Atelier SAGEO 2021 : Traitements spatiaux avec le plugin Python t4gpd dans le contexte d'un Jupyter Notebook

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Traitements spatiaux avec le plugin Python t4gpd dans le contexte d'un Jupyter Notebook

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Plan de la présentation

Pandas

- Bibliothèque Python de manipulation et analyse de données
- Les principales structures de données Pandas sont :
  - les Series pour les données 1D
  - les DataFrame pour les données 2D (ou plus)
- Ces structures de données sont indexées pour plus d'efficacité, couplées à des utilitaires de lecture/écriture de fichiers csv, tableurs xls(x), fichiers HDF5, bases de données SQL, etc.
- Pandas permet la concaténation et la fusion de gros volumes de données (*), l'analyse de séries temporelles (*), facilite la gestion des données manquantes (*), les tableaux croisés dynamiques (*), etc.
- Ce qui suit s'inspire largement de 10 minutes to pandas

Pandas - à propos de Series

- « *Series is a one-dimensional labeled array capable of holding any data type (integers, strings, floating point numbers, Python objects, etc.). The axis labels are collectively referred to as the index.* »
- Series acts similarly to a numpy.ndarray or a fixed-size dict.

```python
from numpy import mean; from pandas import Series

s1 = Series(data=['a1', 'b2', 'c3', 'a4'])
print(s1[ s1.str.startswith('a') ])

s2 = Series(data=range(0, 40, 10))
print(s2[ s2 > mean(s2)])

print(s2.is_monotonic_increasing)

s3 = Series({c:f'a{i}' for i,c in enumerate(['a','b','c'])})
print(s3)

print(s3.iloc[1], s3.loc['b'])

s4 = Series([1, 2, 3, 4, None, 2])
print(s4.hasnans, s4.is_unique)
```

```
In [1]: %run scripts/5_1_pandas.py
0    a1
3    a4
dtype: object

2    20
3    30
dtype: int64

True

a    a0
b    a1
c    a2
dtype: object

a1 a1

True False

In [2]:
```

Pandas - à propos de DataFrame

- « *DataFrame is a 2-dimensional labeled data structure with columns of potentially different types. You can think of it like a spreadsheet or SQL table, or a dict of Series objects.* »

```python
from pandas import DataFrame

df1 = DataFrame(data=[['DE', 'Allemagne', 'Berlin'],
  ['FR', 'France', 'Paris'], ['IT', 'Italie', 'Rome']],
  columns=['code', 'pays','capitale']
  )
print(df1)

df1.set_index(['code'], drop=True, inplace=True)
print(df1)

df1.reset_index(inplace=True)
print(df1)

df2 = df1[~df1.code.isin(['FR'])]
print(df2)

df2.reset_index(drop=True, inplace=True)
print(df2)
```

```
In [1]: %run scripts/5_2_pandas.py
  code       pays capitale
0   DE  Allemagne   Berlin
1   FR     France    Paris
2   IT     Italie     Rome

           pays capitale
code
DE    Allemagne   Berlin
FR       France    Paris
IT       Italie     Rome

  code       pays capitale
0   DE  Allemagne   Berlin
1   FR     France    Paris
2   IT     Italie     Rome

  code       pays capitale
0   DE  Allemagne   Berlin
2   IT     Italie     Rome

  code       pays capitale
0   DE  Allemagne   Berlin
1   IT     Italie     Rome
```

Pandas - concaténation et fusion (jointure attributaire)

- Consulter notamment pandas.concat (...) et pandas.merge (...)

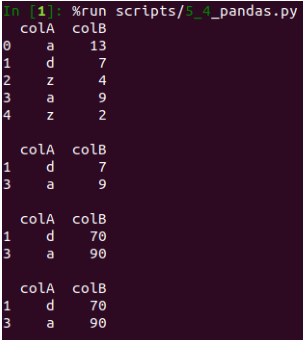
```python
from pandas import concat, DataFrame, merge

df3 = DataFrame(data=[['Allemagne', 'Europe'],
  ['Italie', 'Europe']],
  columns=['pays','continent']
  )
print(df3)

df4 = DataFrame(data=[['Inde', 'Asie']],
  columns=['pays','continent']
  )
print(df4)

df5 = concat([df3, df4])
print(df5)

df5.reset_index(drop=True, inplace=True)
print(df5)

df6 = merge(df5, df1[['pays','capitale']],
  how='left', on='pays')
print(df6)
```

```
        pays continent
0  Allemagne    Europe
1     Italie    Europe

   pays continent
0  Inde      Asie

        pays continent
0  Allemagne    Europe
1     Italie    Europe
0       Inde      Asie

        pays continent
0  Allemagne    Europe
1     Italie    Europe
2       Inde      Asie

        pays continent capitale
0  Allemagne    Europe   Berlin
1     Italie    Europe     Rome
2       Inde      Asie      NaN
```

