

# How extreme was the October 2015 precipitation event in South Carolina?

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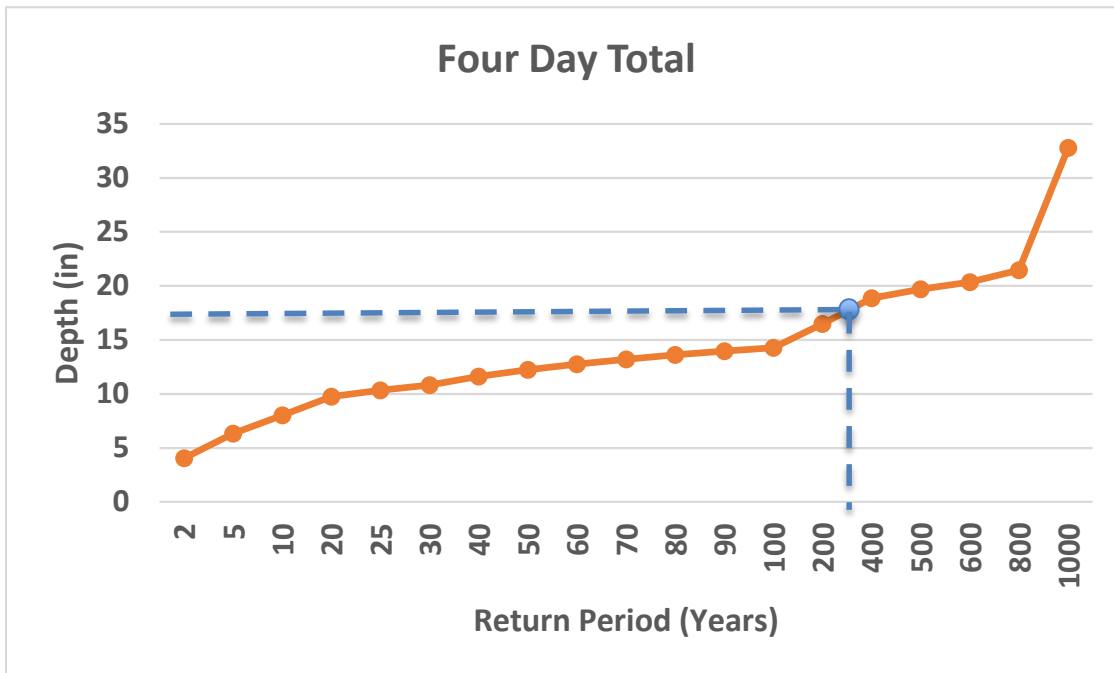
Department of Geography  
University of South Carolina





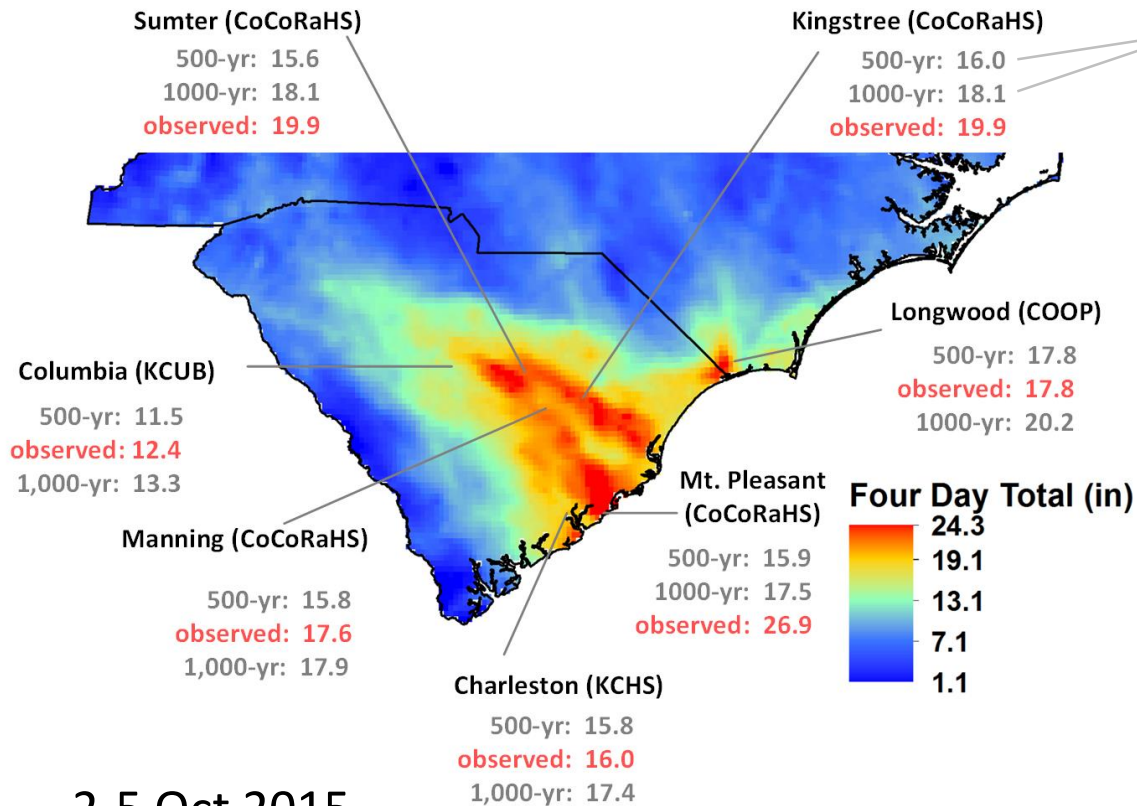
# How extreme?

