Coordinate Reference Systems

WORKING WITH GEOSPATIAL DATA IN PYTHON

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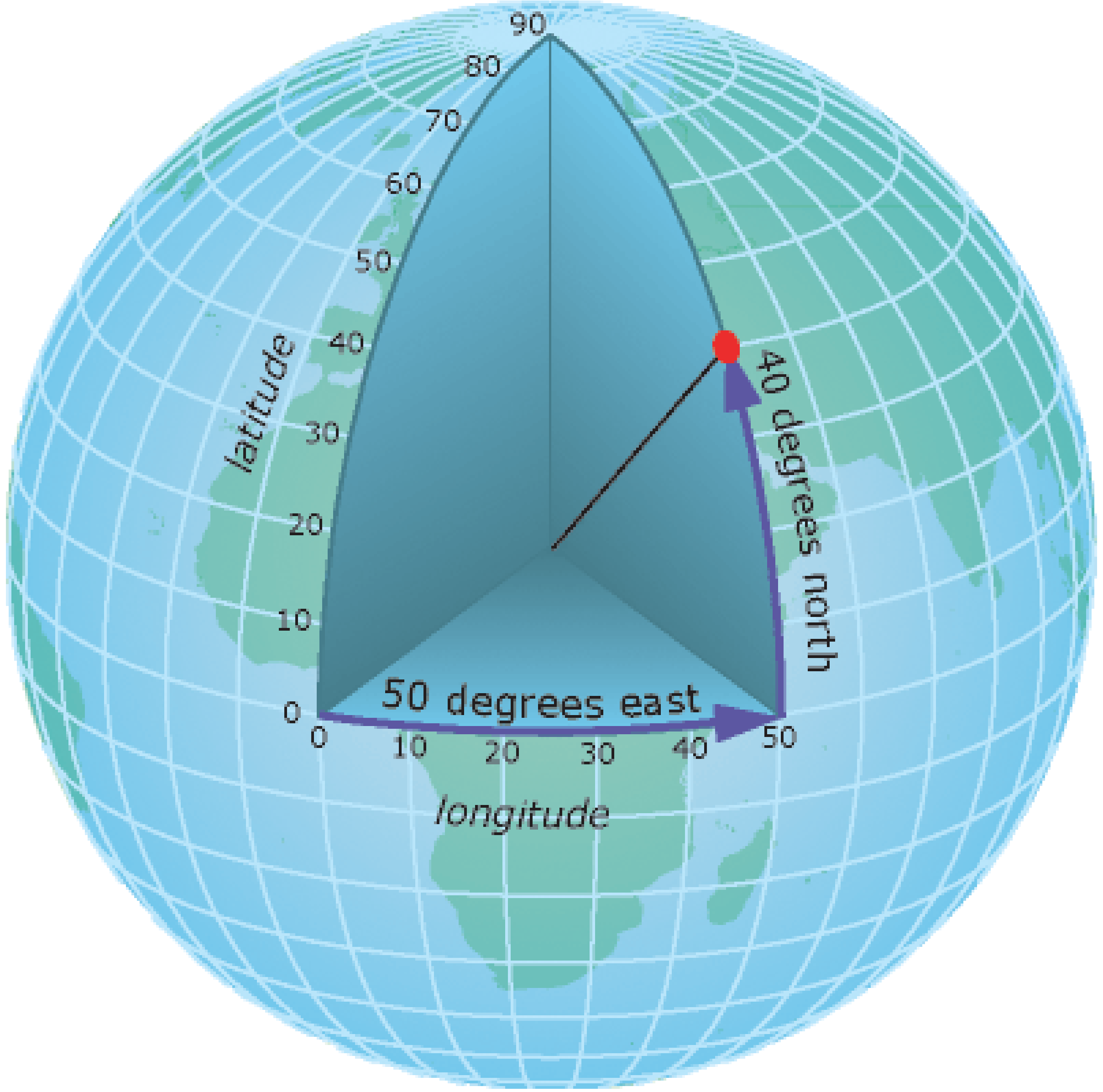
Coordinate Reference System (CRS)

Location of the Eiffel Tower:

```
POINT (2.2945 48.8584)
```

> → The **Coordinate Reference System (CRS)** relates the coordinates to a specific location on earth.

Geographic coordinates



Degrees of latitude and longitude.

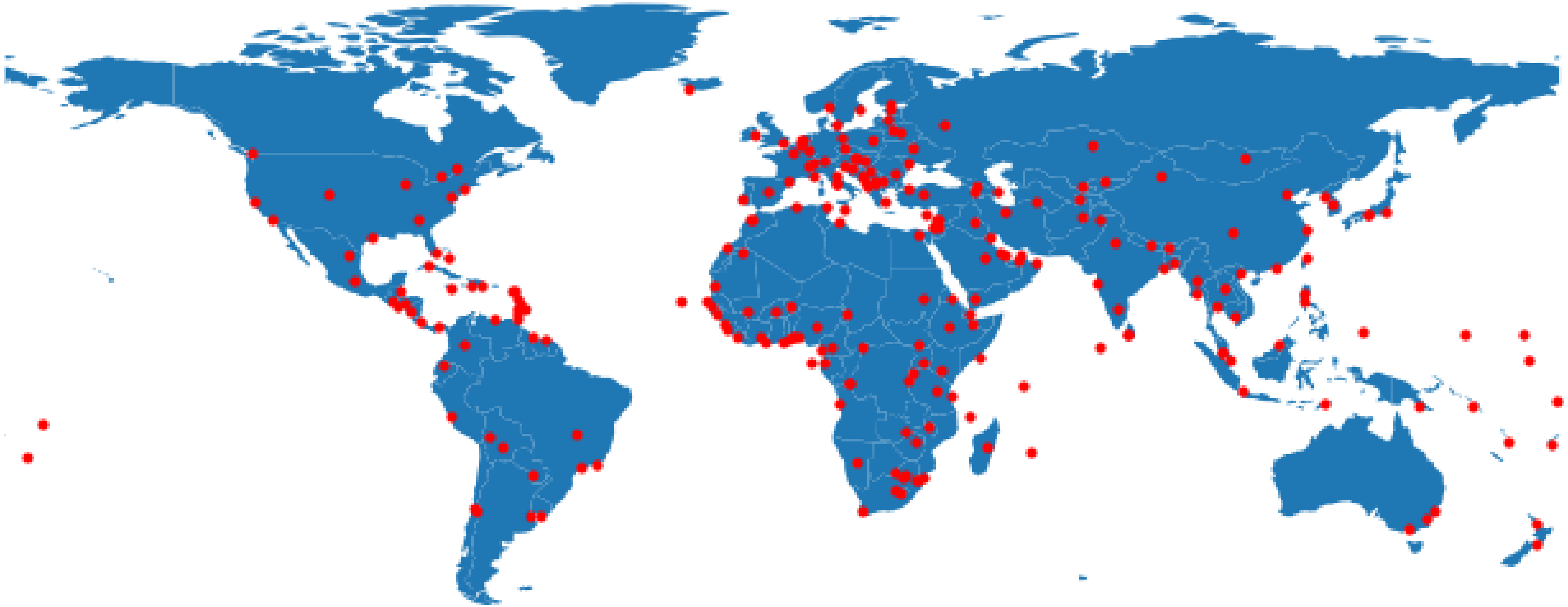
E.g. 48°51′N, 2°17′E

Used in GPS, web mapping applications...

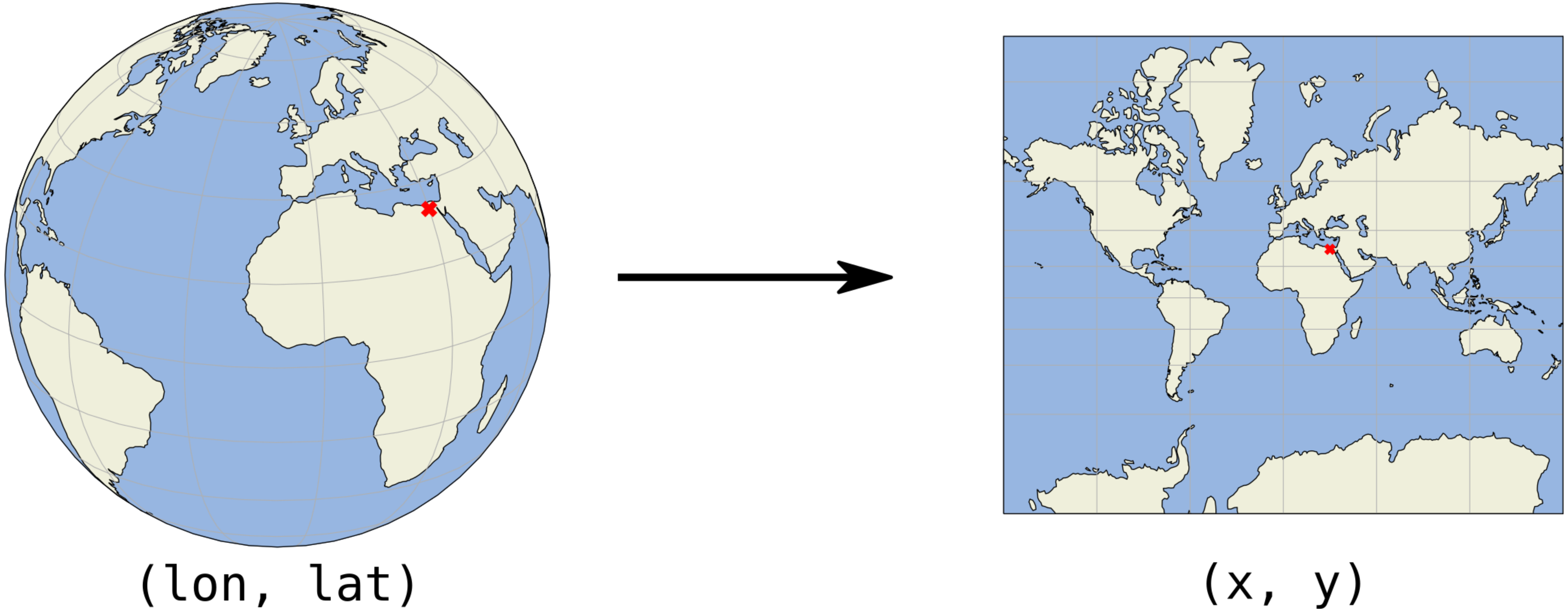
Attention!
in Python we use (lon, lat) and not (lat, long)

