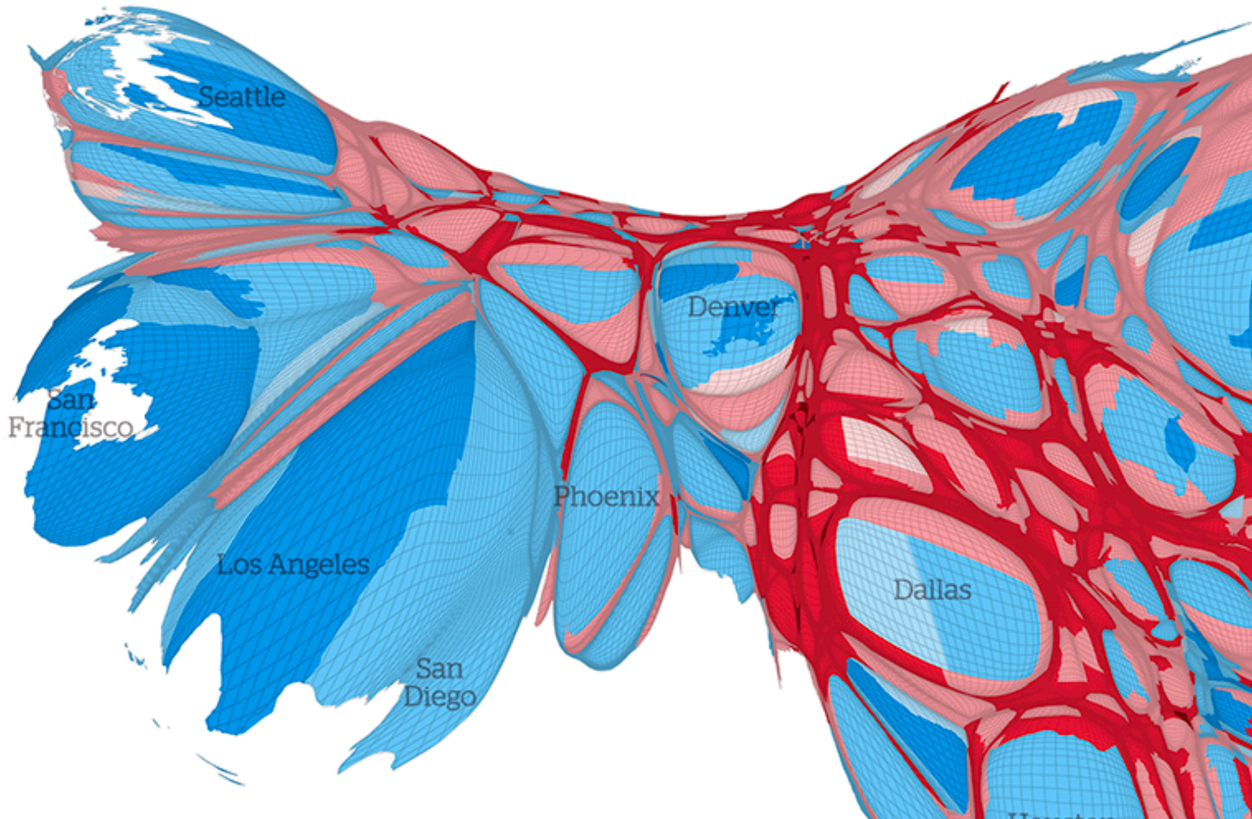
Geospatial Data Science, Spring 2023

# Lecture 14: Spatial Data Visualization

Instructor: Ane Rahbek Vierø

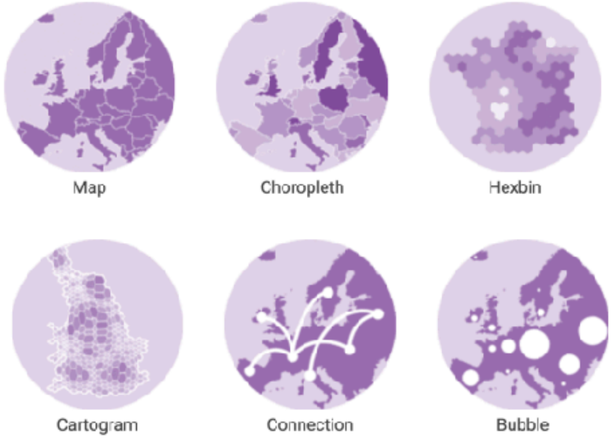
May 8, 2023




IT UNIVERSITY OF COPENHAGEN

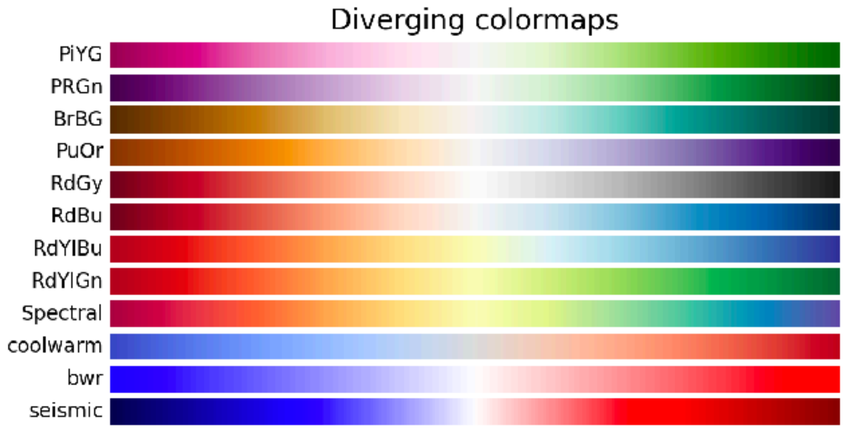
# WHAT WE WILL LEARN TODAY

## Map types




## Cartographic pitfalls

## Tips & tricks for better spatial data viz



“**Geographic visualization** can be defined as the use of concrete visual representations … to make spatial contexts and problems visible, so as to engage the **most powerful human information processing abilities**, those associated with vision.

MacEachren (1994)

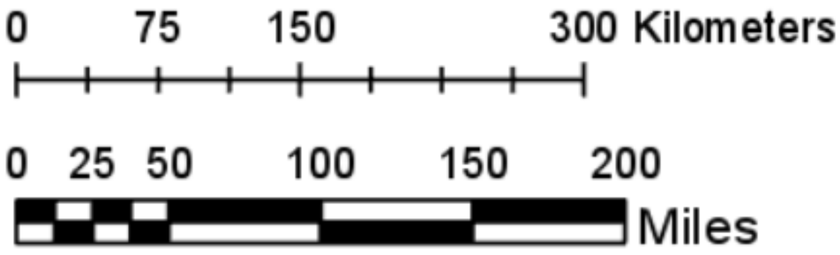
# maps, cartography

maps, cartography

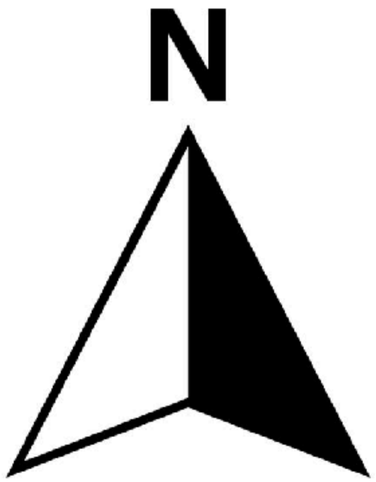
→

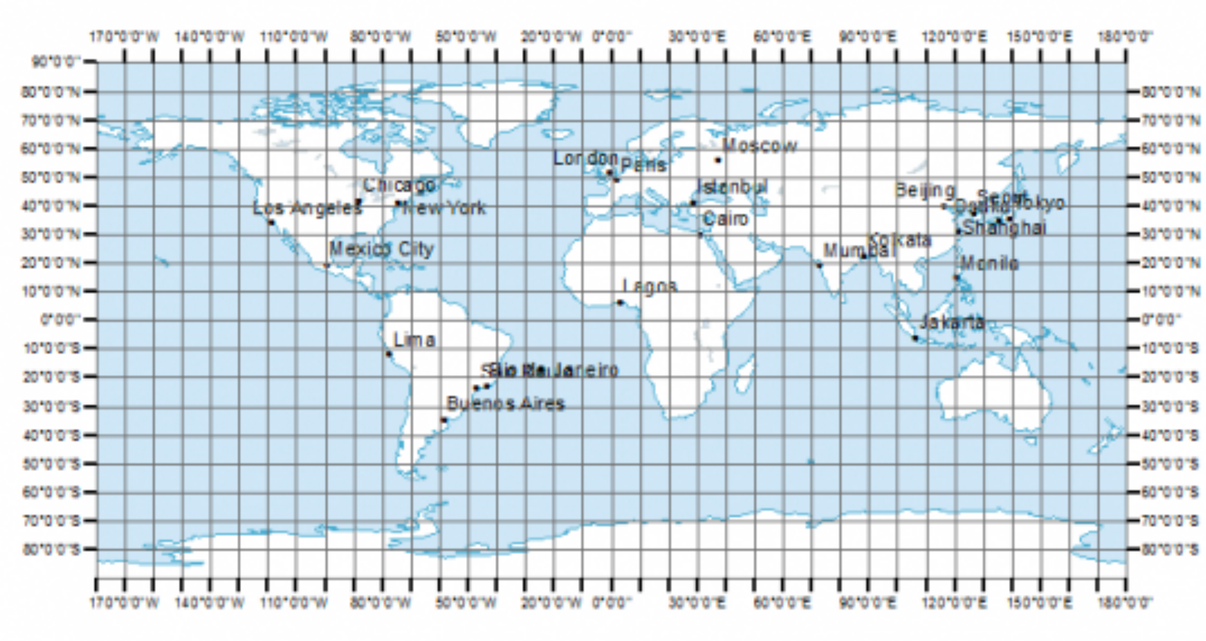
**geospatial data visualization**

# Geospatial data visualization follows different rules




Optional

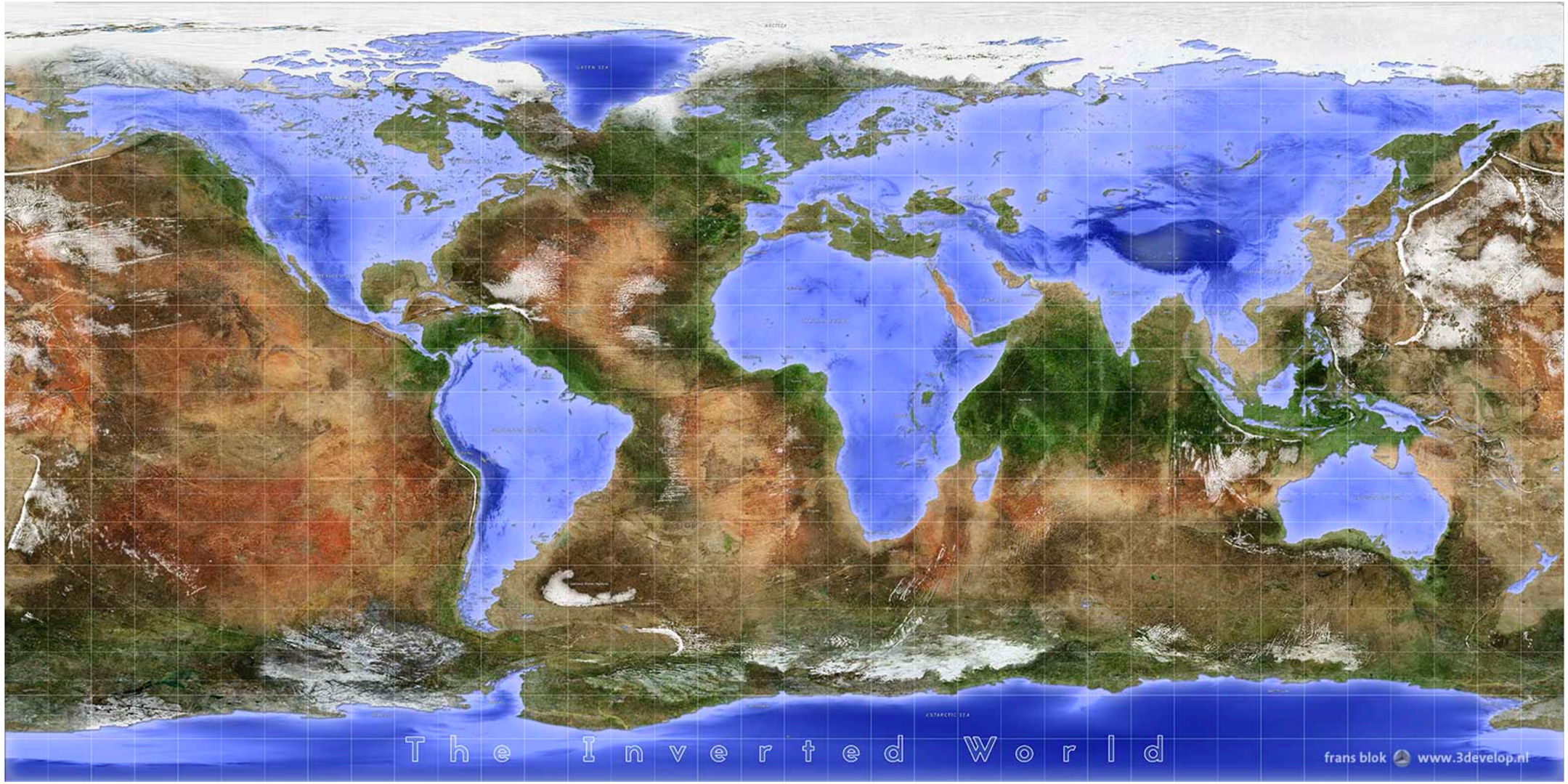


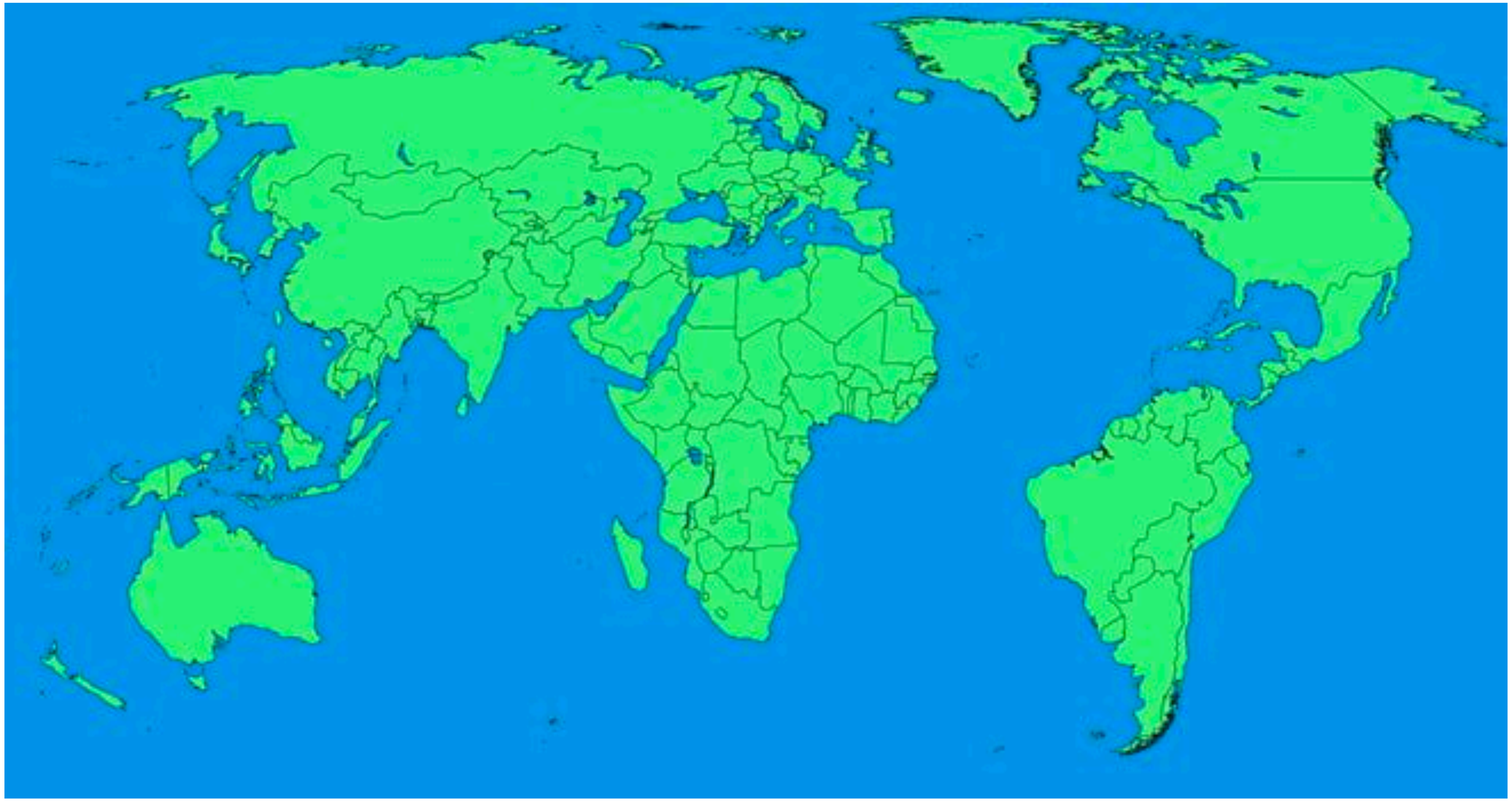

“the map crap”

# Visualizing geospatial data comes with special considerations

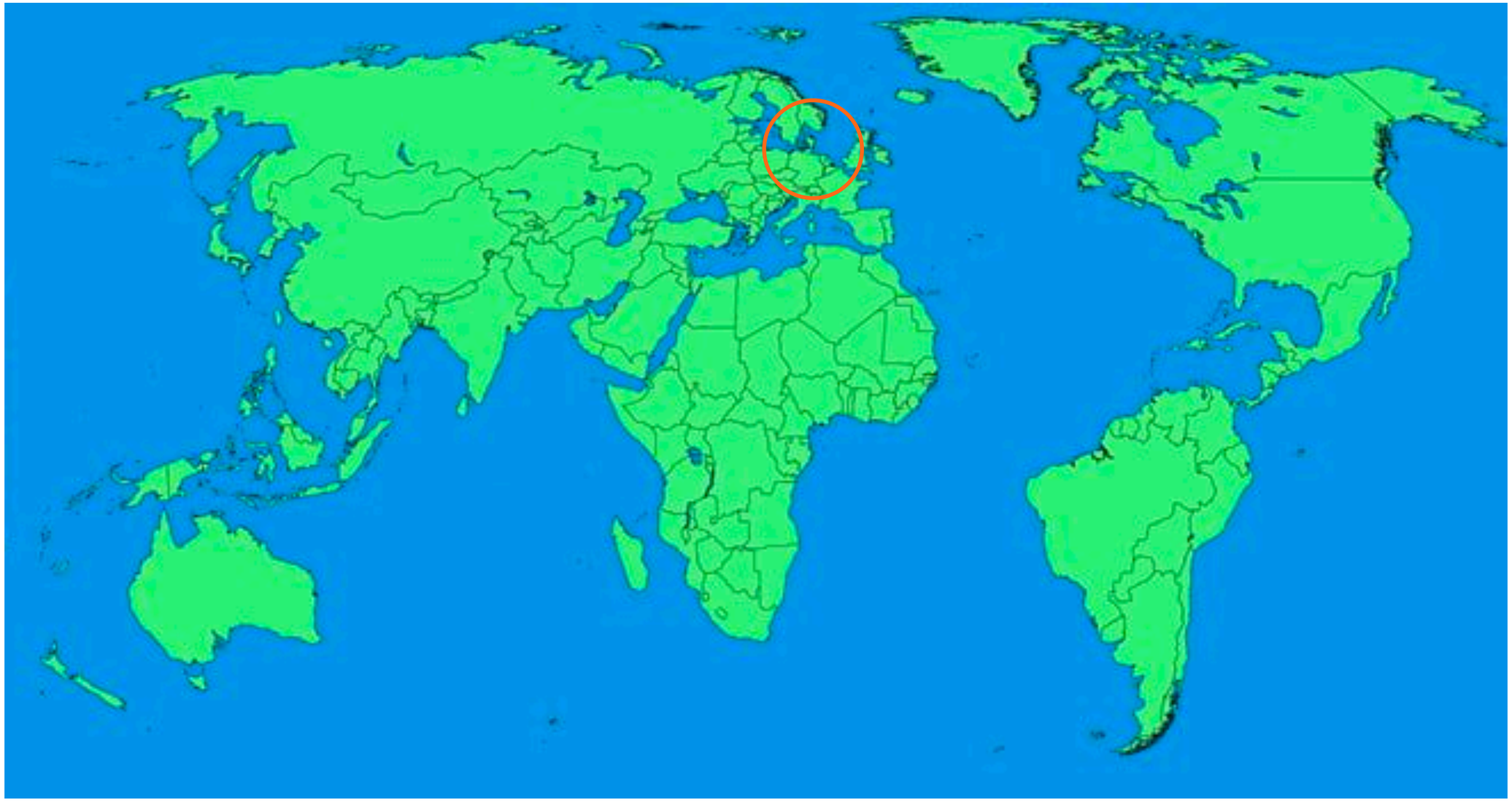
# Geospatial Data Visualizations need to follow certain conventions to be comprehensible…



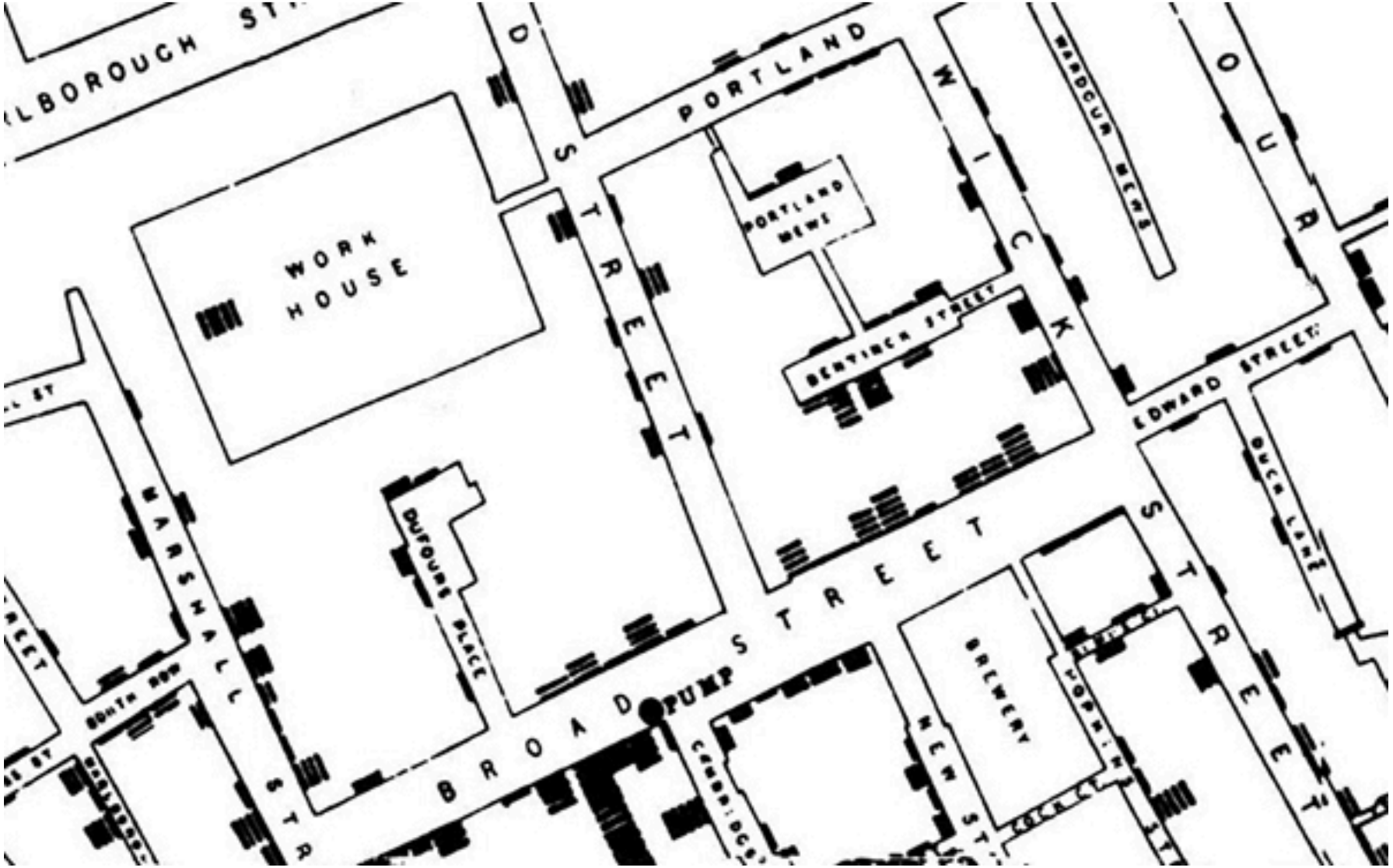
# Geospatial Data Visualizations need to follow certain conventions to be comprehensible…



# Geospatial Data Visualizations need to follow certain conventions to be comprehensible…



# Maps have authority



# Maps have authority

https://www.businessinsider.com/most-controversial-places-on-google-maps-2013-5?r=US&IR=T

# Maps have authority

# Maps have authority

# There are many reasons to make a map

**Analyse (exploratory)**

- Explore data
- Identify patterns and trends
- Formulate/test hypothesis
- Decide on next steps in data analysis/modeling

https://cusp.tbm.tudelft.nl/courses/epa1316/lectures/05-visualisation.pdf

# There are many reasons to make a map

**Analyse (exploratory)**

- Explore data
- Identify patterns and trends
- Formulate/test hypothesis
- Decide on next steps in data analysis/modeling

**Communicate (explanatory)**

- Present information and ideas
- Explain and inform about data/results
- Provide evidence and support
- Influence and persuade

https://cusp.tbm.tudelft.nl/courses/epa1316/lectures/05-visualisation.pdf

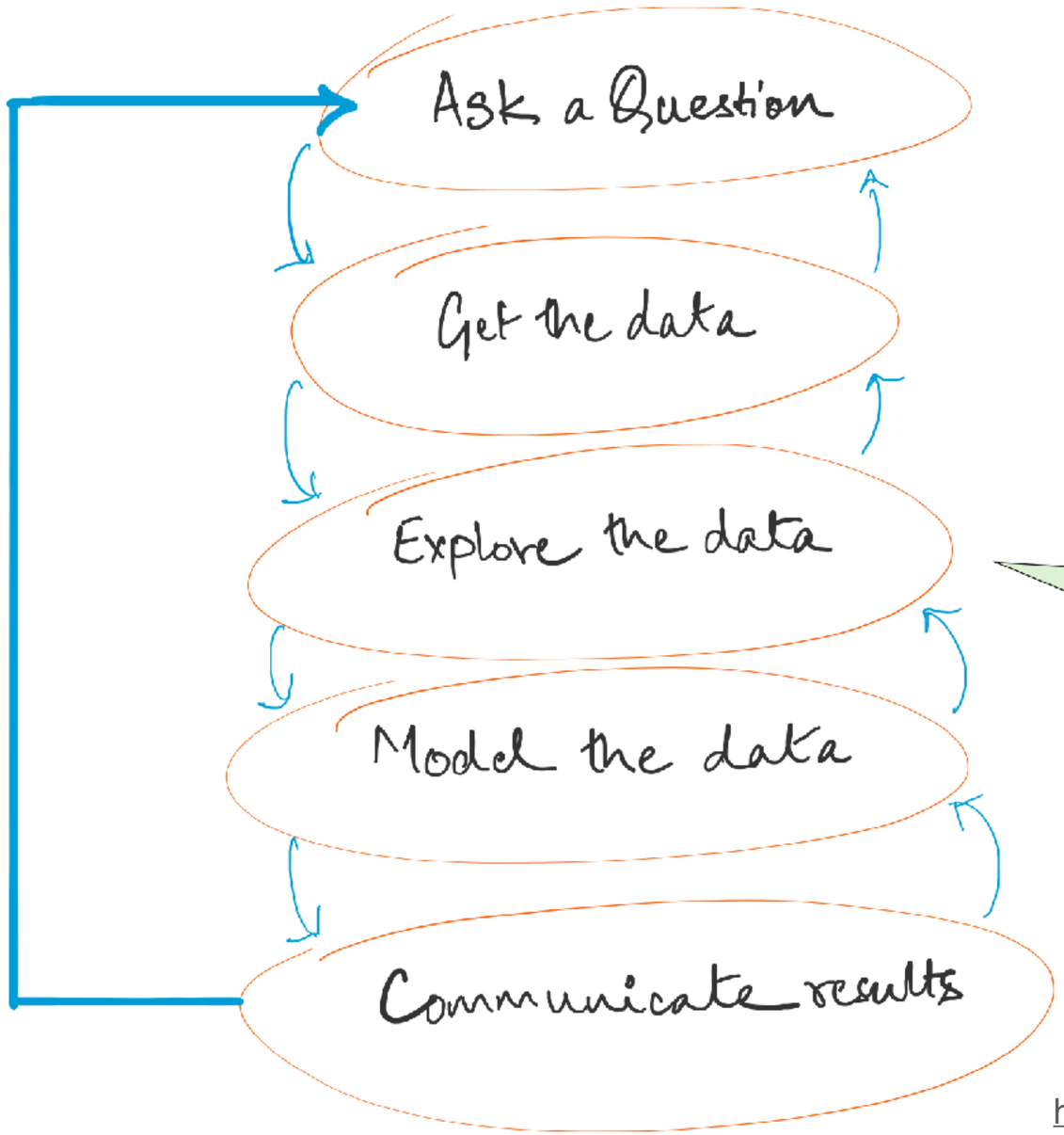
A map is usually providing an answer to an **implicit question**

The map design determines **how** the question is **answered**

# Discuss in groups

- How are you/will you be using maps in your project?
- Are they exploratory or explanatory?
- Which questions should your maps answer?