Pandas - mécanisme de vue

- Attention au mécanisme de vue [1]

```python
from pandas import DataFrame

df1 = DataFrame(data=[['a', 13], ['d', 7], ['z', 4],
  ['a', 9], ['z', 2]], columns=['colA', 'colB'])
print(df1)

df2 = df1[(df1.colB >= 7) & (df1.colB <= 9)]
print(df2) # df2 est une vue de df1

# df2.colB = 10 * df2.colB
# A value is trying to be set on a copy of a slice
# from a DataFrame.
# Try using .loc[row_indexer, col_indexer] = value
# instead

df3 = df1.loc[df1[(df1.colB>=7) & (df1.colB<=9)].index]
df3.colB = 10 * df3.colB
print(df3) # df3 est une copie profonde de df1

df4 = df2.copy(deep=True)
df4.colB = 10 * df4.colB
print(df3) # df4 est une copie profonde de df2
```



1. Une modification de df2 ne sera pas reportée sur df1.

Plan de la présentation

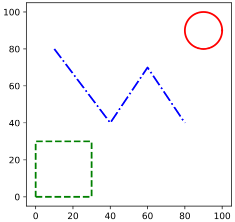
Shapely

- Extrait de https://shapely.readthedocs.io
  - Shapely is a Python package for set-theoretic analysis and manipulation of planar features using (via Python's ctypes module) functions from the well known and widely deployed GEOS library. GEOS, a port of the Java Topology Suite (JTS), is the geometry engine of the PostGIS spatial extension for the PostgreSQL RDBMS. The designs of JTS and GEOS are largely guided by the Open Geospatial Consortium's Simple Features Access Specification 1 (*) and Shapely adheres mainly to the same set of standard classes and operations. Shapely is thereby deeply rooted in the conventions of the geographic information systems (GIS) world, but aspires to be equally useful to programmers working on non-conventional problems.

Shapely

- Déclaration de géométries — représentation discrète du monde

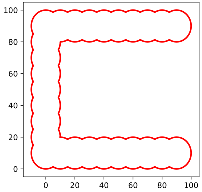
```python
import matplotlib.pyplot as plt
from shapely.geometry import LineString, Point, Polygon

red = Point(90, 90).buffer(10)
blue = LineString([ (10, 80), (40, 40), (60, 70), (80, 40) ])
green = Polygon([ (0, 0), (30, 0), (30, 30), (0, 30) ])

plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.plot(*red.exterior.xy, 'r-', linewidth=2)
plt.plot(*blue.xy, 'b-.', linewidth=2)
plt.plot(*green.exterior.xy, 'g--', linewidth=2)
plt.savefig('../img/6_1_shapely.pdf')
```



Shapely

- Union (efficace) de géométries

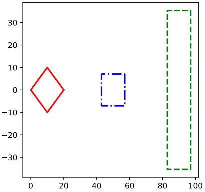
```
import matplotlib.pyplot as plt
from shapely.geometry import MultiPoint
from shapely.ops import unary_union

geoms = list()
for i in range(10, 100, 10):
  geoms.append(MultiPoint([ (0, i), (i, 10), (i, 90) ]).buffer(10))

red = unary_union(geoms)

plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.plot(*red.exterior.xy, 'r-', linewidth=2)
plt.savefig('../img/6_2_shapely.pdf')
```



Shapely

- Transformations affines de géométries

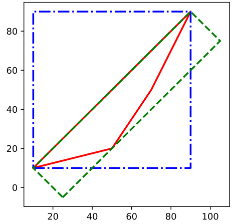
```python
import matplotlib.pyplot as plt
from shapely.affinity import rotate, translate, scale
from shapely.geometry import Point
from shapely.ops import unary_union

red = Point(10, 0).buffer(10, 1)
blue = translate(rotate(red, 45, origin='center'), xoff=40.0, yoff=0.0)
green = scale(translate(blue,xoff=40.0,yoff=0.0),xfact=1,yfact=5,origin='center')

plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.plot(*red.exterior.xy, 'r-', linewidth=2)
plt.plot(*blue.exterior.xy, 'b-.', linewidth=2)
plt.plot(*green.exterior.xy, 'g--', linewidth=2)
plt.savefig('../img/6_3_shapely.pdf')
```



Shapely

- Création de géométries englobantes

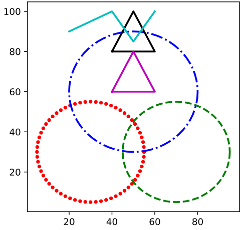
```python
import matplotlib.pyplot as plt
from shapely.geometry import MultiPoint

mpts = MultiPoint( [ (90, 90), (70, 50), (50, 20), (10, 10), (30, 30) ] )
red = mpts.convex_hull
blue = mpts.envelope
green = mpts.minimum_rotated_rectangle

plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.plot(*red.exterior.xy, 'r-', linewidth=2)
plt.plot(*blue.exterior.xy, 'b-.', linewidth=2)
plt.plot(*green.exterior.xy, 'g--', linewidth=2)
plt.savefig('../img/6_4_shapely.pdf')
```