- Longitude: [-180, 180]
- Latitude: [-90, 90]

Maps are 2D



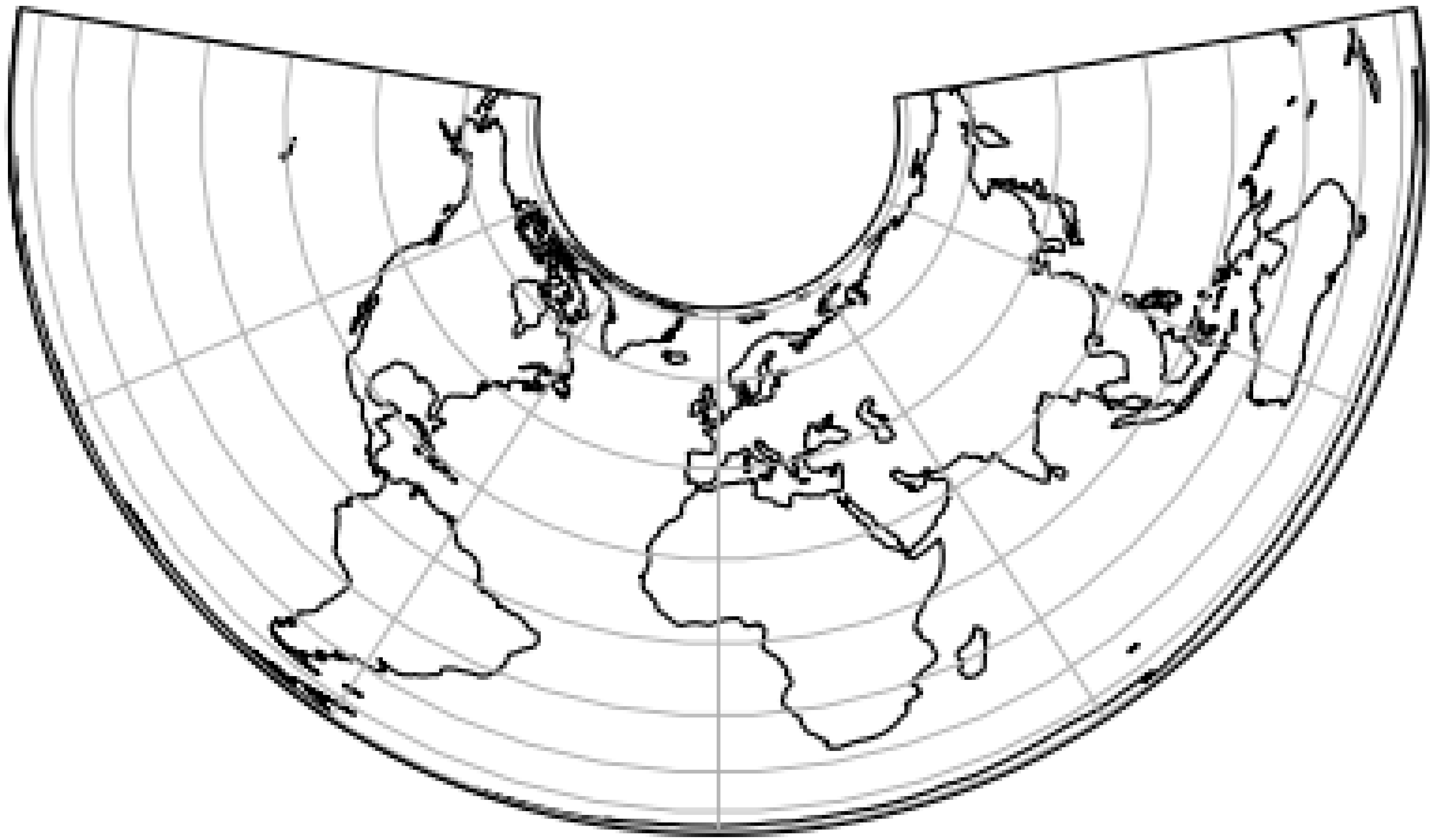
Projected coordinates



`(x, y)` coordinates are usually in meters or feet

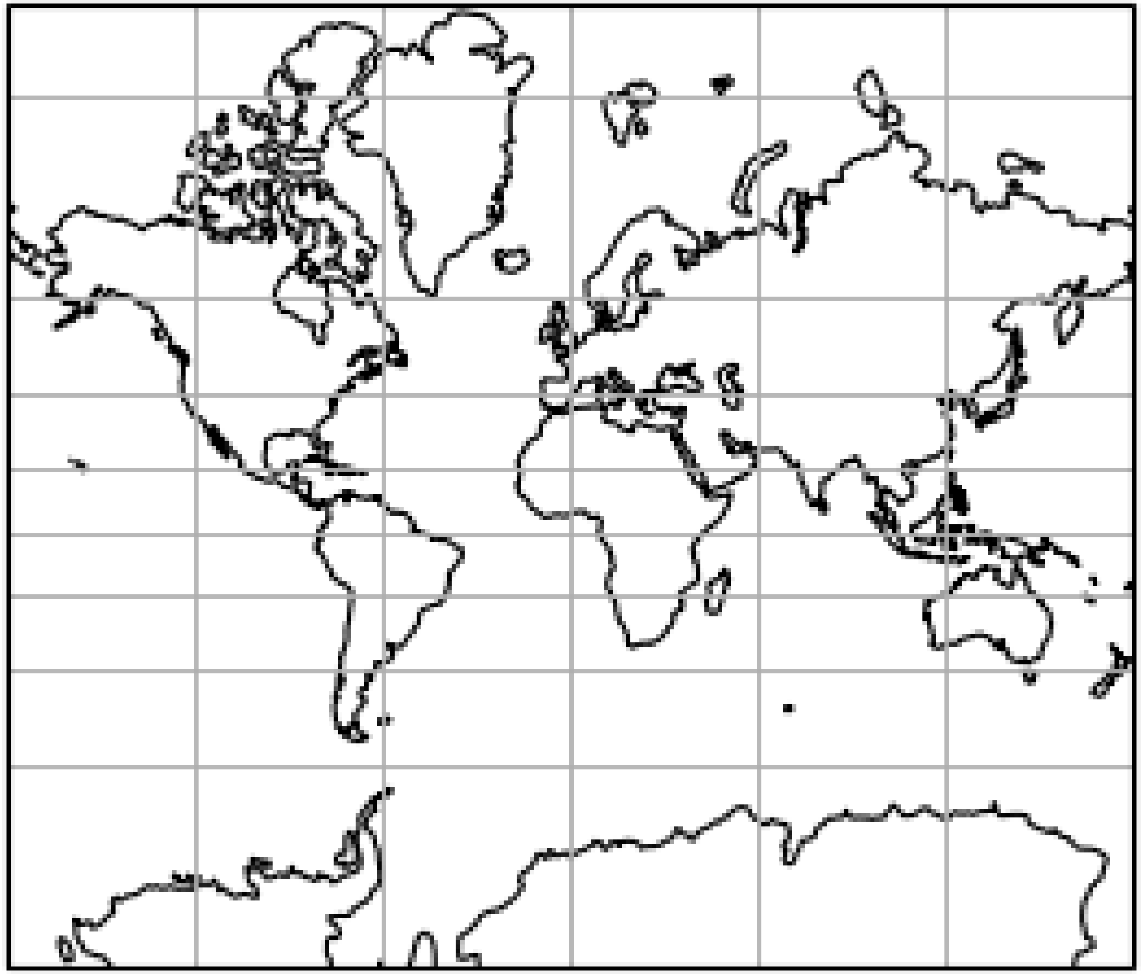
Projected coordinates - Examples

Albers Equal Area projection



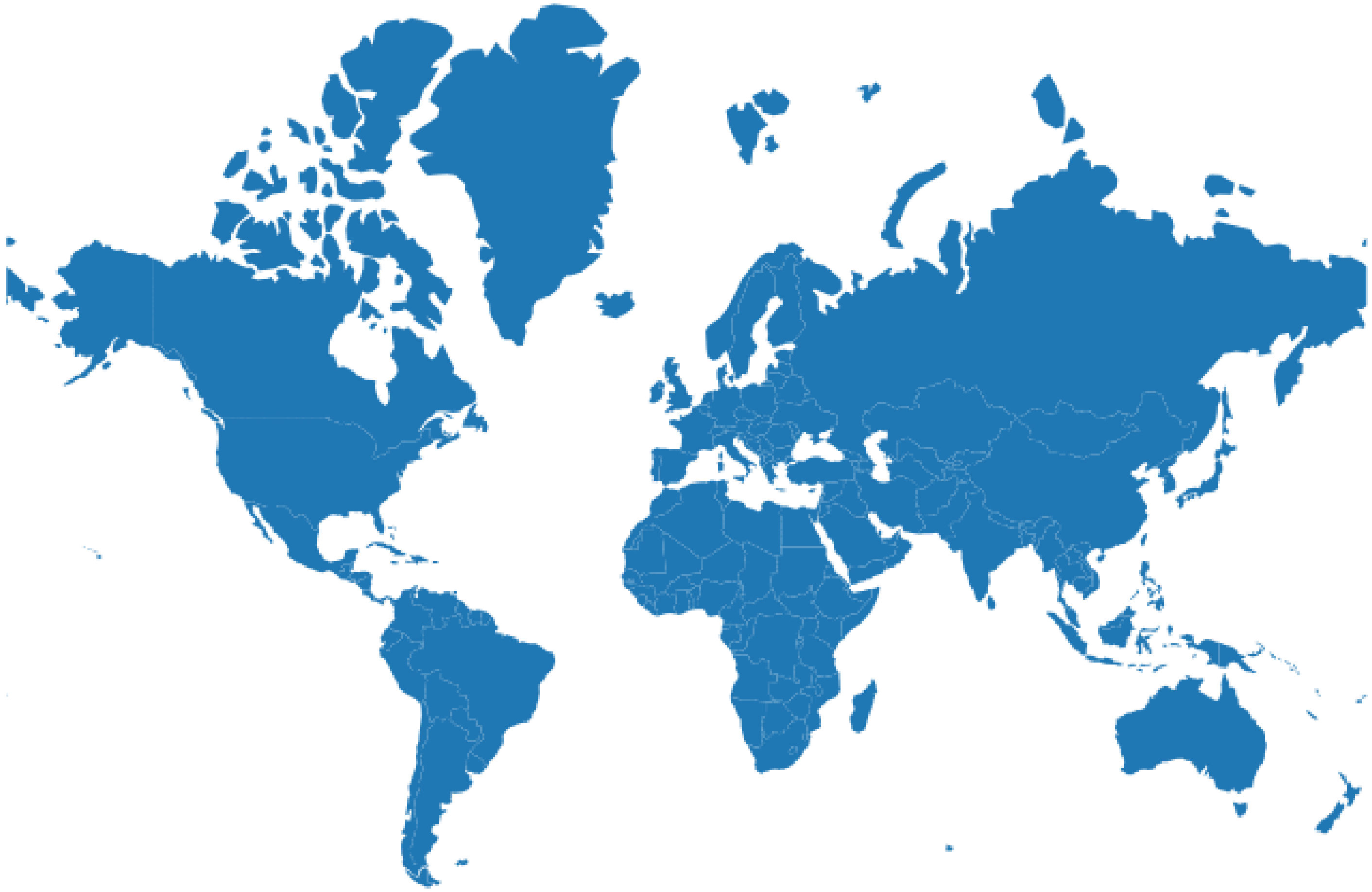
Projected coordinates - Examples

Mercator projection



Projected coordinates - Examples

Projected size vs actual size (Mercator projection)



Specifying a CRS

`proj4` string

Example: `+proj=longlat +datum=WGS84 +no_defs`

Dict representation:

```
{'proj': 'longlat', 'datum': 'WGS84', 'no_defs': True}
```

EPSG code

Example:

`EPSG:4326` = WGS84 geographic CRS (longitude, latitude)

CRS in GeoPandas

The `.crs` attribute of a GeoDataFrame/GeoSeries:

```python
import geopandas
gdf = geopandas.read_file("countries.shp")
print(gdf.crs)
```

```
{'init': 'epsg:4326'}
```

Summary

- "geographic" (long, lat) versus "projected" (x, y) coordinates
- Coordinates Reference System (CRS) in GeoPandas: `.crs` attribute
- Most used geographic CRS: WGS84 or EPSG:4326

Let's practice

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Working with coordinate systems in GeoPandas

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CRS information in GeoPandas

The `.crs` attribute of a GeoDataFrame/GeoSeries:

```python
import geopandas
gdf = geopandas.read_file("countries.shp")
print(gdf.crs)
```

```
{'init': 'epsg:4326'}
```

Setting a CRS manually

```
