O3_1-field-data-treatment-Diamante

February 13, 2024

1 Electrochemical O3 sensor data preprocessing

- Pollutant: Ozone
- Sensor: Alphasense OX-B4

1.1 Constants

1.1.1 Sensors IDs

1.1.2 API Constants

[ ]:
```
HOST = "renovar.lcqar.ufsc.br"
PORT = 8080
RAW_DATA_DIR = "data/raw-data-monit-fix-2022-2023-Diamante/"
RAW_FILE_NAME = "ISB_O31.CSV"

SENSOR_FILE_DIR = 'data/input/'
SENSOR_NAME = 'alpha_o3_1_conc'
SENSOR_FILE_NAME = SENSOR_NAME + 'web_dataframe.csv'
```

1.1.3 Sensor Constants

[ ]:
```
M = 48
lower_limit=15.0
upper_limit=20e3
t_90 = 80     # sensor takes 30 seconds to reach a value of 10e3
t_90_value = 1e3
sampling_period = 15 * 60
```

2 Alphasense O3 Sensor Data

[ ]:
```
import locale
locale.setlocale(locale.LC_TIME, 'pt_BR')
```

[ ]:
```
'pt_BR'
```

[ ]:
```
from GetSensorDataService import GetSensorDataService
```

```
get_sensor_data_service = GetSensorDataService(HOST, PORT)
sensor_data = get_sensor_data_service.
 ↪get_data_from_file(RAW_DATA_DIR+RAW_FILE_NAME, sensor_name=SENSOR_NAME)
sensor_data
```

```
/Users/Fernando/Documents/Projects/Github/lcqar-low-cost-monit-proc/data-pre-
processing/GetSensorDataService.py:13: UserWarning: The argument
'infer_datetime_format' is deprecated and will be removed in a future version. A
strict version of it is now the default, see
https://pandas.pydata.org/pdeps/0004-consistent-to-datetime-parsing.html. You
can safely remove this argument.
  df['DateTime'] = (pd.to_datetime(df[date_time_col],
infer_datetime_format=False, format='%d/%m/%Y/%H/%M/%S'))
```

[ ]:

	latitude	longitude	measuring	DateTime
0	-28.456899	-48.972999	105.77	2022-11-20 13:48:30
1	-28.456899	-48.972999	92.35	2022-11-21 10:40:56
2	-28.456899	-48.972999	73.28	2022-11-21 10:56:42
3	-28.456899	-48.972999	69.64	2022-11-21 11:12:31
4	-28.456899	-48.972999	77.29	2022-11-21 11:28:16
…	…	…	…	…
11671	-28.456899	-48.972999	2.38	2023-04-21 20:53:44
11672	-28.456899	-48.972999	0.40	2023-04-21 21:08:43
11673	-28.456899	-48.972999	1.69	2023-04-21 21:23:43
11674	-28.456899	-48.972999	33.83	2023-04-21 21:38:42
11675	-28.456899	-48.972999	20.38	2023-04-21 21:53:42

[11676 rows x 4 columns]

2.1 Upload Data from File

[ ]:
```
import pandas as pd

df = pd.read_csv(SENSOR_FILE_DIR + SENSOR_FILE_NAME)
df.head()
```

[ ]:

	Unnamed: 0	latitude	longitude	measuring	DateTime
0	0	-28.456899	-48.972999	105.77	2022-11-20 13:48:30
1	1	-28.456899	-48.972999	92.35	2022-11-21 10:40:56
2	2	-28.456899	-48.972999	73.28	2022-11-21 10:56:42
3	3	-28.456899	-48.972999	69.64	2022-11-21 11:12:31
4	4	-28.456899	-48.972999	77.29	2022-11-21 11:28:16

2.1.1 Create Sensor Dataframe as Pandas Series with a period of 15 mins

[ ]:
```
# Remove the first column with the indexes and save data into web dataframe
web_dataframe = df.drop(df.columns[0], axis='columns')
web_dataframe['DateTime'] = (pd.to_datetime(df['DateTime'],␣
 ↪infer_datetime_format=True))

# Resample data with 15 mins period and create sensor dataframe
sensor_dataframe = web_dataframe.sort_values(by='DateTime', ascending=True).
 ↪reset_index().drop(columns='index')
sensor_dataframe.index = sensor_dataframe['DateTime']
sensor_dataframe = sensor_dataframe.drop(columns=['DateTime'])
sensor_dataframe = sensor_dataframe.resample('15T').mean()
sensor_dataframe
```

```
/var/folders/wc/_83zcrx913j1dqwg4g90kbhh0000gp/T/ipykernel_2699/166902210.py:3:
UserWarning: The argument 'infer_datetime_format' is deprecated and will be
removed in a future version. A strict version of it is now the default, see
https://pandas.pydata.org/pdeps/0004-consistent-to-datetime-parsing.html. You
can safely remove this argument.
  web_dataframe['DateTime'] = (pd.to_datetime(df['DateTime'],
infer_datetime_format=True))
```

[ ]:

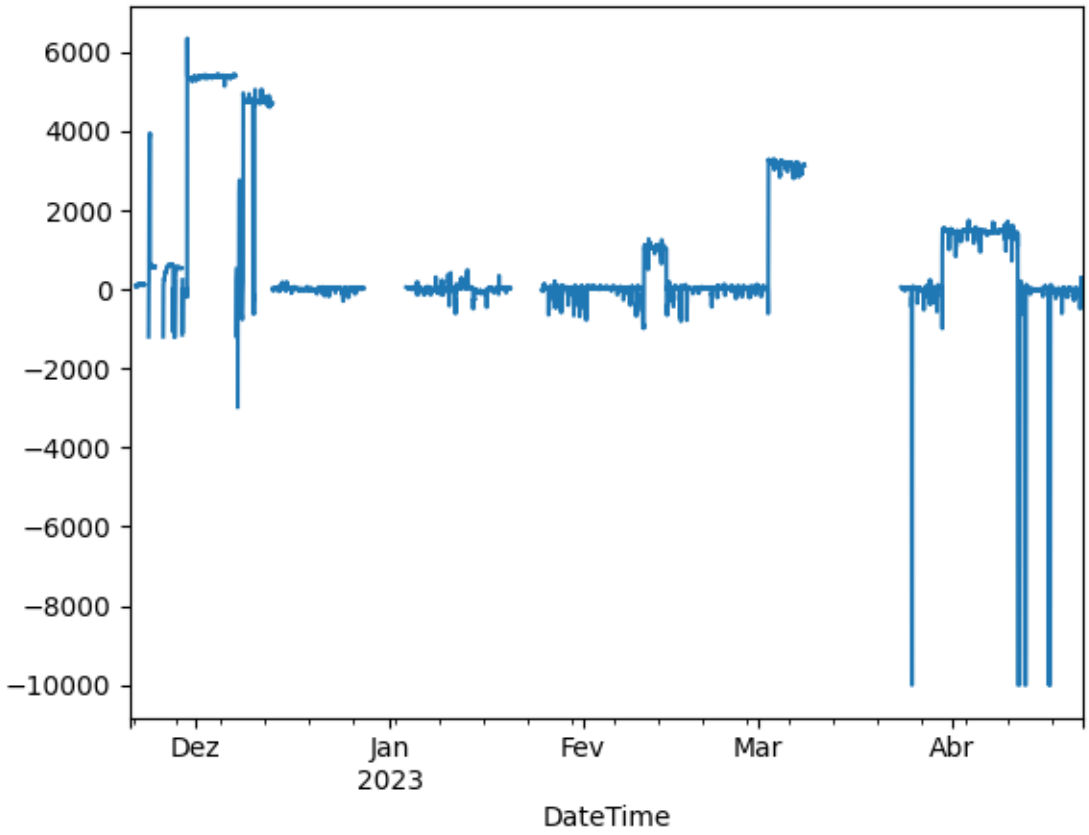
DateTime	latitude	longitude	measuring
2022-11-20 13:45:00	-28.456899	-48.972999	105.77
2022-11-20 14:00:00	NaN	NaN	NaN
2022-11-20 14:15:00	NaN	NaN	NaN
2022-11-20 14:30:00	NaN	NaN	NaN
2022-11-20 14:45:00	NaN	NaN	NaN
…	…	…	…
2023-04-21 20:45:00	-28.456899	-48.972999	2.38
2023-04-21 21:00:00	-28.456899	-48.972999	0.40
2023-04-21 21:15:00	-28.456899	-48.972999	1.69
2023-04-21 21:30:00	-28.456899	-48.972999	33.83
2023-04-21 21:45:00	-28.456899	-48.972999	20.38

[14625 rows x 3 columns]

2.1.2 Plot raw data

[ ]:
```
sensor_dataframe['measuring'].plot()
```

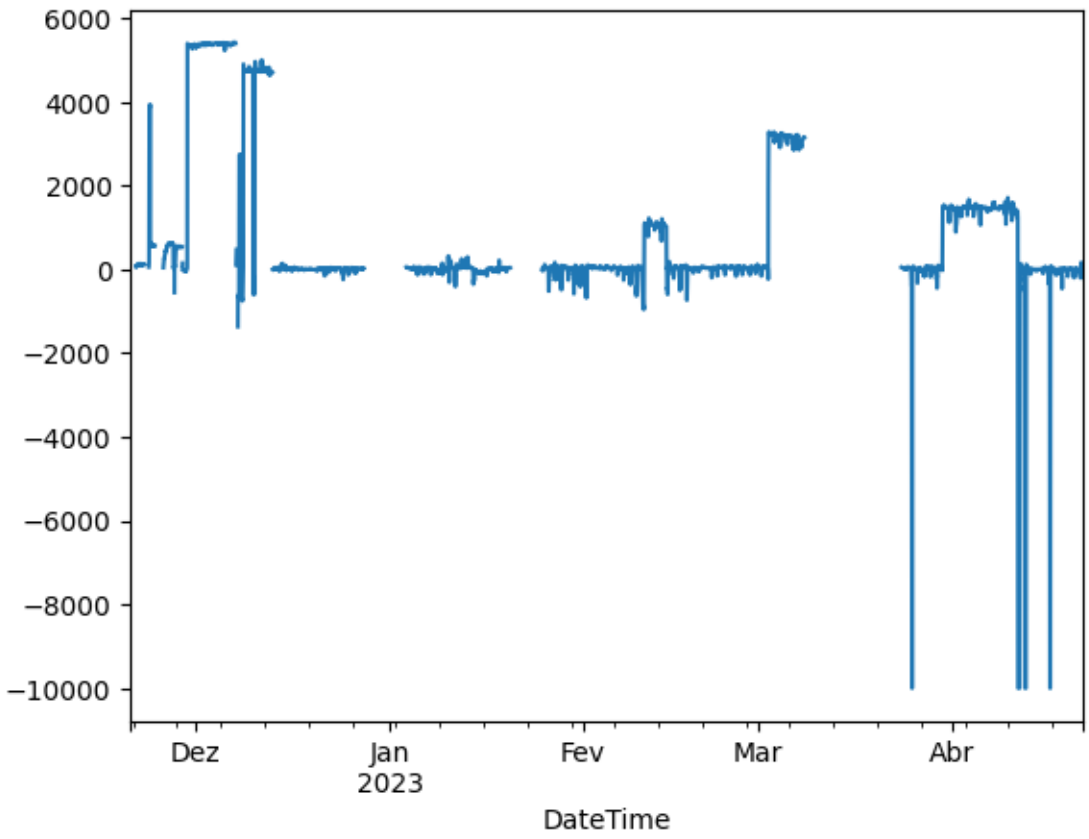
[ ]:
```
<Axes: xlabel='DateTime'>
```



2.1.3 Smooth data with a window of 4 samples, i.e.: an hour of data

[ ]:
```
sensor_dataframe['raw measuring'] = sensor_dataframe['measuring']
sensor_dataframe['measuring'] = sensor_dataframe['measuring'].rolling(window=4).
↪median()
sensor_dataframe['Hour'] = sensor_dataframe.index.hour
sensor_dataframe['measuring'].plot()
```

