

The Value of Visualization

DSC 106: Data Visualization

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UC San Diego

How much data are we producing?

(1 exabyte or 1 EB = 1 *million* terabytes)

2023 – 120,000 EB

***But what is in all
this data??***

A stack of iPads that stretch
2/3rds of the way to the Moon! 🚀

A stack of DVDs stretching from
the Earth to the Moon, and back!

2016 – 16,100 EB

2013 – 4,400 EB

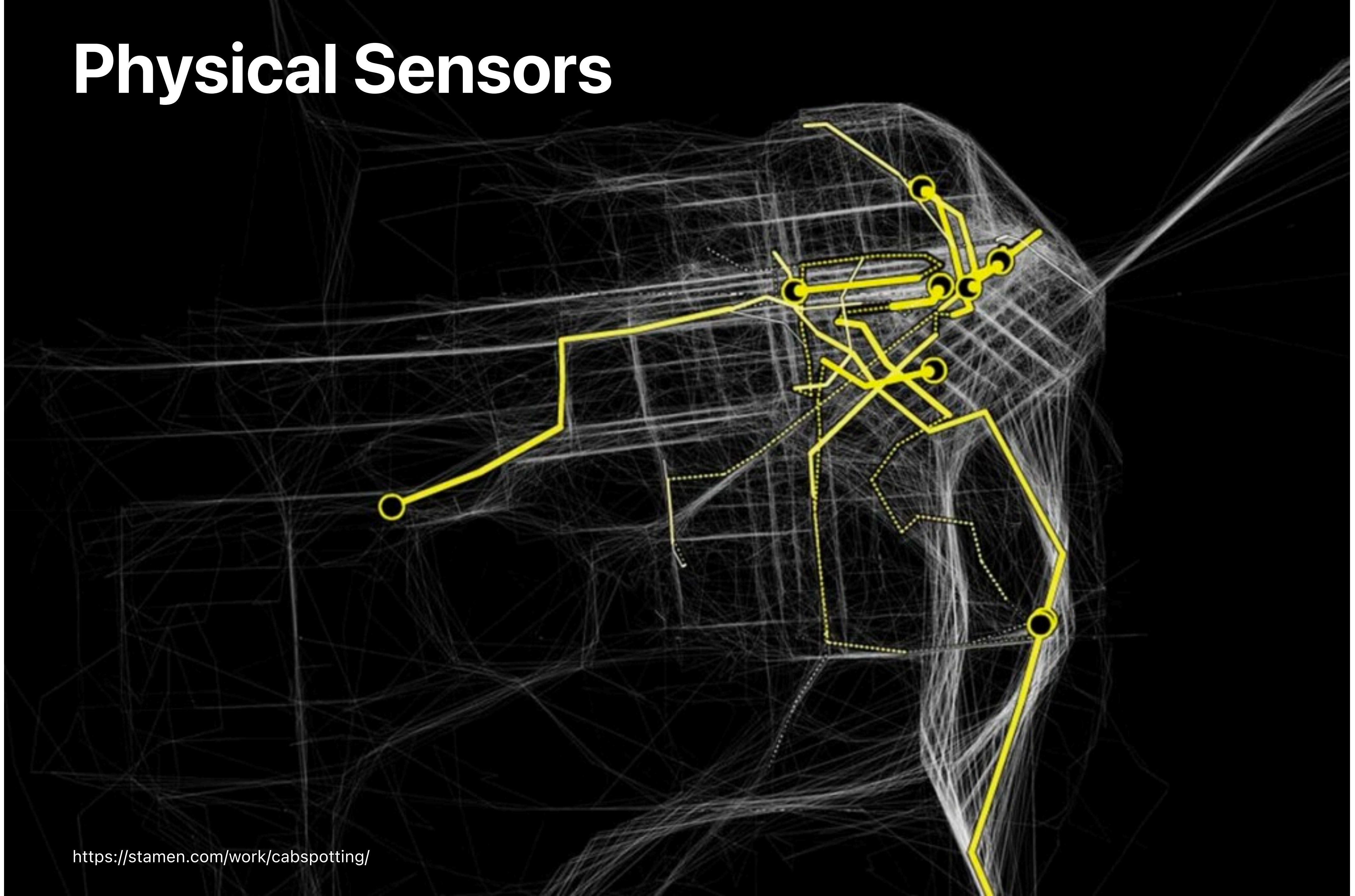
2011 – 1,800 EB

2010 – 1,200 EB

2006 – 161 EB

2002 – 5 EB

Physical Sensors



Health and Medicine



Records of Human Activity



facebook

<https://www.facebook.com/notes/10158791468612200/>

December 2010

"The ability to take data

—to be able to **understand** it, to **process** it, to **extract value** from it, to **visualize** it, to **communicate** it—

that's going to be a hugely important skill in the next decades,

... because now we really do have **essentially free and ubiquitous data**. So the complimentary scarce factor is the ability to understand that data and extract value from it."

Hal Varian, Google's Chief Economist

The McKinsey Quarterly, Jan 2009

But wait! the data

—to be able to **understand** it, to **process** it, to **extract value** from it, to **visualize** it, to **communicate** it—

that's going to be a hugely important skill in the next decades,

"free" to whom?

... because now we really do have **essentially free and ubiquitous data**. So the complimentary scarce factor is the ability **"ubiquitous" about whom?** d extract value from it."

"value" to whose benefit? an, Google's Chief Economist

The McKinsey Quarterly, Jan 2009

TECHNOLOGY

Elon Musk's AI chatbot, Grok, started calling itself 'MechaHitler'

JULY 9, 2025 · 3:12 PM ET

By Lisa Hagen, Huo Jingnan, Audrey Nguyen



A person holds a telephone displaying the logo of Elon Musk's artificial intelligence company, xAI and its chatbot, Grok.

<https://www.npr.org/2025/07/09/nx-s1-5462609/grok-elon-musk-antisemitic-racist-content>



Psychology's Replication Crisis Can't Be Wished Away

It has a real and heartbreaking cost.

ED YONG | MAR 4, 2016 | SCIENCE

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TEXT SIZE
- +

<https://www.theatlantic.com/science/archive/2016/03/psychologys-replication-crisis-cant-be-wished-away/472272>

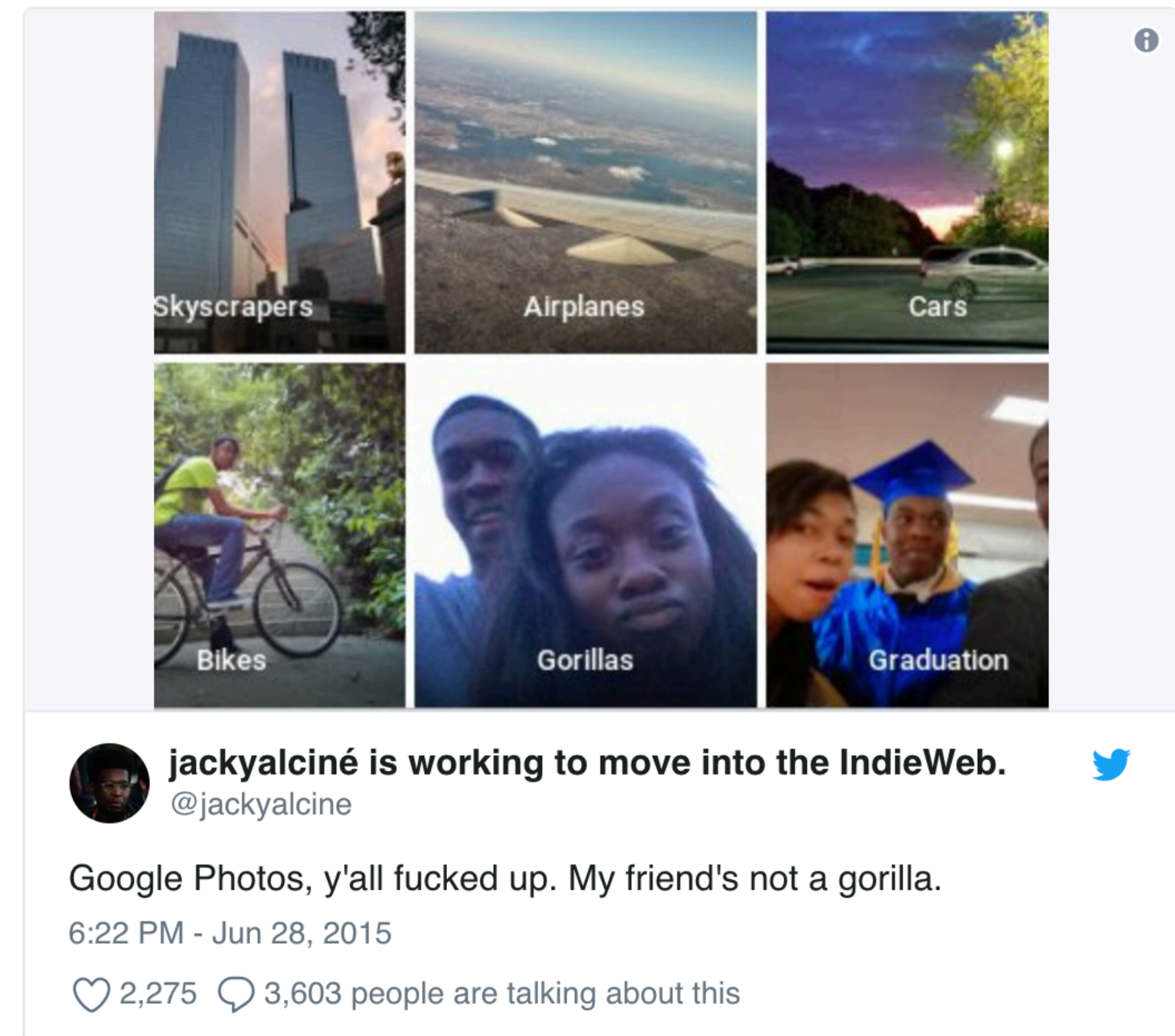
High potential for data abuse...

