MASTER - Notebook 2.i

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In [ ]:
```
# Import libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import matplotlib.dates as mdates
from datetime import datetime
import json
import warnings
warnings.filterwarnings('ignore')
```

In [ ]:
```
# Disply all columns and all rows
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', None)
```

In [ ]:
```
# The file contains the data of the validation of tickets in the city of public transport of Venice.
# The file has been created by the Notebook 1.ipynb

# Import the data into a dataframe of a txt file
path = 'data/processed/dataset_cleaned_validazioni.txt'
# path = 'data/processed/dataset_cleaned_esportazioneCompleta.txt'

df = pd.read_csv(path, header=0, sep='\t')

# Save the name of the file in a variable for future use extracting the name of the file from the path
file_name = path.split('_')[-1].split('.')[0]

# Display the first 5 rows of the dataframe
df.head()
```

```python
# Convert the column 'DATA' to datetime format
df['DATA'] = pd.to_datetime(df['DATA'], format='%Y-%m-%d')
```

In [ ]:
```python
df.head()
```

Out[ ]:

	DATA	ORA	DATA_VALIDAZIONE	SERIALE	FERMATA	DESCRIZIONE	TITOLO	TICKET_CODE	DESCRIZIONE_TITOLO
0	2022-05-13	00:00:00	2022-05-13 00:00:00	65676291870913797	5089	FERROVIA	11149	4	7GG-TPL 43,60-COMVE16,40
1	2022-05-13	00:00:00	2022-05-13 00:00:00	36141384536591364	5032	FERROVIA	11107	2	48H-TPL 24,90-COMVE5,10
2	2022-05-13	00:00:00	2022-05-13 00:00:00	36144856606063108	5031	P.LE ROMA	11108	3	72H-TPL 33,40-COMVE6,60
3	2022-05-13	00:00:00	2022-05-13 00:00:00	36144856474364932	506	VENEZIA	11261	1	DAILY PASS VENEZIA - AVM
4	2022-05-13	00:00:00	2022-05-13 00:00:00	36144856606062852	5031	P.LE ROMA	11108	3	72H-TPL 33,40-COMVE6,60

In [ ]:
```python
df.tail()
```

Out[ ]:

	DATA	ORA	DATA_VALIDAZIONE	SERIALE	FERMATA	DESCRIZIONE	TITOLO	TICKET_CODE	DESCRIZIONE_TI
4427556	2022-07-15	02:27:00	2022-07-15 02:27:00	37271982183271940	4525	SANTA MARIA	11261	1	DAILY PASS VENE
4427557	2022-07-15	02:27:00	2022-07-15 02:27:00	37271982183274756	4525	SANTA MARIA	11261	1	DAILY PASS VENE
4427558	2022-07-15	04:33:00	2022-07-15 04:33:00	36088514819663876	5030	P.LE ROMA	5	7	75'-TPL 6,64-COMV
4427559	2022-07-15	05:06:00	2022-07-15 05:06:00	40832955551087108	509	VENEZIA	12101	7	BIGL.AUT.75'MESTRE/
4427560	2022-07-15	05:13:00	2022-07-15 05:13:00	40832947760207876	509	VENEZIA	12101	7	BIGL.AUT.75'MESTRE/

Focus on specific types of tickets or ticket codes

```
In [ ]: def to_datetime(date: np.datetime64) -> datetime:
            """
              Converts a numpy datetime64 object to a python datetime object
              Input:
                date - a numpy datetime64 object
              Output:
                DATE - a python datetime object

              Credit: Brian Blaylock on GitHub Gist https://gist.github.com/blaylockbk/1677b446bc741ee2db3e943ab7e4cabd
            """
            # timestamp = ((date - np.datetime64('1970-01-01T00:00:00')) / np.timedelta64(1, 's'))
            # return datetime.utcfromtimestamp(timestamp)
            # date = pd.to_datetime(date)
            date = datetime.strptime(date, '%Y-%m-%d')
            return date
```

```
In [ ]: def get_ticket_code_description(ticket_code: str) -> str:
            """
              Given the key of the ticket code, return the description of the ticket code contained in the dictionary dict_
              Input:
                ticket_code - a string that is the key of the dictionary
              Output:
                description - a string that is the description of the ticket code, value of the dictionary
            """
            with open('data/dictionaries/dict_ticket_codes.json') as f:
                data = json.load(f)
            description = data[ticket_code]
            return description
```

```
In [ ]: # Focus on a specific ticket code
        def focus_on_ticket_code(df_tc: pd.DataFrame, ticket_code: str) -> pd.DataFrame:
            """
                This function returns a dataframe with only the rows of the specified ticket code.
                :param df: the dataframe
                :param ticket_code: the ticket code
                :return: the dataframe with only the rows of the specified ticket code
```

```
    """
    # Select only the rows of the specified ticket code
    df_tc = df_tc[df_tc['TICKET_CODE'] == ticket_code]
    return df_tc

# Focus on a specific ticket type
def focus_on_ticket_type(df_tt: pd.DataFrame, ticket_type: str) -> pd.DataFrame:
    """
        This function returns a dataframe with only the rows of the specified ticket type.
        :param df: the dataframe
        :param ticket_type: the ticket type
        :return: the dataframe with only the rows of the specified ticket type
    """
    # Select only the rows of the specified ticket type
    df_tt = df_tt[df_tt['DESCRIZIONE_TITOLO'] == ticket_type]
    df_tt.head()
    return df_tt

# Focus on a specific day
def number_of_tickets_per_day(df_d: pd.DataFrame, target_ticket_code_or_type: str, is_ticket_code: bool) -> None:
    """
        This function plots the number of validations of the specified ticket code for each day.
        :param df: the dataframe
        :param target_ticket_code: the ticket code
        :param is_ticket_code: a boolean that specifies if the target is a ticket code or a ticket type
        :return: None
    """
    # Group the dataframe by date and hour and count the number of validations of the specified ticket code
    df_d = df_d.groupby('DATA').count()['SERIALE'].reset_index()
    df_d['cumulative_sum'] = df_d.groupby('DATA')['SERIALE'].cumsum()

    # Plot the cumulative sum of the number of validations of the target ticket code or type for each day
    plt.figure(figsize=(20, 10))
    plt.plot(df_d['DATA'], df_d['cumulative_sum'])

    if is_ticket_code:
        descr = get_ticket_code_description(target_ticket_code_or_type)
        plt.title('Cumulative sum of the number of validations of the ticket code "{}" - "{}" for each day'.format(
    else:
        plt.title('Cumulative sum of the number of validations of the ticket type "{}" for each day'.format(target_
```

```python
    plt.xlabel('Date - days', fontsize=15)
    plt.ylabel('Cumulative sum', fontsize=15)

    # Calculate the step of the y-axis
    step = int(df_d['cumulative_sum'].max()/10)
    # Manage the y-axis
    plt.yticks(ticks=np.arange(0, df_d['cumulative_sum'].max()+step, step))

    # Manage the x-axis:
    # rotate the labels of the x-axis
    plt.xticks(rotation=45)

    # Add a point for each day
    plt.scatter(df_d['DATA'], df_d['cumulative_sum'], color='darkblue', s=20)

    # Add the date in the plot
    for i, txt in enumerate(df_d['DATA']):
        # Set the date format in %Y-%m-%d
        txt = txt.strftime('%m-%d')
        # Print the date for each point every 10 days or if it is the first or the last point
        # or if it is the point with the highest number of validations or if it is the point with the lowest number
        if i % 10 == 0 or i == 0 or i == len(df_d['DATA'])-1 or i == df_d['SERIALE'].idxmax() or i == df_d['SERIALE
            plt.annotate(txt, (df_d['DATA'][i], df_d['cumulative_sum'][i]), fontsize=10)

    # Add a grid
    plt.grid()

    # Highlight the day with the highest number of validations and the day with the lowest number of validations
    max = df_d[df_d['SERIALE'] == df_d['SERIALE'].max()]
    plt.scatter(max['DATA'], max['cumulative_sum'], color='red', s=50)
    min = df_d[df_d['SERIALE'] == df_d['SERIALE'].min()]
    plt.scatter(min['DATA'], min['cumulative_sum'], color='green', s=50)

    # Add the legend
    plt.legend(['Number of validations', 'Day with the highest number of validations', 'Day with the lowest number

    plt.show()

# Focus on a specific day: min and max number of tickets per day
def min_max_number_of_tickets_per_day(df_d: pd.DataFrame, target_ticket_code_or_type: str, is_ticket_code: bool) ->
```

```
    """
        This function prints the day with the highest and the day with the lowest number of validations of the spec
        :param df: the dataframe
        :param target_ticket_code_or_type: the ticket code or ticket type
        :param is_ticket_code: a boolean that specifies if the target is a ticket code or a ticket type
        :return: None
    """
    # Group the dataframe by date and hour and count the number of validations of the specified ticket code
    df_d = df_d.groupby('DATA').count()['SERIALE'].reset_index()
    max = df_d[df_d['SERIALE'] == df_d['SERIALE'].max()]
    min = df_d[df_d['SERIALE'] == df_d['SERIALE'].min()]

    # Composing the string to print the result, specifying:
    # - if the target is a ticket code or a ticket type,
    # - converting the date to string format '%Y-%m-%d' and
    # - if is a ticket code, getting the description of the ticket code
    if is_ticket_code:
        # Get the description of the ticket code
        descr = ' - "' + get_ticket_code_description(target_ticket_code_or_type) + '"'
    else:
        descr = ''

    s = 'The {} number of validations of the {} "{}"' + descr + ' was {} with {} validations'
    # Print the result
    for i in range(0, 2):
        if i == 0:
            if is_ticket_code:
                print(s.format('highest', 'ticket code', target_ticket_code_or_type, max['DATA'].values[0].astype('
            else:
                print(s.format('highest', 'ticket type', target_ticket_code_or_type, max['DATA'].values[0].astype('
        else:
            if is_ticket_code:
                print(s.format('lowest', 'ticket code', target_ticket_code_or_type, min['DATA'].values[0].astype('d
            else:
                print(s.format('lowest', 'ticket type', target_ticket_code_or_type, min['DATA'].values[0].astype('d

# Focus on a specific month
def barplot_number_of_tickets_per_month(df_m: pd.DataFrame, target_ticket_code_or_type: str, is_ticket_code: bool)
    """
        This function plots the number of validations of the specified ticket code or ticket type for each month.
```

