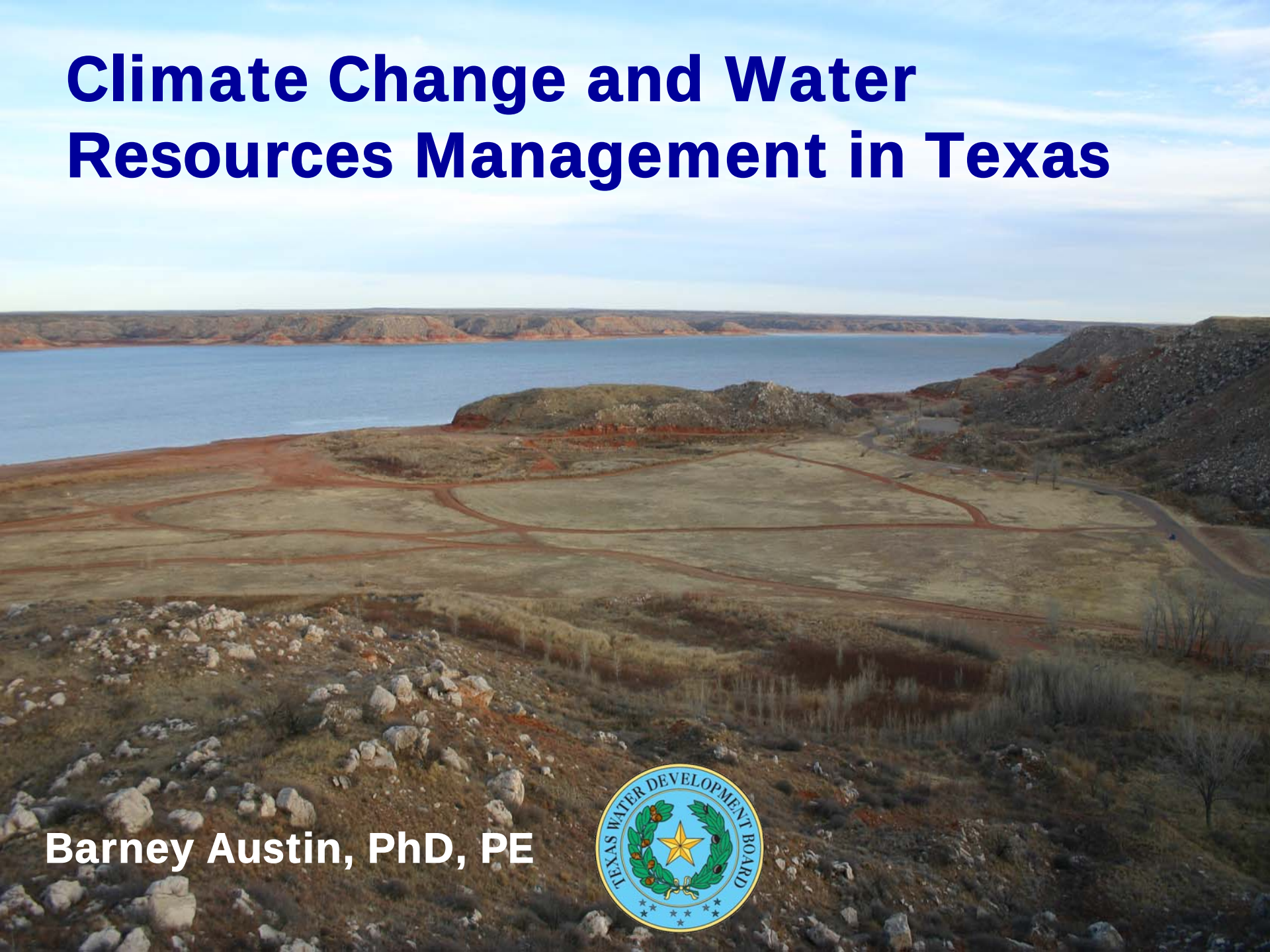
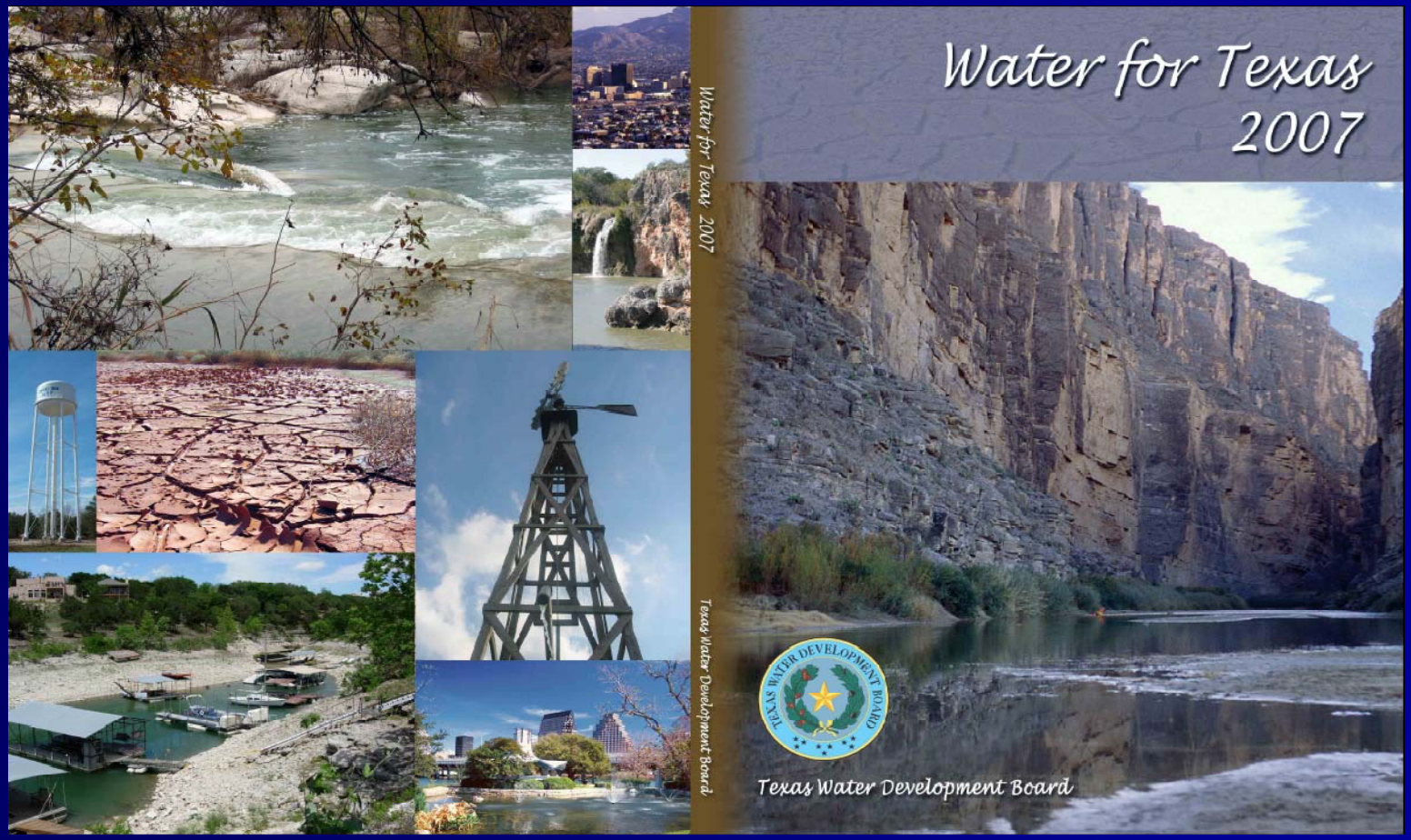
Climate Change and Water Resources Management in Texas