Inequality

Rise of the racist robots - how AI is learning all our worst impulses



There is a saying in computer science: garbage in, garbage out. When we feed machines data that reflects our prejudices, they mimic them - from antisemitic chatbots to racially biased software. Does a horrifying future await people forced to live at the mercy of algorithms?



...amplified by "big data" and ML systems.

How might we use **visualization** to **empower understanding** of data and analysis processes?

What is visualization?

"Transformation of the symbolic into the geometric"

[McCormick et al. 1987]

"... finding the artificial memory that best supports our natural means of perception." [Bertin 1967]

"The use of computer-generated, interactive, visual representations of data to amplify cognition."

[Card, Mackinlay, & Shneiderman 1999]

Set A		Set B		Set C		Set D	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.8	12	9.11	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

Summary Statistics

$$u_X = 9.0 \quad \sigma_X = 3.32$$

$$u_Y = 7.5 \quad \sigma_Y = 2.03$$

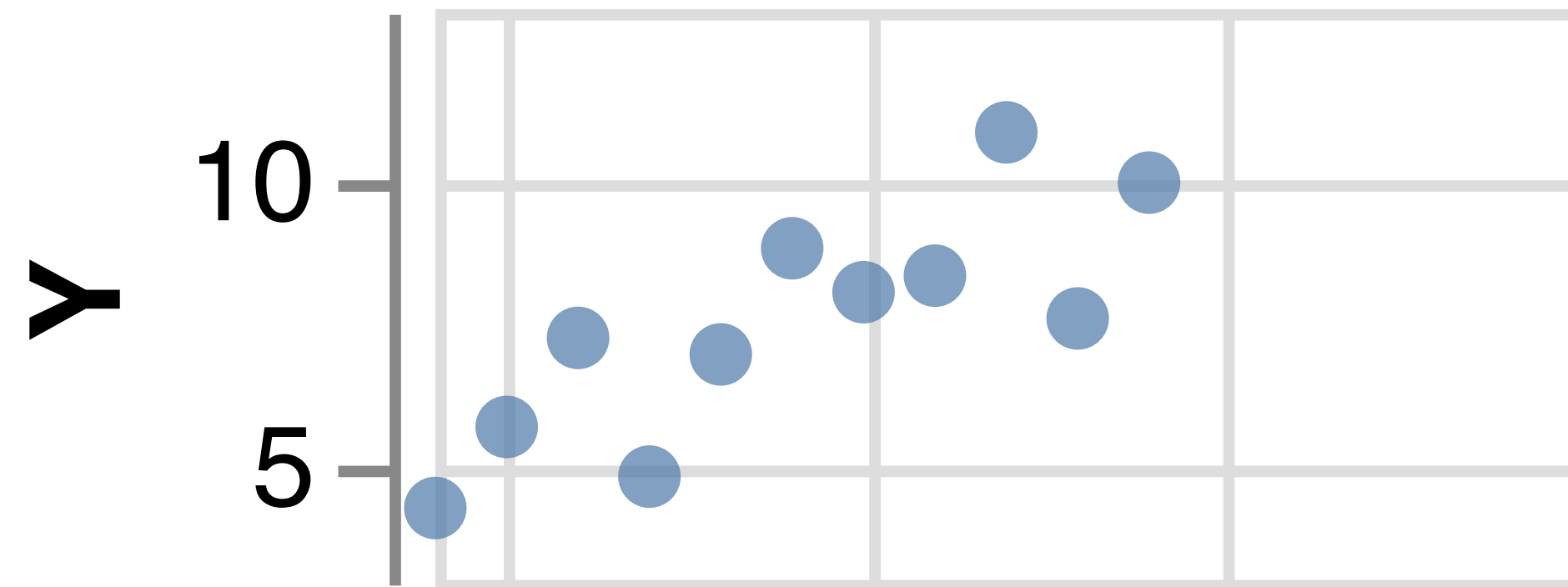
Linear Regression

$$Y^2 = 3 + 0.5 X$$

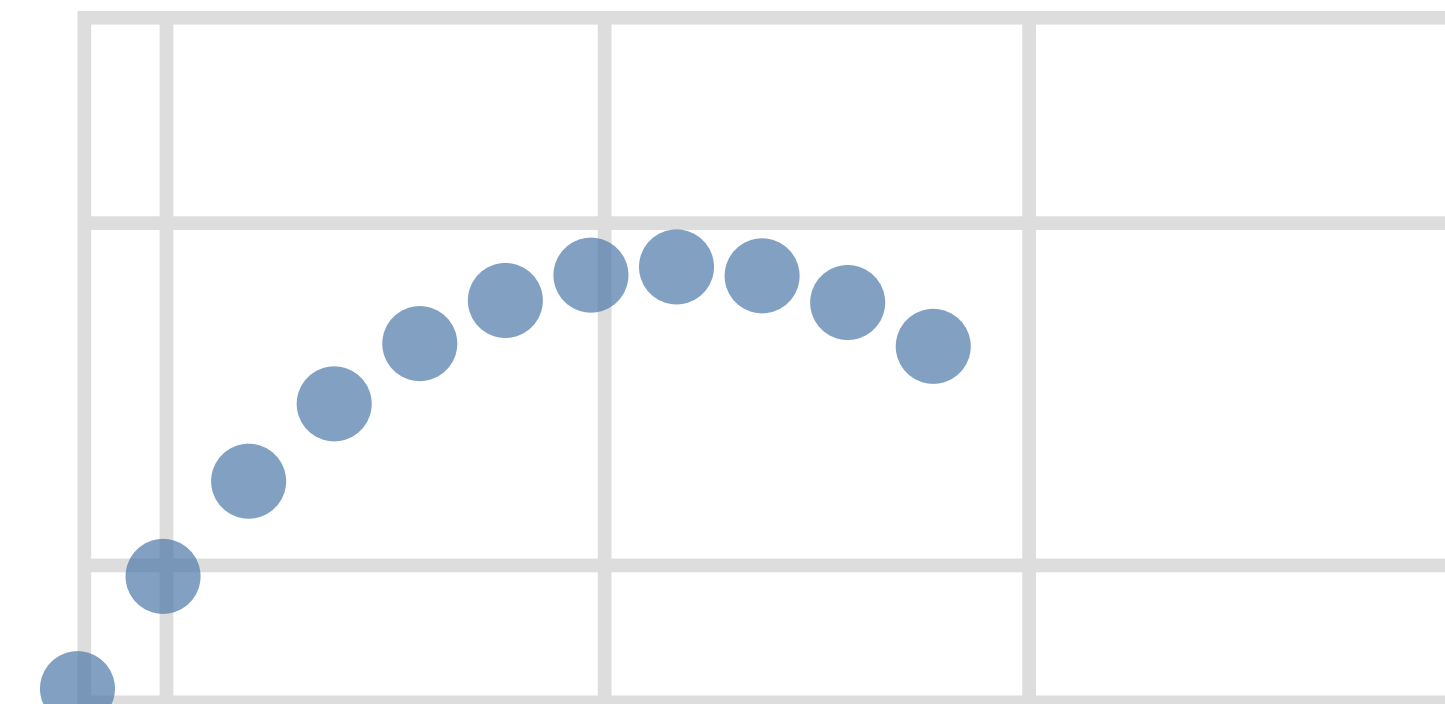
$$R^2 = 0.67$$

[Anscombe 1973]

