NOAA RESEARCH • ESRL • PHYSICAL SCIENCES DIVISION

Understanding and Explaining Causes of Weather and Climate Related Extreme Events

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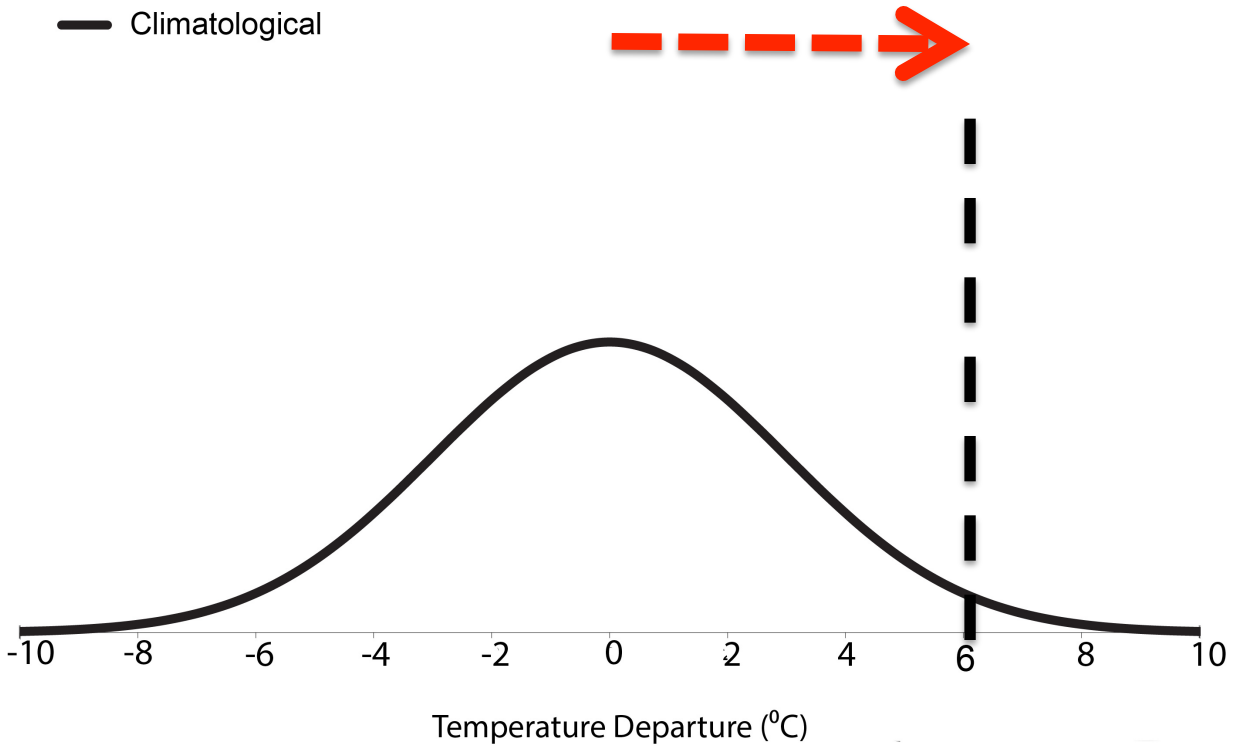
Science Review
12-14 May 2015
Boulder, Colorado

PSD's Objective:
Provide physical explanation of the magnitude and probability of extreme events to assess their predictability



NOAA Mission:

