

# CS 571 - Data Visualization & Exploration

Tasks and Interaction

Instructor: Hamza Elhamdadi

UMassAmherst

## Upcoming Dates

Apr 11: Homework 3 Due at 11:59pm Eastern

Apr 11: Project Milestone

Group Activity Next Class (Apr 10)

Quiz 4 available Apr 10 (due Apr 14)

Homework 4 released Apr 14 (due Apr 28)

# Analyzing Data Visualizations

**What** is shown?

**Why** is the user looking at it?

**How** is it shown?

Abstract vocabulary allows us to avoid domain-specific terms

What-Why-How framework is a scaffold we can use to systematically think about the huge visualization design space

what?

Why?

How?

# Analyzing Data Visualizations

The **tasks** a user performs

what?

Why?

How?

# Tasks

A visualization task is an {action, target} pair

For example:

- Compare Trends
- Discover Distributions
- Locate Outliers

# Actions

Can be separated into high-level,  
mid-level, and low-level actions

High-Level: **Analyze**



Mid-Level: **Search**

Low-Level: **Query**



# Actions

High-Level: Analyze

➔ Analyze

➔ Consume

➔ Discover

➔ Present

➔ Enjoy



➔ Search

➔ Query

# Discover

## A24 Movie Browser

SIZE: WORLDWIDE GROSS (\$M)

FILTER: RT % CRITICS

ACTION COMEDY DRAMA HORROR OTHER ROMANCE THRILLER WESTERN

search...

### Hereditary

2018

ARI ASTER

A family is haunted by an evil presence after the death of their secretive grandmother.

\$81.3m

90% critics

69% audience

### Talk to Me

2023

DANNY AND MICHAEL PHILLIPPOU

When a group of friends discover how to conjure spirits using an embalmed hand, they become hooked on the new thrill, until one of them goes too far.

\$68.7m

94% critics

82% audience

### Moonlight

2016

BARRY JENKINS

An exploration of the life of a young black man from childhood to adulthood and the difficulties he faces growing up.

\$64.9m

98% critics

79% audience

### The Whale

2022

DARREN ARONOFSKY

A 600-pound (272 kg) middle-aged man tries to reconnect with his 17-year-old daughter.

\$40.9m

64% critics

91% audience

### Midsommar

2019

ARI ASTER

A group of friends travels to Sweden for a festival that occurs once every 90 years, only to find themselves in the clutches of a Scandinavian pagancult.

\$46.8m

### It Comes at Night

2017 TREY EDWARD SHULTS

A family hides in a forest as the Earth is taken over by a highly contagious disease.

\$19.7m

88% critics

44% audience

### X

2022 TI WEST

A production team filming a porno finds themselves in danger while staying in a secluded farmhouse in Texas.

\$15.1m

94% critics

### Room

2015

LENNY ABRAHAMSON

Held captive for several years, a young woman and her son manage to escape.

\$36.3m

93% critics

93% audience

### The Children Act

2018

RICHARD EYRE

A judge is given a case where a 17-year-old teenager suffering from leukemia refuses a blood transfusion because it goes against his religious beliefs.

\$14m

74% critics

62% audience

### The Florida Project

2017

SEAN BAKER

A 6-year-old girl lives with her unemployed single mother in a motel in Kissimmee, Florida, as they try to stay out of trouble and make ends meet.

\$11.3m

96% critics

80% audience

### 20th Century Women

2016

MIKE MILLS

A determined single mother in her mid-50s raises her adolescent son in 1970s Southern California.

\$9.4m

88% critics

74% audience

### A Most Violent Year

2014

J. C. CHANDOR

The life of an immigrant in 1981, where the streets of New York City are plagued

### Swiss Army Man

2016

DIR. KWAN AND DANIEL SCHAFFNER

A man stranded on an island tries to escape after becoming friends with a corpse that washes ashore.

\$5.8m

72% critics

### The Last Black Man in San Francisco

2019

JOE TALBOT

A young black man tries to reclaim his childhood home in a gentrified neighborhood of San Francisco.

\$4.2m

69% critics

### Remember

2015

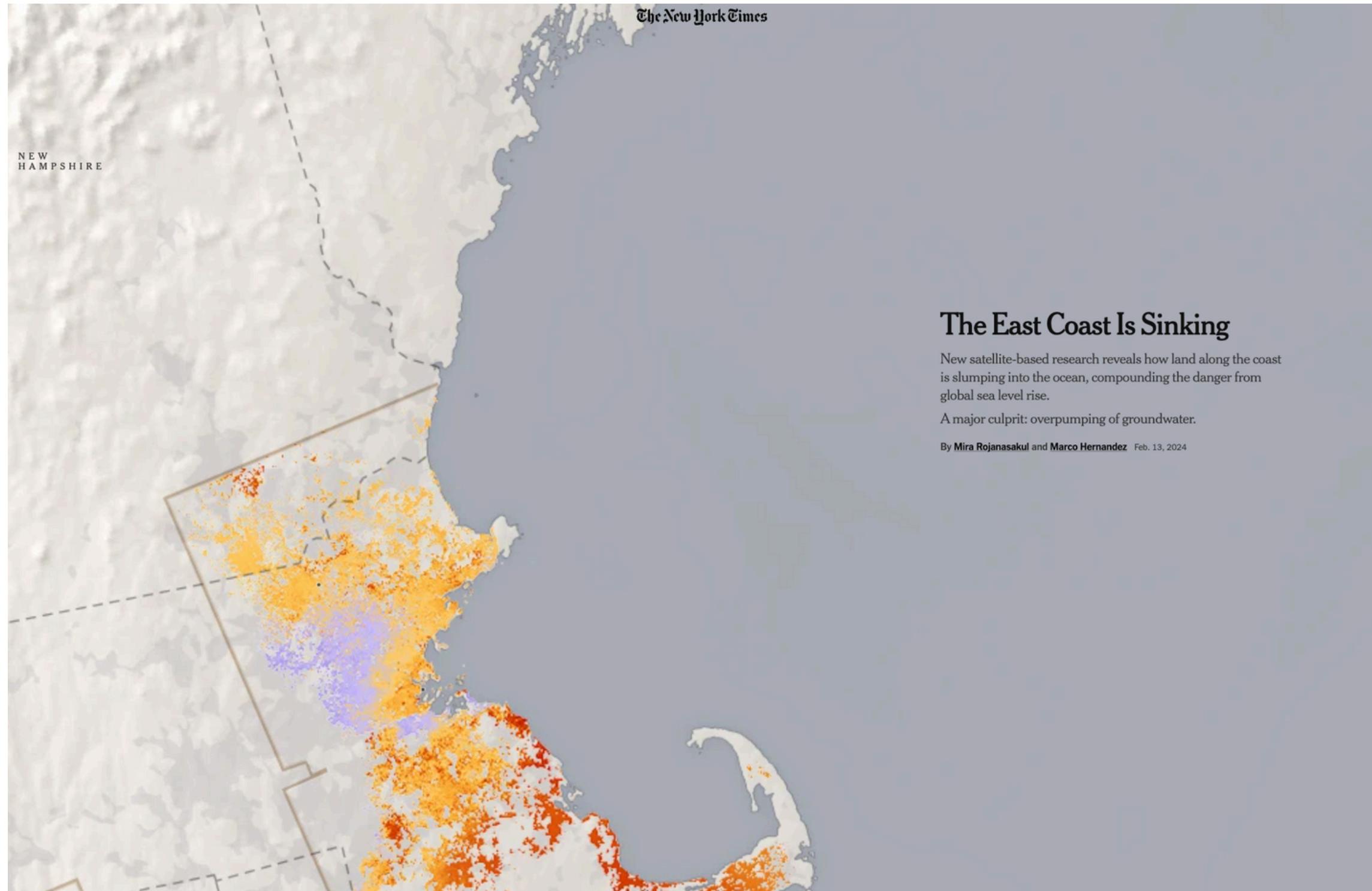
ATOM EGORYAN

A Holocaust survivor with dementia sets out to kill a Nazi war criminal.

\$4.2m

69% critics

# Present



[New York Times](#)

# Enjoy

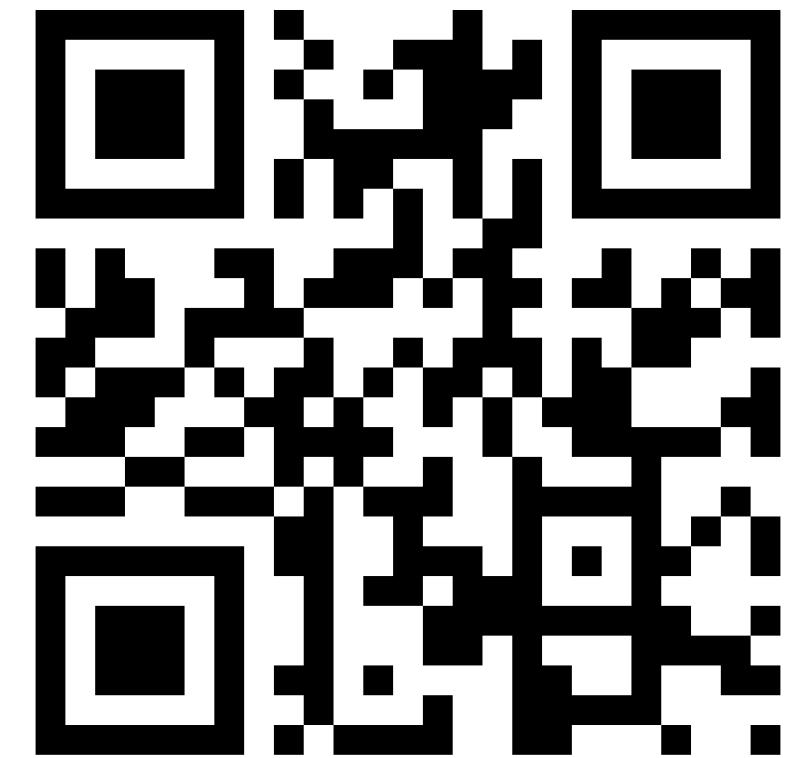
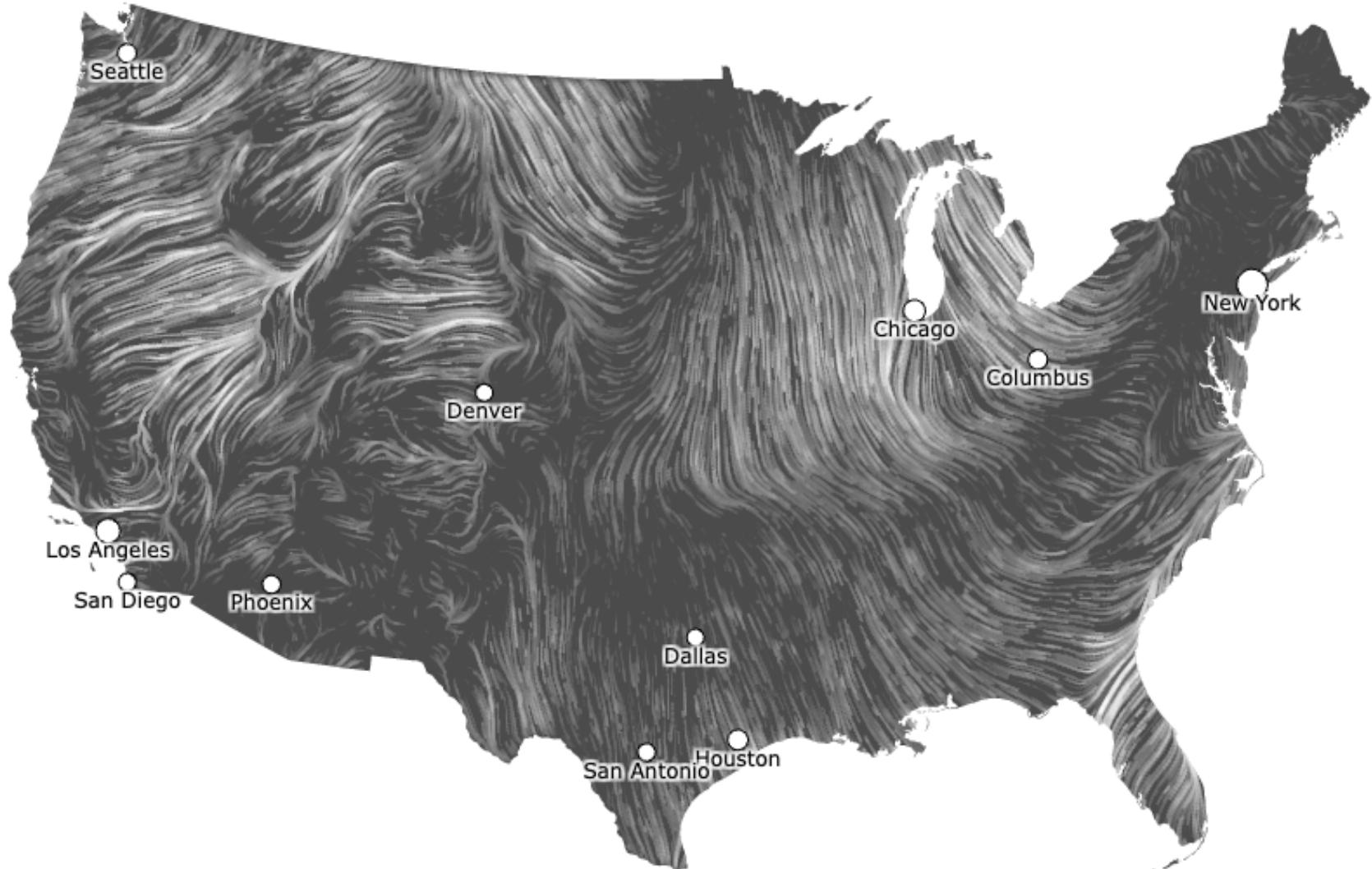
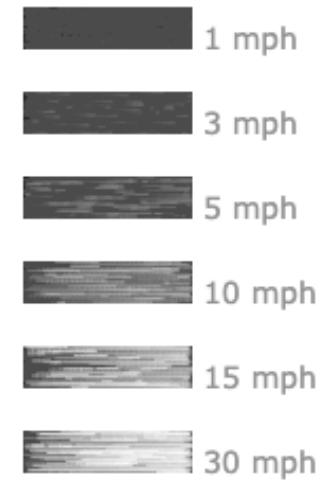
## wind map

