MP10-field-data-treatment-Diamante

February 13, 2024

1 Electrochemical PM10 sensor data preprocessing

- Pollutant: Particulate Matter
- Sensor: Alphasense OPC-N3

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 = "OPC_PM10.CSV"

SENSOR_FILE_DIR = 'data/input/'
SENSOR_NAME = 'alpha_pm_10_conc'
SENSOR_FILE_NAME = SENSOR_NAME + 'web_dataframe.csv'
```

1.1.3 Sensor Constants

[ ]:
```
lower_limit=0.0
upper_limit=2e3
sampling_period = 15 * 60
```

2 Alphasense PM10 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.head()
```

```
/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   -9999.99 2022-11-21 10:44:06
1 -28.456899 -48.972999   -9999.99 2022-11-21 10:59:51
2 -28.456899 -48.972999   -9999.99 2022-11-21 11:15:41
3 -28.456899 -48.972999   -9999.99 2022-11-21 11:31:25
4 -28.456899 -48.972999   -9999.99 2022-11-21 11:47:05
```

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   -9999.99  2022-11-21 10:44:06
1           1 -28.456899 -48.972999   -9999.99  2022-11-21 10:59:51
2           2 -28.456899 -48.972999   -9999.99  2022-11-21 11:15:41
3           3 -28.456899 -48.972999   -9999.99  2022-11-21 11:31:25
4           4 -28.456899 -48.972999   -9999.99  2022-11-21 11:47:05
```

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_4959/166902210.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))
```

[ ]:

```
                      latitude  longitude  measuring
DateTime
2022-11-21 10:30:00 -28.456899 -48.972999   -9999.99
2022-11-21 10:45:00 -28.456899 -48.972999   -9999.99
2022-11-21 11:00:00        NaN        NaN        NaN
2022-11-21 11:15:00 -28.456899 -48.972999   -9999.99
2022-11-21 11:30:00 -28.456899 -48.972999   -9999.99
…                          …          …        …
2023-04-21 20:30:00 -28.456899 -48.972999   -9999.99
2023-04-21 20:45:00 -28.456899 -48.972999   -9999.99
2023-04-21 21:00:00 -28.456899 -48.972999   -9999.99
2023-04-21 21:15:00 -28.456899 -48.972999   -9999.99
2023-04-21 21:30:00 -28.456899 -48.972999   -9999.99

[14541 rows x 3 columns]
```

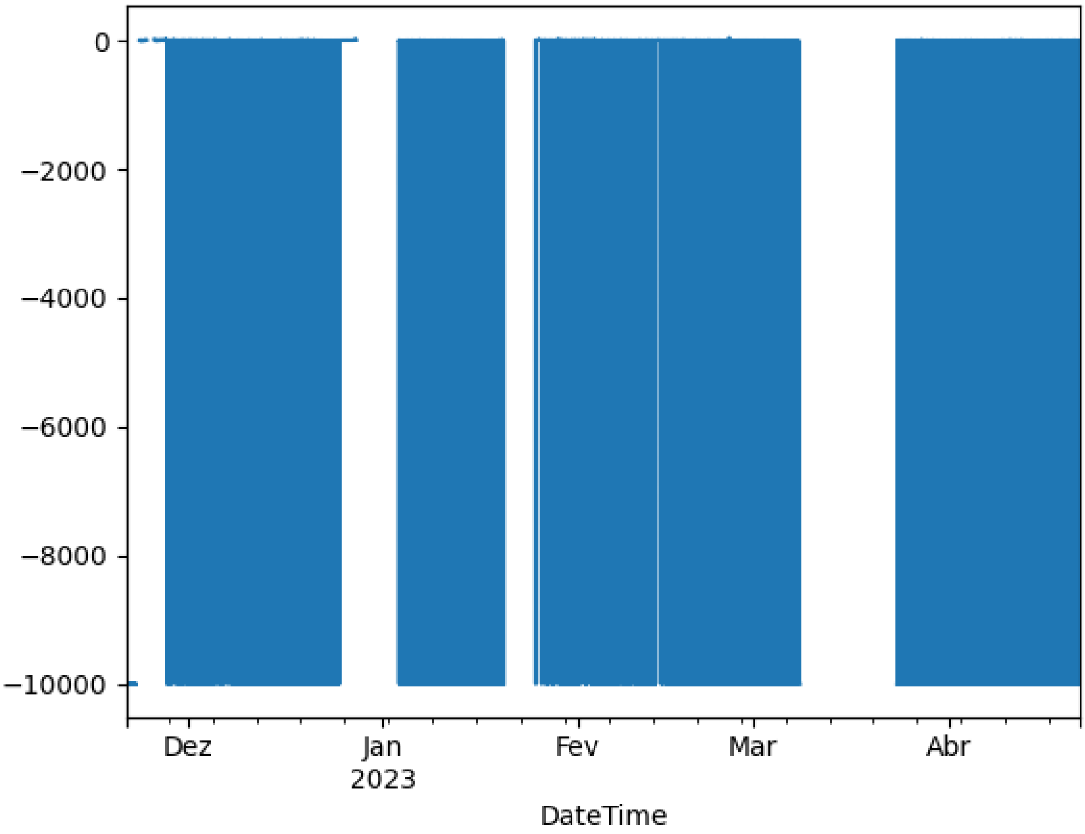
2.1.2 Plot raw data

[ ]:

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

[ ]:

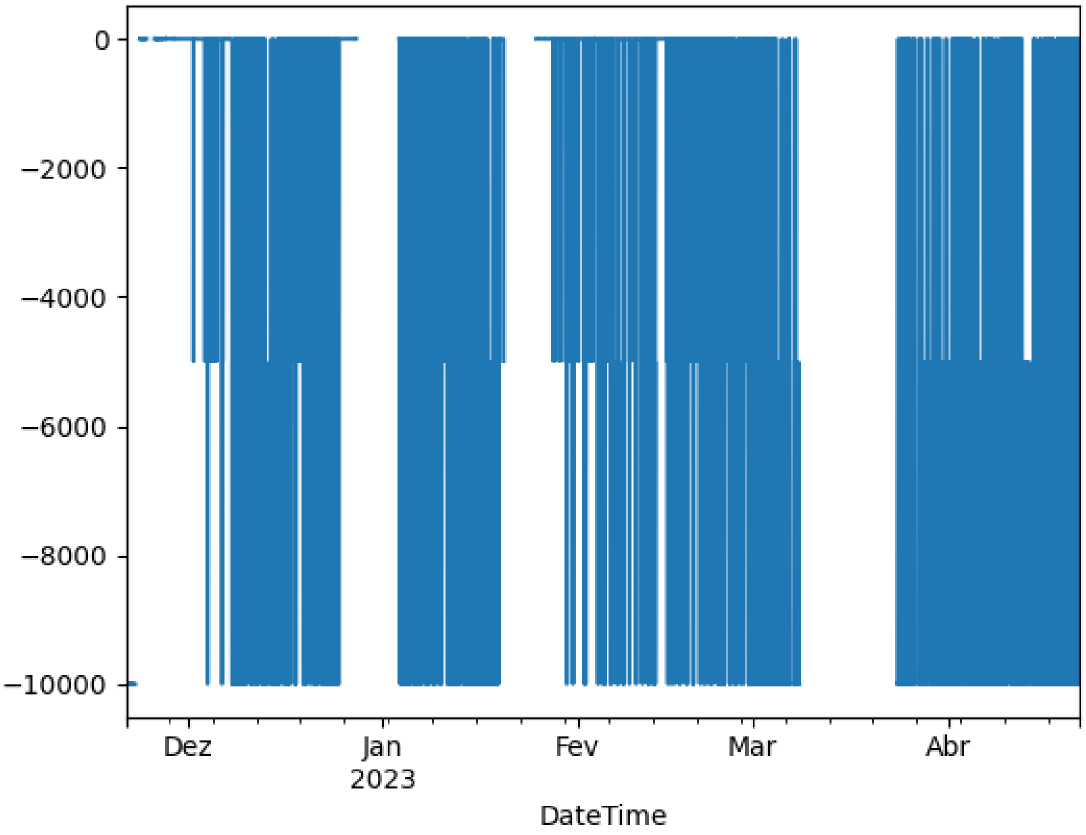
```
<Axes: xlabel='DateTime'>
```



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'>
```



2.2 Tag data

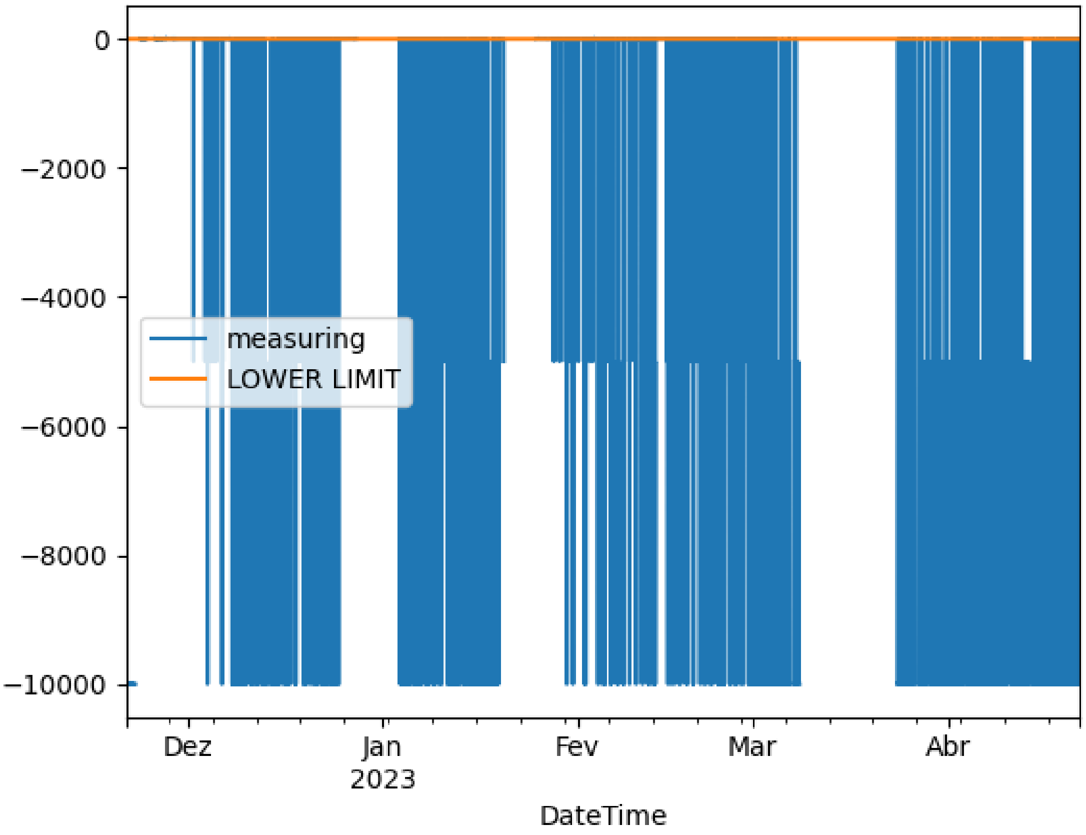
Apply tags to the data according to the quality control processes described above

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

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'>
```

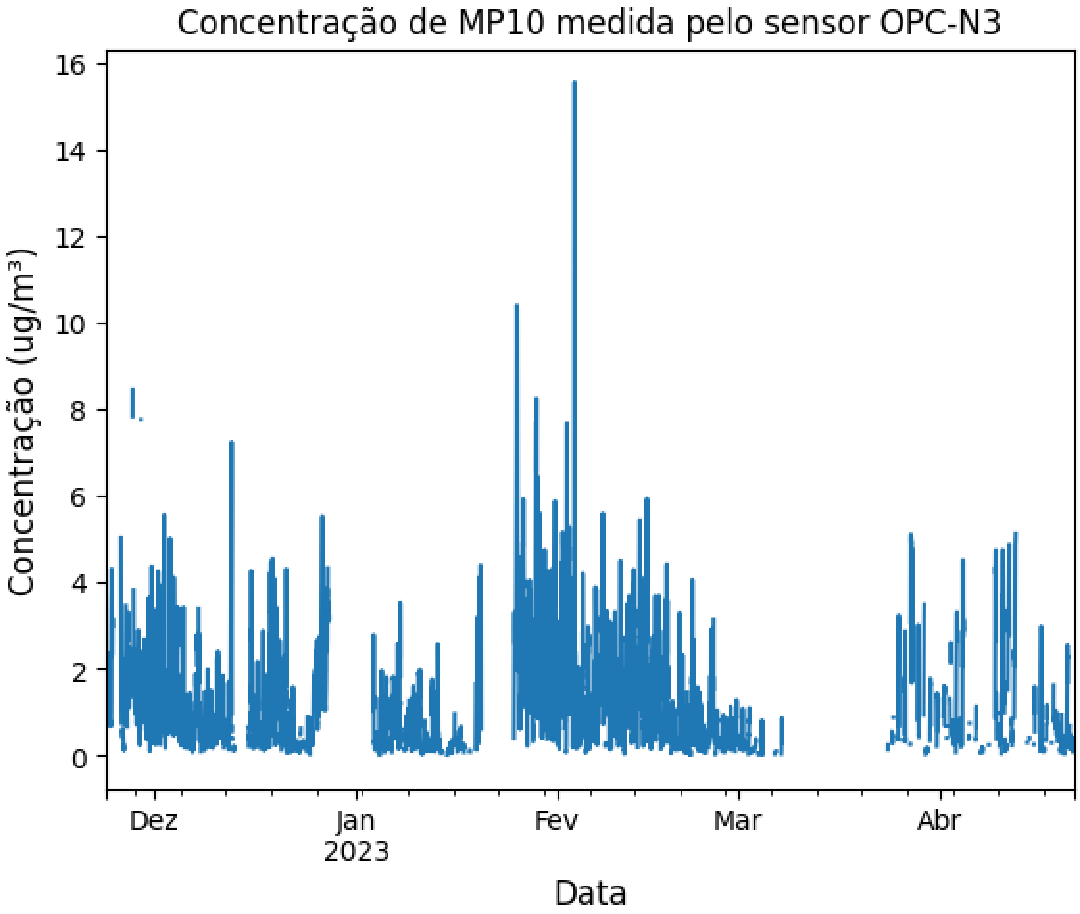


```
[ ]: import numpy as np
     from SensorDataAnalysisService import SensorDataAnalysisService as␣
      ↪sensor_analysis

     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 MP10').resample('15T').mean().plot()
     plt.title('Concentração de MP10 medida pelo sensor OPC-N3')
     ax.set_xlabel('Data', fontsize=12)
     ax.set_ylabel('Concentração (ug/m\N{SUPERSCRIPT THREE})', fontsize=12)
```

```
[ ]: Text(0, 0.5, 'Concentração (ug/m³)')
```