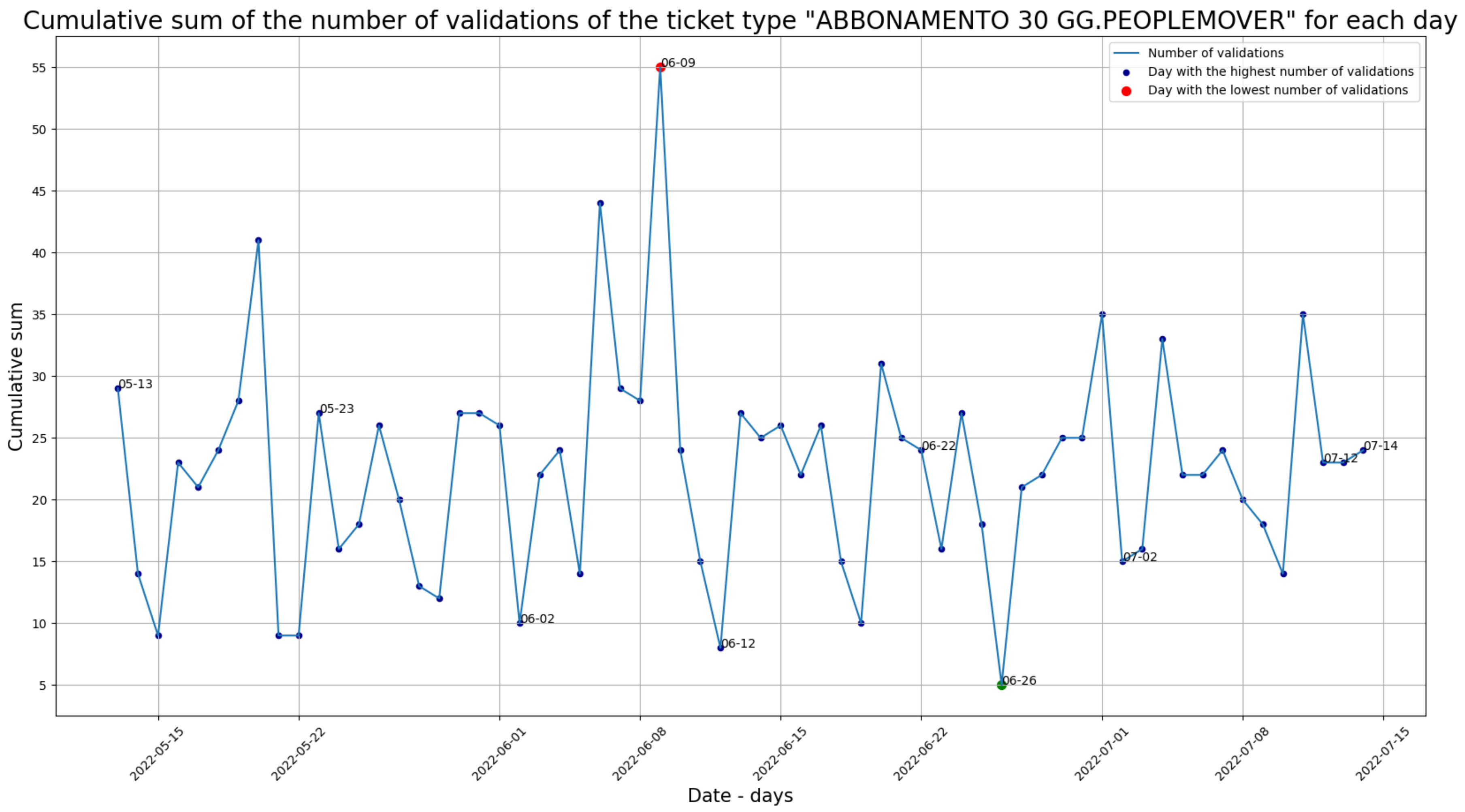
```python
    :param df: the dataframe
    :param target_ticket_code_or_type: the ticket code or ticket type
    :param is_ticket_code: a boolean that specifies if the target is a ticket code or a ticket type
    :return: None
"""
# Set all the values of the date on the first day of the month
df_m['DATA'] = df_m['DATA'].dt.strftime('%Y-%m-01')

# Group the dataframe by date and count the number of validations of the specified ticket code
df_m = df_m.groupby('DATA').count()['SERIALE'].reset_index(drop=False)

# Convert the date to string format '%Y/%m'
df_m['DATA'] = df_m['DATA'].astype('datetime64[M]').astype(str)

# Remove the last 3 characters of the date (the day) to have the date in the format '%Y/%m'
for i in range(0, len(df_m['DATA'])):
    df_m['DATA'][i] = df_m['DATA'][i][:-3]

# Plot the cumulative sum of the number of validations of the target ticket code or type for each month
plt.figure(figsize=(20, 10))
plt.bar(df_m['DATA'], df_m['SERIALE'])

# If the target is a ticket code, get the description of the ticket code, otherwise focus on the ticket type
if is_ticket_code:
    descr = get_ticket_code_description(target_ticket_code_or_type)
    plt.title('Cumulative sum of the number of validations of the ticket code "{}" - "{}" for each month'.forma
else:
    plt.title('Cumulative sum of the number of validations of the ticket type "{}" for each month'.format(targe
plt.xlabel('Date - months', fontsize=15)
plt.ylabel('Cumulative sum', fontsize=15)

# Calculate the step of the y-axis
step = int(df_m['SERIALE'].max()/10)
# Manage the y-axis
plt.yticks(ticks=np.arange(0, df_m['SERIALE'].max()+step, step))

# Manage the x-axis: rotate the labels of the x-axis
# Print the x-axis labels as '%Y/%m', so remove the day from the date and print only the year and the month of
# for i in range(0, len(df_m['DATA'])):
    #df_m['DATA'][i] = df_m['DATA'][i][:-3]
    plt.xticks(rotation=45, ticks=df_m['DATA'])

    # Add the value of the number of validations of the target ticket code or type for each month
    for i in range(0, len(df_m['DATA'])):
        plt.text(x=df_m['DATA'][i], y=df_m['SERIALE'][i], s=df_m['SERIALE'][i], ha='center', va='bottom', fontsize=

    # Add a grid
    plt.grid(axis='y', linestyle='--')

    plt.show()

def min_max_number_of_tickets_per_month(df_m: pd.DataFrame, target_ticket_code_or_type: str, is_ticket_code: bool)
    """
        This function prints the month with the highest and the month with the lowest number of validations of the
        :param df: the dataframe
        :param target_ticket_code_or_type: the ticket code or ticket type
        :param is_ticket_code: a boolean that specifies if the target is a ticket code or a ticket type
        :return: None
    """
    # Convert DATA to datetime
    df_m['DATA'] = pd.to_datetime(df_m['DATA'], format='%Y/%m/%d')
    # Set all the values of the date on the first day of the month
    df_m['DATA'] = df_m['DATA'].dt.strftime('%Y-%m-01')

    # Group the dataframe by date and hour and count the number of validations of the specified ticket code
    df_m = df_m.groupby('DATA').count()['SERIALE'].reset_index()

    max = df_m[df_m['SERIALE'] == df_m['SERIALE'].max()]
    min = df_m[df_m['SERIALE'] == df_m['SERIALE'].min()]

    # Composing the string to print the result, specifying:
    # - if the target is a ticket code or a ticket type,
    # - converting the date to string format '%Y-%m-%d' and
    # - if is a ticket code, getting the description of the ticket code
    if is_ticket_code:
        # Get the description of the ticket code
        descr = ' - "' + get_ticket_code_description(target_ticket_code_or_type) + '"'
    else:
        descr = ''
    s = 'The {} number of validations of the {} "{}"' + descr + ' was the month {} with {} validations.'
    for i in range(0, 2):
        if i == 0:
            if is_ticket_code:
                print(s.format('highest', 'ticket code', target_ticket_code_or_type, max['DATA'].values[0][:-3], ma
            else:
                print(s.format('highest', 'ticket type', target_ticket_code_or_type, max['DATA'].values[0][:-3], ma
        else:
            if is_ticket_code:
                print(s.format('lowest', 'ticket code', target_ticket_code_or_type, min['DATA'].values[0][:-3], min
            else:
                print(s.format('lowest', 'ticket type', target_ticket_code_or_type, min['DATA'].values[0][:-3], min
```

```
In [ ]: # Focus on all TICKET_CODEs
def focus_on_all_ticket_codes(df_tca: pd.DataFrame, dictionary: str) -> None:
    """
        This function focuses on the different ticket codes.
        :param df_tca: the dataframe
        :param dictionary: the dictionary with the ticket codes and their description
        :return: None
    """
    # Open the dictionary
    import json
    with open(dictionary) as json_file:
        dict_ticket_code = json.load(json_file)

    for ticket_code in dict_ticket_code.keys():
        # Select only the rows of the specified ticket code
        df_tca_sup = focus_on_ticket_code(df_tca, ticket_code)
        # If the dataframe is empty, skip the ticket code but launch a warning
        if df_tca_sup.shape[0] == 0:
            print('WARNING: There are no validations of the ticket code "{}"'.format(ticket_code))
        else:
            # If the dataframe is not empty, focus on the ticket code
            df_tc = focus_on_ticket_code(df_tca_sup, ticket_code)
            number_of_tickets_per_day(df_tc, ticket_code, is_ticket_code=True)
            min_max_number_of_tickets_per_day(df_tc, ticket_code, is_ticket_code=True)
            barplot_number_of_tickets_per_month(df_tc, ticket_code, is_ticket_code=True)
            min_max_number_of_tickets_per_month(df_tc, ticket_code, is_ticket_code=True)
```

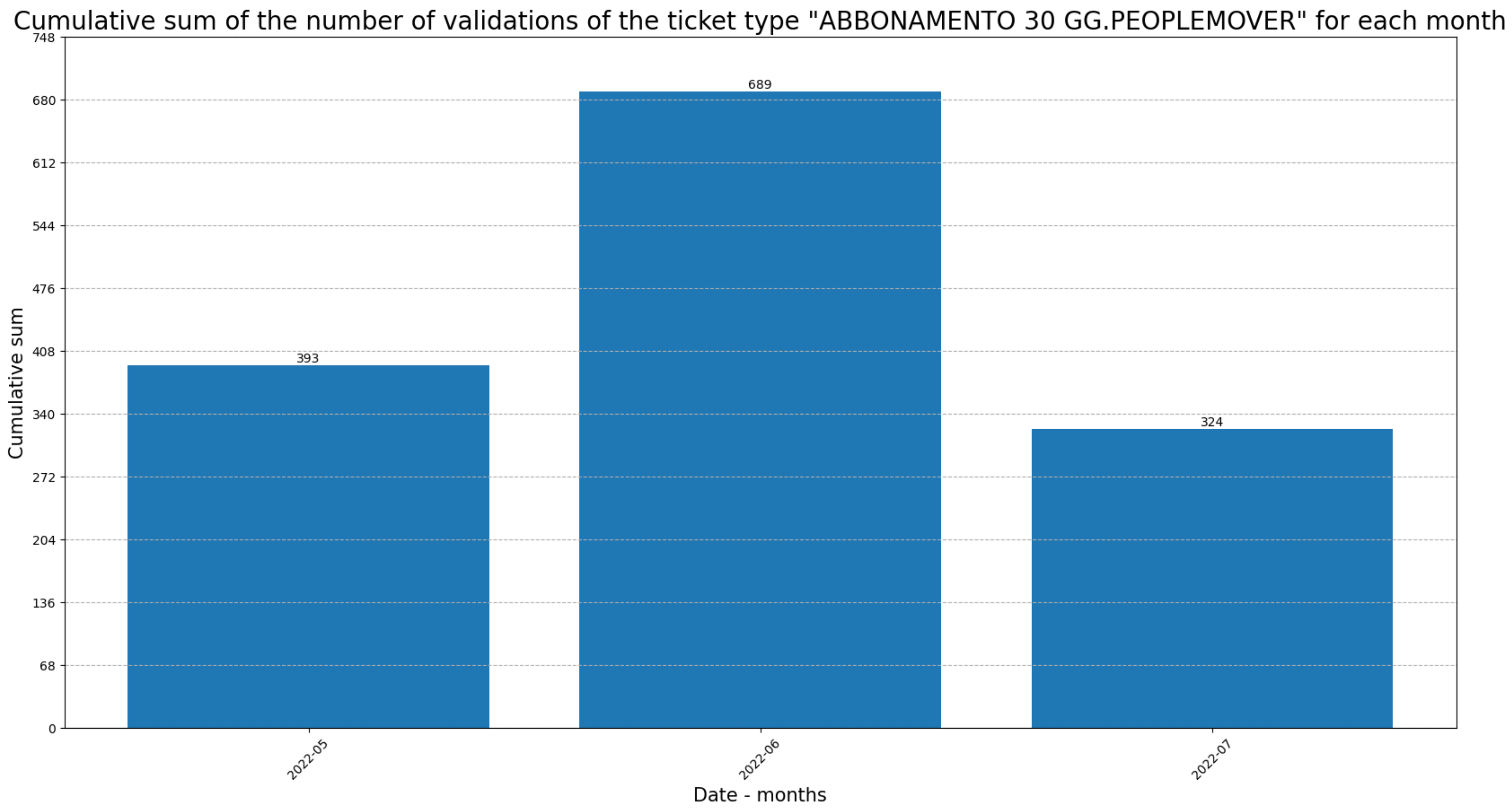
Focus on the type of ticket named ***abbonamento 30 gg.PeopleMover***

The ticket is valid for 30 days and allows you to use the PeopleMover service.

