In Hot Water? How Climate Change May Affect the Groundwater Resources of Texas

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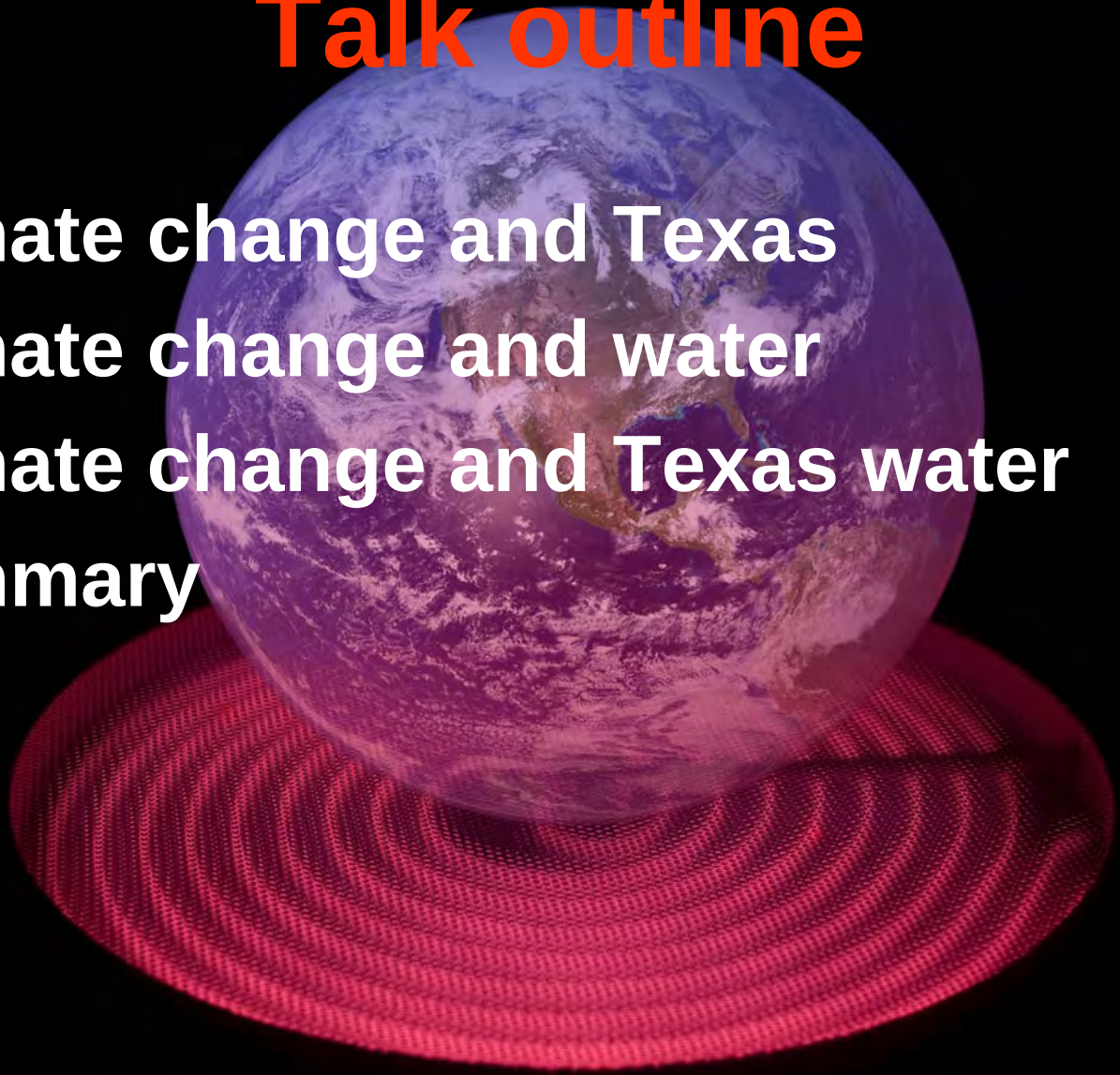
Texas Water Development Board

February 4, 2009; The Future of Groundwater in EPA Region 6

Talk outline

- Climate change and Texas
- Climate change and water
- Climate change and Texas water
- Summary



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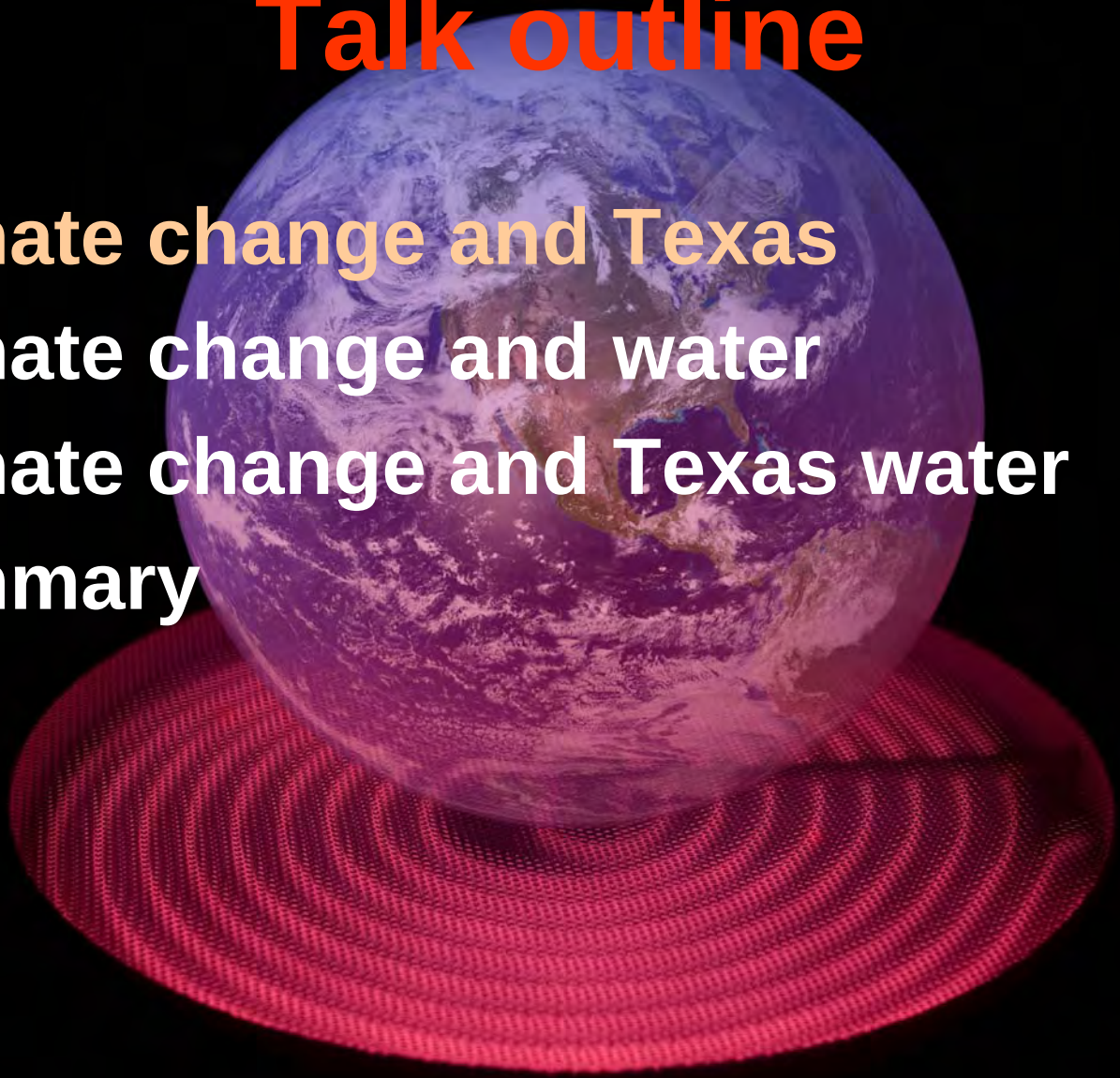
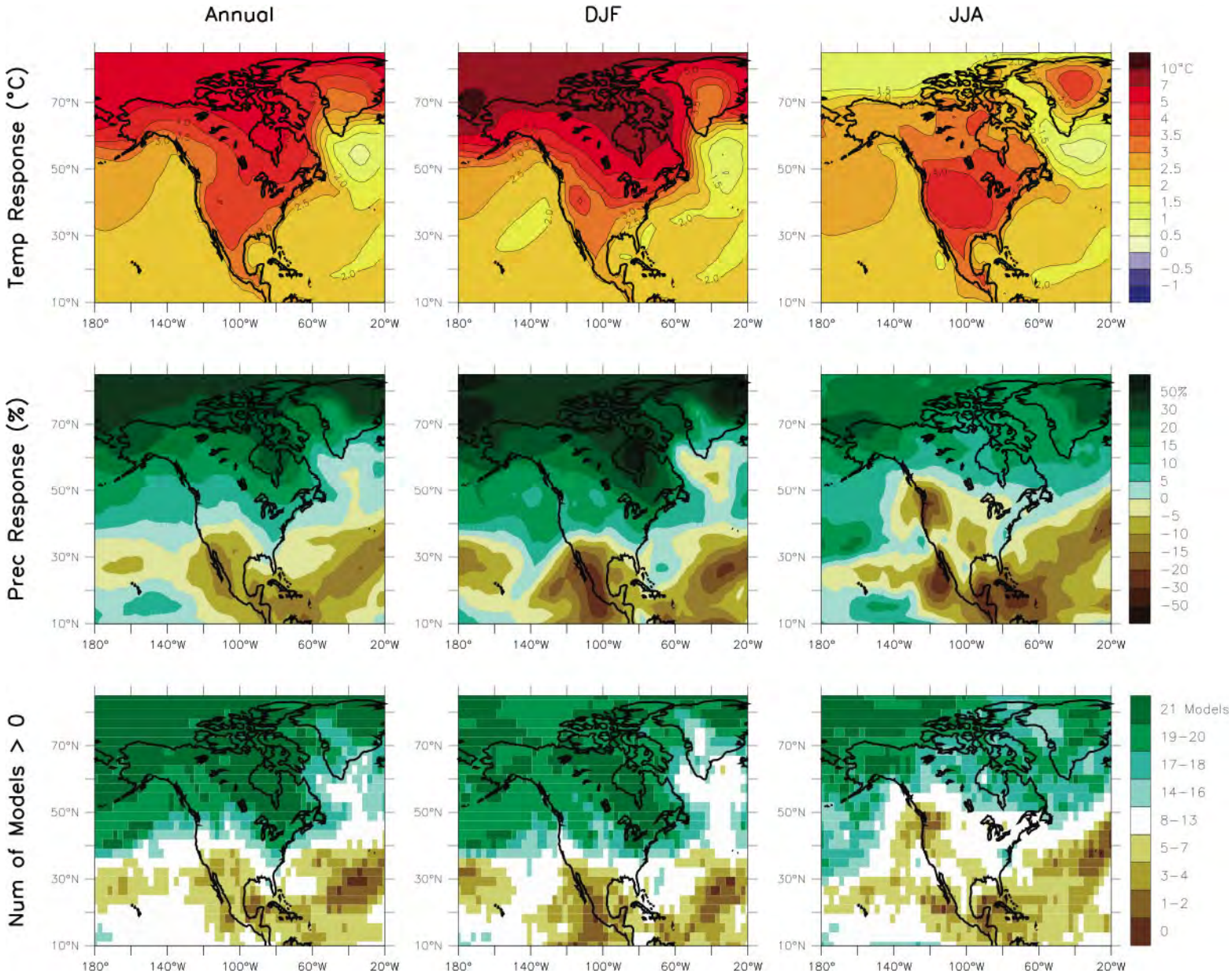



