Extreme weather events: What do the data say?

Slides to accompany lesson

Part 1, Question 1

What are some characteristics of a typical monsoon storm?

Part 1 – spatial variability

- Typical versus extreme monsoon storms have different characteristics
- One difference is in the “patchiness” of the rainfall, also known as spatial variability
- Monsoon video

Understanding variability

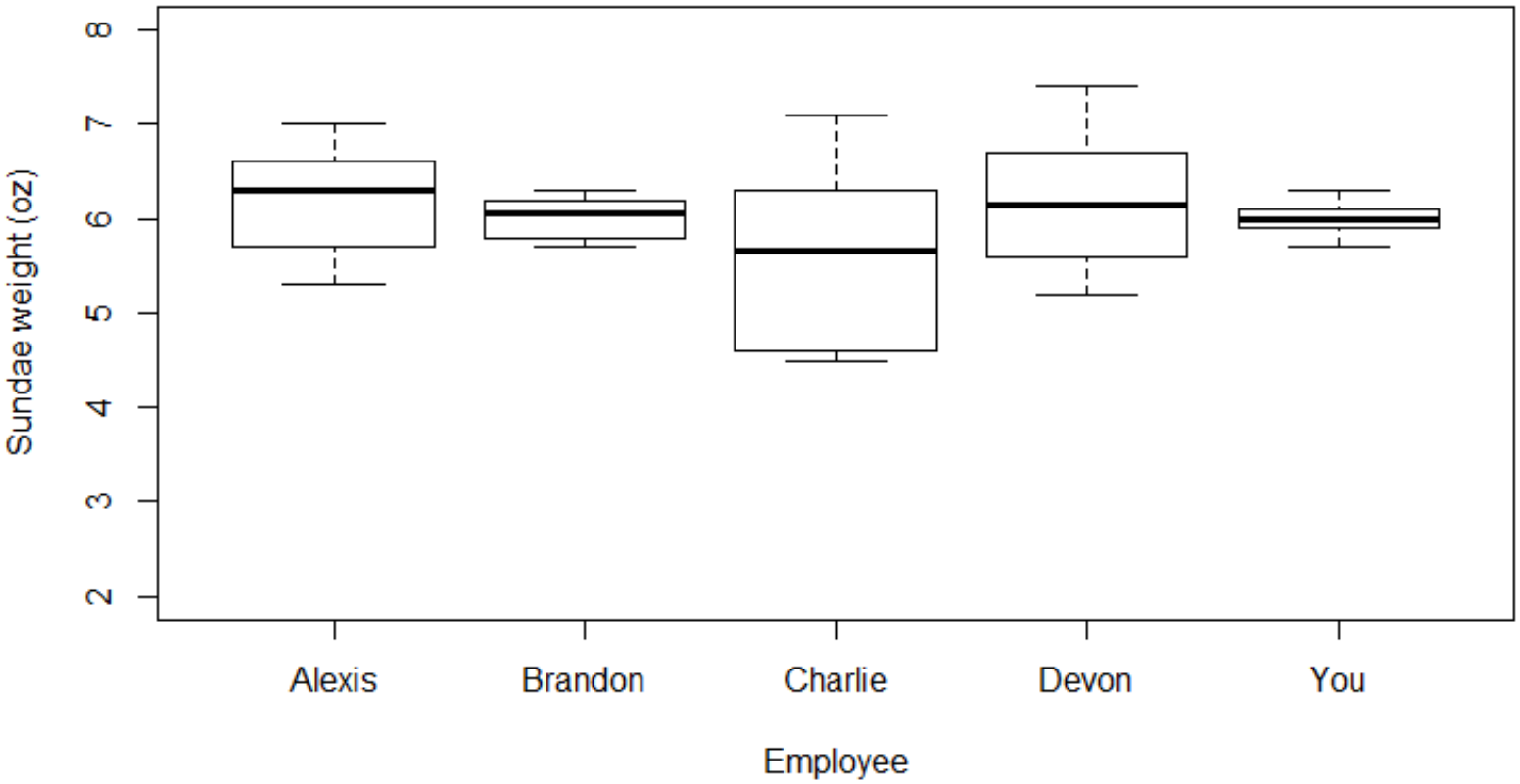
- Often, we see averages or medians reported, e.g. average precipitation per year, median home price
  - These are measures of central tendency
- Scientists are also interested in measures of spread, or the variability of the data