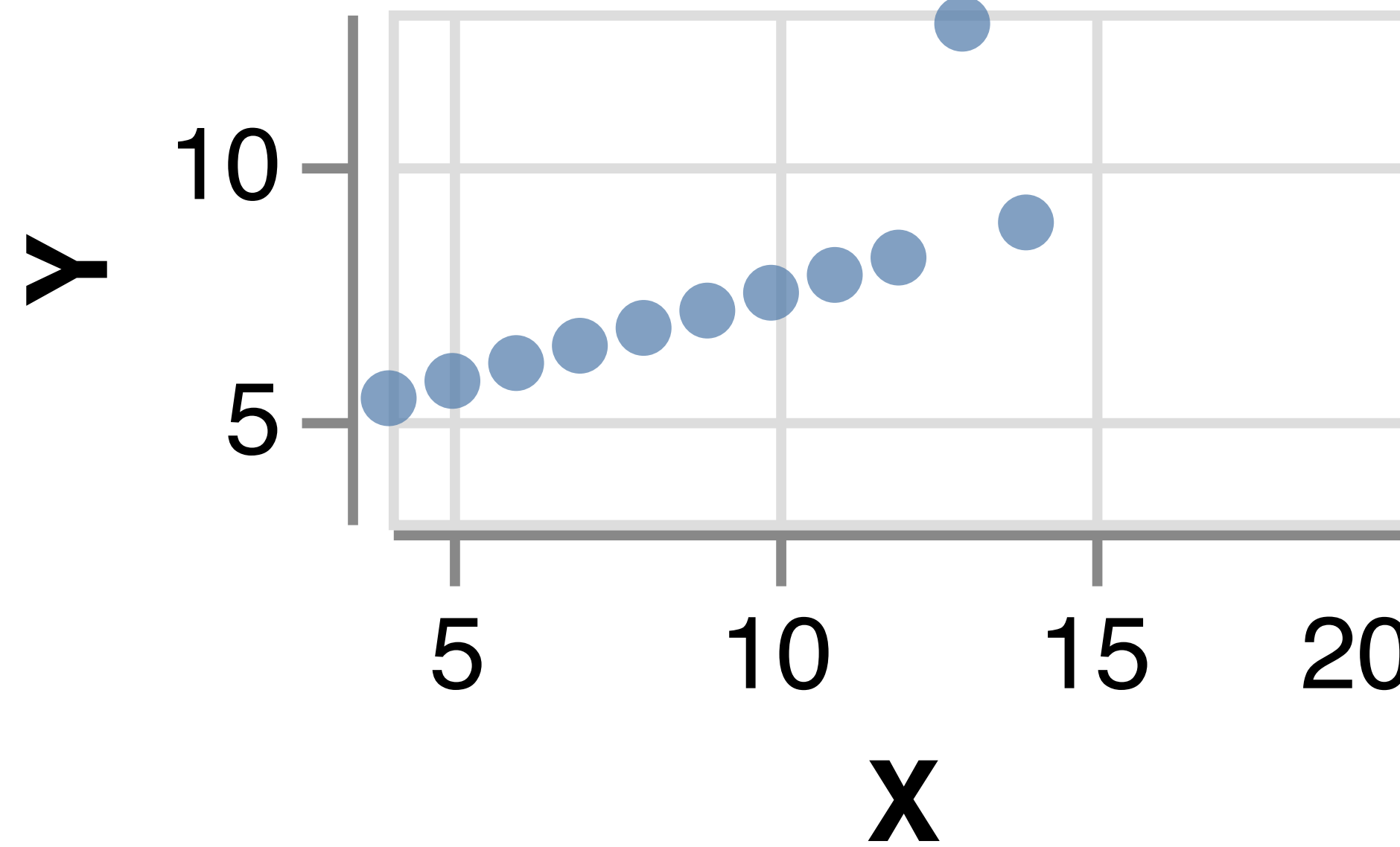
Set A



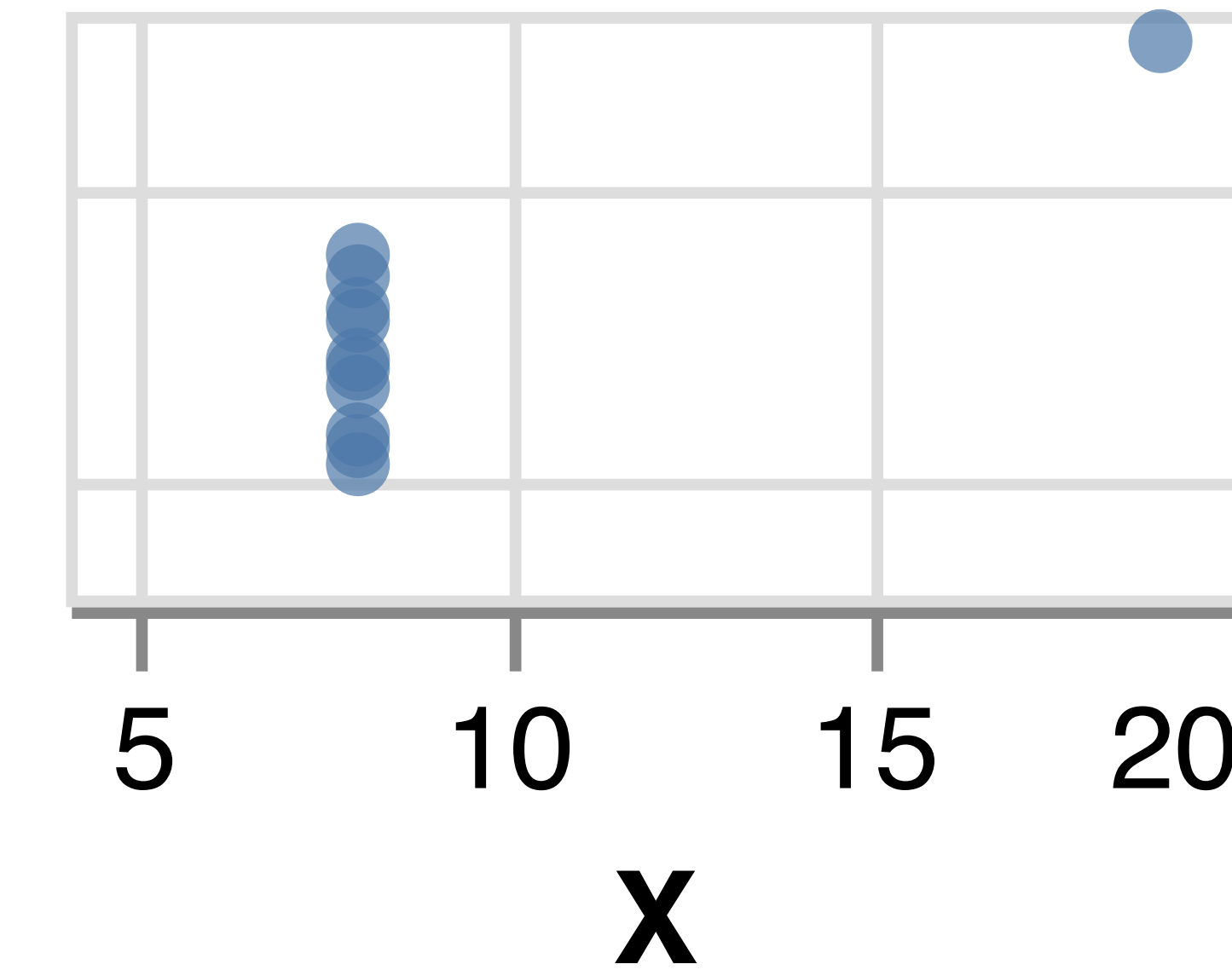
Set B



Set C



Set D



The Value of Visualization

Record information

Blueprints, photographs, seismographs, ...