**April 7, 2025**

5:11 pm EST

(time of forecast download)

top speed: **32.0 mph**  
average: **10.2 mph**



<http://hint.fm/wind/>

# Actions

High-Level: Analyze

→ Analyze

→ Consume

→ Discover

→ Present

→ Enjoy



→ Present



→ Enjoy



→ Produce

→ Annotate

→ Record

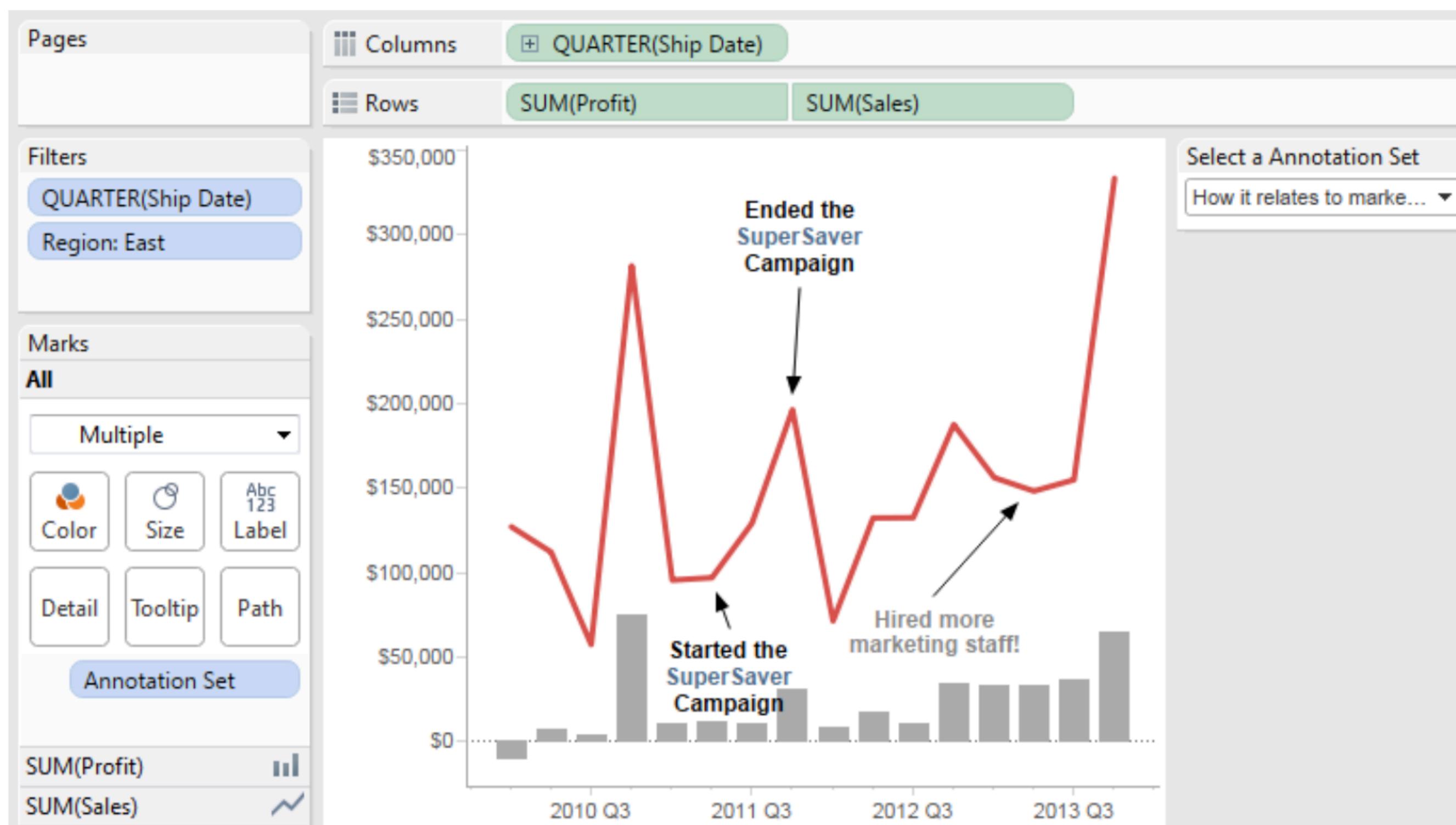
→ Derive



→ Search

→ Query

# Annotate



# Record

**Worksheet History**

**Filters:**

**Graphic Type:** All

**Bookmarks:**  Show Only

**Export** **Reset**

Add Inventory

Show Me!

Move Market Size to Columns

Add Product to Columns

**Central** Major Ma.. Small Mar..  
1,683,579 1,563,045

**East** 1,628,963 624,021

**South** 279,067 760,398

**West** 1,197,654 2,617,410

The screenshot displays a software interface for managing data and visualizations. On the left, a 'Worksheet History' panel includes sections for 'Filters', 'Graphic Type' (set to 'All'), and 'Bookmarks' with a 'Show Only' checkbox. Below these are 'Export' and 'Reset' buttons. To the right of the panel are four main components: 'Add Inventory' (a table with four rows), 'Show Me!' (a bar chart with varying heights), 'Move Market Size to Columns' (a bar chart with one very tall bar), and 'Add Product to Columns' (a line chart with a noisy trend). A small navigation bar at the bottom left contains icons for back, forward, and search.

# Actions

## → Analyze

### → Consume

→ Discover



→ Present



→ Enjoy



### → Produce

→ Annotate



→ Record



→ Derive



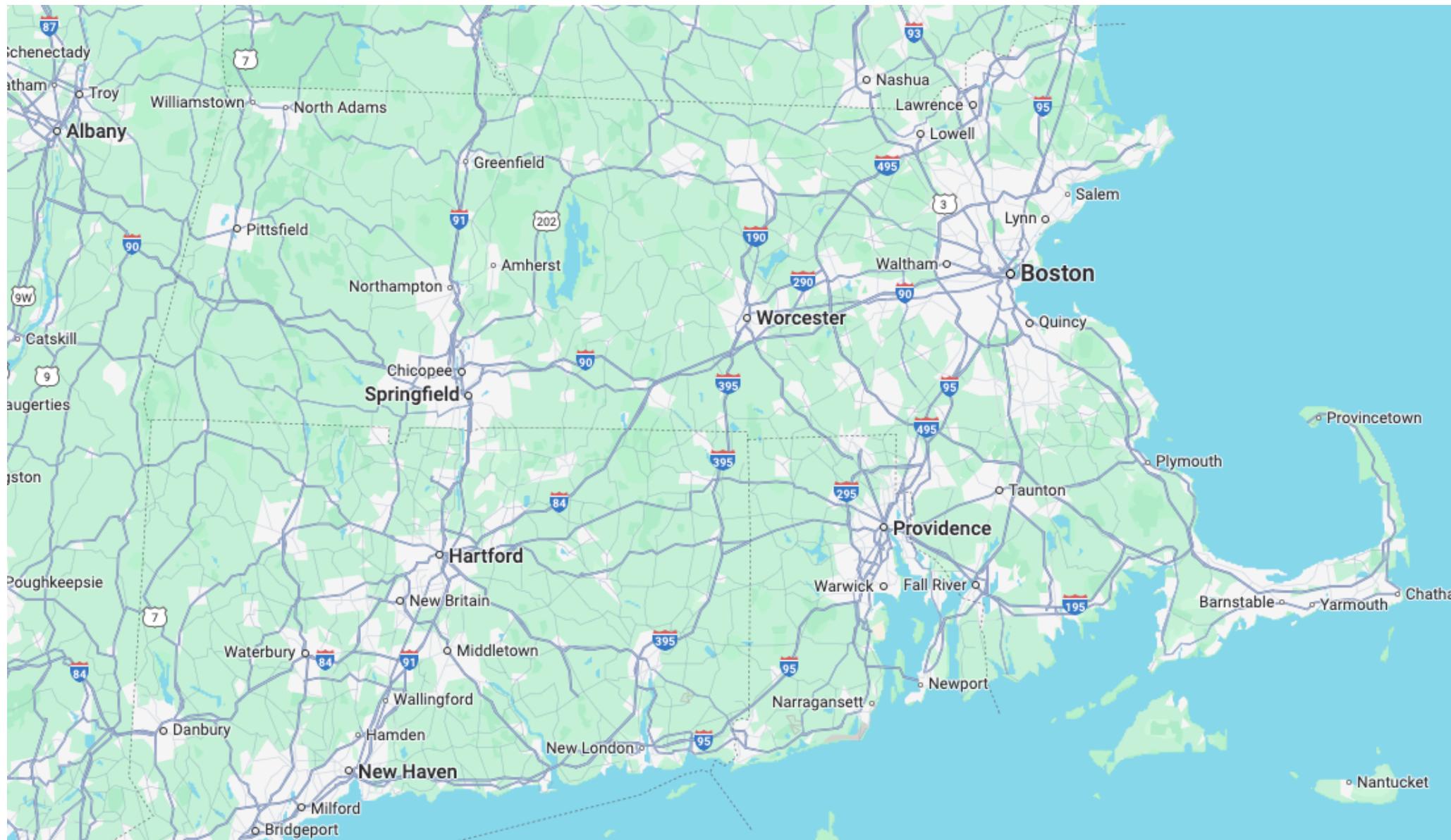
# Mid-Level: Search

## → Search

|                  | Target known        | Target unknown       |
|------------------|---------------------|----------------------|
| Location known   | ••• <i>Lookup</i>   | ••• <i>Browse</i>    |
| Location unknown | ◁•••▷ <i>Locate</i> | ◁•••▷ <i>Explore</i> |

