07_other_libraries

November 23, 2022

1 Other libraries and cool things

[2]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

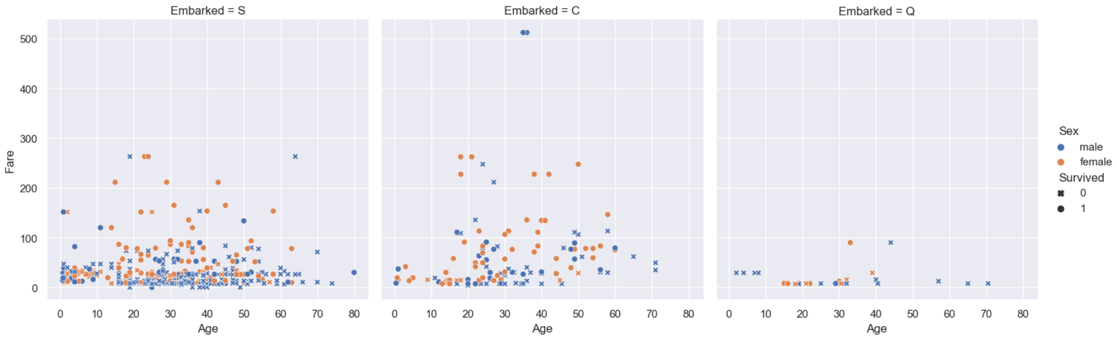
1.1 seaborn

seaborn is a Python data visualisation library for making statistical graphics. It is built on top of matplotlib and integrates very closely with pandas.

Exploratory visualisations are often much easier with seaborn. For example, with only a few lines of code, we can visualise 5 columns from the titanic dataset.

[71]:

```
sns.set_theme(context='notebook', style='darkgrid')

df = pd.read_csv('../data/titanic.csv')

ax = sns.relplot(
    data=df,
    x='Age', y='Fare', col='Embarked',
    hue='Sex',
    style='Survived',
    markers={0: 'X', 1: 'o'},
);
```



1.2 Matplotlib figure anatomy

A `matplotlib` figure is a collection of `Artist` objects stored together in a logical parent-child hierarchy. Here's a neat way to visualise it.

[9]:

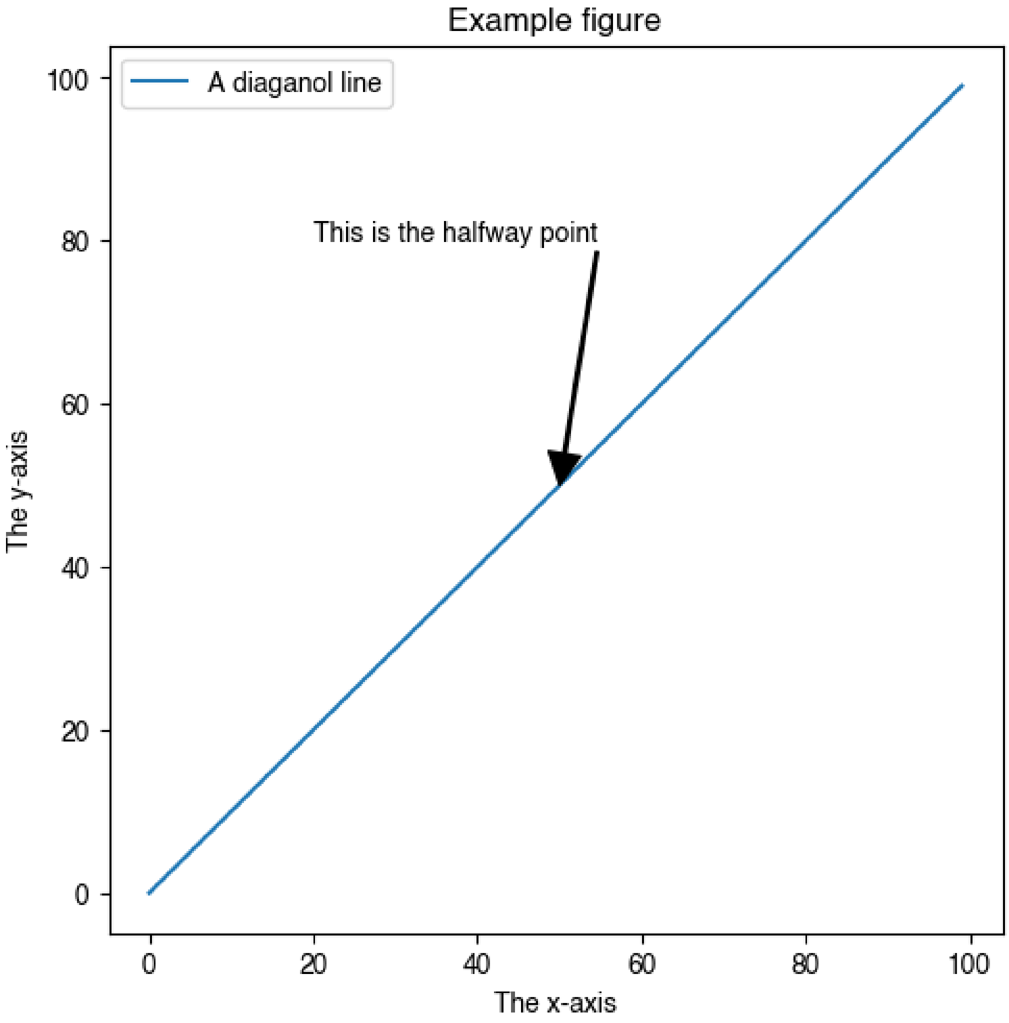
```python
from matplotlib.artist import Artist

# Make a basic example figure
fig, ax = plt.subplots(figsize=(6, 6))
ax.plot(range(100), range(100), label='A diaganol line')
ax.set(
    xlabel='The x-axis',
    ylabel='The y-axis',
    title='Example figure'
)
ax.legend()
ax.annotate(
    text='This is the halfway point',
    xy=(50, 50),
    xytext=(20, 80),
    arrowprops={'width':1, 'facecolor':'k', 'edgecolor':'k'}
)

# A function to plot all of the Artists
def recursive_get_children(artist, depth=0):
    if isinstance(artist, Artist):
        print('  ' * depth + str(artist))
        for child in artist.get_children():
            recursive_get_children(child, depth + 2)

# Call the function on our figure
recursive_get_children(fig)
```

```
Figure(600x600)
    Rectangle(xy=(0, 0), width=1, height=1, angle=0)
    AxesSubplot(0.125,0.11;0.775x0.77)
        Line2D(A diaganol line)
        Annotation(50, 50, 'This is the halfway point')
        Spine
        Spine
        Spine
        Spine
        XAxis(75.0,65.99999999999999)
            Text(0.5, 0, 'The x-axis')
            Text(1, 0, '')
```

```
<matplotlib.axis.XTick object at 0x7fbc8112e310>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
<matplotlib.axis.XTick object at 0x7fbc8112e2e0>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
<matplotlib.axis.XTick object at 0x7fbc915d8670>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
<matplotlib.axis.XTick object at 0x7fbc915de8e0>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
<matplotlib.axis.XTick object at 0x7fbc915e4070>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
<matplotlib.axis.XTick object at 0x7fbc915e4730>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
<matplotlib.axis.XTick object at 0x7fbc915e4e80>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
<matplotlib.axis.XTick object at 0x7fbc915ec610>
    Line2D()
    Line2D()
    Line2D()
    Text(0, 0, '')
    Text(0, 1, '')
```

```
YAxis(75.0,65.99999999999999)
    Text(0, 0.5, 'The y-axis')
    Text(0, 0.5, '')
    <matplotlib.axis.YTick object at 0x7fbc811351f0>
        Line2D()
        Line2D()
        Line2D()
        Text(0, 0, '')
        Text(1, 0, '')
    <matplotlib.axis.YTick object at 0x7fbc8112ea30>
        Line2D()
        Line2D()
        Line2D()
        Text(0, 0, '')
        Text(1, 0, '')
    <matplotlib.axis.YTick object at 0x7fbc915ecf40>
        Line2D()
        Line2D()
        Line2D()
        Text(0, 0, '')
        Text(1, 0, '')
    <matplotlib.axis.YTick object at 0x7fbc915ecd90>
        Line2D()
        Line2D()
        Line2D()
        Text(0, 0, '')
        Text(1, 0, '')
    <matplotlib.axis.YTick object at 0x7fbc915e4be0>
        Line2D()
        Line2D()
        Line2D()
        Text(0, 0, '')
        Text(1, 0, '')
    <matplotlib.axis.YTick object at 0x7fbc915f3490>
        Line2D()
        Line2D()
        Line2D()
        Text(0, 0, '')
        Text(1, 0, '')
    <matplotlib.axis.YTick object at 0x7fbc915f3a90>
        Line2D()
        Line2D()
        Line2D()
        Text(0, 0, '')
        Text(1, 0, '')
    <matplotlib.axis.YTick object at 0x7fbc915fb220>
        Line2D()
        Line2D()
```