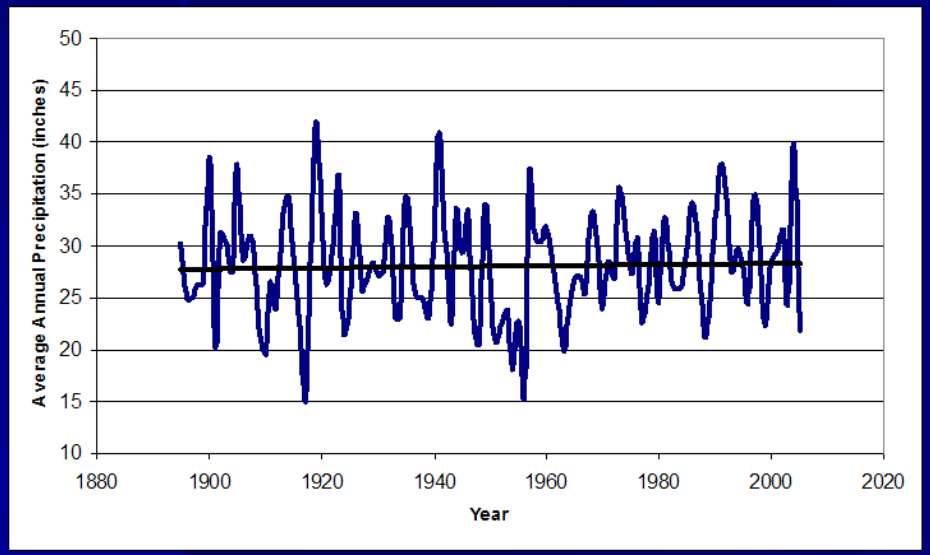
Barney Austin, PhD, PE

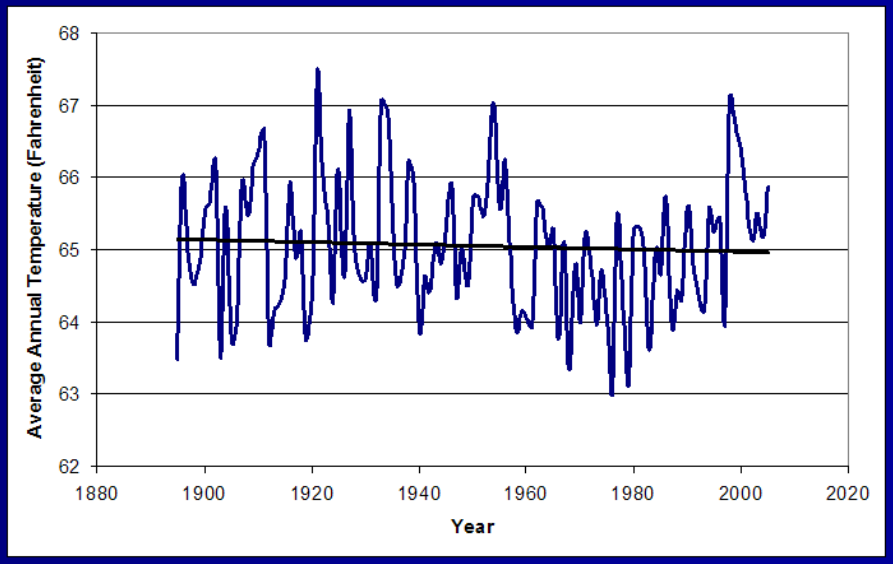
Texas Regional & State Water Planning



2007 State Water Plan

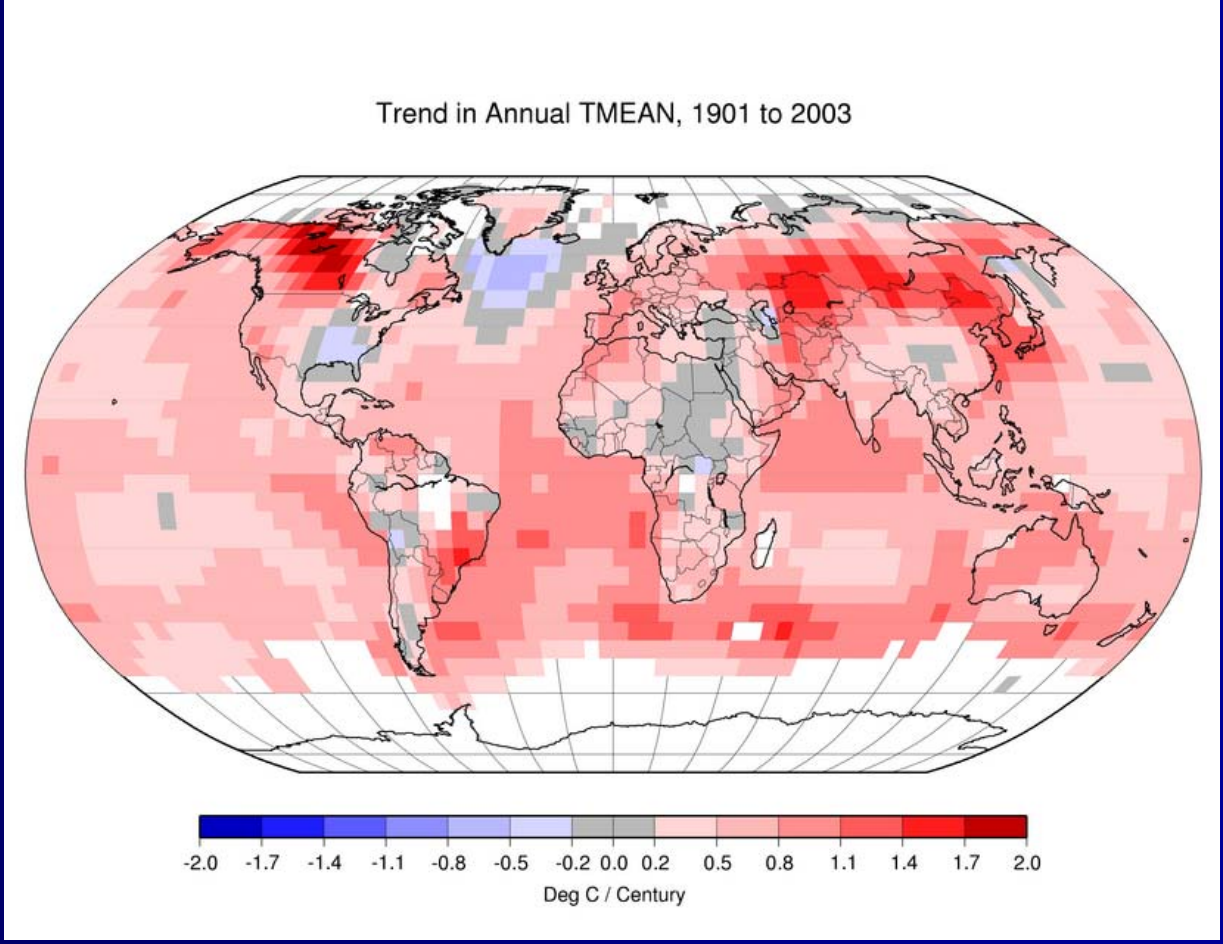
- Section on Climate Change
  - Slightly increasing precipitation
  - Slightly decreasing temperature





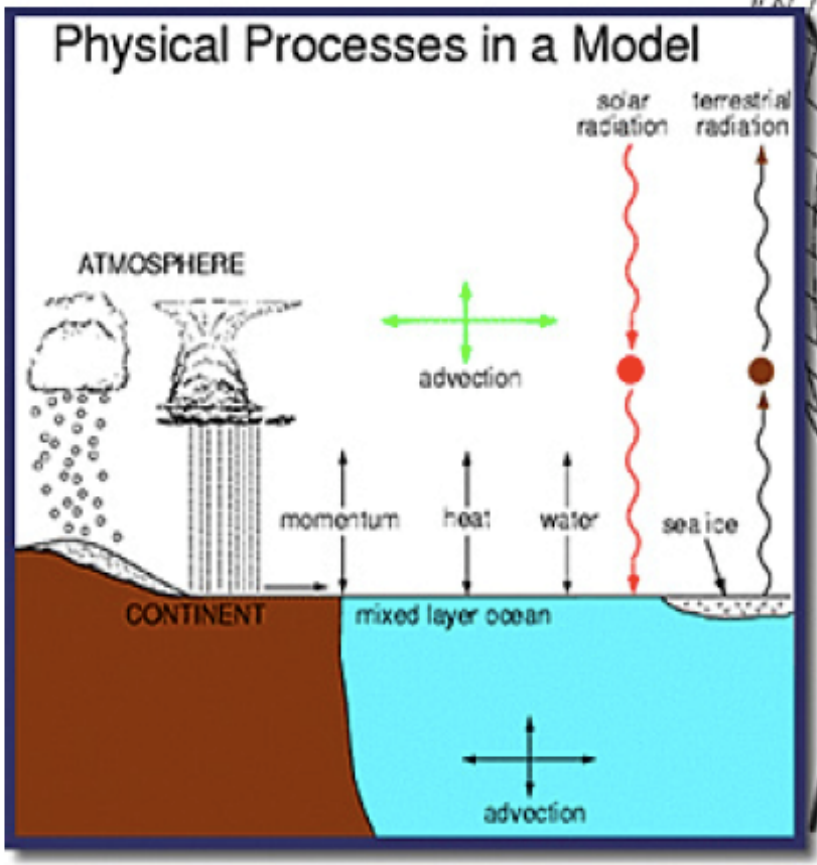
Source: Texas State Climatologist, John Nielson-Gammon, 2005.