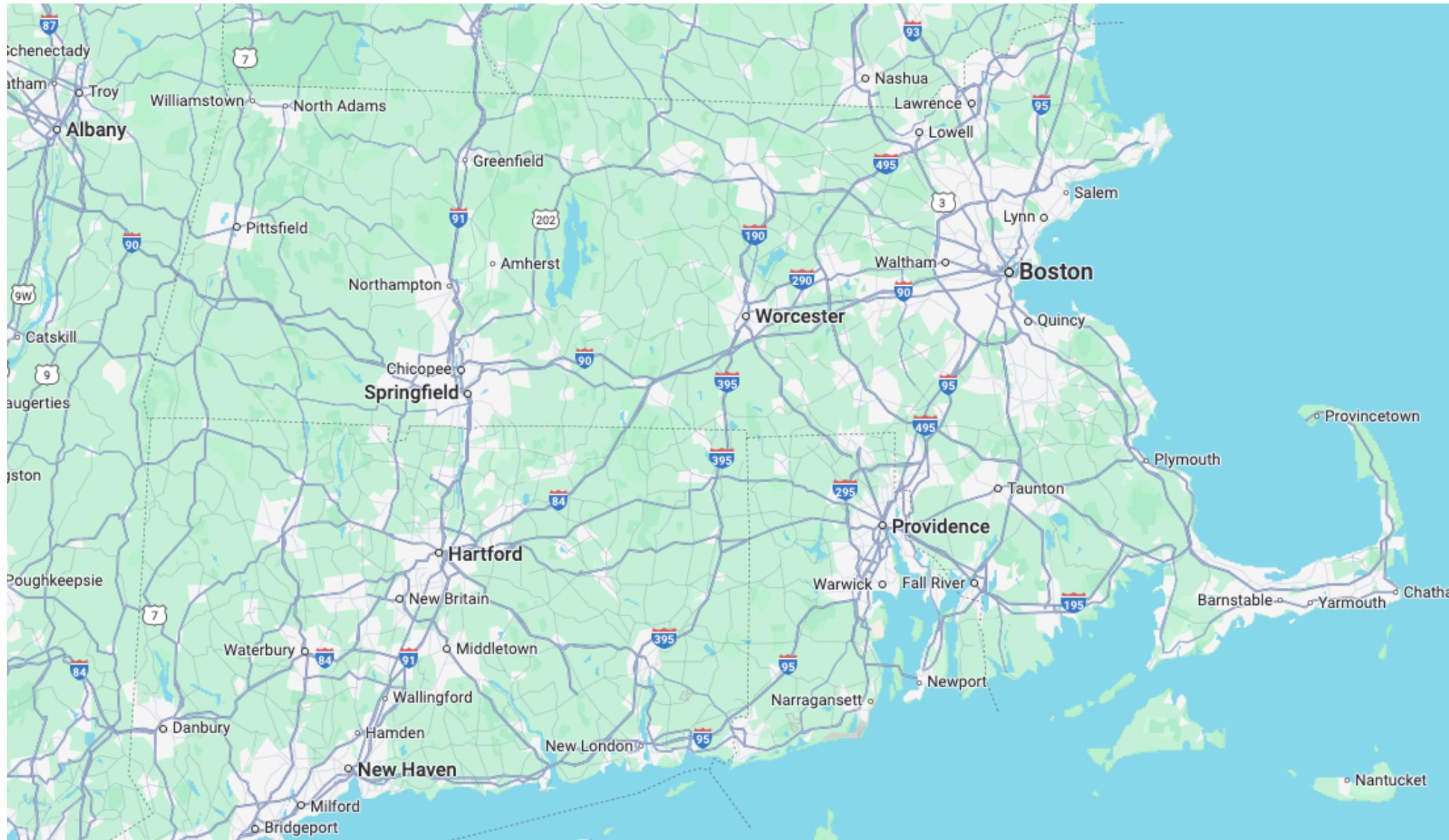
## → Query

# Search



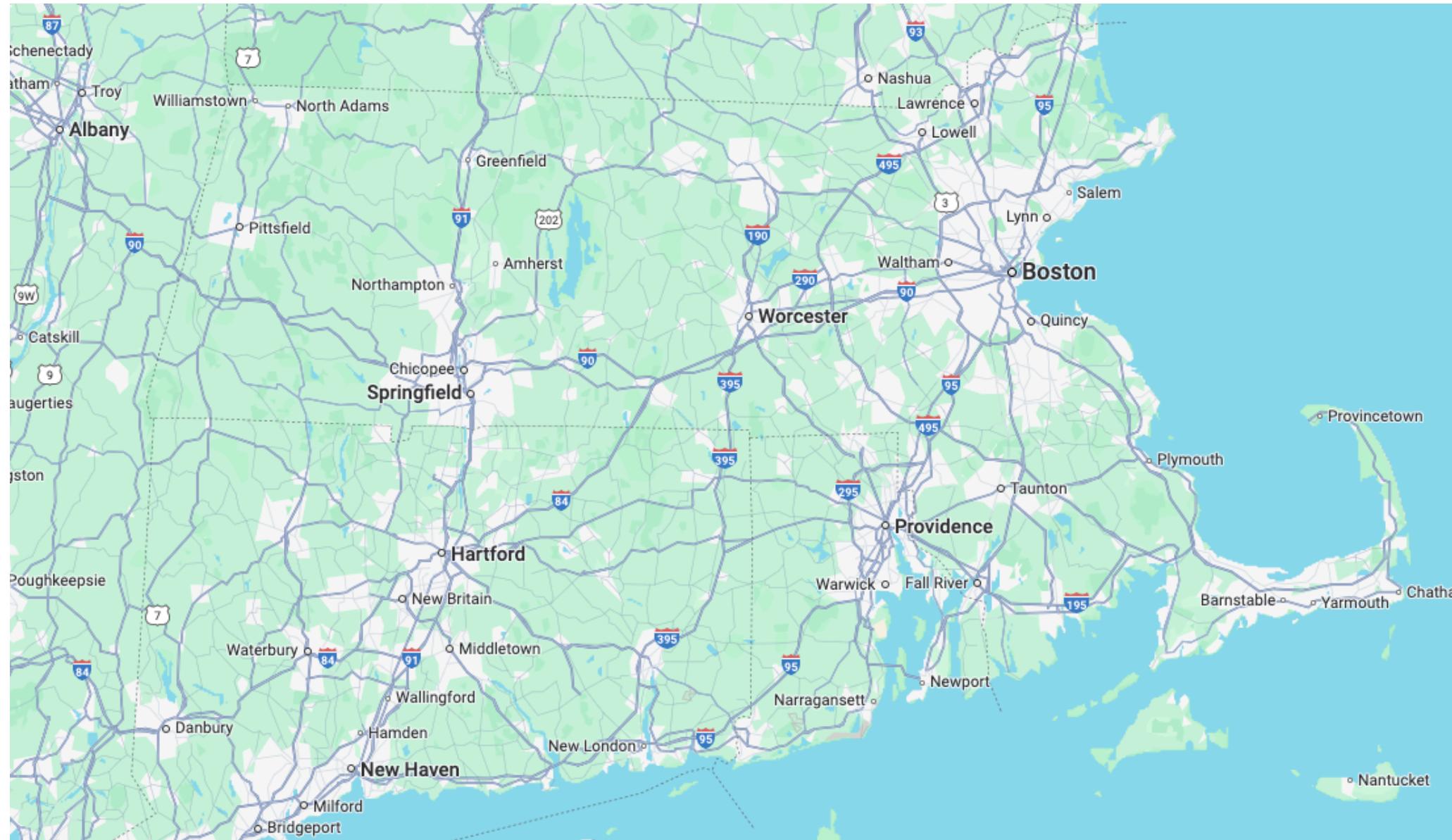
Google Maps

# Search: Lookup



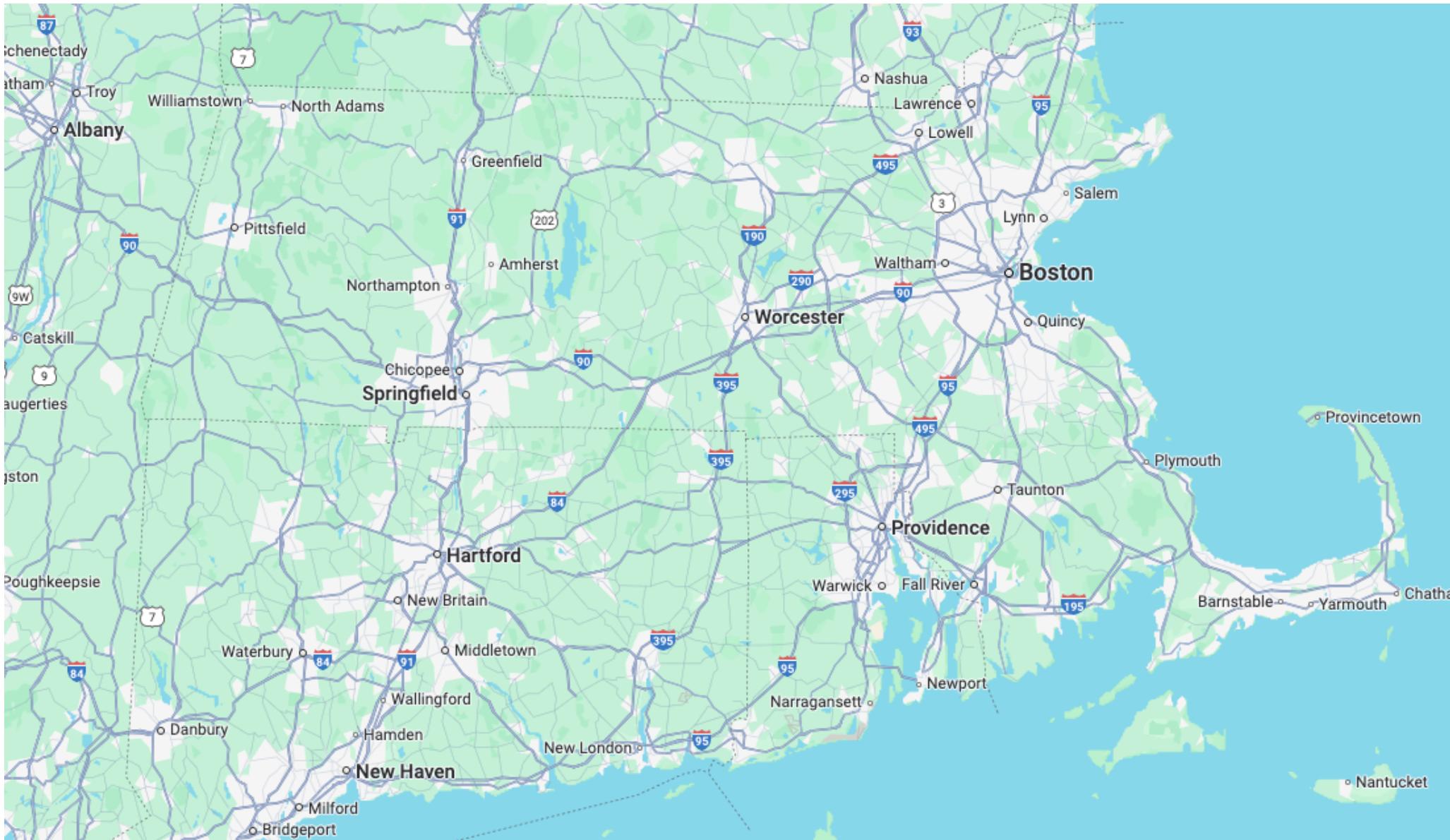
# Location Known, Target Known

# Search: Locate



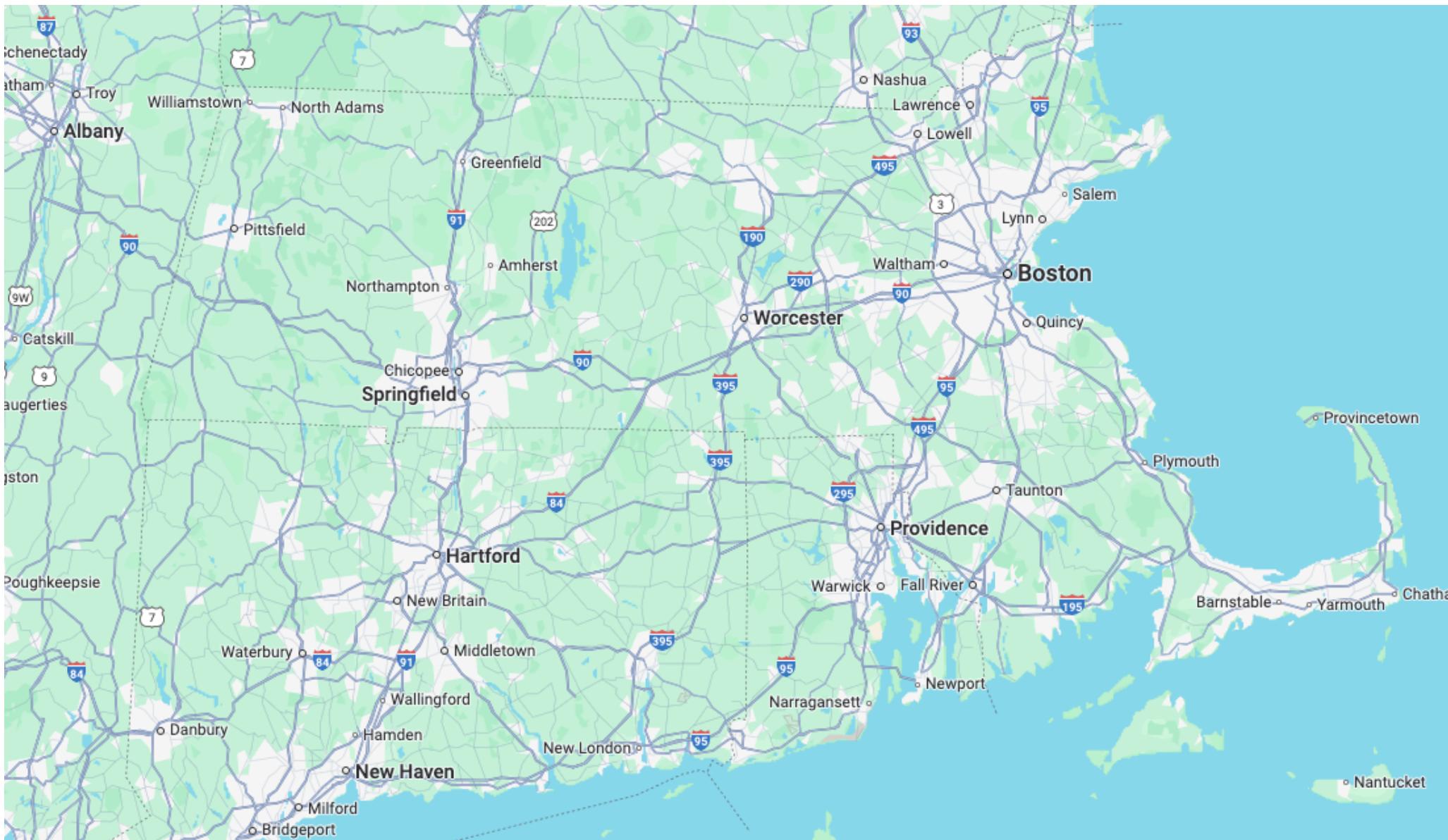
Location Unknown, Target Known

# Search: Browse



Location Known, Target Unknown

# Search: Explore



Location Unknown, Target Unknown

# Actions

→ Analyze

→ Consume

→ Discover

→ Present

→ Enjoy



→ Present



→ Enjoy



→ Produce

→ Annotate

→ Record

→ Derive



## Low-Level: Query

→ Search

|                  | Target known        | Target unknown       |
|------------------|---------------------|----------------------|
| Location known   | ••• <i>Lookup</i>   | ••• <i>Browse</i>    |
| Location unknown | <•••> <i>Locate</i> | <•••> <i>Explore</i> |

→ Query

→ Identify

→ Compare

→ Summarize



# Identify

## A24 Movie Browser

SIZE: WORLDWIDE GROSS (\$M)

FILTER: RT % CRITICS ▾

ACTION COMEDY DRAMA HORROR OTHER ROMANCE THRILLER WESTERN

search...

### Hereditary

2018

ARI ASTER

A family is haunted by an evil presence after the death of their secretive grandmother.

\$81.3m

90% critics

69% audience

### Talk to Me

2023

DANNY AND MICHAEL PHILLIPPOU

When a group of friends discover how to conjure spirits using an embalmed hand, they become hooked on the new thrill, until one of them goes too far.

\$68.7m

94% critics

82% audience

### Moonlight

2016

BARRY JENKINS

An exploration of the life of a young black man from childhood to adulthood and the difficulties he faces growing up.

