



Observed Trends and Future Projections of Drought

Kenneth Kunkel

NOAA Cooperative Institute for Climate and
Satellites
and many others

<http://assessment.globalchange.gov>



Key Messages

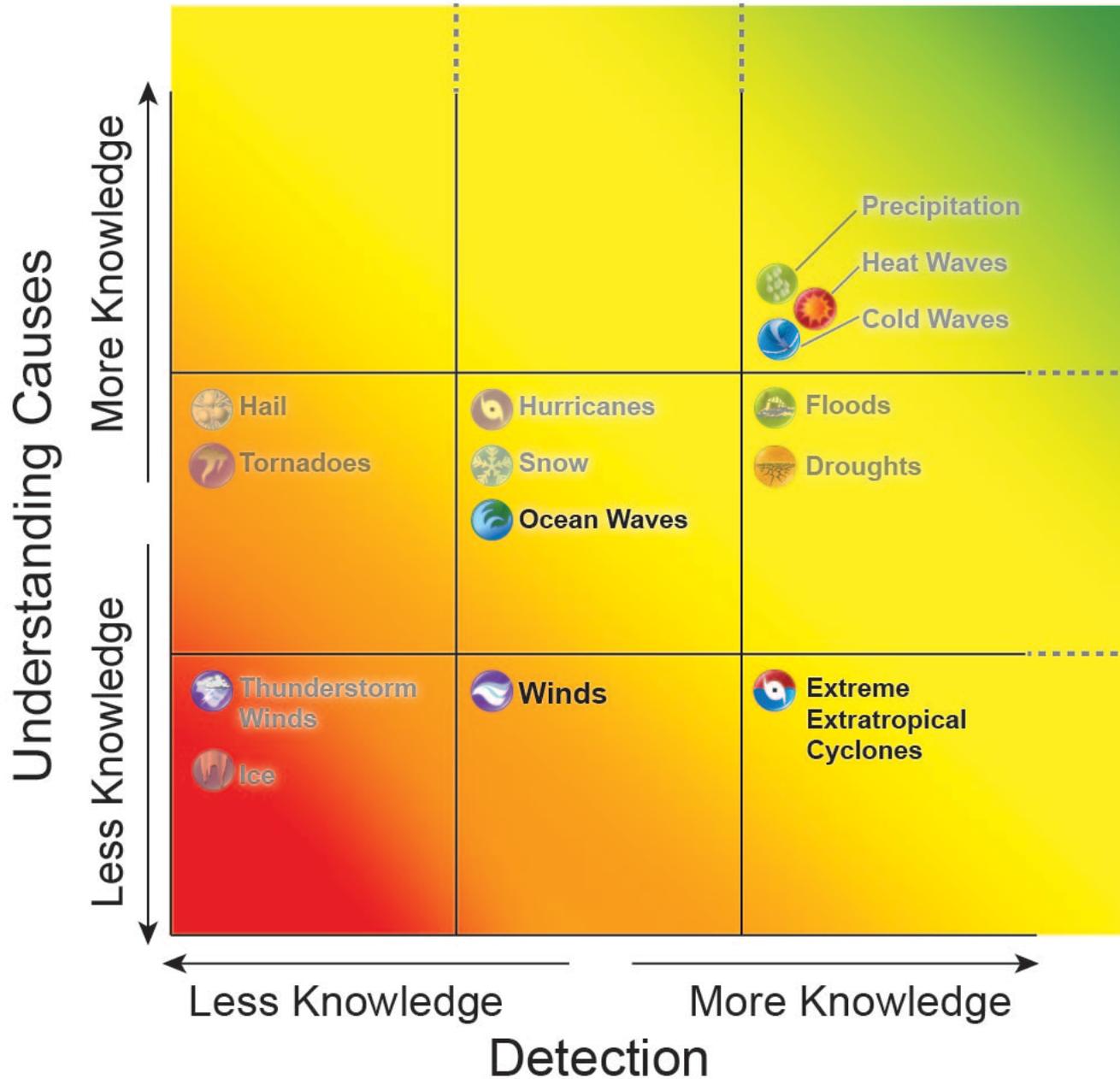
- “Droughts in the Southwest ... are projected to become more intense” from Chapter 2 of NCA3 draft report
- “Drought and fire risk are increasing in many regions as temperatures and evaporation rates rise. The greater the future warming, the more these risks will increase, potentially affecting the entire U.S.” from draft Appendix in NCA3 draft report

