50/100

exercise_2_problems

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1 Exercise Set 2

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Due: **10:00 25 April 2022**

Discussion: **13:00 29 April 2022**

Online submission at via ILIAS in the directory Exercises / Übungen -> Submission of Exercises / Rückgabe des Übungsblätter

2 1. Global CO_2 emissions [100 points]

Open the data in `co2-data.csv` to answer the following questions. It contains historical CO_2 emissions of each country per capita.

[1]:
```
import pandas as pds
import numpy as np

file_name = './co2-data.csv'
df = pds.read_csv(file_name)
df.head(5)
```

[1]:
```
   Unnamed: 0 iso_code      country continent  year    co2  co2_growth_prct  \
0           0      AFG  Afghanistan      Asia  1949  0.015              NaN
1           1      AFG  Afghanistan      Asia  1950  0.084          475.000
2           2      AFG  Afghanistan      Asia  1951  0.092            8.696
3           3      AFG  Afghanistan      Asia  1952  0.092              NaN
4           4      AFG  Afghanistan      Asia  1953  0.106           16.000

   co2_growth_abs  consumption_co2  trade_co2  …  ghg_per_capita  methane  \
0             NaN              NaN        NaN  …             NaN      NaN
1           0.070              NaN        NaN  …             NaN      NaN
2           0.007              NaN        NaN  …             NaN      NaN
3             NaN              NaN        NaN  …             NaN      NaN
4           0.015              NaN        NaN  …             NaN      NaN

   methane_per_capita  nitrous_oxide  nitrous_oxide_per_capita  \
0                 NaN            NaN                       NaN
```

```
1                    NaN             NaN                          NaN
2                    NaN             NaN                          NaN
3                    NaN             NaN                          NaN
4                    NaN             NaN                          NaN

   primary_energy_consumption  energy_per_capita  energy_per_gdp  population  \
0                         NaN                NaN             NaN   7663783.0
1                         NaN                NaN             NaN   7752000.0
2                         NaN                NaN             NaN   7840000.0
3                         NaN                NaN             NaN   7936000.0
4                         NaN                NaN             NaN   8040000.0

            gdp
0           NaN
1  1.949480e+10
2  2.006385e+10
3  2.074235e+10
4  2.201546e+10

[5 rows x 57 columns]
```

a. Compute the mean CO_2 per capita emission in 2017. What is the standard deviation and median? **20 points**

[2]:
```python
co2_per_capita_2017 = df.loc[df['year'] == 2017]
co2_per_capita_2017.head(5)
```

[2]:
```
     Unnamed: 0 iso_code      country continent  year      co2  \
68           68      AFG  Afghanistan      Asia  2017    6.860
155         291      ALB      Albania    Europe  2017    5.404
259         395      DZA      Algeria    Africa  2017  153.448
289         425      AND      Andorra    Europe  2017    0.465
359         495      AGO       Angola    Africa  2017   37.471

     co2_growth_prct  co2_growth_abs  consumption_co2  trade_co2  …  \
68             1.708           0.115              NaN        NaN  …
155           20.212           0.909            6.186      0.782  …
259            3.097           4.609              NaN        NaN  …
289           -0.781          -0.004              NaN        NaN  …
359            9.850           3.360              NaN        NaN  …

     ghg_per_capita  methane  methane_per_capita  nitrous_oxide  \
68              NaN      NaN                 NaN            NaN
155             NaN      NaN                 NaN            NaN
259             NaN      NaN                 NaN            NaN
289             NaN      NaN                 NaN            NaN
359             NaN      NaN                 NaN            NaN
```

```
     nitrous_oxide_per_capita  primary_energy_consumption  energy_per_capita  \
68                        NaN                         NaN                NaN
155                       NaN                         NaN                NaN
259                       NaN                         NaN                NaN
289                       NaN                         NaN                NaN
359                       NaN                         NaN                NaN

     energy_per_gdp  population  gdp
68              NaN  36296000.0  NaN
155             NaN   2884000.0  NaN
259             NaN  41389000.0  NaN
289             NaN     77000.0  NaN
359             NaN  29817000.0  NaN

[5 rows x 57 columns]
```

[3]:
```
co2_per_capita_2017['co2_per_capita'].mean() # mean
```

[3]: 4.87293203883495

[4]:
```
co2_per_capita_2017['co2_per_capita'].std() # unbiased standard deviation
```

[4]: 5.745929455073027

[5]:
```
co2_per_capita_2017['co2_per_capita'].std(ddof=0) #biased standard deviation
```

[5]: 5.731966057870995

Unit?

