TX Water & GW

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Today's Items

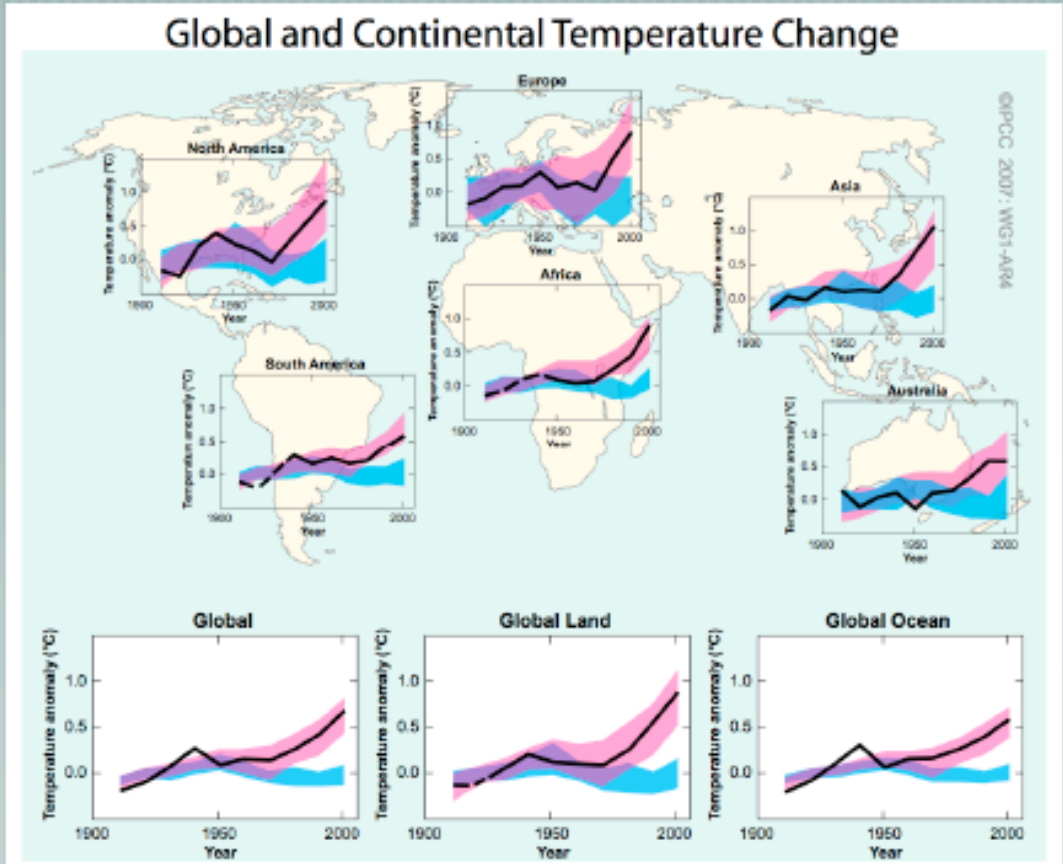
- IPCC and Anthropogenic Global Warming
- Large Scale Changes, Global and Hadley Cell
- Hadley Cell and TX Water
- Is the Dividing Line I35 or I45?

First, some IPCC Results

IPCC 2007:

Understanding and Attributing Climate Change

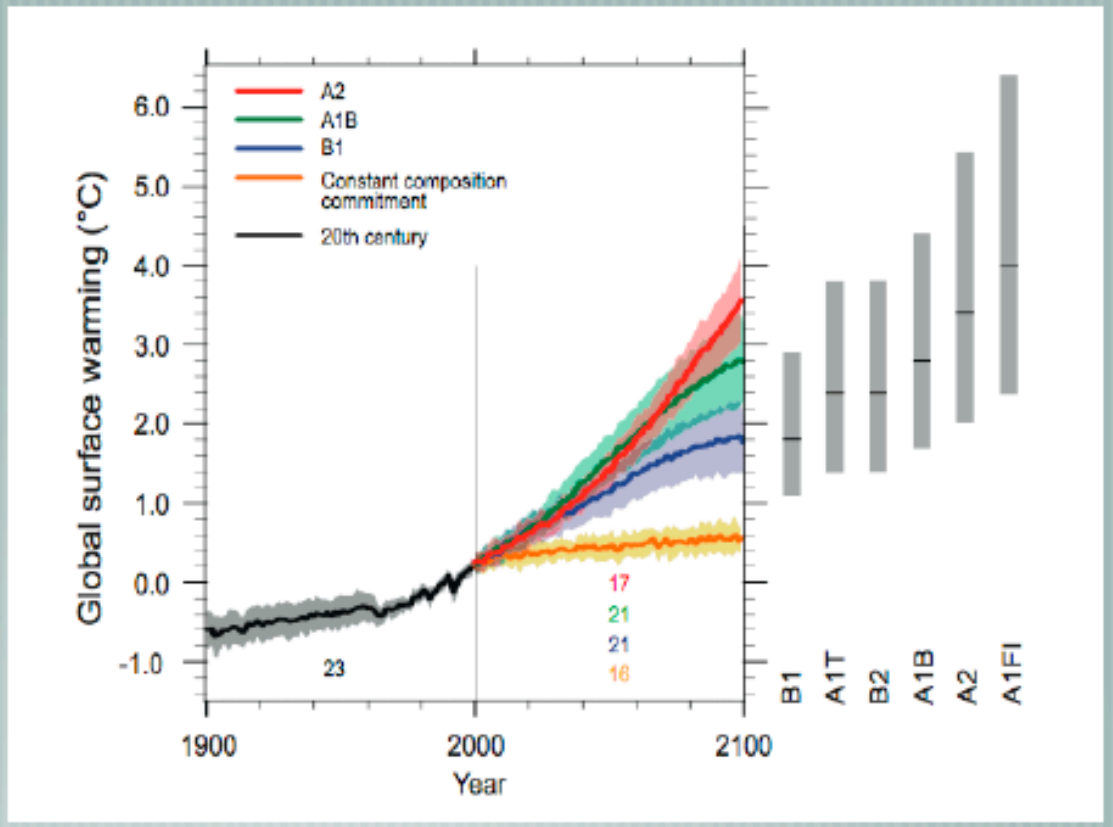
Continental warming *likely* shows a significant anthropogenic contribution over the past 50 years



