In [2]:

```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
%matplotlib inline
%pprint off
#plt.style.use('seaborn')
```

```
Pretty printing has been turned ON
```

In [3]:

```
sns.set_style("ticks")
```

Preparing the dataframes

In [4]:

```
df_all = pd.read_csv('data/dataport-export_gas_oct2015-mar2016.csv')
len(df_all)
```

Out[4]:

```
1584823
```

In [5]:

```
df_all = df_all.set_index(pd.to_datetime(df_all['localminute']))
```

In [6]:

```
df_all = df_all.drop(columns='localminute')
display(df_all.head())
```

	dataid	meter_value
localminute		
2015-10-01 05:00:10	739	88858
2015-10-01 05:00:13	8890	197164
2015-10-01 05:00:20	6910	179118
2015-10-01 05:00:22	3635	151318
2015-10-01 05:00:22	1507	390354

In [7]:

```
groups = df_all.groupby('dataid')
keys = groups.groups.keys()  # keys: an iterable of dataids or meter ids

# check if each group (grouped by meter id) is sorted in ascending order by datetime.
# for key in keys:
#     df_i = groups.get_group(key)
#     print(df_i.index.is_monotonic_increasing)
# each group is already sorted in ascending order by datetime.
```

Check meterids

In [8]:

```
keys_list = list(keys)
print(keys_list)
```

```
[35, 44, 77, 94, 114, 187, 222, 252, 370, 483, 484, 661, 739, 744, 871, 10
42, 1086, 1103, 1185, 1283, 1403, 1415, 1507, 1556, 1589, 1619, 1697, 171
4, 1718, 1790, 1791, 1792, 1800, 1801, 2018, 2034, 2072, 2094, 2129, 2233,
2335, 2378, 2449, 2461, 2470, 2575, 2638, 2645, 2755, 2814, 2818, 2945, 29
46, 2965, 2980, 3036, 3039, 3134, 3310, 3367, 3527, 3544, 3577, 3635, 372
3, 3778, 3849, 3893, 3918, 4029, 4031, 4193, 4228, 4296, 4352, 4356, 4373,
4421, 4447, 4514, 4671, 4732, 4767, 4874, 4998, 5129, 5131, 5193, 5275, 53
17, 5395, 5403, 5439, 5484, 5545, 5636, 5658, 5785, 5810, 5814, 5892, 597
2, 6101, 6412, 6505, 6578, 6673, 6685, 6830, 6836, 6863, 6910, 7016, 7017,
7030, 7117, 7287, 7429, 7460, 7566, 7674, 7682, 7739, 7741, 7794, 7900, 79
19, 7965, 7989, 8059, 8084, 8086, 8155, 8156, 8244, 8386, 8467, 8703, 882
9, 8890, 8967, 9052, 9121, 9134, 9160, 9278, 9295, 9474, 9600, 9620, 9631,
9639, 9729, 9766, 9849, 9956, 9982]
```

Print full-length (6 mth) plot by meterid.

In [9]:

```
# for key in keys_list:
#     df_i = groups.get_group(key)
#     df_i.drop(columns='dataid').plot(figsize=(15,4), title=str(f'meter {key}'))
```

In [10]:

```
key = 3134
df_i = groups.get_group(key).drop(columns='dataid')
```

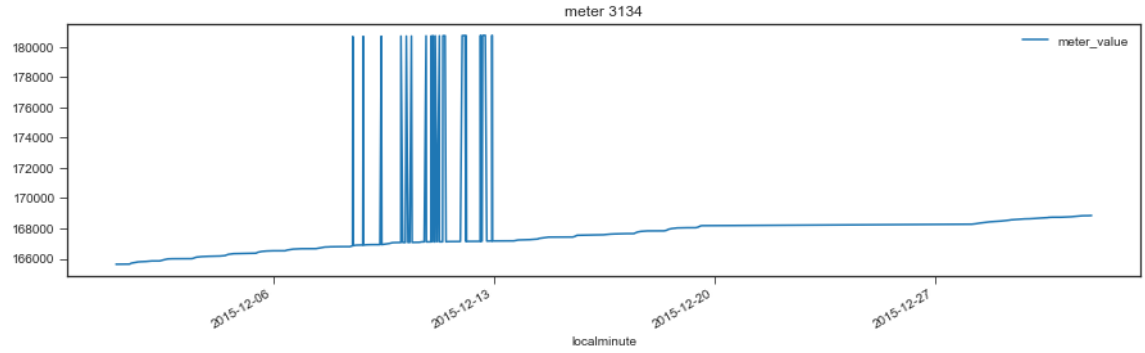
Select data by datetime period. e.g. 1 month. i.e. Zoom in.

In [11]:

```
def zoom(df, start_date, end_date):
    # pre-condition: df is indexed by datetime.
    start_date = pd.to_datetime(start_date)
    end_date = pd.to_datetime(end_date)
    mask = (df.index >= start_date) & (df.index <= end_date)

    new_df = df.iloc[mask]
    return new_df

df_i_bymonth = zoom(df_i, '2015-12-01', '2016-01-01')
df_i_bymonth.plot(figsize=(15,4), title=str(f'meter {key}'))
```

Out[11]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe8185f400>
```

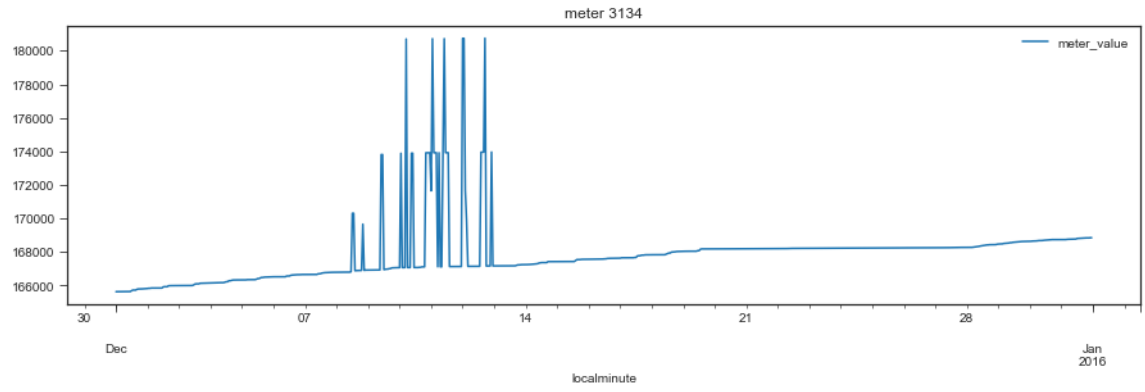


Resample with hourly frequency.

In [12]:

```
df_i_bymonth_resampled = df_i_bymonth.resample('H').mean().ffill()
df_i_bymonth_resampled.plot(figsize=(15,4), title=str(f'meter {key}'))
display(len(df_i_bymonth_resampled))
```

744



Iterate and plot december's hourly-resampled data for each suspicious meter (spiking values).

In [29]:

```
suspicious_meters_list = [1185, 1556, 2335, 2449, 3134, 3544, 4447, 4514, \
                          5129, 5403,6836, 7030, 7117, 8156, 9134, 9639, 9982]

# for meter in suspicious_meters_list:
#     df_i = groups.get_group(meter)
#     df_i_bymonth = zoom(df_i, '2015-12-01', '2016-01-01').drop(columns='dataid')
#     df_i_bymonth_resampled = df_i_bymonth.resample('H').mean().ffill()
#     df_i_bymonth_resampled.plot(figsize=(15,4), title=str(f'meter {meter}, {len(df_i_
bymonth_resampled)} samples'))
```

We clearly see that there is some obvious malfunctioning happening within 7-14 Dec 2015.

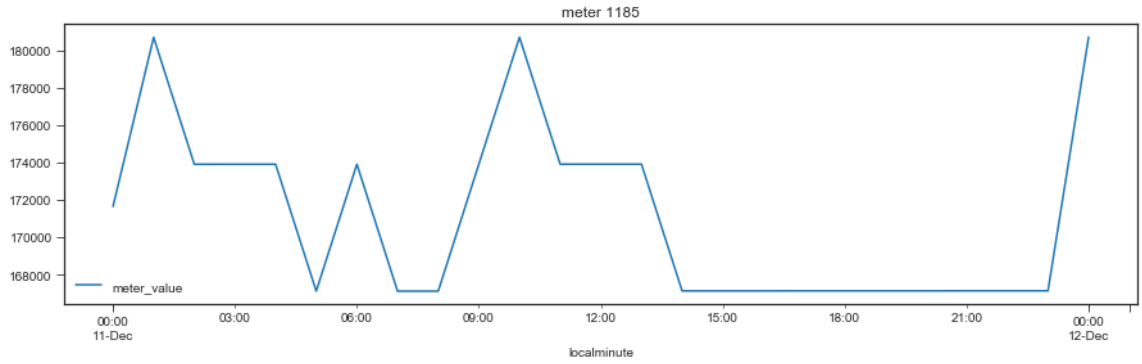
Zoom in deeper within the time period (e.g. one day/24h)

In [30]:

```
df_i_byday = zoom(df_i_bymonth_resampled, '2015-12-11', '2015-12-12')
df_i_byday.plot(figsize=(15,4), title=str(f'meter {key}'))
```

Out[30]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe808f0048>
```



In [31]:

```
# for i in range(7):
#     start_date = f'2015-12-{8+i}'
#     end_date = f'2015-12-{9+i}'
#     df_i_byday = zoom(df_i_bymonth_resampled, start_date, end_date)
#     df_i_byday.plot(figsize=(15,4), title=str(f'meter {key}'))
```

In [32]:

```
less500_list = [4874, 6101, 9620, 7566, 5545, 2814, 2946, 2755,\
                9160, 2645, 6685, 1403, 8703, 9600, 3036, 5658]

def get_month_counts(df_i):
    # get count of samples per month
    df_i_resample_monthly_count = df_i.resample('M').count().rename(columns={'meter_val
ue': 'count'})
    return df_i_resample_monthly_count

for meter in less500_list:
    df_i = groups.get_group(meter)
    df_i_counts = get_month_counts(df_i)
    display(df_i_counts.head(6))
```

	dataid	count
localminute		
2016-02-29	1	1
2016-03-31	1	1

	dataid	count
localminute		
2016-01-31	3	3

	dataid	count
localminute		
2015-10-31	1	1
2015-11-30	0	0
2015-12-31	0	0
2016-01-31	3	3
2016-02-29	13	13
2016-03-31	6	6

	dataid	count
localminute		
2016-01-31	32	32

	dataid	count
localminute		
2015-12-31	3	3
2016-01-31	16	16
2016-02-29	13	13
2016-03-31	1	1

	dataid	count
localminute		
2016-01-31	6	6
2016-02-29	31	31

	dataid	count
localminute		
2016-01-31	45	45

	dataid	count
localminute		
2016-01-31	68	68

	dataid	count
localminute		
2016-01-31	72	72

	dataid	count
localminute		
2015-10-31	12	12
2015-11-30	10	10
2015-12-31	1	1
2016-01-31	19	19
2016-02-29	32	32

	dataid	count
localminute		
2015-10-31	1	1
2015-11-30	0	0
2015-12-31	14	14
2016-01-31	21	21
2016-02-29	39	39
2016-03-31	3	3

	dataid	count
localminute		
2016-01-31	202	202

	dataid	count
localminute		
2015-10-31	134	134
2015-11-30	0	0
2015-12-31	3	3
2016-01-31	117	117
2016-02-29	3	3
2016-03-31	1	1

	dataid	count
localminute		
2016-01-31	330	330

	dataid	count
localminute		
2016-01-31	336	336

	dataid	count
localminute		
2015-11-30	98	98
2015-12-31	176	176
2016-01-31	201	201
2016-02-29	16	16
2016-03-31	2	2

