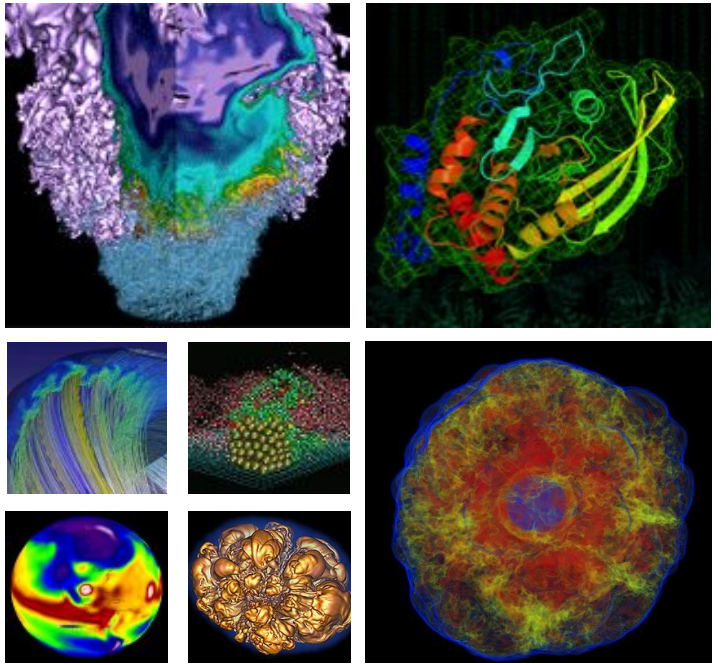
Declarative Python Visualization with Altair



Annette Greiner

NERSC Data Day, October 27, 2022

U.S. DEPARTMENT OF ENERGY | Office of Science

BERKELEY LAB

Declarative Versus Imperative

Imperative

```
draw axes
draw ticks
#layer one
for item in data:
    set color
    draw item
#layer two
for item in data:
…
```

Declarative

```
chart(data).points.encode(
        column1 as x position,
        column2 as y position,
        column3 as color
        )
```

Declarative Versus Imperative

Imperative

```
draw axes
draw ticks
#layer one
for item in data:
    set color
    draw item
#layer two
for item in data:
…
```

How

Declarative

```
chart(data).points.encode(
        column1 as x position,
        column2 as y position,
        column3 as color
        )
```

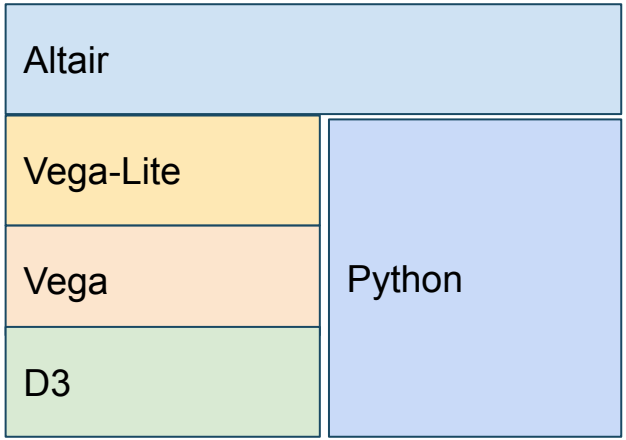
What

Declarative Versus Imperative

Declarative visualization
lets you think
about data and relationships
rather than control flow.

What is Altair?

A python library based on Vega-Lite
Vega-Lite is a high-level grammar of graphics based on Vega
Vega is a declarative grammar with a runtime built on D3
D3 is a low-level Javascript library for data visualization



https://altair-viz.github.io

D3 JavaScript Library

D3js.org

Web outputs!

interaction!

