Introduction

In [ ]:

```
'''
Weekend Rainfall Analysis in Buenos Aires (2020–2025)

This notebook investigates a common belief:
"It rains more on weekends"

Using daily precipitation data from the Buenos Aires Central Observatory, we aim

1. Does daily precipitation (mm/day) differ between weekdays and weekends?
2. Is the probability of rainfall different between the two?
'''
```

Load and prepare data

In [481…

```
#Carga de módulos

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.stats import mannwhitneyu
import statsmodels.api as sm
```

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```
'''
Load of 'export' dataset, downloaded from meteostat.net under the following para
Observatory: Buenos Aires Central Observatory
Date range: 13/11/2020 - 13/11/2025

Field information:
date (YYYY-mm-dd)
tavg: average Temperature (°C)
tmin: minimum temperature (°C)
tmax: maximum temperature (°C)
prcp: total precipitation (mm)
snow: snow depth
wdir: wind (From) direction (°)
wspd: wind speed (km/h)
wpgt: wind peak gust (km/h)
pres: sea-level air pressure (hPa)
tsun: total sunshine duration (minutes)
'''
df = pd.read_csv('export.csv')
df['date'] = pd.to_datetime(df['date'], origin='1899-12-30', unit='D')
df.head()
```

Out[482…

	date	tavg	tmin	tmax	prcp	snow	wdir	wspd	wpgt	pres	tsun
0	2020-11-13	22.2	19.2	26.6	NaN	NaN	NaN	9.0	NaN	1013.1	NaN
1	2020-11-14	22.2	19.3	26.6	NaN	NaN	NaN	4.0	NaN	1010.3	NaN
2	2020-11-15	20.9	15.7	26.0	NaN	NaN	NaN	11.1	NaN	1013.5	NaN
3	2020-11-16	20.5	14.0	26.3	NaN	NaN	NaN	6.8	NaN	1014.6	NaN
4	2020-11-17	23.4	17.7	27.7	NaN	NaN	NaN	8.2	NaN	1013.0	NaN

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```
print('\nStatistical description of data:\n')
print(df.describe(include='all'))
```

```
Statistical description of data:

                                 date         tavg         tmin         tmax  \
count                            1827  1827.000000  1827.000000  1827.000000
mean    2023-05-14 23:59:59.999999744    18.746196    14.418993    24.374330
min               2020-11-13 00:00:00     3.700000    -1.900000     9.200000
25%               2022-02-12 12:00:00    14.100000     9.800000    19.400000
50%               2023-05-15 00:00:00    18.900000    14.600000    24.400000
75%               2024-08-13 12:00:00    23.400000    19.100000    29.400000
max               2025-11-13 00:00:00    33.500000    29.800000    41.500000
std                               NaN     5.840665     5.899633     6.260565

              prcp      snow  wdir         wspd  wpgt         pres  tsun
count  1318.000000  5.000000   0.0  1827.000000   0.0  1827.000000   0.0
mean      3.986419  2.800000   NaN     8.743733   NaN  1015.985495   NaN
min       0.000000  1.000000   NaN     1.100000   NaN   997.400000   NaN
25%       0.000000  2.000000   NaN     6.400000   NaN  1011.800000   NaN
50%       0.000000  2.000000   NaN     8.400000   NaN  1015.700000   NaN
75%       1.600000  2.000000   NaN    10.700000   NaN  1019.850000   NaN
max     127.000000  7.000000   NaN    25.000000   NaN  1034.800000   NaN
std      11.128690  2.387467   NaN     3.281035   NaN     6.091385   NaN
```