Annual
DJF
JJA
Temp Response (°C)
Prec Response (%)
Num of Models > 0
70°N
50°N
30°N
10°N
180°
140°W
100°W
60°W
20°W
10°C
7
5
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
50%
30
20
15
10
5
0
−5
−10
−15
−20
−30
−50
21 Models
19−20
17−16
14−16
8−13
5−7
3−4
1−2
0

IPCC

IPCC Report and Texas

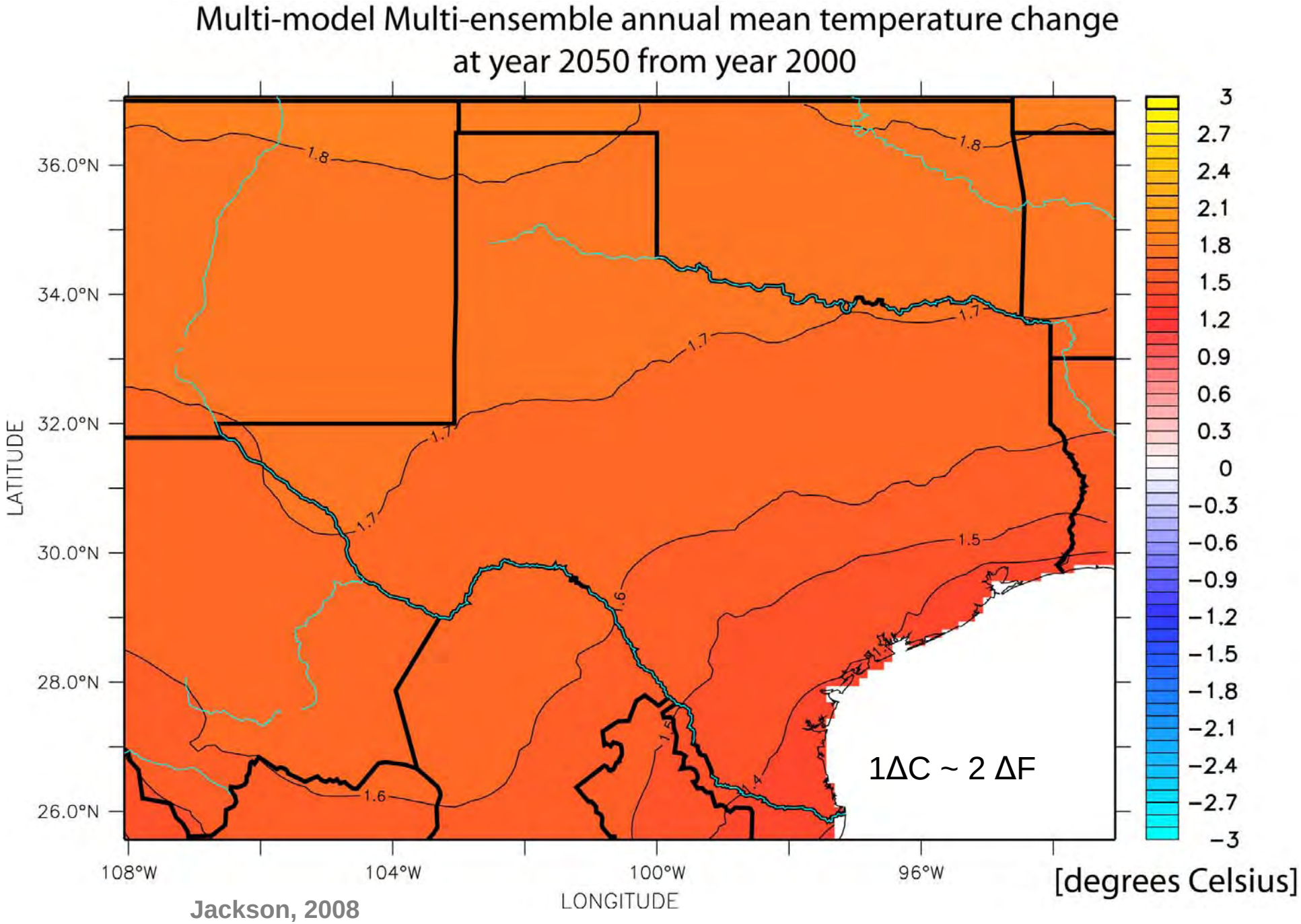
- 4.5 to 6° F increase in temperature over next 100 years
- mean annual runoff may decrease 0 to 10 percent by 2050
- flow seasonality may increase with more rainfall during the wet season and less rainfall during the dry season