Vega Spec for an Area Graph

```
{
  "$schema": "https://vega.github.io/schema/vega/v5.json",
  "description": "A basic area chart example.",
  "width": 500,
  "height": 200,
  "padding": 5,

  "signals": [
    {
      "name": "interpolate",
      "value": "monotone",
      "bind": {
        "input": "select",
        "options": [
          "basis",
          "cardinal",
          "catmull-rom",
          "linear",
          "monotone",
          "natural",
          "step",
          "step-after",
          "step-before"
        ]
      }
    }
  ],

  "data": [
    {
      "name": "table",
      "values": [
        {"u": 1,  "v": 28}, {"u": 2,  "v": 55},
        {"u": 3,  "v": 43}, {"u": 4,  "v": 91},
        {"u": 5,  "v": 81}, {"u": 6,  "v": 53},
        {"u": 7,  "v": 19}, {"u": 8,  "v": 87},
        {"u": 9,  "v": 52}, {"u": 10, "v": 48},
        {"u": 11, "v": 24}, {"u": 12, "v": 49},
        {"u": 13, "v": 87}, {"u": 14, "v": 66},
        {"u": 15, "v": 17}, {"u": 16, "v": 27},
        {"u": 17, "v": 68}, {"u": 18, "v": 16},
        {"u": 19, "v": 49}, {"u": 20, "v": 15}
      ]
    }
  ],

  "scales": [
    {
      "name": "xscale",
      "type": "linear",
      "range": "width",
      "zero": false,
      "domain": {"data": "table", "field": "u"}
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    {
      "name": "yscale",
      "type": "linear",
      "range": "height",
      "nice": true,
      "zero": true,
      "domain": {"data": "table", "field": "v"}
    }
  ],

  "axes": [
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    {"orient": "left", "scale": "yscale"}
  ],

  "marks": [
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      "from": {"data": "table"},
      "encode": {
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          "x": {"scale": "xscale", "field": "u"},
          "y": {"scale": "yscale", "field": "v"},
          "y2": {"scale": "yscale", "value": 0},
          "fill": {"value": "steelblue"}
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        "update": {
          "interpolate": {"signal": "interpolate"},
          "fillOpacity": {"value": 1}
        },
        "hover": {
          "fillOpacity": {"value": 0.5}
        }
      }
    }
  ]
}
```
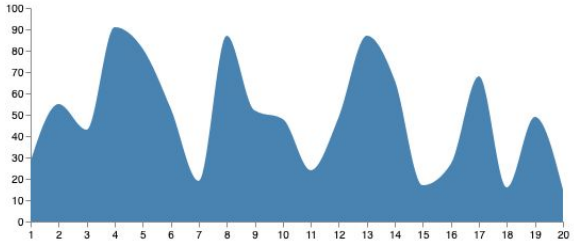
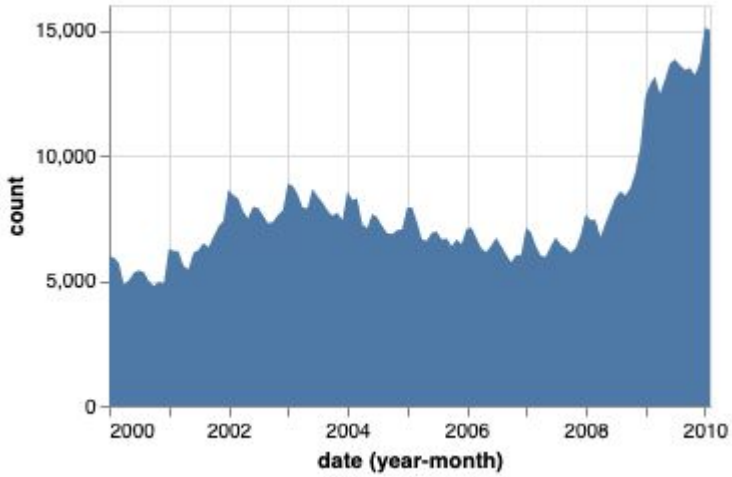



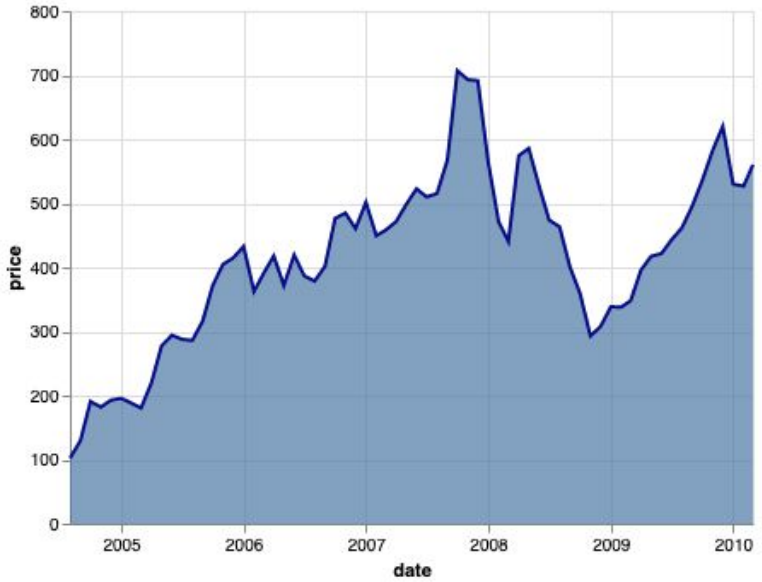
Vega-Lite Spec for an Area Graph

```
{
  "$schema": "https://vega.github.io/schema/vega-lite/v5.json",
  "width": 300,
  "height": 200,
  "data": {"url": "data/unemployment-across-industries.json"},
  "mark": "area",
  "encoding": {
    "x": {
      "timeUnit": "yearmonth", "field": "date",
      "axis": {"format": "%Y"}
    },
    "y": {
      "aggregate": "sum", "field": "count",
      "title": "count"
    }
  }
}
```