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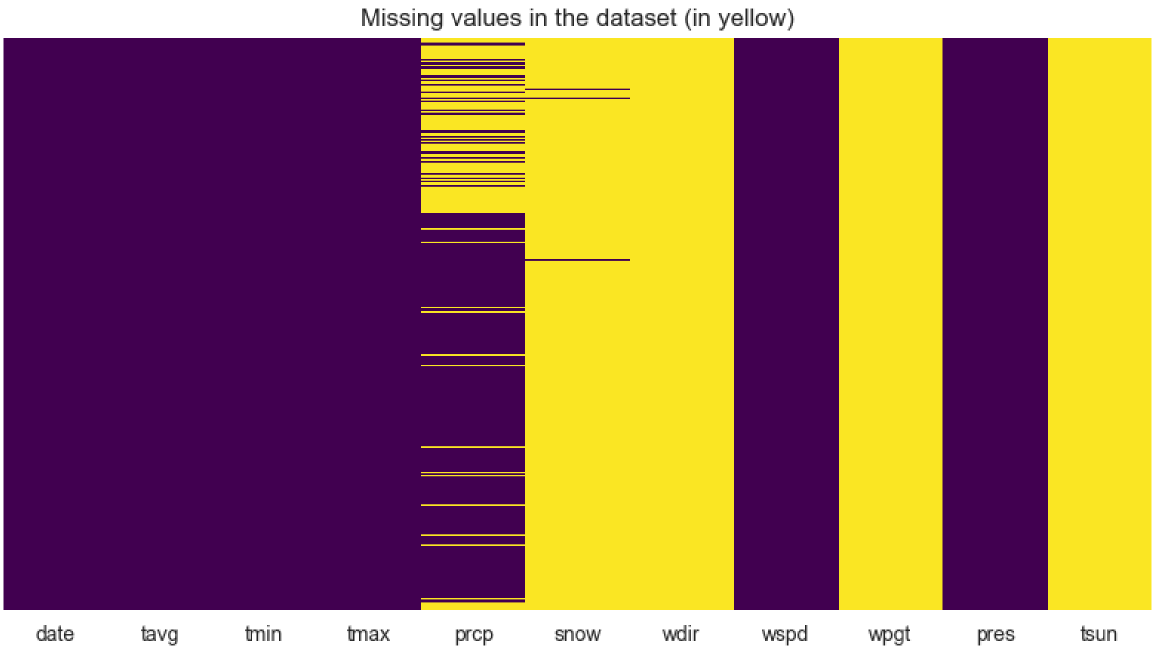
```
print('\nMissing values by field:\n')
print(df.isna().sum())

plt.figure(figsize=(10,5))
sns.heatmap(df.isna(), cmap='viridis', cbar=False, yticklabels=False)
plt.title('Missing values in the dataset (in yellow)')
plt.show()
```

```
Missing values by field:

date       0
tavg       0
tmin       0
tmax       0
prcp     509
snow    1822
wdir    1827
wspd       0
wpgt    1827
pres       0
tsun    1827
dtype: int64
```



Dataset cleaning

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'''
Are there fields that should be eliminated?
-wdir, wpgt and tsun have no non-null values.
-in wspd, snow and pres, the non-null values represent more than 60% of the tota
'''
cols_to_drop=['snow', 'wdir','wspd','wpgt', 'pres','tsun']
df = df.drop(columns=[c for c in cols_to_drop if c in df.columns])

df.head()
```

Out[485…

	date	tavg	tmin	tmax	prcp
0	2020-11-13	22.2	19.2	26.6	NaN
1	2020-11-14	22.2	19.3	26.6	NaN
2	2020-11-15	20.9	15.7	26.0	NaN
3	2020-11-16	20.5	14.0	26.3	NaN
4	2020-11-17	23.4	17.7	27.7	NaN

Null value handling

In [486…

```
'''
Upon reaching our main field of interest (precipitation), we see that there is a
Are they mostly corresponding to days without rain or they have missing data for
To determine it, the daily precipitation is grouped by year (2021-2024) and cont
'''

#Dataset preparation with daily records. Creation of columns 'year' and 'rainy_d

df['year'] =df['date'].dt.year
df['rainy_day'] = df['prcp']>0


df_review = df.groupby('year').agg(
    daily_mm = ('prcp','sum'),
    daily_rainy_days= ('rainy_day','sum'),
)

#Loading the OCBA dataset with annual data.
ocba = pd.read_csv('ocba.csv')
ocba.rename(columns={'mm':'ocba_mm', 'days':'ocba_rainy_days'}, inplace=True)


#Inner join of both datasets.

df_merge = df_review.merge(ocba, left_on='year', right_on='year', how='inner')