# Visualizing should be done throughout the process




**Plot** the data.
Are there **anomalies**?
Are there **patterns**?

https://cusp.tbm.tudelft.nl/courses/epa1316/lectures/05-visualisation.pdf

# Map typologies

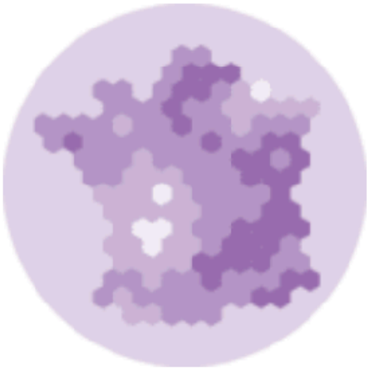
# Different types of maps

…for different purposes

…for different data types

Map

Choropleth



Hexbin

Cartogram

Connection

Bubble

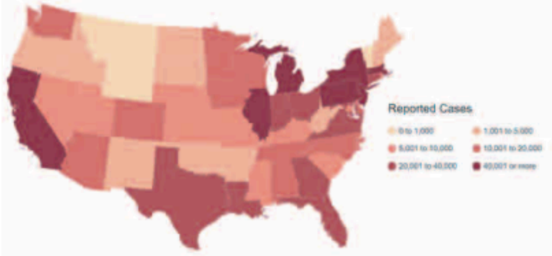
https://www.python-graph-gallery.com/

# Different types of maps supports different messages

A map can both leave you better *or* worse of in terms of understanding

**Figure. Coronavirus Disease 2019 Maps From Different Publicly Available Sources**

**A** US Centers for Disease Control and Prevention

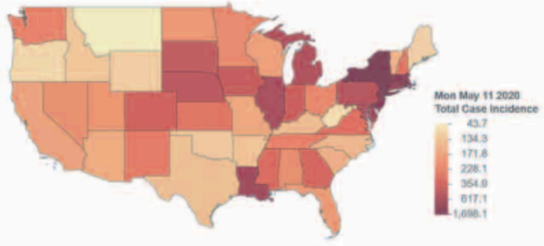



Visualization type: heat
Geographic level: state
Confirmed cases: total

**B** The Kaiser Family Foundation

Visualization type: bubble
Geographic level: state
Confirmed cases: total

**C** University of California, Davis




Visualization type: heat
Geographic level: state
Confirmed cases: per capita

**D** *The New York Times*

Available at:
https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html

Visualization type: heat
Geographic level: county
Confirmed cases: total

**E** Johns Hopkins

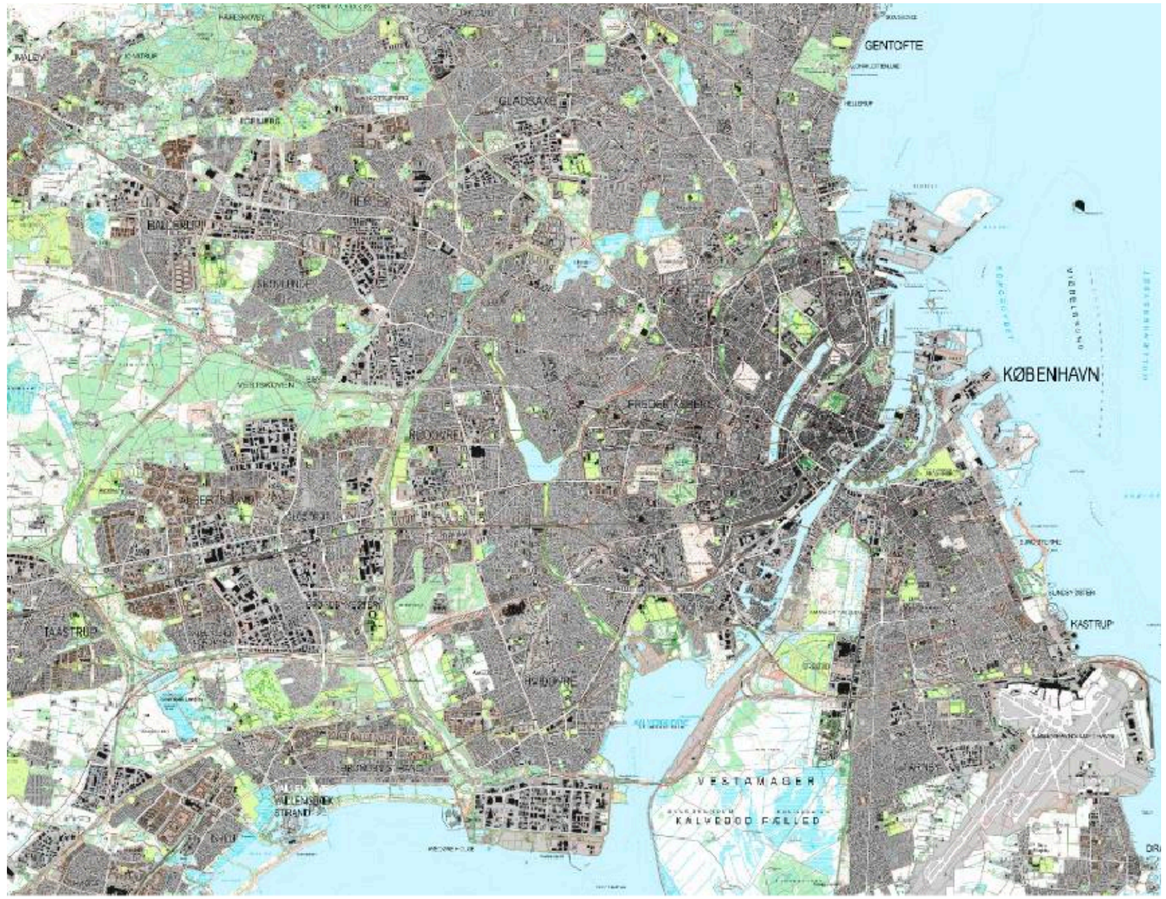
Visualization type: bubble
Geographic level: county
Confirmed cases: total

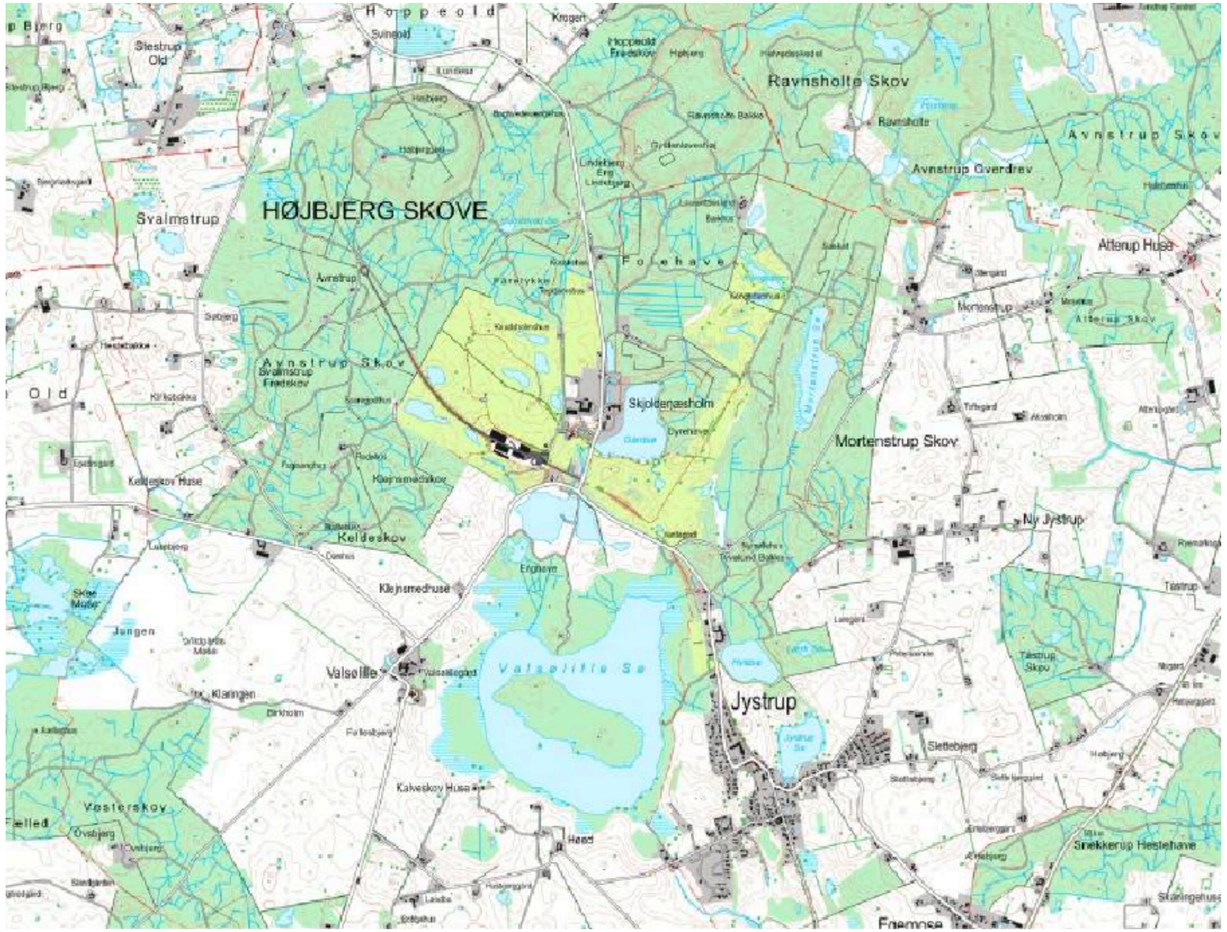
**F** Johns Hopkins

Visualization type: heat
Geographic level: county
Confirmed cases: per capita

https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2774639

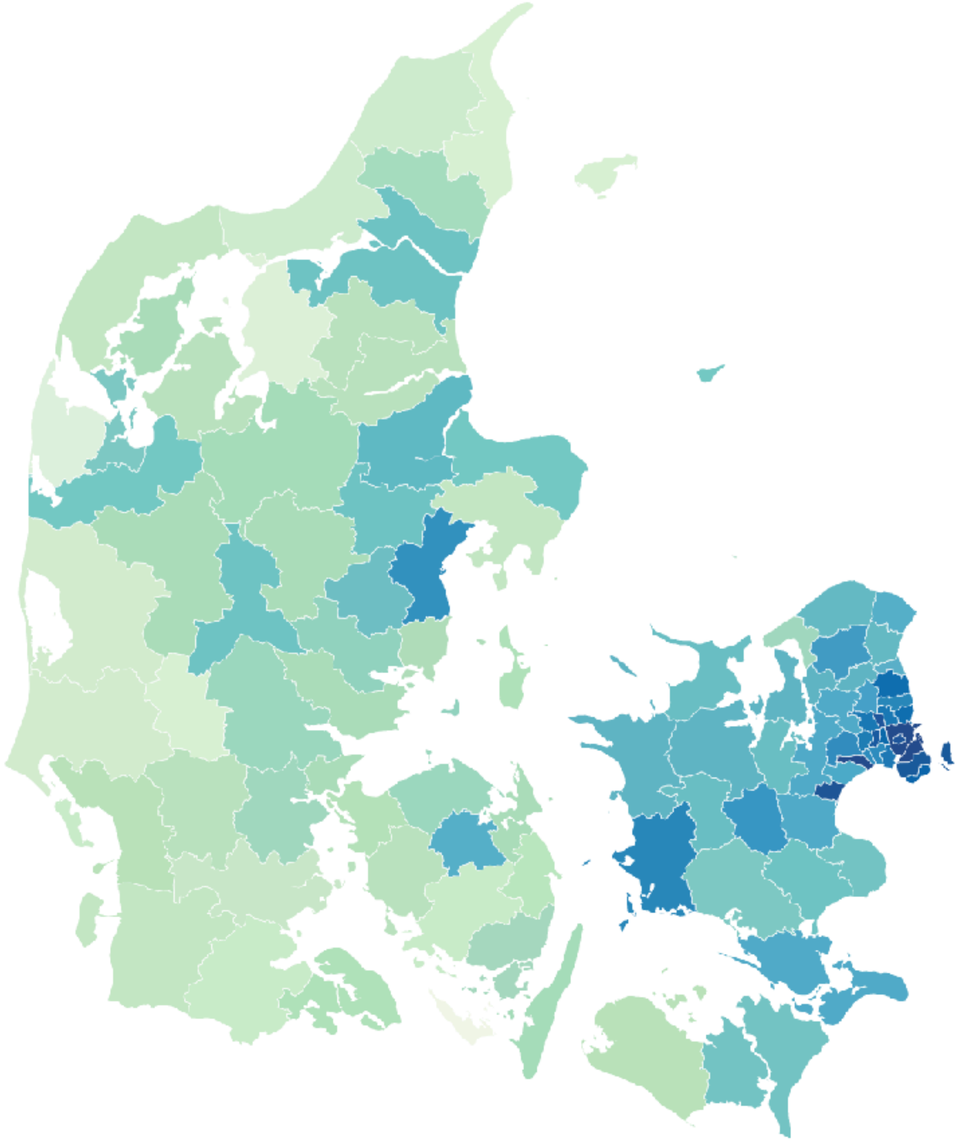
# Topographic maps

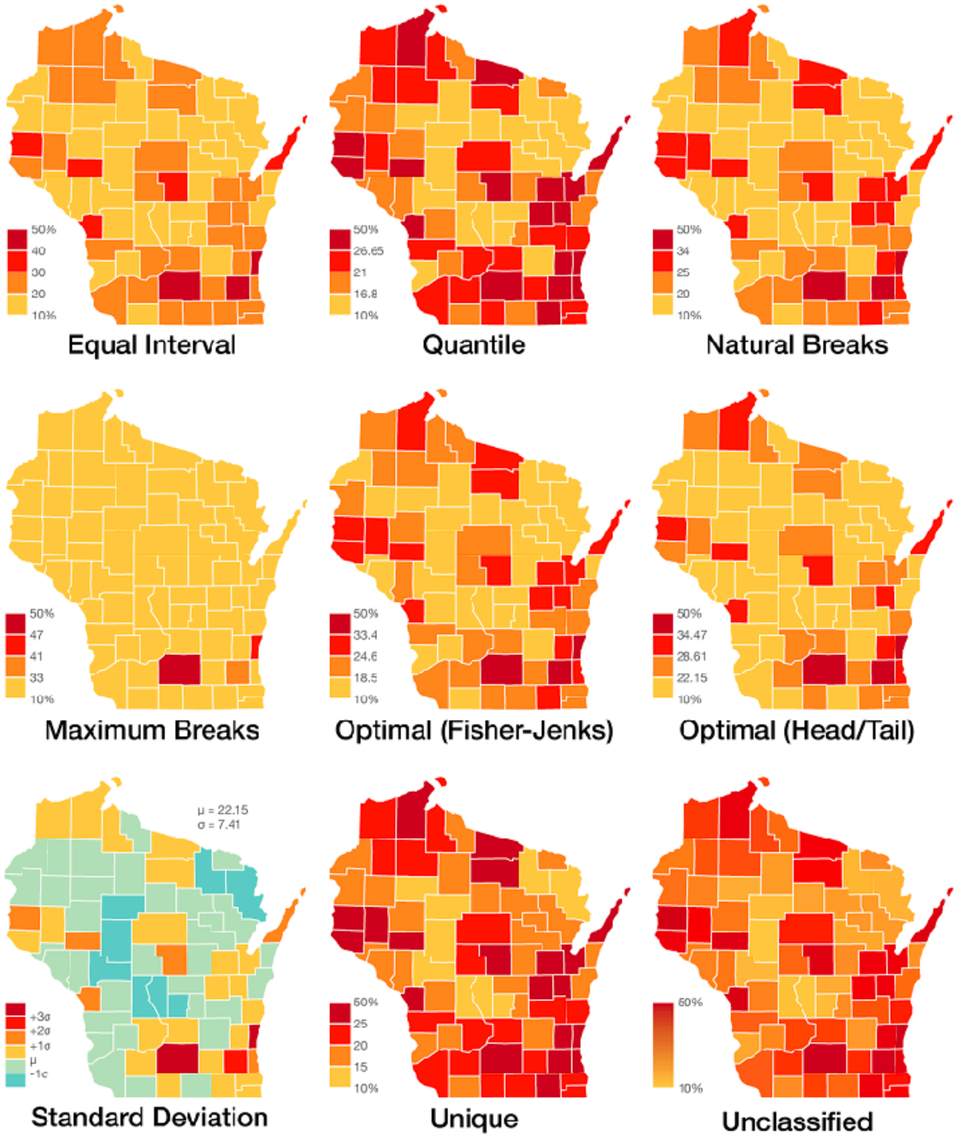



© SDFI

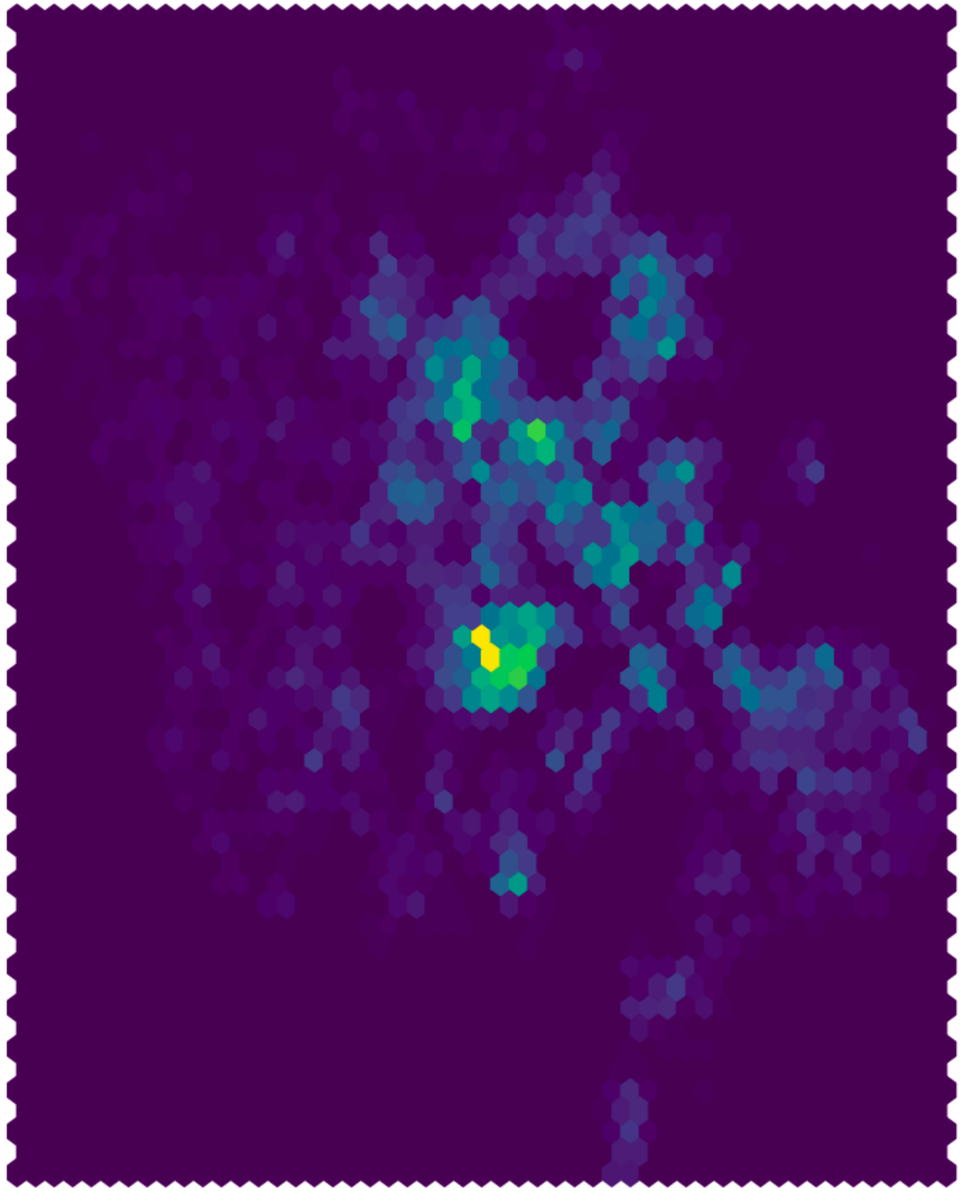
# Choropleth maps

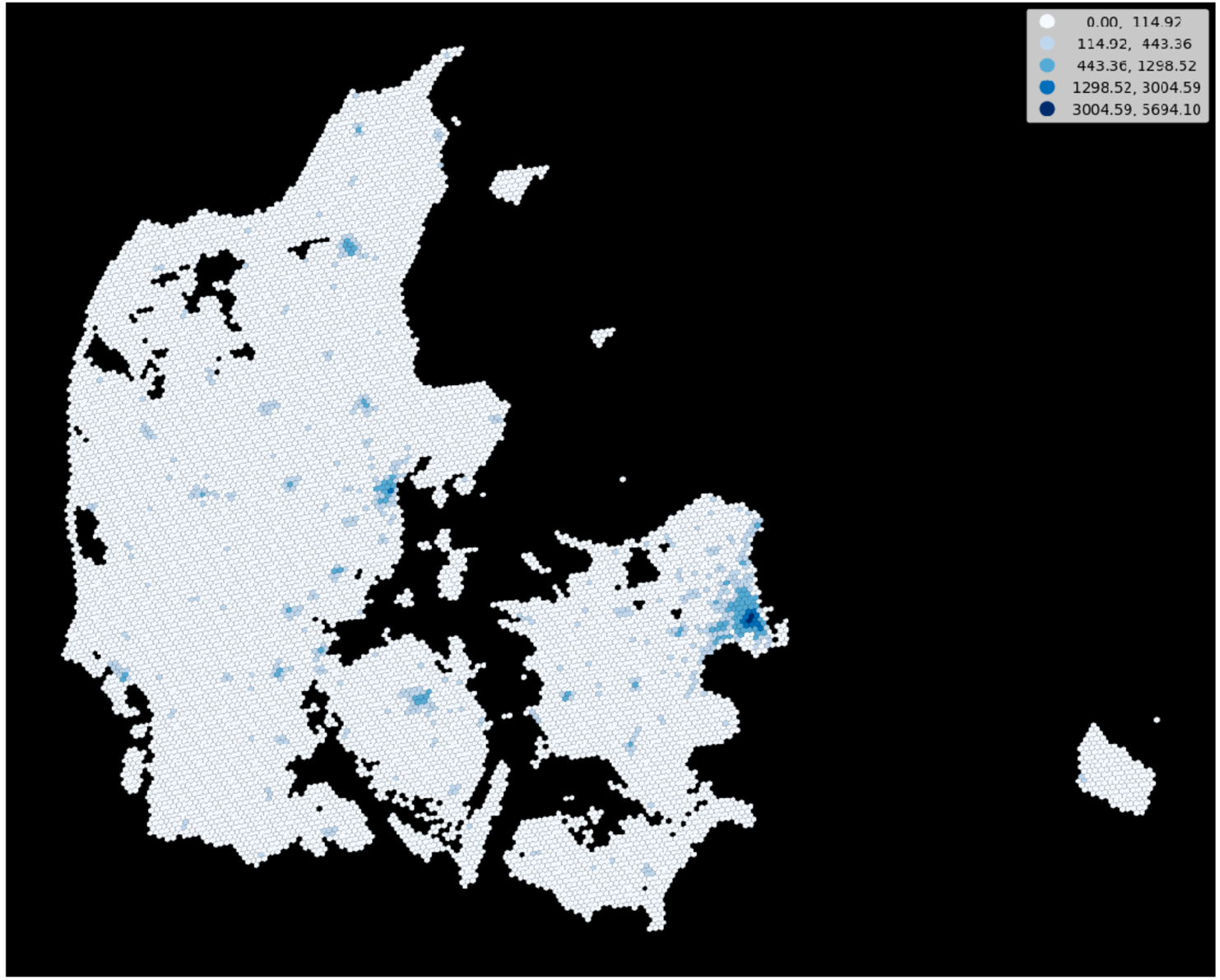





https://gistbok.ucgis.org/bok-topics/statistical-mapping-enumeration-normalization-classification