Shapely

- Prédicats topologiques

```
from shapely.geometry import LineString, Point, Polygon

red = Point((30, 30)).buffer(25)
green = Point((70, 30)).buffer(25)
blue = Point((50, 60)).buffer(30)
black = Polygon([(40, 80), (60, 80), (50, 100)])
magenta = Polygon([(40, 60), (60, 60), (50, 80)])
cyan = LineString([(20,90),(40,100),(50,85),(60,100)])

print(magenta.within(blue))  #~ True
print(blue.contains(magenta))  #~ True
print(red.difference(blue).intersects(green))  #~ True
print(magenta.touches(black))  #~ True
print(black.overlaps(blue))  #~ True
print(cyan.crosses(black))  #~ True
print(black.union(magenta).disjoint(green))  #~ True
```



Shapely

- A propos du Dimensionally Extended 9-Intersection Model (DE-9IM)

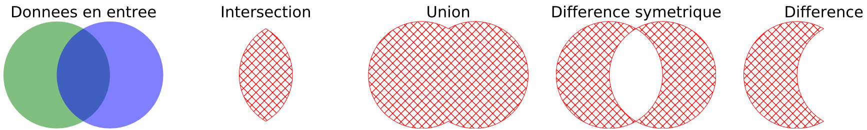
$$DE9IM(a,b) = \begin{bmatrix} dim(I(a) \cap I(b)) & dim(I(a) \cap B(b)) & dim(I(a) \cap E(b)) \\ dim(B(a) \cap I(b)) & dim(B(a) \cap B(b)) & dim(B(a) \cap E(b)) \\ dim(E(a) \cap I(b)) & dim(E(a) \cap B(b)) & dim(E(a) \cap E(b)) \end{bmatrix}$$

  - où `dim` est la dimension de l'intersection ($\cap$) entre l'intérieur (I), la frontière (B) ou le complémentaire (E) des géométries a et b passées en paramètre.
  - cette dimension prend la valeur F si l'intersection est l'ensemble vide ($\varnothing$), 0 si l'intersection est un ensemble de points, 1 si l'intersection est un ensemble de lignes et 2 si l'intersection est un ensemble de polygones.
  - cette matrice peut être sérialisée, ligne après ligne, sous forme d'un *DE-9IM string code*. Ainsi, à partir de l'exemple précédent, l'instruction Shapely : black . relate (magenta) renvoie la chaîne de caractères : FF2F01212.

Shapely

- Opérations géométriques

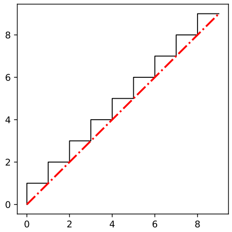
```
green = Point((5,5)).buffer(5)
blue = Point((10, 5)).buffer(5)
_intersection = green.intersection(blue)
_union = green.union(blue)
_symmetric_difference = green.symmetric_difference(blue)
_difference = green.difference(blue)
```



Shapely

- Simplification de géométrie

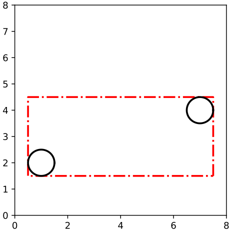
```
import matplotlib.pyplot as plt
from shapely.geometry import LineString

black = LineString([ (i//2, i-i//2) for i in range(19) ])
red = black.simplify(1.0, preserve_topology=True)

plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.plot(*black.xy, 'k-', linewidth=1)
plt.plot(*red.xy, 'r-.', linewidth=2)
plt.savefig('../img/6_7_shapely.pdf')
```



Shapely

- Boîte englobante (aussi appelée *bounding box*)

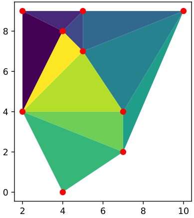
```python
import matplotlib.pyplot as plt
from random import randint
from shapely.geometry import box, MultiPolygon, Point

pts = [Point(1,2).buffer(0.5), Point(7,4).buffer(0.5)]
pts = MultiPolygon(pts)

print(pts.bounds)
#~ (minx, miny, maxx, maxy) = (0.5, 1.5, 7.5, 4.5)
envelop = box(*pts.bounds)

plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.xlim(0, 8)
plt.ylim(0, 8)
plt.plot(*envelop.exterior.xy, 'r-.', linewidth=2)
for pt in pts:
  plt.plot(*pt.exterior.xy, 'k-', linewidth=2)
plt.savefig('../img/6_8_shapely.pdf')
```



Shapely

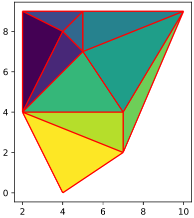
- Triangulation via shapely.ops.triangulate (...)

```python
from shapely.geometry import MultiPoint
from shapely.ops import triangulate

mpts = MultiPoint([(4,0), (7,2), (2,4), (7,4),\
  (5,7), (4,8), (2,9), (5,9), (10,9)])
tin = triangulate(mpts) #~ retourne une liste de "Polygon"
```