Analyze data to support reasoning (**exploratory visualization**)

Develop and assess hypotheses

Find patterns / Discover errors in data

Expand memory

Communicate information to others (**explanatory visualization**)

Share and persuade

Collaborate and revise

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Gallop, Bay Horse "Daisy" [Muybridge]

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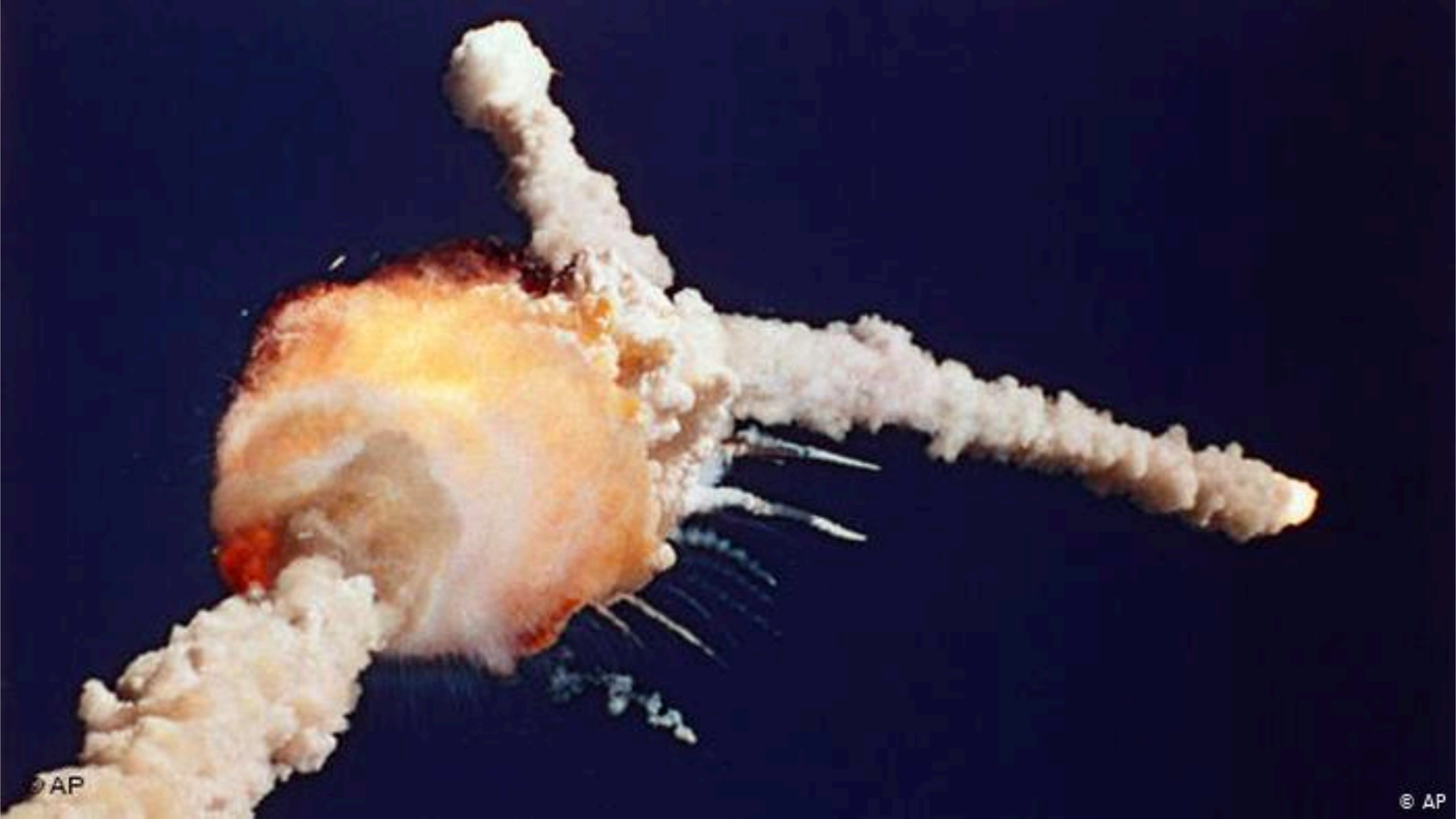
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HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

1169
Oct 30, 1985

	SRM No.	Cross Sectional View			Top View		Clocking Location (deg)
		Erosion Depth (in.)	Perimeter Affected (deg)	Nominal Dia. (in.)	Length Of Max Erosion (in.)	Total Heat Affected Length (in.)	
61A LH Center Field**	22A	None	None	0.280	None	None	36°--66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90

July

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.

**Soot behind primary O-ring.

***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

BLOW BY HISTORY

SRM-15 WORST BLOW-BY

o 2 CASE JOINTS (80°), (110°) ARC

o MUCH WORSE VISUALLY THAN SRM-22

SRM 22 BLOW-BY

o 2 CASE JOINTS (30-40°)

SRM-13A, 15, 16A, 18, 23A 24A

o NOZZLE BLOW-BY

HISTORY OF O-RING TEMPERATURES
(DEGREES - F)

MOTOR	MBT	AMB	O-RING	WIND
DM-4	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-4	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29	10 MPH
			27	25 MPH

2 of 13 pages of material faxed to NASA by Morton Thiokol [from Tufte 1997]

O-Ring
Temp
(°F)

SRM No. 15 A 15 B 10 A 10 B 24 A 24 B 11 A 11 B 1 A 1 B 6 A 6 B 14 A 14 B 17 A 17 B 5 A 5 B 3 A 3 B 2 A 2 B 9 A 9 B 13 A 13 B 18 A 18 B 7 A 7 B 8 A 8 B 16 A 16 B 22 A 22 B 20 A 20 B 23 A 23 B 12 A 12 B 21 A 21 B 19 A 19 B

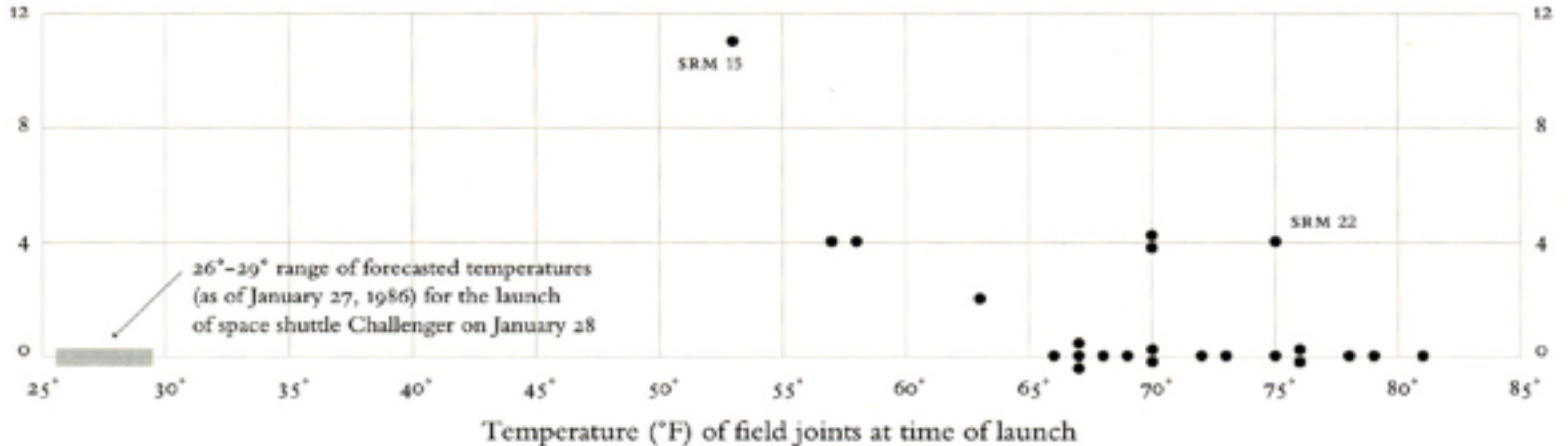
* No Erosion

O-Ring
Temp
(°F)

SRM No. 15 A 15 B 10 A 10 B 24 A 24 B 11 A 11 B 1 A 1 B 6 A 6 B 14 A 14 B 17 A 17 B 5 A 5 B 3 A 3 B 2 A 2 B 9 A 9 B 13 A 13 B 18 A 18 B

Chart of temperatures vs. O-ring damage [Tufte 97]

O-ring damage
index, each launch



But wait! What is an appropriate "damage index"?
Which temperatures, O-ring or outside air?

Cholera Outbreak (remember DSC 10?)

