Run `git pull` in the main branch to follow along today.

JS (Part 2), D3.js

DSC 106: Data Visualization

Sam Lau
UC San Diego

Announcements

Lab 4 due today.

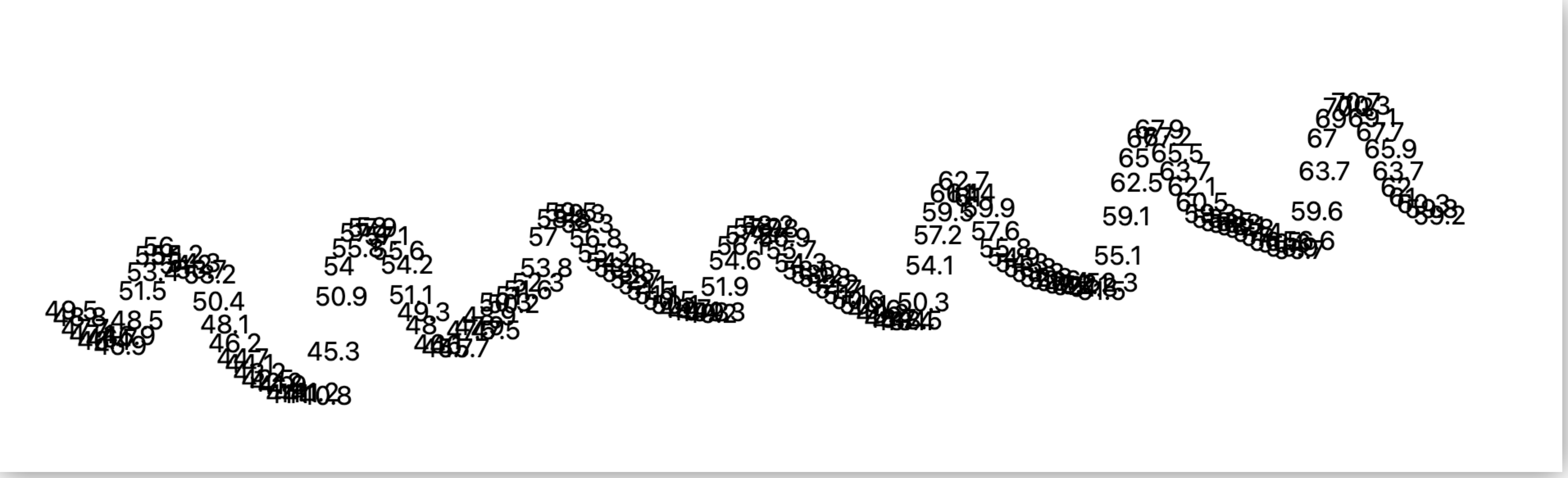
Project 2 due on Tuesday.

FAQs:

1. I’m getting 404 errors when working on the lab! Check that you’re using relatively URLs and they match your folder structure.

JS (Part 2)

Now, let’s make our very first data visualization in JS:

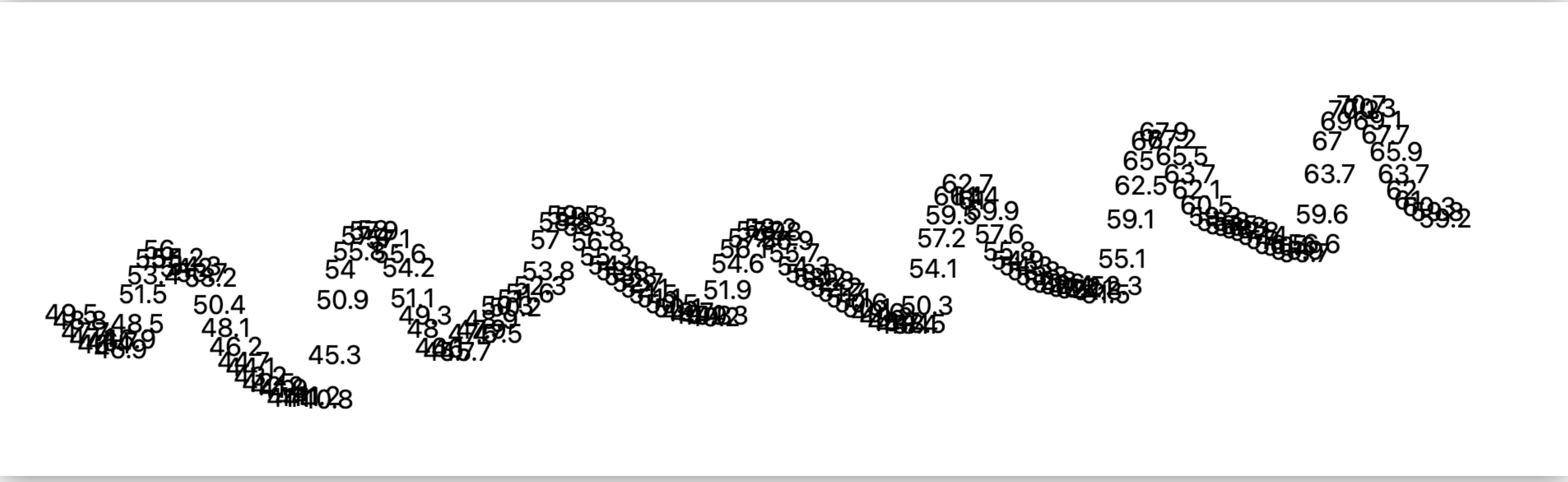


js-lecture/weather02/

(demo)

js-lecture/weather03/

(demo)



How would you add an x-axis and y-axis? Gridlines?

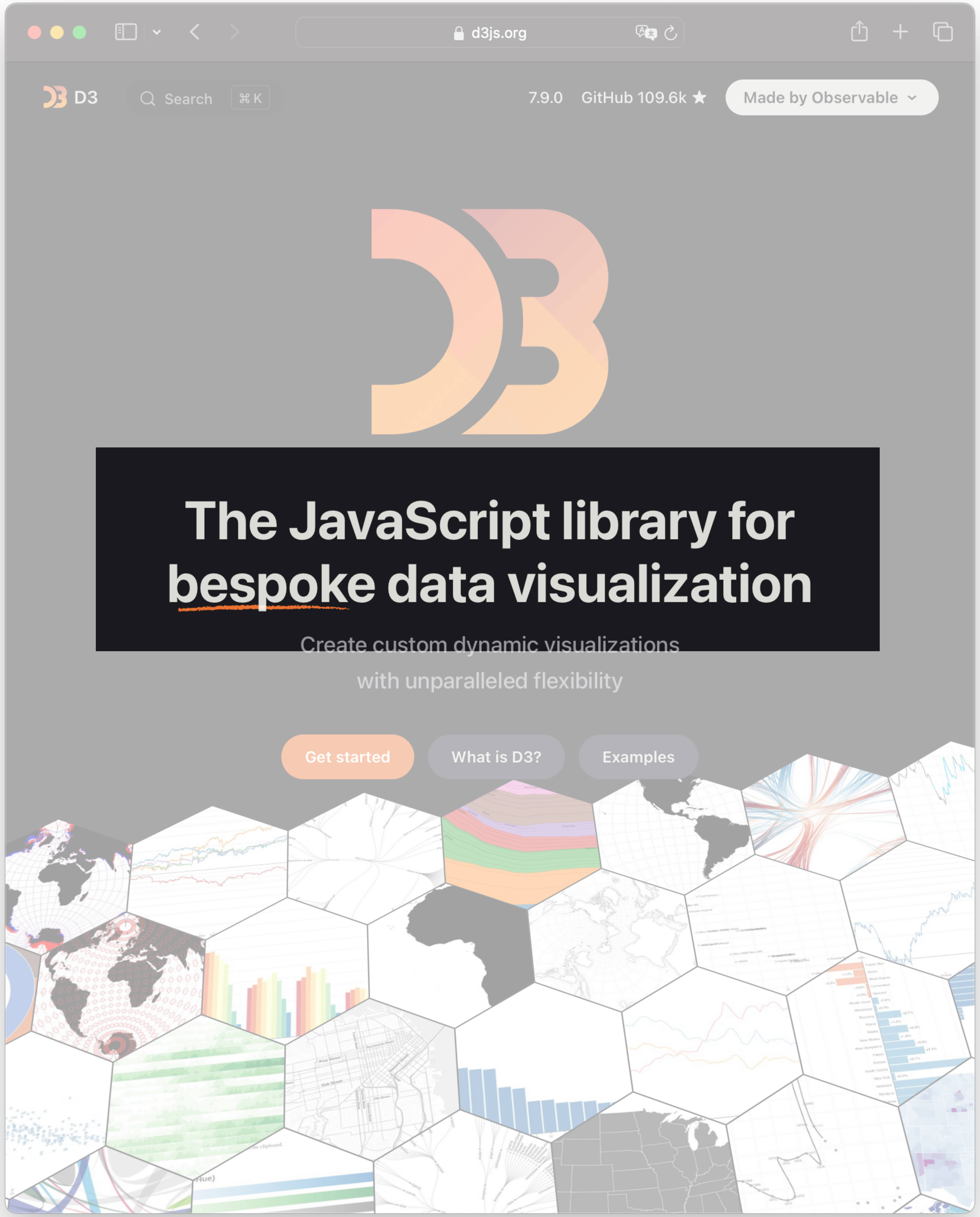
tryclassbuzz.com
Code: **axes**

D3

The JavaScript library for bespoke data visualization

Create custom dynamic visualizations with unparalleled flexibility

https://d3js.org/

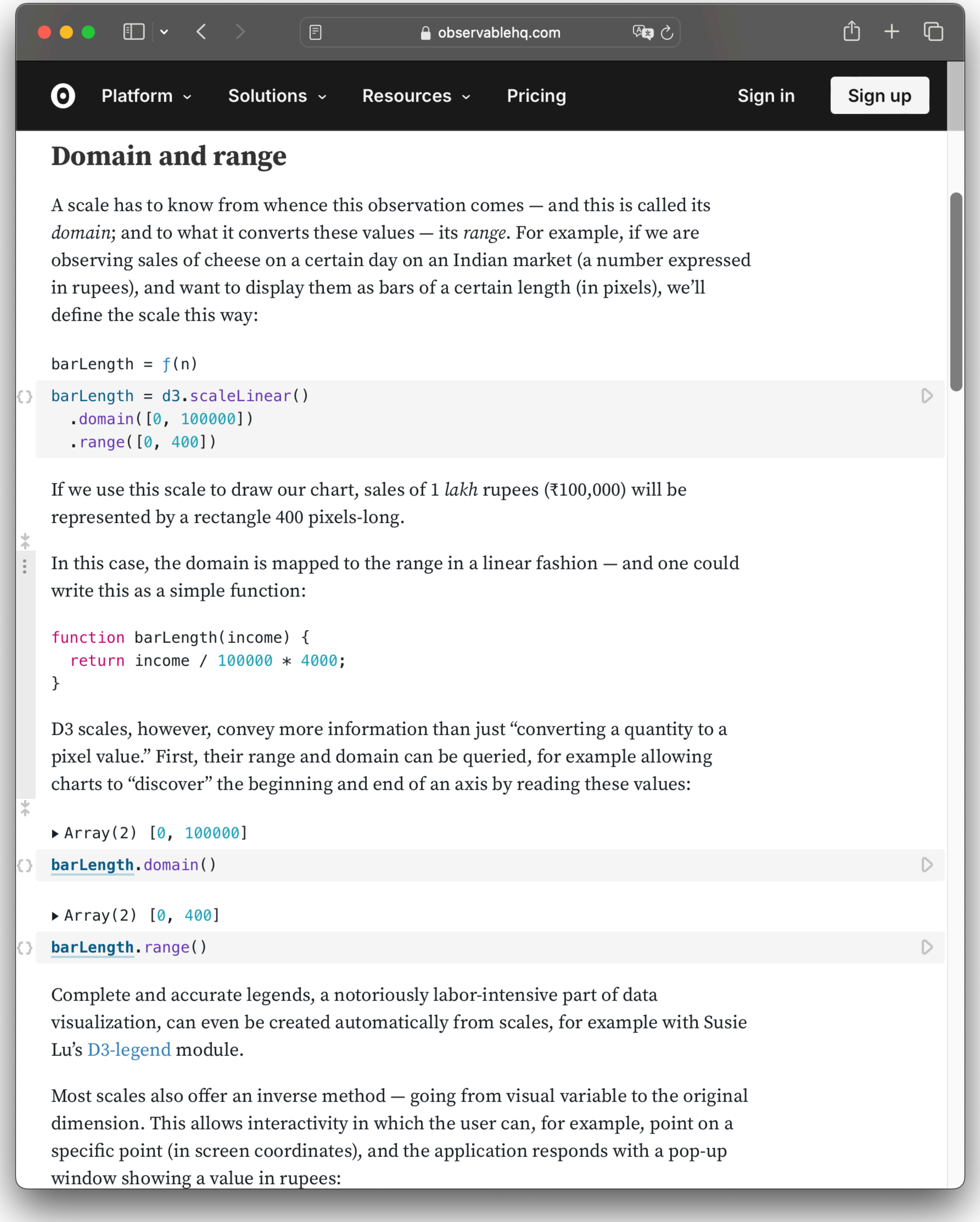


The JavaScript library for bespoke data visualization

Create custom dynamic visualizations with unparalleled flexibility

https://d3js.org/

Bespoke = fully custom



Domain and range

A scale has to know from whence this observation comes — and this is called its *domain*; and to what it converts these values — its *range*. For example, if we are observing sales of cheese on a certain day on an Indian market (a number expressed in rupees), and want to display them as bars of a certain length (in pixels), we'll define the scale this way:

```
barLength = ƒ(n)
```

```
barLength = d3.scaleLinear()
  .domain([0, 100000])
  .range([0, 400])
```

If we use this scale to draw our chart, sales of 1 *lakh* rupees (₹100,000) will be represented by a rectangle 400 pixels-long.

In this case, the domain is mapped to the range in a linear fashion — and one could write this as a simple function:

```
function barLength(income) {
  return income / 100000 * 4000;
}
```

D3 scales, however, convey more information than just "converting a quantity to a pixel value." First, their range and domain can be queried, for example allowing charts to "discover" the beginning and end of an axis by reading these values:

```
▸Array(2) [0, 100000]
barLength.domain()
```

```
▸Array(2) [0, 400]
barLength.range()
```

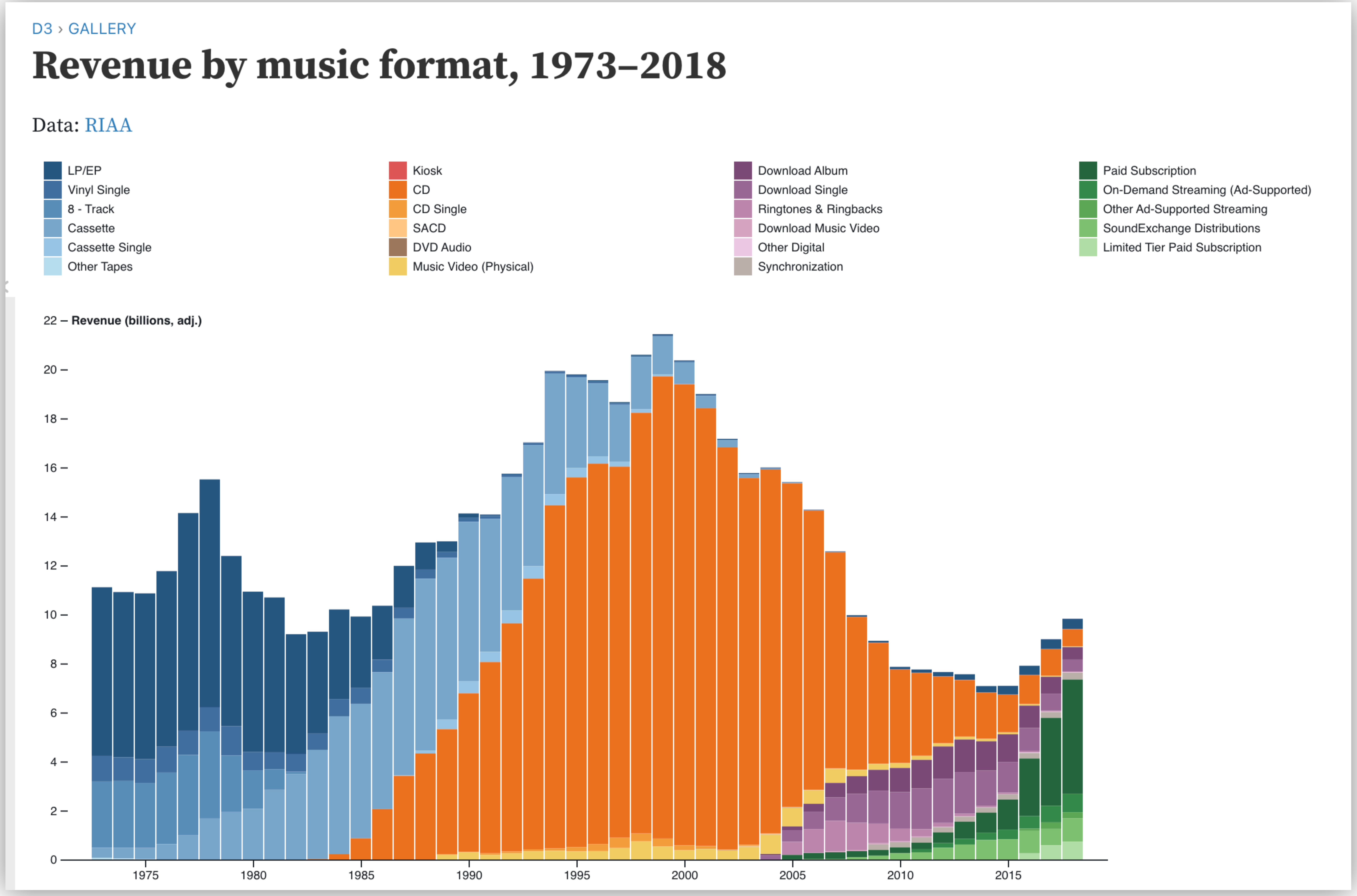
Complete and accurate legends, a notoriously labor-intensive part of data visualization, can even be created automatically from scales, for example with Susie Lu's D3-legend module.