[ ]:
```
<Axes: xlabel='DateTime'>
```



2.1.4 Convert to ug/m3

[ ]:
```
sensor_dataframe['value'] = sensor_dataframe['measuring'].map(lambda v: 0.
↪0409*v*M)
```

2.2 Tag data

Apply tags to the data according to the quality control processes described above

[ ]:
```
sensor_dataframe['Tag'] = 'VALID'
```

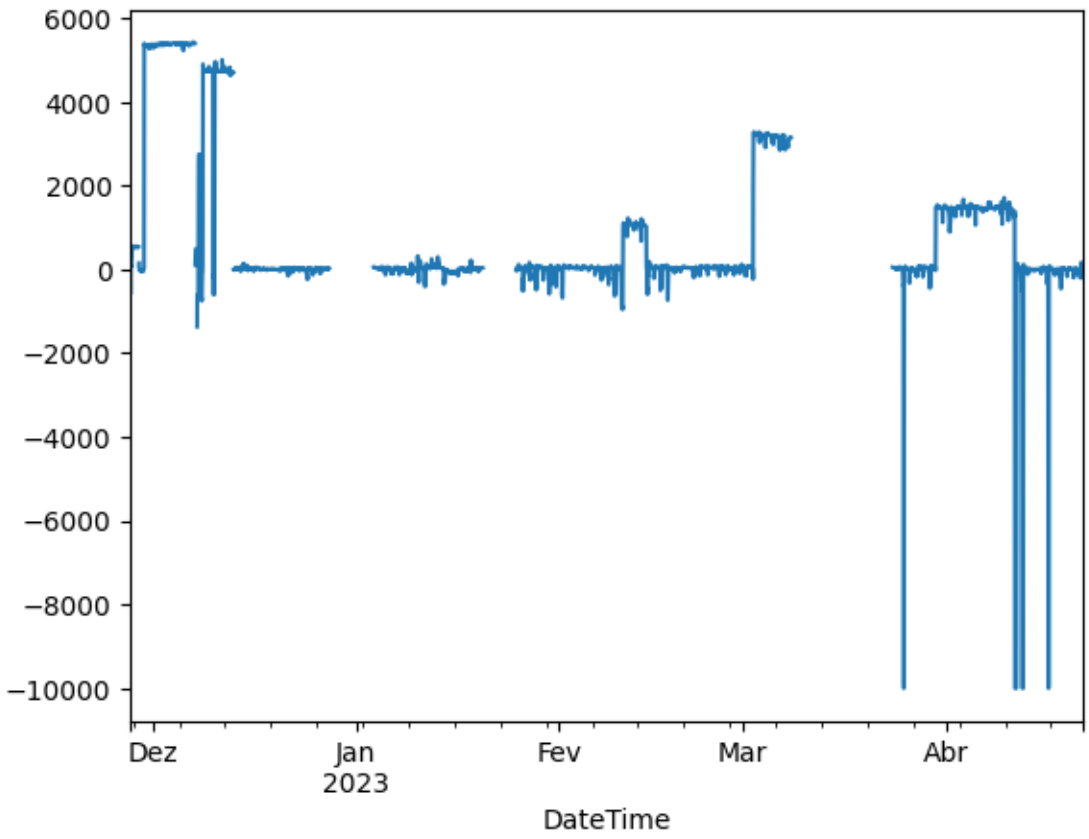
Tag data during stabilizing period AQMesh recomends to considering the first two days after installation as a period for stabilization. In our case, a period of seven days was selected in order to remove outliers candidates detected during that period. For that purpose we detect the first 7 days of uninterrupted measurements

[ ]:
```
# Identify consecutive measurements (15 mins between each)
consecutive_periods = sensor_dataframe.index.to_series().diff().dt.seconds ==␣
↪900
```

```
# Select the first seven days of consecutive measurements (96 = 24 * 60 mins /␣
 ↪15 mins, amount of 15 mins periods in a day)
last_stabilizing_index = sensor_dataframe[consecutive_periods].head(96 * 7).
 ↪index[-1] # 7 days
sensor_dataframe.loc[sensor_dataframe.index[0]:last_stabilizing_index,'Tag'] =␣
 ↪'STABILIZING'
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
 ↪resample('15T').mean().plot()
sensor_dataframe.head()
```

[ ]:

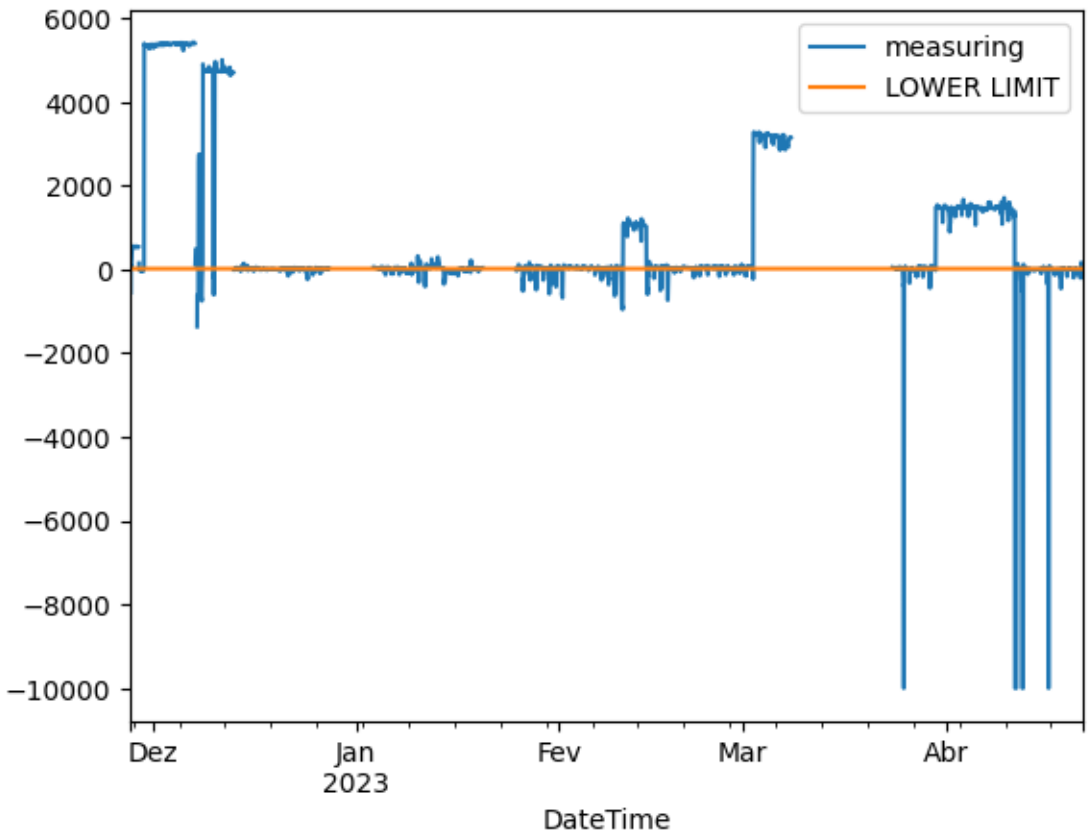
DateTime	latitude	longitude	measuring	raw measuring	Hour	value	Tag
2022-11-20 13:45:00	-28.456899	-48.972999	NaN	105.77	13	NaN	STABILIZING
2022-11-20 14:00:00	NaN	NaN	NaN	NaN	14	NaN	STABILIZING
2022-11-20 14:15:00	NaN	NaN	NaN	NaN	14	NaN	STABILIZING
2022-11-20 14:30:00	NaN	NaN	NaN	NaN	14	NaN	STABILIZING
2022-11-20 14:45:00	NaN	NaN	NaN	NaN	14	NaN	STABILIZING



Tag values that are missing, are greater than sensor span or are lower than sensor resolution The upper limit was too high that affected the graph resolution, therefore it is not plotted

[ ]:
```
sensor_dataframe['UPPER LIMIT'] = upper_limit
sensor_dataframe['LOWER LIMIT'] = lower_limit
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'][['measuring', 'LOWER␣
↪LIMIT']].resample('15T').mean().plot()
```

[ ]:
```
<Axes: xlabel='DateTime'>
```

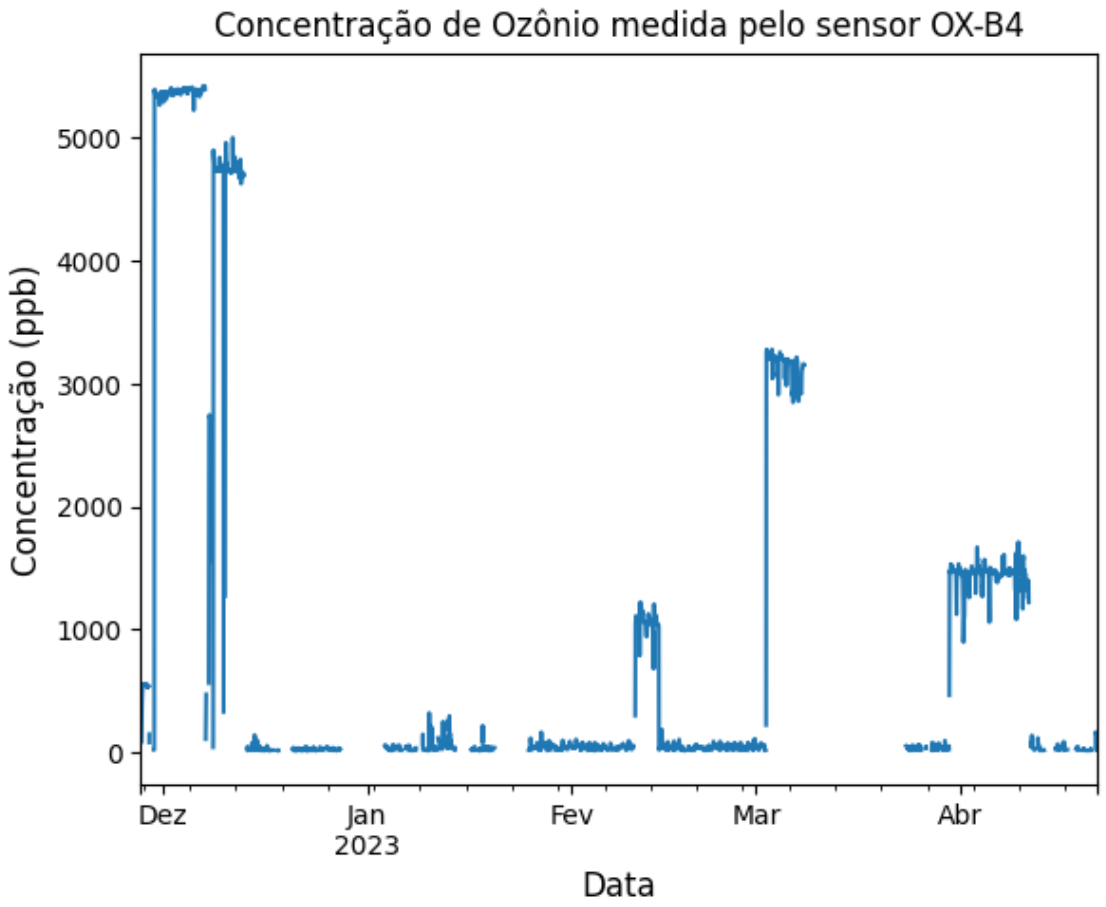


[ ]:
```
import numpy as np
from SensorDataAnalysisService import SensorDataAnalysisService as␣
 ↪sensor_analysis

def tag_by_sensor_limits(value, tag, lower_limit, upper_limit):
 if (tag != 'VALID'): return tag
 return sensor_analysis.get_tags_from_series(value=value,
                                             lower_limit=lower_limit,
                                             upper_limit=upper_limit)

sensor_dataframe['Tag'] = (sensor_dataframe[['measuring', 'Tag']]
                                          .apply(lambda df:␣
 ↪tag_by_sensor_limits(value=df[0], tag=df[1],
                                                                        ␣
 ↪lower_limit=lower_limit,
                                                                        ␣
 ↪upper_limit=upper_limit),
                                                 axis=1))
```

