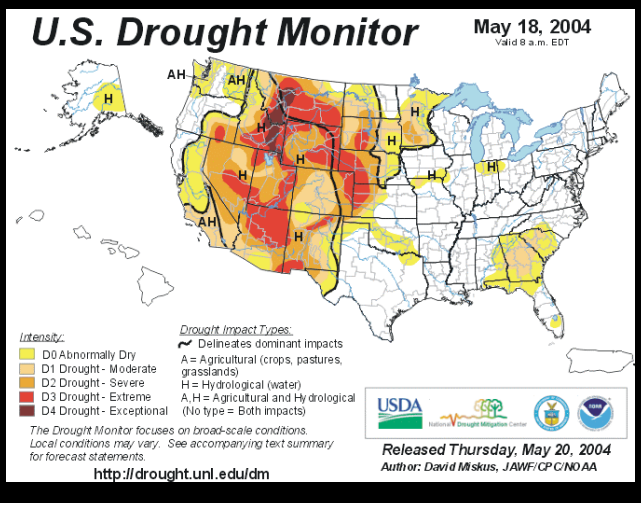
Jonathan Overpeck, The University of Arizona

Is the Earth's Climate System Changing Faster than Expected?



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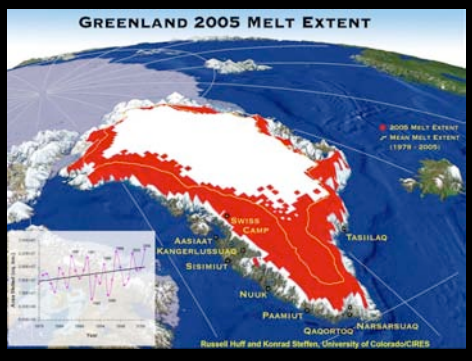
Is the Earth's Climate System Changing Faster than Expected?

Or…

Are big surprises ahead?



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Are we missing some important processes?

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Or…

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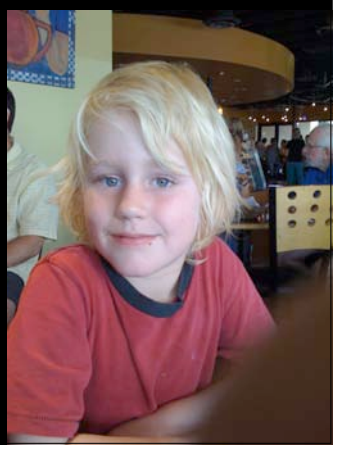
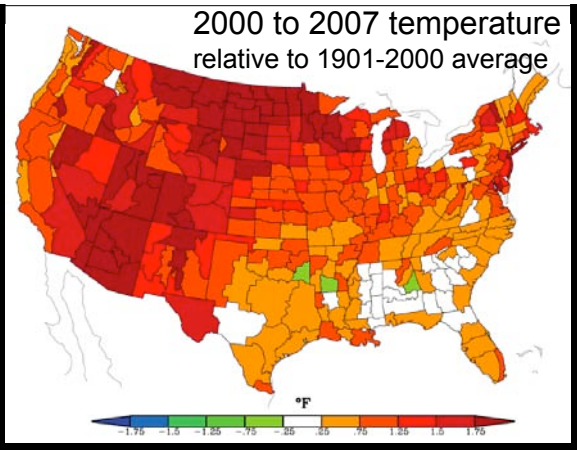
Or

Are we missing some important processes?

Or…

Can the next generation please help!