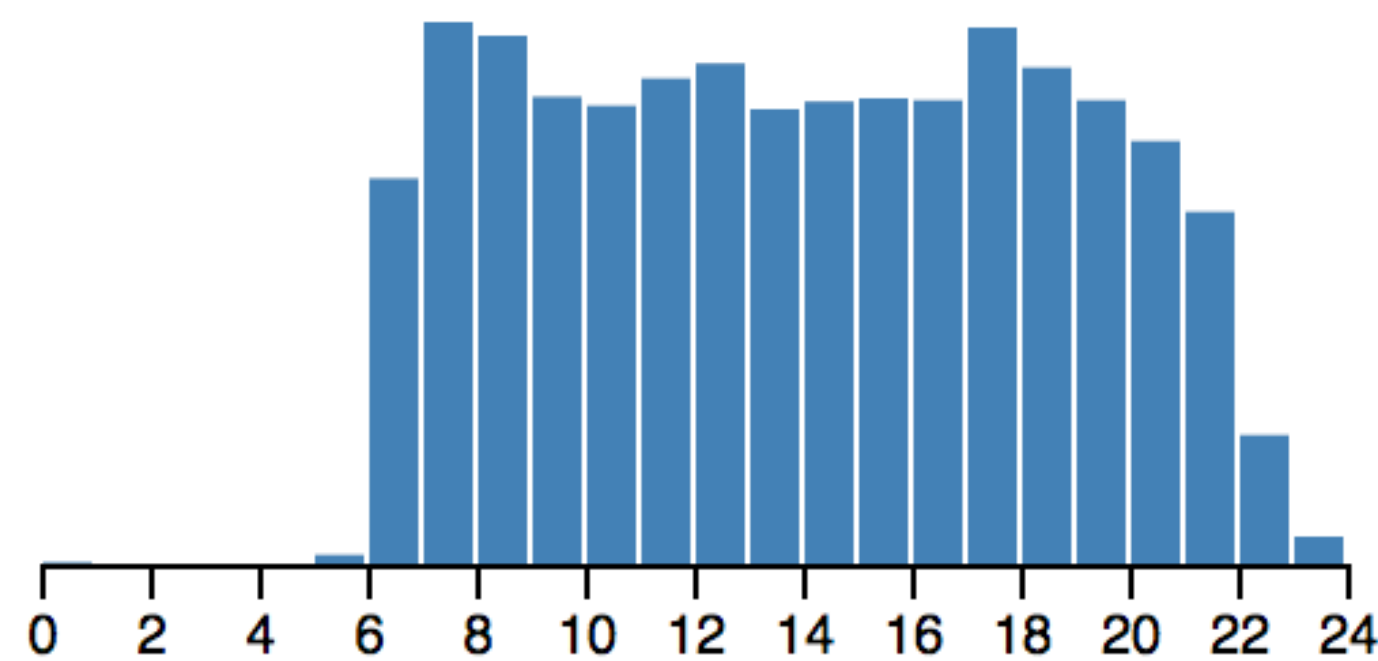


Cholera Outbreak (remember DSC 10?)

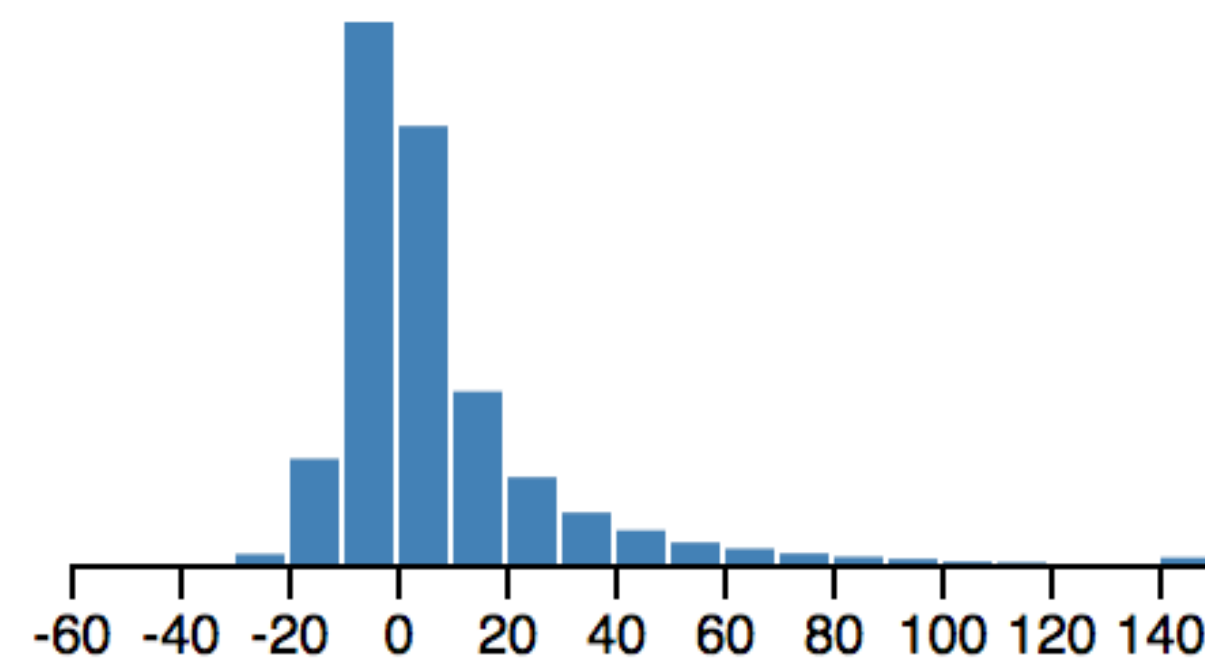


<https://square.github.io/crossfilter/>

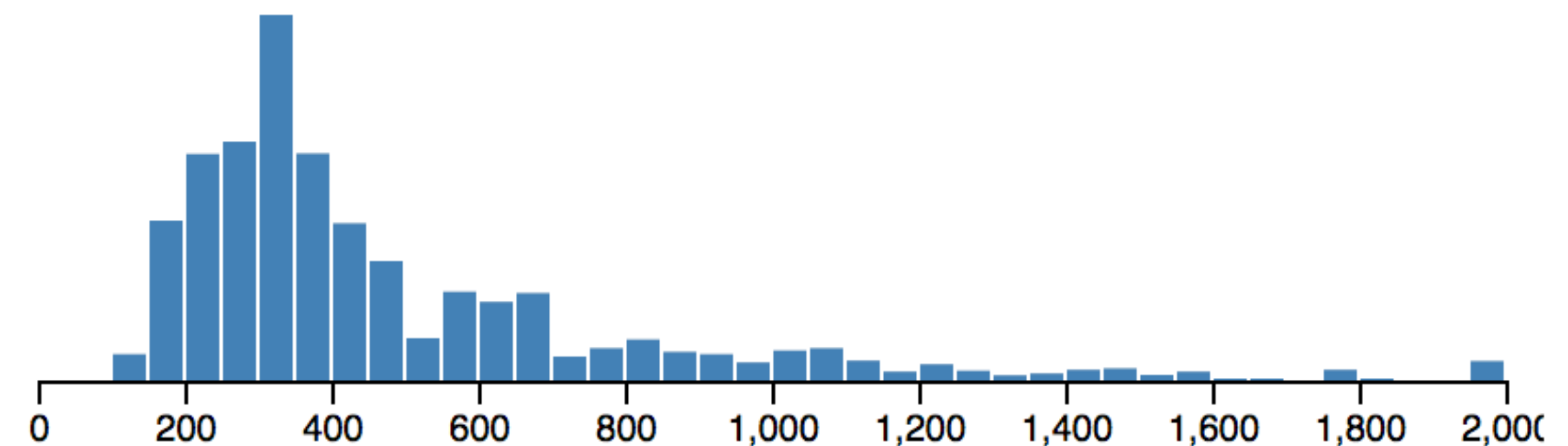
Time of Day



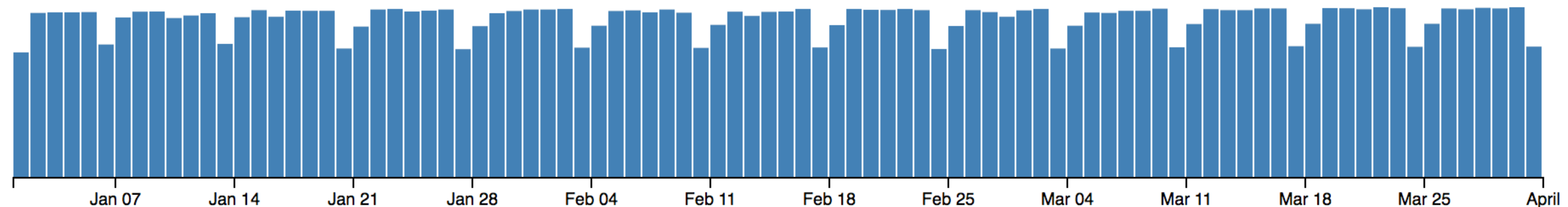
Arrival Delay (min.)



Distance (mi.)