To understand and predict changes in climate, weather, oceans, and coasts

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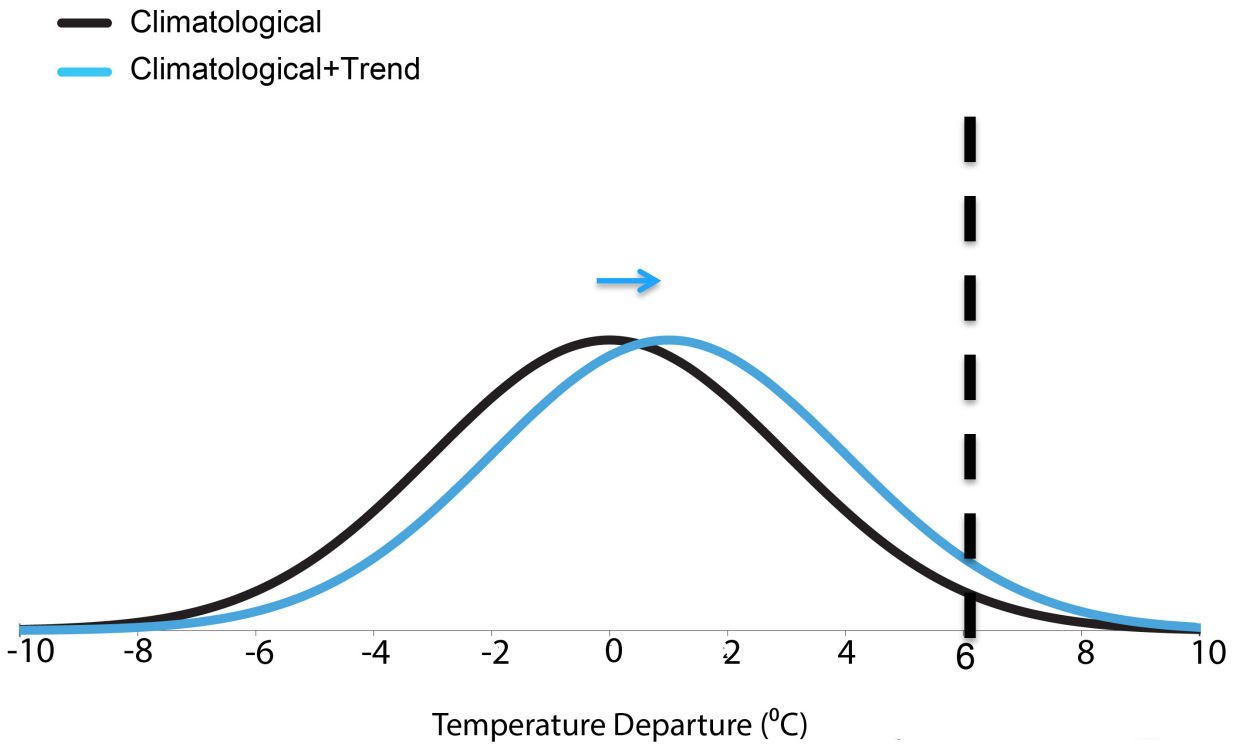

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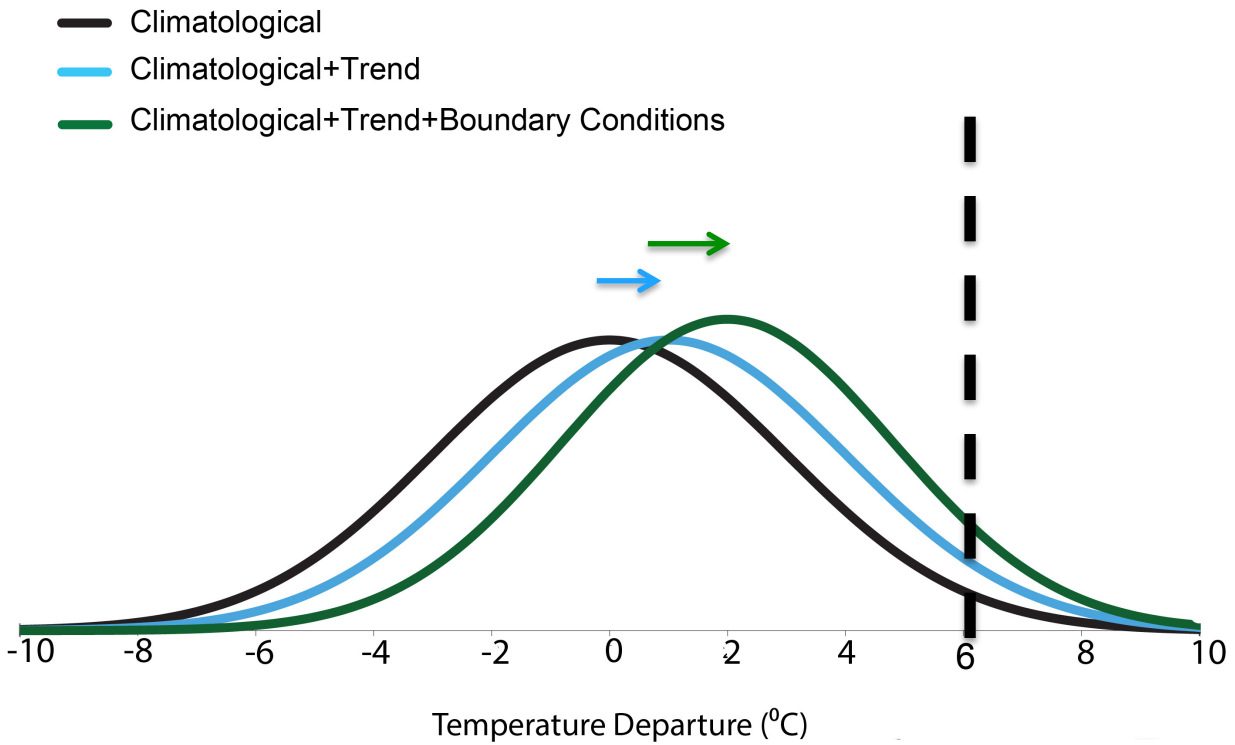