Kundzewicz and others (IPCC), 2007

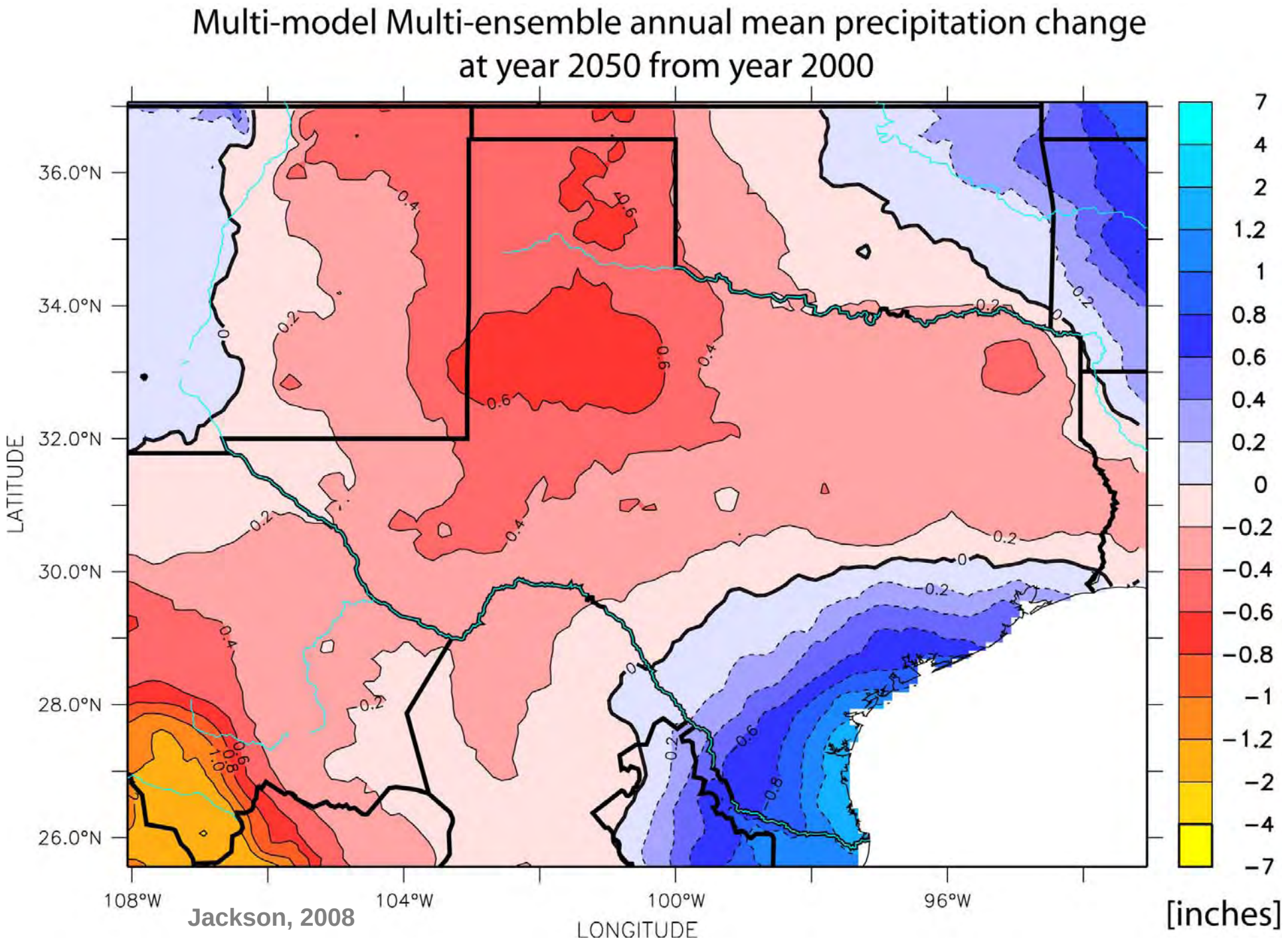
Multi-model Projections for Texas

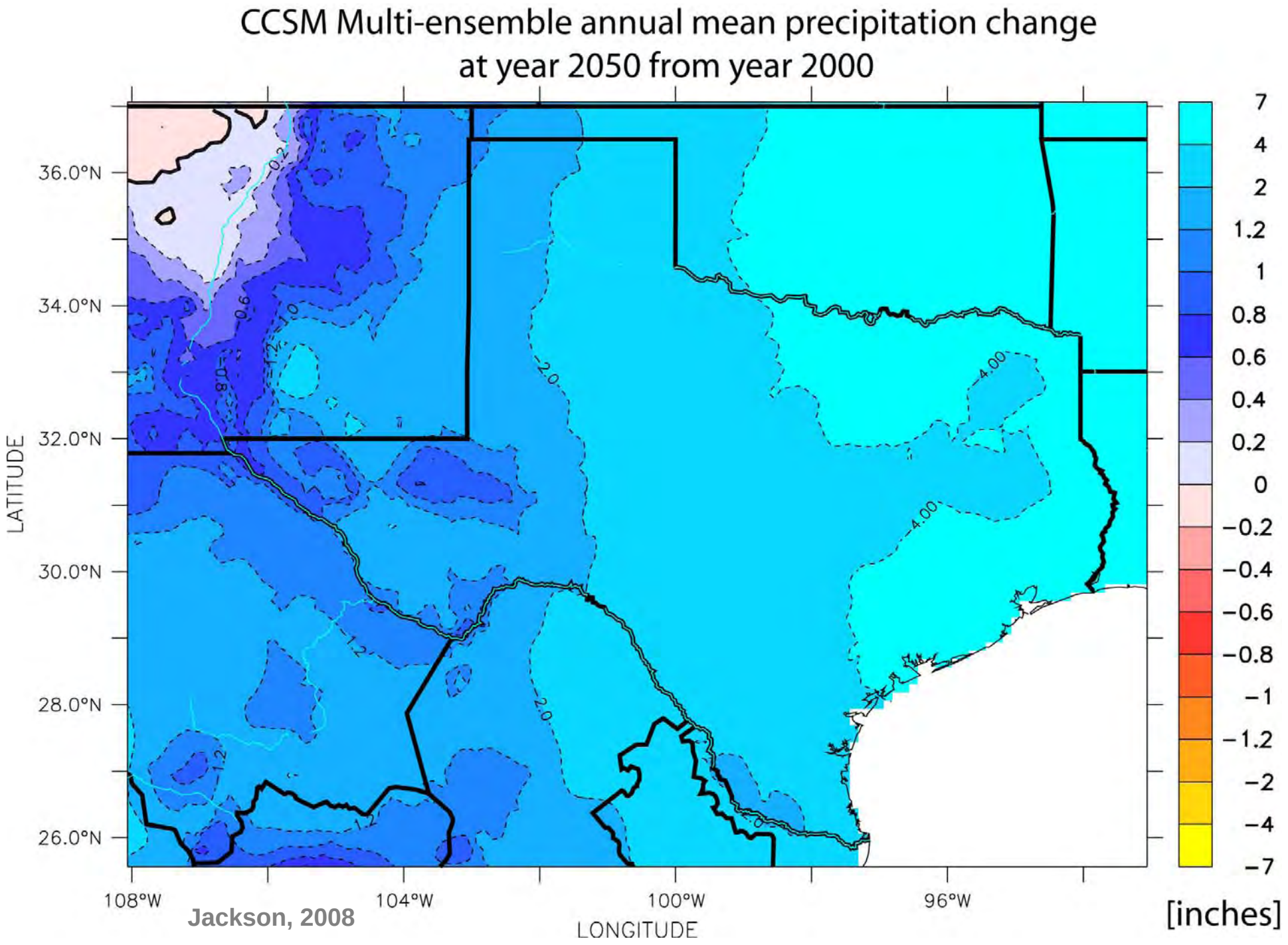
- 16 different climate models of climate from 1950 to 2100
- Results at ~150 km resolution have been statistically downscaled to ~12 km resolution.
- Specific models considered use a 3-member ensemble average of 2040 to 2060 minus 1990 to 2010.

work by Charles Jackson, UT



Jackson, 2008


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
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]
Jackson, 2008