In [ ]:
```python
target_ticket = "abbonamento 30 gg.PeopleMover".upper()
# target_ticket = "48ORE ONLINE AEROBUS CS".upper()
df_PM = focus_on_ticket_type(df, target_ticket)
if df_PM.shape[0] == 0:
    print('WARNING: There are no validations of the ticket type "{}"'.format(target_ticket))
else:
    number_of_tickets_per_day(df_PM, target_ticket, is_ticket_code=False)
    min_max_number_of_tickets_per_day(df_PM, target_ticket, is_ticket_code=False)
    barplot_number_of_tickets_per_month(df_PM, target_ticket, is_ticket_code=False)
    min_max_number_of_tickets_per_month(df_PM, target_ticket, is_ticket_code=False)
```



```
The highest number of validations of the ticket type "ABBONAMENTO 30 GG.PEOPLEMOVER" was 2022-06-09 with 55 valida
tions
The lowest number of validations of the ticket type "ABBONAMENTO 30 GG.PEOPLEMOVER" was 2022-06-26 with 5 validati
ons
```



```
The highest number of validations of the ticket type "ABBONAMENTO 30 GG.PEOPLEMOVER" was the month 2022-06 with 68
9 validations.
The lowest number of validations of the ticket type "ABBONAMENTO 30 GG.PEOPLEMOVER" was the month 2022-07 with 324
validations.
```

Focus on ticket codes

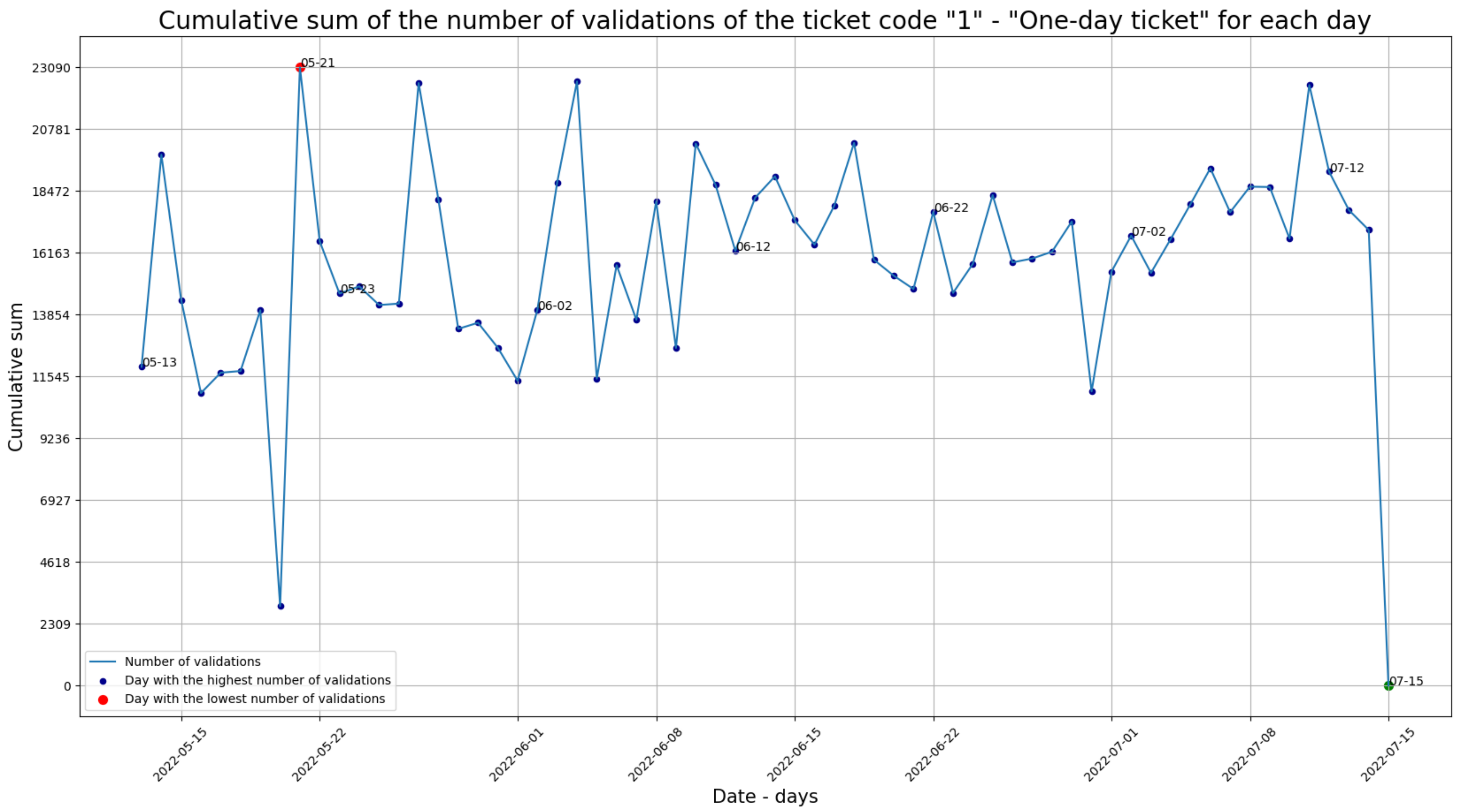
In [ ]:
```
df.head()
```

Out[ ]:

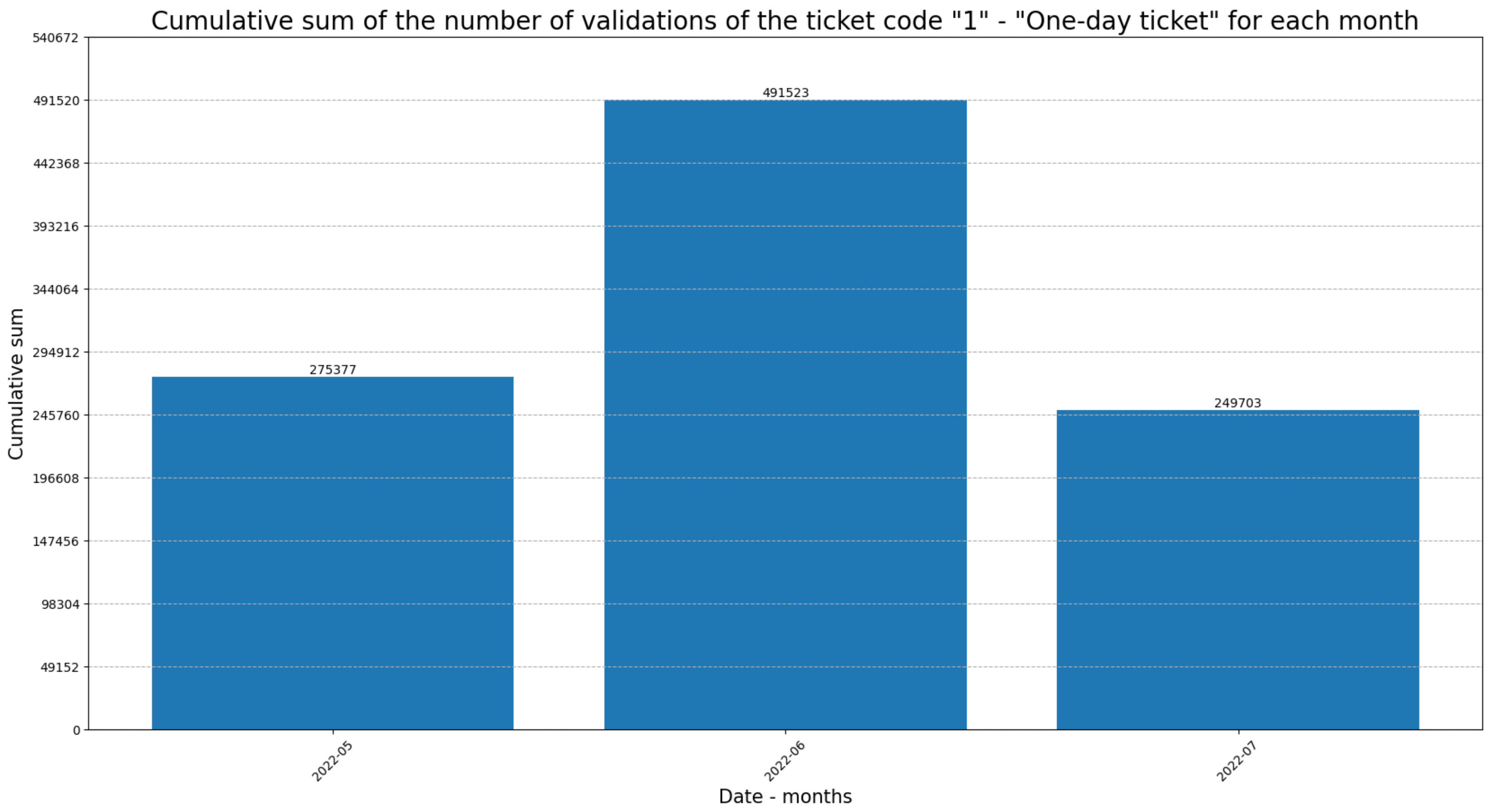
	DATA	ORA	DATA_VALIDAZIONE	SERIALE	FERMATA	DESCRIZIONE	TITOLO	TICKET_CODE	DESCRIZIONE_TITOLO
0	2022-05-13	00:00:00	2022-05-13 00:00:00	65676291870913797	5089	FERROVIA	11149	4	7GG-TPL 43,60-COMVE16,40
1	2022-05-13	00:00:00	2022-05-13 00:00:00	36141384536591364	5032	FERROVIA	11107	2	48H-TPL 24,90-COMVE5,10
2	2022-05-13	00:00:00	2022-05-13 00:00:00	36144856606063108	5031	P.LE ROMA	11108	3	72H-TPL 33,40-COMVE6,60
3	2022-05-13	00:00:00	2022-05-13 00:00:00	36144856474364932	506	VENEZIA	11261	1	DAILY PASS VENEZIA - AVM
4	2022-05-13	00:00:00	2022-05-13 00:00:00	36144856606062852	5031	P.LE ROMA	11108	3	72H-TPL 33,40-COMVE6,60

In [ ]:
```
# Convert the column ticket_code to string
df['TICKET_CODE'] = df['TICKET_CODE'].astype(str)
```

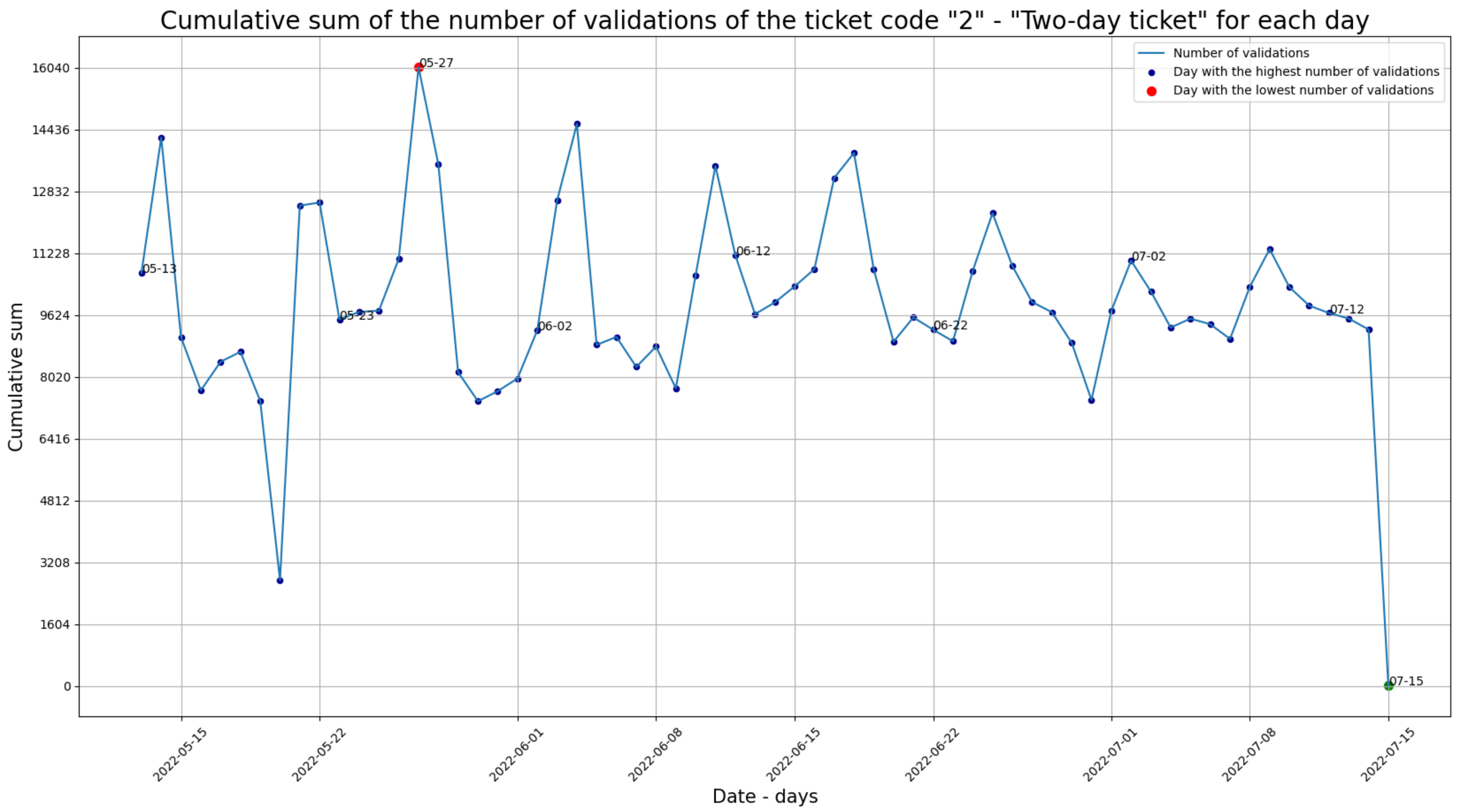
In [ ]:
```
# The TICKET_CODEs are in the dictionary "dict_ticket_codes.json", created in Notebook 1
focus_on_all_ticket_codes(df, 'data/dictionaries/dict_ticket_codes.json')
```