Most scales also offer an inverse method — going from visual variable to the original dimension. This allows interactivity in which the user can, for example, point on a specific point (in screen coordinates), and the application responds with a pop-up window showing a value in rupees:

D3 has a parent company called Observable…

…which has a modified JS language!

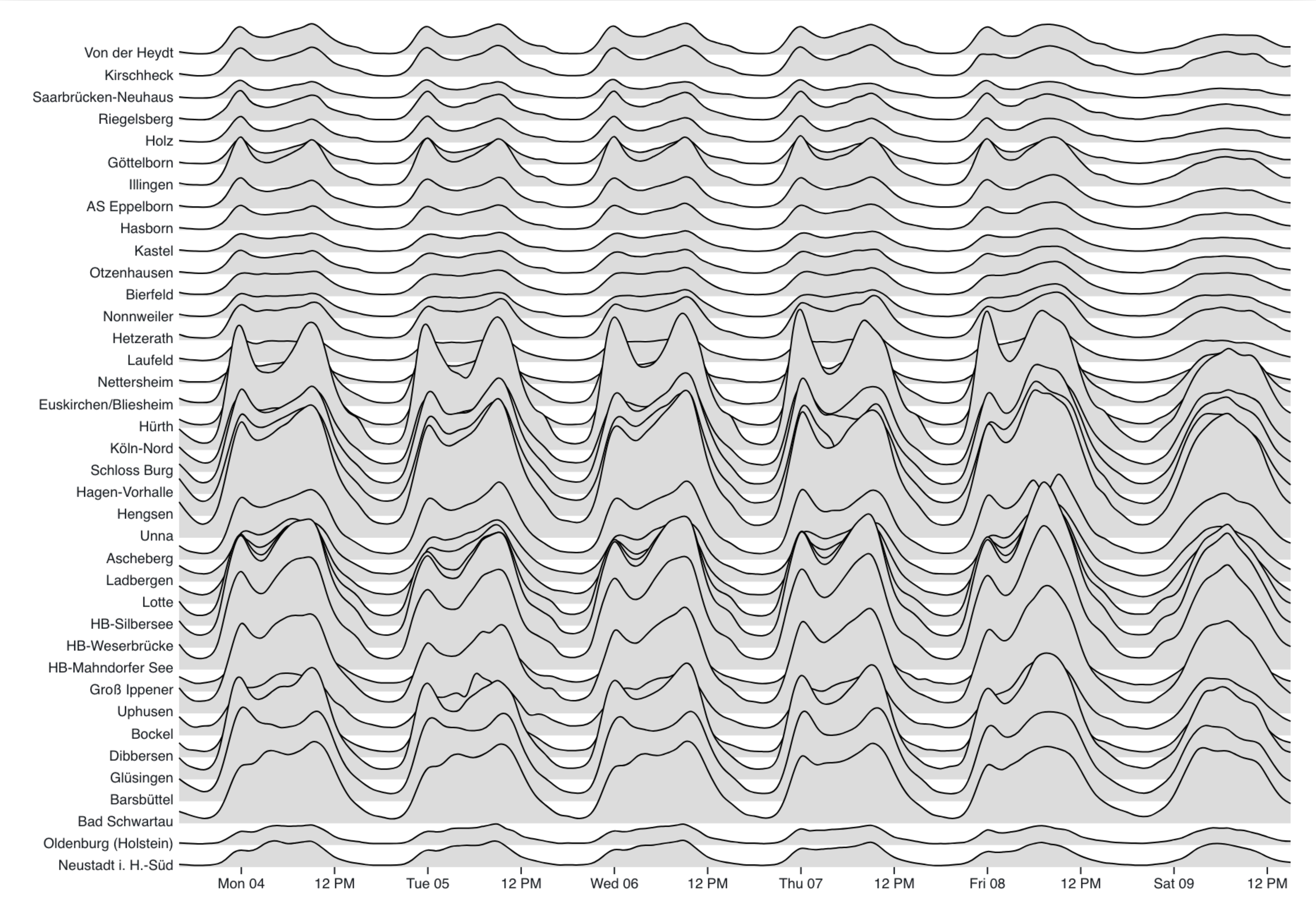
We won't use Observable for this class, but keep that in mind

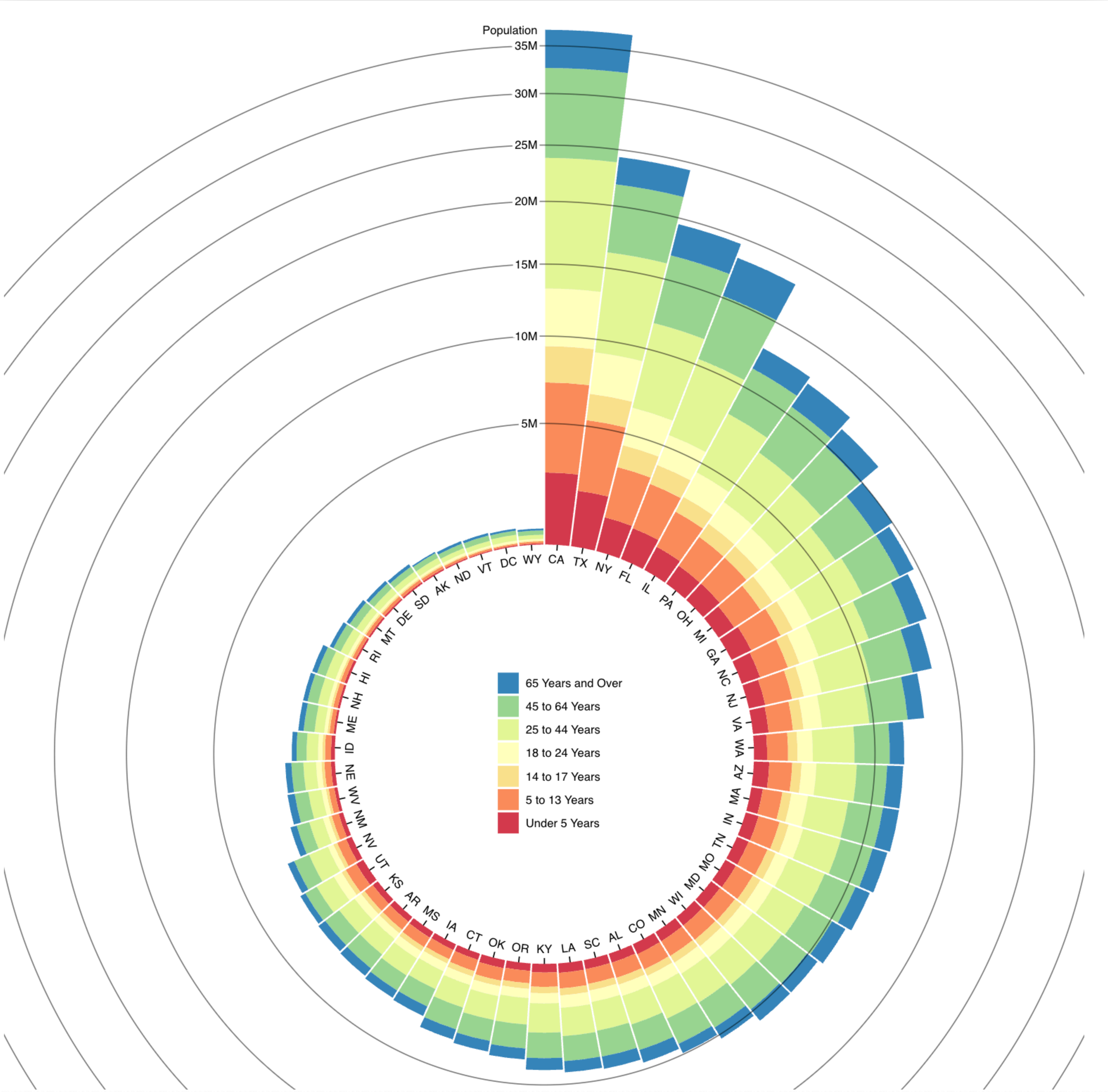


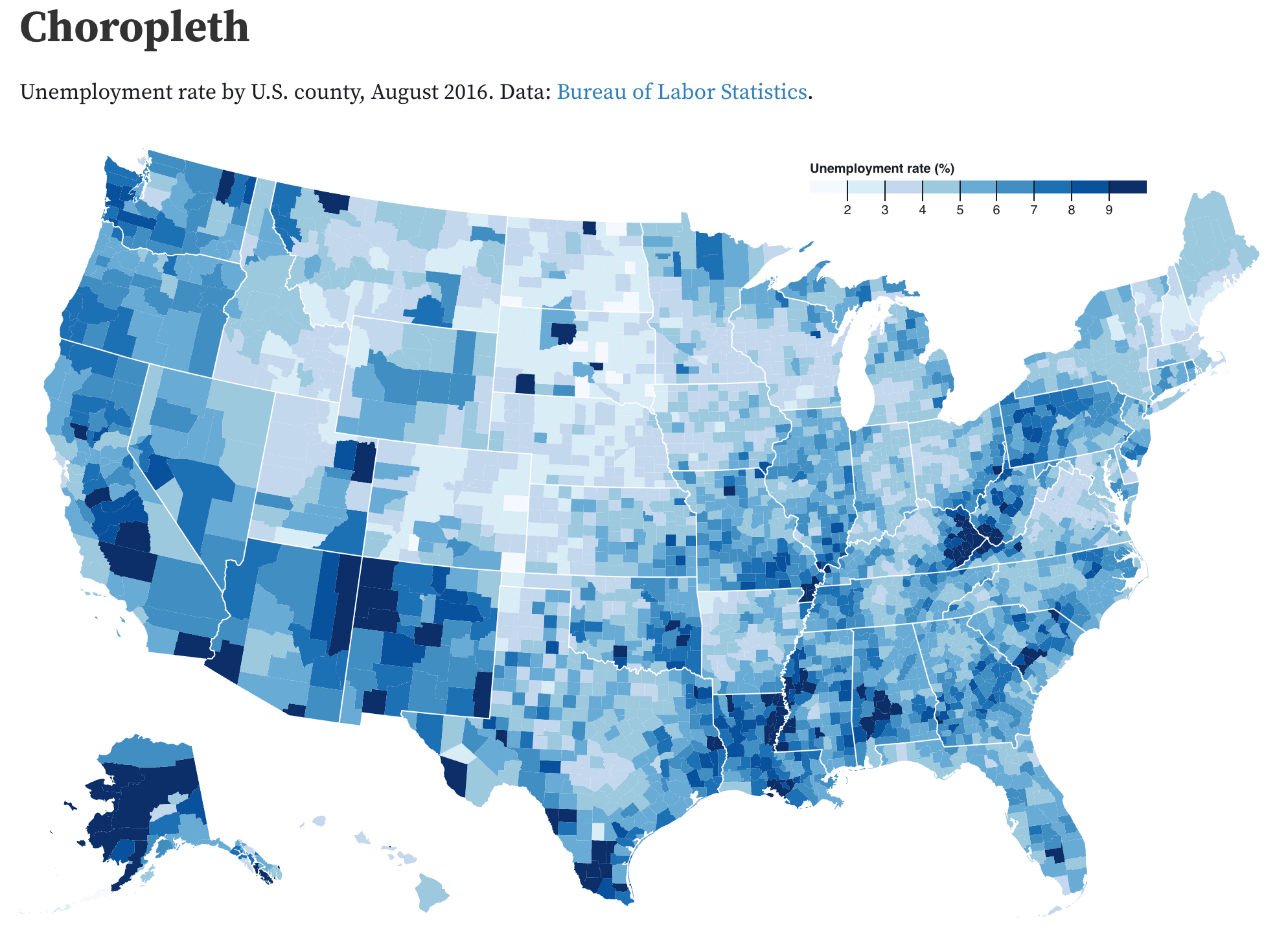
D3 › GALLERY

Revenue by music format, 1973–2018

Data: RIAA


Von der Heydt
Kirschheck
Saarbrücken-Neuhaus
Riegelsberg
Holz
Göttelborn
Illingen
AS Eppelborn
Hasborn
Kastel
Otzenhausen
Bierfeld
Nonnweiler
Hetzerath
Laufeld
Nettersheim
Euskirchen/Bliesheim
Hürth
Köln-Nord
Schloss Burg
Hagen-Vorhalle
Hengsen
Unna
Ascheberg
Ladbergen
Lotte
HB-Silbersee
HB-Weserbrücke
HB-Mahndorfer See
Groß Ippener
Uphusen
Bockel
Dibbersen
Glüsingen
Barsbüttel
Bad Schwartau
Oldenburg (Holstein)
Neustadt i. H.-Süd
Mon 04
12 PM
Tue 05
12 PM
Wed 06
12 PM
Thu 07
12 PM
Fri 08
12 PM
Sat 09
12 PM

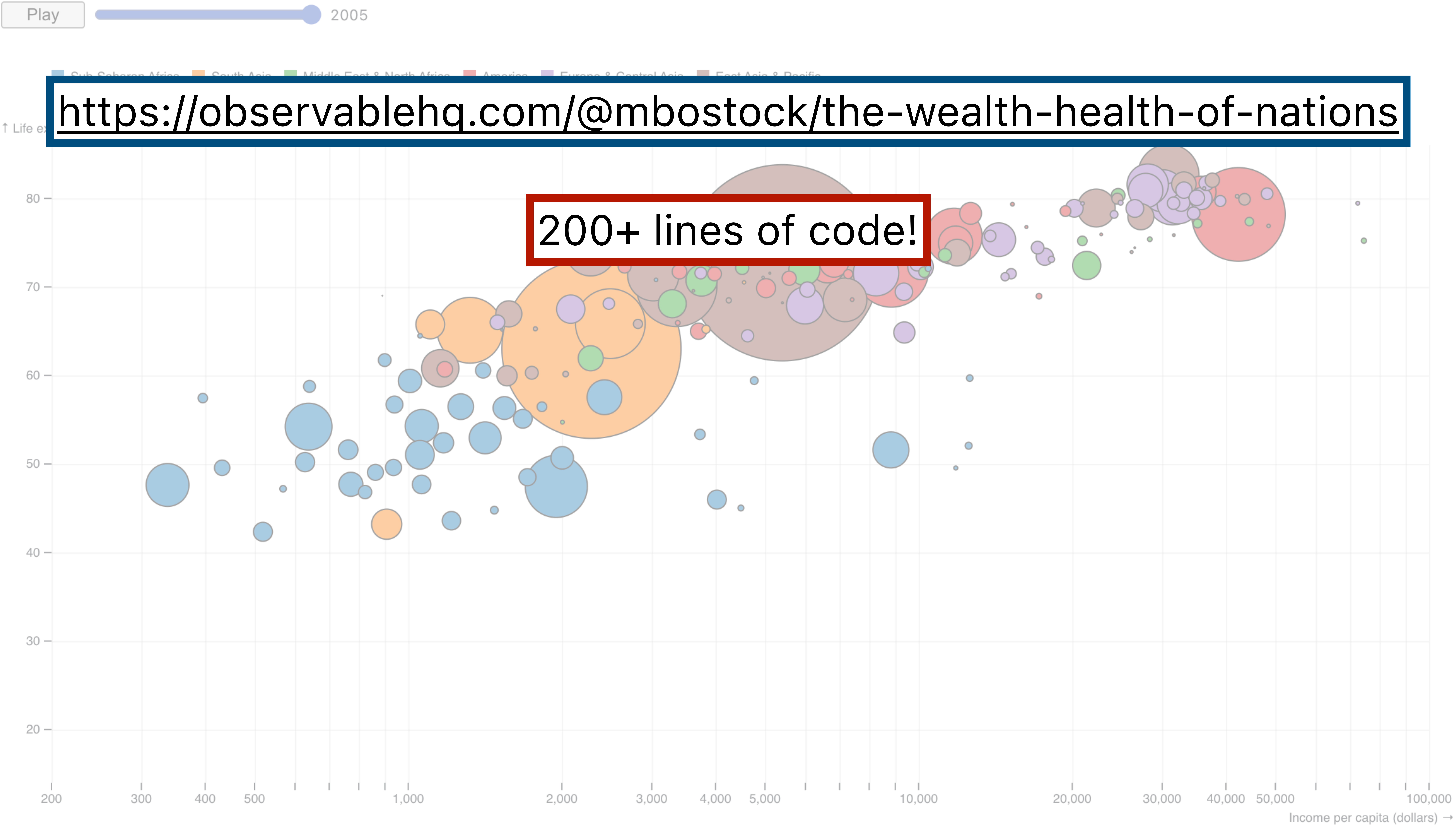

Population
35M
30M
25M
20M
15M
10M
5M
CA
TX
NY
FL
IL
PA
OH
MI
GA
NC
NJ
VA
WA
AZ
MA
IN
TN
MO
MD
WI
MN
CO
AL
SC
LA
KY
OR
OK
CT
IA
MS
AR
KS
UT
NV
NM
WV
NE
ID
ME
NH
HI
RI
MT
DE
SD
AK
ND
VT
DC
WY
65 Years and Over
45 to 64 Years
25 to 44 Years
18 to 24 Years
14 to 17 Years
5 to 13 Years
Under 5 Years



Choropleth

Unemployment rate by U.S. county, August 2016. Data: Bureau of Labor Statistics.