In [33]:

```
count_list = []
for key in keys_list:
    df_i = groups.get_group(key)
    count_list.append(len(df_i.index))

less2000_mask = np.asarray(count_list) < 2000
display(less2000_mask)
```

```
array([False,  True, False, False, False,  True, False, False, False,
       False, False, False, False, False, False, False, False,  True,
       False, False,  True,  True, False, False, False, False, False,
       False, False, False, False,  True, False, False, False, False,
       False, False, False, False, False, False, False, False,  True,
       False, False,  True,  True,  True,  True, False,  True, False,
       False,  True, False, False, False, False, False, False, False,
       False, False, False,  True, False, False, False, False,  True,
        True,  True, False,  True,  True, False, False, False,  True,
       False, False,  True, False, False, False, False, False,  True,
        True, False, False, False,  True, False,  True, False, False,
       False, False, False,  True, False,  True,  True, False,  True,
       False, False,  True, False, False, False, False, False, False,
       False, False,  True, False, False, False, False, False, False,
       False,  True, False,  True, False, False, False, False,  True,
        True, False,  True, False, False, False, False, False, False,
        True, False, False, False,  True,  True, False, False, False,
       False, False,  True,  True])
```

In [34]:

```
less2000_list = []
for i in range(len(less2000_mask)):
    if less2000_mask[i] == True:
        less2000_list.append(keys_list[i])

display(less2000_list)
```

```
[44,
 187,
 1103,
 1403,
 1415,
 1792,
 2470,
 2645,
 2755,
 2814,
 2818,
 2946,
 3036,
 3849,
 4193,
 4228,
 4296,
 4356,
 4373,
 4671,
 4874,
 5317,
 5395,
 5545,
 5658,
 6101,
 6505,
 6578,
 6685,
 6863,
 7566,
 7965,
 8059,
 8244,
 8386,
 8703,
 9160,
 9600,
 9620,
 9956,
 9982]
```

In [35]:

```
# for meter in less2000_list:
#     df_i = groups.get_group(meter).drop(columns='dataid')
#     df_i_resample_monthly_count = df_i.resample('M').count()  # get count of samples
 per month

#     display(f'avg sample per month: {len(df_i)/len(df_i_resample_monthly_count)}',\
#             f'nmonths={len(df_i_resample_monthly_count)}')
```

Resample data hourly, taking last value in the hour as new value.

For each meter:

- Visualise 6month usage
- Visualise 1month usage
- Visualise 1day usage

In [36]:

```
# # Resample by taking last cumulative reading for each hour.

# key = keys_list[4]
# df_i = groups.get_group(key).drop(columns='dataid')
# df_i.plot(figsize=(15,4), title=str(f'meter {key}'))

# # resample hourly using last reading for each hour, forward-filling any missing value
s
# df_i_resample_hourly = df_i.resample('H').last().ffill()
# df_i_resample_hourly.plot(figsize=(15,4), title=str(f'meter {key}'))

# display(f'total samples: {len(df_i)}')
# display(f'no. of hours: {len(df_i_resample_hourly)}')
# first_date = df_i.index.values[0]
# last_date = df_i.index.values[-1]
# display(f'first date: {first_date}')
# display(f'last date: {last_date}')
# display(df_i_resample_hourly.tail())

# # zoom in to particular month
# df_i_month = zoom(df_i_resample_hourly, '2016-01-01', '2016-02-01')
# df_i_month.plot(figsize=(15,4), title=str(f'meter {key}'))

# # zoom in to particular day
# df_i_day = zoom(df_i_month, '2016-01-02', '2016-01-03')
# df_i_day.plot(figsize=(15,4), title=str(f'meter {key}'))

# # find hour on hour change, i.e. marginal hourly usage
# # this is useful to notice hourly consumption patterns
# df_i_day.diff().plot(figsize=(15,4), title=str(f'meter {key}'))
```

In [37]:

```
def remove_mal_data(df):
    # this method finds the start datetime and end datetime of the malfunctioning perio
d and returns a new df without data
    # from that period. NOTE that a new column 'marginal_change' is added to the df.

    # from visualising the data, we can arbitrarily define a spike as a marginal differ
ence of > 2000 cubic metres
    # we have defined malfunction as a marginal increase > 2000
    # and a marginal increase < -2000.
    threshold = 2000
    df['marginal_change'] = df['meter_value'].diff()

    flagged_dates = df[df.marginal_change > threshold].index
    flagged_dates = flagged_dates.append(df[df.marginal_change < -1*threshold].index)

    if len(flagged_dates) > 0:
        start = flagged_dates[0]
        end = flagged_dates[-1]
        mask = (df.index >= start) & (df.index <= end)
        return df.loc[~mask]
    else:
        return df
```

In [38]:

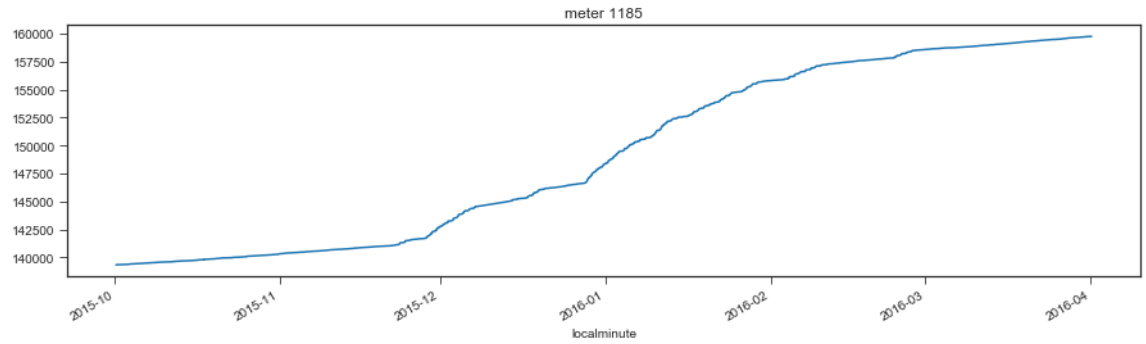
```
key = 1185
df_i = groups.get_group(key).drop(columns='dataid')
display(len(df_i))

df_i_clean = remove_mal_data(df_i)
display(len(df_i_clean))

df_i_clean.meter_value.plot(figsize=(15,4), title=str(f'meter {key}'))
```

```
18456
```

```
17804
```

Out[38]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe80aa4518>
```



In [39]:

```
def remove_negative_marginal(df):
    # remove data points where the marginal change (from prev value) is negative.
    return df.loc[df.marginal_change > 0]
```

In [40]:

```
def remove_outliers(df, coeff=1.5):
    # remove outliers using *IQR rule.

    Q1 = df['marginal_change'].quantile(0.25)
    Q3 = df['marginal_change'].quantile(0.75)
    IQR = Q3 - Q1

    #print(f'{Q1, Q3, IQR}')

    # Filtering Values between Q1-1.5IQR and Q3+1.5IQR
    return df.query('(@Q1 - @coeff * @IQR) <= marginal_change <= (@Q3 + @coeff * @IQR)'
)
```

In [41]:

```
display(len(df_i_clean))
```

```
17804
```

In [42]:

```
df_i_filtered = remove_outliers(df_i_clean)
display(len(df_i_filtered))
```

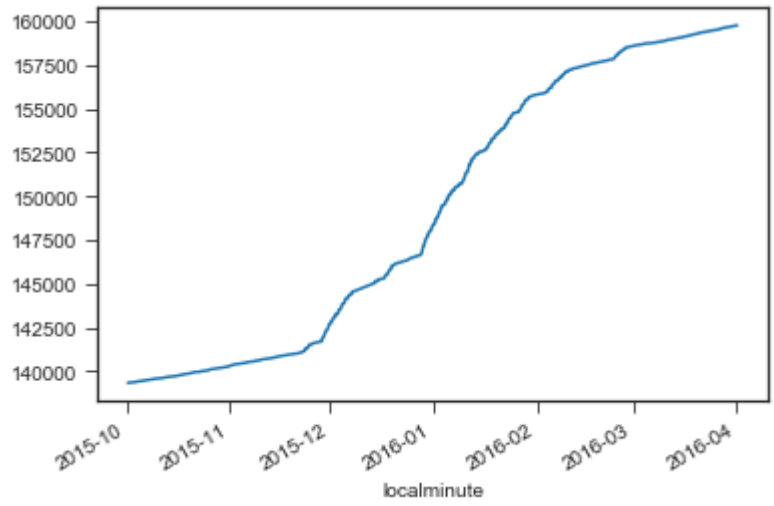
```
15089
```

In [43]:

```
df_i_filtered['meter_value'].plot()
```

Out[43]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe80a35898>
```



Apply cleaning, resampling, and 1.5IQR-filtering to entire 6 month period.

In [44]:

```
for key in suspicious_meters_list:
    df_i = groups.get_group(key).drop(columns='dataid')
    display(len(df_i))


    # first, clean data by removing obvious dirt
    df_i_clean = remove_mal_data(df_i)
    df_i_clean = remove_negative_marginal(df_i_clean)

    # next, resample data by hour.
    df_i_resampled = df_i_clean.drop(columns='marginal_change').resample('H').mean().ff
ill()
    display(df_i_resampled.head())

    # then, obtain new marginal changes.
    df_i_resampled['marginal_change'] = df_i_resampled['meter_value'].diff()
    display(df_i_resampled.head())
    df_i_resampled['marginal_change'].plot(figsize=(15,4), title=str(f'meter {key}'))
    display(len(df_i_resampled))

    # finally, filter by the 1.5IQR rule on marginal_change.
    df_i_filtered = remove_outliers(df_i_resampled)
    display(len(df_i_filtered))

    df_i_filtered['marginal_change'].plot(figsize=(15,4), title=str(f'meter {key}'))
    break
```

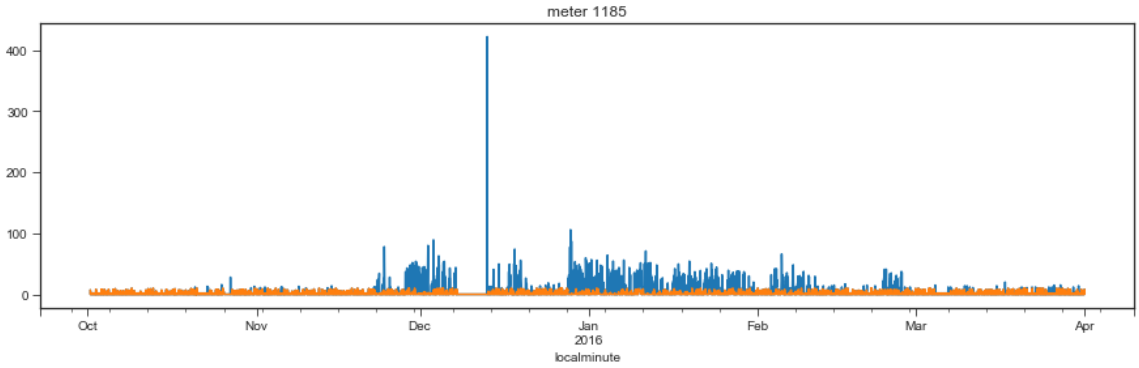
18456

	meter_value
localminute	
2015-10-01 10:00:00	139338.0
2015-10-01 11:00:00	139345.0
2015-10-01 12:00:00	139345.0
2015-10-01 13:00:00	139348.0
2015-10-01 14:00:00	139348.0

	meter_value	marginal_change
localminute		
2015-10-01 10:00:00	139338.0	NaN
2015-10-01 11:00:00	139345.0	7.0
2015-10-01 12:00:00	139345.0	0.0
2015-10-01 13:00:00	139348.0	3.0
2015-10-01 14:00:00	139348.0	0.0

4386

3825



Above code snippet and output shows that IQR-filtering should not be applied to the entire 6 months, because of seasonal changes in household use of gas.

