Applied Geodata Science I

Session 4

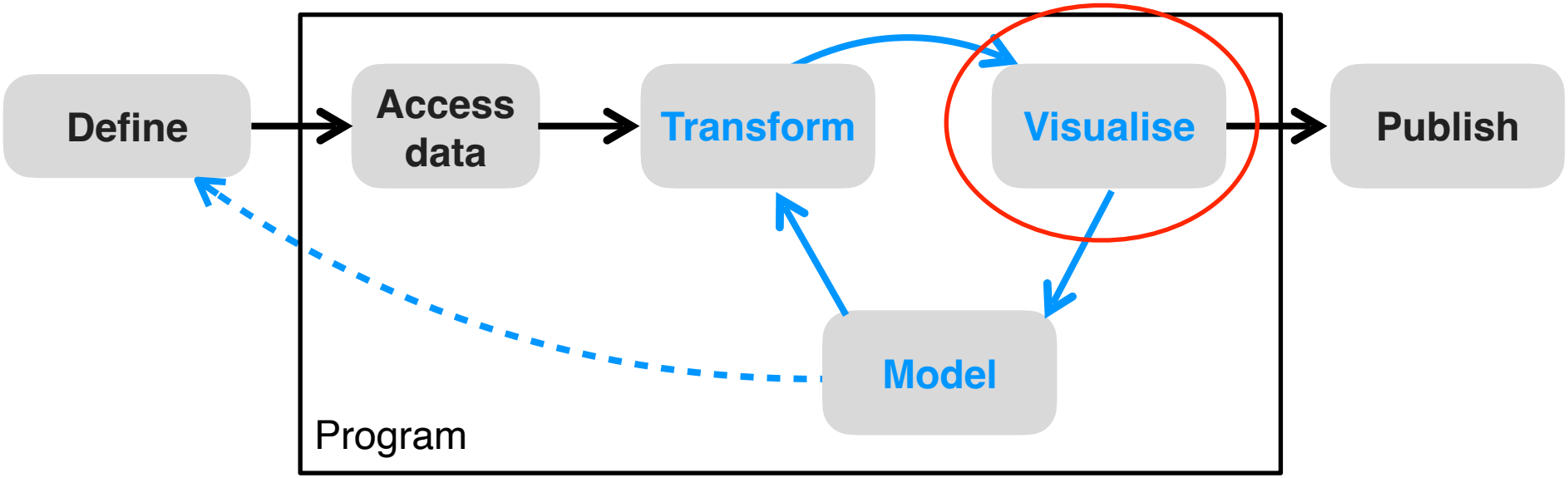
Prof. Dr. Benjamin Stocker

Spring semester 2023

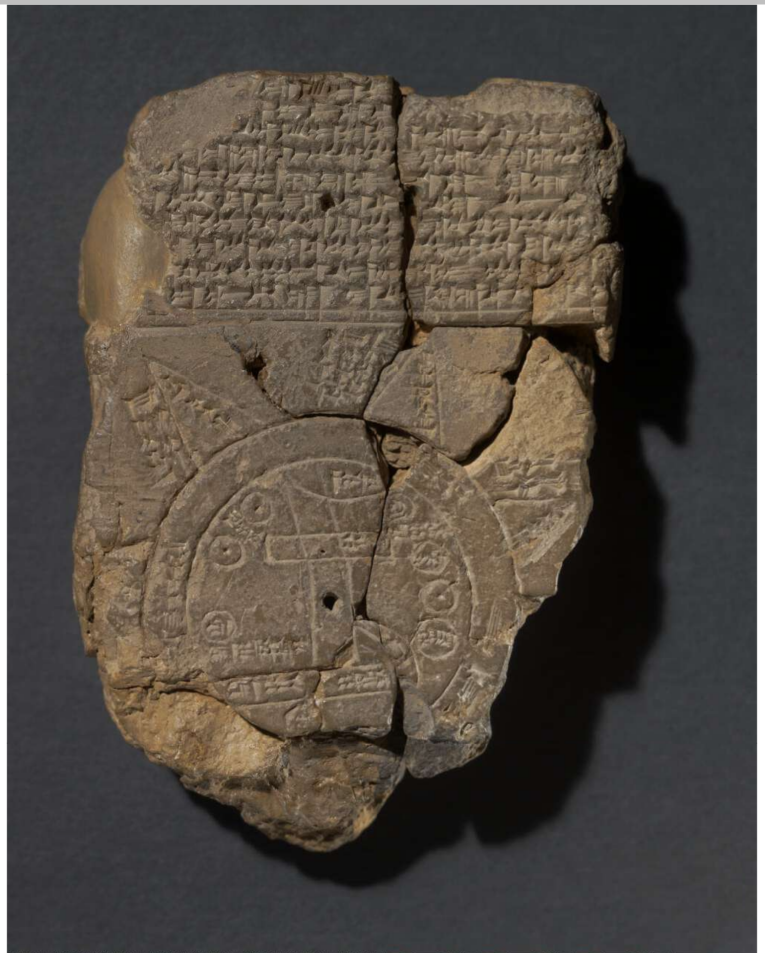
GECO

UNIVERSITÄT BERN

The data science workflow



Earliest data visualisation?

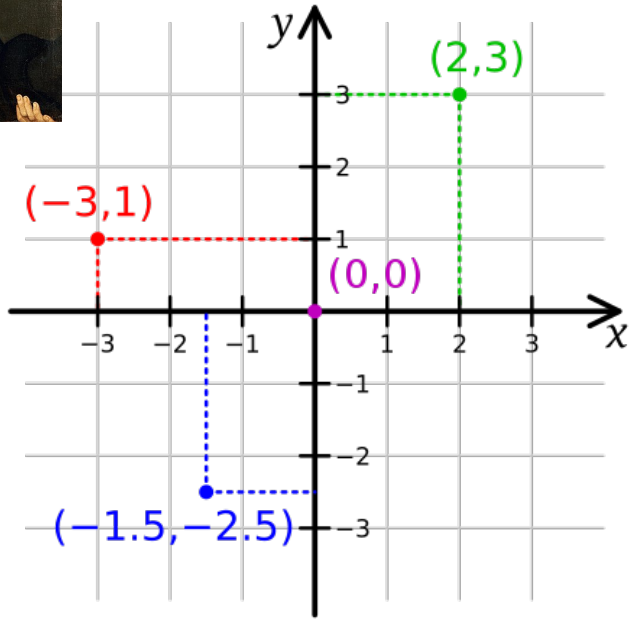


Babylon, ca. 500 BC

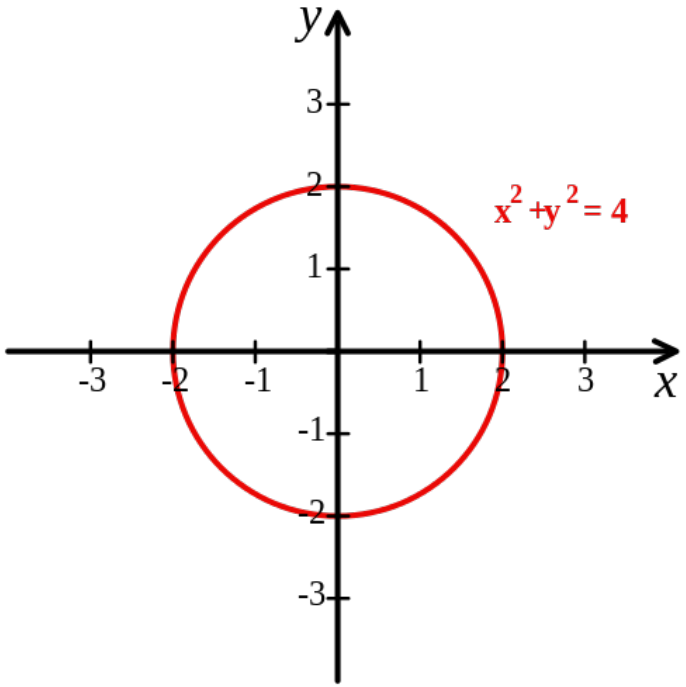
https://www.britishmuseum.org/collection/object/W_1882-0714-509