10/20

[6]:
```
co2_per_capita_2017['co2_per_capita'].median() # median
```

[6]: 2.9515000000000002

Clearly write out your results;) do not accept code/comments

b. This compares the data of countries in numerous stages of development. Try separating the data by continent, then calculate the mean, standard deviation, and median in 2017. Show this data in a convenient plot (maybe in a *box plot*). What are the limitations to this data reduction? **30 points**

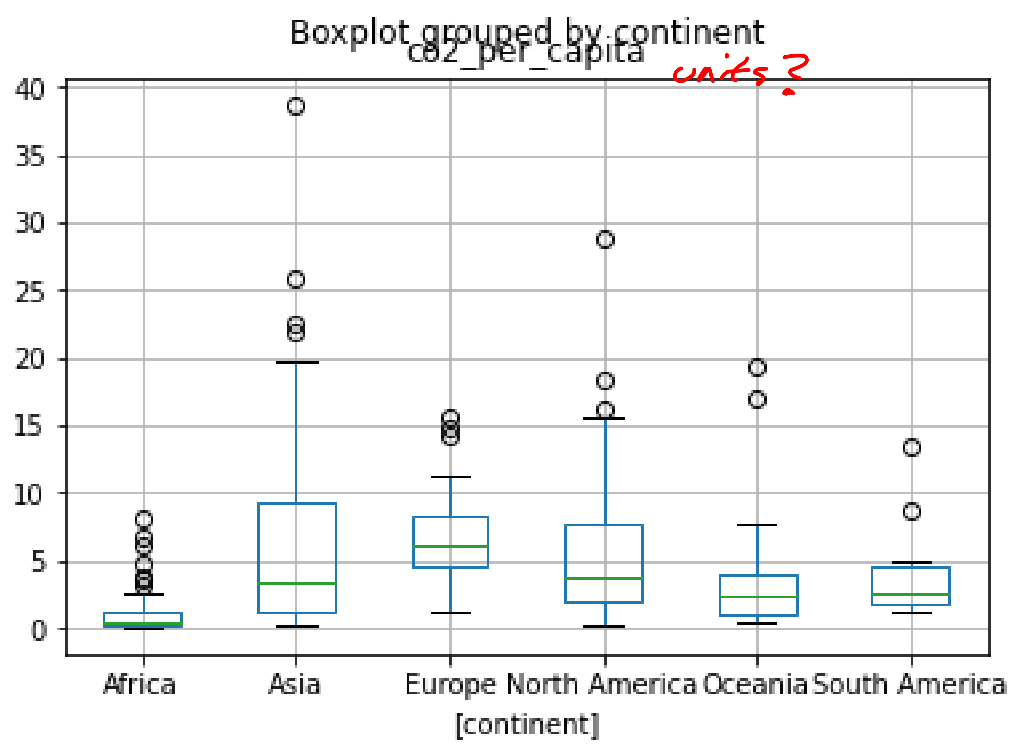
[7]:
```
co2_per_capita_2017_continent=␣
 ↪co2_per_capita_2017[['continent','co2_per_capita']]
print(co2_per_capita_2017_continent)
co2_per_capita_2017_continent.boxplot(by='continent')
```

```
    continent  co2_per_capita
68       Asia           0.189
155    Europe           1.874
259    Africa           3.707
289    Europe           6.043
```

```
359      Africa           1.257
…          …            …
20381      Asia           1.930
20400   Oceania             NaN
20470      Asia           0.363
20540    Africa           0.387
20657    Africa           0.720

[209 rows x 2 columns]
```