\$64.9m

98% critics

79% audience

### The Whale

2022

DARREN ARONOFSKY

A 600-pound (272 kg) middle-aged man tries to reconnect with his 17-year-old daughter.

\$40.9m

64% critics

91% audience

### Midsommar

2019

ARI ASTER

A group of friends travels to Sweden for a festival that occurs once every 90 years, only to find themselves in the clutches of a Scandinavian pagancult.

\$46.8m

### It Comes at Night

2017

TREY EDWARD SHULTS

A family hides in a forest as the Earth is taken over by a highly contagious disease.

\$19.7m

88% critics

44% audience

### X

2022

TI WEST

A production team filming a porno finds themselves in danger while staying in a secluded farmhouse in Texas.

\$15.1m

94% critics

### Room

2015

LENNY ABRAHAMSON

Held captive for several years, a young woman and her son manage to escape.

\$36.3m

93% critics

93% audience

### The Children Act

2018

RICHARD EYRE

A judge is given a case where a 17-year-old teenager suffering from leukemia refuses a blood transfusion because it goes against his religious beliefs.

\$14m

74% critics

62% audience

### The Florida Project

2017

SEAN BAKER

A 6-year-old girl lives with her unemployed single mother in a motel in Kissimmee, Florida, as they try to stay out of trouble and make ends meet.

\$11.3m

96% critics

80% audience

### 20th Century Women

2016

MIKE MILLS

A determined single mother in her mid-50s raises her adolescent son in 1970s Southern California.

\$9.4m

88% critics

74% audience

### A Most Violent Year

2014

J. C. CHANDOR

The life of an immigrant in 1981, where the streets of New York City are violent.

\$5.8m

72% critics

### Swiss Army Man

2016

DAN KWAN AND DANIEL SCHENK

A man stranded on an island tries to escape by becoming friends with a corpse that washes ashore.

\$5.8m

72% critics

### The Last Black Man in San Francisco

2021

JOE TALBOT

A young black man tries to reclaim his childhood home in a gentrified neighborhood of San Francisco.

\$4.2m

69% critics

What was the critics score for “Hereditary”?

# Compare

## A24 Movie Browser

SIZE: WORLDWIDE GROSS (\$M)

FILTER: RT % CRITICS ▾

ACTION COMEDY DRAMA HORROR OTHER ROMANCE THRILLER WESTERN

search...

### Hereditary

2018

ARI ASTER

A family is haunted by an evil presence after the death of their secretive grandmother.

\$81.3m

90% critics

69% audience

### Talk to Me

2023

DANNY AND MICHAEL PHILLIPPOU

When a group of friends discover how to conjure spirits using an embalmed hand, they become hooked on the new thrill, until one of them goes too far.

\$68.7m

94% critics

82% audience

### Moonlight

2016

BARRY JENKINS

An exploration of the life of a young black man from childhood to adulthood and the difficulties he faces growing up.

\$64.9m

98% critics

79% audience

### The Whale

2022

DARREN ARONOFSKY

A 600-pound (272 kg) middle-aged man tries to reconnect with his 17-year-old daughter.

\$40.9m

64% critics

91% audience

### Midsommar

2019

ARI ASTER

A group of friends travels to Sweden for a festival that occurs once every 90 years, only to find themselves in the clutches of a Scandinavian pagancult.

\$46.8m

### It Comes at Night

2017

TREY EDWARD SHULTS

A family hides in a forest as the Earth is taken over by a highly contagious disease.

\$19.7m

88% critics

44% audience

### X

2022

TI WEST

A production team filming a porno finds themselves in danger while staying in a secluded farmhouse in Texas.

\$15.1m

94% critics

### Room

2015

LENNY ABRAHAMSON

Held captive for several years, a young woman and her son manage to escape.

\$36.3m

93% critics

93% audience

### The Children Act

2018

RICHARD EYRE

A judge is given a case where a 17-year-old teenager suffering from leukemia refuses a blood transfusion because it goes against his religious beliefs.

\$14m

74% critics

62% audience

### The Florida Project

2017

SEAN BAKER

A 6-year-old girl lives with her unemployed single mother in a motel in Kissimmee, Florida, as they try to stay out of trouble and make ends meet.

\$11.3m

96% critics

80% audience

### 20th Century Women

2016

MIKE MILLS

A determined single mother in her mid-50s raises her adolescent son in 1970s Southern California.

\$9.4m

88% critics

74% audience

### A Most Violent Year

2014

J. C. CHANDOR

The life of an immigrant in 1981, where the streets of New York City are violent.

\$5.8m

72% critics

### Swiss Army Man

2016

DAN KWAN AND DANIEL SCHENK

A man stranded on an island tries to escape by becoming friends with a corpse that washes ashore.

\$5.8m

72% critics

### The Last Black Man in San Francisco

2021

JOE TALBOT

A young black man tries to reclaim his childhood home in a gentrified neighborhood of San Francisco.

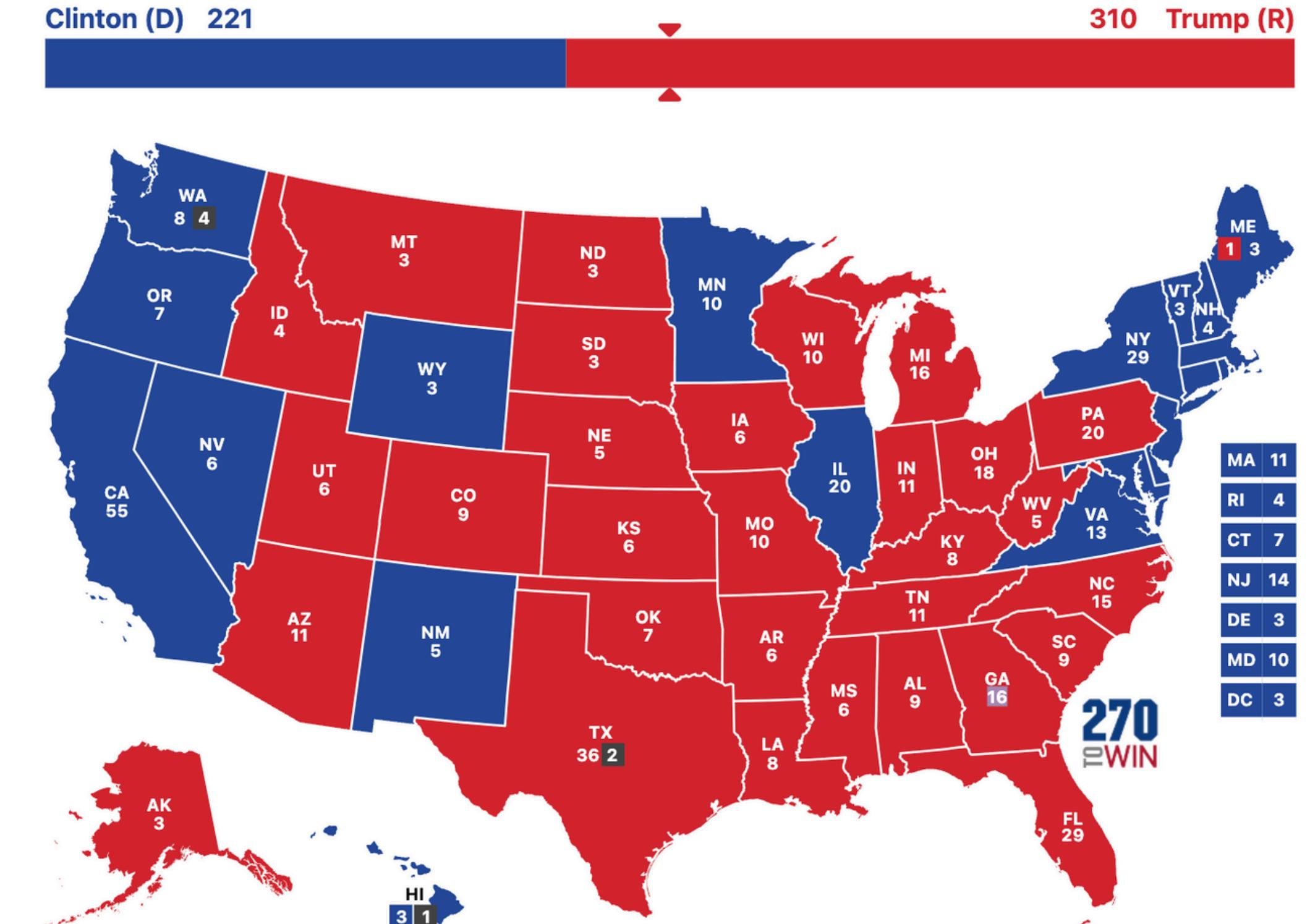
\$4.2m

69% critics

Did “Talk to Me” or “Room” make more money?

# Summarize

What were the results of the 2016 election by state?

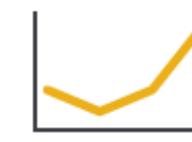


# Targets

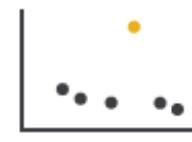
# Targets

→ All Data

→ Trends



→ Outliers



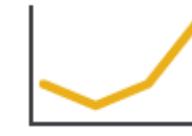
→ Features



# Targets

→ All Data

→ Trends



→ Outliers



→ Features



→ Attributes

→ One



→ Distribution

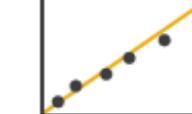


→ Extremes

→ Many



→ Dependency



→ Correlation

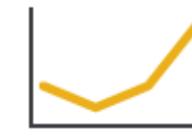


→ Similarity

# Targets

## → All Data

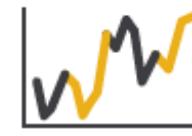
→ Trends



→ Outliers



→ Features

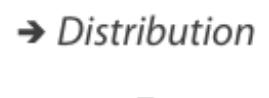


## → Attributes

→ One



→ Many



→ Distribution

→ Dependency

→ Correlation

→ Similarity



→ Extremes



## → Network Data

→ Topology



→ Paths



## → Spatial Data

→ Shape



# Interactions

We often have large data that can't be shown all at once

Interactions can help reduce the complexity of our visualizations

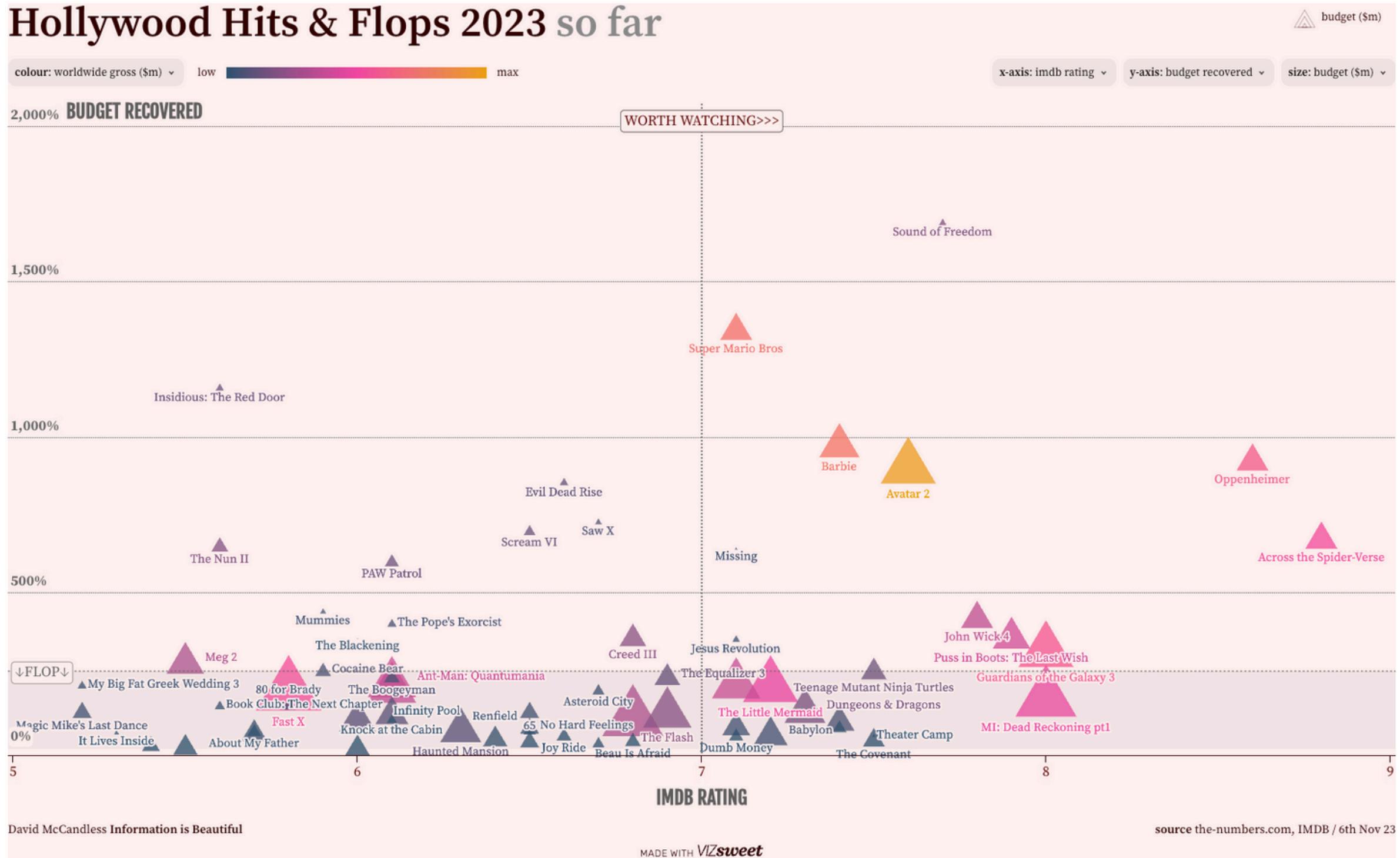
6 types of interactions:

