Advanced graphics

Erasmus Q-Intelligence B.V.

Data Science and Business Analytics
Programming

Content

Software requirements

Software requirements

- $\longrightarrow$ Data from packages `dplyr` and `ggplot2` are used, made available for as csv for Python
- $\longrightarrow$ We use mainly functions from libraries `pandas` and `seaborn`, but also need `matplotlib`, `statsmodel`, `numpy` and `mpl_toolkits` for some specific cases

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from matplotlib import colors as mcolors
import numpy as np
import statsmodels.api as sm
from mpl_toolkits.axes_grid1 import make_axes_locatable
```

Data sets

Atlantic hurricane database track data, 1975-2015

```
storms = pd.read_csv("storms.csv")
storms_2015 = storms[storms['year'] == 2015]
```

US economic time series

```
economics = pd.read_csv("economics.csv")
```

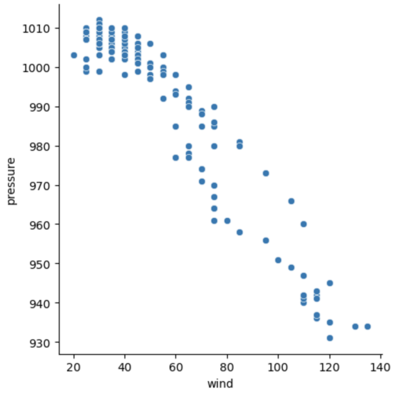
Eredivisie points of Ajax and Feyenoord

```
eredivisie = pd.read_csv("eredivisie.csv")
```

Reminder

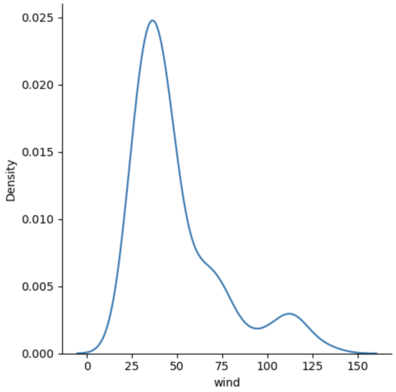
Scatterplot

```
sns.relplot(data = storms_2015, x = "wind",
            y = "pressure")
```



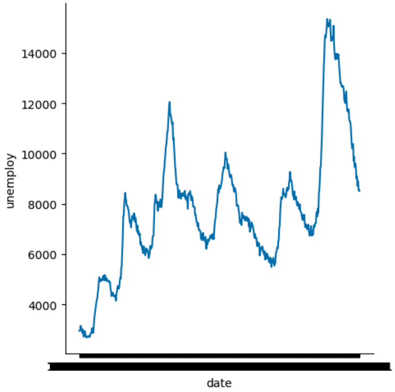
Density plot

```
sns.displot(storms_2015, x = "wind", kind = "kde")
```



Time series plot

```
sns.relplot(economics, kind = "line", x = "date",
            y = "unemploy")
```



Finetuning graphics

Finetuning within in a plot

Finetuning through arguments and functions:

`color` or `c`	Color for points/lines
`alpha`	Transparancy of colors
`marker`	Symbol for points
`linestyle`	Type of line
`s`	Size of points/lines

$\longrightarrow$ If the values should depend on some variable, then use the `hue` and `palette` parameters

(information from those variables is mapped to the visual representation)

Specifying colors

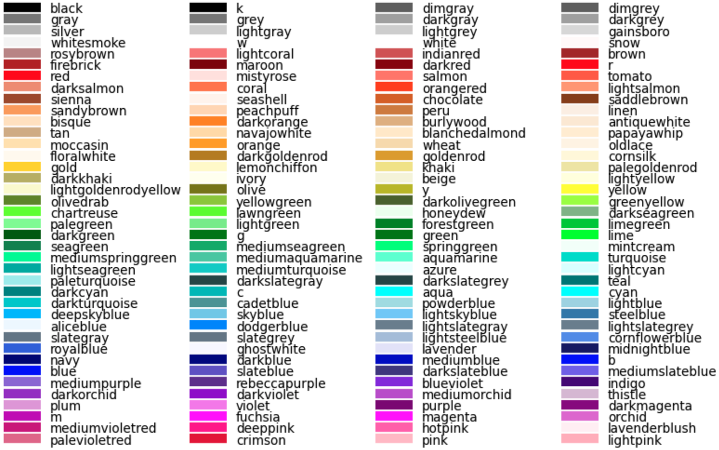
There are many options, such as using single characters for simple, shorthand notation:

- 'b' as blue
- 'g' as green
- 'r' as red
- 'c' as cyan
- 'm' as magenta
- 'y' as yellow
- 'k' as black
- 'w' as white

$\longrightarrow$ For a list of other options: click here

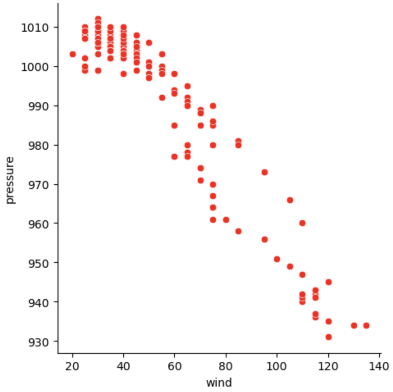
Specifying colors: full name

Another option is to use the full name of a color



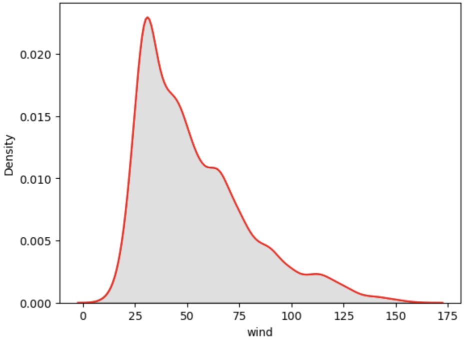
Named colors: scatterplot