Plot valid data after removing samples bellow lower limit

[ ]:
```
import matplotlib.pyplot as plt

fig, ax = plt.subplots(figsize=(1.3*5,5))
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
 ↪rename('Concentração de Ozônio').resample('15T').mean().plot()
plt.title('Concentração de Ozônio medida pelo sensor OX-B4')
ax.set_xlabel('Data', fontsize=12)
ax.set_ylabel('Concentração (ppb)', fontsize=12)
```

[ ]:
```
Text(0, 0.5, 'Concentração (ppb)')
```



2.3 Change point Analysis

2.3.1 Change point analysis of 15 mins data

[ ]:
```
import ruptures as rpt

series = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring']
```

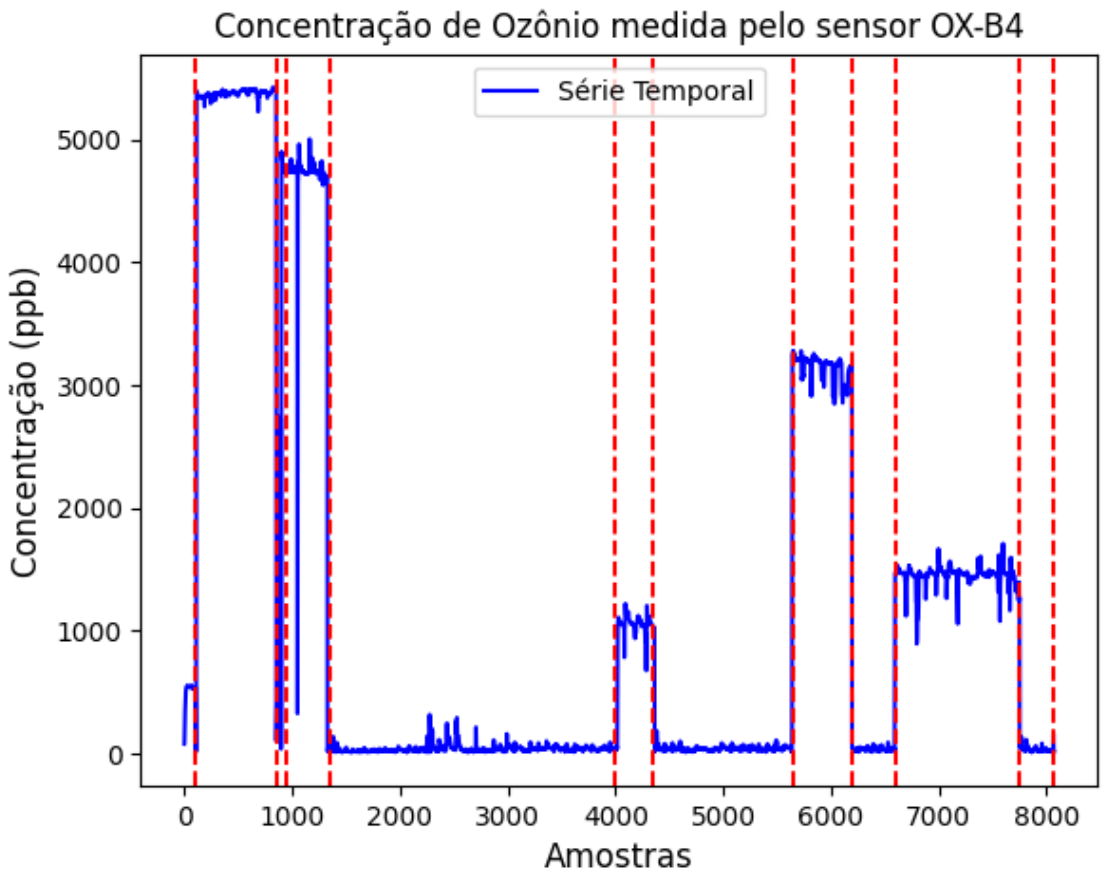
```
signal = np.array(series).reshape(-1, 1)
algo = rpt.Pelt(model="rbf", jump=50, min_size=100).fit(signal=signal)
result = algo.predict(pen=10)
result
```

[ ]: [100, 850, 950, 1350, 4000, 4350, 5650, 6200, 6600, 7750, 8068]

[ ]:
```
change_point_index = series[[x - 1 for x in result]].index
sensor_dataframe['CHANGE POINT'] = False
sensor_dataframe['CHANGE POINT'].loc[change_point_index] = True
```

```
/var/folders/wc/_83zcrx913j1dqwg4g90kbhh0000gp/T/ipykernel_2699/717246363.py:3:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  sensor_dataframe['CHANGE POINT'].loc[change_point_index] = True
```

[ ]:
```
import matplotlib.pyplot as plt

fig, ax = plt.subplots(figsize=(1.3*5,5))
plt.plot(signal, label='Série Temporal', color='blue')
plt.title('Concentração de Ozônio medida pelo sensor OX-B4')
ax.set_xlabel('Amostras', fontsize=12)
ax.set_ylabel('Concentração (ppb)', fontsize=12)

# Plot change points
for point in result:
    plt.axvline(x=point, color='red', linestyle='--')

# Show the plot
plt.legend()
plt.show()
```



[ ]:
```
# 100, 850, 950, 1350, 4000, 4350, 5650, 6200, 6600, 7750, 8068
rebase_df = sensor_dataframe[:change_point_index[3]]
rebase_df = rebase_df + sensor_dataframe[change_point_index[4]:
 ↪change_point_index[5]]
rebase_df = rebase_df + sensor_dataframe[change_point_index[6]:
 ↪change_point_index[7]]
rebase_df = rebase_df + sensor_dataframe[change_point_index[8]:
 ↪change_point_index[9]]
```

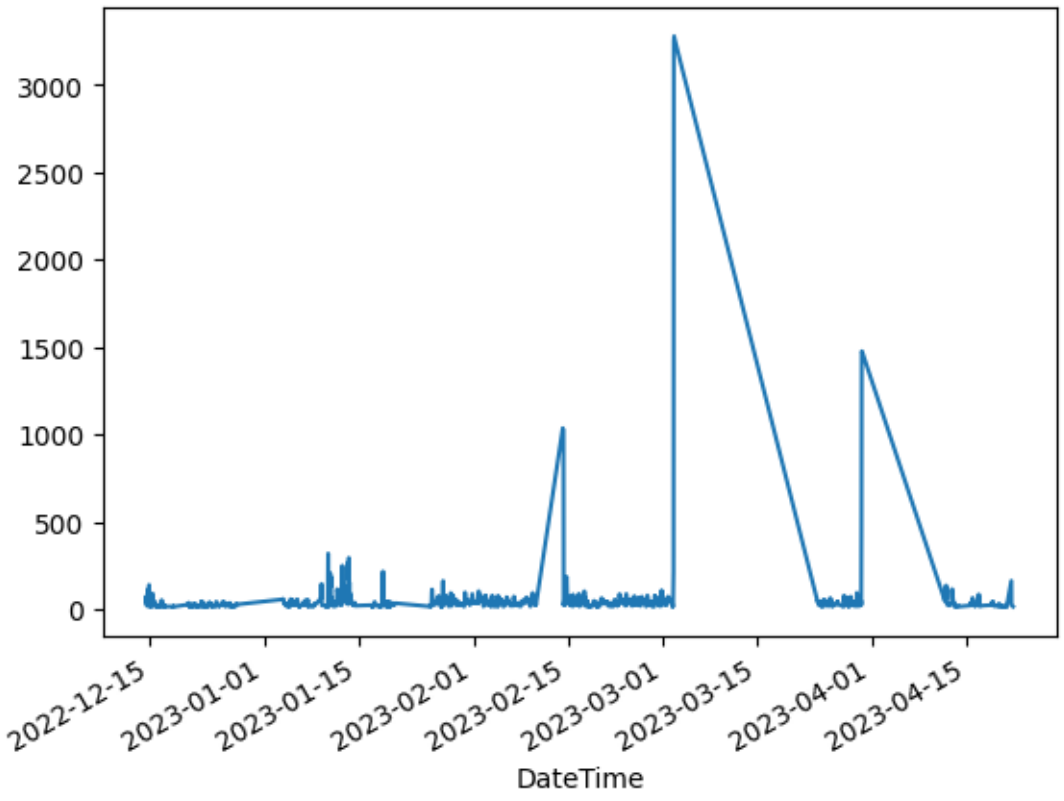
Tag dataframe with changepoints

[ ]:
```
sensor_dataframe.loc[rebase_df.index, 'Tag'] = (sensor_dataframe.loc[rebase_df.
 ↪index, 'Tag']
                                                .apply(lambda t: 'REBASE' if t␣
 ↪== 'VALID' else t) )
sensor_dataframe[sensor_dataframe['Tag'] == 'REBASE'].head()
```