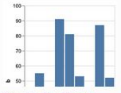
An Area Graph in Altair

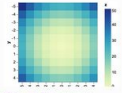
```
From vega_datasets import data
source = data.stocks()

alt.Chart(source).transform_filter(
    'datum.symbol==="GOOG"'
).mark_area(
    line={'color':'darkblue'}).encode(
    alt.X('date:T'),
    alt.Y('price:Q')
)
```

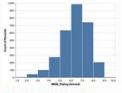


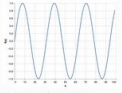
Gallery

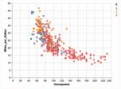
Simple Charts

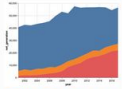

Simple Bar Chart

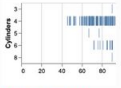

Simple Heatmap


Simple Histogram

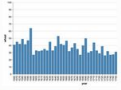

Simple Line Chart

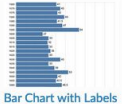

Simple Scatter Plot with Tooltips

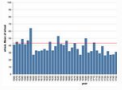

Simple Stacked Area Chart

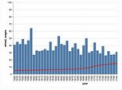

Simple Strip Plot

Bar Charts

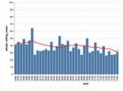

Bar Chart with Highlighted Bar


Bar Chart with Labels

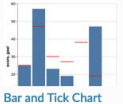

Bar Chart with Line at Mean

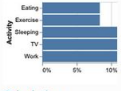

Bar Chart with Line on Dual Axis


Bar Chart with Negative Values

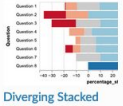

Bar Chart with Rolling Mean


Bar Chart with rounded edges

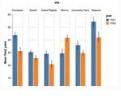

Bar and Tick Chart

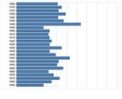

Calculating Percentage of Total

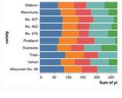

Compact Trellis Grid of Bar Charts

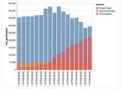

Diverging Stacked Bar Chart

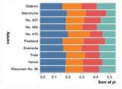

Grouped Bar Chart

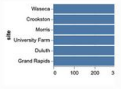


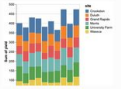


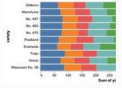


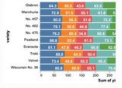

Layered Bar Chart

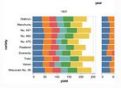

Normalized Stacked Bar Chart


Sorted Bar Chart

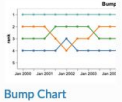

Stacked Bar Chart

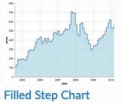

Stacked Bar Chart with Sorted Segments

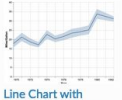

Stacked Bar Chart with Text Overlay

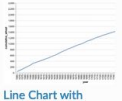

Trellis Stacked Bar Chart

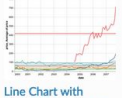
Line Charts

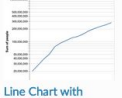

Bump Chart

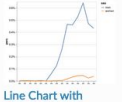

Filled Step Chart

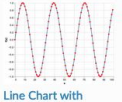

Line Chart with Confidence Interval Band

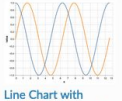

Line Chart with Cumulative Sum


Line Chart with Layered Aggregates


Line Chart with Logarithmic Scale


Line Chart with Percent axis


Line Chart with Points


Line Chart with Sequence Generator


Line Chart with Varying Size

Line Chart with datum

Line Chart with datum for color

Area Charts

Area Chart with Gradient

Cumulative Count Chart

Faceted Density Estimates

Horizon Graph

Interval Selection Example

Layered Area Chart

Normalized Stacked Area Chart

Stacked Density Estimates

Streamgraph

Trellis Area Chart

Trellis Area Sort Chart

Circular Plots

Donut Chart

Pacman Chart

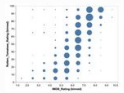
Pie Chart