Cartesian coordinate system

René Descartes
1596-1650

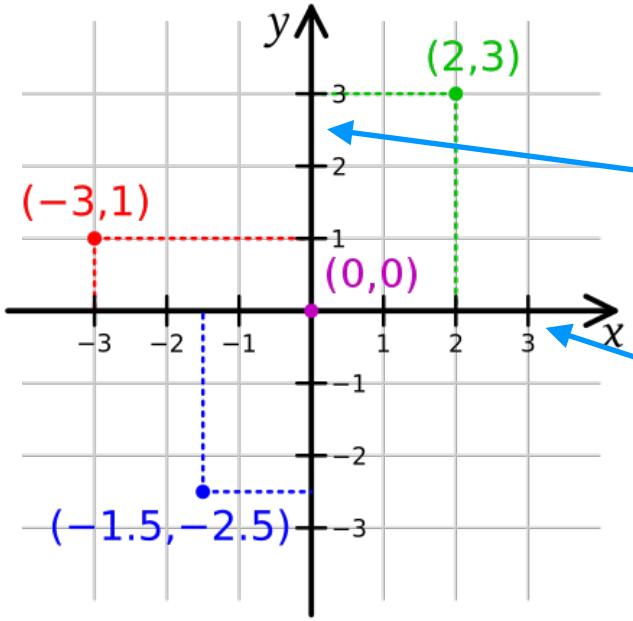


Link between geometry and algebra!



https://en.wikipedia.org/wiki/Cartesian_coordinate_system

Cartesian coordinate system



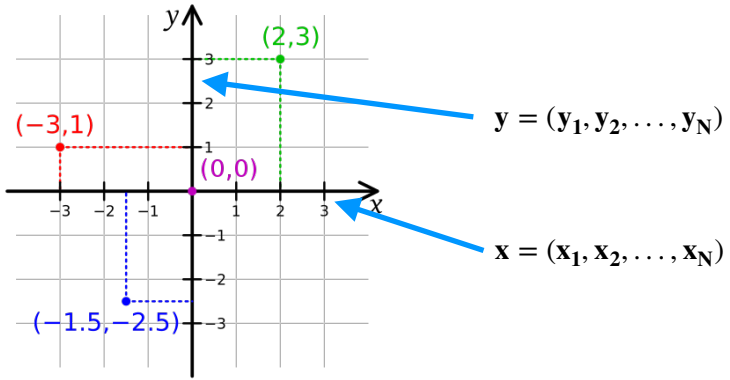
$$\mathbf{y} = (\mathbf{y}_1, \mathbf{y}_2, \ldots, \mathbf{y}_N)$$

$$\mathbf{x} = (\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_N)$$

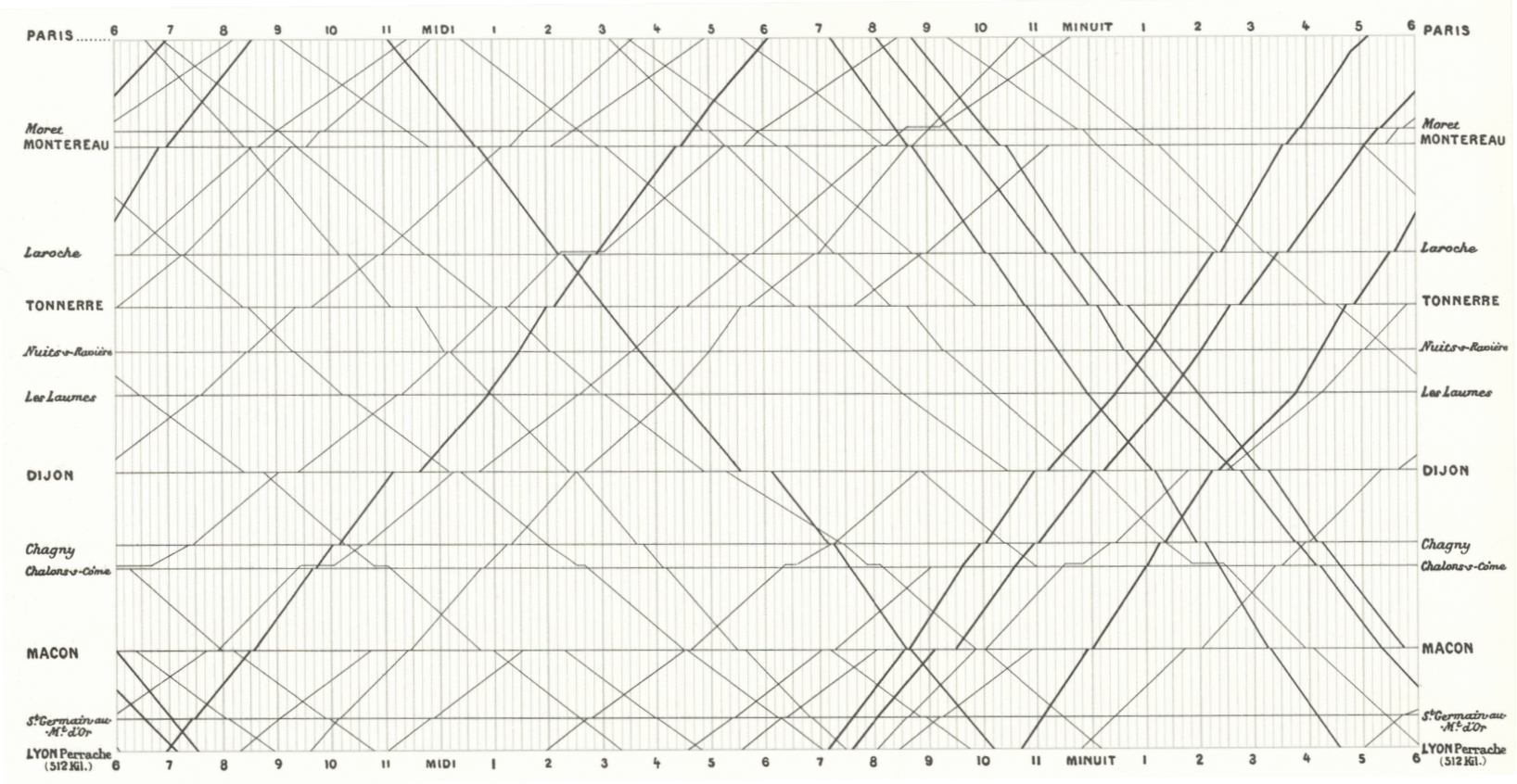
https://en.wikipedia.org/wiki/Cartesian_coordinate_system

Data visualisation and the Grammar of Graphics

- Visualising data is to convert values into visual elements that make up a graphic.
- We "map" data values onto quantifiable features of the resulting graphic - the aesthetics.
- Variation along each “dimension” in the data is mapped onto one aesthetic.