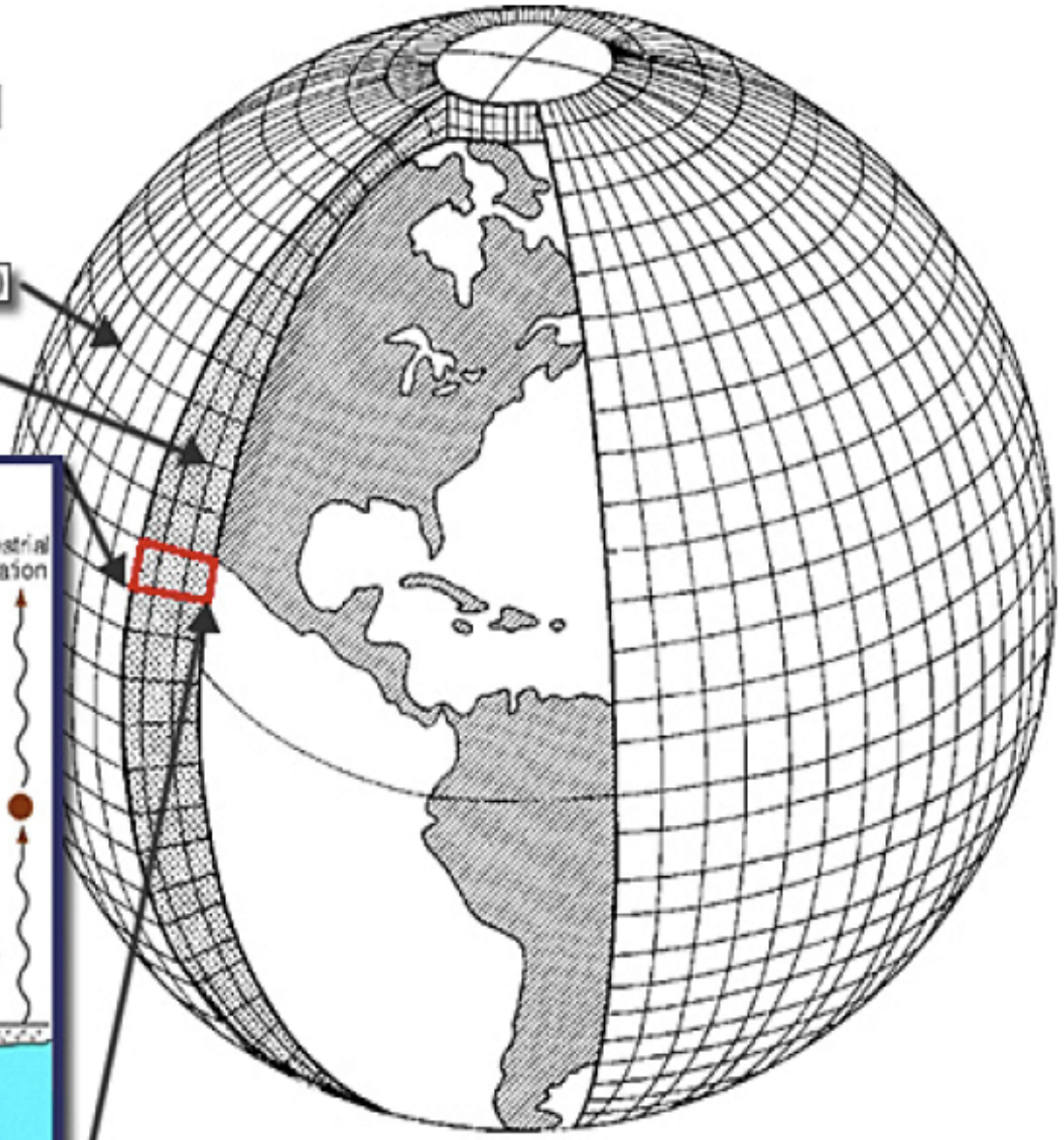
Temperature trends from climatologists...