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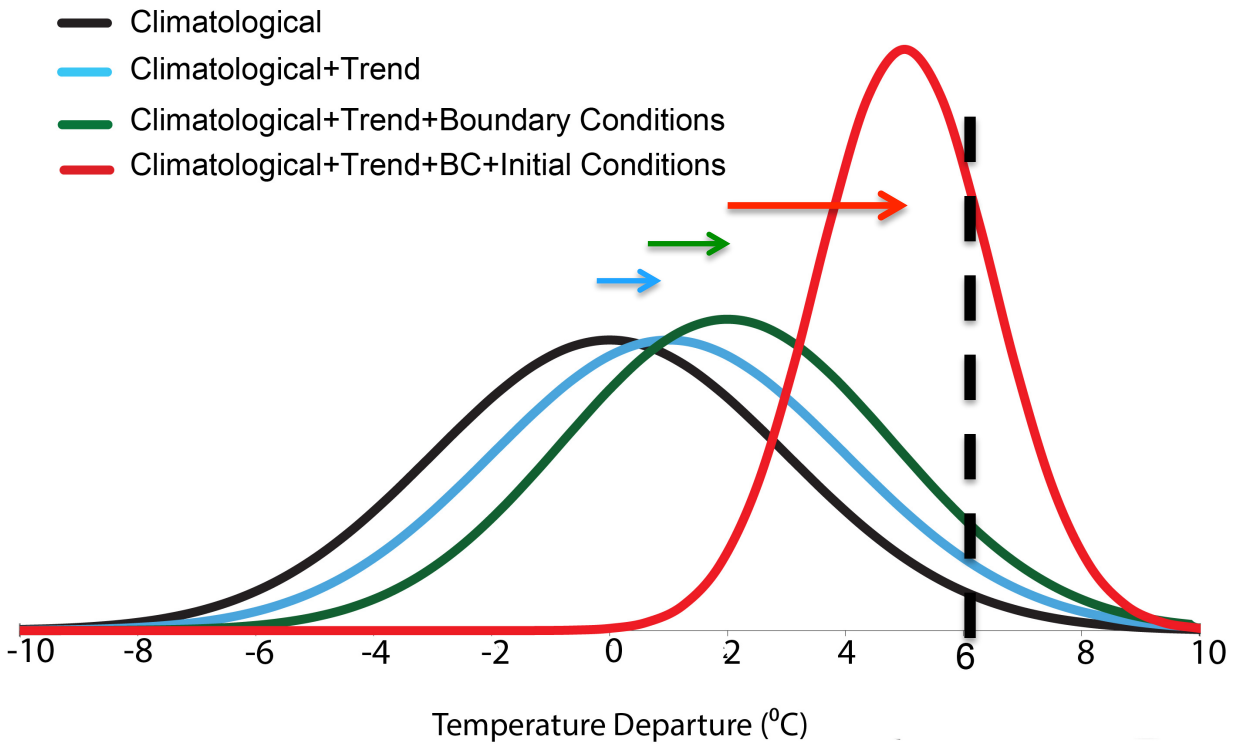