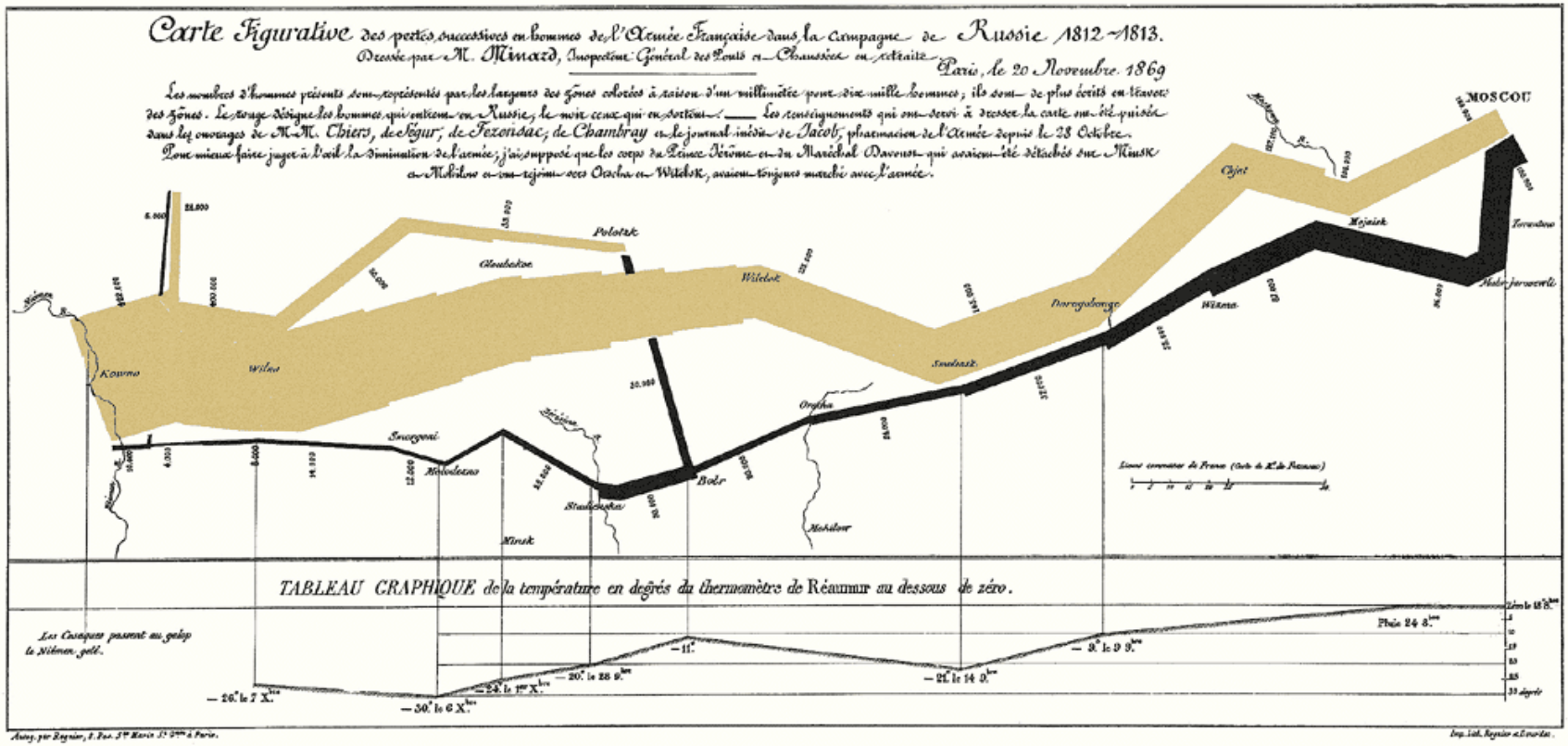


Visualising time



E. J. Marey, 1885
https://badriadhikari.github.io/data-viz-workshop-2021/minards/

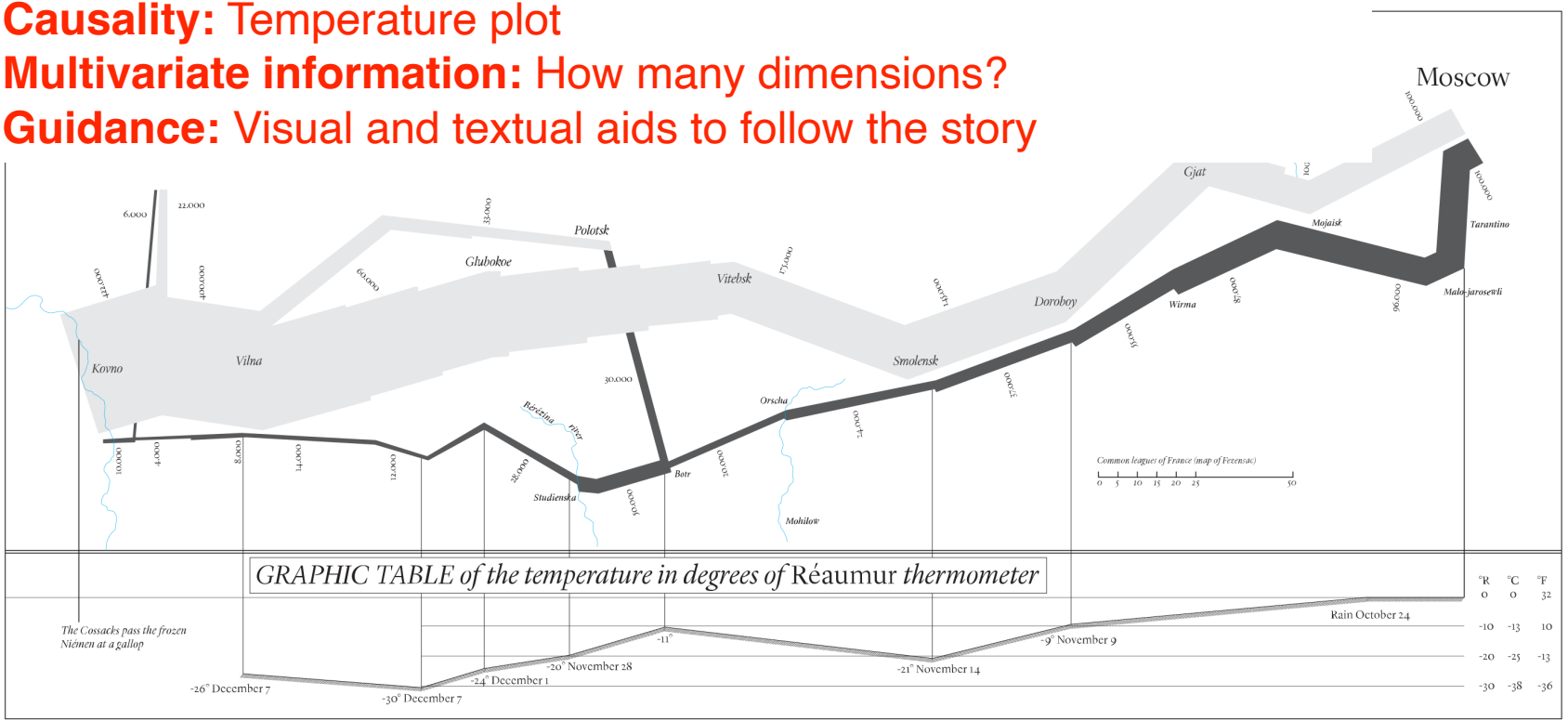
Quantitative information in geographical space



Minard, 1869
https://badriadhikari.github.io/data-viz-workshop-2021/minards/

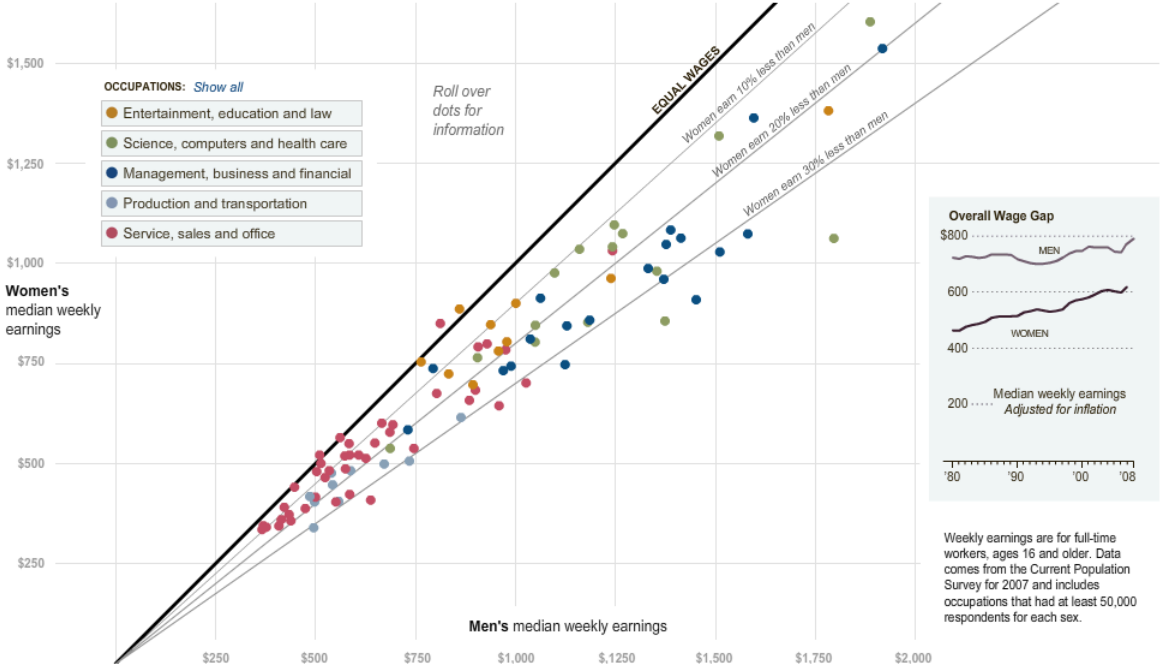
Quantitative information in geographical space

- **Contrast:** Colors of advance and retreat. Width of lines back-to-back
- **Causality:** Temperature plot
- **Multivariate information:** How many dimensions?
- **Guidance:** Visual and textual aids to follow the story