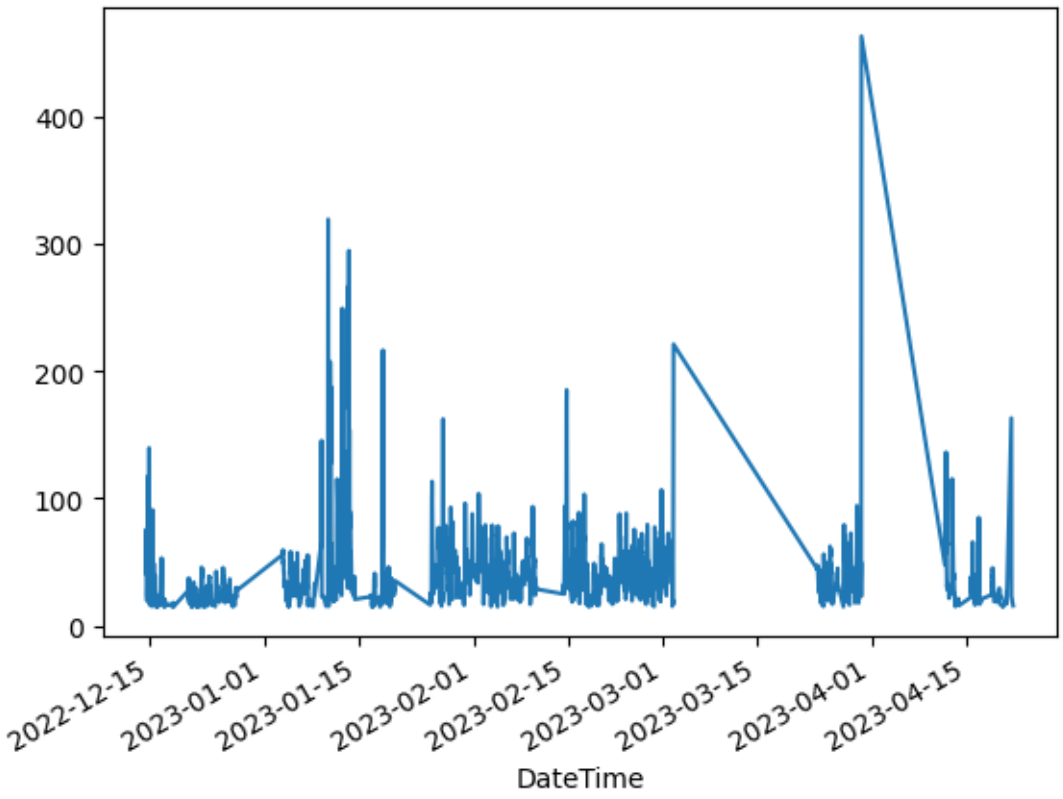
[ ]:
```
                     latitude  longitude  measuring  raw measuring  Hour  \
DateTime
```

```
2022-11-27 14:45:00 -28.456899 -48.972999     81.460         197.19    14
2022-11-27 17:15:00 -28.456899 -48.972999     84.785         171.96    17
2022-11-27 17:30:00 -28.456899 -48.972999    147.105         214.13    17
2022-11-27 17:45:00 -28.456899 -48.972999    193.045         256.06    17
2022-11-27 18:00:00 -28.456899 -48.972999    235.095         289.57    18

                          value     Tag  UPPER LIMIT  LOWER LIMIT  \
DateTime
2022-11-27 14:45:00  159.922272  REBASE      20000.0         15.0
2022-11-27 17:15:00  166.449912  REBASE      20000.0         15.0
2022-11-27 17:30:00  288.796536  REBASE      20000.0         15.0
2022-11-27 17:45:00  378.985944  REBASE      20000.0         15.0
2022-11-27 18:00:00  461.538504  REBASE      20000.0         15.0

                     CHANGE POINT
DateTime
2022-11-27 14:45:00         False
2022-11-27 17:15:00         False
2022-11-27 17:30:00         False
2022-11-27 17:45:00         False
2022-11-27 18:00:00         False
```

[ ]:
```
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].plot()
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']
```



[ ]:
```
sensor_dataframe.loc[sensor_dataframe['measuring'] > 500, 'Tag'] = 'REBASE'
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].plot()
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']
```



Data Tag contabilization

[ ]:
```
tags = ['MISSING','LTLL', 'GTUL', 'STABILIZING', 'BADSPIKE', 'VALID', 'REBASE']
data_contabilization = sensor_analysis.count_tags(tags, sensor_dataframe)
data_contabilization
```

[ ]:

	#	%
MISSING	2750	18.803419
LTLL	3134	21.42906
GTUL	0	0.0
STABILIZING	514	3.51453
BADSPIKE	0	0.0
VALID	4635	31.692308
REBASE	3592	24.560684
TOTAL	14625	100.0

2.4 Analyse valid data

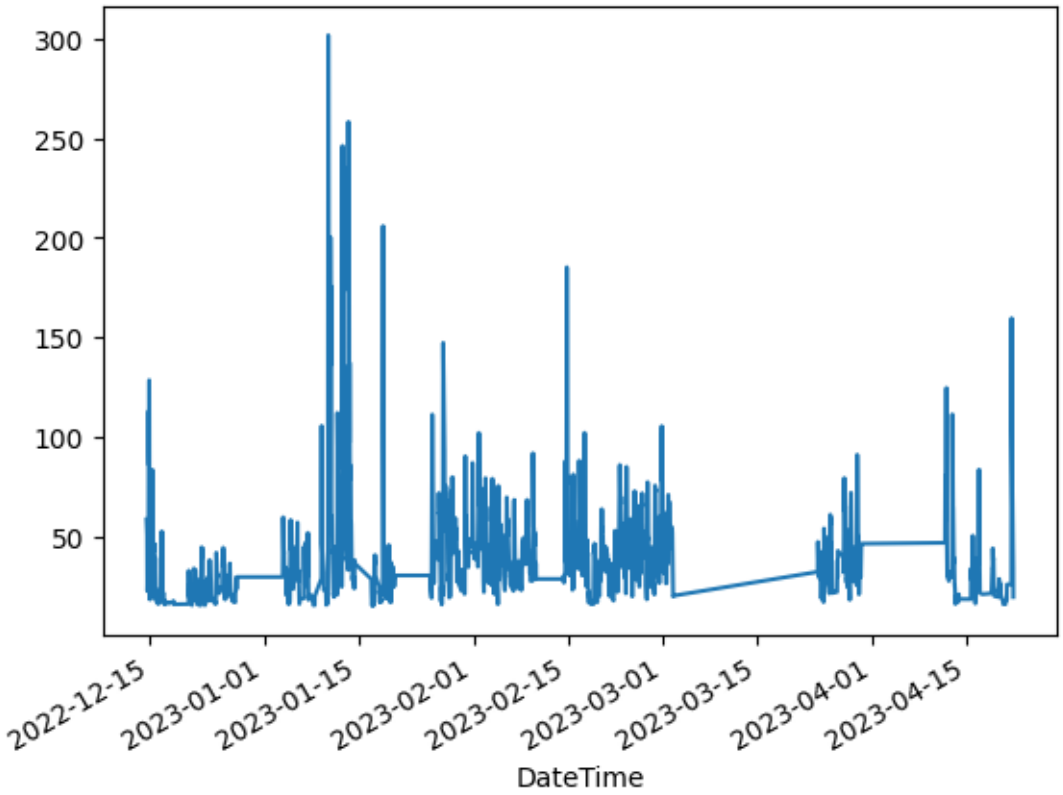
The graph shows the time series of the valid data, box plots of the data grouped by hour of the day, and histogram of the data.

[ ]:
```
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'].
↪drop(columns=['Tag'])
```

2.4.1 Smooth data with a window of 4 samples, i.e.: an hour of data

[ ]:
```
valid_dataframe['raw measuring'] = valid_dataframe['measuring']
valid_dataframe['measuring'] = valid_dataframe['measuring'].rolling(window=4).
↪median()
valid_dataframe['measuring'].plot()
```

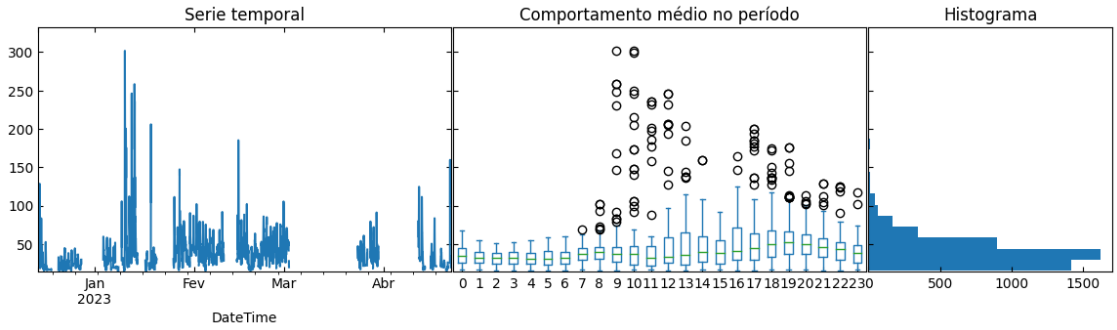
[ ]: <Axes: xlabel='DateTime'>



[ ]:
```
valid_dataframe = valid_dataframe.resample('15T').mean()
sensor_analysis.plot_box_hist(df=valid_dataframe, bins=20)
```

```
/Users/Fernando/Documents/Projects/Github/lcqar-low-cost-monit-proc/data-pre-
processing/SensorDataAnalysisService.py:111: SettingWithCopyWarning:
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

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Hour'] = df['Hour'].astype('int64')
```

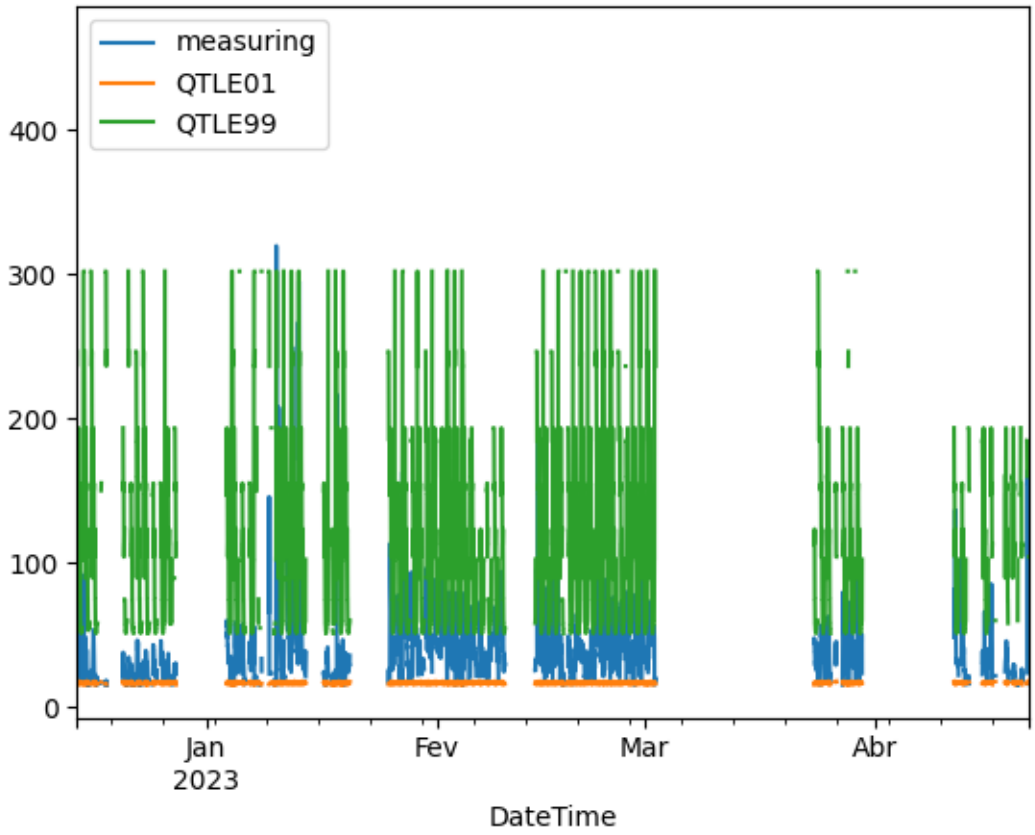


2.4.2 Calculate quantiles

We calculated the 1% and 99 % quantiles of every hour of the day. The values greater outside the 1 % - 99 % where tagged as Greater that Quantile 99 (GTQTLE99) and Lower than Quantile 1 (LTQTLE01)