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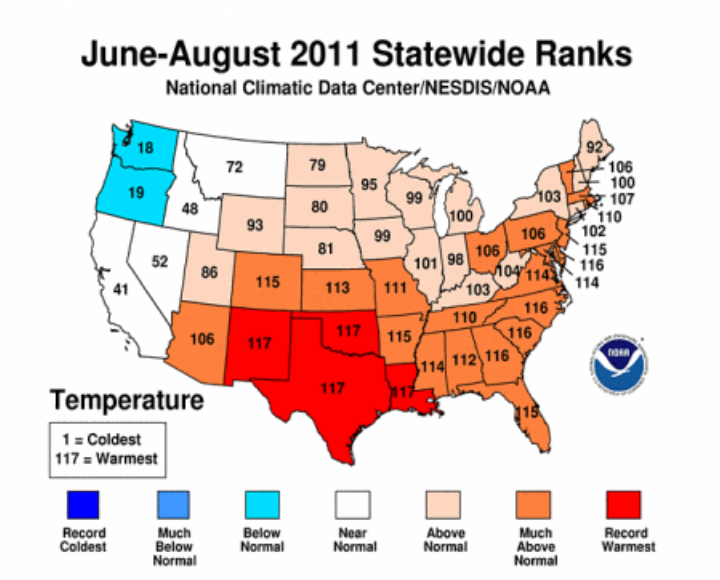
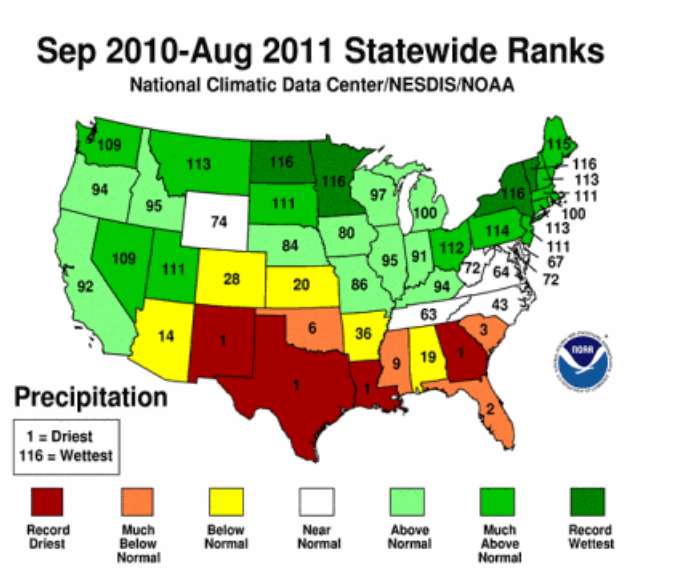
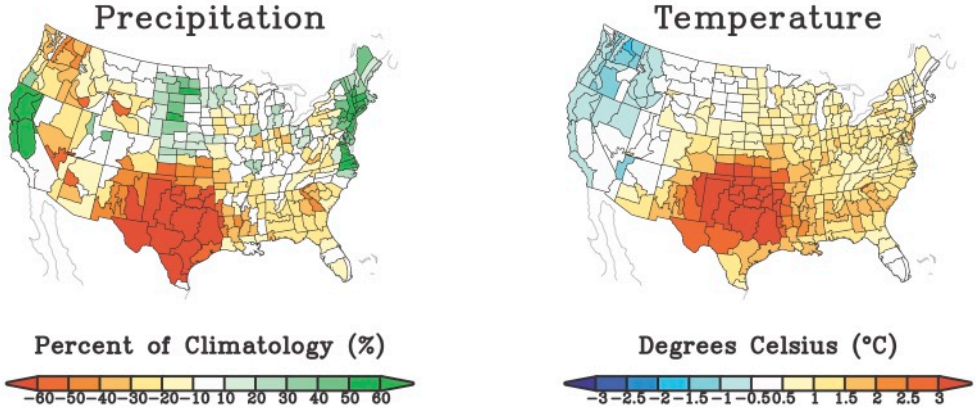
A Tale of Two Extremes-
The 2011 Texas Drought and Heat Wave

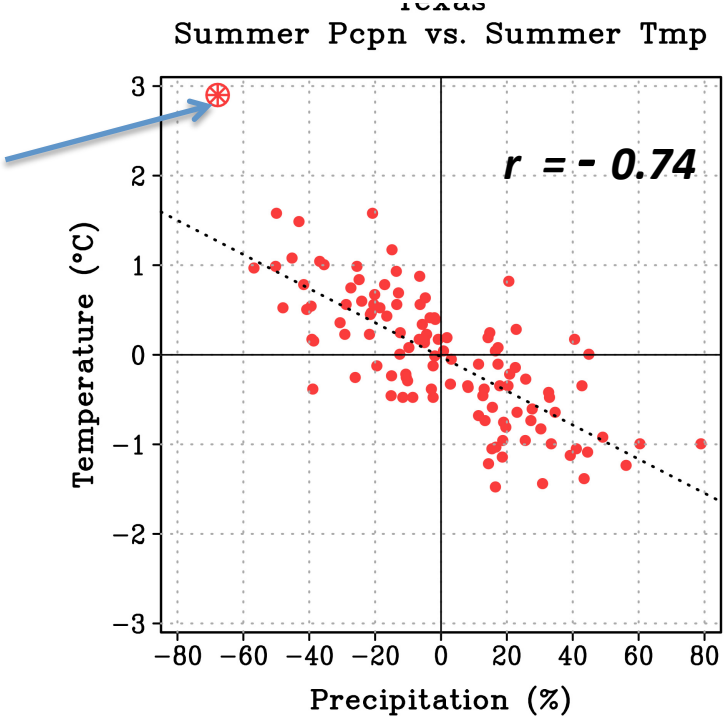




An Extreme Event with more than 7 Billion Dollar in Agricultural Loss Alone

What are possible contributing factors to the 2011 Texas drought and heat wave?