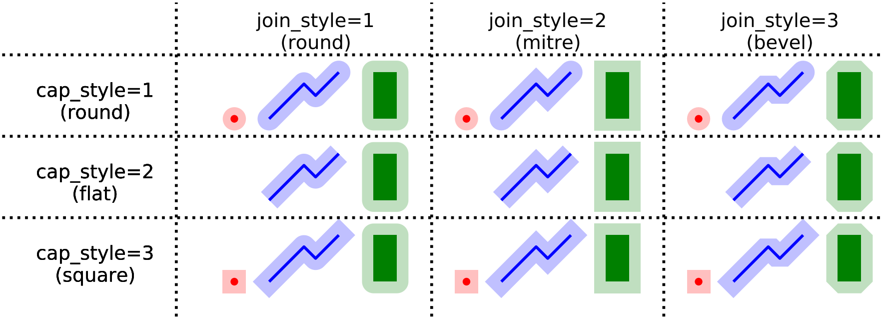
- Polygonisation via shapely.ops.polygonize (...)

```python
from shapely.geometry import MultiLineString
from shapely.ops import polygonize

mls = MultiLineString([[(2,9),(2,4)],[(2,4),(4,8)],\
[(4,8),(2,9)],[(4,8),(5,9)],[(5,9),(2,9)],[(4,8),(5,7)],\
[(5,7),(5,9)],[(5,7),(10,9)],[(10,9),(5,9)],[(5,7),(7,4)],\
[(7,4),(10,9)],[(7,4),(7,2)],[(7,2),(10,9)],[(4,0),(7,2)],\
[(7,2),(2,4)],[(2,4),(4,0)],[(7,4),(2,4)],[(5,7),(2,4)] ])
polygons = polygonize(mls) #~ retourne une liste de "Polygon"
```



Shapely

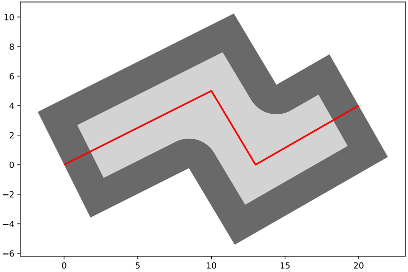
- Dilatation, érosion via buffer(. . .)
  - Point((0, 0)).buffer(distance, resolution=16, cap_style=1, join_style=1, mitre_limit=5.0)



Shapely

- Dilatation, érosion via buffer(. . .)

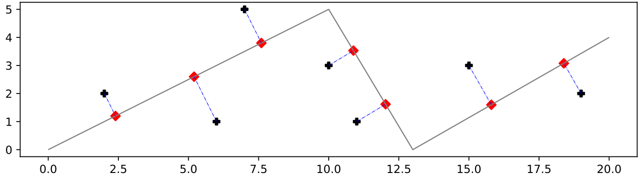
```
from shapely.geometry import LineString
from shapely.geometry import CAP_STYLE, JOIN_STYLE

red = LineString([ (0,0), (10, 5), (13, 0), (20, 4)])
#~ DILATATION
dimgrey = red.buffer(4, cap_style=CAP_STYLE.flat, join_style=JOIN_STYLE.mitre)
#~ EROSION
lightgrey = dimgrey.buffer(−2, join_style=JOIN_STYLE.round)
```



Shapely

- linemerge(. . .), project(. . .) et interpolate(. . .)

```python
from shapely.geometry import LineString, MultiPoint
from shapely.ops import linemerge

black = MultiPoint([(2, 2), (7, 5), (6, 1), (10, 3), (11, 1), (15, 3), (19, 2)])

lines = [LineString([ (0, 0), (10, 5) ]), LineString([ (10, 5), (13, 0) ]),
  LineString([ (13, 0), (20, 4) ])]
grey = linemerge(lines) # LINESTRING (0 0, 10 5, 13 0, 20 4)

red = []
for _point in black.geoms:
  # project(...) retourne une abscisse curviligne
  # interpolate(...) retourne un Point shapely
  red.append( grey.interpolate(grey.project(_point)) )
red = MultiPoint(red)
```



Shapely

- Import-export Well-Known Text (WKT)
  - Export au format WKT :

```
from shapely.geometry import LineString
LineString([ (0,0), (10,0), (10,10) ]).wkt
```

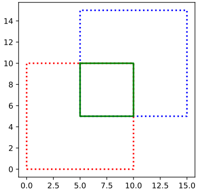
  - Import du format WKT :

```
from shapely import wkt
wkt.loads('LINESTRING (0 0, 10 0, 10 10)')
```