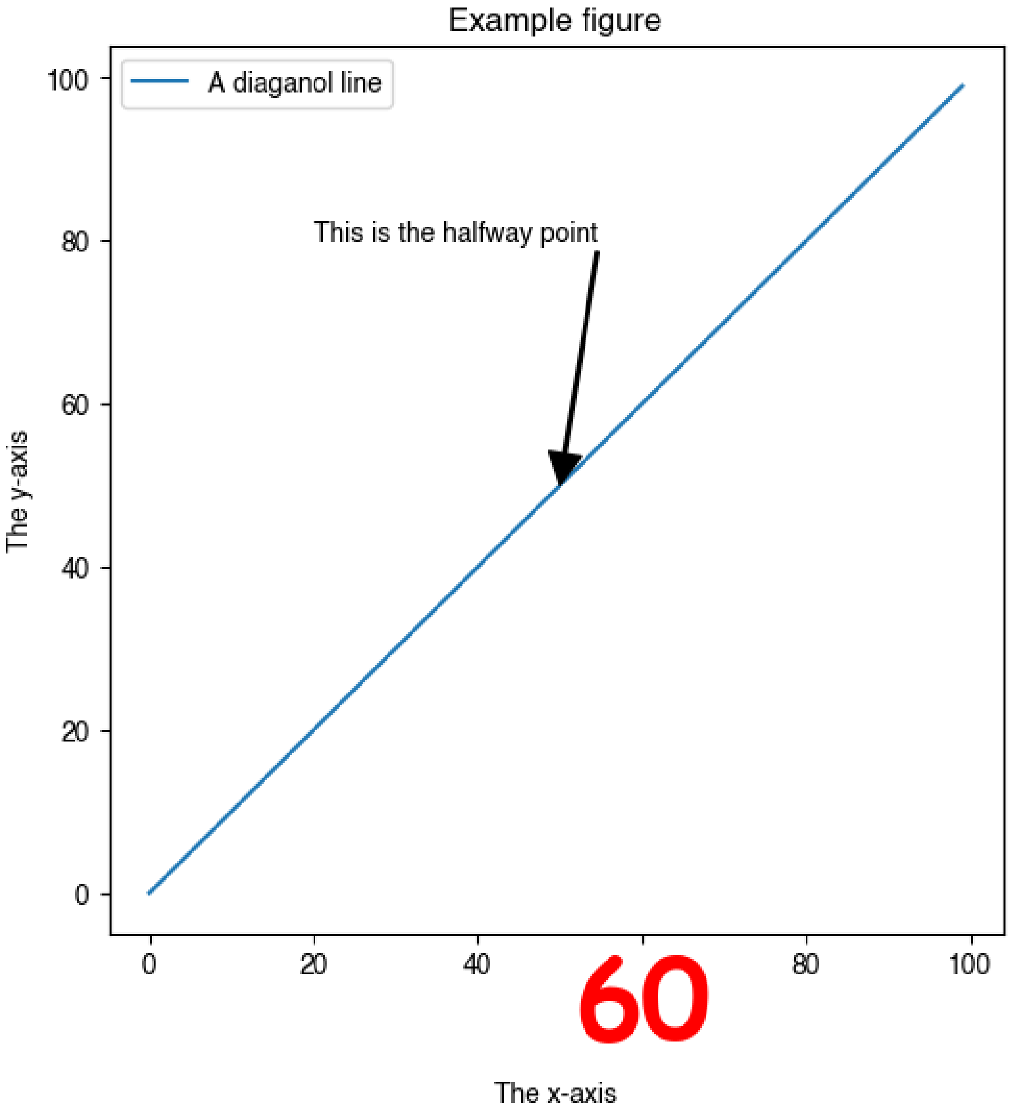
```
                Line2D()
                Text(0, 0, '')
                Text(1, 0, '')
        Text(0.5, 1.0, 'Example figure')
        Text(0.0, 1.0, '')
        Text(1.0, 1.0, '')
        Legend
            <matplotlib.offsetbox.VPacker object at 0x7fbc915d8fd0>
                <matplotlib.offsetbox.TextArea object at 0x7fbc915d8d90>
                    Text(0, 0, '')
                <matplotlib.offsetbox.HPacker object at 0x7fbc915d8c40>
                    <matplotlib.offsetbox.VPacker object at 0x7fbc915d8be0>
                        <matplotlib.offsetbox.HPacker object at 0x7fbc915d8c10>
                            <matplotlib.offsetbox.DrawingArea object at
0x7fbc915d8700>
                                Line2D(A diaganol line)
                            <matplotlib.offsetbox.TextArea object at
0x7fbc915d86d0>
                                Text(0, 0, 'A diaganol line')
            FancyBboxPatch((0, 0), width=1, height=1)
        Rectangle(xy=(0, 0), width=1, height=1, angle=0)
```