Adequacy of Data To Detect Historical Trends

- A series of three workshops was held that brought together about 70 experts to evaluate the quality of historical data and the understanding of causes of trends
- Three workshop report papers published or accepted for publication in the Bulletin of the American Meteorological Society
 - Monitoring and Understanding Changes in **Extreme Storm** Statistics: State of Knowledge. Kunkel, K.E. et al., 2013, BAMS.
 - Monitoring and Understanding Changes in **Heat Waves, Cold Waves, Floods and Droughts** in the United States: State of Knowledge. Peterson, T.C. et al., 2013, BAMS.
 - Monitoring and Understanding Changes in **Extreme Winds, Waves, and Extratropical Storms** along the Coasts: State of Knowledge. Vose, R.S. et al., accepted BAMS.



Adequacy for Detection and Understanding Causes of Changes for Classes of Extremes

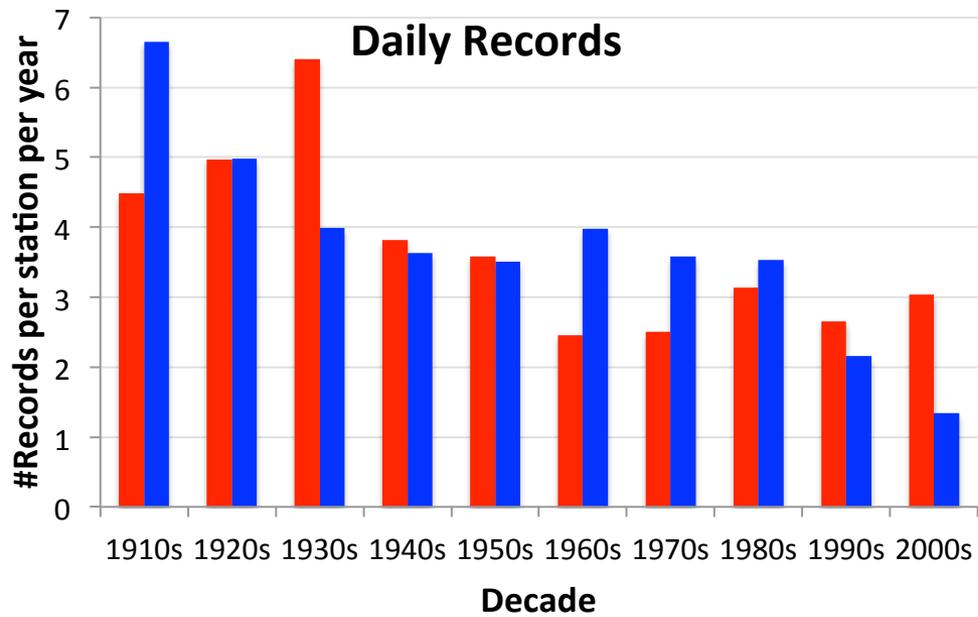


Recent Events

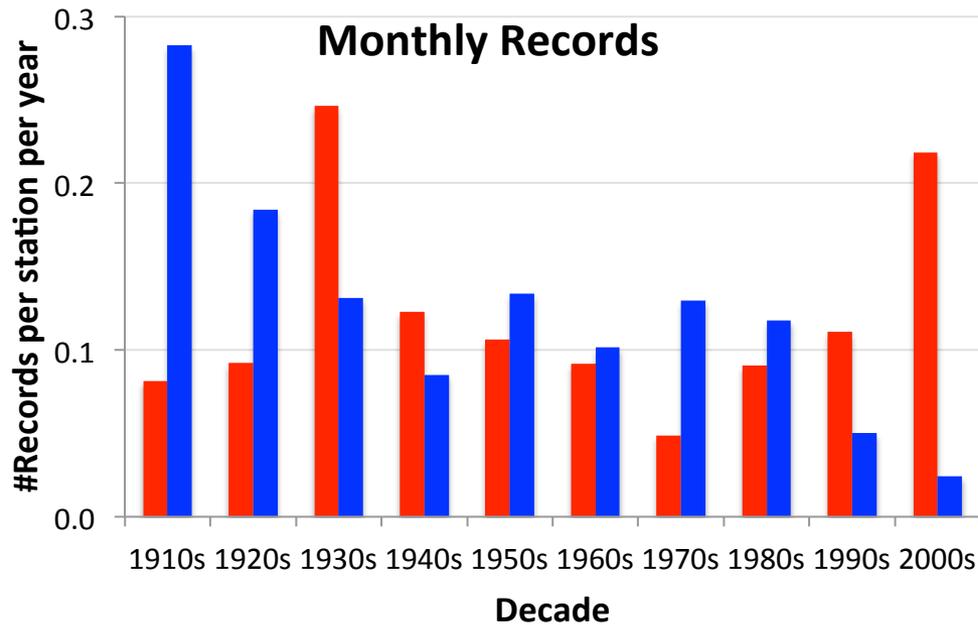
- July 2012 was hottest month on record in contiguous U.S., breaking old record set in July 1936
- Summer 2012 hottest summer on record in CO and WY
- Summer 2011 hottest summer on record in NM, TX, OK, and LA

Observed Extreme Temperature Episodes

- Record hot and cold temperatures
- Daily records
- Monthly temperature records
- Length of freeze-free season