Projections of Future Changes in Climate

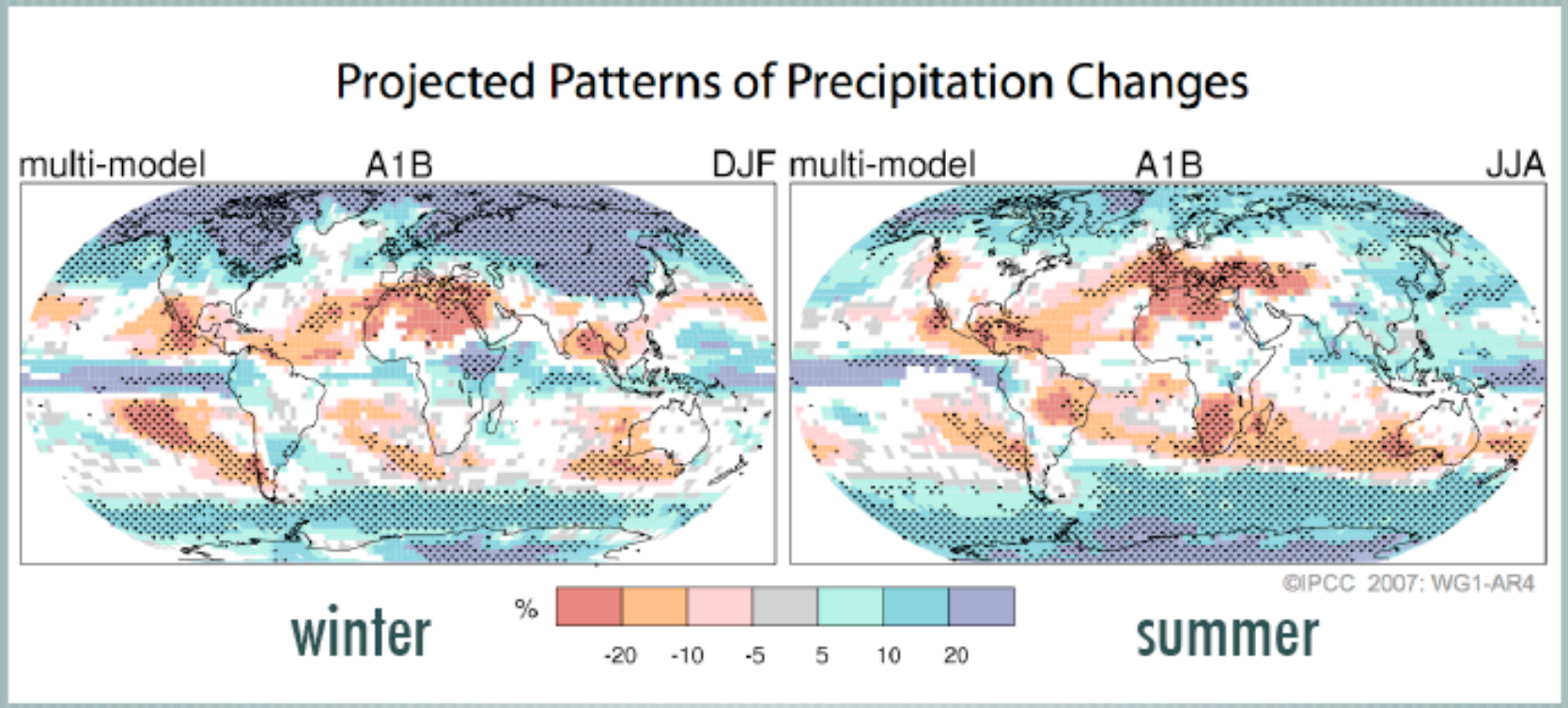
Best estimate for low scenario (B1) is 1.8°C (*likely* range is 1.1°C to 2.9°C), and for high scenario (A1FI) is 4.0°C (*likely* range is 2.4°C to 6.4°C).

