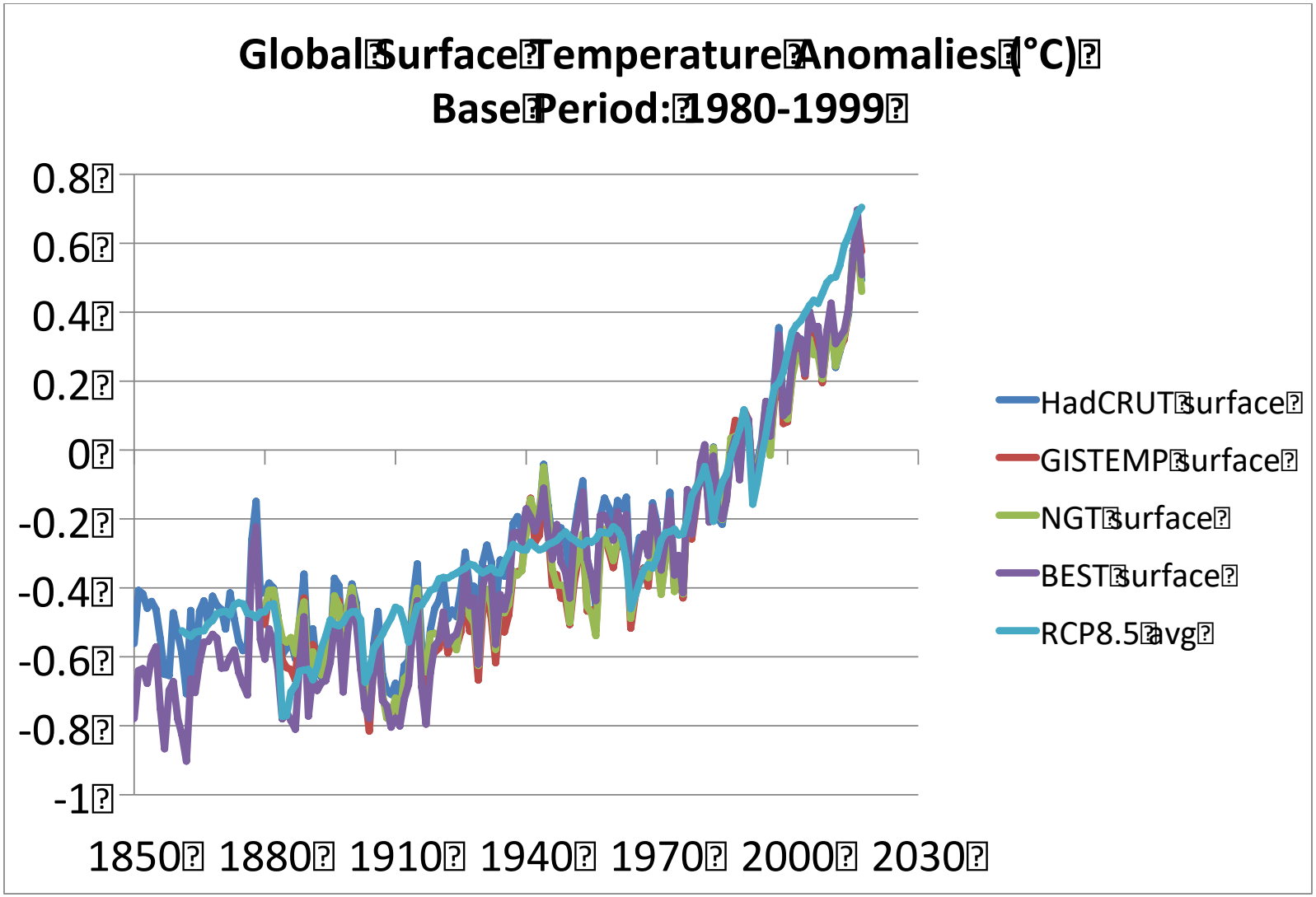
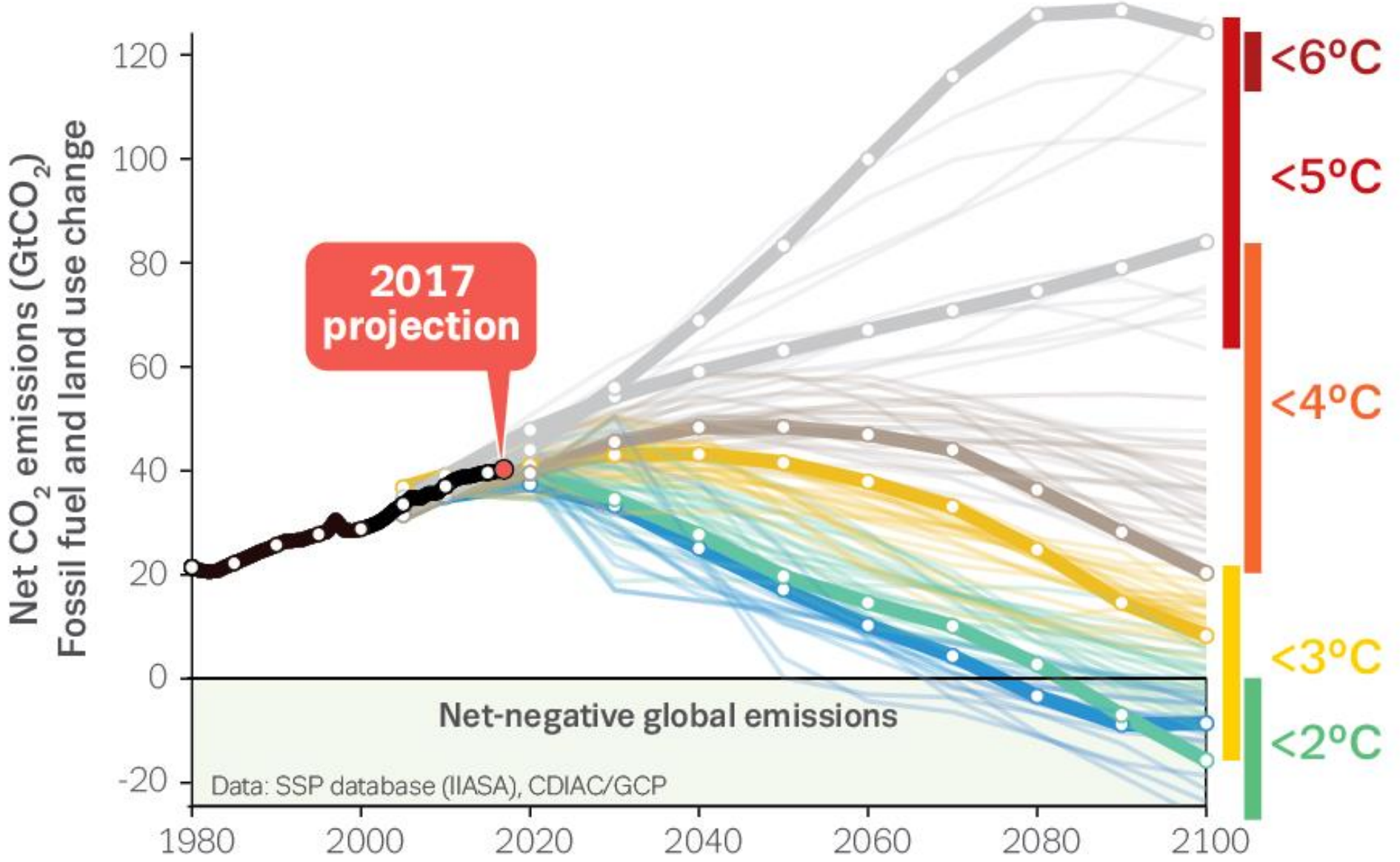
Climate Change, Water, and Texas

John W. Nielsen-Gammon
Texas State Climatologist
Texas A&M University

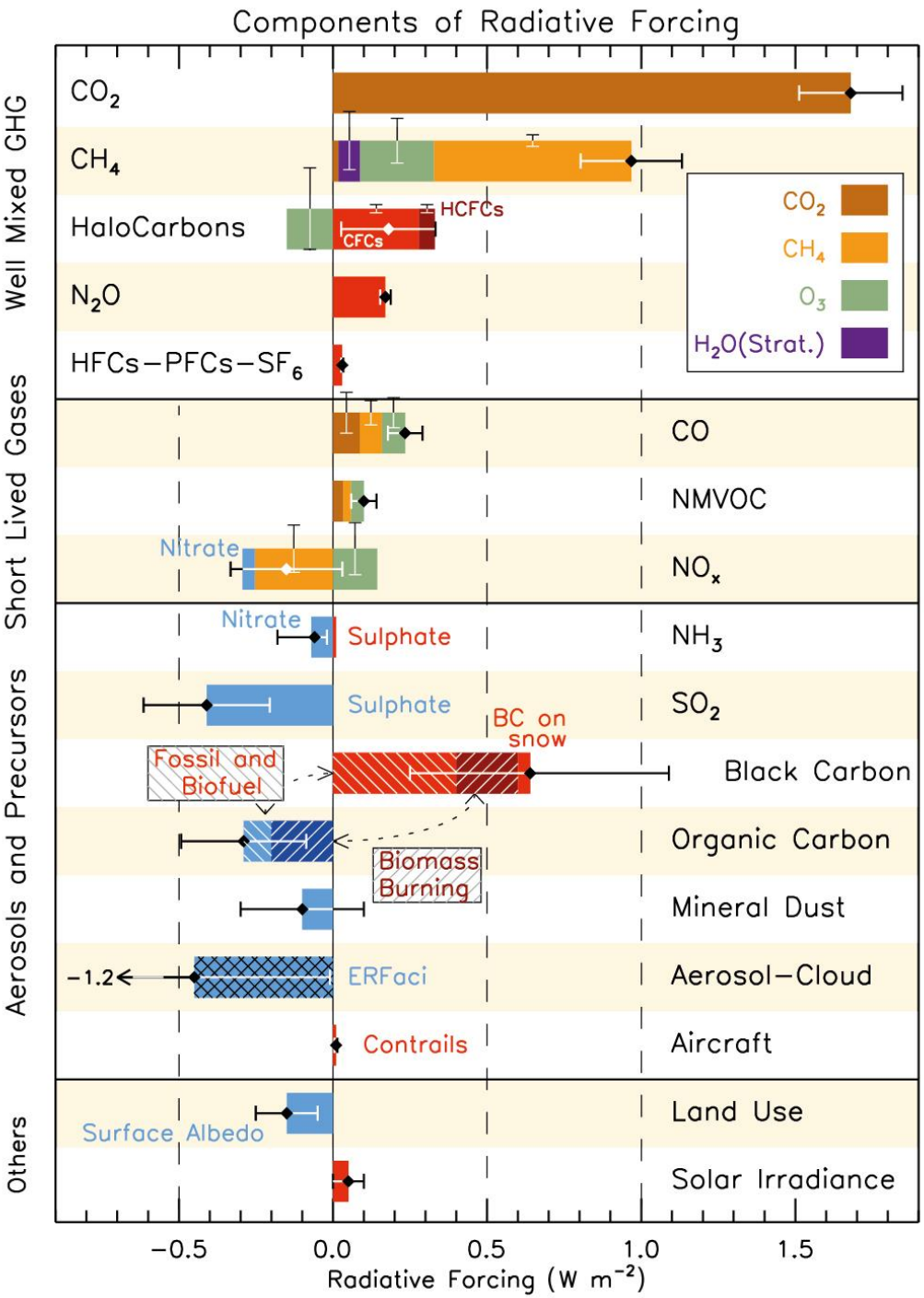

Global Surface Temperature Anomalies (°C)
Base Period: 1980-1999
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
1850 1880 1910 1940 1970 2000 2030
HadCRUT surface
GISTEMP surface
NGT surface
BEST surface
RCP8.5 avg

Future Climate

- What will be in the atmosphere?
- What else will drive global changes?
- How much will that affect the global climate system?
- What are the local consequences?
- What else will happen locally?