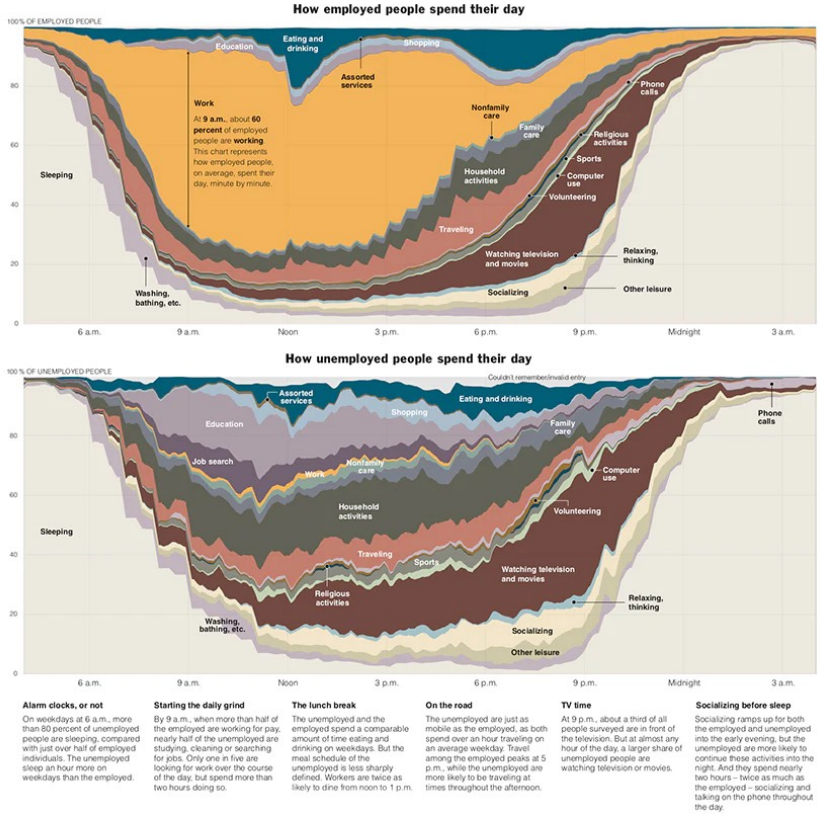
Charles-Joseph Minard, 1869
https://badriadhikari.github.io/data-viz-workshop-2021/minards/

Scatterplots

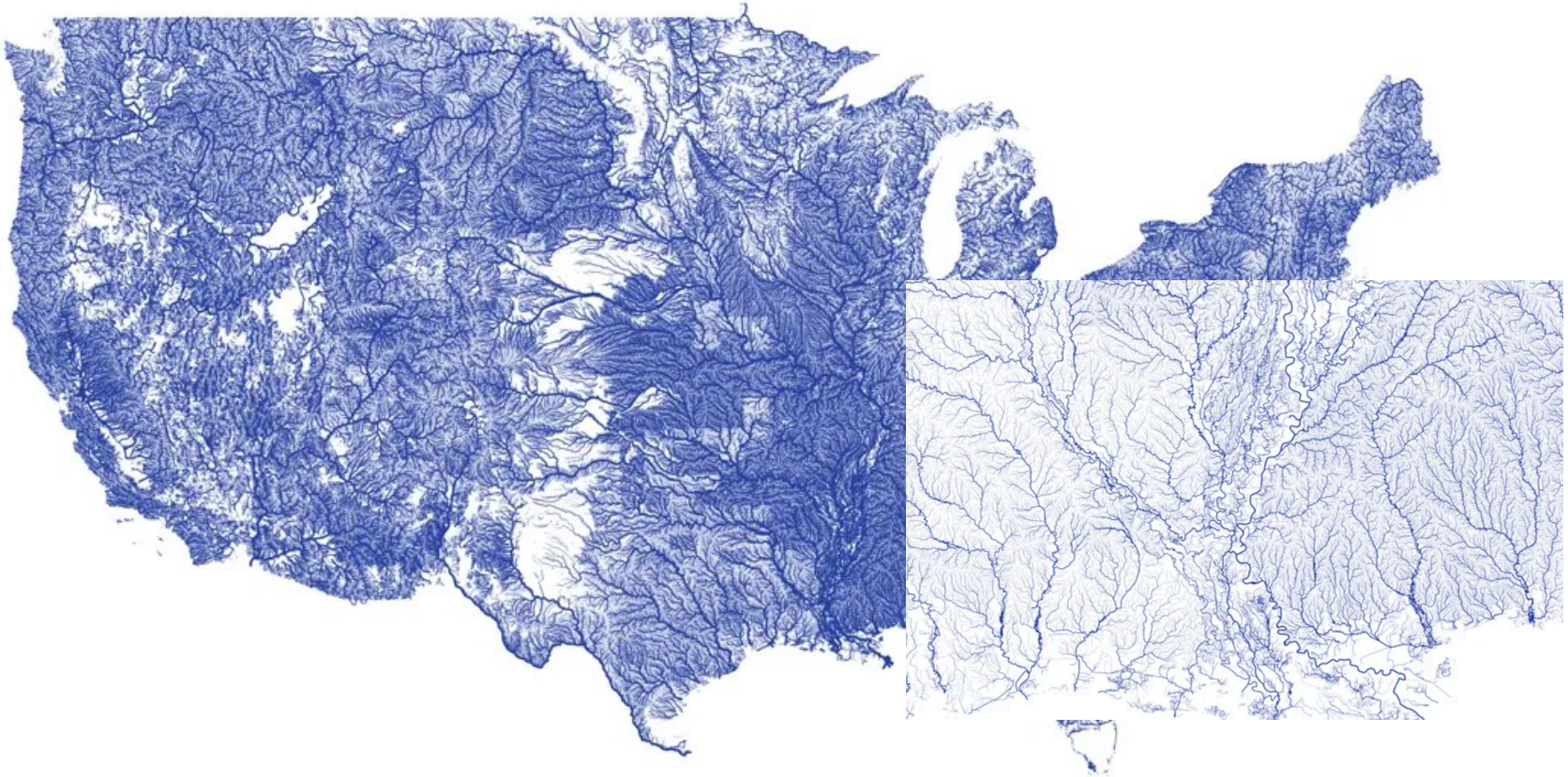


Hannah Fairfield and Graham Roberts
New York Times, 2010
https://eagereyes.org/journalism/the-explanatory-power-of-data-points