Date



What insights do you notice?

tryclassbuzz.com: **crossfilter**

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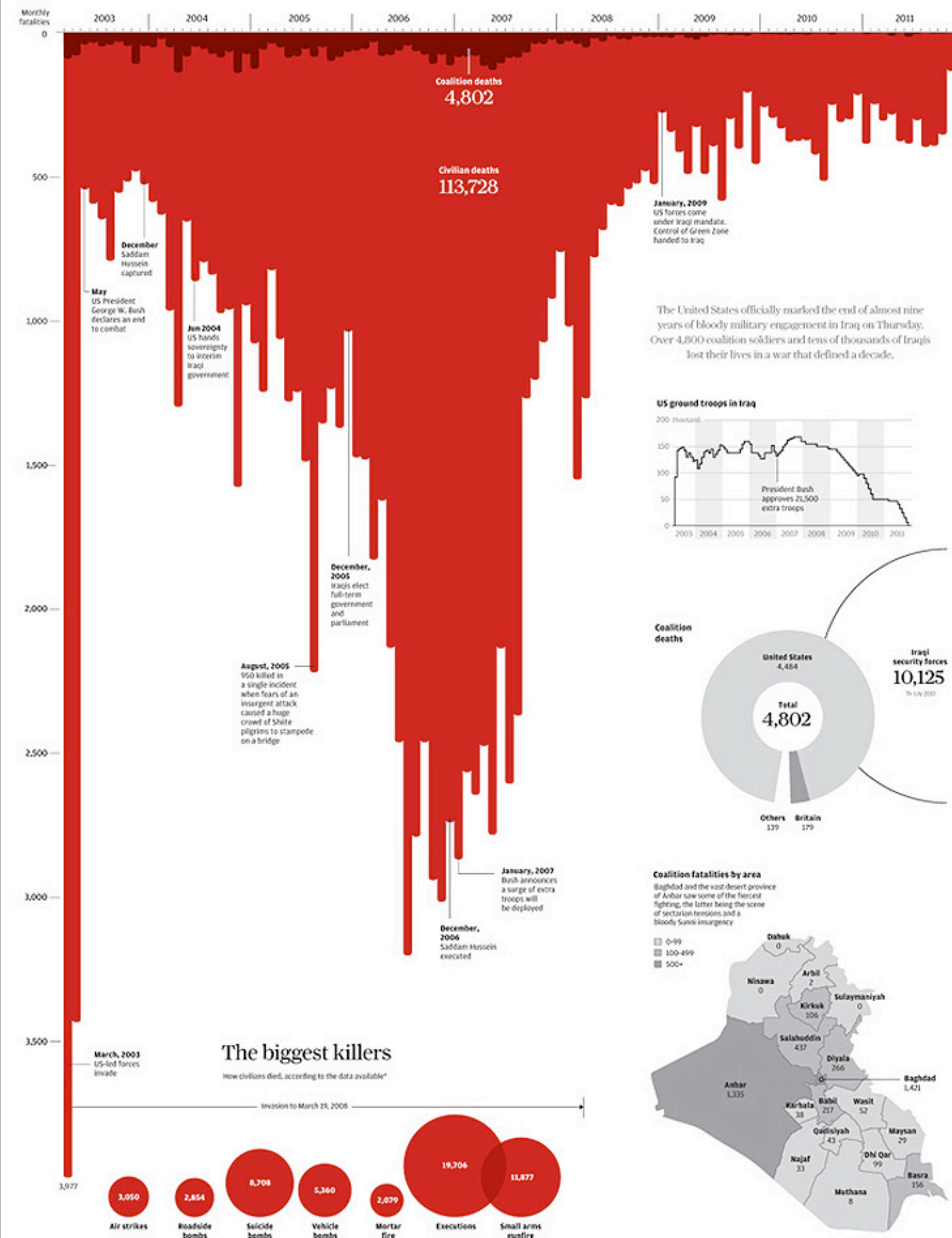
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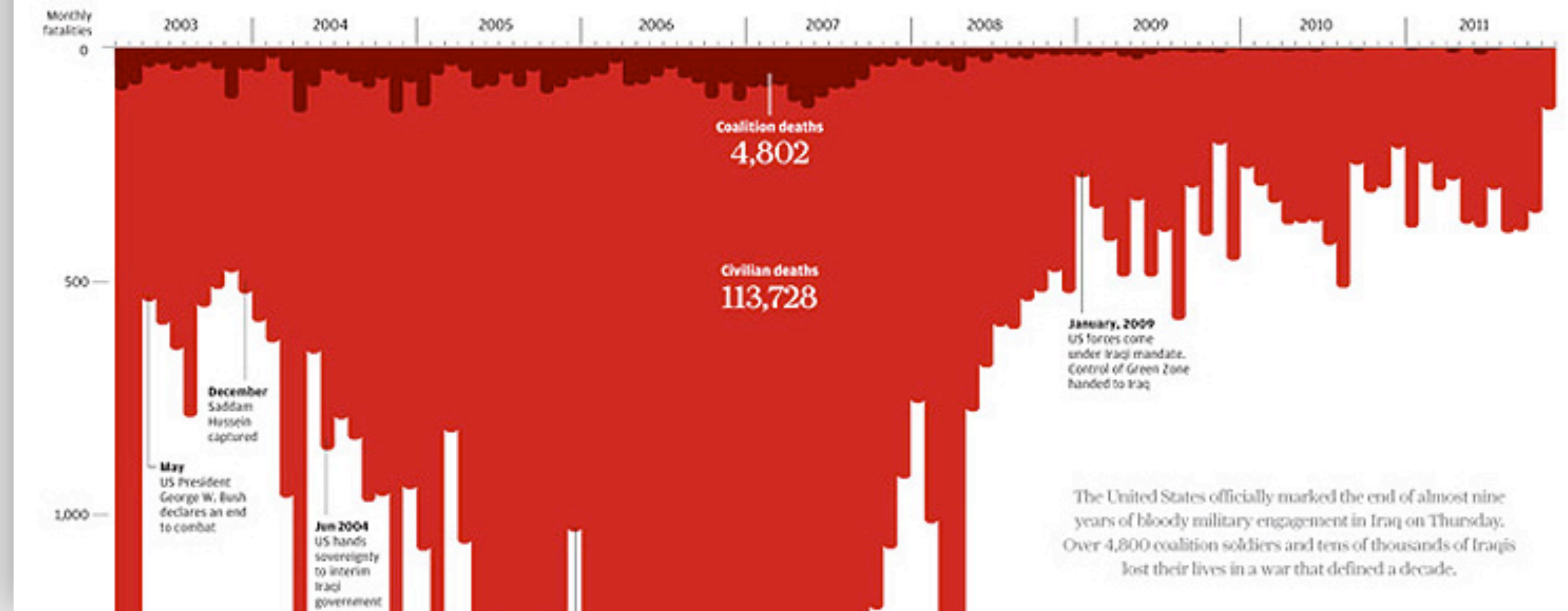
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Iraq's bloody toll



Iraq's bloody toll



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About this Course

About Me

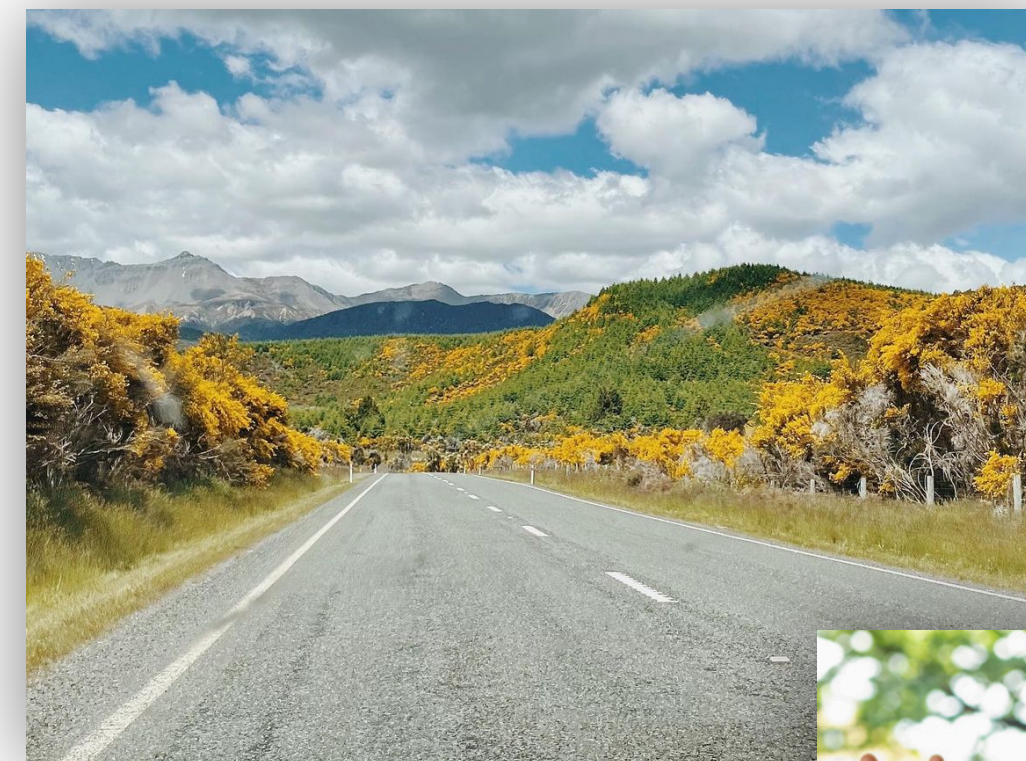
Assistant Teaching Professor, HDSI
[lau.ucsd.edu](mailto:lau@ucsd.edu)

Email: lau@ucsd.edu

Tools for visualizing programs
(Pandas Tutor), curriculum design
(Learning Data Science textbook)

What makes me smile:

My wife, my dogs, traveling, food,
students who put in their best effort!