2.3 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'])
```

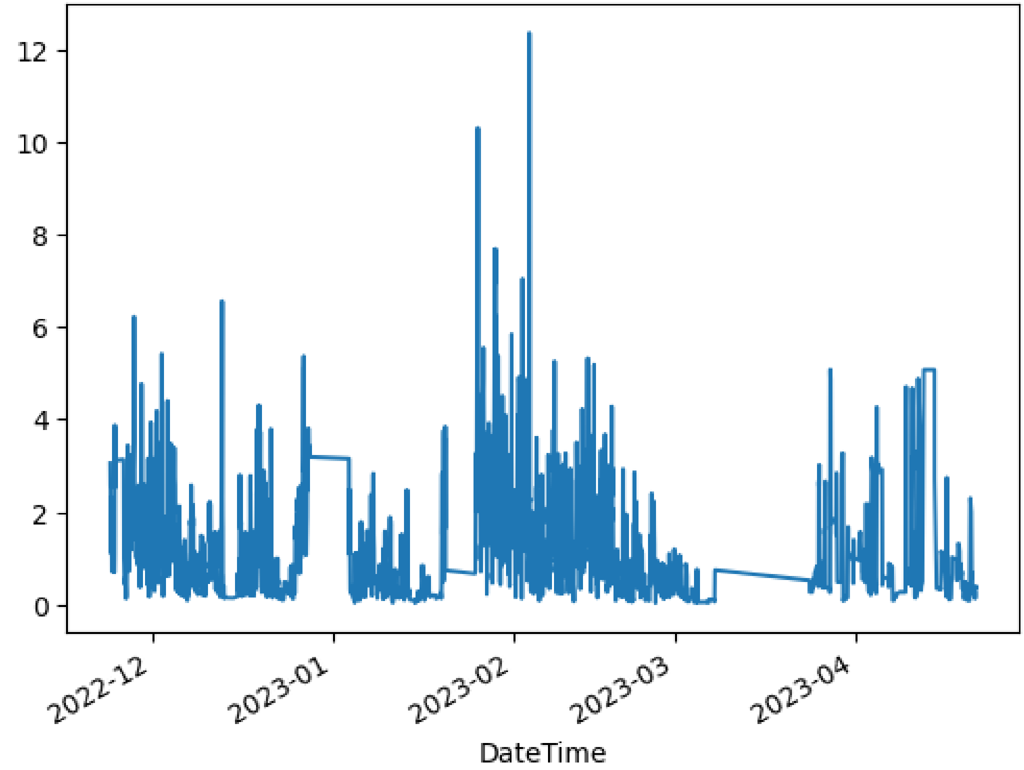
2.3.1 Smooth data with a window of 4 samples, i.e.: an hour of data

[ ]:

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

[ ]:

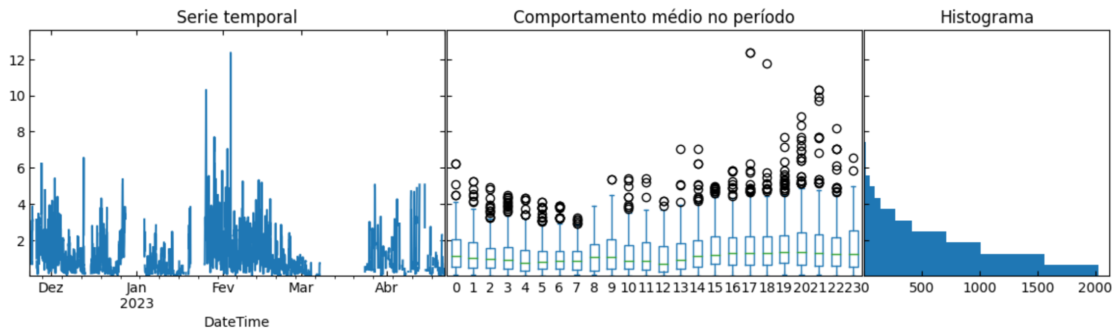
```
<Axes: xlabel='DateTime'>
```



[ ]:

```
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')
```

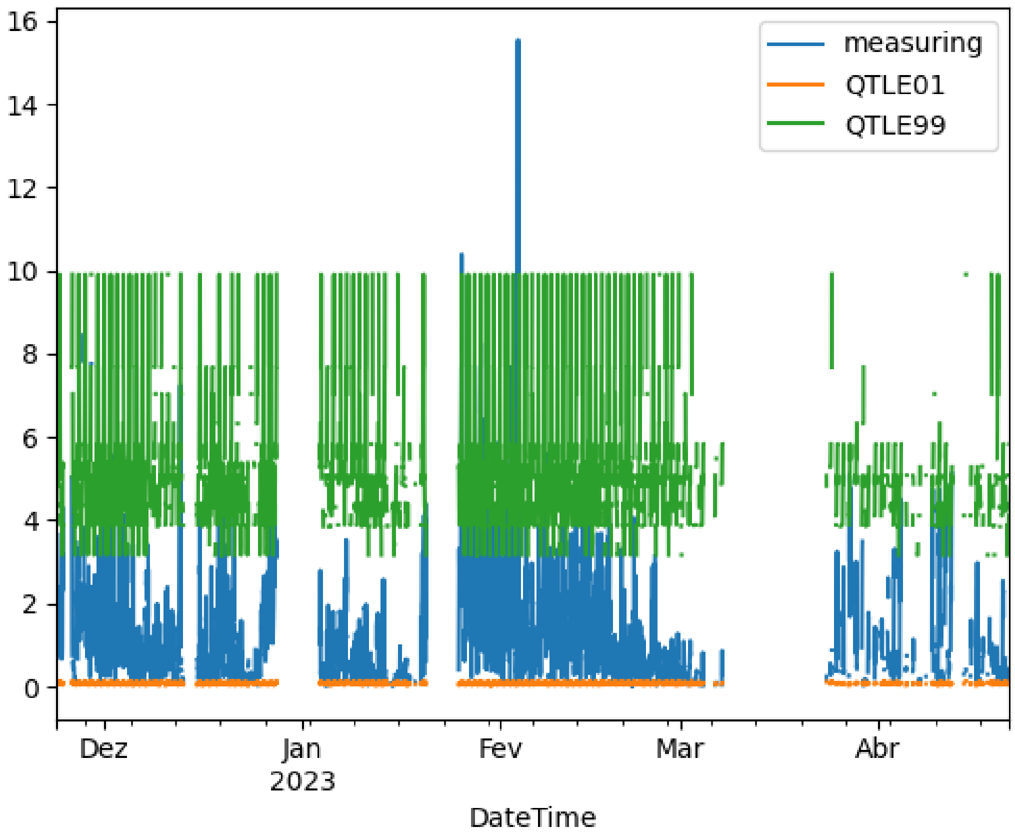


2.3.2 Calculate quantiles

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'>
```



2.3.3 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']
data_contabilization = sensor_analysis.count_tags(tags, sensor_dataframe)
data_contabilization
```

[ ]:

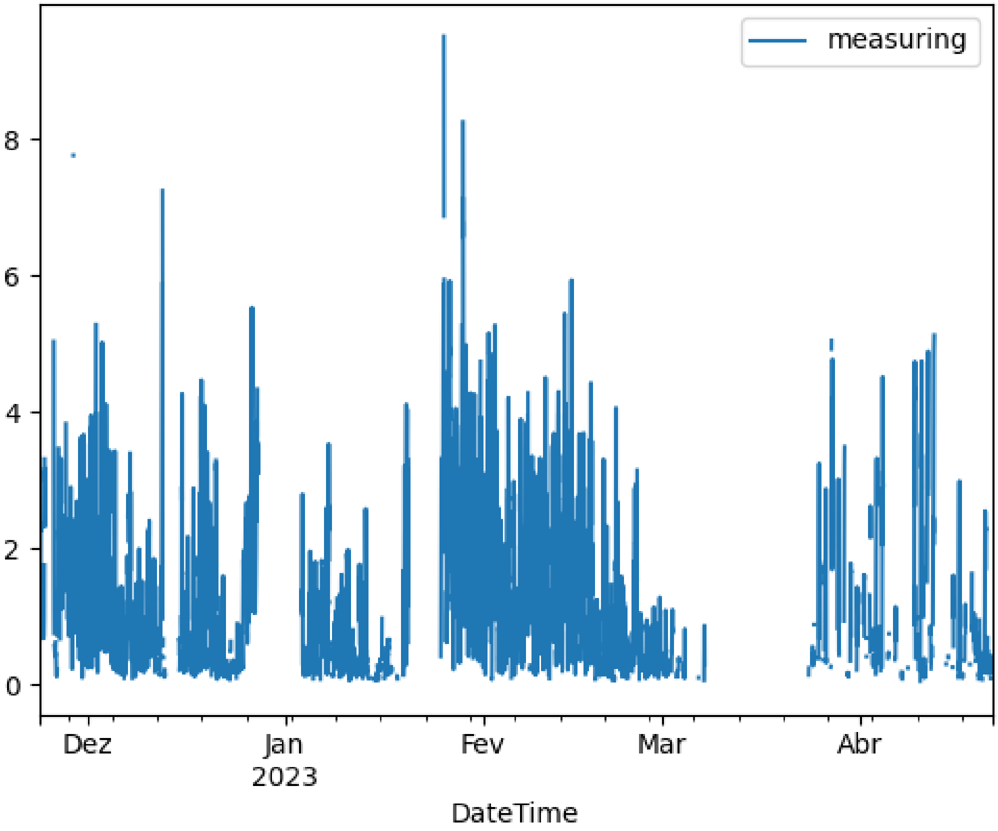
```
                #          %
MISSING      6481  44.570525
```

