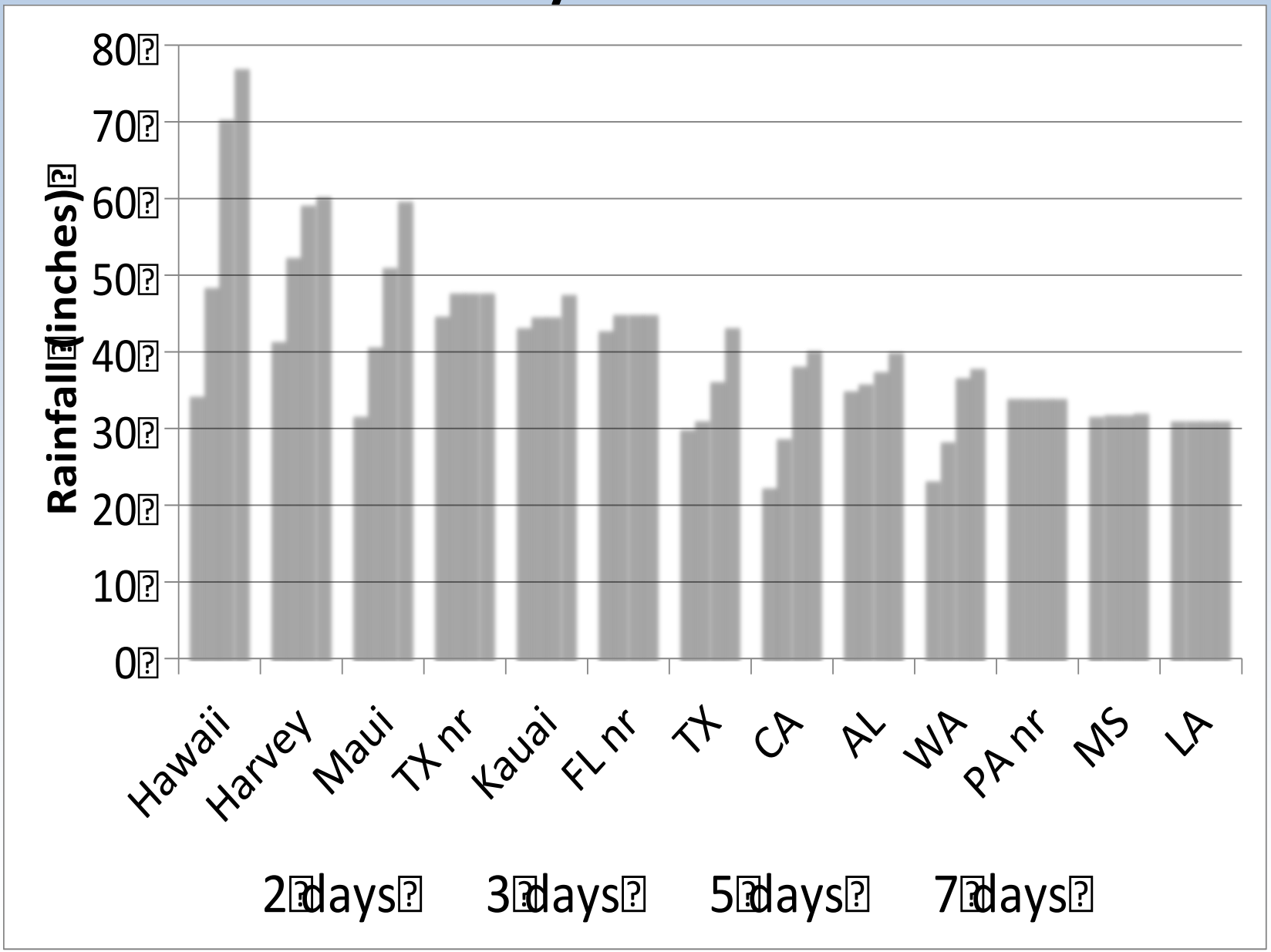
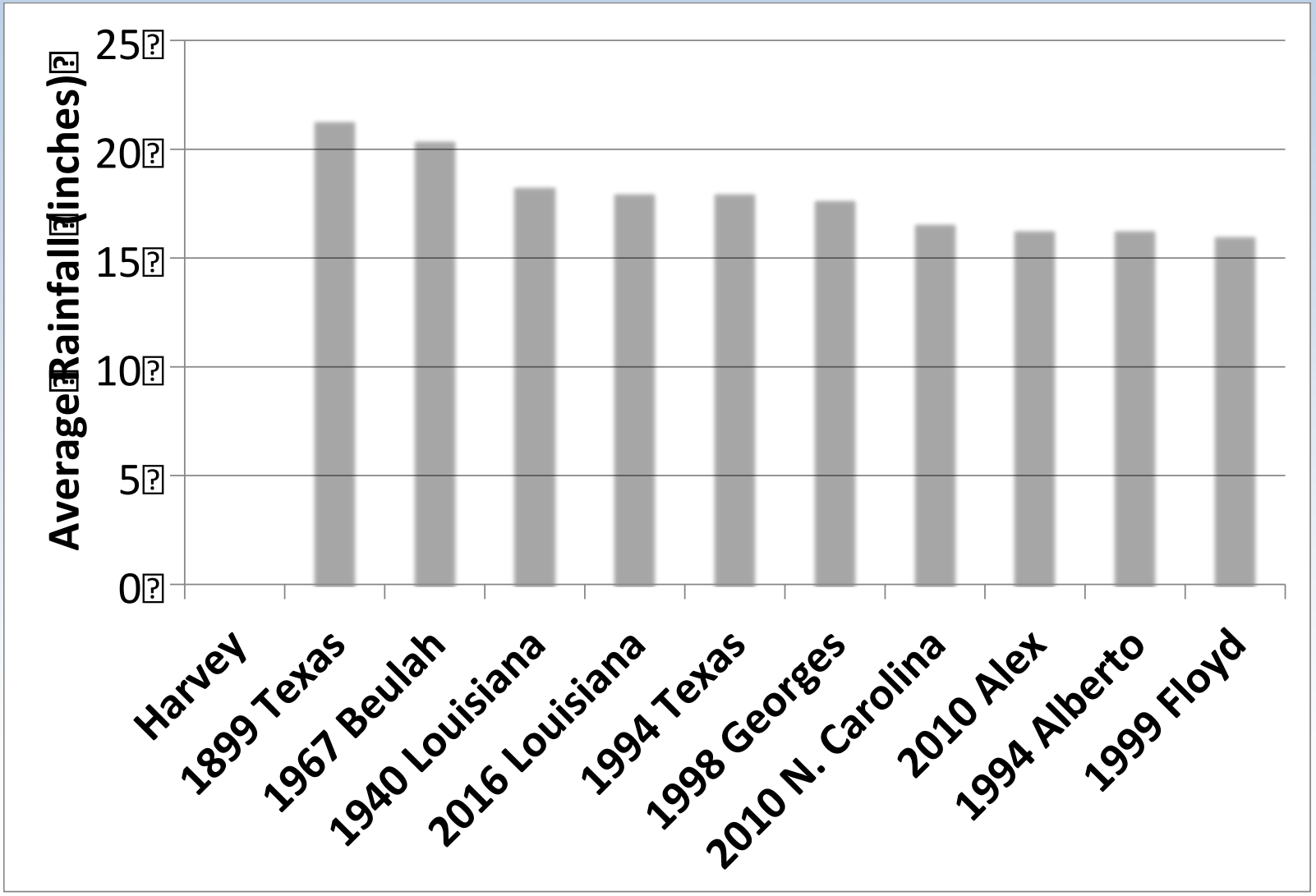
Seeking the New Abnormal

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

US Multi-Day Rainfall Records

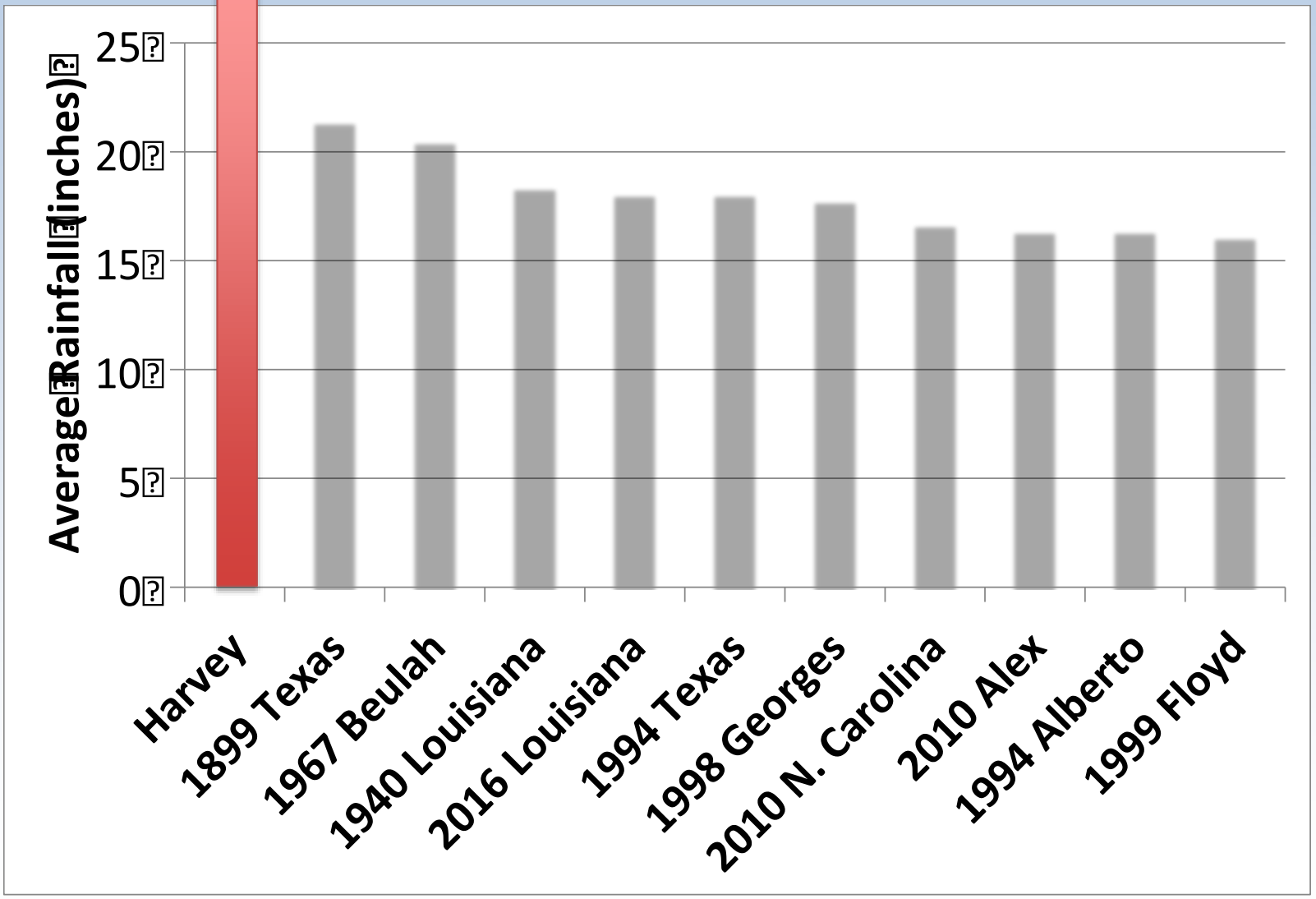


Greatest US Storms: 5 days, 10,000 sq mi



Historic analyses: Applied Weather Associates; US Army Corps of Engineers

Gr[33.28”]st US Storms: 5 days, 10,000 sq mi



Historic analyses: Applied Weather Associates; US Army Corps of Engineers

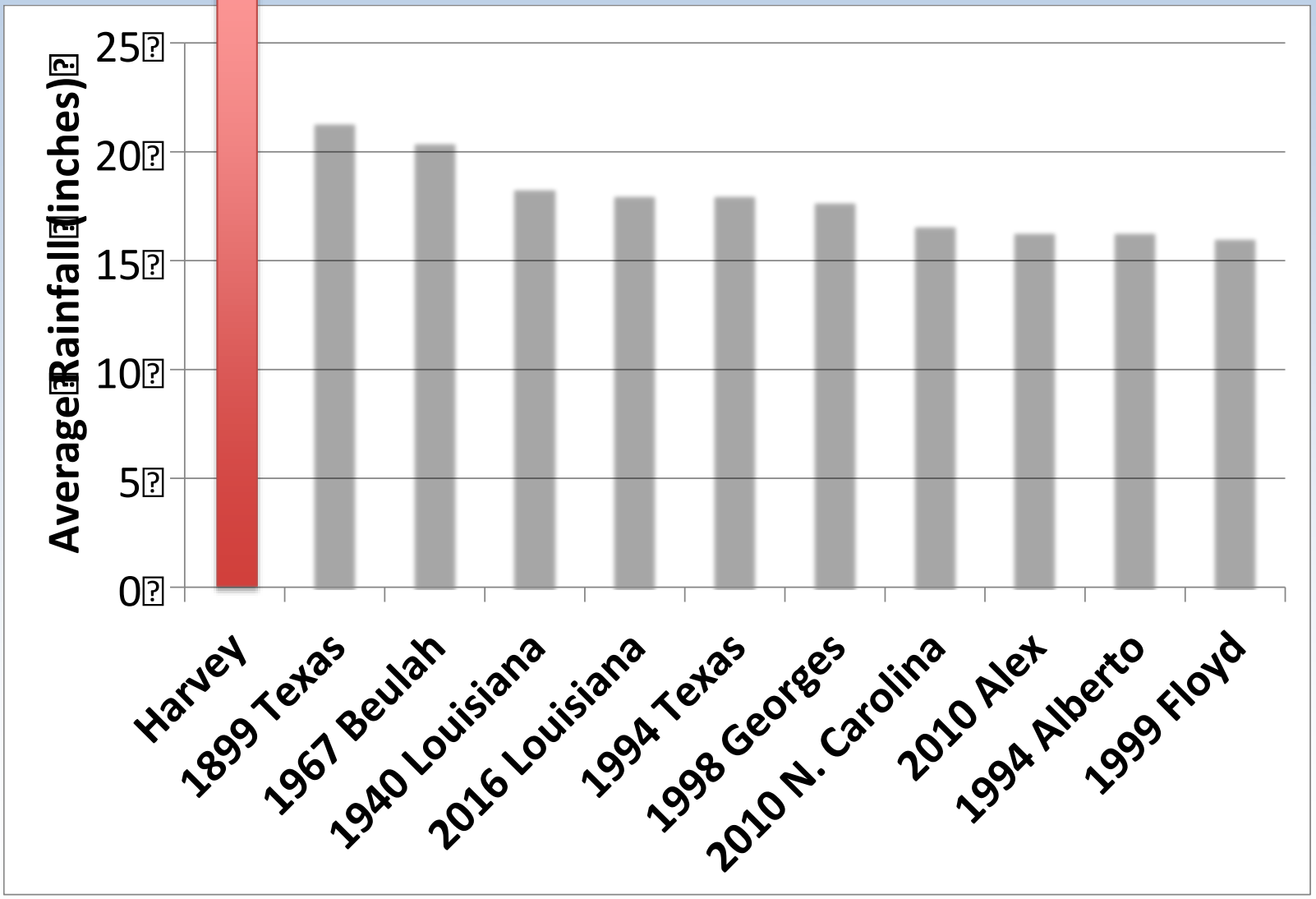
(Central/Eastern) US Depth-Area-Duration All-Time Records Before Harvey

Area\Duration	*2 Days*	*3 Days*	*4 Days*	*5 Days*
1,000 sq mi	Louisiana, August 1940	Louisiana, August 1940	Louisiana, August 1940	Louisiana, August 1940
2,000 sq mi	Louisiana, August 1940	Louisiana, August 1940	Louisiana, August 1940	Louisiana, August 1940
5,000 sq mi	Louisiana, August 1940	Texas, June 1899	Texas, June 1899	Texas, June 1899
10,000 sq mi	Georges, Florida 1998	Texas, June 1899	Texas, June 1899	Texas, June 1899
20,000 sq mi	Georges, Florida 1998	Beulah, Texas 1967	Beulah, Texas 1967	Beulah, Texas 1967
50,000 sq mi	Georges, Florida 1998	Beulah, Texas 1967	Beulah, Texas 1967	Beulah, Texas 1967

(Central/Eastern) US Depth-Area-Duration All-Time Records After Harvey

Area\Duration	*2 Days*	*3 Days*	*4 Days*	*5 Days*
1,000 sq mi	Louisiana, August 1940	Harvey	Harvey	Harvey
2,000 sq mi	Harvey	Harvey	Harvey	Harvey
5,000 sq mi	Harvey	Harvey	Harvey	Harvey
10,000 sq mi	Harvey	Harvey	Harvey	Harvey
20,000 sq mi	Harvey	Harvey	Harvey	Harvey
50,000 sq mi	Harvey	Harvey	Harvey	Harvey

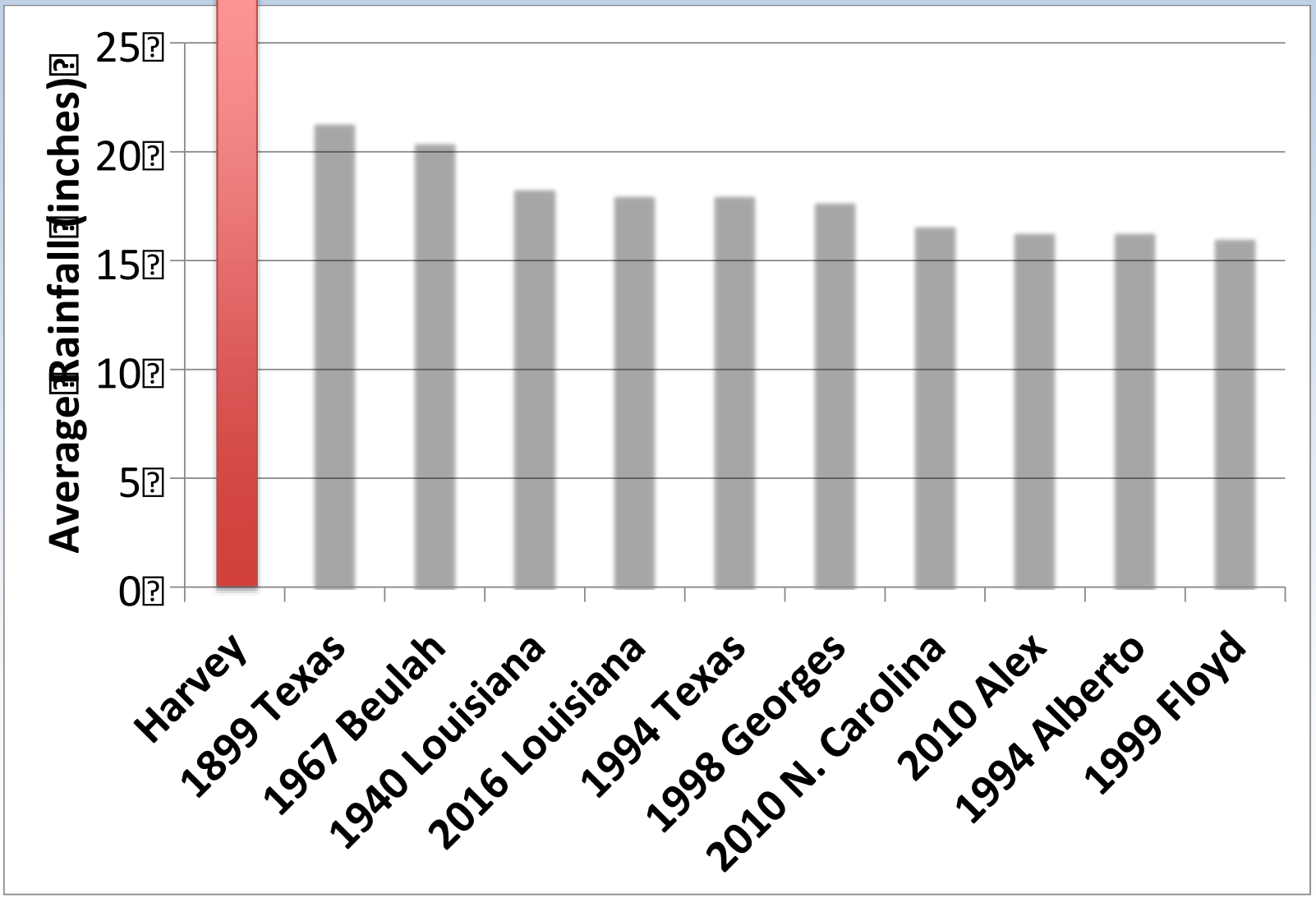
Gr[33.28”]st US Storms: 5 days, 10,000 sq mi