[ ]:
```
import numpy as np

global_qtle_01 = valid_dataframe.pivot(columns='Hour')['measuring'].
 ↪quantile(q=0.01, axis='index', interpolation='lower').dropna()
global_qtle_99 = valid_dataframe.pivot(columns='Hour')['measuring'].
 ↪quantile(q=0.99, axis='index', interpolation='higher').dropna()
sensor_dataframe['QTLE01'] = sensor_dataframe['Hour'].map(lambda hr:␣
 ↪global_qtle_01[hr] if (not np.isnan(hr)) else np.nan)
sensor_dataframe['QTLE99'] = sensor_dataframe['Hour'].map(lambda hr:␣
 ↪global_qtle_99[hr] if (not np.isnan(hr)) else np.nan)
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'][['measuring', 'QTLE01',␣
 ↪'QTLE99']].resample('15T').mean().plot()
```

[ ]:
```
<Axes: xlabel='DateTime'>
```



2.4.3 Tag data according to quantiles

```
[ ]: sensor_dataframe['Tag'] = (sensor_dataframe[['Tag', 'measuring', 'QTLE01',␣
      ↪'QTLE99']]
                                .apply(lambda df: sensor_analysis.
      ↪tag_by_quantiles(current_tag=df[0],
                                                                                ␣
      ↪value=df[1],
                                                                                ␣
      ↪quantile_01=df[2],
                                                                                ␣
      ↪quantile_99=df[3]),
                                       axis=1))
    tags = ['MISSING','LTLL', 'GTUL', 'BADSPIKE', 'VALID', 'LTQTLE01', 'GTQTLE99',␣
      ↪'REBASE']
    data_contabilization = sensor_analysis.count_tags(tags, sensor_dataframe)
    data_contabilization
```

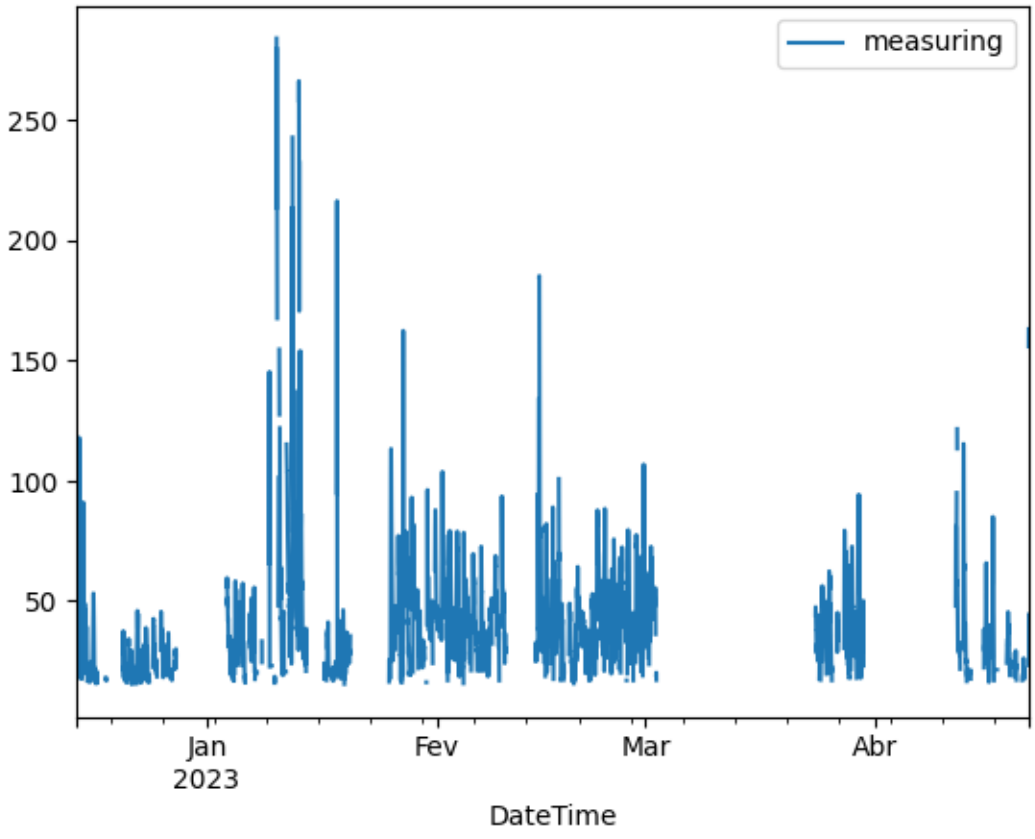
[ ]:

	#	%
MISSING	2750	18.803419
LTLL	3134	21.42906
GTUL	0	0.0
BADSPIKE	0	0.0
VALID	4469	30.557265
LTQTLE01	102	0.697436
GTQTLE99	64	0.437607
REBASE	3592	24.560684
TOTAL	14625	100.0

Plot valid data

[ ]:
```
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'][['measuring']].
↪resample('15T').mean().plot()
```

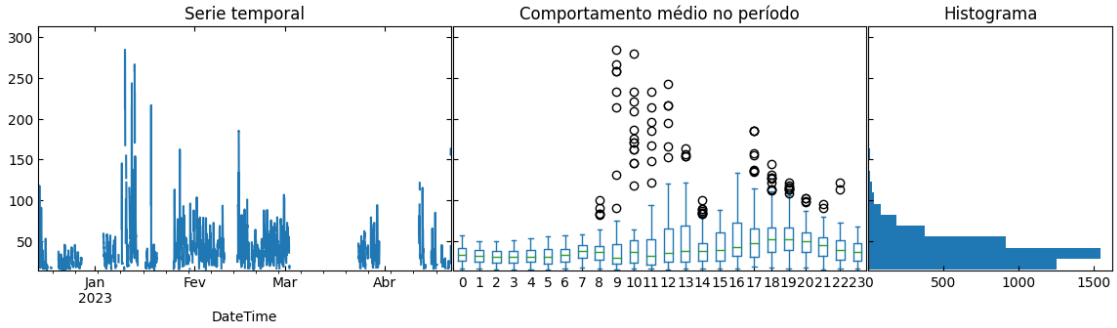
[ ]: <Axes: xlabel='DateTime'>



Analyse data after removing quantiles

[ ]:
```
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'].
  ↪drop(columns=['Tag']).resample('15T').mean()
sensor_analysis.plot_box_hist(df=valid_dataframe, bins=20)
```

```
/Users/Fernando/Documents/Projects/Github/lcqar-low-cost-monit-proc/data-pre-
processing/SensorDataAnalysisService.py:111: SettingWithCopyWarning:
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

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Hour'] = df['Hour'].astype('int64')
```



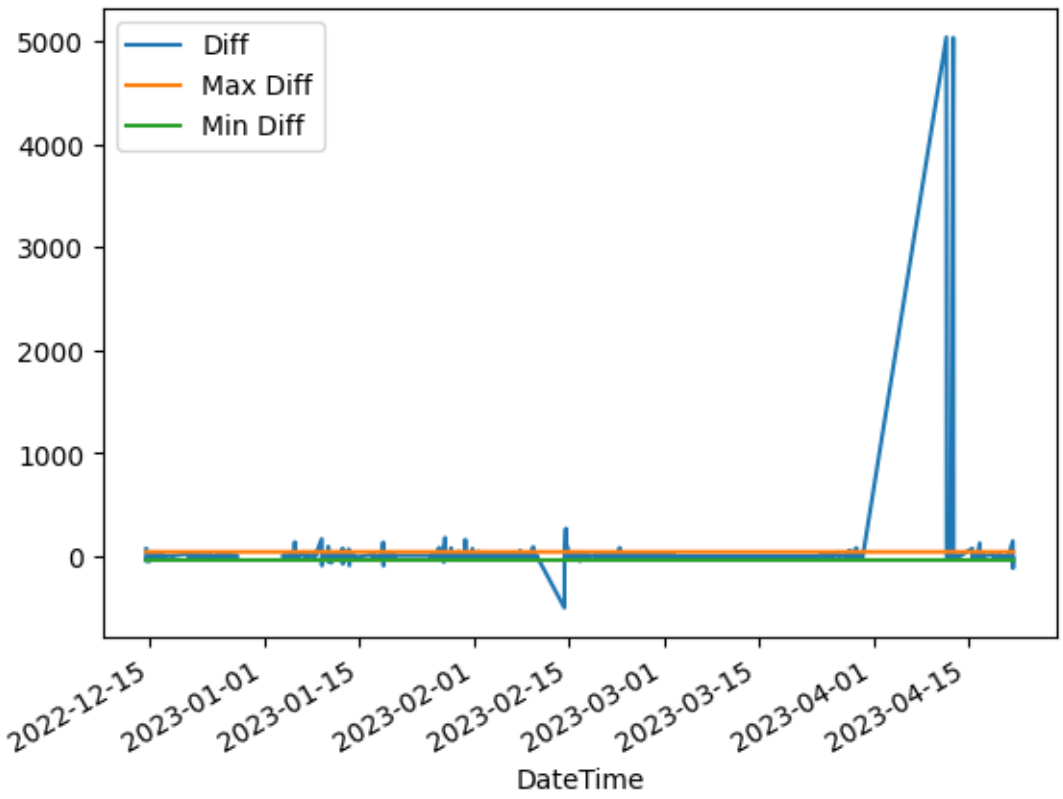
2.5 Analyse data derivatives

Analyse the derivatives of the data for removing abrupt changes in the data (BADSPIKE)

Tag values with derivatives faster than sensor response time The value of 40 ppb was selected based on the maximum derivative found in the reference data. The maximum derivative (with measuring period of 1 hour) found was -45 ppb. Therefore, a maximum of 40 ppb was considered appropriate for a 15 mins period.

