CO-field-data-treatment-Diamante

February 13, 2024

1 Electrochemical CO sensor data preprocessing

- Pollutant: Carbon Monoxide
- Sensor: Alphasense CO-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_CO.CSV"

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

1.1.3 Sensor Constants

[ ]:
```
M = 28.01
lower_limit = 4.0
upper_limit = 1e6
t_90 = 30     # sensor takes 30 seconds to reach a value of 10e3
t_90_value = 10e3
sampling_period = 15 * 60
```

2 Alphasense CO 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	125.92	2022-11-20 13:45:23
1	-28.456899	-48.972999	86.05	2022-11-21 10:37:45
2	-28.456899	-48.972999	86.38	2022-11-21 10:53:33
3	-28.456899	-48.972999	96.05	2022-11-21 11:09:20
4	-28.456899	-48.972999	84.43	2022-11-21 11:25:07

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	125.92	2022-11-20 13:45:23
1	1	-28.456899	-48.972999	86.05	2022-11-21 10:37:45
2	2	-28.456899	-48.972999	86.38	2022-11-21 10:53:33
3	3	-28.456899	-48.972999	96.05	2022-11-21 11:09:20
4	4	-28.456899	-48.972999	84.43	2022-11-21 11:25:07

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_1994/166902210.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))
```

[ ]:

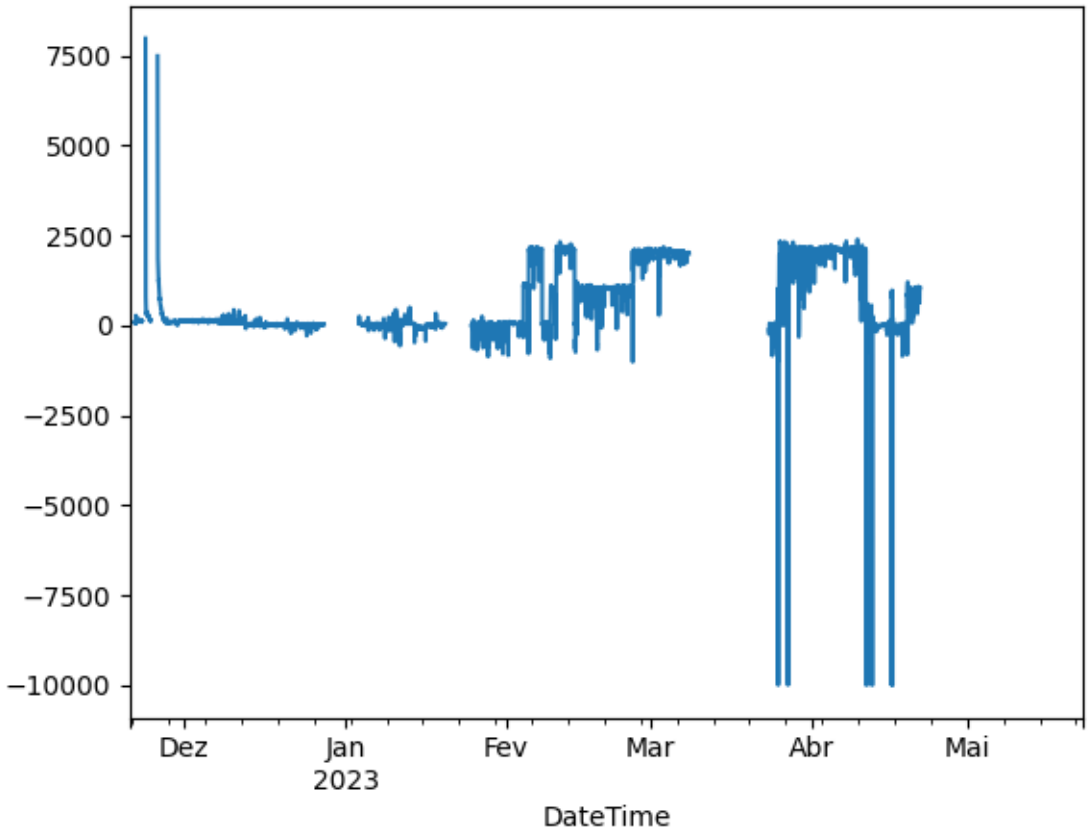
DateTime	latitude	longitude	measuring
2022-11-20 13:45:00	-28.456899	-48.972999	125.92
2022-11-20 14:00:00	NaN	NaN	NaN
2022-11-20 14:15:00	NaN	NaN	NaN
2022-11-20 14:30:00	NaN	NaN	NaN
2022-11-20 14:45:00	NaN	NaN	NaN
…	…	…	…
2023-05-23 08:15:00	NaN	NaN	NaN
2023-05-23 08:30:00	NaN	NaN	NaN
2023-05-23 08:45:00	NaN	NaN	NaN
2023-05-23 09:00:00	NaN	NaN	NaN
2023-05-23 09:15:00	-28.456899	-48.972999	163.04

[17647 rows x 3 columns]

2.1.2 Plot raw data

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

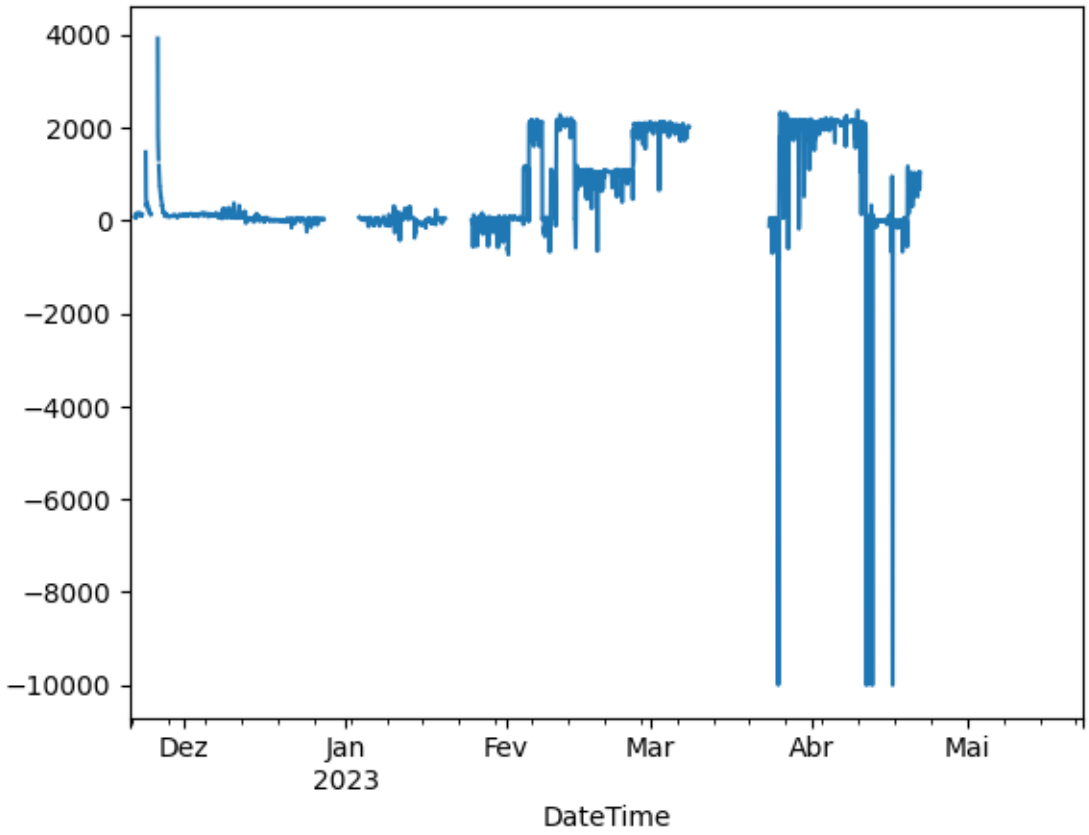
[ ]:
```
<Axes: xlabel='DateTime'>
```



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 ppm

```
[ ]: sensor_dataframe['value'] = sensor_dataframe['measuring'].map(lambda v: v/1e3)
```

2.2 Tag data

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

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

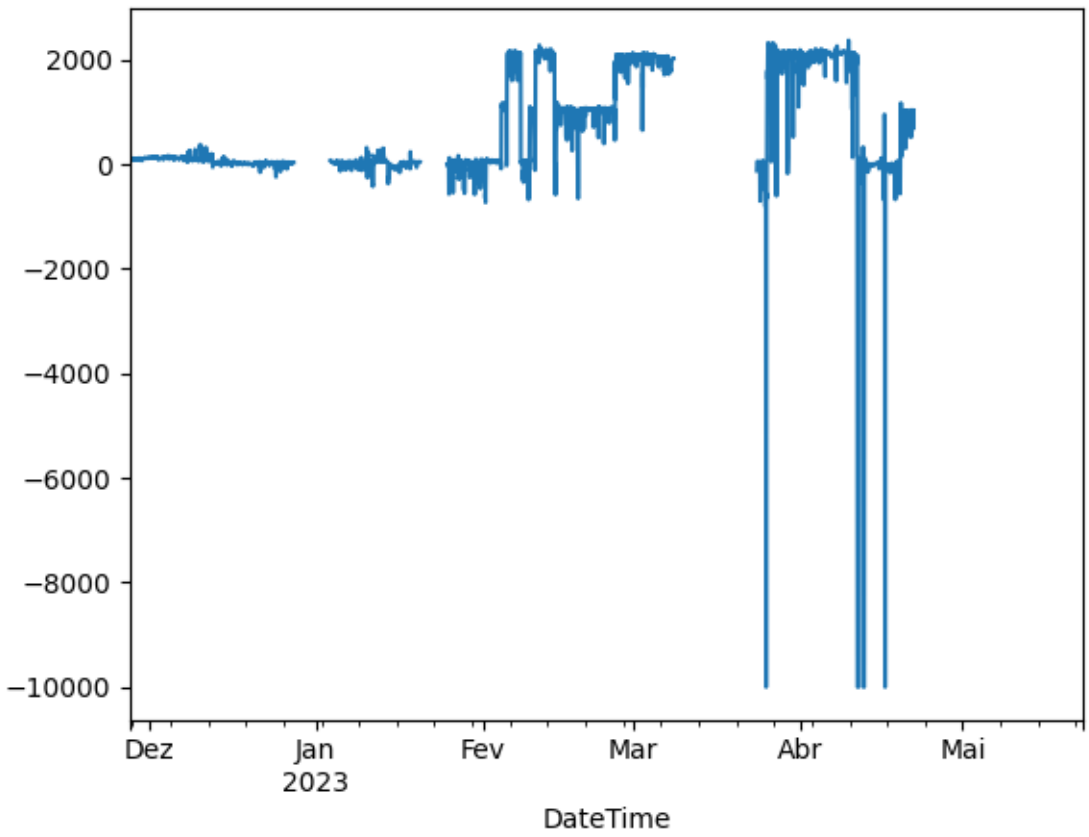
Tag data during stabilizing period AQMesh recomends to considering the first two days after installation as a period for stabilization. In our case, a period of seven days was selected in order to remove outliers candidates detected during that period. For that purpose we detect the first 7 days of uninterrupted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

[ ]:

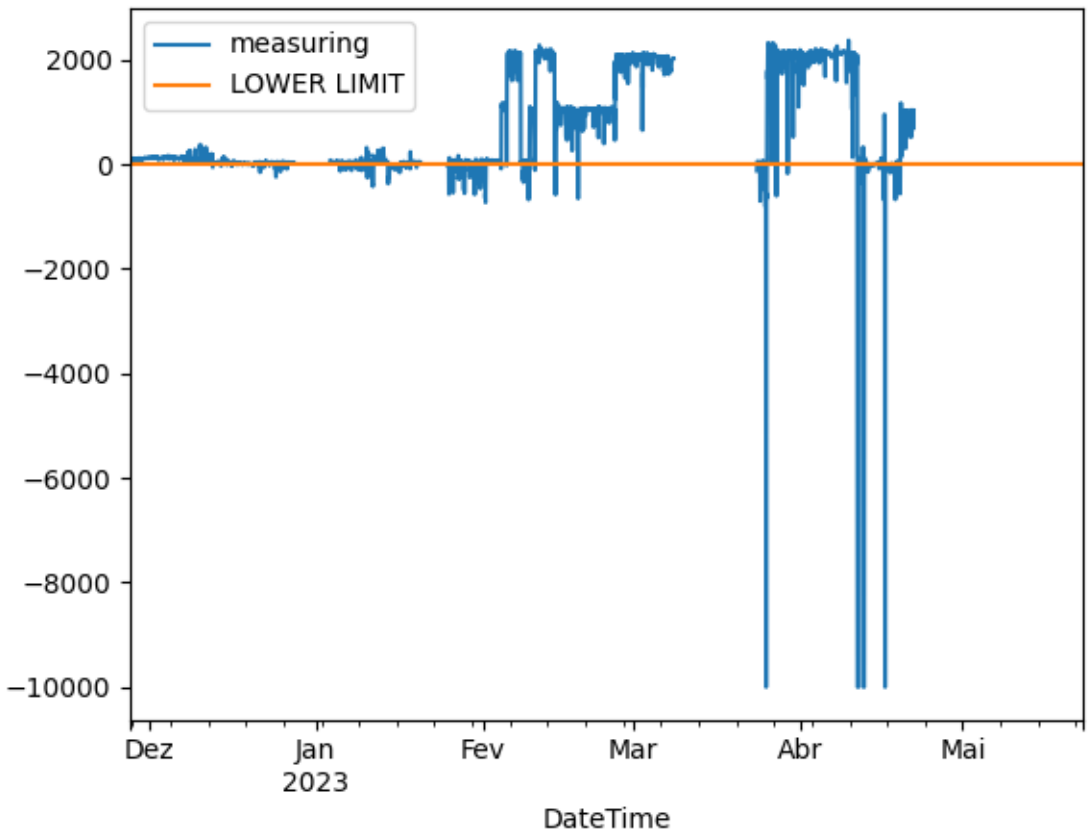
DateTime	latitude	longitude	measuring	raw measuring	Hour	value	Tag
2022-11-20 13:45:00	-28.456899	-48.972999	NaN	125.92	13	NaN	STABILIZING
2022-11-20 14:00:00	NaN	NaN	NaN	NaN	14	NaN	STABILIZING
2022-11-20 14:15:00	NaN	NaN	NaN	NaN	14	NaN	STABILIZING
2022-11-20 14:30:00	NaN	NaN	NaN	NaN	14	NaN	STABILIZING
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'>
```

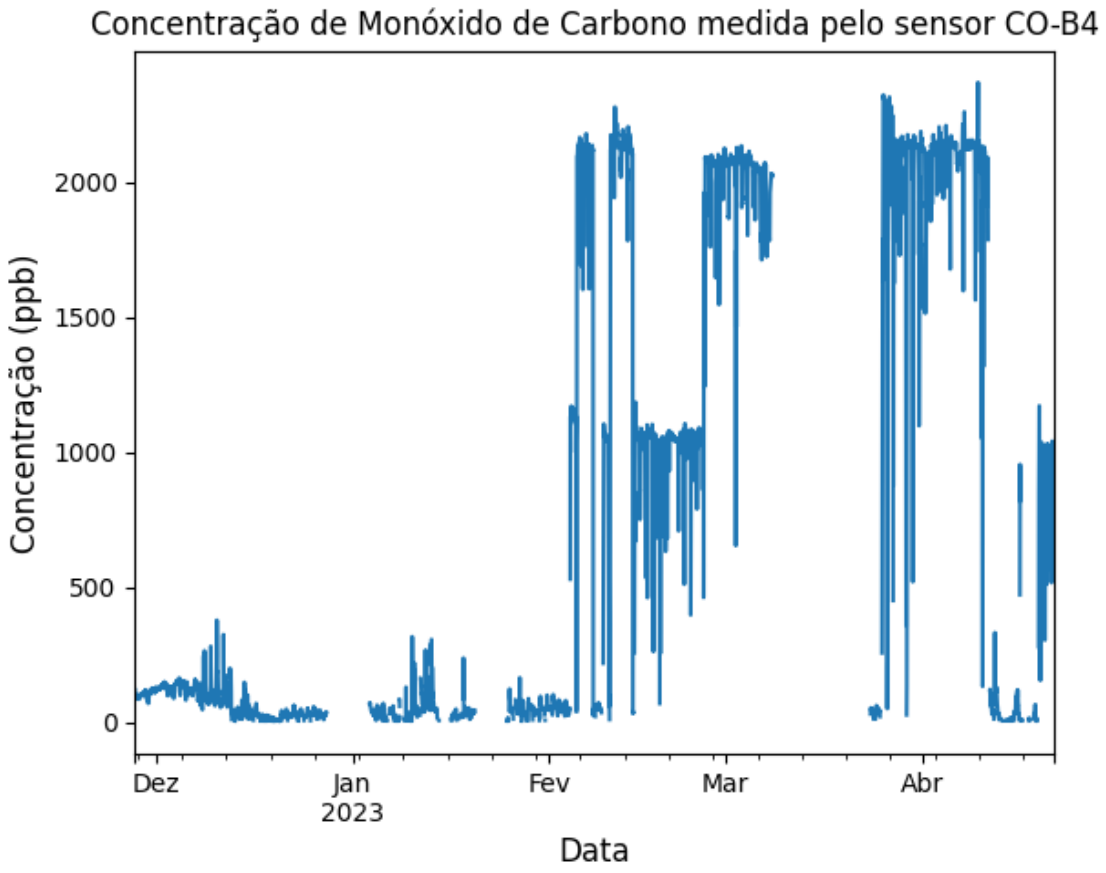


[ ]:
```
import numpy as np
from SensorDataAnalysisService import SensorDataAnalysisService as␣
 ↪sensor_analysis

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 Monóxido de Carbono').resample('15T').mean().plot()
plt.title('Concentração de Monóxido de Carbono medida pelo sensor CO-B4')
ax.set_xlabel('Data', fontsize=12)
ax.set_ylabel('Concentração (ppb)', fontsize=12)
```

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



2.2.1 Data Tag contabilization

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

[ ]:
```
                #          %
MISSING      5756  32.617442
```

```
LTLL          1560   8.840029
GTUL             0        0.0
STABILIZING    673   3.813679
BADSPIKE         0        0.0
VALID         9658  54.728849
TOTAL        17647      100.0
```

2.3 Analyse valid data

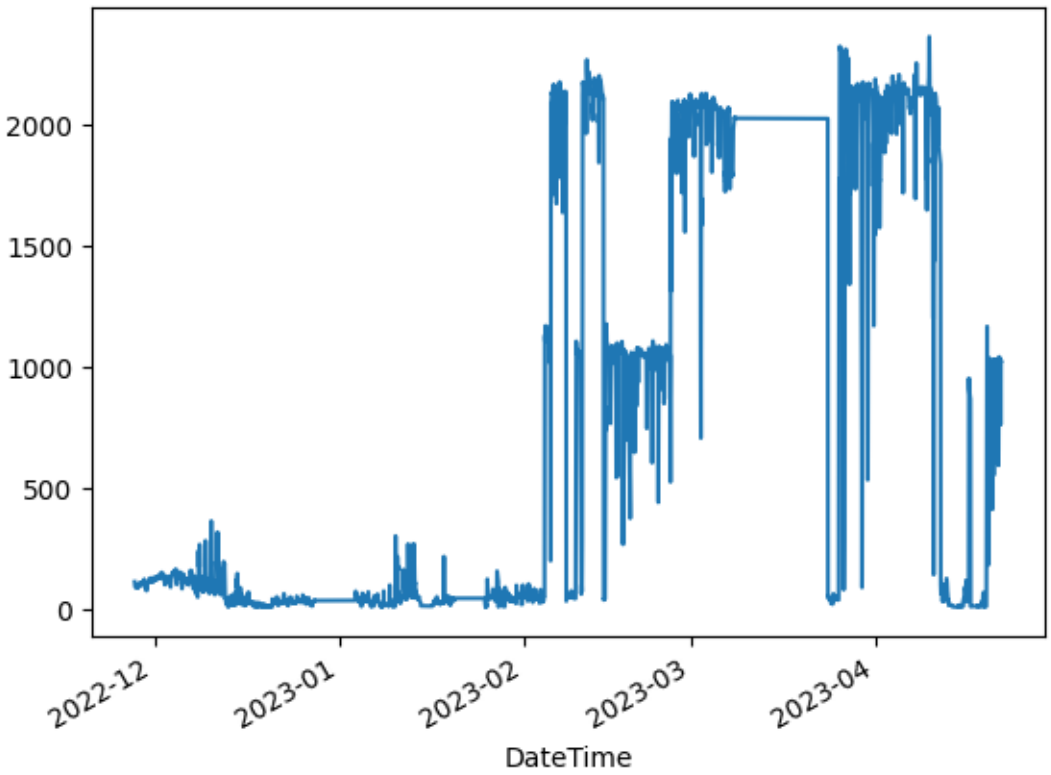
The graph shows the time series of the valid data, box plots of the data grouped by hour of the day, and histogram of the data.

[ ]:
```
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

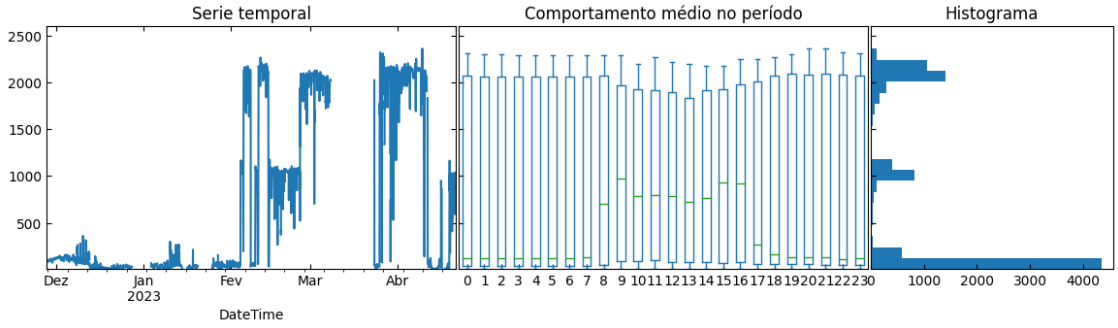
[ ]:
```
valid_dataframe['raw measuring'] = valid_dataframe['measuring']
valid_dataframe['measuring'] = valid_dataframe['measuring'].rolling(window=4).
↪median()
valid_dataframe['measuring'].plot()
```

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

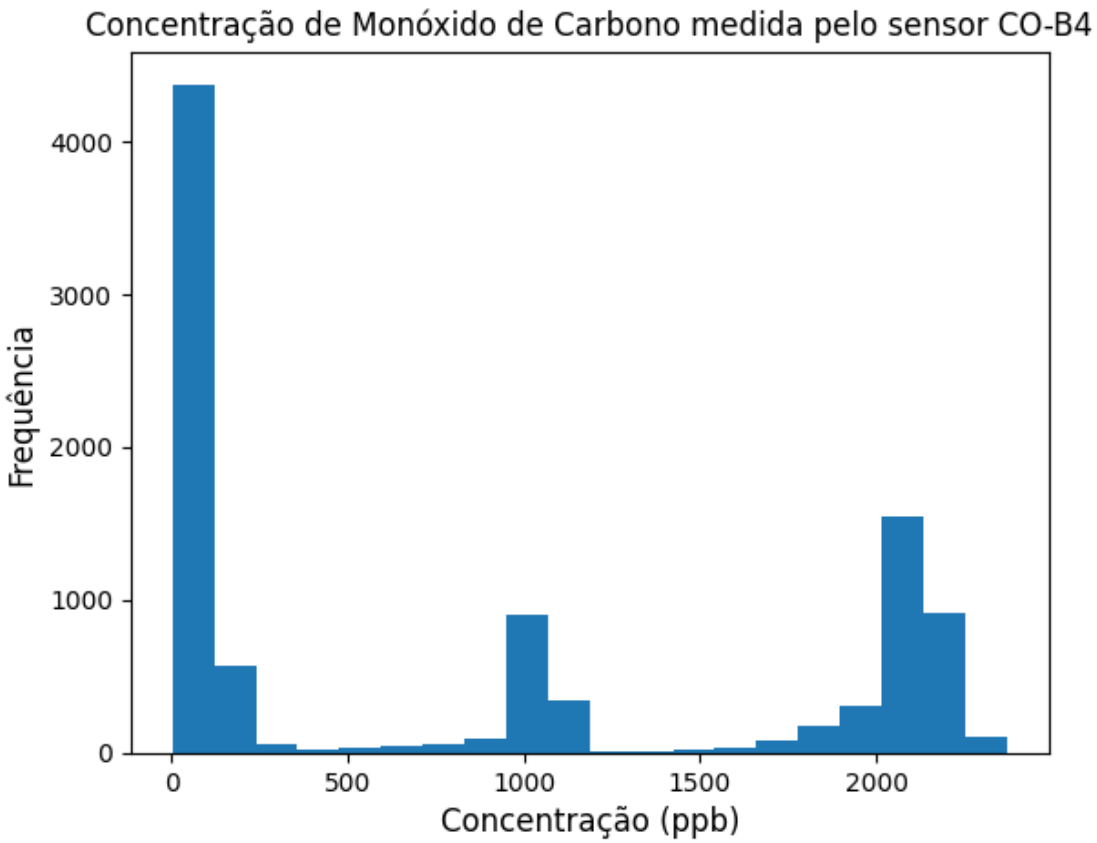


[ ]:
```
valid_dataframe = valid_dataframe.resample('15T').mean()
sensor_analysis.plot_box_hist(df=valid_dataframe, bins=20)
```

```
/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')
```



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



2.4 Change point Analysis

2.4.1 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
```

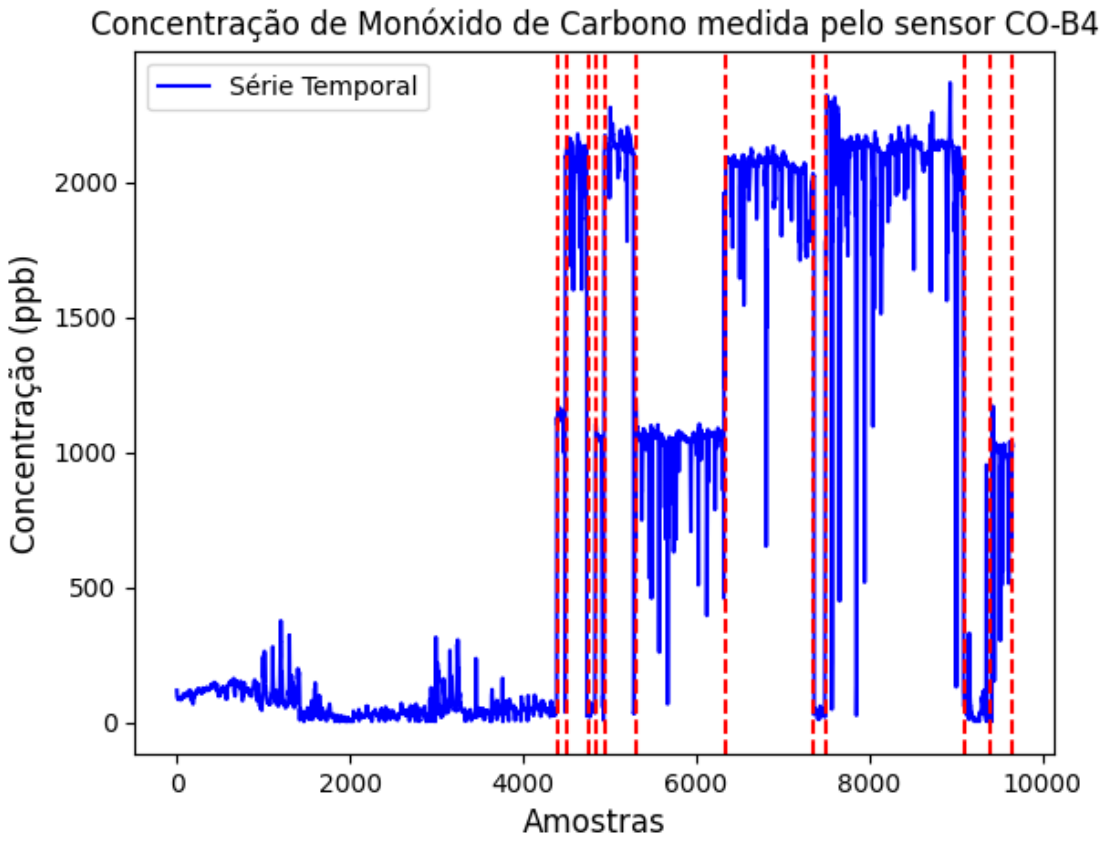
[ ]:
```
[4400, 4500, 4750, 4850, 4950, 5300, 6350, 7350, 7500, 9100, 9400, 9658]
```

[ ]:
```
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_1994/717246363.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
```

[ ]:
```python
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 Monóxido de Carbono medida pelo sensor CO-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()
```



Tag dataframe with changepoints

```
[ ]: sensor_dataframe.loc[change_point_index[0]:, 'Tag'] = (sensor_dataframe.
      ↪loc[change_point_index[0]:, 'Tag']
                                                          .apply(lambda t:␣
      ↪'REBASE' if t == 'VALID' else t))
     sensor_dataframe[sensor_dataframe['Tag'] == 'REBASE'].head()
```

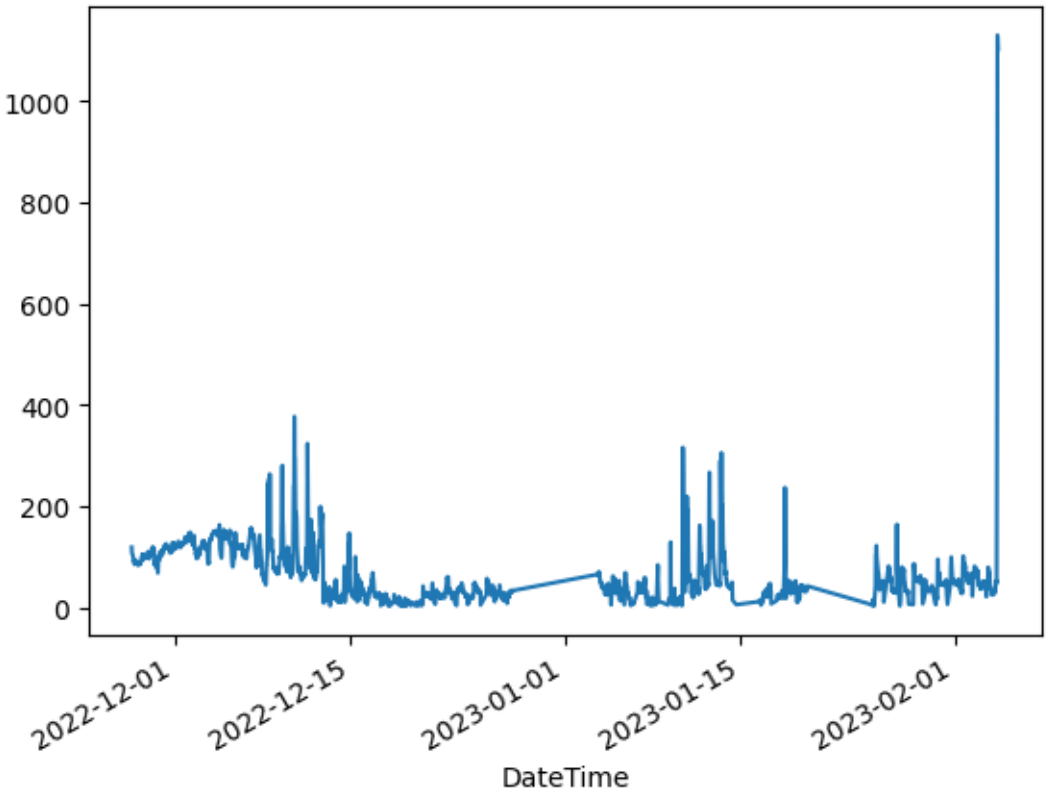
```
[ ]:                      latitude  longitude  measuring  raw measuring  Hour  \
     DateTime
     2023-02-04 11:15:00 -28.456899 -48.972999   1108.640        1109.40    11
     2023-02-04 11:30:00 -28.456899 -48.972999   1110.445        1112.44    11
     2023-02-04 11:45:00 -28.456899 -48.972999   1110.445        1104.39    11
     2023-02-04 12:00:00 -28.456899 -48.972999   1110.920        1113.96    12
     2023-02-04 12:15:00 -28.456899 -48.972999   1113.200        1121.73    12

                           value     Tag  UPPER LIMIT  LOWER LIMIT  CHANGE POINT
     DateTime
     2023-02-04 11:15:00  1.108640  REBASE    1000000.0          4.0          True
     2023-02-04 11:30:00  1.110445  REBASE    1000000.0          4.0         False
     2023-02-04 11:45:00  1.110445  REBASE    1000000.0          4.0         False
     2023-02-04 12:00:00  1.110920  REBASE    1000000.0          4.0         False
     2023-02-04 12:15:00  1.113200  REBASE    1000000.0          4.0         False
```

Data Tag contabilization

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

```
[ ]:                  #          %
     MISSING       5756  32.617442
     LTLL          1560   8.840029
     GTUL             0        0.0
     STABILIZING    673   3.813679
     BADSPIKE         0        0.0
     VALID         4399   24.92775
     REBASE        5259  29.801099
     TOTAL        17647      100.0
```

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

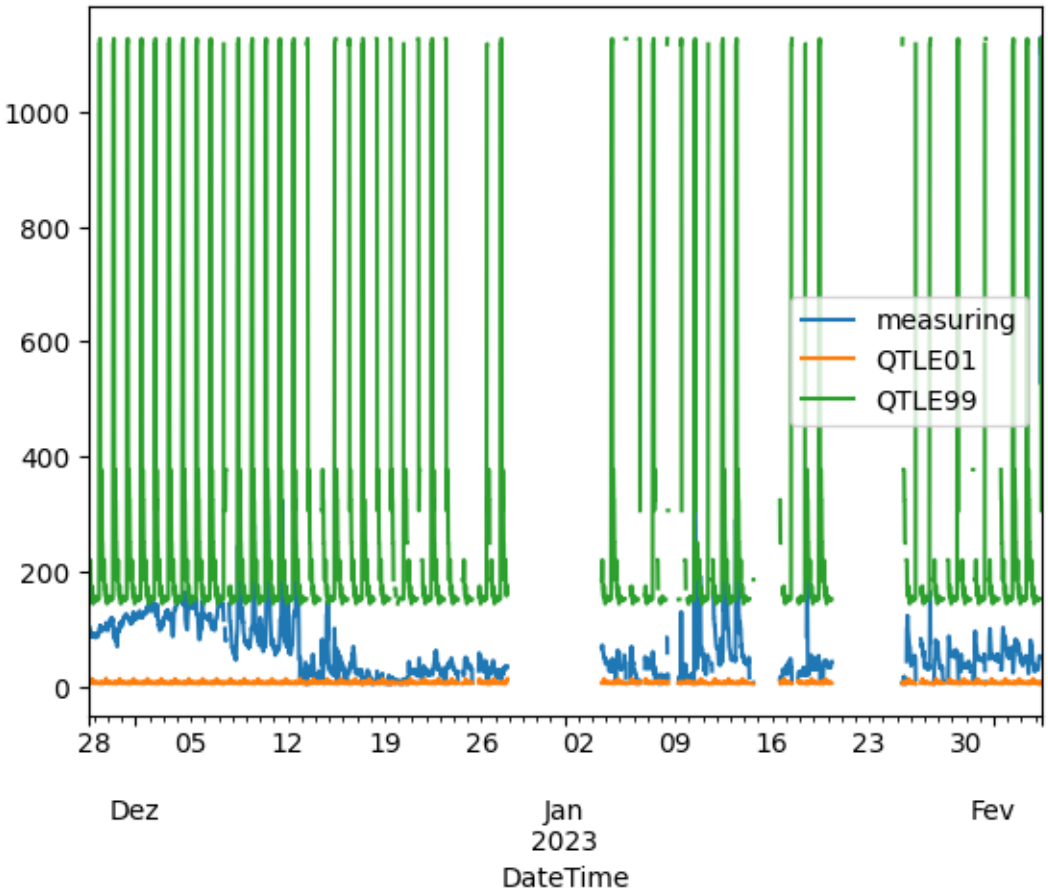


2.4.2 Calculate quantiles

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
```

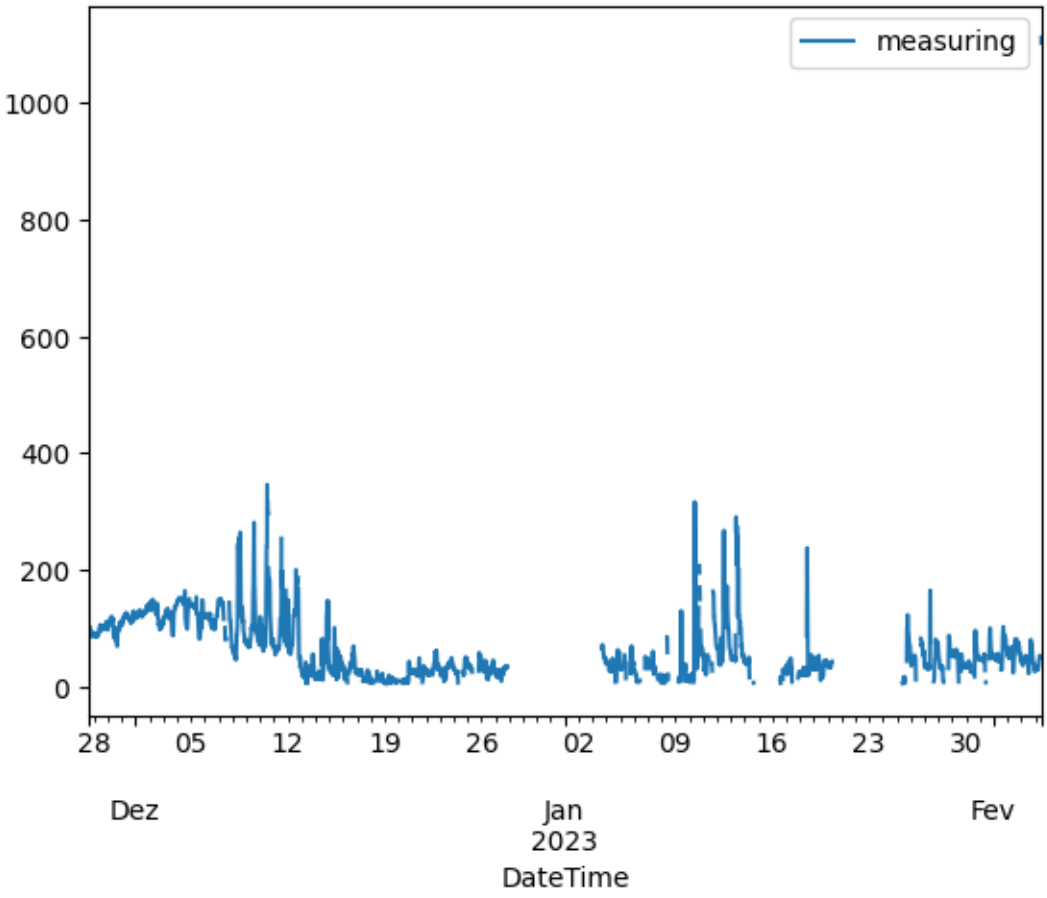
[ ]:

	#	%
MISSING	5756	32.617442
LTLL	1560	8.840029
GTUL	0	0.0
BADSPIKE	0	0.0
VALID	4273	24.213747
LTQTLE01	63	0.357001
GTQTLE99	63	0.357001
REBASE	5259	29.801099
TOTAL	17647	100.0

Plot valid data

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

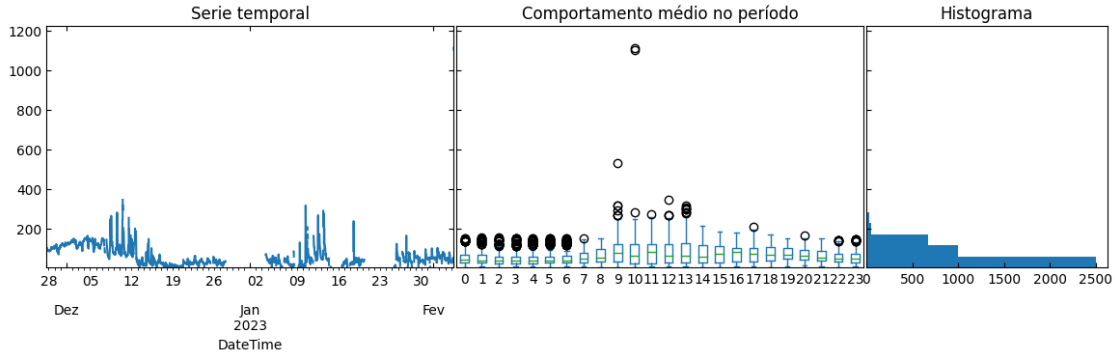
[ ]: <Axes: xlabel='DateTime'>



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')
```



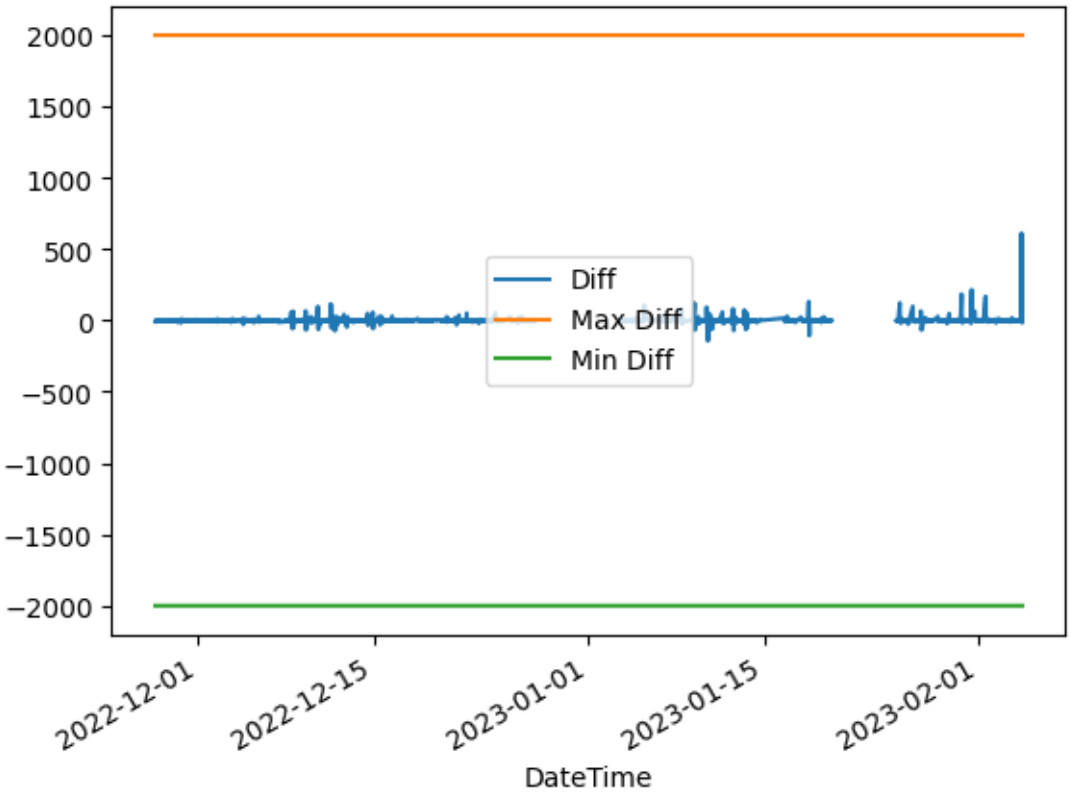
2.5 Analyse data derivatives

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 2000 ppb was selected based on the maximum derivative found in the reference data. The maximum derivative (with measuring period of 1 hour) found was 4200 ppb. Therefore, a maximum of 4000 ppb was considered appropriate for a 15 mins period.

[ ]:
```
max_diff_value = 2000
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()
```

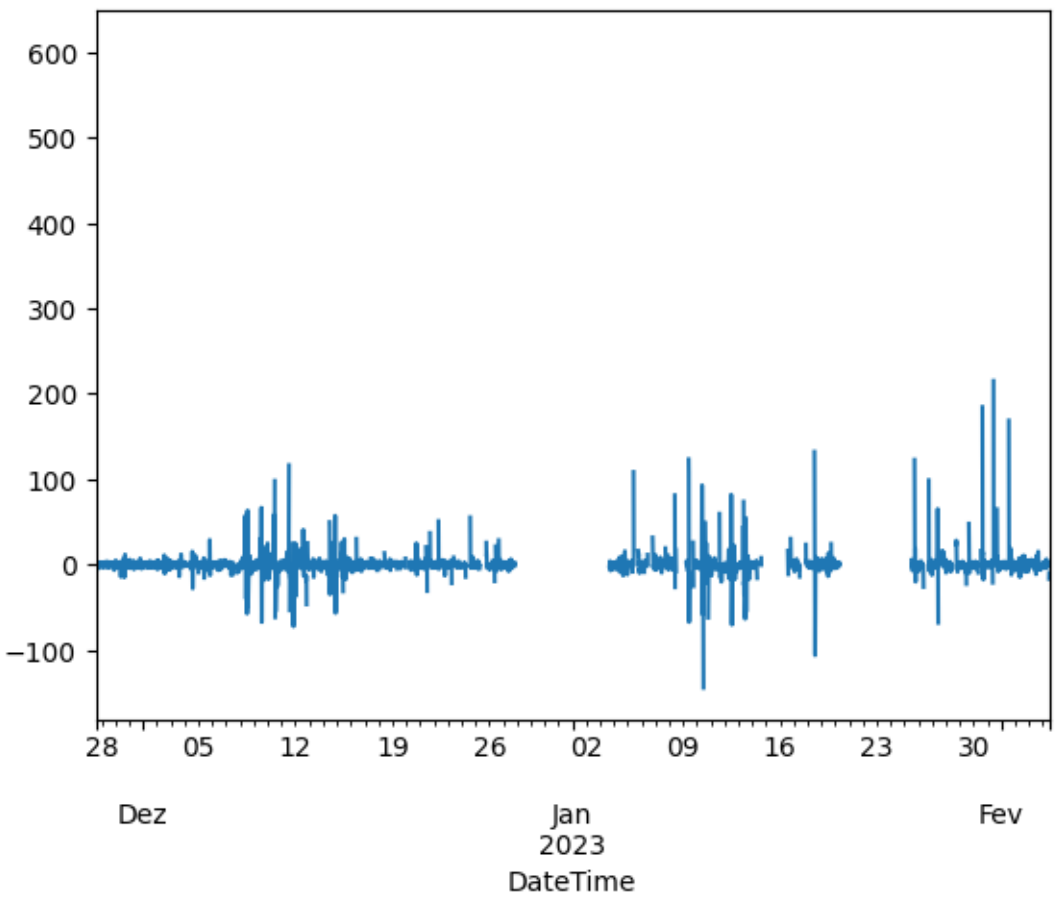
[ ]:
```
<Axes: xlabel='DateTime'>
```



[ ]:
```
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))
```

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

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

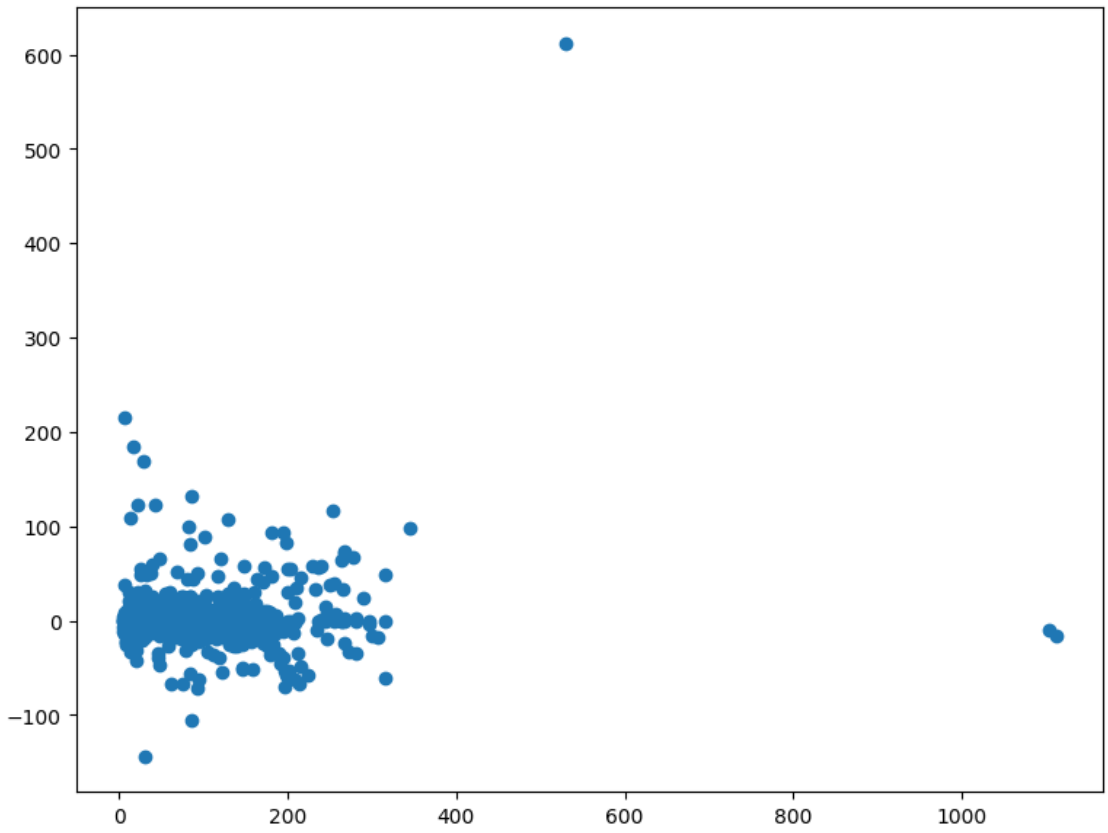


Plot data derivatives vs data

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

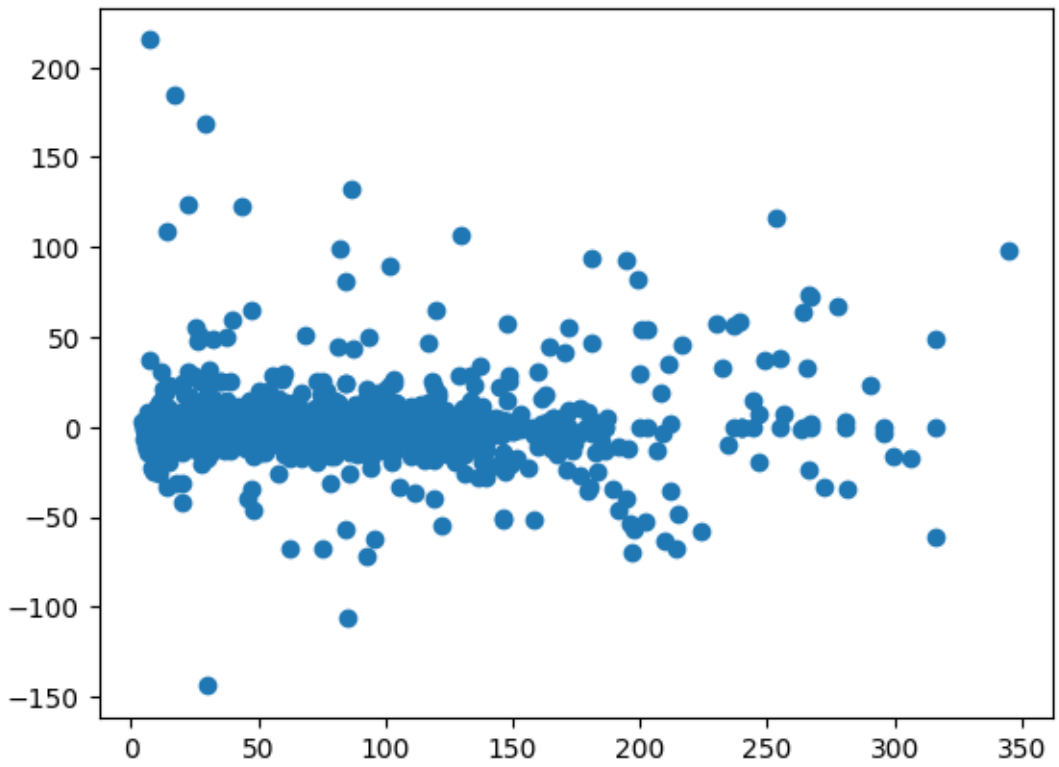
[ ]:
```
import matplotlib.pyplot as plt

fig = plt.figure(figsize=(1.3*7,7))
plt.scatter(valid_dataframe['measuring'], valid_dataframe['Diff'])
```

[ ]:
```
<matplotlib.collections.PathCollection at 0x294b25fd0>
```



Remove sample with derivative 600 and value 1000

[ ]:
```
sensor_dataframe['Tag'] = (sensor_dataframe[['measuring', 'Diff', 'Tag']]
                           .apply(lambda df: 'BADSPIKE' if df[2] == 'VALID' and␣
 ↪(df[1] >= 600 or df[0] >= 1000) else df[2], axis=1))

# sensor_dataframe.loc[sensor_dataframe['Diff'] >= 600, 'Tag'] = 'BADSPIKE'
# sensor_dataframe.loc[sensor_dataframe['measuring'] >= 1000, 'Tag'] =␣
 ↪'BADSPIKE'
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
```

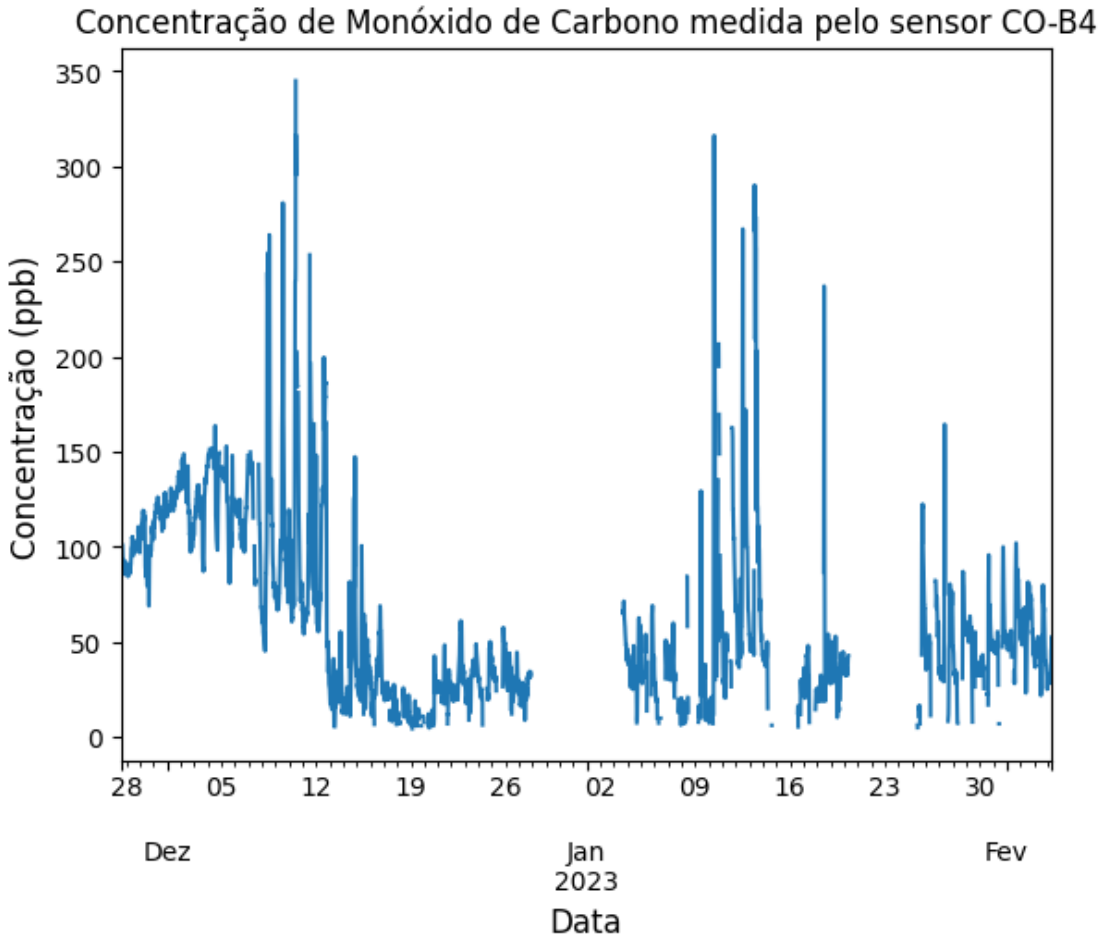
```
[ ]:                #          %
     MISSING       5756  32.617442
     LTLL          1560   8.840029
     GTUL             0        0.0
     STABILIZING    673   3.813679
     BADSPIKE         3      0.017
     VALID         4270  24.196747
     LTQTLE01        63   0.357001
     GTQTLE99        63   0.357001
     REBASE        5259  29.801099
     TOTAL        17647      100.0
```

Plot valid data

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

```
sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
  ↪rename('Concentração de Monóxido de Carbono').resample('15T').mean().plot()
plt.title('Concentração de Monóxido de Carbono medida pelo sensor CO-B4')
ax.set_xlabel('Data', fontsize=12)
ax.set_ylabel('Concentração (ppb)', fontsize=12)
```

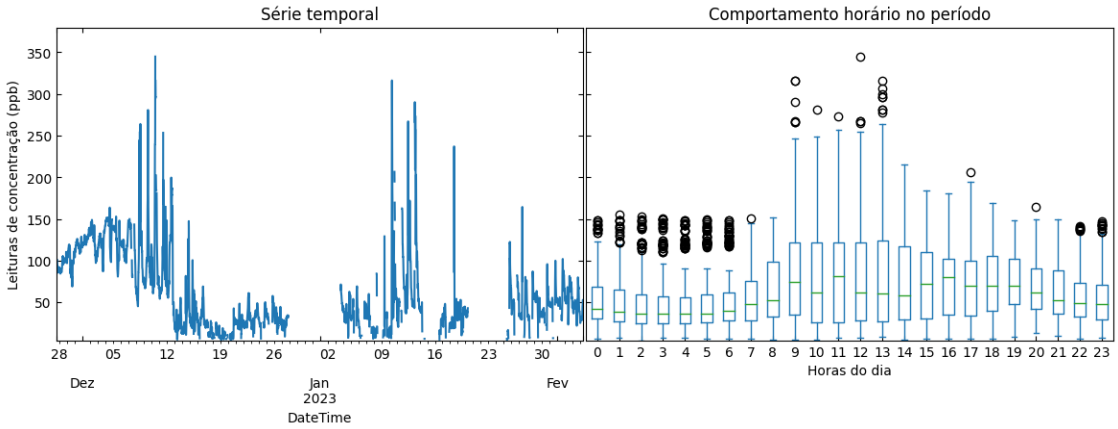
[ ]:
```
Text(0, 0.5, 'Concentração (ppb)')
```



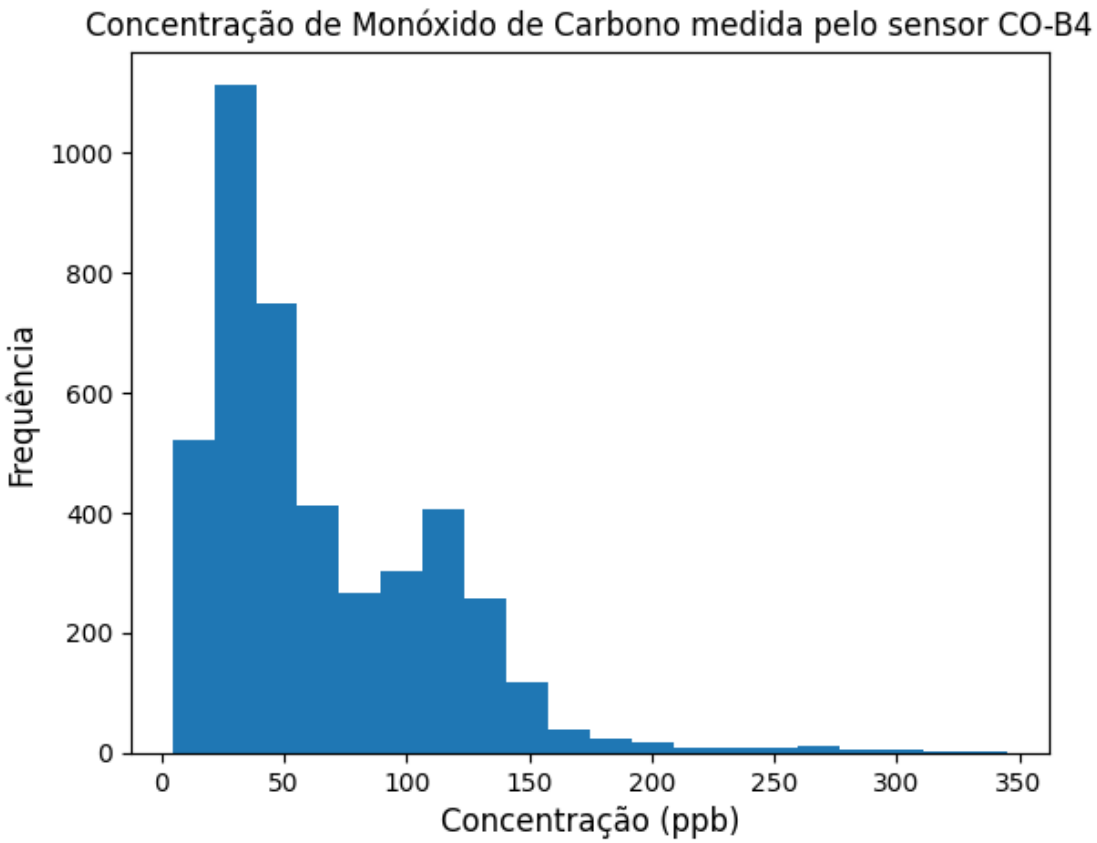
[ ]:
```
valid_dataframe = sensor_dataframe[sensor_dataframe['Tag'] == 'VALID'].
  ↪drop(columns=['Tag']).resample('15T').mean()
sensor_analysis.plot_box(df=valid_dataframe)
```

```
/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')
```

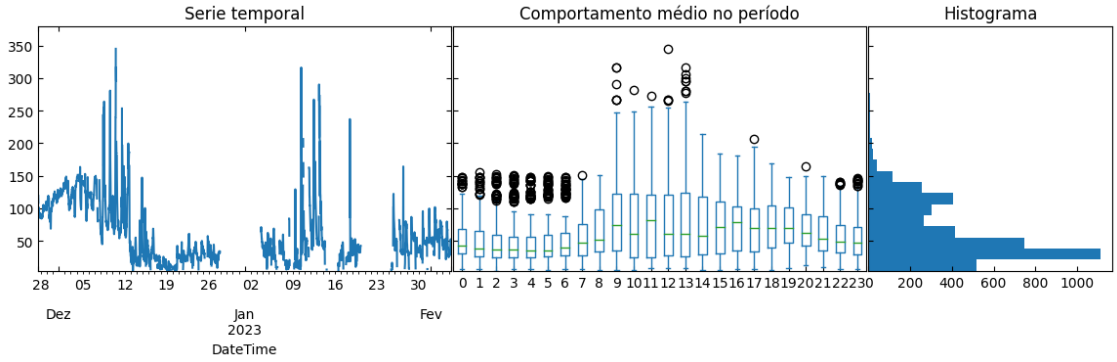


[ ]:
```
fig, ax = plt.subplots(figsize=(1.3*5,5))
(sensor_dataframe[sensor_dataframe['Tag'] == 'VALID']['measuring'].
 ↪rename('Concentração de Monóxido de Carbono')
 .resample('15T').mean().hist(bins=20))
plt.title('Concentração de Monóxido de Carbono medida pelo sensor CO-B4')
ax.set_xlabel('Concentração (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)
```

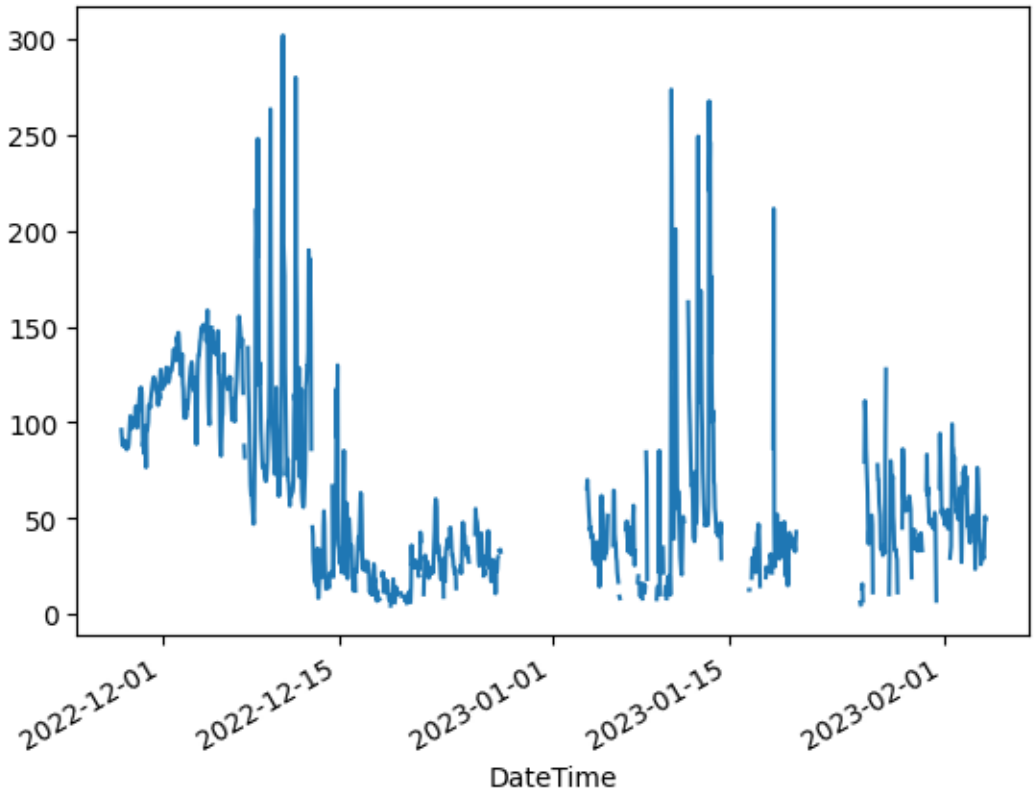
```
/Users/Fernando/Documents/Projects/Github/lcqar-low-cost-monit-proc/data-pre-
processing/SensorDataAnalysisService.py:111: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

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()
```

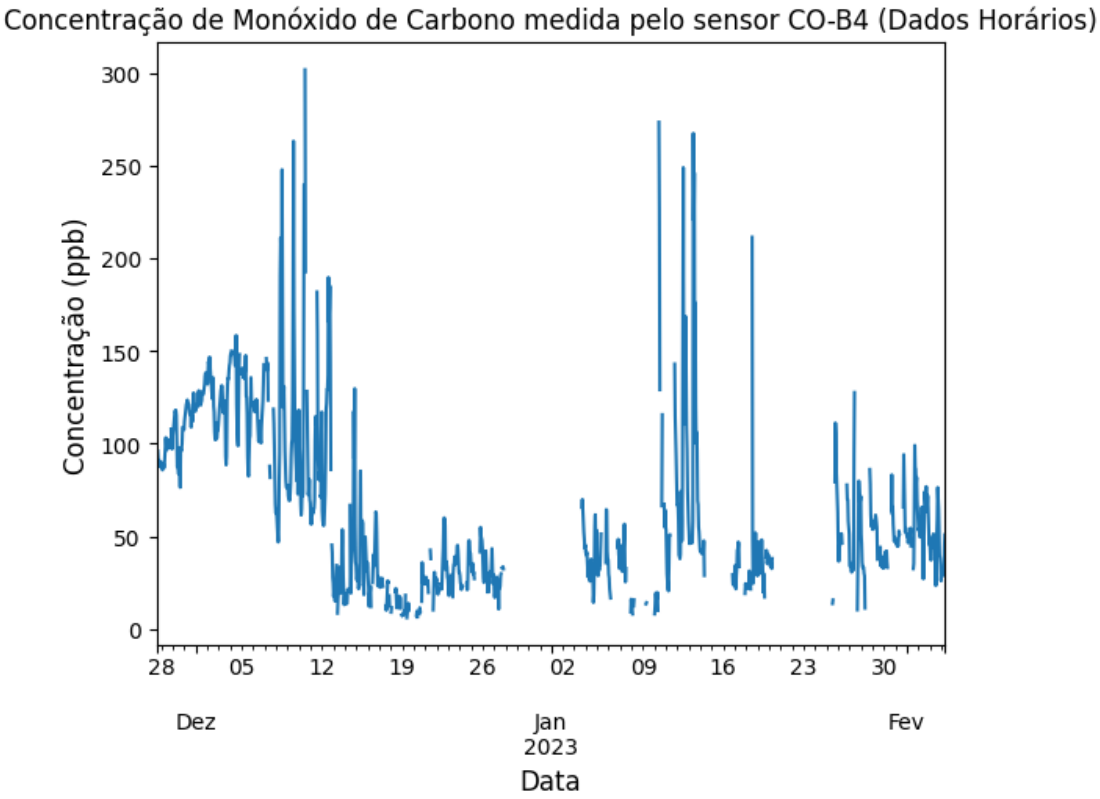
[ ]:
```
<Axes: xlabel='DateTime'>
```



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 Monóxido de Carbono').resample('1H').mean().plot()
plt.title('Concentração de Monóxido de Carbono medida pelo sensor CO-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
```

[ ]:

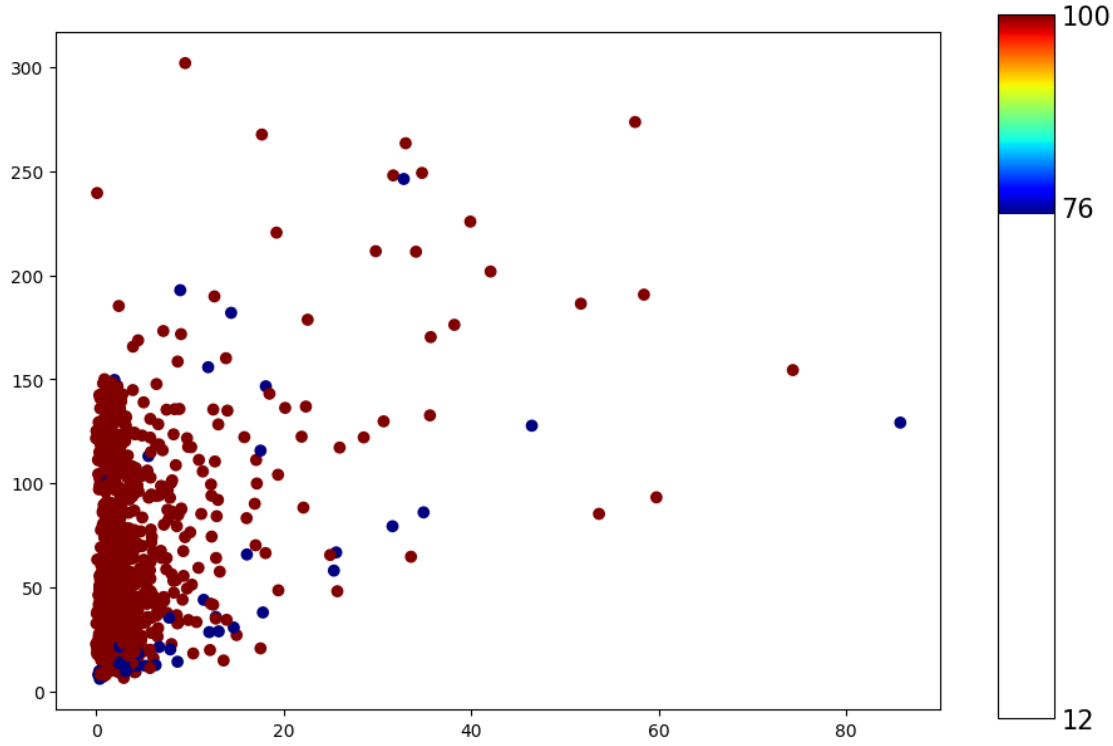
	#	%
LOWSAMPLES	603	36.523319
VALID	1048	63.476681
TOTAL	1651	100.0

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

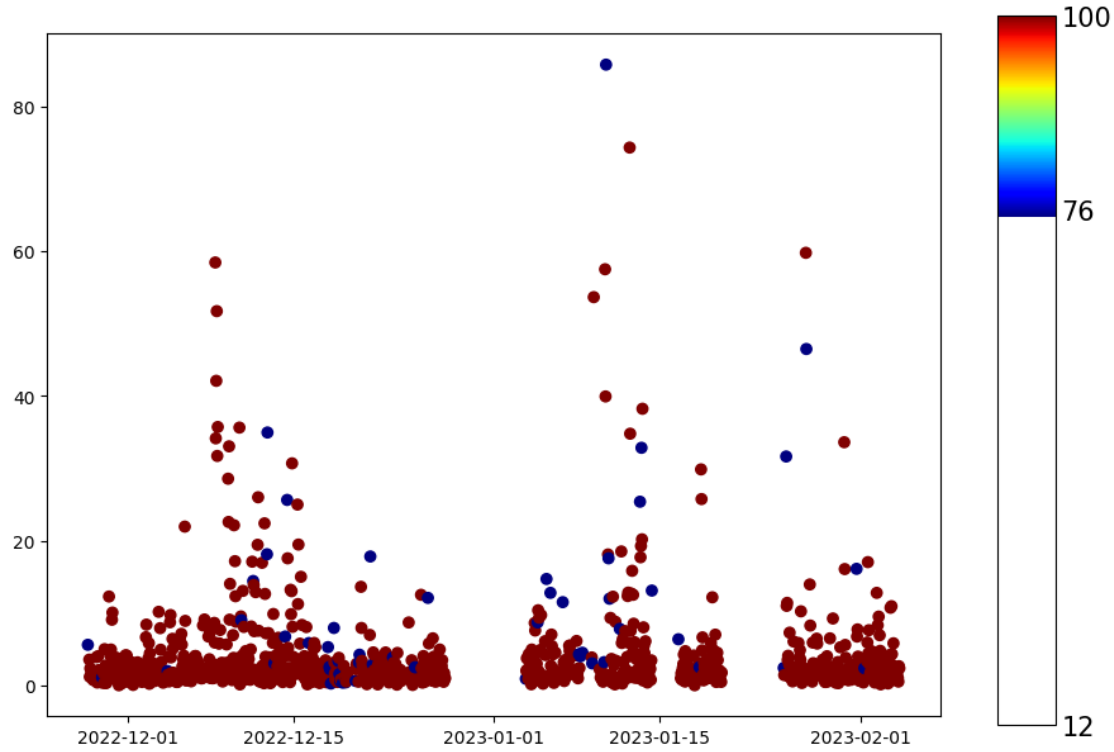
Plot mean (Y axis) vs. standard deviation (X axis) for valid hourly data colored by valid percentage of valid samples

[ ]:
```
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)
```