- Intensity-Duration-Frequency (IDF) Curves



- A station received 18 inch rainfall in four consecutive days
- Duration: 4 days
- Probability:  $1/400$  –  $1/200$

# How extreme?



## Atlas 14:

- NOAA's precipitation frequency estimates
- Engineering standard

2-5 Oct 2015



# NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: SC

## DATA DESCRIPTION

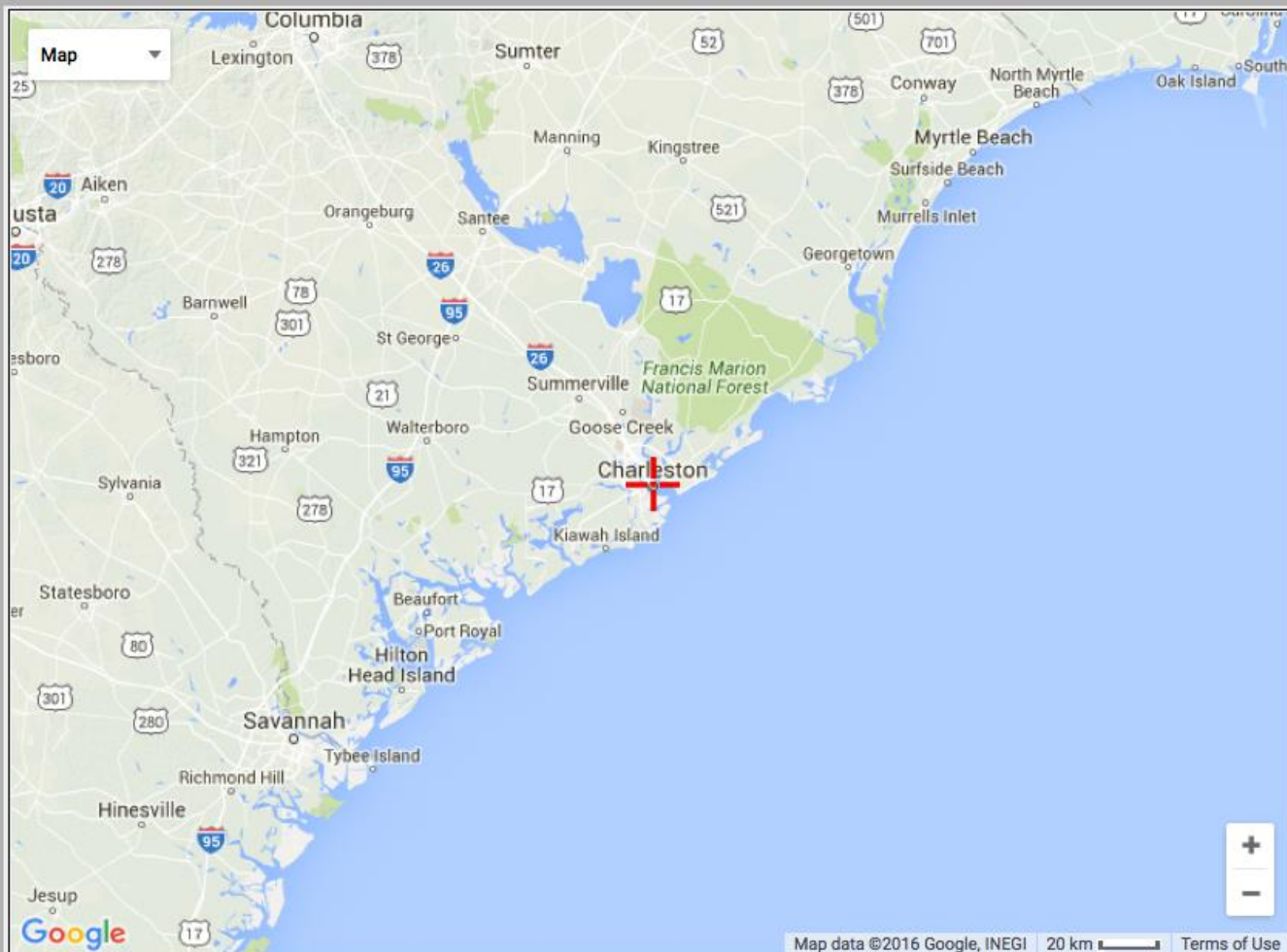
Data type:  Units:  Time series type:

## SELECT LOCATION

### 1. Manually:

- a) Enter location (decimal degrees, use "-" for S and W): latitude:  longitude:
- b) Select station ([click here for a list of stations used in frequency analysis for SC](#)):

### 2. Use map:



Map

Map data ©2016 Google, INEGI 20 km Terms of Use

**a) Select location**  
(move crosshair or double click)

**b) Click on station icon**  
( ☐ show stations on map)

**LOCATION INFORMATION:**  
**Name:** Charleston, South Carolina, US\*  
**Station Name:** CHARLESTON WSO CITY  
**Site ID:** 38-1549  
**Latitude:** 32.7833°  
**Longitude:** -79.9333°  
**Elevation:** 10 ft