Historic analyses: Applied Weather Associates; US Army Corps of Engineers

Gr[33.28”]st US Storms: 5 days, 10,000 sq mi

Climate change rainfall contribution? (Me, guessing)



Historic analyses: Applied Weather Associates; US Army Corps of Engineers

Gr[redacted]st US Storms: 5 days, 10,000 sq mi

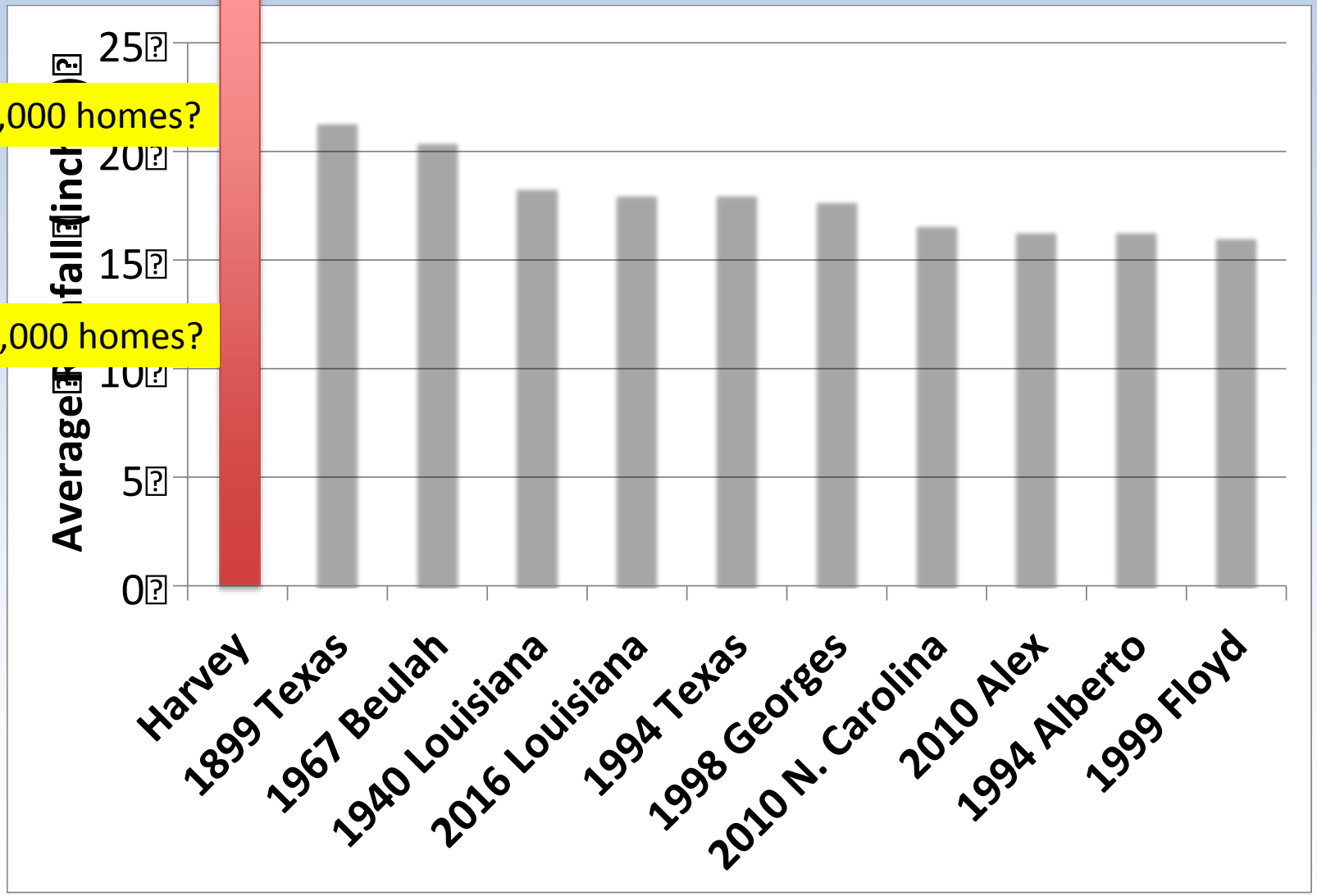
33.28”

100,000 homes?

10,000 homes?

1,000 homes?

Climate change rainfall contribution? (Me, guessing)



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Gr[redacted]st US Storms: 5 days, 10,000 sq mi

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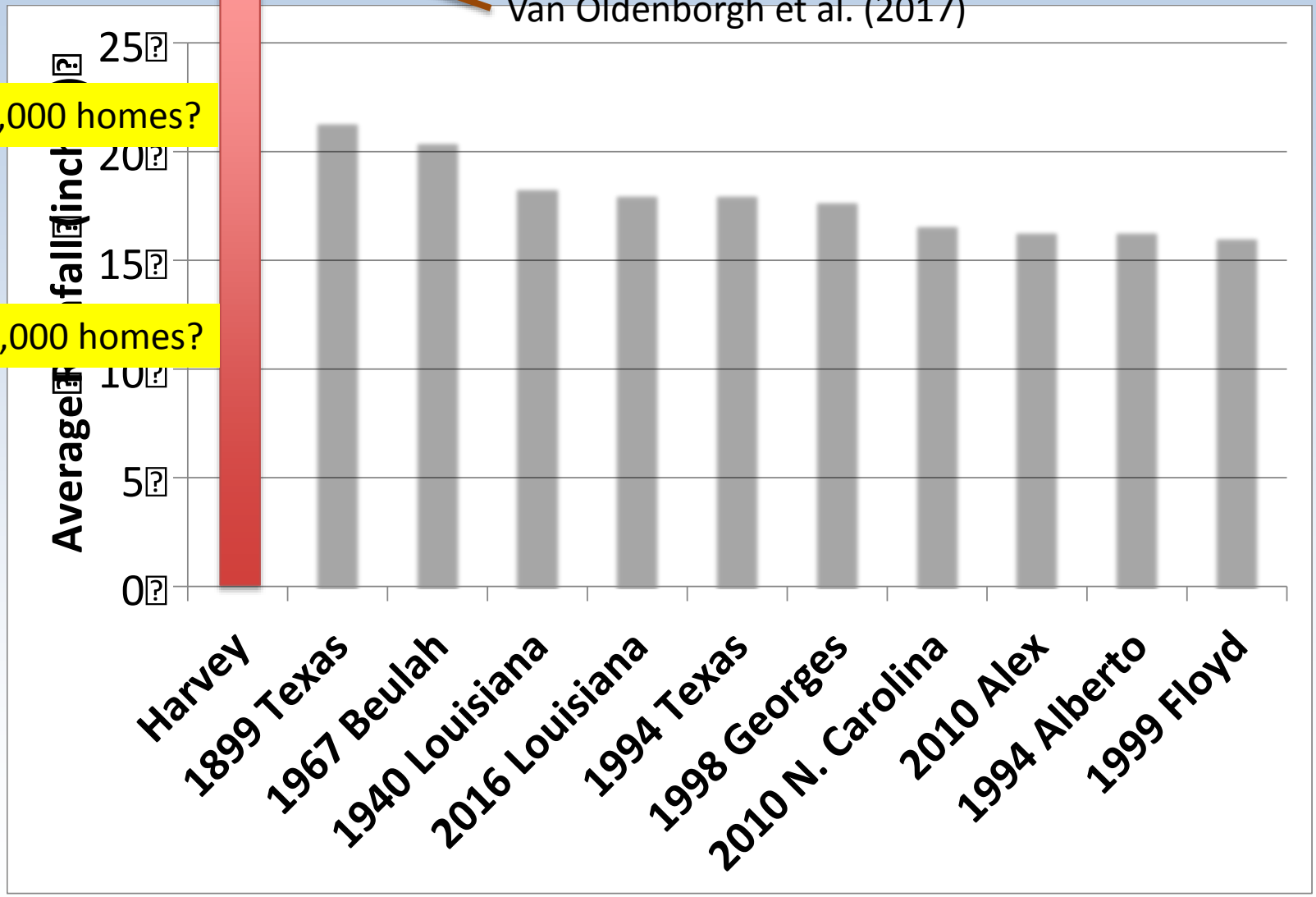
Van Oldenborgh et al. (2017)



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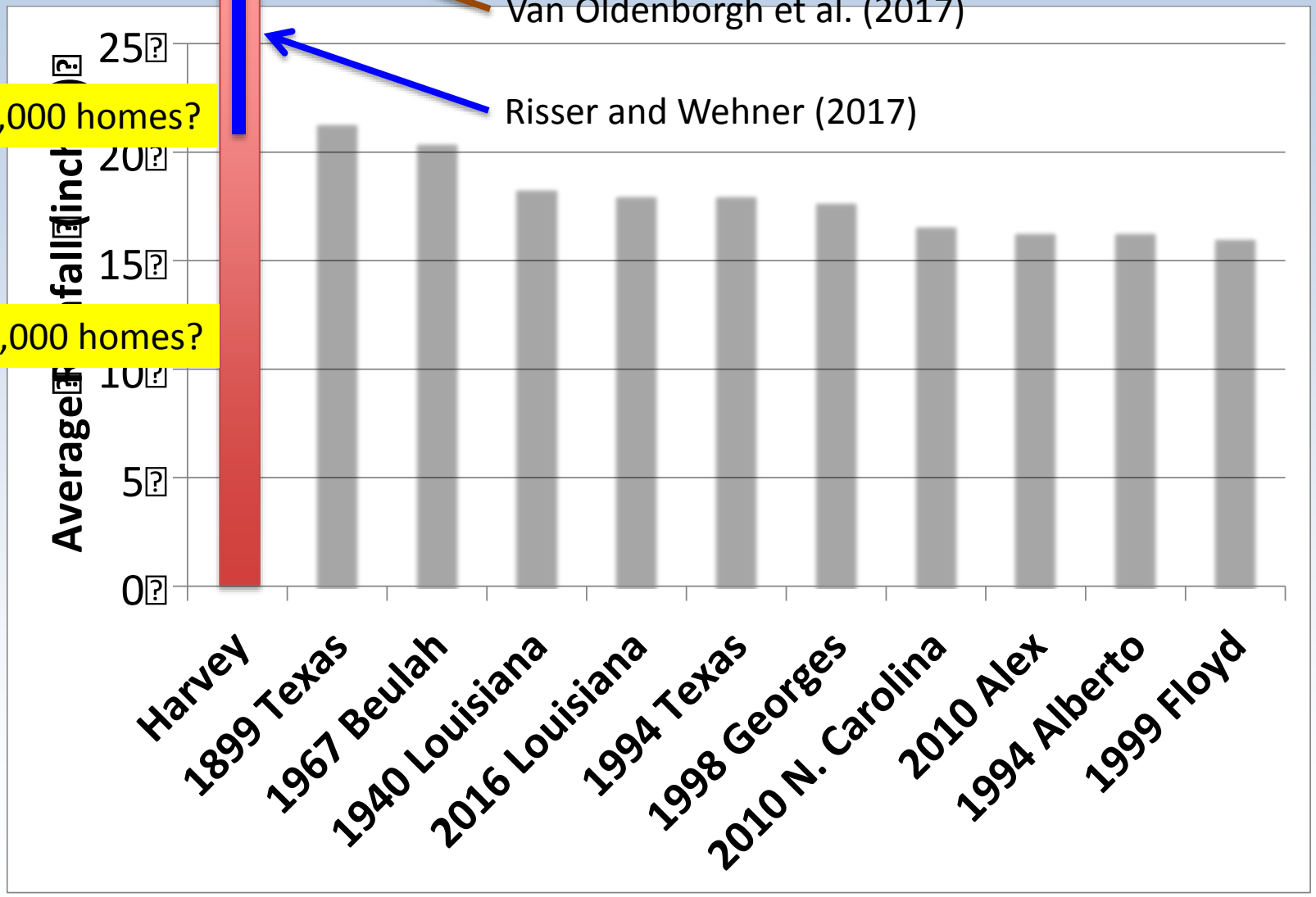
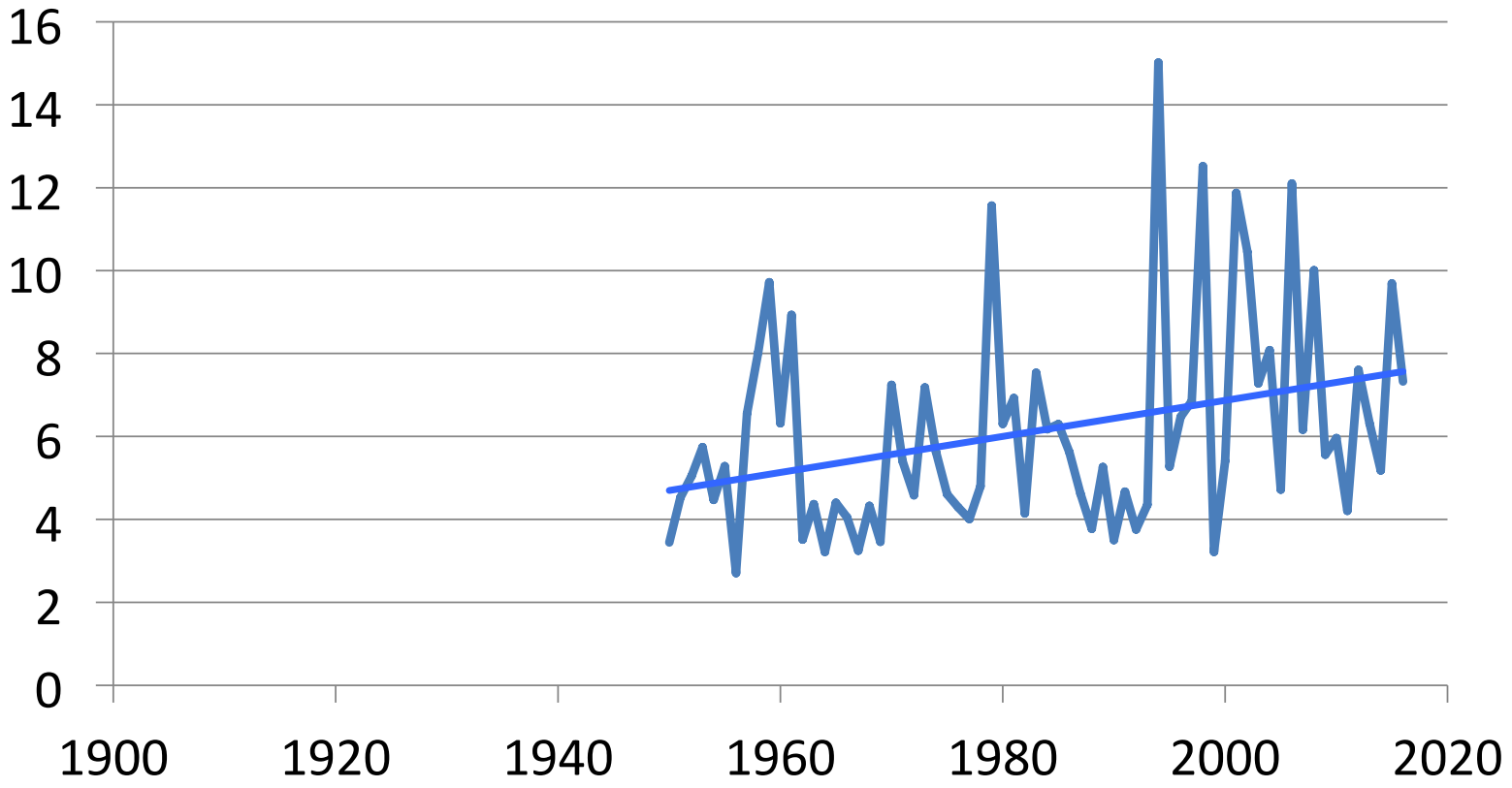
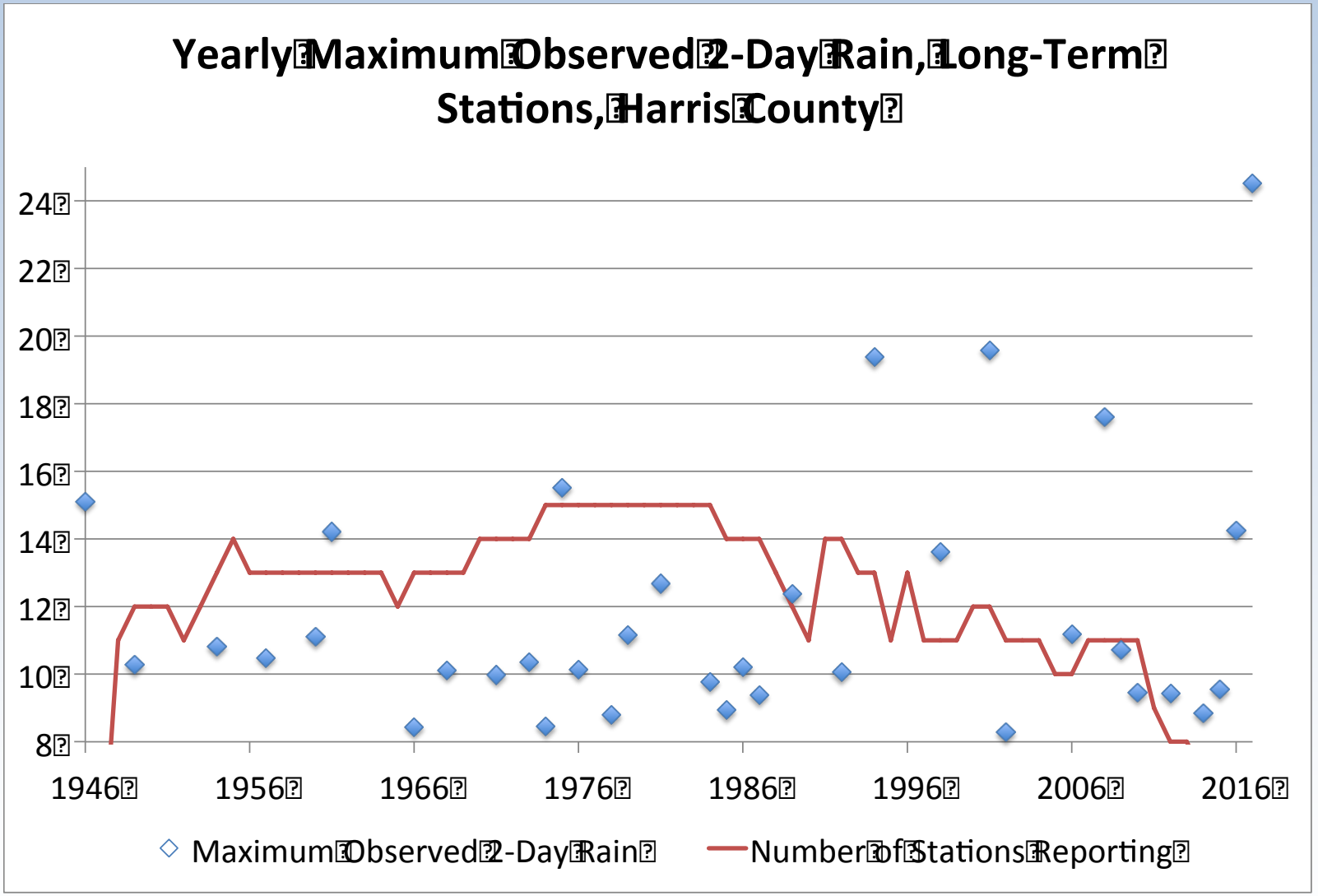
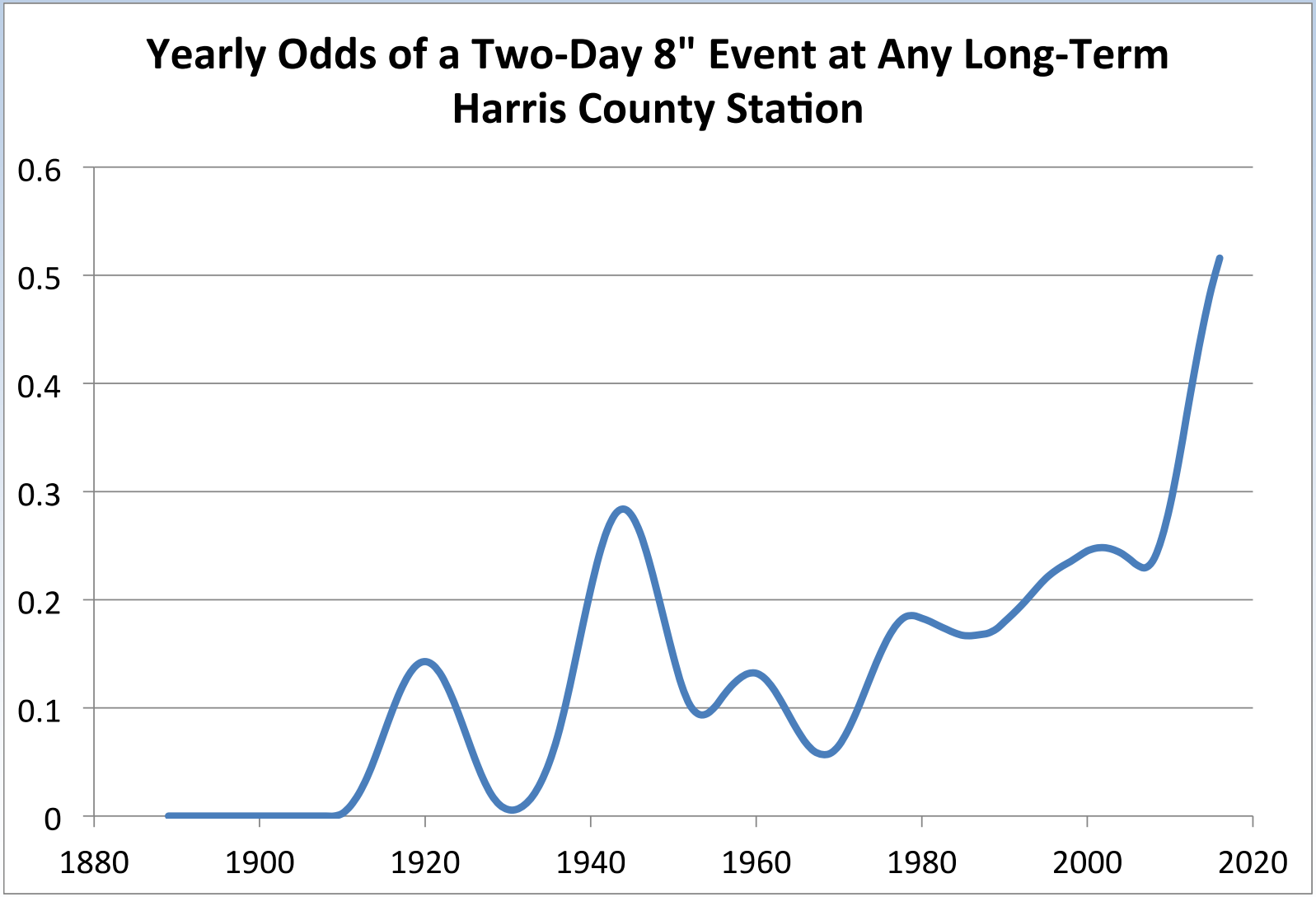