Broadly consistent with span quoted for SRES in TAR, but not directly comparable



Rule of thumb: TX temps will be close to global temps

Projections of Future Changes in Climate

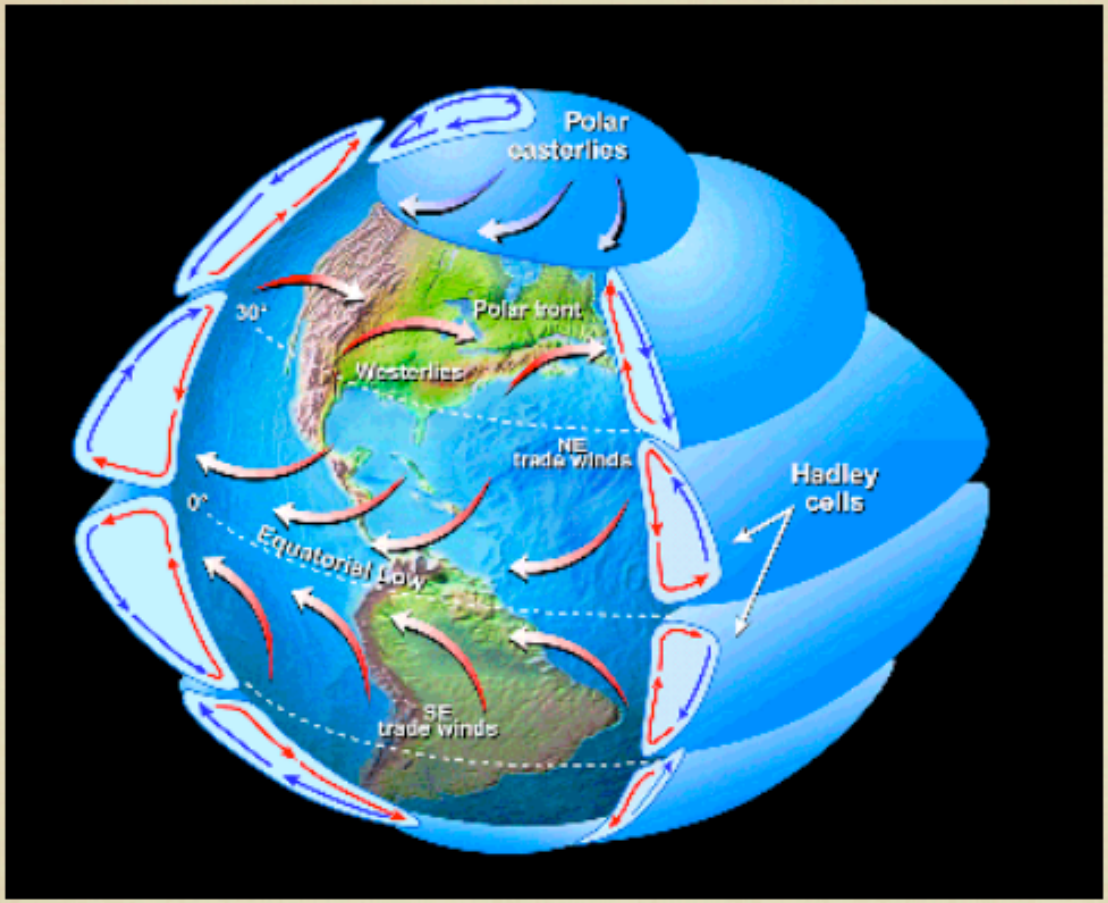


Precipitation increases *very likely* in high latitudes

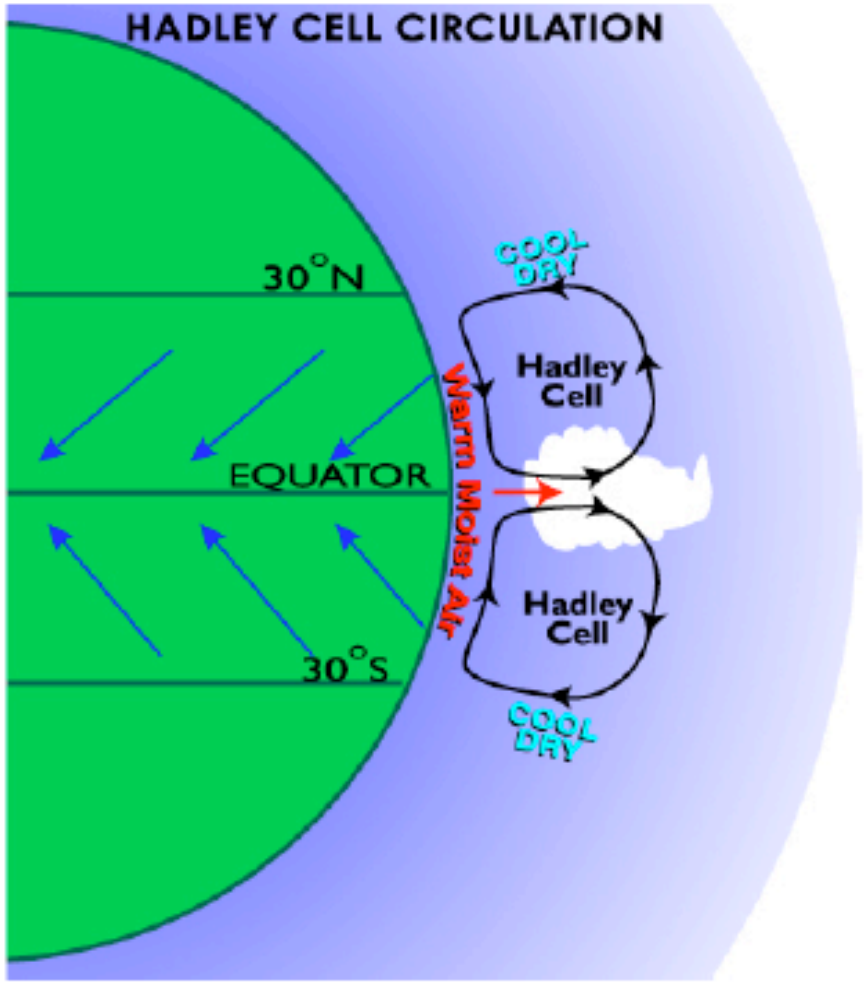
Decreases *likely* in most subtropical land regions

The Hadley Cell

Schematic of Global Circulation

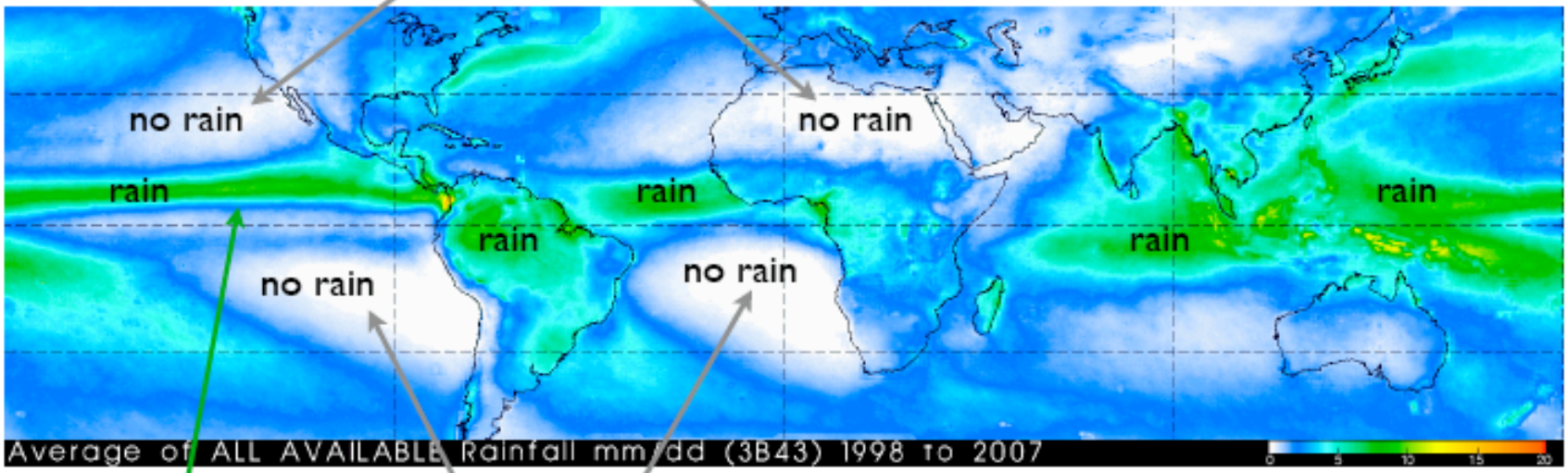


schematic of the Hadley Cell



Annual Average Rainfall from Tropical Rainfall Measuring Mission (TRMM): Present Climate