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
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Jackson, 2008
7
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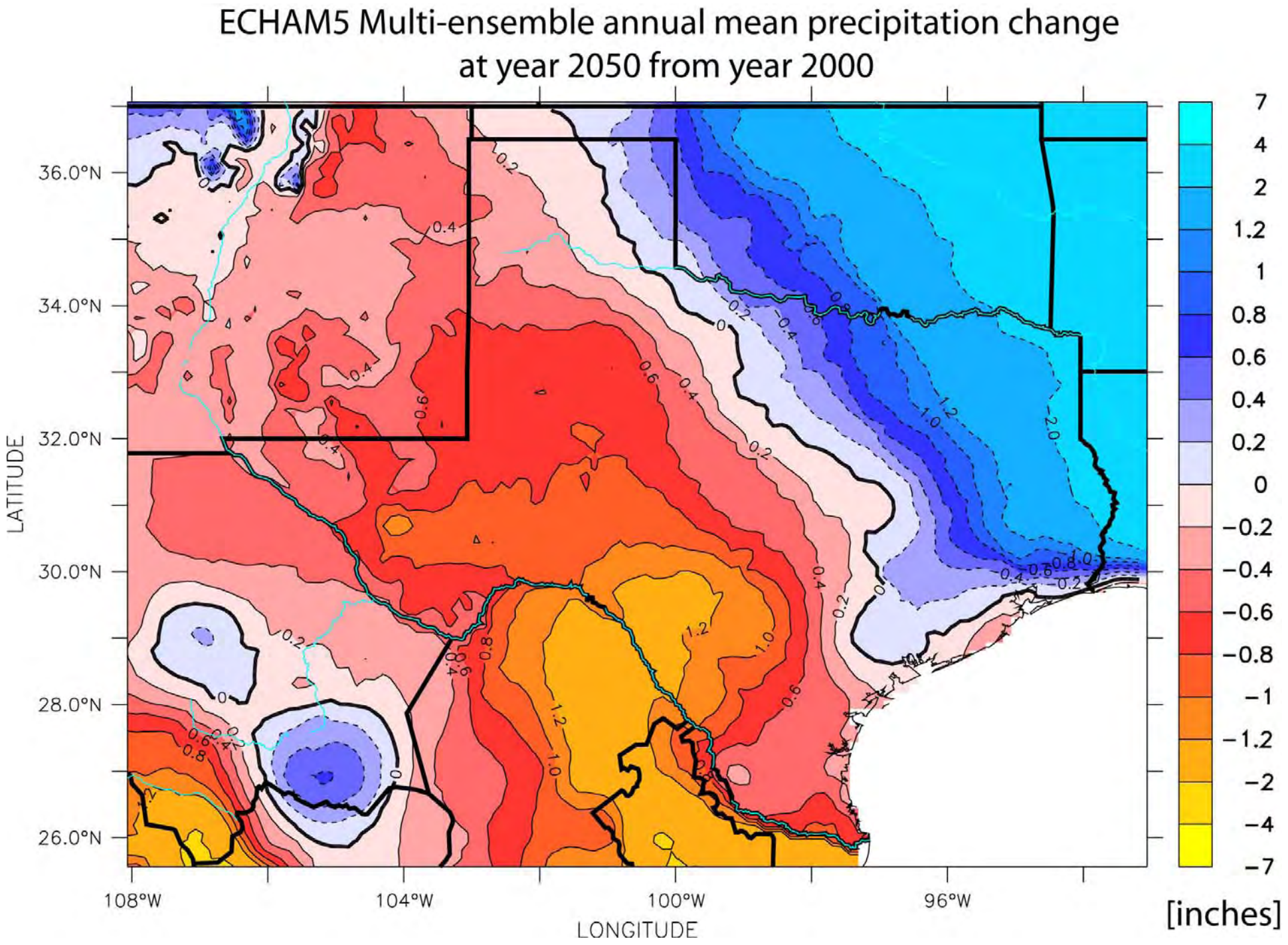
ECHAM5 Multi-ensemble annual mean precipitation change
at year 2050 from year 2000
36.0°N
34.0°N
32.0°N
30.0°N
28.0°N
26.0°N
LATITUDE
108°W
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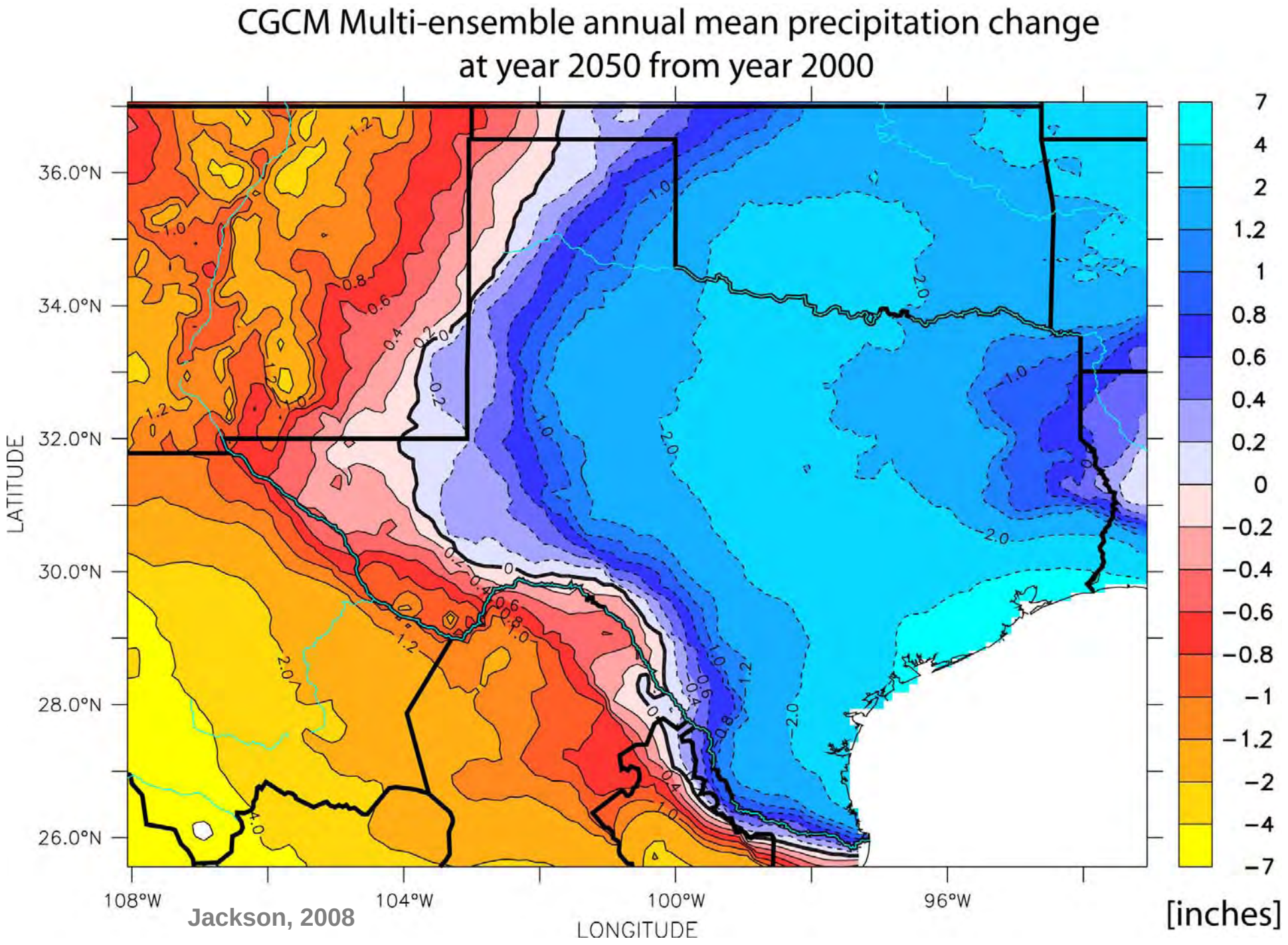
CGCM Multi-ensemble annual mean precipitation change
at year 2050 from year 2000
36.0°N
34.0°N
32.0°N
30.0°N
28.0°N
26.0°N
LATITUDE
108°W
104°W
100°W
96°W
LONGITUDE
Jackson, 2008
7
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0.4
0.2
0
−0.2
−0.4
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- Climate change and water
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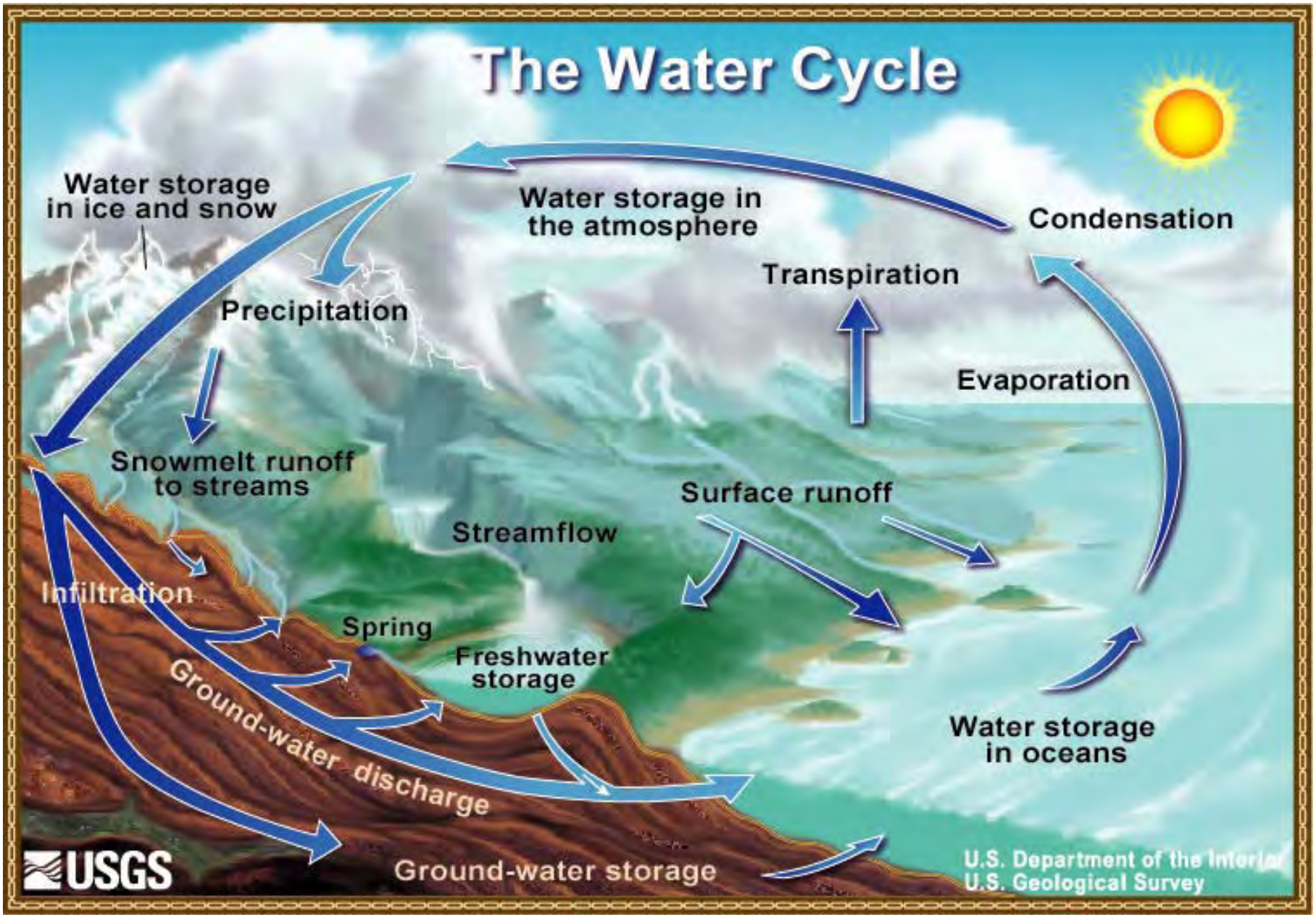
The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Transpiration
Precipitation
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
USGS
Ground-water storage
U.S. 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