Historic analyses: Applied Weather Associates; US Army Corps of Engineers

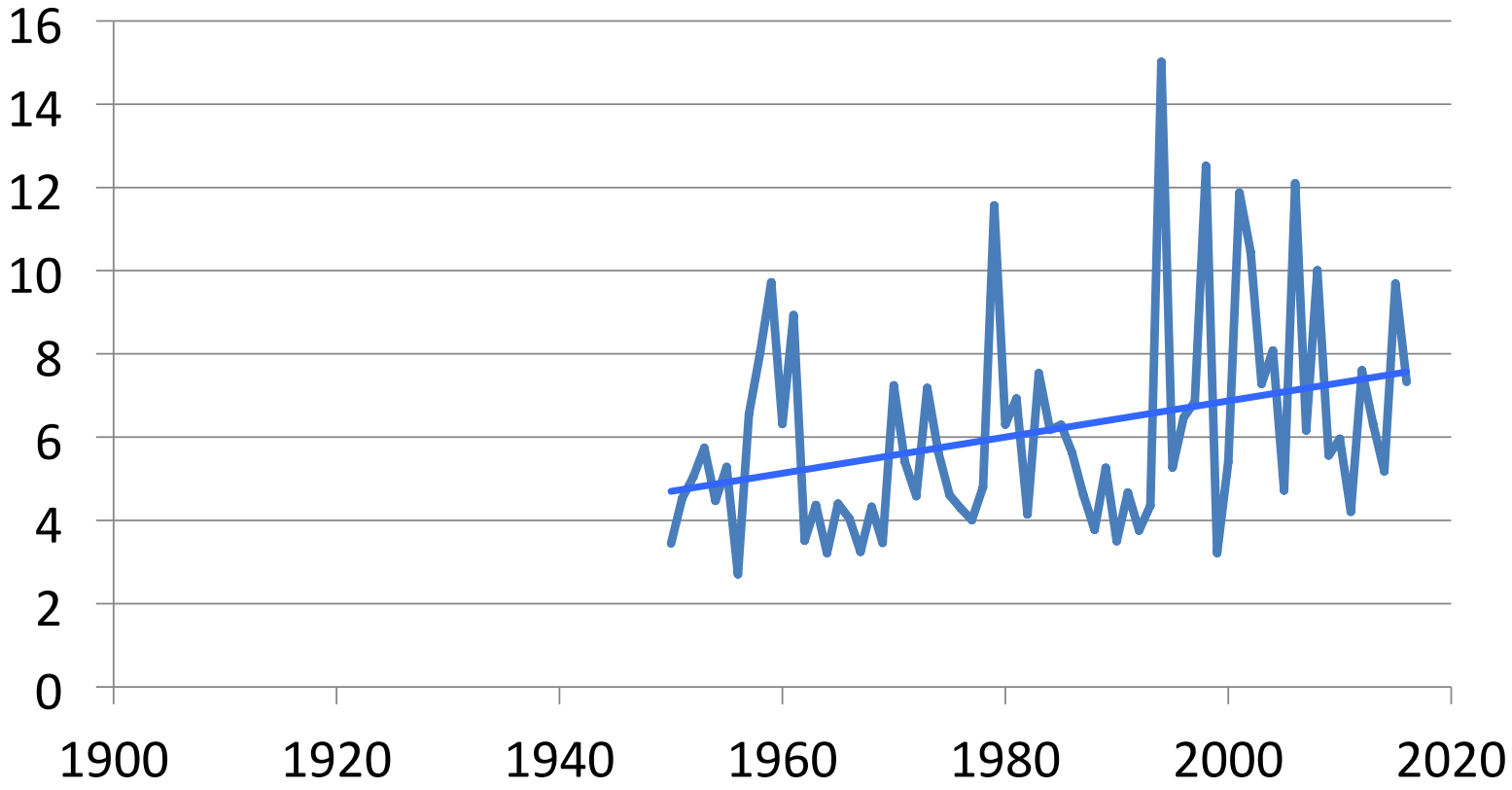
Average Annual Maximum 7-Day Precipitation (inches), SE Texas




Yearly Maximum Observed 2-Day Rain, Long-Term Stations, Harris County
24
22
20
18
16
14
12
10
8
1946
1956
1966
1976
1986
1996
2006
2016
Maximum Observed 2-Day Rain
Number of Stations Reporting


Yearly Odds of a Two-Day 8" Event at Any Long-Term Harris County Station
0.6
0.5
0.4
0.3
0.2
0.1
0
1880
1900
1920
1940
1960
1980
2000
2020

Average Annual Maximum 7-Day Precipitation (inches), SE Texas



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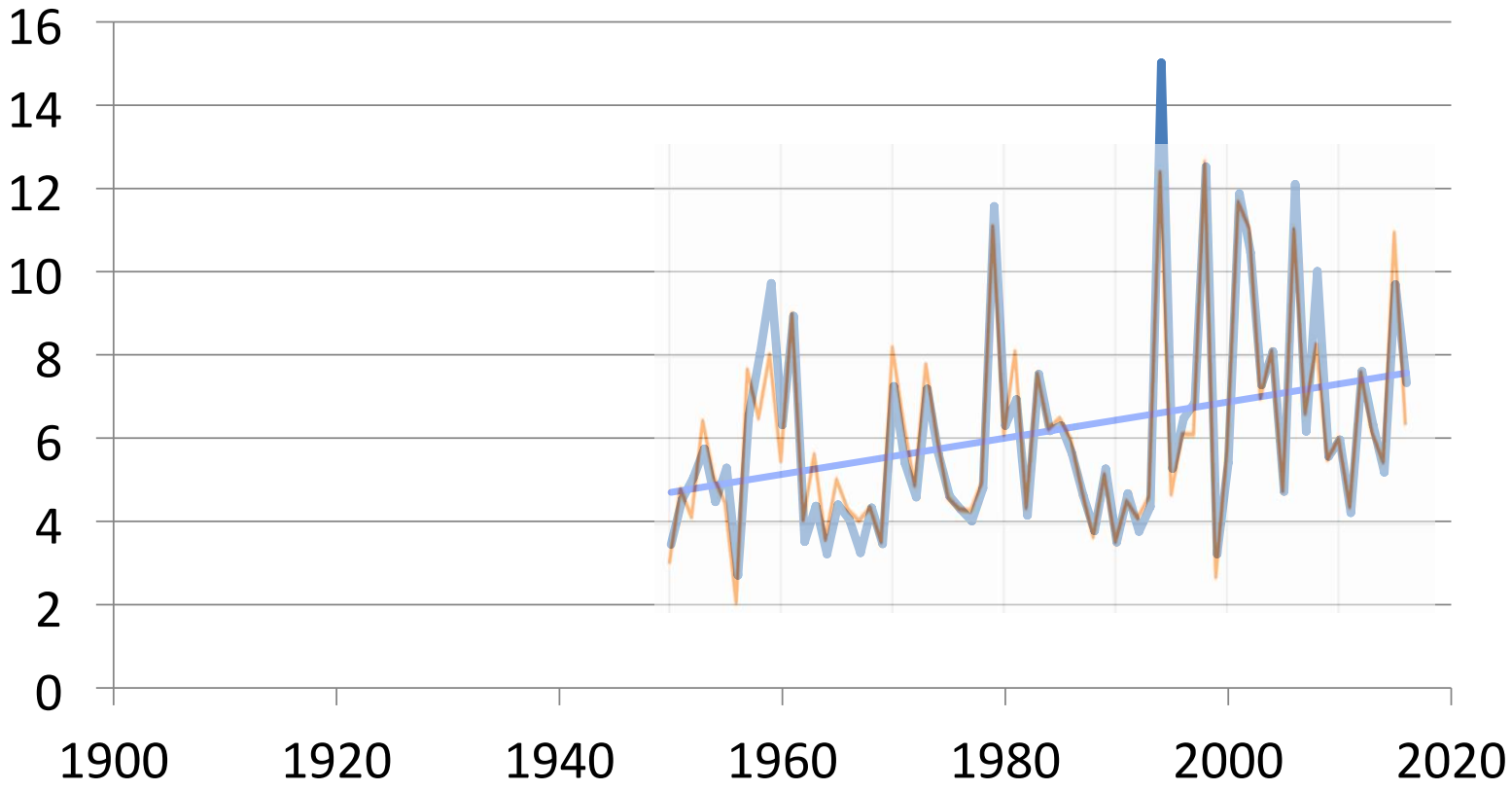
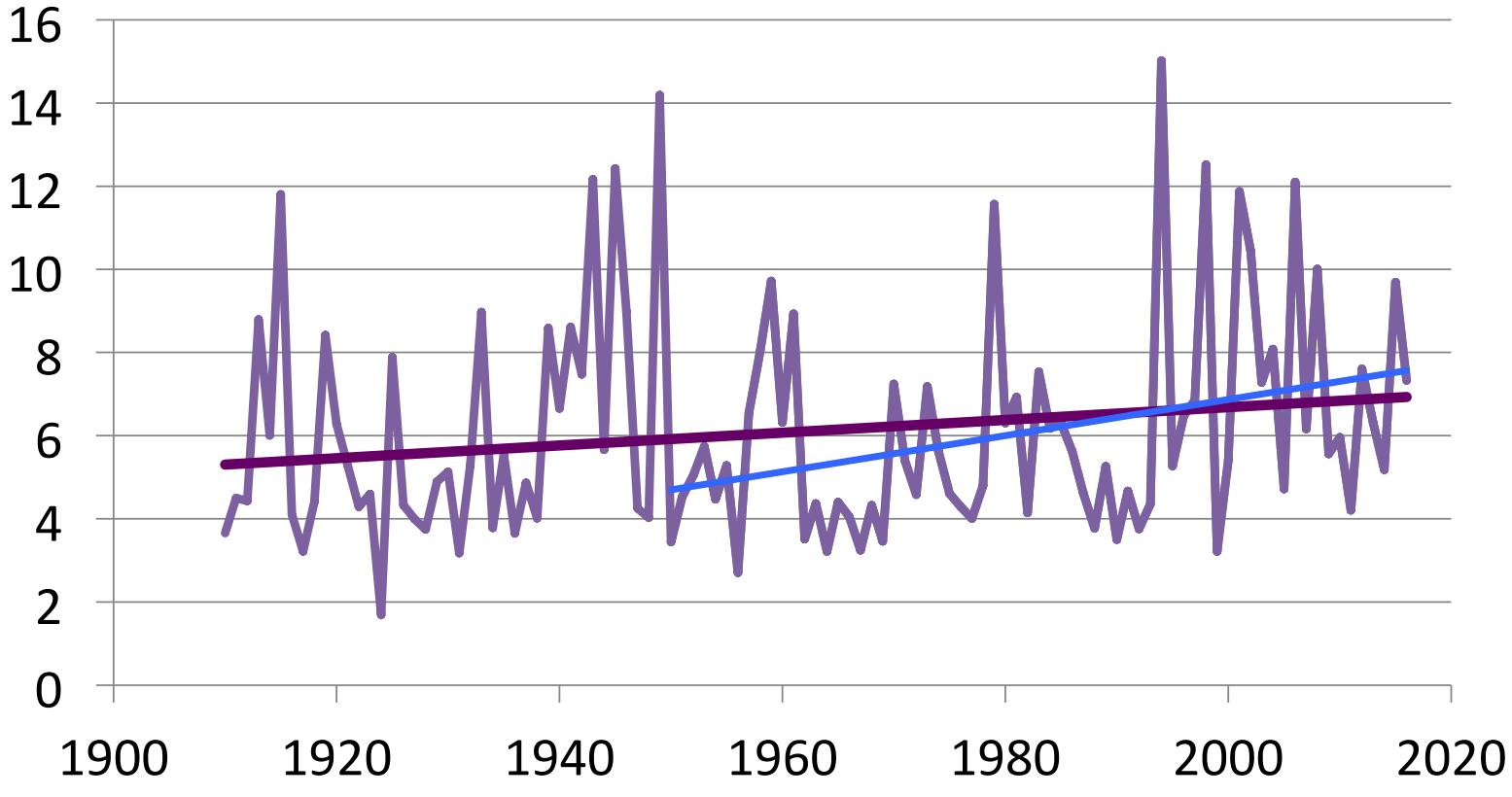
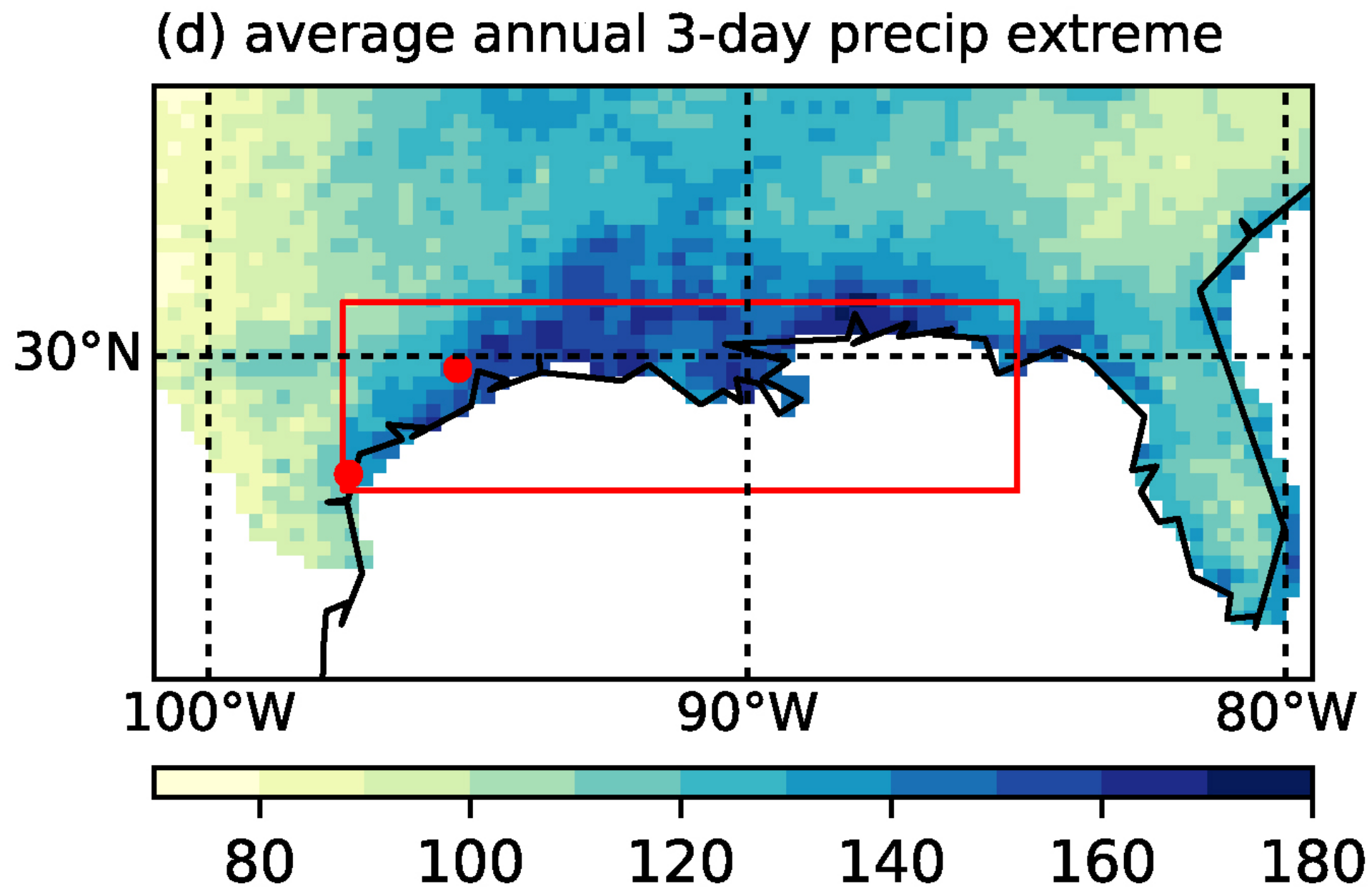


Comparison with Risser & Wehner 2017,
http://onlinelibrary.wiley.com/doi/10.1002/2017GL075888/full

Average Annual Maximum 7-Day Precipitation (inches), SE Texas





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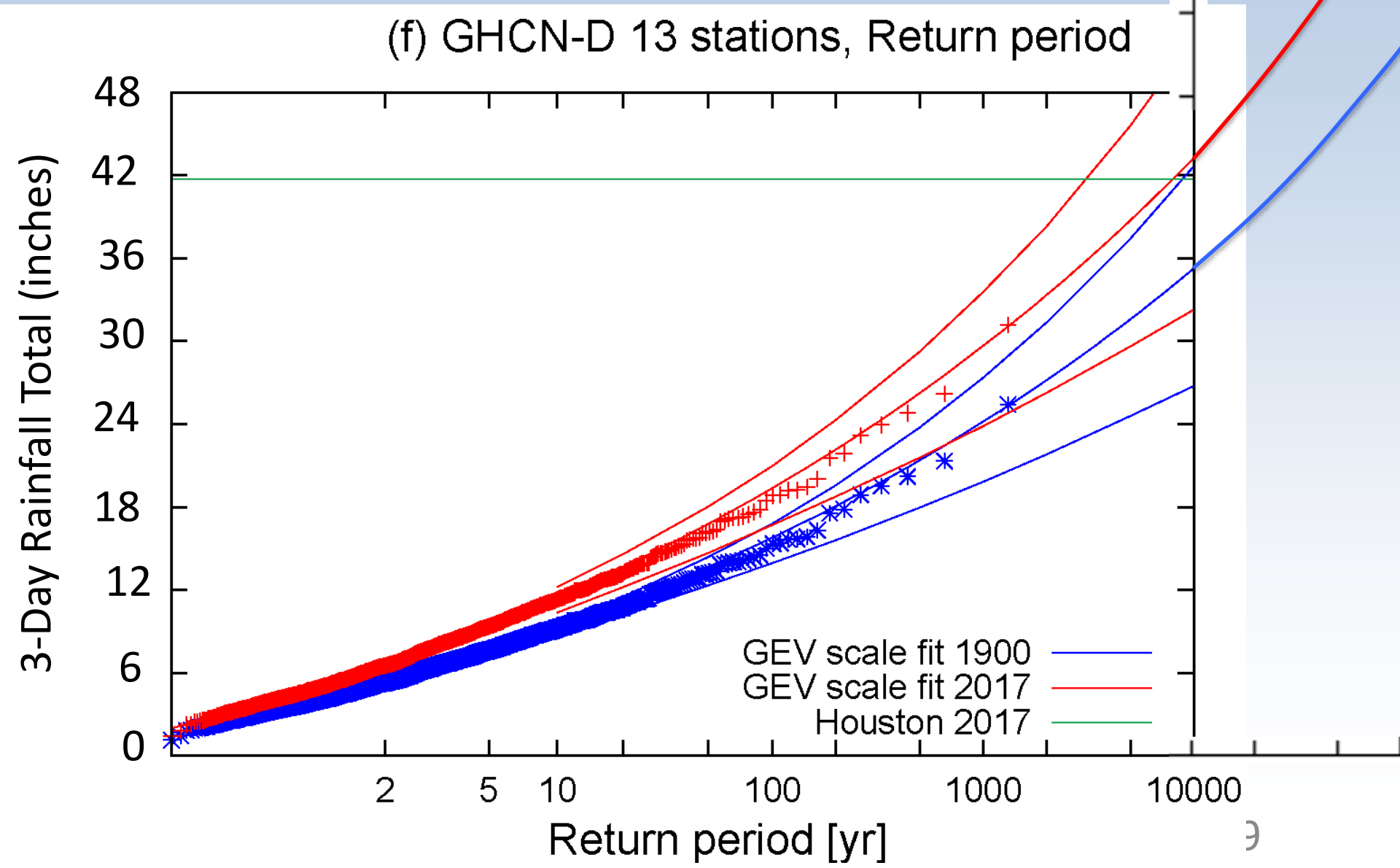