Variability in ice cream sundaes

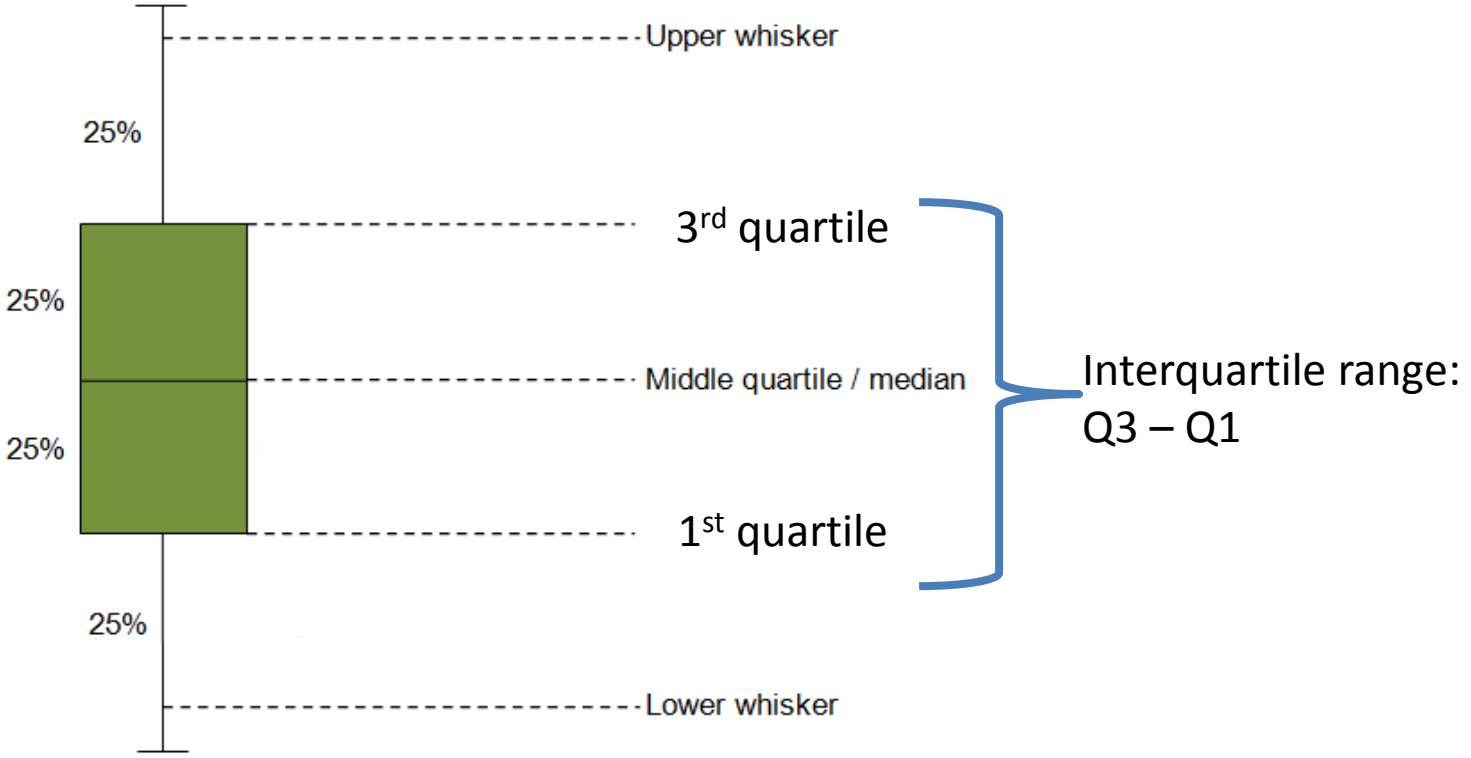
- Your summer job is making ice cream sundaes for a local dessert emporium

- Monthly prizes are awarded to the employee who makes the most consistent sundaes, which should weigh 6 ounces each.

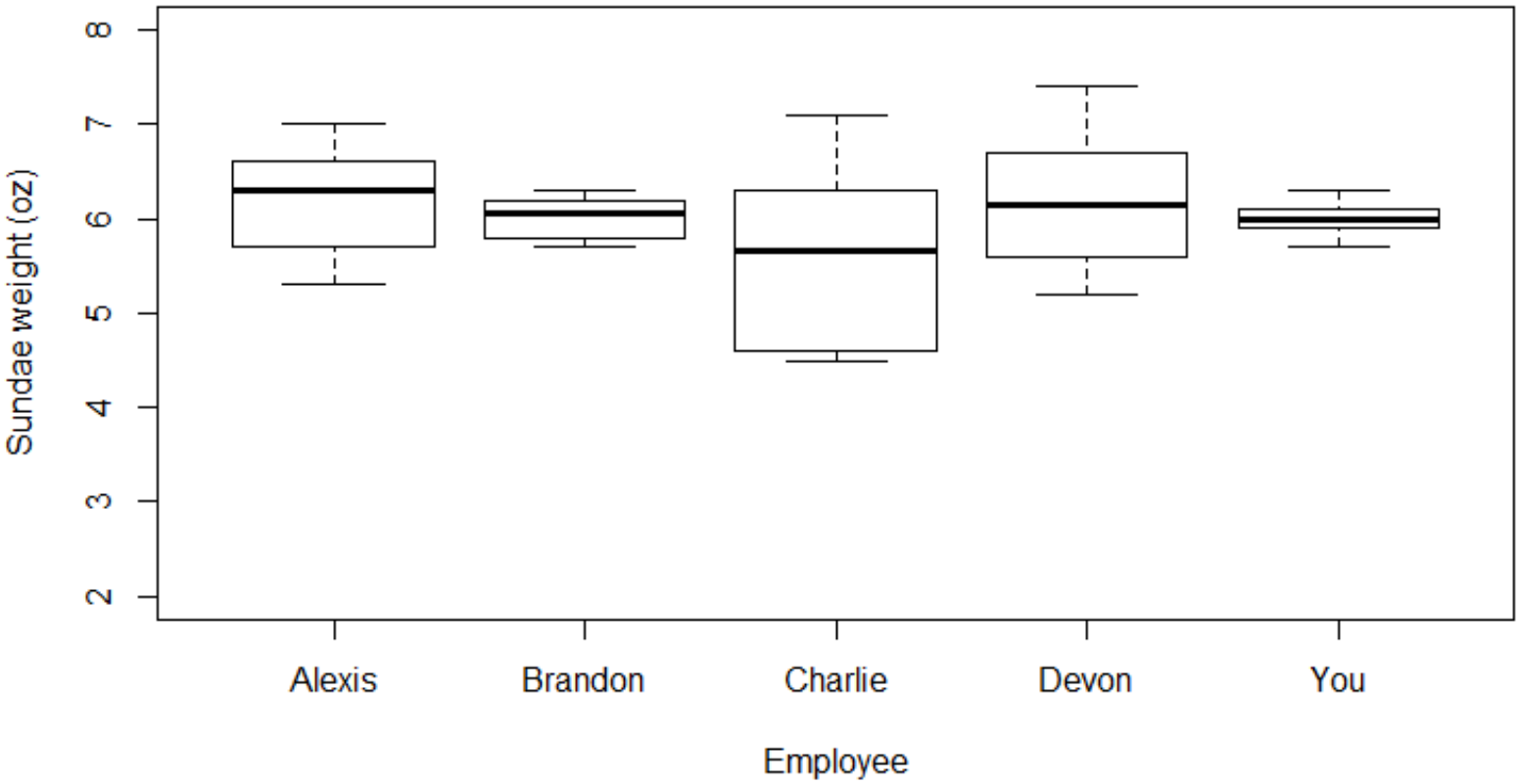
Which employee wins? Why?