Source: Hadley Centre, University of East Anglia, UK, 2005

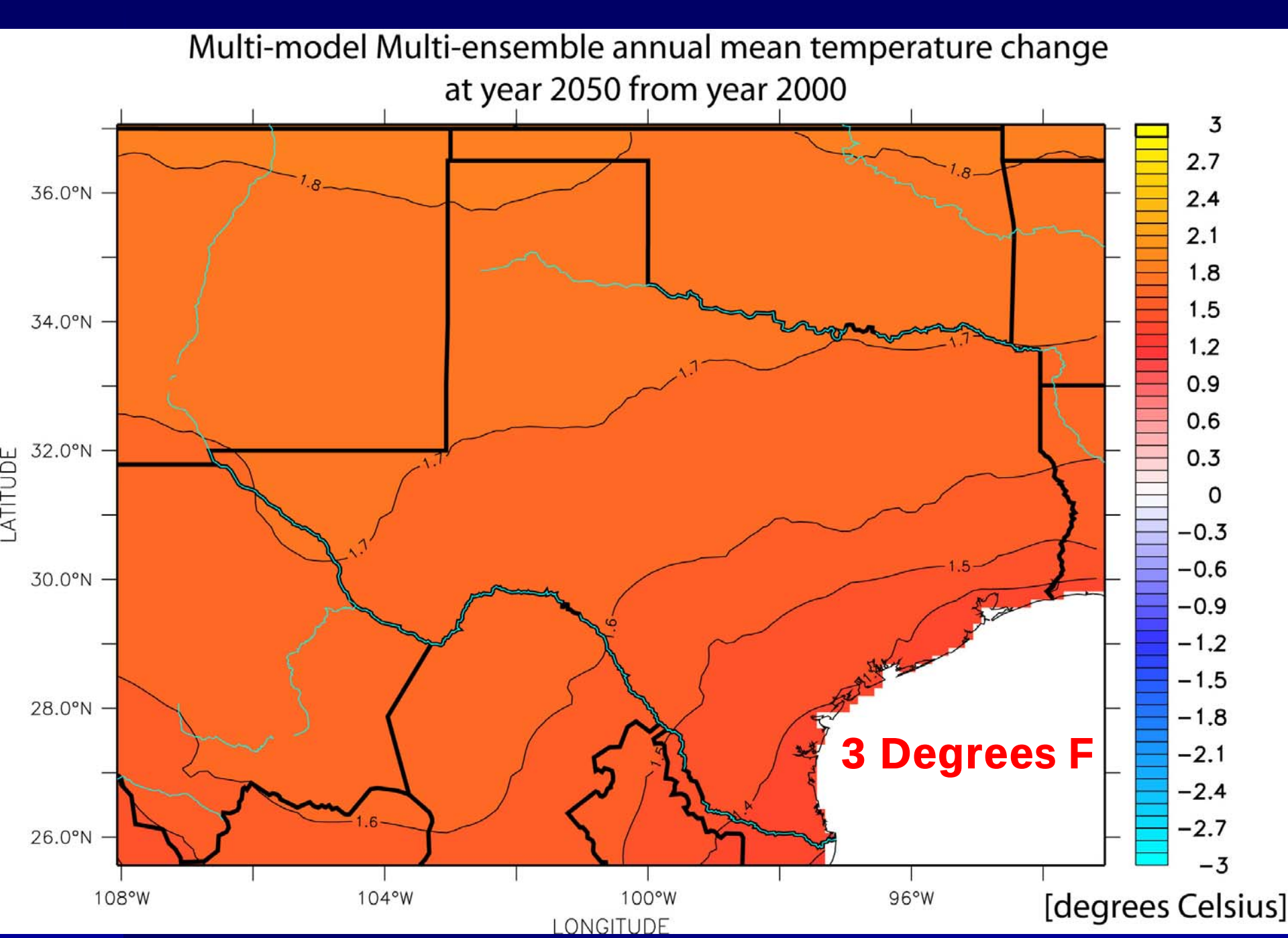
Schematic for Global Atmospheric Model

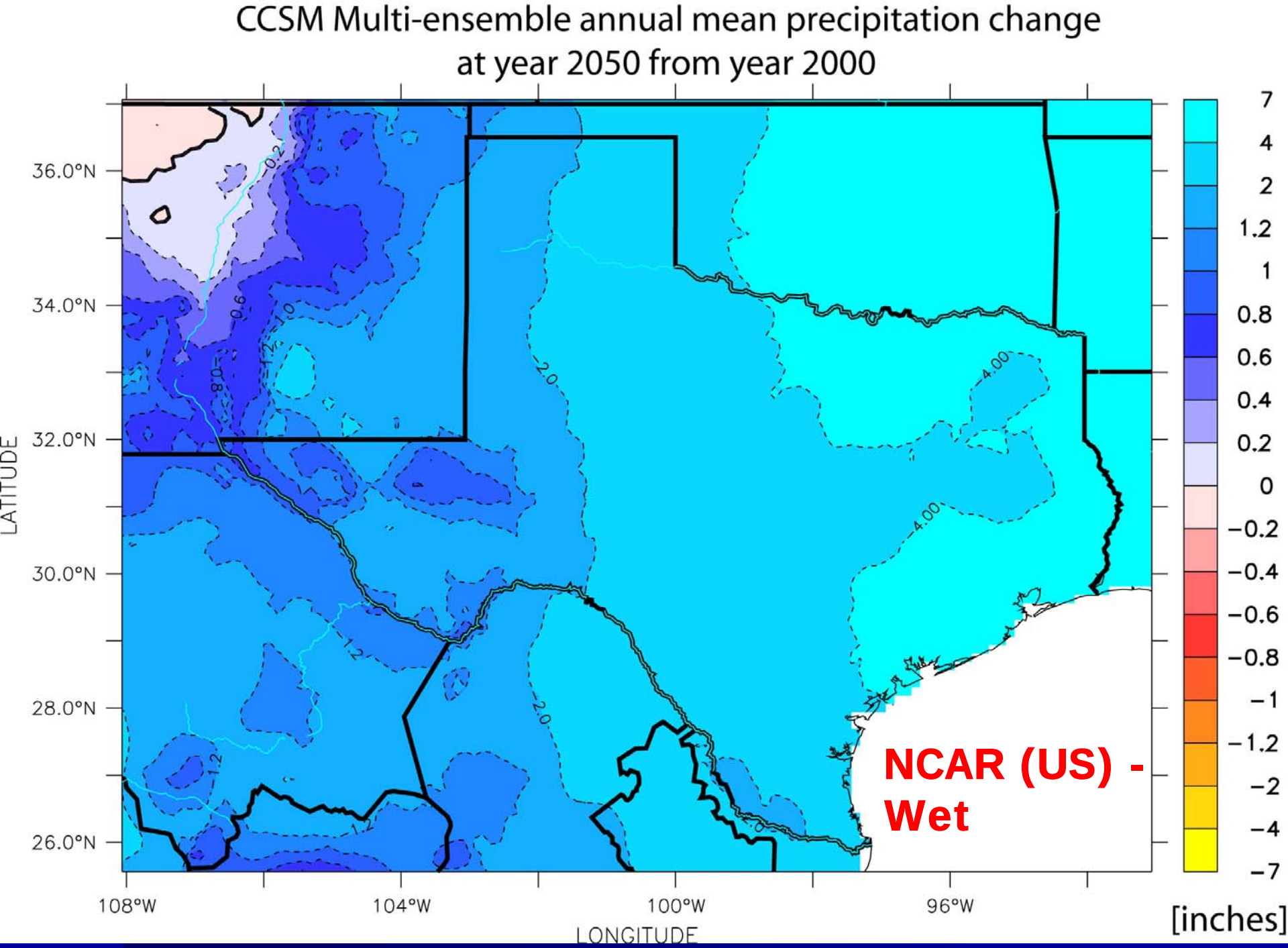


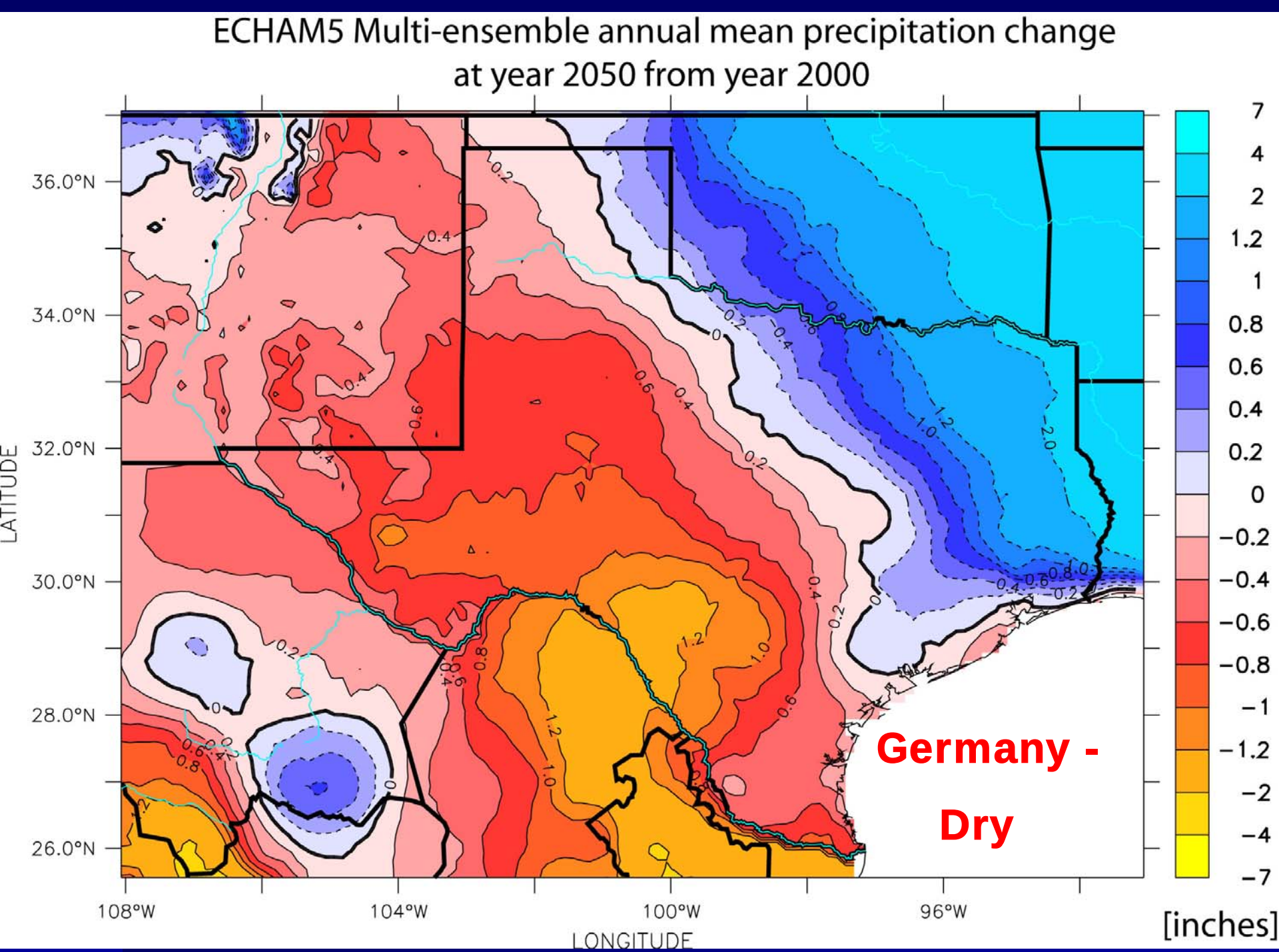


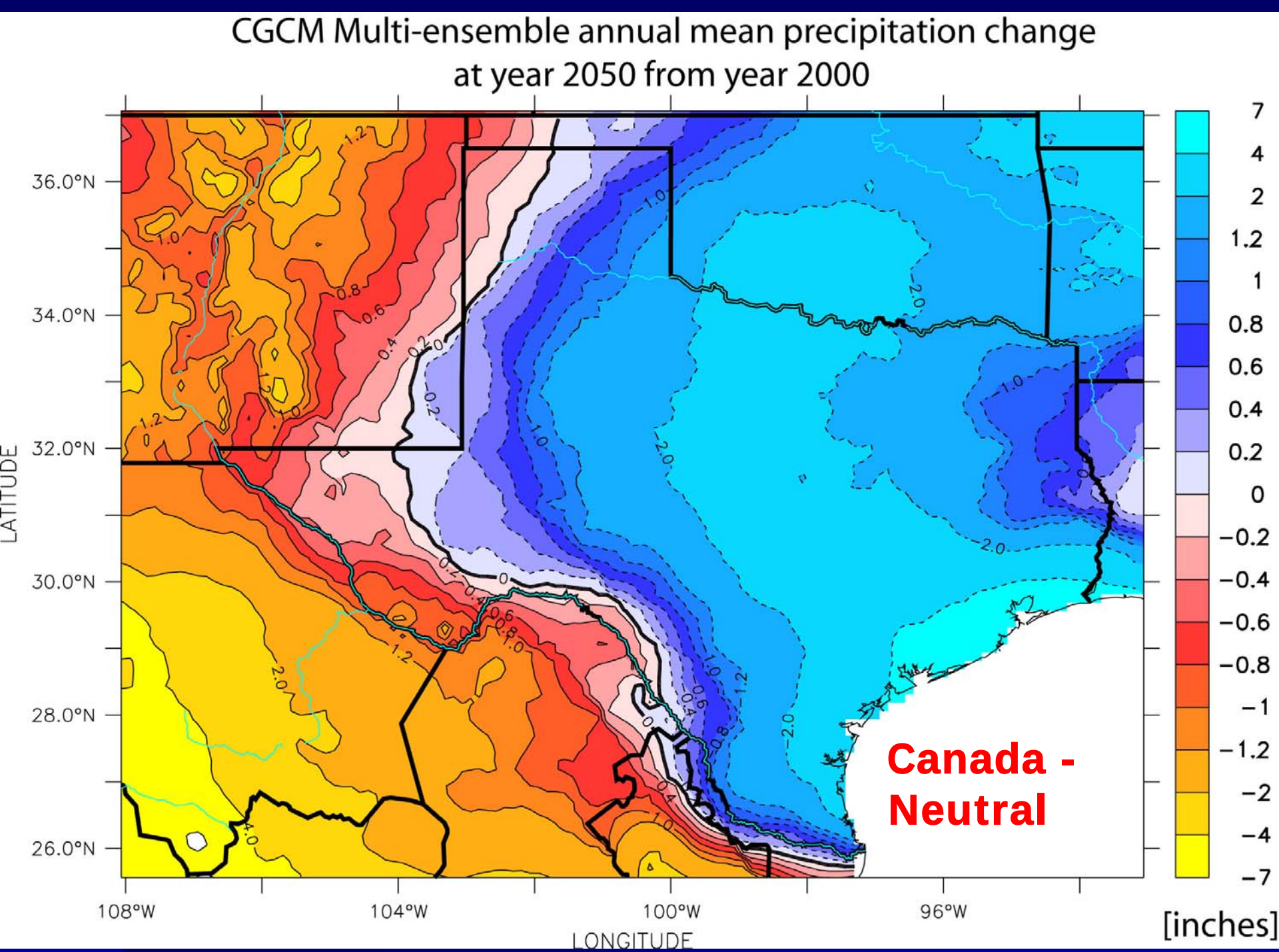
Uncertainty estimation

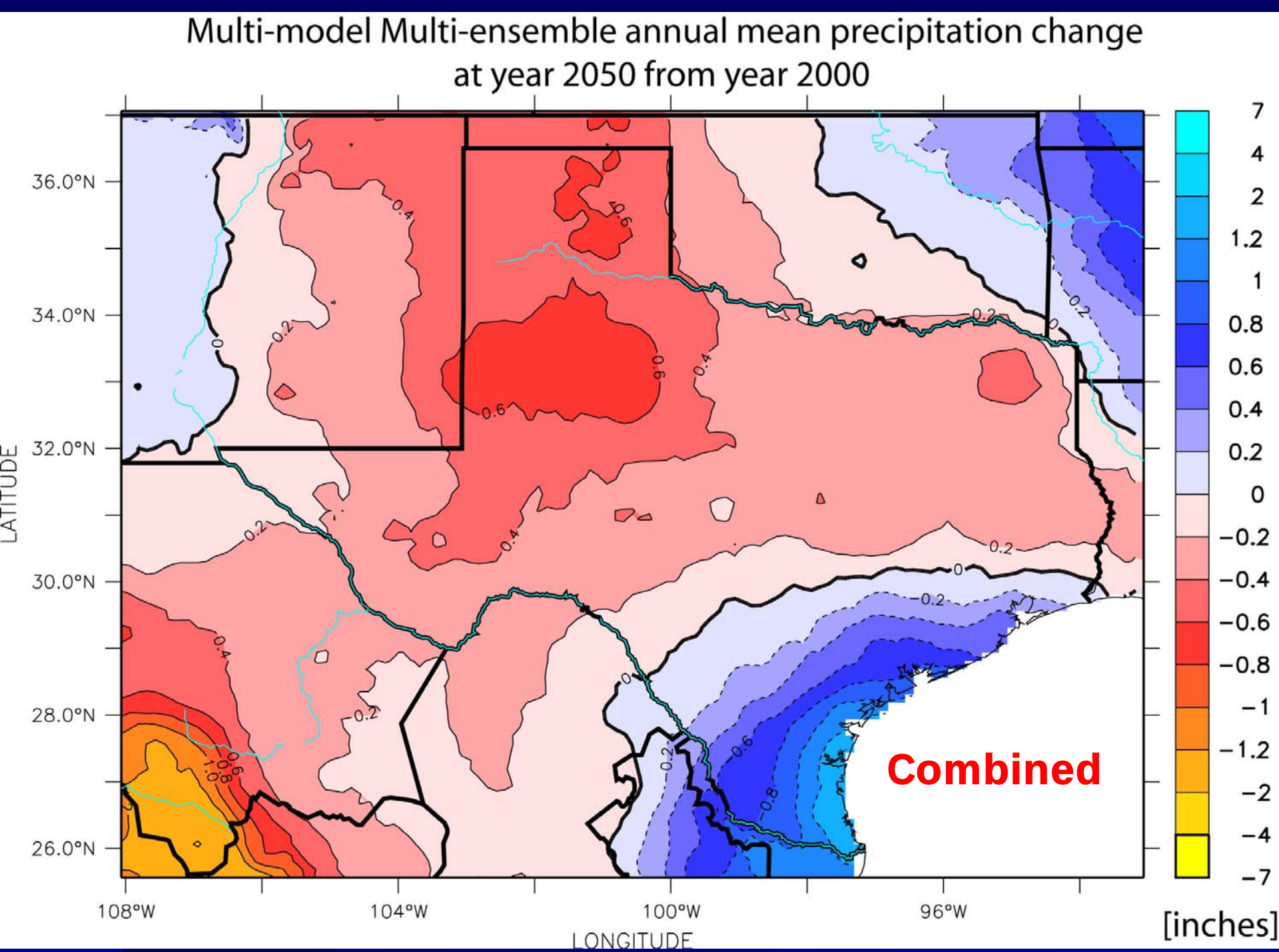
- Estimate effects of internal variability by repeating climate projections with different starting conditions.
- Use climate models from different laboratories to sample uncertainties in model development.
- Dr. Charles Jackson - University of Texas


Multi-model Multi-ensemble annual mean temperature change
at year 2050 from year 2000
36.0°N
34.0°N
32.0°N
30.0°N
28.0°N
26.0°N
LATITUDE
108°W
104°W
100°W
96°W
LONGITUDE
1.8
1.7
1.6
1.5
3 Degrees F
3
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
−0.3
−0.6
−0.9
−1.2
−1.5
−1.8
−2.1
−2.4
−2.7
−3
[degrees Celsius]

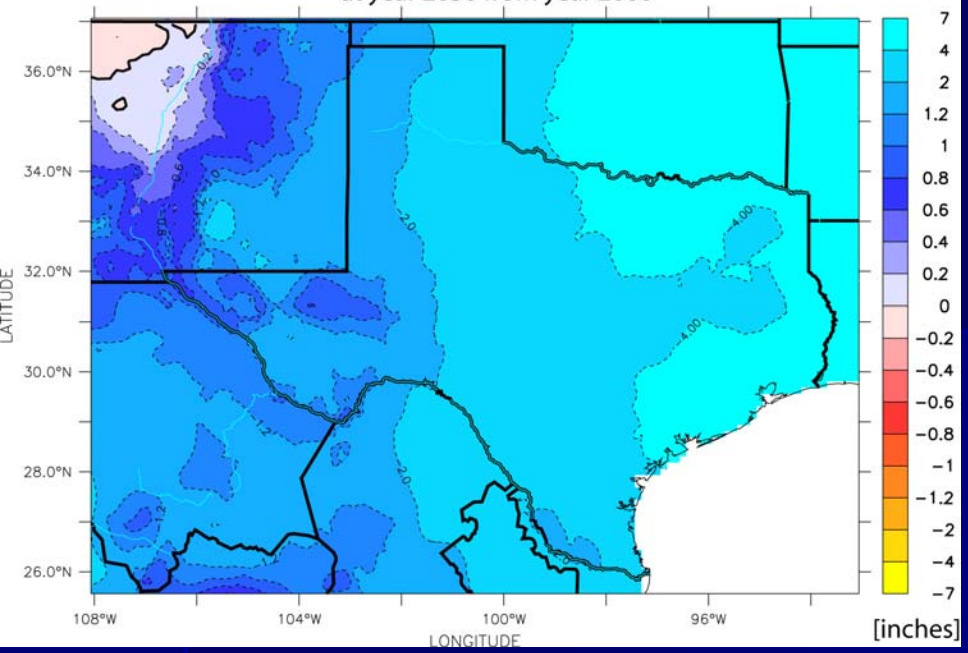

CCSM Multi-ensemble annual mean precipitation change