Course staff

Instructor

Sam Lau

Teaching Assistants

Hemanth Bodala (Head TA)

Ben Pham

Tutors

Susana Haing

Minyoung Kim

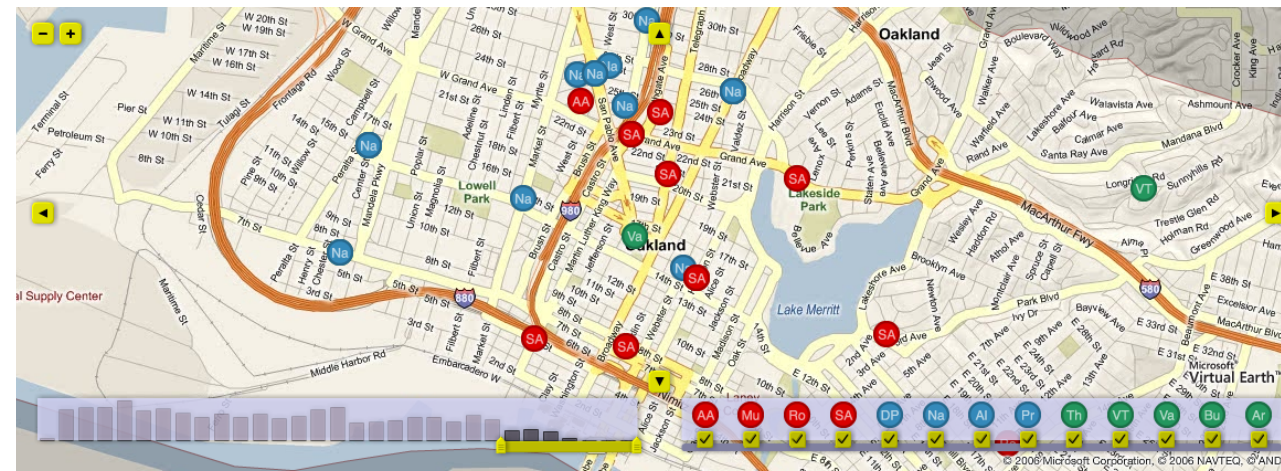
See dsc106.com
for our OH times

Principles

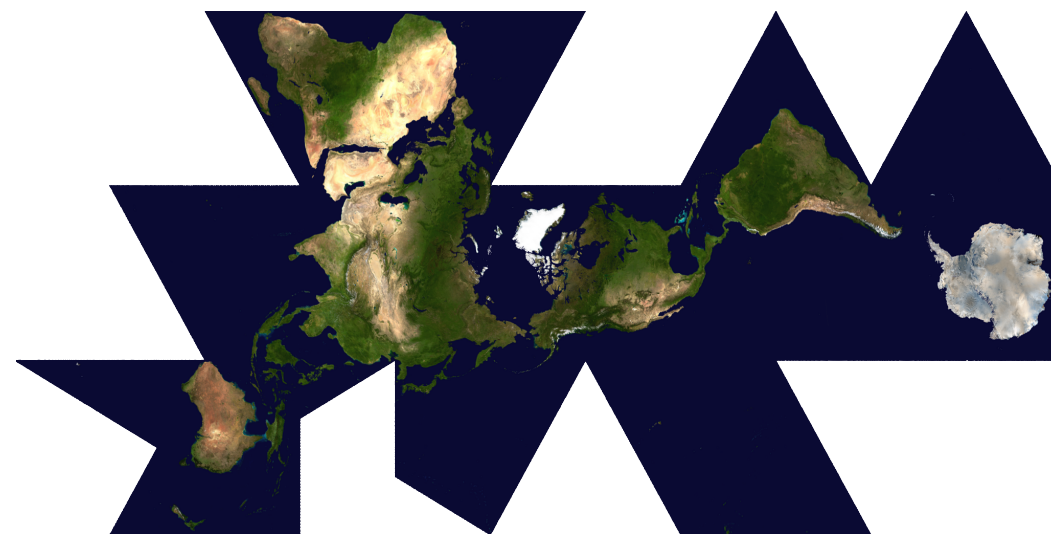
Data and
Image Models

LES VARIABLES DE L'IMAGE					
XY	POINTS		LIGNES	ZONES	
2 DIMENSIONS DU PLAN	x	x	x	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100	12 14
Z	TAILLE				0Q ≠
	VALEUR				0 ≠
LES VARIABLES DE SÉPARATION DES IMAGES					
	GRAIN				0 ≠
	COULEUR				≠
	ORIENTATION				≠

Interaction



Maps



...and many more!

Techniques

HTML/CSS



JavaScript



D3.js



Learning Objectives

By the end of this course:

- Understand and apply key visualization techniques and theory.
- Design, evaluate, and critique visualization designs.
- Implement interactive data visualizations for the web using D3.js.
- Develop a substantial visualization project.

This Quarter: Climate (with Prof Duncan Watson-Parris)



You will visualize climate data in Projects 3, and the Final Project

Duncan will give guest lecture to introduce datasets and background

For Final Project Showcase, we will invite outside guests (industry and SIO)

Grade Breakdown

Component	Weight
Participation	8%
Labs	8%
Project 1	10%
Project 2	15%
Project 3	15%
Project Checkpoints	4%
Final Project	40%

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Final Project	40%

1% per week (2 lowest weeks dropped). 2 options:

1. Attend both lectures, discussion, and participate in the lecture activities.
2. Share and critique 1 viz example on Piazza.

See website for full details.

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Final Project	40%

8 labs, 1% per lab. (No drops)

Grade Breakdown

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Final Project	40%

3 open-ended projects

Grade Breakdown

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Final Project	40%

Final project will span last 4 weeks of course

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Final Project	40%

6 slip days for quarter.

You can use 1 slip day for labs,
2 for project deadlines

But NOT for the Final Project
submission deadline

Communication

Use Piazza for all communication (my email is super slammed these days)

Email Hemanth, cc me for private questions related to course

Course website will stay up-to-date (dsc106.com)