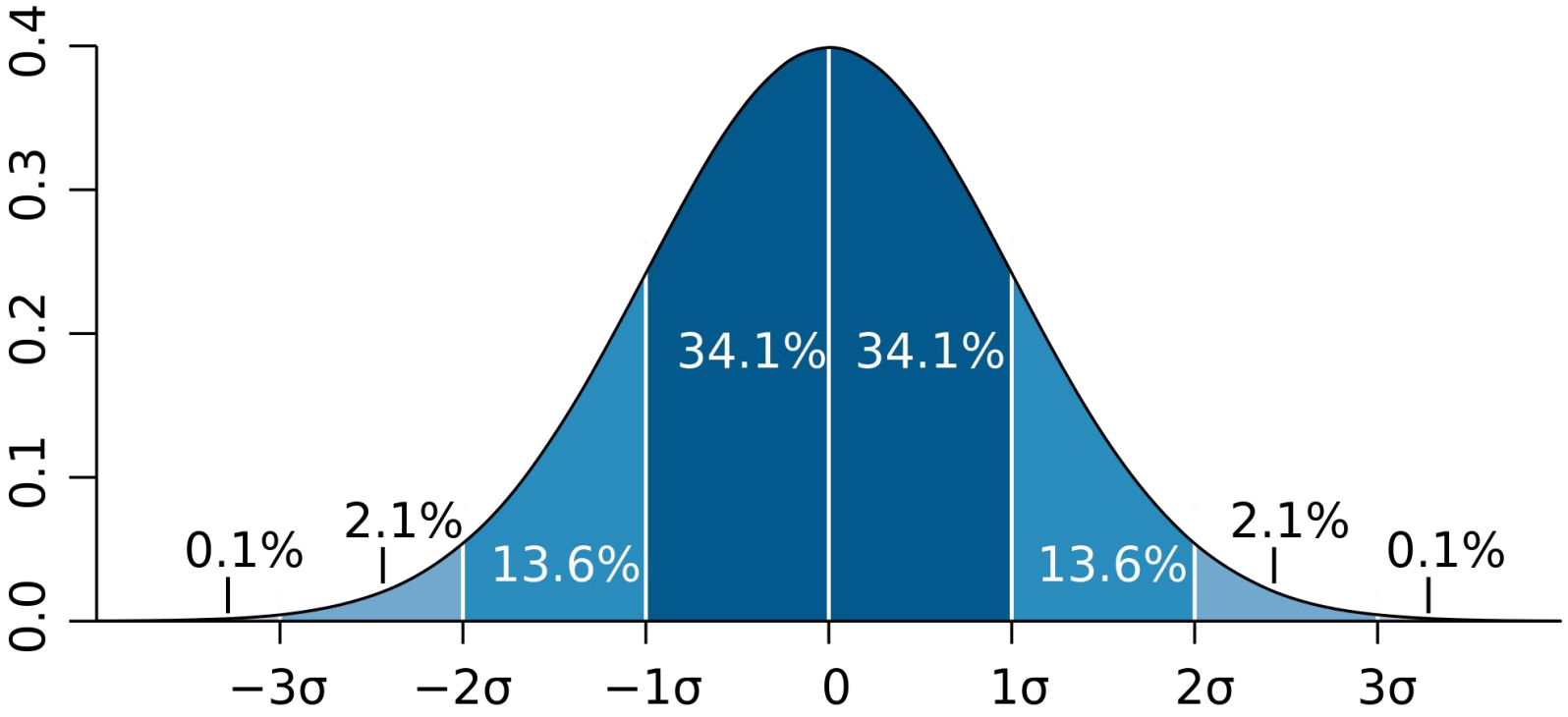
Box and whisker plots



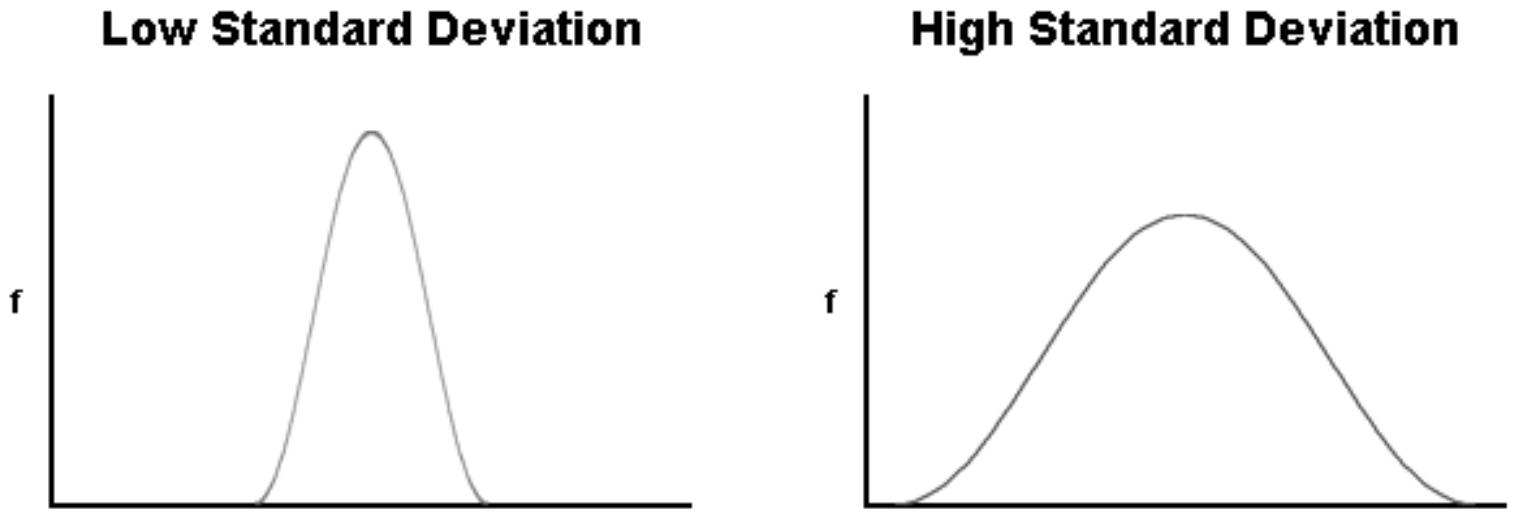