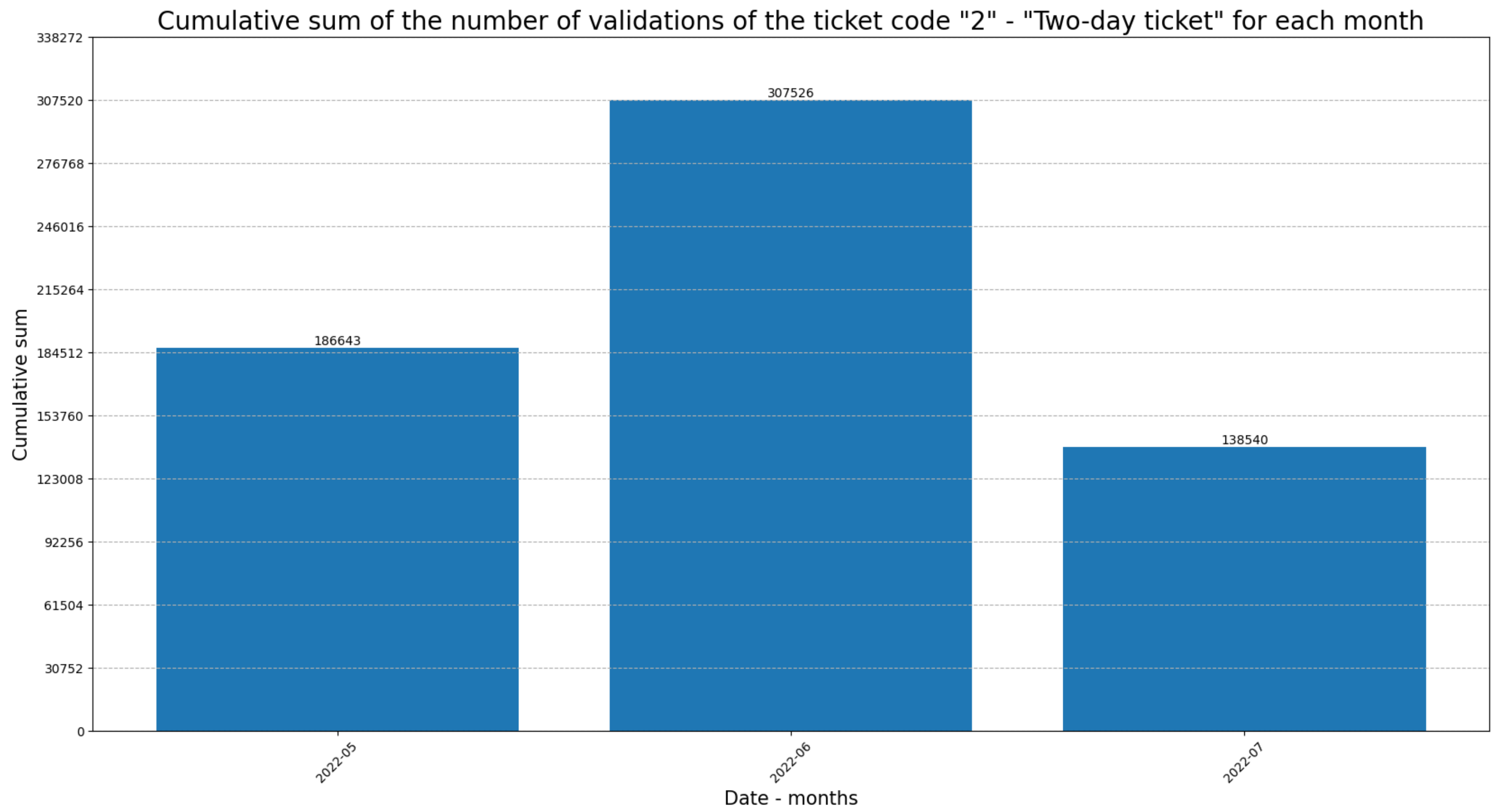
```
The highest number of validations of the ticket code "1" – "One–day ticket" was 2022–05–21 with 23091 validations
The lowest number of validations of the ticket code "1" – "One–day ticket" was 2022–07–15 with 7 validations
```



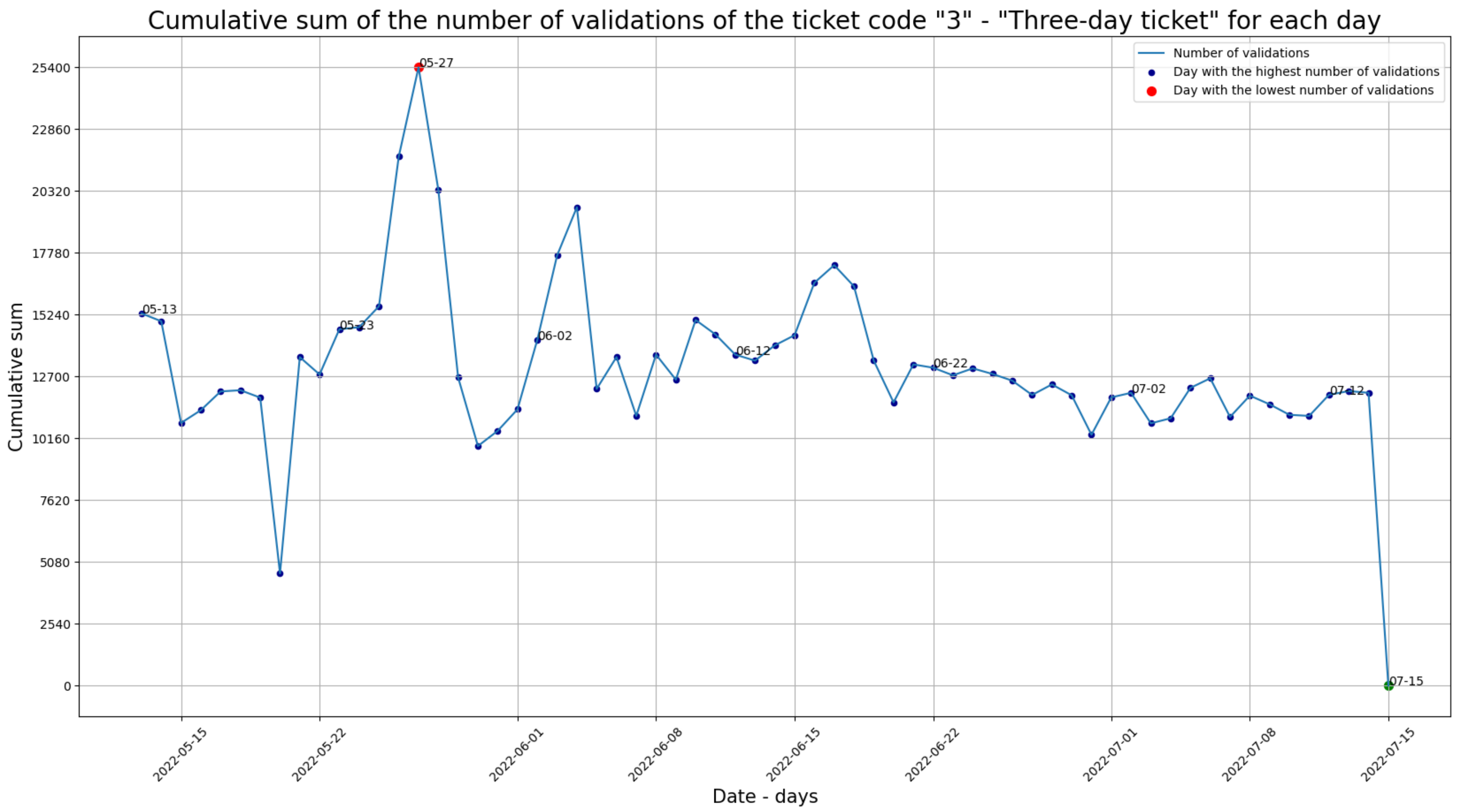
```
The highest number of validations of the ticket code "1" − "One−day ticket" was the month 2022−06 with 491523 vali
dations.
The lowest number of validations of the ticket code "1" − "One−day ticket" was the month 2022−07 with 249703 valid
ations.
```



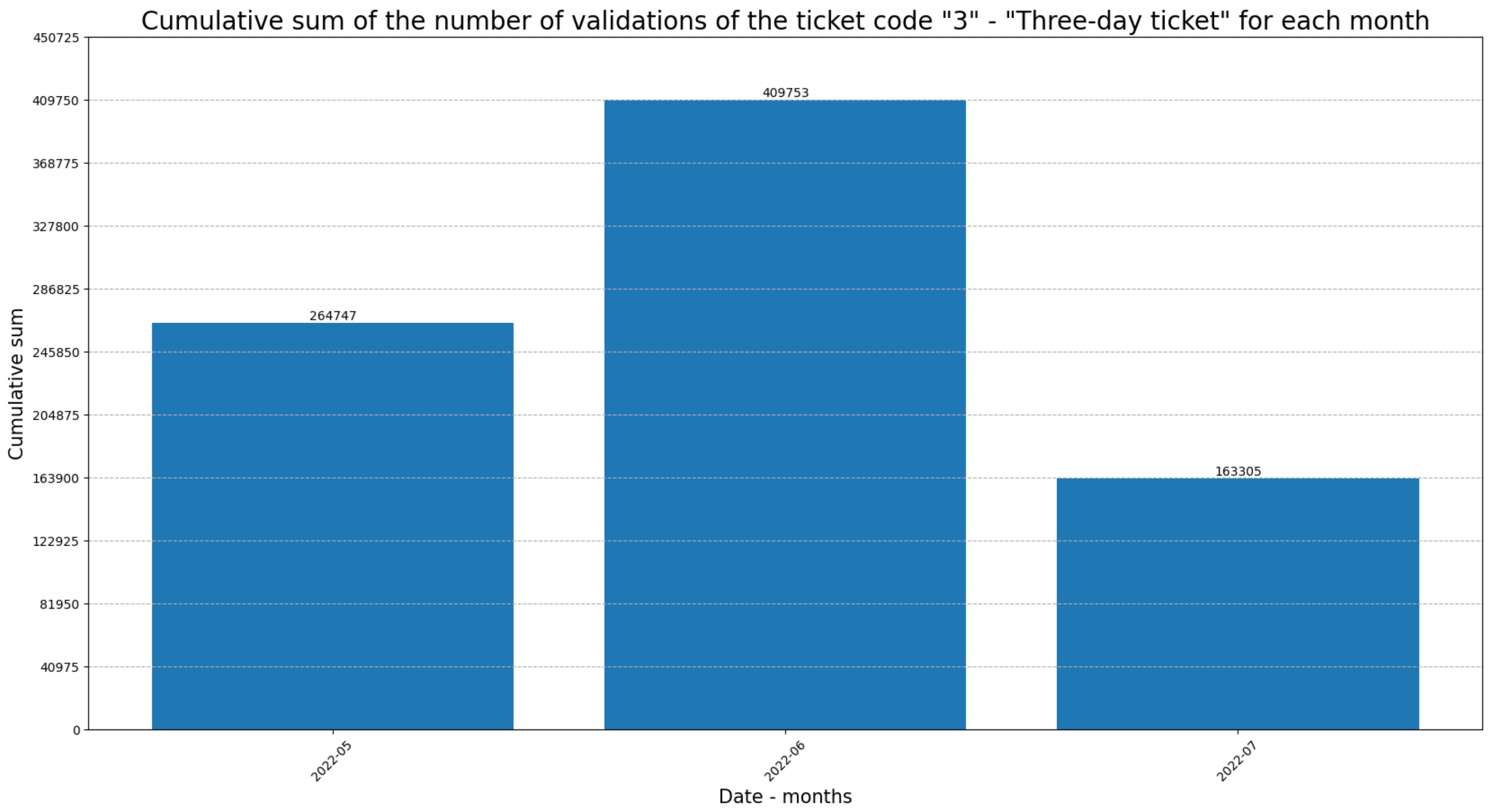
```
The highest number of validations of the ticket code "2" – "Two–day ticket" was 2022–05–27 with 16049 validations
The lowest number of validations of the ticket code "2" – "Two–day ticket" was 2022–07–15 with 6 validations
```