gdf_noCRS = geopandas.read_file("countries_noCRS.shp")
print(gdf_noCRS.crs)
```

```
{}
```

Add CRS information to `crs` :

```
# Option 1
gdf.crs = {'init': 'epsg:4326'}

# Option 2
gdf.crs = {'proj': 'longlat', 'datum': 'WGS84', 'no_defs': True}
```

Transforming to another CRS

```python
import geopandas
gdf = geopandas.read_file("countries_web_mercator.shp")
print(gdf.crs)
```

```
{'init': 'epsg:3857', 'no_defs': True}
```

The `to_crs()` method:

```python
# Option 1
gdf2 = gdf.to_crs({'proj': 'longlat', 'datum': 'WGS84', 'no_defs': True})
# Option 2
gdf2 = gdf.to_crs(epsg=4326)
```

Why converting the CRS?

1) Sources with a different CRS

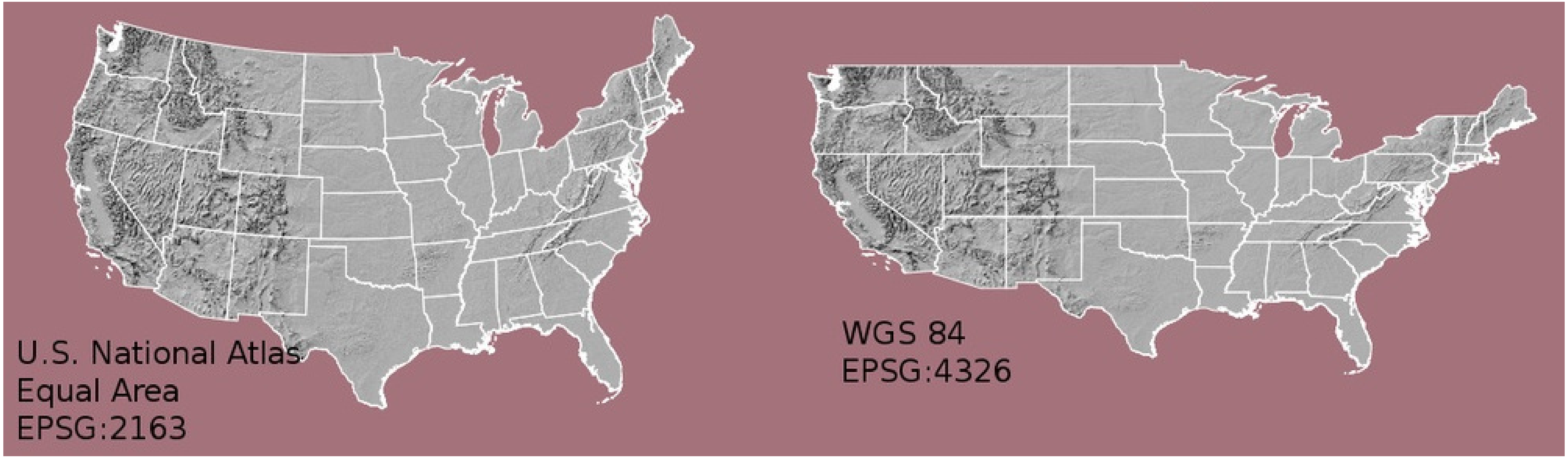
```
df1 = geopandas.read_file(...)
df2 = geopandas.read_file(...)


df2 = df2.to_crs(df1.crs)
```

Why converting the CRS?

1) Sources with a different CRS

2) Mapping (distortion of shape and distances)



Why converting the CRS?

1) Sources with a different CRS

2) Mapping (distortion of shape and distances)

3) Distance / area based calculations

How to choose which CRS to use?

Tips:

- Use projection specific to the area of your data
- Most countries have a standard CRS

Useful sites:

- http://spatialreference.org/
- https://epsg.io/

Summary

- To convert to another CRS: the `to_crs()` method
- Make sure different datasets have the same CRS
- When calculating distance, area, ... -> use a **projected CRS**

Useful sites:

- **http://spatialreference.org/**
- **https://epsg.io/**

Let's practice!