sinking air

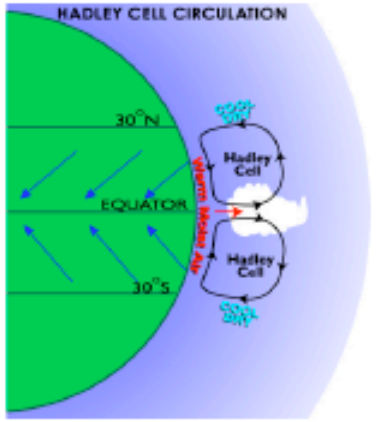


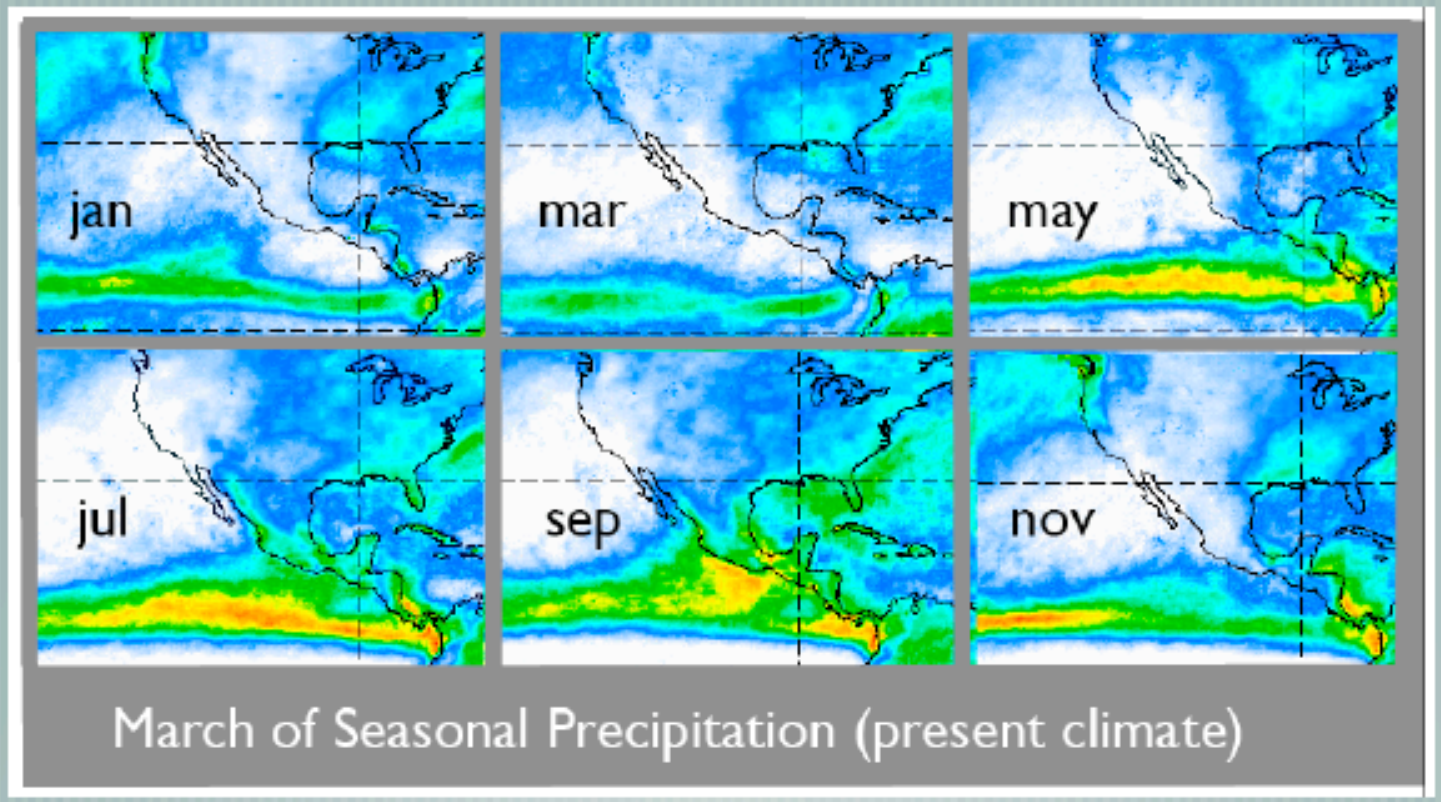
rising air

sinking air

Most white areas are in the Descending Branch of the Hadley Cell (dry)

Green Areas areas are in the Ascending Branch (rainy)





March of Seasonal Precipitation (present climate)

Recent Studies Supporting the Expansion of the Hadley Cell

Observations:

Historical trends in the jet streams

Cristina L. Archer[1] and Ken Caldeira[1]

Received 12 February 2008; revised 10 March 2008; accepted 14 March 2008; published 18 April 2008.

GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L08803, doi:10.1029/2008GL033614, 2008

Climate Models (AR4):

A consistent poleward shift of the storm tracks in simulations of 21st century climate

2005

Jeffrey H. Yin

ESSL/Climate and Global Dynamics Division, National Center for Atmospheric Research, Boulder, Colorado, USA

Received 9 June 2005; revised 12 August 2005; accepted 18 August 2005; published 17 September 2005.

There are many other concurring studies.

Important Recent Paper for US SW Moisture

Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America

2007

Richard Seager,[1]* Mingfang Ting,[1] Isaac Held,[2,3] Yochanan Kushnir,[1] Jian Lu,[4] Gabriel Vecchi,[2] Huei-Ping Huang,[1] Nili Harnik,[5] Ants Leetmaa,[2] Ngar-Cheung Lau,[2,3] Cuihua Li,[1] Jennifer Velez,[1] Naomi Naik[1]

How anthropogenic climate change will affect hydroclimate in the arid regions of southwestern North America has implications for the allocation of water resources and the course of regional development. Here we show that there is a broad consensus among climate models that this region will dry in the 21st century and that the transition to a more arid climate should already be under way. If these models are correct, the levels of aridity of the recent multiyear drought or the Dust Bowl and the 1950s droughts will become the new climatology of the American Southwest within a time frame of years to decades.