'''
To continue, the relative error of the dataset is calculated, taking as the sour
An acceptable relative error of up to +/-5% is considered. Starting from that va
'''
df_merge['prcp_difference']=((df_merge['daily_mm']-df_merge['ocba_mm'])/df_merge
df_merge['rainy_days_difference']=((df_merge['daily_rainy_days']-df_merge['ocba_

df_merge.head()
```

Out[486…

	year	daily_mm	daily_rainy_days	ocba_mm	ocba_rainy_days	prcp_difference	rainy_
0	2021	961.0	79	959.8	80	0.125026	
1	2022	773.2	82	752.4	80	2.764487	
2	2023	912.5	112	954.0	111	-4.350105	
3	2024	1145.4	96	1161.7	93	-1.403116	

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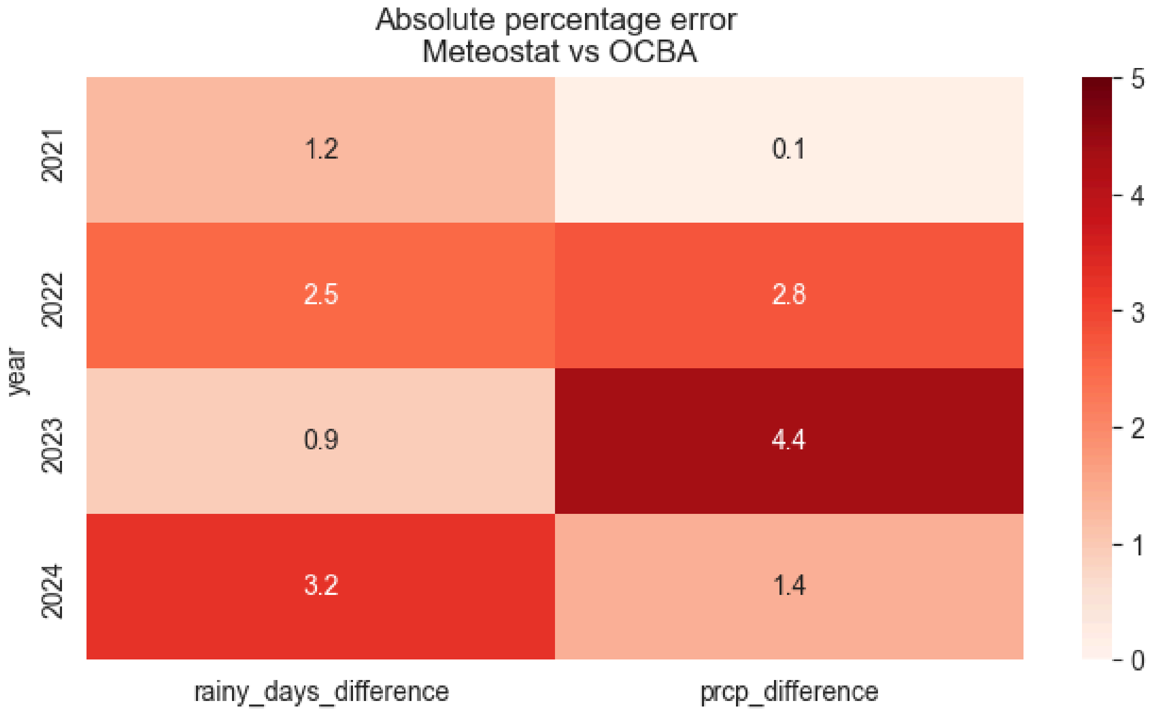
```
plt.figure(figsize=(8,4))
df_abs = df_merge.abs()
sns.heatmap(
    df_abs.set_index('year')[['rainy_days_difference', 'prcp_difference']],
    annot=True, fmt='.1f', cmap='Reds', vmin=0,vmax=5)
plt.title('Absolute percentage error\n Meteostat vs OCBA')
plt.show()
```



In [488…