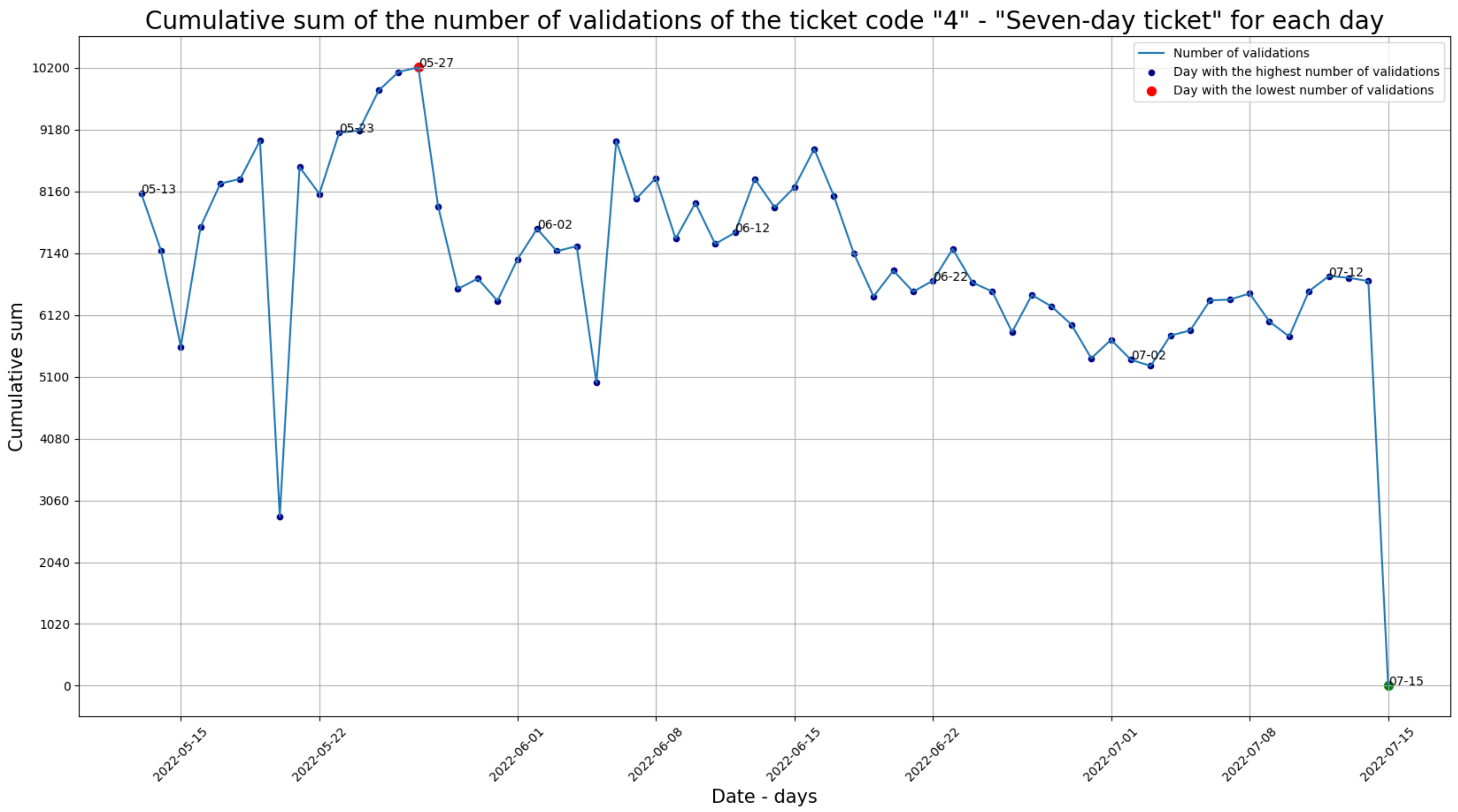
```
The highest number of validations of the ticket code "2" – "Two–day ticket" was the month 2022–06 with 307526 vali
dations.
The lowest number of validations of the ticket code "2" – "Two–day ticket" was the month 2022–07 with 138540 valid
ations.
```



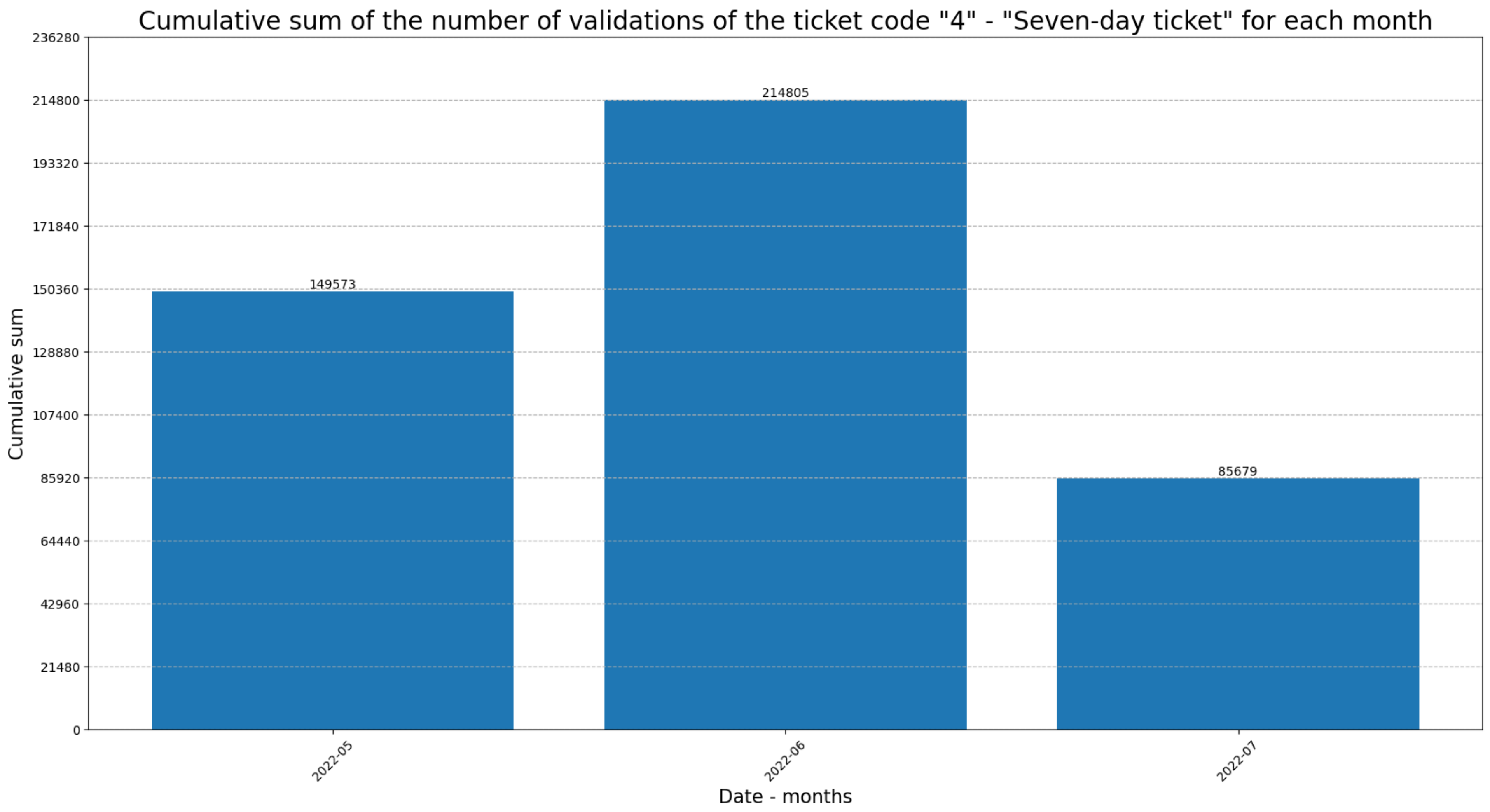
```
The highest number of validations of the ticket code "3" – "Three–day ticket" was 2022–05–27 with 25400 validation
s
The lowest number of validations of the ticket code "3" – "Three–day ticket" was 2022–07–15 with 6 validations
```



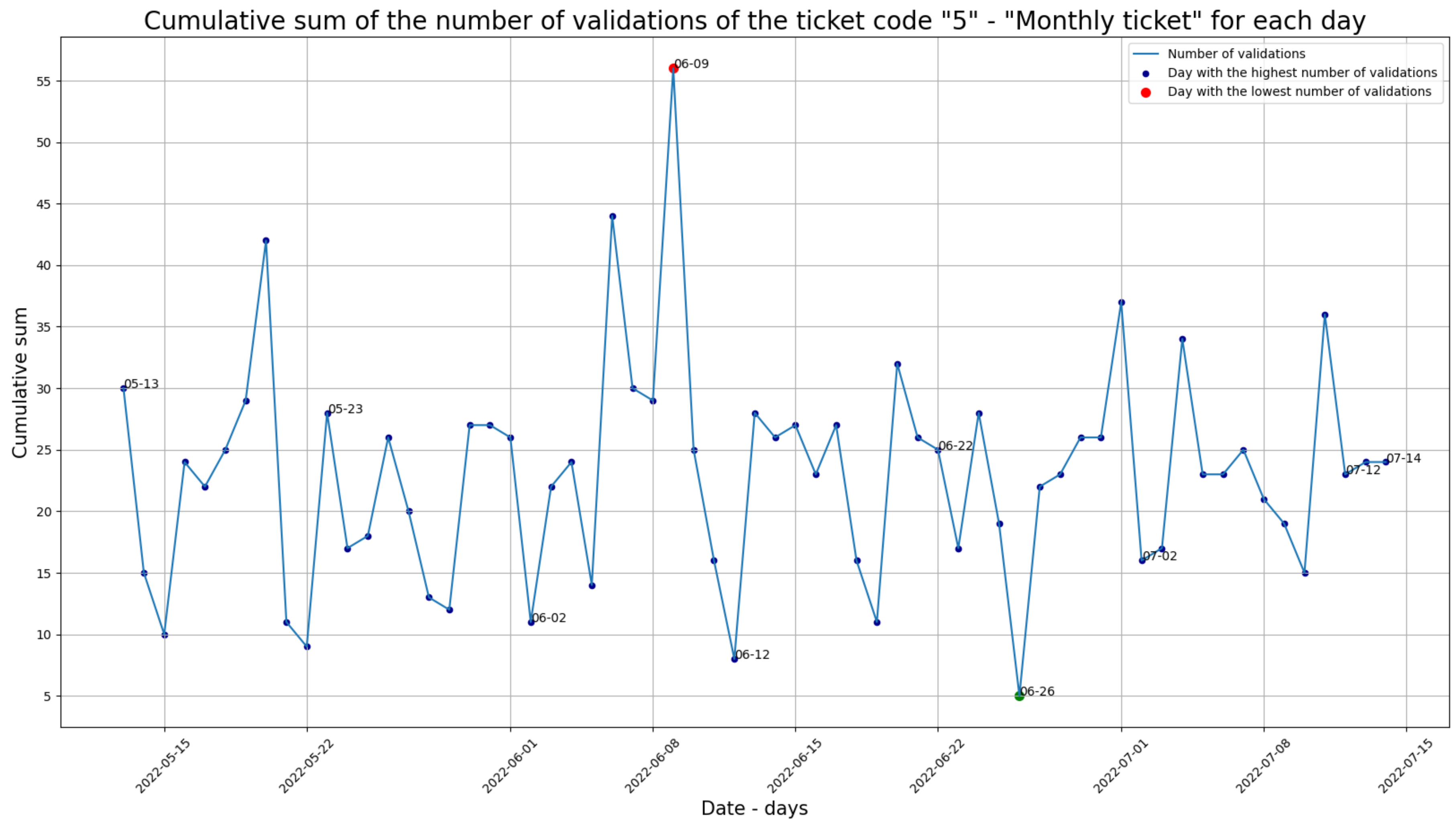
The highest number of validations of the ticket code "3" – "Three–day ticket" was the month 2022–06 with 409753 validations.
The lowest number of validations of the ticket code "3" – "Three–day ticket" was the month 2022–07 with 163305 validations.