```
LTLL        1759   12.09683
GTUL           0        0.0
BADSPIKE       0        0.0
VALID       6098  41.936593
LTQTLE01     117   0.804621
GTQTLE99      86   0.591431
TOTAL      14541      100.0
```

Plot valid data

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

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

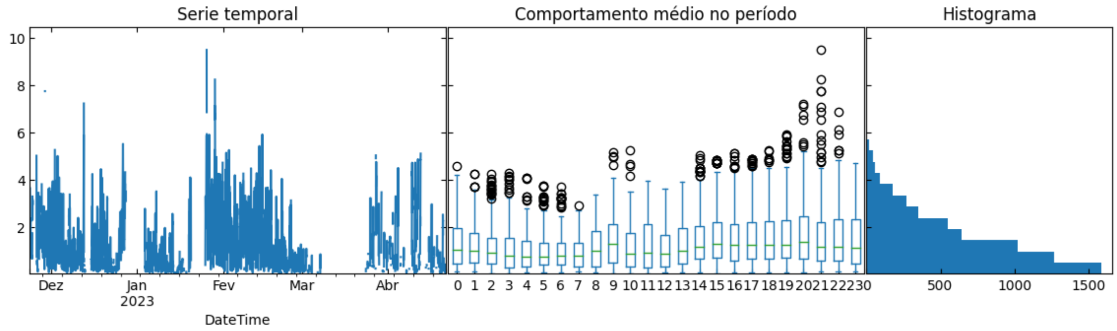


Analyse data after removing quantiles

```
[ ]: 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')
```



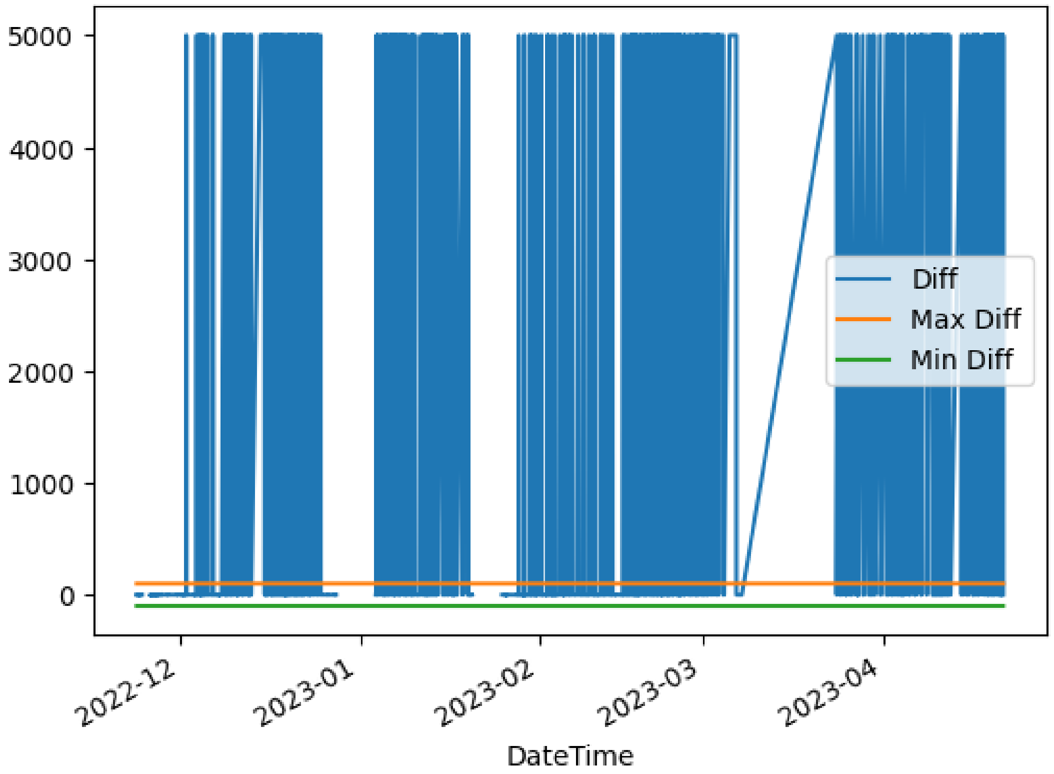
2.4 Analyse data derivatives

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 100 ug/m3 was selected based on the maximum derivative found in the reference data. The maximum derivative (with measuring period of 1 hour) found was 150 ug/m3 ppb. Therefore, a maximum of 100 ug/m3 was considered appropriate for a 15 mins period.

[ ]:
```
max_diff_value = 100
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'>
```



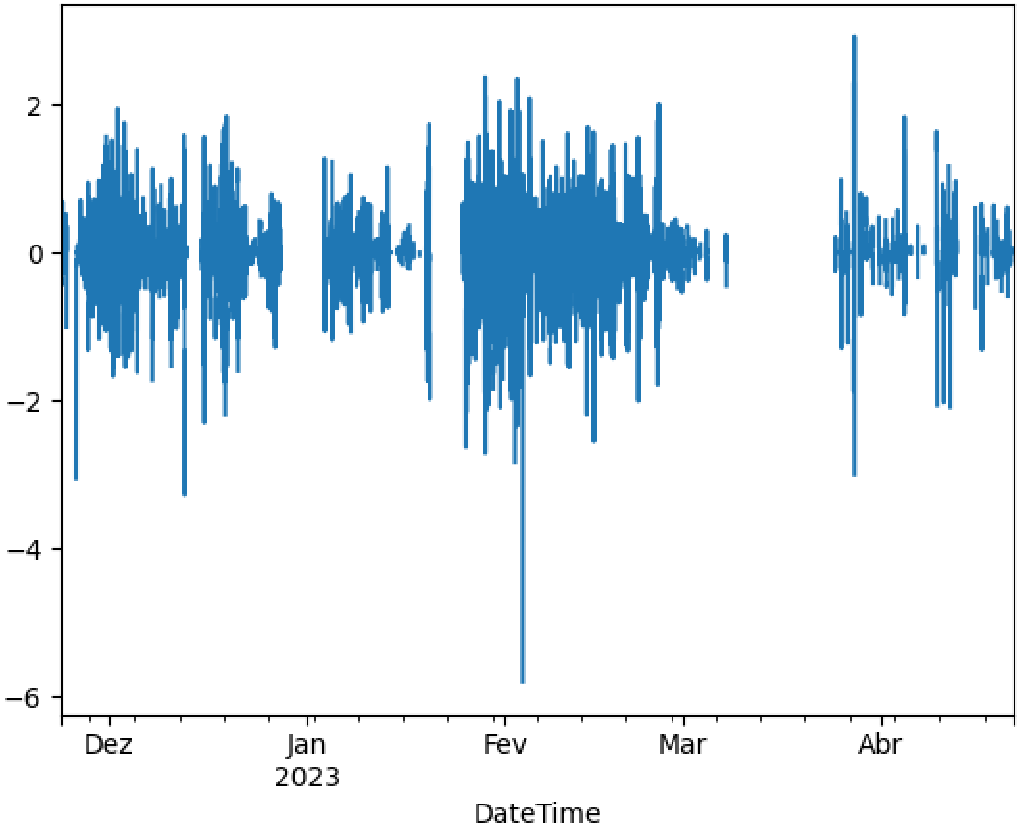
[ ]:

```
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        6481  44.570525
     LTLL           1759   12.09683
     GTUL              0        0.0
     STABILIZING       0        0.0
     BADSPIKE        427   2.936524
     VALID          5671  39.000069
     LTQTLE01        117   0.804621
     GTQTLE99         86   0.591431
     REBASE            0        0.0
     TOTAL         14541      100.0
```

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

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

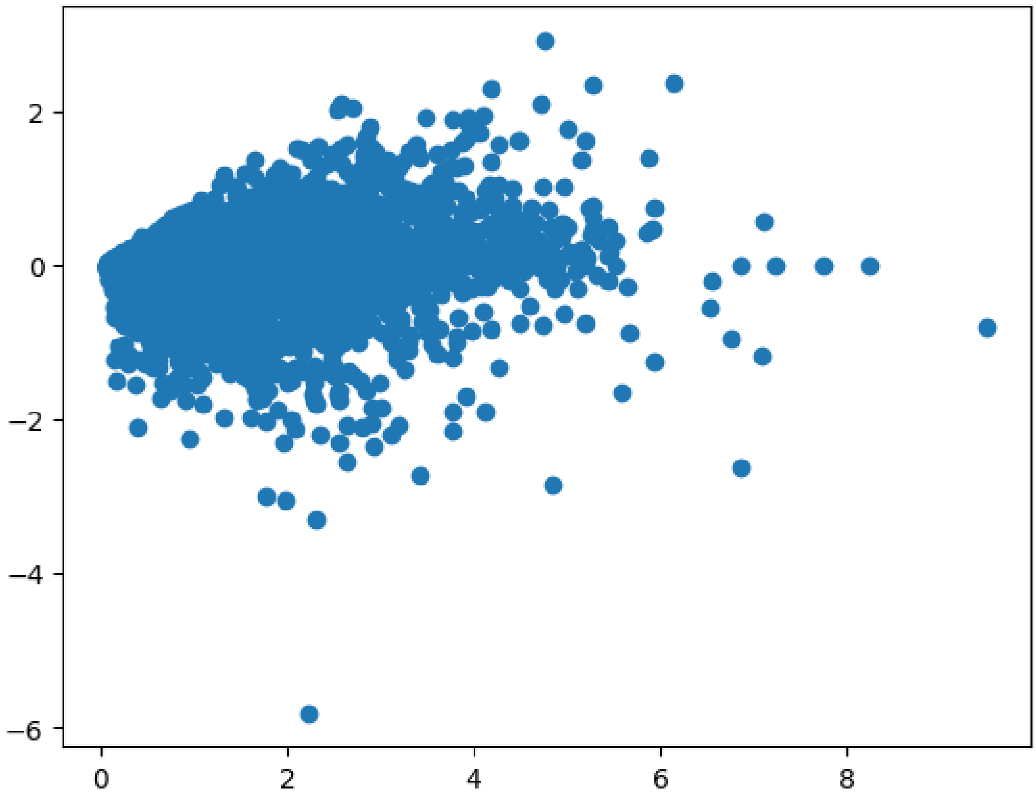


Plot data derivatives vs data

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

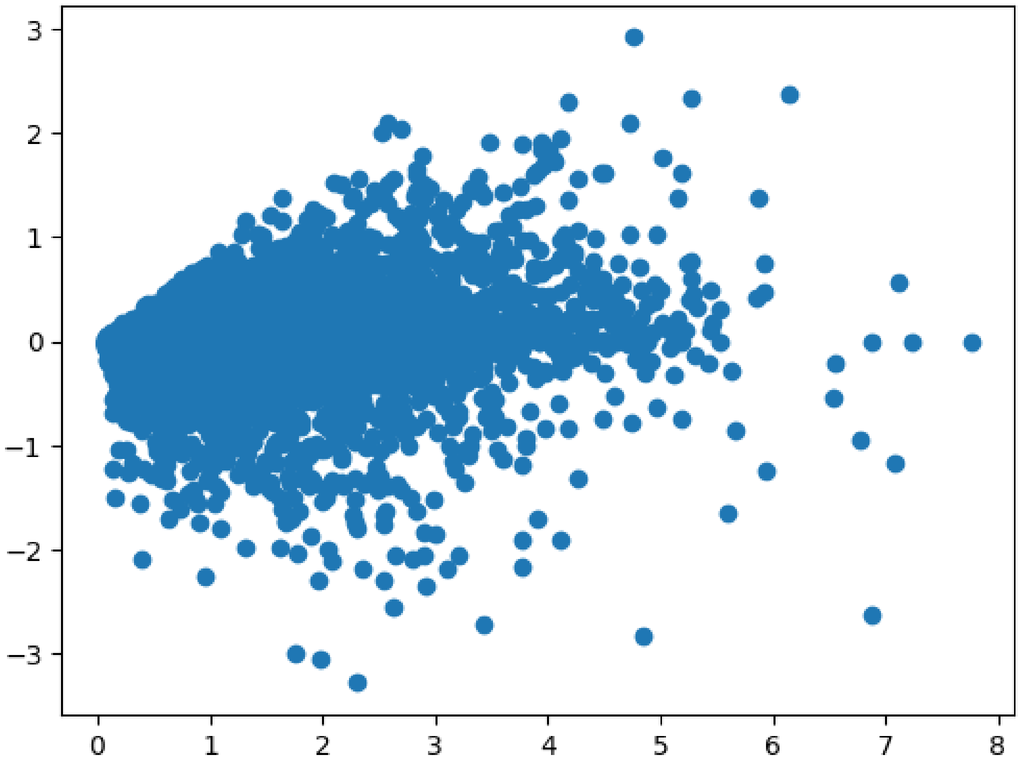
```
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']
fig = plt.figure(figsize=(1.3*5,5))
plt.scatter(valid_dataframe['measuring'], valid_dataframe['Diff'])
```

```
[ ]: <matplotlib.collections.PathCollection at 0x168e1c220>
```



Remove sample with derivative < -4 and value 8

```
[ ]: sensor_dataframe['Tag'] = (sensor_dataframe[['measuring', 'Diff', 'Tag']]
                                   .apply(lambda df: 'BADSPIKE' if df[2] == 'VALID' and␣
       ↪(df[0] > 8 or df[1] <= -4) else df[2], axis=1))
     plt.scatter(sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'],
                 sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['Diff'])
     valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']
```



Data Tag contabilization

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

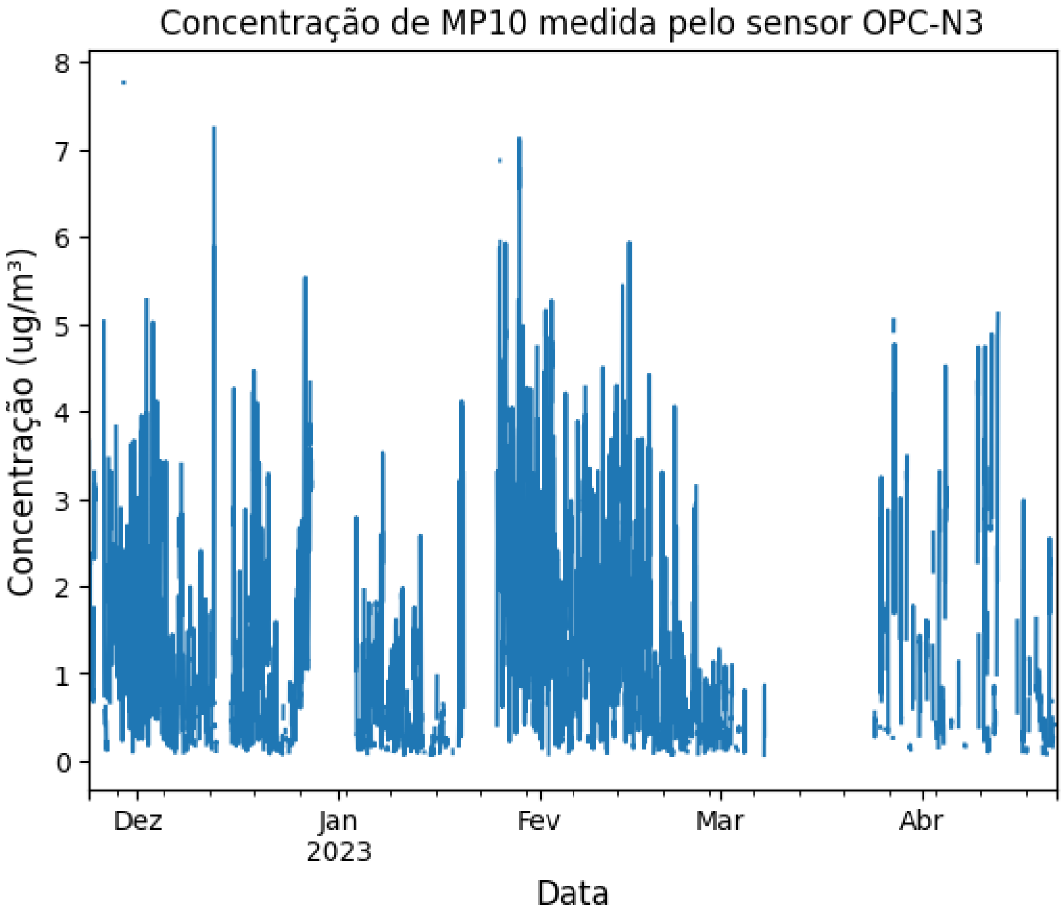
[ ]:
```
                   #          %
MISSING         6481  44.570525
LTLL            1759   12.09683
GTUL               0        0.0
STABILIZING        0        0.0
BADSPIKE         430   2.957156
VALID           5668  38.979437
LTQTLE01         117   0.804621
GTQTLE99          86   0.591431
REBASE             0        0.0
TOTAL          14541      100.0
```

Plot valid data

[ ]:
```
fig, ax = plt.subplots(figsize=(1.3*5,5))
```