Hoerling, M., A. Kumar, R. Dole, J. W. Nielsen-Gammon, J. Eischeid, J. Perlwitz, X. Quan, T. Zhang, P. Pegion, and M. Chen, 2013: An anatomy of an extreme event. J. Climate

Analysis Approach

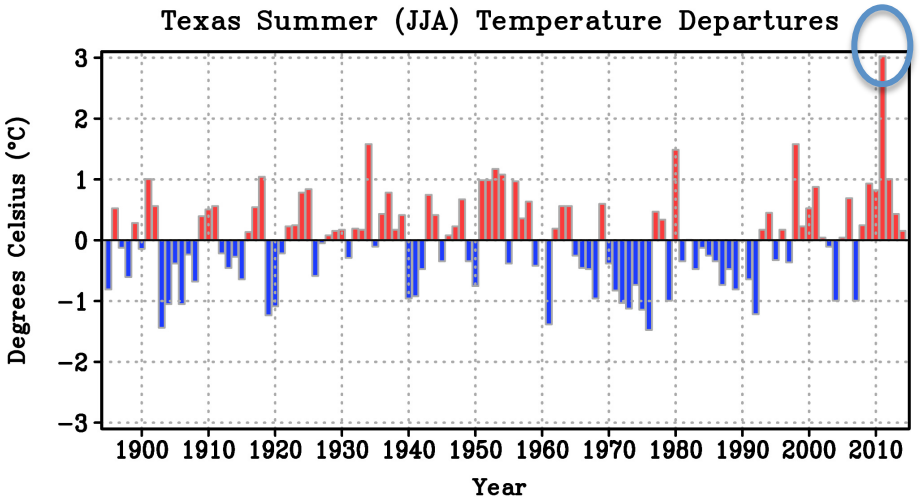
- Role of anthropogenic forcing (including increase in GHGs)
- Role of forcing associated with anomalous boundary conditions (SST, sea ice, soil moisture)
- Unforced internal variations

Hoerling et al. 2013

Observed Temperature and Precipitation Changes

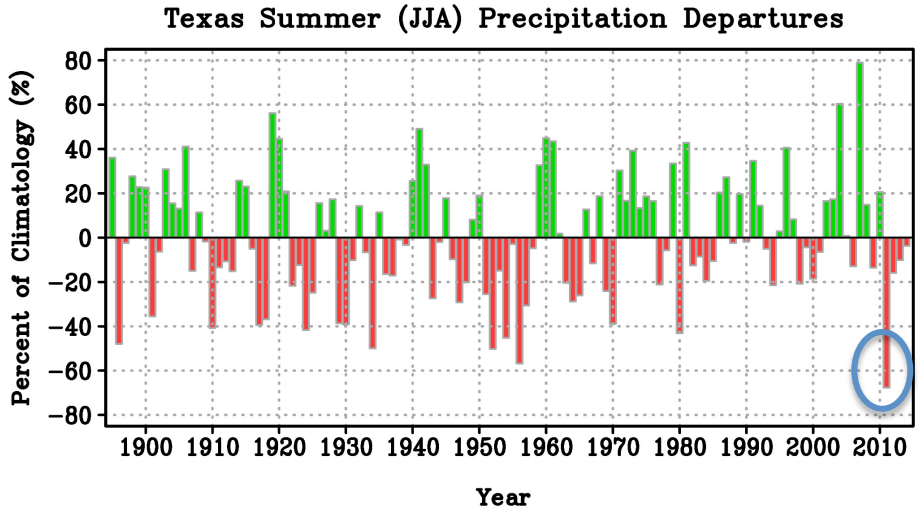
Temperature

- ~ 0.6°C for 1981-2010
- ~ 0°C for periods starting prior to ~1950



Precipitation

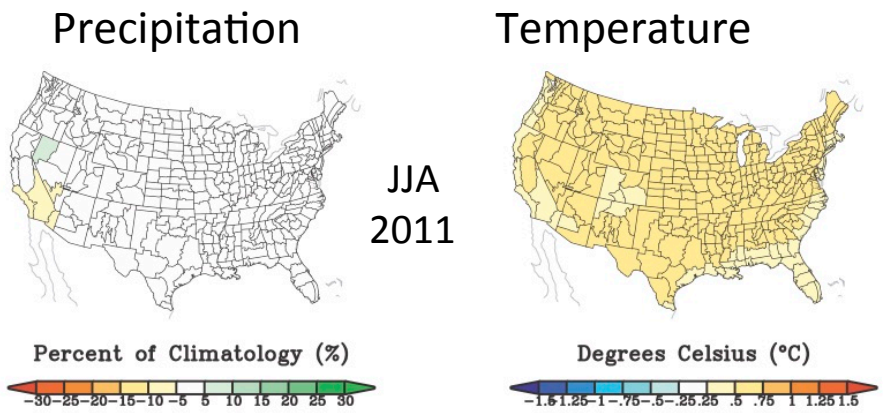
- Century-scale trend towards wetter conditions for annual means