Record High Record Low



National
Climate
Assessment

U.S. Global Change Research Program

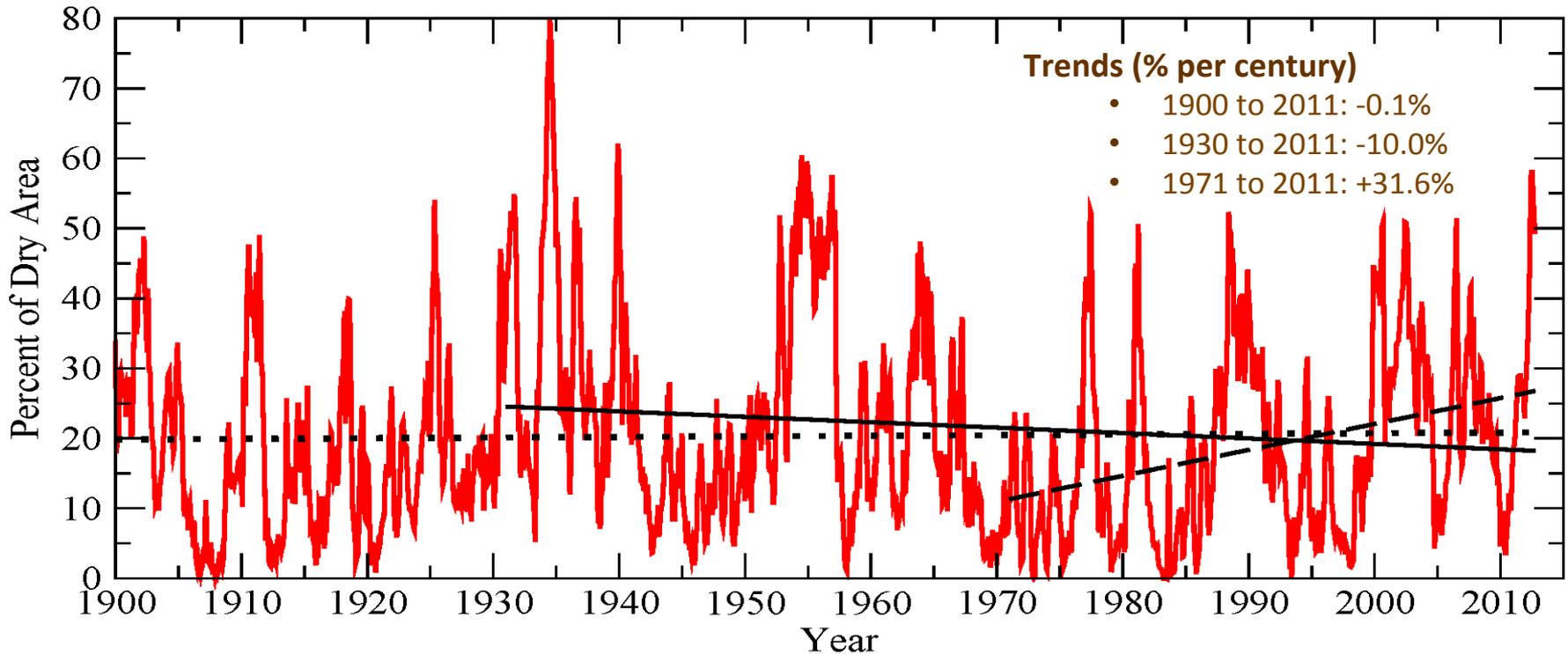
Drought

- No national average trend in areal coverage of severe to extreme drought
- Upward trend in western U.S.

Drought

Percent of U.S. Area in Moderate to Extreme Drought