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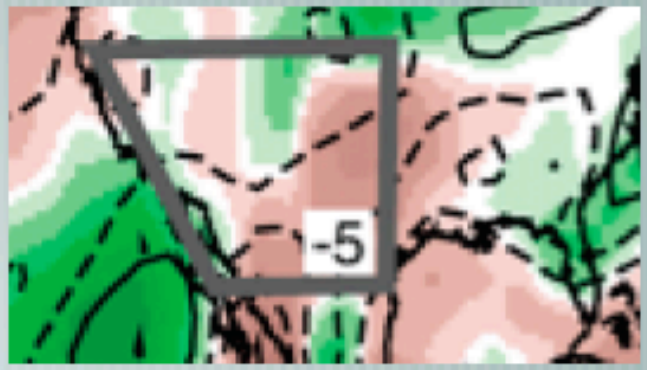
Starting Points in the Study:

"We examined future subtropical drying by analyzing the time history of precipitation in 19 climate models participating in the Fourth Assessment Report (AR4) of the IPCC".

"The future climate projections followed the A1B emissions scenario (4), in which CO2 emissions increase until about 2050 and decrease modestly thereafter, leading to a CO2 concentration of 720 parts per million in 2100".

"The Southwest" (including all land between 125°W and 95°W and 25°N and 40°N) that incorporates the southwestern United States and parts of northern Mexico.



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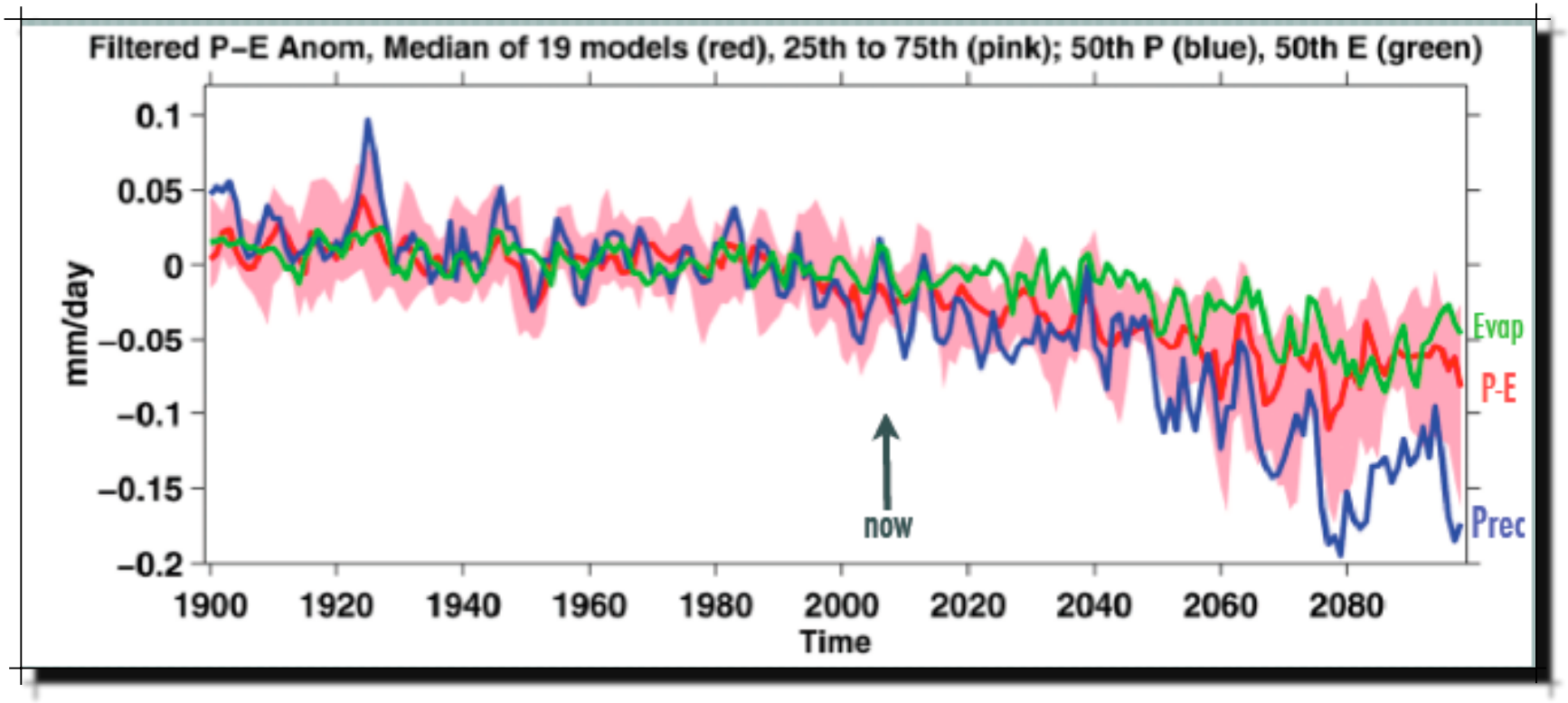
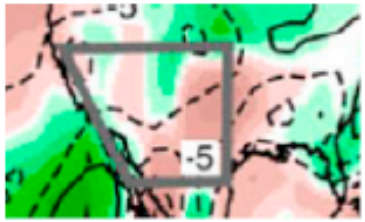

Filtered P–E Anom, Median of 19 models (red), 25th to 75th (pink); 50th P (blue), 50th E (green)
0.1
0.05
0
–0.05
–0.1
–0.15
–0.2
mm/day
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
Time
now
Evap
P-E
Prec