```
sns.relplot(data = storms_2015, x = "wind",
            y = "pressure", color = "red")
```



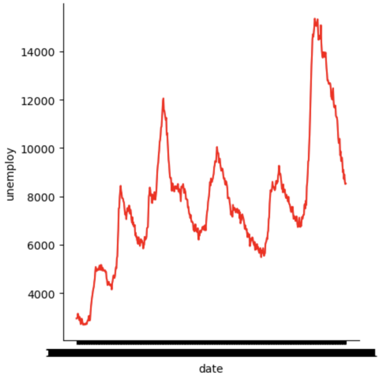
Named colors: density plot

```
sns.kdeplot(data = storms, x = "wind", color = 'grey',
            fill=True)
sns.kdeplot(data = storms, x = 'wind', color = 'red')
```

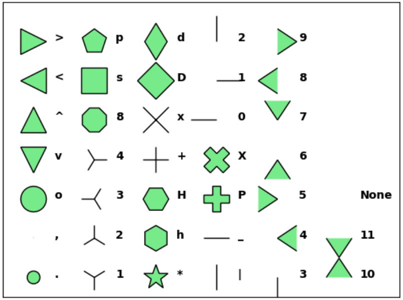


Named colors: time series plot

```
sns.relplot(economics, kind = "line", x = "date",
            y = "unemploy", color = "red")
```



Plot symbols

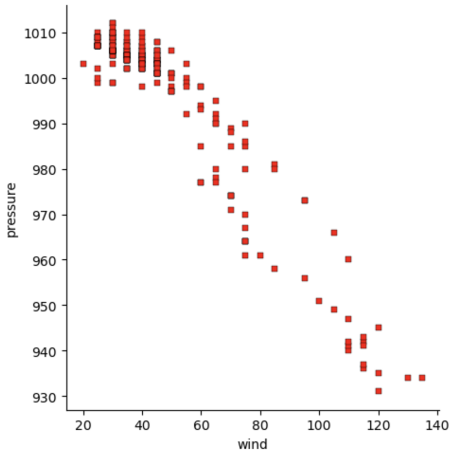


⟶ Specify fill color with parameter `color`, edge color with `edgecolor` and size with `s`

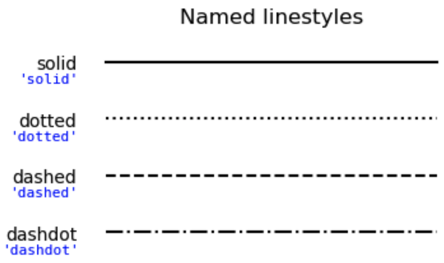
Plot symbols: scatterplot