Now, to demonstrate the power of matplotlib, let's traverse this hierarchy in true object-oriented fashion and make some changes to a single element.

[10]:
```
fig.axes[0].get_xticklabels()[4].set(
    color='r',
    style='italic',
    weight='bold',
    size=42,
    family='Comic Sans MS'
)

fig
```

[10]:

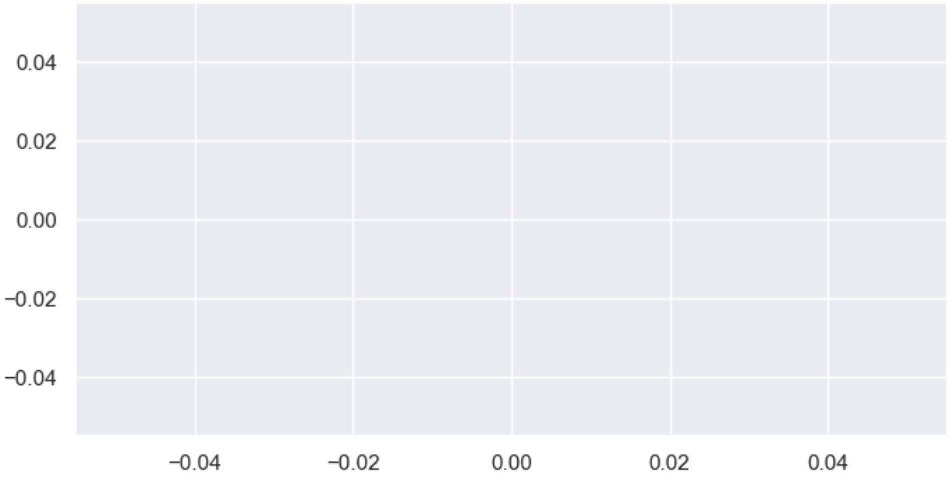


This may seem like a silly exercise, but it reveals much about `matplotlib`. What else about the plot can you change?

1.3 Animations with matplotlib

With `matplotlib`, it is also possible to make animated plots. Here's one that shows the number of cycling accidents over time. Note you may need to install some additional libraries for this to work in a Jupyter notebook.

[137]:
```
from matplotlib.animation import FuncAnimation
%matplotlib widget

df = (
    pd.read_csv('../data/gb_cycling_accidents.csv')
    .assign(index=lambda df_: pd.DatetimeIndex(df_.Date + ' ' + df_.Time))
    .set_index('index')
    .assign(Year=lambda df_: df_.index.year)
    .groupby(['Year', 'Gender'])['Accident_Index']
    .count()
    .unstack()
)

fig, ax = plt.subplots(figsize=(8, 4))
ln_male, = ax.plot([], [], 'ro-')
ln_female, = ax.plot([], [], 'bo-')
ln_other, = ax.plot([], [], 'go-')

def init():
    ax.set_ylim(-1000, df.Male.max()*1.05)
    ax.set_xlim((df.index.min(), df.index.max()))
    ax.set_xlabel('Year')
    ax.set_ylabel('Number of accidents')
    ax.set_title('Cycling accidents in Great Britain (1979-2018)')
    ax.legend([ln_male, ln_female, ln_other], ['Males', 'Females', 'Other'])
    return ln_male, ln_female, ln_other,

def update(frame):
    data = df.iloc[0:frame]
    ln_male.set_data(data.index, data.Male)
    ln_female.set_data(data.index, data.Female)
    ln_other.set_data(data.index, data.Other)


    return ln_male, ln_female, ln_other,

ani = FuncAnimation(fig, update, frames=len(df.index.to_numpy()),
                    init_func=init, blit=True)
plt.show()
```



2 Geographical plots with cartopy

There are various libraries for plotting geospatial data in Python. A good example is the cartopy library. Here, I use cartopy to plot the night-time shading for the current time on a flat map of the earth, along with the location of the University of York, and the 10 most populated cities.