- Change view over time
- Rearrange (Change encodings / attributes)
- Selection and Highlighting
- Linking
- Filtering
- Navigation

# **Change View Over Time**

# Animated Transitions

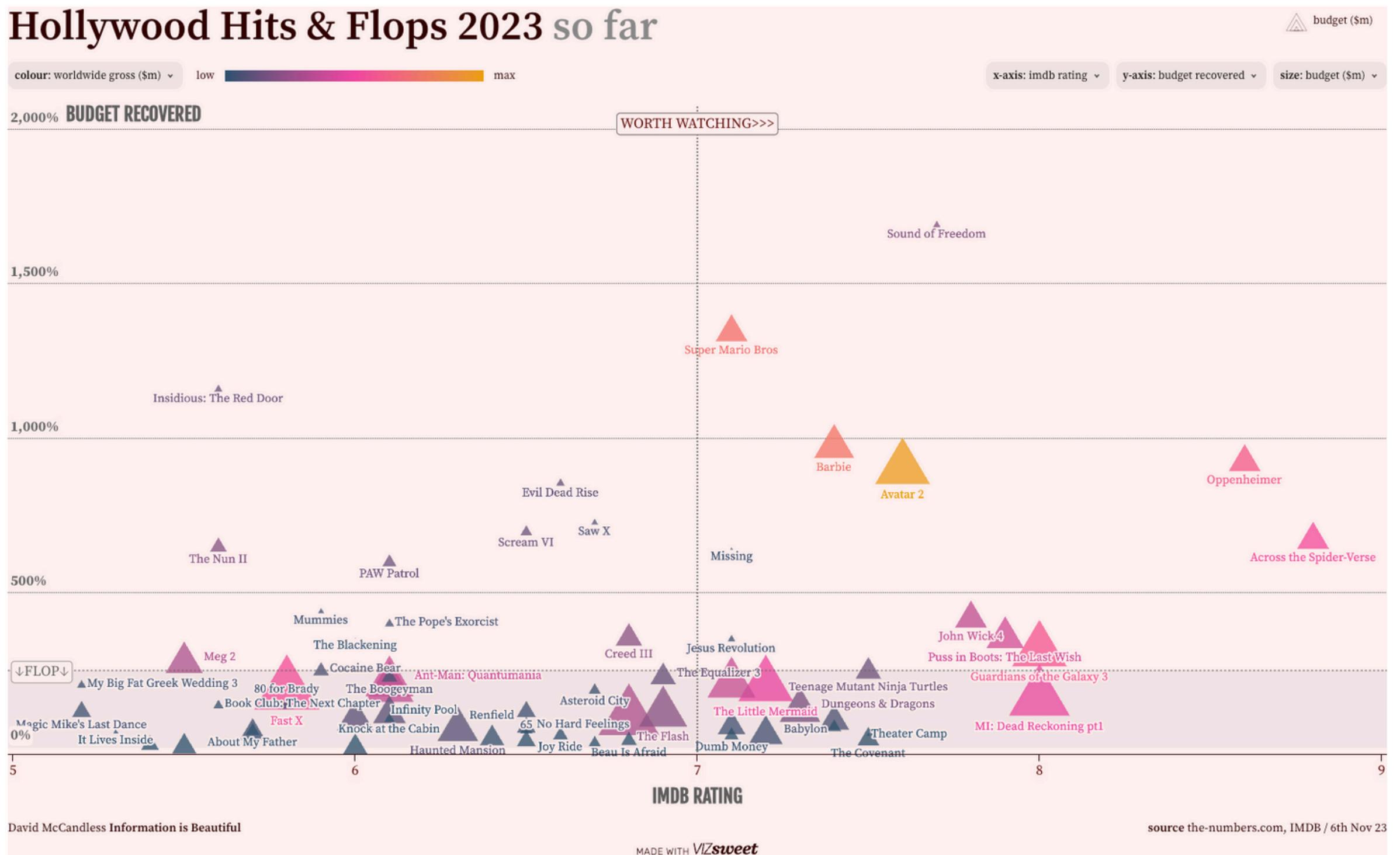
## Hollywood Hits & Flops 2023 so far



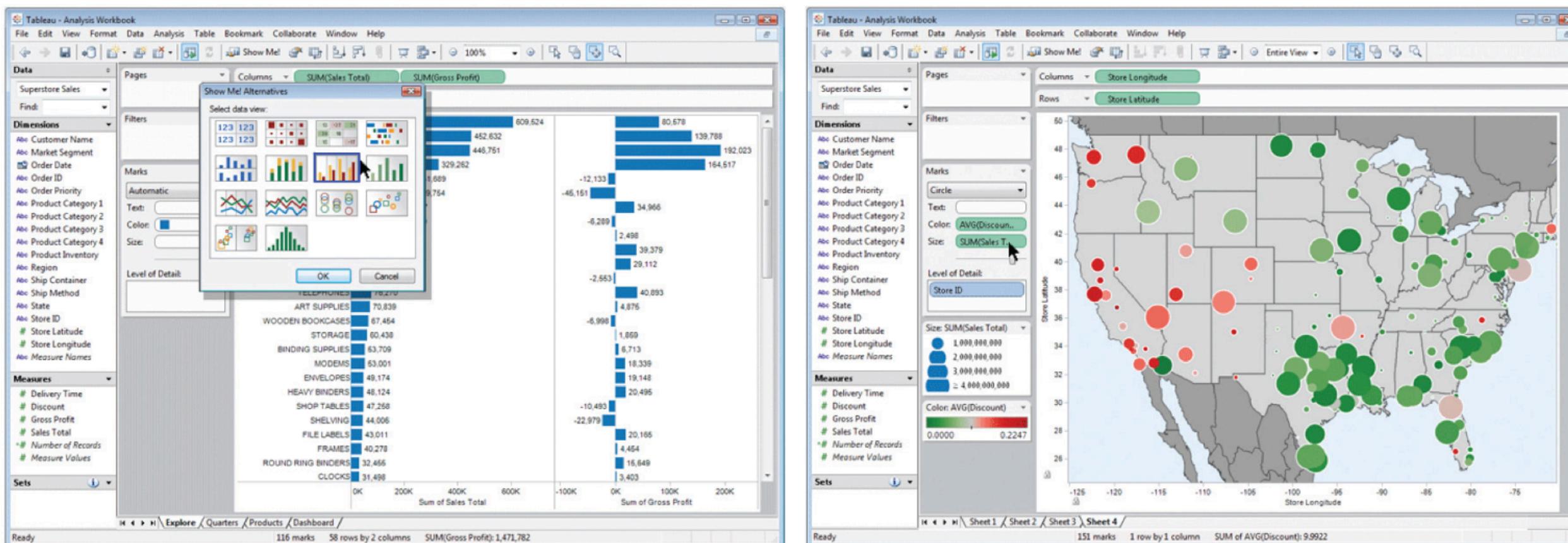
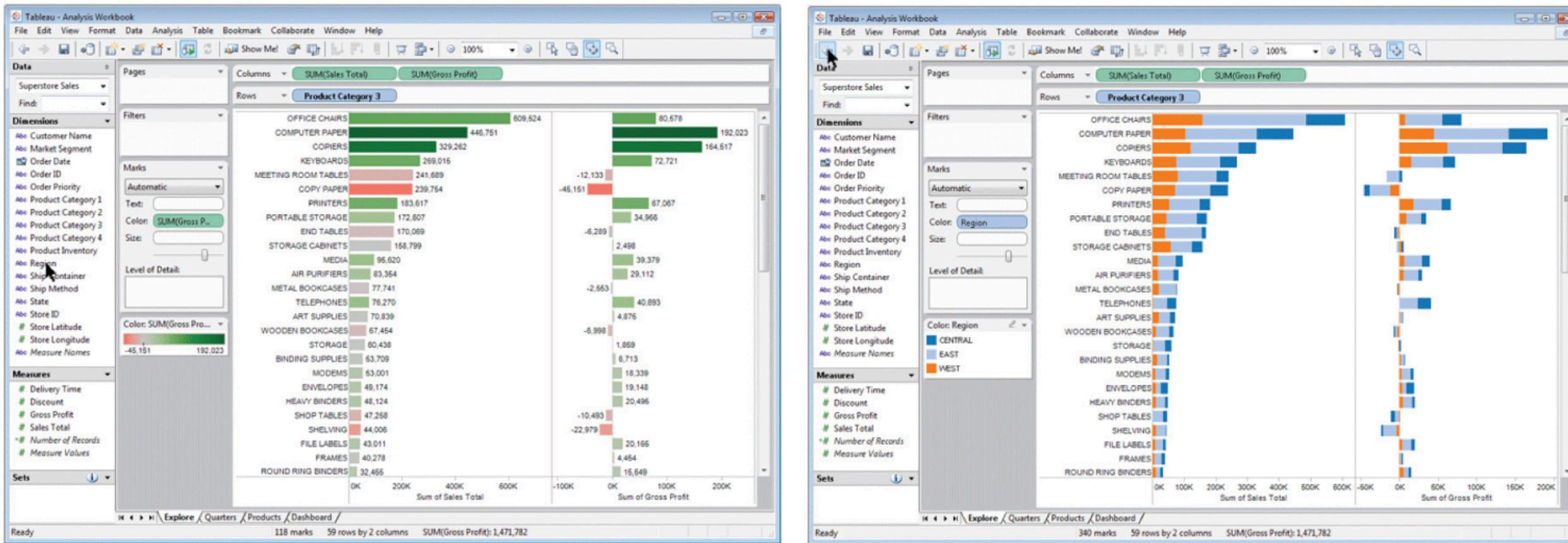
Hollywood Hits and Flops