```
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
 ↪rename('Concentração de MP10').resample('15T').mean().plot()
plt.title('Concentração de MP10 medida pelo sensor OPC-N3')
ax.set_xlabel('Data', fontsize=12)
ax.set_ylabel('Concentração (ug/m\N{SUPERSCRIPT THREE})', fontsize=12)
```

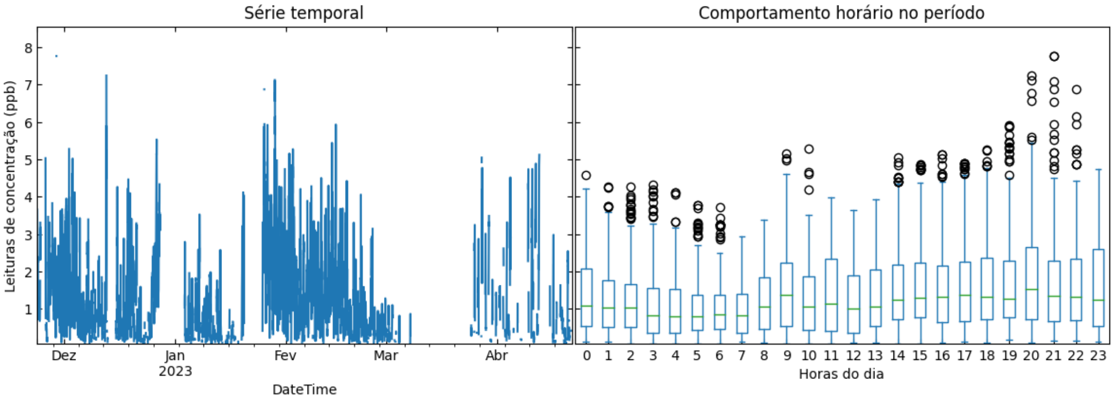
```
[ ]: Text(0, 0.5, 'Concentração (ug/m³)')
```



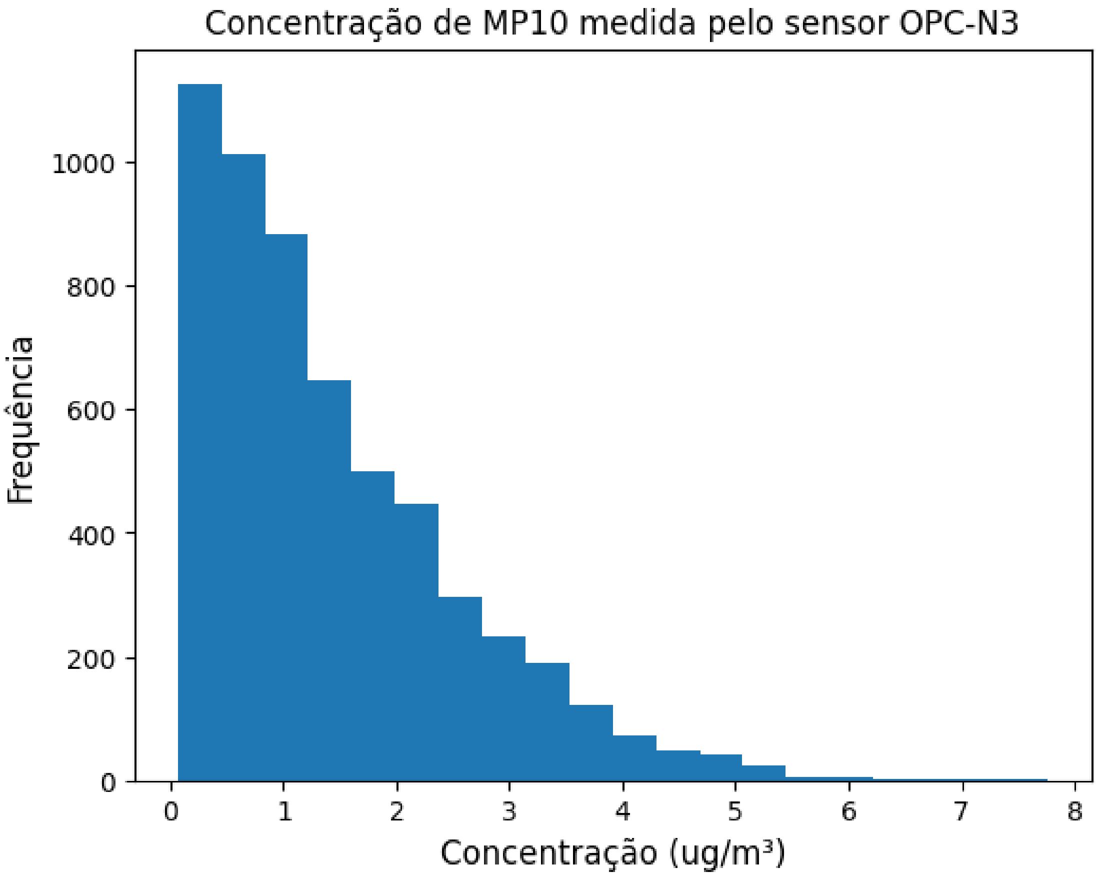
```
[ ]: valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'].
      ↪drop(columns=['Tag']).resample('15T').mean()
     sensor_analysis.plot_box(df=valid_dataframe)
```