WORKING WITH GEOSPATIAL DATA IN PYTHON

Spatial operations: creating new geometries

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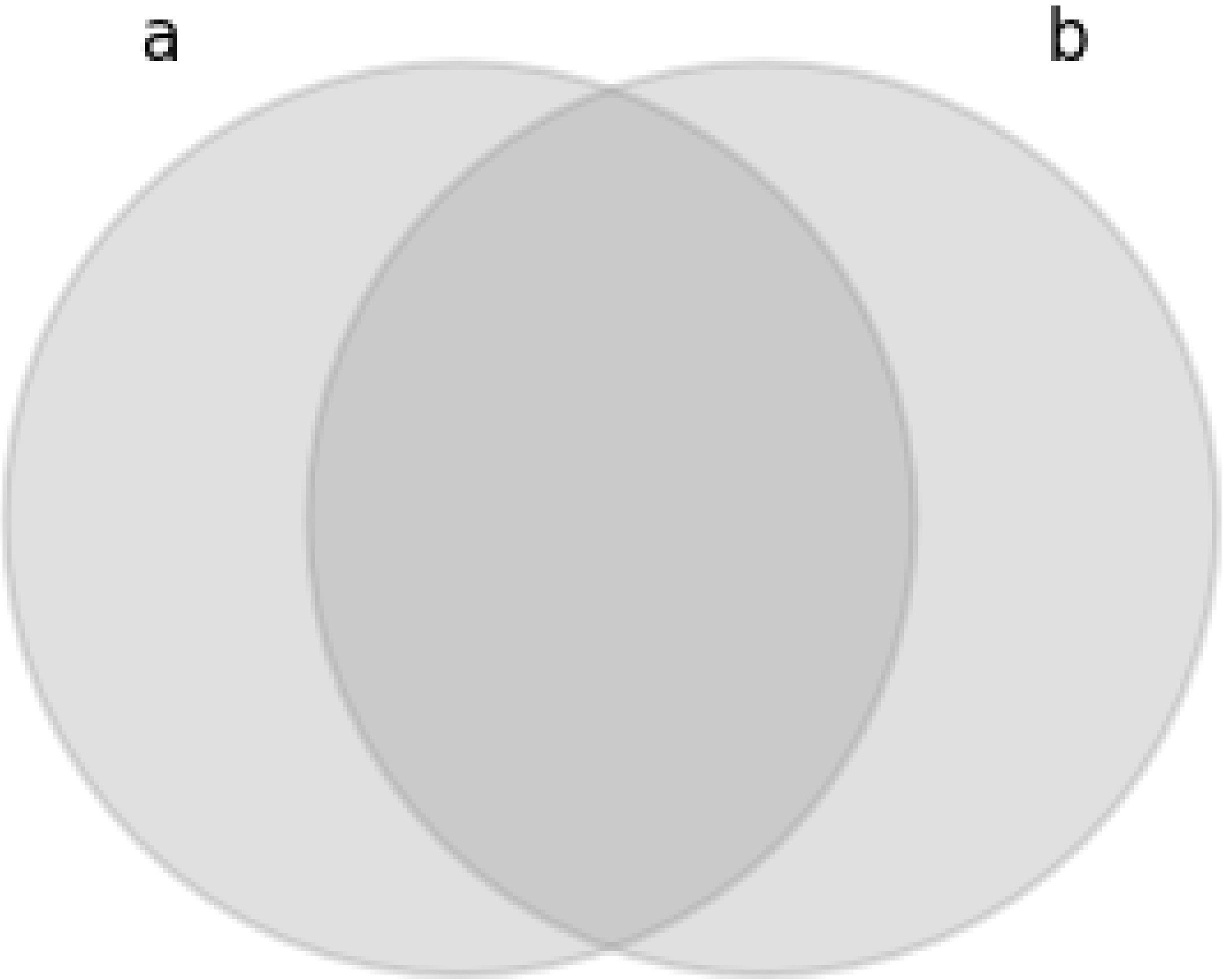
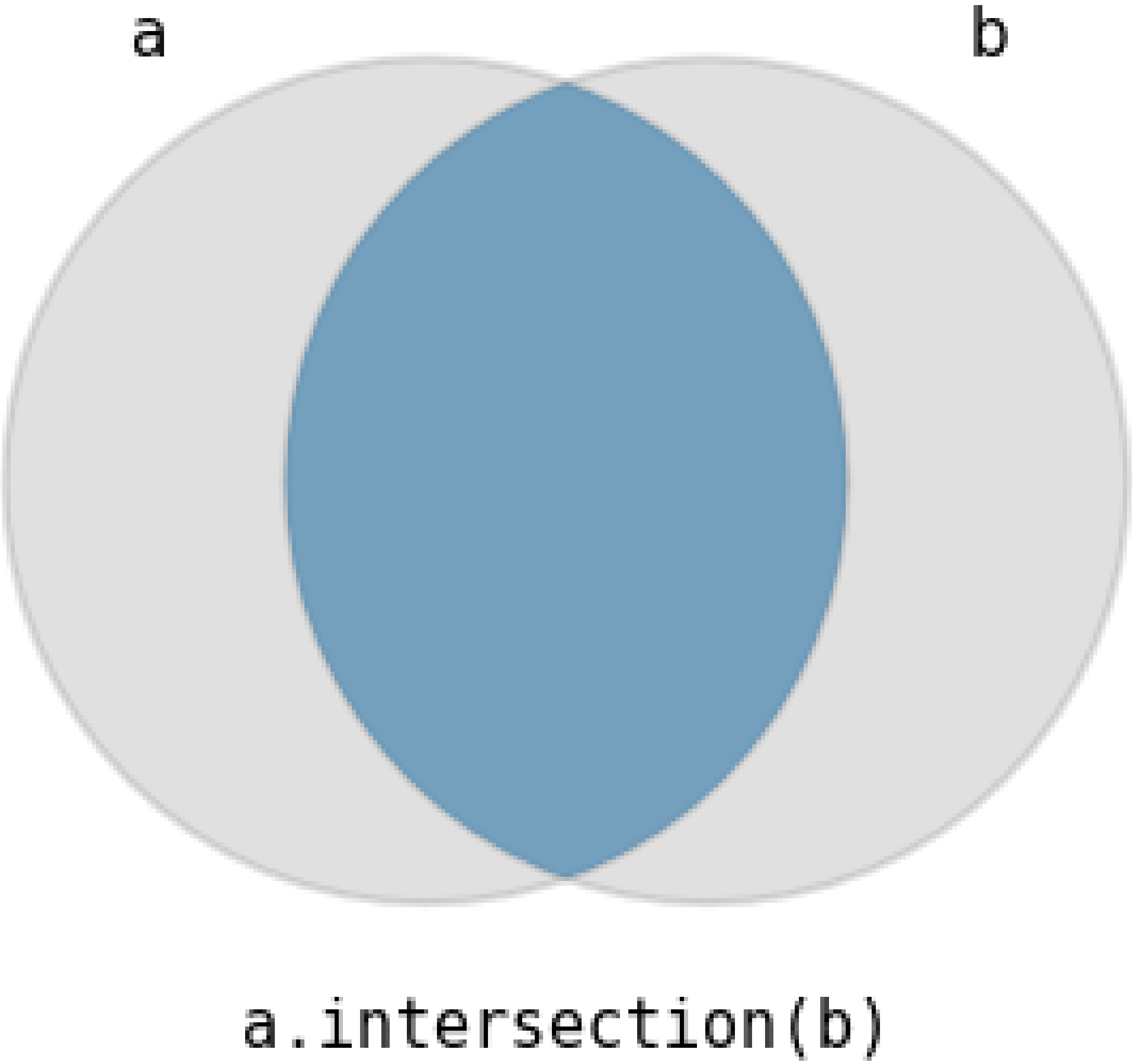
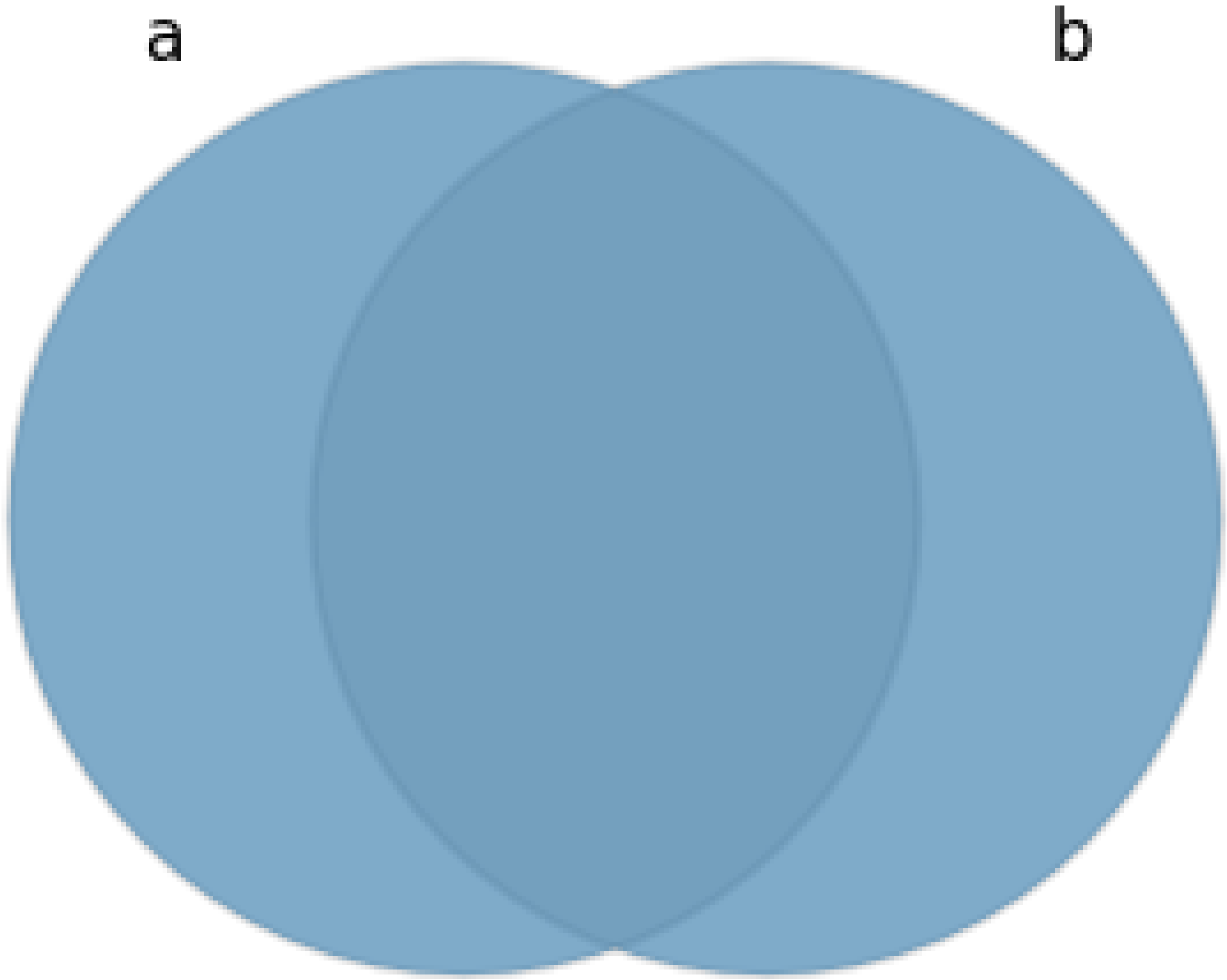
Spatial operations