```
sns.relplot(data = storms_2015, x = "wind",
            y = "pressure", marker = "s",
            color = "red", edgecolor = "black",
            s = 15)
```

Plot symbols: scatterplot



Line types: density plot

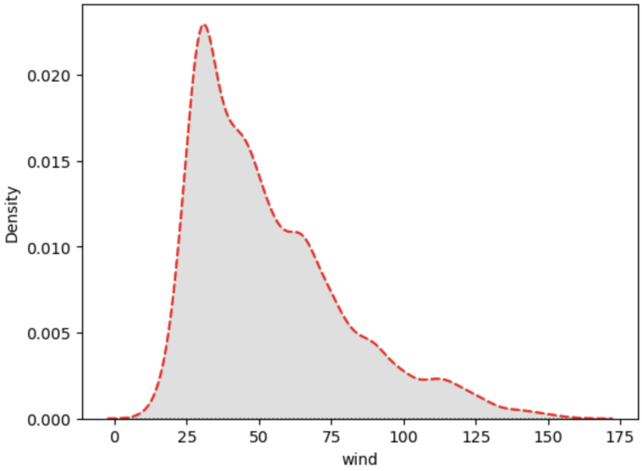


$\longrightarrow$ Other options, such as more white space between dots are possible, but not named. See the jupyter notebook of this lecture for those options.

Line types: density plot

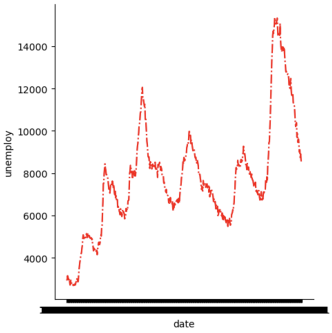
```
sns.kdeplot(data = storms, x = "wind",
            color = 'grey', fill=True,
            linestyle = "dotted")
sns.kdeplot(data = storms, x = 'wind',
            color = 'red', linestyle = "dashed")
```

Line types: density plot



Line types: time series plot

```
sns.relplot(economics, kind = "line",
            x = "date", y = "unemploy",
            color = "red", linestyle = "dashdot")
```



Arguments for finetuning within a plotrevisited

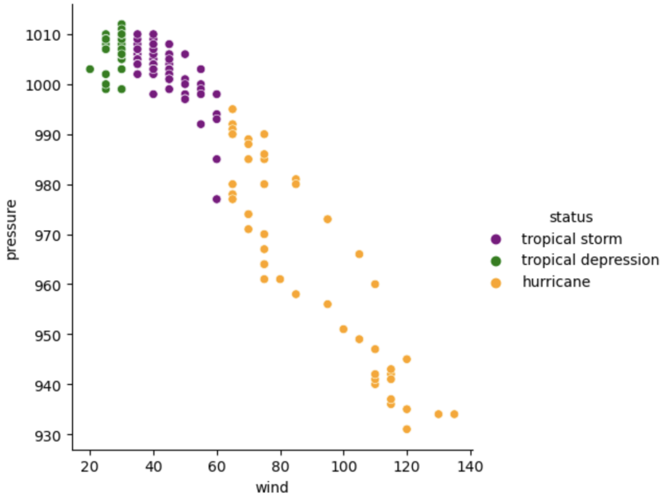
Finetuning through arguments and functions:

`color` or `c`	Color for points/lines
`alpha`	Transparancy of colors
`marker`	Symbol for points
`linestyle`	Type of line
`s`	Size of points/lines

Colors: scatterplot