[7]:
```
<AxesSubplot:title={'center':'co2_per_capita'}, xlabel='[continent]'>
```



[8]:
```
# In the columns indexs, 'mean' is mean, 'std' is standard deviation, '50%' is
↪median
co2_per_capita_continent_groupby = co2_per_capita_2017_continent.
↪groupby('continent')#separating the data by continent
co2_per_capita_continent_groupby.describe()#calculate the mean, standard
↪deviation, and median in 2017
```

[8]:
```
              co2_per_capita                                              \
                       count      mean       std    min      25%     50%
continent
Africa                  53.0  1.201226  1.802184  0.027  0.16000  0.3960
```

Asia	49.0	6.845694	8.142382	0.189	1.27900	3.4190
Europe	43.0	6.774860	3.169785	1.303	4.63800	6.0580
North America	31.0	6.050452	6.440145	0.298	2.07950	3.6960
Oceania	16.0	4.340000	5.702985	0.449	0.94325	2.4250
South America	14.0	4.028357	3.335294	1.167	1.89275	2.6645

units ??

20/30

	75%	max
continent		
Africa	1.25700	8.176
Asia	9.31500	38.741
Europe	8.20600	15.626
North America	7.69950	28.878
Oceania	3.98350	19.295
South America	4.51675	13.337

Clearly write your result.
do not use the output of describe()

c. To fully assess the contribution of each country to global emissions, we should look at the cumulative emission. What are the mean, standard deviation, and median of the dataset? Show this information for both the world and separated by continent. **20 points**

[9]:
```
df[['continent','cumulative_co2']].groupby('continent').describe() #statistics
↪information of cumulative emission separated by continent
```

[9]:

	cumulative_co2					\
	count	mean	std	min	25%	
continent						
Africa	3824.0	300.341422	1440.587225	0.004	2.62025	
Asia	5128.0	2073.347942	10410.663560	0.000	8.30250	
Europe	6590.0	3910.472644	11877.614654	0.000	19.21900	
North America	2519.0	8141.898006	41762.270858	0.004	1.70400	
Oceania	1136.0	551.261707	2181.376940	0.004	0.61500	
South America	1402.0	791.776566	1845.309646	0.004	15.97375	

	50%	75%	max
continent			
Africa	16.6165	80.53125	20722.289
Asia	118.8095	773.44525	219985.862
Europe	270.4970	1847.35825	113884.448
North America	16.3710	183.82200	410238.263
Oceania	3.7685	61.02475	18181.941
South America	82.6695	540.03075	15125.104

It is still a function of time...

[10]:
```
df[['continent','cumulative_co2']].describe() # statistics information of
↪cumulative emission about the world
```

[10]:

	cumulative_co2
count	20599.000000
mean	2902.878474
std	17085.345894
min	0.000000
25%	4.791500
50%	60.419000
75%	644.539000
max	410238.263000

units?

10/20

A plot is useful to compare these..

d. We can also look at this history of CO_2 emissions by each country. Calculate the mean and standard deviation of the annual emission for the U.S., U.K., Germany, and China. Is this metric useful? In which year was the peak emission from these countries? Are they starting to gain control of their emissions? **30 points**

[11]:
```
# get the co2 emission only from the four countries
co2_country_years = df[['country','co2','year']].loc[df['country'].
 ↪isin(['United States','United Kingdom','Germany','China'])]
co2_country_years
```

[11]:

	country	co2	year
3971	China	0.095	1899
3972	China	0.095	1902
3973	China	1.964	1903
3974	China	2.088	1904
3975	China	2.297	1905
…	…	…	…
19806	United States	5412.432	2015
19807	United States	5292.268	2016
19808	United States	5253.606	2017
19809	United States	5424.882	2018
19810	United States	5284.697	2019

[837 rows x 3 columns]