\* source: Google Maps

# POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION

NOAA Atlas 14, Volume 2, Version 3

PF tabular

PF graphical

Supplementary information

 Print Page

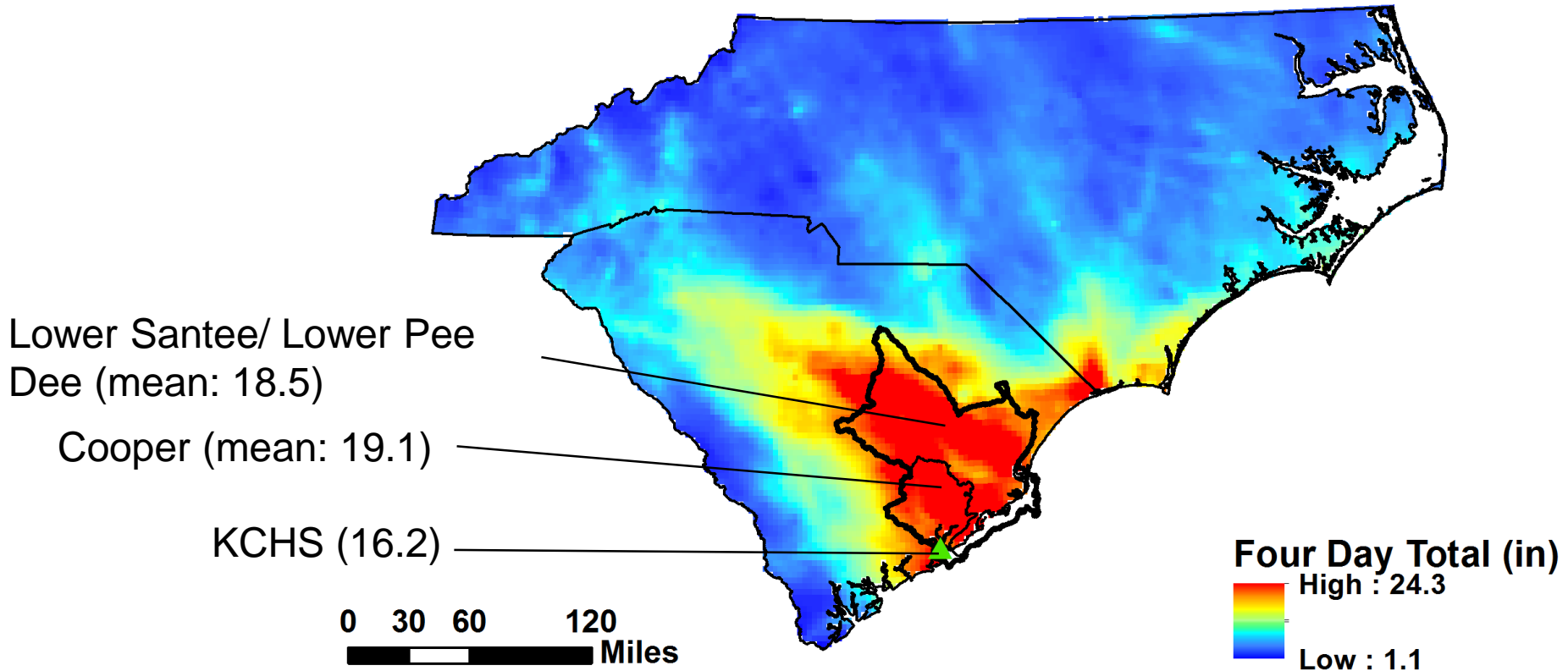
## AMS-based precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup>

Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	1/1000
5-min	0.553 (0.510-0.601)	0.685 (0.632-0.743)	0.778 (0.714-0.841)	0.885 (0.810-0.956)	0.964 (0.878-1.04)	1.04 (0.946-1.13)	1.12 (1.01-1.21)	1.22 (1.09-1.32)	1.31 (1.15-1.42)
10-min	0.885 (0.816-0.961)	1.10 (1.01-1.19)	1.24 (1.14-1.35)	1.41 (1.29-1.52)	1.53 (1.40-1.66)	1.66 (1.50-1.80)	1.78 (1.60-1.92)	1.93 (1.72-2.10)	2.06 (1.81-2.24)
15-min	1.11 (1.03-1.21)	1.39 (1.28-1.51)	1.57 (1.45-1.70)	1.79 (1.64-1.93)	1.94 (1.77-2.10)	2.10 (1.90-2.27)	2.24 (2.02-2.43)	2.43 (2.17-2.64)	2.58 (2.28-2.81)
30-min	1.54 (1.42-1.67)	1.97 (1.82-2.14)	2.28 (2.10-2.47)	2.65 (2.42-2.86)	2.93 (2.67-3.16)	3.21 (2.91-3.48)	3.49 (3.15-3.78)	3.87 (3.45-4.20)	4.18 (3.69-4.55)
60-min	1.93 (1.78-2.09)	2.53 (2.33-2.74)	2.97 (2.73-3.21)	3.53 (3.23-3.81)	3.97 (3.62-4.29)	4.42 (4.01-4.79)	4.89 (4.41-5.30)	5.55 (4.95-6.03)	6.11 (5.39-6.64)
2-hr	2.30 (2.13-2.48)	3.08 (2.86-3.32)	3.68 (3.40-3.95)	4.41 (4.05-4.72)	4.99 (4.56-5.35)	5.57 (5.05-5.97)	6.16 (5.55-6.59)	6.94 (6.20-7.44)	7.57 (6.70-8.15)
3-hr	2.44 (2.27-2.64)	3.29 (3.05-3.54)	3.95 (3.65-4.25)	4.79 (4.39-5.15)	5.47 (4.99-5.88)	6.18 (5.60-6.64)	6.92 (6.21-7.41)	7.92 (7.03-8.52)	8.77 (7.69-9.44)
6-hr	2.88 (2.66-3.14)	3.89 (3.57-4.24)	4.67 (4.28-5.08)	5.69 (5.19-6.19)	6.53 (5.90-7.10)	7.39 (6.63-8.03)	8.30 (7.39-8.99)	9.56 (8.40-10.4)	10.6 (9.21-11.5)
12-hr	3.33 (3.05-3.67)	4.52 (4.12-4.96)	5.46 (4.95-5.98)	6.71 (6.03-7.32)	7.73 (6.91-8.42)	8.81 (7.80-9.59)	9.96 (8.72-10.8)	11.6 (9.96-12.6)	12.9 (11.0-14.1)
24-hr	3.89 (3.52-4.27)	5.34 (4.83-5.84)	6.41 (5.78-7.00)	7.86 (7.05-8.60)	9.00 (8.07-9.84)	10.2 (9.11-11.2)	11.5 (10.2-12.6)	13.3 (11.7-14.5)	14.7 (12.9-16.1)
2-day	4.53 (4.15-4.97)	6.15 (5.62-6.74)	7.33 (6.69-8.03)	8.95 (8.11-9.77)	10.2 (9.22-11.2)	11.6 (10.4-12.6)	13.0 (11.6-14.2)	15.0 (13.3-16.4)	16.6 (14.6-18.1)
3-day	4.82 (4.42-5.27)	6.52 (5.97-7.10)	7.73 (7.06-8.42)	9.38 (8.52-10.2)	10.7 (9.66-11.6)	12.0 (10.8-13.1)	13.5 (12.1-14.6)	15.4 (13.7-16.8)	17.0 (15.1-18.6)
4-day	5.12 (4.70-5.58)	6.88 (6.31-7.47)	8.13 (7.44-8.81)	9.81 (8.94-10.6)	11.1 (10.1-12.0)	12.5 (11.3-13.5)	13.9 (12.5-15.1)	15.9 (14.2-17.3)	17.5 (15.5-19.1)
7-day	5.96 (5.48-6.46)	7.90 (7.28-8.54)	9.27 (8.50-10.0)	11.1 (10.1-12.0)	12.5 (11.3-13.4)	13.9 (12.6-15.0)	15.4 (13.9-16.7)	17.5 (15.7-19.0)	19.1 (17.1-20.8)
10-day	6.71 (6.18-7.25)	8.75 (8.05-9.44)	10.1 (9.31-10.9)	11.9 (10.9-12.8)	13.3 (12.1-14.3)	14.6 (13.3-15.8)	16.1 (14.5-17.4)	18.0 (16.2-19.4)	19.5 (17.5-21.1)
20-day	8.86 (8.20-9.57)	11.4 (10.5-12.3)	13.1 (12.1-14.1)	15.2 (14.1-16.4)	16.9 (15.5-18.2)	18.5 (17.0-20.0)	20.2 (18.5-21.8)	22.5 (20.5-24.3)	24.3 (22.0-26.2)
30-day	10.8 (10.1-11.6)	13.6 (12.8-14.5)	15.4 (14.4-16.4)	17.7 (16.5-18.8)	19.4 (18.0-20.6)	21.0 (19.6-22.4)	22.7 (21.1-24.2)	24.9 (23.0-26.6)	26.6 (24.5-28.5)
45-day	13.5 (12.6-14.3)	16.7 (15.6-17.8)	18.7 (17.5-19.9)	21.3 (19.8-22.6)	23.1 (21.5-24.6)	24.8 (23.1-26.5)	26.6 (24.7-28.4)	28.9 (26.8-30.9)	30.7 (28.3-32.9)
60-day	15.9 (15.0-16.9)	19.6 (18.4-20.7)	21.9 (20.5-23.2)	24.7 (23.1-26.1)	26.6 (24.9-28.2)	28.5 (26.6-30.2)	30.4 (28.3-32.3)	32.9 (30.5-34.9)	34.7 (32.1-36.9)