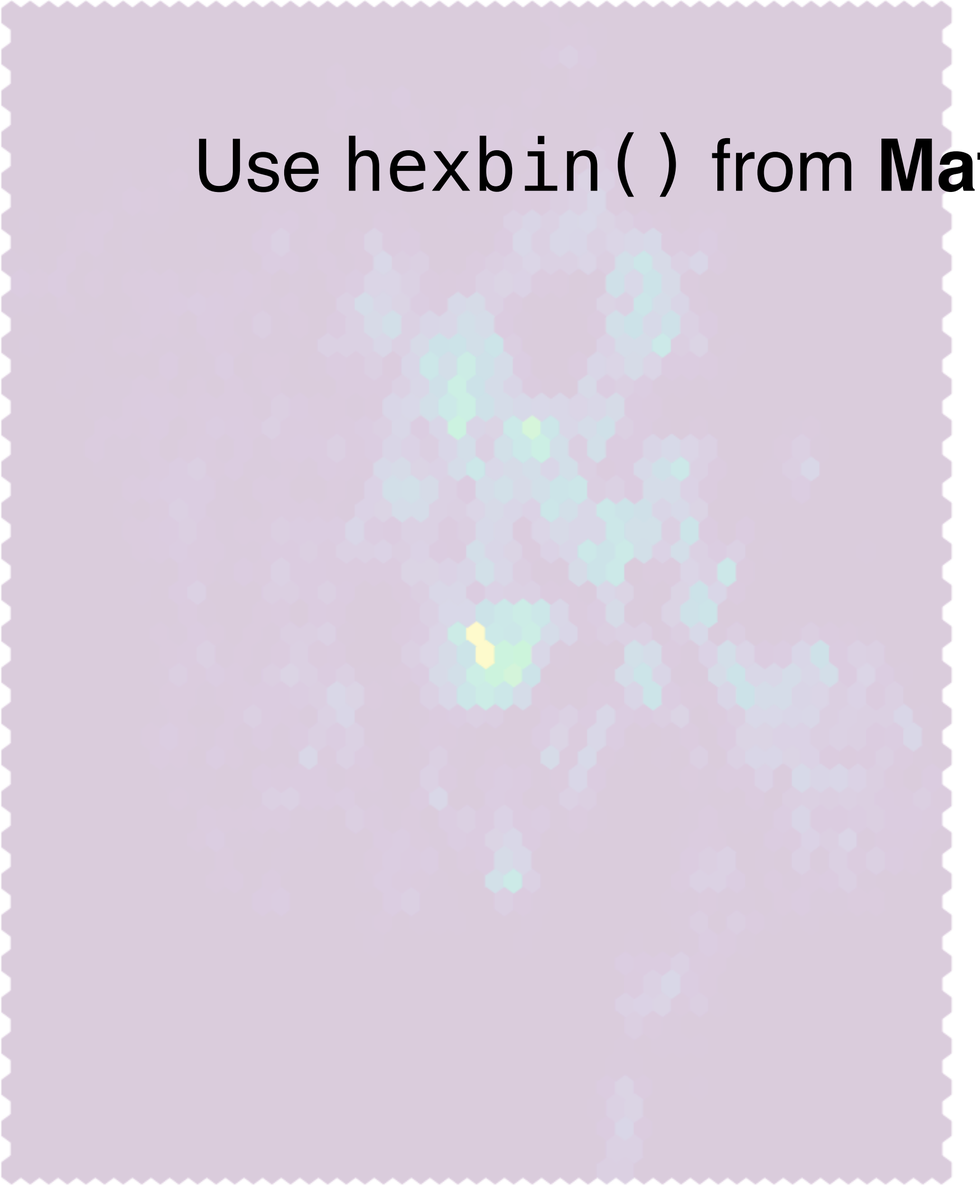
# Bins/grids

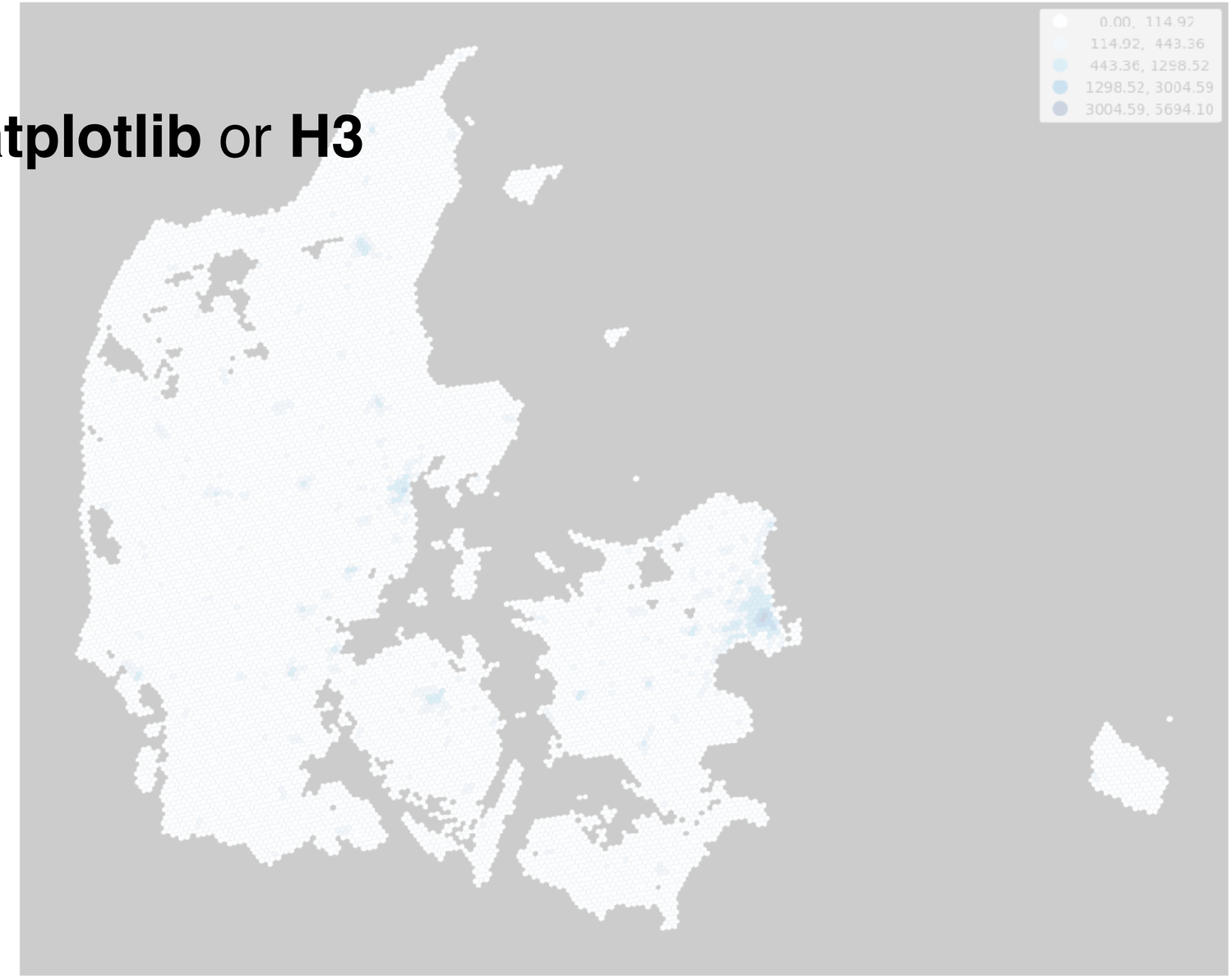



0.00, 114.92
114.92, 443.36
443.36, 1298.52
1298.52, 3004.59
3004.59, 5694.10

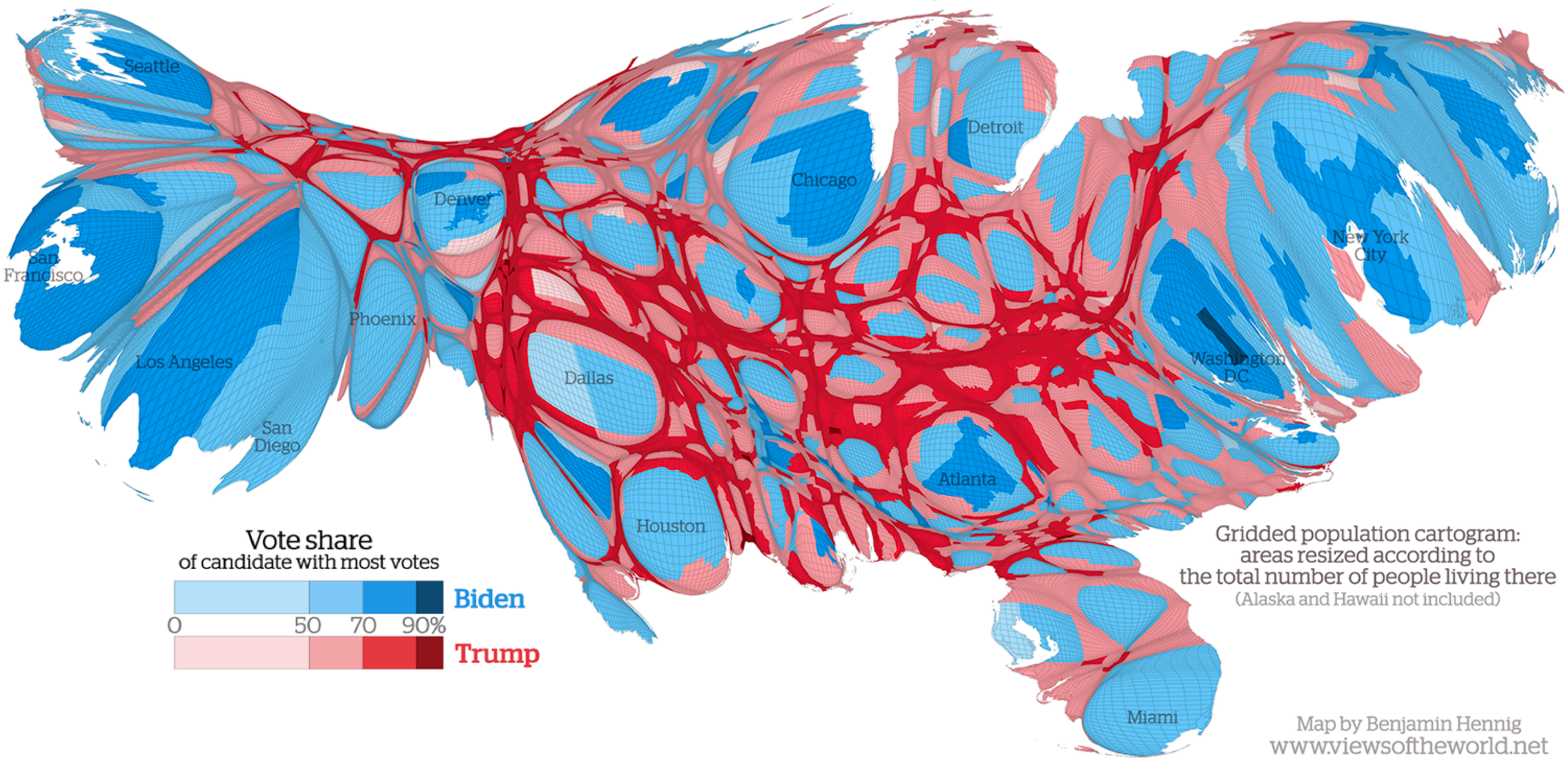
# Bins/grids

Use `hexbin()` from **Matplotlib** or **H3**

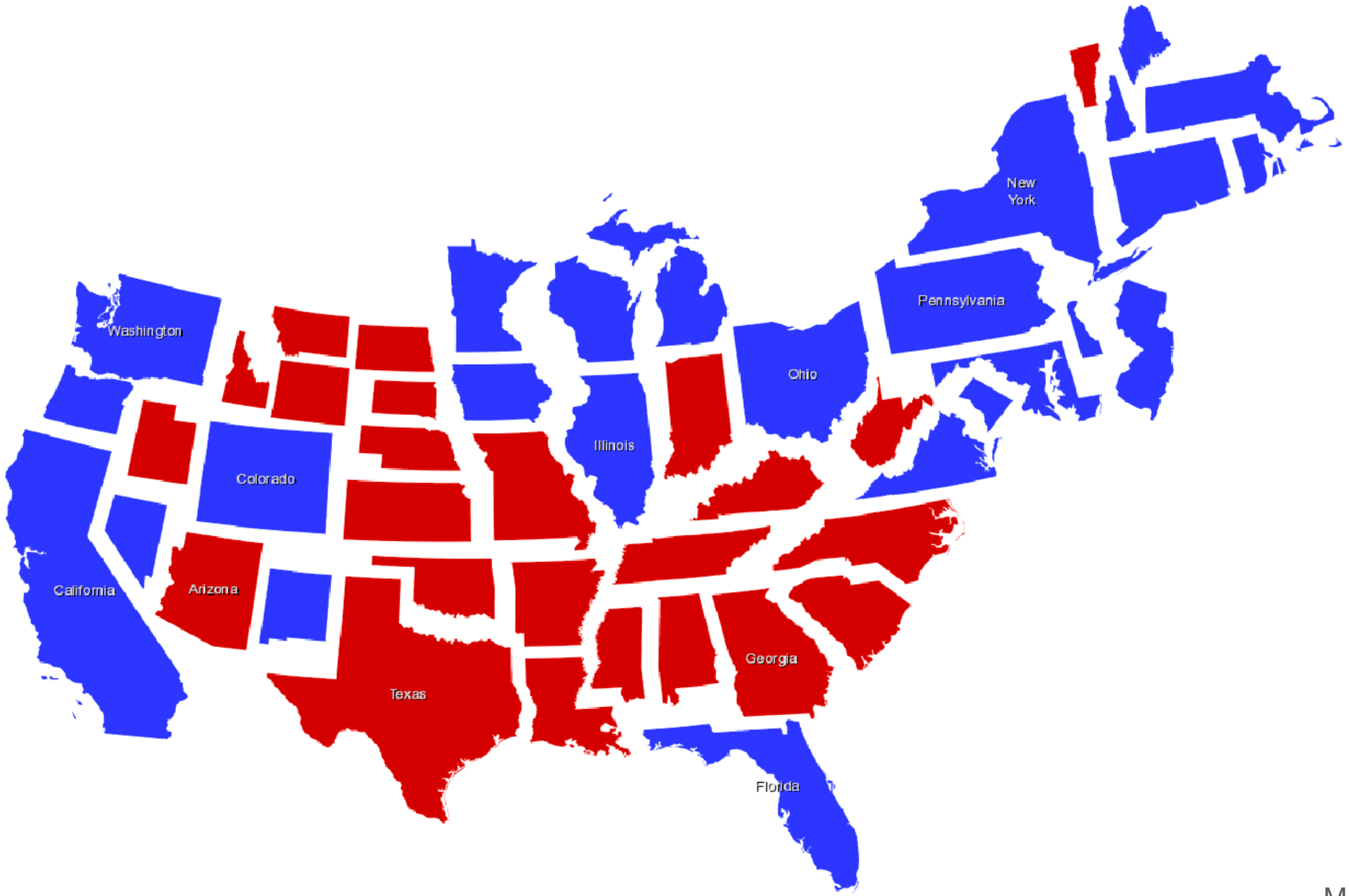




# Cartograms: Density equalizing

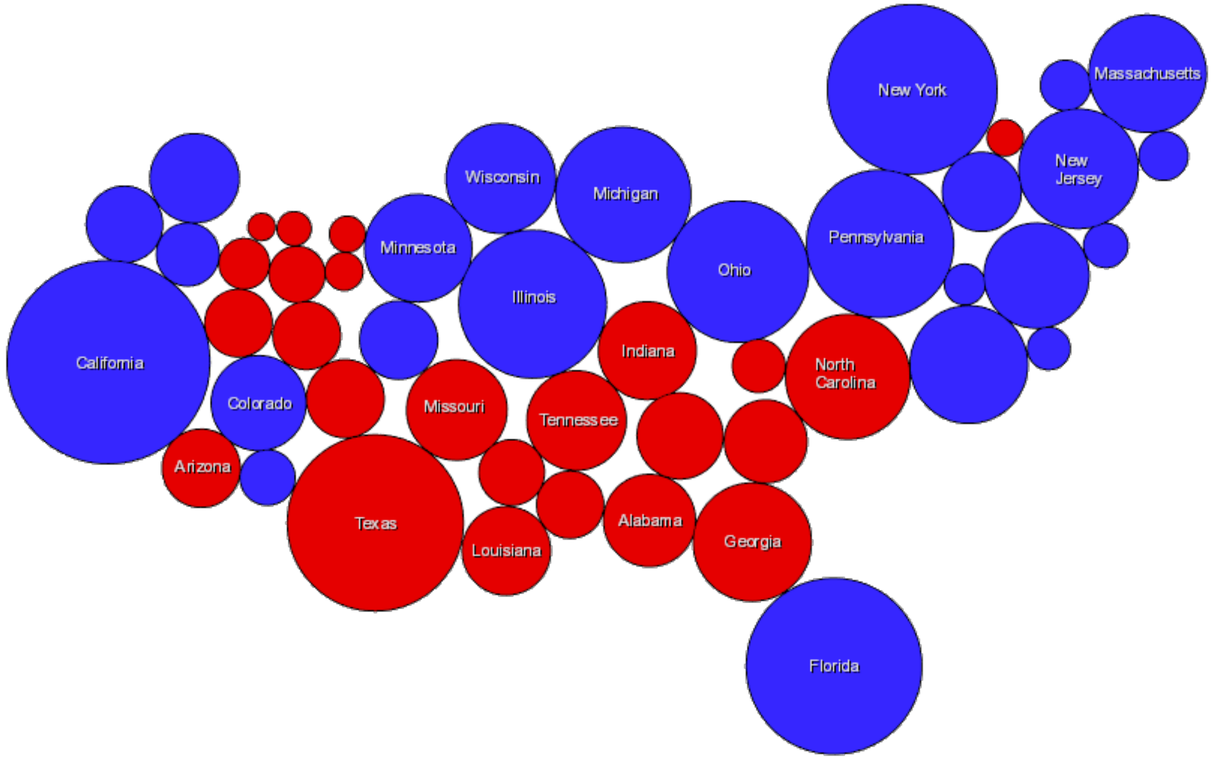


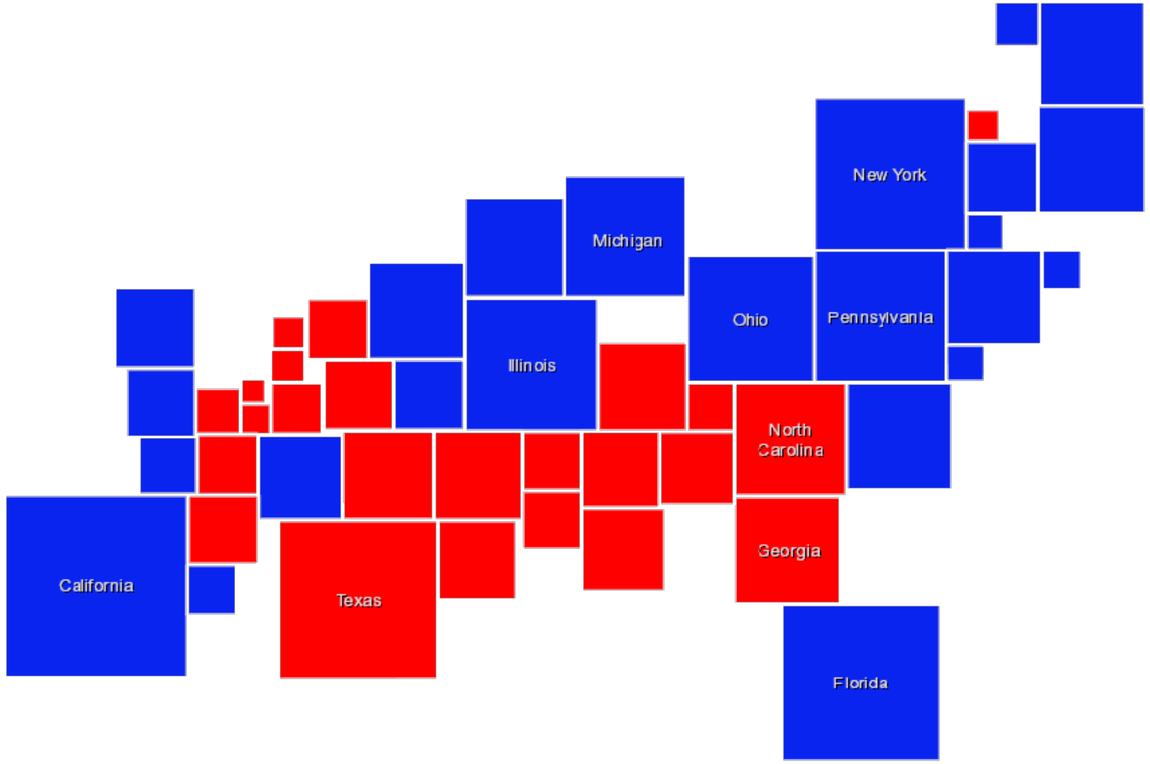
# Cartograms: Non-contiguous




Map by Kenneth Field

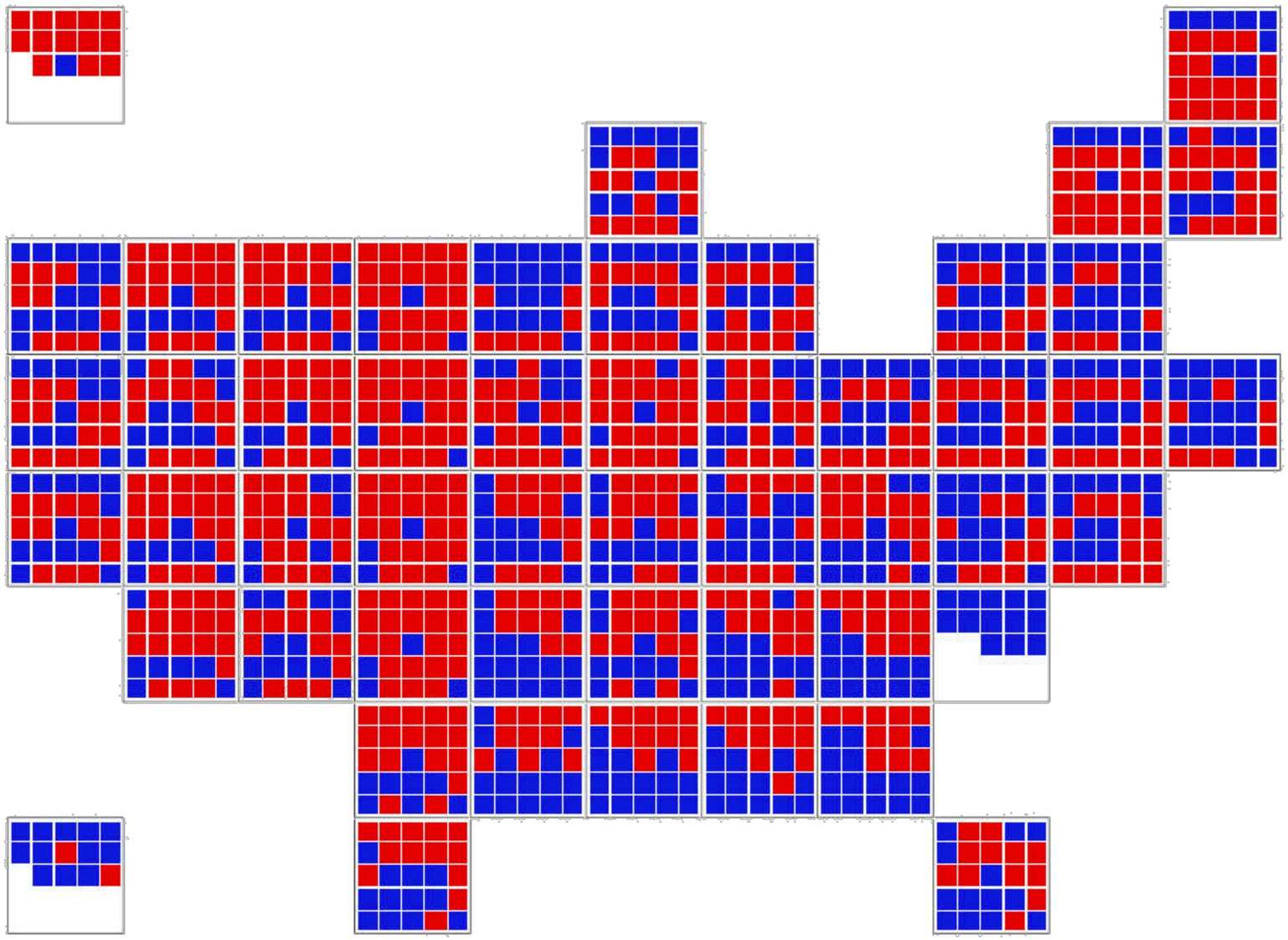
# Cartograms: Graphical cartograms



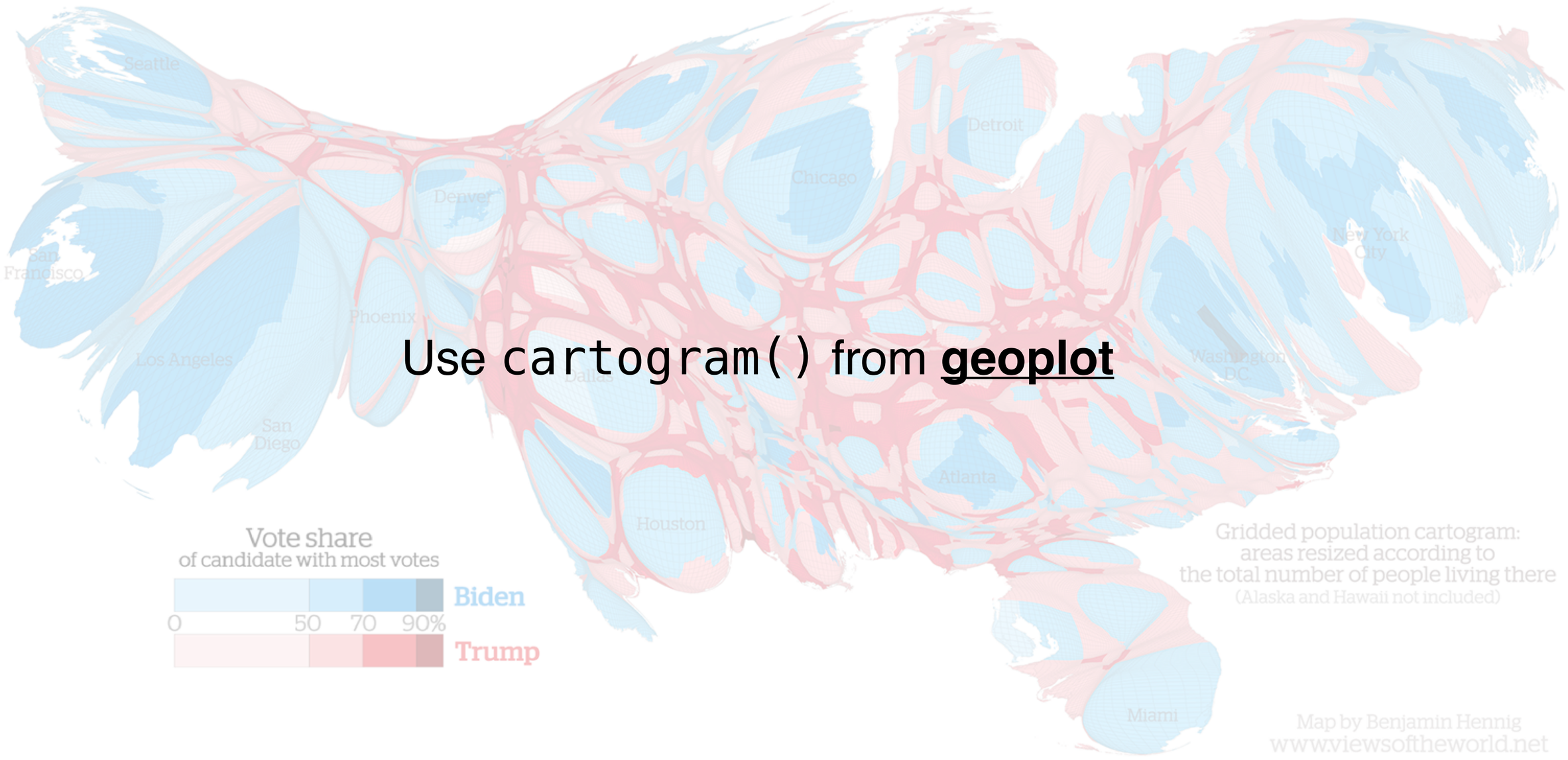

https://gistbok.ucgis.org/bok-topics/2017-quarter-03/cartograms

# Cartograms: Gridded



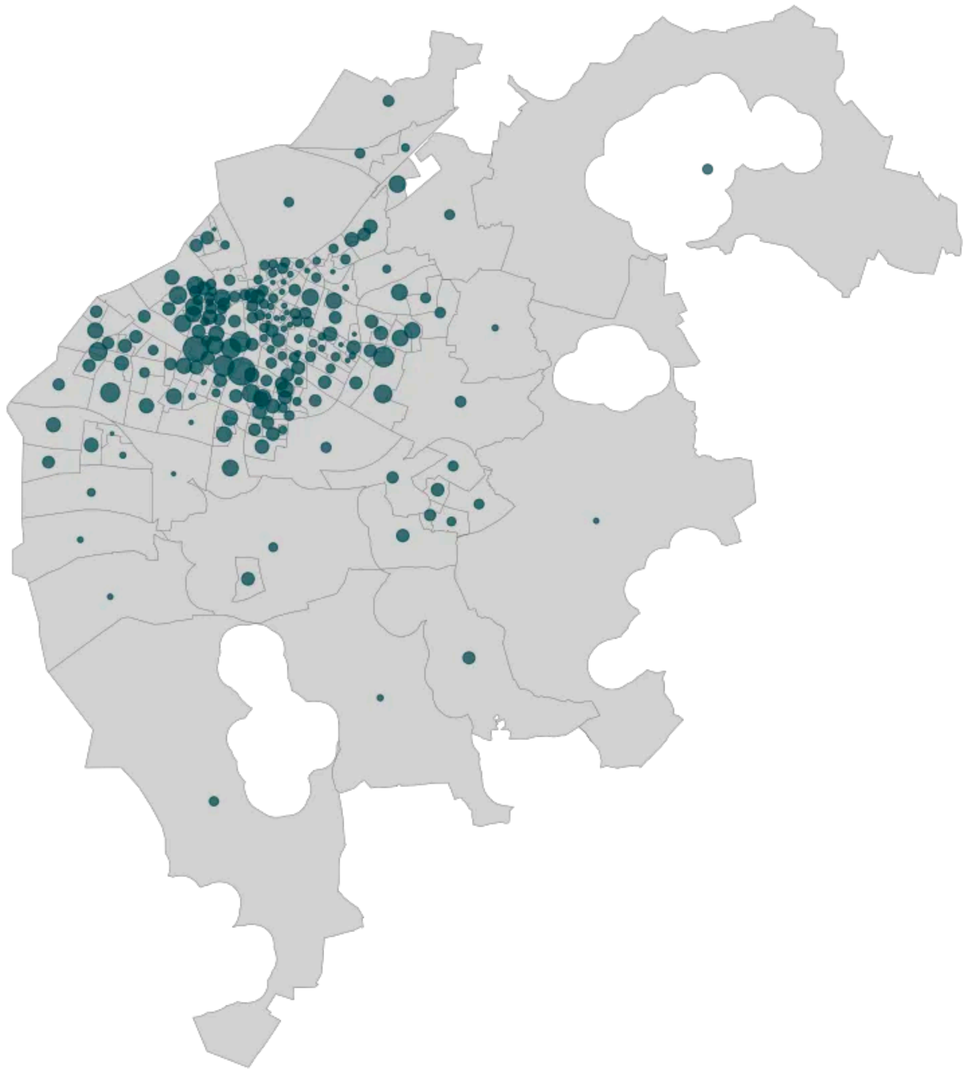
https://gistbok.ucgis.org/bok-topics/2017-quarter-03/cartograms

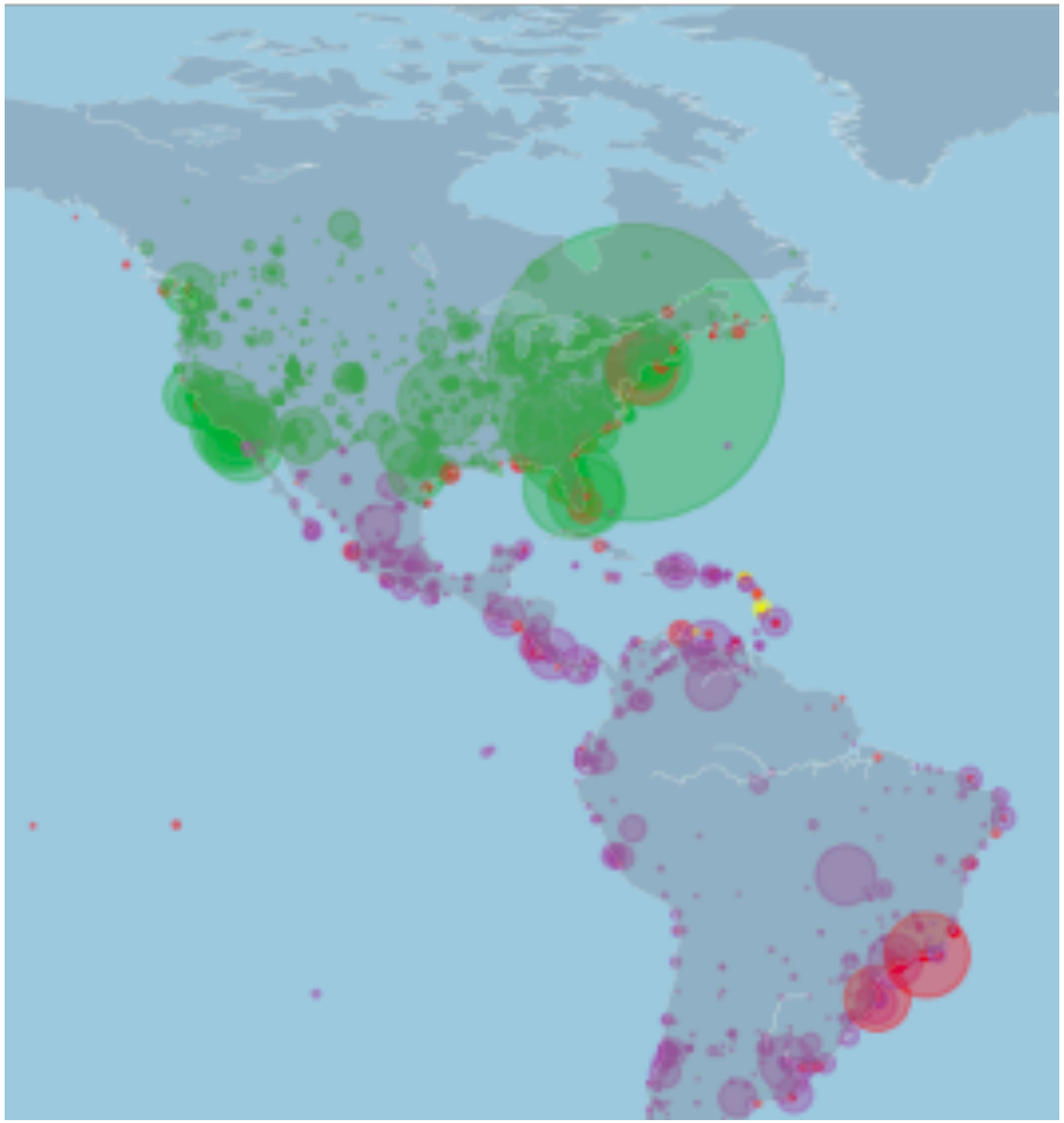
# Cartograms: Density equalizing



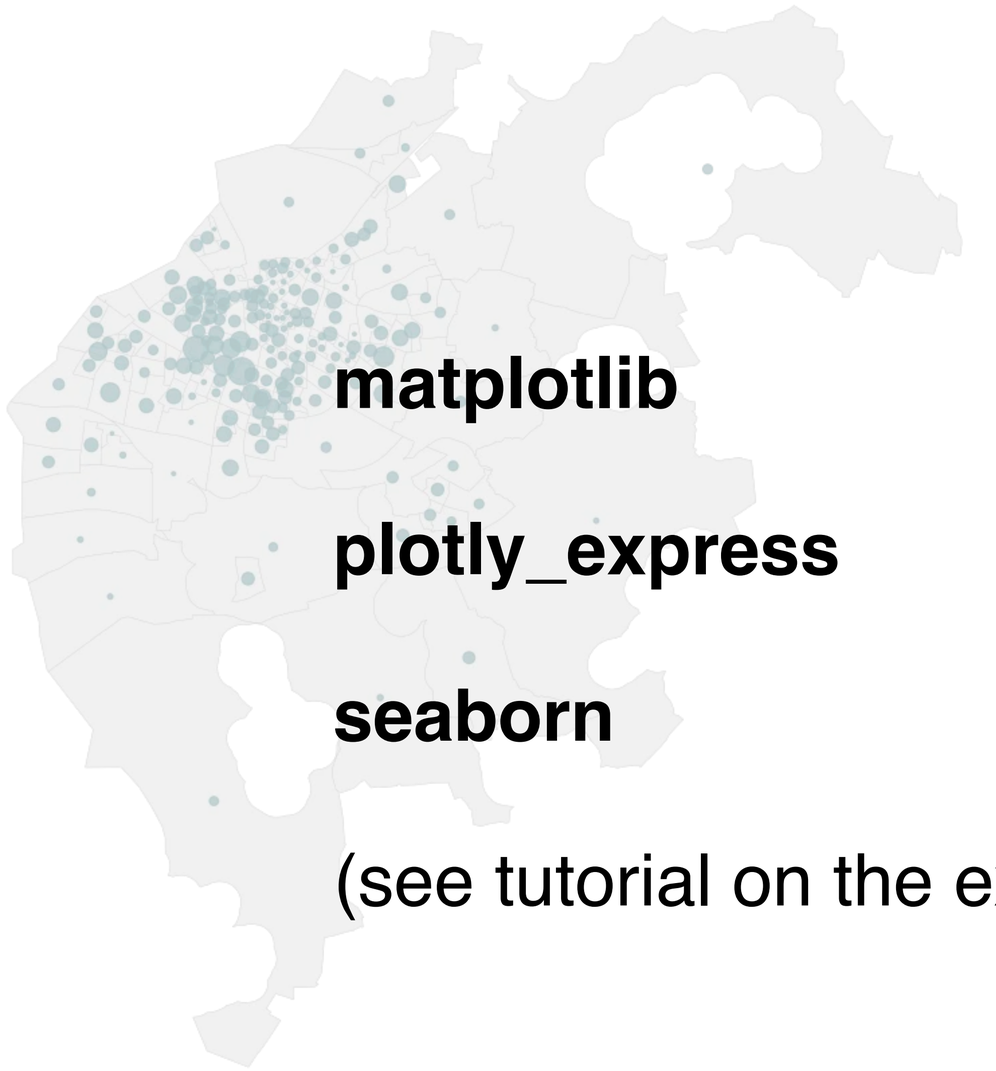

Use `cartogram()` from **geoplot**

# Graduated symbol maps





# Graduated symbol maps



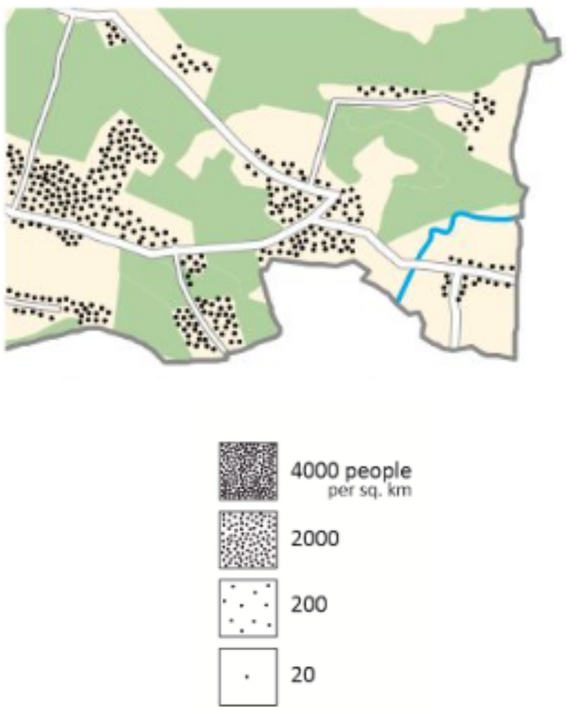
**matplotlib**

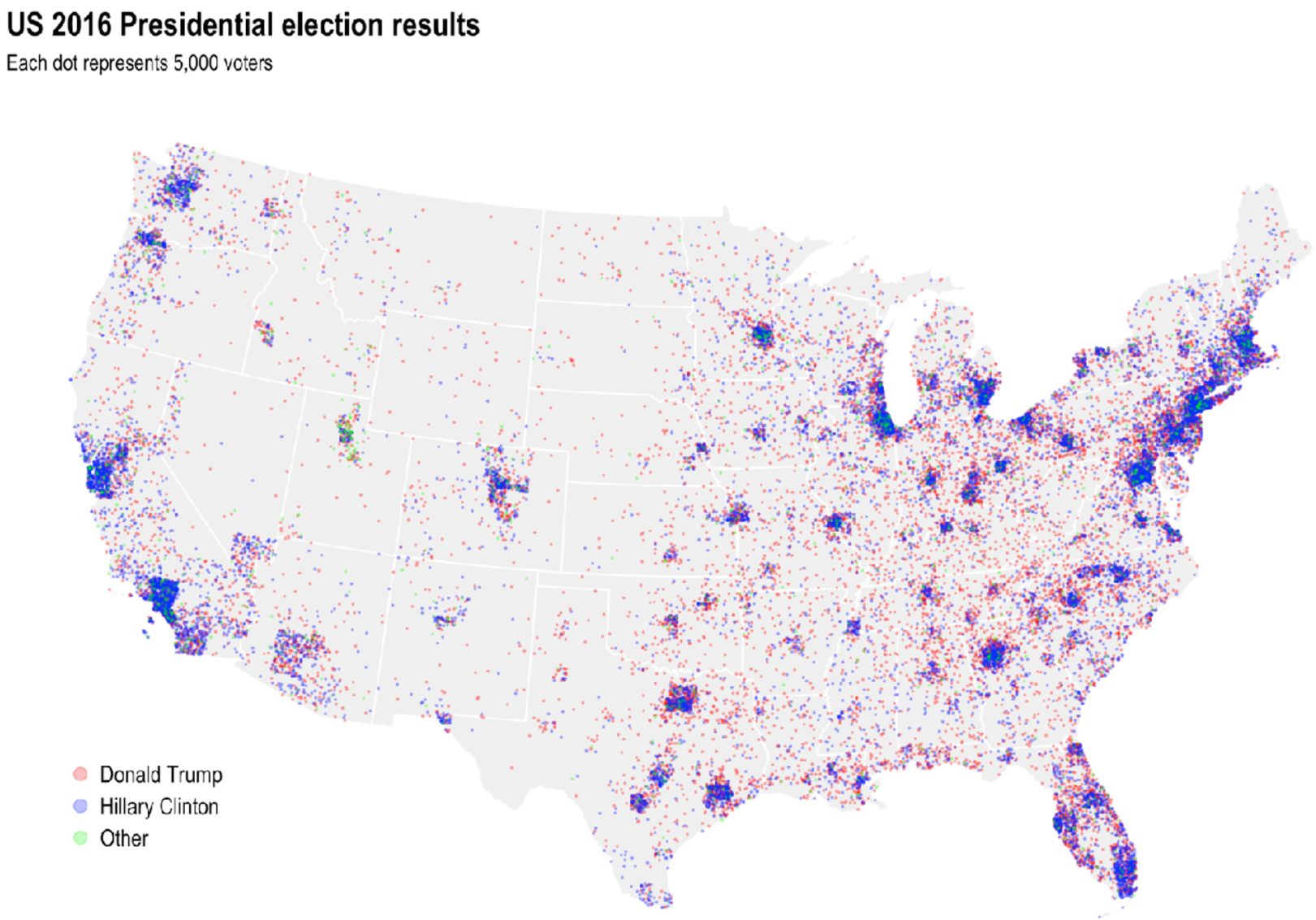
**plotly_express**

**seaborn**

(see tutorial on the exercise repo)