Shapely

- Attention, Shapely est une bibliothèque résolument 2D. La composante en Z des géométries est "décorative".

```
import matplotlib.pyplot as plt
from shapely.affinity import translate
from shapely.geometry import Polygon

red = Polygon([ (0,0,0), (10,0,0), (10,10,0),(0,10,0) ])
blue = translate(red, xoff=5.0, yoff=5.0, zoff=5.0)
green = red.intersection(blue)
print(red.intersects(blue)) #~ True
print(green.wkt)
#~ POLYGON Z ((5 10 2.5, 10 10 0, 10 5 2.5, 5 5 5, 5 10 2.5))

plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.plot(*red.exterior.xy, 'r:', linewidth=2)
plt.plot(*blue.exterior.xy, 'b:', linewidth=2)
plt.plot(*green.exterior.xy, 'g-', linewidth=2)
plt.savefig('../img/6_d_shapely.pdf')
```



Plan de la présentation

GeoPandas

- Extraits de https://geopandas.org
  - GeoPandas is an open source project to make working with geospatial data in python easier. GeoPandas extends the datatypes used by pandas to allow spatial operations on geometric types. Geometric operations are performed by shapely. Geopandas further depends on fiona for file access and descartes and matplotlib for plotting.
  - The goal of GeoPandas is to make working with geospatial data in python easier. It combines the capabilities of pandas and shapely, providing geospatial operations in pandas and a high-level interface to multiple geometries to shapely. GeoPandas enables you to easily do operations in python that would otherwise require a spatial database such as PostGIS.

GeoPandas

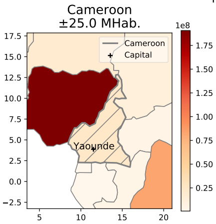
- geopandas.GeoDataFrame est une sous-classe de pandas.DataFrame (de même que geopandas.GeoSeries est une sous-classe de pandas. Series)
- Chaque GeoSeries embarque son propre crs
- Un GeoDataFrame est une combinaison d'une ou plusieurs Series (données attributaires) et d'une ou plusieurs GeoSeries (données spatiales), accompagnée d'un mécanisme d'indexation

	colA	colB	geometry
0	12	34	POINT (12.00000 34.00000)
1	56	89	POINT (56.00000 89.00000)
2	23	45	POINT (23.00000 45.00000)
3	78	90	POINT (78.00000 90.00000)

GeoPandas

- Mise en carte GeoPandas + Matplotlib

```
import geopandas as gpd, matplotlib.pyplot as plt

countries = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))
cities = gpd.read_file(gpd.datasets.get_path('naturalearth_cities'))

africa = countries[ countries.continent == "Africa" ]
cameroon = africa.query('name == "Cameroon"')
yaounde = gpd.sjoin(cities, cameroon)
nHab = cameroon.pop_est.squeeze() / 1e6

_, ax = plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
ax.set_title('Cameroon\n$\pm$%.1f MHab.' % nHab, fontsize=16)

africa.plot(ax=ax, column='pop_est', cmap='OrRd',
  edgecolor='gray', legend=True)
cameroon.boundary.plot(ax=ax, edgecolor='gray', hatch='/',
                       linewidth=2, label='Cameroon')
yaounde.plot(ax=ax, color='black', marker='+', label='Capital')
yaounde.apply(lambda x: ax.annotate(
   s=x.name_left, xy=x.geometry.coords[0],
   color='black', size=12, ha='center'), axis=1);

minx, miny, maxx, maxy = cameroon.buffer(5.0).total_bounds
plt.axis([minx, maxx, miny, maxy])
plt.legend(loc = 'upper right', framealpha=0.5)
plt.savefig('../img/7_1_geopandas.pdf')
```



GeoPandas

- Un GeoDataFrame GeoPandas est un DataFrame pandas (presque) comme les autres. . .

```python
import geopandas as gpd, numpy as np

countries = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))

continents = countries.groupby(by='continent').\
  pop_est.aggregate([np.size, np.sum]).\
  rename(columns={'size': 'NPays', 'sum': 'NHab'}).\
  sort_values('NHab', ascending=False)

print(continents)
```

```
Fichier  Édition  Affichage  Rechercher  Terminal  Aide
In [1]: %run 7_2_geopandas.py
                         NPays        NHab
continent
Asia                        47  4389144868
Africa                      51  1219176238
Europe                      39   746398461
North America               18   573042112
South America               13   418540749
Oceania                      7    36782844
Antarctica                   1        4050
Seven seas (open ocean)      1         140

In [2]: 
```

- avec un champ geometry qui embarque l'information spatiale
- avec une méthode plot et d'autres méthodes spécifiques