at year 2050 from year 2000
36.0°N
34.0°N
32.0°N
30.0°N
28.0°N
26.0°N
LATITUDE
108°W
104°W
100°W
96°W
LONGITUDE
7
4
2
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−2
−4
−7
[inches]
NCAR (US) - Wet


ECHAM5 Multi-ensemble annual mean precipitation change
at year 2050 from year 2000
36.0°N
34.0°N
32.0°N
30.0°N
28.0°N
26.0°N
LATITUDE
108°W
104°W
100°W
96°W
LONGITUDE
7
4
2
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−2
−4
−7
[inches]
Germany -
Dry

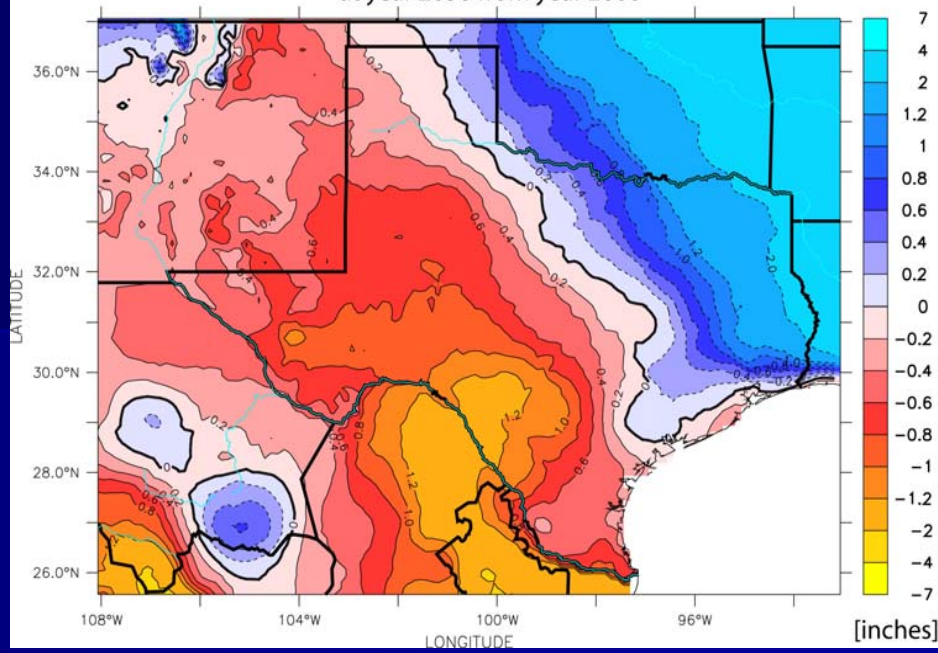

CGCM Multi-ensemble annual mean precipitation change
at year 2050 from year 2000
36.0°N
34.0°N
32.0°N
30.0°N
28.0°N
26.0°N
LATITUDE
108°W
104°W
100°W
96°W
LONGITUDE
7
4
2
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−2
−4
−7
[inches]
Canada -
Neutral


Multi-model Multi-ensemble annual mean precipitation change
at year 2050 from year 2000
36.0°N
34.0°N
32.0°N
30.0°N
28.0°N
26.0°N
LATITUDE
108°W
104°W
100°W
96°W
LONGITUDE
Combined
7
4
2
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−2
−4
−7
[inches]