Which employee wins? Why?



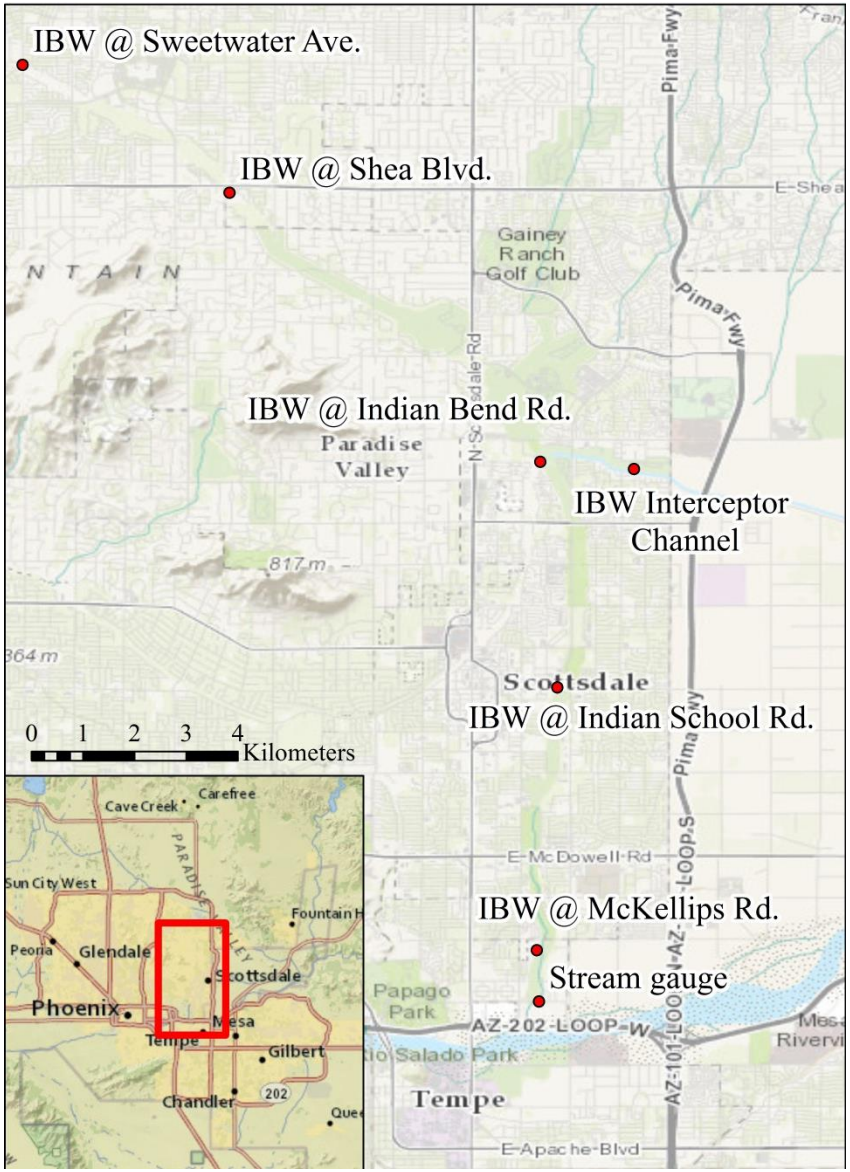
Standard deviation of a normal distribution