Climate change and water

- Precipitation
- Runoff
- Recharge
- Evaporation
- Evapotranspiration
- Use
- Drought

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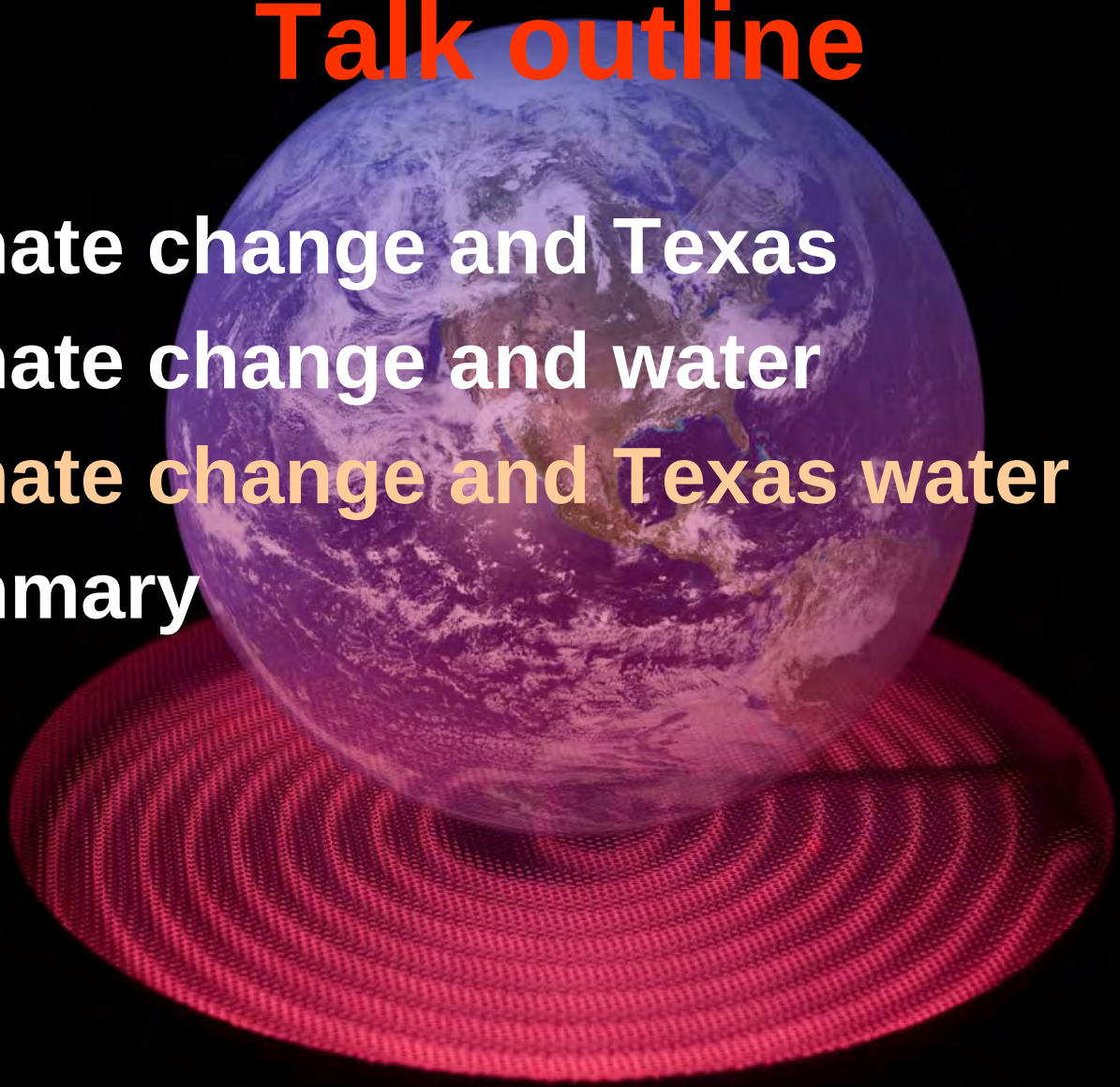
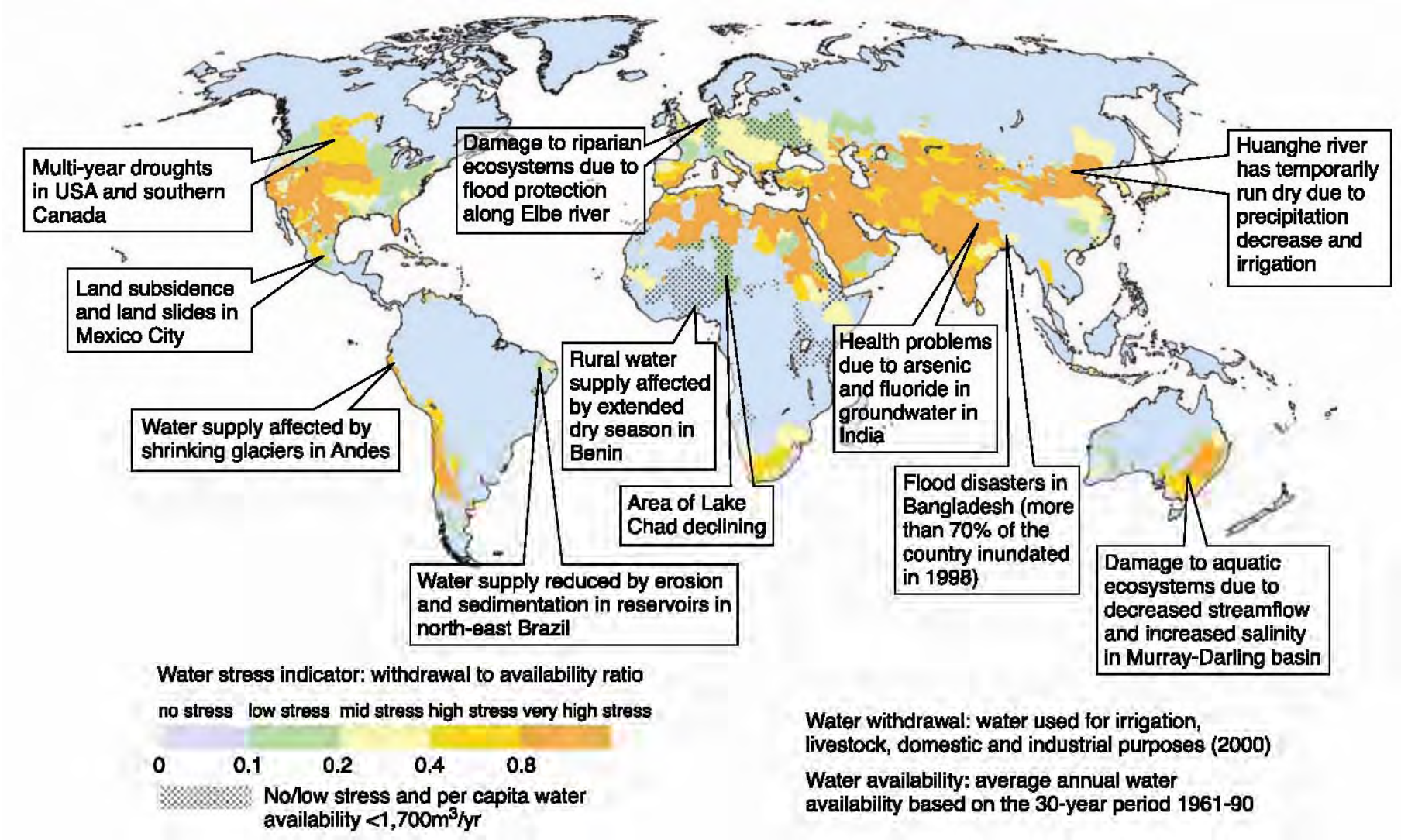
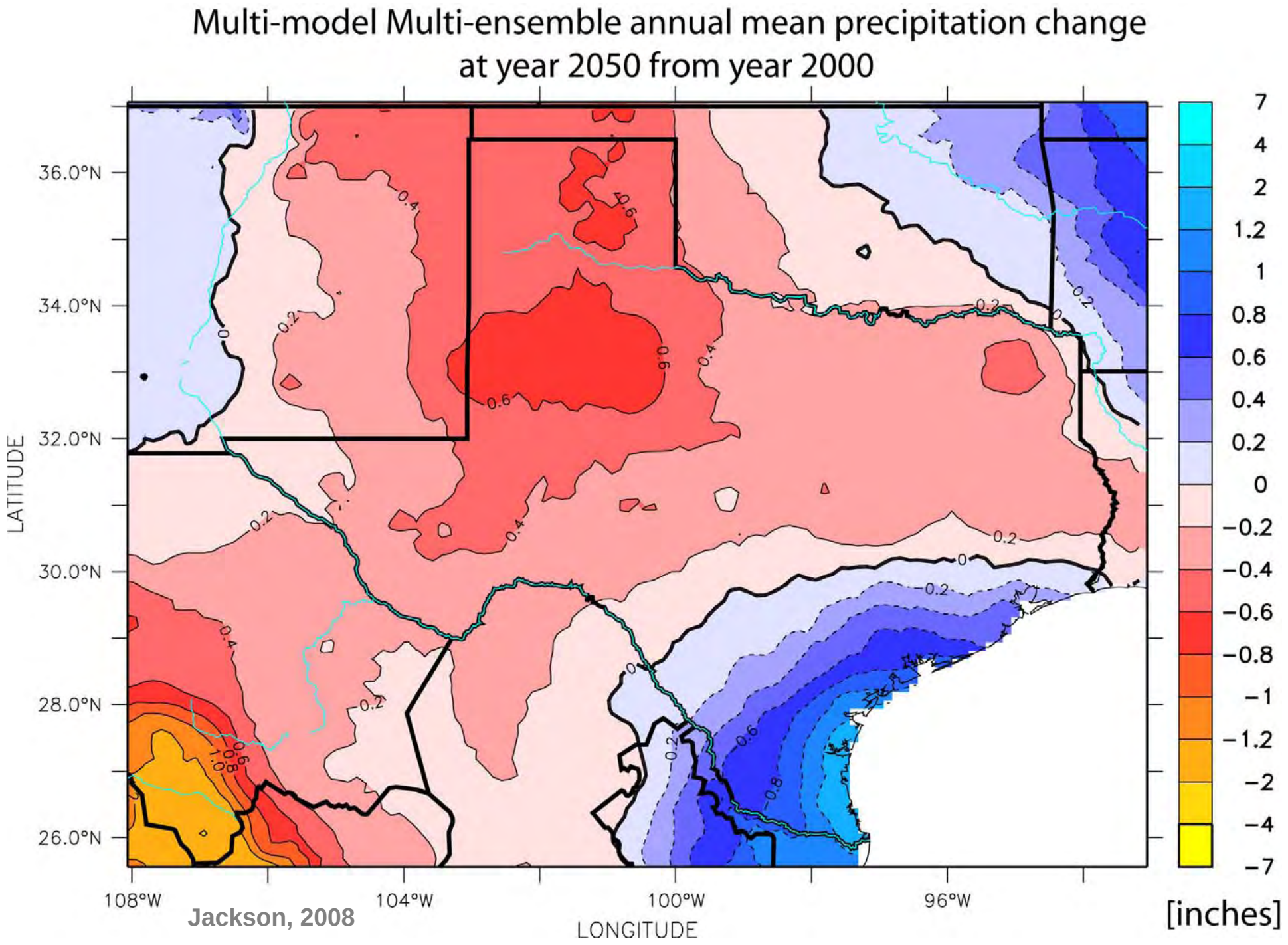