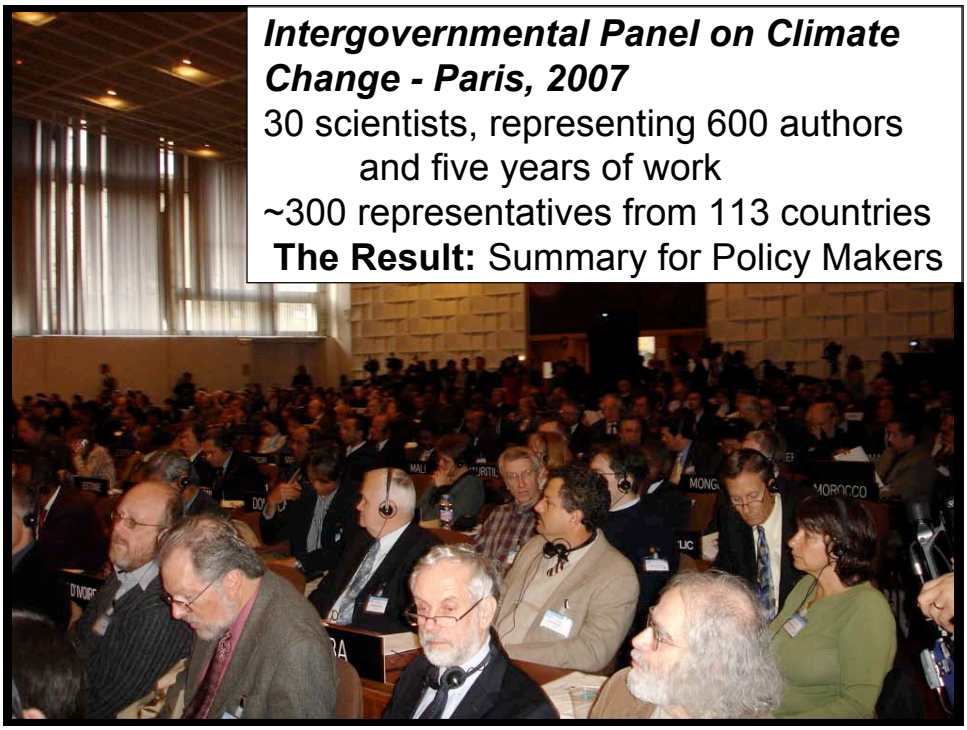




Key observation:
The West is warming!

(map from M. Hoerling, NOAA)

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



Intergovernmental Panel on Climate Change - Paris, 2007

30 scientists, representing 600 authors and five years of work

~300 representatives from 113 countries

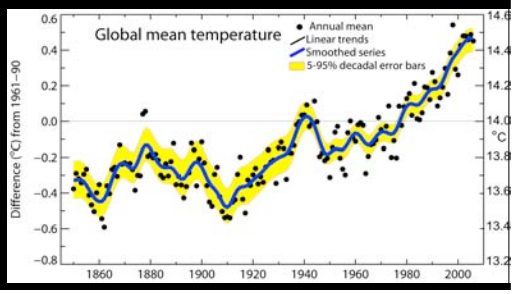
The Result: Summary for Policy Makers

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



Now, what about sea level?

…and the tension between
"model based"
and
"expert opinion"

Projected globally-averaged sea level rise by the end of the 21st century

Case	Sea Level Rise (m at 2090-2099 relative to 1980-1999) Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [b]	NA
B1 scenario	0.18 – 0.38
A1T scenario	0.20 – 0.45
B2 scenario	0.20 – 0.43
A1B scenario	0.21 – 0.48
A2 scenario	0.23 – 0.51
A1FI scenario	0.26 – 0.59

Up to 2 feet

meters

Source: IPCC *Summary for Policy Makers,* February 2007

Projected globally-averaged sea level rise by the end of the 21st century

Note!

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Up to 2 feet

meters

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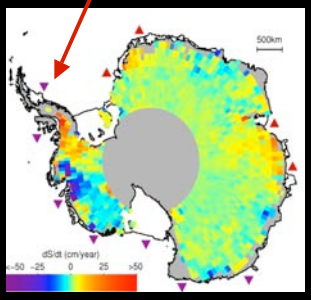
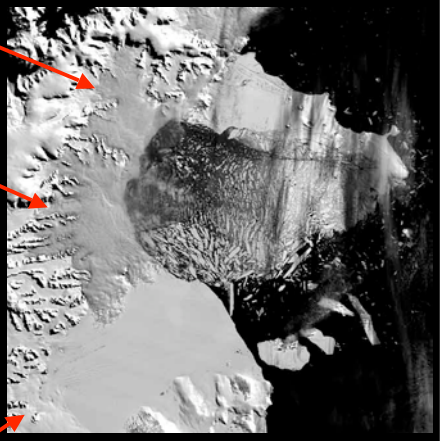
Dynamical changes? For example, ice shelf loss is increasing Antarctic glacier flow