```
/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')
```

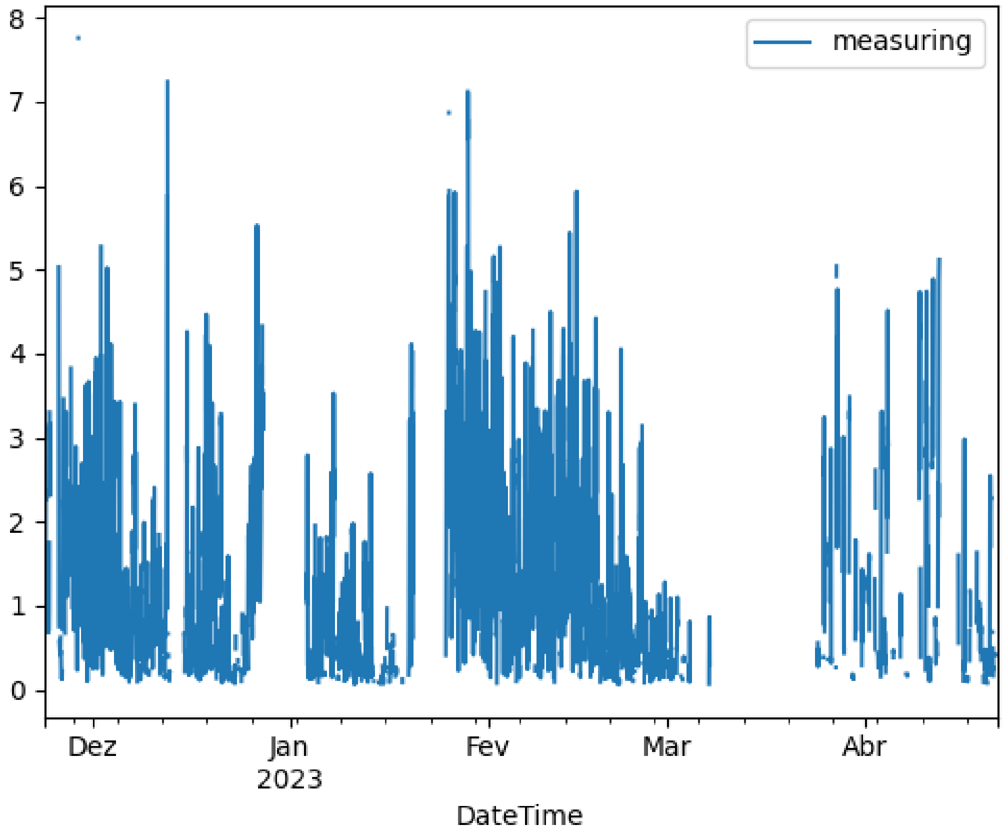


```
[ ]: fig, ax = plt.subplots(figsize=(1.3*5,5))
     (sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
      ↪rename('Concentração de MP10')
      .resample('15T').mean().hist(bins=20))
     plt.title('Concentração de MP10 medida pelo sensor OPC-N3')
     ax.set_xlabel('Concentração (ug/m\N{SUPERSCRIPT THREE})', fontsize=12)
     ax.set_ylabel('Frequência', fontsize=12)
     ax.grid(False)
```



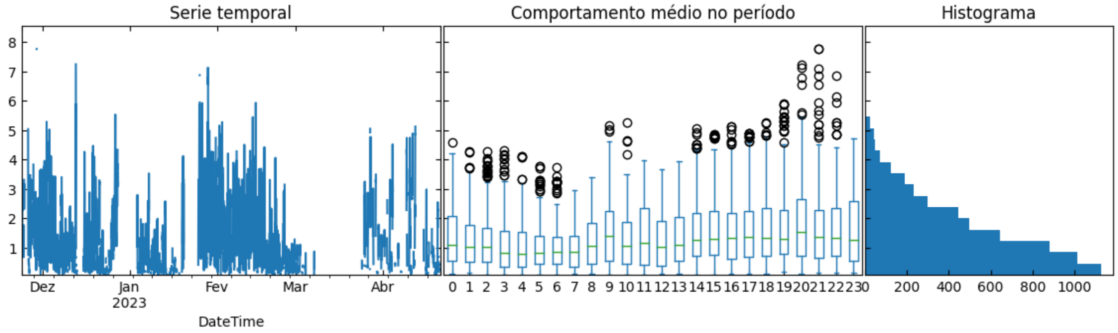
```
[ ]: sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'][['measuring']].
      ↪resample('15T').mean().plot()
```

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



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

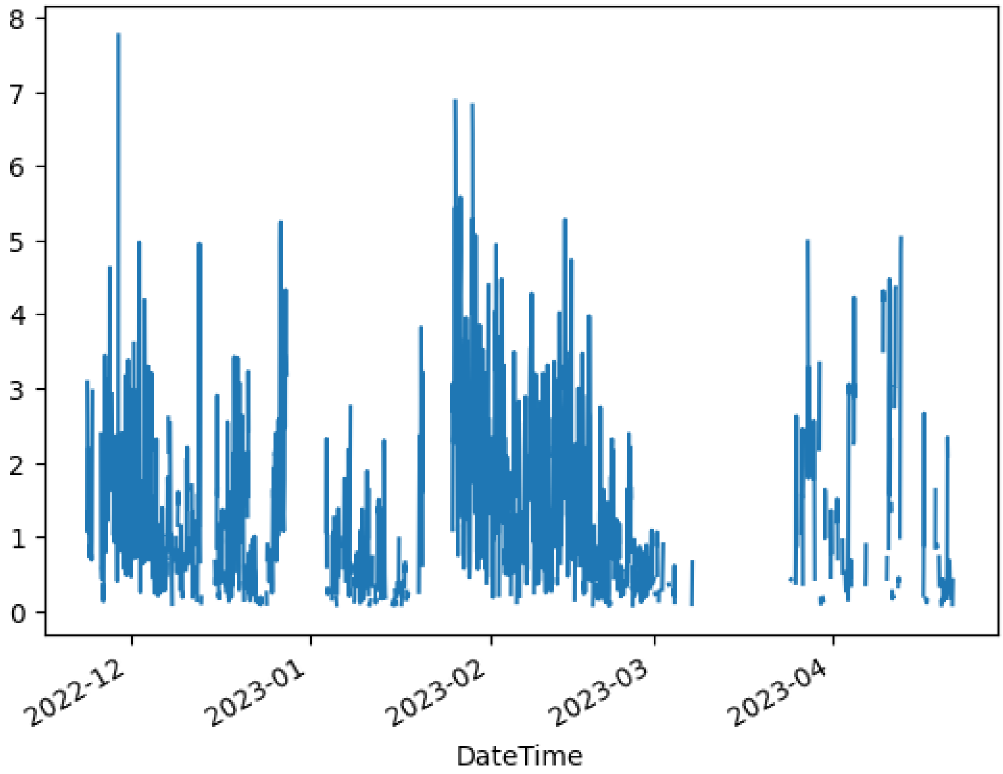
```
/Users/Fernando/Documents/Projects/Github/lcqar-low-cost-monit-proc/data-pre-
processing/SensorDataAnalysisService.py:111: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

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 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()
```

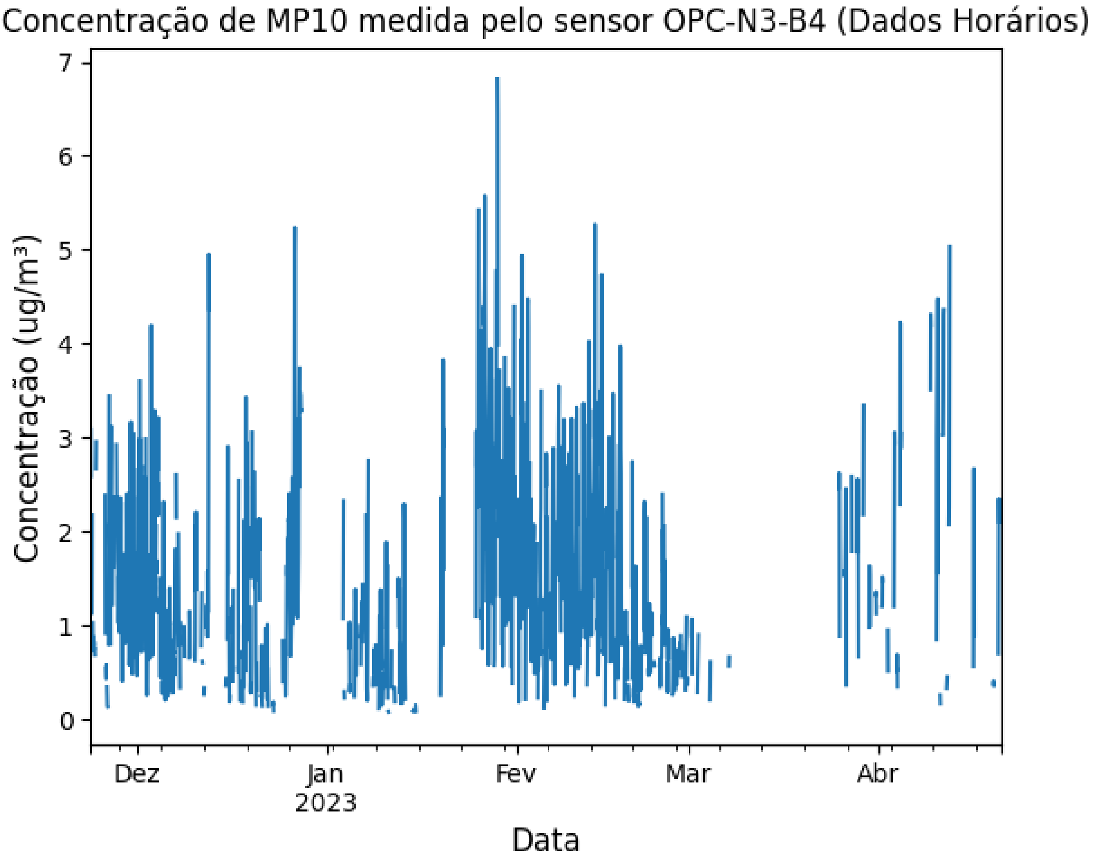
```
[ ]: <Axes: xlabel='DateTime'>
```



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 MP10').resample('1H').mean().plot()
plt.title('Concentração de MP10 medida pelo sensor OPC-N3-B4 (Dados Horários)')
ax.set_xlabel('Data', fontsize=12)
ax.set_ylabel('Concentração (ug/m\N{SUPERSCRIPT THREE})', fontsize=12)
```