# Dot density maps

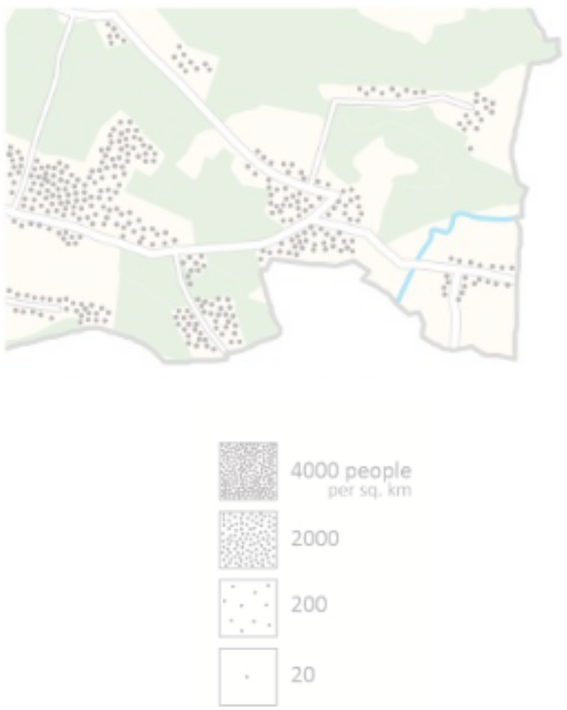


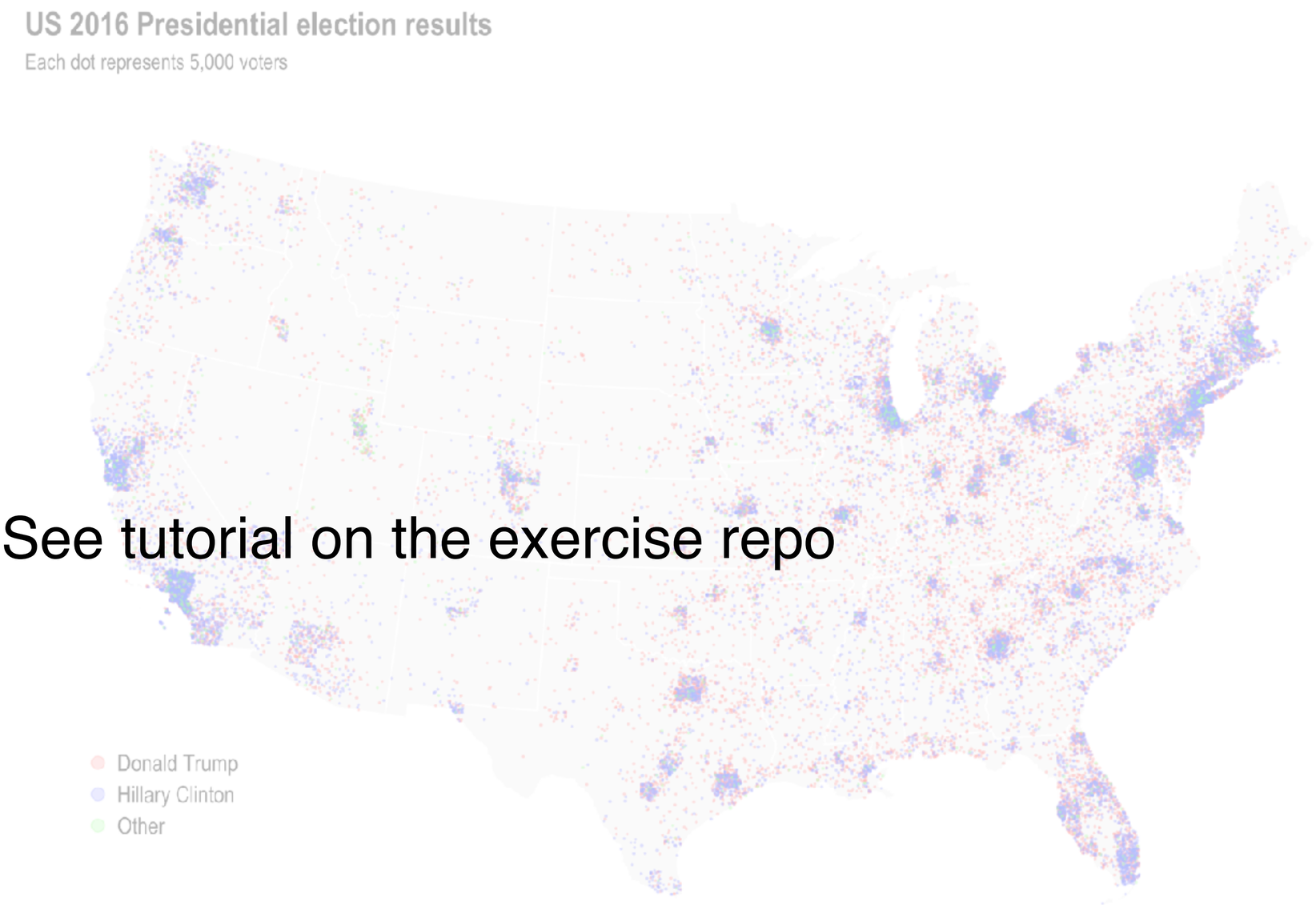




https://gistbok.ucgis.org/bok-topics/common-thematic-map-types

https://www.andybeger.com/blog/2018-05-11-us-2016-dot-density/

# Dot density maps




See tutorial on the exercise repo

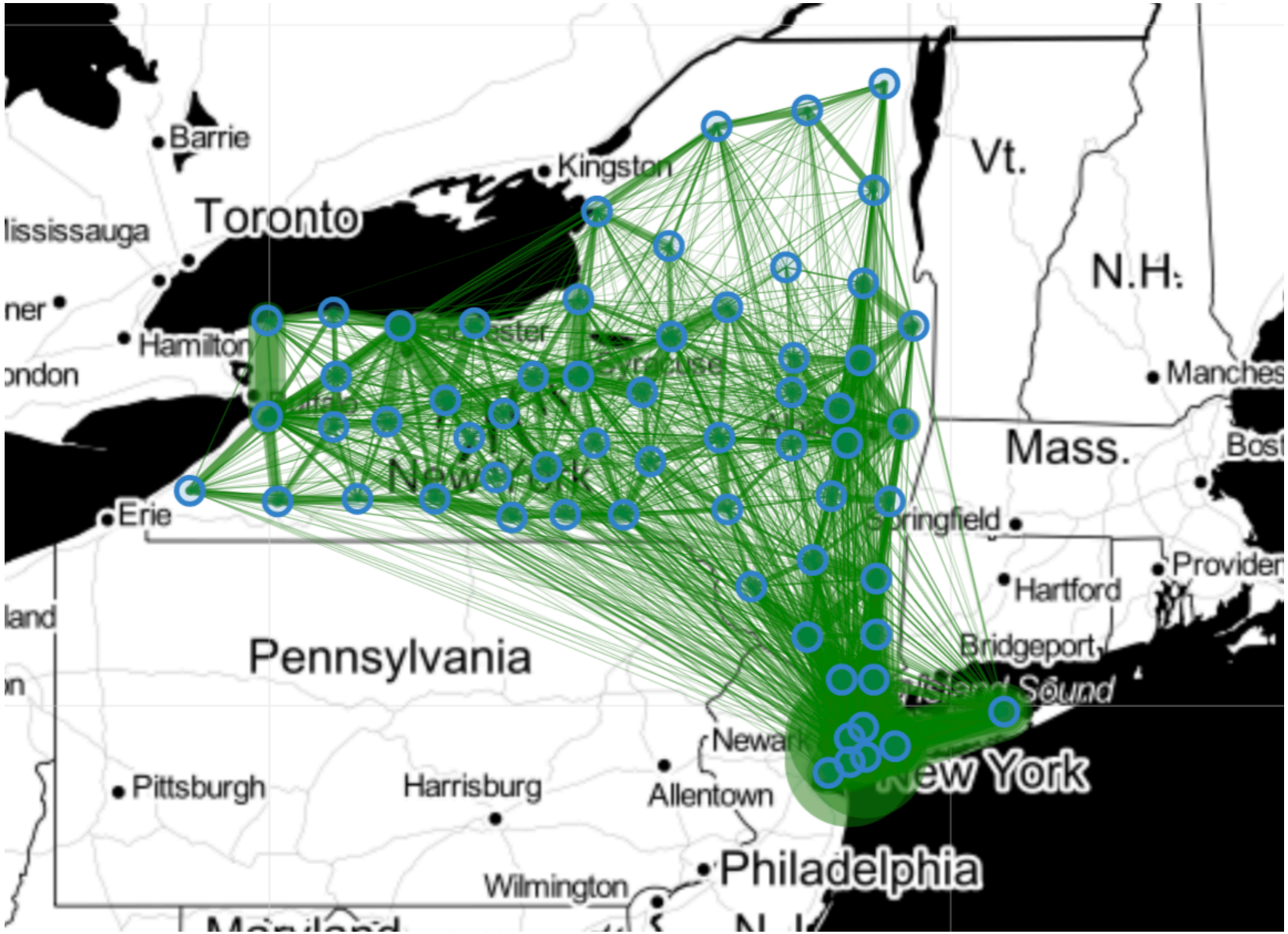
https://gistbok.ucgis.org/bok-topics/common-thematic-map-types

https://www.andybeger.com/blog/2018-05-11-us-2016-dot-density/

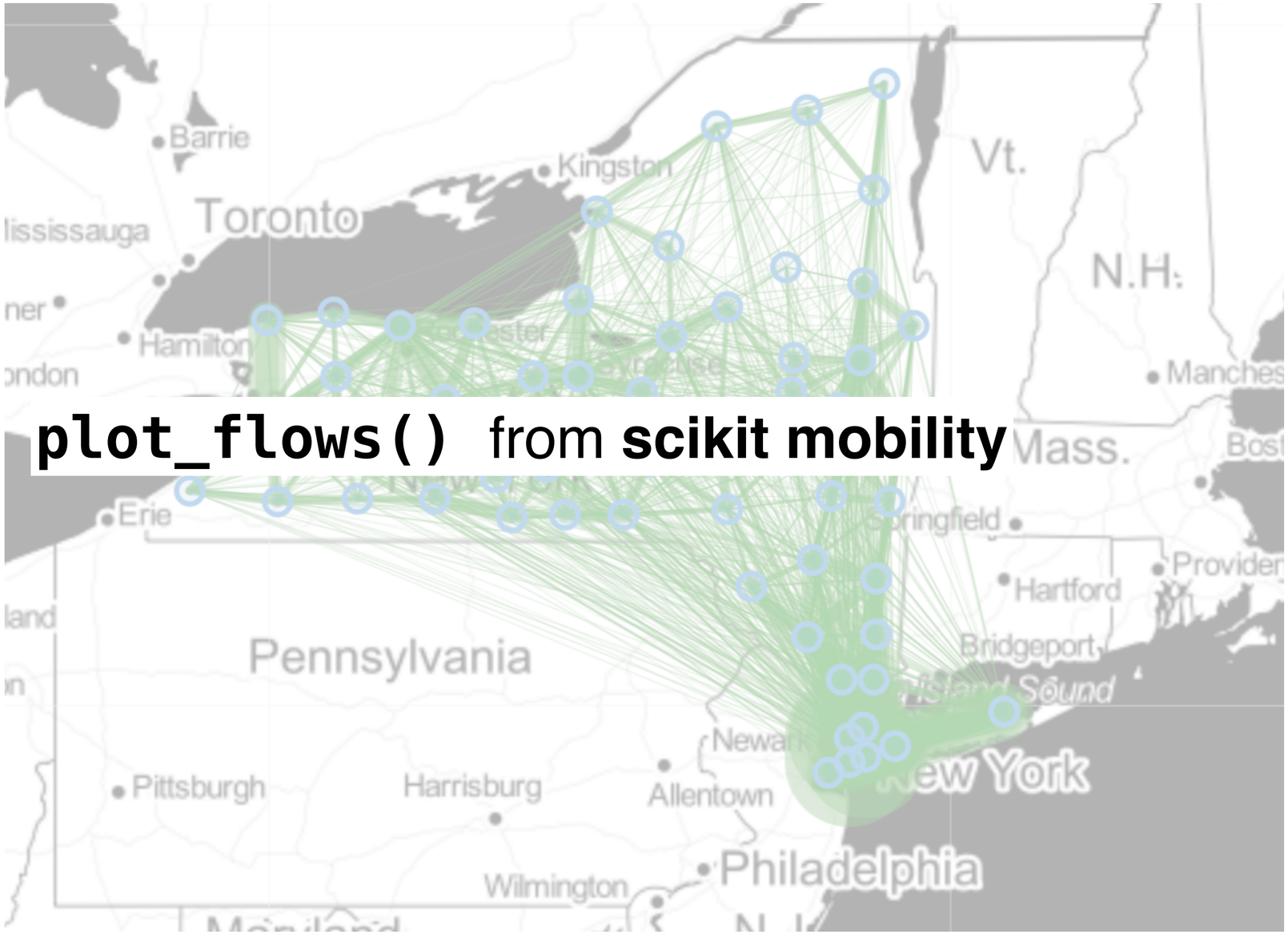
# Connection/flow maps

https://www.pythonmaps.com/

# Connection/flow maps



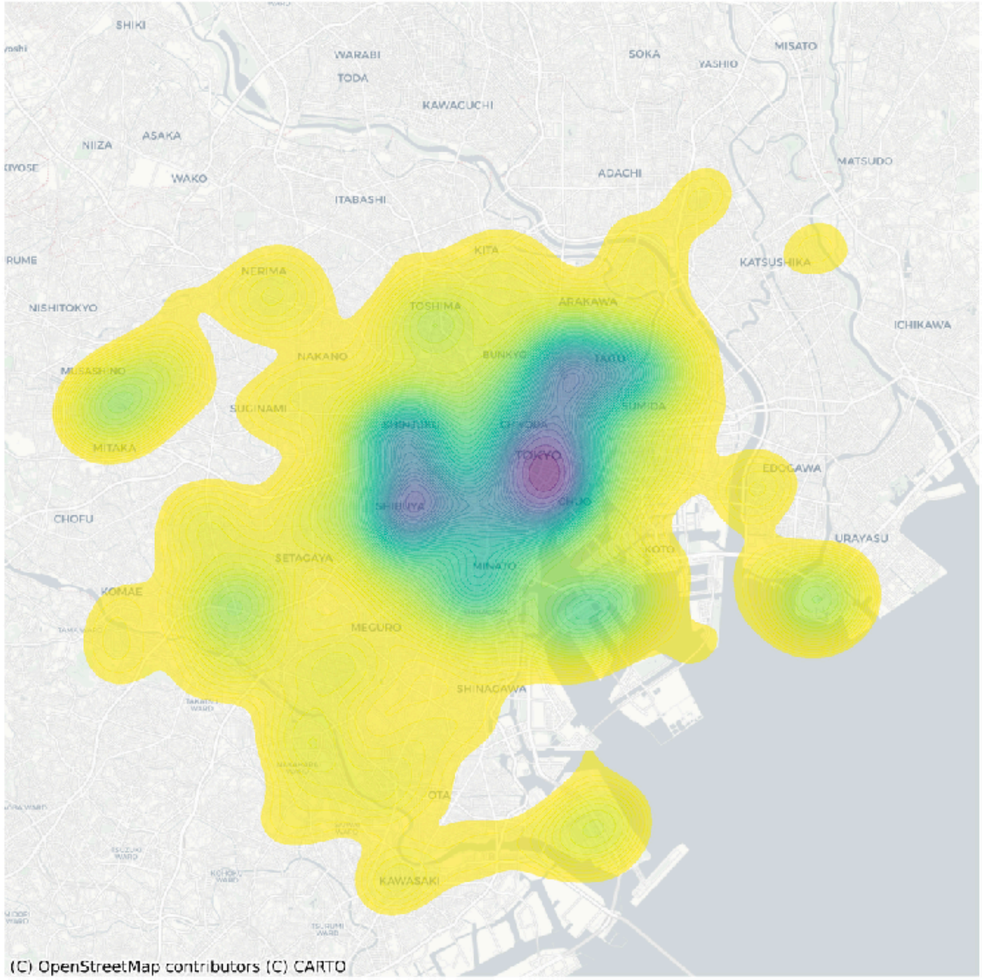
# Connection/flow maps

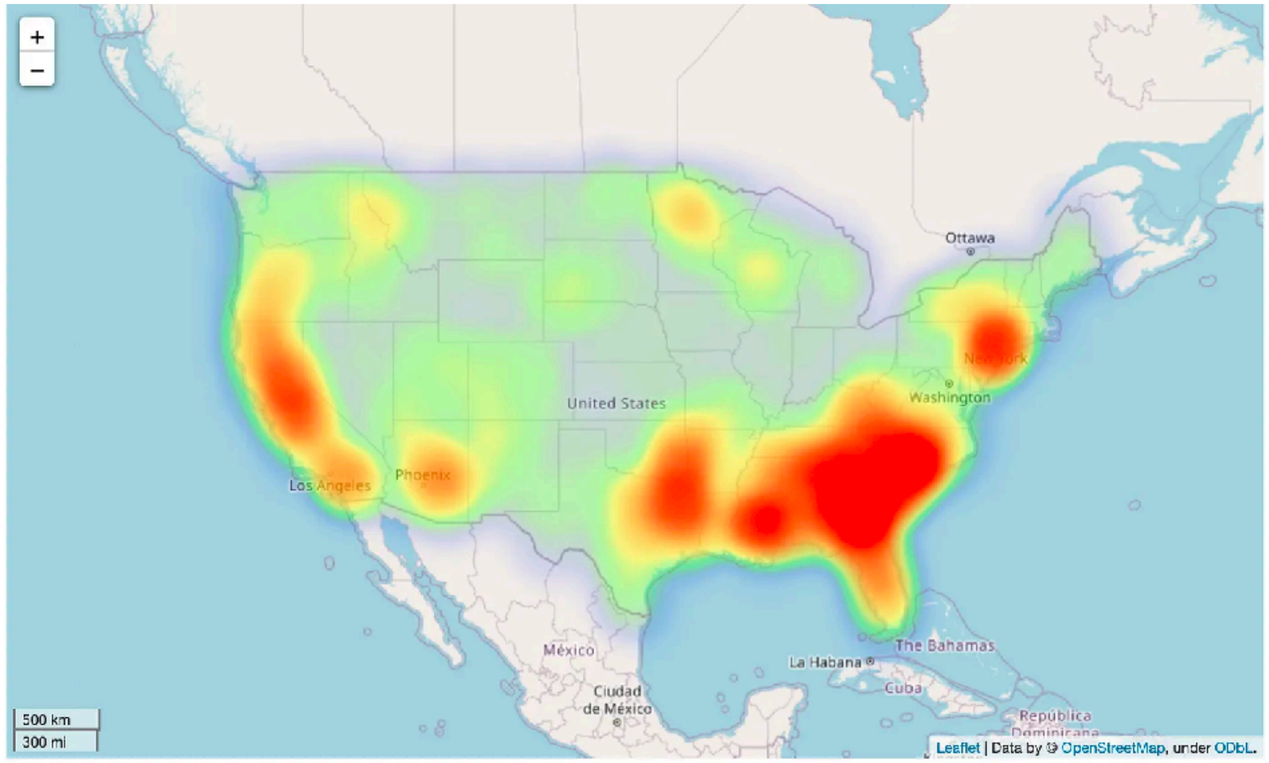



`plot_flows()` from **scikit mobility**

# Heatmaps

Geospatial name for KDE (Kernel Density Estimate) maps



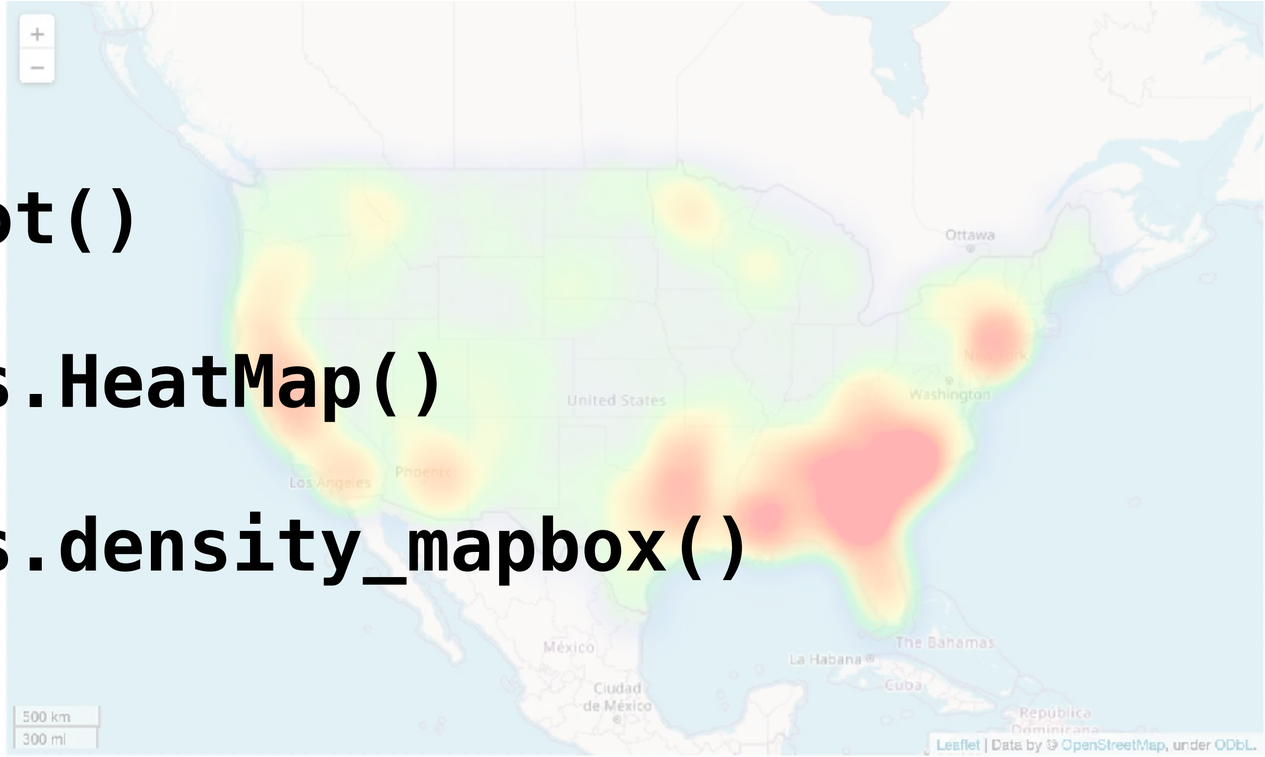
# Heatmaps

Geospatial name for KDE (Kernel Density Estimate) maps

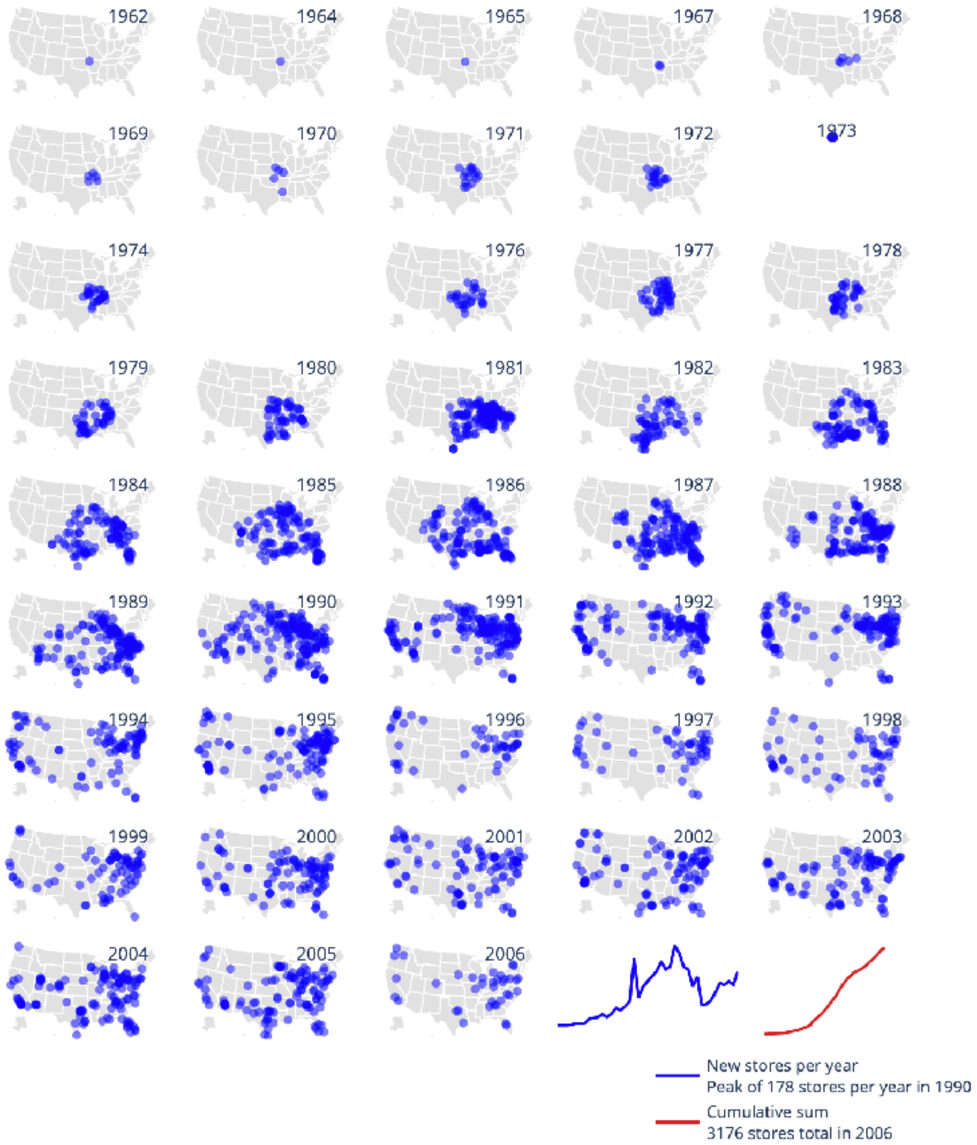
```
seaborn.kdeplot()

folium.plugins.HeatMap()

plotly_express.density_mapbox()
```



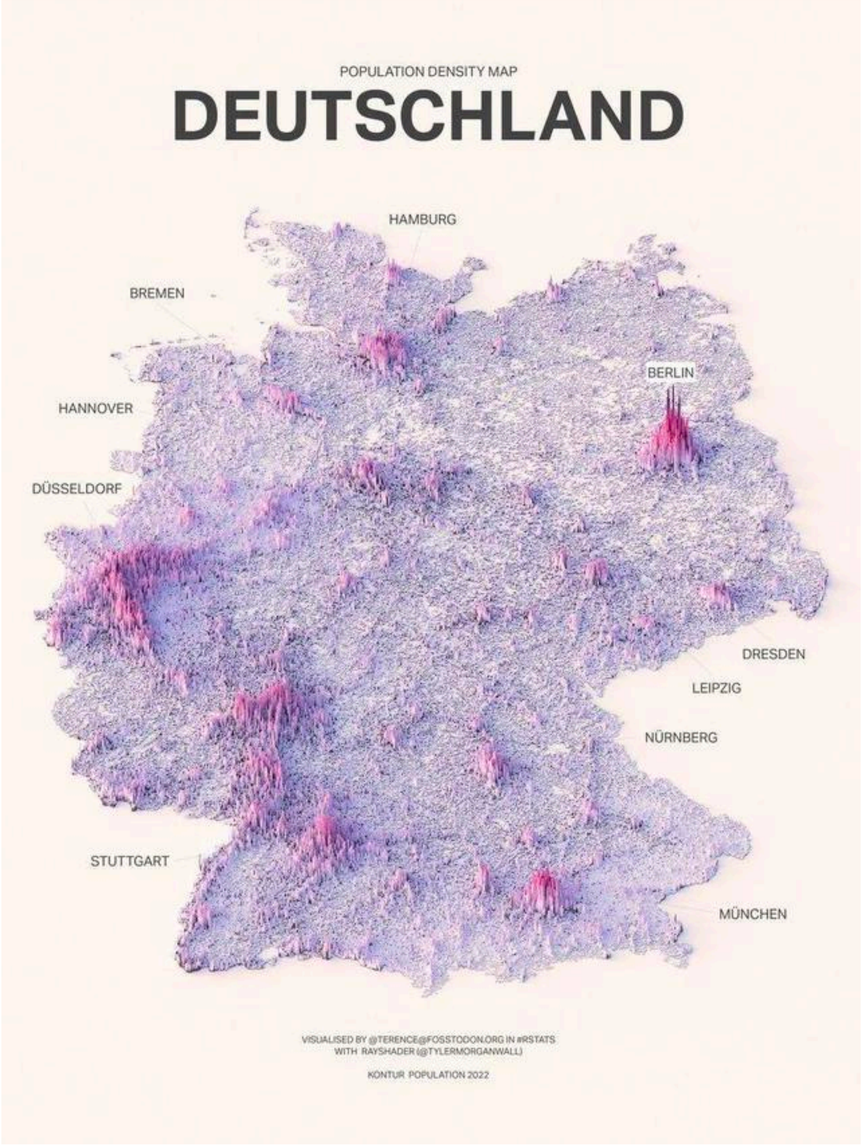
# Small multiples

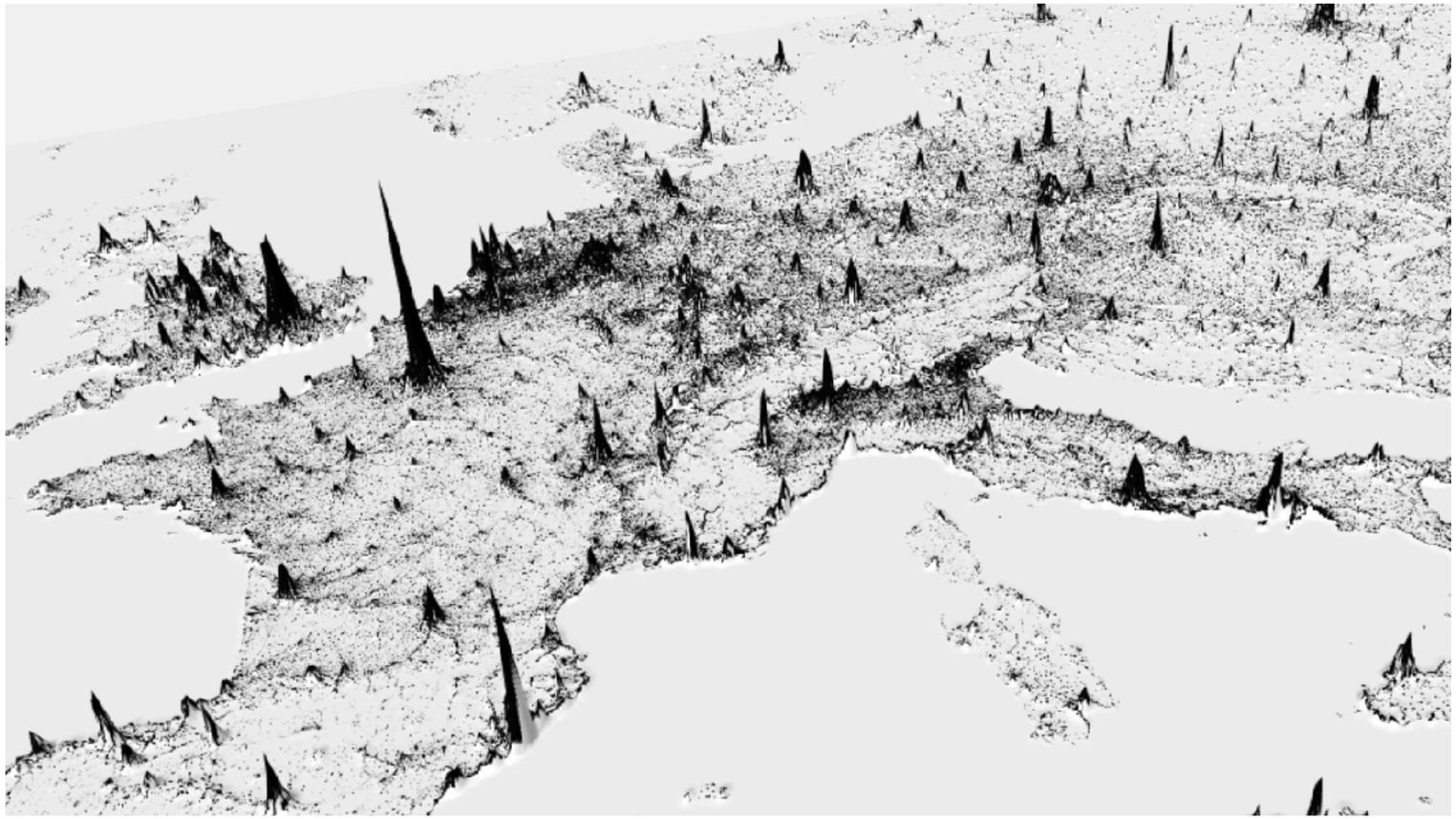



Good for showing change over time

https://plotly.com/python/map-subplots-and-small-multiples/

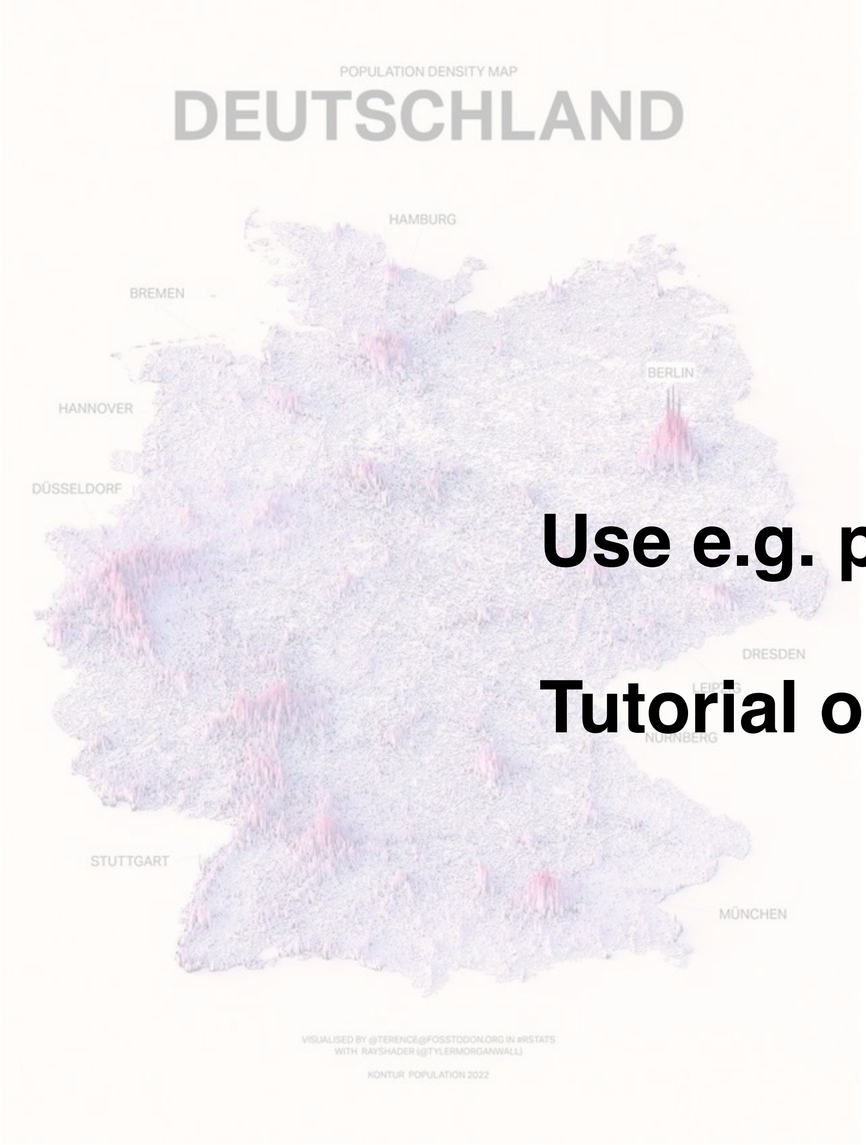
# 3D-maps



Terence T & Topi Tjukanov

# 3D-maps



**Use e.g. pydeck**

**Tutorial on the exercise repo**

Terence T & Topi Tjukanov

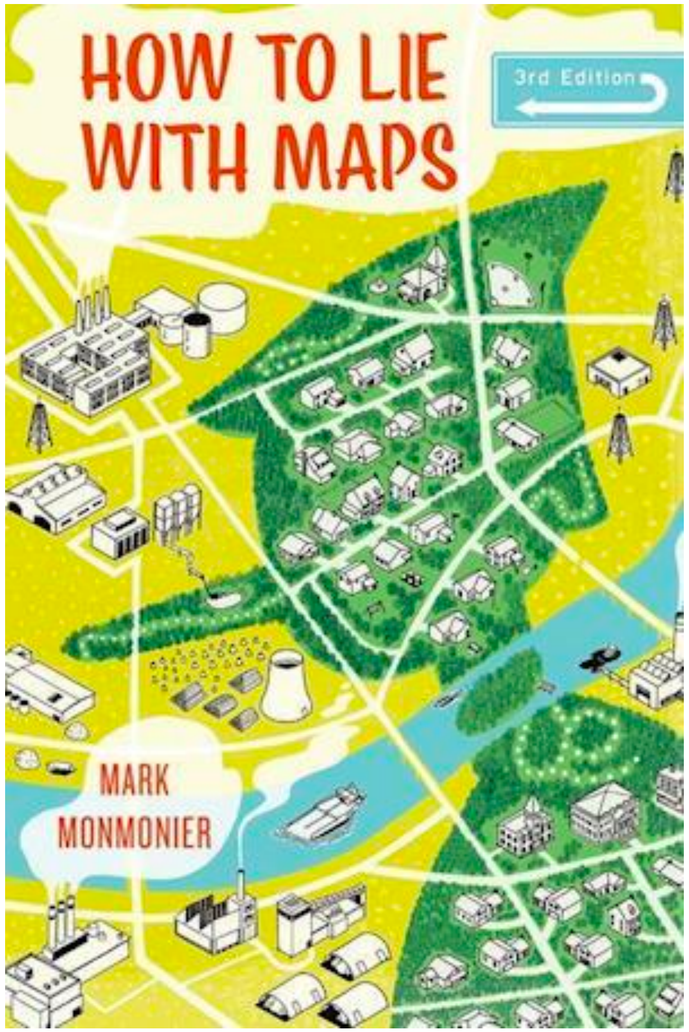
# Choosing your map type

Consider the map(s) in your projects:

- What should the map(s) communicate about your data?
- Which map type(s) would work best?