[12]:
```
co2_country_years[['country','co2']].groupby('country').describe()#Calculate␣
 ↪the mean and standard deviation of the annual emission for the U.S., U.K.,␣
 ↪Germany, and China.
```

[12]:

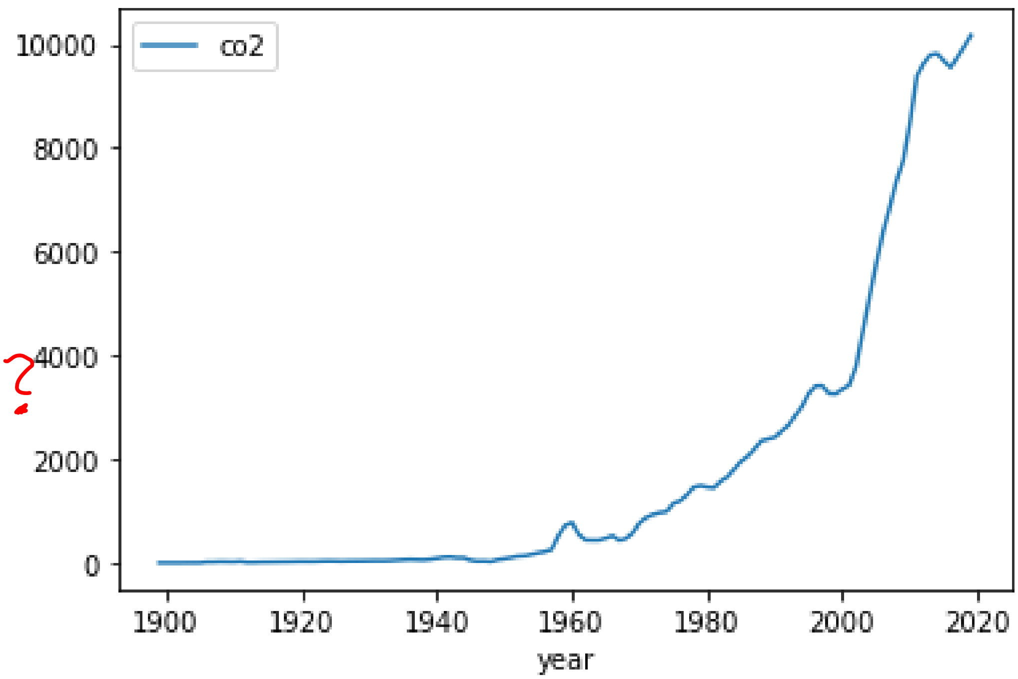
	co2						\
	count	mean	std	min	25%	50%	
country							
China	119.0	1848.620706	2890.360371	0.095	34.60100	435.7040	
Germany	228.0	403.418079	382.868824	0.443	13.78500	329.3440	
United Kingdom	270.0	288.280374	225.313168	9.351	41.94775	315.1280	
United States	220.0	1864.719400	2065.292513	0.253	36.91050	1231.4285	

```
                        75%          max
country
China             2403.83700   10174.681
Germany            787.54025    1117.882
United Kingdom     482.72500     660.388
United States     3286.61450    6131.893
```