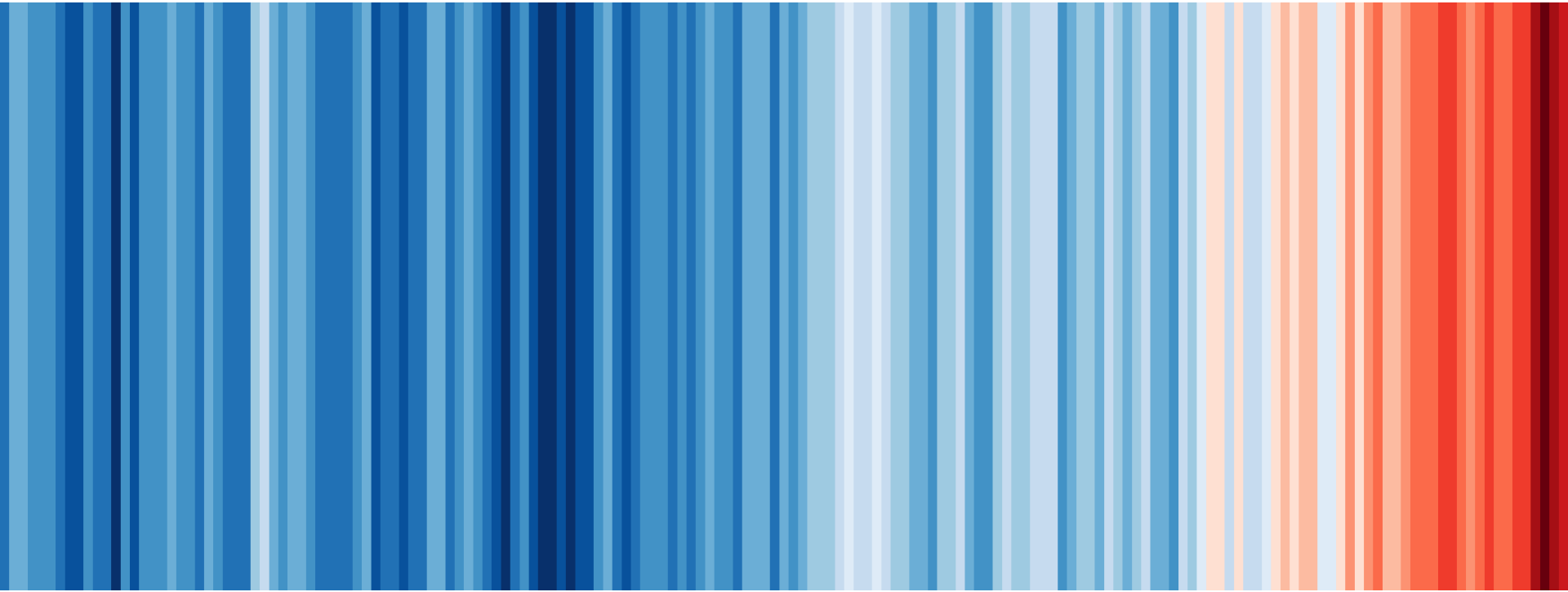
Proportions over time



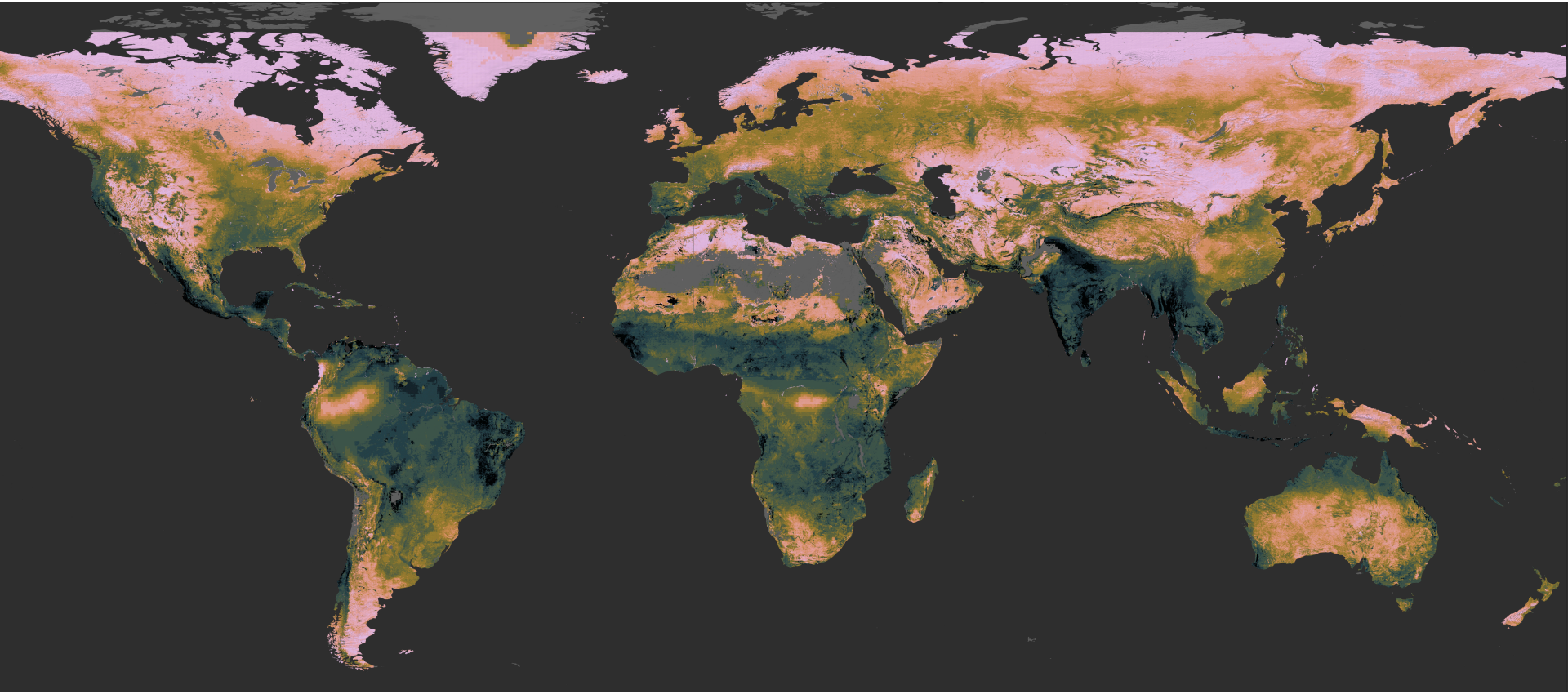
Amanda Cox, *New York Times*
https://gestalten.com/blogs/journal/visualizing-a-new-new-york-times



Nelson Minar,
https://www.wired.com/2013/06/infographic-this-detailed-map-shows-every-river-in-the-united-states/?viewall=true

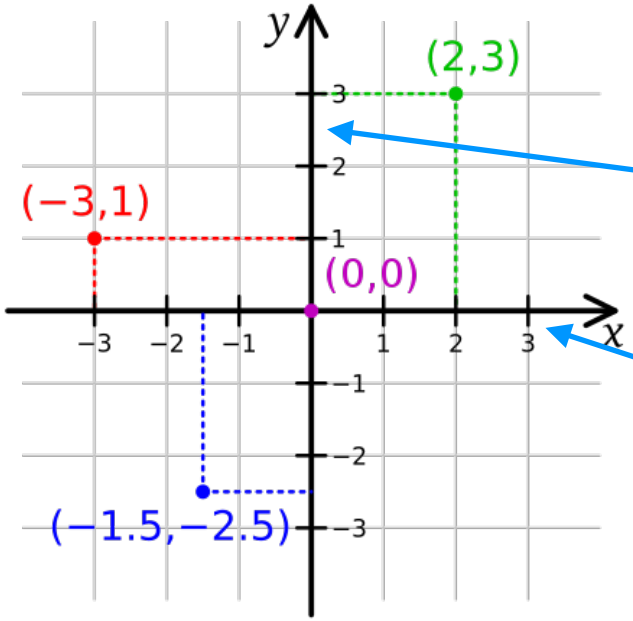


Ed Hawkins
https://www.climate-lab-book.ac.uk/2018/2018-visualisation-update/



Stocker et al., 2023 *Nature Geoscience*

Cartesian coordinate system



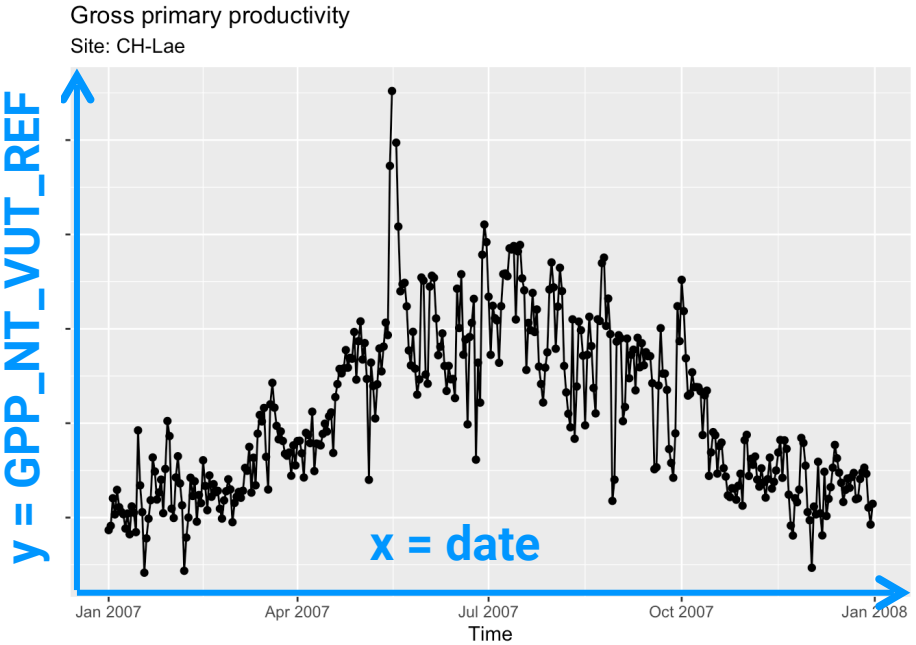
$$\mathbf{y} = (\mathbf{y_1}, \mathbf{y_2}, \ldots, \mathbf{y_N})$$

