Where are the Great Plains?
How Does Climate Define the Great Plains?
Annual Precipitation Defines the Great Plains
Precipitation Inefficiency Defines the Great Plains
A Summer Rainy Season Defines the Great Plains
Preludes to Drought
What Recent Drought Behavior Foretells of the Future

Martin Hoerling, NOAA ESRL

The 2014 Great Plains Symposium
The 40th Annual Center for Great Plains Studies Symposium
April 1-5 2014
A Tale of Two Plains

Annual Precipitation

**Great Plains**
- avg = 582 mm
- σ = 74 mm
- cv = 12.7%

**Northern Plains**
- avg = 433 mm
- σ = 59 mm
- cv = 13.5%

**Southern Plains**
- avg = 724 mm
- σ = 114 mm
- cv = 15.7%
The Two Seasons

Nov-Apr Precipitation

Great Plains
- avg = 200mm
- σ = 36mm
- cv = 18.9%
- %ann = 34.3%

Northern Plains
- avg = 122mm
- σ = 19mm
- cv = 15.9%
- %ann = 28.1%

Southern Plains
- avg = 273mm
- σ = 68mm
- cv = 24.9%
- %ann = 37.7%
What Caused the Drought During the Dust Bowl?
What Caused the Drought During the Dust Bowl?

- World War I Need for Grain
- Gas Powered Farm Equipment
- Deep Rooted Prairie Grasses Dug Up
- Drought
- Exposed Top Soil
- More Acres Under Cultivation
- High Winds

Lincoln Caused

Dust Bowl
On the Meteorological Cause of the Dust Bowl

by Schubert, Suarez, Pegion, Koster, Bacmeister, 2004
The Gulf Source of Moisture....Bermuda High
1930s: Gulf Source of Moisture Untapped
OBS Rainfall Departures During the Dust Bowl

by Schubert, Suarez, Pegion, Koster, Bacmeister, 2004
GCM Rainfall Departures During the Dust Bowl

by Schubert, Suarez, Pegion, Koster, Bacmeister, 2004
Factors Contributing to Drought & Heat in 1930s

Cook, Miller, and Seager 2009
Oceans for Drought: Winter View

Nov–Apr SST vs. Nov–Apr PPT
1896–2013

Great Plains

Northern Plains

Southern Plains
La Niña: The Southern Plains Drought Producer
Oceans for Drought: Summer

May–Oct SST vs. May–Oct PPT
1896–2013

Great Plains

Northern Plains

Southern Plains

Correlation Coefficient

-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.1
0.2
0.3
0.4
0.5
0.6
Ranking U.S. Droughts Since 1895

PEAK % AREA IN DROUGHT
LOWER 48 STATES, SINCE 1895

DATA SOURCE: NCDC

- JUL 1934: 79.9%
- DEC 1939: 62.1%
- JUL 1954: 60.4%
- DEC 1956: 57.6%
- SEP 1931: 54.9%
- JUN 2012: 54.6%
- AUG 1936: 54.4%
- MAY 1925: 54.0%
- JUN 1977: 52.5%
- JUN 1988: 52.3%

Events
Southern Plains Drought: 2011 vs 1954

Seager and Coauthors 2005

Hoerling and Coauthors 2013
Northern Plains Drought: 2012 vs 1934

2012

Hoerling and Coauthors 2014

1934

Schubert and Coauthors 2004
A Recent Increase in U.S. Drought….”Naturally”

Seager and Hoerling 2014

Percent Area of the Contiguous U.S.
with Soil Moisture < $-1\sigma$

Year
A Recent Increase in U.S. Drought...”Naturally”

Seager and Hoerling 2014

Percent Area of the Contiguous U.S.
with Soil Moisture $< -1\sigma$
A Recent Increase in U.S. Drought...”Naturally”

Seager and Hoerling 2014

Percent Area of the Contiguous U.S.
with Soil Moisture $< -1\sigma$

- ECHAM5
- CAM4
A Recent Increase in U.S. Drought...”Naturally”

Seager and Hoerling 2014

Percent Area of the Contiguous U.S.
with Soil Moisture < −1σ

Year
Familiar Ocean Pattern for Drought---”Naturally”

Plains’ Rainy Season Hasn’t Warmed Much...Yet
Plains’ Winter has Warmed Substantially.. *Already*
“For some regions including central North America, droughts have become less frequent, less intense, or shorter in duration since about 1950. Conditions over the Great Plains and Midwest have been as bad, or worse, than the current [2011] drought numerous times in our instrumental record.”
-- IPCC SREX 2012

“The frequency and intensity of drought has likely decreased in central North America”
-- IPCC AR5 2013

“It is likely that anthropogenic warming has increased drought impacts over North America in recent decades through increased water stresses associated with warmer conditions, but the magnitude of the effect is uncertain.”
Is A Transition to Semi-Permanent Drought Imminent in the Great Plains?

Hoerling and Coauthors 2012

(a) Change in average surface temperature (1986–2005 to 2081–2100)

(b) Change in average precipitation (1986–2005 to 2081–2100)
Global warming and 21st century drying

Cook, Smerdon, Seager, Coats 2014
Global warming and 21st century drying

Cook, Smerdon, Seager, Coats 2014

Central Plains

PDSI

PDSI–ALL  PDSI–PRE  PDSI–PET

-6 -5 -4 -3 -2 -1 0 1 2 3
“Although the predicted future changes in drought occurrence [based on CMIP3 soil moisture] are essentially monotonic increasing globally and in many regions, they are generally not statistically different from contemporary climate or natural variability for multiple decades”

---- Sheffield and Wood, Clim. Dyn., 2008

“There is overall low confidence [in drought projections over much of the US Great Plains] because of insufficient agreement of projections of drought changes, dependent both on model and dryness index.”

---- IPCC SREX, 2012

“Regional projected decreases in soil moisture and increased agricultural drought are likely (medium confidence) in presently dry regions by the end of this century under the RCP8.5 scenario.”

--- IPCC AR5, 2013
So…… What **Does** Recent Drought Behavior Foretell of the Future?