Climate change in the southwestern US: mechanisms, evidence and projections.
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Outline of talk:
(1) Update on global climate change and the U.S.
(2) Special focus on the Southwest
(3) Global warming plus decadal megadrought could be biggest threat
(4) Aggressive focus on both climate change adaptation and mitigation probably wise

IPCC, 2007
Global Warming is unequivocal

Since 1970, rise in:
- Global surface temperatures
- Lower atmosphere temperatures
- Global sea-surface temperatures
- Ocean heat content
- Water vapor
- Rainfall intensity
- Extratropical precipitation
- Hurricane intensity
- Global sea level
- Drought
- Extreme high temperatures
- Heat waves

Decrease in:
- NH Snow extent
- Arctic sea ice
- Glaciers
- Cold temperatures
Global mean temperatures are rising faster with time


The Earth has warmed almost everywhere
Very likely due to humans

Note!

Temperature trend from 1901 to 2005
IPCC, 2007
Recent Changes in March and April Percent Snow Coverage

Red lines show recent 0° and 5°C isotherms


Projected future global warming

Likely warming depends on emissions scenario

Presently on the fast-track
**Bottom lines…**

A **global** average warming of up to 6.4°C (11.5°F) is possible by 2100 if carbon emissions are not curbed.

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

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**Projected changes in precipitation over the 21st century**

White areas are where less than two thirds of the models agree in the sign of the change.

Source: IPCC *Working Group I Report (in press)*
Nearly all IPCC Projections indicate winter drying in the Southwest

This is a reduced carbon emission scenario (A2)!

Projected Annual Precipitation Anomalies: 2091-2100

Data from Hoerling & Eischeid, NOAA ESRL
Anomalies relative to 1971-2000

May 18, 2004
Valid 8 a.m. EDT

US Drought Monitor

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying tabular summary for forecast statements.

http://drought.unl.edu/DM

Released Thursday, May 20, 2004
Author: David Mocko, JARFO/NOAA
As we entered summer 2007, the drought still persisted...

As we exit summer 2007, the drought still persists...
March snowpack will be rare by mid-century...

Projected percent change in March snow depth by mid-21st century

(as simulated by the Canadian Regional Climate Model - change only plotted where there is currently at least 5mm of average snow depth in March)

The Southwest will be hit hard

*Increased temperatures, decreased precipitation and increased probability of drought are all likely*

Palmer Drought Severity Index (PDSI)

WHITE color means no drought

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

Tree-ring reconstructed hydrologic balance, 1 AD to 2003 AD

After Cook et al., Science, 2004
After Cook et al., Science, 2004

Mean PDSI, 1130-1300 Megadrought

170 years of drought

Conclusions (1 of 2)

• 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

Arizona population (5M) projected to double by 2030

California population to go up 37% (up 12M) by 2030
Conclusions (2 of 2)

• **Biggest changes are avoidable** if action is taken to start soon to dramatically reduce carbon emissions to the atmosphere

• *California’s goal of reducing emissions to 80% below 1990 levels by 2050 probably on target*

Photo: J. Overpeck