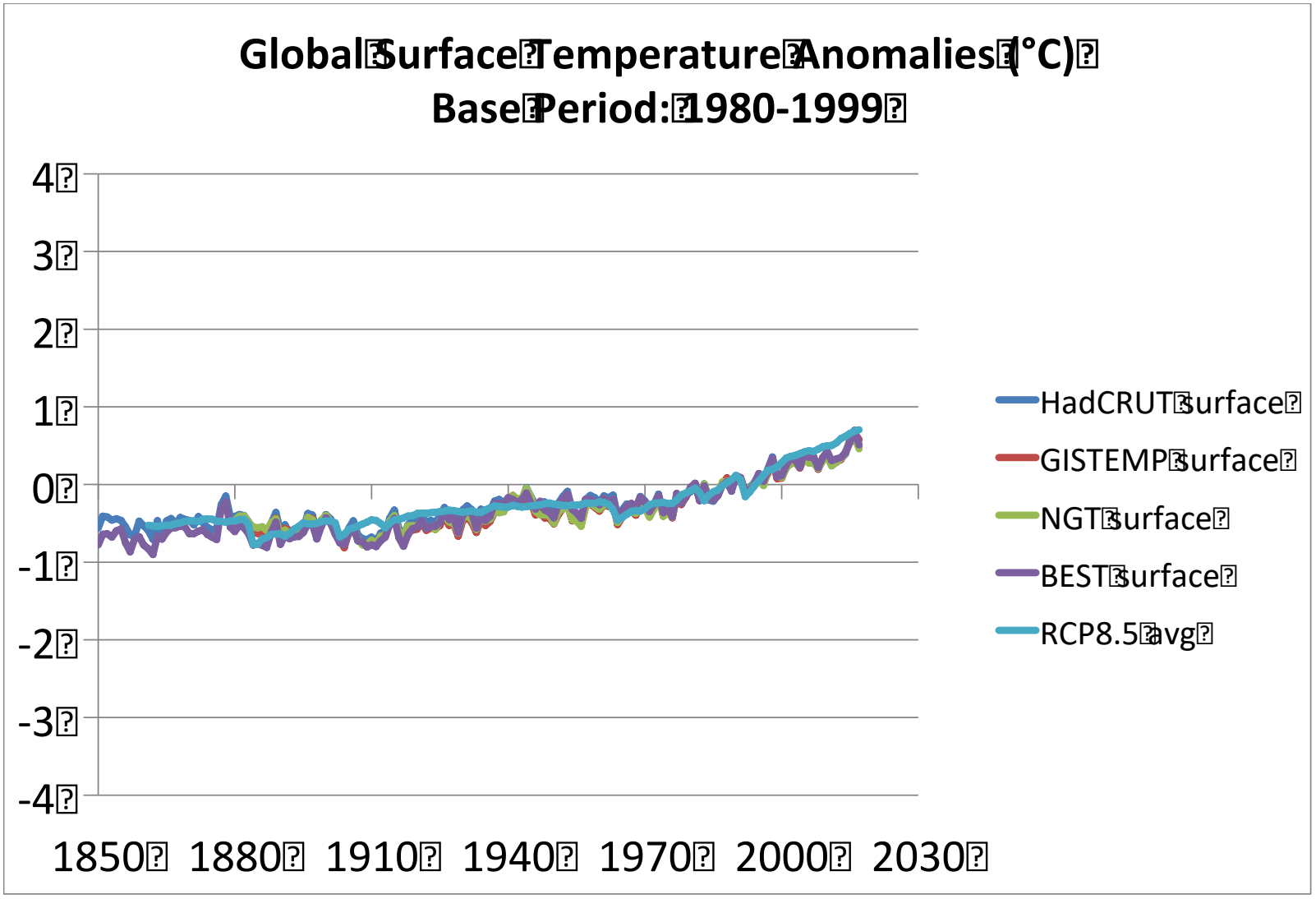


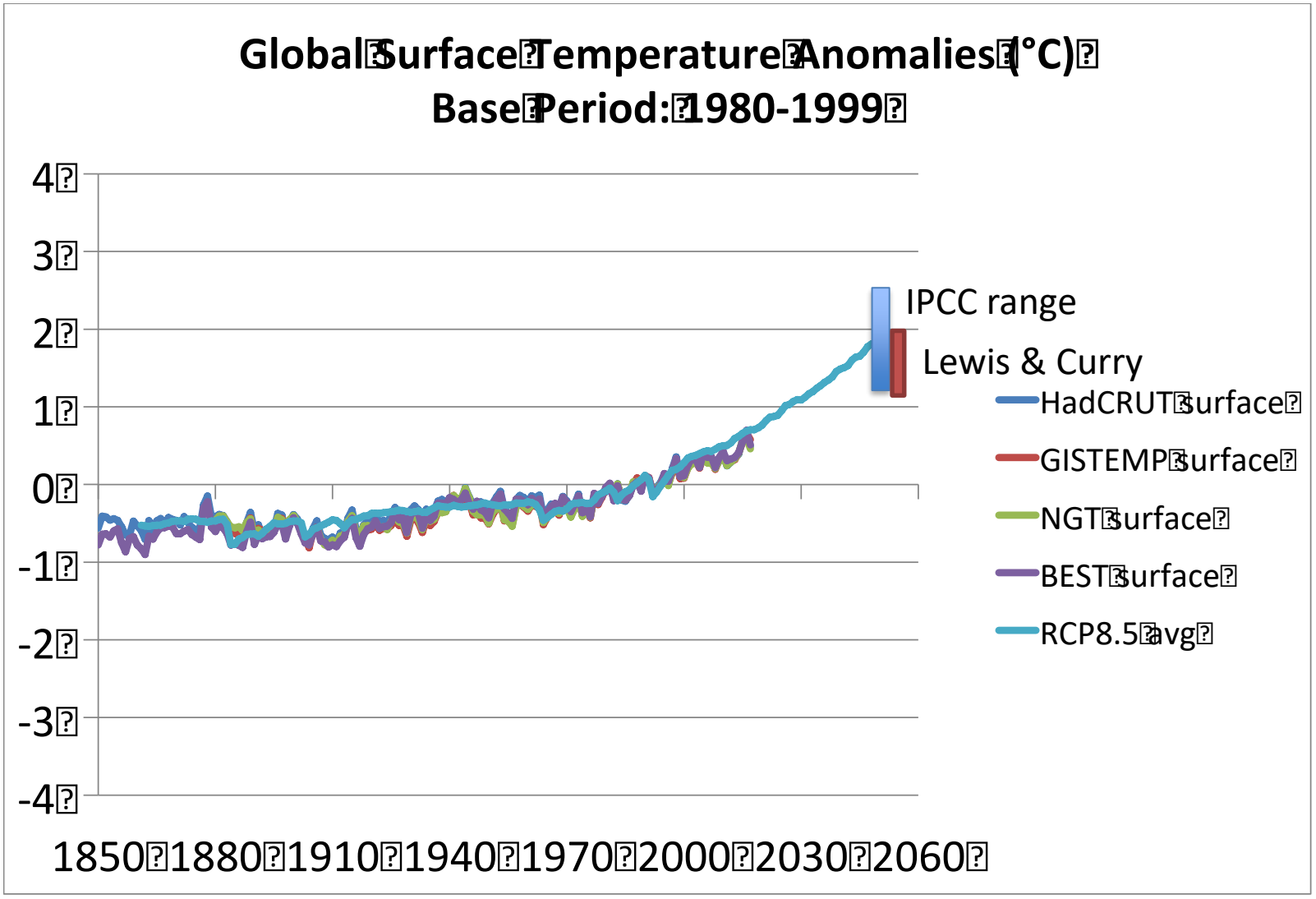
Globalcarbonproject.org



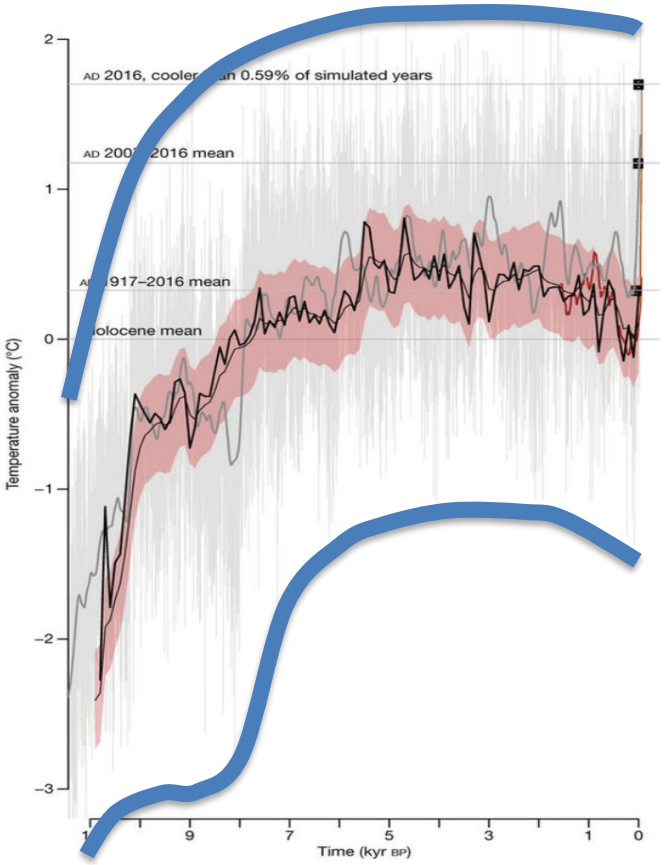
IPCC AR5 WG1
Fig. 8.17

Image: groundtruthtrekking.com

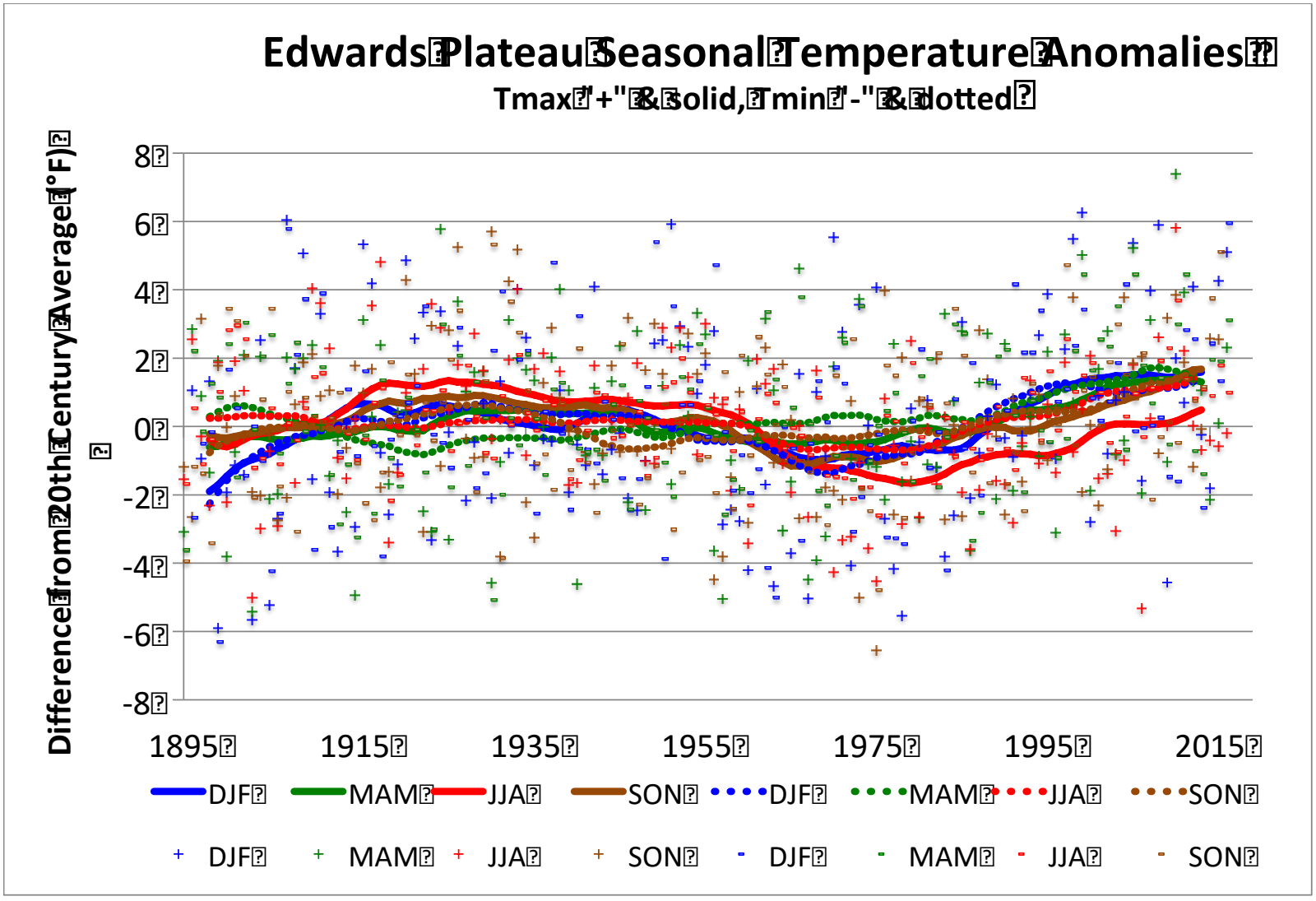

Global Surface Temperature Anomalies (°C)
Base Period: 1980-1999
4
3
2
1
0
-1
-2
-3
-4
1850
1880
1910
1940
1970
2000
2030
HadCRUT surface
GISTEMP surface
NGT surface
BEST surface
RCP8.5 avg

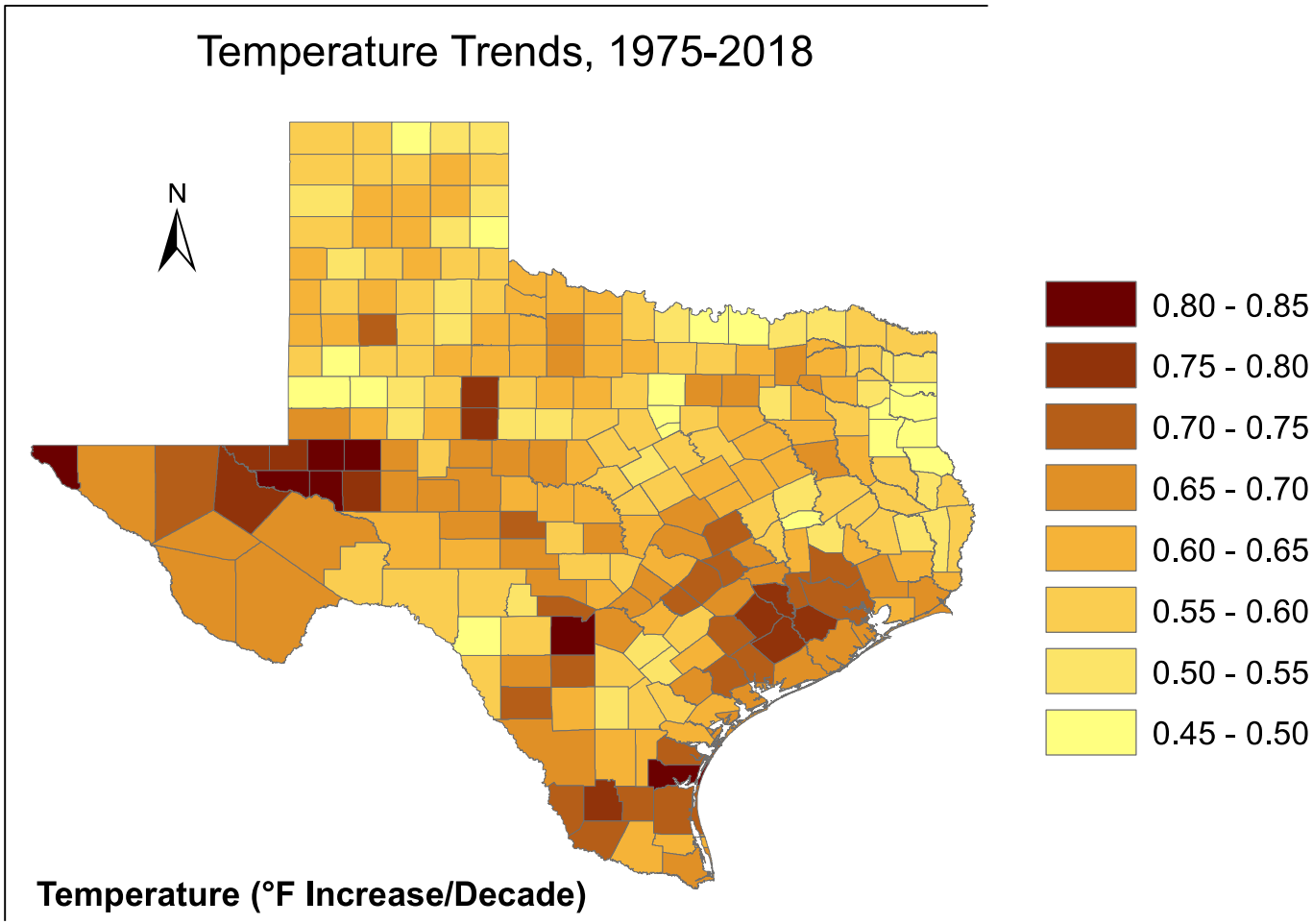

Global Surface Temperature Anomalies (°C)
Base Period: 1980-1999
4
3
2
1
0
-1
-2
-3
-4
1850 1880 1910 1940 1970 2000 2030 2060
IPCC range
Lewis & Curry
HadCRUT surface
GISTEMP surface
NGT surface
BEST surface
RCP8.5 avg