The city data are freely available at the following web page:

- https://simplemaps.com/data/world-cities

[2]:
```
import pandas as pd

# Load the city data
df = (
    pd.read_csv('../data/worldcities.csv')
    .sort_values('population', ascending=False)
    .head(10)
)
df
```

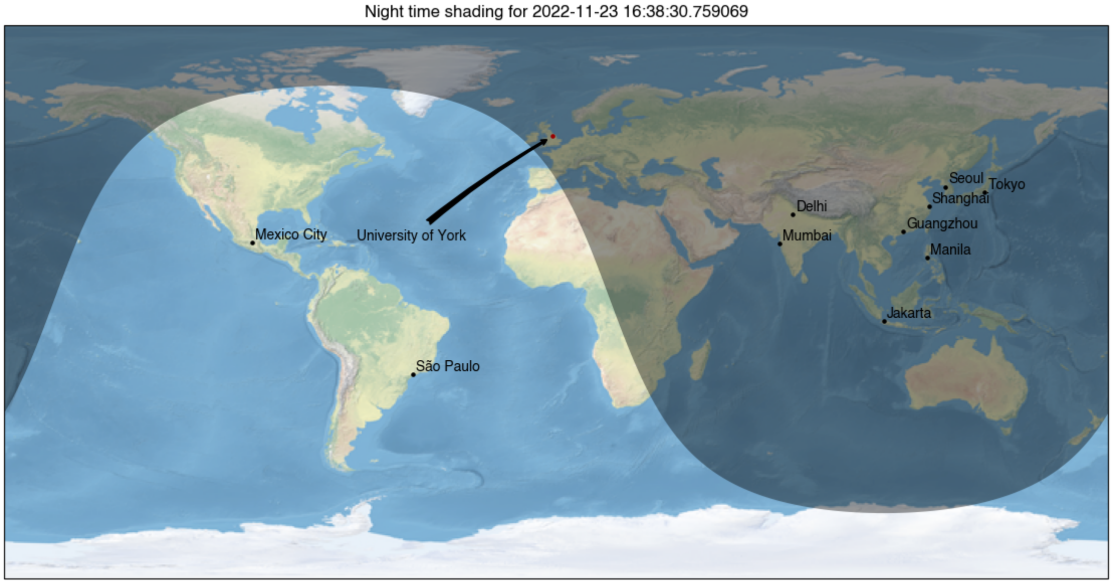
[2]:
```
           city    city_ascii      lat       lng      country iso2 iso3  \
0         Tokyo         Tokyo  35.6839  139.7744        Japan   JP  JPN
1       Jakarta       Jakarta  -6.2146  106.8451    Indonesia   ID  IDN
2         Delhi         Delhi  28.6667   77.2167        India   IN  IND
3        Manila        Manila  14.6000  120.9833  Philippines   PH  PHL
4     São Paulo     Sao Paulo -23.5504  -46.6339       Brazil   BR  BRA
5         Seoul         Seoul  37.5600  126.9900  South Korea   KR  KOR
6        Mumbai        Mumbai  19.0758   72.8775        India   IN  IND
7      Shanghai      Shanghai  31.1667  121.4667        China   CN  CHN
```

```
8  Mexico City  Mexico City  19.4333  -99.1333       Mexico   MX  MEX
9    Guangzhou    Guangzhou  23.1288  113.2590        China   CN  CHN

         admin_name  capital  population          id
0             Tōkyō  primary  39105000.0  1392685764
1           Jakarta  primary  35362000.0  1360771077
2             Delhi    admin  31870000.0  1356872604
3            Manila  primary  23971000.0  1608618140
4         São Paulo    admin  22495000.0  1076532519
5             Seoul  primary  22394000.0  1410836482
6       Mahārāshtra    admin  22186000.0  1356226629
7          Shanghai    admin  22118000.0  1156073548
8  Ciudad de México  primary  21505000.0  1484247881
9         Guangdong    admin  21489000.0  1156237133
```