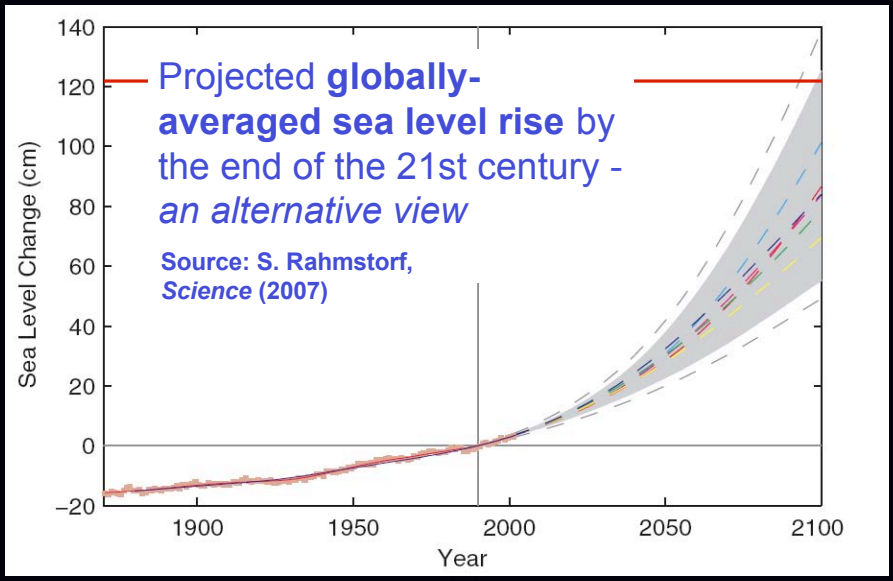


Glaciers lost ice shelf and sped up



Glacier still has ice shelf and did not speed up

Pictures are from http://nsidc.org/iceshelves/larsenb2002/index.html



More from the 2007 IPCC report…

Current models suggest ice … mass balance becomes negative at a global average warming (relative to pre-industrial values) in excess of 1.9 to 4.6°C. **If a negative surface mass balance were sustained for millennia, that would lead to … sea level rise of about 7 m [23 feet].**

Source: IPCC *Summary for Policy Makers,* February 2007

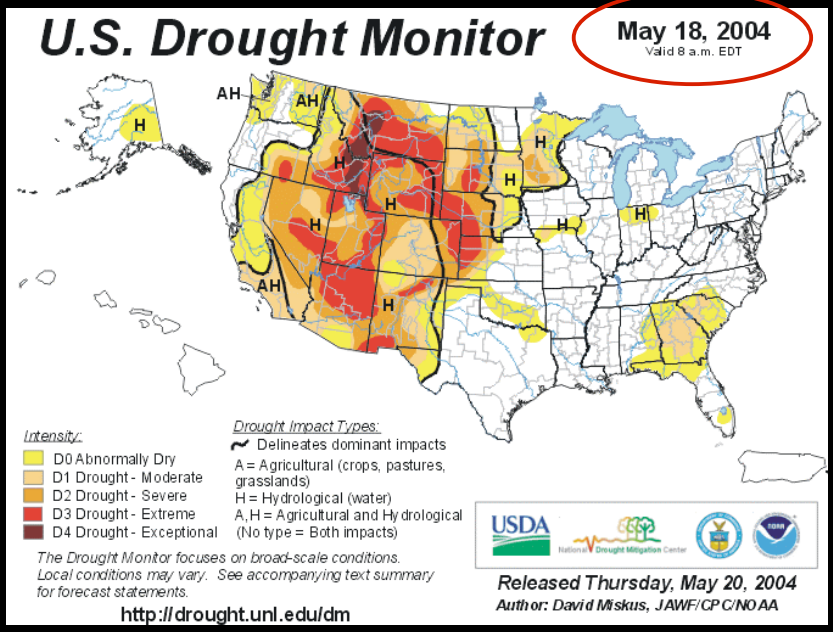
More from the new IPCC report…

Current models suggest ice … mass balance becomes negative at a global average warming (relative to pre-industrial values) in excess of 1.9 to 4.6°C. **If a negative surface mass balance were sustained for millennia, that would lead to … sea level rise of about 7 m [23 feet].**