Climate Model Results: Future SW Moisture

Region Included



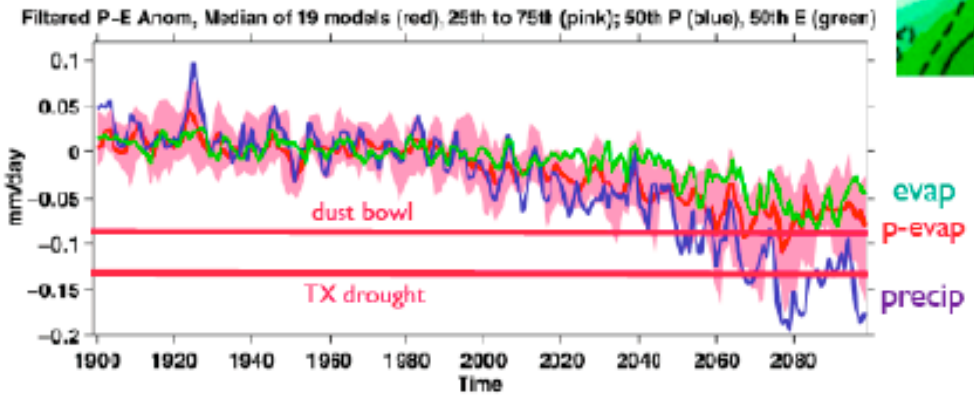


Fig. 1. Modeled changes in annual mean precipitation minus evaporation over the American Southwest (125°W to 95°W and 25°N to 40°N, land areas only), averaged over ensemble members for each of the 19 models. The historical period used known and estimated climate forcings, and the projections used the SResA1B emissions scenario. The median (red line) and 25th and 75th percentiles (pink shading) of the $P - E$ distribution among the 19 models are shown, as are the ensemble medians of P (blue line) and E (green line) for the period common to all models (1900–2098). Anomalies (Anom) for each model are relative to that model's climatology from 1950–2000. Results have been 6-year low-pass Butterworth-filtered to emphasize low-frequency variability that is of most consequence for water resources. The model ensemble mean $P - E$ in this region is around 0.3 mm/day.

SEAGER et al., *Science*, 2007

BOTTOM LINE: MUCH LESS WATER IN THE SOUTHWEST

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A Few Texas Results

(but see later talks by Nielsen-Gammon and Jackson)

20th Century Trends in Precipitation

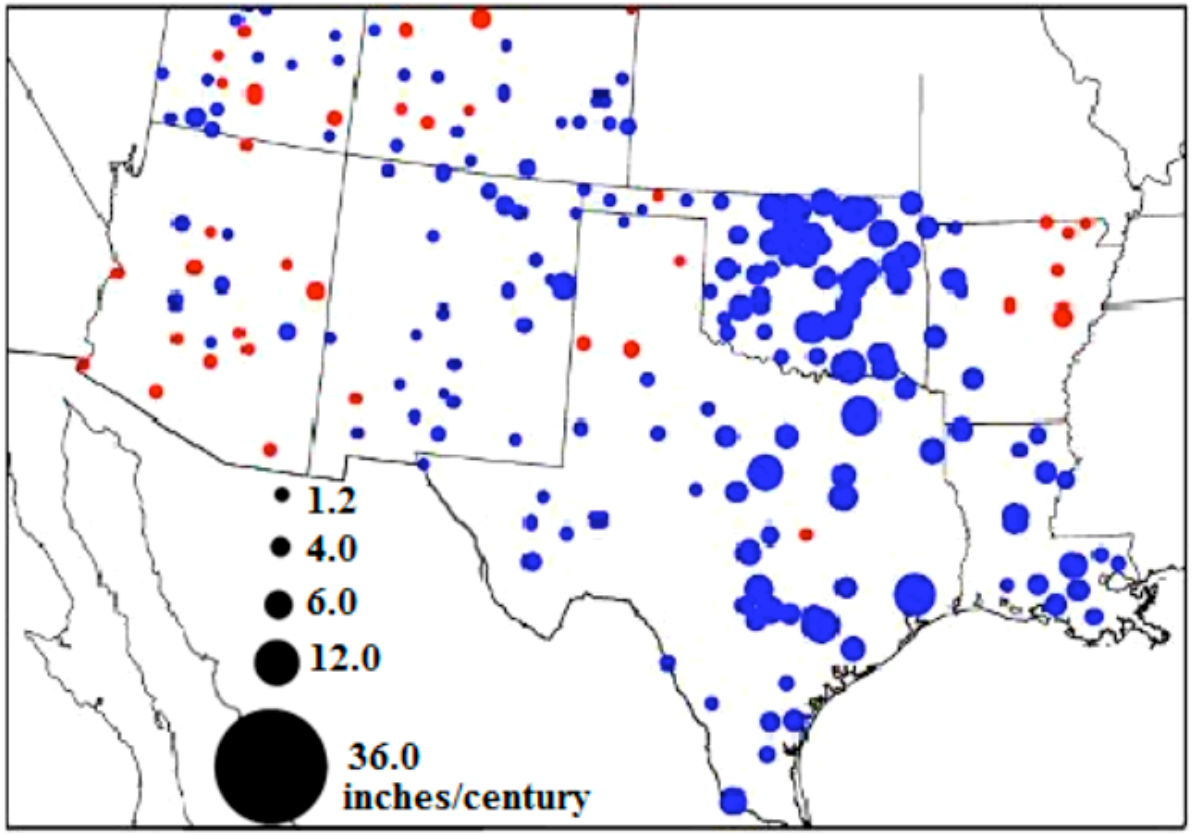


FIG 9.3. Dot plot map of precipitation trends over the 20th century using the UIY dataset. The legend refers to the trend in inches per century.

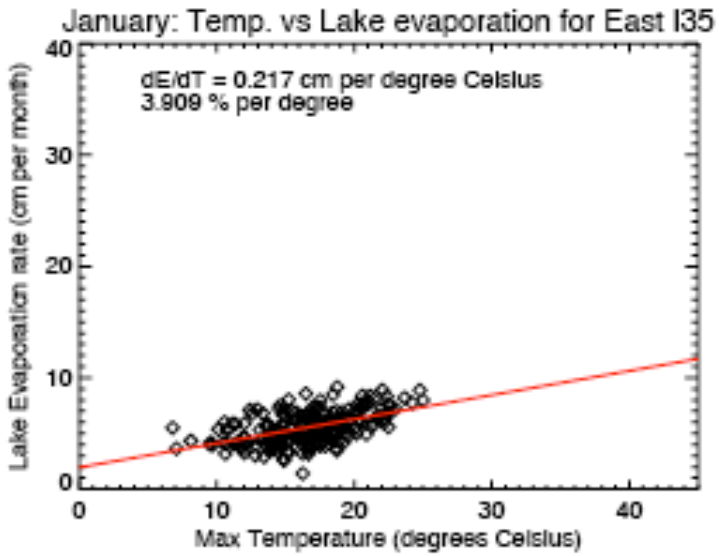
Brent McRoberts, MS Thesis, 2008

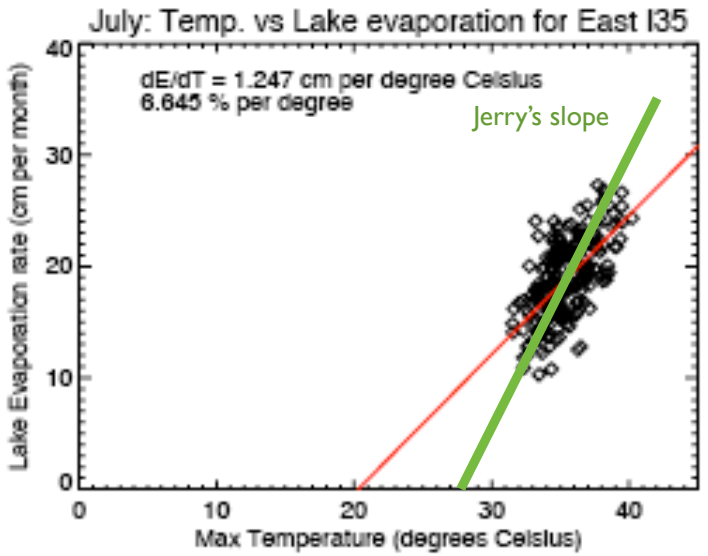
Thanks to Brent McR. & John Nielsen-Gammon

How Does Evaporation Change with Warming?

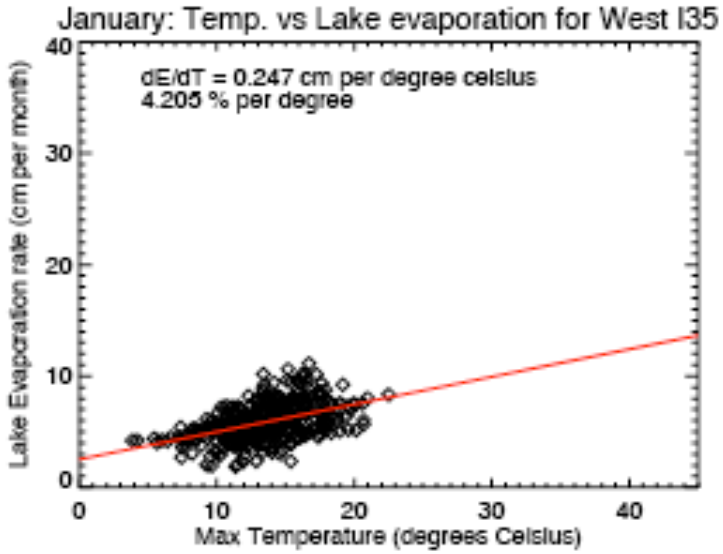
Collaborator: Cody Lockhart (A&M undergrad)