# Don’t lie with maps

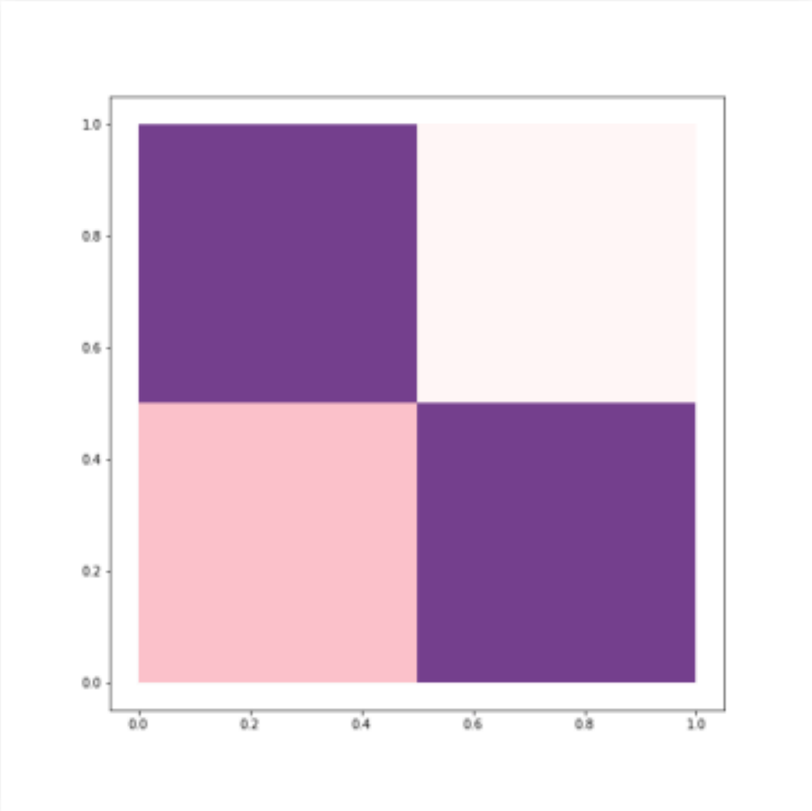
# How to Lie with Maps

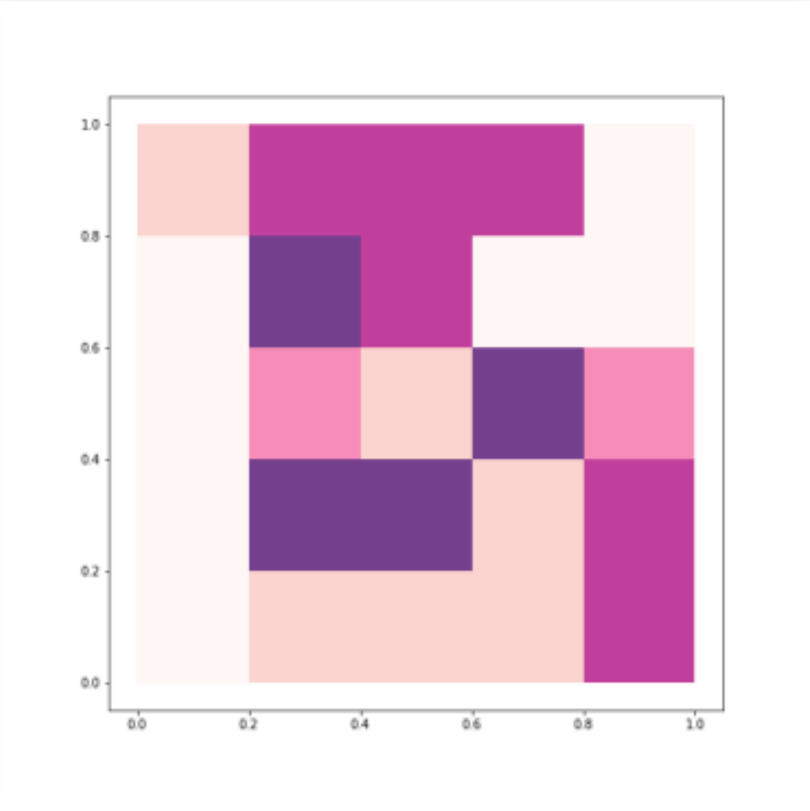


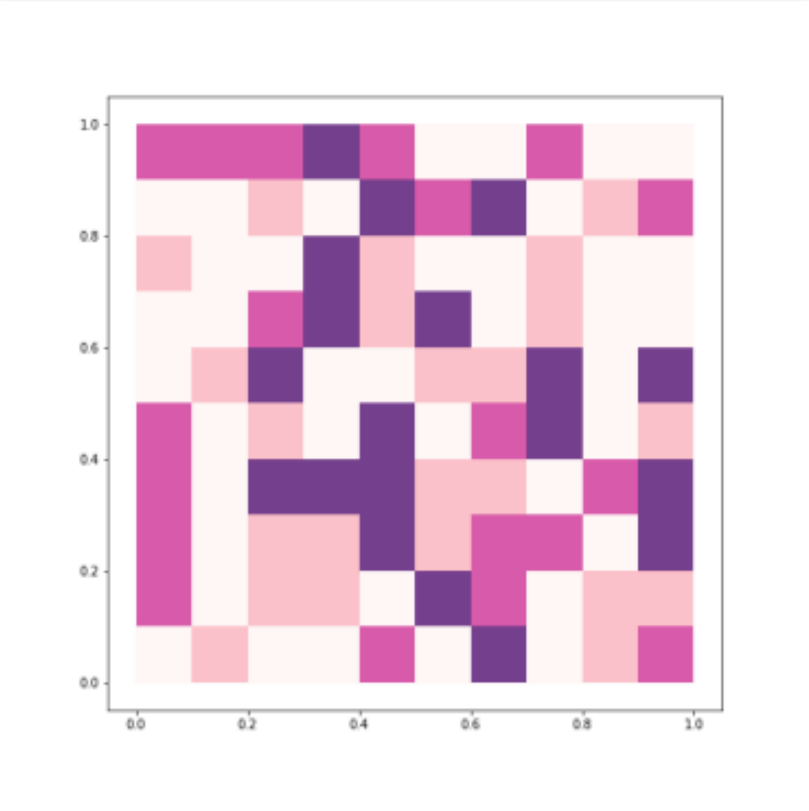
# How to Lie with Maps: Projections

Attribution

# How to Lie with Maps: MAUP



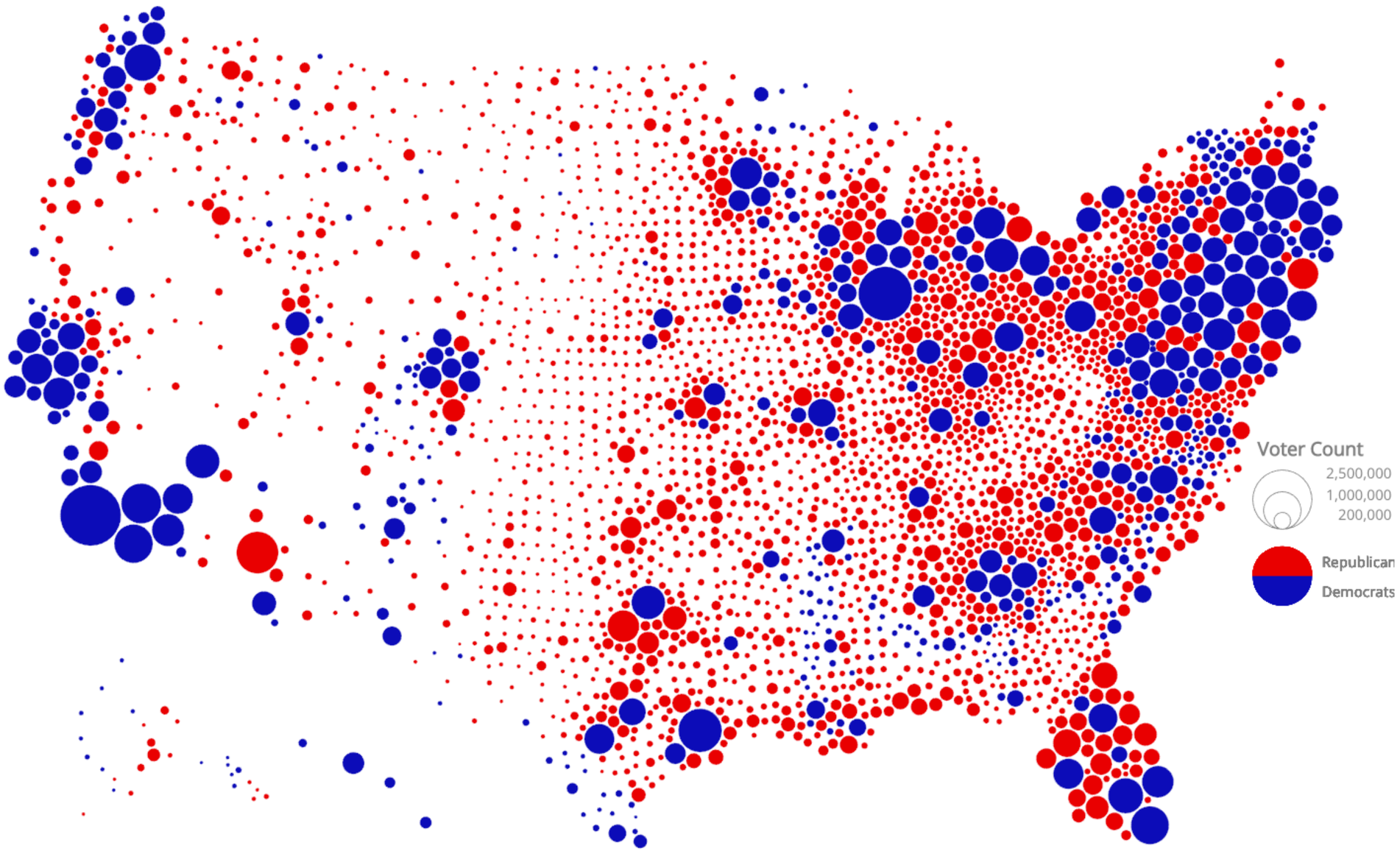




https://gist.github.com/darribas/8b5a7b93d4085223f1c5

# How to Lie with Maps: Area is not population

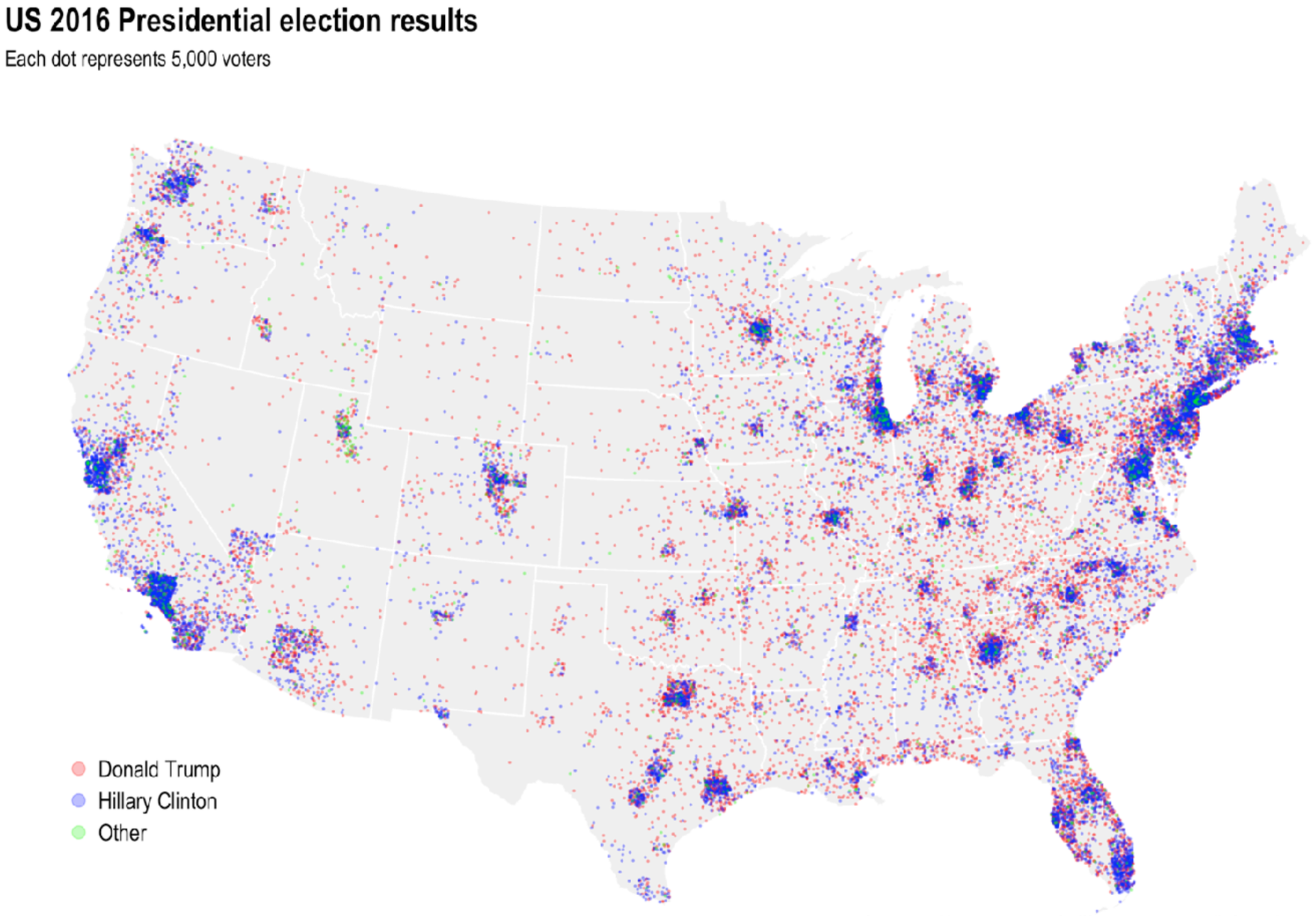
http://try-to-impeach-this.jetpack.ai/

# How to Lie with Maps: Area is not population




http://try-to-impeach-this.jetpack.ai/

# How to Lie with Maps: Area is not population




https://www.andybeger.com/blog/2018-05-11-us-2016-dot-density/

# Mapping uncertainty

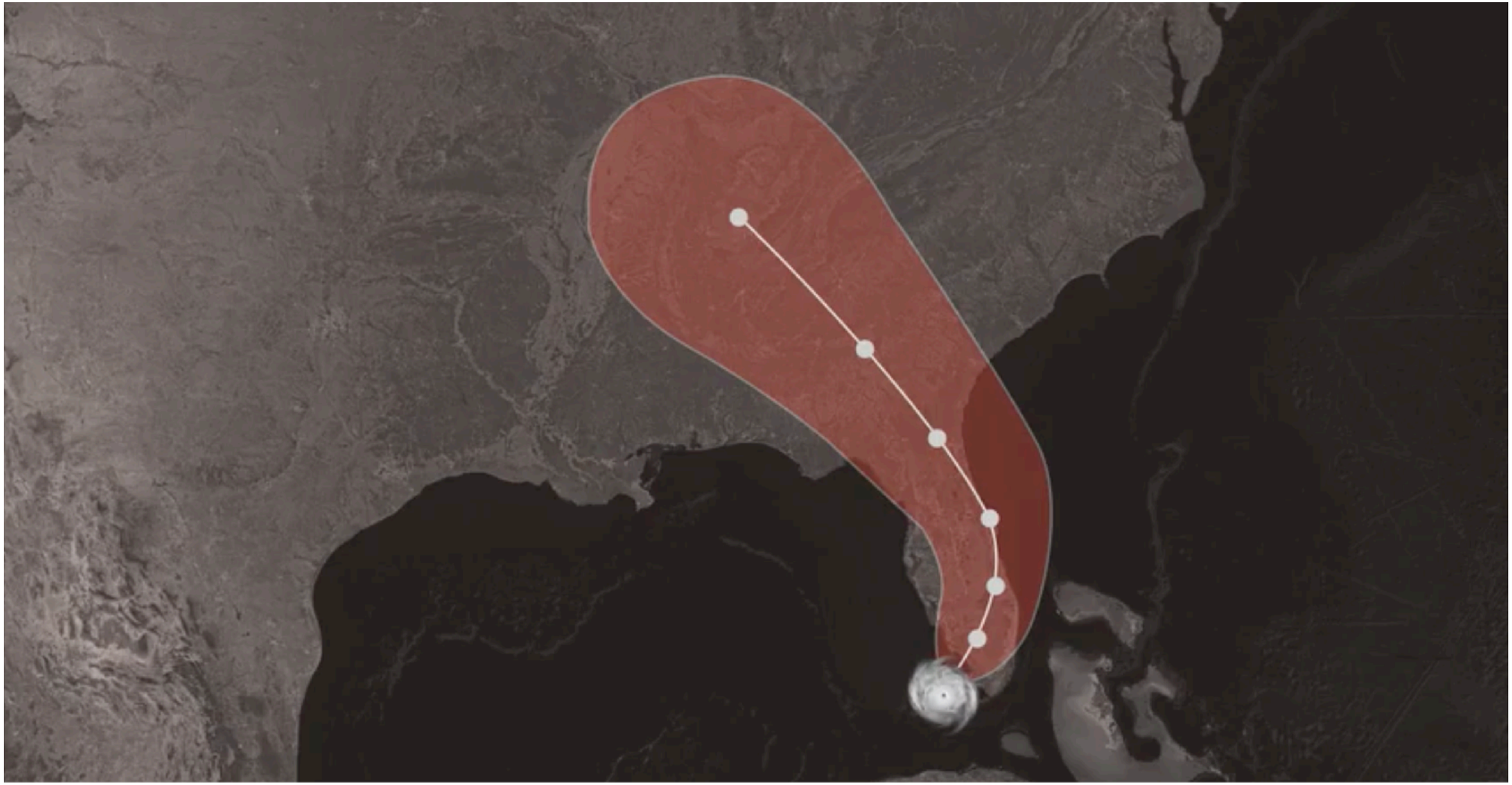
# Uncertainty & accuracy

https://gistbok.ucgis.org/bok-topics/spatial-data-uncertainty

“…the importance of an uncertainty depends on how much it could affect the decision, not simply the outcomes.”

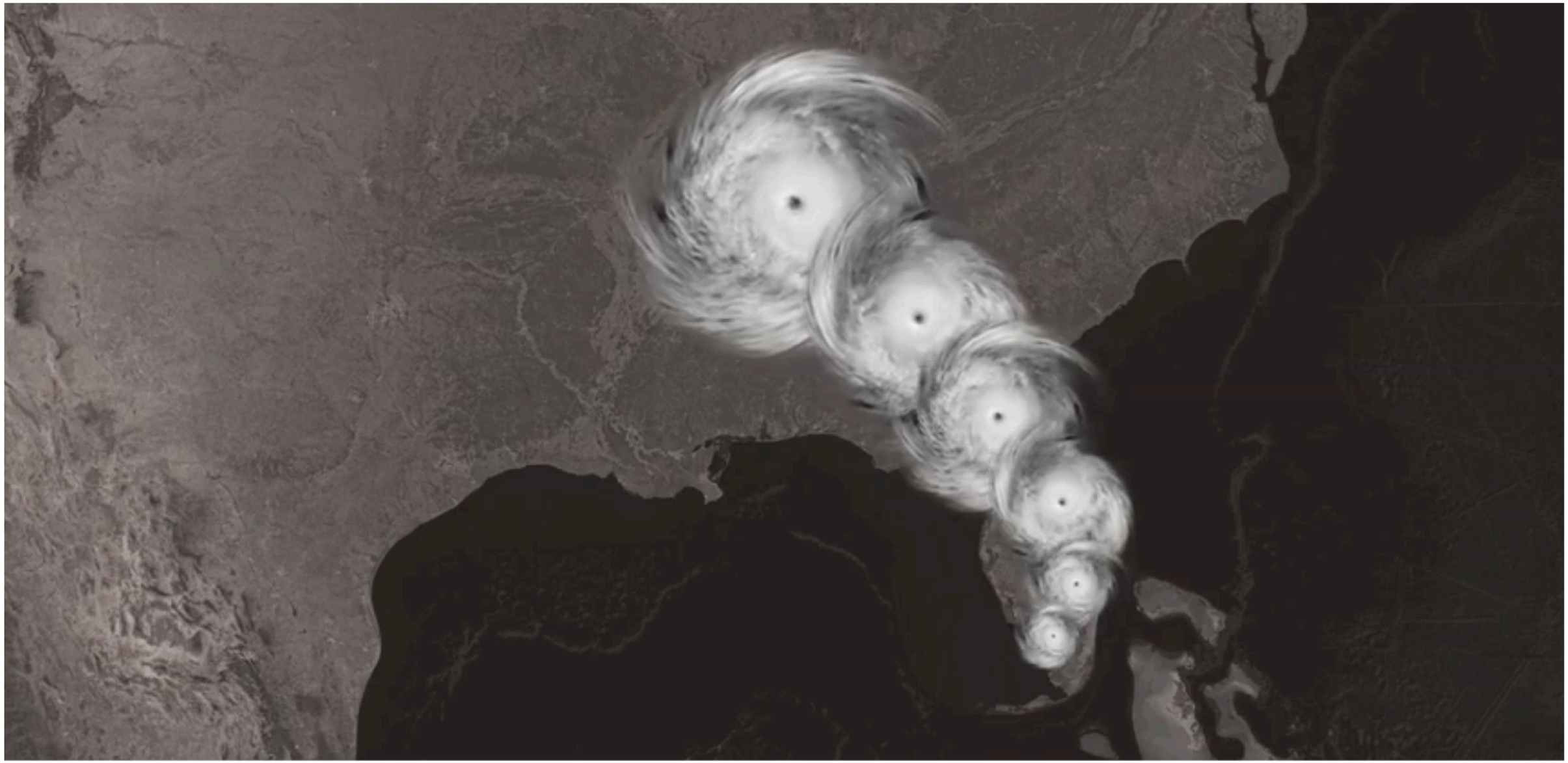
Morgan and Henrion, 1990

# Uncertainty & accuracy



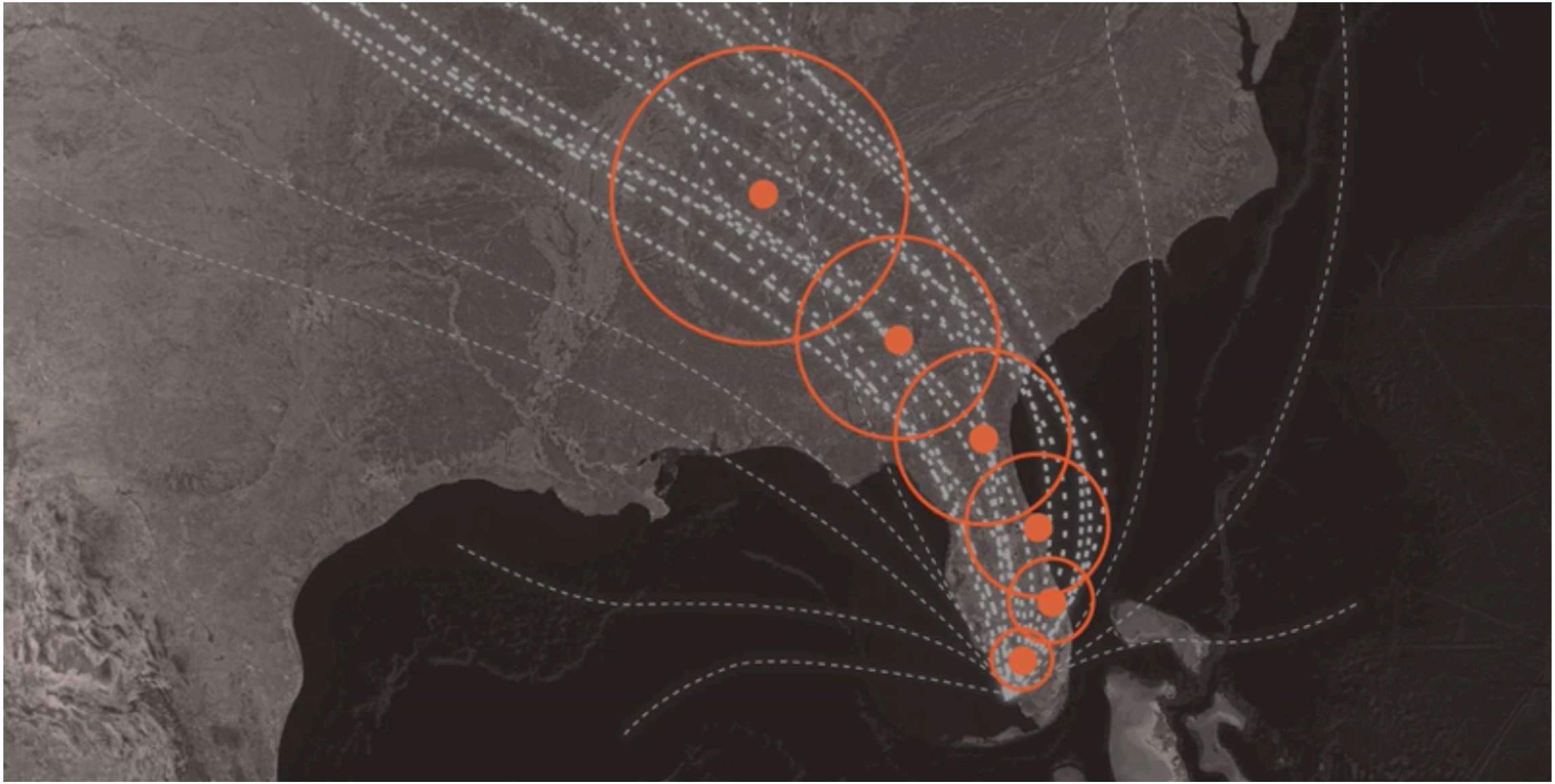
https://www.nytimes.com/interactive/2019/08/29/opinion/hurricane-dorian-forecast-map.html

# Uncertainty & accuracy



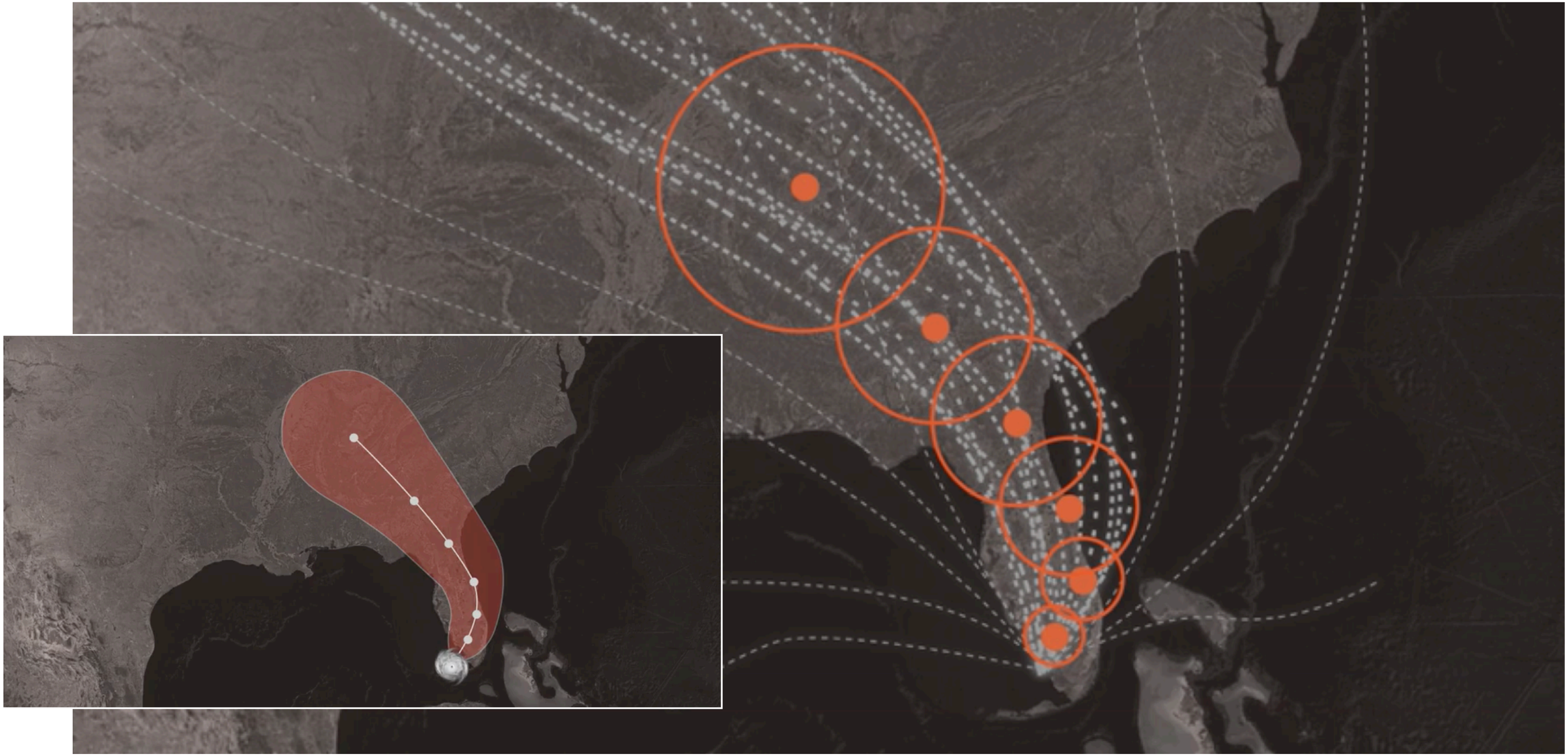
https://www.nytimes.com/interactive/2019/08/29/opinion/hurricane-dorian-forecast-map.html