[ ]:
```
max_diff_value = 40
sensor_dataframe['Diff'] = sensor_dataframe['measuring'].resample('15T').mean().
  ↪diff()
sensor_dataframe['Max Diff'] = max_diff_value
sensor_dataframe['Min Diff'] = -max_diff_value
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'][['Diff', 'Max Diff', 'Min␣
  ↪Diff']].plot()
```

[ ]:
```
<Axes: xlabel='DateTime'>
```



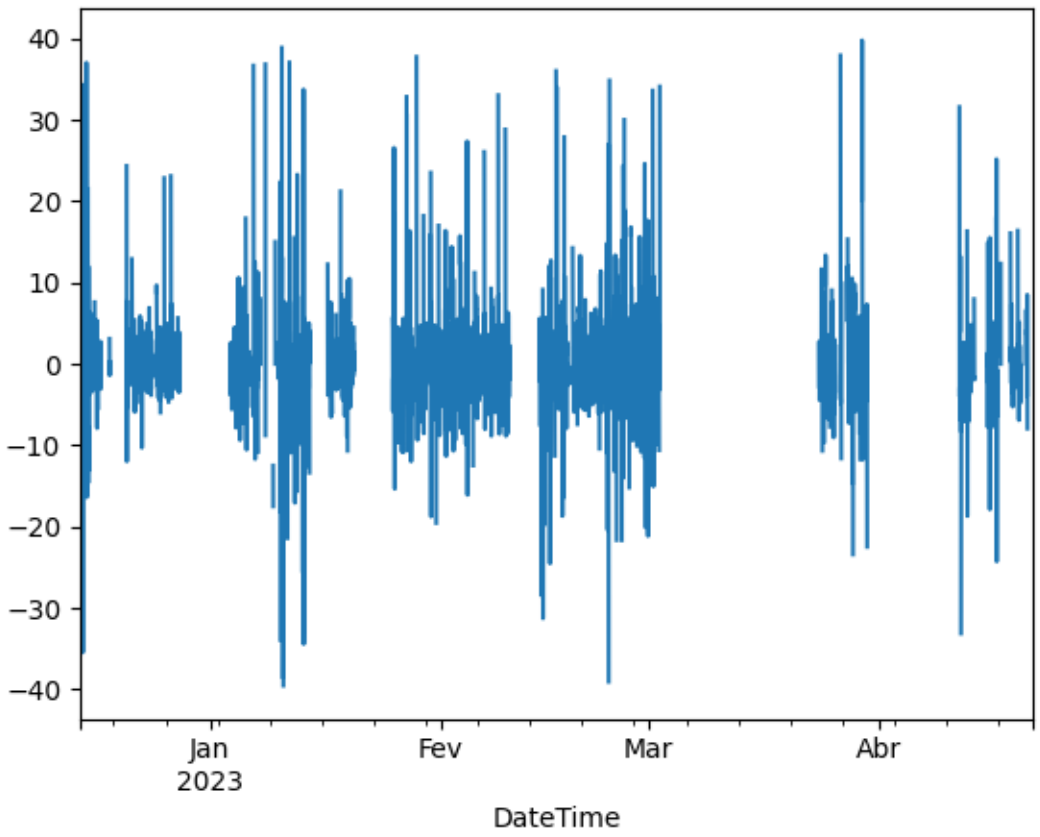
[ ]:
```
import numpy as np

def tag_data_with_derivatives(tagged_df, max_diff_value):
        current_tag = tagged_df[0]
        value = tagged_df[1]
        if ((current_tag != 'VALID') or (np.isnan(value))): return current_tag
        if ((value > max_diff_value) or (value < -max_diff_value)): return␣
 ↪'BADSPIKE'
        return 'VALID'

sensor_dataframe['Tag'] = (sensor_dataframe[['Tag', 'Diff', 'Max Diff']]
                           .apply(lambda df:␣
 ↪tag_data_with_derivatives(tagged_df=df, max_diff_value=df[2]),
                                  axis=1))

tags = ['MISSING','LTLL', 'GTUL', 'STABILIZING', 'BADSPIKE', 'VALID',␣
 ↪'LTQTLE01', 'GTQTLE99', 'REBASE']
data_contabilization = sensor_analysis.count_tags(tags, sensor_dataframe)
data_contabilization
```

[ ]:

	#	%
MISSING	2750	18.803419
LTLL	3134	21.42906
GTUL	0	0.0
STABILIZING	514	3.51453
BADSPIKE	56	0.382906
VALID	4413	30.174359
LTQTLE01	102	0.697436
GTQTLE99	64	0.437607
REBASE	3592	24.560684
TOTAL	14625	100.0

[ ]:
```
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['Diff'].resample('15T').
↪mean().plot()
```

[ ]: <Axes: xlabel='DateTime'>

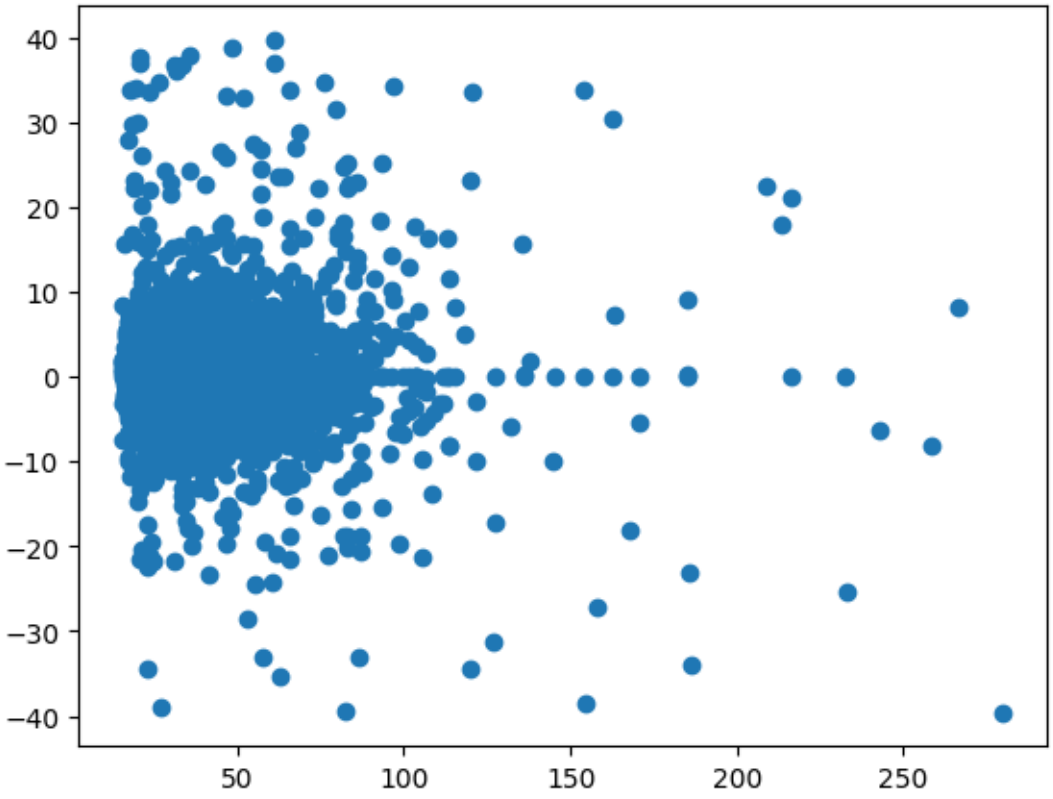


Plot data derivatives vs data

[ ]:
```
import matplotlib.pyplot as plt
```

```
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']
fig = plt.figure(figsize=(1.3*5,5))
plt.scatter(valid_dataframe['measuring'], valid_dataframe['Diff'])
```

[ ]: <matplotlib.collections.PathCollection at 0x158b33580>



Data Tag contabilization

[ ]:
```
tags = ['MISSING','LTLL', 'GTUL', 'STABILIZING', 'BADSPIKE', 'VALID',␣
↪'LTQTLE01', 'GTQTLE99', 'REBASE']
data_contabilization = sensor_analysis.count_tags(tags, sensor_dataframe)
data_contabilization
```

[ ]:

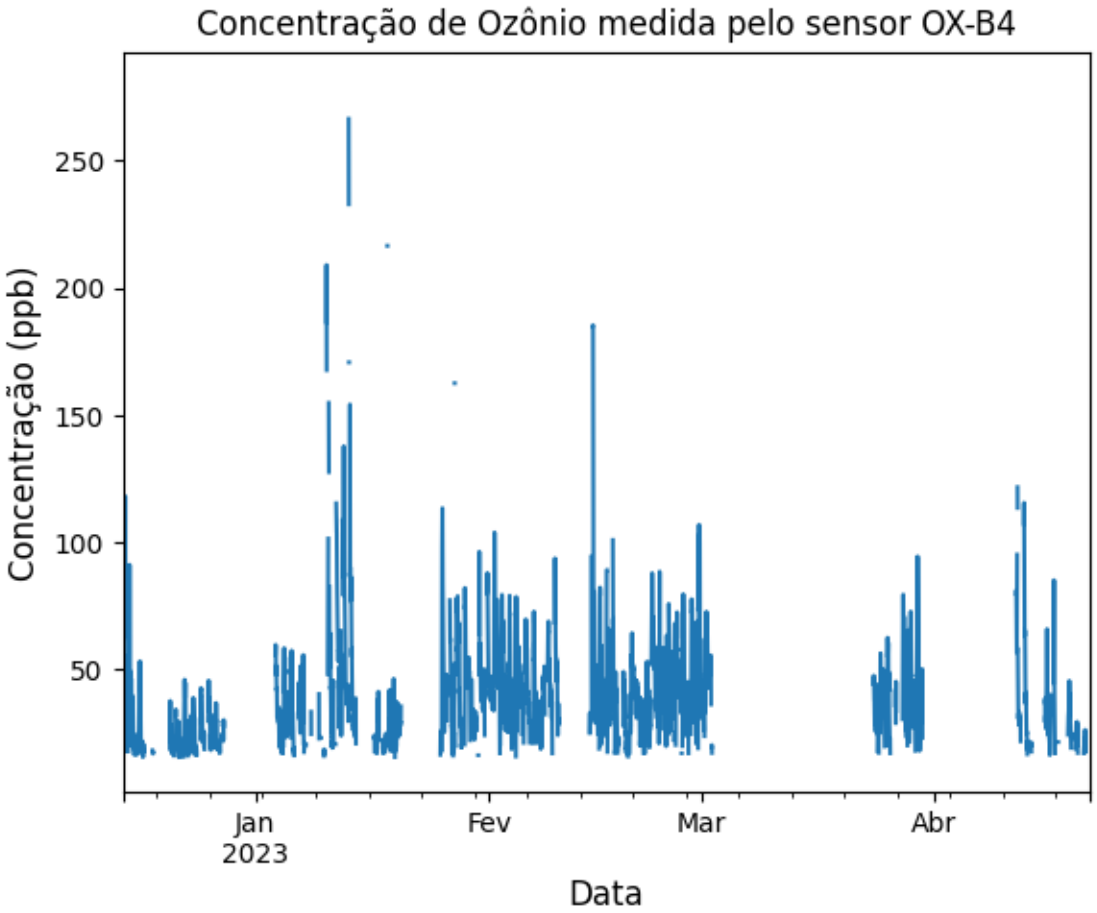
	#	%
MISSING	2750	18.803419
LTLL	3134	21.42906
GTUL	0	0.0
STABILIZING	514	3.51453
BADSPIKE	56	0.382906
VALID	4413	30.174359
LTQTLE01	102	0.697436
GTQTLE99	64	0.437607

```
REBASE        3592  24.560684
TOTAL        14625      100.0
```

Plot valid data

[ ]:
```
fig, ax = plt.subplots(figsize=(1.3*5,5))
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
  ↪rename('Concentração de Ozônio').resample('15T').mean().plot()
plt.title('Concentração de Ozônio medida pelo sensor OX-B4')
ax.set_xlabel('Data', fontsize=12)
ax.set_ylabel('Concentração (ppb)', fontsize=12)
```