```
sns.relplot(data = storms_2015, x = "wind",
            y = "pressure", hue = "status",
            palette = ['purple', 'green', 'orange'])
```

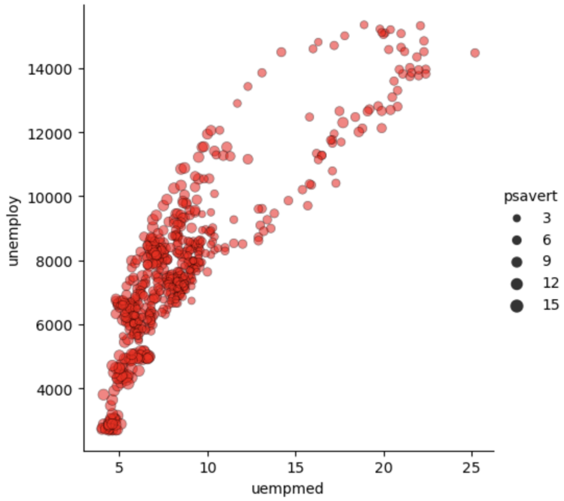
Colors: scatterplot



Size: scatterplot

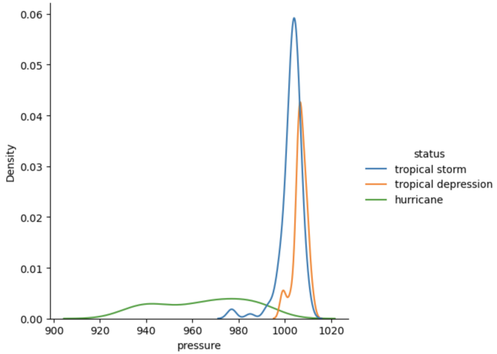
```
sns.relplot(data = economics, x = "uempmed",
            y = "unemploy", color = "red",
            edgecolor = "black", size = "psavert",
            alpha = 0.5)
```

Size: scatterplot



Colors: density plot

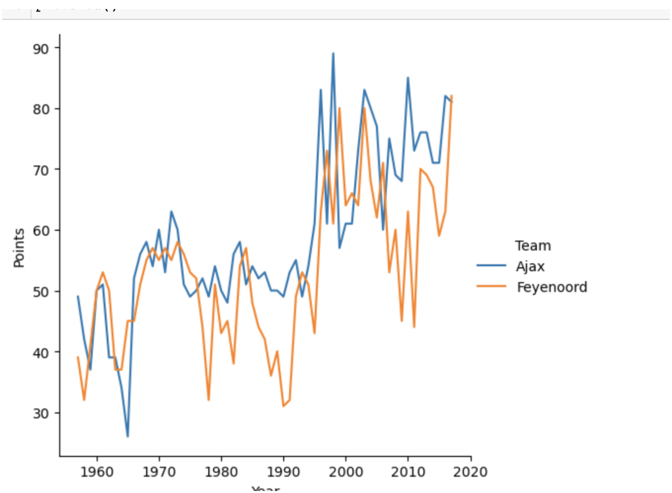
```
sns.displot(storms_2015, x = "pressure",
            hue = "status", kind = "kde")
```



Colors: time series plot

```
sns.relplot(eredivisie, x = "Year",
            y = "Points", hue = "Team",
            kind = "line")
```

Colors: time series plot



Exercises

$\longrightarrow$ Download file *AdvancedGraphics-Exercises.pdf* from Canvas and open it

$\longrightarrow$ Do Exercise 1

Manual scales

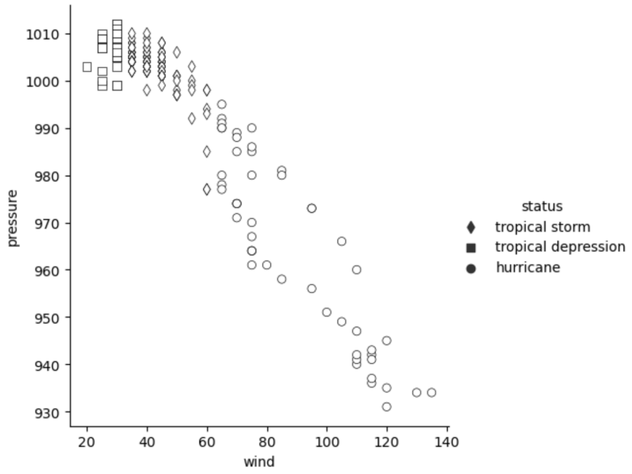
$\longrightarrow$ Built-in scales are used to obtain default values

$\longrightarrow$ Manual scales can be applied, how depends on the change you would like to make

Plot symbols: scatterplot

```
sns.relplot(data = storms_2015, x = "wind",
            y = "pressure", style = "status",
            markers = ['d', 's', 'o'],
            color = "white", edgecolor = "black")
```

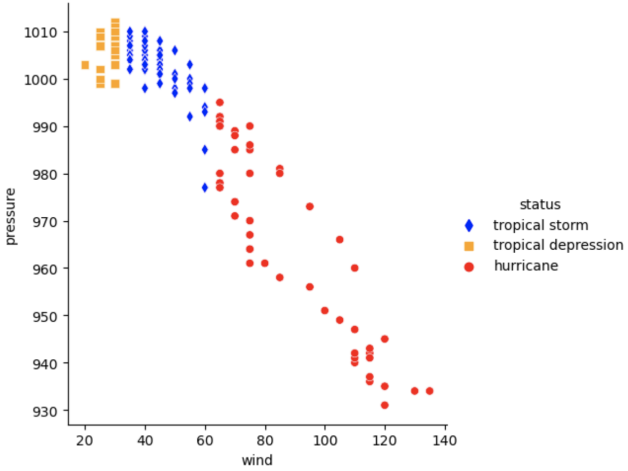
Plot symbols: scatterplot



Plot symbols: scatterplot