[ ]:
```
Text(0, 0.5, 'Concentração (ug/m³)')
```



Valid data contabilization

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

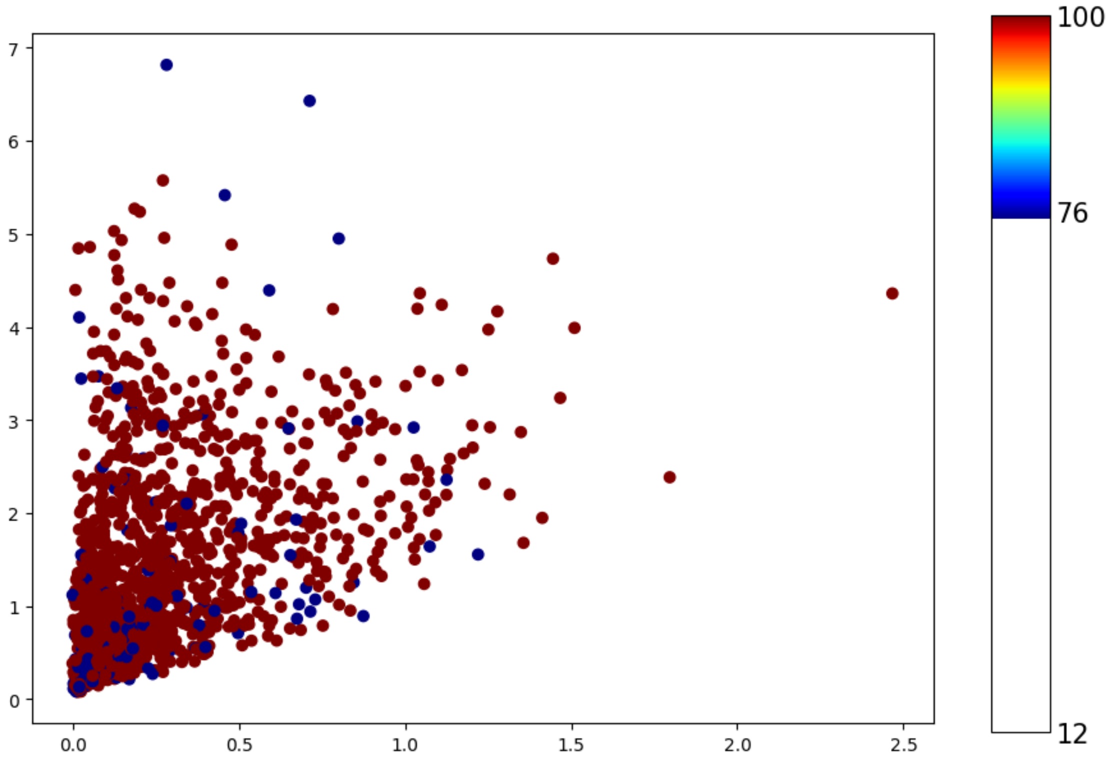
```
[ ]:                #        %
     LOWSAMPLES  2269  63.3445
     VALID       1313  36.6555
     TOTAL       3582    100.0
```

2.6 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

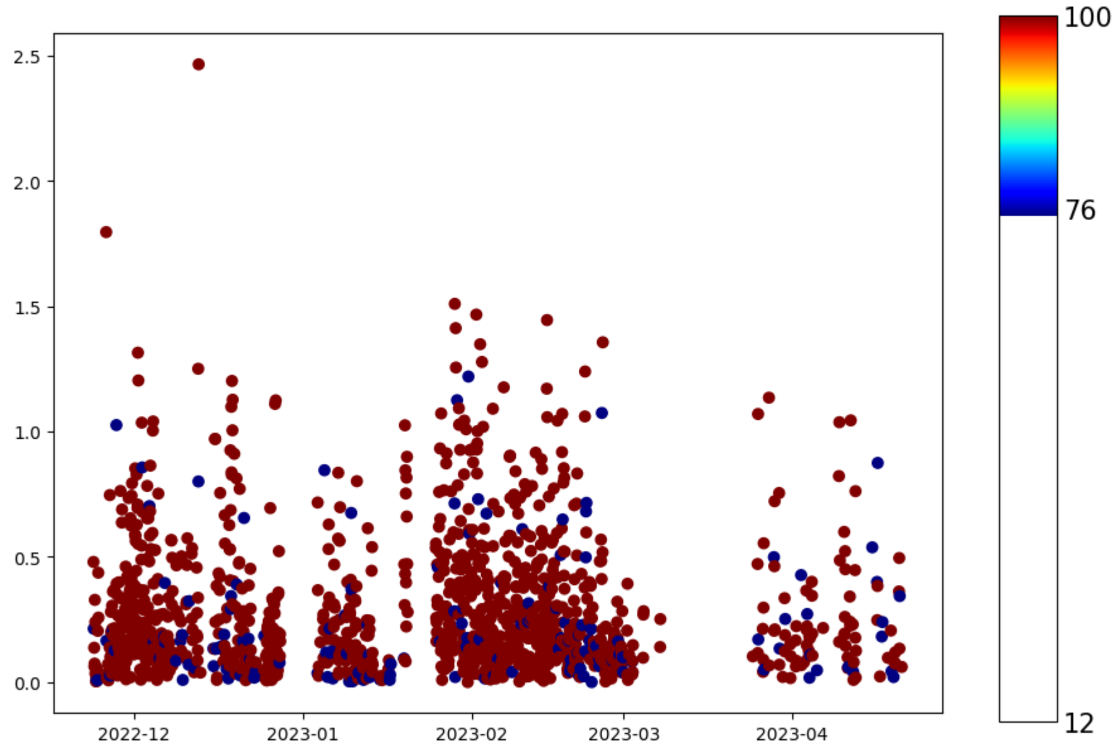
Plot mean (Y axis) vs. standard deviation (X axis) for valid hourly data colored by valid percentage of valid samples

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



2.6.1 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
```

```python
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'].to_csv(valid_file_path_output)
resampled_dataframe[resampled_dataframe['Tag'] == 'VALID']['measuring'].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'].to_csv(valid_processing_file_path)
resampled_dataframe[resampled_dataframe['Tag'] == 'VALID']['measuring'].to_csv(valid_processing_1HR_file_path)
sensor_dataframe.to_csv(processing_dataframe_path)
resampled_dataframe.to_csv(processing_dataframe_path_1HR)
```