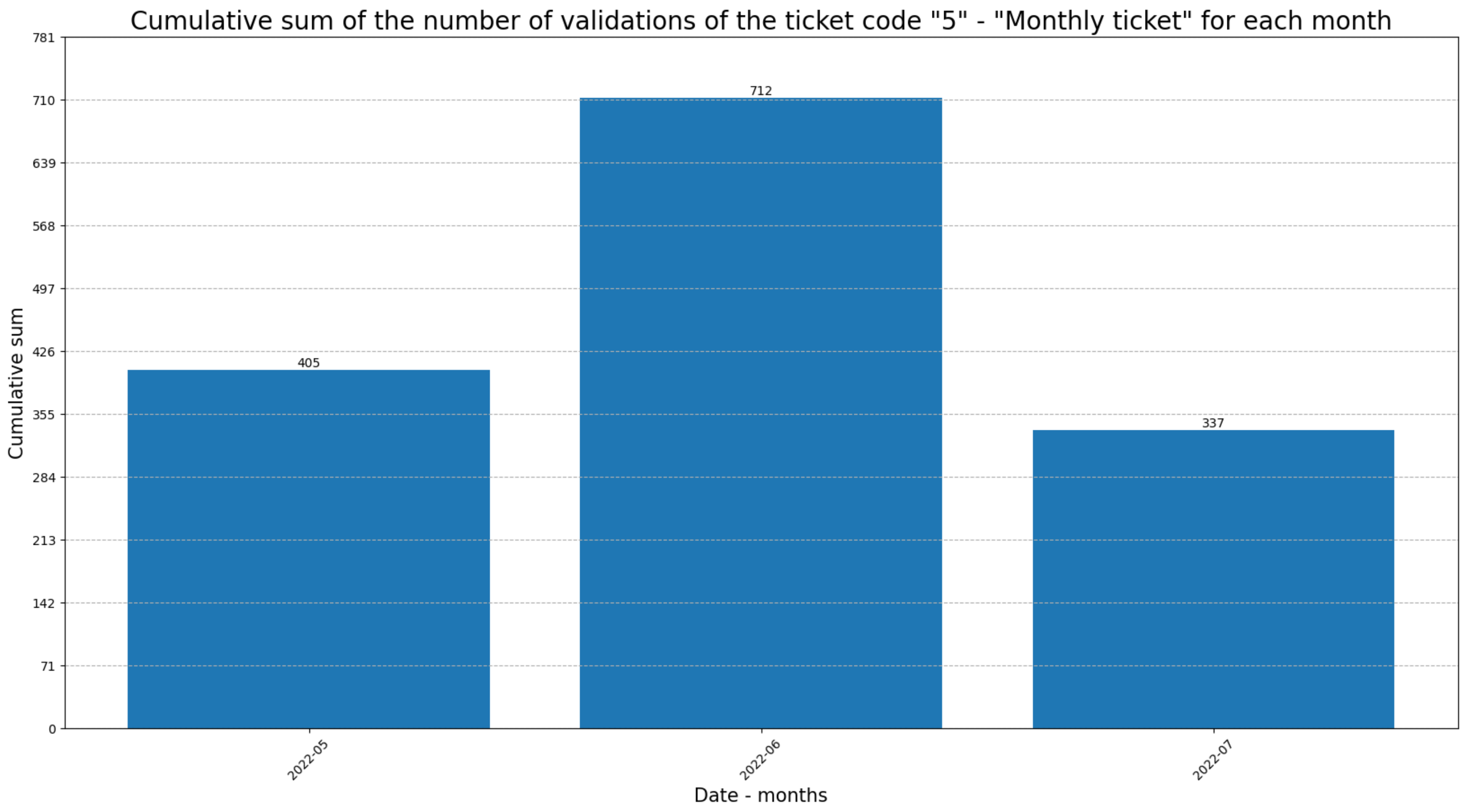
```
The highest number of validations of the ticket code "4" - "Seven-day ticket" was 2022-05-27 with 10206 validation
s
The lowest number of validations of the ticket code "4" - "Seven-day ticket" was 2022-07-15 with 3 validations
```



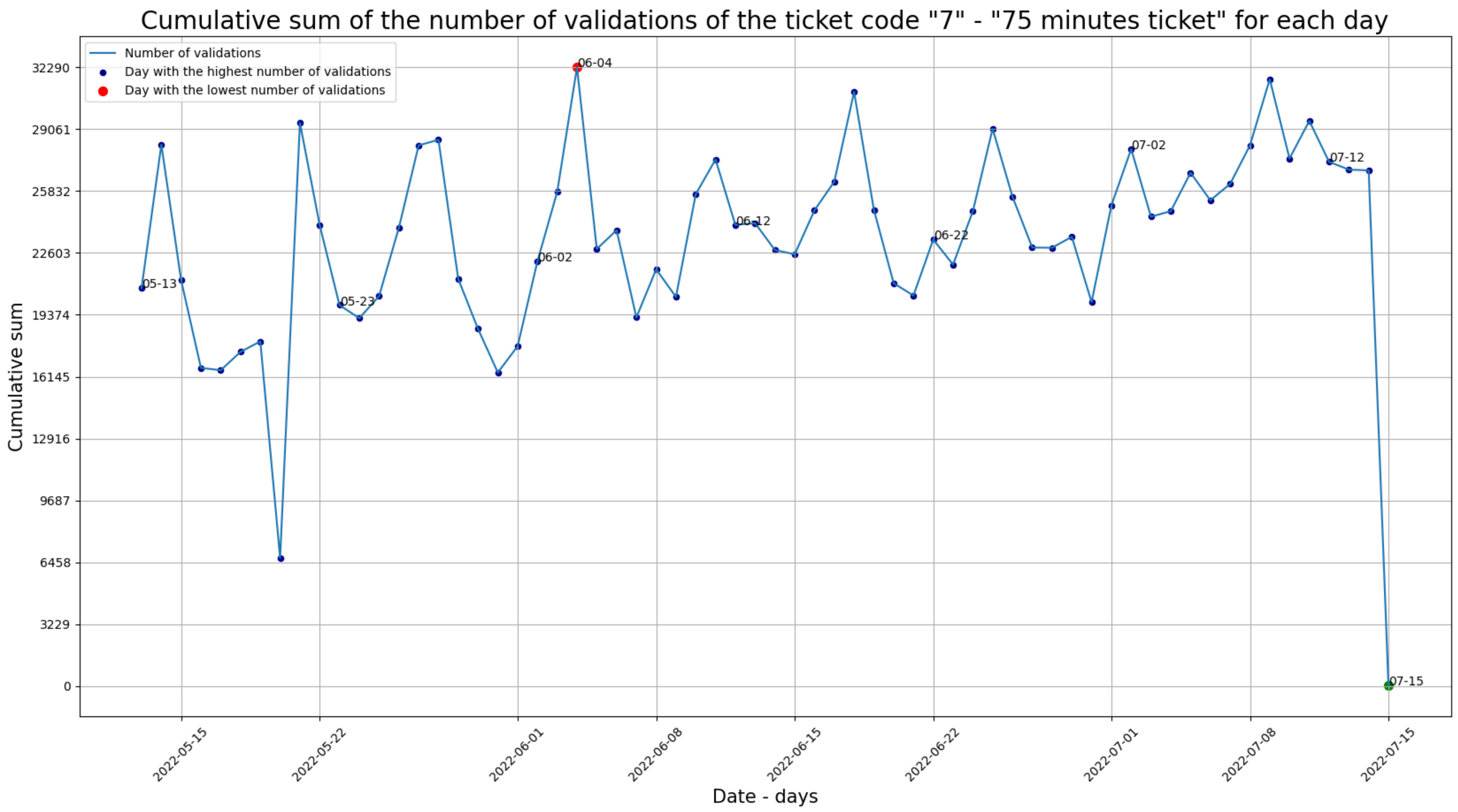
```
The highest number of validations of the ticket code "4" - "Seven-day ticket" was the month 2022-06 with 214805 va
lidations.
The lowest number of validations of the ticket code "4" - "Seven-day ticket" was the month 2022-07 with 85679 vali
dations.
```



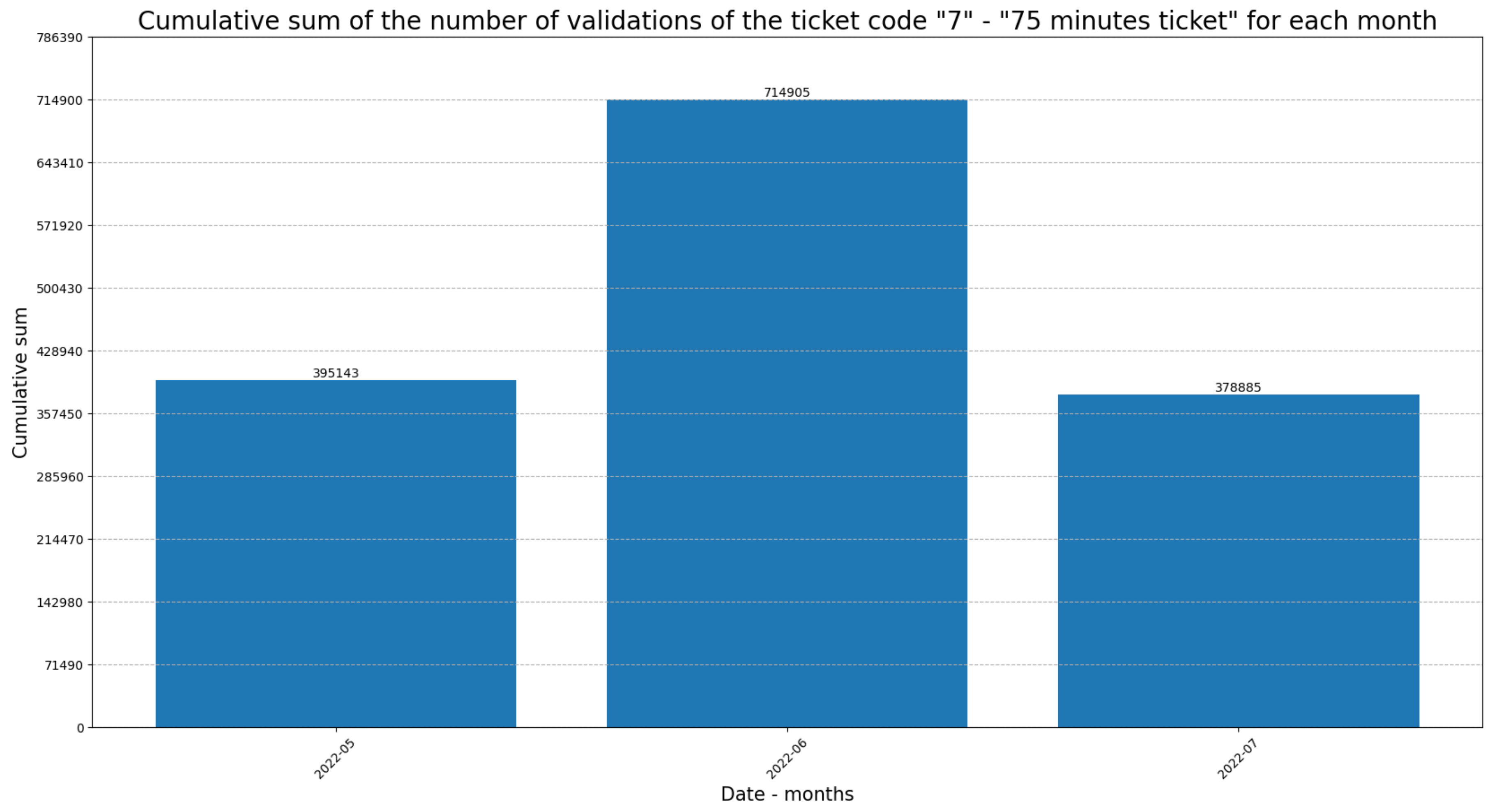
```
The highest number of validations of the ticket code "5" – "Monthly ticket" was 2022–06–09 with 56 validations
The lowest number of validations of the ticket code "5" – "Monthly ticket" was 2022–06–26 with 5 validations
```



```
The highest number of validations of the ticket code "5" - "Monthly ticket" was the month 2022-06 with 712 validat
ions.
The lowest number of validations of the ticket code "5" - "Monthly ticket" was the month 2022-07 with 337 validati
ons.
WARNING: There are no validations of the ticket code "5-STUD"
WARNING: There are no validations of the ticket code "5-RET"
WARNING: There are no validations of the ticket code "5-WKRS"
WARNING: There are no validations of the ticket code "6"
WARNING: There are no validations of the ticket code "6-STUD"
WARNING: There are no validations of the ticket code "6-RET"
WARNING: There are no validations of the ticket code "6-WKRS"
```



```
The highest number of validations of the ticket code "7" - "75 minutes ticket" was 2022-06-04 with 32294 validatio
ns
The lowest number of validations of the ticket code "7" - "75 minutes ticket" was 2022-07-15 with 19 validations
```