In [64]:

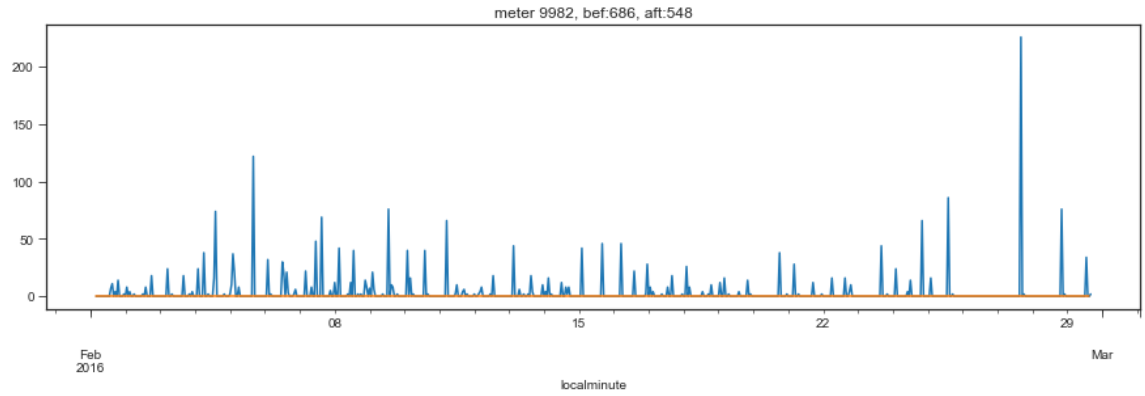
```
### key = 1185
df_i = groups.get_group(key).drop(columns='dataid')
display(len(df_i))

# zoom into 1 month
df_i_1mth = zoom(df_i, '2016-02-01', '2016-03-01')

def clean_resample_filter(df_i):

    # first, clean data by removing obvious dirt
    df_i_clean = remove_mal_data(df_i_1mth)
    df_i_clean = remove_negative_marginal(df_i_clean)

    # next, resample data by hour.
    df_i_resampled = df_i_clean.drop(columns='marginal_change').resample('H').mean().ff
ill()
    #display(df_i_resampled.head())

    # then, obtain new marginal changes.
    df_i_resampled['marginal_change'] = df_i_resampled['meter_value'].diff()

    # finally, filter by the IQR rule on marginal_change.
    # 1.5IQR filter
    df_i_filtered15 = remove_outliers(df_i_resampled, 1.5)

    # plot
    df_i_resampled['marginal_change'].plot(figsize=(15,4), title=str(f'meter {key}'))
    df_i_filtered15['marginal_change'].plot(figsize=(15,4), \
                                            title=str(f'meter {key}, bef:{len(df_i_resa
mpled)}, aft:{len(df_i_filtered15)}'))
    plt.show()
    plt.cla()

    # 3.0IQR filter
    df_i_filtered30 = remove_outliers(df_i_resampled, 4.0)

    # plot
    df_i_resampled['marginal_change'].plot(figsize=(15,4), title=str(f'meter {key}'))
    df_i_filtered30['marginal_change'].plot(figsize=(15,4), \
                                            title=str(f'meter {key}, bef:{len(df_i_resa
mpled)}, aft:{len(df_i_filtered30)}'))
    plt.show()
    plt.clf()
```

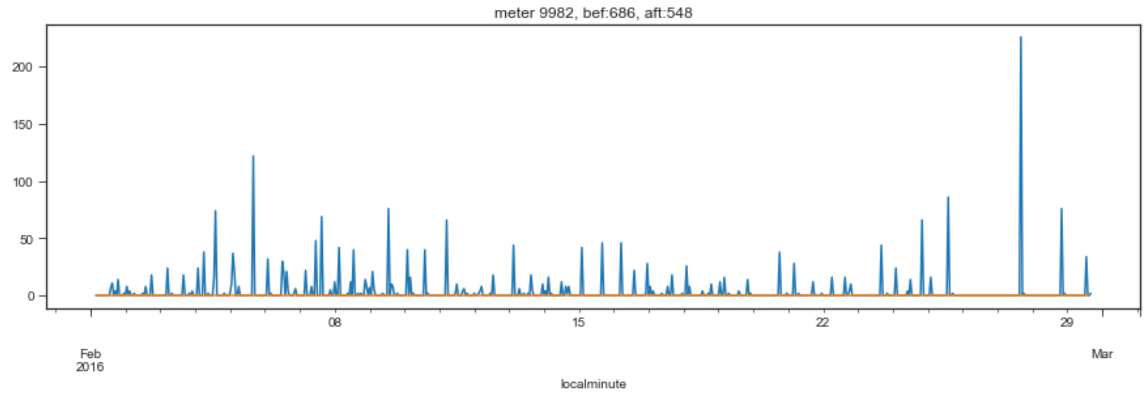
```
1540
```

In [65]:

```
clean_resample_filter(df_i_1mth)
```

```
C:\Users\Melvin\Anaconda3\lib\site-packages\ipykernel_launcher.py:9: Setti
ngWithCopyWarning:
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: http://pandas.pydata.org/pandas-doc
s/stable/indexing.html#indexing-view-versus-copy
  if __name__ == '__main__':
```






```
<Figure size 432x288 with 0 Axes>
```

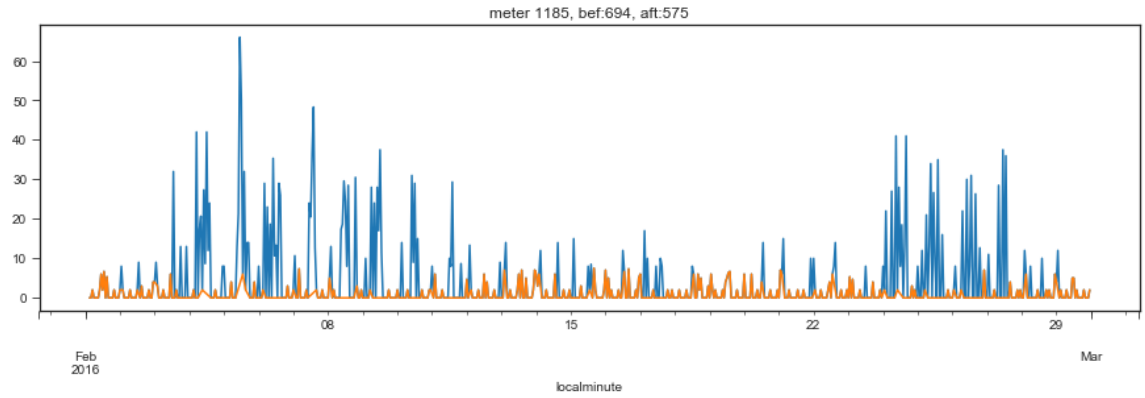
IQR-filtering seems more reasonable after constraining the time period to one month.

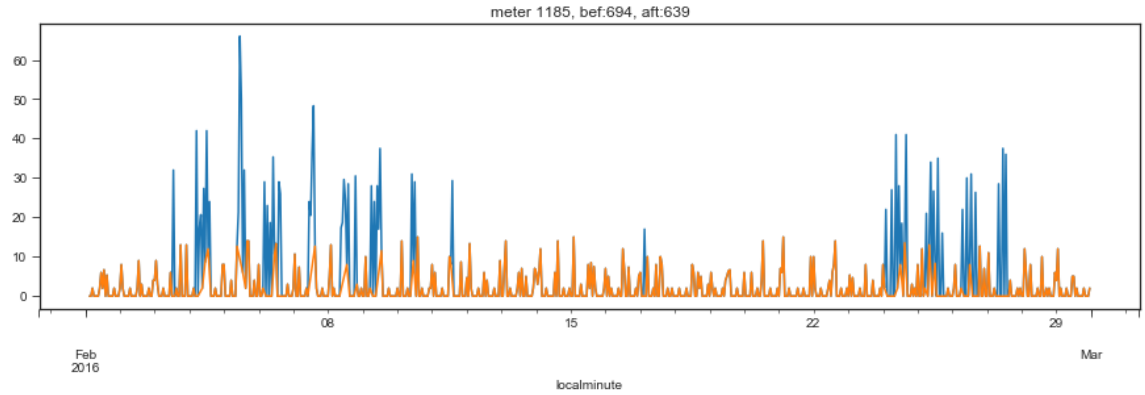
In [52]:

```
for key in suspicious_meters_list:
    df_i = groups.get_group(key).drop(columns='dataid')
    display(len(df_i))
    df_i_1mth = zoom(df_i, '2016-02-01', '2016-03-01')
    clean_resample_filter(df_i)
```

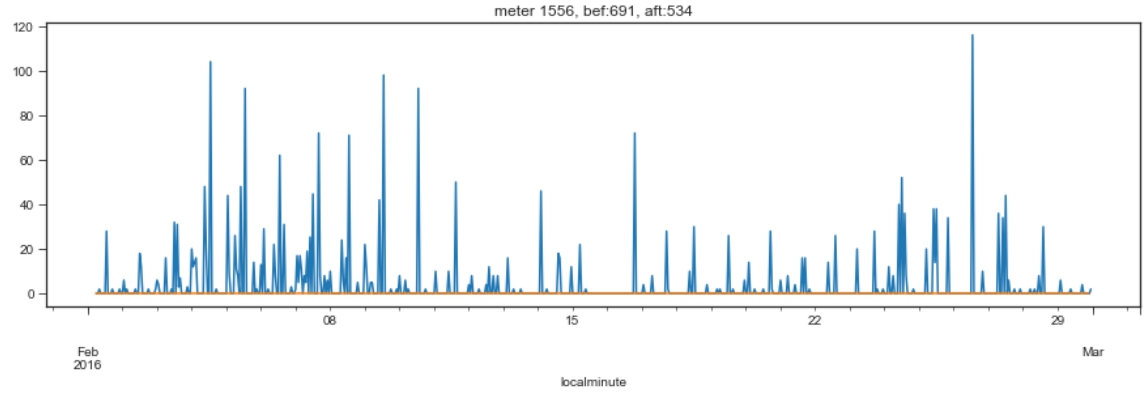
```
18456
```

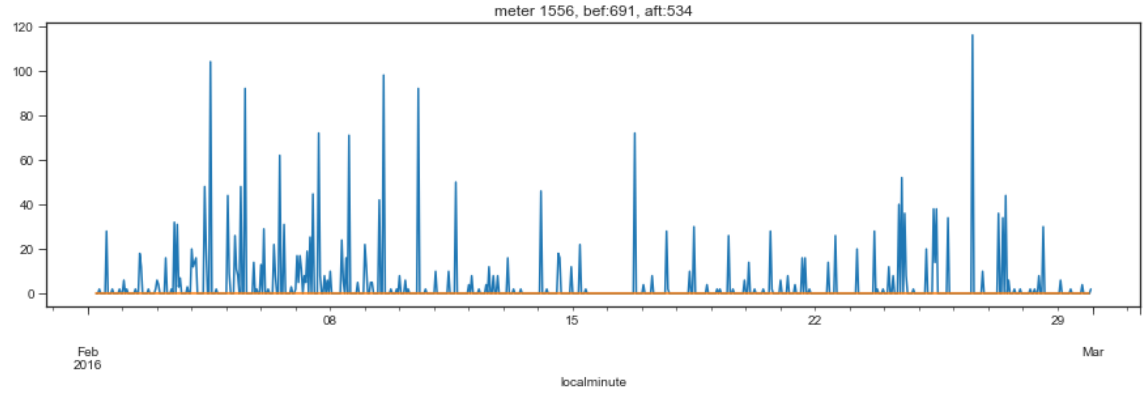
```
C:\Users\Melvin\Anaconda3\lib\site-packages\ipykernel_launcher.py:9: Setti
ngWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-doc
s/stable/indexing.html#indexing-view-versus-copy
  if __name__ == '__main__':
```






```
3690
```