Where you're headed: Final Project

Explorable Explanation

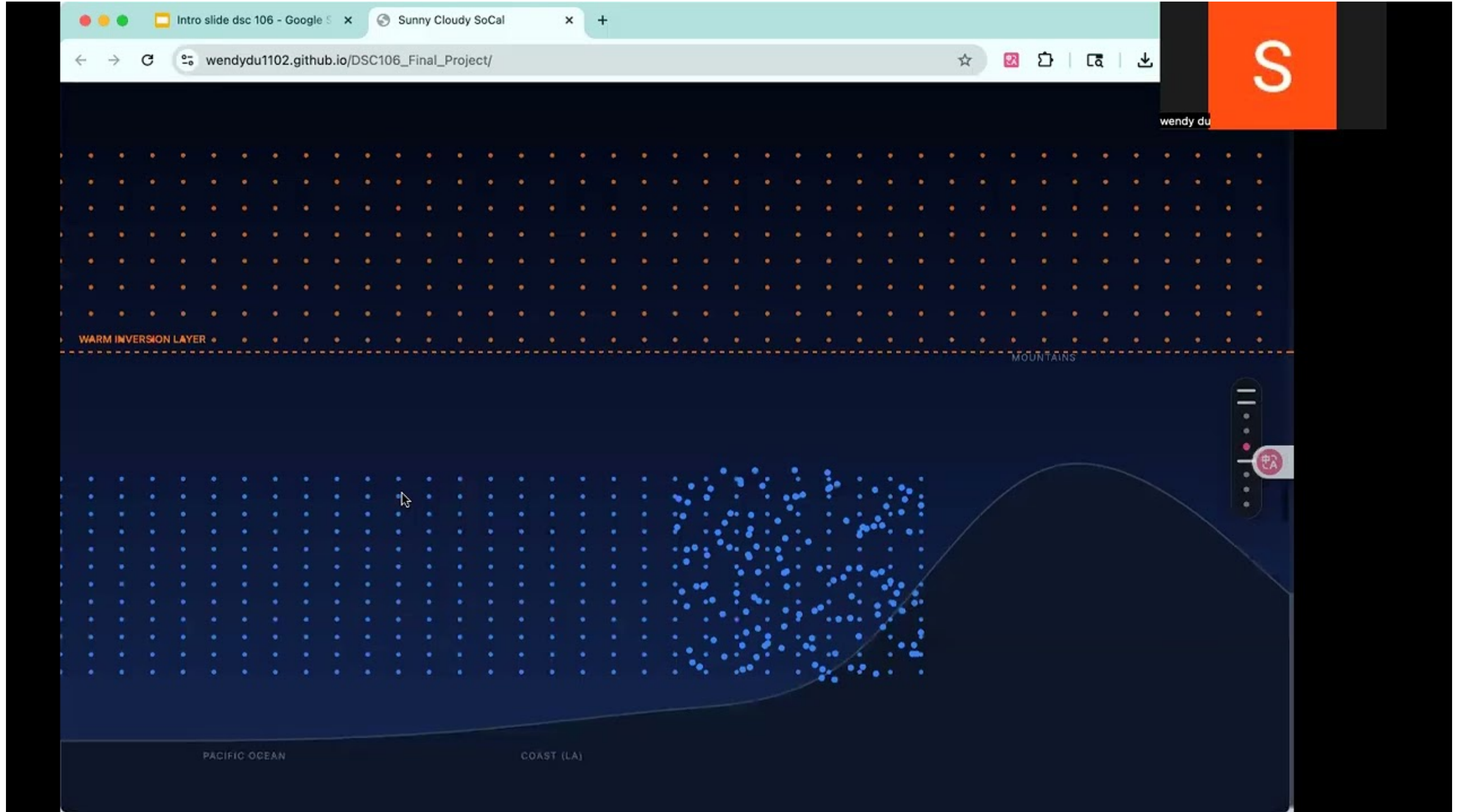
Initial **prototype** and **design reviews**

In-class demonstration **videos**

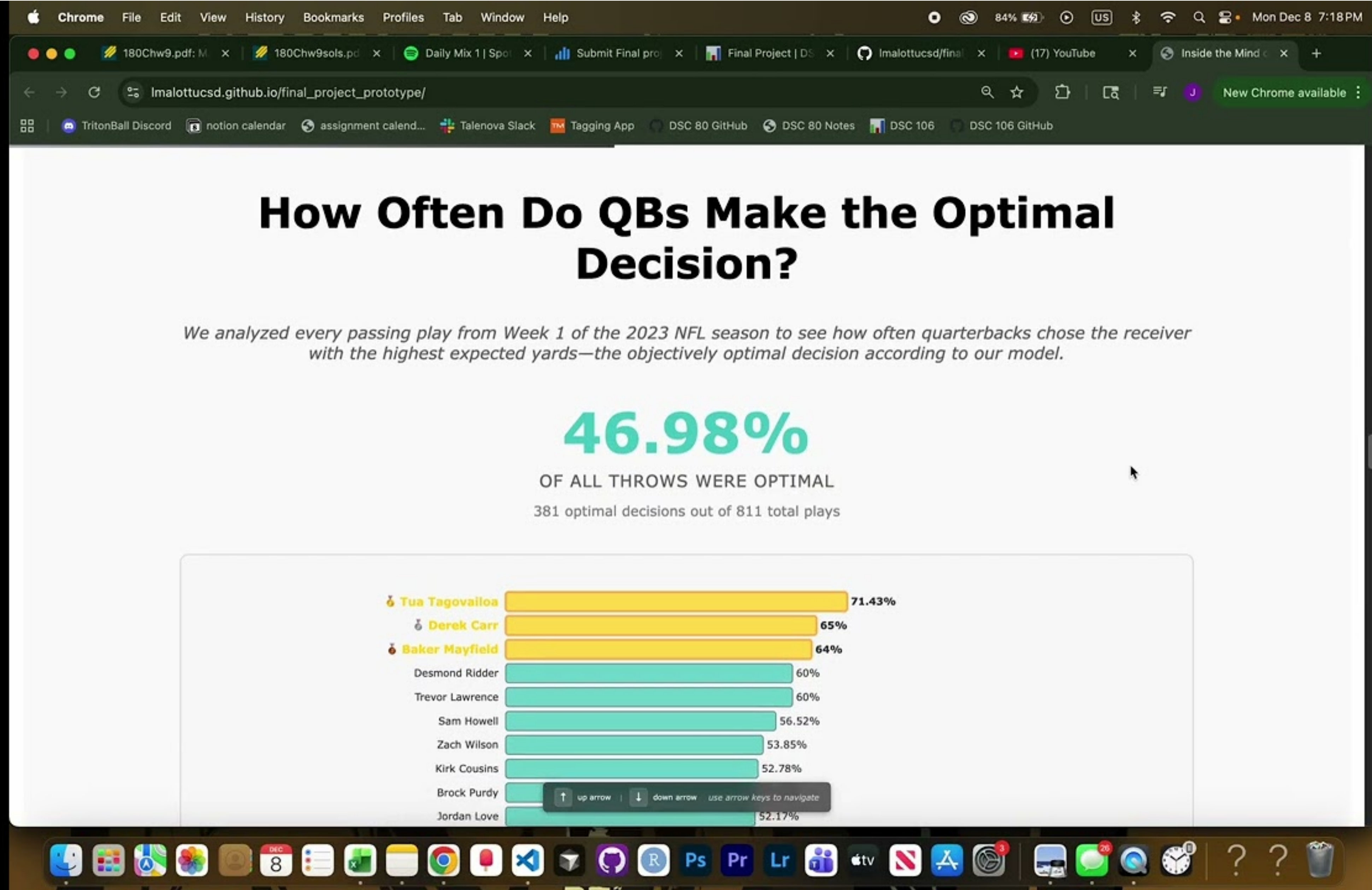
Submit and publish online

In Finals Week, **Final Project Showcase**

See past projects at:
dsc-courses.github.io/dsc106-2025-fa/showcase



https://wendydu1102.github.io/DSC106_Final_Project/



https://lmalottucsd.github.io/final_project_prototype/

Lab 1: Introduction to the Web Platform

Lab 1 released, due Friday.

Step 4: Add a photo

- 1 Create an `images` folder in the root of your repository
- 2 Find a photo of yourself (or anything else you want) and save it in the `images` folder
- 3 Add an `<img>` element to your HTML page, with the `src` attribute set to the path to your image file (`images/your-image-file-name.jpg`)
- 4 Add an `alt` attribute to the `<img>` element with a short description of the image as you would describe it to someone who cannot see it.

Katie-test: Personal site and portfolio

Hi, I'm Katie. I'm a web developer and designer. I'm currently working on my personal site and portfolio. Check back soon for updates!

Lorem ipsum dolor, sit amet consectetur adipiscing elit. Ea quia aspernatur mollitia pariatur cupiditate inventore et? Voluptatum, iste praesentium corrupti culpa itaque, repudiandae ut, porro veniam doloremque dolor dolorum perferendis.

Lorem, ipsum dolor sit amet consectetur adipiscing elit. Minus libero commodi vel dolore consectetur molestiae eligendi, delectus veritatis blanditiis facilis vero nesciunt. Excepturi distinctio impedit odio hic consequatur in ipsum.



please enjoy an actual photo of my dog

Figure 5: Our page now has a photo!

Project 1: Expository visualization

Create **one static visualization** for a dataset (see course website).

Pick a **guiding question**, use it to title your vis.

Design a **static visualization** for that question.

You are free to **use any tools** (inc. Python, Tableau, pen & paper).

Deliverables (upload via Gradescope; see Project 1 page)

Image of your visualization (PNG or JPG format)

Short description + design rationale (≤ 4 paragraphs)

Advice from past students

If you want to be ambitious, it's really easy to do that in this class! Try and create something you're proud of. It's worth it. :)

Go to OH and use AI!!

The rubric is there to guide you, but you won't get anything from this class if your main objective is to simply get all the points. Be creative and take risks with what you visualize.

Most common advice:

Just please start your labs and projects early because I feel like if I did, a lot of headache of doing stuff on the last day would be eliminated :)

Questions?