shown on this map. Small hydropower resources in Canada and incremental hydropower resources in the US that fall within QRA boundaries are quantified, even though they are not shown on this map.
LEGEND
Qualified resource area
Canadian hydropower resources
Conventional discovered geothermal
Solar thermal resource
Direct normal insolation (kWh/sqmtr/day)
6.5 - 7.0
7.0 - 7.5
7.5 +
Wind resource
Wind power class
3
4
5
6
7
Total western states, plus Baja, Alberta and British Columbia
235,004 MW
Western Renewable Energy Zones
A joint initiative of the Western Governors' Association and U.S. Department of Energy
Wyoming
Nebraska
Nevada
Utah
Colorado
Kansas
California
Oklahoma
Arizona
New Mexico
Texas
Sonora
Chihuahua
http://www.westgov.org/wga/initiatives/wrez/comments.htm

Arizona (Tucson!) has the opportunity to be the market leader in technological and knowledge solutions to climate change (and drought), and to save our skin at the same time.

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**Thanks…**