$$\mathbf{x} = (\mathbf{x_1}, \mathbf{x_2}, \ldots, \mathbf{x_N})$$

https://en.wikipedia.org/wiki/Cartesian_coordinate_system

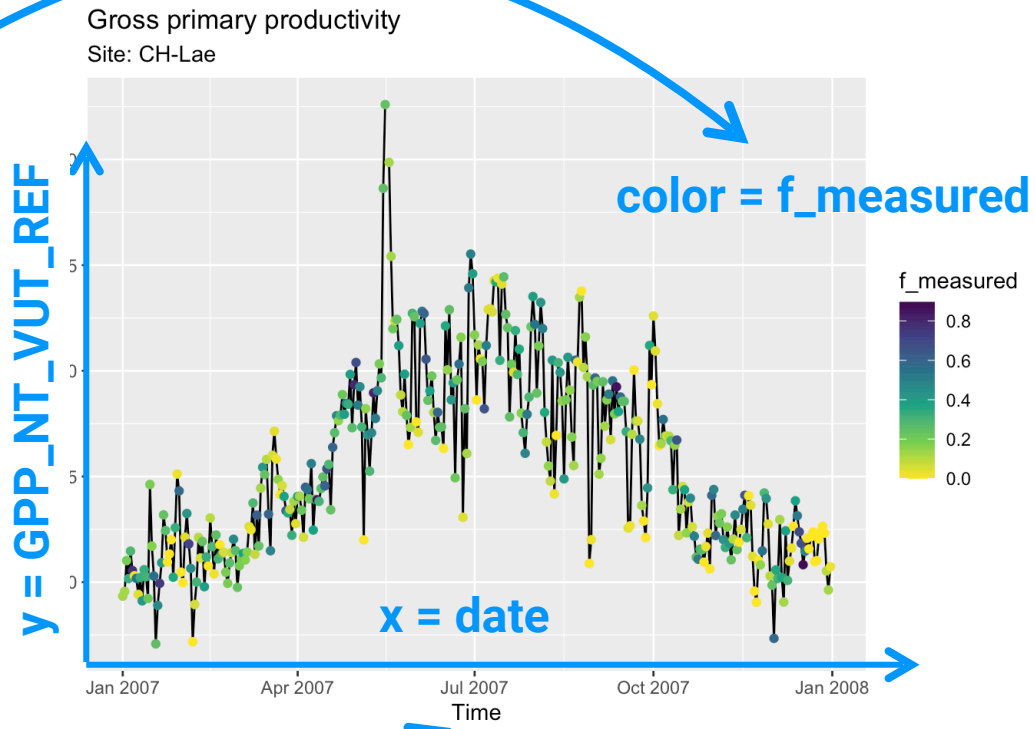
Mapping to two aesthetics

```
> df
# A tibble: 3,912 x 3
   date       GPP_NT_VUT_REF f_measured
   <date>              <dbl>      <dbl>
 1 2004-03-31           1.62      0.333
 2 2004-04-01           5.03      0.396
 3 2004-04-02           3.73      0.312
 4 2004-04-03           3.87      0.5
 5 2004-04-04           6.06      0.333
 6 2004-04-05           4.46      0.396
 7 2004-04-06          10.5       0.0417
 8 2004-04-07           7.09      0.312
 9 2004-04-08           6.90      0.208
10 2004-04-09           4.66      0.667
# … with 3,902 more rows
```



Mapping to three aesthetics

```
> df
# A tibble: 3,912 x 3
   date       GPP_NT_VUT_REF f_measured
   <date>              <dbl>      <dbl>
 1 2004-03-31           1.62      0.333
 2 2004-04-01           5.03      0.396
 3 2004-04-02           3.73      0.312
 4 2004-04-03           3.87      0.5
 5 2004-04-04           6.06      0.333
 6 2004-04-05           4.46      0.396
 7 2004-04-06          10.5       0.0417
 8 2004-04-07           7.09      0.312
 9 2004-04-08           6.90      0.208
10 2004-04-09           4.66      0.667
# … with 3,902 more rows
```



ggplot2

A data frame

Aesthetics mapping

```
ddf %>%
  ggplot(aes(x = date, y = GPP_NT_VUT_REF)) +
  geom_line() +
  geom_point()
```

(A second visualisation element)

Visualisation element

ggplot2

```
> df
# A tibble: 3,912 x 3
   date       GPP_NT_VUT_REF f_measured
   <date>              <dbl>      <dbl>
 1 2004-03-31           1.62      0.333
 2 2004-04-01           5.03      0.396
 3 2004-04-02           3.73      0.312
 4 2004-04-03           3.87      0.5
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# … with 3,902 more rows
```
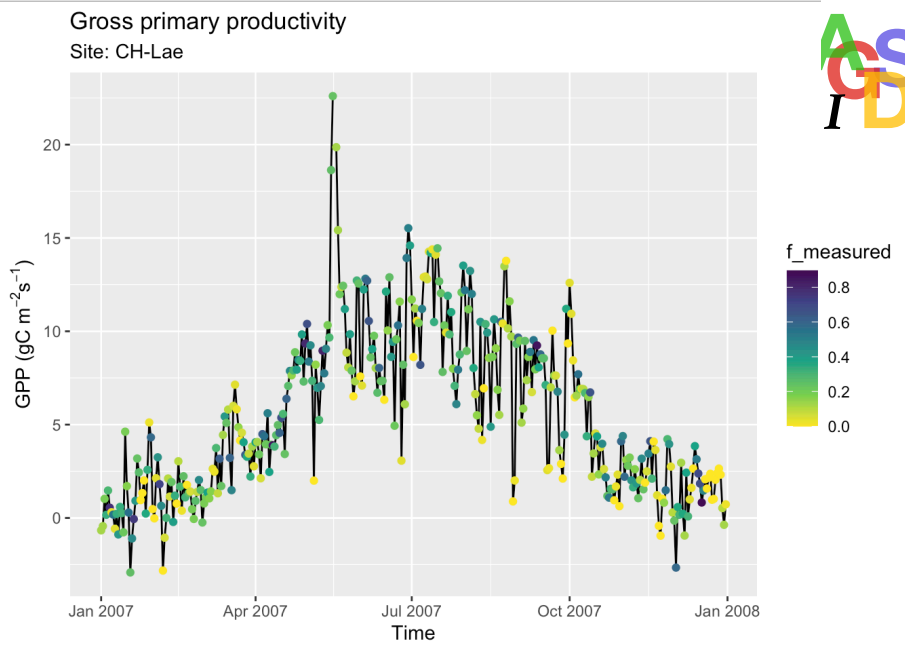




```
ddf %>%
  ggplot(aes(x = date, y = GPP_NT_VUT_REF, color = f_measured)) +
  geom_line() +
  geom_point() +
  scale_color_viridis_c()
```