```
#As can be observed both analytically and graphically, the absolute relative err
df['prcp'] = df['prcp'].fillna(0)
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1827 entries, 0 to 1826
Data columns (total 7 columns):
 #   Column      Non-Null Count  Dtype         
---  ------      --------------  -----         
 0   date        1827 non-null   datetime64[ns]
 1   tavg        1827 non-null   float64       
 2   tmin        1827 non-null   float64       
 3   tmax        1827 non-null   float64       
 4   prcp        1827 non-null   float64       
 5   year        1827 non-null   int32         
 6   rainy_day   1827 non-null   bool          
dtypes: bool(1), datetime64[ns](1), float64(4), int32(1)
memory usage: 80.4 KB
```

Outlier Detection

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```
'''
The appearance of outliers can affect the final conclusions of the analysis, so
possible atypical values in both a graphical and analytical manner.
Given that the nature of a precipitation time series has an extremely high level
is not normal, is considerably asymmetric and has a long tail, only the data wit
'''

sns.boxplot(x=df[df['rainy_day'] == True]['prcp'])
plt.title('Precipitation distribution for rainy days')

#Values above the 99.5 percentile
p995 = df[df['rainy_day'] == True]['prcp'].quantile(0.995)
df_outliers = df.loc[df['prcp'] > p995, ['date', 'prcp']]
df_neg = df.loc[df['prcp'] < 0, ['date','prcp']]
```

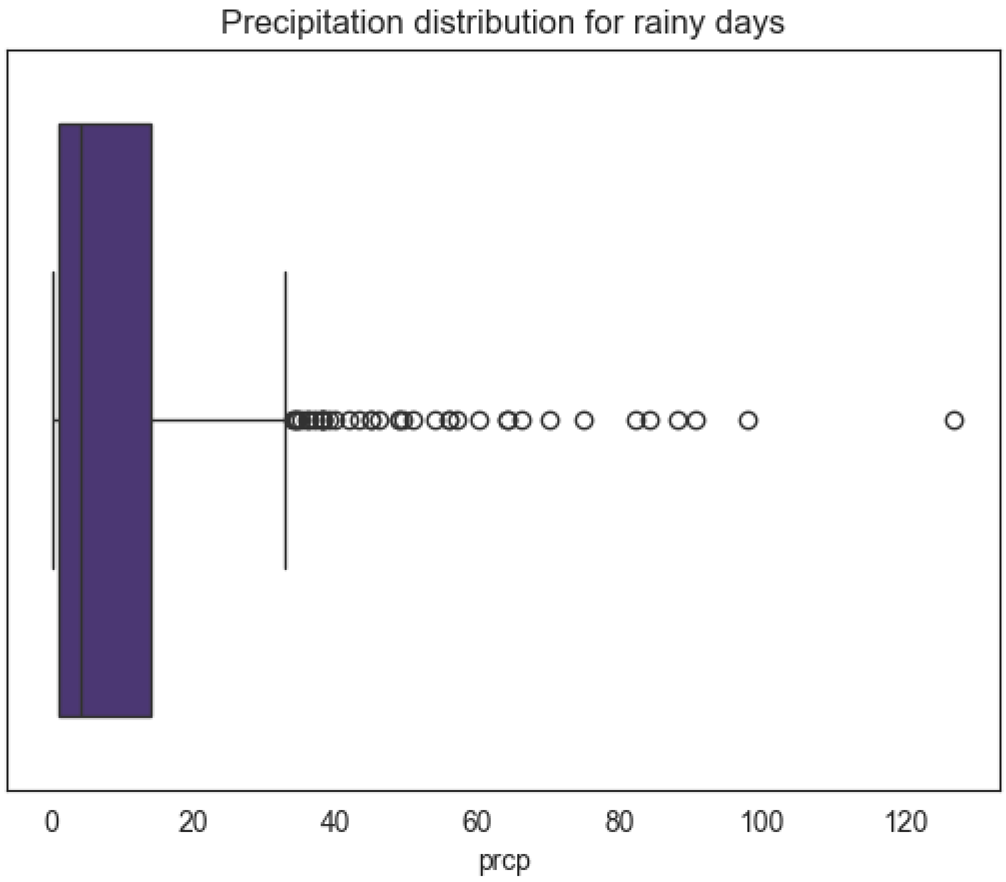
```
print(f'Values above the 99.5 percentile\n\n {df_outliers}\n')
print(f'Negative precipitations\n\n {df_neg}')
```

```
Values above the 99.5 percentile

            date   prcp
731   2022-11-14   90.5
1215  2024-03-12  127.0
1646  2025-05-17   98.0

Negative precipitations

 Empty DataFrame
Columns: [date, prcp]
Index: []
```