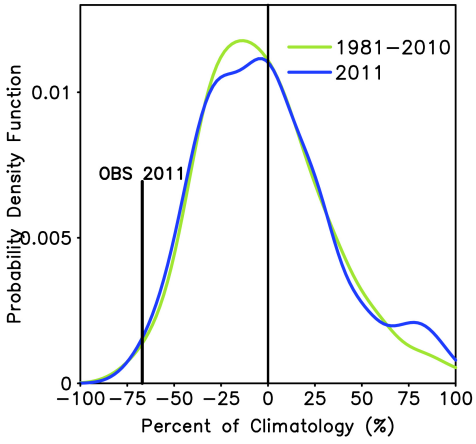


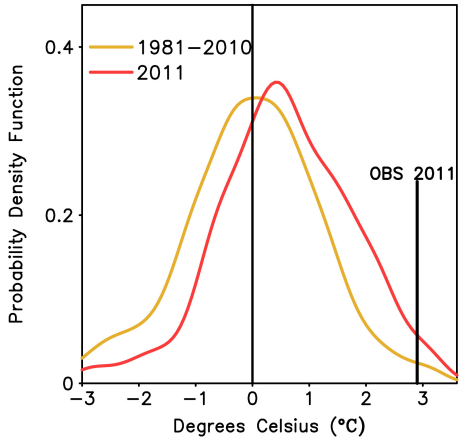
Hoerling et al. 2013

Role of Anthropogenic Forcing (based on 20 CMIP5 models)

- No significant change in precipitation
- Nearly homogenous temperature pattern over U.S.
- ~ 0.6°C temperature increase over Texas (20%)
- Increase in probability for new temperature record from 3% to 6%







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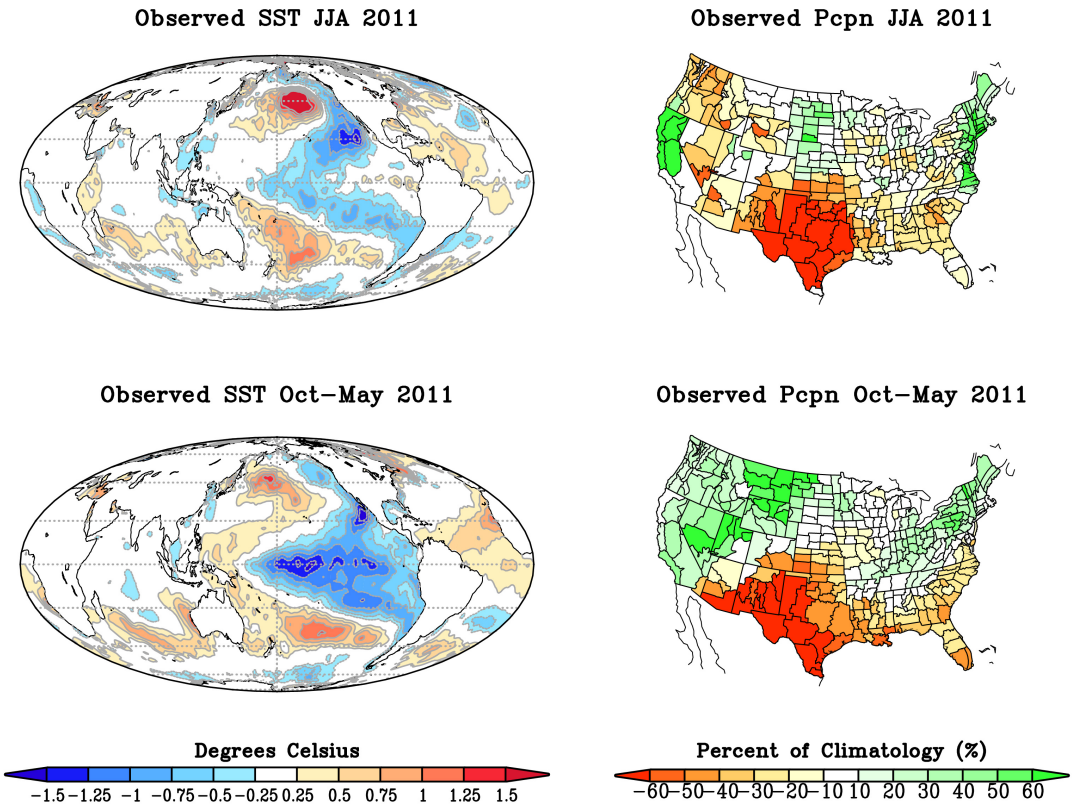
Anomalous Lower Boundary Conditions

Concurrent
Summer 2011

Preceding
Oct 2010-
May 2011



- Preceding moderate La Niña event that decayed by summer
- La Niña related preceding drought conditions