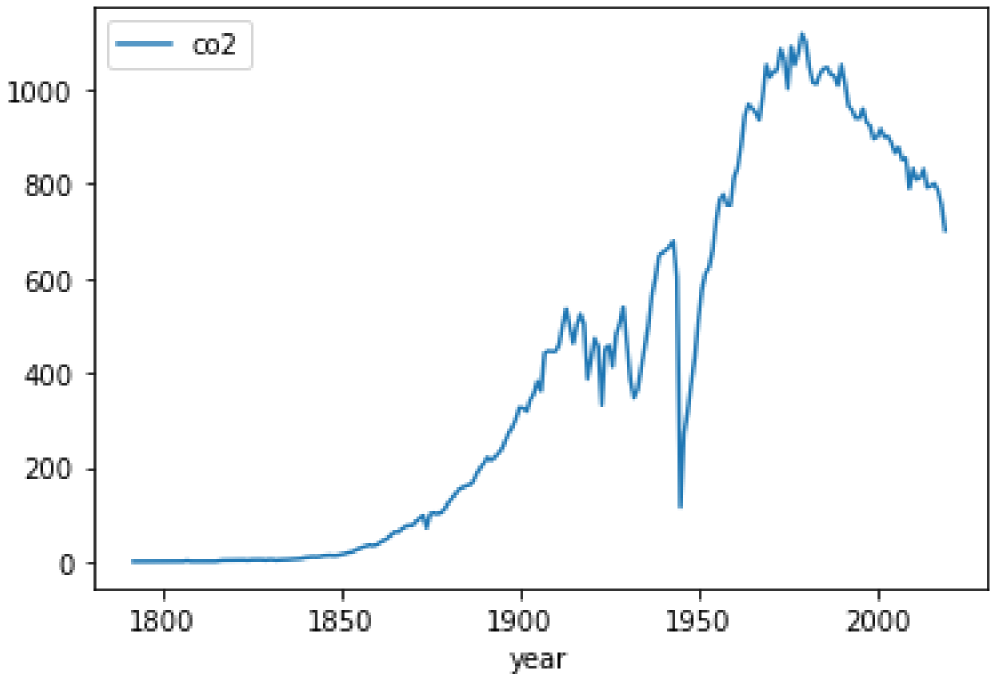
[13]:
```python
co2_country_years.groupby('country').plot(x='year',y='co2')
```

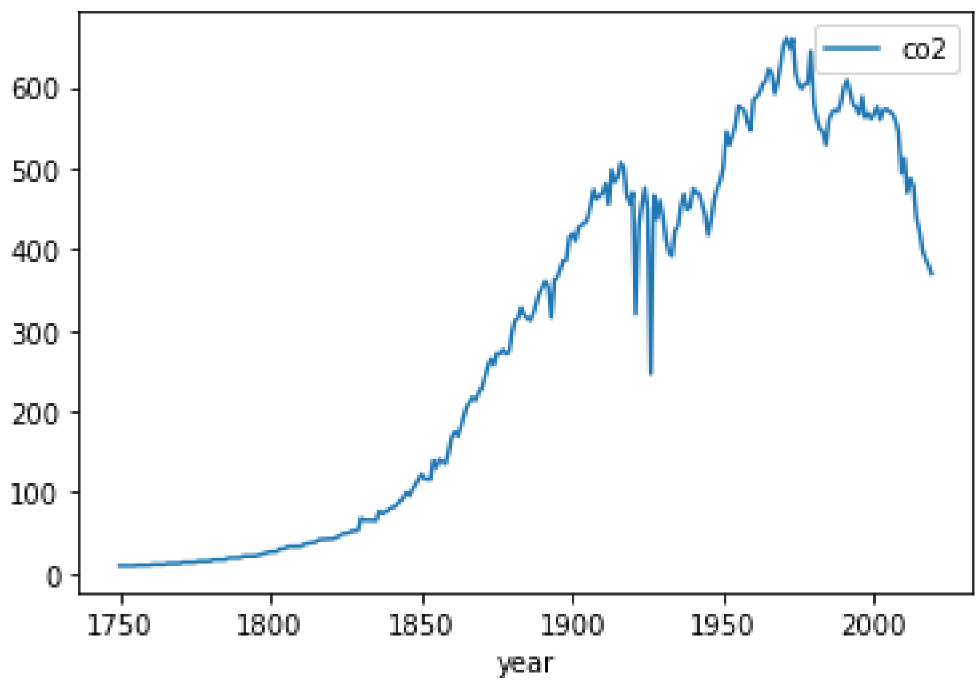
[13]:
```
country
China               AxesSubplot(0.125,0.125;0.775x0.755)
Germany             AxesSubplot(0.125,0.125;0.775x0.755)
United Kingdom      AxesSubplot(0.125,0.125;0.775x0.755)
United States       AxesSubplot(0.125,0.125;0.775x0.755)
dtype: object
```