meter 1556, bef:691, aft:534
120
100
80
60
40
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0
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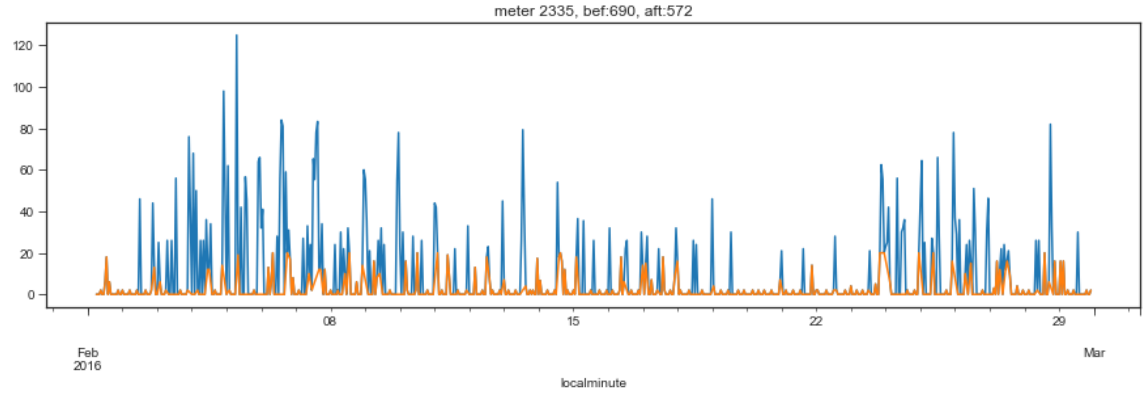
29
Feb
2016
Mar
localminute

8910


meter 2335, bef:690, aft:572
120
100
80
60
40
20
0
08
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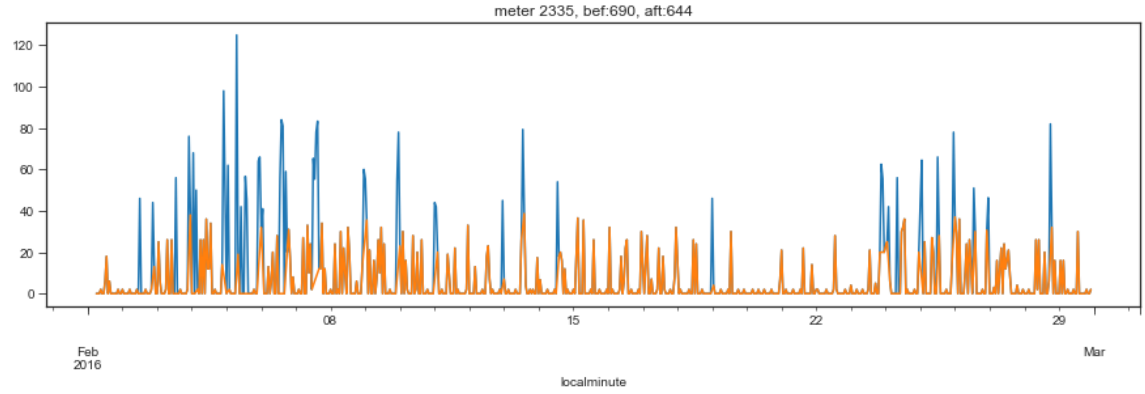
22
29
Feb
2016
Mar
localminute


meter 2335, bef:690, aft:644
120
100
80
60
40
20
0
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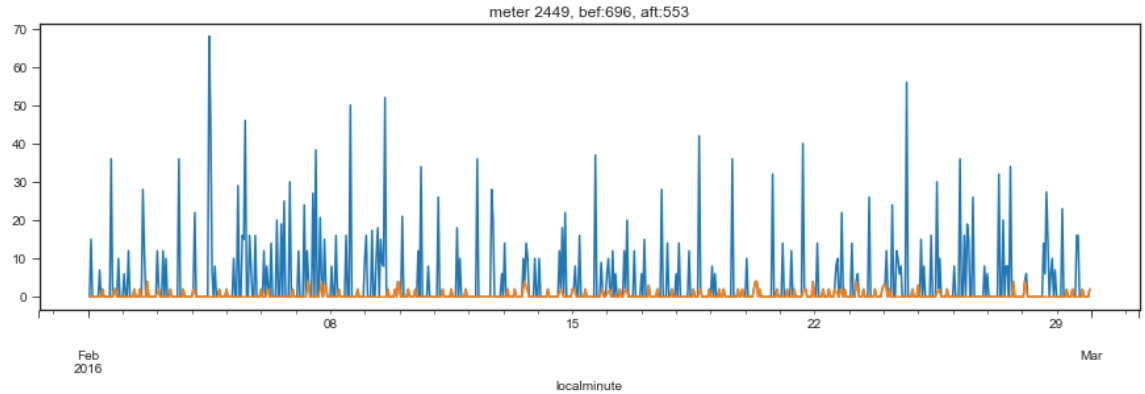
22
29
Feb
2016
Mar
localminute

5449


meter 2449, bef:696, aft:553
70
60
50
40
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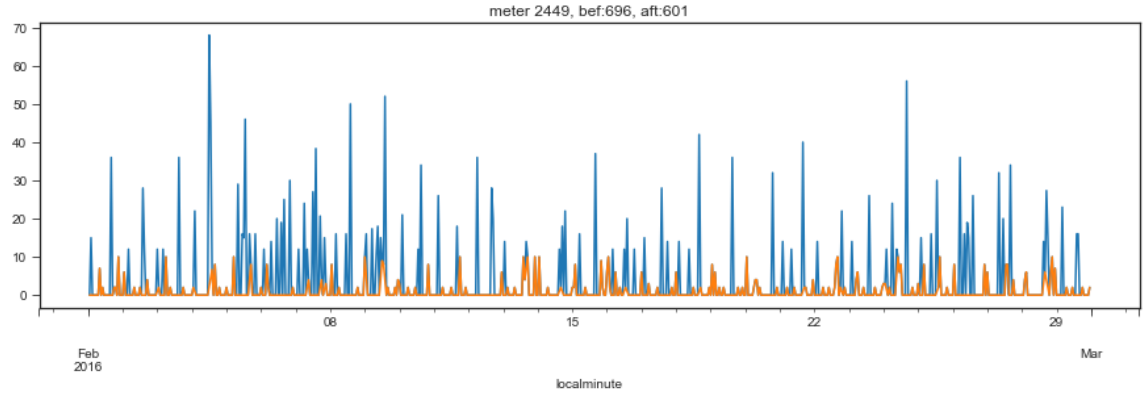
Feb
2016
Mar
localminute


meter 2449, bef:696, aft:601
70
60
50
40
30
20
10
0
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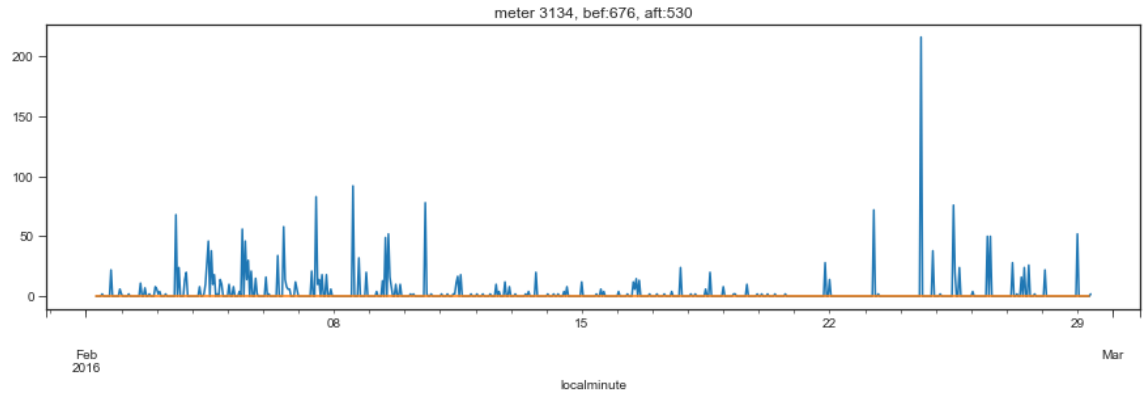
Feb
2016
Mar
localminute

4017


meter 3134, bef:676, aft:530
200
150
100
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0
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Feb
2016
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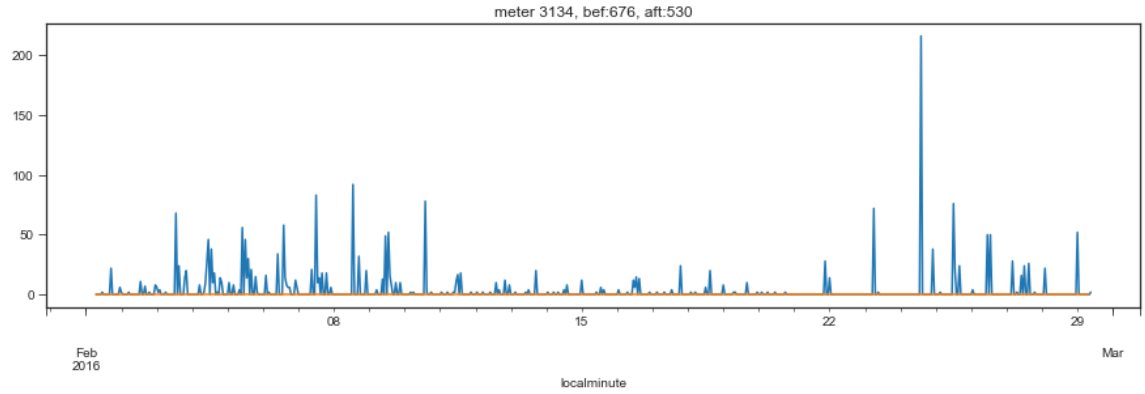
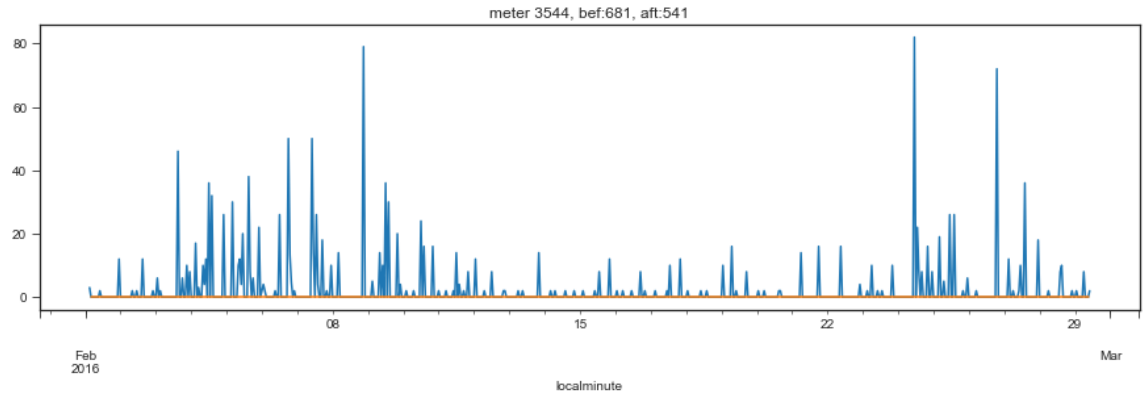
localminute


meter 3134, bef:676, aft:530
200
150
100
50
0
08
15
22
29
Feb
2016
Mar
localminute

2221


meter 3544, bef:681, aft:541
80
60
40
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08
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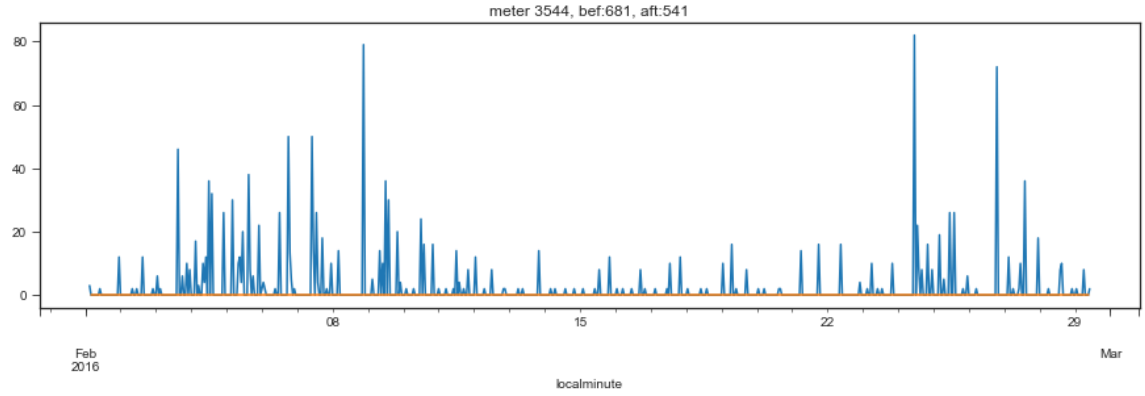
Feb
2016
Mar
localminute


meter 3544, bef:681, aft:541
80
60
40
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08
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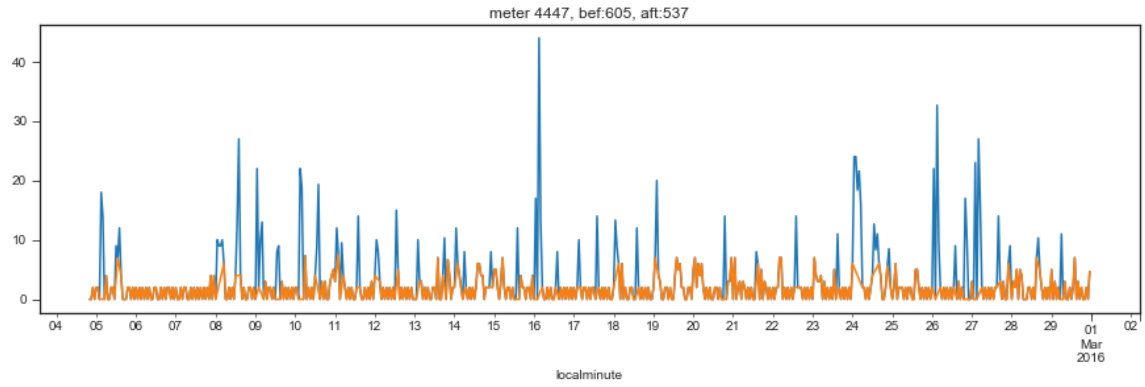
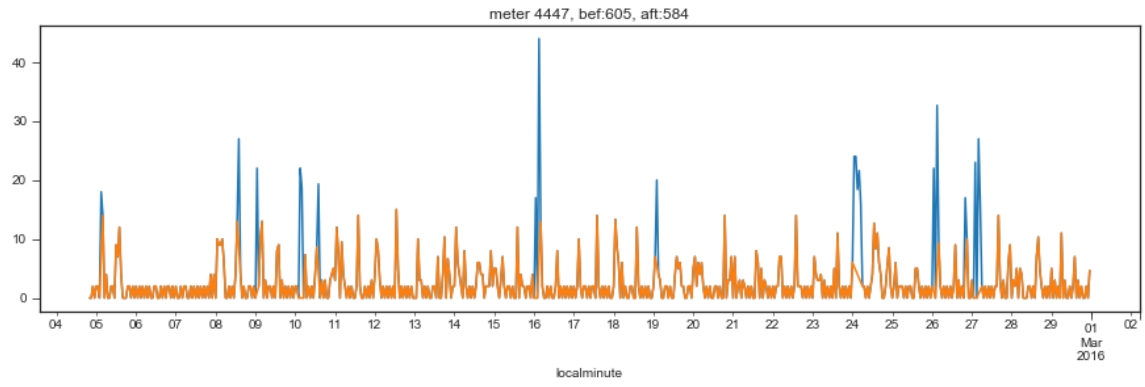
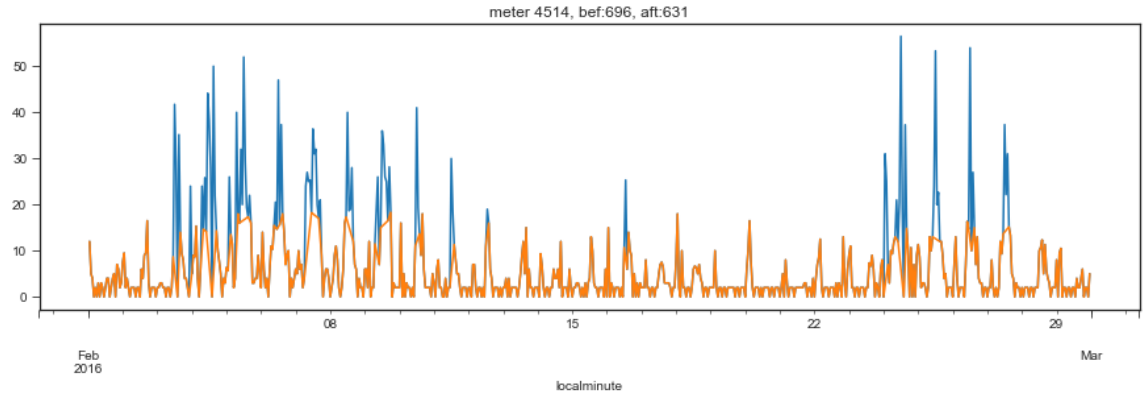
29
Feb
2016
Mar
localminute

9158


meter 4447, bef:605, aft:537
40
30
20
10
0
04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 01 02
Mar
2016
localminute


meter 4447, bef:605, aft:584
40
30
20
10
0
04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 01 02
Mar
2016
localminute

19074


meter 4514, bef:696, aft:631
50
40
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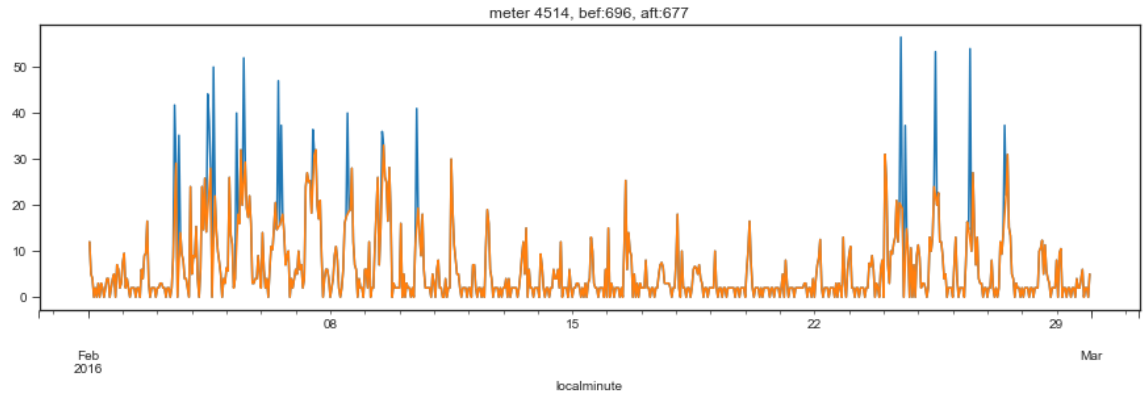
Feb
2016
Mar
localminute


meter 4514, bef:696, aft:677
50
40
30
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0
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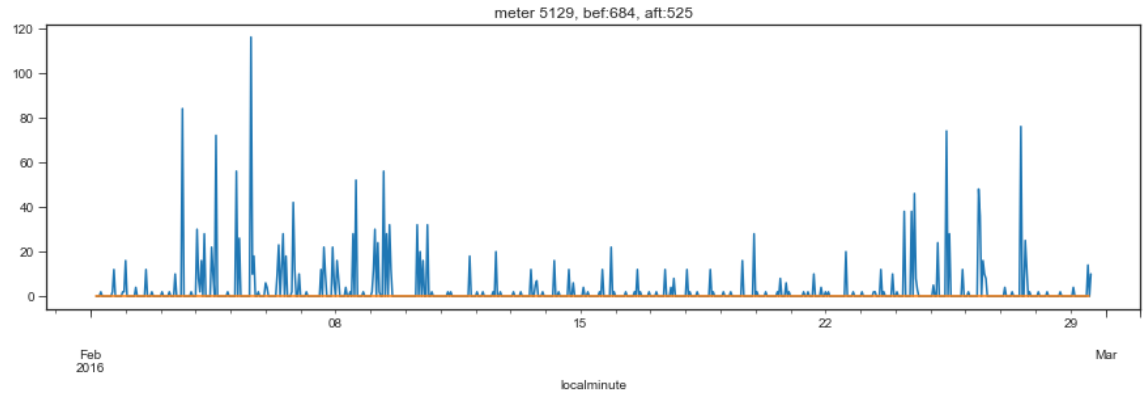
29
Feb
2016
Mar
localminute

4486


meter 5129, bef:684, aft:525
120
100
80
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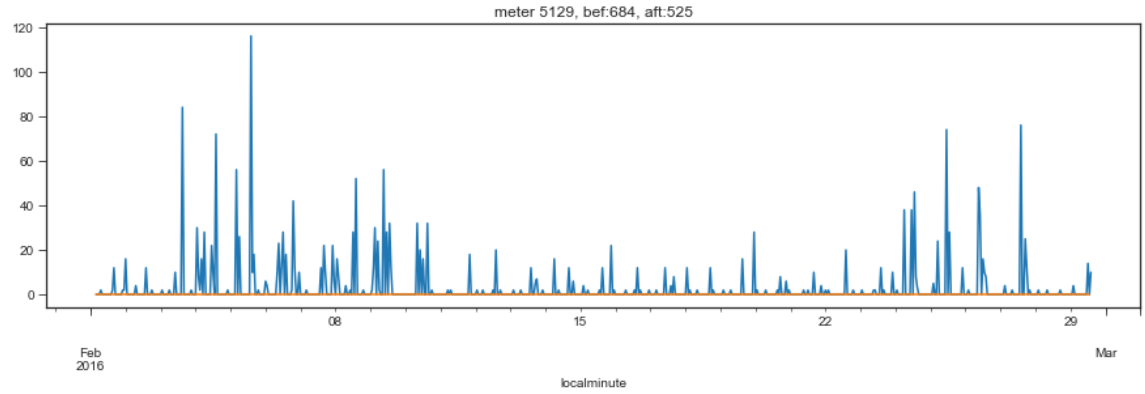
Feb
2016
Mar
localminute


meter 5129, bef:684, aft:525
120
100
80
60
40
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0
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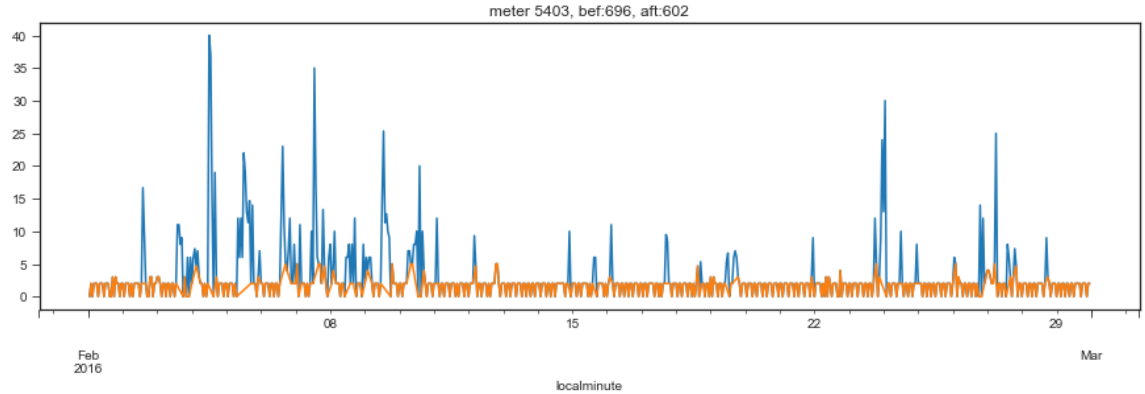
29
Feb
2016
Mar
localminute

25559


meter 5403, bef:696, aft:602
40
35
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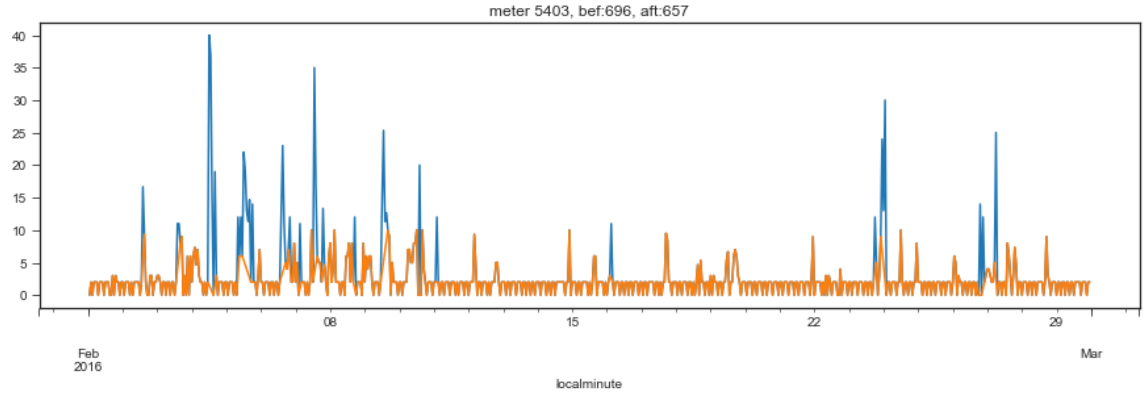
Feb
2016
Mar
localminute


meter 5403, bef:696, aft:657
40
35
30
25
20
15
10
5
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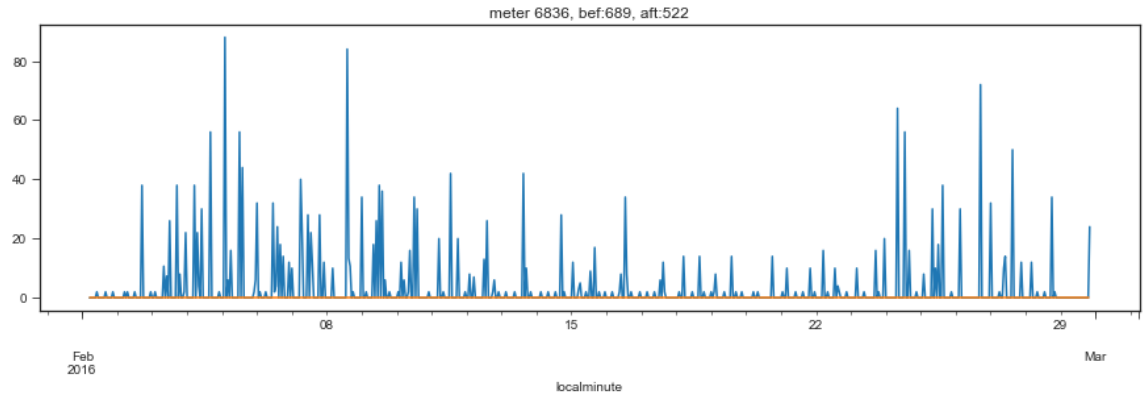
29
Feb
2016
Mar
localminute

4520


meter 6836, bef:689, aft:522
80
60
40
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0
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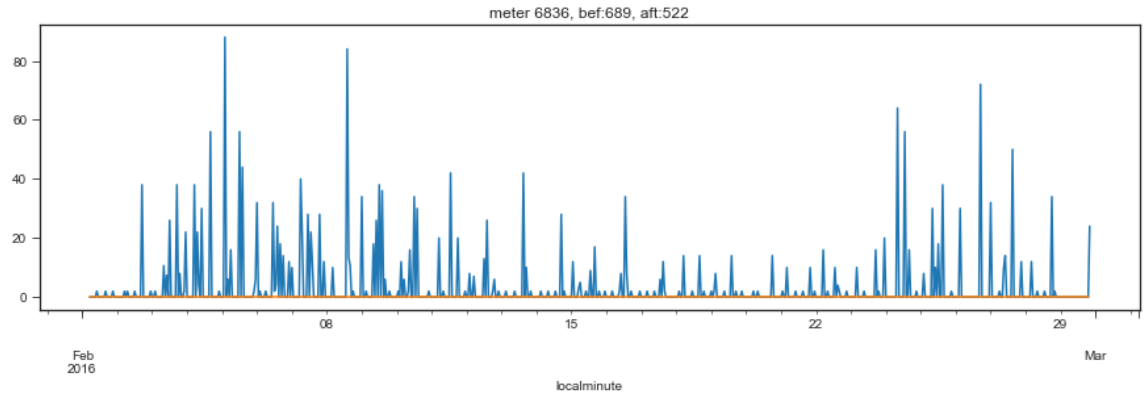
29
Feb
2016
Mar
localminute


meter 6836, bef:689, aft:522
80
60
40
20
0
08
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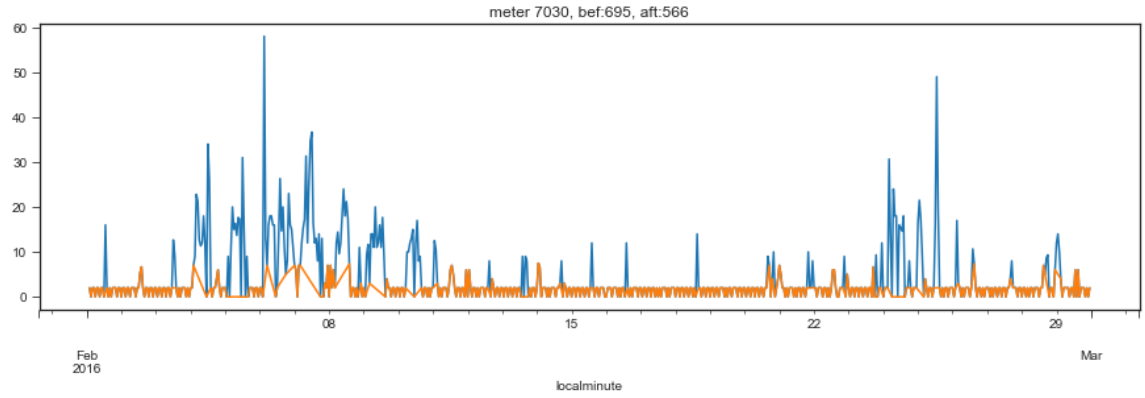
22
29
Feb
2016
Mar
localminute

17915


meter 7030, bef:695, aft:566
60
50
40
30
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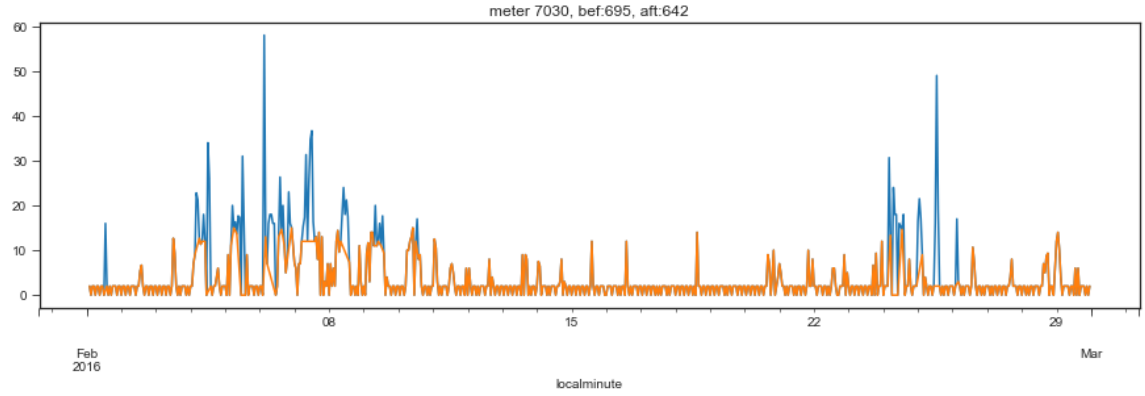
Feb
2016
Mar
localminute


meter 7030, bef:695, aft:642
60
50
40
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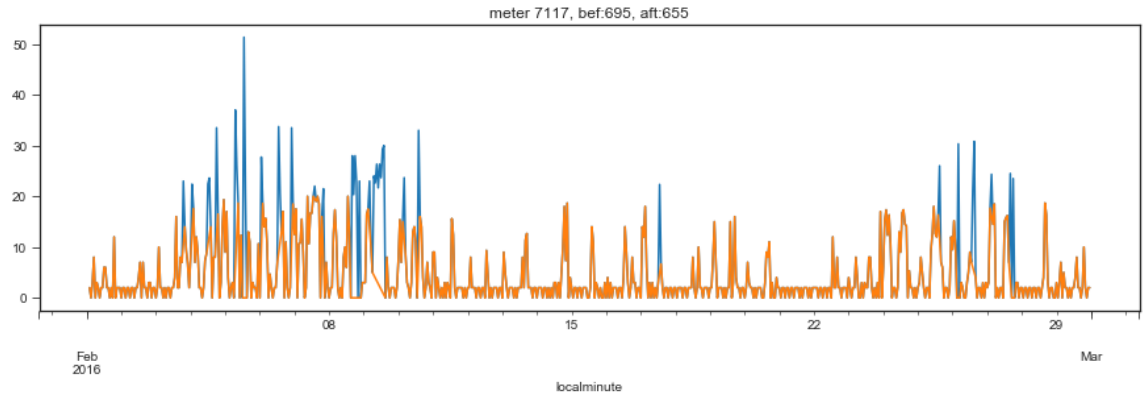
Feb
2016
Mar
localminute

20493


meter 7117, bef:695, aft:655
50
40
30
20
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0
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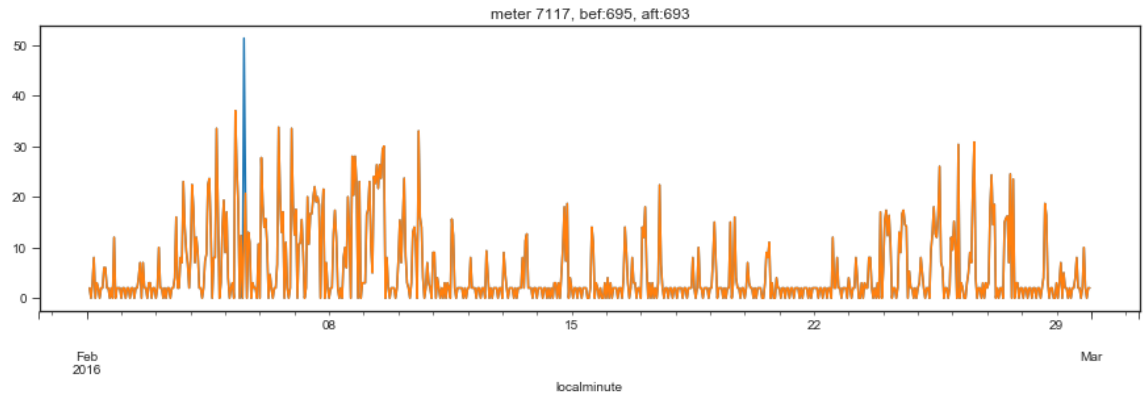
22
29
Feb
2016
Mar
localminute


meter 7117, bef:695, aft:693
50
40
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0
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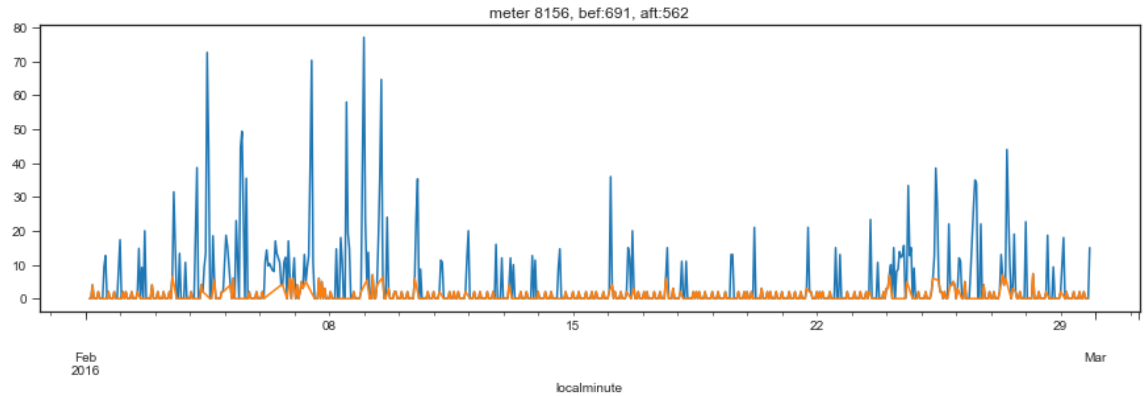
29
Feb
2016
Mar
localminute

25296


meter 8156, bef:691, aft:562
80
70
60
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40
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0
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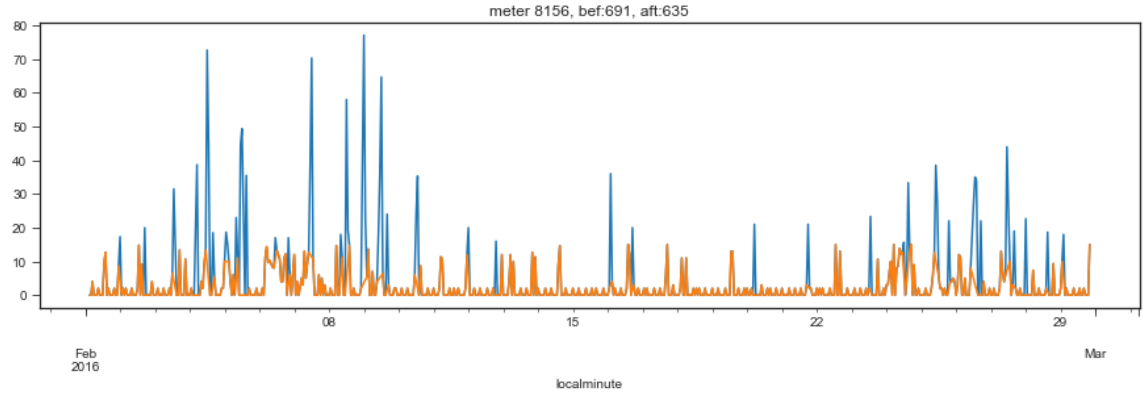
Feb
2016
Mar
localminute


meter 8156, bef:691, aft:635
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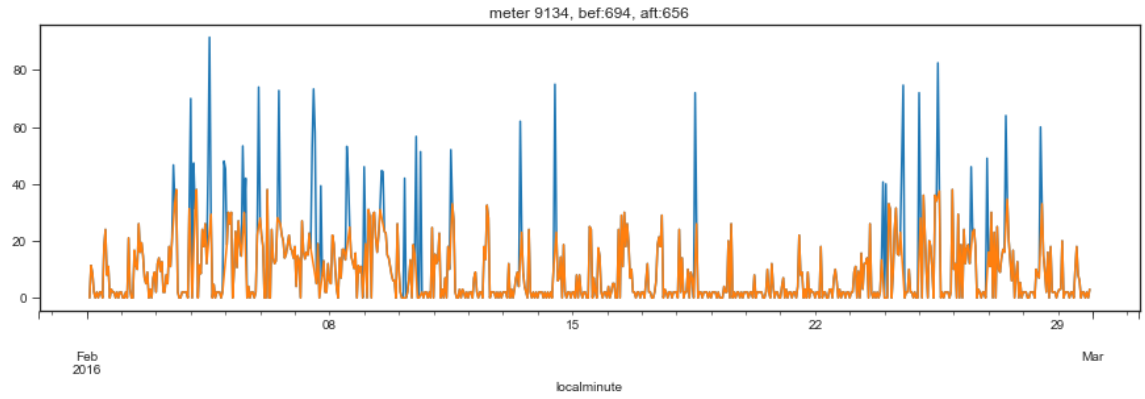
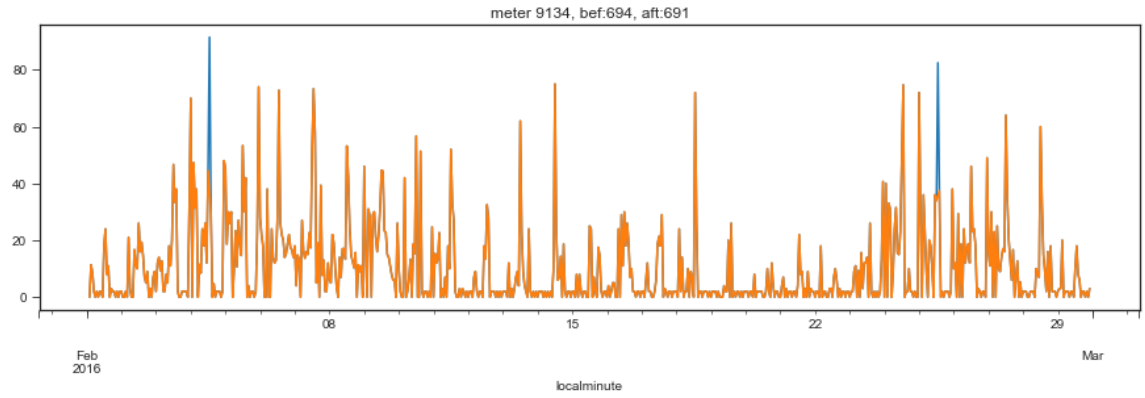
70
60
50
40
30
20
10
0
08
15
22
29
Feb
2016
Mar
localminute

14064


meter 9134, bef:694, aft:656
80
60
40
20
0
08
15
22
29
Feb
2016
Mar
localminute


meter 9134, bef:694, aft:691
80
60
40
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0
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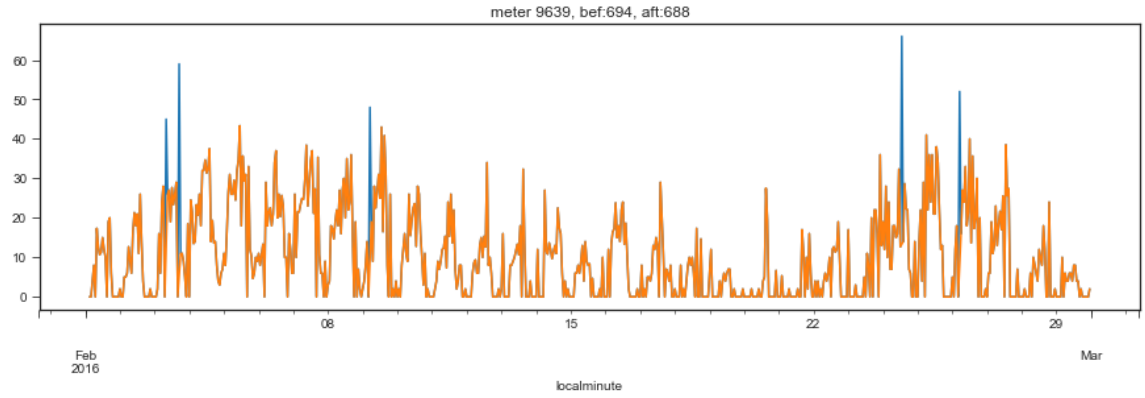
29
Feb
2016
Mar
localminute

13796


meter 9639, bef:694, aft:688
60
50
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2016
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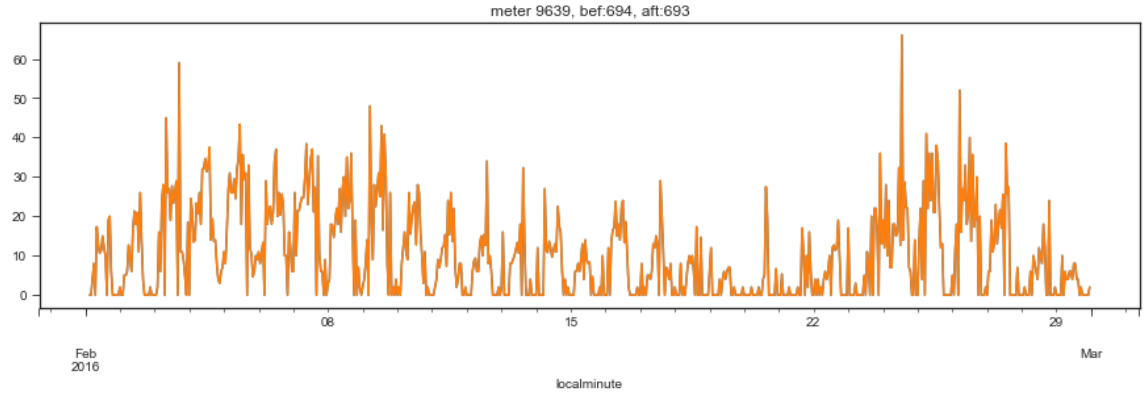
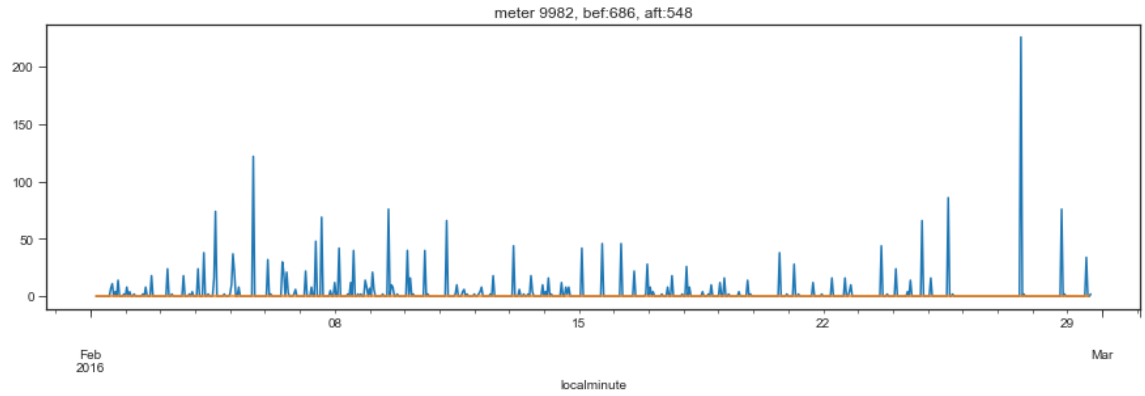
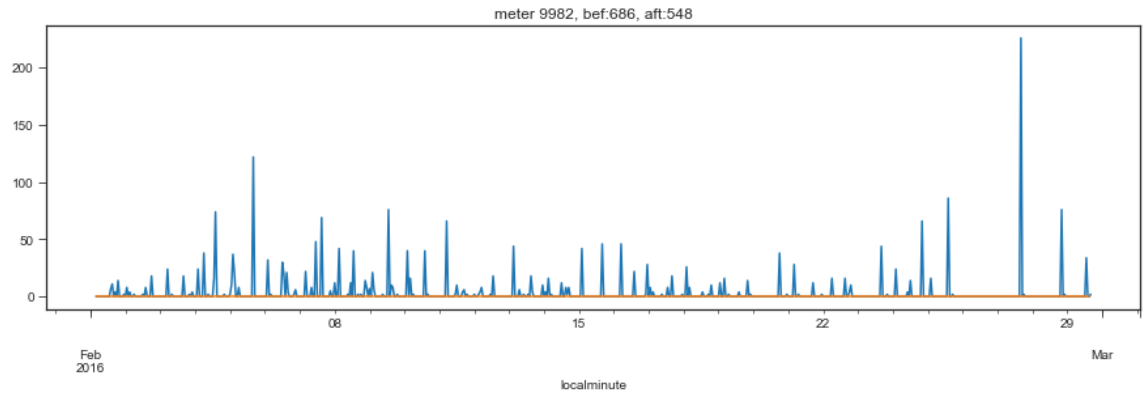
localminute




```
1540
```

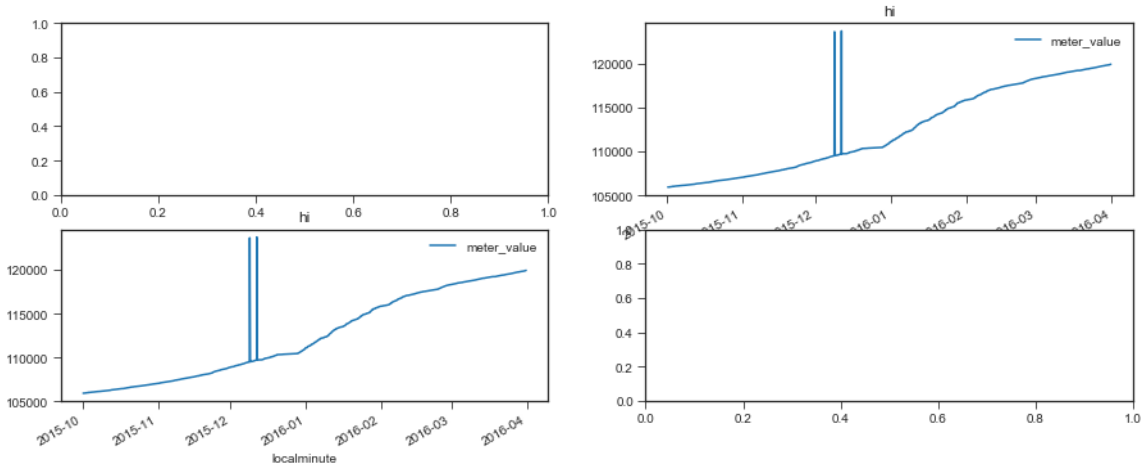





```
<Figure size 432x288 with 0 Axes>
```

In [116]:

```
# Plotting test
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(15,6))

df_i.plot(ax=axes[0,0], title='hi')
df_i.plot(ax=axes[0,1], title='hi')
df_i.plot(ax=axes[1,0], title='hi')
axes[0,0].clear()
```



In [117]:

```
df_i.plot(ax=axes[0,0], title='hi')
df_i.plot(ax=axes[0,1], title='hi')
df_i.plot(ax=axes[1,0], title='hi')
```

Out[117]:

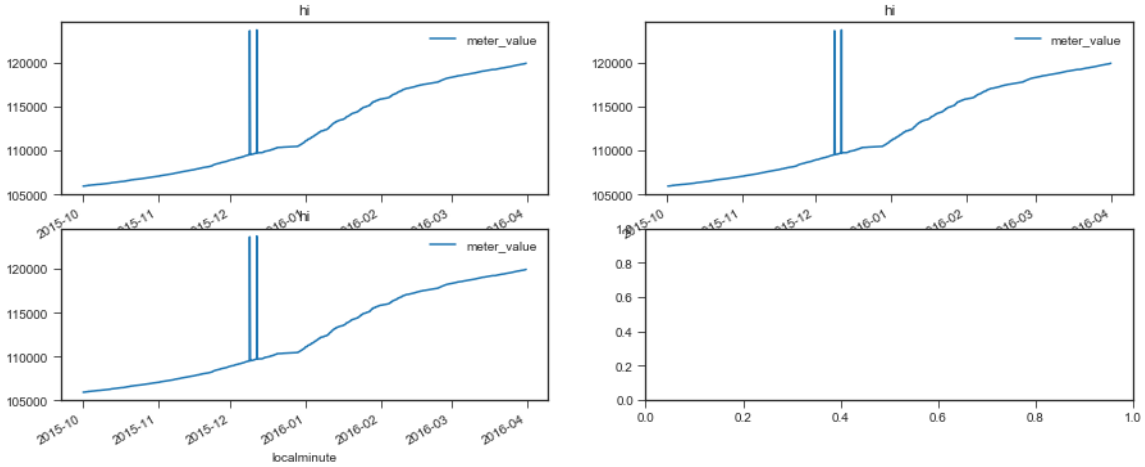
```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe8aeed9e8>
```

In [118]:

```
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(15,6))
# seems like I must call this again everytime i plot in a new cell?
# otherwise, no plot is shown when I call plot().

df_i.plot(ax=axes[0,0], title='hi')
df_i.plot(ax=axes[0,1], title='hi')
df_i.plot(ax=axes[1,0], title='hi')
```

Out[118]:

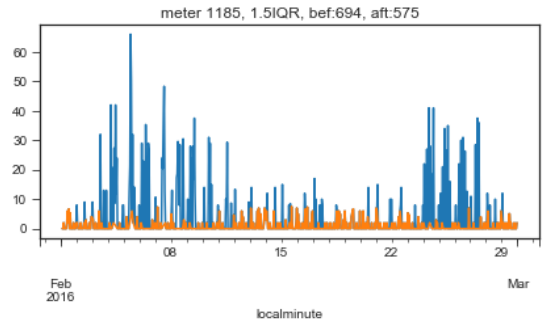
```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe898e0e10>
```

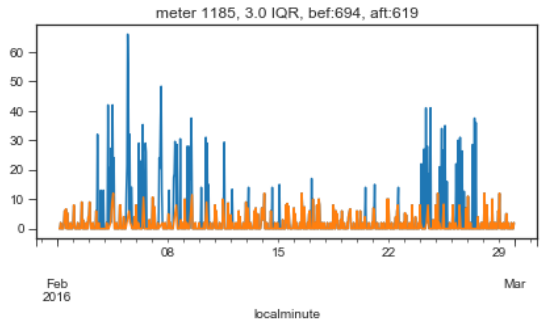


In [127]:

```
# zoom into 1 month
key = 1185
df_i = groups.get_group(key).drop(columns='dataid')
df_i_1mth = zoom(df_i, '2016-02-01', '2016-03-01')

def clean_resample_filter2(df_i):
    # v2 of this method uses/tests multiple plots
    fig, axes = plt.subplots(nrows=1, ncols=2, figsize=(15,3))

    # first, clean data by removing obvious dirt
    df_i_clean = remove_mal_data(df_i_1mth)
    df_i_clean = remove_negative_marginal(df_i_clean)

    # next, resample data by hour.
    df_i_resampled = df_i_clean.drop(columns='marginal_change').resample('H').mean().ff
ill()
    #display(df_i_resampled.head())

    # then, obtain new marginal changes.
    df_i_resampled['marginal_change'] = df_i_resampled['meter_value'].diff()

    # finally, filter by the IQR rule on marginal_change.
    # 1.5IQR filter
    df_i_filtered15 = remove_outliers(df_i_resampled, 1.5)

    # plot
    df_i_resampled['marginal_change'].plot(ax=axes[0])
    df_i_filtered15['marginal_change'].plot(ax=axes[0], \
                                            title=str(f'meter {key}, 1.5IQR, bef:{len(d
f_i_resampled)}, aft:{len(df_i_filtered15)}'))

    # 3.0IQR filter
    df_i_filtered30 = remove_outliers(df_i_resampled, 3.0)

    # plot
    df_i_resampled['marginal_change'].plot(ax=axes[1])
    df_i_filtered30['marginal_change'].plot(ax=axes[1], \
                                            title=str(f'meter {key}, 3.0 IQR, bef:{len
(df_i_resampled)}, aft:{len(df_i_filtered30)}'))

clean_resample_filter2(df_i_1mth)
```

```
C:\Users\Melvin\Anaconda3\lib\site-packages\ipykernel_launcher.py:9: Setti
ngWithCopyWarning:
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: http://pandas.pydata.org/pandas-doc
s/stable/indexing.html#indexing-view-versus-copy
  if __name__ == '__main__':
```





In [ ]:

```
for keys in keys_list:
    df_i = groups.get_group(key).drop(columns='dataid')
    df_i_1mth = zoom(df_i, '2016-02-01', '2016-03-01')
    clean_resample_filter2(df_i_1mth)
```