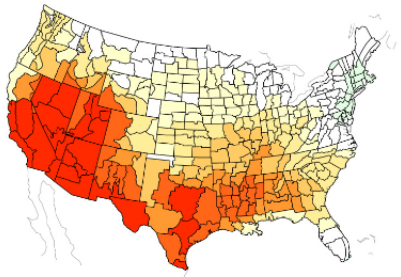
Hoerling et al. 2013

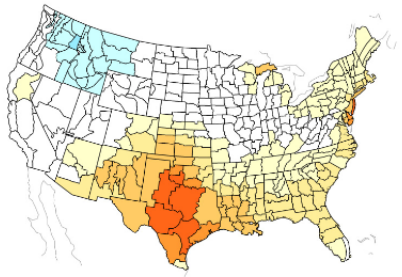
Role of SST patterns (GF AMIP ensemble)

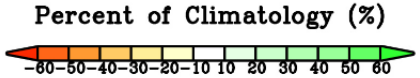
Precipitation

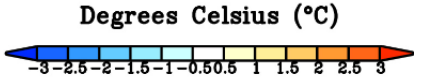
Temperature

JJA
2011

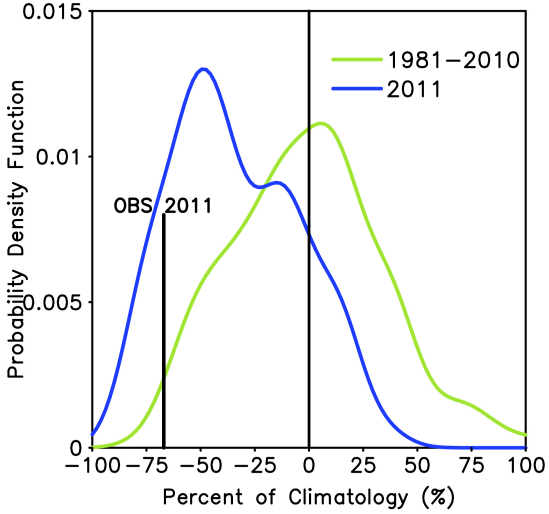


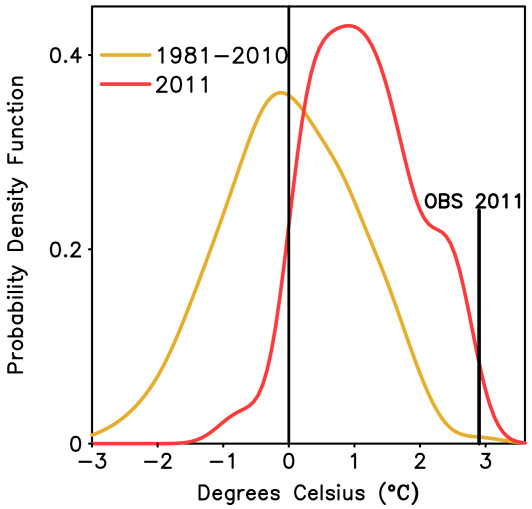






- Forced atmospheric response captures several regional features of 2011 climate conditions
- ~1.1°C temperature increase over Texas (40%)
- Increase in probability for new temperature record from 4% to 23%





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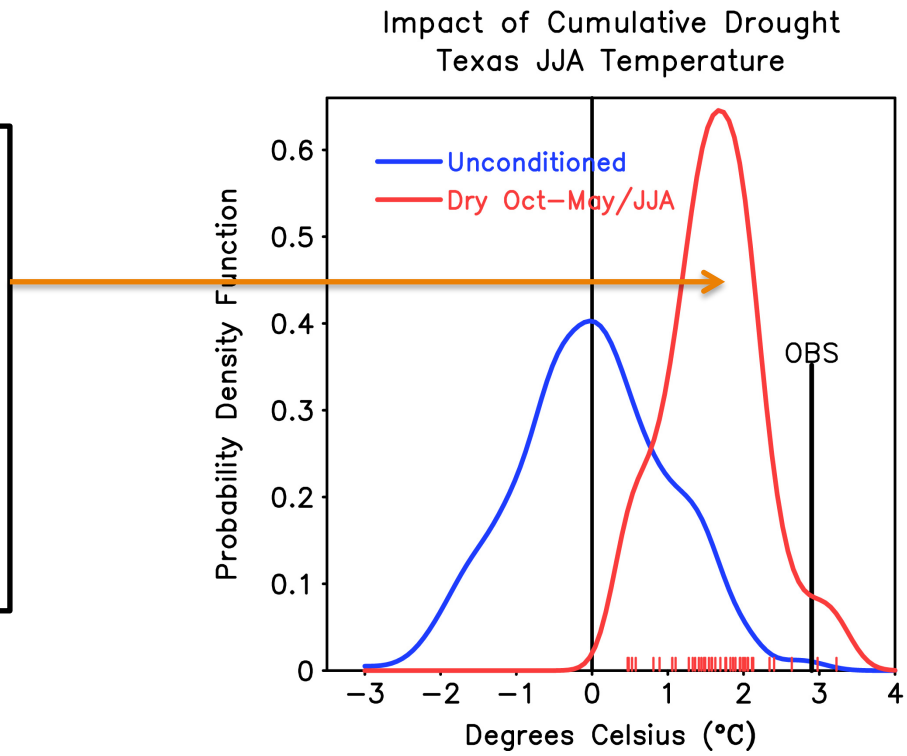
Role of Prolonged Drought Conditions