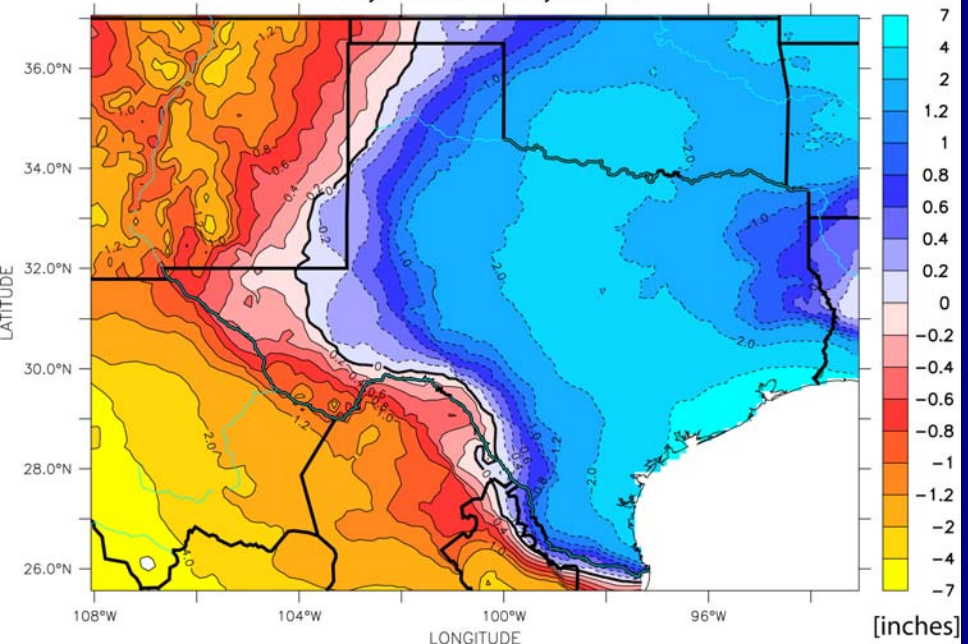
CCSM Multi-ensemble annual mean precipitation change
at year 2050 from year 2000



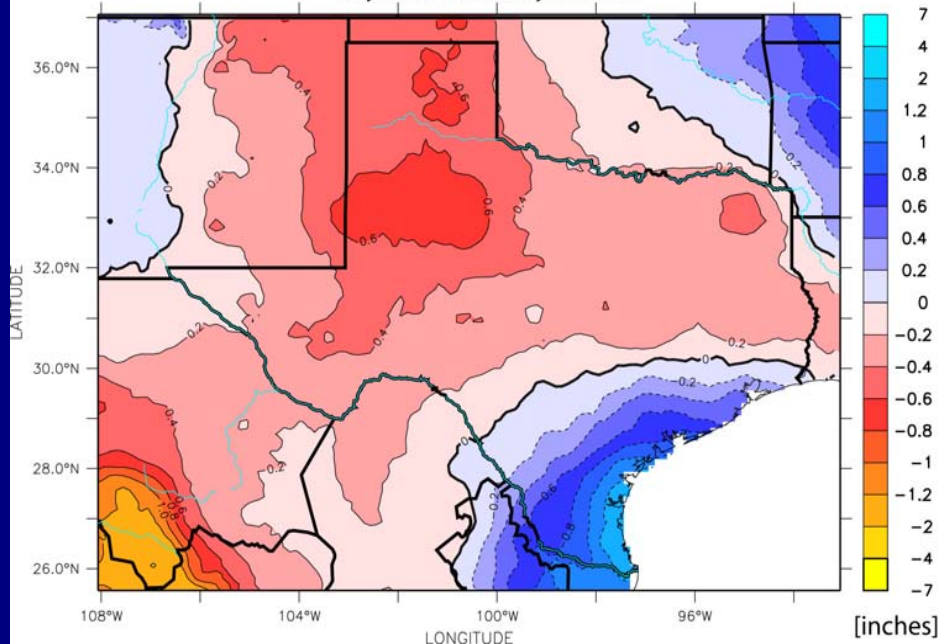
ECHAM5 Multi-ensemble annual mean precipitation change
at year 2050 from year 2000

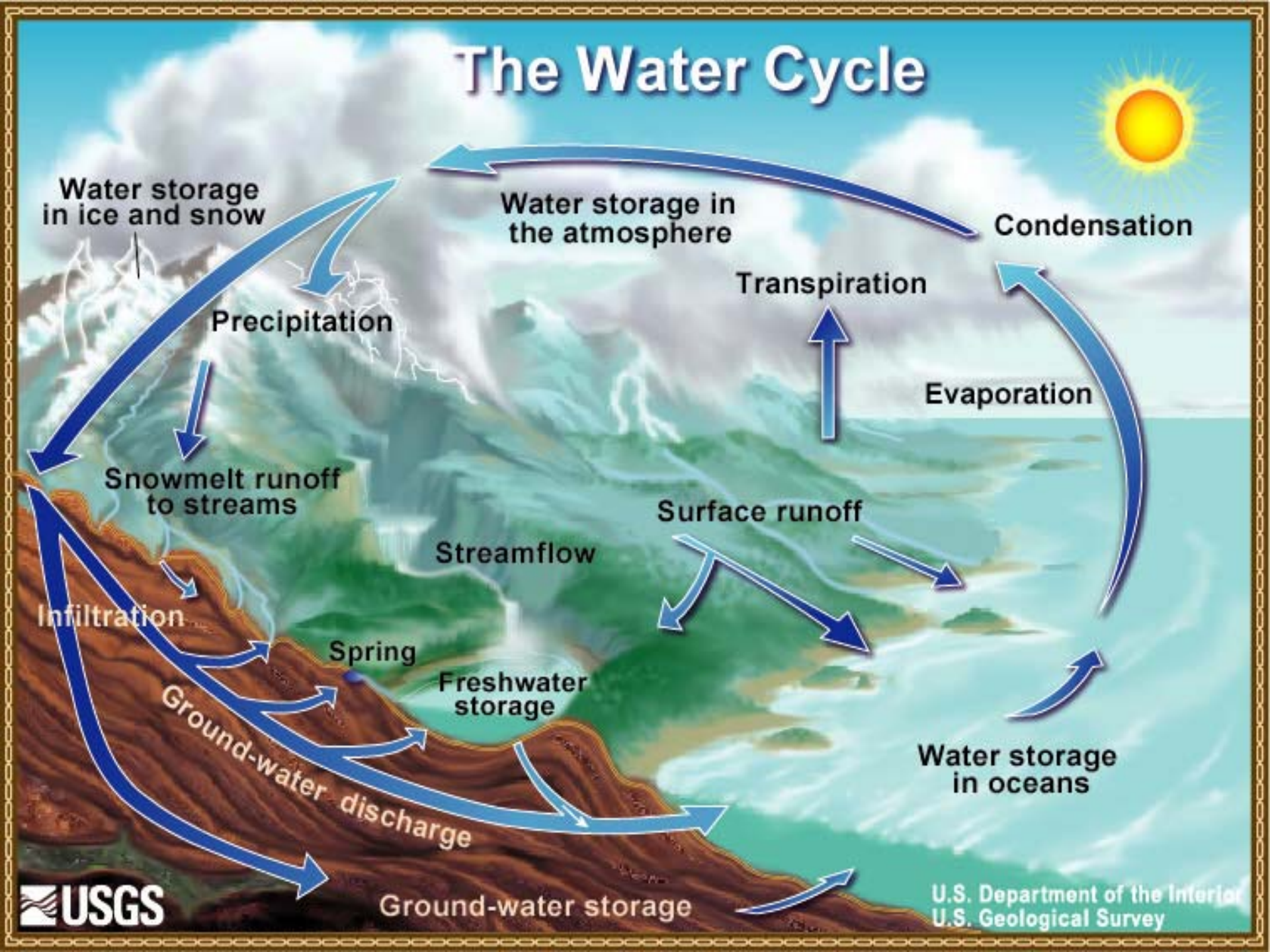


CGCM Multi-ensemble annual mean precipitation change
at year 2050 from year 2000



Multi-model Multi-ensemble annual mean precipitation change
at year 2050 from year 2000




The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Transpiration
Precipitation
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
Ground-water storage
USGS
U.S. Department of the Interior
U.S. Geological Survey