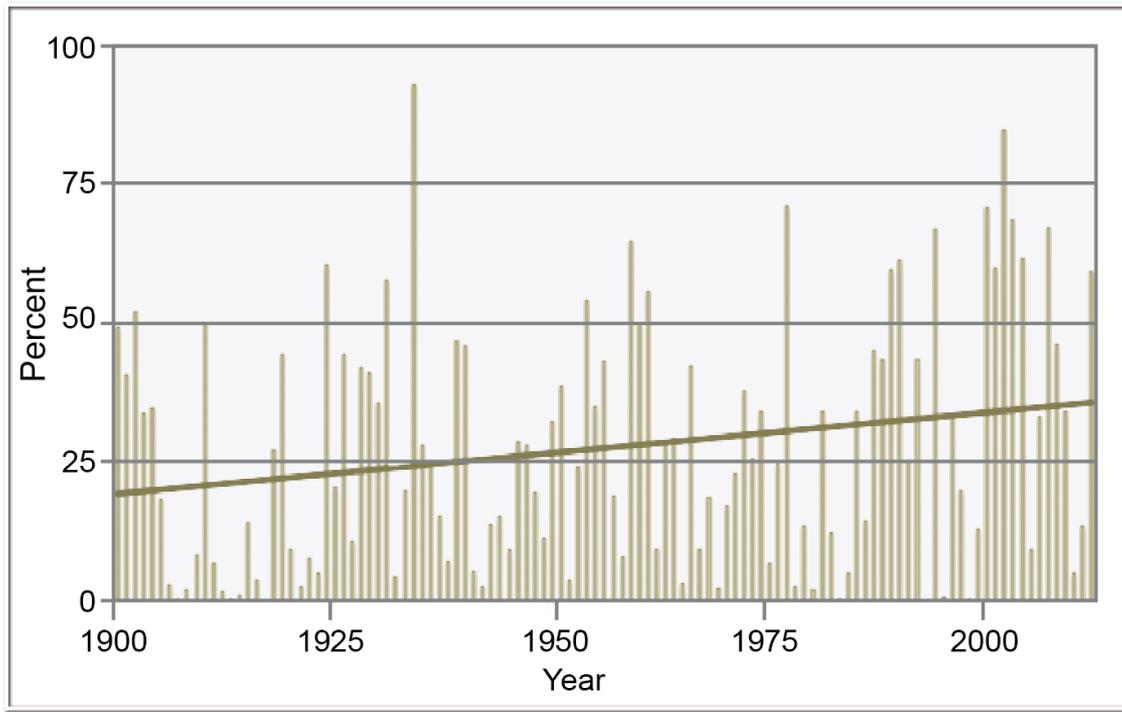
January 1900 to October 2012



- Widespread persistent drought
 - 1930s (Central and Northern Great Plains, Northwest, Great Lakes)
 - 1950s (Southern Plains, Southwest), 1980s (West, Southeast)
 - First decade of the 21st century (West, Southeast)

Peterson, T. C. et al., 2013.