# NOAA Atlas 14

- Engineering standard
- Point based
- Interpolation: smoothing effect
- Spatial resolution: 0.5 mile
- Volume in a basin matters

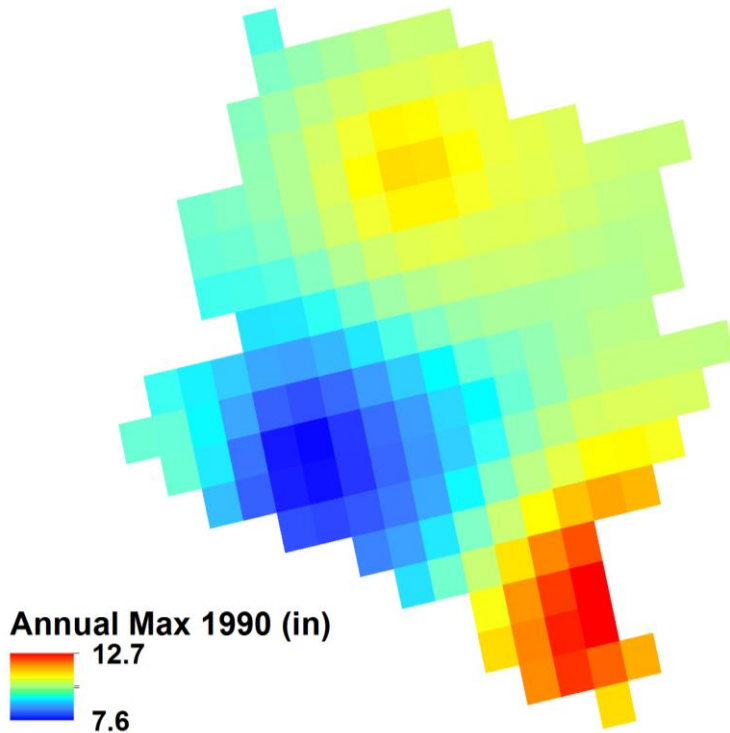
# Do individual stations tell us enough?



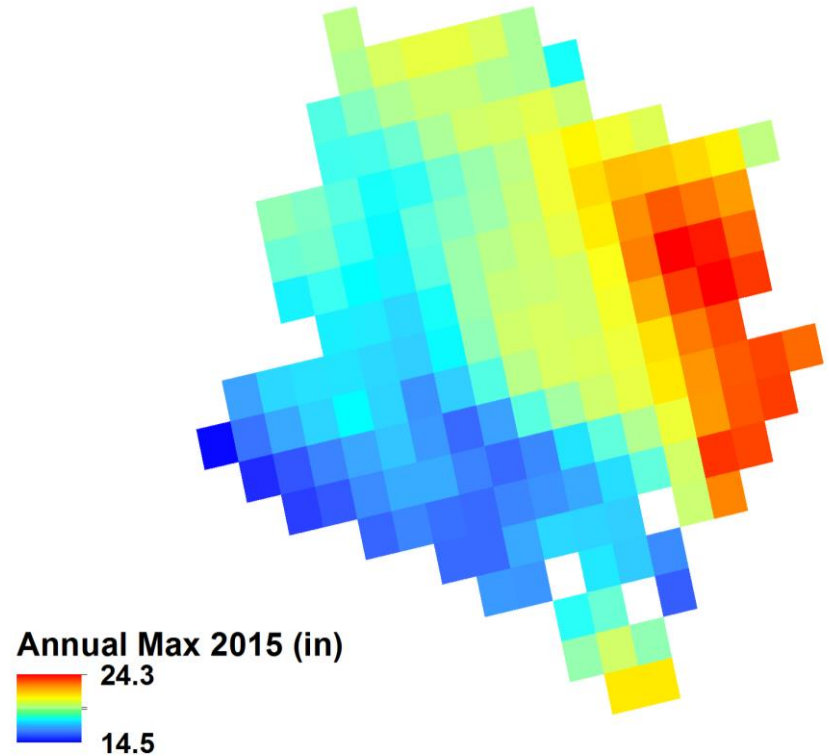
Daily PRISM data: 4\*4 km grids (Parameter-elevation Relationships on Independent Slopes Model)