GeoPandas

- *Table-Oriented Programming* : manipulation de données (cf. Comparison with SQL)
  - `type(countries.pop_est) #~ pandas.core.series.Series`
  - `type(countries.geometry) #~ geopandas.geoseries.GeoSeries`
  - SELECT continent, pop_est FROM countries WHERE countries LIKE 'Cameroon'
  - `countries[countries.name == 'Cameroon'][['name', 'pop_est']]`
  - SELECT continent, pop_est FROM countries WHERE countries LIKE 'Cameroon' OR countries LIKE 'France'
  - `countries[countries.name.isin(['Cameroon', 'France'])][['name', 'pop_est']]`
  - ```
    countries[~countries.continent.isin(['Africa', 'Asia', 'Europe', \
    'North America', 'South America'])][['name', 'continent']]
    ```
  - `sum(countries.pop_est)`
    ```

GeoPandas

- *Table-Oriented Programming* : manipulation de données
  - ```
    cities [ cities .geometry.y == max(cities.geometry.y) ]
    ```
  - ```
    cities [ abs( cities .geometry.y) == min(abs(cities.geometry.y)) ]
    ```
  - ```
    cities [ cities .name == 'Paris' ]. geometry.y.squeeze()
    ```
  - ```
    countries [( countries . continent == 'Europe') & (countries.bounds.maxx < 5)].name
    ```
  - ```
    north = cities [ cities .geometry.y >= 0]
    south = cities [ cities .geometry.y < 0]
    lesCapitales = south.append(north)
    ```
  - ```
    countries . continent . unique()
    ```

GeoPandas

- *Table-Oriented Programming* : manipulation de données
  - Jointure attributaire : pandas.merge (...)

```python
import geopandas as gpd, pandas as pd
from numpy import round

countries = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))

continents = countries.groupby(by='continent').sum().\
  rename(columns={'pop_est': 'NHab'})

result = pd.merge(countries, continents, how='left',\
  left_on='continent', right_index=True, validate='m:1')
result['ratio'] = round(100 * result.pop_est / result.NHab, 1)
result.sort_values('ratio', ascending=False, inplace=True)

print(result[['continent', 'name', 'ratio']].head(7))
```

```
Fichier  Édition  Affichage  Rechercher  Terminal  Aide
In [1]: %run 7_3_geopandas.py
                  continent                        name  ratio
23    Seven seas (open ocean)   Fr. S. Antarctic Lands  100.0
159                Antarctica                Antarctica  100.0
137                   Oceania                 Australia   63.2
4               North America  United States of America   57.0
29              South America                    Brazil   49.5
139                      Asia                     China   31.4
98                       Asia                     India   29.2

In [2]:
```

GeoPandas

- *Table-Oriented Programming* : manipulation de données
  - Jointure spatiale : geopandas.sjoin (...)

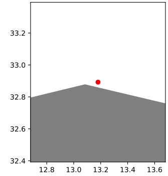
```python
import geopandas as gpd

countries = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))
cities = gpd.read_file(gpd.datasets.get_path('naturalearth_cities'))

#~ op: binary predicate, one of {'intersects', 'contains', 'within'}
result = gpd.sjoin(cities, countries, how='left', op='intersects',
  lsuffix='city', rsuffix='country')
result.sort_values('pop_est', ascending=True, inplace=True)
result.rename(columns={'pop_est': 'NHab_country'}, inplace=True)

print(result[['name_city','continent','name_country','NHab_country']].head(7))
```

```
Fichier  Édition  Affichage  Rechercher  Terminal  Aide
In [1]: %run 7_4_geopandas.py
202 202
               name_city      continent name_country  NHab_country
132              Nicosia           Asia    N. Cyprus      265100.0
46             Reykjavík         Europe      Iceland      339747.0
105             Belmopan  North America       Belize      360346.0
103  Bandar Seri Begawan           Asia       Brunei      443593.0
49            Paramaribo  South America     Suriname      591919.0
3             Luxembourg         Europe   Luxembourg      594130.0
19             Podgorica         Europe   Montenegro      642550.0

In [2]: 
```

GeoPandas

- *Table-Oriented Programming* : manipulation de données
  - Jointure spatiale : geopandas.sjoin (...)

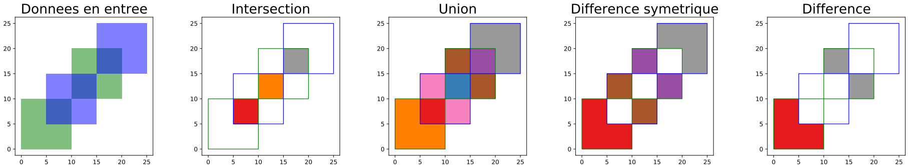
```python
import geopandas as gpd, matplotlib.pyplot as plt

countries = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))
cities = gpd.read_file(gpd.datasets.get_path('naturalearth_cities'))

result = gpd.sjoin(cities, countries, how='left', op='intersects',
  lsuffix='city', rsuffix='country')
print('Nombre de capitales sans pays de rattachement : %d' %
  len(result[result.name_country.isnull()]))
#~ Nombre de capitales sans pays de rattachement : 30

countries = countries[countries.name == 'Libya']
cities = cities[cities.name == 'Tripoli']

_, ax = plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
ax = countries.plot(ax=ax, color='grey')
cities.plot(ax=ax, color='red', marker='o')
minx, miny, maxx, maxy = cities.buffer(0.5).total_bounds
plt.axis([minx, maxx, miny, maxy])
plt.savefig('../img/7_5_geopandas.pdf')
```



GeoPandas

- *Table-Oriented Programming* : manipulation de données
  - Overlay : geopandas.overlay (...)