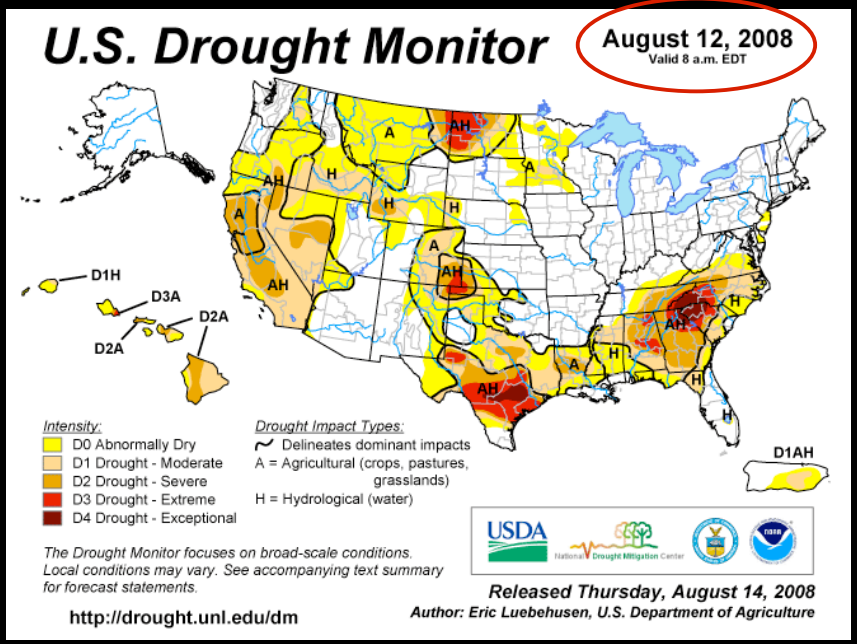
Source: IPCC *Summary for Policy Makers,* February 2007

Emerging consensus: could be centuries

The current western drought began in 1999…



And has not let up yet…



Nature Geoscience (2007) **PROGRESS ARTICLE**

Widening of the tropical belt in a changing climate

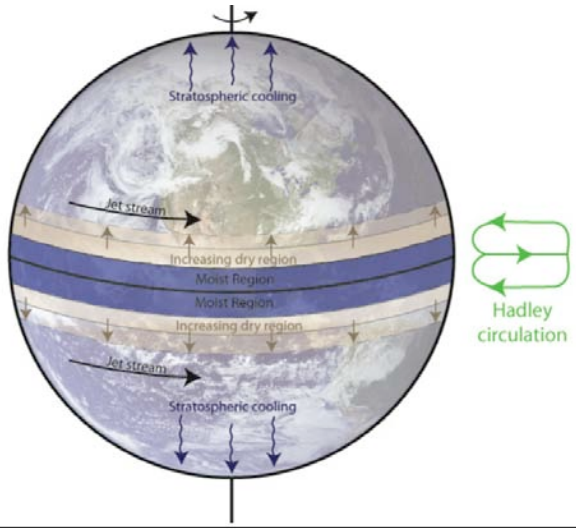
DIAN J. SEIDEL[1], QIANG FU[2],
WILLIAM J. RANDEL[3], THOMAS J. REICHLER[4]

Models suggest 2 degree latitude expansion by 2100 under high emission scenario

Issued: March 26, 2008

Southwest Climate Outlook

THE UNIVERSITY OF ARIZONA.



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Data suggest 2 to 5+ degree latitude expansion …

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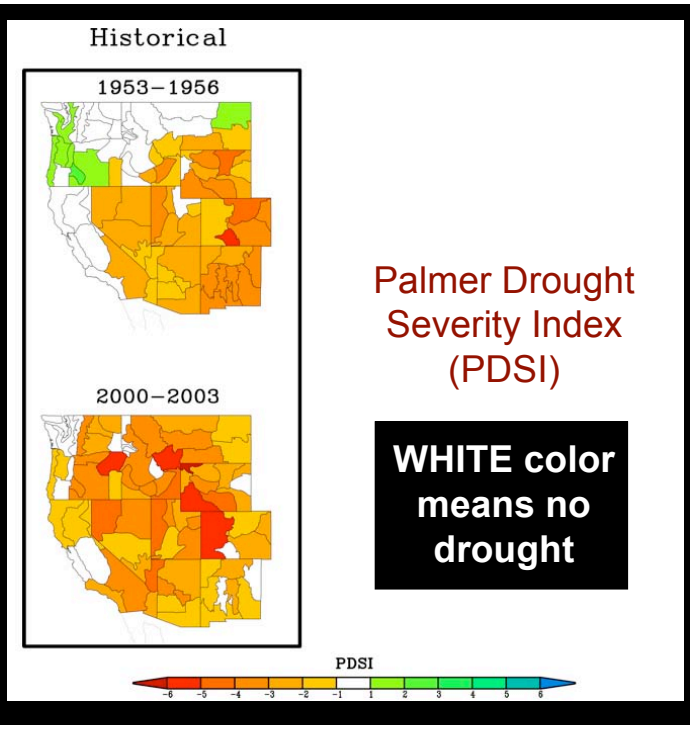
Data suggest 2 to 5+ degree latitude expansion **since 1979**