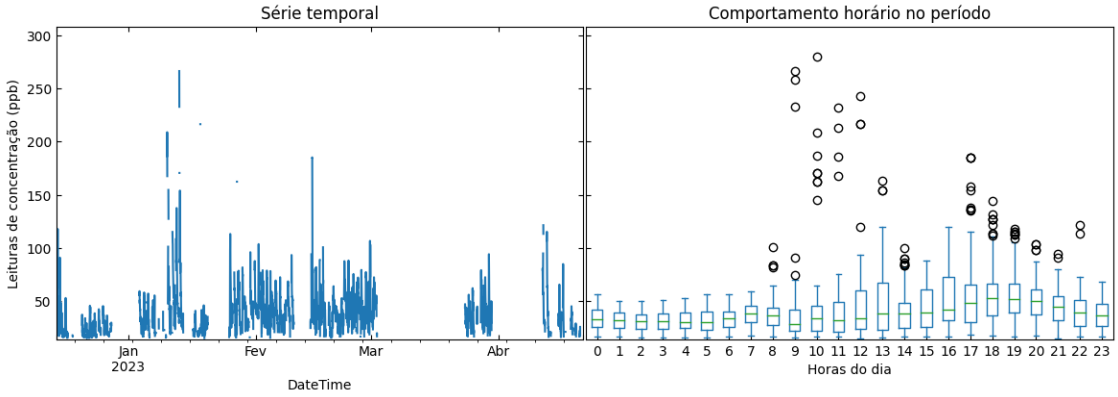
[ ]:
```
Text(0, 0.5, 'Concentração (ppb)')
```



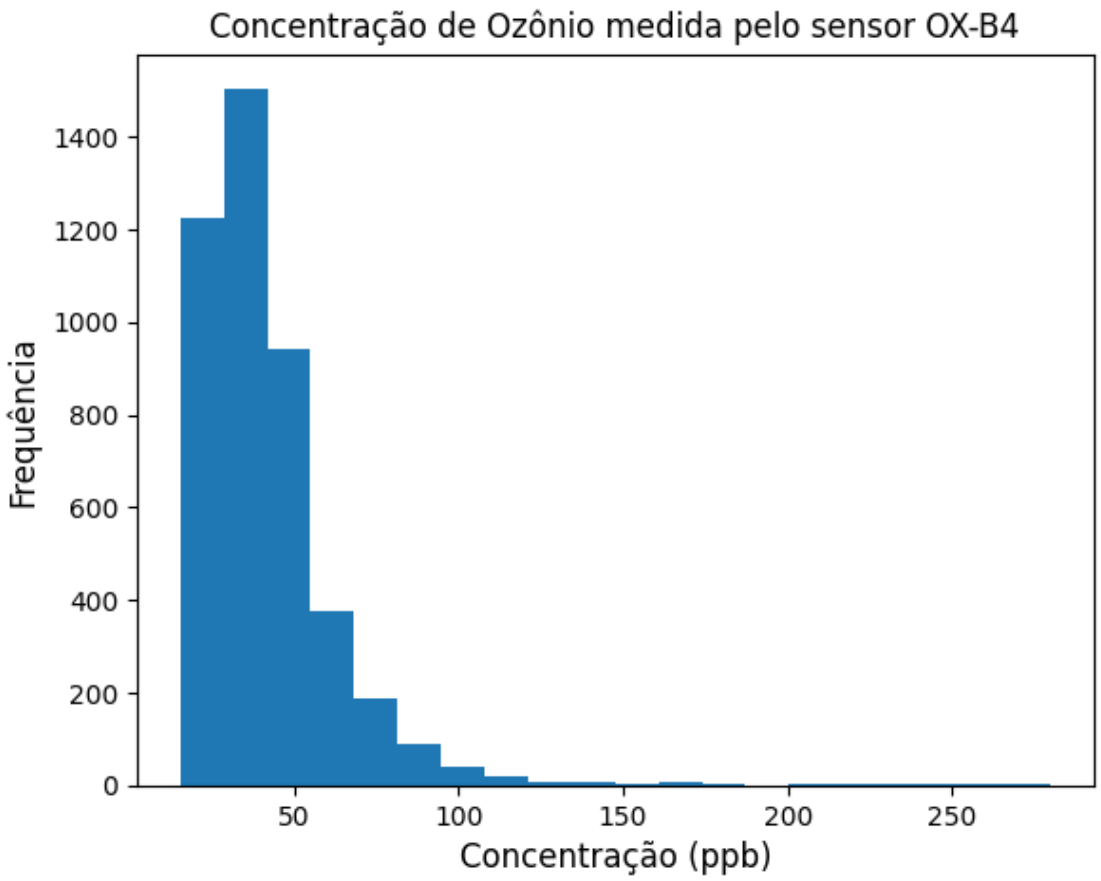
[ ]:
```
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'].
  ↪drop(columns=['Tag']).resample('15T').mean()
sensor_analysis.plot_box(df=valid_dataframe)
```

```
/Users/Fernando/Documents/Projects/Github/lcqar-low-cost-monit-proc/data-pre-
```

```
processing/SensorDataAnalysisService.py:143: SettingWithCopyWarning:
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

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Hour'] = df['Hour'].astype('int64')
```

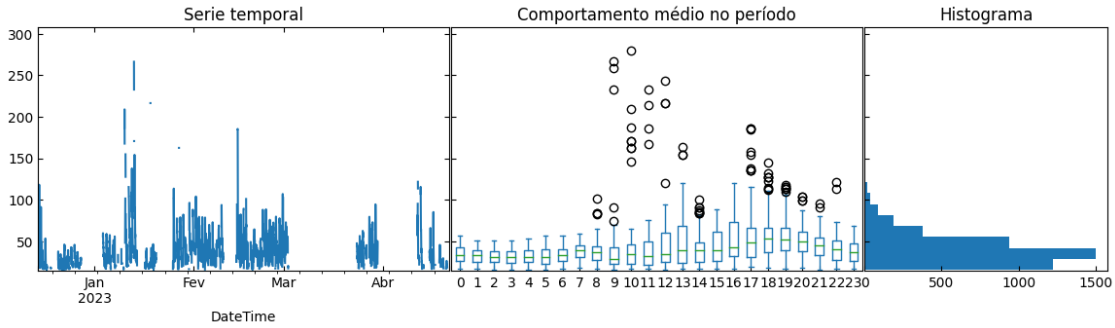


[ ]:
```
fig, ax = plt.subplots(figsize=(1.3*5,5))
(sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
 ↪rename('Concentração de Ozônio')
 .resample('15T').mean().hist(bins=20))
plt.title('Concentração de Ozônio medida pelo sensor OX-B4')
ax.set_xlabel('Concentração (ppb)', fontsize=12)
ax.set_ylabel('Frequência', fontsize=12)
ax.grid(False)
```



[ ]:
```
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'].
 ↪drop(columns=['Tag']).resample('15T').mean()
sensor_analysis.plot_box_hist(df=valid_dataframe, bins=20)
```

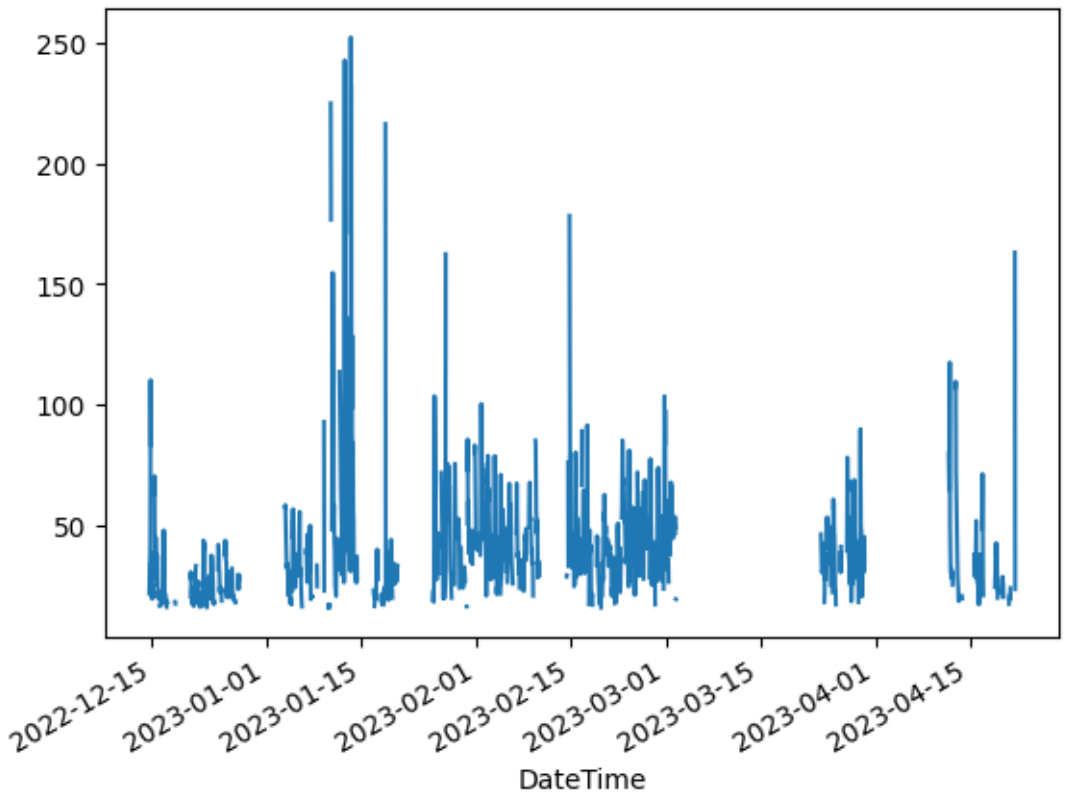
```
/Users/Fernando/Documents/Projects/Github/lcqar-low-cost-monit-proc/data-pre-
processing/SensorDataAnalysisService.py:111: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Hour'] = df['Hour'].astype('int64')
```



2.6 Resample valid data to 1 HR

[ ]:
```
resampled_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'].
 ↪drop(columns=['Tag']).resample('H').mean()
resampled_dataframe['Hour'] = resampled_dataframe.index.hour
resampled_dataframe['Count'] = (valid_dataframe['measuring'].resample('H').
 ↪count())
resampled_dataframe['Std'] = (valid_dataframe['measuring'].resample('H').std())
resampled_dataframe.index = resampled_dataframe.index.map(lambda t: t.
 ↪replace(minute=30, second=0))
resampled_dataframe['measuring'].plot()
```