Multi-year droughts in USA and southern Canada
Land subsidence and land slides in Mexico City
Water supply affected by shrinking glaciers in Andes
Damage to riparian ecosystems due to flood protection along Elbe river
Rural water supply affected by extended dry season in Benin
Area of Lake Chad declining
Water supply reduced by erosion and sedimentation in reservoirs in north-east Brazil
Health problems due to arsenic and fluoride in groundwater in India
Flood disasters in Bangladesh (more than 70% of the country inundated in 1998)
Huanghe river has temporarily run dry due to precipitation decrease and irrigation
Damage to aquatic ecosystems due to decreased streamflow and increased salinity in Murray-Darling basin
Water stress indicator: withdrawal to availability ratio
no stress
low stress
mid stress
high stress
very high stress
0
0.1
0.2
0.4
0.8
No/low stress and per capita water availability <1,700m3/yr
Water withdrawal: water used for irrigation, livestock, domestic and industrial purposes (2000)
Water availability: average annual water availability based on the 30-year period 1961-90
IPCC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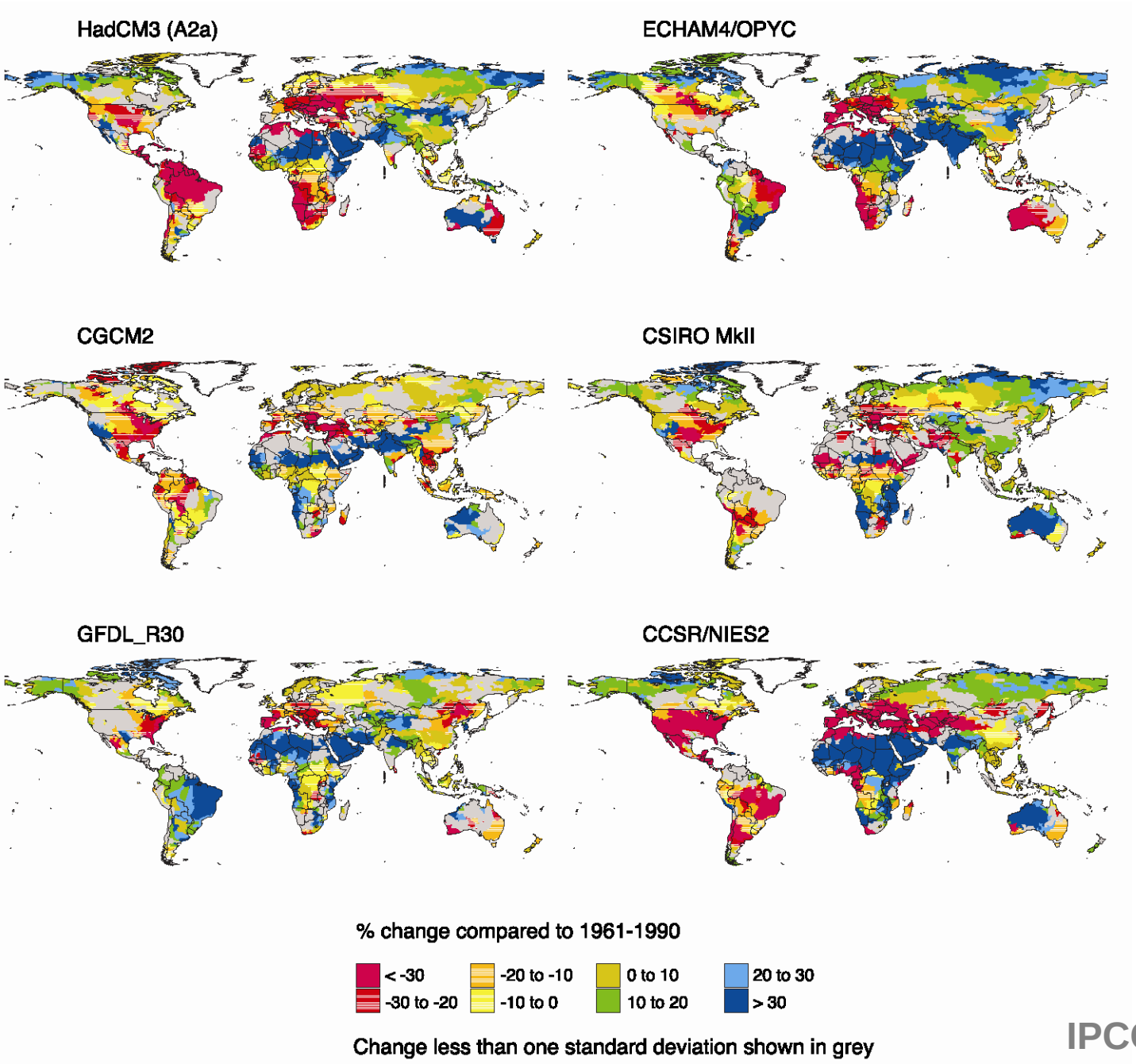
Jackson, 2008


HadCM3 (A2a)
ECHAM4/OPYC
CGCM2
CSIRO MkII
GFDL_R30
CCSR/NIES2
% change compared to 1961-1990
< -30
-30 to -20
-20 to -10
-10 to 0
0 to 10
10 to 20
20 to 30
> 30
Change less than one standard deviation shown in grey
IPCC

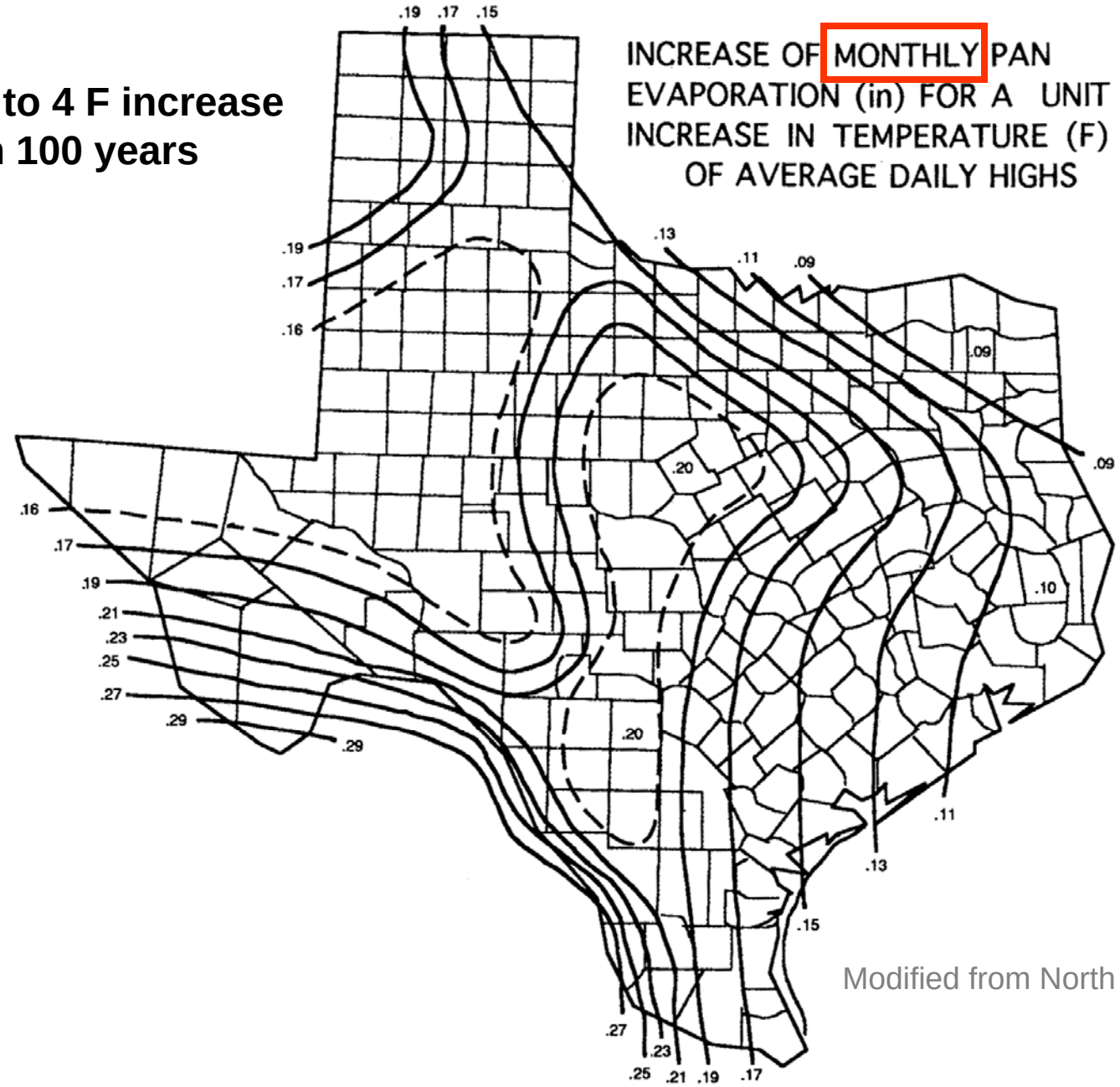
Recharge

- recharge is expected to increase 2 percent worldwide
- recharge in the western US is expected to increase by 30 percent
- recharge in West Texas could increase or decrease by 30 percent

Kundzewicz and others (IPCC), 2007

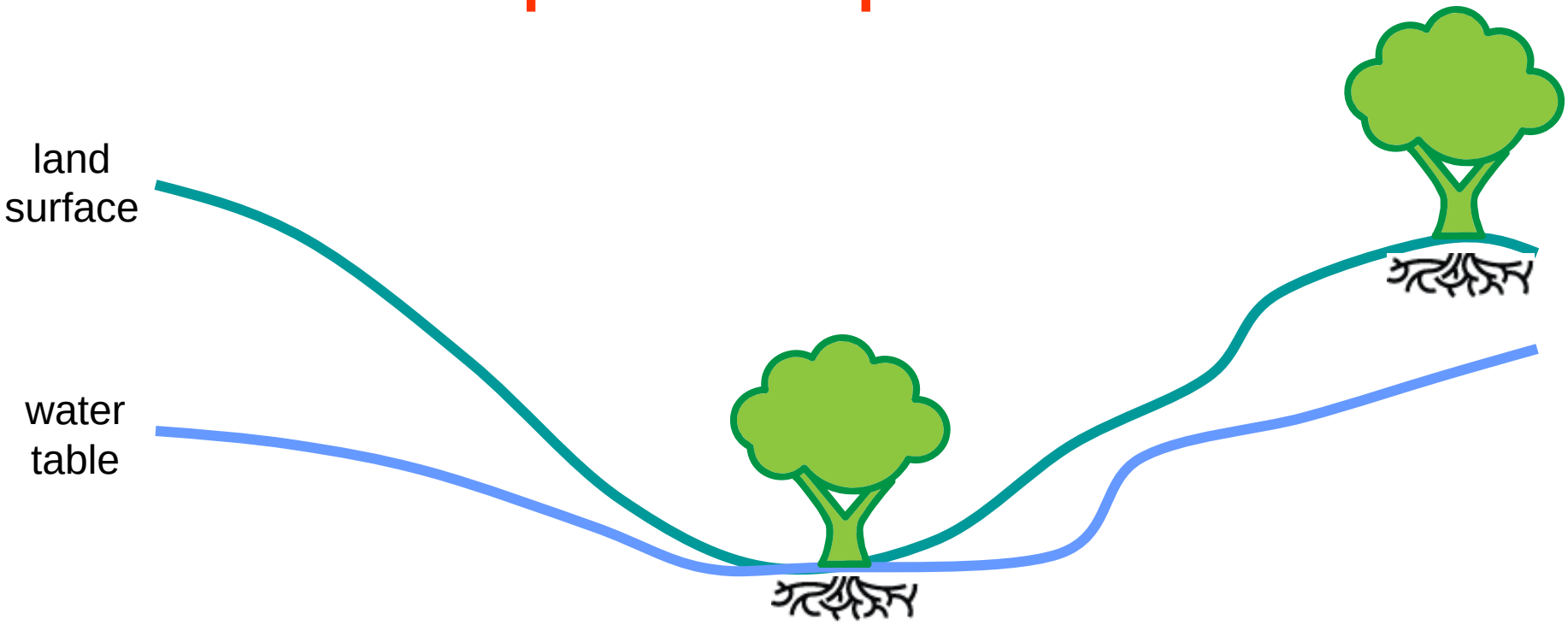
We're 9 kinds of skeptical on these results…
"Just like politics, all recharge is local."

3 to 4 F increase in 100 years



Modified from North and others (1995)

evapotranspiration



An expected overall decrease in evapotranspiration

“Just like recharge, all evapotranspiration is local.”

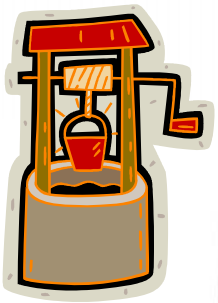
use

- the increase in municipal and industrial use is likely to be less than five percent by the 2050s

  Kundzewicz and others (IPCC), 2007

- for South Central Texas area:
  - 1.5 to 3.5 % increase in municipal demand
  - ~31% increase in irrigation demand

  Chen and others (A&M), 2000



pumping (indirect)