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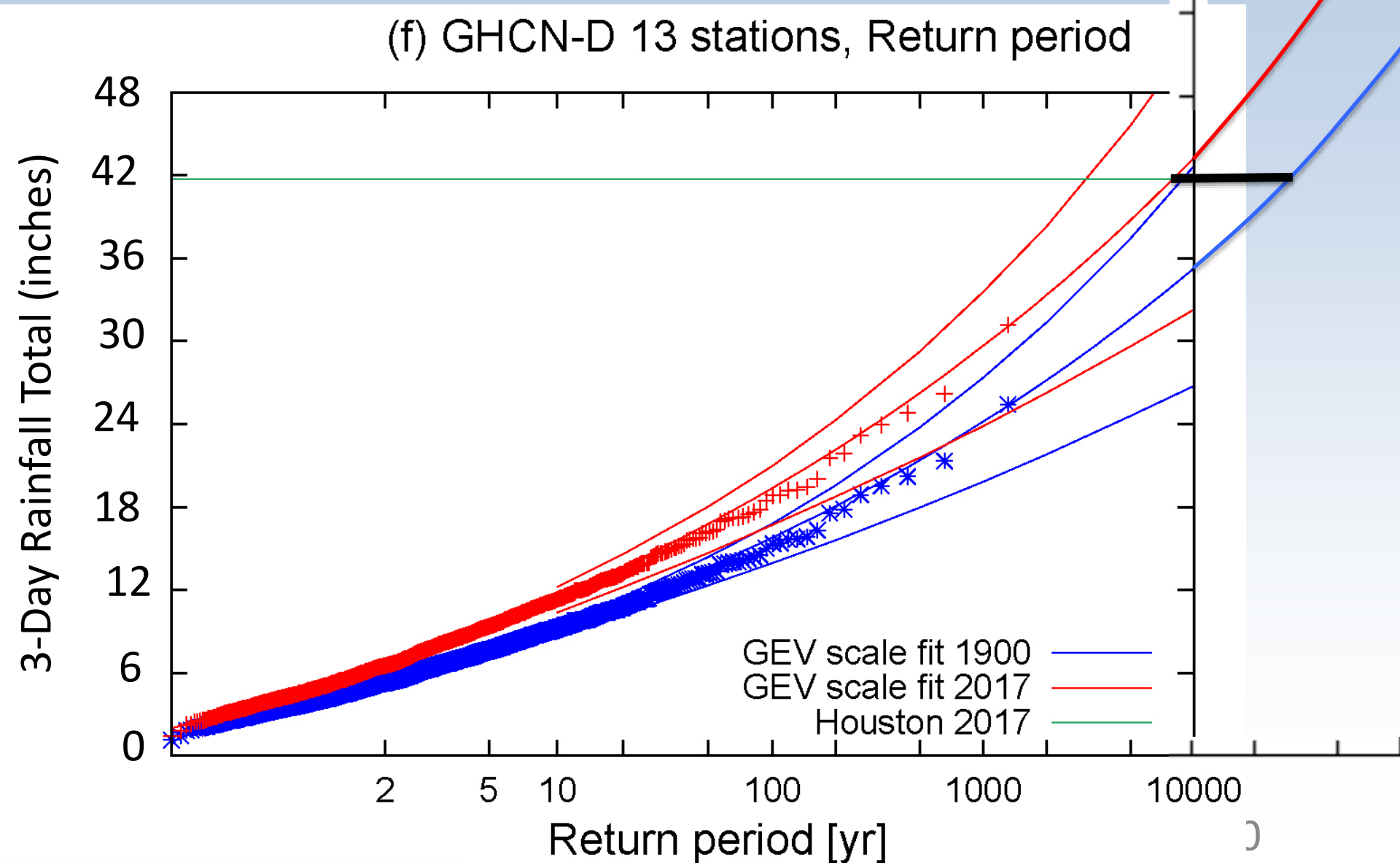

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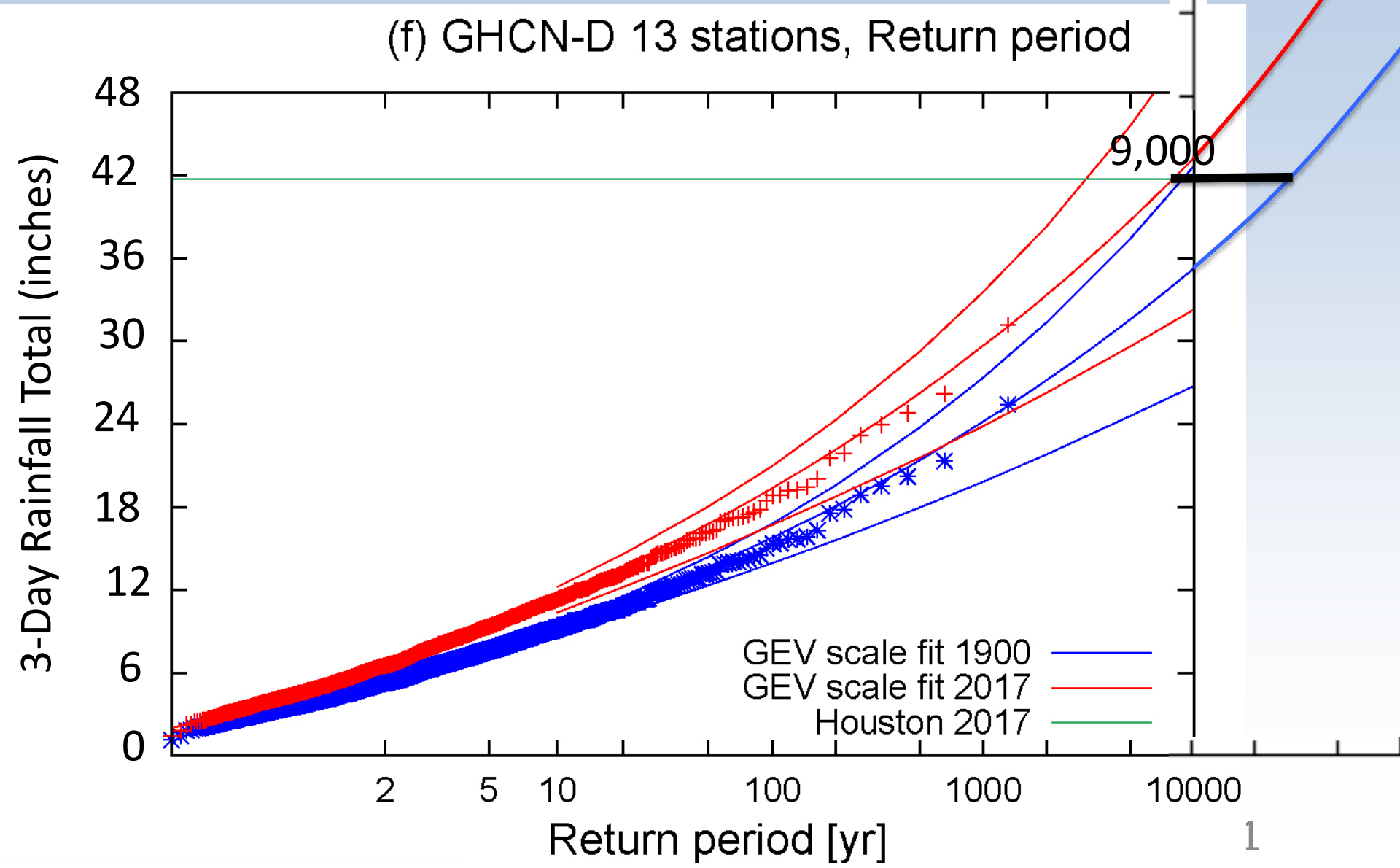

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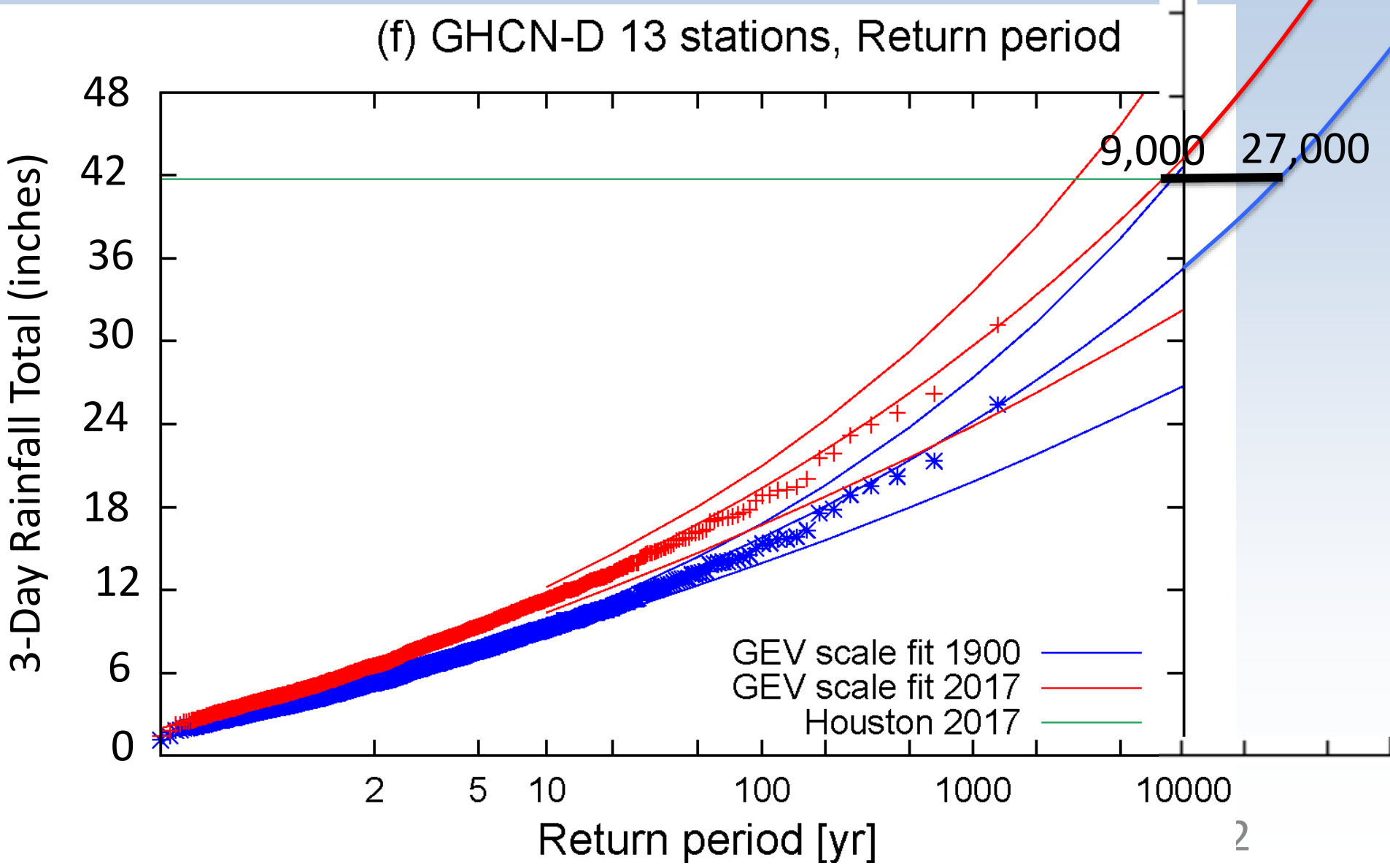

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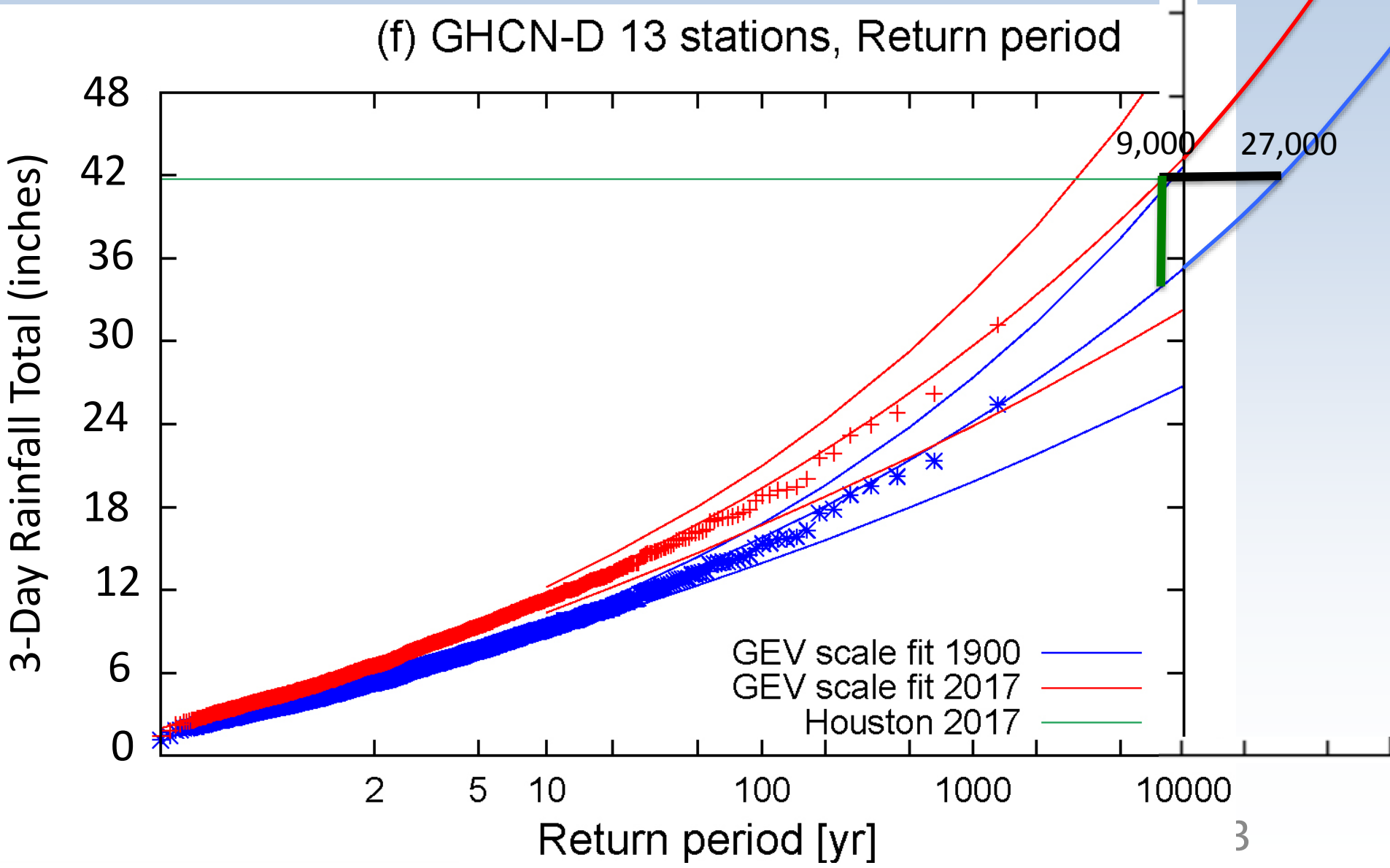

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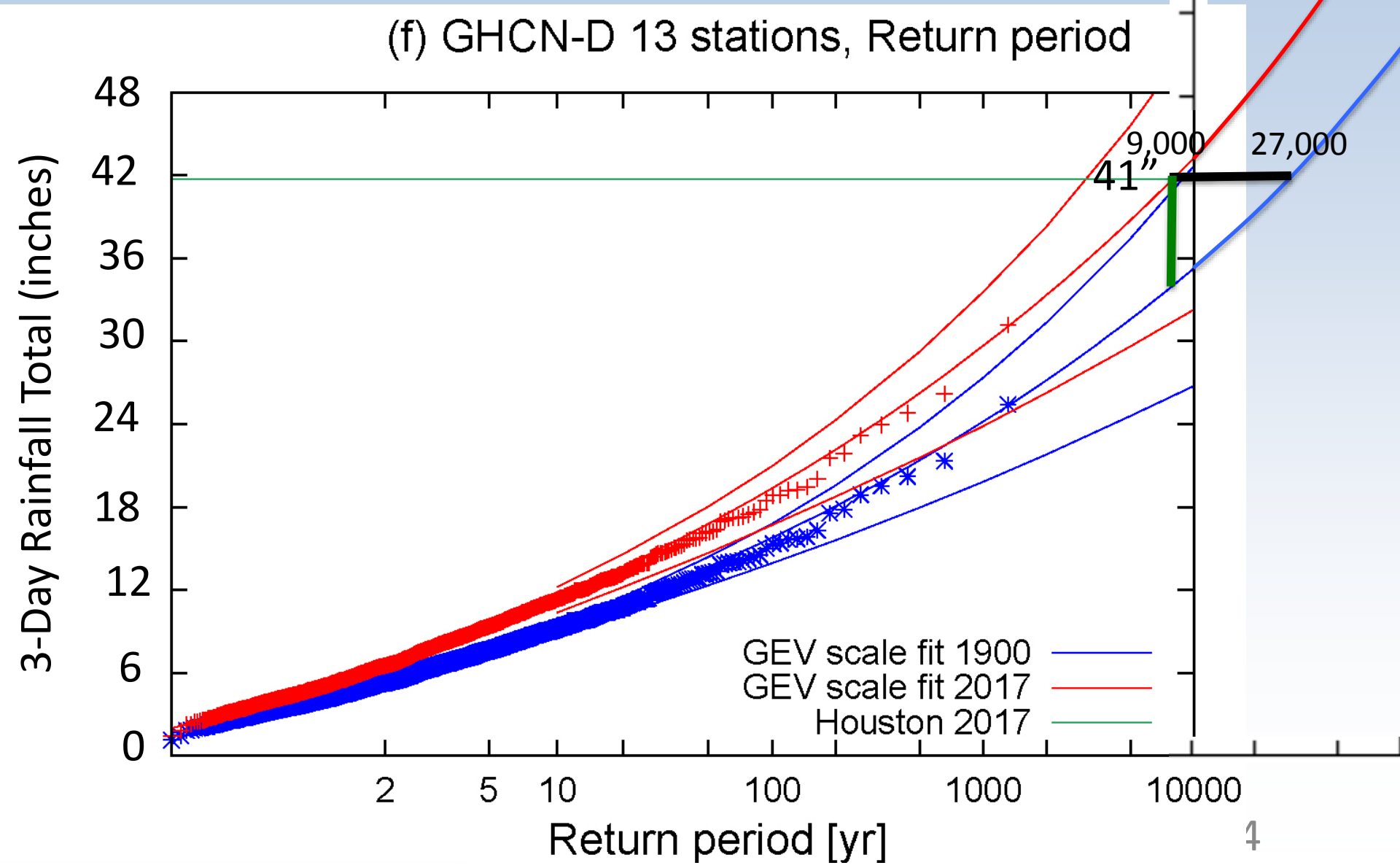