Spatial operations: intersection

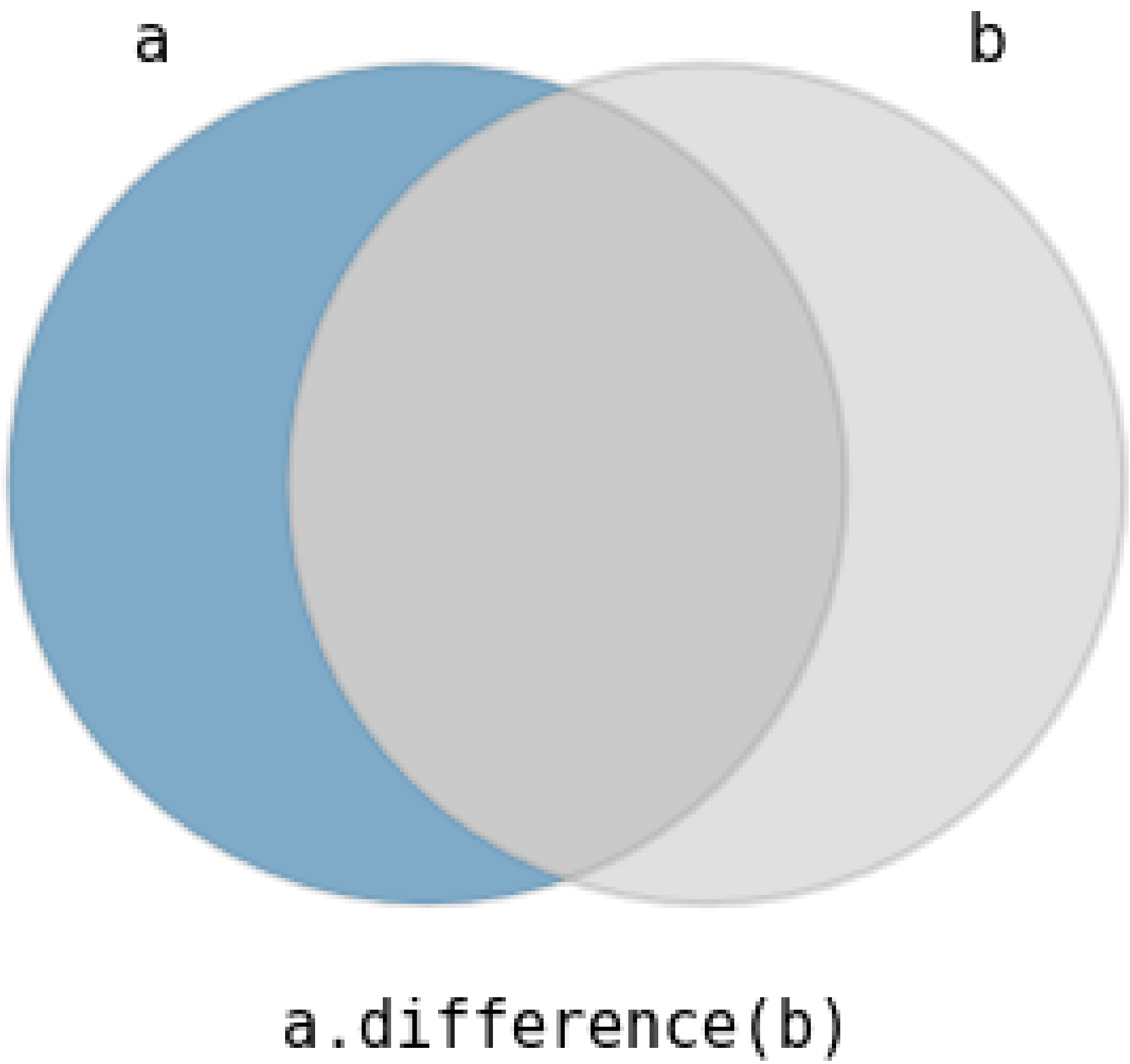


Spatial operations: union



a.union(b)