# Uncertainty & accuracy



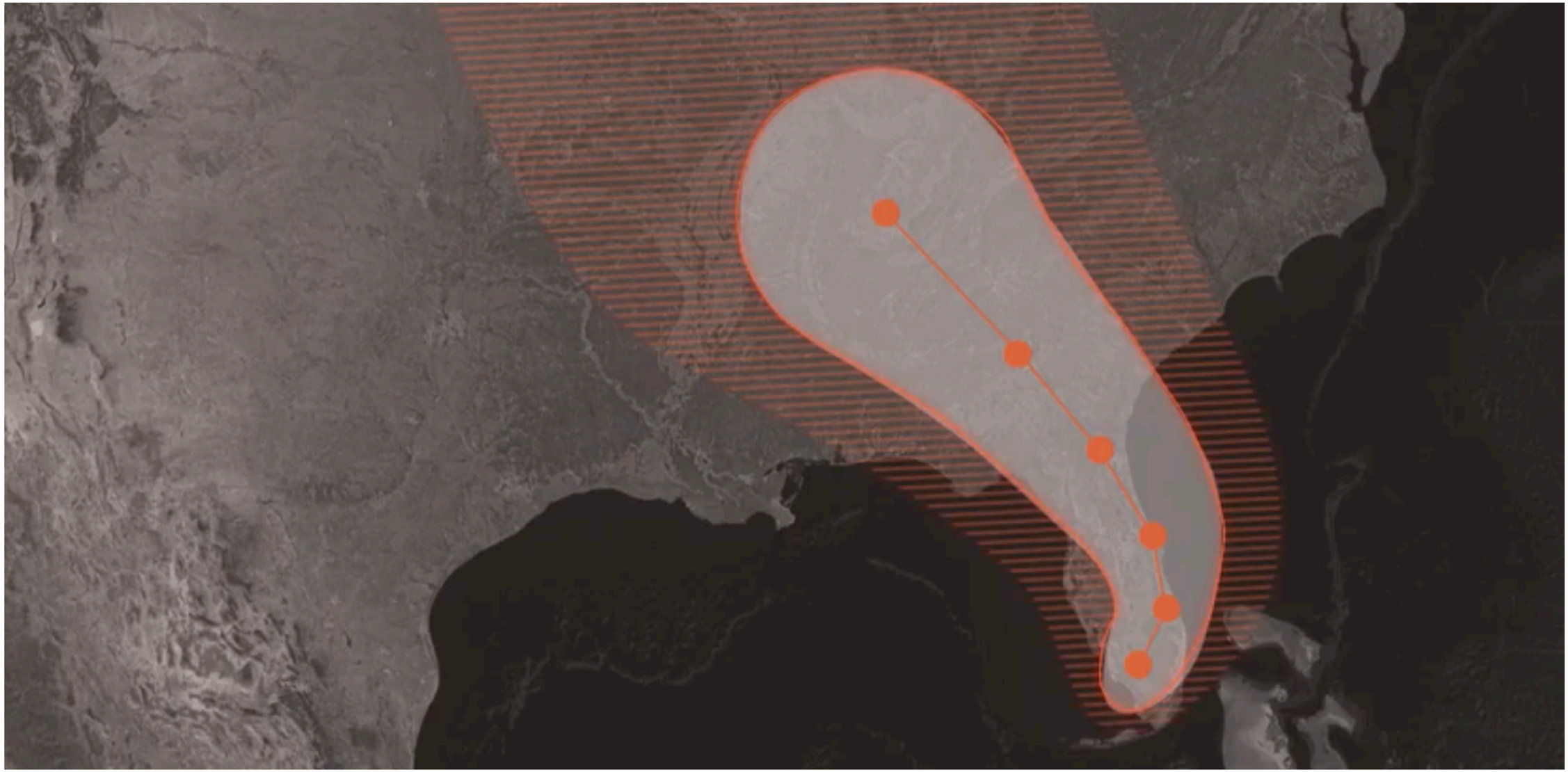
https://www.nytimes.com/interactive/2019/08/29/opinion/hurricane-dorian-forecast-map.html

# Uncertainty & accuracy



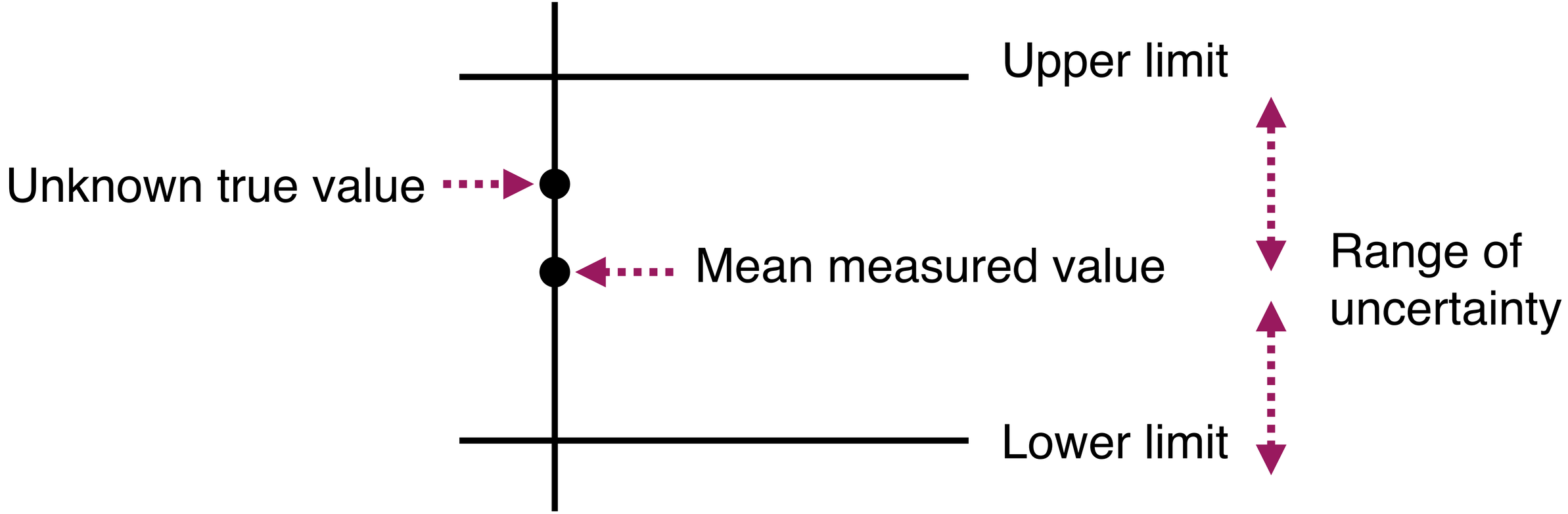
https://www.nytimes.com/interactive/2019/08/29/opinion/hurricane-dorian-forecast-map.html

# Uncertainty & accuracy



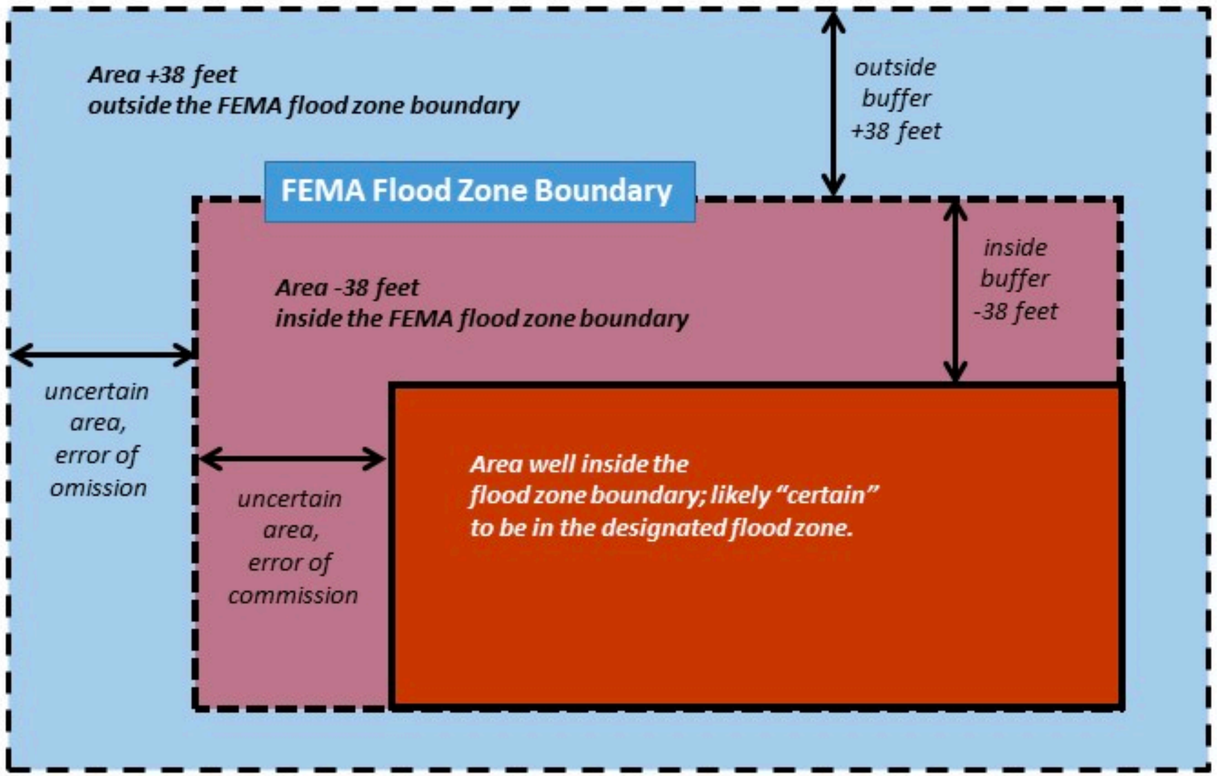
https://www.nytimes.com/interactive/2019/08/29/opinion/hurricane-dorian-forecast-map.html

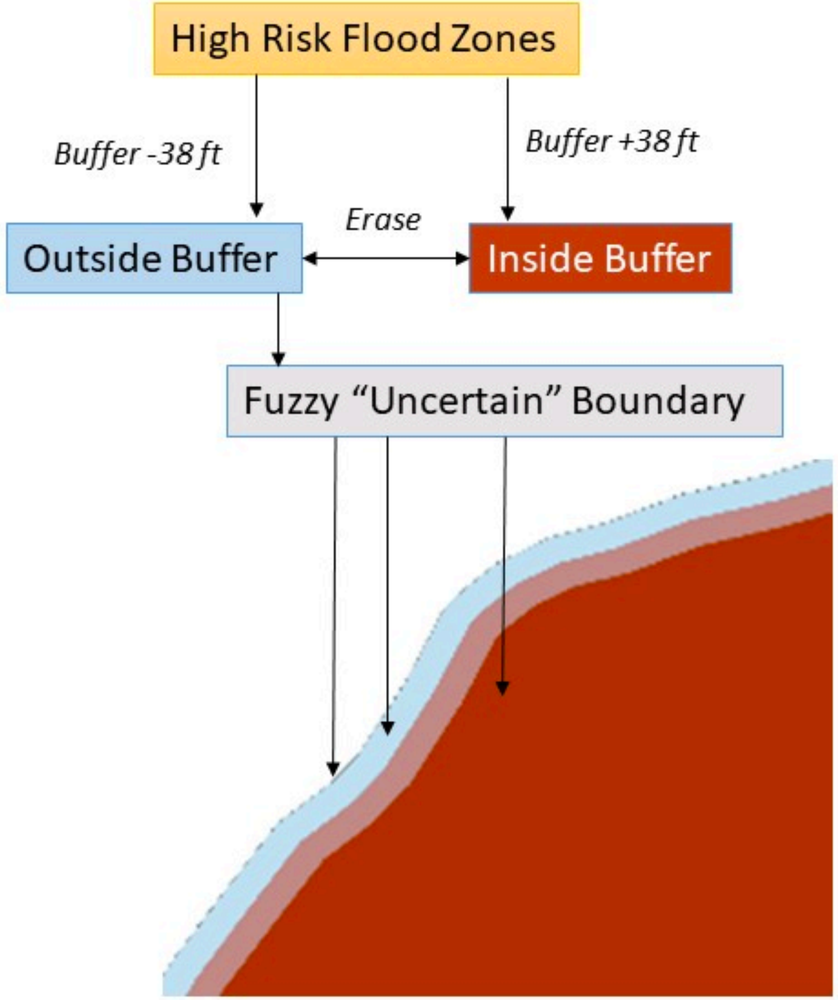
# Uncertainty & accuracy




https://www.cdc.gov/dhdsp/maps/gisx/training/module4/files/4_mapping_uncertainty_module-508.pdf

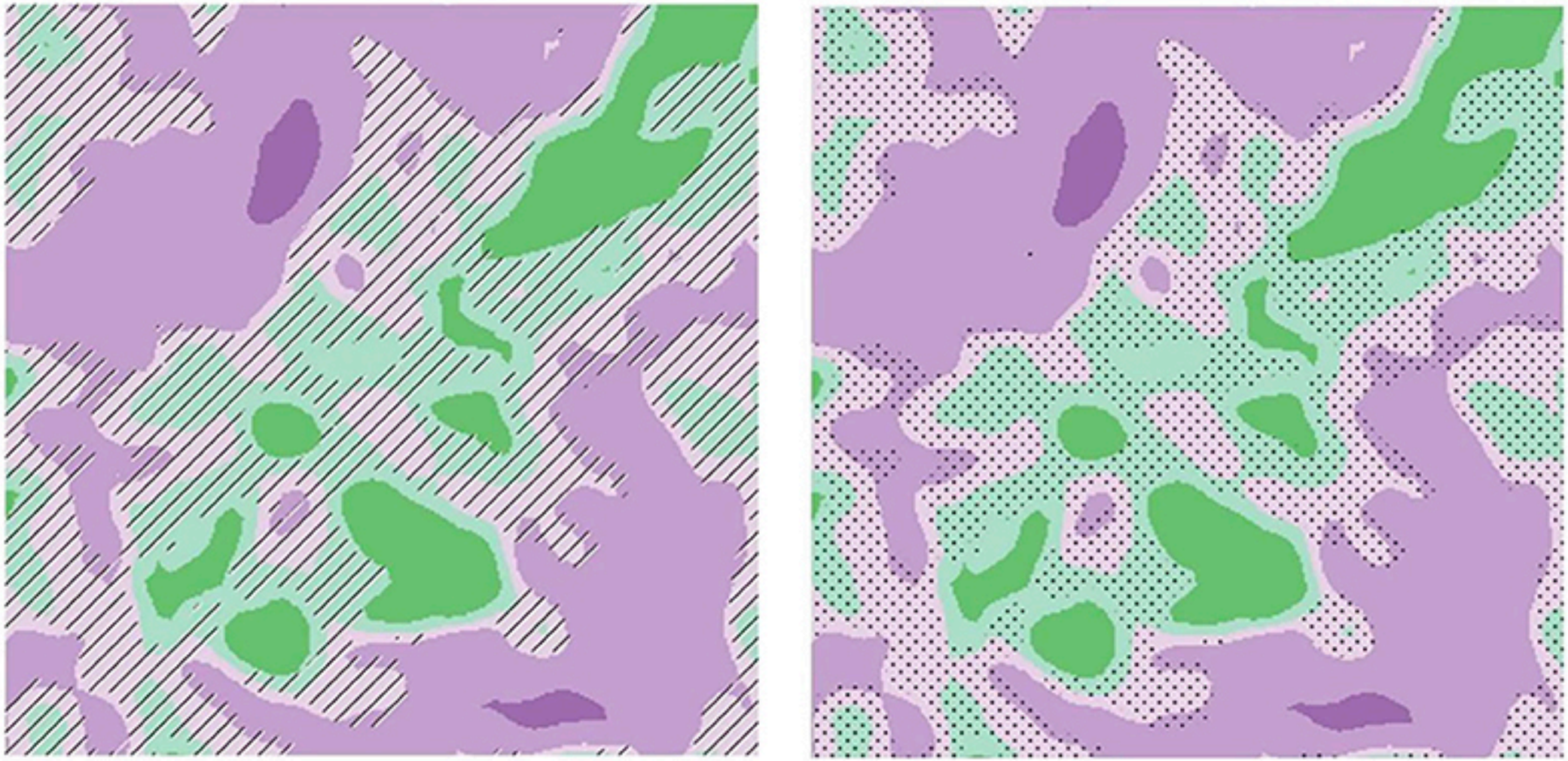
# Uncertainty & accuracy



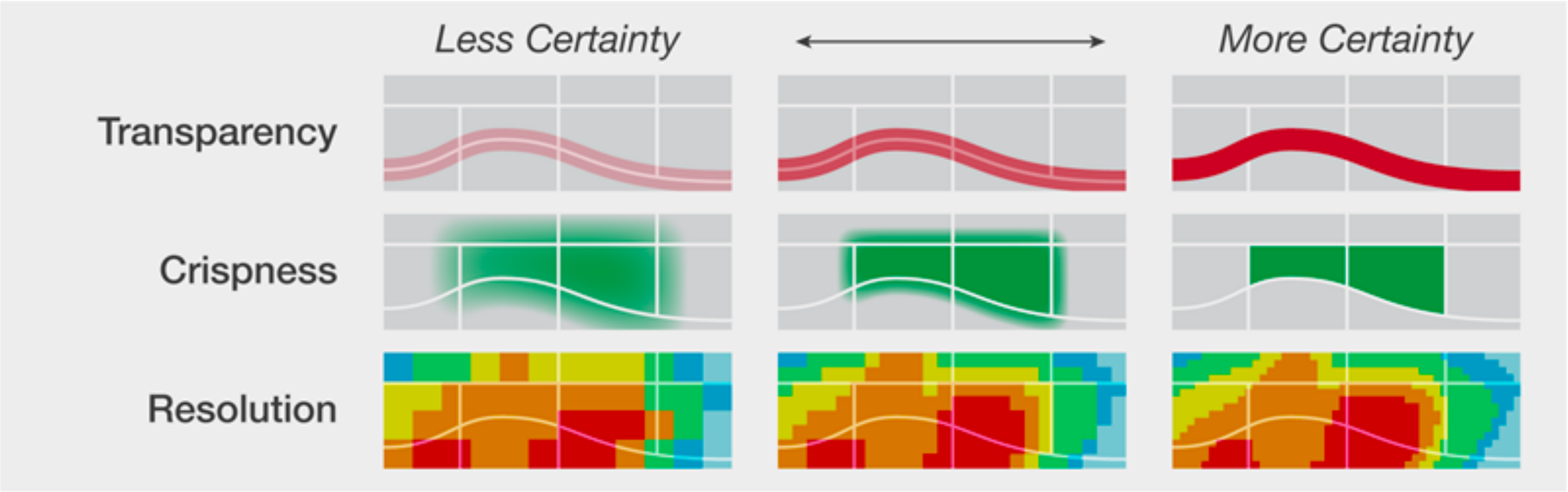

https://gistbok.ucgis.org/bok-topics/spatial-data-uncertainty

# Uncertainty & accuracy



https://www.frontiersin.org/articles/10.3389/fcomp.2020.00032/full

# Uncertainty & accuracy




https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables

# Cartographic guidelines & best practices

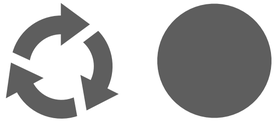
# Visual hierarchy

We process:

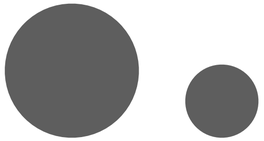
- Picture before text

text text
text text
text text

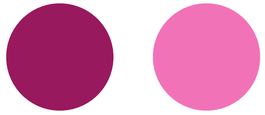
- Moving elements before static



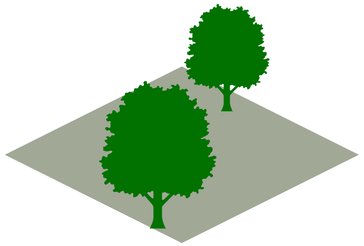
- Large before small



- Dark before light

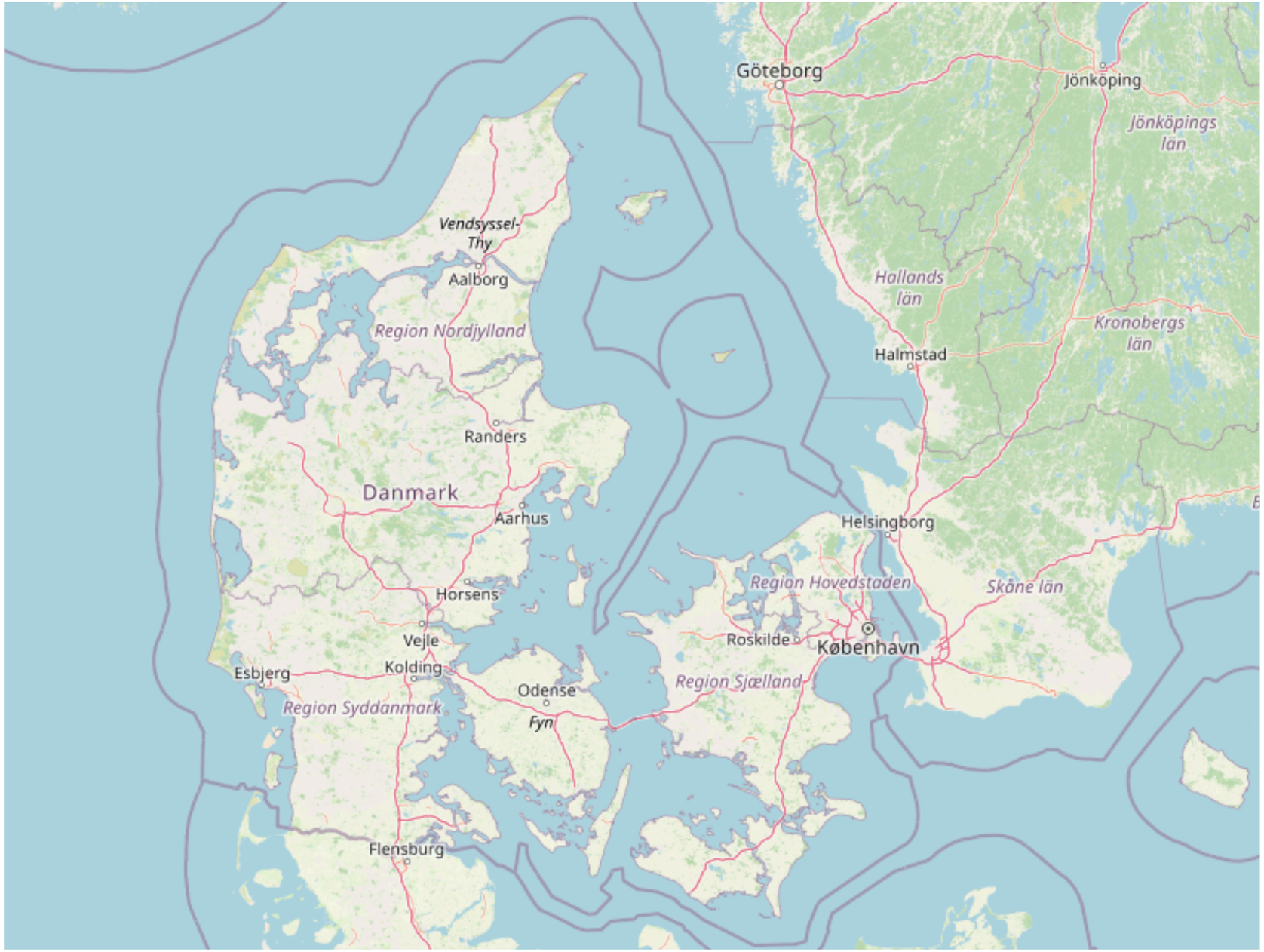


- Near things before distant things



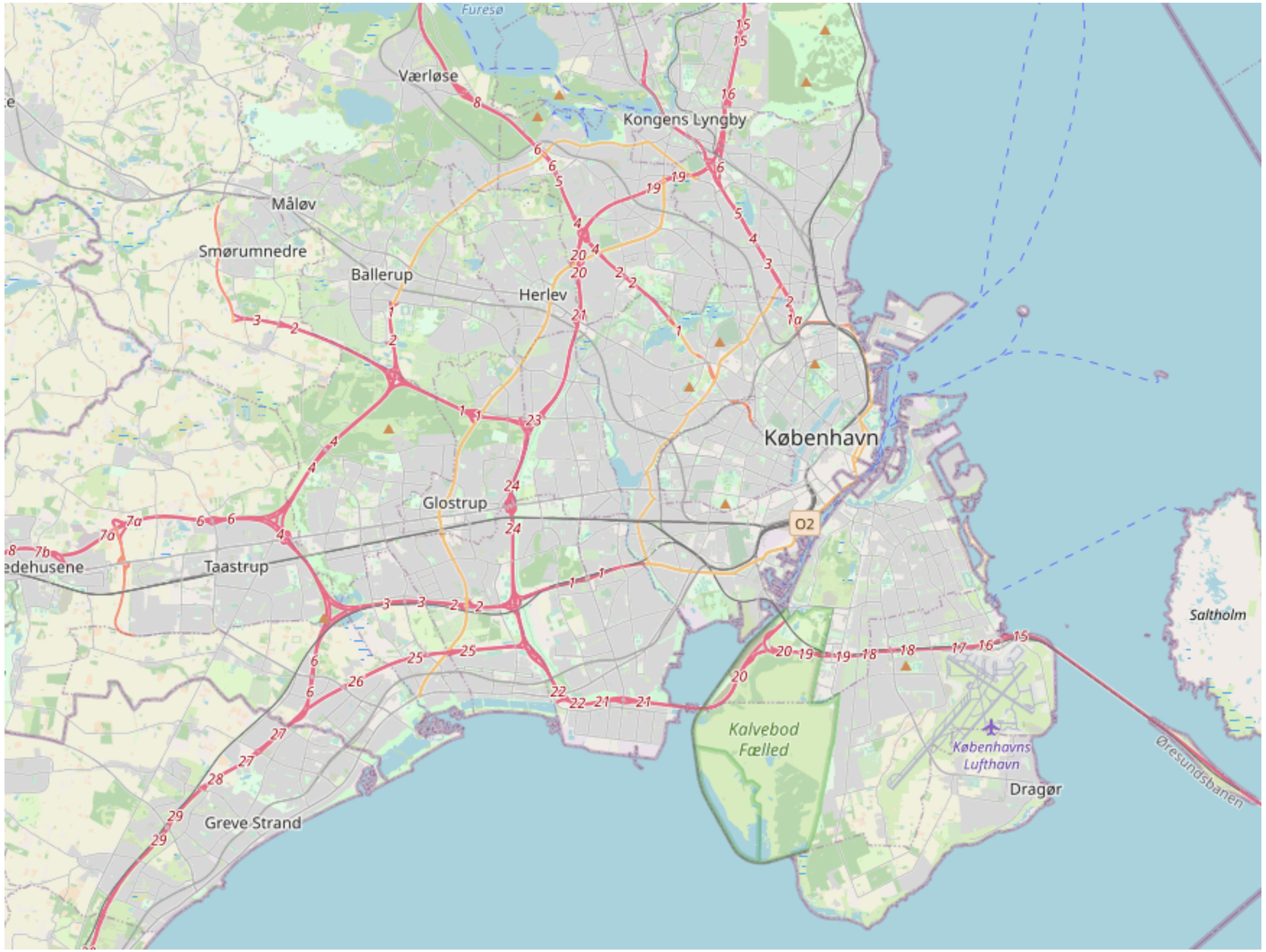
https://spatial-analytics.readthedocs.io/en/latest/lessons/L5/visual-analytics.html