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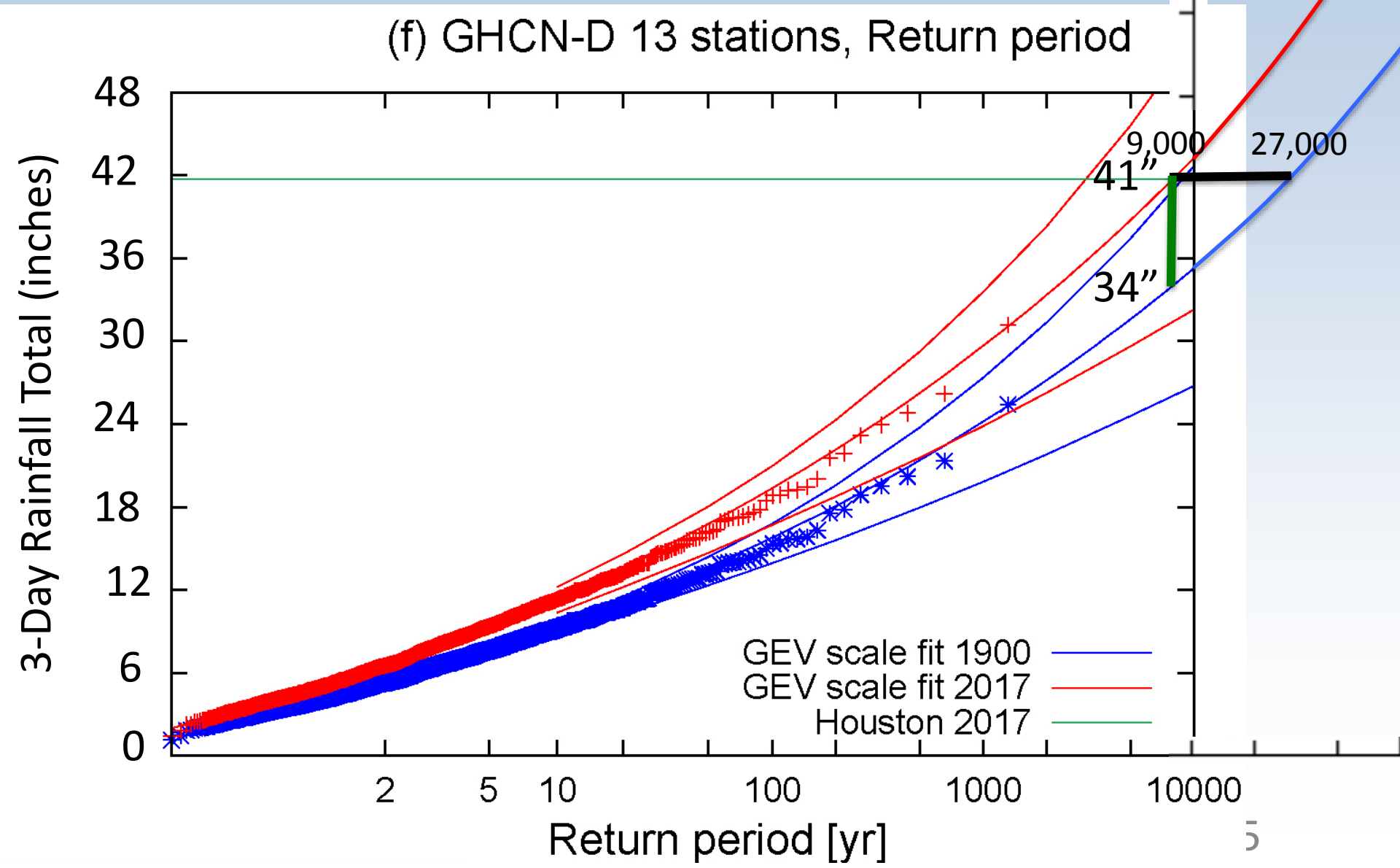

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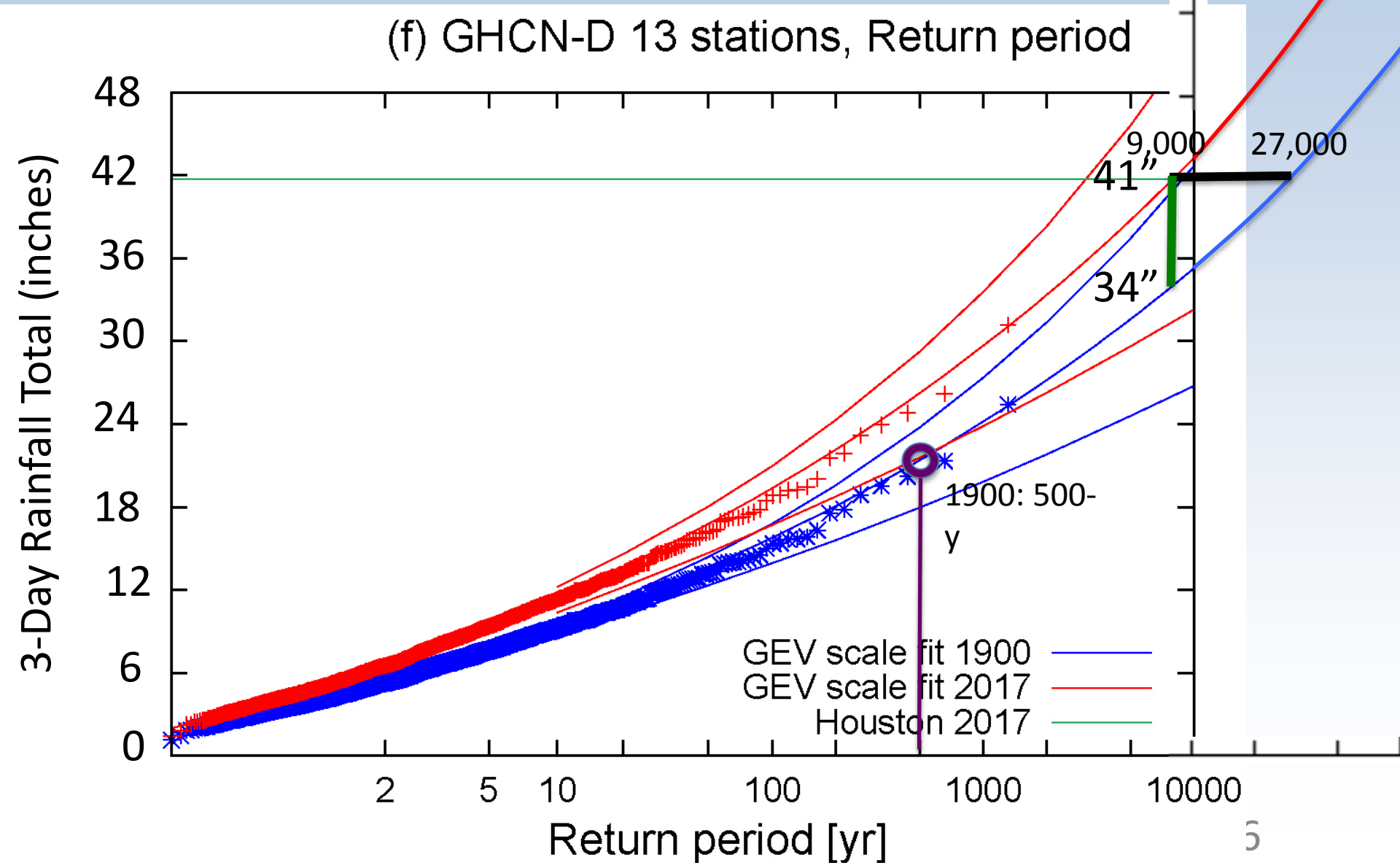

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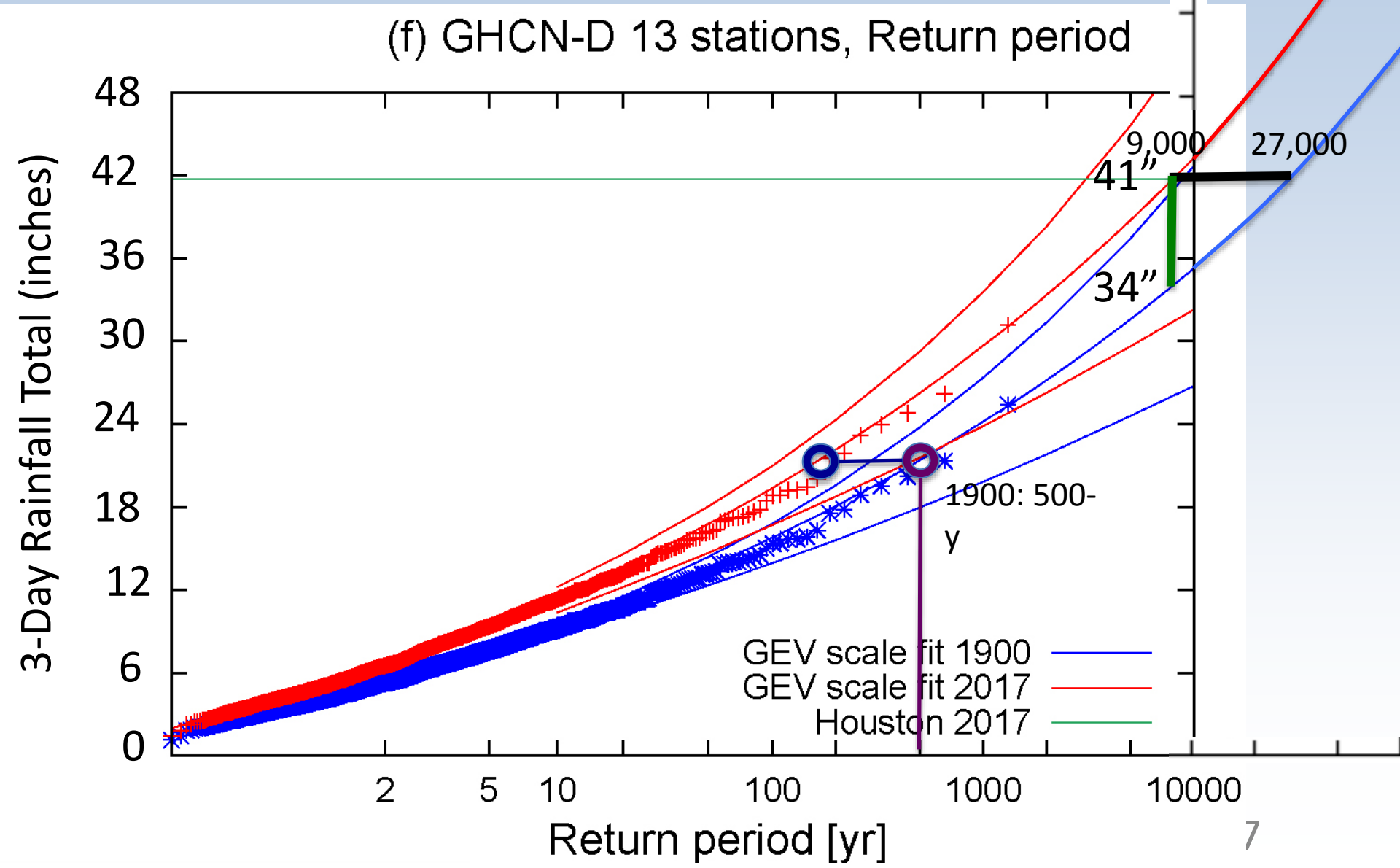

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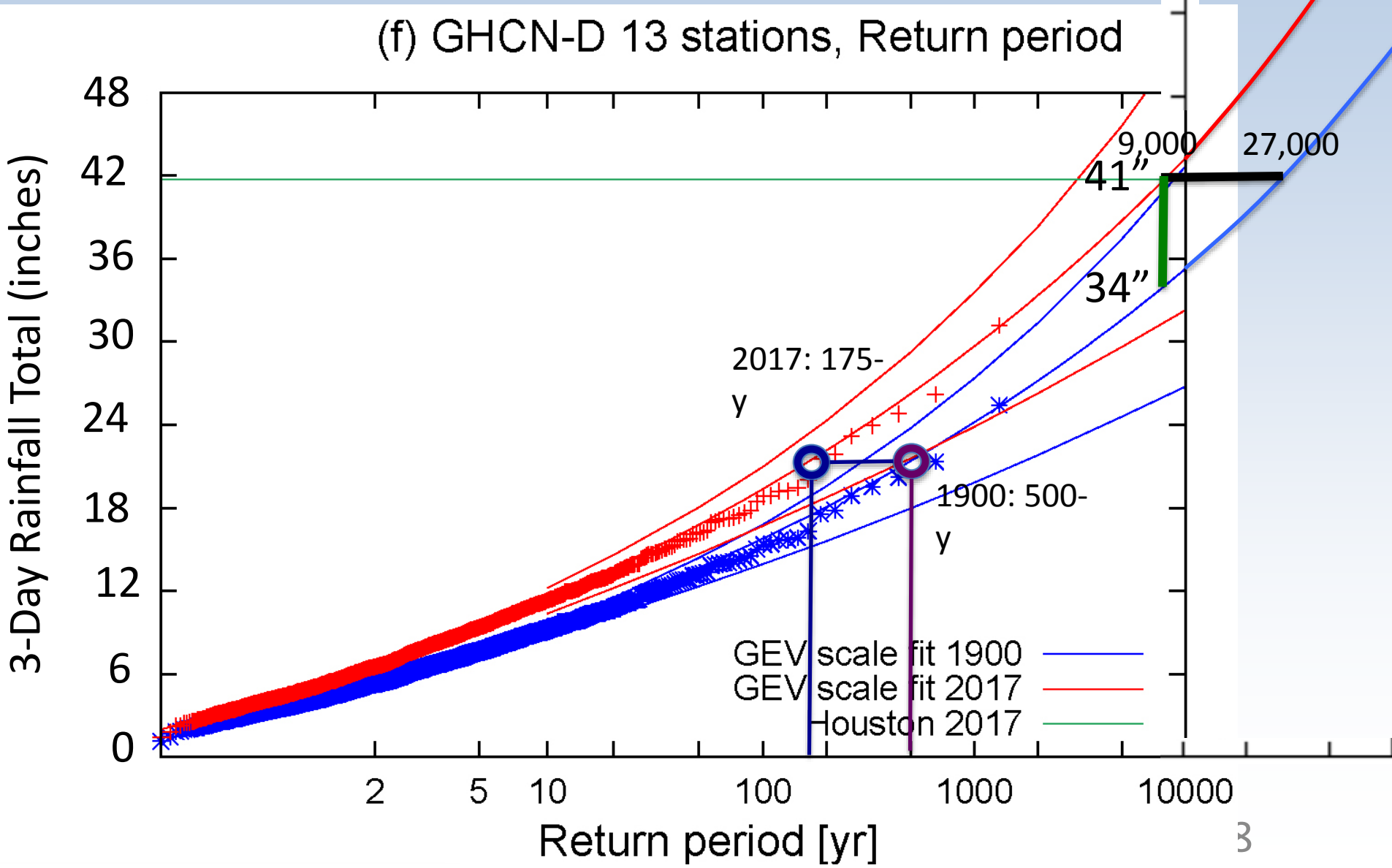

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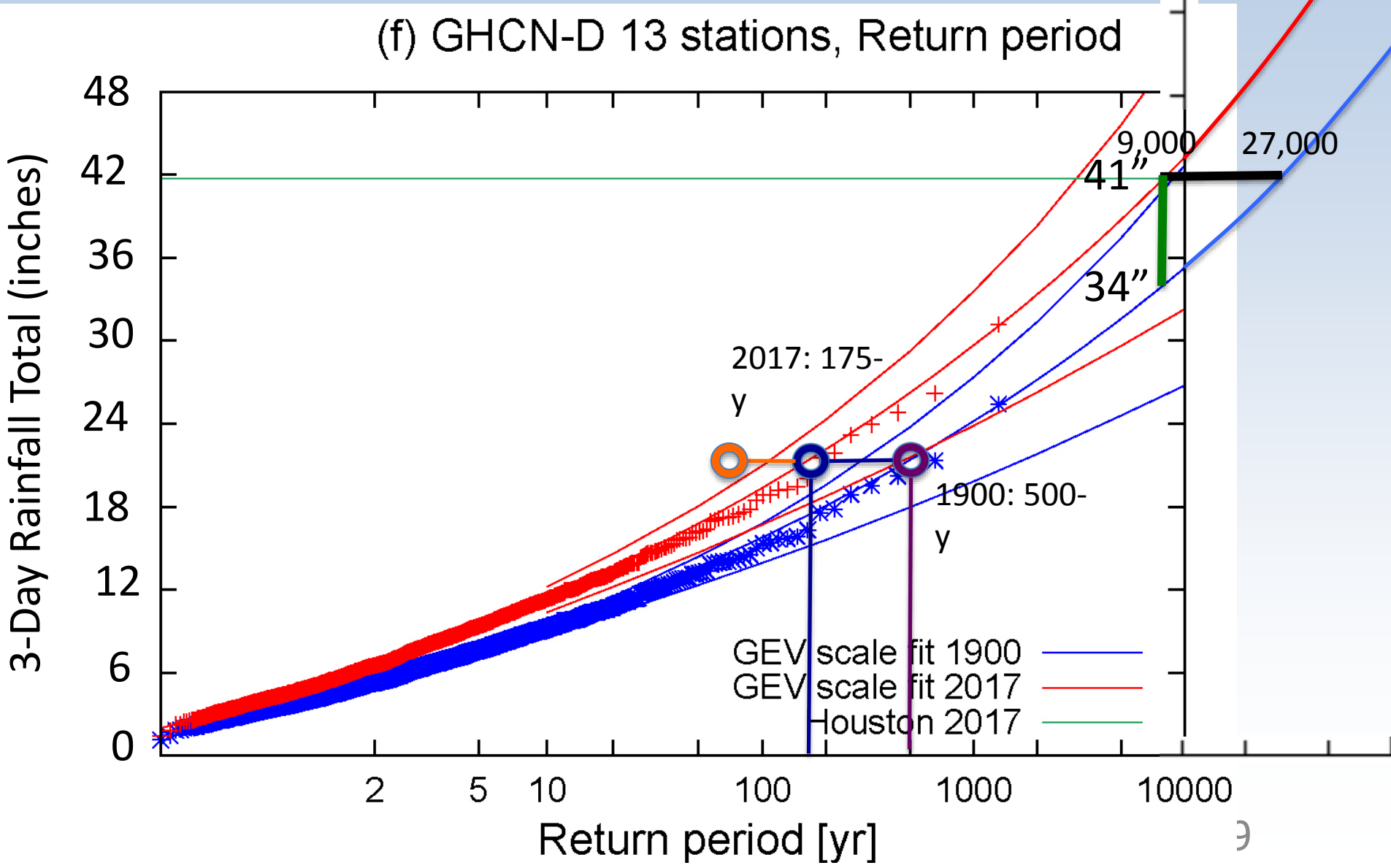

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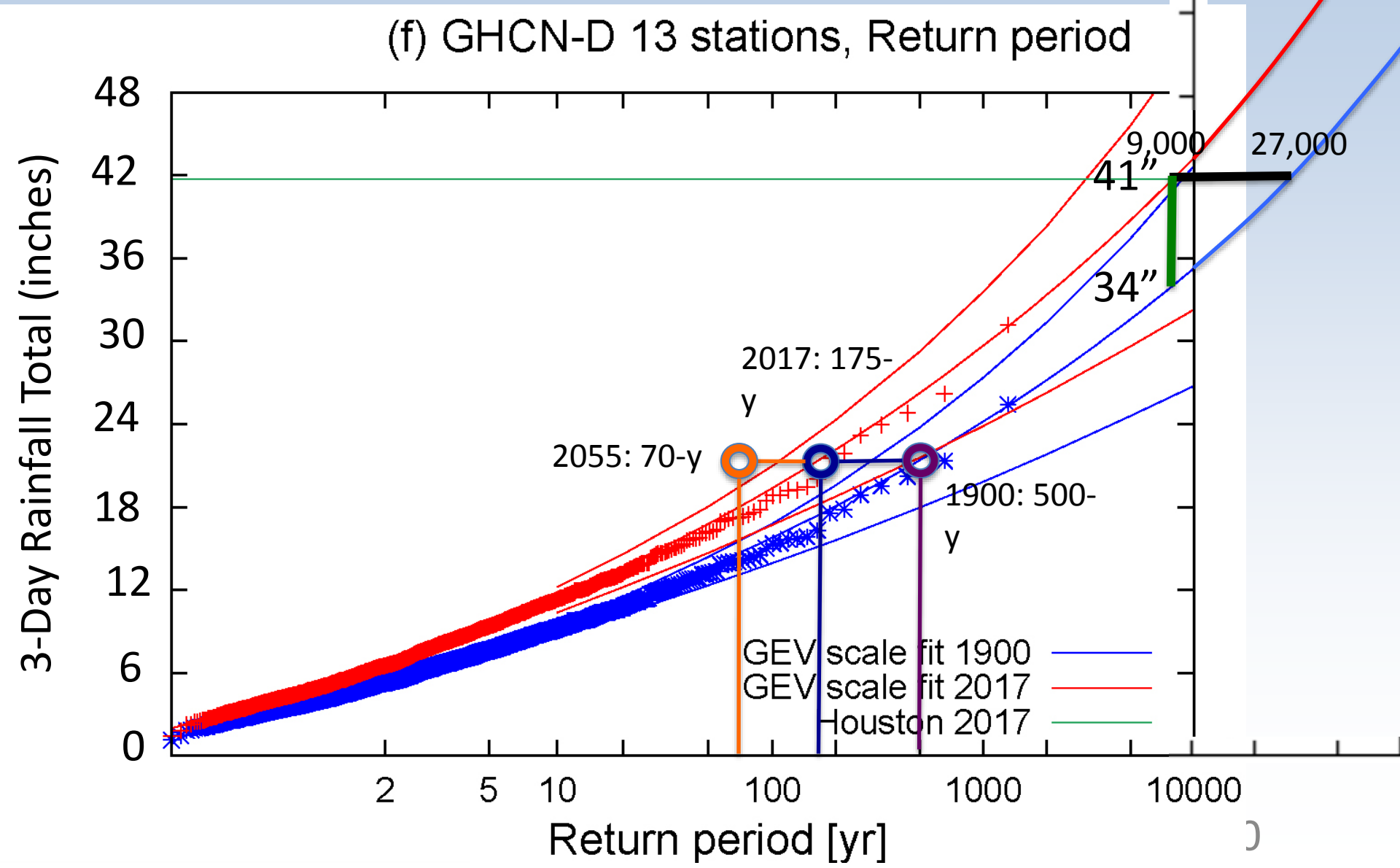
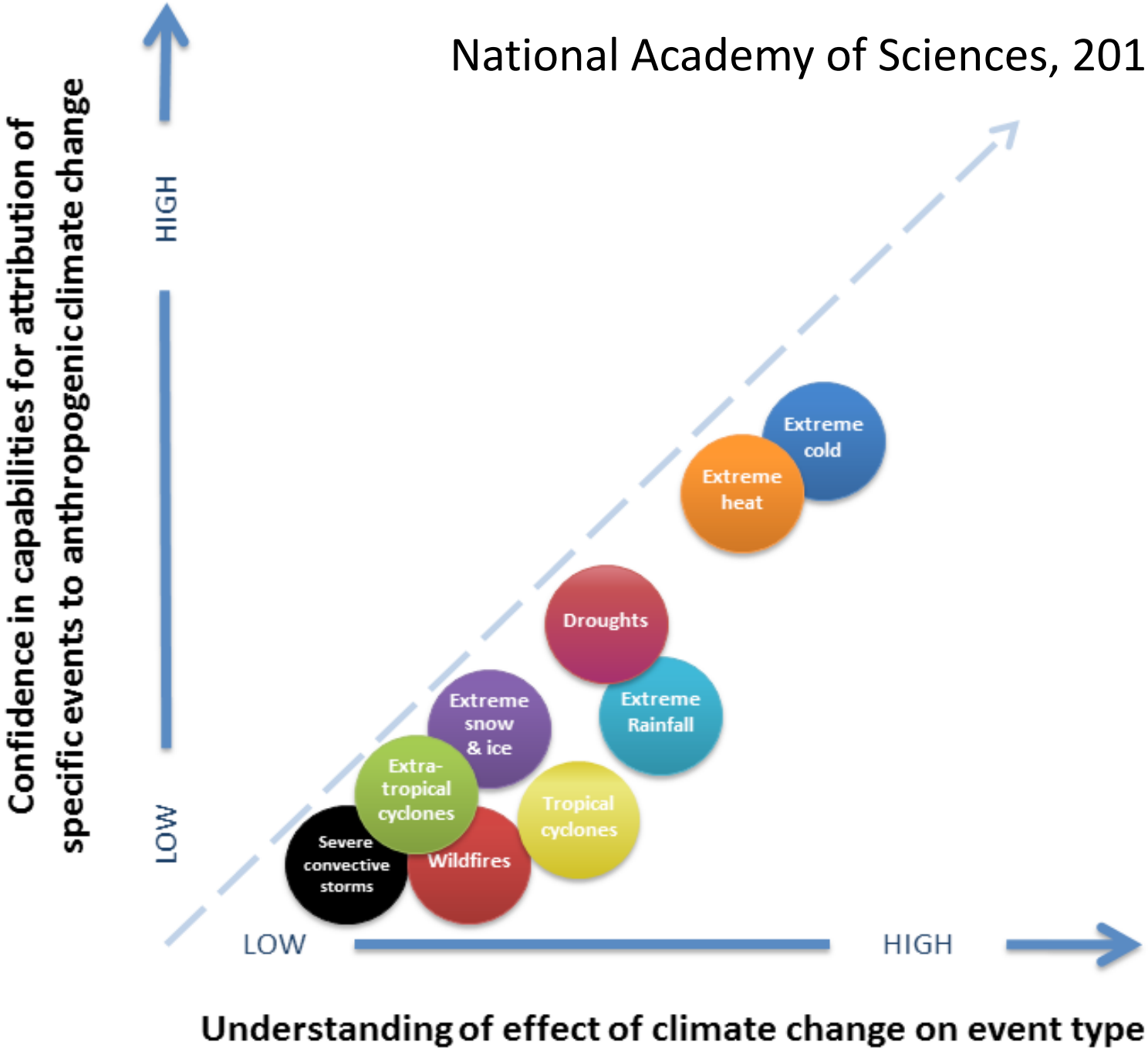


National Academy of Sciences, 2016



Drought: Consider the Possibilities

Total Rainfall Amount

Heavy Rain Intensity	Increase	Steady	Decrease
Steady			
Increase			

Drought: Consider the Possibilities

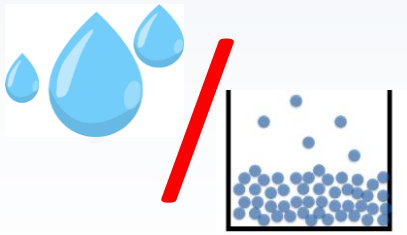
Total Rainfall Amount

Heavy Rain Intensity	Increase	Steady	Decrease
Steady	X		
Increase			

Drought: Consider the Possibilities

Total Rainfall Amount

Heavy Rain Intensity

	Increase	Steady	Decrease
Steady	X		
Increase			

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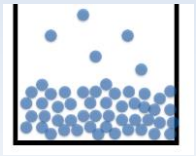
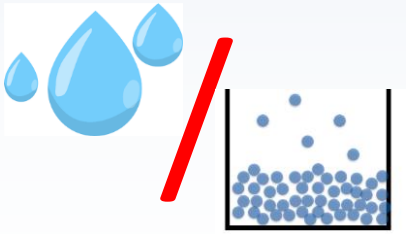
Total Rainfall Amount

Heavy Rain Intensity

	Increase	Steady	Decrease
Steady	X		
Increase			

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Heavy Rain Intensity

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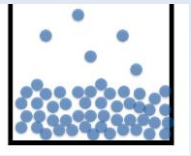
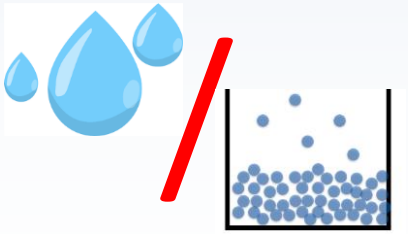
Steady	X		
Increase			

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Heavy Rain Intensity

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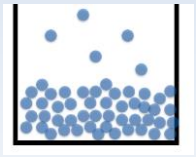
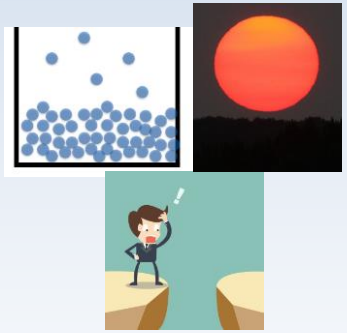
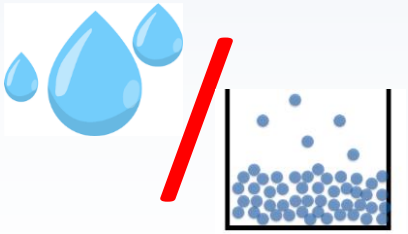
Steady	X		
Increase			

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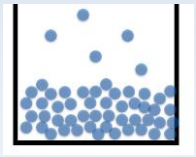
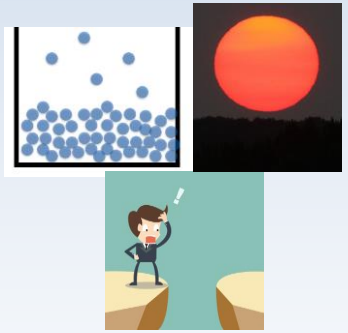
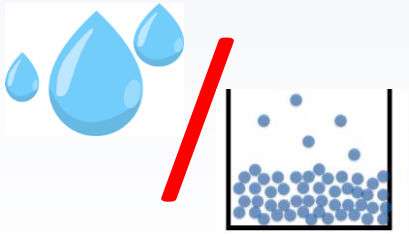
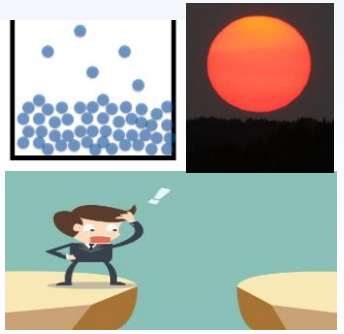
Heavy Rain Intensity

	Increase	Steady	Decrease
Steady	X		
Increase			

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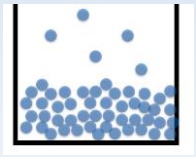
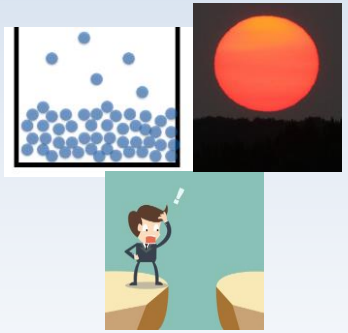
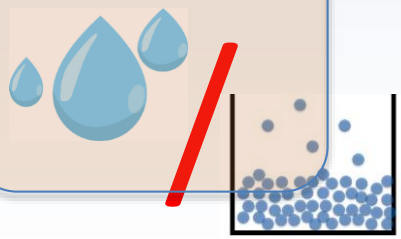
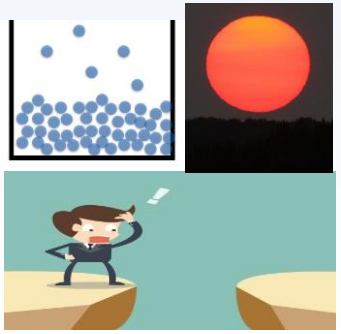
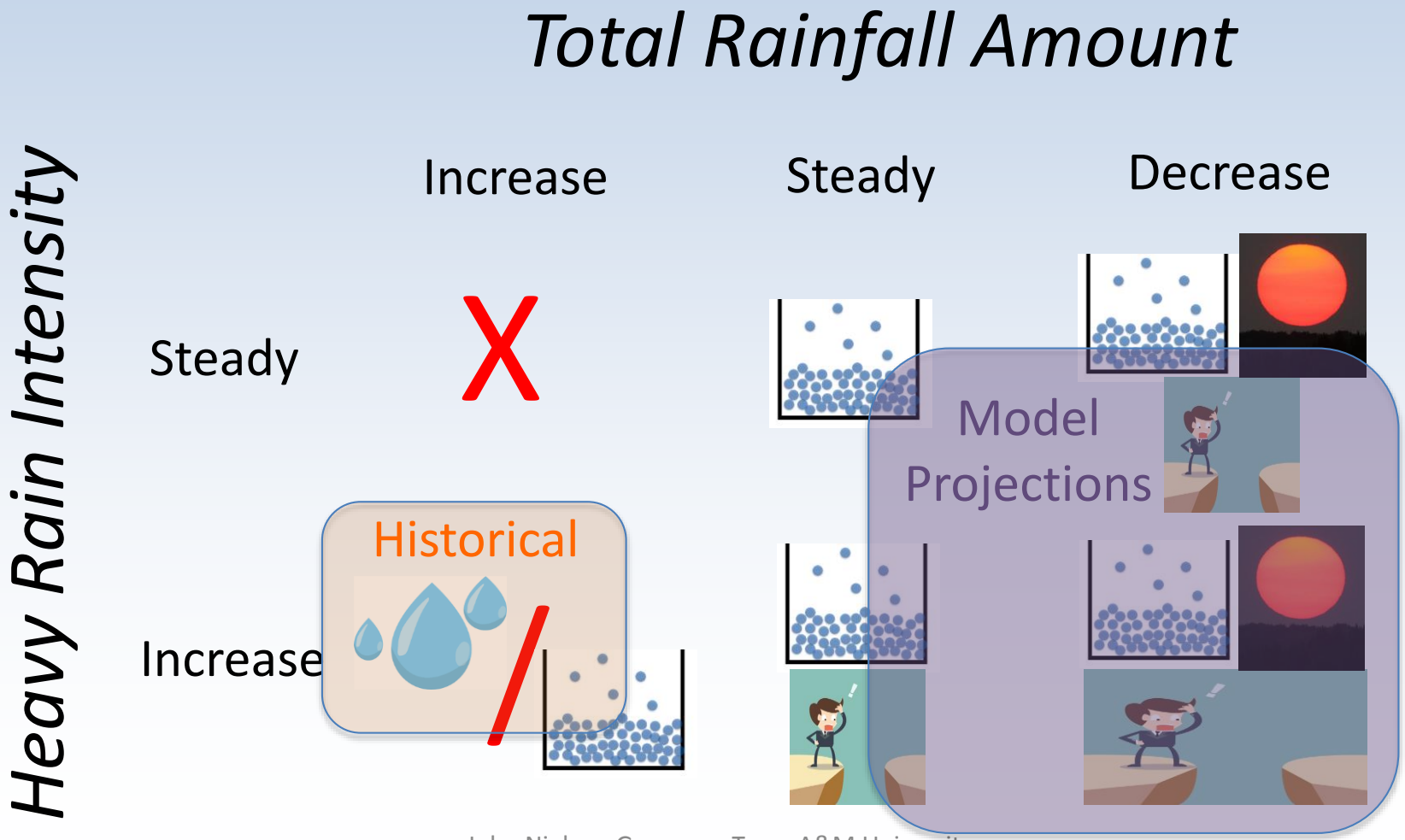
Heavy Rain Intensity

	Increase	Steady	Decrease
Steady	X		
Increase	Historical 		

Drought: Consider the Possibilities



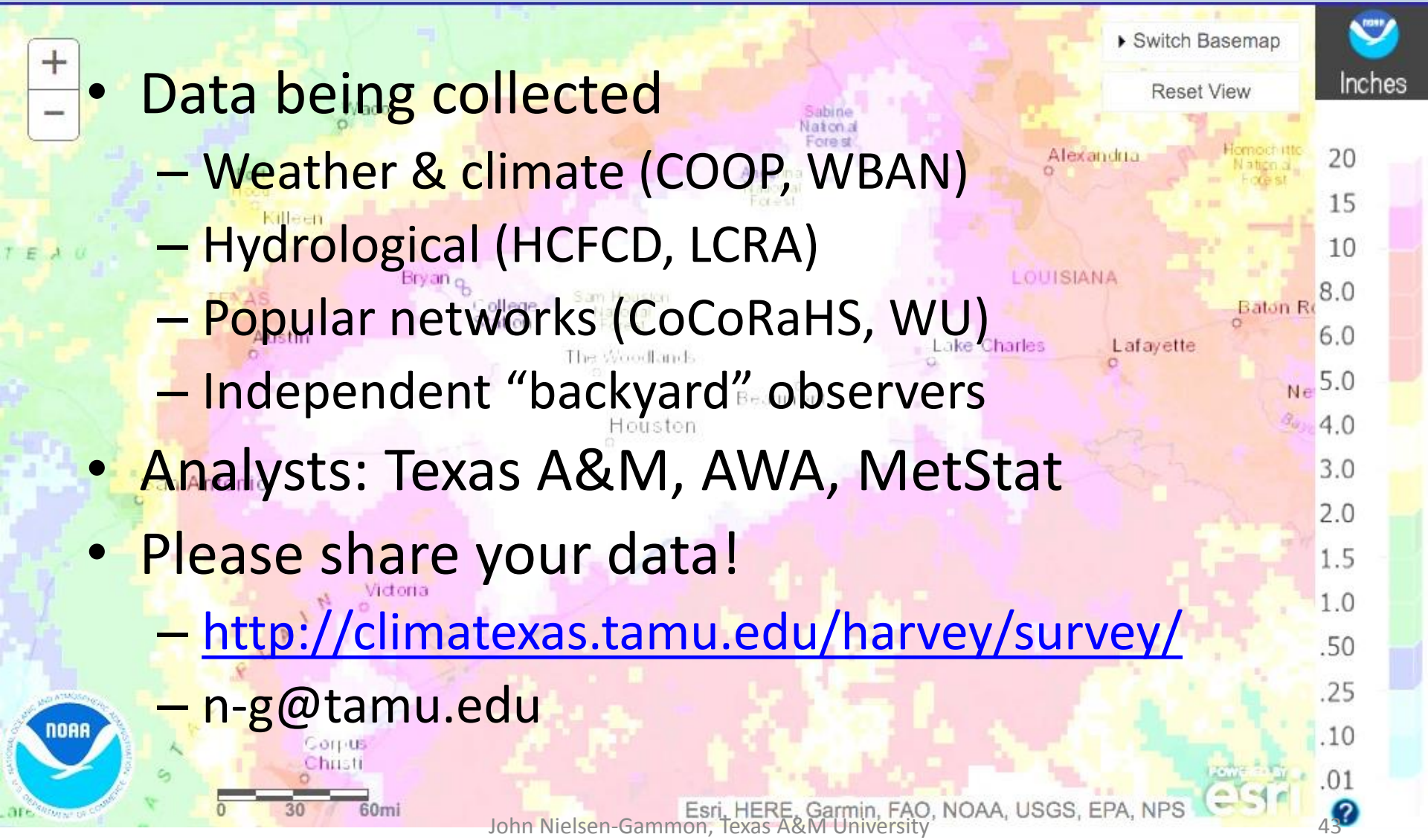
Messages

- Harvey was exceptional
- Odds of extreme rainfall have increased
  - And will continue to increase
  - Odds change ballpark estimate: Factor of 3 (2-8) per °C global warming
  - Amount change ballpark estimate: 15% (10-30%) per °C global warming

More Messages

- Annual rainfall amounts have increased
  - But may decrease in future
- Future drought intensity depends on:
  - Intensity of heavy rain
  - Overall rainfall amounts
  - Increasing temperatures (a given)
- Houston has been unlucky

Comprehensive Rainfall Survey (NSF-funded project)



- Data being collected
  - Weather & climate (COOP, WBAN)
  - Hydrological (HCFCD, LCRA)
  - Popular networks (CoCoRaHS, WU)
  - Independent “backyard” observers
- Analysts: Texas A&M, AWA, MetStat
- Please share your data!
  - http://climatexas.tamu.edu/harvey/survey/
  - n-g@tamu.edu

Bonus Slides

Measure of Stalling: Corral Size

- Contains all storm locations over three days

Harvey's corral radius: 123 km centered at 12 UTC Aug 27

Average maximum sustained wind while stalled: 50 kt (26 m/s)

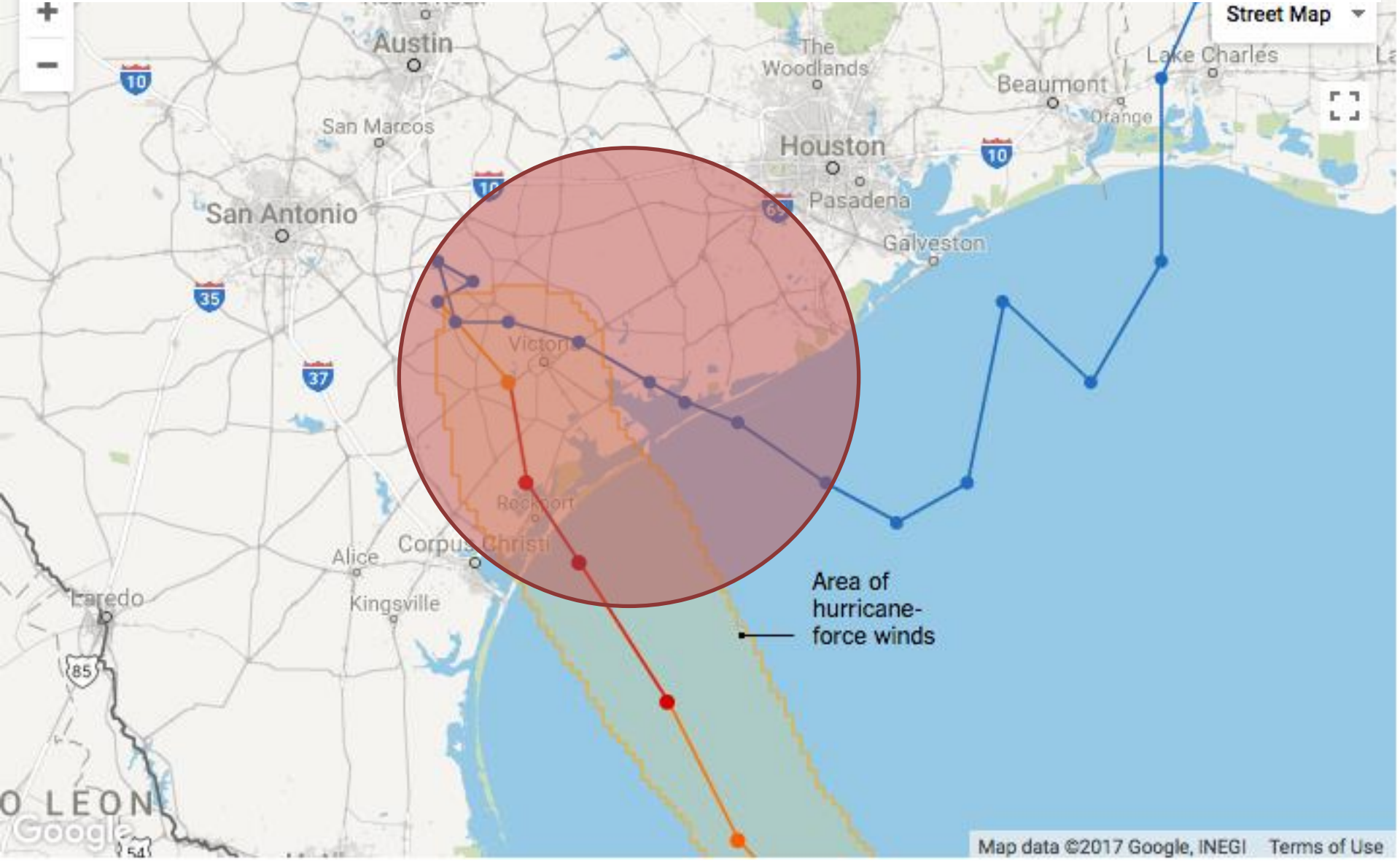
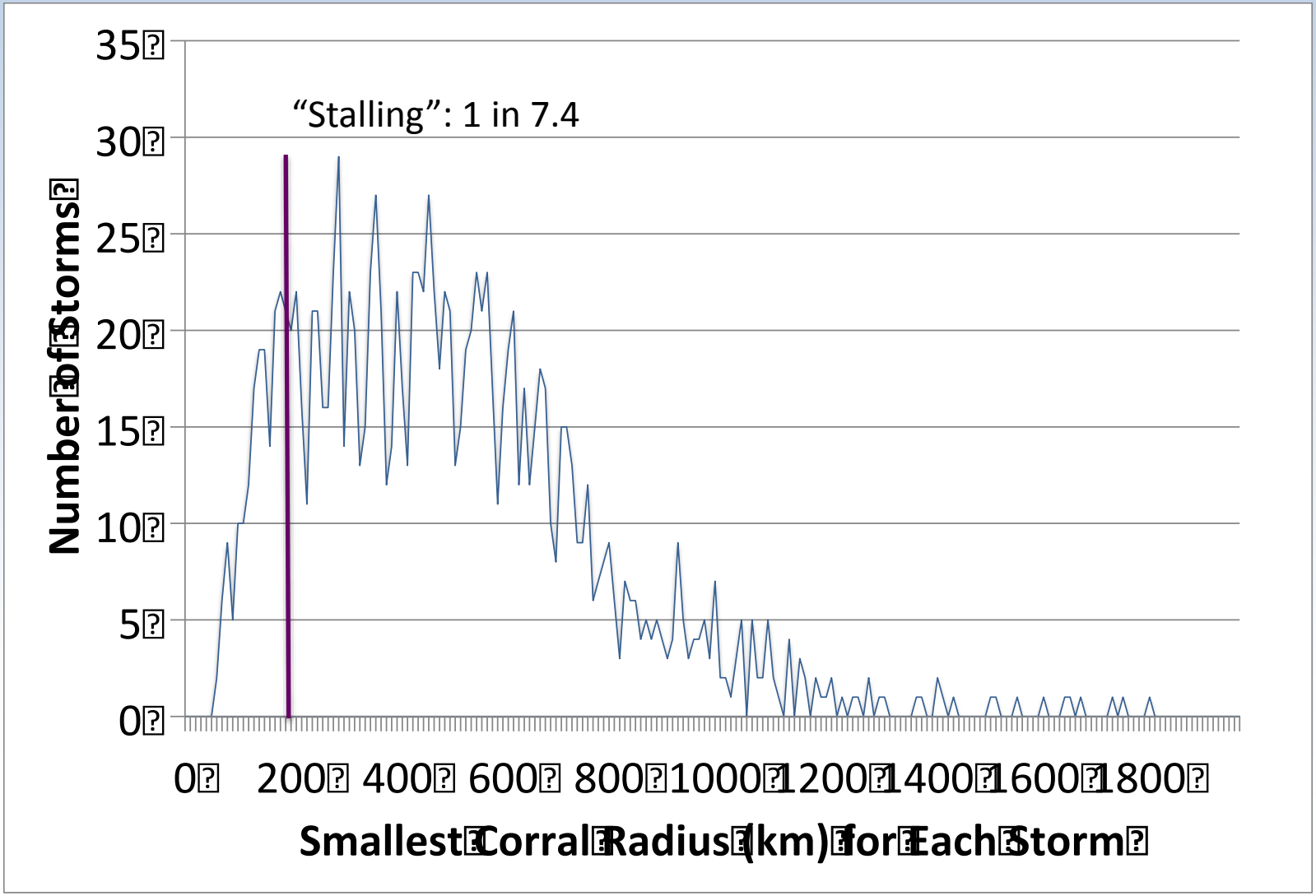
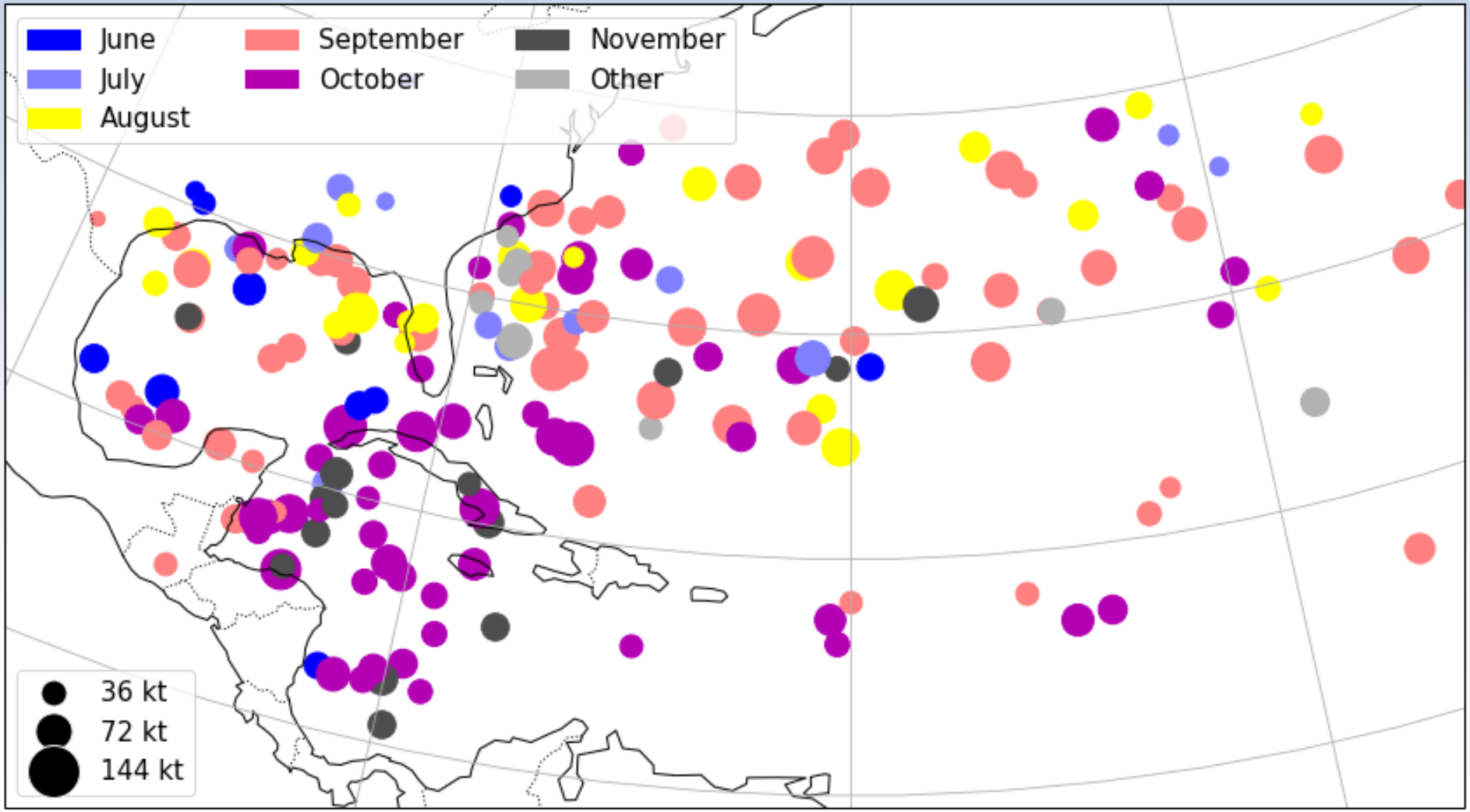


Image: New York Times 2017, with data from NWS, NASA GEOS, and IBTRACS

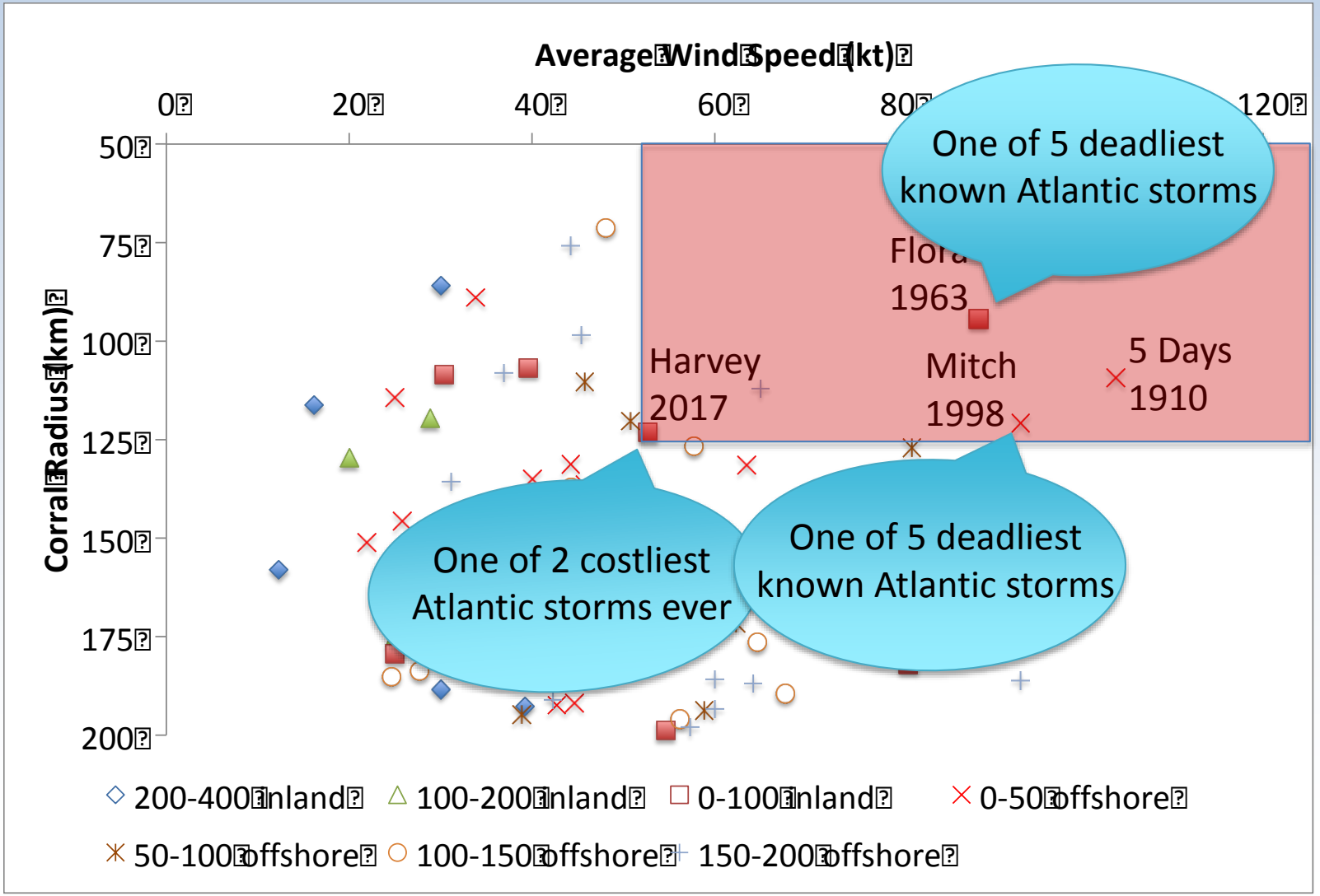
How Slow Can Tropical Cyclones Go?



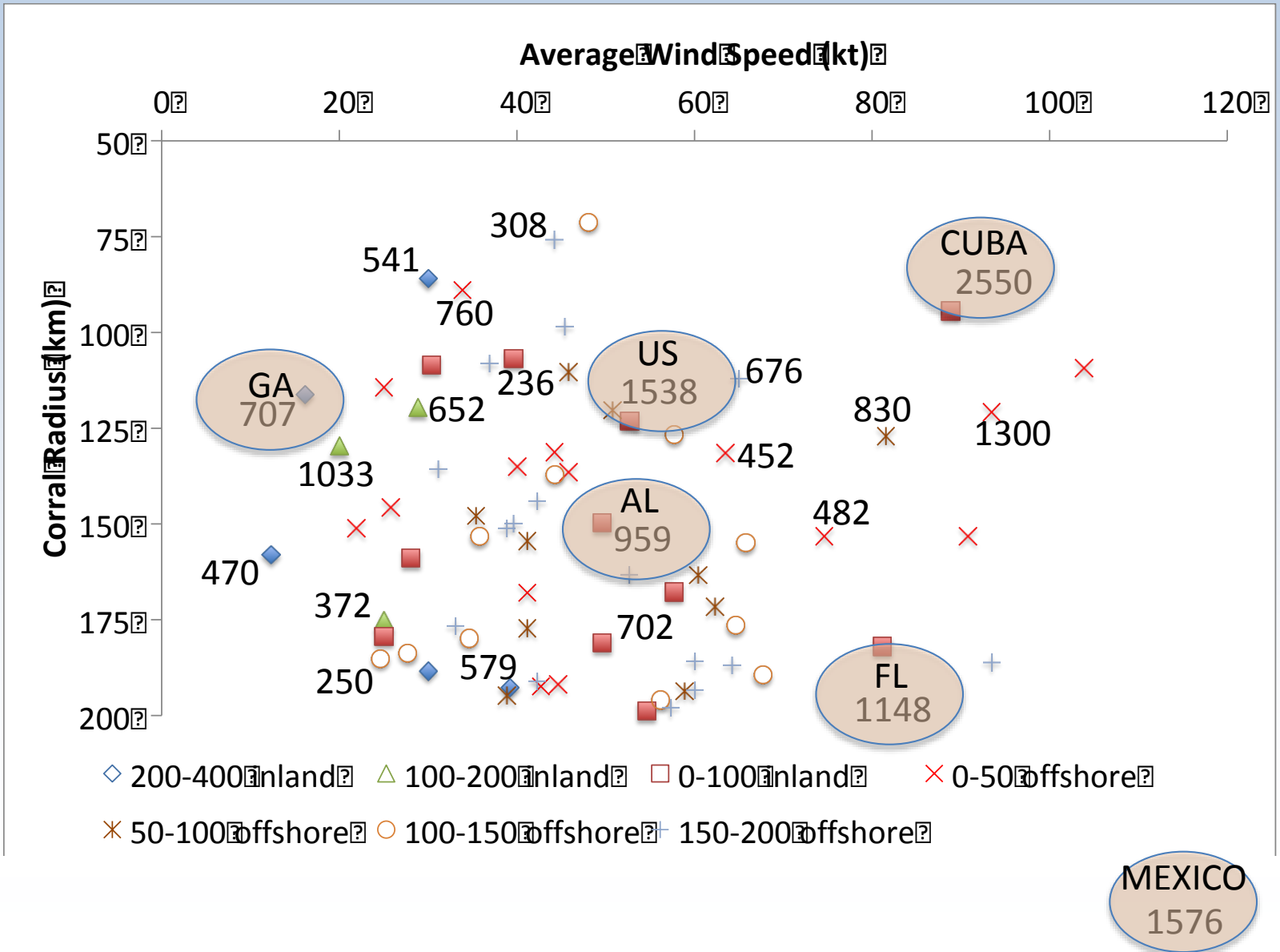
Stalled Tropical Cyclones: Month, Intensity



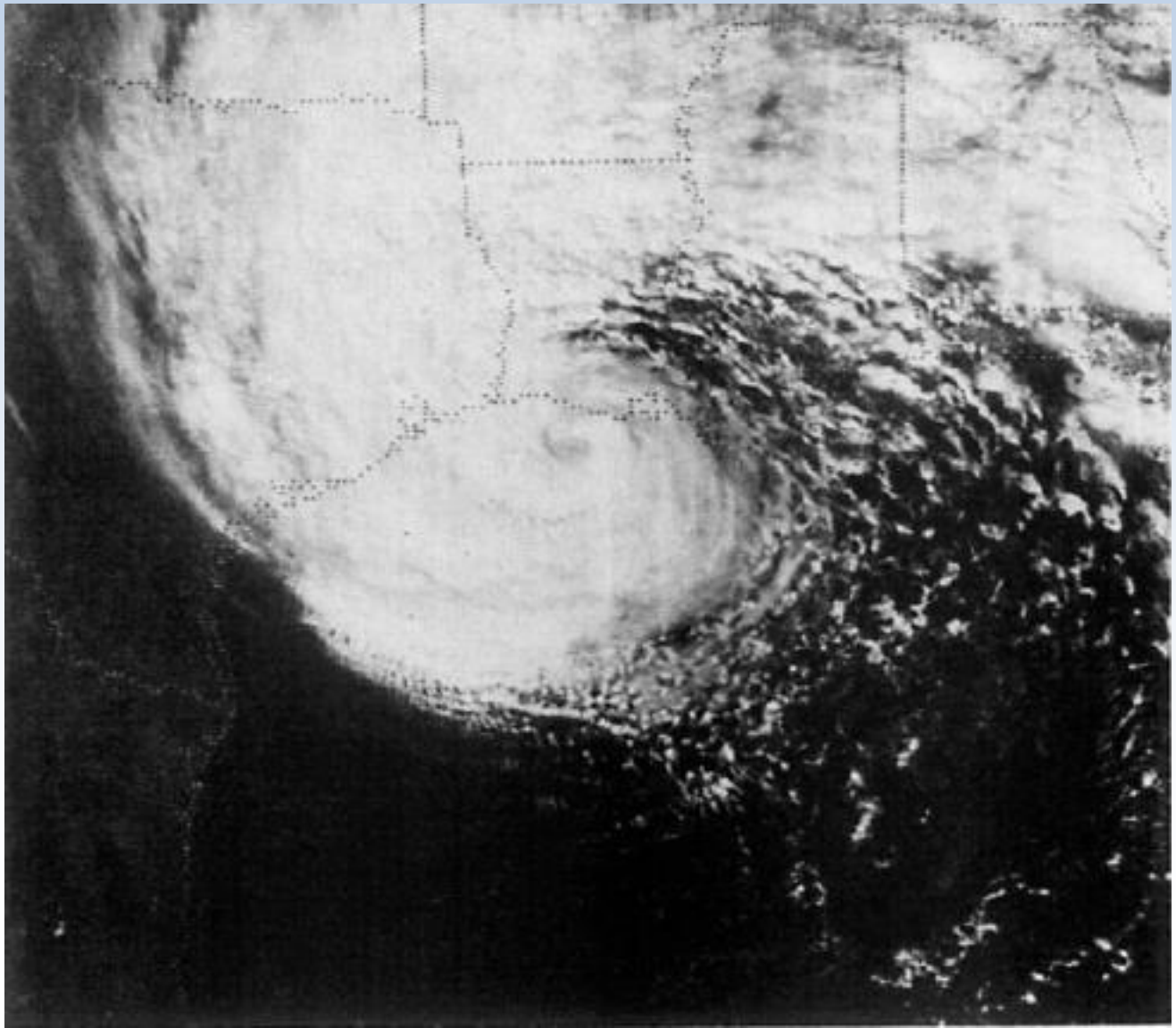
Coastal Stalls At Least As Slow and Intense As Harvey