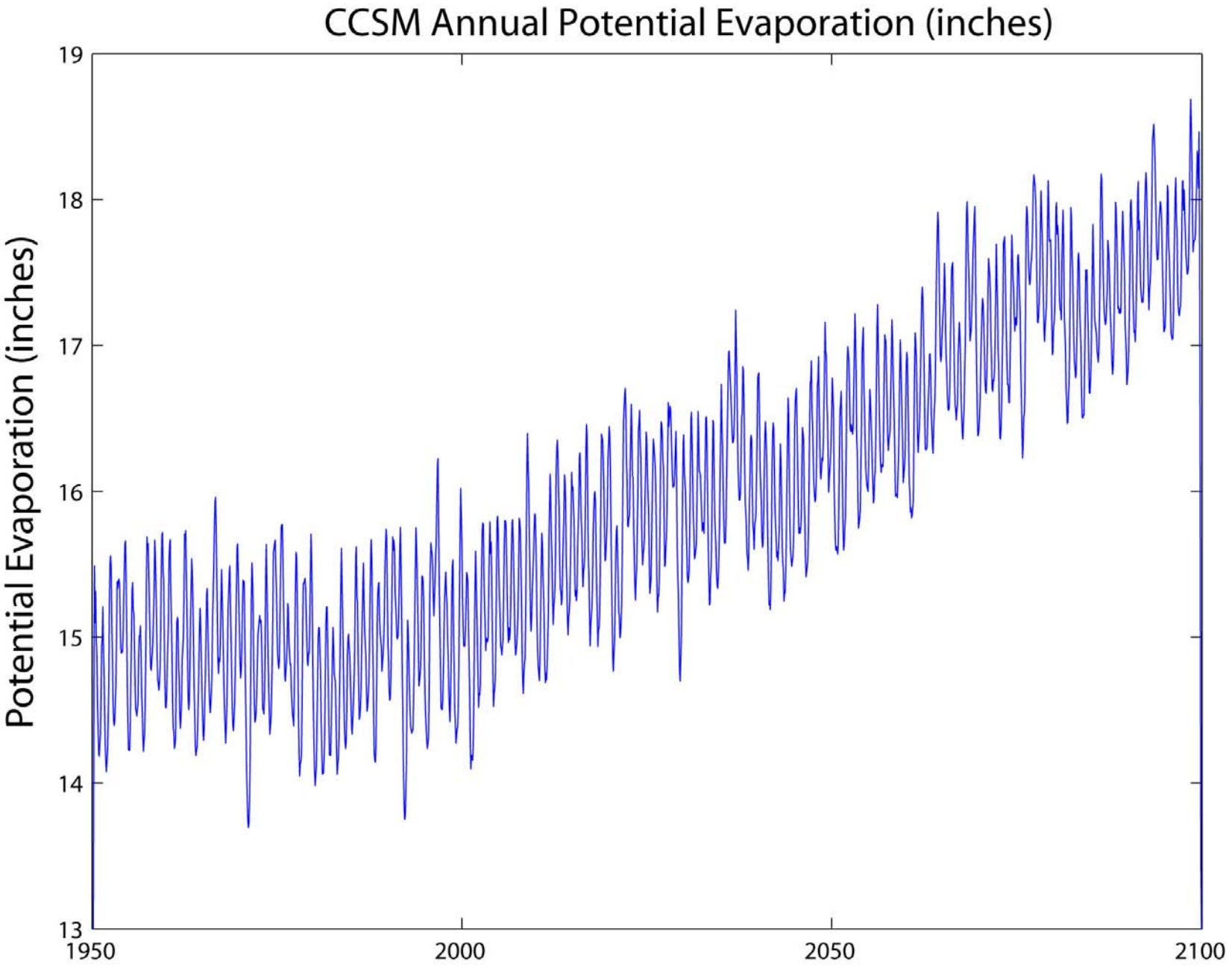
IPCC Report and Water

"quantitative projections of changes in precipitation, river flows, and water levels at the river-basin scale remain uncertain"

Kundzewicz and others (IPCC), 2007

"climate projections from global climate models are not easy to incorporate into hydrological studies because of significant uncertainties in the modeling process"

Kundzewicz and others (IPCC), 2007


CCSM Annual Potential Evaporation (inches)
Potential Evaporation (inches)
19
18
17
16
15
14
13
1950
2000
2050
2100

IPCC Report and Texas

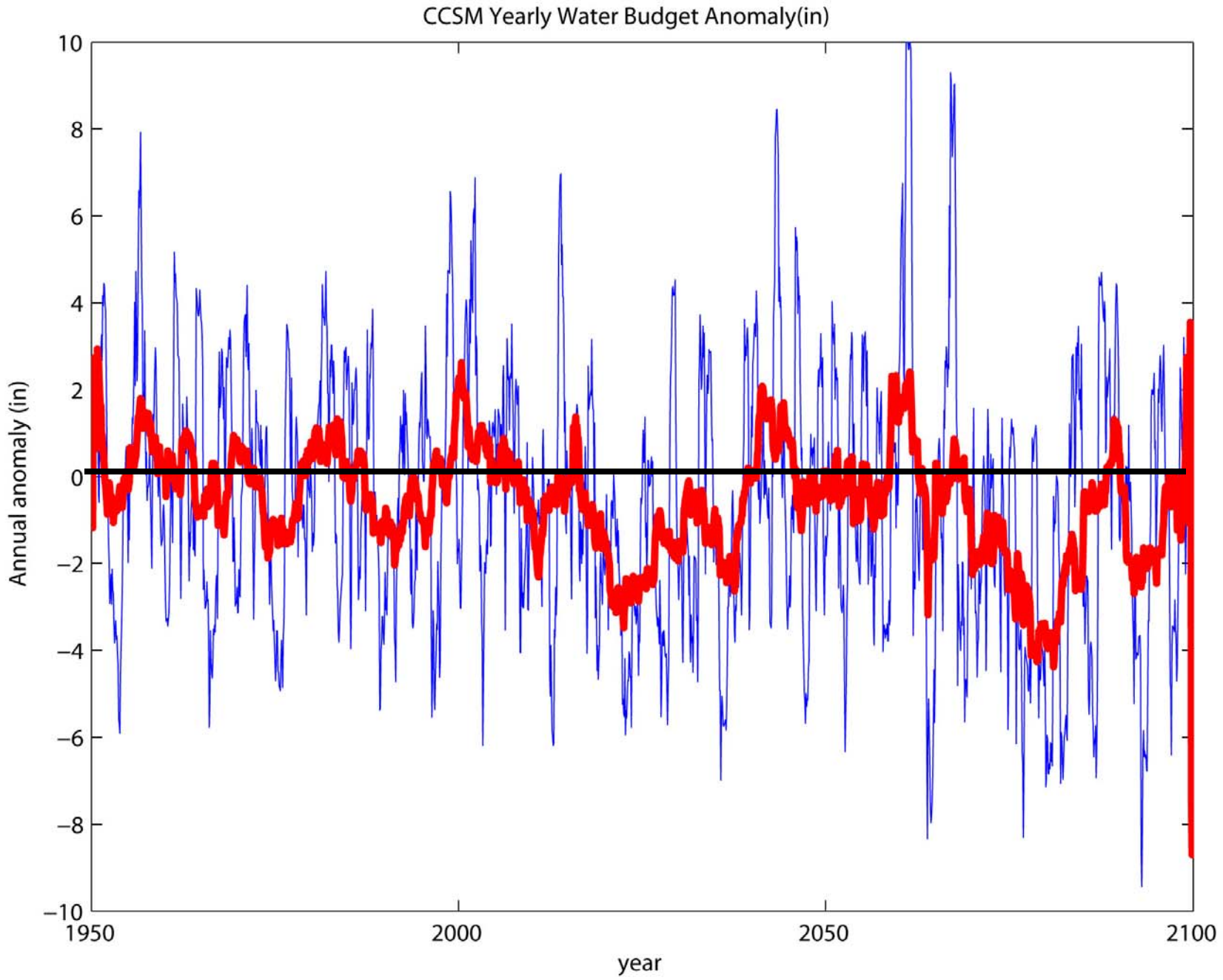
- 4.5 to 6° F increase in temperature over next 100 years
- mean annual runoff may decrease 0 to 10 percent by 2050
- flow seasonality may increase with more rainfall during the wet season and less rainfall during the dry season