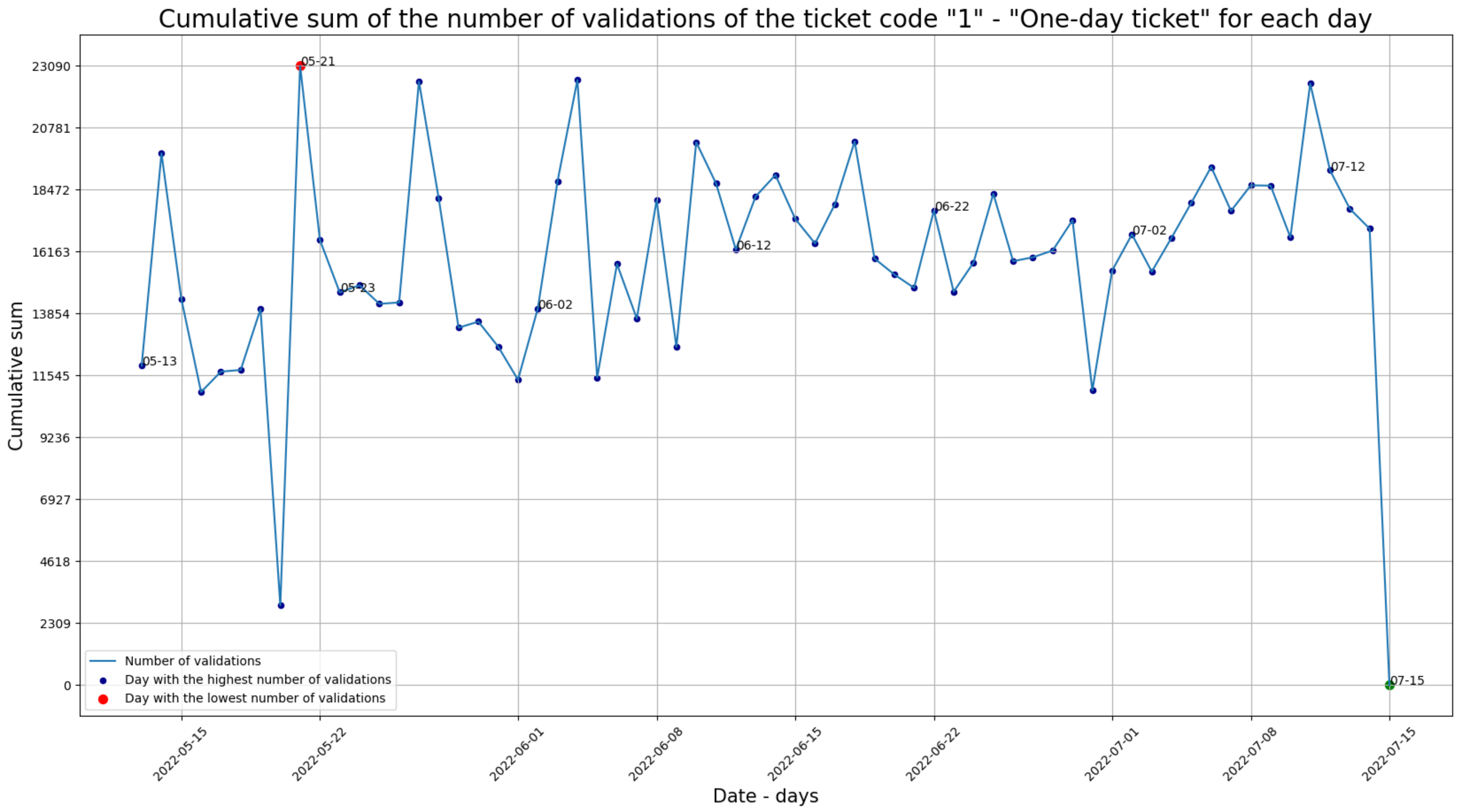


```
The highest number of validations of the ticket code "7" - "75 minutes ticket" was the month 2022-06 with 714905 v
alidations.
The lowest number of validations of the ticket code "7" - "75 minutes ticket" was the month 2022-07 with 378885 va
lidations.
WARNING: There are no validations of the ticket code "8"
```

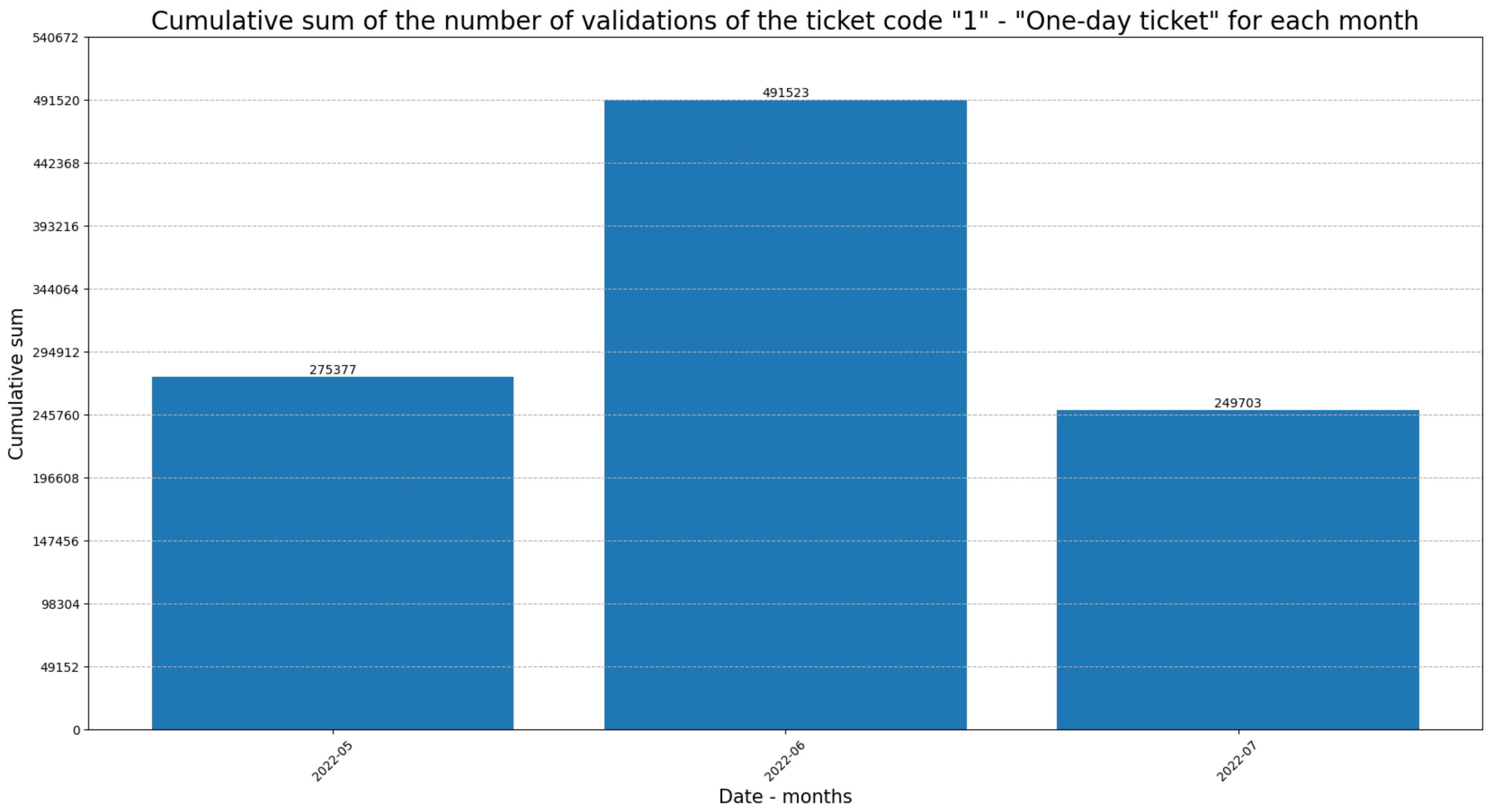
Focus on the ticket code *1*

In [ ]:
```
# Focus on TICKET_CODE = 1
target_ticket_code = '1'
```

```python
df_tc1 = focus_on_ticket_code(df, target_ticket_code)
if df_tc1.shape[0] == 0:
    print('WARNING: There are no validations of the ticket code "{}"'.format(target_ticket_code))
else:
    number_of_tickets_per_day(df_tc1, target_ticket_code, is_ticket_code=True)
    min_max_number_of_tickets_per_day(df_tc1, target_ticket_code, is_ticket_code=True)
    barplot_number_of_tickets_per_month(df_tc1, target_ticket_code, is_ticket_code=True)
```



```
The highest number of validations of the ticket code "1" - "One-day ticket" was 2022-05-21 with 23091 validations
The lowest number of validations of the ticket code "1" - "One-day ticket" was 2022-07-15 with 7 validations
```



Focus on SERIALE

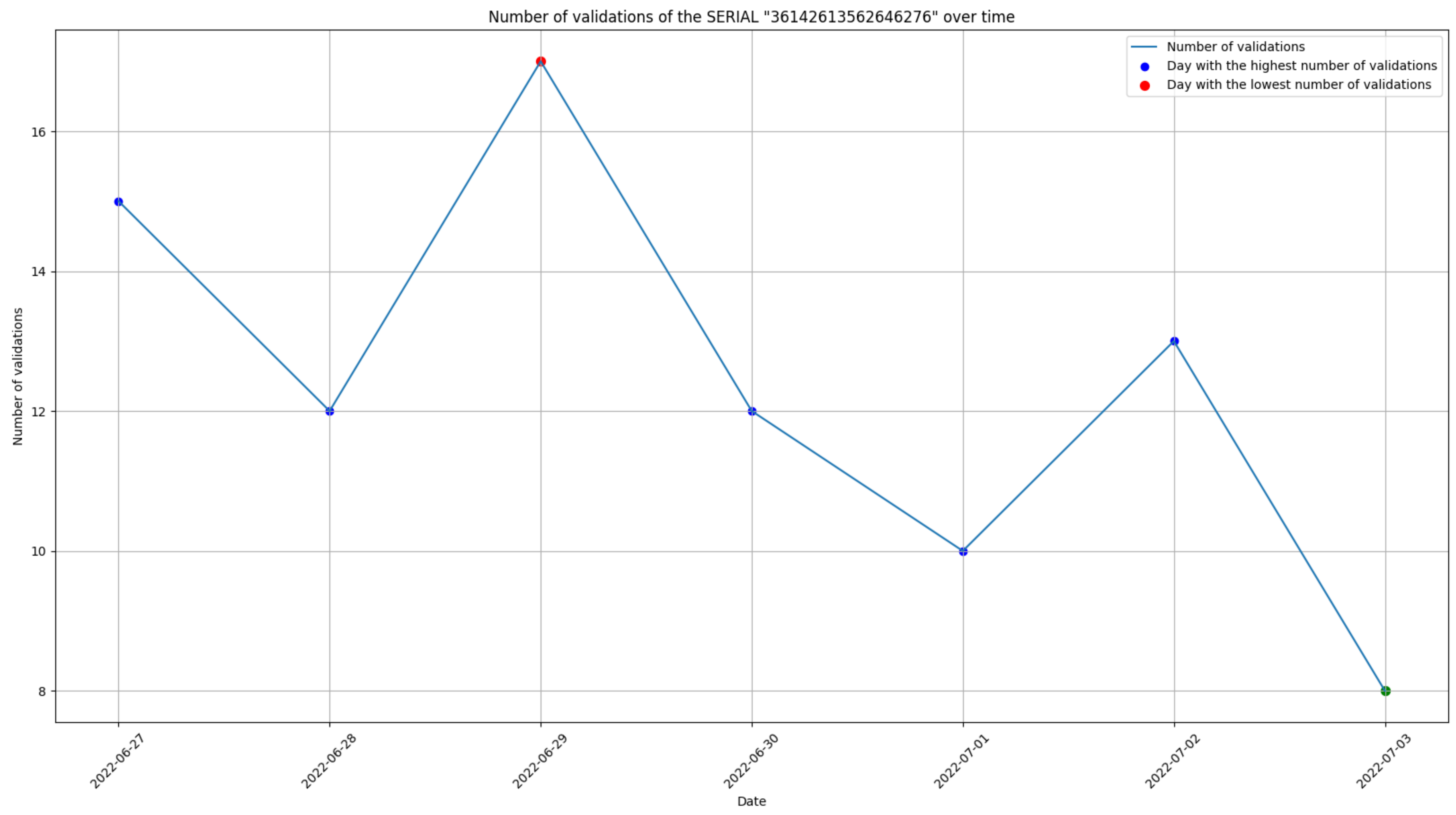
The SERIALEs represent the different users.

```
In [ ]: def focus_on_serial(df_s: pd.DataFrame, serial: str):
            """
                This function focuses on the specified SERIAL.
```

```python
        :param df: the dataframe
        :param serial: the SERIAL
        :return: the dataframe focused on the specified SERIAL
    """
    return df_s[df_s['SERIALE'] == serial]

# Focus on serial over time (all the validations of the SERIAL)
def focus_on_serial_over_time(df_s: pd.DataFrame, serial: str):
    """
        This function focuses on the specified SERIAL over time.
        :param df: the dataframe
        :param serial: the SERIAL of the user
        :return: None
    """
    # Select only the rows of the specified SERIAL
    df_sup = focus_on_serial(df_s, serial)
    # If the dataframe is empty, skip the SERIAL but launch a warning
    if df_sup.shape[0] == 0:
        print('WARNING: There are no validations of the SERIAL "{}"'.format(serial))
    else:
        # If the dataframe is not empty, focus on the SERIAL
        df_s = focus_on_serial(df_sup, serial)
        # Convert DATA to datetime
        df_s['DATA'] = pd.to_datetime(df_s['DATA'], format='%Y/%m/%d')
        # Set all the values of the date on the first day of the month
        df_s['DATA'] = df_s['DATA'].dt.strftime('%Y-%m-%d')
        # Group the dataframe by date and hour and count the number of validations of the specified ticket code
        df_s = df_s.groupby('DATA').count()['SERIALE'].reset_index()
        # Plot the number of validations per day
        plt.figure(figsize=(20, 10))
        plt.plot(df_s['DATA'], df_s['SERIALE'])
        # Add points to the plot
        plt.scatter(df_s['DATA'], df_s['SERIALE'], color='blue')
        plt.title('Number of validations of the SERIAL "{}" over time'.format(serial))
        plt.xlabel('Date')
        plt.ylabel('Number of validations')
        plt.xticks(rotation=45, ticks=df_s['DATA'])

        # Manage the y-axis
        if df_s['SERIALE'].max() < 10:
            plt.yticks(ticks=range(0, df_s['SERIALE'].max() + 6))
        else:
            plt.yticks(ticks=range(0, df_s['SERIALE'].max() + 6, 2))

        # Highlight the day with the highest number of validations and the day with the lowest number of validation
        max = df_s[df_s['SERIALE'] == df_s['SERIALE'].max()]
        plt.scatter(max['DATA'], max['SERIALE'], color='red', s=50)
        min = df_s[df_s['SERIALE'] == df_s['SERIALE'].min()]
        plt.scatter(min['DATA'], min['SERIALE'], color='green', s=50)

        # Add the legend
        plt.legend(['Number of validations', 'Day with the highest number of validations', 'Day with the lowest num

        # Add the grid
        plt.grid()


        plt.show()
```