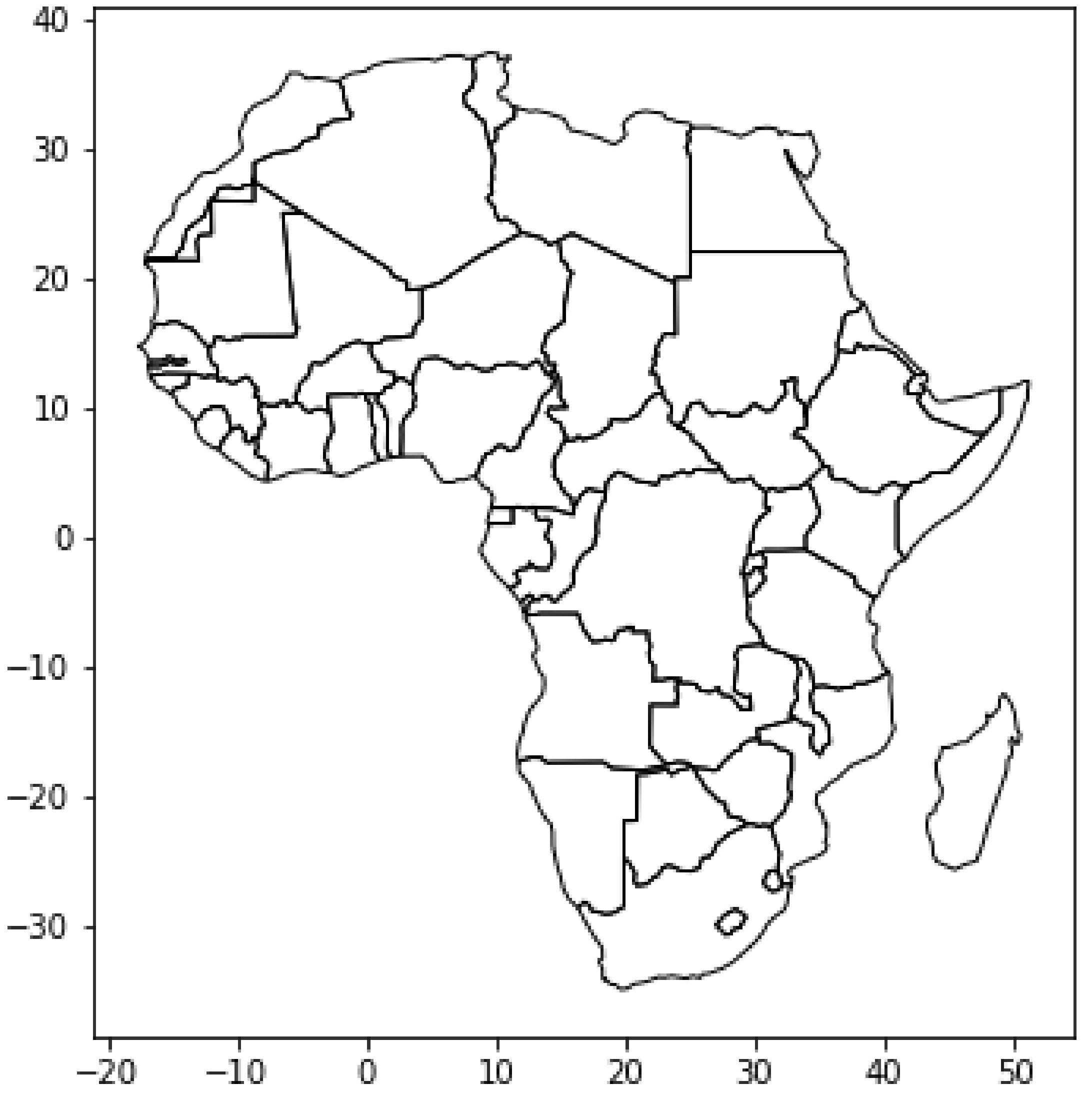
Spatial operations: difference



Spatial operations with GeoPandas

```
africa.head()
```

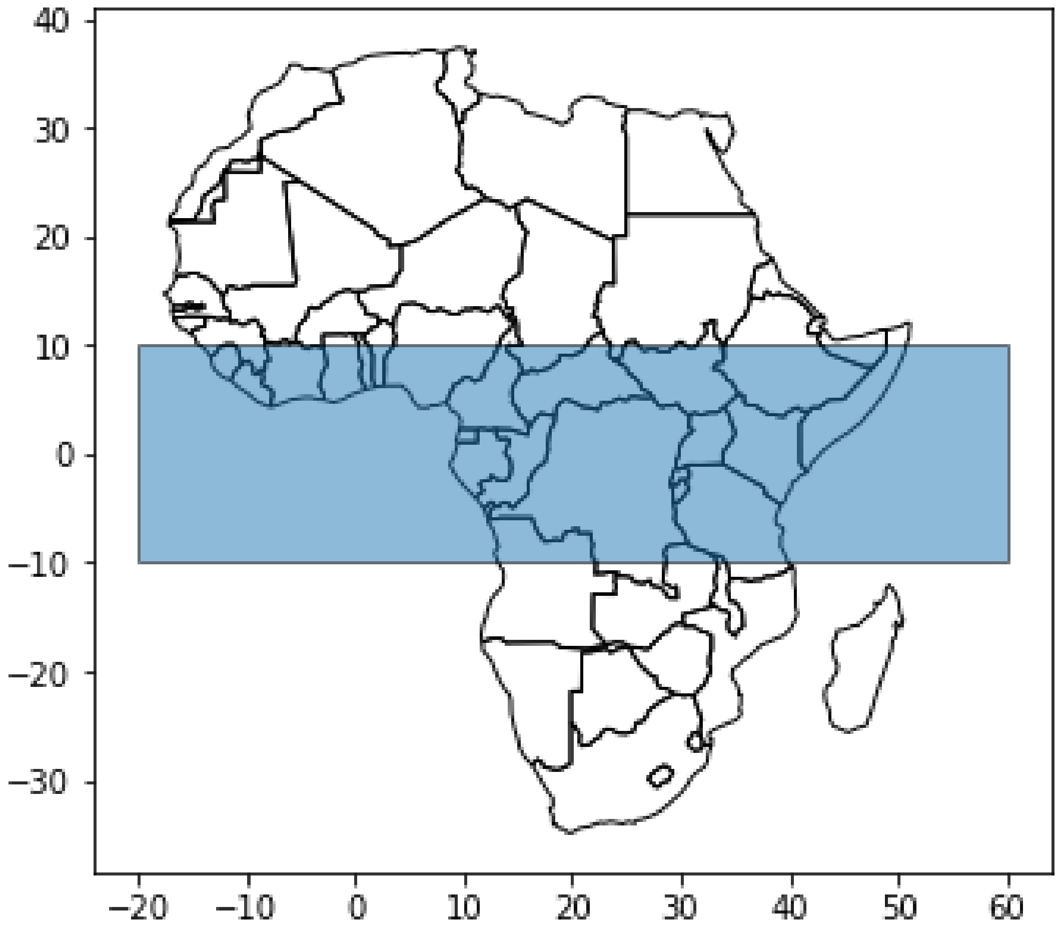
```
           name                 geometry
0        Angola  (POLYGON ((23.90...
1       Burundi  POLYGON ((29.339...
2         Benin  POLYGON ((2.6917...
3  Burkina Faso  POLYGON ((2.1544...
4      Botswana  POLYGON ((29.432...
```



Spatial operations with GeoPandas

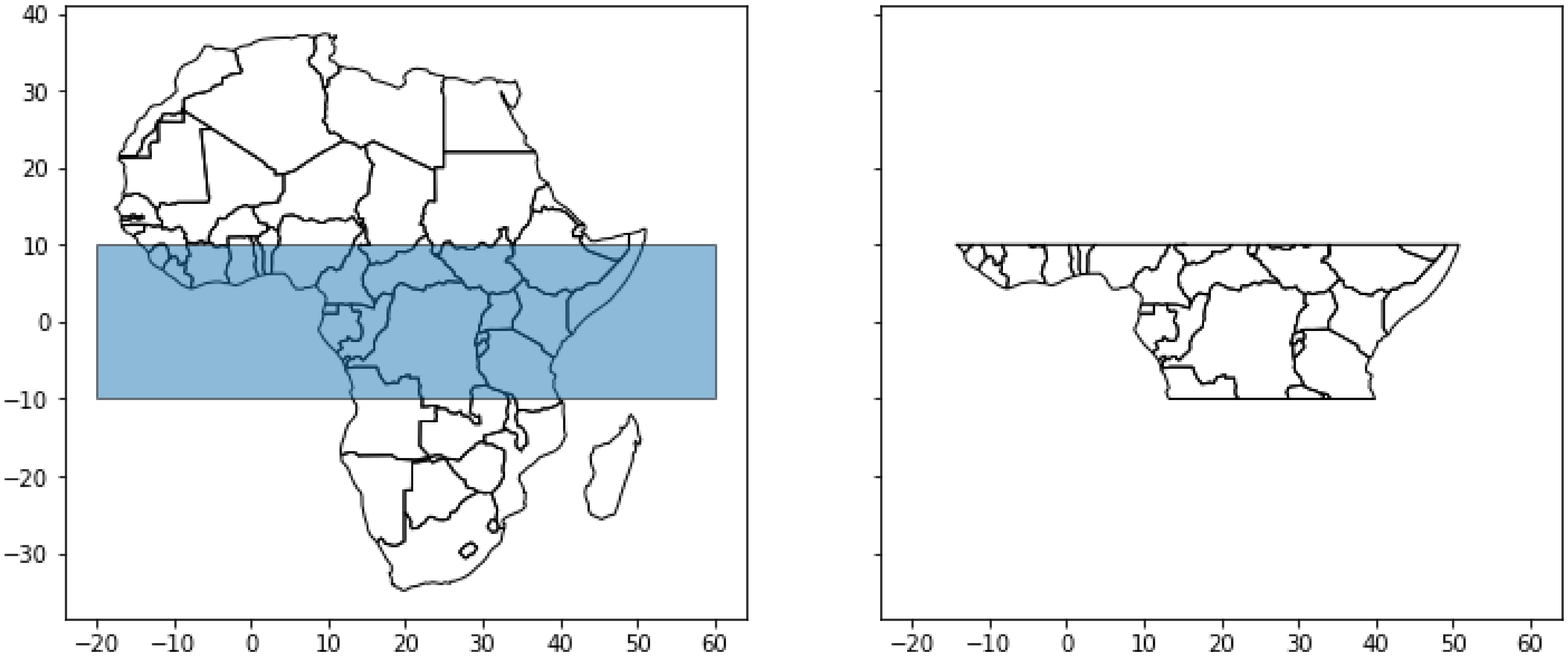
```
print(box)
```

```
POLYGON ((60 10, 60 -10, -20 -10, -20 10)
```



Spatial operations with GeoPandas

```
africa.intersection(box)
```



Spatial operations with GeoPandas

```
africa.head()
```

```
          name                                            geometry
0       Angola  (POLYGON ((23.90415368011818 -11.7222815894063...
1      Burundi  POLYGON ((29.33999759290035 -4.499983412294092...
2     Botswana  POLYGON ((29.43218834810904 -22.09131275806759...
...
```

```
africa.intersection(box)
```

```
0    (POLYGON ((13.22332255001795 -10, 13.120987583...
1    POLYGON ((29.33999759290035 -4.499983412294092...
2                                                   ()
...
dtype: object
```

Let's practice!