```
sns.relplot(data = storms_2015, x = "wind",
            y = "pressure", hue = "status",
            palette = ['blue', 'orange', "red"],
            style = "status",
            markers = ['d', 's', 'o'])
```

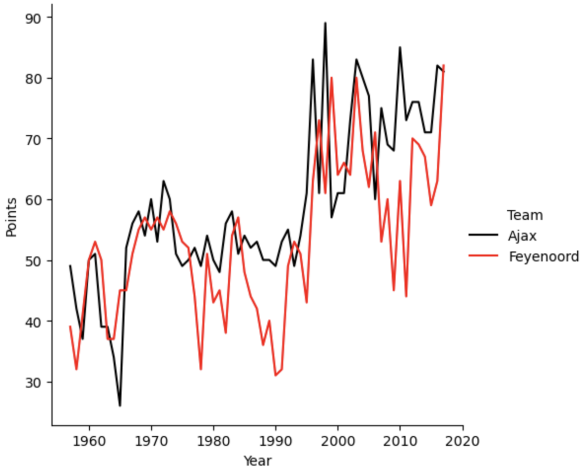
Plot symbols: scatterplot



Colors: time series plot

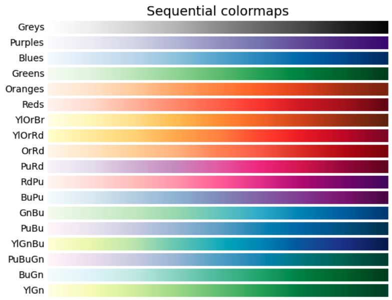
```
sns.relplot(eredivisie, x = "Year", y = "Points",
            hue = "Team", kind = "line",
            palette = {"Ajax": "black",
                       "Feyenoord": "red"})
```

Colors: time series plot



Continuous scales

Continuous scales through argument `cmap`:



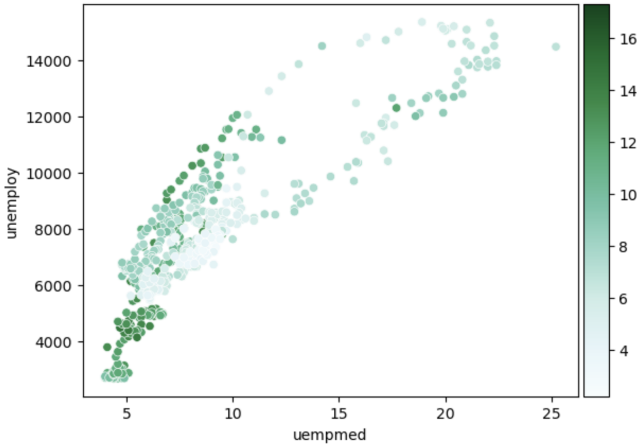
$\longrightarrow$ Useful if points/lines/areas depend on a continuous variable

$\longrightarrow$ Click here for an overview of other color maps

Colors: scatterplot

```
ax = sns.scatterplot(data = economics, x = "uempmed",
                     y = "unemploy", hue = "psavert",
                     palette = "BuGn")

# Create color bar
norm = plt.Normalize(economics['psavert'].min(),
                     economics['psavert'].max())
smap = plt.cm.ScalarMappable(cmap="BuGn", norm=norm)
smap.set_array([])