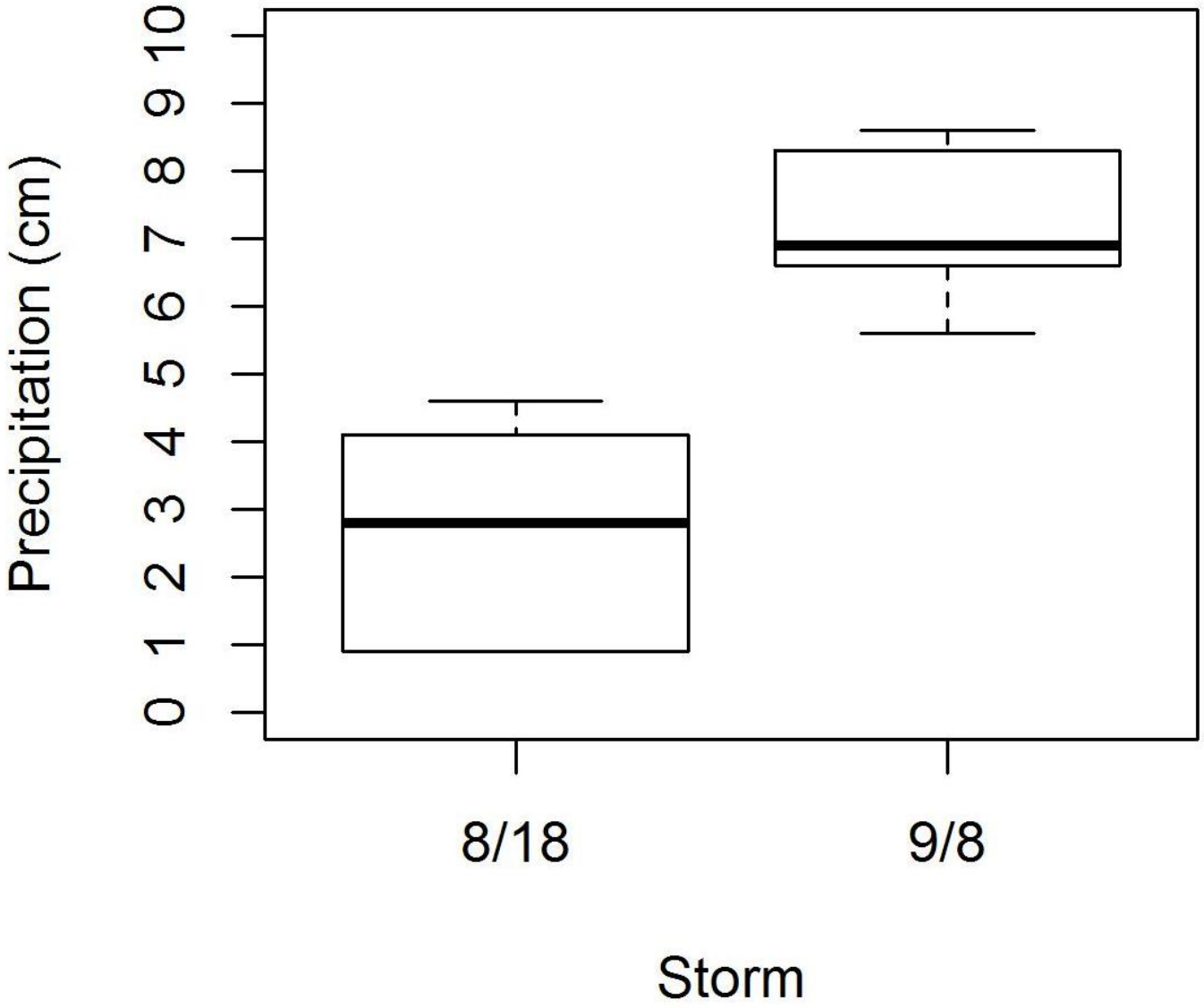


Can we compare standard deviations?



Indian Bend Wash




Precipitation (cm)
0 1 2 3 4 5 6 7 8 9 10
8/18
9/8
Storm

Part 1, Question 2

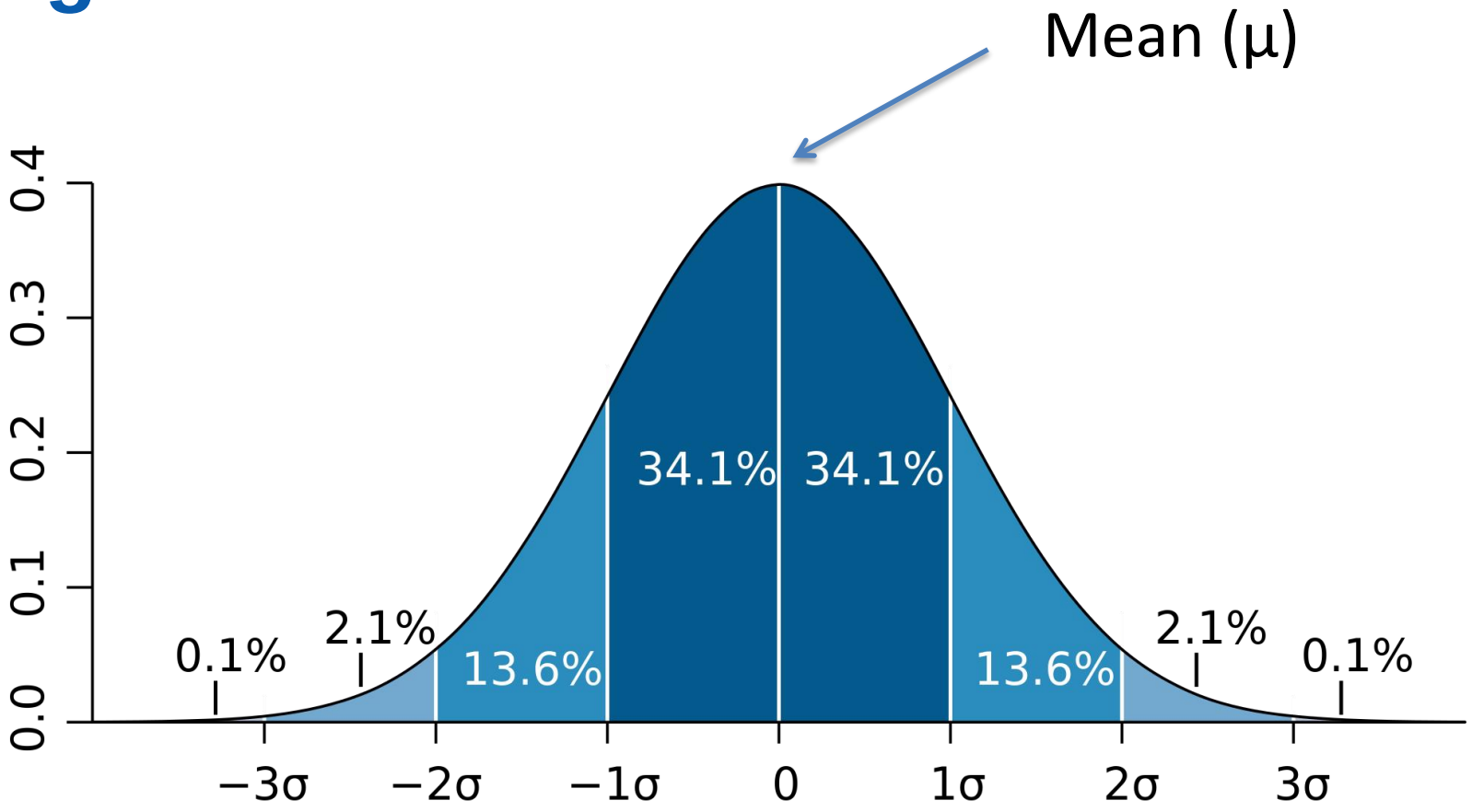
Find the interquartile range for each storm:

8/18 storm		9/8 storm	
Interquartile range:	4.1-0.9 = 3.2	Interquartile range:	8.3-6.6 = 1.7

Part 1, Question 3

Which storm had greater spatial variability, the typical monsoon from 8/18 or the extreme monsoon from 9/8?

High school extension



Larger μ may result in larger σ

- So, to compare variation between datasets with very different means, we can normalize (divide) the standard deviation by the mean

$$CV = \frac{\sigma}{\mu}$$

- CV or coefficient of variation is the percent of the mean that is the standard deviation

Part 1, Question 4

Find the mean, standard deviation, and CVs for each storm.

Part 1, Question 4 answers

8/18 storm		9/8 storm	
Mean (μ):	2.68	Mean (μ):	7.15
Standard deviation (σ):	1.42	Standard deviation (σ):	1.04
CV:	0.53	CV:	0.14

Part 1, Question 5

Which storm had the larger CV? How did this compare to your answer using boxplots and IQR?

Flash floods

Rapid flooding of low-lying areas is called a flash flood

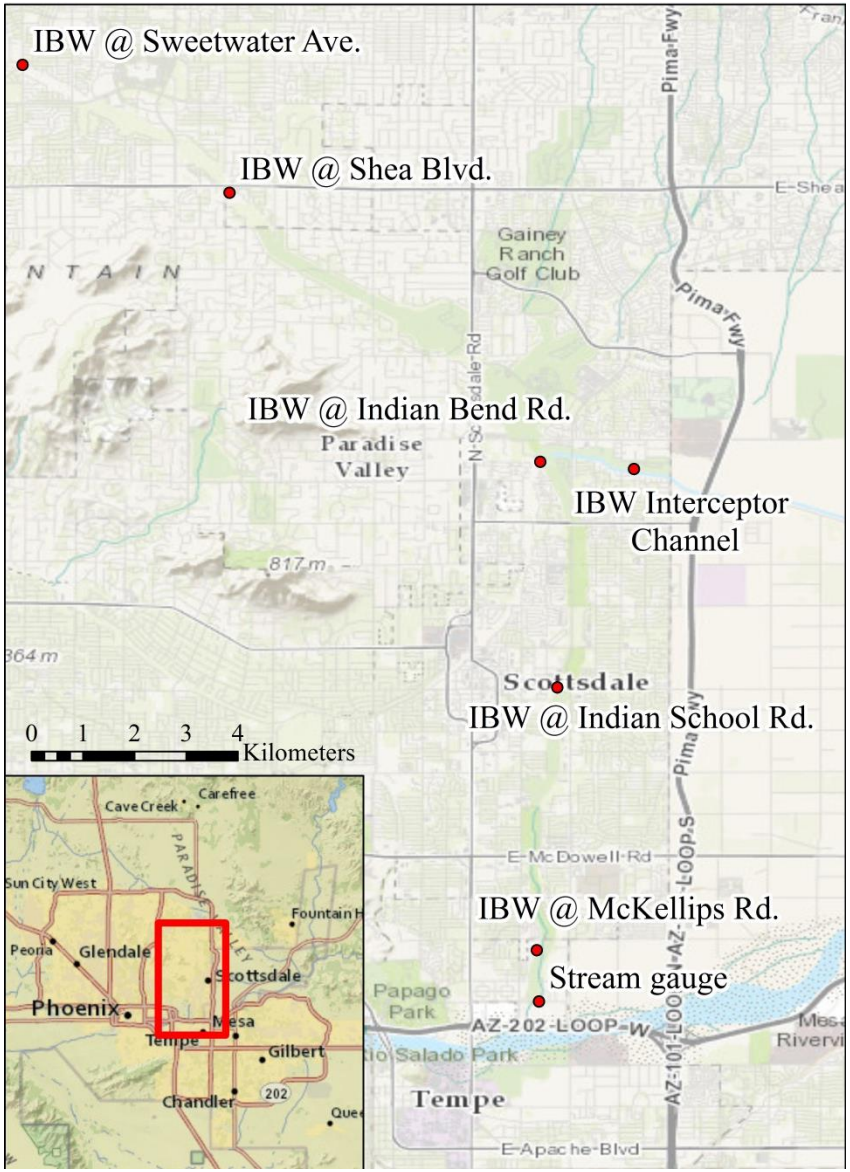
azgolfhomes.com

ABC15

Part 2 – precipitation and streamflow

- In many of Phoenix's dry washes, streamflow only occurs after it rains
- How does the relationship between precipitation and streamflow differ between typical and extreme monsoon storms?