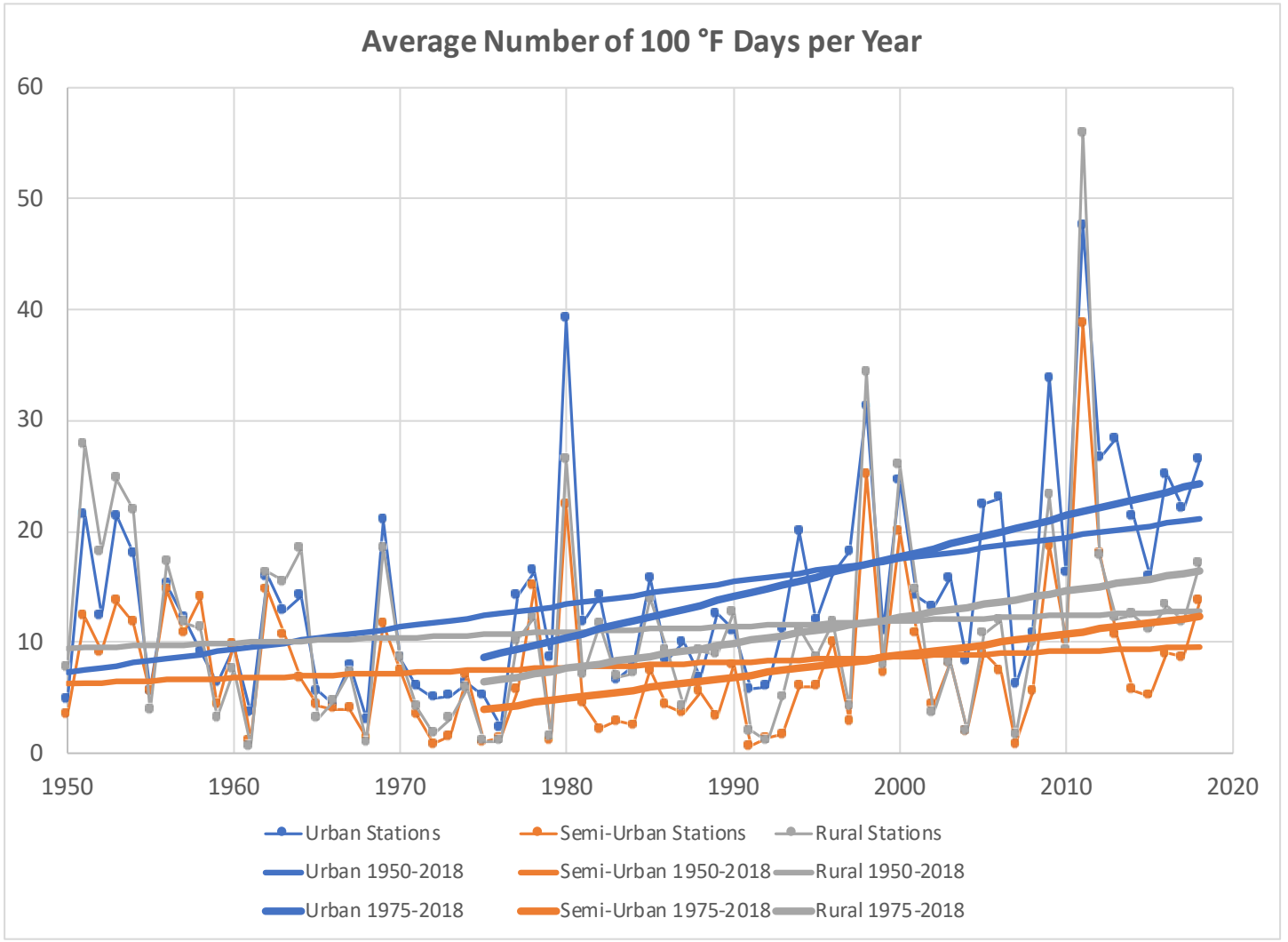
IPCC range, 20-40 years from now



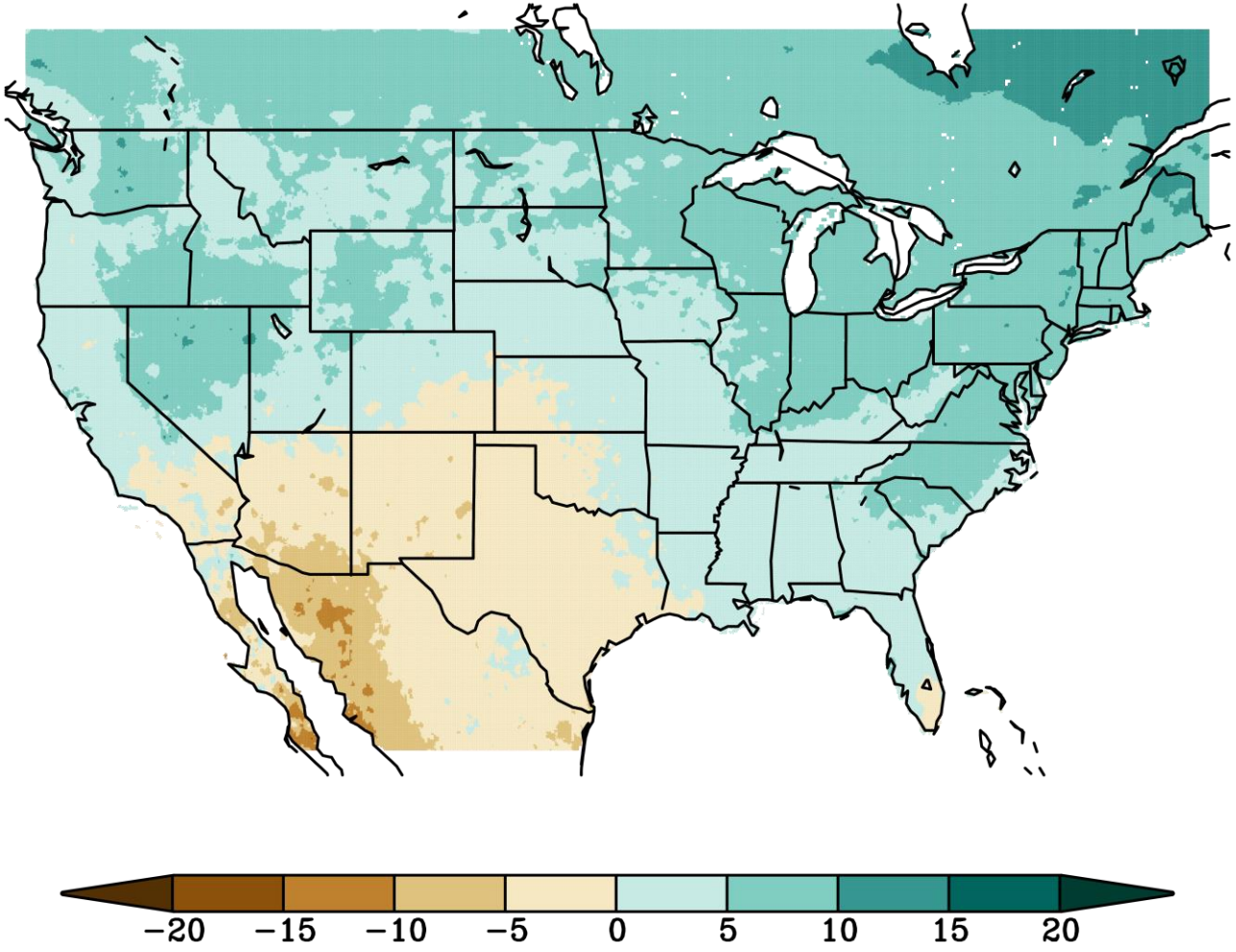
Marsicek et al, 2018, Nature


Edwards Plateau Seasonal Temperature Anomalies
Tmax "+" & solid, Tmin "-" & dotted
Difference from 20th Century Average (°F)
8
6
4
2
0
-2
-4
-6
-8
1895
1915
1935
1955
1975
1995
2015
DJF
MAM
JJA
SON
DJF
MAM
JJA
SON
DJF
MAM
JJA
SON
DJF
MAM
JJA
SON

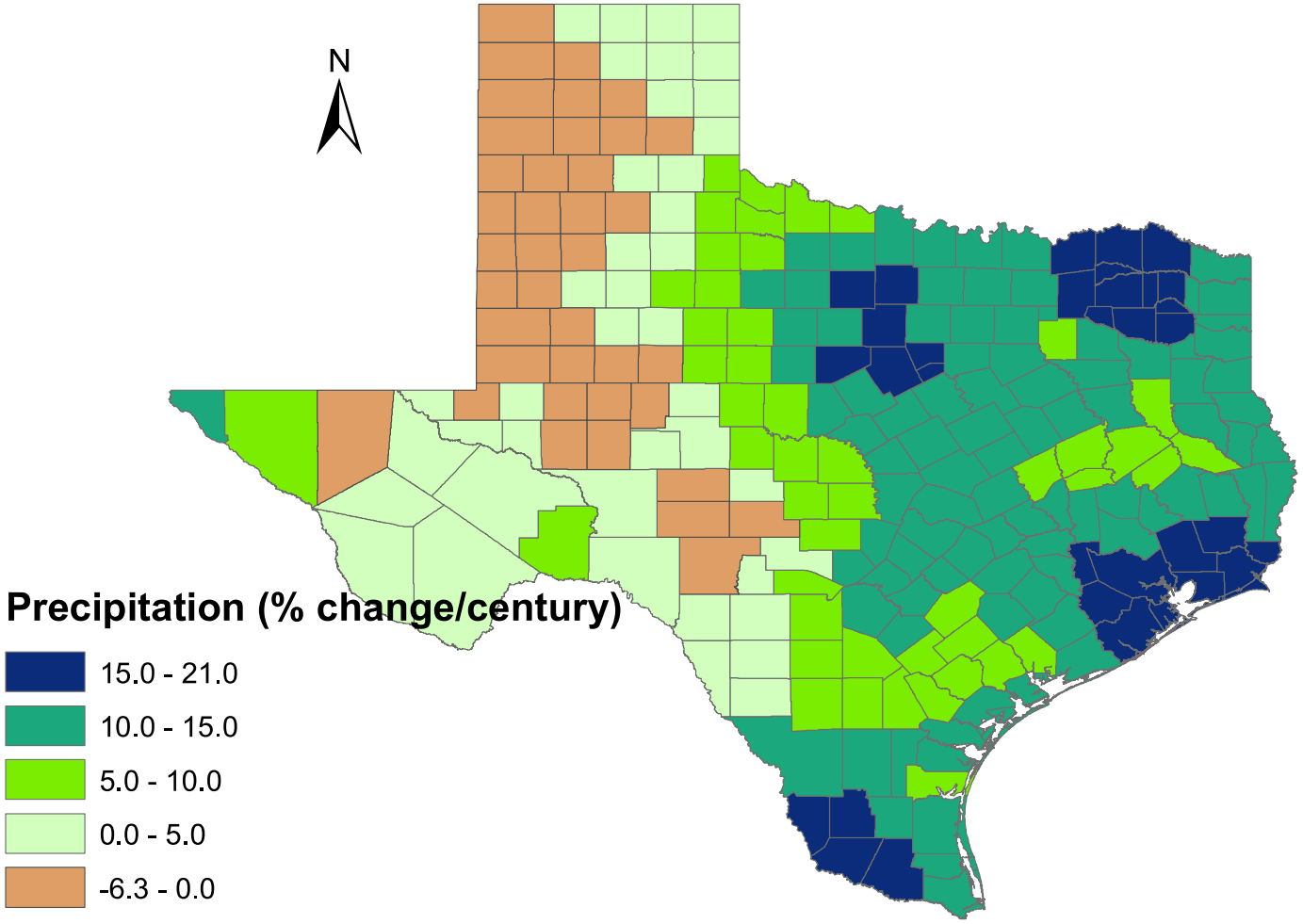

Temperature Trends, 1975-2018
N
0.80 - 0.85
0.75 - 0.80
0.70 - 0.75
0.65 - 0.70
0.60 - 0.65
0.55 - 0.60
0.50 - 0.55
0.45 - 0.50
Temperature (°F Increase/Decade)

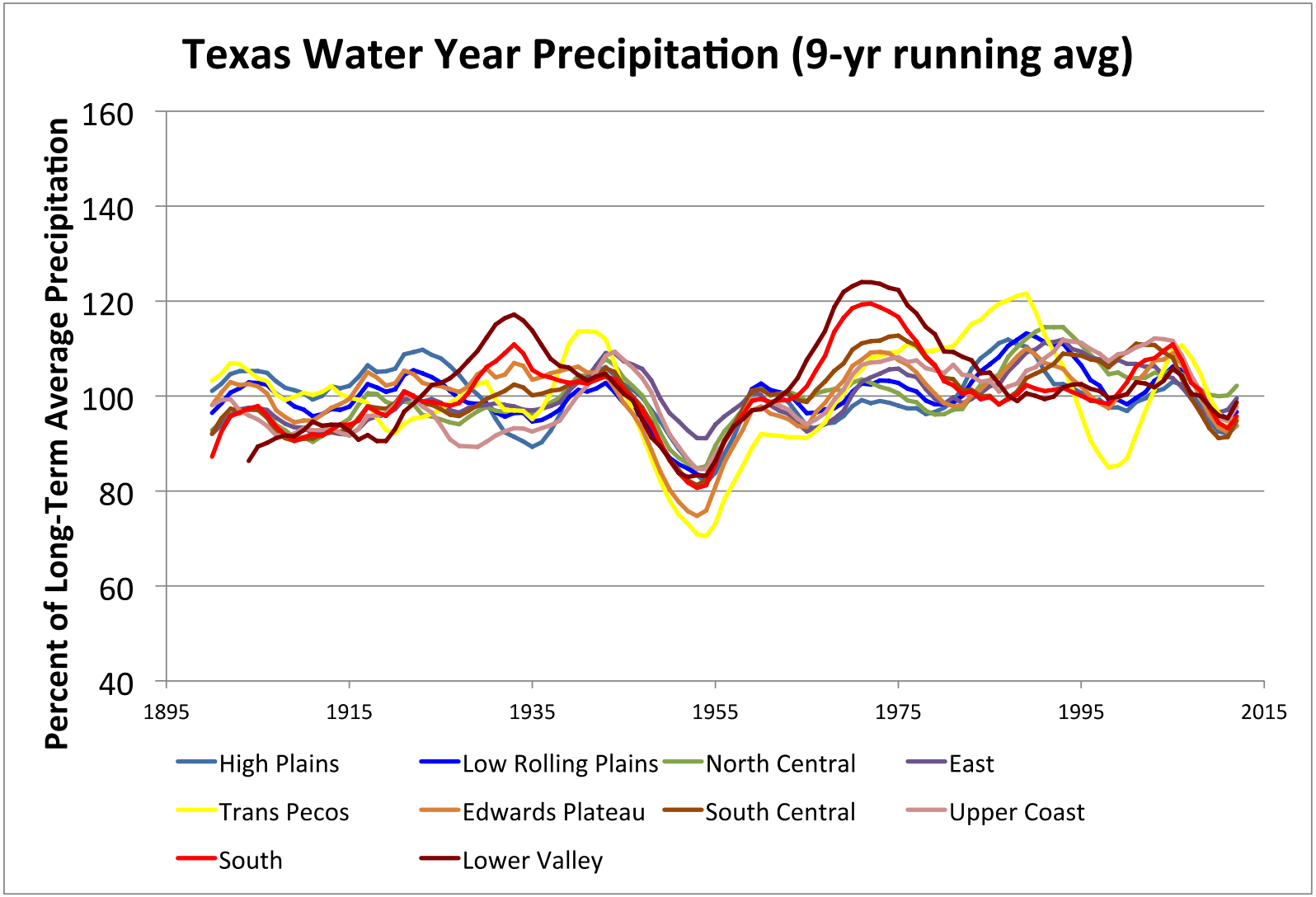

Average Number of 100 °F Days per Year
60
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
2020
Urban Stations
Semi-Urban Stations
Rural Stations
Urban 1950-2018
Semi-Urban 1950-2018
Rural 1950-2018
Urban 1975-2018
Semi-Urban 1975-2018
Rural 1975-2018

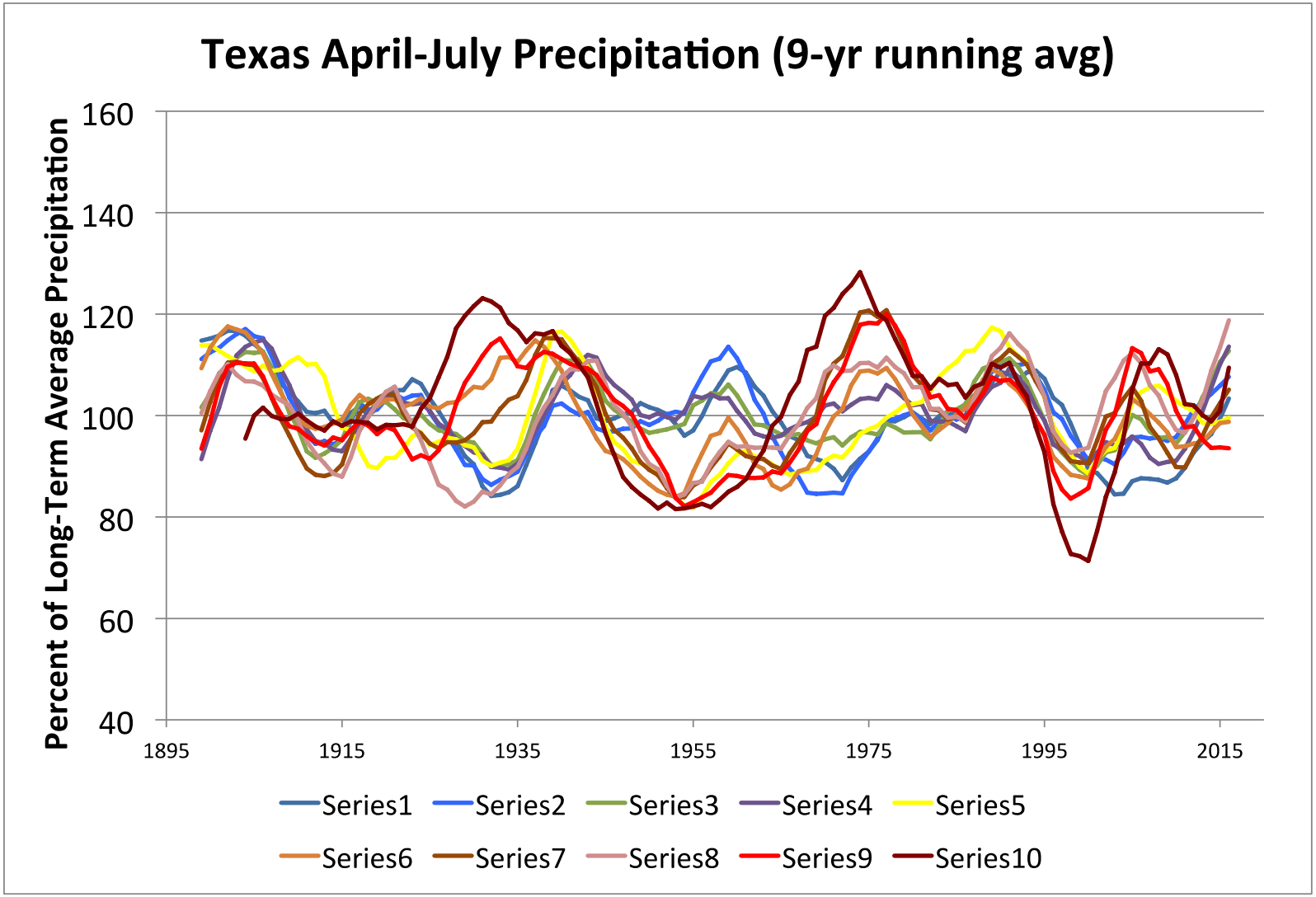
Change (%) in annual total precip by mid 21st century