Estimated PDF of Texas summer temperatures when the preceding and concurrent precipitation were both in lowest 20% of AMIP runs over years 1950-2010



- Extreme warm summer conditions were more likely in AMIP simulations when both preceding and concurrent conditions are dry.

Hoerling et al. 2013

Conclusions of Study

- No strong evidence for a detected change towards either hotter or drier summer based on historical records.
- Virtually all the precipitation deficits appear to be related to natural variability.
- Contributing factors to heat wave magnitude relative to 1980-2010:
  - ~40% due to a severe rainfall deficit (antecedent and concurrent season) related to anomalous SST (including La Niña)
  - ~20% due to human induced climate change

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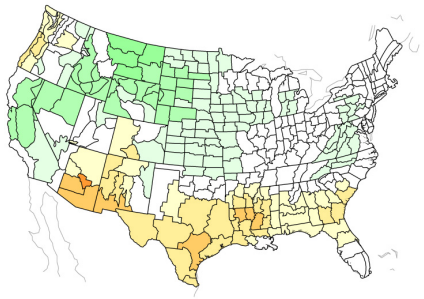
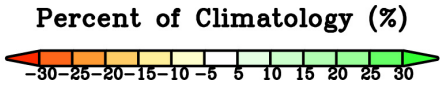
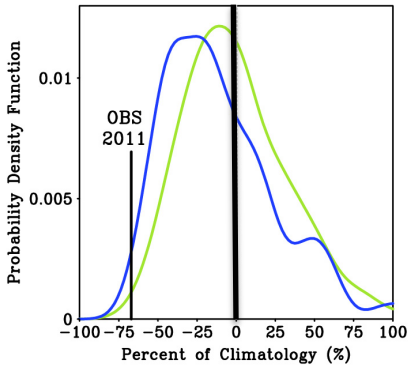
Was this event predictable?

CFSv2

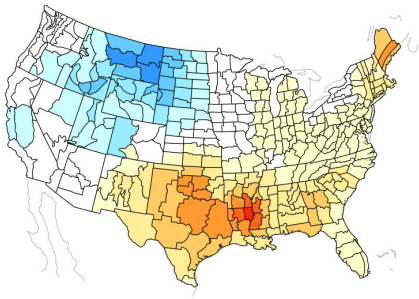
Precipitation

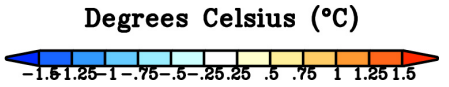


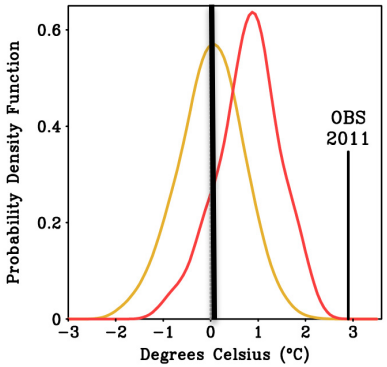




Temperature







- Forecasts initialized in May were able to anticipate much of the SST-enhanced risk for an extreme summer drought/heat wave over Texas.

Hoerling et al. 2013

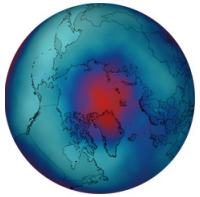
Each Extreme Event has Different Predictive Attributes

Atmospheric internal variability

2010 Russian Heat Wave *(Dole et al. 2011)*

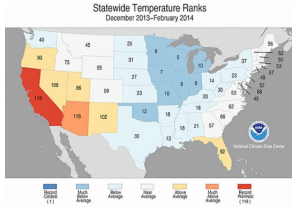
Phenomena on all time scales from climate change to weather (including MJO event)

2012 Midwest March Record Warmth *(Dole et al. 2014)*



Ozone chemistry-climate interactions

2011 Record Spring NAO (*Karpechko, Perlwitz et al. 2014)*



Snow cover

2013/2014 Upper Midwest Unusual Cold *Winter (Wolter et al. 2015, submitted)*