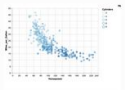
Pie Chart with Labels

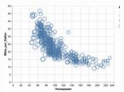
Radial Chart

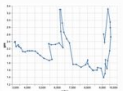
Gallery

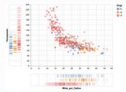
Scatter Plots

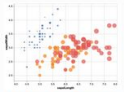

Binned Scatterplot

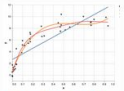

Brushing Scatter Plot to show data on a table

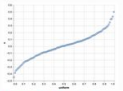

Bubble Plot

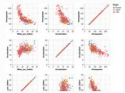

Connected Scatterplot (Lines with Custom Paths)

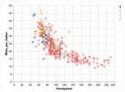

Dot Dash Plot

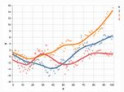

Multifeature Scatter Plot


Polynomial Fit Plot with Regression Transform

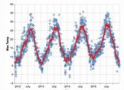

Quantile-Quantile Plot

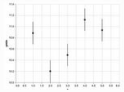

Scatter Matrix

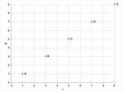

Scatter Plot with Href

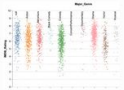

Scatter Plot with LOESS Lines


Scatter Plot with Minimap


Scatter Plot with Rolling Mean


Simple Scatter Plot with Errorbars


Simple Scatter Plot with Labels


Stripplot

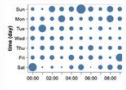
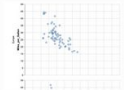
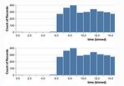


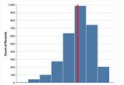
Table Bubble Plot (Github Punch Card)

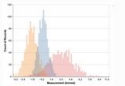

Trellis Scatter Plot

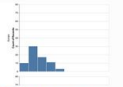

Wind Vector Map

Histograms


Histogram with Responsive Bins


Histogram with a Global Mean Overlay


Layered Histogram


Trellis Histogram

Maps


Choropleth Map


Locations of US Airports

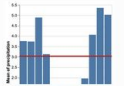

Repeated Choropleth Map

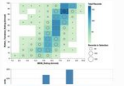

US Income by State: Wrapped Facet

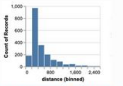

World Map

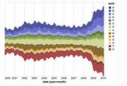

World Projections

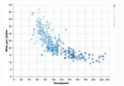
Interactive Charts

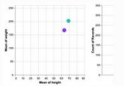

Interactive Average

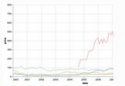

Interactive Chart with Cross-Highlight


Interactive Crossfilter

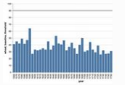

Interactive Legend

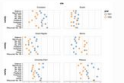

Interactive Rectangular Brush

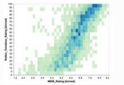

Interactive Scatter Plot and Linked Layered Histogram


Multi-Line Highlight


Multi-Line Tooltip


Bar Chart with Highlighted Segment


Becker's Barley Trellis Plot (wrapped facet)


Binned Heatmap

Boxplot with Min/Max Whiskers

Candlestick Chart

Comet Chart Example

Error Bar with Standard Deviation

Error Bars showing Confidence Interval

Facetted Scatterplot with marginal histograms

Gantt Chart

Hexbin Chart

Image tooltip

Isotype Grid

Layered chart with Dual-Axis

Multiple Marks

Normalized Parallel Coordinates Example

Parallel Coordinates Example

Pyramid Pie Chart

Ranged Dot Plot

Ridgeline plot Example

Sorted Error Bars showing Confidence Interval

Stem and Leaf Plot

Text over a Heatmap

Violin Plot

What Can Altair Take as Input?

Dataframes

CSV

TSV

JSON

URLs

Geo data (e.g., GeoDataFrame, GeoJSON)

What Can Altair Output?