[13]:

```python
import datetime
import matplotlib.pyplot as plt
import numpy as np
import cartopy.crs as ccrs
from cartopy.feature.nightshade import Nightshade

# Create a figure with a GeoAxes by specifying
fig = plt.figure(figsize=(12, 6))
ax = fig.add_subplot(1, 1, 1, projection=ccrs.PlateCarree())

# Get current date and time
dt = datetime.datetime.now()

# Location of University of York
location = (-1.0311947681813436, 53.94930227196749)

# Arrow props
arrowprops=dict(
    arrowstyle='fancy',
    shrinkA=5,
    shrinkB=5,
    fc="k", ec="k",
    connectionstyle="arc3,rad=-0.05",
)

# Add title
ax.set_title(f'Night time shading for {dt}')

# Draw a standard flat map of the world
ax.stock_img()

# Add the nightshade feature
```

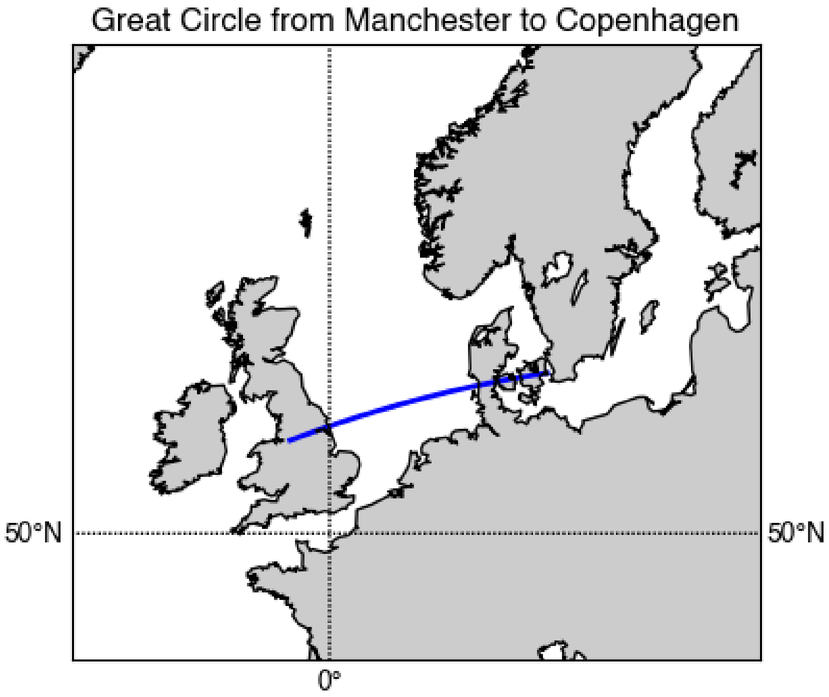
```
ax.add_feature(Nightshade(dt, alpha=0.4))

# Add University of York location and annotate
ax.scatter(*location, c='r', s=5)
ax.annotate(
    text='University of York',
    xy=location,
    xytext=(-65, 20),
    arrowprops=arrowprops
)

# Plot the city locations
ax.scatter(df.lng, df.lat, c='k', s=5)

# Annotate with the names of the cities
for idx, row in df.iterrows():
    ax.annotate(
        text=row.city,
        xy=(row.lng+1, row.lat+1)
    )

plt.tight_layout()
plt.show()
```



`matplotlib` has its own Basemap Toolkit which predates `cartopy`. Soon I'll be off to Copenhagen, so I decided to use it to plot the great circle route between airports.

[103]:

```
from mpl_toolkits.basemap import Basemap
import numpy as np
import matplotlib.pyplot as plt

# create new figure, axes instances.
fig=plt.figure(figsize=(12, 4))
ax=fig.add_axes([0.1,0.1,0.8,0.8])

# setup mercator map projection.
m = Basemap(
    llcrnrlon=-15.,llcrnrlat=45.,urcrnrlon=25.,urcrnrlat=65.,
    rsphere=(6378137.00,6356752.3142),
    resolution='l',projection='merc',
    lat_0=40.,lon_0=-20.,lat_ts=20.
)

# lat/lon for manchester and copenhagen
cop_lat, cop_lon = 55.62798787190983, 12.643942953245418
man_lat, man_lon = 53.35544507391249, -2.277185420260674

# draw great circle route between manchster and copenhagen
m.drawgreatcircle(cop_lon,cop_lat,man_lon,man_lat,linewidth=2,color='b')
m.drawcoastlines()
m.fillcontinents()

# draw parallels
m.drawparallels(np.arange(10,90,20), labels=[1,1,0,1])

# draw meridians
m.drawmeridians(np.arange(-180,180,30),labels=[1,1,0,1])

ax.set_title('Great Circle from Manchester to Copenhagen')
plt.show()
```


Great Circle from Manchester to Copenhagen
50°N
50°N
0°

[ ]: