

# correlation

August 14, 2022

```
[1]: import os

import networkx as nx
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
import plotly.express as px
import plotly.graph_objects as go
```

```
[2]: import plotly.io as pio
pio.renderers.default = "plotly_mimetype+notebook+vscode+pdf"
```

## 0.1 Modify Data

### 0.1.1 Create Merged .csv File with Data from All Cities

```
[3]: # setup global variables - data file directory and name
DATA_FILES_DIR = 'original_data_files'
DATA_FILE_NAME = 'data/data.csv.gz'

all_data_files = os.listdir(DATA_FILES_DIR)

def create_data_file():
    # read each data original data file and concatenate it to single df
    os.chdir(DATA_FILES_DIR)
    df = pd.concat(map(pd.read_csv, all_data_files), ignore_index=True)
    os.chdir('..') # return to previous dir - main dir

    # remove some patterns from city column
    df['city'] = df['city'].str.replace(',Croatia', '')
    df['city'] = df['city'].str.replace(r'+', ' ', regex=False)

    # fix json
    df['weatherIconUrl'] = df['weatherIconUrl'].str.replace("\['value': '", '"')
    df['weatherIconUrl'] = df['weatherIconUrl'].str.replace("']", '"')

    df['weatherDesc'] = df['weatherDesc'].str.replace("\['value': '", '"')
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df['weatherDesc'] = df['weatherDesc'].str.replace("']]", "")

# sort data by datetime and city and save it to .csv file
df = df.sort_values(by=['date_time', 'city'])
df.to_csv(DATA_FILE_NAME, index=False, compression='gzip')
print('Data processed successfully')

# create data file if does not exist
if not os.path.exists(DATA_FILE_NAME):
    print('Creating data file')
    create_data_file()
else:
    print('Data has already been processed')

# import data
df_full_data = pd.read_csv(DATA_FILE_NAME, compression='gzip')

```

Data has already been processed

## 1 Correlation

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[4]: def create_folder(folder_name):
    if not os.path.exists(folder_name):
        print(f'Creating folder {folder_name}')
        os.mkdir(folder_name)

# to always have the newest plot versions, delete file before creating new one
def remove_file_if_exists(file_path):
    if os.path.exists(file_path):
        os.remove(file_path)

create_folder('data/')
create_folder('data/correlation')

[5]: # keep only needed data
def truncate_df(df, columns_to_keep, years=None, months=None, hours=None,
    ↪ additional_conditions=None):
    # modify timestamp column
    df['date_time'] = pd.to_datetime(df['date_time'], format='%Y-%m-%d %H:%M:%S')

    # build prefix str
    prefix_str = 'columns-' + '_'.join(columns_to_keep)

    if additional_conditions:
        for additional_condition in additional_conditions:
            column, sign, value = additional_condition

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        if sign == '<':
            df = df.loc[df[column] < value]
        elif sign == '>':
            df = df.loc[df[column] > value]
        elif sign == '=':
            df = df.loc[df[column] == value]
        elif sign == 'in':
            df = df.loc[df[column].isin(value)]
        prefix_str += f'-condition-{column}-{sign}-' + '_'.join(value)

columns_to_keep = ['date_time'] + columns_to_keep + ['city']
df = df[columns_to_keep]

if years:
    df = df[df['date_time'].dt.year.isin(years)]
    prefix_str += '-years-' + '_'.join(map(str, years))

if months:
    df = df[df['date_time'].dt.month.isin(months)]
    prefix_str += '-months-' + '_'.join(map(str, months))

if hours:
    df = df[df['date_time'].dt.hour.isin(hours)]
    prefix_str += '-hours-' + '_'.join(map(str, hours))

prefix_str = prefix_str.replace(' ', '')
return df, prefix_str

```

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[6]: # function to calculate correlation matrix values
def create_correlation_matrix(data, towns, field):
    if len(field) == 1:
        field = field[0]
    else:
        pass
        # TO DO - merge and somehow calculate on multiple fields

    towns_cnt = len(towns)
    # init zero matrix with m=n=count of cities
    # set values to -13, just to be sure it is an imposible correlation value
    ret_matrix = np.zeros((towns_cnt, towns_cnt)) - 13

    # iterate through every city combination and calculate the correlation
    for i, town1 in enumerate(towns):
        town1_values = np.array(data.loc[data['city'] == town1][field])
        # town1_values = (town1_values - np.mean(town1_values)) / (np.
        ↪ std(town1_values) * len(town1_values))

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# correlation 1 on diagonal
ret_matrix[i,i] = 1.0

# having in mind that ret_matrix[i,j] == ret_matrix[j,i]
for j, town2 in enumerate(towns[i+1:], i+1):
    town2_values = np.array(data.loc[data['city'] == town2][field])
    # town2_values = (town2_values - np.mean(town2_values)) / (np.
    ↪std(town2_values))
    # ret_matrix[i,j] = np.correlate(town1_values, town2_values)[0]
    ret_matrix[i,j] = np.corrcoef(town1_values, town2_values)[0,1]
    ret_matrix[j,i] = ret_matrix[i,j]

return ret_matrix

```

```

[7]: # global variables
CORRELATION_DIR = 'correlation_plots'
# select which columns to keep
COLUMNS_TO_KEEP = ['tempC']
# COLUMNS_TO_KEEP = ['humidity']

# create directory if does not exist
create_folder(CORRELATION_DIR)

# list of all towns
unique_towns = sorted(list(df_full_data['city'].unique()))

# create dataframe and string needed to create out files
df_data, PREFIX_STR = truncate_df(
    df=df_full_data,
    columns_to_keep=COLUMNS_TO_KEEP,
    # months=[6,7,8,9]
    # additional_conditions=[('weatherDesc', 'in', ['Clear', 'Sunny', ], )]
    # additional_conditions=[('weatherDesc', 'in', ['Partly cloudy', 'Cloudy', ],
    ↪), )]
)

# modify output folder
CORRELATION_DIR = f'{CORRELATION_DIR}/{PREFIX_STR}'
create_folder(CORRELATION_DIR)

CORRELATION_DATA_FILENAME = f'data/correlation/{PREFIX_STR}_correlation_data.
    ↪.npy'

# check if we already have correlation matrix saved
if os.path.exists(CORRELATION_DATA_FILENAME):
    print('Correlation file exists!')
    corr_matrix = np.load(CORRELATION_DATA_FILENAME)

```

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else:
    print('Correlation file does not exist.. Creating one...')
    corr_matrix = create_correlation_matrix(
        data=df_data,
        towns=unique_towns,
        field=COLUMNS_TO_KEEP
    )
    np.save(CORRELATION_DATA_FILENAME, corr_matrix)

```

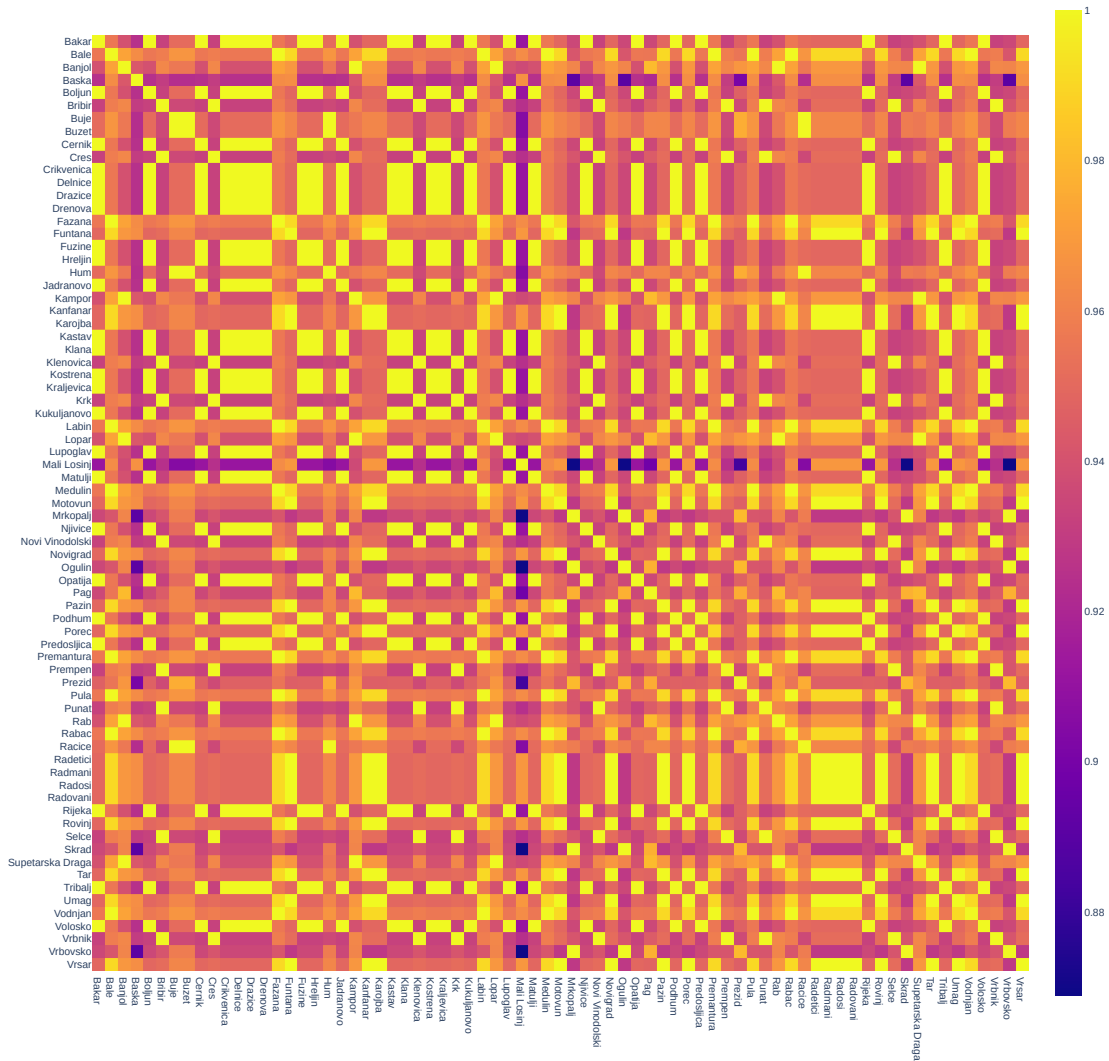
Correlation file does not exist.. Creating one..

```

[8]: # plot correlation matrix
CORRELATION_MATRIX_FILENAME = f'{CORRELATION_DIR}/
↳{PREFIX_STR}_correlation_matrix.png'
remove_file_if_exists(CORRELATION_MATRIX_FILENAME)
fig = px.imshow(
    corr_matrix,
    x=unique_towns,
    y=unique_towns,
    width=1300,
    height=1300
)
fig.update_layout(
    title_text=f'Correlation Matrix Analysis',
    title_x=0.5
)
fig.write_image(CORRELATION_MATRIX_FILENAME)
fig.show()

```

# Correlation Matrix Analysis



```
[9]: # function to plot correlation bar chart
def plot_town_bar_chart(cor, towns, field):
    for i, town in enumerate(towns):
        CORRELATION_IMAGE_FILENAME = f'{CORRELATION_DIR}/
        ↪{field}_{town}_correlation_chart.png'
        remove_file_if_exists(CORRELATION_IMAGE_FILENAME)

        curr_towns = towns.copy()
        curr_towns.remove(town)

        curr_values = cor[i]
        curr_values = np.delete(curr_values, i)
```



## 1.1 Correlation Map

```
[11]: # plot map with values from SVD_V (towns to concept)
def plot_correlation_map(partitions, data_geo, corr_matrix, map_borders):
    named_colorscales = px.colors.DEFAULT_PLOTLY_COLORS * 10
    CORR_MAP_FILENAME = f'{CORRELATION_DIR}/
    ↪{PREFIX_STR}_correlation_map_{len(partitions)}communities.png'
    remove_file_if_exists(CORR_MAP_FILENAME)

    mapbox_access_token = (open(".mapbox_token").read())
    fig = go.Figure()
    fig.update_layout(
        width=1800,
        height=800,
    )

    # create a list with all dfs to plot cities in scatter plot at the end
    list_data_geo_nodes = []

    # iterate through partitions and draw them on the map
    for i, partition in enumerate(partitions):
        # cast set to list and extract wanted cities from df
        partition = list(partition)

        # if there is a single element in the partition, print it
        data_geo_nodes = data_geo.loc[data_geo.index.isin(partition)]
        if len(partition) < 2:
            ind = partition[0]
            print(f'There is a single element partition: {unique_towns[ind]}')
            fig.add_trace(
                go.Scattermapbox(
                    mode = "markers",
                    lon=data_geo_nodes['LNG'],
                    lat=data_geo_nodes['LAT'],
                    name=data_geo_nodes['CITY'].values[0],
                    legendgroup=f'Partition {i+1}',
                    showlegend=True,
                    marker=dict(color=named_colorscales[i], size=14)
                )
            )
            continue

    # append df to list
    list_data_geo_nodes.append(data_geo_nodes)
```



```

# iterate through elements in partition and plot the pairs
for j in range(len(partition)-1):
    # extract values
    corr_value = corr_matrix[partition[j], partition[j+1]]
    nodes_index = [partition[j], partition[j+1]]

    # truncate df to just two cities
    data_geo_pair = data_geo_nodes.loc[data_geo_nodes.index.
↪isin(nodes_index)]
    city_from, city_to = data_geo_nodes.at[partition[j], "CITY"],
↪data_geo_nodes.at[partition[j+1], "CITY"]

    # calculate scaled width and opacity
    scaled_width = scale_range(
        old_value=corr_value,
        corr_matrix=corr_matrix,
        new_min=0.5,
        new_max=3.5,
    )
    scaled_opacity = scale_range(
        old_value=corr_value,
        corr_matrix=corr_matrix,
        new_min=0.3,
        new_max=1.0,
    )

    # draw lines and group them by partitions using legendgroup
    fig.add_trace(
        go.Scattermapbox(
            mode = "lines",
            lon = data_geo_pair['LNG'],
            lat = data_geo_pair['LAT'],
            name=f'{city_from} - {city_to}: corr:{round(corr_value,
↪2)}',

            legendgroup=f'Partition {i+1}',
            showlegend=True,
            line=dict(color=named_colorscales[i], width=scaled_width),
            # opacity=scaled_opacity
        )
    )

# plot cities as scatters on the map with different color
all_data_geo_nodes = pd.concat(list_data_geo_nodes)
fig.add_trace(
    go.Scattermapbox(
        mode = "markers",

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        lon = all_data_geo_nodes['LNG'],
        lat = all_data_geo_nodes['LAT'],
        text=all_data_geo_nodes['CITY'],
        showlegend=False,
        marker=dict(color=named_colorscales[i+1], size=7)
    )
)

# setup layout parameters
fig.update_layout(
    width=1485,
    height=700,
    margin = {
        'l':15,
        'r':35,
        't':35,
        'b':15,
    },
    autosize=True,
    mapbox = {
        'accesstoken': mapbox_access_token,
        'center': {
            'lon': np.average(map_borders[0:2]),
            'lat': np.average(map_borders[2:4])
        },
        'style': "open-street-map",
        'zoom': 7.5
    },
    title_text=f'Correlation Between Cities ({len(partitions)} Partitions)',
    title_x=0.5
)

fig.write_image(CORR_MAP_FILENAME)
fig.show()

```

```

[12]: from geopy.distance import geodesic as GD

# function to scale up correlation values
def scale_range(old_value, corr_matrix, new_min, new_max):
    old_min = np.min(corr_matrix)
    old_max = np.max(corr_matrix)

    old_range = old_max - old_min
    new_range = new_max - new_min

    if old_value == old_min:
        return new_min

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        new_value = (((old_value - old_min) * new_range) / old_range) + new_min
        return new_value

# function to create graph from correlation matrix
def create_graph(corr_matrix, towns_index, data_geo):
    G = nx.Graph()
    for i in towns_index:
        for j in towns_index[i+1:]:
            G.add_edge(i, j, weight=corr_matrix[i,j])

    return G

```

```

[13]: # import cities with its logitude and latitude
GEO_POSITION_FILENAME = 'data/geo_position.csv'
df_geo_position = pd.read_csv(GEO_POSITION_FILENAME, )
df_geo_position.sort_values(by=['CITY'], inplace=True)
df_geo_position.reset_index(drop=True, inplace=True)

# left right up down
map_borders = (
    np.min(df_geo_position['LNG']),
    np.max(df_geo_position['LNG']),
    np.max(df_geo_position['LAT']),
    np.min(df_geo_position['LAT']),
)

# call function to create graph G
G = create_graph(
    corr_matrix=corr_matrix,
    towns_index=list(df_geo_position.index),
    data_geo=df_geo_position
)

# send G to create n partitions and plot them on data
resoulution_value = 1
min_no_of_communities = 4
while True:
    while True:
        G_partitions = nx.algorithms.community.louvain_communities(
            G=G,
            weight='weight',
            seed=100,
            threshold=1e-07,
            resolution=resoulution_value
        )
        curr_len = len(G_partitions)

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    if curr_len >= min_no_of_communities:
        break
    resoulution_value += 0.001

    # break if there are 3 more communities than minimum set
    if len(G_partitions) >= min_no_of_communities + 3 or min_no_of_communities_
↪ == 8:
        break

    # order them by number of cities in partition (just to have it better drawn)
    G_partitions.sort(key=len)

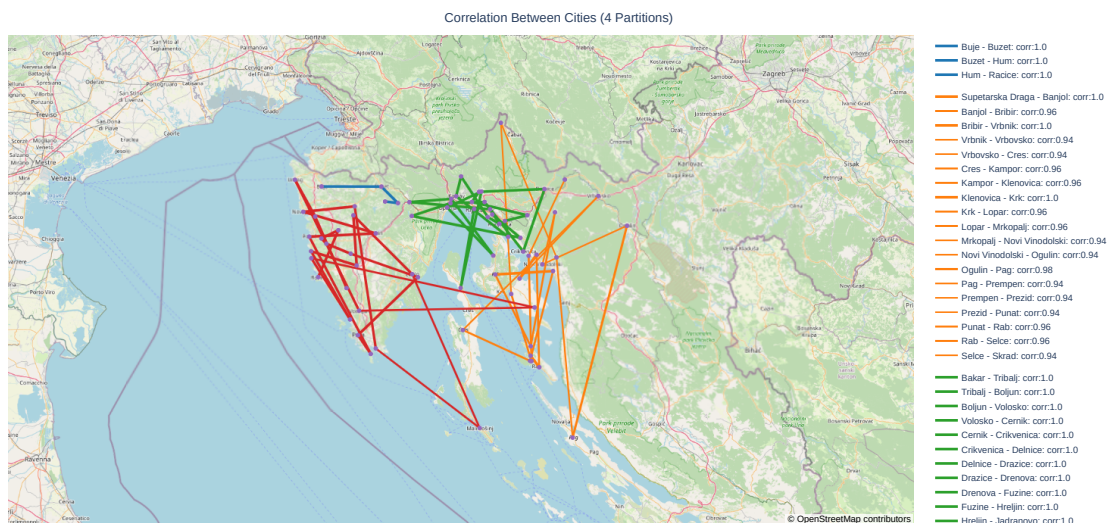
    print(f'Min comununities: {min_no_of_communities} -- Resoluton value:
↪ {resoulution_value}')

    # plot map
    plot_correlation_map(
        partitions=G_partitions,
        data_geo=df_geo_position,
        corr_matrix=corr_matrix,
        map_borders=map_borders,
    )

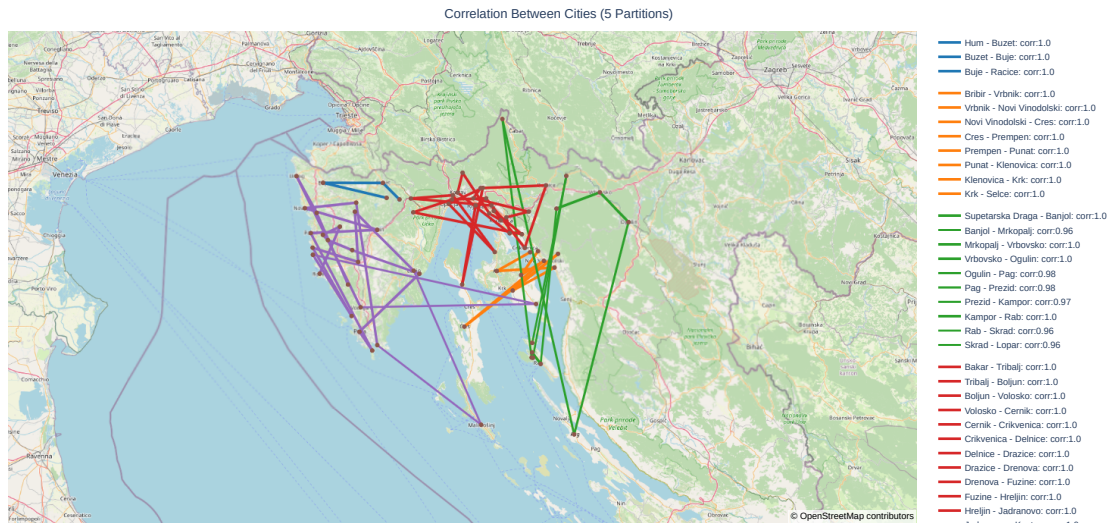
    # increase min no of communities
    min_no_of_communities += 1

```

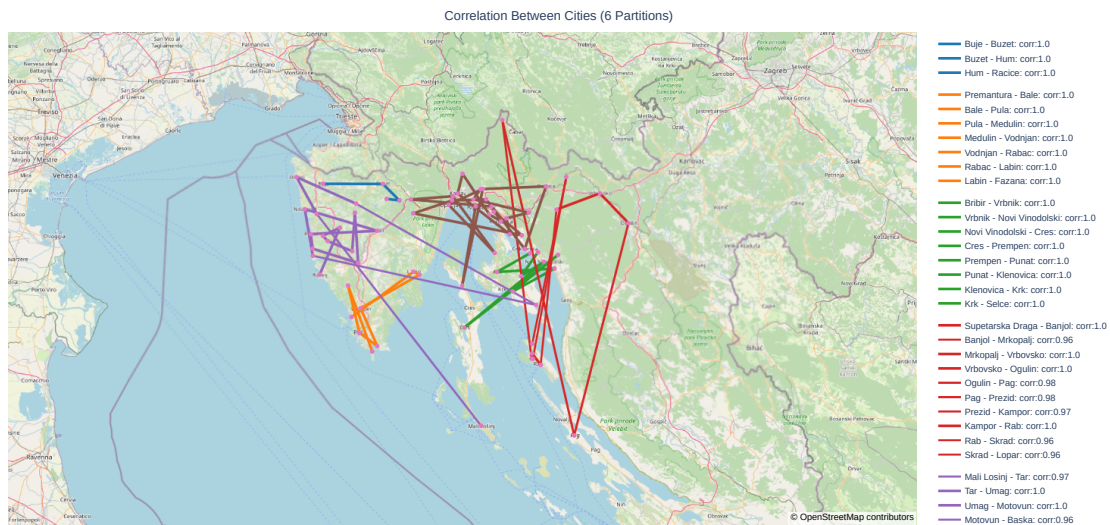
Min comununities: 4 -- Resoluton value: 1.0189999999999998



Min comununities: 5 -- Resoluton value: 1.0279999999999997



Min communities: 6 -- Resoluton value: 1.03199999999999965



## 2 Export to HTML

```
[14]: # save notebook before nbconvert
import IPython
```

```
[15]: %%javascript
IPython.notebook.save_notebook()
```

<IPython.core.display.Javascript object>

```
[16]: # export notebook results to HTML and PDF
jupyter_out_filename = f'{PREFIX_STR}_correlation'
!jupyter nbconvert --output-dir 'output' --output {jupyter_out_filename}
↪--to=HTML correlation.ipynb
!jupyter nbconvert --output-dir 'output' --output {jupyter_out_filename}
↪--to=pdf correlation.ipynb

jupyter_out_filename_no_code = f'{PREFIX_STR}_correlation_no_code'
!jupyter nbconvert --output-dir 'output' --output
↪{jupyter_out_filename_no_code} --no-input --to=HTML correlation.ipynb
!jupyter nbconvert --output-dir 'output' --output
↪{jupyter_out_filename_no_code} --no-input --to=pdf correlation.ipynb
```

[NbConvertApp] Converting notebook correlation.ipynb to HTML

[NbConvertApp] Writing 4536207 bytes to output/columns-tempC\_correlation.html