M. Hoerling and J. Eischeid (***Southwest Hydrology***, 2007)

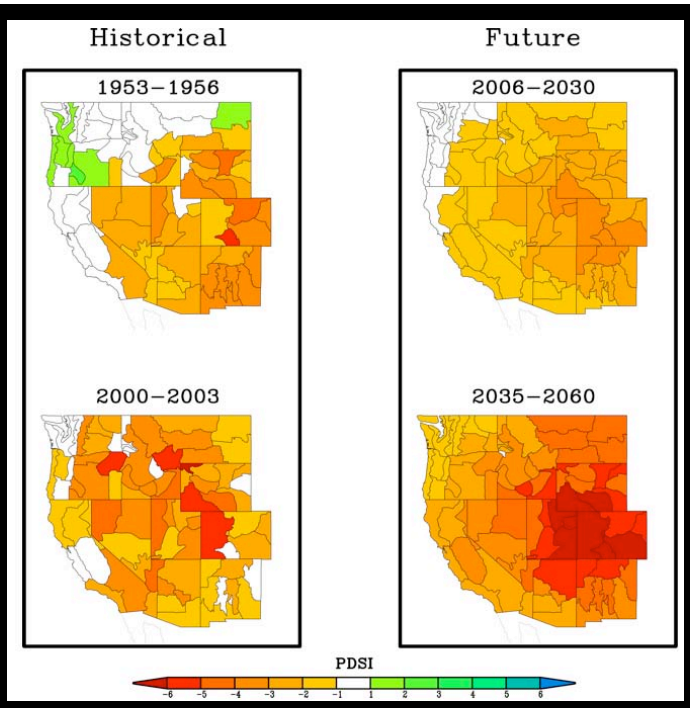


Palmer Drought Severity Index (PDSI)

WHITE color means no drought

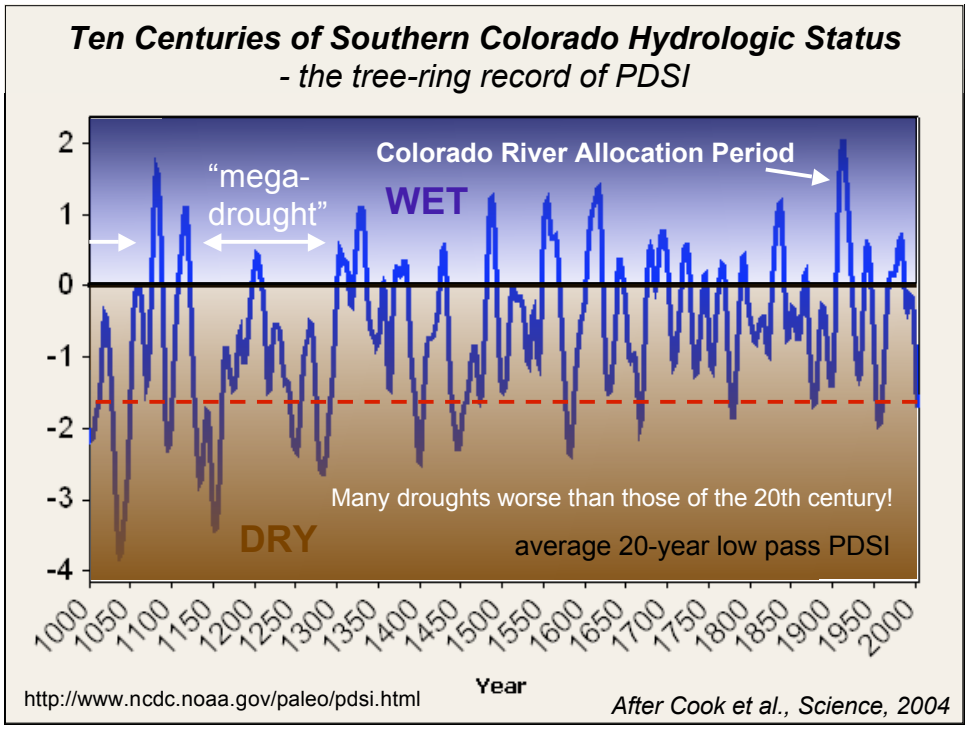
M. Hoerling and J. Eischeid (*Southwest Hydrology*, 2007)