Indian Bend Wash



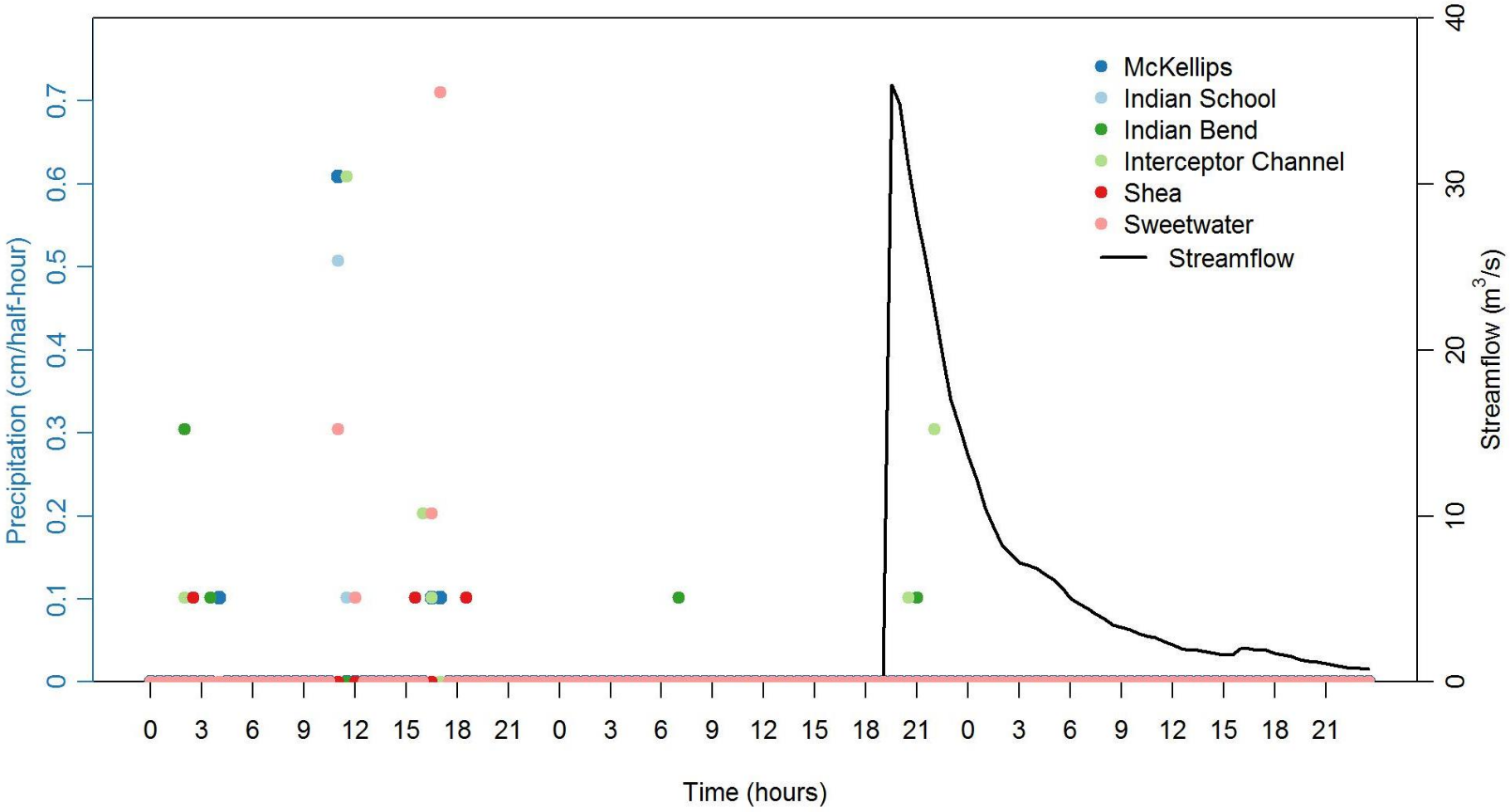
Stream flow gauge along Indian Bend Wash