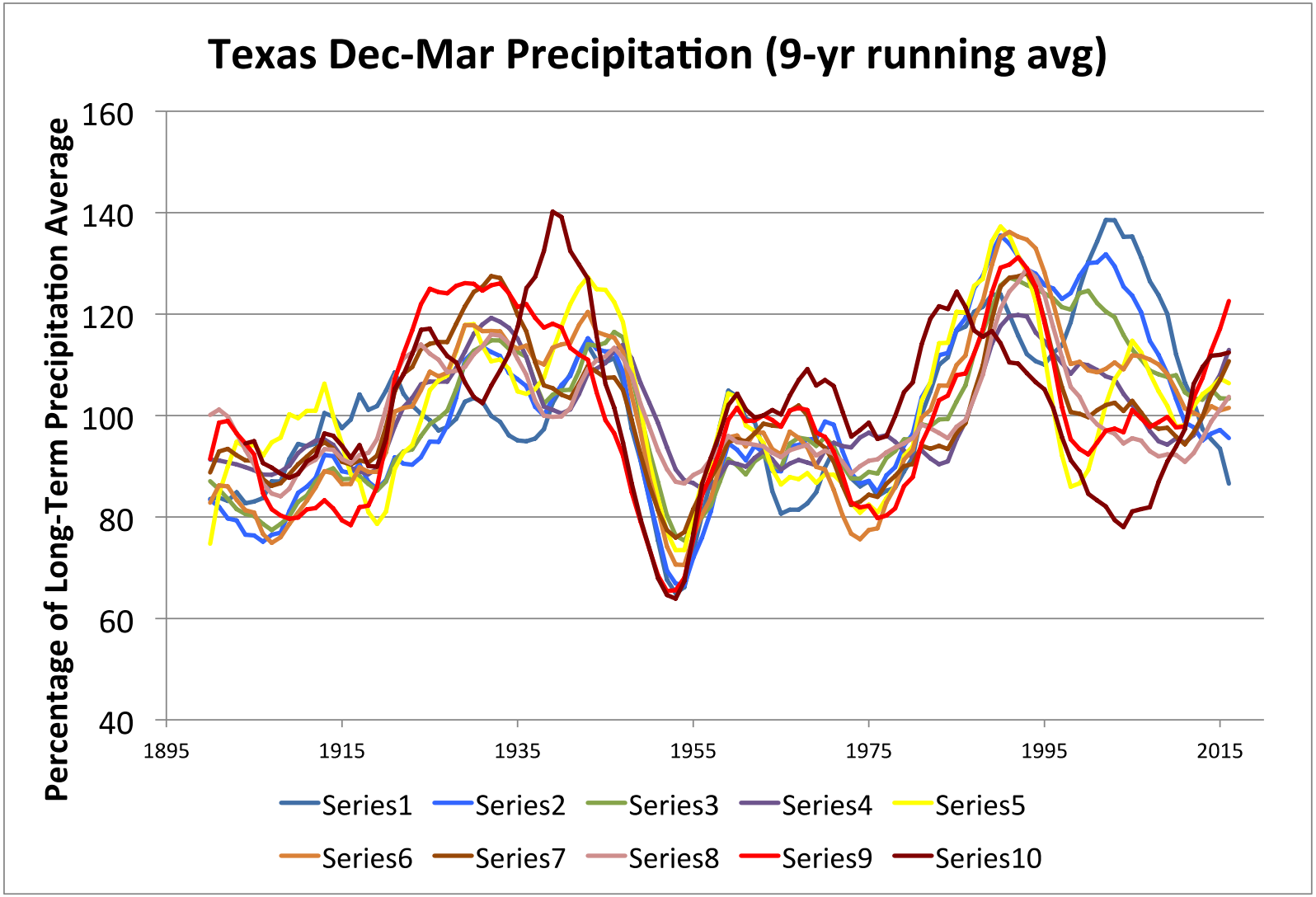


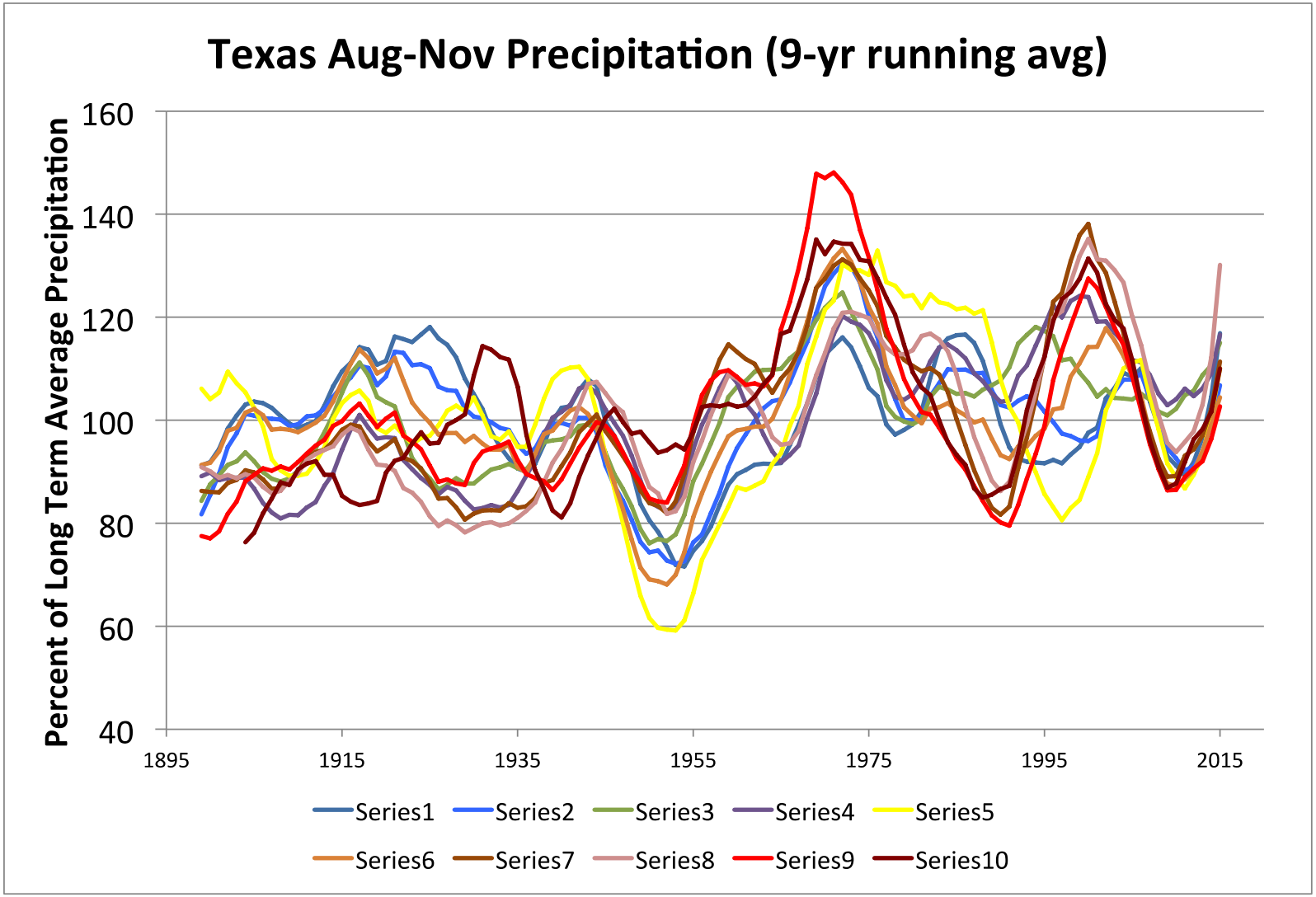
Precipitation Trends, 1895-2018

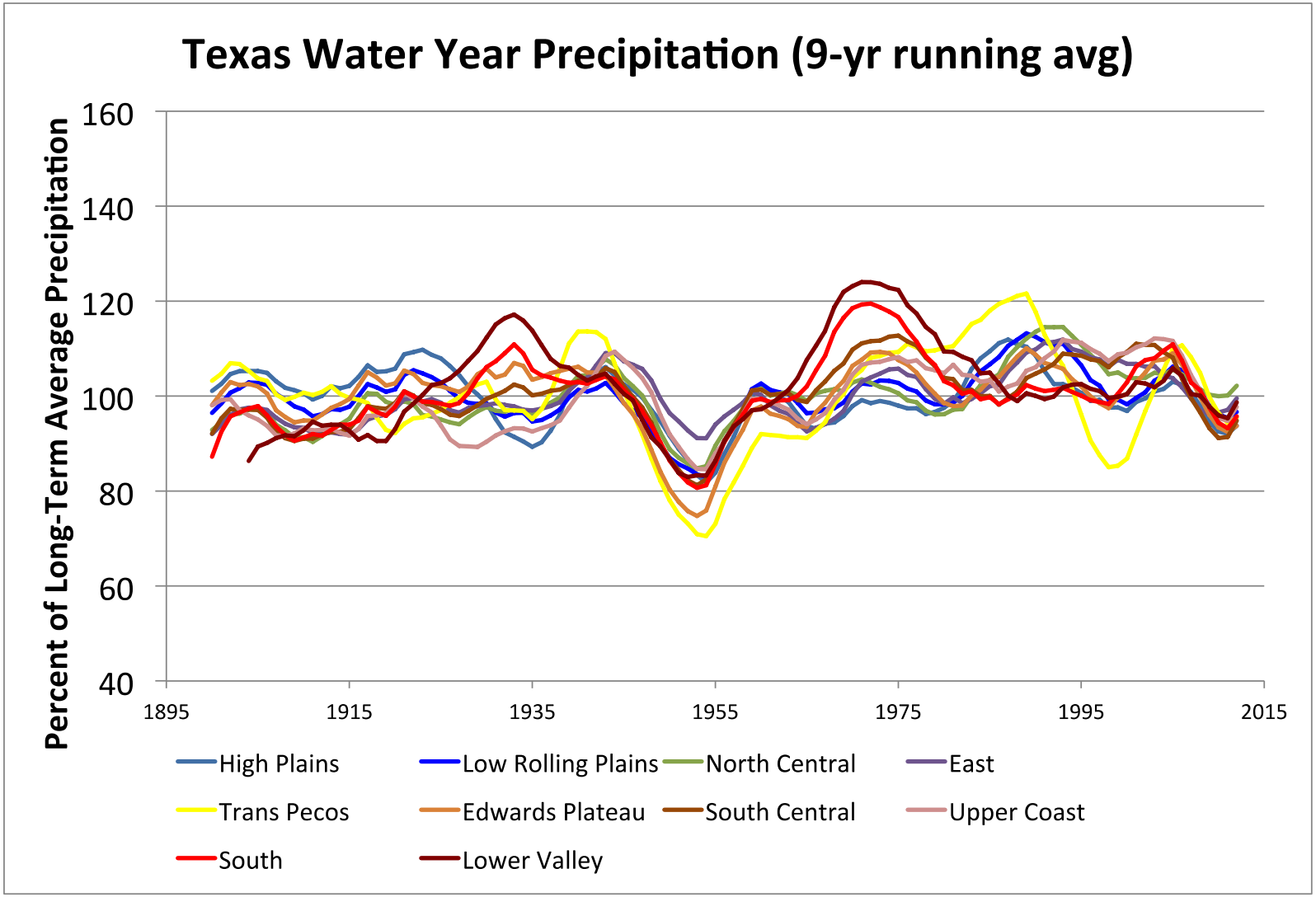



Texas Water Year Precipitation (9-yr running avg)
Percent of Long-Term Average Precipitation
160
140
120
100
80
60
40
1895
1915
1935
1955
1975
1995
2015
High Plains
Low Rolling Plains
North Central
East
Trans Pecos
Edwards Plateau
South Central
Upper Coast
South
Lower Valley


Texas April-July Precipitation (9-yr running avg)
Percent of Long-Term Average Precipitation
160
140
120
100
80
60
40
1895
1915
1935
1955
1975
1995
2015
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10


Texas Dec-Mar Precipitation (9-yr running avg)
Percentage of Long-Term Precipitation Average
160
140
120
100
80
60
40
1895
1915
1935
1955
1975
1995
2015
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10


Texas Aug-Nov Precipitation (9-yr running avg)
Percent of Long Term Average Precipitation
160
140
120
100
80
60
40
1895
1915
1935
1955
1975
1995
2015
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10


Texas Water Year Precipitation (9-yr running avg)
Percent of Long-Term Average Precipitation
160
140
120
100
80
60
40
1895
1915
1935
1955
1975
1995
2015
High Plains
Low Rolling Plains
North Central
East
Trans Pecos
Edwards Plateau
South Central
Upper Coast
South
Lower Valley

Climate Change and Precipitation

- Within a given storm, where rain is being produced:
  - Higher temperatures →
  - Greater water vapor content
- For a given updraft velocity:
  - Greater water vapor content →
  - Greater precipitation
- Change: 4% more per °F

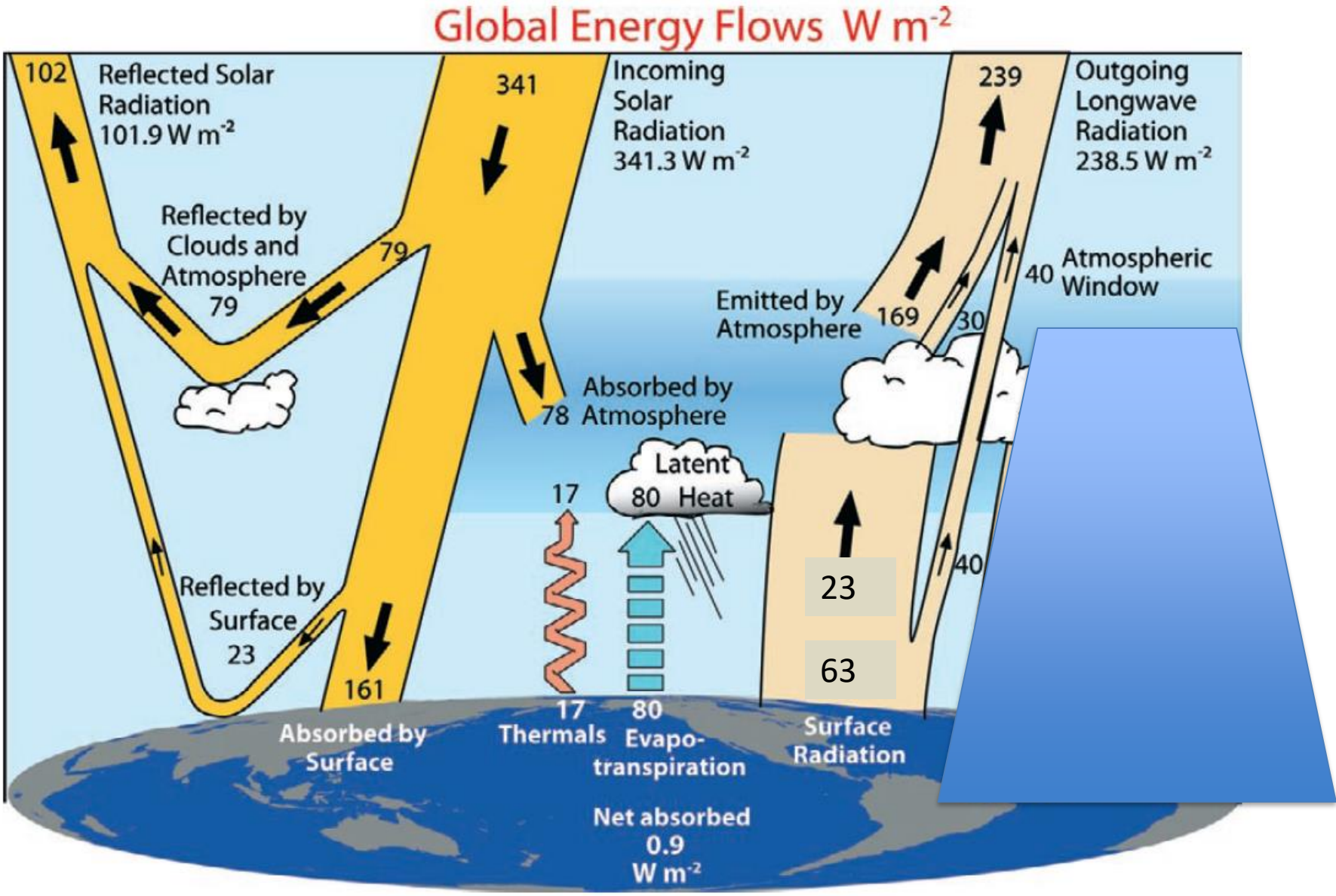
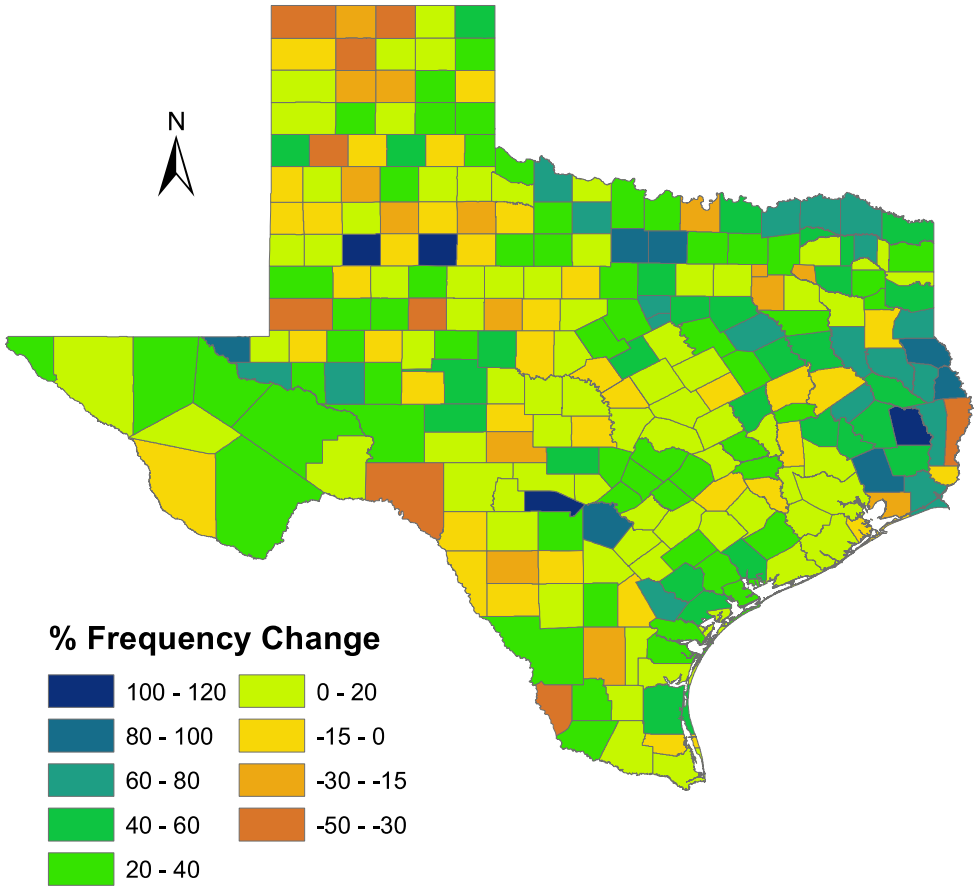


FIG. 1. The global annual mean Earth's energy budget for the Mar 2000 to May 2004 period (W m^{-2}). The broad arrows indicate the schematic flow of energy in proportion to their importance.