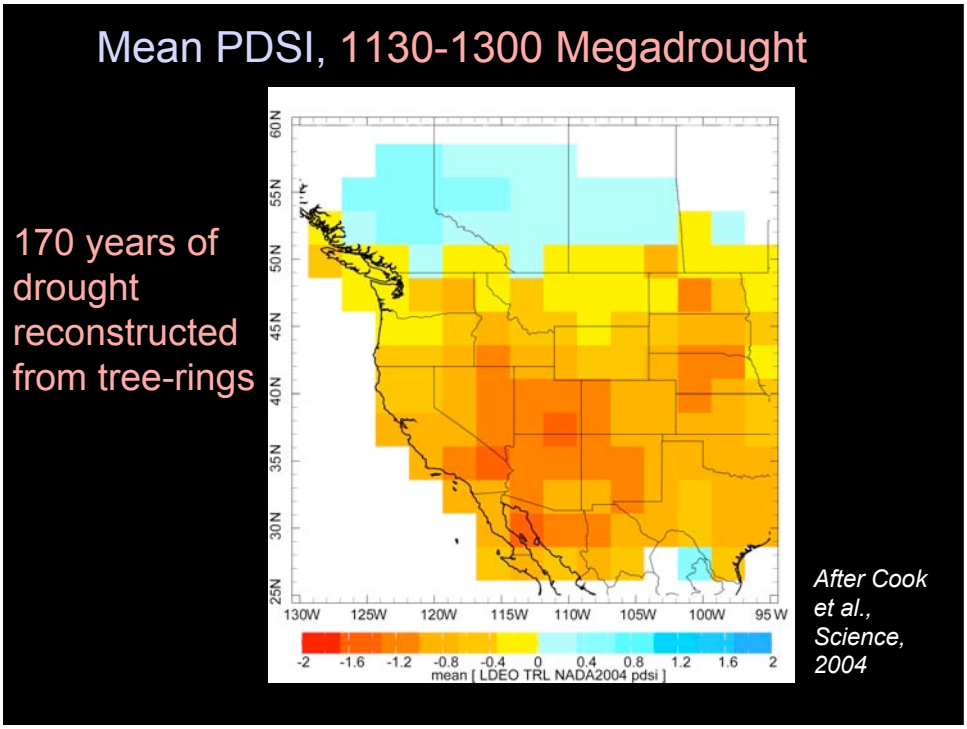
The U.S. West is destined to become more drought-like ***on average***



*So, increased **temperature** will drive a more arid west…*

*…but don't forget the ability of the climate system to deprive the West of **moisture** for decades at a time, even without climate change…*


Ten Centuries of Southern Colorado Hydrologic Status
- the tree-ring record of PDSI
Colorado River Allocation Period
"mega-drought"
WET
DRY
Many droughts worse than those of the 20th century!
average 20-year low pass PDSI
2
1
0
-1
-2
-3
-4
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
Year
http://www.ncdc.noaa.gov/paleo/pdsi.html
After Cook et al., Science, 2004


Mean PDSI, 1130-1300 Megadrought
170 years of drought reconstructed from tree-rings
60N
55N
50N
45N
40N
35N
30N
25N
130W
125W
120W
115W
110W
105W
100W
95W
-2
-1.6
-1.2
-0.8
-0.4
0
0.4
0.8
1.2
1.6
2
mean [LDEO TRL NADA2004 pdsi]
After Cook et al., Science, 2004

Take home thoughts…

- 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 (and drought!) is a sure bet - ***we must develop adaptation capability***

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A major landscape transformation has already begun in the West

Take home thoughts…

- 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 (and drought!) is a sure bet - ***we must develop adaptation capability***

But… planning for IPCC-projected changes might not be enough - change might come in unanticipated ways (e.g., faster)

Photo: J. Overpeck