Pause
1964
Sub-Saharan Africa
South Asia
Middle East & North Africa
America
Europe & Central Asia
East Asia & Pacific
↑ Life expectancy (years)
80
70
60
50
40
30
20
200
300
400
500
1,000
2,000
3,000
4,000
5,000
10,000
20,000
30,000
40,000
50,000
100,000
Income per capita (dollars) →

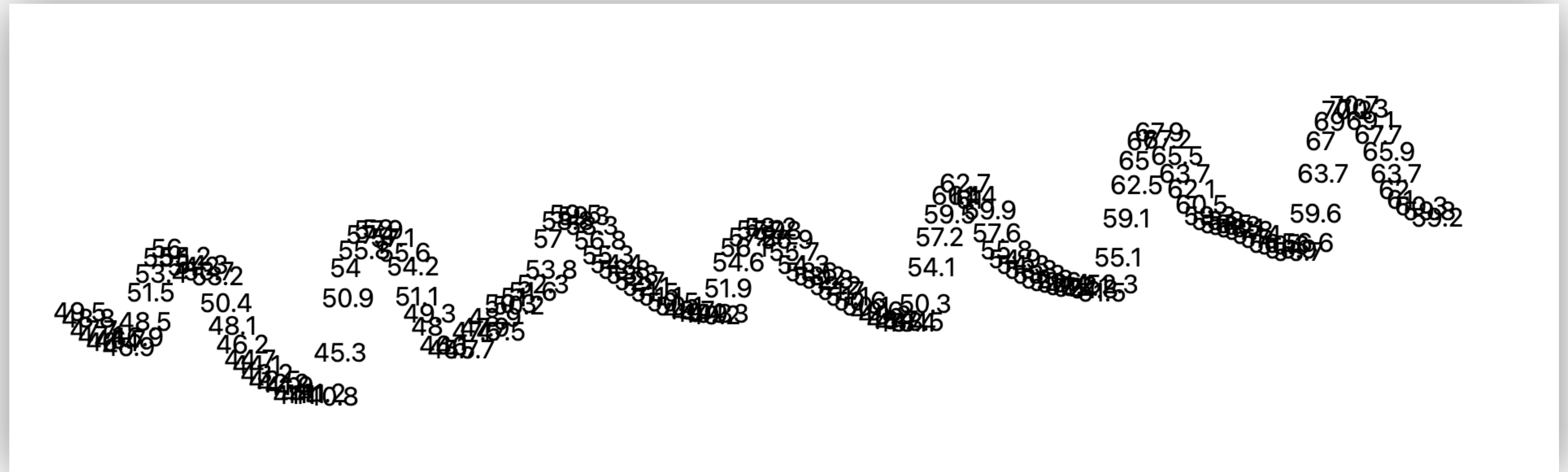


https://observablehq.com/@mbostock/the-wealth-health-of-nations

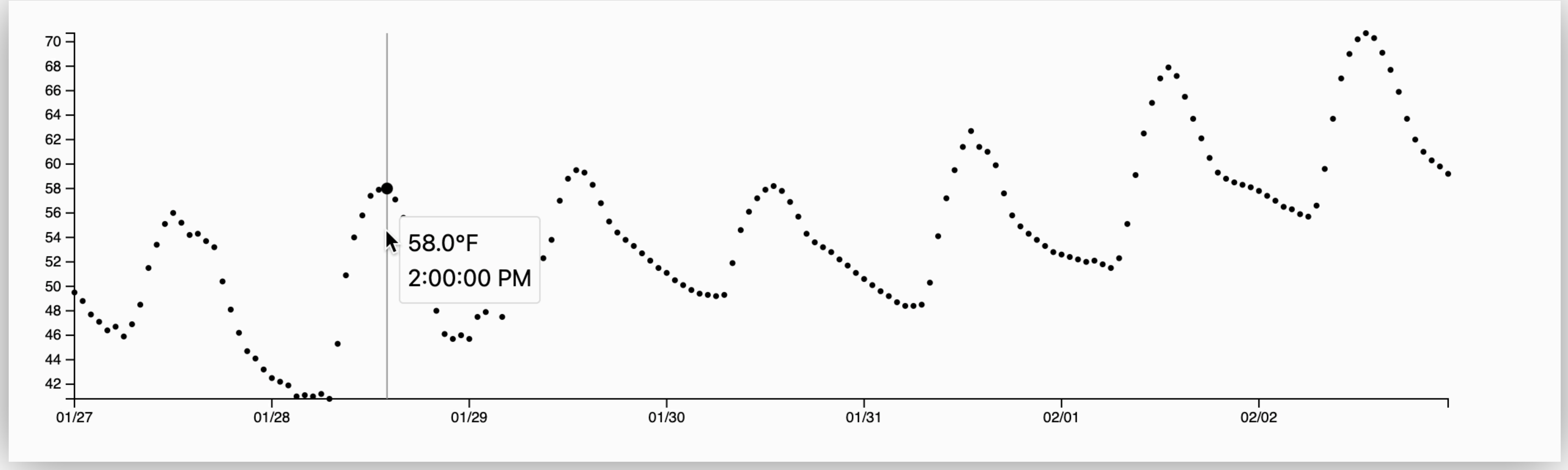
200+ lines of code!

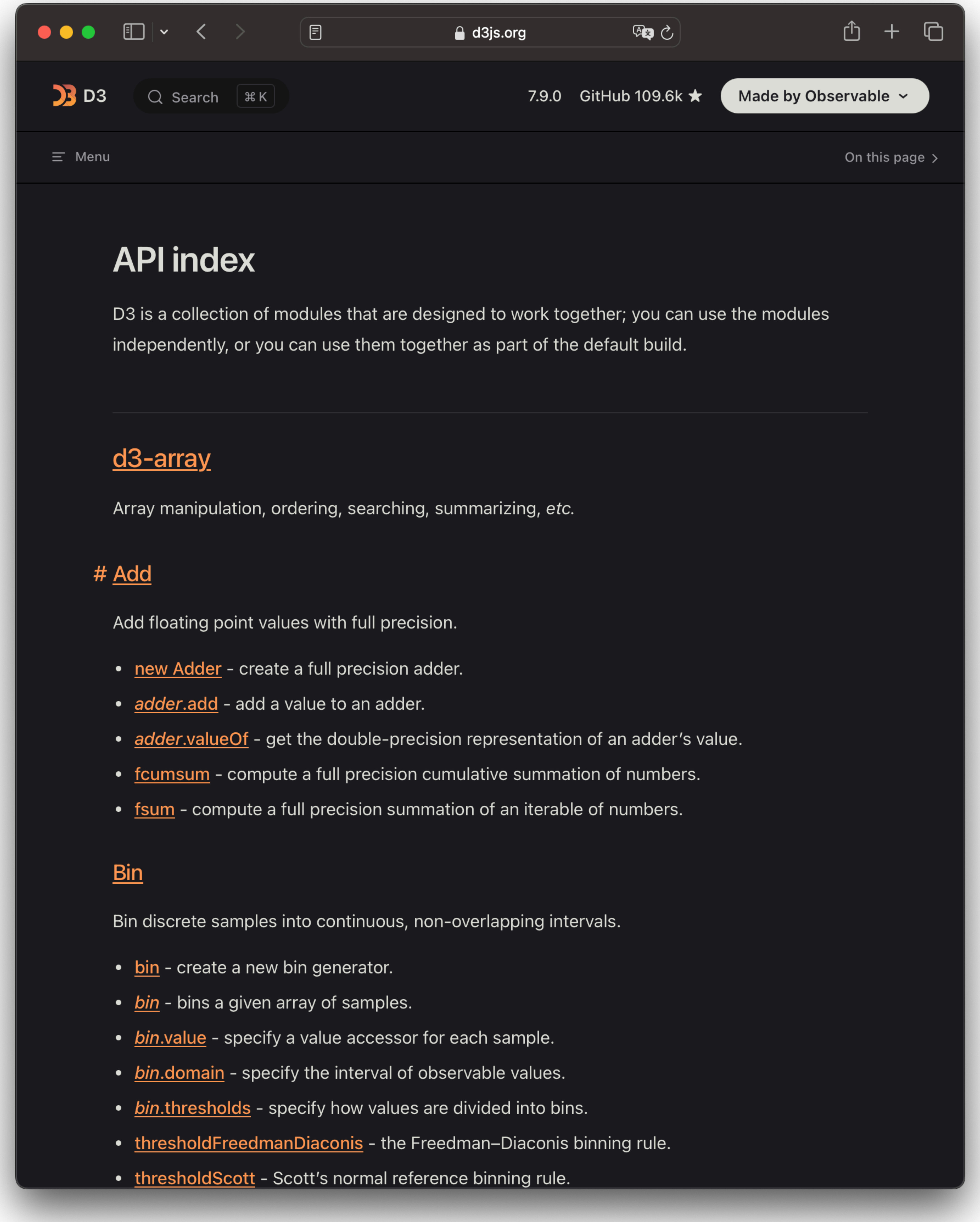
Today: Making an interactive scatterplot

Before:



After:





API index

D3 is a collection of modules that are designed to work together; you can use the modules independently, or you can use them together as part of the default build.

d3-array

Array manipulation, ordering, searching, summarizing, *etc.*

Add

Add floating point values with full precision.

- new Adder - create a full precision adder.
- *adder*.add - add a value to an adder.
- *adder*.valueOf - get the double-precision representation of an adder's value.
- fcumsum - compute a full precision cumulative summation of numbers.
- fsum - compute a full precision summation of an iterable of numbers.

Bin

Bin discrete samples into continuous, non-overlapping intervals.

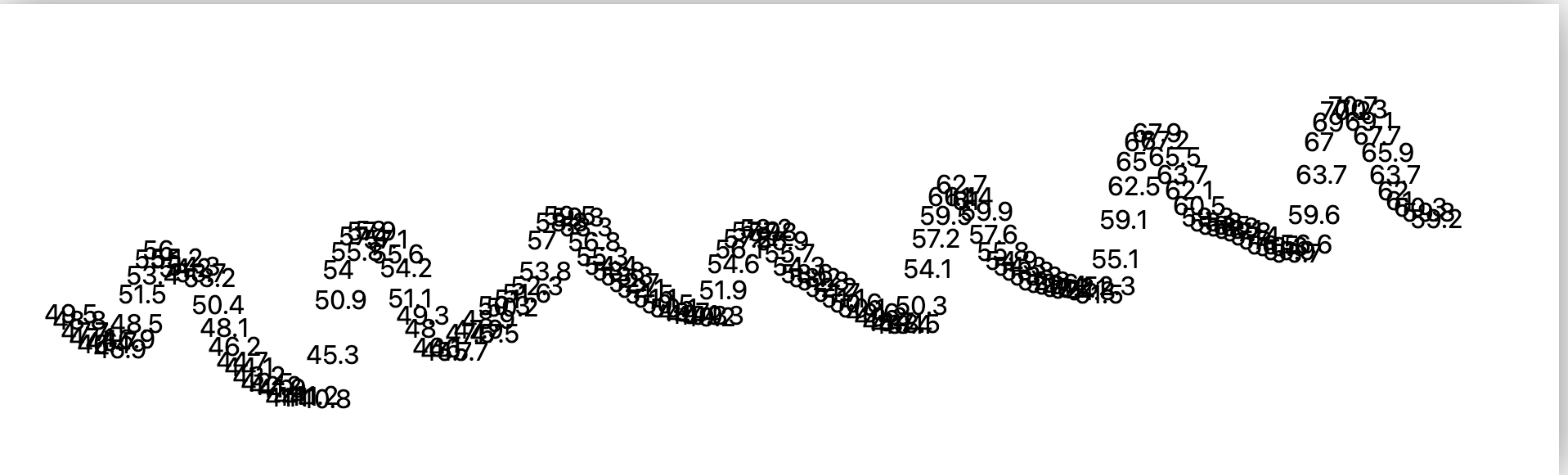
- bin - create a new bin generator.
- *bin* - bins a given array of samples.
- *bin*.value - specify a value accessor for each sample.
- *bin*.domain - specify the interval of observable values.
- *bin*.thresholds - specify how values are divided into bins.
- thresholdFreedmanDiaconis - the Freedman–Diaconis binning rule.
- thresholdScott - Scott's normal reference binning rule.

d3 is a huge library, 30 submodules, >1k methods!

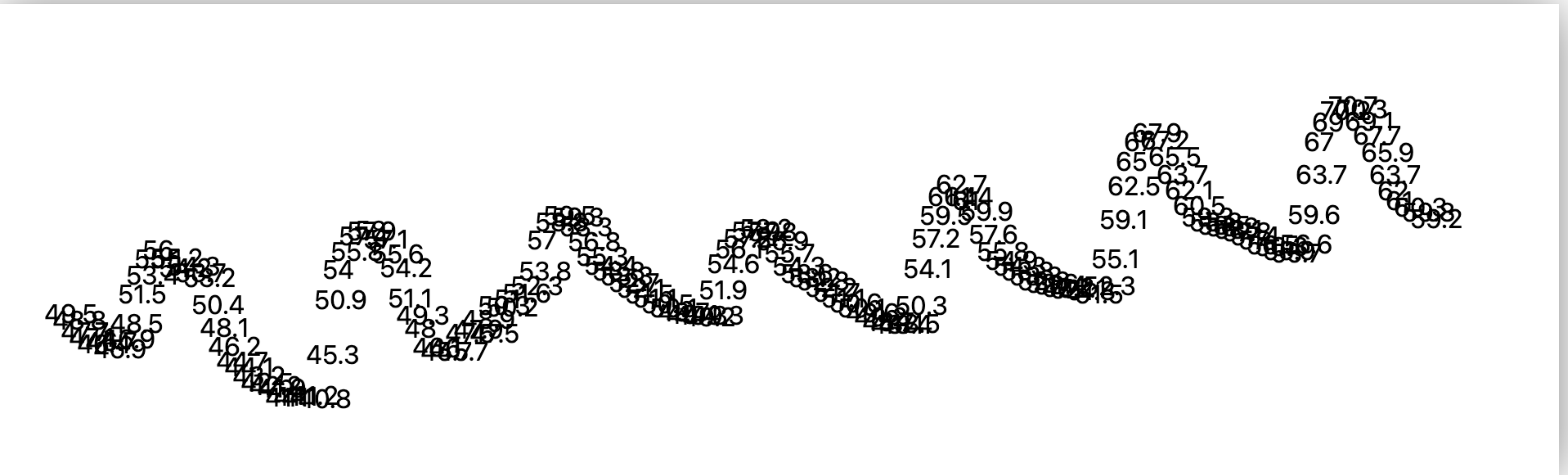
80/20 rule: Learn 20% and you'll be able to do 80% of what d3 is capable of.

Step 1: Using D3 instead of plain JS

Before:



After:

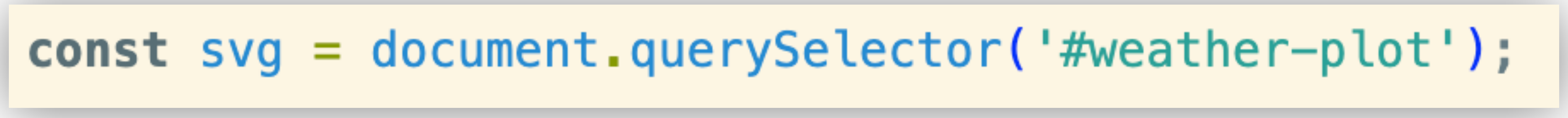


But in D3!

Demo: `d3-lecture/weather01`

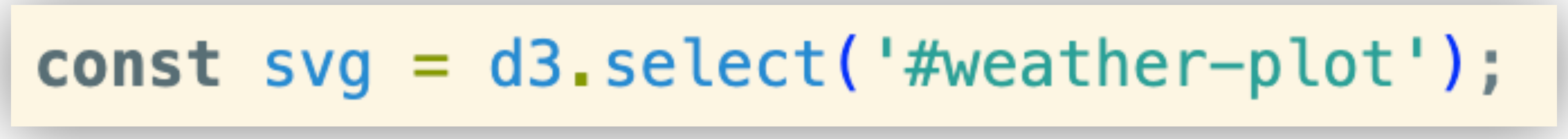
D3 Selections

Before:



```
const svg = document.querySelector('#weather-plot');
```

After:

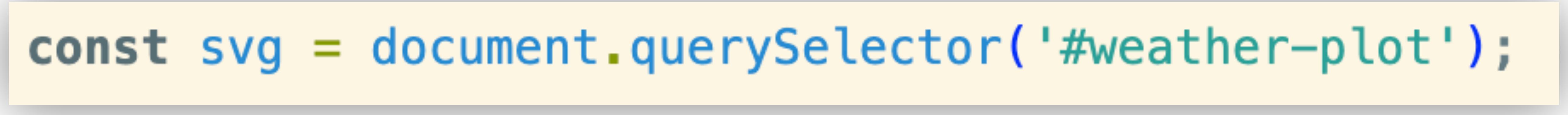


```
const svg = d3.select('#weather-plot');
```

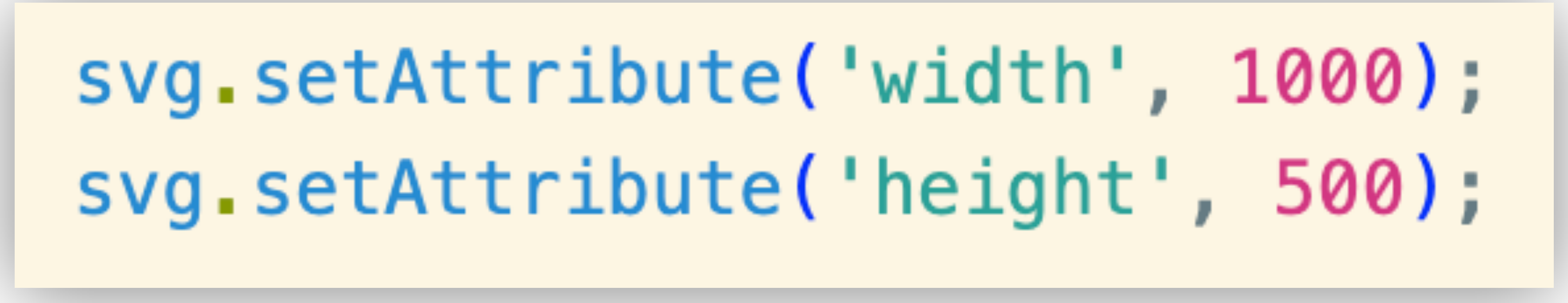
This is a D3 selection object, so it has D3 methods (not HTML methods!)