# Rearrange

# Rearrange

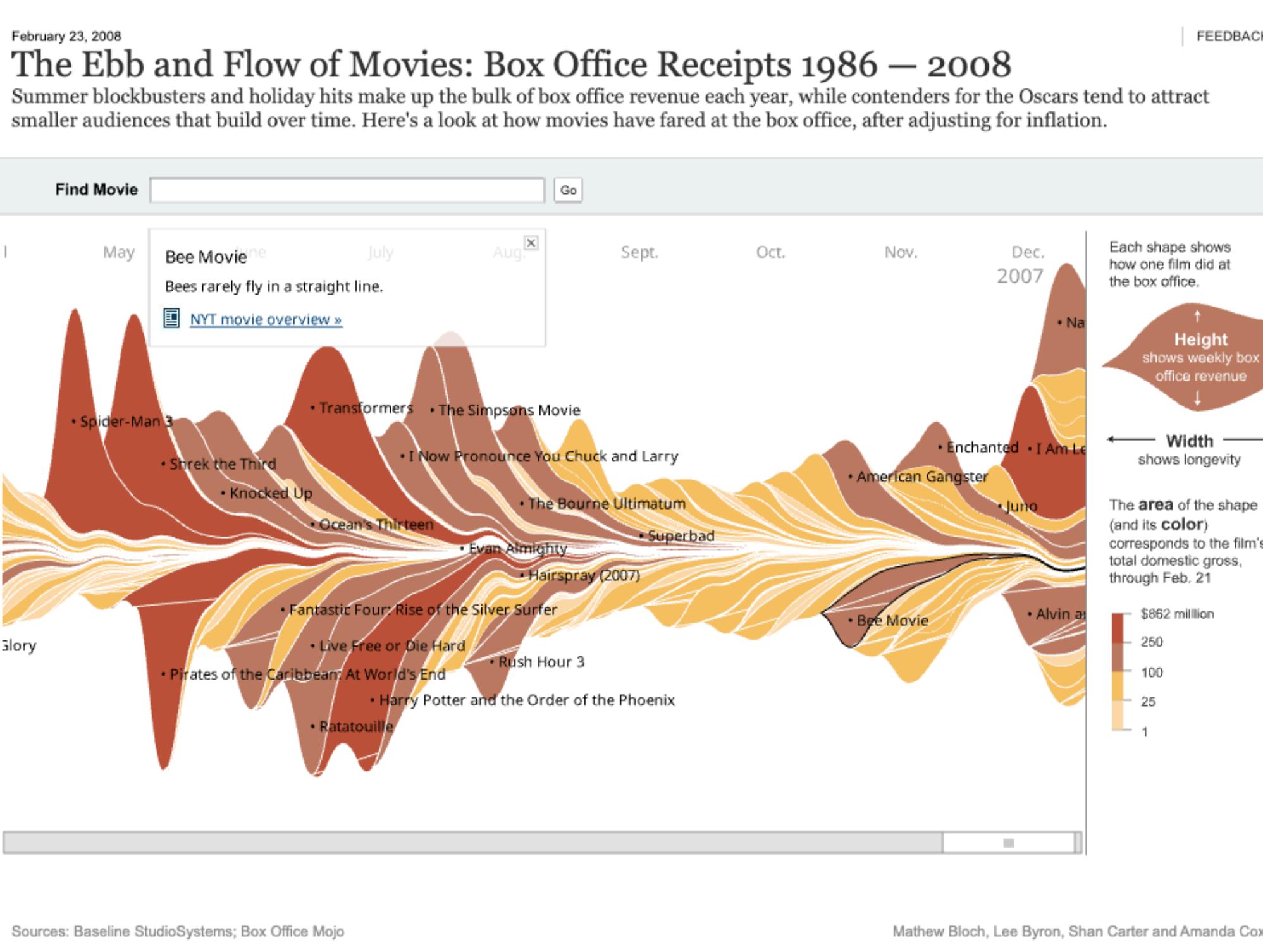


# Hollywood Hits and Flops



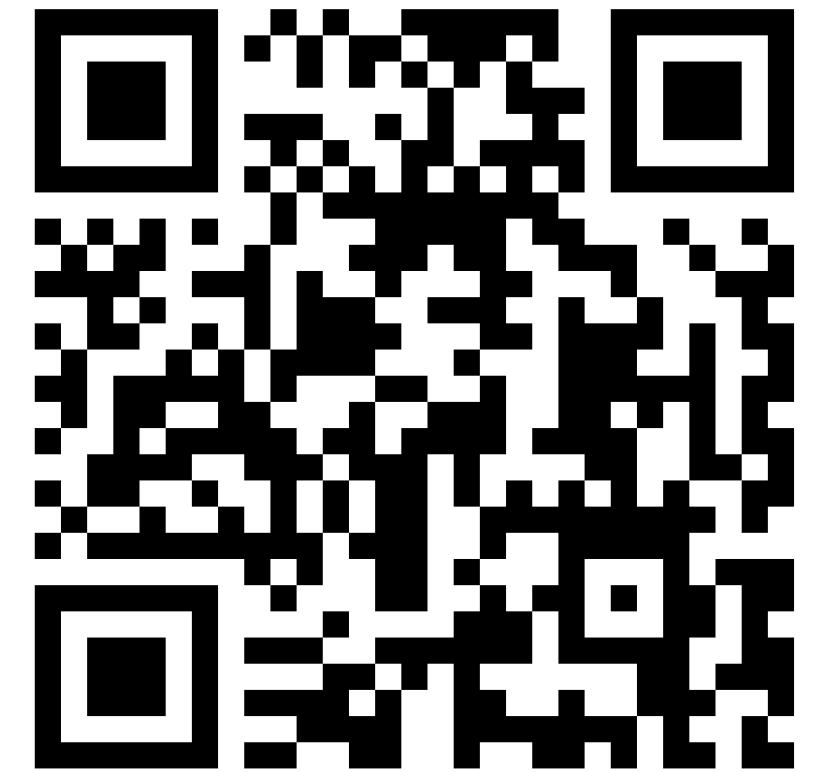
# Select and Highlight

# Select and Highlight



Stream Graph with Selection

# Select and Highlight



[https://sharadbhat.github.io/  
Formula-1-VRD/](https://sharadbhat.github.io/Formula-1-VRD/)

# Select and Highlight - Decision Considerations

What buttons/actions can be used to select?

- left click, right click, hover
- tap, press and hold, double tap

How many items can be selected?

- one? many?
- spatially contiguous only?
- multiple passes?

What does selecting do?

- just highlight?
- filter? rearrange? link?

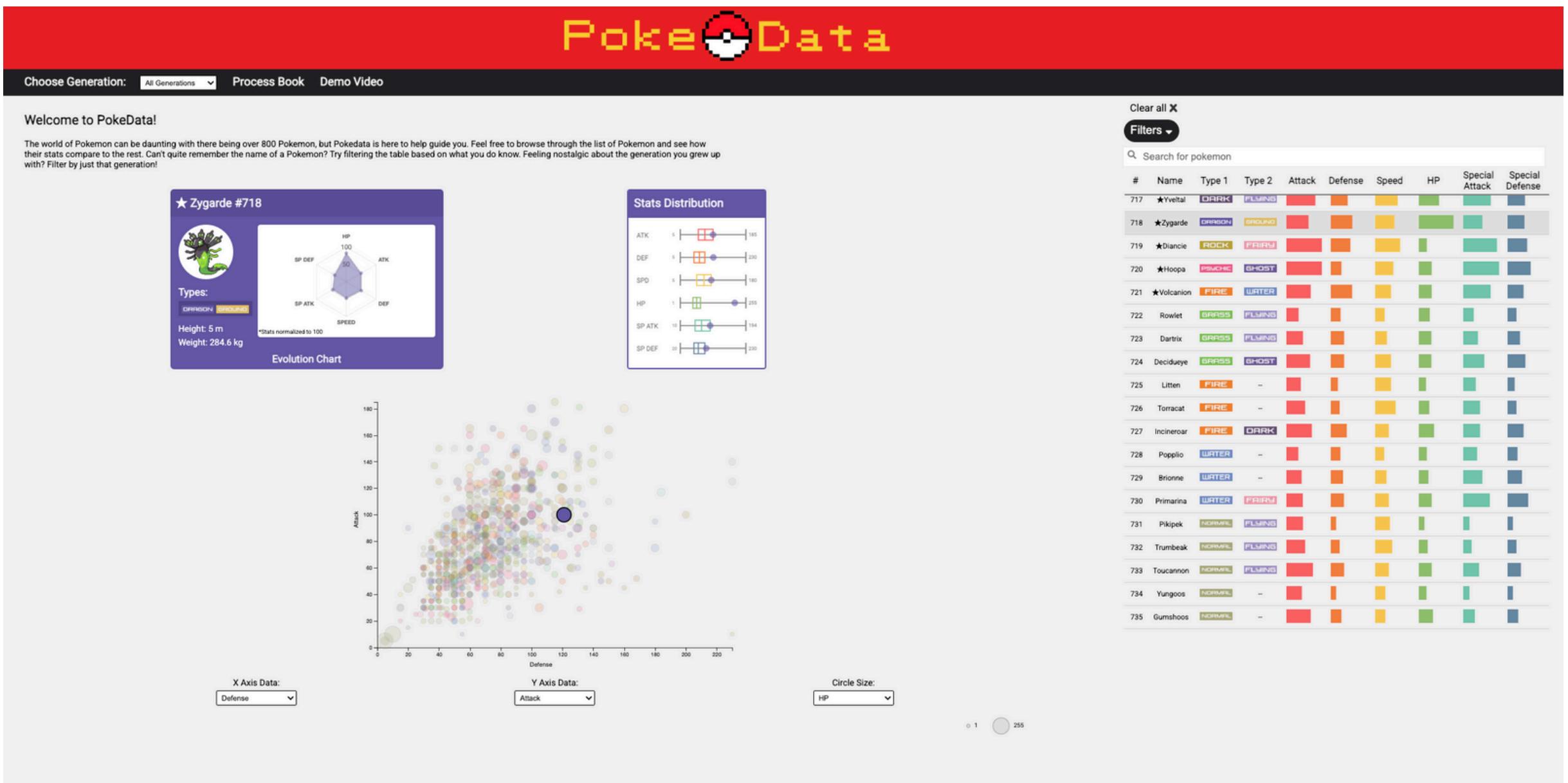
# Linking

# Linking



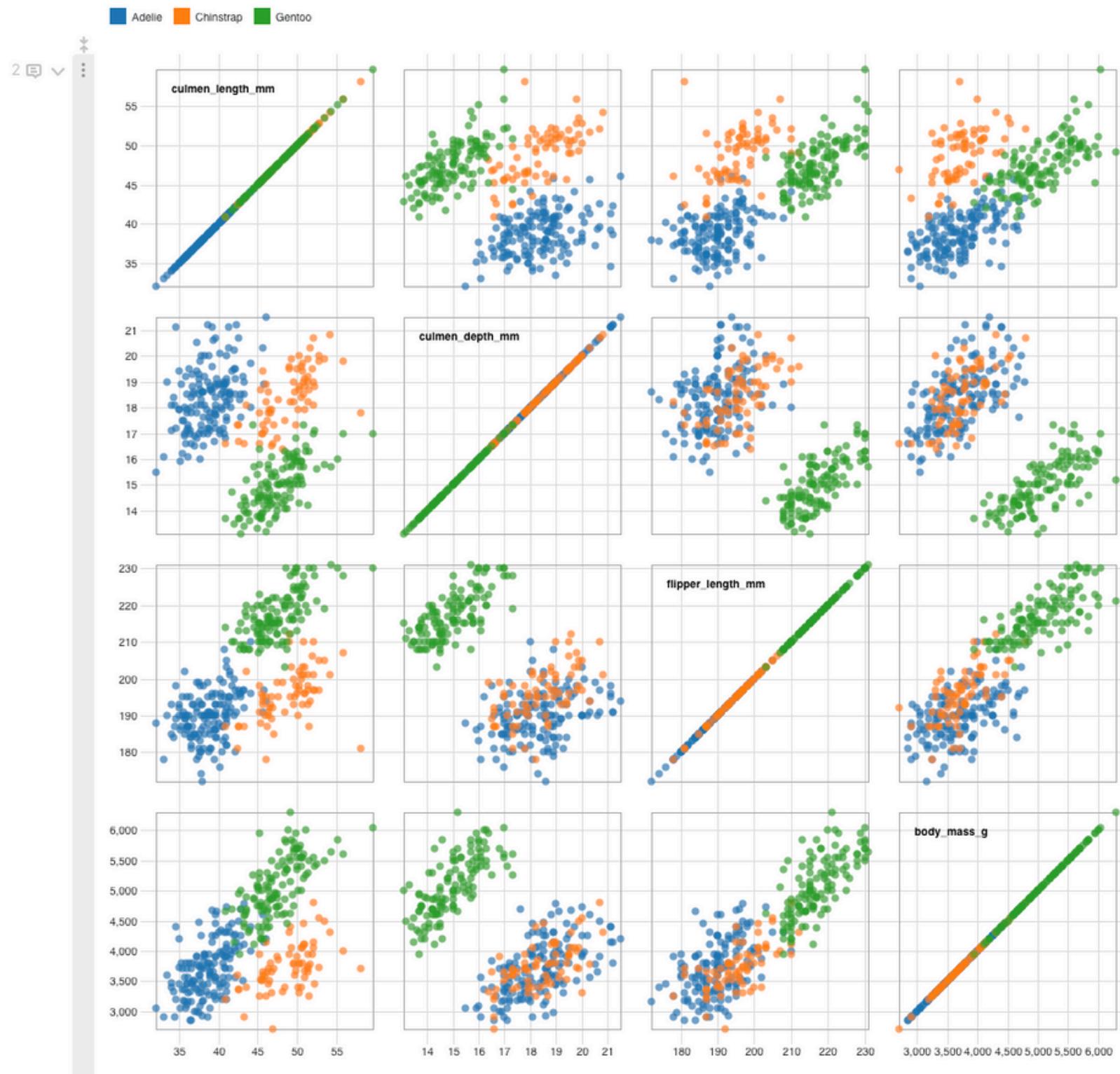
[https://sharadbhat.github.io/  
Formula-1-VRD/](https://sharadbhat.github.io/Formula-1-VRD/)

# Linking



[https://sunsiu.github.io/  
poke-data/](https://sunsiu.github.io/poke-data/)