WORKING WITH GEOSPATIAL DATA IN PYTHON

Overlaying spatial datasets

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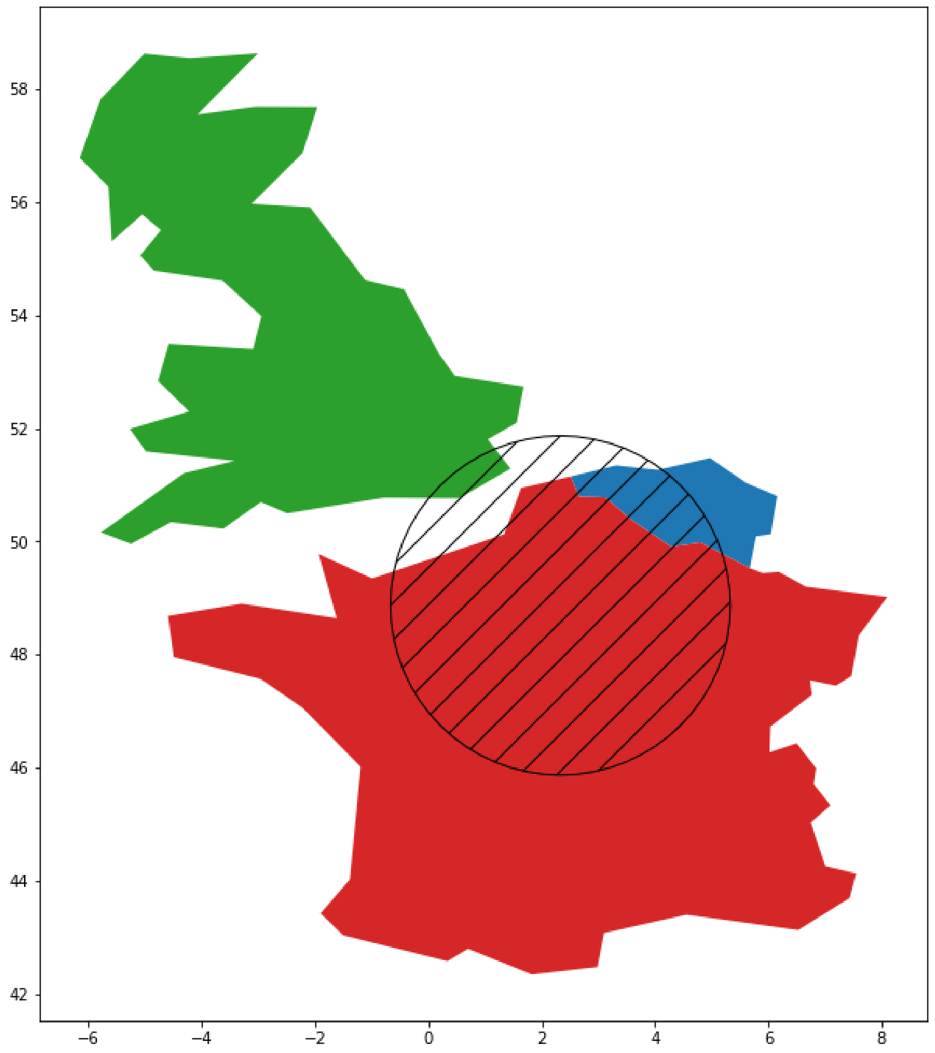
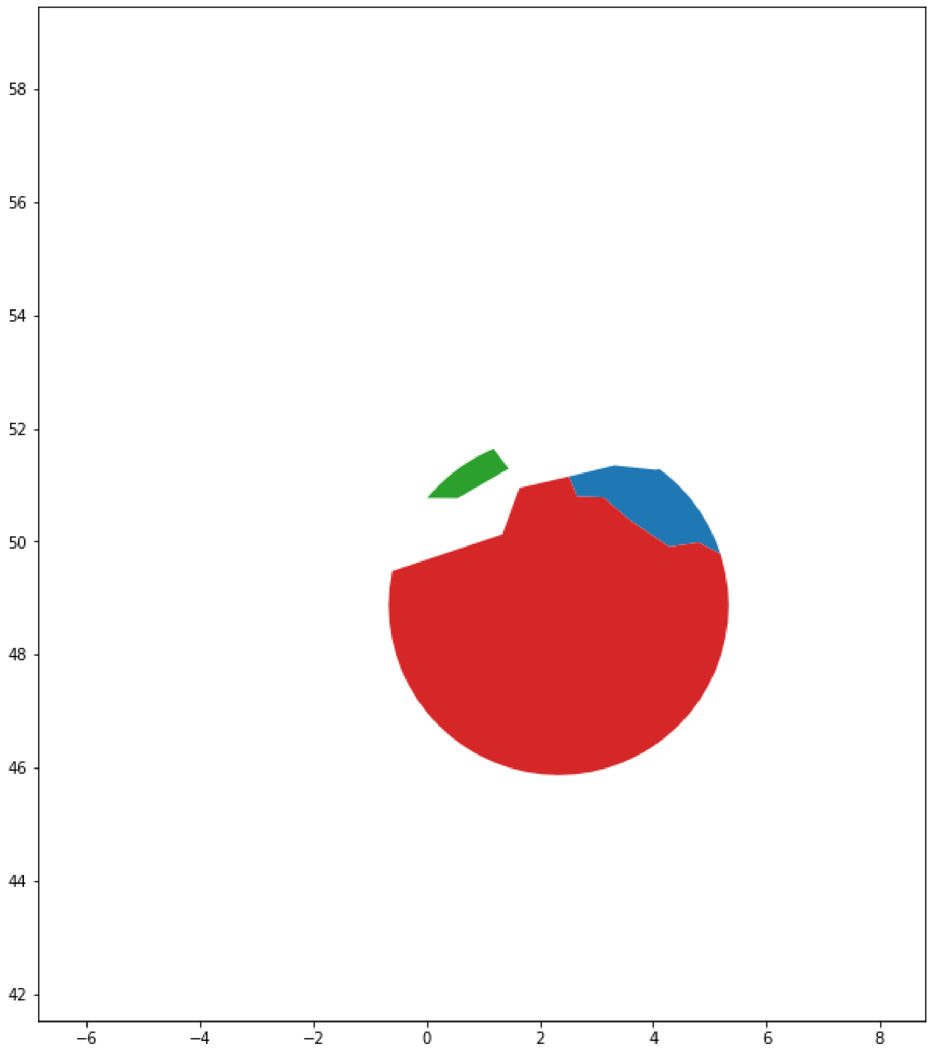
Intersection with a polygon