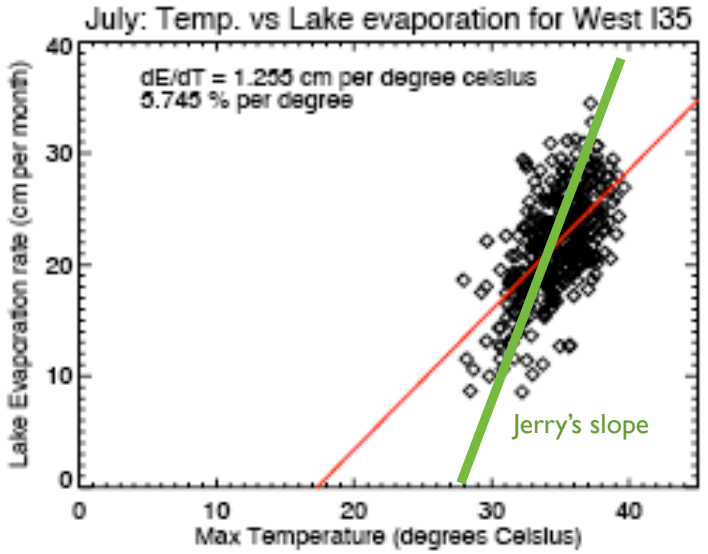
Clausius-Clapeyron gives 7%/deg C





Ken's slope





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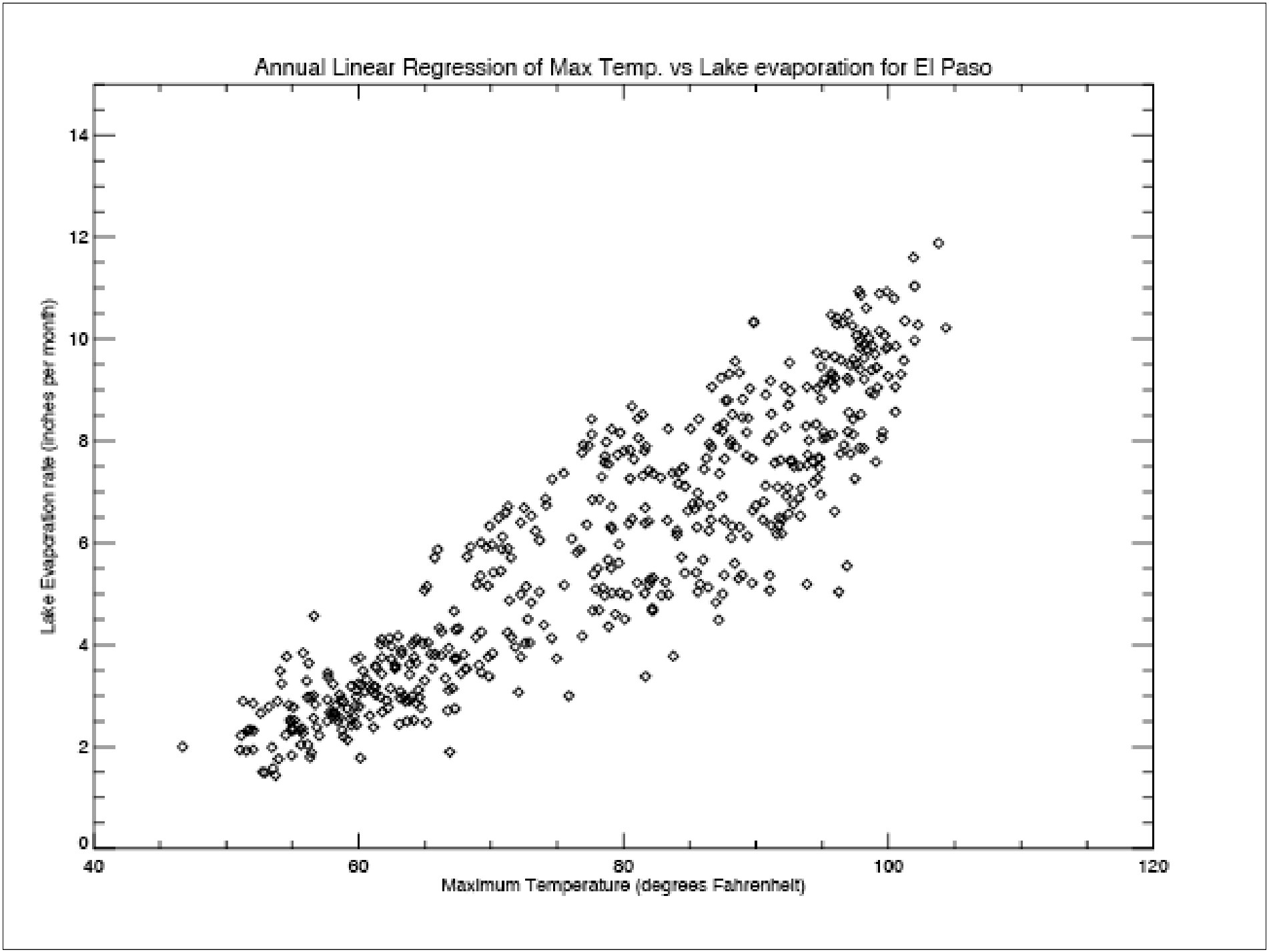
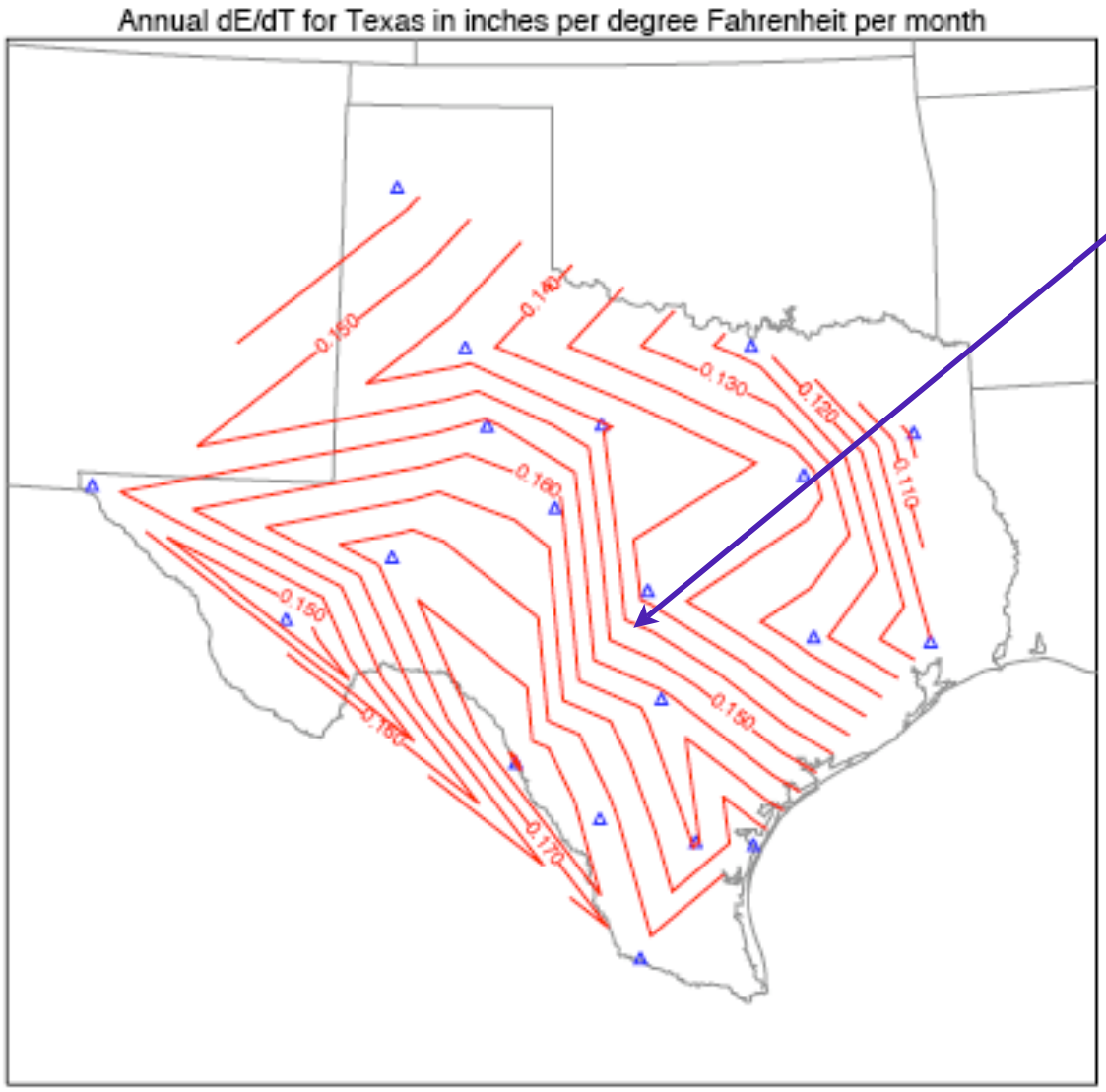

Annual Linear Regression of Max Temp. vs Lake evaporation for El Paso
Lake Evaporation rate (inches per month)
0
2
4
6
8
10
12
14
40
60
80
100
120
Maximum Temperature (degrees Fahrenheit)

dE/dT (inches/mon./deg F)



Austin Example:
0.15in/mon/deg F.
Rain Rate in Aus.
2.5 in/mon

Now, Warm Austin
by 3 deg F

Lake evap rate goes
up by 0.5 in./mon.

Does the tree line
move East?

(Preliminary Results)

Other Factors in Precipitation

*SSTs and Precip (ENSO Cycle, Others)

*Texas: East is East, West is West

*Precip is very hard to model
(different mechanisms, E and W)

*Hurricanes, Sea Level

1. 'Drought of Record': valid benchmark?
2. Climate Models: Believable?
3. Keep your Plans Flexible
4. Take a 'No Regrets' Approach
5. Trust the Scientific Method

Is Texas the Most Vulnerable State?