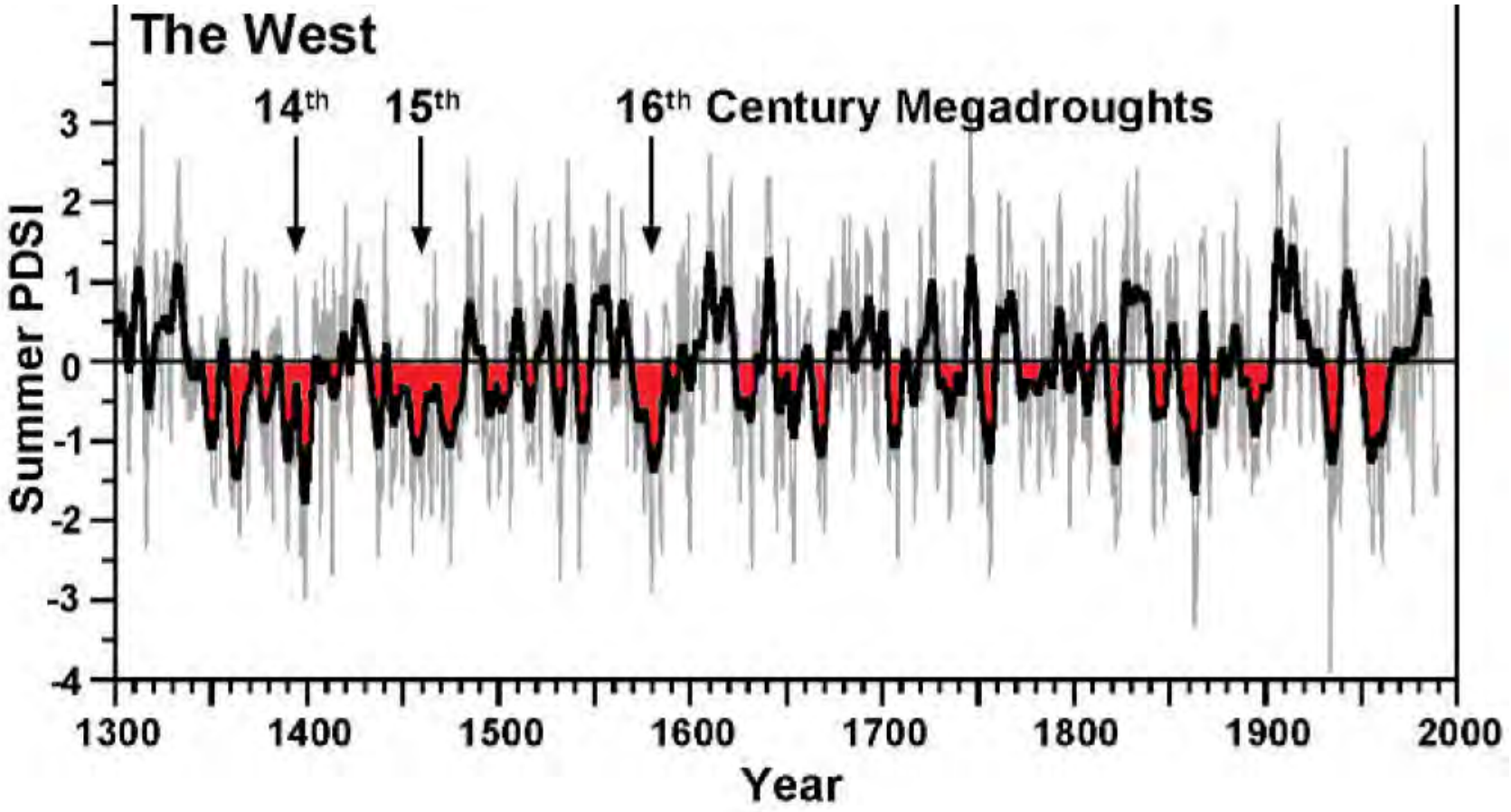
- **overall greater demand for groundwater?**
  - less surface water = more groundwater pumping
  - biofuels = more groundwater pumping
  - Lower CO2 emissions for power plants = more water use
- **pumping of groundwater affects surface water…**

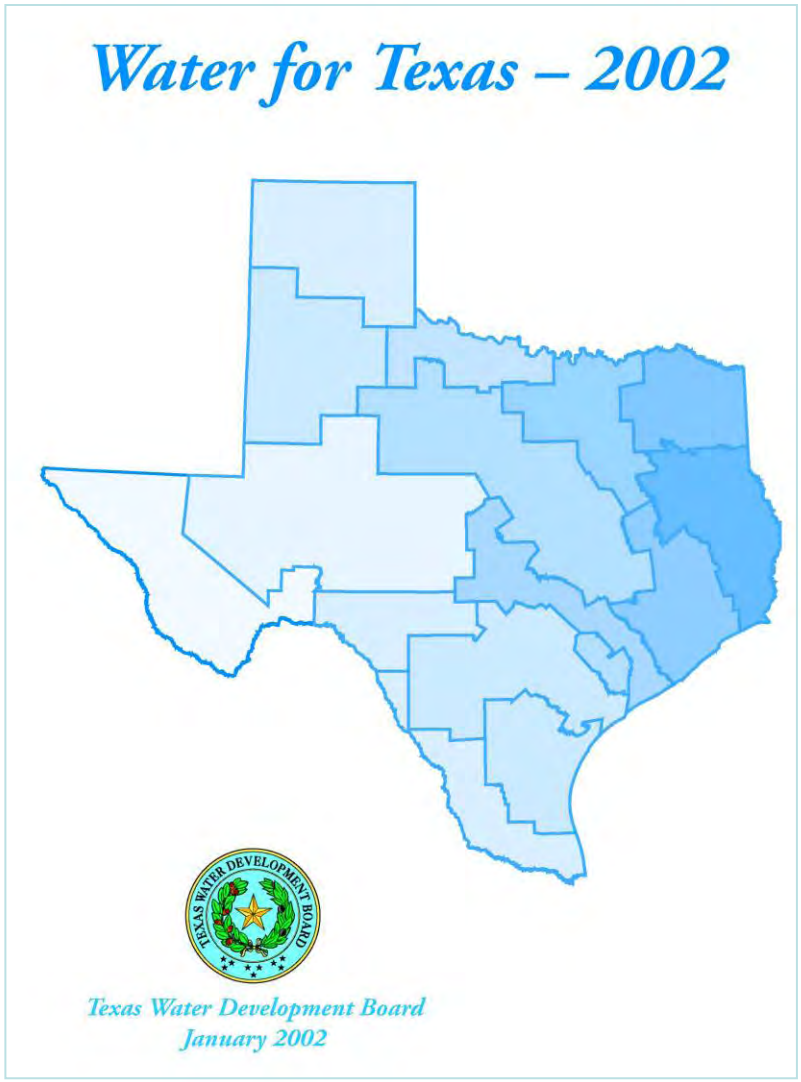
Drought

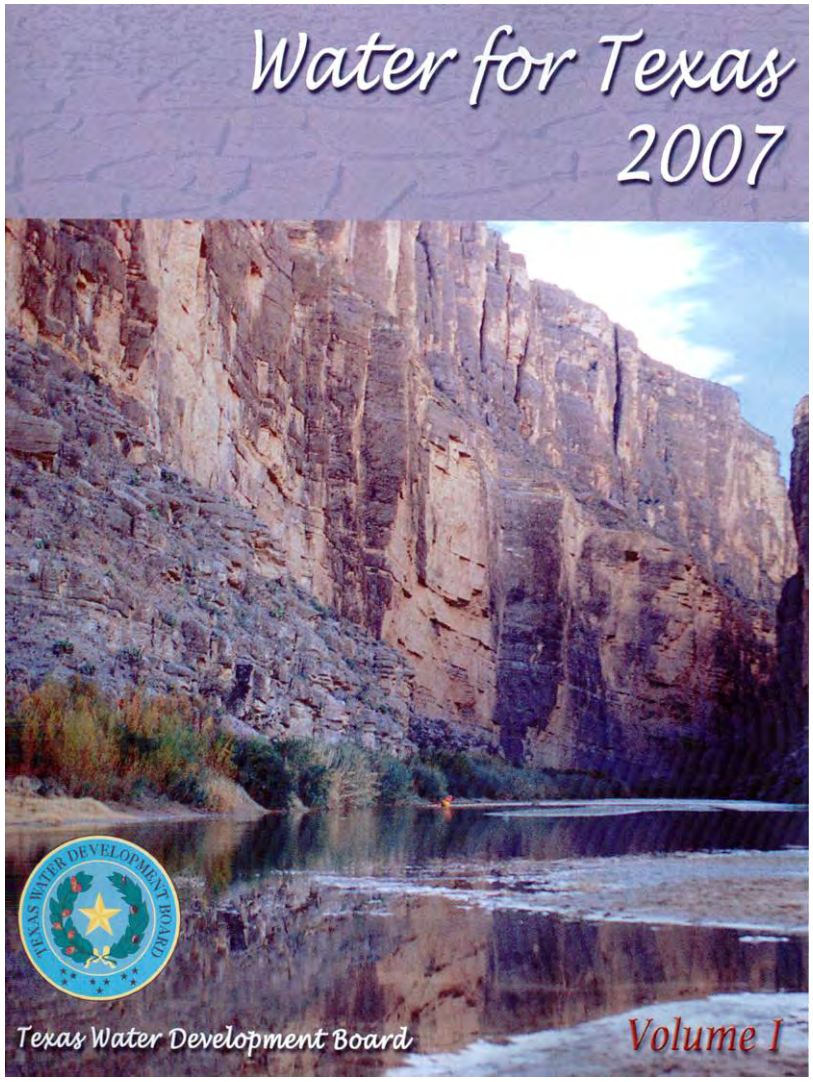
- number of extreme drought events per 100 years are expected to increase 2 to 6 times by the 2090s

Kundzewicz and others (IPCC), 2007

tree rings


The West
14th
15th
16th Century Megadroughts
Summer PDSI
3
2
1
0
-1
-2
-3
-4
1300
1400
1500
1600
1700
1800
1900
2000
Year





Water for Texas 2012…

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Summary

- It gettin’ hot in here
- …and it’s gonna get hotter
- A warmer world will affect our water
- …but there’s still a lot to know
- …so we have to be flexible

More about water in Texas

Water in Texas:

www.twdb.state.tx.us

The Aquifer Monitor

Groundwater Resources Division
Texas Water Development Board

Robert E. Mace:

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groundwater resources division