Percent of West in Summer Drought



From draft Third National Climate Assessment Report, public review draft released in January 2013, <http://ncadac.globalchange.gov/>

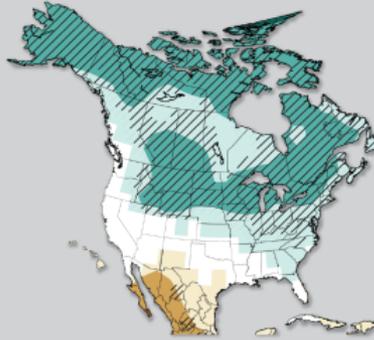
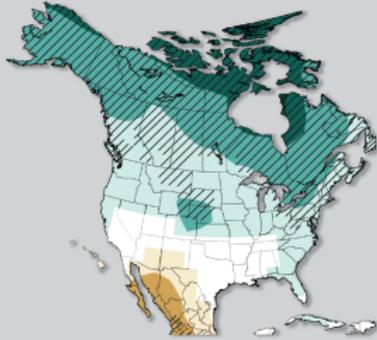
Drought

- Increased temperature leads to increased evaporation rates and tendency toward decreased soil moisture
- Projection info:
 - CMIP5 precipitation projections
 - North America
 - Averaged over NCA regions
 - VIC simulations driven by CMIP3 models
 - Changes in PDSI

Low Pathway (RCP 2.6)

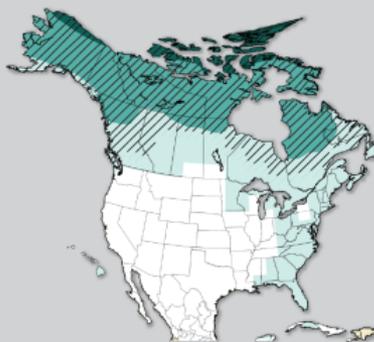
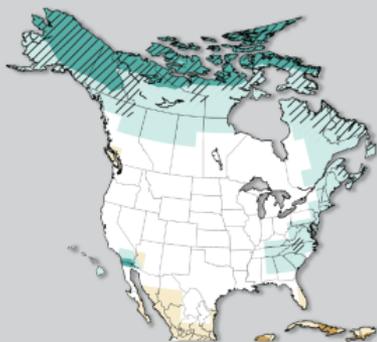
Winter

Spring



Summer

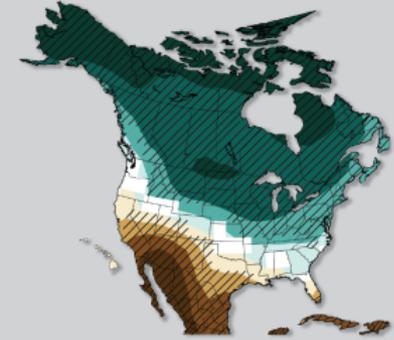
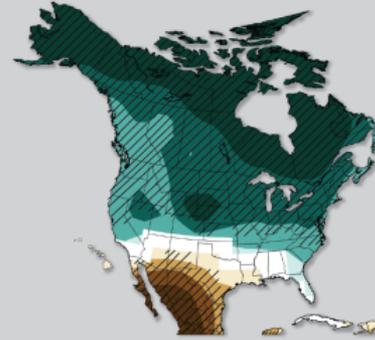
Fall



High Pathway (RCP 8.5)

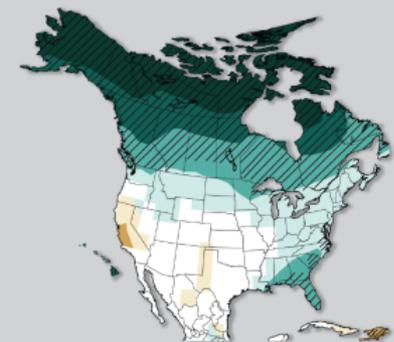
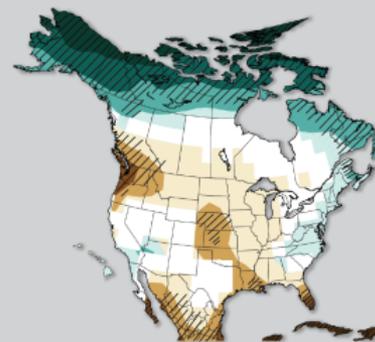
Winter