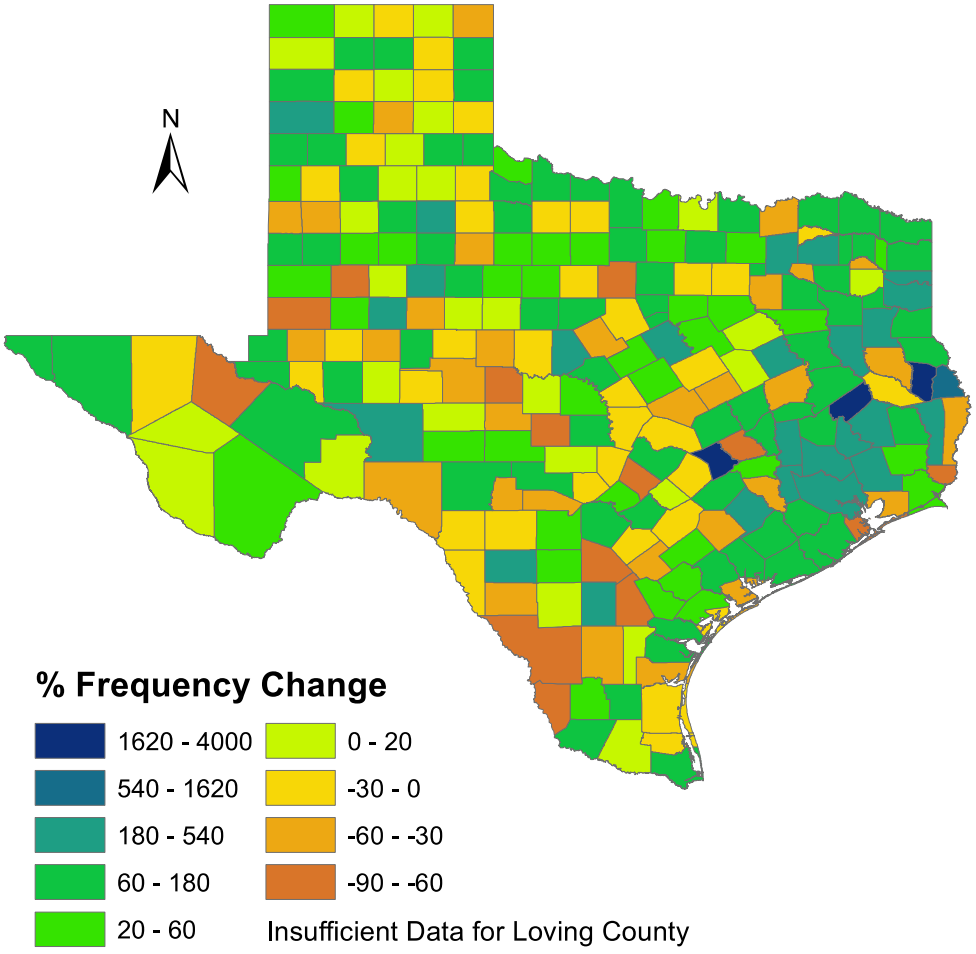
Climate Change and Precipitation

- Precipitation happens when lots of energy needs to be transferred upward into the atmosphere
  - Condensation adds heat (evaporation cools)
- Total global precipitation changes are driven by global energy changes
  - Enhanced greenhouse effect → 1% more per °F

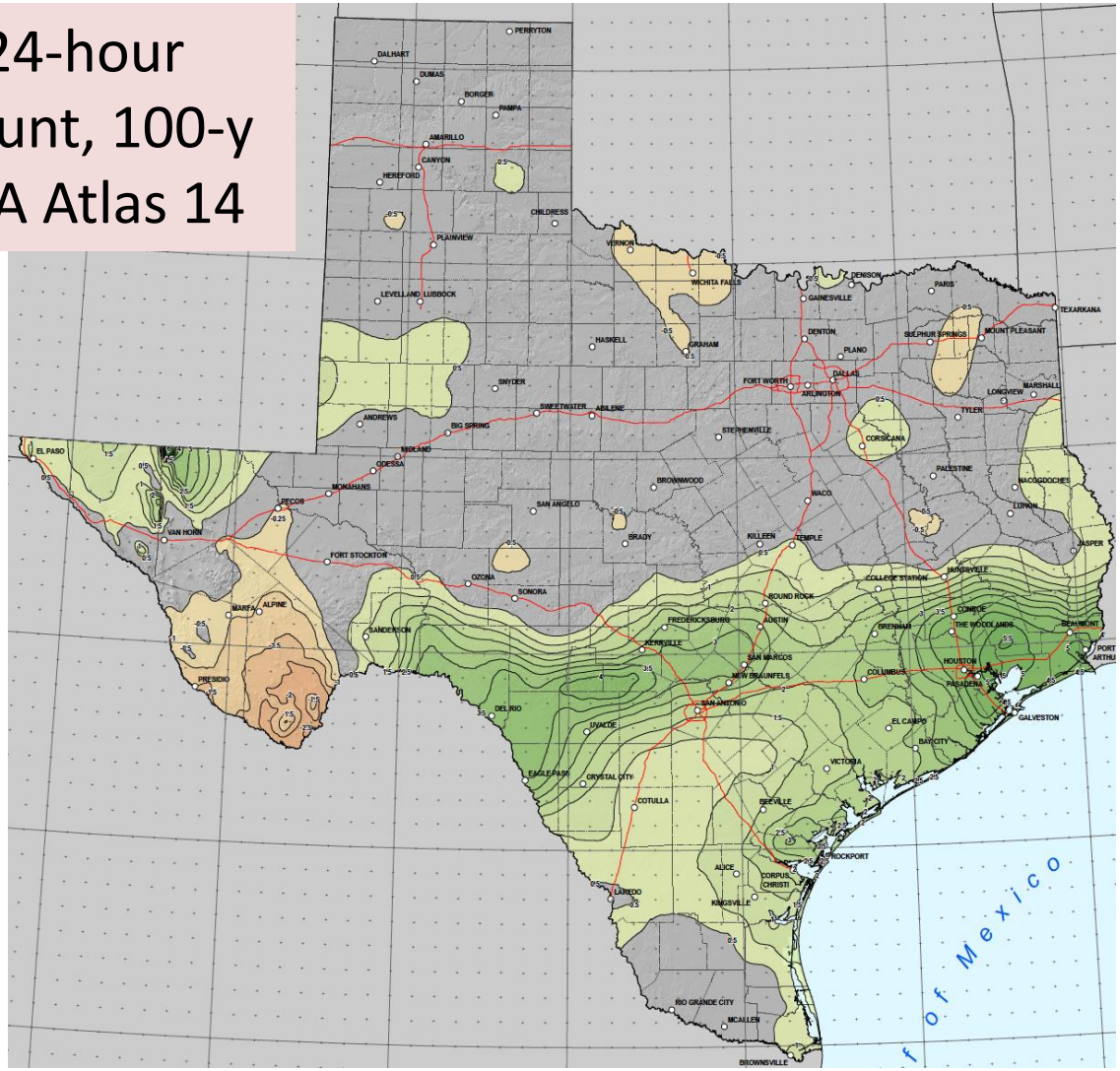
1 Year Return Period, One-Day Rainfall



10 Year Return Period, One-Day Rainfall



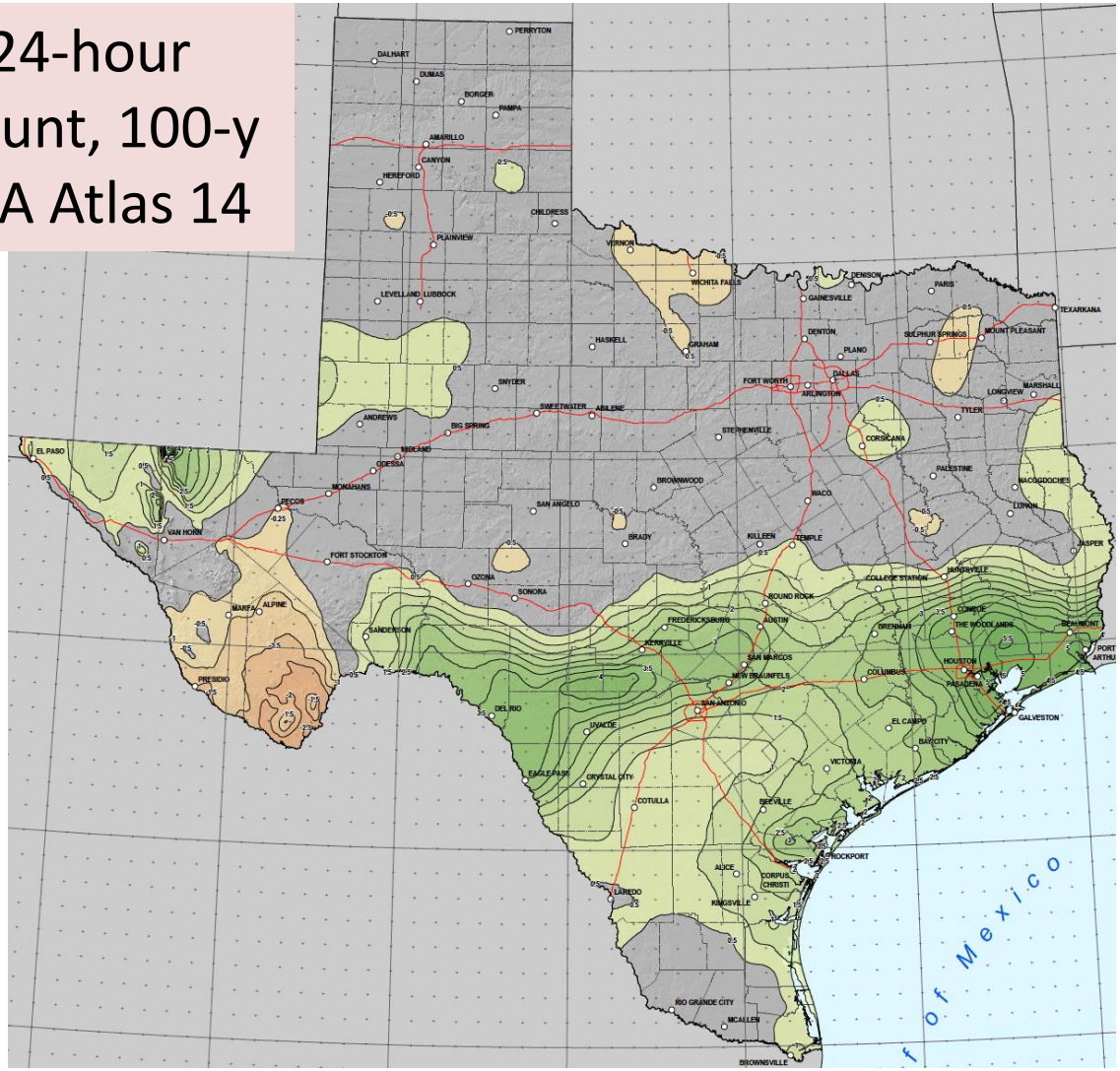
Change, 24-hour rainfall amount, 100-y event, NOAA Atlas 14

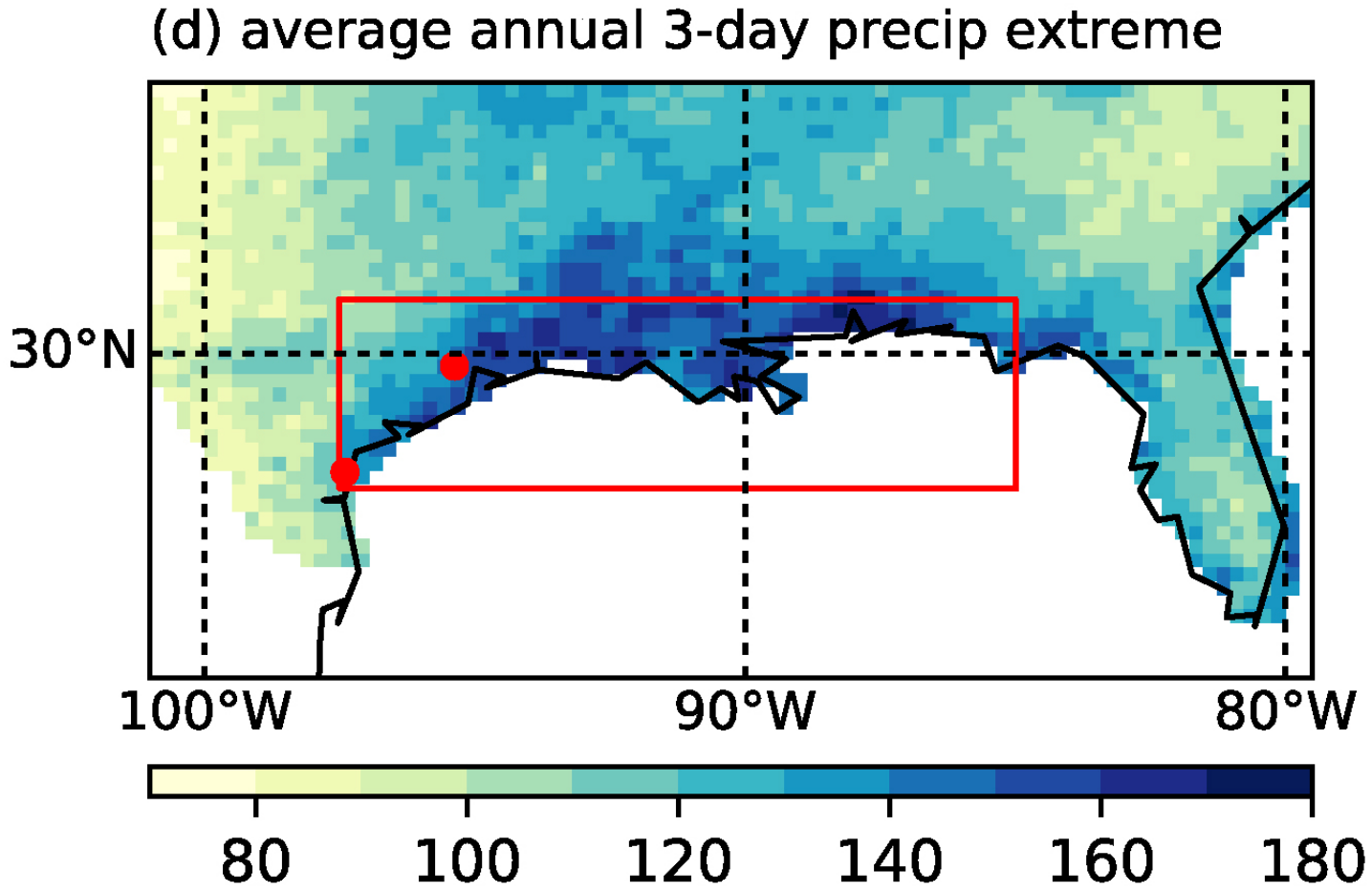


Why 100-year events matter

- NOAA determines 100-year rainfall
- Hydrologists use models to determine 100-year flood
- People within floodplain must buy flood insurance
- What happens when floodplain changes?

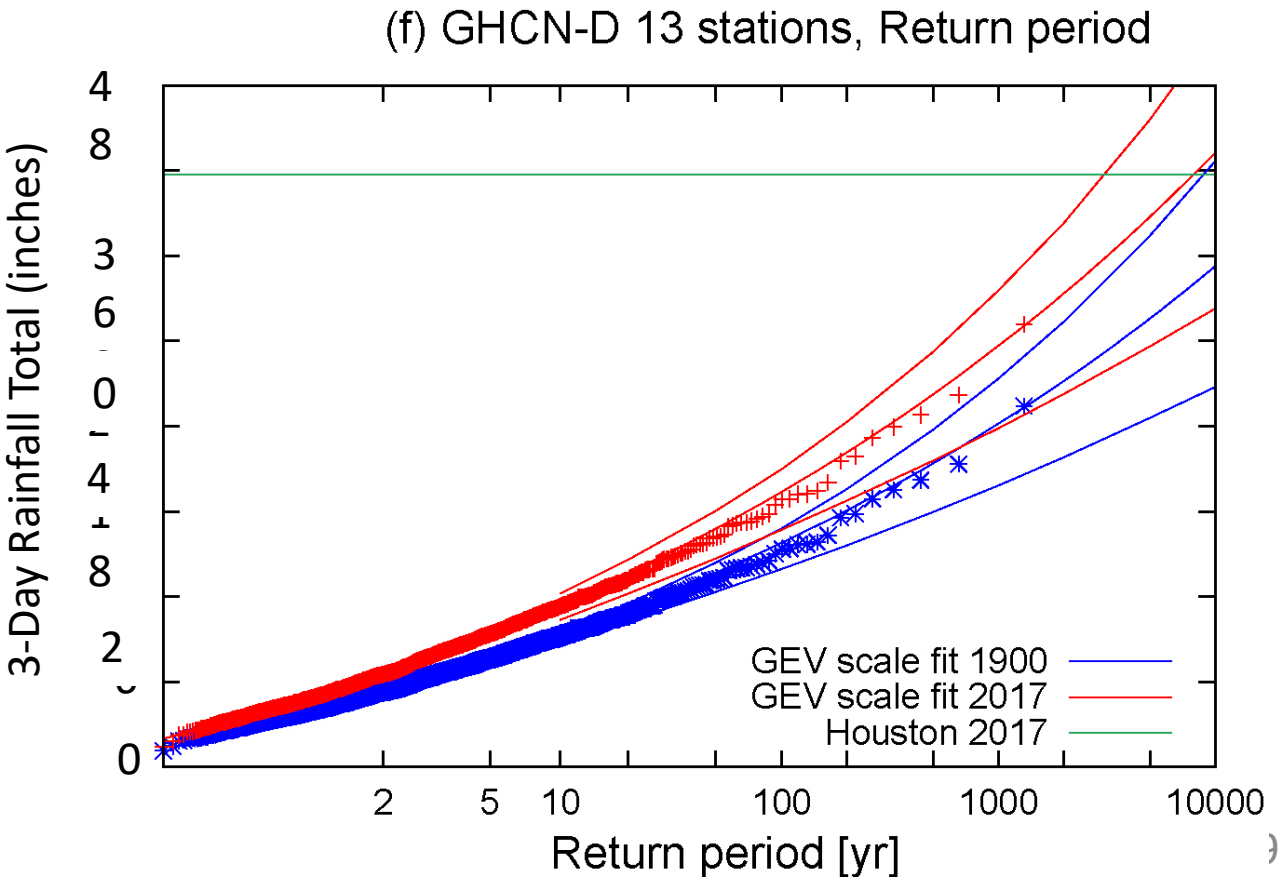
Change, 24-hour rainfall amount, 100-y event, NOAA Atlas 14

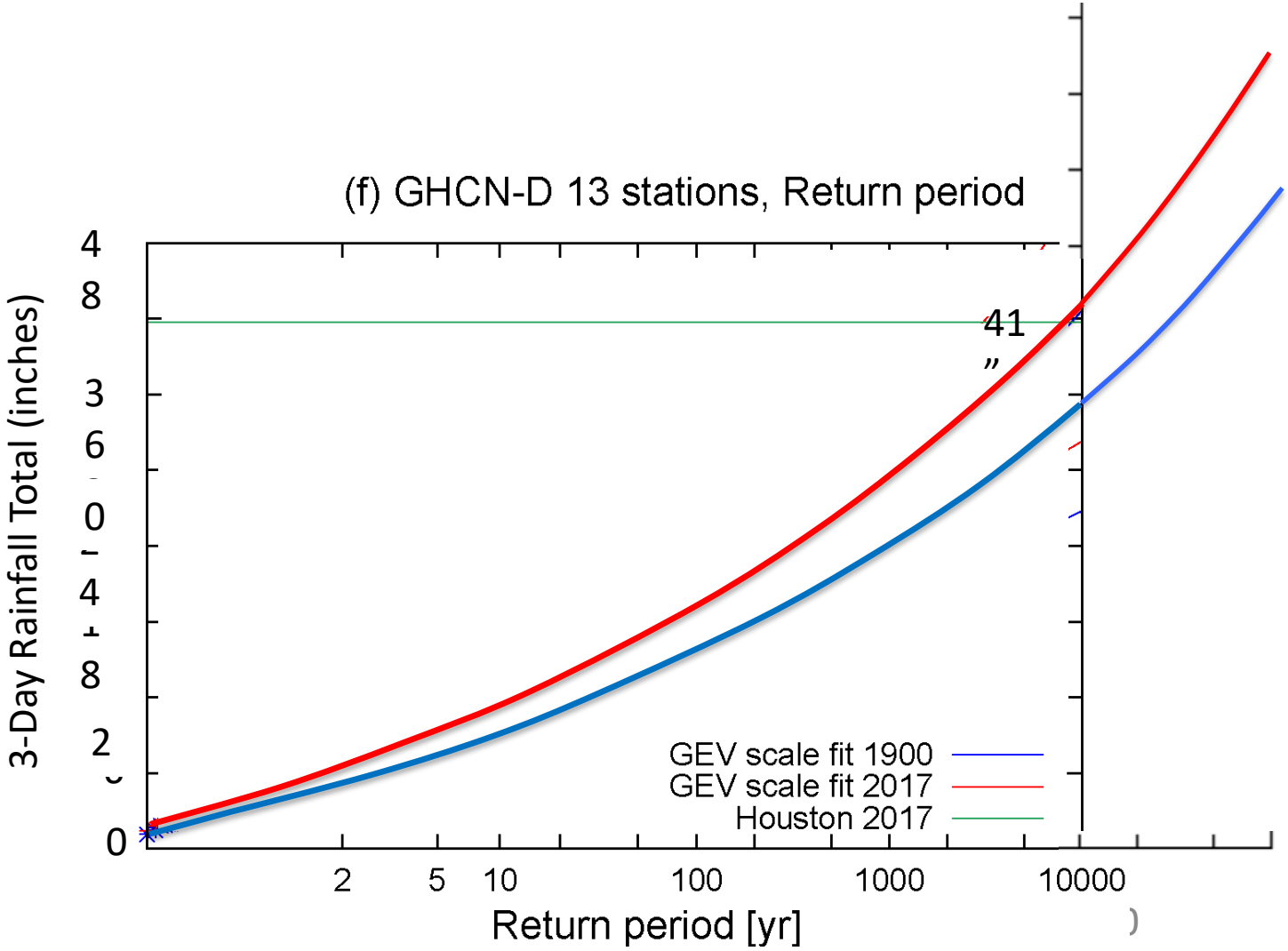


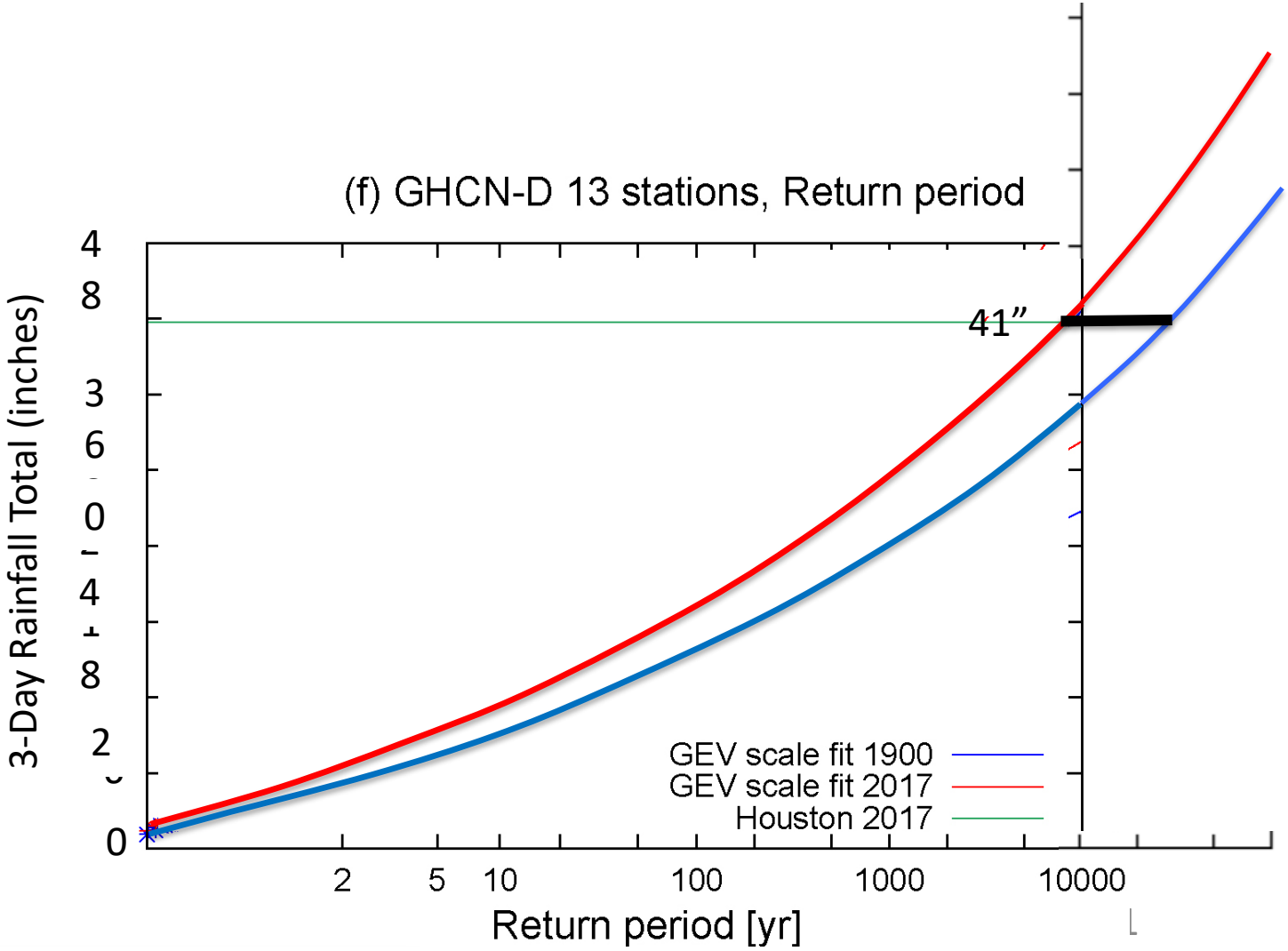


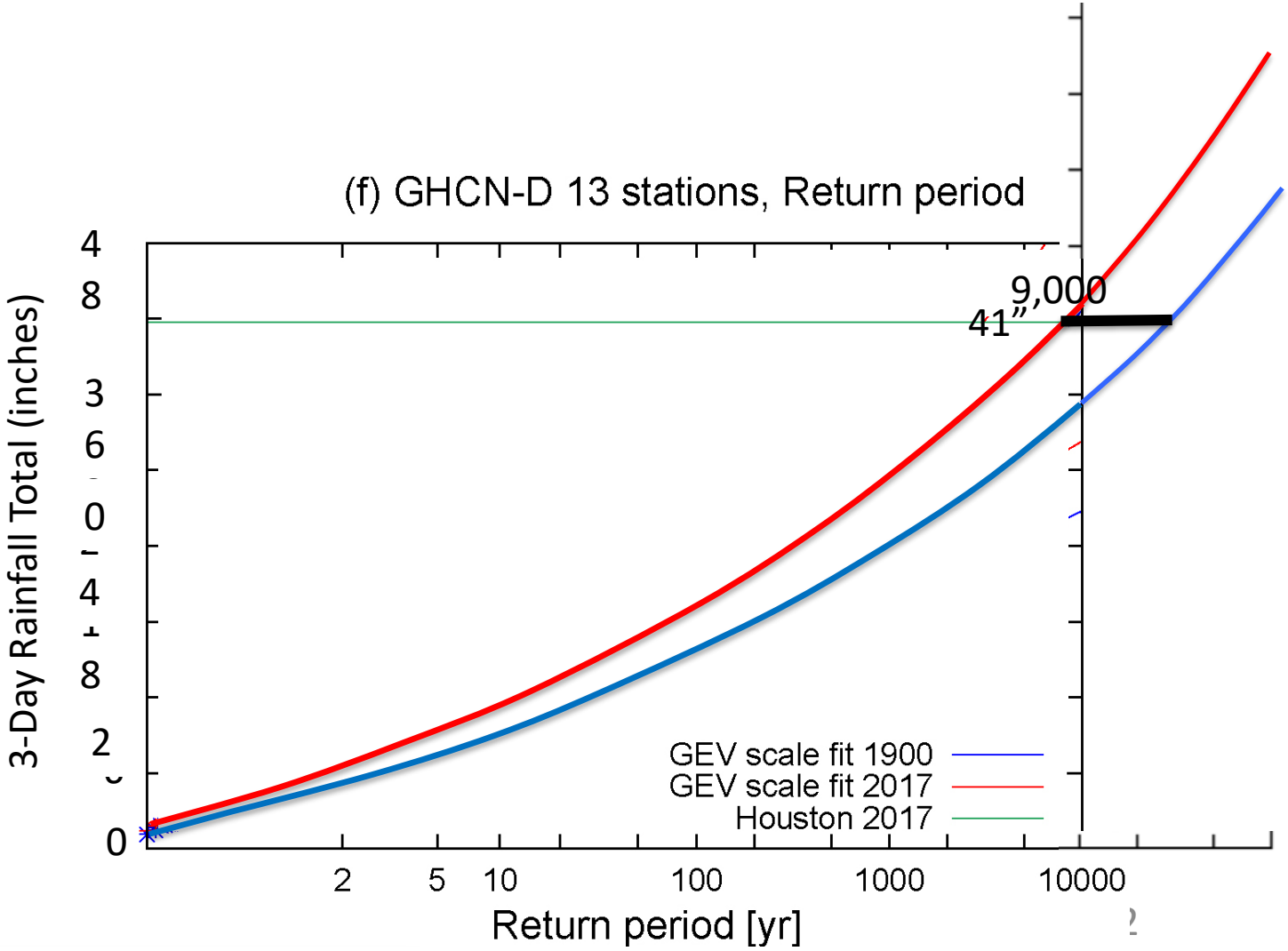
http://iopscience.iop.org/article/10.1088/1748-9326/aa9ef2/meta

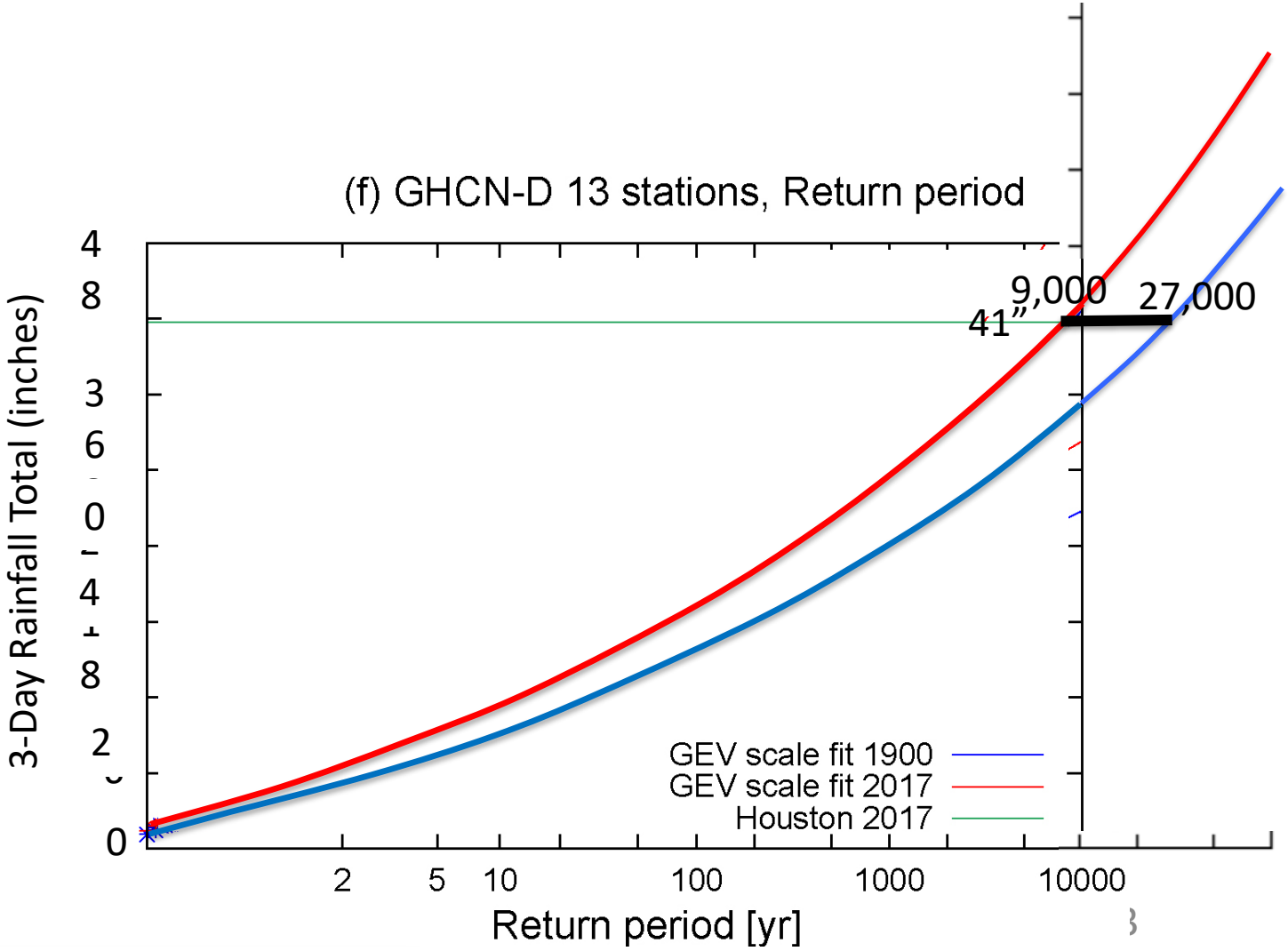
http://iopscience.iop.org/article/10.1088/1748-9326/aa9ef2/meta

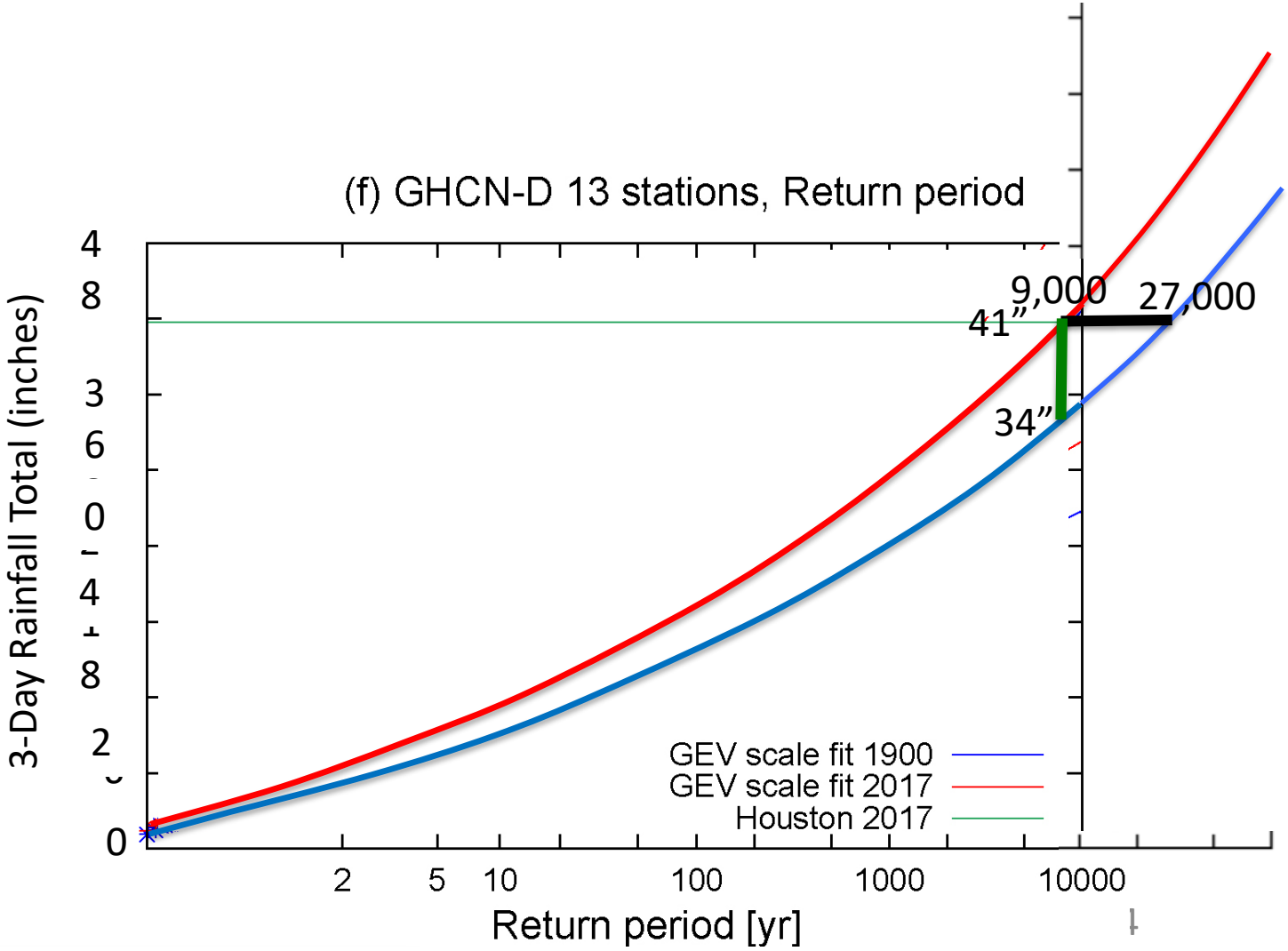


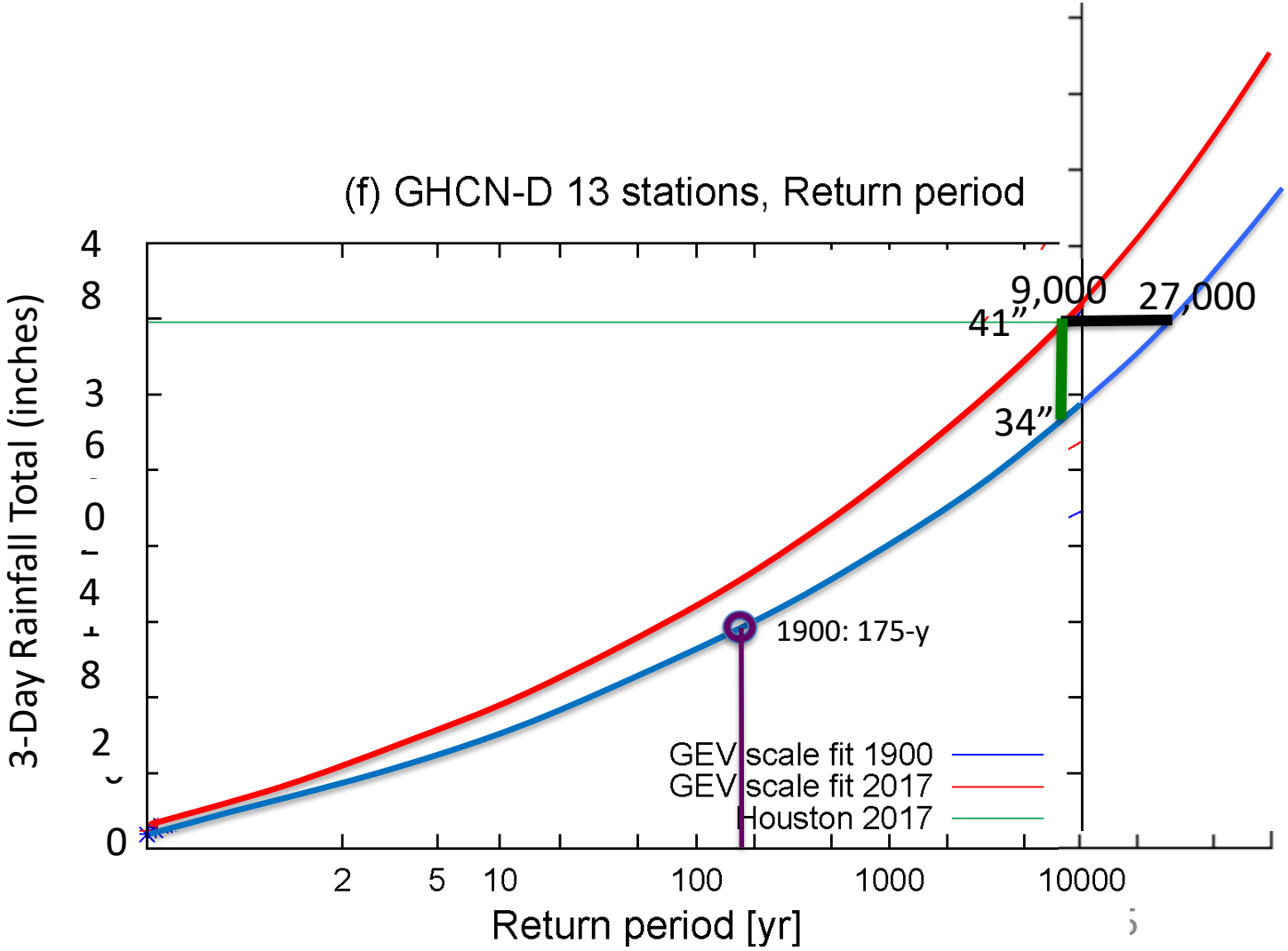

(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
41
"
GEV scale fit 1900
GEV scale fit 2017
Houston 2017
Return period [yr]
2
5
10
100
1000
10000

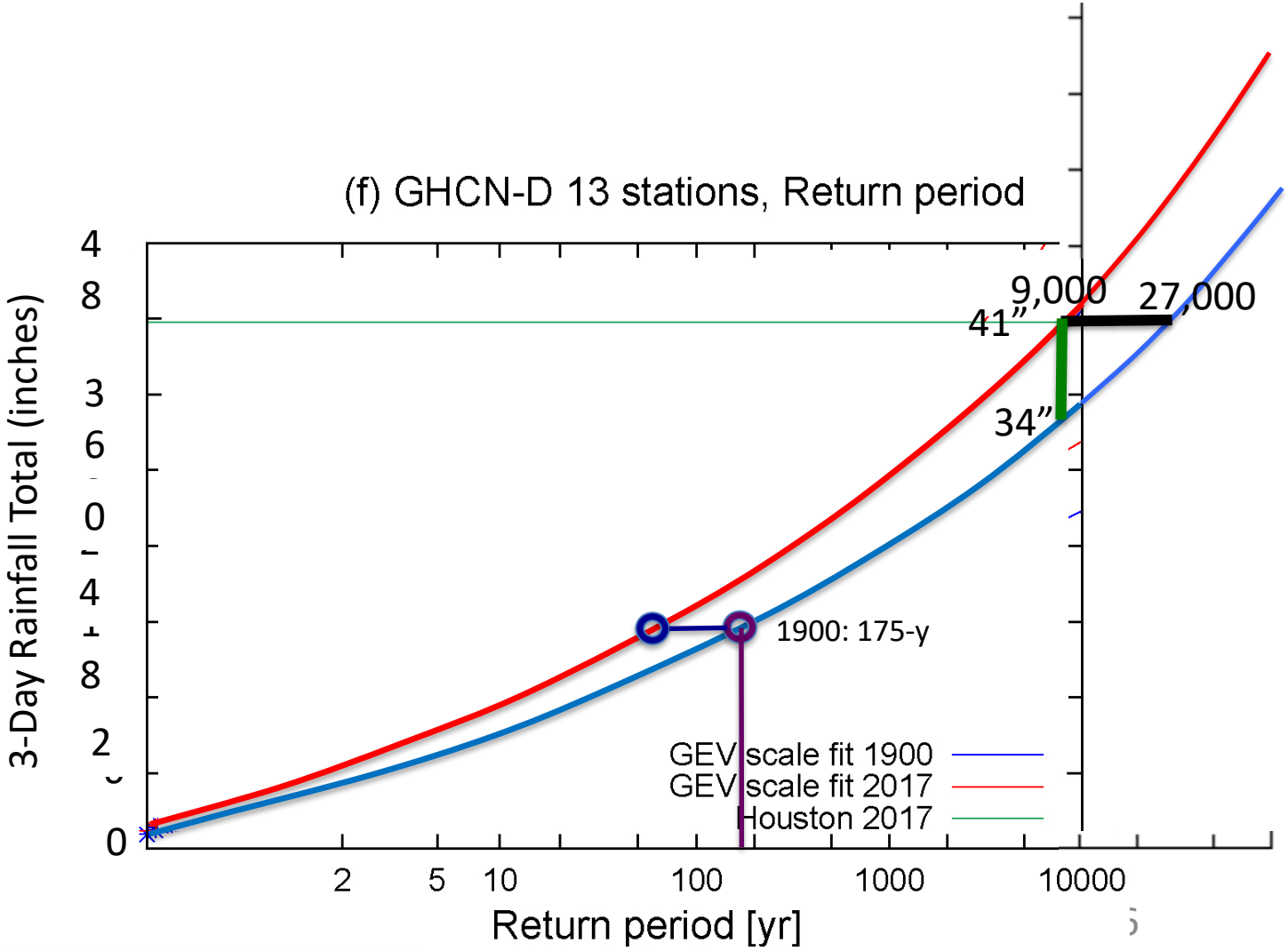

(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
4
8
3
6
0
4
8
2
0
41”
GEV scale fit 1900
GEV scale fit 2017
Houston 2017
2
5
10
100
1000
10000
Return period [yr]

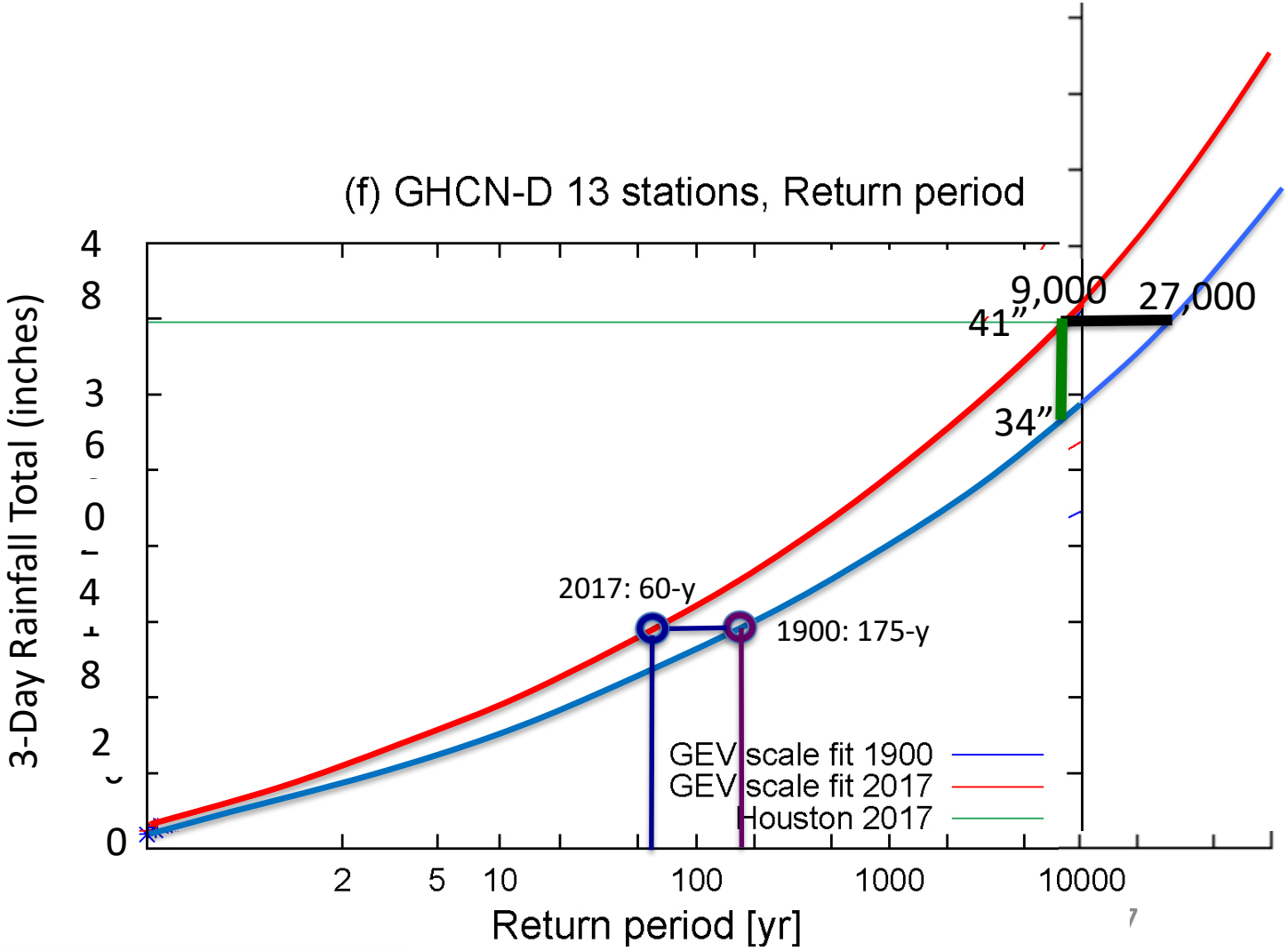

(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
41”
GEV scale fit 1900
GEV scale fit 2017
Houston 2017

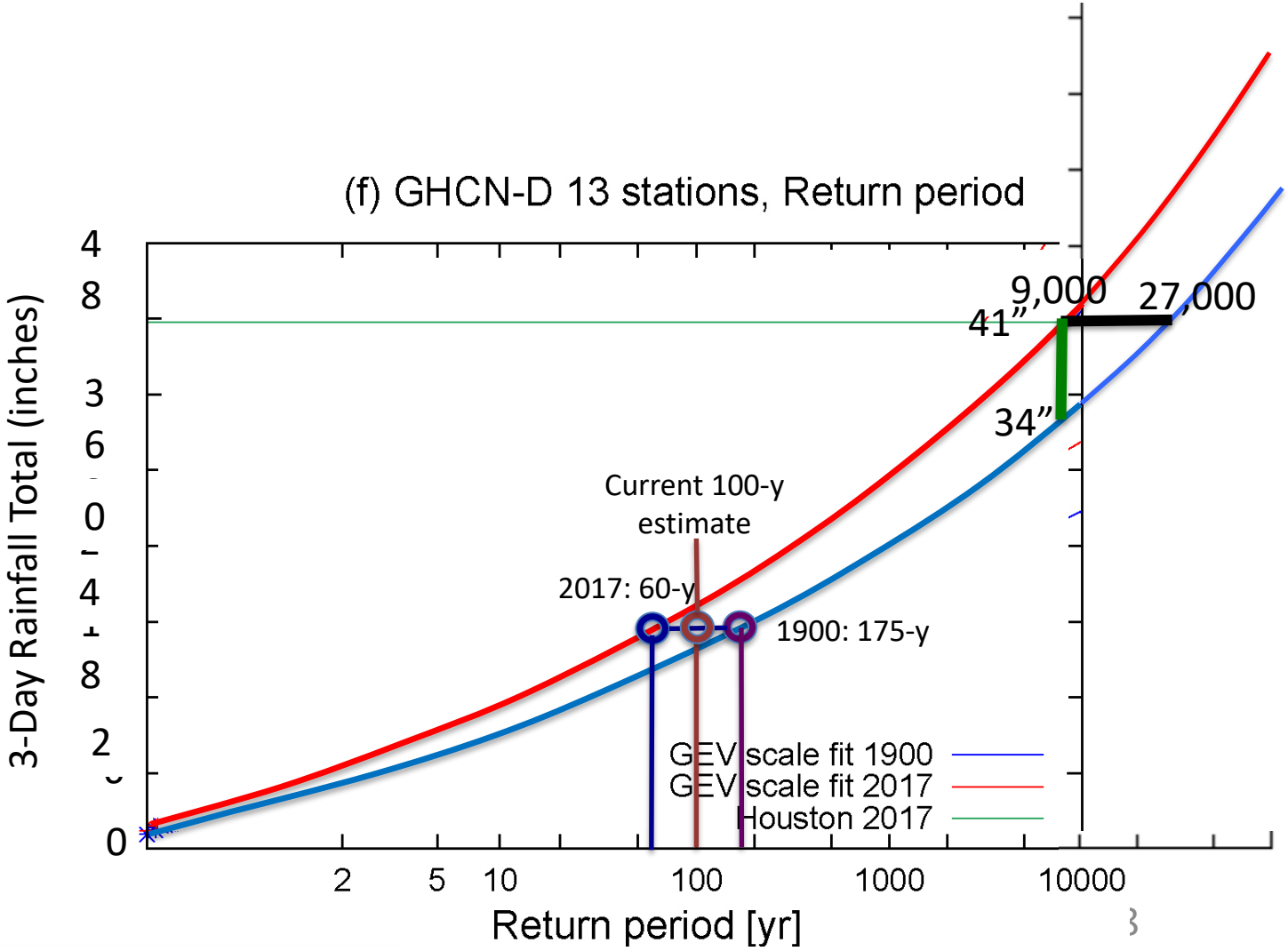

(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
41"
9,000
27,000
GEV scale fit 1900
GEV scale fit 2017
Houston 2017

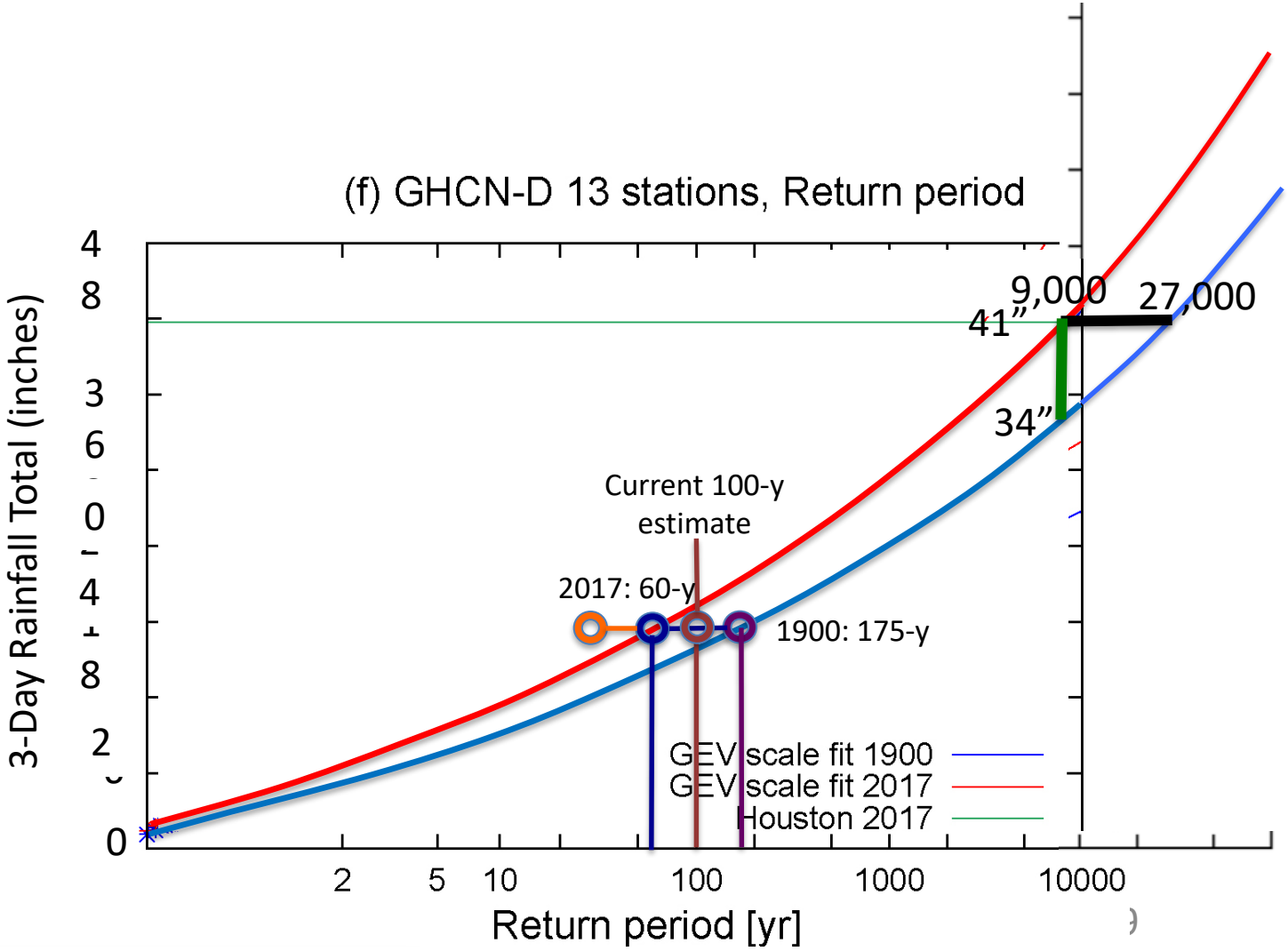

(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
27,000
41”
34”
GEV scale fit 1900
GEV scale fit 2017
Houston 2017

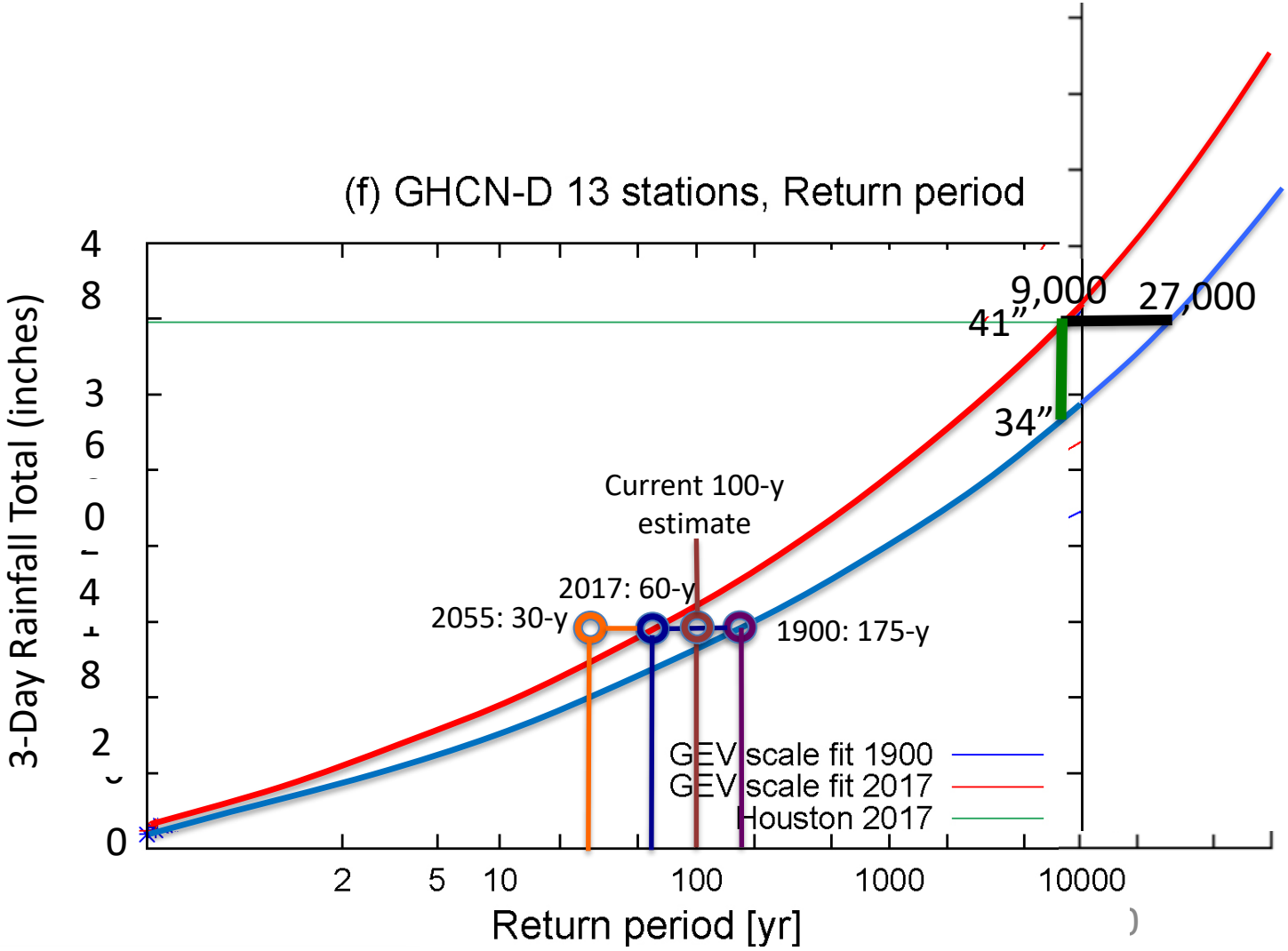

(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
27,000
41”
34”
1900: 175-y
GEV scale fit 1900
GEV scale fit 2017
Houston 2017


(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
27,000
41”
34”
1900: 175-y
GEV scale fit 1900
GEV scale fit 2017
Houston 2017


(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
27,000
41”
34”
2017: 60-y
1900: 175-y
GEV scale fit 1900
GEV scale fit 2017
Houston 2017


(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
27,000
41”
34”
Current 100-y
estimate
2017: 60-y
1900: 175-y
GEV scale fit 1900
GEV scale fit 2017
Houston 2017


(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
27,000
41”
34”
Current 100-y
estimate
2017: 60-y
1900: 175-y
GEV scale fit 1900
GEV scale fit 2017
Houston 2017

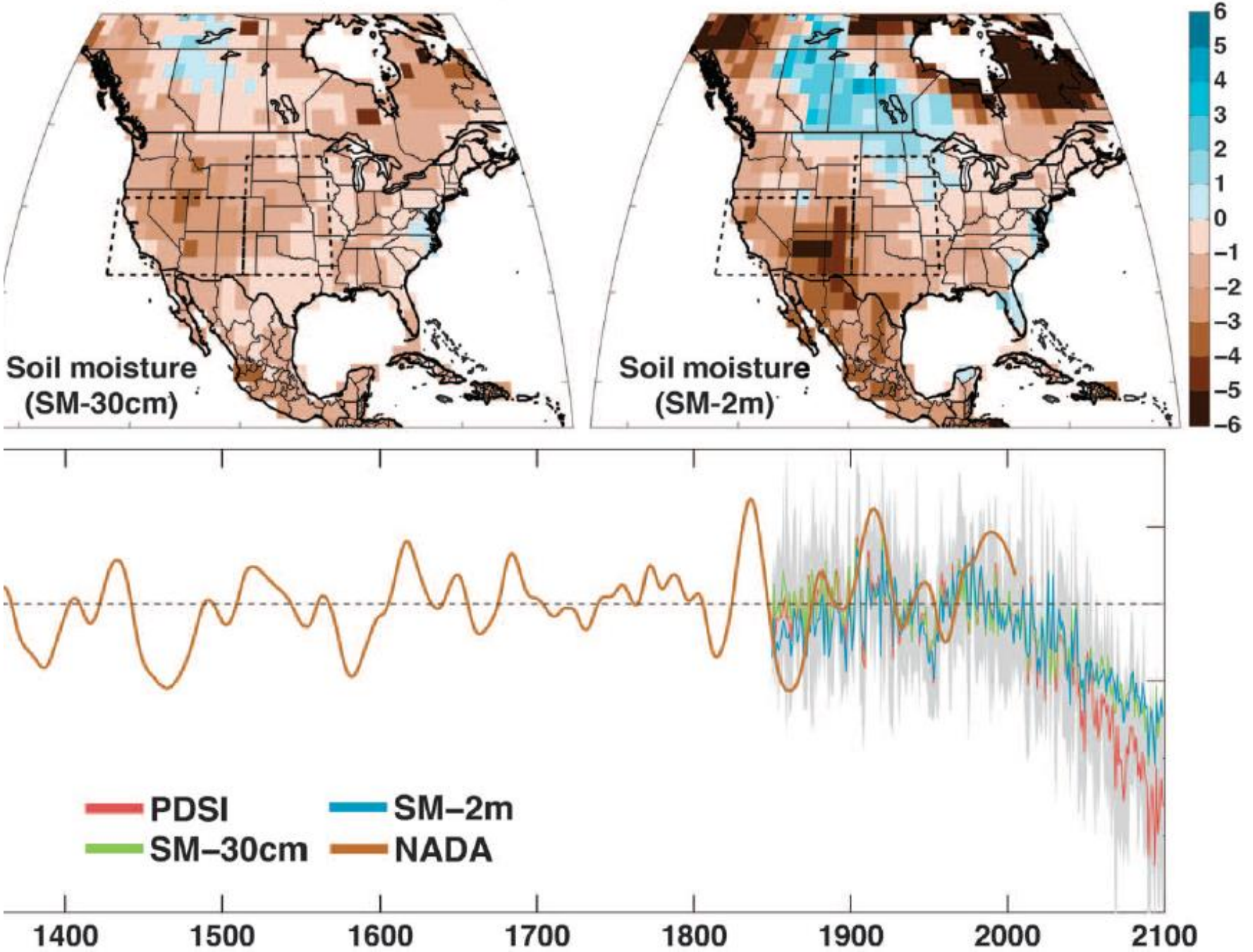

(f) GHCN-D 13 stations, Return period
3-Day Rainfall Total (inches)
Return period [yr]
2
5
10
100
1000
10000
9,000
27,000
41”
34”
Current 100-y
estimate
2017: 60-y
2055: 30-y
1900: 175-y
GEV scale fit 1900
GEV scale fit 2017
Houston 2017

Implications

- Water affects just about everything
- What do you care about?
- Possibilities:
  - Floods
  - Agriculture
  - Reservoirs
  - Springs
  - Coasts
  - …

ıt Projections (RCP 8.5, 2050-2099 CE)

(Cook et al. 2015)



Contact Information

- John W. Nielsen-Gammon
- n-g@tamu.edu
- 979-862-2248
- http://climatexas.tamu.edu
- Social media: climatexas