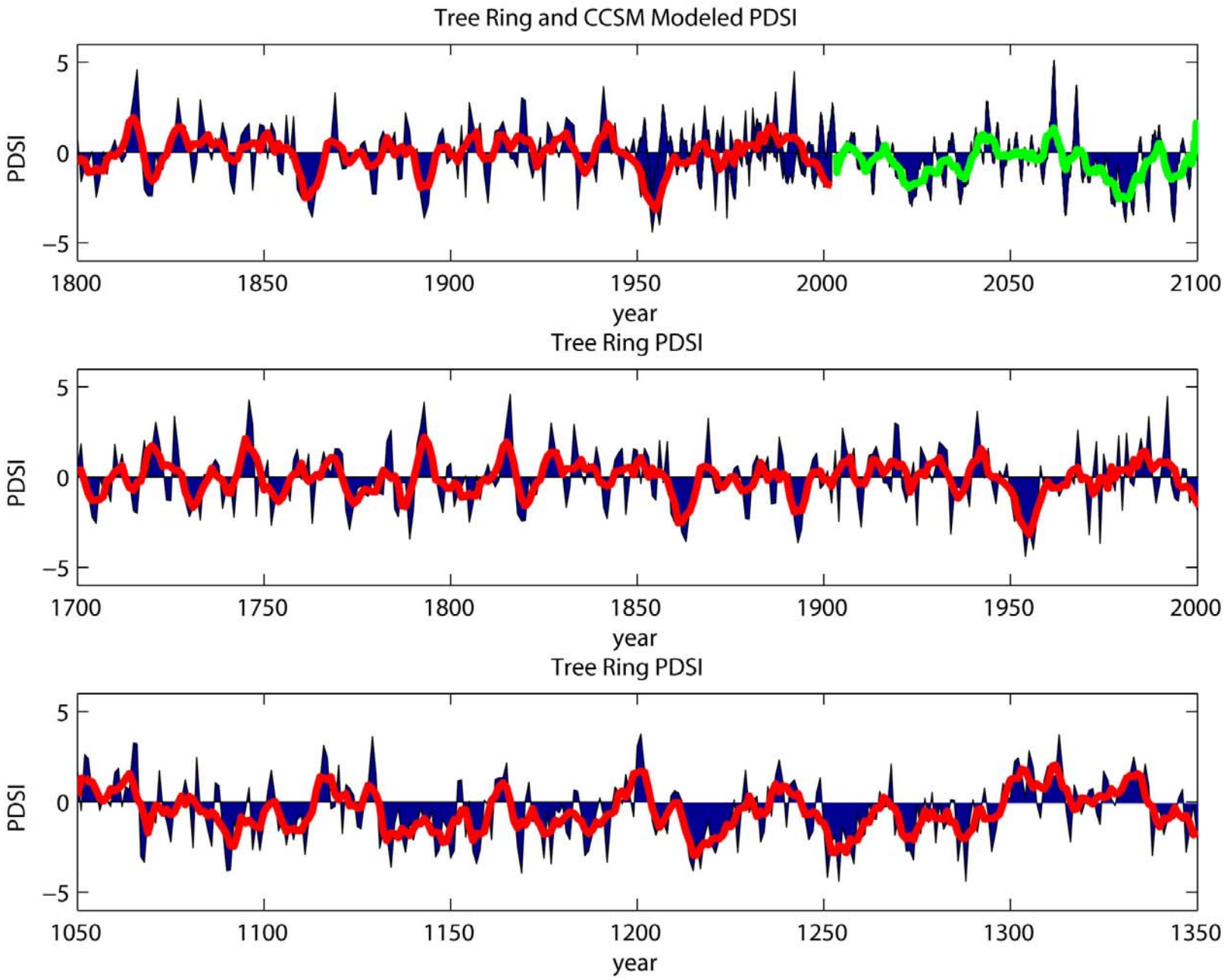
Kundzewicz and others (IPCC), 2007

Drought

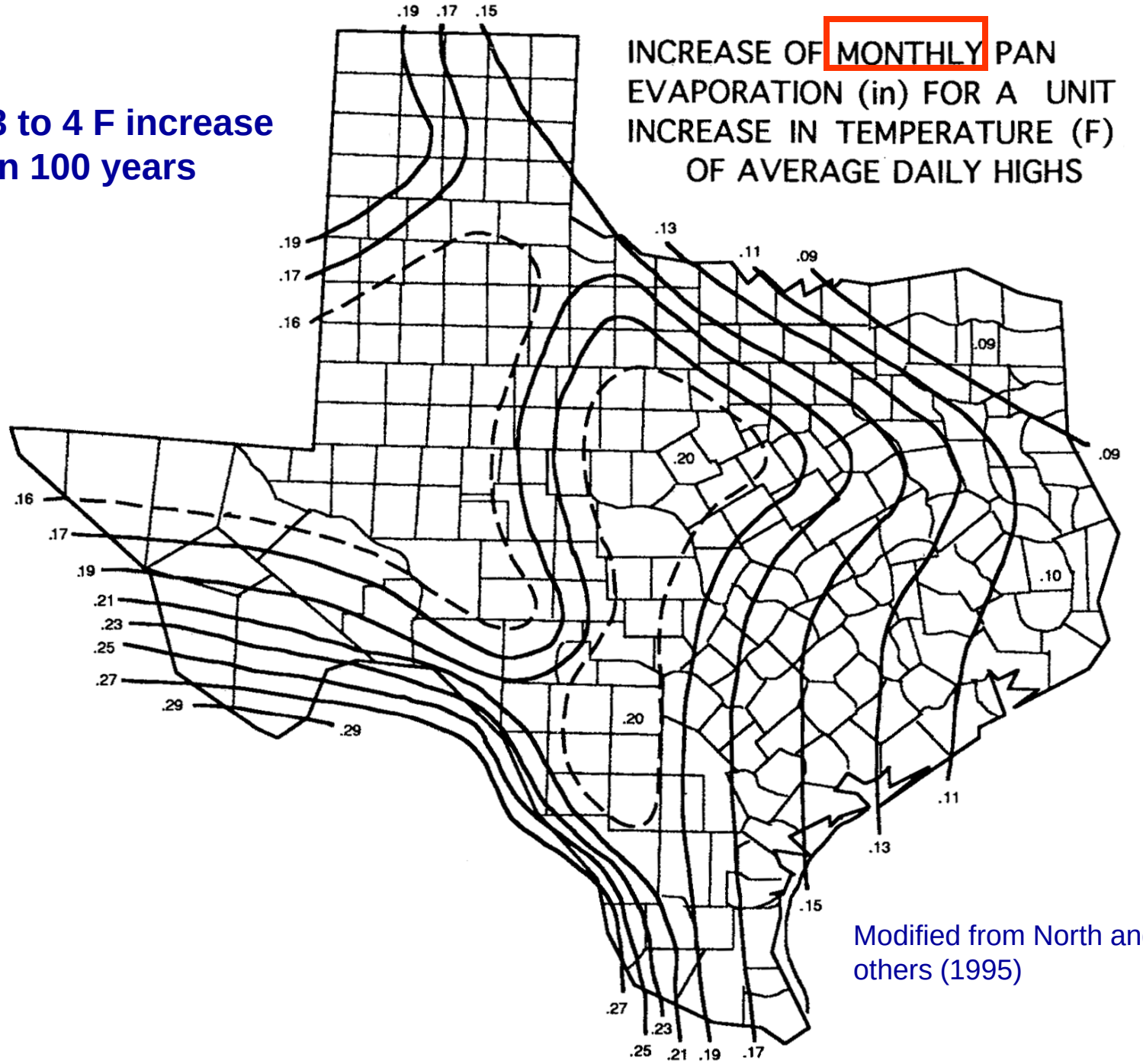
- Number of extreme drought events per 100 years are expected to increase 2 to 6 times by the 2090s

Kundzewicz and others (IPCC), 2007


CCSM Yearly Water Budget Anomaly(in)
Annual anomaly (in)
year
10
8
6
4
2
0
−2
−4
−6
−8
−10
1950
2000
2050
2100


Tree Ring and CCSM Modeled PDSI
PDSI
5
0
−5
1800
1850
1900
1950
2000
2050
2100
year
Tree Ring PDSI
PDSI
5
0
−5
1700
1750
1800
1850
1900
1950
2000
year
Tree Ring PDSI
PDSI
5
0
−5
1050
1100
1150
1200
1250
1300
1350
year

3 to 4 F increase in 100 years



Modified from North and others (1995)

Hydrological projections

- Downscaling for regions/watersheds
  - Statistic
  - Dynamic
- How do you apply a trend (temperature/precipitation) to a rainfall-runoff model?
- How do you choose the best-performing GCM? Do you work with an ensemble of models?

2012 State Water Plan: Risk & Uncertainty

Models

Permitting

Population projections

Land use

Implementation

Economics

Politics

Climate change

Considerations

- How is demand affected by CC?
- Different sectors impacted differently
- What is the role of paleohydrology?
- How do you deal with non-stationarity?
  - Rule curves and reallocation of storage in federal reservoirs
  - Flood & drought frequency analysis
- Choose water management strategies wisely – resilience to climate change!

Adaptive management

- Develop projections
  - Climatological – hydrological
  - Population
  - Demand
  - Land use change
  - Etc…
- Monitor

Frequency?

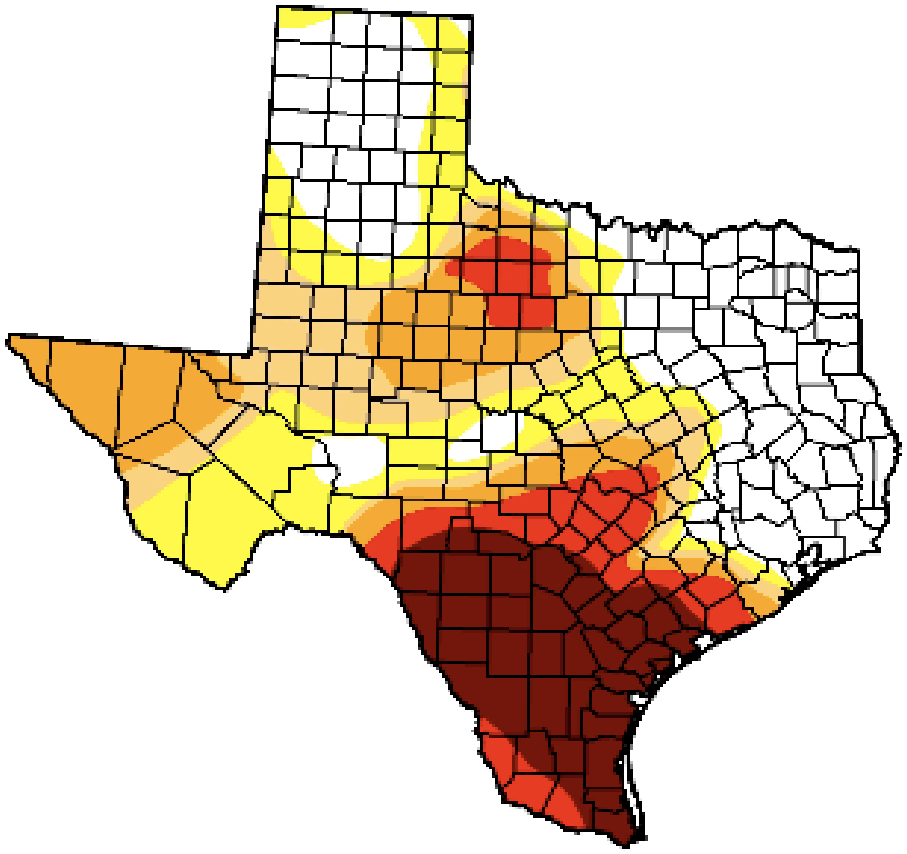
U.S. Drought Monitor

Texas

May 12, 2009
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	31.2	68.8	50.5	38.0	23.7	14.9
Last Week (05/05/2009 map)	28.2	71.8	53.7	39.2	21.6	9.7
3 Months Ago (02/17/2009 map)	4.1	95.9	61.8	43.1	19.9	8.6
Start of Calendar Year (01/06/2009 map)	41.7	58.3	24.5	15.0	9.1	4.2
Start of Water Year (10/07/2008 map)	67.2	32.8	20.5	11.0	3.6	0.0
One Year Ago (05/13/2008 map)	46.7	53.3	36.6	24.3	6.9	0.0



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

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

http://drought.unl.edu/dm

Released Thursday, May 14, 2009

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