D3 Selections

Before:



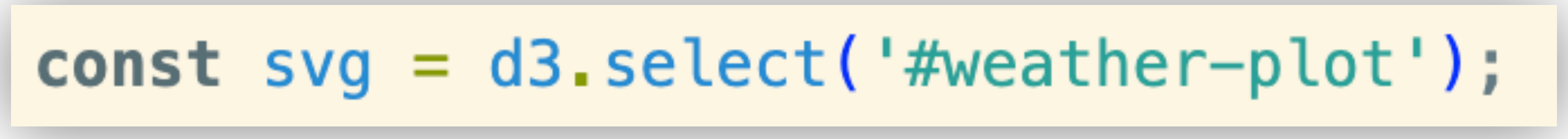
```
const svg = document.querySelector('#weather-plot');
```



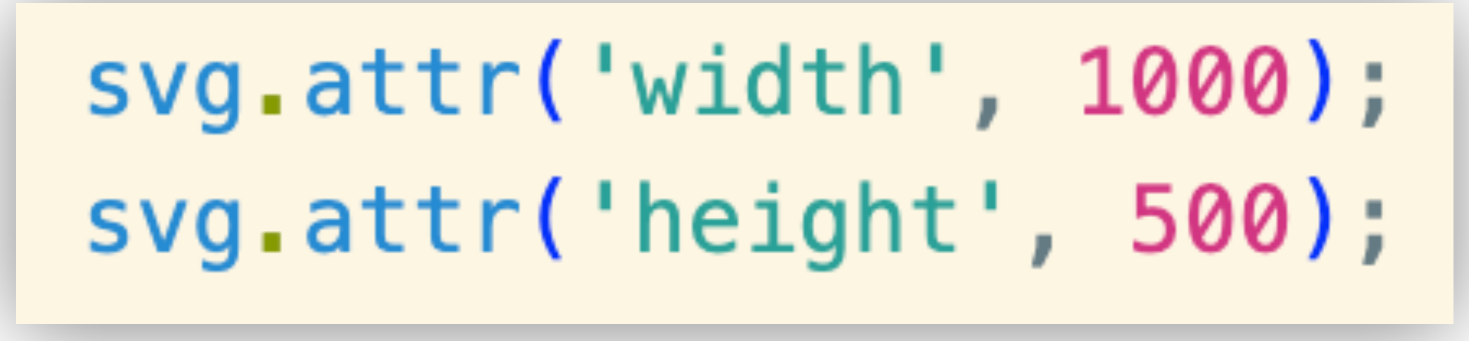
```
svg.setAttribute('width', 1000);
svg.setAttribute('height', 500);
```

HTML element method

After:



```
const svg = d3.select('#weather-plot');
```



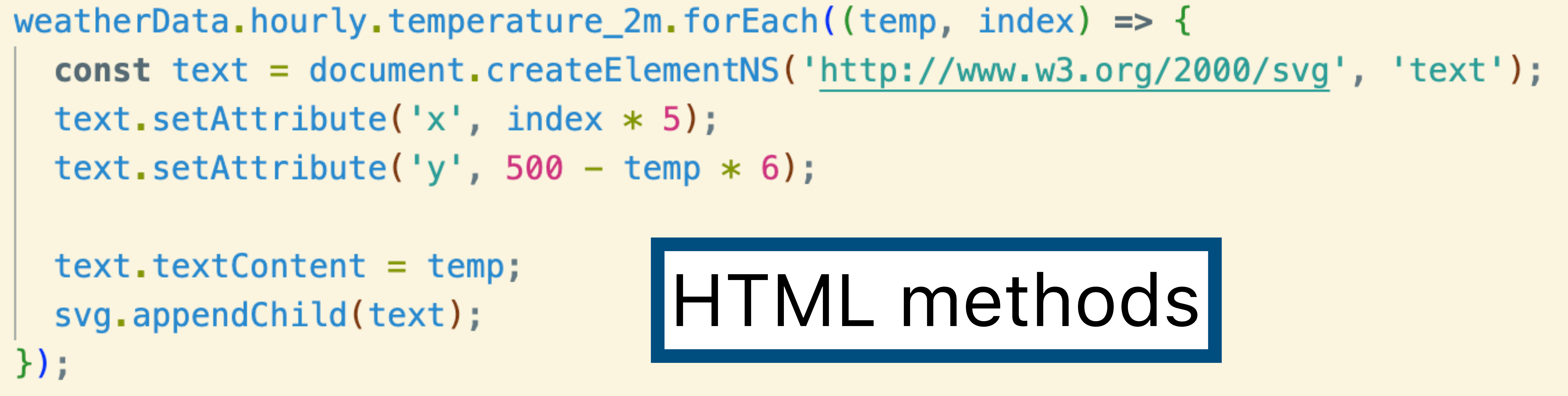
```
svg.attr('width', 1000);
svg.attr('height', 500);
```

D3 equivalent

Don’t memorize method names,
just use Copilot / ChatGPT

Data Joins

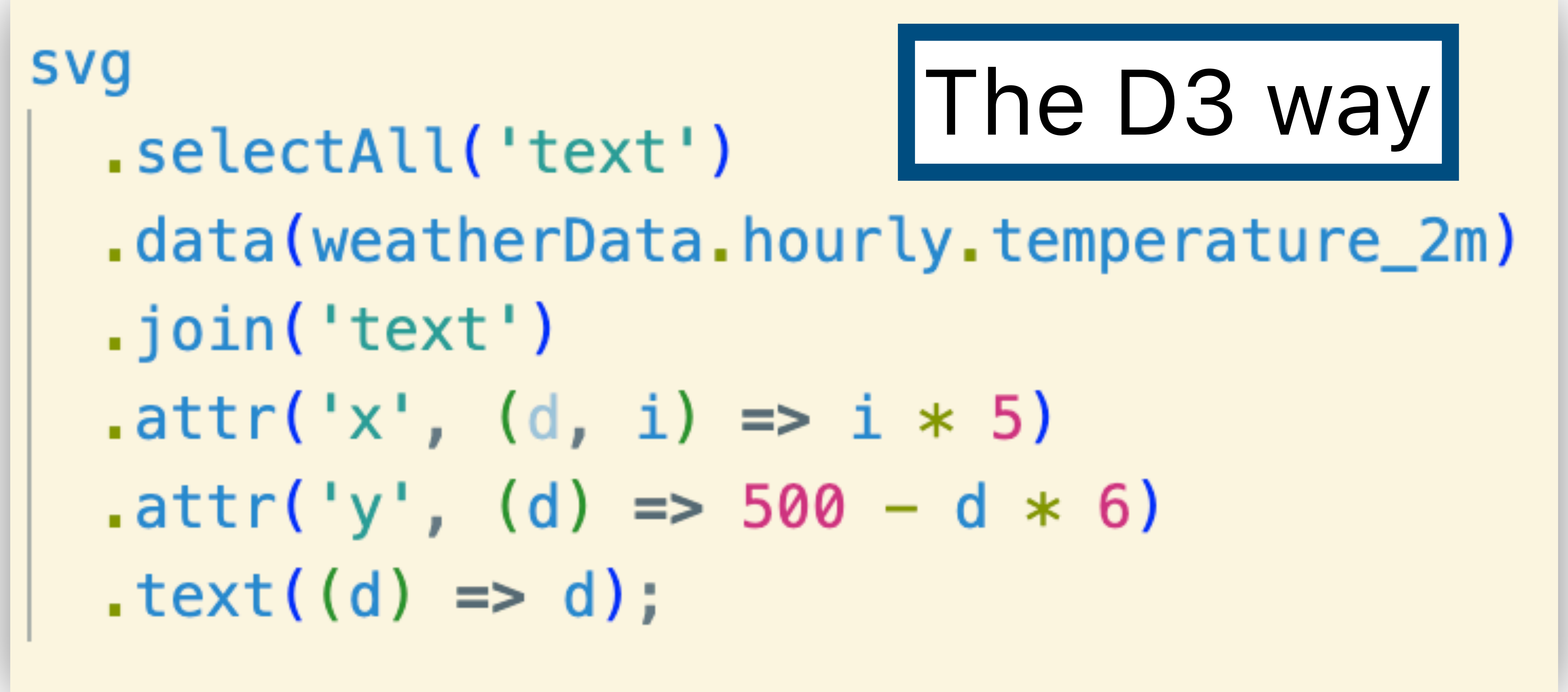
Before:



```
weatherData.hourly.temperature_2m.forEach((temp, index) => {
  const text = document.createElementNS('http://www.w3.org/2000/svg', 'text');
  text.setAttribute('x', index * 5);
  text.setAttribute('y', 500 - temp * 6);

  text.textContent = temp;
  svg.appendChild(text);
});
```

HTML methods

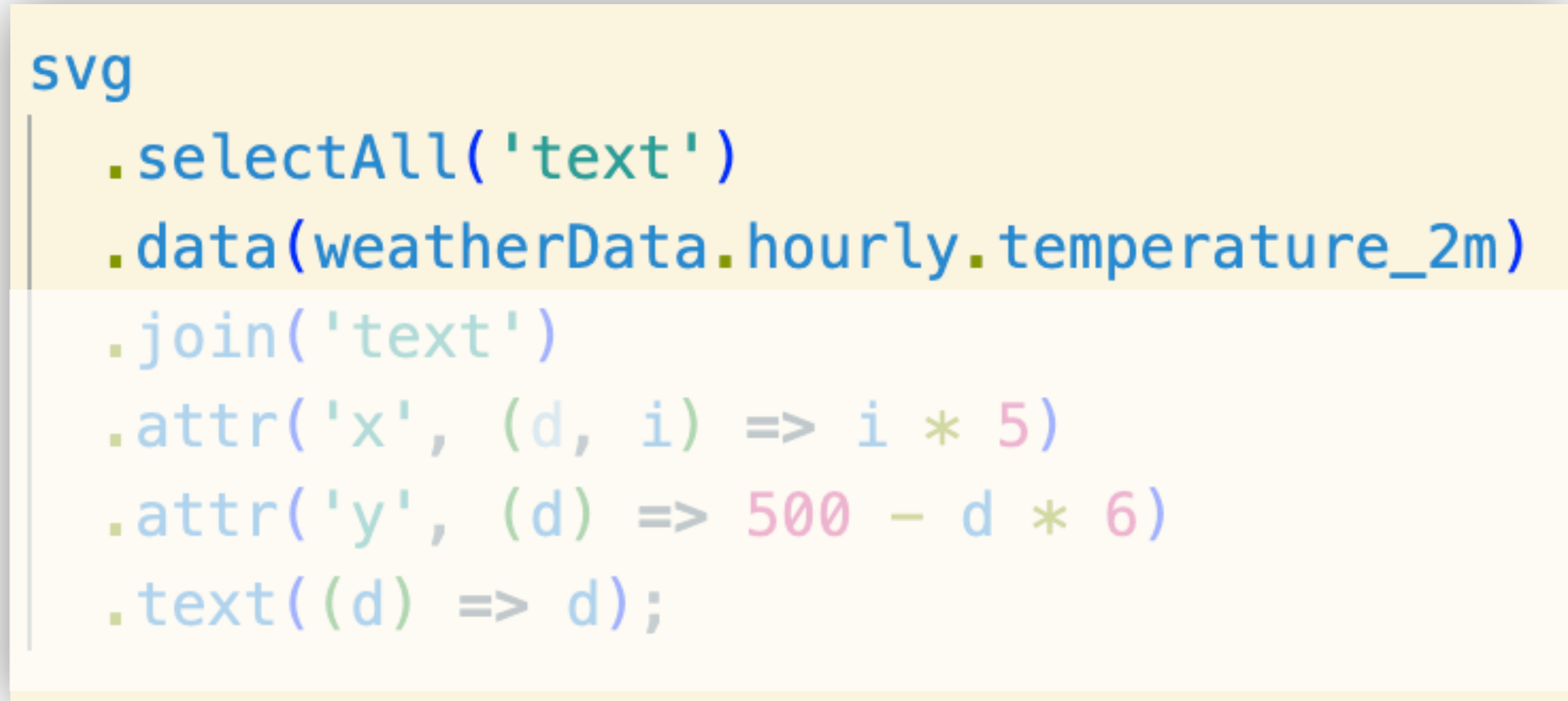
After:



```
svg
  .selectAll('text')
  .data(weatherData.hourly.temperature_2m)
  .join('text')
  .attr('x', (d, i) => i * 5)
  .attr('y', (d) => 500 - d * 6)
  .text((d) => d);
```

The D3 way

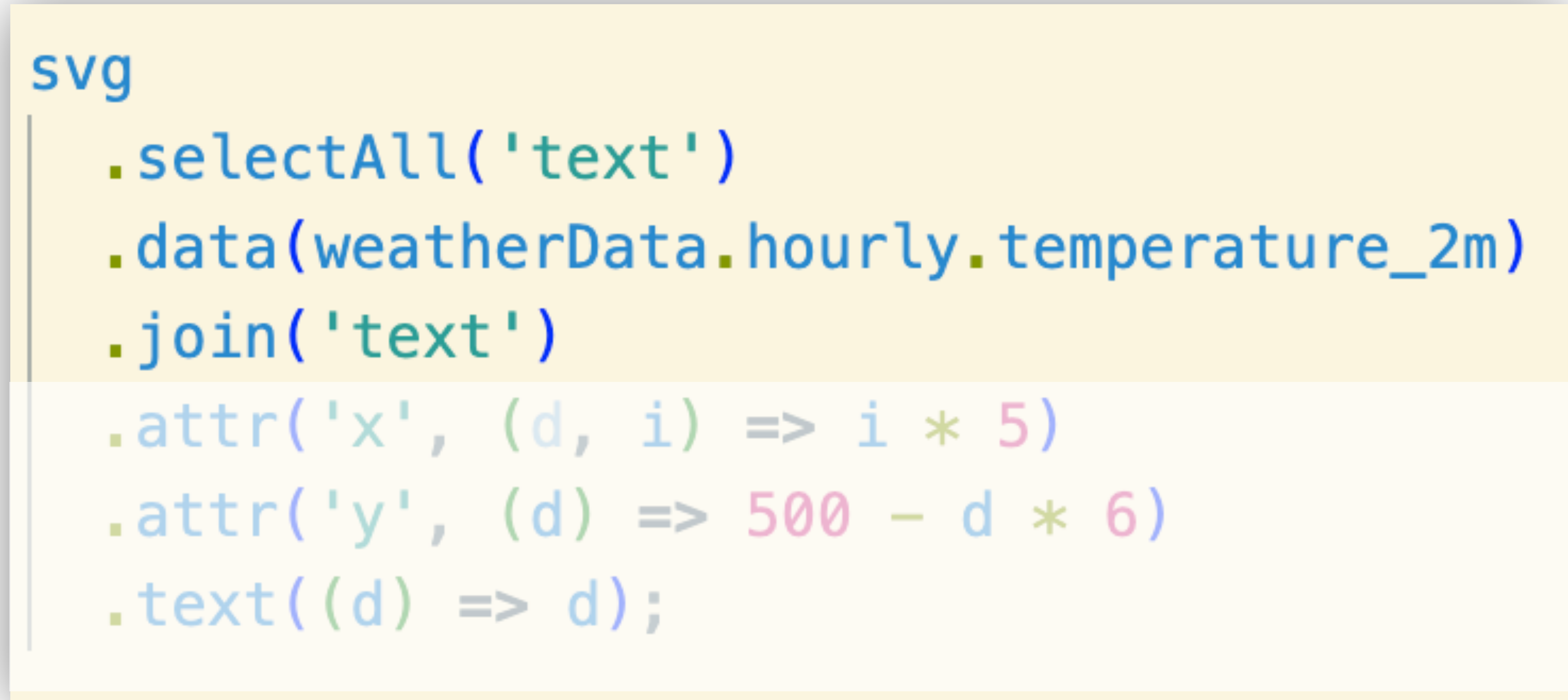
Data Joins



```
svg
    .selectAll('text')
    .data(weatherData.hourly.temperature_2m)
    .join('text')
    .attr('x', (d, i) => i * 5)
    .attr('y', (d) => 500 - d * 6)
    .text((d) => d);
```