```
green1 = Polygon([ (0,0), (10,0), (10,10), (0,10) ])
green2 = Polygon([ (10,10), (20,10), (20,20), (10,20) ])
blue1 = Polygon([ (5,5), (15,5), (15,15), (5,15) ])
blue2 = Polygon([ (15,15), (25,15), (25,25), (15,25), (15,15) ])
green = gpd.GeoDataFrame( [{'geometry': green1}, {'geometry': green2}] )
blue = gpd.GeoDataFrame( [{'geometry': blue1}, {'geometry': blue2}] )

_intersection = gpd.overlay(green, blue, how='intersection')
_union = gpd.overlay(green, blue, how='union')
_symmetric_difference = gpd.overlay(green, blue, how='symmetric_difference')
_difference = gpd.overlay(green, blue, how='difference')
```



GeoPandas

- *Table-Oriented Programming* : manipulation de données
  - Overlay : geopandas.overlay (...)

```python
from geopandas import GeoDataFrame, overlay
from shapely.geometry import Polygon

green1 = Polygon([ (0,0), (10,0), (10,10), (0,10) ])
green2 = Polygon([ (10,10), (20,10), (20,20), (10,20) ])
blue1 = Polygon([ (5,5), (15,5), (15,15), (5,15) ])
blue2 = Polygon([ (15,15), (25,15), (25,25), (15,25), (15,15) ])
green = GeoDataFrame( [{'geometry': green1, 'id': 'g1'},
  {'geometry': green2, 'id': 'g2'}] )
blue = GeoDataFrame( [{'geometry': blue1, 'id': 'b1'},
  {'geometry': blue2, 'id': 'b2'}] )

print( overlay(green, blue, how='intersection') )
```

```
Fichier  Édition  Affichage  Rechercher  Terminal  Aide
In [1]: %run 7_7_geopandas.py
  id_1 id_2                                          geometry
0   g1   b1  POLYGON ((5.00000 10.00000, 10.00000 10.00000,...
1   g2   b1  POLYGON ((10.00000 10.00000, 10.00000 15.00000...
2   g2   b2  POLYGON ((15.00000 20.00000, 20.00000 20.00000...

In [2]: 
```

GeoPandas

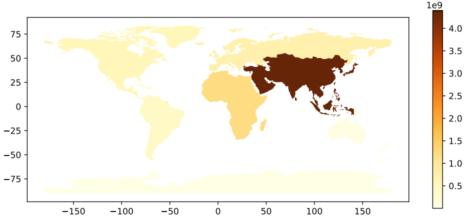
- Manipulation de données : geopandas.clip (...)

```python
import geopandas as gpd, matplotlib.pyplot as plt
from shapely.geometry import box
from os import path
if path.exists('c:/Users/tleduc'):
    HOMEDIR = 'c:/Users/tleduc'
elif path.exists('/home/tleduc'):
    HOMEDIR = '/home/tleduc'
bdtopo = HOMEDIR + '/data/bdtopo/\
BDTOPO_3-0_TOUSTHEMES_SHP_LAMB93_D044_2020-06-15/BDTOPO\
/1_DONNEES_LIVRAISON_2020-06-00047\
/BDT_3-0_SHP_LAMB93_D044-ED2020-06-15/BATI'

roi = 355019.3, 6689077.3, 355311.4, 6689528.0
red = gpd.read_file(bdtopo + '/BATIMENT.shp', bbox=roi)

roi = box(*roi)
grey = gpd.clip(red, roi)

_, basemap = plt.subplots(figsize=(0.5*8.26, 0.5*8.26))
plt.axis('off')
red.plot(ax=basemap, color='red')
grey.plot(ax=basemap, color='grey')
plt.savefig('../img/7_8_geopandas.pdf', bbox_inches='tight')
```

GeoPandas

- Manipulation de données : aggrégation de géométries via dissolve (...)

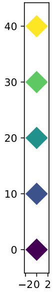
```
import geopandas as gpd, matplotlib.pyplot as plt
from shapely.ops import unary_union

countries = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))

continents = countries[['continent', 'pop_est', 'geometry']].\
  dissolve(by='continent', aggfunc='sum')

_, basemap = plt.subplots(figsize=(1.2*8.26, 0.5*8.26))
#~ continents.reset_index(inplace=True)
#~ continents.plot(ax=basemap, column='continent', cmap='tab10')
continents.plot(ax=basemap, column='pop_est', cmap='YlOrBr', legend=True)
plt.savefig('../img/7_9_geopandas.pdf', bbox_inches='tight')
```



- l'argument cmap de la méthode plot permet de spécifier la palette de couleurs choisie.

GeoPandas

- *Table-Oriented Programming* : modification de données
  - ```
    countries.drop(columns=['iso_a3', 'gdp_md_est'], inplace=True)
    cities.drop(cities[(abs(cities.geometry.x) > 5)].index, inplace=True)
    ```
  - ```
    countries.rename(columns={'pop_est': 'NHab.', 'name': 'NomPays'}, inplace=True)
    ```
  - ```
    from shapely.geometry import Point
    cities.append({'name': 'Nantes', 'geometry': Point((47.2173, -1.5534))}, ignore_index = True)
    ```
  - ```
    cities['hemisphere'] = cities.geometry.apply(lambda geom: 'Nord' if (geom.y > 0) else 'Sud')
    ```
  - ```
    result.NHab_country.dtypes #~ de type float64
    result.NHab_country.astype(int) #~ Cannot convert non-finite values (NA or inf) to integer
    result.NHab_country.fillna(-9999, inplace=True) #~ remplacement des valeurs NaN par -9999
    result.NHab_country = result.NHab_country.astype(int)
    ```
    ```