Spring

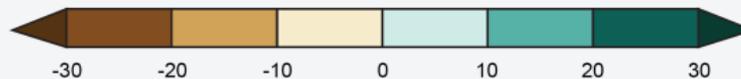


Summer

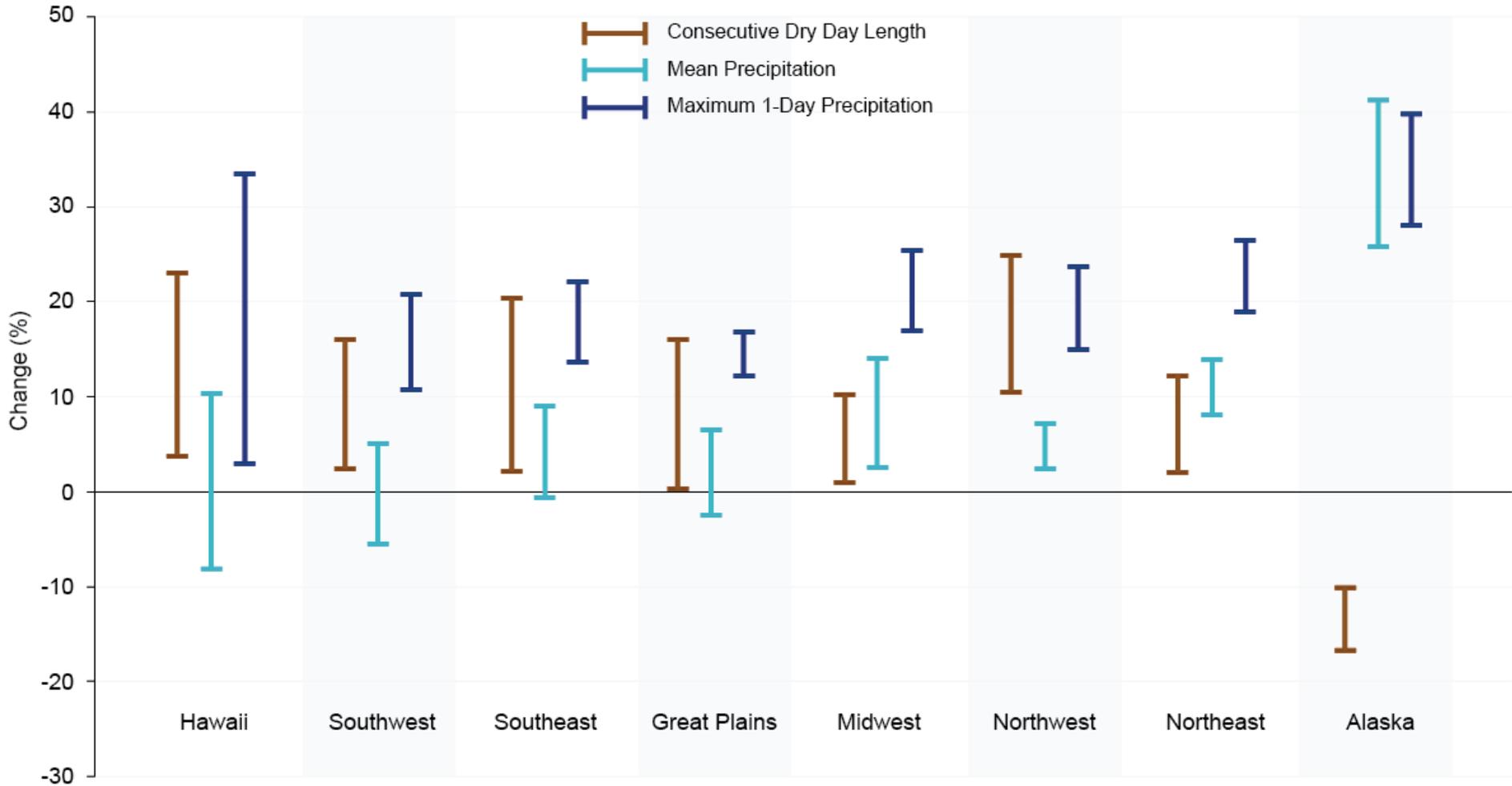
Fall



Percent Change



Change in Simulated CMIP5 Precipitation (Middle 50% of Models)
 RCP 8.5, 2070-2099 minus 1971-1999