In [ ]:

```
'''
What conclusions can be drawn from the results obtained?
When analyzing a meteorological variable such as precipitation, typical values m
In this case, the three detected days were compared with the SMN records on the

Inevitably erroneous values would, in this case, be negative values or values gr
In this analysis, none of these two types of errors have been found.
'''
```

Dataset transformation

In [491…

```
'''
Fields are created to discriminate records by type of day of the week:
day_of_week indicates the weekday number, starting from index 0 (Monday)
is_weekend is a boolean variable that returns True for Friday, Saturday, and Sun
'''
```

```
df['day_of_week'] = df['date'].dt.dayofweek
df['is_weekend'] = df['day_of_week']>3
df.head()
```

Out[491…

	date	tavg	tmin	tmax	prcp	year	rainy_day	day_of_week	is_weekend
0	2020-11-13	22.2	19.2	26.6	0.0	2020	False	4	True
1	2020-11-14	22.2	19.3	26.6	0.0	2020	False	5	True
2	2020-11-15	20.9	15.7	26.0	0.0	2020	False	6	True
3	2020-11-16	20.5	14.0	26.3	0.0	2020	False	0	False
4	2020-11-17	23.4	17.7	27.7	0.0	2020	False	1	False

Hypothesis testing

In [492…

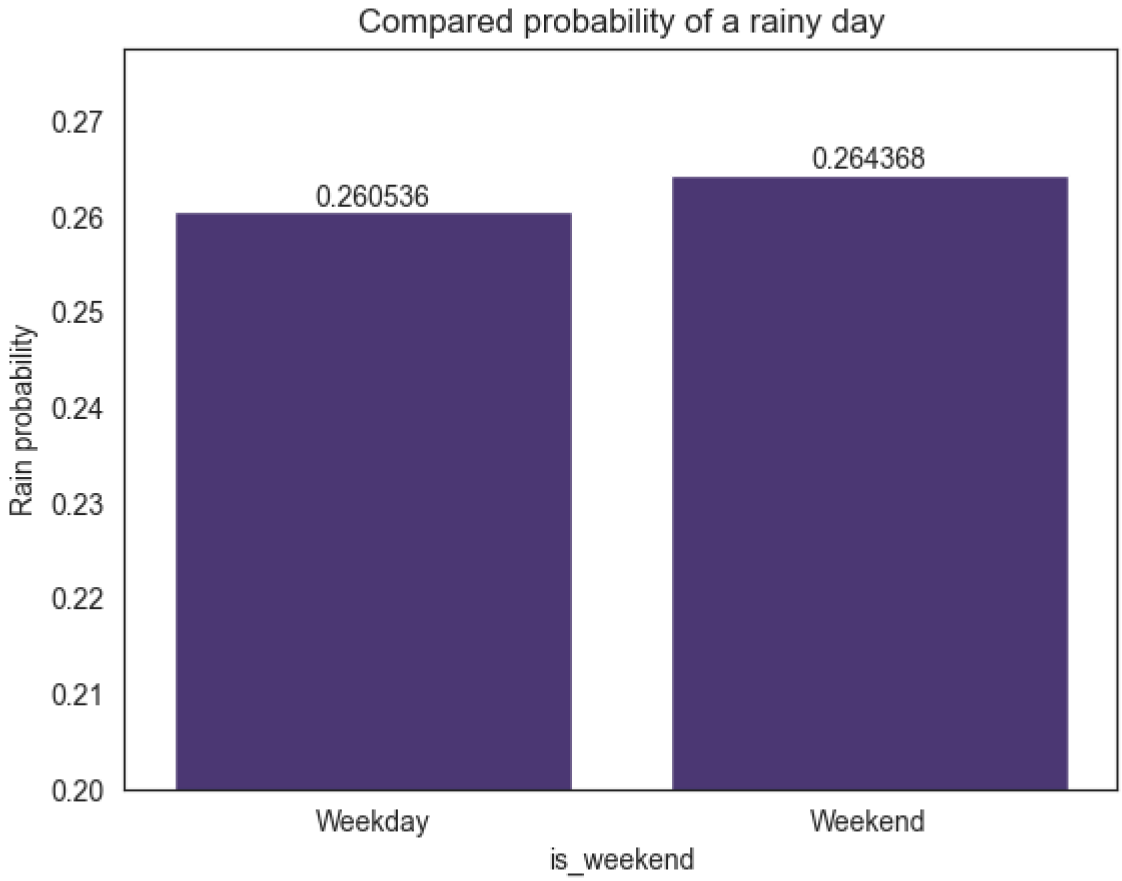
```
'''
It's time to test our two questions:
1) Is there really a higher probability of rain on the weekend than on the rest
2) On average, does it rain more on the weekend than on the rest of the days?

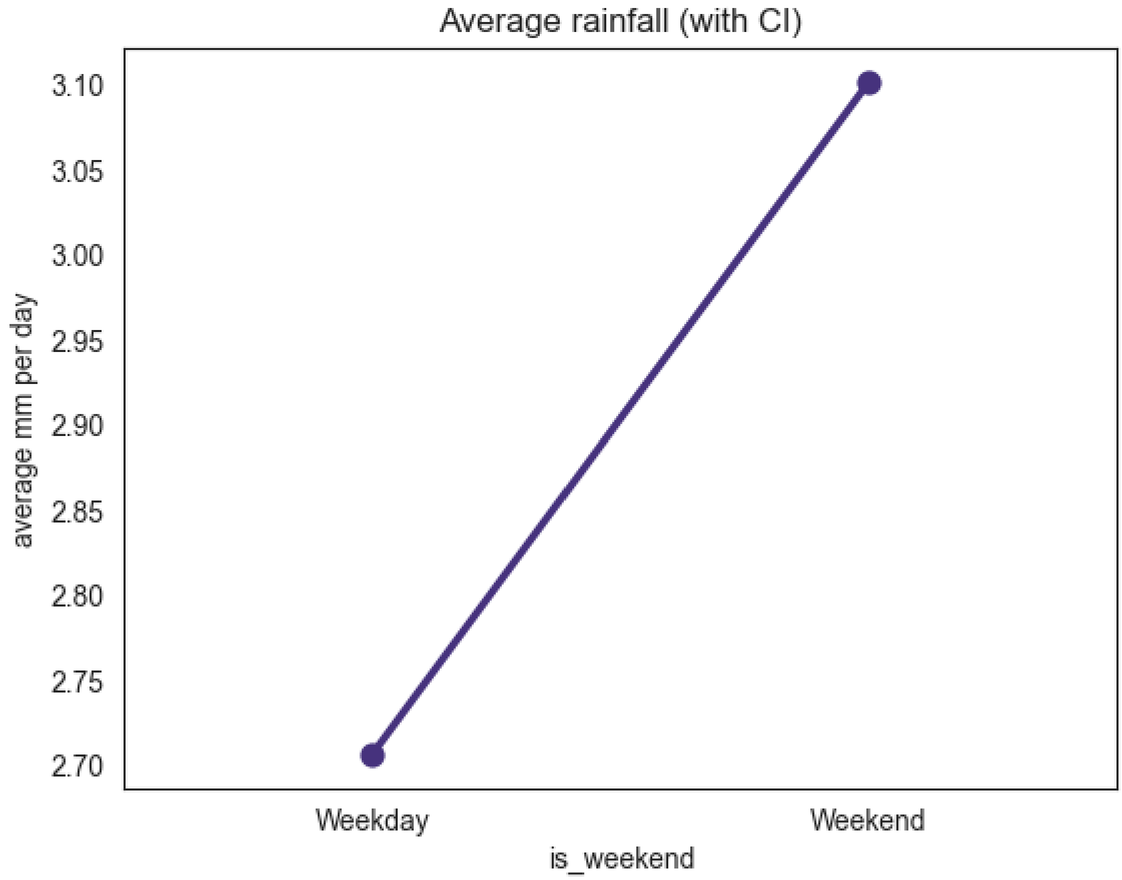
Let's start by grouping our data and examining the results.
'''
prcp_by_weekday = df.groupby('is_weekend').agg(
    prcp = ('prcp', 'mean'),
    rainy_days = ('rainy_day', 'mean'),
    total_days = ('is_weekend', 'count')
)


ax = sns.barplot(
    data=prcp_by_weekday.reset_index(),
    x="is_weekend",
    y="rainy_days"
)
ax.set_ylim(bottom=0.20)
ax.bar_label(ax.containers[0])
plt.xticks([0,1], ["Weekday", "Weekend"])
plt.ylabel("Rain probability")
plt.title("Compared probability of a rainy day")
plt.show()

sns.pointplot(
    data=prcp_by_weekday.reset_index(),
    x="is_weekend",
    y="prcp",
    capsize=0.2
)
plt.xticks([0,1], ["Weekday", "Weekend"])
plt.ylabel("average mm per day")
plt.title("Average rainfall (with CI)")
plt.show()

prcp_by_weekday
```