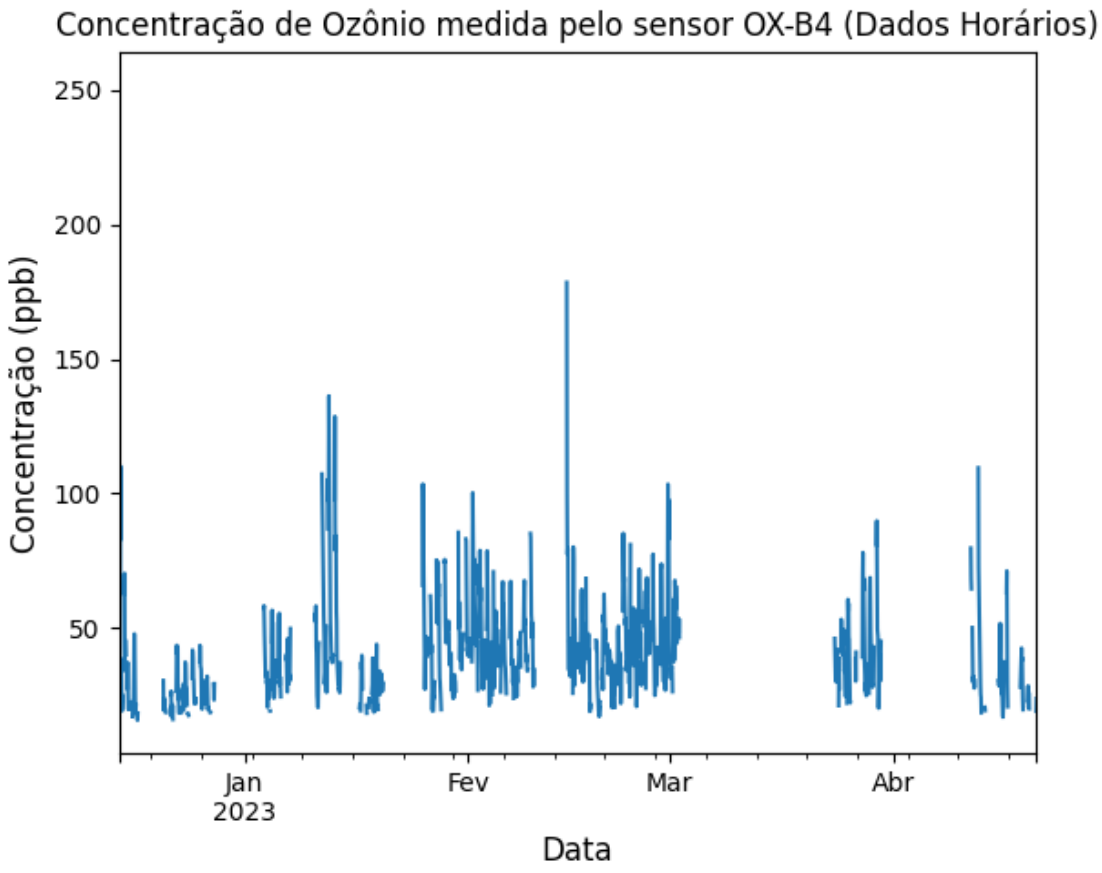
[ ]:
```
<Axes: xlabel='DateTime'>
```



Tag hourly data according to the number of samples in an hour At least 3 samples must be valid in an hour (75 %) for the hourly data be considered as valid

[ ]:
```
original_freq = sensor_dataframe.index.freq
resampled_dataframe['% valid'] = (resampled_dataframe['Count']
                                  .map(lambda c:
                                       c / (pd.Timedelta("1 hour") /␣
 ↪original_freq) * 100))
resampled_dataframe['Tag'] = (resampled_dataframe['% valid']
                              .map(lambda c: 'VALID' if c >= 75 else␣
 ↪'LOWSAMPLES'))

fig, ax = plt.subplots(figsize=(1.3*5,5))
resampled_dataframe[resampled_dataframe['Tag'] == 'VALID']['measuring'].
 ↪rename('Concentração de Ozônio').resample('1H').mean().plot()
plt.title('Concentração de Ozônio medida pelo sensor OX-B4 (Dados Horários)')
ax.set_xlabel('Data', fontsize=12)
ax.set_ylabel('Concentração (ppb)', fontsize=12)
```

[ ]:
```
Text(0, 0.5, 'Concentração (ppb)')
```



Valid data contabilization

[ ]:
```
tags = ['LOWSAMPLES','VALID']
data_contabilization = sensor_analysis.count_tags(tags, resampled_dataframe)
data_contabilization
```

[ ]:

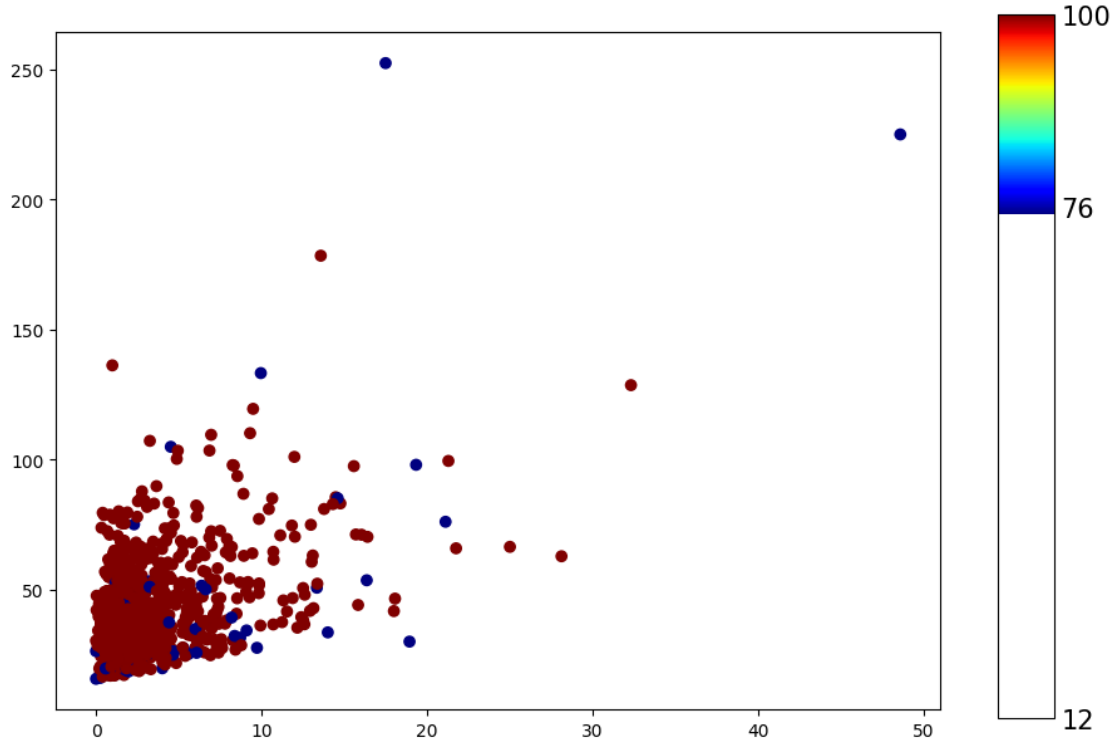
	#	%
LOWSAMPLES	2020	65.669701
VALID	1056	34.330299
TOTAL	3076	100.0

2.7 Analyse the mean and standard deviation of the resampled data

The color of each data point represents the percentage of valid 15 mins samples found in an hour

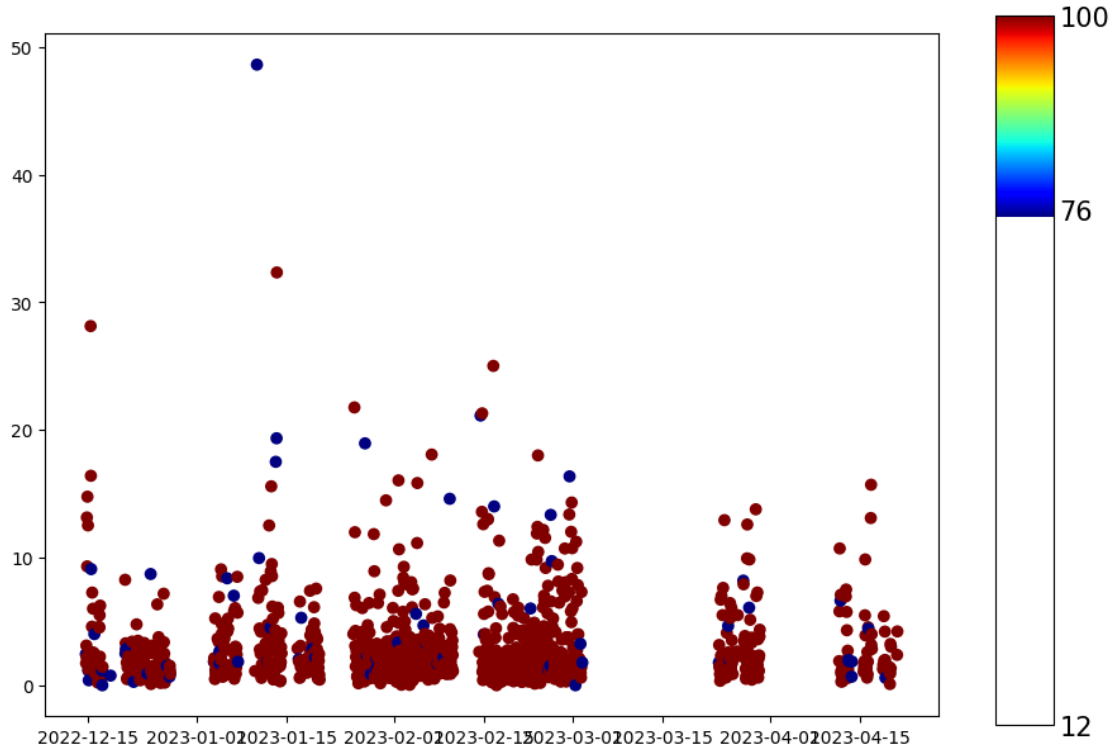
Plot mean (Y axis) vs. standard deviation (X axis) for valid hourly data colored by valid percentage of valid samples

[ ]:
```
valid_resampled_dataframe = resampled_dataframe[resampled_dataframe['Tag'] ==␣
↪'VALID']
sensor_analysis.plot_mean_vs_std(valid_resampled_dataframe)
```



2.7.1 Plot standard deviation in time colored according to the percentage of valid samples

[ ]:
```
sensor_analysis.plot_std_in_time(valid_resampled_dataframe)
```



3 Save Data

[ ]:
```
import os

output_directory_path = 'data/output/'
processing_directory_path = '../data-processing/input/'
valid_1HR_filename = '_valid_data_1HR.csv'
valid_filename = '_valid_data.csv'
dataframe_filename = '_dataframe.csv'
dataframe_1HR_filename = '_dataframe_1hr.csv'

valid_1HR_file_path_output = output_directory_path + SENSOR_NAME +␣
 ↪valid_1HR_filename
valid_file_path_output = output_directory_path + SENSOR_NAME + valid_filename

dataframe_path_1HR_output = output_directory_path + SENSOR_NAME +␣
 ↪dataframe_1HR_filename
dataframe_path_output = output_directory_path + SENSOR_NAME + dataframe_filename

valid_processing_1HR_file_path = processing_directory_path + SENSOR_NAME +␣
 ↪valid_1HR_filename
```

```
valid_processing_file_path = processing_directory_path + SENSOR_NAME +␣
 ↪valid_filename

processing_dataframe_path_1HR = processing_directory_path + SENSOR_NAME +␣
 ↪dataframe_1HR_filename
processing_dataframe_path = processing_directory_path + SENSOR_NAME +␣
 ↪dataframe_filename

if not os.path.exists(output_directory_path):
    os.makedirs(output_directory_path)

if not os.path.exists(processing_directory_path):
    os.makedirs(processing_directory_path)

sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'][['measuring', 'value']].
 ↪to_csv(valid_file_path_output)
resampled_dataframe[resampled_dataframe['Tag'] == 'VALID'][['measuring',␣
 ↪'value']].to_csv(valid_1HR_file_path_output)
sensor_dataframe.to_csv(dataframe_path_output)
resampled_dataframe.to_csv(dataframe_path_1HR_output)

sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'][['measuring', 'value']].
 ↪to_csv(valid_processing_file_path)
resampled_dataframe[resampled_dataframe['Tag'] == 'VALID'][['measuring',␣
 ↪'value']].to_csv(valid_processing_1HR_file_path)
sensor_dataframe.to_csv(processing_dataframe_path)
resampled_dataframe.to_csv(processing_dataframe_path_1HR)
```