Match data with text elements

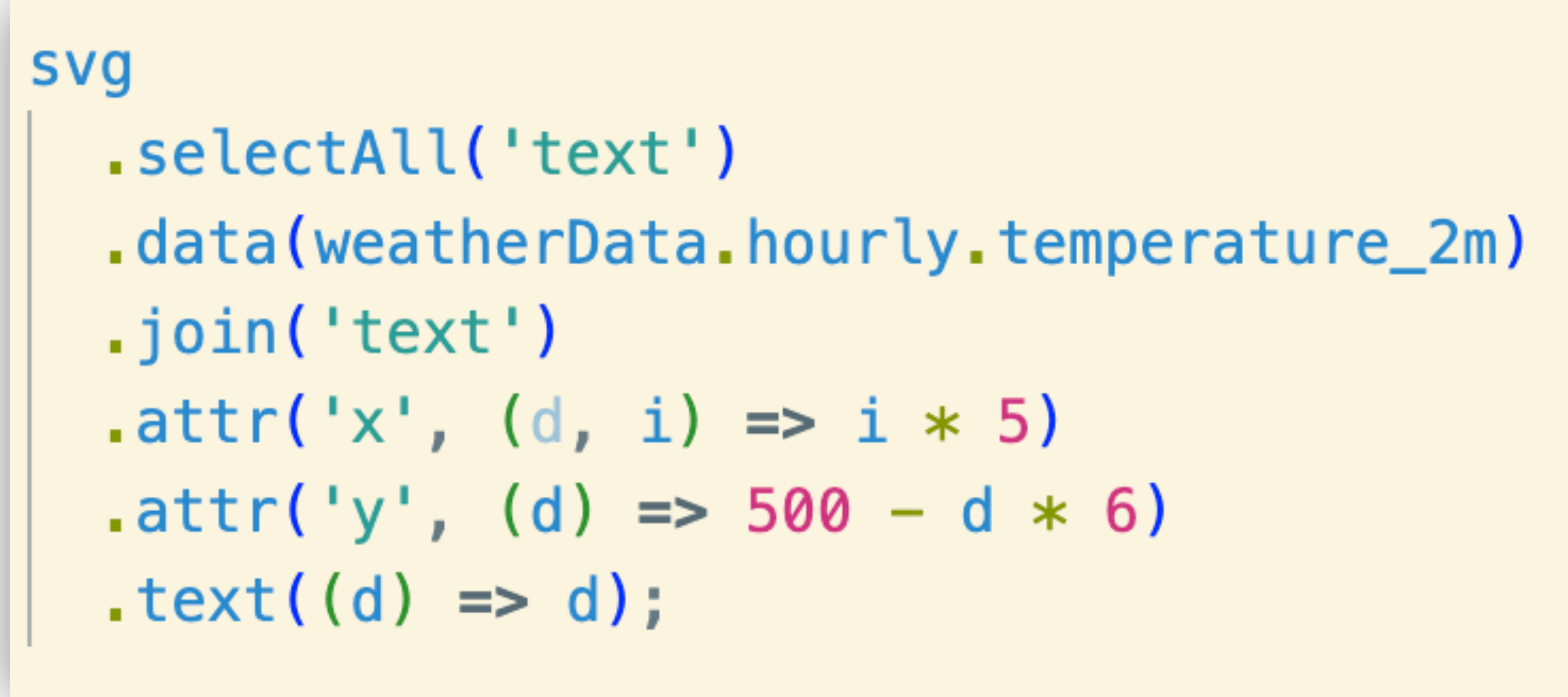
Data Joins



```
svg
  .selectAll('text')
  .data(weatherData.hourly.temperature_2m)
  .join('text')
  .attr('x', (d, i) => i * 5)
  .attr('y', (d) => 500 - d * 6)
  .text((d) => d);
```

Create one new text element for each datum

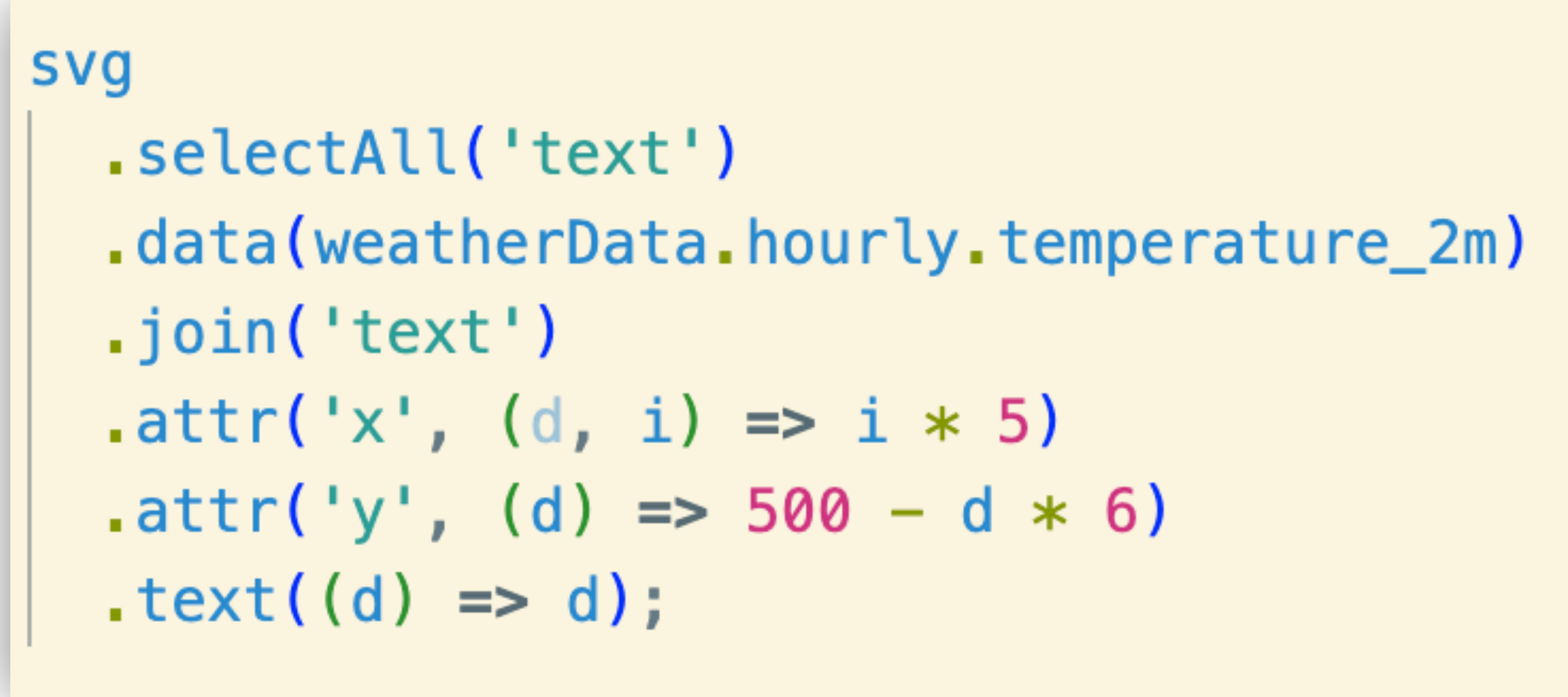
Data Joins



```
svg
    .selectAll('text')
    .data(weatherData.hourly.temperature_2m)
    .join('text')
    .attr('x', (d, i) => i * 5)
    .attr('y', (d) => 500 - d * 6)
    .text((d) => d);
```

Set the x, y, and text content of each text element

Data Joins



```
svg
  .selectAll('text')
  .data(weatherData.hourly.temperature_2m)
  .join('text')
  .attr('x', (d, i) => i * 5)
  .attr('y', (d) => 500 - d * 6)
  .text((d) => d);
```

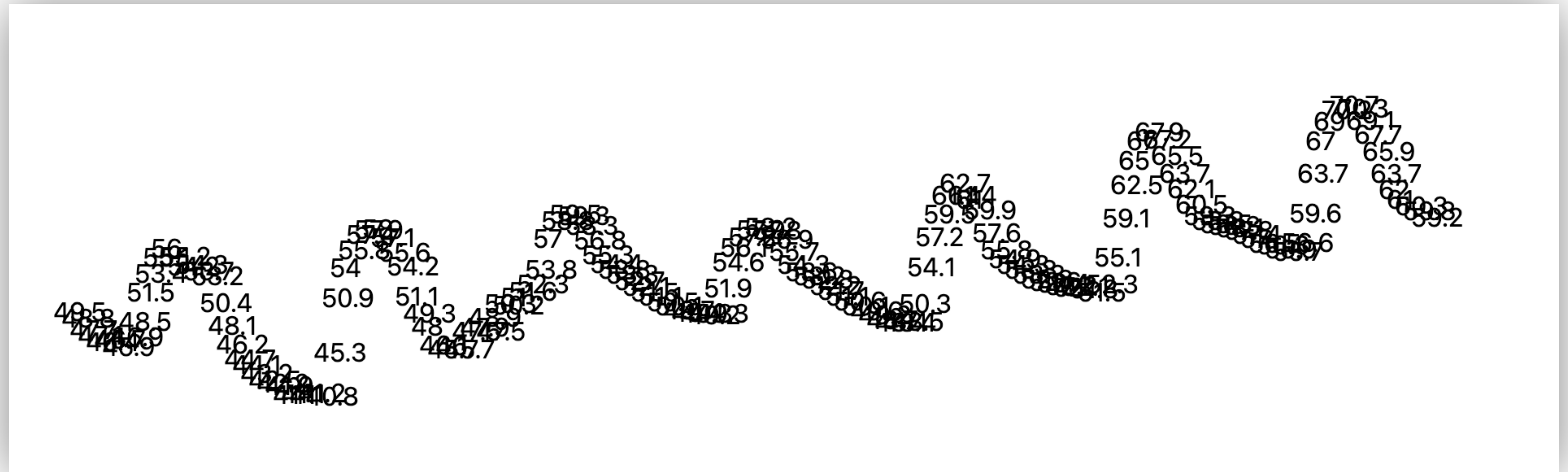
Set the x, y, and text content of each text element

What do the numbers 5, 6, and 500 mean?

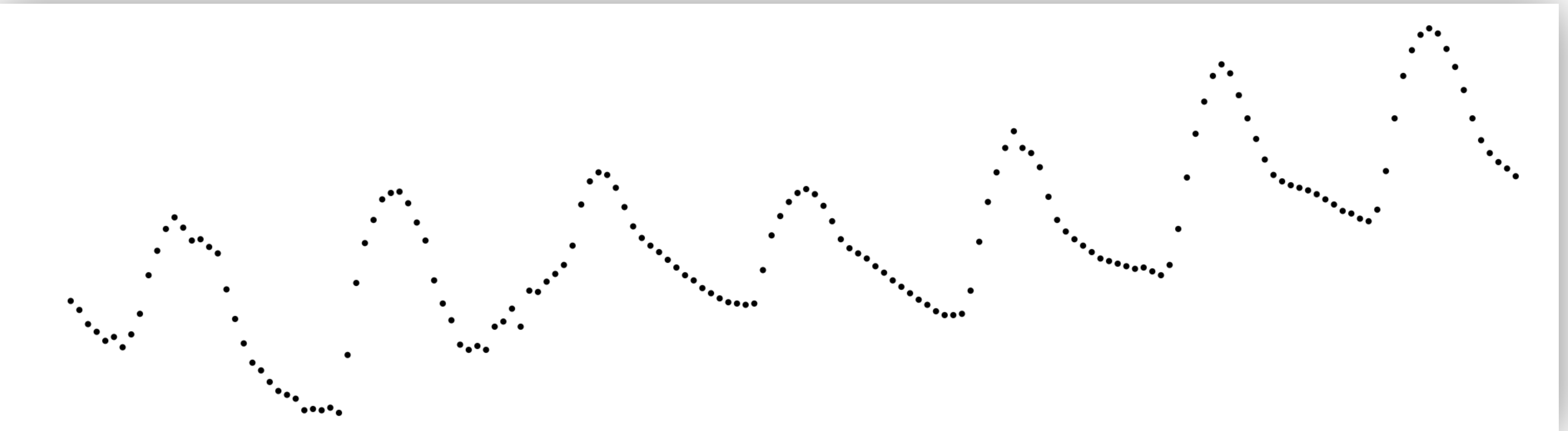
Nothing really, why not do that automatically?

Step 2: Making circles and using d3 scales

Before:



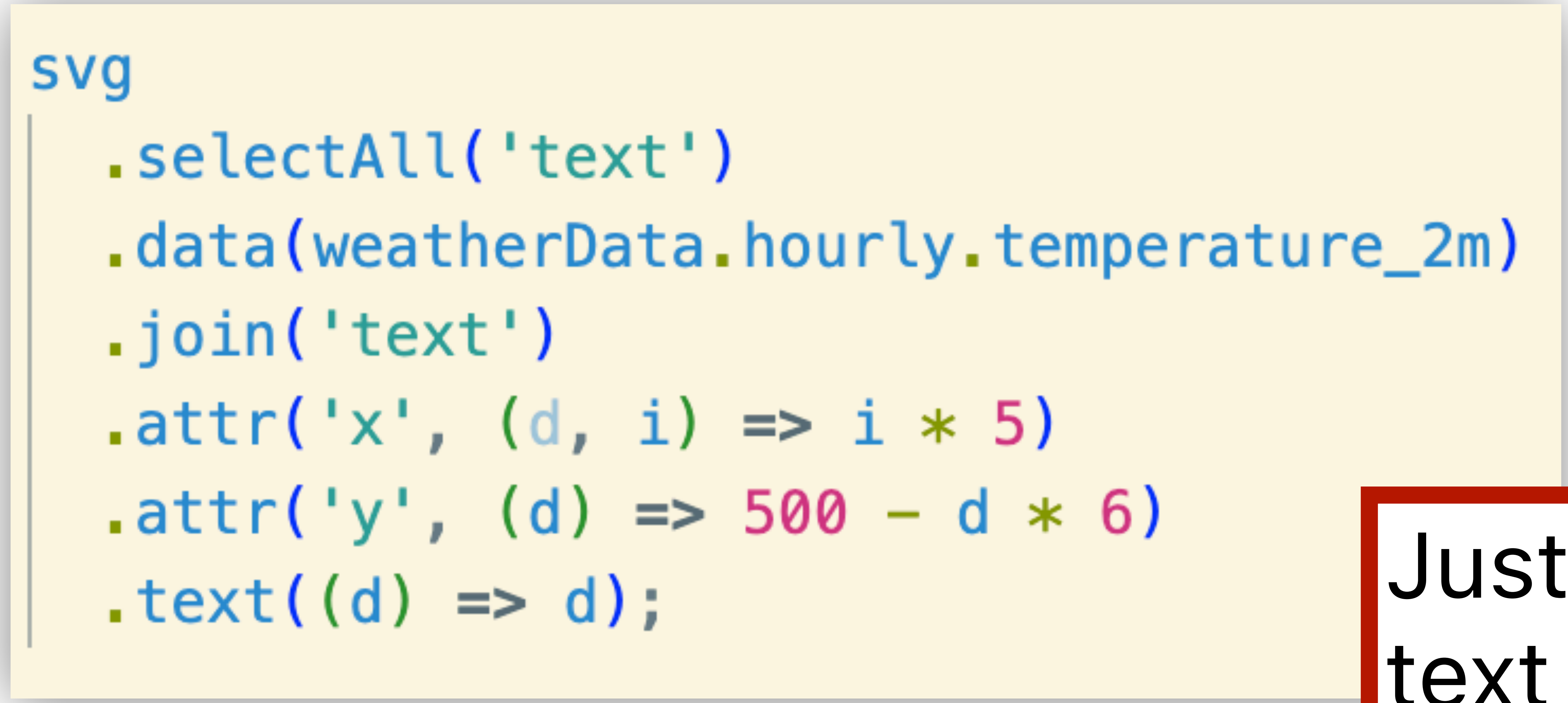
After:



Demo: `d3-lecture/weather02`

Making circles

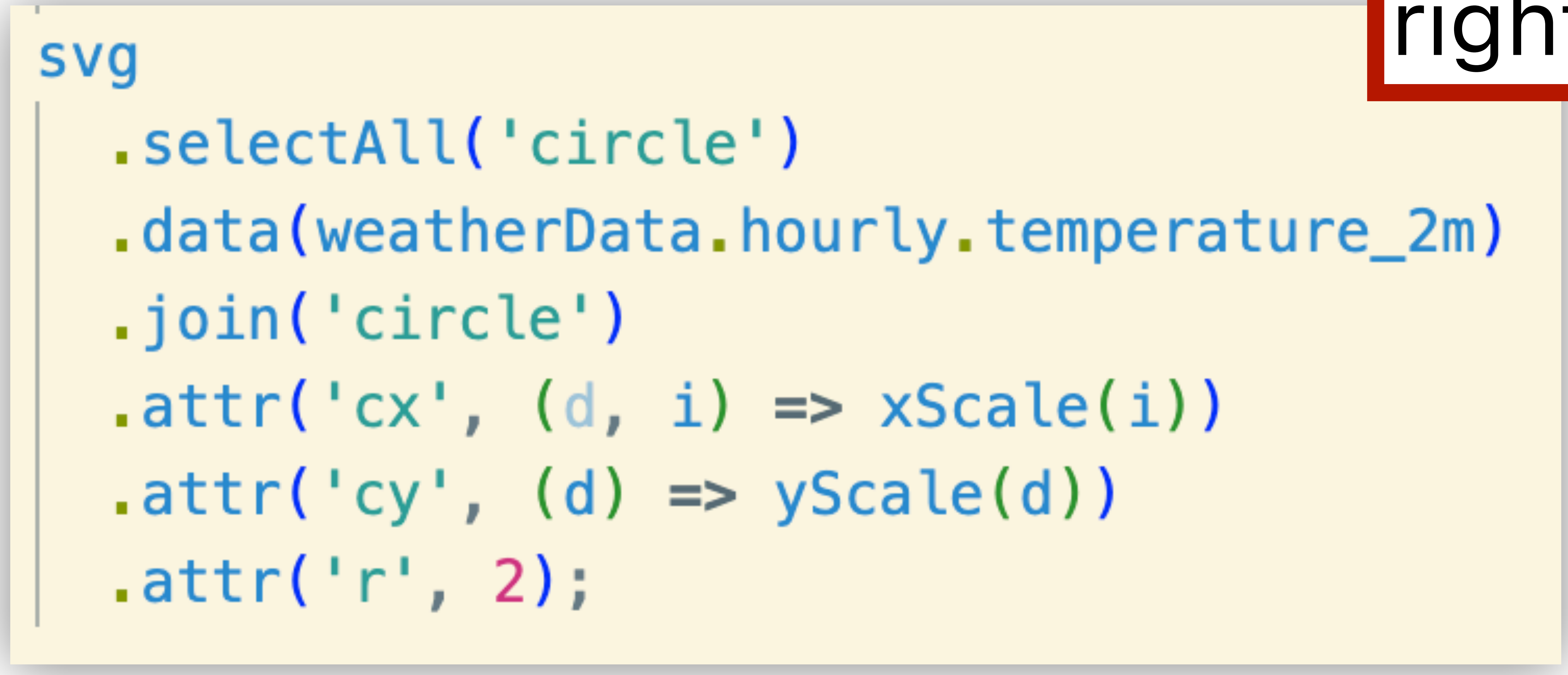
Before:



```
svg
  .selectAll('text')
  .data(weatherData.hourly.temperature_2m)
  .join('text')
  .attr('x', (d, i) => i * 5)
  .attr('y', (d) => 500 - d * 6)
  .text((d) => d);
```

Just needed to swap out text with circle + set the right attributes.