Focus on a specified SERIALE

In [ ]:
```
# Select the serial of the user with the highest number of validations
# Ask in input the index of the serial to focus on
index = int(input('Insert the index of the serial to focus on: '))

if index >= len(df['SERIALE'].value_counts()):
    print('WARNING: The index is not valid. The index must be less than {}'.format(len(df['SERIALE'].value_counts()
else:
    serial = df['SERIALE'].value_counts().index[index]
    df_s = focus_on_serial(df, serial)
    focus_on_serial_over_time(df_s, serial)
```



Focus on a specified period and focus on the Carnival of Venice period

```
In [ ]: def focus_on_period(df_p: pd.DataFrame, start_date: str, end_date: str):
            """
                This function focuses on the specified period.
                :param df: the dataframe
                :param start_date: the start date of the period
                :param end_date: the end date of the period
```

```python
        :return: the dataframe focused on the specified period
    """
    return df_p[(df_p['DATA'] >= start_date) & (df_p['DATA'] <= end_date)]
```

In [ ]:
```python
def focus_on_carnival_period(df_c: pd.DataFrame):
    """
        This function focuses on the Carnival of Venice period (4th of February 2023 - 21st of February 2023),
        and compares the number of validations of the different ticket codes with the number of validations of the
        ticket codes in the previous and next period (18 days before the Carnival of Venice and
        18 days after the Carnival of Venice).
        :param df: the dataframe
        :return: None
    """
    # Focus on the period 4th of February 2023 - 21st of February 2023 (the period of the Carnival of Venice)
    df_carnival = focus_on_period(df, '2023-02-04', '2023-02-21')

    # How many days are there in the Carnival of Venice?
    print('There are {} days in the Carnival of Venice'.format(df_carnival['DATA'].nunique()))

    # Search if there is an increase in the number of validations of the ticket code 1 during the Carnival of Venic
    # Create a dataframe of 18 days before the Carnival of Venice and 18 days after the Carnival of Venice
    df_no_carnival_prev = focus_on_period(df, '2023-01-17', '2023-02-03')
    df_no_carnival_next = focus_on_period(df, '2023-02-22', '2023-03-12')

    # For each ticket code, find the average number of validations and compare it with the average number of valida
    # Use the ticket code contained in the dictionary
    with open('data/dictionaries/dict_ticket_codes.json') as json_file:
        ticket_codes = json.load(json_file)

    for ticket_code in ticket_codes:

        # Get the description of the ticket code
        description = ticket_codes[ticket_code]

        # Focus on the ticket code
        df_tc_prev = focus_on_ticket_code(df_no_carnival_prev, ticket_code)
        df_tc_next = focus_on_ticket_code(df_no_carnival_next, ticket_code)
        # If the dataframe is empty, skip the ticket code but launch a warning
        if df_tc_prev.shape[0] == 0 or df_tc_next.shape[0] == 0 and ticket_code != '8':
            print('WARNING: There are no validations of the ticket code "{}"'.format(ticket_code))
        else:
            # If the dataframe is not empty, focus on the ticket code
            df_tc_prev = focus_on_ticket_code(df_no_carnival_prev, ticket_code)
            df_tc_next = focus_on_ticket_code(df_no_carnival_next, ticket_code)
            # Convert DATA to datetime
            df_tc_prev['DATA'] = pd.to_datetime(df_tc_prev['DATA'], format='%Y/%m/%d')
            df_tc_next['DATA'] = pd.to_datetime(df_tc_next['DATA'], format='%Y/%m/%d')
            # Set all the values of DATA to the same format
            df_tc_prev['DATA'] = df_tc_prev['DATA'].dt.strftime('%Y-%m-%d')
            df_tc_next['DATA'] = df_tc_next['DATA'].dt.strftime('%Y-%m-%d')
            # Group the dataframe by date and hour and count the number of validations of the specified ticket code
            df_tc_prev = df_tc_prev.groupby('DATA').count()['TICKET_CODE'].reset_index()
            df_tc_next = df_tc_next.groupby('DATA').count()['TICKET_CODE'].reset_index()
            # Find the average number of validations of the ticket code
            avg_no_carnival_prev = df_tc_prev['TICKET_CODE'].mean()
            avg_no_carnival_next = df_tc_next['TICKET_CODE'].mean()

            # Focus on the period of the Carnival of Venice
            df_tc_carnival = focus_on_ticket_code(df_carnival, ticket_code)
            if df_tc_carnival.shape[0] == 0:
                print('WARNING: There are no validations of the ticket code "{}" during the Carnival of Venice'.for
            else:
                # Convert DATA to datetime
                df_tc_carnival['DATA'] = pd.to_datetime(df_tc_carnival['DATA'], format='%Y/%m/%d')
                # Set all the values of DATA to the same format
                df_tc_carnival['DATA'] = df_tc_carnival['DATA'].dt.strftime('%Y-%m-%d')
                # Group the dataframe by date and hour and count the number of validations of the specified ticket
                df_tc_carnival = df_tc_carnival.groupby('DATA').count()['TICKET_CODE'].reset_index()
                # Find the average number of validations of the ticket code
                avg_carnival = df_tc_carnival['TICKET_CODE'].mean()


                # Compare the average number of validations of the ticket code during the Carnival of Venice with t
                if avg_carnival > avg_no_carnival_prev and avg_carnival > avg_no_carnival_next:
                    print('The average number of validations of the ticket code "{} - {}" during the Carnival of Ve
                elif avg_carnival > avg_no_carnival_prev and avg_carnival < avg_no_carnival_next:
                    print('The average number of validations of the ticket code "{} - {}" during the Carnival of Ve
                elif avg_carnival < avg_no_carnival_prev and avg_carnival > avg_no_carnival_next:
                    print('The average number of validations of the ticket code "{} - {}" during the Carnival of Ve
                elif avg_carnival < avg_no_carnival_prev and avg_carnival < avg_no_carnival_next:
```

```
            print('The average number of validations of the ticket code "{} - {}" during the Carnival of Ve
        else:
            print('The average number of validations of the ticket code "{} - {}" during the Carnival of Ve


        # Represent these information in a plot
        plt.figure(figsize=(20, 10))
        plt.plot(df_tc_prev['DATA'], df_tc_prev['TICKET_CODE'], label='Previous period', color='blue')
        plt.plot(df_tc_carnival['DATA'], df_tc_carnival['TICKET_CODE'], label='Carnival of Venice', color='
        plt.plot(df_tc_next['DATA'], df_tc_next['TICKET_CODE'], label='Next period', color='green')

        plt.title('Average number of validations of the ticket code {} - "{}" during the Carnival of Venice
        plt.xlabel('Date')
        plt.ylabel('Number of validations')

        # Hihglight the period of the Carnival of Venice in the plot (2023-02-04', '2023-02-21')
        plt.axvspan('2023-02-04', '2023-02-22', alpha=0.5, color='lightgrey')

        # Color the x-axis labels according to the period (previous: blue, carnival: orange, next: green)
        for label in plt.gca().get_xticklabels():
            if label.get_text() < '2023-02-04':
                label.set_color('blue')
            elif label.get_text() > '2023-02-21':
                label.set_color('green')
            else:
                label.set_color('orange')

        # For each period, add a line that represents the average number of validations of the ticket code
        # Draw these lines only in the corresponding period
        plt.axhline(y=avg_no_carnival_prev, color='blue', linestyle='--', xmin=0.05, xmax=0.35, label='Avg.
        plt.axhline(y=avg_carnival, color='orange', linestyle='--', xmin=0.35, xmax=0.65, label='Avg. numbe
        plt.axhline(y=avg_no_carnival_next, color='green', linestyle='--', xmin=0.65, xmax=0.96, label='Avg

        # For each period, add the points of the maximum and minimum number of validations of the ticket co
        # Draw these points only in the corresponding period
        plt.plot(df_tc_prev['DATA'].iloc[df_tc_prev['TICKET_CODE'].idxmax()], df_tc_prev['TICKET_CODE'].max
        plt.plot(df_tc_prev['DATA'].iloc[df_tc_prev['TICKET_CODE'].idxmin()], df_tc_prev['TICKET_CODE'].min
        plt.plot(df_tc_carnival['DATA'].iloc[df_tc_carnival['TICKET_CODE'].idxmax()], df_tc_carnival['TICKE
        plt.plot(df_tc_carnival['DATA'].iloc[df_tc_carnival['TICKET_CODE'].idxmin()], df_tc_carnival['TICKE
        plt.plot(df_tc_next['DATA'].iloc[df_tc_next['TICKET_CODE'].idxmax()], df_tc_next['TICKET_CODE'].max
                plt.plot(df_tc_next['DATA'].iloc[df_tc_next['TICKET_CODE'].idxmin()], df_tc_next['TICKET_CODE'].min

                # Make the plot more readable
                plt.xticks(rotation=45)
                plt.tight_layout()

                # Add a grid
                plt.grid()

                # Add a legend
                plt.legend()

                plt.show()
```

```
In [ ]: # Focus on the period of the Carnival of Venice (2023-02-04', '2023-02-21') and
        # comparison with the previous and the next period
        # Execute this cell only if the variable file_name is 'esportazioneCompleta'
        if file_name == 'esportazioneCompleta':
            focus_on_carnival_period(df)
        else:
            print('The analysis regarding the Carnival of Venice is available only on the dataset "esportazioneCompleta".')
```

```
The analysis regarding the Carnival of Venice is available only on the dataset "esportazioneCompleta".
```