# Remove the legend and add a colorbar
ax.get_legend().remove()
ax.figure.colorbar(smap)
```

Colors: scatterplot



Removing or adding legends

⟶ For some plots, the legend might not provide new information, while for other plots the legend might be highly informative.

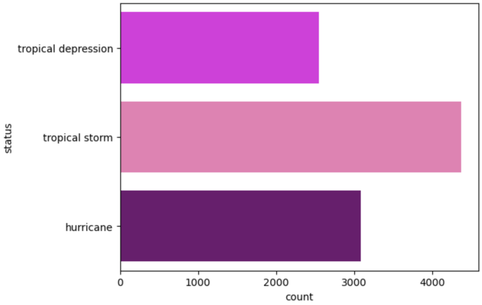
⟶ In both `pandas` as `seaborn` the legend can be removed by setting the argument `legend` to `False`

Flipping coordinates

- $\longrightarrow$ Some plots (e.g., barplots or conditional boxplots), are better displayed horizontally than vertically
  - Lengths are easier to judge for humans than heights
  - Easier to fit group labels
- $\longrightarrow$ Flipping coordinates can be done by swapping `x` and `y` in a barplot or boxplot.

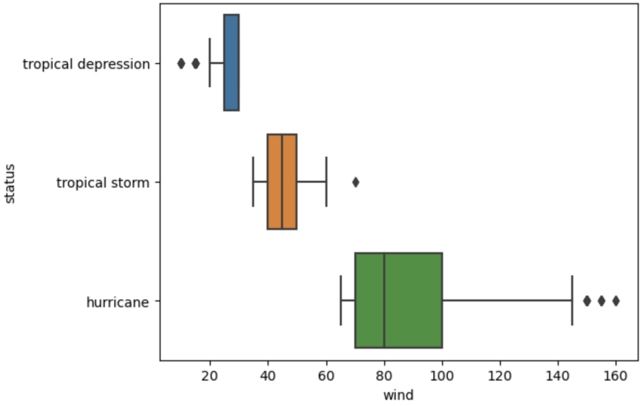
Flipping coordinates: barplot

```
sns.countplot(data = storms, y = 'status',
        palette = ["magenta", "hotpink", "purple"])
```



Flipping coordinates: conditional boxplots

```
sns.boxplot(data = storms, x = "wind", y = "status")
```



Axis limits and annotation

Axis limits:

`set_xlim()`	*x*-Axis limits
`set_ylim()`	*y*-Axis limits

$\longrightarrow$ Two values for lower and upper limit, get current axes using function `plt.gca()`

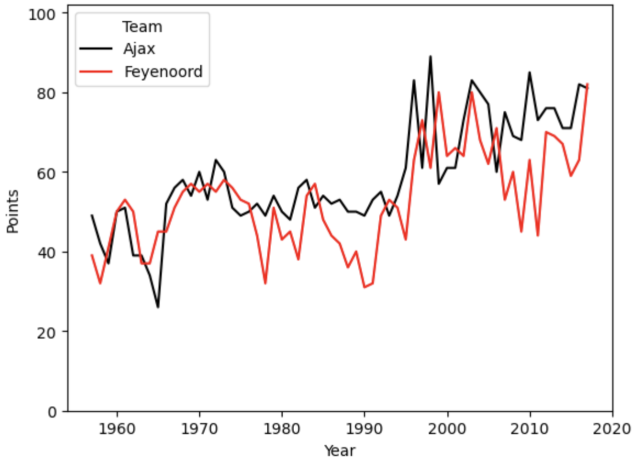
Annotation: use functions on the current axes to add title and labels

`set_title()`	Plot title
`set_xlabel()`	*x*-Axis label
`set_ylabel()`	*y*-Axis label

Axis limits: time series plot

```
sns.lineplot(eredivisie, x = "Year", y = "Points",
             hue = "Team",
             palette = {"Ajax": "black",
                        "Feyenoord": "red"})
ax = plt.gca()
ax.set_ylim(0, 102)
```

Axis limits: time series plot



Exercises

$\longrightarrow$ Open file *AdvancedGraphics-Exercises.pdf*

$\longrightarrow$ Do Exercise 2

Adding to plots

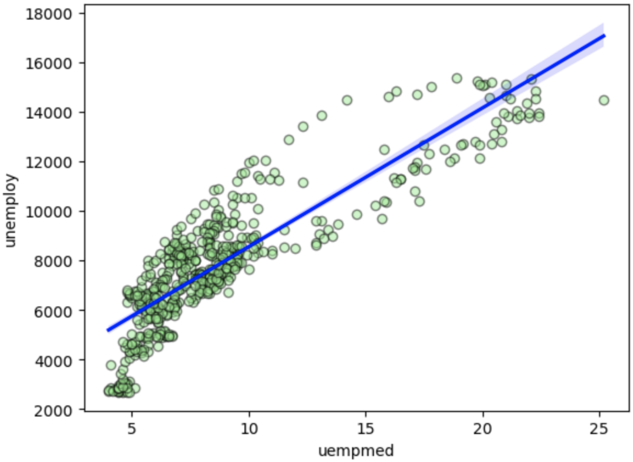
Layers

- $\longrightarrow$ `matplotlib` works in layers
- $\longrightarrow$ Allows to add additional information to a plot
- $\longrightarrow$ Made easy by `seaborn`

Adding a scatterplot smoother