# Historic extreme precipitation events in Cooper Basin



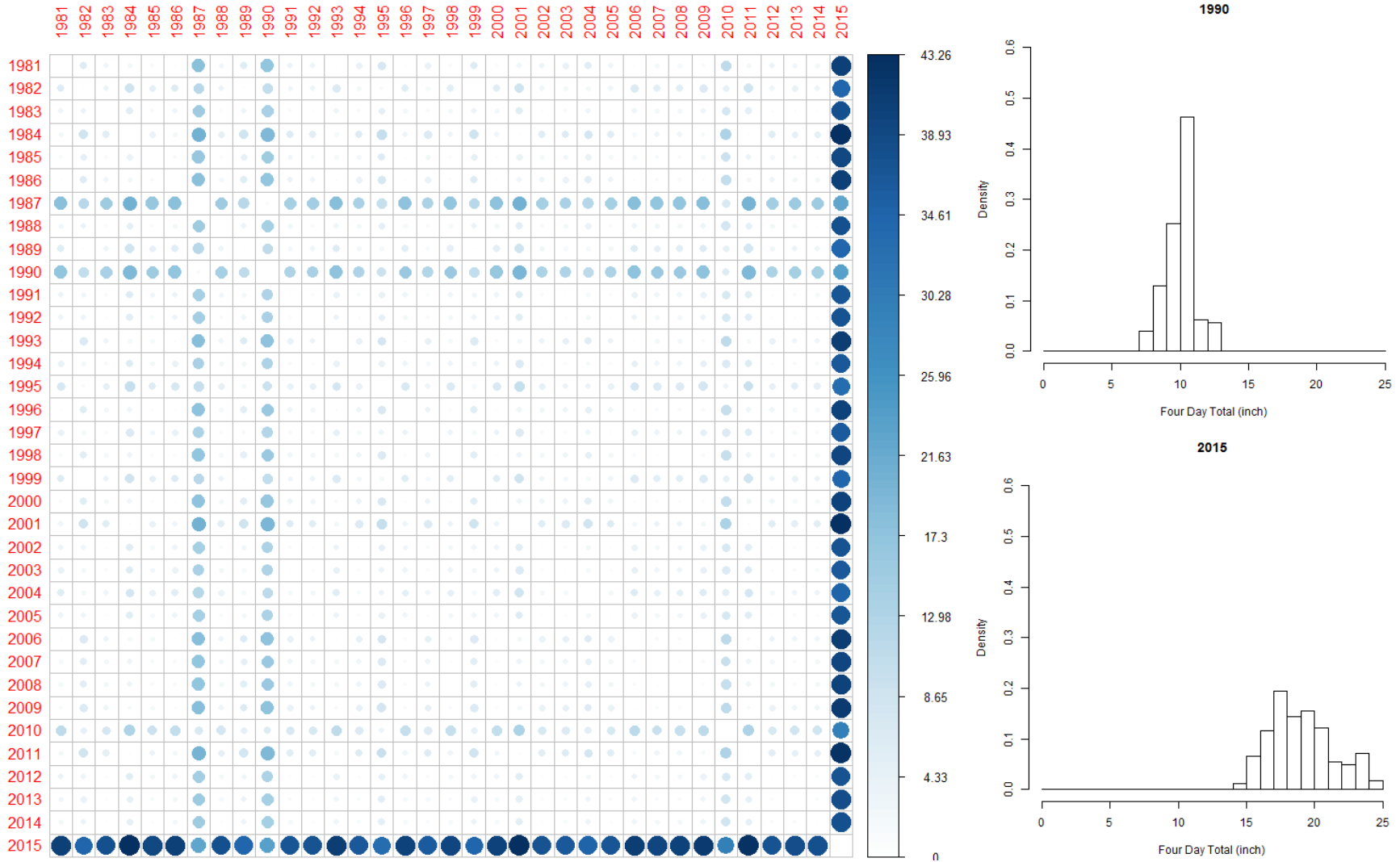
10-13 October 1990



2-5 October 2015

1265 sq. mi  
179 grids (4\*4 km)