Aesthetics for continuous and categorical data

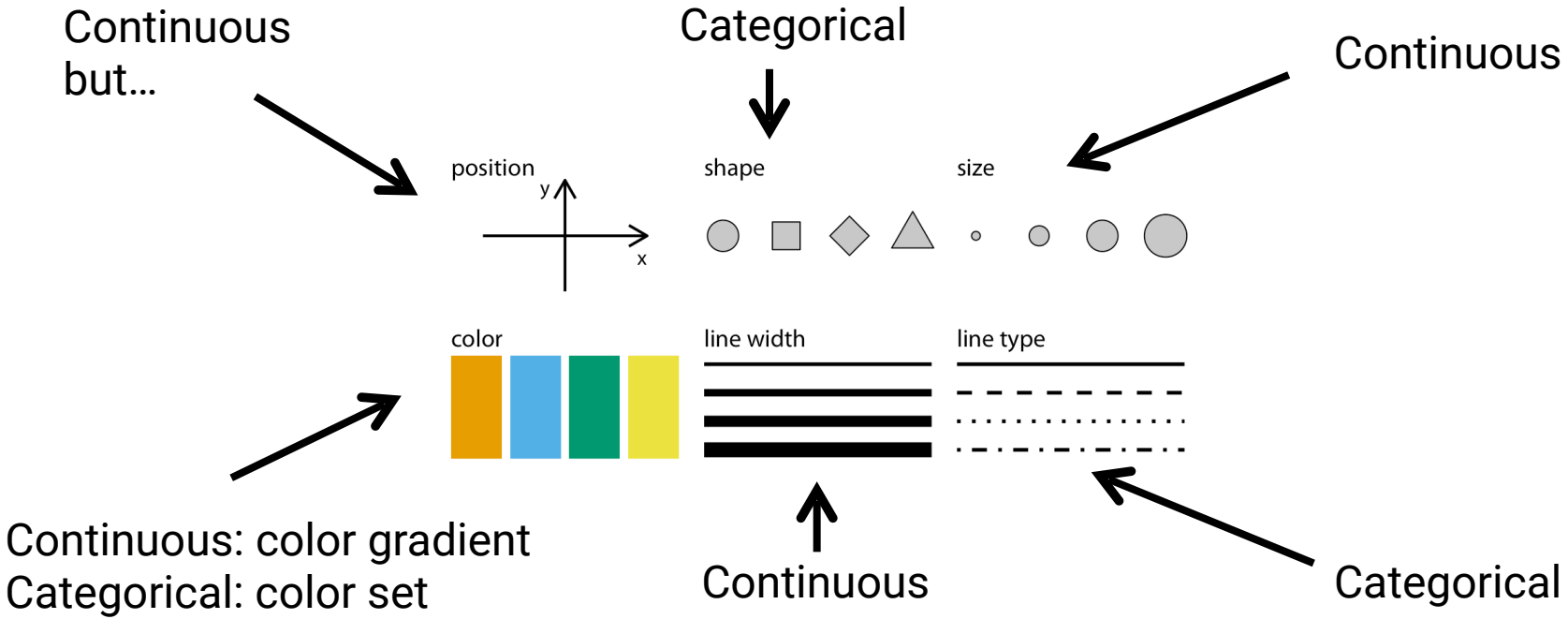
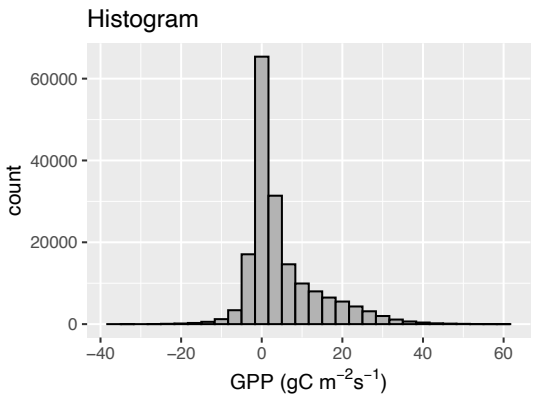
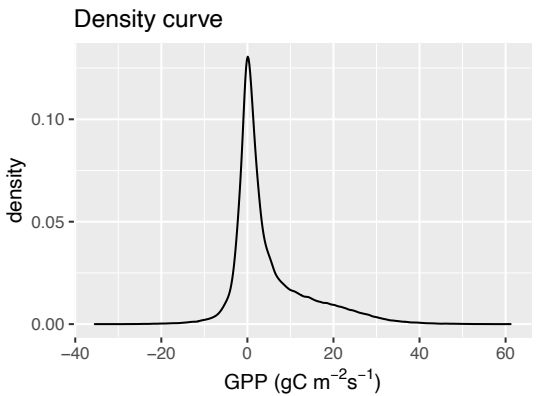


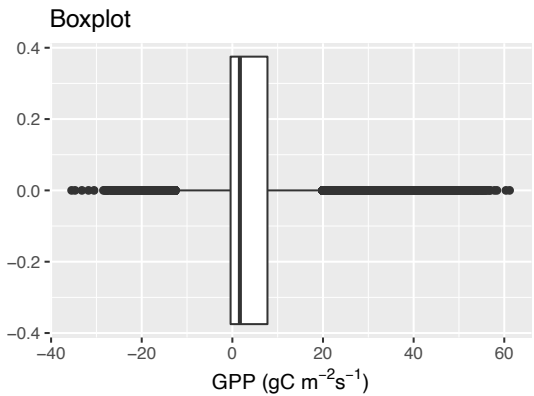
Figure from: Wilke, Data Visualization
https://clauswilke.com/dataviz/aesthetic_mapping_files/figure-html/common-aesthetics-1.png