# Scale: Include only necessary information



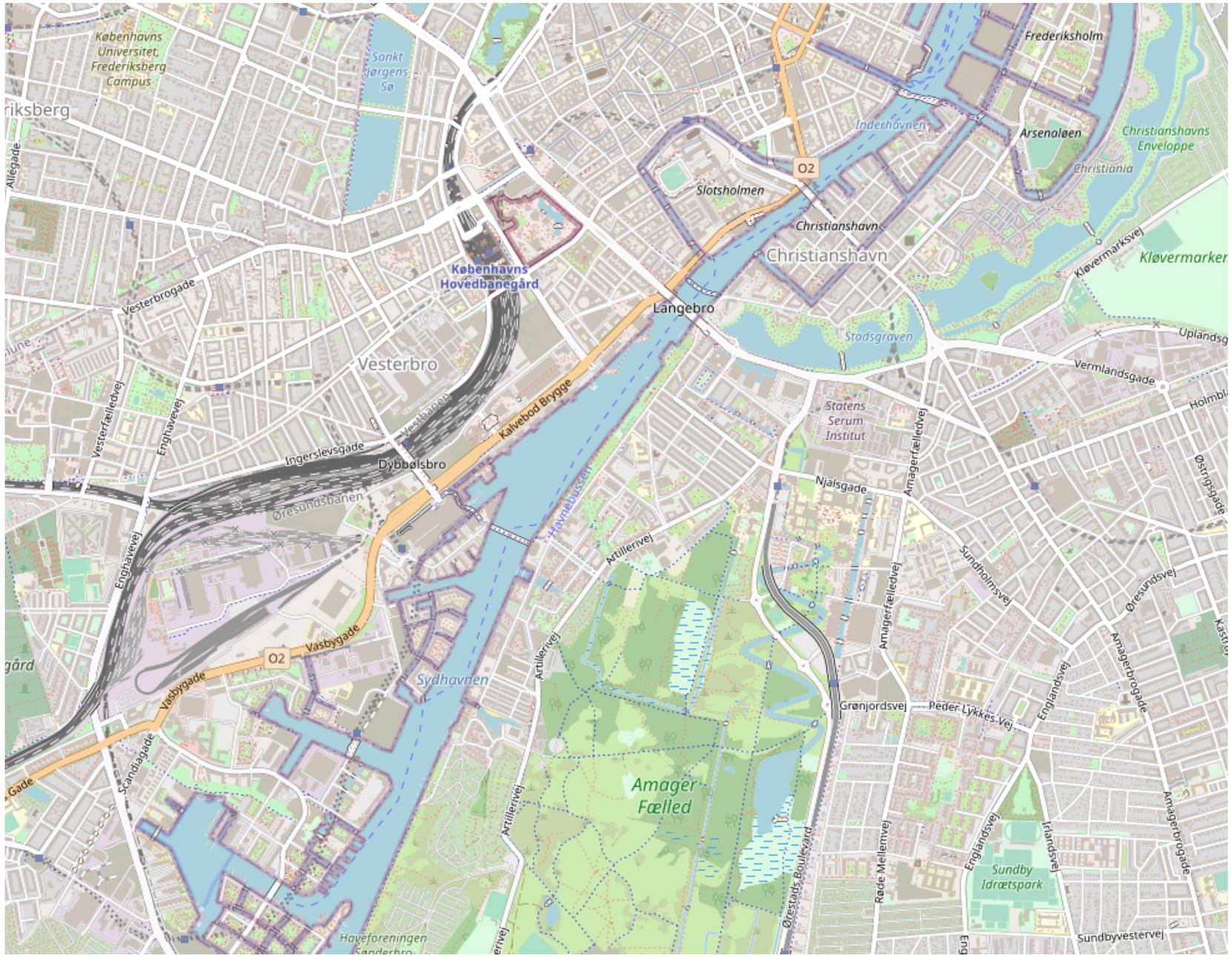

OpenStreetMap

# Scale: Include only necessary information



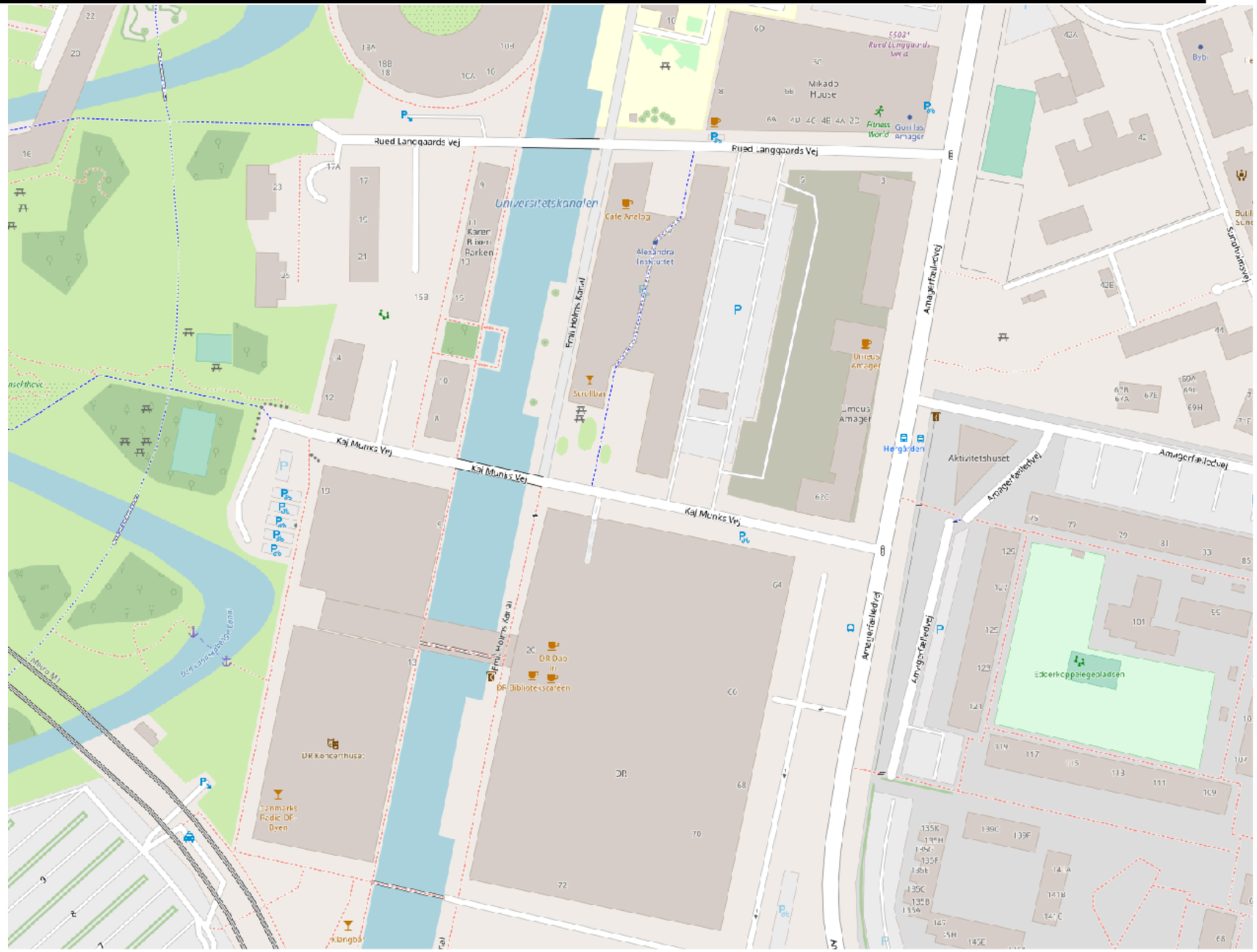

OpenStreetMap

# Scale: Include only necessary information



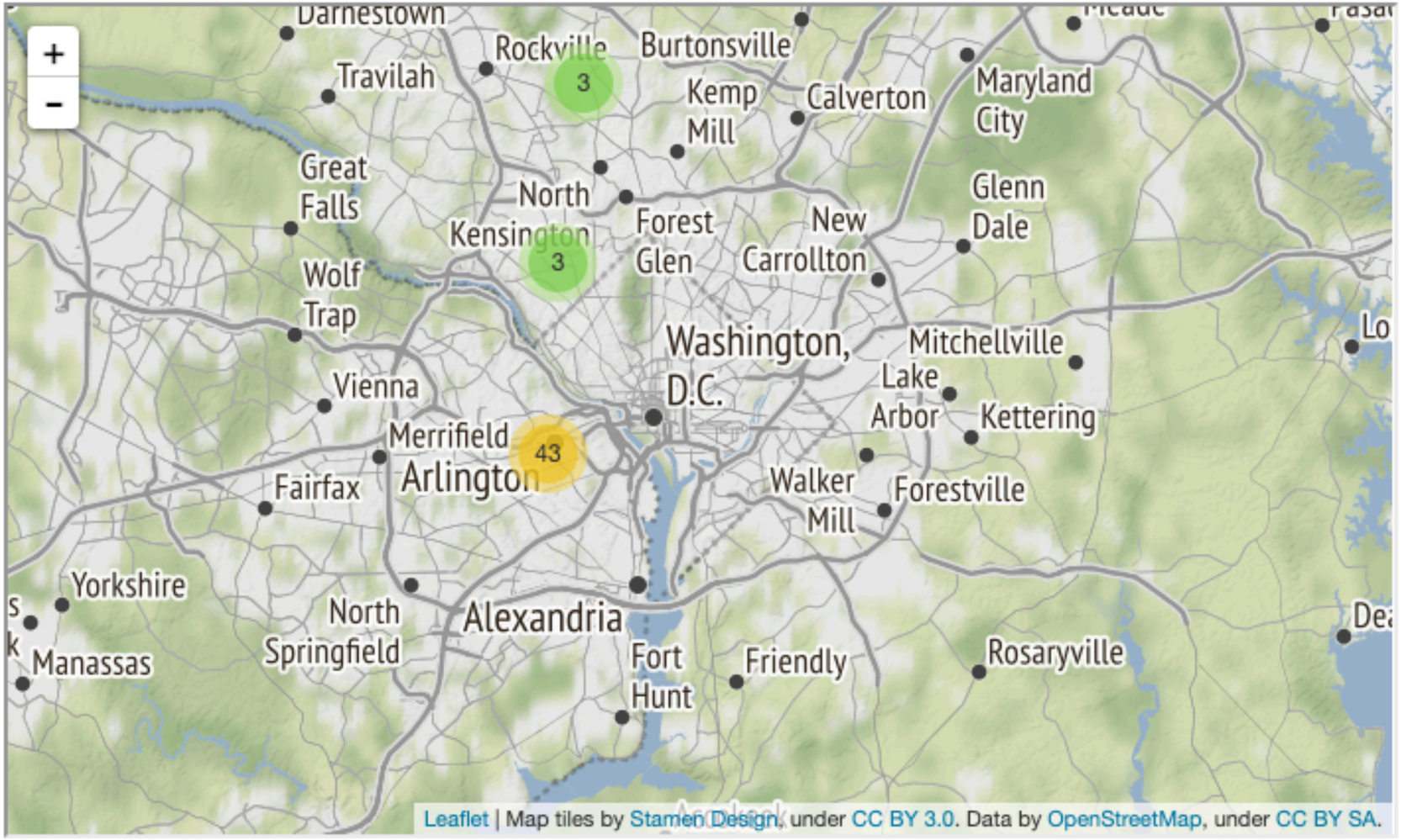

OpenStreetMap

# Scale: Include only necessary information



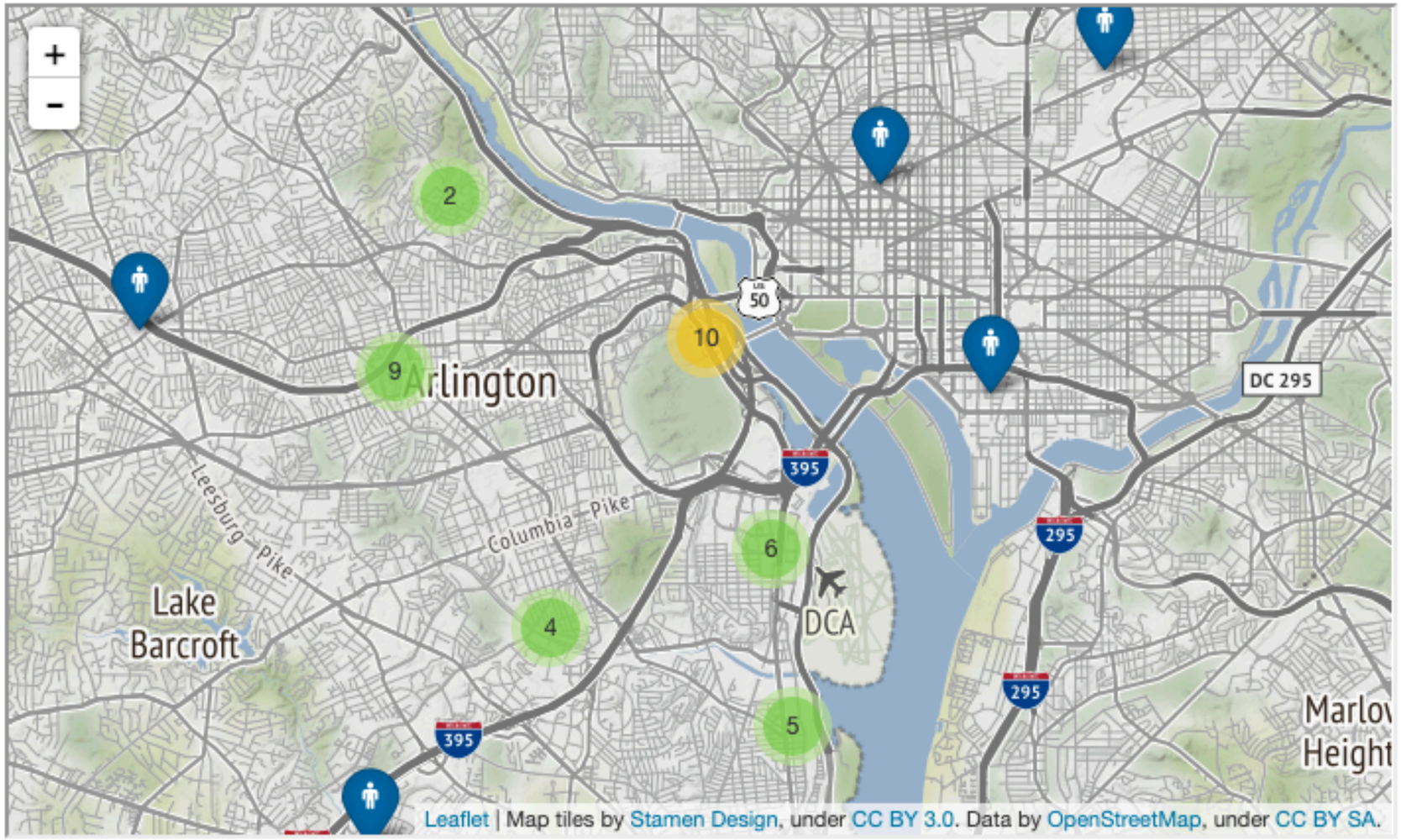

OpenStreetMap

# Scale: Aggregate for simplicity



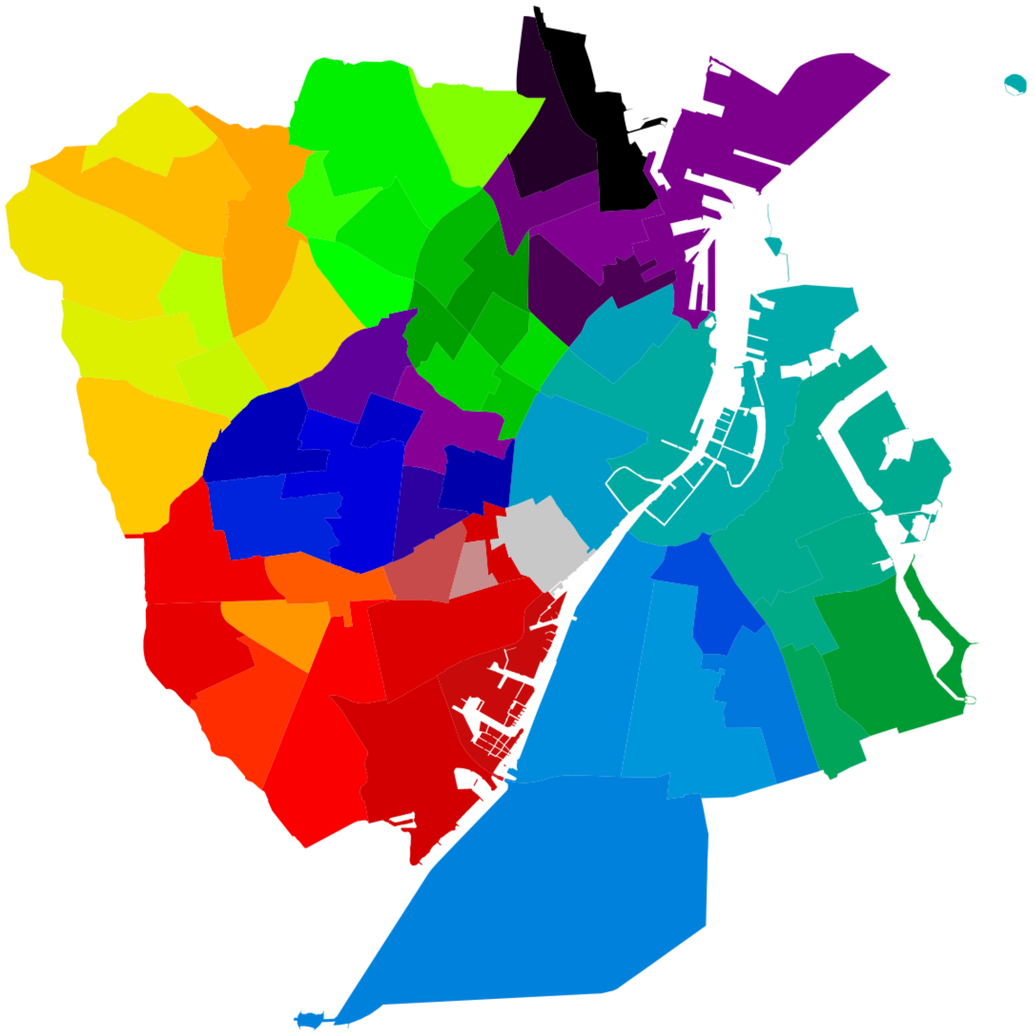

https://georgetsilva.github.io/posts/mapping-points-with-folium/

# Scale: Aggregate for simplicity




https://georgetsilva.github.io/posts/mapping-points-with-folium/

# Colors

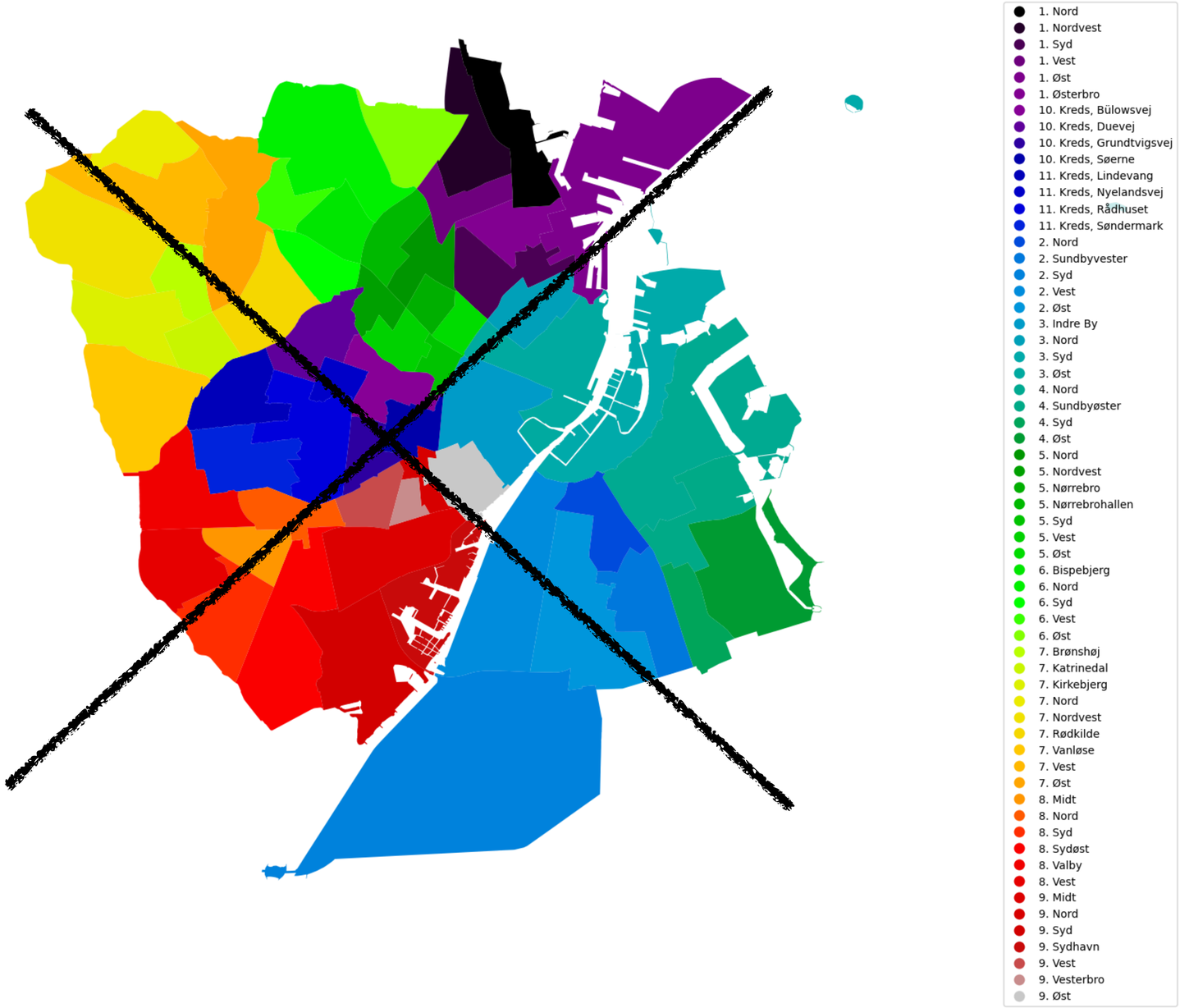


- 1. Nord
- 1. Nordvest
- 1. Syd
- 1. Vest
- 1. Øst
- 1. Østerbro
- 10. Kreds, Bülowsvej
- 10. Kreds, Duevej
- 10. Kreds, Grundtvigsvej
- 10. Kreds, Søerne
- 11. Kreds, Lindevang
- 11. Kreds, Nyelandsvej
- 11. Kreds, Rådhuset
- 11. Kreds, Søndermark
- 2. Nord
- 2. Sundbyvester
- 2. Syd
- 2. Vest
- 2. Øst
- 3. Indre By
- 3. Nord
- 3. Syd
- 3. Øst
- 4. Nord
- 4. Sundbyøster
- 4. Syd
- 4. Øst
- 5. Nord
- 5. Nordvest
- 5. Nørrebro
- 5. Nørrebrohallen
- 5. Syd
- 5. Vest
- 5. Øst
- 6. Bispebjerg
- 6. Nord
- 6. Syd
- 6. Vest
- 6. Øst
- 7. Brønshøj
- 7. Katrinedal
- 7. Kirkebjerg
- 7. Nord
- 7. Nordvest
- 7. Rødkilde
- 7. Vanløse
- 7. Vest
- 7. Øst
- 8. Midt
- 8. Nord
- 8. Syd
- 8. Sydøst
- 8. Valby
- 8. Vest
- 9. Midt
- 9. Nord
- 9. Syd
- 9. Sydhavn
- 9. Vest
- 9. Vesterbro
- 9. Øst

# Colors

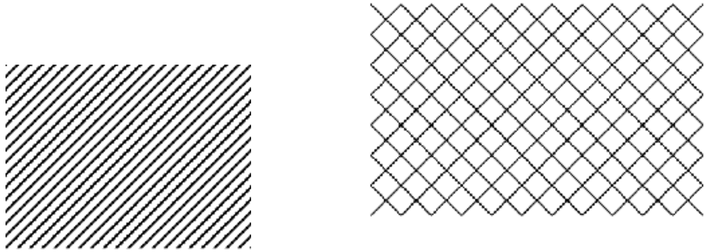
Avoid too many colors

Ideally < 10



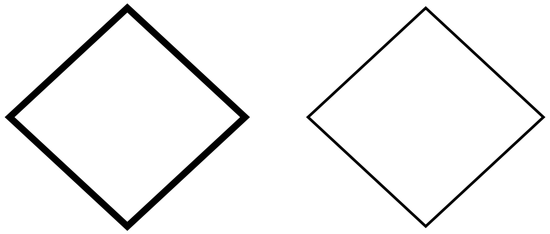
# We can create additional symbols with…

Hatches



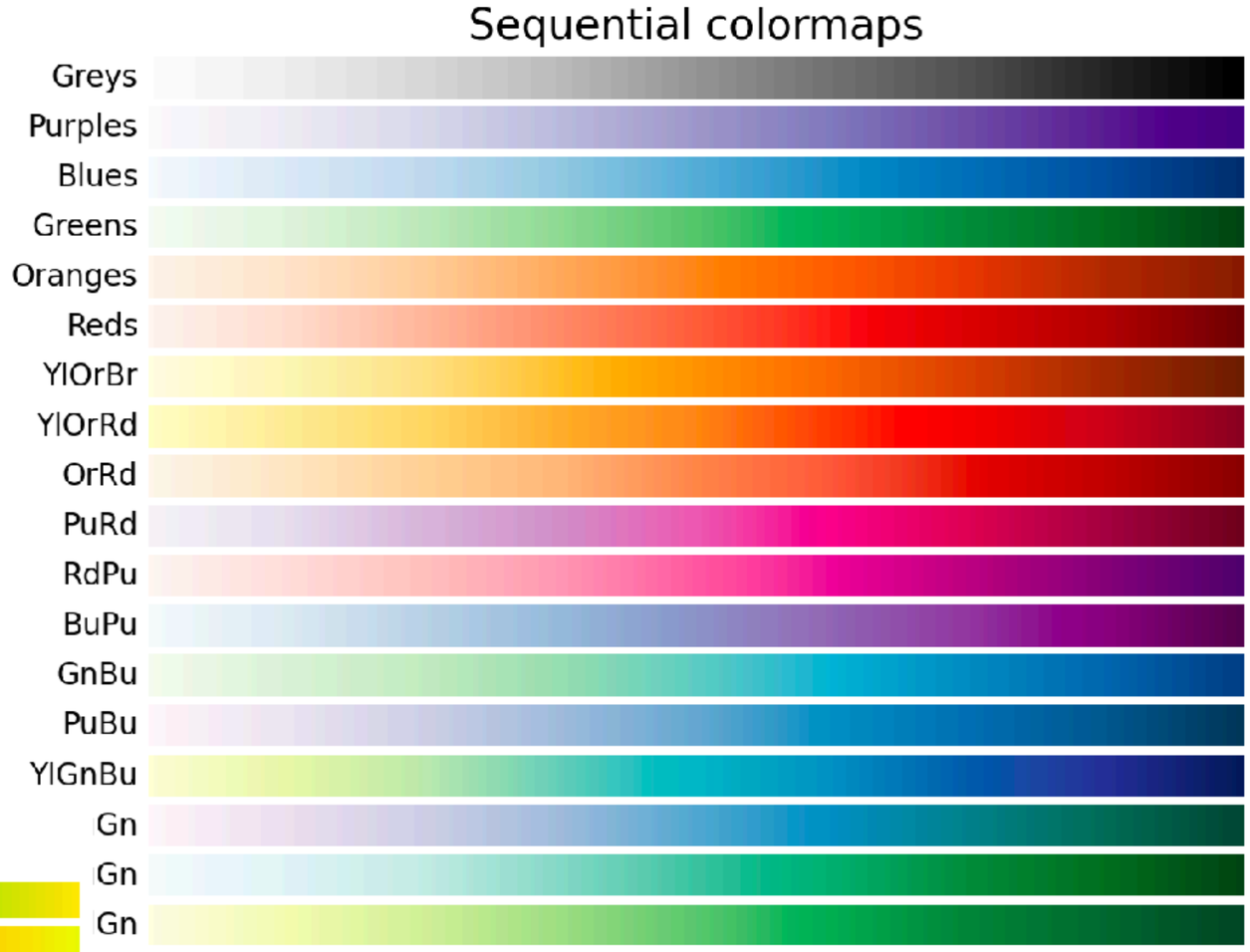
Transparency

Line weight



# Colormaps: Sequential colormaps

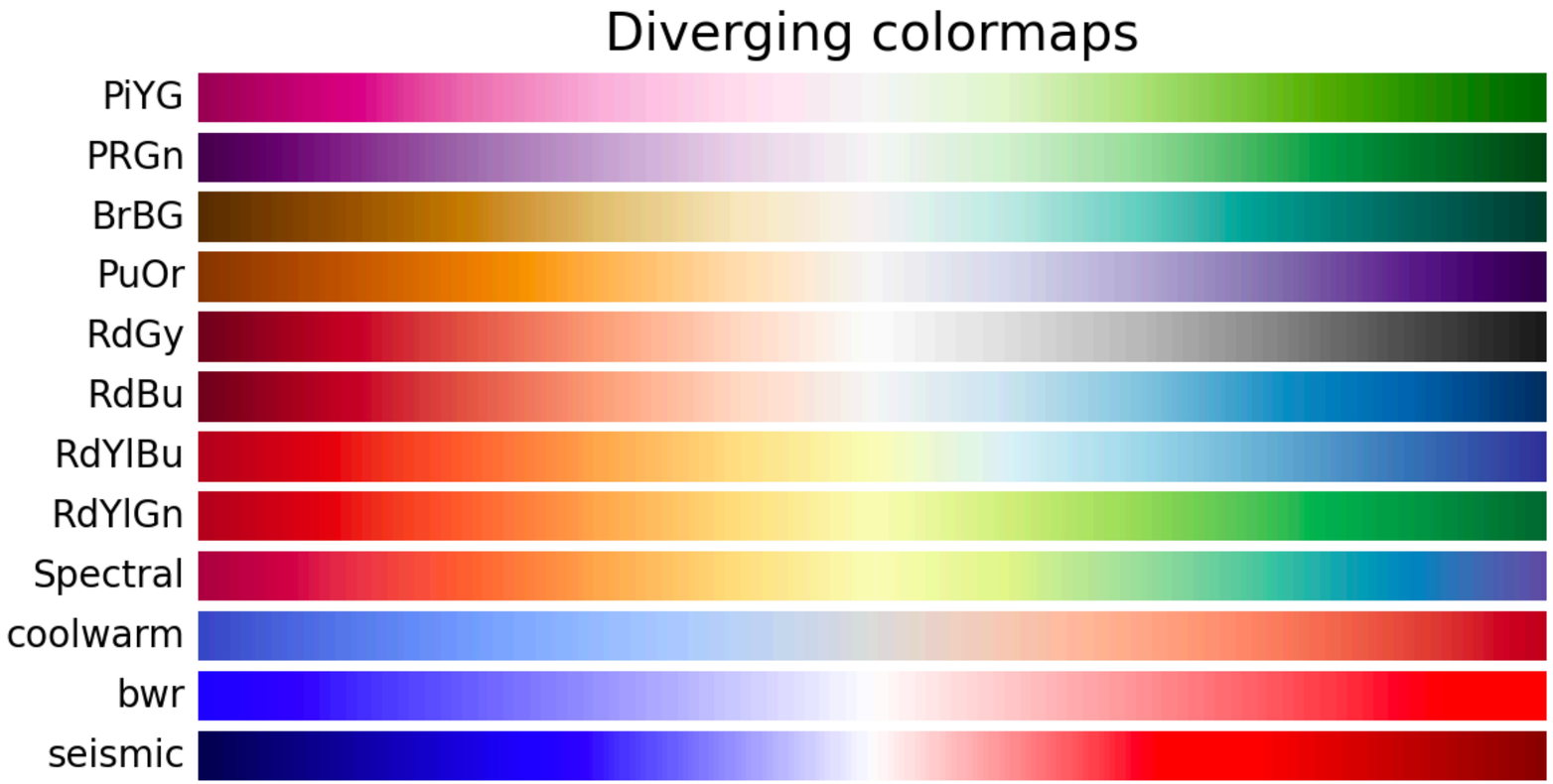
For mappings of ordinal values



https://matplotlib.org/stable/tutorials/colors/colormaps.html

# Colormaps: Diverging colormaps

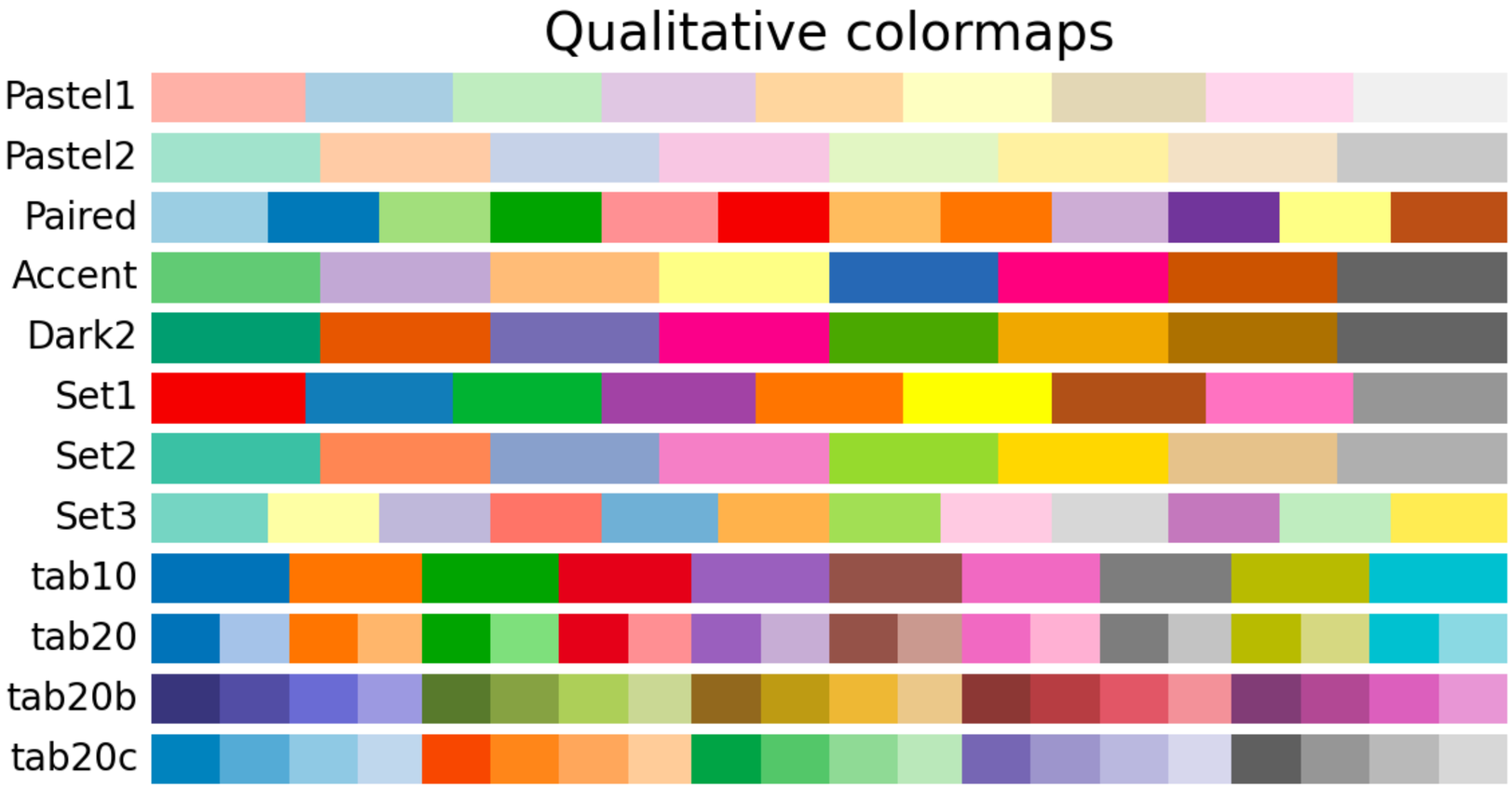
For ordered value ranges spanning across a null point (difference maps)




https://matplotlib.org/stable/tutorials/colors/colormaps.html

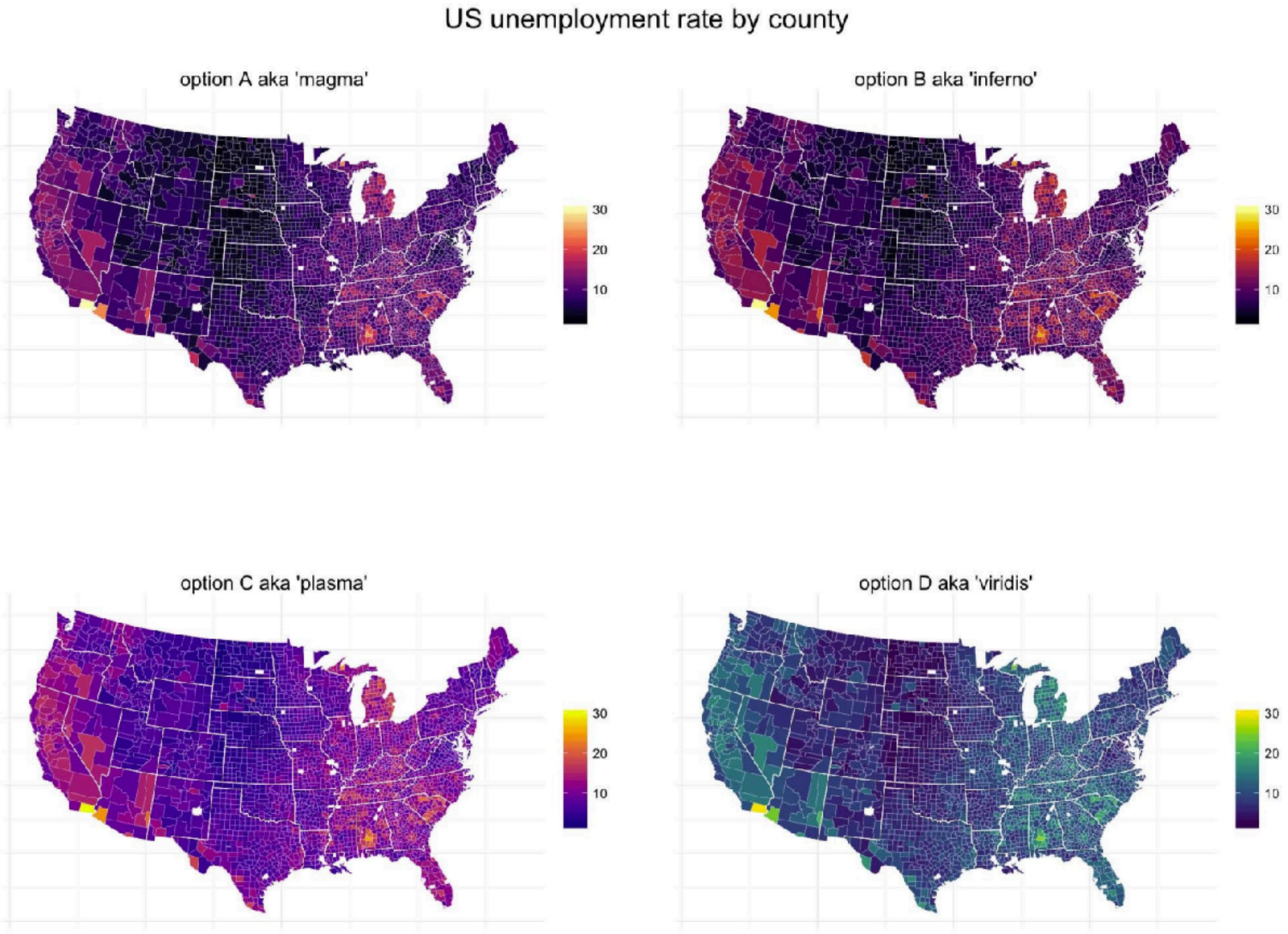
# Colormaps: Qualitative/categorical colormaps