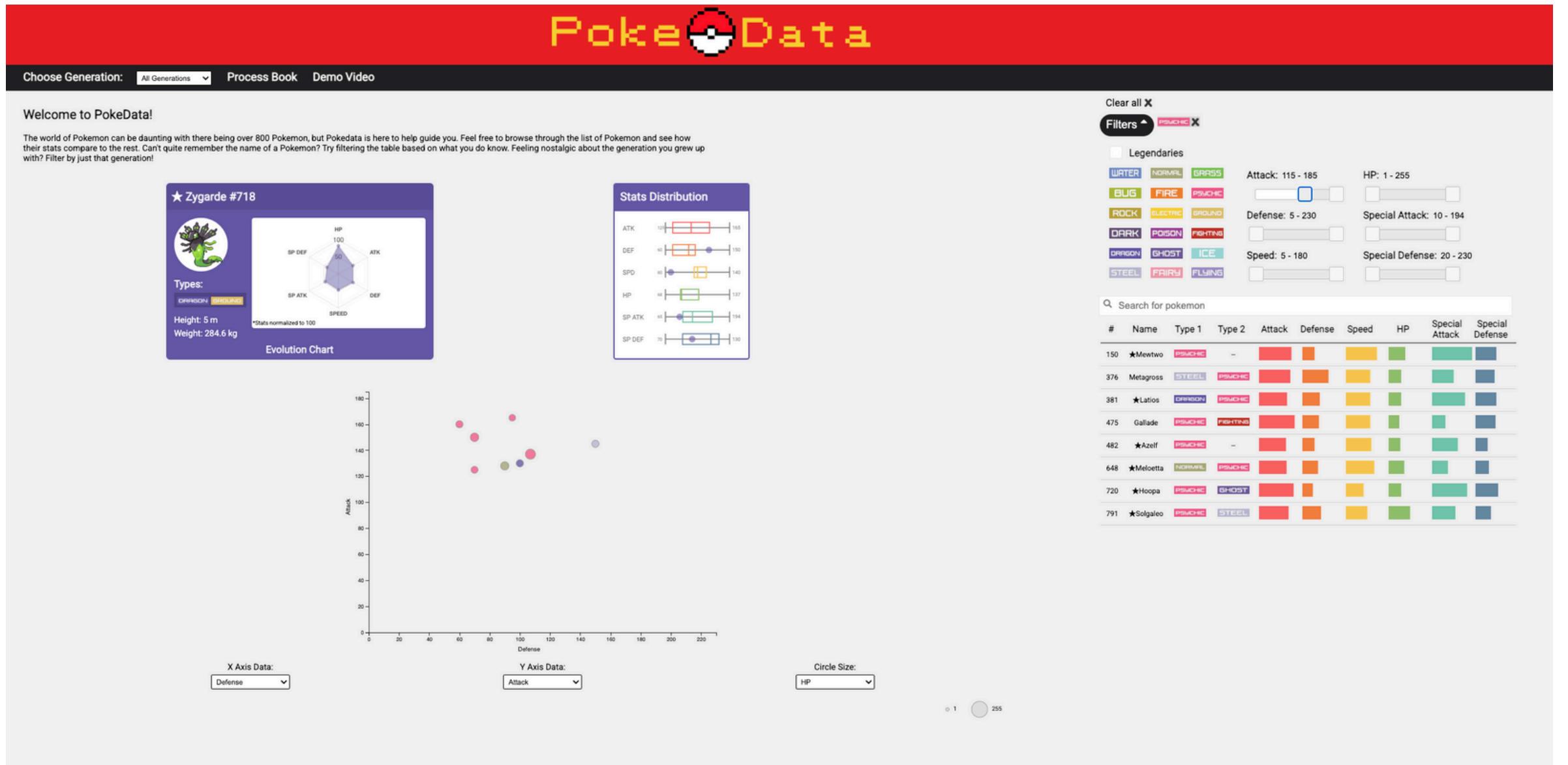
# Linking



Brush and Link Scatterplot Matrix

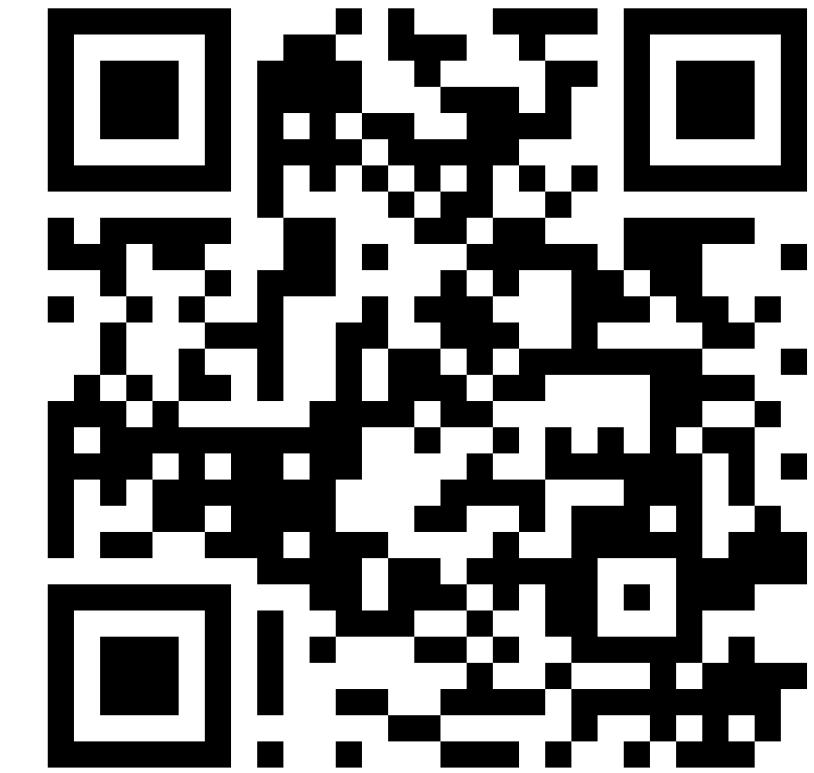
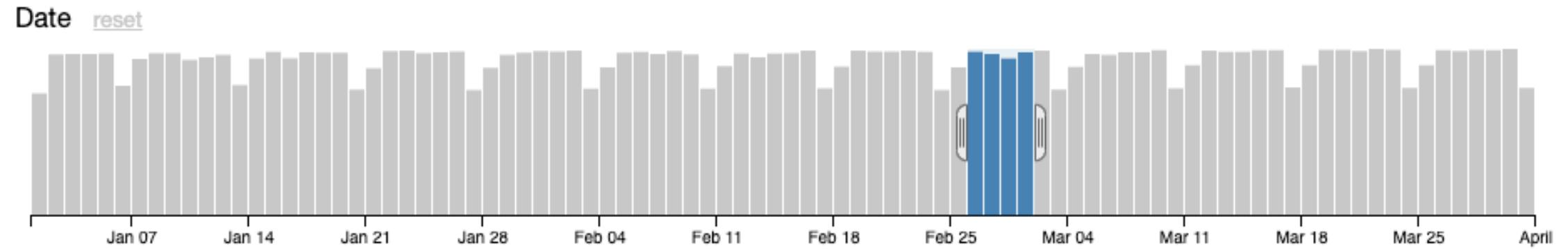
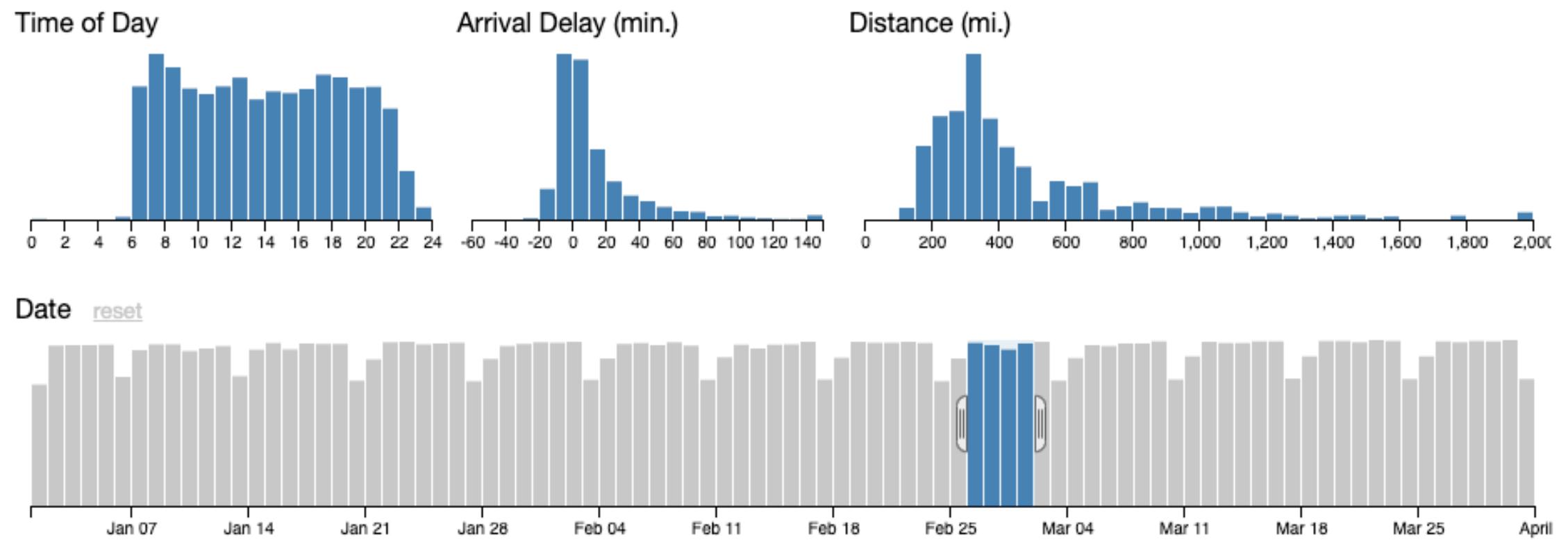
# Filtering

# Filtering



[https://sunsiu.github.io/  
poke-data/](https://sunsiu.github.io/poke-data/)

# Filtering

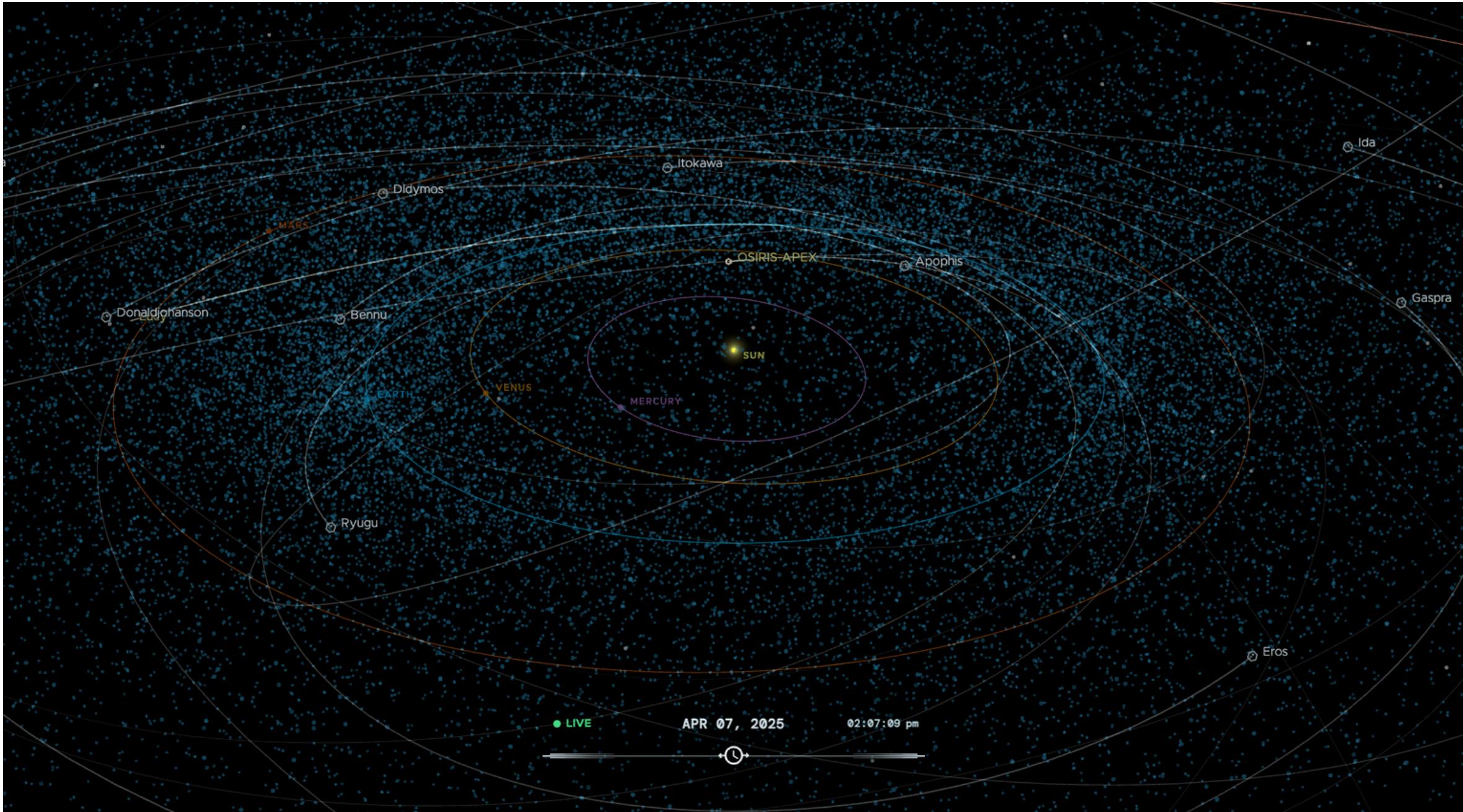


[CrossFilter Library](#)