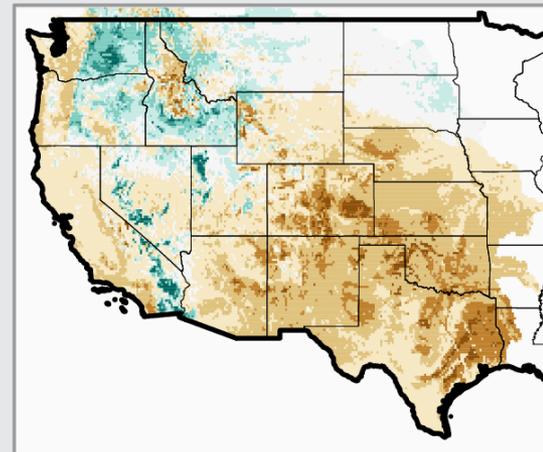
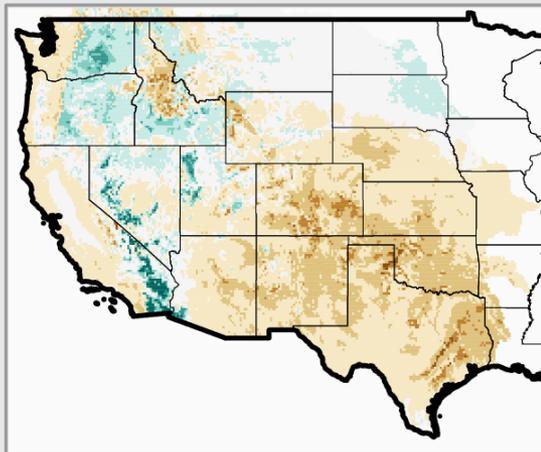


Pattern of Projected Changes in Soil Moisture

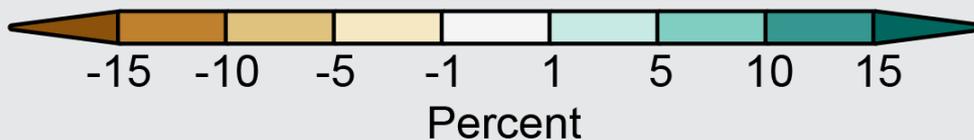
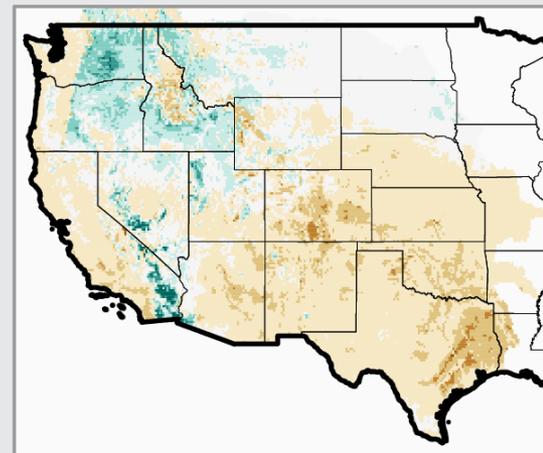
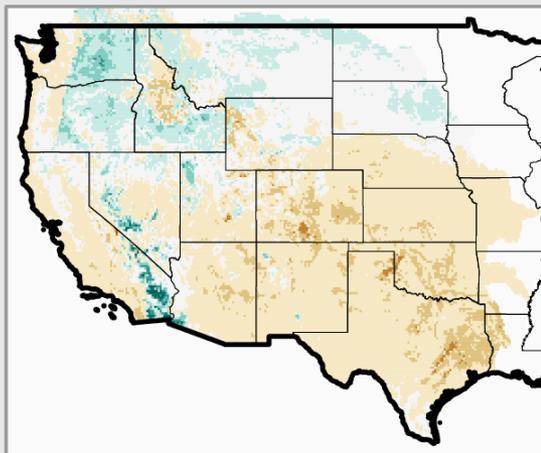
Mid-Century Changes

End-of-Century Changes

Higher Emissions Scenario (A2)



Lower Emissions Scenario (B1)