For mapping variables that cannot be ordered




https://matplotlib.org/stable/tutorials/colors/colormaps.html

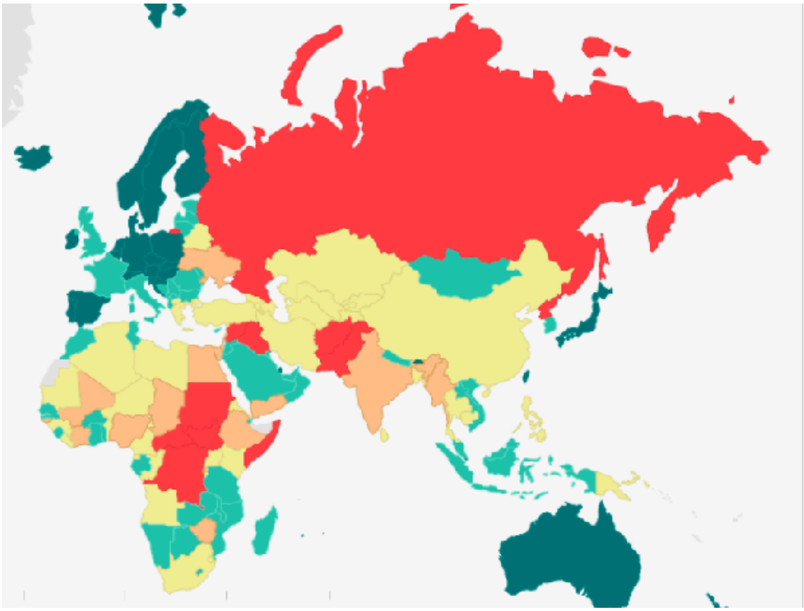
# Colormaps



***Viridis*** color map for better changes in perception

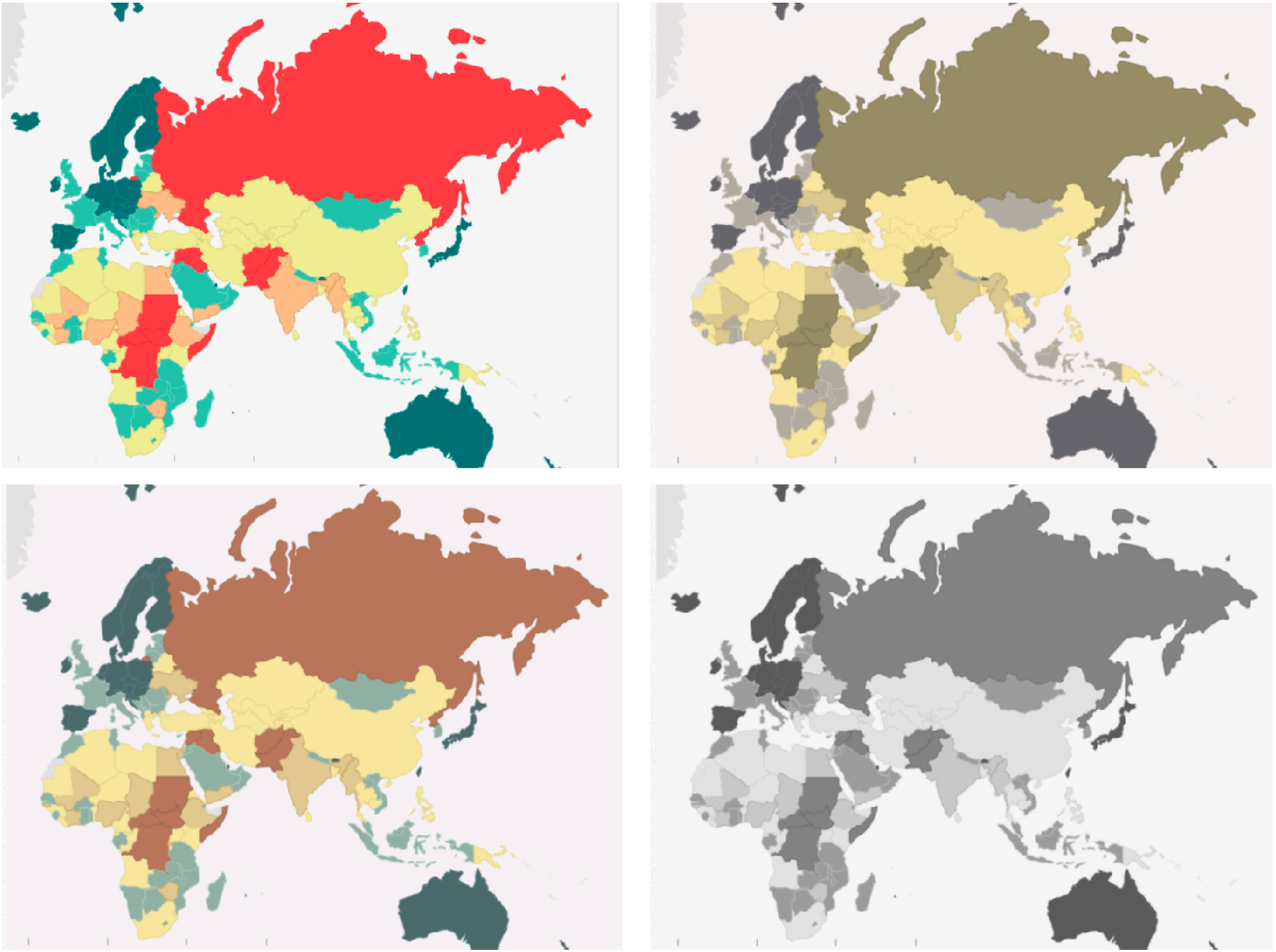
https://cusp.tbm.tudelft.nl/courses/epa1316/lectures/05-visualisation.pdf

# Color blindness



https://www.color-blindness.com/coblis-color-blindness-simulator/

# Color blindness



https://www.color-blindness.com/coblis-color-blindness-simulator/

# Tools for Spatial Data Visualization

# Static maps

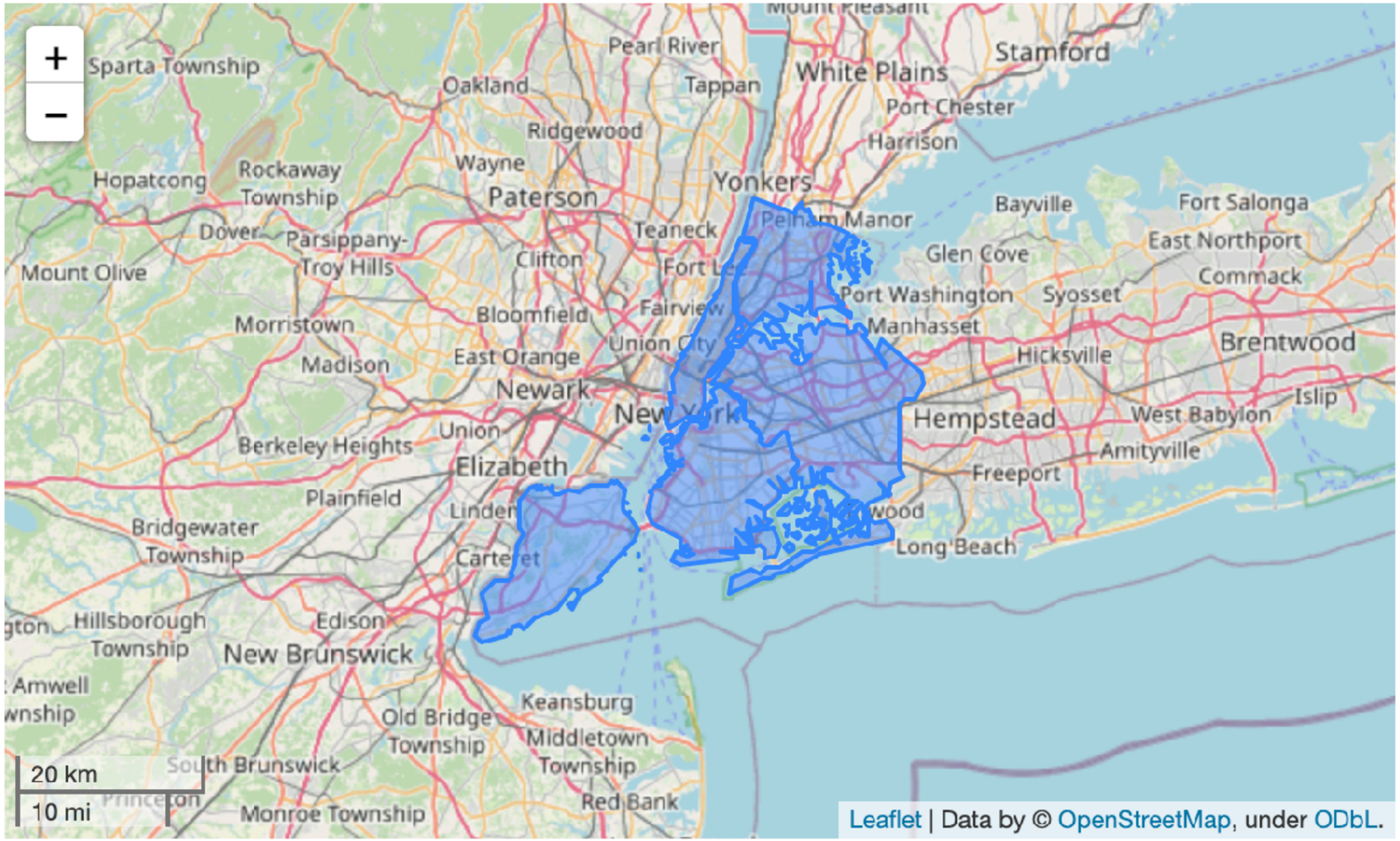
GeoPandas

matplotlib

See also GeoViews

https://geopandas.org/en/stable/docs/user_guide/mapping.html

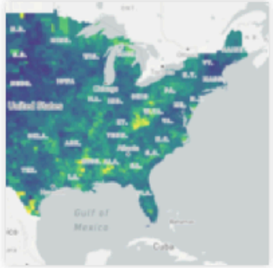
# Interactive maps: Folium




What we get from gdf.explore()

https://python-visualization.github.io/folium/

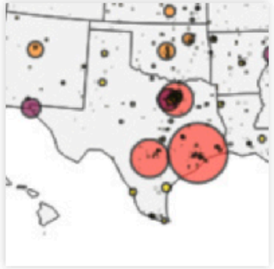
# Interactive maps: Plotly



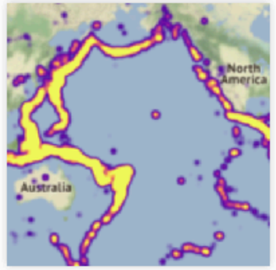
Mapbox Choropleth Maps

Lines on Mapbox

Filled Area on Maps



Bubble Maps

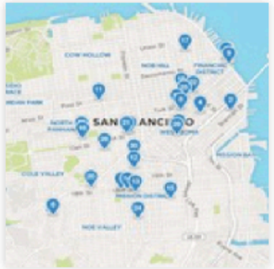



Mapbox Density Heatmap

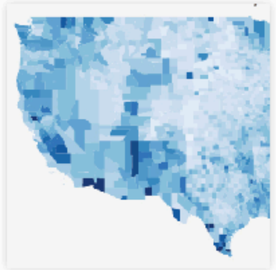
Lines on Maps

Choropleth Maps

Mapbox Map Layers

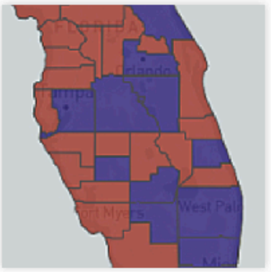


Scatter Plots on Mapbox

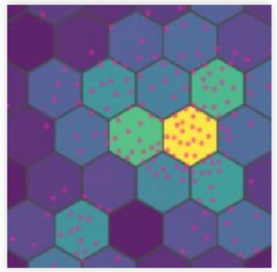


USA County Choropleth Maps

Scatter Plots on Maps



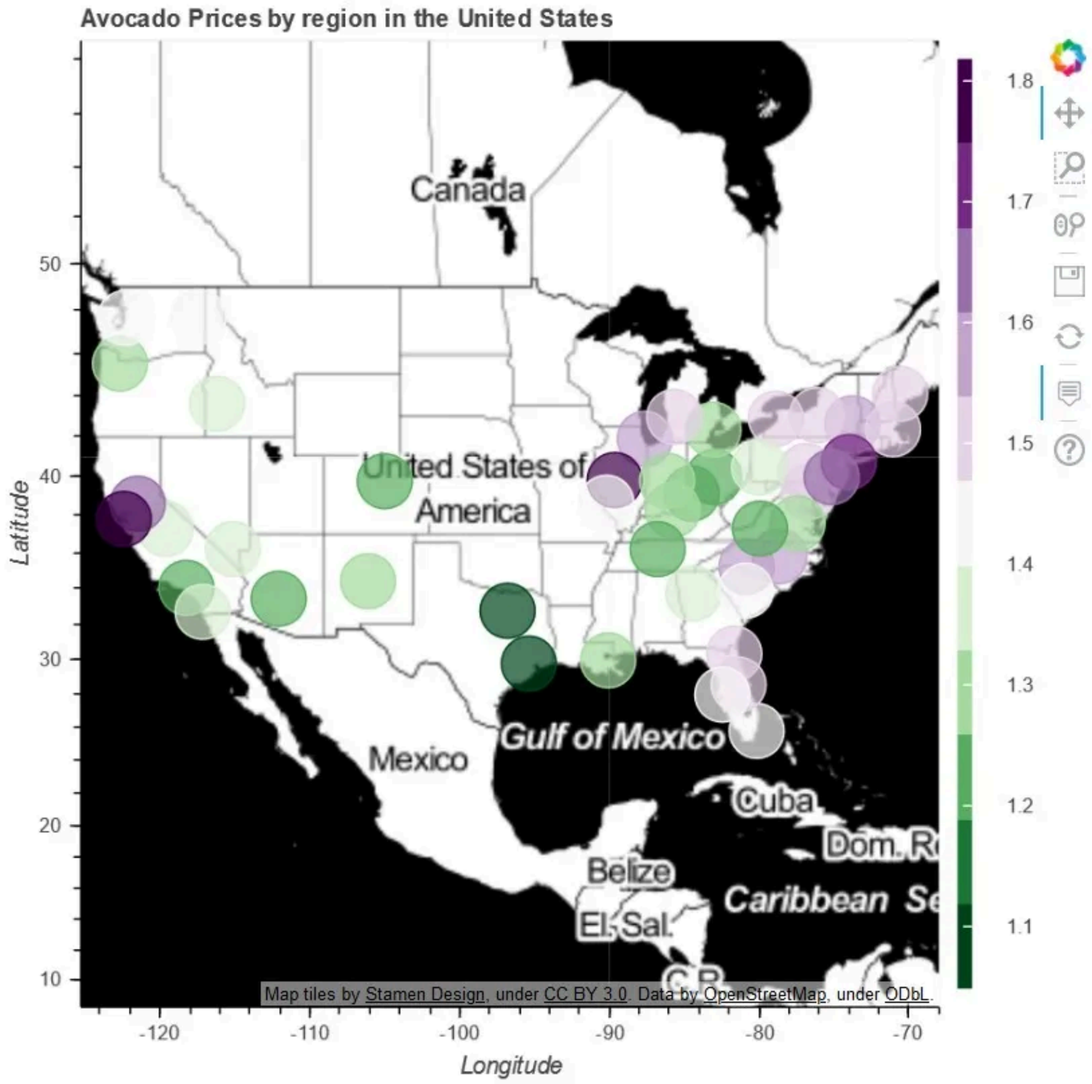
Map Configuration and Styling

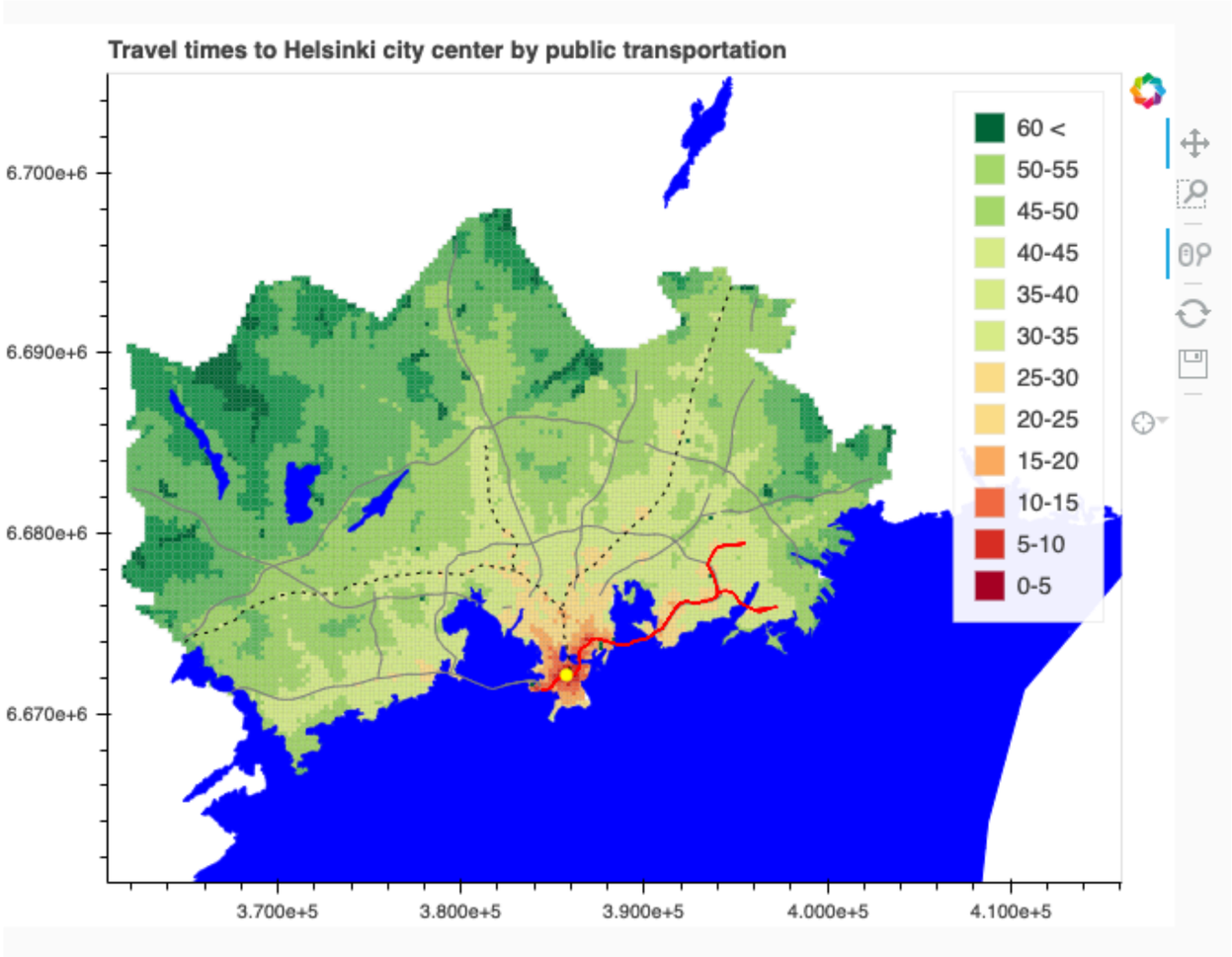


Hexbin Mapbox

https://plotly.com/python/maps/

# Interactive maps: Bokeh

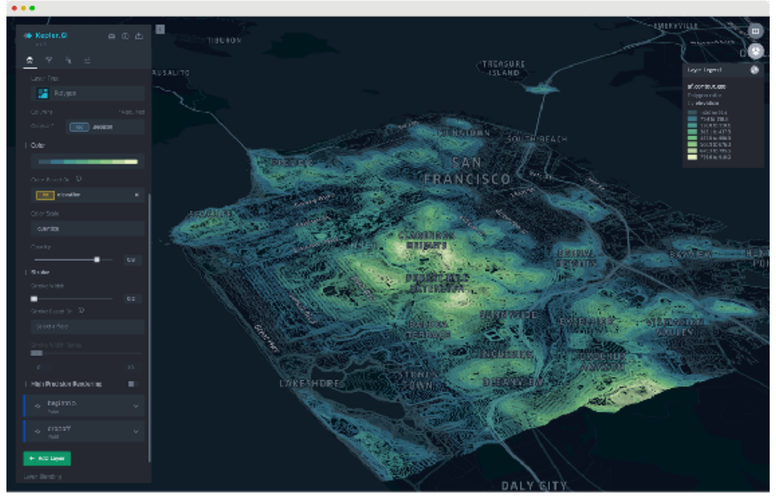


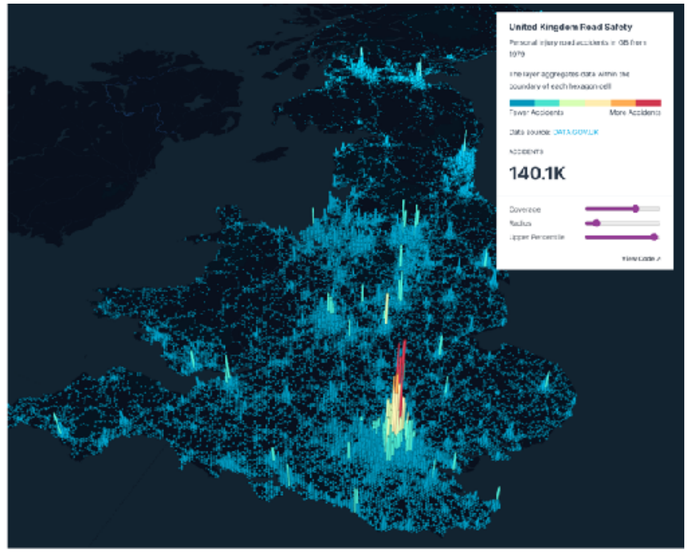

https://docs.bokeh.org/en/latest/index.html

# Visualizing large-scale datasets on the web

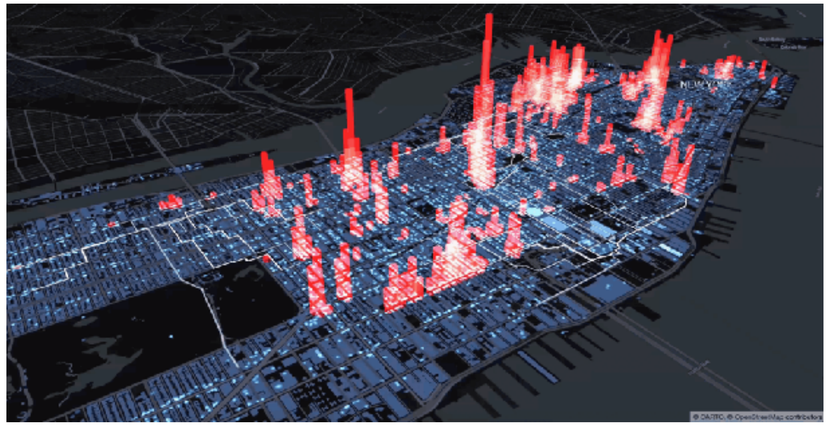
kepler.gl




deck.gl

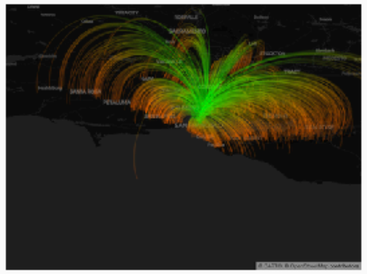



CARTO

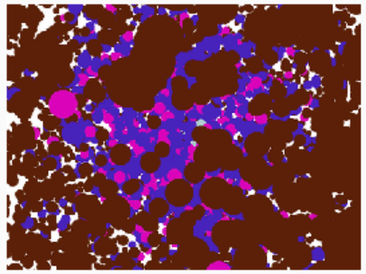


# Pydeck

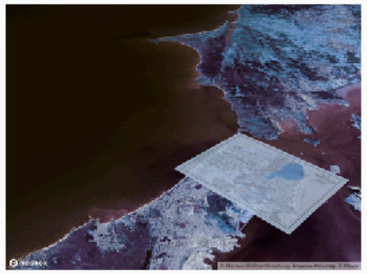
Python binding for deck.gl



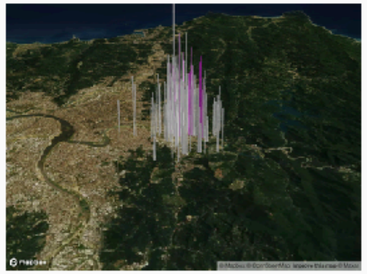
ArcLayer



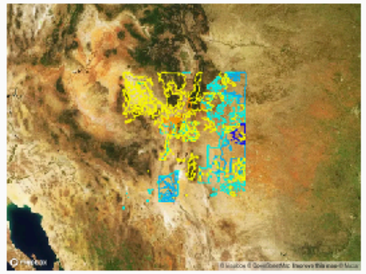
Binary Transport



BitmapLayer



ColumnLayer



ContourLayer

CustomLayer

GeoJsonLayer

Geopandas Integration

GlobeView

https://pydeck.gl/index.html

# Pydeck

Python binding for deck.gl

**tutorial on the exercise repo!**

https://pydeck.gl/index.html

# Exam questions?

- **Demonstrate GIS/GDS concepts and be able to use relevant Python libraries** programmatically to import, manipulate and analyze spatial data in different formats. Apply a number of spatial analysis techniques and explain how to interpret the results, in a process of turning data into insights.

- **Reflect on the motivation and inner workings** of the main methodological approaches of GDS, both analytical and visual.

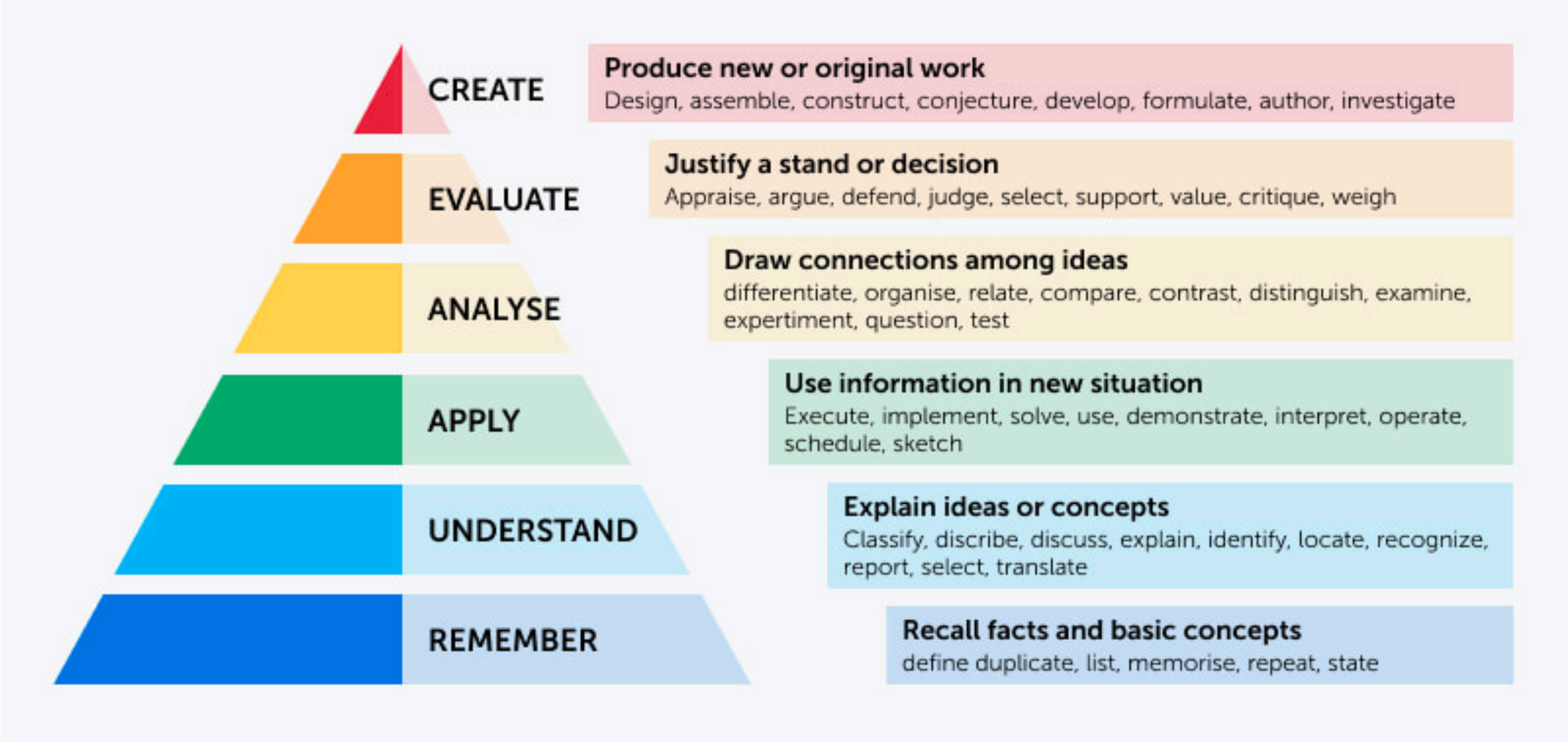
- **Critically evaluate the suitability** of a specific GDS technique, what it can offer and how it can help answer questions of interest.

- **Apply a number of spatial analysis techniques and explain** how to interpret the results, in a process of turning data into insights.

- When faced with a new data-set, work independently using GIS/GDS tools programmatically to **extract valuable insight.**

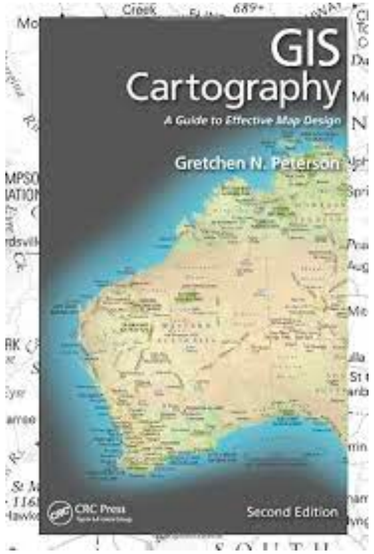
https://learnit.itu.dk/local/coursebase/view.php?ciid=1170

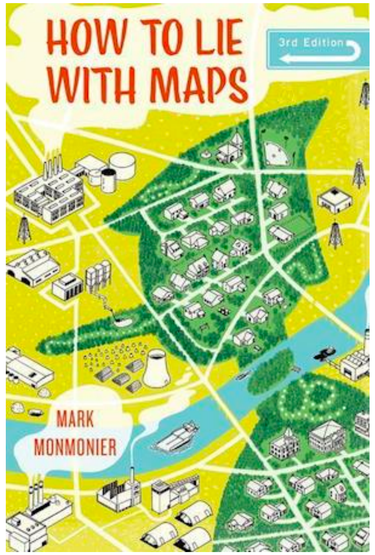
# Bloom’s Taxonomy



# Jupyter

# Sources and further materials for today's class




https://gistbok.ucgis.org/topic-keywords/map-design-techniques

https://courses.spatialthoughts.com/python-dataviz.html

Introduction to Urban Data Science: EDA & Visualization

Geographic Data Science - Lecture III (Geo-)Visualization

https://courses.spatialthoughts.com/python-dataviz.html

# THANK YOU

Course evaluation is still open :)

Questions or problems during the exam period? → anev@itu.dk