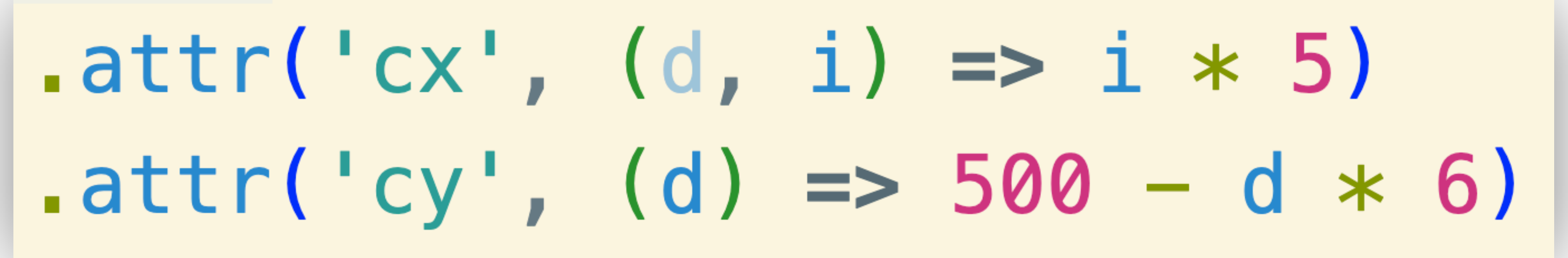
After:



```
svg
  .selectAll('circle')
  .data(weatherData.hourly.temperature_2m)
  .join('circle')
  .attr('cx', (d, i) => xScale(i))
  .attr('cy', (d) => yScale(d))
  .attr('r', 2);
```

Scales

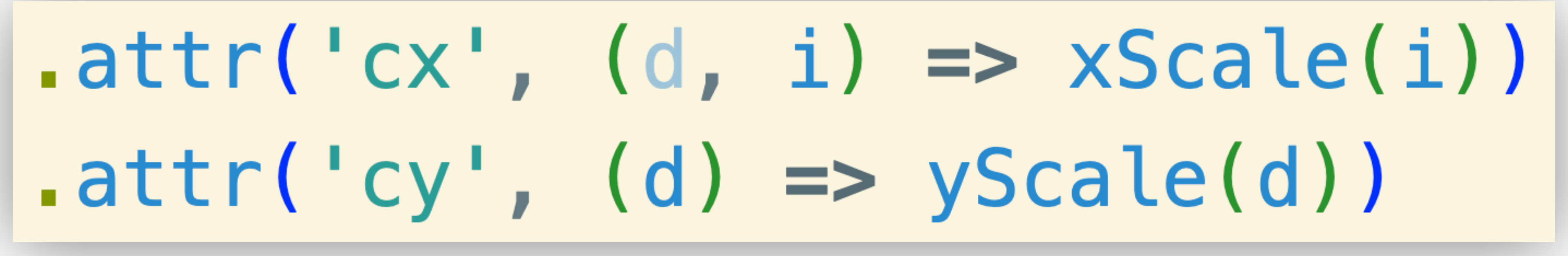
Before:



```
.attr('cx', (d, i) => i * 5)
.attr('cy', (d) => 500 - d * 6)
```

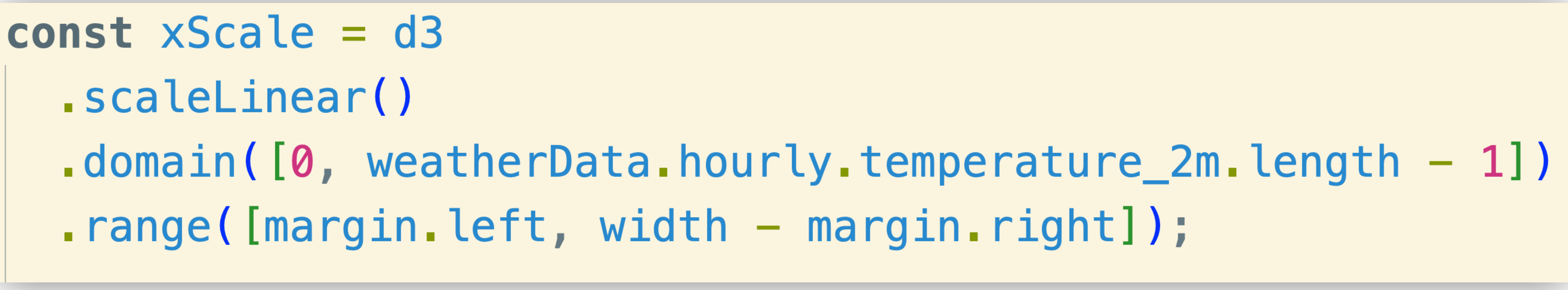
Magic numbers!

After:



```
.attr('cx', (d, i) => xScale(i))
.attr('cy', (d) => yScale(d))
```

D3 scales



```
const xScale = d3
  .scaleLinear()
  .domain([0, weatherData.hourly.temperature_2m.length - 1])
  .range([margin.left, width - margin.right]);
```

Domain = possible inputs

Range = possible outputs

D3 scales will automatically make plot fit the space.

Scales

Input type	Output type	Example scales

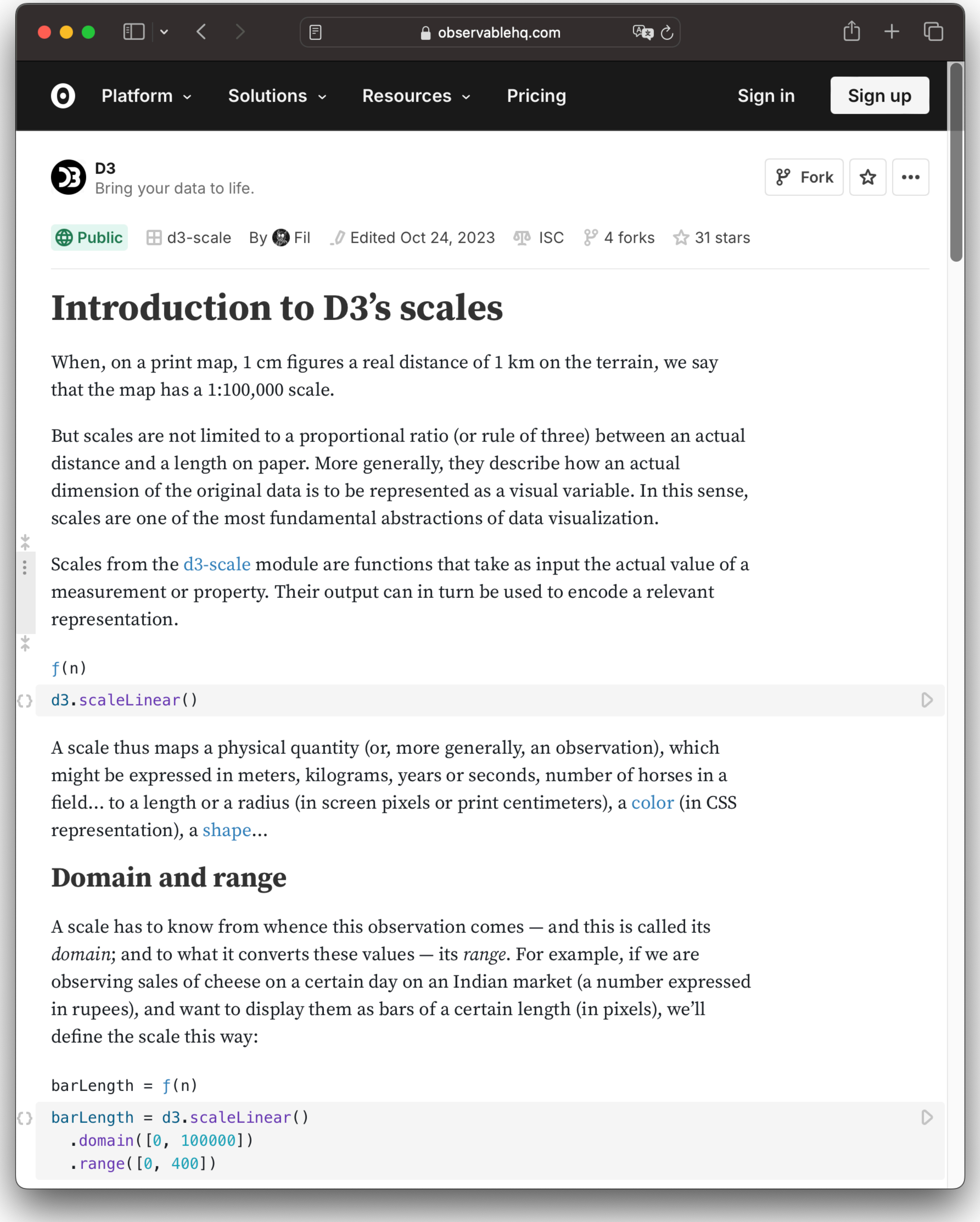
Number	Number	`d3.scaleLinear([10, 130], [0, 960])`
		`d3.scaleLog([1, 10], [0, 960])`

Datetime	Number	`d3.scaleUtc([`
		`  new Date(“2000-01-01"), new Date(“2000-01-02”),`
		`], [0, 960]);`

Category	Category	`d3.scaleOrdinal(["a", "b", “c"],`
		`                [“red", "green", "blue"])`

Number	Color	`d3.scaleSequential([0, 100], d3.interpolateBlues)`
		`d3.scaleDiverging([-1, 0, 1], d3.interpolateRdBu)`

Number	Quantized color	`d3.scaleQuantize([0, 100], d3.schemeBlues[9])`



D3
Bring your data to life.

Public d3-scale By Fil Edited Oct 24, 2023 ISC 4 forks 31 stars

Introduction to D3's scales

When, on a print map, 1 cm figures a real distance of 1 km on the terrain, we say that the map has a 1:100,000 scale.

But scales are not limited to a proportional ratio (or rule of three) between an actual distance and a length on paper. More generally, they describe how an actual dimension of the original data is to be represented as a visual variable. In this sense, scales are one of the most fundamental abstractions of data visualization.

Scales from the d3-scale module are functions that take as input the actual value of a measurement or property. Their output can in turn be used to encode a relevant representation.

```
ƒ(n)
d3.scaleLinear()
```

A scale thus maps a physical quantity (or, more generally, an observation), which might be expressed in meters, kilograms, years or seconds, number of horses in a field… to a length or a radius (in screen pixels or print centimeters), a color (in CSS representation), a shape…

Domain and range

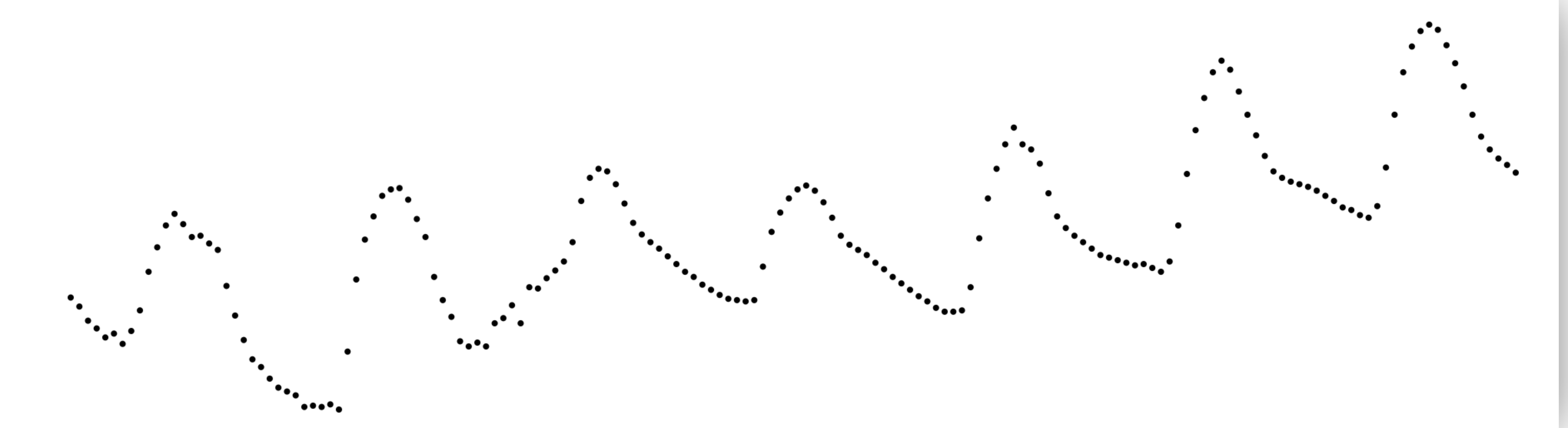
A scale has to know from whence this observation comes — and this is called its *domain*; and to what it converts these values — its *range*. For example, if we are observing sales of cheese on a certain day on an Indian market (a number expressed in rupees), and want to display them as bars of a certain length (in pixels), we'll define the scale this way:

```
barLength = ƒ(n)
barLength = d3.scaleLinear()
  .domain([0, 100000])
  .range([0, 400])
```

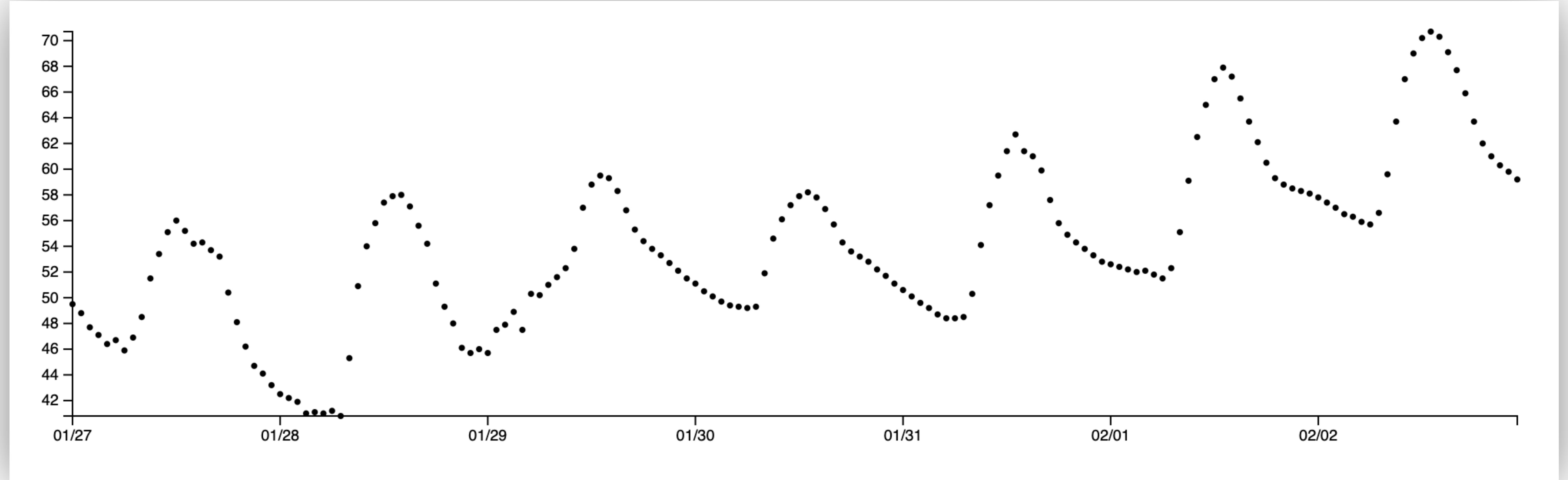
https://observablehq.com/@d3/introduction-to-d3s-scales?collection=@d3/d3-scale

Step 3: Adding axes

Before:

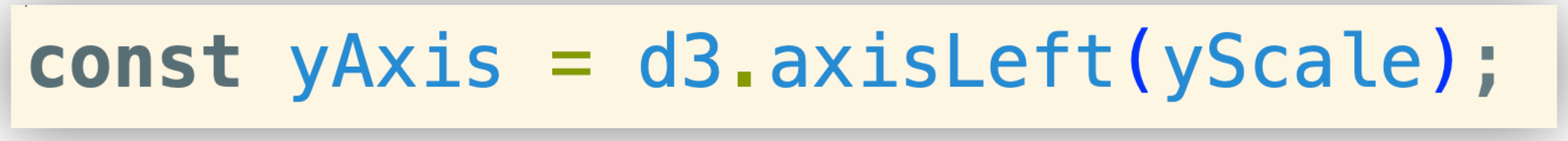


After:



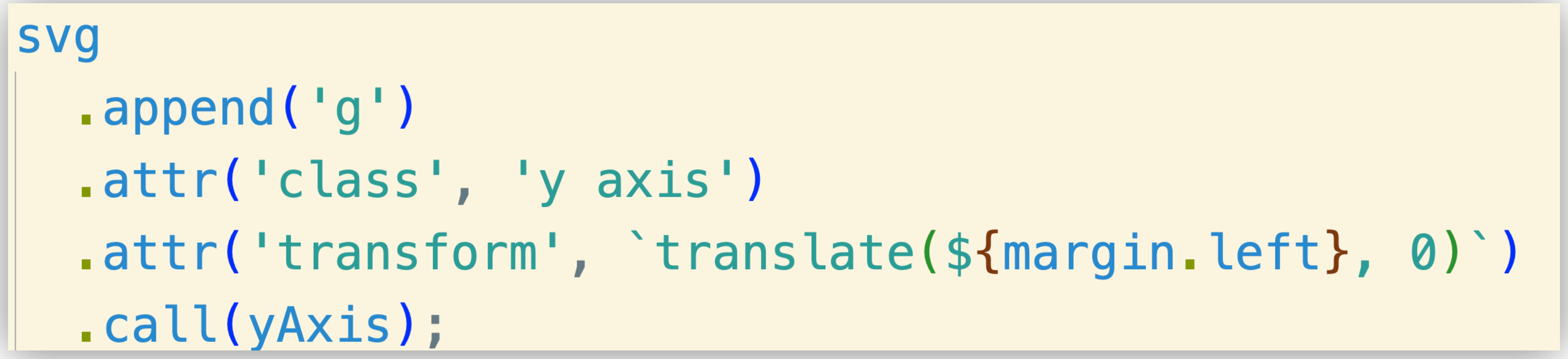
Demo: `d3-lecture/weather03`

Axes



```
const yAxis = d3.axisLeft(yScale);
```

Creates a D3 axis object

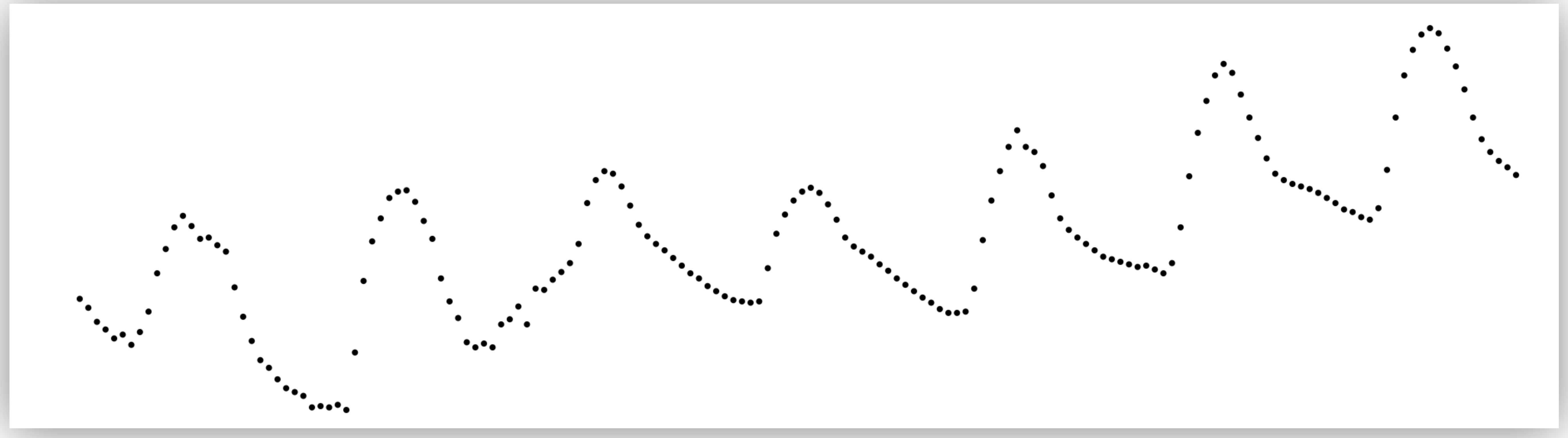


```
svg
  .append('g')
  .attr('class', 'y axis')
  .attr('transform', `translate(${margin.left}, 0)`)
  .call(yAxis);
```

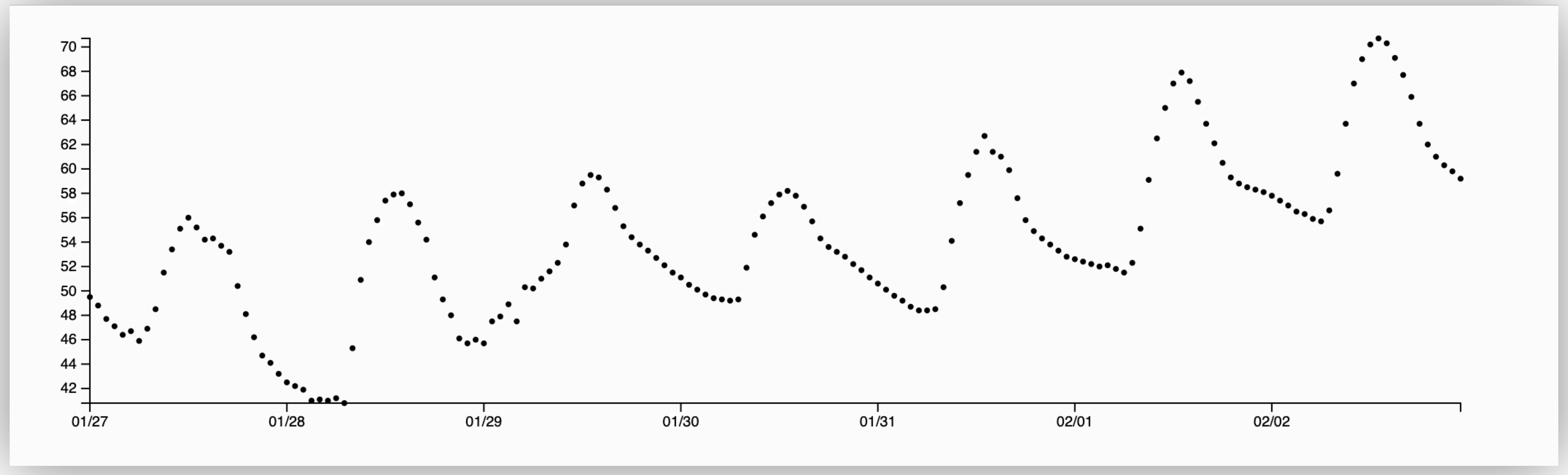
Creates an SVG <g> object, then draws axis into it

Step 4: Adding a basic tooltip

Before:

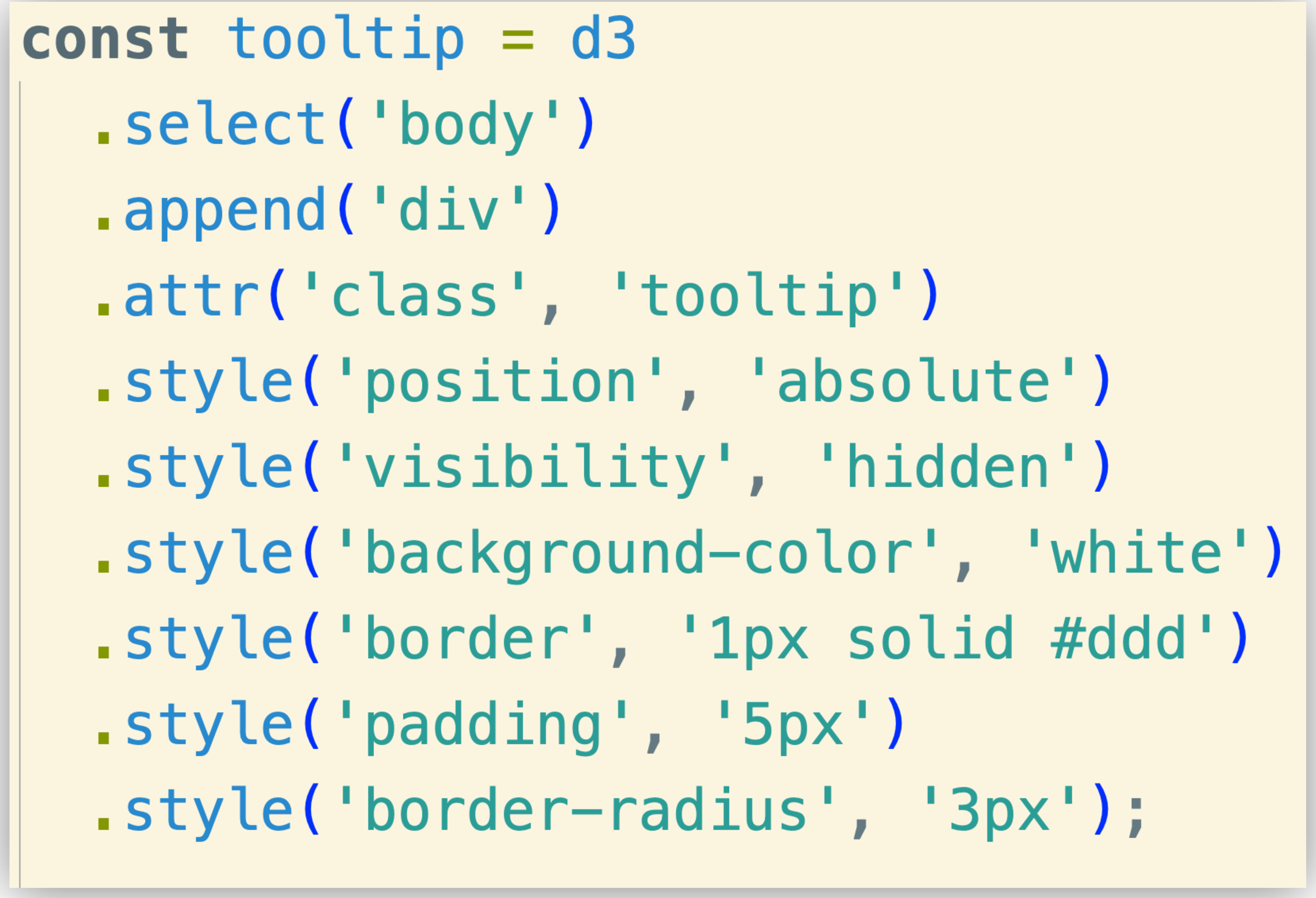


After:



Demo: `d3-lecture/weather04`

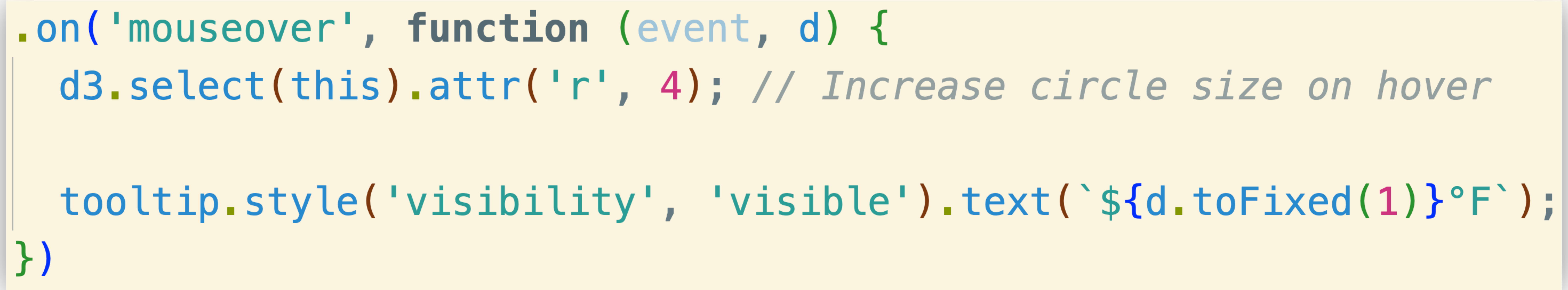
Making a tooltip



```
const tooltip = d3
  .select('body')
  .append('div')
  .attr('class', 'tooltip')
  .style('position', 'absolute')
  .style('visibility', 'hidden')
  .style('background-color', 'white')
  .style('border', '1px solid #ddd')
  .style('padding', '5px')
  .style('border-radius', '3px');
```

Creates a <div>, styles it, and hides it so that it'll only show up with interaction

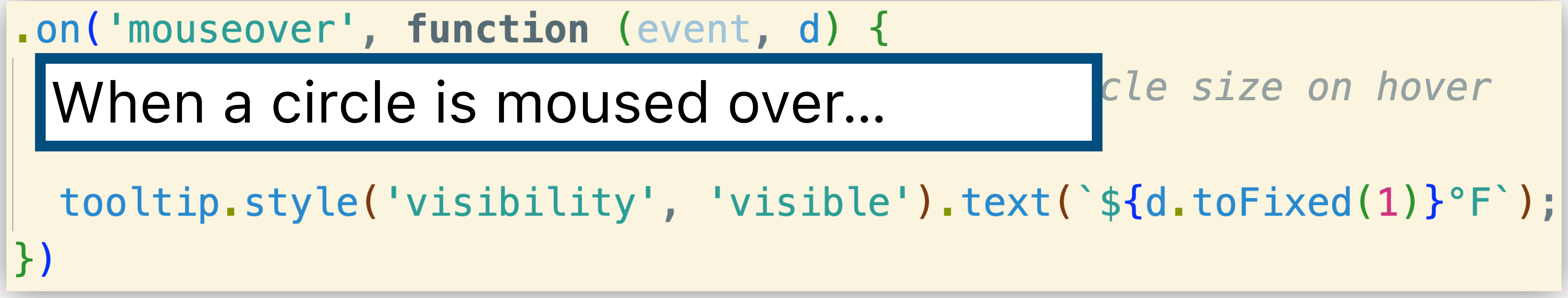
Adding interaction



```
.on('mouseover', function (event, d) {
  d3.select(this).attr('r', 4); // Increase circle size on hover

  tooltip.style('visibility', 'visible').text(`${d.toFixed(1)}°F`);
})
```

D3 version of event listener + handler

Adding interaction

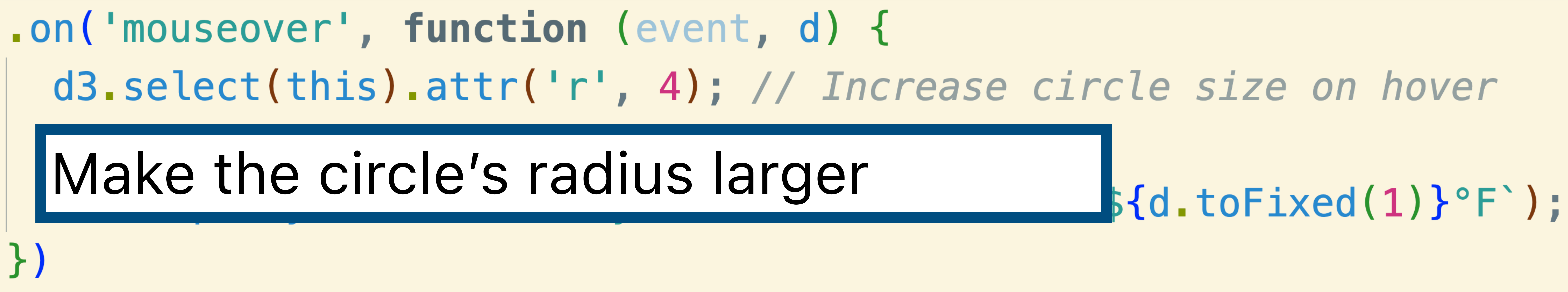


```
.on('mouseover', function (event, d) {
                                                      cle size on hover

  tooltip.style('visibility', 'visible').text(`${d.toFixed(1)}°F`);
})
```

When a circle is moused over…

D3 version of event listener + handler

Adding interaction

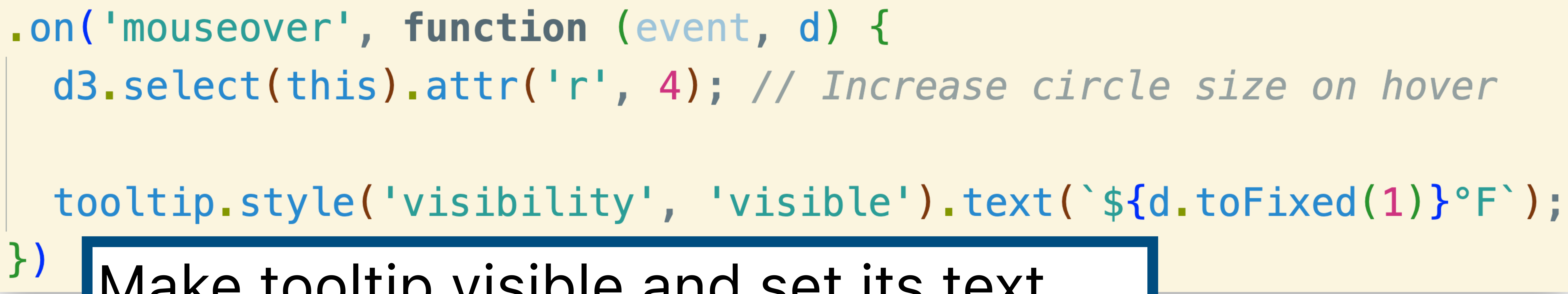


```
.on('mouseover', function (event, d) {
  d3.select(this).attr('r', 4); // Increase circle size on hover
                                                  ${d.toFixed(1)}°F`);
})
```