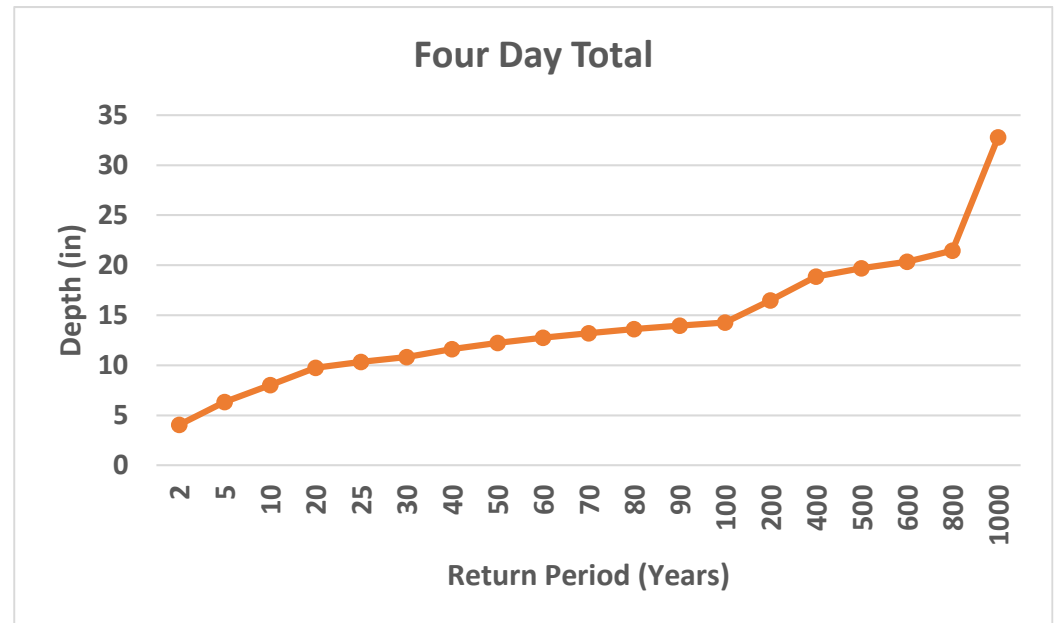
# Comparing events in the Cooper Basin



# Measuring extremes for an area

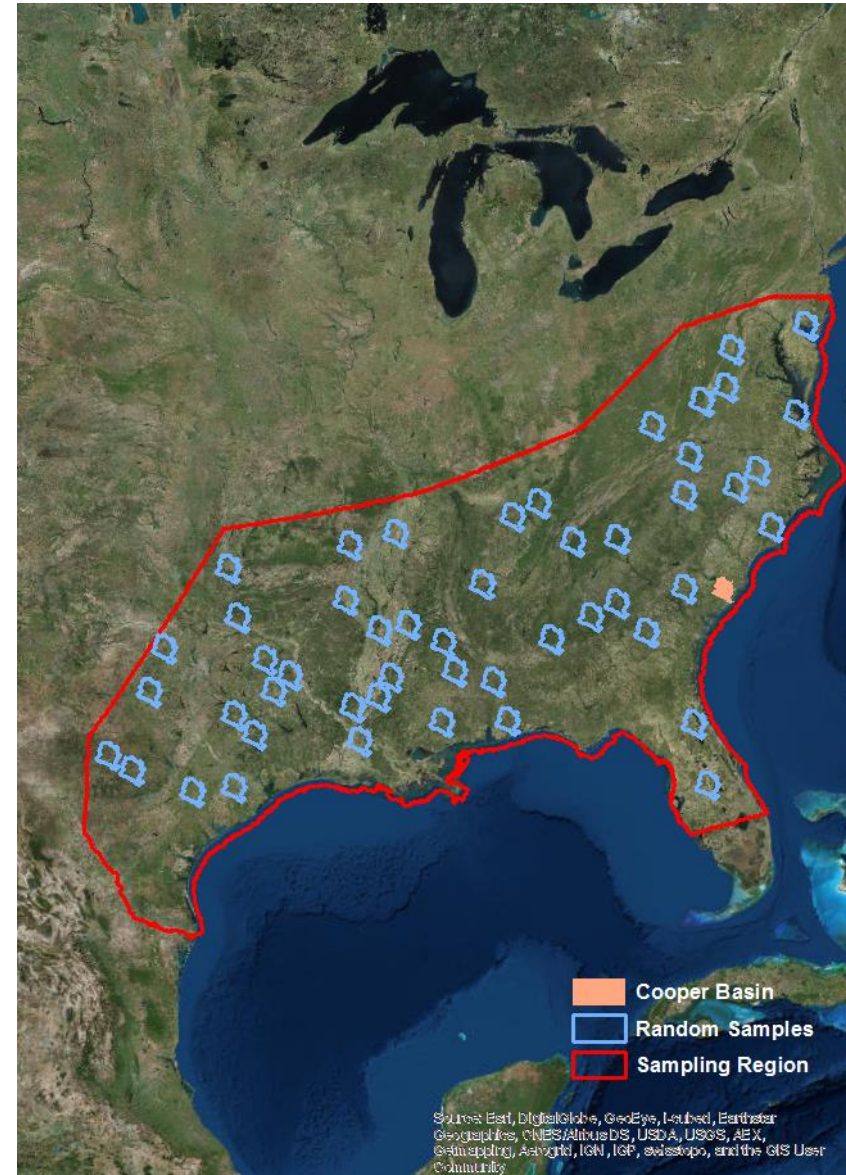
Generalized Extreme Value (GEV) distribution:  
Intensity-Duration-Frequency (IDF) Curves

Sample length too short  
(e.g., PRISM:1981 to  
2015)