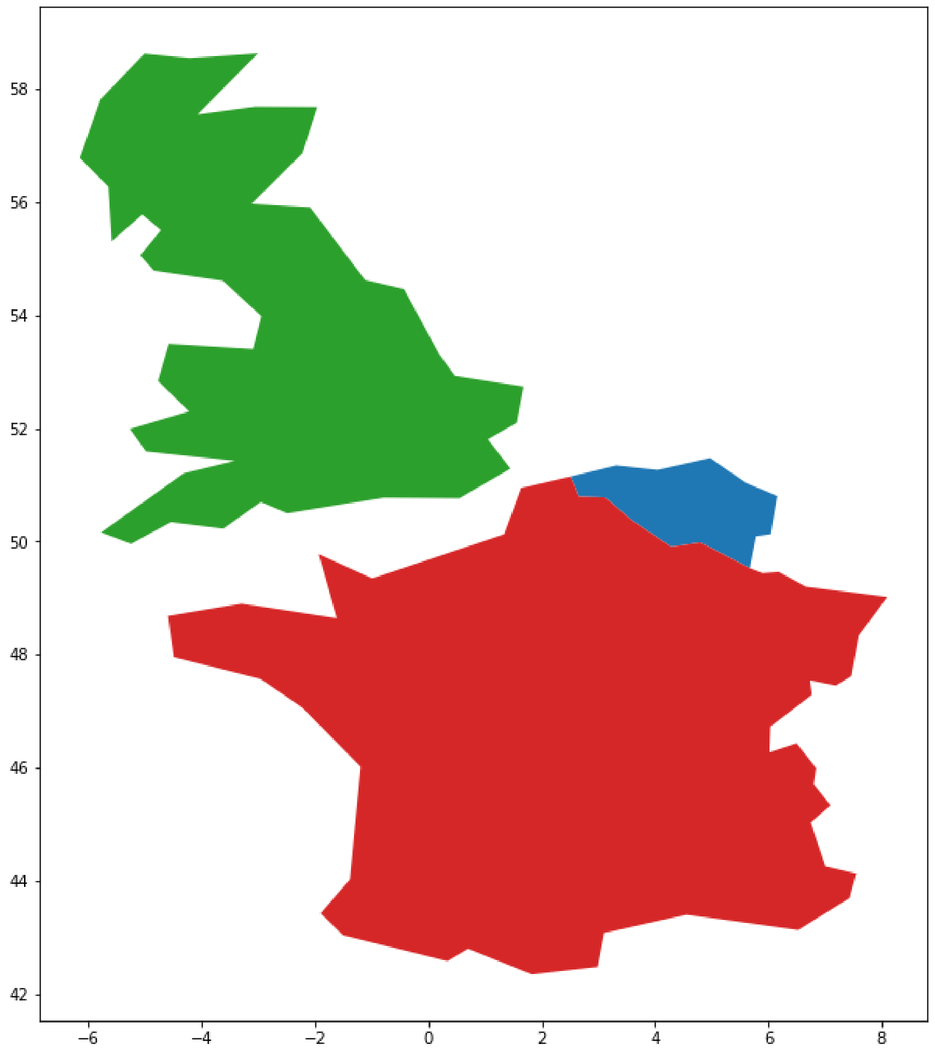
```
countries.intersection(circle)
```

Intersection with a polygon

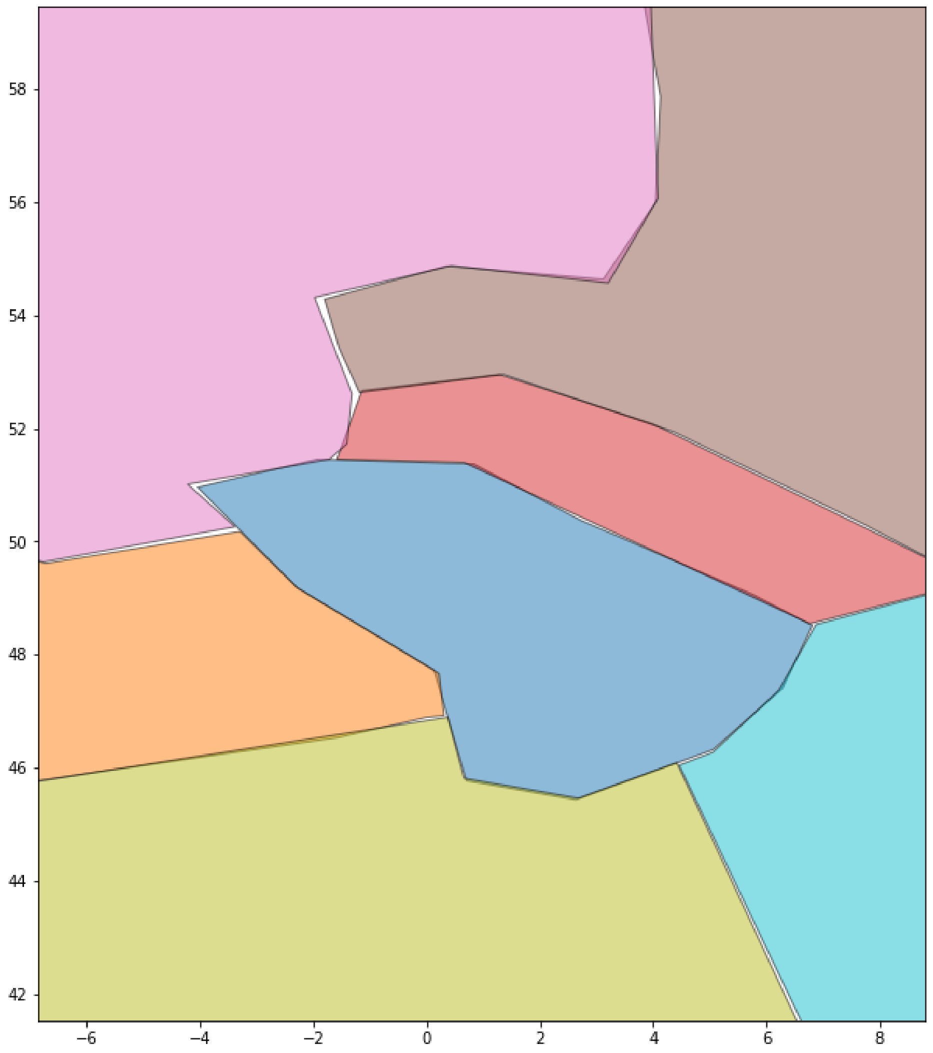
Limitations of `countries.intersection(circle)` :

- Only intersecting a GeoSeries with a single polygon
- Does not preserve attribute information

Overlaying two datasets

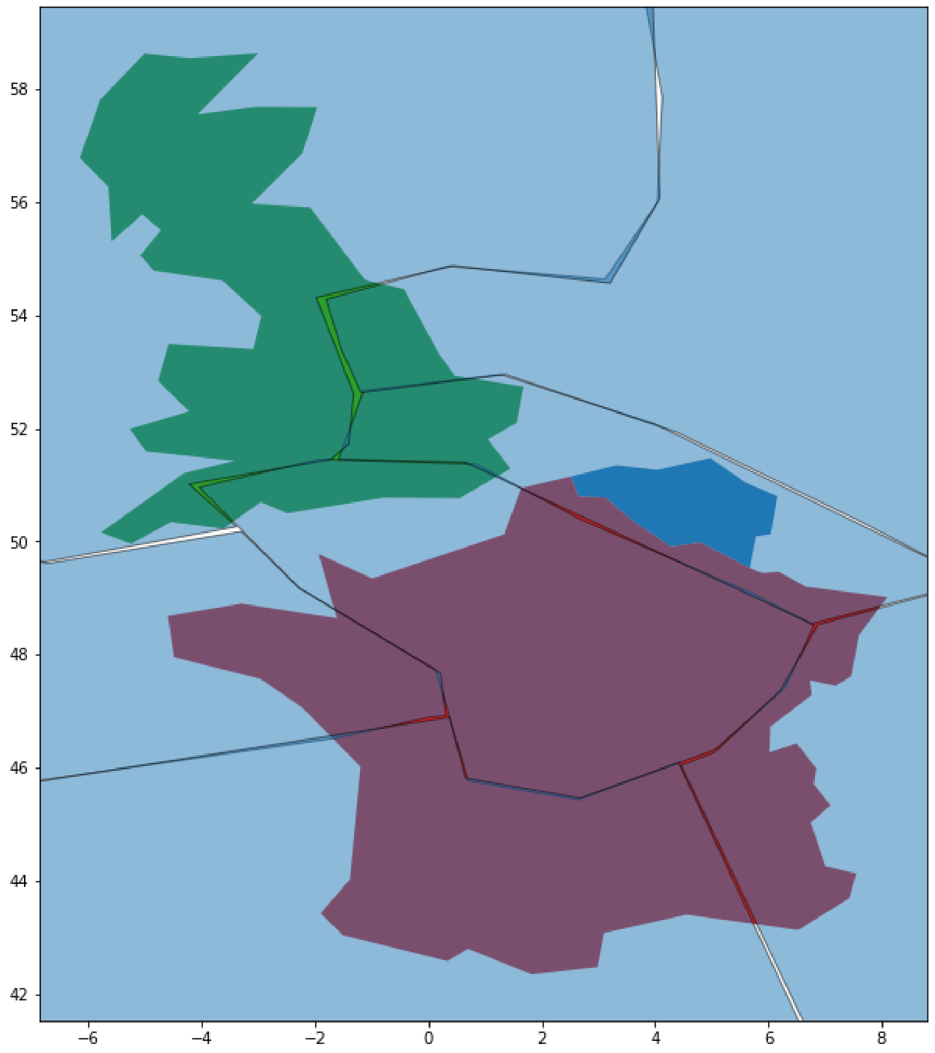


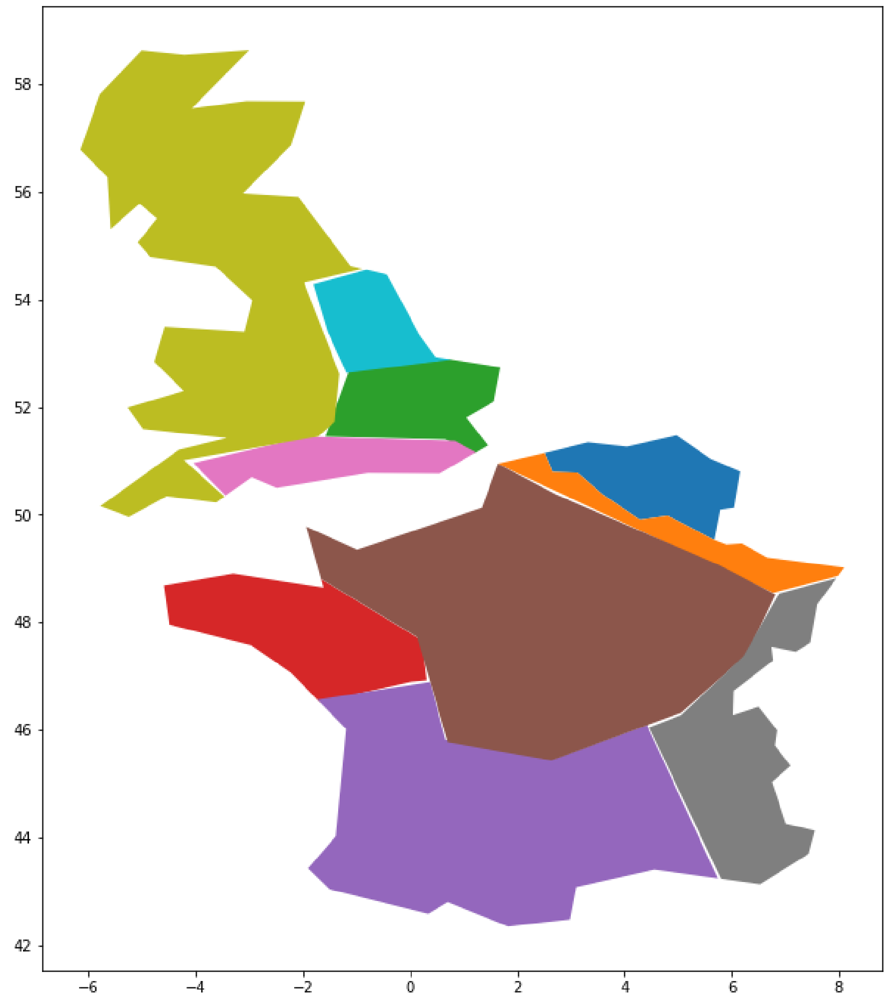
```
countries.plot()
```



```
geologic_regions.plot()
```

Overlaying two datasets





```
geopandas.overlay(countries, geologic_regions,
                  how='intersection')
```

Overlay vs intersection

Intersection method (with single polygon)

```
countries.intersection(geologic_region_A)
```

```
0                            ()
1    POLYGON ((-1.661 48.803...
2    POLYGON ((1.201 51.145,...
dtype: object
```

Overlay method

```
geopandas.overlay(countries, geologic_regions,
                  how='intersection')
```

```
     name geologic_region              geometry
1  France               C  POLYGON ((2.5 51....
2      UK               C  POLYGON ((0.7 52 ...
3  France               B  POLYGON ((-1.7 46...
..    ...             ...                   ...
```

Let's practice!

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