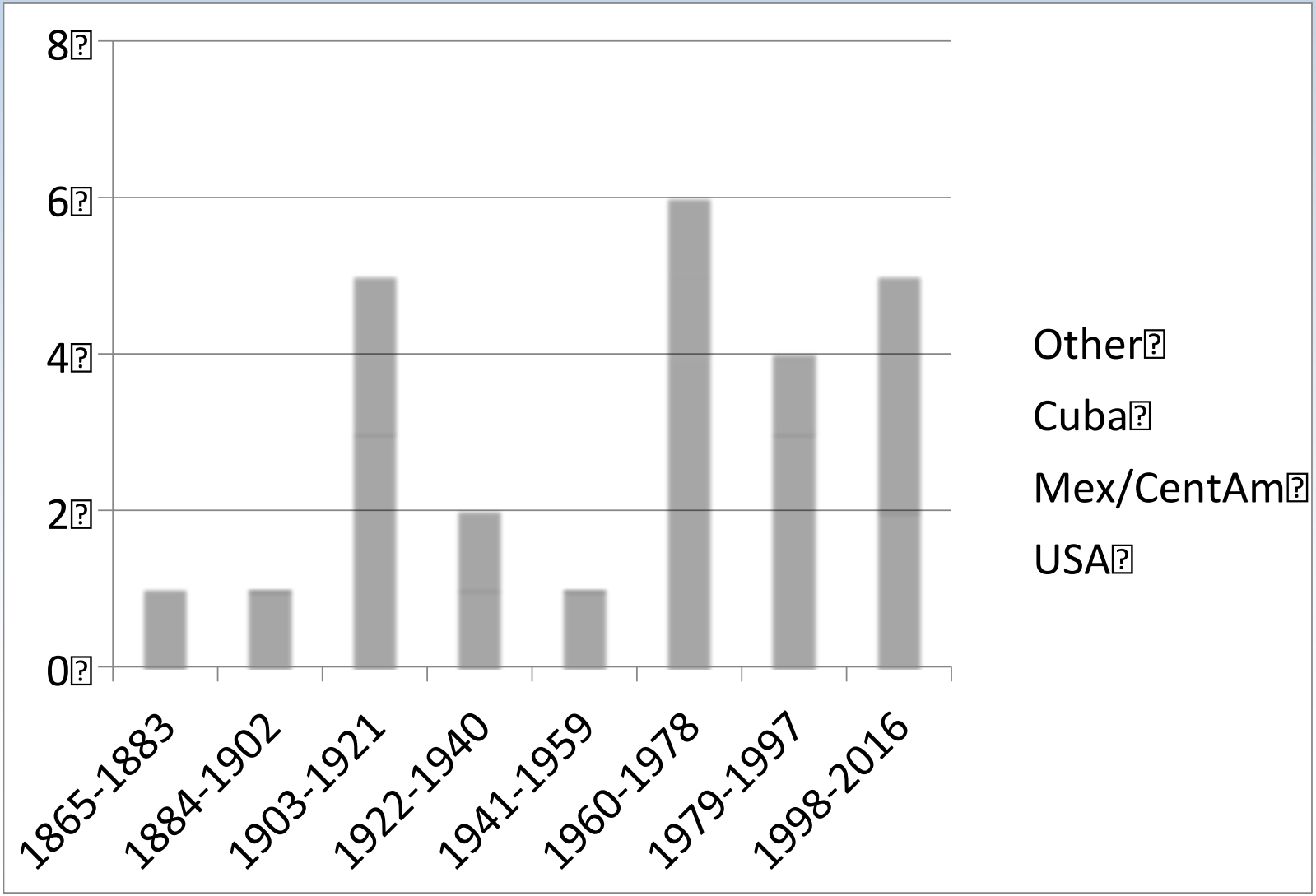
Record Totals (mm)



Juan (1985)



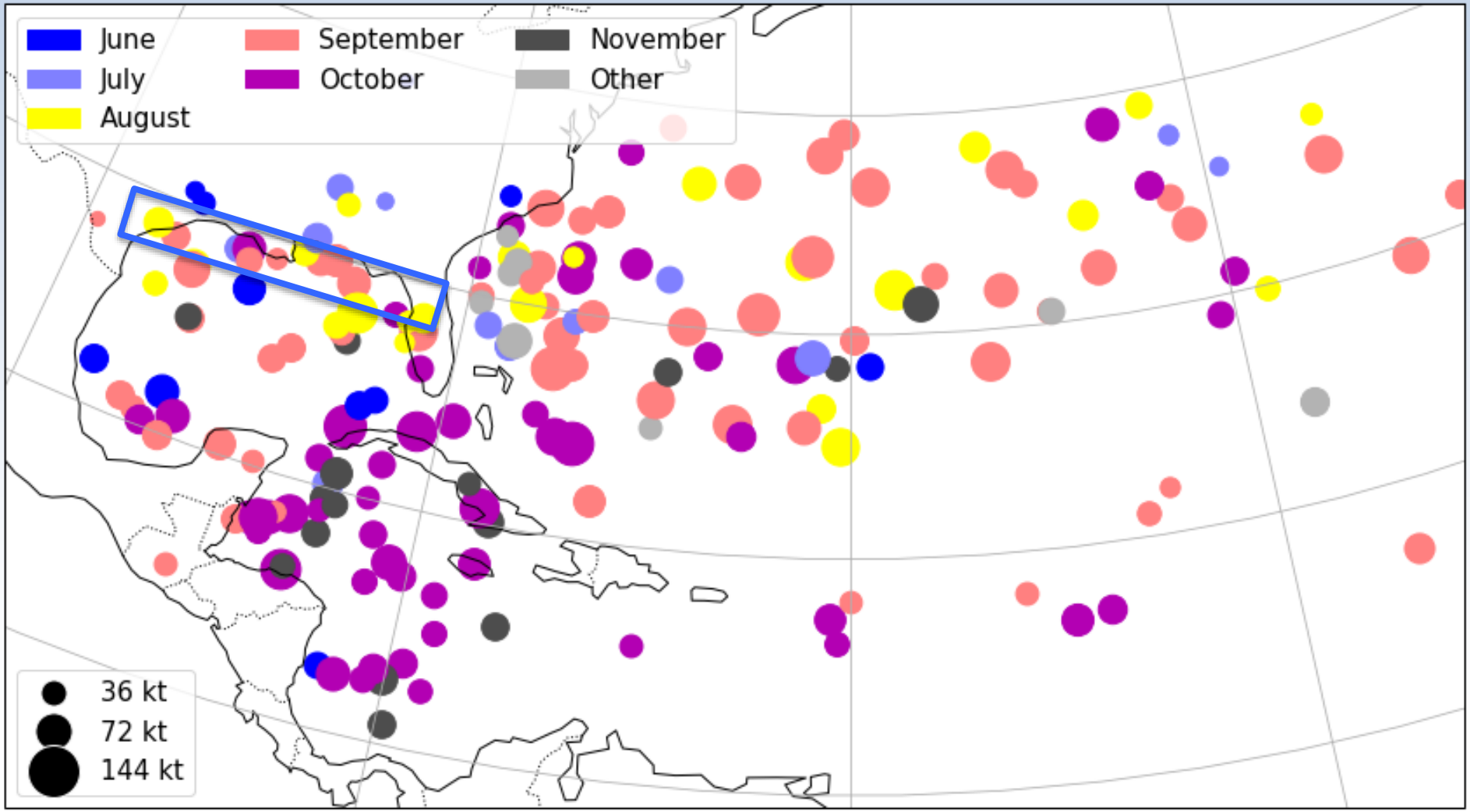
Number of Coastal Stalls: 100 km inland to 50 km offshore



Probability of Harvey Rain

- Probability of strong stall
- Conditional probability of moisture channel

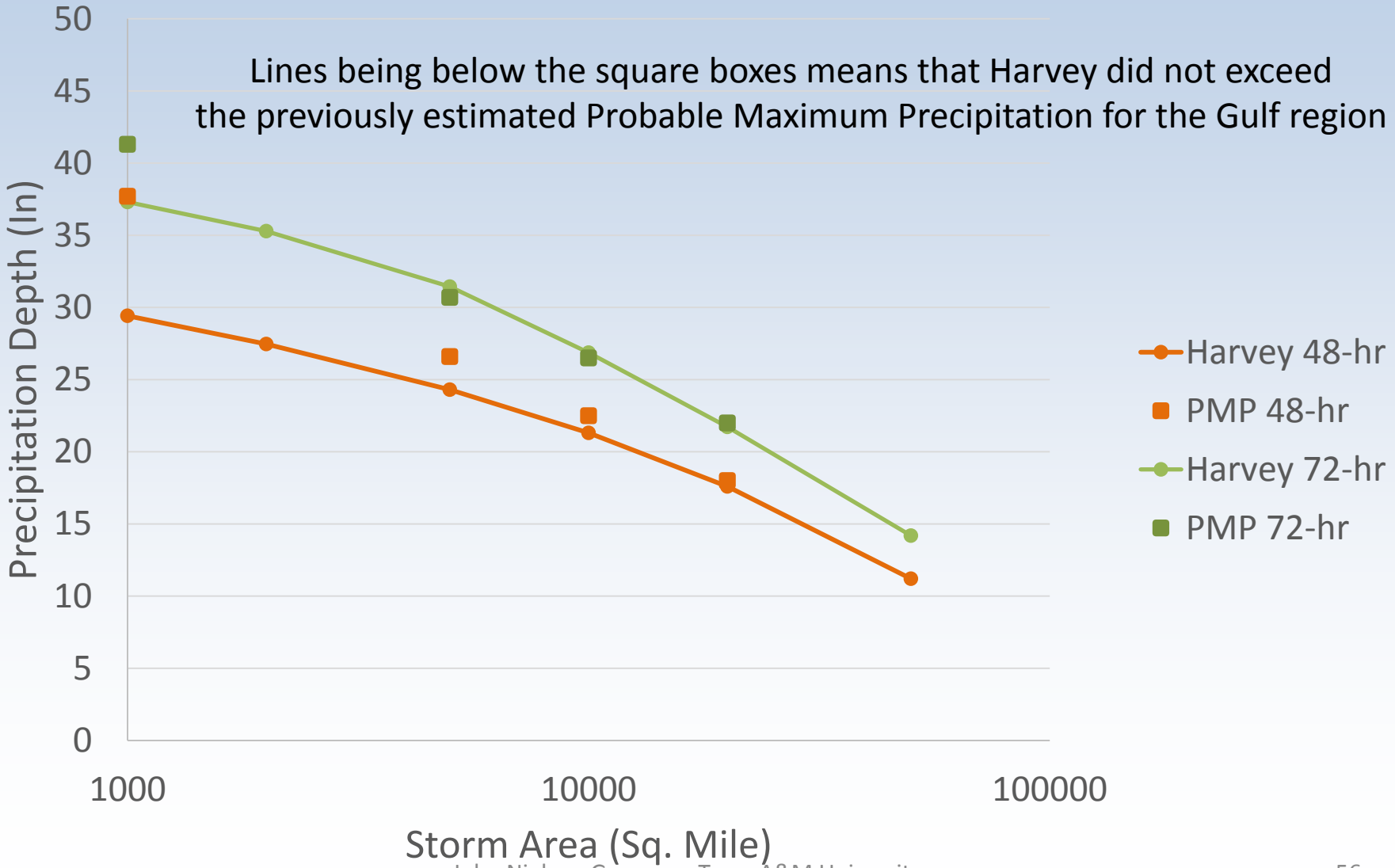
Stalled Tropical Cyclones: Month, Intensity



Probability (per century) of Strong Stall in 1°x1° Box

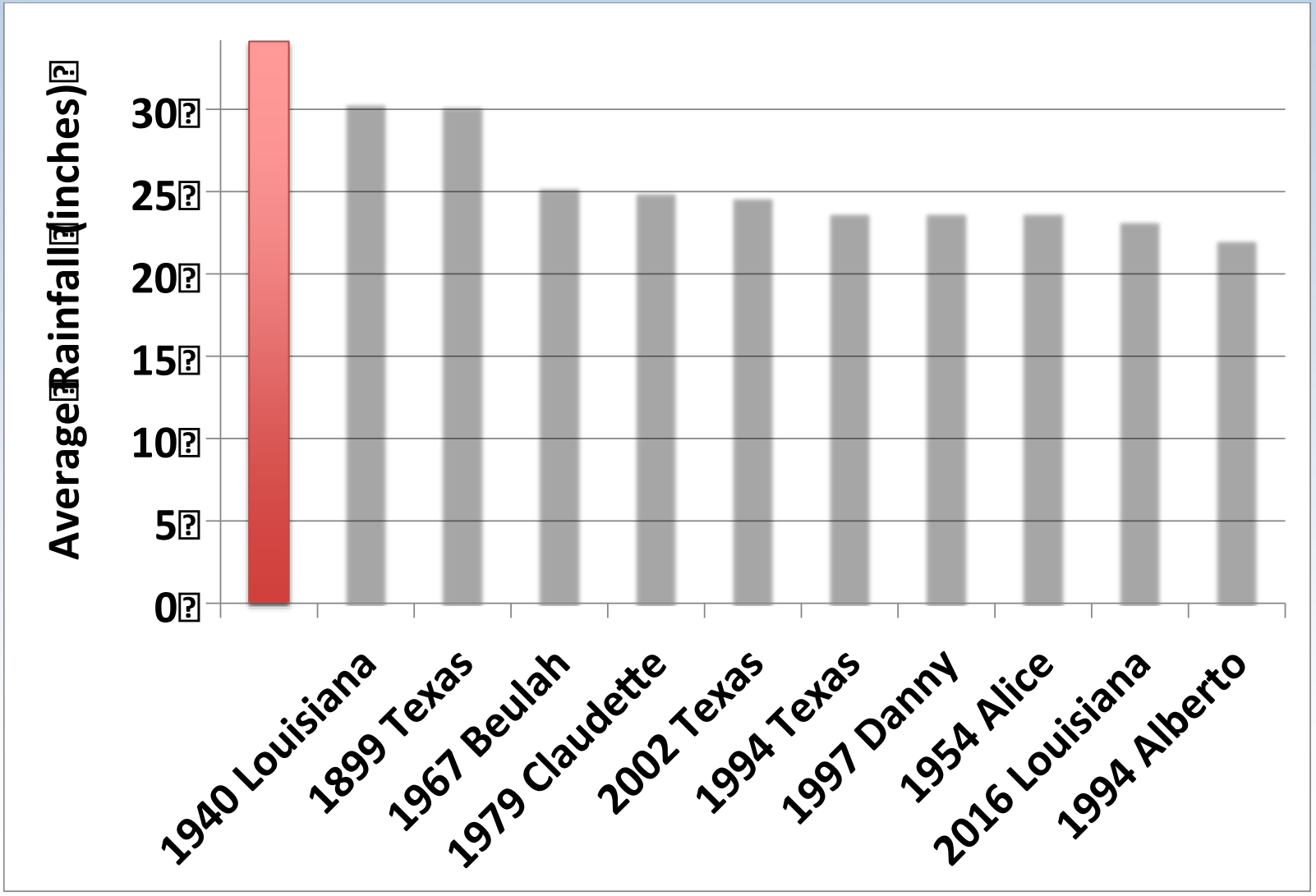
- 1917-2017: 0.08
- 1967-2017: 0.13
- Superstall (<100 km): 0.02

Comparison Between Harvey and Probable Maximum Precipitation



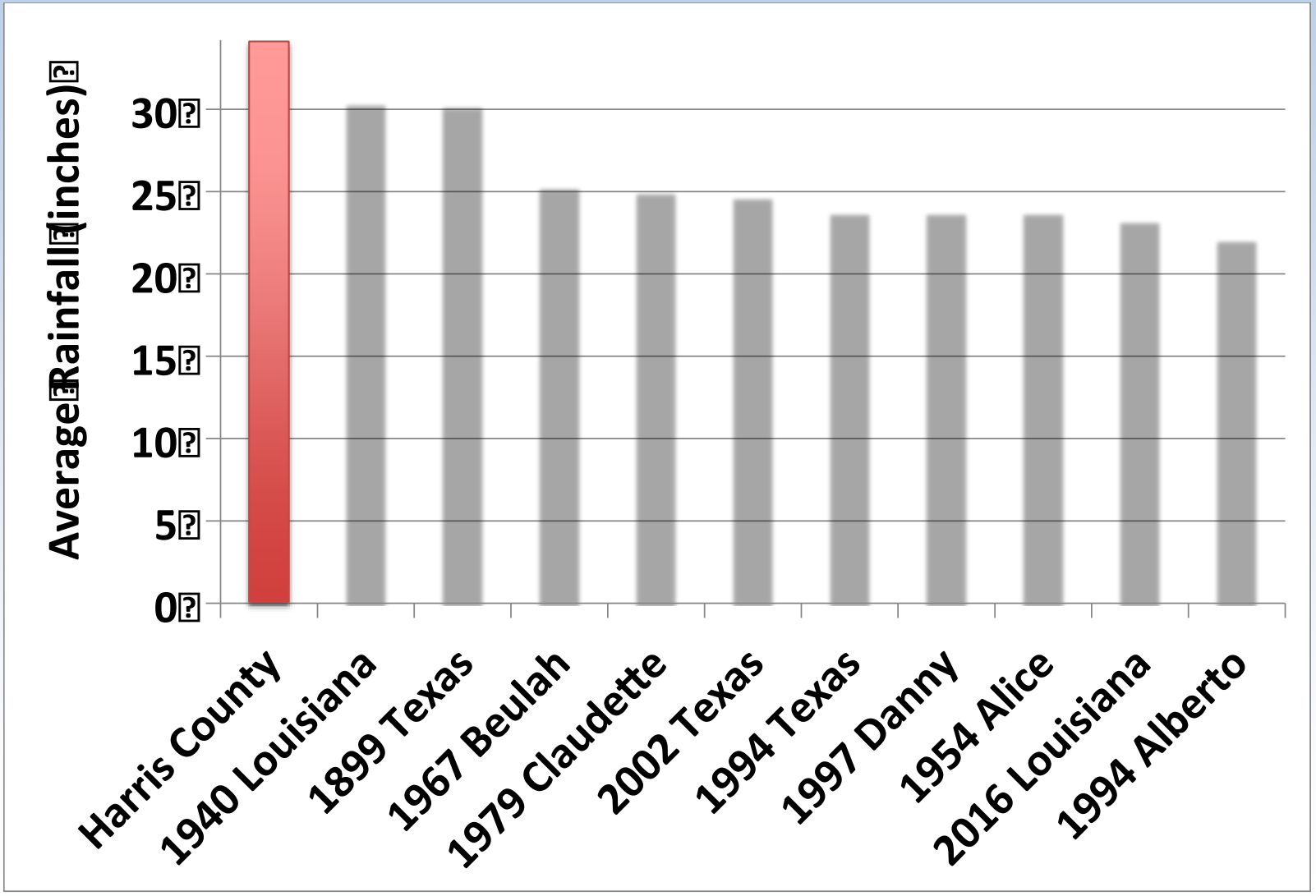
Graphic by David Maidment, University of Texas at Austin

Greatest US Storms: 5 days, 1,777 sq mi



Historic analyses: Applied Weather Associates

Greatest US Storms: 5 days, 1,777 sq mi



Historic analyses: Applied Weather Associates

Contact Information

- John Nielsen-Gammon
- n-g@tamu.edu
- http://climatexas.tamu.edu