```
sns.regplot(x = 'uempmed', y = 'unemploy',
            data = economics, ci = 95,
            scatter_kws = {"alpha": 0.5,
              "edgecolors": "black",
              "color": "lightgreen"},
            line_kws = {"color": "blue"})
```

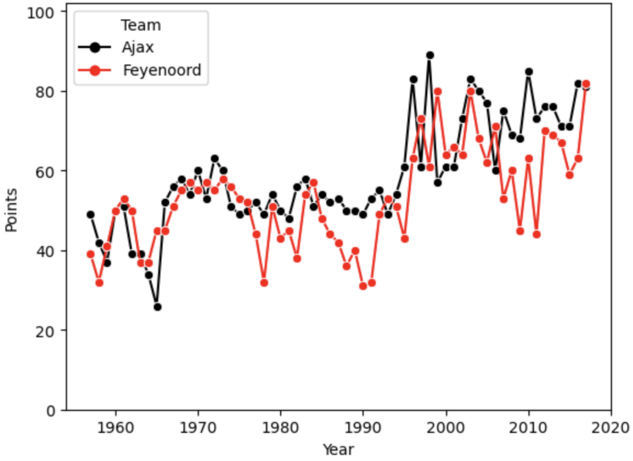
Adding a scatterplot smoother



Plotting both points and lines

```
sns.lineplot(eredivisie, x = "Year",
             y = "Points", hue = "Team",
             palette = {"Ajax": "black",
                        "Feyenoord": "red"},
             style = "Team",
             dashes = False,
             markers= ["o", "o"])
ax = plt.gca()
ax.set_ylim(0, 102)
```

Plotting both points and lines



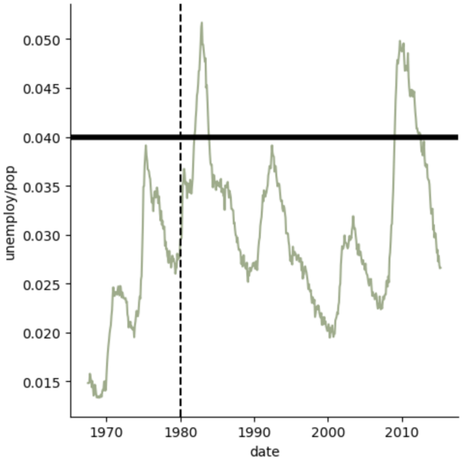
Adding vertical lines

```
# Turn date into a datetime type to get the axis correct
economics['date'] = pd.to_datetime(economics['date'])

# Calculate the unemployement relative to the population
economics['unemploy_pop'] =
      economics['unemploy']/economics['pop']

# Create figure
sns.relplot(economics, kind = "line",
            x = "date", y = "unemploy_pop",
            color = "#9aad88")
```

Adding vertical lines

```
# Add horizontal and vertical lines
plt.axhline(y = 0.04, c = "black", linewidth = 4)
plt.axvline(x = pd.to_datetime("1980-01-01"),
            c = "black", linestyle = "dashed")

# Axis labels and adjust ticks
plt.ylabel("unemploy/pop")
plt.xlabel("date")
```

Adding vertical lines



General settings for finetuning

Use style sheets to change the general settings

- `sns.set()` for the 'default' of `seaborn`
- `sns.set_theme(style="white", palette= "pastel")` to change the style to white using pastel colors e.g.
- `sns.reset_defaults()` to reset to the default of Python

$\longrightarrow$ Many more options: click here

$\longrightarrow$ If the same setting should be used for all points/lines/areas, you can change the general settings

Conclusions

Conclusions

- Library `pandas` offers a less flexible framework and less lengthy code.
- Library `seaborn` offers a wrapper around `matplotlib` which is still quite flexible and can produce high-quality graphics for publications.
- Sometimes `seaborn` does not suffice and one can use the more flexible library `matplotlib`, this can result in quite lengthy code.

Exercises

$\longrightarrow$ Open file *AdvancedGraphics-Exercises.pdf*

$\longrightarrow$ Do Exercise 3 and 4