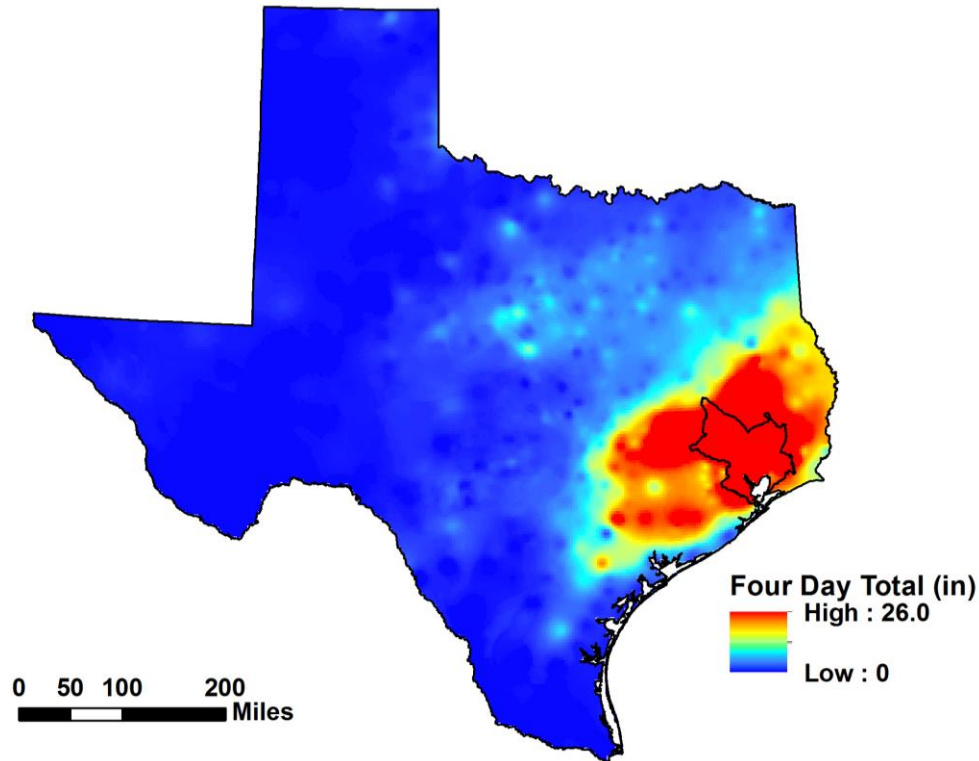


# Bootstrap Sampling

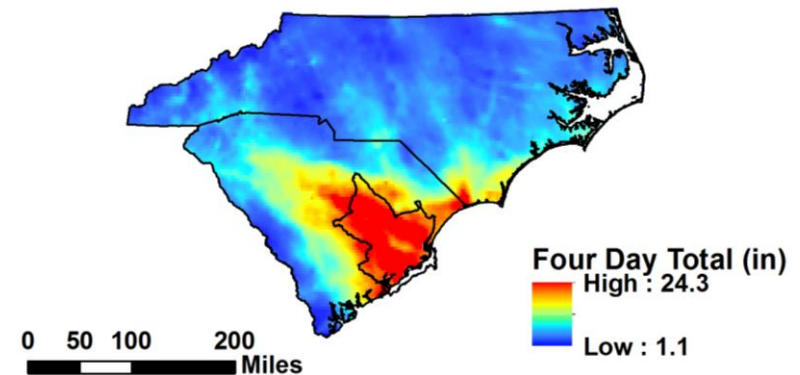
- Substitute space for time by “borrowing” across the southeastern US
  - 50 random samples \* 35 years
  - repeat 10 times = 17500 samples
- 1-, 2-, and 4-day totals



# Captured historic extreme events



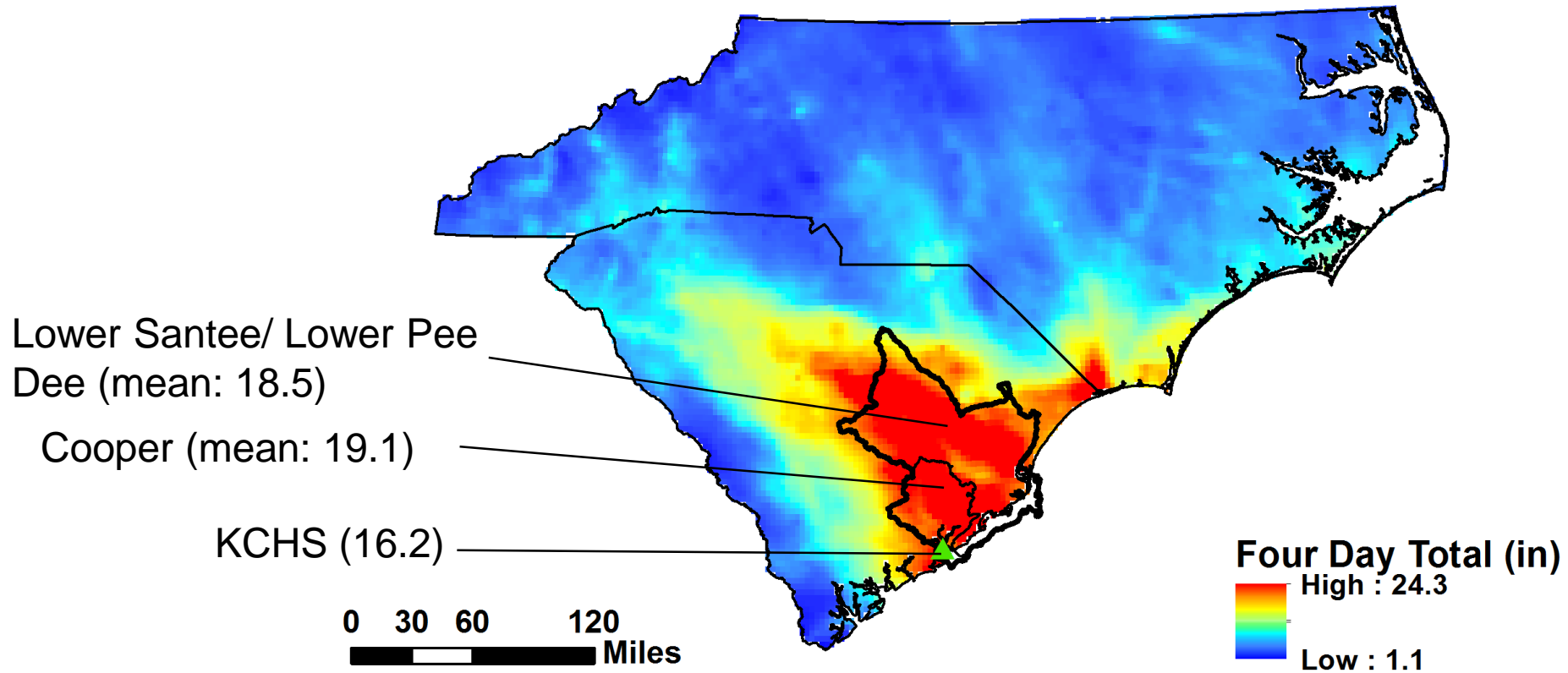
16-19 October 1994  
Mean: 17.9 inches



2-5 October 2015  
Mean: 18.5 inches



# How extreme: a station vs. an area?



# 1-day annual max

Location	2015 Event	1/50	1/100	1/500	1/1000	Data Source
KCHS	9.3	9.07	10.3	13.4	14.9	Atlas 14