# Navigation

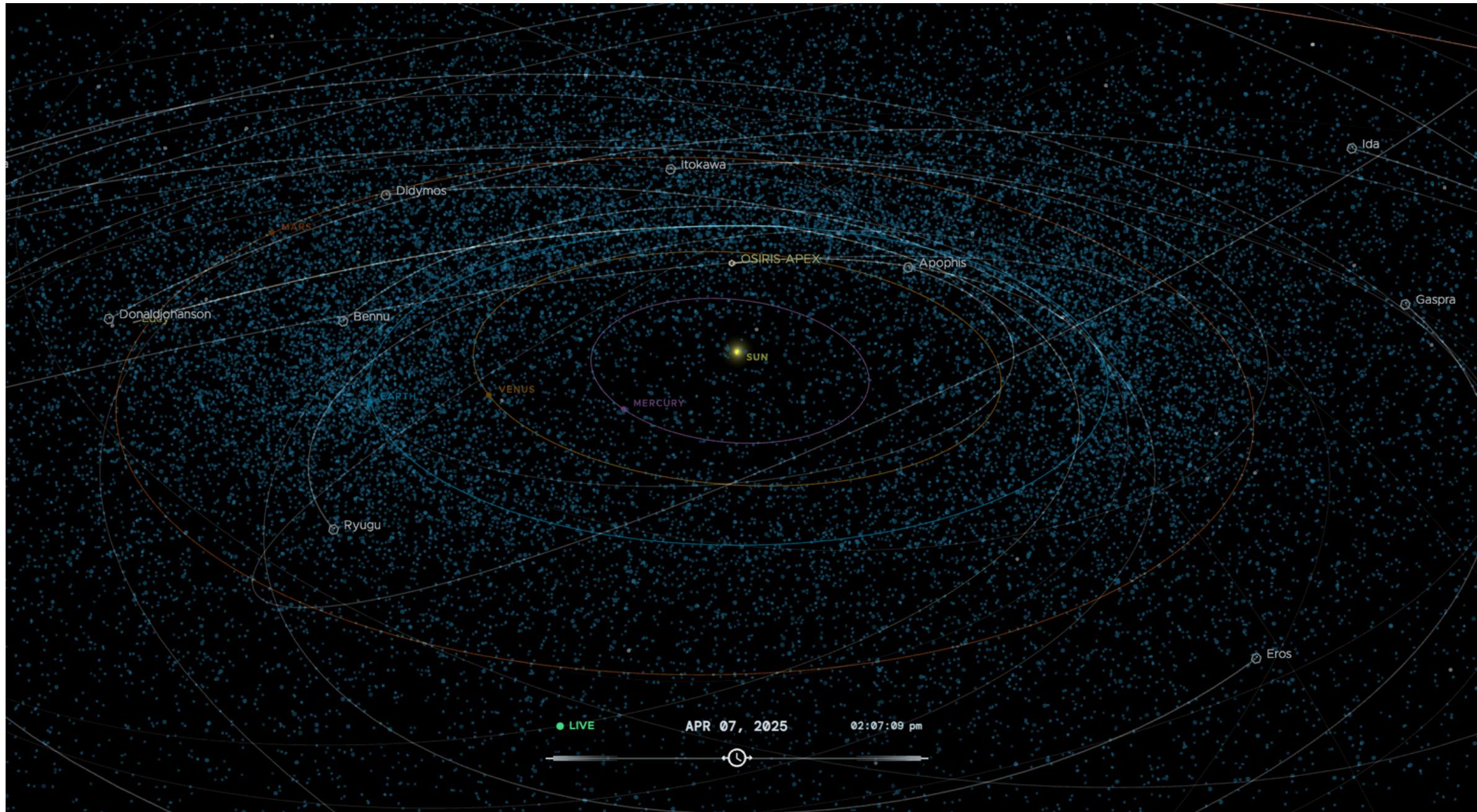
# Navigation

# Navigation: Pan (Translate)



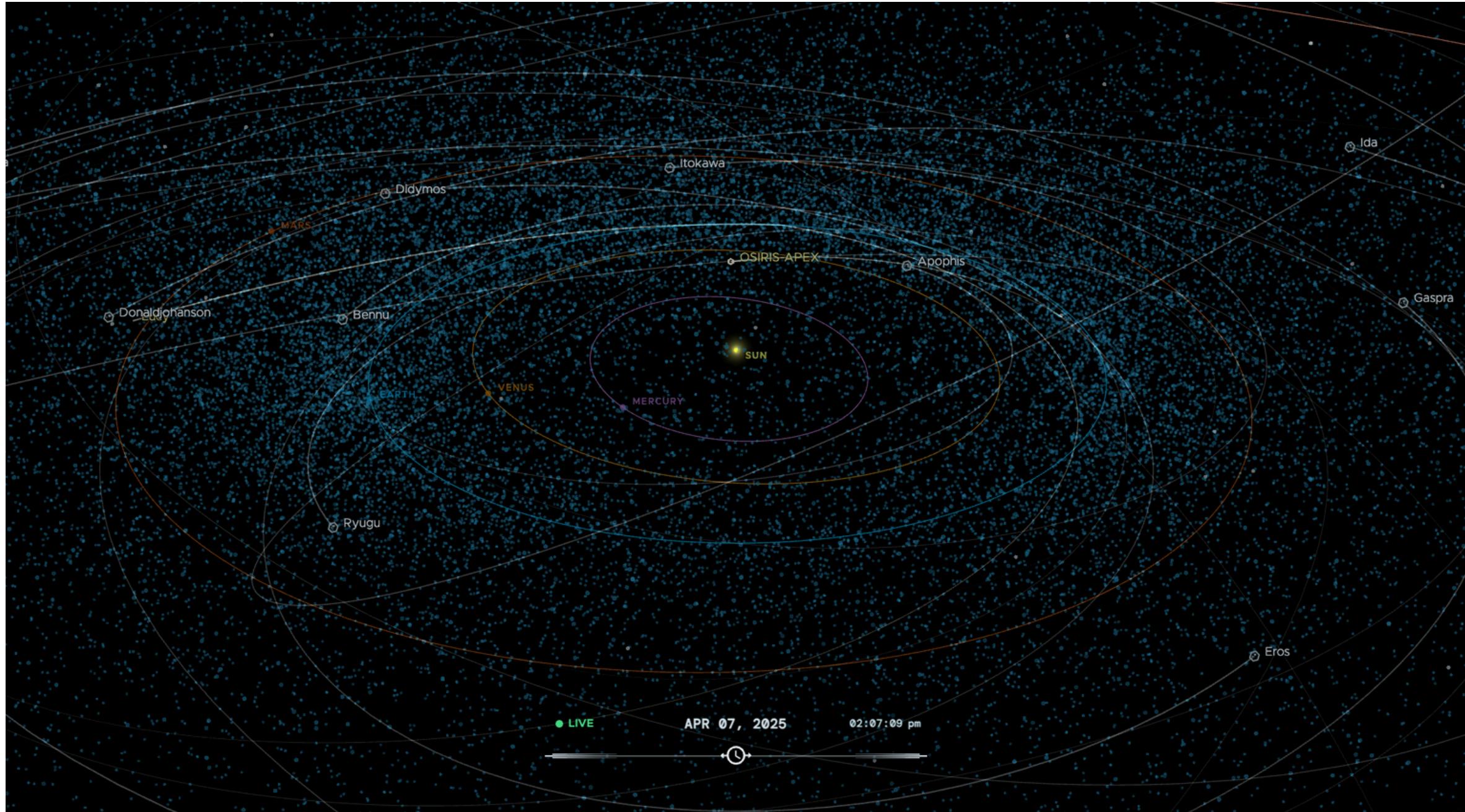
<https://eyes.nasa.gov/apps/asteroids/#/home>

# Navigation: Rotate



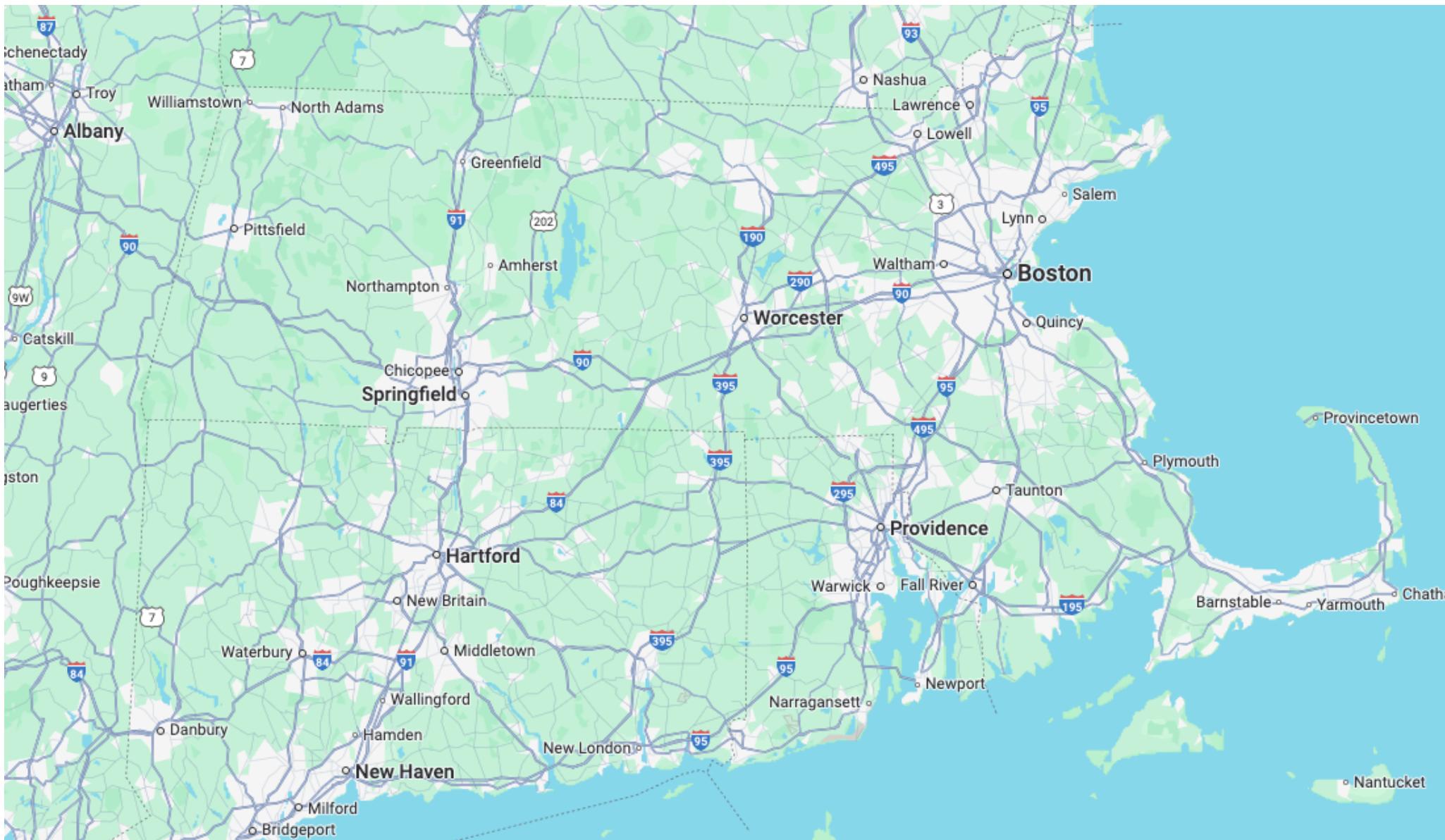
<https://eyes.nasa.gov/apps/asteroids/#/home>

# Navigation: Geometric Zoom



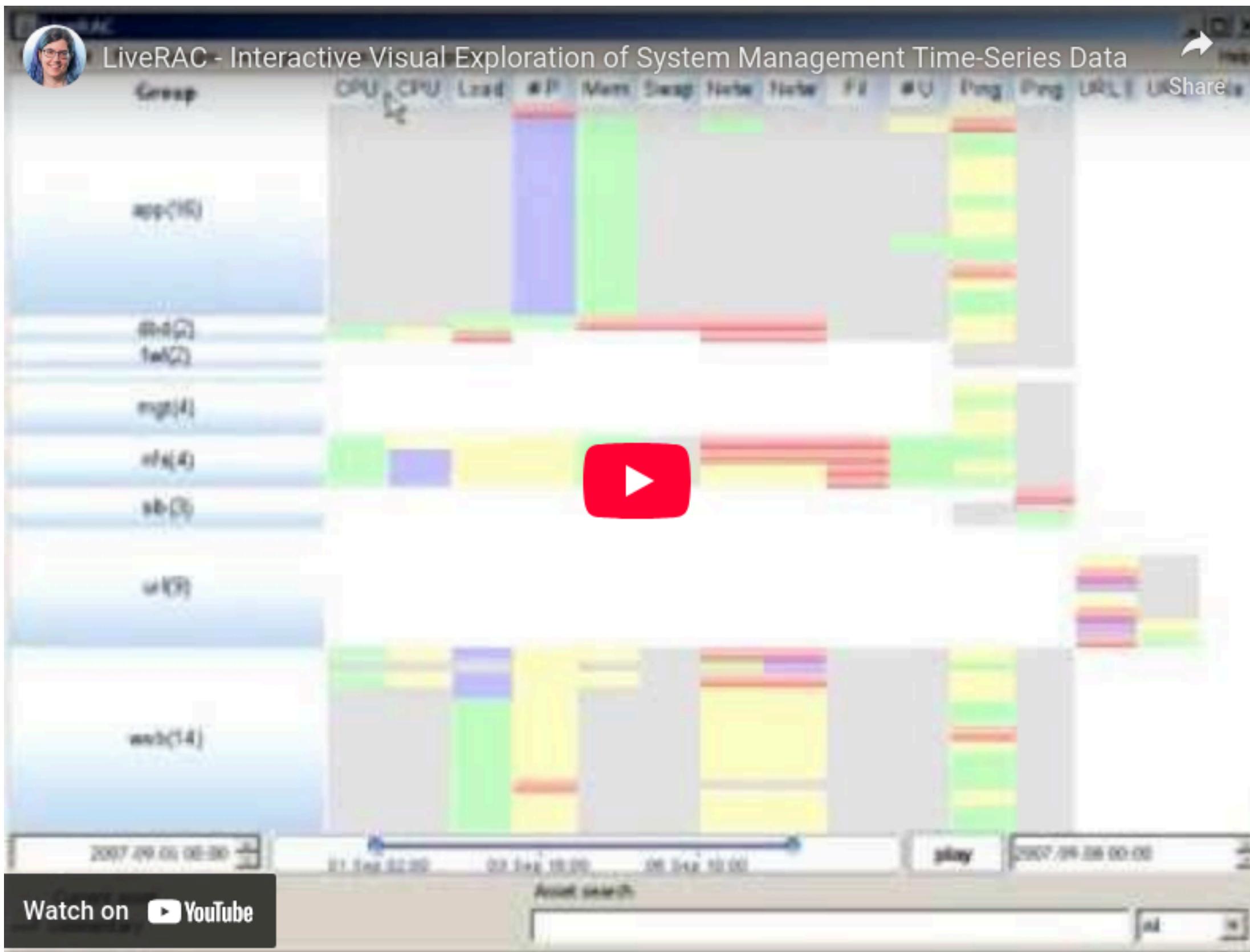
<https://eyes.nasa.gov/apps/asteroids/#/home>

# Navigation: Semantic Zoom



Google Maps

# Navigation: Semantic Zoom



A Useful Data Visualization Slogan:  
**“Overview First,  
Zoom and Filter,  
Details-On-Demand”**

**FIN**

## Upcoming Dates

Apr 11: Homework 3 Due at 11:59pm Eastern

Apr 11: Project Milestone

Group Activity Next Class (Apr 10)

Quiz 4 available Apr 10 (due Apr 14)

Homework 4 released Apr 14 (due Apr 28)