VIC Model simulations

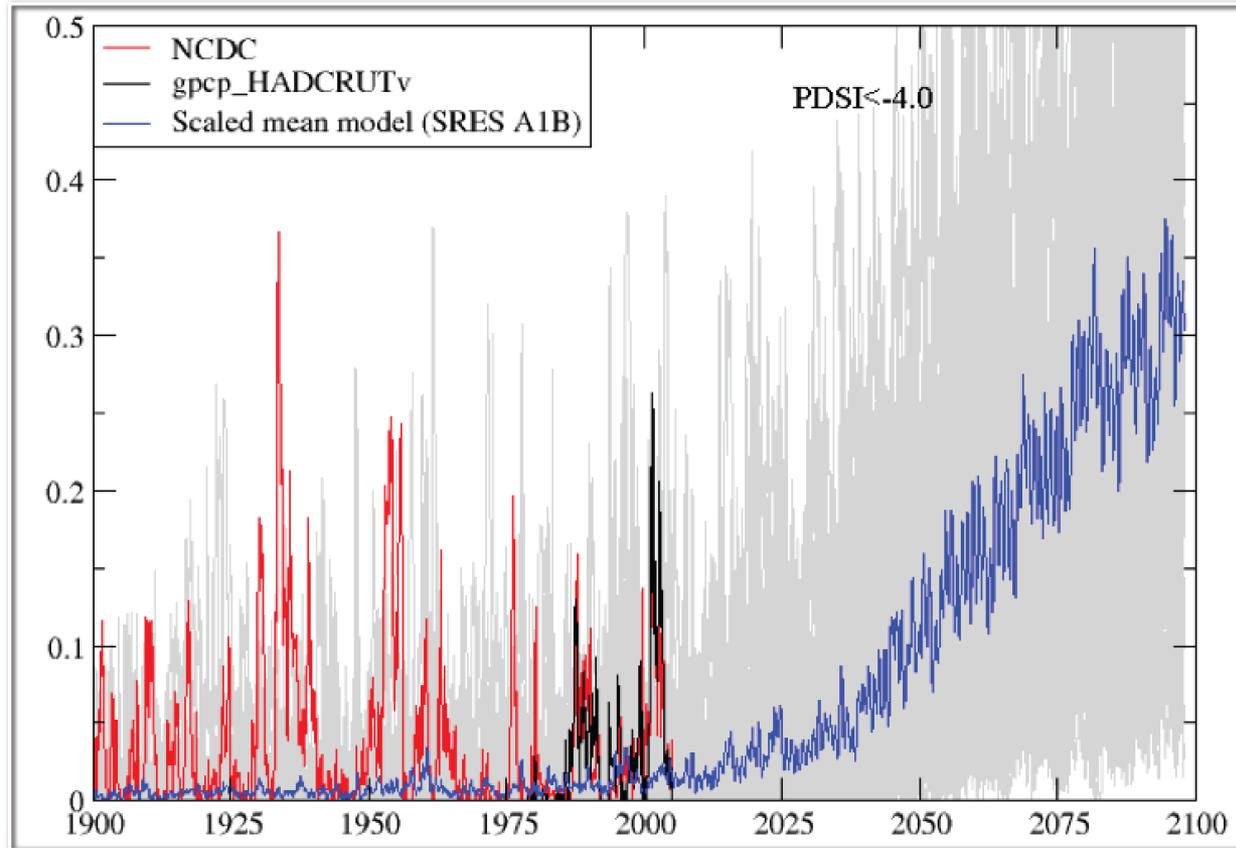
From draft Third National
Climate Assessment
Report, public review draft
released in January 2013,
[http://
ncadac.globalchange.gov/](http://ncadac.globalchange.gov/)



**National
Climate
Assessment**

U.S. Global Change Research Program

Extreme Drought in the U.S. and Mexico, Past and Future



From Wehner, M., D.R. Easterling, J.H. Lawrimore, R.R. Heim Jr, R.S. Vose, and B.D. Santer, 2011: Projections of Future Drought in the Continental United States and Mexico. *Journal of Hydrometeorology*, **12**, 1359-1377 doi: 10.1175/2011JHM1351.1 [Available online at <http://journals.ametsoc.org/doi/abs/10.1175/2011JHM1351.1>]



**National
Climate
Assessment**

U.S. Global Change Research Program

Key Messages

- “Droughts in the Southwest ... are projected to become more intense” from Chapter 2 of NCA3 draft report
- “Drought and fire risk are increasing in many regions as temperatures and evaporation rates rise. The greater the future warming, the more these risks will increase, potentially affecting the entire U.S.” from draft Appendix in NCA3 draft report