Area	2015 Event	1/100	1/500	1/800	1/1000	Approach
Cooper	9.9	7.1	9.8	10.3	15.3	Bootstrap
Lower Santee/ Lower Pee Dee	8.6	6.1	8.1	8.5	12.0	Bootstrap

## 2-day annual max

Location	2015 Event	1/100	1/500	1/1000	Data Source
KCHS	11.7	11.7	15.1	16.7	Atlas 14



Area	2015 Event	1/100	1/500	1/800	1/1000	Approach
Cooper	14.5	9.8	13.2	14.4	22.0	Bootstrap
Lower Santee/ Lower Pee Dee	13.0	8.5	11.2	12.0	17.4	Bootstrap

## 4-day annual max

Location	2015 Event	1/100	1/500	1/1000	Data Source
KCHS	16.2	12.6	15.8	17.4	Atlas 14



Area	2015 Event	1/100	1/500	1/800	1/1000	Approach
Cooper	19.1	11.2	14.9	16.2	24.1	Bootstrap
Lower Santee/ Lower Pee Dee	18.5	10.1	13.4	14.0	19.7	Bootstrap



# Return period summary

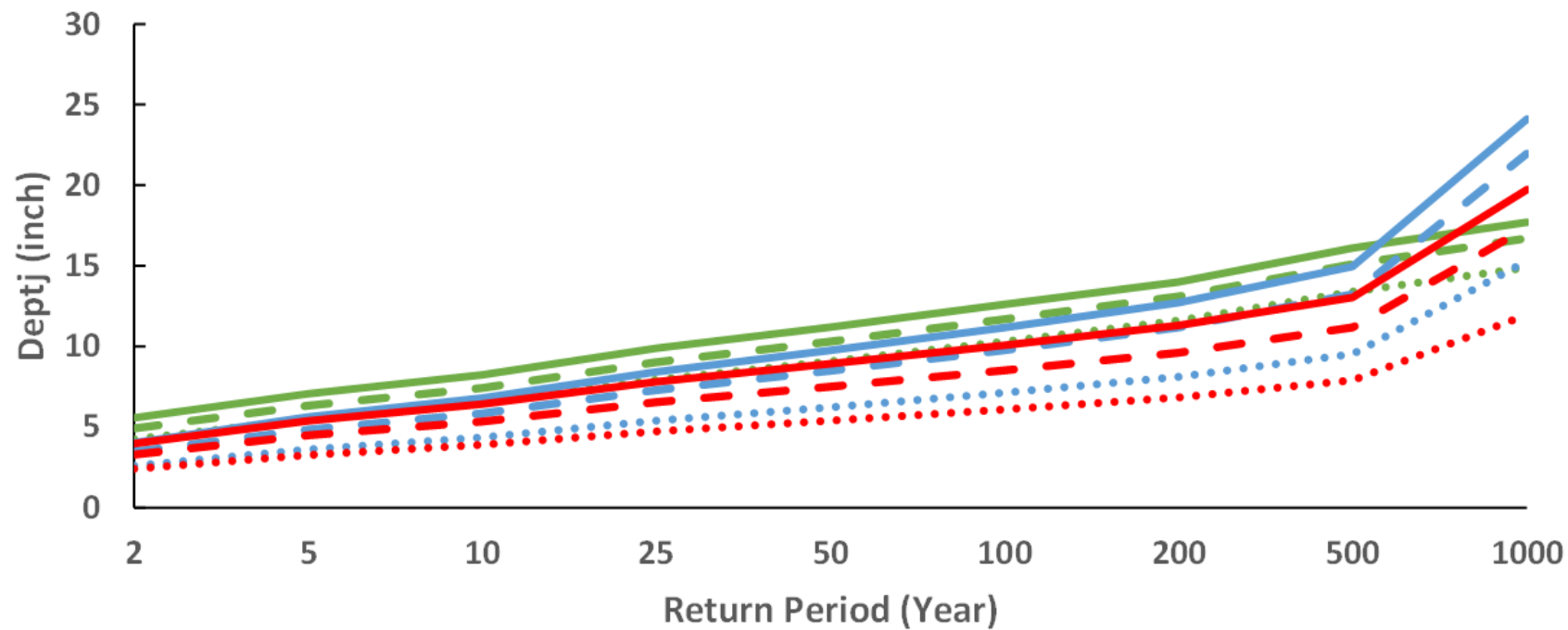
Location/Area	1-day	2-day	4-day
KCHS	50 – 100 yr	100	500 - 1000
Cooper	500 – 800	800 - 1000	800 - 1000
Lower Santee/ Lower Pee Dee	800 - 1000	800 - 1000	800 - 1000



# Summary

- By all measures, 2-5 October precipitation totals represent a 500- to 1000-yr event (annual probability: 0.2-0.1%)
- Our areal-based approach (bootstrapping) shows several differences with (point-based) Atlas 14:
  - longer return periods for 1- and 2-day totals
  - higher values for 1000-yr events (0.1% annual probability)
- Atlas-14 is the engineering standard, but:
  - volume (in a basin) matters

Optimal Solution: An areally-based metric with large sample sizes and long time series.



..... KCHS 1 day      - - - KCHS 2 days      — KCHS 4 days  
..... Cooper 1 day      - - - Cooper 2 days      — Cooper 4 days  
..... LS/LPD 1 day      - - - LS/LPD 2 days      — LS/LPD 4 days

	100 year	500 year	1000 year	total number of samples for 10 sets
Cooper 1 day	160	17	0	17500
Cooper 2 days	159	22	0	
Cooper 4 days	150	28	0	
LS/LPD 1 day	93	11	0	10500
LS/LPD 2 days	111	10	0	
LS/LPD 4 days	94	21	0	