Different “geoms” for different aspects of the data

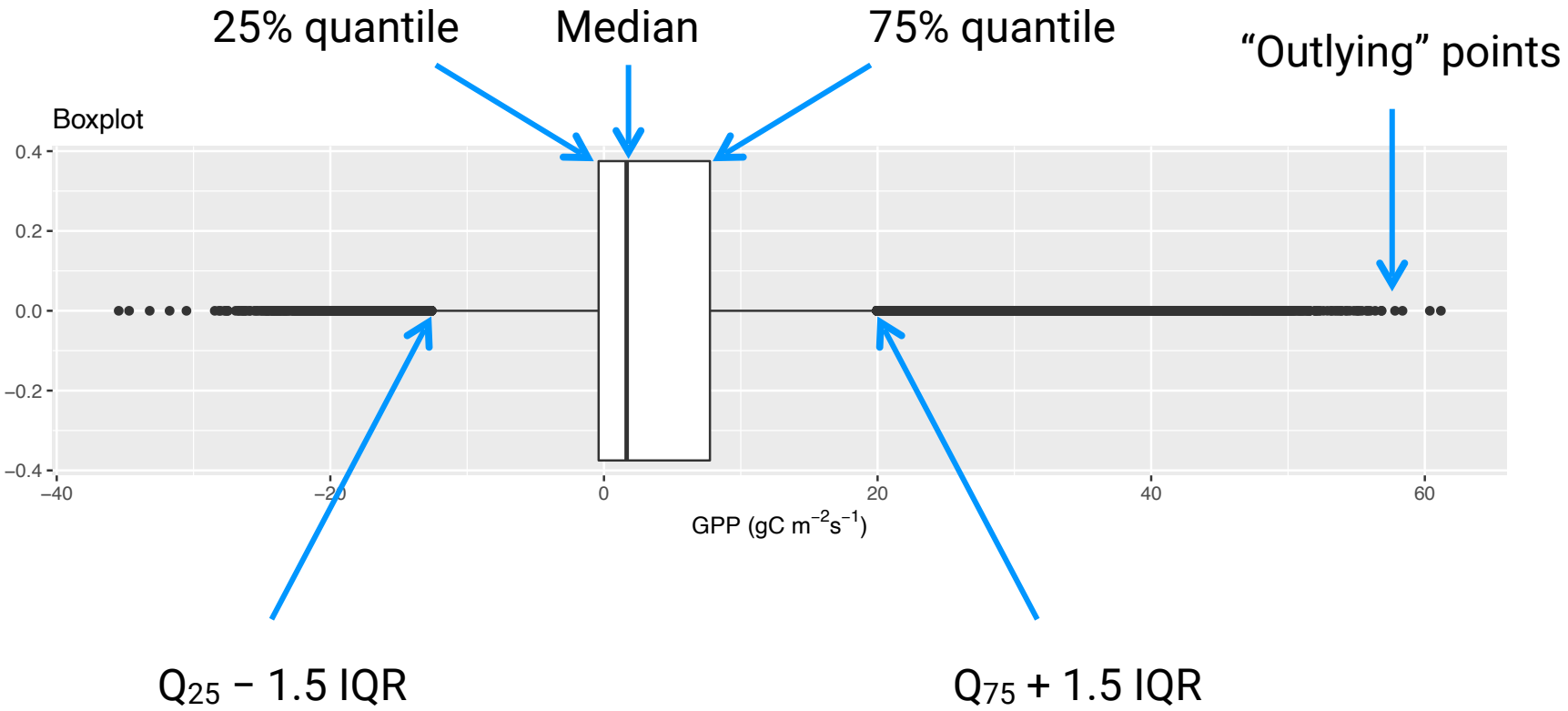
Distributions





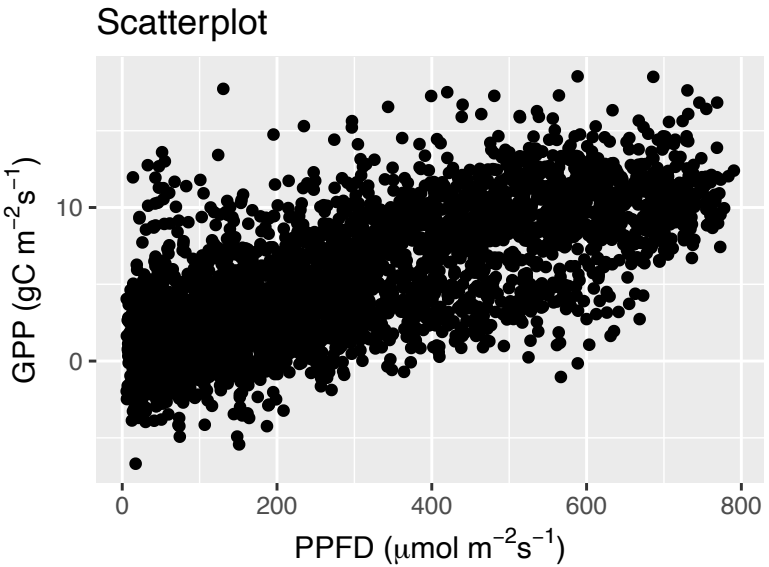


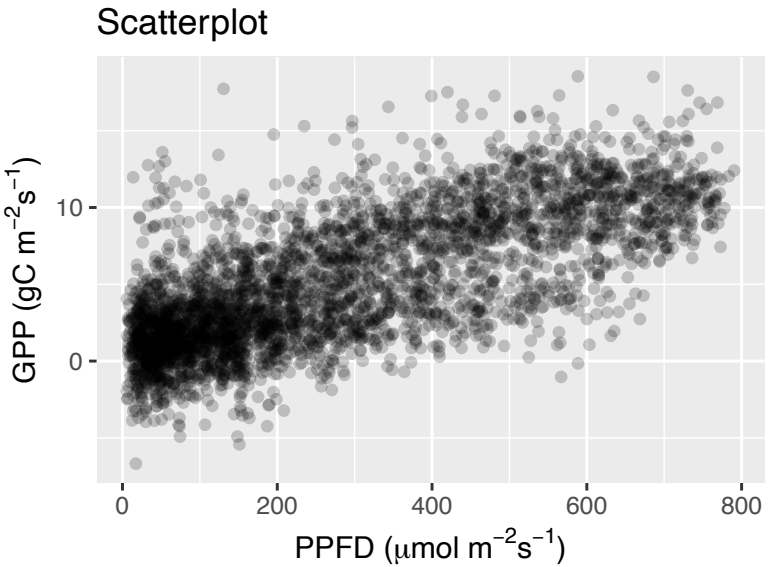
Boxplot


25% quantile
Median
75% quantile
“Outlying” points
Boxplot
0.4
0.2
0.0
−0.2
−0.4
−40
−20
0
20
40
60
GPP (gC m^{-2}s^{-1})
Q_{25} − 1.5 IQR
Q_{75} + 1.5 IQR

Different “geoms” for different aspects of the data

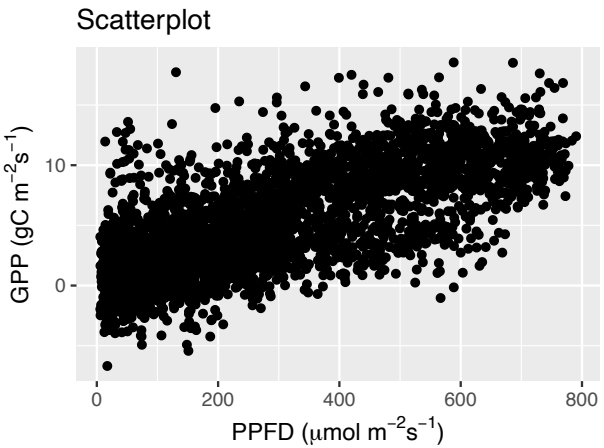
Relationships

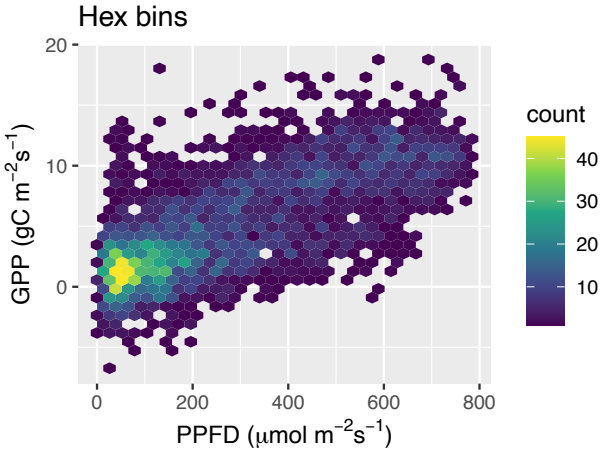


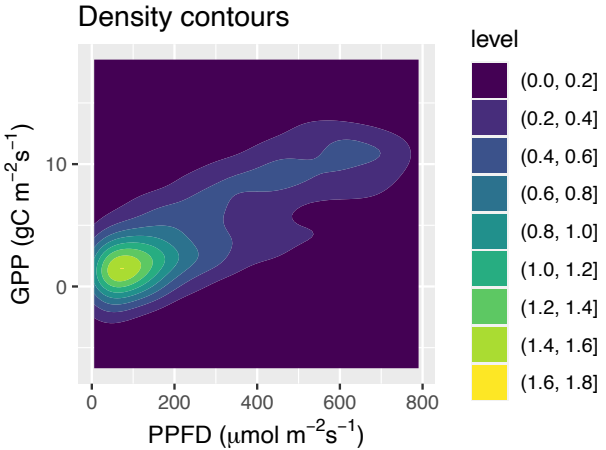


Different “geoms” for different aspects of the data

Relationships

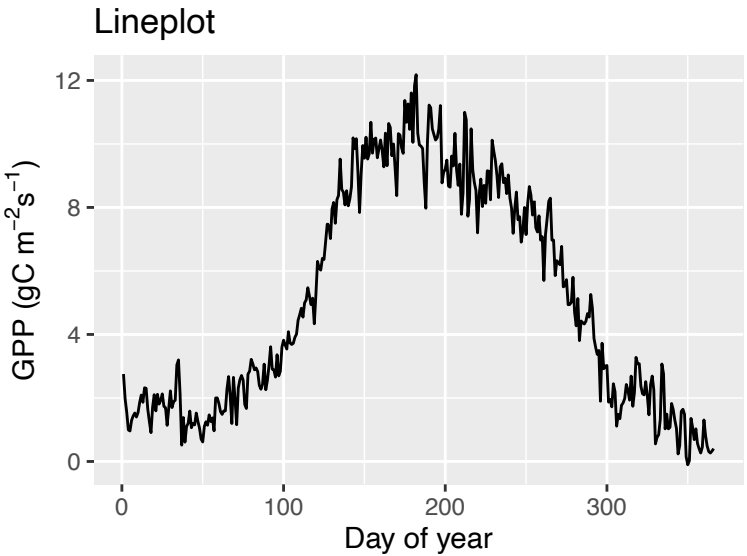






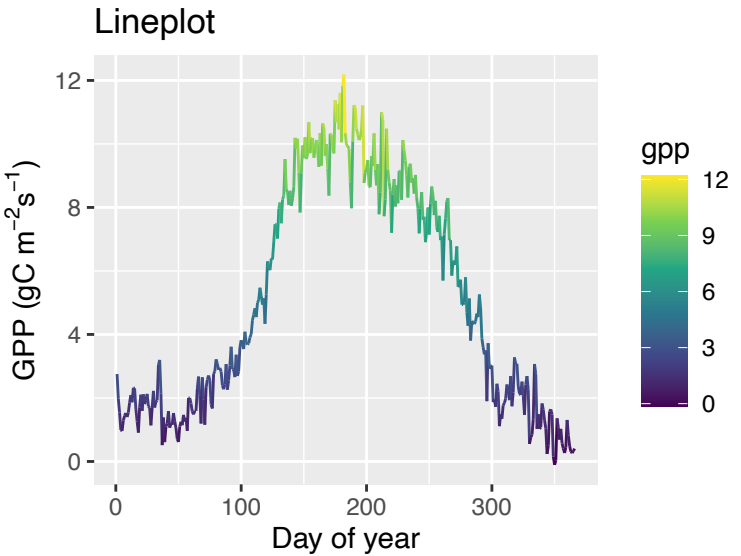
Different “geoms” for different aspects of the data

Time series



Avoid:

- Same dimension to multiple aesthetics



Different “geoms” for different aspects of the data

Avoid:

- Non-monotonic color scale for numeric values
- Color scale not adjusted to color vision deficiency