GeoPandas

- Création de GeoDataFrame, ajout d'un champ et modification de la référence au champ geométrique

```
import geopandas as gpd, matplotlib.pyplot as plt
from shapely.geometry import Point

gdf = gpd.GeoDataFrame([ {'geometry': Point((0, i)), 'gid': i}
  for i in range(0,50,10)], crs='epsg:2154')
gdf['disc'] = gdf.buffer(2, resolution=1)
gdf.set_geometry('disc', inplace=True)
gdf.plot(column='gid')
plt.savefig('../img/7_a_geopandas.pdf', bbox_inches='tight')
```



- Modification du système de coordonnées
  - ```
    import geopandas as gpd
    cities = gpd.read_file(gpd.datasets.get_path('naturalearth_cities'))
    cities = cities[cities.name == 'Paris']
    cities.crs #~ EPSG:4326 - WGS 84
    cities = cities.to_crs('epsg:2154')
    cities.crs #~ EPSG:2154 - RGF93 / Lambert-93
    ```
    ```

GeoPandas

- Entrées-sorties (*)
  - Chargement de SHP (l'usage d'un filtre – cf. arguments **bbox** ou **mask** – peut substantiellement accélérer le chargement)
    - ```python
      import geopandas as gpd
      myGrid = gpd.read_file('data/ville_numerique/insee/\
          Filosofi2015_carreaux_200m_metropole/Filosofi2015_carreaux_200m_metropole.shp')
      ```
  - Ecriture de SHP (mais aussi GeoJSON, GPKG)
    - ```python
      myGrid.to_file('data/grid200.shp', driver='ESRI Shapefile')
      ```
  - Ecriture de CSV (avec encodage WKT des géométries)
    - ```python
      myGrid.to_csv('data/grid200.csv')
      ```
      ```

GeoPandas

- GeoPandas en quelques liens
  - https://geopandas.org/
  - https://geopandas.readthedocs.io/en/latest/
  - https://automating-gis-processes.github.io/

Plan de la présentation

t4gpd

- Cinq registres de forme (Lévy, 2005) :
  1. l'approche de la forme urbaine comme **forme du paysage urbain** - l'espace saisi visuellement dans sa tridimensionnalité et dans sa matérialité plastique,
  2. l'approche de la forme urbaine comme **forme sociale** - l'espace étudié dans son occupation par les divers groupes sociaux ou la distribution des activités et fonctions dans la ville,
  3. l'approche de la forme urbaine comme **forme bioclimatique** - l'espace étudié dans sa dimension environnementale, microclimatique (héliothermique, écologique, etc.),
  4. l'approche de la forme urbaine comme **forme des tissus** - étude des interrelations parcellaire/viaire/libre/bâti, formes de mobilité/formes de ville,
  5. l'approche de la forme urbaine comme **forme des tracés** - forme du plan (organique/planifié, orthogonal/radioconcentrique).

t4gpd

- L'outil t4gpd permet d'analyser les formes d'espace construit dans différents registres, de **l'analyse bioclimatique** (orientation héliothermique, vue du ciel, etc.), à **l'analyse de tracés** (orientations, distances sur un graphe, etc.), en passant par des **analyses à connotations paysagères** (visibilités, études d'alignements d'arbres, etc.) ou des **analyses de composantes des tissus urbains** (identification de rues canyons, typologie d'intersections, etc.).
- Développé au sein de AAU-CRENAU, il bénéficie autant d'un ensemble de travaux conduits depuis plusieurs décennies à l'école nationale supérieure d'architecture de Nantes, que des développements récents autour de bibliothèques telles que GeoPandas ou Shapely.

t4gpd

- *t4gpd* s'inscrit dans une « filiation ». Il hérite d'un ensemble de connaissances développées dans :
  - le plugin SketchUp *t4su*
  - les scripts *t4qg* utilisables en console Python de QGIS 2 et 3
  - mais aussi Solene, GearScape, OrbisGIS, etc.
- C'est un plugin Python 3 qui se télécharge sur SourceSup et se déploie, dans le contexte d'un environnement Miniconda3 (notamment), via un : `pip install t4gpd-0.2.0.tar.gz`
- Pour plus de détails concernant son installation, rendez-vous sur `https://github.com/crenau/t4gpd`.

t4gpd

- https://github.com/crenau/t4gpd
- https://t4gpd-docs.readthedocs.io