Compared probability of a rainy day
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
Rain probability
0.260536
0.264368
Weekday
Weekend
is_weekend


Average rainfall (with CI)
3.10
3.05
3.00
2.95
2.90
2.85
2.80
2.75
2.70
average mm per day
Weekday
Weekend
is_weekend

Out[492…

	prcp	rainy_days	total_days
is_weekend			
False	2.706418	0.260536	1044
True	3.101660	0.264368	783

Is there really a higher probability of rain on the weekend than on the rest of the days?

In [493…

```
'''
We can observe that, in Buenos Aires, it rained on 26.44% of weekend days compar
Although the percentage difference seems small, we want to determine whether thi
To do so, we will perform the well-known two-proportion Z-test, which evaluates
In our case, the groups are weekend (Fri-Sun) and weekdays (Mon-Thu).

Statements:
Null Hypothesis (H0): The proportion of rainy days is the same for weekends and
Alternative Hypothesis (H1): The proportion of rainy days differs between weeken
'''

# We will begin the test by creating Boolean series determining whether it is a
rain_weekday = df[df['is_weekend'] == False]['rainy_day']
rain_weekend = df[df['is_weekend'] == True]['rainy_day']

count = [rain_weekend.sum(), rain_weekday.sum()]  #number of successes (rain) fo
nobs = [len(rain_weekend), len(rain_weekday)]     #number of days in each group

z_stat, p_value = sm.stats.proportions_ztest(count, nobs)
print('p-value for the Z-test:', p_value)
```

```
p-value for the Z-test: 0.8538041244079058
```

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```
'''
The p-value is the probability of obtaining the results observed in a study, ass
the p-value must be less than or equal to 0.05. In this case, a p-value of 0.853
In other words, there is no evidence to reject H0, so we cannot conclude that th
'''
```

Is there any difference in daily precipitation between the weekend and the rest of the days?

In [495…

```
'''
To answer this question, we will compare the precipitation distributions between
Given the nature of a precipitation distribution (previously explained), the Man
This non-parametric test (does not assume normality) is indicated for data with
In this case, we state:

Null Hypothesis (H₀): There is no difference in the daily precipitation distribu
Alternative Hypothesis (H₁): There is a difference in the daily precipitation di
'''

#We create the x and y series to separate precipitations into the two groups
x = df[df["is_weekend"] == False]["prcp"]  #weekdays
y = df[df["is_weekend"] == True]["prcp"]   #weekends

#Test
u_stat, p_value = mannwhitneyu(x, y, alternative='two-sided')
```

```
print("p-value:", p_value)
```

```
p-value: 0.61690366009889
```

In [ ]:

```
'''
With a p-value of 0.6170, we cannot reject H₀. That is, there is no evidence tha
'''
```

General Conclusions

In [ ]:

```
'''
In this analysis, we asked whether there is truly a greater chance of rain on th
To make the study more robust, we also wanted to see whether there was a differe
To answer these questions, we followed the classic processes of exploratory data
handling of missing data, and selection of relevant variables.

Then, we formally stated our hypotheses and performed the percentile statistical
In this case, both hypotheses were raised for both cases, so the differences fou
are due to the natural variability of the climate for the period 2020-2025 in Bu

We can say that the perception that it rains more likely when the weekend arrive
than to a climatological pattern.
'''
```