Is the stream gauge recording flow right now?
aroundguides.com

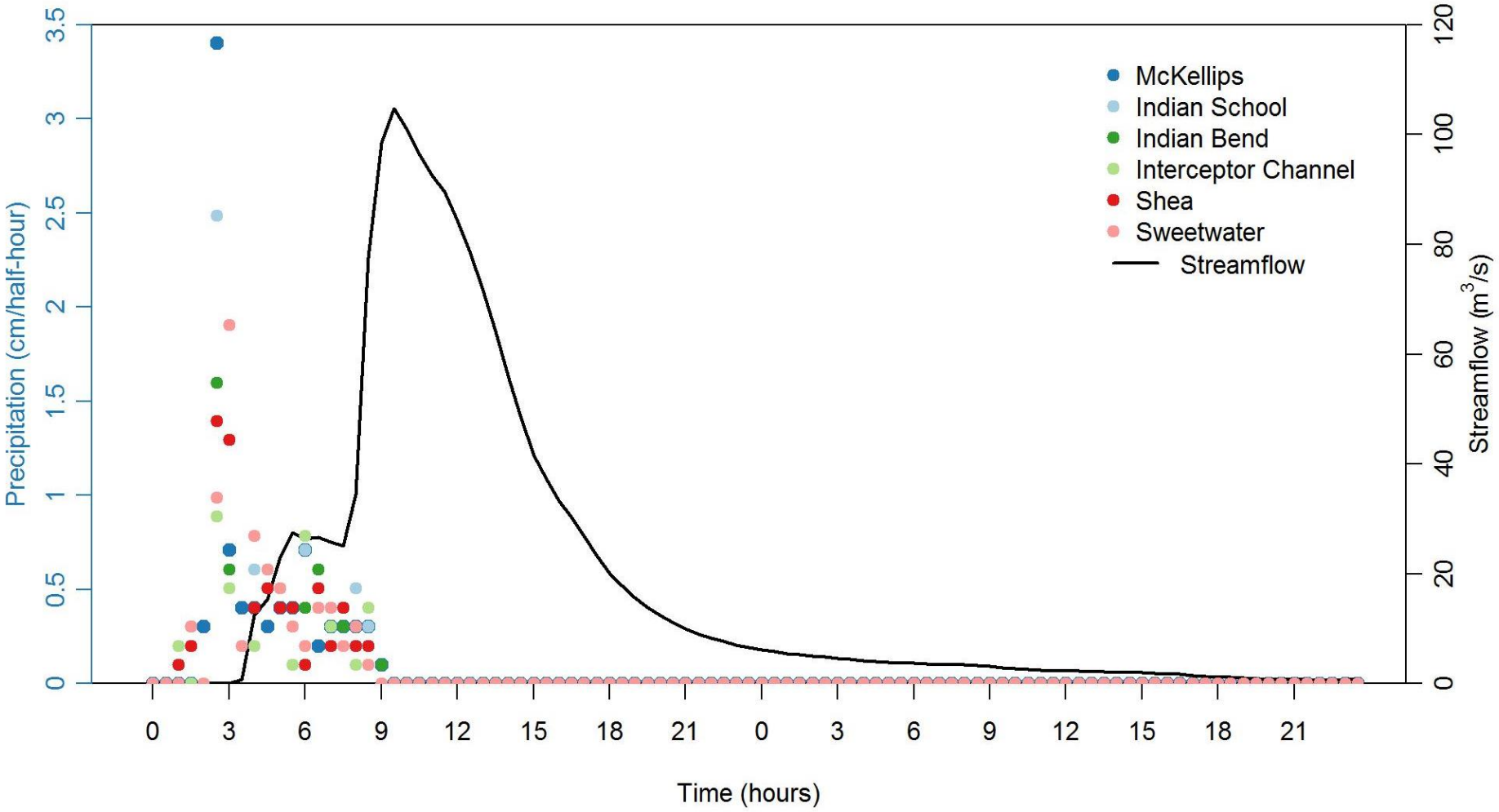
How about now?

Dave Seibert/The Republic

8/18 storm


McKellips
Indian School
Indian Bend
Interceptor Channel
Shea
Sweetwater
Streamflow
Precipitation (cm/half-hour)
Streamflow (m3/s)
Time (hours)
0 3 6 9 12 15 18 21 0 3 6 9 12 15 18 21 0 3 6 9 12 15 18 21

9/8 storm


Precipitation (cm/half-hour)
0
0.5
1
1.5
2
2.5
3
3.5
Streamflow (m3/s)
0
20
40
60
80
100
120
McKellips
Indian School
Indian Bend
Interceptor Channel
Shea
Sweetwater
Streamflow
0
3
6
9
12
15
18
21
0
3
6
9
12
15
18
21
Time (hours)

Part 2, Question 1

Estimate 6 quantities from the graph of precipitation and streamflow from each storm

Part 2, Question 1 answers

Quantity	8/18 storm	9/8 storm
Maximum precipitation (cm)	0.7	3.4
Maximum streamflow (m^3/s)	35	100
Time from max ppt to max streamflow (hours)	27	8
Duration of precipitation (hours)	45	9
Duration of streamflow (hours)	26	45
Mode* of precipitation (cm)	0.1	0.4

Part 2, Questions 2, 3, & 4

2) How does precipitation differ between each storm?
3) How does streamflow differ between each storm?
4) How does the relationship between precipitation and streamflow differ between each storm?

Part 3 extension: BOTE calculations

Back of the envelope (BOTE) calculations allow us to estimate a value from known values using simplifying assumptions and unit conversions

For example, let's assume that the streamflow gauge broke just before a large storm. Could we estimate streamflow from just the precipitation?

Estimation premise

We know the area of the watershed and the mode of the precipitation height, which means we can multiply the two to estimate the volume of water produced in one 30-minute increment.

What are the two major assumptions we have to make to use this method of estimation?

Simplifying assumptions (that we know to be untrue, but are useful anyway)

1. All rainfall ends up in the stream.

   Is this true?

   If not, will our BOTE be an over- or under-estimate of the true streamflow?

2. Rain falls evenly over the watershed.

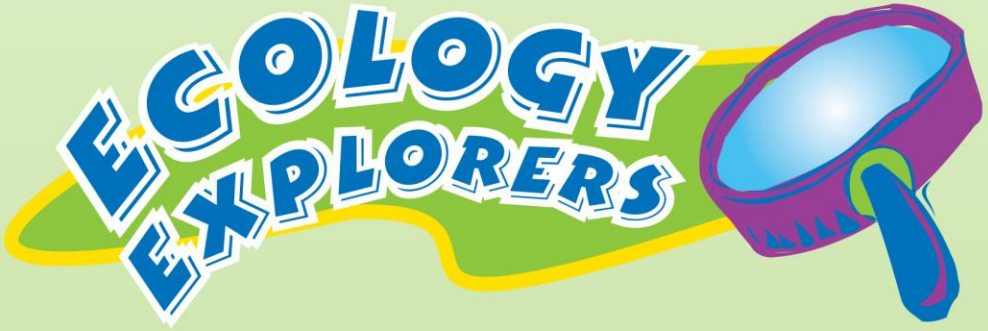
   Is this true?

   If not, will the accuracy of this estimation method depend on the type of storm?

Thank you for listening!

And a huge thanks to Monica Elser, Lisa Herrmann, Melissa Wagner, and Joanna Merson for their help and feedback on this activity.

Do you have any questions for me?



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