JSON

HTML

PDF

SVG

PNG

Altair in Jupyter at NERSC

Create a Conda env to use as a Jupyter kernel

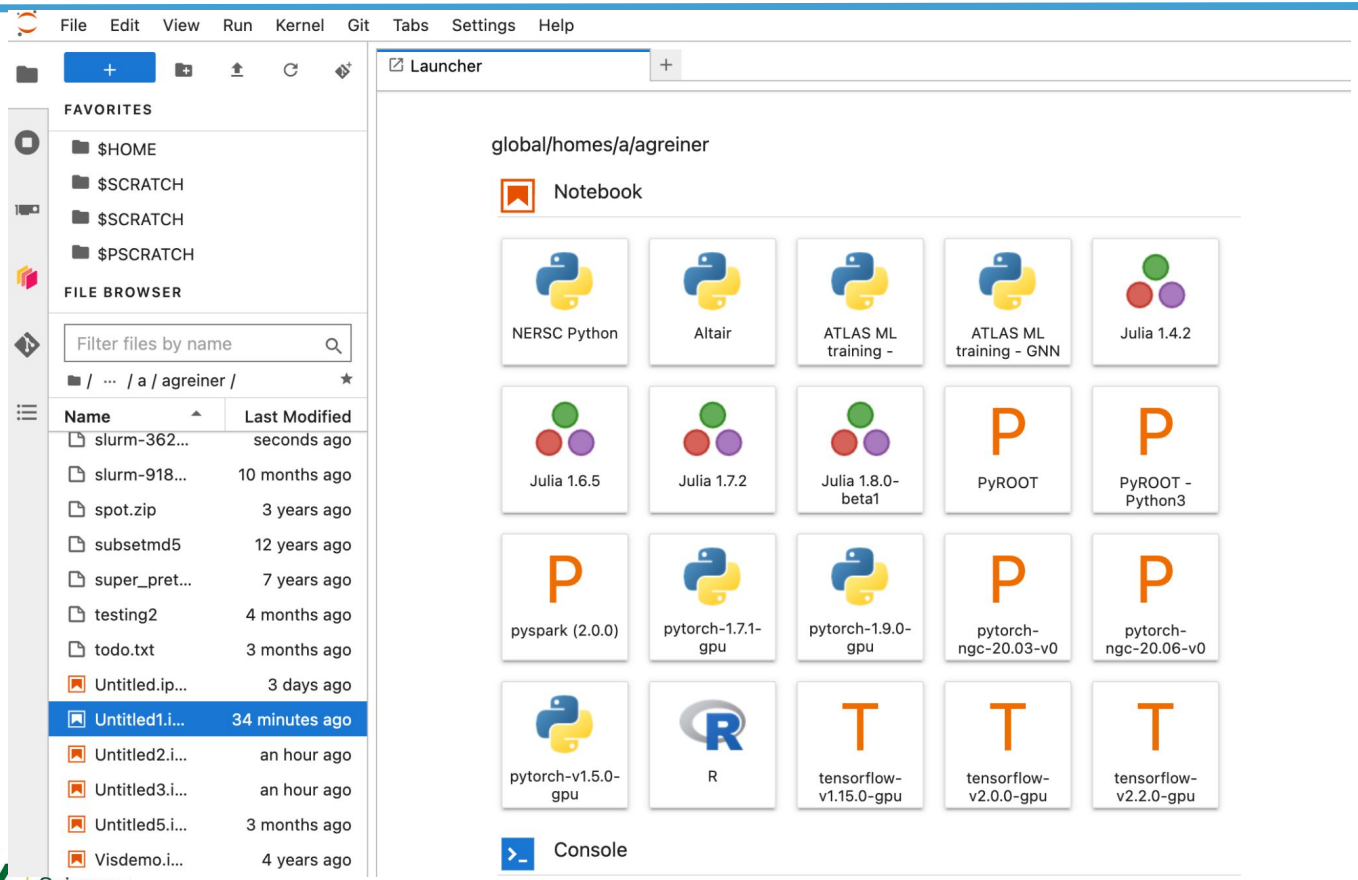
```
agreiner@cori06>module load python
agreiner@cori06>conda create -n altair python=3.9 ipykernel altair
agreiner@cori06>conda activate altair
(altair) agreiner@cori06>python -m ipykernel install --user --name altair
--display-name Altair
Installed kernelspec altair in
/global/u1/a/agreiner/.local/share/jupyter/kernels/altair
```

Grab some handy datasets to play with

```
(altair) agreiner@cori06>conda install -c conda-forge vega_datasets
```

https://github.com/altair-viz/vega_datasets

Altair in Jupyter at NERSC



Demo

Thank You