Make the circle’s radius larger

D3 version of event listener + handler

Adding interaction



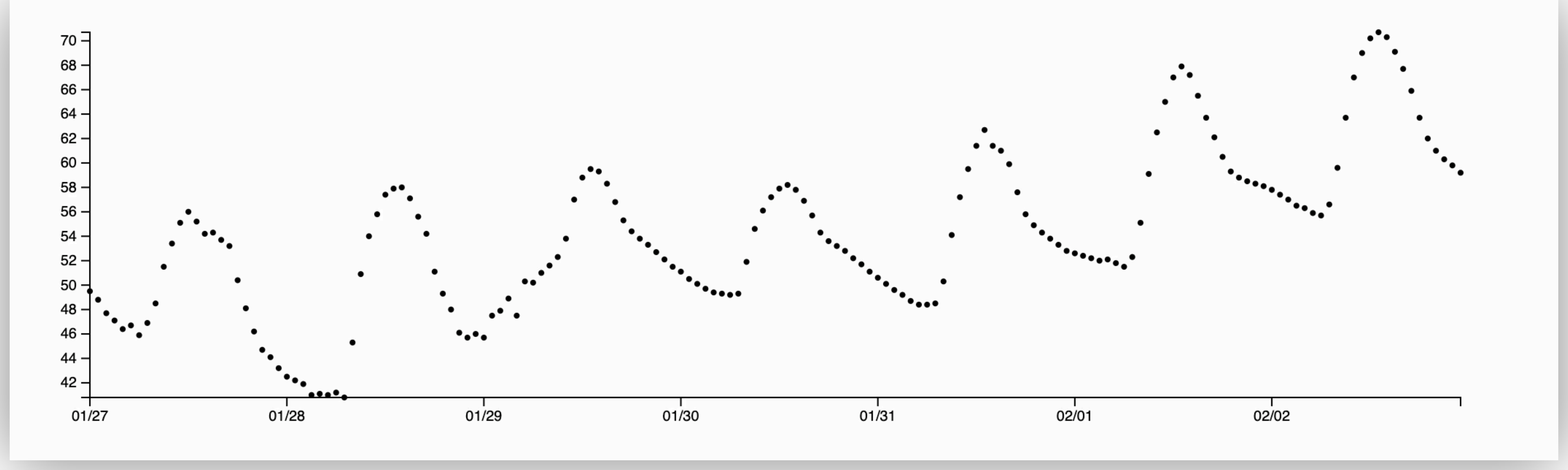
```
.on('mouseover', function (event, d) {
  d3.select(this).attr('r', 4); // Increase circle size on hover

  tooltip.style('visibility', 'visible').text(`${d.toFixed(1)}°F`);
})
```

Make tooltip visible and set its text

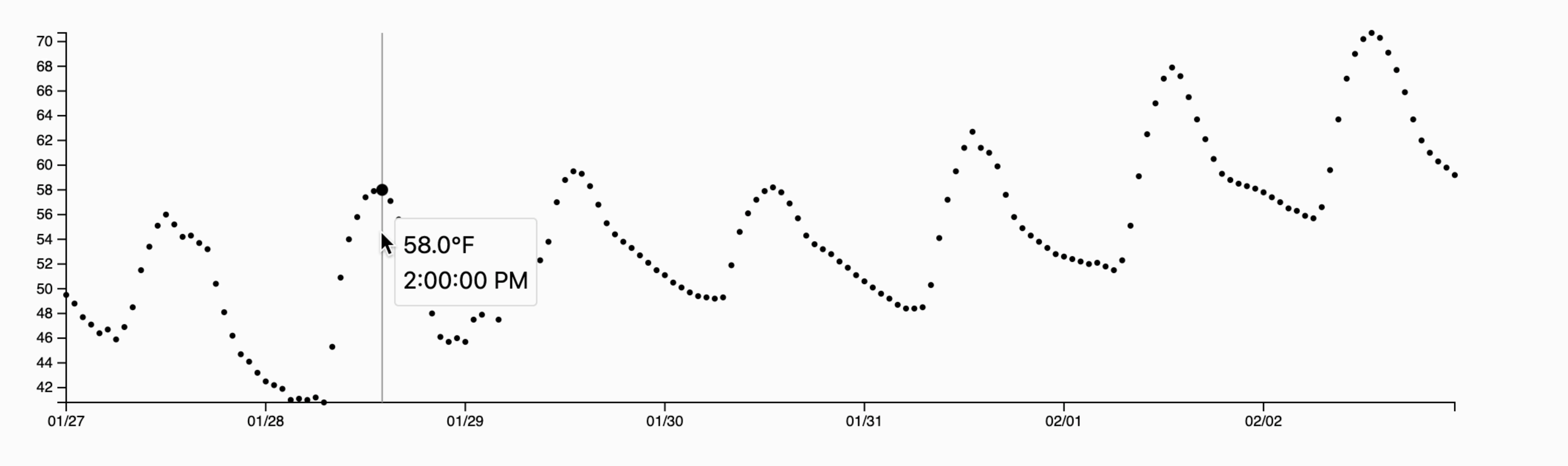
D3 version of event listener + handler

Step 5: Improving our tooltip

Before:

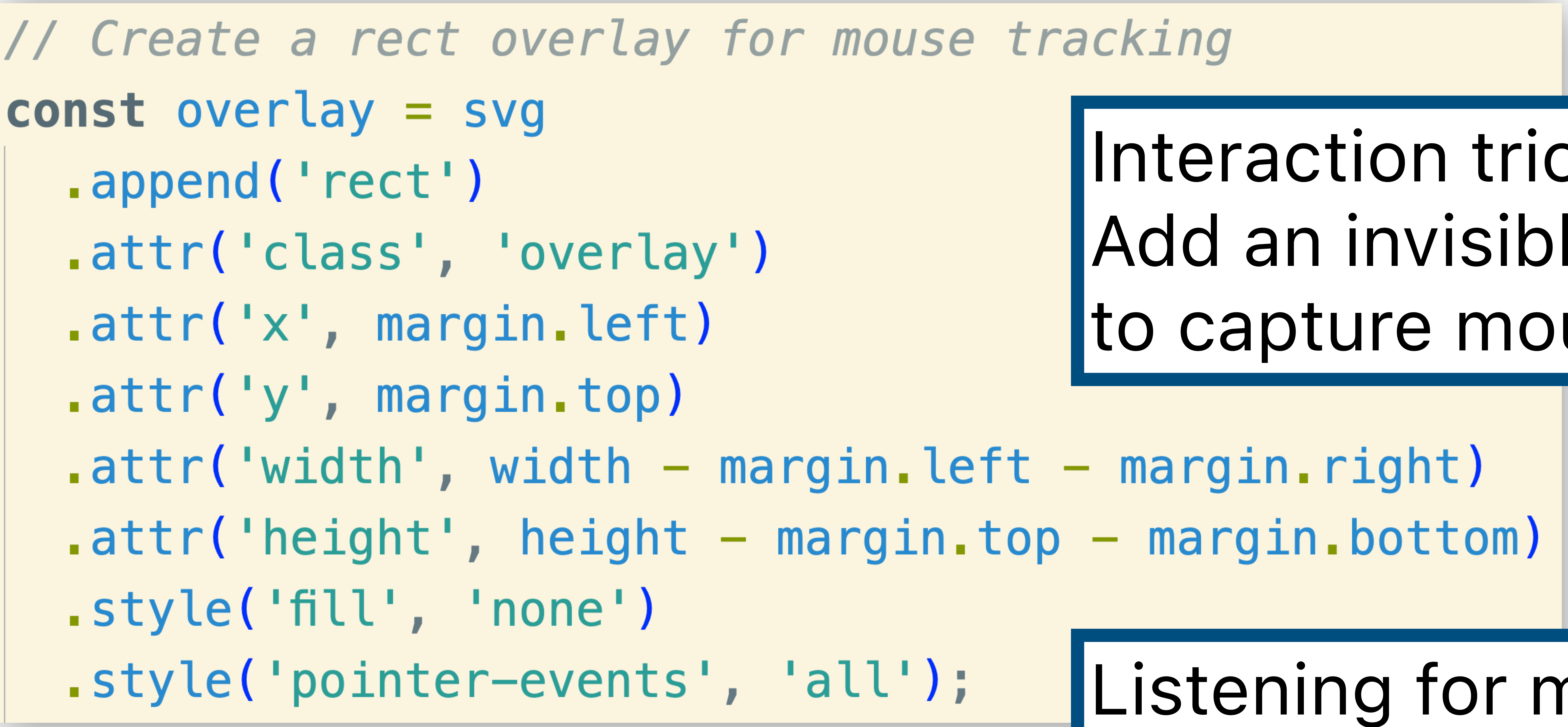


After:



Demo: `d3-lecture/weather05`

Interacting with the plot, not just points

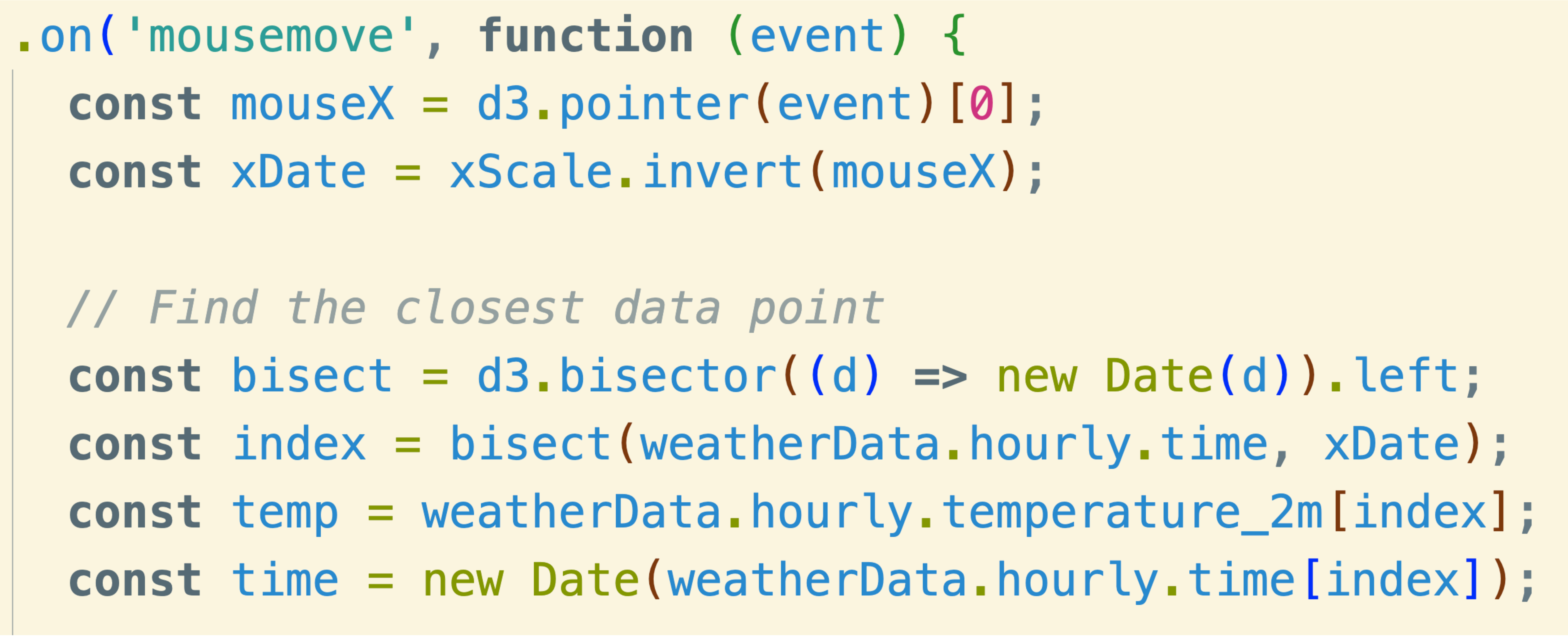


```
// Create a rect overlay for mouse tracking
const overlay = svg
  .append('rect')
  .attr('class', 'overlay')
  .attr('x', margin.left)
  .attr('y', margin.top)
  .attr('width', width - margin.left - margin.right)
  .attr('height', height - margin.top - margin.bottom)
  .style('fill', 'none')
  .style('pointer-events', 'all');
```

Interaction trick:
Add an invisible rectangle just to capture mouse events

Listening for mouse events on the parent <svg> tag also ok

Improving interaction

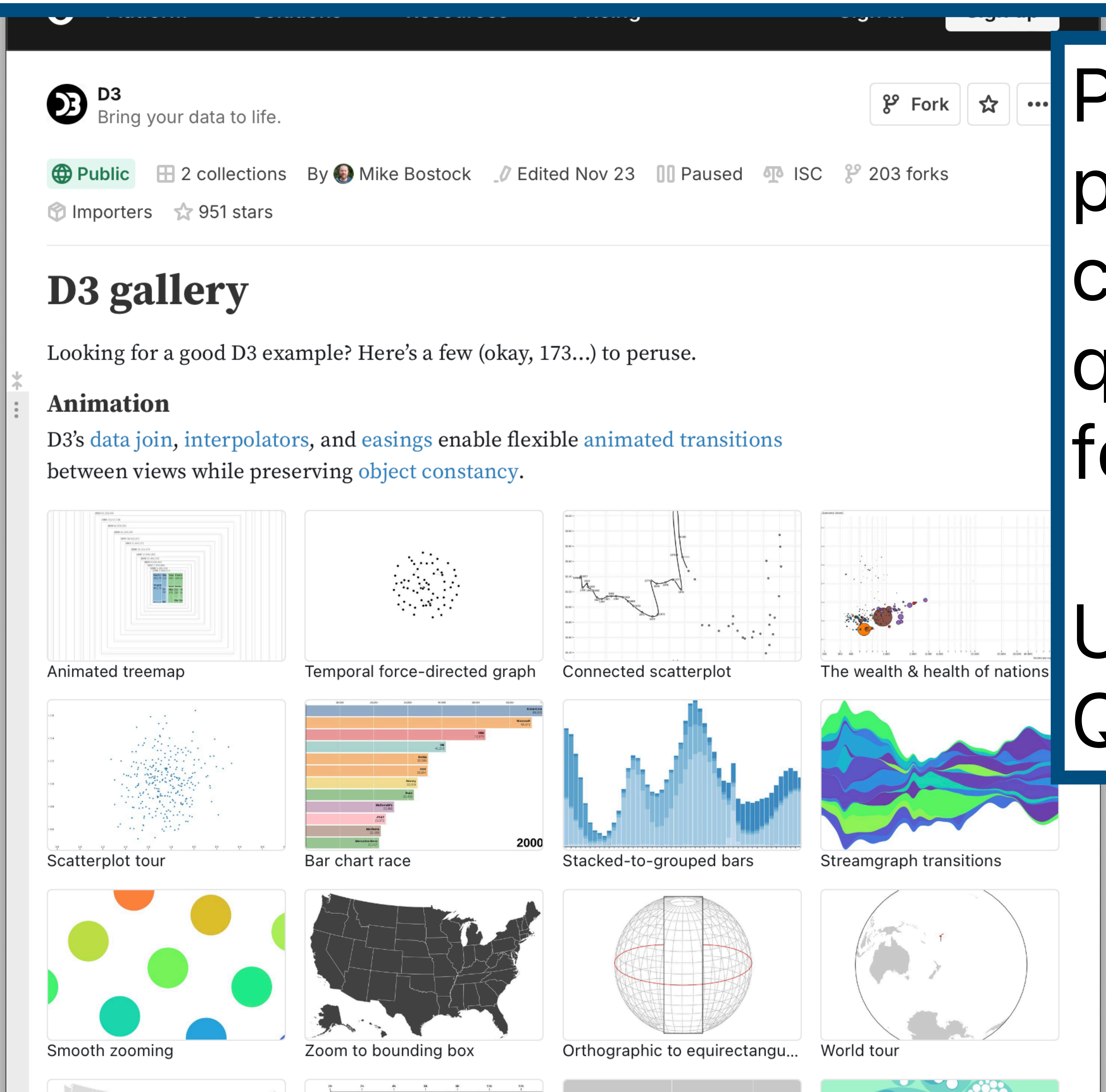


```
.on('mousemove', function (event) {
  const mouseX = d3.pointer(event)[0];
  const xDate = xScale.invert(mouseX);

  // Find the closest data point
  const bisect = d3.bisector((d) => new Date(d)).left;
  const index = bisect(weatherData.hourly.time, xDate);
  const temp = weatherData.hourly.temperature_2m[index];
  const time = new Date(weatherData.hourly.time[index]);
```

Challenge: since we're not hovering directly over points, we have to use the mouse position to find nearest point

You Try: Explain D3 code

https://observablehq.com/@d3/gallery



D3 gallery

Looking for a good D3 example? Here's a few (okay, 173...) to peruse.

Animation

D3's data join, interpolators, and easings enable flexible animated transitions between views while preserving object constancy.

Pick a simple visualization (scatter plot, line plot, bar chart). Explain the code to your neighbor, then write a question about the code using this format:

URL: ...
Question: ...

tryclassbuzz.com
Code: **explain-d3**