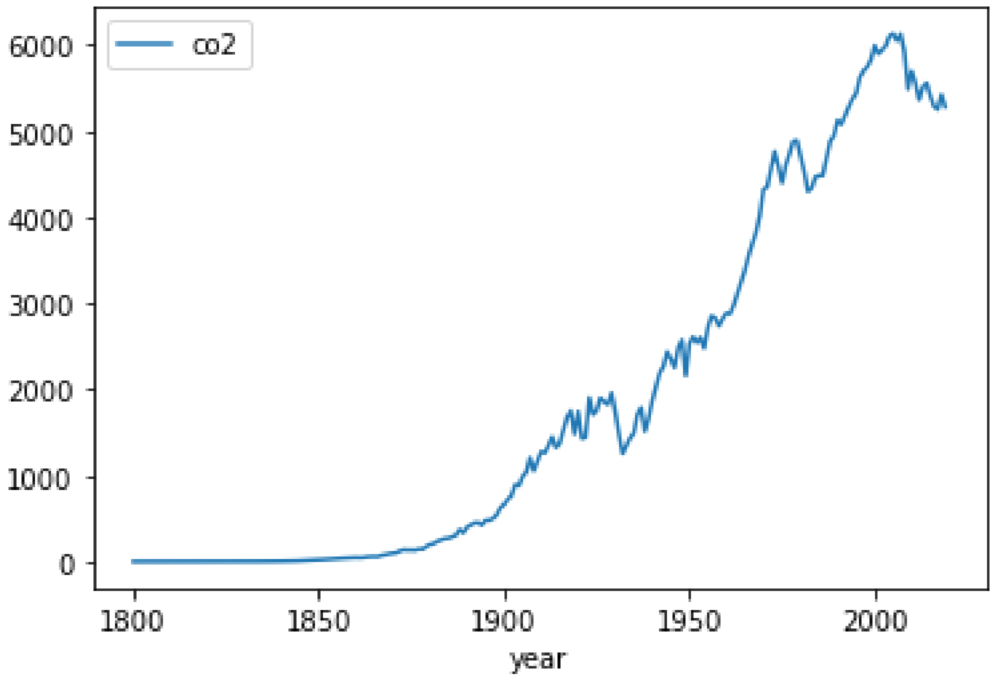
units?



these need to be labeled


co2
1000
800
600
400
200
0
1800
1850
1900
1950
2000
year


co2
600
500
400
300
200
100
0
1750
1800
1850
1900
1950
2000
year



[14]:
```
co2_country_years_idxmax=co2_country_years.groupby('country')['co2'].idxmax()
↪#get the index of the max emission of different countries
co2_country_years_idxmax
```

[14]:
```
country
China              4089
Germany            7212
United Kingdom    19542
United States     19796
Name: co2, dtype: int64
```

[15]:
```
co2_china_year_max = co2_country_years.loc[4089]  # China peaked at 2019 and
↪didn't start to control
co2_china_year_max
```

[15]:
```
country        China
co2        10174.681
year            2019
Name: 4089, dtype: object
```

[16]:
```
co2_germany_year_max = co2_country_years.loc[7212] # Germany peaked at 1979,
↪and has already started to control since 1979
co2_germany_year_max
```

[16]:
```
country      Germany
co2         1117.882
year            1979
Name: 7212, dtype: object
```

[17]:
```
co2_UK_year_max = co2_country_years.loc[19542]  # Germany peaked at 1979, and␣
↪has already started to control since 1971
co2_UK_year_max
```

[17]:
```
country    United Kingdom
co2               660.388
year                 1971
Name: 19542, dtype: object
```

[18]:
```
co2_USA_year_max = co2_country_years.loc[19796] #USA peaked at 2005,and has␣
↪already started to control since 2005
co2_USA_year_max
```

[18]:
```
country    United States
co2             6131.893
year                2005
Name: 19796, dtype: object
```

10/30

you must put your data in one plot & clearly write your results

you did not comment on the usefulness of this type of analysis...